Method to search for axion-like particles at storage rings, demonstrated at COSY

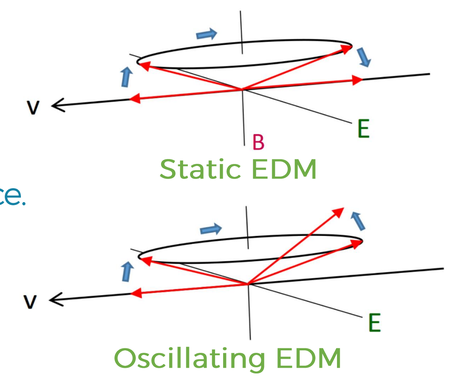
Swathi Karanth on behalf of JEDI collaboration
Institute of Physics, Jagiellonian University, Kraków, Poland

Axions or Axion-Like Particles (ALPs)

Proposed to explain the lack of CP violation in the strong interaction	Candidate for dark matter in the universe
Axions	
Axion – gluon coupling introduces an oscillating Electric Dipole Moment (EDM)	Light mass and weakly coupled to nucleons

Oscillating EDM allows us to search for ALPs in a storage ring.

Search using in-plane polarized deuteron beam at COSY → Axion oscillation frequency = $g-2$ spin precession frequency → Accumulation of vertical polarization P_y



Assumptions:

- Axion field has large spatial and time coherence.
- Axions are dense and extend beyond the ring
- EDMs oscillate coherently. Phase is unknown.

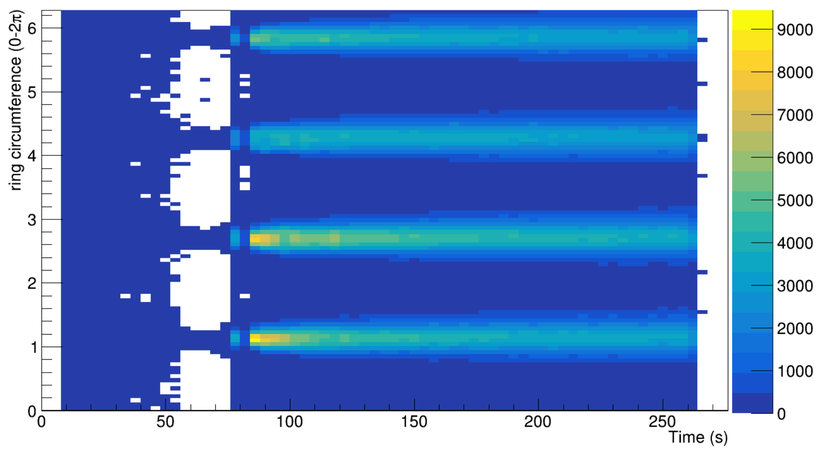
Experimental setup

Unknown phase problem:

right frequency + right phase ⇒ P_y accumulation ✓

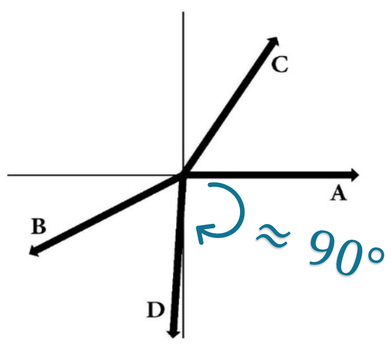
right frequency + wrong phase ⇒ P_y accumulation ✗

Solution
Simultaneous searches with beams having perpendicular polarization.

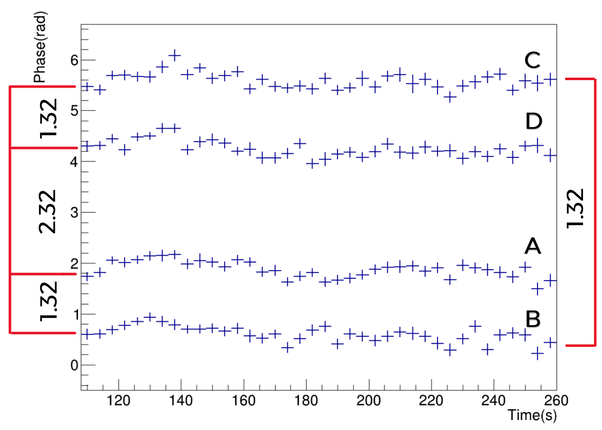


2D plot of the time evolution of the beam in the ring

Vertically polarized deuteron beam $0.970\ \mathrm{Gev}/C$ → Electron cooled + 4 bunches → Flipped to horizontal plane with a RF solenoid, run at harmonic of the revolution frequency (f_{COSY}).



Polarization direction of the 4 bunches in the horizontal plane in lab frame.



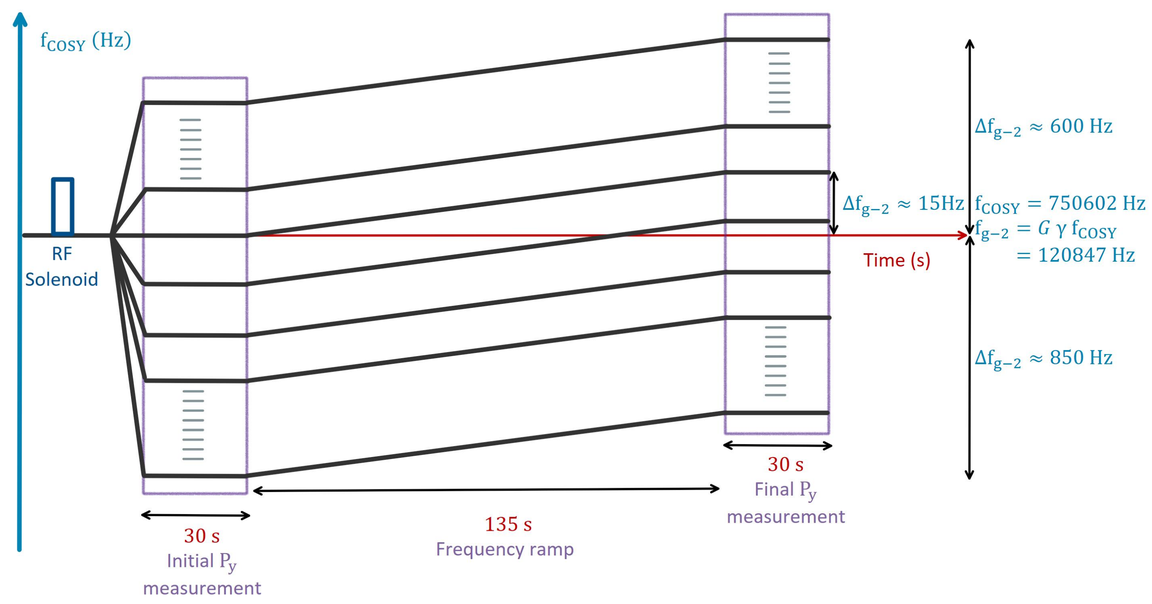
Phase measurement verifies the polarization pattern at the detector.

Plan for frequency scanning

Vary the spin precession frequency (f_{g-2}) in search of resonance.

Ramp speed $\approx 0.1\ \mathrm{Hz/s}$

Compare initial and final polarization measurements.

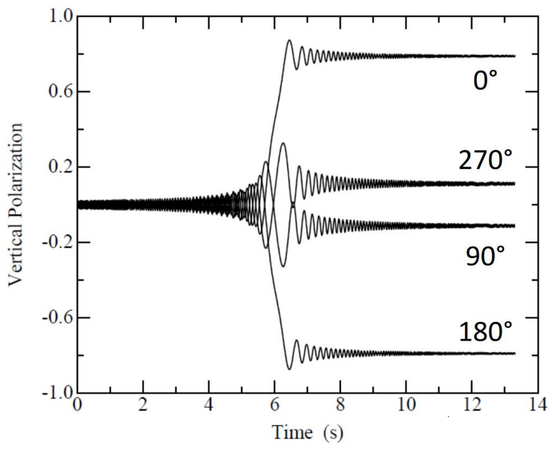


Expected results

Simulations with a single bunch for 4 different phases 90° apart

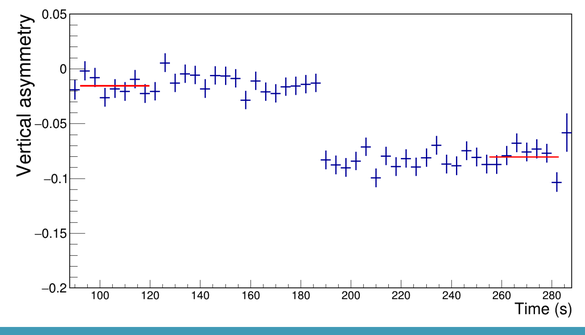
Resonance crossing speed $0.5\ \mathrm{Hz/s}$

Strength of oscillating EDM $1.6 \times 10^{-21} e \cdot \mathrm{cm}$

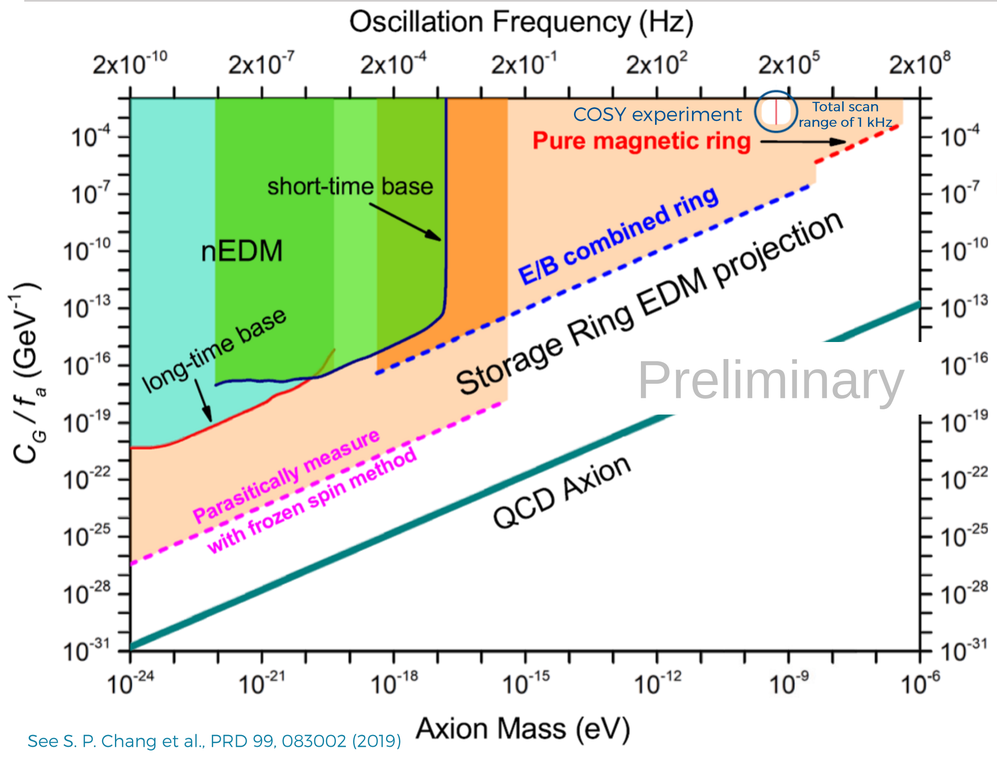


Tests with RF Wien filter:

- Generate signal similar to axion.
- Calibrate polarization jumps.



Results of the first COSY experiment



Preliminary analysis: Sensitivity for oscillating EDM, from the scans of 1kHz range, quoted at a 3σ limit

See S. P. Chang et al., PRD 99, 083002 (2019)

Email: swathi.karanth@doctoral.uj.edu.pl