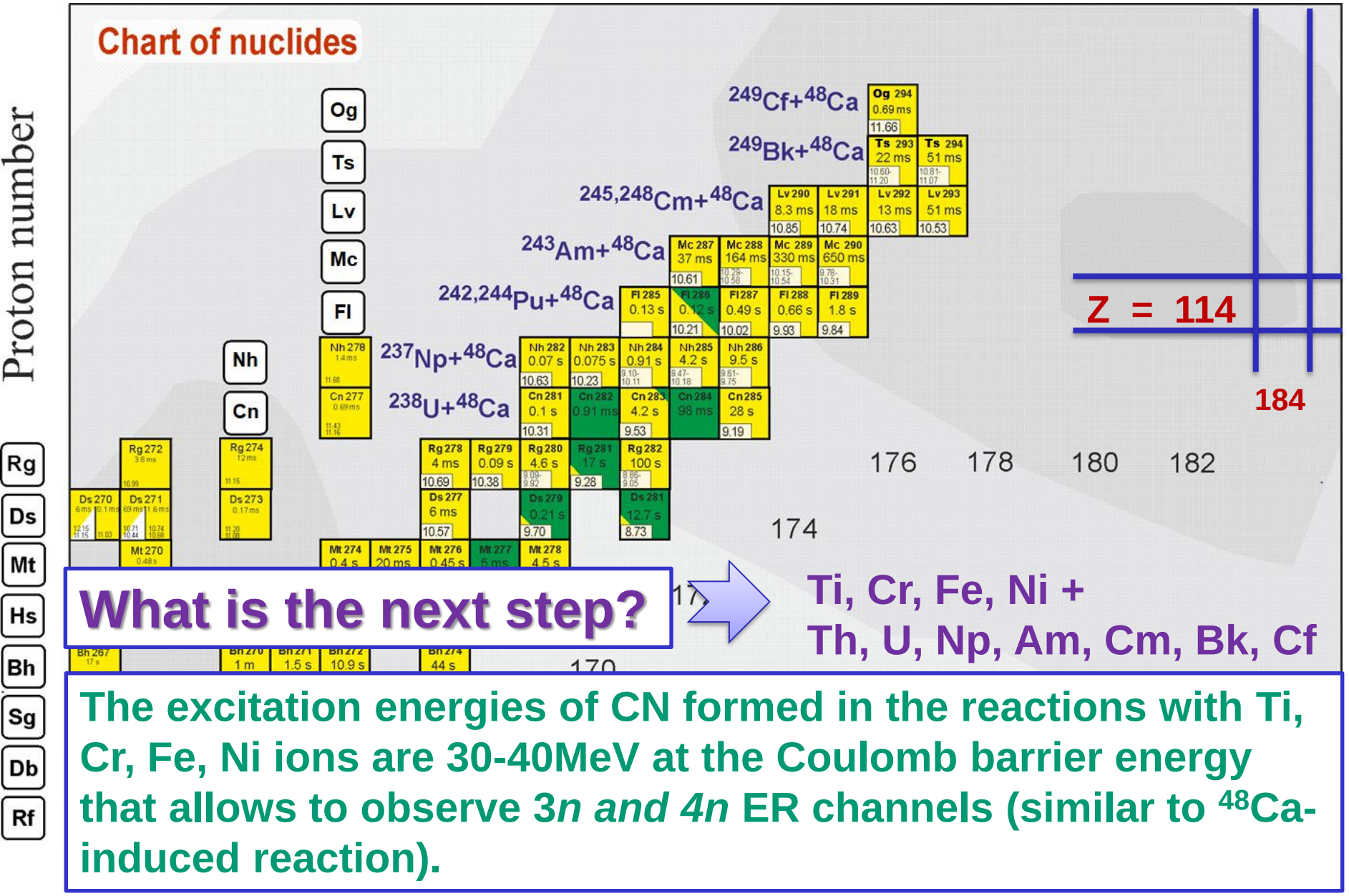
International large research infrastructure of JINR, Dubna.

M.G.Itkis

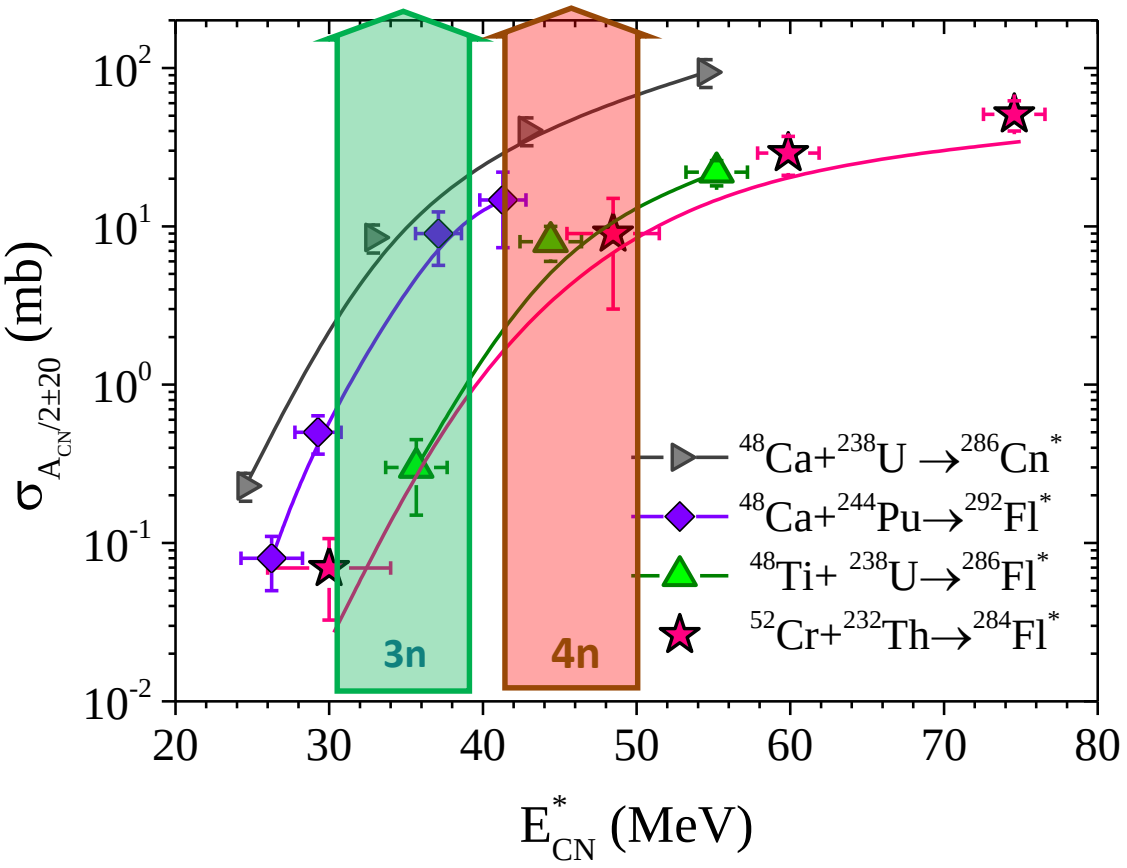
24-30 September, Budva

* Search for superheavies



The excitation energies of CN formed in the reactions with Ti, Cr, Fe, Ni ions are 30-40MeV at the Coulomb barrier energy that allows to observe 3*n and 4n* ER channels (similar to ^{48}Ca-induced reaction).

Cross sections of symmetric fragment formations



- **For 4*n* channel (E^*=40÷50MeV):**

$^{48}Ca+^{238}U \rightarrow ^{48}Ca+^{244}Pu$

$\sigma(A_{CN}/2\pm20)$ drops ~**2** times

$^{48}Ca+^{238}U \rightarrow ^{48}Ti+^{238}U$

$\sigma(A_{CN}/2\pm20)$ drops ~**10** times

- **For 3*n* channel (E^*=30÷40MeV):**

$^{48}Ca+^{238}U \rightarrow ^{48}Ca+^{244}Pu$

$\sigma(A_{CN}/2\pm20)$ drops ~**10** times

$^{48}Ca+^{238}U \rightarrow ^{48}Ti+^{238}U$

$\sigma(A_{CN}/2\pm20)$ drops ~**100** times

For the studied reactions the excitation energies at the barrier energy vary strongly (36MeV for the Ca+Pu, 44MeV for the Ti+U and 41MeV for the Cr+Th). It leads to decrease of CS in the case of Ti+U and Cr+Th for 3n ER channel.

Superheavy Elements (SHE) Factory – the Goals

- **Experiments at the extremely low (σ<100 fb) cross sections:**
  - Synthesis of new SHE in reactions with ^{50}Ti, ^{54}Cr ...(119, 120);
  - Shaping of the region of SHE (synthesis of new isotopes of SHE);
  - Study of decay properties of SHE;
  - Study of excitation functions.

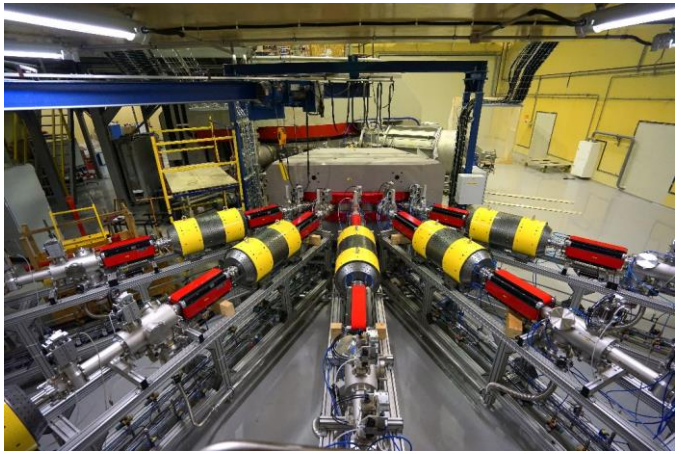
- **Experiments requiring high statistics:**
  - Nuclear spectroscopy of SHE;
  - Precise mass measurements;
  - Study of chemical properties of SHE.

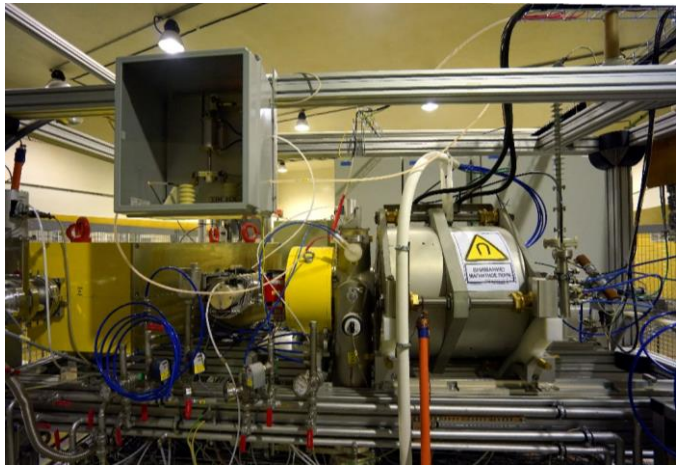

March 2012, Dubna

Superheavy Element Factory

Onset of day-one experiments – Nov. – Dec. 2018

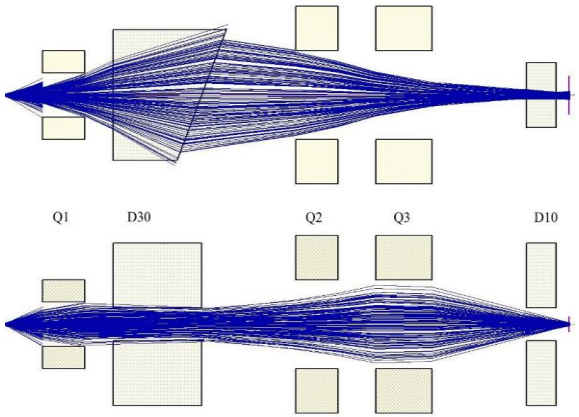
Specialized high-current cyclotron DC280





DC280 (expected) E=4÷8 MeV/A		
^{7}Li	4	1×10^{14}
^{18}O	8	1×10^{14}
^{40}Ar	5	6×10^{13}
^{48}Ca	5	1×10^{14}
^{54}Cr	5	2×10^{13}
^{136}Xe	5	1×10^{14}
^{238}U	7	5×10^{10}

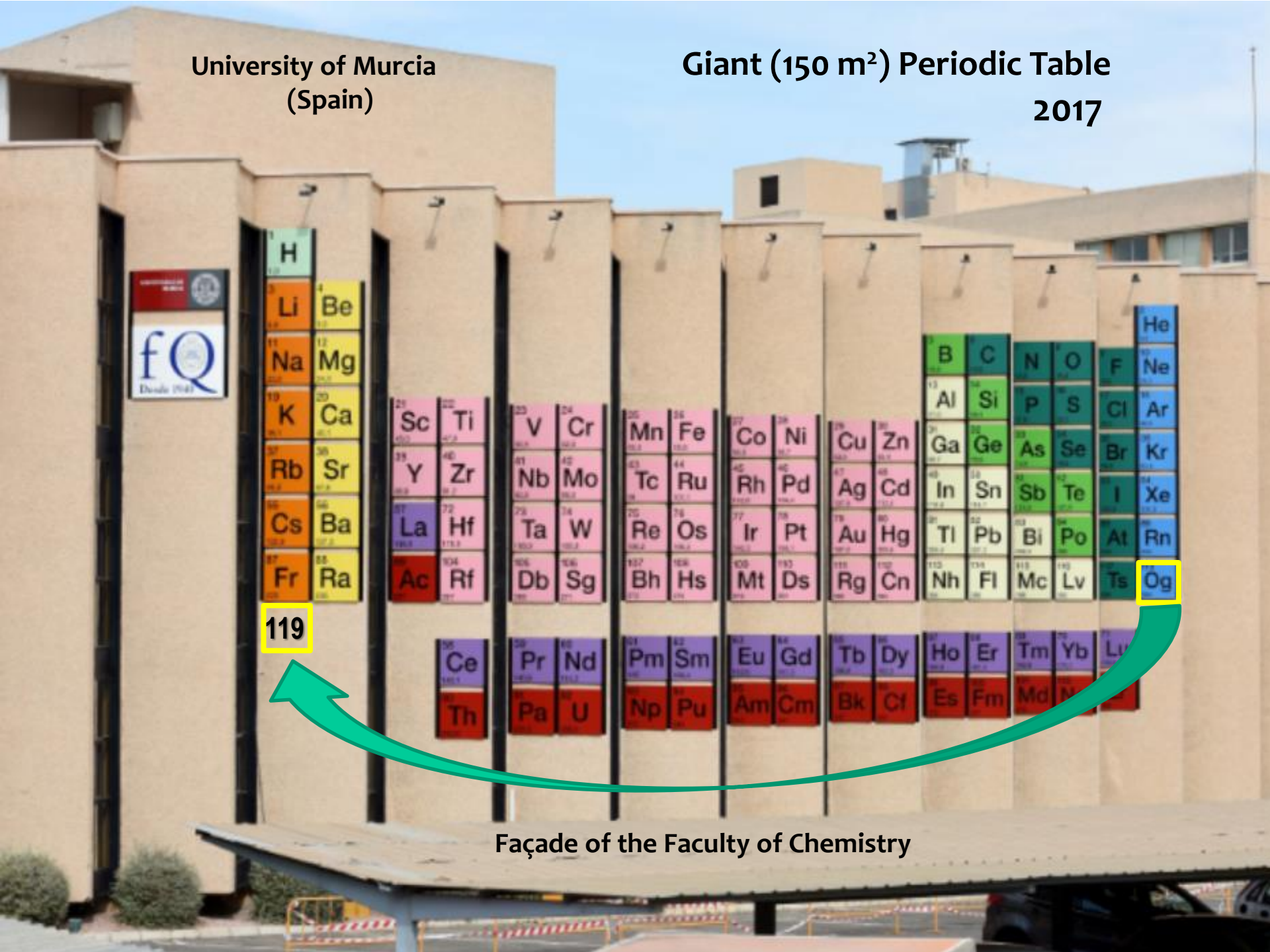
New FLNR's gas-filled separator



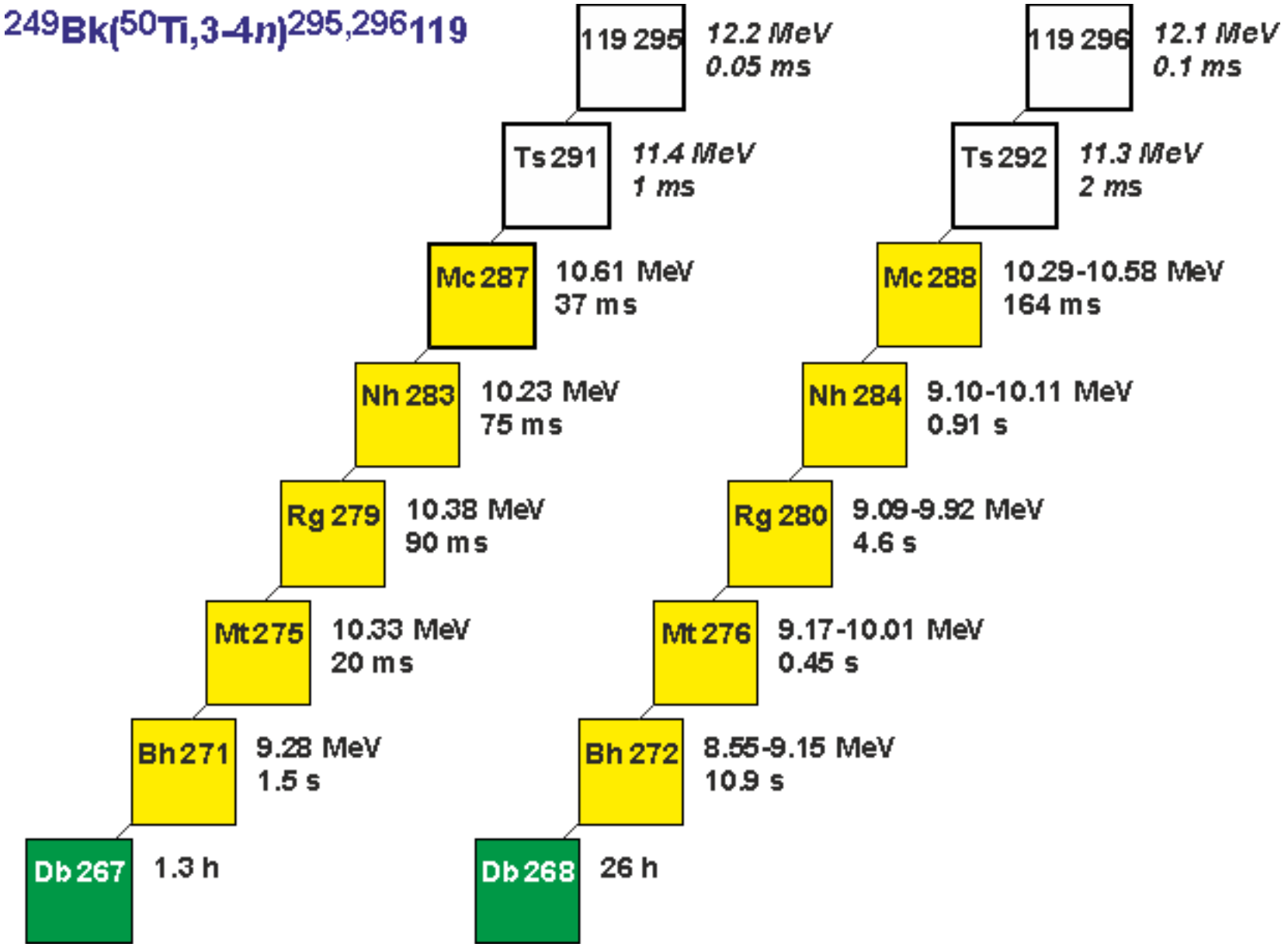
Reaction	Transmission
$^{244}Pu(^{48}Ca,3n)^{289}114$	60 %
$^{244}Pu(^{58}Fe,4n)^{298}120$	75 %

University of Murcia
(Spain)

Giant (150 m²) Periodic Table
2017



Façade of the Faculty of Chemistry


249Bk(50Ti,3-4n)295,296119
119 295
12.2 MeV
0.05 ms
Ts 291
11.4 MeV
1 ms
Mc 287
10.61 MeV
37 ms
Nh 283
10.23 MeV
75 ms
Rg 279
10.38 MeV
90 ms
Mt 275
10.33 MeV
20 ms
Bh 271
9.28 MeV
1.5 s
Db 267
1.3 h
119 296
12.1 MeV
0.1 ms
Ts 292
11.3 MeV
2 ms
Mc 288
10.29-10.58 MeV
164 ms
Nh 284
9.10-10.11 MeV
0.91 s
Rg 280
9.09-9.92 MeV
4.6 s
Mt 276
9.17-10.01 MeV
0.45 s
Bh 272
8.55-9.15 MeV
10.9 s
Db 268
26 h

Experiments

Synthesis of element 119 in the ^{249}Bk + ^{50}Ti reaction *(first experiment)*
The amount of ***^{249}Bk*** target material is **35 mg**;
The average beam intensity of ^{50}Ti is 5 pμA.
Irradiation time is 150 days_____***June–December 2019***

When element 117 is synthesized in the *^{249}Bk + ^{48}Ca reaction*:
$I(^{48}Ca) = 5$ pμA

$\Delta x(^{249}Bk) = 0.35$ mg/cm^2

$P(^{249}Bk) = 35$ mg

$L = 0.88 \cdot 10^{18} \cdot 3 \cdot 10^{13} = 2.65 \cdot 10^{31}$ cm^{-2}·s^{-1}

Expected number of events:

$N = 2.65 \cdot 10^{31} \cdot 2.5 \cdot 10^{-36} \cdot 0.5 \cdot 0.864 \cdot 10^{5} = 3$/d or 450 / 150 d

In the ^{249}Bk + ^{50}Ti reaction
At a cross section of 25 fb 4-5 /150 d

Mega-science project at JINR: Nuclotron Based Ion Collider Facility (NICA)

NICA (Nuclotron-based Ion Colider fAcility)

Main targets: **http://nica.jinr.ru/**

- *study of hot and dense baryonic matter*
  at the energy range of max baryonic density
- *investigation of nucleon spin structure, polarization phenomena*

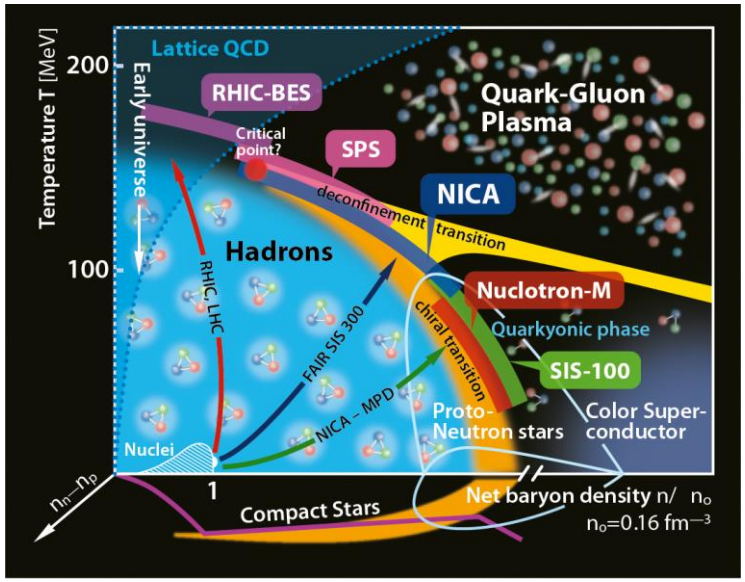
Construction of Collider of relativistic ions from p to Au,
polarized protons and deuterons

with max energy up to $\sqrt{S_{NN}}$= 11 GeV (Au^{79+}) and =27 GeV (p)

$\sqrt{S_{NN}}$ = 11 GeV (Au^{79+} , L ~ 10^{27} cm^{-2} c^{-1})

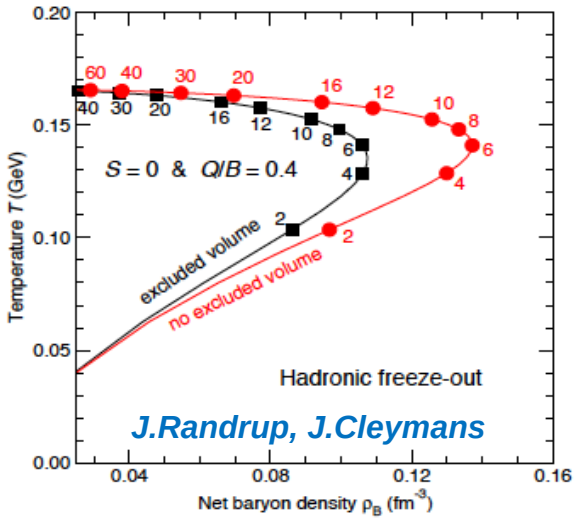
$\sqrt{S}$ =27 GeV (p, L ~ 10^{32} cm^{-2} c^{-1})

Physics at NICA



QCD matter at MPD@NICA *:*

- *Highest net baryon density*
- *Energy range covers onset of deconfinement*
- *Complementary to the RHIC/BES, FAIR , J-PARC-HI and CERN experimental programs*



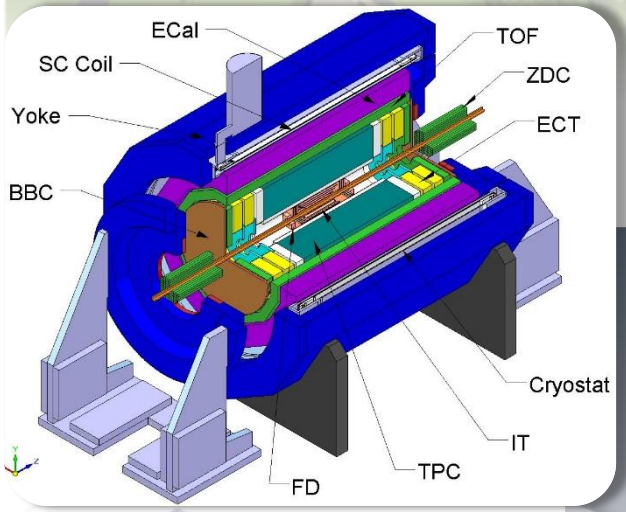
- **Bulk properties, EOS** - *particle yields & spectra, ratios, femtoscopy, flow*
- **In-Medium modification of hadron properties**
- **Deconfinement (chiral), phase transition at high r_B** - *enhanced strangeness production*
- **QCD Critical Point -** *event-by-event fluctuations & correlations*
- **Strangeness in nuclear matter** - *hypernuclei*

***The observables in AA, pA and pp collisions:* multiplicity of produced hadrons (π, K, p, Λ, Ξ, Ω), electromagnetic probes: electrons, gammas, vector meson decays , event-by-event fluctuations, femtoscopy of π, K, p, Λ**

Status of the NICA complex realization

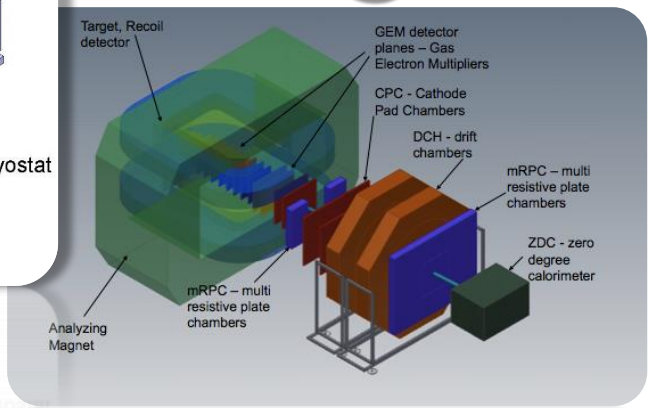
NICA infrastructure developments:

- Development of liquid helium and liquid nitrogen plants
- Operation of the SC-magnets test facility
- Modernization of electricity systems
- Upgrading of the water pipelines, thermal grids and sewer lines
- Construction of buildings



MPD

BM@N



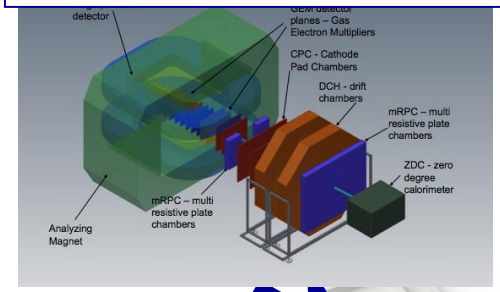
NICA Center

QCD matter at the NICA energies:

- *maximum in the net baryon density – **density frontier**;*
- *maximum in K^+/π^+ ratio;*
- *maximum in Λ/π ratio;*
- *maximum yield if hypernuclei*
- *transition from a Baryon dominated system to a Meson dominated one;*
- *maximum of the Λ polarization;*
- *1-st order transition & mixed phase creation;*
- *Critical Endpoint ?*

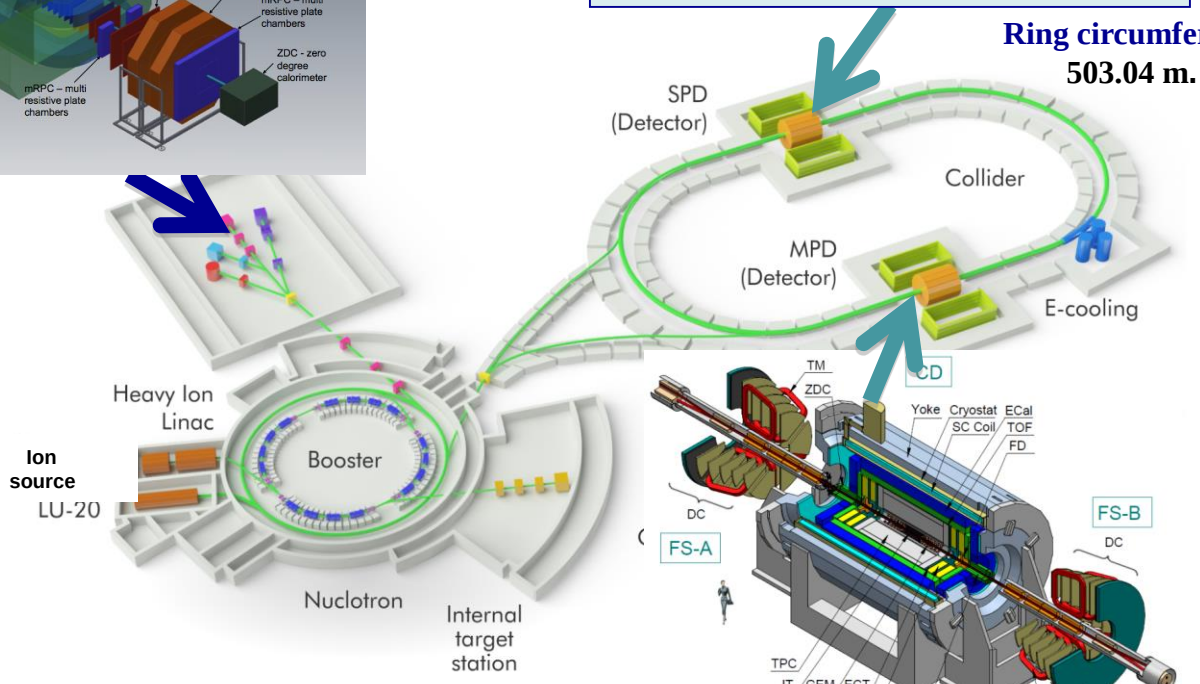
NICA Complex

Baryonic Matter at Nuclotron (BM@N)



SPD (Spin Physics Detector)

Ring circumference
503.04 m.

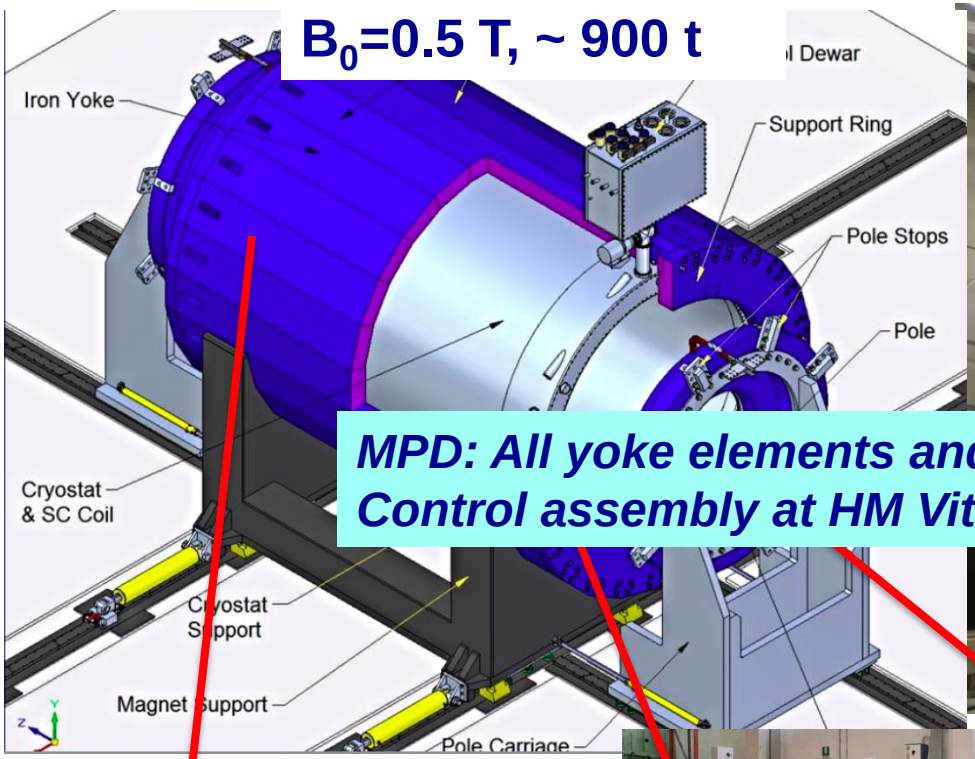


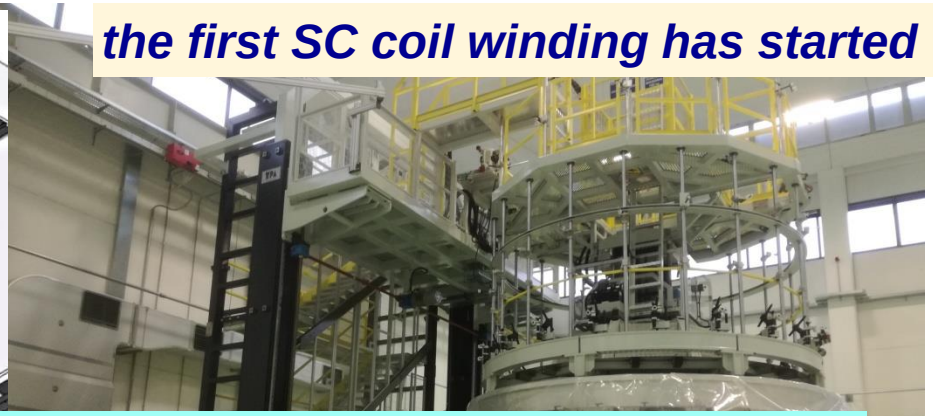
MultiPurpose Detector (MPD)

Site of the Collider construction

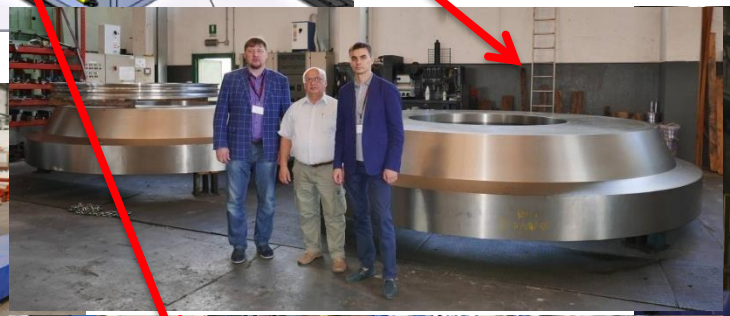
June 2018

Magnet production: *at ASG (Genova) & Vitkovice HM*





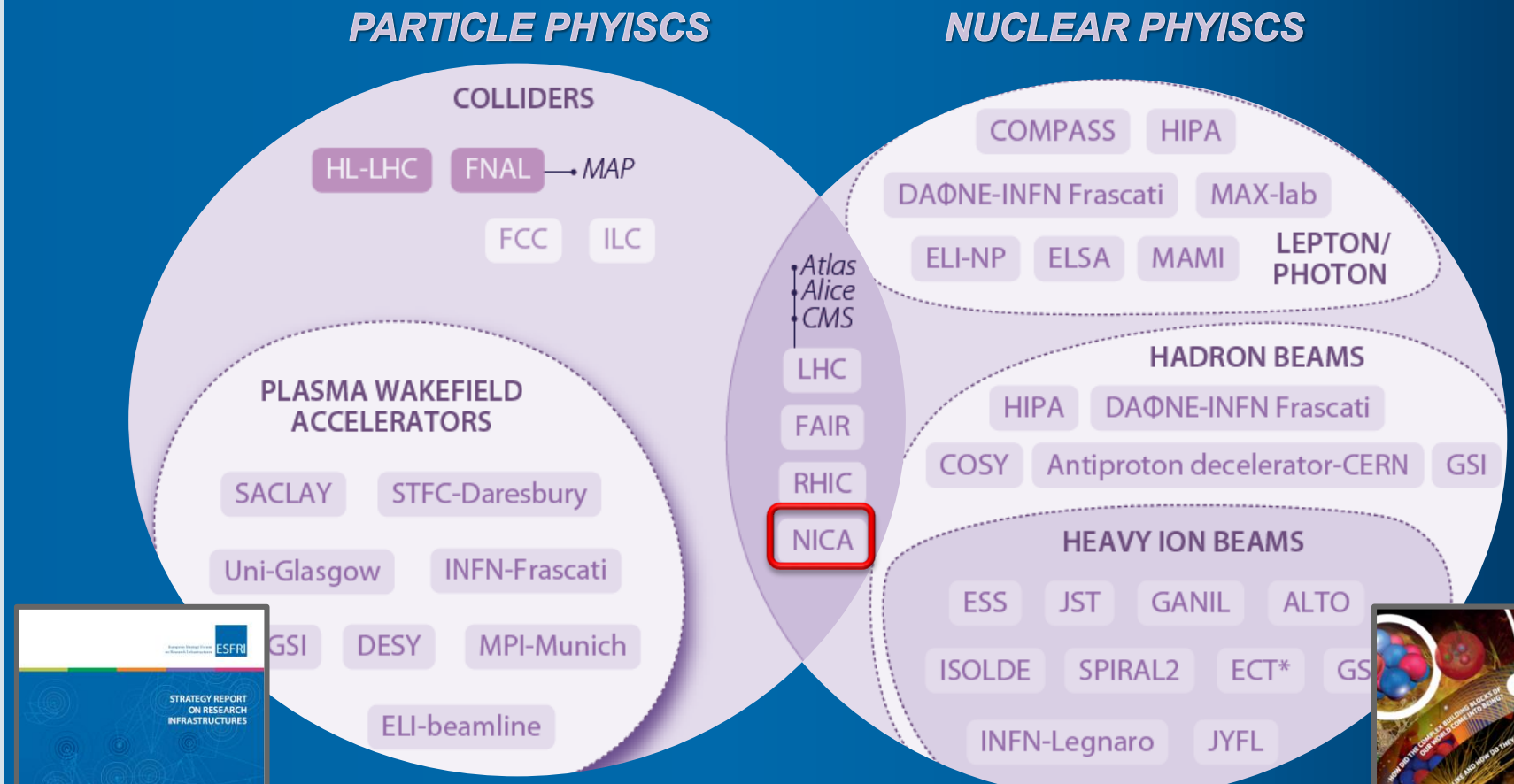
MPD: All yoke elements and support structure are produced; Control assembly at HM Vitkovice (Czech Rep.) will start soon.



Development of the facility for assembling and cryogenic tests of superconducting magnets for NICA

New issue of the ESFRI Roadmap

Main Research Infrastructure in Particle and Nuclear Physics



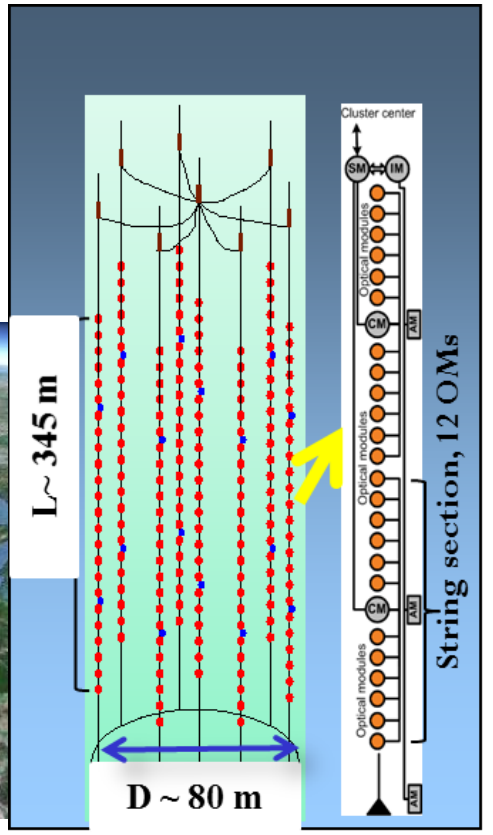
NICA – Complementary Project

Neutrino program

Бруно Понтекорво

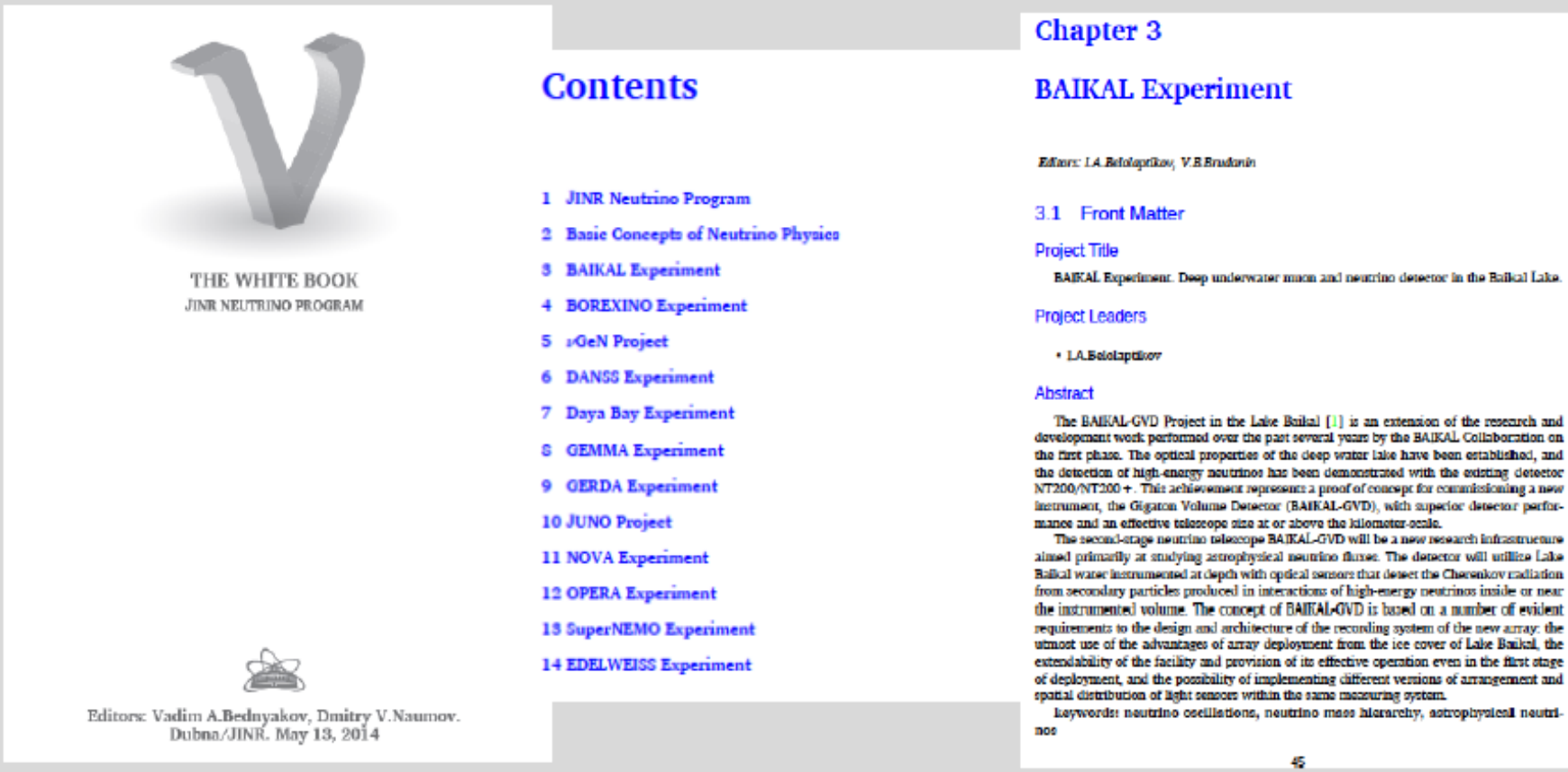
Coherent neutrino-nucleus scattering (vGEN)
Precise measurements of neutrino oscillations (Daya Bay, BOREXINO)
Neutrino mass hierarchy (JUNO, NOvA)
Neutrinoless 2β –Decay search: (SuperNEMO, GERDA, Majorana)

Astrophysical neutrino sources



"White Book" documents the JINR neutrino program

Every experiment — participant of the neutrino program — is described in a uniform format in the Book (about 300 pages):



THE WHITE BOOK
JINR NEUTRINO PROGRAM

Editors: Vadim A.Bednyakov, Dmitry V.Naumov.
Dubna/JINR. May 13, 2014

Contents

Chapter 3

BAIKAL Experiment

Editors: I.A.Belolaptikov, V.B.Brudanin

3.1 Front Matter

Project Title

BAIKAL Experiment. Deep underwater muon and neutrino detector in the Baikal Lake.

Project Leaders

• I.A.Belolaptikov

Abstract

The BAIKAL-GVD Project in the Lake Baikal [1] is an extension of the research and development work performed over the past several years by the BAIKAL Collaboration on the first phase. The optical properties of the deep water lake have been established, and the detection of high-energy neutrinos has been demonstrated with the existing detector NT200/NT200+. This achievement represents a proof of concept for commissioning a new instrument, the Gigaton Volume Detector (BAIKAL-GVD), with superior detector performance and an effective telescope size at or above the kilometer-scale.

The second-stage neutrino telescope BAIKAL-GVD will be a new research infrastructure aimed primarily at studying astrophysical neutrino fluxes. The detector will utilize Lake Baikal water instrumented at depth with optical sensors that detect the Cherenkov radiation from secondary particles produced in interactions of high-energy neutrinos inside or near the instrumented volume. The concept of BAIKAL-GVD is based on a number of evident requirements to the design and architecture of the recording system of the new array: the utmost use of the advantages of array deployment from the ice cover of Lake Baikal, the extendability of the facility and provision of its effective operation even in the first stage of deployment, and the possibility of implementing different versions of arrangement and spatial distribution of light sensors within the same measuring system.

Keywords: neutrino oscillations, neutrino mass hierarchy, astrophysical neutrinos

About 200 (100) participants (scientists) take part in the JINR neutrino program, 60 of them are younger 35 years old. JINR member-states are strongly involved. Internationality — NOvA, JUNO, EDELWEISS, SuperNEMO, ... → http://dlnp.jinr.ru/en/neutrino-research

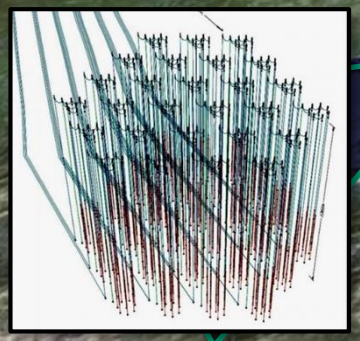
Neutrino programme: Baikal

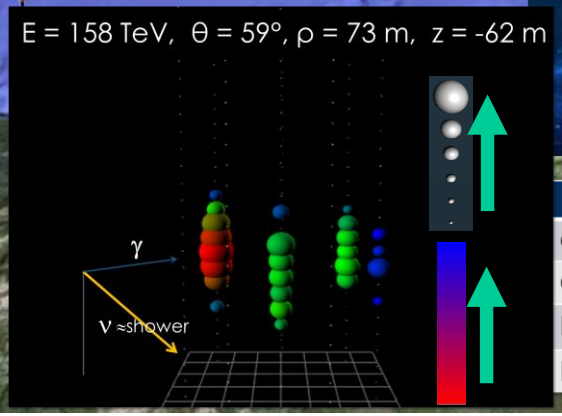
Project Baikal-GVD

Central Physics Goals:

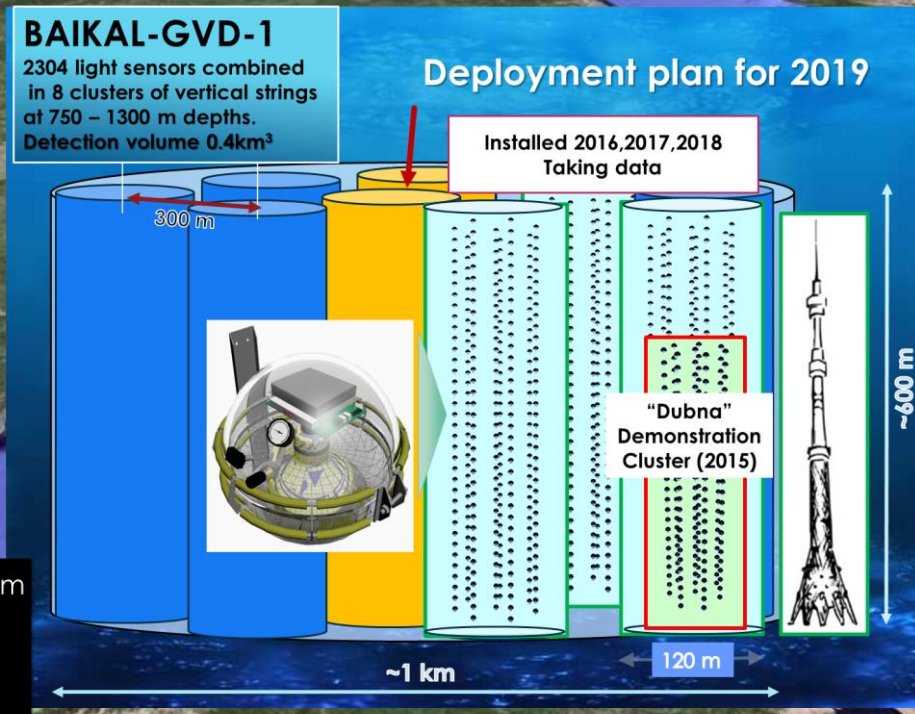
- Investigate Galactic and extragalactic neutrino "point sources" in energy range > 3 TeV
- Diffuse neutrino flux – energy spectrum, local and global anisotropy, flavor content
- Transient sources (GRB, binaries, …)
- Dark matter – indirect search
- Exotic particles – monopoles, Q-balls, nuclearites, …

Shore station





BAIKAL-GVD-1
2304 light sensors combined in 8 clusters of vertical strings at 750 – 1300 m depths.
Detection volume 0.4km³



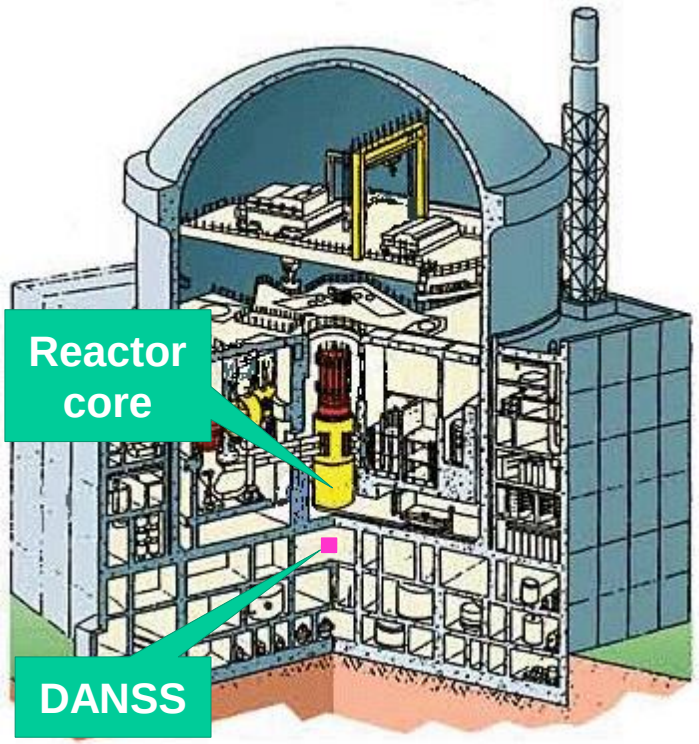
	GVD-1
OMs	2304
Clusters (8 Strings)	8
Depths, m	750 – 1275
Eff. Volume (E_{SH} > 100 TeV)	0.4 km³

Directional resolution
Cascades: ~3°
Muons: 0.25° - 0.5°

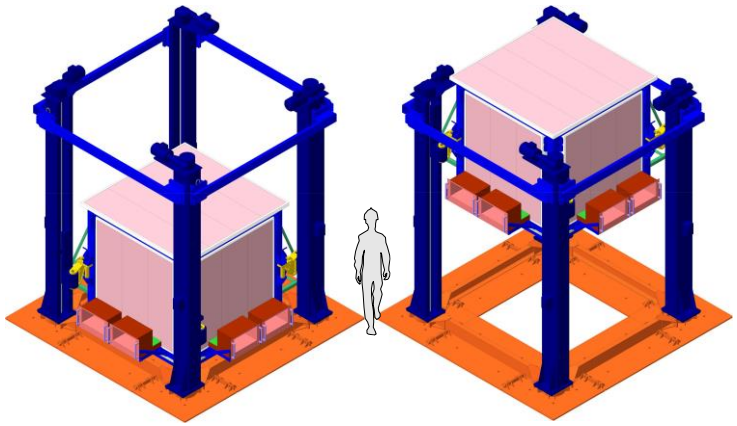
Neutrino programme: DANSS

Reactor monitoring and search for short-range neutrino oscillations

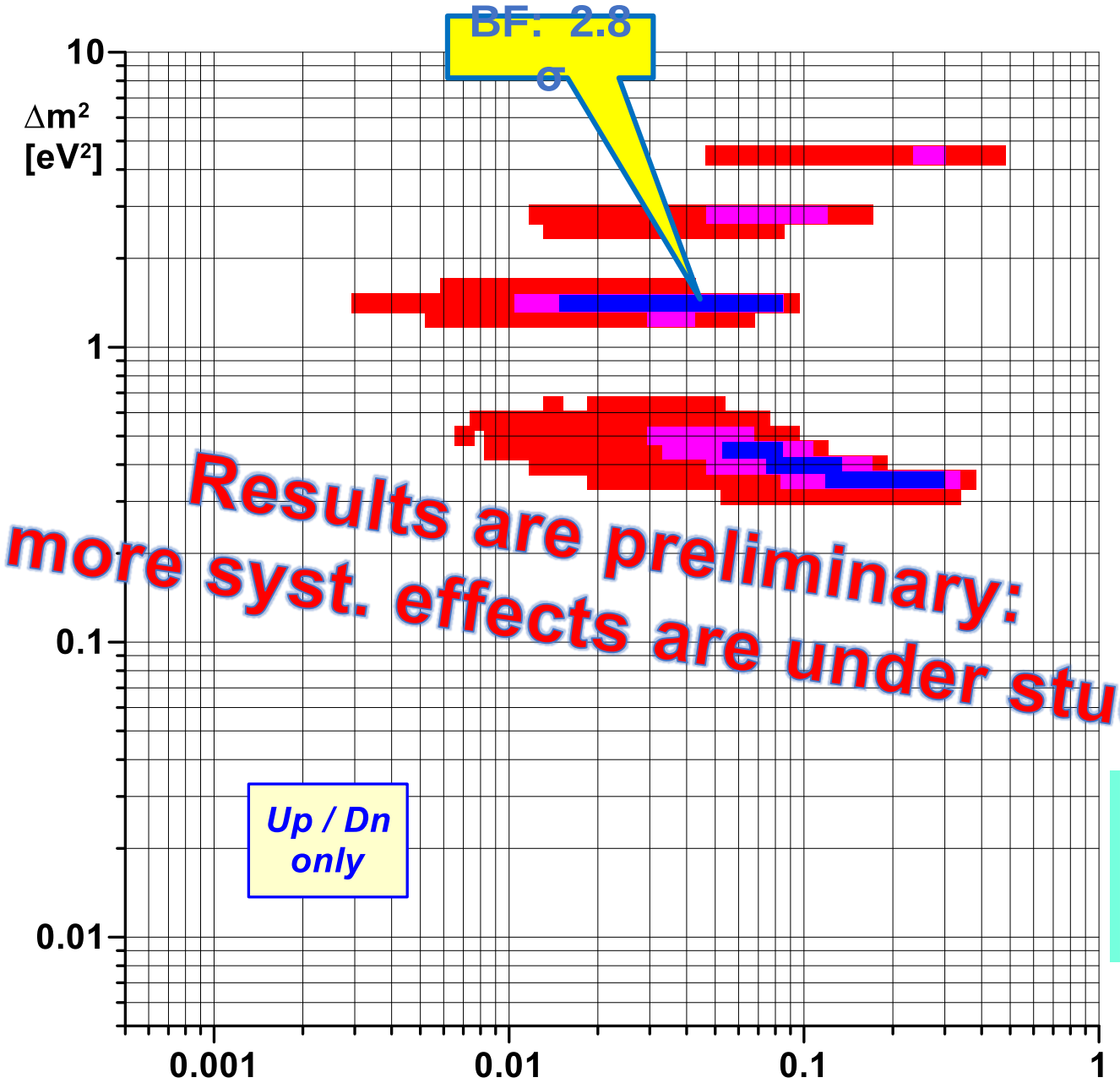
JINST 11 (2016) no.11, P11011; arXiv:1606.02896



- Segmented "XY" plastic scintillator (1 m^3 =1.1 tn) close to the core of the Kalinin NPP reactor #4
- Overburden ~ 50 m w.e. (reactor cauldron, cooling pond, concrete)
- 3D-information about each event
- IBD count rate $\sim 4000\ \bar{\nu}_e$ / day; Signal / BG ~ 40
- Lifting platform => distance variable on-line (L ≈ 10.7-12.7 m)
- Status: data taking



Significance of the best regions



3 σ means
not a discovery,
but just
a cause of thinking

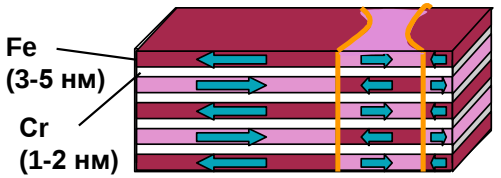
JINR's Large-Scale Basic Facilities

The IBR-2M pulsed reactor of periodic action is included in the 20-year European strategic programme of neutron scattering research.

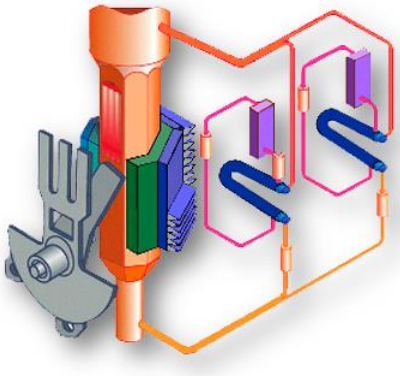
Fuel: PuO_2 , Average power: 2 MW ($8 \cdot 10^{12}$ n/cm^2/s), 5Hz, Pulsed power:1500 MW ($5 \cdot 10^{15}$ n/cm^2/s), width: 215/320 μs, 14 neutron channels.

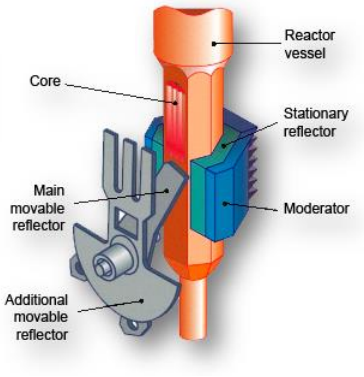
Nanosystems and Nanotechnologies

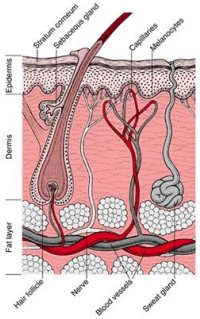
Novel Materials



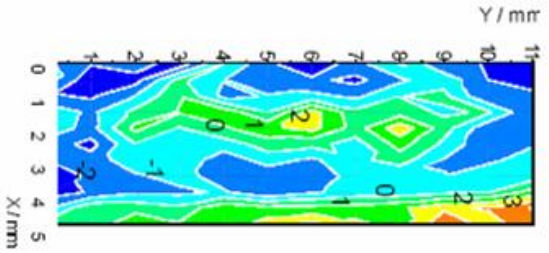
Biomedical Research







Engineering diagnostics. Earth Sciences



Fundamental and applied research in condensed matter physics and related fields: biology, medicine, material sciences, geophysics, engineer diagnostics - aimed at probing the structure and properties of nanosystems, new materials, and biological objects, and at developing new electronic, bio- and information nanotechnologies.

Thank You!