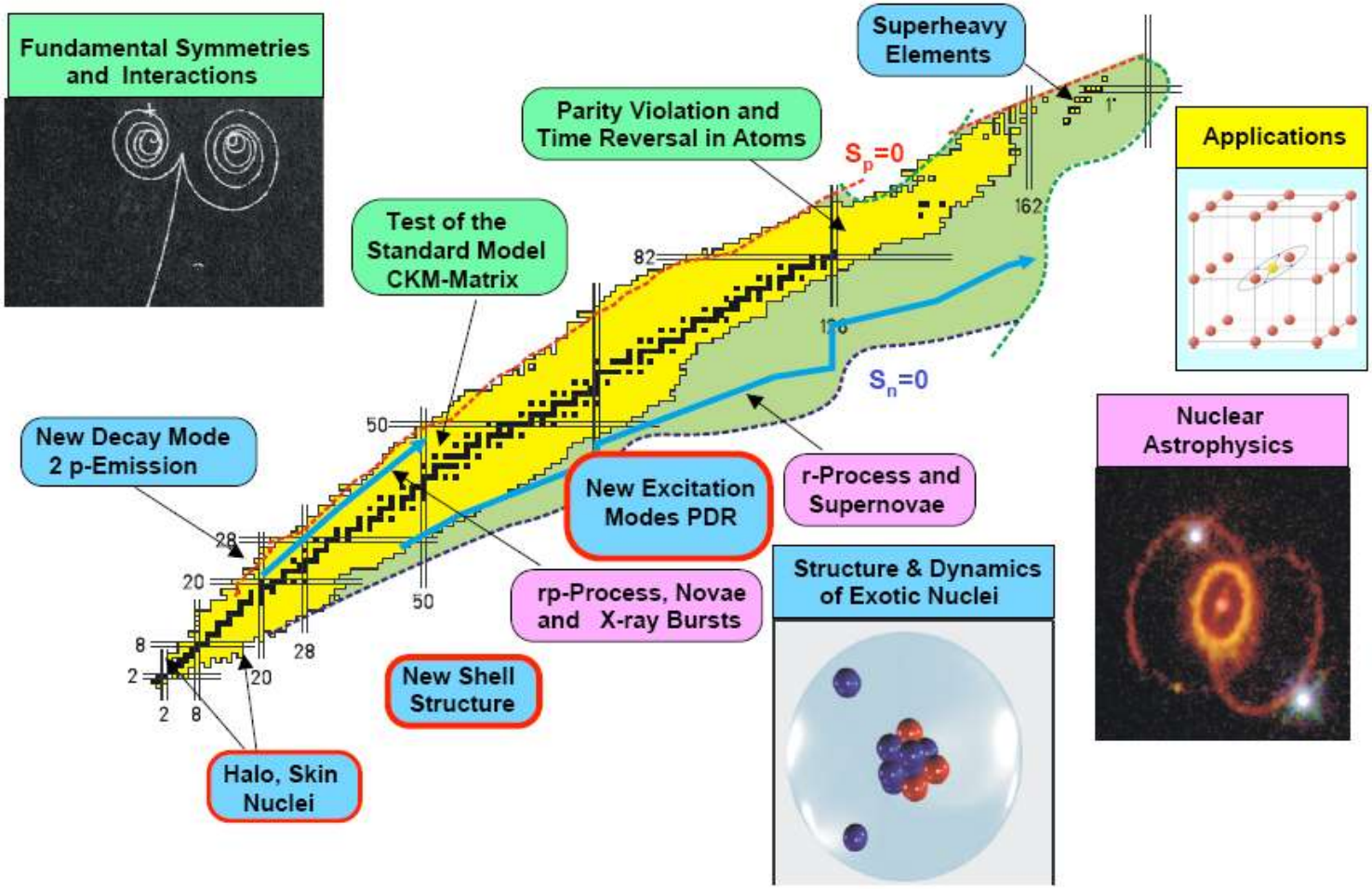
The IRIN project at the reactor PIK

Direction 5 of the scientific program of PNPI NRC KI "Fundamental and applied researches with the neutrons":

The project development and construction of the ISOL facility IRIN at the PIK reactor for study of neutron-rich nuclei far from ß-stability and production radioisotopes for medicine

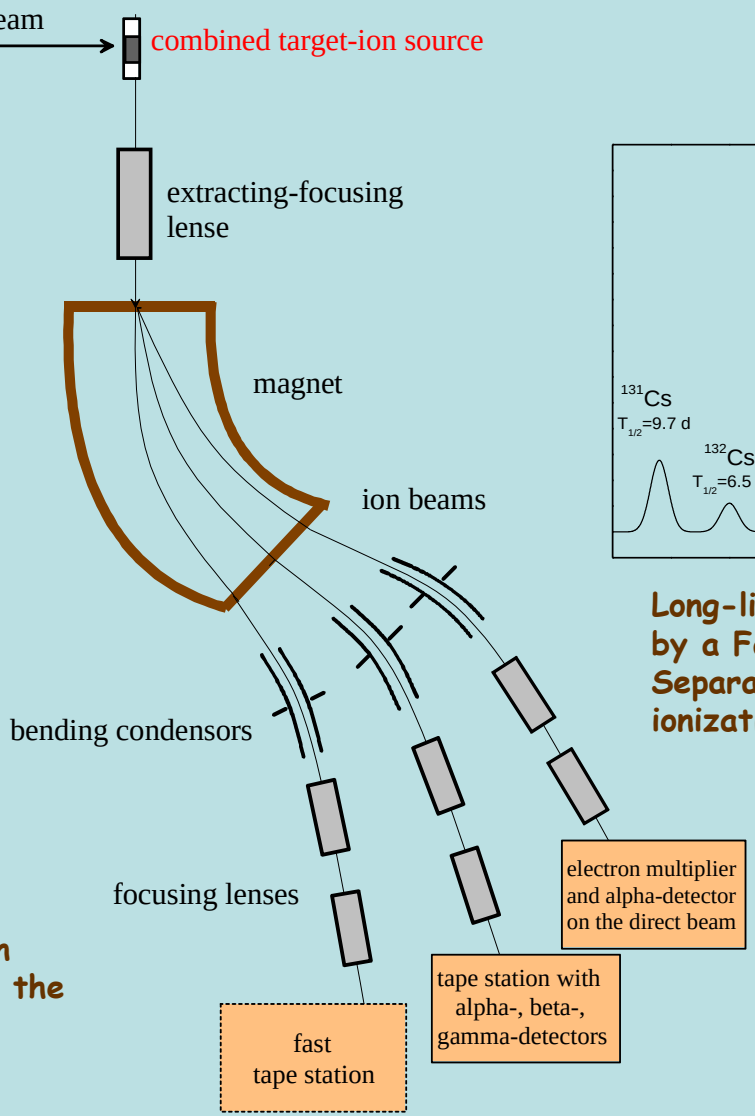
Physics with Exotic Nuclei

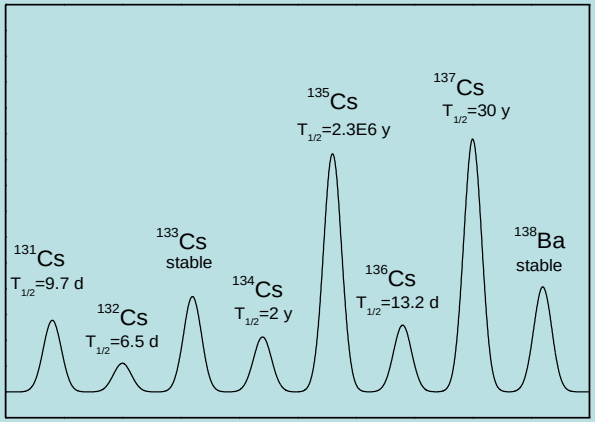


IRIS facility – the ISOL installation at the beam of PNPI synchrocyclotron (in function from 1975), collaboration with ISOLDE (CERN)

The target room of IRIS (Investigation of Radioactive Isotope at Synchrocyclotron) installation

IRIS is the only in Russia on-line installation on nuclear and astrophysics investigations of radioactive isotopes. Targets from foils of refractory metals, melted metals, high temperature metal carbides have been developed for production and investigation of radioactive isotopes of the most elements of the Periodic table.

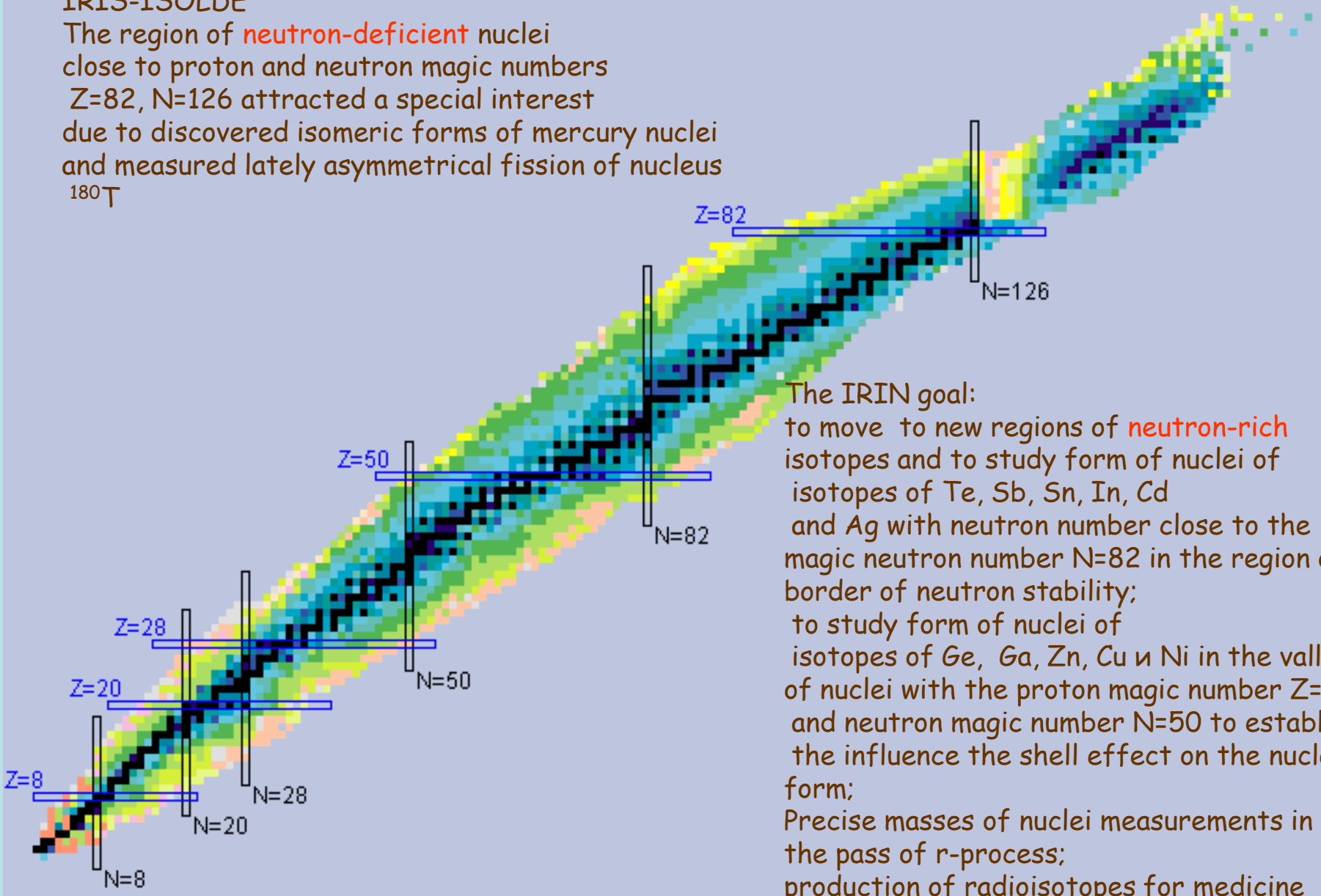




Long-lived Cs isotopes measured by a Faraday cap at the mass-Separator collector. The release-ionization efficiency ~ 70%

IRIS-ISOLDE

The region of neutron-deficient nuclei close to proton and neutron magic numbers Z=82, N=126 attracted a special interest due to discovered isomeric forms of mercury nuclei and measured lately asymmetrical fission of nucleus ^{180}T



The IRIN goal:

to move to new regions of neutron-rich isotopes and to study form of nuclei of isotopes of Te, Sb, Sn, In, Cd and Ag with neutron number close to the magic neutron number N=82 in the region of border of neutron stability;

to study form of nuclei of isotopes of Ge, Ga, Zn, Cu и Ni in the valley of nuclei with the proton magic number Z=28 and neutron magic number N=50 to establish the influence the shell effect on the nucleus form;

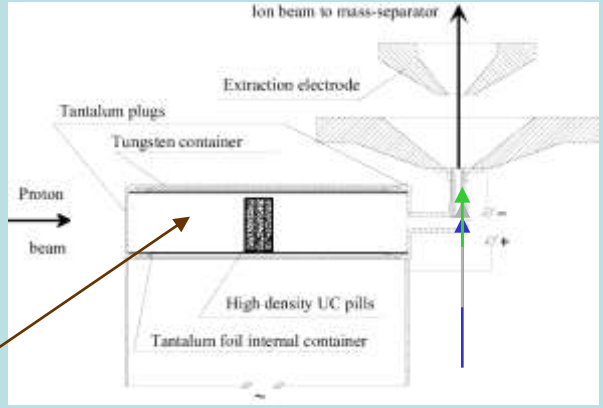
Precise masses of nuclei measurements in the pass of r-process;

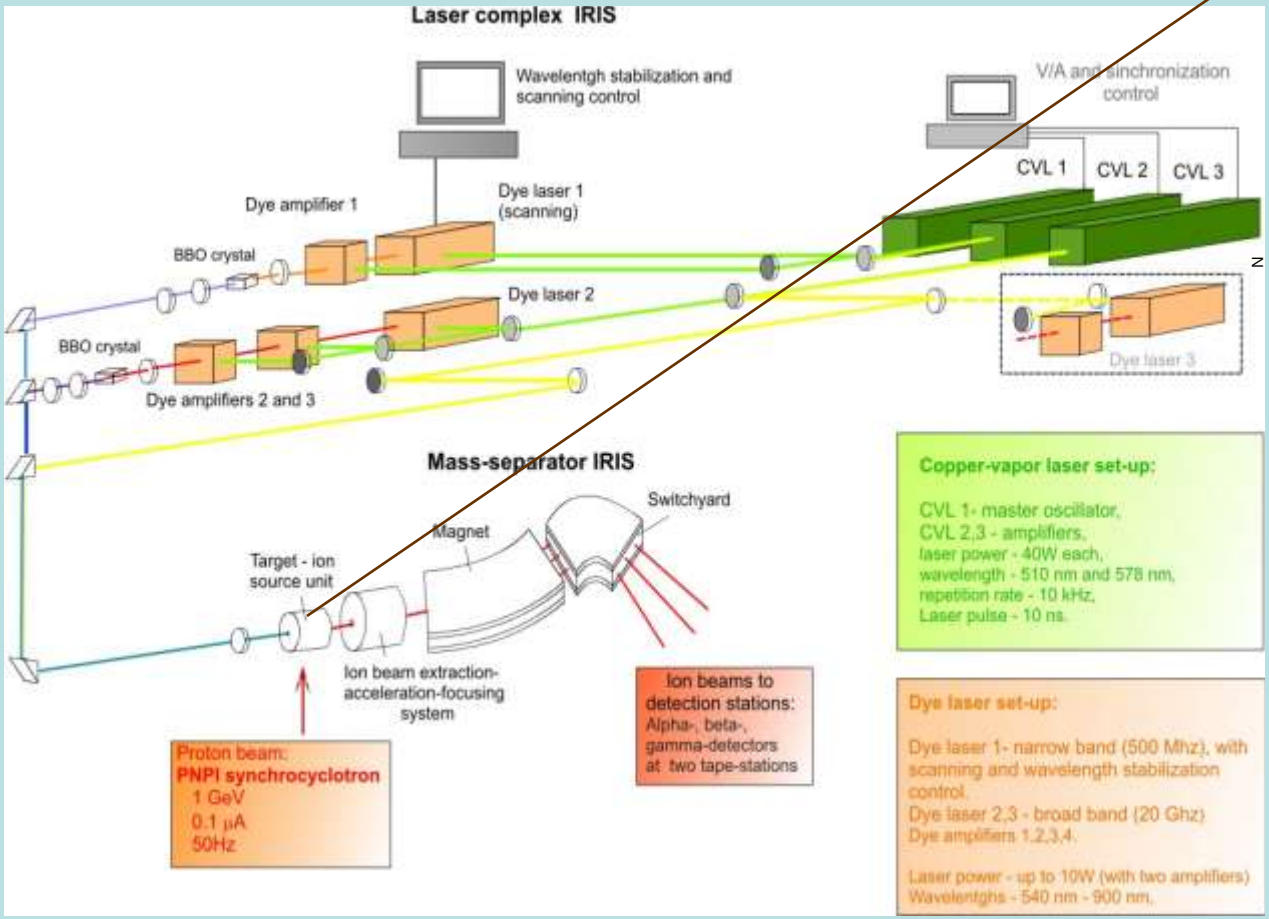
production of radioisotopes for medicine

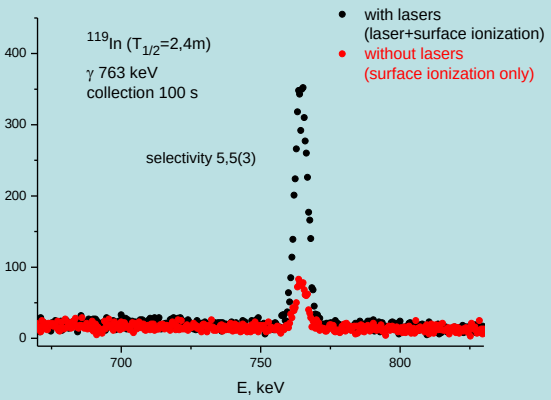
The lay-out of nuclear-laser complex IRIS - ULISS

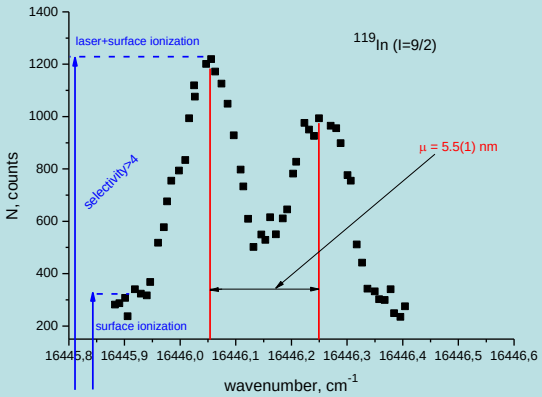
ULISS provides selective highly efficient ionization of radioactive species produced
and gives the possibility to measure on-line nuclear charge radii and electromagnetic moments of nuclei

UC target for short-lived isotope production

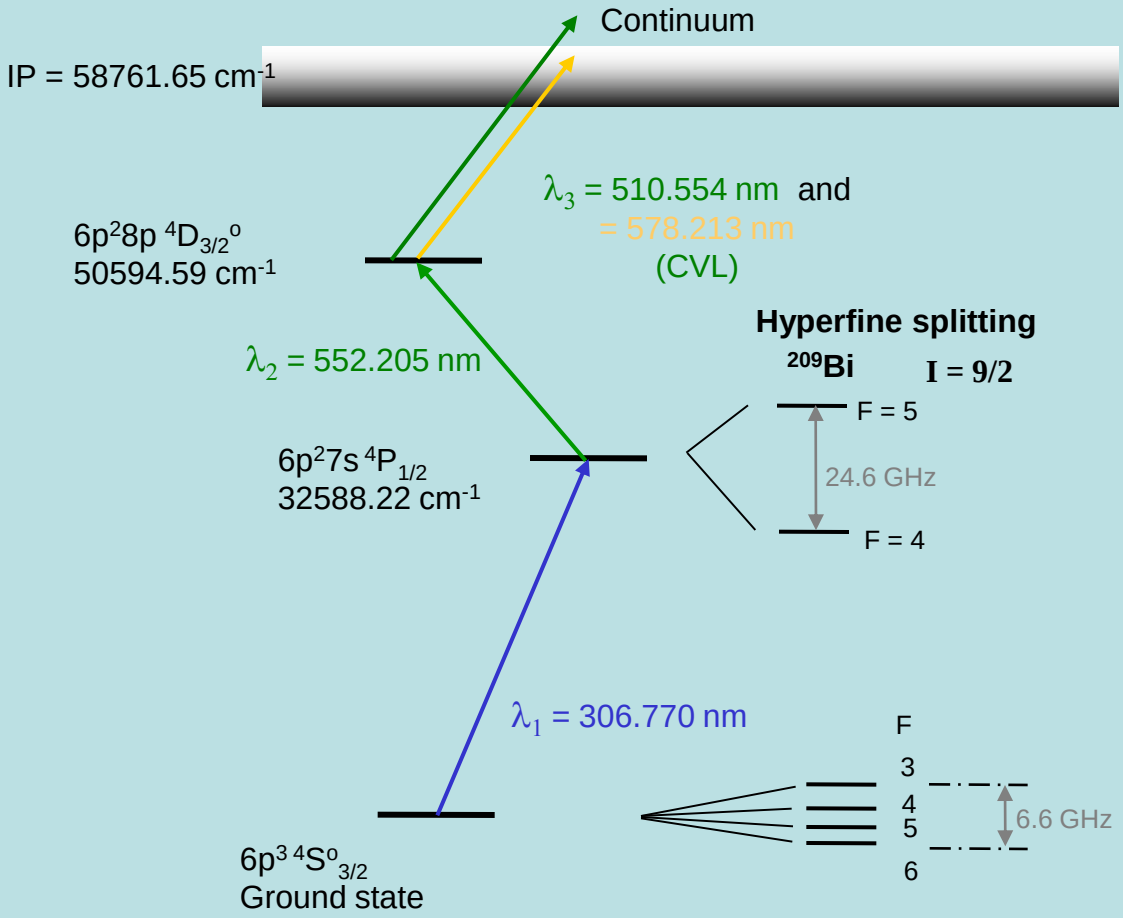


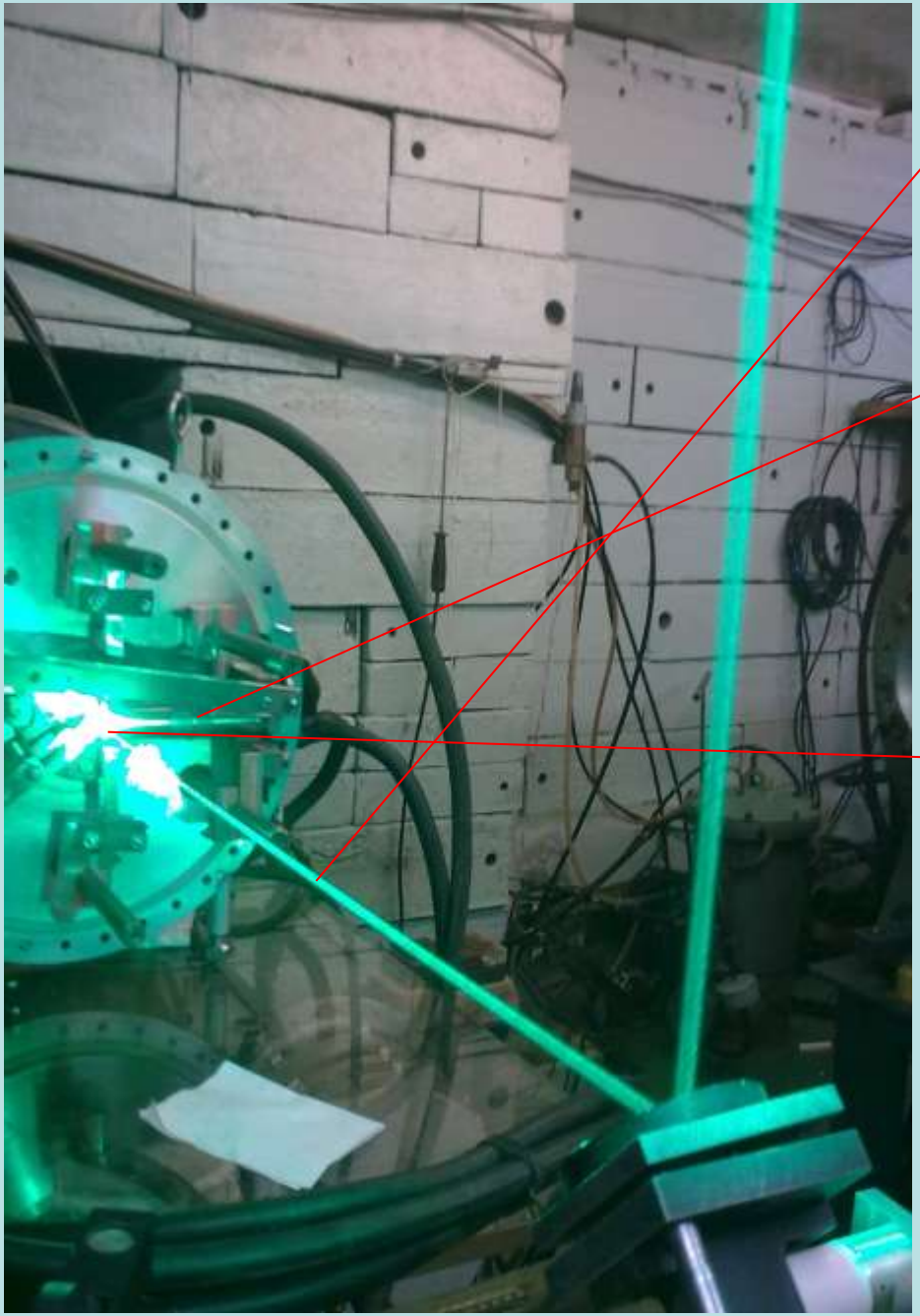






The ionization scheme of Bi



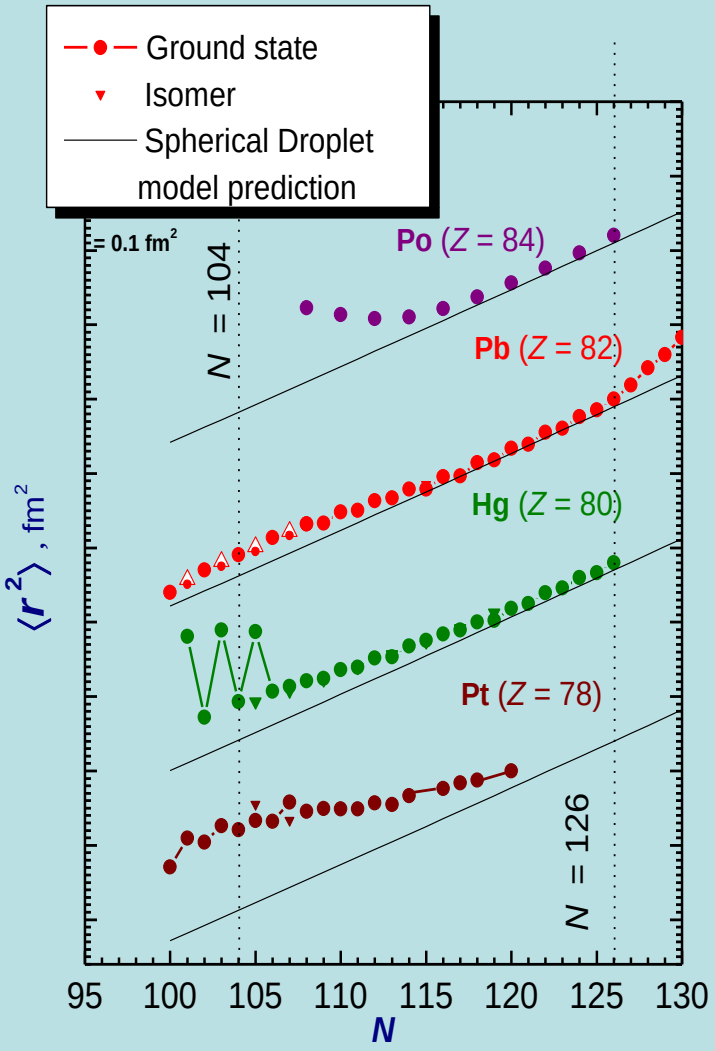


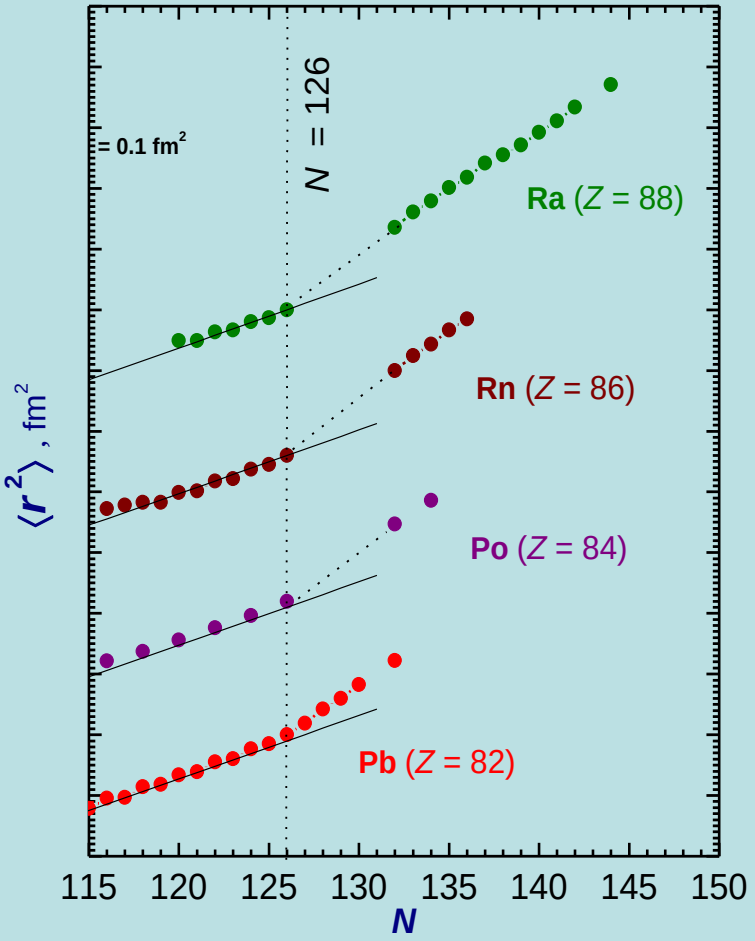
Laser beams focused into the volume of laser ion source

UC target of a High density

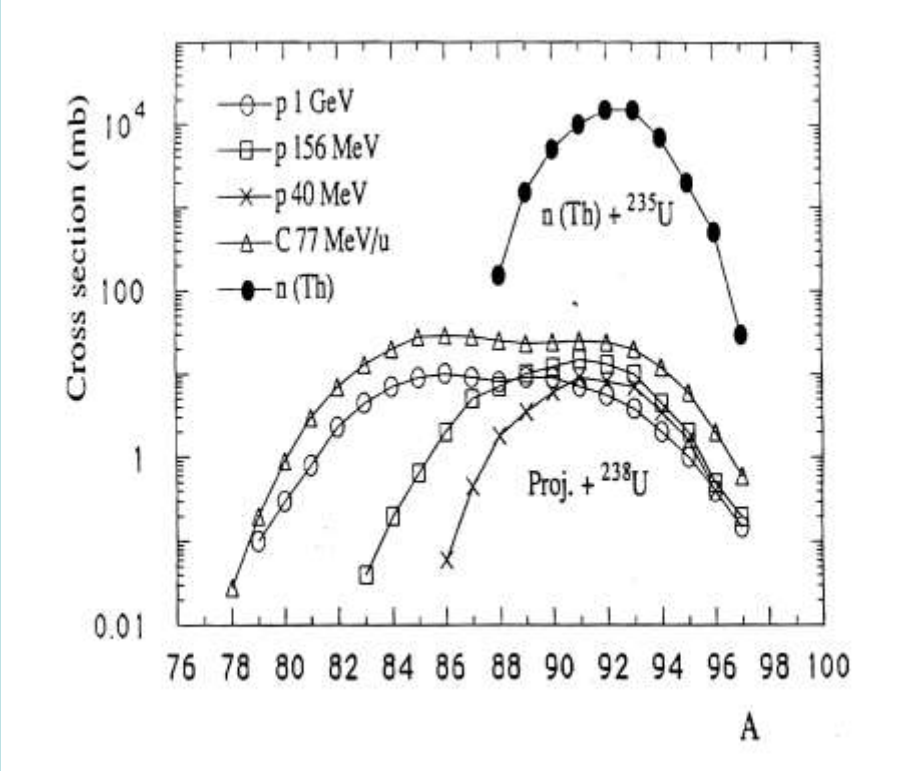
Laser ion source

The charge radii of nuclei in the led region (Z=82)



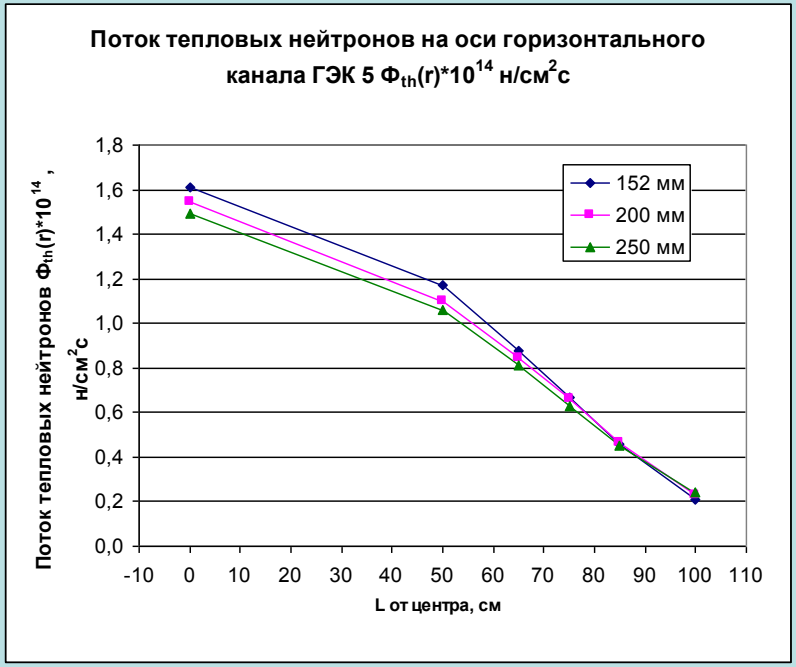


The project IRIN (Investigation of Radioactive Isotopes produced by Neutrons)

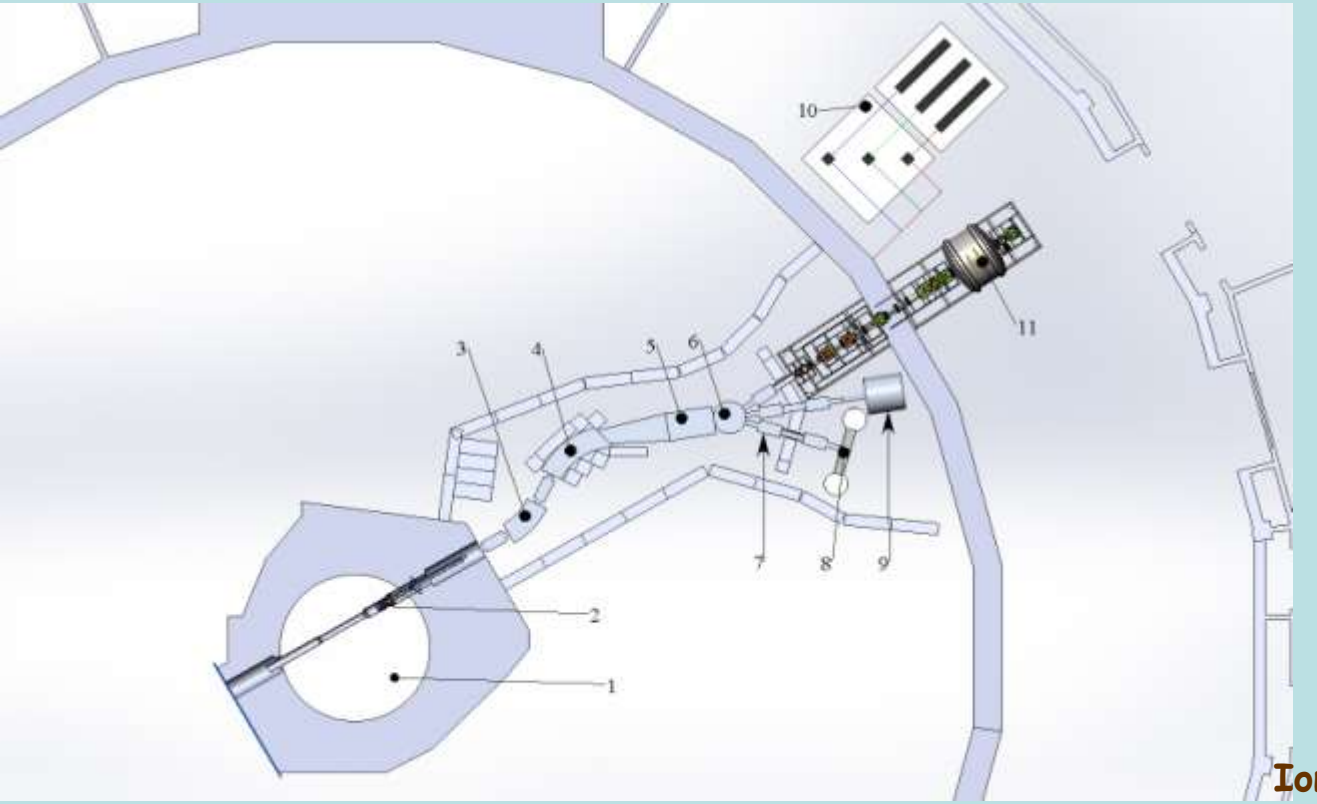


The production cross-section of Rb isotopes at different particle beams

The reactor flux of thermal neutrons higher than 10^{13} n/см^{2}s, allows to obtain the highest yields of neutron-rich nuclei far from the region of beta-stability



The lay-out of the IRIN facility at the reactor PIK



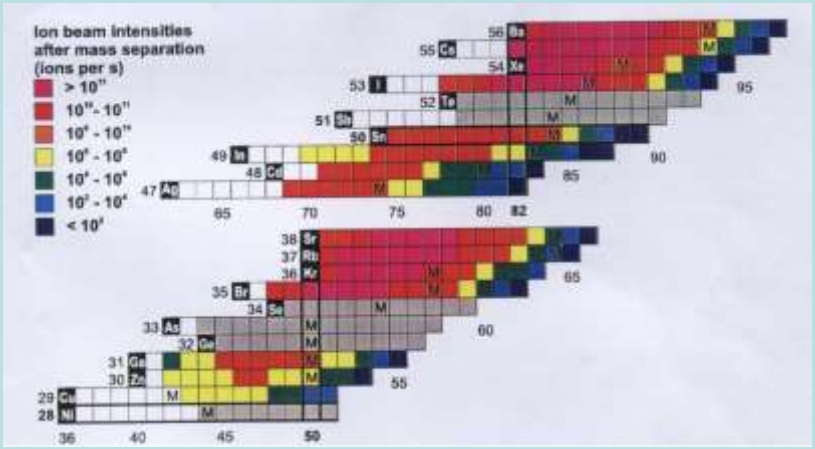
Target–
Highly enriched ^{235}U prepared as uranium carbide of a high density

Uranium mass – 3-4 g.

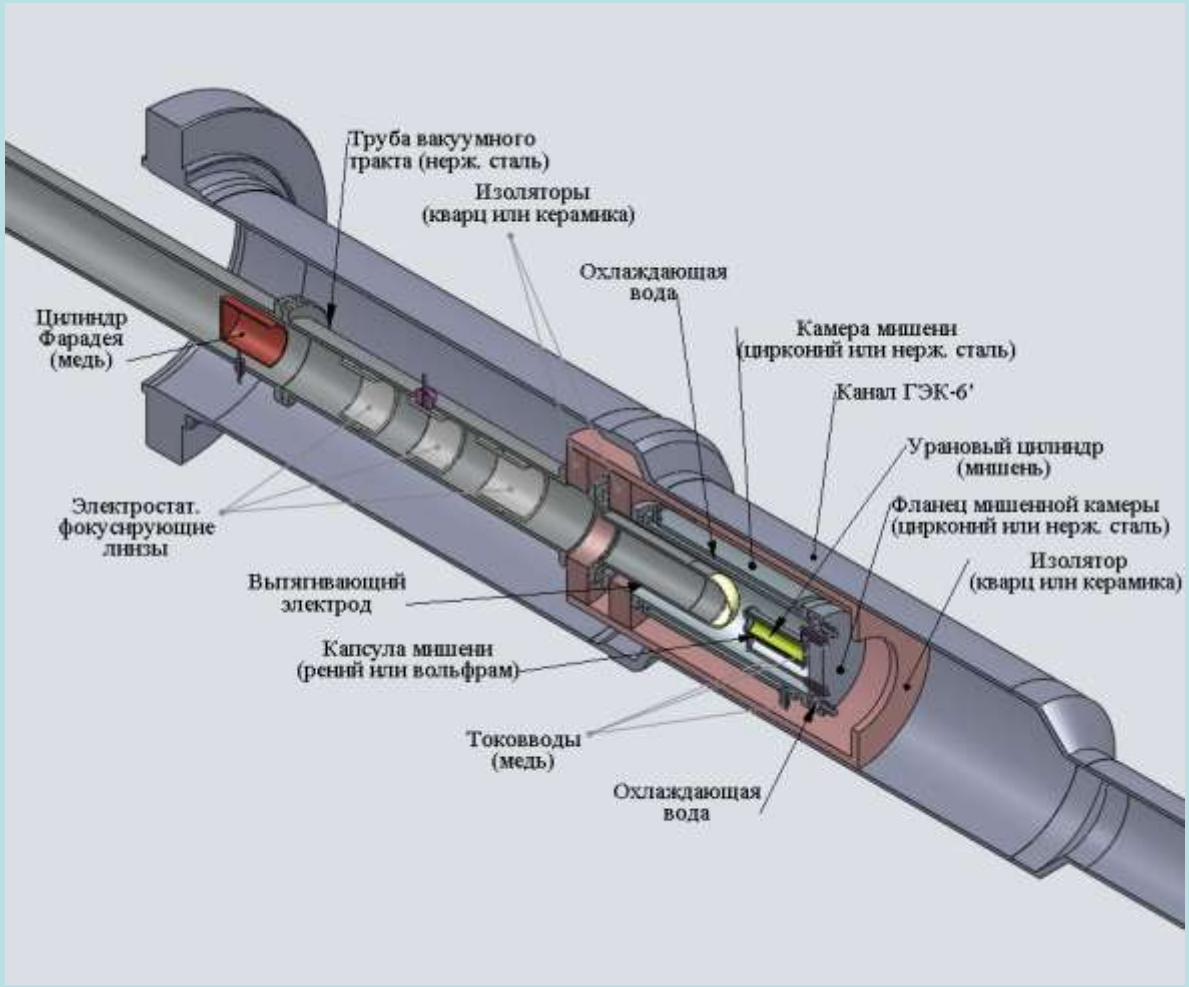
Neutron flux through the target - $(3\text{-}5)\times10^{13}$ n/см^{2}s

Power dissipated by the target - 2.5 – 3 кW.

Ion Penning traps at one of the mass-separator beams allows to measure masses of nuclei far from stability with the precision of several кeV



The yields of neutron-rich nuclei at the collectot of the mass-separator of IRIN facility



Target-ion source with the ion optical system in the horizontal channel GEC-6-6' of the PIK reactor

The time table of the poject IRIN works

2010-2015г.г.
Development and tests of U-238 target devices at IRIS facility at the beam of PNPI synchrocyclotron

2015-2016
Construction and tests of the prototype of the ion-optical system of the IRIN mass-separator.

2015-2018
Detailed elaboration of the project, facility construction

2019
Trial start of the facility

Summary

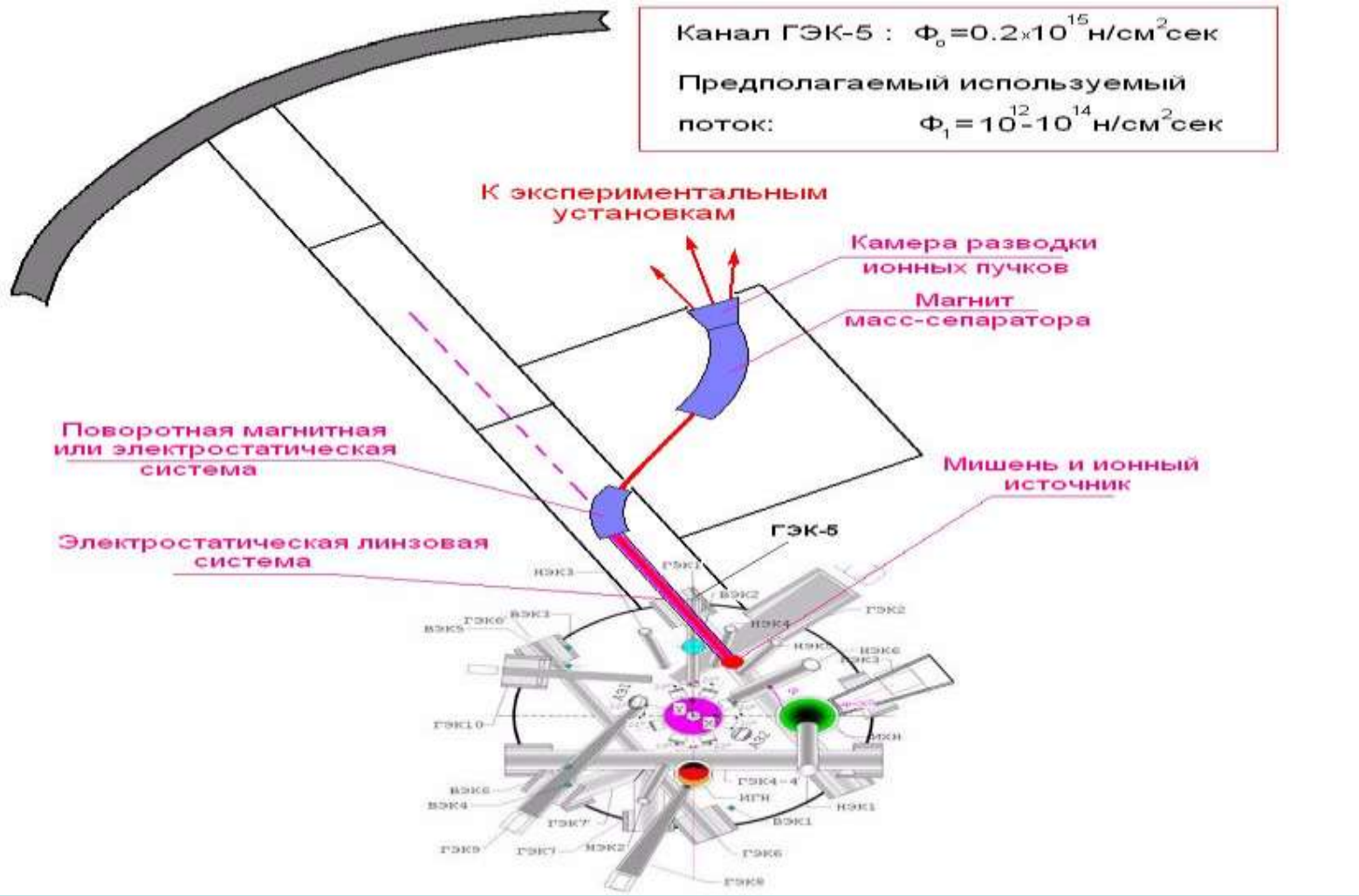
ISOL facility IRIN at the PIK reactor with the neutron flux on the target up to 5×10^{13} n/cm^{2}s will allow to obtain the highest yields of neutron-rich nuclei. It gives the possibility considerably expand the region of investigated nuclei, especially to reach almost not studied isotope region with a big excess of neutrons that is very important for astrophysics (r-process)

The use of Penning traps (ISOLTRAP type) allows to measure the masses of a large amount of nuclei far from stability with a very high precision (several keV).

Making use of a high sensitive and high selective method of resonant laser-ionization spectroscopy give the possibility to measure charge radii and electromagnetic moments of nuclei in the most interesting for nuclear physics regions, surrounding double magic nuclei ^{132}Sn and regions of nuclei with the magic amount of neutrons N= 50 (neutron-rich isotopes of Ge, Ga, Zn, Cu и Ni).

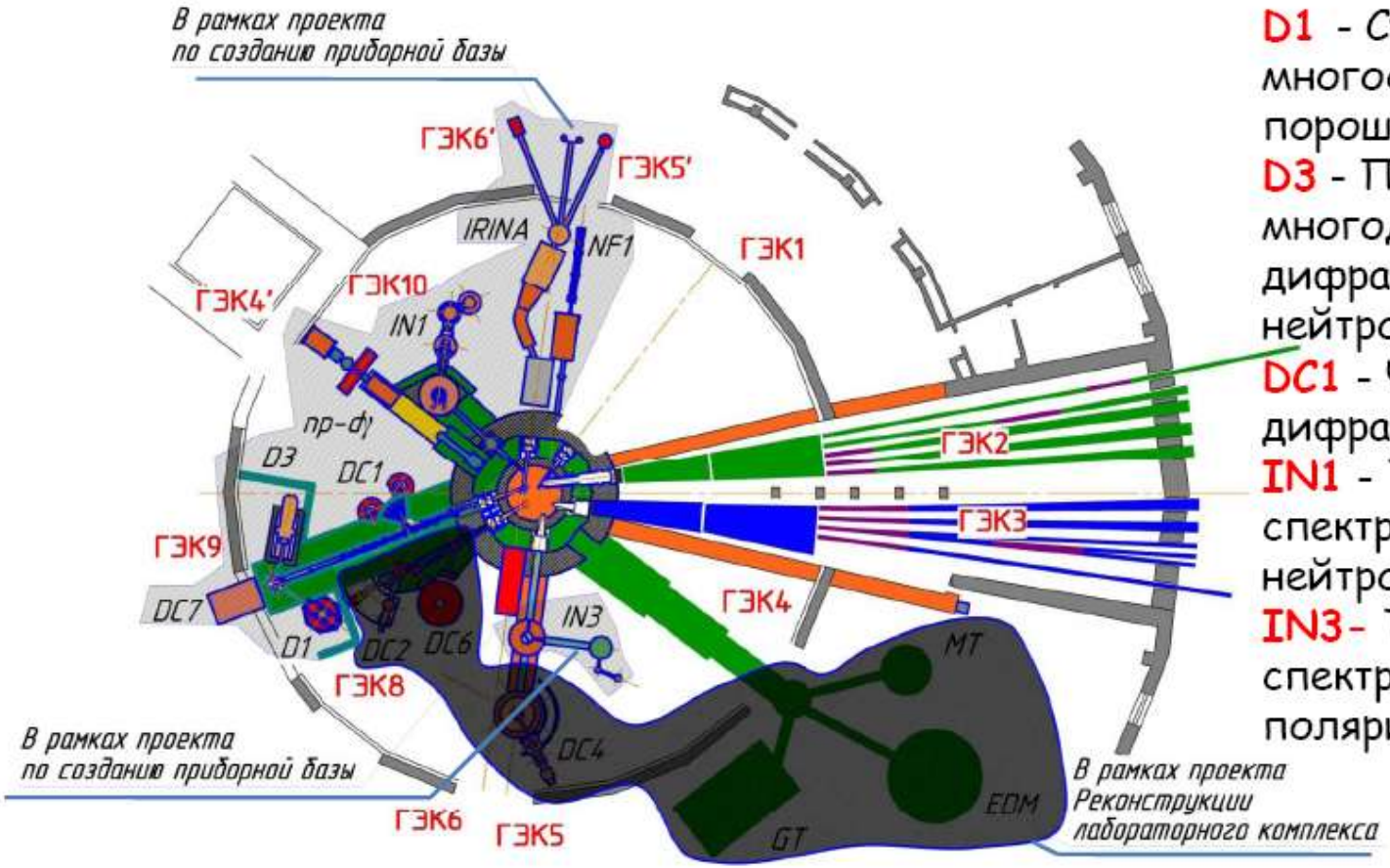
Additionally, at the IRIN facility there are planned for production of a high purity radionuclides for medicine.

The arrangement scheme of IRIN facility at one of the channel of the PIK reactor



Создание приборной базы реакторного комплекса ПИК

Зал горизонтальных каналов (8шт.)



D1 - Суперпозиционный многосекционный порошковый дифрактометр

D3 - Порошковый многодетекторный дифрактометр тепловых нейтронов

DC1 - Четырехкружный дифрактометр

IN1 - Трехосный спектрометр тепловых нейтронов

IN3 - Трехосный спектрометр поляризованных нейтронов

- **np-dγ** -Установка «Бета-распад нейтрона»
- **IRINA** - Масс-сепараторный лазерно-ядерный комплекс ИРИНА
- **n4** - Установка «Нейтрино» (расположена в подреакторном пространстве)

Из доклада директора ОНИ В.В. Воронина на Уч. Сов. ПИЯФ