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TRIUMF Ultra Cold Advanced Neutron source

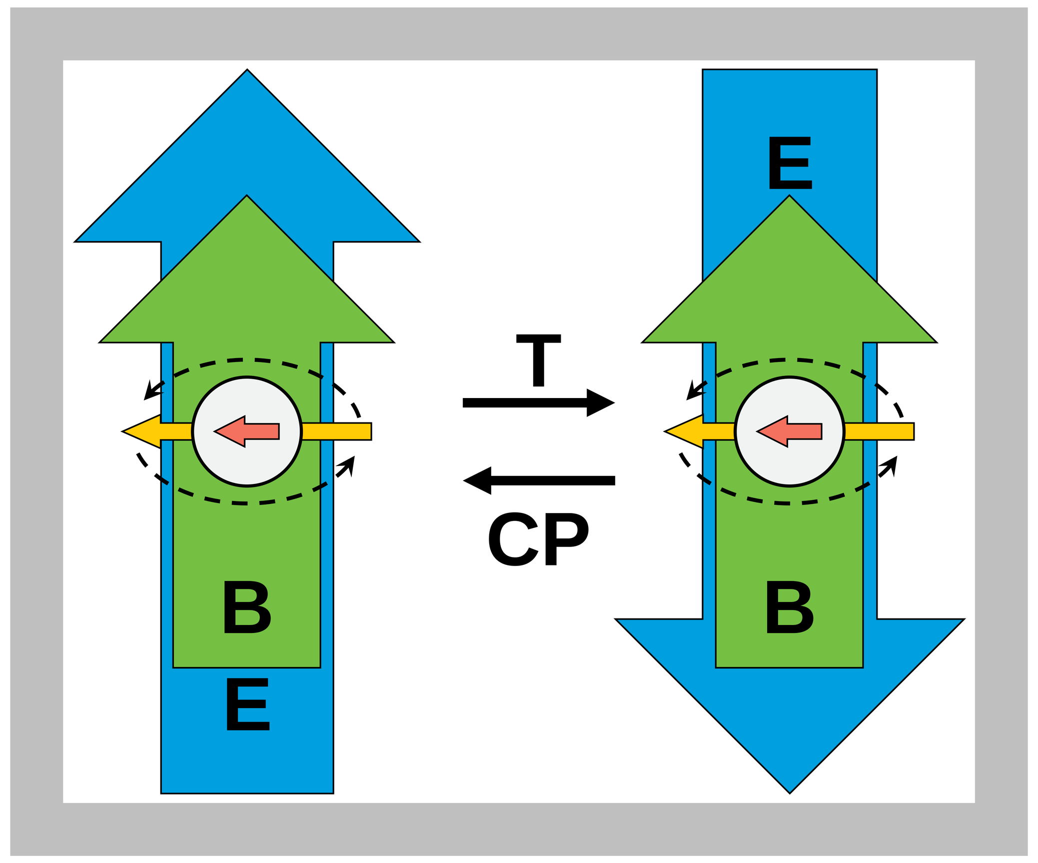
The TRIUMF UltraCold Advanced Neutron source and electric dipole moment experiment

W. Schreyer[1], R. Picker[1,2] for the TUCAN collaboration
[1]TRIUMF, [2]Simon Fraser University

Neutron electric dipole moment (nEDM)

A permanent electric dipole moment of the neutron would **violate CP symmetry**, a necessary ingredient to explain the **matter-antimatter asymmetry** in the universe.

Our goal: search for an nEDM with a sensitivity of 10^{-27} *e*·cm (10x better than current upper limit) by measuring the precession frequency of neutron spins in magnetic and electric fields using Ramsey's method of separated oscillatory fields.



A neutron's magnetic dipole moment (yellow) precessing in a magnetic field B. If the neutron also possesses an electric dipole moment (red) the precession frequency changes when the electric field E is flipped.

Magnetically shielded room

Several layers of Mu metal **shield the nEDM measurement from external magnet fields**. Construction started in October.

Field coils and magnetometry

Various magnetic coils in the room generate **extremely stable and homogeneous magnetic fields**, monitored by several laser-driven magnetometers with ~10 fT resolution.

Precession cells

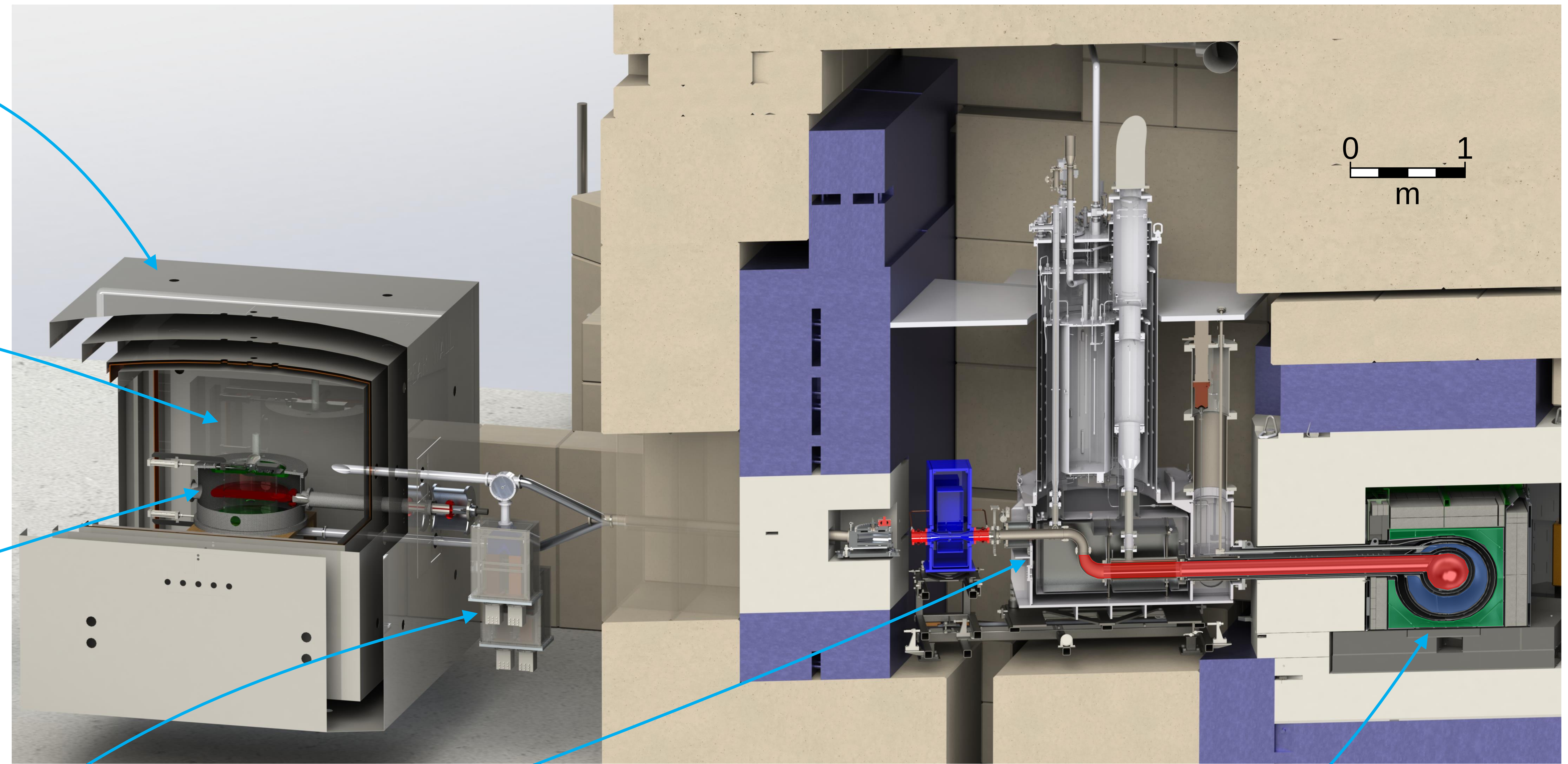
Several million ultracold neutrons are filled into two cells and stored for several minutes while their spins precess. Electrodes capping the cells apply a strong electric field of ~12 kV/cm.

Ultracold-neutron detectors

After the storage period the remaining ultracold neutrons are emptied into detectors to measure their polarization. Multiple fill-store-detect cycles are needed to determine the precession frequency.

Ultracold neutrons (UCN)

Neutrons with energies so small (~100 neV) that they **can be stored in vessels for several minutes**. They are ideal for an nEDM measurement, as sensitivity increases with storage duration.



^{3}He fridge

85 L of isotopically purified, superfluid ^{4}He convert cold neutrons into ultracold neutrons. Large pumps and a heat exchanger filled with ^{3}He **cool the superfluid helium to 1.1 K while removing a heat load of up to 10 W**.

Achieved milestones

2016 Beamline and spallation target completed

2017 New CFI funding secured

2017-19 UCN production with prototype source

2017-19 Concept design of new UCN source

2019-21 Detailed design and construction start

2021 Radiation shielding reconfigured

2021 ^{3}He fridge shipped from Japan to TRIUMF

Spallation target and neutron moderators

A 20 kW proton beam from TRIUMF's 520 MeV cyclotron generates spallation neutrons in a tungsten target. Graphite, heavy water, and liquid deuterium moderate the neutrons so they can be converted to ultracold neutrons in a central volume of superfluid helium. The superfluid-helium vessel has been completed and successfully tested with UCN at LANL. We expect this to become the **most intense ultracold-neutron source** in the world. A second experiment port will be made available to external users.

Discovery, accelerated