THE TEMPERATURE DEPENDENCE OF THE UCN "SMALL HEATING" PROBABILITY AND THE TOTAL UCN LOSSES ON A SURFACE OF HIGHT-TEMPERATURE FOMBLINE OILS
(New experimental data)

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Our fist results for Fomblin was reported during ISINN-20 (Alushta, Crimea):

Aims of the work:

1. Choosing of "high temperature oil" type for precise experiments with UCN (like neutron life time measurements)

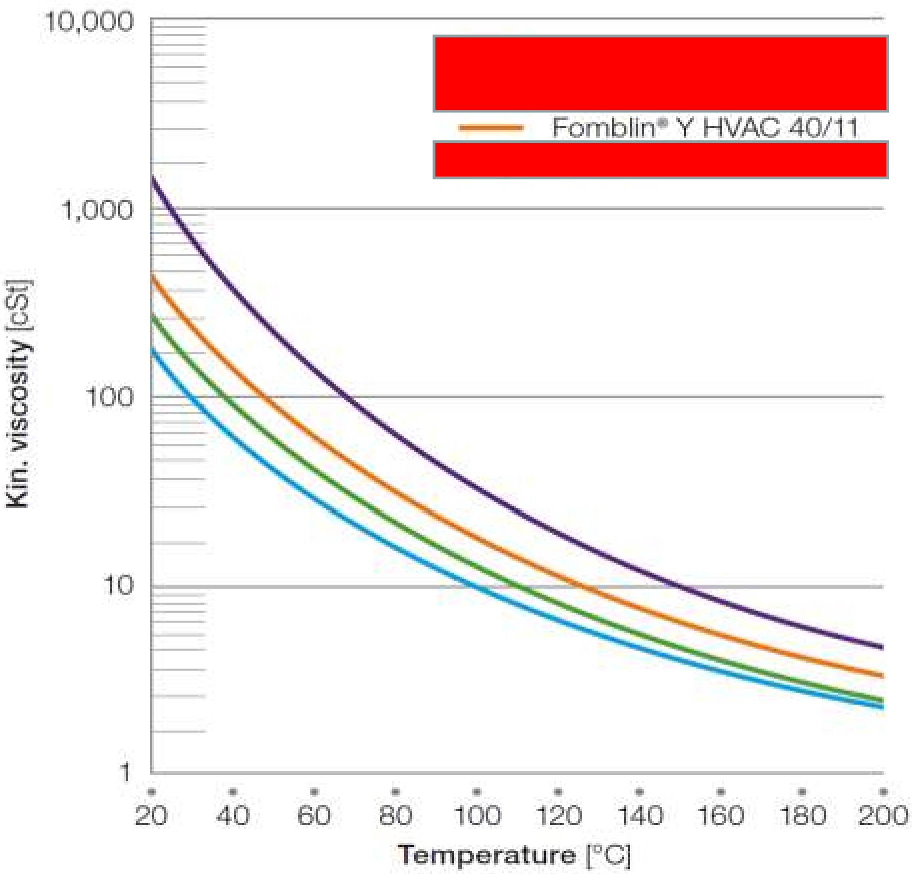
Better to have small losses and small energy change probability

2. Determination of temperature region for these experiments.

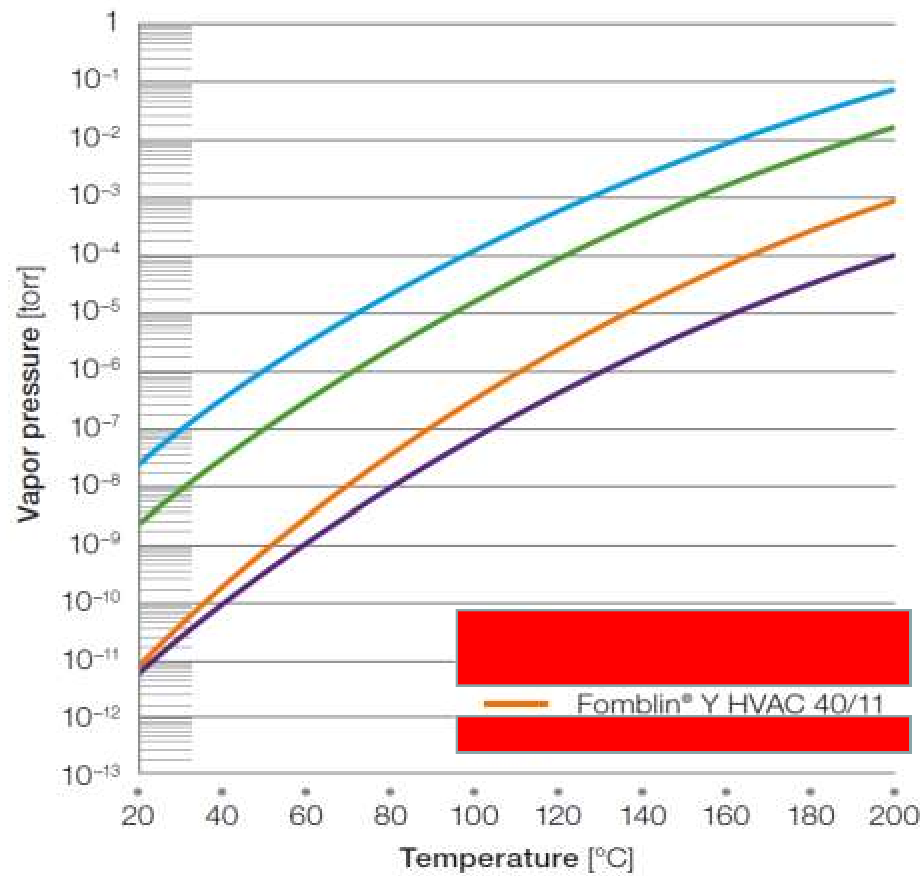
3. Investigation of small heating of UCN at liquids

Investigated oils

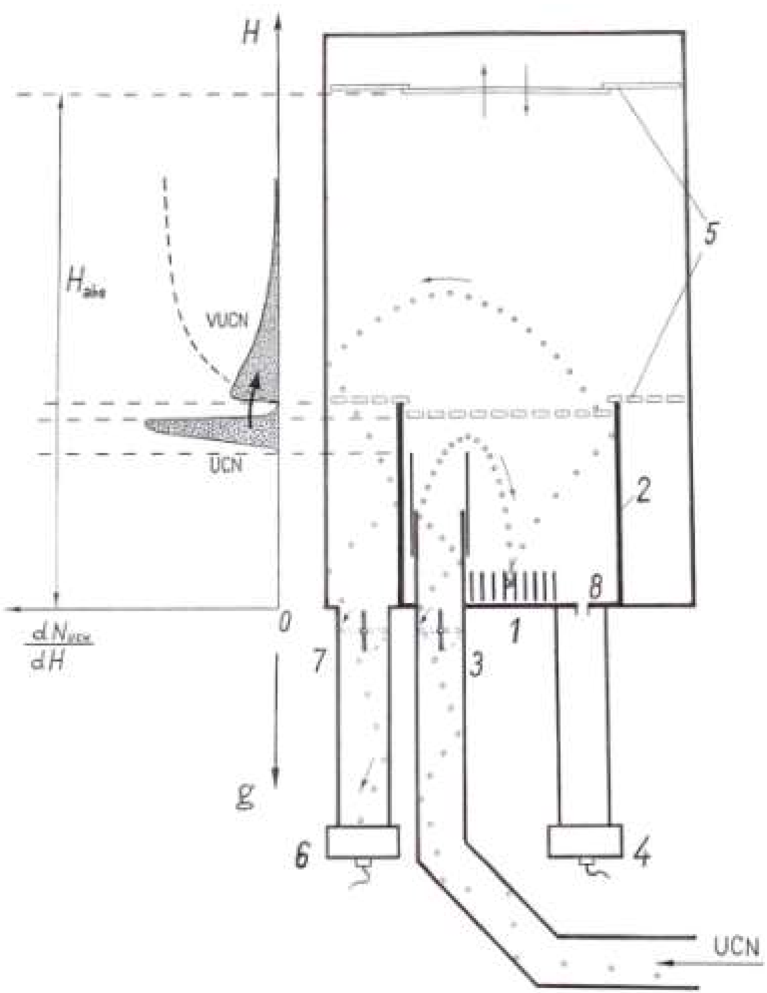
Fomblin® Y HVAC – kinematic viscosity vs. temperature



Fomblin® Y HVAC – vapor pressure vs. temperature

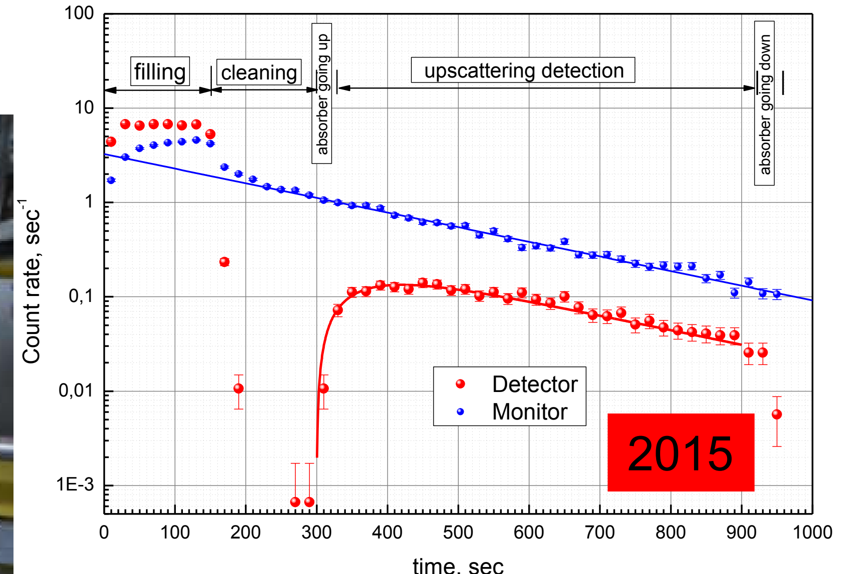


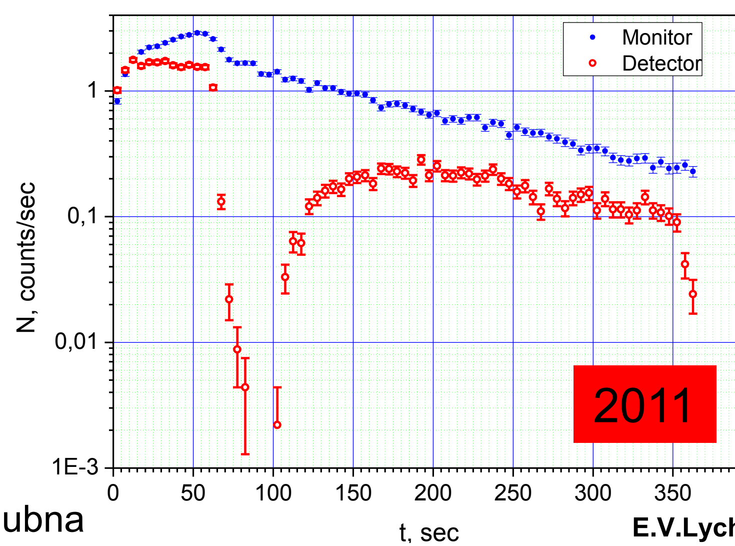
Experimental set-up is BGS



Experimental set-up is BGS

To measure loses at Fomblins we “paint” walls of storage volume by Oil with 6500 a.m.w





So, we decrease losses, increase statistics but increase the “cleaning time” too.

Samples

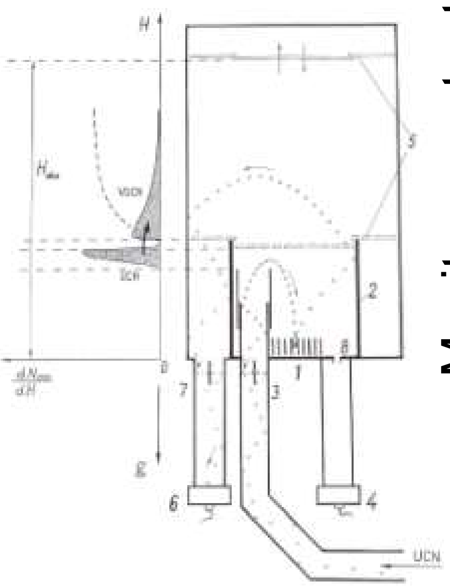
Aluminum foils “painted” by oils.

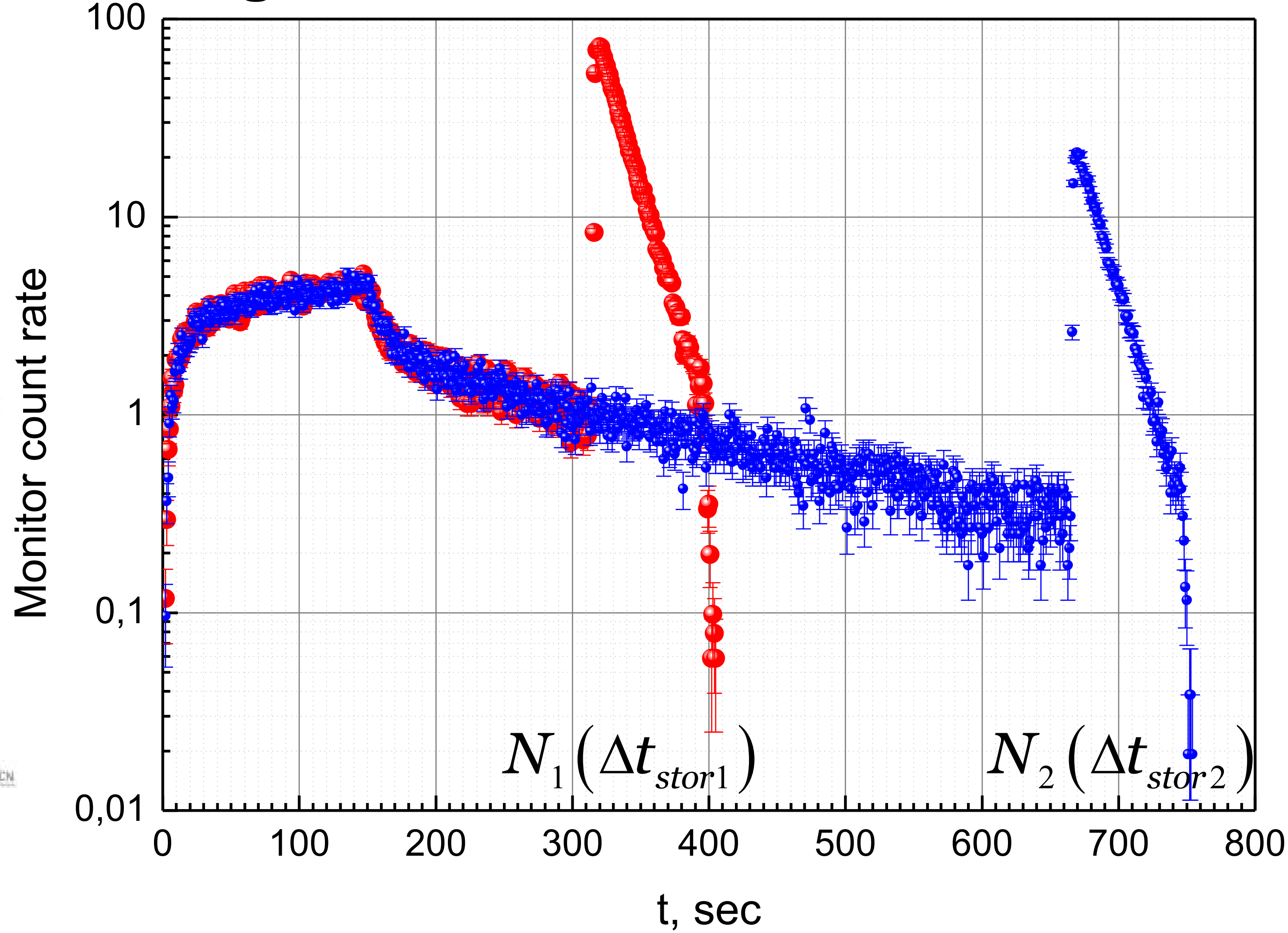
Thickness of oil layers is about 1-10 μ (estimated by outgo of oils).

Total surface 0.74 m^2

Height is 5 cm

Storage time measurements





Storage time measurements

$$\tau_{st} = \left(\Delta t_{stor2} - \Delta t_{stor1}\right) \Big/ \ln \frac{N_1\left(\Delta t_{stor1}\right)}{N_2\left(\Delta t_{stor2}\right)}$$

T, K	τ_{st} , sec
Empty spectrometer	
298	335.7±1.1
Sample F-6500	
298	261±1.4
267	286±2
240	300±1.8
140	333.3±1.8
100	331±2.5
Sample F-3300	
298	294±1.9
266	320±2
Sample F-2800	
298	286±2,2
270	314±2,1
240	325±1,4
163	349±3
150	358±4
140	355±2

Losses factor

$$\begin{cases} \dfrac{1}{\tau_{st1}(298K)} = \eta_{6500}(298K)\gamma_{sp} + \dfrac{1}{\tau_\beta} + \dfrac{1}{\tau_{slits}} \\ \dfrac{1}{\tau_{st2}(298K)} = \eta_{6500}(298K)\gamma_{sp+sample} + \dfrac{1}{\tau_\beta} + \dfrac{1}{\tau_{slits}} \end{cases} \Rightarrow$$

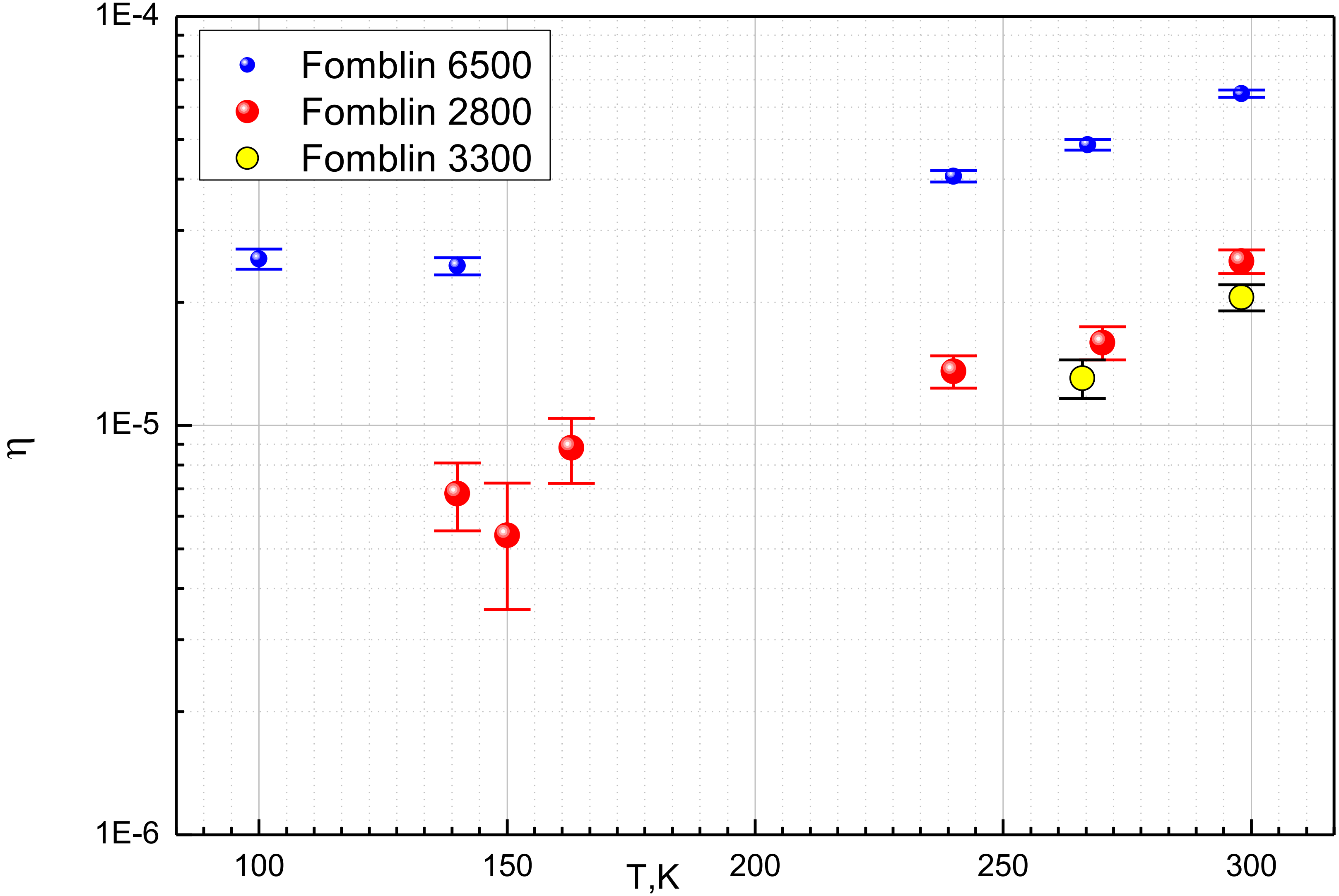
$$\begin{cases} \eta_{6500}(298K) = \left(\dfrac{1}{\tau_{st2}(298K)} - \dfrac{1}{\tau_{st1}(298K)}\right)\dfrac{1}{\left(\gamma_{sp+sample} - \gamma_{sp}\right)} = \left(\dfrac{1}{\tau_{st2}(298K)} - \dfrac{1}{\tau_{st1}(298K)}\right)\dfrac{1}{\gamma_{sample}} \\ \dfrac{1}{\tau_{slits}} = \dfrac{1}{2}\left(\dfrac{1}{\tau_{st1}(298K)} + \dfrac{1}{\tau_{st2}(298K)} - \eta_{6500}(298K)\left(\gamma_{sp} + \gamma_{sp+sample}\right)\right) - \dfrac{1}{\tau_\beta} \end{cases}$$

$$\gamma(h_o) = \sqrt{\frac{g h_{\lim}}{2}} \frac{\int_S \left(\arcsin\sqrt{\dfrac{h_o - h}{h_{\lim}}} - \sqrt{\dfrac{h_o - h}{h_{\lim}}}\sqrt{1 - \dfrac{h_o - h}{h_{\lim}}}\right) dS(h)}{\int_V \sqrt{\dfrac{h_o - h}{h_{\lim}}}\, dV(h)}$$

$$\eta_{6500}(T) = \frac{1}{\tau_{st2}(T)} - \frac{1}{2\gamma_{sp+sample}}\left(\frac{1}{\tau_{st1}(298K)} + \frac{1}{\tau_{st2}(298K)} - \eta_{6500}(298K)\left(\gamma_{sp} + \gamma_{sp+sample}\right)\right)$$

$$\begin{aligned} \frac{1}{\tau_{st2800}(T)} &= \eta_{6500}(T)\gamma_{sp} + \eta_{2800}(T)\gamma_{sample} + \frac{1}{\tau_\beta} + \frac{1}{\tau_{slits}} = \\ &= \eta_{6500}(T)\gamma_{sp} + \eta_{2800}(T)\gamma_{sample} + \\ &+ \frac{1}{2}\left(\frac{1}{\tau_{st1}(298K)} + \frac{1}{\tau_{st2}(298K)} - \eta_{6500}(298K)\left(\gamma_{sp} + \gamma_{sp+sample}\right)\right) \end{aligned}$$

Losses factor

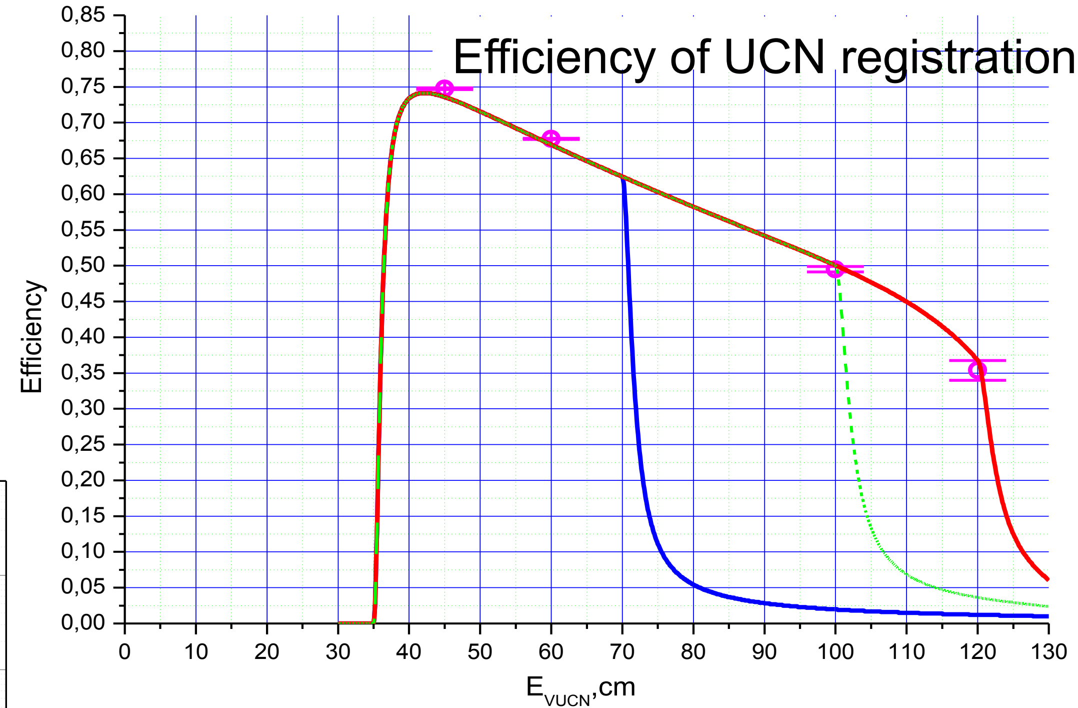


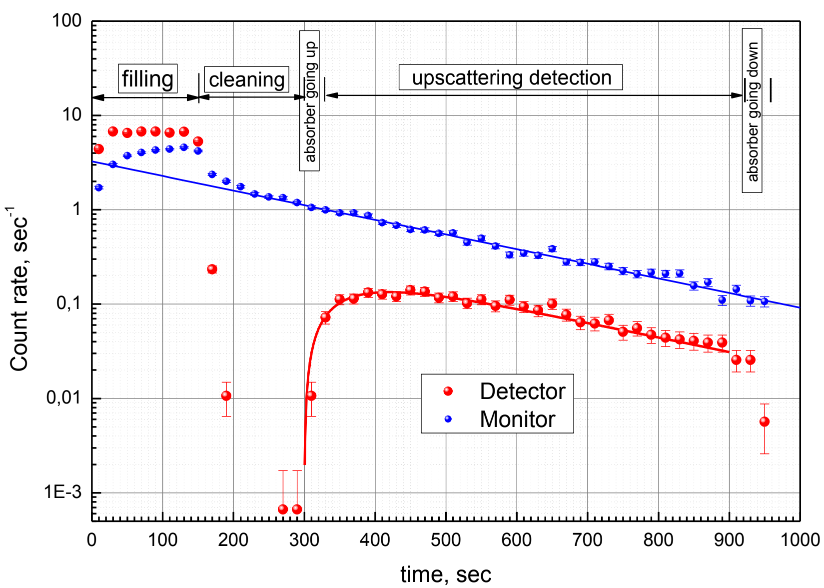
“Small heating”

$$P_{VUCN} = \frac{N_{det}}{N_{mon}\varepsilon} \frac{S_{mon}}{S_{sample}}$$

$$\varepsilon(h) = \frac{\tau_{stor}(h) - \tau_{VUCN}(h)}{\tau_{stor}(h)}$$

$$\varepsilon \approx 0.65$$





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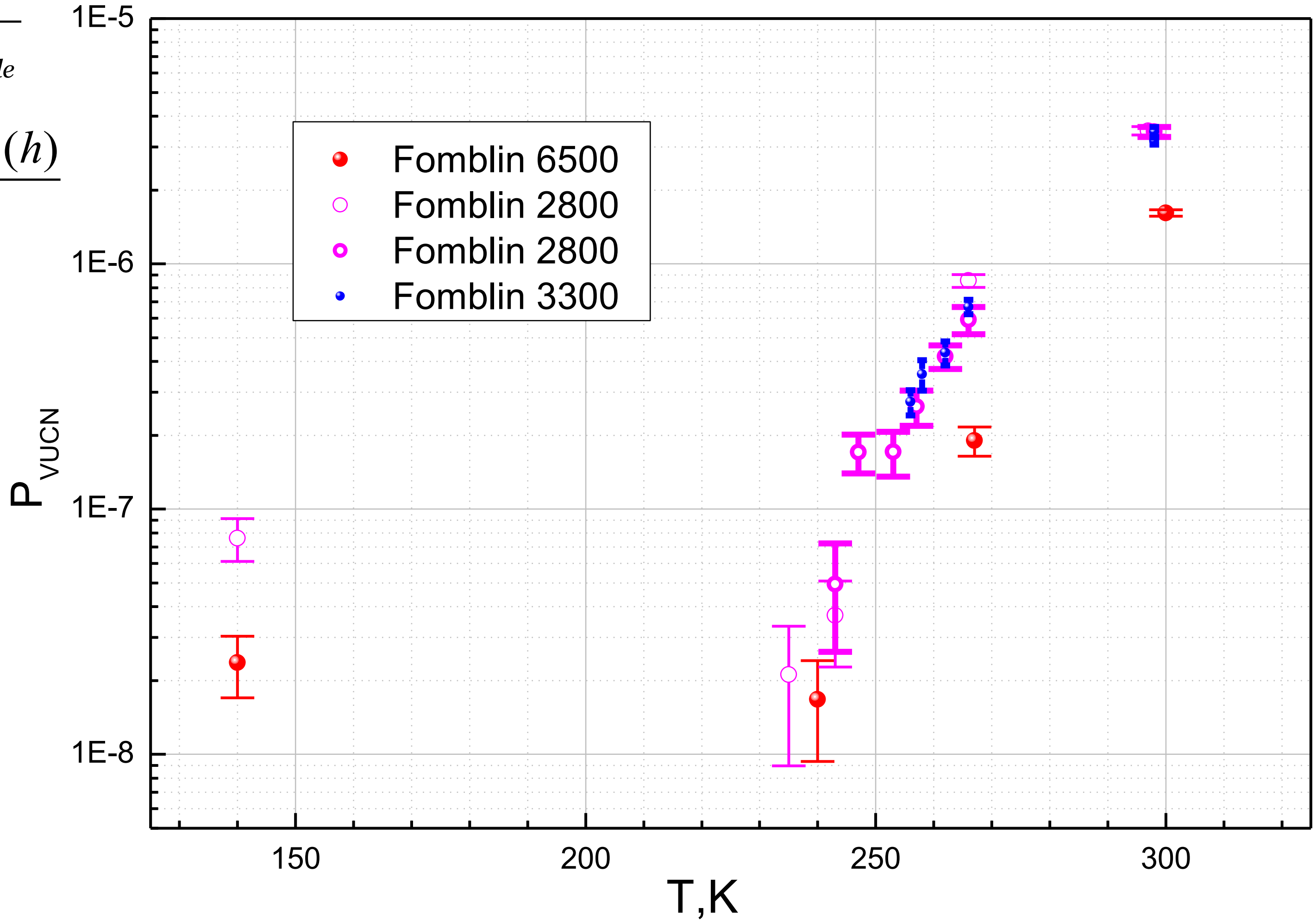
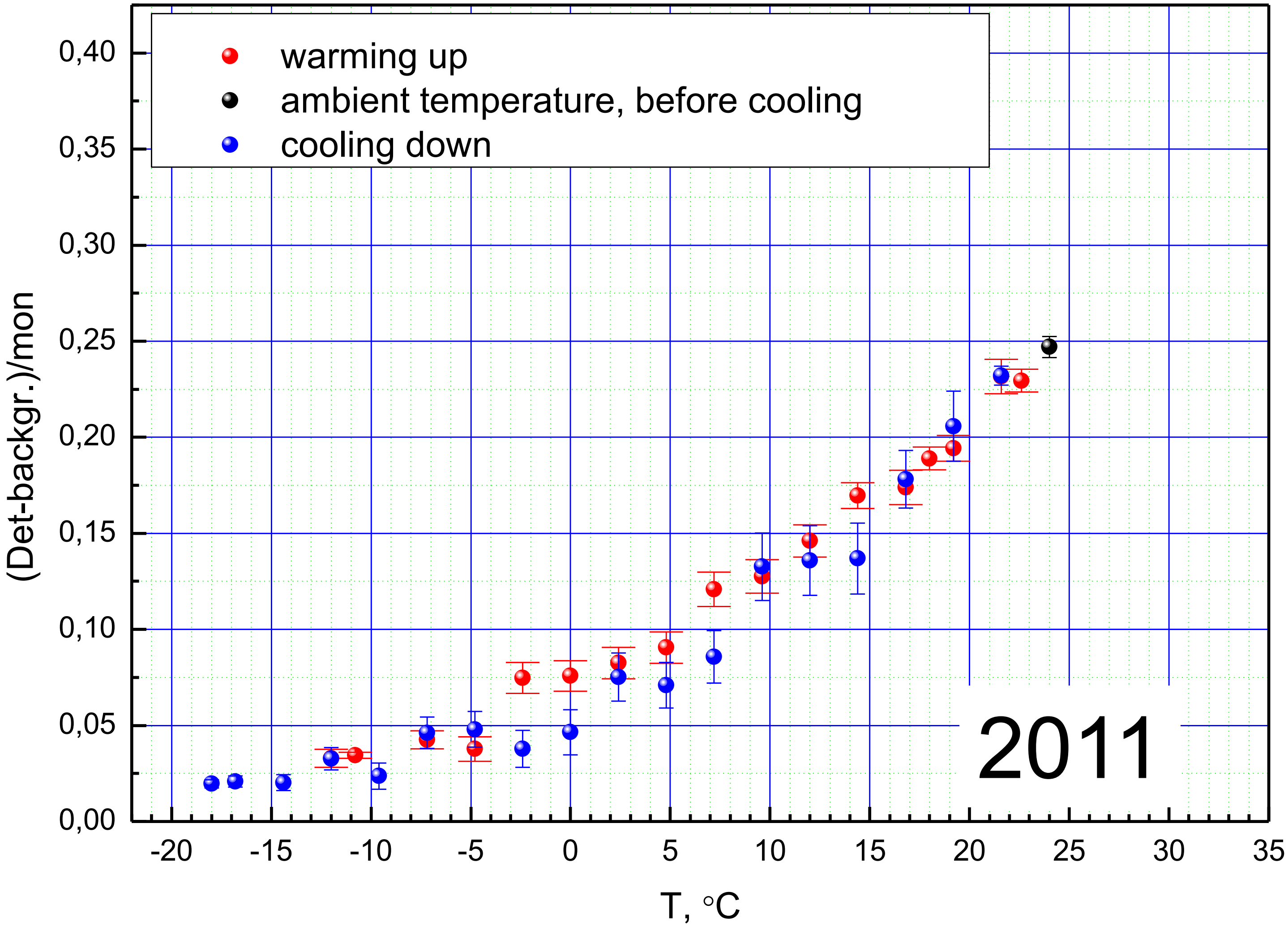


Observation of oil layer destroying at deep cooling

Spontaneous breaking of the coatings was oserved in the temperature range 150-100 K for all types of oils and for Fomblin grease.

Comparing with previous measurements at 2011 for Fomblin 2800



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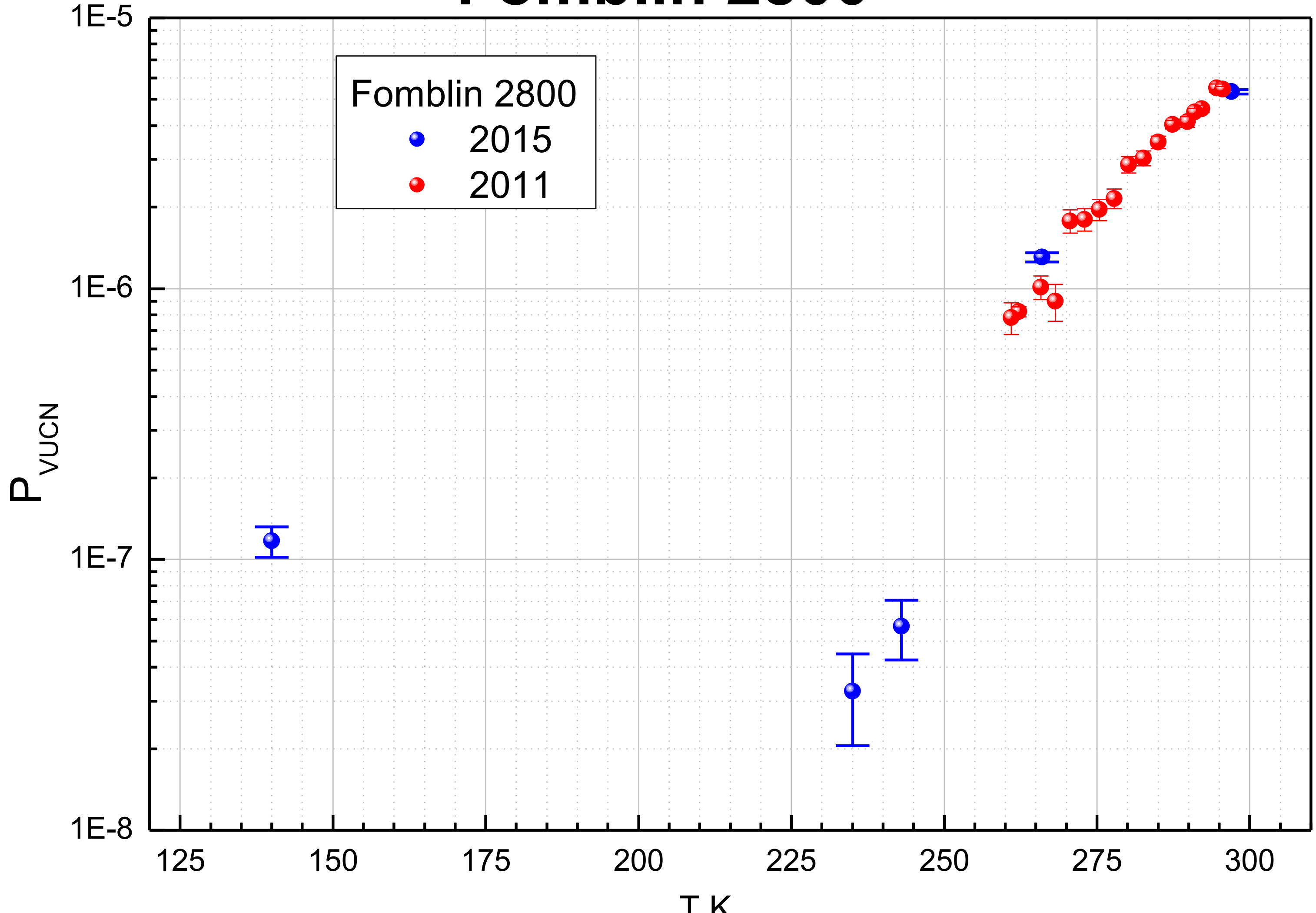
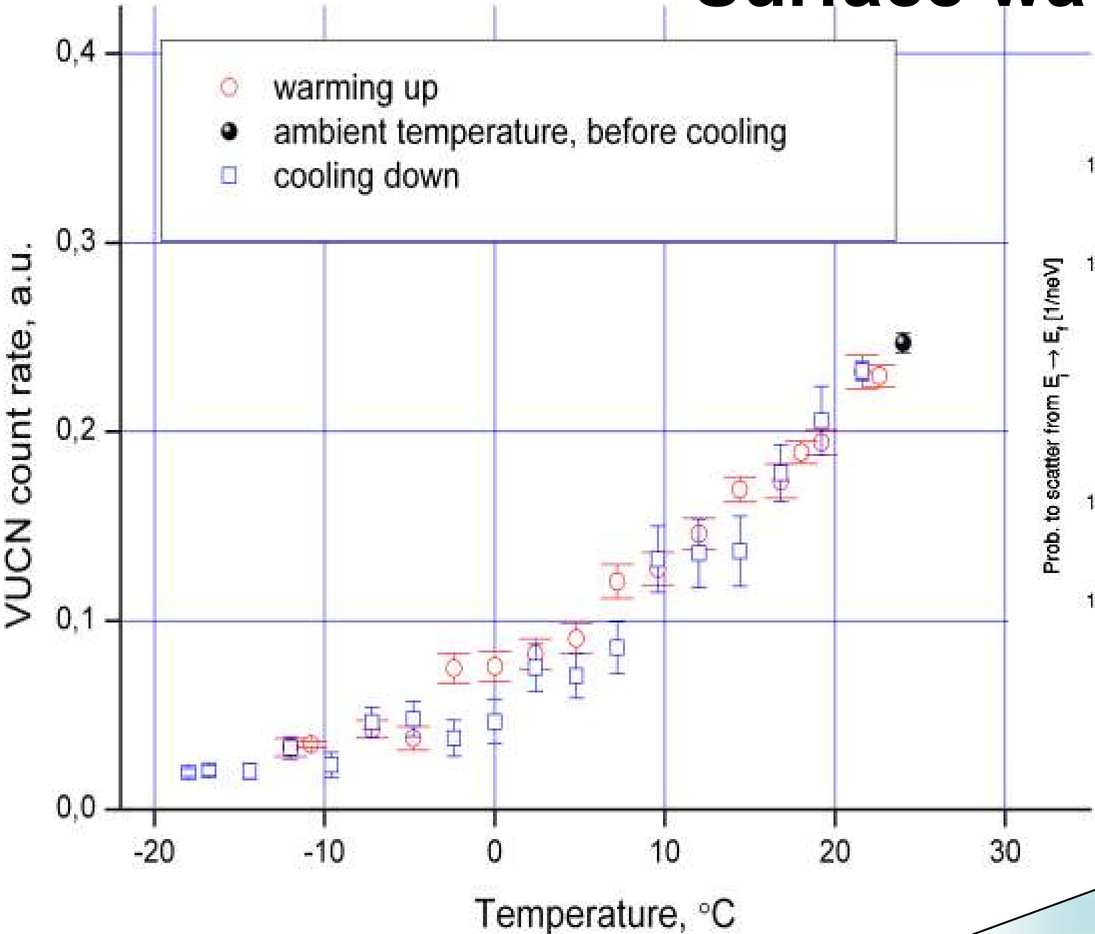
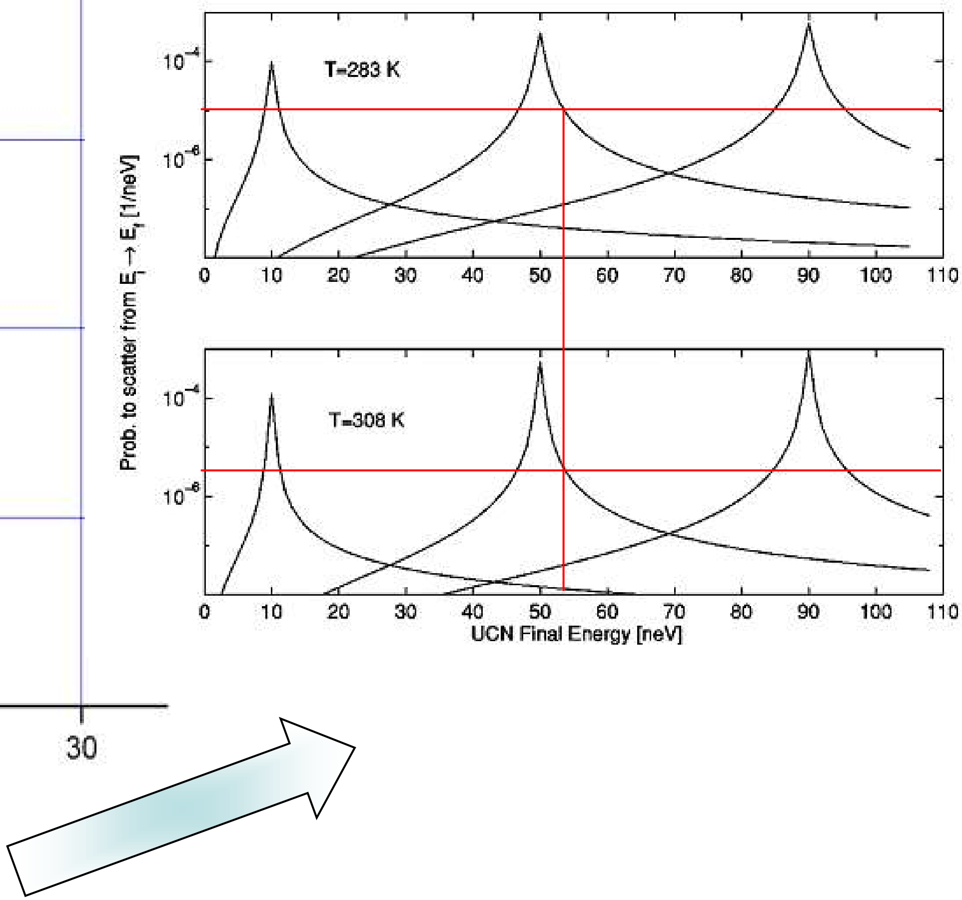


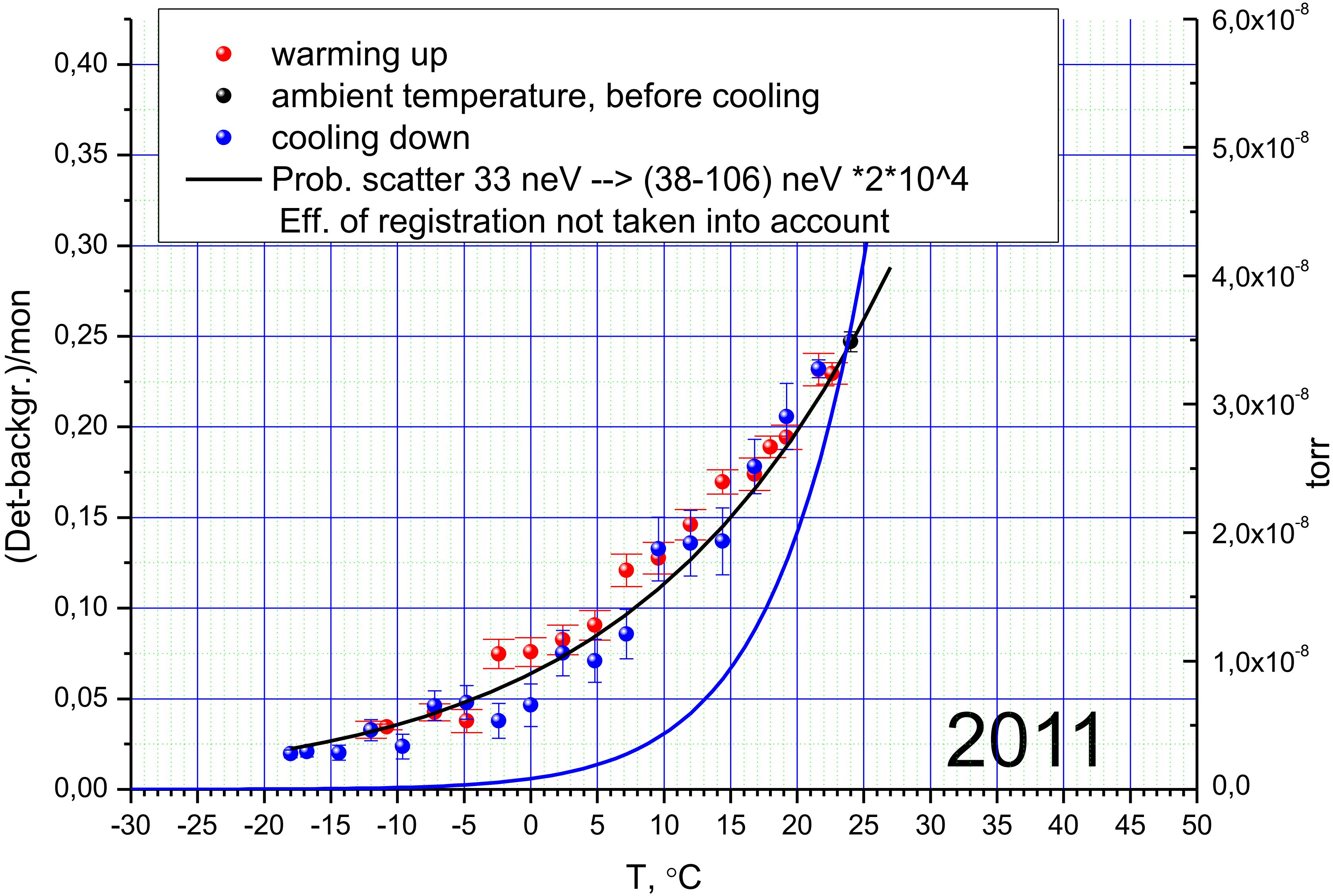
Surface waves





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

Surface waves



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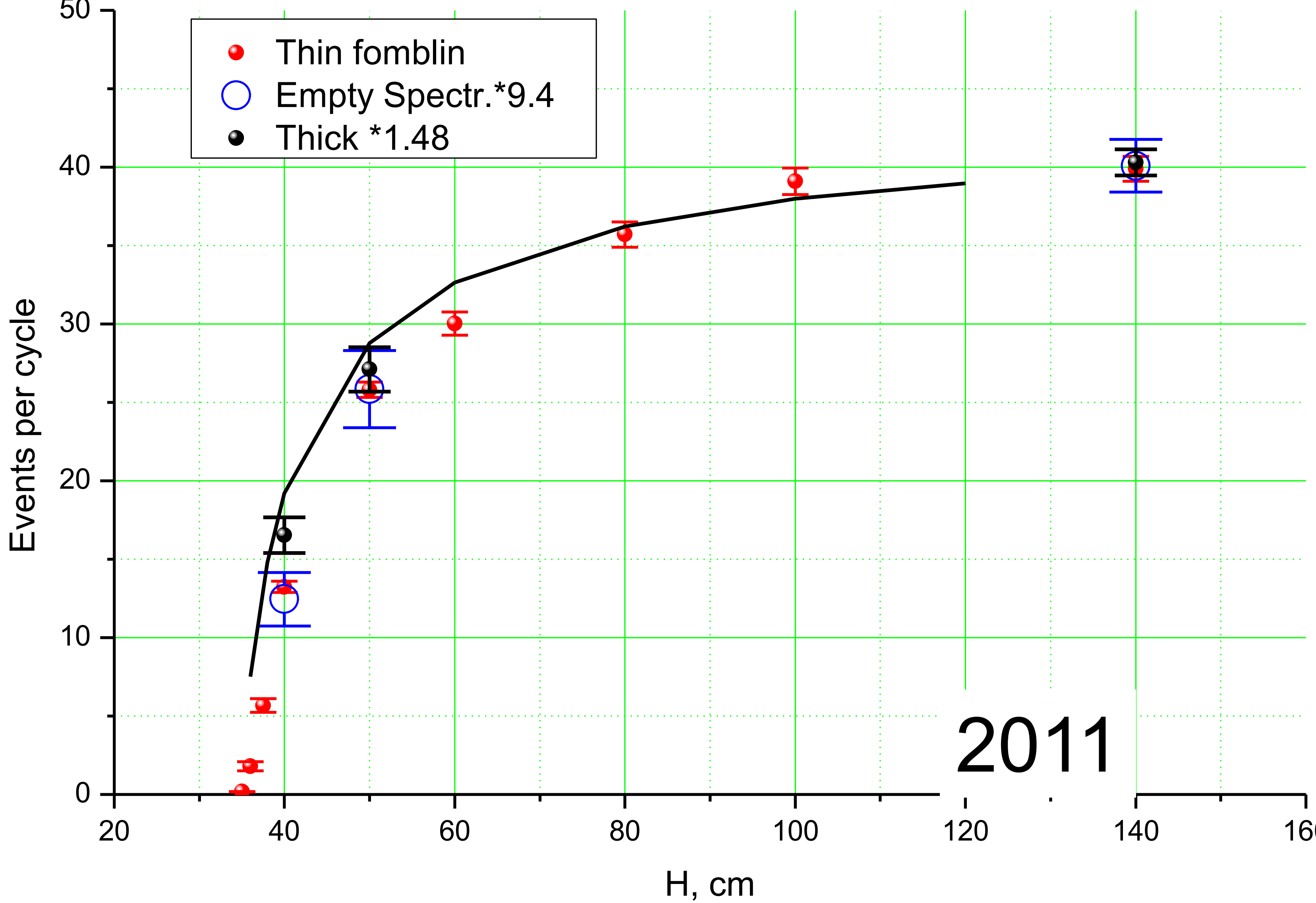

Conclusions

1. "Small heating" decreases quickly with decreasing of the temperature and become less then 10-7 under 240K for all type of investigated oils.
2. Thin layers (about several microns) of all oils crack spontaneously after cooling down to 150K-100K.
3. Best oil for precise measurements F-3300 (it has relatively small losses factor and relatively small upscattering).
4. Optimal temperature range for precise measurements with trap covered by thise oil is between 150K and 240K.
5. Experimental data not contradict to hypothesis of inelastic UCN scattering at surface waves as the reason of small heating on liquid surfaces.

Thank you for your attention.