The PSI source of ultracold neutrons (UCN)

Manfred Daum for the PSI UCN collaboration

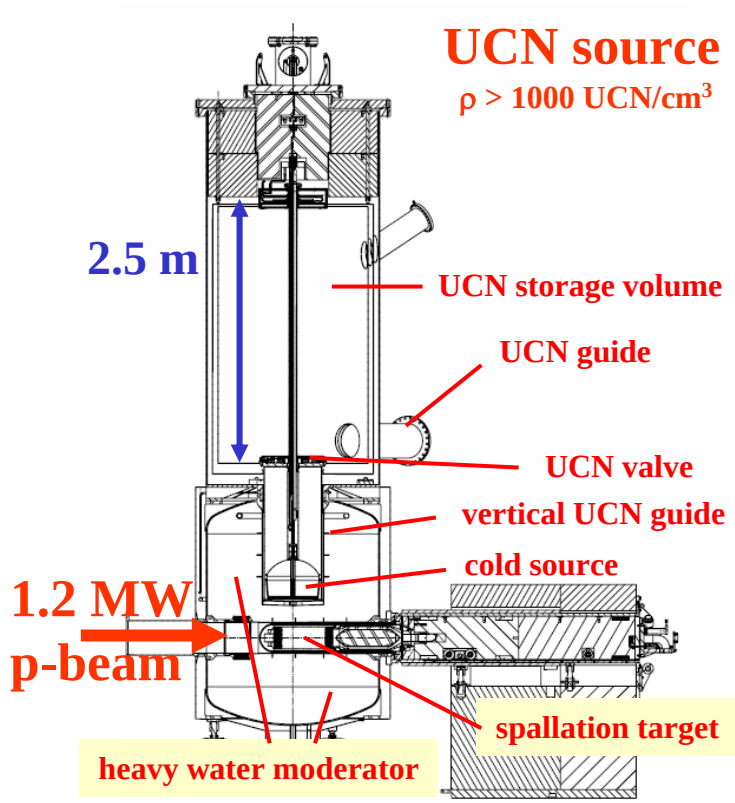
Ultra Cold Neutron Source

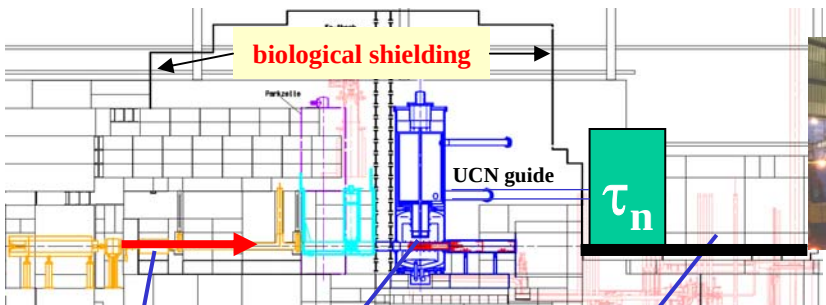
Ultracold Neutrons (UCN)

- UCN have velocities up to ~8m/s (→kinetic energies E_{kin} < 300neV).
- The interaction between UCN and a wall is described by a coherent strong interaction potential, the Fermi potential V_f. UCN are reflected under any angle of incidence if their kinetic energies are less than the Fermi potential of the wall material. Neutrons with kinetic energies above the Fermi potential can still be reflected if their velocity component normal to the reflecting surface is less than the critical velocity, $v_c = \sqrt{2}\, V_f / m_n$, with m_n the mass of the free neutron.

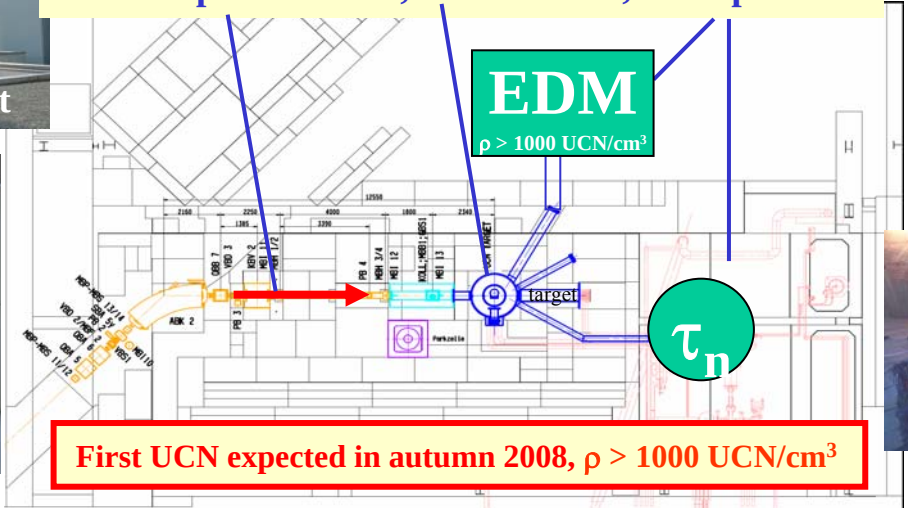
PSI UCN source principle

- Protons from the 600 MeV PSI ring cyclotron hit a spallation target (mainly Lead). About 10 fast neutrons per proton are produced.
- These neutrons are thermalized in heavy water at 300 K. When thermalized they have a lifetime in the heavy water of about 5 ms, i.e. a range of ~10 m.
- Some thermal neutrons hit a cold (5 K) solid Deuterium (sD_2) moderator in the center of the thermal moderator and are downscattered into the UCN energy range, E_{kin} < 300neV.
- In the sD_2 the UCN have a lifetime of about 30 ms during that time some reach the top surface of the sD_2 moderator and are guided upwards into the UCN storage tank. Here, their lifetime, determined from losses at walls and slits is about 400 s.
- The duty cycle of the proton beam on the spallation target is 1 %, e.g. 4s of beam every 400 s or 8 s of beam every 800 s.
- A UCN density of 1000/cm³ is expected for experiments corresponding to an increase over almost two orders of magnitude over existing UCN sources worldwide.
- From the storage tank, UCN can be transported by corresponding guides through the biological shielding to experiments, e.g. the determination of the neutron electric dipole moment or the improvement of its upper limit, respectively.





1.2 MW proton beam, UCN source, Exp. Areas



First UCN expected in autumn 2008, ρ > 1000 UCN/cm³