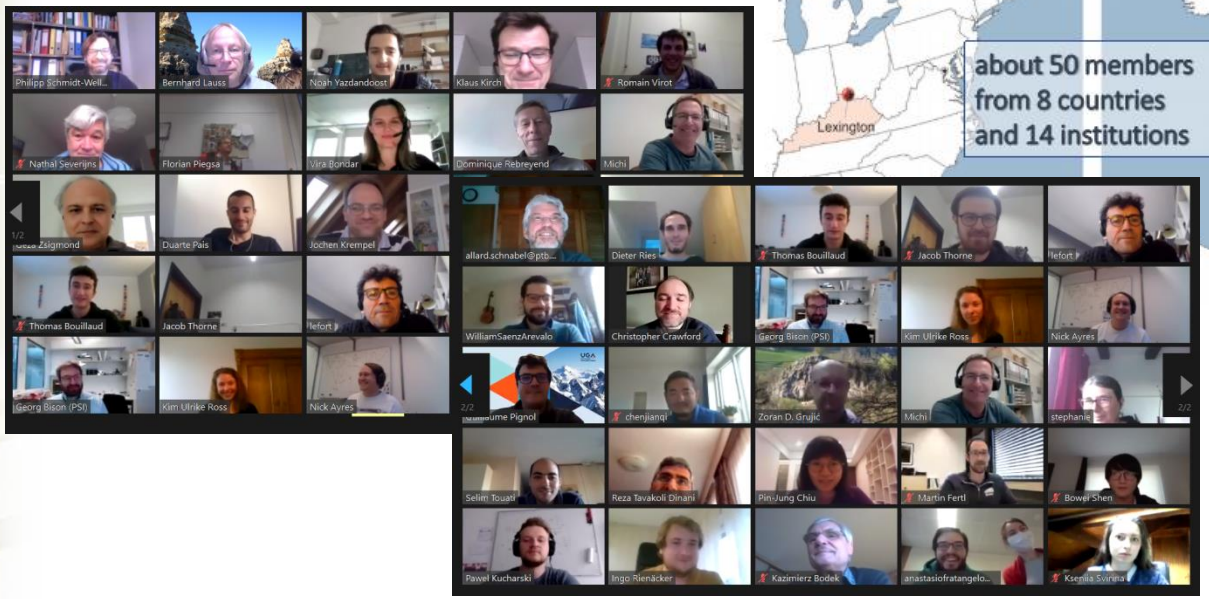
Ongoing installation of the n2EDM experiment

Kseniia Svirina
LPSC Grenoble

The nEDM collaboration



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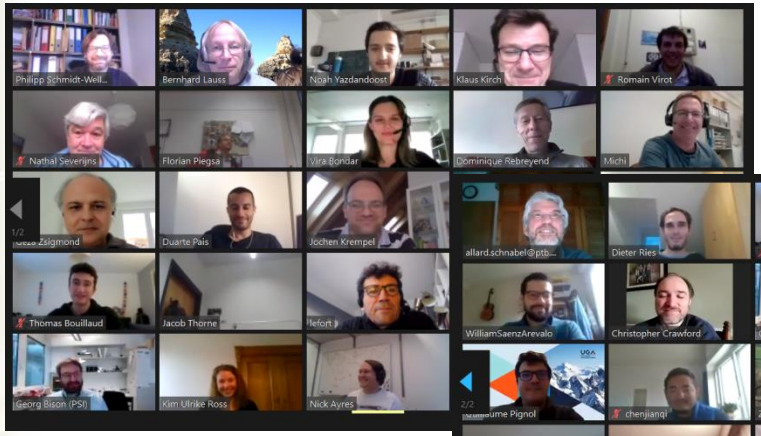
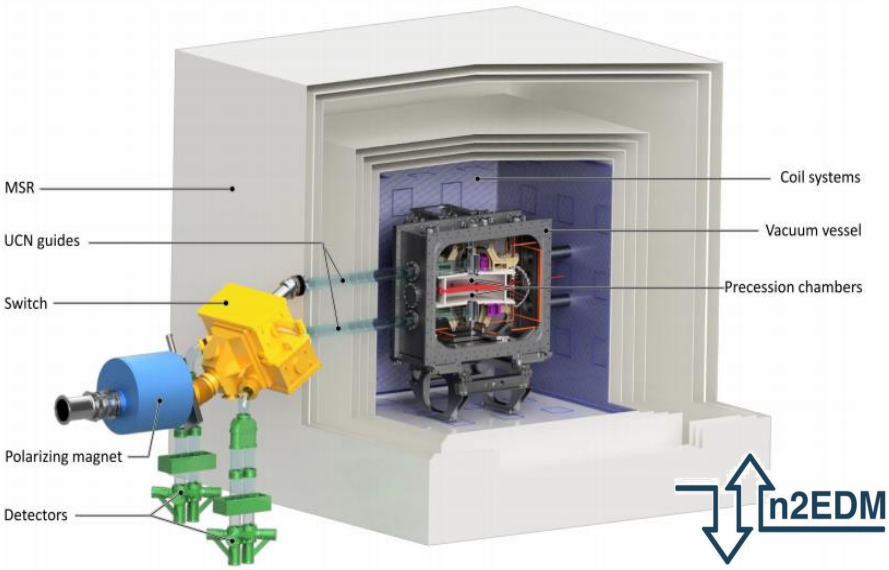


Search for the neutron EDM

PSI, Switzerland



under construction at the UCN source at the Paul Scherrer Institute (PSI)

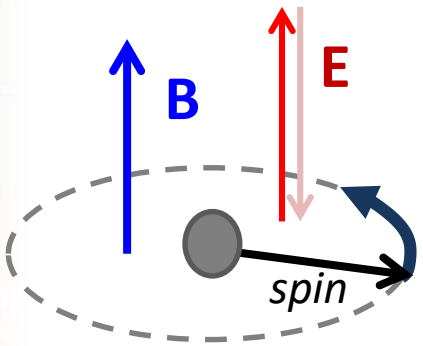
Measurement of the neutron EDM

The actual upper limit (2020):

$$|d_n| < 1.8 \times 10^{-26}\ e\ \text{cm}\ (90\%\ \text{C.L.})$$

C. Abel et al. Phys. Rev. Lett. 124, 081803

Neutron spin precession



$$2\pi f = \frac{2\mu}{\hbar} B \pm \frac{2d}{\hbar} |E| \quad \Rightarrow \quad f(\uparrow\uparrow) - f(\uparrow\downarrow) = -\frac{2}{\pi\hbar} d\, E$$

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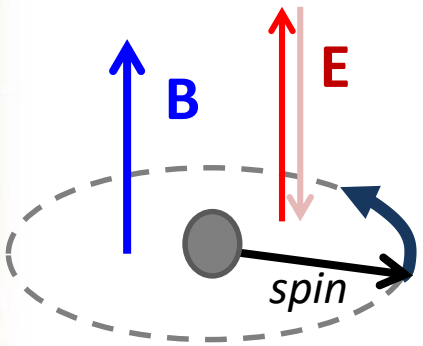

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B = 1μT

Larmor frequency:

f = 30Hz

E = 15kV/cm

with $d = 10^{-26} e\ cm$

1 full turn of the spin: ~160 days

$f = 10^{-8}$Hz

☹

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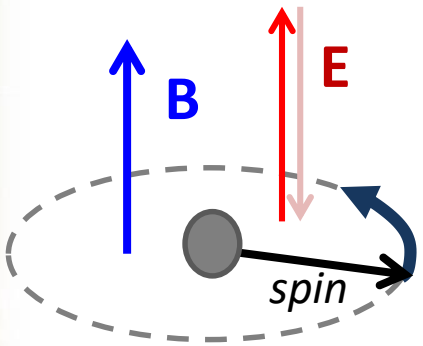

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Solutions:

- Maximize the exposure of the neutrons in E -> ***UCNs*** *(can be stored up to 15min)*
- Maximize the statistics -> *good* ***UCN transport system****, large UCN* ***storage volume***
- Control of the magnetic field -> Hg co-magnetometer; measurements of the m.field uniformity;

shielding: MSR, AMS.

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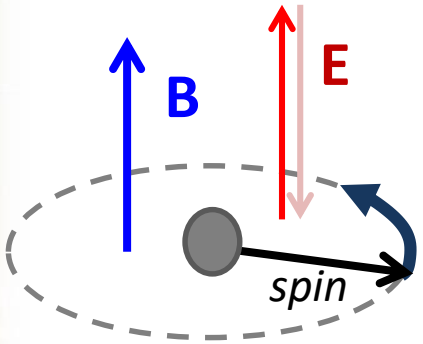

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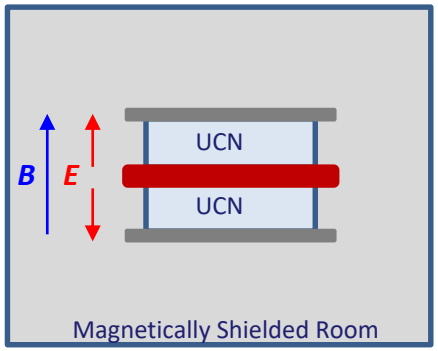

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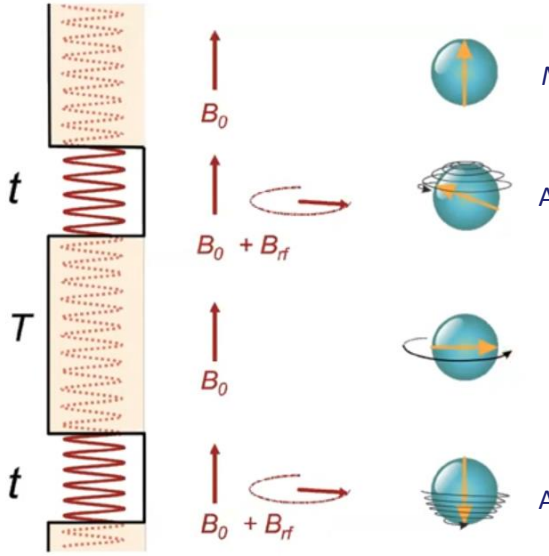
Measurement of the neutron EDM

Ramsey's method

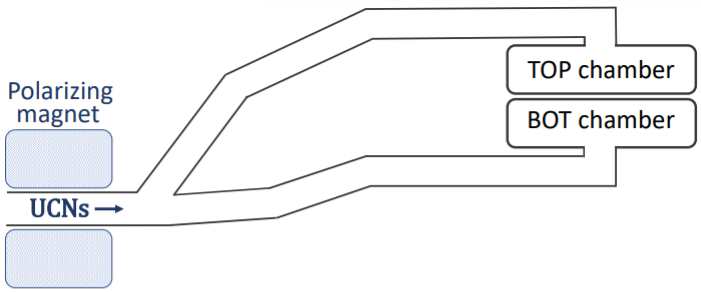


Neutron spin ∥ B_0

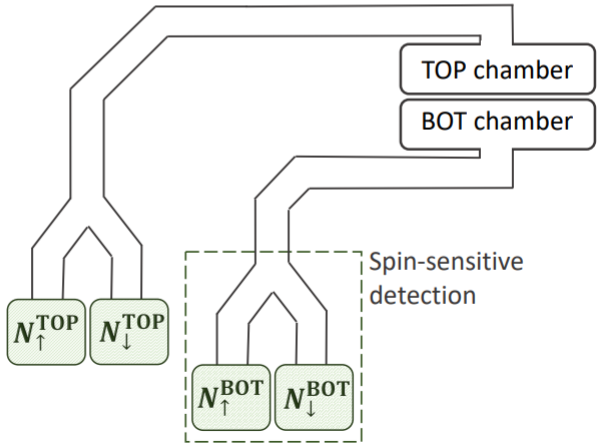
Apply oscillating m.field ⊥ B_0

Let precess for 180 s

Again apply oscillating m.field ⊥ B_0



(a) Polarized UCNs fill the precession chambers



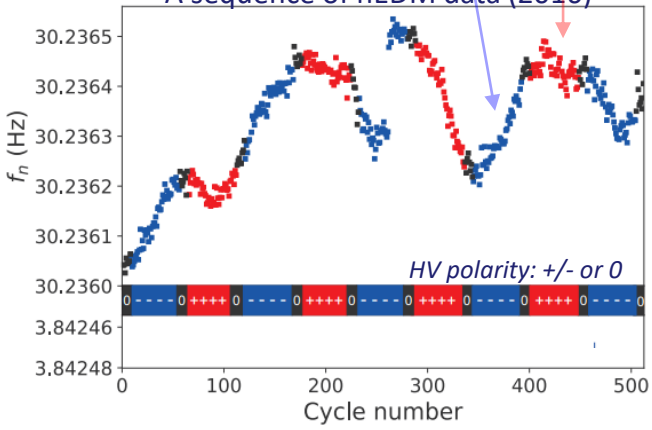
(b) UCNs are guided towards the spin-sensitive detectors.

- > Obtain neutrons with spin either UP or DOWN,
Count the number of each, which depends on f_n

Measurement of the neutron EDM

$$d = \frac{\pi\hbar}{2|E|}\left(f(\uparrow\downarrow) - f(\uparrow\uparrow)\right)$$

A sequence of nEDM data (2016)



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f_n is affected by drifts of the magnetic field!

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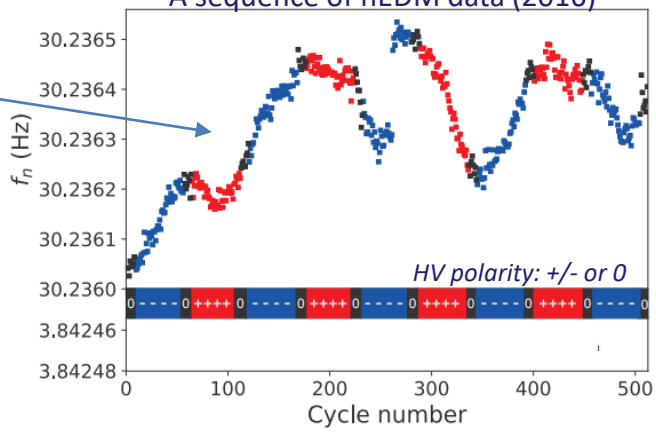

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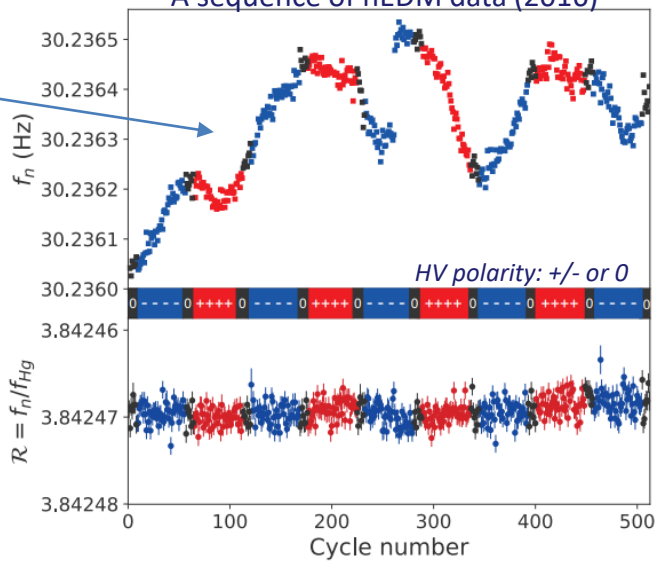
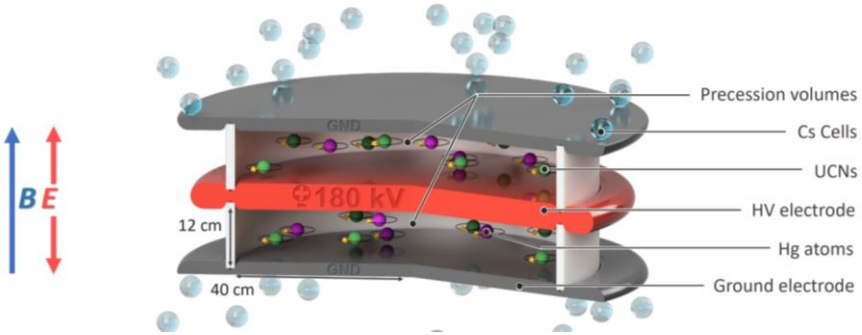


Solution:
Mercury co-magnetometer

Polarized ^{199}Hg atoms precess in the same chambers



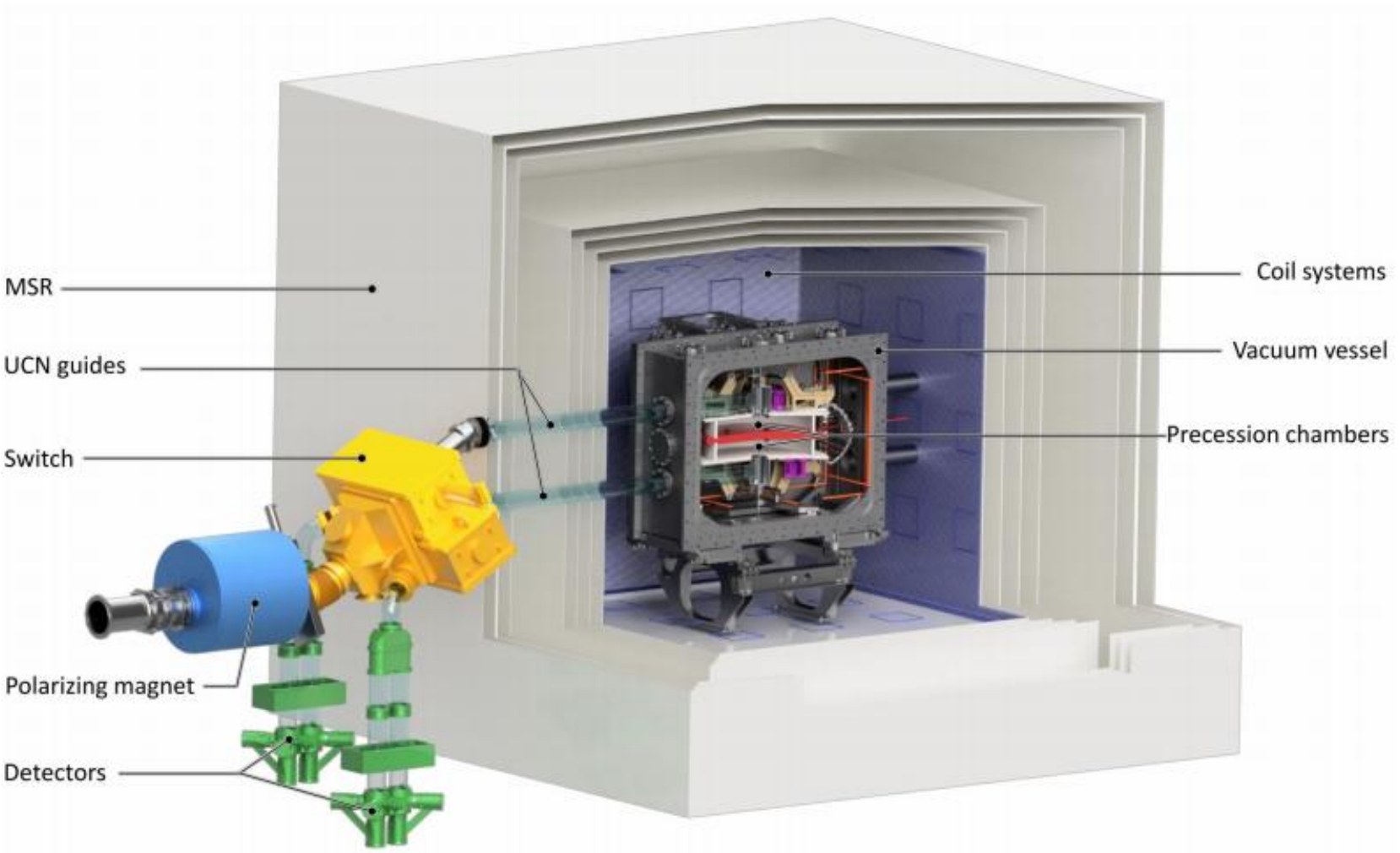
Simultaneous measurement of f_n and f_{Hg}

$$\mathcal{R} \equiv \frac{f_n}{f_{\mathrm{Hg}}} = \left|\frac{\gamma_n}{\gamma_{\mathrm{Hg}}}\right| \mp \frac{|E|}{\pi\hbar f_{\mathrm{Hg}}} d_{\mathrm{n}}$$

$$d_{\mathrm{n}} = \frac{\pi\hbar f_{\mathrm{Hg}}}{4|E|}\left(\mathcal{R}^{\mathrm{TOP}}_{\uparrow\downarrow} - \mathcal{R}^{\mathrm{TOP}}_{\uparrow\uparrow} + \mathcal{R}^{\mathrm{BOT}}_{\uparrow\downarrow} - \mathcal{R}^{\mathrm{BOT}}_{\uparrow\uparrow}\right).$$

f_{Hg} measurement principle:
a UV probe beam transverses the chambers
-> record the absorbtion of the light (an oscillating signal),
extract f_{Hg}

n2EDM experiment



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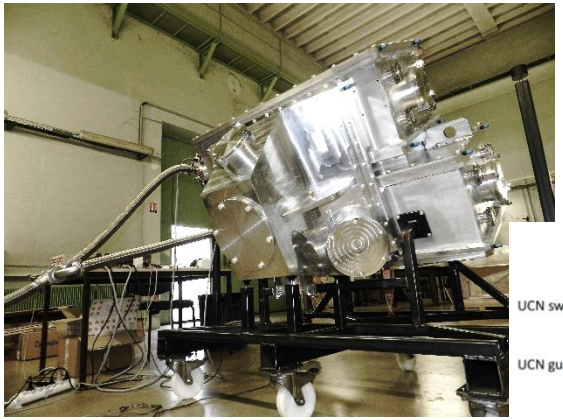
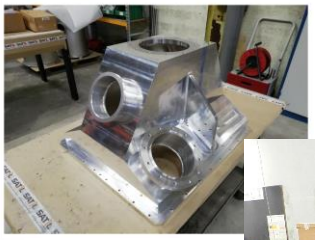
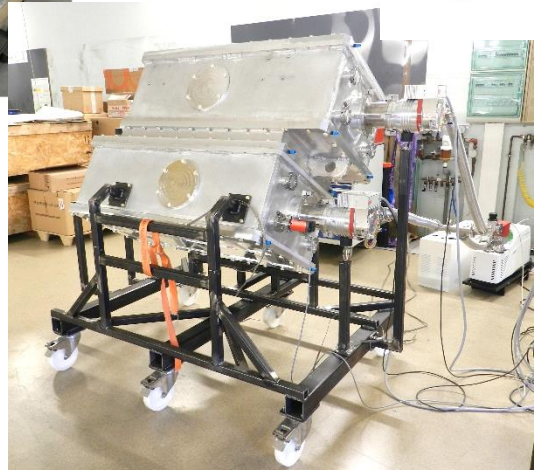
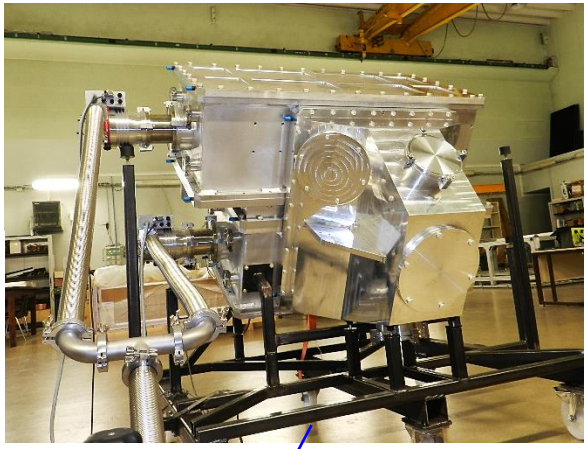
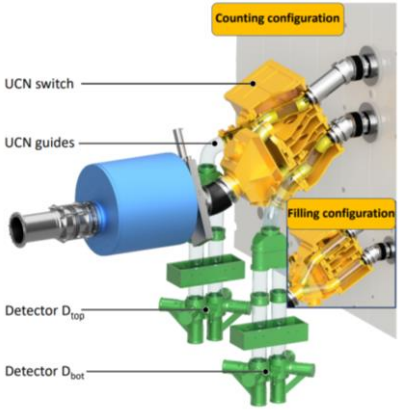


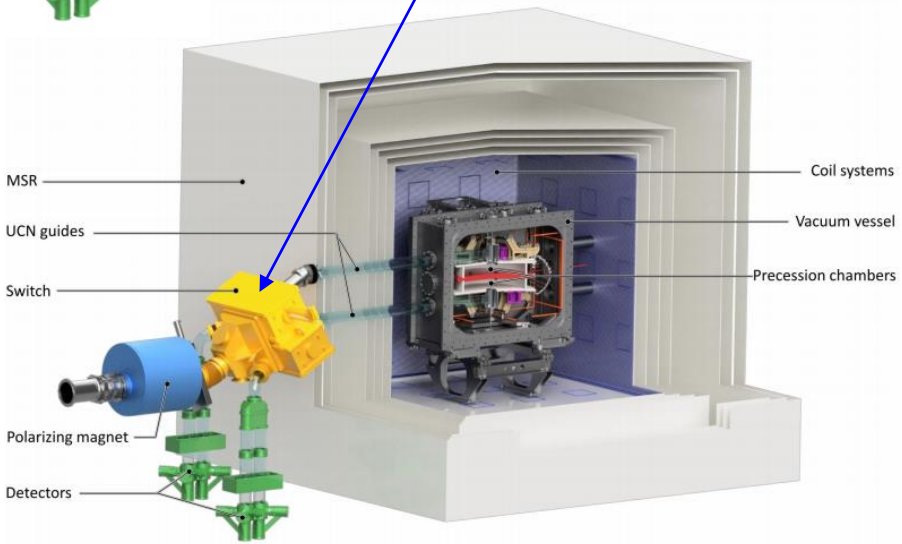




The switch



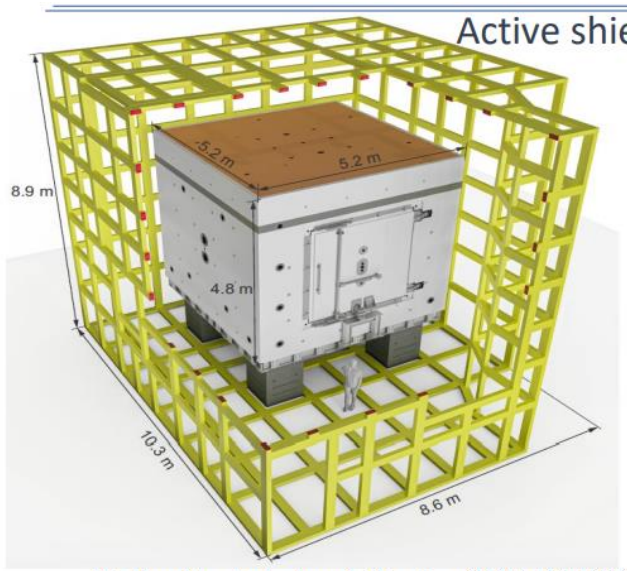




n2EDM experiment

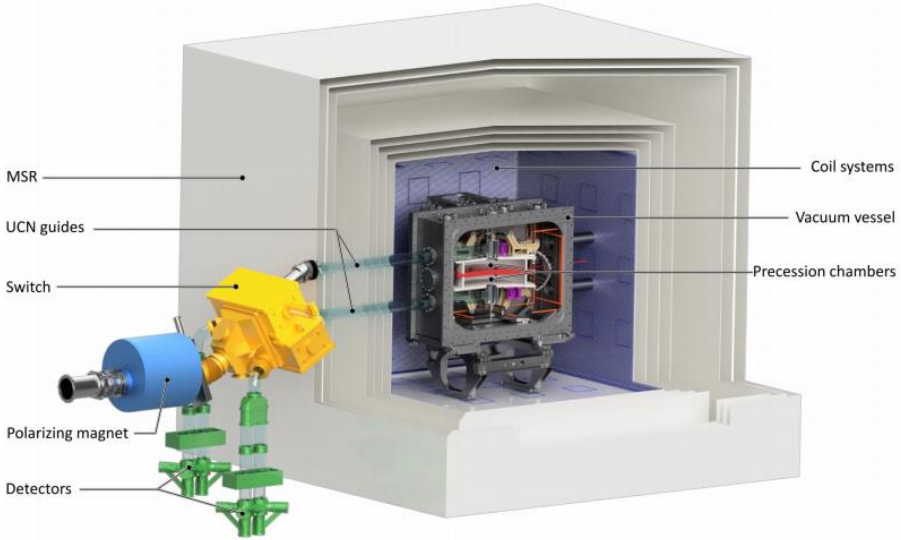
Thermohouse

AMS



M. Rawlik *et al.*, Am. J. Physics 86(8), 602 (2018)

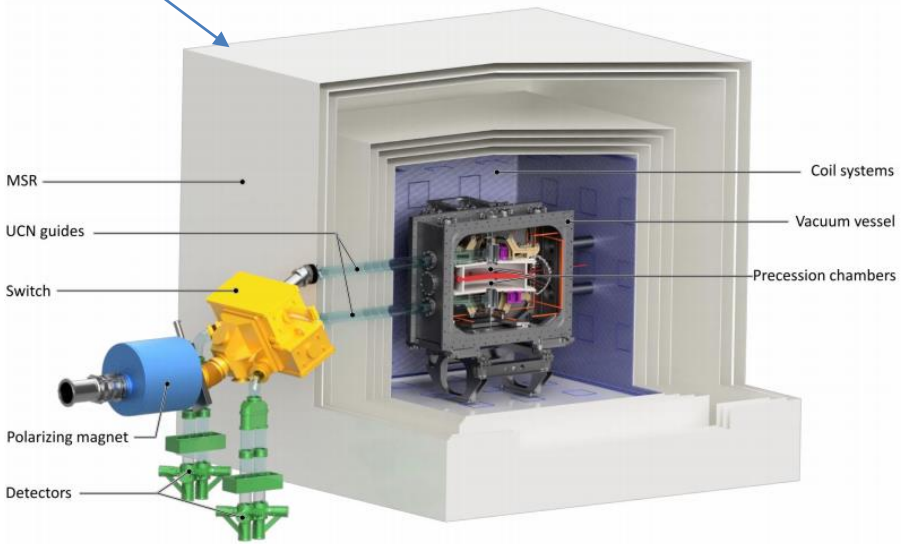
- 8 actively-controlled coils
- Spanning a volume of ~1000m^3
- Compensates field disturbances from outside
- Stable and uniform magnetic field around MSR



n2EDM experiment

- 6 mu-metal layers
- Inner dimensions 2.93m x 2.93m x 2.93m
- Quasi-static shielding factor 100’000
- Residual fields < 150 pT (in central volume)

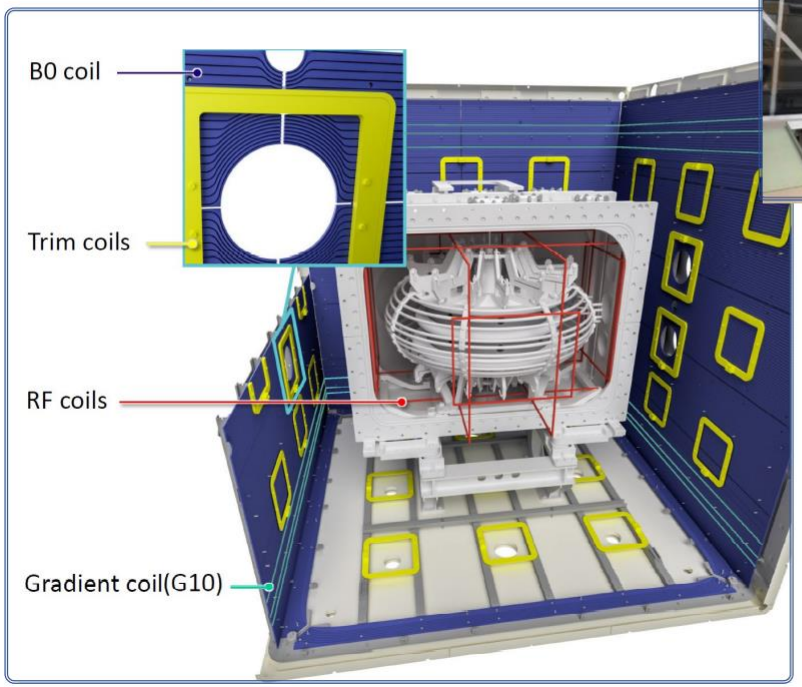
MSR

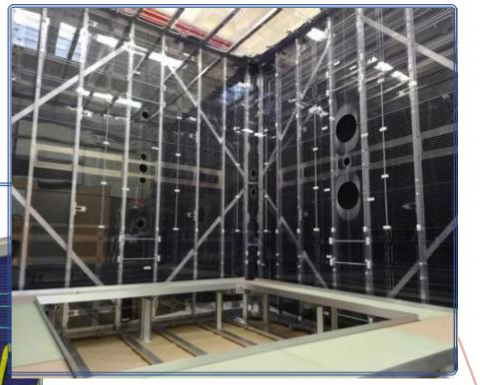


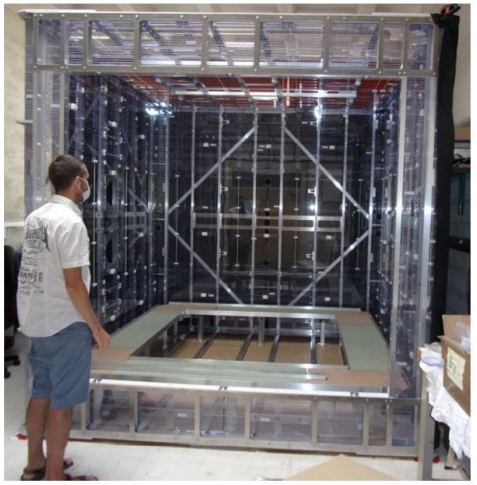
n2EDM experiment

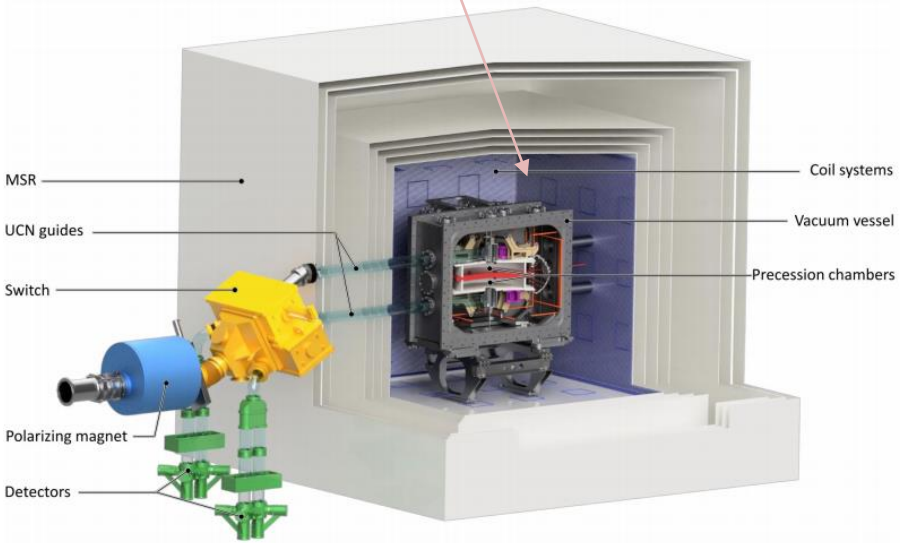
Coil systems

- Produce a very uniform B0 field (1µT)
- Produce specific gradients
- Hold the UCN polarisation
- Neutron spin manipulation









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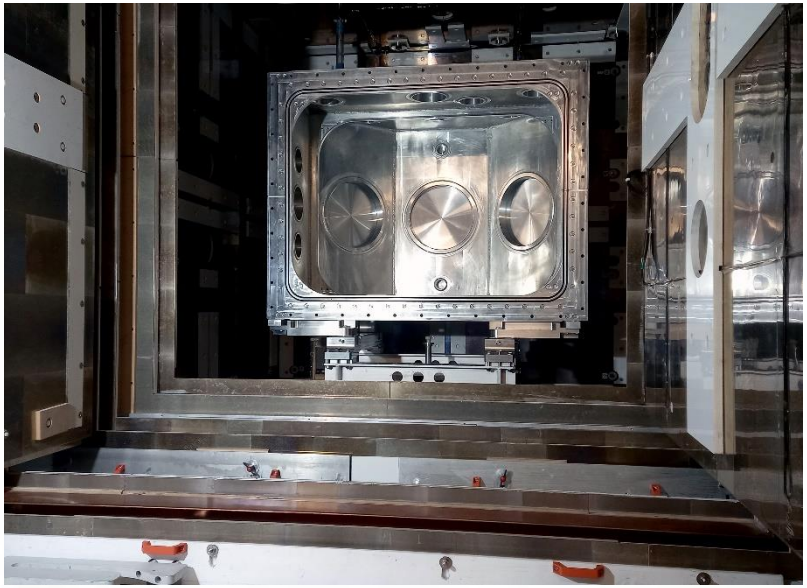
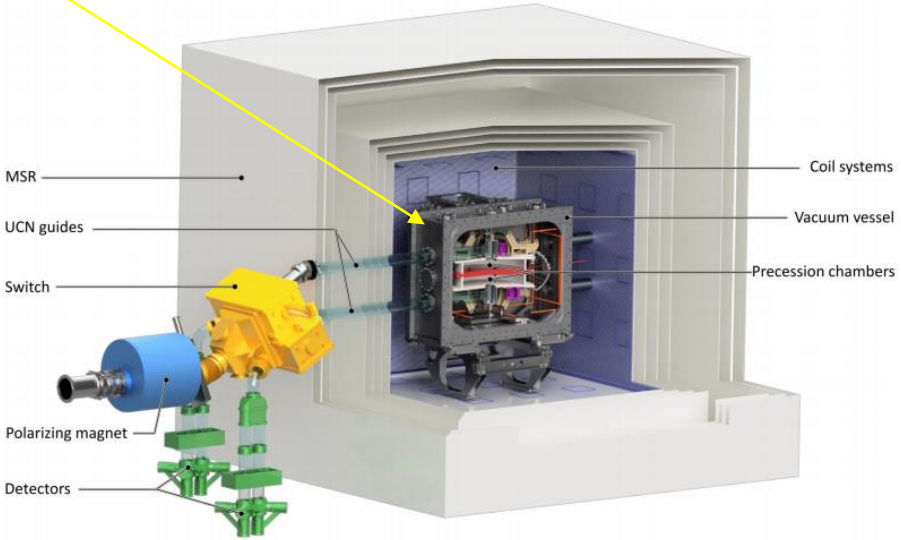


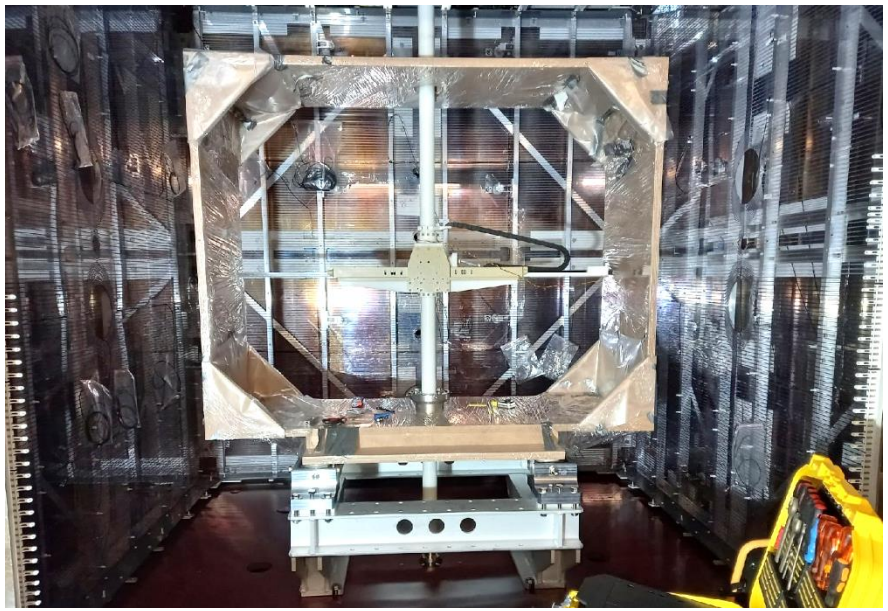
Vacuum tank

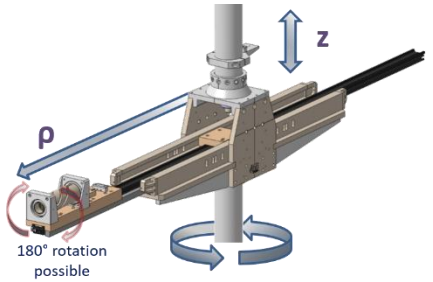


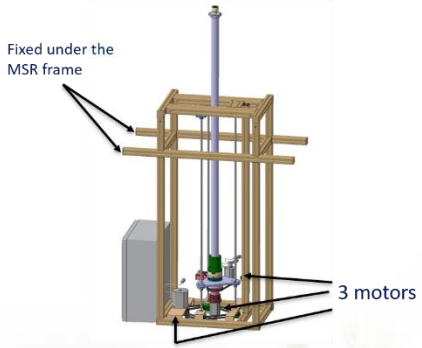
n2EDM experiment

- coil system cartography
- offline control of high-order gradients
- searches for magnetic contamination

The magnetic field mapper







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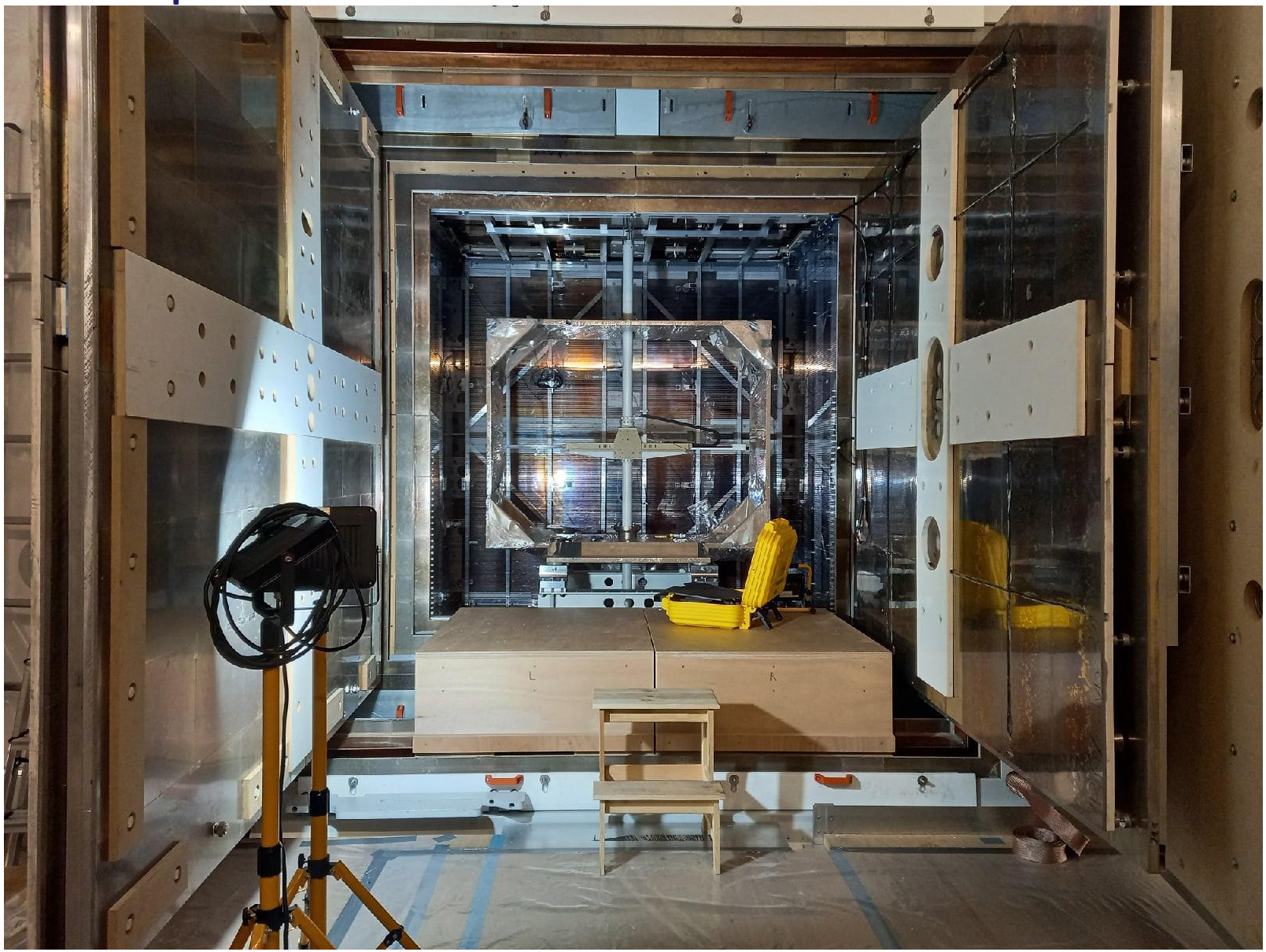


Thank you!