JOHANNES GUTENBERG UNIVERSITÄT MAINZ

Institut für Kernchemie

Cubic boron nitride- a new material for ultracold neutron application

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Saint Petersburg 2009

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Status of the UCN sources in Mainz

University of Mainz

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Neutron optical potential

$$V = \frac{2\pi}{m}\hbar^2 \cdot \sum_i N_i b_i$$

N: scattering center density
b: bound coherent scattering length
M: neutron mass

→ Critical velocity: $v_c = \sqrt{\frac{2 \cdot V}{m}}$

Common materials:

material	**Fermi potential [neV]**	velocity [m/s]
Be	**252**	6.9
Ni	**252**	6.9
stainless steel	**200**	6
Al	**54**	3.3

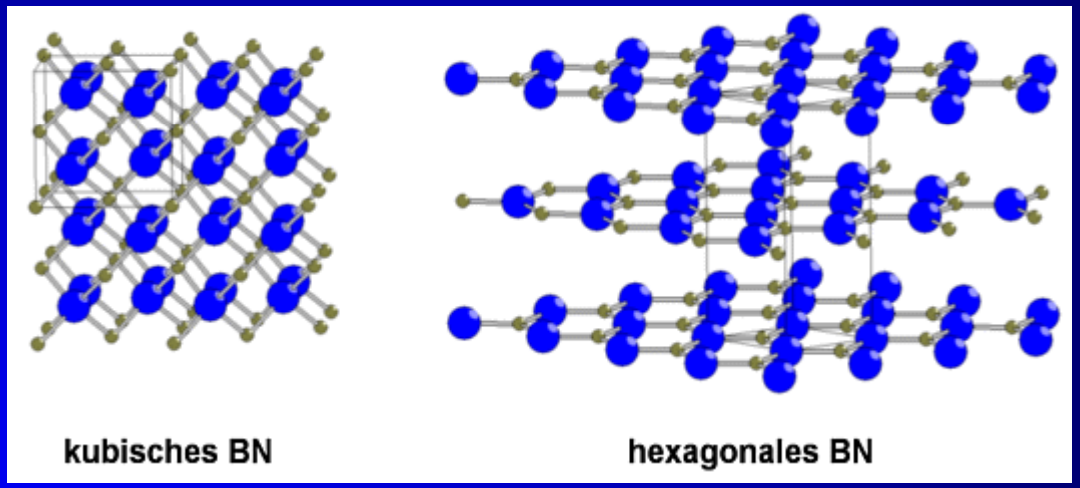
Non common Materials

material	**Fermi potential [neV]**	velocity [m/s]	Typical Application	disadvantage
^{58}Ni	**335**	8	UCN guides	Expensiv
BeO	**257**	7.2	Storage vessel	toxic
Diamond	**305**	7.6	Storage vessel	Production (H_2)
DLC	**250 - 270**	6.9 - 7.2	Storage vessel, guides	Production (H_2)

Looking for new candidates with improved characteristics

Boron nitride

BN:		
	molar mass:	24,83 g·mol^{-1}
	scattering length:	14.66 fm
	insulator:	>10^{15} Ohm cm
	melting point:	2000°C



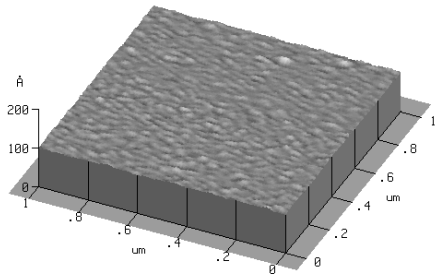
Density:	3,45 g·cm^{-3}	2,25 g·cm^{-3}
Fermipotential:	338 neV	220neV

Film Production

Coating performed at IST Braunschweig (M.Keunecke)

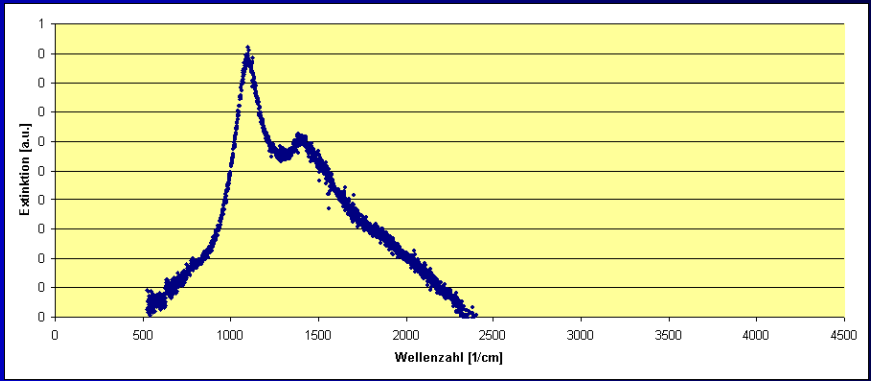
Reactive RF- sputtering in nitrogen
Atmosphere from boron carbide target

Special procedure was developed by the IST to obtain 2µm layers of cBN



c-BN-Schicht ca. 0,2 µm
RMS-Rauhigkeit 2,27 Å

Infrared spectrum of typical samples



- cBN peak at 1090 1/cm
- hBN fraction from peak at 790 1/cm

First samples

Natural boron (20% ^{10}B)

$$V_F = 338neV$$

UCN death !!!

767 barn absorption

Isotopic enriched ^{11}B

0.0055 barn absorption

+ 2 barn of N_2

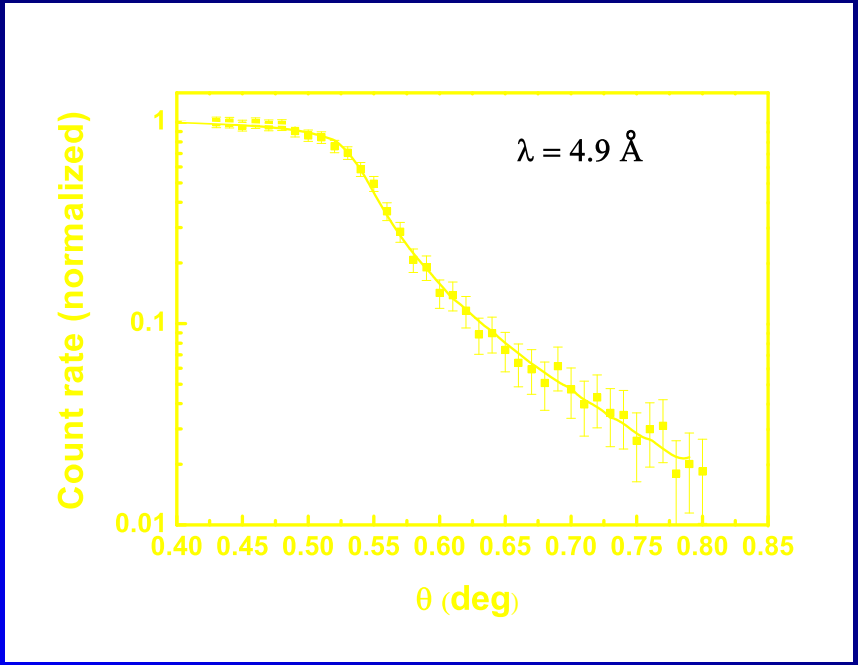
Standard 3“ Silicon wafer
Coated with 300nm of cBN structur

$$V_F \approx 350neV$$

nat. Ni 4.5 barn

Neutron reflectometry

Cold neutron (4.8 A) reflectometry performed at HMI (Th.Krist)

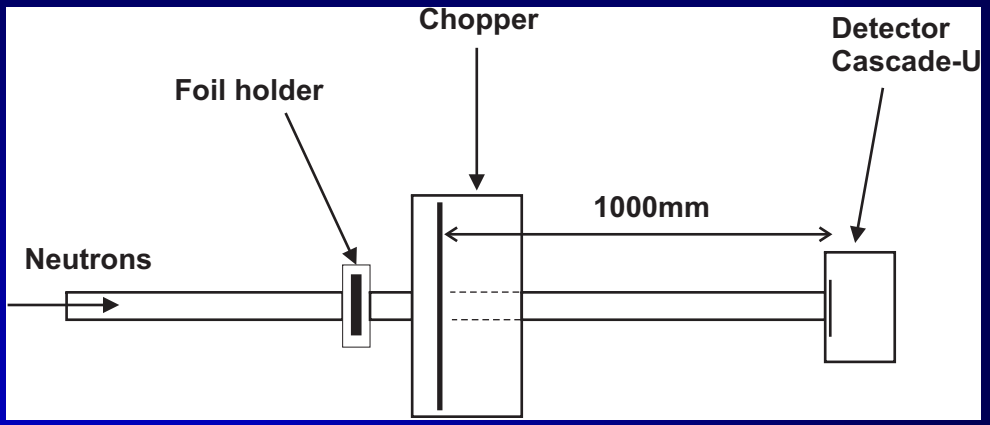


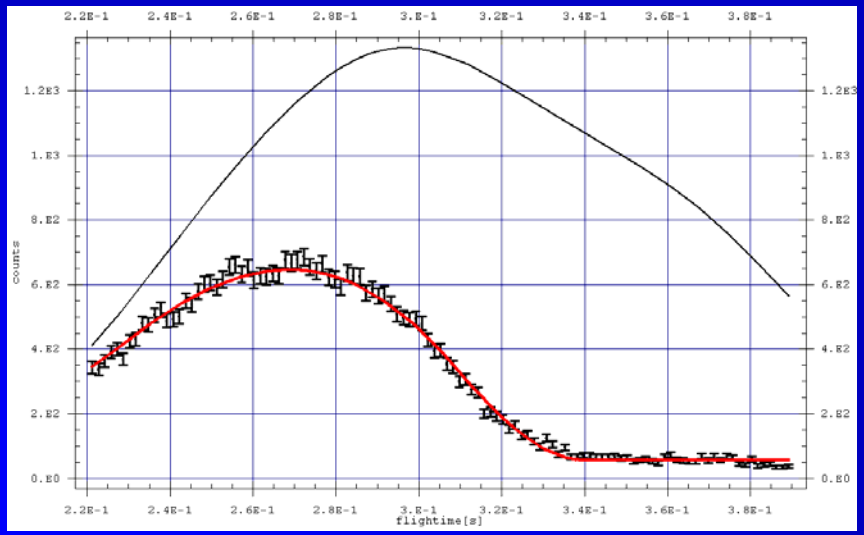
waviness of sample ⟶ not exact cut off angle

Fit Result: 300+/- 30neV

Transmission of UCN

Time of flight method





Result of the fit

305 +/- 15neV

91% of theoretical density

Check of TOF methode

Crosscheck:

500nm Ni on Si wafer

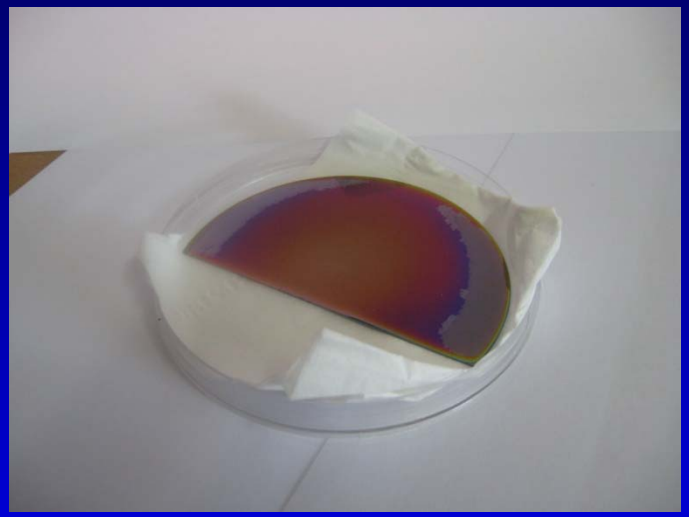
Fit Result :

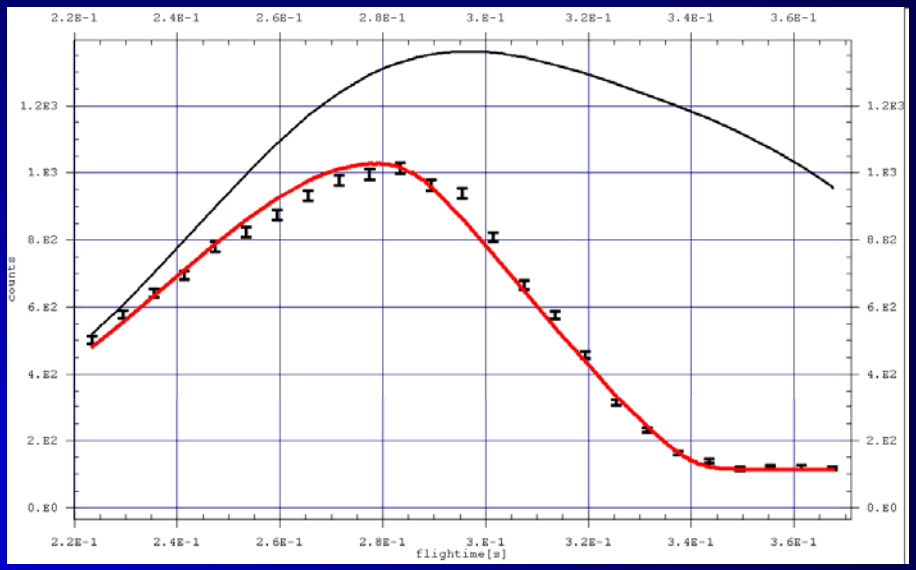
245 +/- 15neV

98.2% of theoretical density

Density verified by x-ray diffraction measurement !

First $c^{11}BN$ sample (96.22% ^{11}B)





First boron 11 sample:

- 340nm cBN on Si wafer
- Stresses in layer !!
- Production parameters are different from standard target

- smaller absorption (100barn) !!
- Preliminary Result of Fermi Potential

~ 315 +/- 10neV

~ 93% of theoretical density

Conclusion and Outlook

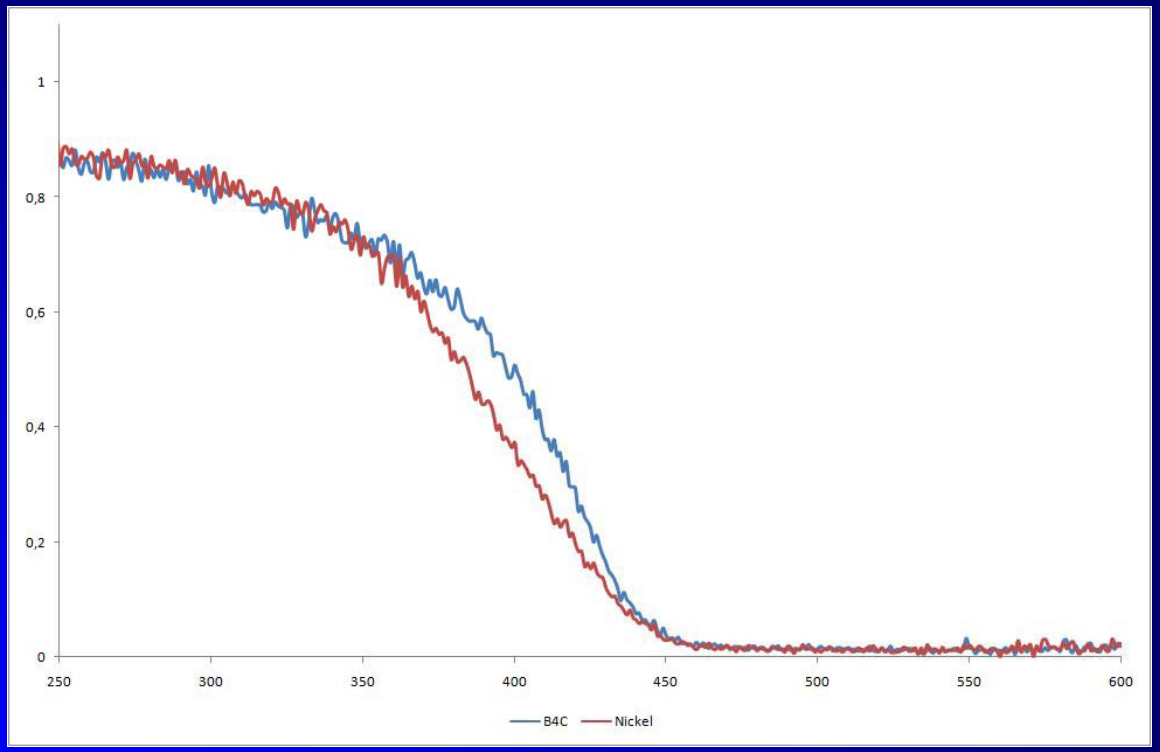
- First measurement of the Fermi Potential of natural and isotopic enriched cubic boron nitride

- Further improvements of production parameters for isotopic boron are needed

- Investigation of losses during storage of ultracold neutrons in a vessel coated with highly enriched cubic boron-11 nitride

Conclusion and Outlook

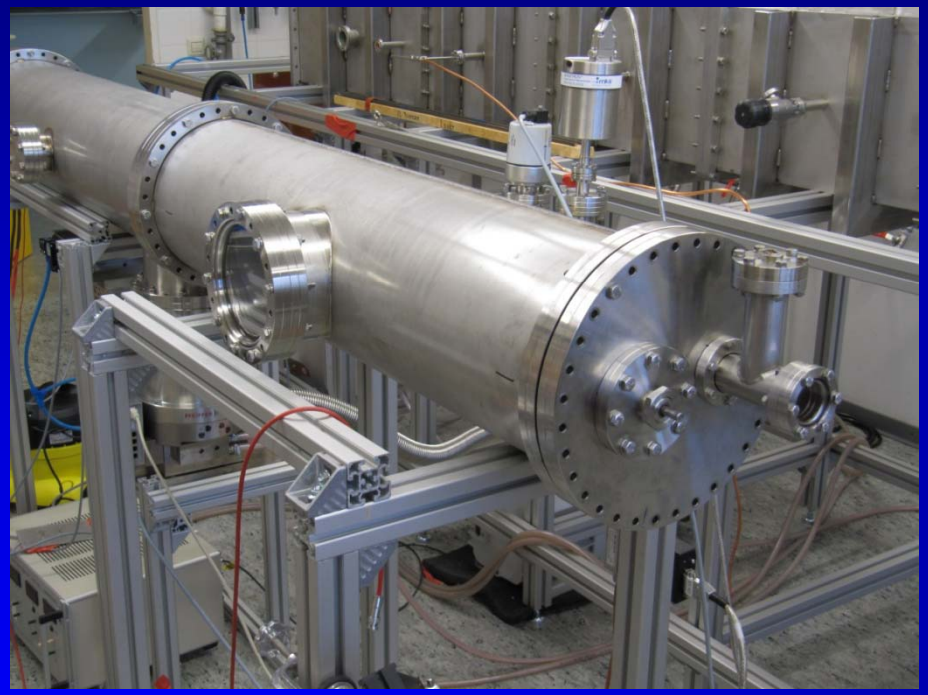
Investigation of B4C for non depolarizing UCN guides based on B_4C



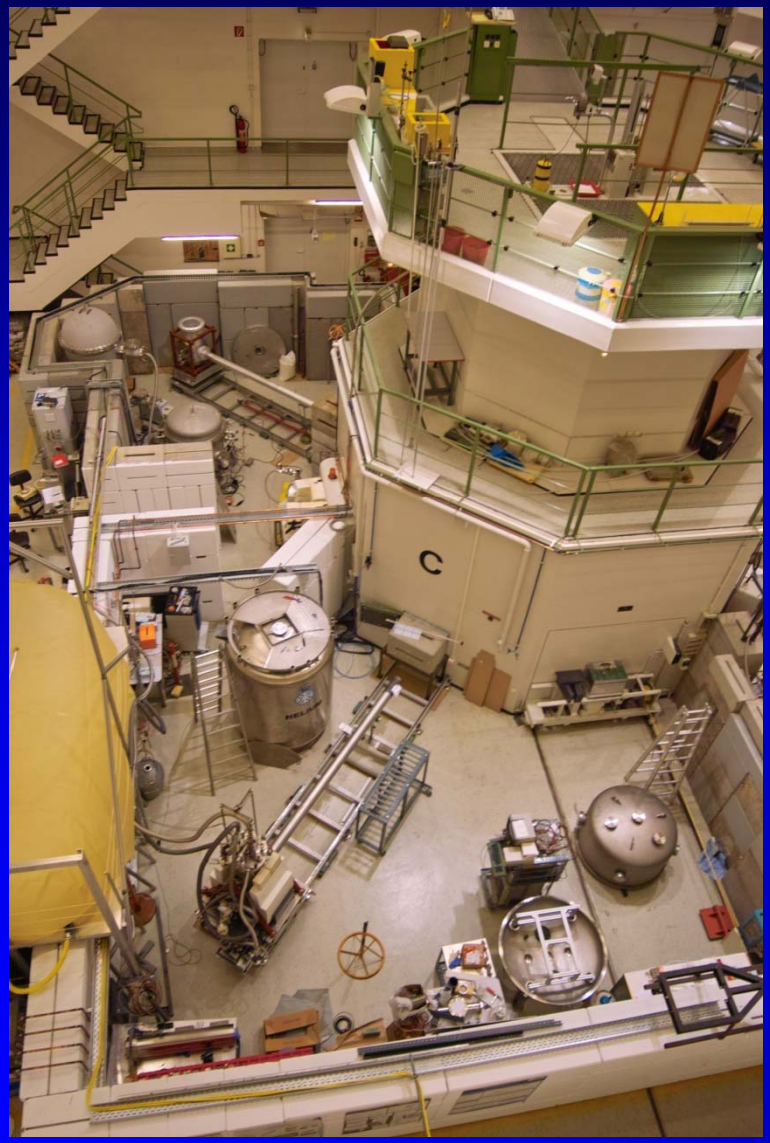
Expected: 220neV Measured: ~ 211neV

Conclusion and Outlook

Production of UCN guides based on discussed materials



Ultracold neutrons at the TRIGA Mainz



Triga Mark II

Pulse mode 250MW in peak
constant power 100kW

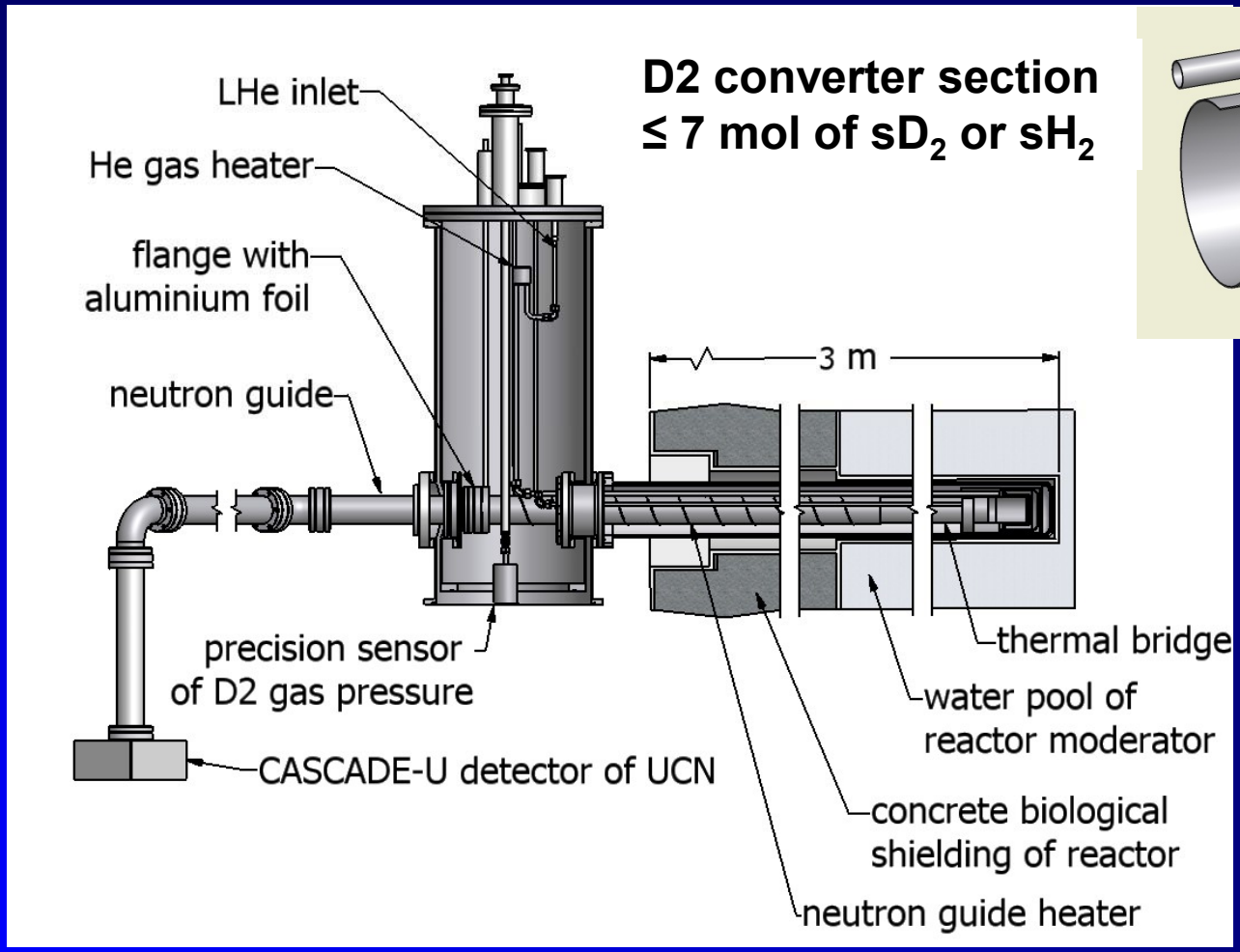
UCN C (tangential beamline)

operation since 2006)
200000 UCN/2$ Puls
Filling time 2.2 sec
Helium consumption 16l/h
Crystal Preparation 3 hours

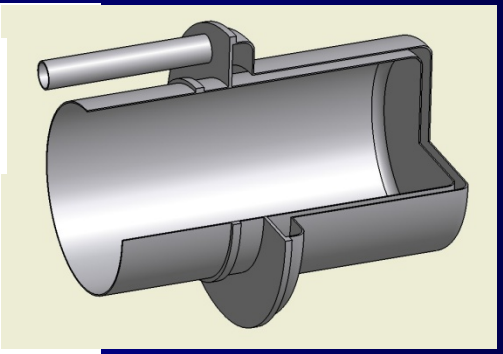
UCN D (Radial beamline)

Source ready!
Waiting for German TÜV approval

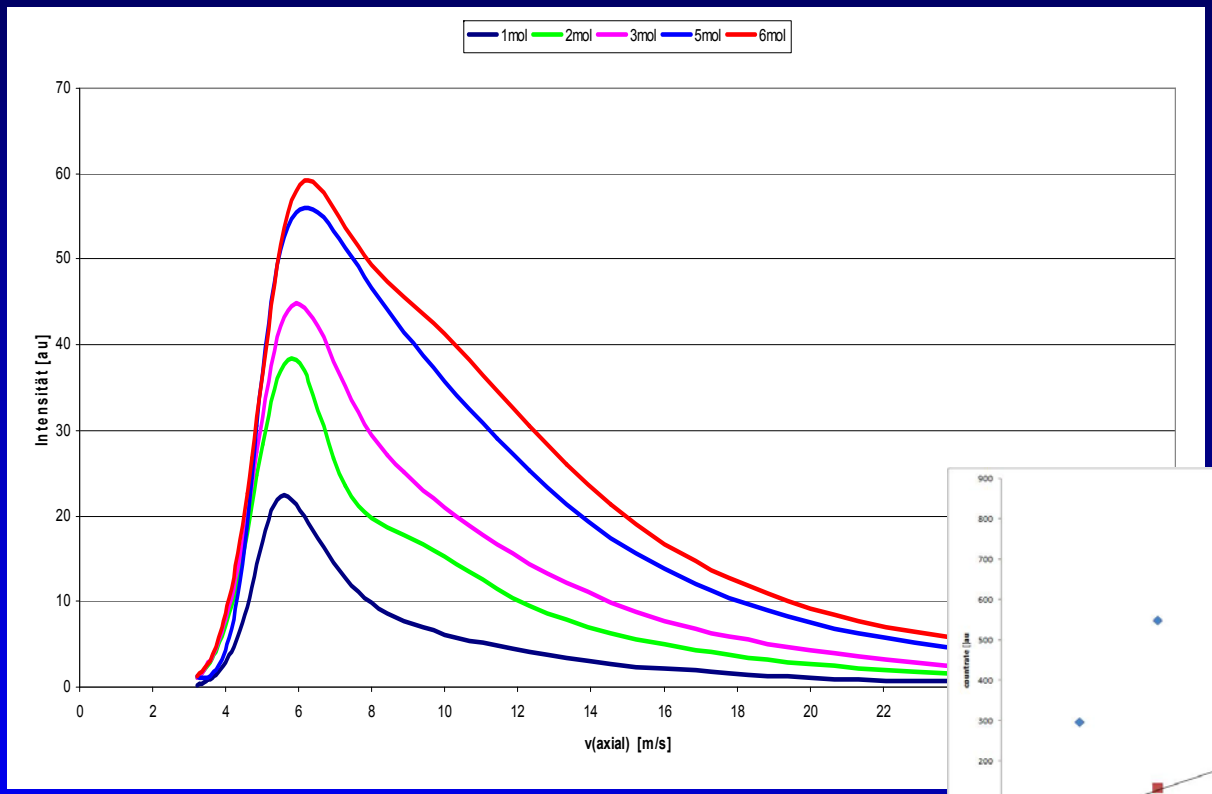
Munich/Mainz Prototype source

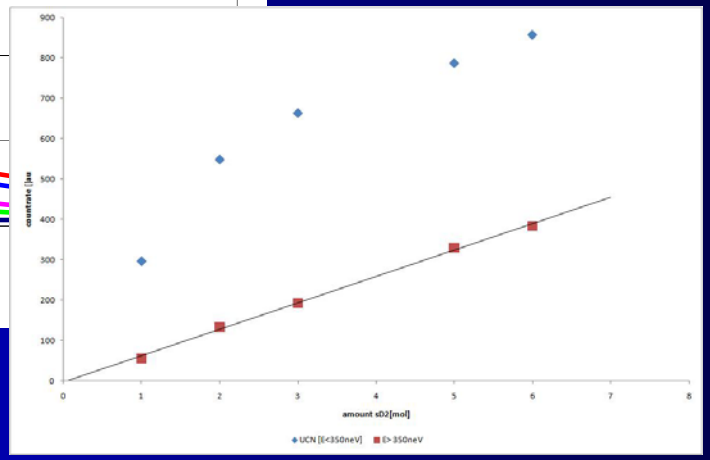


D2 converter section
≤ 7 mol of sD_2 or sH_2



Investigation of sD2

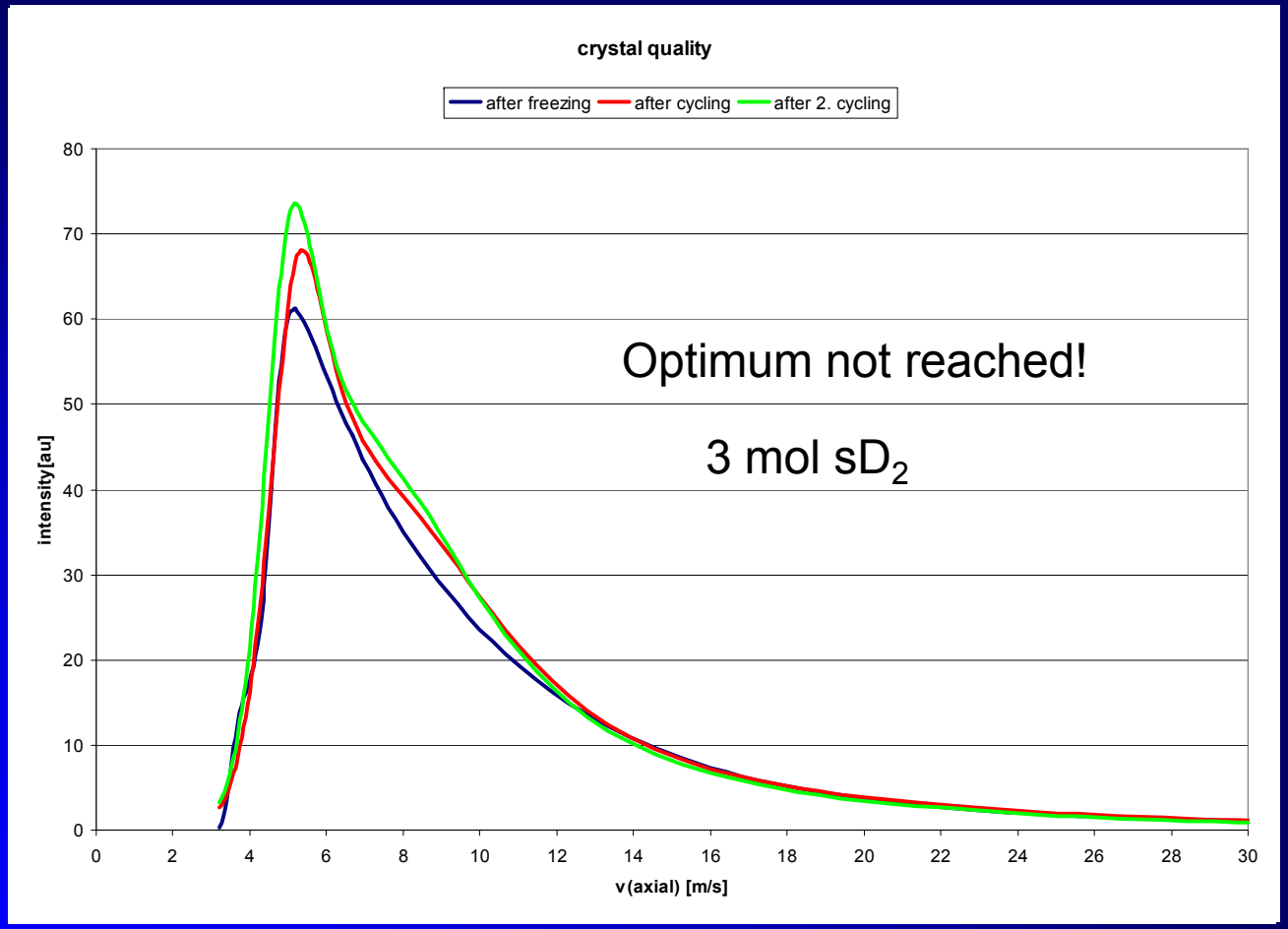




Mean free path of UCN inside sD2 <2cm

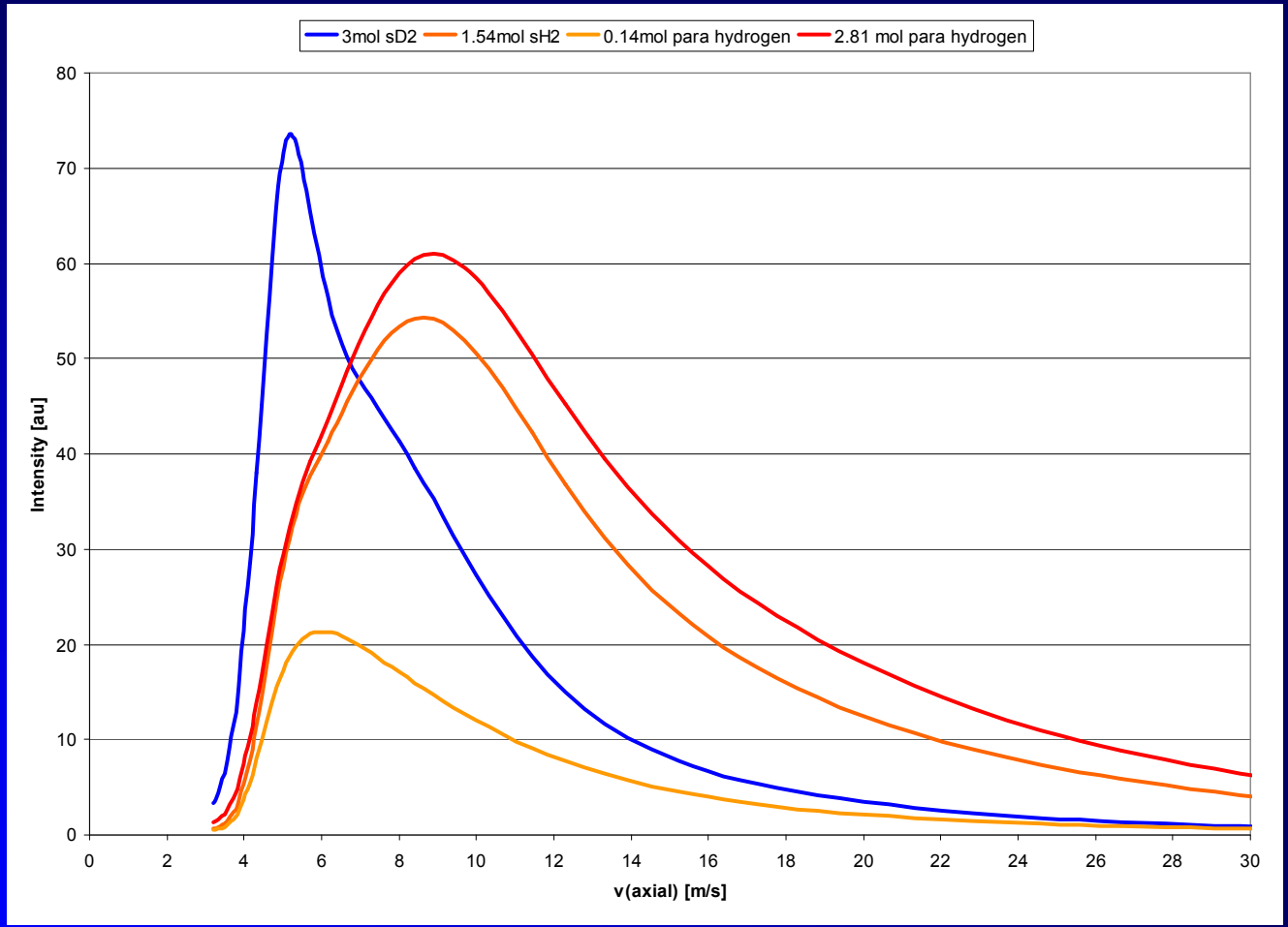
premoderator should be separated from converter volume

Investigation of sD2



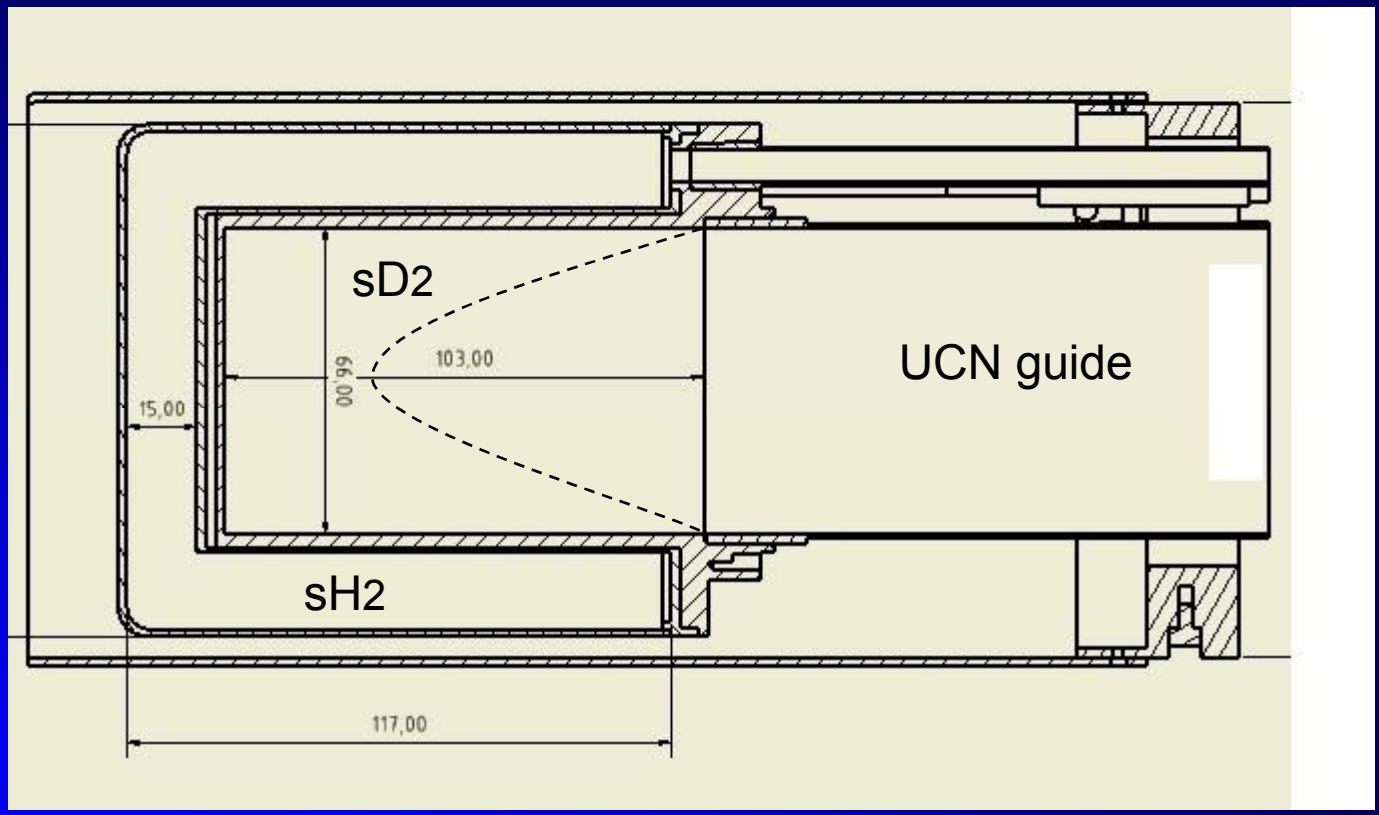
30min Cycling improves transparency of deuterium

Investigation of sH2



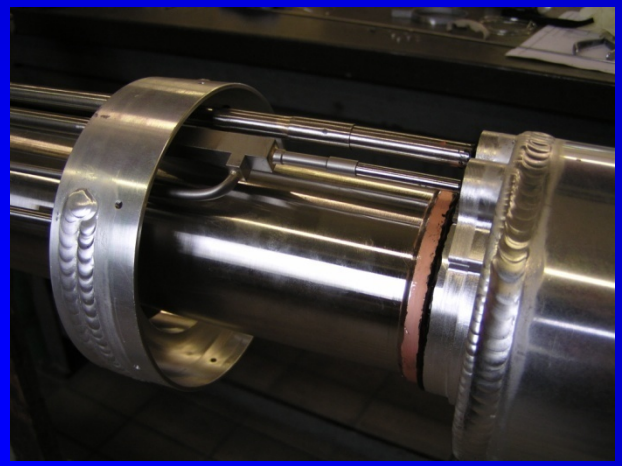
First measured TOF spectras of a solid hydrogen UCN source

New beamline at radial channel



New Design of the converter section

New beamline at radial channel



Blablabla !!

Thank you

for your attention !