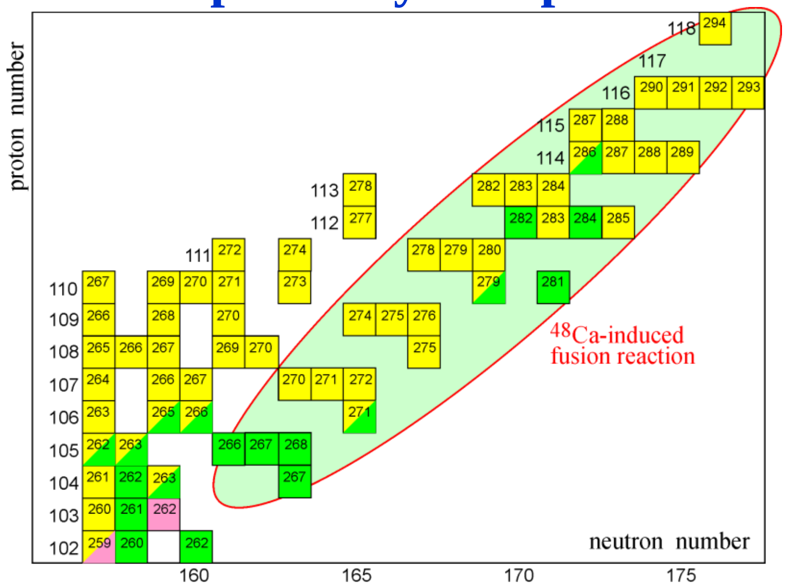
JINR SCIENTIFIC COUNCIL
108th Session, 23-24 September 2010, Dubna

STATUS
of MAJOR BASIC FACILITY PROJECTS of the SEVEN-YEAR:
DRIBs – III PROJECT

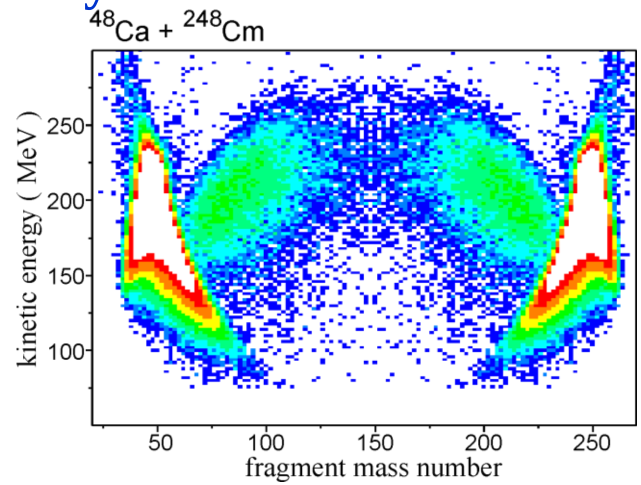
S.N. DMITRIEV
Flerov Laboratory of Nuclear Reactions,
Joint Institute for Nuclear Research

MAIN RESULTS in STUDY of SUPERHEAVY NUCLEI

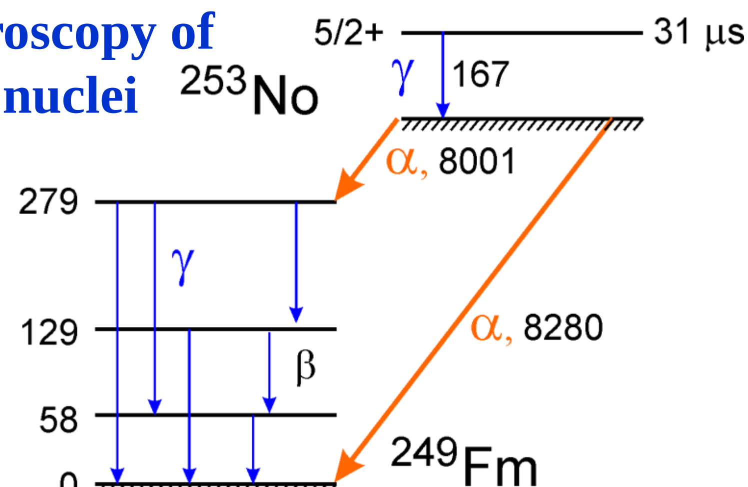
Synthesis of 5 new elements and 34 new superheavy isotopes



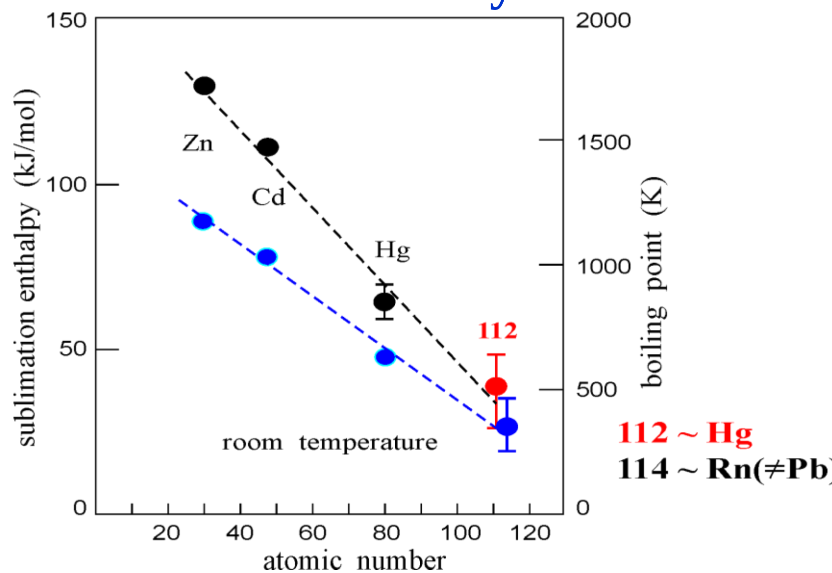
Limiting role of quasi-fission in synthesis of SH nuclei



Spectroscopy of heavy nuclei

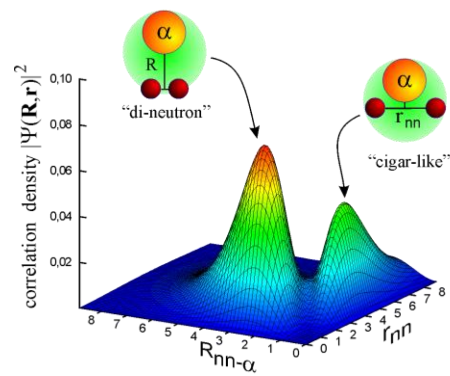


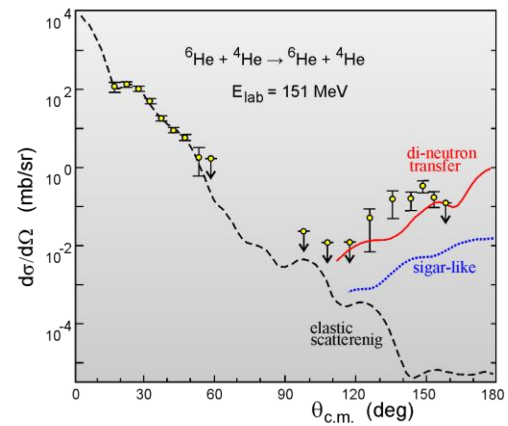
Relativistic chemistry of SHE

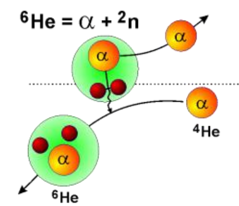


MAIN RESULTS in STUDY of EXOTIC NUCLEI

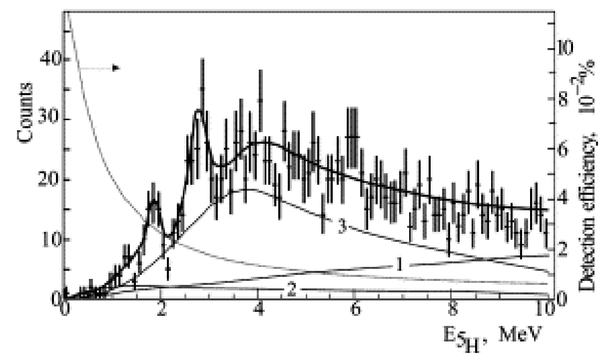
Discovery of di-neutron inside ^{6}He





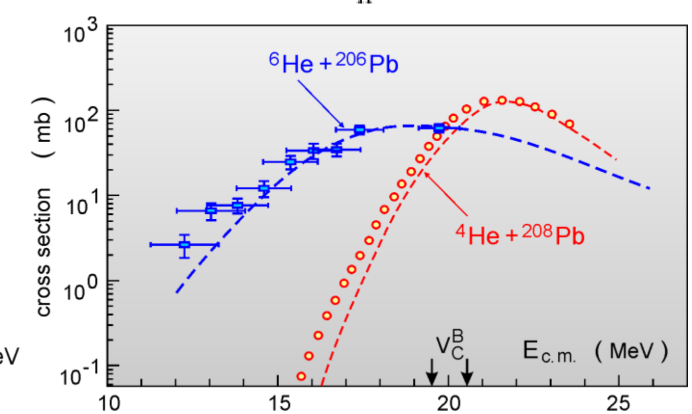


Observation of energy structure of neutron-rich exotic nuclei ^{5}H, ^{7}H, ^{10}He



Observation of sub-barrier fusion enhancement of ^{6}He

$$\left.\frac{\sigma(^6\mathrm{He} + ^{206}\mathrm{Pb} \to ^{212}\mathrm{Po})}{\sigma(^4\mathrm{He} + ^{208}\mathrm{Pb} \to ^{212}\mathrm{Po})}\right|_{E_{c.m.} = 15\ \mathrm{MeV}} = 1000\ !$$



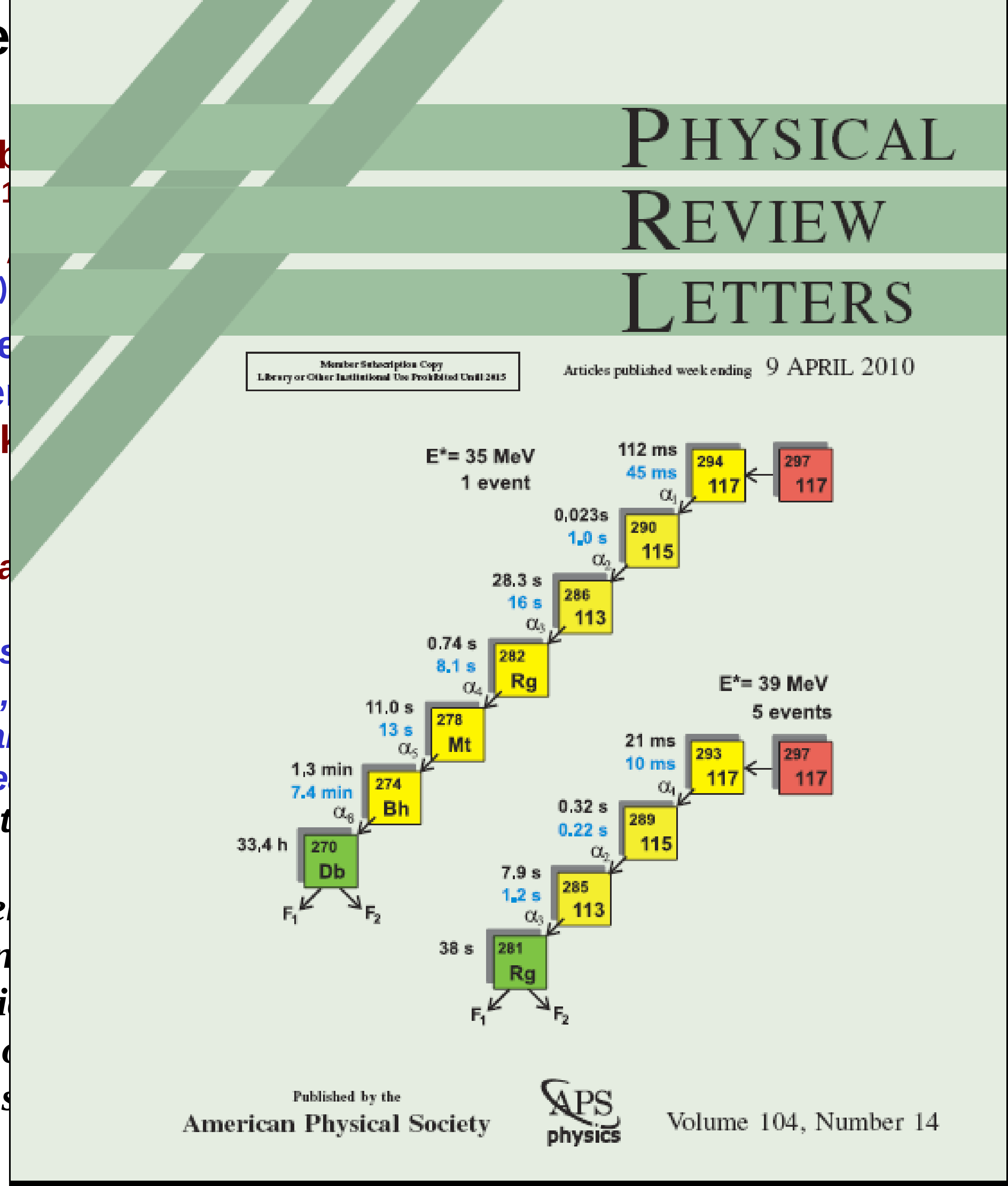
Synthesis of a new ele

Yu. Ts. Oganessian,[1)] F. Sh. Ab
M. E. Bennett,[3)] S N. Dmitriev,[1
M. G. Itkis,[1)] Yu. V. Lobanov,[1)]
A.N. Polyakov,[1)] C. E. Porter,[2)]
M. A. Ryabinin,[6)] K. P. Rykacze
I.V. Shirokovsky,[1)] M. A. Stoye
Yu. S. Tsyganov,[1)] V. K. Utyonk
and P. A. Wilk[5)]

1 Joint Institute for Nuclear Resea
2 Oak Ridge National Laboratory,
3 University of Nevada Las Vegas
4 Vanderbilt University, Nashville,
5 Lawrence Livemore National La
6 Research Institute of Atomic Re

(Dat

The discovery of a new chemical e
^{293}117 and ^{294}117 were produced in
involving eleven new nuclei were i
The measured decay properties sho
validating the concept of the long s



Isotope	Decay mode	Half-life[a]	E_α (MeV)	Q_α (MeV)
$^{293}117$	α	14^{+11}_{-4} ms	11.03± 0.08	11.18± 0.08
$^{289}115$	α	220^{+260}_{-80} ms	10.31± 0.09	10.45± 0.09
$^{285}113$	α	$5.5^{+5.0}_{-3.7}$ s	9.74± 0.08 9.48± 0.11	9.88± 0.08
^{281}Rg	SF	26^{+25}_{-8} s	-	<9.4

Isotope	Decay mode	Half-life[a]	E_α (MeV)	Q_α (MeV)
$^{294}117$	α	78^{+370}_{-36} ms	10.81± 0.10	10.96± 0.10
$^{290}115$	α	16^{+75}_{-8} ms	9.95± 0.40	10.09± 0.40
$^{286}113$	α	20^{+94}_{-9} s	9.63± 0.10	9.76± 0.10
^{282}Rg	α	$0.51^{+2.5}_{-0.23}$ s	9.00± 0.10	9.13± 0.10
^{278}Mt	α	$7.7^{+37.}_{-3.5}$ s	9.55± 0.19	9.69± 0.19
^{274}Bh	α	53^{+250}_{-24} s	8.80± 0.08	8.93± 0.08
^{270}Db	SF/α/EC	23^{+110}_{-10} h	-	<7.9

Decay properties of the nuclei in the decay chains of Z=117 isotopes

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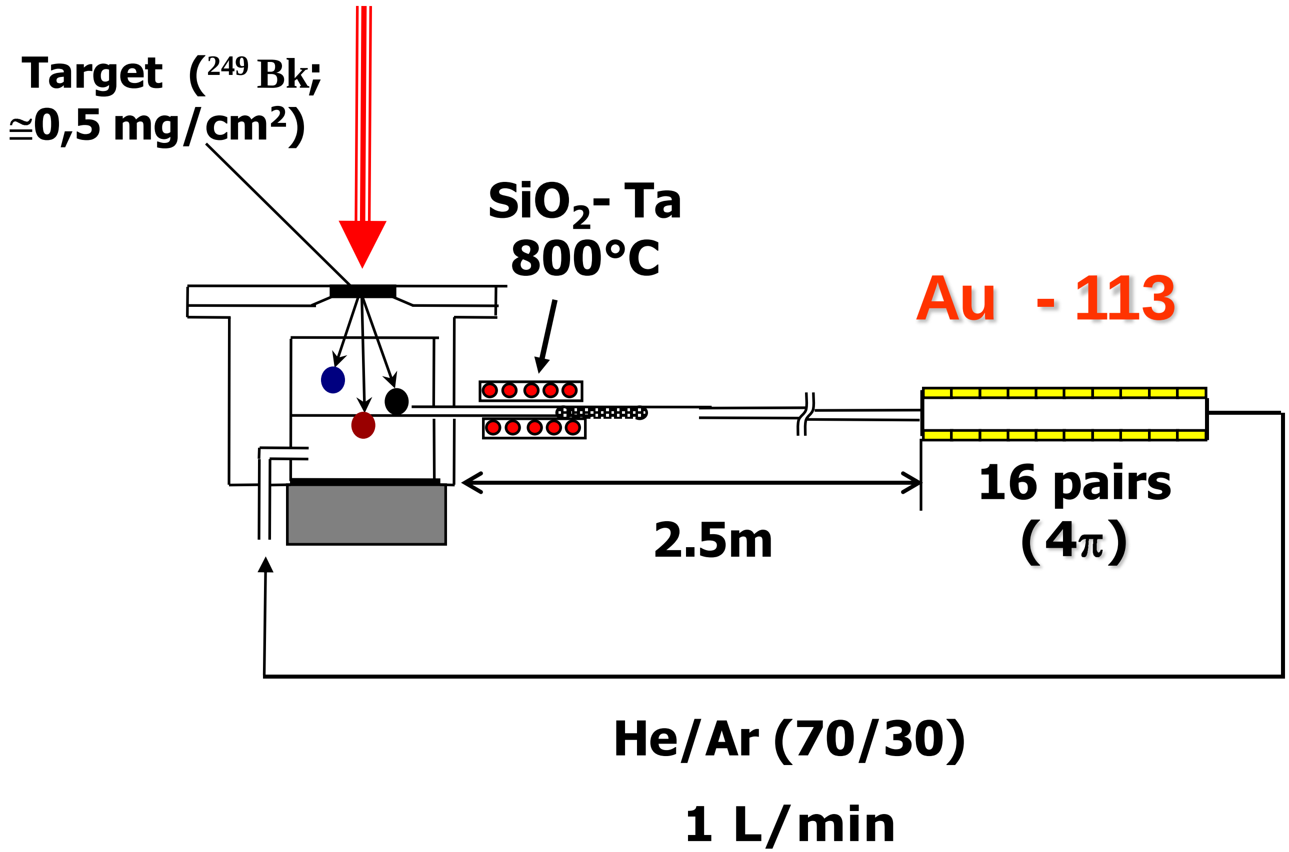
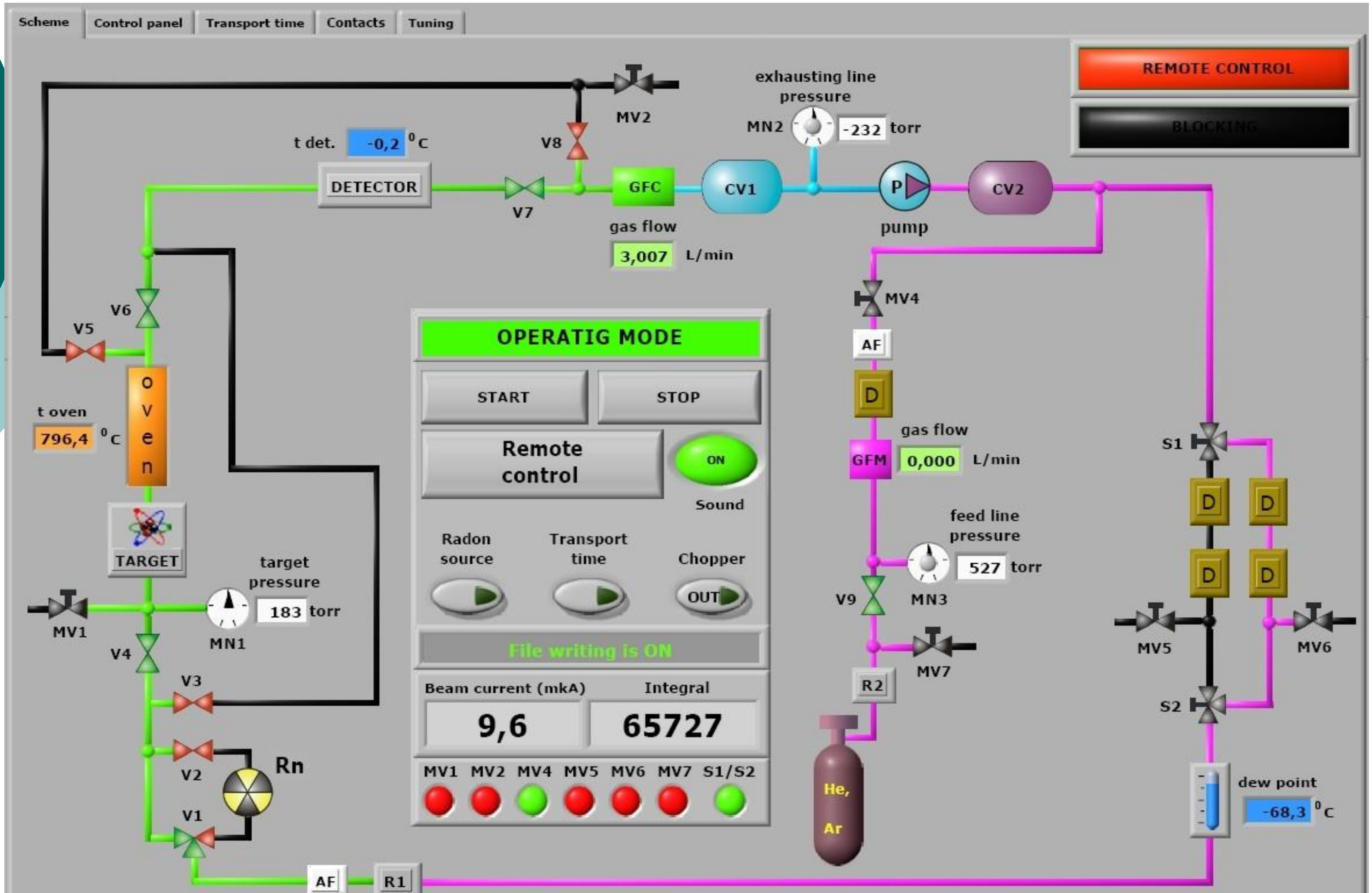
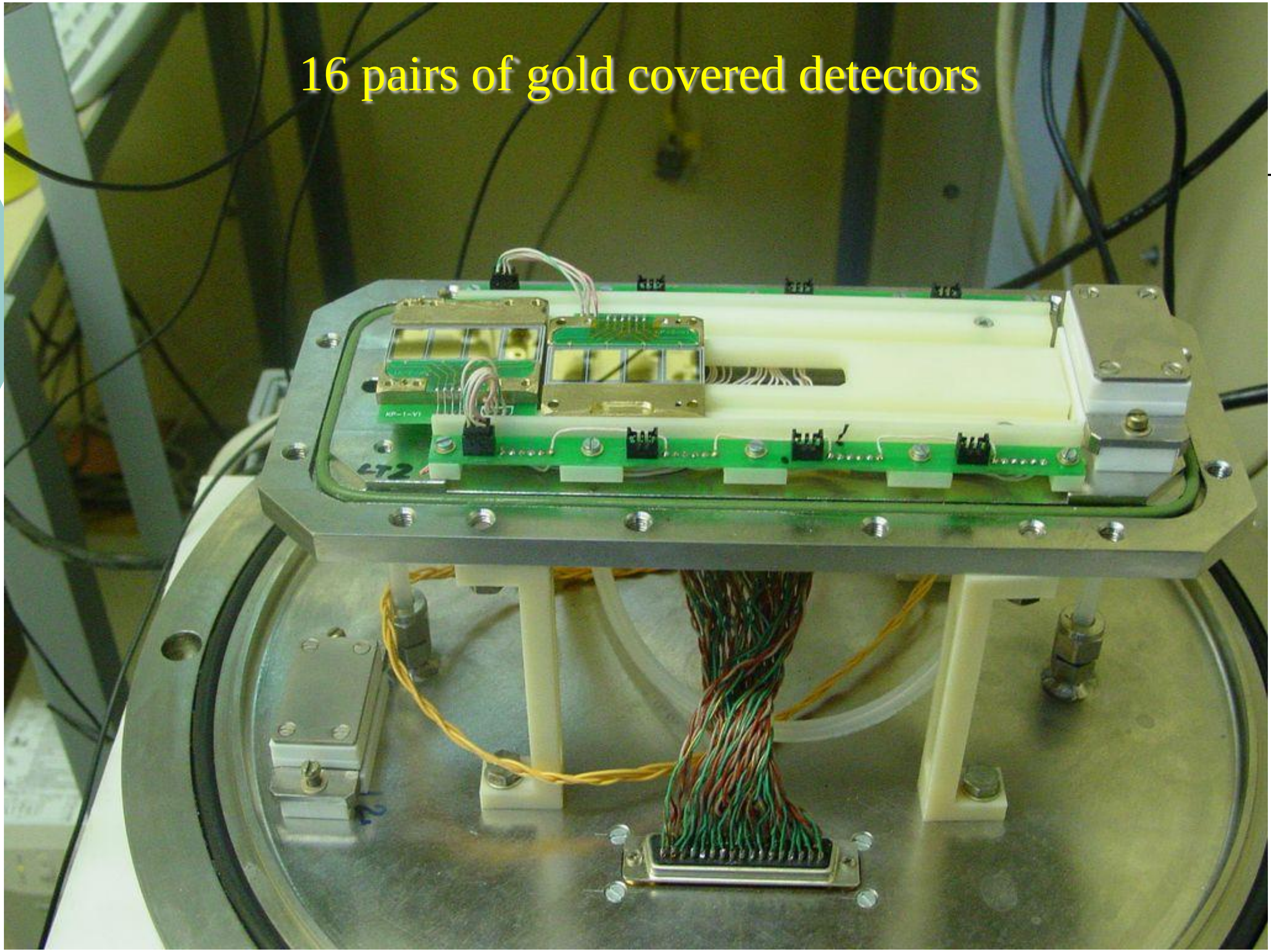
Yu. Oganessian 2010

CHEMISTRY OF THE 113 ELEMENT





Capillary length from target chamber to detector system is 2.5 m


16 pairs of gold covered detectors
LT2

$^{48}Ca + ^{249}Bk$

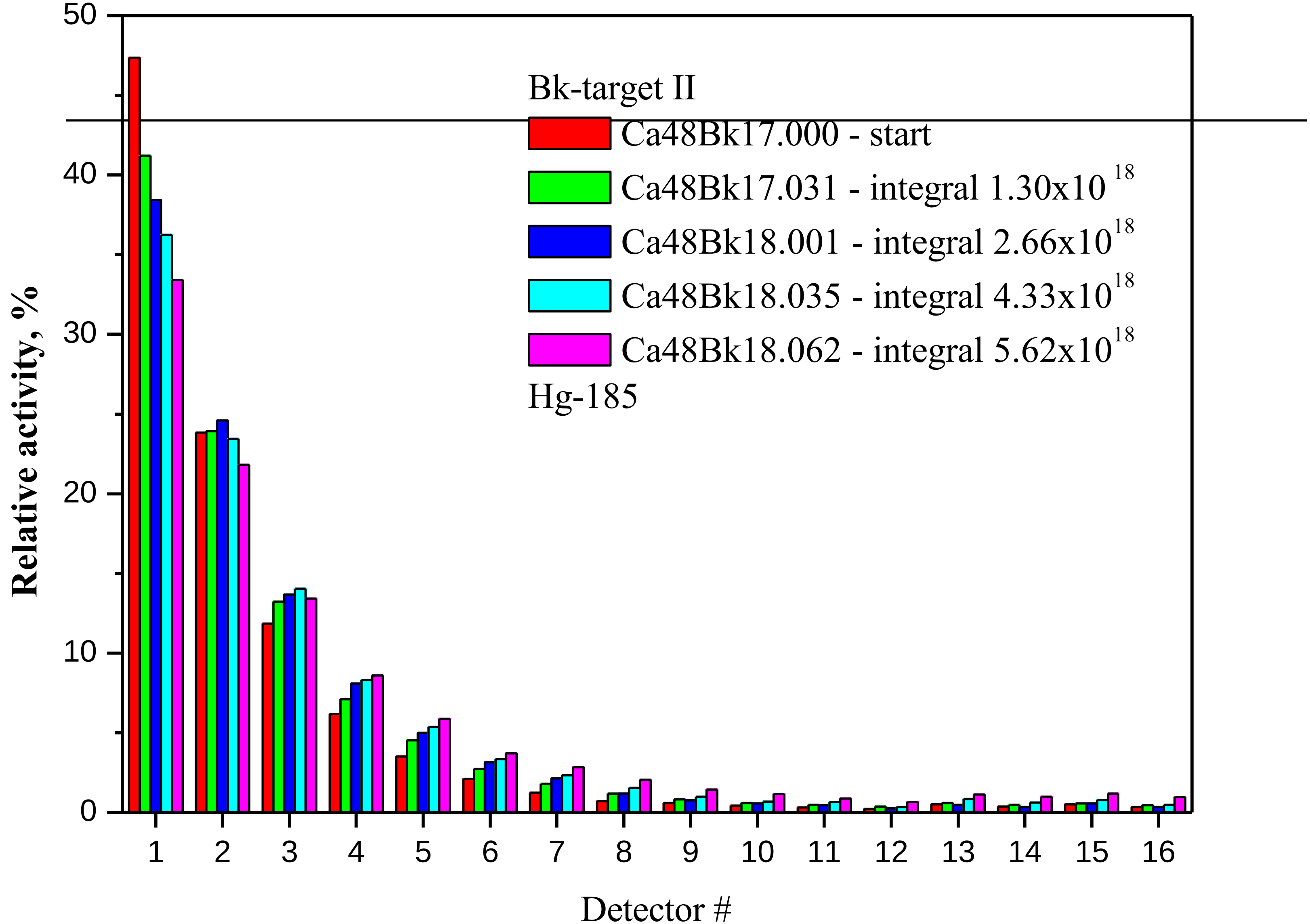
Target	**^{249}Bk (0.5 mg·cm^{-2})** **^{nat}Nd (30 µg·cm^{-2})**
^{48}Ca	**$E_{mid.\ target}$ = 252 MeV** **I ~ 9 eµA**

Irradiation: - 18.04.2010 – 31.05.2010;

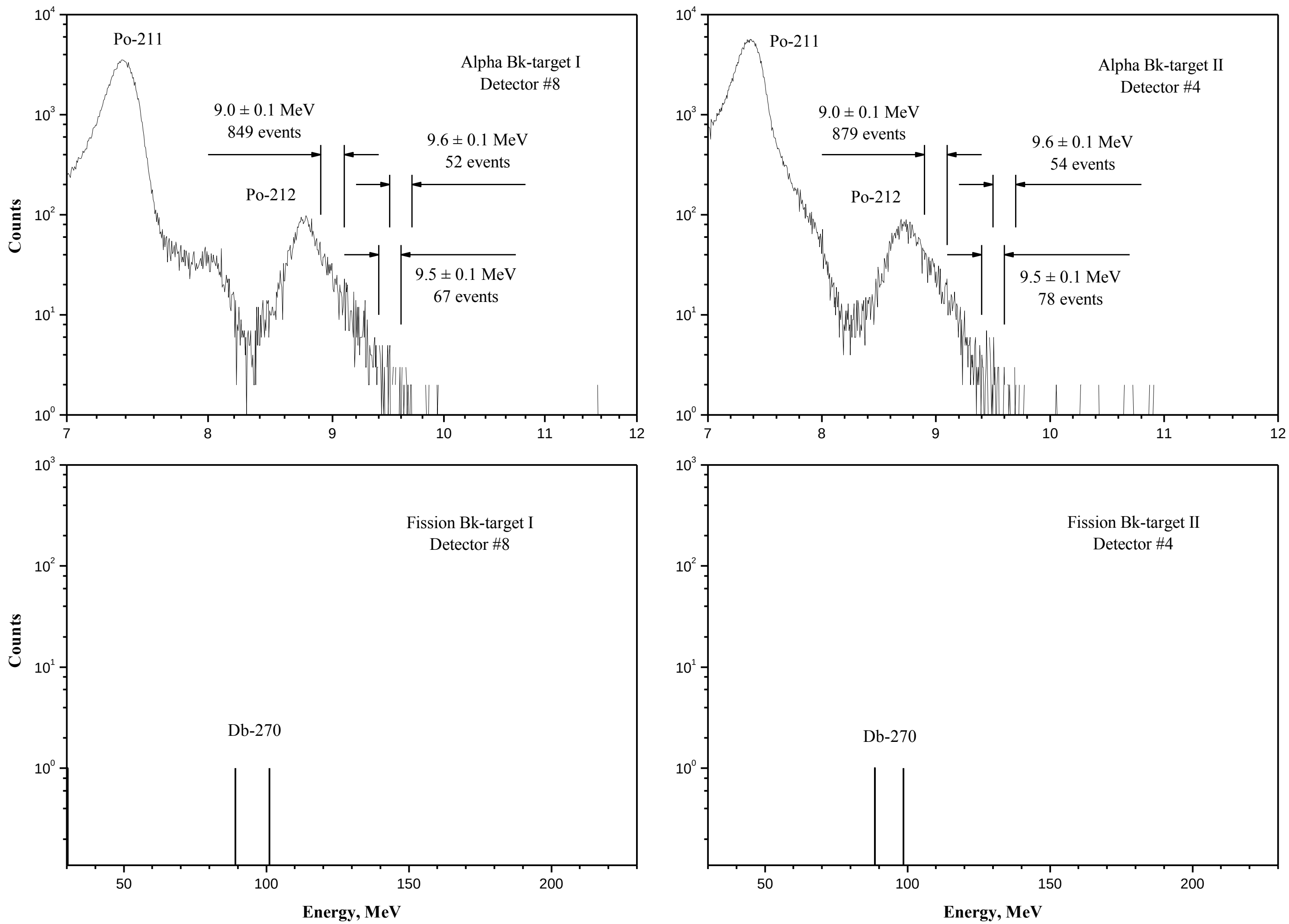
target I - 3.5 10^{18} ; **target II - 5.6 10^{18}**

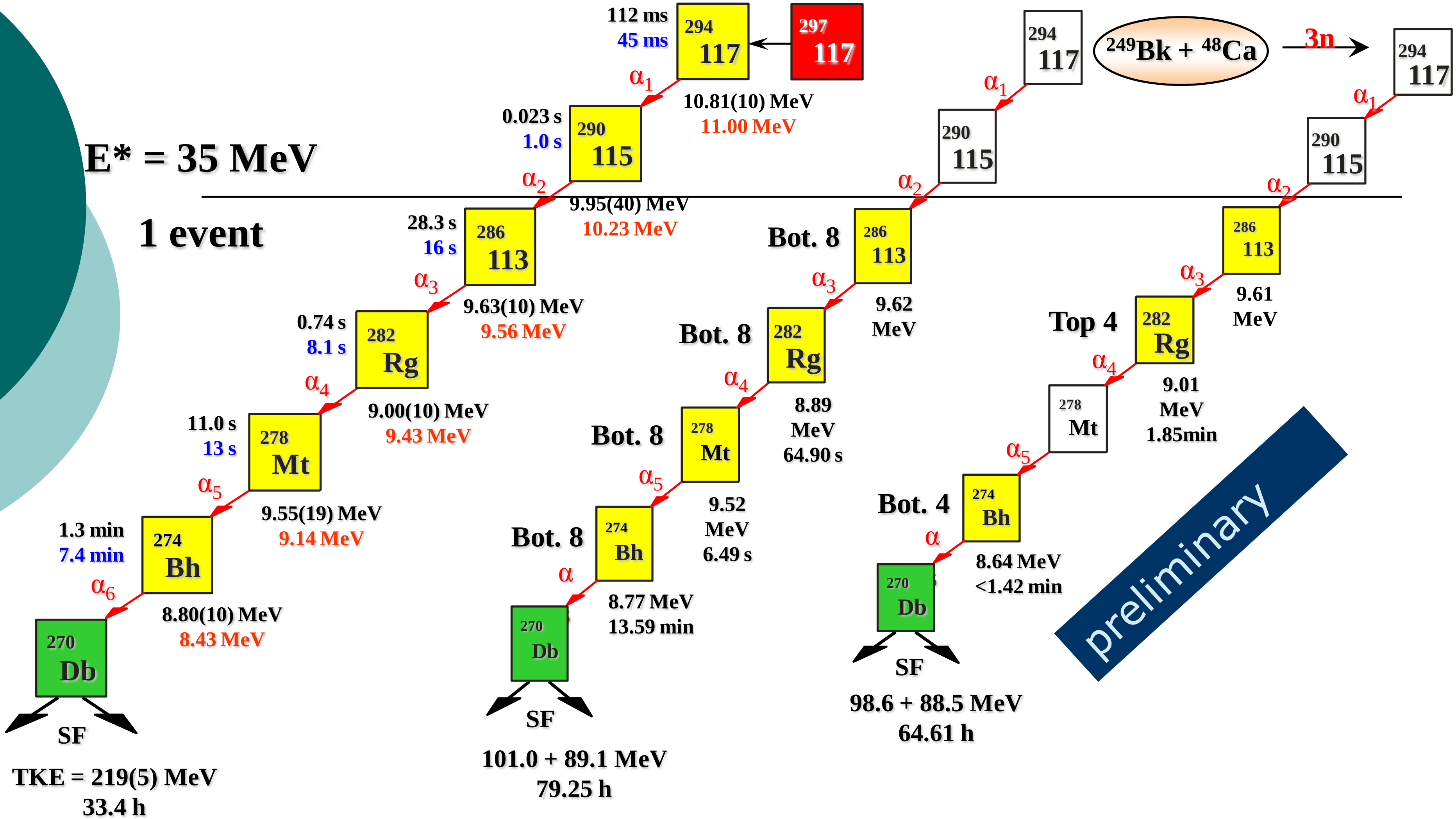
$\Sigma = 9.1 \cdot 10^{18}$

Hg-185 DISTRIBUTION



Alpha and SF spectra (1000 hr)





DGFRS

04 May 2010 10:05:46
Bk-target I

16 May 2010 02:29:54
Bk-target II

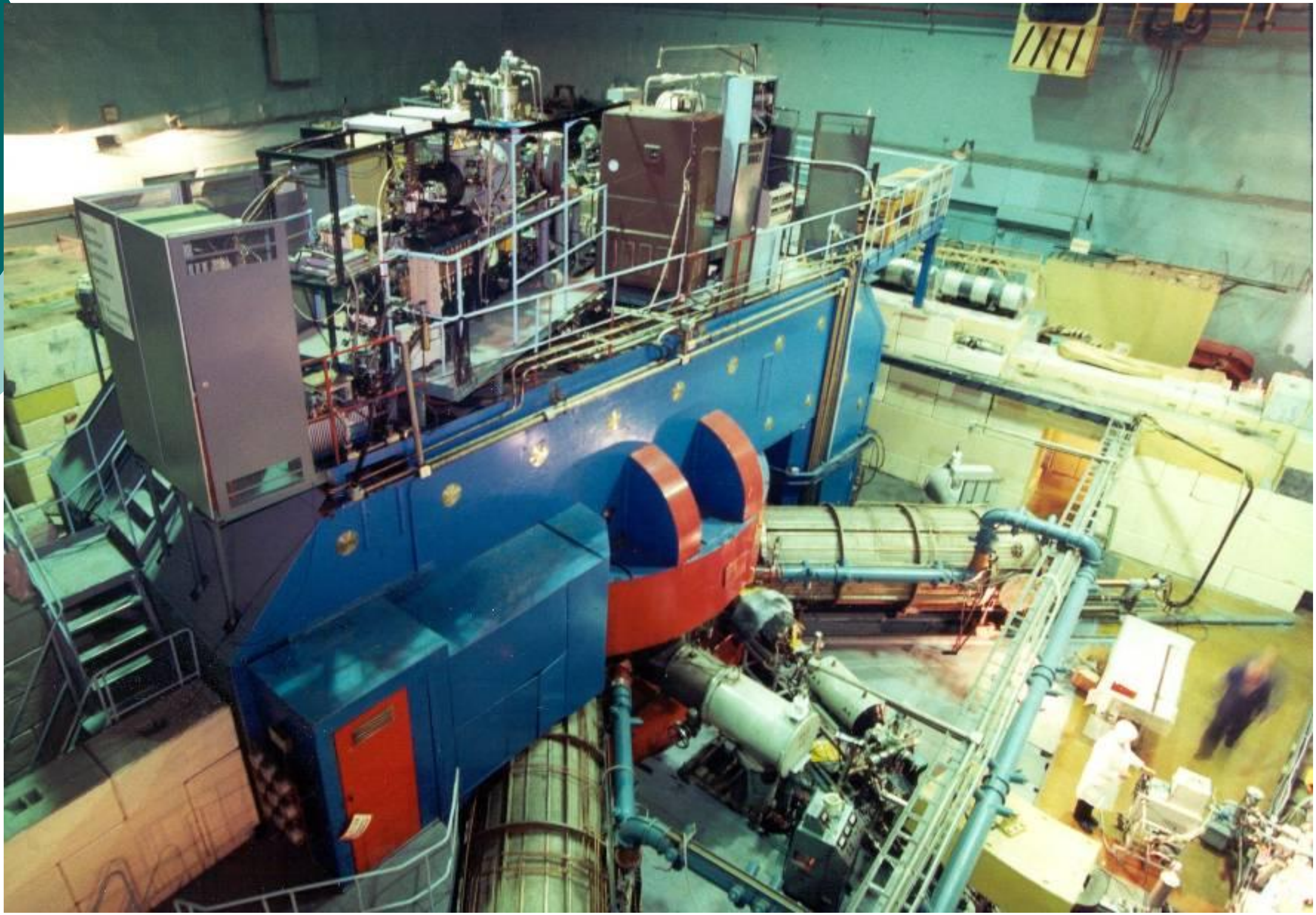
DRIBs-III

- **Modernization of existing accelerators (U400M & U400)**
- **Creation of the new experimental hall (≈ 2600 м^2)**
- **Development and creation of next generation set-ups**
- **Creation of high current heavy ion accelerator**

(A≤ 100, E ≤ 10 MeV ·A , I≥10 pμA)

2010 -2016 **≈ 60 M$**

U400M CYCLOTRON



Modernization of U400M in 2006 - 2010

- new axial injection line;
- new “warm” ECR ion source (DECRIS-2);
- new magnetic structure of the central region of U400M;
- new 1MWt magnet power supply;
- second direction beam extraction system;
- acceleration of “low” energy “heavy” ions;
- new producing target for secondary beams;
- improved local radiation shielding;
- superconducting 18-GHz primary beam ion source (under testing);
- “warm” 14-GHz secondary beam ion source (under testing).

What we need to do at U400M?

Increasing the cyclotron operation reliability!

1. Alteration of the HF generators (the existing are 30 years in operation).

2. Alteration of the acceleration structure control system (to increase the HV phase and amplitude stability).

3. Creation of a new low energy extraction system (to increase the extraction efficiency by a factor of 2-3).

U400 CYCLOTRON

Modernization of U400 in 2006 - 2010

- **new stable ion beams injection system (stand-alone mode);**
- **new RIBs injection system (post-accelerator mode);**
- **new beam extraction system;**
- **new microprocessor based control system;**
- **reconstruction of HF generators;**
- **new beam diagnostic systems;**
- **new beam lines;**
- **bringing the experimental hall in accordance with modern radiation safety requirements;**

What we need to do at U400?

Increase intensity and quality of beams.

- increase intensity of ^{48}Ca beam up to 2.5 pμA,
- decreasing beam energy spread an emittance,
- providing stepwise and smooth energy variation,
- reducing the power consumption.

- reconstruct the magnet;
- reconstruct the HF acceleration system

The project is fully prepared!

Time schedule of U400 modernization I

Name of works	1 year												2 year			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	4
Disassembly of the U-400 chamber equipment and resonators																
Disassembly of the «O» channels																
Disassembly of the axial injection and ECR source																
Creation of the erection site for the poles																
Disassembly of the pole I, dismantling																
Assembly of the pole I - beading																
Disassembly of the pole II, dismantling																
Assembly of the pole II - beading																
Assembly of the correcting coil current lead for the magnetic measurements																
Assembly of the magnetic measurement system																
Magnetic field forming																

Time schedule of U400 modernization II

Name of works	1 year												2 year			
	1	**2**	**3**	**4**	**5**	**6**	7	8	9	10	11	12	**9**	**10**	**11**	**12**
Assembly of the ground and support for the ECR source and axial injection																
Disassembly of the erection site, assembly of the U-400 rostra in the experimental room																
Assembly of the U-400 vacuum chamber																
Assembly of the regular scheme of the correcting coils current lead																
Assembly of the claddings, center and reducers																
Assembly of the resonators with the accelerator																
Assembly of the communication device for the HF resonators																
Assembly of the current probes																
Assembly of the extraction foil and inflector probes																

Time schedule of U400 modernization III

Name of works	1 year												2 year			
	1	**2**	**3**	4	5	6	7	8	9	10	**11**	**12**	**1**	**2**	**3**	**4**
Disassembly of the EMC current wire and water lead, assembly of the new one, setup																
Assembly of the EMC power supply, setup																
Stand assembly of the resonators																
Disassembly of "Khrizolit"																
Assembly of the new HF generators																
Setup of the HF system with the equivalent																
Assembly of the feeder lines																
Assembly of the axial injection and ECR source																
Assembly of the «O» channels																
Assembly of the vacuum equipment																
Assembly of the water lead; commutation and elements of the cooling control																
Assembly of the power supply the control system																
System by system and complex setup																
Getting the accelerated beam																

NEW FLNR ACCELERATOR

In order to improve efficiency of the experiments for the next 7 years it is necessary to obtain the accelerated ion beams with following parameters.

Energy	4÷8 MeV/n
Masses	10÷100
Intensity (up to 48Ca)	10 pμA

Beam emittance less 30 π mm·mrad

Efficiency of beam transfer >50%

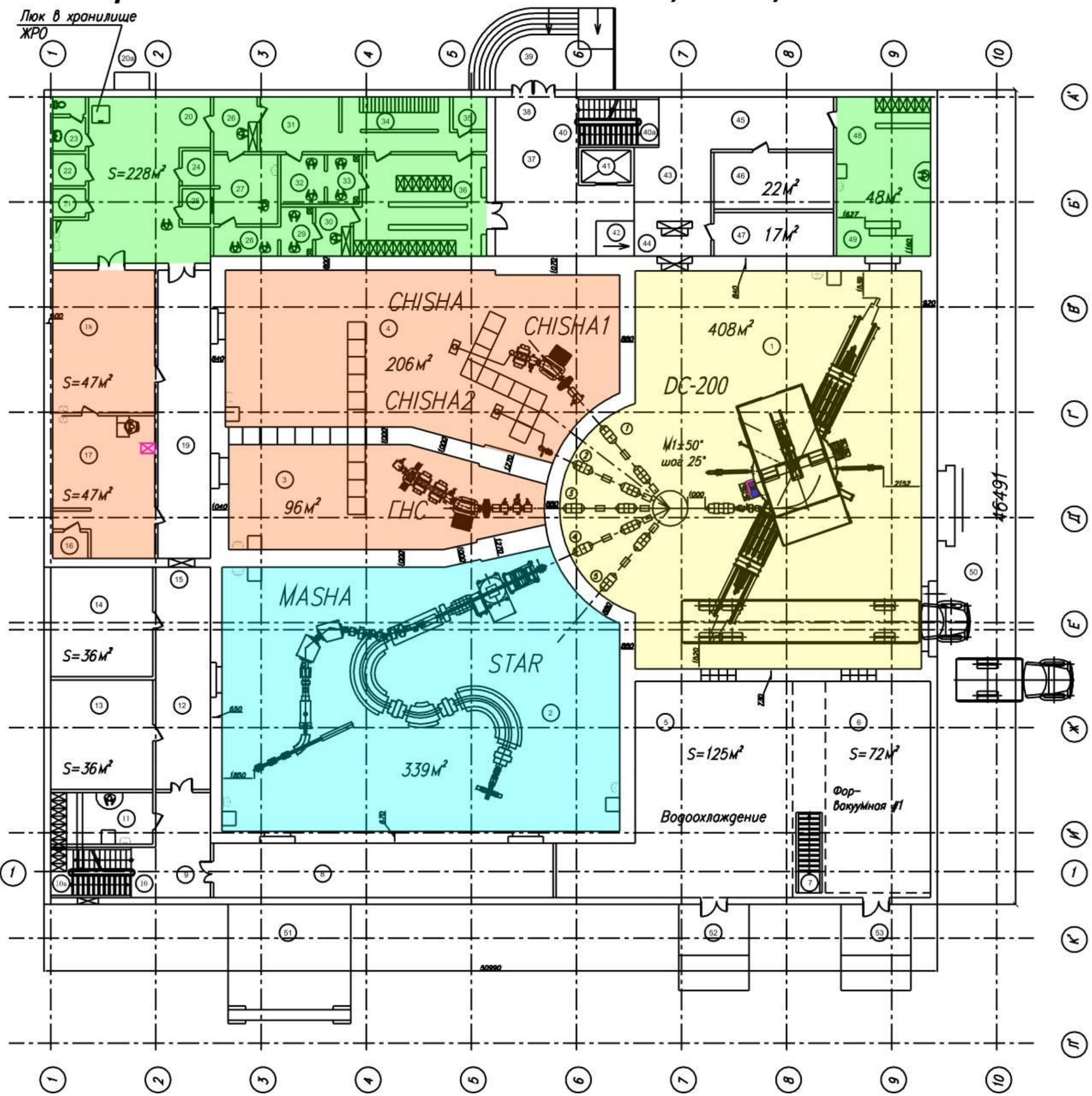
ECR frequency 18÷28 GHz

DC200 MAIN PARAMETERS

Pole diameter	4 m
Magnetic field level	0.65÷1.15 T
K factor	200
Weight	500 T
A/Z range	4÷7
Injecting beam potential	Up to 100 kV
Dee voltage	2x130 kV
Flat-top dee voltage	2x14 kV
Power consumption	250 kW
Beam turns separation	10 mm
Radial beam bunch size	3 mm
Efficiency of beam transferring	60%
Total accelerating potential	up to ~ 40 MV

NEW EXPERIMENTAL HALL

Первый этаж на отметках 0,5+1,0



ЭКСПЛИКАЦИЯ ПОМЕЩЕНИЙ. Этаж №1

Номер по плану	Наименование	Площадь, кв.м	Класс помещений по ПУЭ	Категории производства по взрывной, взрыво-пожарной и пожарной опасности
1	Зал ускорителя DC-200			
2	Установка STAR			
3	Установка ГНС			
4	Установка CHISHA			
5	Участок "Система водоохлаждения"			
6	Участок "Форвакуумная №1"			
7	Лестница			
8	Корридор			
9	Тамбур			
10	Лестница			
10a	Лестничная площадка			
11	Саншлюз			
12	Корридор			
13	Помещение технологическое			
14	Помещение технологическое			
15	Аварийный выход			
16	Хранилище РВ			
17	РХЛ II класса			
18	РХЛ II класса			
19	Корридор			
20	Тамбур санпропускника			
21	Пом-ние для помыва пневнокостюмов			
22	Кладовая для хранения индивидуальных средств защиты			
23	Санузел мужской			
24	Кладовая уборщицы			
25	Кладовая грязной спецодежды			
26	Пункт радиометрического контроля кожных покровов и спецодежды			
27	Помещение раздевания грязной спецодежды			
28	Душевая (после загрязнения)			
29	Обдувочная			
30	Пункт радиометрического контроля кожных покровов и спецодежды			
31	Тамбур			
32	Душевая (без загрязнений)			
33	Обдувочная			
34	Гардеробная чистой спецодежды			
35	Кладовая чистой спецодежды			
36	Раздевалка			
37	Вестибюль			
38	Центральный вход			
39	Крыльцо			
40	Лестница			
40a	Лестничная площадка			
41	Грузовой лифт			
42	Пандус			
43	Эстакада запасного выхода			
44	Запасной выход из зала ускорителя DC-200			
45	Корридор			
46	Мастерская			
47	Склад материалов для мастерской			
48	Саншлюз			
49	Вход в зал ускорителя DC-200			
50	Въездные ворота в зал ускорителя DC-200			
51	Разгрузочная площадка под кран-балкой			
52	Разгрузочная для участка "Система водоохлаждения"			
53	Разгрузочная для участка "Форвакуумная №1"			

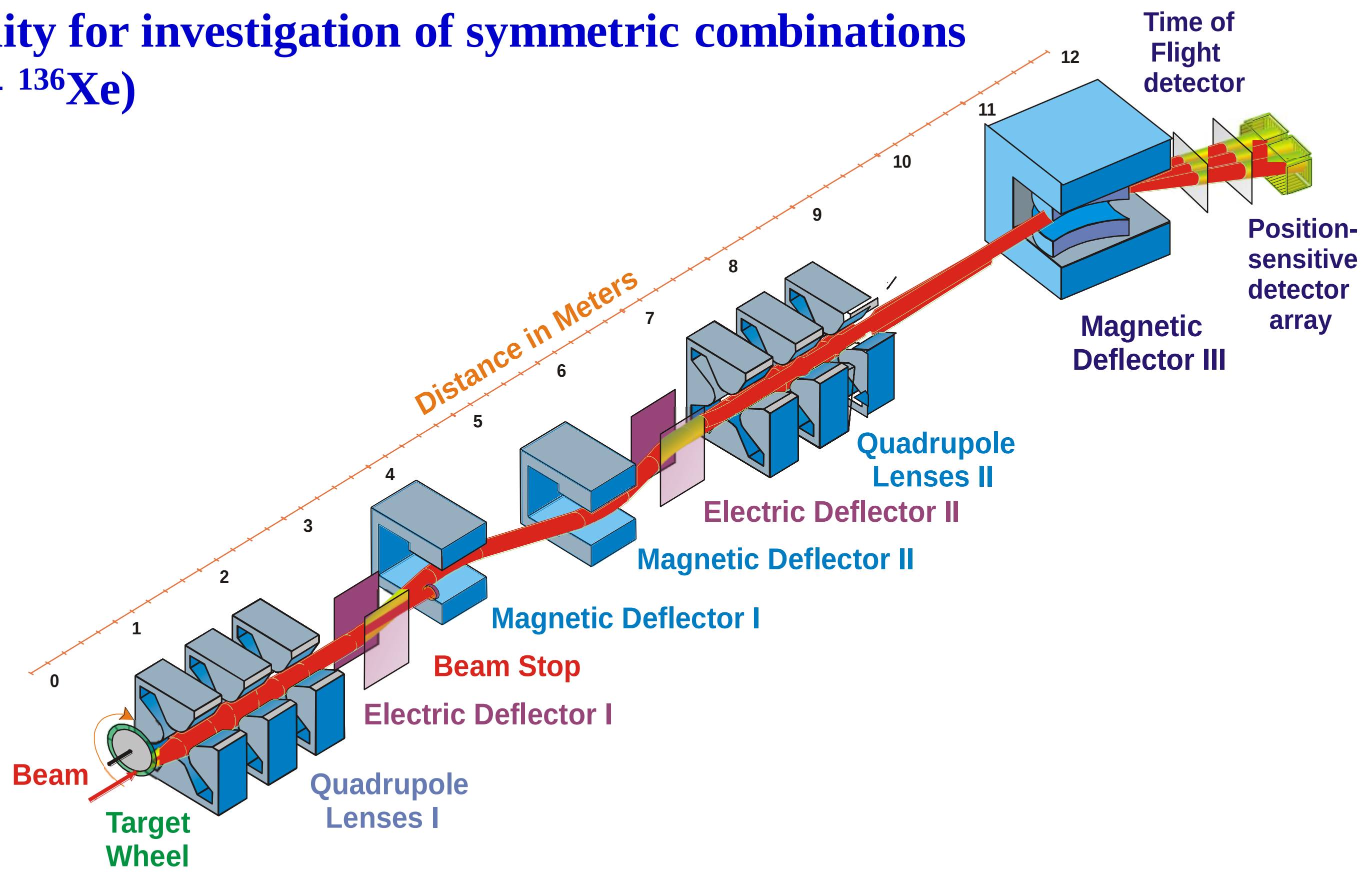
Velocity filter for spectroscopic studies, joint project FLNR – IN2P3 (France)

(Grant from ANR - 435 k€, FLNR budget ≈600 k$)

Launching 2011

Increased transmission for asymmetric combinations (beams of ^{12}C, $^{14,15}N$, $^{16,18}O$, $^{20,22}Ne$)

Possibility for investigation of symmetric combinations ($^{136}Xe + ^{136}Xe$)



Manufacturing of the dipole magnets in St. Petersburg

64 spectrometry channel system 4 amplifiers
with 16 channel built in multiplexers
4 ADC a (8192 ch.), 4 ADC SF (4096 ch.)
Conversion time 2 msec

New power supplies for quadrupole lenses

PAC for Nuclear Physics

31st Meeting, 25-26 January 2010

A. Yeremin "Status report on the GABRIELA set-up",

Recommendation:

The PAC strongly supports the approval of the proposed upgrade of the GABRIELA and VASSILISSA complex with high priority.

STATUS of the MASS-SPECTROMETER

Mass-spectrometer MASHA at the beam line of the cyclotron U-400M

- New beam line with low energy of the U-400M was built
- Mass-spectrometer mounted at the new beam line
- Hot catcher is ready
- Focal plane detector system is ready
- Start of test experiments – December of 2009

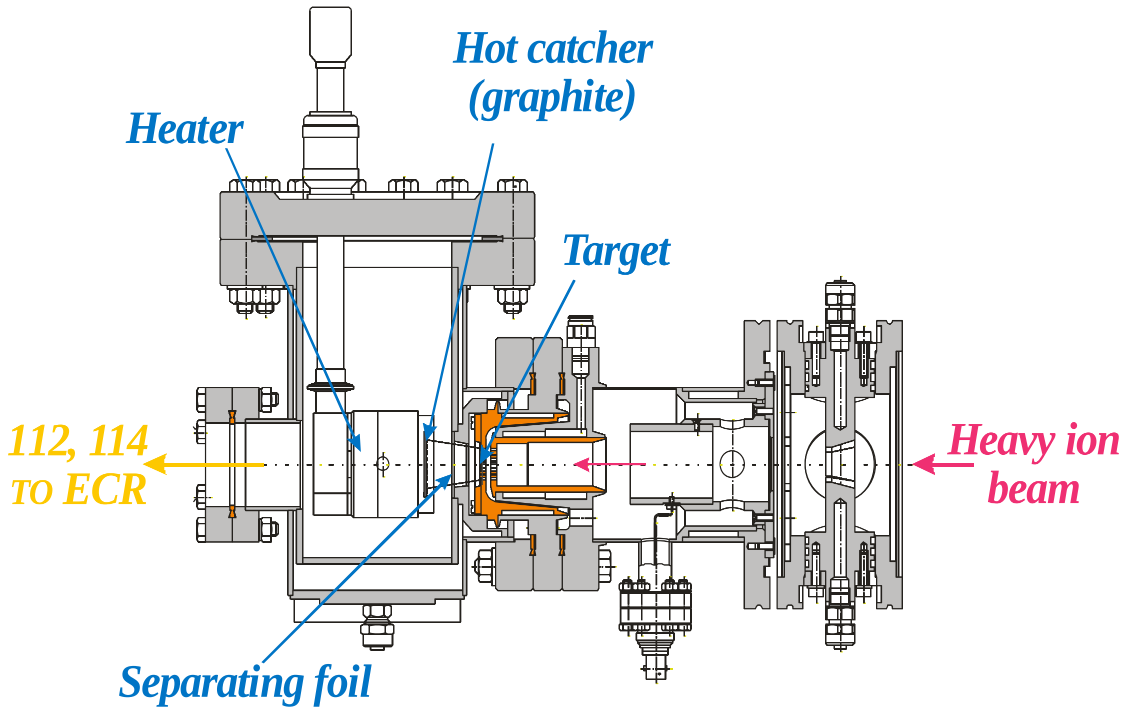
FIRST EXPERIMENTS

- Mass identification of 112 и 114 elements synthesized at the reactions

  $^{242}Pu(^{48}Ca,3n)^{287}114(0.5\ s) \rightarrow {}^{283}112(4\ s)$

- Mass identification of 113 elements synthesized at the reaction

  $^{243}Am(^{48}Ca,3n)^{288}115\ (0.1\ s) \rightarrow {}^{284}113\ \ (0.5\ s)$



PAC for Nuclear Physics

31st Meeting, 25-26 January 2010

A. Rodin "Status report on the MASHA set-up",

Recommendation:

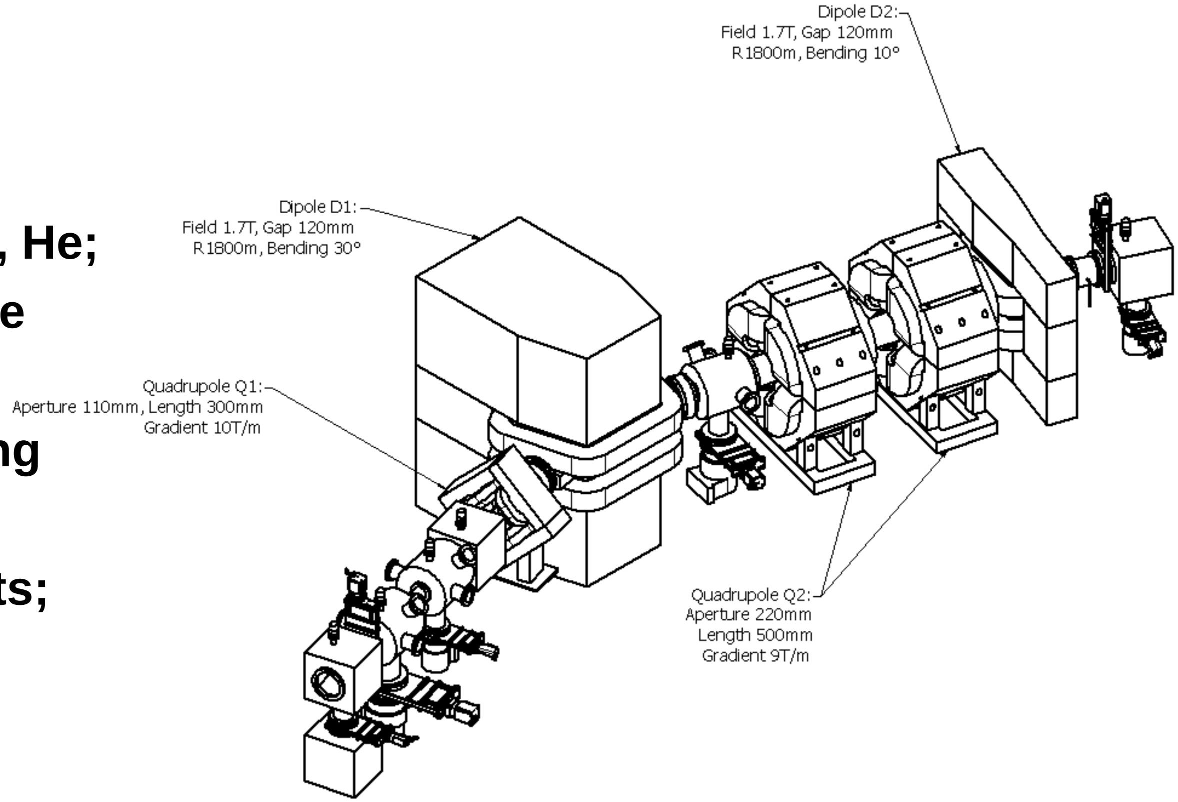
The PAC strongly supports the intension of the FLNR Directorate to start experiments with the MASHA mass spectrometer in 2010. The PAC recommends the installation of a gas-catcher and optimization of its properties for use at the MASHA set-up.

Gas-Filled Separator

(DANFYSIKs technical drawing, 1.5 years, 1.5 M€)

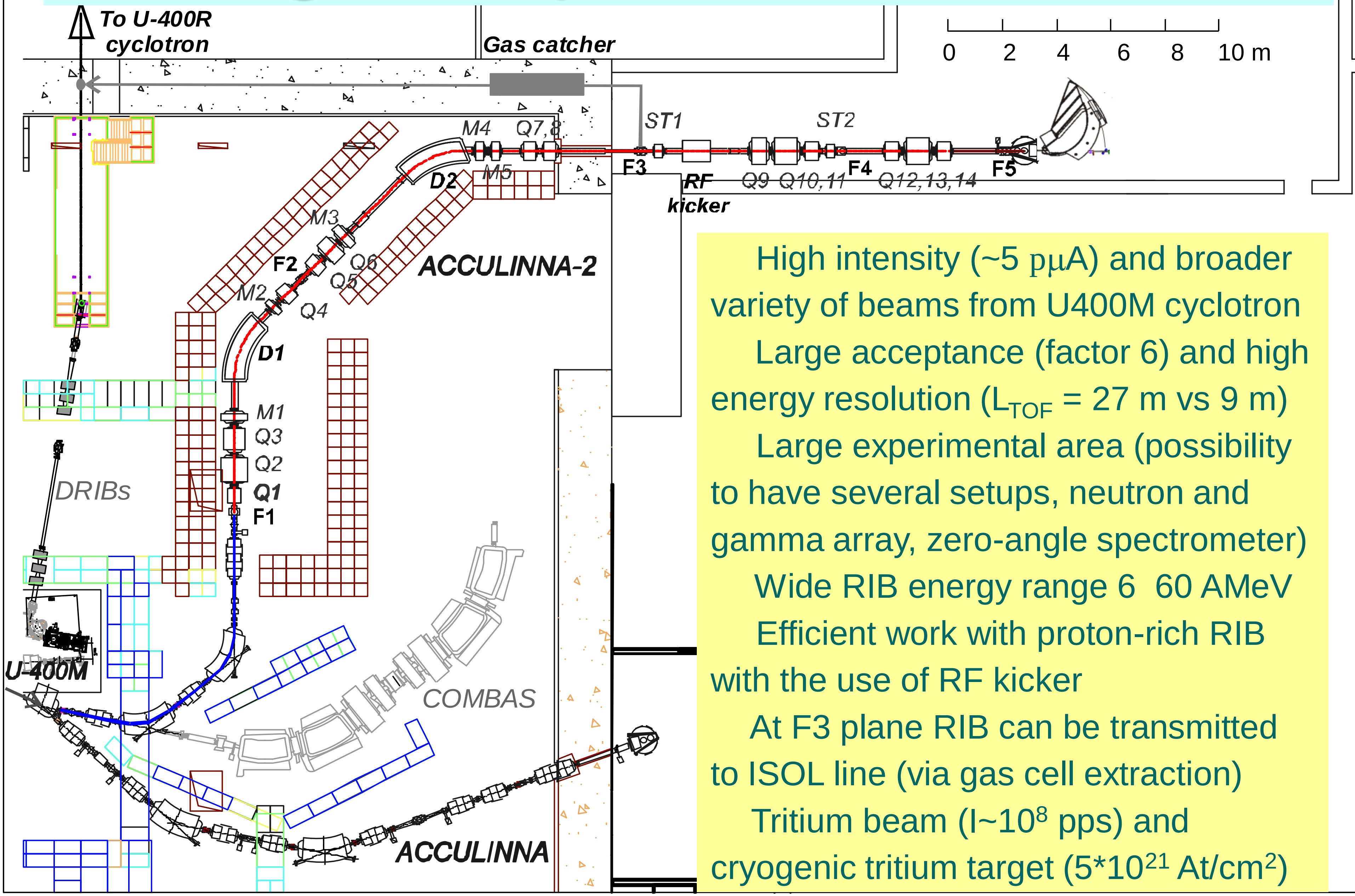
ADVANTAGES:

- **presence of a gas – H_2, He;**
- **high energy and charge acceptances;**
- **additional target cooling through convection;**
- **low number of elements;**
- **no high voltage.**



Ready time must be synchronized with the construction of the new experimental hall & accelerator

Fragment-separator *ACCULINNA-2*



High intensity (~5 pμA) and broader variety of beams from U400M cyclotron

Large acceptance (factor 6) and high energy resolution (L_{TOF} = 27 m vs 9 m)

Large experimental area (possibility to have several setups, neutron and gamma array, zero-angle spectrometer)

Wide RIB energy range 6 60 AMeV

Efficient work with proton-rich RIB with the use of RF kicker

At F3 plane RIB can be transmitted to ISOL line (via gas cell extraction)

Tritium beam (I~10^8 pps) and cryogenic tritium target ($5*10^{21}$ At/cm^2)

PAC for Nuclear Physics

32nd Meeting, 17-18 June 2010

A. Popeko "Universal gas-filled separator for studies of heavy nuclei ",

Recommendation:

The PAC strongly supports approval of the project of this universal gas-filled separator and recommends continuation of discussions on the final project at its next meeting.

A. Fomichev "Fragment-separator ACCULINNA-2",

Recommendation:

The PAC recommends starting a more detailed technical design of the fragment-separator ACCULINNA-2 by reconsidering its initial broad scientific programme at its next meeting.

BASIC DIRECTIONS of RESEARCH

1. Heavy and superheavy nuclei

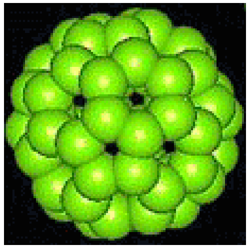
- **Synthesis and study of properties of superheavy elements**
- **Chemistry of new elements**
- **Fusion-fission and multi-nucleon transfer reactions**
- **Mass-spectrometry and nuclear spectroscopy of SH nuclei**

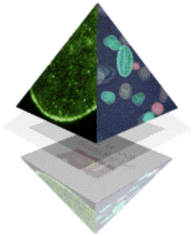
2. Light exotic nuclei

- **Properties and structure of light exotic nuclei**
- **Reactions with exotic nuclei**

3. Radiation effects and physical bases of nanotechnology

“DUBNA” Nanocenter



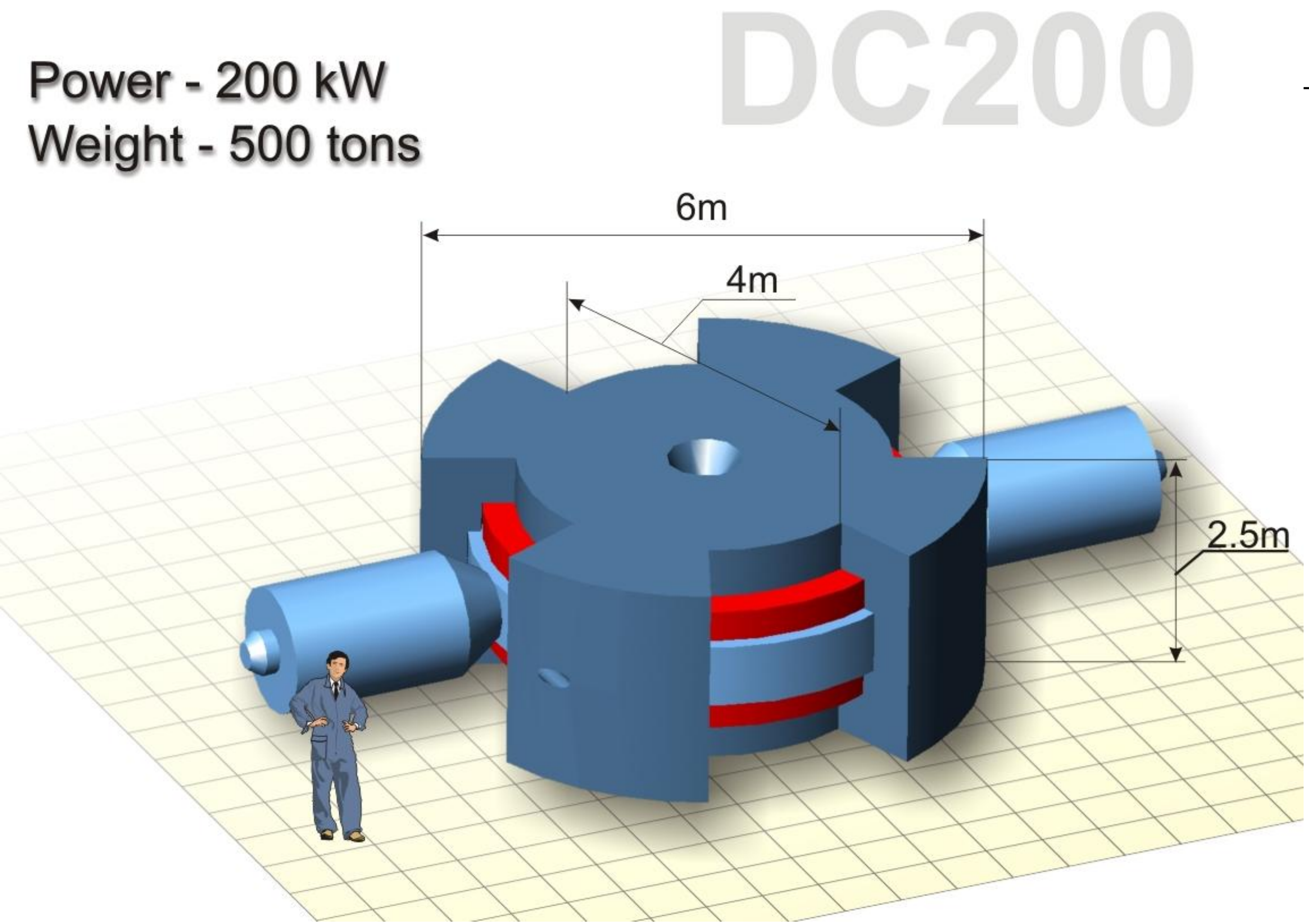


- **On 26 March 2010, JINR together with its partners won the first competition organized by the Russian state corporation «Rosnanotech» for the creation of multifunctional infrastructure nanotechnology center in Dubna. On 31 August 2010 ROSNANO and JINR signed an investment agreement, according to which the nanocenter project is now developed.**
- **At the expense of ROSNANO, modern equipment will be purchased (over 1,0 billion rubles), and located in JINR and some other large companies – residents of the Dubna SEZ.**
- **ROSNANO and JINR are establishing the center for technology transfer – CJSC «International Innovative nanotechnology Center», which will coordinate the employment of personnel in all nanocenter infrastructure in Dubna and will provide formation of project teams and start-ups.**

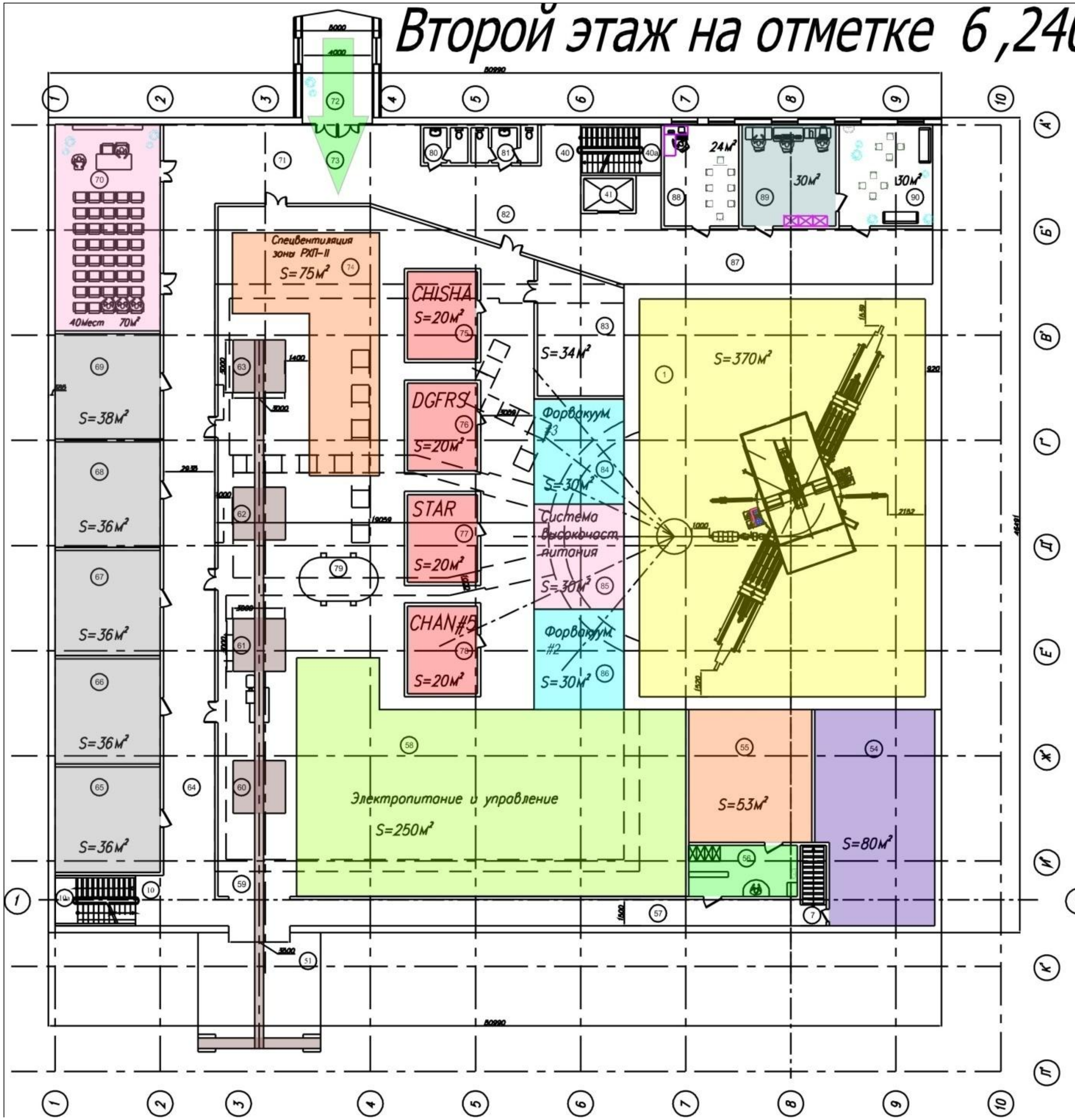
THANKS FOR YOUR ATTENTION!

DC200 CYCLOTRON DESIGN

Power - 200 kW
Weight - 500 tons



NEW EXPERIMENTAL HALL

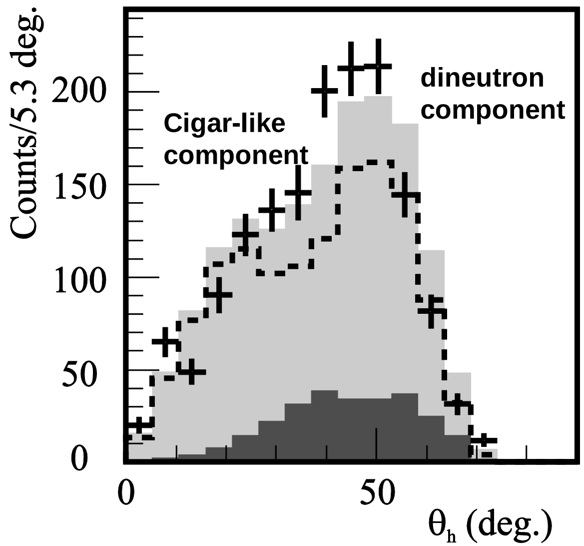


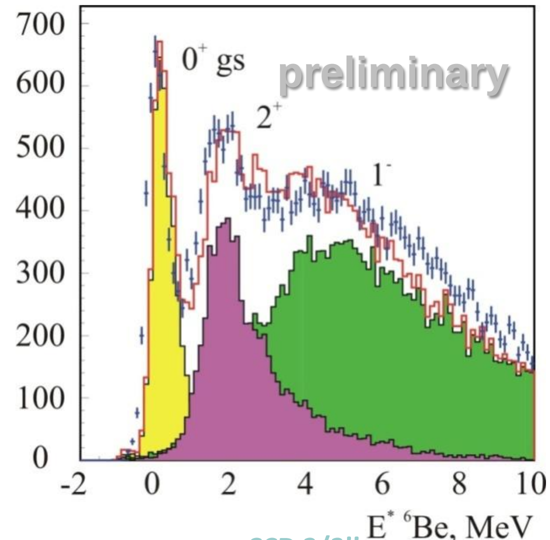
ЭКСПЛИКАЦИЯ ПОМЕЩЕНИЙ. Этаж №2

Номер по плану	Наименование	Площадь, кв.м	Класс помещений по ПУЭ	Категории производства по взрывной, взрыво-пожарной и пожарной опасности
54	Общеобменная вентиляция			
55	Вентиляция РХЛ III кл			
56	Саншлюз			
57	Корридор			
58	Участок "Электропитание и управление"			
59	Кран-балка грузопод. 3 - 5 тн			
60	Грузовой люк для канала №5			
61	Грузовой люк над установкой "STAR"			
62	Грузовой люк над установкой "ГНС"			
63	Грузовой люк над установкой "CHISHA"			
64	Корридор			
65	Помещение для персонала			
66	Помещение для персонала			
67	Помещение для персонала			
68	Помещение для персонала			
69	Помещение для персонала			
70	Конференц-зал			
71	Корридор у входной двери			
72	Галлерея			
73	Вход из галлереи в Экспериментальный корпус			
74	Участок "Спецвентиляция зоны РХЛ-II кл			
75	Помещение для оборудования установки "CHISHA"			
76	Помещение для оборудования установки "ГНС"			
77	Помещение для оборудования установки "STAR"			
78	Помещение для оборудования установки на канале №5			
79	Танк с жидким азотом			
80	Туалет женский			
81	Туалет мужской			
82	Корридор			
83	Мастерская вакуумных систем			
84	Участок "Форвакуумная №3"			
85	Участок "Система высокочастотного питания"			
86	Участок "Форвакуумная №2"			
87	Корридор			
88	Помещение начальника ускорительного комплекса DC-200			
89	Пульт управления DC-200			
90	Помещение для отдыха персонала			
91	Хранилище ЖРО			

FLNR 2010: Structure of light exotic nuclei near and beyond the drip-lines

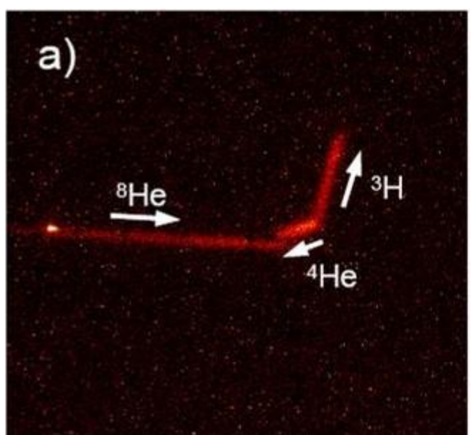
The direct experimental manifestation of the dineutron and cigar-like components of the ^{6}He WF was observed in the reaction of quasifree Scattering ^{4}He(^{6}He,2α)2n. NPA 840 (2010) 1-18

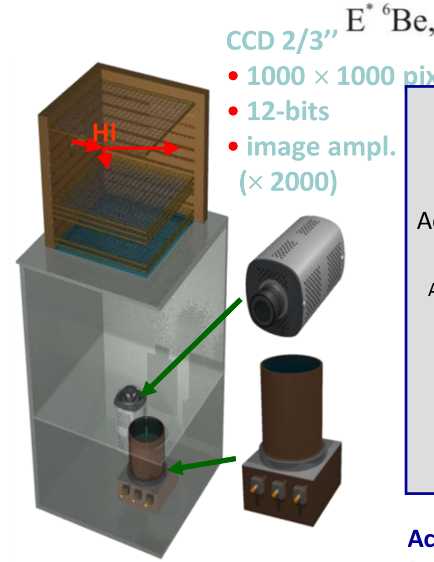


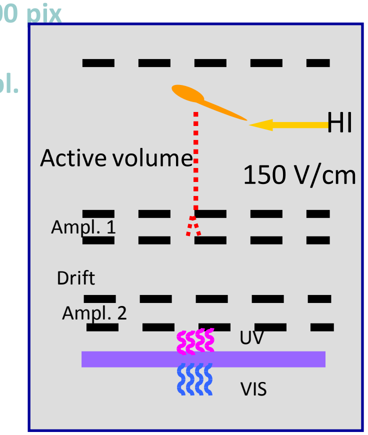


For the first time the isovector soft-dipole mode of excitation was discovered in the spectrum of unbound proton-rich nuclear system ^{6}Be obtained in the reaction ^{6}Li+p

The Optical Time Projection Chamber, created in Warsaw University, was successfully tested at the fragment-separator ACCULINNA with the ^{8}He beam.







Active volume: 20×20×15 cm^3
Drift velocity: ≈ 0.5 cm/μs

NEW RESOURCES AND RESEARCH OPPORTUNITIES

	U 400M E/A=34÷50 MeV/u		**U 400** E/A=3÷29 MeV/u		**U 400M** E/A=34÷50 MeV/u E/A=4.5÷9 MeV/u		**U 400R** E/A=1÷27 MeV/u		**DC 200** E=4÷8 MeV/u		
beam	E/A (MeV)	intensity (pps)	E/A (MeV)	intensity (pps)	E/A (MeV)	intensity (pps)	E/A (MeV)	intensity (pps)	E/A (MeV)	intensity (pps)	**Physics**
light RIB 6He 8He 24Ne			11	3×10^{7}			2.8 ÷ 14 1.6 ÷ 8 0.8 ÷ 20	10^{8} 10^{5} ?			structure of light exotic nuclei, reactions, **sub-barrier fusion, astrophysics**
$6<A<40$ 7Li 18O 40Ar	35 33 40	4×10^{13} 8×10^{12} 7×10^{11}	17 19 5	6×10^{13} 2×10^{13} 9×10^{12}	35 33 40	6×10^{13} 10^{13} 10^{12}	17 19 5	1×10^{14} 1×10^{14} 3×10^{13}	4 8 5	1×10^{14} 1×10^{14} 6×10^{13}	production of light RIB, fragmentation, transfer, structure of light exotic nuclei
A ~ 60 48Ca 54Cr 58Fe	-- -- --	-- -- --	5 5 5	7×10^{12} 4×10^{12} 4×10^{12}	5 5 5	6×10^{12} 3×10^{12} 3×10^{12}	5 5 5	1.5×10^{13} 6×10^{12} 6×10^{12}	5 5 5	6×10^{13} 2×10^{13} 1×10^{13}	**SHE with $Z>118$** ($\sigma<0.1$ pb) spectroscopy of SHE, fusion-fission, quasi-fission
A ~ 150 124Sn 136Xe			5 5	3×10^{11} 5×10^{11}	5 5	2×10^{11} 4×10^{11}	5 5	2×10^{12} 3×10^{12}	5 5	6×10^{11} 2×10^{12}	deep inelastic scattering, multi-nucleon transfer, **new neutron rich nuclei**, shell effects
A ~ 240 238U			7	3×10^{10}	7	2×10^{10}	7	10^{11}	7	5×10^{10}	**neutron-rich SHE, new heavy isotopes, ternary fission, super strong electric fields, $e^{+}e^{-}$ formation**
	to date				2010		2011		2014		