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

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# 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).

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

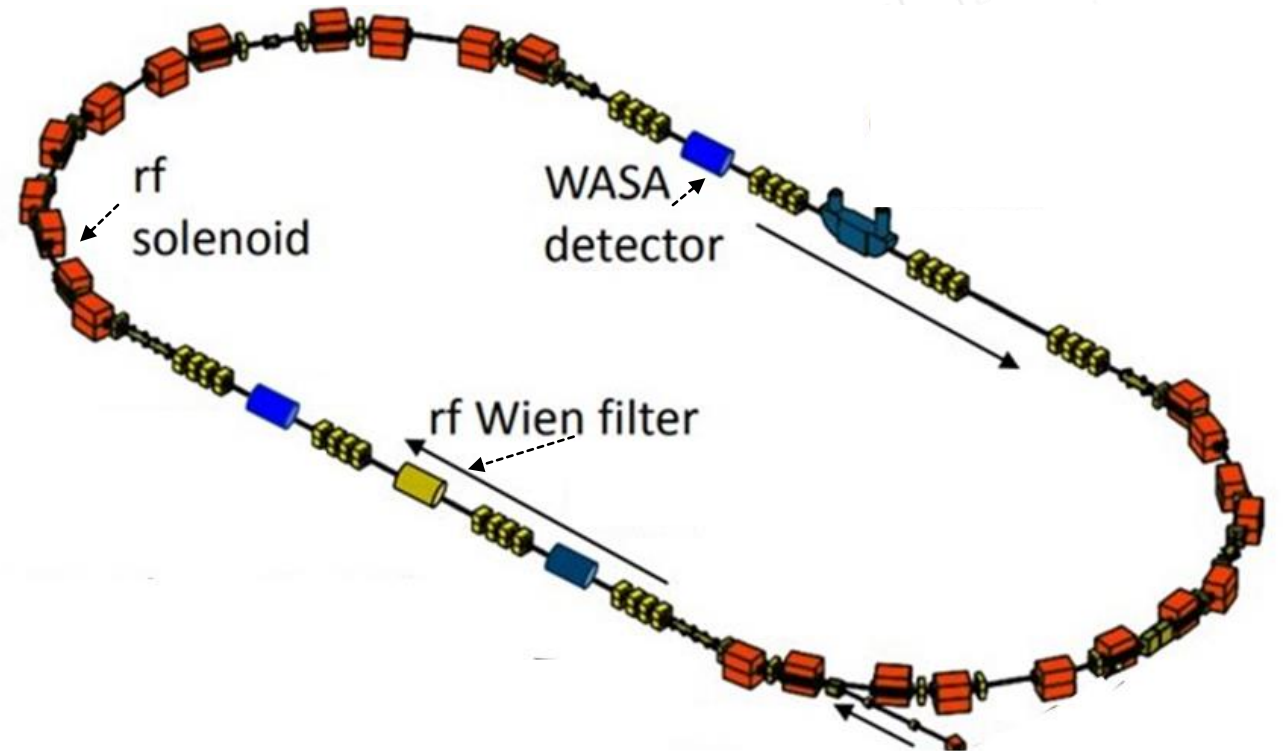
Oscillation frequency connected to axion mass  $\omega = \frac{m_a c^2}{\hbar}$

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
- WASA detector as the polarimeter



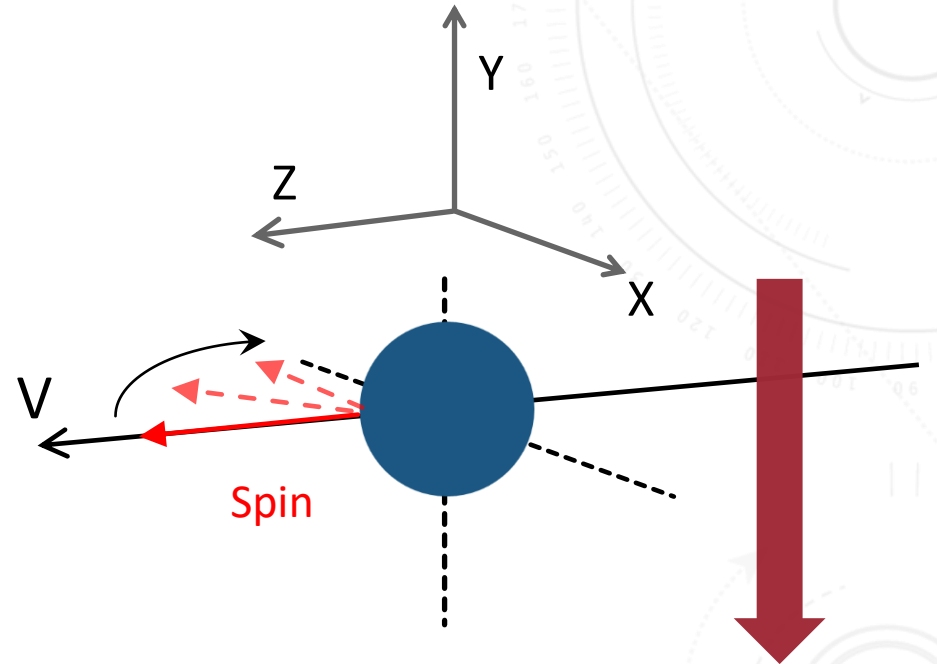
# How to search for ALPs in a storage ring?

- Horizontally polarized beam
- Spintune( $\nu_s$ ) =  $\frac{\text{\#spin rotation}}{\text{\#particle revolution}}$

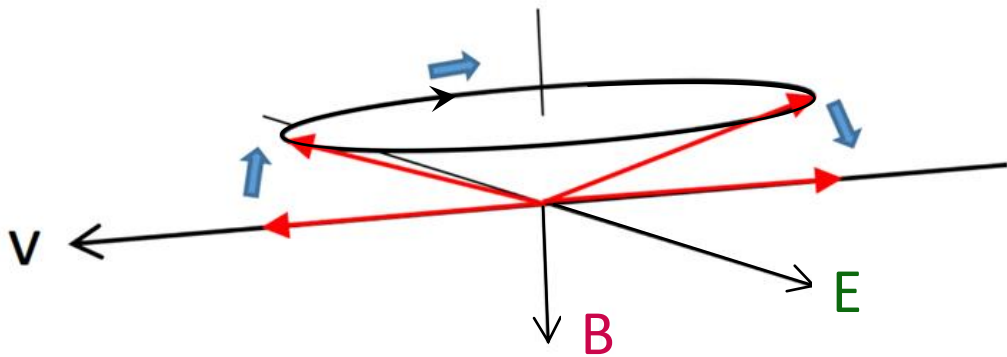
$$\nu_s = G\gamma$$

$G$ : anomalous magnetic moment

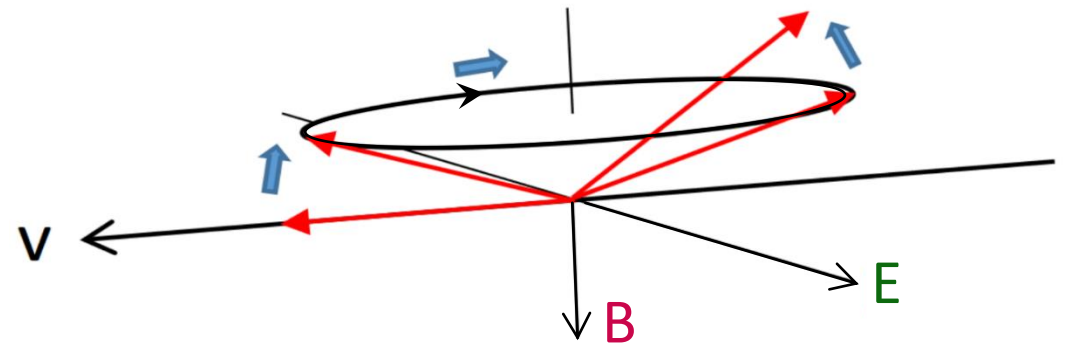
$\gamma$ : Lorentz factor



# How to search ALPs in a storage ring?



Static EDM



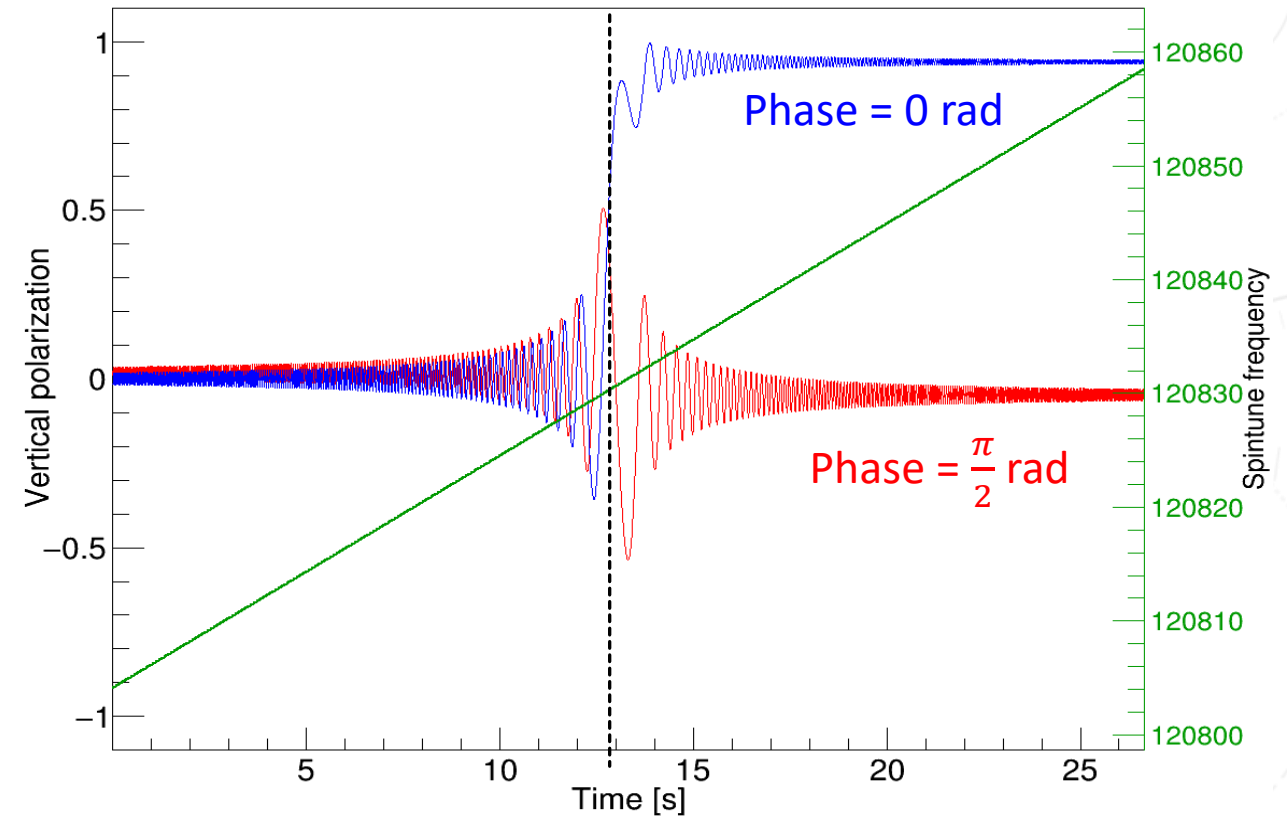
Oscillating EDM

Axion oscillation frequency = Spin tune frequency  $\Rightarrow$  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.

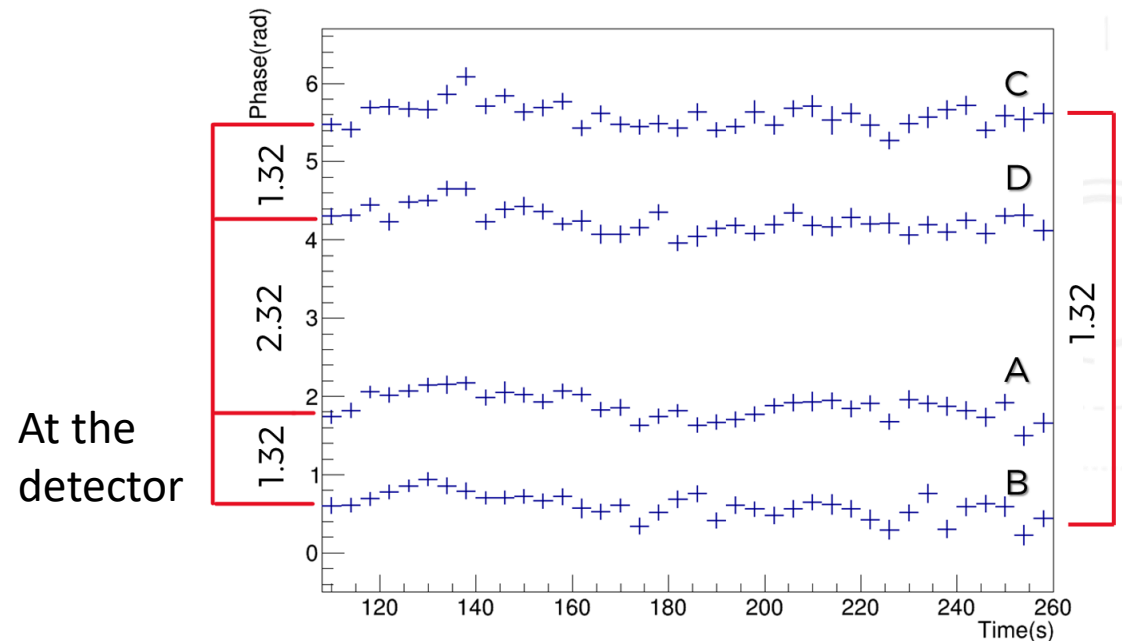
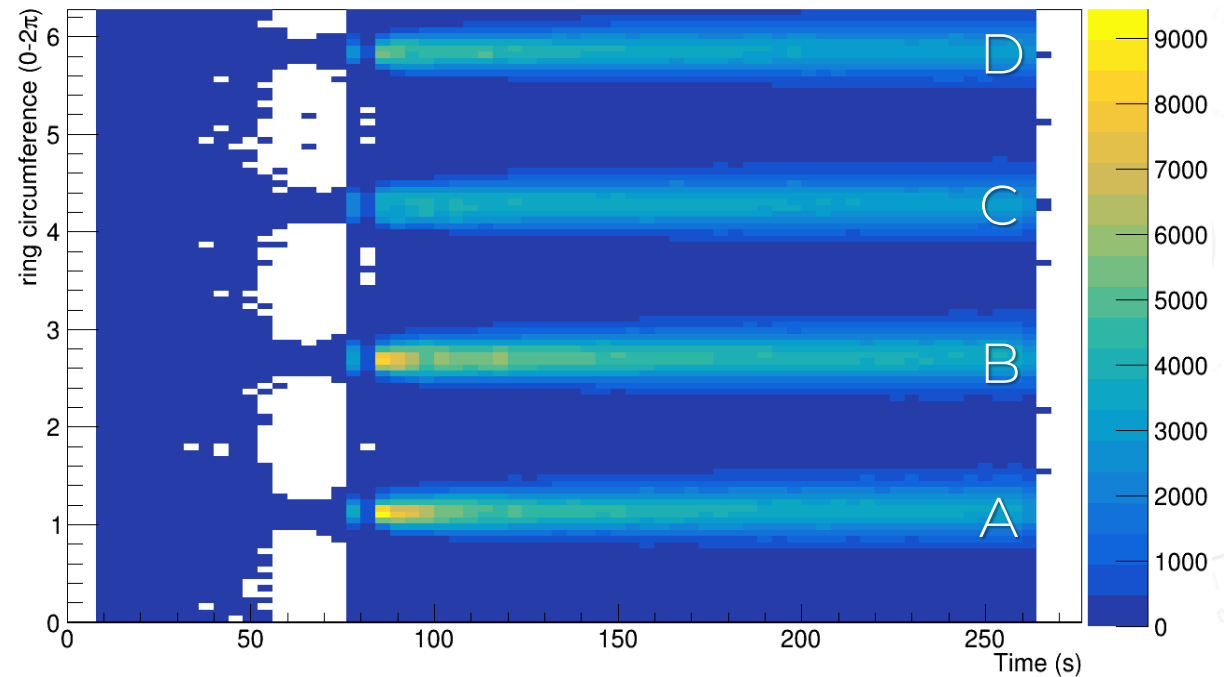
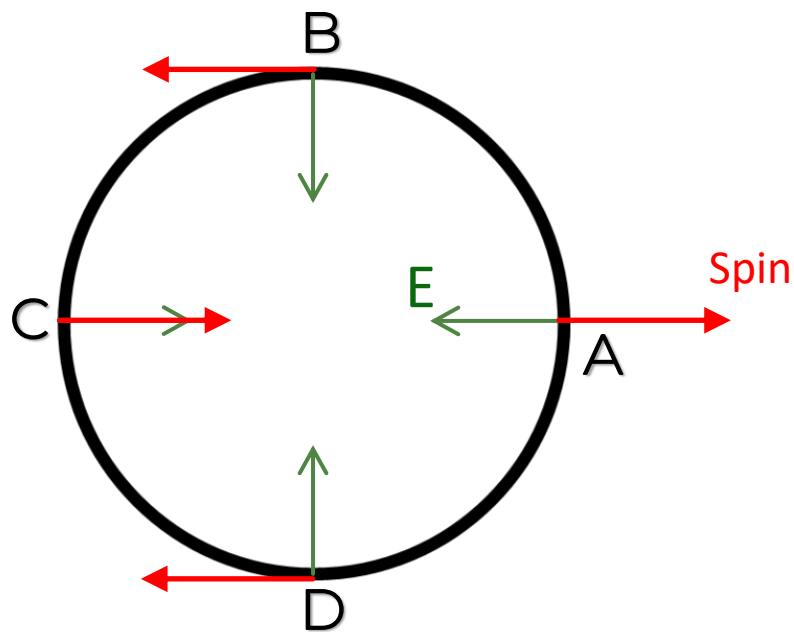
← Unknowns of the experiment:  
frequency and phase



# Phase problem and 4 bunches

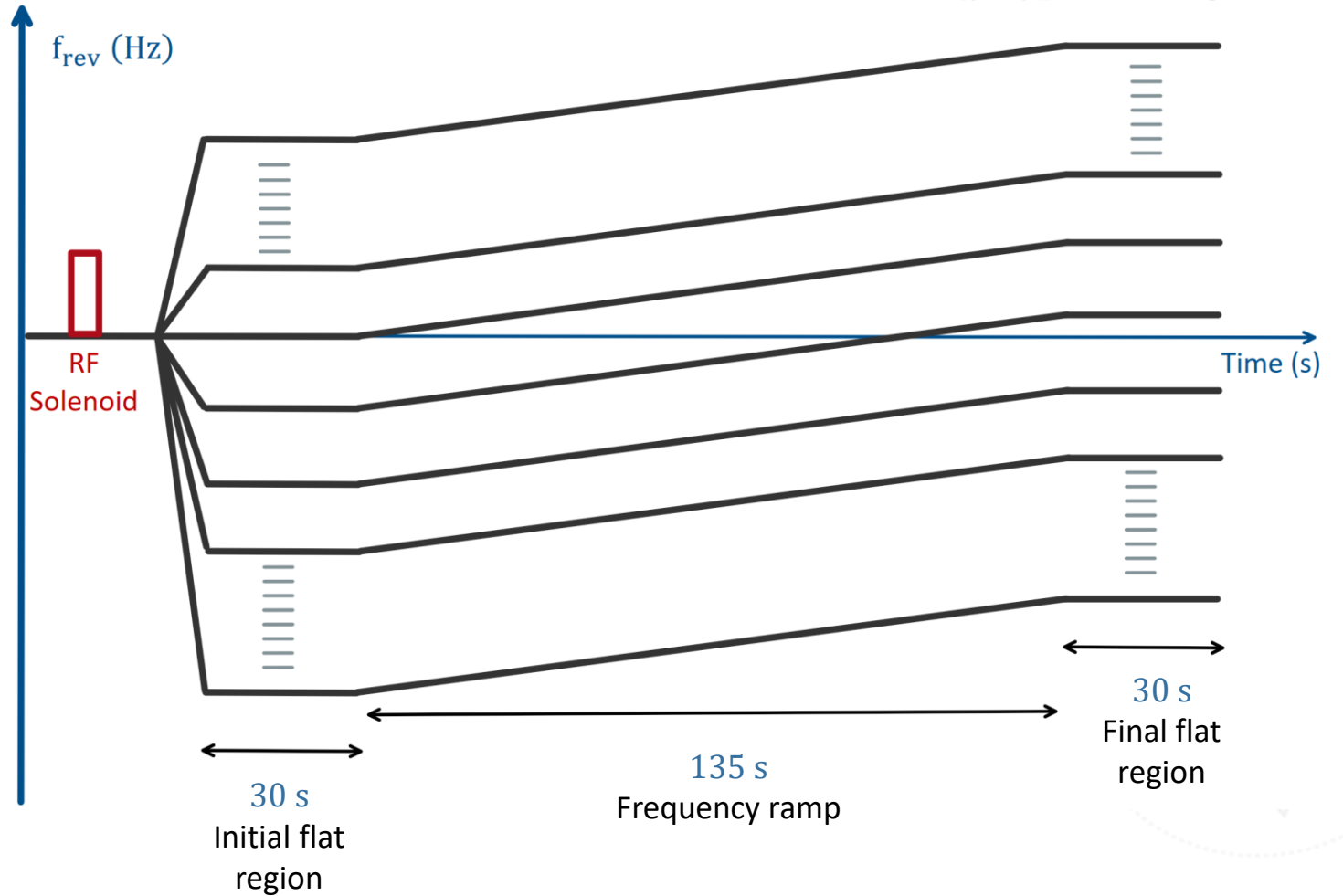
- Simultaneous searches with perpendicular beam polarization using 4 bunches.
- RF solenoid run at  $f_{\text{rev}}(1 + G\gamma)$

A top down view of the ring.



# Measurement procedure

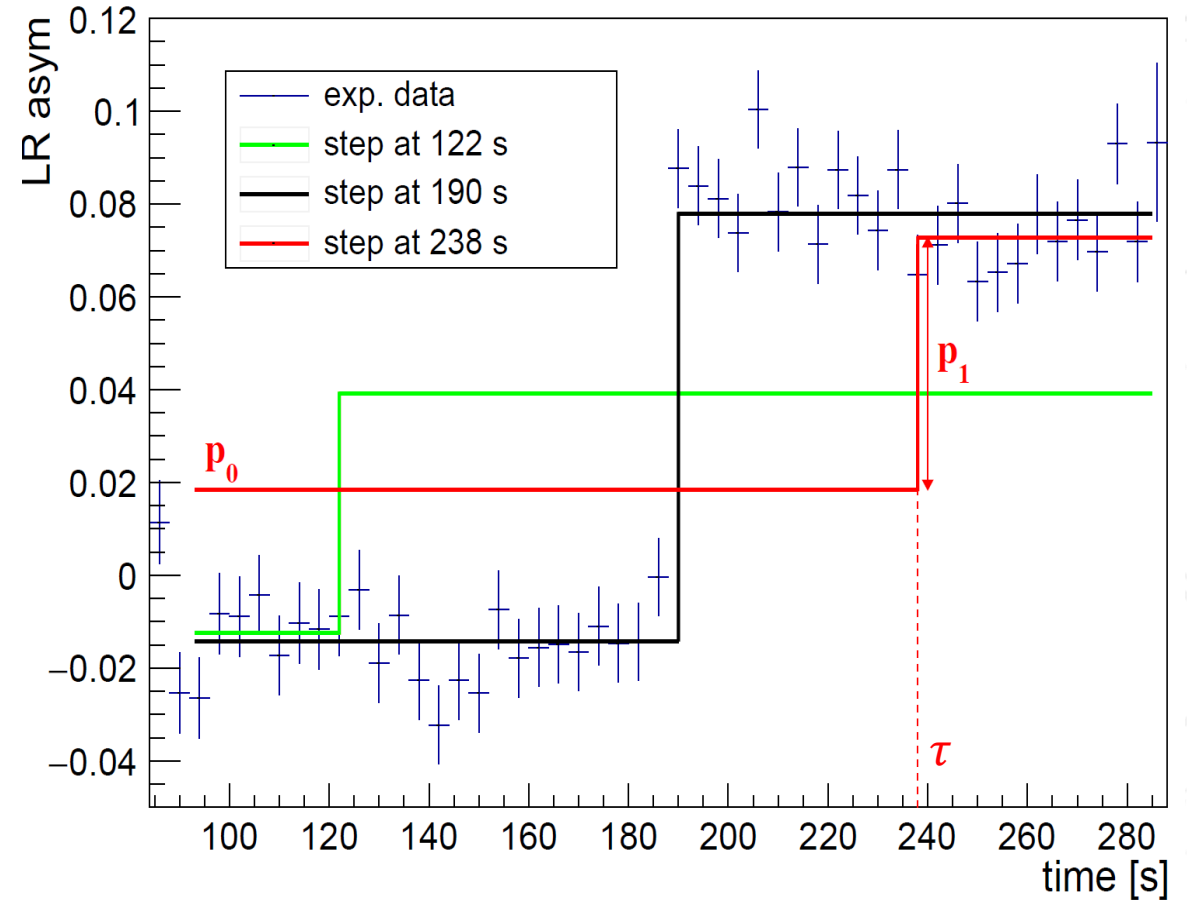
- Vary the spintune frequency (ramp rate  $\approx 0.1\text{Hz/s}$ ) in search of resonance.
- Measure polarization.
- About 100 scans
  - Frequency Range  
119997 Hz – 121457 Hz
  - Total width  $\approx 1500$  Hz
  - ALP mass range  
 $4.96 \times 10^{-9}\text{eV} - 5.02 \times 10^{-9}\text{eV}$





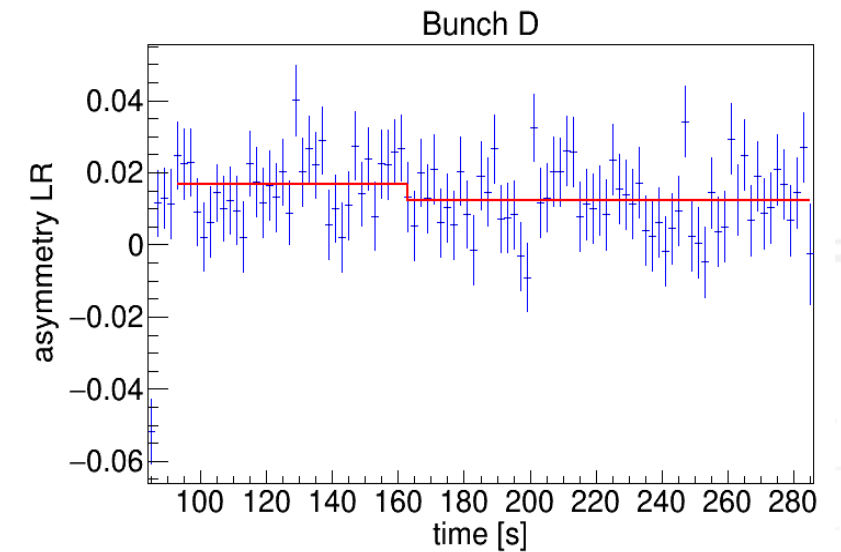
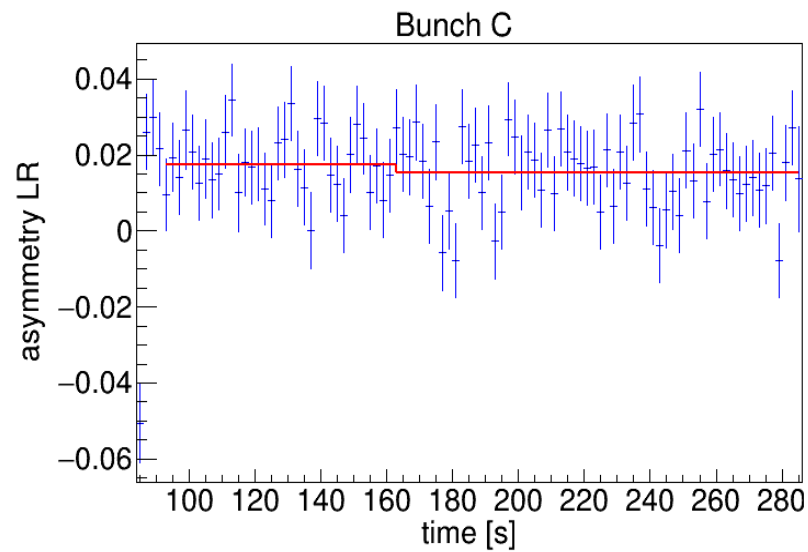
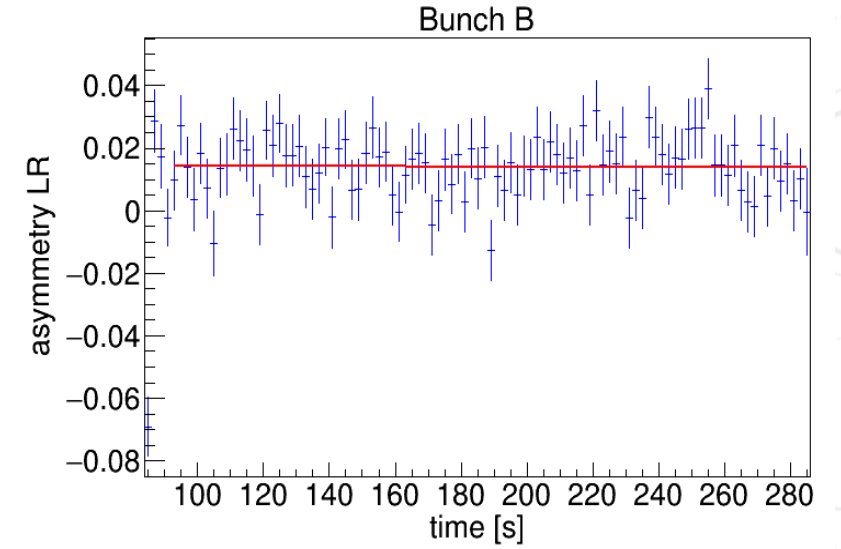
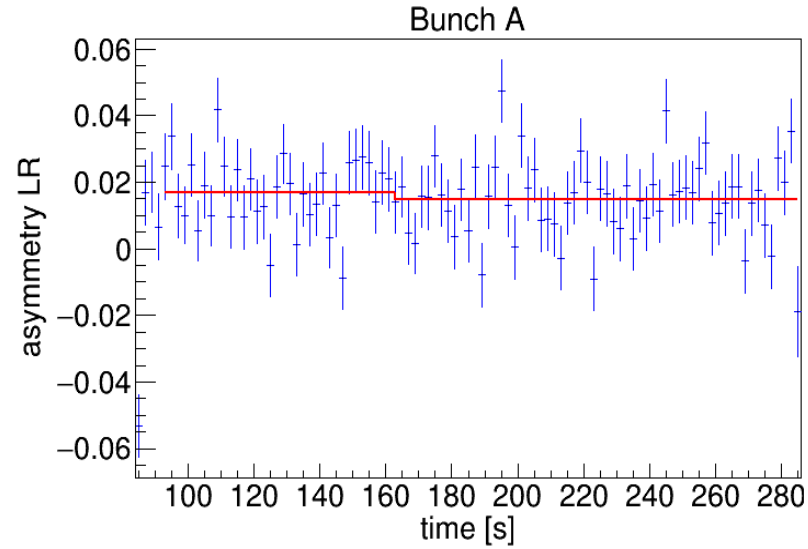
# RF Wien filter scan and analysis of data

- A test of methodology.
- A check for the calibration used to calculate the  $d_{osc}$  from data.



# Axion scan

- Analysis is ongoing.
- No signal seen.



# 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.
  - Frequency Range 119997 Hz – 121457 Hz. Total width  $\approx$  1500 Hz.
  - ALP mass range  $4.96 \times 10^{-9} \text{eV} - 5.02 \times 10^{-9} \text{eV}$ .
- RF Wien filter used as a test to observe a signal at resonance crossing.
- No signal was found.



Thank You