JEDI Overview

December 19, 2016 | Andreas Lehrach

Forschungszentrum Jülich (IKP-4) & RWTH Aachen University (Ex.Physik IIIb)

on behalf of the JEDI collaboration

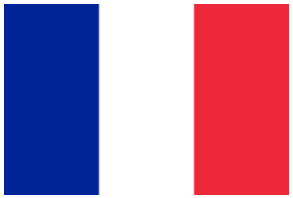
(Jülich Electric Dipole Moment Investigations)

Members

In total 126 collaboration members

from 11 countries

BELARUS



FRANCE

GEORGIA

GERMANY

ITALIA

POLAND

REPUBLIC OF KOREA

RUSSIA

SWEDEN

UK

USA

and 37 institutes

Recent Publications

1) **PRL** letter paper, "How to reach thousand second in-plane polarization lifetime with 0.97 GeV/c deuterons in a storage ring", Phys. Rev. Lett. 117, 054801 (2016).

- Editor's Suggestion https://journals.aps.org/prl/highlights/
- Highlights, APS Physics https://physics.aps.org/

2) **NIM A** paper, "Electromagnetic simulation and design of a novel waveguide RF Wien Filter for electric dipole moment measurements of protons and deuterons", Nuclear Instruments and Methods in Physics Research A 828 (2016) 116

3) **CERN Courier** article, "Storage ring steps up search for electric dipole moments, CERN Courier Volume 56, No. 7, September 2016

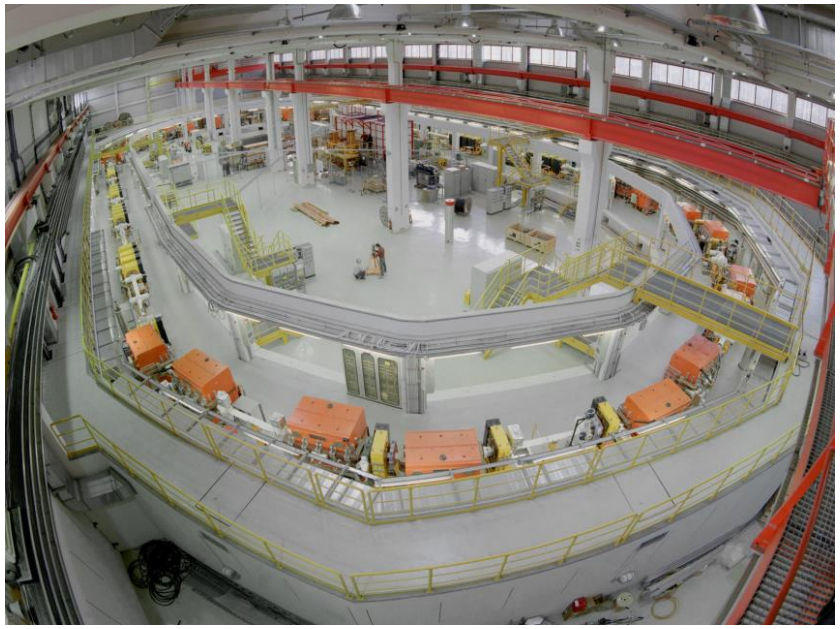
4) **Paper draft for PRST-AB** on the "Spin tune mapping", in its final preparation phase by the editorial team (A. Saleev et al.), posted soon on JEDI web page.

The list of the considered publications accessible from the internal JEDI wiki page: http://collaborations.fz-juelich.de/ikp/jedi/apps/wiki/index.php/Publication_Committee

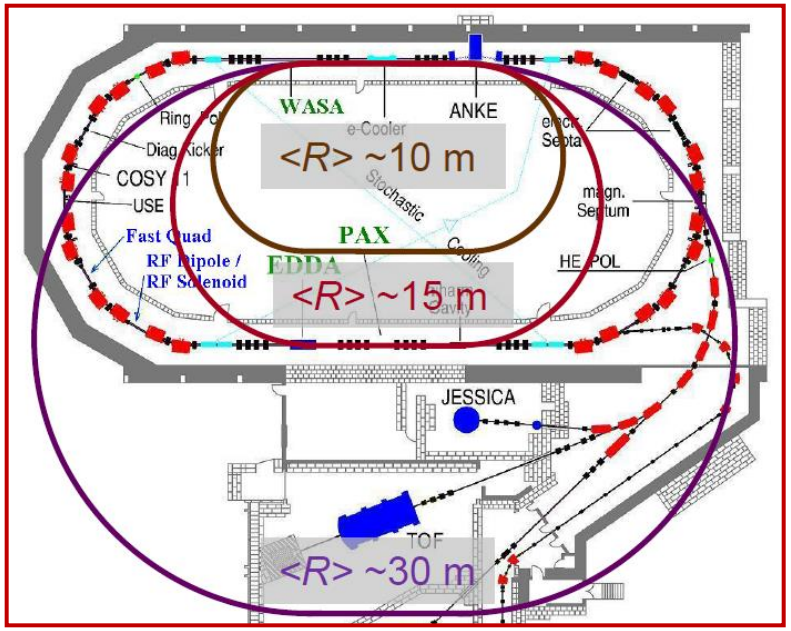
Stepwise Approach for JEDI

Measurements of charged particle EDMs
from COSY to a dedicated EDM storage ring

Cooler Synchrotron COSY



Dedicated EDM Ring



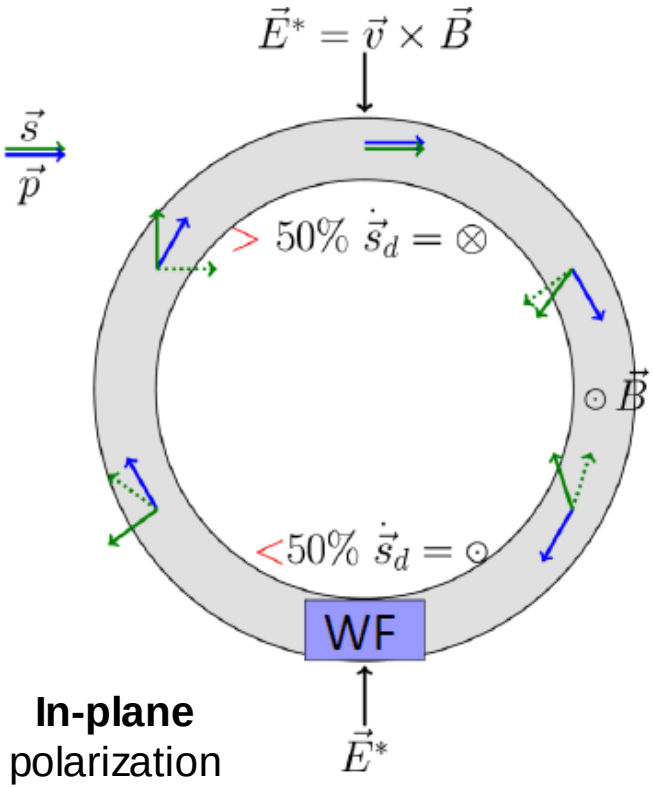
- Ideal starting point for R&D work
- Deliver first direct EDM measurement for deuterons
- Improve sensitivity by CW-CCW
- Injector for dedicated EDM ring

- All-in-One storage ring for p,d,He-3
- CW-CCW beams
- High precision alignment
- High sensitivity BPMs

Resonance Method in Magnetic Rings

Deliver first direct EDM measurement for deuterons at COSY

$$\boldsymbol{E^* = 0 \Rightarrow E_R = -\beta \times B_y}$$ „Magic RF Wien Filter“ no Lorentz force → **Indirect** EDM effect



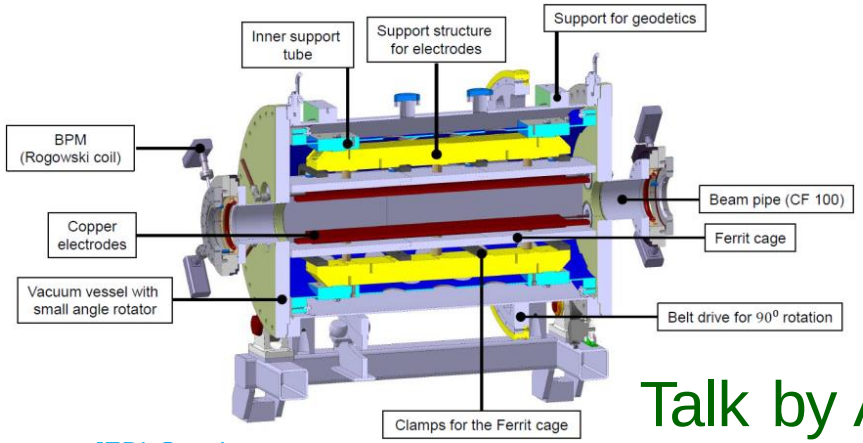
In-plane polarization

- Modulation of horizontal spin precession
- EDMs interaction with the motional electric field in the rest of the ring

→ continuous buildup of vertical polarization in a horizontally polarized beam.

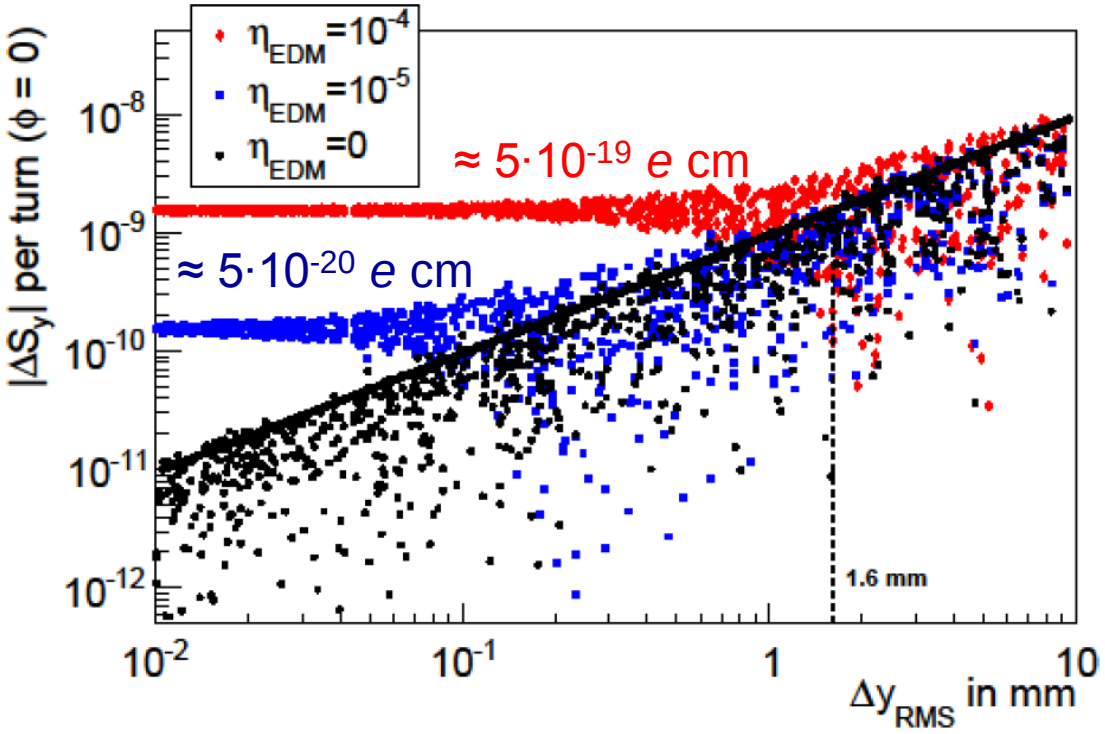
→ Investigation of systematic limitations

Waveguide RF *ExB* Wien filter



Talk by A. Nass

Systematic Limitations for EDM Measurements at COSY



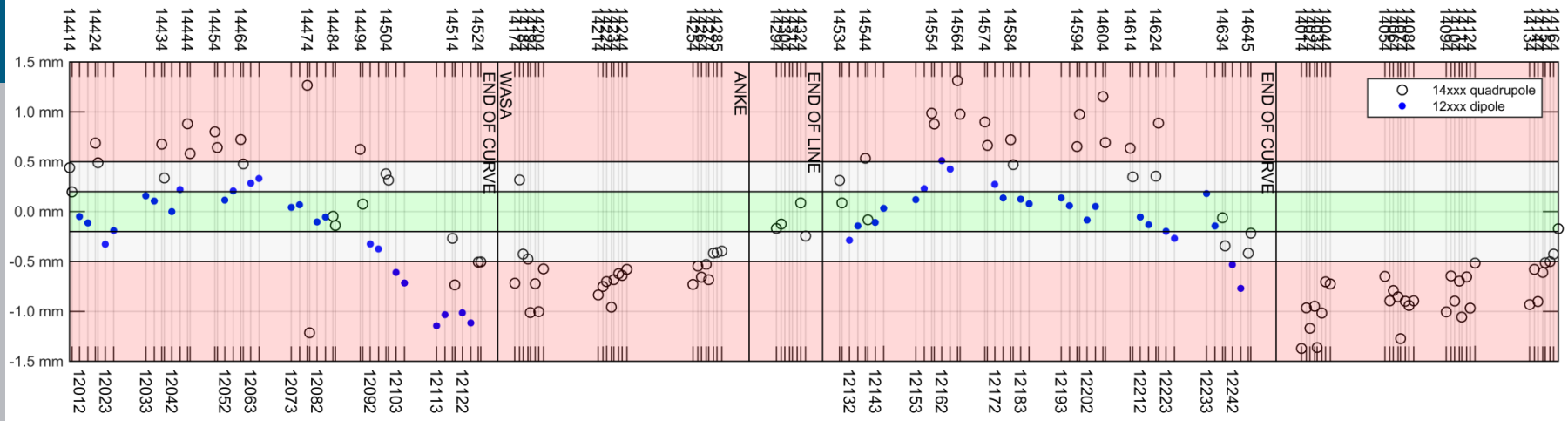
Absolute average change of the vertical spin component ΔS_y per turn for different Δy_{RMS} and an initial Wien filter phase 0°. Wien filter magnetic field 10^{-4} mT (0.8 m length) and corresponding electric field. Different Δy_{RMS} generated by randomized vertical quadrupole shifts assuming Gaussian distributed misalignment errors.

- Solid line shows the 90% upper confidence limit for pure misalignments.
- Dashed line refers to the location for which the false signal by misalignments is equal to an EDM signal corresponding to $\eta_{EDM} = 10^{-4}$.

Courtesy: M. Rosenthal

Vermessungsbüro Dipl.-Ing. H. J. Stollenwerk
Öffentlich bestellter Vermessungsingenieur
Bahnstraße 8 D-50126 Bergheim Telefon 02271/4721-0 Telefax 02271/472124

Vertical deviations of measured points from the best-fit-plane

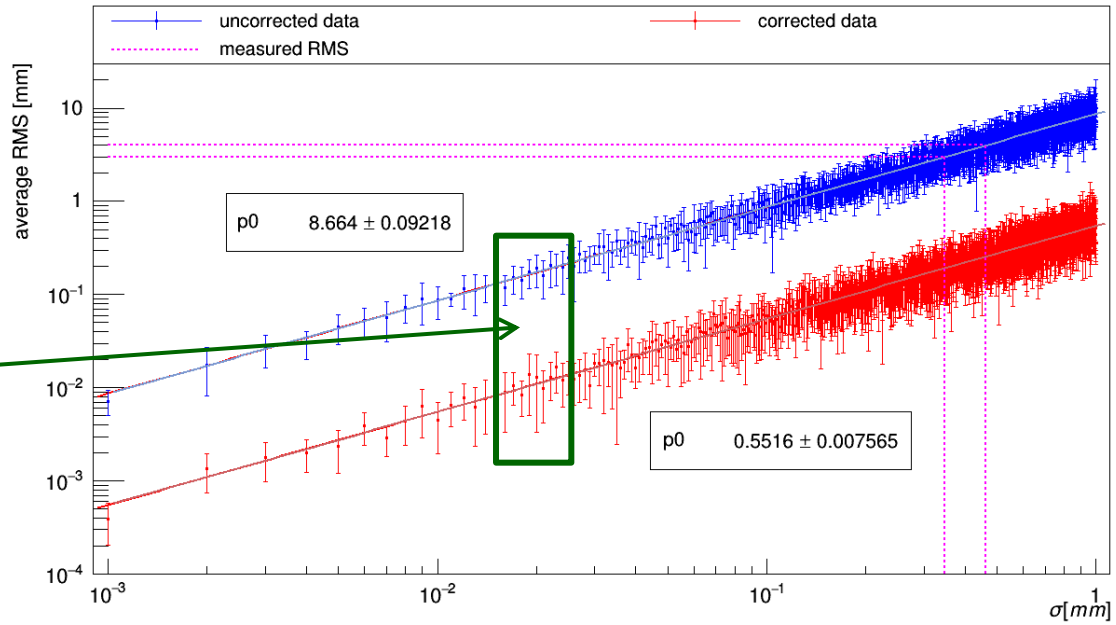


	Dipoles	Quadrupoles
dev <= 0.2 mm	56 %	10 %
0.2 mm < dev <= 0.5 mm	25 %	20 %
0.5 mm < dev <= 1.5 mm	19 %	70 %

Preparation for Improved Closed-Orbit Correction

Horizontal closed-orbit

Accessible range



Random positioning and rotation errors of dipoles and quadrupoles Gaussian distributed. For each point 1000 seeds. Dashed line: measured “rms” orbit at COSY. p0: slope of linear fit.

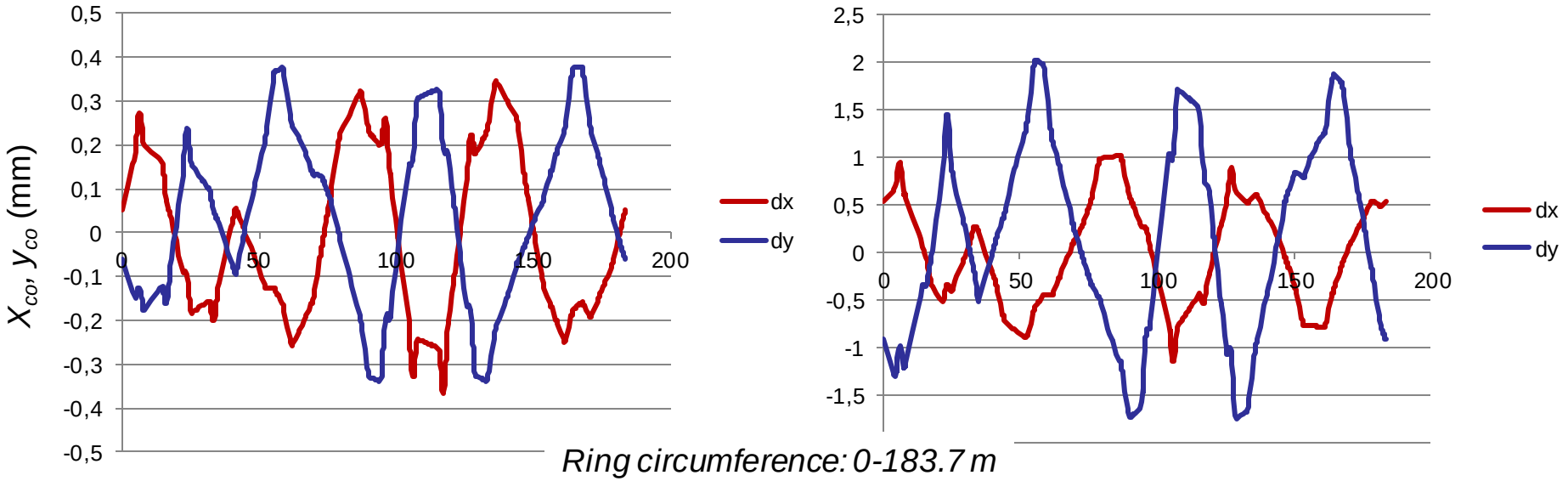
New survey of COSY has been provided and discussed.
Alignment procedure will be performed soon.
Upgrade of beam position monitor electronics also in preparation.

Estimation: COSY with Quadrupole Shunts

Shunt is an additional power supply that adds / subtracts an additional current

Quadrupole current: $I_{total} = I + dI$, focusing strength: $k_{total}=k(I+dI)=k(I)+dk$

Typically values for current change: few % to 10 %



Ring circumference: 0-183.7 m

MAD simulations with 10 mm offset of single quadrupole and 5 % shunts, resulting example orbits (there are many more, nothing spectacular observed)

→ For relative orbit measurement of 10µm the orbit can be aligned with an accuracy of roughly 100µm in quadrupoles

Courtesy: B. Lorentz

Summary of Deuteron Data Base Run

Weeks 46 and 47, 2016

Goal: Carbon targets are expected for the EDM polarimeter.
Produce d+C data sets (multiple energies) for $d\sigma/d\Omega$, A_y, T_{20}, and T_{22}.
Measure p and d (etc.), all φ angles, and θ angles from 4° to 17°.
Maximize efficiency and sensitivity for deuteron polarimetry.

Use these data to optimize the WASA Forward Detector for polarimetry.
Test designs (Geant) for WASA and new EDM polarimeters (best FOM).
Expect WASA FD to be big improvement over EDDA.
Expect higher energies (>236 MeV) to be better for spin experiments.

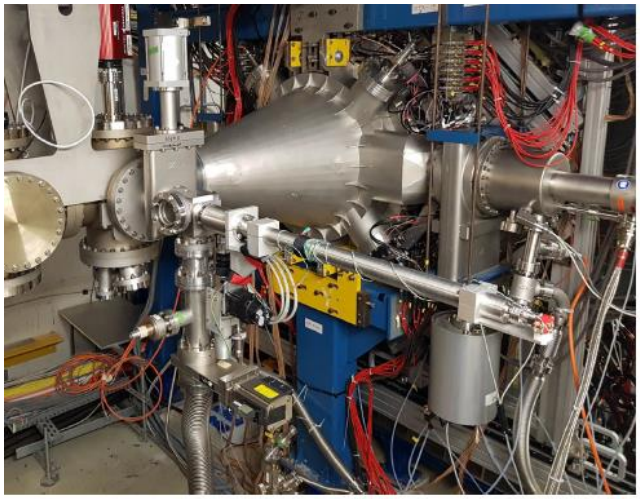
Run looked at 170, 200,* 235, 270,* 300, 340, 380 MeV.
Ran ~2 days at each energy, used C and CH_2 targets on ANKE ladder.
(From CH_2 we calibrate cross sections, add polarization checks.)
Used 5 polarization states (Unpolarized, V+, V−, T+, and T−.)

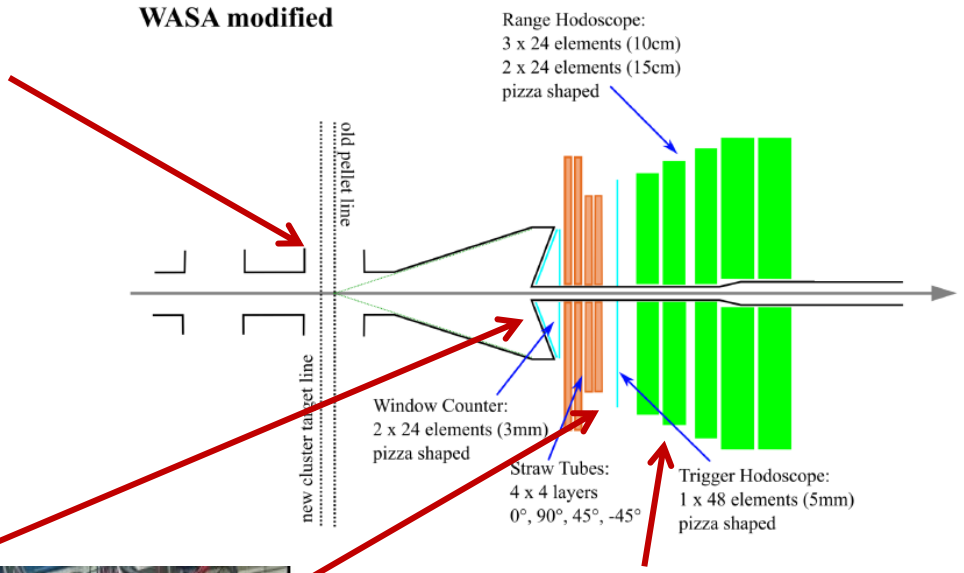
Great run!
Thanks to all!

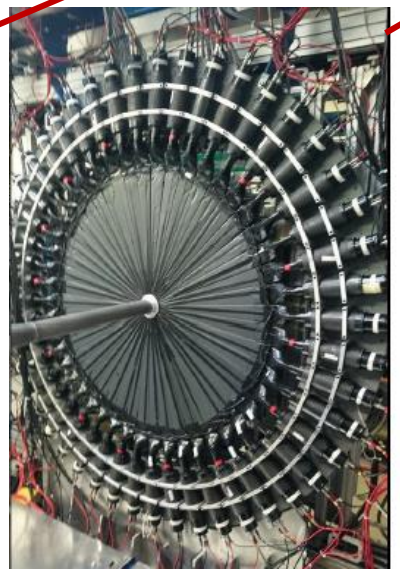
*Energies with reference polarization data.
Extra energies.

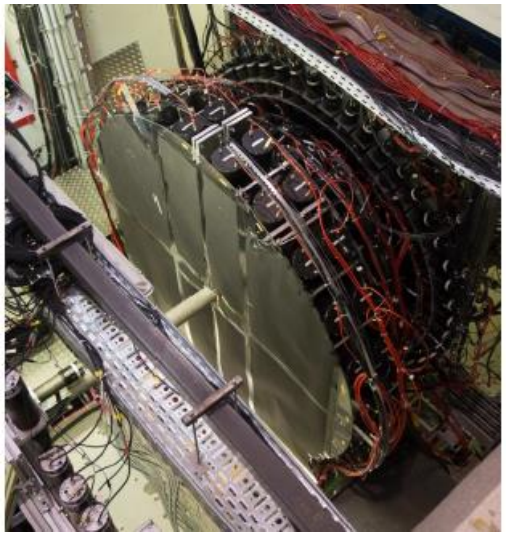
WASA Modifications for Polarimetry

Central Detector Barrel removed and ANKE strip target added





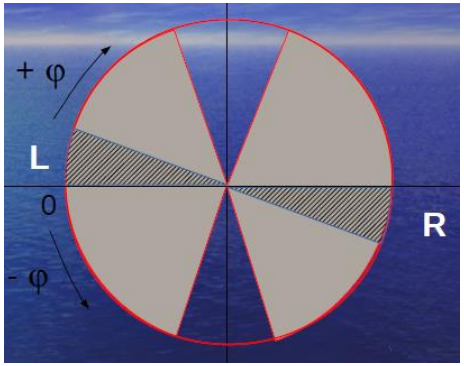




Courtesy: V. Hejny, E. Stephenson

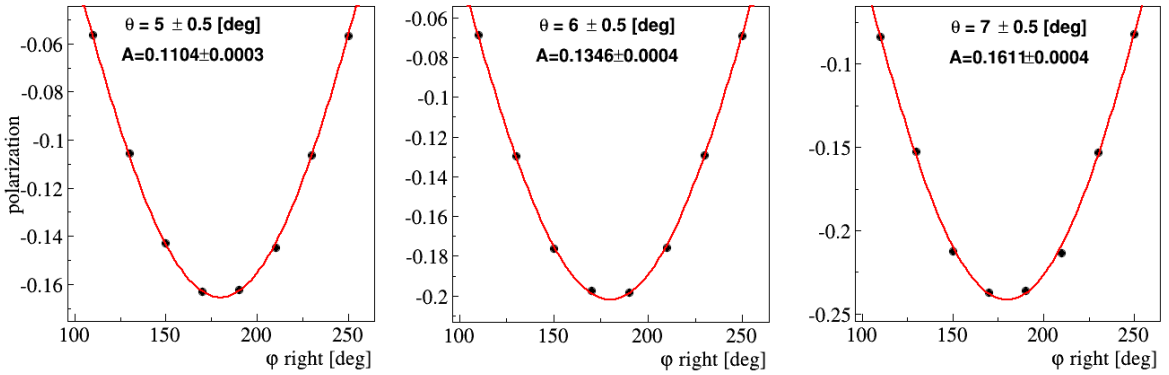
270 MeV d+C Elastic Vector Polarization

Choose 20° slices of φ, analyzed states 1 and 2 using cross ratio to cancel systematics.



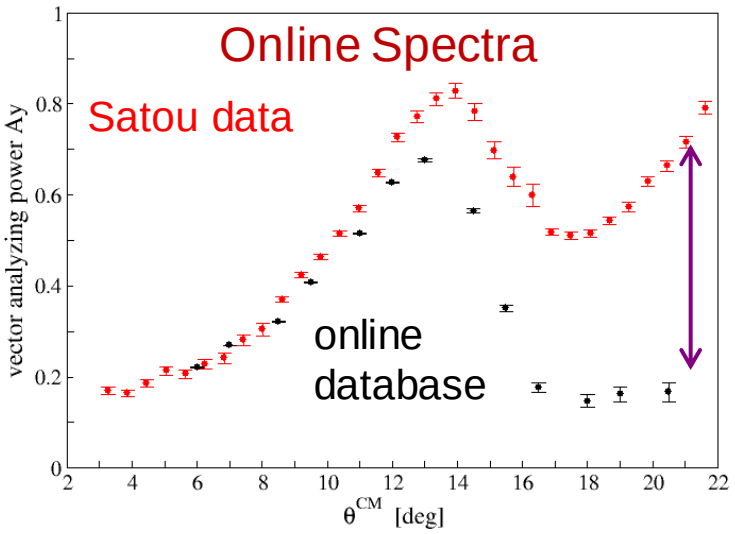
Amplitude is $p_Y A_Y$.

do not separate from elastic scattering in the online analysis



red curves follow *cos (φ)*

Comparison with Satou data at 270 MeV



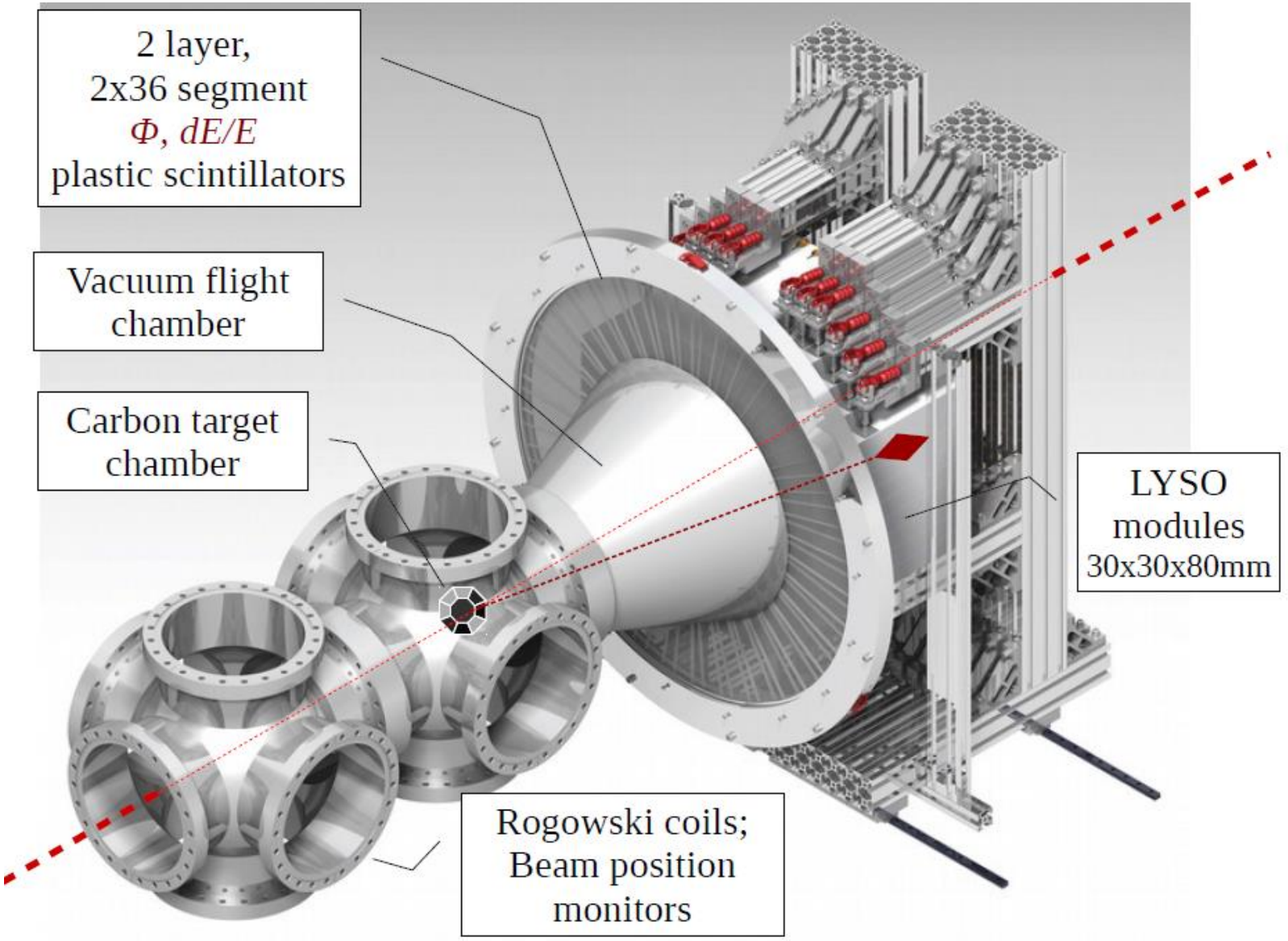
Physics Letters B 549 (2002) 307–313

Very good match at lower angels gives correct beam polarization

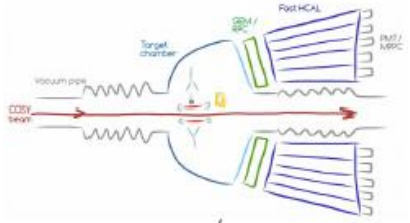
Growing disagreement comes from background from inelastic channels

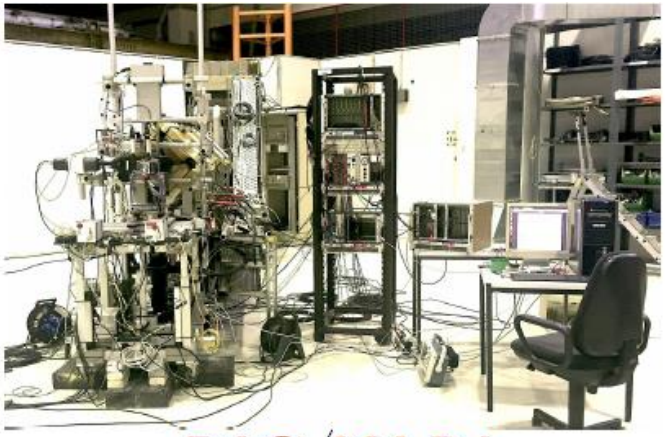
Courtesy: I. Ciepal, E. Stephenson

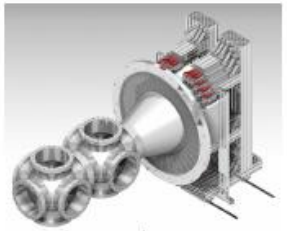
EDM Polarimeter – Concept



EDM Polarimeter – Development







BIG/KARL

COSY

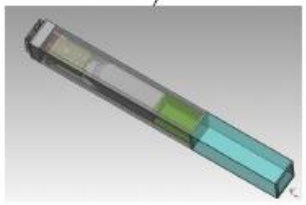
2014/9

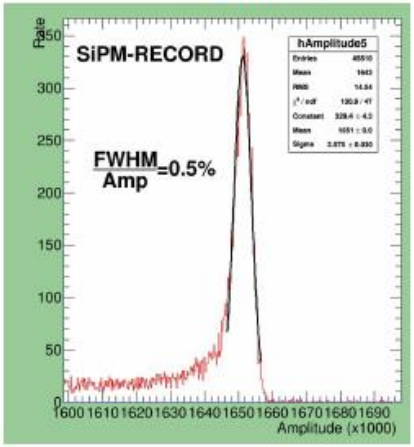
2015

2016/3

2016/2017

2018





Lab tests

1 Week BT

Coming beam tests

Talk by I. Keshelashvili

Submitted Beam Time Requests to CBAC Meeting #5

1) Waveguide RF Wien Filter: Commissioning and initial investigations (E005.2) (Talk by A. Nass)

Spokespersons for the beam time: R. Gebel, A. Nass, F. Rathmann

Requested weeks for 2017: 3·(2 weeks + 1 MD)

Goal: Commissioning of the system with vector polarized deuteron beam including feedback loops and first EDM measurements

2) Towards the EDM Polarimetry (E002.3) (Talk by I. Keshelashvili)

Spokespersons for the beam time: I. Keshelashvili, B. Lorentz

Goal: The goal of the new request is further development and optimization of the DAQ performance and the new SiPM based LYSO modules.

Requested weeks for 2017: 1 week + MD


Thank you!