

## One big European Laboratory 45 + VA facilities

*A. Navin*

*Grand Accélérateur National d'Ions Lourds, Caen, France*

*on behalf of the EURO-LABS Steering committee  
Adam, Ilias, Maria, Maria Jose, Marko, Paolo, Barbara@*



**What is it**

**Access-technology-Science- Training-Open data  
A little Flavor Science and Technology**

**CERN COURIER** | Reporting on international high-energy physics

Physics ▾ Technology ▾ Community ▾ In focus Magazine

POLICY | MEETING REPORT

**Research across borders**

4 November 2022



Attendees of the EURO-LABS's kick-off meeting mapped out the strategy for a European transnational access programme to foster knowledge transfer. Credit: EURO-LABS.

2 Nuclear Physics News, Vol. 33, No. 2, 2023

**Nuclear Physics News**

Volume 33/No. 2



editorial

**EURO-LABS: Europe's Super Community of Subatomic Researchers**



This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101057511.



About ▾ Activities ▾ Transnational Access ▾ Results ▾ News ▾

Highlights

**EURO-LABS**  
**Newsletter**

ISSUE No.1 | JANUARY 2024



Second Annual Meeting of EURO-LABS at Krakow, Poland, from October 9<sup>th</sup>-11<sup>th</sup>, 2023



Participants of BTS23 (IFIN-HH, Bucharest-Măgurele, Romania) in the salt mine used for low-background work

**EDITORIAL**

M.J.G. Borge, CSIC  
B. Pezzotta, INFN

**NEWS ON COMING HANDS-ON SCHOOLS**

**EURO-LABS ANNUAL MEETING**

Maria Colonna, INFN  
The 2nd Annual Meeting of EURO-LABS (SAM EURO-LABS) was held in Krakow from the 9<sup>th</sup> to 11<sup>th</sup> October 2023, hosted by IFJ PAN

**BASIC TRAINING SCHOOL BTS23**

Livius Trache, IFIN-HH  
The first basic training School held at IFIN-HH in February 2023

**RADIATIVE DECAY OF THE 229Th CLOCK ISOMER**

Sean Freeman, CERN

**AGATA**

JJ Valiente-Dobon, INFN

**D-MAPS in EURO-LABS**

Marko Mikuž, JSI

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101057511.



*The most ambitious EU research & innovation programme ever*

**2021-2027 95.5 billion €**

*1. Marie Skłodowska-Curie Actions*

**2. Research Infrastructures --**

**→1/11→1/5→1/4→**

*HORIZON-INFRA-2021-SERV-01-07: Research infrastructures services advancing frontier knowledge*

**→1/3 Particle and nuclear physics**

**14.5M€ (2022- 2026)**



*3. Health*

*4. Culture, creativity and inclusive society*

*5. Civil Security for Society*

*6. Digital, Industry and Space*

*7. Climate, Energy and Mobility*

*8. Food, Bioeconomy, Natural Resources, Agriculture and Environment*

*9. European Innovation Ecosystems (EIE)*

*10. Widening participation and strengthening the European Research Area*

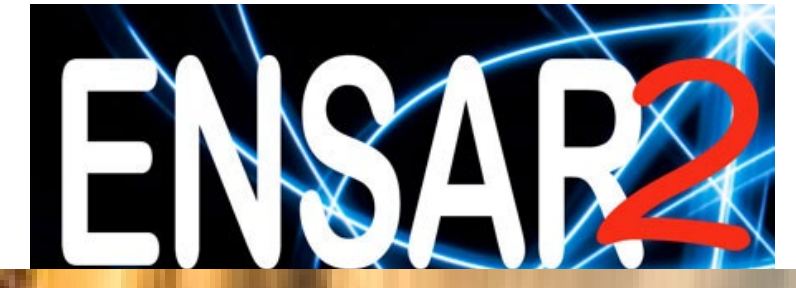
*11. Missions*



2009-2013



2014-2018



2022-2026



2009-2013

*Build a super community of sub-atomic researchers and the associated technical staff to enhance Europe's potential for successfully facing the upcoming new challenges of the coming decades*



AIDA

2022-2026  
2021-2025



Many more earlier

# GOAL

*Pioneering proposal in Europe*

*Brings together three communities engaged in Nuclear Physics and accelerator/detector technology for High Energy Physics for the first time*

*To foster the sharing of knowledge and technologies across scientific fields*

*Provide Efficient **access** to the improved available resources at a major fraction of EUROpean Laboratories for Accelerator Based Sciences*

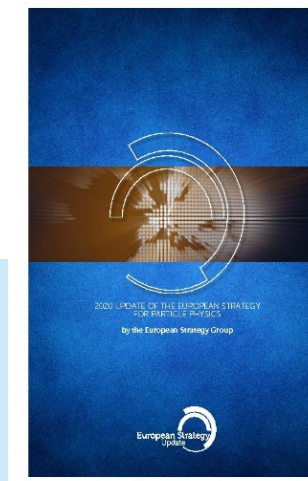
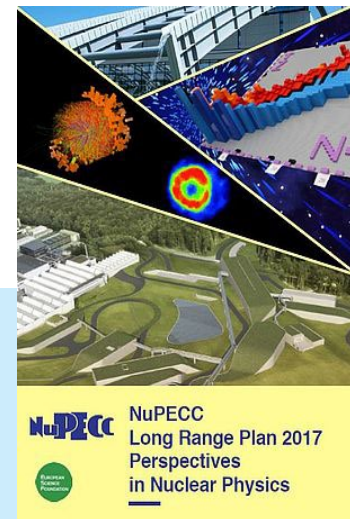
*Large and diverse community of users to choose the most appropriate state-of-the-art  
Research infrastructures (33 RI(s) in 18 countries)*

*for the optimal use of the large number of RIs potential for scientific and technological discoveries and beyond  
Make the best science and also develop technology for tomorrow*

*Implementation of good practices for data management*

*Provide broad and focussed joint training activities with hands-on experience at the RI's to develop diverse skills of  
the next generation researchers*

SYNOPSIS OF THE 2021 ECFA DETECTOR RESEARCH AND DEVELOPMENT ROADMAP  
by the European Committee for Future Accelerators Detector R&D Roadmap Process Group



## Integrated Access Service Improvements

**WP1**  
Management



**WP2**  
**Access for Physics**  
*Stable Ion beams*  
*Radioactive Ion beams*  
*Neutron beams*  
*Theoretical support*  
*Service improvements*

**WP3**  
**Access for Accelerators**  
*Material Testing*  
*Technology Infrastructures*  
*Electron beams*  
*Applications*

**WP4**  
**Access for Detectors**  
*Test beams*  
*Detector Characterization*  
*Irradiation facilities*  
*Service improvements*

*Sharing Knowledge and Technology in an Open, Diverse and Inclusive manner*

**WP5**  
**Open Diverse and inclusive Science**  
*Diversity & dissemination*  
*Open data*  
*Machine Learning*  
*Training*



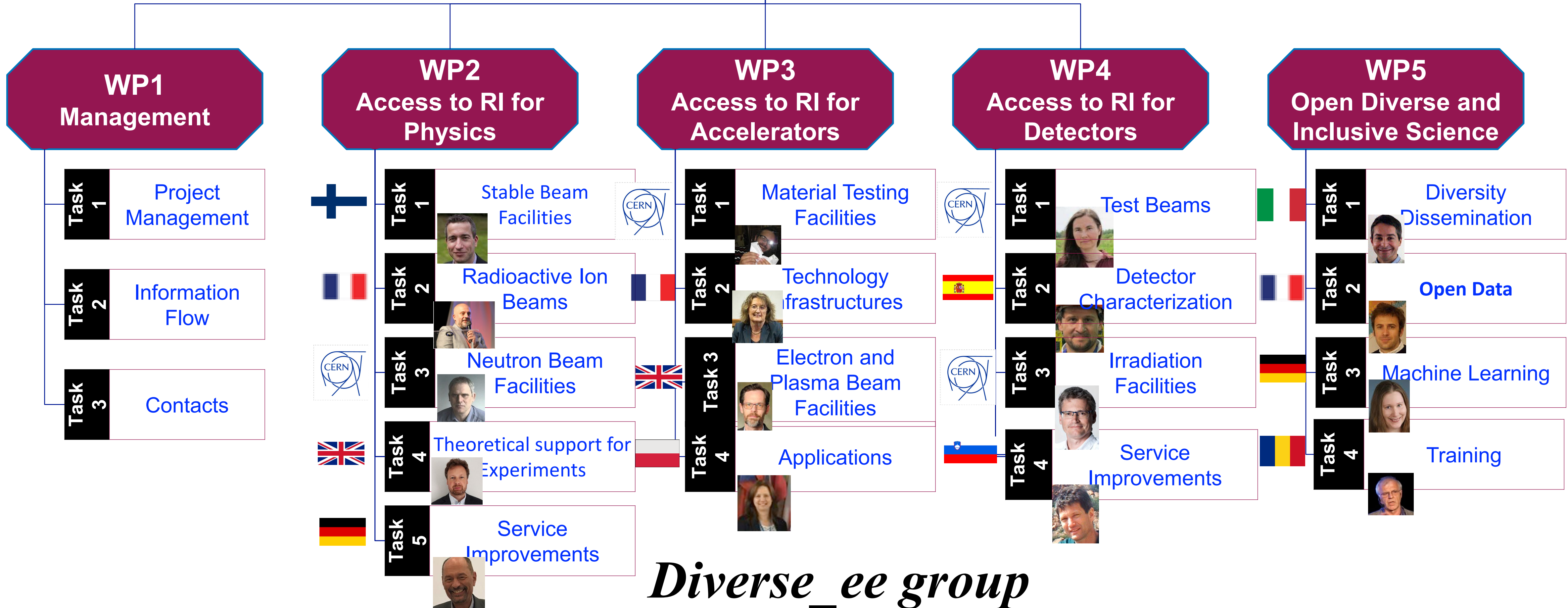
# EURO-LABS Structure



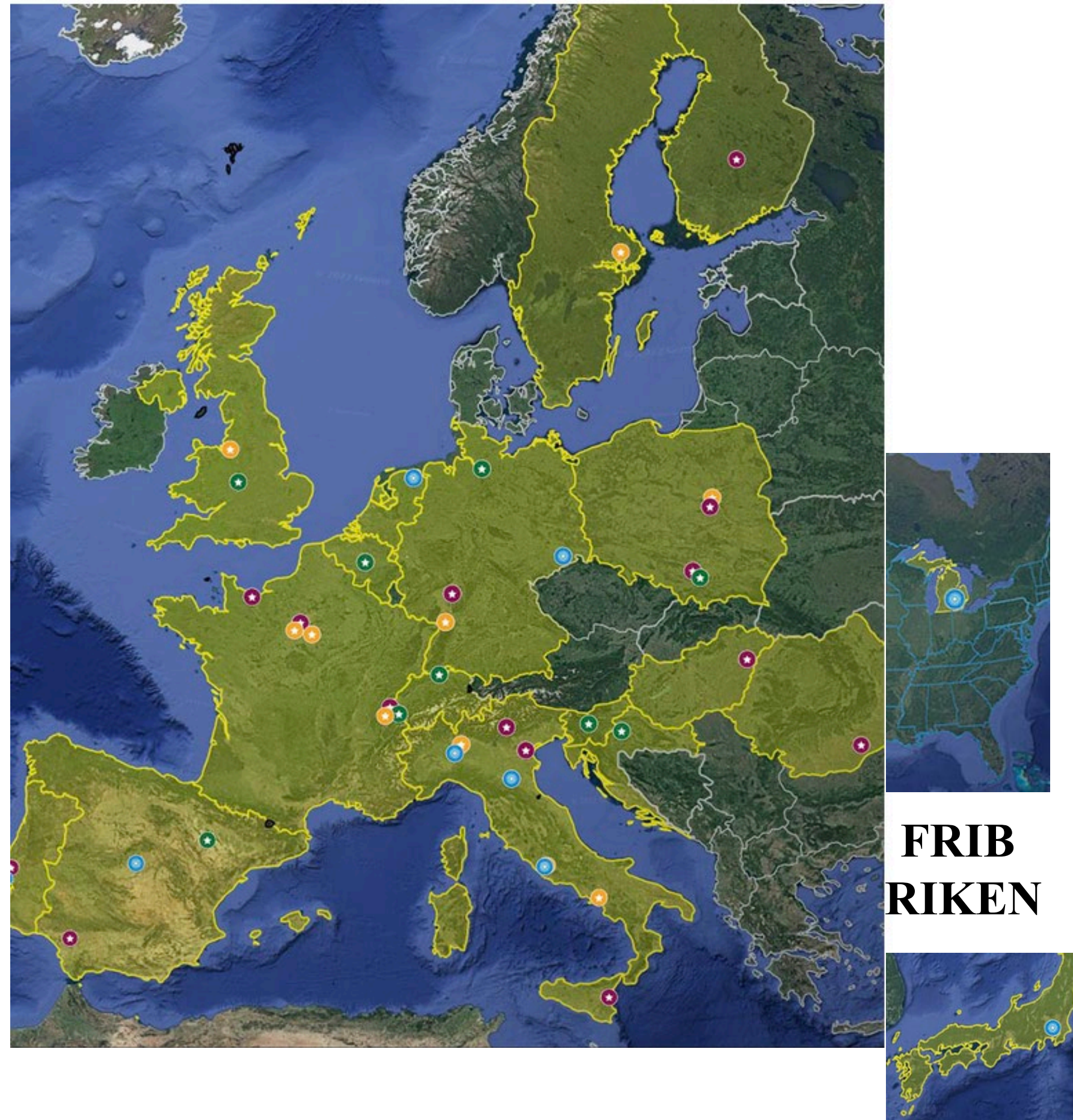
**Governing Board**



**Scientific Coordinator +  
3 Deputies + Project Coordinator and Office: INFN**



*Diverse\_ee group*



*To boldly go and use new and improved facilities for outstanding opportunities and ideas where no (wo)man has pushed to the limits before*

# What Science and Technology does EURO-LABS cover

Research infrastructures services advancing frontier knowledge

*New elements (stable beams)*

Today  $Z=118$

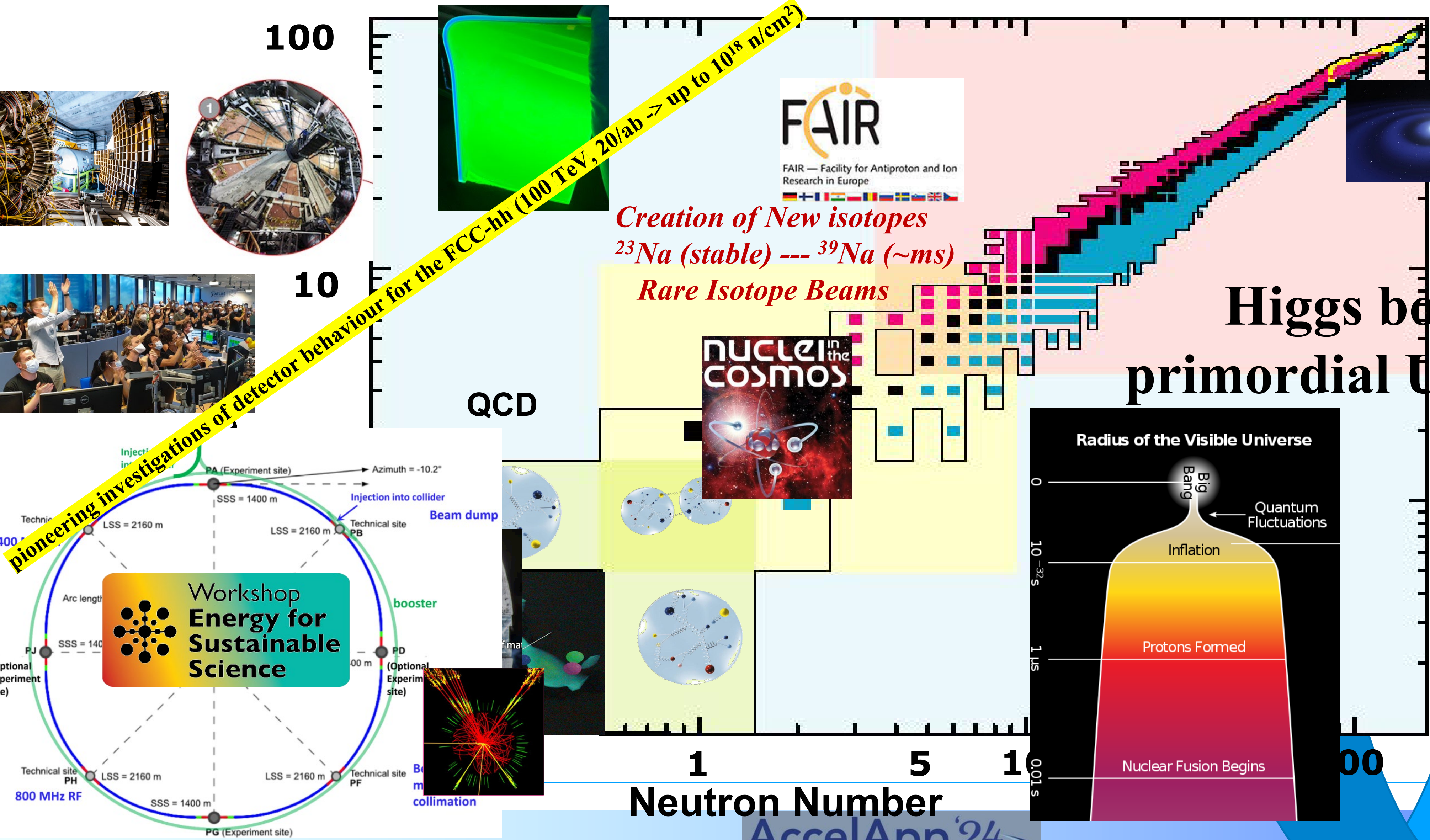
Searching:  $Z=119, 120$

*Creation of Heavy elements  
Au, Pt in the universe*

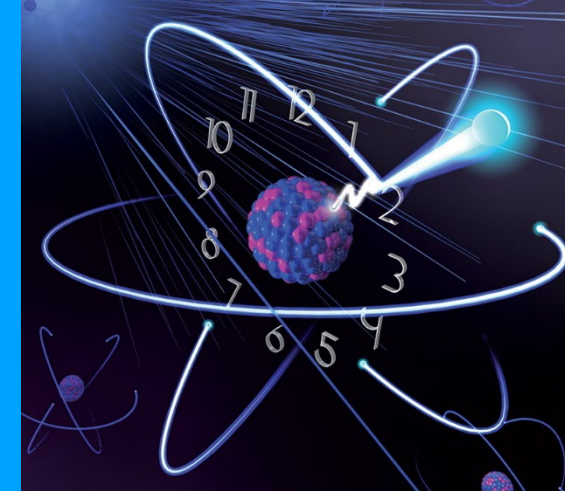
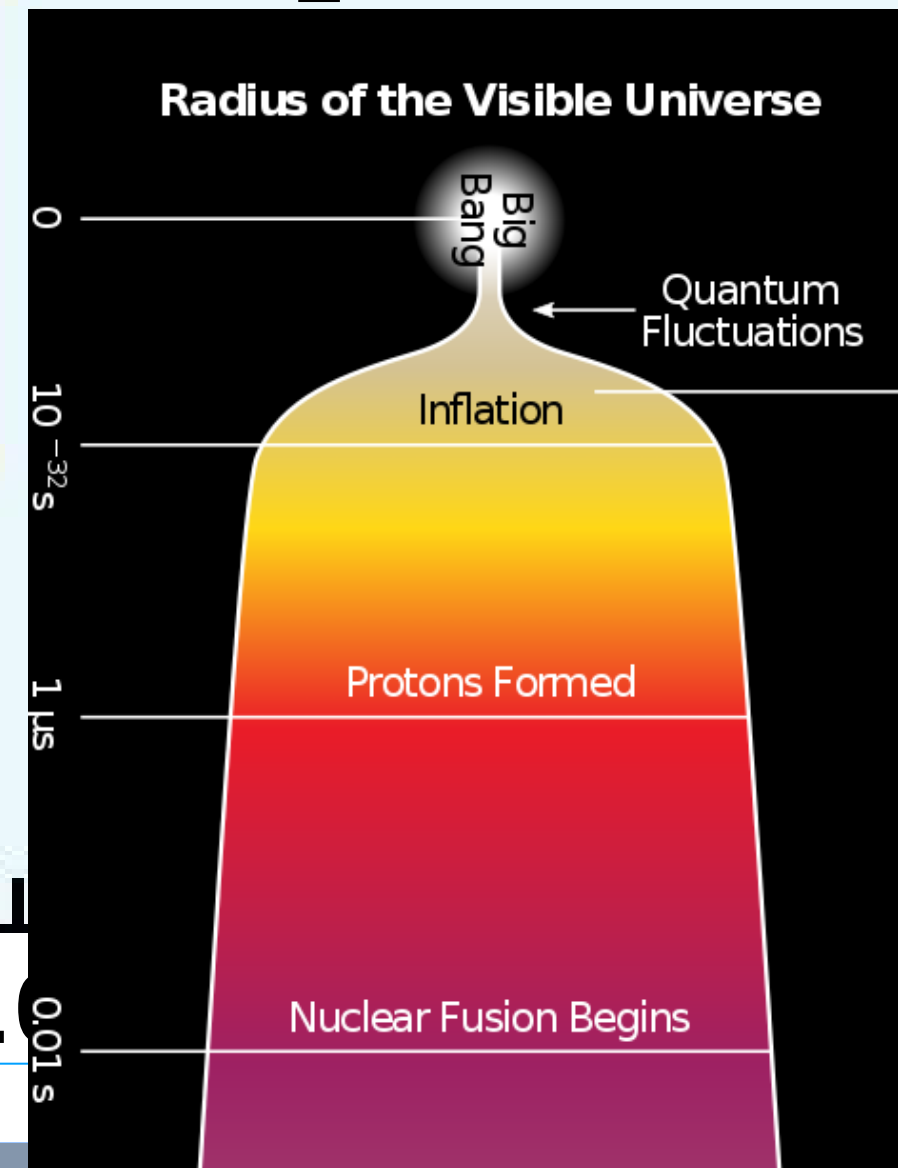
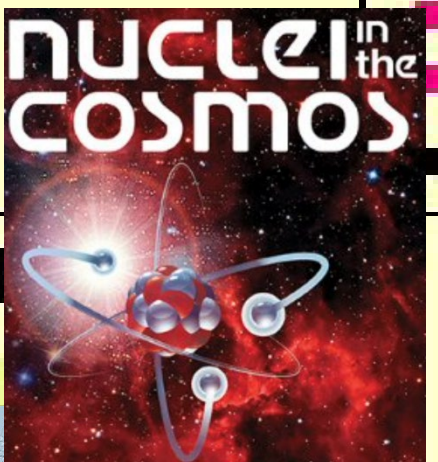
Higgs boson  
primordial Universe

100

10



*Creation of New isotopes*  
 $^{23}\text{Na}$  (stable) ---  $^{39}\text{Na}$  (~ms)  
*Rare Isotope Beams*

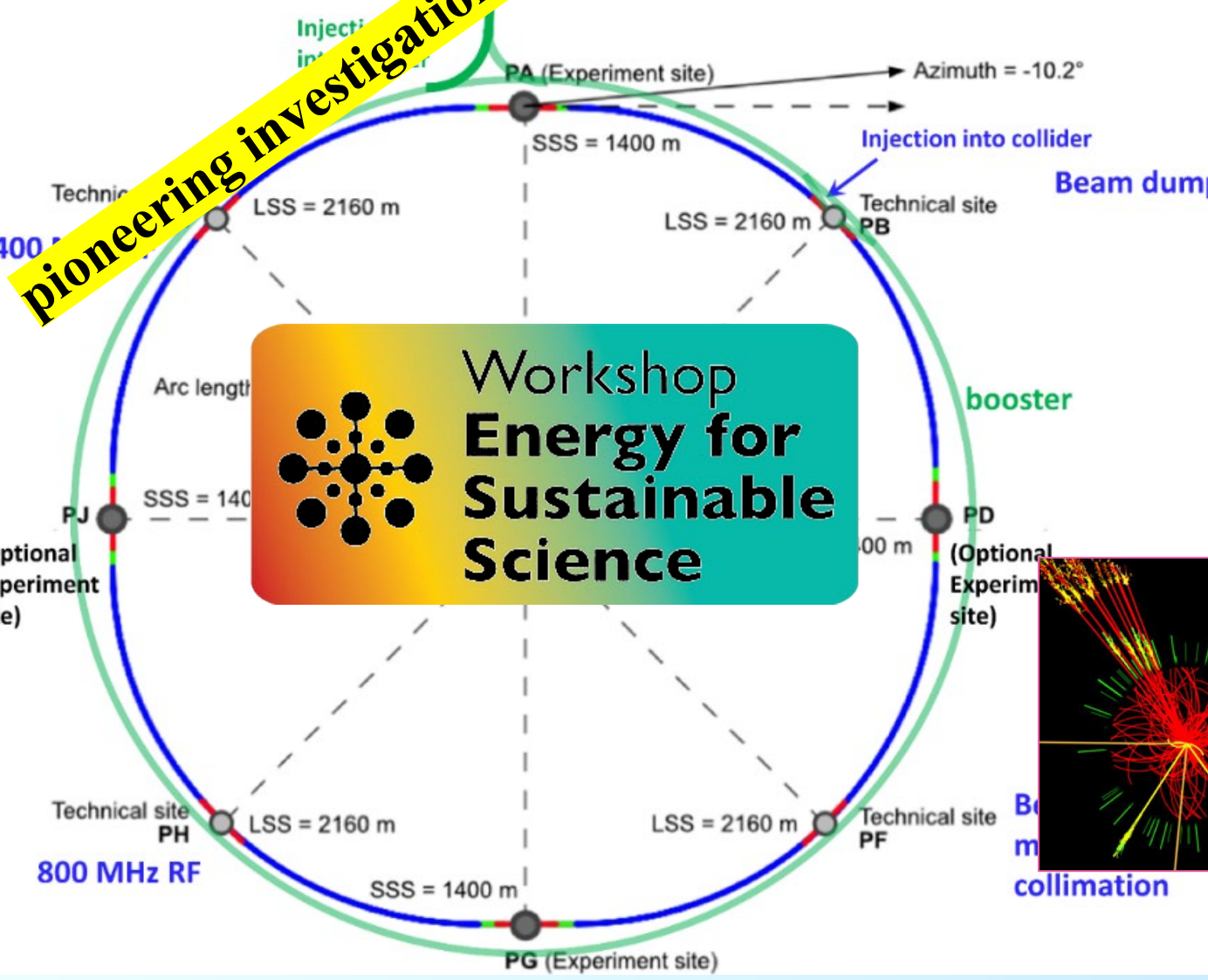
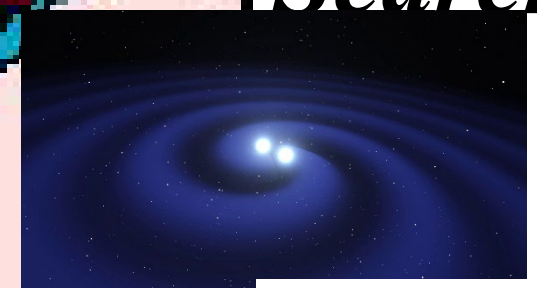
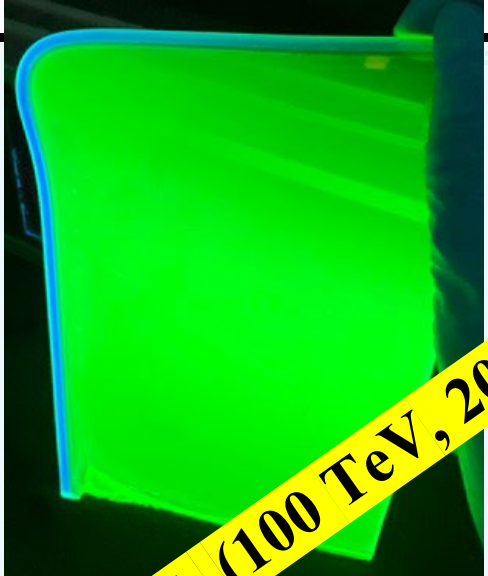
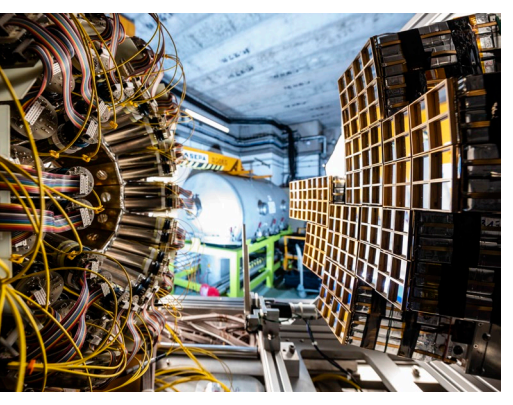


**FLASH RT**

⚡

⏳ ≤ 200 ms

Ultra-high dose-rates

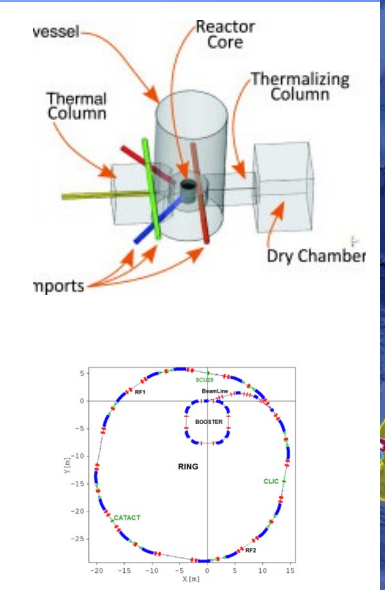
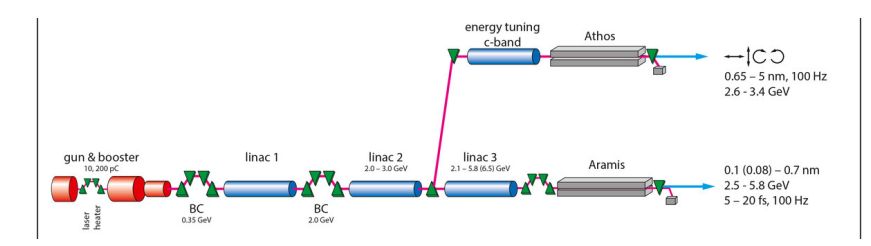
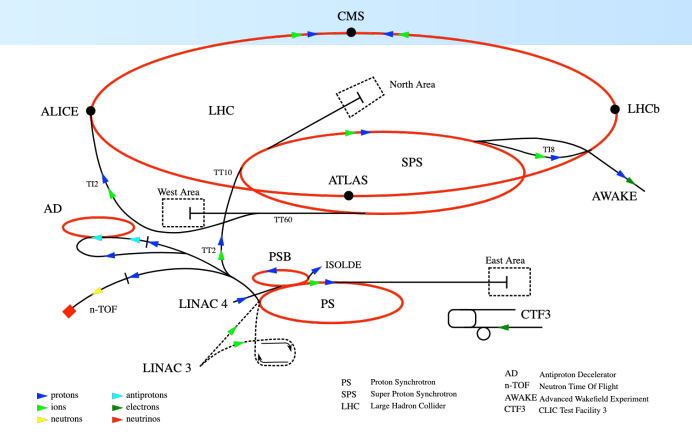
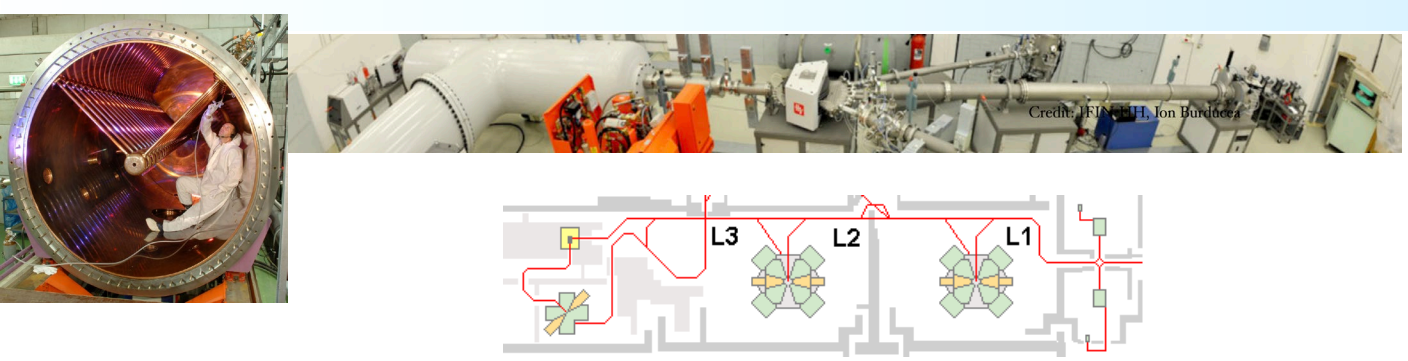


Neutron Number

AccelApp'24



# Arsenal of EU Accelerators & Detectors



**Tandems** 1 MV 1MV 2MV 3MV 3MV 6MV 9MV 15MV

16MV, Unilac

**Tandetrans** 1MV 1MV 3MV

**VAN de GRAFF** 2.5MV 7.0MV

**Cyclotrons** K= 16.5 30, 40 70 110 144 160 230 380 380 265

800 160

**SC LINAC** X 3, Far infra red

PS SPS SIS

**Storage rings** CRY KARA

$e^-$  10 MeV 200 140 780 MeV 50MeV/c

$e^+e^-$  6 GeV

**Thermal, Fast neutrons**  $\mu$ ons  $\pi$  200, 350

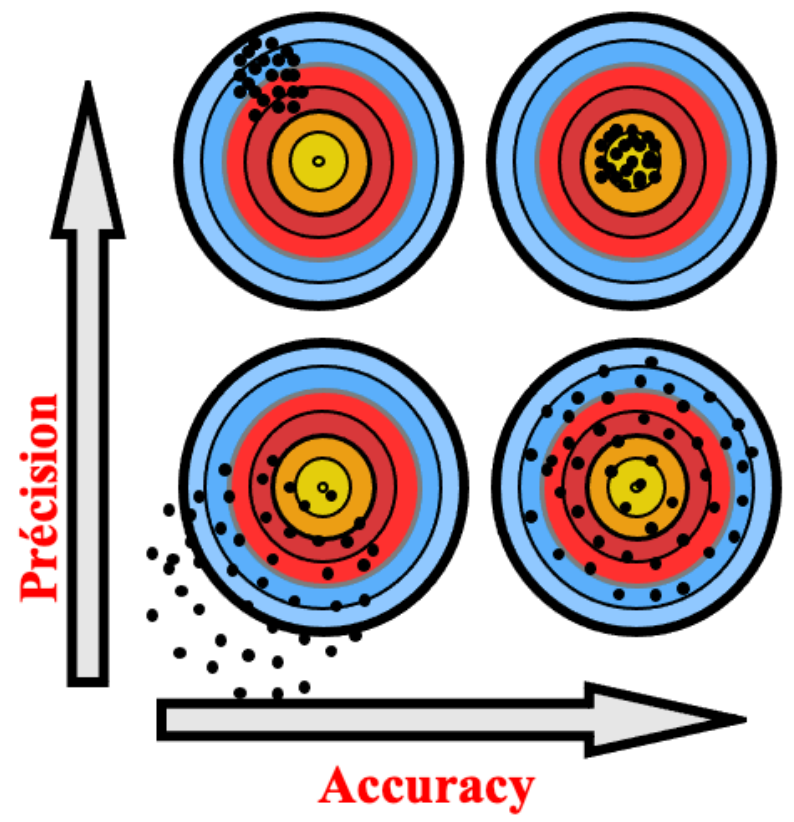
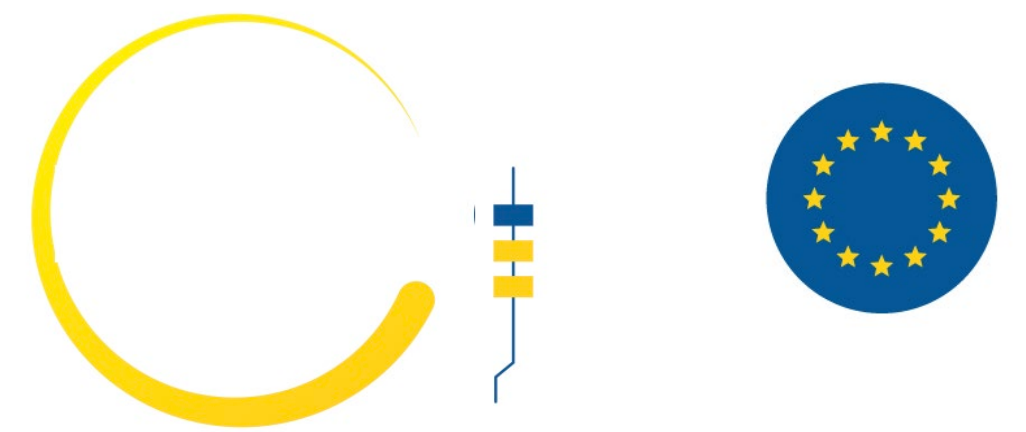
$\mu$ ons

$\pi$  200, 350

$\pi$  Swimming pool reactor

**TBq Source**

**LASERS** 100 250 TW 10PW



Virtual access Theo4Exp

**Detectors**

Name and we have it  
gas, Si, scintillators, new materials, spectrometers ...






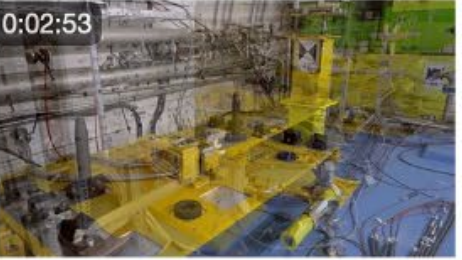










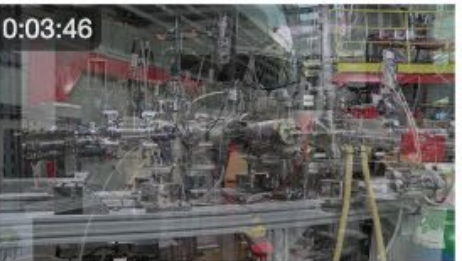


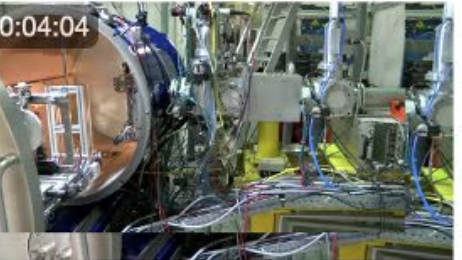






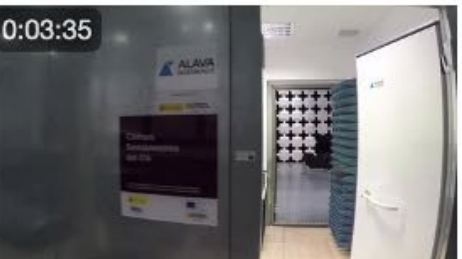
**Accelerator technologies centres**

**SC Magnets Acc. structures, characterization**



[https://mediawall.infn.it/view/?catName=euro-labs&lang=en\\_US](https://mediawall.infn.it/view/?catName=euro-labs&lang=en_US)


<https://web.infn.it/EURO-LABS/transnational-access/>

 <b>N-TOF</b> FHD 0 Views 17 hours Ago Fabio Bisi	 <b>Xbox</b> FHD 1 Views 17 hours Ago Fabio Bisi	 <b>INCT-Rapid</b> FHD 6 Views 22 hours Ago Roberto Giacomelli	 <b>FAIR</b> FHD 1 Views 1 day Ago Fabio Bisi	 <b>SPARC_LAB</b> FHD 17 Views 1 week Ago Fabio Bisi	 <b>HiRadMat</b> FHD 6 Views 1 week Ago Fabio Bisi
 <b>ISOLDE</b> FHD 7 Views 1 week Ago Fabio Bisi	 <b>FREIA</b> FHD 6 Views 1 month Ago Fabio Bisi	 <b>TANDEM</b> FHD 12 Views 1 month Ago Fabio Bisi	 <b>CERN-CLEAR</b> FHD 13 Views 1 month Ago Fabio Bisi	 <b>NLC-SLCJ</b> FHD 8 Views 1 month Ago Roberto Giacomelli	 <b>AIC-144</b> FHD 10 Views 2 months Ago Roberto Giacomelli
 <b>CCB</b>	 <b>CNRS-IJCLab-SUPRATECH</b>	 <b>CEA-IRFU-Synergium</b>	 <b>GANIL-SPIRAL2</b>	 <b>CNRS-IJCLab-ALTO</b>	 <b>CEA-LIDYL-LPA-UHI100</b>
 <b>INFN-LNL-NSDBF</b> FHD 21 Views 5 months Ago Roberto Giacomelli	 <b>UCLouvain-CRC</b> FHD 11 Views 5 months Ago Roberto Giacomelli	 <b>RBI-AF</b> FHD 16 Views 5 months Ago Roberto Giacomelli	 <b>JSI-TRIGA</b> FHD 16 Views 5 months Ago Roberto Giacomelli	 <b>DESI-II</b> FHD 18 Views 5 months Ago Roberto Giacomelli	 <b>CERN-PSSPS</b> FHD 11 Views 5 months Ago Roberto Giacomelli
 <b>CERN-IRRAD</b> FHD 9 Views 5 months Ago	 <b>CERN-GIF</b> FHD 11 Views 5 months Ago	 <b>ITAINNOVA-EMClab</b> FHD 11 Views 5 months Ago			

# Centres for Accelerator technologies

**Future projects - FCC**

Vacuum technology @ KARA



SuzHi septum test @ FREIA




**World-wide R&D**

PIP-II Cavity validation @ SUPRATECH



Proton Improvement Plan-II



**HL-LHC**

HL-LHC collimators @ HIRadMat



Crab cavity test @ FREIA



WP3-RIs

**Applications**



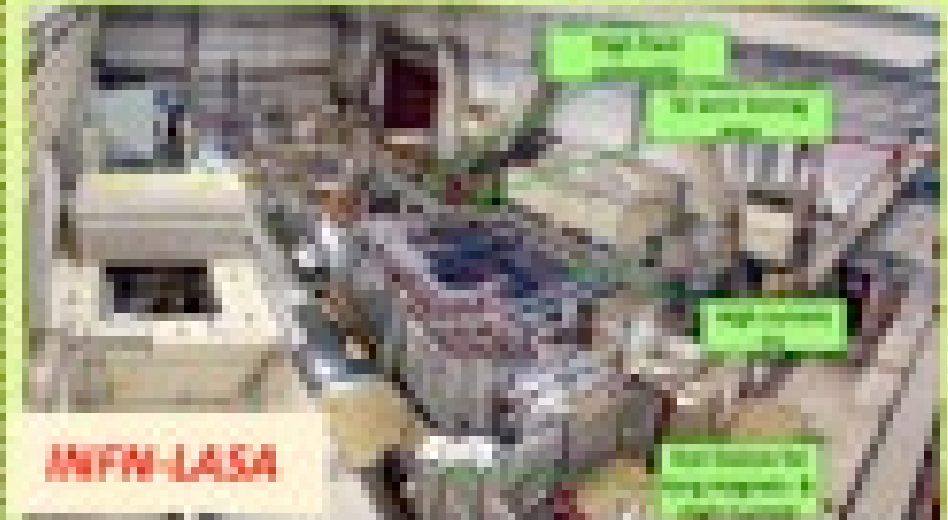
Fibre-optic fabric for UHDR real-time dosimetry for FLASH radiotherapy @ CLEAR-CERN

**Technology**

QPR sample conditioning and testing for HZB @ SUPRATECH



IRIS - applied Superconductivity



INFN-LASA



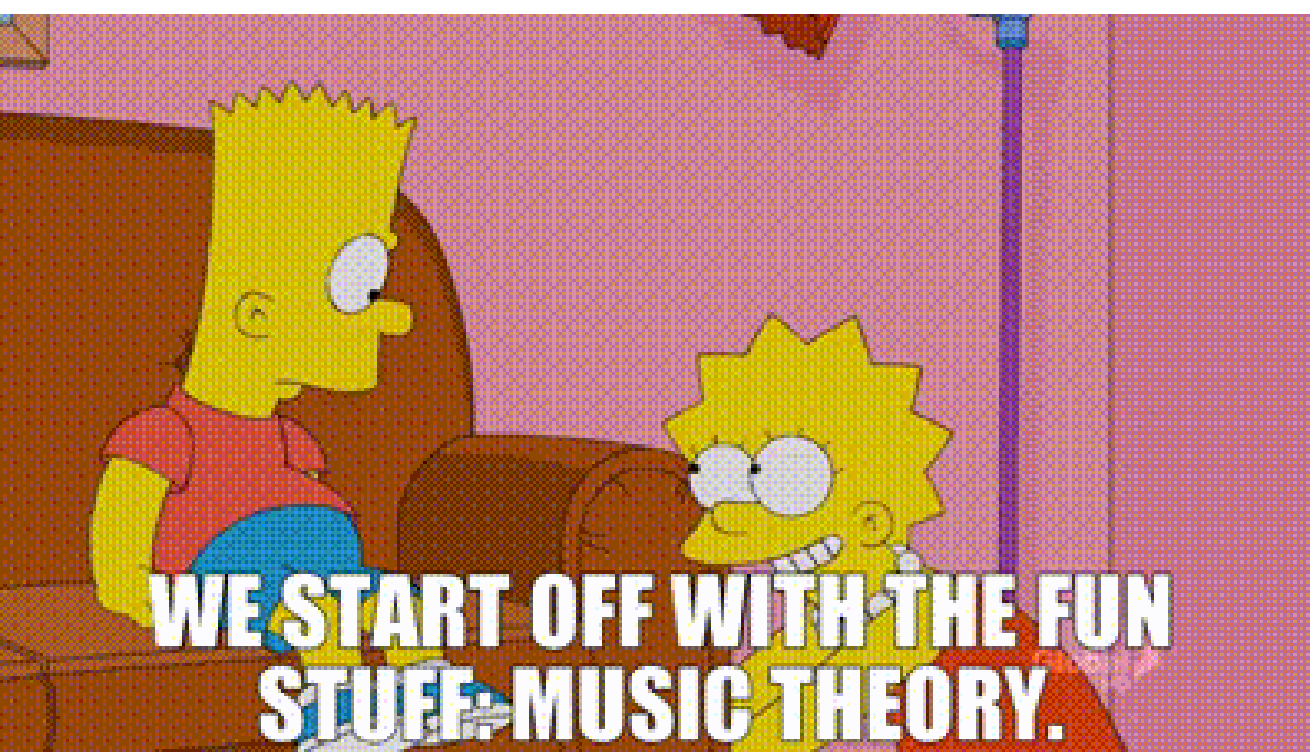
INFN-THOR

Laboratori Acceleratori e Superconduttività Applicata



**Developments → Access → Experiments → Science-Technology → Training → Open Data**

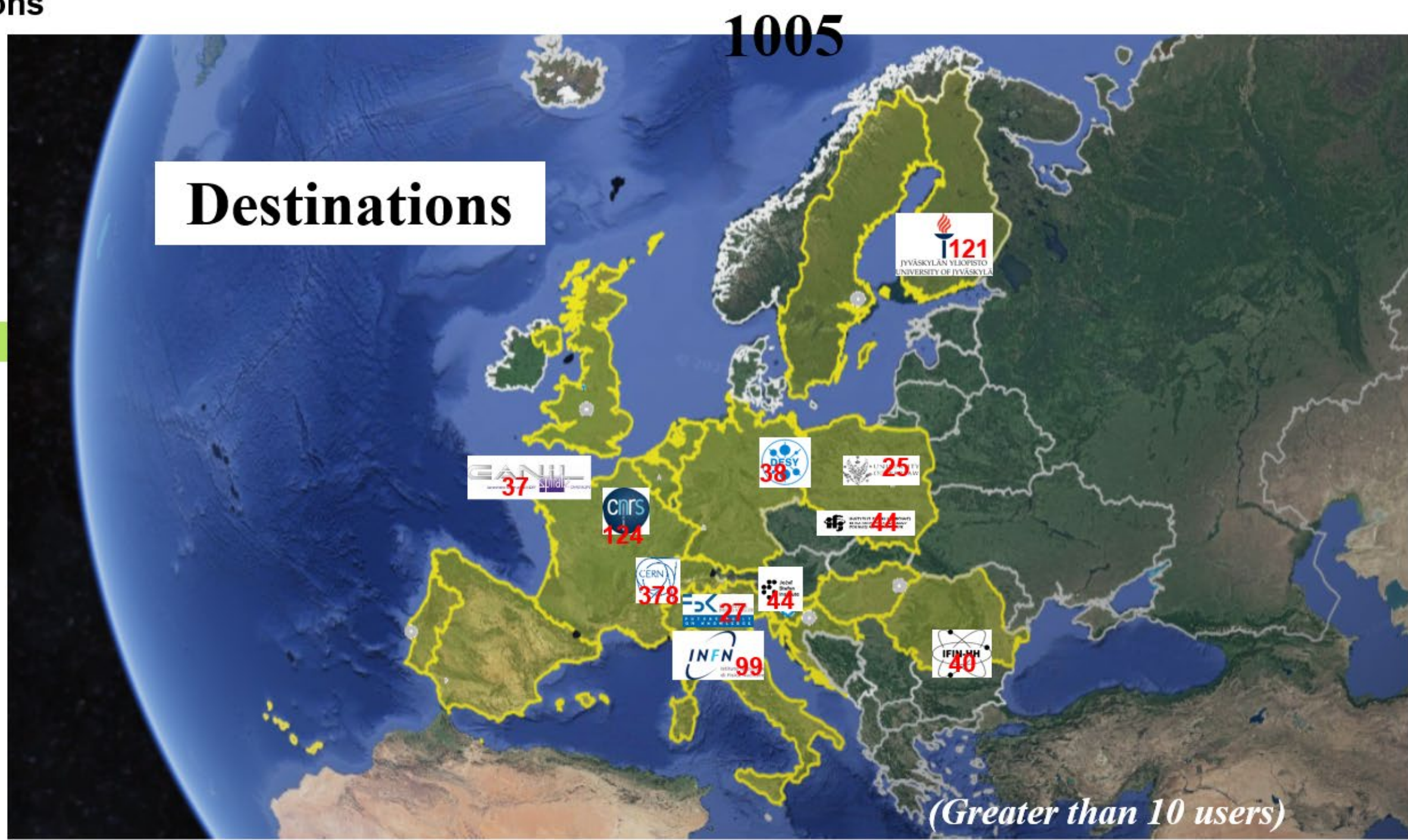
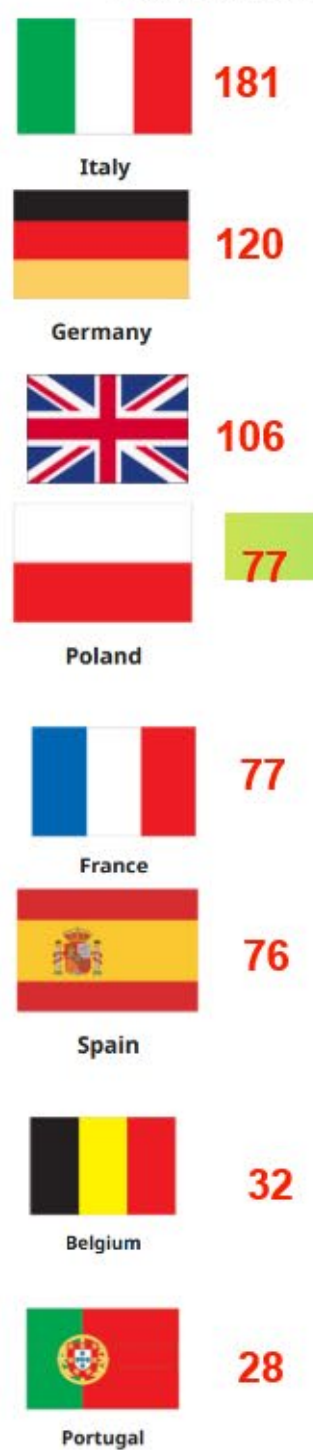
**R&D  
Technology**



"I'm here about the details."

# Who and where have we been going Year 1 (Sept. 2022 - Aug. 2023)

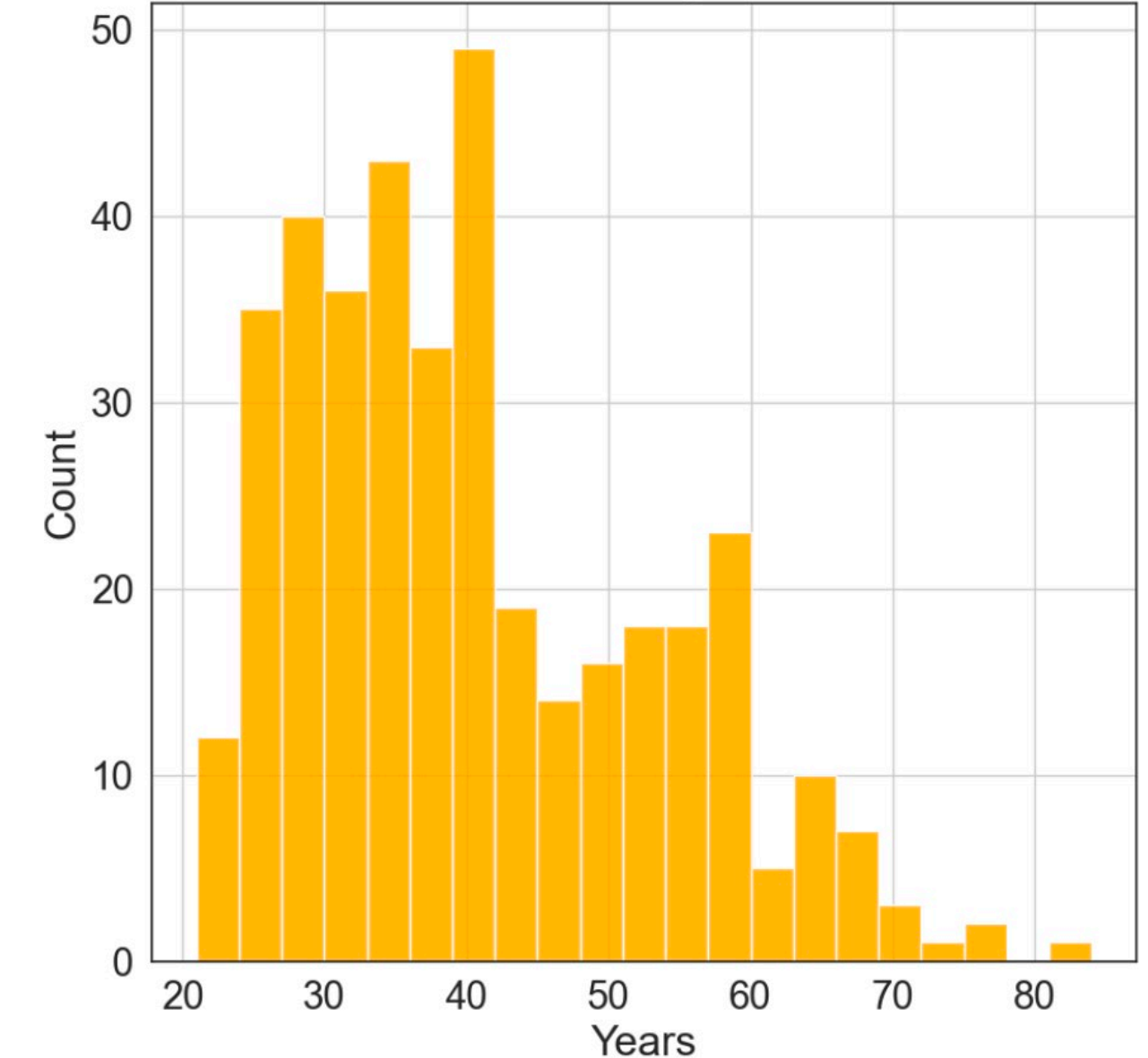
## Countries of user institutions



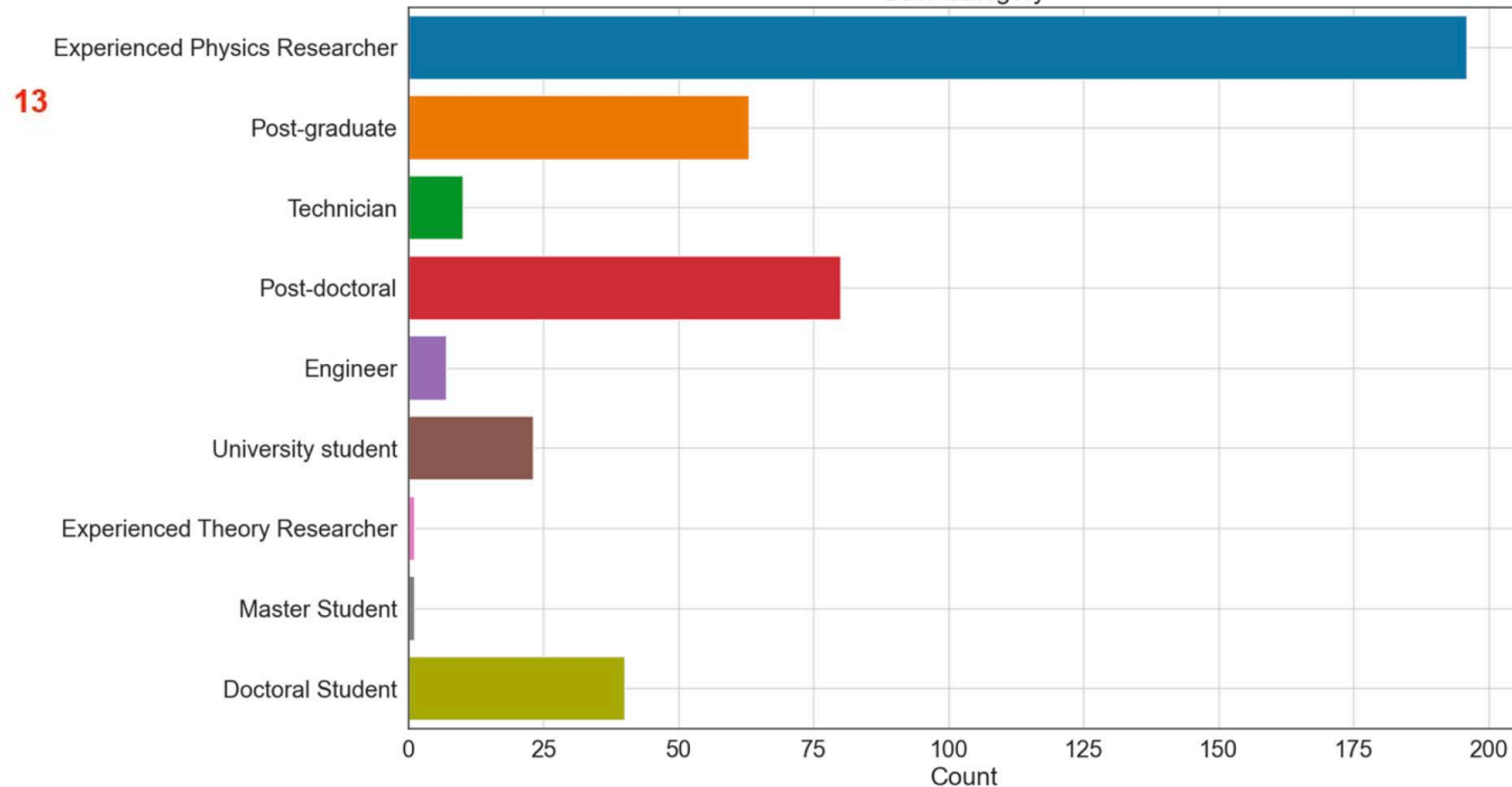
## Countries of user institutions



## User Age



## User Category

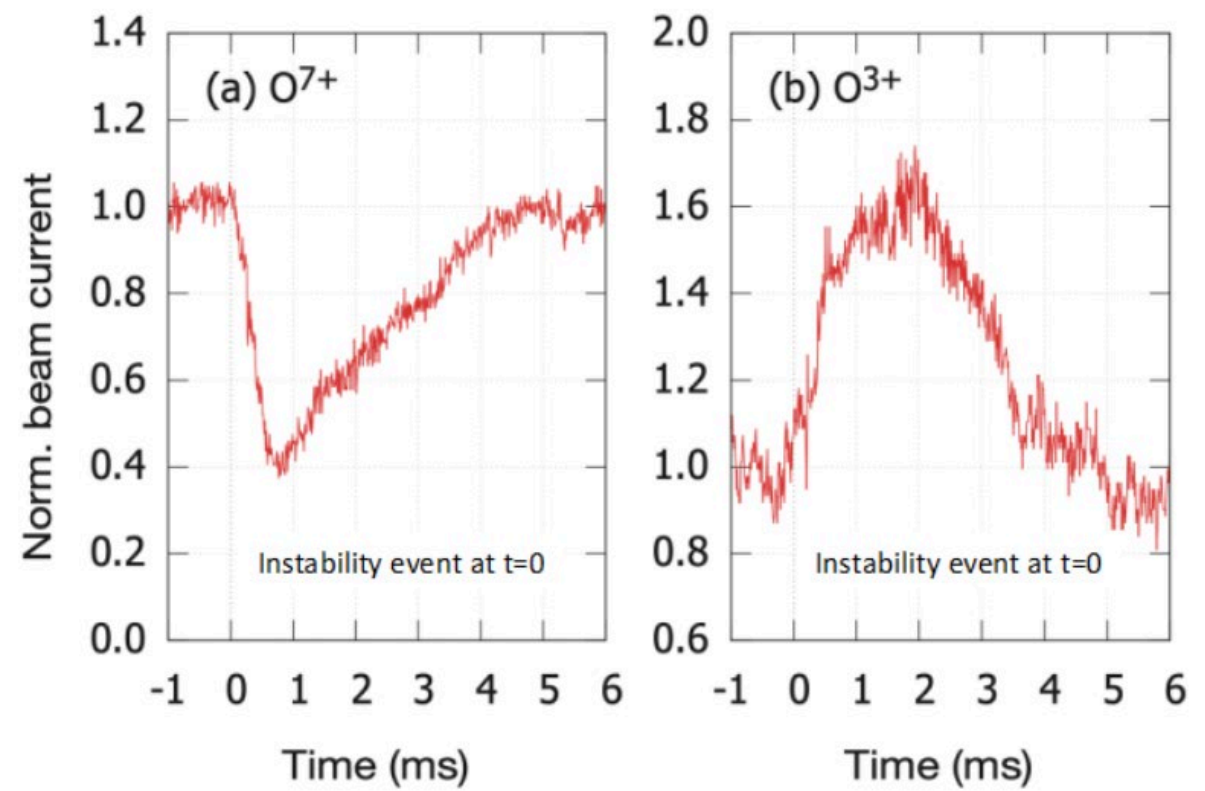




## WP4

The main requirements for the design of the new IRRAD-BPM DAQ were the possibility to measure currents in the 1-100's nA range with a variable sampling rate reaching the 1 ms range

University of Jyväskylä + Finland **WP2**



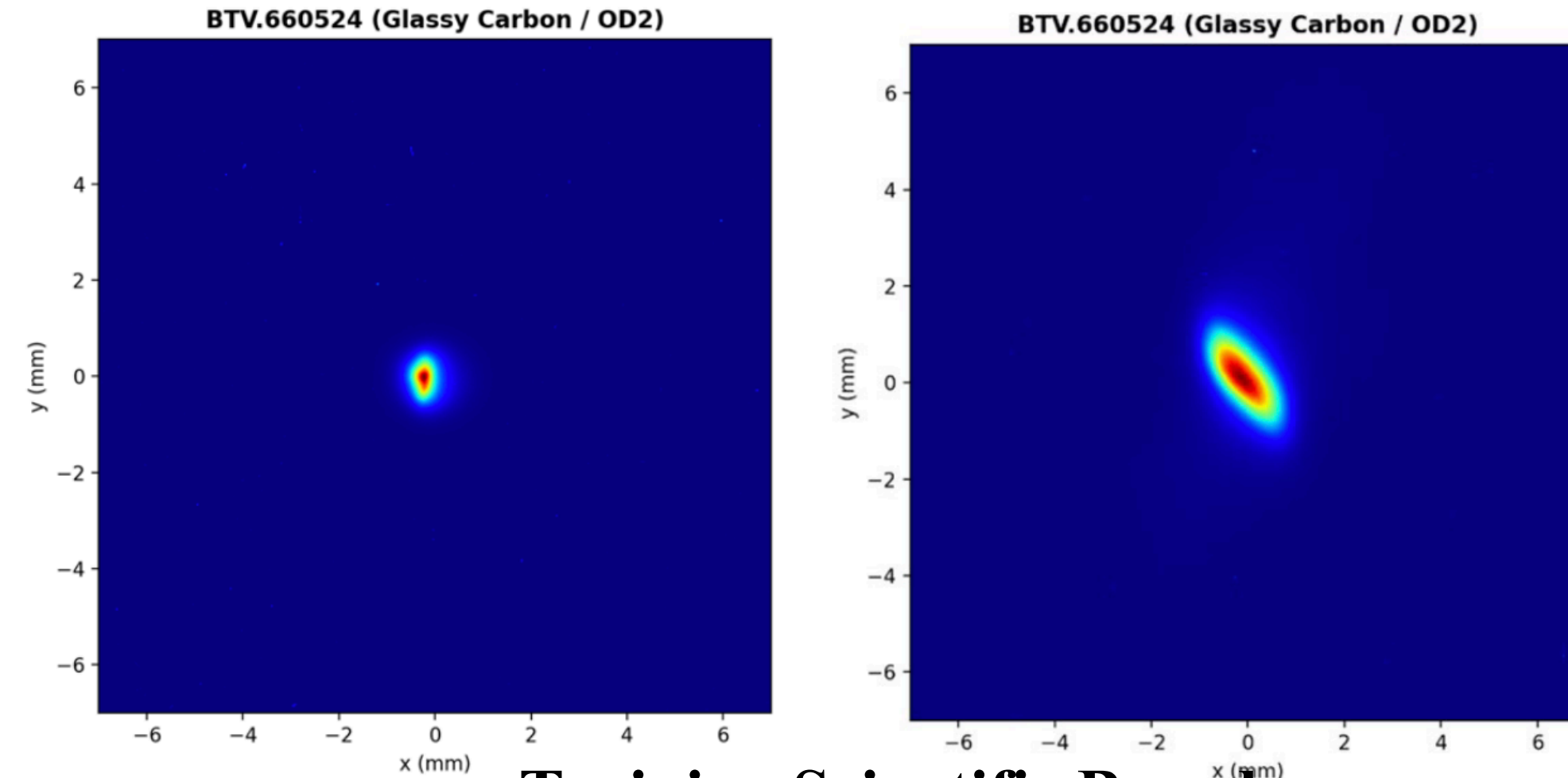
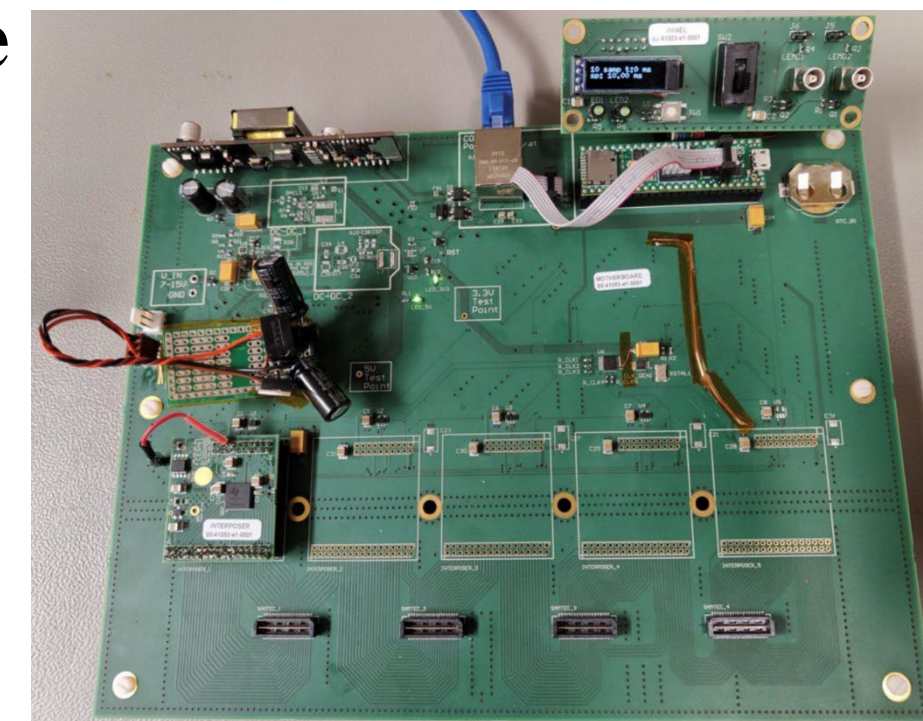
Beam stability

## WP5

ML toolkit prototype (GeOFF) available on a shared platform

## HIRADMAT – CERN **WP3**

Difference in the spot-size in different optics: Not clear what the reason is.



## WP5

FAIR data principles towards effective Open Science in the community.  
The conceptual design for a prototype openNP catalog  
Centralize the metadata of their datasets  
Research Infrastructure and researchers  
**Data Management Plan**

Training Scientific Board.  
**WP2 WP3 WP4 WP5**

TO LEARN.  
STUDENTS NEED TO  
DO SOMETHING



## Objective:

- Use Machine Learning (ML) methods to improve beam quality, transport efficiency and reproducibility.

Shared and tackled by different facilities

- The Project **focuses** on open tools and platforms:

Developing a virtually accessible beam diagnostic data base and optimizer toolkit

**Generic Optimization Frontend & Framework (GeOFF)** is a widely used framework for testing automation at CERN

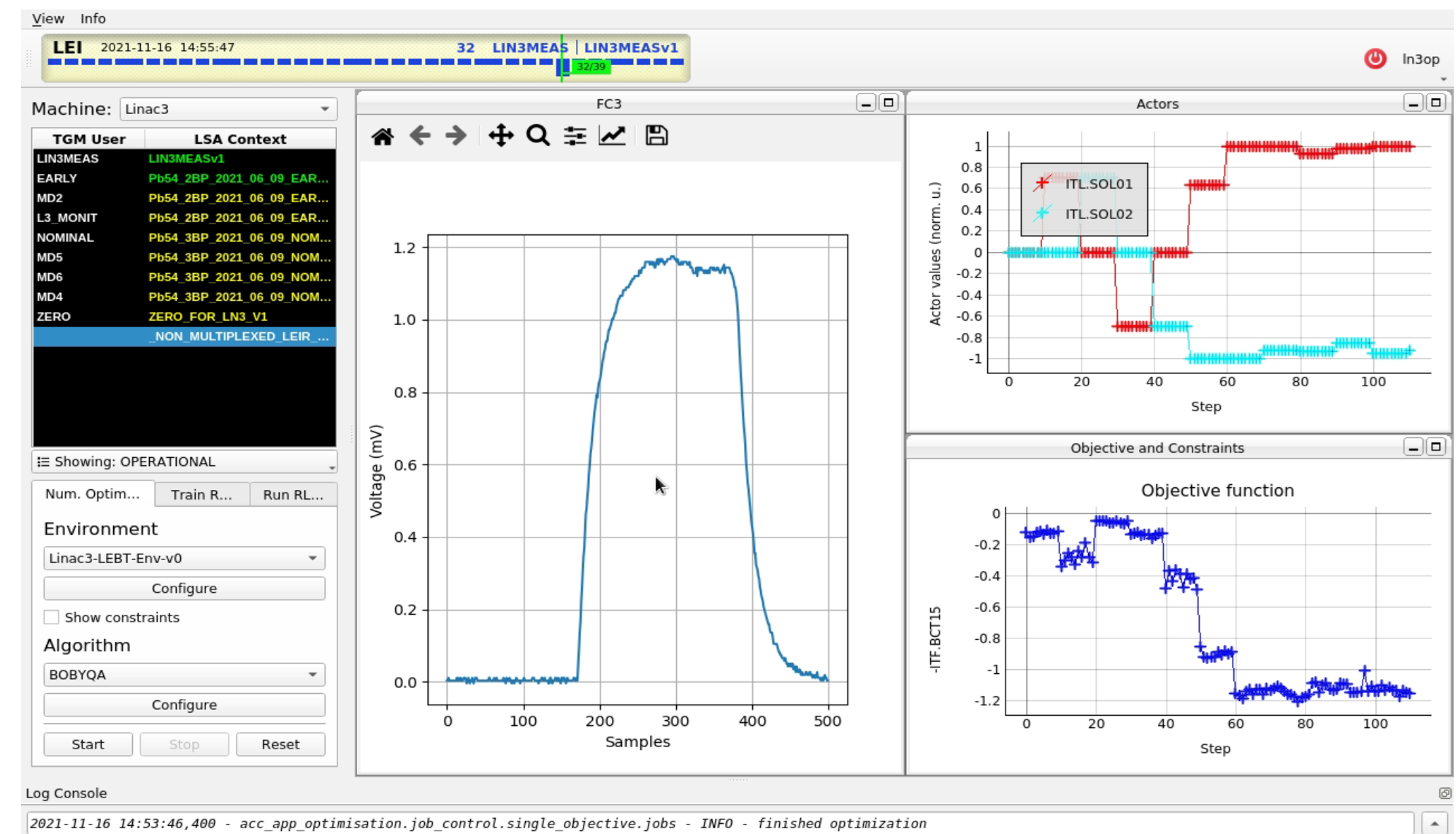
- Python-based framework with use of pjlisa

- *Adaption of code quickly and on-the-fly during shift:*
- *Flexibility of framework made this easy*

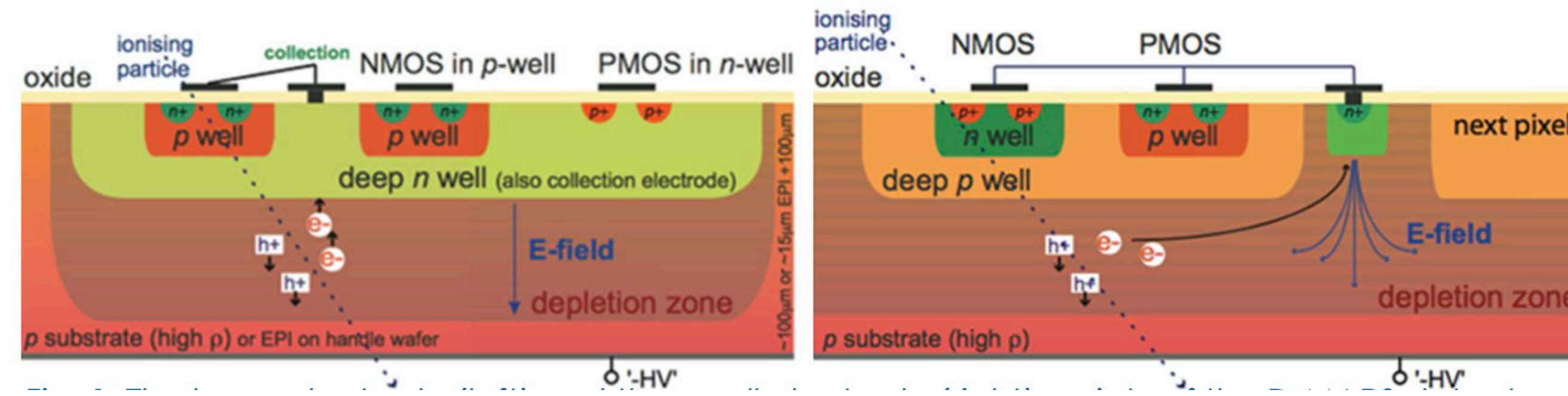
*At CERN, where with GeOFF the slow extraction could setup in several minutes.  
The manual adjustment has takes before up to 8 hours.*

FRagment Seperator at GSI : Automatic online steering  
Online beam steering in **50 iteration** and took **18 minutes**

**Open source: Each centre make its compatible with their needs**



D-MAPS in EURO-LABS



Absence of interconnection between the sensor and the read-out ASIC  
by costly bump bonding, ultra-low sensor capacitance, thin, almost zero-mass devices,  
and access to commercial foundries with huge production capability.  
a physicist's dream

Prototype detectors are being irradiated with protons and neutrons, at Birmingham to Ljubljana, irradiations at other EURO-LABS facilities are also planned.

The devices are tested in the high-energy test-beams at CERN and DESY, supplying decisive results on detector performance both before and after various levels of radiation damage.

Planned **ITS3 upgrade of the ALICE vertex detector**

A future upgrade challenge for Depleted -MAPS is the planned exchange of the innermost pixel layers of **ATLAS and CMS at about one half of HL-LHC luminosity**, and the steady LHC-B vertex detector upgrade



Measurement of  $^{237}\text{Np}$  at CNA-AMS after commissioning.  
 Study of the **impact of radioactive dumping** on seaweed samples collected close to Gothenburg (Baltic Sea).

Study oxidation of sulfur containing peptides and identify the final products. **WP3**

**Damage induced by proton beam irradiation of cellulose-based materials WP2**

**WP2 OECD-NEA High Priority Request List NTOF**  
**Capture cross sections of Er astrophysics + medicine**

**FLASH therapy WP2-WP3**

**WP2 Nuclear Astrophysics stable + Radioactive ion beams**

**WP3 HiRadMat facility**:recreating a laboratory analogue of ultra-relativistic blazar-induced pair jets propagating into the intergalactic tenuous plasma answering the question:

Given that a cascade of GeV inverse-Compton scattered photons is not observed from blazar's jets, our results imply that such an absence must be the related to the presence of intervening magnetic fields in the intergalactic plasma of primordial origin.

*Nuclear clock*

*$^{229}\text{Th}$  has an isomeric state at an unusually low excitation energy of around 8.3. eV*

*WP4 Technological solutions for digital electromagnetic calorimeters.*

*CMOS Detectors MAPS - Depleted Monolithic Active Pixel Sensor*

*Radiation hardness and Capacitance (performance)*

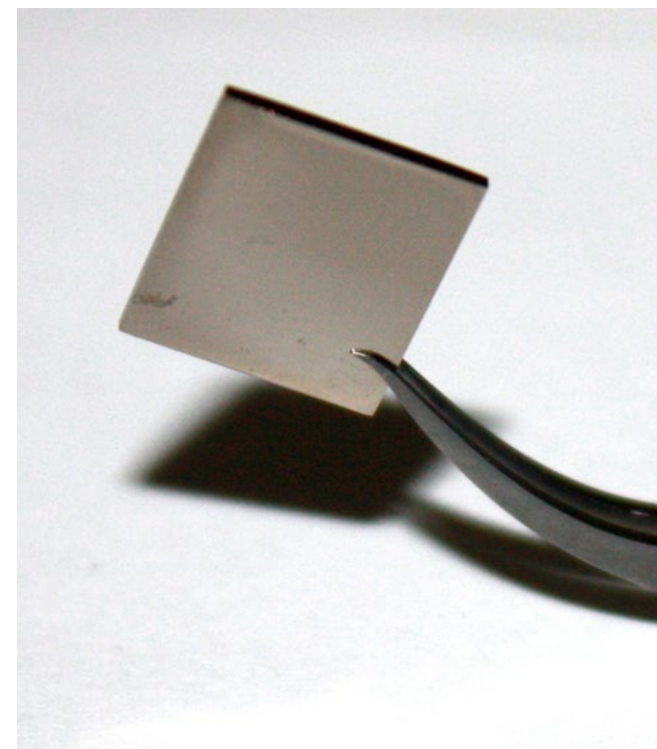
**WP4 provide access to conditions for Higgs factory detectors:**

*WP4 irradiate the FEE, low-voltage power supply (LVPS) and FPGA with 50MeV protons up to a dose of 0.76Gy and 0.71Gy respectively, equating to 2-10 years in space (depending on the shielding). (Protons)*

**WP2, JYL, GANIL**

**Functionalisation:** the upper surface (5-200 nm depth) of a medical/industrial sample is modified for one, well-selected goal.  
In the Atomki ECRIS Laboratory we irradiated dental implants (Ti, ZrO<sub>2</sub>) by non-standard (Au, Ca, Si) ion beams.

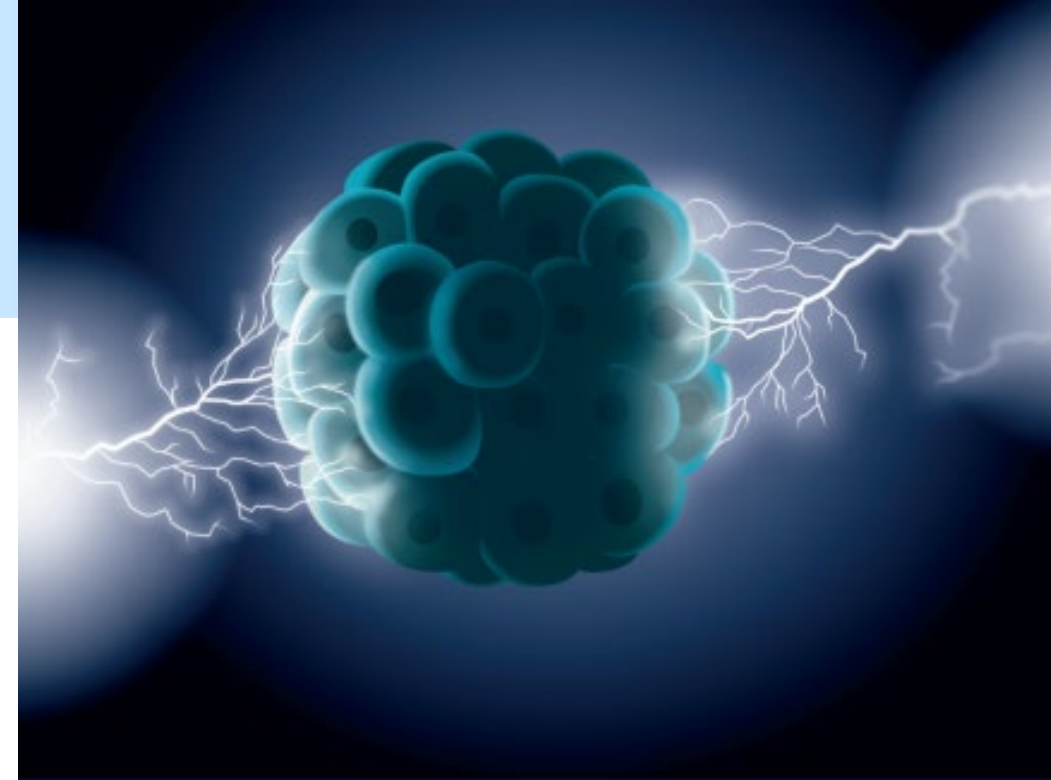
new multiply-charged ion (MCI) beams were developed in the Atomki ECRIS Laboratory (e.g. Au, Ag, Ca, Si, Mg, P) and dental implants were irradiated with different energy and dose.



A. After gold irradiation and heat treatment the formed GNPs (Gold Nano-Particles) can chemically bond many types of biomolecules.

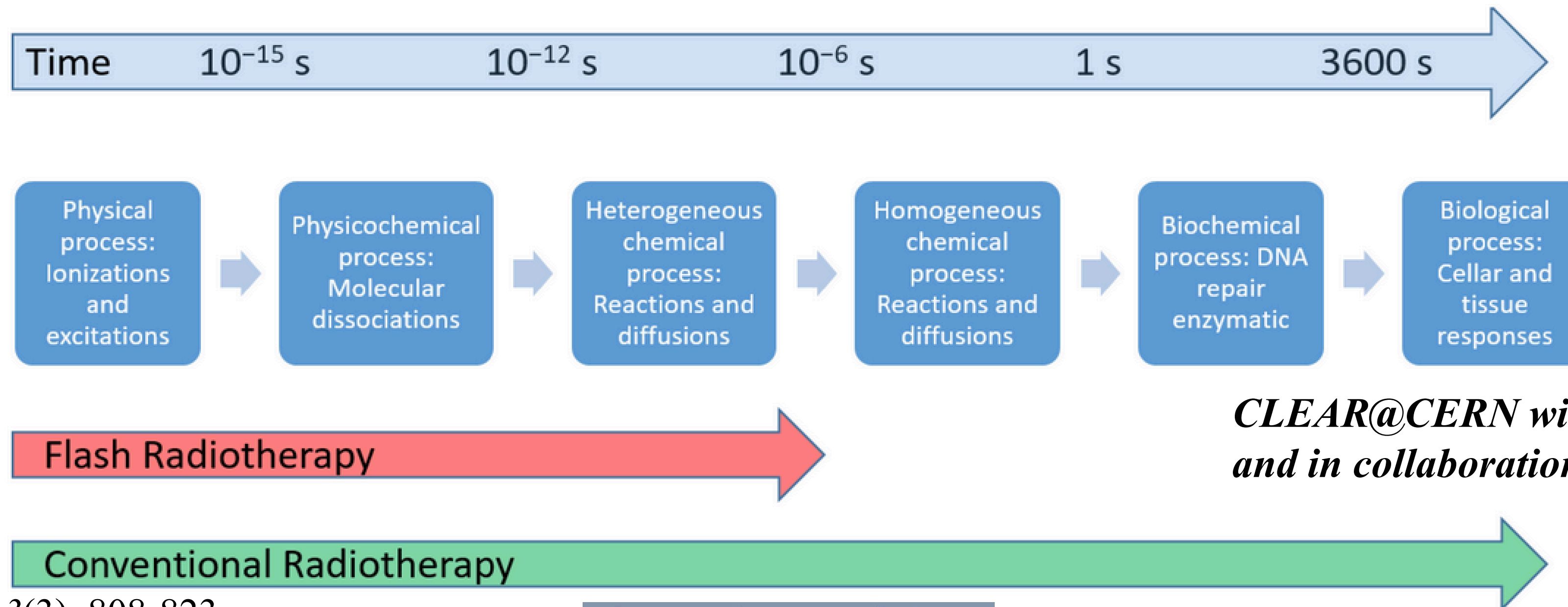
B. The implanted Ca ions can increase and accelerate the adherence of the human tissue due to diffusion.

C. ZrO<sub>2</sub> (non-silica-) based restorations have become very popular in the dentistry (esthetic). Silicon implantation was done in order to bond polymer molecules to the ceramic.



**FLASH RADIOTHERAPY**  
Is this modality ready for clinical translation?

Schematic diagram showing initial physical, chemical, and biological processes that occur after cells and tissues are exposed to radiation. In this context, conventional radiotherapy interferes with both the chemical and biological processes, whereas Flash-RT does not interact with the biochemical steps, allowing it to bypass these processes.



*CLEAR@CERN with electron beams and in collaboration with CHUV-Lausanne*

# Support to proton therapy clinical centers to start FLASH radiotherapy in Europe within EURO-LABS

HIGH ENERGY STABLE BEAMS

He/CO<sub>2</sub> FLASH beam monit

3D-printed Ripple-Filter Modulator

Binary range shifter

3D-printed SOBP-Modulator

field collimator

Pre-



FLASH is very promising for the future of radiation oncology

Whilst charged particles are the most mature technique for clinical translational, more pre-clinical research is needed

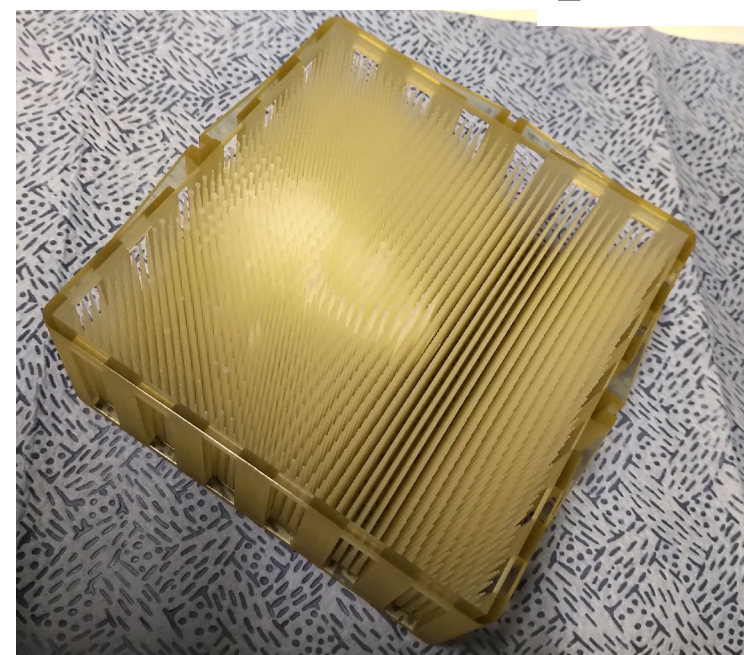
Following experiments with electrons, photons, and protons, GSI confirmed for the first time the FLASH effect with high-energy <sup>12</sup>C-ions *in vitro* and *in vivo*.

In addition to the reduction of normal tissue toxicity, we measured reduced tumor growth and distal metastasis. **The suppression of lung metastases, may be a unique feature of particle beams.**

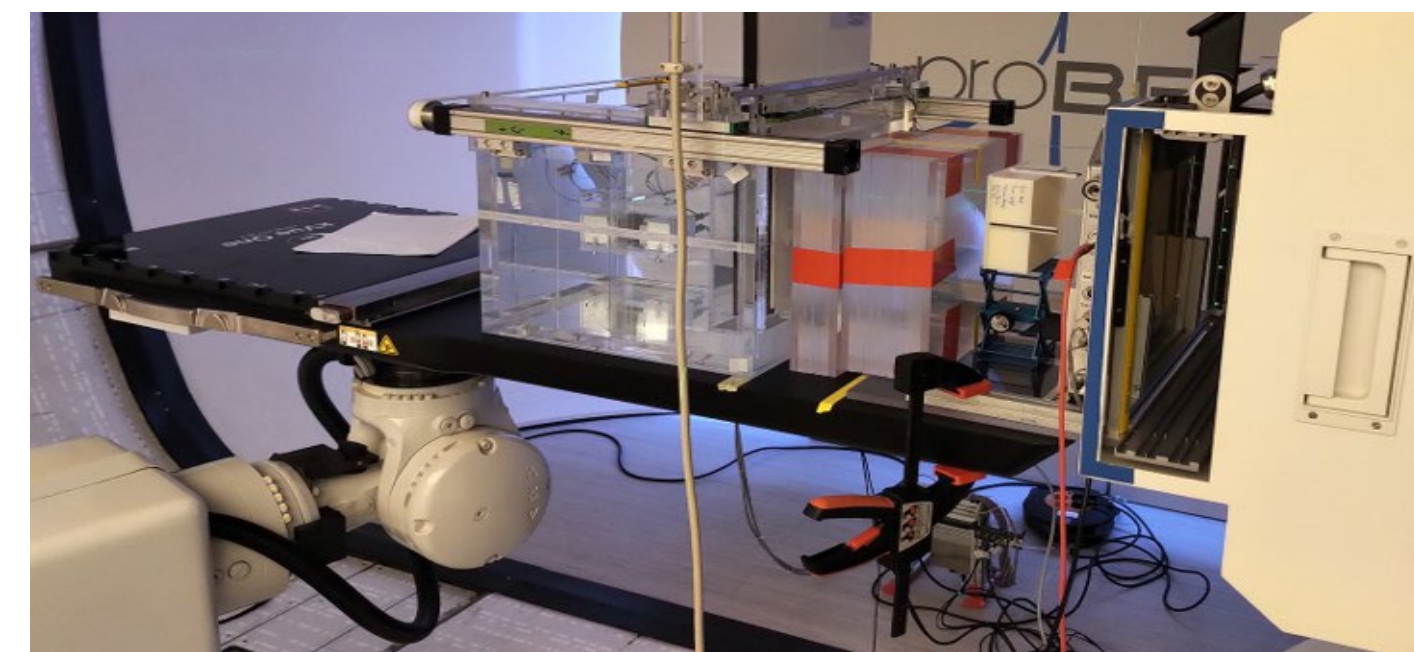
Coming 2024-2025 at GSI will clarify the role of C-ions in FLASH radiotherapy and the potential for clinical translation

Aarhus Medical Center, Denmark

Beam exit <sup>12</sup>C 240 MeV/u



**High-precision modulator for FLASH manufactured @GSI**

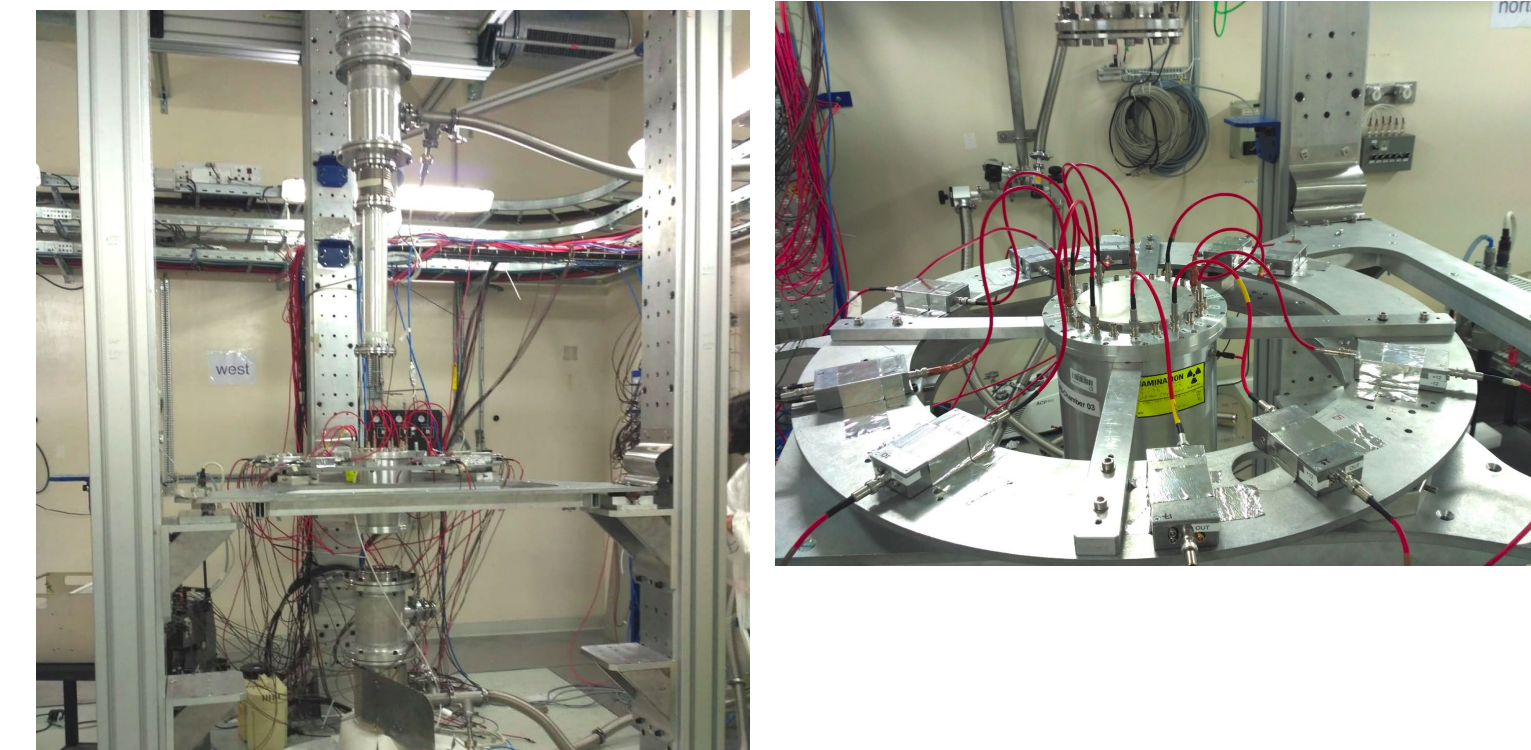
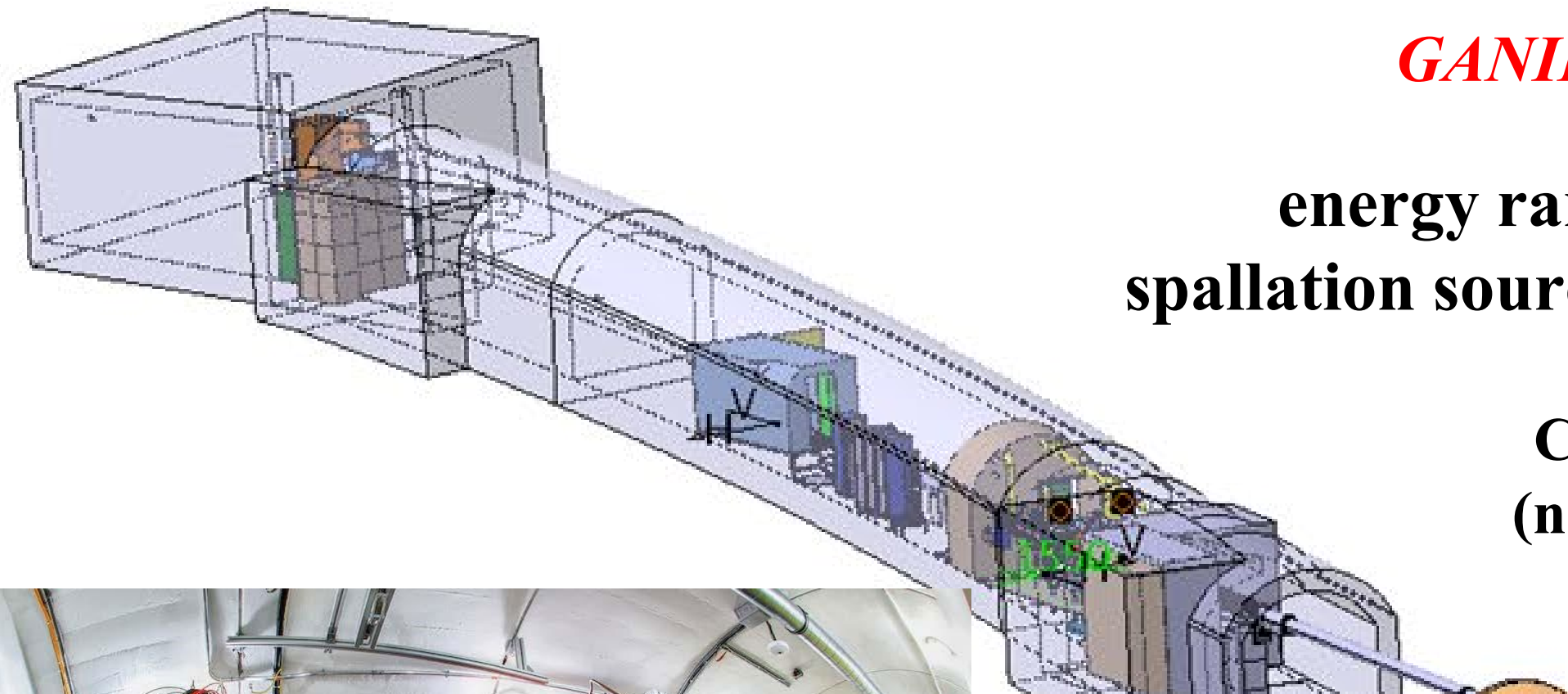


Holland PTC, The Netherlands

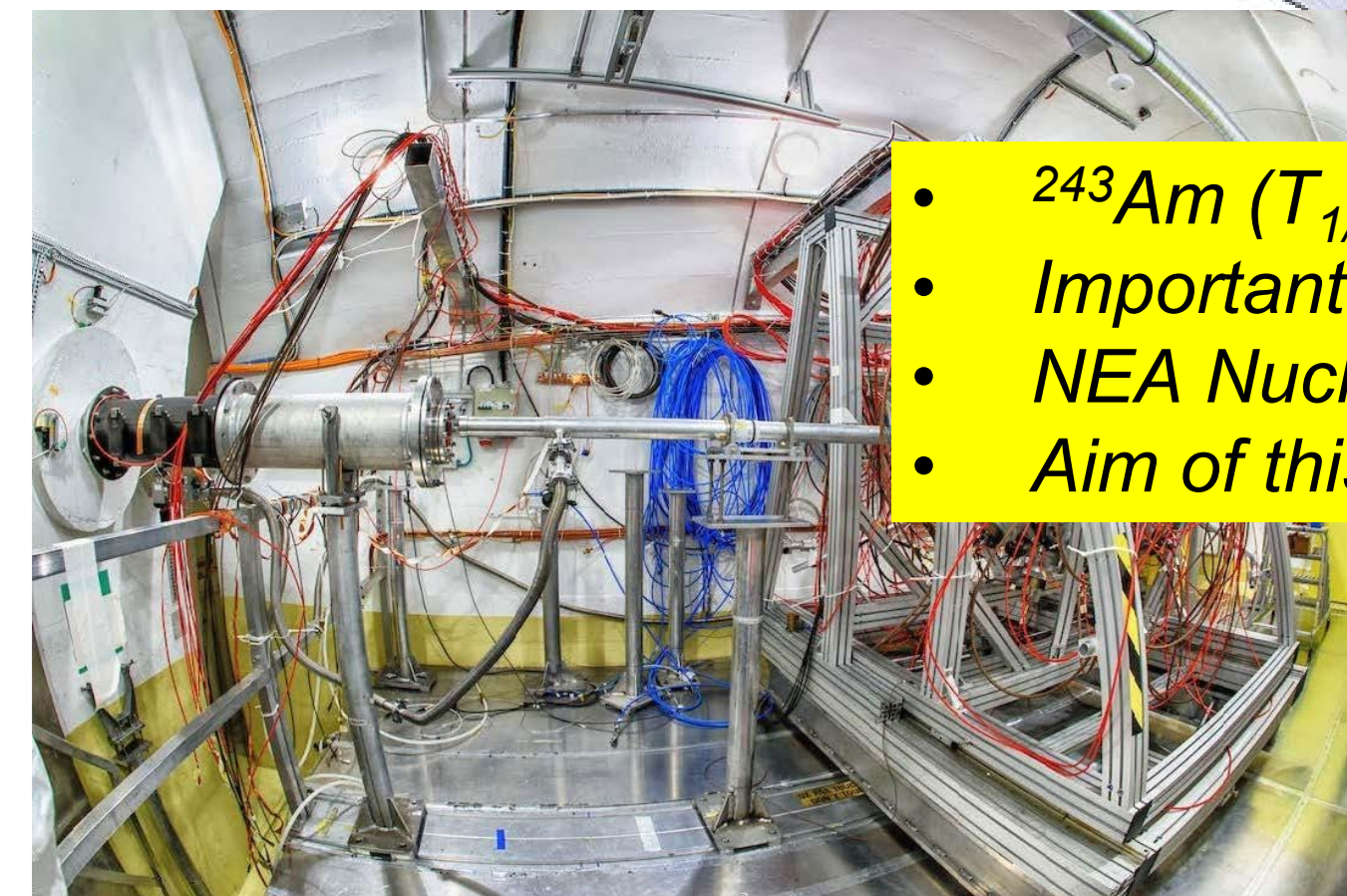
*GANIL-SPIRAL2 – NFS, LICORNE ...*

**energy range covered by other  
spallation sources (ESS, SNS and others)**

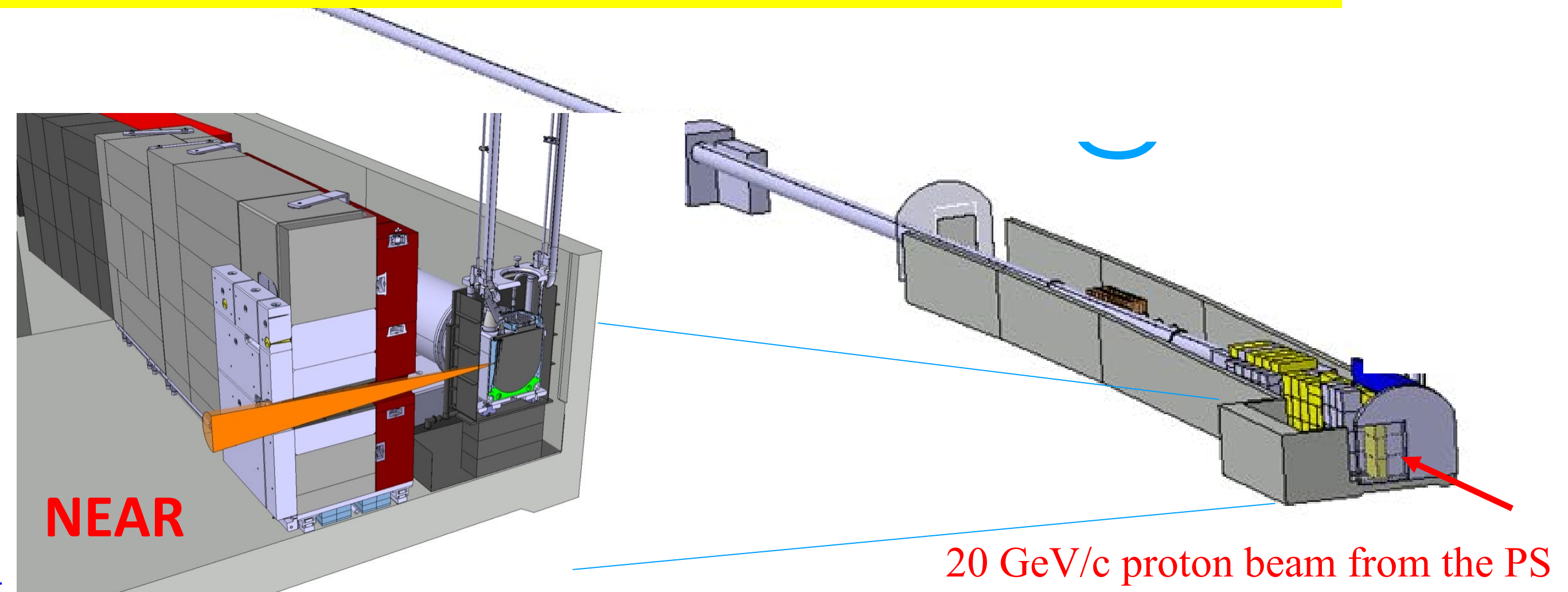
**Completely different science cases covered  
(no nuclear physics at ESS, SNS and others)**



- $^{243}\text{Am}$  ( $T_{1/2} = 7364\text{y}$ ) contributes to the radiotoxicity of nuclear waste via  $^{239}\text{Pu}$  production through decays
- Important candidate for use as burnable actinide in future reactors
- NEA Nuclear Data High Priority Request List (<https://www.oecd-nea.org/dbdata/hprl/search.pl?vsec=on>)
- Aim of this work: To provide a single high-quality dataset from thermal up to 100s MeV for the first time



**EAR1**



**NEAR**

20 GeV/c proton beam from the PS

*Neutron Physics with particle accelerators*  
N. Colonna, F. Gunsing, and F. Käppeler

[Progress in Particle and Nuclear Physics, 101, 177 \(2018\)](#)

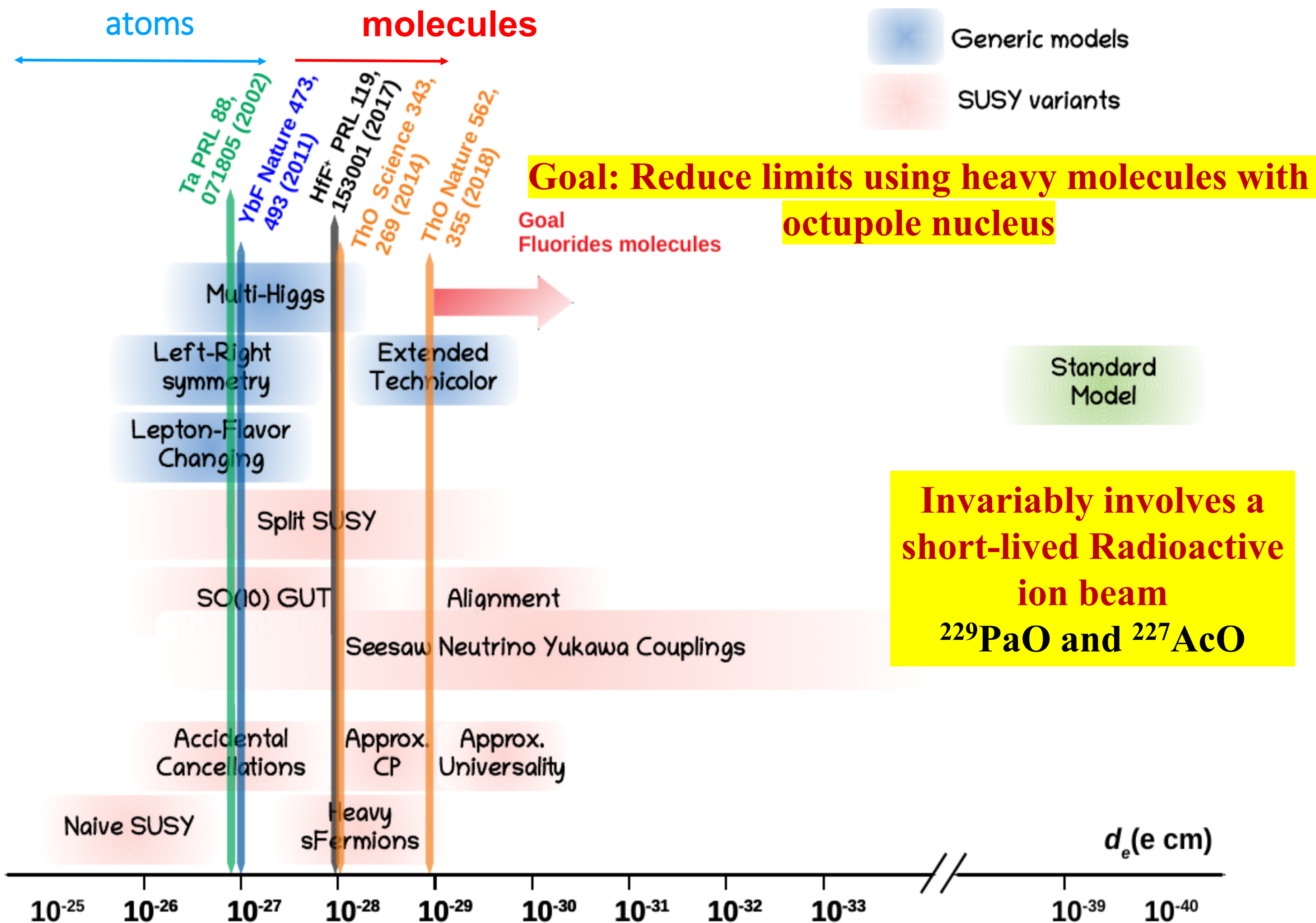
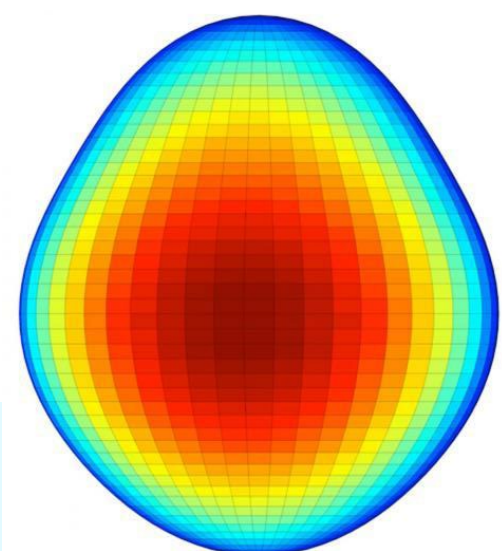
Searching for effects of EDM in atomic energy levels provides a precision method to test fundamental physics..

Static nuclear octupole deformation of the heavy element can add an additional enhancement via the atomic Schiff moment.

Polarization of molecules of heavy elements amplifies the interaction with external electric fields by factors of up to  $10^6$  and are less sensitive to problematic systematic effects.

Where do octupole nuclei lie away from stability and what signatures?

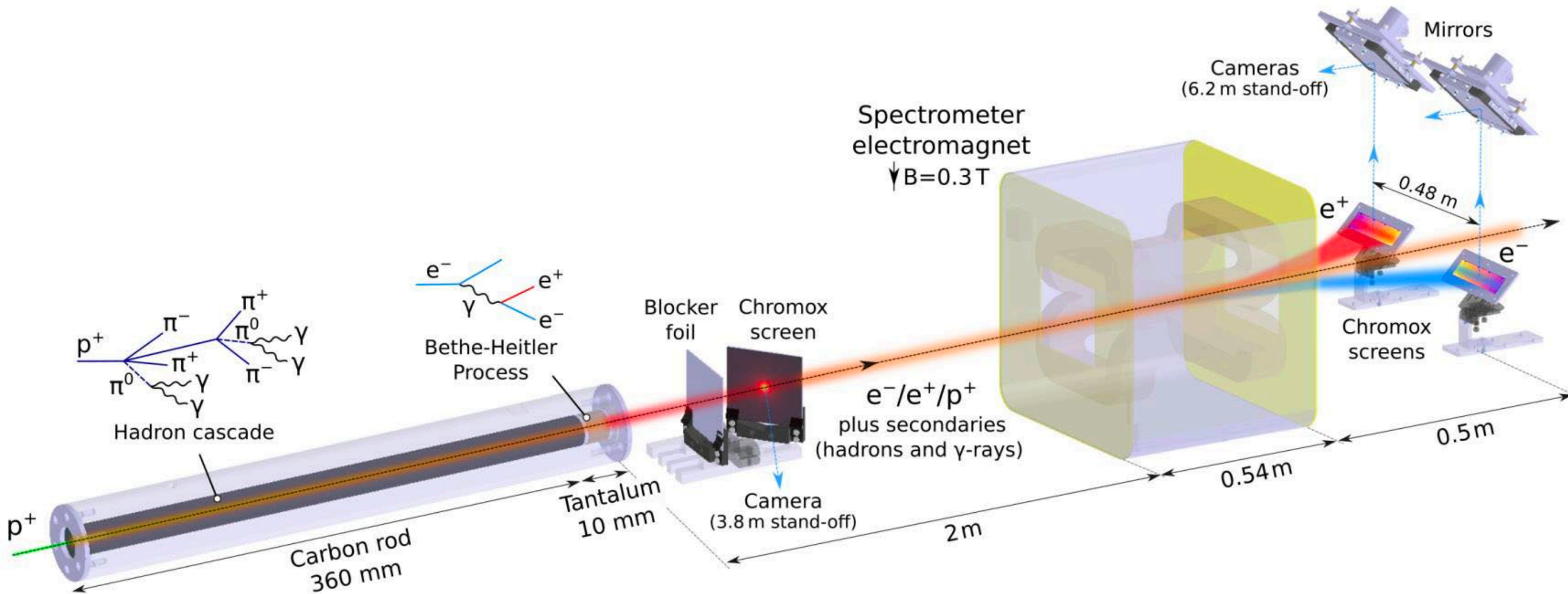
Molecular spectroscopy of heavy molecules?



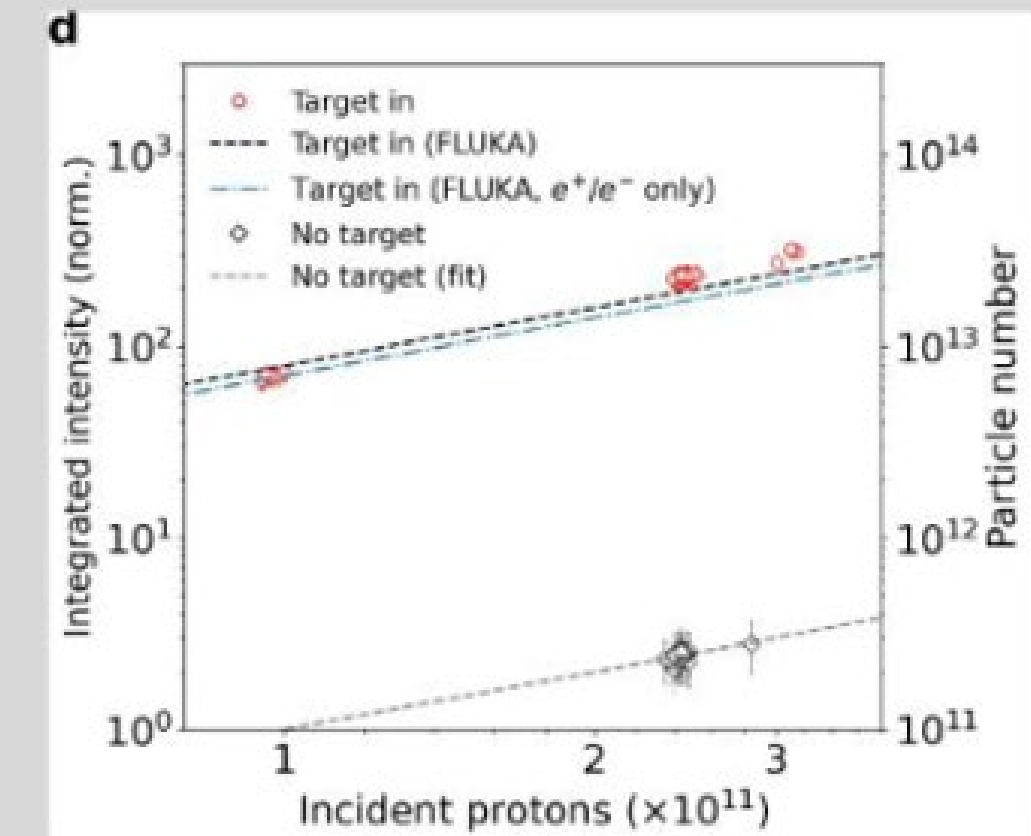
Relativistic outflows enriched with electron-positron pair plasma highly energetic astrophysical environments, e.g. around active galactic nuclei, black holes or in the jets of gamma ray bursts.

Energy dissipation and the radiative signatures observable → Plasma instabilities associated with such pair-dominated outflows-

High intensity, high density, ultra-relativistic, quasi-neutral electron-positron pair beam production was achieved,



- Luminescence screens show significant increase in electron/positron signal compared to proton beam only.
- Energy deposition for different species is accounted for.
- **Estimated pair number is  $>10^{13}$**  (in agreement with FLUKA simulations).



## Training +

ECT\*, Trento (Italy)



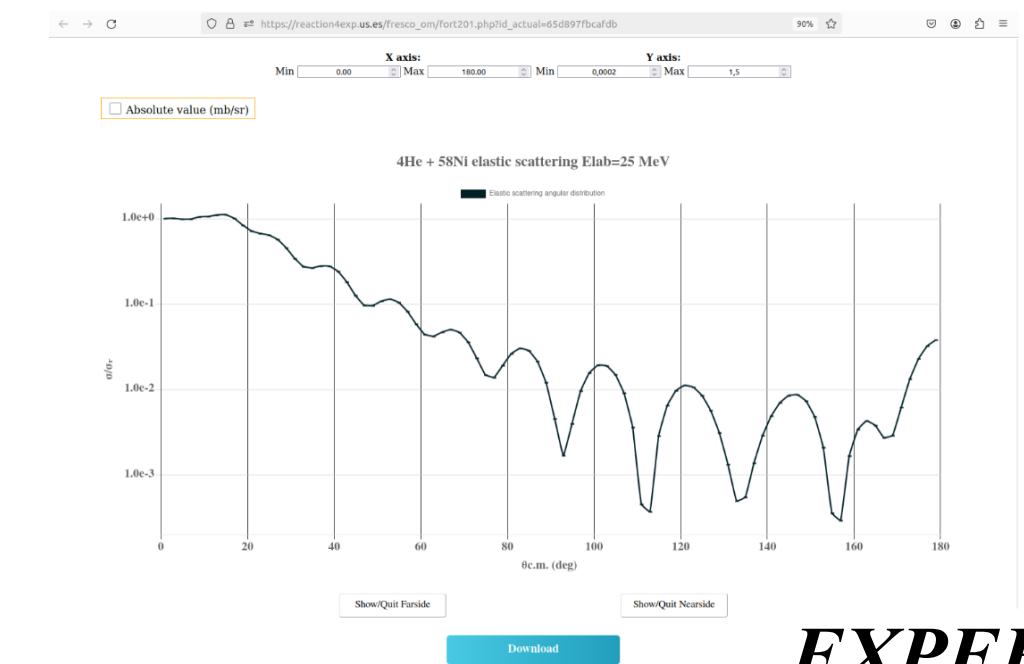
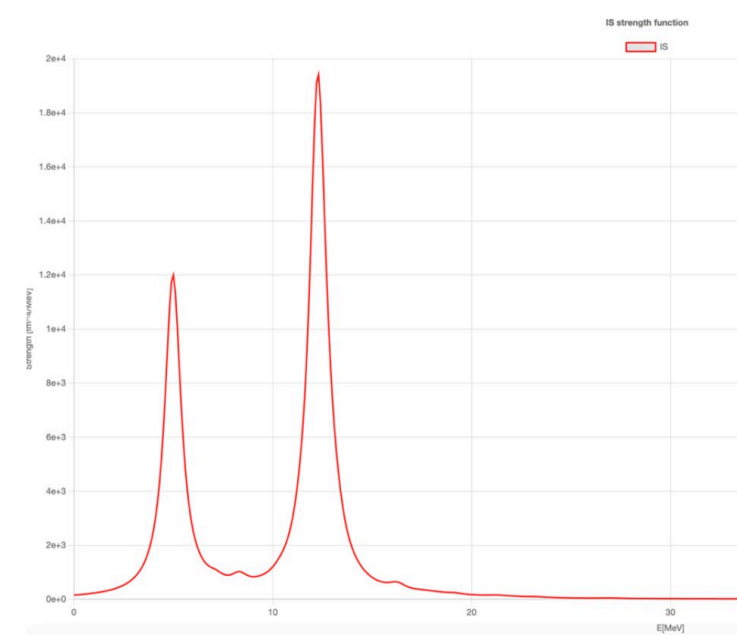
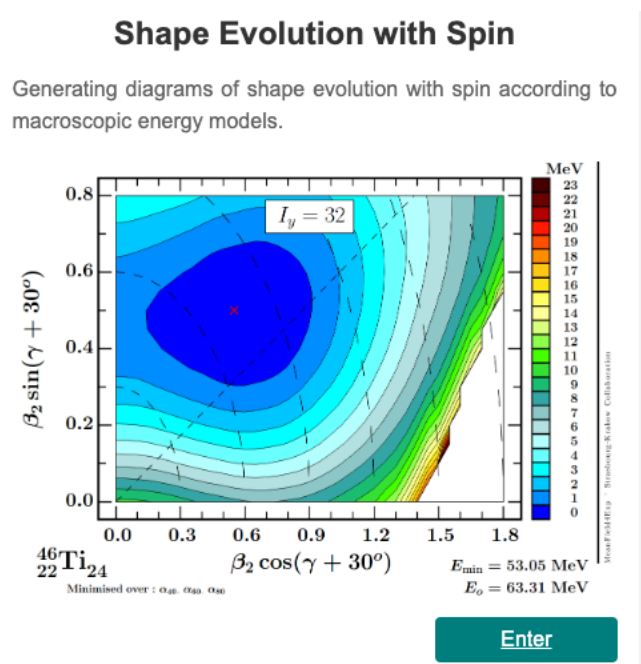
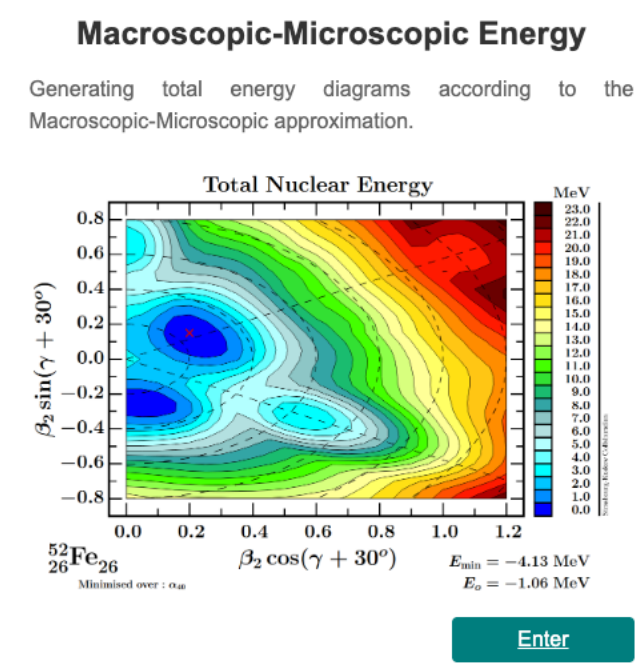
# THEO4EXP

A FACILITY PROVIDING VIRTUAL ACCESS TO NUCLEAR THEORY TOOLS

**MeanField4Exp**

**Structure4Exp**  
VIRTUAL ACCESS

**REACTIO4EXP**  
VIRTUAL ACCESS INFRASTRUCTURE - UNIVERSITY OF SEVILLE



**EXPERT HELP**





**F**indable



**A**ccessible



**I**nteroperable



**R**eusable

## Opportunities of for "Open Science" Nuclear Physics

- ▶ Improve drastically management and visibility of data-sets
- ▶ Develop new collaborations based on combined or reused data-sets.
- ▶ Enhance the scientific impact of the available and future data-sets

**Require strong involvement of all stakeholders (Researchers, RI, IT departments ...)**  
starting from having Data Management Plans

*Research Data Management is an Opportunity for RI and researchers.  
A lot of tools already exists, that needs to be made available to the community.*

**Perform Experiments.**  
Add hands-on experiments to spark student curiosity about what you are learning.



## Basic training school of 2023 BTS23 IFIN-HH, Bucharest - Măgurele



- In a target preparation laboratory.
- Vacuum technology for accelerators and special detectors.
- Overview of most used gamma-ray and particle detectors
- Digital Data Acquisition systems
- Manning experiments at the 9 MV and 3 MV tandems
- Calibration of the accelerator and of detectors used.
- De-activation measurements in an ultra-low background lab
- Guided visits to other major facilities of IFIN-HH

<https://indico.nipne.ro/event/246/timetable/#20230913>

**INTRANS 2024 Workshop**  
22-25 January 2024



<https://indico.ijclab.in2p3.fr/event/9682/timetable/#20240122>

### Advanced Training School on Operation of Accelerators

Courses - Hands-on – Simulation  
3 Facilities  
CLEAR, ISOLDE, PSB  
June 3<sup>rd</sup> -7<sup>th</sup>, 2024

The CERN accelerator complex  
Complexe des accélérateurs du CERN

**Content**

- Accelerator Complex
- Control system
- Beam characterization
- Phasing SC Cavities
- Mass Scans
- Steering Algorithms
- Other advances
- Topics

**How to apply**

EURO-LABS Webpage:  
<https://web.infn.it/EURO-LABS/>

**Deadline for application**  
January 31st

Contact & other info: [mj.borge@csic.es](mailto:mj.borge@csic.es)



**The Basic Training School on Accelerators 2024, organized at HIL and INCT, will June 18-27 in Warsaw U200-P cyclotron ,INCT electron accelerators.**

**15 - 20 students (early PhD students or last year master degree students) will be selected and will perform experiments with heavy ion and electron beams as well as with radioactive sources to get a basic knowledge and develop skills on use of detectors, electron beam control and dosimetry.**



## Bringing Life to science

*Great Scientific and Technological progress  
A trained next generation  
Europe's SUPER COMMUNITY*



This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101057511.

**Thank my colleagues who provided material for the talk**  
*Thank you for your time and attention*



**AccelApp '24**  
2024 International Topical Meeting on Nuclear Applications of Accelerators  
March 17-21, 2024  
Hosted by Jefferson Lab  
Norfolk, Virginia

