Flerov Laboratory of Nuclear Reactions

Alexander Karpov

LABORATORY FOUNDER

Georgiy Nikolaevich FLEROV

1913 – 1990

1940	Discovery of spontaneous fission of uranium
1942-1950	Participation in Russian atomic project
1955	First beams of accelerated heavy ions
1957	Foundation of Laboratory of Nuclear Reactions (Dubna)
1962-1975	Synthesis of new elements: 102, 103, 104, 105 (Dubnium), 106, 107
2012	Element 114 named Flerovium

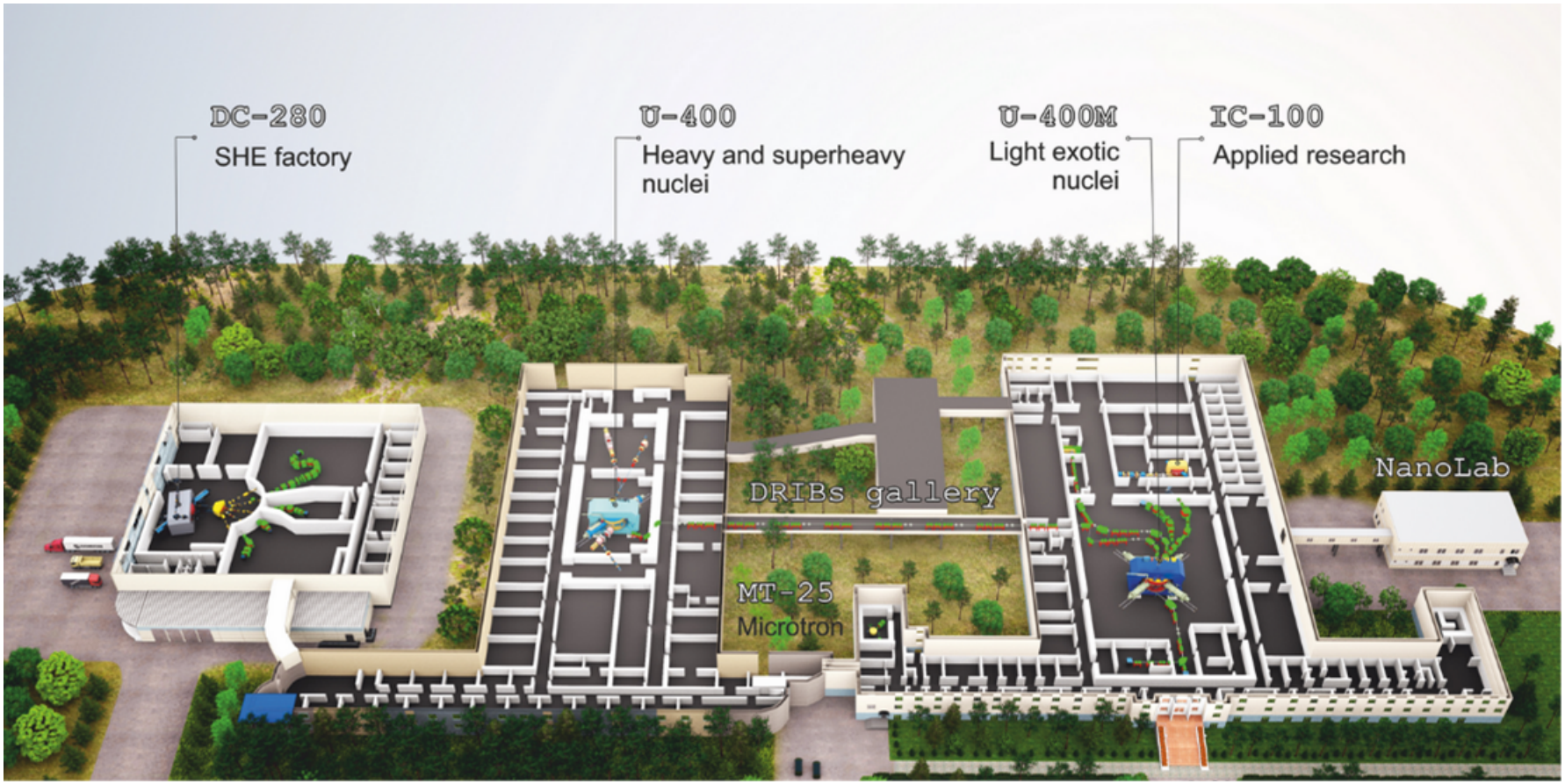
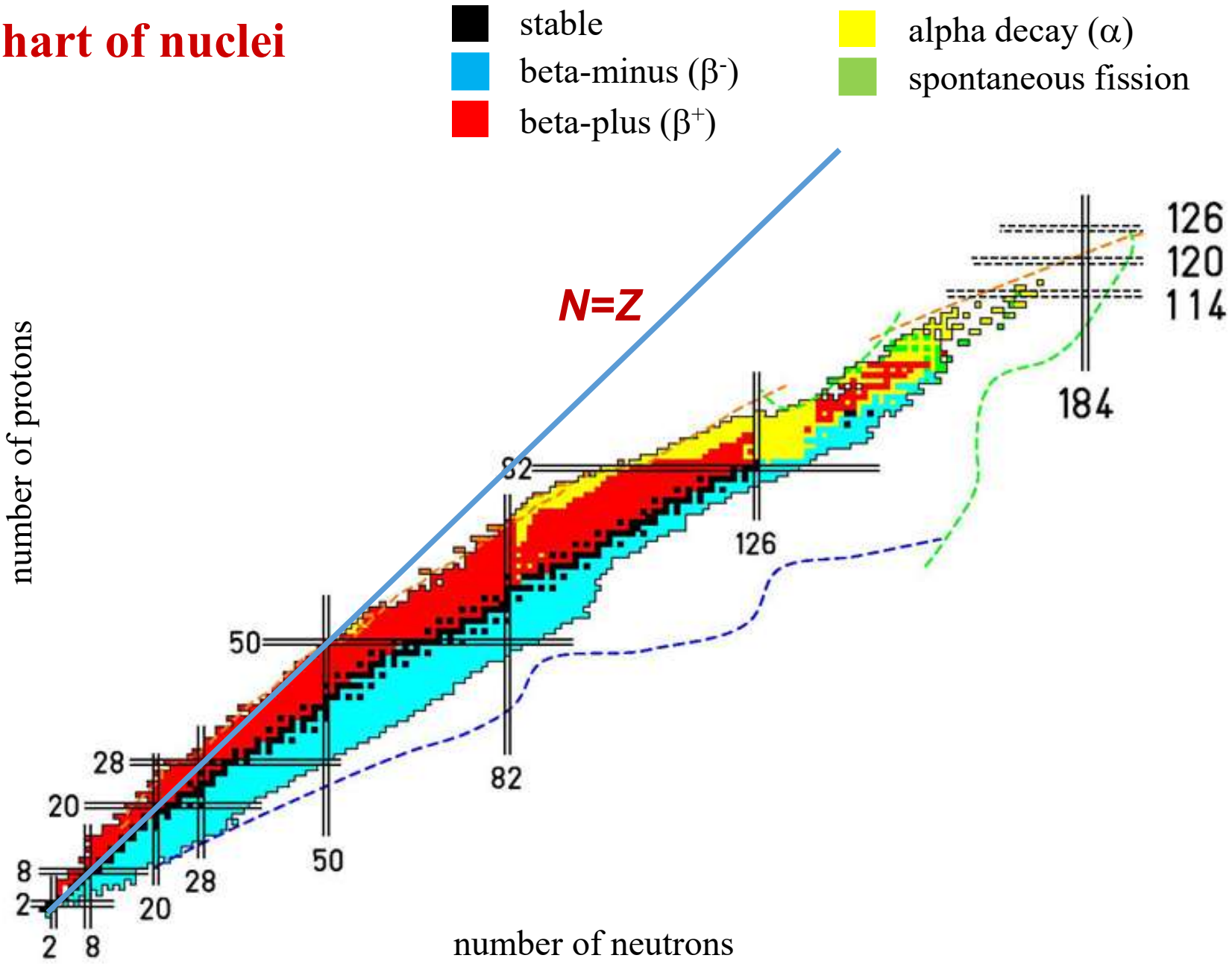

DC-280
SHE factory
U-400
Heavy and superheavy nuclei
U-400M
Light exotic nuclei
IC-100
Applied research
DRIBs gallery
MT-25
Microtron
NanoLab

Chart of nuclei



FLNR's Basic Directions of Research

1. Heavy and superheavy nuclei:

- synthesis and study of properties of superheavy elements
- chemistry of new elements
- fusion-fission and multi-nucleon transfer reactions
- nuclear- , mass-, & laser-spectrometry of SH nuclei.

2. Light exotic nuclei:

- properties and structure of light exotic nuclei
- reactions with exotic nuclei.

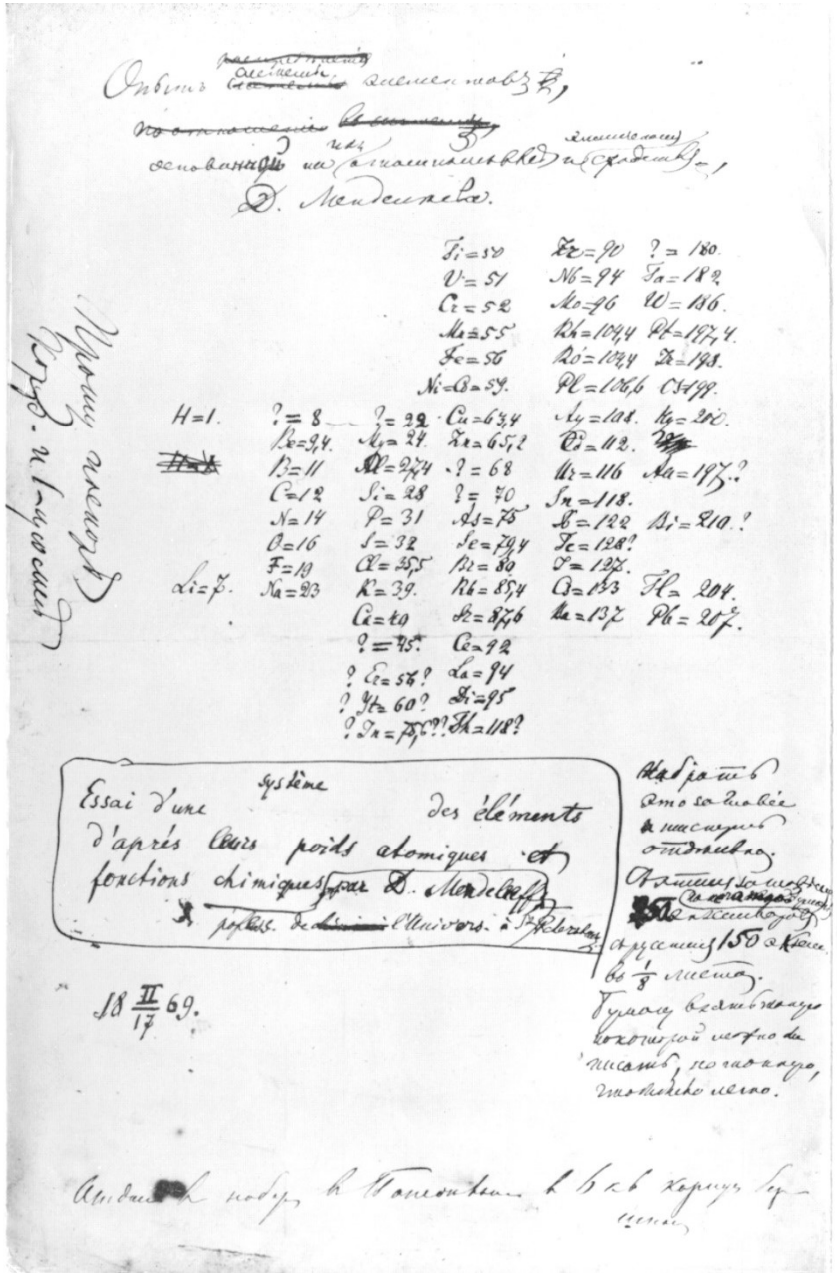
3. Radiation effects and physical groundwork of nanotechnology

4. Accelerator technologies

Staff : ~450 people

Heavy and superheavy nuclei

Mendeleev's Table (~150 years ago)

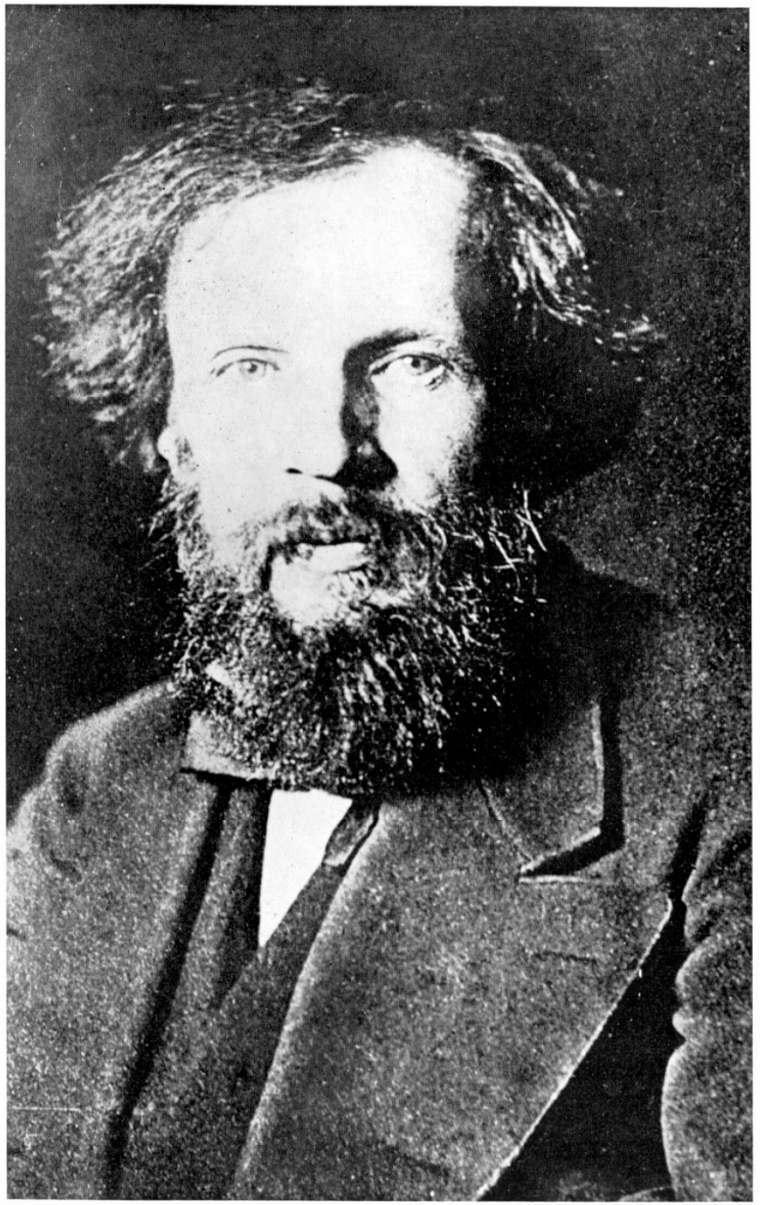


Опыт системы элементов, основанной на их атомном весе и химическом сходстве. Д. Менделеев.

				Ti=50	Zr=90	?=180.
				V=51	Nb=94	Ta=182.
				Cr=52	Mo=96	W=186.
				Mn=55	Rh=104,4	Pt=197,4.
				Fe=56	Ru=104,4	Ir=198.
				Ni=Co=59.	Pl=106,6	Os=199.
H=1.		?=8	?=22	Cu=63,4	Ag=108.	Hg=200.
		Be=9,4.	Mg=24.	Zn=65,2	Cd=112.	
		B=11	Al=27,4	?=68	Ur=116	Au=197?.
		C=12	Si=28	?=70	Sn=118.	
		N=14	P=31	As=75	Sb=122	Bi=210?
		O=16	S=32	Se=79,4	Te=128?	
		F=19	Cl=35,5	Br=80	J=127.	
Li=7.		Na=23	K=39.	Rb=85,4	Cs=133	Tl=204.
			Ca=40	Sr=87,6	Ba=137	Pb=207.
			?=45.	Ce=92		
			?Er=56?	La=94		
			?Yt=60?	Di=95		
			?In=75,6?	Th=118?		

Essai d'une système des éléments d'après leurs poids atomiques et fonctions chimiques par D. Mendeleeff professeur de l'Université à St Pétersbourg

18 II/17 69.



Mendeleev's Table Today (since Nov. 28, 2016)

International Union of Pure and Applied Chemistry

May 2012:

Official approval of the name *Flerovium* for element *114*
and the name *Livermorium* for element *116*

30th December 2015:

Approval of the discovery of new elements *113, 115, 117, and 118*

- element 113: RIKEN (Japan)
- elements *115* and *117*: JINR (Dubna) - LLNL (USA) – ORNL (USA) collaboration
- element *118:* JINR (Dubna) – LLNL collaboration.

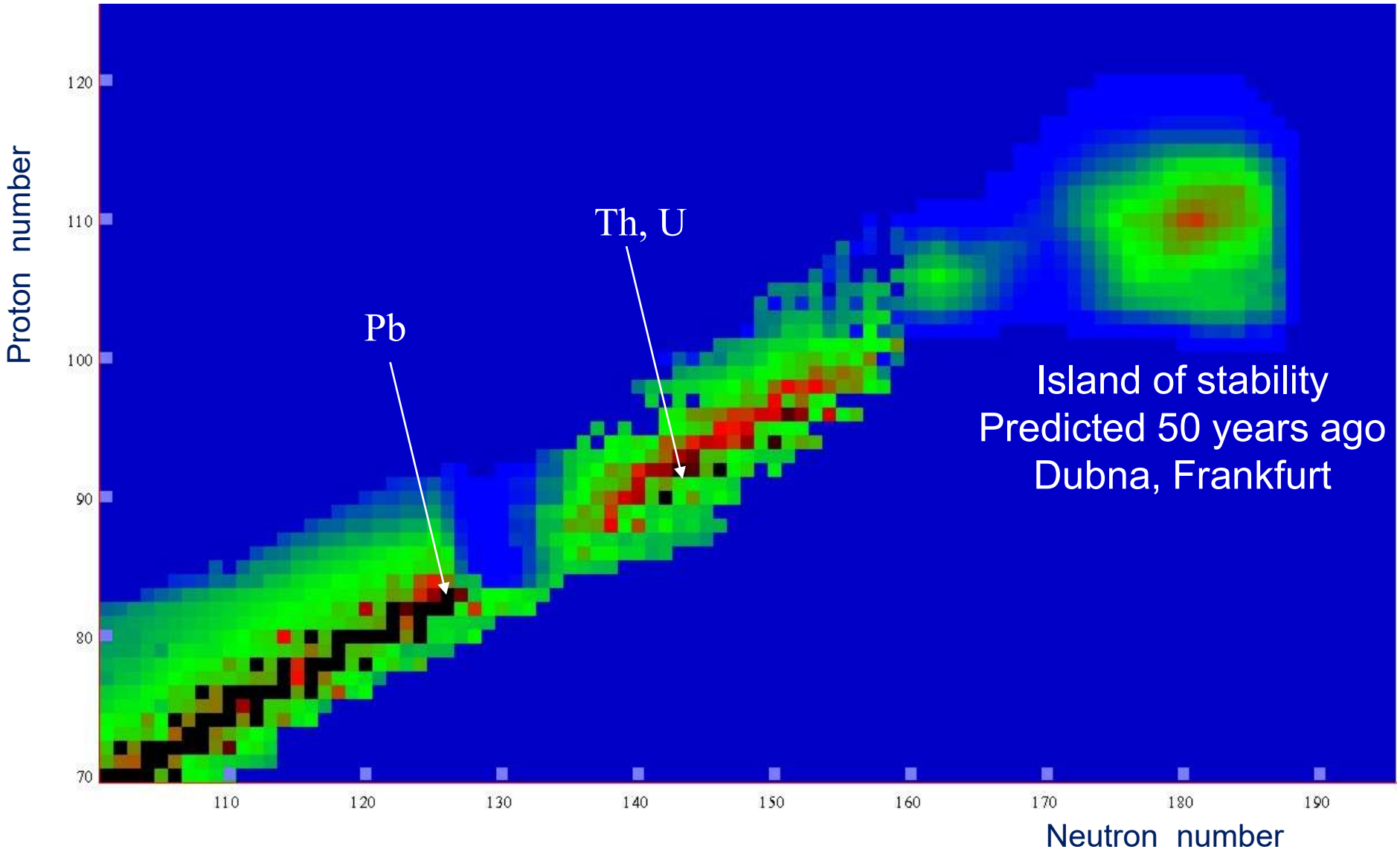
28th November 2016:

IUPAC formally approved names and symbols of new elements:

Nihonium (Nh) for element 113,
Moscovium (Mc) for element **115**,
Tennessine (Ts) for element **117,** and
Oganesson (Og) for element **118**.

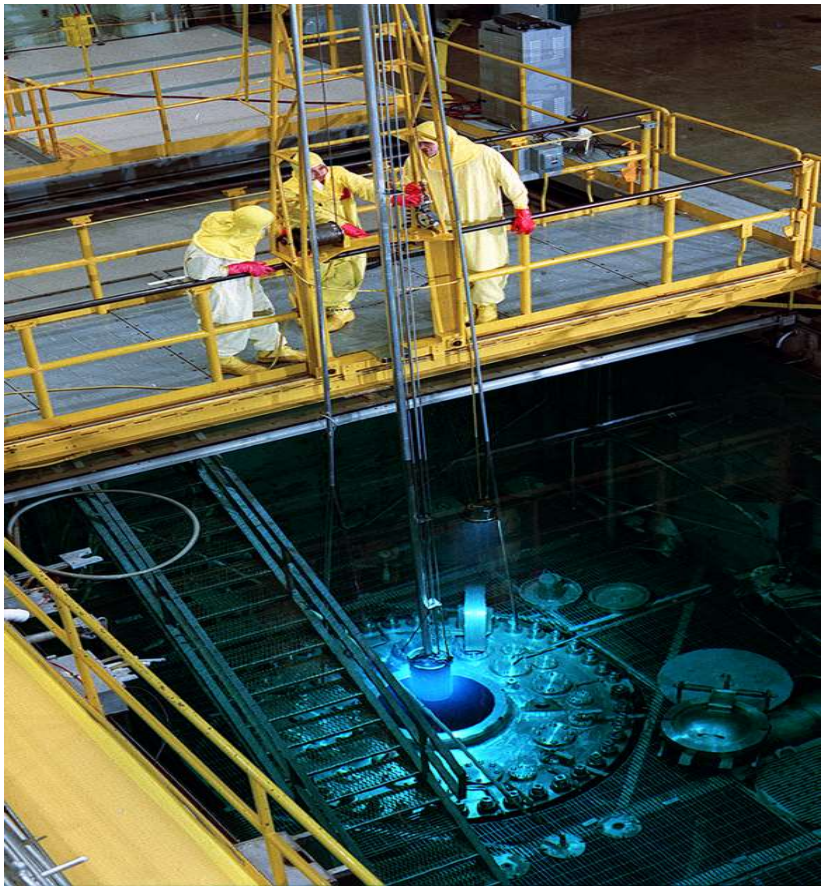
All these elements were synthesized for the first time at the U-400 accelerator complex of the Flerov Laboratory of Nuclear Reactions of JINR.

Chart of Nuclei



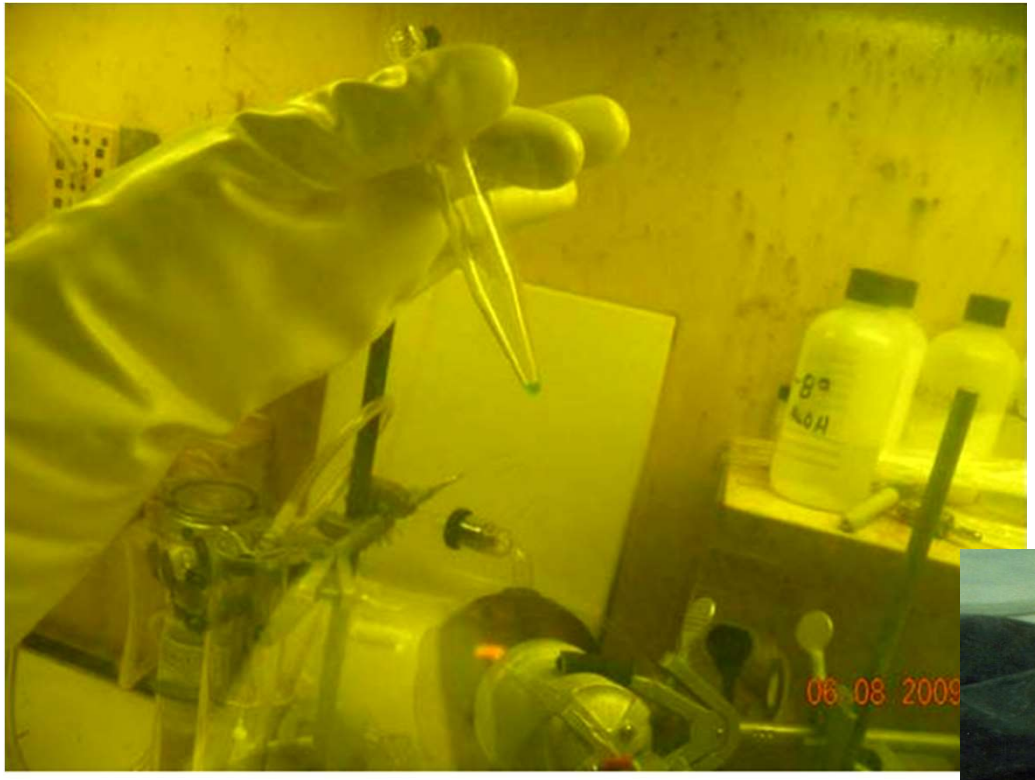
Isotope reactors

HFIR, ORNL, Oak Ridge, USA, 85 MW



CM-3, IAR, Dimitrovgrad, RF, 100 MW

22 mg of ^{249}Bk have been produced in HIFR ORNL



$Bk(NO_3)_3$Product

Prices per 1 mg

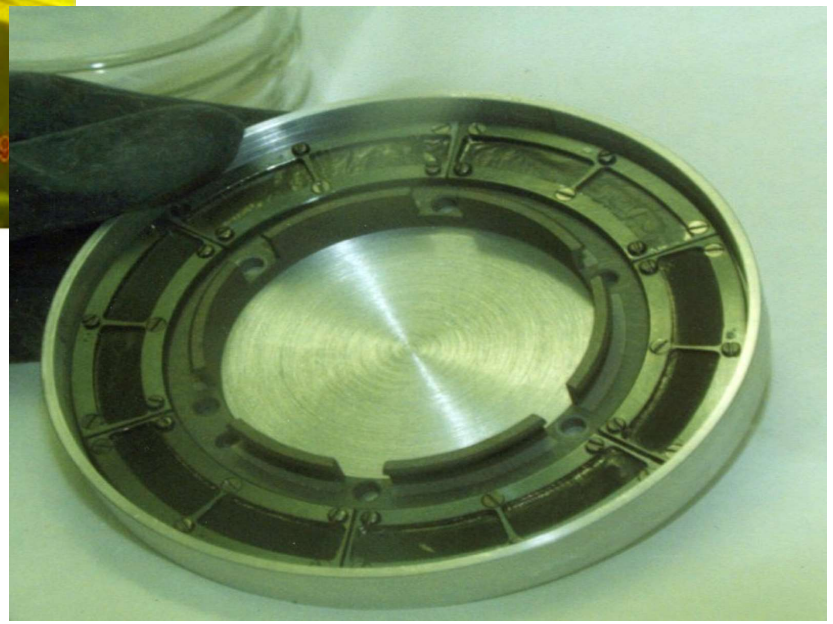
$^{197}Au \approx 0.045$ US$

$^{nat}U_3O_8 \approx 0.03$ US$

$^{239}Pu \approx 4$ US$

$^{249}Cf \approx 60\,000$ US$

Target wheel



Superconducting 18 GHz ECR ion sources

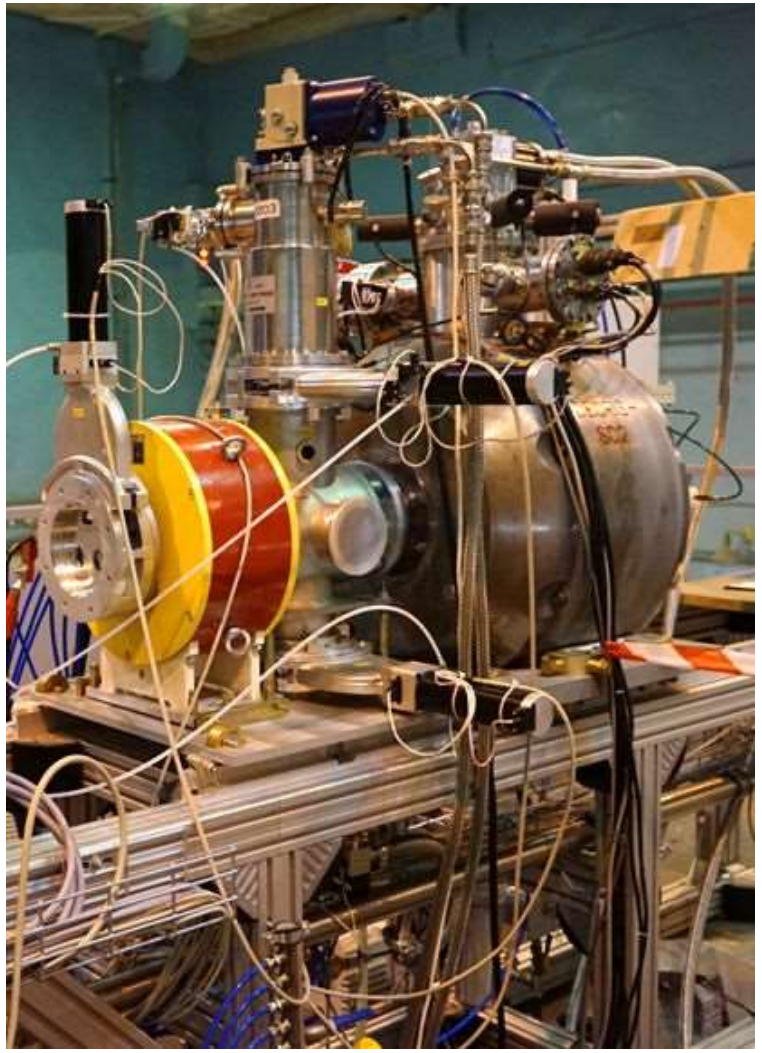
~2 grams of ^{48}Ca

Consumption: 0.5-0.8 mg/h

Prices per 1 mg

$^{197}Au \approx 0.045$ US$
$^{nat}U_3O_8 \approx 0.03$ US$
$^{239}Pu \approx 4$ US$
$^{48}Ca \approx 250$ US$

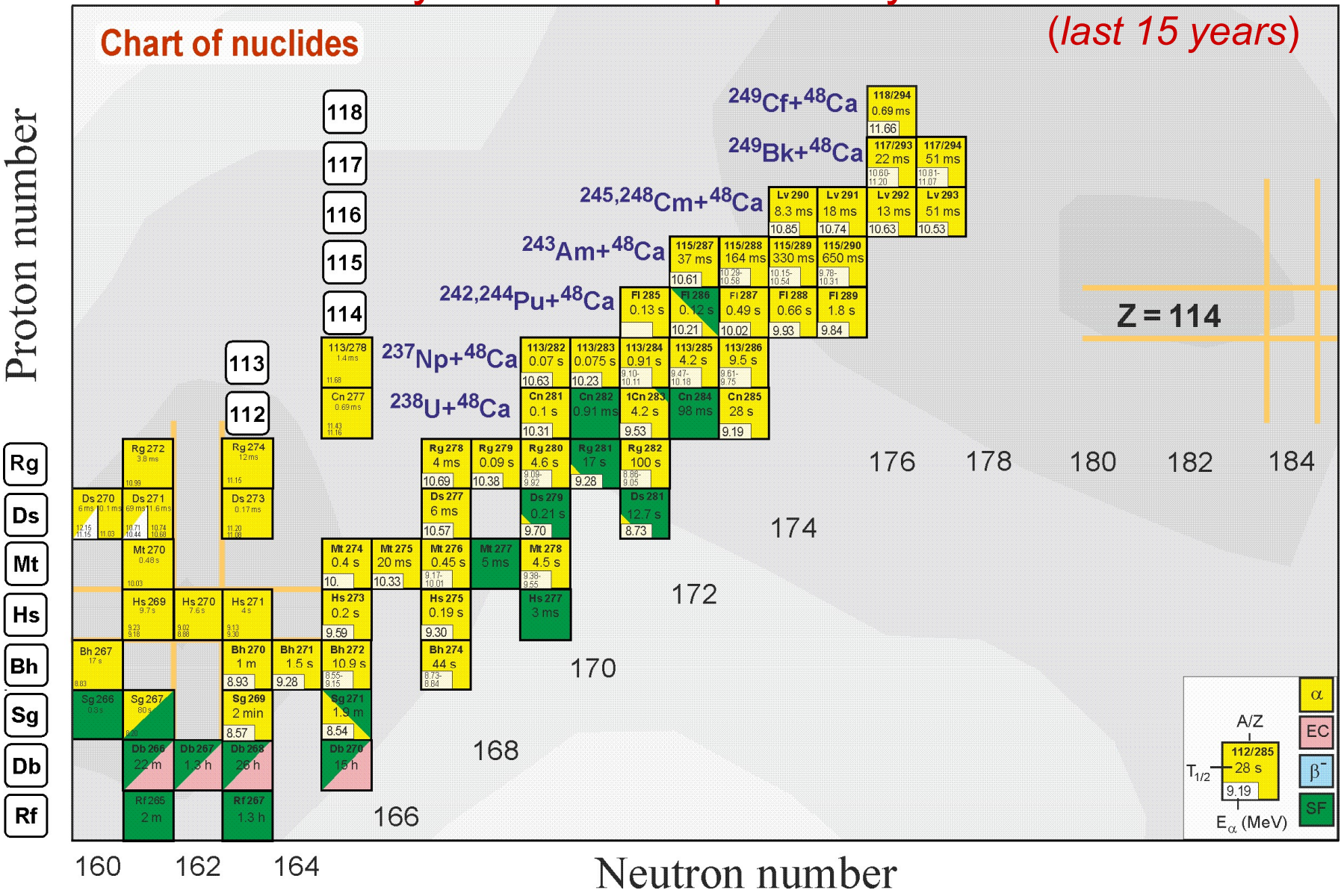
Ion source DECRIS-SC2



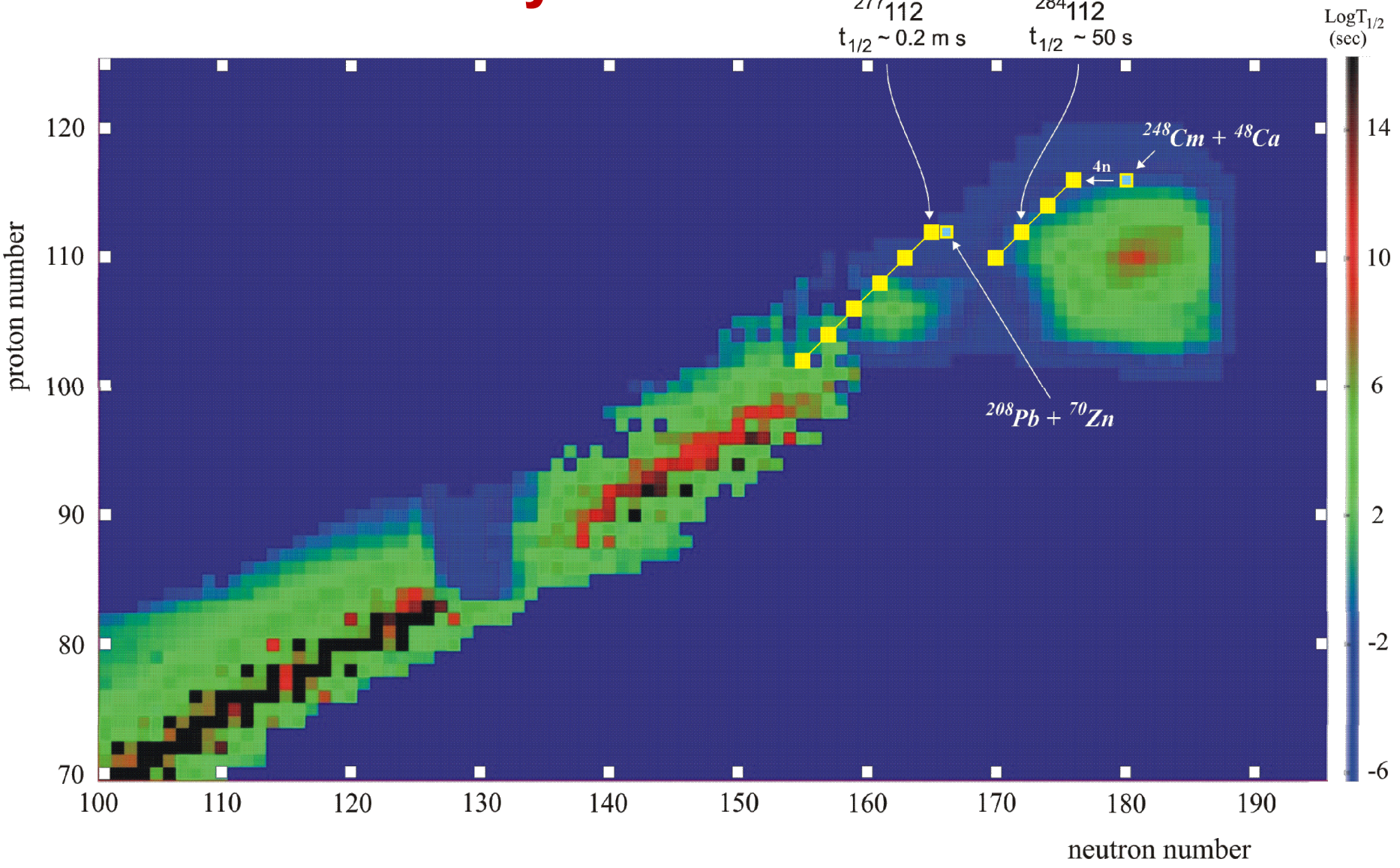
Synthesis of Superheavy Elements (U-400)

GREAT PROGRESS

in Synthesis of Superheavy Nuclei



Island of Stability Exists!



Inauguration of elements 115 (Moscovium), 117 (Tennessine), 118 (Oganesson)

Prof. N. Tarasova
IUPAC

Dr. K. Reed
IUPAP

Prof. O. Vasilieva
Minister of S&E, Russia

Prof. L. Kostov
CPP of JINR Member States

Moscow
Central House of Scientists
of RAS
March 2, 2017

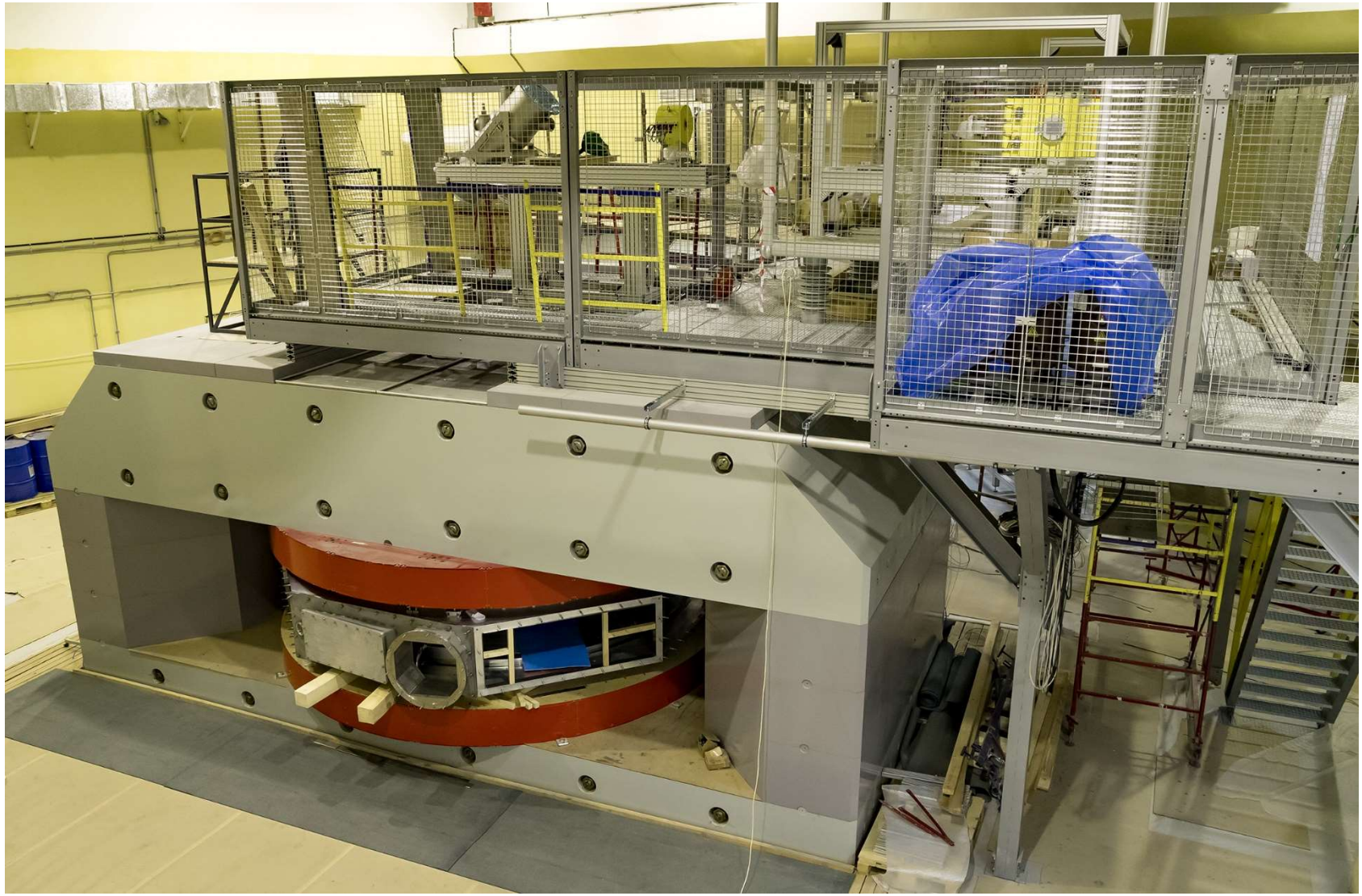
SuperHeavy Elements (SHE) Factory

included into the NuPECC Long-Range Plan

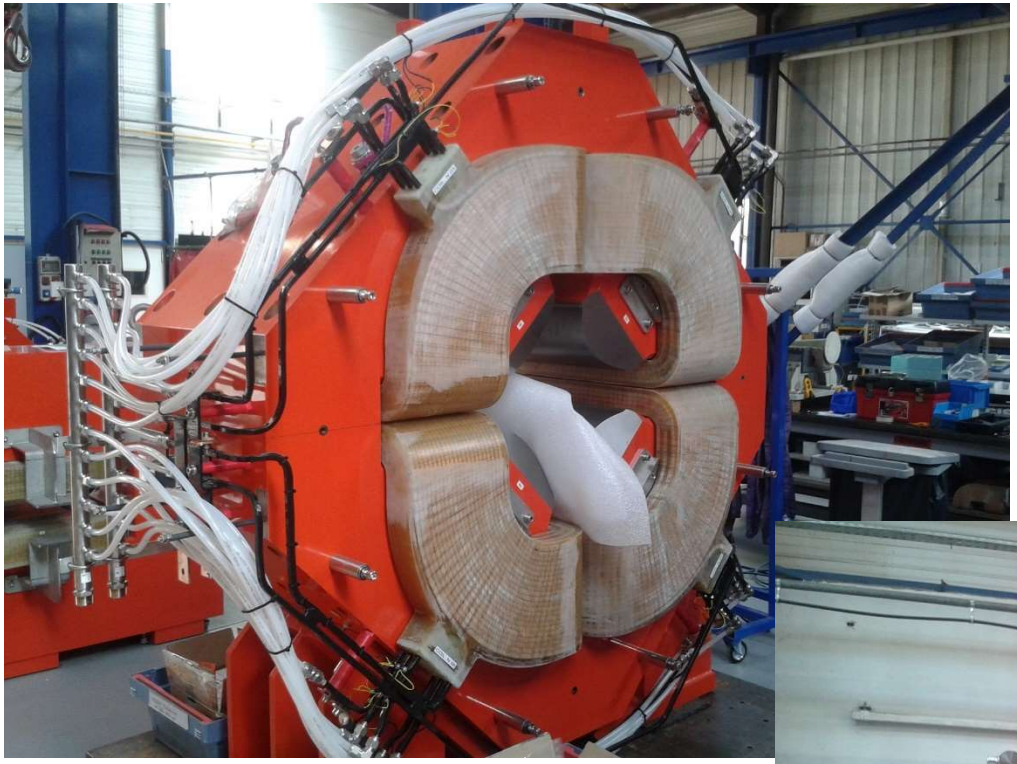
SHE Factory Building

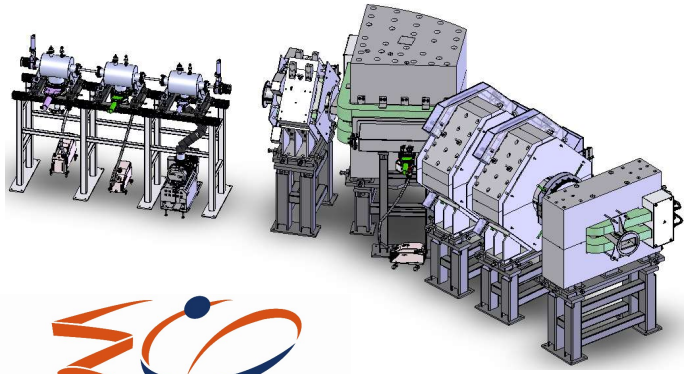
SuperHeavy Elements (SHE) Factory

DC-280 cyclotron



SuperHeavy Elements (SHE) Factory



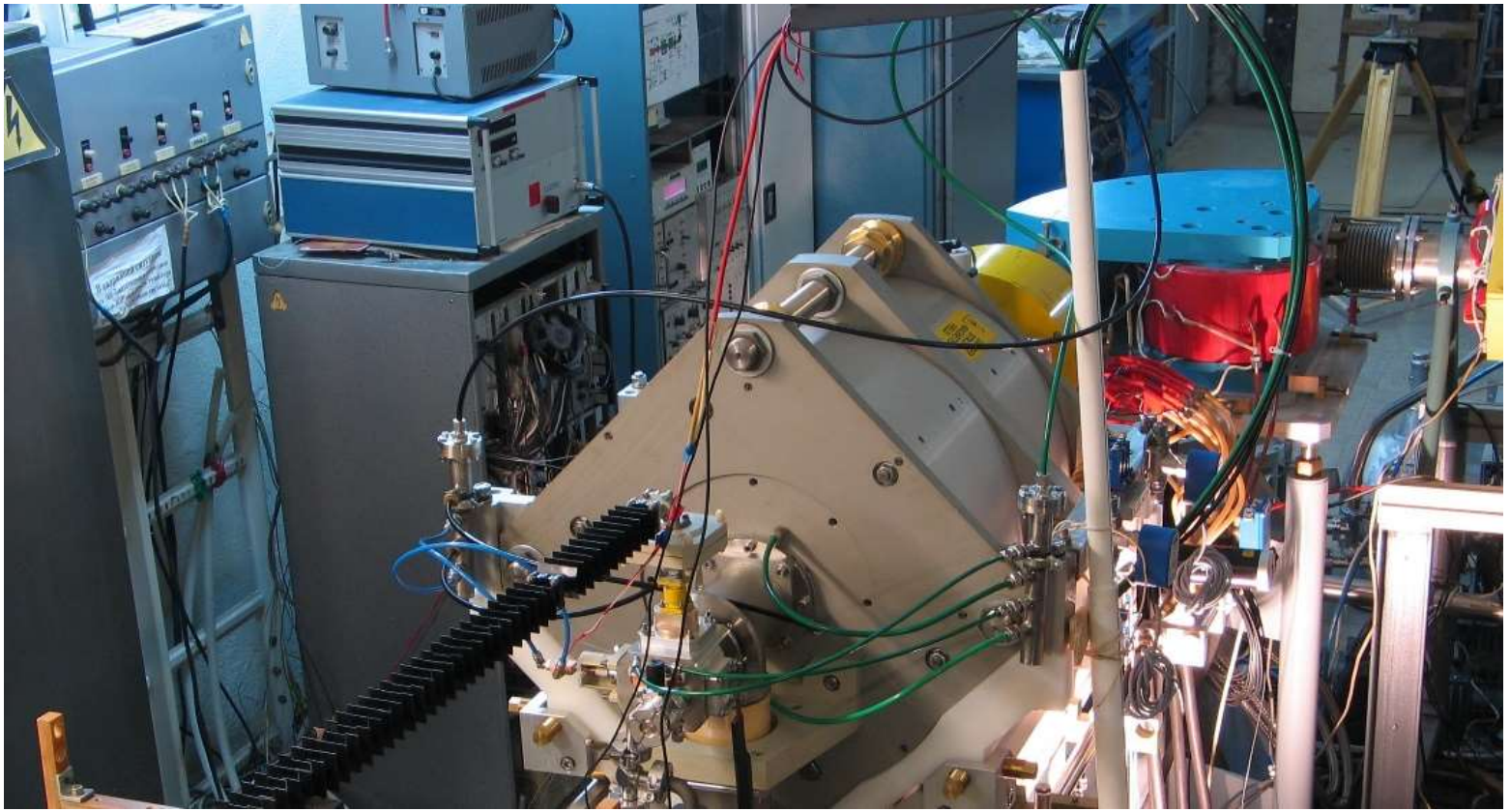


SIGMAPHI
MAGNETS AND BEAM TRANSPORT

New gas-filled separator

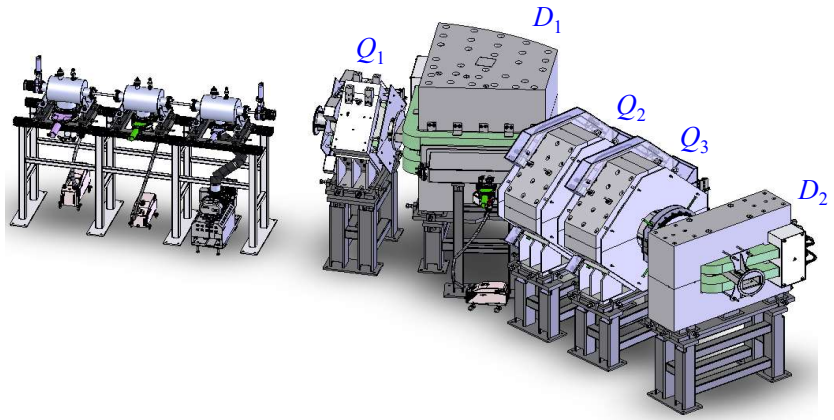
SuperHeavy Elements (SHE) Factory

Ion source



SuperHeavy Elements (SHE) Factory

- Assembling the **DC-280** cyclotron. Installation of new **G**as-**F**illed **R**ecoil **S**eparator. (*2017 – 1st half of 2018*)
- **First experiments** (*2nd half of 2018*)



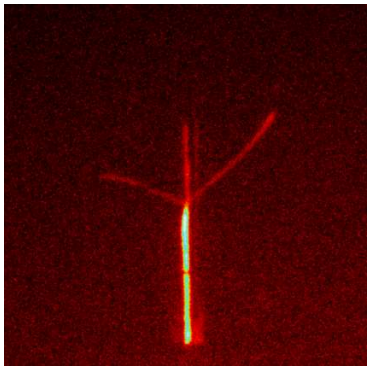
Study of exotic nuclei close and beyond the nucleon stability limits

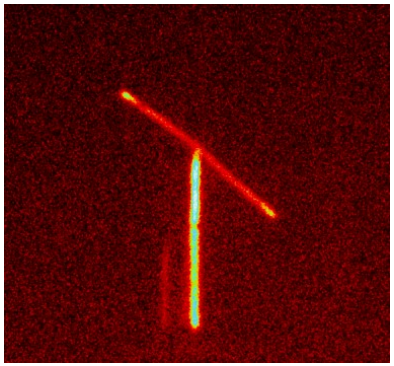
January 2015

ACCULLINA-2

New separator
for study light exotic nuclei
and reactions with them

2015/16: *commissioning tests, 1st runs*
2016: *zero angle spectrometer*
2018/19: *unique cryogenic tritium target*

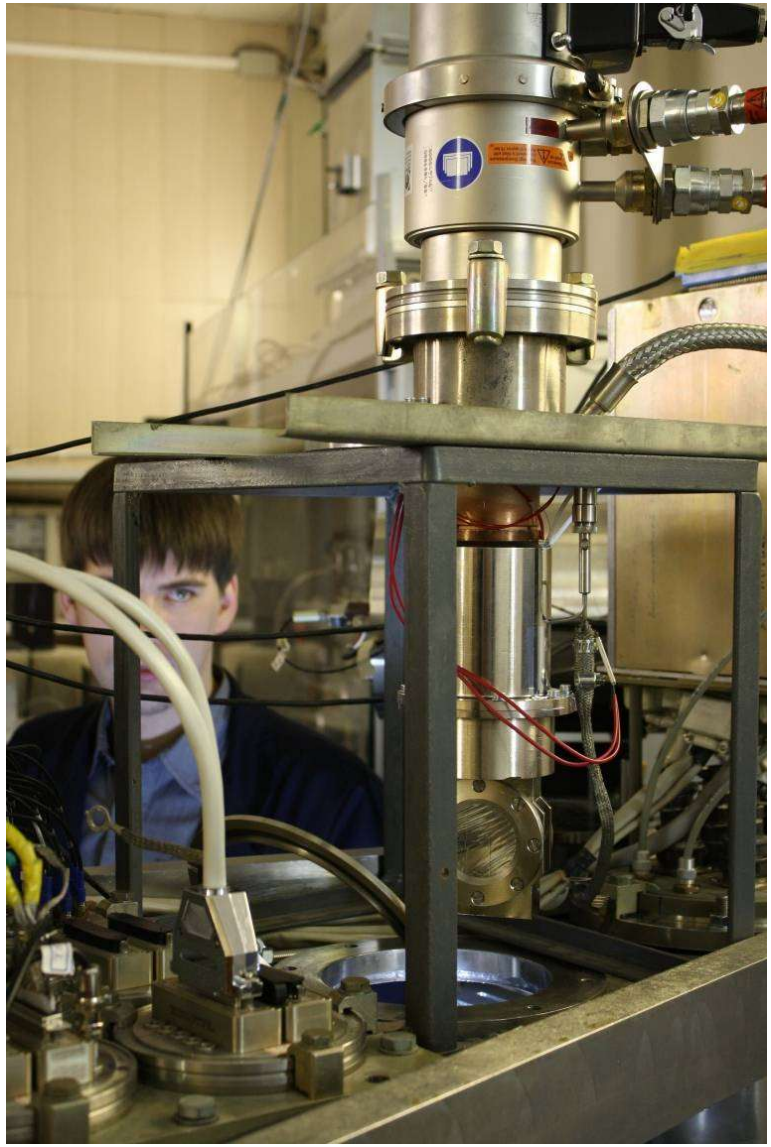


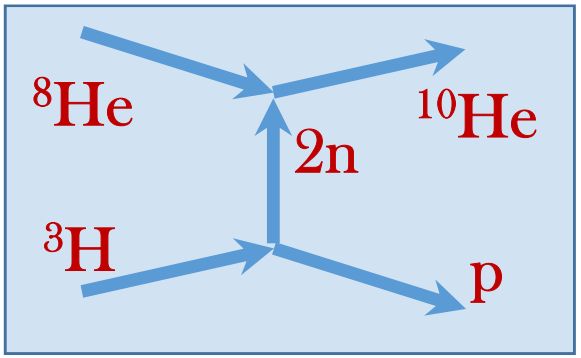


Directions of the future researches:

- structure of light exotic nuclei
- reactions with exotic nuclei
- study of rare decay modes

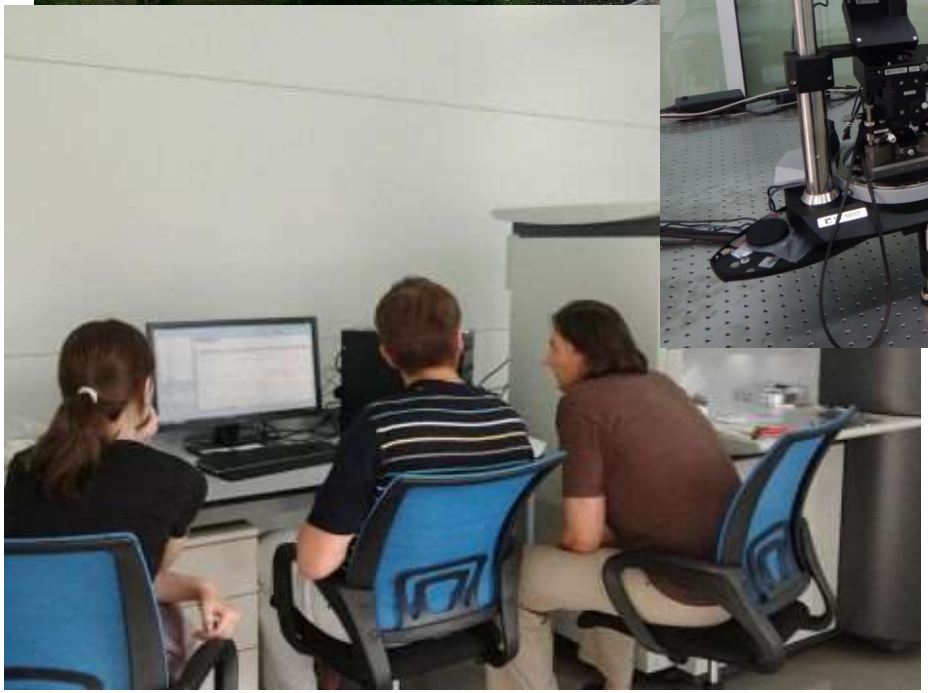
^{10}He: 2n-transfer





Applied research

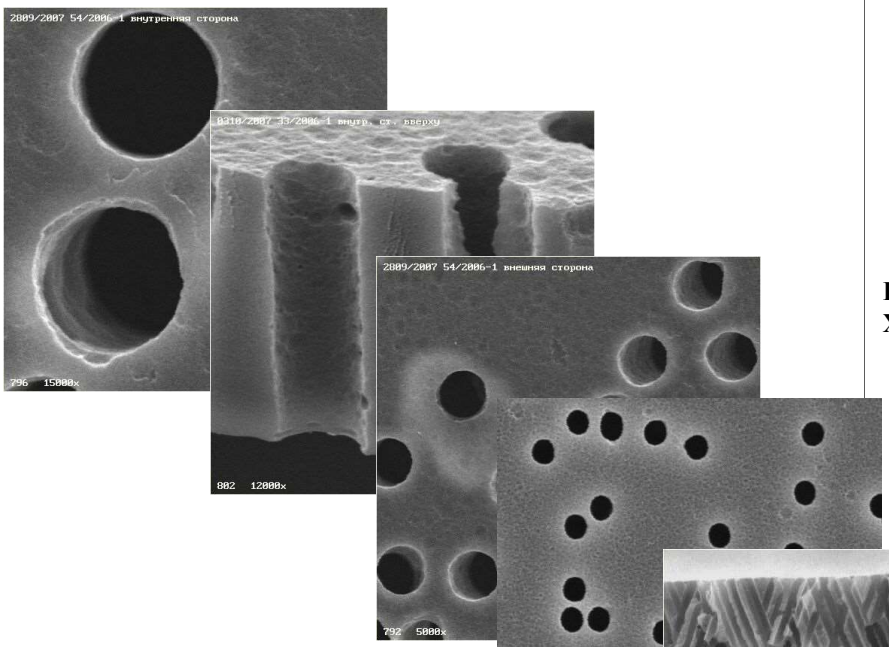
Nano Laboratory

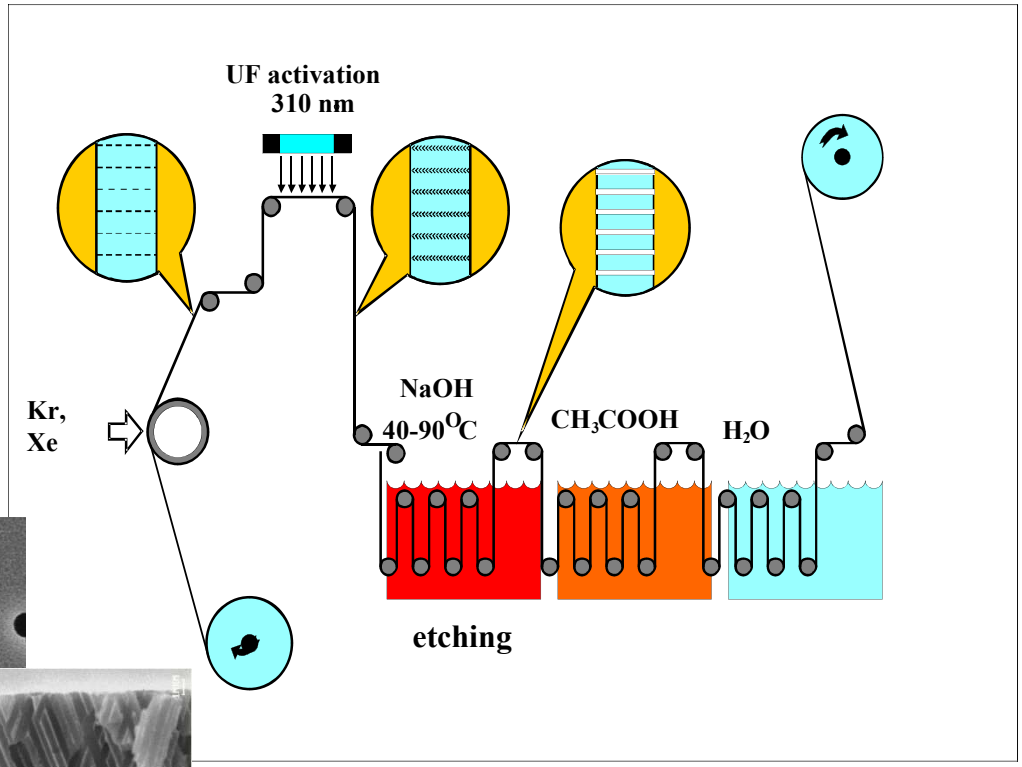


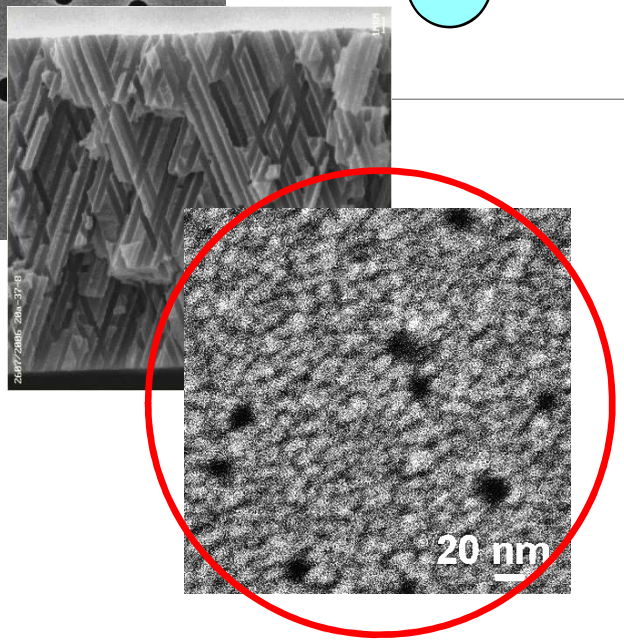
- Scanning electron microscopes
- Atomic force microscopy
- X-Ray photoelectron spectroscopy
- Equipment for sample preparation
- …

Production of track membranes (IC-100)

Micrometers

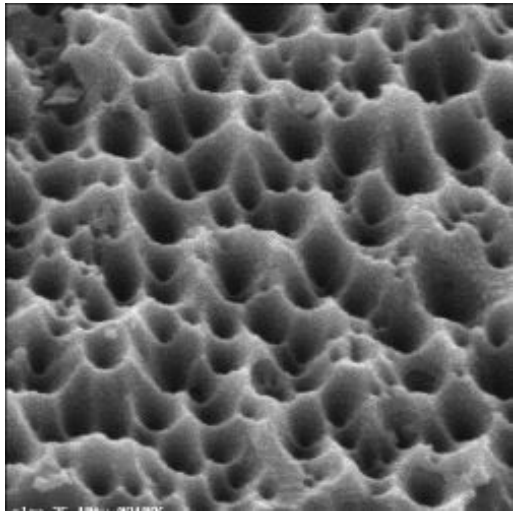


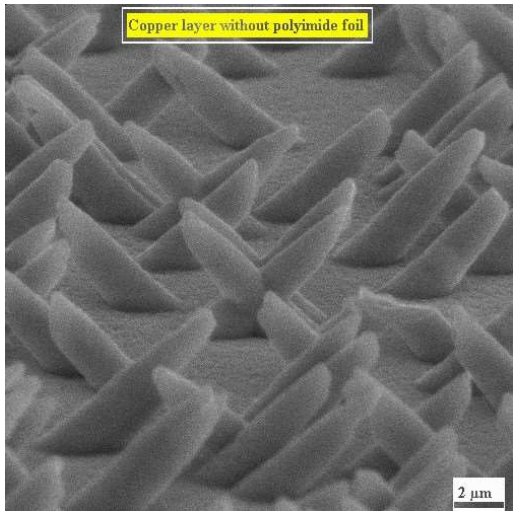




Nanometers

Accelerators-born nanostructures



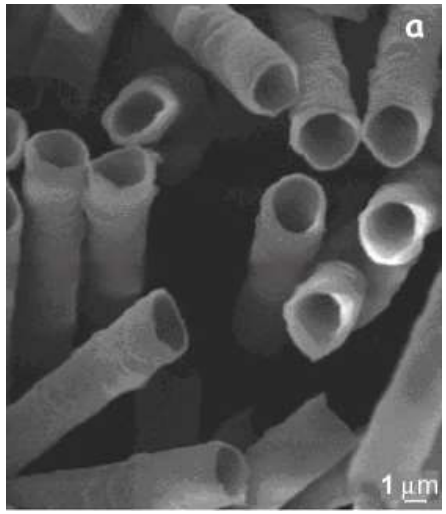


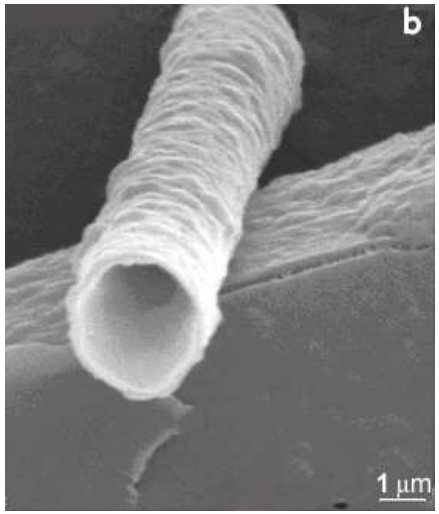
new composite materials:

- extended layers adhesion strength
- increased thermal resistance
- flexible printed circuit boards

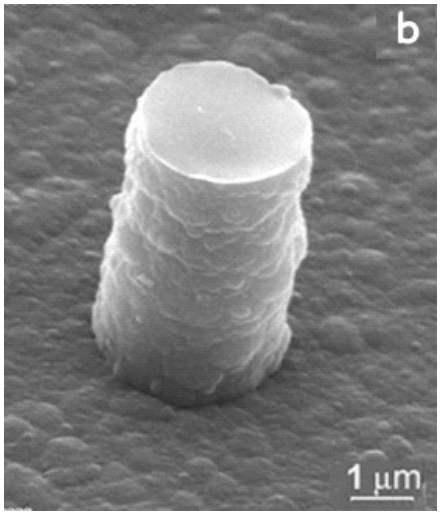
Polymer composites produced with the use of track membranes

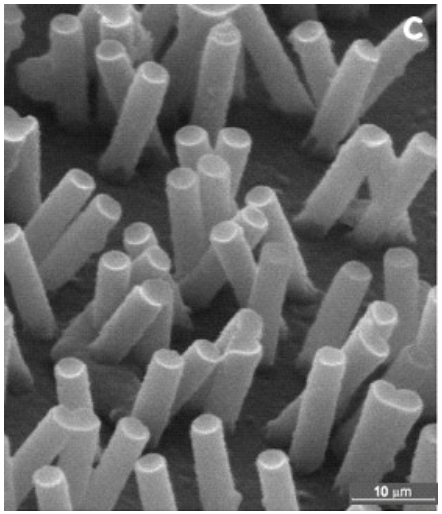
nanotubes





nanowires

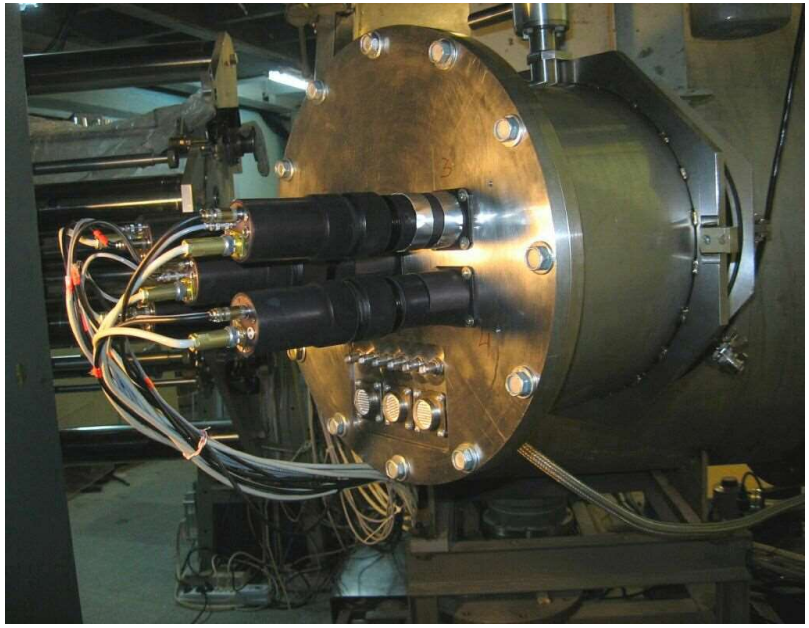




Radiation Hardness Tests For Electronic Components

Development of radiation-proofed electronic components is the first priority task of the modern high-class electronic industry.

Long-distance space flights, long-lived sputniks, etc. are extremely critical to the quality of electronic chips.



Welcome to DUBNA!