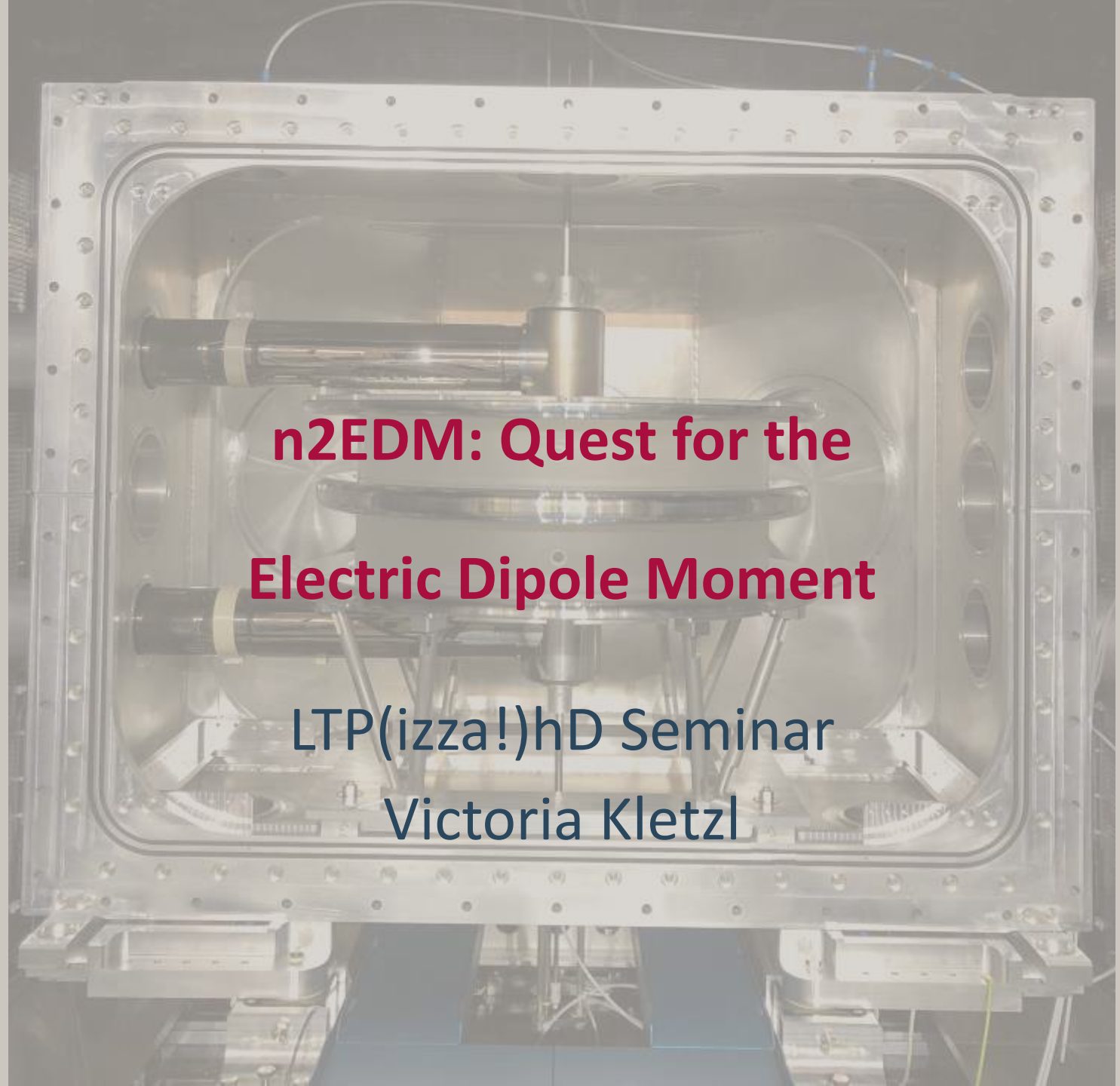
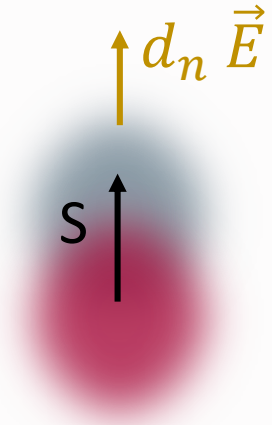


n2EDM: Quest for the Electric Dipole Moment

LTP(izza!)hD Seminar

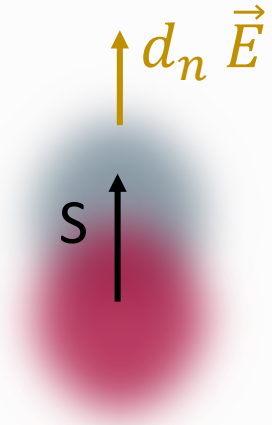
Victoria Kletzl

An experimentalist’s view on the EDM



An experimentalist's view on the EDM

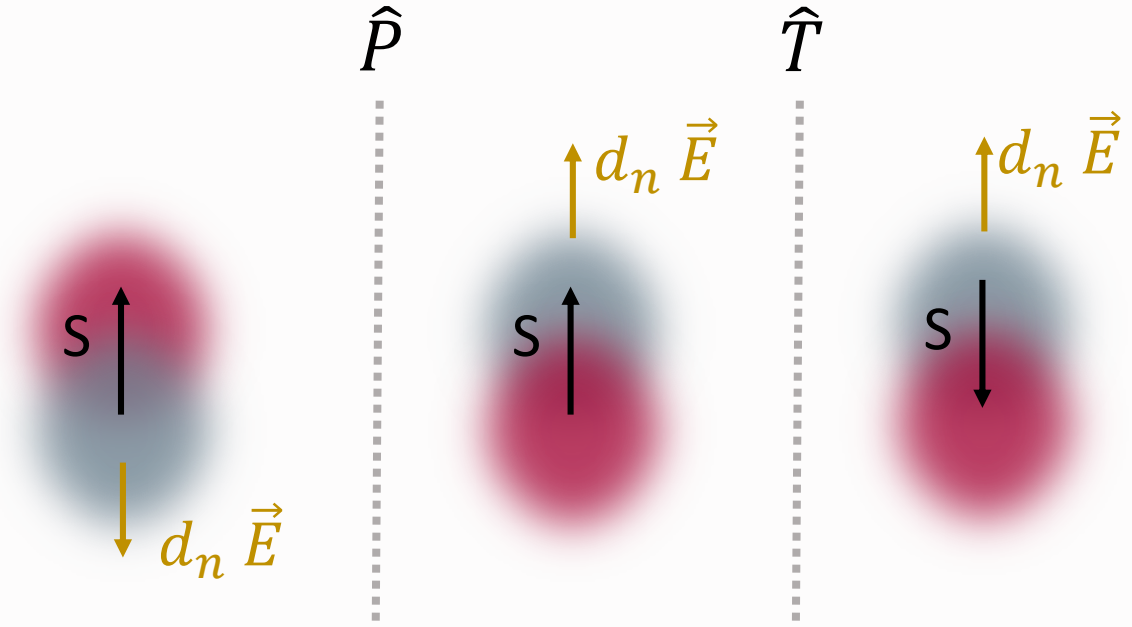
- Separation of charges ⟶ d_n



$$\hat{H} = -\mu_n \frac{\vec{S}}{S} \cdot \vec{B} - d_n \frac{\vec{S}}{S} \cdot \vec{E}$$

An experimentalist's view on the EDM

- Separation of charges ⟶ d_n
- $d_n \neq 0$ ⟶ CP violation

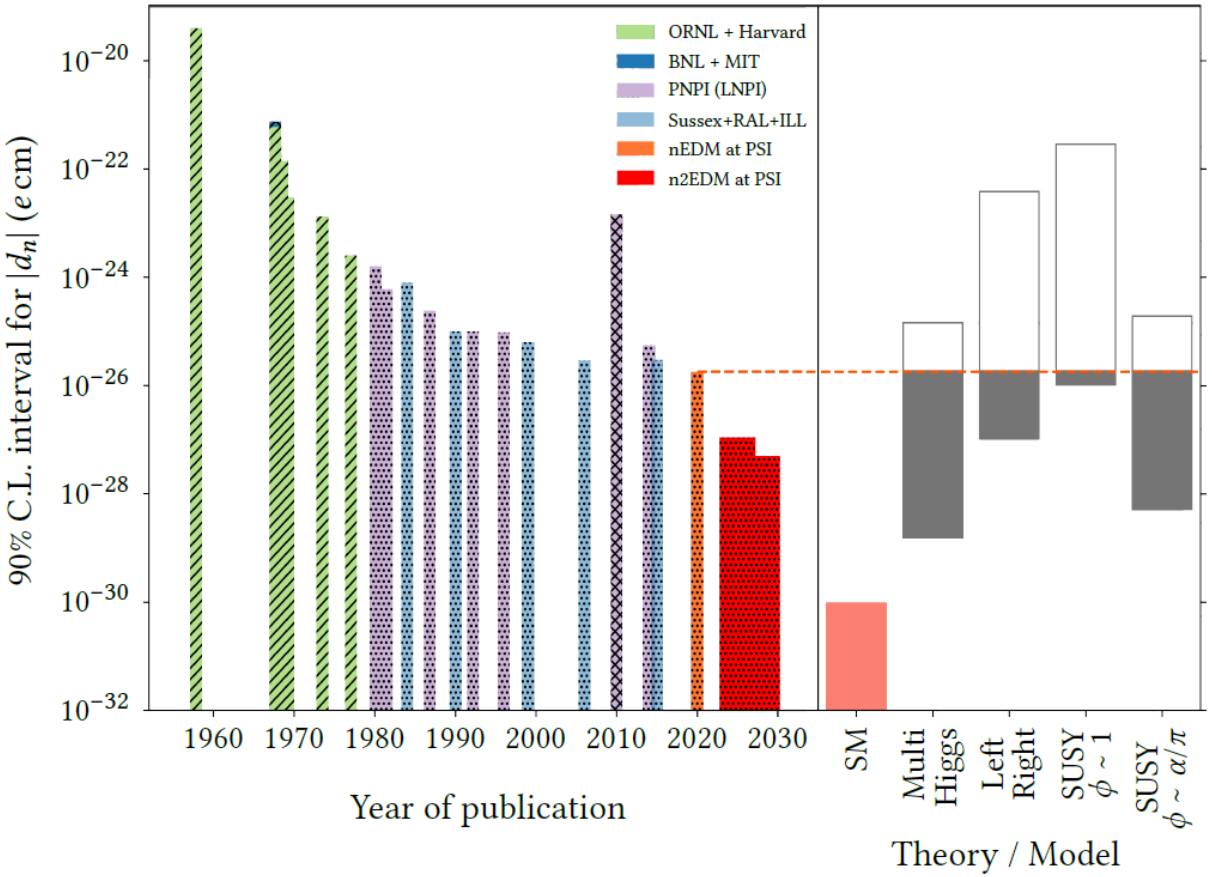


$$\hat{H} = -\mu_n \frac{\vec{S}}{S} \cdot \vec{B} - d_n \frac{\vec{S}}{S} \cdot \vec{E}$$

Search for the nEDM

- $d_{n,SM} \sim 10^{-32}\ e$ cm
- $|d_{n,2020}| < 1.8 \times 10^{-26}\ e$ cm

New Physics!



Search for the nEDM

- $d_{n,SM} \sim 10^{-32}\ e$ cm
- $|d_{n,2020}| < 1$

New Physics!

If you want to know
about this part:
Ask your theory friends ☺

How to detect a nEDM?

- Measure neutron precession frequency:

$$hf_L = d_n E$$

How to detect a nEDM?

- Measure neutron precession frequency:

$$hf_L = d_n E$$

- BUT:

$$f_L \approx 7\ \mathrm{nHz}$$

We need a trick …

Use the magnetic moment!

- neutron's magnetic moment μ
- Apply magnetic field B_0
- Observe Larmor precession

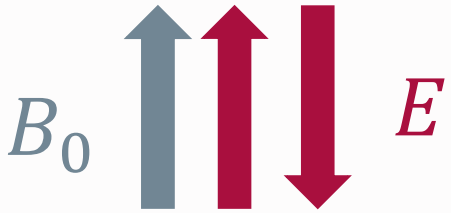
Depends on orientation of E

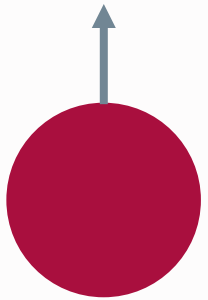
$$hf_L = 2(\underbrace{\mu B_0}_{\approx 30\text{Hz}} \pm \underbrace{d_n E}_{\approx 7\ \text{nHz}})$$

Interlude:

Ramsey’s method of separated oscillating fields

Ramsey's method

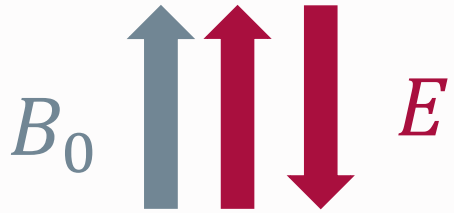




Polarised neutrons

Time

Ramsey's method

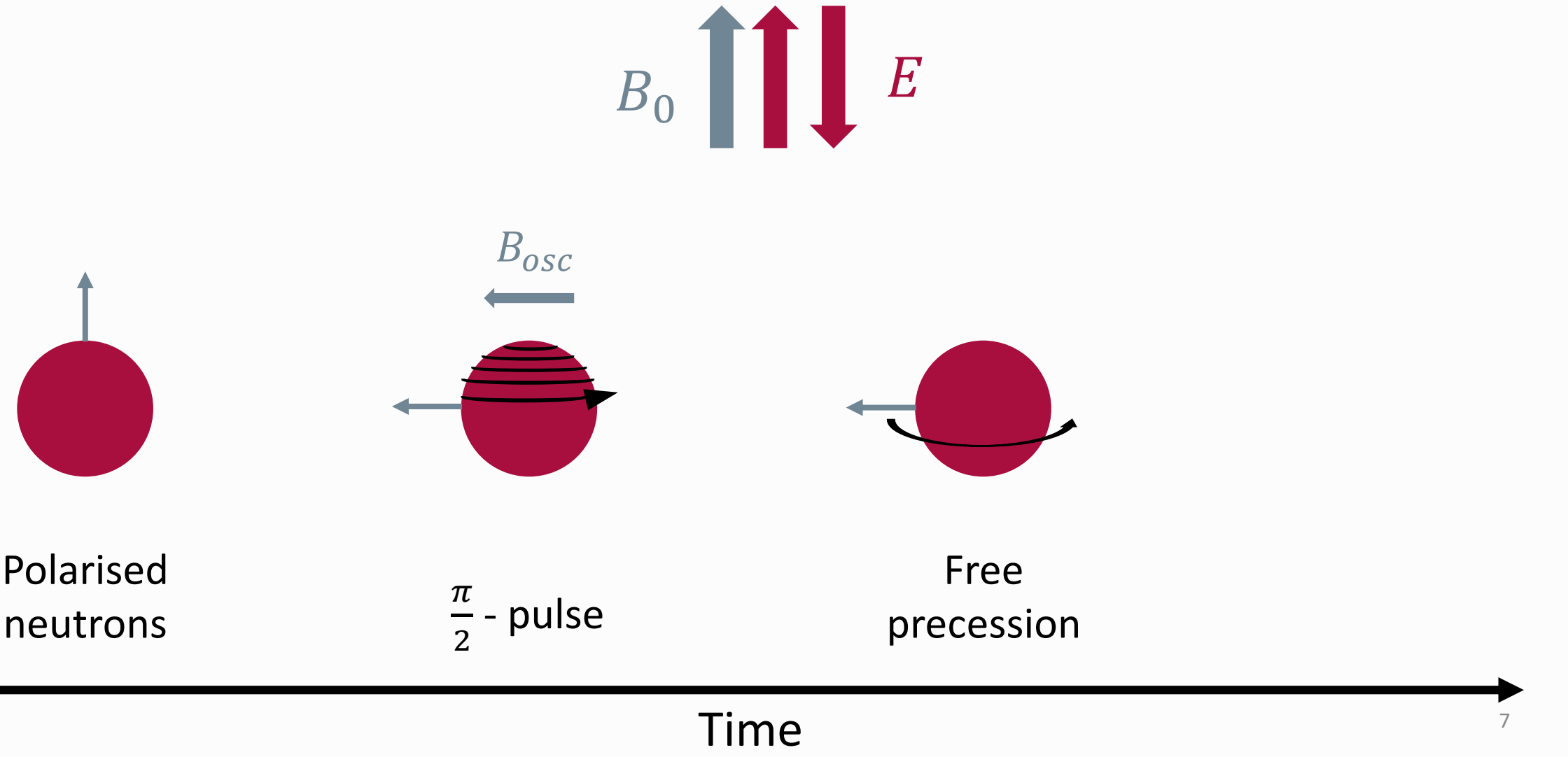


Polarised neutrons

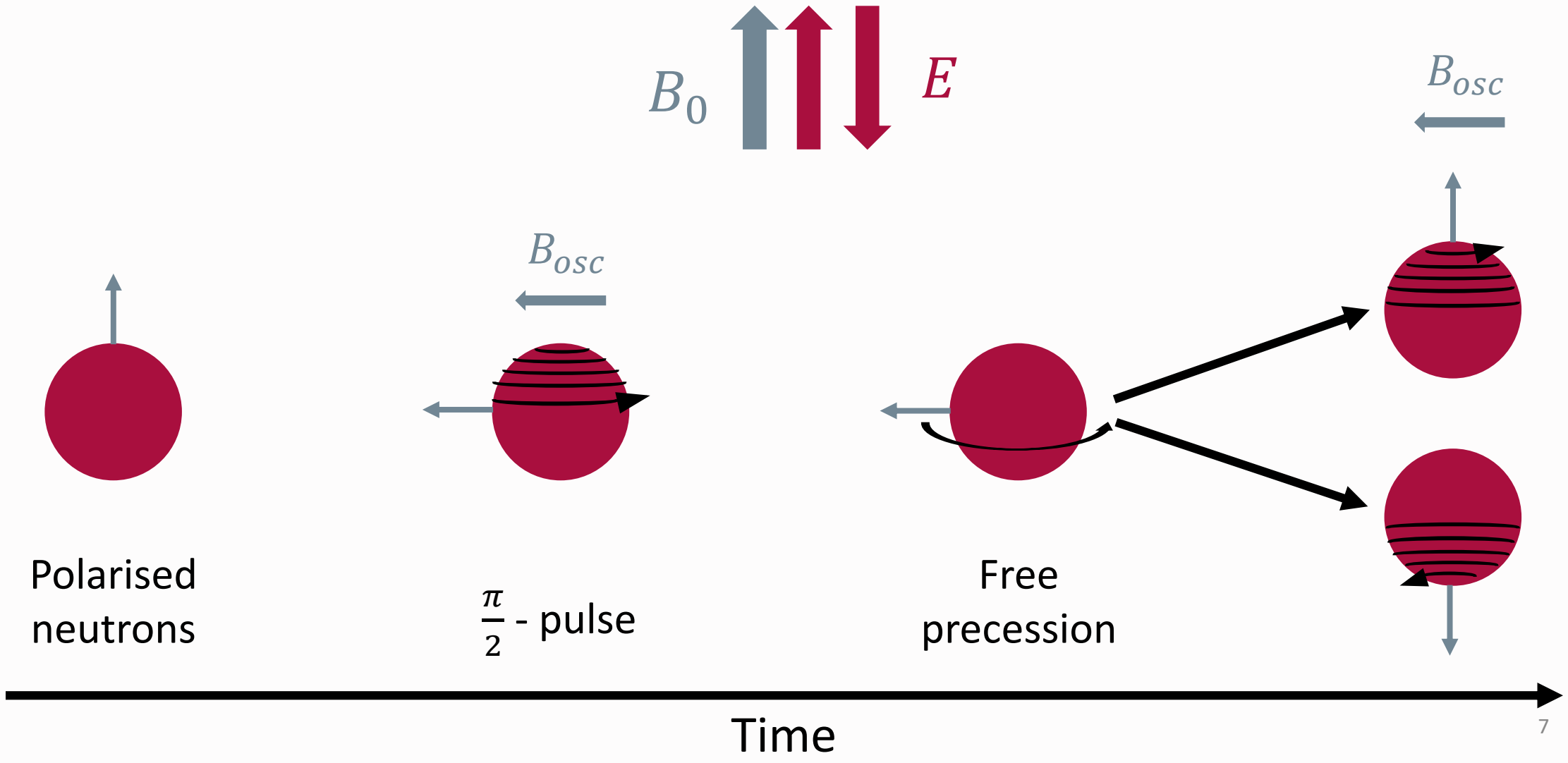
$\frac{\pi}{2}$ - pulse

Time

Ramsey's method

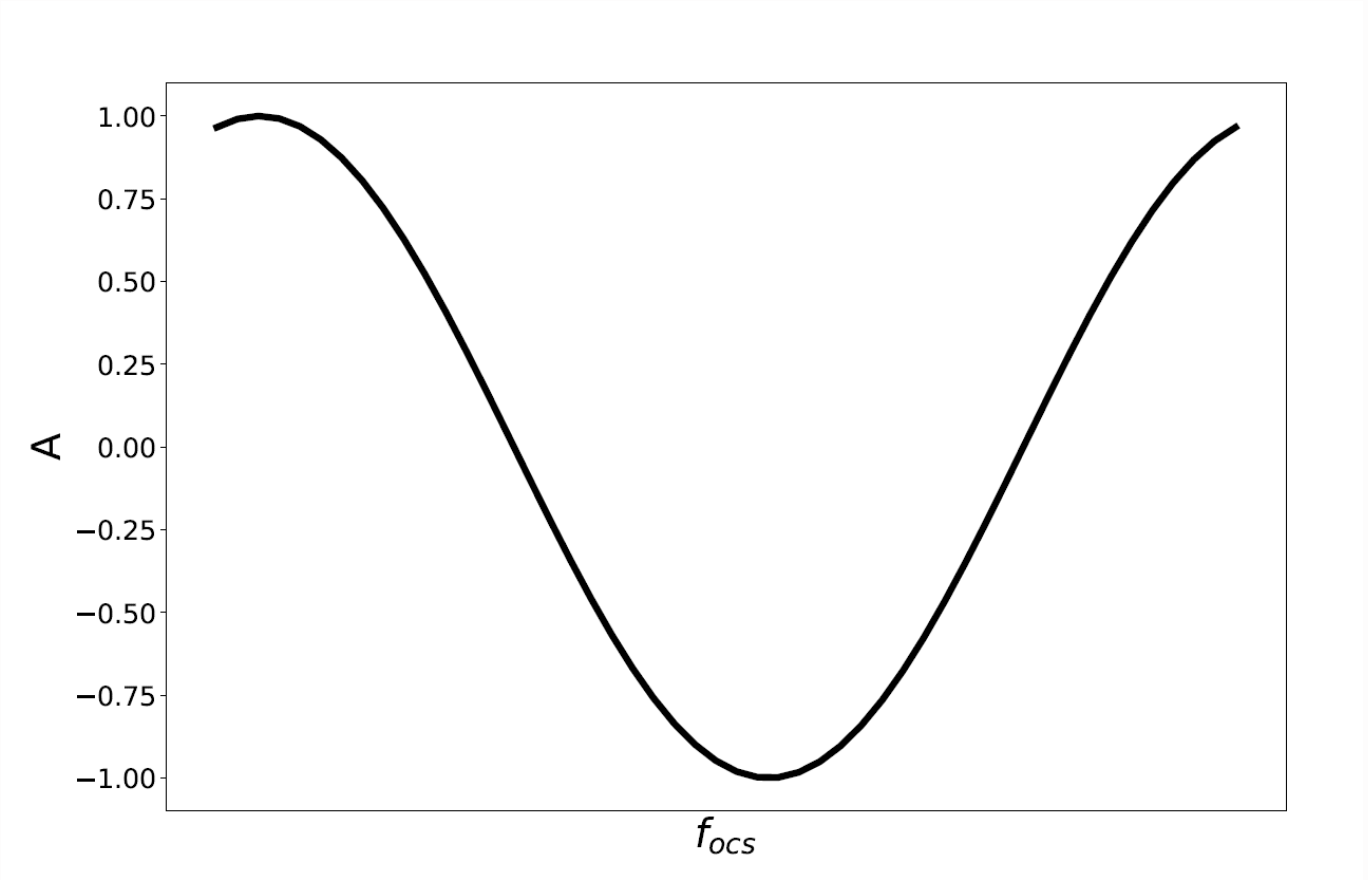


Ramsey's method



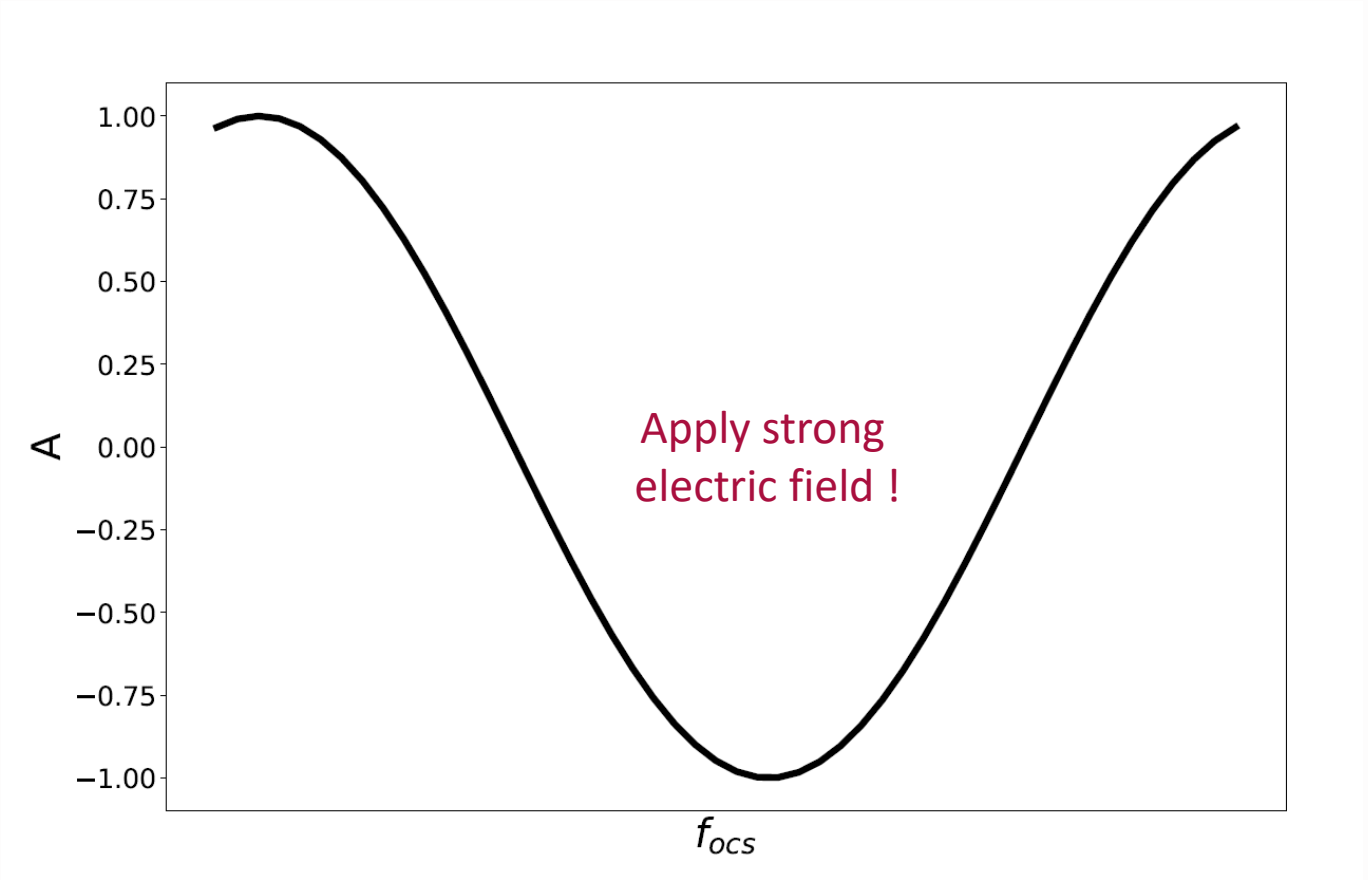
Scan of $f_{\mathbf{osc}}$

$$A(f_{osc}) = \frac{(N_\uparrow - N_\downarrow)}{(N_\uparrow + N_\downarrow)}$$



Scan of $f_{\mathbf{osc}}$

$$A(f_{osc}) = \frac{(N_\uparrow - N_\downarrow)}{(N_\uparrow + N_\downarrow)}$$



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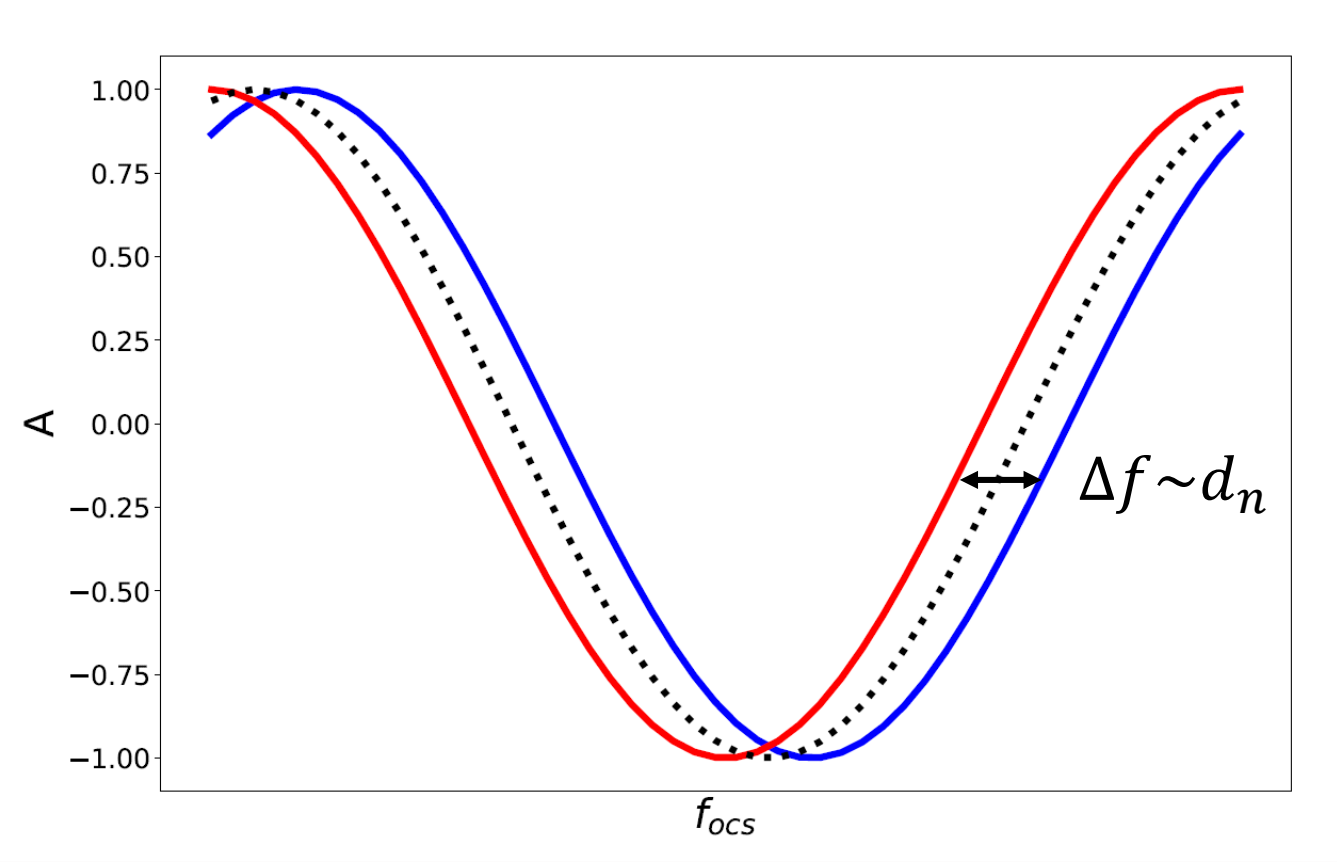


So, what do we need for n2EDM?

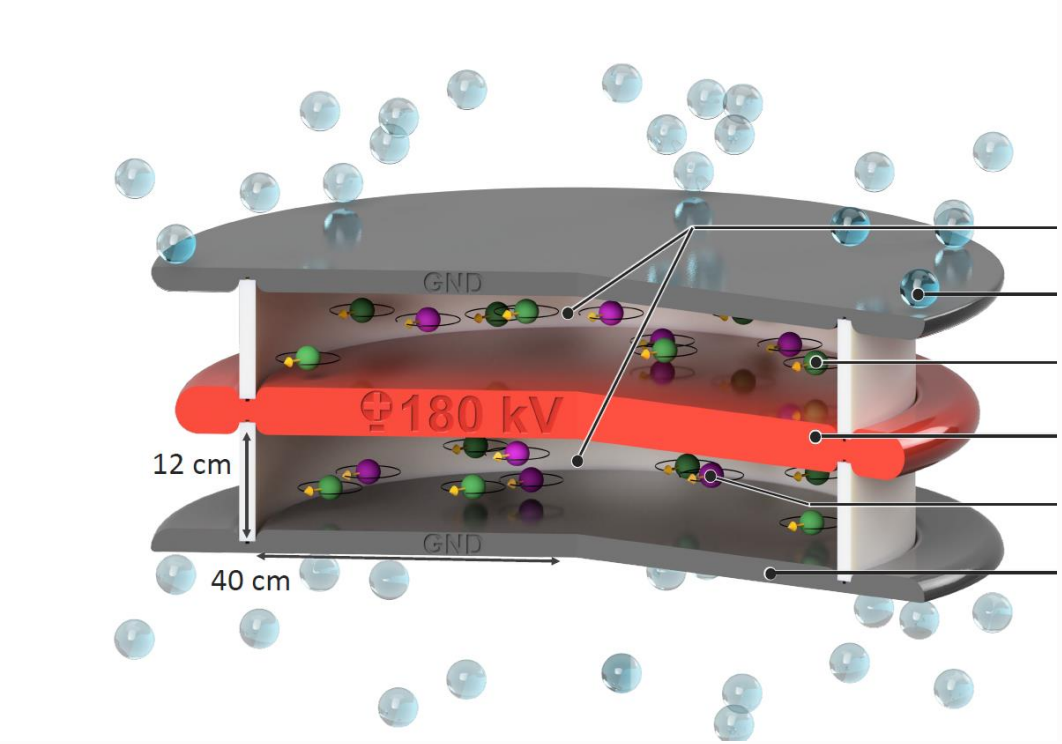
Think super basic ;)

Our ingredient's for a successful experiment:

- Neutrons!
- High electric field
- Spin dependent neutron detection
- Precisely known and controlled magnetic fields

$$\sigma(d_n) = \frac{\hbar}{2\alpha E T\sqrt{N}}$$

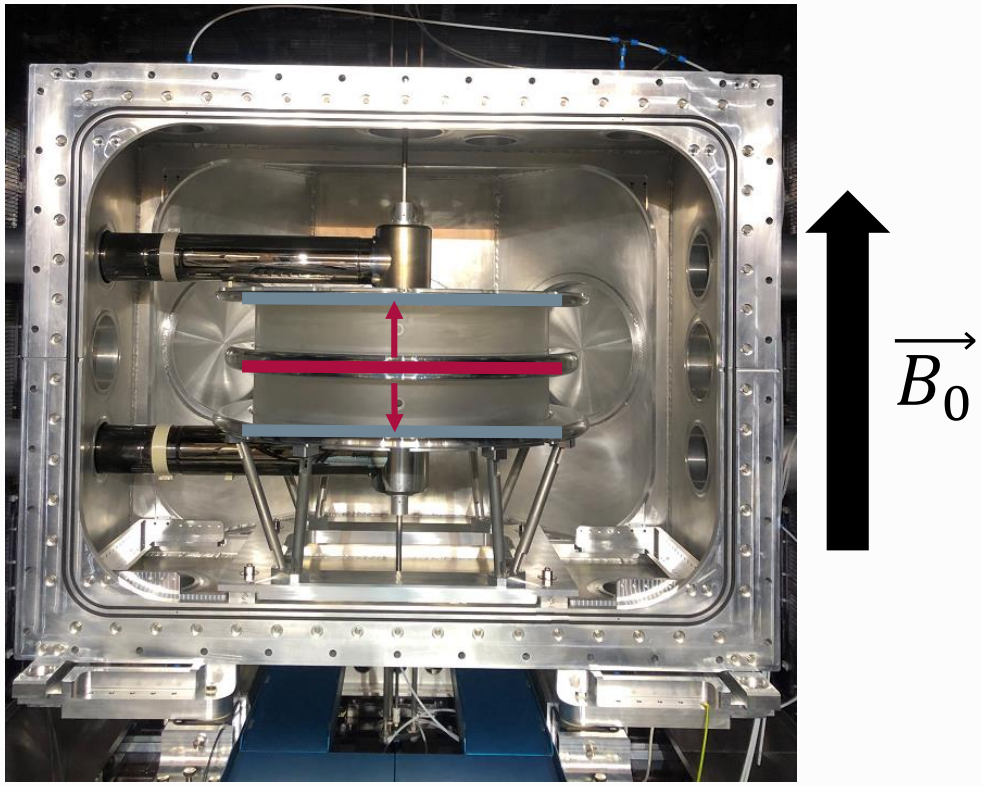
Neutrons @ n2EDM



- Ultracold neutrons (UCN)
- Produced via spallation + cooling
- < 300 neV
- 5 m/s
- Reflected off materials (storage possible!)

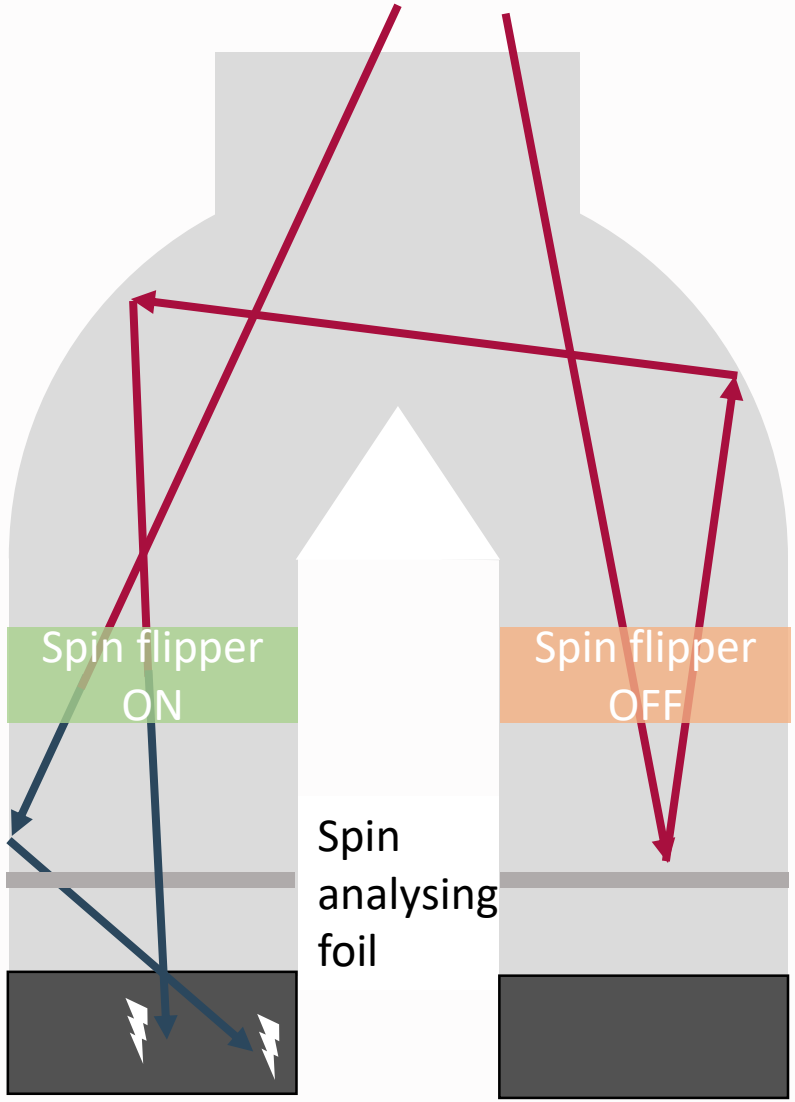
Electric field @ n2EDM

GND
HV
GND



- 1 HV electrode (± 180kV)
- 2 ground electrodes

Neutron detectors @n2EDM

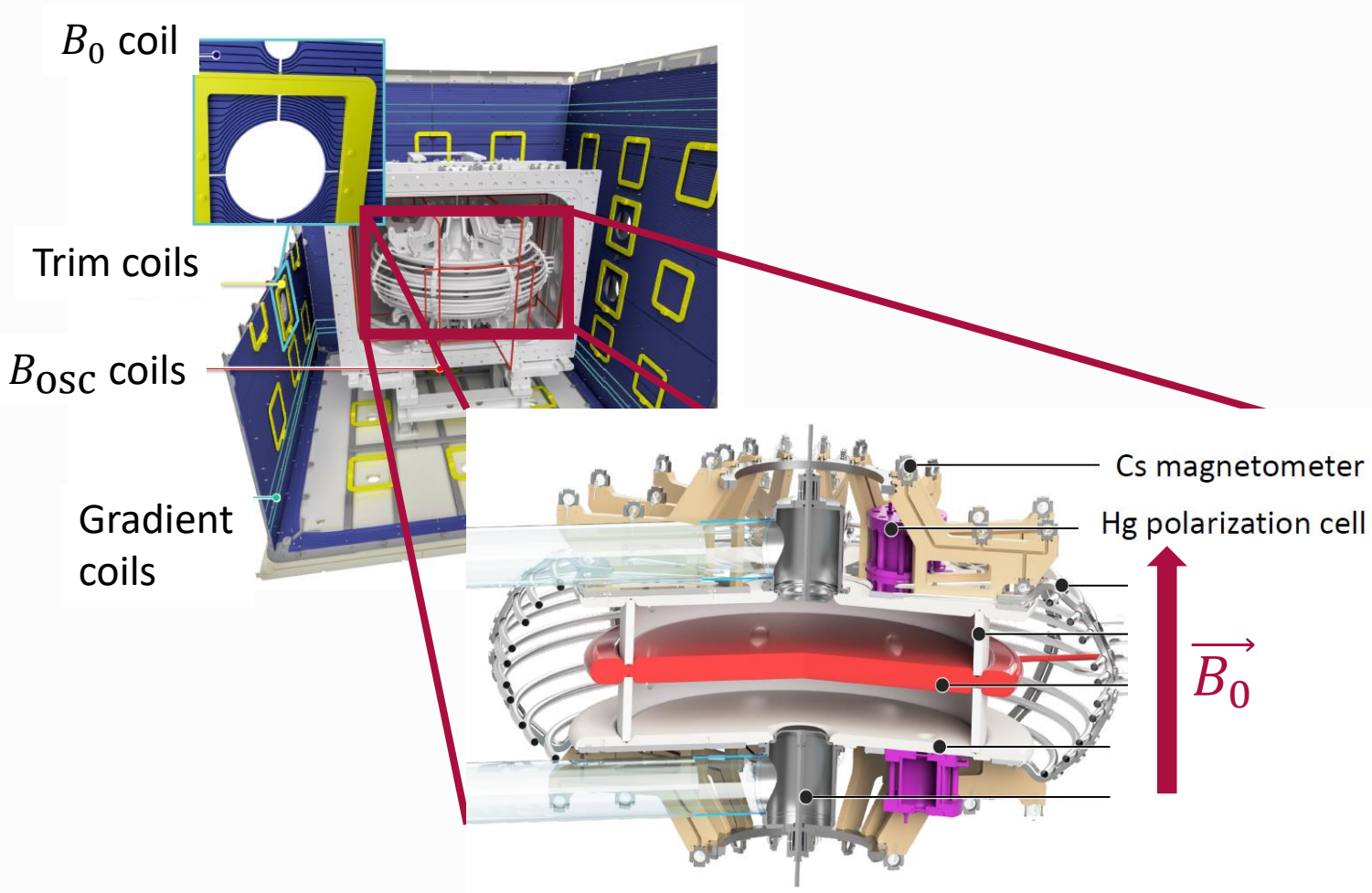


- Gaseous detector
- Capture neutrons: $n + {}^{3}He \rightarrow p + {}^{3}_{0}H$
- Scintillation in CF_4

Spin up

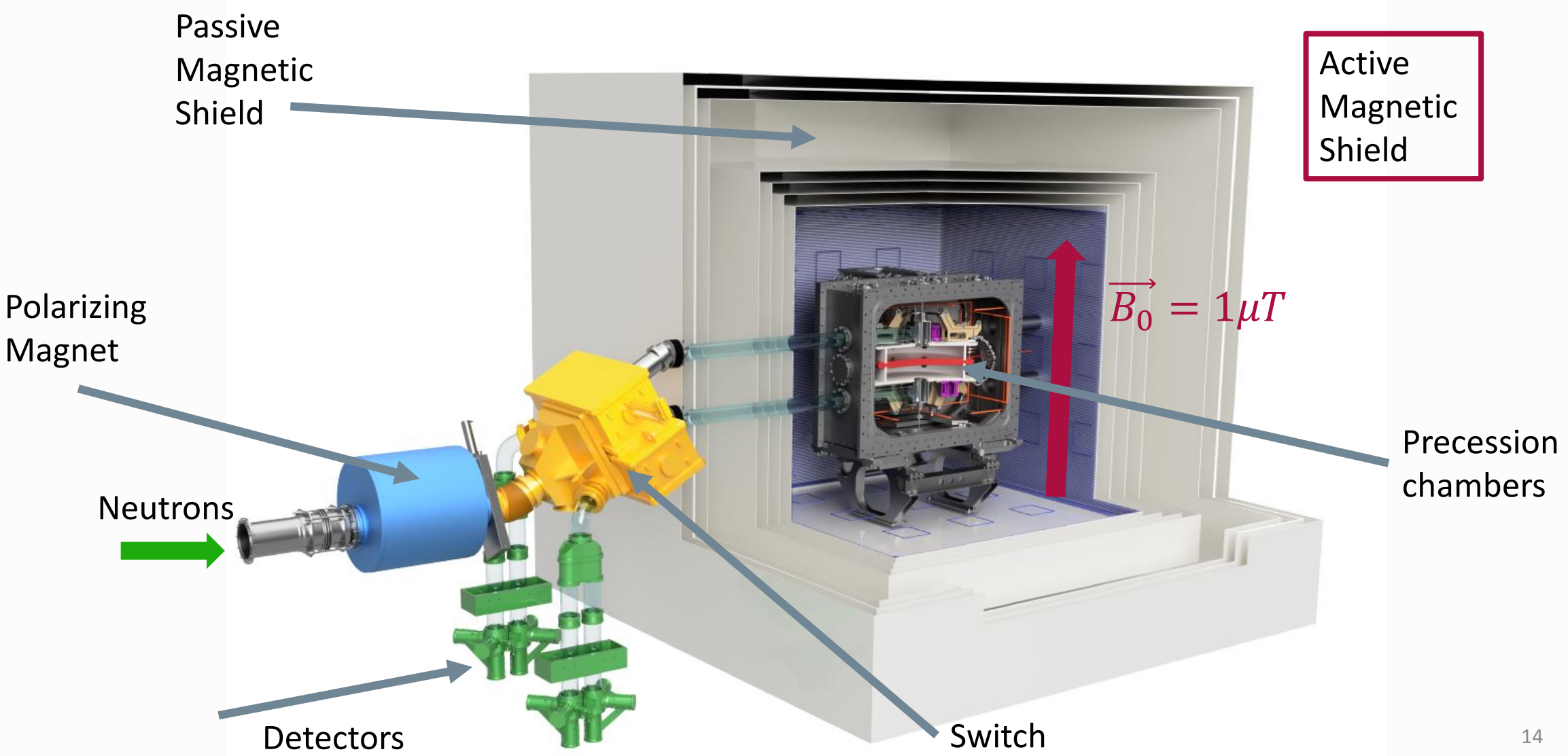
Spin down

Magnetic field @ n2EDM



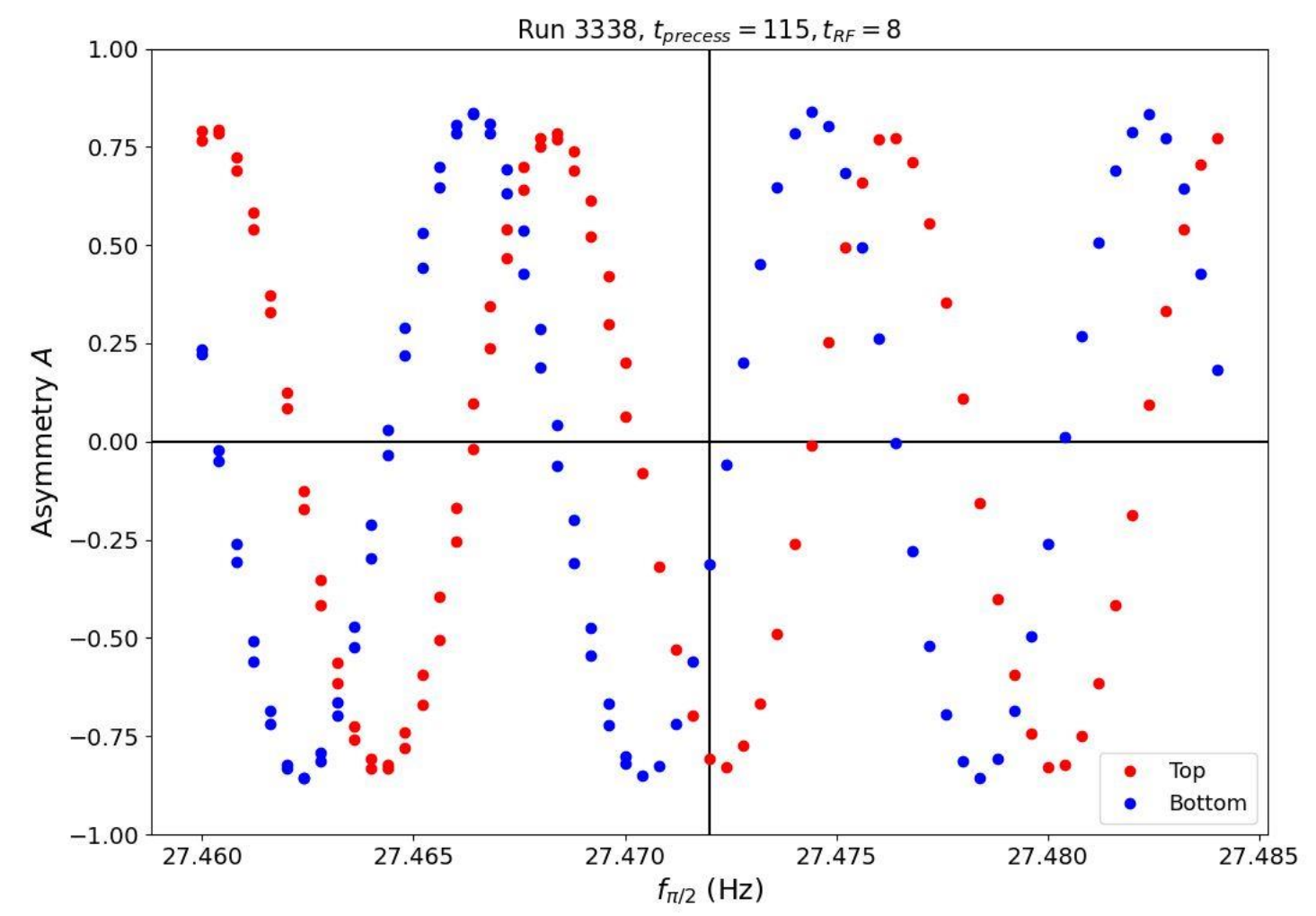
- Passive magnetic shield
- Active magnetic shield
- B_0 coil + 56 trim coils
- 2 Magnetometry systems
  1. Hg co-magnetometer
  2. Cs array

The n2EDM experiment

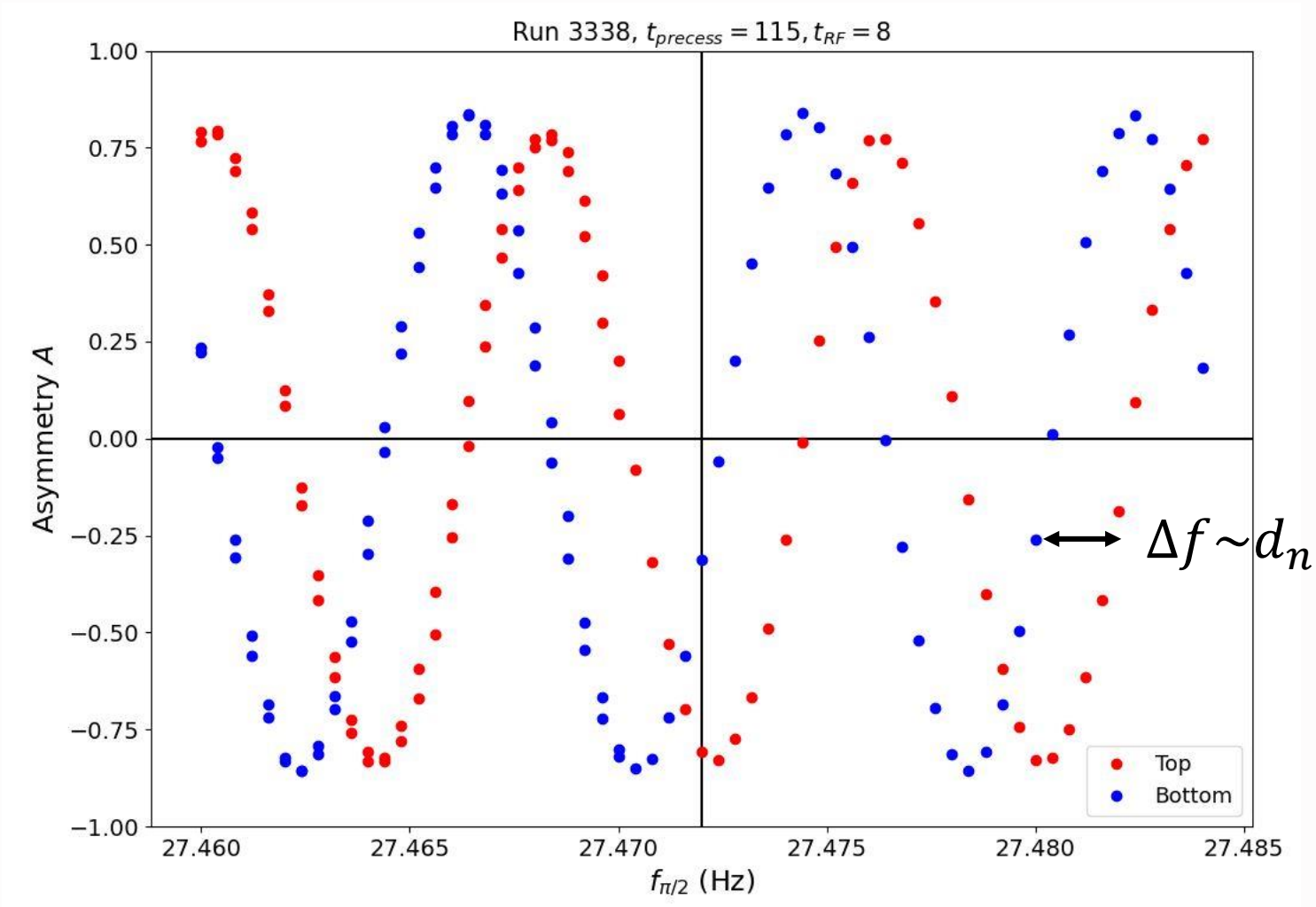


And then last year …

Our first Ramsey cycle!



Did we already find the nEDM?



Unfortunately, no … ☹

(Experiments are never as easy as we hope!)

We still have some things to look forward to!!

- Online magnetic field characterisation
- Increased neutron statistics
- High voltage

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- Online magnetic field characterisation
- Increased neutron statistics
- High voltage

$$d_n = ? \times 10^{-27}\ e\text{cm}$$

Tours?

Thr 22.2. 5pm/after the colloquium
Fr 23.2. 5pm

(Or just e-mail me any time)