Storage Ring Electric Dipole Moment Measurement – Achievements at Cooler Synchrotron COSY

J. Pretz RWTH Aachen & FZ Jülich on behalf of the JEDI & CPEDM collaboration



JENAS Topical Meeting, September 2020

Stage 1

precursor experiment

at Cooler Synchrotron COSY



magnetic storage ring

Staged approach Stage 2

prototype ring

Stage 3

dedicated storage ring



- initially electrostatic storage ring
- simultaneous 🖒 and 🖒 beams



• magic momentum

(701 MeV/c)



this talk

Stage 1

now

10^{⊥17}

precursor experiment at Cooler Synchrotron COSY



magnetic storage ring

Staged approach Stage 2

prototype ring



- initially electrostatic storage ring
- simultaneous \circlearrowright and \circlearrowright beams

5 years

 10^{-18} 10^{-19} 10^{-20} 10^{-21} 10^{-22} 10^{-23} 10^{-24} 10^{-25} 10^{-26} 10^{-27} 10^{-28}

Stage 3

dedicated storage ring



• magic momentum

10^{_29}

(701 MeV/c)

10 years

Stage 1: Precursor Experiment



Measurement Principle

Accelerate and store ($\approx 1000s$) a polarized proton or deuteron beam



Observe a build-up of a vertical polarization due to the EDM.

Activities & Achievements at COSY

- required for first EDM measurement:
 - maximize spin coherence time (SCT)
 - precise measurement of spin precession (spin tune)
 - polarization feed back
 - RF- Wien filter (needed in magnetic storage ring to observe polarization build-up due to EDM)
- to reduce systematic errors:
 - development of high precision beam position monitors
 - beam based alignment
- Interpretation of results:
 - theory (pEDM, dEDM, nEDM, $\ldots \rightarrow$ underlying theory)
 - spin tracking simulation (measured polarization \rightarrow EDM)
- Design of dedicated storage ring:
 - accelerator lattice
 - polarimeter development
 - development of (electro static) deflectors
- other observables:
 - axion searches, general relativity

Activities & Achievements at COSY



ent: (SCT) ecession (spin tune)

netic storage ring to observe polarization

- to reduce systematic errors:
 - development of high precision beam position monitors
 - beam based alignment
- Interpretation of results:
 - $\bullet\,$ theory (pEDM, dEDM, nEDM, $\ldots \rightarrow$ underlying theory)
 - spin tracking simulation (measured polarization \rightarrow EDM)
- Design of dedicated storage ring:
 - accelerator lattice
 - polarimeter development
 - development of (electro static) deflectors
- other observables:
 - axion searches, general relativity

Activities & Achievements at COSY



ent: (SCT) recession (spin tune)

netic storage ring to observe polarization

• to reduce systematic errors:

development of high precision beam position monitors



 $\ldots
ightarrow$ underlying theory) red polarization ightarrow EDM)

Activities & Act



to reduce systematic errors:
 development of high precision to





 $\ldots
ightarrow$ underlying theory) red polarization ightarrow EDM)

Activities & Act



to reduce systematic errors:
 development of high precision to





Long Spin Coherence Time (SCT)

Long Spin Coherence time > 1000 s reached



Phys. Rev. Lett. 117, 054801 (2016)

Long Spin Coherence Time (SCT)

Long Spin Coherence time > 1000 s reached



Phys. Rev. Lett. 117, 054801 (2016)

Spin Tune ν_s



 $\sigma(\nu_s = \gamma G) \approx 10^{-10} \text{ in } 100 \text{ s}$ $\sigma(\nu_s = \gamma G) \approx 10^{-8} \text{ in } 2 \text{ s}$ Phys. Rev. Lett. 115, 094801 (2015)

Polarization feedback

Controlling 120kHz precession



Phys. Rev. Lett, 119, 014801 (2017)

Precursor Experiment

Observation of polarization build-up



- radio-frequency Wien filter (WF) provides partially frozen spin
- polarization build-up proportional to EDM ... and many perturbations
- perturbations are under investigation

Heraeus Seminar

STIFTUNG AKTIVITÄTEN VERANSTALTUNGEN



> Wilhelm und Else Heraeus Stiftung > VERANSTALTUNGEN > 744. WE-Heraeus-Seminar

Main	>
Organizers	>
Program	>
Application	>
Venue	>

> zurück zu allen Veranstaltungen

Towards Storage Ring Electric Dipole Moment Measurements

744. WE-Heraeus-Seminar

29 Mar - 31 Mar 2021	
Where:	Physikzentrum Bad Honnef
Scientific organizers:	Dr. Michael Lamont, CERN • Prof. Dr. Jörg Pretz, FZ Jülich und RWTH Aachen • PD Dr. Andreas Wirzba, FZ Jülich

Not only from a particle physicist point of view our existence is still a mystery. According to