



# Search for UCN upscattering by SAW



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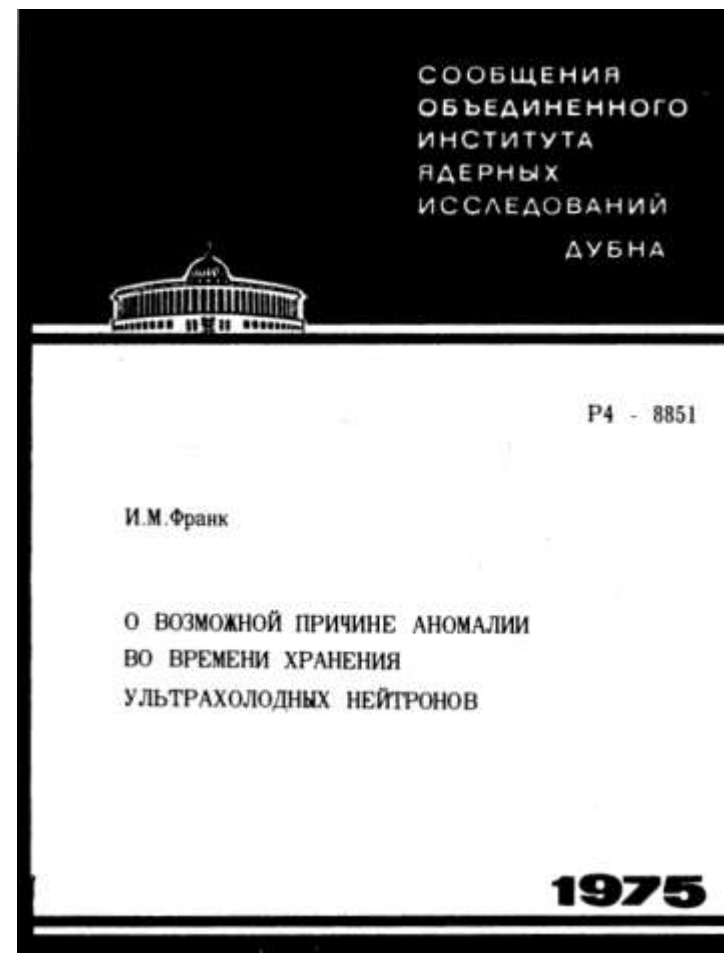
# Outline:

1. Motivation
2. Idea of the experiment
3. Background problem and velocity filter
4. Setup
5. Optical calibration of the sample with SAW
6. Investigation of the UCN spectrum inside the chamber
7. Preliminary results
8. Conclusion



# Motivation

- The first who pointed out that UCNs have to be upscattered by SAW was I.M.Frank (**I.M. Frank JINR Comm. R4-8851 (1975)**).
- UCN upscattering in the case of waves at the surface of a fluid:
- **Yu. N. Pokotilovski. Phys. Lett A, 255, (1999) 173**
- **S. K. Lamoreaux and R. Golub, Phys. Rev. C 66, 044309 (2002)**
- UCN upscattering by SAW have never been observed in a experiment

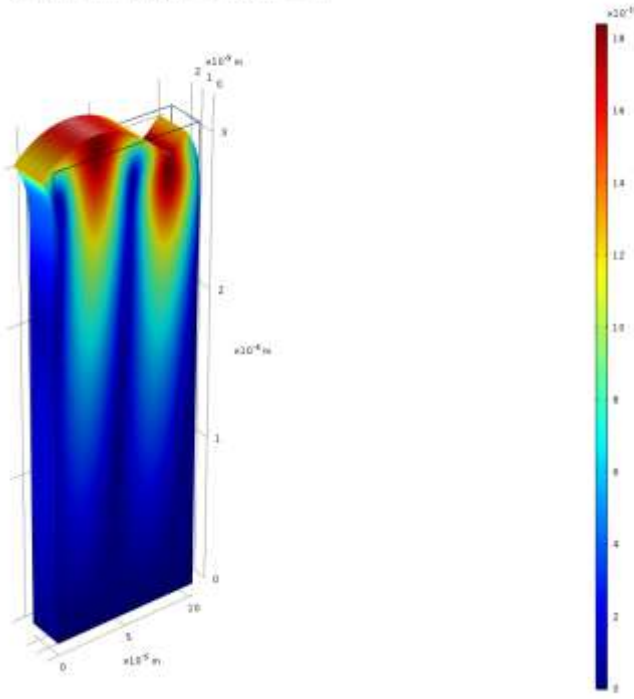


# Motivation



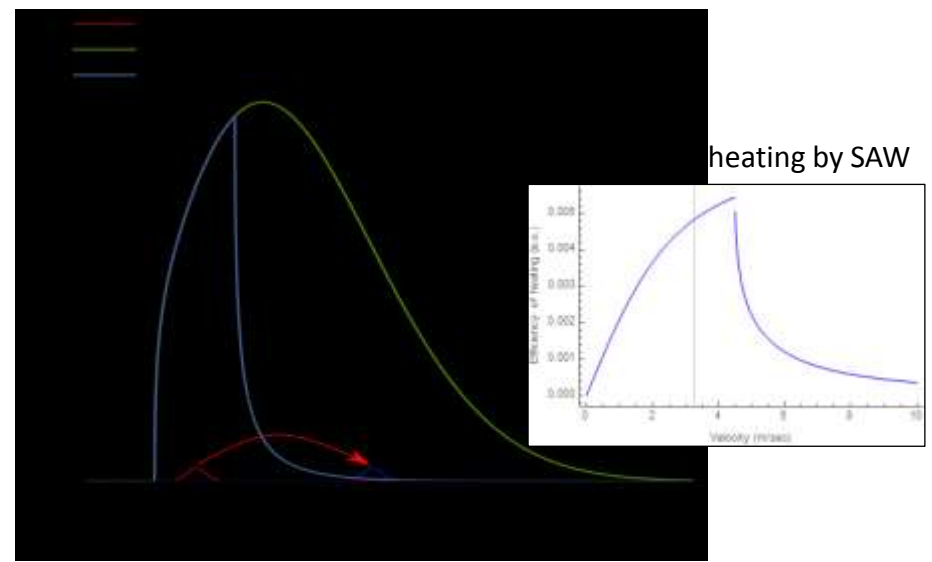
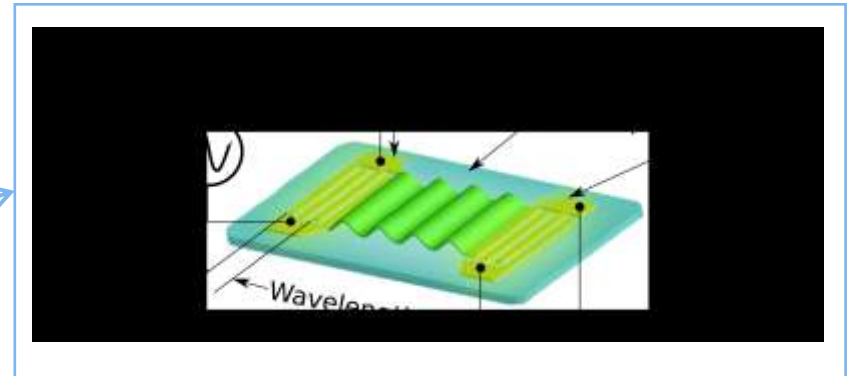
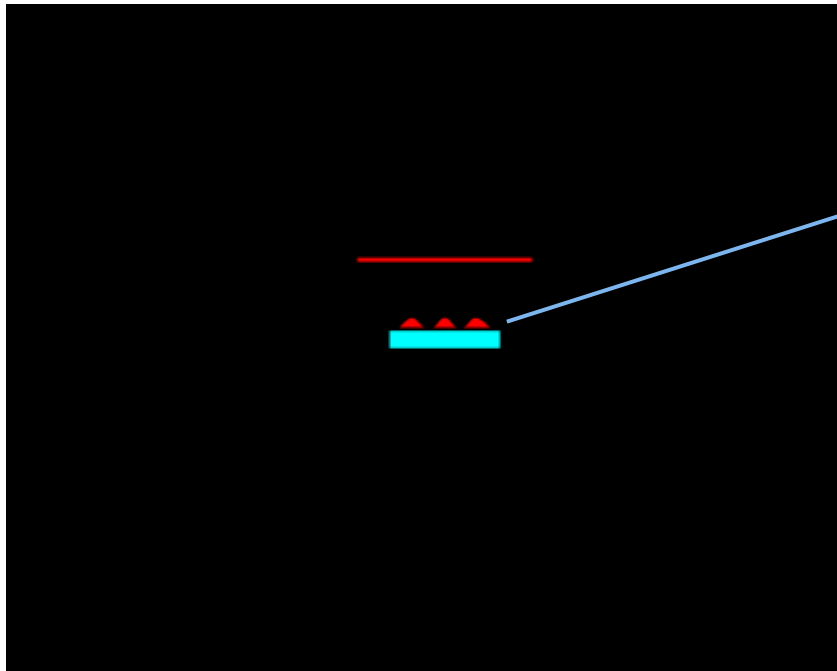
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Eigenfrequency=3.386367 [10] Hz Surface: Total displacement [m]

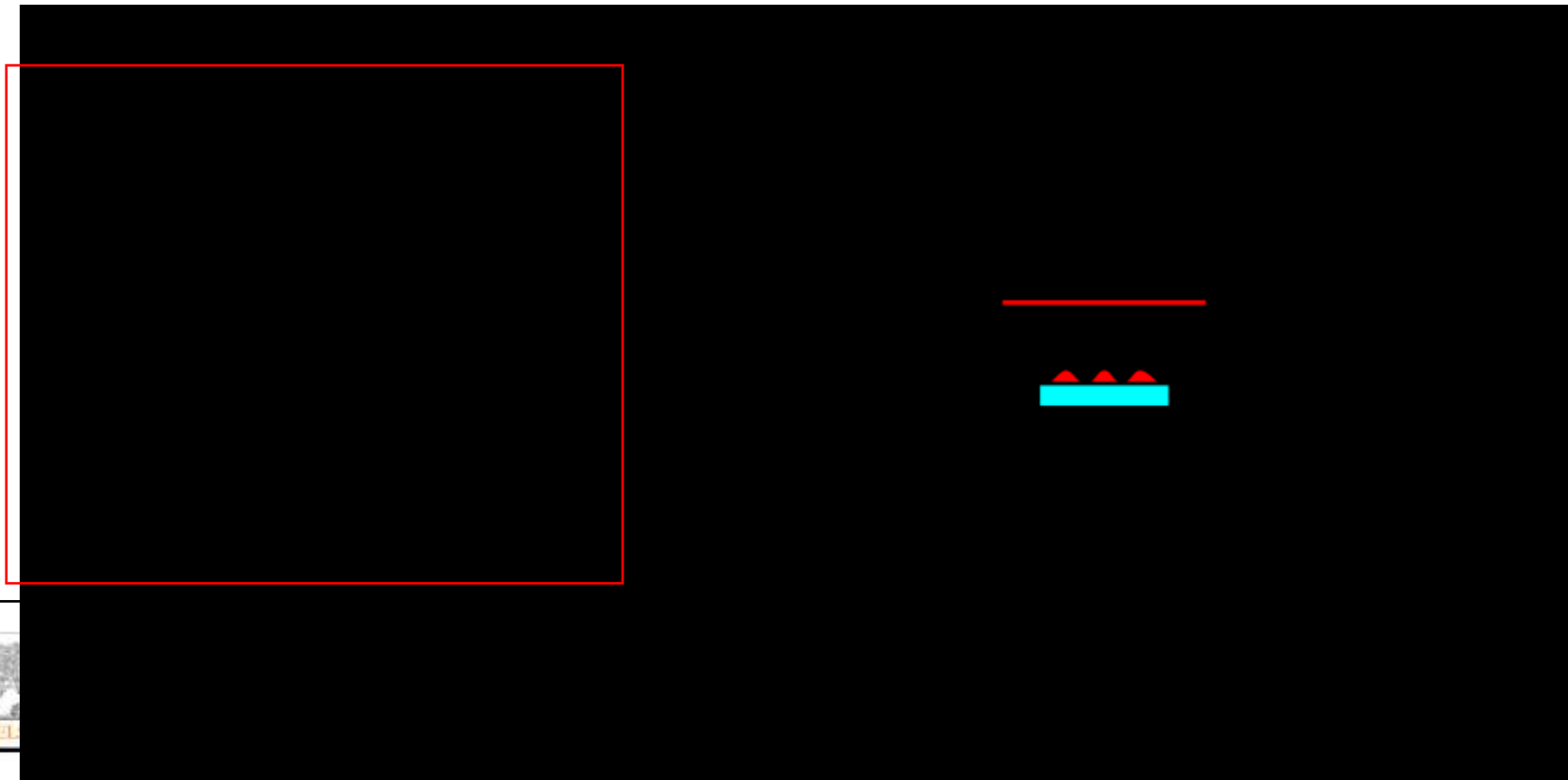


- The acceleration of matter in SAW could reaches extreme value  $10^8 \text{m/s}^2$
- Test of the validity of the effective potential model for the matter moving with extreme acceleration
- A.I. Frank hypothesized the existence of a critical acceleration for a matter at which one would expect a violation of the effective potential model (*JETP Lett.* **100** (2014) 613).
- According to this hypothesis the critical acceleration linearly depends on neutron energy. Its value for UCN is about  $4 \cdot 10^5 \text{m/s}^2$

# Idea of the experiment



# Velocity filter



## A low-pass velocity filter for ultracold neutrons

M. Daum<sup>a,b,\*</sup>, A. Frei<sup>c</sup>, P. Geltenbort<sup>d</sup>, E. Gutmiedl<sup>c</sup>, P. Höbel<sup>e</sup>, H.-C. Koch<sup>e</sup>, A. Kraft<sup>e</sup>, T. Lauer<sup>e</sup>,  
A.R. Müller<sup>c,1</sup>, S. Paul<sup>e</sup>, G. Zsigmond<sup>d</sup>

<sup>a</sup> PSI, Paul-Scherrer-Institut, CH-5250 Würenlingen, Switzerland

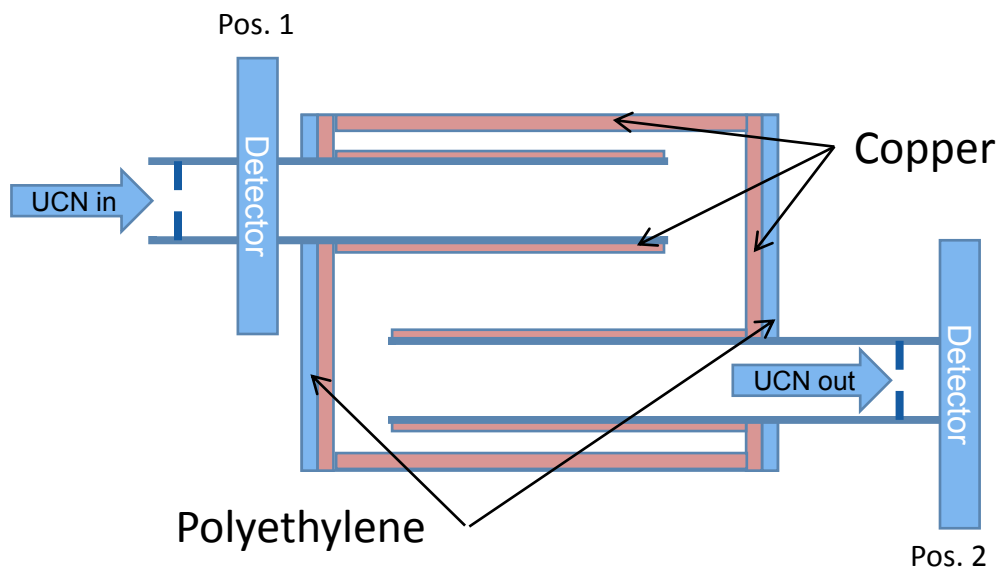
<sup>b</sup> Department of Physics, University of Virginia, Charlottesville, VA 22904-4714, USA

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<sup>e</sup> Institut für Physik, Johannes-Gutenberg-Universität, 55128 Mainz, Germany

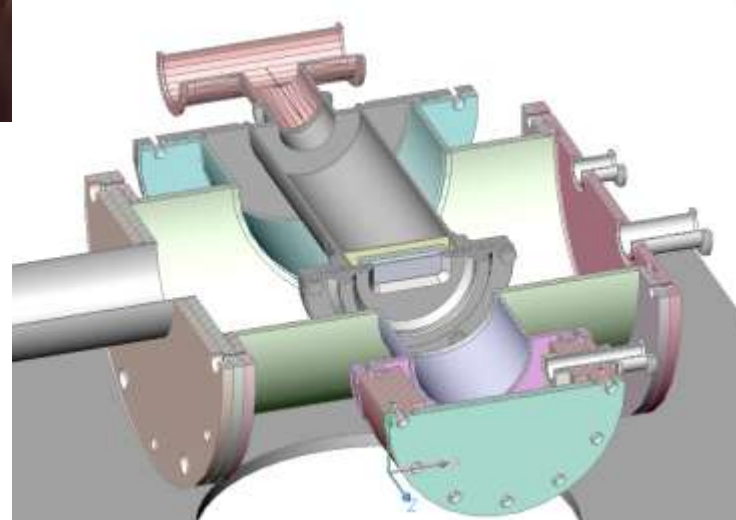
# Unwanted background suppression



	Total UCN flux density, cps/cm <sup>2</sup>	Flux density of useful UCN, cps/cm <sup>2</sup>	Flux density of background, cps/cm <sup>2</sup>	Useful/backgr. UCN ratio
UCN before velocity filter	1681,4	687,3	994,1	0.7
UCN after velocity filter	80,2	79,0	1,2	65,8

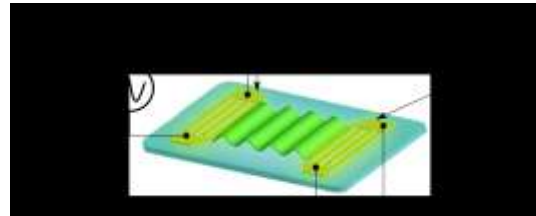
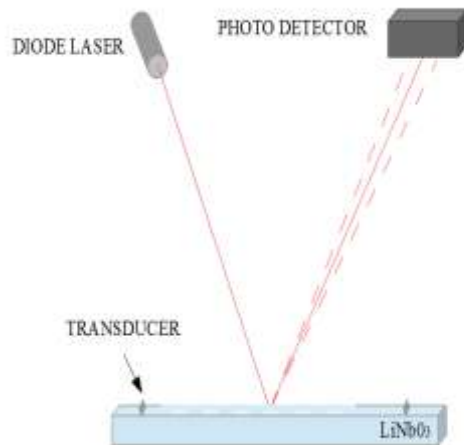


# Setup @ PF2 instrument, ILL(France)





# Optical measurement of SAW amplitude



Frequency is 34MHz  
Amplitude is about 1.6nm  
Wavelength is 100um  
Maximum velocity of the surface is 0,34m/s  
Maximum medium acceleration is  $7 \cdot 10^7 \text{m/s}^2$

- Linear dependence of the amplitude of the signal at IDT-receiver on SAW amplitude was measured
- SAW amplitude doesn't change significantly on the sample aperture
- Average SAW amplitude is 1.6 nm

In detail see poster of Natalya Rebrova

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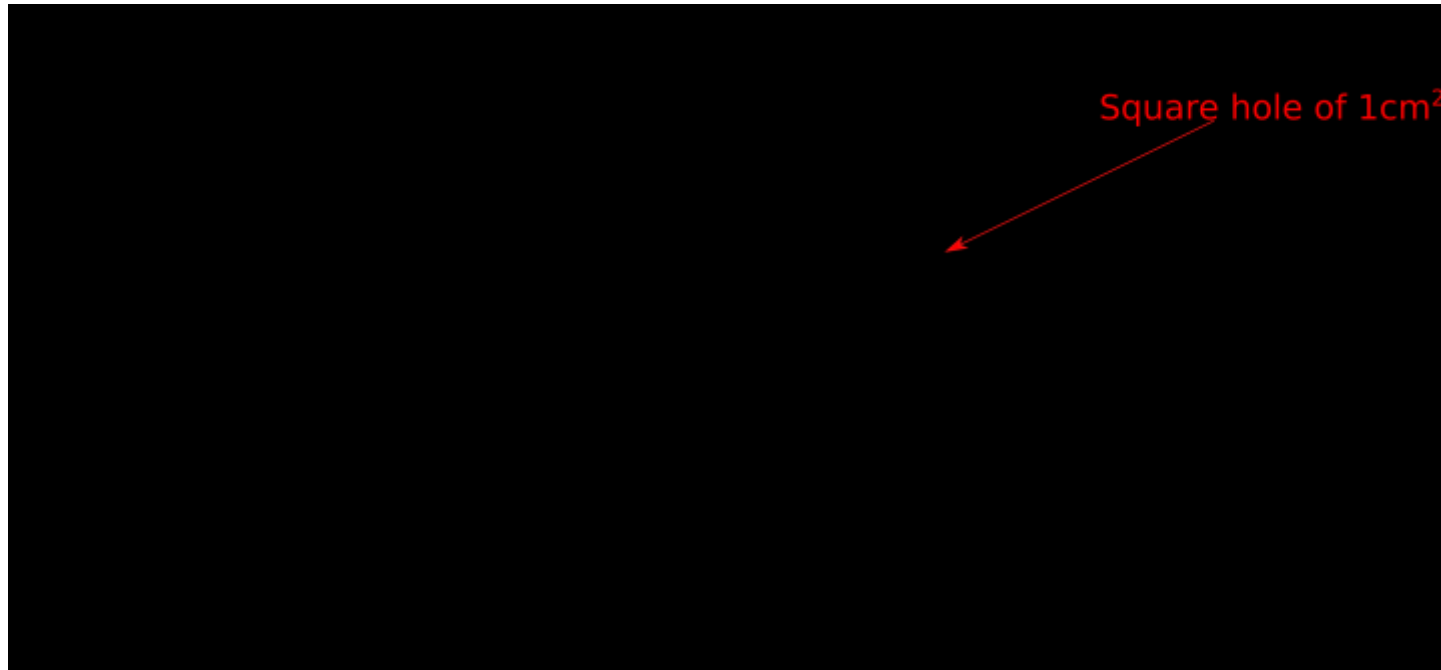
Frank Laboratory of Neutron Physics  
Лаборатория нейтронной физики им. ИМ. Франка

FLNP

## MEASUREMENT OF SURFACE ACOUSTIC WAVE AMPLITUDE BY LASER LIGHT DIFFRACTOMETRY

N. V. Rebrova, G. V. Kulin, S. V. Goryunov, A. I. Frank, M. A. Zakharov  
Frank Laboratory of Neutron Physics, JINR, Russia

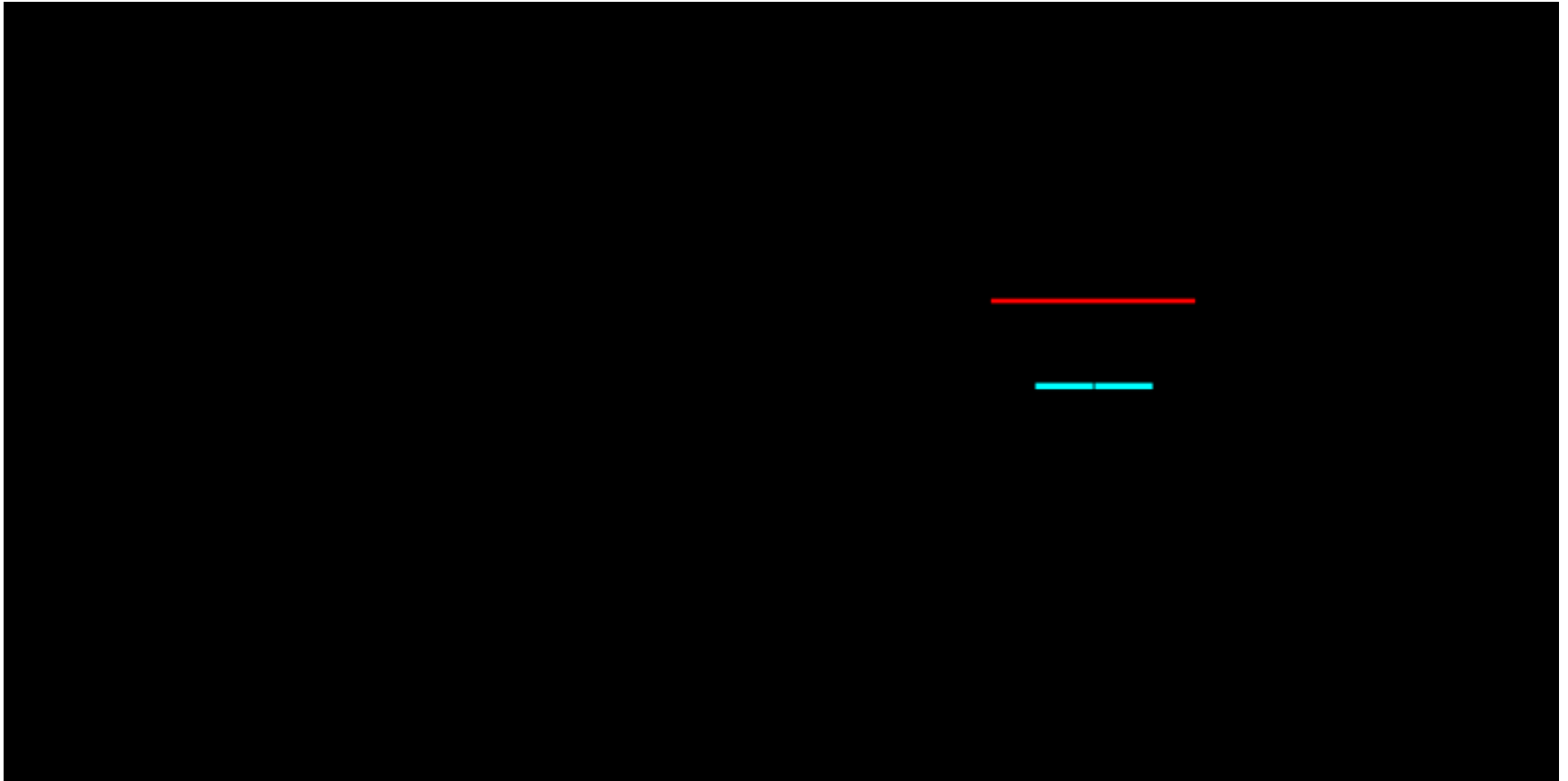
# Measurement of the flux density inside the main chamber



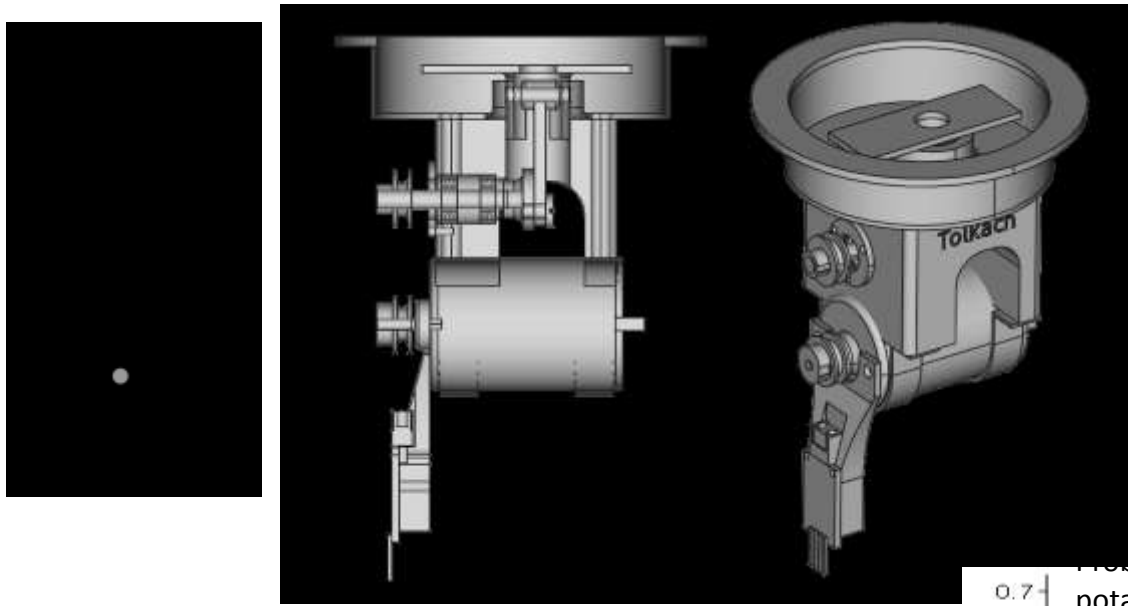
Total flux density, cps/cm <sup>2</sup>	Flux density of the background, cps/cm <sup>2</sup>	Useful/background UCN ratio
52	0,24	216



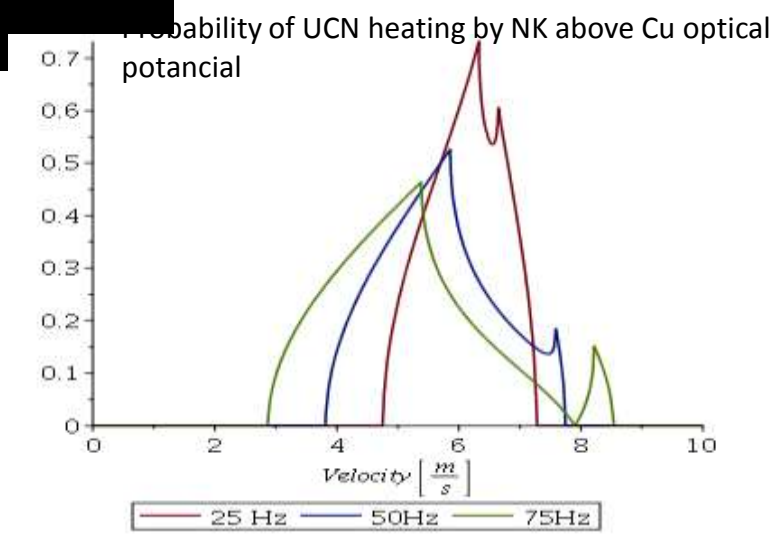
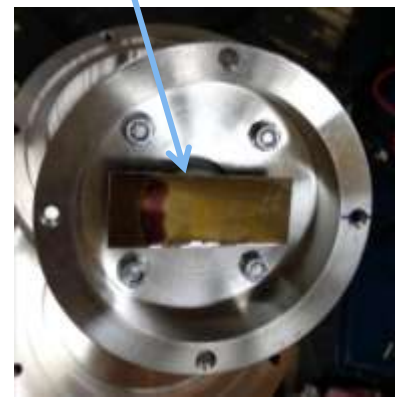
# How to test the setup?



“Neutron kicker” (NK) is a device for UCN spectrum investigation in the main chamber.

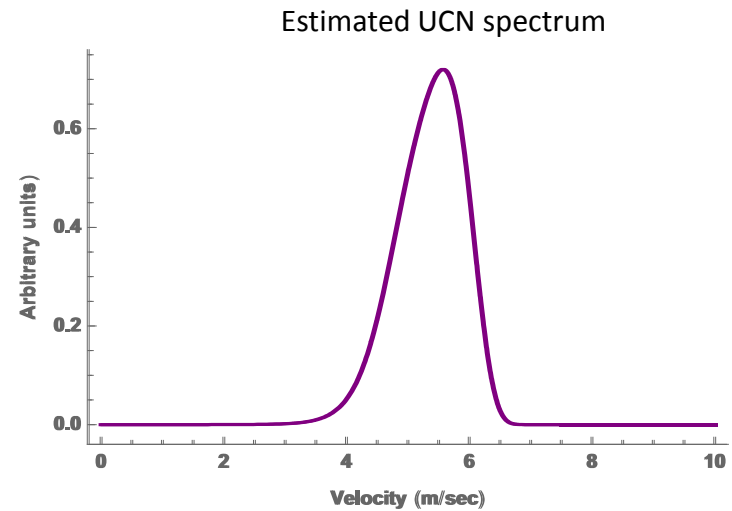


Ni mirror



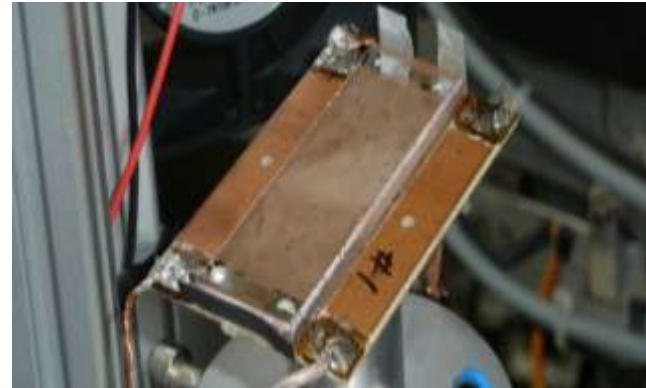
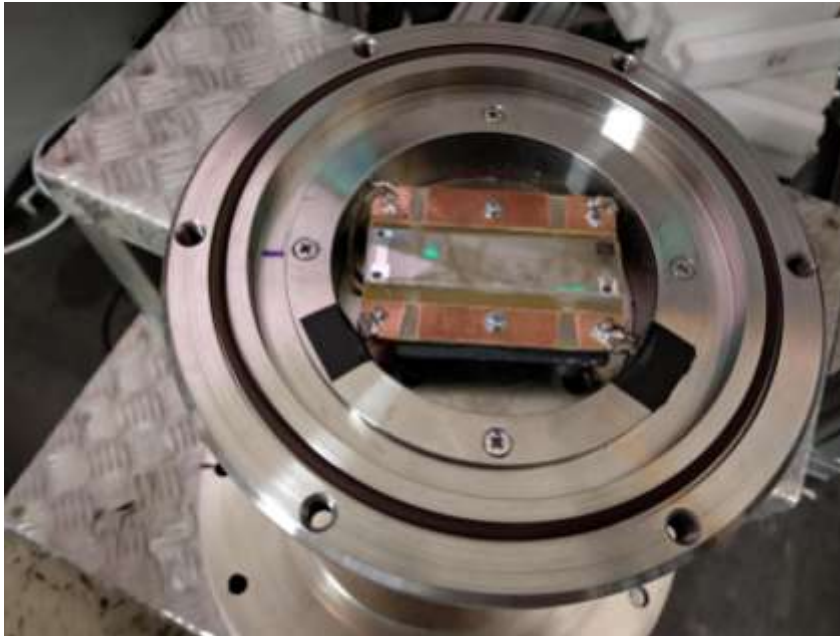
# Estimation of UCN spectrum inside the main chamber

- The spectrum corresponding to the data with NK was determined
- Knowing the **SAW amplitude**, the **flux density** inside the chamber and **the spectrum** one can predict flux of UCN upscattered by SAW
- The predicted effect is **0,07 cps**



Frequency, Hz	Maximum velocity transfer, m/s	UCN count rate in the detector, cps	Count rate of UCN heated by NK(exp.), cps	Count rate of UCN heated by NK(calc.), cps
0	0	11,8	0	0
25	0,94	15,8	4	3.8
50	1,88	24,9	13,1	14.1
75	2,82	39,5	27,7	24.7

# Measurement of UCN upscattering at SAW



The difference in count rate of the detector with and without SAW was measured.



During 8 hours of measurements we had got difference  $-0,035 \pm 0,047$  cps while predicted effect is  $0,07$  cps





# Summary

- The useful/background UCN ratio was increased by 100 times, while lost in useful neutrons was only about 10 times.
- Using “neutron kicker” UCN spectrum inside the main chamber was estimated.
- Optical calibration of samples with SAW was done. We got not only knowing of SAW amplitude but also proportionality of the signal from output Transducer to the SAW amplitude. The last thing allows us to know the amplitude in situ
- During 8 hours measurement we got the difference in the count rate of the detector with and without SAW  $-0,035 \pm 0,047$  cps, while predicted is 0,07 cps
- Continuation of the experiment was submitted and beam time at PF2EDM beam was allocated (20 days, Autumn 2019).



Thank you for your attention!