Leonid Grigorenko

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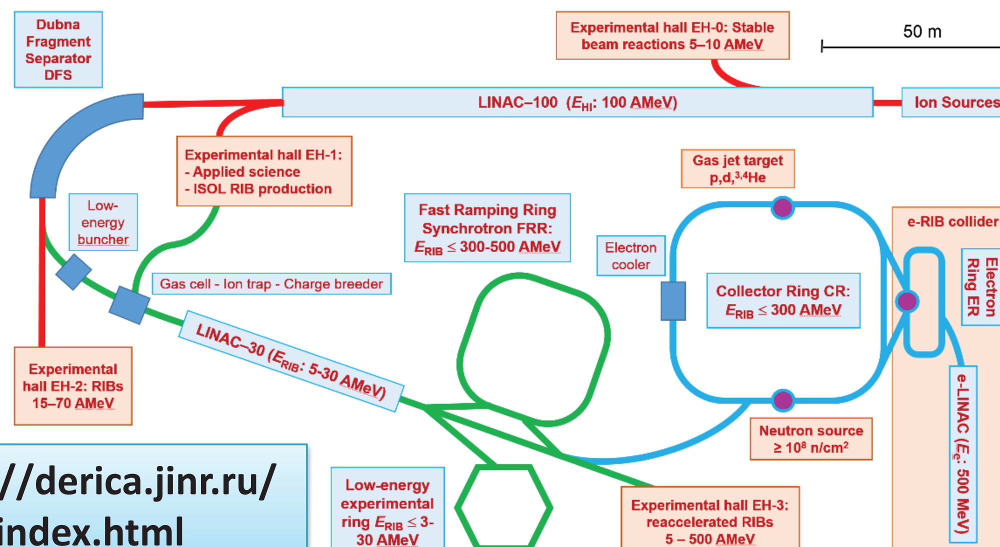
# DERICA - prospective facility for radioactive ion studies in storage rings and electron collider


http://derica.jinr.ru/index.html



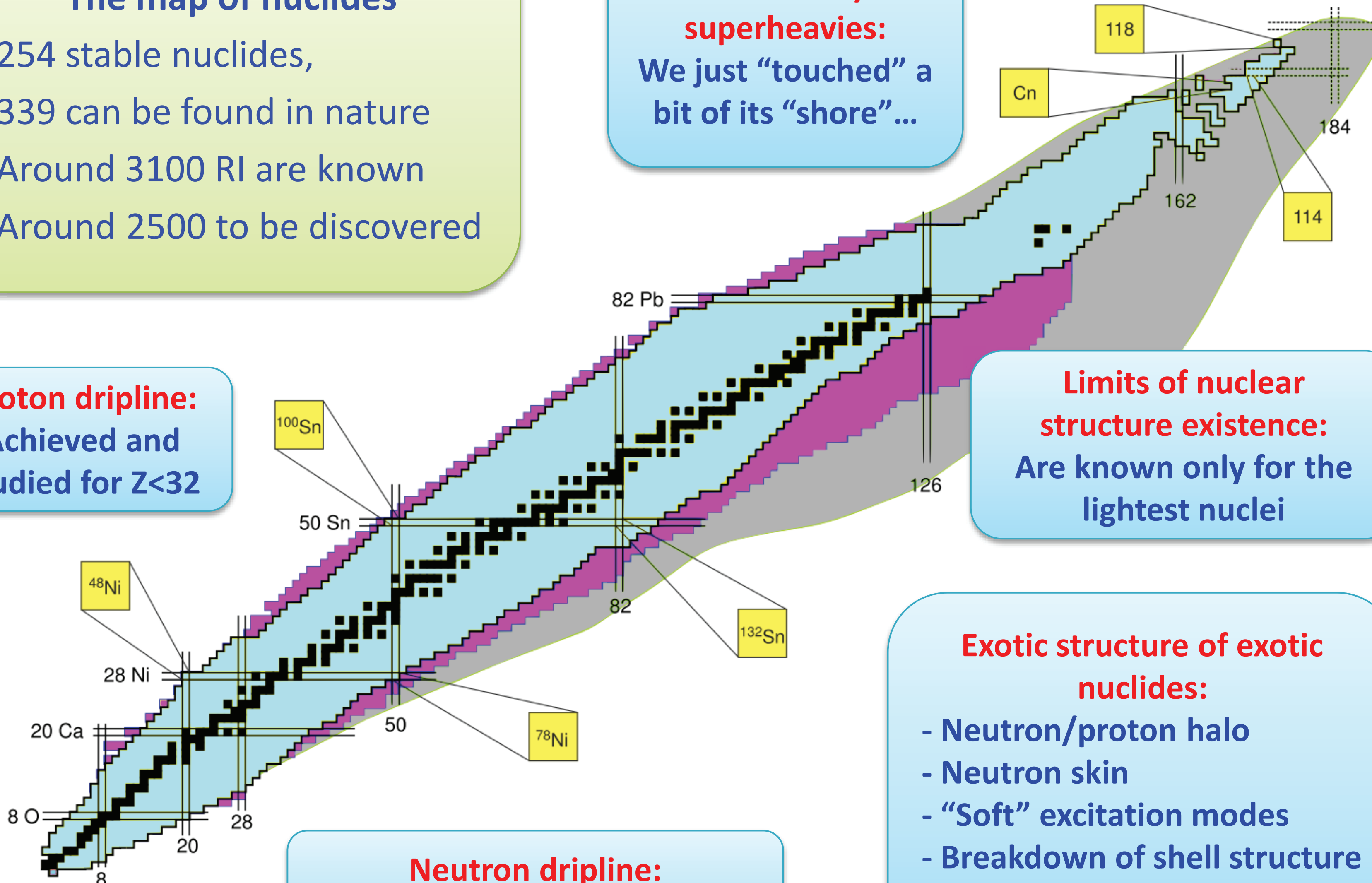
# RADIOACTIVE ION BEAM (RIB) physics

# Radioactive Ion Beam (RIB) physics

**The map of nuclides**

- 254 stable nuclides,
- 339 can be found in nature
- Around 3100 RI are known
- Around 2500 to be discovered

**"Isle of stability" for superheavies:**
**We just "touched" a bit of its "shore"…**



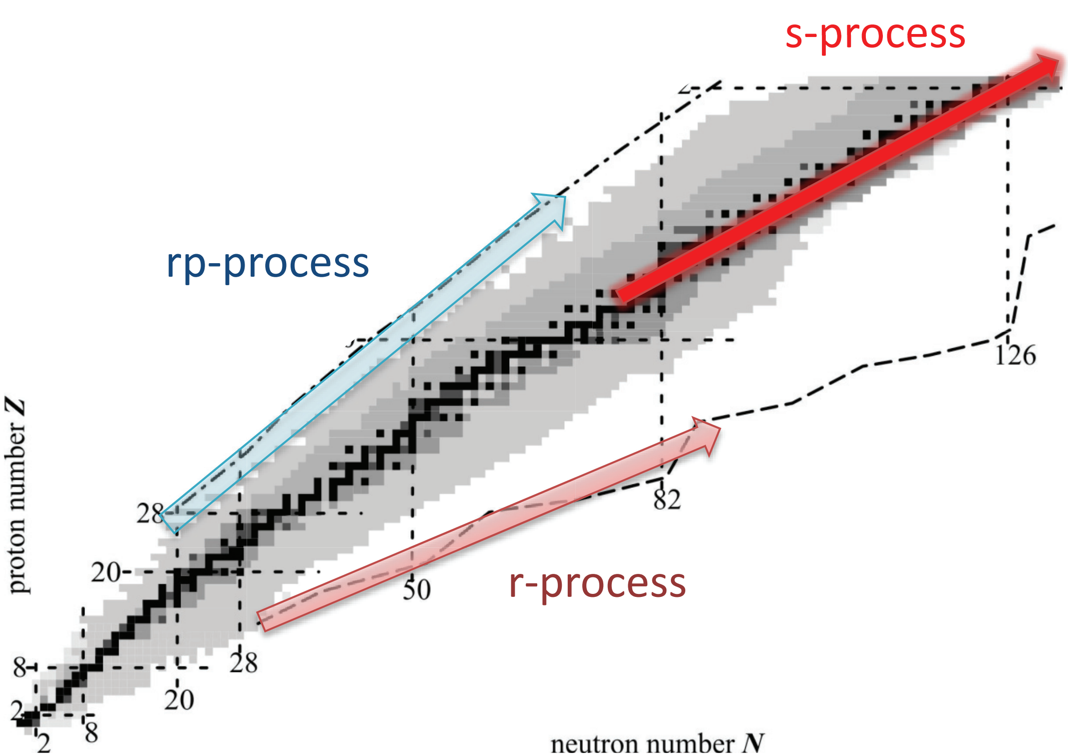

**Proton dripline:**
**Achieved and studied for Z<32**

**Limits of nuclear structure existence:**
**Are known only for the lightest nuclei**

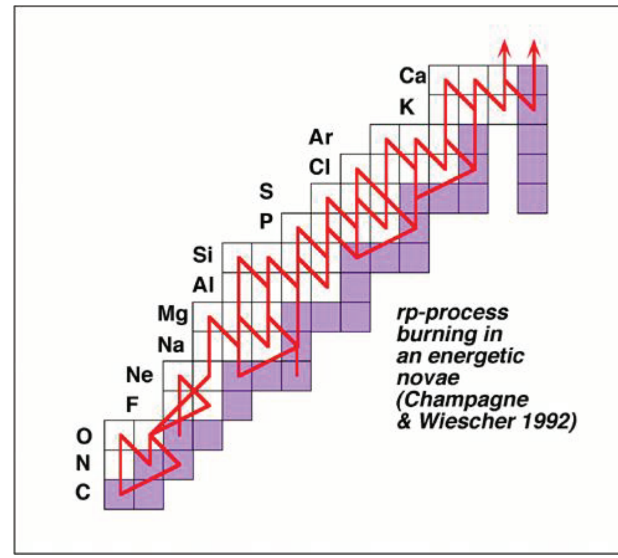
**Exotic structure of exotic nuclides:**
- **Neutron/proton halo**
- **Neutron skin**
- **"Soft" excitation modes**
- **Breakdown of shell structure**
- **New "magic numbers"**

**Neutron dripline:**
**Achieved and studied for N<20**

# Motivation – Applications to nucleosynthesys




rp-process fragment




- Hydrostatic burning – slow process
- Explosive burning – rapid processes
- R-process nucleosynthesis: supernovae and collisions of neutron stars
- Rp-process nucleosynthesis: gamma-bursts

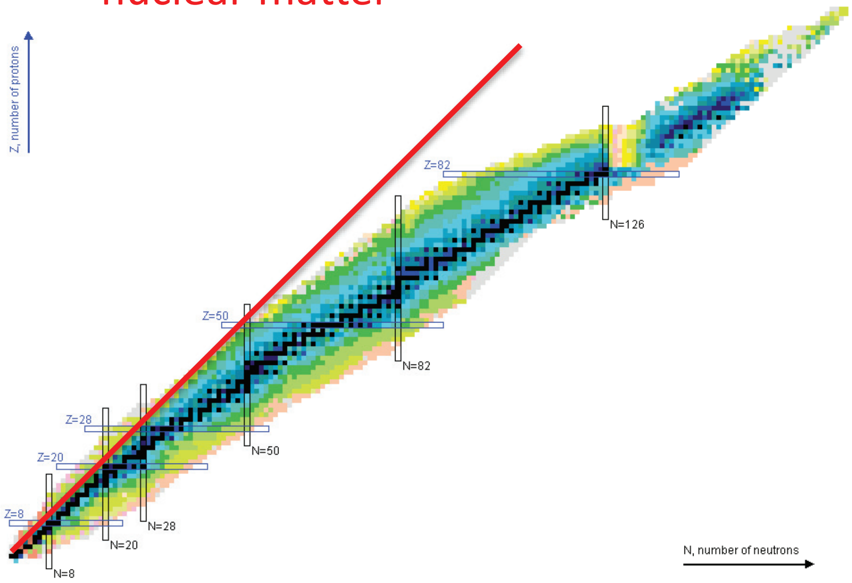
**Here will be no reliable knowledge about rapid nucleosynthesis unless we study nuclides up to the driplines**

# Motivation – Applications to neutron stars

**PV = (m/μ) RT**

**Equation of state for ideal gas. What about nuclear matter?**

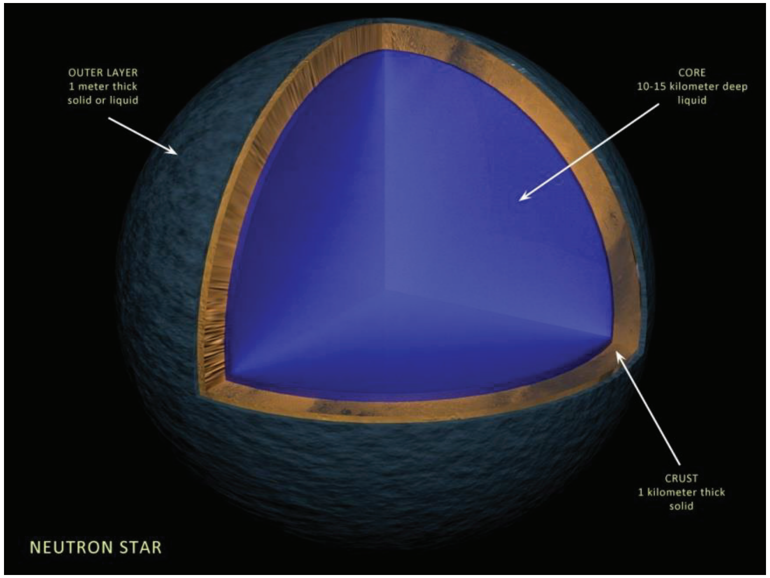
Known nuclei: practically symmetric nuclear matter




**All the heavy elements in the Universe are produced in explosive nucleosynthesys**

**Supernovae explosions. How we get from neutron star to Supernova?**

Neutron star: very large nucleus with absolutely asymmetric nuclear matter




**Moving towards the driplines we get experimental knowledge about more and more asymmetric nuclear matter**

# Flerov Laboratory of Nuclear Reactions

# RIB studies at FLNR

# What we already have at Flerov lab

Elements 102 - 108 and 113 - 118 were synthesized at FLNR JINR

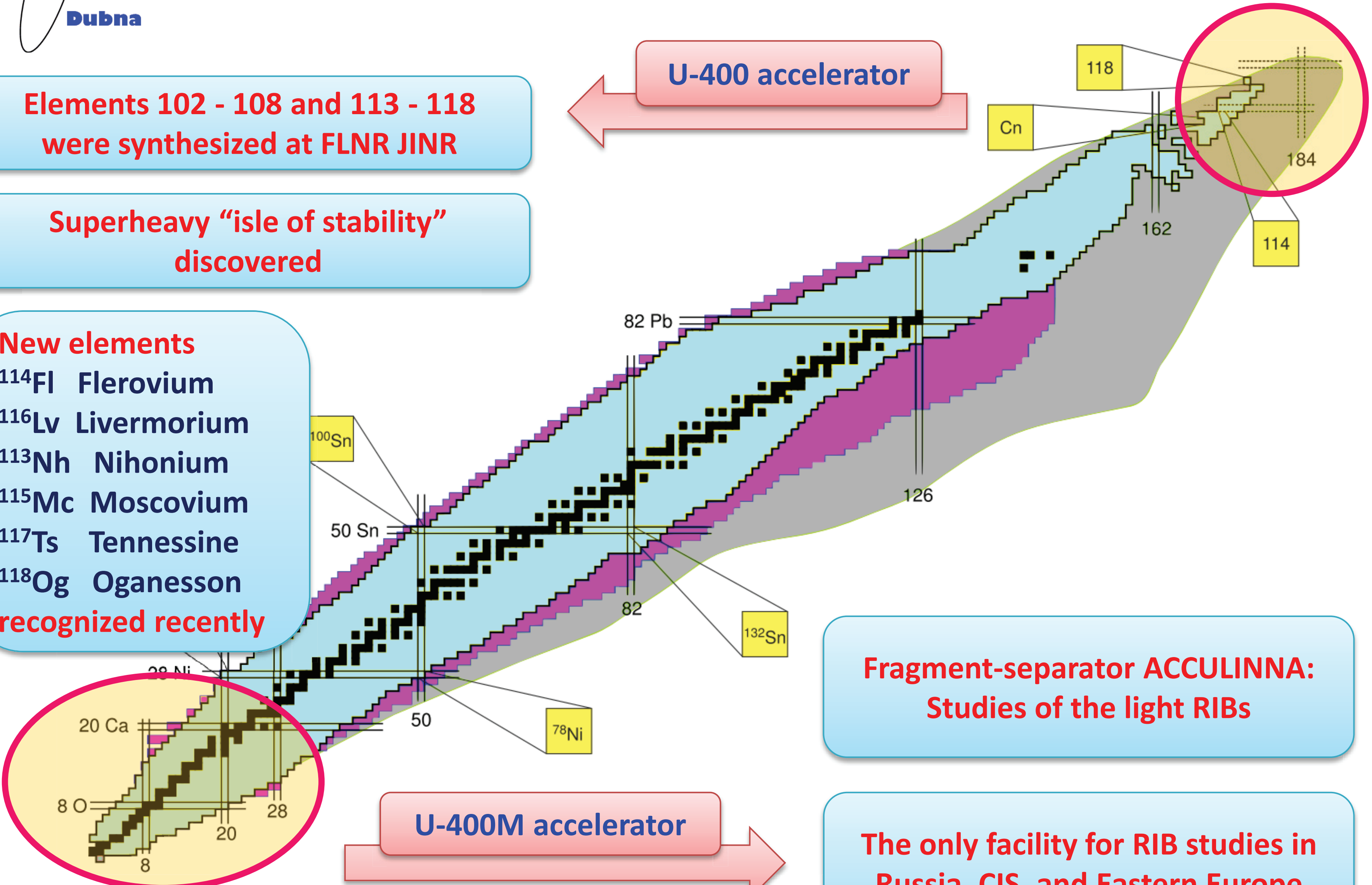
Superheavy "isle of stability" discovered

**New elements**

$^{114}$Fl Flerovium
$^{116}$Lv Livermorium
$^{113}$Nh Nihonium
$^{115}$Mc Moscovium
$^{117}$Ts Tennessine
$^{118}$Og Oganesson

recognized recently

U-400 accelerator




U-400M accelerator

Fragment-separator ACCULINNA: Studies of the light RIBs

The only facility for RIB studies in Russia, CIS, and Eastern Europe

# March 30 2018 – The Lomonosov great gold medal is awarded to Yuri Oganessian and Bjorn Jonson

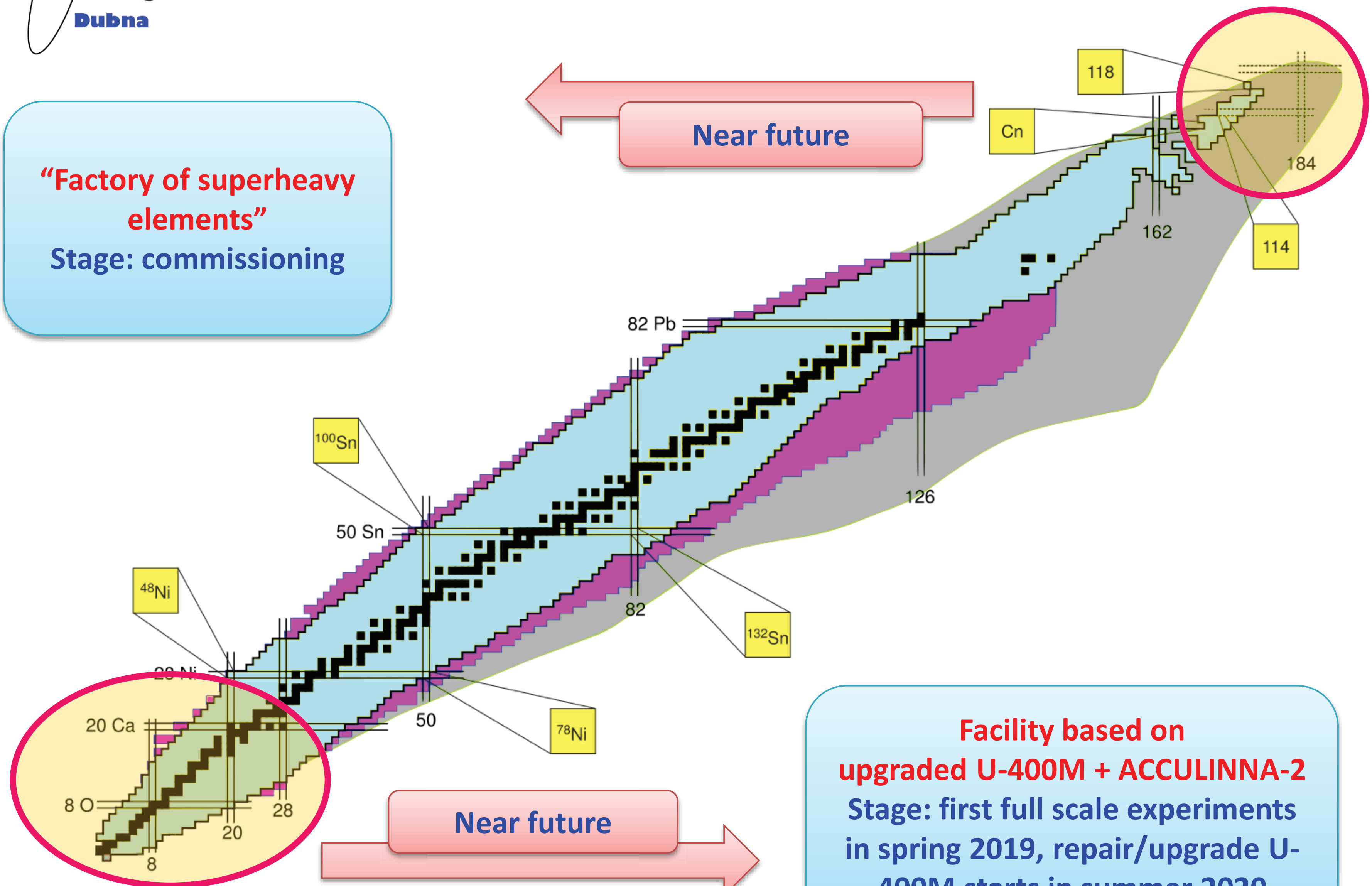
**Yu.Ts. Oganessian –** synthesis of superheavy elements

**B. Jonson –** contribution of studies of exotic nuclei (ISOL method and nucleon halo)

2019 – is the "year of Mendeleev periodic law"

# Mid-range planning prospects

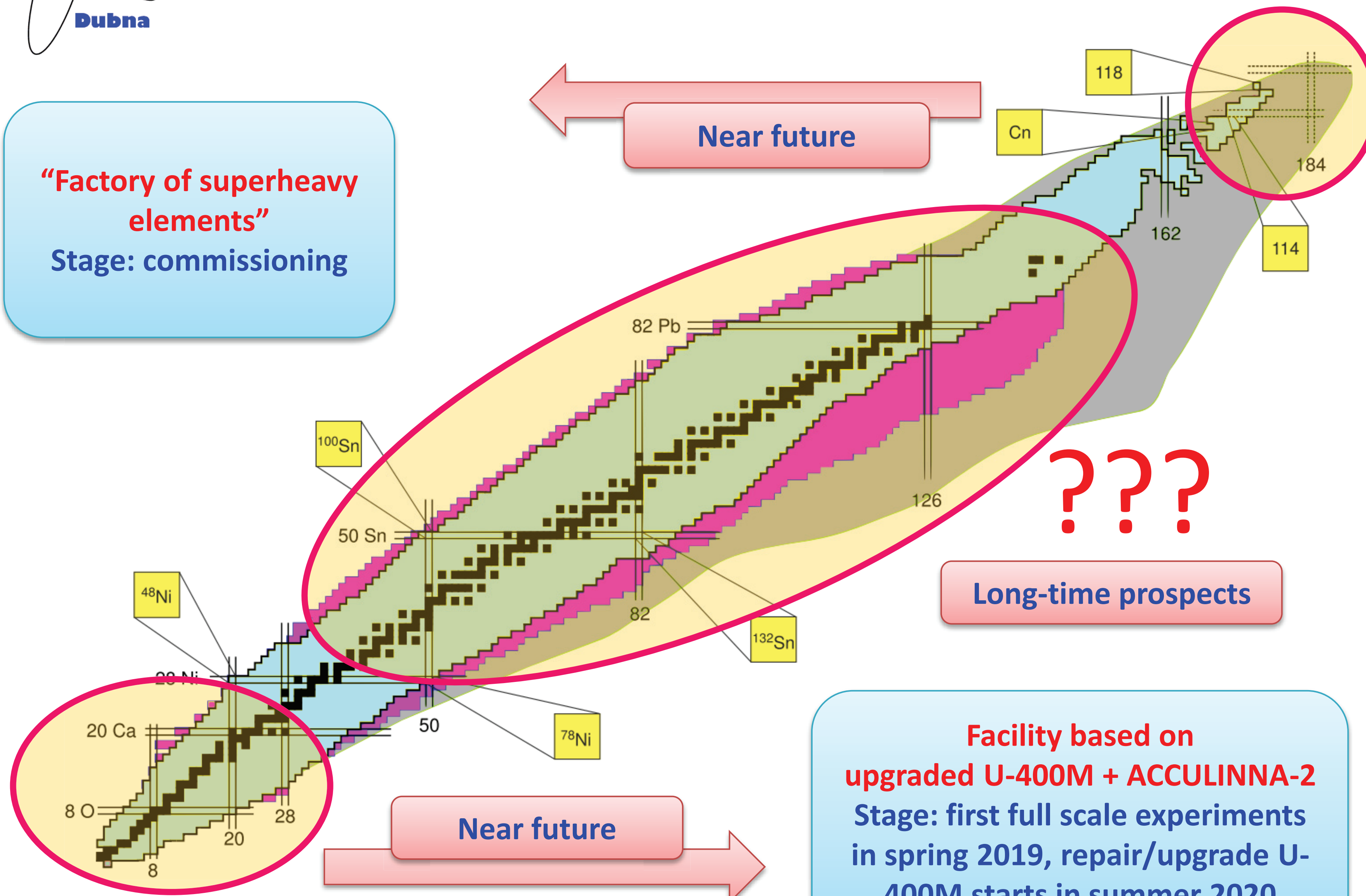
"Factory of superheavy elements"
Stage: commissioning




Facility based on upgraded U-400M + ACCULINNA-2
Stage: first full scale experiments in spring 2019, repair/upgrade U-400M starts in summer 2020

# Long-range planning prospects

"Factory of superheavy elements"
Stage: commissioning

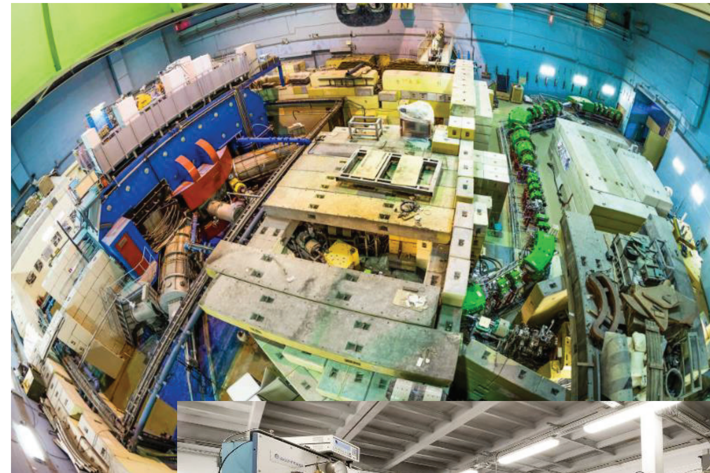



Facility based on
upgraded U-400M + ACCULINNA-2
Stage: first full scale experiments in spring 2019, repair/upgrade U-400M starts in summer 2020

# New facilities at FLNR

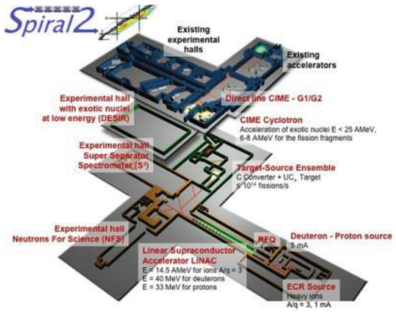
## "Factory of superheavy elements"

## ACCULINNA-2 fragment-separator



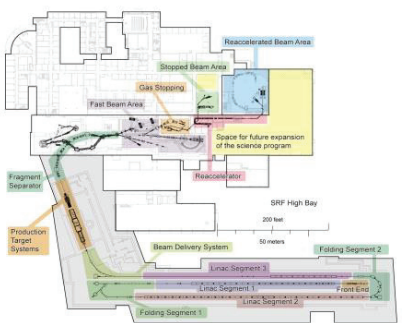
# RIB facilities in the world

# RIB factories: Big, bigger, the biggest…

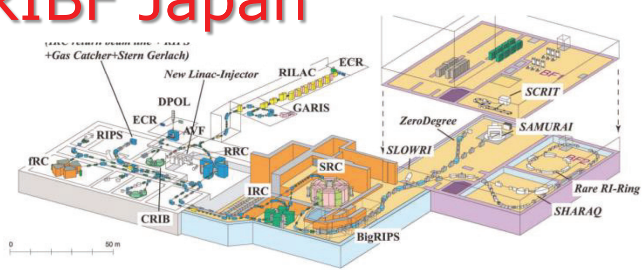


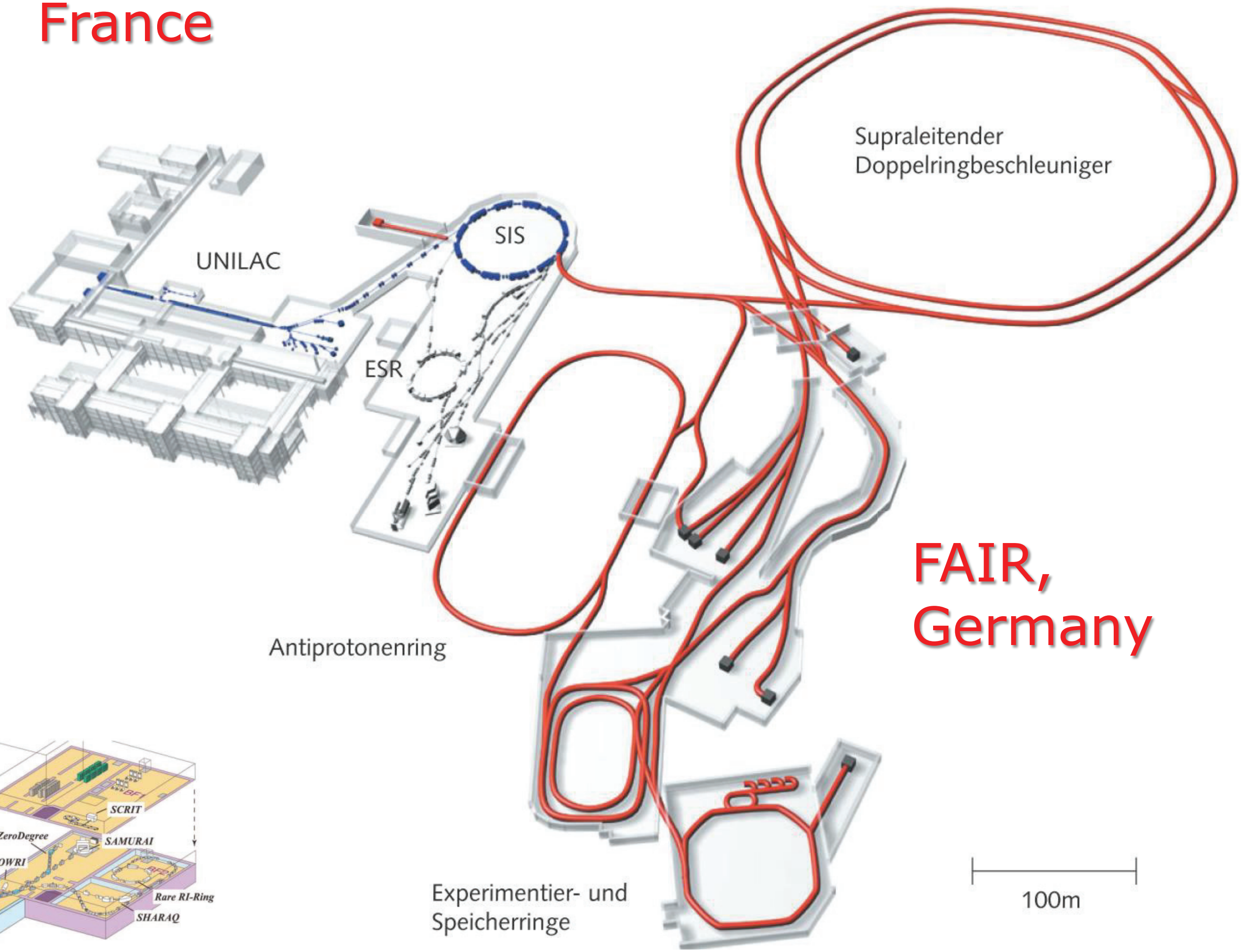

SPIRAL2
France

FRIB USA




RIBF Japan

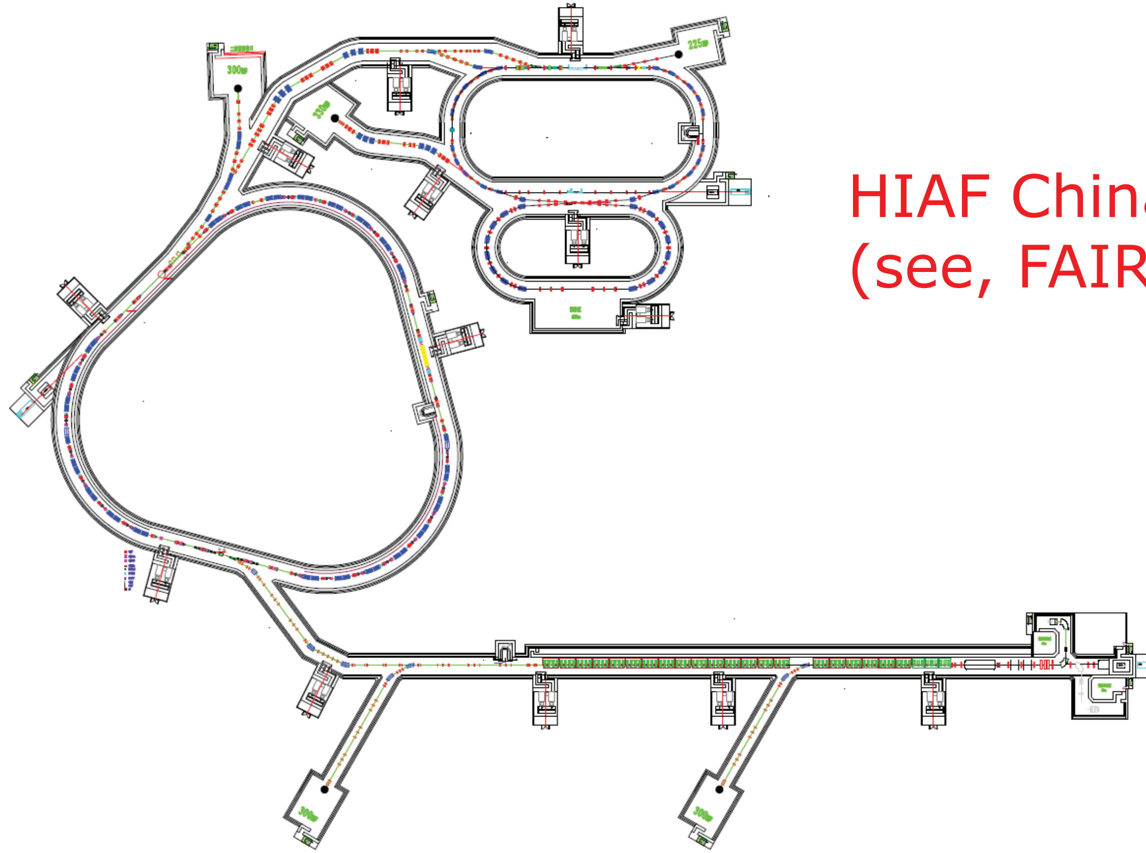



FAIR,
Germany

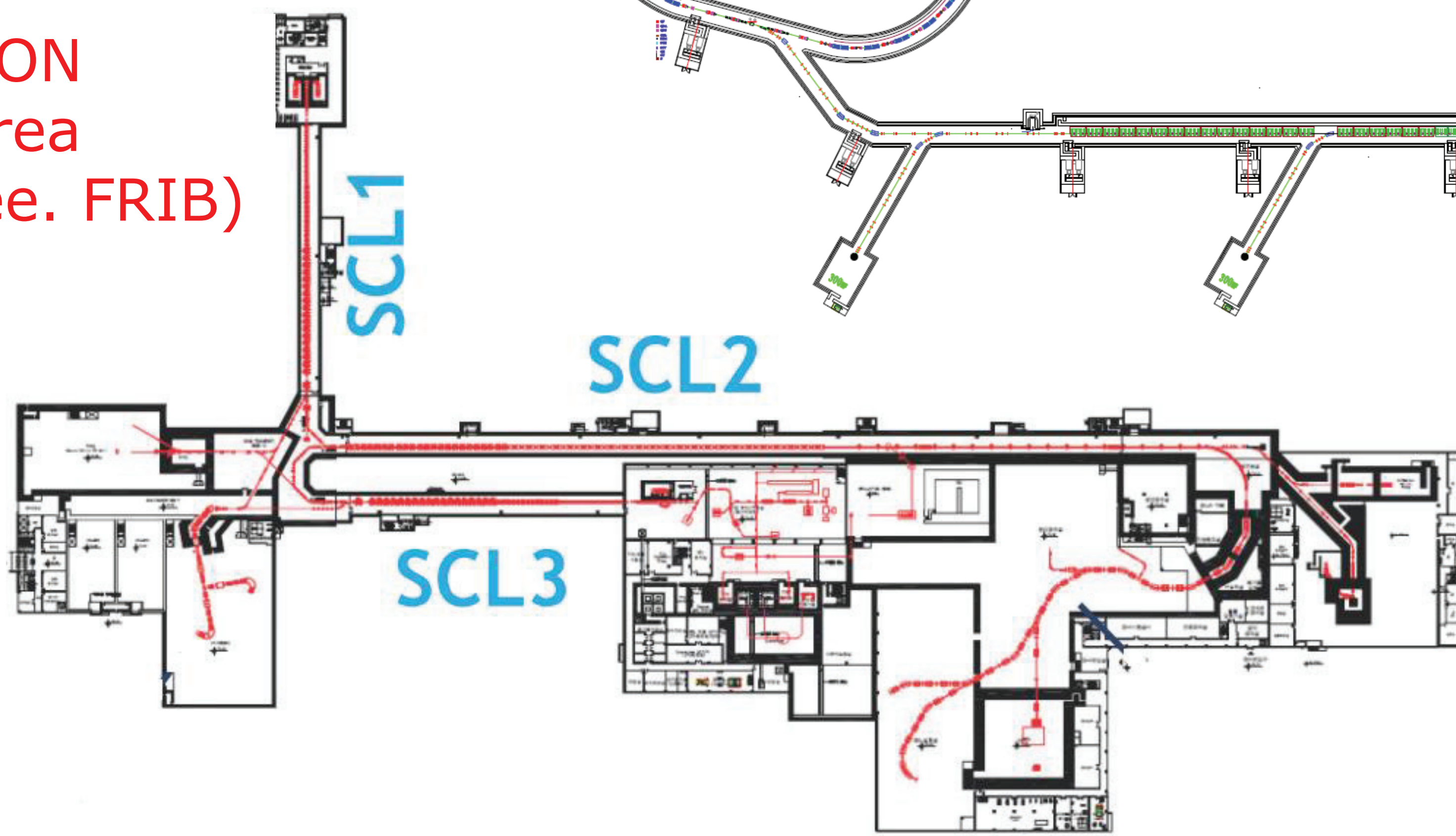
# However,
# even bigger…

**Horizontal size of the slide ~1 km**



HIAF China
(see, FAIR)

RAON
Korea
(see. FRIB)



**Huge increase in the scale of modern and prospective RIB facilities:**
**Starting price tag 1-2 G€**

**Scale increase – (i) RIB production increase via primary beam energy increase and (ii) universality of RIB facility**

**Is it possible to have world competitive RIB program with modest investment scale?**

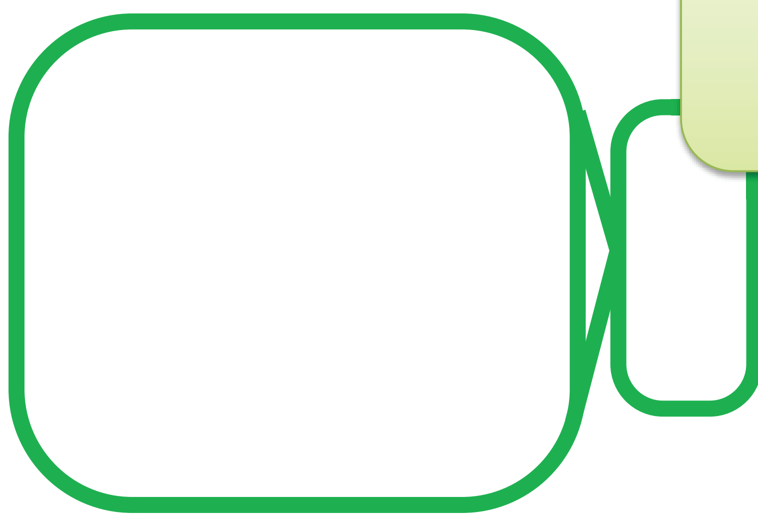
To limit universality

To go to "underdeveloped" fields

# Empty “ecological niche”

**Underdeveloped field: storage ring physics with RIBs**

**Empty field: studies of RIBs in electron-RIB collider**




**Studies of electromagnetic formfactors of exotic nuclei in e-RIB collider**

Isochronous mass spectromentry

Precision reaction studies on internal gas jet target

Atomic physics studies with striped ions

Radioactivity studies with striped ions

Etc….

# Low-energy nuclear physics in storage rings

# Electron scattering

**After masses, the radial properties are the most important characteristics of nuclei**

**Robert Hofstadter** 1915-1990,
1961 Nobel Prize "for his pioneering studies of electron scattering in atomic nuclei and for his consequent discoveries concerning the structure of nucleons.."

- First Born approximation, fast electrons, relatively light nuclei

$$\left(\frac{d\sigma}{d\Omega}\right)_{\text{PWBA}} = \frac{\sigma_M}{1 + (2E/M_A)\sin^2(\theta/2)} |F_{\text{ch}}(q)|^2$$

$$\sigma_M = (e^4/4E^2)\cos^2(\theta/2)\sin^{-4}(\theta/2)$$

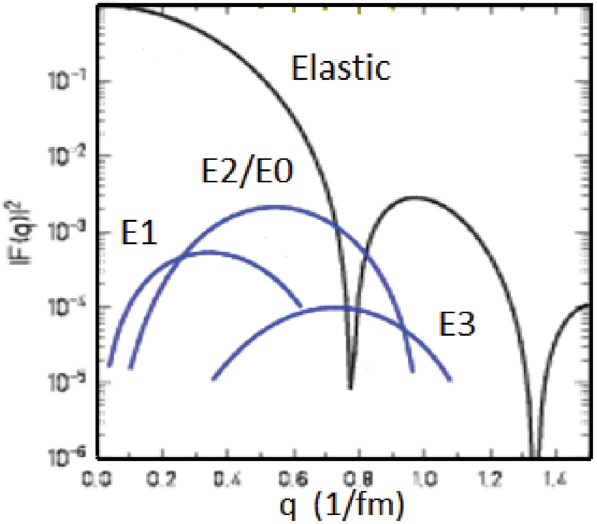
$$q = 2k\sin(\theta/2)$$

**Electromagnetic probe is the most reliably studied**
- Electron scattering

- Charge formfactor, charge radius

$$F_{\text{ch}}(q) = 4\pi \int_0^\infty dr\, r^2 j_0(qr)\rho_{\text{ch}}(r)$$

$$F_{\text{ch}}(q)/Z = 1 - \frac{q^2}{6}\langle r^2_{\text{ch}}\rangle + \cdots$$




- Experiments in traps – “static” EM characteristics -> derivation of $r_{\text{ch}}$

- Electron scattering – differenttial characteristics

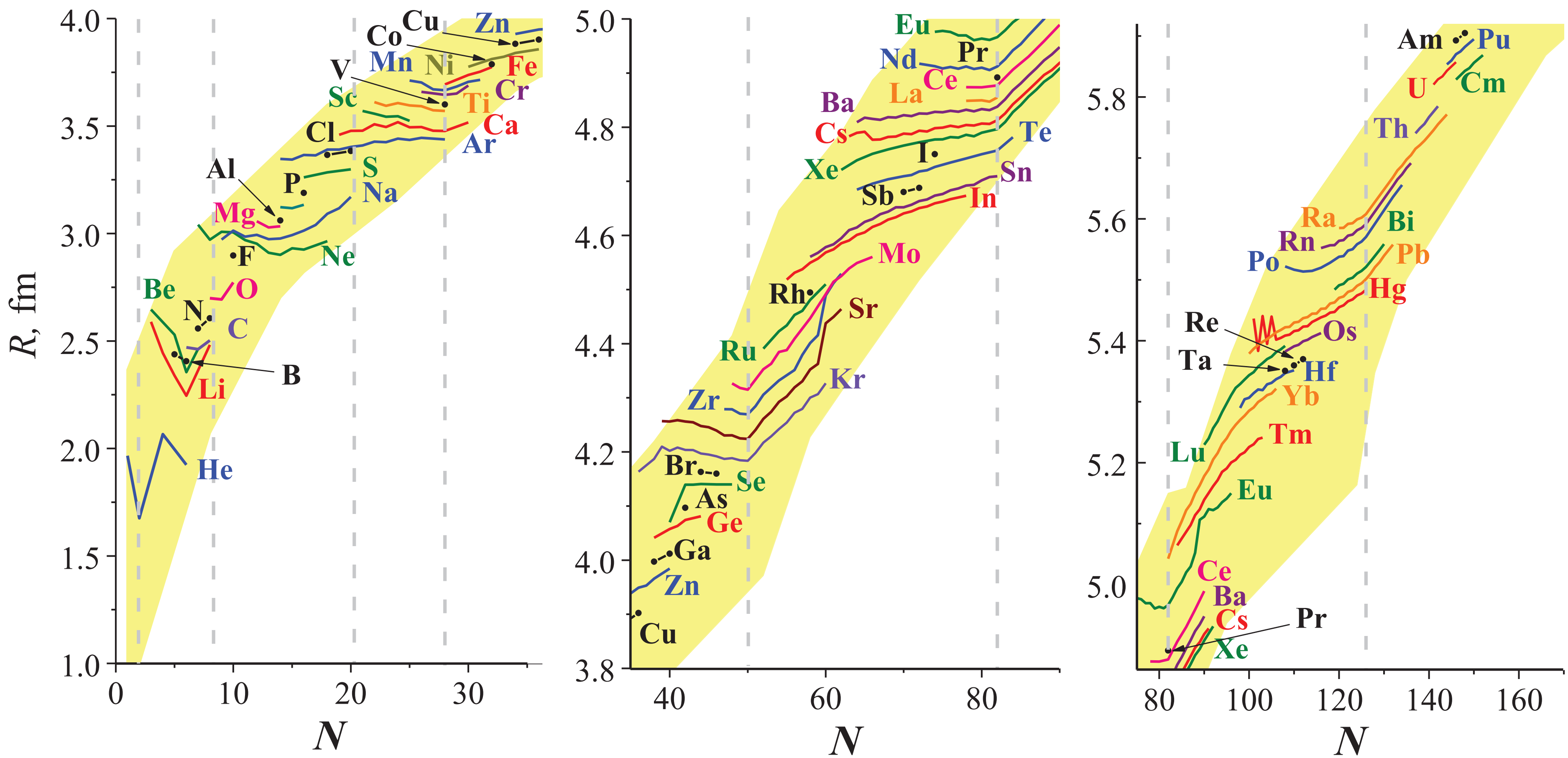
# Status of charge radii studies – broad field for exploration

**900 measured for 3100 known nuclear-stable isotopes**

**Some isotopic chains are well studied – some not at all**

**Somewhere driplines is nearly achieved – somewhere very far**

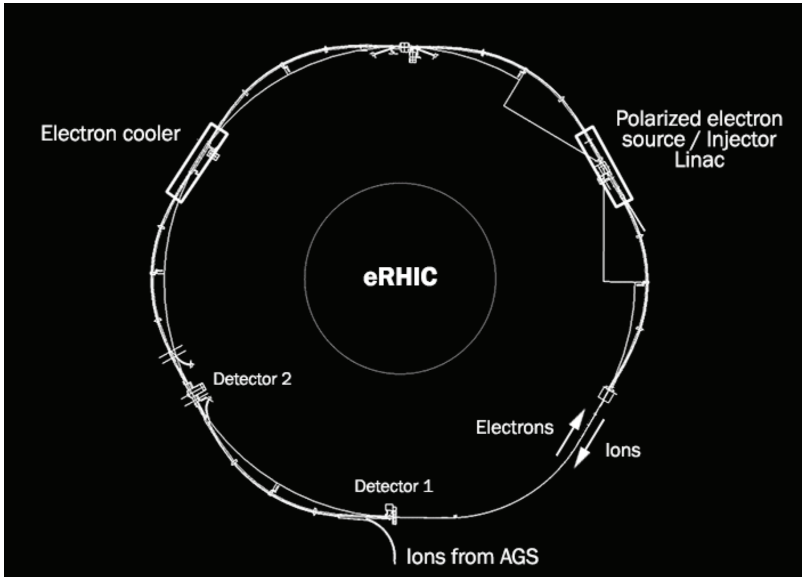
**Systematics demonstrate complicated dynamical effects in the isotopic chains, especially near the driplines**

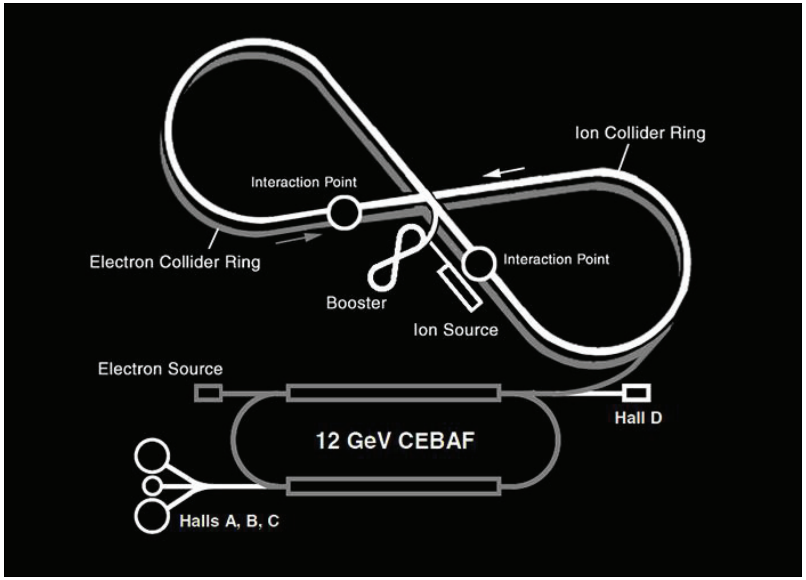


# Electron-ion colliders in high-energy physics …

**eRHIC – RHIC upgrade, Brookhaven National Laboratory**

**JLEIC – JLab Electron-Ion Collider, Thomas Jefferson National Accelerator Laboratory**




**Need for e-ion colliders:**
**– RIB physics: difficult to create an ion target in lab system**
**– High-energy physics: opportunity to flexibly choose the kinematical conditions and opportunity of polarized beam studies**

# К4-К10 project at FLNR


**Yu.Ts. Oganessian *et. al.*, Z. Phys. A341 (1992) 217**

Injection from U-400M

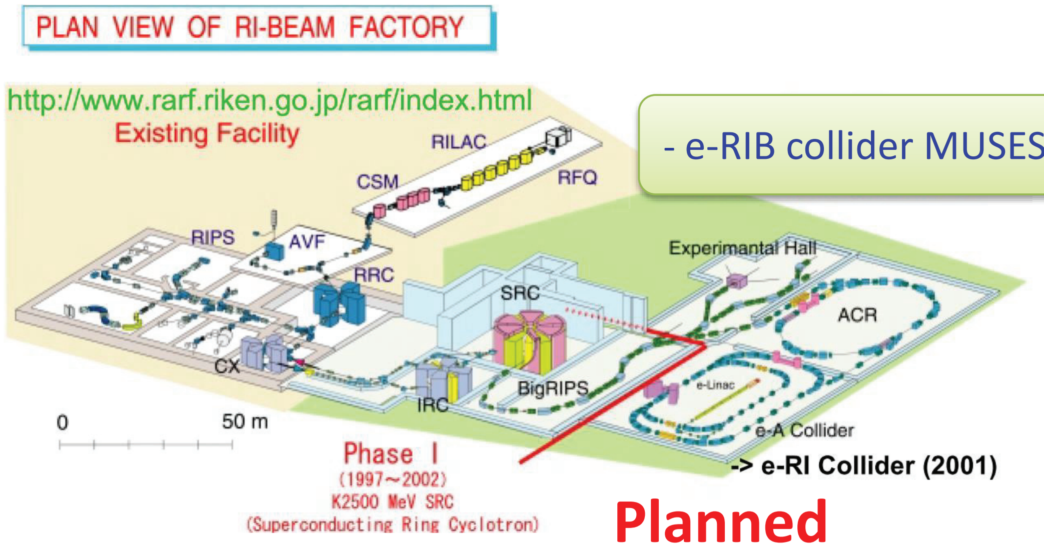
K4 ring (magnetic field 4 Tm)
- Storage
- Cooling
- Bunching
- Acceleration

Production and separation channel (fragment-separator)

K10 ring (magnetic field 10 Tm)
- High resolution spectrometer
- Reactions on the internal target

**Electron-ion collider**

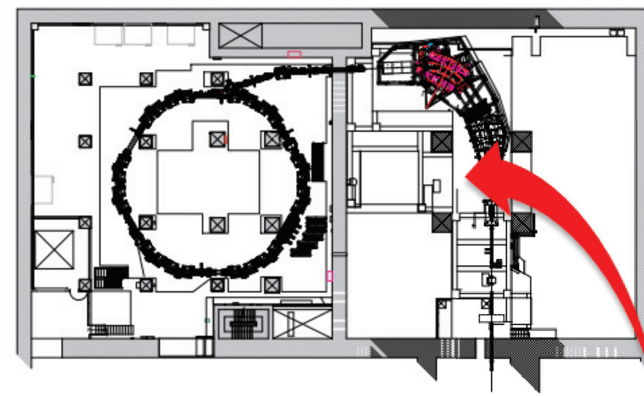
# e-RIB collider: evolution of RIKEN



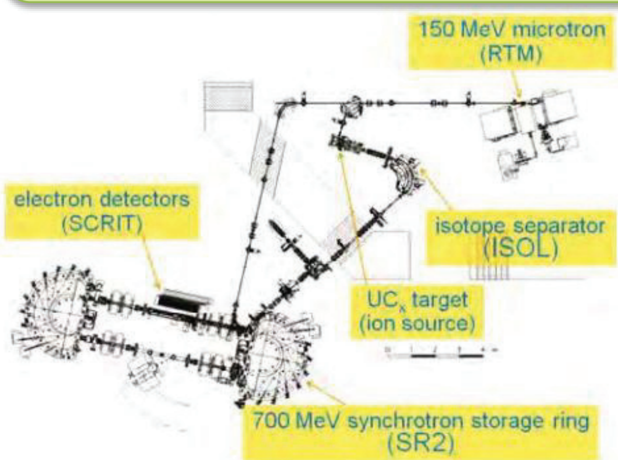

- e-RIB collider MUSES

**Planned**

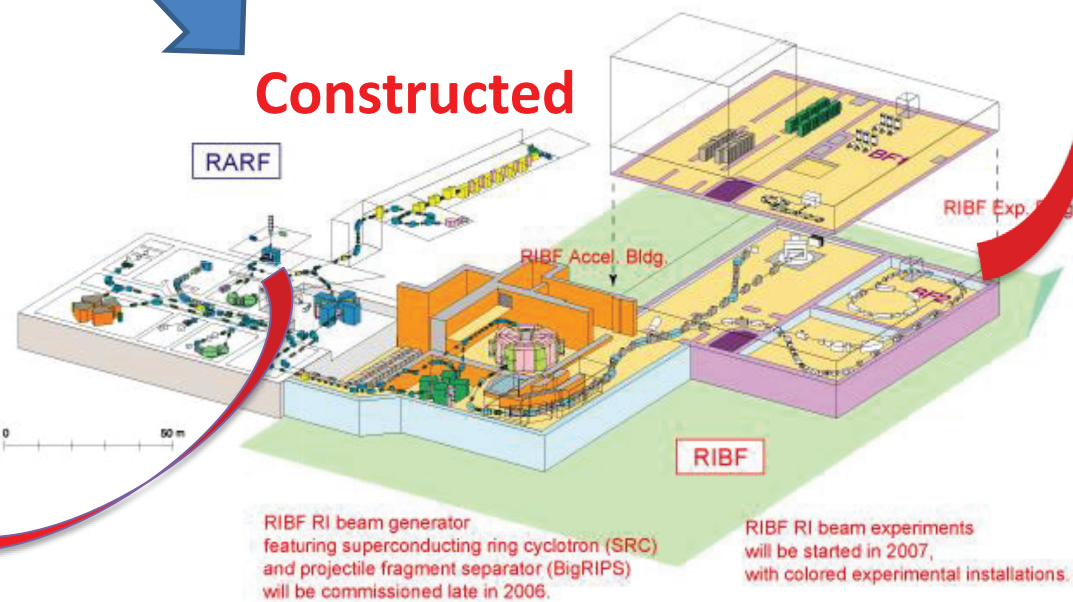
**RI-Ring**: isochronous mass spectroscopy for very rare events



**SCRIT**: separate small ISOL facility for e-RIB collisions in trap




**Constructed**

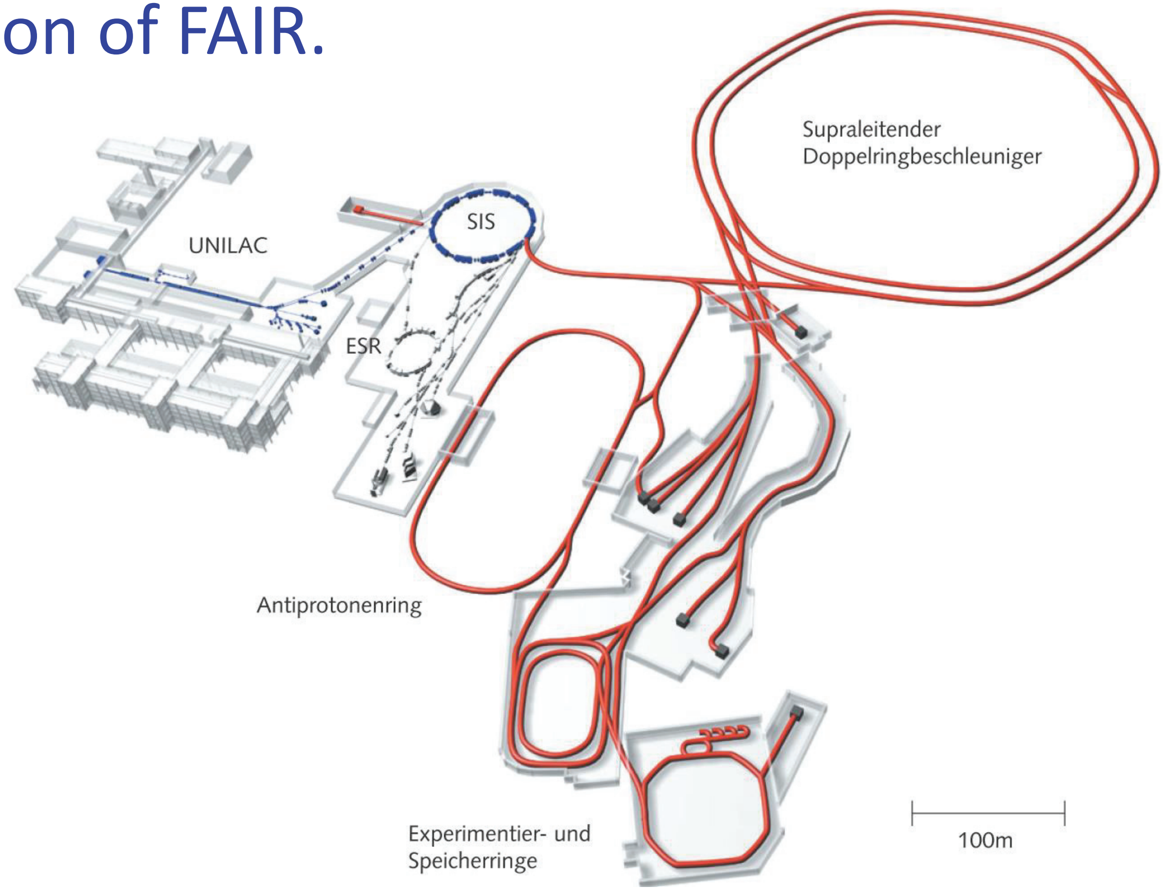


# e-RIB collider: evolution of FAIR.

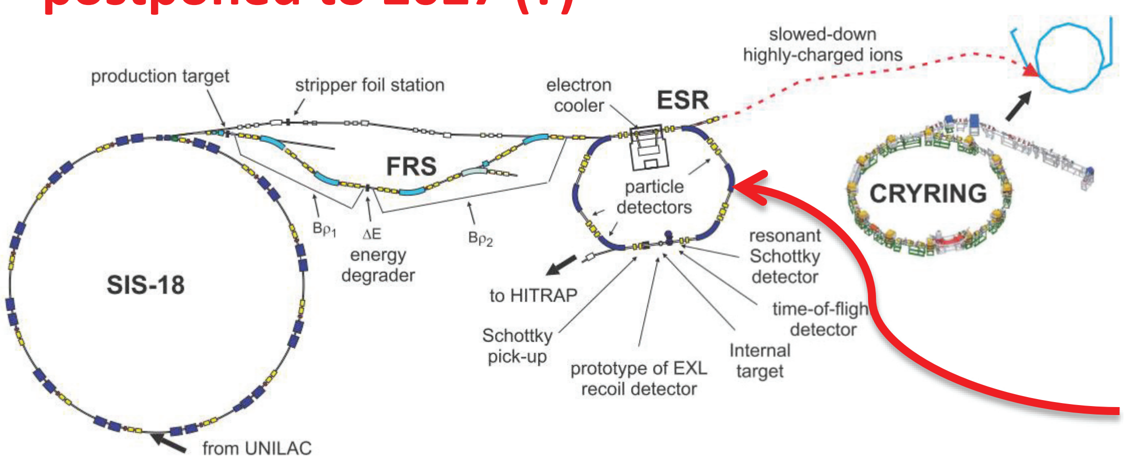
## Planned

**FAIR "Ring Branch":**
- Storage ring CR
- Experimental ring NESR

**NESR@FAIR:**
- e-RIB collider ELISE
- internal gaz target EXL




## Decision postponed to 2027 (?)

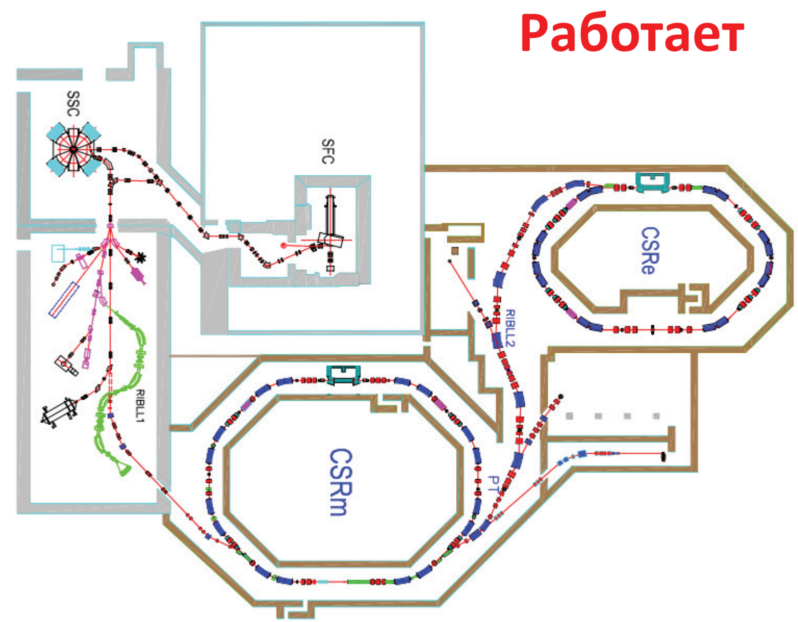


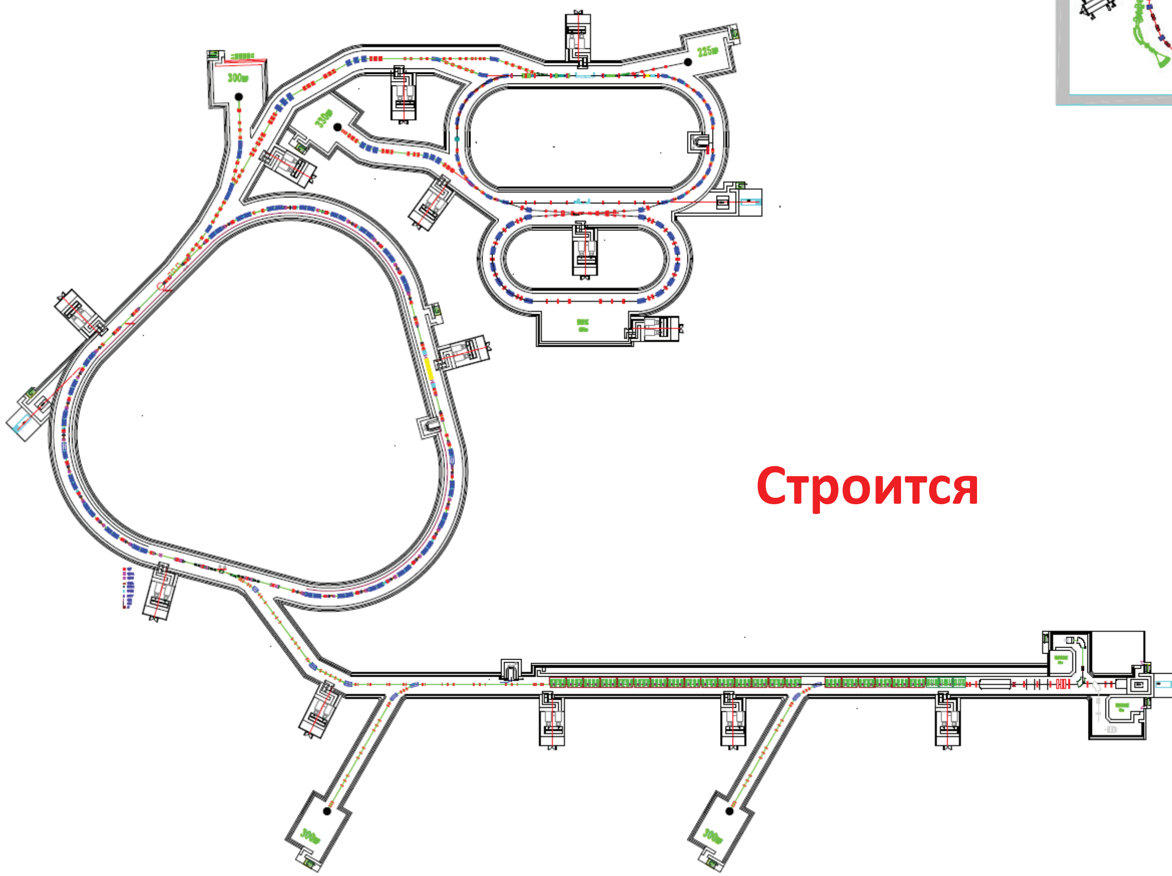

Low-energy program CRYRING relocation from Sweden

Opportunity to include ESR in FAIR: beam line from SuperFRS ???
L ~ 200 m !!!

# Storage rings in China

**HIRFL-CSR@Lanzhou**
- Weak "driver"
- Driver upgrade considered




**HIAF:**
- 2 storage rings
- 1-st – mainly "spectrometer"
- 2-nd – reactions in "merged beam" kinematics

**These are all "different" storage rings...**

# Continuous interest to low-energy nuclear physics in storage rings and e-RIB collision topic

DERICA - is female name of German origin with meaning “beloved leader, ruler of the people”

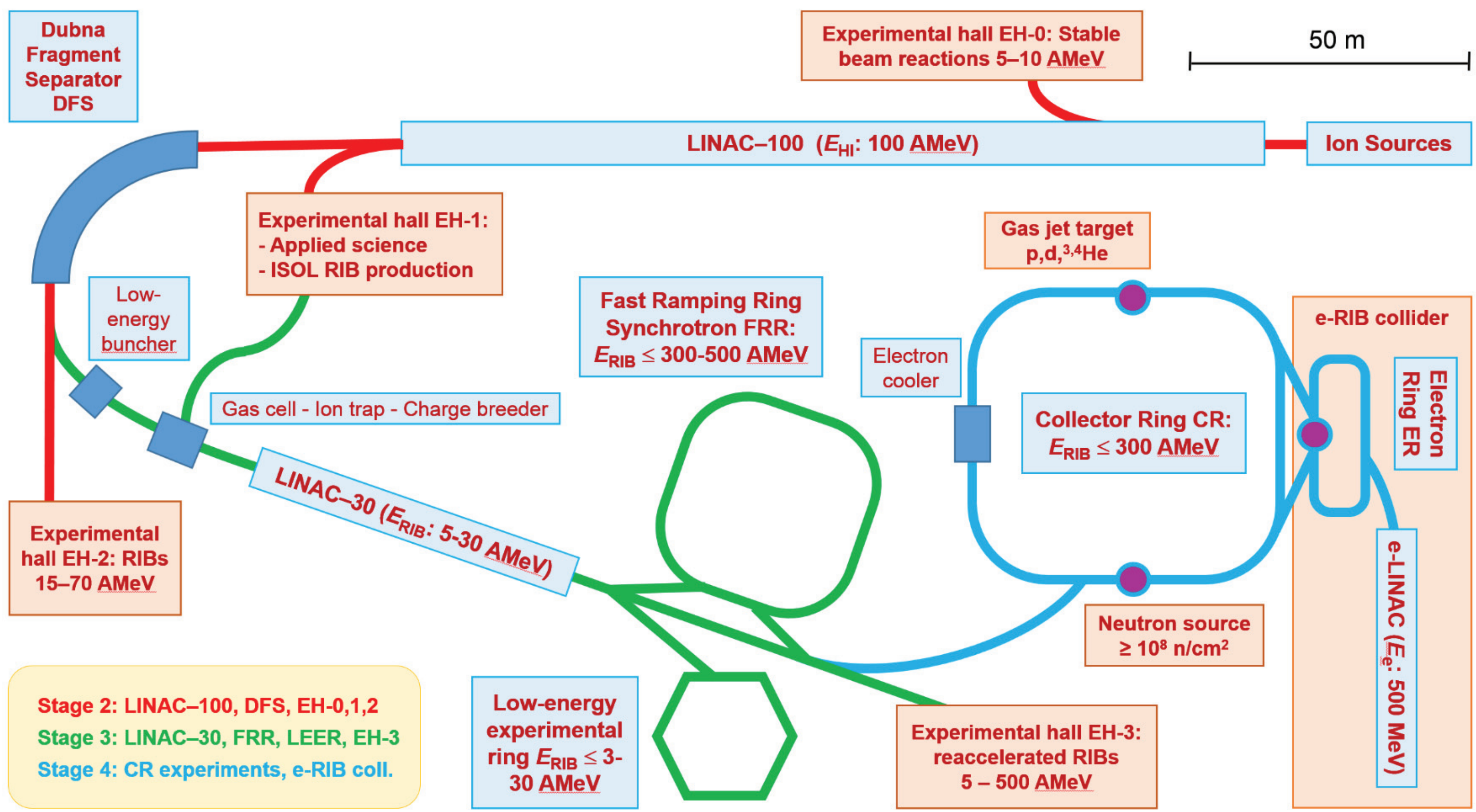
# DERICA – Dubna Electron-Radioactive Isotope Collider fAcility

## Project emphasis

Reaccelarated RIBs, storage ring physics including e-RIB collider

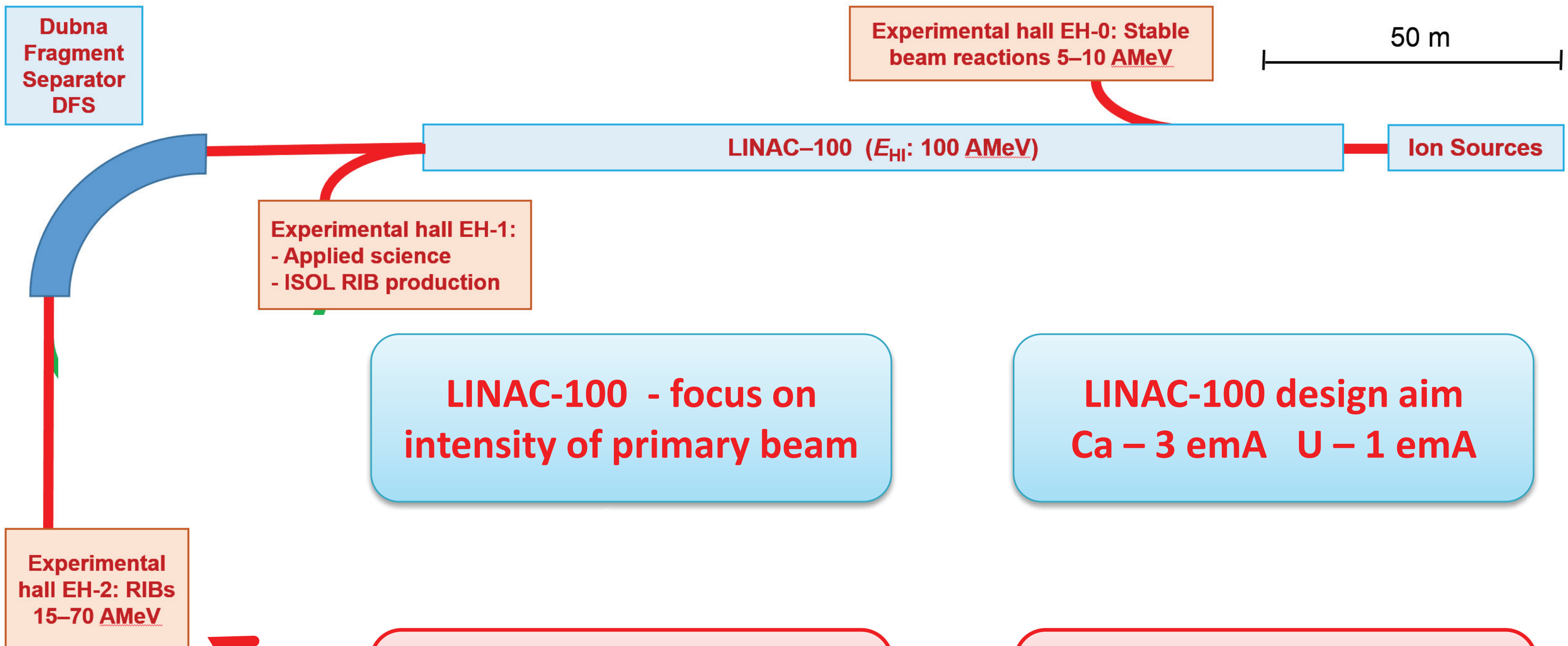
## Basic facility

High-current superconducting HI cw-LINAC-100



# DERICA stage 2

**New scientific opportunities emerging on each stage**




**LINAC-100 - focus on intensity of primary beam**

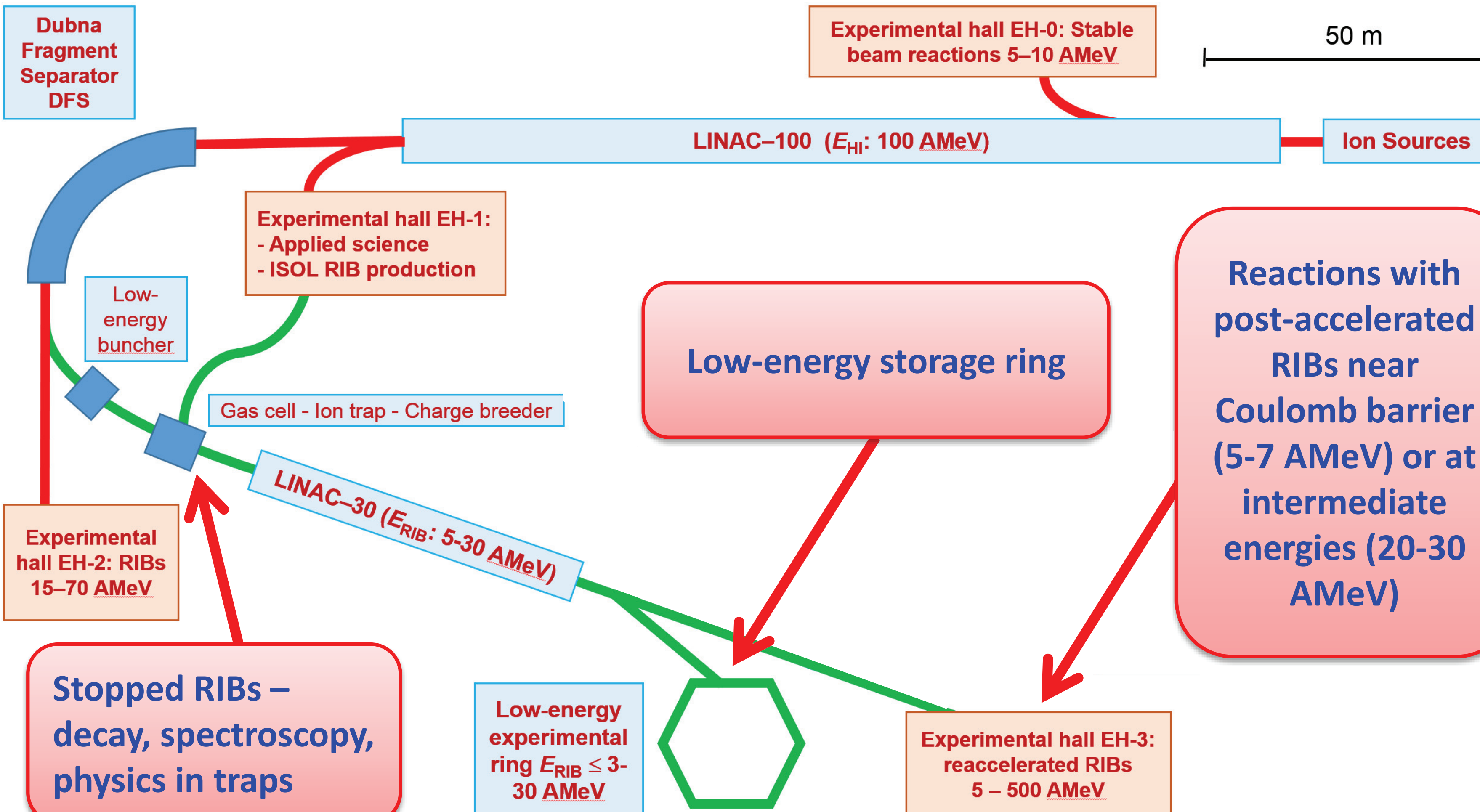
**LINAC-100 design aim**
**Ca – 3 emA U – 1 emA**

**Direct reactions with RIBs at intermediate energies (30-80 AMeV)**

**Aim to get record intensitis of 30-80 AMeV RIBs**

# DERICA stage 3.1

New scientific opportunities emerging on each stage



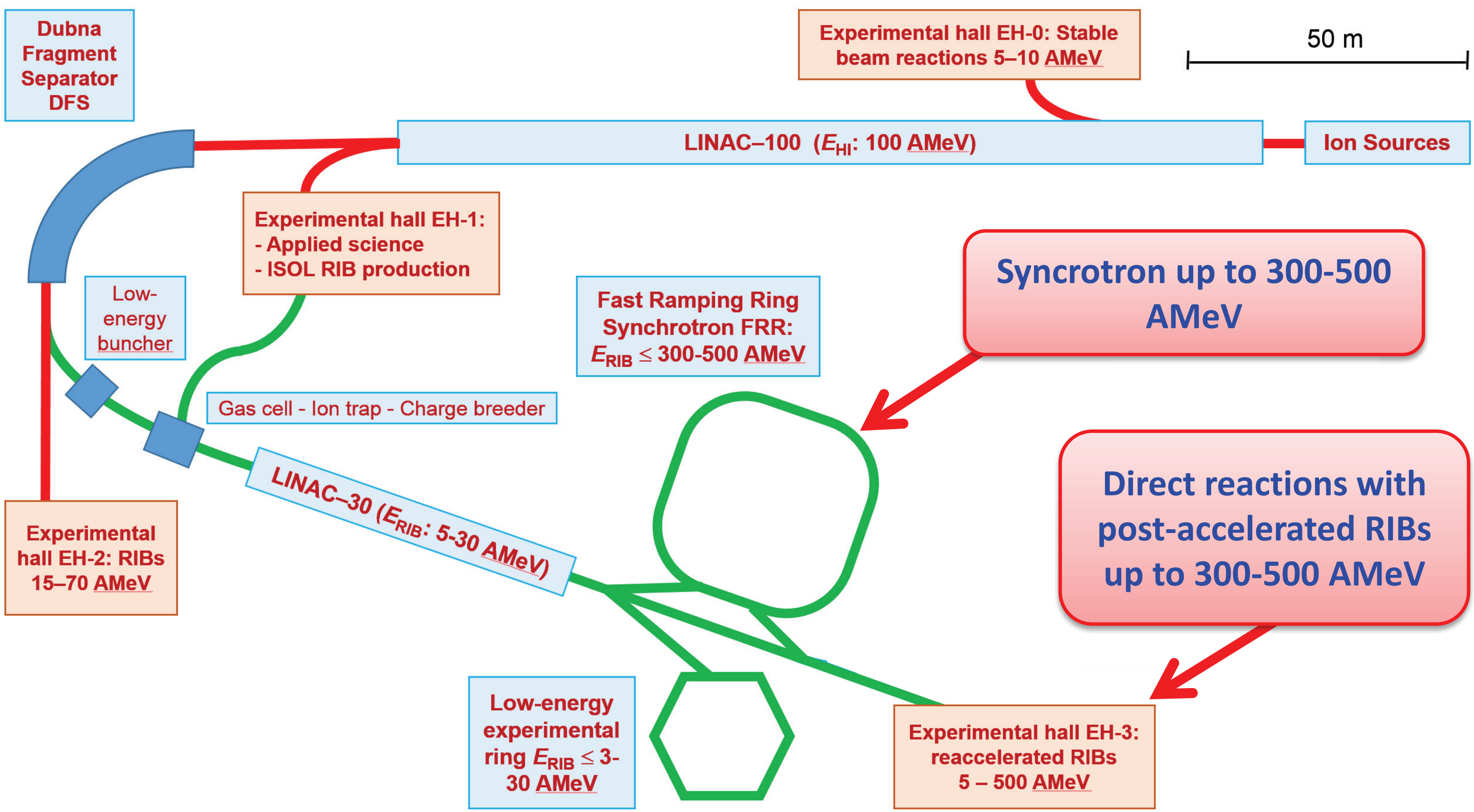

Low-energy storage ring

Reactions with post-accelerated RIBs near Coulomb barrier (5-7 AMeV) or at intermediate energies (20-30 AMeV)

Stopped RIBs – decay, spectroscopy, physics in traps

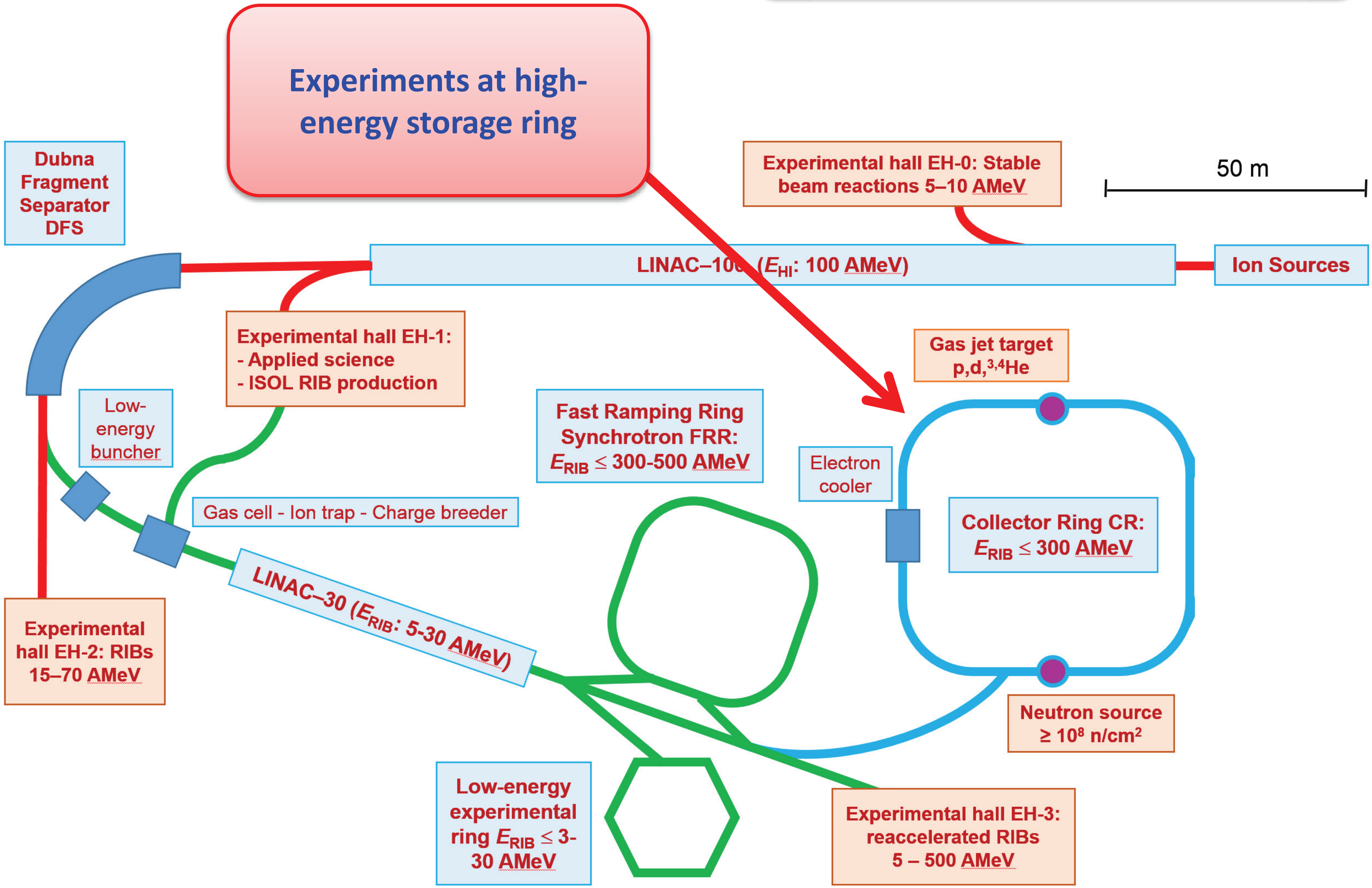
# DERICA stage 3.2

New scientific opportunities emerging on each stage



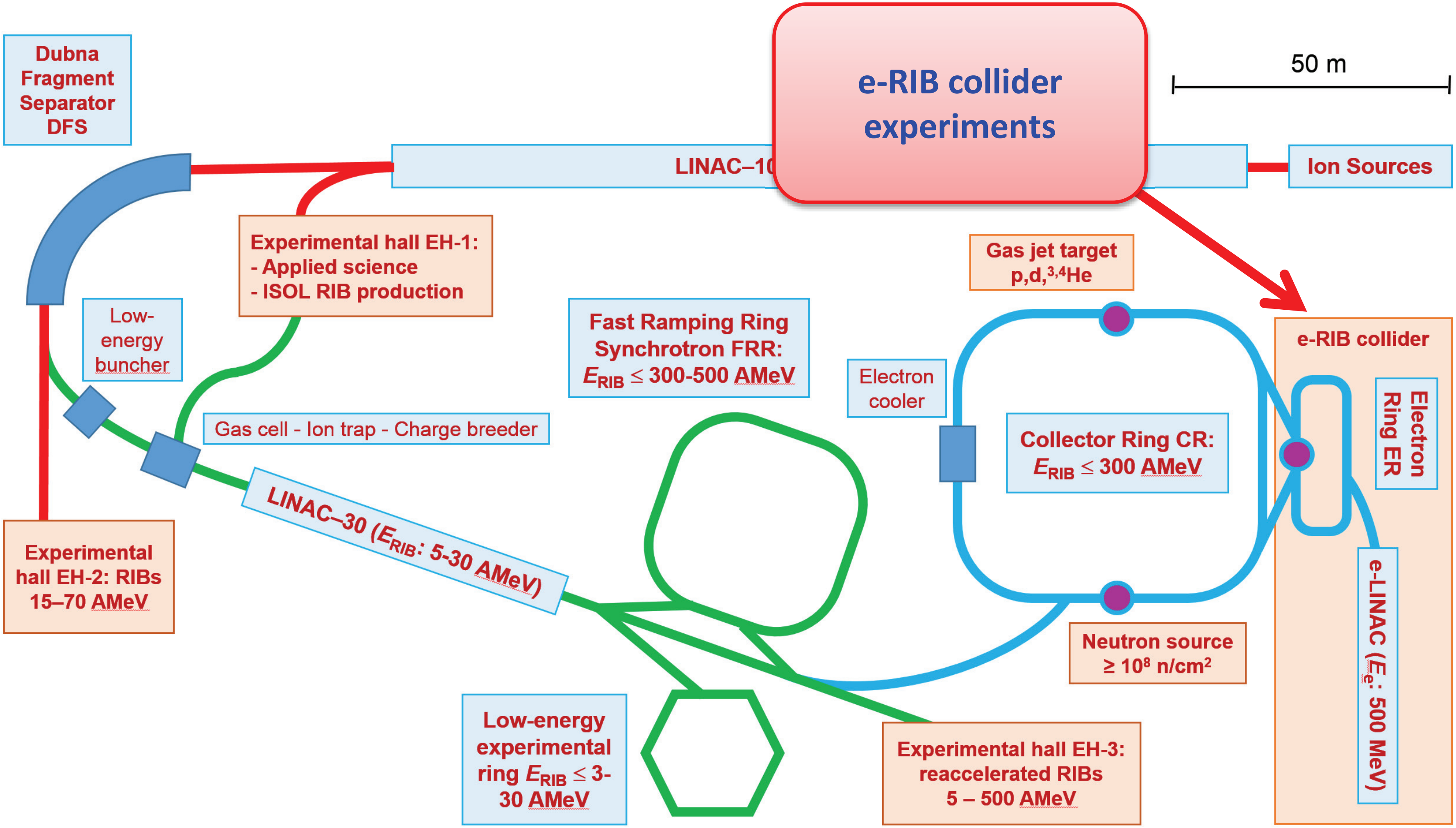
# DERICA stage 4.1

New scientific opportunities emerging on each stage



# DERICA stage 4.2

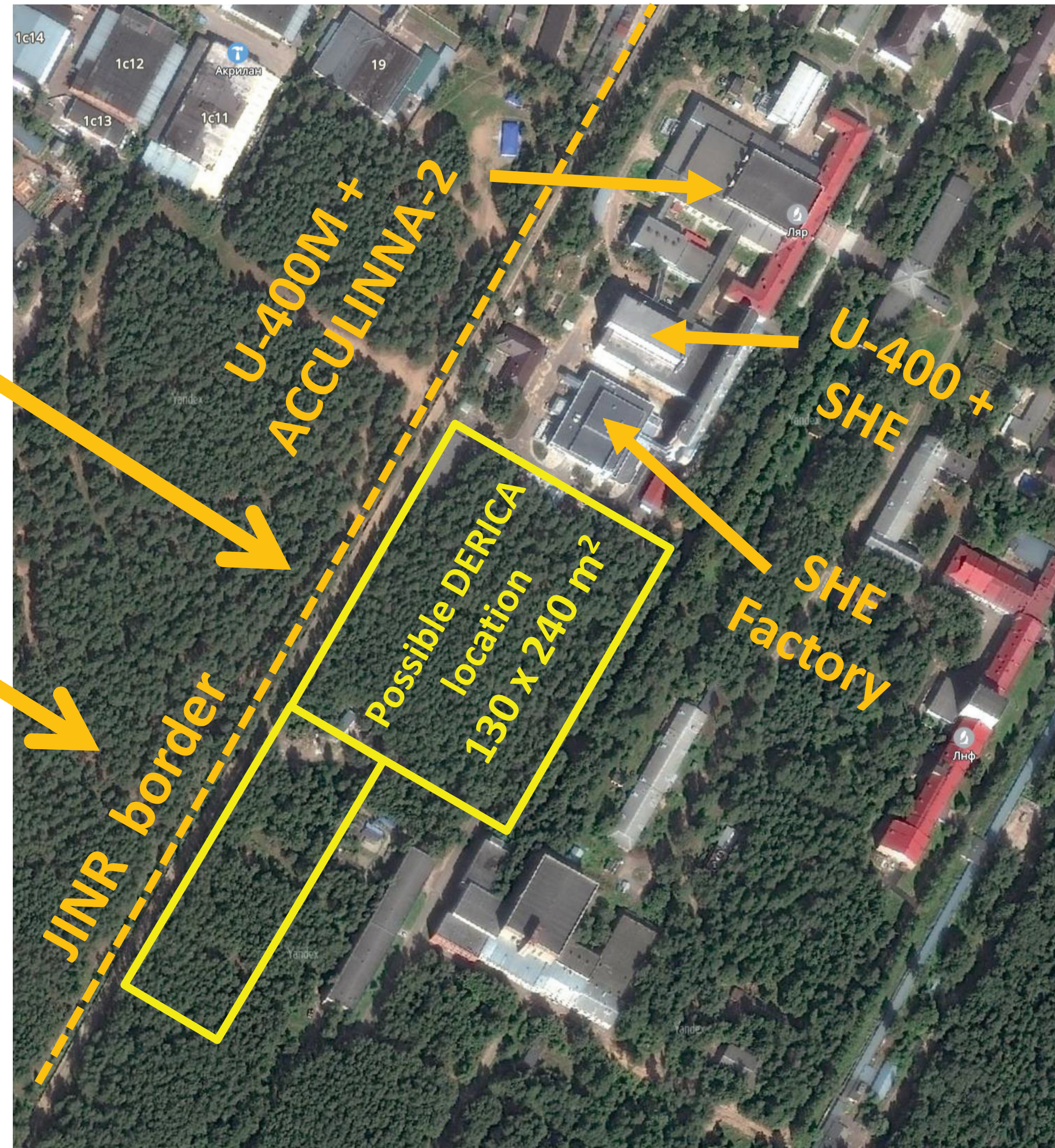
New scientific opportunities emerging on each stage



# Possible DERICA location

**Sufficient free place**

**Considerable possibilities for upgrade**



# Primary beams at modern and prospective RIB factories

| | |
|---|---|
| RIBF (RIKEN) | 370 AMeV |
| FAIR (Darmstadt) | 1800 AMeV |
| FRIB (MSU) | 240 AMeV |
| RAON (S.Korea) | 200 AMeV |
| HIAF (China) | 800 AMeV |

**No way to compete in primary beam energies**

# DERICA strategy for RIB production

Focus efforts on HIGH INTENSITY of primary beams with relatively MODEST ENERGIES ~100-160 AMeV

**Advantages of relatively low-energy RIBs:**

- **Easier to study direct reactions at 20-70 AMeV**
- **Easier to work with stopped beams**

**The first challenge of the project – to construct record high-current (e.g. Ca beam ~3 emA, U beam ~1 emA) ~30 pmA heavy-ion superconducting cw-LINAC**

# Advantages of the proposed facility

**Unusual facility layout**

**Ordinary approach 1:**
ISOL RIB production ->
problem to reaccelerate RIBs

**Ordinary approach 2:**
In-flight RIB production ->
Problem to stop/cool RIBs

**DERICA approach:**
In-flight RIB production + RIB “cooling” in gas cell + reaccelerated RIBs up to 500 AMeV

**Staged development**

- Continuity and flexibility of the research program
- Low technological risks
- Highly upgradable facility design

**Unique opportunities**

- World most intense RIBs for direct reaction studies at intermediate (20-70 AMeV) energies
- Reaccelerated RIBs up to 500 AMeV
- e-RIB collider experiment

# Developments of DERICA project

# Letter of Intent:
# Russian review journal Physics-Uspekhi (2019)

`

## Scientific program of DERICA – prospective accelerator and storage ring facility for radioactive ion beam research

L.V. Grigorenko, B.Yu. Sharkov, A.S. Fomichev, A.L. Barabanov, W. Barth, A.A. Bezbakh, S.L. Bogomolov, V. Chudoba, S.N. Dmitriev, V.K. Eremin, S.N. Ershov, M.S. Golovkov, A.V. Gorshkov, I.V. Kalagin, A.V. Karpov, T. Katayama, O.A. Kiselev, A.A. Korsheninnikov, S.A. Krupko, T.V. Kulevoy, Yu.A. Litvinov, E.V. Lychagin, I.P. Maksimkin, I.N. Meshkov, I.G. Mukha, E.Yu. Nikolskii, Yu.L. Parfenova, V.V. Parhomchuk, M. Pfutzner, S.M. Polozov, C. Scheidenberger, S.I. Sidorchuk, P.G. Sharov, P.Yu. Shatunov, Yu.M. Shatunov, V.N. Shvetsov, N.B. Shulgina, H. Simon, R.S. Slepnev, G.M. Ter-Akopyan, G.V. Trubnikov, A.A. Yukhimchuk, S. Yaramyshev, M.V. Zhukov

***Abstract.*** *Studies of radioactive ions (RI) is the most intensively developing field of the low-energy nuclear physics. In this paper the concept and the scientific agenda of prospective accelerator and storage ring facility for the RI beam (RIB) research are proposed for the large-scale international project based at the Flerov Laboratory of Nuclear Reactions of the Joint Institute for Nuclear Research. The motivation for the new facility is discussed and its characteristics are briefly presented, showing to be comparable to those of the advanced world centers, the so-called "RIB factories". In the project the emphasis is made on the studies with the short-lived RIBs in storage rings. A unique feature of the project is the possibility to study the electron-RI interactions in the collider experiment for determination of fundamental properties of the nuclear matter, in particular, electromagnetic form-factors of exotic nuclei.*

**http://derica.jinr.ru/publications.html**

# Public visibility of the project

★ ECT* workshop on "Probing exotic structure of short-lived nuclei by electron scattering", July 16 – 20, 2018

★ 41 European Cyclotron Progress Meeting, Dubna, Russia, September 3 – 5, 2018

★ EXON 2018, Petrozavodsk, September 10 – 14, 2018

★ General meeting of the Physical Section of RAS November 12, 2018

★ Technical Meeting on Novel Multidisciplinary Applications with Unstable Ion Beams and Complementary Techniques , IAEA Headquarters, Vienna, Austria, December 10–14, 2018

★ Nuclear Physics section of RAS meeting, JINR, Dubna, March 14 – 15, 2019

★ NUPECC meeting, Dubna, Russia, June 20 – 21, 2019

April 26, 2018. The is project is submitted to Russian Ministry of Education and Science on the call for «Proposals to build "megascience"-class facilities on the territory of Russian Federation» as joint JINR-BINP venture

In September 2018 evaluation by Russian Academy of Sciences positioned DERICA in the top of the proposals list.

# LINAC-100 workshop February 7-8, JINR

**Declaration of most urgent task**

**To start development of the "front end" for LINAC-100 immediately**

**Workshop consequence: support by JINR directorate for 2019**

**- Resources allocated: 600 k$**

# Recommendations

**DERICA workshop February 7-8, JINR**

The expert board of the technical meeting recommends to initiate the development of the technical design for the high-current heavy-ion cw-LINAC and fragment-separator DFS conjugated to it. The R&D works for the prospective LINAC "front end" (new generation 28 GHz ECR ion source and RFQ) should be started ASAP as this is the most long-term development in the LINAC construction. It is recommended to conduct simultaneously the conceptual design studies for the prospective storage-ring and collider DERICA facility. The design has to be developed in such a way that guarantee upgradeability of the LINAC-50+DFS to the "full format" of the DERICA facility.

Recommendations support February 08, 2019

W. Barth (GSI Darmstadt)

A. Facco (INFN-Laboratori Nazionali di Legnaro)

A.A. Feschenko (INR RAS Moscow)

A.A. Kolomiets (NRC "Kurchatov Institute" - ITEP)

T.V. Kulevoy (NRC "Kurchatov Institute" - ITEP Deputy director for direction "accelerator technique")

Yu. Litvinov (GSI Darmstadt)

I.N. Meshkov (LHEP JINR chief research scientist)

S.M. Polozov (NRNU "MEPhI" Head of "DINUS" research laboratory)

B.Yu. Sharkov (JINR Vice-director)

P. Shatunov (BINP Novosibirsk)

H. Simon (GSI Darmstadt)

S. Yaramyshev (GSI Darmstadt)

V. Zvyagintsev (TRIUMF Vancouver RF Operations Group Leader)

A.A. Korsheninnikov (NRC "Kurchatov Institute" KNP Center Director)

V. Zalesski (PTI NAS Minsk Director)

# Support for 2019

## ЛЯР

**Увеличение расходов бюджета ОИЯИ на 2019 год за счет остатка фактического исполнения бюджета ОИЯИ 2018 года**

(тыс. долларов США)

**Предложение лаборатории**

| | Проект DERICA - создание прототипа начальной секции сильноточного линейного ускорителя тяжелых ионов* | ВСЕГО |
|---|---|---|
| МНТС | | 0,0 |
| Материальные затраты, НИОКР, строительство | 650,0 | 650,0 |
| Ремонт | | 0,0 |
| **ВСЕГО** | **650,0** | **650,0** |

* срок реализации проекта 3 года. Общая стоимость 3,5 млн. долларов США

**Решение директора ОИЯИ**

| | | |
|---|---|---|
| МНТС | | 0,0 |
| Материальные затраты, НИОКР, строительство | 650,0 | 650,0 |
| Ремонт | | 0,0 |
| **ВСЕГО** | **650,0** | **650,0** |

**FLNR**

**- 2019 budget increase via JINR budgetary funds return for 2018.**

**- Development of the front-end prototype for high-current heavy ion cw-LINAC**

**650 k$**

# JINR PAC, June 24-25

**New research project at JINR for 2020-2021**

**- Resources allocated 2020: 1400 k$ - 2021: 1450 k$**

Project: **“Construction of a prototype of the initial section of the high-current heavy-ion linear accelerator for the production of intense radioactive ion beams for basic research”**

Supplement for the physical program of the project **“Development of the FLNR accelerator complex and experimental setups (DRIBs-III)”** on the years 2020/2021.
Theme: 03-0-1129-2017/21

Project leaders:
L.V. Grigorenko (FLNR JINR)
T.V. Kulevoy (NRC “KI” - ITEP)

Deputy project leaders:
A.S. Fomichev (FLNR JINR)
A.A. Efremov (FLNR JINR)
S.M. Polozov (NRNU MEPhI)

**Expected output by the end 2021**

**- TDR + prototypes for LINAC-100**

**- CDR for DERICA**

# Two modalities of the project development

## (1) LINAC-100 + DFS

**Started**

**can be build within JINR budget**

## (2) “Full DERICA”

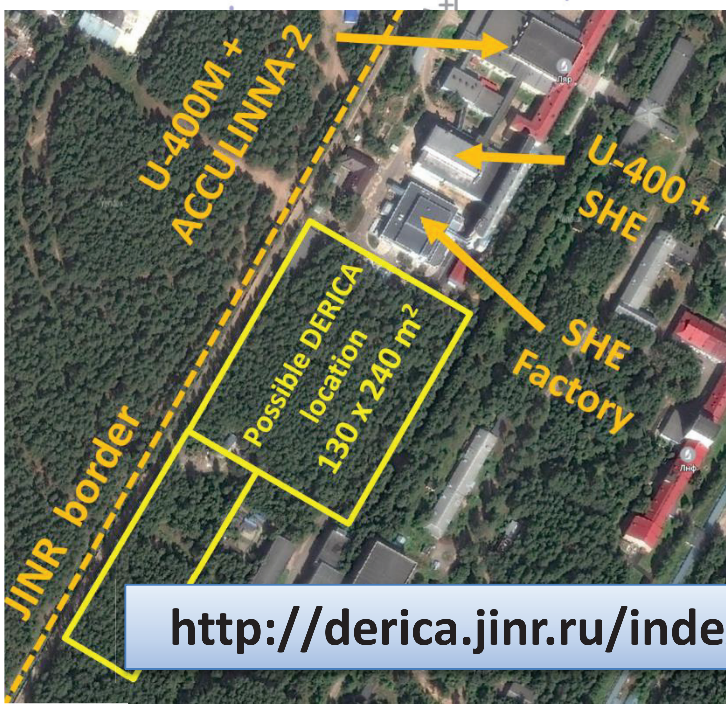
**Discussed**

**national scale megaproject, can be built only with high-level political approval**

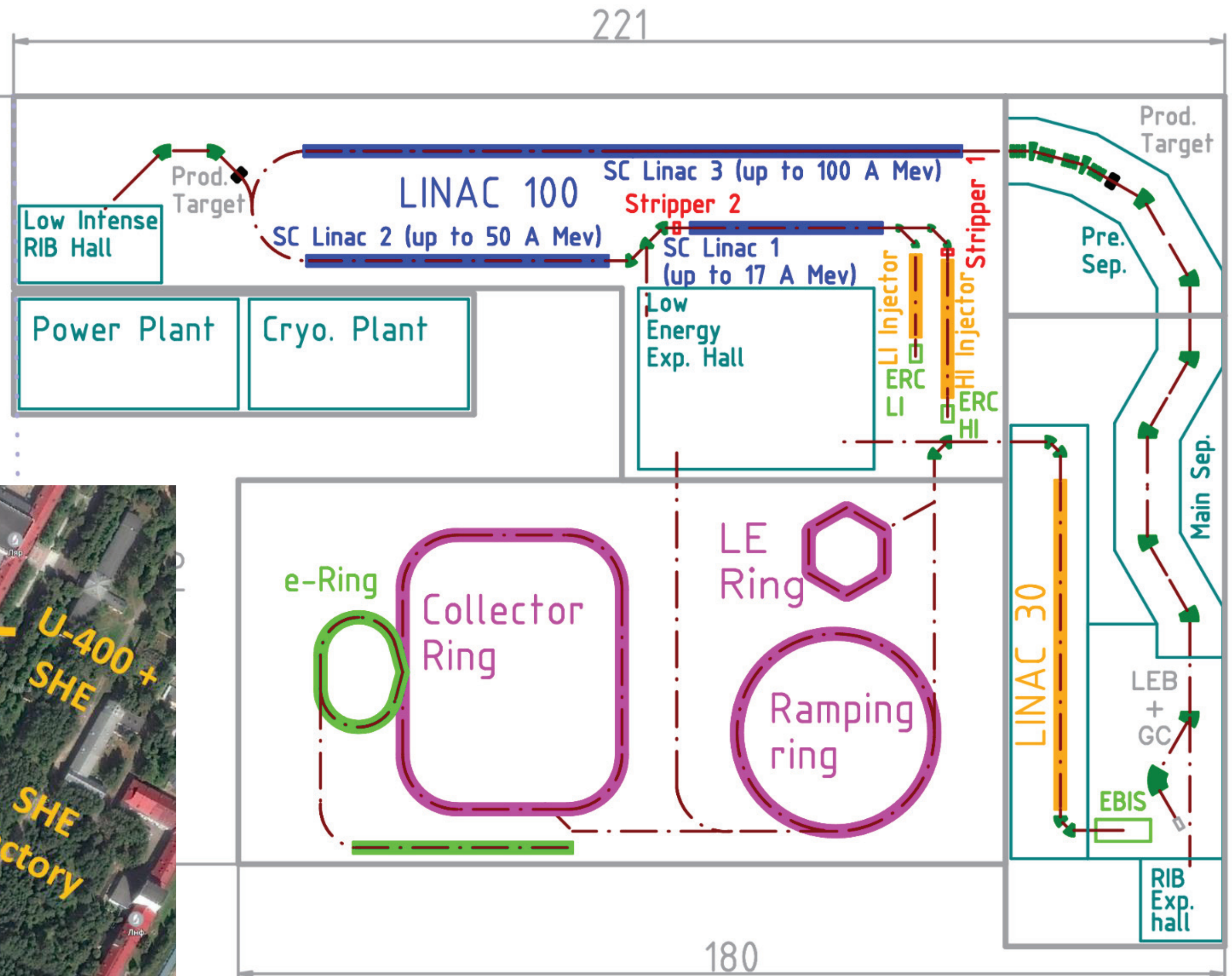
The full DERICA layout is to be defined now

# Towards LINAC-100 and DERICA CDRs

Scientific program development




http://derica.jinr.ru/index.html




CDR works, basic layout

# LINAC-100 working plans

## LINAC-100 concept

– Front-end: 1 (universal A/Z~3-8) or 2 (A/Z~3 + A/Z~6-8)
– Ratio of warm/cryogenic parts to be decided
– "Acceleration tactics" – A/Z, strippers, etc. **MEPhI + ITEPh + GSI**

## Prospective ECR ion source 28 GHz

– Design **FLNR** – Magnet system **NIIFA** – RF system **IAP Nizniy Novgorod**

## Prototyping front-end for LINAC-100

– Test ECR на for current ~ 3-5 mA **FLNR + NIIFA**
– Up to 3 sections of RFQ **VNIITPh**
– Test assembly ECR + LEBT + RFQ **FLNR + ITEPh + NRI Troitsk**

**By the end 2021: TDR for LINAC-100, front-end prototype, prototype parts for ECR-28**

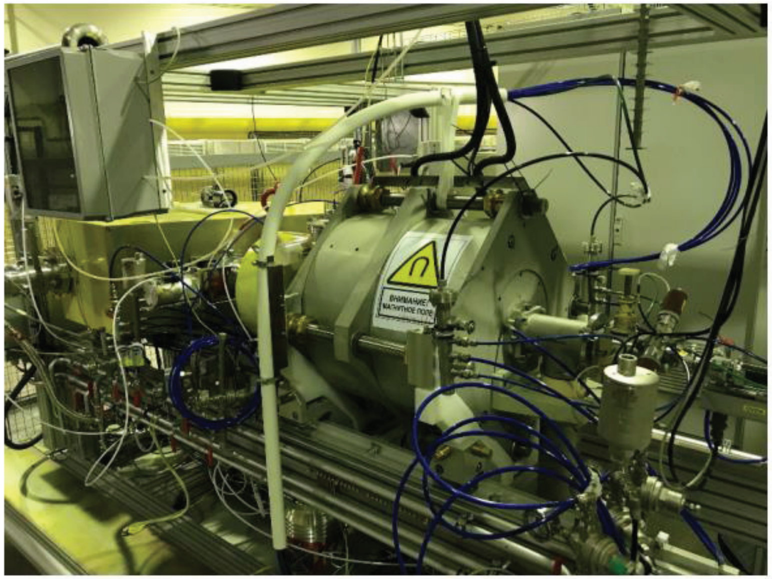
**By A. Efremov**

| Source | Year | Location | Application |
|---|---|---|---|
| DECRIS-1 | 1990 | Dubna | Dismounted in 1994 |
| DECRIS-2 | 1995 | Dubna | Cyclotron MC-400 FLNR |
| DECRIS-2m | 2002 | Bratislava Slovakia | Two ion sources for CCSR |
| DECRIS-3 | 1997 | Belgrad Serbia | Vinca Institute of Nuclear Sciences |
| DECRIS-3 | 2006 | Astana Kazakhstan | Cyclotron DC-60 |
| DECRIS-4 | 2005 | Dubna | FLNR ECR test bench |
| DECRIS-5 | 2012 | Dubna | Cyclotron DC-110 For industrial applications |
| DECRIS-SC1 | 2004 | Dubna | Cyclotron IC-100 FLNR |
| DECRIS-SC2 | 2014 | Dubna | Cyclotron MC-400 FLNR |
| DECRIS-PM | 2017 | Dubna | Cyclotron DC-280 FLNR |

By A. Efremov

# *DECRIS-PM*

550 kg of PM



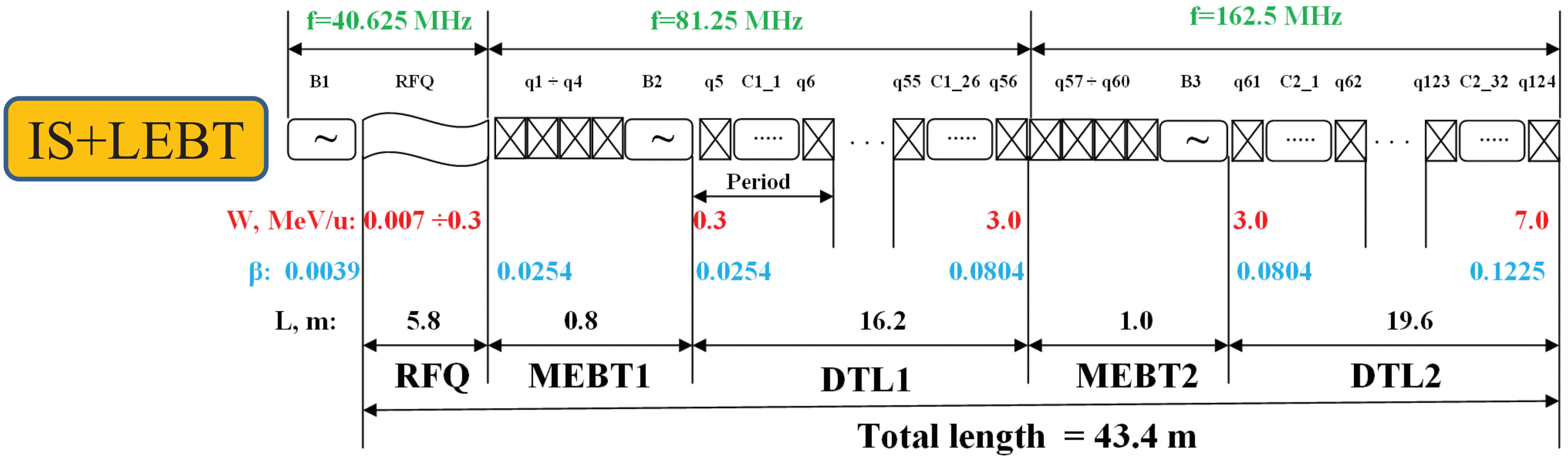
All PM ECRIS drawbacks:

- ❑ the fixed distribution of the magnetic field: system should be strongly optimized for the desired operation mode
- ❑ strong forces between the individual parts of the system: the correction of the magnetic field after the assembly of the magnetic system is practically impossible without the degaussing of it

| Ion | DECRIS-PM | LAPECR2 | Supernanogan | DECRIS-3 | ECR 4M |
|---|---|---|---|---|---|
| $Ar^{8+}$ | 920 | 460 | 300 | 720 | 600 |
| $Ar^{9+}$ | 500 | 355 | 150 | | 450 |
| $Ar^{11+}$ | 210 | 166 | 35 | 156 | 200 |
| $Ar^{12+}$ | 150 | 62 | 12 | 68 | 100 |
| $Xe^{20+}$ | 75 | 85 | | 84 | |
| $Xe^{26+}$ | 50 | 40 | 7($Xe^{25+}$) | 23 | 25($Xe^{25+}$) |

By T. Kulevoy

# Layout of normal conducting part of LINAC for DERICA



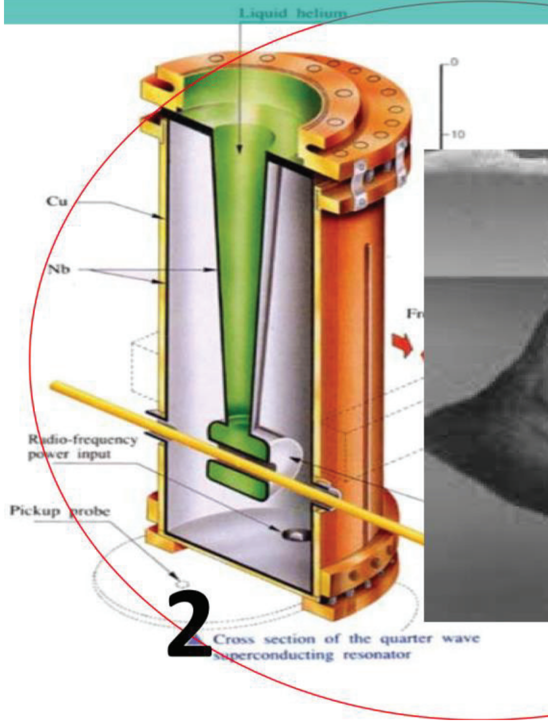

- A/Z ≤ 7
- CW *Input current=1 mA*
- *Input transverse emittance ε=1 π·mm·mrad*
- *$E_{smax}$=1.5 Kp*
- *$V_k$ / ε ≥ 6*
- *$R_b$ /$R_a$ ≤ 0.75, $R_b$ – beam radius; $R_a$ – aperture radius*
- *Transport ($N_{out}$ /$N_{inj}$) = 100%*
- *Transmission ($N_{out}$ (accel)/$N_{inj}$) = 100%*

By T. Kulevoy

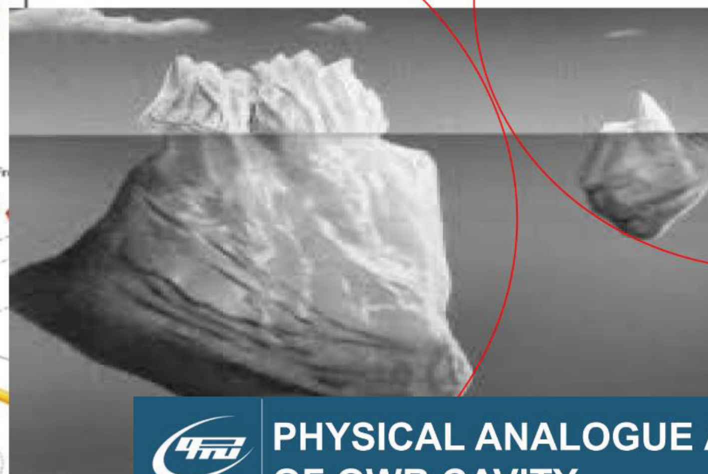
# Main parameters of NC linac

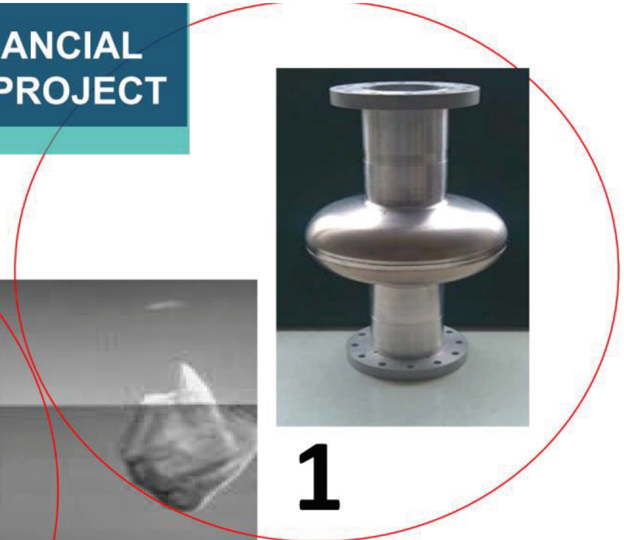
| Structure | RFQ | DTL1 | DTL2 |
|---|---|---|---|
| A/Z | ≤ 7 | | |
| Operating frequency, MHz | 40.625 | 81.25 | 162.5 |
| Beam energy, MeV/u | 0.007 ÷0.3 | 0.3 ÷ 3.0 | 3.0÷ 7.0 |
| Injection current, mA | 1 | | |
| Normalized emittance, π mm mrad | 1 ÷ 1.15 | 1.15 ÷ 1.35 | 1.35 ÷ 1.45 |
| Normalized acceptance, π mm mrad | 6 | 7 | 8 |
| Synchronous phase, deg | -90 ÷ -36 | -40 ÷ -30 | -40 ÷ -30 |
| Intervane voltage, kV | 154 | - | |
| Maximum gap field, kV/cm | - | 100 | 120 |
| Maximum field strength, Kp | 1.5 | | |
| Average radius, mm | 14 | 15 | 15 |
| Maximum vane modulation | 1.72 | - | |
| Number of magnetic lenses | | 52 | 64 |
| Maximum field gradient, T/m | - | 85 | 130 |
| Number of cavity | - | 26 | 32 |
| Length of cavity, m | | 0.3 ÷ 0.5 | 0.3 ÷ 0.4 |
| Total length, m | 5.8 | 16.2 | 19.6 |

# COMPARISON OF TECHNICAL AND FINANCIAL COSTS FOR THE FIRST AND SECOND PROJECT

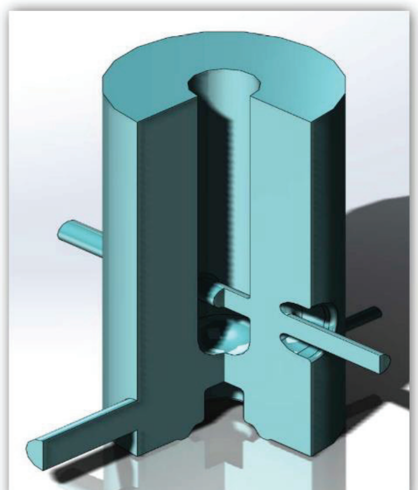


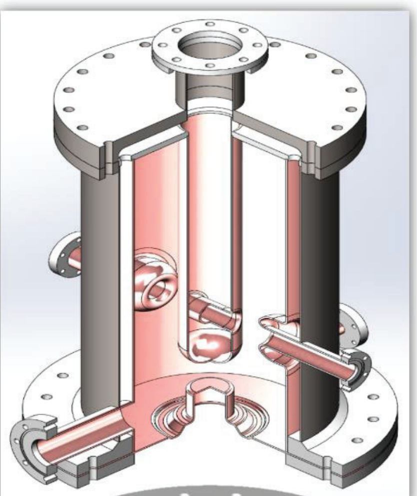
Cross section of the quarter wave superconducting resonator






# PHYSICAL ANALOGUE AND DESIGN OF QWR CAVITY





By V. Zaleski

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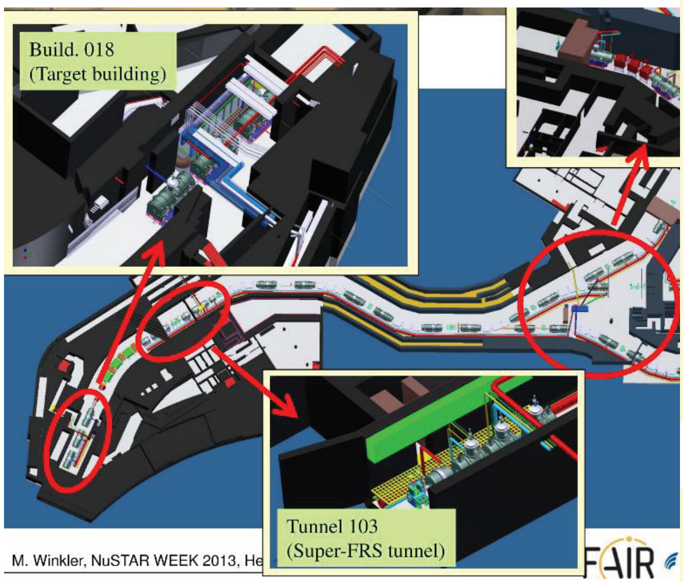
# Challenge of DFS – DERICA Fragment separator

**DERICA, DFS**

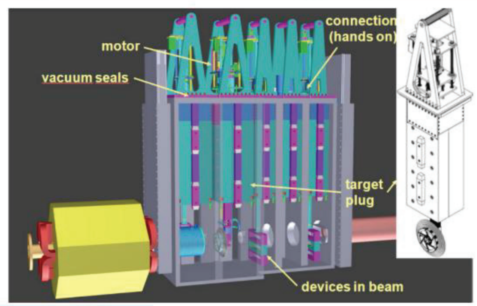
- Ca beam ~3 emA ~250 pμA 1500 kW beam
- U beam ~1 emA ~30 pμA 600 kW beam

**FAIR, SuperFRS**

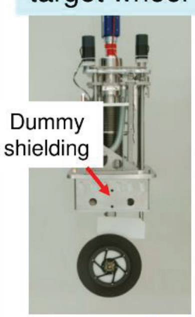
U beam ~1500 AMeV
план: ~1 pμA
реальность: ~200 pnA



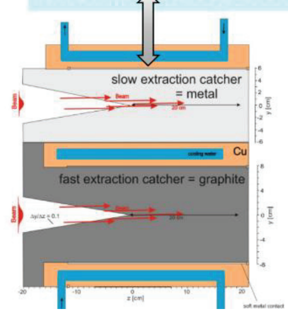

target chamber including plug inserts

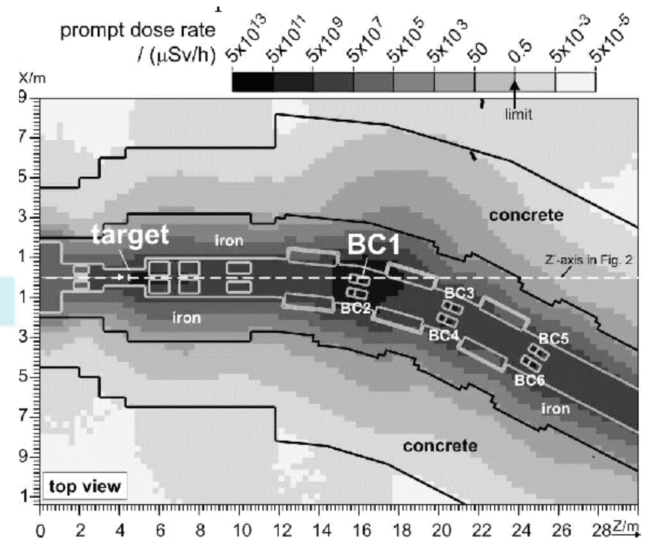



prototype target wheel




two-halves catcher

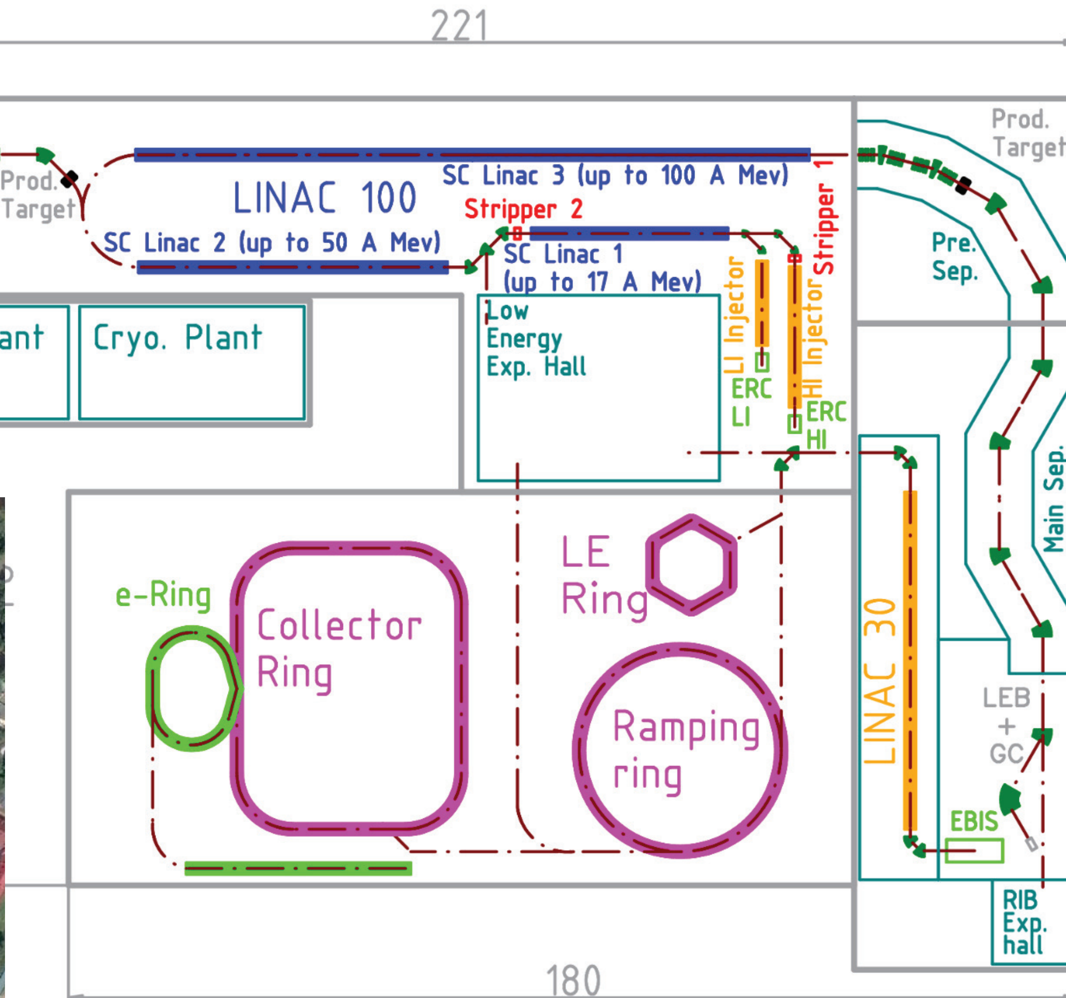


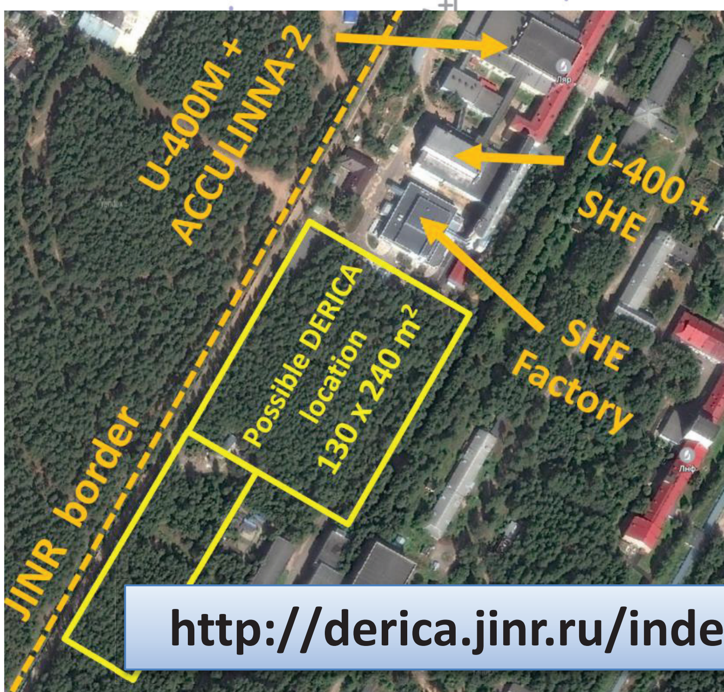




**By the end of 2021 CDR for production target, radiation shielding and DFS are ready**

# Towards LINAC-100 and DERICA CDRs

**Scientific program development**




**http://derica.jinr.ru/index.html**

**CDR works, basic layout**

# Challenge of ring branch

**Low-energy storage ring**

– Energies 3-30 AMeV – Shape – probably «hexagon» (???)

**Fast ramping synchrotron FRR**

– Injection ~30 AMeV, extraction 100-500 AMeV (???)

**High-energy storage ring**

– Energies 100-500 AMeV (???) – Shape – probably «square» (???)

**e-RIB collider facility**

– e-LINAC – electron storage ring

– collision point (???) – electron spectrometer (???)

**Expected that by the end of 2021 BINP Novosibirsk produce important part of CDR for the ring branch**

All three ion storage rings of the DERICA projects are to be equipped with electron cooling systems

# Experts

# LINAC-100 + DFS

A realistic option to replace aging U-400M cyclotron and give bright future to existing RIB program at FLNR (aim – at least factor 100 in beam intensities)

# DERICA

In certain sense it is not a project with well defined end point, but a strategy for the low-energy nuclear physics development in Russia for 15-30 years