Plans of FLNR in the field of heavy ion physics for 2003-2009 (guidelines)

M.G. Itkis

We propose to keep three traditional directions in heavy-ion physics investigations in FLNR:

- **Synthesis of new nuclei and study of nuclear properties and heavy ion reaction mechanisms using ion beams of stable and radioactive isotopes;**
- **Development of the FLNR U400+U400M cyclotrons + MT25 microtron Complex for producing intensive beams of accelerated ions of stable and radioactive Isotopes (DRIBs project);**
- **Radiation effects and modification of materials, radioanalytical and radioisotopic investigations with heavy ions, applied research.**

Search for Z = 118

Reaction: $^{48}Ca + ^{249}Cf$

$E_x^{min} = 26.6$ MeV

EVR: $^{294}118$ (N =176) via 3n- channel

Expected
cross section: $\sigma_{3n}^{max} \sim 0.5$ pb *(at E_x= 30 MeV)*

$\sigma_{4n}^{max} < 0.1$ pb *(at E_x= 40 Mev)*

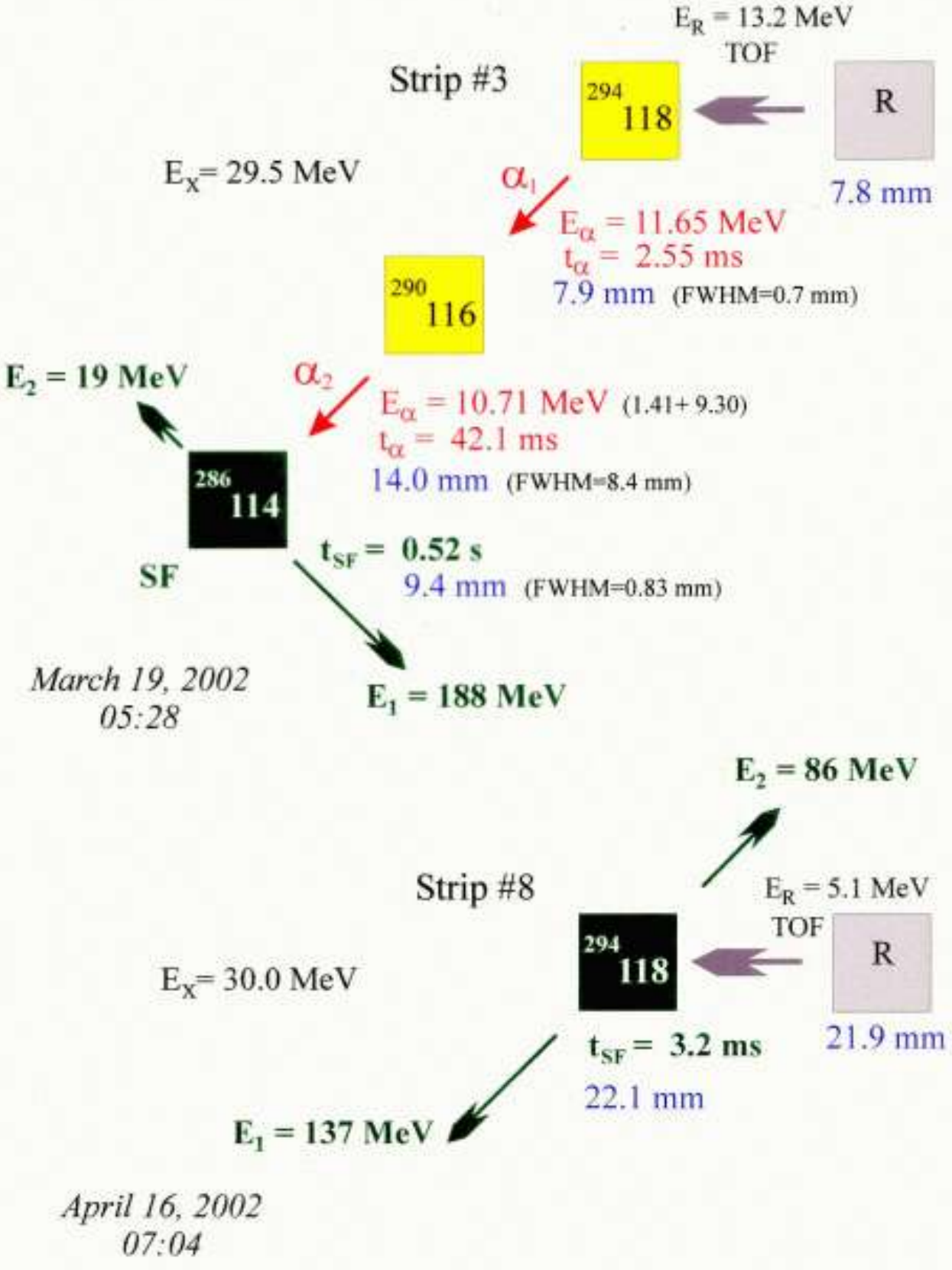
Target: ^{249}Cf (97.3%) 230 μg/cm^2)
total: 7.1 mg (2.10^9 α/s)

Beam: ^{48}Ca $E_L = 5.1$ MeV/n *(E_x= 29 MeV)*
i = 0.8 pμA

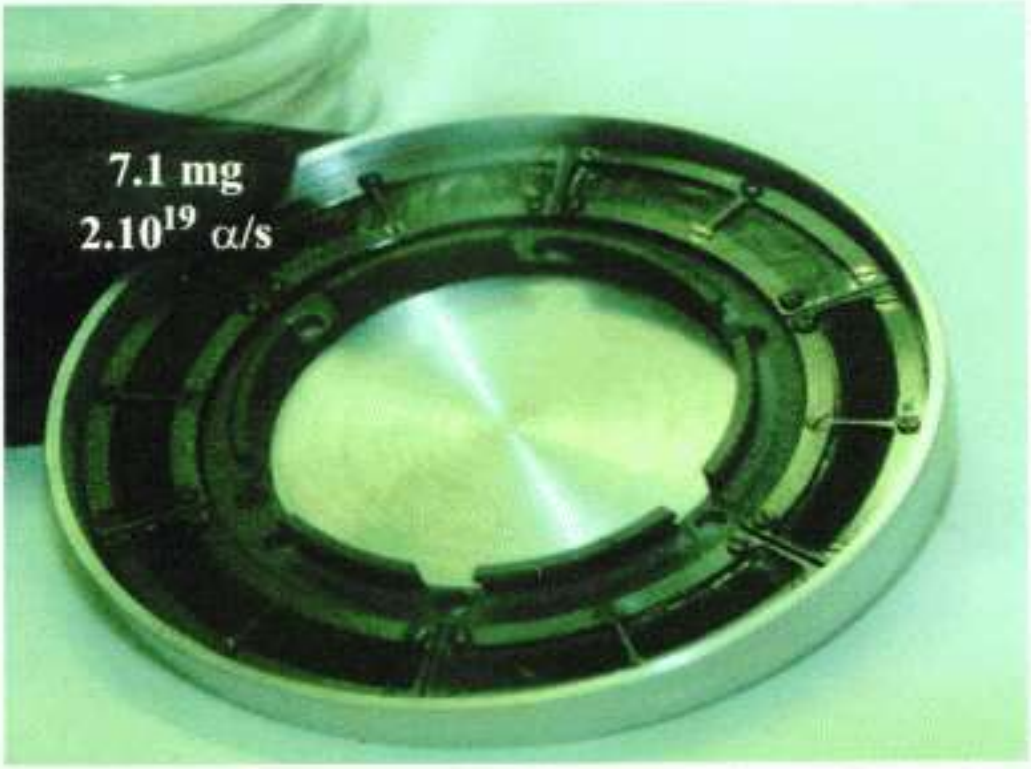
Beam dose: $\sim 2.10^{19}$

Beam time: 75 days

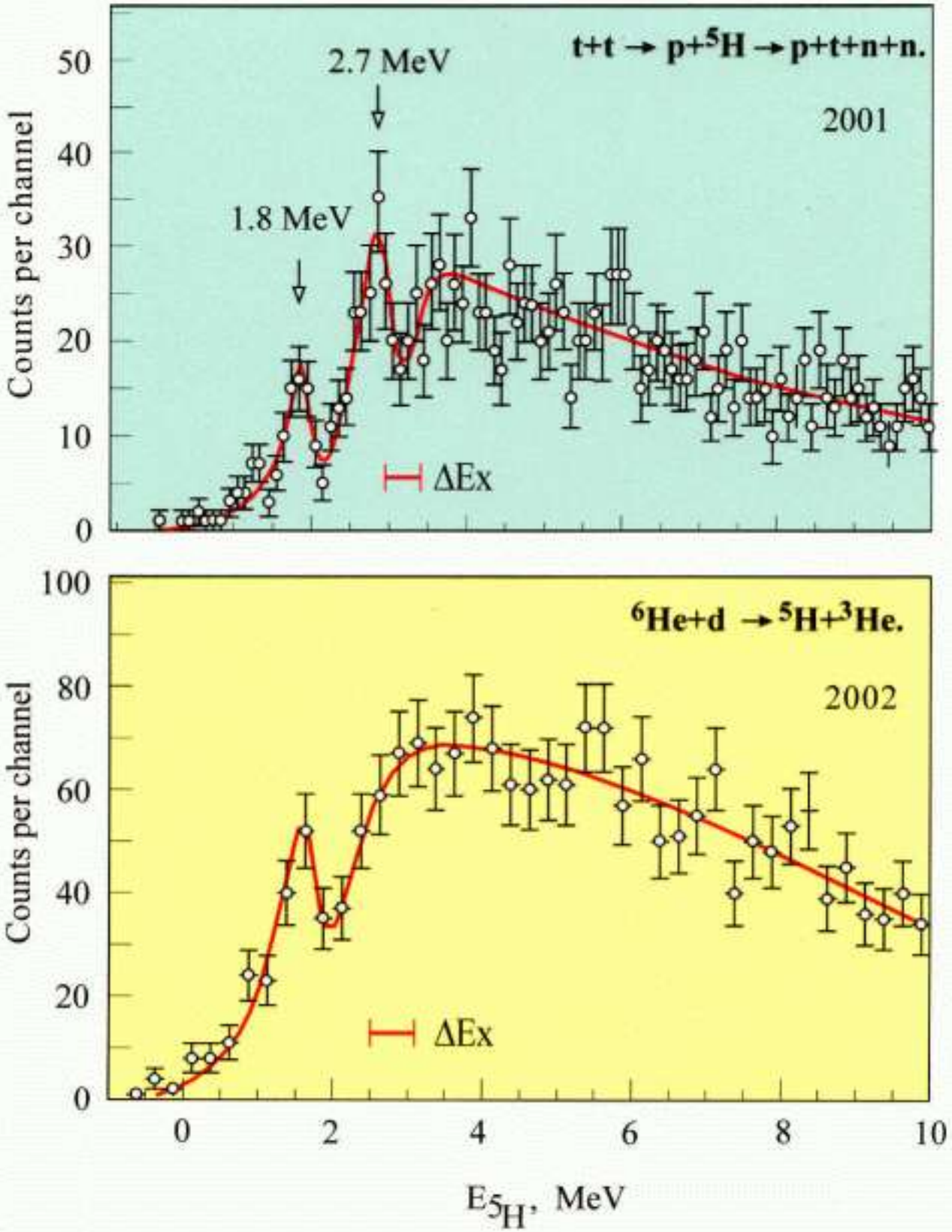
Decay sequences obtained in the $^{48}Ca + ^{249}Cf$ reaction



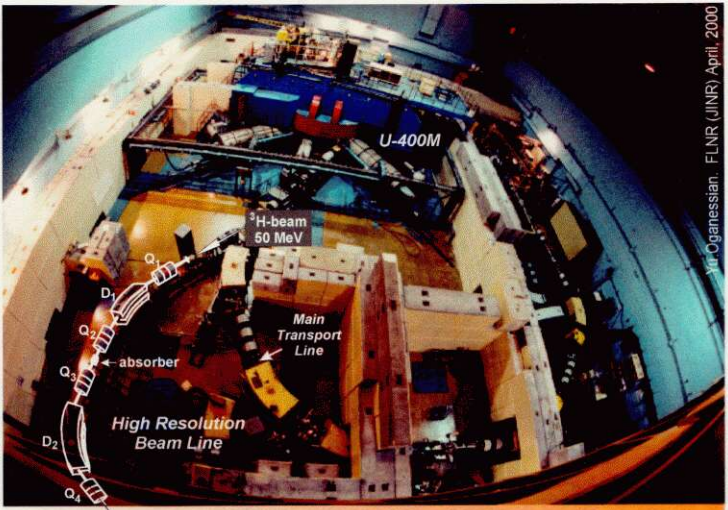
^{249}Cf - target

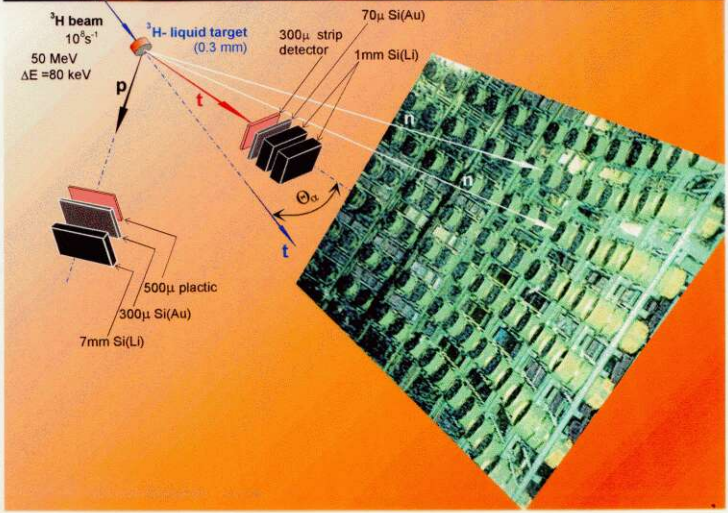


Exotic nucleus ^{5}H



Experiment on $^3H + ^3H \longrightarrow p + t + n + n$





HEAVY-ION PHYSICS
(2003-2009)

A promising programme for heavy ion physics is associated both with research on the most fundamental problems of **modern nuclear physics such as the stability of super-heavy nuclei and the boundaries of the existence of elements in nature, the structure and properties of the lightest elements close to and beyond neutron and proton drip-lines, the interaction mechanism for composite nuclei and with advancements in applied research in the field of** the physics of condensed matter, acceleration technologies, creating new materials etc.

At present FLNR is in the front line of those researches. These achievements are difficult to gain because the basic heavy ion accelerators and experimental set-ups **have practically exhausted their reserves and experiments are carried out at the limit of their capabilities. Based upon this, the main strategic aim for the immediate 7 years is to keep the lead of JINR in heavy ion physics and ensure carrying out research at world level during the ensuing 20-25 years.**

DRIBs - Dubna Radioactive Ion BeamS

U400 Accelerator

Vertical Section

DRIBs-I Units in Gallery

DRIBs-I in U400M Hall

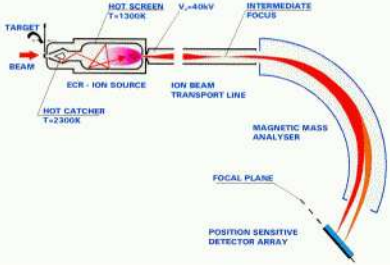
DRIBs-I above U400

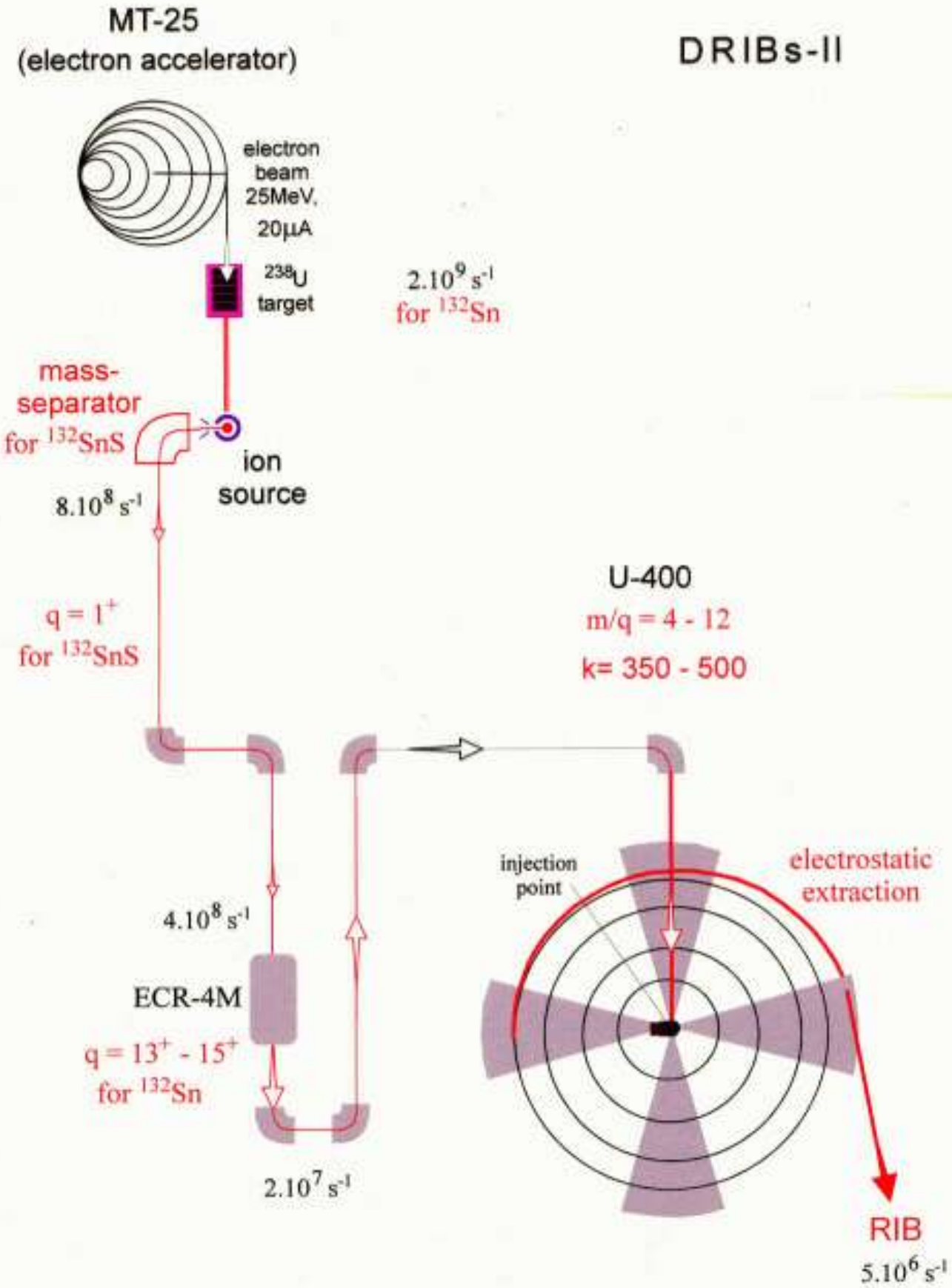
DRIBs-I Start Section

Microtron MT-25

U400M Accelerator

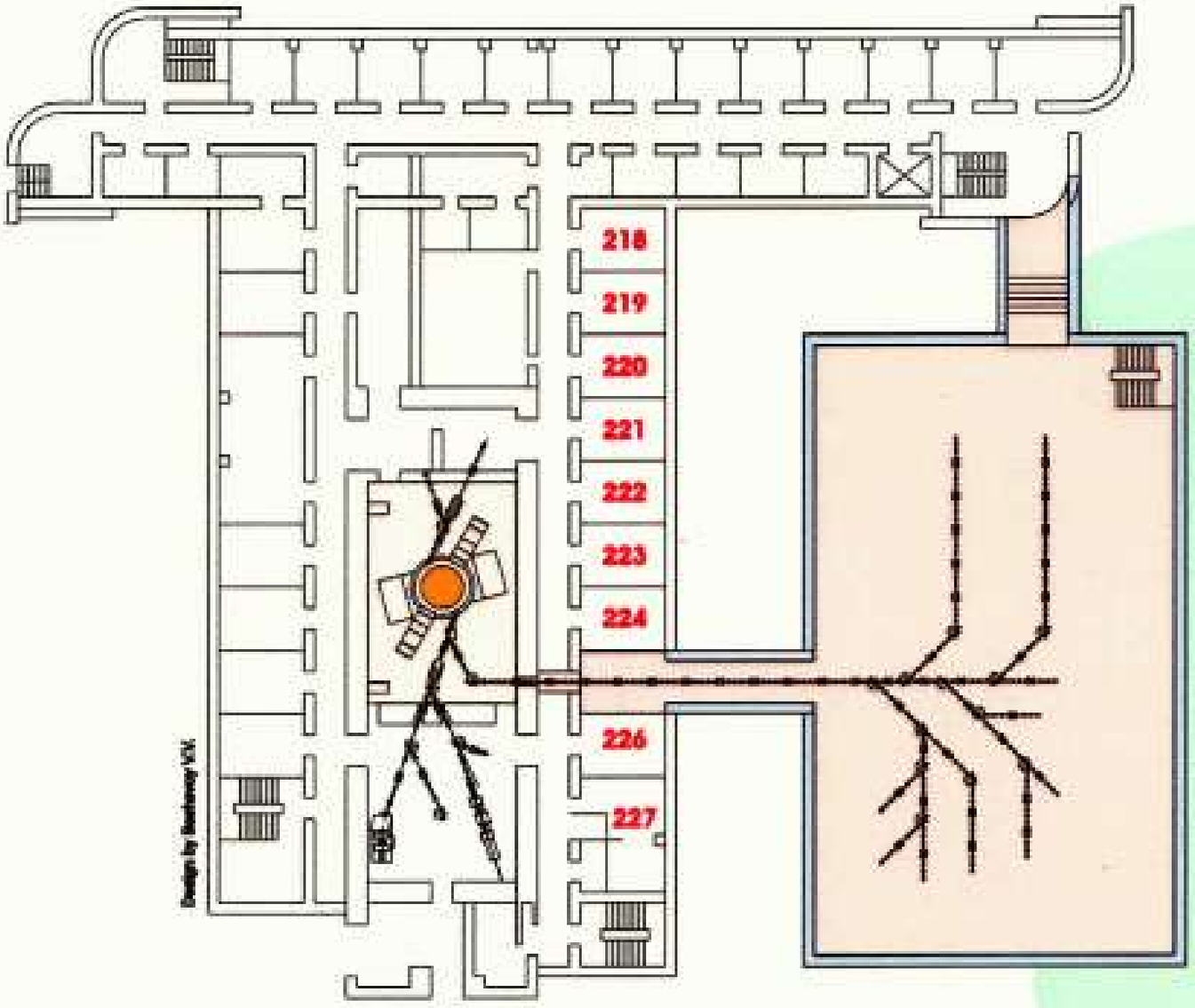
MASHA - Mass Analyser of Super Heavy Atoms




MT-25
(electron accelerator)
DRIBs-II
electron
beam
25MeV,
20μA
^{238}U
target
2.10^9 s^{-1}
for ^{132}Sn
mass-
separator
for ^{132}SnS
ion
source
8.10^8 s^{-1}
q = 1$^+$
for ^{132}SnS
U-400
m/q = 4 - 12
k= 350 - 500
injection
point
electrostatic
extraction
4.10^8 s^{-1}
ECR-4M
q = 13$^+$ - 15$^+$
for ^{132}Sn
2.10^7 s^{-1}
RIB
5.10^6 s^{-1}

The new U400 experimental hall S=2000 m^2

Building №131



To achieve this aim, it is necessary:

1. **To complete the DRIBs and MASHA projects in full measure.**

2. To modernise the **U-400 accelerator**.
   - To increase the intensity of beams of **stable and radioactive nuclei by a factor of 10 (up to 10^{14} p/s) and improve the** utilisation efficiency for working substances of rare isotopes by a factor of 10;
   - make the energy range of accelerated ions wider, providing smooth **adjustment from 0.8 MeV/n to 25 MeV/n at a beam energy resolution of less than or equal to $\Delta E/E \approx 10^{-3}$;**
   - decrease the power consumption by a **factor of 4 (from 1 MW/h to 0.25 MW/g).**

3. **To build a new experimental hall of area 2500 m^2 for working with beams of radioactive and stable nuclei. To** accommodate JINR's new experimental set-ups, including expensive set-ups from other science centres.

4. **To modernise the U-400M accelerator. To create a new ECR source operating at a frequency of 18 GHz.**
5. **To create a cyclotron EC-100 – DC-60 complex for research on** solid state physics (metals, alloys, polymers) for the purpose of expanding fundamental research on the interaction of **heavy ions of 0.02-2 MeV/n energies with solids. To create** novel technologies for producing materials for micro and nanoelectronics, medicine and biotechnology.
6. **To essentially increase the quota of young scientists and** specialists from the JINR **member states (up to 30%).**

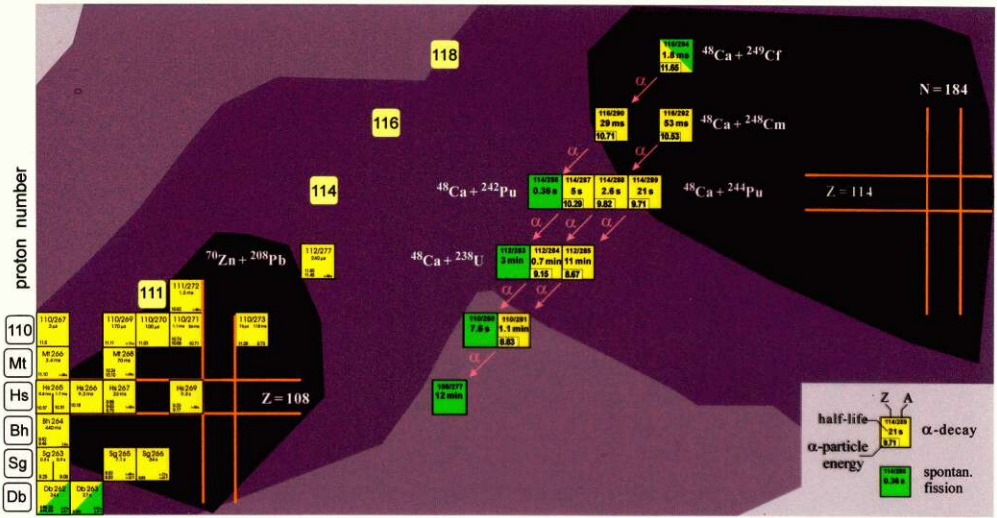
The implementation of items 1-3 will allow a qualitatively new level of research to be **reached in 2006 already.**

a) In the region of super-heavy elements, new capabilities will enable carrying out experiments characterised by cross **sections of 0.1 pb, determining the mass of** a super-heavy nucleus with an accuracy of **0.3 amu, studying the chemical properties of super-heavy elements.**

b) Record intensities of ^{6}He and ^{8}He beams will enable producing and studying the structural properties of light super-neutron-rich nuclei such as ^{5}H, ^{7}H, ^{8}H, ^{8}He, ^{10}He etc.

c) Accelerated beams of double-magic nuclei of ^{132}Sn open up new possibilities for studying the fusion-fission of composite nuclei and for using those processes in the problem of the synthesis of super-heavy nuclei in the immediate vicinity of the peak of the island of stability **(N=184).**

CHART OF THE NUCLIDES



Yu.Oganessian FLNR (JINR) Apr., 2002

TRACK-ETCH TECHNOLOGY

TRACK-ETCH + ELECTROPLATING TECHNOLOGY

II. MICRO- AND NANOSTRUCTURED SURFACES


MODIFIED SURFACES

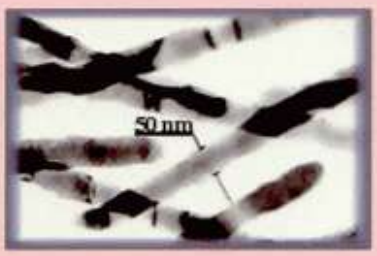
METALLIC NEEDLES


ALUMINUM FRACTAL STRUCTURES


ARRAYS OF NANOWIRES


COPPER MICROTUBES

PROFILES OF COPPER NANOWIRES




FLEROV LABORATORY OF NUCLEAR REACTIONS
JOINT INSTITUTE FOR NUCLEAR RESEARCH

NEW ACCELERATORS FOR NUCLEAR MEDICINE AND HIGH TECHNOLOGIES

➢ Cyclotron DC-72 (72 MeV protons, heavy ions)

Cyclotron Center of Slovak Republic (CCSR), Bratislava, 2001-2006

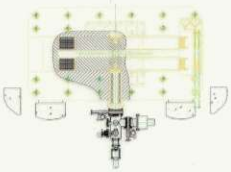
Model of the DC-72 magnet

- production of radioisotopes for nuclear medicine
- beam therapies (proton therapy of the eye, therapy by fast neutrons)
- new technologies with the use of heavy ion beams (new composite materials, modification of material properties for micro-electronics, track membranes)
- basic scientific research

➢ Cyclotron DC-60 (heavy ions with E=0.2-1.5 MeV/A)

Interdisciplinary Cyclotron Center (ICC), Astana, Kazakhstan, 2002-2004

- semi-industrial, technological facilities for micro- and nanoelectronics, biotechnologies and medicine
- technological use of heavy ions for the modification of properties of known materials and creation of new ones with set properties
- basic and applied research in laboratories of atomic physics and new materials

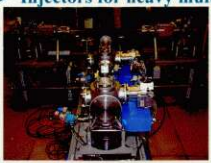


➢ Cyclotron IC-100 (heavy ions with E=0.02-1.2 MeV/A)

FLNR JINR, Dubna (Russia) – Saxony (Germany), 2001-2003

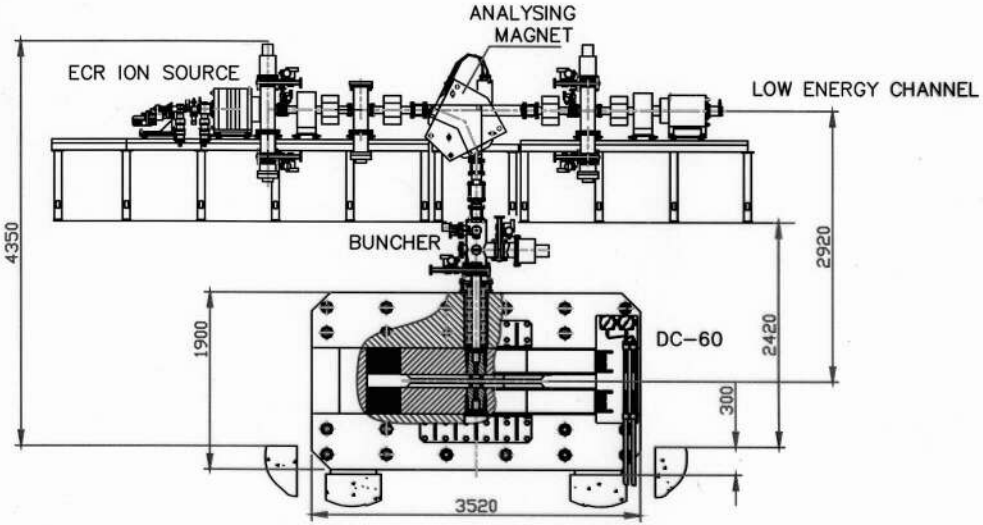
- production of track membranes with set properties
- treatment of surfaces
- research in the field of solid state physics, research of materials and new technologies for industry

➢ Injectors for heavy multi-charged ions (ECR-sources)



- CCSR (Bratislava) – 2001
- ICC (Astana) – 2002-2003

AXIAL INJECTION SYSTEM of DC−60 CYCLOTRON



Plans of FLNR for 2003-2009

(under discussion)

New experimental set-ups:

1. MASHA
2. CORSET+DEMON
3. ISTRA+DEMON
4. GNS-II
5. MSP-144
6. VASSILISSA-II
7. Radiochemical laboratory
8. Low energy RIB laboratory
9. Condensed matter physics laboratory

Plans of FLNR 2003-2009

Infrastructure

1. Refurbishment of the buildings
2. Construction of the new U400 experimental hall
3. Reconstruction of the radiochemical laboratory
4. Construction of the low energy RIB-laboratory building
5. Reconstruction of the computer net of the FLNR

Financing

1. Basic facilities - 15 M$
2. Experimental set-ups - 2,5 M$
3. Infrastructure - 4 M$