

Discussion

Relating to Albert Young's and Chen-Yu Liu's talks
(neutrons)

Jeff Martin, discussion leader

- **What ideas could (or could not) be turned into actual experiments at TRIUMF/CENPA?**
- **What homework do we need to do to figure this out?**
- **Should we form a working group to answer such questions?**
- **Who are key people to target for this working group?**

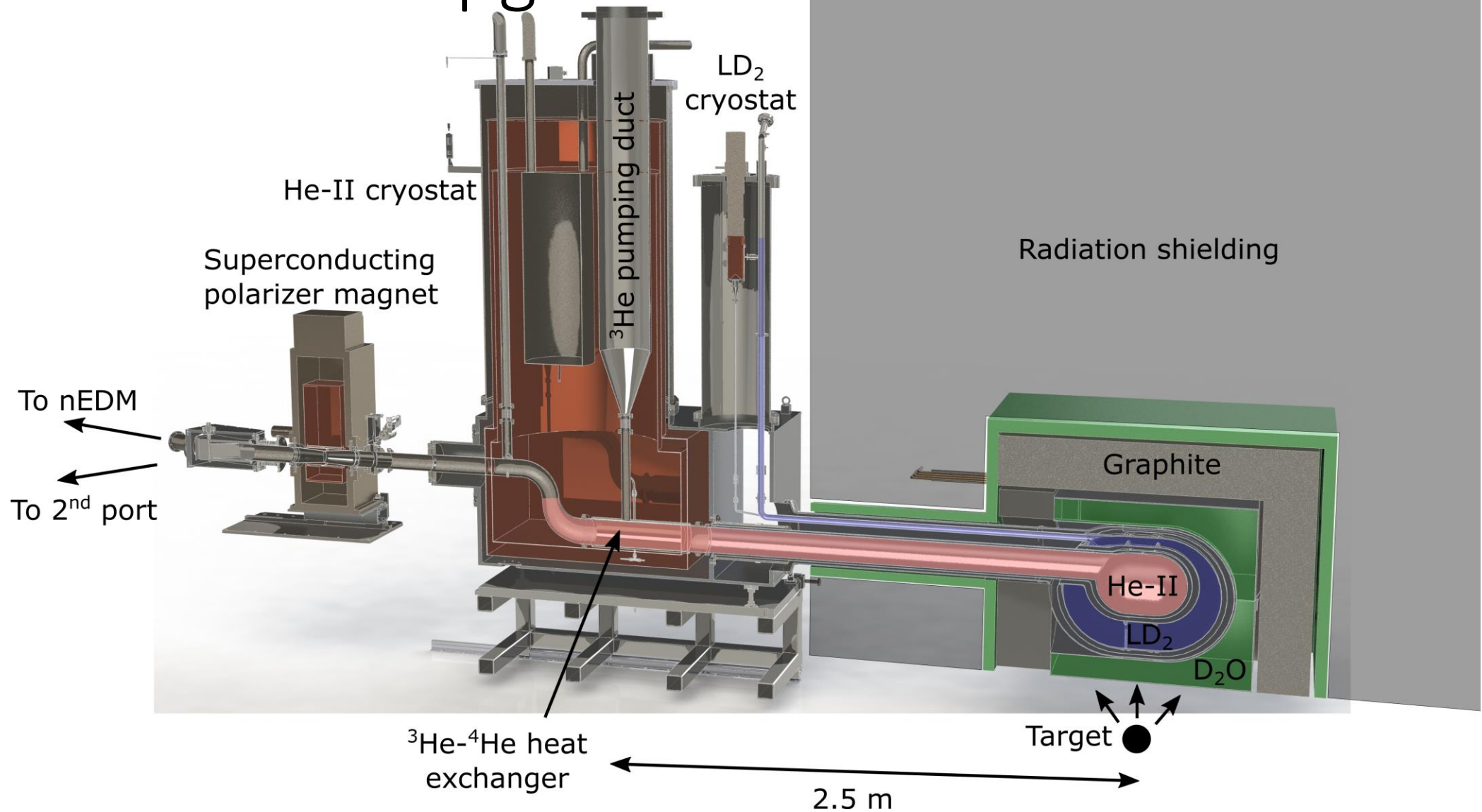
Ultracold neutron sources that would welcome your experiments

Place	Neutrons	UCN converter	Status
ILL	Reactor, CN	Turbine	Running
J-PARC	Spallation	Doppler shifter	Running
ILL SUN-2	Reactor, CN	Superfluid He	Running
ILL SuperSUN	Reactor, CN	Superfluid He	Future
RCNP/KEK/TRIUMF	Spallation	Superfluid He	Running/Upgrading
Gatchina WWR-M	Reactor	Superfluid He	Future
LANL	Spallation	Solid D2	Running
Mainz	Reactor	Solid D2	Running
PSI	Spallation	Solid D2	Running/Upgrading
NSCU Pulsar	Reactor	Solid D2	Running
FRM-II	Reactor	Solid D2	Future

KEK-TRIUMF combination of spallation target and superfluid helium is unique. Upgrade schedule is competitive with other leading sources of UCN.

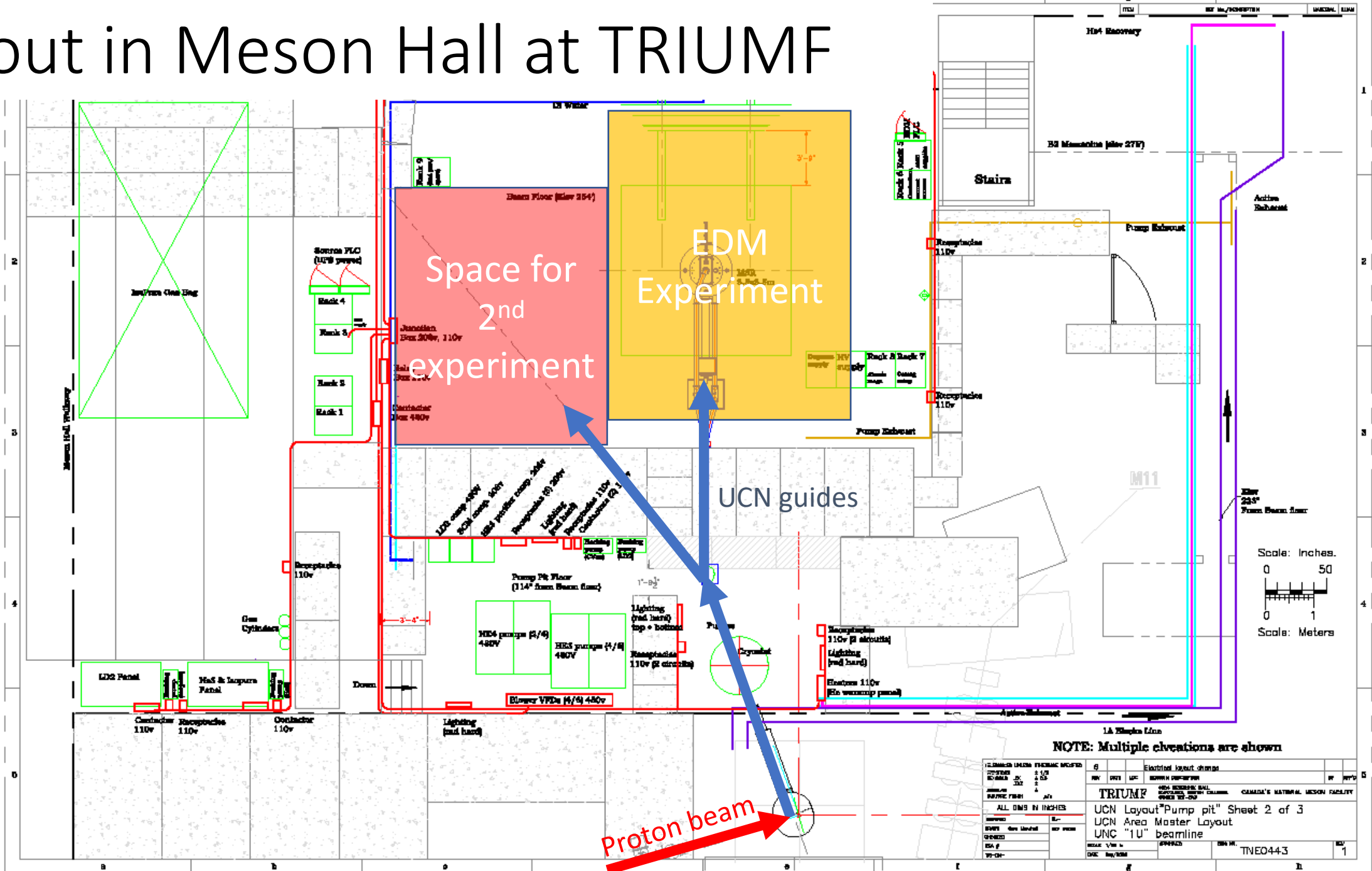
TUCAN Source upgrade

TUCAN = TRIUMF Ultra-Cold Advanced Neutron



Cryostat testing (Japan) successful/ongoing, installation at TRIUMF in 2021-22.

Layout in Meson Hall at TRIUMF



TUCAN EDM: Opportunities for collaboration, and physical distancing

- Based on examples from R&D, there are many opportunities for external (to TRIUMF) involvement:
 - UCN detector development and testing
 - UCN source cryogenics
 - UCN guide coating
 - CN experiment analysis
 - Hg comagnetometer development
 - Cs magnetometer development
 - Internal coil design
 - External coil design
 - Beam physics and magnetic mapping
- Each has students and/or university-based PDF/RA involved.
- Running at TRIUMF:
 - Ran the prototype UCN source one month per year 2017-2019.
 - Cryogenic testing of the UCN source upgrade at TRIUMF over the next two years. Expect two PhD's (UBC, Manitoba) focused on cryogenic aspects.
 - UCN production from upgraded source 2022.
 - Magnetically shielded room installed 2022 will serve as focal point for magnetic and sensor testing.
 - EDM commissioning/running 2023 and beyond.
 - Future projects.
- Good opportunity to get involved now in local particle physics project at TRIUMF.

Key parameters of the TUCAN Source and EDM experiment (also a reference design for other possible experiments)

- Source produces **1.6×10^7 UCN/s** when driven by 40 μ A beam.
- Operate 1 minute beam on (loading the EDM experiment), 3 minutes beam off (EDM measurement and counting) duty cycle.
- EDM experiment cells (**2 x 30 L**) store **20×10^6 UCN** at t=0 (after loading).
- Ultimately, at the end of each Ramsey measurement we would detect 2×10^6 UCN (includes storage and transport losses, detection efficiency).
- We repeat this cycle over and over again. Aim for **$\delta d_{n,\text{stat.}} = 1 \times 10^{-27}$ ecm in 400 days** of running (+years for systematic studies).
- Competitive with/complementary to CENPA ^{199}Hg EDM program.

Experiments with ultracold neutrons

- The “best” experiments:
 - Beta decay correlations
 - Neutron lifetime (CKM unitarity, new particles in loops, neutron lifetime problem)
 - EDM (strong CP problem, SUSY CP problem, EW baryogenesis, ...)
 - Gravitational levels (modification to gravity at $\sim \mu\text{m}$ scale, chameleon fields)
- Others?
 - Invisible and not-so-invisible decays of neutrons (neutron lifetime problem).
 - Mirror neutrons (anomalous losses, neutron lifetime problem)
 - Axionlike particles (time-varying EDM's, precision clock comparisons)
 - n - \bar{n} oscillation search (B-violation)

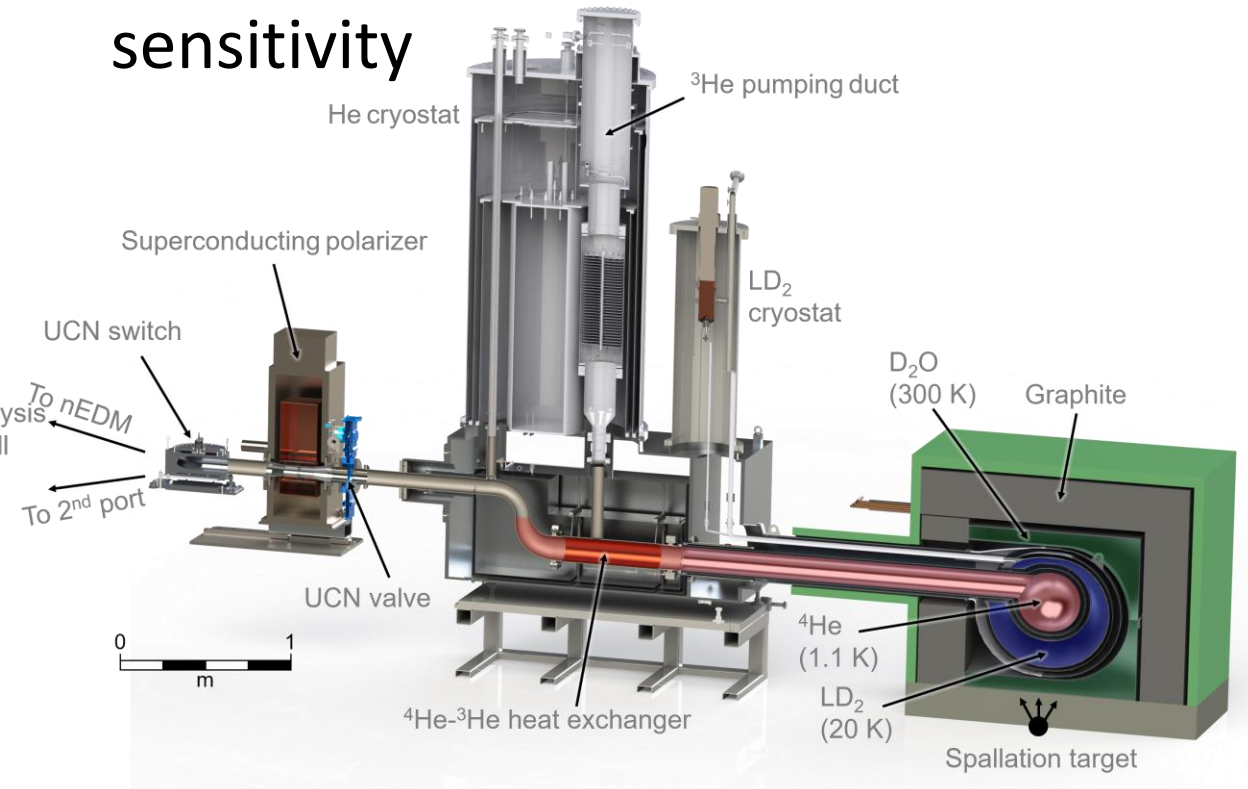
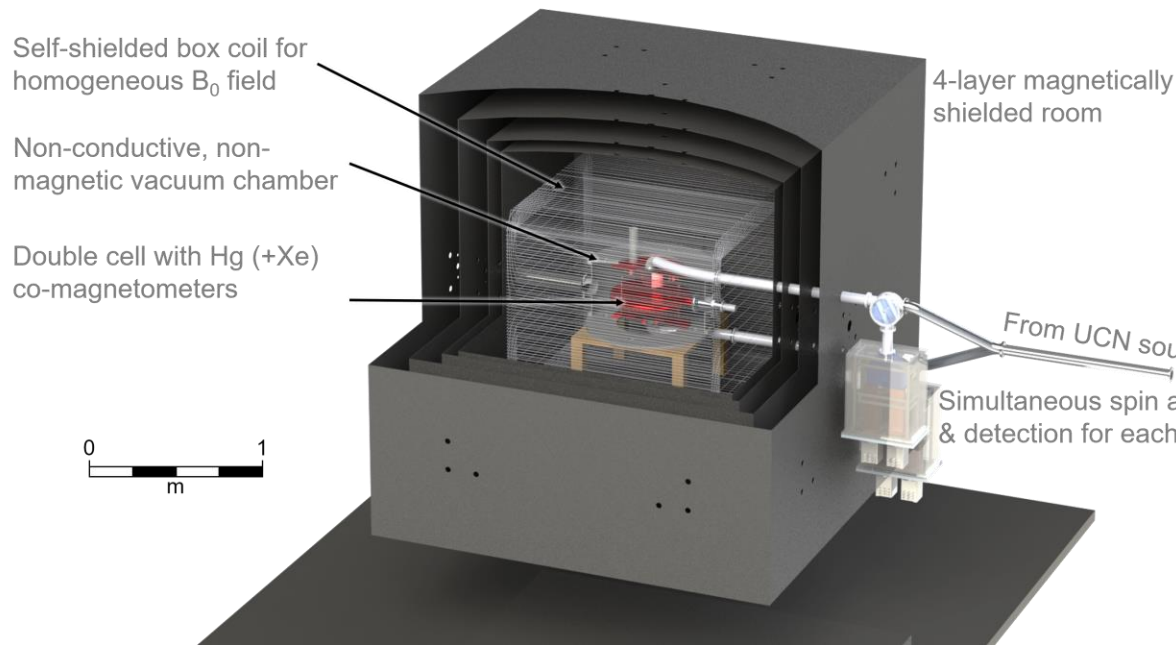
Discussion points

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- New geometry for experiment measuring $A(\beta)$
- Mirror neutrons
 - Neutron disappearance vs. magnetic field
 - What about effect on precession frequency? Pseudo-magnetic field, non-linearity with B , time-varying fields.
- ALP's
- Short-range forces – microfluidic device for short-range force search.
- CRES
- n - \bar{n} ?
- new ideas in neutron lifetime?
- dark decay, doing better?
- mirror neutrons using cold neutron beam (Broussard)
- EDM, n - \bar{n} , beta-decay, bouncing neutrons in quantum states

Plans for next five years

- 2021-22: UCN source installation and commissioning
- 2022: MSR installation, begin precision magnetometry in situ
- 2023: nEDM commissioning, thereafter data-taking
- Helium liquefaction upgrade in Meson Hall needed to reach full sensitivity



Plans for 2027-36

- EDM data analysis and possible additional data taking
- Upgrades to UCN source or EDM experiment
 - E.g. Xe comagnetometer
- UCN source designed as user facility with second port available for other experiments:
 - Neutron lifetime puzzle
 - Neutron gravity levels experiment
 - Exotic interactions
 - Bring your ideas!

