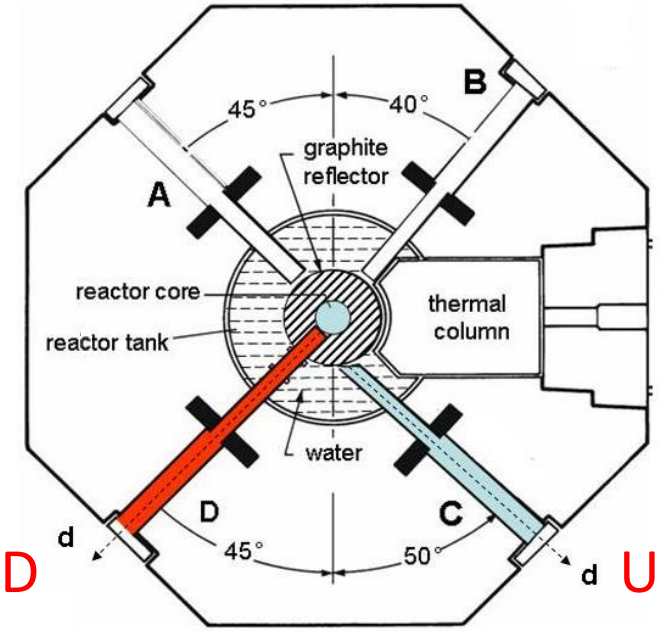
Status of the UCN source at beamport D of the research reactor TRIGA Mainz

Yu. Sobolev[1], M. Beck[2], K. Eberhardt[1], Ch. Geppert[1], J. Karch[2], S. Karpuk[1], F. Kories[2], W. Heil[2], T. Reich[1], Ch. Siemensen[1], N. Trautmann[1]

[1]Institute of Nuclear Chemistry, Johannes Gutenberg University Mainz, 55099 Mainz, Germany
[2]Institute of Physics, Johannes Gutenberg University Mainz, 55099 Mainz, Germany

International Workshop: Probing Fundamental Symmetries and Interactions with UCN
11-15 April 2016, Waldthausen Castle, Mainz

Research reactor TRIGA Mainz



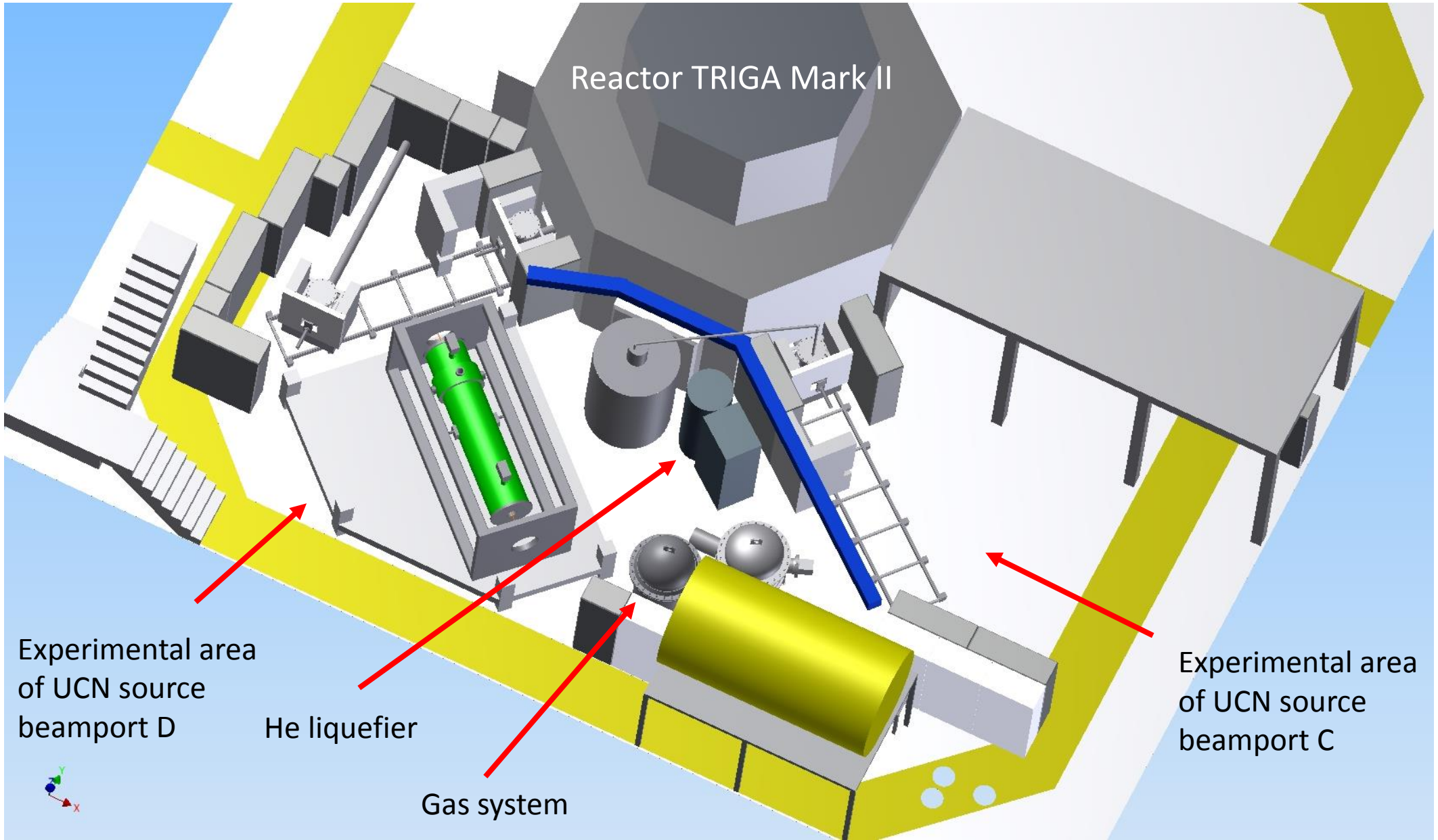
UCN-D UCN-C

two operation modes:

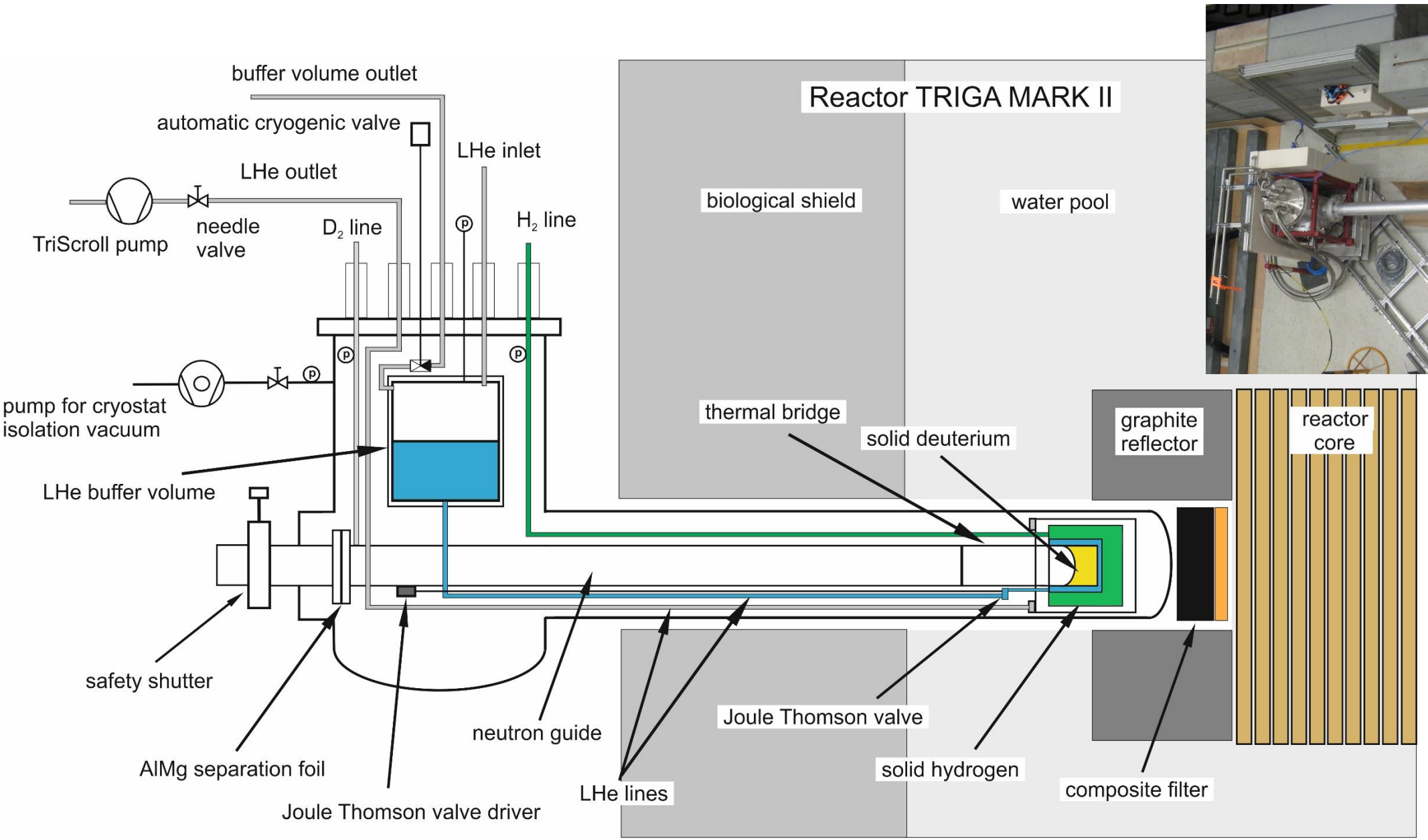
steady state:
100 kW_{th} , 10^{12} n/cm^2s

pulse mode:
250 MW_{th} (30 ms),
$2 \cdot 10^{15}$ n/cm^2s

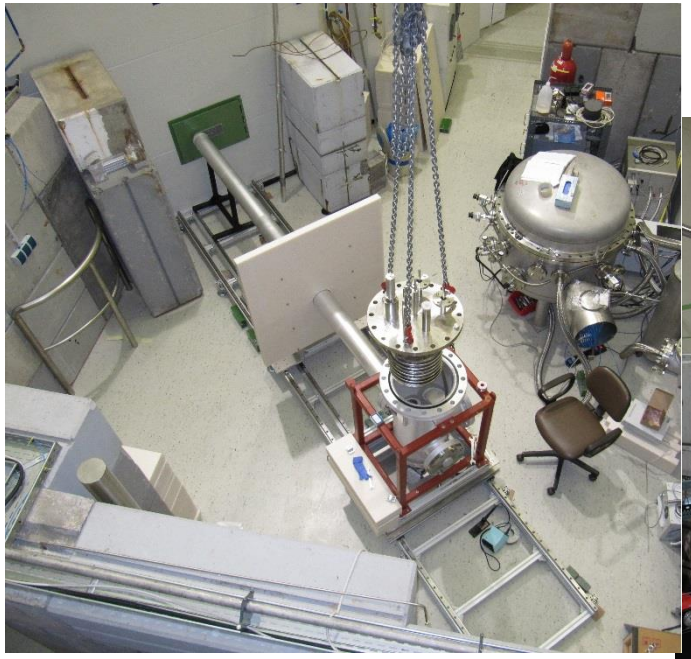
UCN facilities at TRIGA Mainz



UCN source at beamport D of the TRIGA Mainz



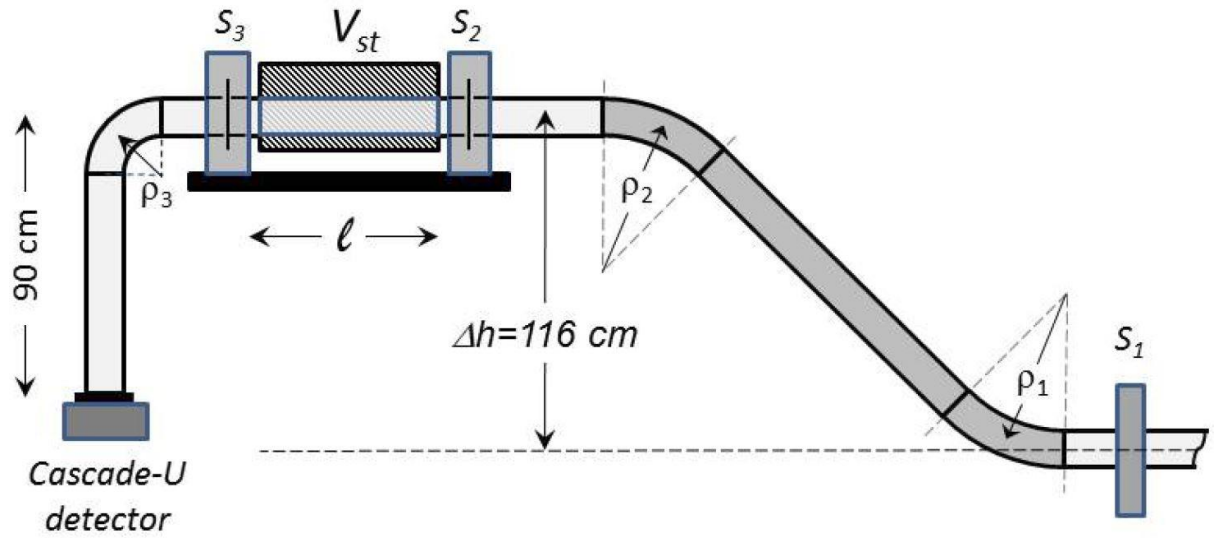
UCN source at beamport D : brief history

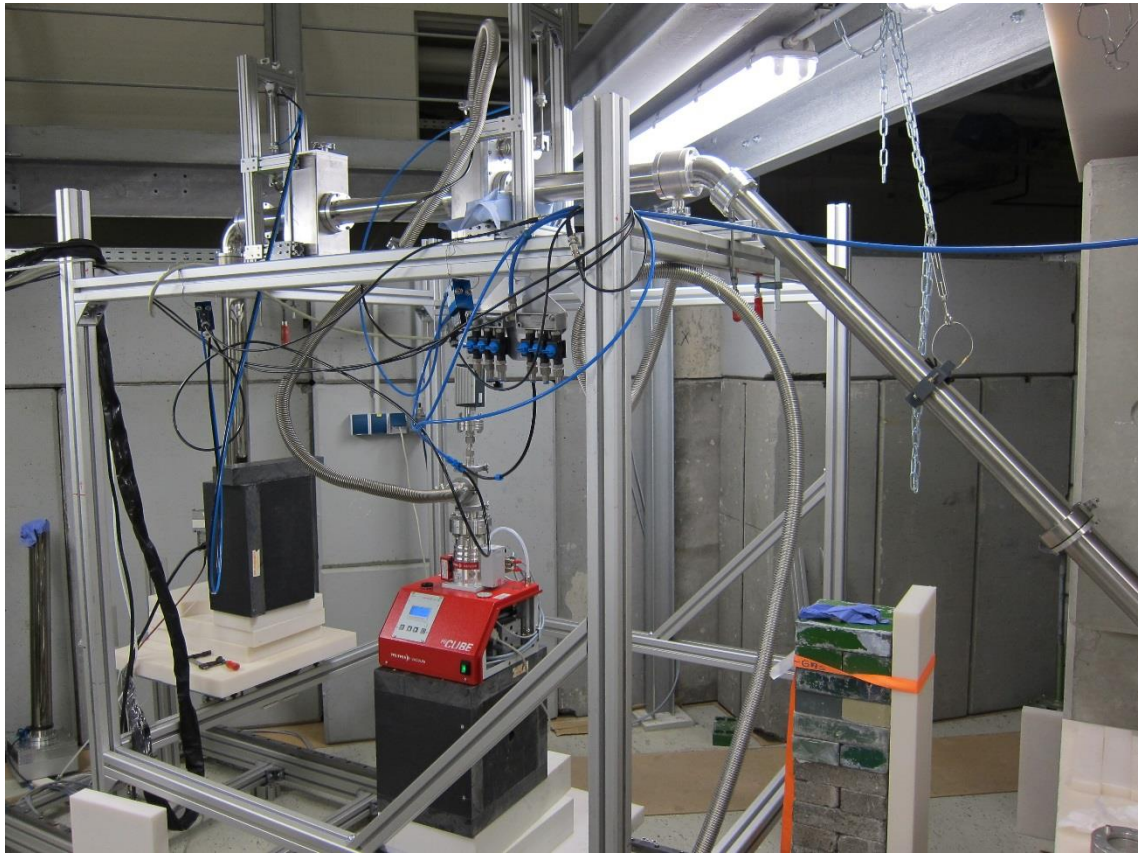


2007-2011	Construction of the gas system and the cryostat of the UCN source
May 2011	First yield of UCN at beamport D
2012-2013	Optimization of the heat load for solid deuterium, UCN density measurements
2014	Installation and commissioning of the helium liquefier
2015-2016	Regular operation of UCN source at beamport D

Measurements of UCN source performance

Setup

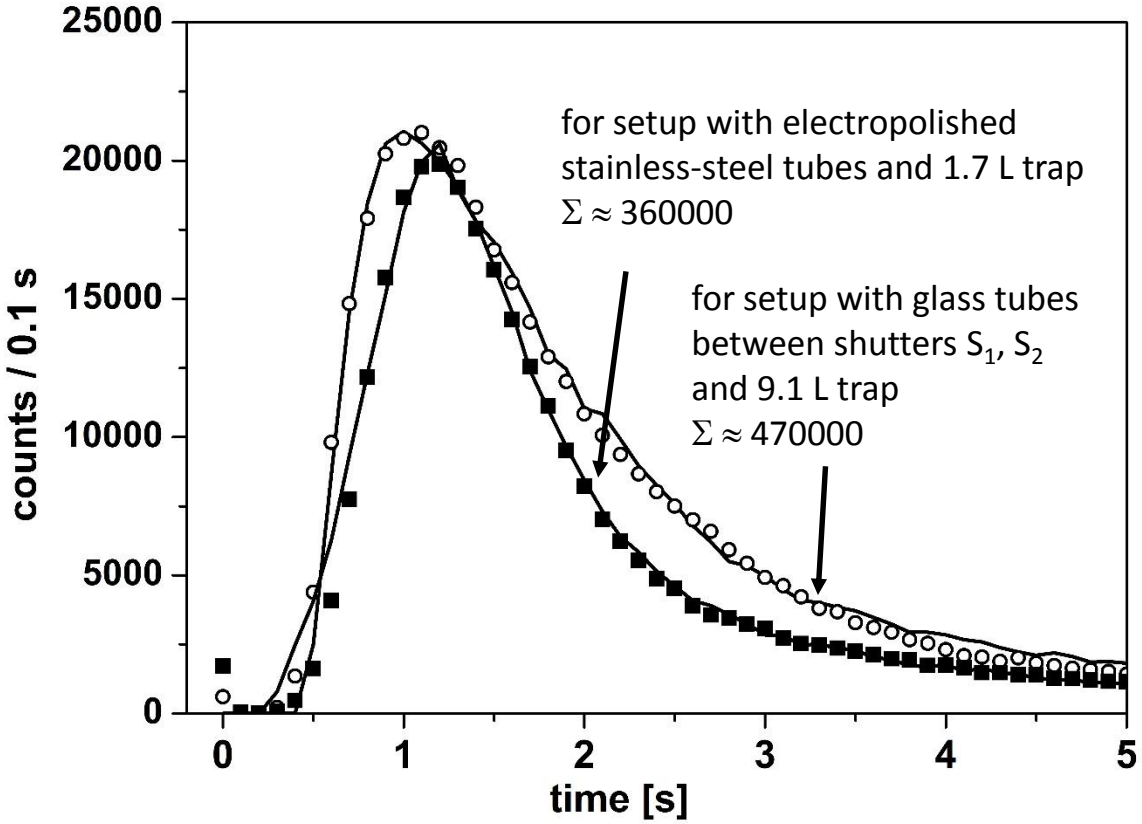




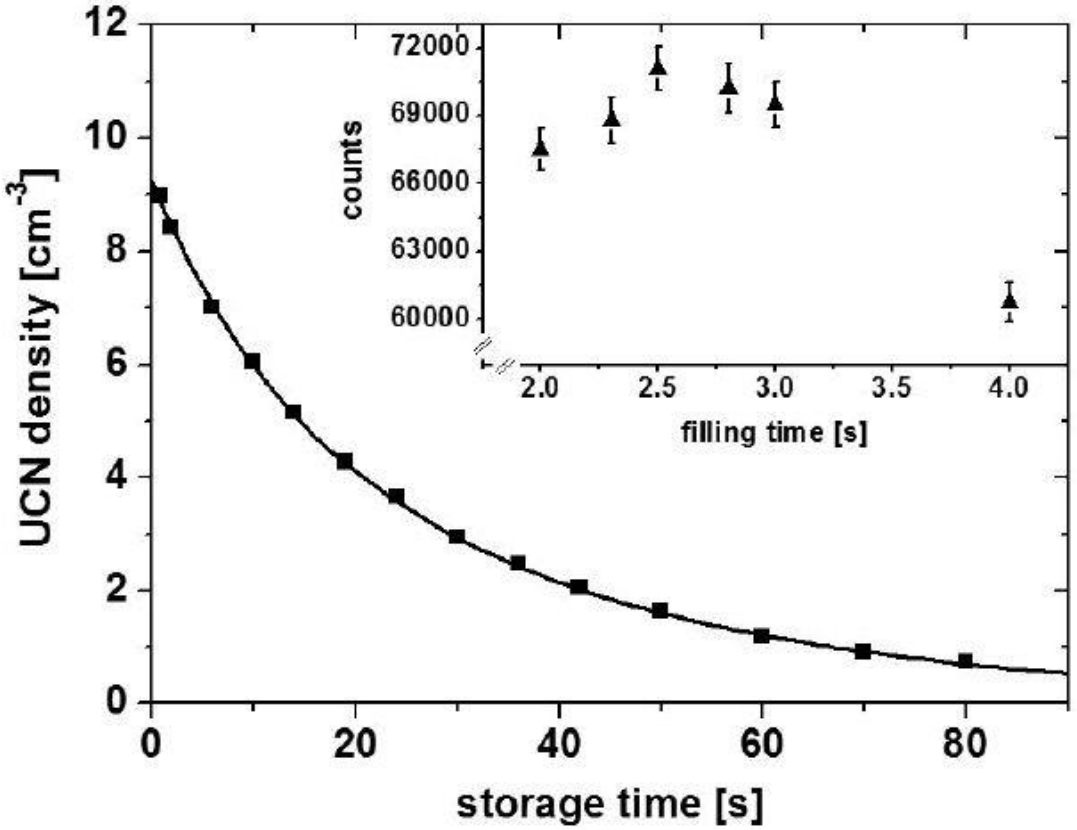
Experimental setup used to measure the UCN&VCN source performance: S_1 safety shutter at the exit of the UCN source;
V_{st} – storage vessel; fast shutters S_2 and S_3 with opening and closing times of 0.1 s.
A vertical guide (90 cm) leads to the Cascade-U detector.
UCN density measurements were performed in the storage mode, whereas UCN&VCN yields were measured in flow-through mode (all shutters S_1-S_3 were open during pulse).

UCN measurements

results



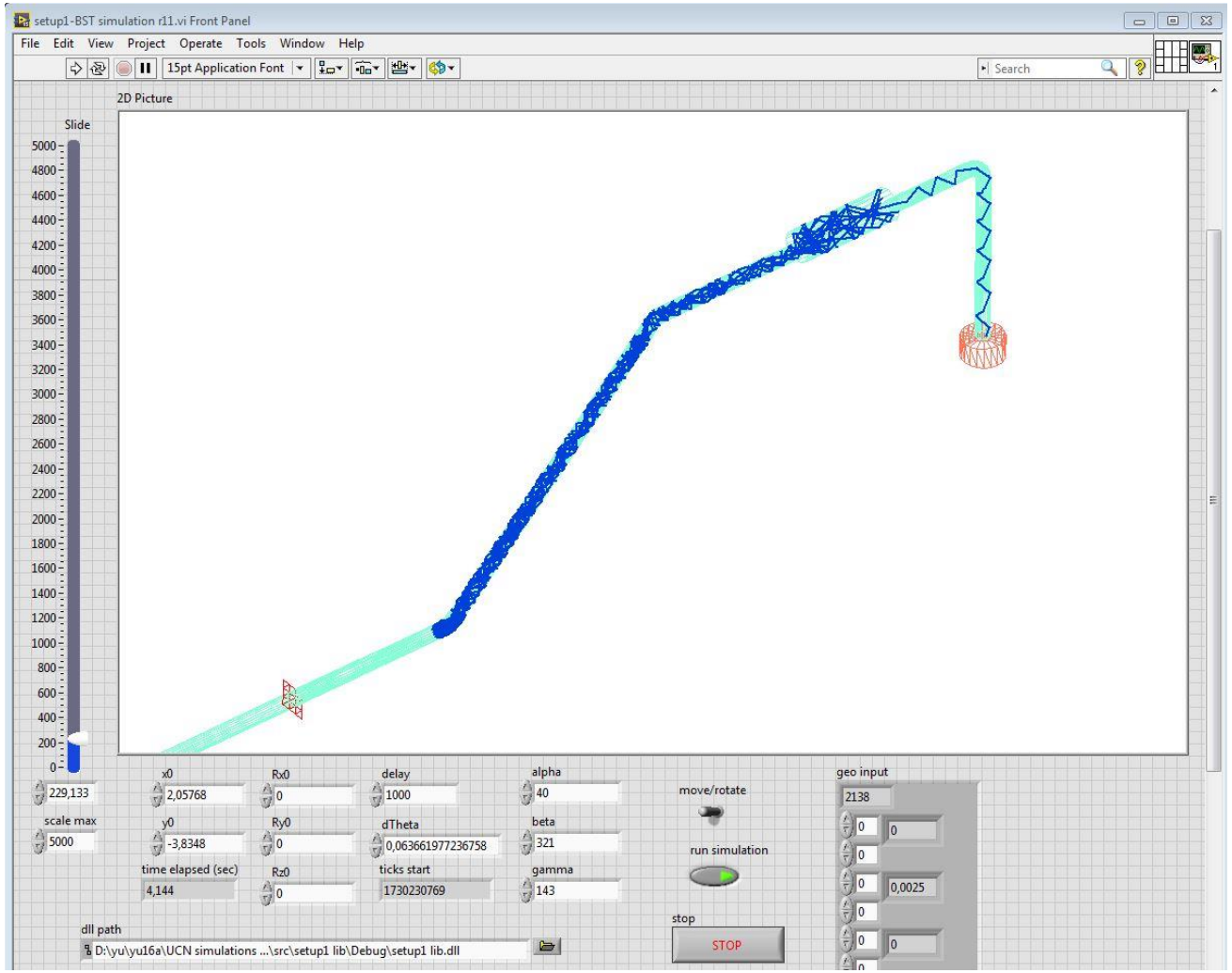
Measured UCN&VCN counts/0.1s in the flow mode *versus* time after a reactor pulse at t_0 = 0 s.
The full squares and the open circles represent experimental data whereas solid lines show fits. MC simulation gives ~ 2.4x10^5 UCN at the experimental area.



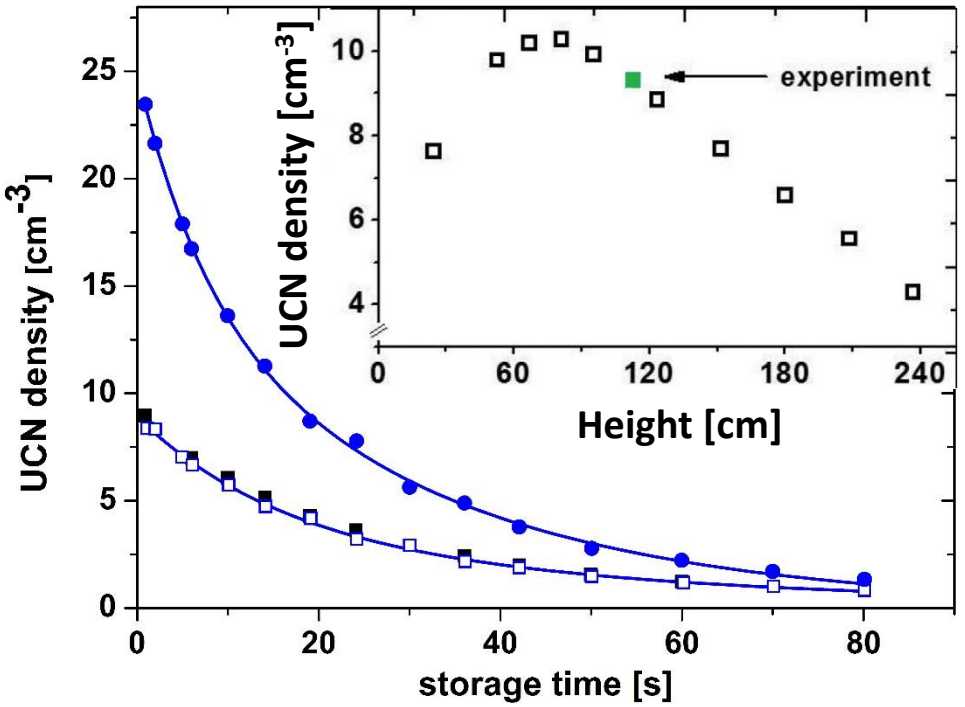
UCN density (ρ_{ucn}) per reactor pulse (10 MJ) as a function of the storage time T_{st} of UCN in a volume of V_{st} = 9.5 L (filling time was set to Δt = 2.5 s).

Karch, J., Sobolev, Yu., Beck, M. et al.: Performance of the solid deuterium ultra-cold neutron source at the pulsed reactor TRIGA Mainz, Eur. Phys. J. A 50 (2014) 78.

Upgrade of the UCN source at beamport D : MC simulations



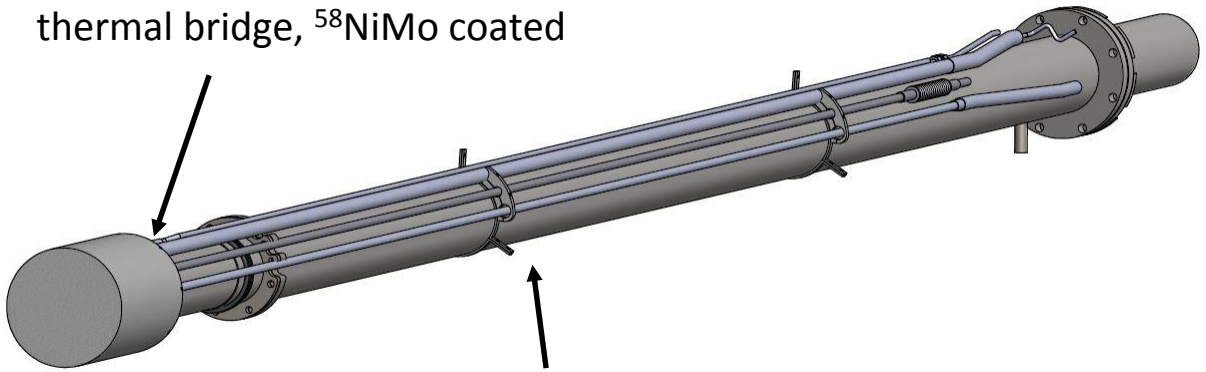
Simulation program for UCN source & storage setup



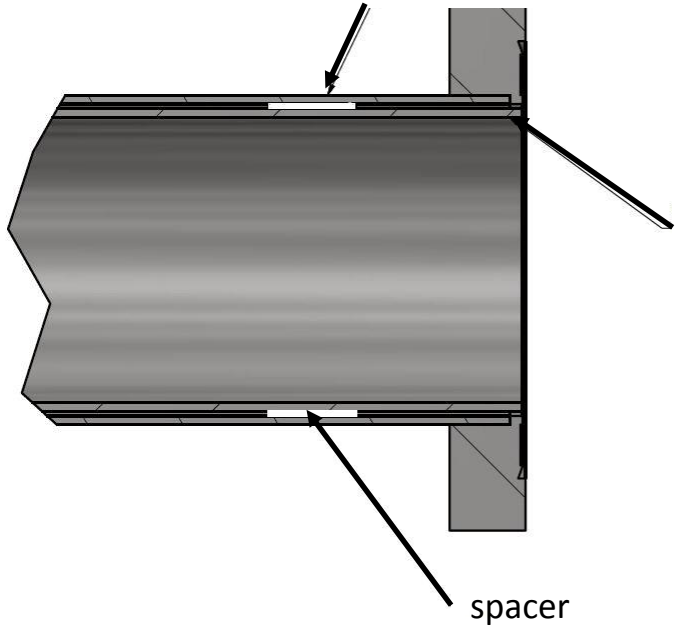
Expected UCN densities (hollow squares) per reactor pulse (10 MJ) in a storage vessel of V_{st} = 9.5 L plotted as a function of the storage time T_{st}. The experimental data are also shown in the diagram (full squares).
MC simulations (full circles) using ^{58}NiMo-coated stainless-steel tubes predict a UCN density ($T_{st} \rightarrow 0$) of about 25/cm^3.

Upgrade of the UCN source at beamport D: Concept & transmission measurements

Electropolished converter cup & thermal bridge, ^{58}NiMo coated



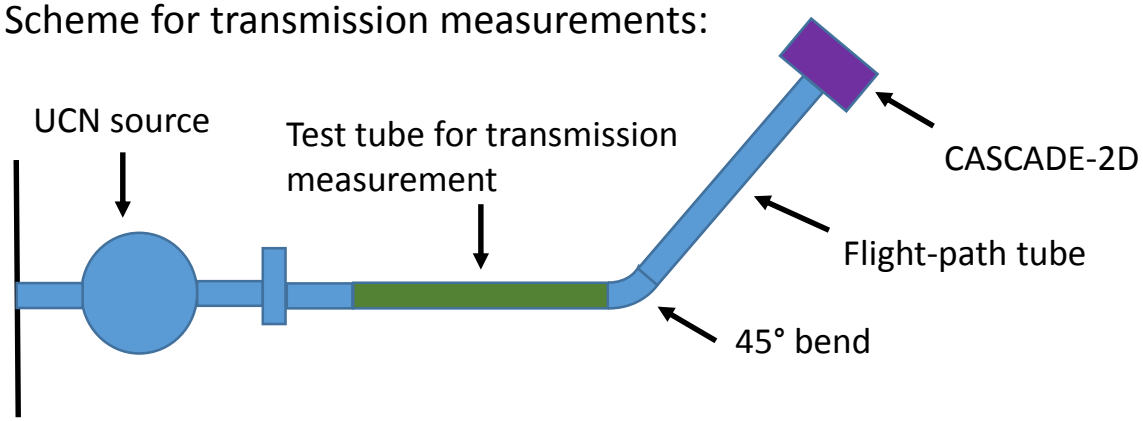
outer tube



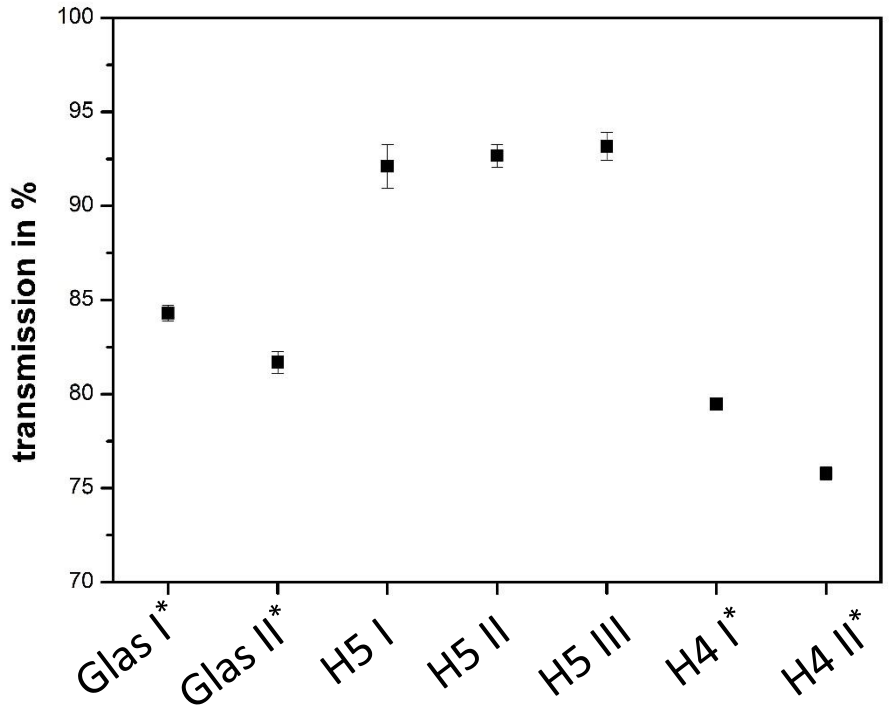
Inner guide (electropolished), Ra < 90 nm

spacer

Scheme for transmission measurements:



Transmission measurements



Conclusions and outlook

- A new superthermal UCN source at beamport D of the TRIGA Mainz is in regular operation since April 2015. After installation and commissioning of a helium liquefier in 2014, it has been used for long-term experiments.

- Currently the UCN source can deliver up to 240000 UCN per 10 MJ reactor pulse at the experimental area. UCN density ~ 10 UCN/cm^3 in a 10 L storage vessel has been obtained.

- From MC simulations we can expect a factor > 2 higher UCN density per reactor pulse by using neutron guides with a better surface quality (smaller surface roughness) and ^{58}NiMo coating. The upgrade of the UCN source has just been started.

Acknowledgements:

This work was supported by the DFG under the contract number He 2308/2-1(2-2), by the Rhineland/Palatinate Foundation, project number 961- 386261/993, and by the Cluster of Excellence PRISMA “Precision Physics, Fundamental Interactions and Structure of Matter”, Exc 1098.
We thank the reactor staff, workshops of Institute of Nuclear Chemistry and Institute of Physics, Mainz and Th. Lauer for their help.