Status of work on the creation of a cryogenic target of the lightest gases (hydrogen, deuterium and helium-4) with GM cryocooler for the BM@N physical facility

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BM@N meeting
October 26, 2020
LHEP, JINR
Dubna

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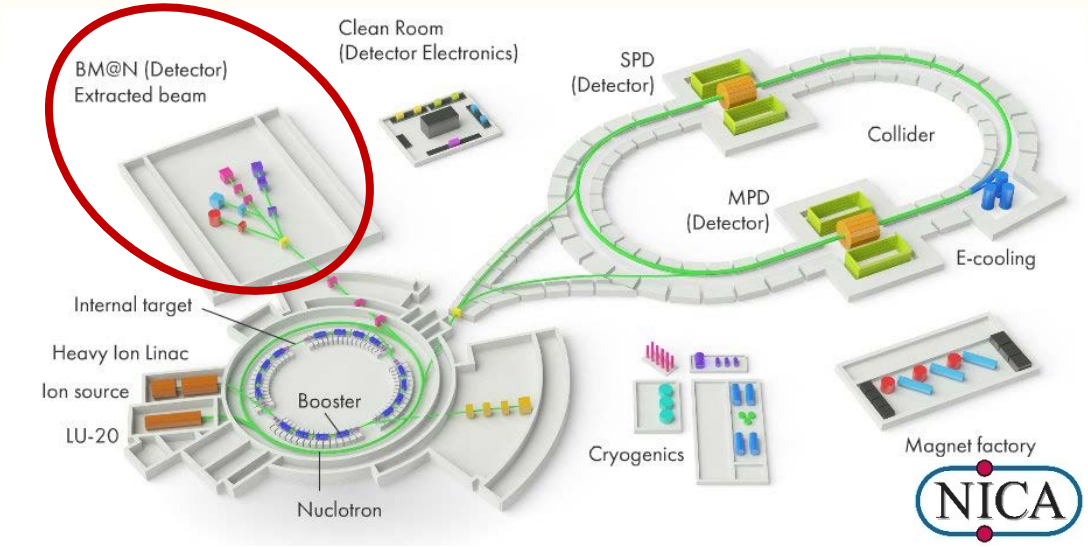
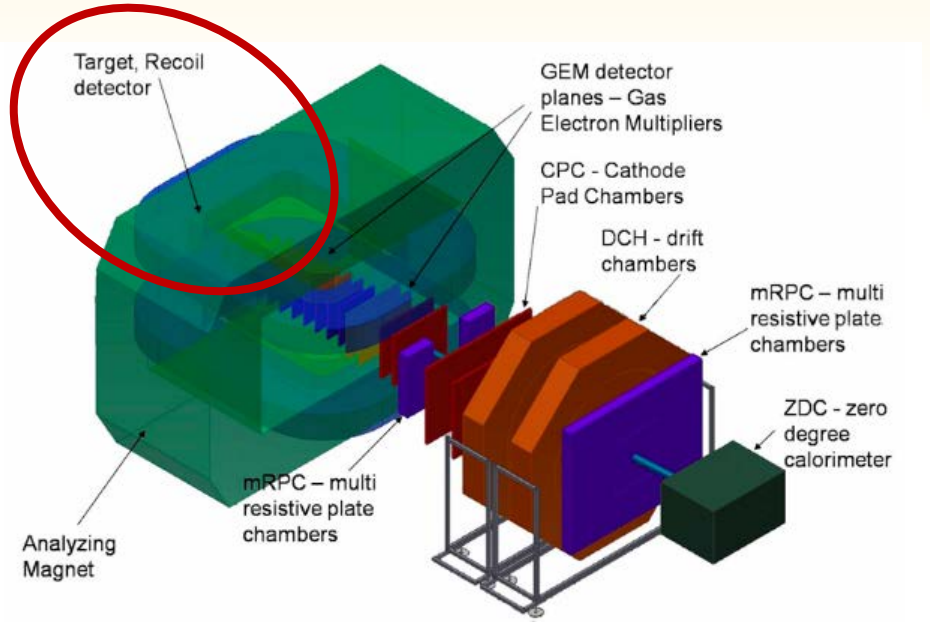
INTRODUCTION

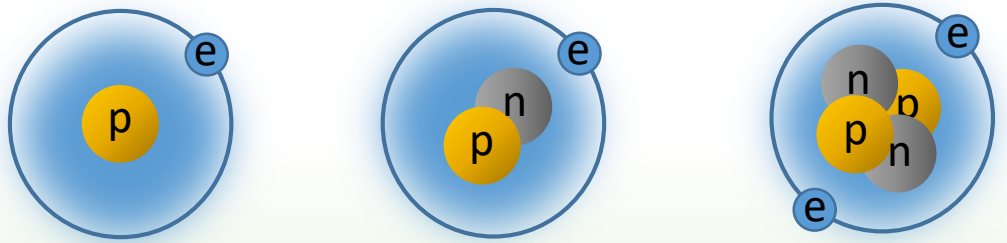
NICA (Nuclotron based Ion Collider fAcility)



BM@N (Barionic Matter at Nuclotron)



LIGHTEST GASES



hydrogen **deuterium** **helium - 4**

INTRODUCTION

requirements of physicists for target

MAX *amounts of working substance in min volume*

can only be achieved using cryogenic temperatures

MIN *the mass of the target's housing and elements,*

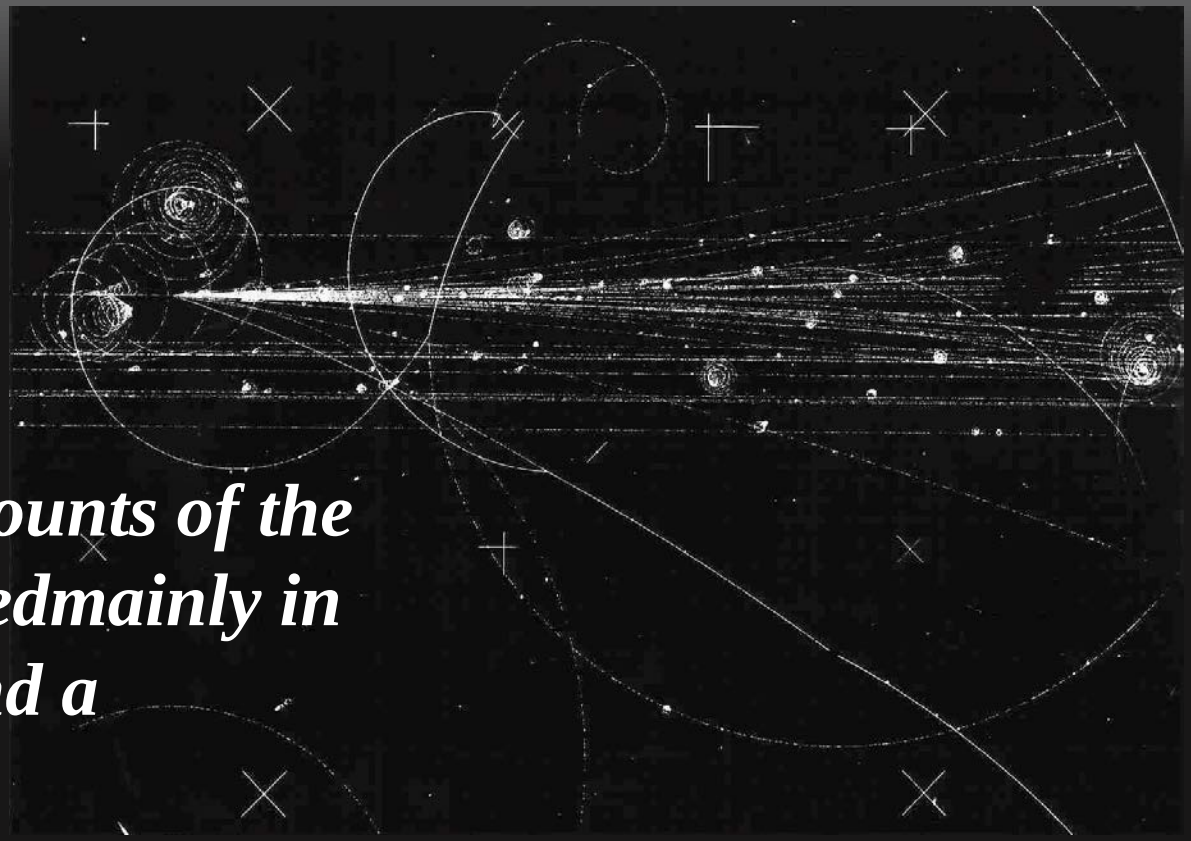
which may have the interaction with an ion beam, result the secondary particles, and initiate the background events

AND *safety, efficiency, mobility, autonomy*

INTRODUCTION

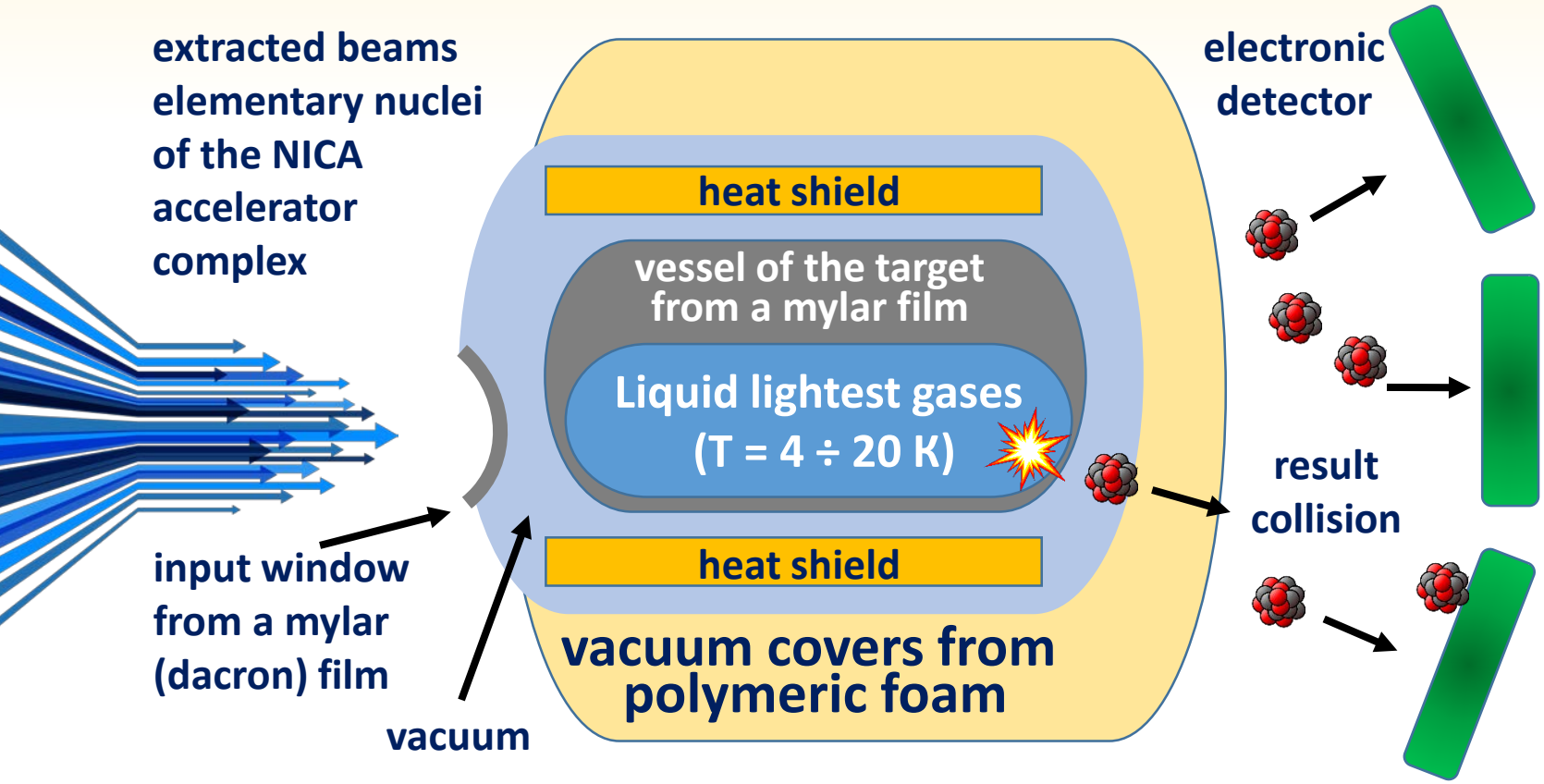
first: bubble chambers

Direct feeding liquid into the target chamber



This way is good enough when large amounts of the working substance are used, and was usedmainly in bubble chambers that served as target and a detector both.

INTRODUCTION
new solution for physicists



MATERIAL	Density, g/sm3	Thickness, mm
Mylar (dacron)	$1,33$	$0,1 \div 0,17$
Polymeric foam	$0,08$	$10 \div 15$
Stainless steel 304	$7,95$	$1 \div 5$

Today, the most well studied and widely used type of cryogenic targets is a hydrogen targets with recondensation of the vapor phase by liquid helium. A feature of these targets is an inside condenser, which removes the hydrogen vapor's heat of vaporization by evaporation of liquid helium.

MAIN SECTION

photo cryogenic target

Uriy T. Borzunov on assembly the target

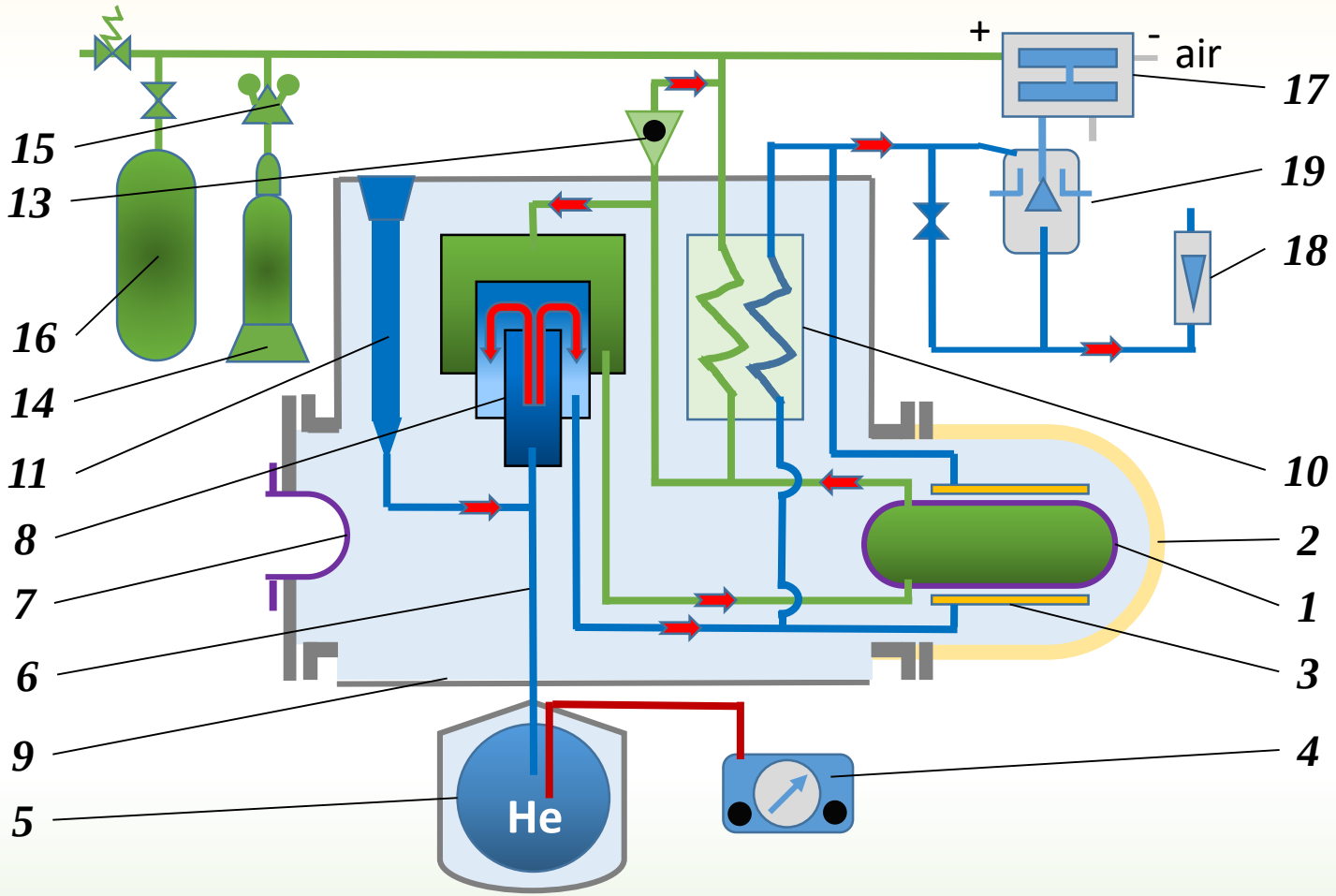
Cryogenic target on the BM@N experiment

Cryogenic target developed at JINR worked at Saclay Nuclear Research Centre (France)

Different types of the target's vessels and covers

MAIN SECTION

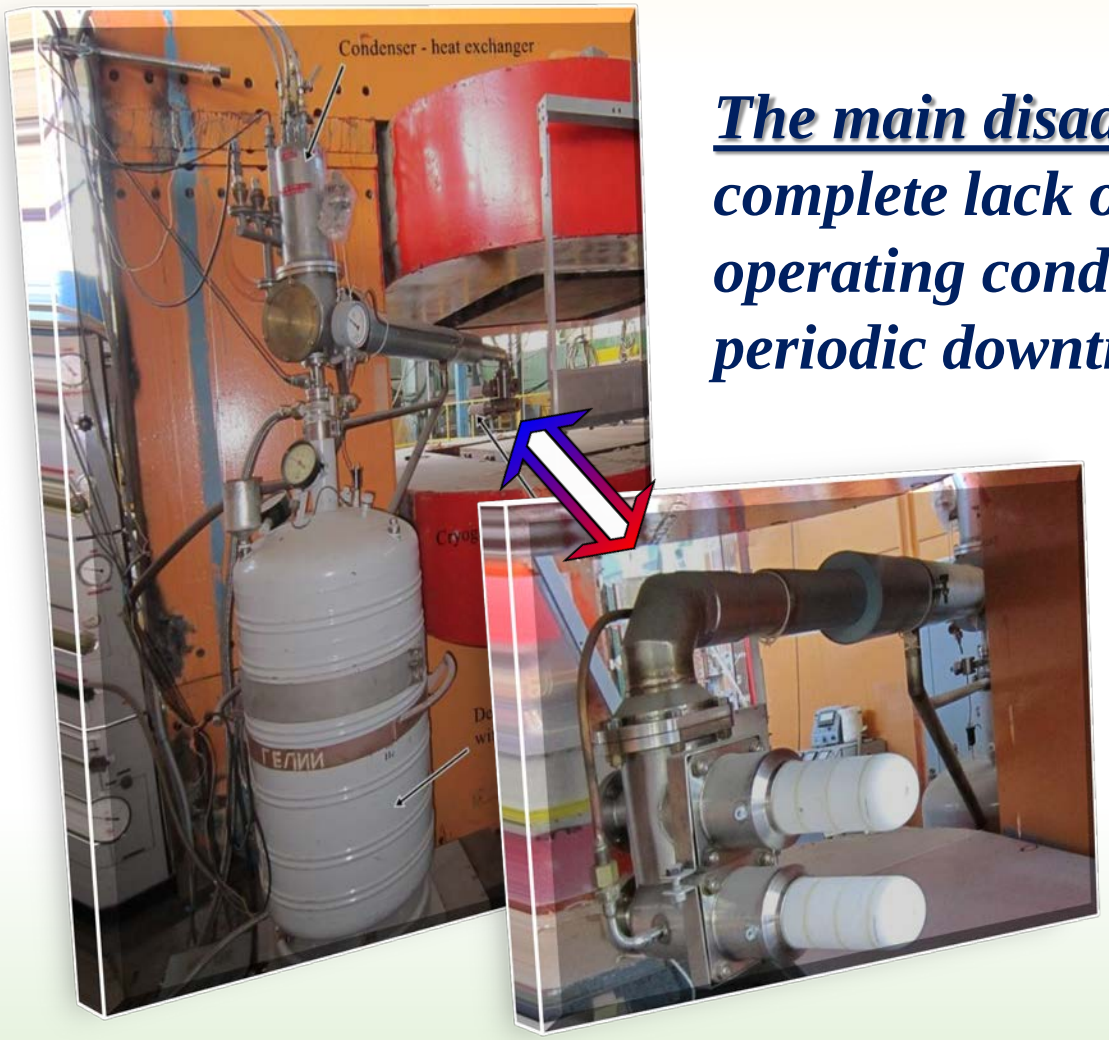
cryogenic target with helium recondensation



1 - Inner chamber of the target
L= 300mm, D=60 mm;
2 - a vacuum housing;
3 - heat shield;
4 - l-He level meter;
5 - Dewar vessel;
6 - helium supply tube;
7 - mylar window;
8 - heat exchanger-condenser;
9 - vacuum cabinet;
10 - pre-cooling heat exchanger;
11 - helium filling neck;
12 - aperture;
13 - check valve;
14 - cylinder with compressed gas;
15 - pressure regulator valve;
16 - receiver;
17 - differential manometer;
18 - flow meter;
19 - the control unit CU

MAIN SECTION
as a result

Cryogenic target with helium recondensation

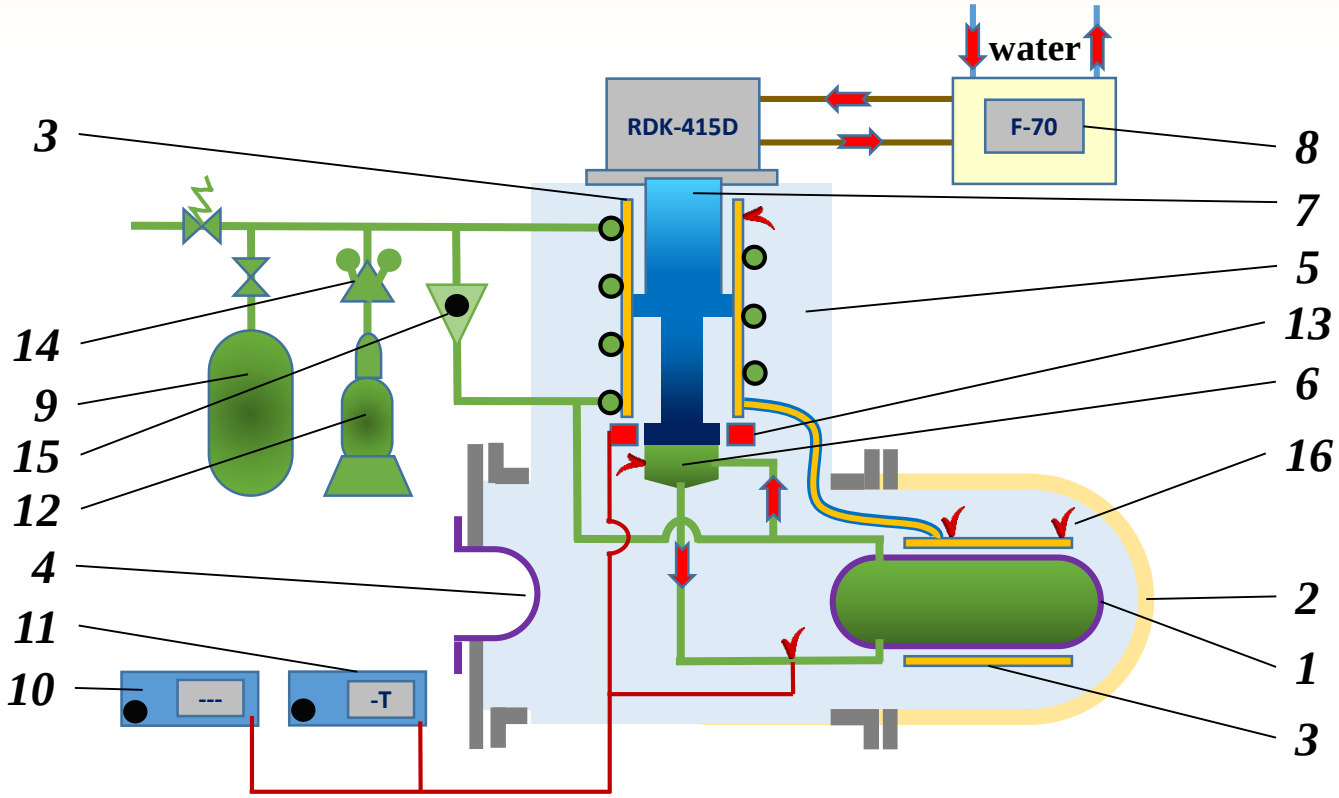


***The main disadvantages** of such targets include the practically complete lack of mobility, difficulty in maintenance and keeping of operating condition and necessity of continuous service, leading to periodic downtime of the accelerator.*

A large cooling capacity provided by helium liquefier has not previously required a detailed study of the influence of heat losses, ionizing radiation, and temperature distribution across the screens, as well as the permeability of materials under vacuum conditions on the target's cryogenic system.

MAIN SECTION

cryogenic target with GM cryocooler

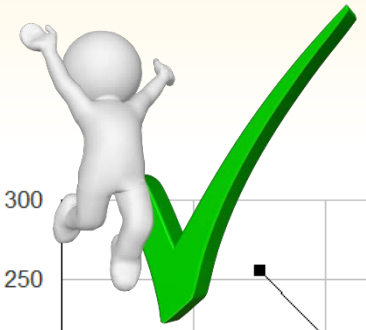


- *1 - Inner chamber of the target L= 350mm, D=40 mm;*
- *2 - a vacuum casing;*
- *3 - heat shield;*
- *4 - mylar window;*
- *5 - vacuum housing;*
- *6 - condenser;*
- *7 - cryocooler RDK-415D;*
- *8 - helium compressor F-50;*
- *9 - receiver;*
- *10 - temperature monitor;*
- *11 - temperature controller;*
- *12 - cylinder with compressed gas;*
- *13 - heater;*
- *14 – gas reducer;*
- *15 - check valve;*
- *16 - thermometer;*

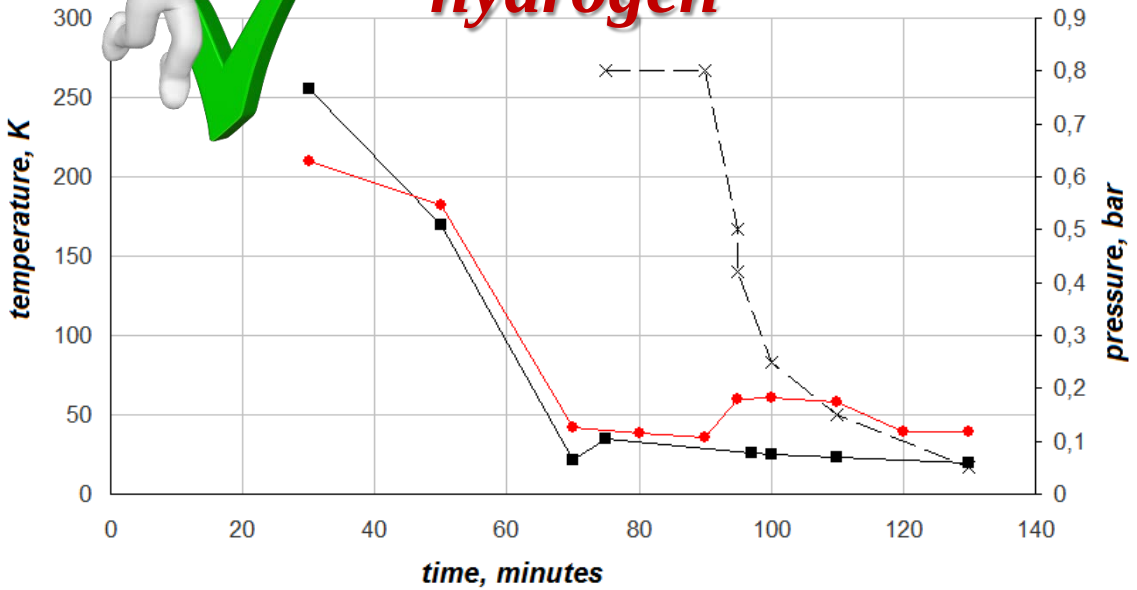
MAIN SECTION

experiment

Cool down of working substance filled target by cryogenic supply system with GM cryocooler



hydrogen

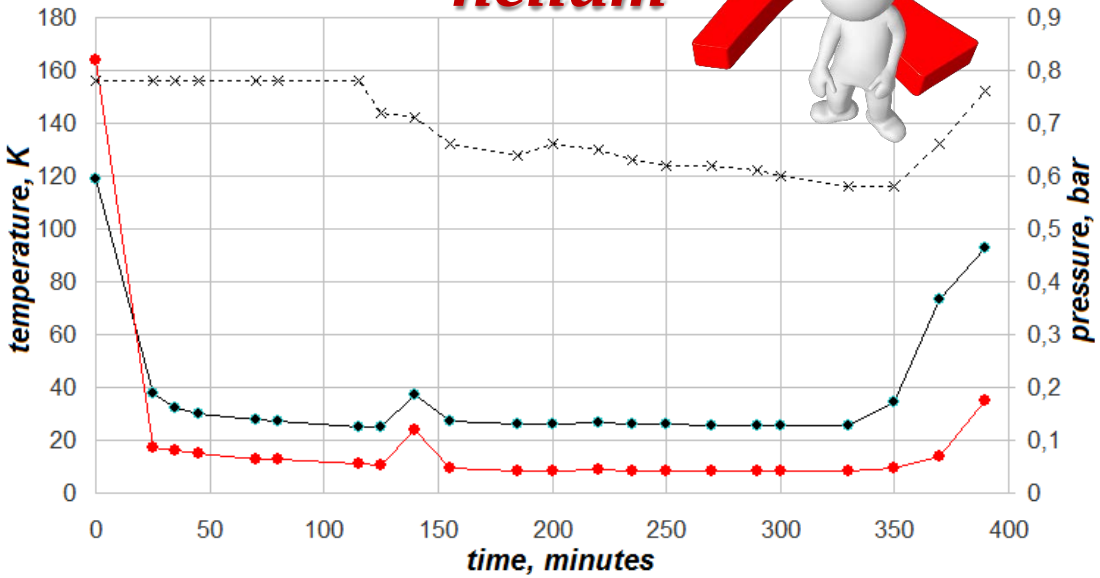


--■---■-- *temperature in chamber*

--●---●- *temperature in the shield*

--x---x-- *pressure in chamber*

helium



--●---●- *temperature in chamber*

--■---■-- *temperature in the shield*

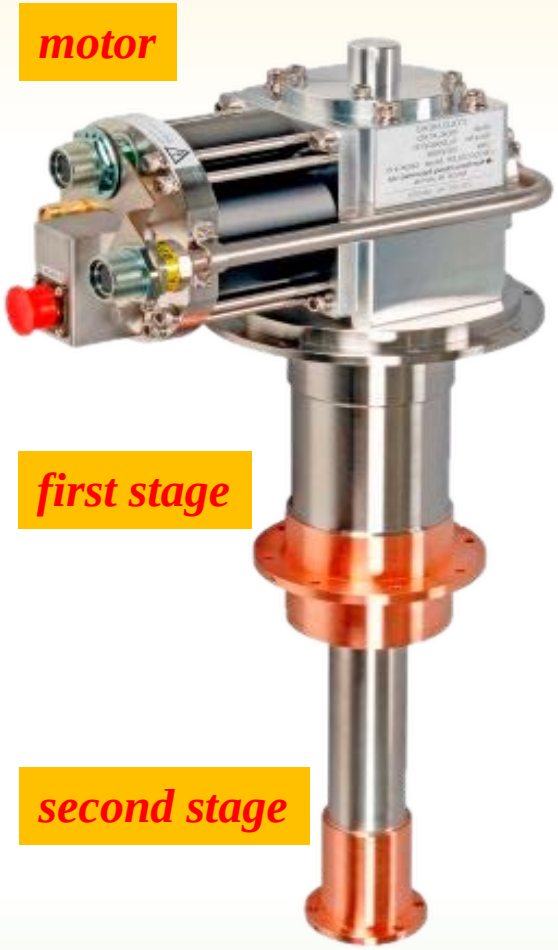
--x---x-- *pressure in chamber*

MAIN SECTION
magnetic field

G-M coolers are sensitive to magnetic field in the region of a displacer motor, cooler displacers and regenerators.

The Sumitomo recommends that the motor area is not exposed to fields higher than 0.03 T. Fields around 0.03–0.05 T will have a detrimental effect on service life and fields above 0.07 T may cause the motor to stall [5]. Other sources give the same limit for magnetic field on the motor of 0.05–0.07 T [4], [6].

The second stage region could be exposed in some configurations of magnetic field up to 1.9–2.0 T [7], [8].



MAIN SECTION
plan

Details and equipment.
*** except controller and monitor temperature**

2020

Target assembly and testing.

2021

Installation of the target on the BM@N. Commissioning.

2021

Study and analysis of influences of magnetic field and analysis of local temperature distribution in the target and generally in the cryogenic support system

CONCLUSIONS

The cryogenic target with a GM cryocooler satisfies the needs of physicists for targets with unique ratios between the amount of working substance (liquid hydrogen, deuterium or helium) and the mass of the target body, as well as the requirements of safety, mobility and autonomy.

Now that we have all the parts and equipment, it is necessary to assemble and test the target. Then the target must to mount and commissioning on the BM@N facility.

In the future it remains to solve the problem of increasing the efficiency of the target with the subsequent possibility of its work on helium and the problem of influence magnetic field.