THE TEMPERATURE DEPENDENCE OF THE UCN "SMALL HEATING" PROBABILITY AND THE SPECTRUM OF UCN UP-SCATTERED ON A SURFACE OF FOMBLINE Y-HVAC 18/8 OIL

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Content:

1. Introduction and motivation

VUCN - Vaporizing Ultra Cold Neutrons

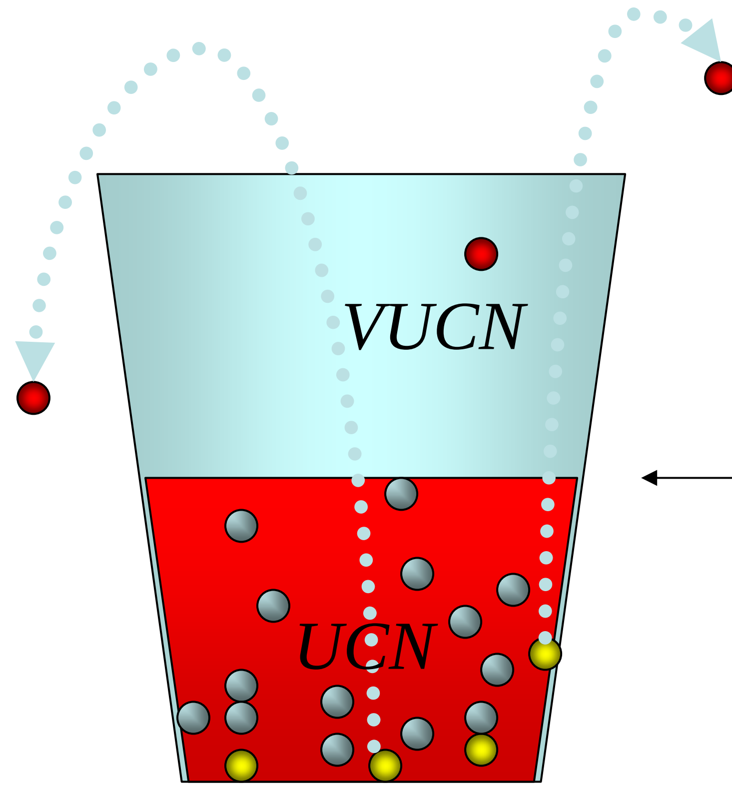
$VUCN:$

$\Delta E \sim 10^{-7}\, eV$

$\Delta V \sim 1 m/s$

$P_{VUCN} \sim 10^{-8} - 10^{-3}$

per collision with wall



Level of UCN gas

$UCN:$

$V_{UCN} \sim (1 \div 6) m/s$

$E_{UCN} \sim 10^{-7}\, eV$

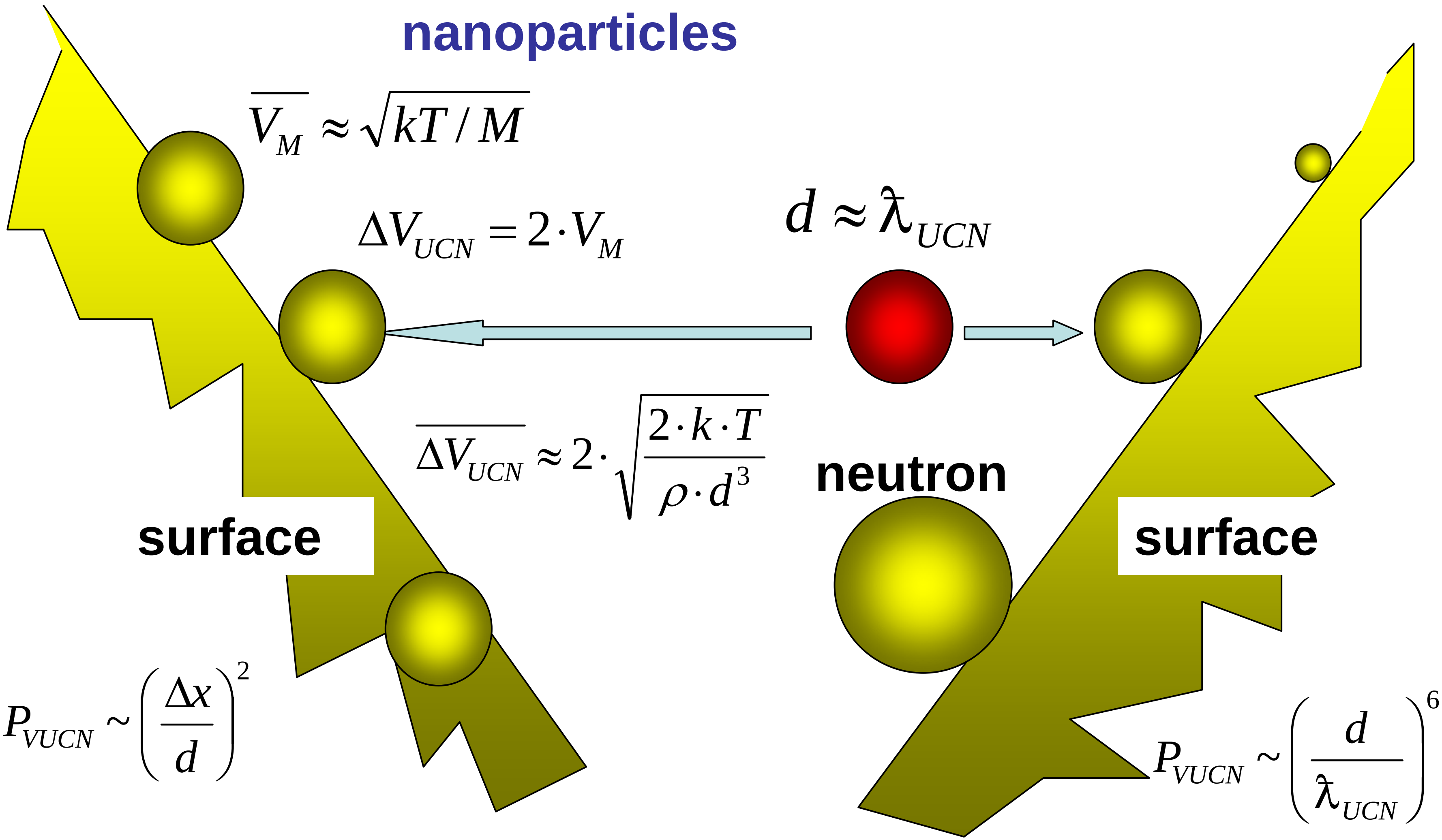
$H_{UCN}^{Earth's\ field} \sim 1m$

$T \sim 1mK$

A.V.Strelkov, V.V.Nesvizhevsky, P.Geltenbort et al, NIM 440A(3), 695-703 (2000)

V.V.Nesvizhevsky, A.V.Strelkov, P.Geltenbort et al, ILL Annual Report 1997, p.62-64; Physics of Atomic Nuclear 62(5), 776-786 (1999)

Interaction of neutrons with nanoparticles

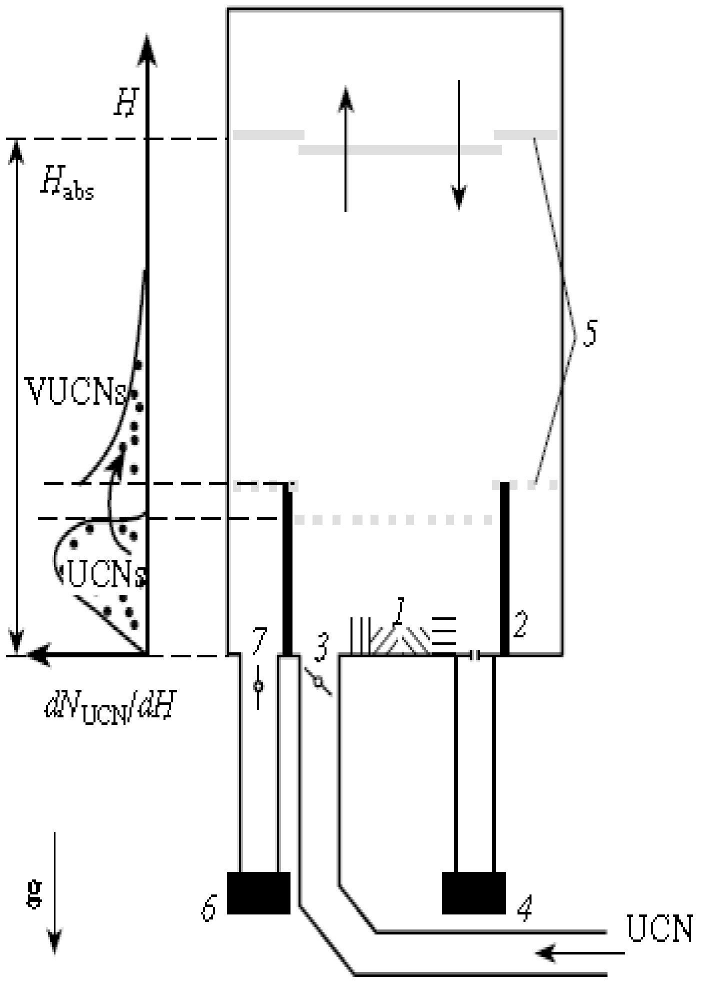


Fomblin oil:

1. Liquid (might be another physics of the process)
2. Popular surface in UCN storage
(in particular, for the neutron lifetime measurements)
3. Large measured probability
4. We have never measured it in our dedicated aparatus and nobody has measured the spectrum of up-scattered neutrons et all.

2. Experimental set-up

Our Big Gravitational Spectormeter (BGS) of the total UCN energy :



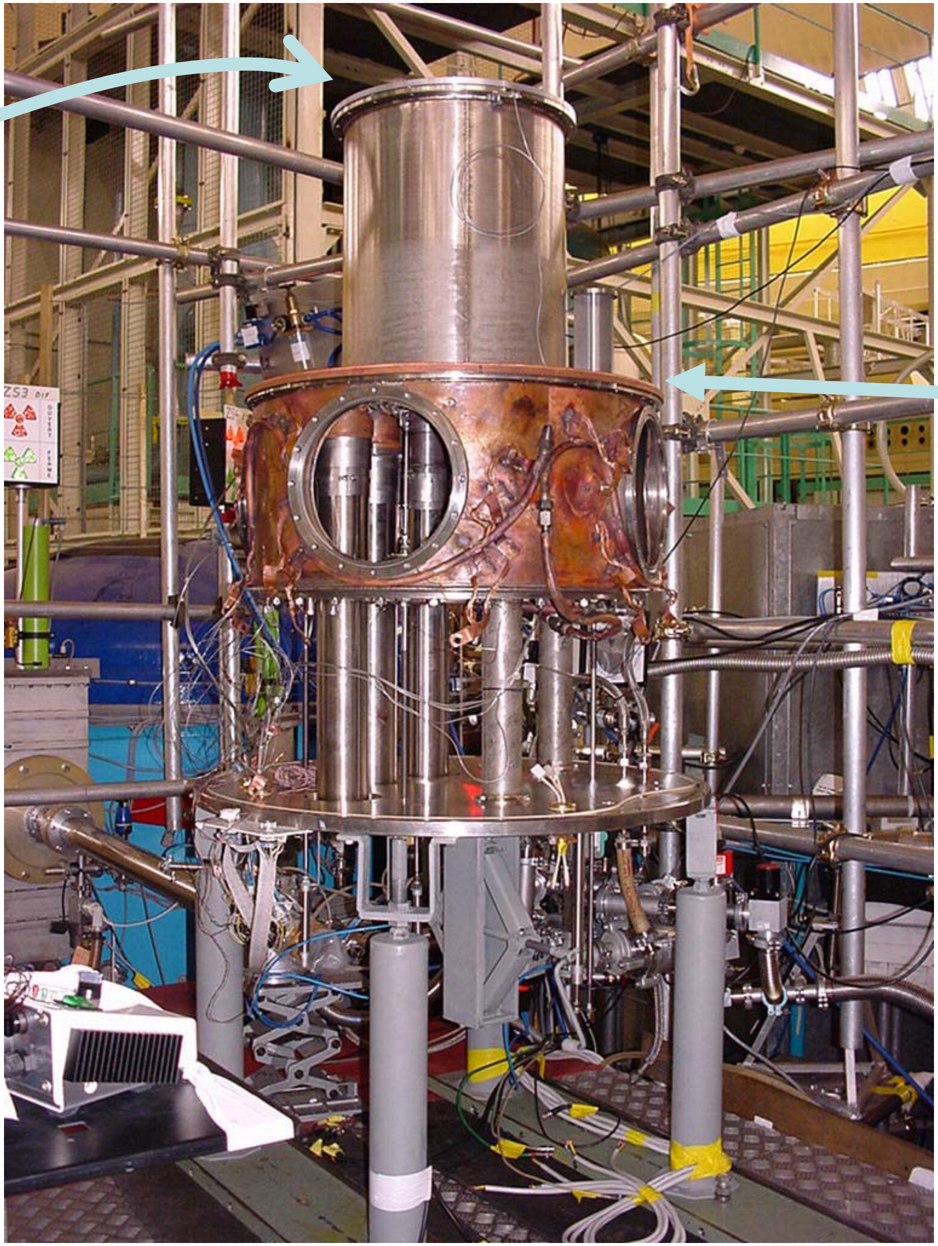
Advantage:

- Higher efficiency of VUCN detection
- Measurement (not estimation) of the efficiency of VUCN detection
- Broader energy range for detectable VUCN
- Reliable measurement of temperature dependencies
- Easy change of samples
- Flexible adaptation of this setup to different experiments

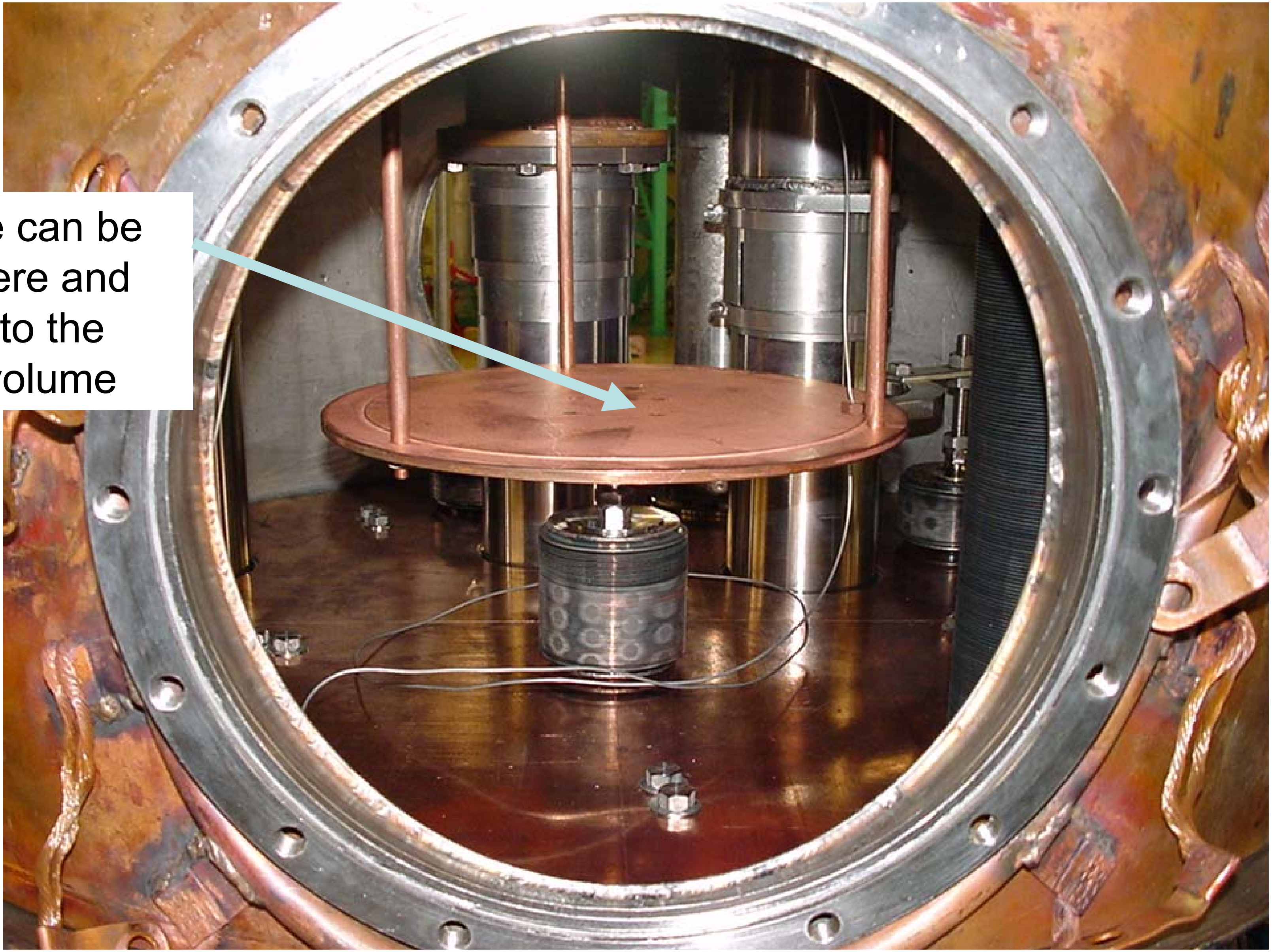
Layout of the BGS :

(1) sample,
(2) gravitational barrier,
(3) entrance valve,
(4) UCN monitor detector,
(5) UCN absorber,
(6) VUCN detector,
(7) exit valve.

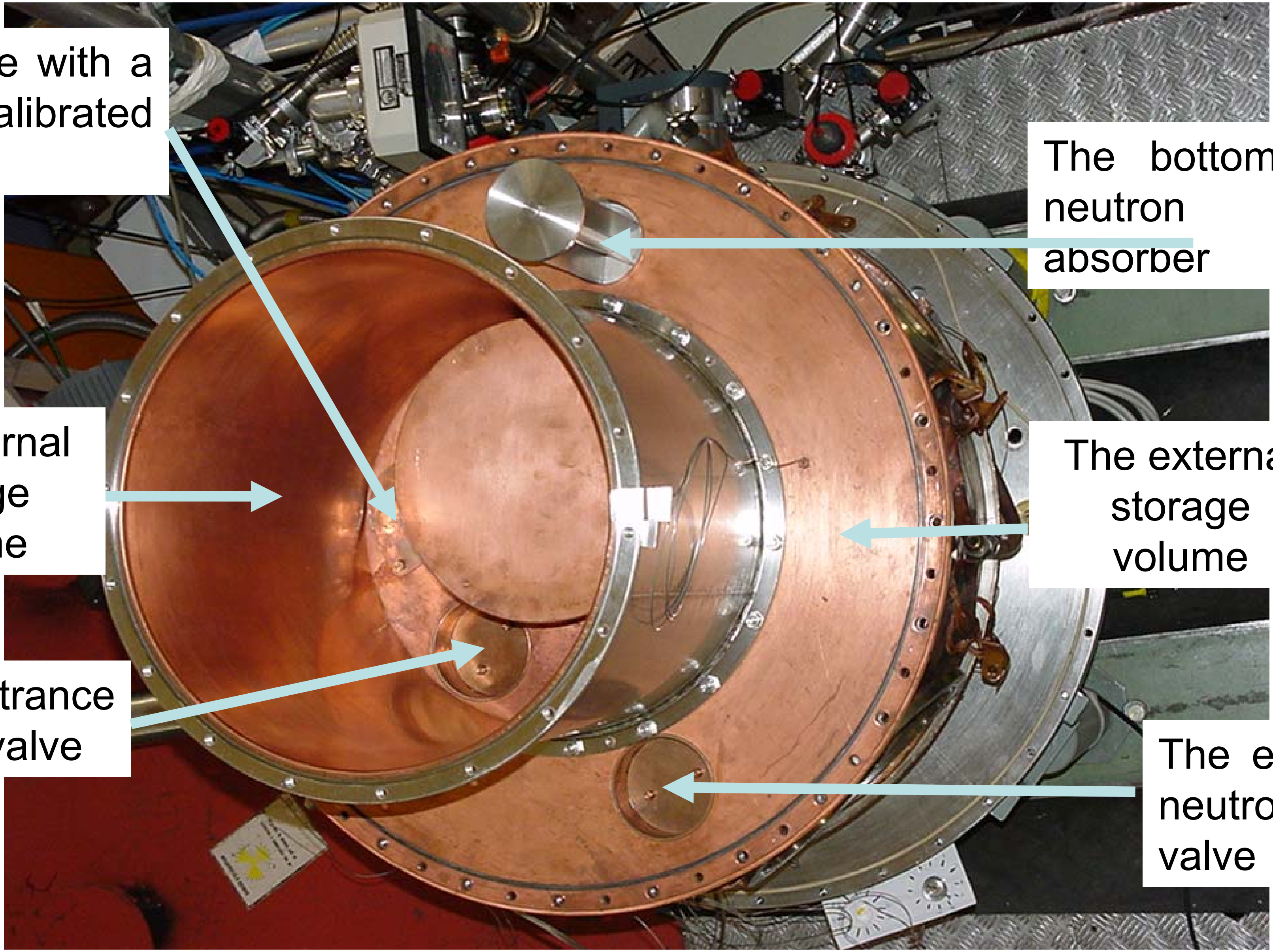
The internal storage volume for UCN (copper inside)

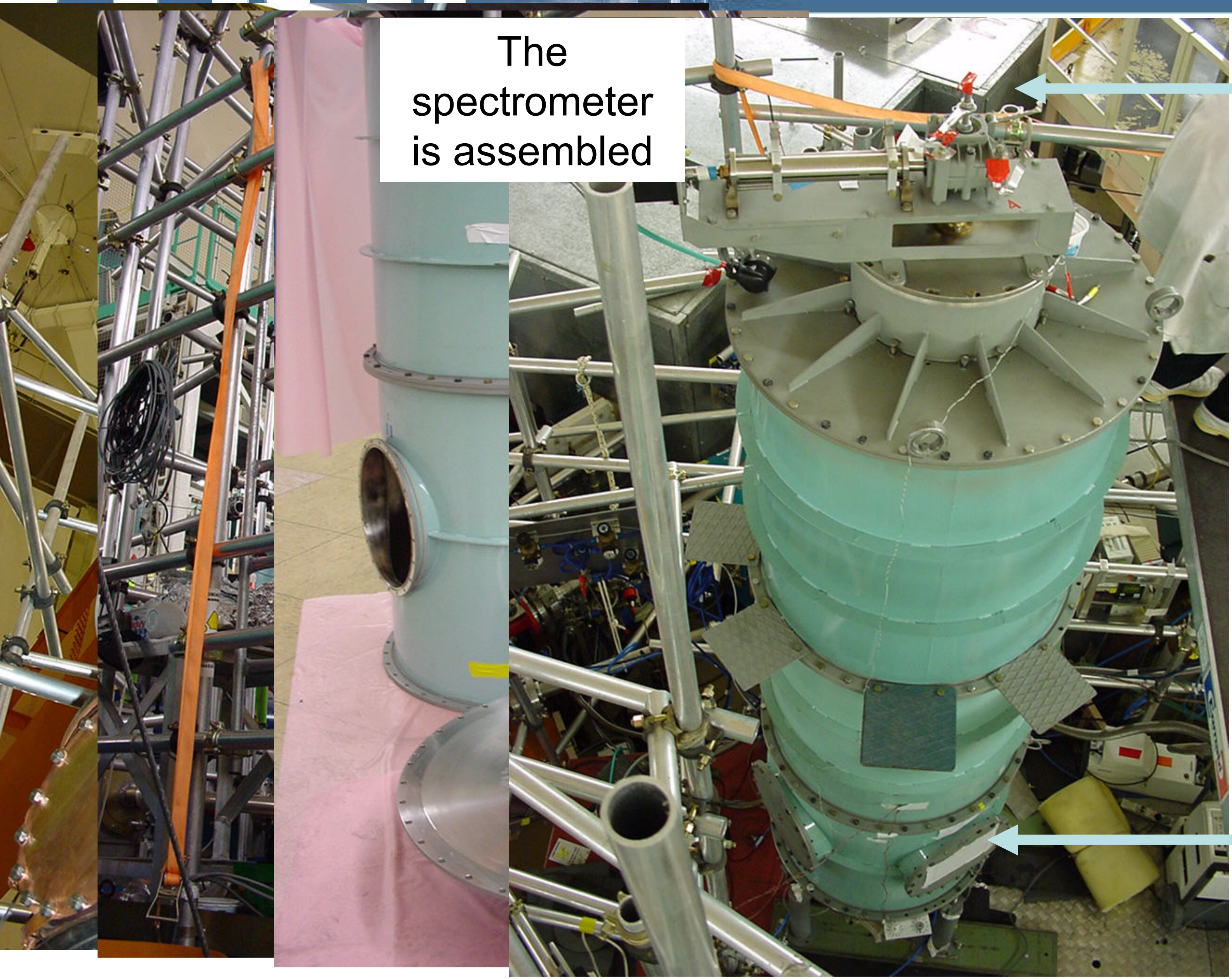


The bottom for the internal storage volume and the external storage volume



A sample can be placed here and lifted up to the storage volume


The valve with a small calibrated window
The bottom neutron absorber
The internal storage volume
The external storage volume
The entrance neutron valve
The exit neutron valve



The spectrometer is assembled

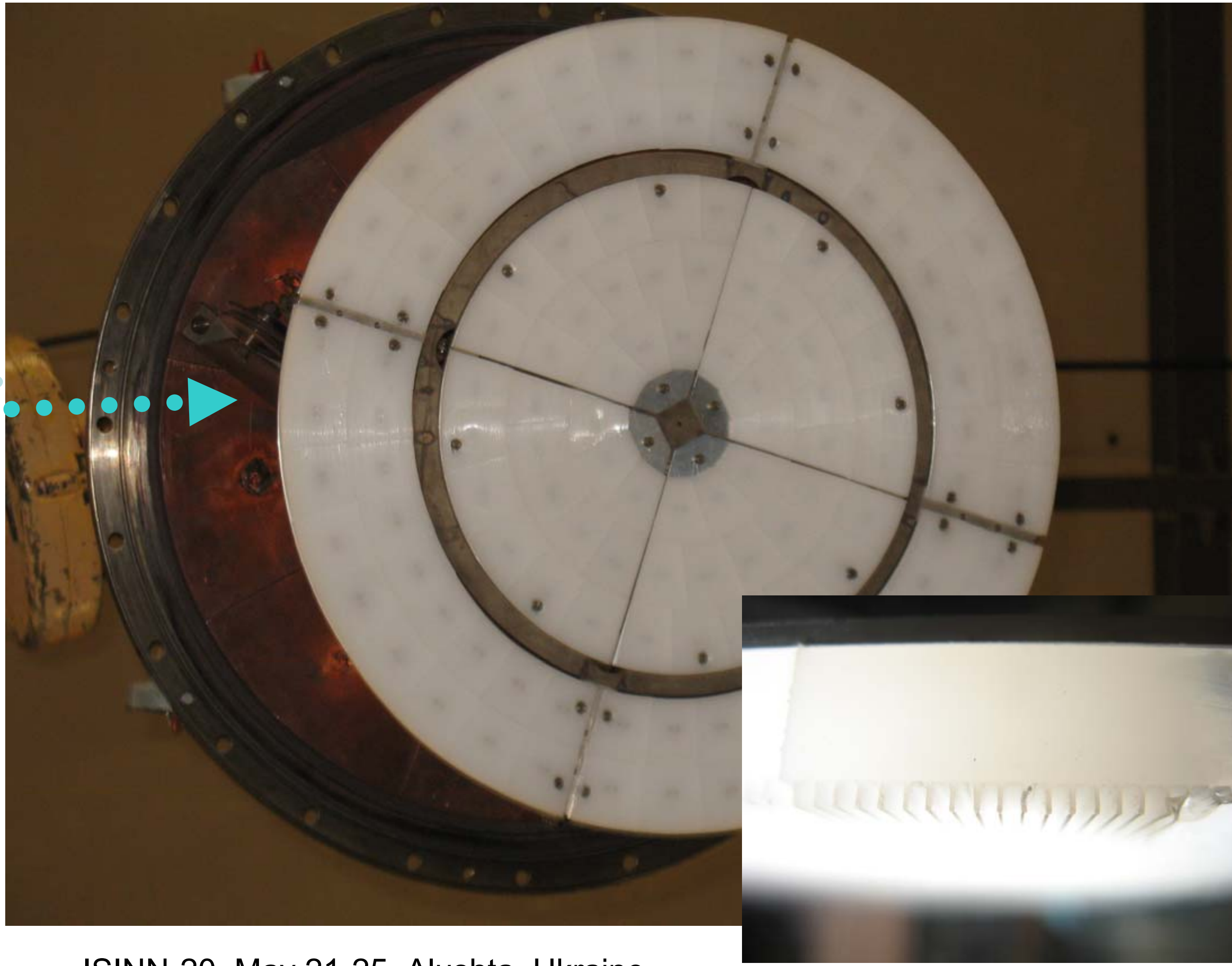
Movement of the absorber

Access to the sample changer

Some technical changing in the measurements

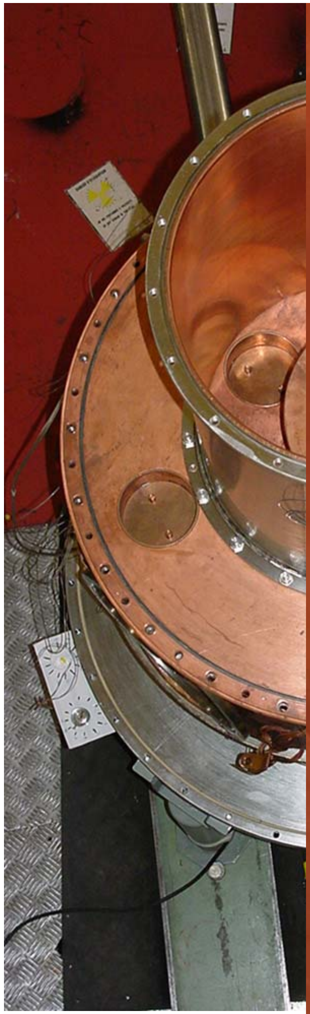
1

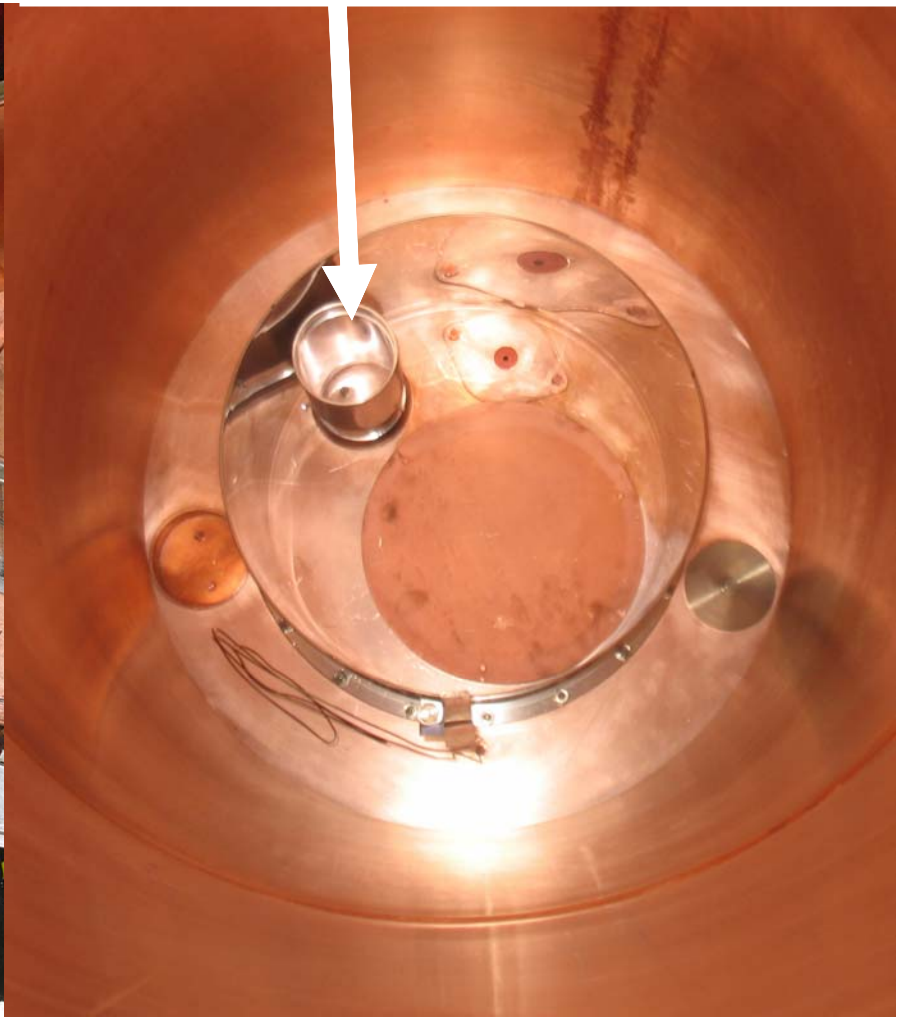
Polyethylene absorber with highly developed surface



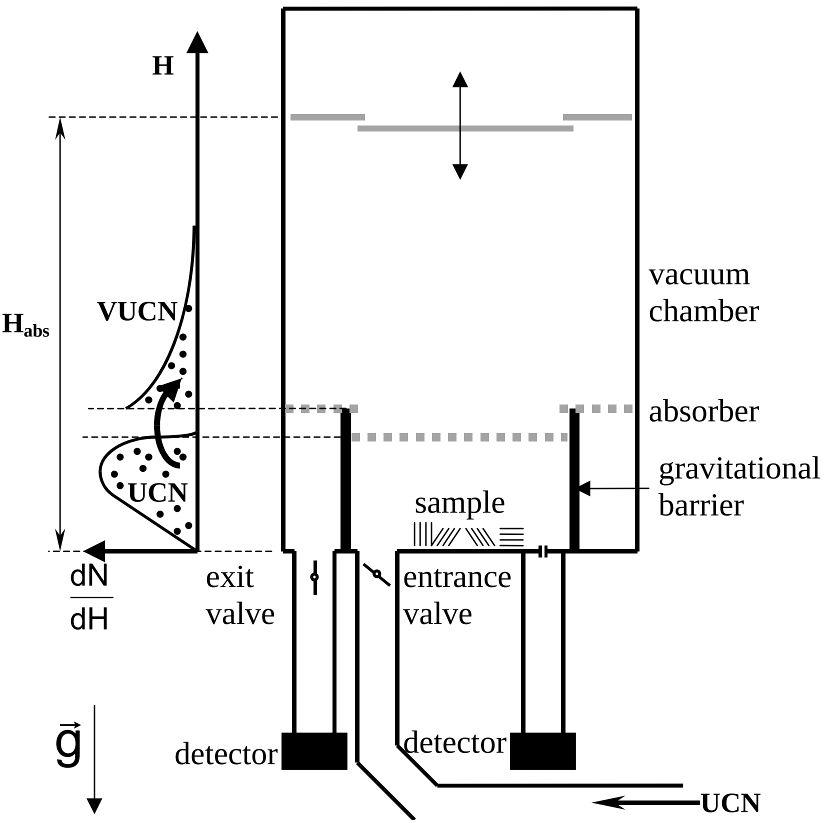
Some technical modification in the measurements

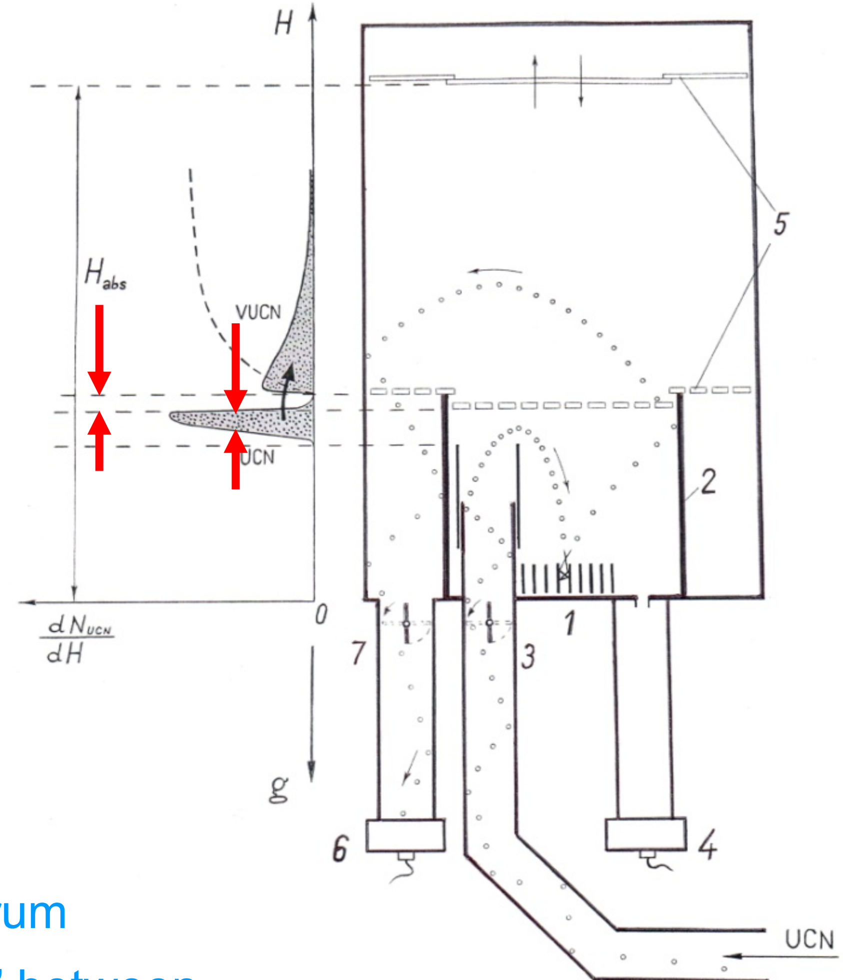
3. New entrance neutron guide



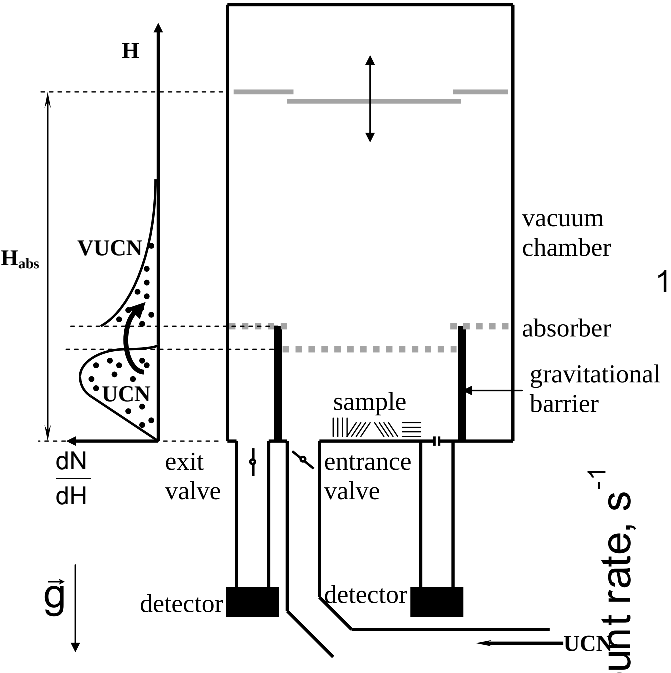


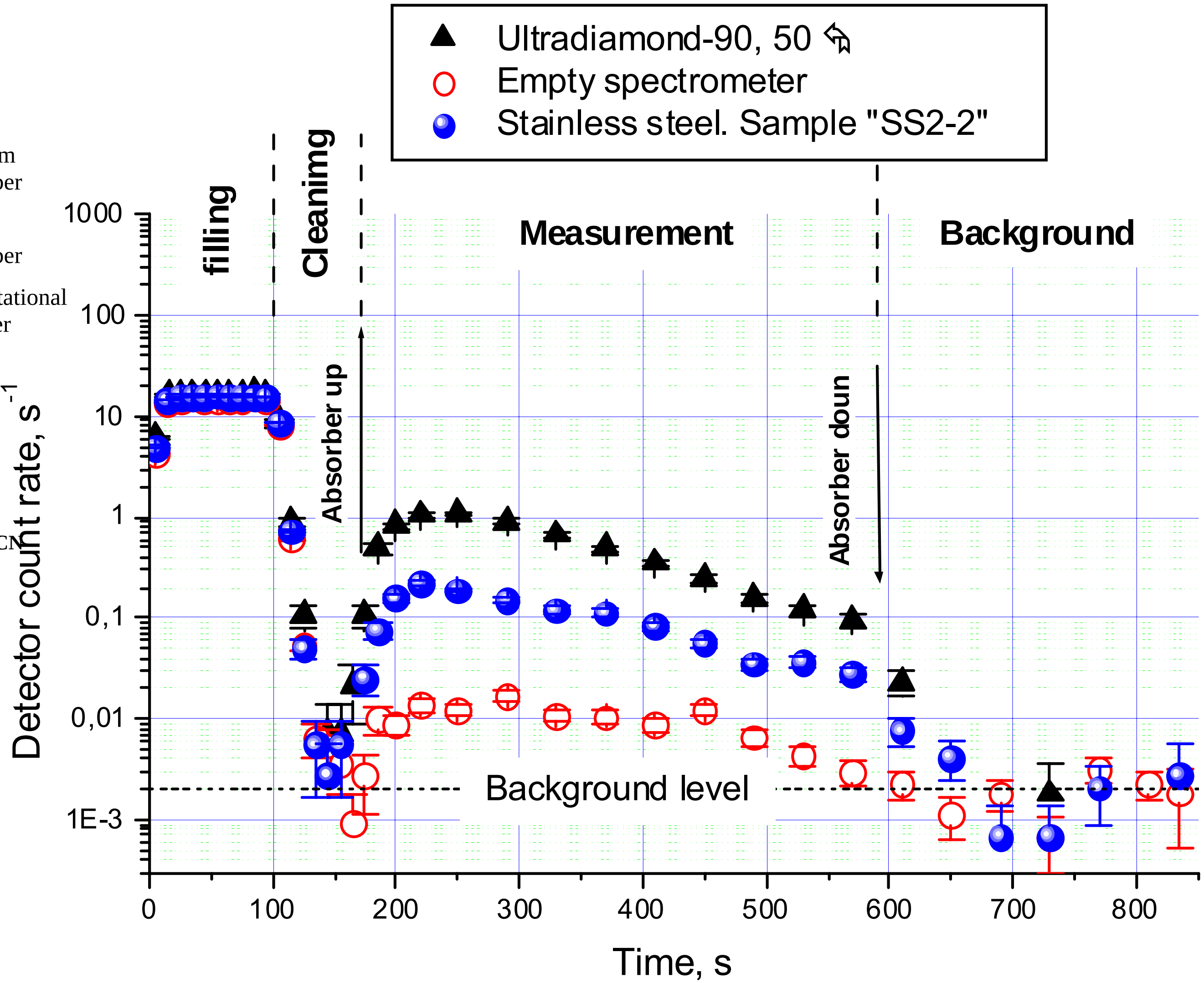
So, compared to our previous measurements we have:





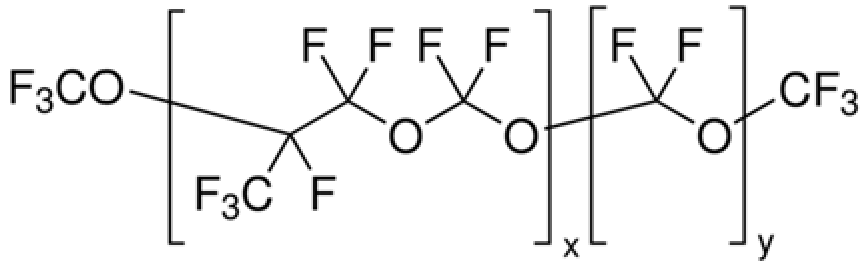
1. Narrower initial spectrum
2. Narrower "dead zone" between initial and final UCN spectra


H
H_{abs}
VUCN
UCN
$\frac{dN}{dH}$
exit valve
vacuum chamber
absorber
gravitational barrier
sample
entrance valve
detector
detector
UCN
$\vec{g}$


Ultradiamond-90, 50
Empty spectrometer
Stainless steel. Sample "SS2-2"
filling
Cleanimg
Measurement
Background
Absorber up
Absorber doun
Background level
Detector count rate, s^{-1}
Time, s
1000
100
10
1
0,1
0,01
1E-3
0
100
200
300
400
500
600
700
800

3. Samples

FOMBLINE Y-HVAC 18/8 OIL :



E_{lim}~110 neV

Vapor Pressure (Torr)
@20°C: 2.1×10^{-8}
@100°C: 1.2×10^{-4}

"PF2" oil
"Morozov's" oil

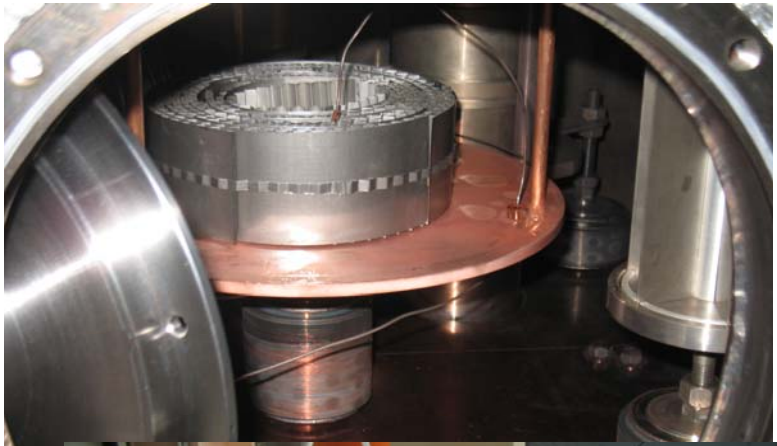
	Units	18/8
Average molecular weight	a.m.u.	2800
Specific gravity (20°C) (68°F)	g/cm³	1.89
Flash Point	—	None
Kinematic Viscosity @20°C (68°F) @100°C (212°F) @200°C (392°F) cSt	cSt	 190 9 2
Pour Point	°C	–42
Refractive Index, n^{20}_D @20°C (68°F)	°C	1.300
Specific Heat (cal/g) @38°C (100°F)	cal/g	0.24
Surface Tension @25°C (77°F)	dyne/cm	20
Heat of vaporization (200°C) (392°F)	cal/g	9

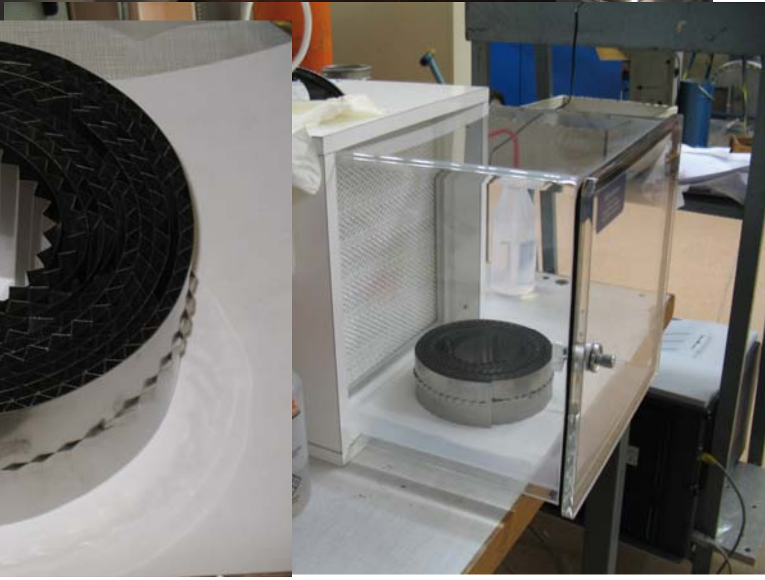
Samples

1 Thin film on stainless steel foils.

It is dipped into the oil and left for 24 hours to flow the oil down in a clean room.

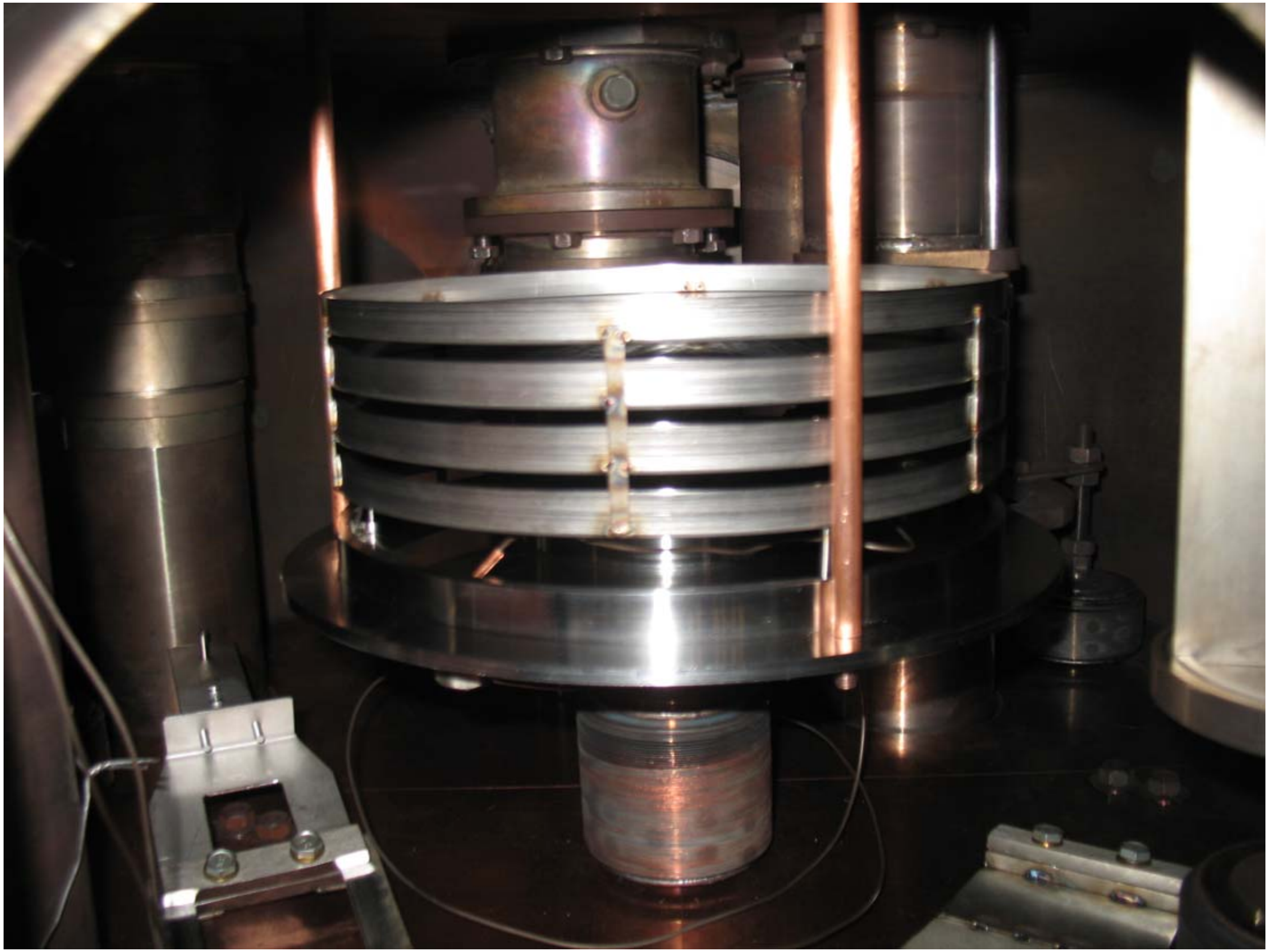
The thickness is about several microns



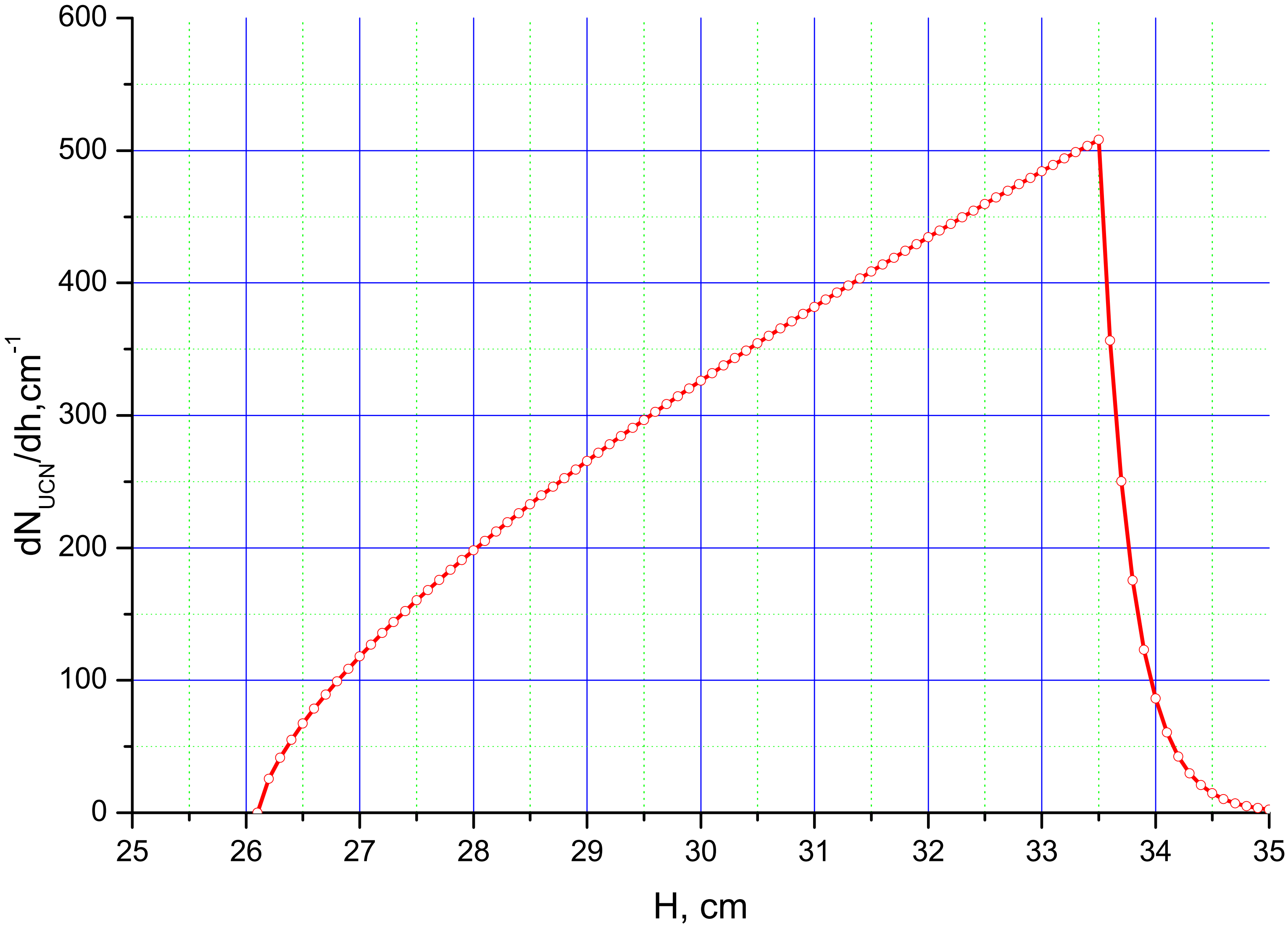


Samples

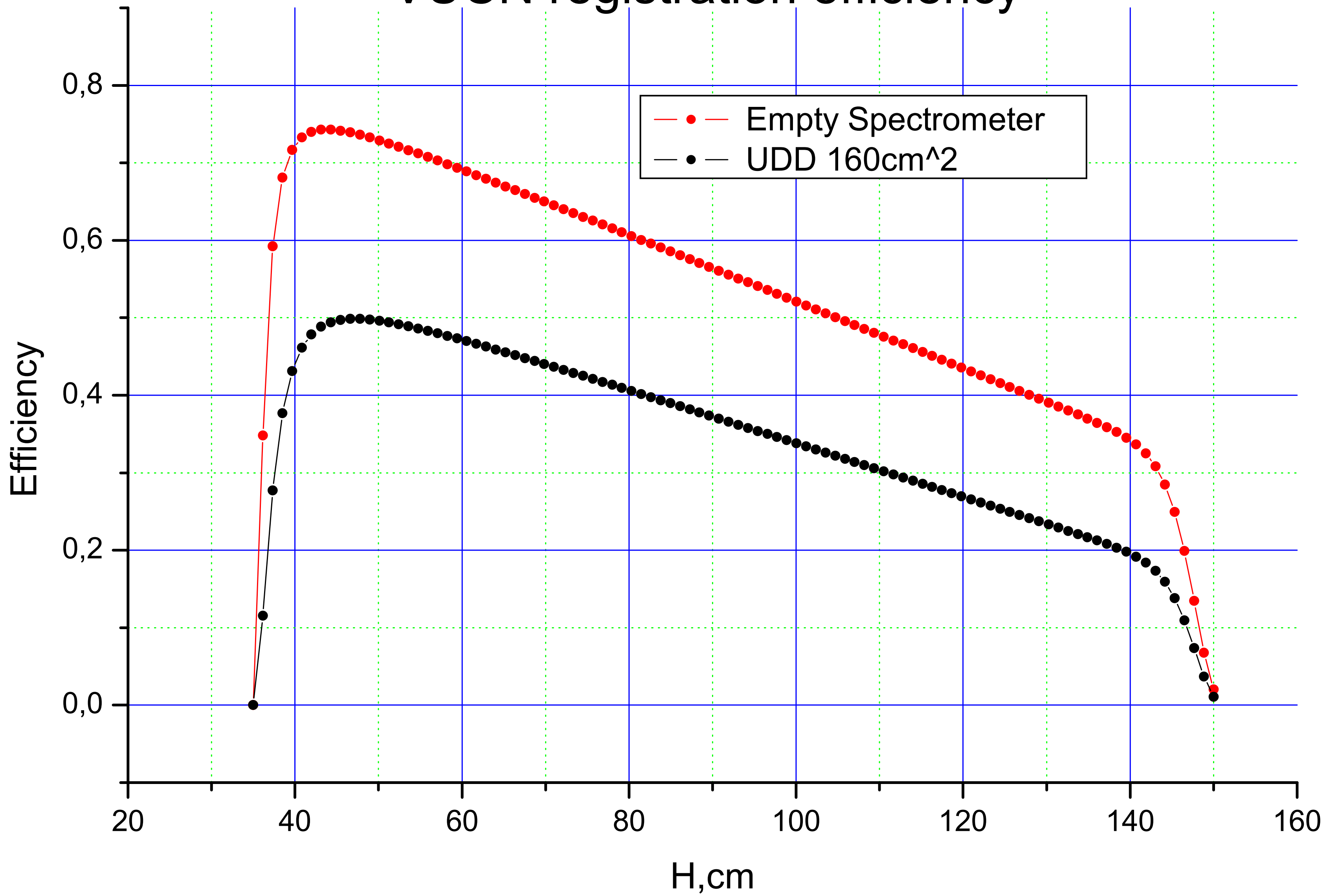
2 Thick (1-2 mm) layers in the “plates”.



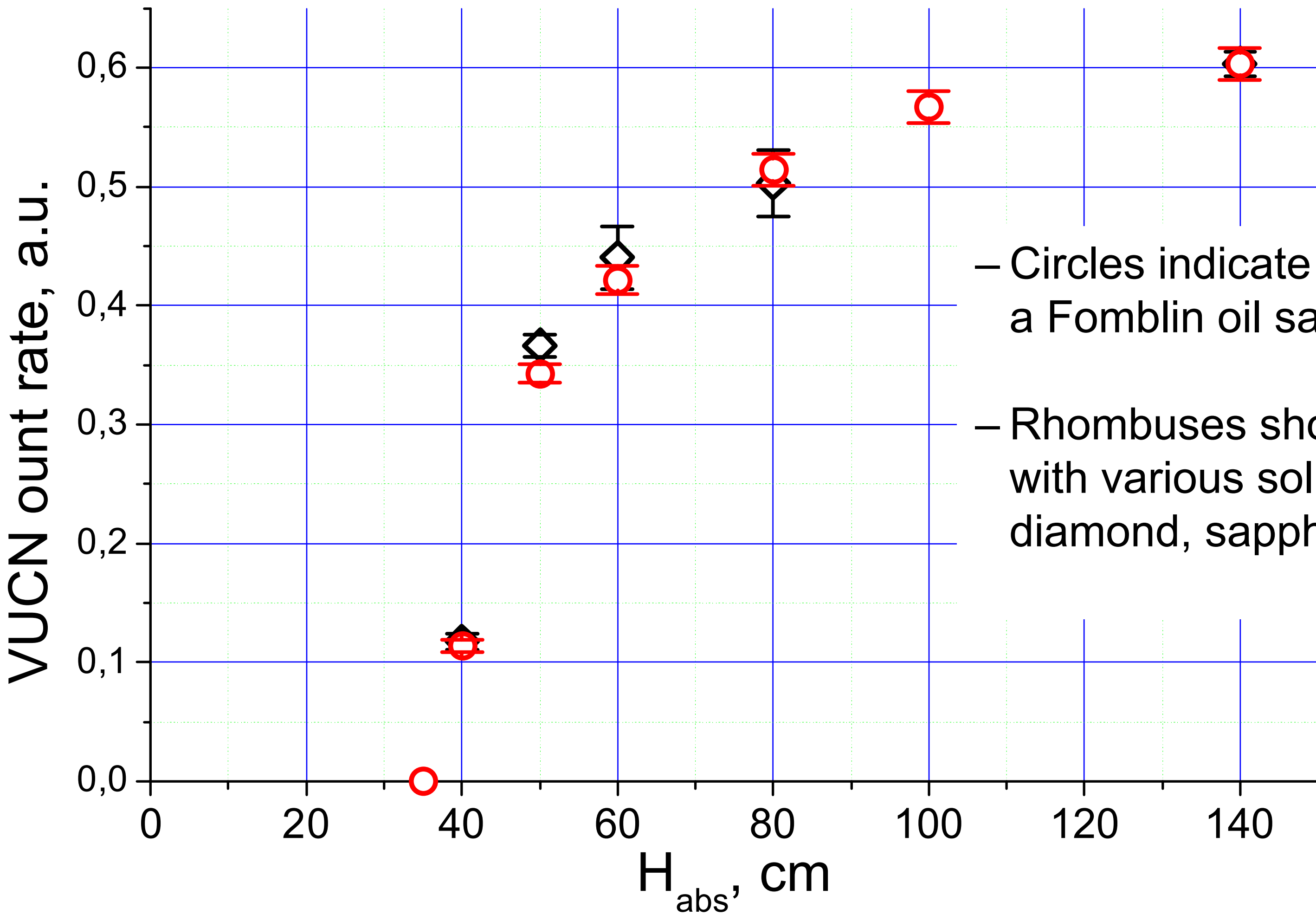
4. Experimental results and their comparison with theoretical models


600
500
400
300
200
100
0
dN_UCN/dh,cm^-1
25
26
27
28
29
30
31
32
33
34
35
H, cm

VUCN registration efficiency

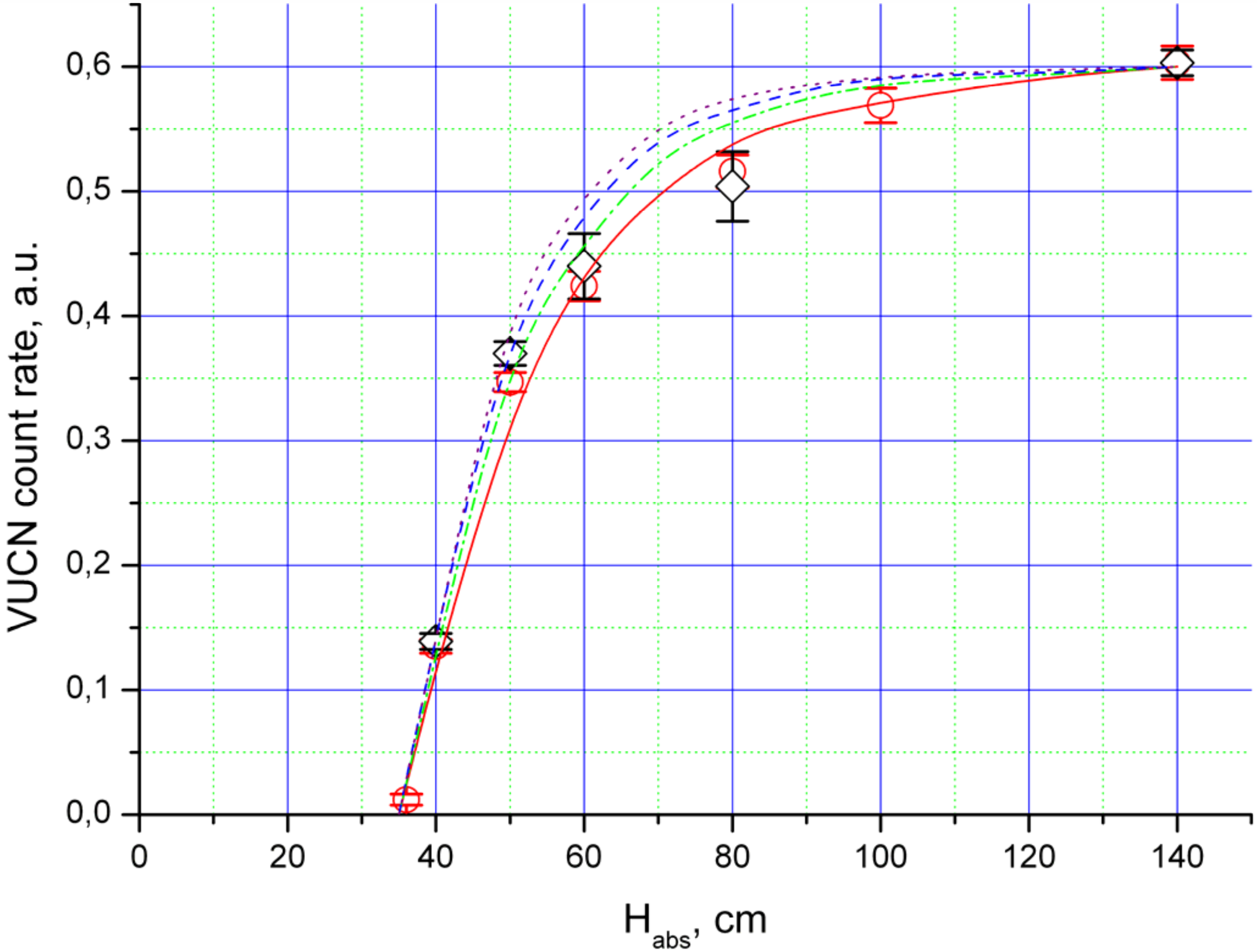


Integral spectrum of VUCN is the same for all Fomblin samples



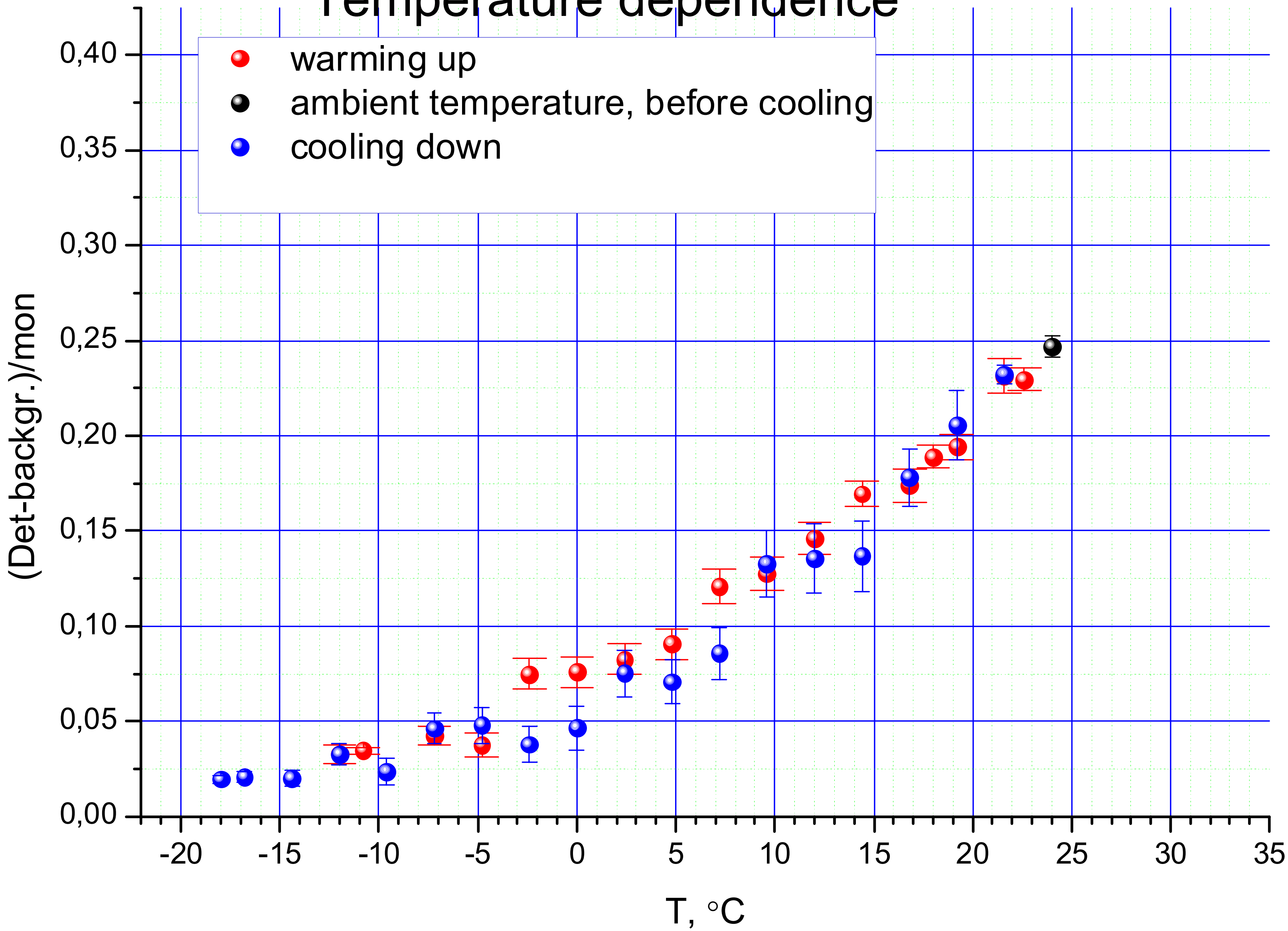
- Circles indicate data measured with a Fomblin oil sample.
- Rhombuses show results measured with various solid nanoparticles: diamond, sapphire, copper.

Comparing with the model of nano-droplets over surface

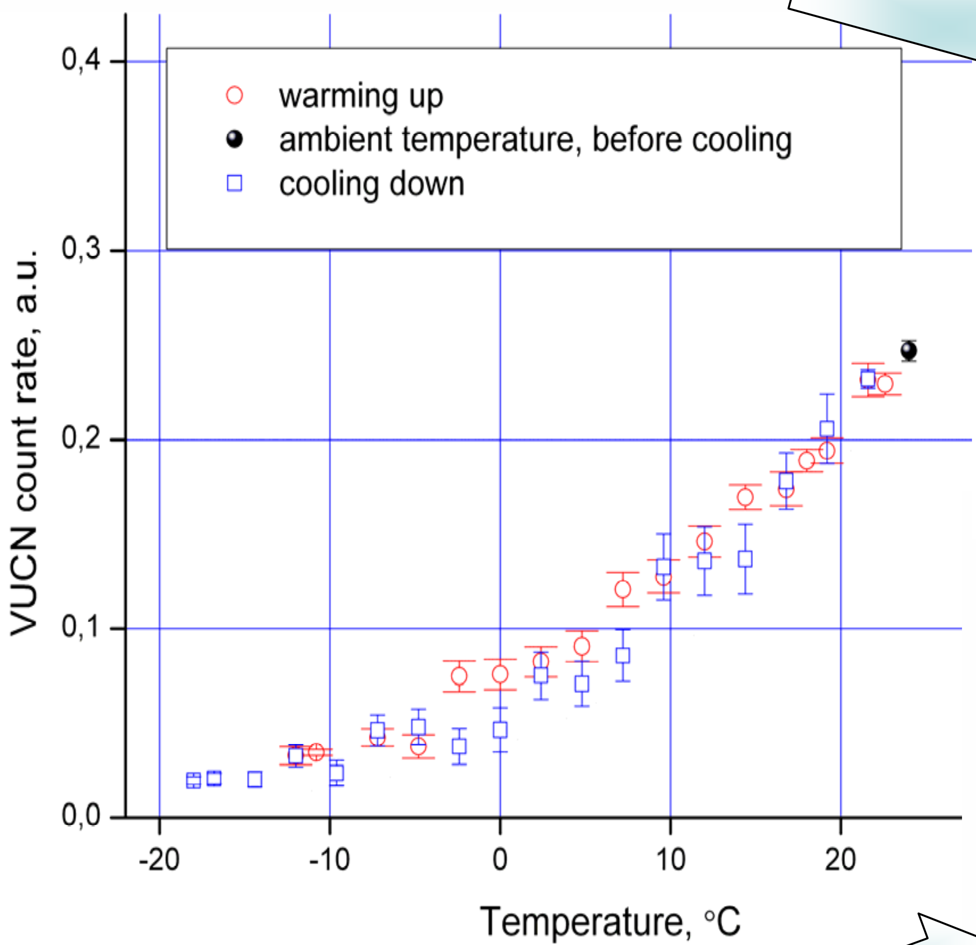


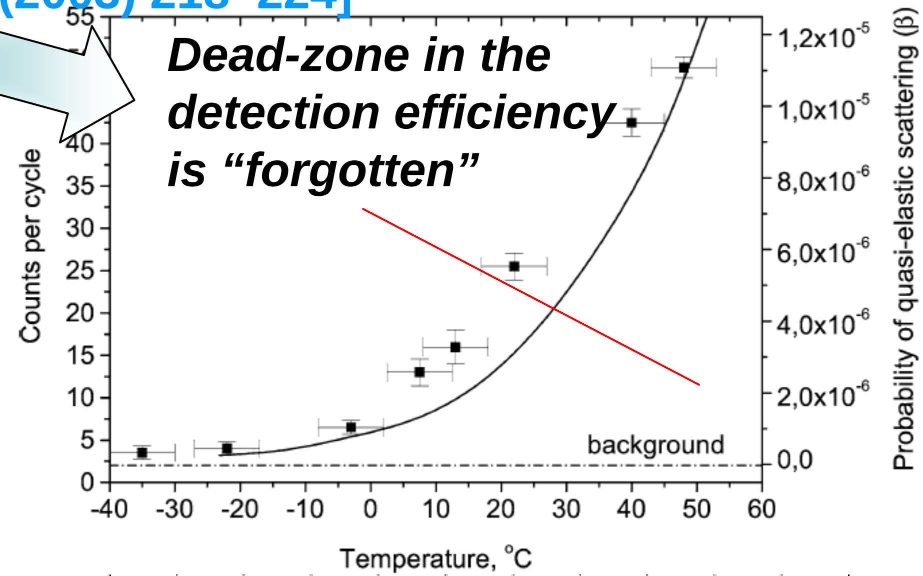
lines correspond to calculations of VUCN spectra on the Fomblin surface, for four hypothesizes on the size distribution of nano-droplets $(R/R_0)^{-l}$, $l=1;2;3;4$

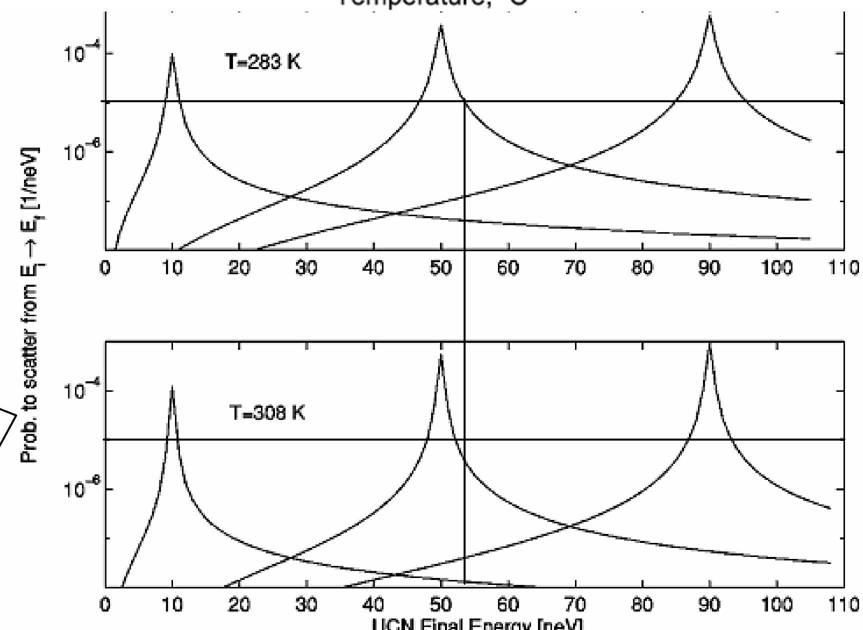
Temperature dependence



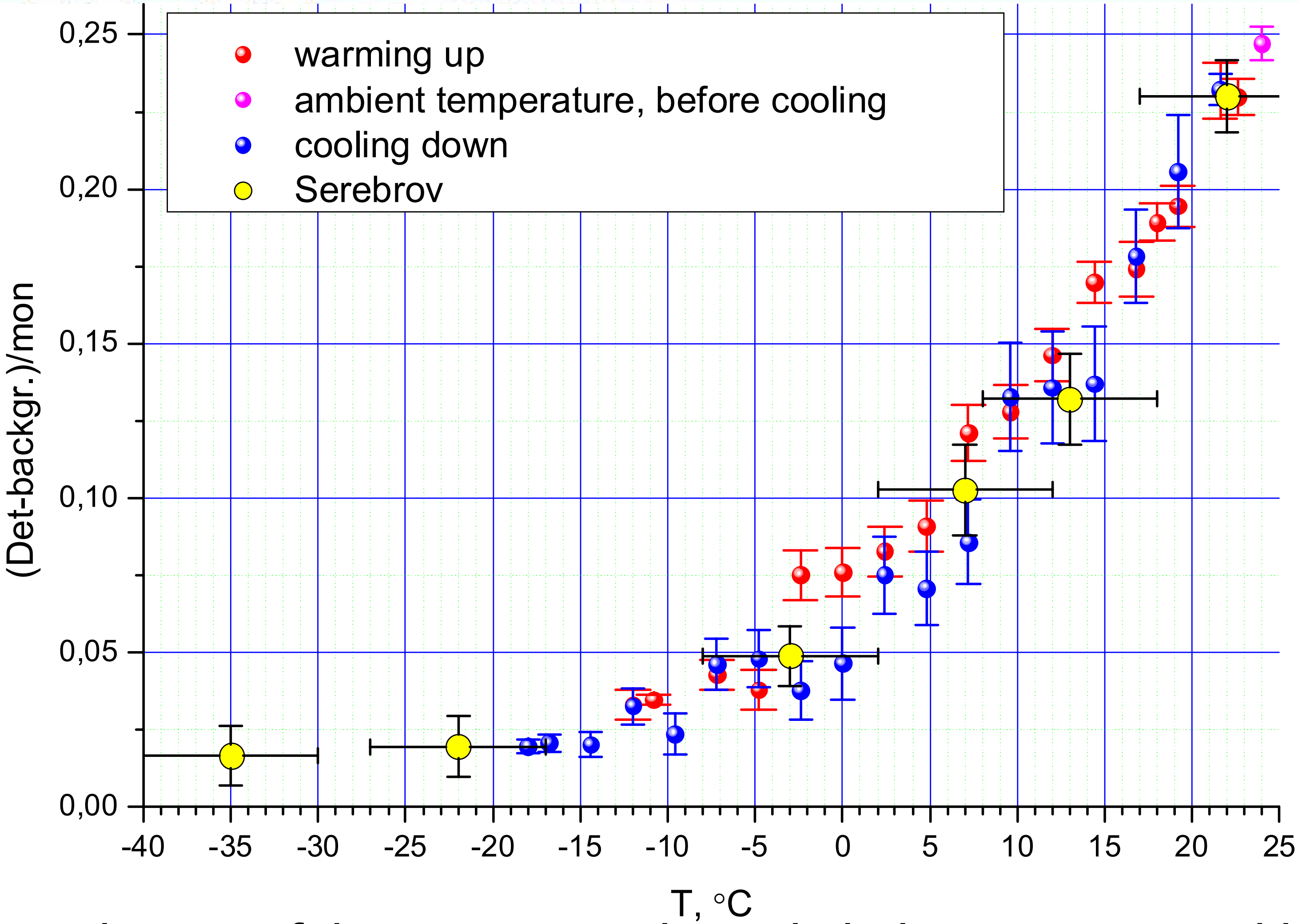
[A.P. Serebrov et al, Physics Letters A 309 (2003) 218–224]



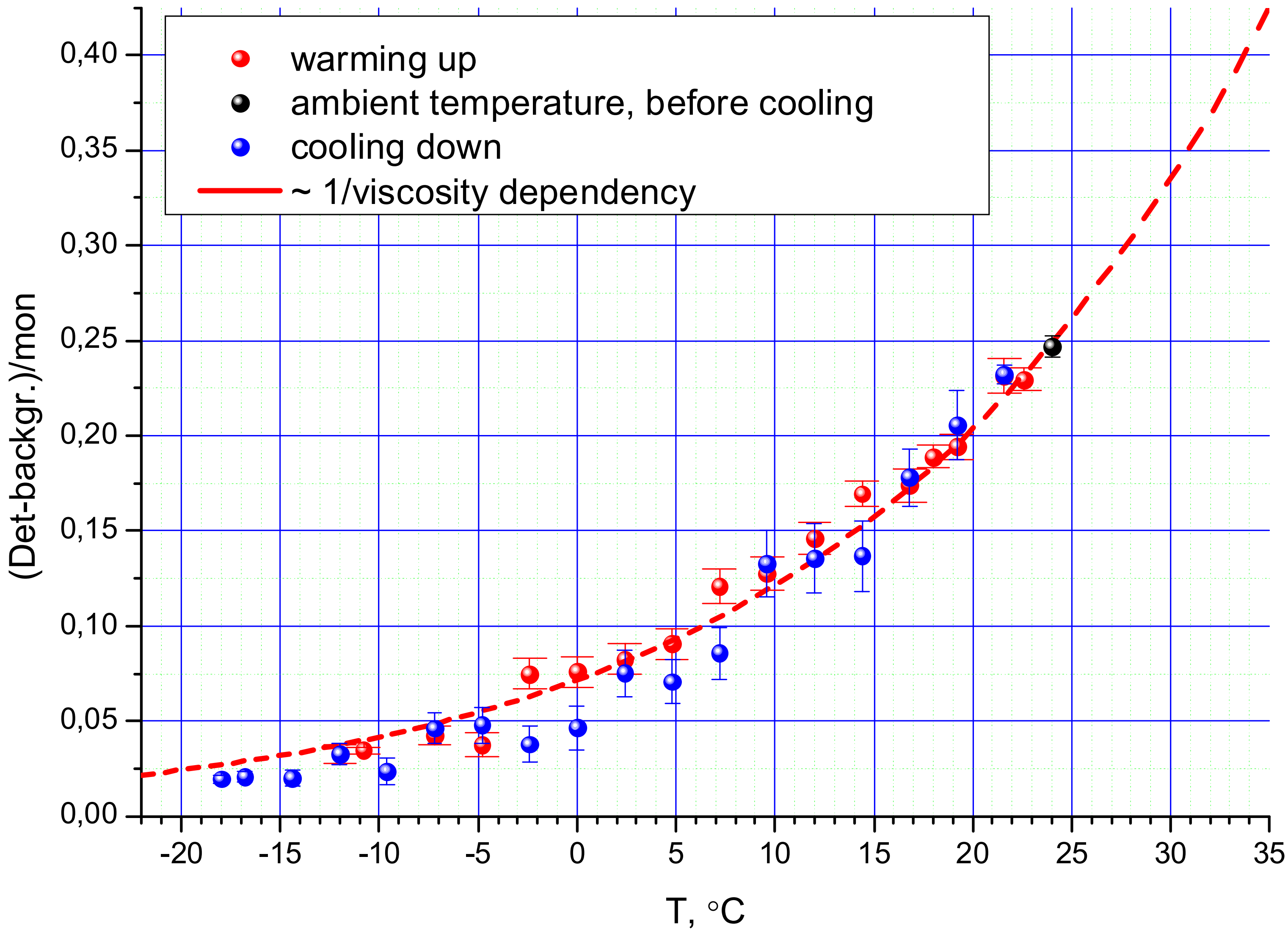




[S.K. Lamoreaux, P.A., R. Golub, *Phys. Rev. C* 2002, Vol. 66, 044309]



Minor change of the spectrum shape is in in agreement with nanoparticles hypothesis and contradicts to hypothesis of Lamoreaux and Serebrov’s conclusion.


warming up
ambient temperature, before cooling
cooling down
~ 1/viscosity dependency
(Det-backgr.)/mon
0,00
0,05
0,10
0,15
0,20
0,25
0,30
0,35
0,40
-20
-15
-10
-5
0
5
10
15
20
25
30
35
T, °C

Conclusions:

1. The spectra measured for Fomblin look exactly like the spectra measured for solid surfaces and for nanoparticles, also like the theoretical predictions within the hypothesis on levitating nanoparticles.

2. Our measured temperature dependence is opposite to the dependence calculated in [S.K. Lamoreaux, P.A., R. Golub, Phys. Rev. C 2002, Vol. 66, 044309]. This result indicates that their hypothesis does not explain the experimental data for UCN small heating on Fomblin surfaces.

3. The temperature dependence of the probability is analogous to the results of work [A.P. Serebrov et al, Physics Letters A 309 (2003) 218–224] in spite of the fact that another fraction of the up-scattered neutron spectrum was measured. This similarity indicates that the spectra shape depends weakly on temperature that contradicts to the hypothesis of Lamoreaux and agrees to the nanoparticles hypothesis.

Thank you for your attention.