23rd STFC Nuclear Physics Summer School (2026)

New and future nuclear research facilities

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July 26th - August 8th 2026

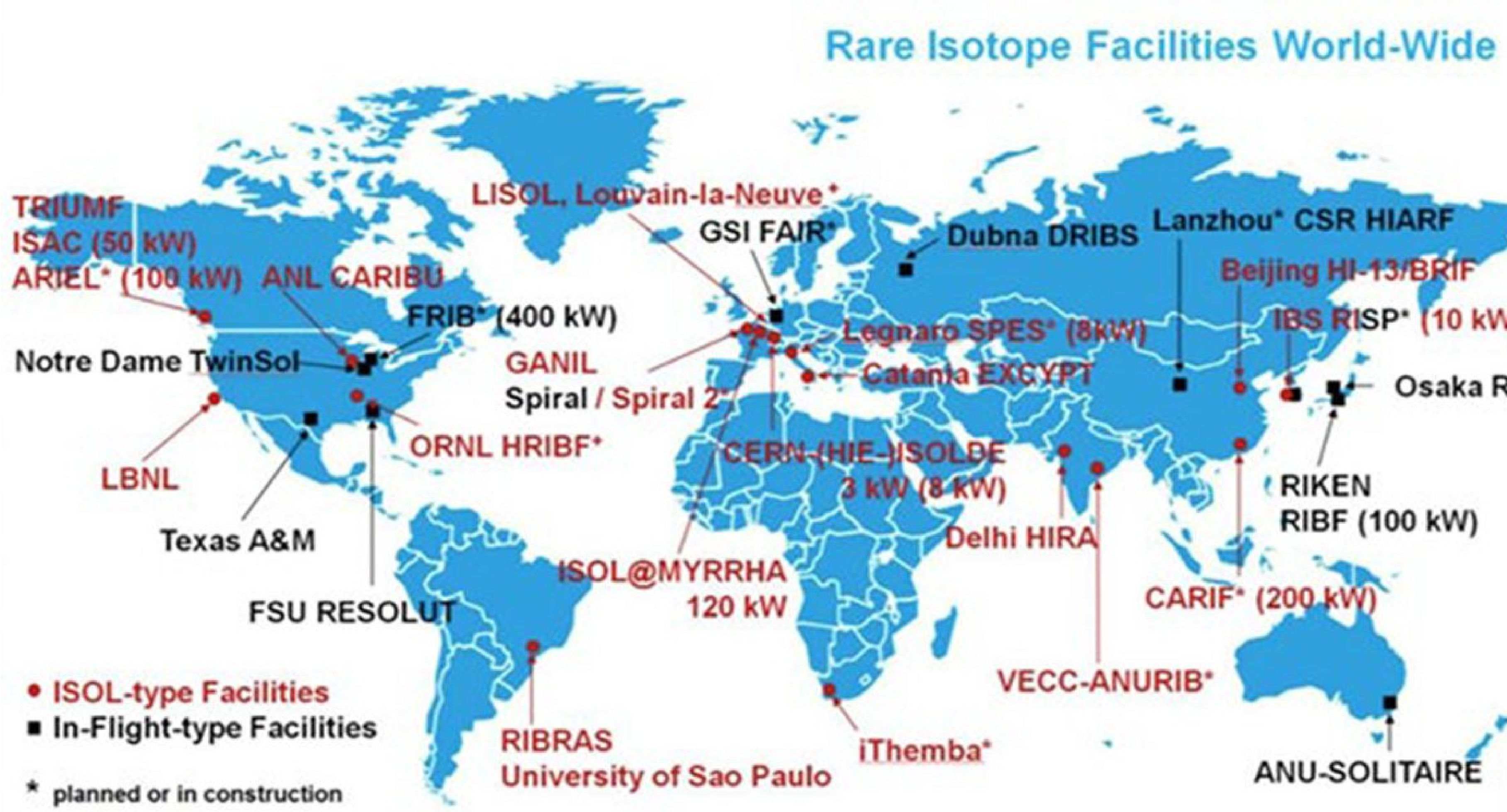
University of Aberdeen, Scotland

Overview:

L1: Introduction
- RIB production
  - ISOL and in-flight fragmentation
  - Primary beams
- Next generation separators
- Importance of instrumentation

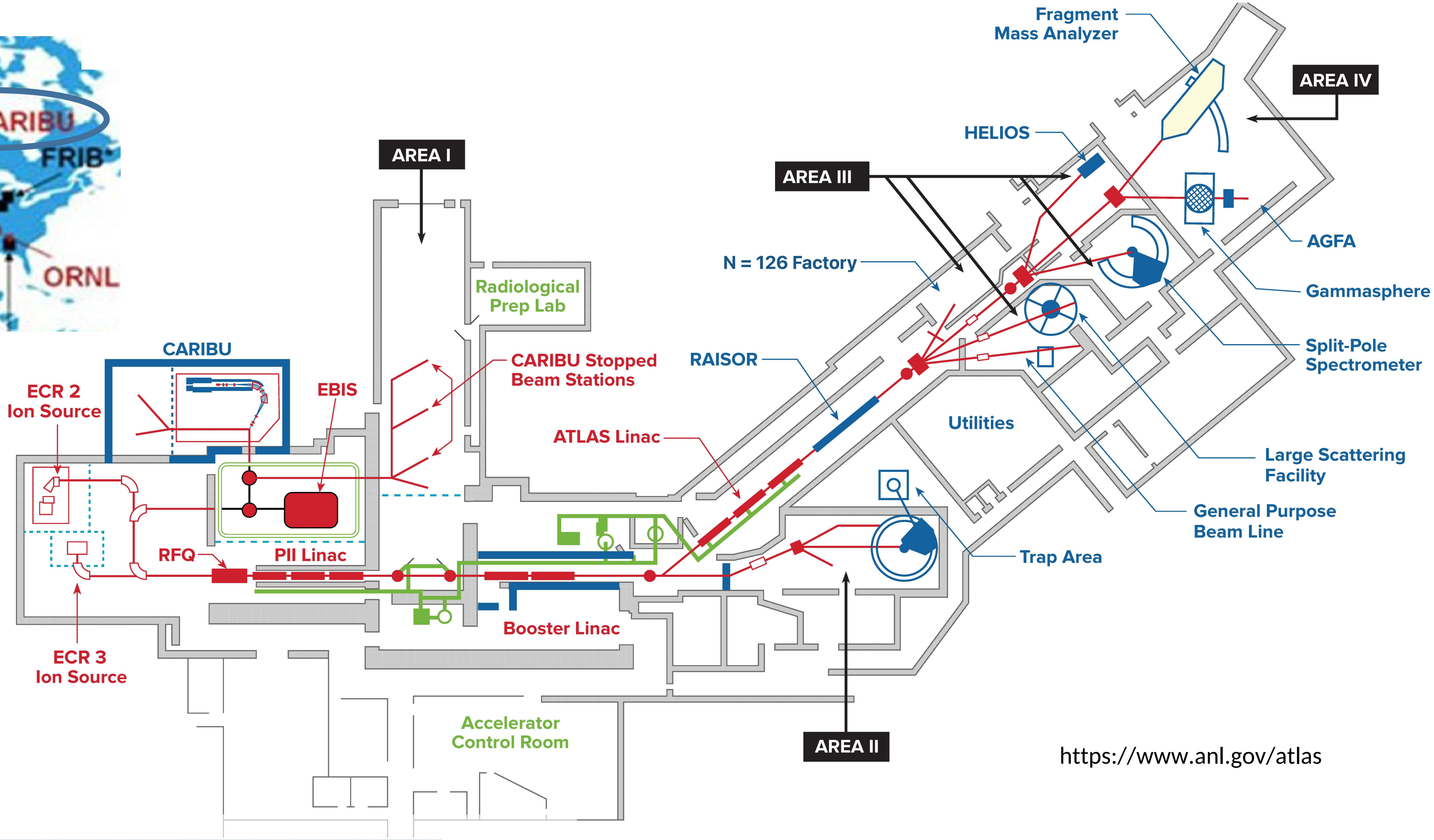
L2:
- In-flight fragmentation in
  - North America
  - Asia
  - Europe
- (plus some other highlights)

Overview of world-wide RIB facilities



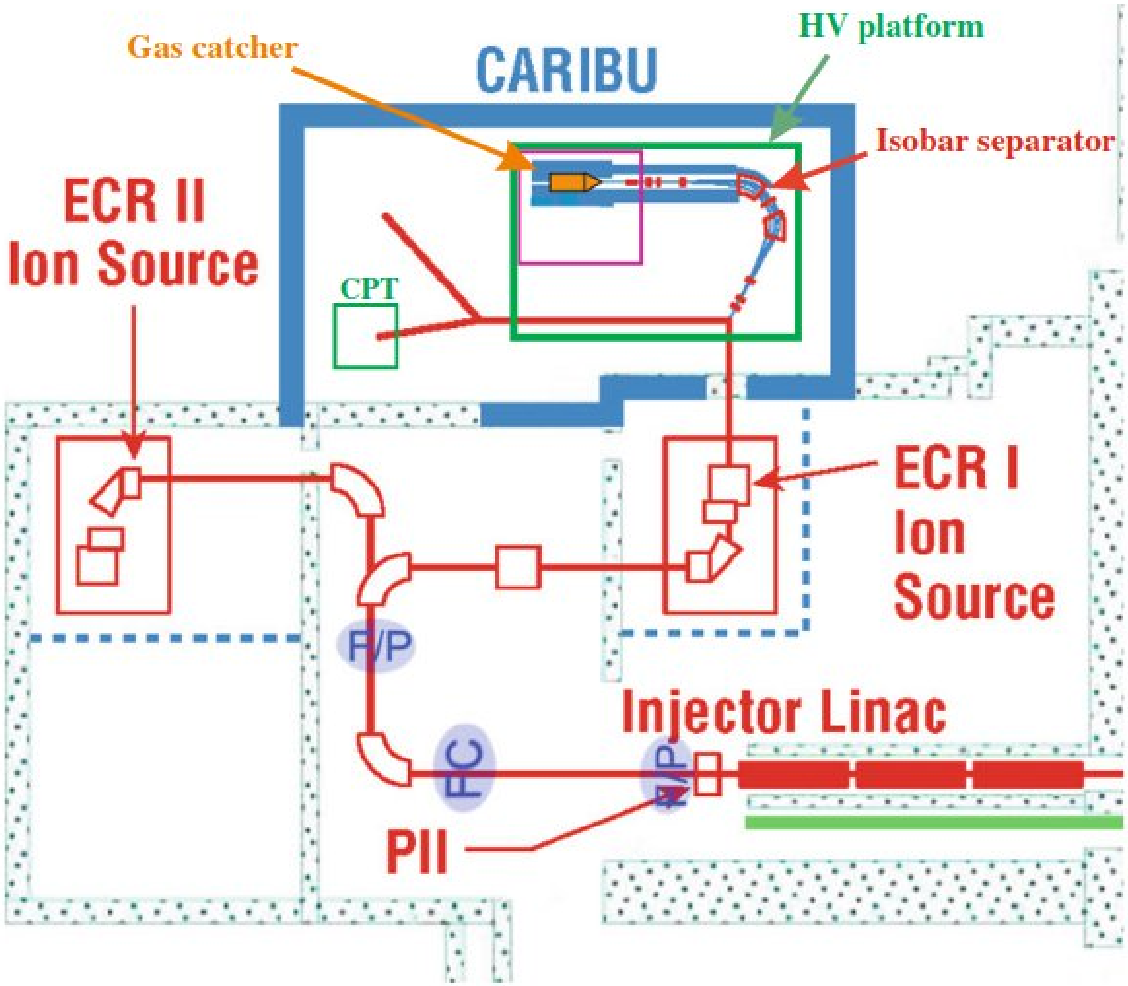
Eur. Phys. J. Plus (2025) 140:638

New mechanisms for production of neutron-rich nuclei: CARIBU



https://www.anl.gov/atlas

New mechanisms for production of neutron-rich nuclei: CARIBU



G. Savard *et al.*, Hyperfine Interact (2011) 199:301–309

- Californium Rare Ion Breeder Upgrade (**CARIBU**) at the ATLAS facility, Argonne National Lab (USA)
- CARIBU produced ***low-energy*** and ***re-accelerated*** beams of neutron-rich isotopes produced in the ***fission of ^{252}Cf***
- Challenge - fission products are emitted isotropically with >200 MeV
- Challenge - ~1 Ci (3.7 x 10^{10} Bq) source produced in nuclear reactor

Fission products stopped in gas catcher
(large volume of very high-purity He enclosed in RF structure)

Extraction RFQ
(extraction time 10s ms)

Electrostatic acceleration
(accelerated to 50 kV, low energy spread)

Mass separation via high-res spectrometer and MR-TOF
(selection from cocktail of extracted products)

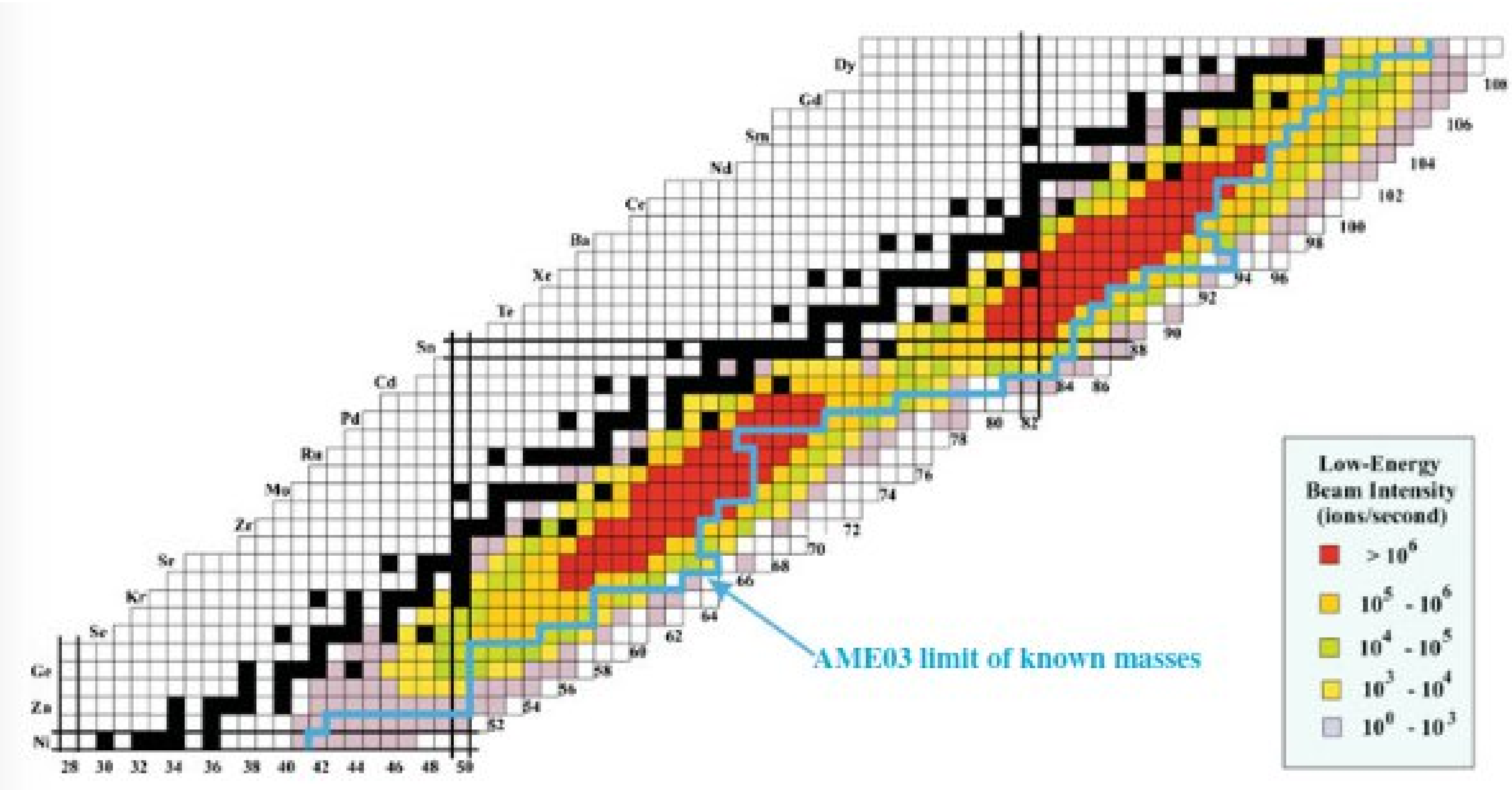
Sent to low-energy experiment
or post-acceleration *(after charge breeder, up to 15 MeV/u)*

CARIBU to nuCARIBU

- Experiments at GAMMASPHERE/FMA, HELIOS (Coulex, transfer reactions) → probing nuclear structure effects and r-process nucleosynthesis
- Low-energy experiments → CPT (after RF buncher for pulsed beams at low energy), decay station

Problem - source becomes weak, difficulties producing thin sources.

- Experiments starting using ***nuCARIBU*** recently commissioned neutron-generator-based source of ^{235}U fission for higher reliability and intensity
- Shift in fission peaks



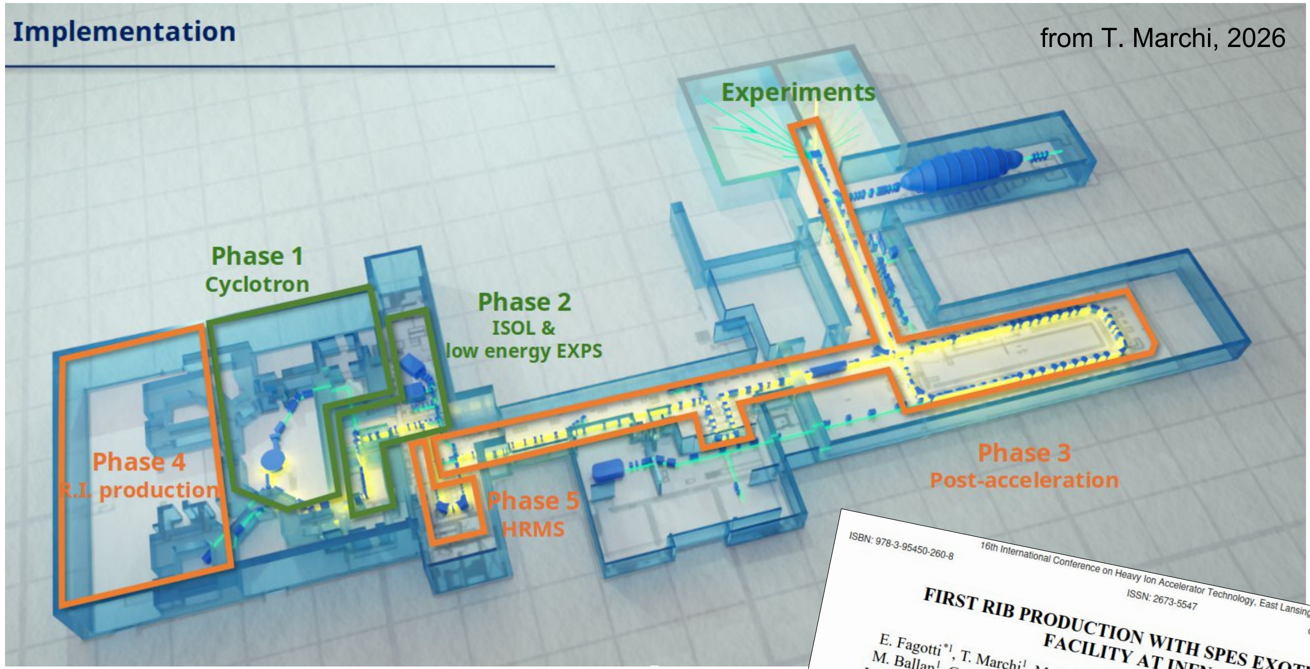
G. Savard *et al.*, Hyperfine Interact (2011) 199:301–309

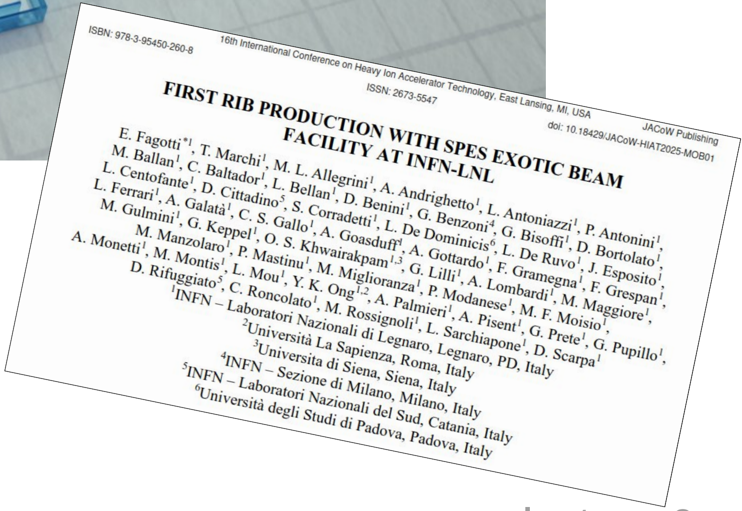
- Main systems ***commissioned***
- nuCARIBU beams ***serving experiments*** for significant part of 2026 beamtime

Example of future ISOL facility: SPES LNL

- *SPES (Selective Production of Exotic Species)* ‘second generation’ ISOL facility at Legnaro National Lab (LNL, INFN, Italy)
- RIB production via a high-intensity proton beam incident on a thick target (typically UCx) to induce fission
- Ions extracted, ionized and selected then post-accelerated to experiments

- **Phase 1**: cyclotron recommissioning and beamline tests, primary proton driver, commercial cyclotron, 35-70 MeV, up to 700µA
- **Phase 2**: First RIB production (low energy) transported to tape station at LERIB area
- **Phase 3**: Installation and commissioning with stable beams to CB, MRMS and RFQ
- **Phase 4**: radionuclide production (mainly for medical applications)
- **Phase 5**: RIB selection, transport to high-energy experimental halls





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ISSN: 2673-5547
doi: 10.18429/JACoW-HIAT2025-MOB01

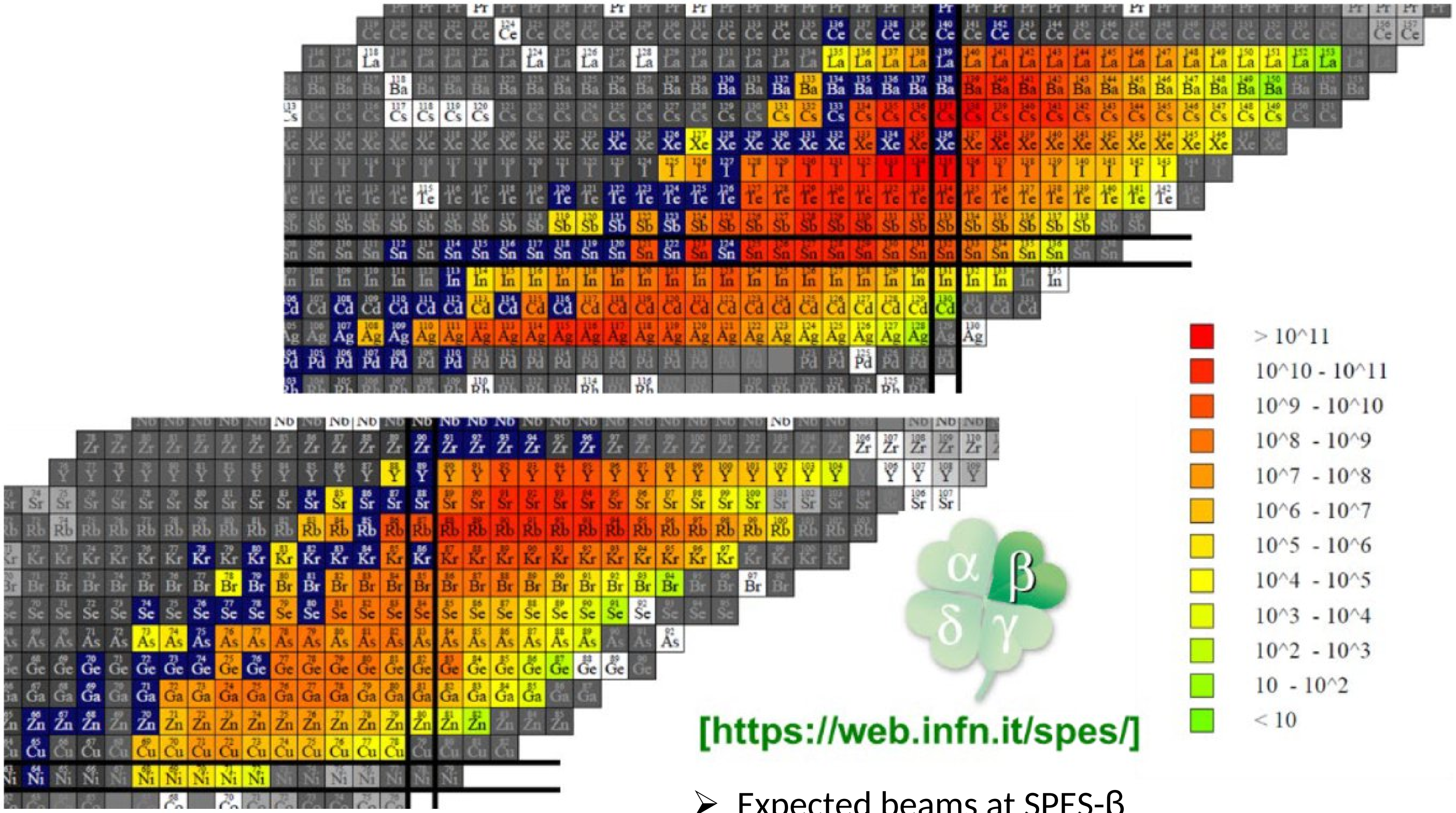
FIRST RIB PRODUCTION WITH SPES EXOTIC BEAM FACILITY AT INFN-LNL

E. Fagotti*[1], T. Marchi[1], M. L. Allegrini[1], A. Andrighetto[1], L. Antoniazzi[1], P. Antonini[1], M. Ballan[1], C. Baltador[1], L. Bellan[1], D. Benini[1], G. Benzoni[4], G. Bisoffi[1], D. Bortolato[1], L. Centofante[1], D. Cittadino[5], S. Corradetti[1], L. De Dominicis[6], L. De Ruvo[1], J. Esposito[1], L. Ferrari[1], A. Galatà[1], C. S. Gallo[1], A. Goasduff[1], A. Gottardo[1], F. Gramegna[1], F. Grespan[1], M. Gulmini[1], G. Keppel[1], O. S. Khwairakpam[1,3], G. Lilli[1], A. Lombardi[1], M. Maggiore[1], M. Manzolaro[1], P. Mastinu[1], M. Miglioranza[1], P. Modanese[1], M. F. Moisio[1], A. Monetti[1], M. Montis[1], L. Mou[1], Y. K. Ong[1,2], A. Palmieri[1], A. Pisent[1], G. Prete[1], G. Pupillo[1], D. Rifuggiato[5], C. Roncolato[1], M. Rossignoli[1], L. Sarchiapone[1], D. Scarpa[1]
[1]INFN – Laboratori Nazionali di Legnaro, Legnaro, PD, Italy
[2]Università La Sapienza, Roma, Italy
[3]Universita di Siena, Siena, Italy
[4]INFN – Sezione di Milano, Milano, Italy
[5]INFN – Laboratori Nazionali del Sud, Catania, Italy
[6]Università degli Studi di Padova, Padova, Italy

Phases 1 and 2 complete -> first RIBs confirmed

FIRST RIB PRODUCTION WITH SPES EXOTIC BEAM FACILITY AT INFN-LNL, December 2025; DOI:10.18429/JACoW-HIAT2025-MOB01

Example of future ISOL facility: SPES LNL



- Expected beams at SPES-β

Marchi et al., J. Phys.: Conf. Ser. 1643 (2020) 012036

Power of storage rings

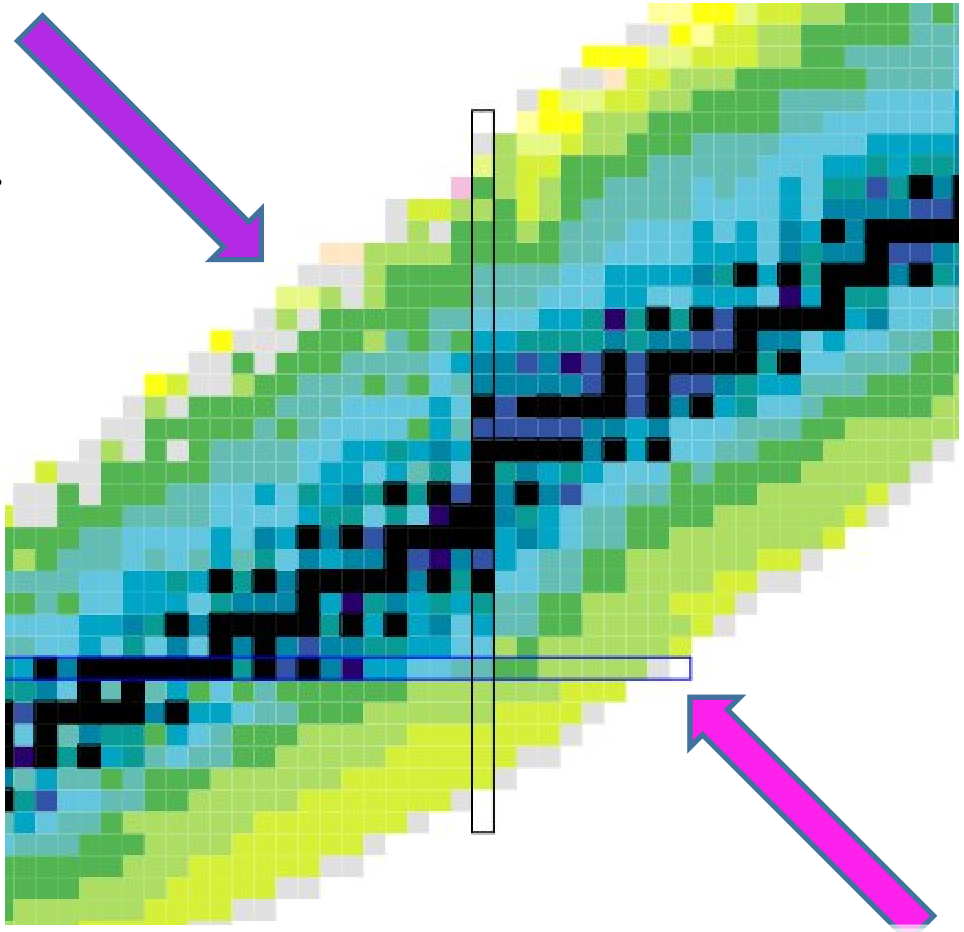
Example: Are decay properties subject to change?

The number of electrons in the atomic system can ***modify*** the decay properties.

e.g. *What happens when you ionise an atom that can only decay by EC?*

→ temperature-dependent stability!

Huge impact in hot stellar plasmas, where atoms are typically **highly-ionised.**



'Ordinary' types of beta decay:

i) $p \rightarrow n + e^{+} + \nu_e$

ii) $n \rightarrow p + e^{-} + \bar{\nu}_e$

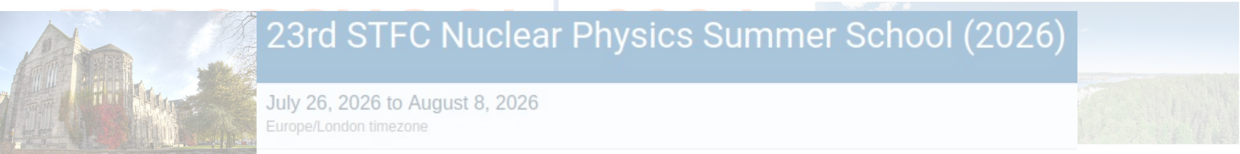
↓

'Continuum' decays: energy and momentum shared between the two leptons

iii) $p + e^{-}_{b} \rightarrow n + \nu_e$

↓

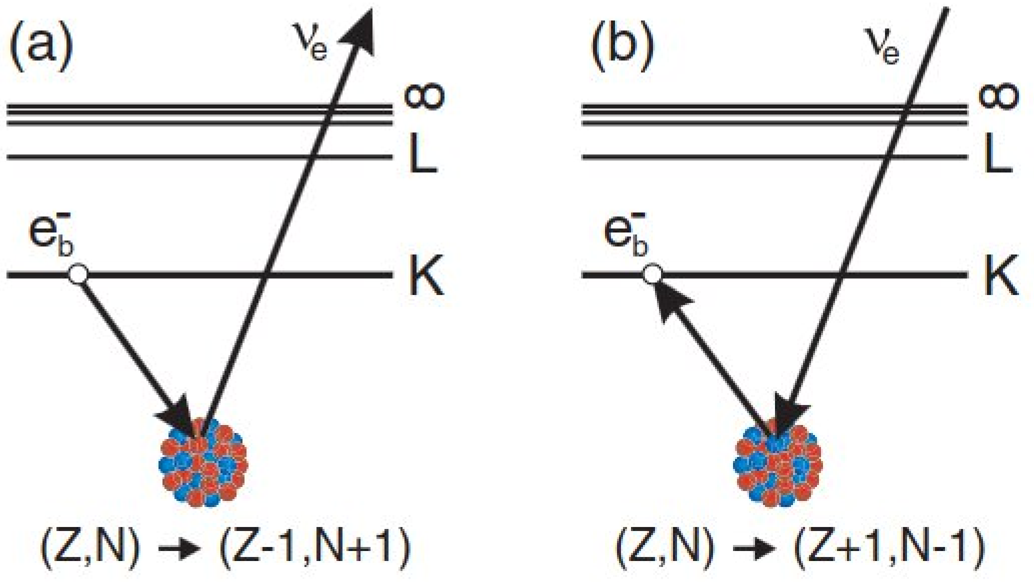
Electron capture: two-body decay where bound electron is annihilated and monochromatic electron neutrino produced



Power of storage rings

Example: Are decay properties subject to change?

EC and time-mirrored β_b process



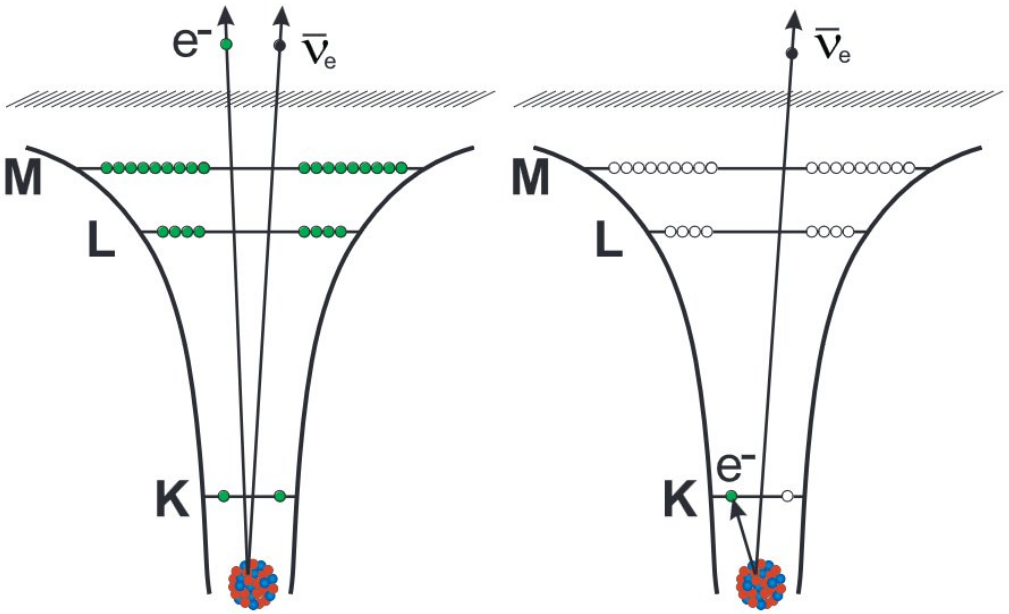
Yu. A. Litvinov *et al.*, Phys. Scr. T144 (2011) 014001 (6pp)

$$\beta_b\text{: } \mathbf{n} + \nu_e \rightarrow \mathbf{p} + \mathbf{e}^-_b$$

- **Bound-state β⁻ decay**: predicted in 1947 by R. Daudel, M. Jean and M. Lecoin (J. Phys. Radium 8, 238 (1947))
- Experimentally observed in the early 90s at GSI (Phys. Rev. Lett. 68, 2164 (1992)) in ^{163}Dy

An electron neutrino is absorbed (equiv. emission of anti-neutrino) and a β- particle is created directly in a bound state of the daughter nucleus

Rare process in neutral atoms, where the inner shells are occupied

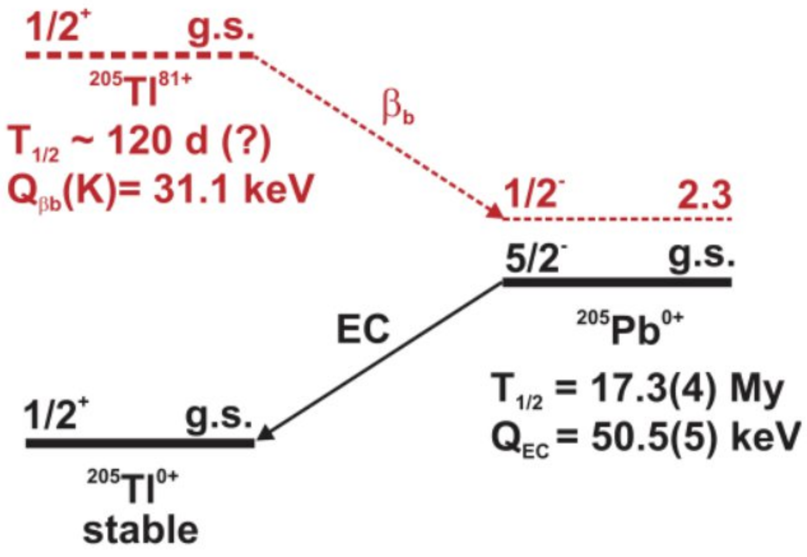


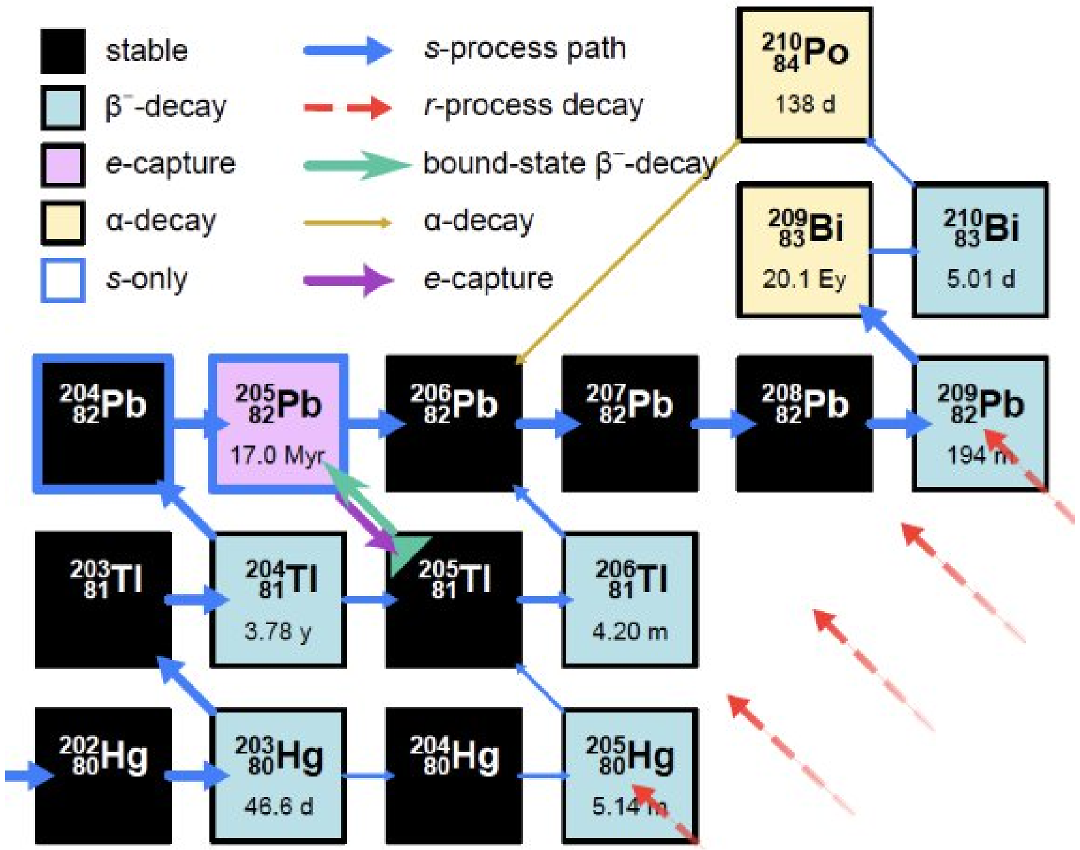
Power of storage rings

Example: Are decay properties subject to change?

- Neutral ^{205}Tl is ***stable***
- EC of ^{205}Pb has Q-value of 50.5 keV
- Binding energy of K-electrons in Tl is ~85 keV
- β_b decay of ***fully-ionised*** or H-like ^{205}Tl can occur, primarily to the first excited state of ^{205}Pb

critical for s-process nucleosynthesis!

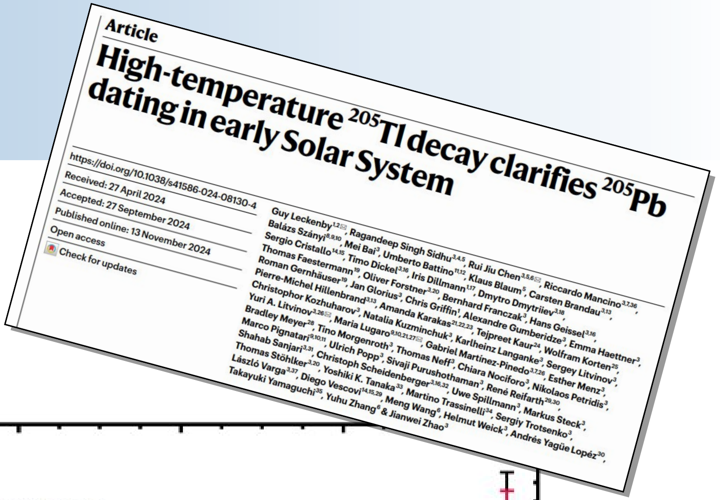




Leckenby *et al.*, EPJ Web of Conferences 279, 06010 (2023)

Power of storage rings

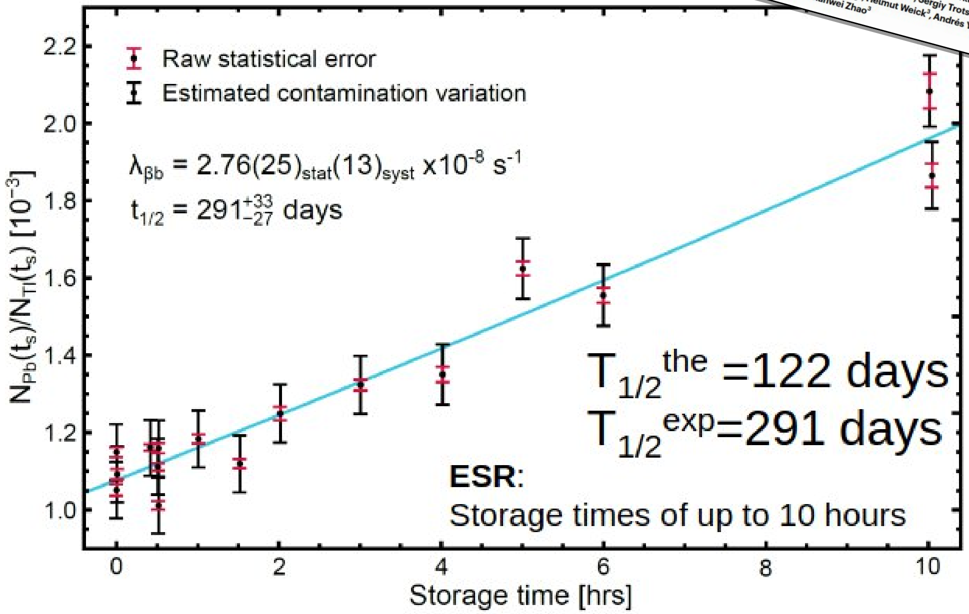
Example: Are decay properties subject to change?

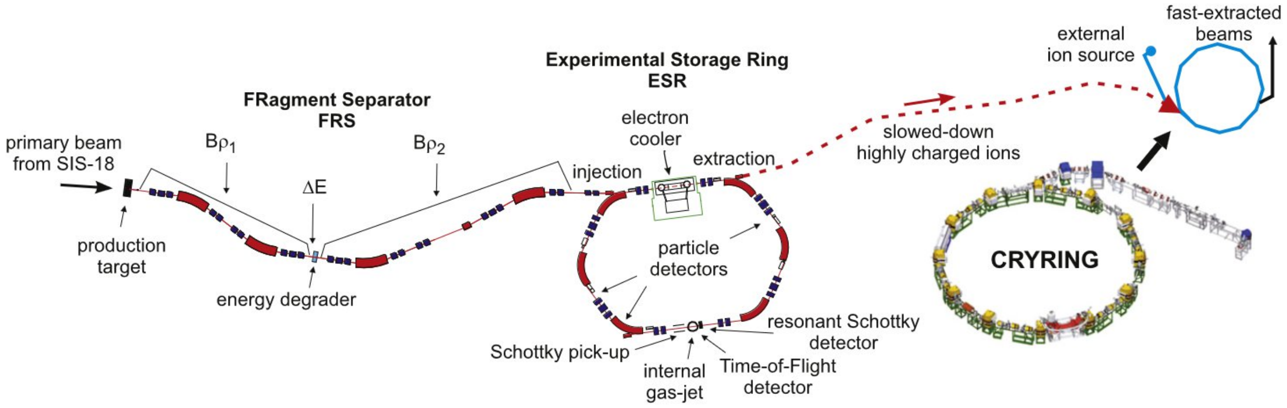

Article

High-temperature ^{205}Tl decay clarifies ^{205}Pb dating in early Solar System

https://doi.org/10.1038/s41586-024-08130-4
Received: 27 April 2024
Accepted: 27 September 2024
Published online: 13 November 2024
Open access
Check for updates

- Studied at the GSI **Experimental Storage Ring** (ESR)
- $^{205}Tl^{81+}$ produced in projectile fragmentation and separated by the **FRagment Separator (FRS)**
- $^{205}Tl^{81+}$ ions stored for up to 10 hours to **accumulate ^{205}Pb**
- **Bound electrons stripped** with Ar gas to produce $^{205}Pb^{82+}$

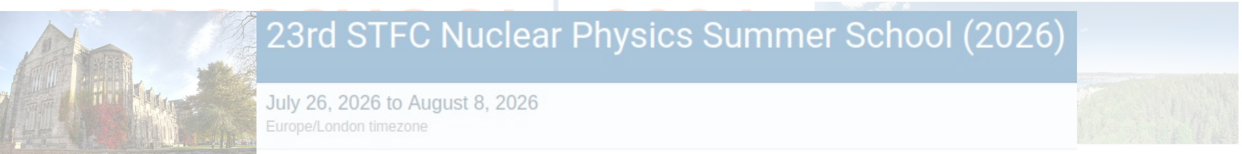




Leckenby et al, Nature, volume 635, pages 321–326 (2024)

Y. H. Zhang *et al.*, Phys. Scr. 91 (2016) 073002

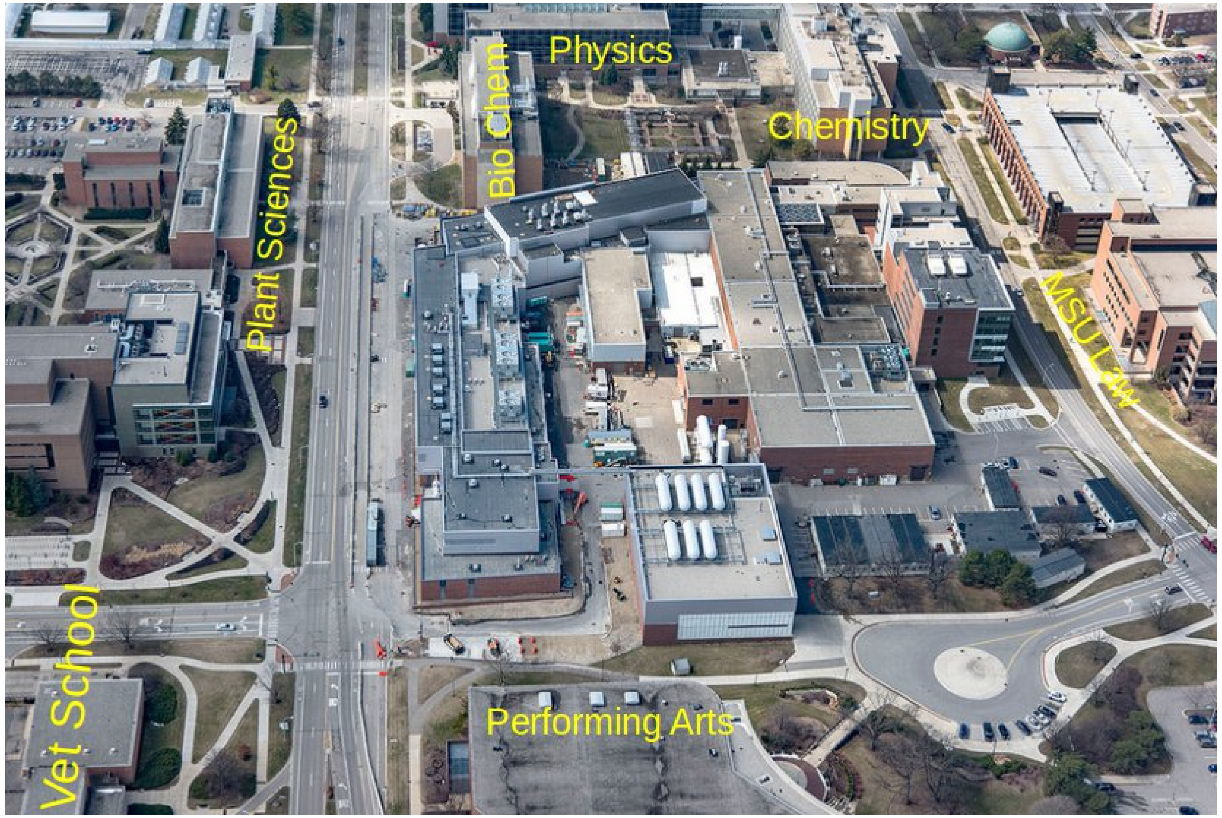
Storage rings in operation (e.g. ESR, R3,...), in early operation (e.g. HIAF) and planned (FAIR)...



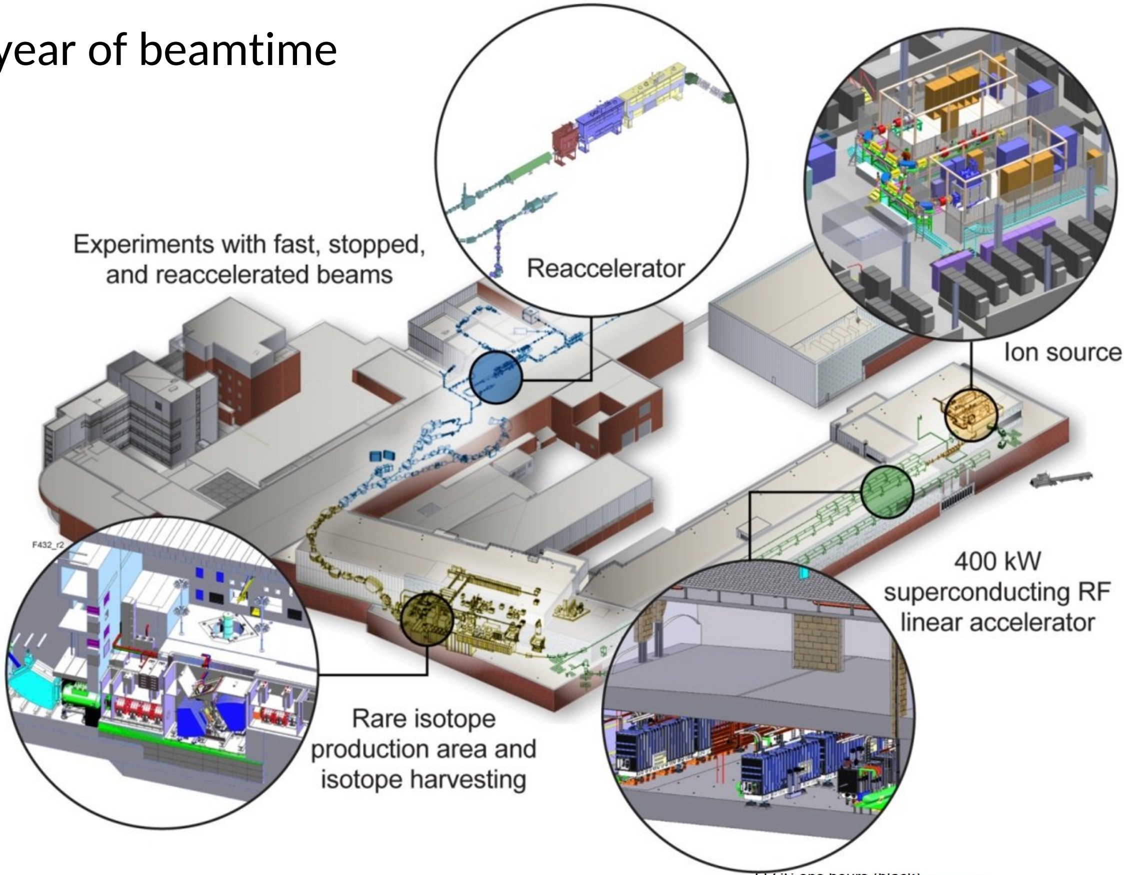
Facility for Rare Isotope Beams (FRIB) *at a glance*

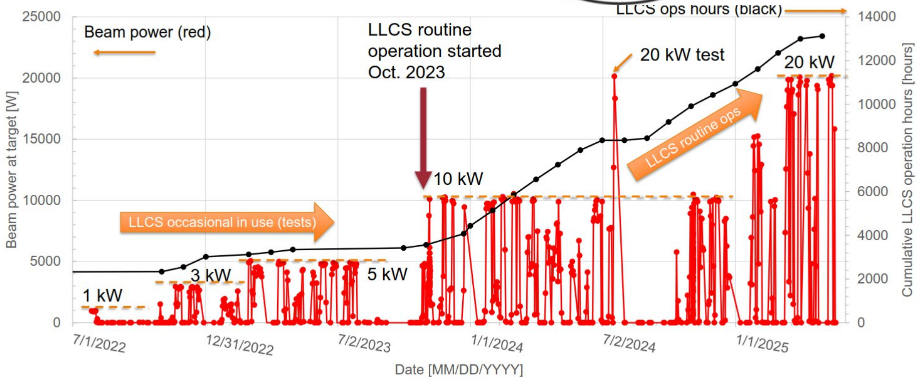
Courtesy A. Gade, FRIB MSU

- **User facility** located in Michigan, USA
- User operation started in **May 2022**
- Primary beams up to **200 MeV/u**
- **>6000 hours** per year of beamtime
- **>90% availability**



Nuclear Physics News, Vol. 34, No. 3, 2024





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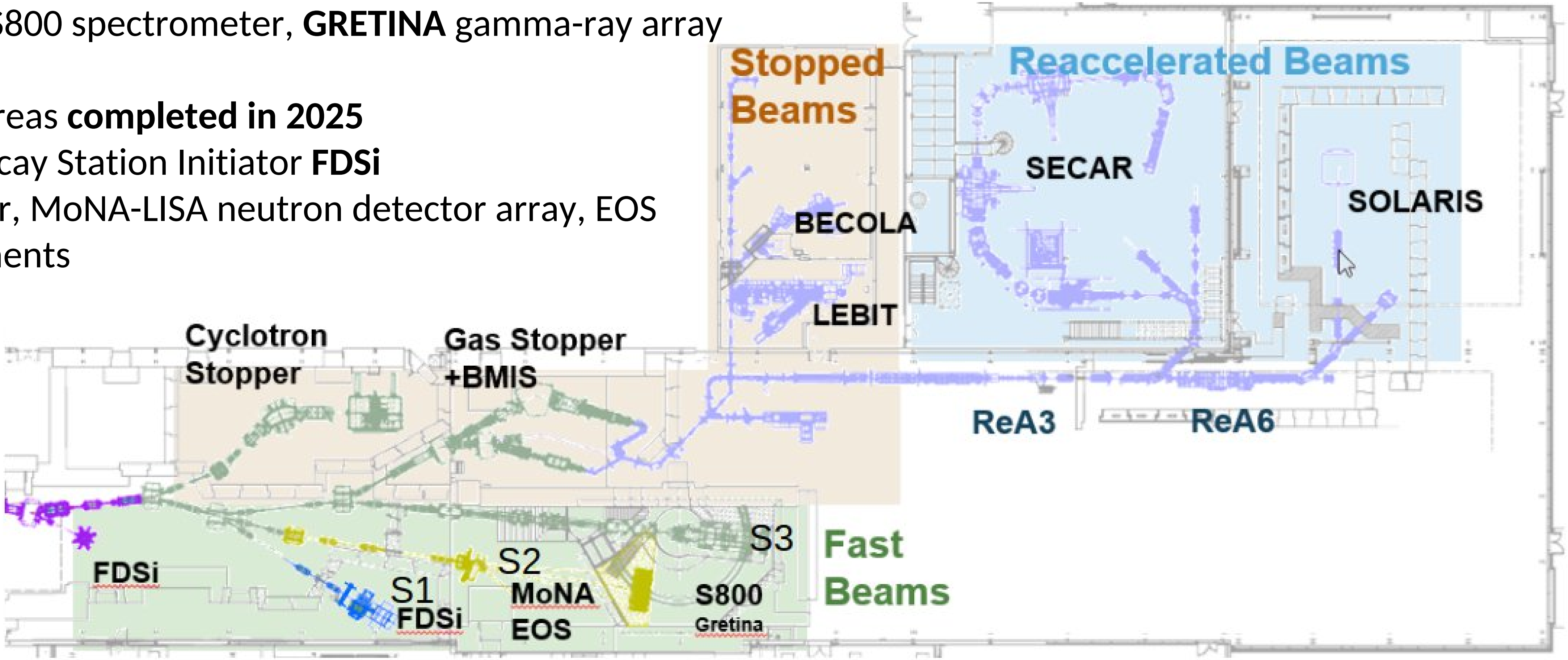
July 26, 2026 to August 8, 2026

Europe/London timezone

Facility for Rare Isotope Beams (FRIB) *at a glance*

- Experimental areas for **stopped** and **reaccelerated** beams
  - (LEBIT, BECOLA, SECAR, SOLARIS, SeGA)
- S3 vault -> S800 spectrometer, **GRETINA** gamma-ray array

- S1 and S2 areas **completed in 2025**
  - FRIB Decay Station Initiator **FDSi**
  - Sweeper, MoNA-LISA neutron detector array, EOS experiments

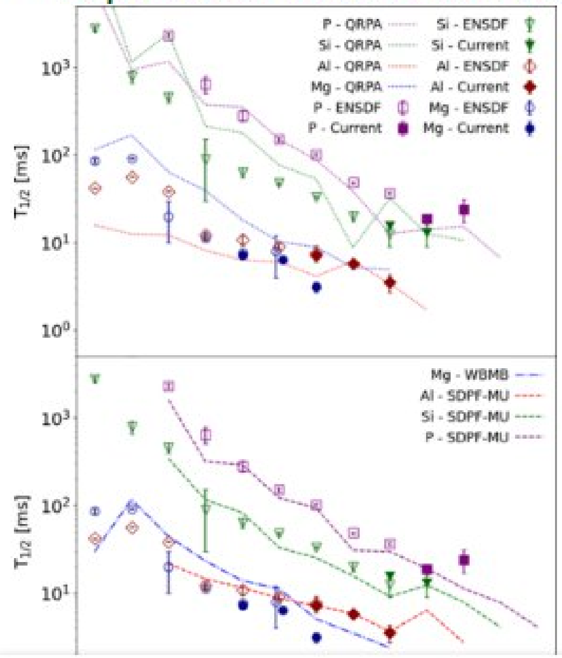


Courtesy A. Gade, FRIB MSU

Facility for Rare Isotope Beams (FRIB) *First publications from FRIB already in 2022!*

Slide adapted from Sean Liddick

- Experiment focused on decay of isotopes near *N=28* (LBNL led)



- 5 isotopes with no published half-life information were studied
- Overall agreement with available shell-model calculations is consistent with a well-developed region of deformation
- Clear evidence for erosion of Z=14 subshell closure

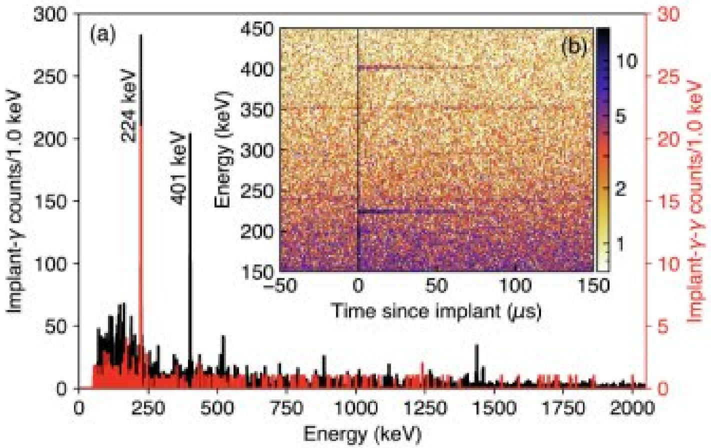
PHYSICAL REVIEW LETTERS **129**, 212501 (2022)

Editors' Suggestion | Featured in Physics

Crossing $N = 28$ Toward the Neutron Drip Line: First Measurement of Half-Lives at FRIB

H. L. Crawford,[1,*] V. Tripathi,[2] J. M. Allmond,[3] B. P. Crider,[4] R. Grzywacz,[5] S. N. Liddick,[6,7] A. Andalib,[6,8] E. Argo,[6,8] C. Benetti,[2] S. Bhattacharya,[2] C. M. Campbell,[1] M. P. Carpenter,[9] J. Chan,[5] A. Chester,[6] J. Christie,[5] B. R. Clark,[4] I. Cox,[5] A. A. Doetsch,[6,8] J. Dopfer,[6,8] J. G. Duarte,[10] P. Fallon,[1] A. Frotscher,[1] T. Gaballah,[4] T. J. Gray,[3] J. T. Harke,[10] J. Heideman,[5] H. Heugen,[5] R. Jain,[6,8] T. T. King,[3] N. Kitamura,[5] K. Kolos,[10] F. G. Kondev,[9] A. Laminack,[3] B. Longfellow,[10] R. S. Lubna,[6] S. Luitel,[4] M. Madurga,[5] R. Mahajan,[6] M. J. Mogannam,[6,7] C. Morse,[11] S. Neupane,[5] A. Nowicki,[5] T. H. Ogunbeku,[4,6] W.-J. Ong,[10] C. Porzio,[1] C. J. Prokop,[12] B. C. Rasco,[3] E. K. Ronning,[6,7] E. Rubino,[6] T. J. Ruland,[13] K. P. Rykaczewski,[3] L. Schaedig,[6,8] D. Seweryniak,[9] K. Siegl,[5] M. Singh,[5] S. L. Tabor,[2] T. L. Tang,[2] T. Wheeler,[6,8] J. A. Winger,[4] and Z. Xu[5]

- A newly identified microsecond isomer was observed in ^{32}Na
- First microsecond isomer in this region
- Results suggest low-lying states are dominated by deformation



+6 international

PHYSICAL REVIEW LETTERS **130**, 242501 (2023)

Featured in Physics

Microsecond Isomer at the $N = 20$ Island of Shape Inversion Observed at FRIB

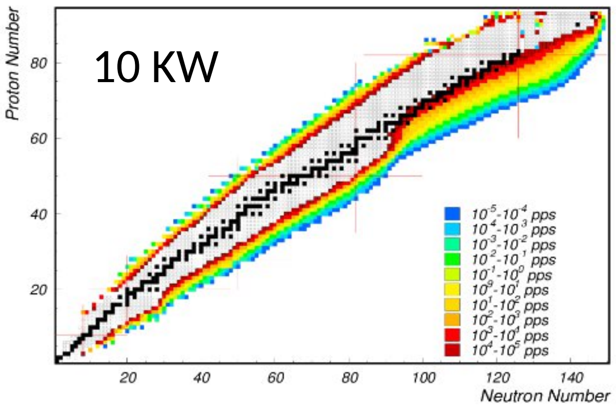
T. J. Gray,[1] J. M. Allmond,[1] Z. Xu,[2] T. T. King,[1] R. S. Lubna,[3] H. L. Crawford,[4] V. Tripathi,[5] B. P. Crider,[6] R. Grzywacz,[2,1] S. N. Liddick,[3,7] A. O. Macchiavelli,[1] T. Miyagi,[8,9] A. Poves,[10] A. Andalib,[3,11] E. Argo,[3,11] C. Benetti,[5] S. Bhattacharya,[5] C. M. Campbell,[4] M. P. Carpenter,[12] J. Chan,[2] A. Chester,[3] J. Christie,[2] B. R. Clark,[6] I. Cox,[2] A. A. Doetsch,[3,11] J. Dopfer,[3,11] J. G. Duarte,[13] P. Fallon,[4] A. Frotscher,[6] T. Gaballah,[6] J. T. Harke,[13] J. Heideman,[2] H. Huegen,[2] J. D. Holt,[14,15] R. Jain,[3,11] N. Kitamura,[2] K. Kolos,[13] F. G. Kondev,[12] A. Laminack,[1] B. Longfellow,[13] S. Luitel,[6] M. Madurga,[2] R. Mahajan,[3] M. J. Mogannam,[3,7] C. Morse,[16] S. Neupane,[2] A. Nowicki,[2] T. H. Ogunbeku,[6,3] W.-J. Ong,[13] C. Porzio,[4] C. J. Prokop,[17] B. C. Rasco,[1] E. K. Ronning,[3,7] E. Rubino,[3] T. J. Ruland,[18] K. P. Rykaczewski,[1] L. Schaedig,[3,11] D. Seweryniak,[12] K. Siegl,[2] M. Singh,[2] A. E. Stuchbery,[19] S. L. Tabor,[5] T. L. Tang,[5] T. Wheeler,[3,11] J. A. Winger,[6] and J. L. Wood[20]

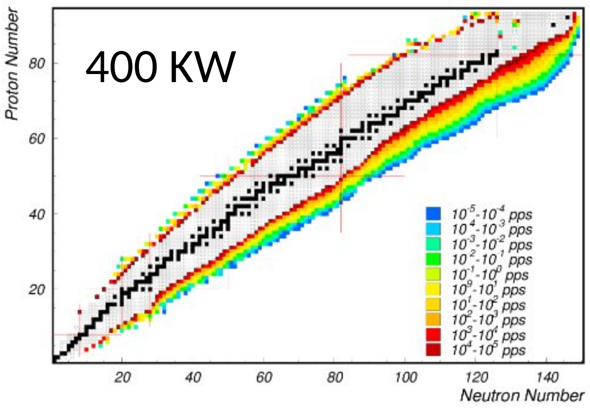
Courtesy A. Gade, FRIB MSU

Facility for Rare Isotope Beams (FRIB)

What's to come in the future at FRIB?

- **FRIB400 upgrade** doubles the beam energy to 400 MeV/u - addition of 11 cryomodules
- Significantly extending reach in neutron-rich territory





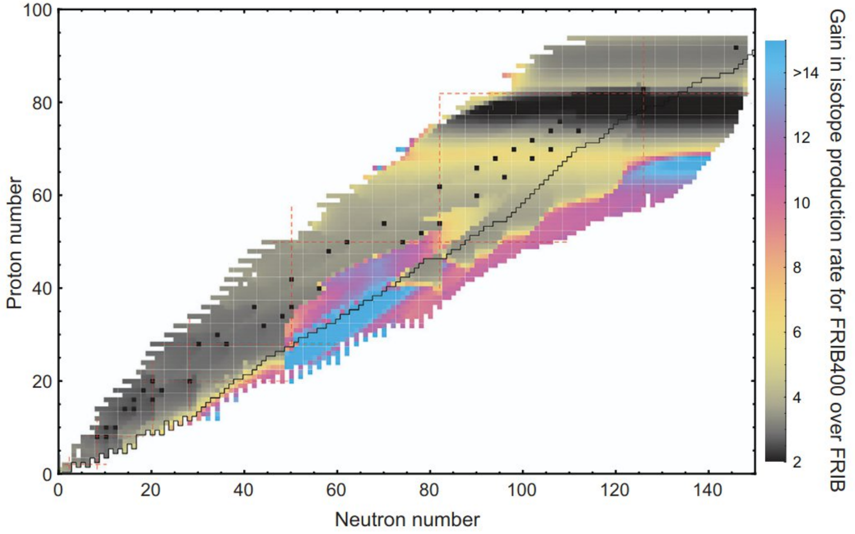


Figure 5.10: The gain in isotope production at FRIB400 relative to the nominal FRIB facility is shown. Gains are given for isotopes that are produced at rates of more than one atom per week.

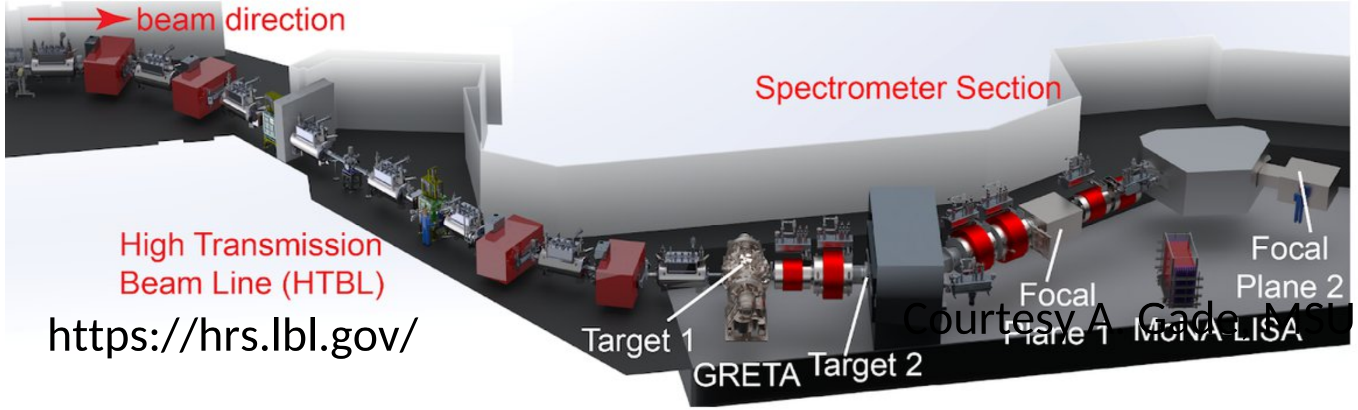
The Scientific Case for the 400 MeV/u Energy Upgrade of FRIB by the FRIB Science Community

High-rigidity spectrometer (HRS, 8Tm)

– Fast-beam program -> Access to extremely rare isotopes using thick targets (high luminosity)

HRS final design report was published in 2024

Approval granted in 2025 to start execution of HTBL



https://hrs.lbl.gov/

Courtesy A. Gade, MSU

Radioactive Isotope Beam Factory (RIBF) *at a glance*

- At the ***RIKEN Nishina center*** in Japan
- Optimised for in-flight production of fission fragments with **high-intensity uranium beam**
- SRC delivers 345 MeV/u U beam

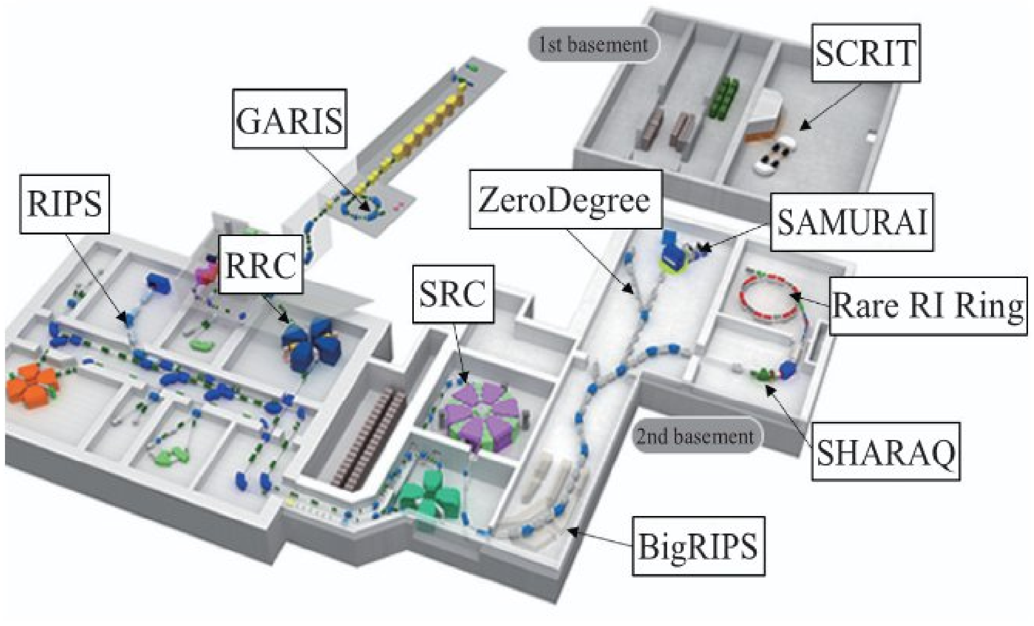


Fig. 1 Facility layout of RIBF (Courtesy of RIKEN).

Hiroyoshi Sakurai, Front. Phys. 13(6), 132111 (2018)

- In-flight separator BigRIPS for separation and identification
- Bρ up to 9 Tm, primary beams at 345 MeV/u from cyclotron
- In operation since 2007

✓ ~700 RI beams to 250 experiments

✓ >170 new isotopes

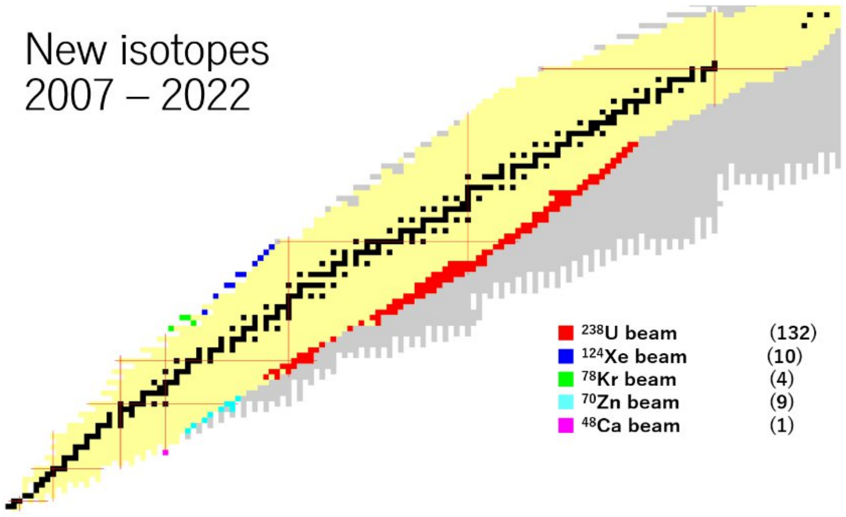


Figure 4.2 New isotopes discovered at the RIBF since 2007. In total, 156 new isotopes were reported. The numbers in the parentheses denote the number of new isotopes produced by the respective primary beams.

Radioactive Isotope Beam Factory (RIBF) *What's to come in the future at RIBF?*

- Major upgrade plans with staged planning over several (~8) years
- ***Goal to raise ^{238}U intensity*** from ~100 pnA to ~2000 pnA (x20 increase) - *1×10^{13} ions per second(!)*
- Re-engineering of uranium accelerator chain
- Upgrades to BigRIPS and experiment instrumentation

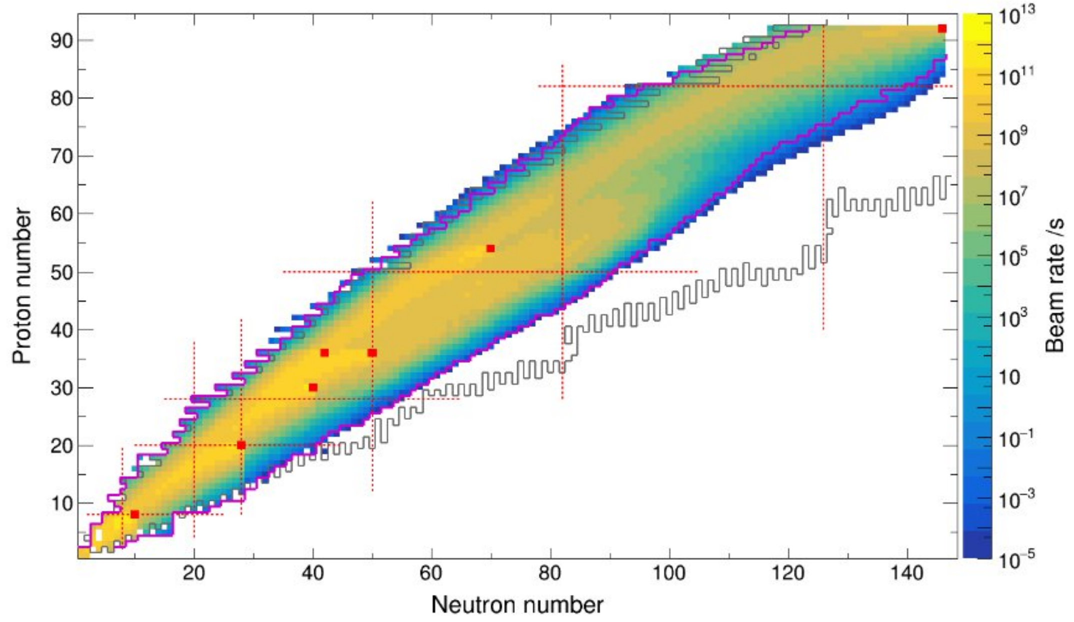


Figure 4.5 RI beam intensities evaluated for the primary beam intensity of 2,000 pnA. The color code denotes the expected intensity in the unit of particles per second (pps). The primary beam species are indicated by the red squares. The boundaries of the known nuclei (red lines) and the predicted driplines by the KTUY mass formula [KOU05] (black lines) are shown.

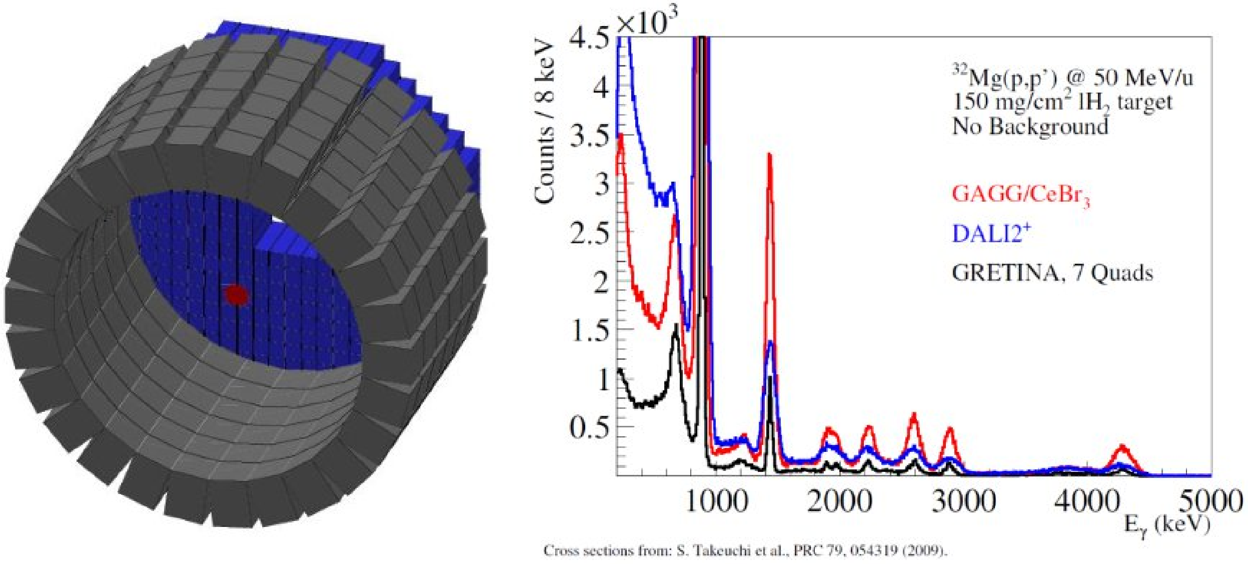
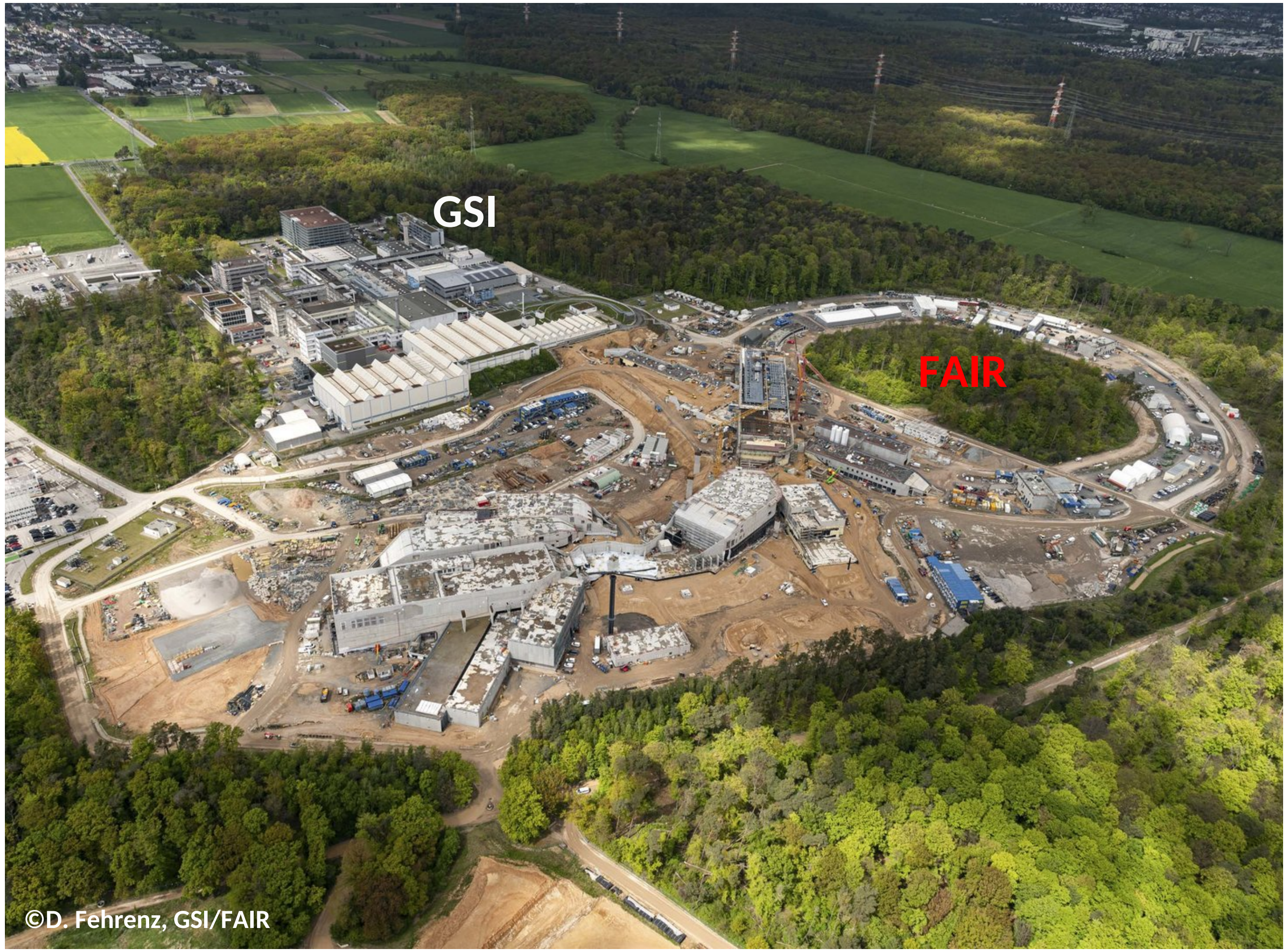
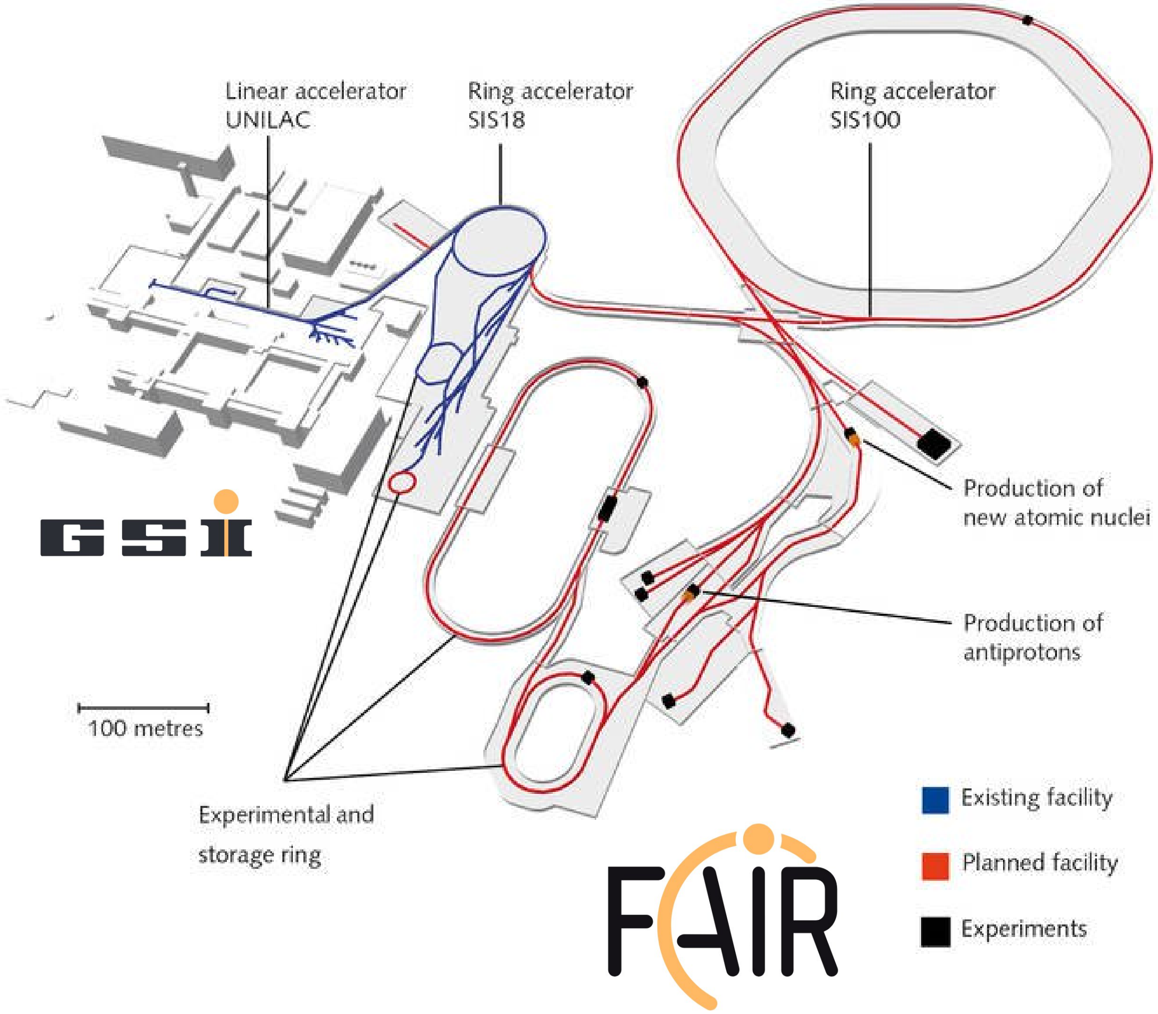


Figure 5.7 (left) Layout of scintillation-based γ-ray spectrometer containing 384 HR-GAGG and 624 CeBr$_3$ detectors. The latter are packed in common housing of 2×2 crystals and arranged in anannular configuration with an inner radius of ~250 mm. (right) GEANT4 simulation of inelastic scattering of ^{32}Mg on liquid hydrogen for new scintillation array, DALI2$^+$, and the GRETINA setup containing 7 quads. Note that background was not included into the simulation.

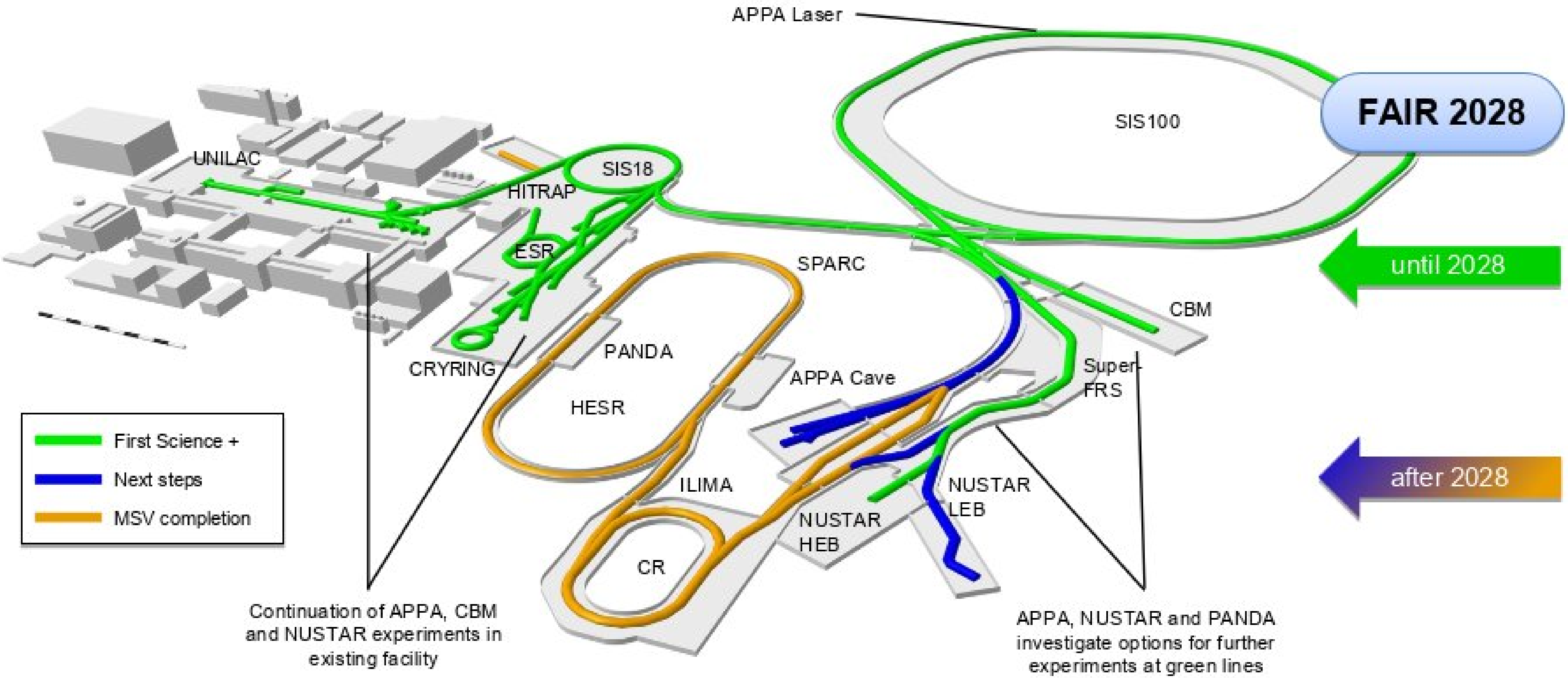
https://www.nishina.riken.jp/researcher/RIBFupgrade/RIBF

Facility for Antiproton and Ion Research (FAIR)





Facility for Antiproton and Ion Research (FAIR)



FAIR Darmstadt

- **25 accelerator and experimental structures,** labs and other operation and supply structures
- **Underground accelerator ring** with a circumference of approx. 1,100 m
- **Around 150,000 m²** of total area

- World-leading accelerator laboratory for decades
- Unique research in physics and applications

- Landmark in the European research roadmap (ESFRI)
- Top priority in the European nuclear physics community

Construction volumes

2 million m^3
of soil
to be moved

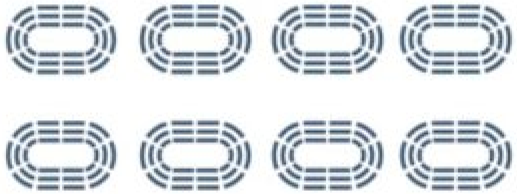
600,000 m^3
of concrete
to be used

65,000 tons
of steel
to be utilized

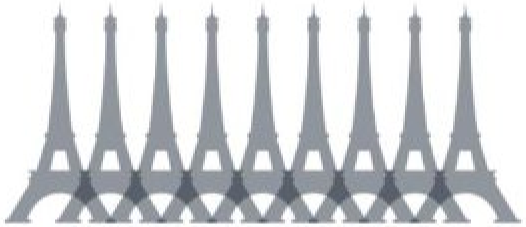
status October 2022 : more than 50 % completed

– as much as for 5,000 single-family homes.

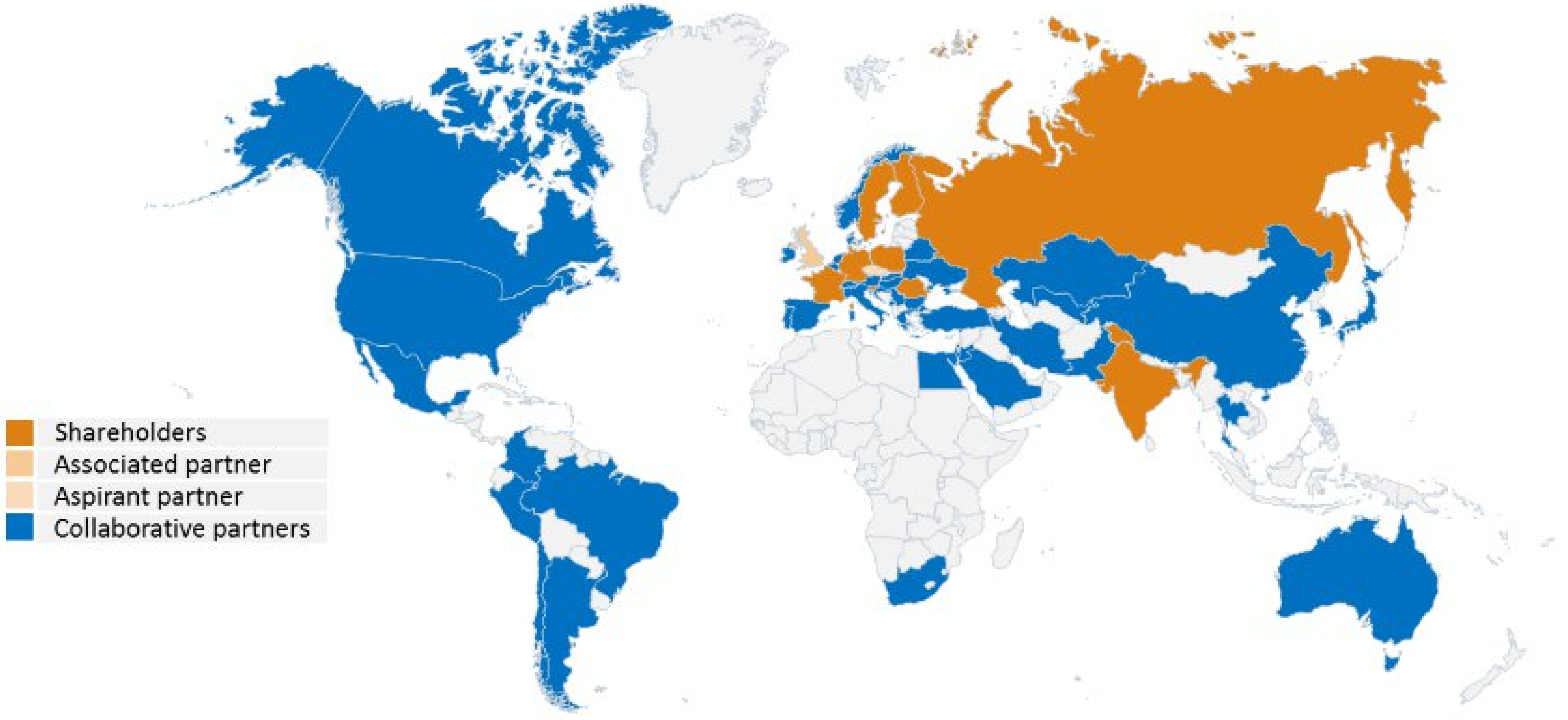
– as much as eight Frankfurt football stadiums.



– as much as nine Eiffel Towers.

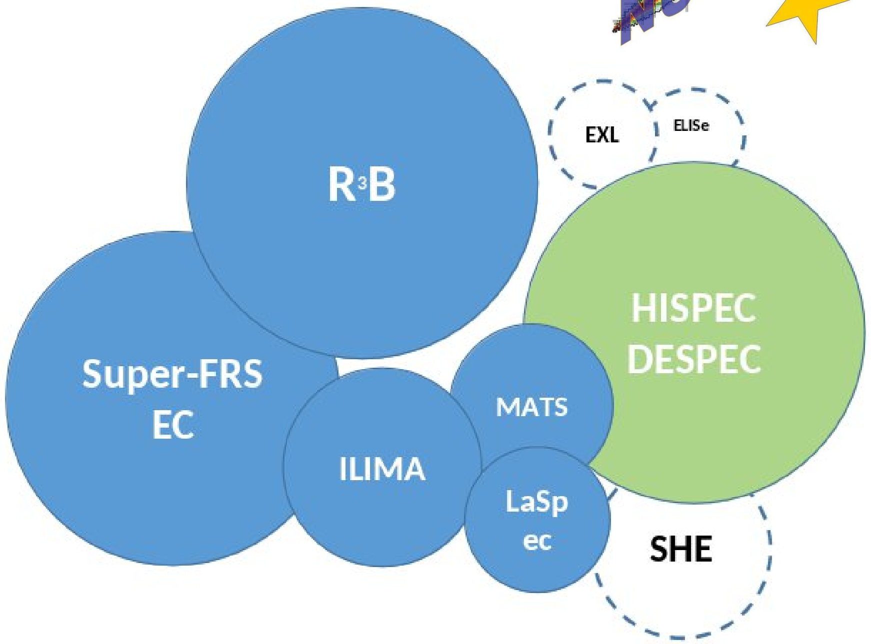


Facility for Antiproton and Ion Research (FAIR)



NUclear STructure Astrophysics and Reactions (NUSTAR)

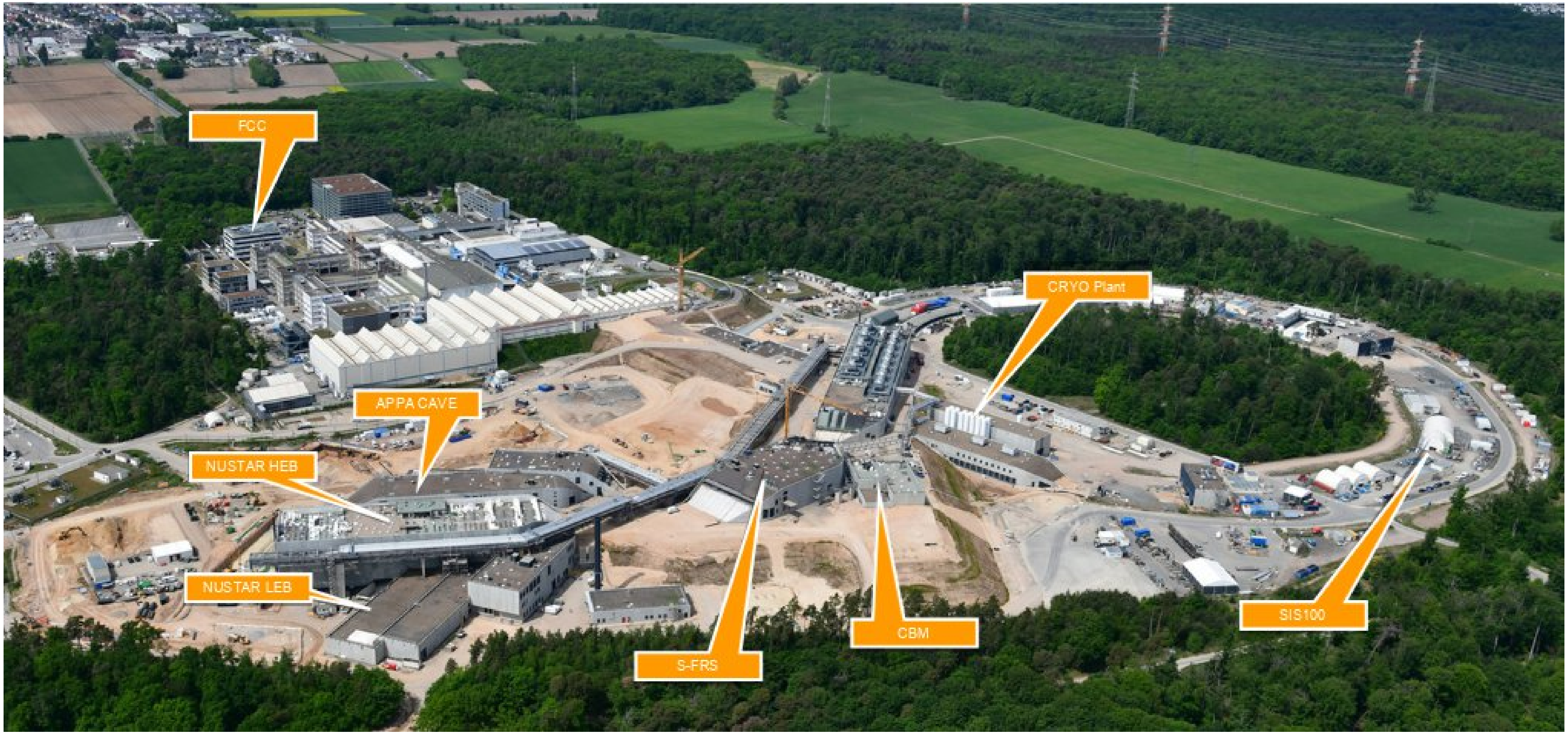
Overarching physics case:
The creation of the chemical elements



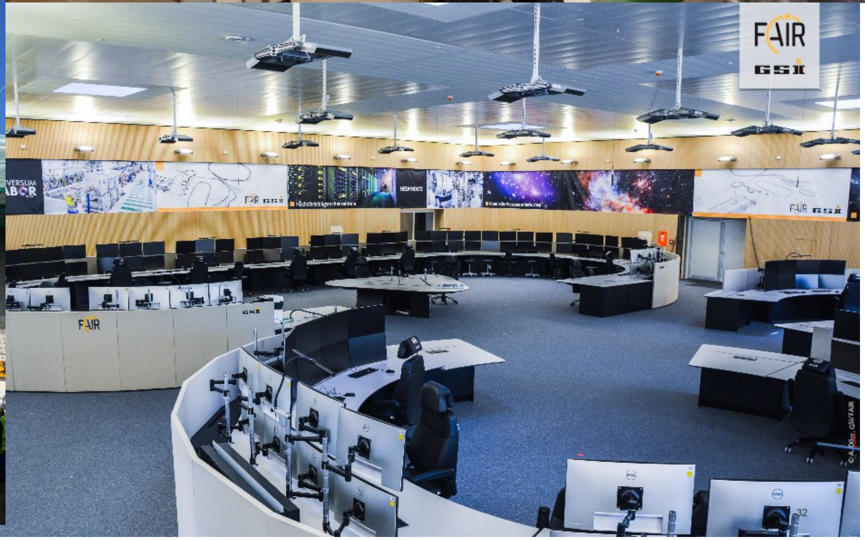
> 1000 listed "interested" scientists
> 630 registered members (incl. students, etc.)
~ 420 senior members (PhD holder w/o Russia)
> 150 institutes from 36 countries

A "collaboration of collaborations"

FAIR campus overview



FAIR impressions and status



23rd STFC Nuclear Physics Summer School (2026)

July 26, 2026 to August 8, 2026

Europe/London timezone

FAIR April 2026

Moving forward!

HITRAP moves and becomes PARTIH — GSI interim solutions are progressing at full speed

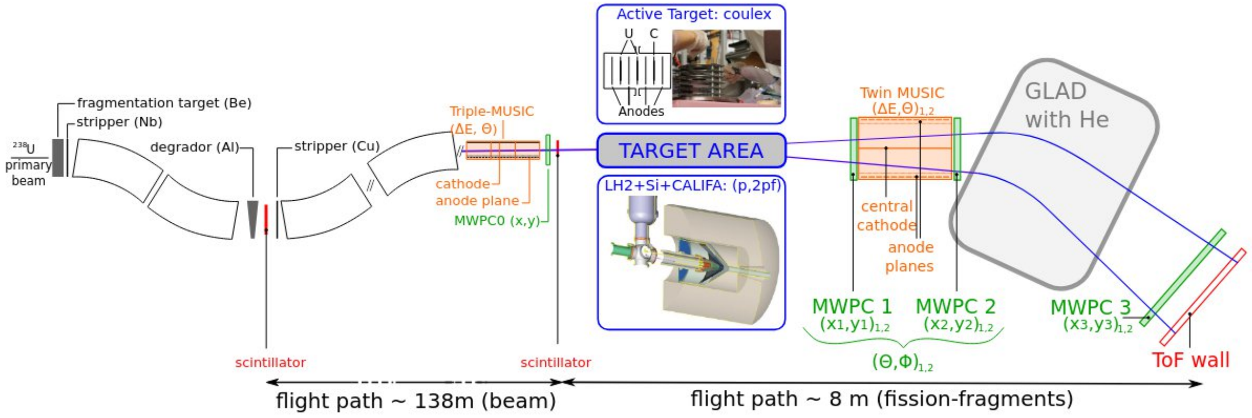
Short (1-2 years), Intermediate (3-5 years) and long-term (> 5 years) solutions already underway!

"It was decided that turning the HITRAP decelerator around and using it as an accelerator is the fastest path to Carbon beams for FAIR commissioning. HITRAP was recently used to decelerate highly charged gold ions and to irradiate them onto a surface in order to investigate induced transformations in the surface. PARTIH, HITRAP turned around, became a sub-project in the GSI project for restoring beam operation."

https://www.gsi.de/en/start/news/details/2026/07/30/hitrap-wird-zu-partih

Highlight from FAIR Phase-0

Fission investigated using the advanced SOFIA R³B setup



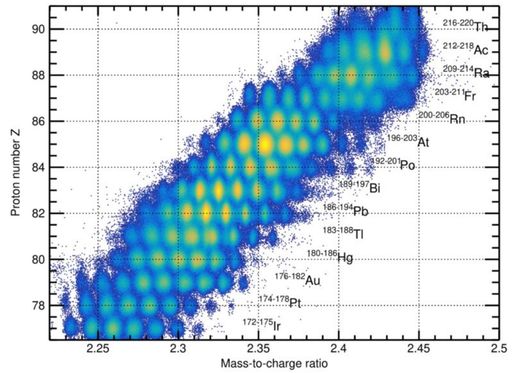
Experiment carried out in Phase-0 2021

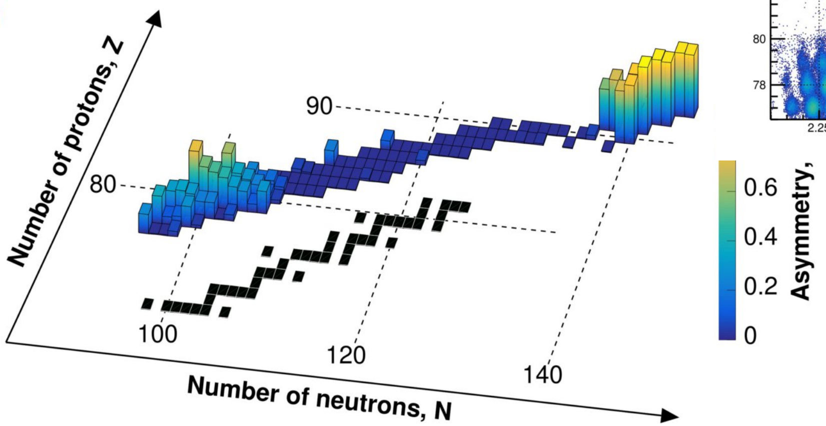
- Fission study of 100 neutron-deficient exotic nuclei from iridium to thorium (12 FRS settings)
- Fission induced by Coulomb excitation
- Detection of both fission fragment in coincidence

Motivation

➔ What are the limits of the new asymmetric fission island?

➔ What shell effects are responsible for the asymmetric split





- First set of charge distribution across a wide range of exotic fissioning systems.
- Experimental evidence of strong proton-shell stabilization at Z=36

P. Morfouace *et al.* Nature 641, 339 (2025)
DOI 10.1038/s41586-025-08882-7

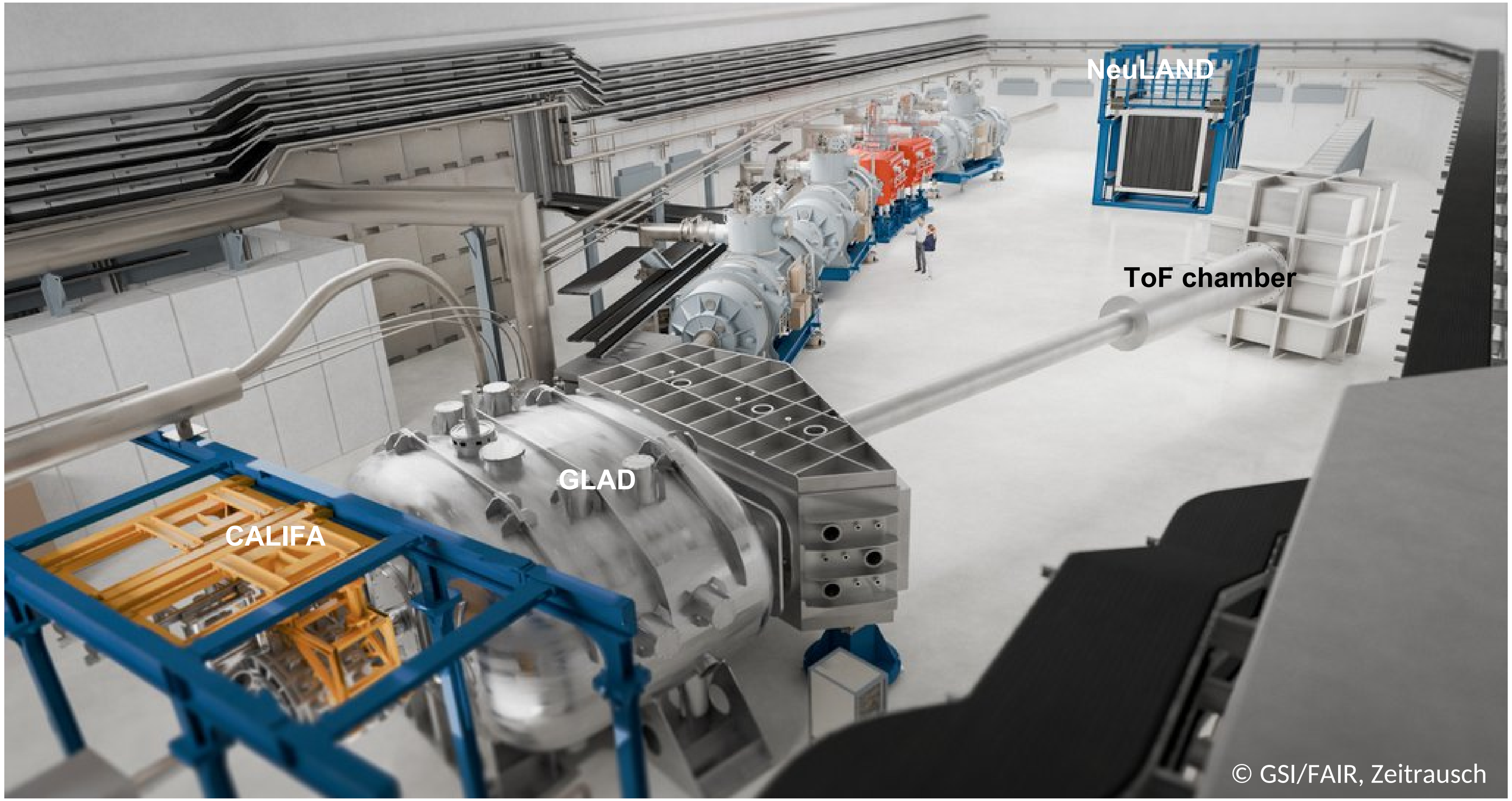
New measurements at FAIR

New fission measurements with R^3B setup in the high-energy cave after commissioning phase

- Continuation of program and completely new investigations!

Gains to be made from:

- improved beam purity
- increased fragment production
- transmission with Super-FRS
- space availability in High-Energy Cave



Future opportunities for decay spectroscopy:
Isomers as tools

- Isomers are sensitive probe of nuclear structure

AND..... a very useful tool!

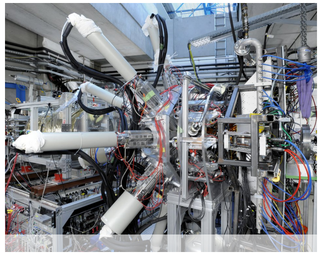
100s ns!

Exotic nuclei produced in fragmentation reactions

Separated, identified and transmitted in-flight by a powerful separator

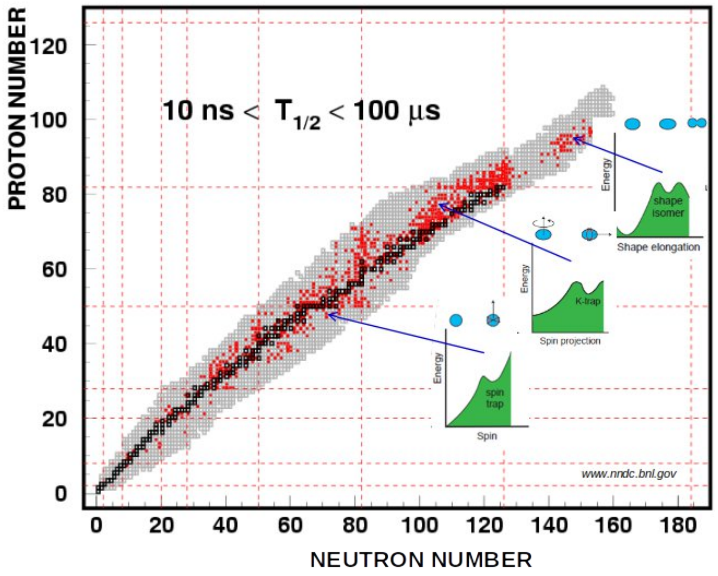
Stopped inside of experimental setup

Decay properties studied



Why do isomeric states exist?

– decays are ***hindered*** due to the structural surroundings (nature of single-particle orbits and the collective behaviour).



Main causes of isomerism:

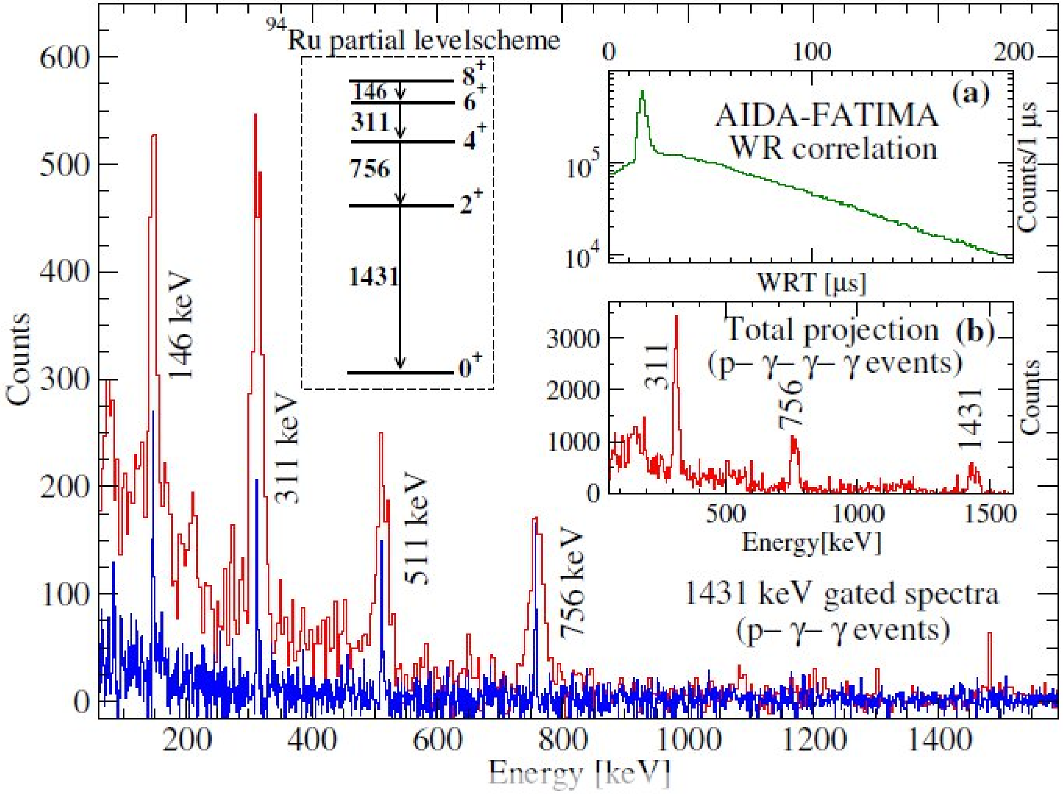
A) different structural matrix elements
B) small decay energy
C) large change in angular momentum

- ➢ Spherical regions - spin and seniority isomers.
- ➢ Deformed regions - K, shape, fission isomers.

The types can occur in any combination - sometimes difficult to disentangle the effects!

Future opportunities for decay spectroscopy:
Isomers as tools

- Experiment to measure lifetimes of excited states in ***N=50 isotone ^{94}Ru.***
- Ions produced in fragmentation of 850-MeV/u ^{124}Xe ions on ^{9}Be, products separated and identified by the FRagment Separator and implanted into the DESPEC setup.
- γ rays measured after **β-delayed proton emission** following implantation of ^{95}Pd ($21/2^+$ isomer) feeding 8^+ isomer in ^{94}Ru (~70 μs).



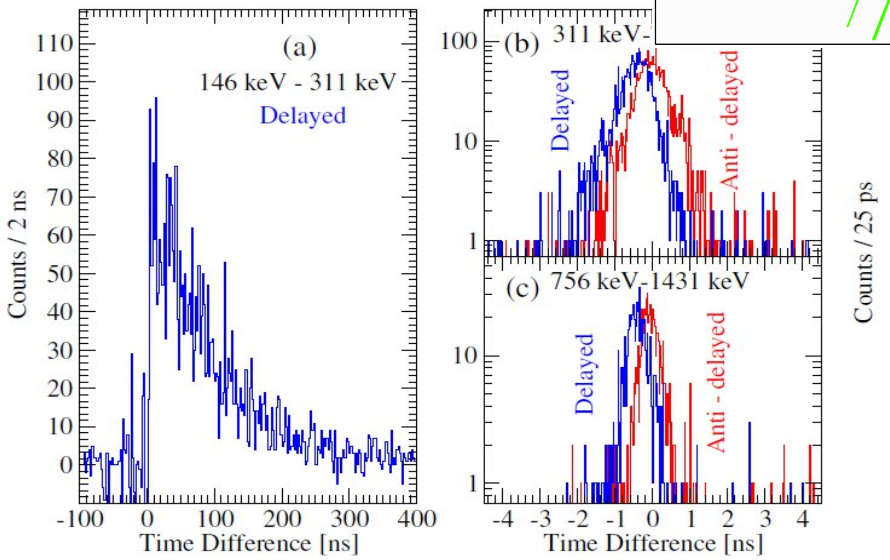


TABLE I. Experimental mean lifetimes and B(E2) strengths in ^{94}Ru in comparison with various shell model predictions. Experimental data except for $8^+ \to 6^+$ [41, 45] are from the present work.

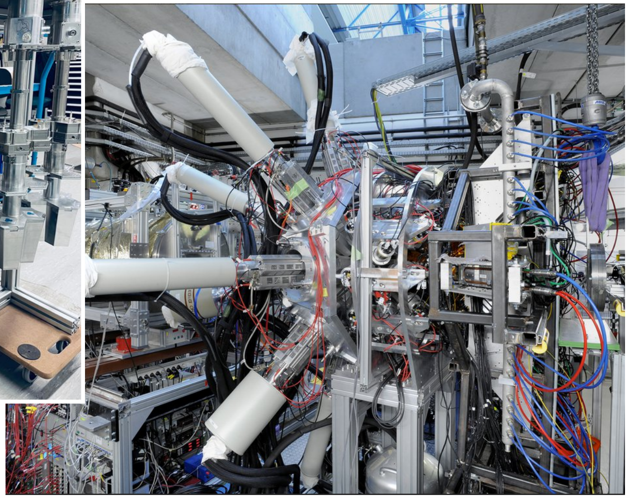
$I_i^\pi \to I_f^\pi$	τ [ps]	$B_{EX}(E2)$ [$e^2 fm^4$]	$B_{SMLB}(E2)$ [$e^2 fm^4$]	$B_{SDGN}(E2)$ [$e^2 fm^2$]
$8^+ \to 6^+$	$102(4) \times 10^6$	0.09(1)	2.0	0.77
$6^+ \to 4^+$	$91(3) \times 10^3$	3.0(2)	6.1	17.3
$4^+ \to 2^+$	32(11)	103(24)	6.8	85.2
$2^+ \to 0^+$	≤ 15	≥ 10	225	295

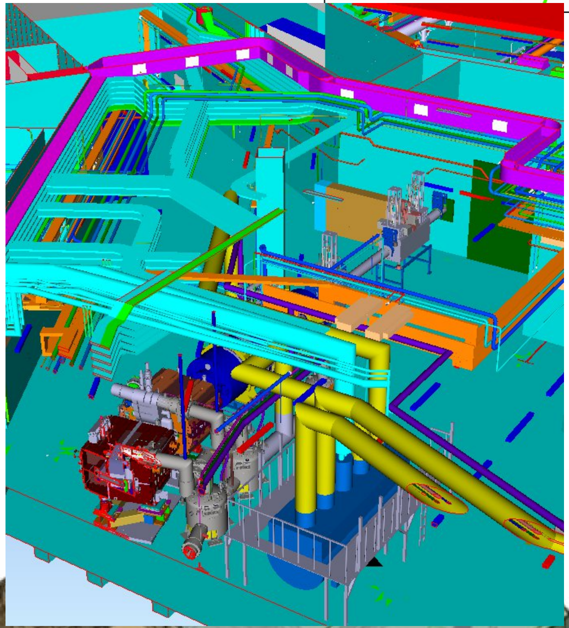
- **$4^+ \to 2^+$ transition strength not as expected.**
- Interpreted as constructive interference between *v*=2 and *v*=4 configurations of same spin.

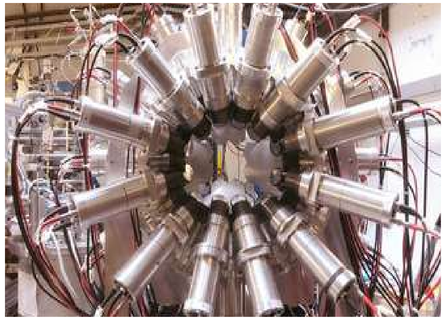
B. Das *et al.*, PRC Letters 105 (2022) L031304

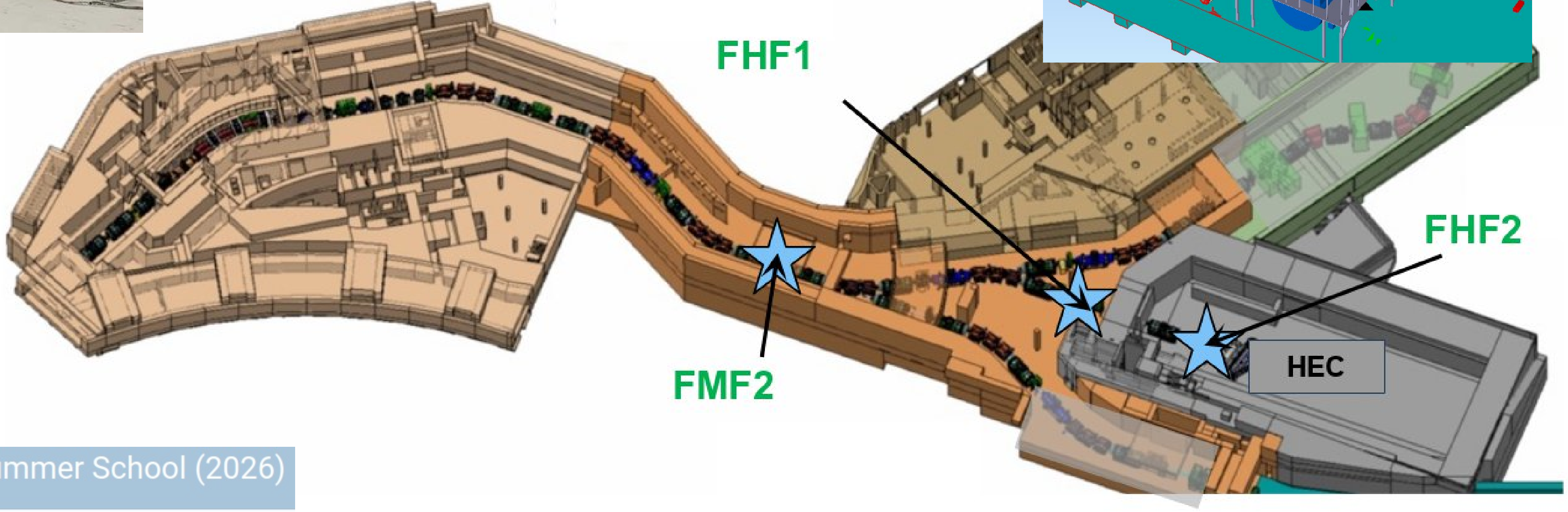
Future opportunities for decay spectroscopy - HISPEC/DESPEC @ FAIR

Construction status of FHF1



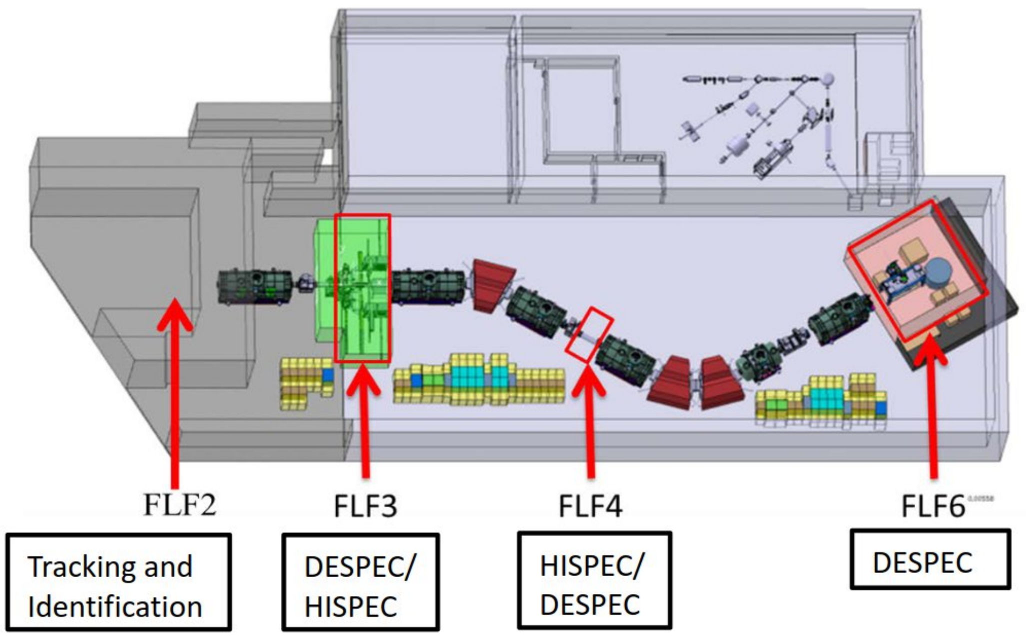




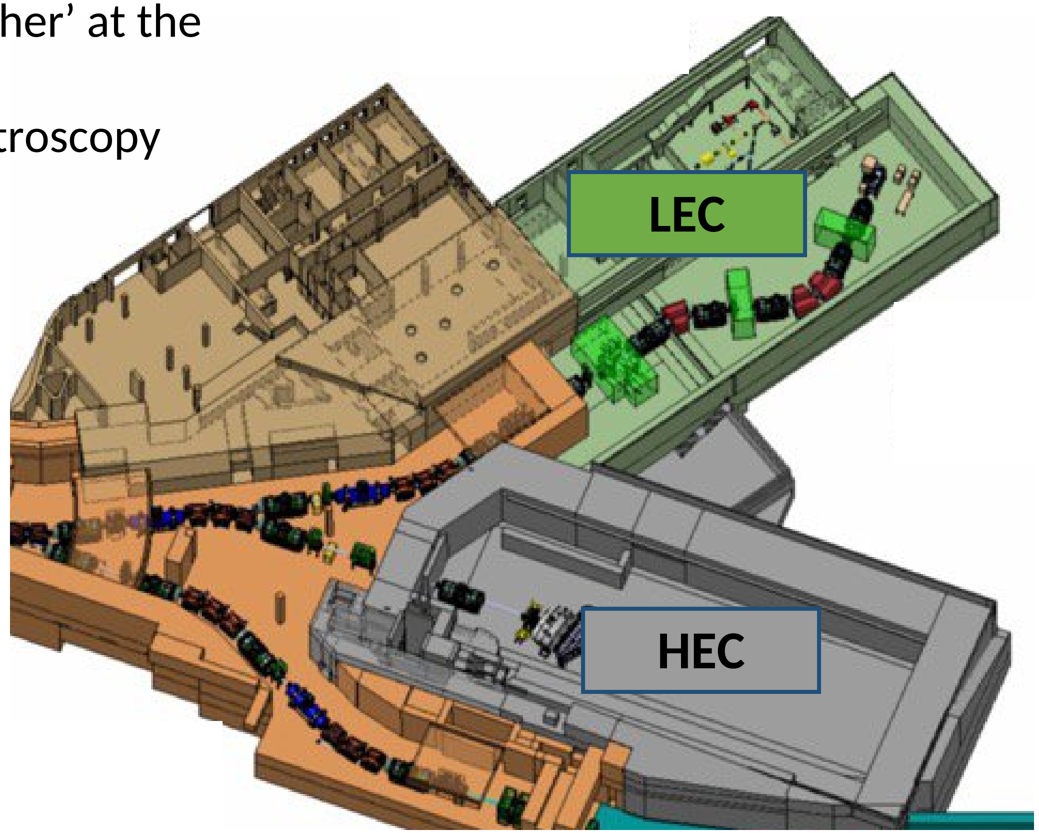


Future opportunities for decay spectroscopy - HISPEC/DESPEC @ FAIR

- Full 'low-energy' branch and 'low-energy cave' expected to be brought into operation after the completion of the high-energy branch
- DESPEC setup to be positioned at the end of the 'Energy Buncher' at the final focal plane.
- Combined in-beam spectroscopy with AGATA and decay spectroscopy possible!



From HISPEC/DESPEC infrastructure public Technical Design Report



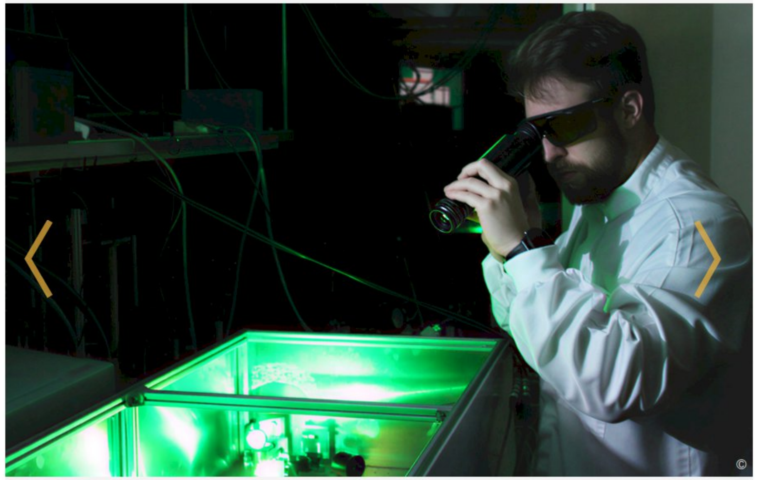
The emerging role of digital twins

https://frib.msu.edu/news-center/news

"*LASE-FUSE ... focuses on developing a* ***comprehensive, modular simulation framework*** *that serves as a* ***digital twin*** *of fusion laser systems and, for the first time, enables holistic modeling of all relevant system components—from laser generation through beam shaping and amplification to transport just before interaction with the fusion fuel."*

BMFTR awards millions in funding for fusion research – Dr. Yannik Zobus of GSI/FAIR secures a young investigators group

https://www.gsi.de/en/start/news



https://www.fntsoftware.com/en/press

FNT Software and DC Smarter Collaborate with the GSI Helmholtz Center for Heavy Ion Research to Drive Sustainable and Smart Data Center Operations

"*The integrated solution from FNT and DC Smarter provides all the components and connections of the data center infrastructure in the form of a digital twin. The FNT Command platform forms the data basis and enables intuitive, interactive access and inventory management of the entire data center in real time. Augmented Reality (AR) technology, integrated by DC Vision®, provides on-site technical teams with comprehensive transparency regarding resources and operating processes."*

"The project will develop artificial intelligence, or AI, tools—specifically, physics-informed "digital twins"—that could transform how heavy-ion accelerators and isotope separators are operated.... By uniting government, industry, academia and philanthropy, it is accelerating breakthroughs in energy, scientific discovery and national security through a new platform that combines AI, supercomputing, quantum systems and advanced scientific instruments... The FRIB-Argonne team will develop physics-informed digital twins ... the project will create adaptive digital twins that provide a powerful new tool for accelerator optimization and control. ... The long-term goal is to create an integrated digital representation of the accelerator and isotope separator systems rather than optimizing each component independently."

FRIB-led collaboration named U.S. Genesis Mission awardee for AI-powered accelerator research

23 July 2026

Share this article:

23rd STFC Nuclear Physics Summer School (2026)

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Europe/London timezone

Tutorial discussion point

Discussion point: challenges ahead

Goal: to start thinking of possible strategies for dealing with challenges for nuclear physics-based research in the long term

In the context of new facilities, what are the biggest challenges facing the nuclear physics community on i) a European level and ii) the world-wide stage in the next decades?

Note: the group could be split into two smaller groups and then the ideas shared and compared at the end.

Challenges can be grouped into (e.g.):

- scientific
- technological
- societal/political

How can the community best prepare in order to overcome these challenges?
Some ideas to get the discussion started:

- application of AI / machine learning
- high-performance computing
- next-generation theoretical models and simulations
- future accelerator- and detector-based technology
- other new technologies (quantum science,...)
- collaborative topics (universities, large-scale facilities, international,…)
- open science (FAIR principles)
- community outreach work
- generation of sustainable workforce
- accessibility/diversity
- training opportunities
- ...

Points to take home

L1: Introduction
RIB production
ISOL and in-flight fragmentation
Primary beams
Next generation separators
Importance of instrumentation

L2:
In-flight fragmentation in
North America
Asia
Europe
(plus some other highlights)

- "Facilities" are much more than just buildings
  - Don't forget **instrumentation**, and **expertise**!
- The **science questions** need to be at the centre of experiment design
- New exciting **global possibilities** (but some are just around the corner)
- Will the next (next) generation "facilities" be **digital**?