Joint Institute for Nuclear Research

SCIENCE BRINGS NATIONS TOGETHER

FLNP Frank Laboratory of Neutron Physics

Universal Cryogenic Moderator for Research Neutron Sources of Any Power and Intensity

(concept)

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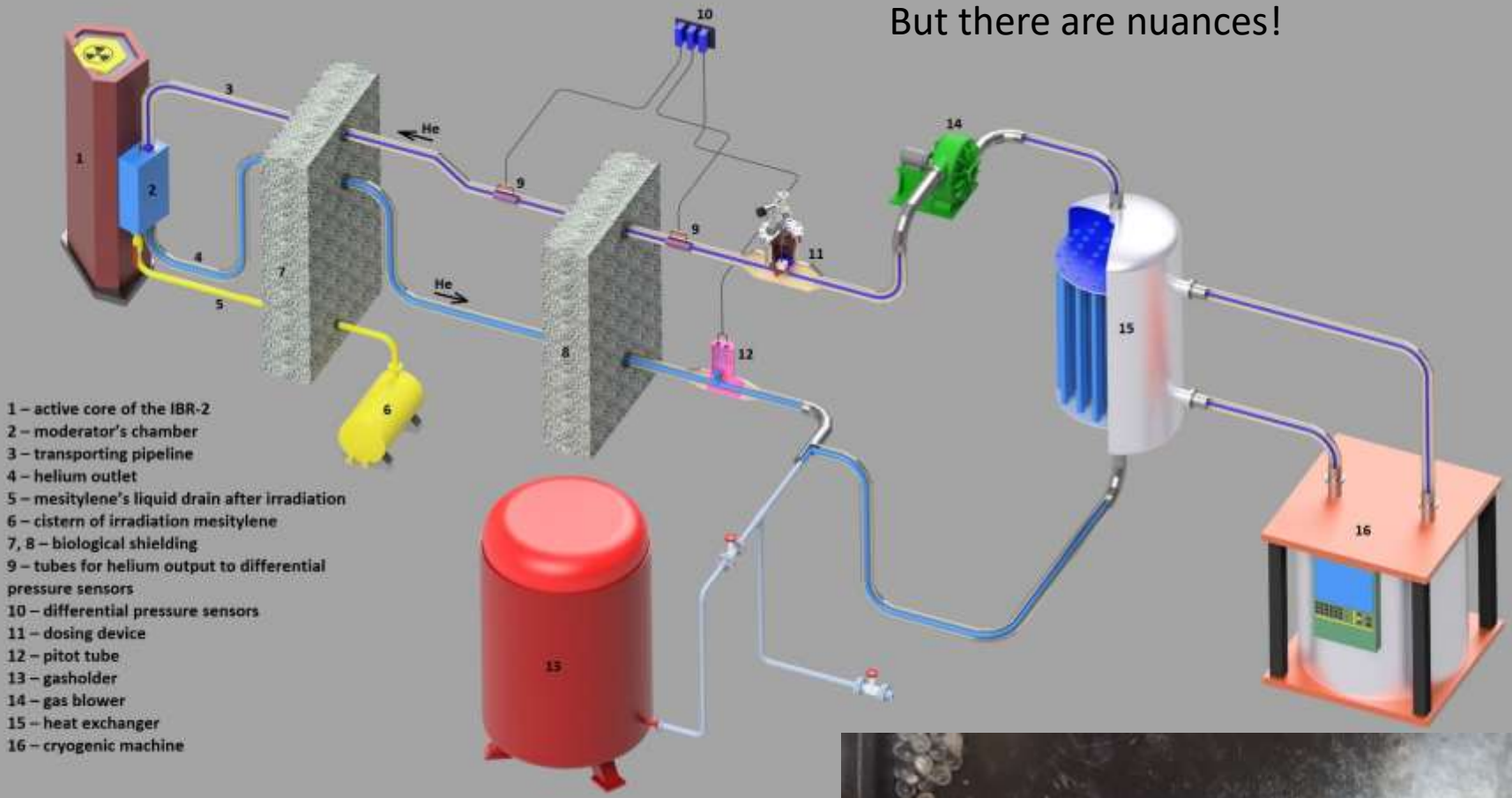
ISINN-31, 26-30 May 2025
Dongguan

Universal cryogenic moderator based on solid hydrocarbons

- The main idea is that we have a new method, technologies and a new principle of work for the pelletized cryogenic moderator, which allows us to use perspective solid hydrogen-containing materials at low temperatures to effectively slow down neutrons and use it long time during the neutron campaign at the source
- This technology can be used on any neutron source – compact (10^{10}-10^{11} n/cm^2/s), medium-intensity (10^{12} n/cm^2/s) and high-intensity source (more than 10^{13} n/cm^2/s)
- Perspective solid materials: methane, aromatic hydrocarbons (mes+mx), tpm.
- ! Don’t use liquid hydrogen as a cold moderator material at for universal moderator at any sources (small compact and middle and high intensity fast pulse reactor). There is no best intensity!
- Universal cold moderator is pelletized cold moderator at first (can be monolith when we talk about the compact neutron source)

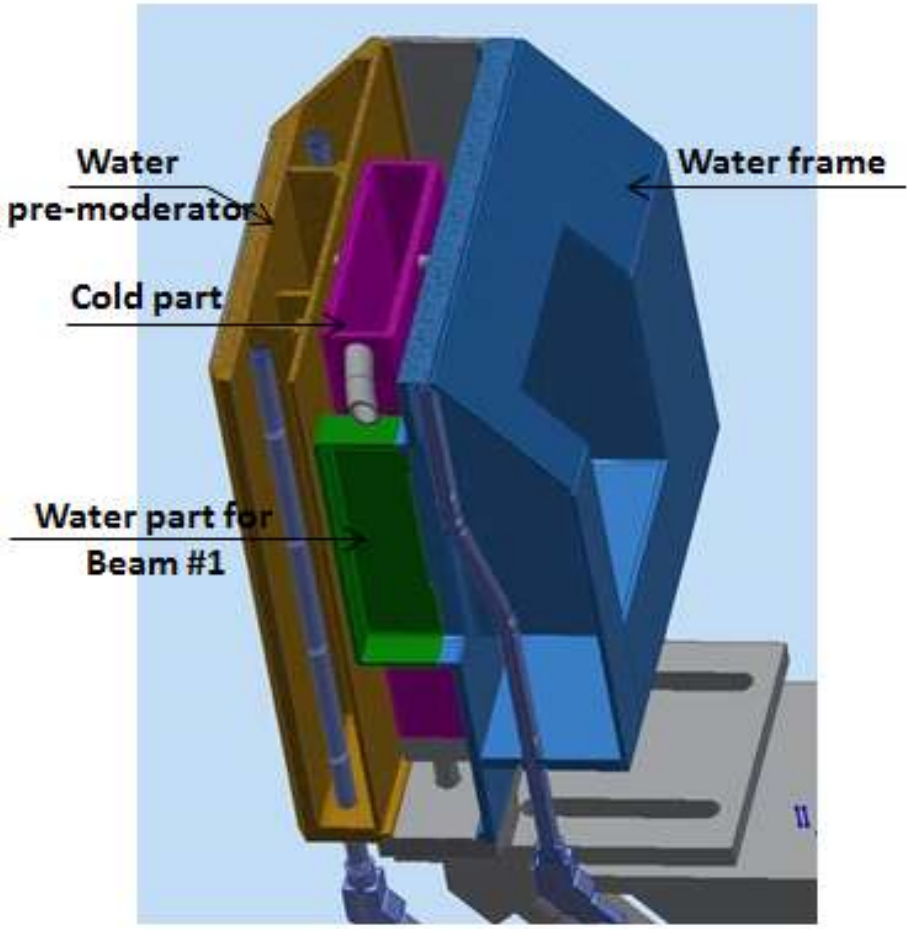
Pelletized cold moderator

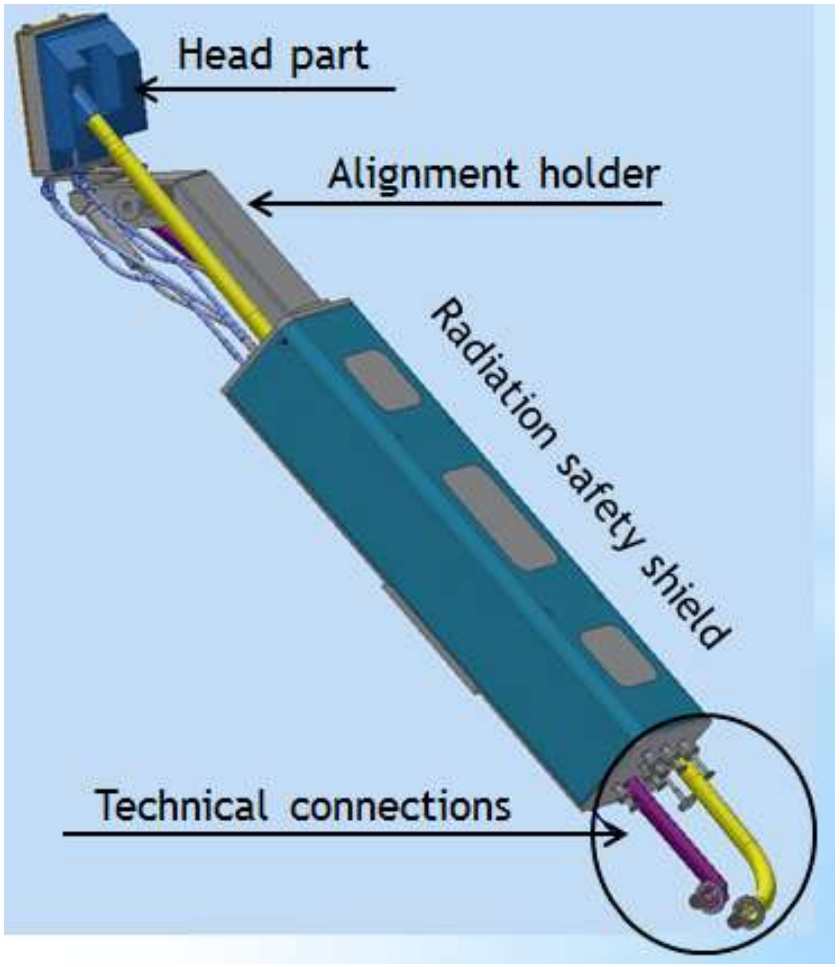
But there are nuances!



Chamber of moderators

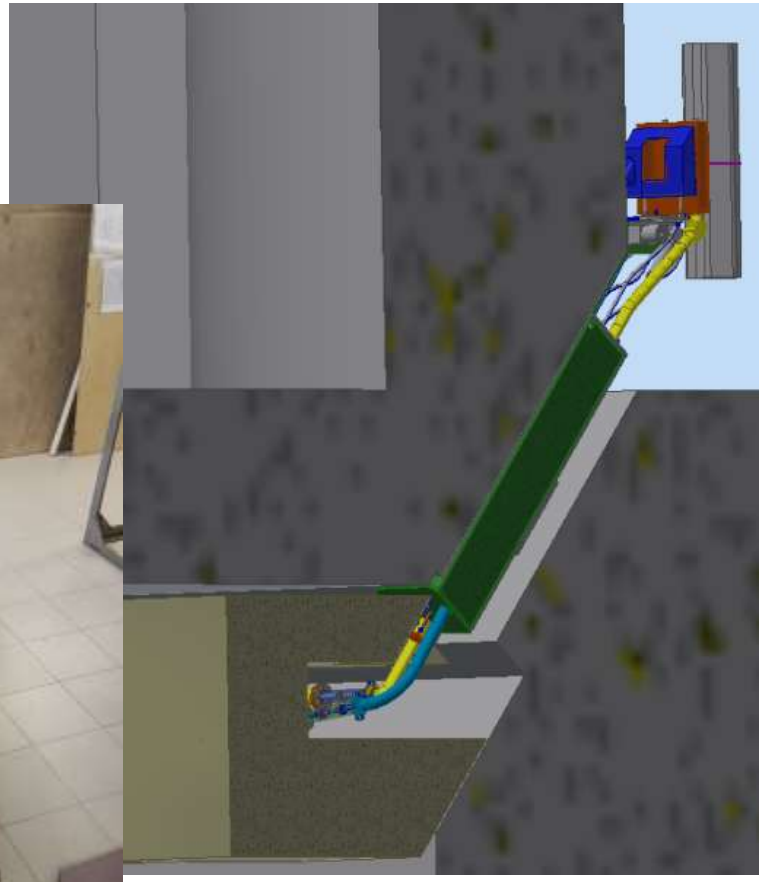
Moderator for central direction
(beams: 1, 4, 5, 6, 9) – 6 instruments

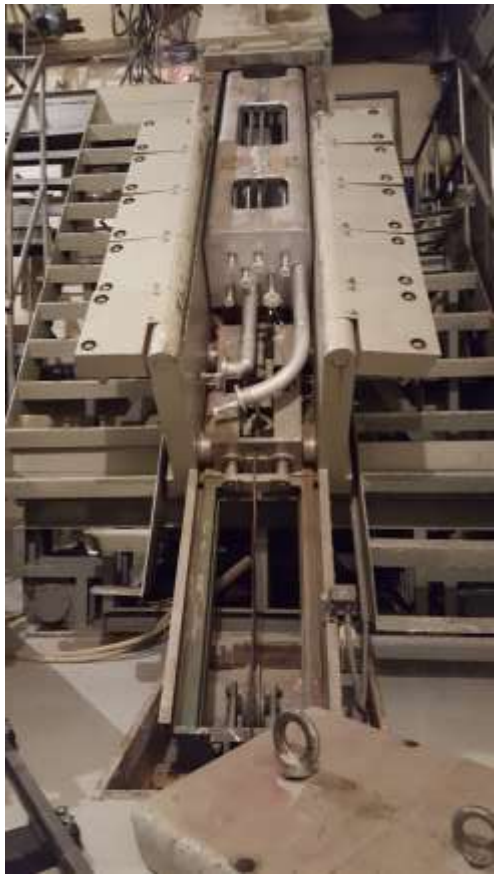




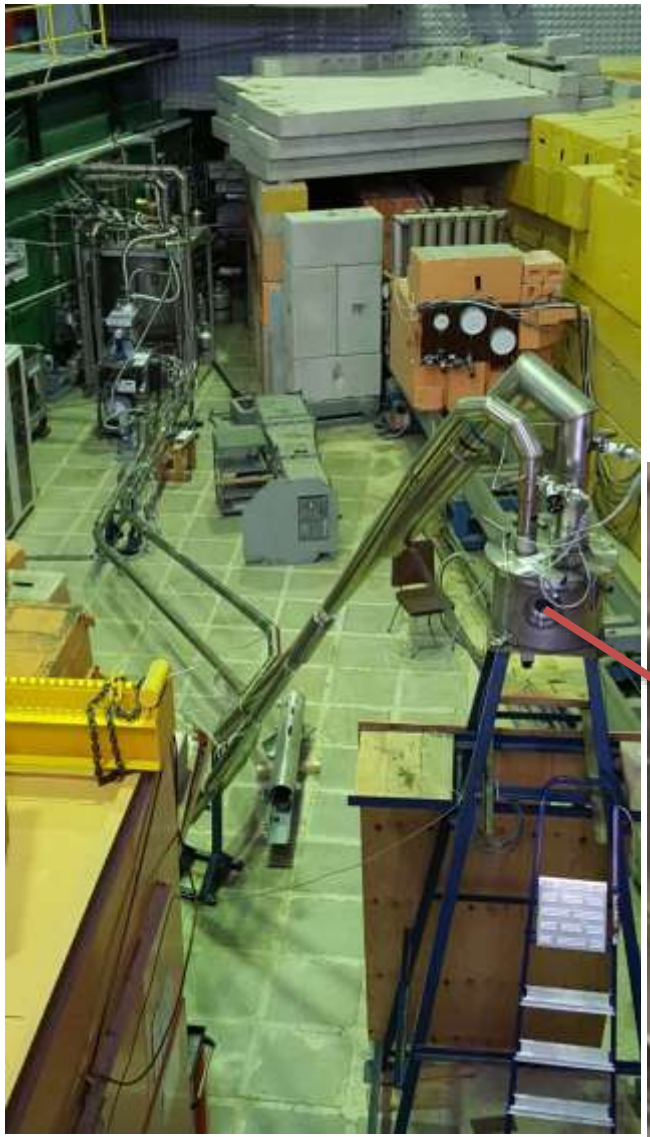
Chamber of moderators

Moderator for central direction



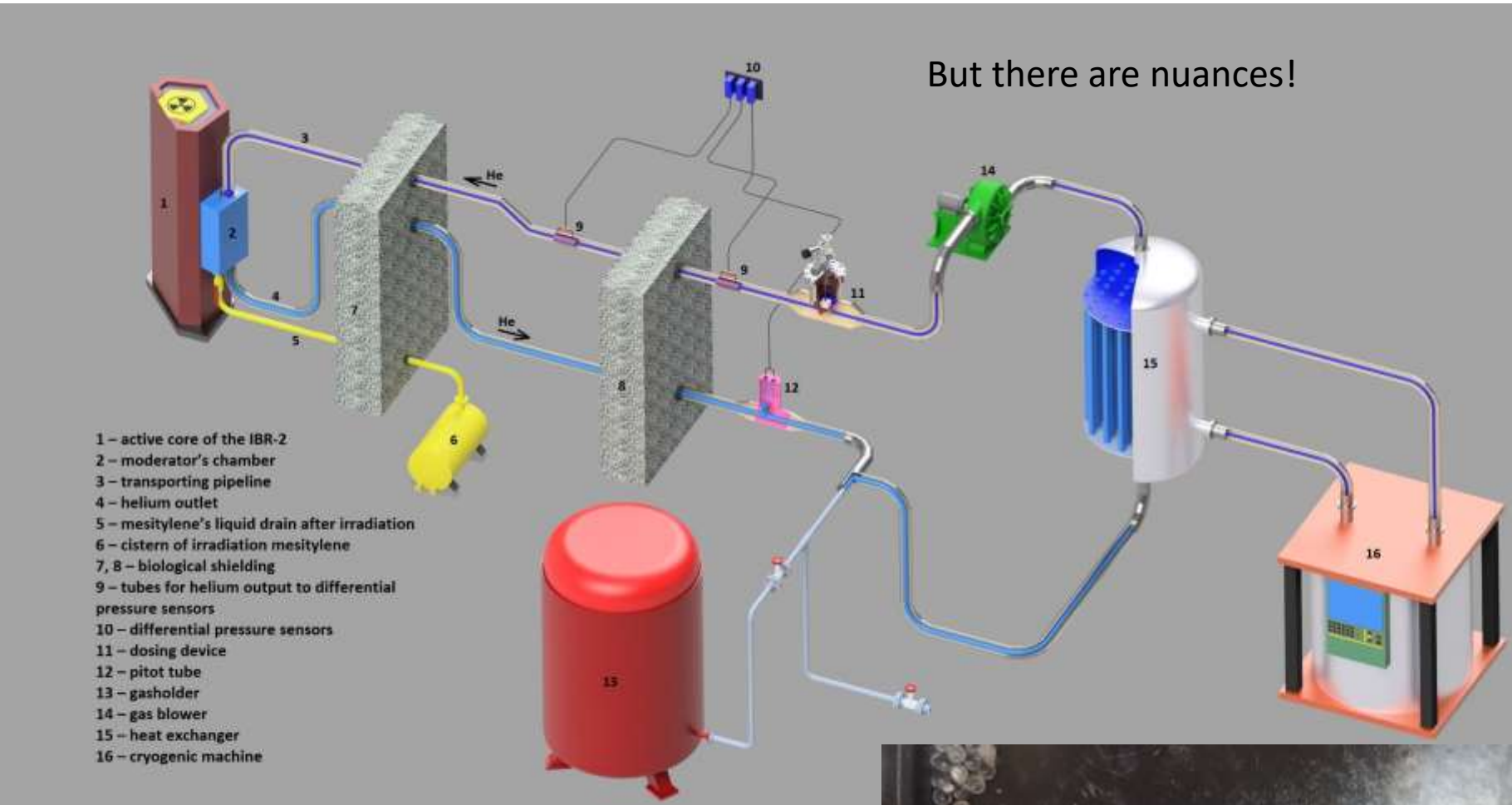


Test stand



Pelletized cold moderator is not universal c.m.

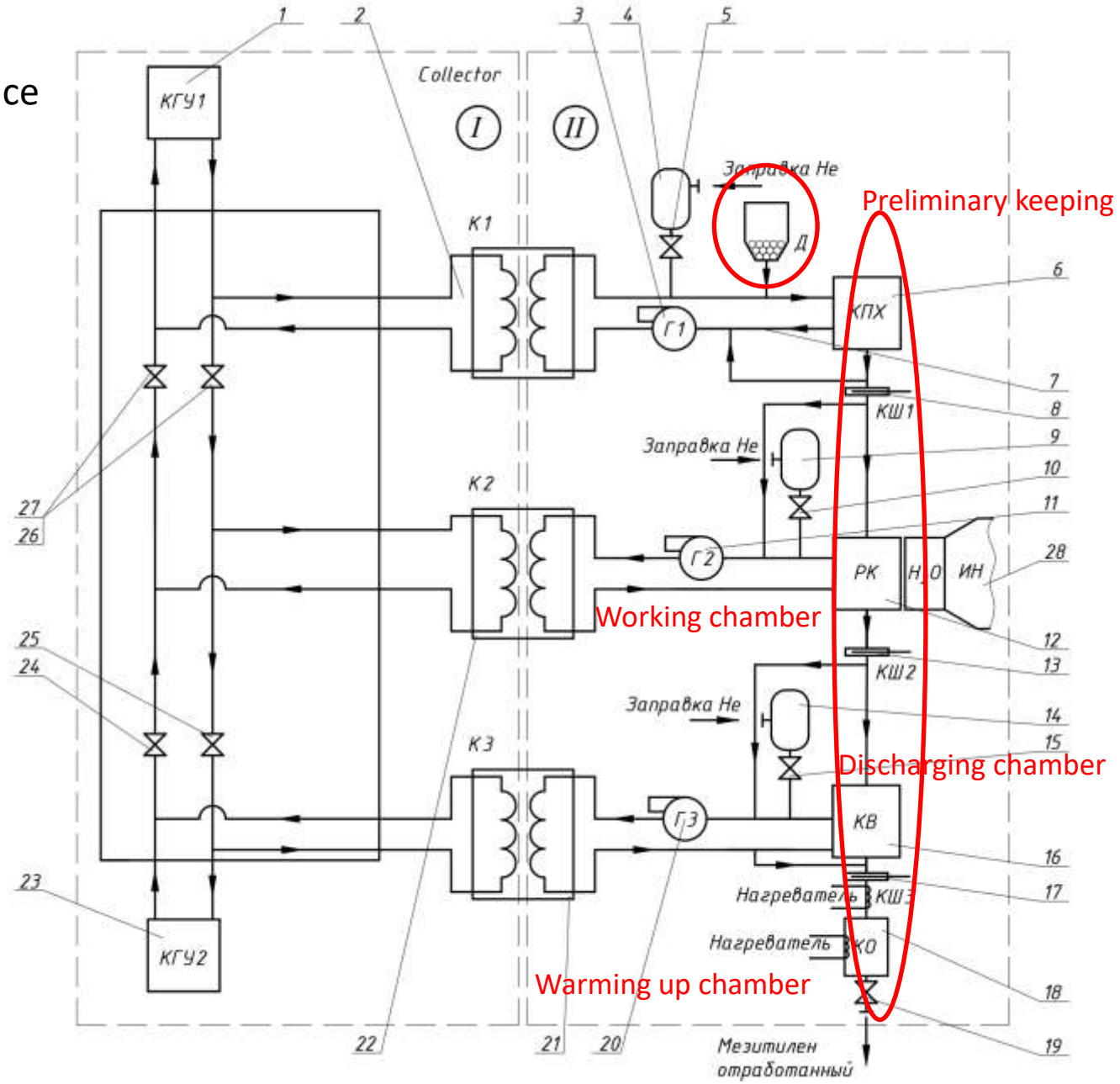
But there are nuances!



- Example 1 – methane moderator at the IBR-2
- Example 2 – mesitylene moderator at the NEPTUN reactor

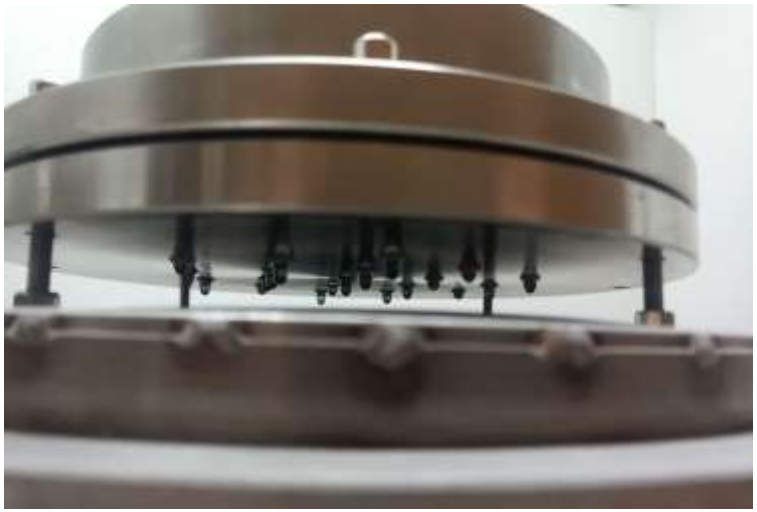
Universal cold moderator: principle of work

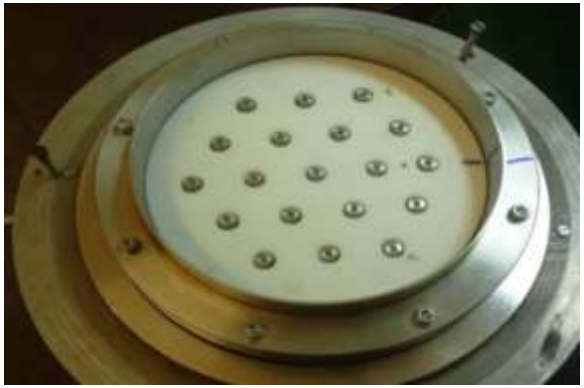
Key point 1 – high-performance facility producing of frozen drops (1 l/h – 1l/d)
Key point 2 – charging device with fast feed rate
Key point 3 – system for fast discharging of moderator material (irradiated frozen drops/pellets)

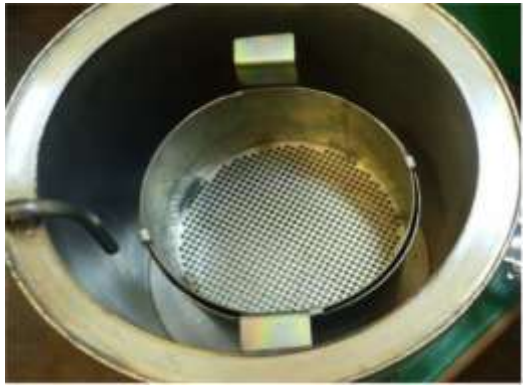


Key point 1 – high-performance facility producing of frozen drops

50 ml/h

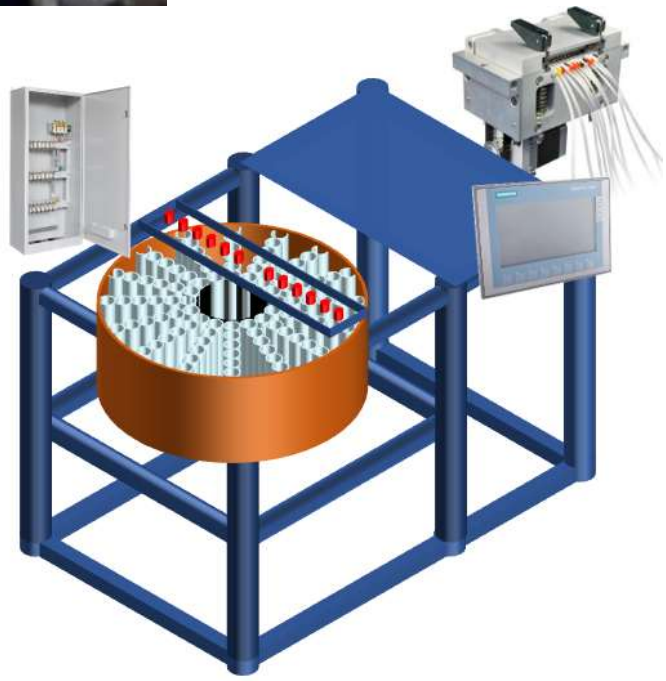




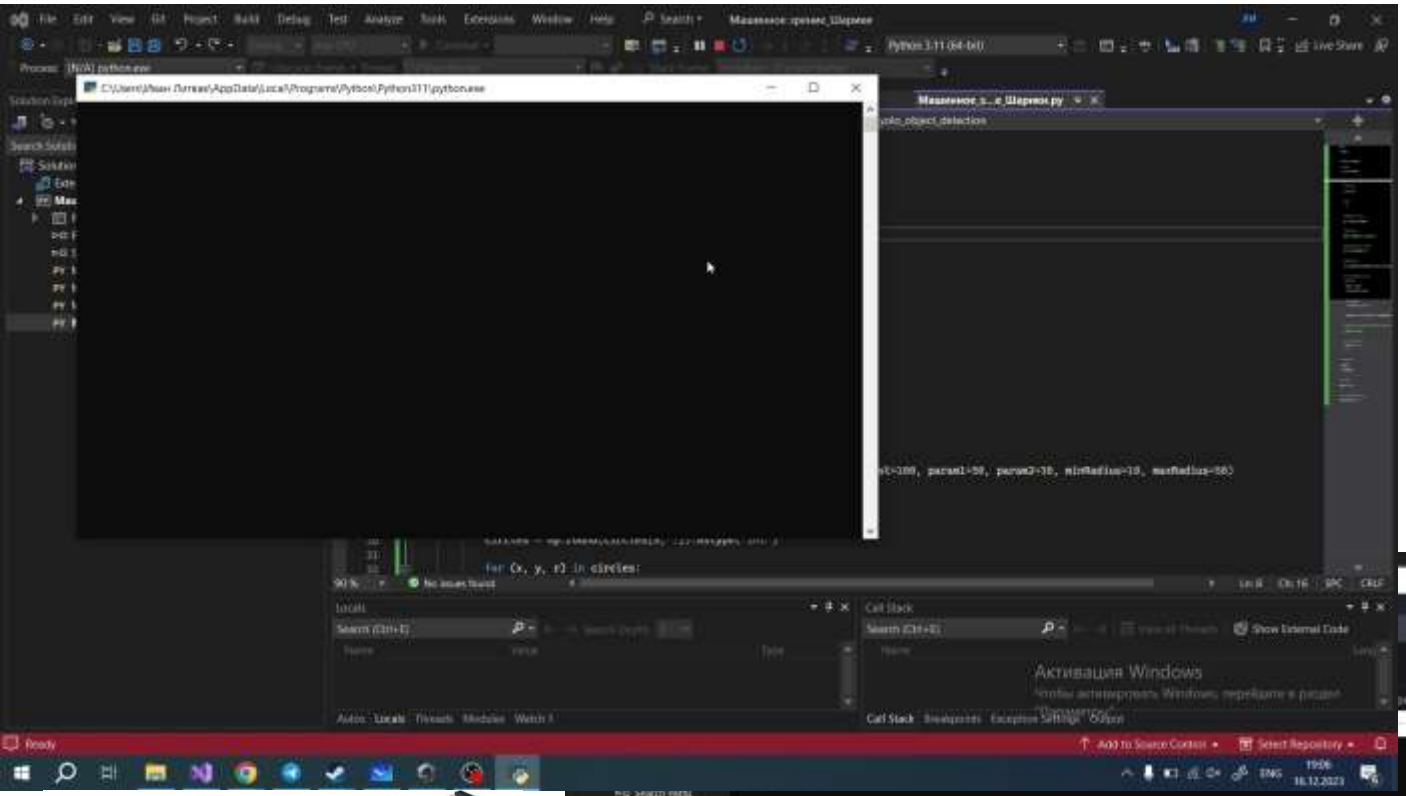


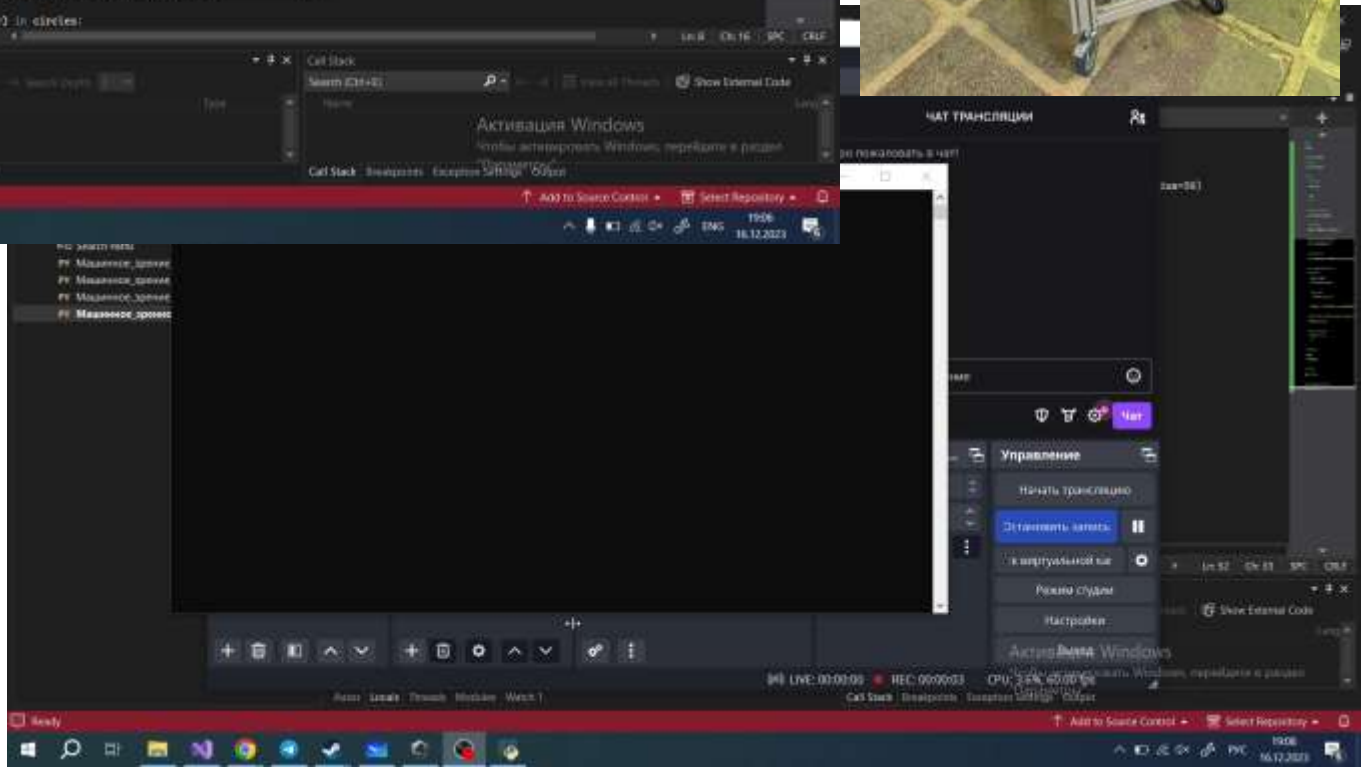
Key point 1 – high-performance facility producing of frozen drops

1,3 l/h

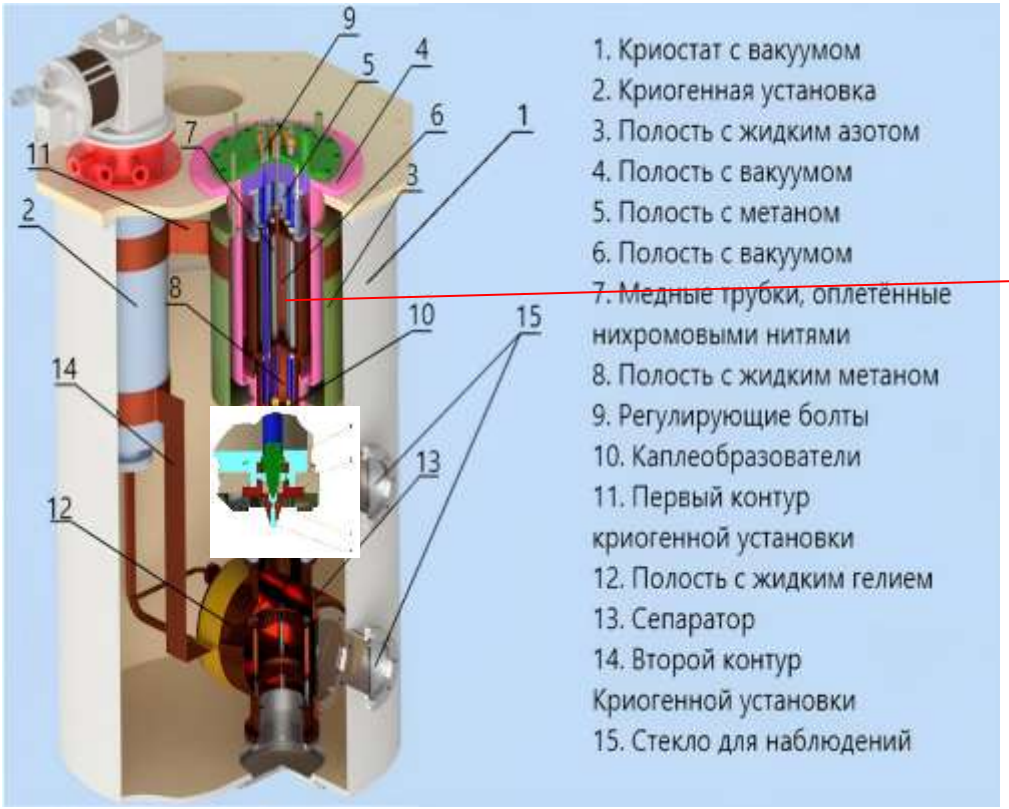


Key point 1 – high-performance facility producing of frozen drops

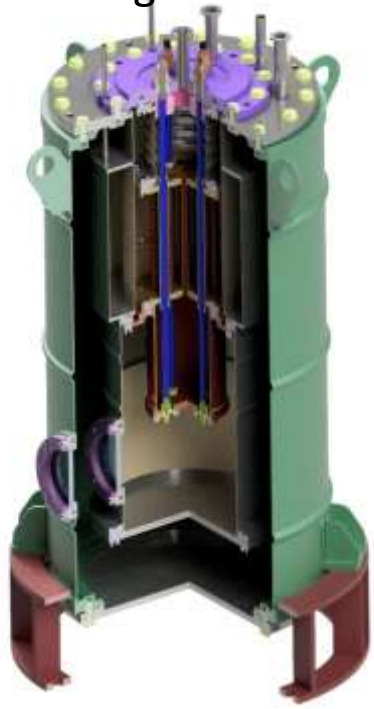


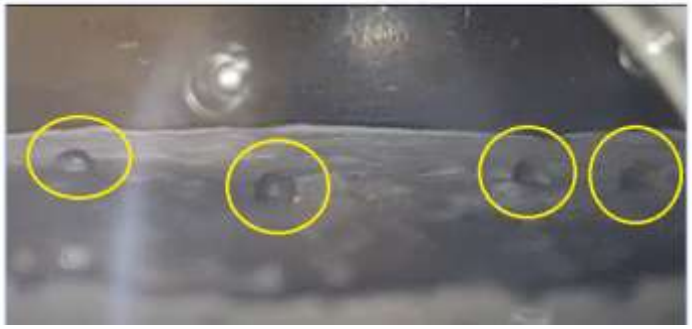


Key point 1 – high-performance facility producing of frozen drops (methane)



1 stage – methane in nitrogen, argon



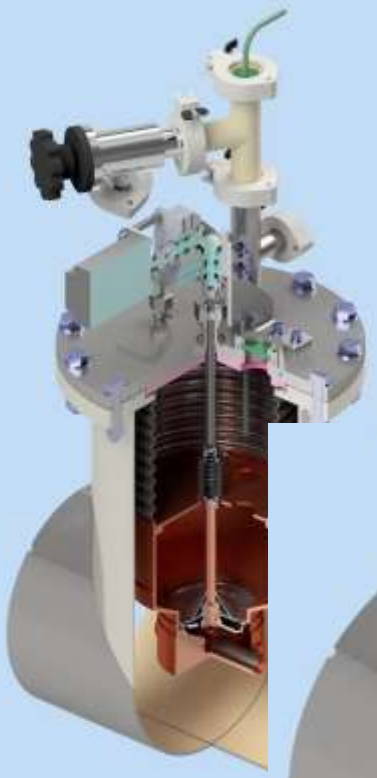


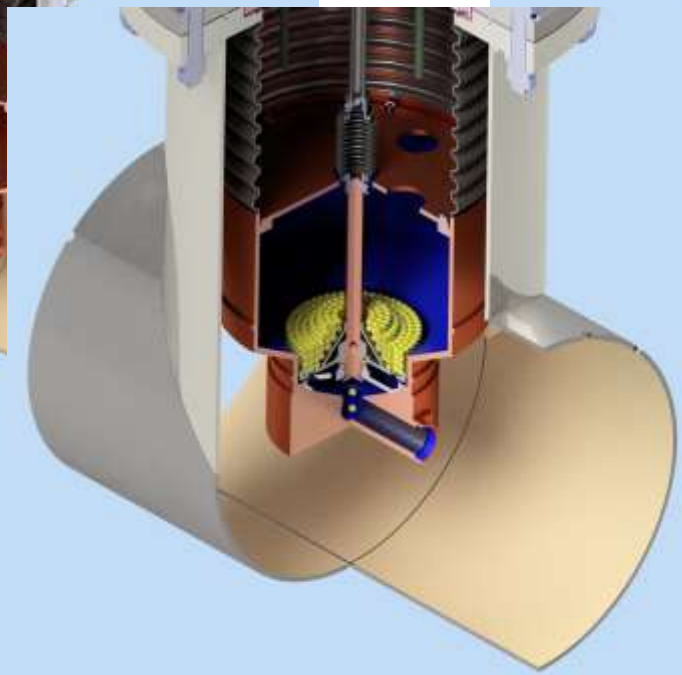
supercooled methane drop

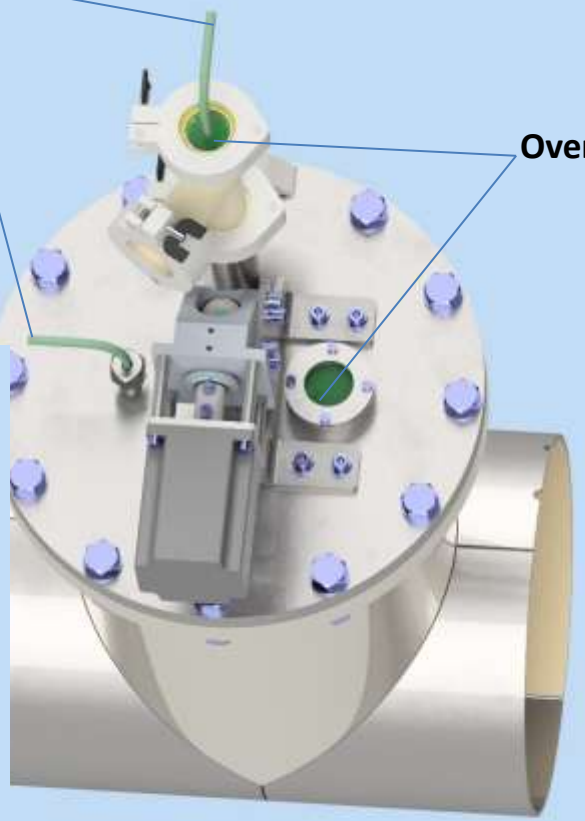
!2 stage – methane beads in xenon, helium, hydrogen

(In progress)

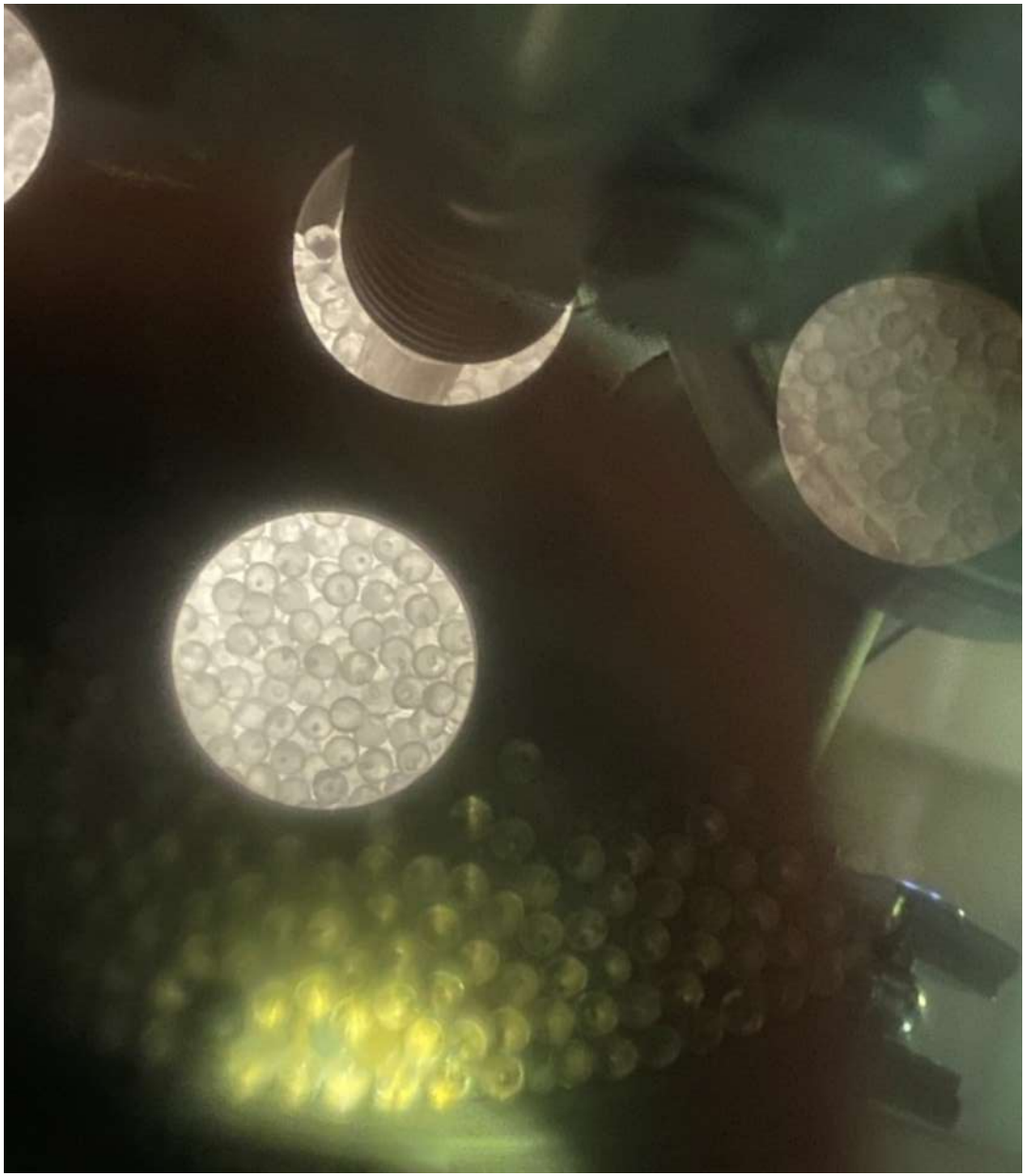
Key point 2 – charging device with fast charging



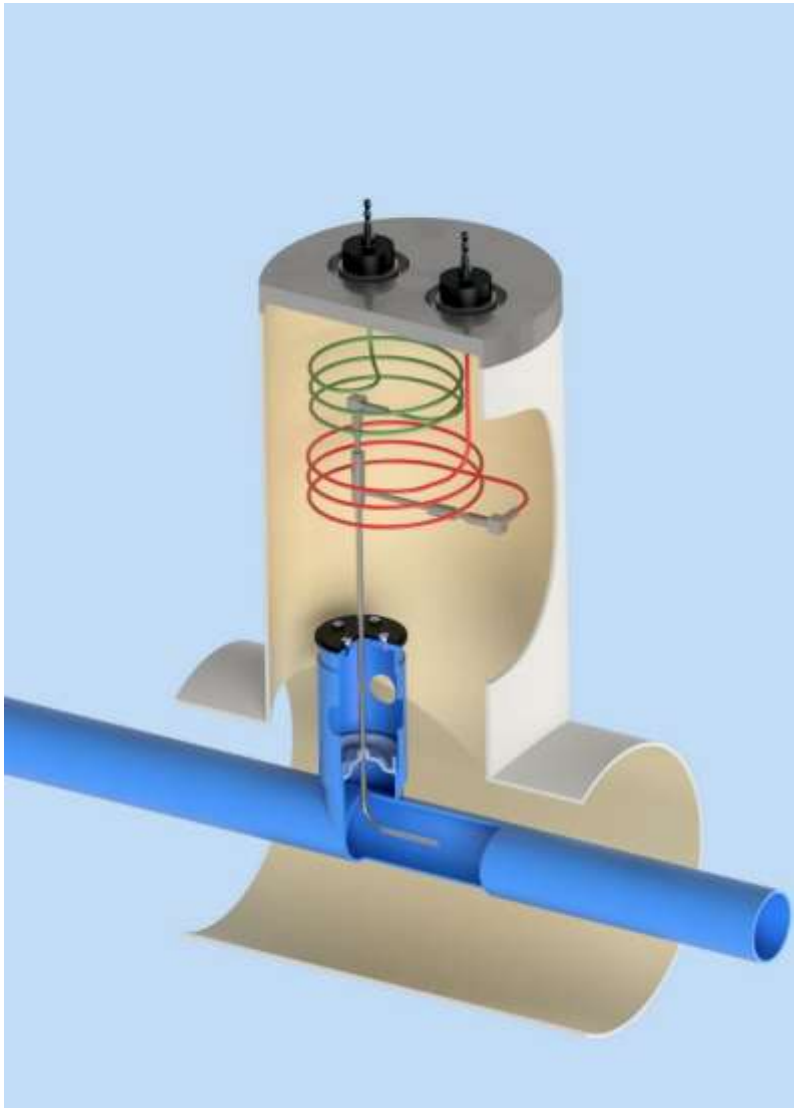


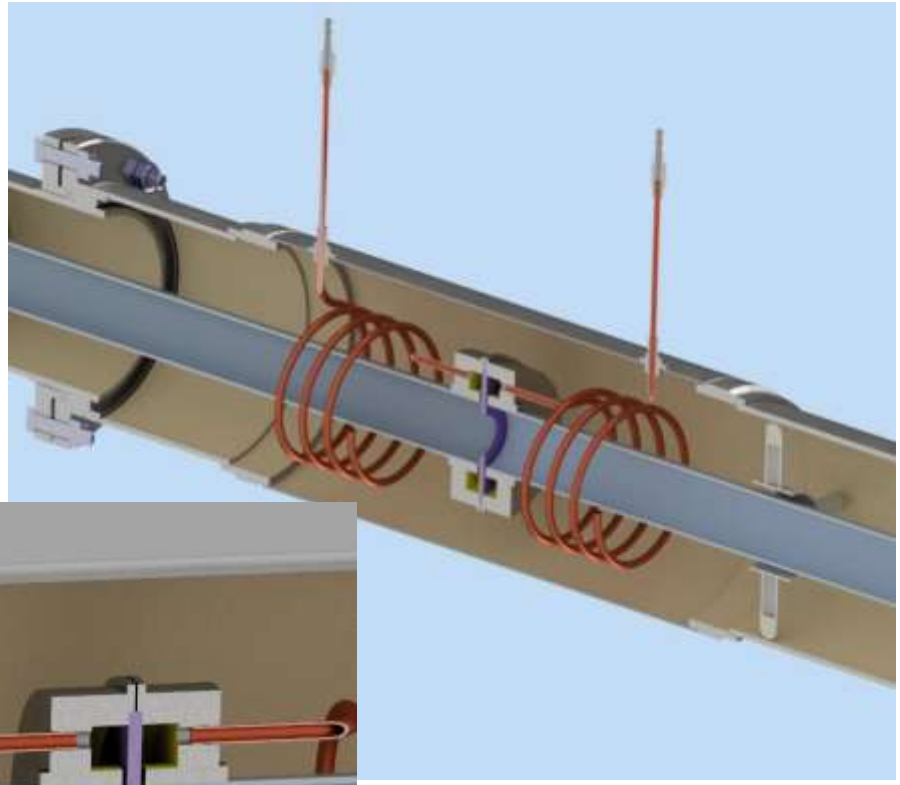


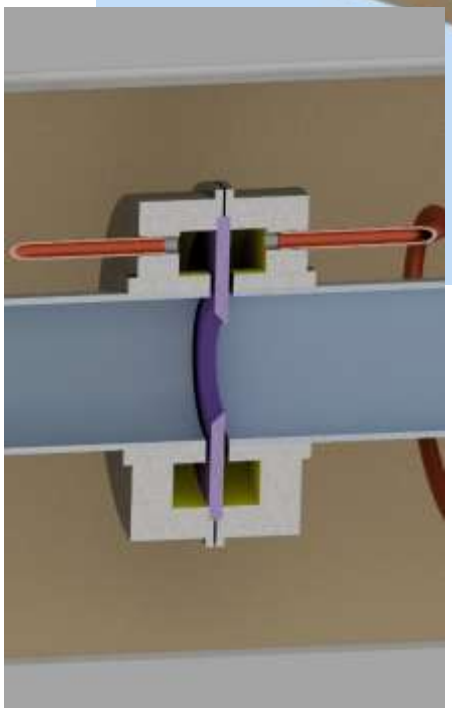
Key point 2 – charging device with fast charging



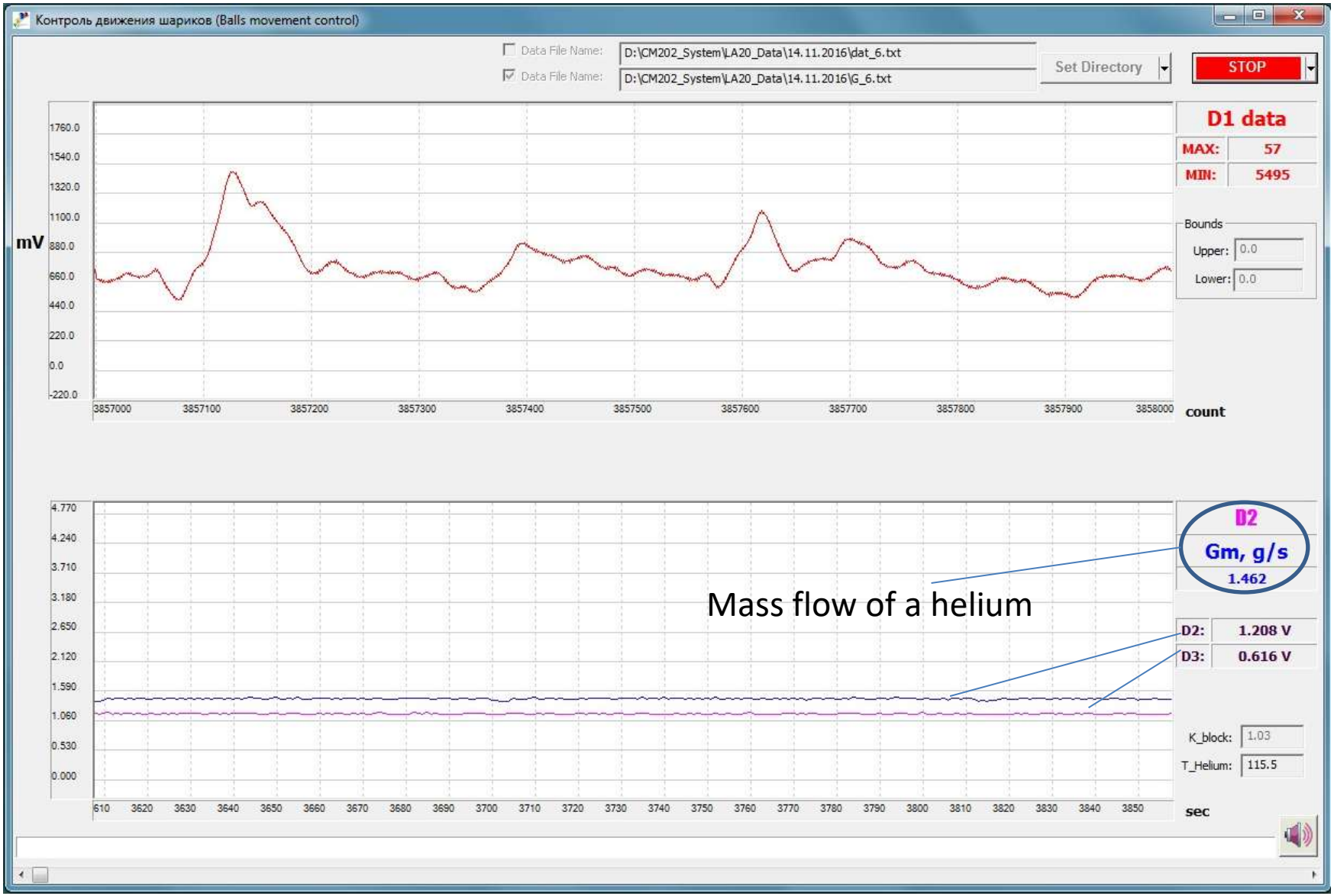
Beads’ transport and gas flow sensors



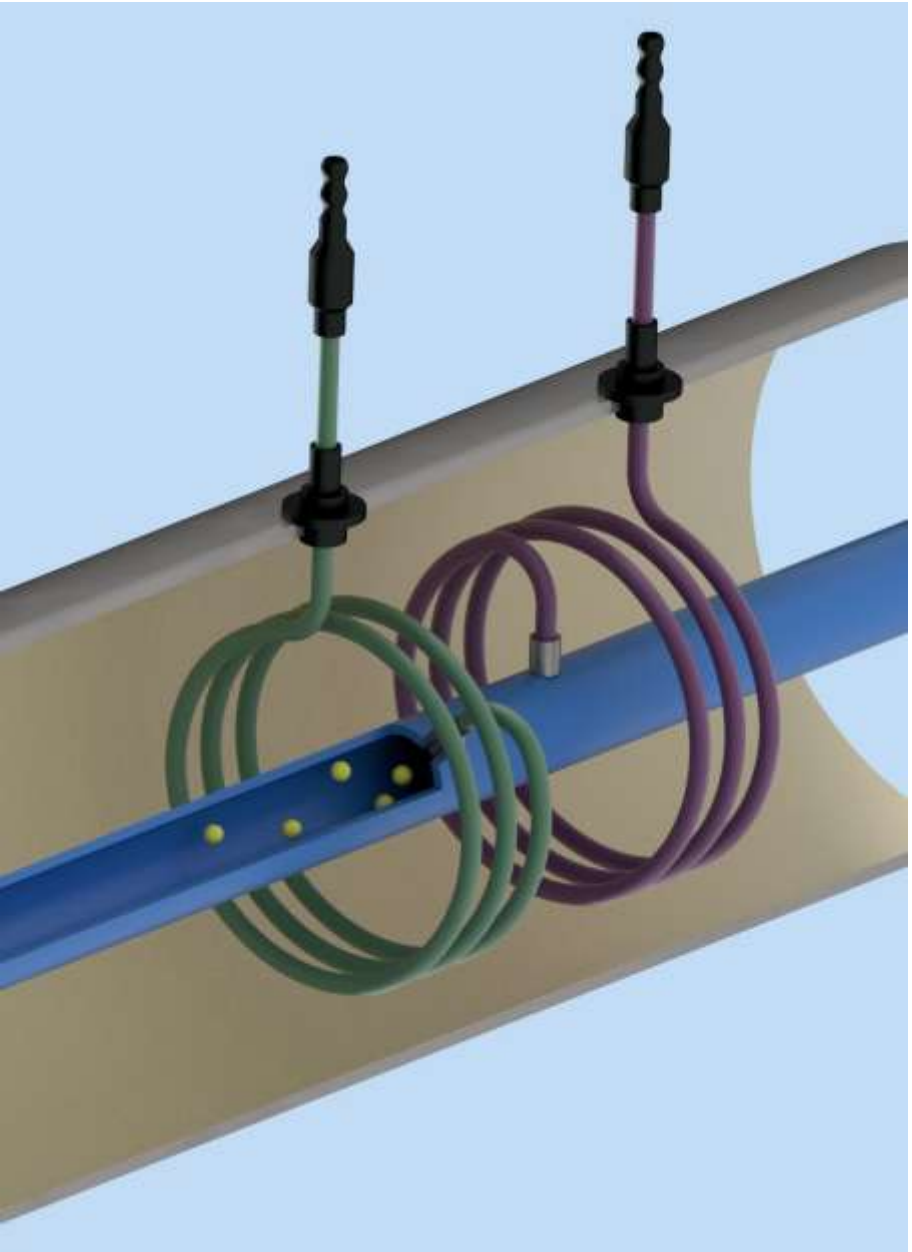




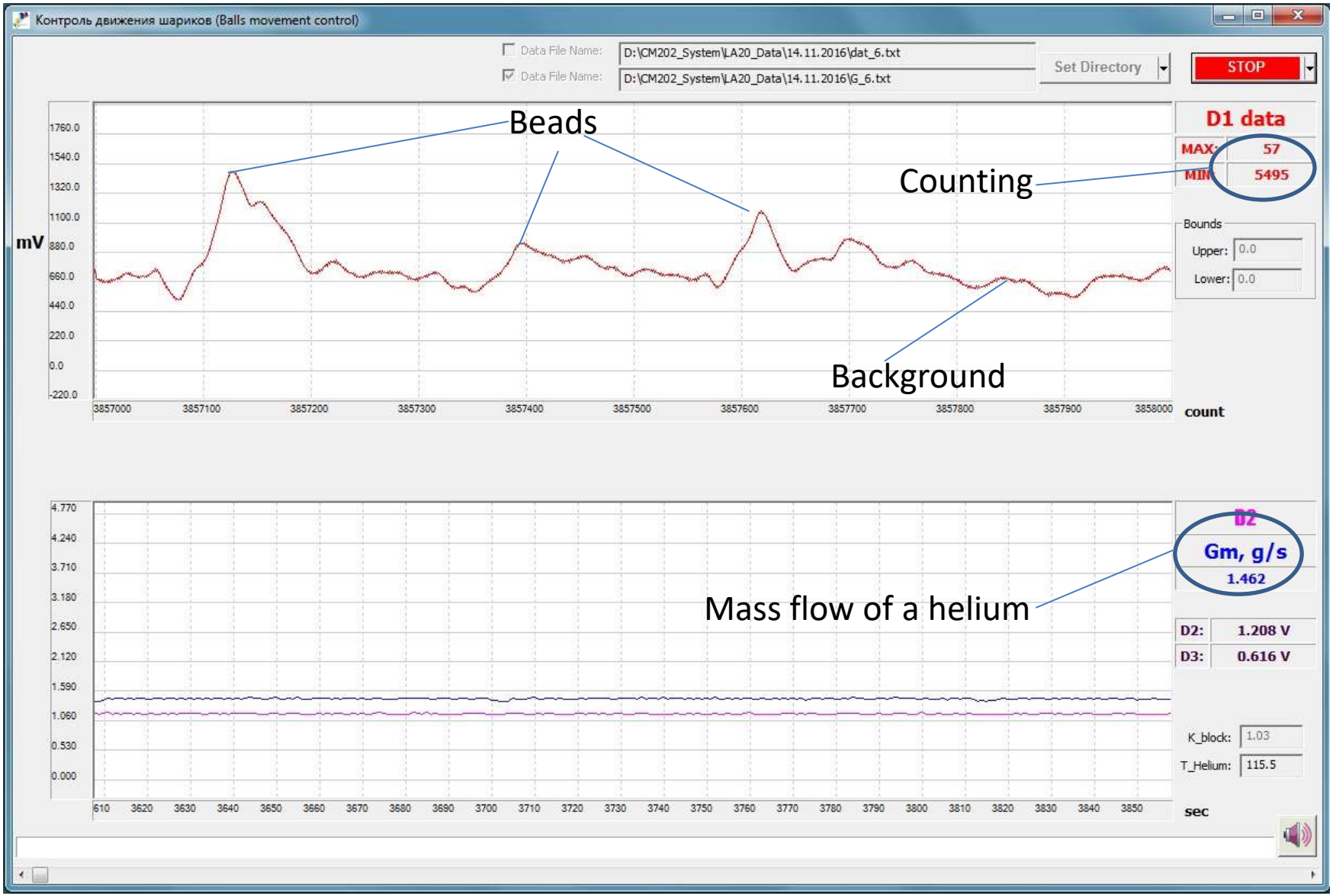
Beads’ transport and gas flow sensors



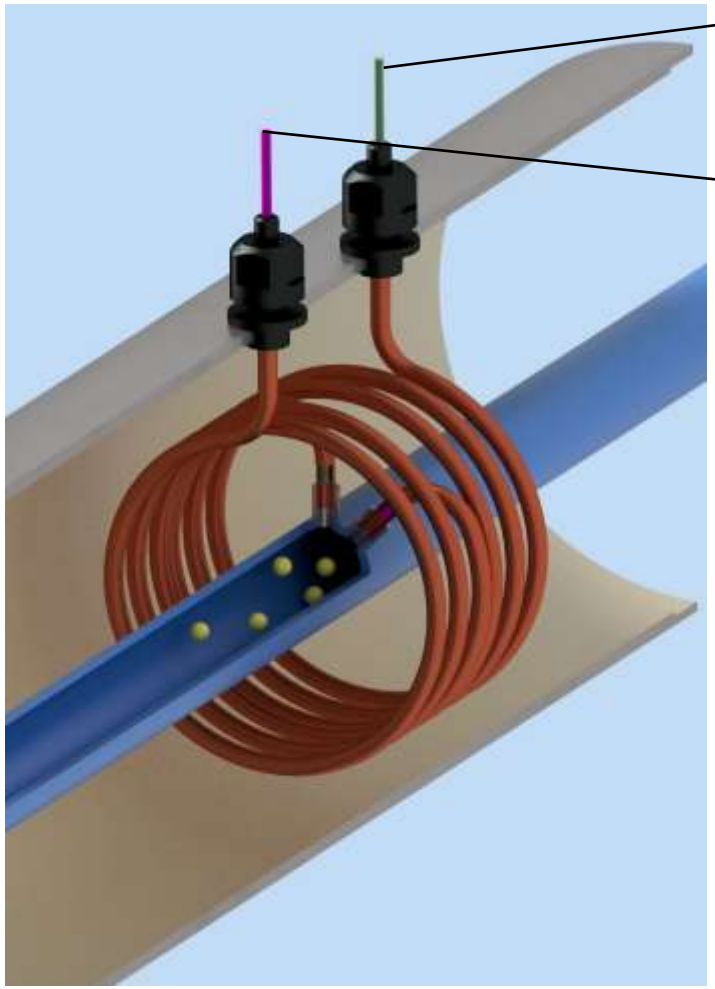
Gas dynamic beads' movement sensors

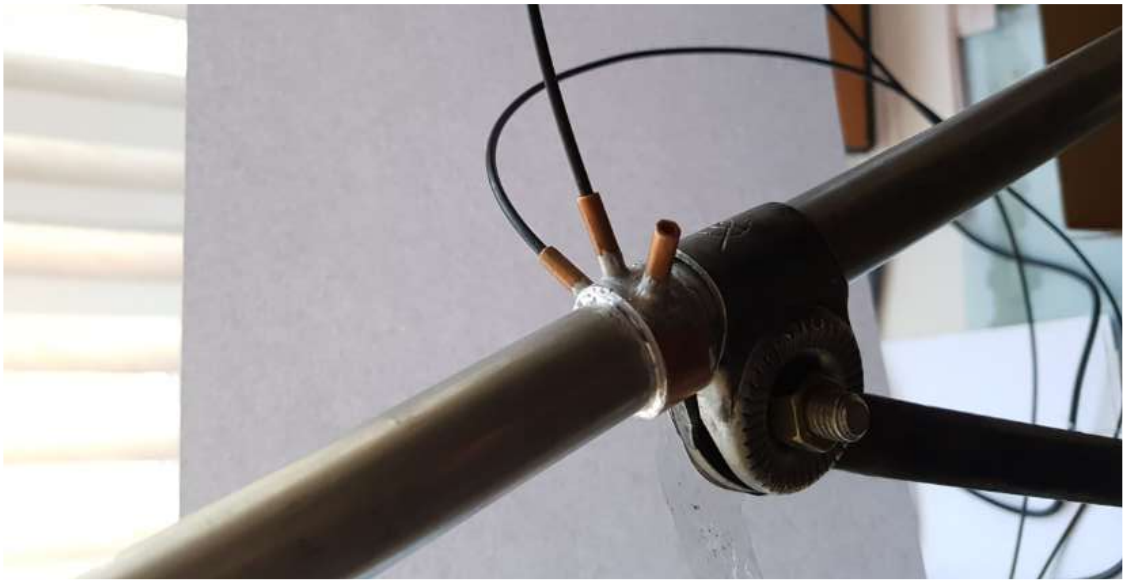


Gas dynamic beads' movement sensors

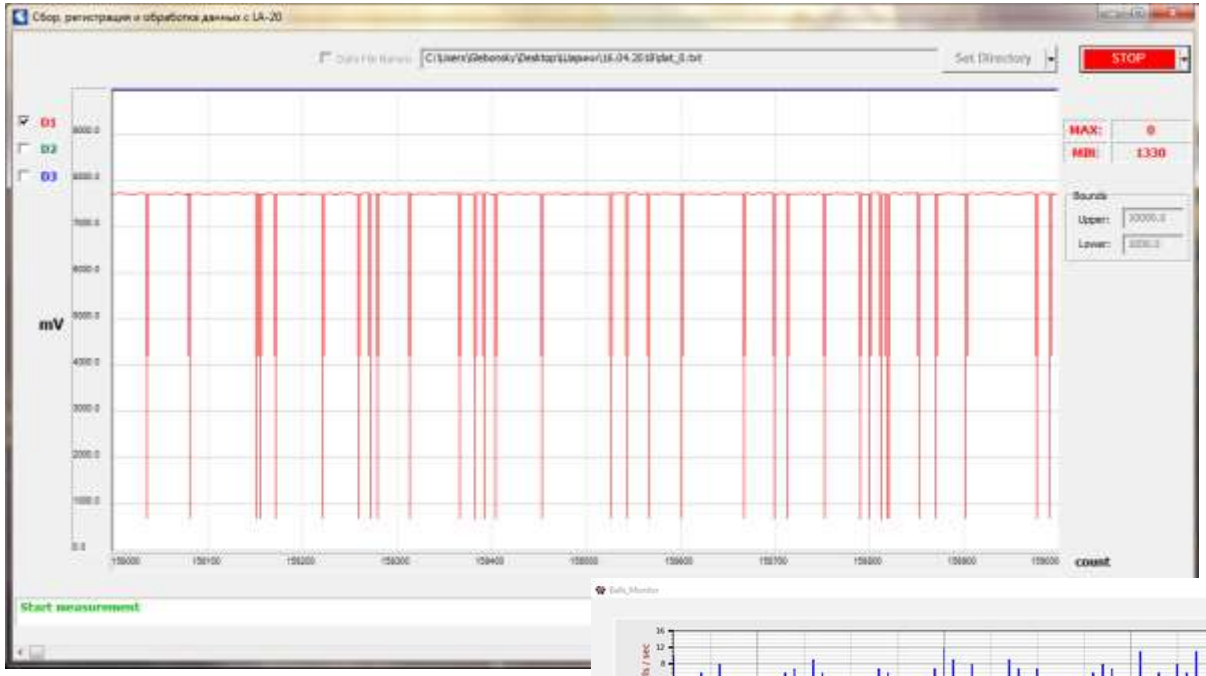


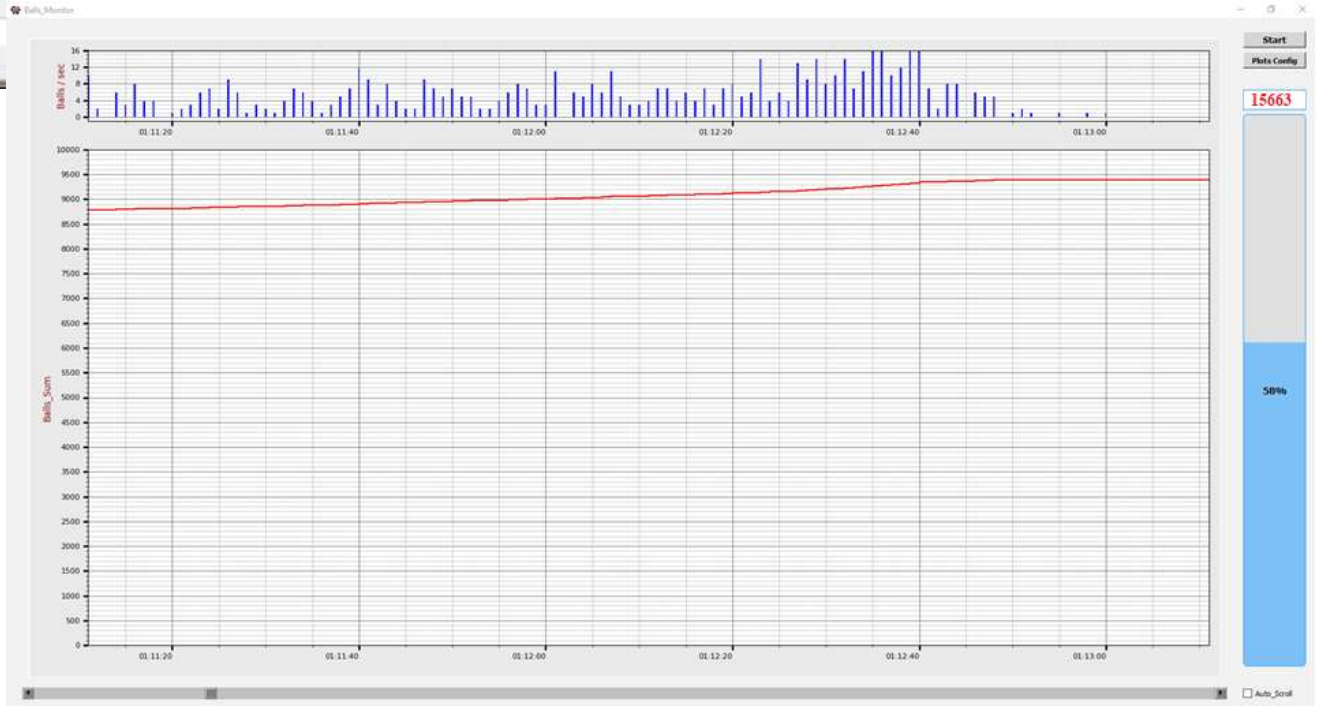
Optical sensor

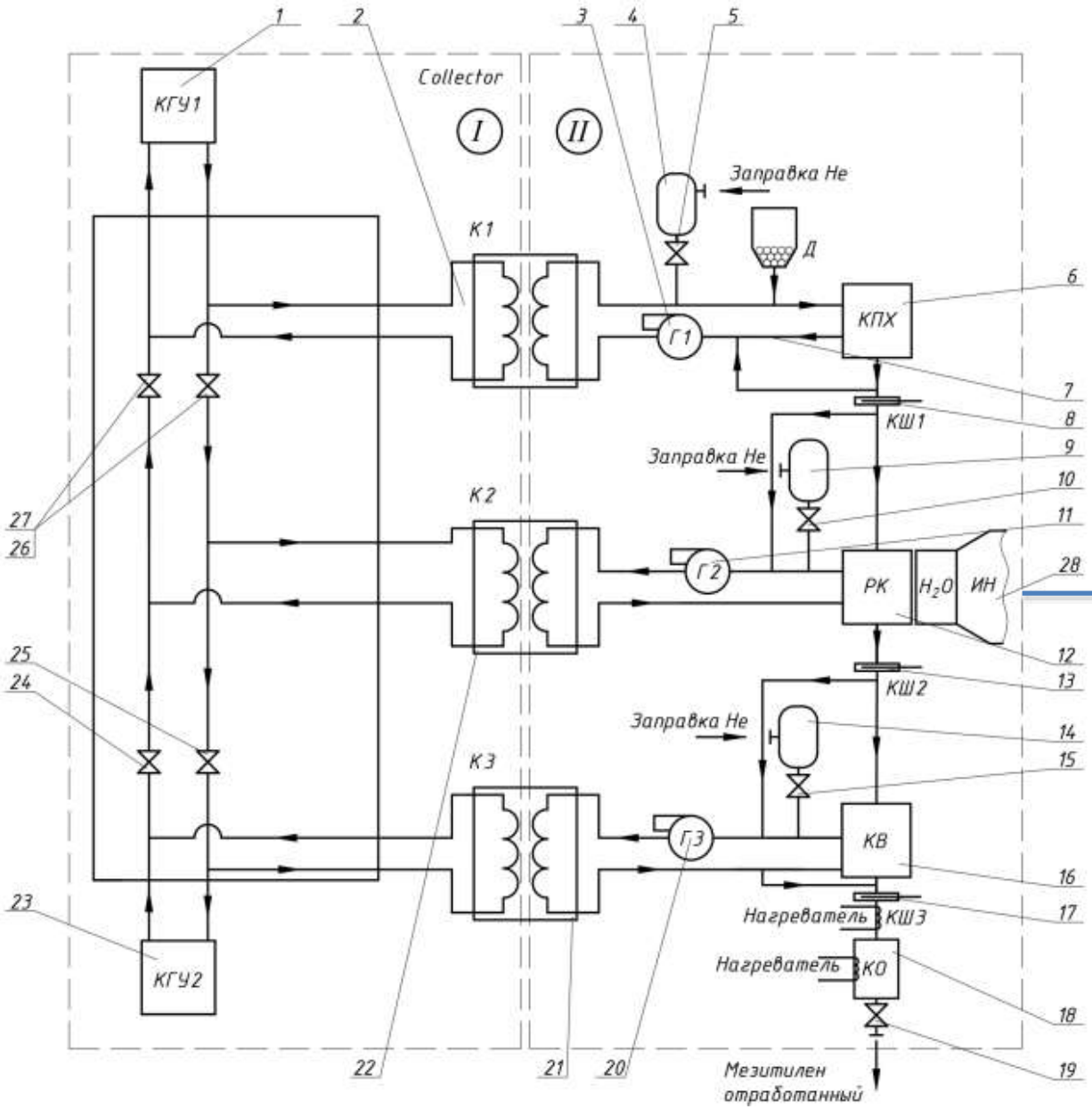


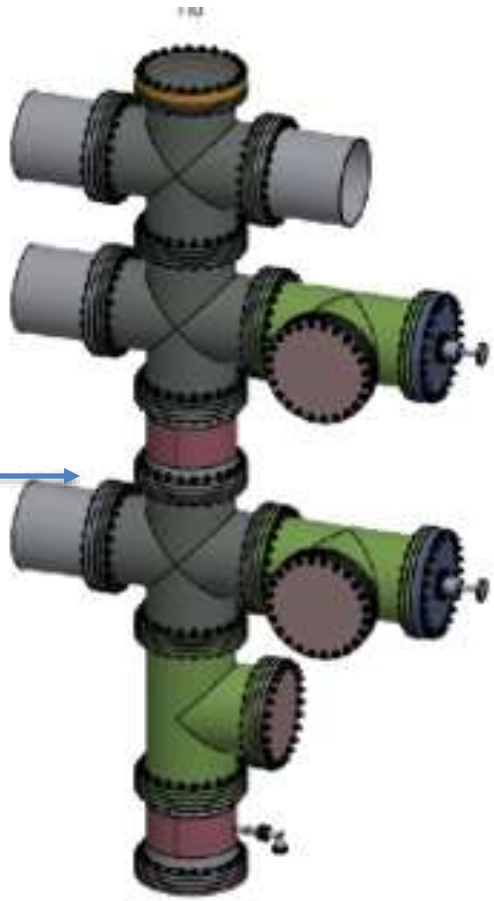


Optical sensor






1
2
3
4
5
Collector
I
II
КГУ1
Заправка Не
Д
К1
КПХ
Г1
6
7
8
КШ1
Заправка Не
9
10
К2
27
26
11
Г2
РК
H_2O
ИН
28
12
13
КШ2
Заправка Не
14
15
К3
25
24
Г3
КВ
16
17
Нагреватель
КШ3
23
КГУ2
Нагреватель
КО
18
19
22
21
20
Мезитилен
отработанный



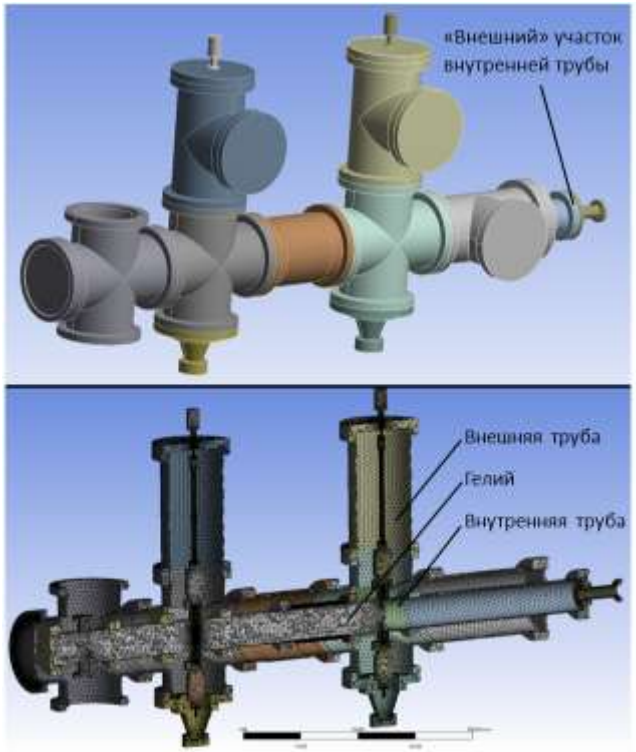


Рисунок 2 – Общий вид упрощенной геометрии для теплогидравлического расчета

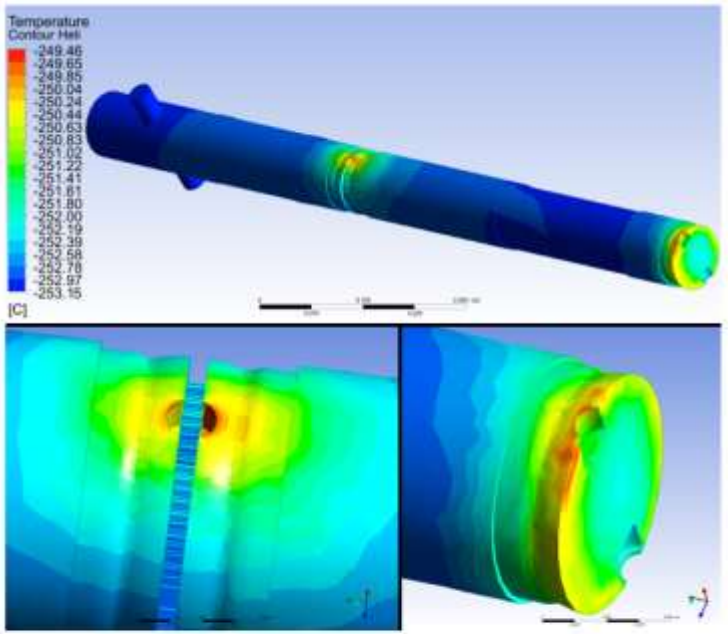
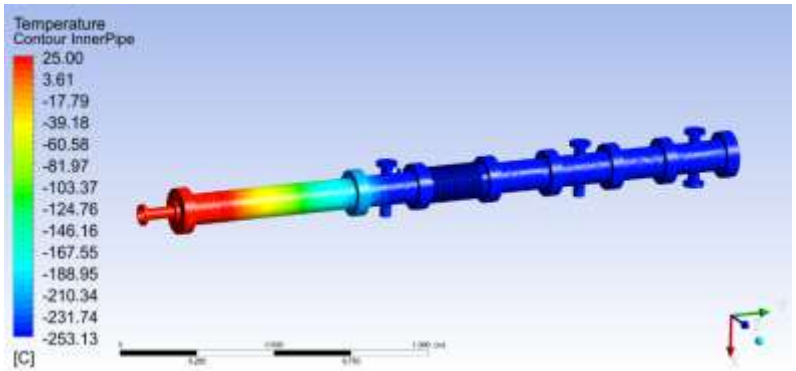
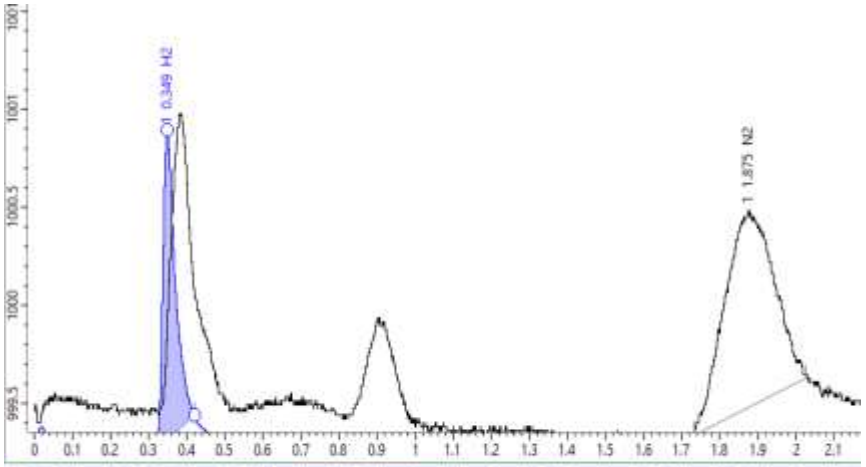


Рисунок 6 – Распределение температур в гелии

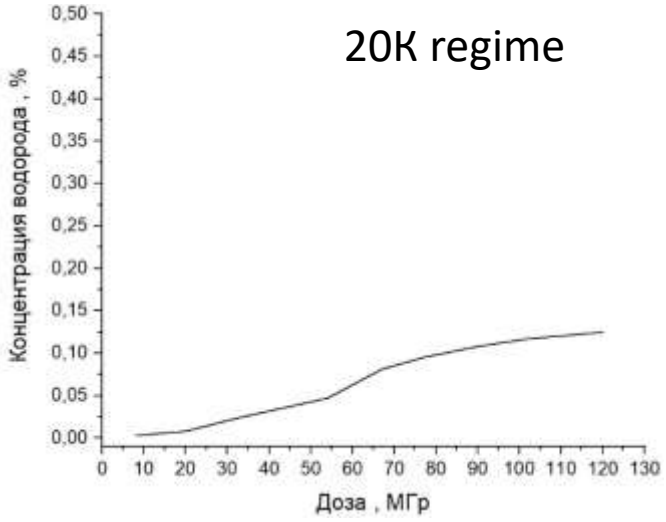
Максимальная температура внутренней трубы составила 298,15 К (соответствует ГУ «внешнего» участка внутренней трубы), минимальная температура составила 20,02 К.

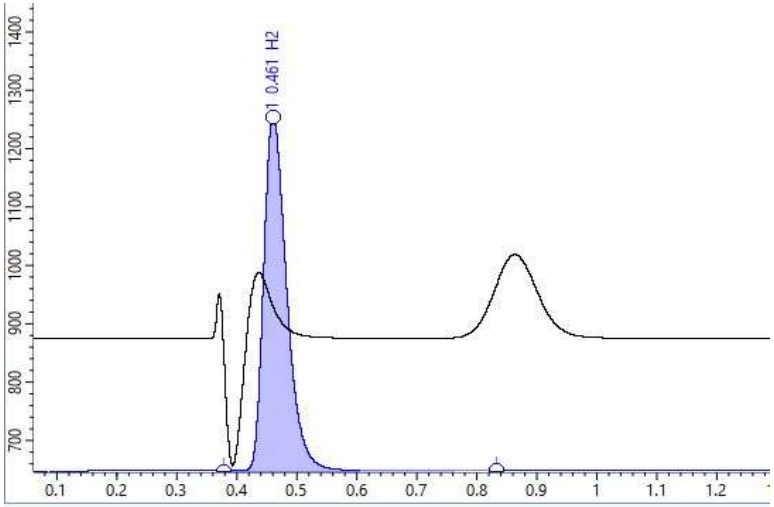


Radiolitic hydrogen

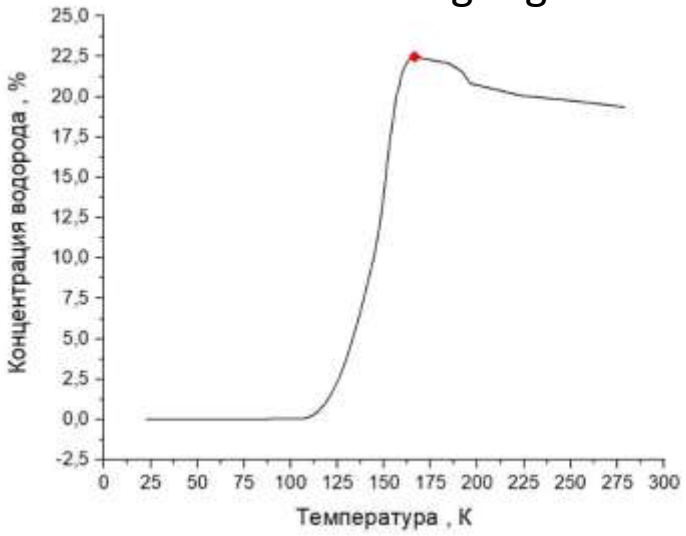


Название	Группа	Время, мин	Детектор	Концентрация	Ед. измерения	Площадь	Высота
N2		1.875	ДТП-1	0.002079		9.071	1.007
H2		0.349	ДТХ-1	0.1229		20.281	8.991

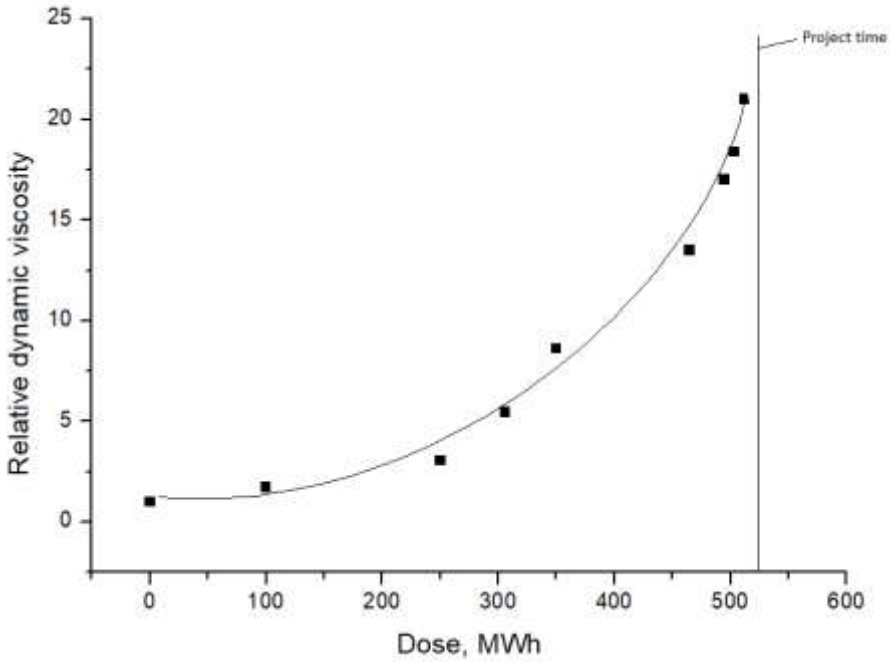




Название	Группа	Время, мин	Детектор	Концентрация	Ед. измерения	Площадь	Высота
N2		1.840	ДТП-1	1.010	моль. %	3903.646	382.417
H2		0.461	ДТХ-1	22.498	моль. %	47462.597	17616.620

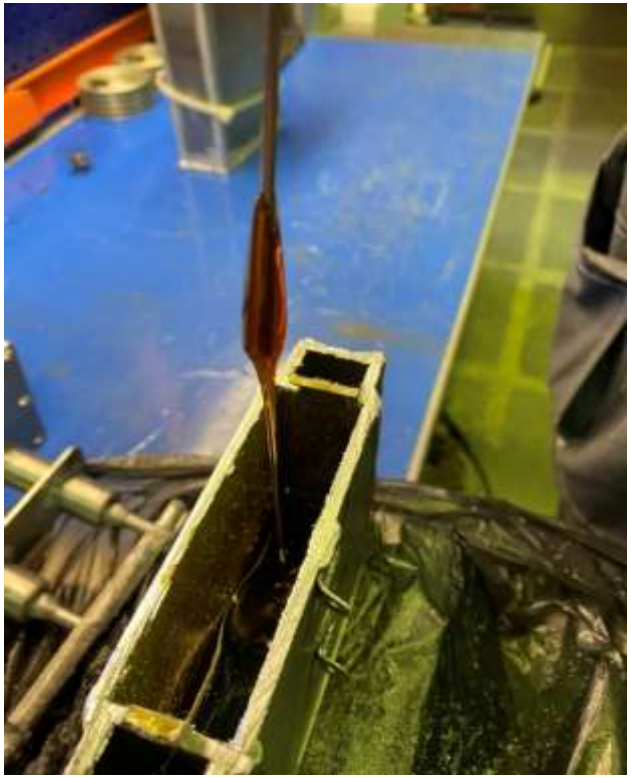


Irradiated mesitylene



	До облучения, масс. %	После облучения с дозой 120 МГр, масс. %
Мезитилен (1,3,5-триметилбензол)	82,6	0
Метаксилол (1,3-диметилбензол)	16,7	0
Псевдокумол (1,2,4-триметилбензол)	0,45	35
3-этилтолуол (1-метил-3-этилбензол)	0,25	0
Параксилол (1,4-диметилбензол)	0	15
Прочие, в т.ч. неидентифицированные химические вещества	0	50

Irradiated mesitylene



Thank you for your attention!