Horizon 2020

Call: H2020-INFRADEV-1-2014-1

Topic: INFRADEV-1-2014

Type of action: RIA

Proposal number: 653939

Proposal acronym: EDM

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How to fill in the forms

The administrative forms must be filled in for each proposal using the templates available in the submission system. Some data fields in the administrative forms are pre-filled based on the previous steps in the submission wizard.

Proposal ID **653939** *Acronym* **EDM**

1 - General information

Topic	INFRADEV-1-2014	Type of action	RIA
Call identifier	H2020-INFRADEV-1-2014-1	Acronym	EDM

Proposal title* Novel precision storage rings for Electric Dipole Moment searches

Note that for technical reasons, the following characters are not accepted in the Proposal Title and will be removed: < > " &

Duration in months *42*

Fixed keyword 1 *NATURAL SCIENCES* Add

Fixed keyword 2 *ENGINEERING AND TECHNOLOGY* Add Remove

Free keywords *PACS: 29.27.Hj Polarized beam in particle accelerators, 24.70.+s Polarization in nuclear reactions, 29.20.db Storage rings, 11.30.Er CP invariance, 24.80.+y Nuclear tests of Symmetry,*

Abstract

One of the great mysteries in the natural sciences is the dominance of matter over antimatter in the universe. According to our present understanding, the early universe contained the same amount of matter and antimatter. If the universe had behaved symmetrically as it developed, every particle would have been annihilated by one of its antiparticles. We therefore owe our very existence to mechanisms that have led to a world where something that we call matter remains. We propose to study such mechanisms by searching for electric dipole moments (EDMs) of charged hadrons in a new class of precision storage rings. Our project will lay the foundations for a new European flagship research infrastructure.

The breaking of the combined charge conjugation and parity symmetries (CP-violation) in the Standard Model is not strong enough to explain the observed excess of matter and further sources of CP-violation must be sought. These sources could manifest themselves in Electric Dipole Moments of elementary particles, which occur when the centroids of positive and negative charges are mutually and permanently displaced. The observation of an electric dipole moment will elucidate the mechanisms which led to the matter that dominates the universe.

Although the measurement principle, the time development of the polarization vector subject to a perpendicular electric field, is simple, the smallness of the effect makes this an enormously challenging project. This can only be mastered through the common effort of an international team of accelerator and particle physicists, working closely with engineers. The proponents of this design study and the research environment at the Forschungszentrum Jülich (Germany), including the conventional storage ring COSY, provide the optimal basis for one of the most spectacular possibilities in modern science: finding an EDM as a signal for new physics beyond the Standard Model and perhaps explaining the puzzle of our existence.

Remaining characters 18

Has this proposal (or a very similar one) been submitted in the past 2 years in response to a call for proposals under the 7th Framework Programme, Horizon 2020 or any other EU programme(s)? ○ Yes ◉ No

Proposal ID **653939**	Acronym **EDM**

Declarations

1) The coordinator declares to have the explicit consent of all applicants on their participation and on the content of this proposal.	☒
2) The information contained in this proposal is correct and complete.	☒
3) This proposal complies with ethical principles (including the highest standards of research integrity — as set out, for instance, in the [European Code of Conduct for Research Integrity](#) — and including, in particular, avoiding fabrication, falsification, plagiarism or other research misconduct).	☒

4) The coordinator confirms:

- to have carried out the self-check of the financial capacity of the organisation on https://ec.europa.eu/research/participants/portal4/desktop/en/organisations/lfv.html. Where the result was "weak" or "insufficient", the coordinator confirms being aware of the measures that may be imposed in accordance with the H2020 Grants Manual (Chapter on Financial capacity check); or	☐
- is exempt from the financial capacity check being a public body including international organisations, higher or secondary education establishment or a legal entity, whose viability is guaranteed by a Member State or associated country, as defined in the H2020 Grants Manual (Chapter on Financial capacity check); or	☒
- as sole participant in the proposal is exempt from the financial capacity check.	☐

5) The coordinator hereby declares that each applicant has confirmed:

- they are fully eligible in accordance with the criteria set out in the specific call for proposals; and	☒
- they have the financial and operational capacity to carry out the proposed action.	☒

The coordinator is only responsible for the correctness of the information relating to his/her own organisation. Each applicant remains responsible for the correctness of the information related to him and declared above. Where the proposal to be retained for EU funding, the coordinator and each beneficiary applicant will be required to present a formal declaration in this respect.

According to Article 131 of the Financial Regulation of 25 October 2012 on the financial rules applicable to the general budget of the Union (Official Journal L 298 of 26.10.2012, p. 1) and Article 145 of its Rules of Application (Official Journal L 362, 31.12.2012, p.1) applicants found guilty of misrepresentation may be subject to administrative and financial penalties under certain conditions.

Personal data protection

Your reply to the grant application will involve the recording and processing of personal data (such as your name, address and CV), which will be processed pursuant to Regulation (EC) No 45/2001 on the protection of individuals with regard to the processing of personal data by the Community institutions and bodies and on the free movement of such data. Unless indicated otherwise, your replies to the questions in this form and any personal data requested are required to assess your grant application in accordance with the specifications of the call for proposals and will be processed solely for that purpose. Details concerning the processing of your personal data are available on the privacy statement. Applicants may lodge a complaint about the processing of their personal data with the European Data Protection Supervisor at any time.

Your personal data may be registered in the Early Warning System (EWS) only or both in the EWS and Central Exclusion Database (CED) by the Accounting Officer of the Commission, should you be in one of the situations mentioned in:
-the Commission Decision 2008/969 of 16.12.2008 on the Early Warning System (for more information see the Privacy Statement), or
-the Commission Regulation 2008/1302 of 17.12.2008 on the Central Exclusion Database (for more information see the Privacy Statement) .

Proposal ID **653939** *Acronym* **EDM**

2 - Administrative data of participating organisations

PIC	***Legal name***
999980470	*FORSCHUNGSZENTRUM JUELICH GMBH*

Short name: FORSCHUNGSZENTRUM JUELICH GMBH

Address of the organisation

Street WILHELM JOHNEN STRASSE

Town JUELICH

Postcode 52428

Country Germany

Webpage www.fz-juelich.de

Legal Status of your organisation

Research and Innovation legal statuses

Public body .... no

Non-profit .... yes

International organisation .... no

International organisation of European interest .... no

Secondary or Higher education establishment .... no

Research organisation .... yes

Small and Medium-sized Enterprises (SMEs) .... no

Legal person .... yes

Nace code 721 -

Department(s) carrying out the proposed work

Department 1

Department name	Institut für Kernphysik
Street	WILHELM JOHNEN STRASSE
Town	JUELICH
Postcode	52428
Country	Germany

☒ Same as organisation address

Dependencies with other proposal participants

Character of dependence	***Participant***	

Proposal ID **653939** *Acronym* **EDM**

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Prof.
Sex: (•) Male ( ) Female

First name: **Hans** Last name: **Stroeher**

E-Mail: **h.stroeher@fz-juelich.de**

Position in org.: Director

Department: Institut für Kernphysik

Street: WILHELM JOHNEN STRASSE

☒ Same as organisation address

Town: JUELICH Post code: 52428

Country: Germany

Website: http://www.fz-juelich.de/ikp/EN/Home/home_node.html

Phone: +492461614408 Phone 2: +xxx xxxxxxxxx Fax: +492461613930

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Frank	Rathmann	f.rathmann@fz-juelich.de	+491757801444
Anne	Bosch	a.bosch@fz-juelich.de	

Proposal ID **653939** *Acronym* **EDM**

PIC	***Legal name***
999983962	*RHEINISCH-WESTFAELISCHE TECHNISCHE HOCHSCHULE AACHEN*

Short name: RWTH AACHEN

Address of the organisation

Street	TEMPLERGRABEN 55
Town	AACHEN
Postcode	52062
Country	Germany
Webpage	www.rwth-aachen.de

Legal Status of your organisation

Research and Innovation legal statuses

Public body .... yes

Legal person .... yes

Non-profit .... yes

International organisation .... no

International organisation of European interest ...... no

Secondary or Higher education establishment .... yes

Research organisation .... yes

Small and Medium-sized Enterprises (SMEs) .... no

Nace code - Not applicable

Proposal ID **653939** *Acronym* **EDM**

Department(s) carrying out the proposed work

Department 1

Department name	III. Physikalisches Institut B
Street	Otto-Blumenthal Straße
Town	Aachen
Postcode	52074
Country	Germany

☐ Same as organisation address

Dependencies with other proposal participants

Character of dependence	***Participant***	

Proposal ID **653939** *Acronym* **EDM**

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title	Prof.	Sex	(●) Male ( ) Female
First name	**Achim**	Last name	**Stahl**
E-Mail	**stahl@physik.rwth-aachen.de**		
Position in org.	Chair of Institute		
Department	III. Physikalisches Institut B		
Street	TEMPLERGRABEN 55	☒ Same as organisation address	
Town	AACHEN	Post code	52062
Country	Germany		
Website	http://www.physik.rwth-aachen.de/institute/institut-iiib/kontakt/		
Phone	+492418027301	Phone 2	+xxx xxxxxxxxx
Fax	+492418022244		

Proposal ID **653939** *Acronym* **EDM**

PIC	***Legal name***
999839626	*UNIVERSITA DEGLI STUDI DI FERRARA*

Short name: UNIFE

Address of the organisation

Street	SAVONAROLA 9
Town	FERRARA
Postcode	44100
Country	Italy
Webpage	www.unife.it

Legal Status of your organisation

Research and Innovation legal statuses

Public body	yes	Legal person	yes
Non-profit	yes		
International organisation	no		
International organisation of European interest	no		
Secondary or Higher education establishment	yes		
Research organisation	yes		
Small and Medium-sized Enterprises (SMEs)	no		

Nace code 853 -

Proposal ID **653939** *Acronym* **EDM**

Department(s) carrying out the proposed work

Department 1

Department name	Dipartimento di Fisica e Scienze della Terra
Street	via Saragat, 1
Town	Ferrara
Postcode	44122
Country	Italy

☐ Same as organisation address

Dependencies with other proposal participants

Character of dependence	*Participant*	

Proposal ID **653939** *Acronym* **EDM**

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Prof.

Sex: (●) Male ( ) Female

First name: **Paolo**

Last name: **Lenisa**

E-Mail: **lenisa@fe.infn.it**

Position in org.: Researcher

Department: Dipartimento di Fisica e Scienze della Terra

Street: via Saragat, 1

☐ Same as organisation address

Town: Ferrara

Post code: 44122

Country: Italy

Website:

Phone: +390532974309

Phone 2: +393473642527

Fax: +390532974343

Proposal ID **653939**	*Acronym* **EDM**

PIC	***Legal name***
940017883	*High Energy Physics Institute of Tbilisi State University*

Short name: High Energy Physics Institute of Tbilisi State University

Address of the organisation

Street	University 9
Town	Tbilisi
Postcode	0186
Country	Georgia
Webpage	http://hepi.edu.ge/ge/index.shtm

Legal Status of your organisation

Research and Innovation legal statuses

Public body	no	Legal person	yes
Non-profit	no		
International organisation	no		
International organisation of European interest	no		
Secondary or Higher education establishment	no		
Research organisation	no		
Small and Medium-sized Enterprises (SMEs)	no		

Nace code

Proposal ID **653939** *Acronym* **EDM**

Department(s) carrying out the proposed work

Department 1

Department name	High Energy Physics Institute of Tbilisi State University
Street	University 9
Town	Tbilisi
Postcode	0186
Country	Georgia

☐ Same as organisation address

Dependencies with other proposal participants

Character of dependence	***Participant***	

Proposal ID **653939** *Acronym* **EDM**

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Prof.

Sex: (•) Male ( ) Female

First name: **Mikheil**

Last name: **Nioradze**

E-Mail: **m.nioradze@hepi.edu.ge**

Position in org.: Director

Department: High Energy Physics Institute of Tbilisi State University

Street: University 9

☒ Same as organisation address

Town: Tbilisi

Post code: 0186

Country: Georgia

Website: http://hepi.edu.ge/ge/index.shtml

Phone: +995322188907

Phone 2: +995322187317

Fax: +995322189852

Proposal ID **653939** *Acronym* **EDM**

PIC	***Legal name***
999642716	*UNIWERSYTET JAGIELLONSKI*

Short name: UNIWERSYTET JAGIELLONSKI

Address of the organisation

Street Ul. Golebia 24

Town KRAKOW

Postcode 31007

Country Poland

Webpage www.uj.edu.pl

Legal Status of your organisation

Research and Innovation legal statuses

Public body .... yes

Non-profit .... yes

International organisation .... no

International organisation of European interest .... no

Secondary or Higher education establishment .... yes

Research organisation .... yes

Small and Medium-sized Enterprises (SMEs) .... no

Legal person .... yes

Nace code - Not applicable

Proposal ID **653939** *Acronym* **EDM**

Department(s) carrying out the proposed work

Department 1

Department name	Faculty of Physics, Astronomy and Applied Computer Science
Street	Reymonta 4
Town	Krakow
Postcode	30-059
Country	Poland

☐ Same as organisation address

Dependencies with other proposal participants

Character of dependence	***Participant***	

Proposal ID **653939** *Acronym* **EDM**

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title	Prof.		Sex	(●) Male ( ) Female	
First name	**Andrzej**		Last name	**Magiera**	
E-Mail	**andrzej.magiera@uj.edu.pl**				
Position in org.	Professor				
Department	Department of Physics, Astronomy and Applied Computer Science				
Street	Reymonta 4				☐ Same as organisation address
Town	Krakow		Post code	30-059	
Country	Poland				
Website	www.fais.uj.edu.pl/en_GB/start-en				
Phone	+48126635821	Phone 2	+48126635890	Fax	+48126637086

Proposal ID **653939** *Acronym* **EDM**

PIC	***Legal name***
999997930	*CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE*

Short name: CNRS

Address of the organisation

Street Rue Michel -Ange 3

Town PARIS

Postcode 75794

Country France

Webpage www.cnrs.fr

Legal Status of your organisation

Research and Innovation legal statuses

Public body ....yes

Non-profit ....yes

International organisation ....no

International organisation of European interest ......no

Secondary or Higher education establishment ....no

Research organisation ....yes

Small and Medium-sized Enterprises (SMEs) ....no

Legal person .... yes

Nace code 721 -

Department(s) carrying out the proposed work

Department 1

Department name	Pôle Accélérateurs et Sources d'Ions
Street	53 rue des Martyrs
Town	Grenoble
Postcode	38026
Country	France

☐ Same as organisation address

Dependencies with other proposal participants

Character of dependence	***Participant***	

Proposal ID **653939** *Acronym* **EDM**

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title	Prof.	Sex	(•) Male ( ) Female
First name	**Jean-Marie**	Last name	**Deconto**
E-Mail	**deconto@lpsc.in2p3.fr**		
Position in org.	Professor (Joseph Fourier University)		
Department	Pole Accélérateurs et Sources d'ions		
Street	LPSC, 53 rue de Martyrs	☐ Same as organisation address	
Town	Grenoble	Post code	38026
Country	France		
Website			
Phone	(33)476284098	Phone 2	+xxx xxxxxxxxx
Fax	+xxx xxxxxxxxx		

Proposal ID **653939** *Acronym* **EDM**

3 - Budget for the proposal

Participant	Country	(A) Direct personnel costs/€	(B) Other direct costs/€	(C) Direct costs of sub-contracting/€	(D) Direct costs of providing financial support to third parties/€	(E) Costs of inkind contributions not used on the beneficiary's premises/€	(F) Indirect Costs / € (=0.25(A+B-E))	(G) Special unit costs covering direct & indirect costs / €	(H) Total estimated eligible costs / € (=A+B+C+D+F+G)	(I) Reimburse-ment rate (%)	(J) Max. grant / € (=H*I)	(K) Requested grant / €
FORSCHUNGSZEN	DE	1 138 800	34 000	0	0	0	293 200	0	1 466 000	100	1 466 000	1 466 000
RWTH AACHEN	DE	489 250	33 000	0	0	0	130 563	0	652 813	100	652 813	652 813
UNIFE	IT	172 000	15 000	0	0	0	46 750	0	233 750	100	233 750	233 750
High Energy Physics	GE	40 200	18 000	0	0	0	14 550	0	72 750	100	72 750	72 750
UNIWERSYTET JAG	PL	55 800	14 000	0	0	0	17 450	0	87 250	100	87 250	87 250
CNRS	FR	223 195	16 000	0	0	0	59 799	0	298 994	100	298 994	298 994
Total		2 119 245	130 000	0	0	0	562 312	0	2 811 557		2 811 557	2 811 557

Proposal ID **653939** *Acronym* **EDM**

4 - Ethics issues table

1. HUMAN EMBRYOS/FOETUSES		Page
Does your research involve Human Embryonic Stem Cells (hESCs)?	◯ Yes ◉ No	
Does your research involve the use of human embryos?	◯ Yes ◉ No	
Does your research involve the use of human foetal tissues / cells?	◯ Yes ◉ No	
2. HUMANS		**Page**
Does your research involve human participants?	◯ Yes ◉ No	
Does your research involve physical interventions on the study participants?	◯ Yes ◉ No	
Does it involve invasive techniques?	◯ Yes ◉ No	
3. HUMAN CELLS / TISSUES		**Page**
Does your research involve human cells or tissues (other than from Human Embryos/ Foetuses, i.e. section 1)?	◯ Yes ◉ No	
4. PERSONAL DATA (ii)		**Page**
Does your research involve personal data collection and/or processing?	◯ Yes ◉ No	
Does your research involve further processing of previously collected personal data (secondary use)?	◯ Yes ◉ No	
5. ANIMALS (iii)		**Page**
Does your research involve animals?	◯ Yes ◉ No	

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6. THIRD COUNTRIES		Page
Does your research involve non-EU countries?	(•) Yes ( ) No	53
Georgia (Country Associated to HORIZON 2020)		
Do you plan to use local resources (e.g. animal and/or human tissue samples, genetic material, live animals, human remains, materials of historical value, endangered fauna or flora samples, etc.)? (v)	( ) Yes (•) No	
Do you plan to import any material from non-EU countries into the EU? *For data imports, please fill in also section 4.* *For imports concerning human cells or tissues, fill in also section 3.*	( ) Yes (•) No	
Do you plan to export any material from the EU to non-EU countries? *For data exports, please fill in also section 4.* *For exports concerning human cells or tissues, fill in also section 3.*	( ) Yes (•) No	
If your research involves low and/or lower middle income countries, are benefits-sharing measures foreseen? (vii)	(•) Yes ( ) No	53
Could the situation in the country put the individuals taking part in the research at risk?	( ) Yes (•) No	
7. ENVIRONMENT & HEALTH and SAFETY See legal references at the end of the section. (vi)		Page
Does your research involve the use of elements that may cause harm to the environment, to animals or plants? *For research involving animal experiments, please fill in also section 5.*	( ) Yes (•) No	
Does your research deal with endangered fauna and/or flora and/or protected areas?	( ) Yes (•) No	
Does your research involve the use of elements that may cause harm to humans, including research staff? *For research involving human participants, please fill in also section 2.*	( ) Yes (•) No	
8. DUAL USE (vii)		Page
Does your research have the potential for military applications?	( ) Yes (•) No	
9. MISUSE		Page
Does your research have the potential for malevolent/criminal/terrorist abuse?	( ) Yes (•) No	

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10. OTHER ETHICS ISSUES		Page
Are there any other ethics issues that should be taken into consideration? Please specify	○ Yes ◉ No	

I confirm that I have taken into account all ethics issues described above and that, if any ethics issues apply, I will complete the ethics self-assessment and attach the required documents. ☒

Proposal ID **653939** *Acronym* **EDM**

5 - Call specific questions

Open Research Data Pilot in Horizon 2020

If selected, all applicants have the possibility to participate in the Pilot on Open Research Data in Horizon 2020[1], which aims to improve and maximise access to and re-use of research data generated by actions. Participating in the Pilot does not necessarily mean opening up all research data. Actions participating in the Pilot will be invited to formulate a Data Management Plan in which they will determine and explain which of the research data they generate will be made open.

We wish to participate in the Pilot on Open Research Data in Horizon 2020 on a voluntary basis	(•) Yes	( ) No

Participation in this Pilot does not constitute part of the evaluation process. Proposals will not be evaluated favourably because they are part of the Pilot and will not be penalised for not participating.

[1] *According to article 43.2 of Regulation (EU) No 1290/2013 of the European Parliament and of the Council, of 11 December 2013, laying down the rules for participation and dissemination in "Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020)" and repealing Regulation (EC) No 1906/2006.*

Data management activities

The use of a Data Management Plan (DMP) is required for projects participating in the Open Research Data Pilot in Horizon 2020, in the form of a deliverable in the first 6 months of the project.

All other projects may deliver a DMP on a voluntary basis, if relevant for their research.

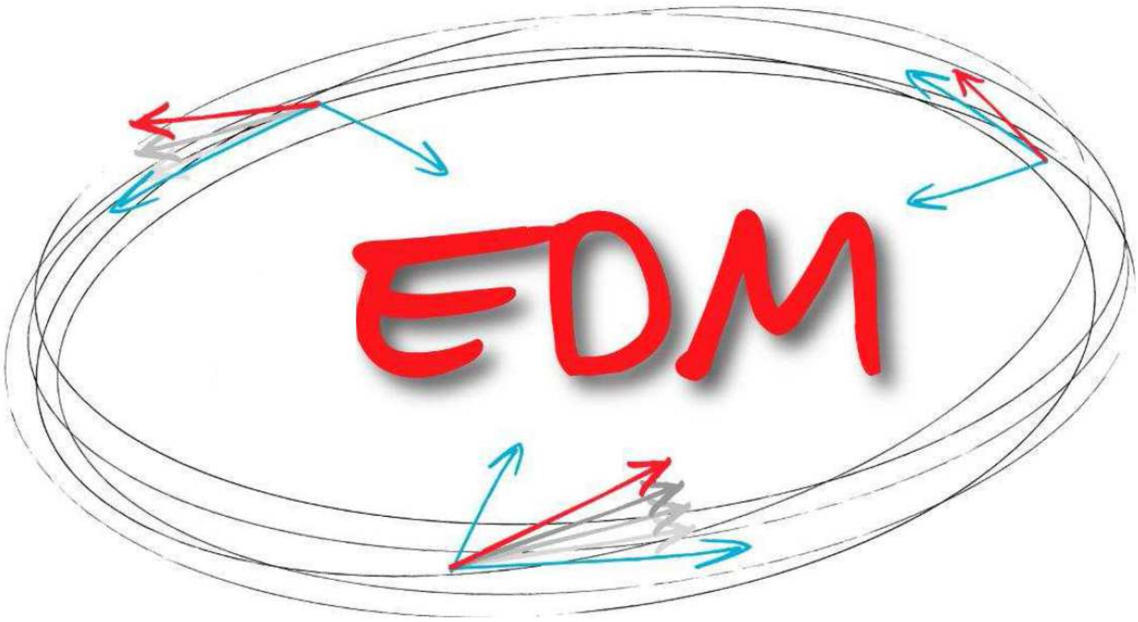
Are data management activities relevant for your proposed project?	(•) Yes	( ) No

A Data Management Plan will be delivered (Please note: Projects participating in the Open Research Data Pilot **must** include a Data Management Plan as a deliverable in the first 6 months of the project).	☒
Data Management is part of a Work Package.	☐
Data Management will be integrated in another way.	☐

Title of Proposal

Novel precision storage rings for Electric Dipole Moment searches

(Sections 1 - 3)



List of participants

Participant No	Participant organisation name	Country
1 (Coordinator) Jülich	Forschungszentrum Jülich GmbH	Germany
2 Aachen	RWTH Aachen	Germany
3 Ferrara	Universita degli Studi di Ferrara	Italy
4 Tbilisi	Ivane Javakhishvili Tbilisi State University	Georgia
5 Krakow	Uniwersytet Jagiellonski w Krakowie	Poland
6 Grenoble	Centre National de la Recherche Scientifique	France

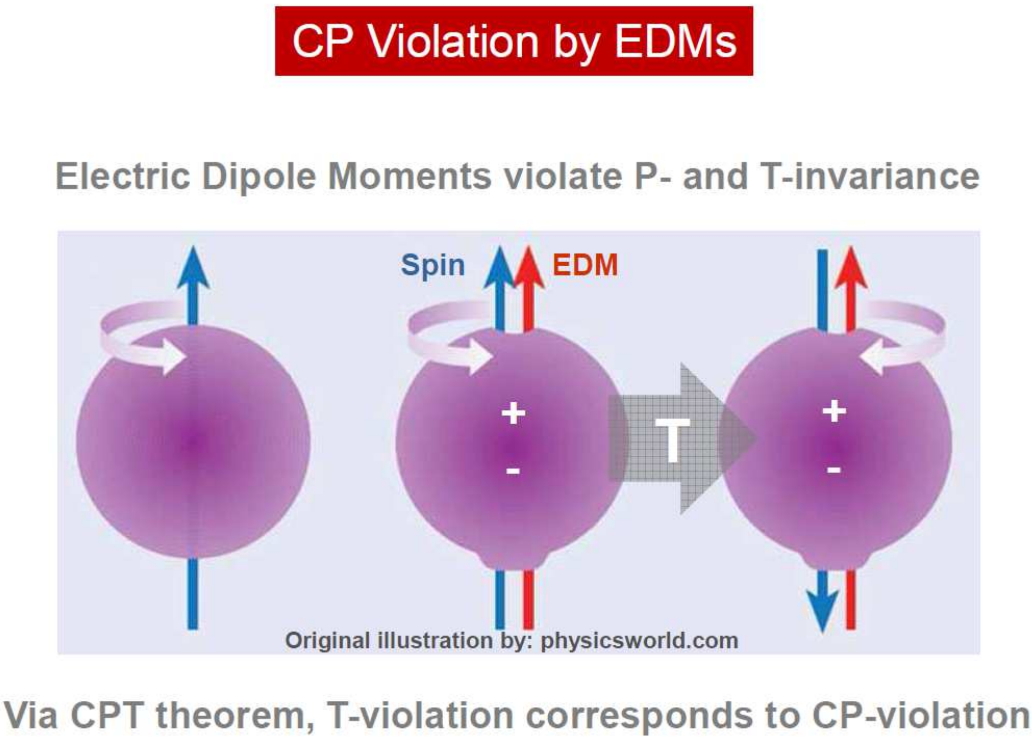
Table of Contents

1. Excellence

1.1 Objectives

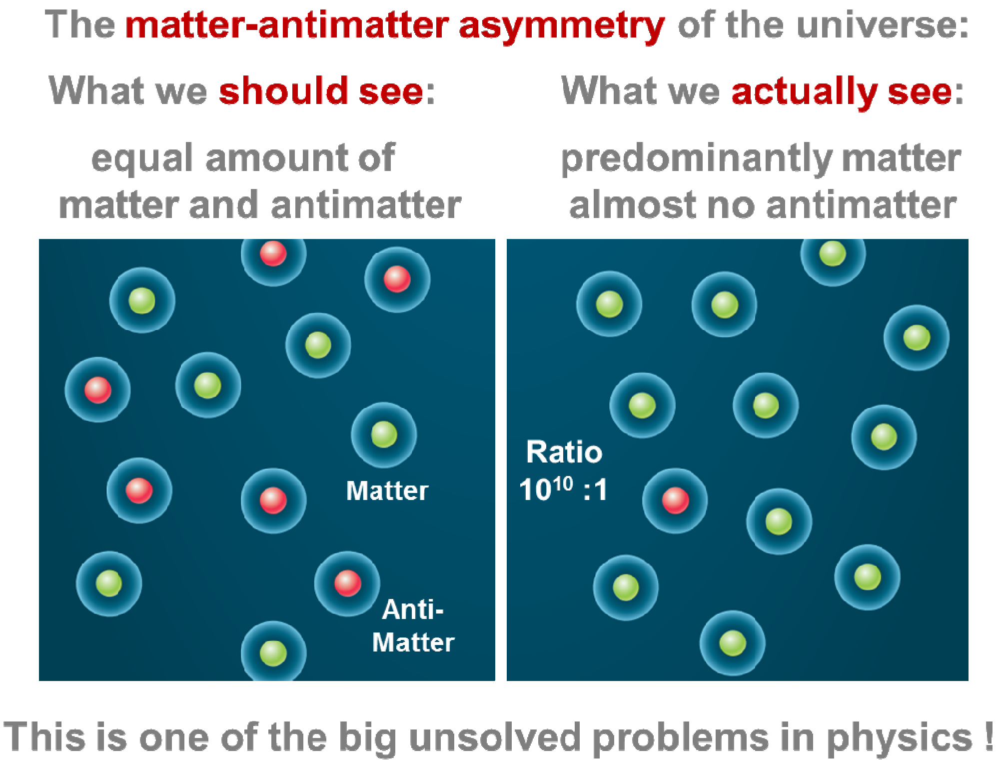
A new class of hitherto not existing precision storage rings is required to search for electric dipole moments (EDM) of charged particles with unprecedented sensitivity. This encompasses the complete chain from design and building to operation of the storage ring and includes instrumentation for control/feedback of the beam(s) and its polarization – it is the aim of this proposal to provide the design of such a *beyond state-of-the-art* facility.

Symmetries and symmetry violations ("breaking") play a very important role in physics. Permanent EDMs of particles violate both time reversal (T) (see figure: the resulting state after the T-operation is different from the original one!) and parity (P) invariance. Via the CPT theorem (which is based on very general assumptions and is therefore generally believed to be an exact symmetry) EDMs are also CP-violating (the combination of charge (C) conjugation and parity exchange) to compensate the breaking of T.



The breaking of CP-symmetry (CPV) is thought to be responsible for the different behavior of particles and antiparticles, leading, e.g., to the apparent matter-antimatter asymmetry in the Universe (see figure below). Only because of this cosmic asymmetry, our Universe (including ourselves) exists. CPV is found in the electroweak part of the Standard Model (SM), but since SM-CPV is much too weak to explain the so called baryon asymmetry, other sources are sought for – with the most obvious one being EDMs. Finding a finite EDM would be a major discovery, which most probably will also indicate *new physics*, not contained in the SM. Inevitably such an EDM search requires to investigate different systems (leptons, atoms, nucleons and light nuclei) – not the least to identify the CPV source after a possible EDM observation.

Science Case



EDMs are very small – the best current upper limit for the *neutron* is 10^{-26} e·cm – and the aim for *charged particles* (i.e., our project) is 10^{-29} e·cm or even better. Although the measurement principle – following the time development of the polarization vector of particles subject to a perpendicular electric field – is simple, the smallness of the effect makes this an enormously challenging project, which can only be mastered in the common effort of a most experienced team of accelerator and spin-physics scientists, together with mechanical and electrical engineers.

The proponents of the EDM project will proceed to tackle these challenges by primarily focusing on:

Design of the precision storage ring: **This is the objective of the current Design Study with the Conceptual Design Report (CDR) as the major and final deliverable.**

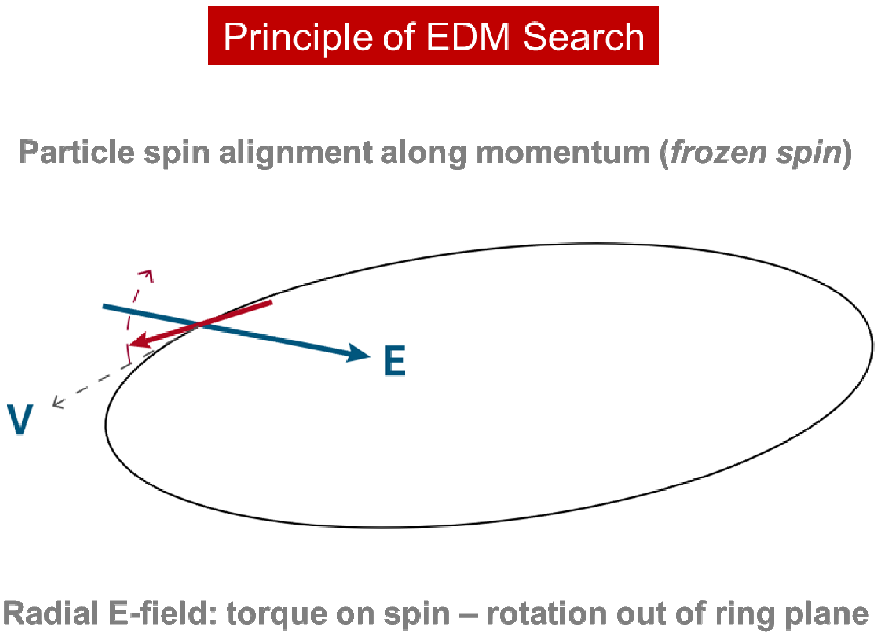
Concurrently to the Design Study, research and development exploiting the existing infrastructures will be pursued. This comprises two aspects: *i)* systematic studies and tests measurements at the Cooler Synchrotron COSY and development of large-scale simulations on the supercomputers of Forschungszentrum Jülich; this is an ongoing activity by the JEDI ("Jülich Electric Dipole Moment Investigations") collaboration and will continue during the coming years. The second aspect relates to *ii)* a precursor experiment at COSY with the aim to provide a proof-of-principle measurement for EDM searches of charged particles (and a first *direct* measurement of EDM limits for protons and deuterons) in storage rings. Preparations for such a measurement have been started and the measurements will be conducted after the necessary COSY upgrades are accomplished.

1.2 *Relation to the work programme*

The outcome of the proposed Design Study will be the conceptual design of a new accelerator facility – a precision storage ring for polarized light ions (p, d, and ^{3}He), very probably with two counter-rotating beams – which, if realized subsequently, will unquestionably be a new world-class research infrastructure with a multitude of new technical features. The scientific case, i.e. the quest to fundamentally understand the difference between matter and anti-matter, which has led to our matter-dominated Universe, belongs to the grand challenges in contemporary physical sciences – this has been acknowledged, e.g., in recently published strategy reports of the European and the US high-energy physics community. From the technical point-of-view, the many-fold challenges will be best met by a transnational European initiative (as will be true for its later realization), in which experts of different fields are joining forces – potentially extended into a world-wide collaboration. Benefits to society of the project are manifold: from new precision simulation codes and techniques on supercomputers, novel surface treatment measures for highest electric field deflectors, highly effective magnetic shielding for accelerators and support components and new target/detector systems for precision polarimetry to novel operation, measurement and analysis schemes. Our proposed project "Novel precision storage rings for Electric Dipole Moment searches" (EDM) is thus very well suited for the call INFRADEV 1-2014: Design Studies.

1.3 *Concept and approach*

Up to now measurements of electric dipole moments concentrated on *neutral* systems (neutron, atoms, and molecules) – for *charged* hadrons, no direct measurements exist. This is due to the fact that charged particles are accelerated in electric fields and thus cannot be kept in small volumes like traps. Storage rings have to be used to perform these kinds of experiments. However, those charged systems (specifically proton, deuteron and ^{3}He) are not only complimentary and more sensitive, but they are required to disentangle the possible (different) EDM source(s) (see subsection c) below).



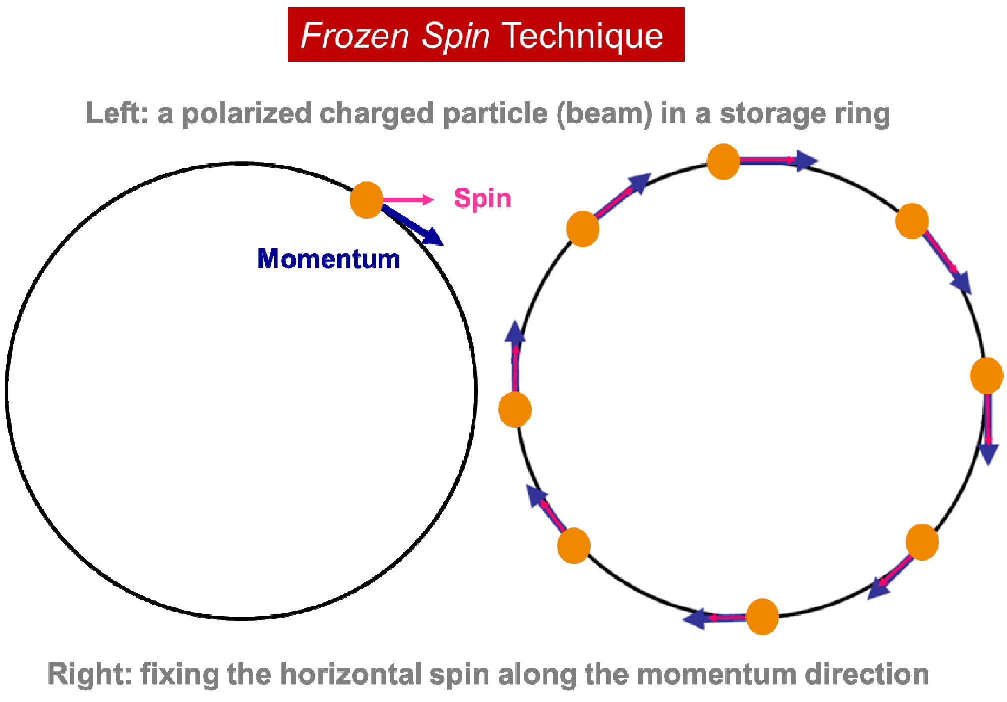
As mentioned, the principle of such measurements is quite simple (see figure above): if an electric dipole moment exists, the spin vector, which is oriented parallel to the EDM direction, will experience a torque in an external electric field, resulting in a change of the original spin direction. This minuscule spin rotation can be determined with the help of a so called polarimeter (a detector to determine the spin direction). Alternatively, one can search for a tiny change of the spin precession frequency due to an EDM.

In view of the necessary requirements, the existing cooler storage ring COSY at the Forschungszentrum Jülich with its capability to provide polarized protons and deuterons up to momenta of 3.7 GeV/c is an ideal starting point for a research and development program and a first direct charged-particle EDM measurement. For an ultimate precision measurement, however, a new class of dedicated storage rings is required, which does not yet exist. At this stage, COSY might be used as injector to prepare the beams for the EDM ring. As already mentioned, searches for proton and deuteron EDMs bear the potential to reach a sensitivity of 10^{-29} e·cm per year of running, which is at least one order of magnitude better than what is aimed at in future neutron EDM searches.

In spite of the simplicity of the measurement principle, the smallness of the expected effect as well as possible background and fake contributions make this a very challenging experiment, which will require paramount precision. Up to now it has only been possible to obtain a very moderate limit of ~10^{-19} e·cm for the muon (μ, a lepton) as by-product in the "$(g\text{-}2)_\mu$ -experiment". The newly founded JEDI collaboration, together with the US-based storage ring EDM (srEDM) collaboration, is pursuing research and development to cover all scientific and technological challenges and to come up with concepts for precision EDM storage rings for protons, deuterons and ^{3}He.

a) Concepts for EDM storage rings

The spin precession in a storage ring is governed by the famous Thomas-Bargmann-Michel-Telegdi (Thomas BMT) equation. The main challenge is that in general the spin precession due to the magnetic dipole moment (MDM) is many orders of magnitude larger than the spin precession expected from an EDM. The aim is thus to find electro-magnetic field configurations where the contribution due to the MDM vanishes, i.e., where the spin vector does not precess and always points along the momentum vector in the absence of an EDM. This technique is called "frozen spin".



For protons with their positive anomalous magnetic moment, this can be achieved with *purely electric fields* for a "magic" beam momentum of p = 700.74 MeV/c. For particles with negative anomalous magnetic moment (like deuterons and ^{3}He) a *combination of electric and magnetic fields* has to be used. In either case a non-vanishing EDM results in a build-up of a vertical polarization component for a beam that was initially polarized in the horizontal plane. A purely electric ring for protons is proposed by the srEDM collaboration at Brookhaven National Laboratory (BNL, USA) [http://www.bnl.gov/edm/Proposal.asp]. A radial electric field of about 17 MV/m between field plates approximately 2 cm apart results in a ring with a bending radius of about 30 m.

One alternative is to use a combined electric-magnetic machine with radial electric and vertical magnetic fields. By suitable combinations of the E- and B-fields, a ring with a radius between 10 and 30 m could be used for protons, deuterons and ^{3}He nuclei ("all-in-one" ring).

For both options the use of clock-wise (CW) and counter clock-wise (CCW) beams is mandatory for the following reason: The main systematic error will come from an unwanted spin precession due to the MDM in radial magnetic fields which will be indistinguishable from the EDM signal. A radial magnetic field, however, causes forces in different directions for the beams in opposite directions and thus it can be controlled to a very high accuracy.

b) Advantages of the proposed approach compared to state-of-the-art neutron EDM studies

The principal observable of every electric dipole moment measurement is the angle of precession of the spin in an electric field, the size of which depends on the product of the electric field times the precession (observation) time. In the neutron beam magnetic resonance technique, a restriction comes from the short time of flight of neutrons through the magnet. Stored ultra-cold neutrons (UCN) allow one to increase the precession time by about four orders in magnitude. However, ultimately the precession time is bound from above by the neutron lifetime (about 880 s). Furthermore, considering the typical size of the UCN storage cell one loses in the strength of the applied electric field. Thus important virtues of dedicated proton (or d, ^{3}He) EDM storage rings experiments are:

i. The large number of stored particles ($10^{10} – 10^{11}$).

ii. The envisioned use of electric fields, which will be an order of magnitude larger than those in UCN experiments (srEDM experiments: >10 MV/m *vs.* typically 1 MV/m in UCN experiments).

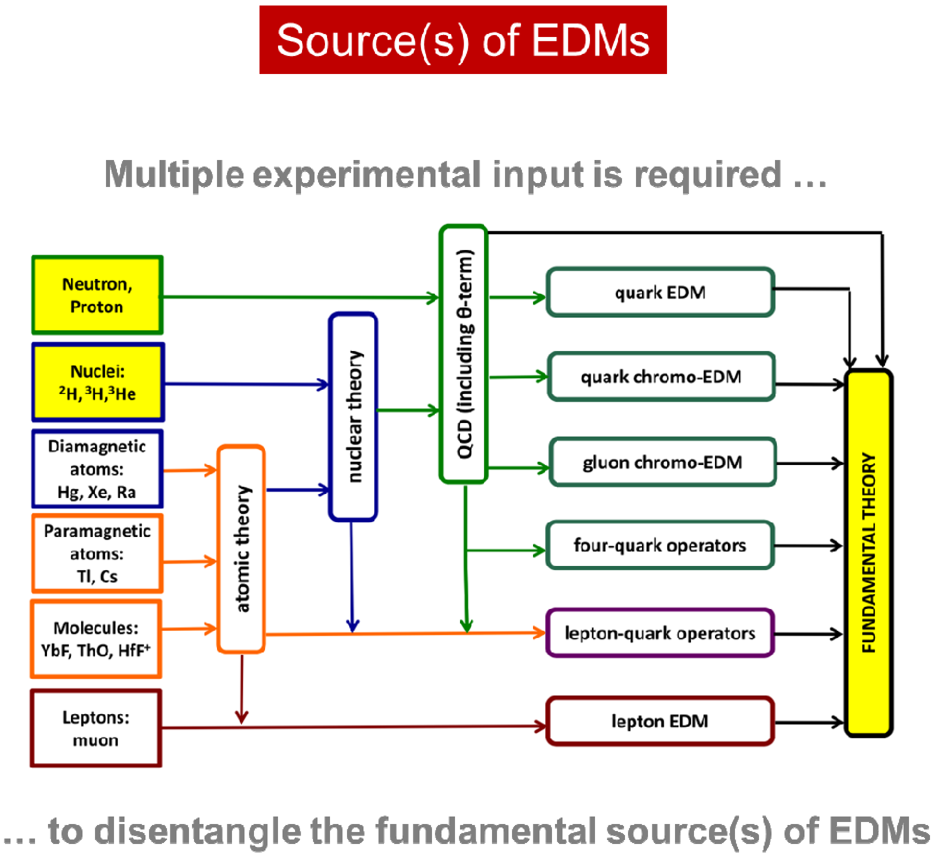
iii. Since contrary to neutrons, protons do not decay, the achievable observation (precession) times (also for *d*, ^{3}He) are potentially much longer than the neutron lifetime. Therefore, it is of critical importance to ascertain that large spin coherence times (SCT) – one of the highest risk factors in all proposals of storage ring EDM searches – can be achieved in dedicated pure electric (E) and conventional magnetic(B) (as well as combined E-B) storage rings. It should be noted that a SCT on the order of hundreds of seconds have already been achieved with the conventional magnetic storage ring COSY, and further improvements are expected.

The ultimate EDM experiment, capable of surpassing the sensitivity of the neutron EDM experiments and aiming at $d_{p,d} \sim 10^{-29}$ e·cm per year, is within reach for the approach of frozen longitudinal spins in a dedicated storage ring. In order to achieve the aspired goals, many of the basic storage-ring-related experimental and theoretical concepts need to be developed beyond the present state-of-art.

c) Need for charged particle EDMs

If an EDM is measured, e.g., for the neutron, an important question remains: is it caused by *strong* CP violation within the Strong Interaction sector of the Standard Model of elementary particle physics (the so called θ-term) or from physics beyond the Standard Model (BSM)? Experimental data on the EDMs of light nuclei can provide an answer to this question. First of all, it is clear that a single EDM measurement can be interpreted (fitted) by any source, so that at least two measurements are needed to say something about the origin of the CP violation.

In order to determine which systems are most promising, in recent years several calculations have been performed for EDMs of the nucleon (neutron, proton) and several light nuclei, using modern effective-theory techniques: it has been shown that the θ-term could be identified with good accuracy, once EDM measurements of the neutron, proton and deuteron have been performed. For this source the EDMs of these systems are all expected to be of the same order of magnitude, but the precise quantitative relations between the individual EDMs are a clear prediction of the θ-term. In this way, the existence of strong CP violation can be convincingly determined, potentially solving a puzzle which has been around for almost fifty years.



On the other hand, the size of the deuteron EDM, with respect to the EDM of proton and neutron, is an excellent probe for physics beyond the Standard Model (BSM): as mentioned, the θ-term expects similar size EDMs for the nucleon and the deuteron, while certain BSM sources predict the deuteron EDM to be significantly larger, up to an order of magnitude. Such a signal, obtained in the envisioned storage ring experiment, would be a "smoking gun" for BSM physics.

In summary, it is necessary to determine electric dipole moments of different systems in order to disentangle the source(s) by discriminating between the different model predictions. Especially the deuteron EDM has a large discriminating power due to its unique spin-(S = 1) – isospin-(I = 0) properties.

The figure above gives a schematic general overview of the experimental input and its relation to the potential EDM sources, leading to a basic understanding in a fundamental theory: while leptons are directly related, the hadronic results are more complex, but also much more interesting.

d) Status and approach of charged particle EDM searches

The charged particle EDM project is at an early stage but – as outlined above – it has most promising perspectives:

i. The idea for the measurement is simple and matured.

ii. The unprecedented sensitivity aimed at will comprise a huge discovery potential.

iii. The ongoing R&D at an existing (conventional) magnetic storage ring (COSY at Forschungszentrum Jülich, Germany) has already contributed significantly to the progress for feasibility studies – for example by showing that the required precision for the beam polarimetry can be achieved, and the anticipated measuring time of 1000 s per cycle is in reach.

iv. Simulations with the "COSY-Infinity" code on supercomputers have advanced to a level of quantitative benchmarking of the experimental results.

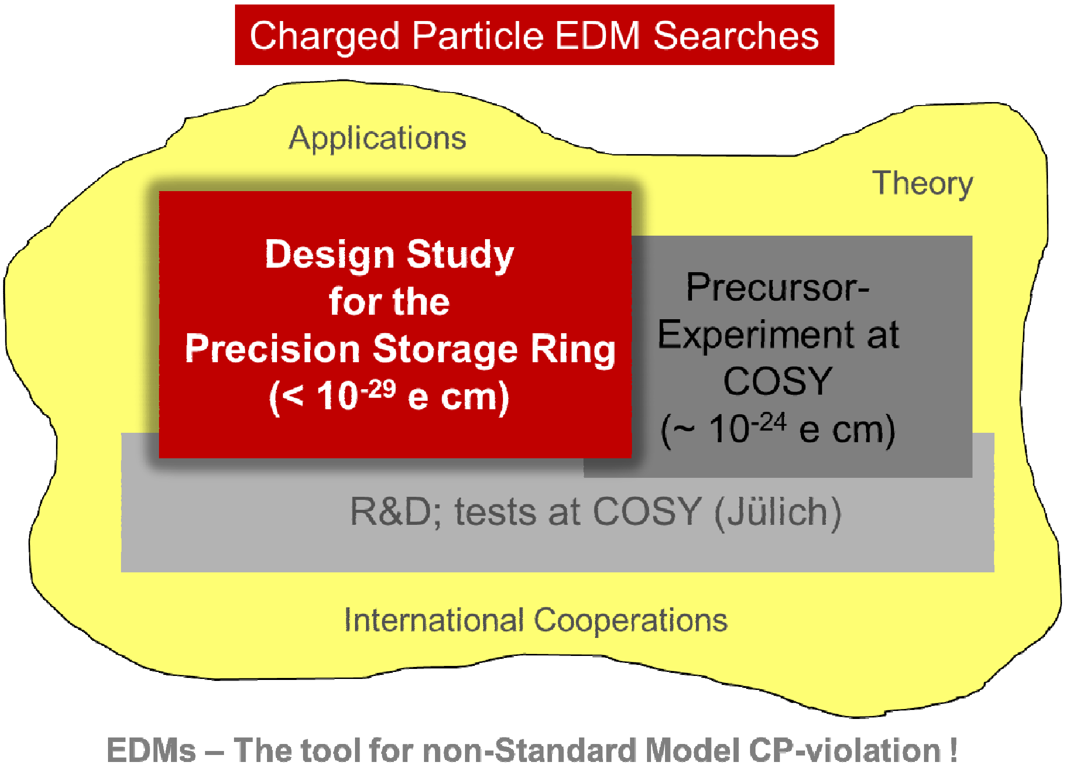
However, for the final precision storage ring, a new design (with two counter-rotating beams) will be necessary to reduce systematic uncertainties and get rid of fake signals. For this ring, only ideas exist up to now, which are more advanced for the "all-electric" ring (applicable only for protons (and charged leptons)) than for the "all-in-one" ring (for *p*, *d* and ^{3}He).

The overall strategy of the JEDI collaboration towards a precision storage ring for charged particle EDM searches is as follows (see figure below):

i. There is an ongoing R&D effort – laboratory tests and test measurements at COSY – in order to demonstrate feasibility wherever it is possible with the best storage ring facility currently available for polarized beams.

ii. There is an ongoing project to exploit COSY for a "precursor" experiment, not aiming at the highest sensitivity, but demonstrating the proof-of-principle (and obtaining invaluable experience for the precision ring).

iii. There is ongoing work for the design of the final precision ring, which will be very much advanced with this Design Study. The whole project is embedded in the international community, encompassing the corresponding theory groups, enforced by international collaborations, also with the aim of applications, e.g., for accelerators and measurement methodology.



Currently two groups are working towards a charged particle storage ring EDM project:

i. The US-based "srEDM" collaboration (Brookhaven National Laboratory (BNL), more recently including Fermilab (FNAL)).

ii. The (mostly) European "JEDI" collaboration, centred at Forschungszentrum Jülich.

It should be emphasized that both collaborations are working together in common R&D efforts and in particular in the test measurements at COSY (Jülich). Dedicated two-beam tests, e.g., for beam-position monitors, may also be performed at BNL´s (Brookhaven National Laboratory) RHIC (Relativistic Heavy Ion Collider) in the future.

Besides the Design Study core team, scientists from the following groups/research centres are involved in the storage ring EDM project:

i. Collider Accelerator Department of Brookhaven National Laboratory (BNL) (Upton, NY; USA) (contact person T. Roser)

ii. Physics Department of Brookhaven National Laboratory (BNL) (Upton, NY; USA) (contact person W. Morse) *iii.* Department of Physics of Indiana University (Bloomington, IN; USA) (contact person E. Stephenson)

iv. Department of Physics and Astronomy, Michigan State University (East Lansing, MI; USA) (contact person: M. Berz)

v. Budker Institute of Nuclear Physics (BINP) (Novosibirsk, Russia) (contact person I. Koop)

vi. Korea Advanced Institute of Science and Technology (KAIST) (Daejeon, Republic of Korea) (contact person Y. Semertzidis)

Physical sciences in Europe, and in particular in Germany, are still male-dominated – which is also reflected in the list of leading scientists for this project. On the other hand, Forschungszentrum Jülich, RWTH Aachen and the other institutions are committed to increase the female-to-male ratio by imposing target-settings. (As one example: we have recently succeeded to replace the retired head of the Jülich accelerator institute by a female scientist – see section 4.1 a).) For the EDM Design Study, we will strive to hire at least as many female as male scientists.

1.4 ***Ambition***

COSY is the state-of-the-art storage ring for polarized proton and deuteron beams on a world-wide scale: after more than 20 years of operation for hadron physics, it has all but a so called "Siberian Snake" necessary to perform every required spin-manipulation with polarized stored beams – the snake will be delivered by the end of 2014. Therefore, COSY is the only machine in the world where most of the necessary tests for the storage ring EDM project can be performed – including the precursor experiment once the planned COSY upgrades are completed.

However, it will not be possible to convert COSY into the precision storage ring with two counter-rotating beams, which is required for the ultimate precision EDM search: a newly designed ring is required. Such simultaneously counter rotating beams are used in colliders but here its position and spin direction needs to be stabilized and tracked with the highest possible precision. Therefore, it must be equipped with beam position sensors and polarimeters of highest sensitivity, which continuously monitor both beams and provide feedback signals. The whole ring must be exceedingly shielded against unwanted external magnetic fields. The effects of beam-beam and beam-wall interactions have to be investigated as well as, e.g., the possible impact of gravitation.

It can be shown that with reasonable assumptions about beam intensity ($5 \cdot 10^{10}$ particles per fill), polarization of the beam (80%), electric fields (10 MV/m), spin coherence time (1000 s) and polarimetry (analysing power 60%, accuracy 0.5%), a statistical accuracy of 10^{-29} e·cm can be achieved after one year of measurement. In passing, we mention that – given the proton would have the size of the earth – the separation of the charge centroids would be less than a micro-meter!

One of the aims of the ongoing R&D is to improve all *statistically* relevant parameters of the EDM machine. At the same time, the Design Study will allow us to specify how far beyond the present state-of-the-art one has to go in order to match statistical and systematic sensitivity at the 10^{-29} e·cm level. This is very challenging, because all *systematic errors* have to be brought to the same level. In detail, this involves to provide beyond state-of-the-art

i. measurement of the relative beam-position of the two counter-rotating beams,

ii. shielding of the machine against external magnetic fields, *iii.* alignment for all optical elements in the machine,

iv. electric fields of the electrostatic deflector elements beyond 10 MV/m, and

v. beam polarimetry on the ppm (parts per million) level.

The goal is to come to solid conclusions about how far beyond the present technological state-of-the-art one has to go in order to reach the ambitious sensitivity limit, potentially leading to the discovery of new physics.

2. Impact

2.1 Expected impacts

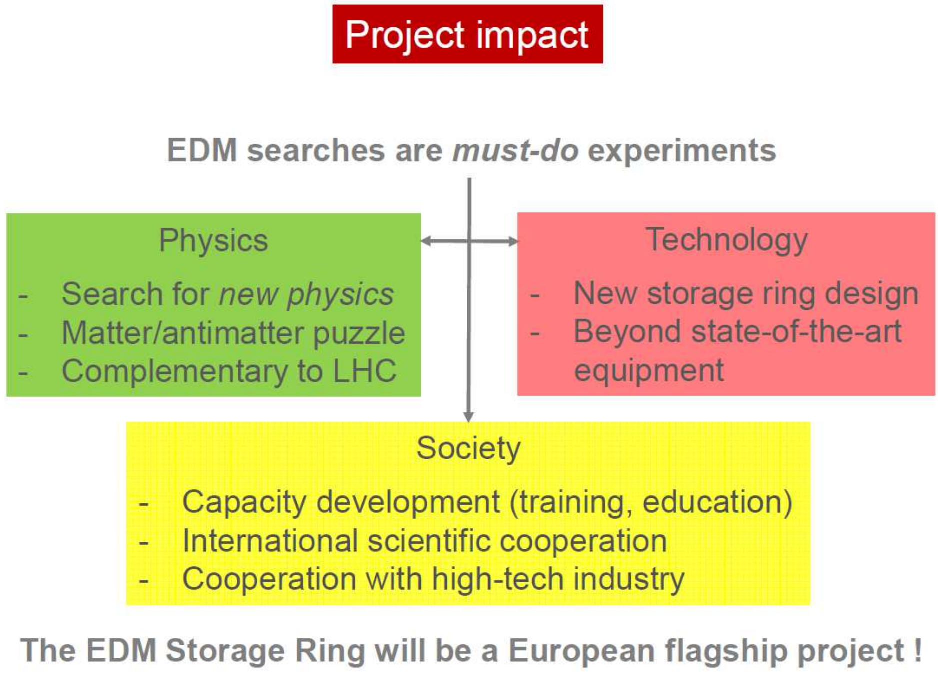
Accelerators are the tools for discovery and innovation, not only in the fields of elementary particle, hadron and nuclear physics, but also, e.g., in medical and industrial applications. This is why all developed countries, and in particular Europe, put a lot of emphasis into the further development of accelerators, from high-energy colliders and synchrotron radiation facilities to spallation neutron sources.

The physics case behind the current project requires the design of a completely new innovative *storage ring*: in order to reduce systematic errors and to identify/control fake effects, counter-rotating beams must be used. In the case of an “all-electric” ring (for protons at the magic momentum only), the two beams can be stored in one common vacuum chamber, while for an “all-in-one” machine with combined electric and magnetic fields (which can be used for protons, deuterons and ^{3}He and for different energies), two separate beam tubes must be used. Together with the requirement of ultimate precision, these represent significant challenges. By mastering these, many innovations are expected: from surface treatment of electrostatic deflectors (to provide highest electric fields), shielding techniques (of external electric and magnetic fields), beam position and polarization measurement to simulation techniques on supercomputers.

While for the design phase, physicists and engineers (from research centres and universities) have to collaborate, the later construction of such a precision storage ring will inevitably also involve technologically oriented institutes like, e.g., the Central Institute for Engineering, Electronics and Analytics (ZEA) of Forschungszentrum Jülich, and high-tech companies, e.g., for building combined E-B deflectors.

An important extra impact will be the capacity development, i.e., the training and education of students and young researchers in a wide range of activities: simulations, hardware development and data analysis.

In addition, already existing collaborations at different levels between the core-team participants will be further developed and intensified. It will also foster interactions within the worldwide community.



The precision EDM storage ring will be a unique new world-class European flagship research infrastructure, which, when realised, would combine advanced accelerator technologies with basic research in the natural sciences. It would serve as an example for other dedicated research infrastructures within the "precision frontier" to complement the "energy frontier" (e.g., LHC) in its quest for discoveries.

2.2 *Measures to maximise impact*

a) Dissemination and exploitation of results

The major deliverable of the project is a conceptual design report (CDR) of the ring layout of a precision storage ring with counter-rotating light-ion beams (p, d, ^{3}He), which – after being built – will allow to search for electric dipole moments with unprecedented sensitivity: the CDR will be made public as soon as its contents has been agreed upon by the Design-Study collaborators (subject, e.g., to possible patents pending).

The CDR will form the basis for a review by an international committee to scrutinize the design and this in turn should be the basis for implementing the project in future national (e.g., Helmholtz Association) and international (e.g., ESFRI: European Strategy Forum on Research Infrastructures) roadmaps for new scientific infrastructures. It has not yet been decided who would take on this next step, but it seems obvious that the proponents of this Design Study will be deeply involved. The subsequent step will then be a discussion and/or decision how and where to build the ring, with Forschungszentrum Jülich being an excellent host institution.

b) Communication activities

We have already started to promote the storage ring EDM project on various levels:

i. In 2011 it was included into the "Helmholtz-Roadmap for Future Research Infrastructures" (of the German Helmholtz Association) as "EDM@COSY". It is planned to adjust it in the forthcoming new roadmap next year.

ii. In 2011, an international "WE Heraeus Seminar" on "Search for Electric Dipole Moments (EDM) at Storage Rings" was conducted at Bad Honnef (Germany) with major involvement (Chairman) of proponents of this Design Study.

iii. In 2012, an international workshop on "EDM Searches at Storage Rings" was conducted at ECT* in Trento (Italy) with major involvement (Chairman) of proponents of this Design Study.

iv. In 2013 it was proposed as the future facility of Forschungszentrum Jülich in the "Programme oriented Funding" of the research field "Matter", programme "Cosmic Matter in the Laboratory") of the Helmholtz Association (which received highest scientific grades).

v. In 2014, it was included into the "Struktur- und Entwicklungplan" (STEP) of Forschungszentrum Jülich. In 2012, a new section of the cooperation of Forschungszentrum Jülich and RWTH Aachen University ("JARA-Fame") was founded in a public ceremony including the Nobel-laureate Samuel Ting.

vi. From autumn 2014 on, we are planning to conduct so called technical workshops on selected items of the project, like, e.g., electrostatic deflectors, polarimeter, and simulations, including a broader audience of interested scientists.

The international JEDI-collaboration ("Jülich Electric Dipole Moment Investigations") with more than 100 members has been founded as well (see: http://collaborations.fz-juelich.de/ikp/jedi/). The science case has already been presented at various national and international conferences, workshops and in seminars at universities.

After a successful application, we will not only work hard to achieve the goals of our project, but we will also intensify our communication activities:

i. Advertisement of the positions of the project in international journals (e.g., CERN Courier).

ii. Set-up of a dedicated web-site, providing all necessary background and the obtained achievements ("green" open access).

iii. Outreach articles in scientific newspapers, such as Physik Journal, CERN Courier, Nuclear Physics News International etc.

iv. Publications of scientific results in the arXiv ("gold" open access) and in the appropriate refereed journals.

v. We will continue and intensify the presentation of the project at topical national and international workshops and conferences.

vi. We will apply to host the next "Symposium on Symmetries in Subatomic Physics" in 2017 in Jülich with (at least one of) the chairmen from the project core team.

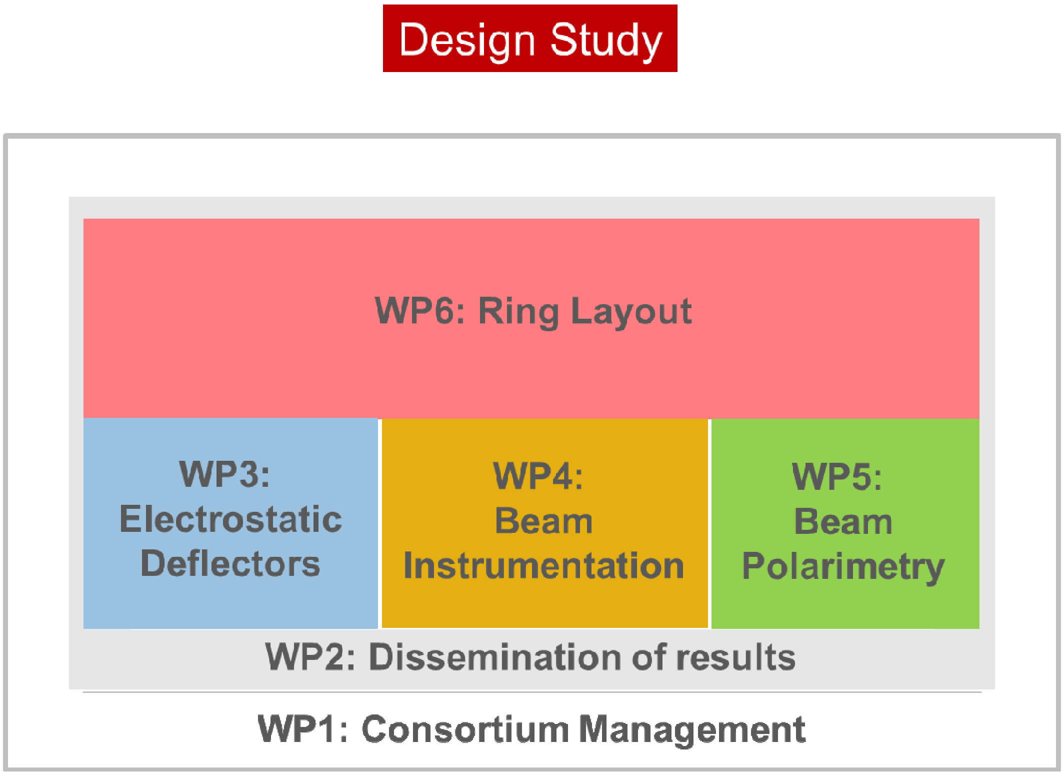
vii. The CDR will be presented to the public in an official event.

All activities are aimed to further promote the project as well as to attract additional collaborators from within Europe and beyond, e.g., USA, South Korea, and China.

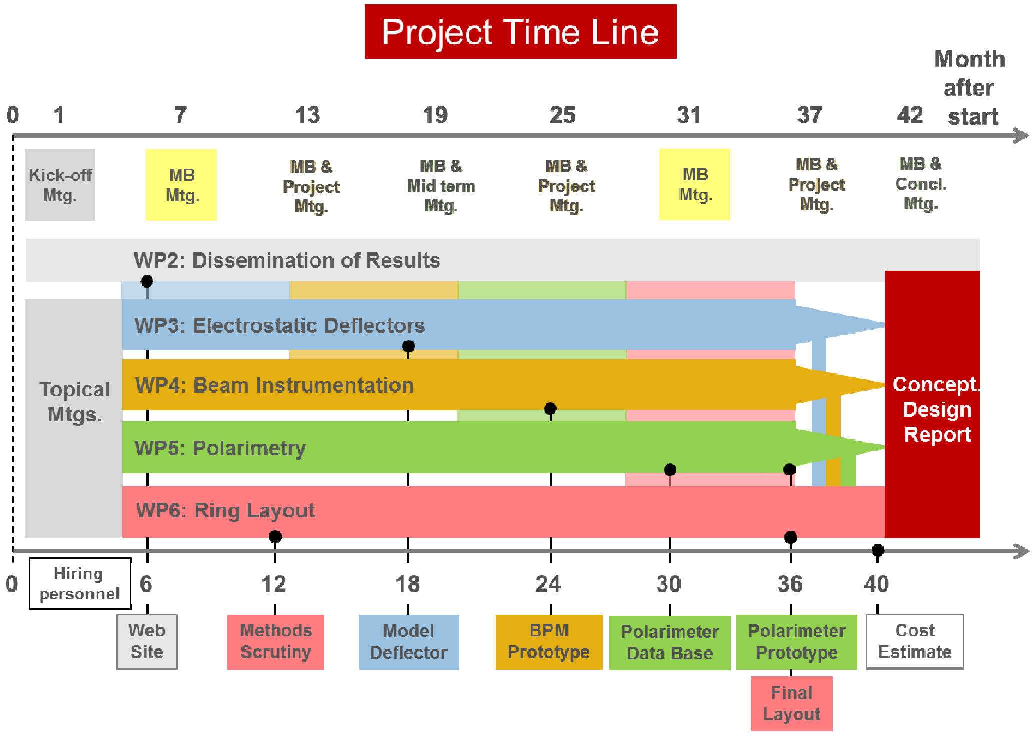
3. Implementation

3.1 Work plan — Work packages, deliverables and milestones

The overall structure of the Design Study is shown in the following diagram, indicating the relations between the 6 work packages of the project. The main aim is the design (concept and technical realization) of the layout of the new high-precision storage ring with counter-rotating beams (WP6). In order to lay the experimental and technical foundations, WP3 (Electrostatic deflectors), WP4 (Beam instrumentation) and WP5 (Beam polarimetry) need to be worked out: this does, however, not imply that WP6 can only be started after WPs3-5 have been finalized; on the contrary, all of them have to be addressed in parallel and in an iterative and interrelated procedure. WP2 (Dissemination of results) will assure that all of the results obtained in WPs3-6 will be documented and reported in a timely fashion. WPs2-3 are embedded in WP1 (Consortium management), which takes care of all organizational and managerial issues which are encountered. WP1 will also be responsible for a cost estimate of the facility.



The following chart shows the contemplated time line of the Design Study: we will start with a project kick-off meeting and so called topical meetings for WPs3-6 in order to review the current status; over the project time of 42 months, regular meetings of the management board (MB) and the project will be scheduled, and the (intermediate) results will be continuously disseminated. Concurrent with WP6, the findings in WPs3-5 will be used as input, finally leading to the Conceptual Design Report at the end of the project. Milestones as given in the lower part of the figure are distributed along the time line to scrutinize the project´s progress.



The experimental and technical resources required to successfully complete the proposed Design Study have already been secured through internal funding. Therefore in the present application no funds for investment are required for equipment.

Table 3.1a: Work package description

a) Consortium Management

Work package number	**1**	**Start Date or Starting Event**			**Month 1**
Work package title	**Consortium Management**				
Participant number	**1**	**2**	**3**	**4**	**5**	**6**
Short name of participant	**Jülich**	**Aachen**	**Ferrara**	**Tbilisi**	**Krakow**	**Grenoble**
Person/months per participant:	**18**	**1**	**1**	**1**	**1**	**1**

Objectives WP1 (Consortium management) will assure the efficient and effective collaboration between the participants, e.g., by organizing regular Management Board (MB) meetings as well as project meetings for WPs3-6 to follow the progress, the hiring of personnel, the control of money flow, and the timely completion of scientific and financial reports to the EU-Commission. WP1 will also set up the CDR writing committee and produce a cost estimate for the facility outlined in the CDR. In order to do so, a managerial structure (see figure in section 3.2 (Management structure and procedures))

will be implemented.

Description of work	
Consortium Management	**Lead participant Jülich**

1. **Management Board (MB) meetings**

   Over the course of the project (42 months), a “kick-off meeting” right after the start of the Design Study, 2 annual meetings (possibly at the different participant locations), including a mid-term meeting and a “conclusion meeting” will be organized.

2. **Topical and project meetings**

   For each one of the work packages WPs3-6, a topical meeting shortly after (or in conjunction with) the kick-off meeting will be organized. Possibly in conjunction with each of the WB meetings, but at least once a year, a common project meeting will take place to follow the progress of the project.

3. **Preparation of scientific and financial reports**

   All scientific progress reports and financial reports of the Design Study consortium will be organized in order to assure a coherent and timely preparation.

4. **Cost estimate**

   An estimation of the cost of the storage ring facility for different scenarios will be provided.

In addition to regular (weekly) electronic contacts, if necessary, short-term telephone and/or video conferences will be scheduled at any time in between.

Deliverables		
D-WP1.1	**Kick-off meeting, topical meetings**	**Month 1**
D-WP1.2	**1st MB meeting**	**Month 7**
D-WP1.3	**2nd MB meeting, and 1st project meeting**	**Month 13**
D-WP1.4	**3rd MB meeting, project mid-term meeting**	**Month 19**
D-WP1.5	**4th MB meeting, and 2nd project meeting**	**Month 25**
D-WP1.6	**5th MB Meeting**	**Month 31**
D-WP1.7	**6th MB meeting, and 3rd project meeting**	**Month 37**
D-WP1.8	**Cost estimates for different machine options**	**Month 40**
D-WP1.9	**7th MB meeting, and project conclusion meeting**	**Month 42**

b) Dissemination of Results

Work package number	2	Start Date or Starting Event			Month 1
Work package title	**Dissemination of results**				
Participant number	**1**	**2**	**3**	**4**	**5**	**6**
Short name of participant	**Jülich**	**Aachen**	**Ferrara**	**Tbilisi**	**Krakow**	**Grenoble**
Person/months per participant:	**12**	**0**	**0**	**36**	**0**	**0**

Objectives
WP2 (Dissemination of results) will assure that all of the results, including intermediate steps, will be documented and reported in a timely fashion, e.g., on the web-site, in conferences and in refereed scientific journals; best care and attention will be taken that results as well as the project itself will be presented to the broader scientific community and to the public.

Description of work

Dissemination of results — **Lead participant Tbilisi**

1. **Implementation and maintenance of web-site** **(Lead participant Tbilisi)**
   As soon as the project is accepted, a project web-site will be installed in which the project will be described and all relevant material will be stored for internal and (partial) external access. A restricted part (only for the project members) of the site, which, e.g., contains internal reports and preliminary results not ready for public release, will be password-protected.
2. **Scientific internal and external reporting** **(Lead participant Tbilisi)**
   All internal reports, (seminar- and conference-) talks, conference reports and scientific publications will be attended and documented, the latter with the help of a publication committee, which also decides on the public release of data.
3. **Data management** **(Lead participant Jülich)**
   Great care will be taken to assure that all the experimental (and technical) data will be saved in such a way that they will be easily accessible in the future.
4. **Patent management** **(Lead participant Jülich)**
   If technical developments are made that may lead to a patent, the project participants will strive to file a patent with the help the corresponding department, e.g., of Forschungszentrum Jülich.

Deliverables		
D-WP2.1	**Consortium website**	**Month 6**
D-WP2.2	**Data management plan**	**Month 6**
D-WP2.3	**Conceptual Design Report (CDR)**	**Month 42**

c) Electrostatic Deflectors

Work package number	**3**	**Start Date or Starting Event**				**Month 1**
Work package title	**Electrostatic Deflectors**					
Participant number	**1**	**2**	**3**	**4**	**5**	**6**
Short name of participant	**Jülich**	**Aachen**	**Ferrara**	**Tbilisi**	**Krakow**	**Grenoble**
Person/months per participant:	**12**	**60**	**18**	**0**	**0**	**24**

Objectives

Since the effect of an electric dipole moment depends on its interaction with an electric field (E), it is of utmost importance to operate the precision storage ring with as high E-fields as possible. WP3 is aiming to determine the technologically possible limit for stable operation.

Description of work

Development of electrostatic elements for electric storage rings	**Lead participant Jülich**

1. **Development of new surfaces and their treatment** **(Lead participant Aachen)**
   This development aims at reaching much higher electric fields than the ~6 MV/m provided by the Tevatron deflector elements. To this end, a laboratory environment has been set up at Aachen to study the HV capacity with small scale prototypes**.** The development will address new materials, new surface coatings and their surface treatment, and their characterization in terms of the spark rate and HV capabilities.
2. **Study development and manufacturing techniques** **(Lead participant Aachen)**
   Based on the electrostatic elements that were recently received from Fermilab (previously employed in the Tevatron) will allow us to carry out tests with real-size deflector elements towards high electric field beyond 10 MV/m. In a second step, new materials will allow us to replace the FNAL stainless steel deflectors and to test them in a laboratory environment which provides shielding of the X-rays produced upon sparking.
3. **Testing of large-scale deflector elements at COSY** (**Lead participant Jülich**)
   One of the FNAL deflector elements could be tested at COSY to study modification of the spin tune as a method to determine the electric field contributions to the Thomas-BMT equation. Thereby, it will become possible to determine the integral electric field directly, which is otherwise not possible experimentally.
4. **Develop precise monitoring system for the electrostatic elements** **(Lead participant Ferrara)**
   Monitoring the electric field of each electrostatic element in the final machine shall be accomplished by Fabry-Perot interferometry. This is possible because the electric field is defined by the surface potential and the geometry; and the geometry of the surface itself will be monitored online while the EDM experiment is running.
5. **Development of electrostatic multipole elements** **(Lead participant Grenoble)**
   Besides electrostatic dipole elements, the dedicated machine needs to flexible electrostatic multipole elements (quadrupoles, sextupoles, etc.) which are necessary to focus the beam in the ma-

chine, to adjust the working point, etc.

Deliverables		
D-WP3.1	**Small scale model deflector element**	**Month 18**
D-WP3.2	**Proposal to study electrostatic deflector elements at COSY**	**Month 36**
D-WP3.3	**Monitoring System for electrostatic elements**	**Month 36**
D-WP3.4	**Design of electrostatic multipole elements**	**Month 36**

d) Beam Instrumentation

Work package number	**4**		**Start Date or Starting Event**		**Month 1**
Work package title	**Beam Instrumentation**				
Participant number	**1**	**2**	**3**	**4**	**5**	**6**
Short name of participant	**Jülich**	**Aachen**	**Ferrara**	**Tbilisi**	**Krakow**	**Grenoble**
Person/months per participant:	**30**	**30**	**0**	**0**	**0**	**0**

Objectives

The EDM measurement requires a precise monitoring of the beam properties to understand systematic effects. The main objective of this work package is the construction of a SQUID (Superconducting QUantum Interference Device) based beam position monitor system to be tested in the COSY ring. Connected to this beam current and beam phase space measurements will be addressed.

The main systematic error of an EDM measurement is supposed to come from radial magnetic fields which will, via the interaction with the magnetic moment of the particle, mimic an EDM effect.

A radial magnetic field is of the order of 10^{-17} T would correspond to an EDM of 10^{-29} e·cm. Such a small field cannot be measured directly. The concept we would like to follow is to make use of two counter rotating beams in the ring. A radial magnetic field will lead to a vertical separation of the two beams which leads to a non-vanishing magnetic field which could be measured with SQUIDs. A first estimate shows that one needs sensitivity of the order of 1fT/√Hz. The SQUID sensitivity was discussed by D. Kawall at the 485. Heraeus Seminar, Bad Honnef (2011): SQUIDs with this sensitivity are available but were never tested in an accelerator environment. SQUIDs were used as a beam current monitor but never as a beam position monitor where a new 4-fold coil setup to measure up-down and left-right positions will be used. This will be addressed in this work package. Note that only the relative positions of the two beams have to be measured. This method only works if the beam currents and phase space of the two beams are the same or are determined very precisely. This issue and the question how many BPM are needed in the ring will also be addressed in this WP together with WP6 (ring layout).

Description of work	
Design of a SQUID based BPM system	**Lead participant Aachen**

An engineer experienced in the construction of liquid Helium cooled devices will design a SQUID prototype setup to be used first in the laboratory. Already at the design stage it will be guaranteed that this setup can later be inserted in the COSY ring with only minor modifications.

1. **Prototype built in work shop** **(Lead participant Jülich)**
   According to the design the prototype will be built in the workshops at Jülich.
2. **Measurement in the laboratory** **(Lead participants Jülich and Aachen)**
   The two counter rotating beams will be mimicked by two wires which can be set to different currents and at different positions. The test measurements in the laboratory shall prove that the required accuracy can be reached.
3. **Test measurements at COSY** **(Lead participant Jülich)**
   After a successful test in the laboratory the prototype will be installed in COSY and tested in a real accelerator environment. The second beam not present in COSY will be substituted by a wire.

Deliverables		
D-WP4.1	**Design Report of a SQUID based beam position monitor system**	**Month 12**
D-WP4.2	**Construction of a prototype and tests in the laboratory at COSY**	**Month 24**

e) Polarimetry

Work package number	**5**		**Start Date or Starting Event**		**Month 1**
Work package title	**Polarimetry**				
Participant number	**1**	**2**	**3**	**4**	**5**	**6**
Short name of participant	**Jülich**	**Aachen**	**Ferrara**	**Tbilisi**	**Krakow**	**Grenoble**
Person/months per participant:	**24**	**12**	**24**	**30**	**30**	**0**

Objectives

The polarimeter for the EDM Storage Ring must operate continuously with high efficiency and high polarization sensitivity (analyzing power) so that polarization rotations of the beam as small as a μrad may be detected if they happen within a time of about 1000 s. There also needs to be control of the systematic errors in detecting this change to a similar level of precision. The conditions of high efficiency (1%) and analyzing power (~0.6) are fulfilled for medium energy protons and deuterons when using a thick (few cm) carbon block onto which the beam particles are directed continuously during the experiment. Elastic scattering of the beam particles from the atomic nuclei in the carbon target will be observed in a series of detectors installed behind the target.

Feasibility studies conducted at COSY have already demonstrated this level of performance and error suppression for a carbon block mounted at the edge of the circulating beam. In an experiment in which the polarization direction is periodically reversed, first-order errors arising from beam position or angle errors, or rate-induced acceptance changes in the detector system, may be cancelled using combinations of the elastic scattering rates for different azimuthal angles. Higher-order systematic effects related to the shape of the beam profile may be corrected based on the information from a reconstruction of individual scattering events if the carbon target is supplemented with a hydrogen gas jet (or frozen pellet beam) that crosses the beam. So part of the polarimeter detector will be a tracking system that allows tracing each particle back to its point or origin, and another outside the first that identifies particles that have scattered elastically. The hydrogen target will also give rise to Coulomb scattered (with spin independence) particles that oscillate about the beam centre line and strike the thick carbon blocks on subsequent trips around the storage ring.

The goal of the WP would be the design, construction and testing of a prototype polarimeter for use in the first EDM storage ring experiment. This will comprise the following steps:

- Development of a broad-band database for p-C and d-C scattering;
- Detector characterization;
- Polarimeter modelling and Monte Carlo simulations;
- Realization and test of a prototype.

In parallel to the presented development, we will investigate the option to observe the EDM-induced vertical component of polarization by detecting the slow precession of the vertical polarization ($f=10^{-9}$ s^{-1}). This assignment requires performing highest-sensitivity frequency measurements. In synergy with the development of WP4 we will investigate the potential to accomplish the task offered by the use of SQUID detectors.

Description of work	
Design and construction of a prototype polarimeter	**Lead participant Ferrara**

1. Acquisition of a database for proton and deuteron induced reactions on carbon (Lead participant Krakow)

Generally, the literature contains insufficient information for the design of a polarimeter since most nuclear physics experiments at medium energies have been narrowly focused on one or a small set of reaction channels studied to answer a specific question about nuclear structure or reaction dynamics. For the purpose of polarimeter design, a set of data showing all reaction channels is needed with excitation energies extended well into the continuum. Analyzing power is needed along with the differential cross section, and for deuterons both tensor and vector analyzing powers become important.

One way to provide these data would be to build a thin carbon target for the WASA 4π detector system presently installed at COSY. This system has a forward detector cone (out to 17°) with good tracking and energy resolution. Data recording and analysis software systems already exist.

2. Detector characterization (Lead participants Ferrara and Aachen)

There are a number of detector technologies that are potential candidates for use in the polarimeter, particularly for the tracking part. These include silicon strip, gas electron multiplier, drift chamber, straw tube, and micromegas designs. The JESSICA beam line at COSY is a suitable place to run small sample detectors near a thick carbon target in order to observe the characteristics of signals, especially at high rates.

3. Polarimeter modelling (Lead participant Tbilisi)

Data on reaction cross sections and spin dependence will be combined with information about how detectors respond to light nuclei and other associated types of radiation to construct a model of the response of various EDM polarimeter designs. This will lead to a choice of the best technology for the EDM experiment and a design for the polarimeter.

4. **Build and test prototype** **(Lead participant Jülich)**

   Once a suitable design concept has been verified by simulation, this can be turned into a specific design. The design must meet the installation standards for COSY. The prototype design will be optimized in Ferrara, while its realization will be accomplished in the Workshop of FZJ. The synergy between the two groups has been already exploited in the past (PAX-project).

   COSY beam times will be used to complete a calibration of the spin-sensitivity and efficiency of the instruments, and to assess its ability to provide stable information with correction for systematic errors.

5. **Investigation about a new polarimeter concept based on SQUID frequency measurements (Lead participants Aachen, Jülich)**

   We will investigate the option of using a SQUID detector discussed in WP4 also as a polarimeter. The small magnetic moment of the proton (with respect to the electron for example) makes the task extremely difficult, but the method offers the major advantage of constituting a non-invasive polarization measurement.

Deliverables		
D-WP5.1	Data base on polarized proton-carbon and deuteron-carbon scattering	**Month 30**
D-WP5.2	Polarimeter prototype constructed and tested	**Month 36**
D-WP5.3	Feasibility study for a SQUID polarimeter	**Month 36**

f) Ring Layout

Work package number	**6**	**Start Date or Starting Event**			**Month 1**
Work package title	**Ring Layout**				
Participant number	**1**	**2**	**3**	**4**	**5**	**6**
Short name of participant	**Jülich**	**Aachen**	**Ferrara**	**Tbilisi**	**Krakow**	**Grenoble**
Person/months per participant:	**60**	**0**	**0**	**0**	**0**	**24**

Objectives

Design of lattice with electric and magnetic field deflectors for CW-CCW beams.

The main focus of lattice design is to ensure the capability to reach long spin coherence time and supress systematic rotations induced by the magnetic moment. An optimised pole shape of electromagnetic deflector elements, appropriate multipole corrections, efficient magnetic shielding and strong beam cooling systems are essential tasks of the lattice design. Different concepts of dedicated frozen-spin EDM machines will be investigated and compared.

Description of work	
Ring layout	**Lead participant Jülich**

1. Lattice design for a dedicated frozen-spin EDM machine (Lead participant Jülich)

The following requirements have to be taken into account for the EDM ring layout:

- Polarization “frozen” (relative to the beam velocity) with very high accuracy and extremely long spin coherence time (> 10^3 s)
- Optimize lattice optics to improve the precision of vertical beam separation determination of CW-CCW beams
- Ultra-high current- and emittance matched counter-circulating beams to be able to measure differences of vertical polarizations and beam separation for systematic correction
- About 10^{10} particles stored in multiple, low emittance, low energy spread, highly polarized bunches for roughly one hour

With accessible electric field gradients in the MV/m range, the spin will be tipped by a minuscule angle 10^{-13}−10^{-12} rad per single pass and the build-up of an observable polarization in the tenth-of-percent range demands a spin coherence during 10^9−10^{10} revolutions (roughly 10^3−10^4 s) of the stored beam and strong suppression of unwanted field components. False spin rotations as a function of beam properties, focussing structure, field and alignment errors of deflectors will be studied and minimized. A multipole correction scheme to further optimize the ring layout will be developed.

2. Optimization of electric pole shape to maximize spin coherence time and minimize field errors (Lead participant Grenoble)

The spin coherence time has to be larger than 1000 seconds to reach the anticipated statistical sensitivity of the experiment. During this time each particle performs about 10^9 turns in the storage ring moving on different trajectories through the optics elements at different beam momenta. The spin tune spread in the ring elements due to different types of space and time dependent nonlinearities plays a crucial role. The resulting spin tune spread leads to a reduced spin coherence time. Time-dependent spin tune spreads are related to different times of flight in focusing and deflecting elements. The space-dependent spin tune spreads are associated with differences of focusing and deflecting fields on the trajectory of particles. Recent simulations indicate that the optimization of the pole shape of the electrostatic deflector elements can significantly increase the spin coherence time. In a second approach it has been shown, that an alternating change of pole shape can further increase the spin coherence time. This study has been performed with a generic lattice. The aim of this task is to utilize the final lattice developed in this Design Study and to verify these preliminary results. In addition the influence of the pole shape on systematic vertical spin rotations has to be studied.

3. Development of high-precision spin-tracking codes and its benchmarking for supercomputers (Lead participant Jülich)

Full spin-tracking simulations of the entire experiment are absolutely crucial to explore the feasibility of the planned storage ring EDM experiments and to investigate systematic limitations. The COSY Infinity simulation program and its updates are used to simulate beam and spin motion in storage rings. To study subtle effects and simulate the particle and spin dynamics during the storage and build-up of the EDM signal, one needs custom-tailored fast trackers capable of following up to 100 billion turns for samples of up to 10^6 particles. Given the complexity of the tasks, particle and spin dynamics simulations performed with the “COSY Infinity” code must be benchmarked with other simulation programs and experiments performed at COSY to ensure the required accuracy of the obtained simulation results.

4. **Development of magnetic shielding based on mu-metal and SC tubes**
(Lead participant Jülich)
The whole ring needs to be shielded from unwanted external magnetic fields: e.g., the earth magnetic field has to be reduced by a factor of ~$3 \cdot 10^8$. Being common to all of EDM projects, this problem can be addressed with a coordinated effort among the different collaborations. Dedicated experience in magnetic shielding exists at e.g., at PTB in Berlin, where high-sensitive magnetometers are adopted to measure the magnetic fields originated by patients inner organs (i.e., heart, brain, etc.). In that environment the shielding is realized by means of an active outer shield, and a passive inner shield. The scheme adopted in the proton EDM project foresees, in addition, the introduction of an inner active shield which could not be used in the medical application.

Deliverables		
D-WP6.1	**Comparison of physics potential and systematic limitations for different methods**	**Month 12**
D-WP6.2	**First ring layout including investigation of required beam properties**	**Month 24**
D-WP6.3	**Full beam simulation and optimization of final ring layout**	**Month 36**

The following Table 3.1b shows the proposed distribution of resources in person-months for the different work packages (WPs1-6). All of them will start during the first month of the project and will be conducted for 36 (WPs3-5) and 42 (WPs1, 2 and 6) months, respectively (see also the “Project time line” on page 16). It is expected that during the last half year of the project, the results of WPs3-5 will be consolidated and, together with the cost estimate of WP1, be included in the CDR.

Table 3.1b: List of work packages

Work package No	Work Package Title	Lead Participant No	Lead Participant Short Name	Person-Months	Start Month	End month
1	Consortium Management	1	Jülich	23	1	42
2	Dissemination	4	Tbilisi	48	1	42
3	Electrostatic Deflectors	2	Aachen	114	1	36
4	Beam Instrumentation	2	Aachen	60	1	36
5	Polarimetry	3	Ferrara	120	1	36
6	Ring Layout	1	Jülich	84	1	42
				449		

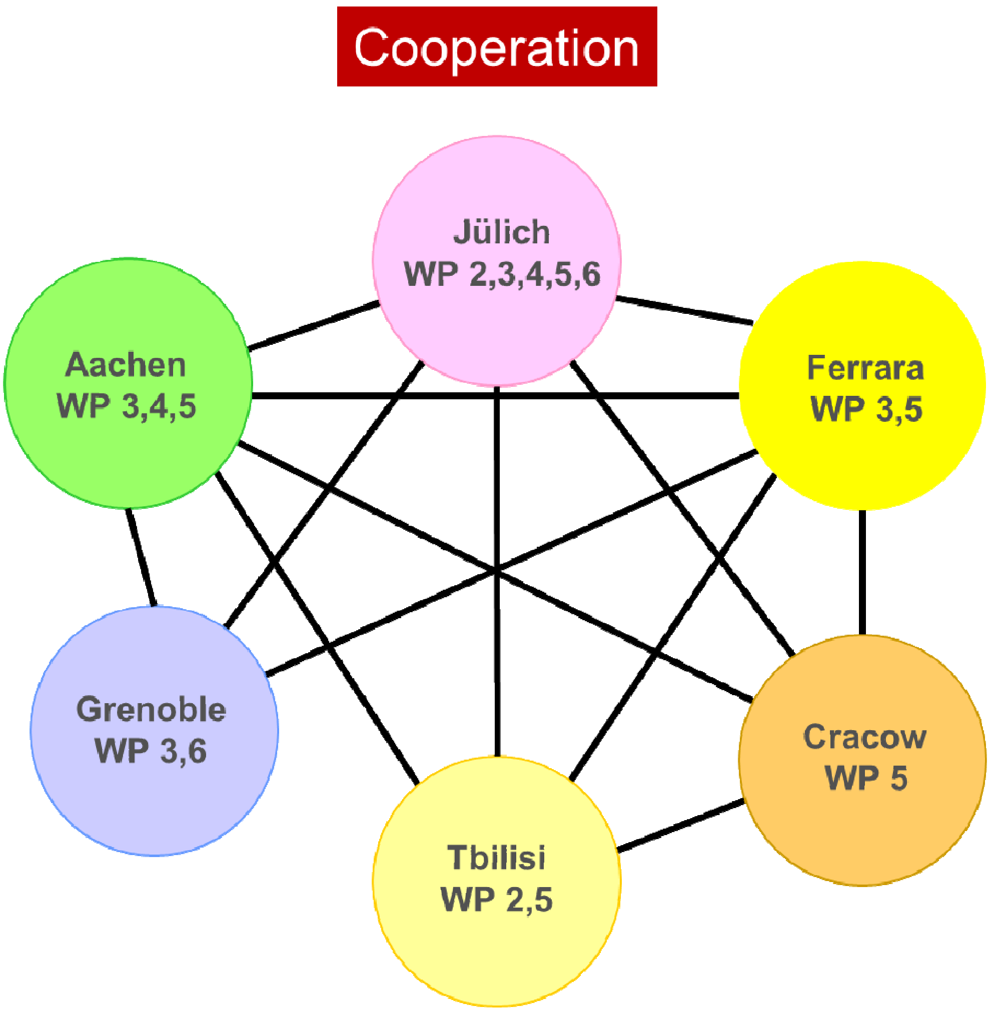
The following Table 3.1.c summarizes the deliverables ordered according to their delivery date and the work package. The dissemination level is public, i.e. fully open (“PU”) or confidential (“CO”) – it is our understanding that the CO-dissemination gives full access to all members of the Design Study, e.g., via the website, but is password-protected against the outside world. This will assure that internal information or preliminary results are confined within the core team until it is released by the Dissemination Committee. As also mentioned elsewhere the Conceptual Design Report as the final deliverable will be published and thus open to the public.

Table 3.1c: List of Deliverables

Deliverable (number)	Deliverable name	Work package number	Short name of lead participant	Type	Dissemination level	Delivery date
1	D-WP1.1	1	Jülich	R	CO	1
2	D-WP2.1	2	Tbilisi	DEC	PU	6
3	D-WP2.2	2	Tbilisi	R	PU	6
4	D-WP1.2	1	Jülich	R	CO	7
5	D-WP4.1	4	Aachen	R	PU	12
6	D-WP6.1	6	Jülich	R	PU	12
7	D-WP1.3	1	Jülich	R	CO	13
8	D-WP1.4	1	Jülich	R	CO	19
9	D-WP4.2	4	Aachen	DEM	PU	24
10	D-WP6.2	6	Jülich	R	PU	24
11	D-WP1.5	1	Jülich	R	CO	25
12	D-WP5.1	5	Ferrara	R	PU	30
13	D-WP1.6	1	Jülich	R	CO	31
14	D-WP3.1	3	Aachen	DEM	PU	36
15	D-WP3.2	3	Jülich	R	PU	36
16	D-WP3.3	3	Ferrara	R	PU	36
17	D-WP3.4	3	Grenoble	R	PU	36
18	D-WP5.2	5	Ferrara	DEM	PU	36
19	D-WP5.3	5	Ferrara	R	PU	36
20	D-WP6.3	6	Jülich	R	PU	36
21	D-WP1.7	1	Jülich	R	CO	37
22	D-WP1.8	1	Jülich	R	CO	40
23	D-WP1.9	1	Jülich	R	CO	42
24	D-WP2.3	2	Tbilisi	R	PU	42

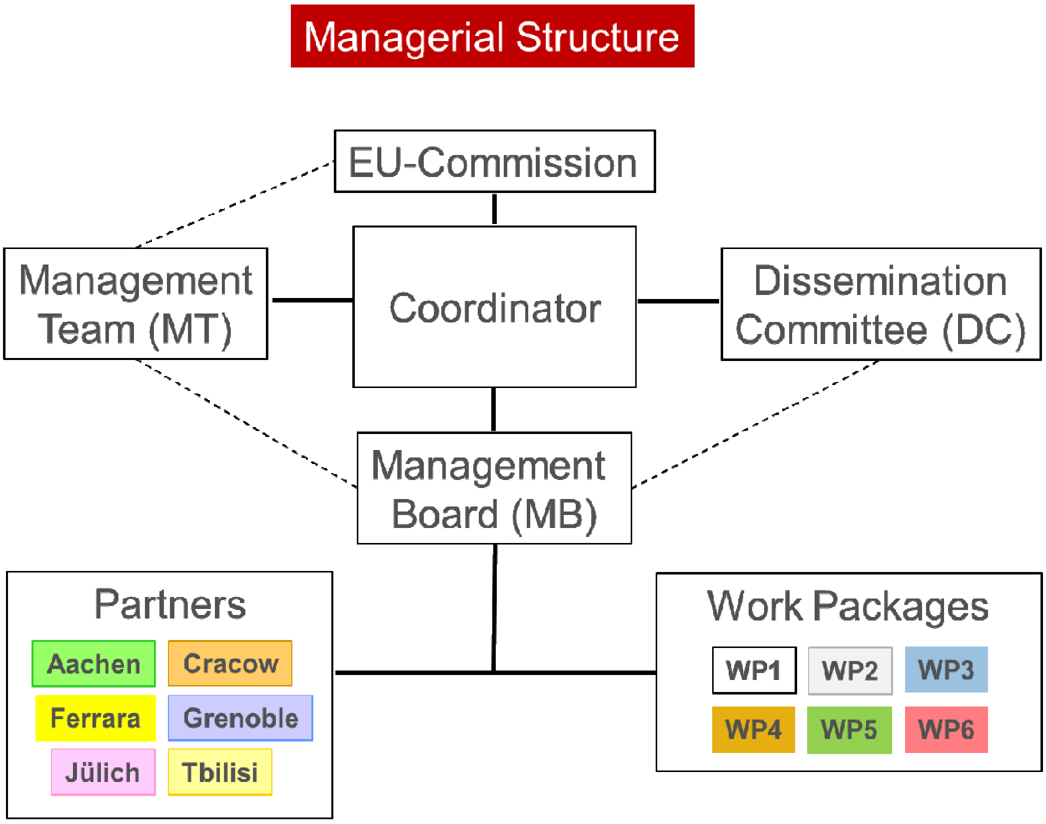
3.2 *Management structure and procedures*

The organizational interaction of the Design Study project participants in terms of their individual contributions to the different work packages is given in the diagram below: it demonstrates the strongly interwoven structure in which each institution is directly connected with at least three participants. The addition of WP1 will produce a symmetric interaction between all participants.



The envisioned management structure of the project is sketched in the diagram below: the primary decision making body is the Management Board (MB), which consists of the responsible person of each of the work packages WPs1-6 and one representative of each participant institution – with the consortium manager (WP1) acting as its chairman. A deputy chairman will be elected by the MB on its kick-off meeting. The MB discusses at its meeting all relevant project-items and makes decisions – if possible on mutual agreement; if consent cannot be achieved, a decision will be made by voting with all MB members having one vote.

The consortium manager is at the same time the project Coordinator who is closely working with the Management Team (MT), comprising administrators of the host institution (Forschungszentrum Jülich) and the participants; if necessary there is the possibility for mutual contact between members of the MT and the EU-Commission. Usually, however, these contacts are with the project coordinator – if necessary including the MT-member of the host institution. The Coordinator supervises the Dissemination Committee (DC) and reports to the MB on their meetings. It is, however, also possible for the DC and the MT to directly contact the MB.



All milestones listed in the table below correspond to key deliverables of WPs, ordered with respect to the date of delivery.

Table 3.2a: List of milestones

Milestone number	Milestone name	Related work package(s)	Estimated date	Means of verification
1	D-WP2.1	2	6	DEC
2	D-WP6.1	6	12	R
3	D-WP3.1	3	18	DEM
4	D-WP4.2	4	24	DEM
5	D-WP5.1	5	30	R
6	D-WP5.2	5	36	DEM
7	D-WP6.3	6	36	R
8	D-WP1.9	1	40	R

Table 3.2b lists critical risks as they are identified at the time of this writing. During the course of the project, additional critical items may appear which will be reported to the MB and addressed by a risk assessment task force.

Table 3.2b: Critical risks for implementation

Description of risk	Work package(s) involved	Proposed risk-mitigation measures
Beam instrumentation does not achieve the required sensitivity.	4 and 6	Lower systematic sensitivity will be reached.
Electric field gradients beyond 10 MV/m are not reached.	3	Ring design has to allow for a larger diameter.
Spin coherence time >1000 s is not reached.	6	Measurement time to achieve sensitivity goal needs to be increased.
Passive shielding of magnetic fields does not reach required level.	6	Development of an active shielding scheme.

We are aware that this Design Study constitutes a high-risk high-impact endeavour; therefore we are prepared to face unforeseen challenges throughout the project.

3.3 Consortium as a whole

The consortium consists of 6 members, many of whom have already collaborated in other projects like, e.g., COSY hadron physics experiments (ANKE and WASA collaboration) and in the ERC-supported PAX activity (POLPBAR). The cooperation between Jülich (Institute for Nuclear Physics of Forschungszentrum Jülich) and Aachen (different institutes of RWTH Aachen University) is particularly strong via the Jülich-Aachen Research Alliance (JARA) through the newly founded section JARA-Fame (Forces and Matter Experiments), which aims to investigate “The Fate of Antimatter”. The new participant is CNRF Grenoble, which brings in additional expertise in accelerator science.

3.4 Resources to be committed

Table 3.4a: Summary of staff effort

	WP 1	WP 2	WP 3	WP 4	WP 5	WP 6	Total Person/ Months per Participant
1 Jülich	**18**	**12**	**12**	**30**	**24**	**60**	**156**
2 Aachen	**1**	**0**	**60**	**30**	**12**	**0**	**103**
3 Ferrara	**1**	**0**	**18**	**0**	**24**	**0**	**43**
4 Tbilisi	**1**	**36**	**0**	**0**	**30**	**0**	**67**
5 Krakow	**1**	**0**	**0**	**0**	**30**	**0**	**31**
6 Grenoble	**1**	**0**	**24**	**0**	**0**	**24**	**49**
Total Person/Months	**23**	**48**	**114**	**60**	**120**	**84**	**449**

We have taken the same ansatz for all participants with respect to travel costs, i.e., one travel (at a cost of 1000 € per travel) for every 6 person-months applied for. Because of the low wages in Poland and Georgia, however, in the case of the participants from Krakow and Tbilisi the ratio of ‘other direct cost’ over ‘personnel costs’ exceeds 15%, as indicated in the tables below.

Table 3.4b: ‘Other direct cost’ items (travel, equipment, other goods and services, large research infrastructure)

Participant 4 Tbilisi	**Cost (€)**	**Justification**
Travel	14000	Required in order for Tbilisi to effectively manage WP2 as lead participant and the tasks involved in WP5.
Equipment	0	
Other goods and services	4000	Allocated cost for the organization of meetings at Tbilisi, invited speakers, rent for conference rooms, etc.
Total	18000	

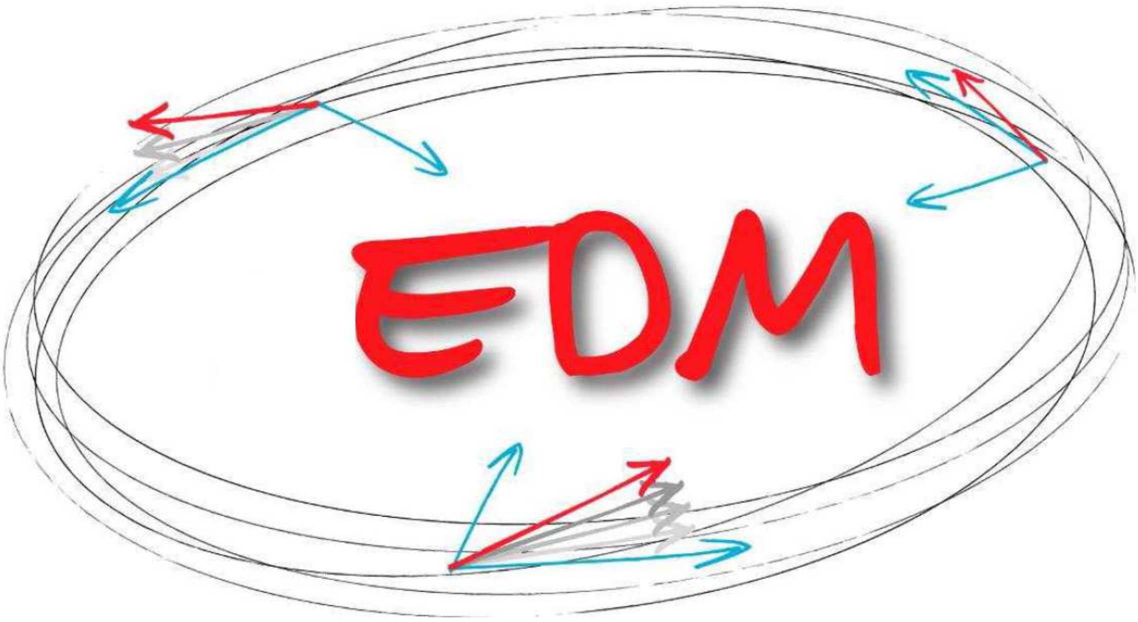
Participant 5 Krakow	**Cost (€)**	**Justification**
Travel	10000	Required in order for Krakow to effectively manage the tasks involved in WP5.
Equipment	0	
Other goods and services	4000	Allocated cost for the organization of meetings at Krakow, invited speakers, rent for conference rooms, etc.
Total	14000	

None of the participants would like to declare costs of large research infrastructure.

Title of Proposal

Novel precision storage rings for Electric Dipole Moment searches

(Sections 4 - 5)



List of participants

Participant No	Participant organisation name	Country
1 (Coordinator) Jülich	Forschungszentrum Jülich GmbH	Germany
2 Aachen	RWTH Aachen	Germany
3 Ferrara	Universita degli Studi di Ferrara	Italy
4 Tbilisi	Ivane Javakhishvili Tbilisi State University	Georgia
5 Krakow	Uniwersytet Jagiellonski w Krakowie	Poland
6 Grenoble	Centre National de la Recherche Scientifique	France

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4. Members of the consortium

4.1. Participants (applicants)

a) Jülich

Forschungszentrum Jülich (FZJ, Jülich) is one of Europe´s largest interdisciplinary research centers, which was founded in 1956 and currently has a staff of more than 5500, including close to 2000 scientists. Jülich is aiming to identify comprehensive solutions to the grand challenges facing society. Research comprises the fields of health, energy and environment, and information technology with a strong basis in the physical sciences – here in particular the structure of matter. World-class tools such as accelerators, supercomputers, analytical equipment and imaging instrumentation are employed to generate results with direct benefits for society.

Within the program “Structure of Matter”, Jülich exploits its equipment and experience, e.g., by taking on a leading role in hadron physics at FAIR (construction of the High Energy Storage Ring (HESR) and contributions to PANDA). Jülich operates and develops the cooler synchrotron (COSY) and pursues plans for advanced accelerator-based future research infrastructures, building on the experience with this storage ring for more than 20 years of operation in hadron physics with polarized beams. In this context, the direct access and close cooperation with the Jülich Supercomputer Center (JSC) and with the Central Institute for Engineering, Electronics and Analytics (ZEA) is an invaluable asset.

Jülich has close scientific contacts (common appointments of professors) with many of the surrounding universities in Germany (Aachen, Bochum, Bonn, Cologne, Düsseldorf, Essen, Erlangen-Nürnberg, Münster, Wuppertal) and abroad (e.g., Leuven, Belgium) and cooperates with major laboratories worldwide. Together with RWTH Aachen University it has founded the “Jülich-Aachen Research Alliance” (JARA), comprising 5 sections, one of which is “JARA-Fame” (Forces and Matter Experiments), which aims to investigate the “Fate of Antimatter”.

Hans Ströher (male, 21.08.1952): Curriculum Vitae

- **Current Position:** Director of the Institut für Kernphysik (IKP-2) of Forschungszentrum Jülich (since 1998), and Full Professor (C4) at Institute for Nuclear Physics at the University of Cologne, Germany (since 1998)
- **Scientific Degrees:**
  - Diploma in physics, University of Giessen, Germany (1980)
  - PhD in physics, University of Giessen, Germany (1983)
  - Habilitation in physics, University of Giessen, Germany (1990)
- **Previous Positions:**
  - Post Doc, University of Giessen; short-term stays in JINR (Dubna, Russia), LBL (Berkeley, USA) and BNL (Brookhaven, USA) (1983 – 1987)
  - Scientific assistant, GSI Darmstadt, Germany (1987 – 1990)
  - Scientific staff, University of Giessen, Germany (1990 – 1995)
  - Professor (C3), University of Mainz, Germany (1995 – 1998)

Scientific interests: hadron physics with electromagnetic and hadronic probes; symmetries and symmetry violation; spin physics. Received an ERC Advanced Grant ("POLPBAR") in 2010. Co-author of more than 200 scientific papers and more than 70 invited talks at international conferences. Served on many program advisory and review committees and was/is (co-)chairman of a number of international scientific conferences. Member of the "International Spin Physics Committee" (ISPC) since 2010 and of JARA-Fame since 2012. Has been awarded honorary doctors at Tbilisi State University (TSU) in 2010 and Georgian Technical University (GTU) in 2014.

Publications relevant for the proposed research:

1. C. Weidemann et al. (PAX collaboration), ***Toward polarized antiprotons: Machine development for spin-filtering experiments at COSY,*** arXiv: 1407.6724v1 (24 July2014), submitted to Phys. Rev. STAB;
2. P. Adlarson et al. (WASA collaboration), ***Evidence for a new resonance from polarized neutron-proton scattering,*** DOI: 10.1103/PhysRevLett.112.202201;
3. P. Goslawski et al. (ANKE collaboration), ***High precision beam momentum determi-nation in a synchrotron using a spin resonance method***, DOI: 10.1103/PhysRevSTAB.13.022803, 2010;
4. W. Augustyniak et al. (PAX collaboration), ***Polarization of a stored beam by spin-filtering*** Phys. Lett. **B 718** (2012) 64;
5. D. Oellers et al. (PAX collaboration), ***Polarizing a stored beam by spin flip?,*** Phys. Lett. **B 674** (2009) 269. See also: D. Oellers et al. (PAX collaboration), ***New experimental upper limit of the electron-proton spin-flip cross section,*** Nucl. Instr. Meth. in Phys. Res. **A 759** (2014) 6.

Mei Bai (female, March 1968): Curriculum Vitae

- **Current Position:** Scientist (tenured) @ Brookhaven National Laboratory, New York, USA

  Incoming new Director of the Institut für Kernphysik (IKP-4), anticipated starting date Dec. 2014
- **Scientific Degrees:**
  - M.S. in physics, University of Science and Technology, Hefei, China (1992)
  - PhD in physics, Indiana University, Bloomington, IN (USA) (1999)
- **Previous Positions:**
  - Scientist, RHIC Accelerator Group, BNL (2005 – 2014)
  - Associate Scientist, RHIC Accelerator Group, BNL (2001 -2004)
  - Research Associate, RHIC Accelerator Group, BNL (1999 – 2001)
- **Awards:**
  - International Particle Accelerator Conference'10 Accelerator Prize for an individual, in the early part of his or her career, having made a recent significant, original contribution to the accelerator field, 2010

- Beam Dynamics Outstanding Doctoral Thesis Award (2000)
- McCormick Science Grant, Indiana University (1998)

Her expertise is in accelerating polarized beams and spin manipulation. She earned her Ph. D by demonstrating a novel technique of overcoming strong intrinsic spin resonances using an RF dipole. Over the past decade, she made significant contributions to the spin physics program at Relativistic Heavy Ion Collider (RHIC), and established polarized proton operation at RHIC. In addition to spin dynamics, she also has the expertise in beam manipulations, and conducts research in both linear and non-linear beam dynamics.

Publications relevant for the proposed research:

1. Bai, M., et al., ***Overcoming Intrinsic Spin Resonances with an rf Dipole.*** Phys. Rev. Lett. **80**, 4673 (1998), http://prola.aps.org/pdf/PRL/v80/i21/p4673_1;
2. Bai, M., Brown, K. A., Fischer, W., Roser, T., Tsoupas, N., and van Zeijts, J. ***Adiabatic excitation of longitudinal bunch shape oscillations,*** Phys. Rev. ST Accel. Beams **3**, 064001 (2000), http://prst-ab.aps.org/pdf/PRSTAB/v3/i6/e064001;
3. Bai, M., et al., ***Observation of a Hybrid Spin Resonance.*** Phys. Rev. Lett. **84**, 1184 (2000), http://prola.aps.org/pdf/PRL/v84/i6/p1184_1;
4. Bai, M., MacKay, W.W., Roser, T, ***Comment on "spin manipulation of 1.94 GeV/c polarized protons stored in the COSY cooler synchrotron***, Phys. Revi. ST Accel. Beams **8**, 099001, (2005), http://prst-ab.aps.org/pdf/PRSTAB/v8/i9/e099001;
5. Bai, M., Roser, T., ***Full Spin Flipping in the Presence of Full Siberian Snakes.*** Phys. Rev. Lett. **96**, 174801 (2006).

Ralf Gebel (male, 12.12.1961): Curriculum Vitae

- **Current Position:** Scientist at the Nuclear Physics Institute IKP-4 at Forschungszentrum Jülich (since 1995) CERN research associate
- **Scientific Degrees:**
  - Diploma in Physics, University of Bonn at ISKP (1989)
  - PhD in physics, University of Bonn at ISKP (1994)
- **Previous Positions:**
  - Scientist, University Bonn, ISKP (1990 - 1995)

He is experienced in the field of experimental hadron physics, accelerator physics, polarized ion and atomic beam sources, detectors for polarized beams, cyclotron applications, and the development of accelerator components. He has worked on experiments with polarized beams at Bonn, PSI and COSY, on the polarized ion source for COSY, sources and LEBT for the COSY SC Linac project Cyclotron vacuum, RF and extraction upgrades, injection kicker systems for HESR at FAIR, and the ion source development for ELENA/CERN and future accelerators. He is presently member of the International Organization Committee of Cyclotrons and their applications, and the Scientific Committee of European Cyclotron Progress Meeting.

Publications relevant for the proposed research:

1. P. Benati et al., ***Synchrotron oscillation effects on an rf-solenoid spin resonance***, DOI:10.1103/PhysRevSTAB.15.124202 (2012);
2. P. Goslawski et al., ***High precision beam momentum determination in a synchrotron using a spin resonance method***, DOI: 10.1103/PhysRevSTAB.13.022803 (2010);
3. D. Chiladze et al., ***Determination of Deuteron Beam Polarizations at COSY***, DOI:10.1103/PhysRevSTAB.9.050101 (2007);
4. P.D. Eversheim et al., ***Precise position- and angle-control of a proton beam***, DOI:10.1016/0168-9002(95)01008-4
5. P.D. Eversheim, et al., ***Parity violation in proton-proton scattering at 13.6 MeV***, Phys. Lett. B DOI:10.1016/0370-2693(91)90209-9

Andro Kacharava (male, 22.08.1959) Curriculum Vitae

- **Current Position:** Scientist at Institut für Kernphysik at Jülich (since 2008)
- **Scientific Degrees:**
  - Diploma in physics, Joint Institute for Nuclear Research, Dubna Russia (1989)
  - PhD in physics, Tbilisi State University, Tbilisi, Georgia (1994)
- **Previous Positions:**
  - PostDoc at the Laboratory of Nuclear Problems at JINR, Dubna (1994 – 2000)
  - Visiting professor (COE) of the Research Center for Nuclear Physics, Osaka University, Japan (2000 – 2001)
  - Research assistant at the Physikalisches Institut II, Universität Erlangen-Nürnberg, Erlangen, Germany (2002 – 2007)

Since 2005, he is the spokesperson of the ANKE collaboration at COSY. He has been scientific coordinator for the Georgian group of High Energy Physics Institute of Tbilisi State University for 3 approved projects related to spin physics and supported by SRNSF (Shota Rustavelli National Science Foundation) including the ongoing project - "Jülich Electric Dipole Moment Investigations" (DI/19/6-200/11).

In frame of the project - "Georgian-German Science Bridge" - he has been supervisor for 4 doctoral and 6 diploma theses based on the results obtained in Jülich using the COSY facilities. He is author more than 140 publications in international journals. Recently (July 2014), he has been awarded with Ivane Javakishvili medal of Tbilisi State University. Presently he is the head of the publication committee of the JEDI collaboration.

Publications relevant for the proposed research:

1. C. Weidemann et al. (PAX collaboration), ***Toward polarized antiprotons: Machine development for spin-filtering experiments at COSY,*** arXiv: 1407.6724v1 (24 July2014), submitted to Phys. Rev. STAB;
2. P. Goslawski et al. (ANKE collaboration), ***High precision beam momentum determi-nation in a synchrotron using a spin resonance method***, DOI:10.1103/PhysRevSTAB.13.022803, 2010;

3. W. Augustyniak et al. (PAX collaboration), ***Polarization of a stored beam by spin-filtering*** Phys. Lett. **B 718** (2012) 64;
4. Z. Bagdasarian, et al., ***Measuring the Polarization of a Rapidly Precessing Deuteron,*** Phys. Rev. ST – Accel. Beams **17**, 052803 (2014);
5. A. Kacharava and C. Wilkin (ANKE collaboration), ***Results from the spin programme at COSY-ANKE***, Nuclear Physics News (NuPECC) Vol. 23, No.2 (2013).

Volker Hejny (male, 26.11.1967): Curriculum Vitae

- **Current Position:** Scientist at the Nuclear Physics Institute IKP at Forschungszentrum Jülich (since 2002)
- **Scientific Degrees:**
  - Diploma in Physics, University of Gießen (1993)
  - PhD in physics, University of Gießen (1998)
- **Previous Positions:**
  - PostDoc, Forschungszentrum Jülich, IKP (1999 - 2002)

He has a longtime experience in experimental hadron physics with electromagnetic and hadronic probes, development and operation of particle detectors at storage rings, data acquisition systems and data analysis. He has worked on experiments with TAPS at MAMI and GSI as well as with the ANKE and WASA detector systems at COSY. The main physics interests are production and decays of light mesons and symmetries and symmetry breaking in hadronic systems.

Publications relevant for the proposed research:

1. Z. Bagdasarian, et al., ***Measuring the Polarization of a Rapidly Precessing Deuteron,*** Phys. Rev. ST – Accel. Beams **17**, 052803 (2014);
2. P. Benati et al., ***Synchrotron oscillation effects on an rf-solenoid spin resonance***, Phys. Rev ST – Accel. Beams **15**, 124202 (2012);
3. D. Chiladze et al., ***Determination of Deuteron Beam Polarizations at COSY***, DOI:10.1103/PhysRevSTAB.9.050101, 2007;

Irakli Keshelashvili (male, 23.12.1978): Curriculum Vitae

- **Current Position:** Scientist at Institut für Kernphysik at Jülich (since 2014)
- **Scientific Degrees:**
  - MS. in Physics, Tbilisi State University, Georgia (2002)
  - PhD in physics, Tbilisi State University, Georgia (2006)
- **Previous Positions:**
  - PostDoc, Institut für Kernphysik at Jülich (2007 – 2008)
  - PostDoc, University of Basel (2008 - 2014)

He has experience of preparing and performing experiments in particle physics. In different times, he worked with electromagnetic and hadronic probes, as well as the development and operation of particle detectors using photon and hadronic beams. He has worked for different experiments like, Crystal Ball/TAPS at MAMI (Mainz), Crystal Barrel/TAPS at ELSA (Bonn) as well, as ANKE and WASA detectors at the COSY storage ring. The main physics interests are understanding of the structure of nucleons and the nature of strong interaction. Developing of new instrumentation or the optimization of the existing detectors were the main goal of his work. He was supervising Master's and co-supervising of Ph.D. work. He has experiences of lecturing of detector and nuclear reactor physics courses.

Publications relevant for the proposed research:

1. H. J. Stein at al., ***Determination of target thickness and luminosity from beam energy losses***, Phys. Rev. ST Accel. Beams **11**, 052801;
2. M. Gottschall et al., ***First Measurement of the Helicity Asymmetry for $\gamma p \rightarrow p\pi^0$ in the Resonance Region***, Phys. Rev. Lett. **112**, 012003;
3. J. Hartmann et al., ***N(1520) 3/2− Helicity Amplitudes from an Energy-Independent Multipole Analysis Based on New Polarization Data on Photoproduction of Neutral Pions***, Phys. Rev. Lett. **113**, 062001;
4. M. H. Sikora et al., ***Measurement of the $H1(\vec{\gamma}, \vec{p})\pi^0$ Reaction Using a Novel Nucleon Spin Polarimeter***, Phys. Rev. Lett. **112**, 022501:
5. D. Hornidge et al., ***Accurate Test of Chiral Dynamics in the $\vec{\gamma} p \rightarrow \pi^0 p$ Reaction***, Phys. Rev. Lett. **111**, 062004.

Bernd Lorentz (male, 03.11.1965): Curriculum Vitae

- **Current Position:** Scientist at Institut für Kernphysik at Jülich (since 1999)
- **Scientific Degrees:**
  - Diploma in physics, Ruprecht-Karls Universität Heidelberg (1993)
  - Master of Science in Physics, University of Wisconsin – Madison (1996)
  - PhD in Physics, University of Wisconsin – Madison (1998)
- **Previous Positions:**
  - MPI für Kernphysik, Heidelberg (1991 – 1993)
  - University of Wisconsin – Madison (1993 – 1999)

He has longtime experience with operation of storage rings with polarized beams and targets. Since 1999 he works on beam polarimetry and beam dynamics for many different hadron physics experiments carried out at the Cooler Synchrotron COSY of the Forschungszentrum Jülich. He is part of the Jülich engagement in the collaboration designing and building the High Energy Storage Ring (HESR) for antiprotons at the future Facility for Antiproton and Ion Research (FAIR) at Darmstadt.

Publications relevant for the proposed research:

1. H. O. Meyer et al., ***Polarization lifetime near an intrinsic depolarizing resonance***, Phys. Rev. **E.59**, 3578 (1997);
2. B. Lorentz et al., ***Angular distribution of the longitudinal pp spin correlation parameter Azz at 197.4 MeV***, Phys. Rev. **C.51**, 054002 (2000);
3. D. Chiladze et al., ***Determination of Deuteron Beam Polarizations at COSY***, Phys. Rev. STAB **9**, 050101 (2007);
4. V. S. Morozov et al., ***Experimental Verification of Predicted Beam-Polarization Oscillations near a Spin Resonance,*** Phys. Rev. Lett. **100**, 054801 (2008);
5. P. Goslawski et al., ***High precision beam momentum determination in a synchrotron using a spin resonance method***, Phys. Rev. STAB **13** 022803 (2010);

Hans-Joachim Krause (male, 12.12.1963): Curriculum Vitae

- **Current Position:** Scientist at Peter Grünberg Institute at Jülich (since 1997)
- **Scientific Degrees:**
  - Diploma in Physics, RWTH Aachen (1990)
  - PhD in Physics, RWTH Aachen (1993)
- **Previous Positions:**
  - Visiting professor, Université Pierre et Marie Curie, Paris (2011)
  - Post-doctoral researcher at Institut für Schicht- und Ionentechnik at Jülich (1993-1997)

Expertise in development and applications of magnetic field sensors and their readout electronics, on SQUID magnetometry and magnetic biosensing, on magnetic nanoparticle actuation and detection, and on low field nuclear magnetic resonance.

Publications relevant for the proposed research:

1. J. Zhao, Y. Zhang, Y.-H. Lee, H.-J. Krause, Investigation and optimization of low-frequency noise performance in readout electronics of dc superconducting quantum interference device, Review of Scientific Instruments **85**, 054707 (2014).
2. J. Zeng, Y. Zhang, M. Mück, H.-J. Krause, A.I. Braginski, X. Kong, X. Xie, A. Offenhäusser, Mianheng Jiang, High intrinsic noise and absence of hysteresis in superconducting quantum interference devices with large Steward-McCumber parameter, Appl. Phys. Lett. **103**, 042601 (2013).
3. C. Liu, Y. Zhang, M. Mück, H.-J. Krause, A.I. Braginski, X. Xie, A. Offenhäusser, M. Jiang, An insight into voltage-biased superconducting quantum interference devices, Appl. Phys. Lett. **101**, 222602 (2012).
4. Y. Zhang, G. Zhang, H. Wang, Y. Wang, H. Dong, X. Xie, M. Mück, H.-J. Krause, A.I. Braginski, A. Offenhäusser, M. Jiang, Comparison of noise performance of the dc SQUID bootstrap circuit with that of the standard flux modulation dc SQUID readout scheme, IEEE Trans. Appl. Supercond. **21**, 501-504 (2011).

Andreas Lehrach (male, 16.09.1965): Curriculum Vitae

- **Current Position:** Interim Director, Institut für Kernphysik (IKP-4), Forschungszentrum Jülich, Germany (since March 2014), Professor for physics of particle accelerators at RWTH Aachen University (since July 2013)
- **Scientific Degrees:**
  - Diploma in Physics, Rheinische Friedrich-Wilhelms-Universität Bonn (1994)
  - PhD in Physics, Rheinische Friedrich-Wilhelms-Universität Bonn (1997)
  - Habilitation in Physics, Rheinische Friedrich-Wilhelms-Universität Bonn (2008)
- **Previous Positions:**
  - PhD student, Institut für Kernphysik, Forschungszentrum Jülich, (1995 – 1997)
  - Postdoc, Institut für Kernphysik, Forschungszentrum Jülich (1998)
  - Postdoc, Collider-Accelerator Department, Brookhaven National Laboratory (1999 – 2000)
  - Staff scientist, Institut für Kernphysik, Forschungszentrum Jülich (2001 – 2013)

Longtime expertise in beam- and spin dynamics of polarized hadron beams in circular accelerators. He developed the concept and commissioned polarized proton and deuteron beam acceleration in the Cooler Synchrotron COSY of the Forschungszentrum Jülich and is responsible for beam dynamics and lattice design of the High-Energy Storage Ring (HESR) for antiprotons at the future Facility for Antiproton and Ion Research (FAIR) at Darmstadt.

Co-spokesperson of the JEDI collaboration (http://collaborations.fz-juelich.de/ikp/jedi), aiming at electric dipole moment measurements of protons and deuterons.

Publications relevant for the proposed research:

1. A. Lehrach et al., ***Matching Intrinsic Spin Harmonics at COSY***, Nucl. Instrum. Meth. A439:26 (2000);
2. I. Alekseev et al., ***Polarized Proton Collider at RHIC***, Nucl. Instrum. Meth. A499:392 (2003);
3. F. Rathmann et al., ***A Method to Polarize Stored Antiprotons to a High Degree***, Phys. Rev. Lett. 94:014801 (2005);
4. V.S. Morozov et al**.**, ***Spin manipulating stored 1.85 GeV/c vector and tensor polarized spin-1 bosons***, Phys. Rev. ST Accel. and Beams 8:061001 (2005);
5. P. Goslawski et al**.**, ***High precision beam momentum determination in a synchrotron using a spin resonance method***, Phys. Rev. ST Accel. Beams 13:022803 (2010.

Frank Rathmann (male, 05.10.1961): Curriculum Vitae

- **Current Position:** Scientist at Institut für Kernphysik at Jülich (since 2000)
- **Scientific Degrees:**
  - 1st State Examination in Physics and Physical Education, Philipps-University Marburg (1989)
  - 2nd State Examination in Physics and Physical Education, Studienseminar Bensheim (1991)
  - PhD in Physics, Philipps-University Marburg (1994)
  - Habilitation, Friedrich-Alexander Universität Erlangen (2000)
- **Previous Positions:**
  - University of Wisconsin-Madison, USA (1994 – 1997)
  - Friedrich-Alexander Universität Erlangen (1997 – 2000)
- **Awards:**
  - Feodor Lynen Fellowship of the Alexander von Humboldt Foundation at Madison, WI, USA (1994 – 1997)

Expertise with polarized probes in storage ring experiments, few nucleon physics, and antiproton polarization. He is Co-spokesperson of the PAX collaboration (http://collaborations.fz-juelich.de/ikp/pax), aiming at the production of a stored beam of polarized antiprotons. He is Co-spokesperson of the JEDI collaboration (http://collaborations.fz-juelich.de/ikp/jedi), aiming at electric dipole moment measurements of protons and deuterons.

He served as an elected member on the International Spin Physics Committee (2003 to 2010), and as a member of the Scientific and Technical Council of Forschungszentrum Jülich (2007 to 2008). He has managed for the PAX collaboration the Joint Research Activity POLANTIP inside the Framework Programme 7 (as part of *Hadron Physics - Study of strongly interacting Matter*).

Publications relevant for the proposed research:

1. F. Rathmann, C. Montag, D. Fick et al., ***New method to polarize protons in a storage ring and implications to polarized antiprotons***, Phys. Rev. Lett. **71** (1993) 1379;
2. D. Oellers, et al., ***Polarizing a stored beam by spin-flip?***, Phys. Lett. **B 674** (2009) 269;
3. W. Augustyniak, et al. ***Polarization of a stored beam by spin-filtering***, Physics Lett. **B 718** (2012) 64;
4. P. Benati, et al., ***Synchrotron oscillation effects on an rf-solenoid spin resonance***, Phys. Rev. ST Accel. Beams **15** (2012) 124202;
5. C. Weidemann et al. (PAX collaboration), ***Toward polarized antiprotons: Machine development for spin-filtering experiments at COSY,*** arXiv: 1407.6724v1 (24 July 2014), submitted to Phys. Rev. STAB.

Helmut Soltner (male, 12.12.1961): Curriculum Vitae

- **Current Position:** Scientist at the Central Institute of Engineering, Electronics and Analytics (ZEA-1) Jülich (since 2001)
- **Scientific Degrees:**
  - Diploma in physics, RWTH Aachen University (1989)
  - PhD in physics, RWTH Aachen University (1994)

He studied physics at the RWTH Aachen University, and is specialized in solid state physics and in thin film high-temperature superconductivity. As a post-doc at Forschungszentrum Jülich, he investigated topics in bio-magnetism and non-destructive evaluation based on SQUID sensors from high-temperature superconductors. In 2001, he joined the staff of the European Spallation Source project. His current position in Jülich involves the design of magnetic devices like e.g., superconducting high-field magnets, permanent magnet assemblies, or magnetically shielded enclosures for particle beam lines and experiments.

Publications relevant for the proposed research:

1. Y. Zhang, W. Zander, J. Schubert, F. Röders, H. Soltner, M. Banzet, ... & A.I. Braginski, ***Operation of high-sensitivity radio frequency superconducting quantum interference device magnetometers with superconducting coplanar resonators at 77 K***, Appl. Phys. Lett. 71(5), (1997) 704;
2. M.L. Lucia, R. Hohmann, H. Soltner, H.J. Krause, W. Wolf, H. Bousack, A. Binneberg, ***Operation of HTS SQUIDs with a portable cryostat: A SQUID system in conjunction with eddy current technique for non-destructive evaluation***, Applied Superconductivity, IEEE Transactions on, 7(2), (1997) 2878.
3. H. Soltner, U. Pabst, R. Tölle, ***Magnetic-field calculations of the superconducting dipole magnets for the High-Energy Storage Ring at FAIR***,. Particle Accelerator Conference, 2007. PAC IEEE (2007) pp. 194;
4. C. R. Davidson, R. H. Griffin, K. J. Best, L. Maltin, W. Wolf, Y. Zhang, ..., H. Soltner, ***Design of a Magnetically Shielded Room for Development of HTS SQUID Systems for Magnetocardiography***, Biomag 96 Springer New York (2000) 35.
5. H. Soltner, U. Pabst, M. Butzek, M. Ohl, T. Kozielewski, M. Monkenbusch, ... ,and D. Fugate, ***Design, construction, and performance of a magnetically shielded room for a neutron spin echo spectrometer***, Nucl. Instr. Meth. Phys. Res. **A644**, (2011) 40.

b) Aachen

RWTH Aachen University, established in 1870, is one of 11 elite universities in Germany. It is divided into 9 faculties, including the medical faculty. Currently around 40,375 students are enrolled in over 130 academic programs. The number of foreign students (6,395) substantiates the university´s international orientation. Every year, more than 5,800 graduates and 750 doctoral graduates leave the university. Approximately 512 professors as well as 4675 academic and 2443 non-academic colleagues work at RWTH Aachen University. The university budget amounts to 884 million Euros, of which nearly 445 million Euros are funded by third parties. Moreover, special field research, 27 graduate colleges, among them 15 founded by the

German Research Foundation, 16 affiliated institutes with strong industrial alignment illustrate the university´s considerable research potential.

The RWTH Aachen University is one of the leading technical universities in Germany with a strong focus in engineering and natural sciences. It provides an ideal environment for the most challenging technological developments. Embedded in the department of physics is the III. Physikalische Institut with its focus on basic research in particle physics and spin-off into radiation therapy. The institute is involved in the CMS experiment at CERN, neutrino physics projects IceCube, DoubleChooz, T2K, LENA, and JUNO and in the search for EDMs. It operates a computer station in the World Wide LHC Computing Grid, has extensive laboratories and excellent support from mechanical and electronics engineering groups.

Relevant for the Design Study is the JARA (Jülich-Aachen Research Alliance) section “Fame”, (Forces and Matter Experiments), which aims to investigate the “Fate of Antimatter.

Achim Stahl (male, 1962) Curriculum Vitae

- **Current Position:** Full professor and head of the III. Physikalisches Institut B at the RWTH Aachen University (since 2004)
- **Scientific Degrees:**
  - Diploma in physics, University Tübingen (1988)
  - PhD in Physics with distinction , University of Heidelberg (1992)
  - Habilitation, Universität Bonn (1999)
- **Previous Positions:**
  - Postdoc, Universität Bonn (1992 – 2001)
  - leading scientist at the Deutsches Elektronensysnchrotron DESY (2001 – 2004)
- **Awards:**
  - Feodor-Lynen fellowship (1996 – 1998)
  - 'Distinguished professor' at RWTH Aachen University (2013)
  - Scientific Associate Ship, CERN (2014)

He worked on e^+e^- colliders in the experiments ALEPH, OPAL, SLD, BaBar, and TESLA and on the accelerator development E166 at SLAC. He is a member of the neutrino physics experiments Double Chooz and JUNO, and of the JEDI collaboration. His speciality is the physics of tau leptons and neutrino oscillations. He has a very broad experience in detector development. His major projects were the ALEPH trigger, the barrel part of the BaBar calorimeter, the positron polarimeter of the E166 experiment, the silicon tracker end caps of the CMS detector, and the trigger system of Double Chooz. Currently he is working on the front-end electronics of the JUNO detector and on the electrostatic deflectors for the EDM ring. He is director of the Jülich Aachen Research Alliance, section FAME, national representative of the German groups in the CMS collaboration and spokesperson of the BMBF research focus "Particle Physics with the CMS experiment" (http://www.fsp102-cms.de/).

Both mandates for CMS will end in June 2015. He is also national representative in the JUNO collaboration.

Publications relevant for the proposed research:

1. A. Stahl, ***Physics with tau leptons***, Springer Tracts Mod. Phys.160 (2000) 1;
2. S. Chatrchyan et al. [CMS Collaboration], ***Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC***, JHEP 06 (2013) 081;
3. K. Abe et al. [T2K Collaboration], ***Indication of Electron Neutrino Appearance from an Accelerator produced Off-axis Muon Neutrino Beam***, Phys. Rev. Lett. 107 (2011) 041801;
4. Y. Abe et al. [DoubleChooz Collaboration], ***Indication for the disappearance of reactor electron antineutrinos in the Double Chooz experiment***, Phys. Rev. Lett. 108 (2012) 131801;
5. J. Beringer et al. [Particle Data Group], ***Review of Particle Physics***, Phys. Rev. D86 (2012) 010001.

Jörg Pretz (male, 01.06.1966): Curriculum Vitae

- **Current Position:** Professor of physics at RWTH Aachen University (since 2012)
- **Scientific Degrees:**
  - Maitrise de Physique, University de Provence Marseille (1990)
  - Diploma in Physics, Mainz University (1992)
  - PhD in Physics, Mainz University (1997)
  - Habilitation and Privatdozent, Bonn University (2007 – 2008)
- **Previous Positions:**
  - Yale University (1998 – 2000)
  - University Bonn (2000 – 2011)
  - CERN Scientific Associate (Oct 2004 – Aug. 2005)

He has experience in hadron physics, studying the spin structure of the nucleon at the COMPASS experiment at CERN and in precision physics working on the muon g-2 experiment at Brookhaven National Laboratory. For both experiment he worked as analysis coordinator and was deputy technical coordinator for the COMPASS experiment. Currently he is co-spokesperson of the JEDI collaboration.

Publications relevant for the proposed research:

1. Z. Bagdasarian, et al., ***Measuring the Polarization of a Rapidly Precessing Deuteron Beam***, Phys. Rev. ST – Accel. Beams 17, 052803 (2014);
2. J. Pretz, ***Measurement of Permanent Electric Dipole Moments of Charged Hadrons in Storage Rings***, Hyperfine Interact. 214 (2013) 1-3, 111;
3. J. Pretz, ***Comparison of methods to extract an asymmetry parameter from data***, Nucl. Instrum. Meth. A659 (2011) 456;
4. J. Bieling et al., ***Implementation of mean-timing and subsequent logic functions on an FPGA***, Nucl. Instrum. Meth. A 672 (2012) 13;

5. H. Brown et al. [Muon g-2 Collaboration], ***Precise measurement of the positive muon anomalous magnetic moment***, Phys. Rev. Lett. 86 (2001) 2227.

c) Ferrara

The Ferrara group at the Dipartimento di Fisica e Scienze della Terra of the **University of Ferrara** possesses expertise in:

- Experiments in (polarized) physics with both electromagnetic (HERMES, JLAB) and hadronic probes (LEAR, E835, PAX).
- Polarized targets. The group was responsible for the running of the Internal Polarized Target and of the Polarimeter of the HERMES experiment. A laboratory for the development of high-intensity polarized sources is equipped in Ferrara.
- Storage cells. The mechanical workshop has been responsible for the design and production of the storage cells of the HERMES, OLYMPUS and PAX experiment.
- Detector design. The group is presently responsible for the design and realization of the beam polarimeter of the PAX experiment.
- Analysis of polarized data (HERMES, JLAB, PAX).
- DAQ. The electronic workshop has worked to the design and realization of the DAQs system for different high-energy physics experiments (NA48, NA62 and LHCb– CERN, E835-Fermilab, and Babar-SLAC).
- Superconductivity. Prototype construction, characterization, and precise mapping.
- Coordination activities in international collaborations (HERMES, PAX).

Paolo Lenisa (male, 17.06.1965): Curriculum Vitae

- **Current Position:** Associated professor at University of Ferrara (2014)
- **Scientific Degrees:**
  - Degree in Nuclear Engineering, Politecnico di Milano (1992)
  - PhD in Physics, University of Ferrara (1997)
  - Habilitation for full and associated professor in Experimental Physics of Fundamental Interactions (MIUR-2014)
- **Previous Positions:**
  - MPI – Heidelberg (1997-1998)
  - Researcher at University of Ferrara (1998-2014)

Trained in atomic physics, in 1998 he got involved in spin-physics as member of the HERMES collaboration (deep inelastic scattering experiment at HERA-DESY, Hamburg), where from 2000 to 2005 he was coordinator of the international group of researchers running the polarized target. Since 2004, he is co-spokesperson of the PAX Collaboration (Polarized Antiproton eXperiments). He has been scientific coordinator for the University of Ferrara for 3 projects approved by the MIUR (PRIN 2003, 2006, 2008) devoted to the study of transversity of the nucleon and of 4 approved European projects devoted to polarized antiprotons. Since 2011, he is member of the International Committee for the spin physics. Since 2012 he is member of the INFN – Scientific Commission 3. He is author of more than 150 publications in international journals, tutor of 7 doctoral theses and 8 diploma theses in physics.

Since 1999 he is lecturer of the courses of General Physics at the University of Ferrara.

Publications relevant for the proposed research:

1. *Z. Bagdasarian, et al.*, ***Measuring the Polarization of a Rapidly Precessing Deuteron Beam***, Phys. Rev. ST – Accel. Beams **17** (2014) 052803;
2. D. Oellers, et al., ***Polarizing a stored beam by spin-flip?***, Phys. Lett. **B 674** (2009) 269;
3. W. Augustyniak, et al. ***Polarization of a stored beam by spin-filtering***, Physics Lett. **B 718** (2012) 64;
4. P. Benati, et al., ***Synchrotron oscillation effects on an rf-solenoid spin resonance***, Phys. Rev. ST Accel. Beams **15** (2012) 124202;
5. C. Baumgarten et al., ***An atomic beam polarimeter to measure the nuclear polarization in the HERMES gaseous polarized hydrogen and deuterium target***, Nucl. Instrum. Meth. **A 482** (2002) 606.

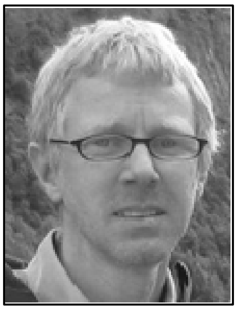
Greta Guidoboni (female, 13.04.1984): Curriculum Vitae

- **Current Position:** Postdoc at the Ferrara University (since 2013)
- **Scientific Degrees:**
  - Bachelor Degree in Physics, Ferrara University (2006)
  - Master Degree in Physics, Ferrara University (2009)
  - PhD in Physics, Ferrara University (2013)

She has experience in hadron physics, studying the spin structure of the nucleon at the PAX experiment at COSY (COoler SYnchrotron) in Jülich, and in precision physics working for the EDM (Electric Dipole Moment) experiment at COSY. For the PAX experiment she developed an interlock system to guarantee safe working condition of the detection system, based on a FPGA control. Currently she is part of the JEDI collaboration which aims to measure the EDM of charge particles using a storage ring. Her research activity is focused on the data analysis of a polarized deuteron beam through the development of a no-lattice model, which represent a simple tool to interpret the experimental results.

Publications relevant for the proposed research:

1. *Z. Bagdasarian, et al.*, ***Measuring the Polarization of a Rapidly Precessing Deuteron Beam***, Phys. Rev. ST – Accel. Beams **17** (2014) 052803;
2. W. Augustyniak, et al., ***Polarization of a stored beam by spin-filtering***, Physics Lett. B **718** (2012) 64;
3. P. Benati, et al., ***Synchrotron oscillation effects on an rf-solenoid spin resonance***, Phys. Rev. Special Topics Accelerators and Beams **15** (2012) 124202;
4. D. Oellers et al., ***Updated experimental limit on electron-proton spin-flip cross section*** Nucl. Instr. and Meth. A **759** (2014) 6:
5. S. Dymov, et al., ***Measurement of spin observables in the quasifree*** $np \rightarrow pp_s\pi^-$ ***reaction at 353 MeV,*** Phys. Lett. B **712**, (2012) 375.



Guido Zavattini (male, 17.04.1963): Curriculum Vitae

- **Current Position:** Professor of physics at University of Ferrara (since 2009)
- **Scientific Degrees:**
    - Laurea in physics at Pisa University (1989)
    - PhD in Physics, Bologna University (1993)
    - Habilitation for Full Professorship (2014)
- **Previous Positions:**
    - Post-Doc for INFN - Trieste (1993 – 1994)
    - Researcher at University Ferrara (1994 – 2009)
    - Senior Research Scientist at University of California, Davis, CA, USA (Aug 2002 – Aug. 2003)

He has experience in both precision optics studying the structure of QED vacuum by measuring vacuum magnetic birefringence with the PVLAS apparatus (non linear effect connected to light-light scattering) and position sensitive x-ray detectors for applications in Positron Emission Tomography and Single Photon Emission Tomography. In both activities he has contributed to all aspects of the experiments (design, electronics, acquisition, analysis). He has also been group leader in both activities. For the PVLAS experiment he is spokesperson since 2008.

Publications relevant for the proposed research:

1. G. Zavattini et al. ***On measuring birefringences and dichroisms using Fabry-Perot cavities.*** App. Phys. B **83** (2006) 571;
2. M. Bregant et al. ***Frequency locking to a high-finesse Fabry-Perot cavity of a frequency doubled Nd:YAG laser used as the optical phase modulator.*** Rev. Sci. Instrum. 73 (2002) 4142.

d) Tbilisi

The High Energy Physics Institute of **Ivane Javakhishvili Tbilisi State University** (HEPI TSU) is founded in 1980 on a base of the Nuclear Physics Problem Laboratory. Scientific research is mainly carried out within a framework of the international collaboration with such research centers such as the Joint Institute for Nuclear Research (Dubna, Russia), European Center for Nuclear Research (Geneva, CERN), Research Center Jülich (Germany), and Japan Proton Accelerator Research Complex (J-PARC, Tokai, Japan).

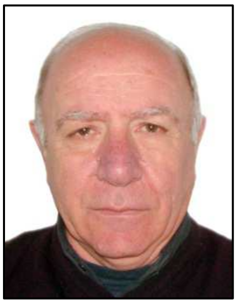
The Institute has three scientific departments: experimental physics, theoretical physics and information technology.

Experimental researches are conducting in following areas: hadron physics (spin structure of nucleon-nucleon interaction, top quark rare decays via FCNC, electric dipole moment search of charged particles, lepton flavor violating muon decays), and relativistic ion physics (collective leakage phenomena in nucleus-nucleus collisions).

Theoretical investigations are carrying out in following spheres: quark structure of hadrons, spin physics (deep inelastic processes and polarization phenomena), and physics beyond Standard Model (flavor changing neutral currents).

In the Information & Technology Department scientific-technical works are performing in following direction: GRID technology (creation of GRID infra-structure in Georgia and applications in field of high energy physics) and development of computer network.

High Energy Physics Institute closely co-operates with the Faculty of Exact and Natural Sciences of TSU.



Mikheil Nioradze (male, 06.12.1941): Curriculum Vitae

- **Current Position:** since 2004 Director of High Energy Physics Institute of Tbilisi State University, Tbilisi, Georgia
- **Scientific Degrees:**
  - Candidate of Phys.-Math. Sciences, JINR, Dubna, Russia (1975)
  - Doctor of Phys.- Math. Sciences, JINR, Dubna, Russia (1991)
  - Professor of Tbilisi State University (since 1993)
- **Previous Positions:**
  - Researcher Fellow of High Energy Physics Institute of Tbilisi State University (1965 – 1975)
  - Senior Researcher of High Energy Physics Institute of Tbilisi State University (1976 – 1980)
  - Head of Laboratory of Hydrogen Bubble Chamber, High Energy Physics Institute of Tbilisi State University (1981 – 1991)
  - Head of Nuclear Physics Department, High Energy Physics Institute of Tbilisi State University (1992 – 2004)
- **Awards:**
  - Georgian National Award (2009)
  - The Second Prize of the Joint Institute for Nuclear Research (1998)
  - American Physical Society (1993)

M. Nioradze has extensive experience in the interaction of light nuclei with the hydrogen target. From 1971 – 1990 he participated in experiments at synchrophasotron of the Joint Institute for Nuclear Research (JINR, Dubna, Russia) by means of the hydrogen bubble chamber. This was one of the first experiments in the relativistic nuclear physics, which was carried out in the framework of an international collaboration. Since 1992 Nioradze with his group from Georgia (High Energy Physics Institute of Tbilisi State University) participated in experiments at the synchrotron COSY (Research Center Jülich, Germany) in the frame of the international collaboration ANKE. New proposal on the experimental study of the spin structure of amplitude of the elementary $np \rightarrow pn$ charge-exchange process was suggested, prepared and carried out by Georgian group under leadership of Nioradze. New type of Cherenkov detectors of total internal reflection for particle identification was also proposed and produced by this Georgian group. In 2005-2008, Nioradze collaborated with the Elementary Particle Physics Institute of the Montreal University in the frame of project ("Nuclear and radiation safety of nuclear plants") financed by the International Science and Technology Center. With his Georgian team he now participates in preparatory works for experiment on the search for electric dipole moment of charged particles in the frame of the JEDI collaboration. In parallel he coordinates the preparatory works for COMET (COherent Muon-Electron Transition) experiment which is planned at the J-PARC (Japan Proton Accelerator Research Complex) in 2016.

Publications relevant for the proposed research:

1. D. Mchedlishvili et al., ***The neutron-proton charge exchange amplitudes measured in the dp→ppn reaction***, Eur. J. of Physics A 49 (2013) 49;
2. S. Dymov et al., ***Measurement of spin observables in the quasi-free $np \to \{pp\}_s \pi^0$ reaction at 353 MeV***, Phys. Rev. C 88 (2013) 014001;
3. D. Mchedlishvili et al., ***Excitation of the $\Delta(1232)$ isobar in deuteron charge exchange on hydrogen at 1.6, 1.8 and 2.3 GeV***, Phys. Lett. B 726 (2013) 145;
4. V. Shmakova et al., ***First measurement of spin correlations in the $np \to d\pi^0$ reaction***, Phys. Lett. B 726 (2013) 634;
5. D. Tsirkov et al., ***Differential cross section and analysing power of the $pp \to \{pp\}\pi^0$ reaction at 353 MeV***, Phys. Lett. B 712 (2012) 370;

e) Krakow

The **Jagiellonian University** has an ongoing tradition of research in natural sciences. One of the leading science faculties is the Faculty of Physics, Astronomy and Applied Computer Science, which consists of the Astronomical Observatory, Institute of Physics, and Department of Applied Computer Science. The faculty plays an important and active role in international and local developments in research, education and in application-related projects. Physics research is concentrated in the Institute of Physics and is run in 14 experimental physics departments (Nuclear Physics being the largest one) and in 9 theoretical physics departments. In total in the Institute of Physics there are 52 professors employed, 34 associated professors and a number of post-docs.

In the current project the physicists from the Nuclear Physics Department will be strongly involved. They have a large experience in experimental nuclear physics of low and high energies. Up to now they have performed numerous experiments in collaboration with Forschungszentrum Jülich, GSI Darmstadt, ETH Zürich, KVI Groningen, and INFN Catania. The performed investigations cover a broad spectrum of nuclear physics problems for various beams and targets in the beam energy range from several MeV up to several GeV.

In the Nuclear Physics Department there is a group of physicists involved for a long time in experiments using polarized proton and deuteron beams. Extensive experience in measurements of the polarization observables gained in those experiments will be extremely beneficial in the present project. This group have performed detailed investigations of the vector and tensor analysing powers in proton-deuteron elastic scattering and proton induced deuteron break-up reactions. The experiments were performed at KVI Groningen and Forschungszentrum Jülich using proton and deuteron vector and tensor polarized beams with energy of around 100 MeV/nucleon. At higher deuteron beam energy of about 1.15 GeV this group has also measured the tensor polarization observables investigating specific eta-meson production reaction, using polarized deuteron from the COSY accelerator at Forschungszentrum Jülich.

Andrzej Magiera (male, 18.11.1955): Curriculum Vitae

- **Current Position:** Professor of physics at the Jagiellonian University, Kraków (since 2004)
- **Scientific Degrees:**
  - Diploma in Physics, Jagiellonian University, Kraków (1979)
  - PhD in Physics, Jagiellonian University, Kraków (1985)
  - Habilitation, Jagiellonian University, Kraków (1997)
- **Previous Positions:**
  - Ph.D. fellowship in Kernforschungsanlage Jülich (1982-1985)
  - Jagiellonian University, Kraków (1985 – 2004)
  - visiting scientist, Forschungszentrum Jülich (1999 – 2000)

He has experience in low and high energy nuclear physics and in hadron physics. He investigated various nuclear and hadron reactions, with special emphasis on determining polarization observables. He was actively working in GEM, MOMO, PISA, HIRES and WASA collaborations at COSY accelerator. He was a spokesperson of several experiments in GEM and WASA-at-COSY collaborations, especially those dedicated to studies of low cross section, forbidden charge symmetry breaking reactions. In WASA-at-COSY collaboration he is a member of Publication Committee. He was a member of Program Advisory Committee at COSY accelerator (2006-2011). Presently he is a co-spokesperson of the Gamma-CCB experiment in Cyclotron Centre Bronowice, aiming at development of new methods of dose deposition imaging during hadron therapy.The results of these investigations were published in numerous papers.

Publications relevant for the proposed research:

1. A. Budzanowski, et al., ***Cross section and tensor analysing power of the*** $dd\rightarrow\eta\alpha$ ***reaction near threshold***, Nucl. Phys. **A 821** (2009) 193;
2. E. Stephan, et al., ***Three-nucleon interaction dynamics studied via the deuteron-proton break-up***, Int. J. Mod. Phys. **A 24** (2009) 515;
3. I. Ciepał, et al., ***Vector analyzing powers of deuteron-proton elastic scattering and breakup at 130 MeV***, Phys. Rev. **C 85** (2012) 017001;
4. B. Kłos, et al., ***Systematic studies of the three-nucleon system dynamics in the deuteron-proton breakup reaction***, Acta. Phys. Pol. **B 44** (2013) 345;
5. I. Ciepał, et al., ***Investigations of Few-Nucleon System Dynamics in Medium Energy Domain***, Few-Body Syst. **54** (2013) 1301.

Aleksandra Wrońska (female, 14.08.1976): Curriculum Vitae

- **Current Position:** Assistant Professor at the Jagiellonian University (since 2010)
- **Scientific Degrees:**
  - Diploma in Physics, Jagiellonian University Kraków (2000)
  - Ph.D. In Physics, Jagiellonian University Kraków (2005)
- **Previous Positions:**
  - Post-doc in the Institute of Physics, Jagiellonian University Kraków (2005-2010)
  - Researcher, Forschungszentrum Jülich (2001-2004)

Hadron physicist, from the beginning her scientific career has developed in connection with the Forschungszentrum Jülich. She has worked at various experiments there, *inter alia* in GEM and WASA-at-COSY, in the projects addressing the issue of charge- and isospin symmetry breaking, and in ANKE, where she lead a project investigating the possibility of existance of eta-mesic nuclei. In 2005-2008 member of the software development group in the PANDA experiment at FAIR. In 2011 she has become active in the Few Body Experiment group, studying the three-body effects in strong nuclear interaction (precision experiment). Since 2013 she is a co-spokesperson of the Gamma-CCB experiment in Cyclotron Centre Bronowice, aiming at development of new methods in medical imaging.The results of these investigations were published in numerous papers.

Publications relevant for the proposed research:

1. D. Chiladze et al., ***Determination of deuteron beam polarizations at COSY***, Phys. Rev. ST Accel.Beams **9** (2006) 050101;
2. T. Mersmann et al., ***Precision study of the*** $\eta\,{}^3He$ ***system using the*** $dp \to {}^3He\,\eta$ ***reaction***, Phys. Rev. Lett. **98** (2007) 242301;
3. I. Ciepał et al., ***Vector analyzing powers of deuteron-proton elastic scattering and breakup at 130 MeV***, Phys.Rev. **C 85** (2012) 017001;
4. P. Adlarson et al., ***Investigation of the*** $dd \to {}^3He\, n\, \pi^0$ ***reaction with the FZ Jülich WASA-at-COSY facility***, Phys. Rev. **C 88** (2013) 1, 014004.

f) Grenoble

Centre National de la Recherche Scientifique (CNRS)

The Centre National de la Recherche Scientifique (National Centre for Scientific Research) is a government-funded research organization, under the administrative authority of France's Ministry of Research. The CNRS operates thanks to a structure more than 1100 research unities, with 33,000 employees and a global 2014 budget of 3.4 billion euros. As the largest fundamental research organization in Europe, CNRS carried out research in many fields of knowledge, through its research departments:

- Institut des sciences biologiques (INSB)
- Institut de chimie (INC)
- Institut écologie et environnement (INEE)
- Institut des sciences humaines et sociales (INSHS)
- Institut des sciences de l'information et de leurs interactions (INS2I)
- Institut des sciences de l’ingénierie et des systèmes (INSIS)
- Institut national des sciences mathématiques et de leurs interactions (INSMI)

- Institut de physique (INP)
- Institut national de physique nucléaire et physique des particules (IN2P3)
- Institut national des sciences de l'univers (INSU)

The **Pôle Accélérateurs et Sources d'Ions** (15 persons) is part of the LPSC (Laboratory for Subatomic Physics and Cosmology, UMR 5821 set up by CNRS and by Université Joseph Fourier), a 220 person laboratory in IN2P3. The pole is involved in the SPIRAL2 program (RF power couplers, ions sources), ECR ion source development, Accelerator Driven System programs like GUINEVERE and MYRRHA. It develops and operates neutrons generators based on electrostatic accelerators. The pole has a general expertise on beam dynamics and accelerator design (general design, magnetic and RF design). In the pole, the accelerator group activities (present or recent) are:

- the design, construction and operation of the GENEPI1, 2 and 3 electrostatic accelerators. The last one is now coupled to the VENUS reactor in Mol (Belgium), within the GUINEVERE program. GENEPI2 is used for neutron irradiation programs (electronic components for example);
- the design and production of the RF power couplers for the SPIRAL2 superconducting linac;
- the study (models and simulation) of the spin dynamics for the SUPERB project; and
- the construction of LINAC4 RF power amplifiers (CERN)

Jean-Marie De Conto (male, 10.12.1960): Curriculum Vitae

- **Current Position:** Professor of Physics, Joseph Fourier University (since 2005)
- **Scientific Degrees:**
  - Master of mathematics (1981)
  - Engineering degree (Ecole Supérieure d'Electricité, 1983)
  - Habilitation in Physics (2003)
- **Previous Positions:**
  - Engineer (Thomson CSF, 1983-1985)
  - Engineer (Hewlett-Packard, 1985-1989)
  - Research engineer (CNRS, 1989-2005)
- **Awards**:
  - Cristal du CNRS (2003)

After a 6 year experience in industry (Thomson, Hewlett-Packard), Pr De Conto joined CNRS at LPSC in 1989. He got the Habilitation à Diriger des Recherches in Physics in 2003 (Joseph Fourier University). His main activity is accelerator design. He has been Project leader for the French hadrontherapy project ETOILE, member of the Comité National du CNRS (2008-2011), coordinator of the HIPPI/WP4 workpackage (CARE FP6 program) and of the networking activity ACCNET/RFTECH (EUCARD FP7 program) and member of the EUCARD Governing Board.

Maud Baylac (female, 9.3.1973): Curriculum Vitae

- **Current Position:** Group leader of the Accelerator Group at LPSC Grenoble (since 2006)
- **Scientific Degrees:**
  - PhD in physics, University Claude Bernard (Lyon) (2000)
- **Previous Positions:**
  - Thomas Jefferson National Accelerator Facility (2001-2005)
- **Awards:**
  - Southern Universities Research Association (SURA) CEBAF thesis prize (2000)
  - Cristal du CNRS (2012)

After a 4-year experience on beam-based Compton polarimetry, Dr Baylac joined the LPSC in 2005. Her main activity is to lead the development, construction and operation of the GENEPI-3C accelerator for the GUINEVERE program at SCK•CEN. She also participates in European programs of accelerator R&D.

Publications relevant for the proposed research (Maud Baylac and Jean-Marie De Conto):

1. A. Billebaud et al. (M. Baylac, D. Bondoux, J. Bouvier, S. Chabod, J.-M. De Conto, A. Nuttin), Guinevere collaboration, ***Construction of a Zero-Power Pb ADS at Mol***, Proc. à paraître (IAEA Proceedings Series). International Topical Meeting on Nuclear Research Applications and Utilization of Accelerators AcApp'09, Satellite Meeting European Fast Neutron Transmutation Reactor Projects (MYRRHA/Xt-ADS), Vienna, Austria, May 4 – 8, 2009.
2. P. Baeten et al. (M. Baylac, A. Nuttin, A. Billebaud, D. Bondoux, J. Bouvier, S. Chabod, J.-M. De Conto), ***The Guinevere project at the VENUS-F facility***, Proc. on line ENC 2010 Transactions ISBN 9789295064096 5p. European Nuclear Conference (ENC 2010), Barcelona, Spain, May 30 – June 2, 2010.
3. M. Baylac et al.(A. Billebaud, D. Bondoux, J. Bouvier, S. Chabod, J.-M. de Conto, E. Froidefond, A. Nuttin), Guinevere collaboration, ***Some highlights of experimental ADS programs in Europe***. 1st International Workshop on Accelerator-Driven Sub-critical Systems & Thorium Utilization, Blacksburg, Virginia, USA, September 27 – 29, 2010.
4. R. Ferdinand et al. (Y. Gomez Martinez), ***Status and challenges of Spiral2 SRF Linac***, Proc. on line Jacow (SRF13) 11-17 MOIOA02. 16th International Conference on RF Superconductivity (SRF2013), Paris, France, September 23 – 27, 2013
5. Y. Gomez Martinez, T. Cabanel, J. Giraud, R. Micoud, M. Migliore, J. Morfin, F. Vezzu et al., ***Power couplers for Spiral 2***, Proc on line Jacow SRF2011 FRIOA04 947-950. 15th International Conference on RF Superconductivity (SFR 2011), Chicago, USA, July 25 – 29, 2011.

1.2. Third parties involved in the project (including use of third party resources)

As mentioned above at the bottom of section 1.3, we are collaborating with other institutes from the US, Russia and South Korea. The JEDI collaboration comprises more than 100 members from 11 countries and is supported by the srEDM collaboration, working towards the same goal. A close cooperation between the two collaborations exists – a number of scientists have signed in for both.

For the participants in the Design Study from **Jülich, Aachen, Ferrara, Tbilisi, and Krakow**, there are ***no third parties involved***.

For **Grenoble**, the involvement of third parties is described below.

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	**N**
Does the participant envisage that part of its work is performed by linked third parties	**Y**
In Grenoble, the activity will be done in the LPSC laboratory, involving CNRS personnel but also Pr Jean-Marie De Conto, professor at Joseph Fourier University. Hence Université Joseph Fourier will be a third party linked to the beneficiary CNRS, as employer of Prof J.M. De Conto, and as partner institution of LPSC, Joint Research Unit (UMR 5821). Université Joseph Fourier will be active via the participation of Pr Jean-Marie De Conto who will perform the tasks.	
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	**Y**
Université Joseph Fourier, employer of Prof J.M. De Conto.	

5. Ethics and Security

5.1 Ethics

The comment with respect to item 6 of Part A regarding ethics concerns the inclusion of Georgia as a member of our Design Study. According to the EU rules, Georgia is a country associated to HORIZON 2020. We are collaborating with Georgia – the High Energy Physics Institute of Tbilisi State University (TSU) and the Georgian Technical University (GTU) – since more than 20 years in different projects at COSY (ANKE, PAX, and JEDI). Our collaborators have proven to be reliable partners with outstanding expertise in various fields: this will also greatly help for the EDM Design Study. It will, likewise, also help our Georgian participants in many ways: *i)* access to world-class research infrastructures for their researchers and students, *ii)* capacity building within an international cooperation, and *iii)* help to develop the country after returning to Georgia.

5.2 Security

Please indicate if your project will involve:

- activities or results raising security issues: (**NO**)
- 'EU-classified information' as background or results: (**NO**)