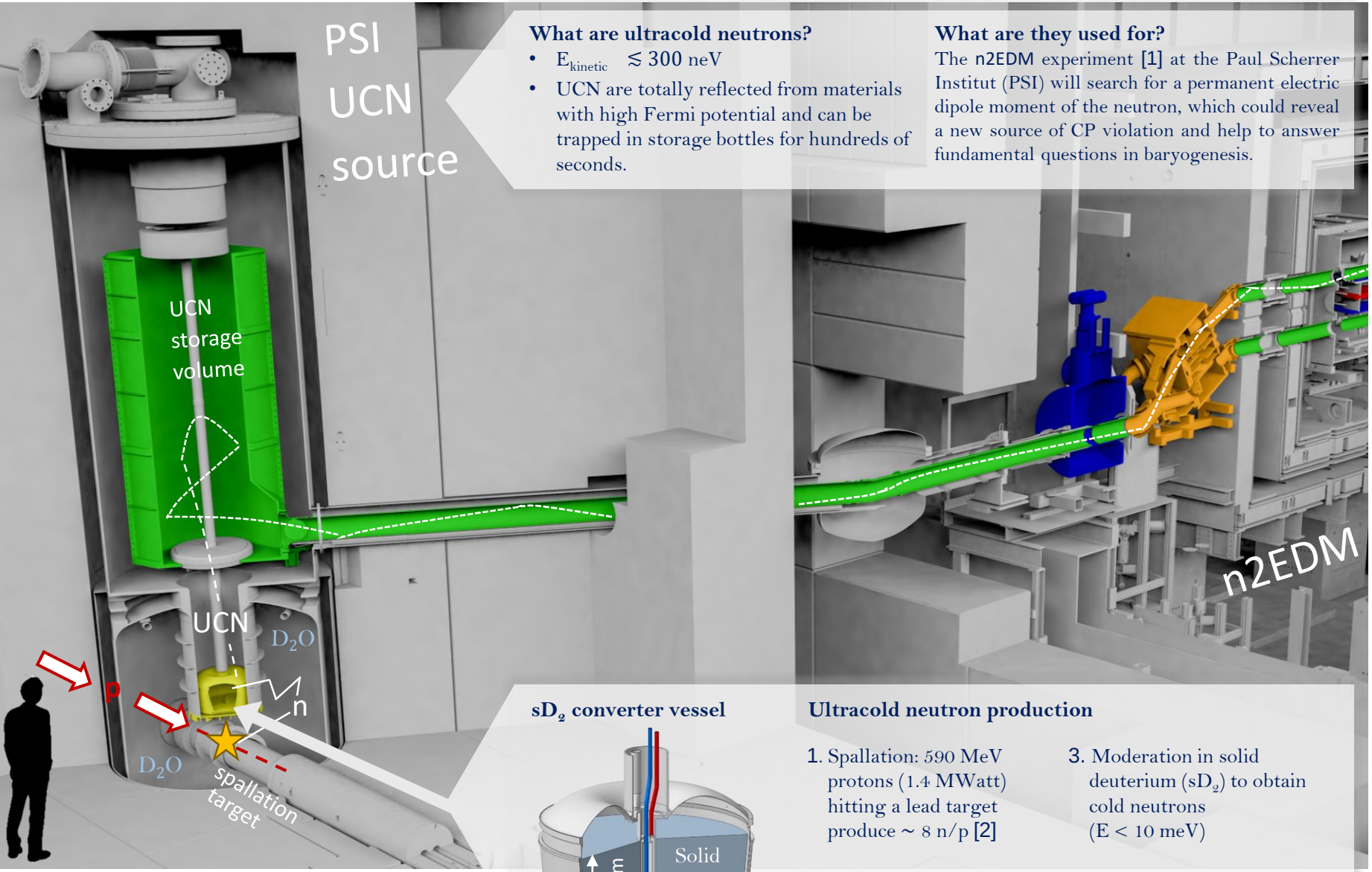
UltraCold Neutron production and extraction from the solid deuterium converter at the PSI UCN source

Ingo Rienäcker
on behalf of the
PSI UCN group

PAUL SCHERRER INSTITUT PSI

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich



What are ultracold neutrons?

- $E_{kinetic} \lesssim 300$ neV
- UCN are totally reflected from materials with high Fermi potential and can be trapped in storage bottles for hundreds of seconds.

What are they used for?

The n2EDM experiment [1] at the Paul Scherrer Institut (PSI) will search for a permanent electric dipole moment of the neutron, which could reveal a new source of CP violation and help to answer fundamental questions in baryogenesis.

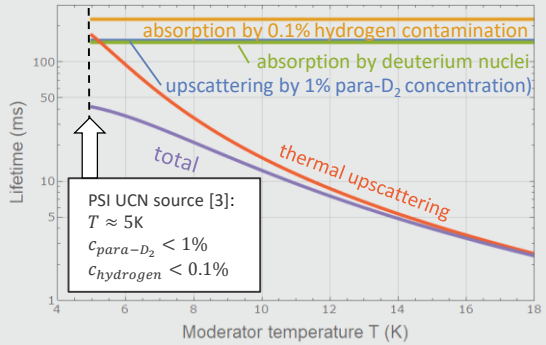
sD_2 converter vessel

Ultracold neutron production

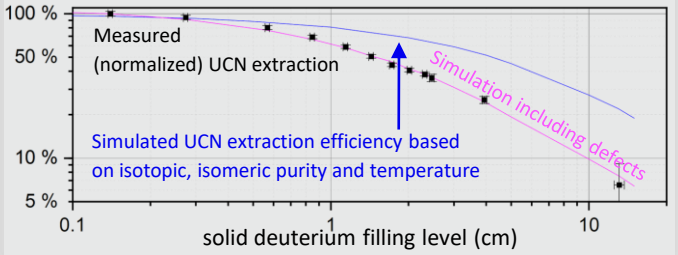
1. Spallation: 590 MeV protons (1.4 MWatt) hitting a lead target produce ~ 8 n/p [2]
2. Neutrons thermalize in a heavy water moderator
3. Moderation in solid deuterium (sD_2) to obtain cold neutrons (E < 10 meV)
4. Conversion to UCN by phonon excitations

The challenge - UCN extraction

The UCN lifetime in sD_2 is limited by upscattering and neutron absorption. The isotopic & isomeric purity as well as the sD_2 temperature must be controlled.

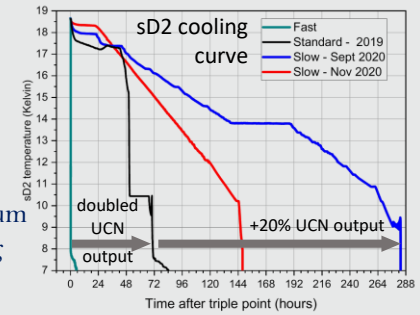


Elastic scattering on defects in the solid deuterium (caused by thermal stress during cooling) leads to longer dwell times, reducing the UCN output.



Recent progress

We improved the UCN extraction by slow freezing and thermal annealing of the solid deuterium (22'000 cm^3) during cooling to 5 K.



[1] nEDM collaboration, Eur.Phys.J. C (2021) 81: 512
[2] Becker et.al., Nucl.Instrum.Methods Phys.Res. 777 (2015) 20–27
[3] N. Hild, DISS. ETH NO. 26412