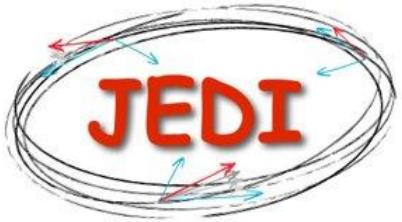


New method to search for axion-like particles with a polarized beam at the COSY storage ring

SWATHI KARANTH

MARIAN SMOLUCHOWSKI INSTITUTE OF PHYSICS, JAGIELLONIAN UNIVERSITY, CRACOW, PL

24-28 MAY 2021

IPAC 2021

Zoom session on 26th May 2021

Axion – axion-like particle (ALPs)

- Proposed to explain the lack of CP violation in the strong interaction.
- Candidates for dark-matter in the universe.
- Axion/ALPs – gluon coupling induces an oscillating Electric Dipole Moment (EDM).

$$d = d_{static} + \boldsymbol{d_{osc}}\,\boldsymbol{cos}(\boldsymbol{\omega t} + \boldsymbol{\phi})$$

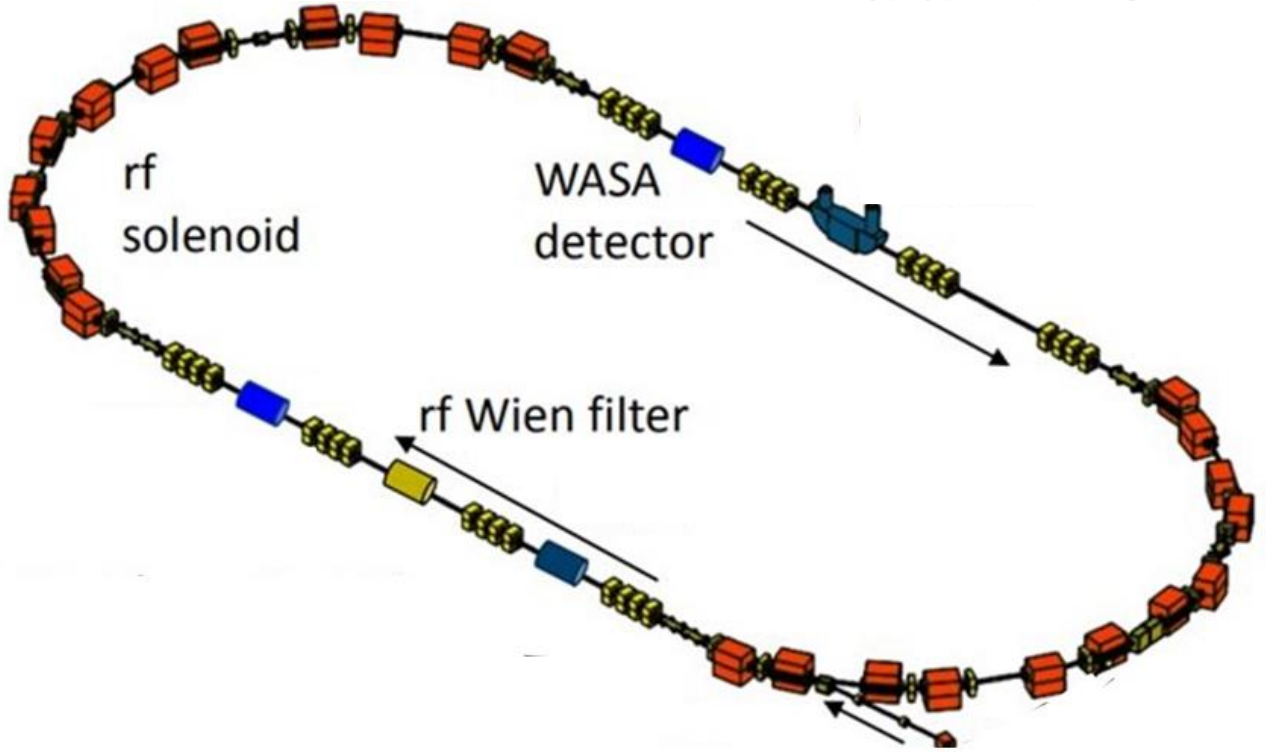
Oscillation frequency connected to axion mass $\omega = \frac{m_a c^2}{\hbar}$

Phase of the oscillating EDM is unknown.

See: P. W. Graham et al., PRD 84, 055013 (2011)

Cooler Synchrotron (COSY)

- A proof-of-principle experiment to search for ALPs
- Polarized deuterons:
  - Bunched
  - Cooled
  - Sextupole corrected
- WASA detector as the polarimeter

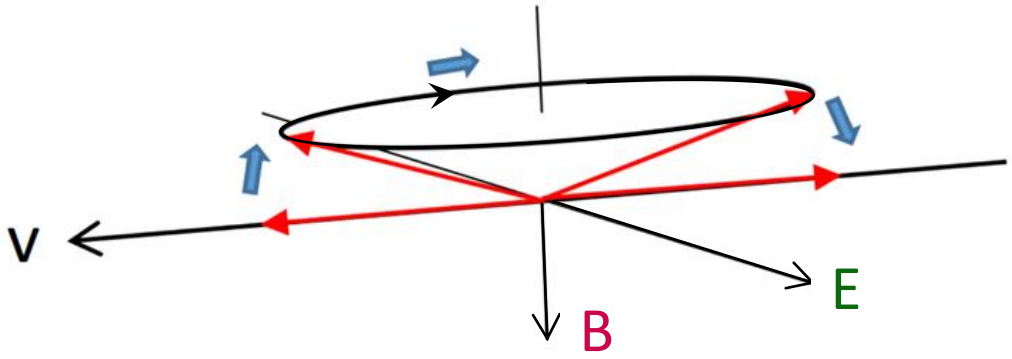


$$\text{Spintune}(\nu_s) = \frac{\#\text{spin rotation}}{\#\text{particle revolution}} = G\gamma$$

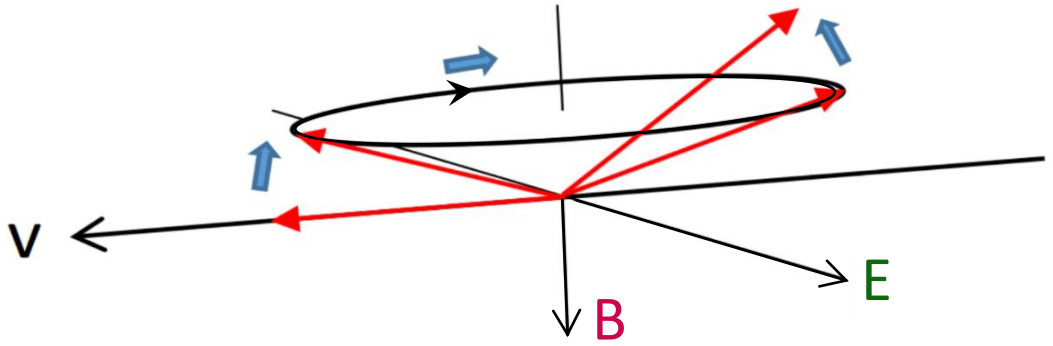
G: anomalous magnetic moment

γ: Lorentz factor

How to search ALPs in a storage ring?



Static EDM

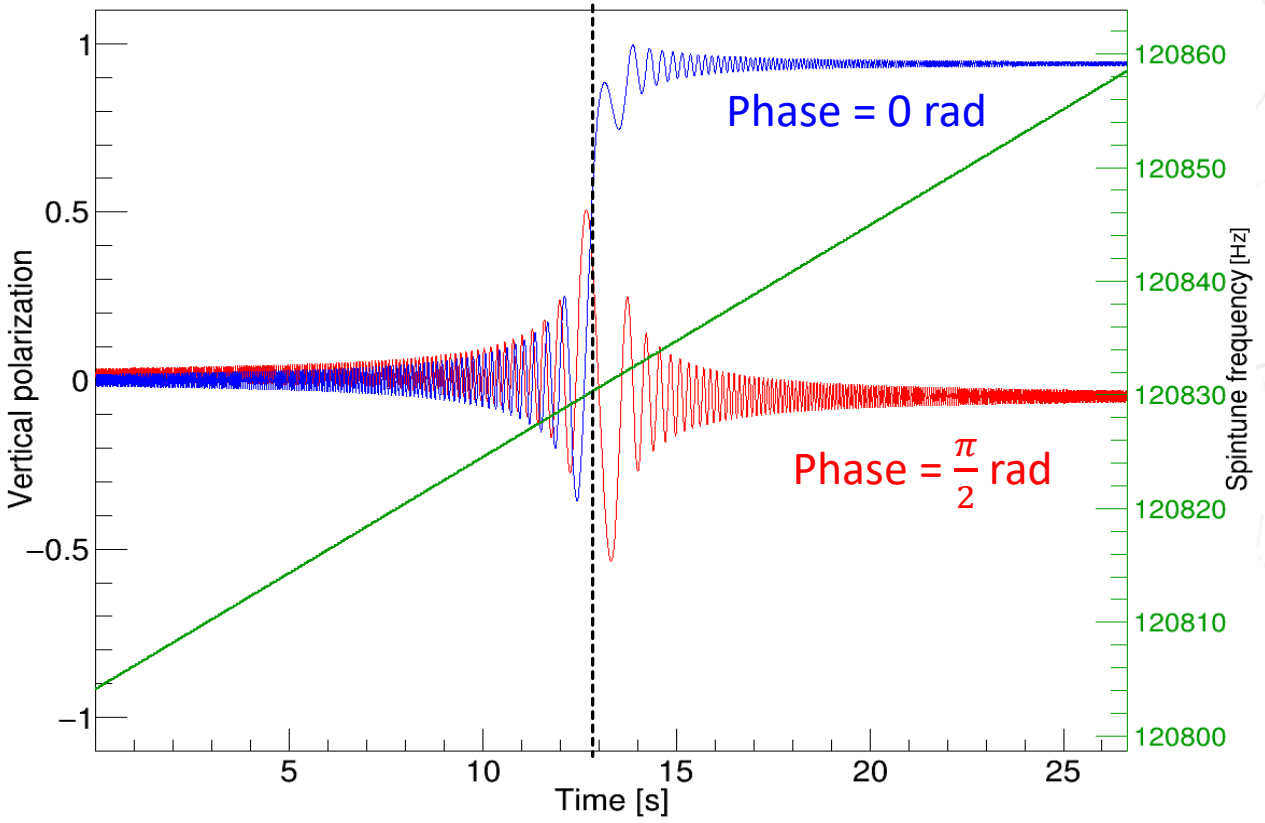


Oscillating EDM

Axion oscillation frequency = Spin tune frequency ⇒ Accumulation of vertical polarization

Model calculations

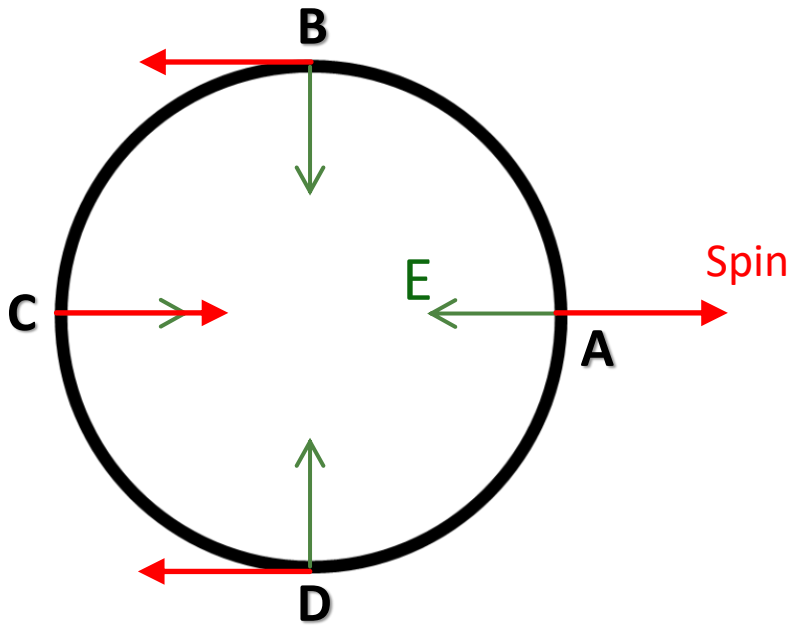
- Ramp frequency in search of resonance.
- Describe the polarization jump at resonance crossing.
- Phase plays an important role in determining the jump.



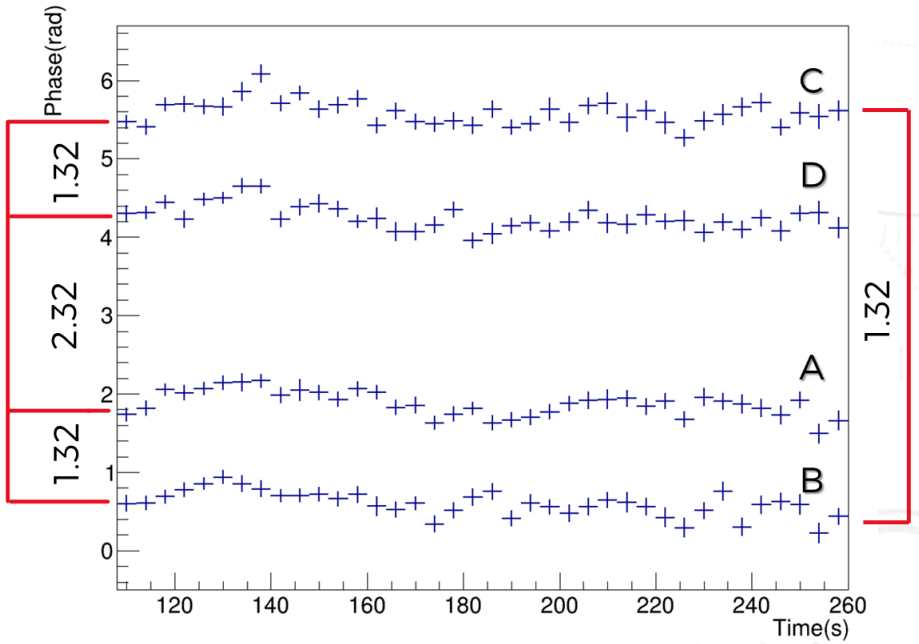
Phase problem and 4 bunches

- Simultaneous searches with perpendicular beam polarization.
- RF solenoid run at $\mathrm{f_{rev}}(1 + G\gamma)$.

A top down view of the ring

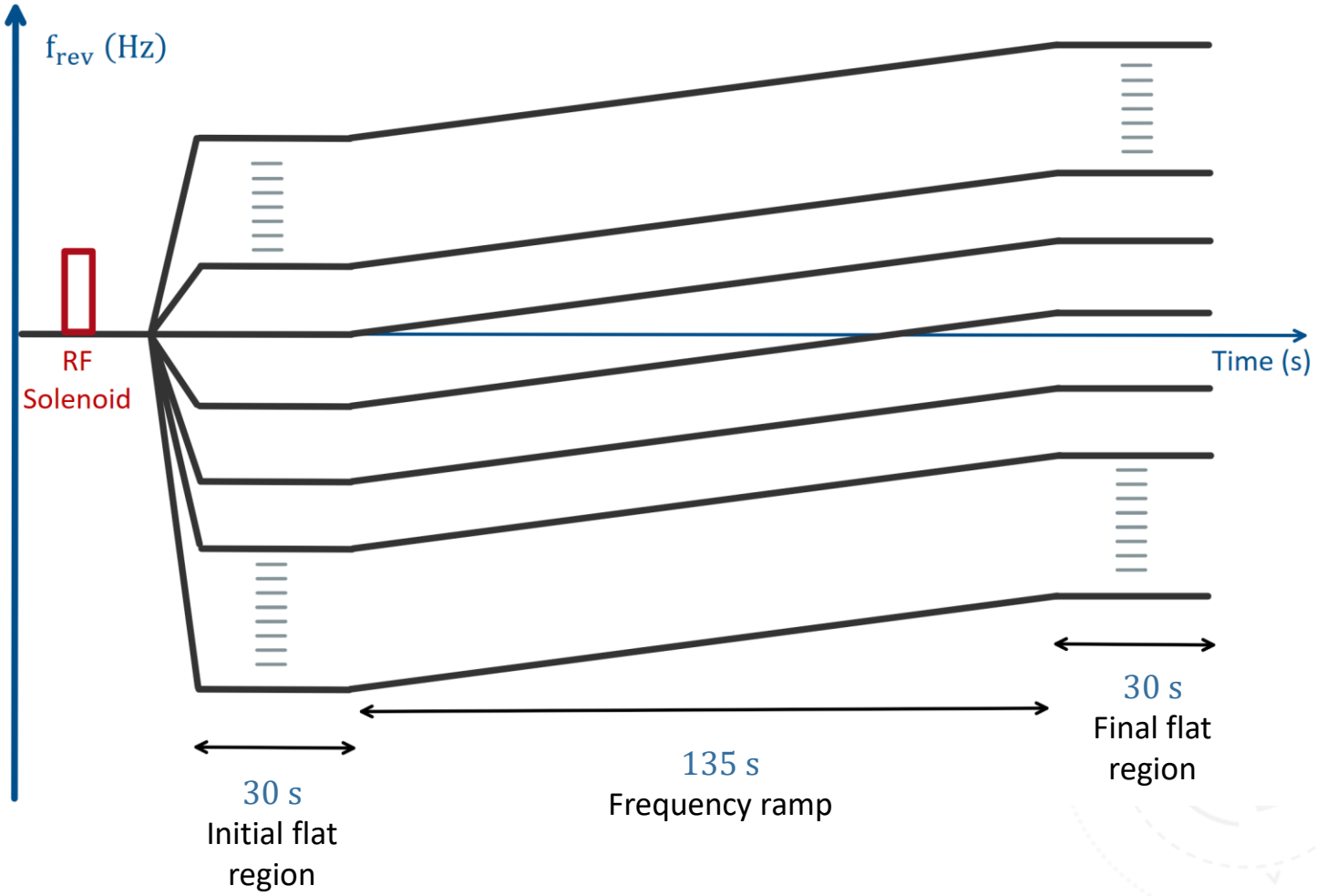


At the detector



Measurement procedure

- Vary the spintune frequency (ramp rate $\approx 0.1\mathrm{Hz/s}$) in search of resonance.
- Measure polarization.
- About 100 scans.
  - Frequency Range
    $119997\ \mathrm{Hz} - 121457\ \mathrm{Hz}$
  - Total width $\approx 1.5\ \mathrm{kHz}$
  - ALP mass range
    $4.96 \times 10^{-9}\mathrm{eV} - 5.02 \times 10^{-9}\mathrm{eV}$



Summary

- ALP induces an oscillating EDM (d_{osc}), allows searching for ALPs in a storage ring.
- Polarized deuteron beam to search for resonance between the oscillating EDM frequency and the spintune frequency.
- RF Wien filter used as a test to observe a signal at resonance crossing.

For questions and further discussion please

visit my zoom session on 26th May 2021.