

SERESSA 2022

5th to 9th of December at CERN, Geneva



The RADNEXT irradiation facility network

Andrea Coronetti, (CERN, UM), on behalf of the RADNEXT network



Agenda

- ❑ Introduction
- ❑ Project partners and supporters
- ❑ Project structure
- ❑ Joint-Research Activities
- ❑ Transnational Access
- ❑ Facilities in the Network
- ❑ Getting involved

Introduction

Q: Do we still need radiation effects testing?

“State of US electronic parts space radiation testing infrastructure”

TESTING AT THE SPEED OF LIGHT

THE STATE OF U.S. ELECTRONIC PARTS
SPACE RADIATION TESTING INFRASTRUCTURE

(PDF available online: <https://www.nap.edu/catalog/24993/testing-at-the-speed-of-light-the-state-of-us>)

Highlighted overall findings and recommendations (not complete):

- ❑ *the radiation-testing infrastructure system is fragile; it is already experiencing **long wait times and rising testing prices**, and it could easily suffer major strains if even a single major facility closes down suddenly.*
- ❑ *The combination of this fragility and overloading of current beam-line facilities for space radiation testing, together with the growing complexity of commercially available microelectronic and optoelectronic systems that will further strain the system, and increasing requirements for accelerator testing by the private sector, all together project a **growing shortage of available testing facilities to support future space missions among space agencies and industry.***
- ❑ *An apparent bimodal distribution in the radiation testing workforce exposes the risk that **critical knowledge** may not be transferring at a sufficient rate from mid-career to early career radiation engineers.*
- ❑ *The most important step to take is therefore to **provide some high-level strategic coordination across the radiation testing community.***

RADiation facility Network for the EXploration of effects for indusTry and research

Framework: H2020 INFRAIA (2018-2020)
RADNEXT: INFRAIA-02-2020
Integrating Activities for **Starting** Communities

Coordination by CERN
Project Leader: Rubén García Alía
Total budget: 5 M€

Final submission 14th May 2020
Approved for funding on 3rd November 2020
Project start: June 2021 (4 years)

Proposal preparation 10.2019 – 05.2020
(*“inspired” by RADSAGA Marie Curie project,*
<http://radsaga.web.cern.ch/>)



radnext.web.cern.ch



radnext.network@cern.ch



linkedin.com/company/radnext



twitter.com/RADNEXT_EU



RADSAGA



This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement number 721624.

What is RADNEXT?

A network of European (+ TRIUMF!) **irradiation facilities** and related research and outreach activities with the main purpose of **enhancing accessibility** to accelerator infrastructures for **research activities on radiation effects in electronics**

How do we plan to enhance accessibility? Through:

- ❑ **6000h of beam time over 4 years**, free-of-cost to users, and to be awarded via a competitive proposal process, evaluated by independent experts
- ❑ A rich **quantity and variety of facilities**, targeting at satisfying user needs in terms of beam characteristics and timeline
- ❑ A **centralized access point and procedure** for requesting beam time for research on radiation effects in electronics
- ❑ An ambitious **research program** devoted to improving radiation effects testing, both on the facility and user side

Mission

- ❑ Successfully deliver the 6000h of beam time to happy users 😊
- ❑ Enhance **communication and coordination** between users (notably industry) and facilities
- ❑ **Centralize** information and **harmonize** procedures linked to radiation effects testing
- ❑ Create a structure for irradiation facility access that will be **sustainable** beyond the RADNEXT timeline
- ❑ Make significant **progress in research topics** that will improve the irradiation procedure and experience as a whole, both on the side of the users and facilities
- ❑ Establish bridges to neighboring communities (e.g., medical, laser plasma acceleration...)

Project partners and associates

Website as central entry point (for members, users, general public...)

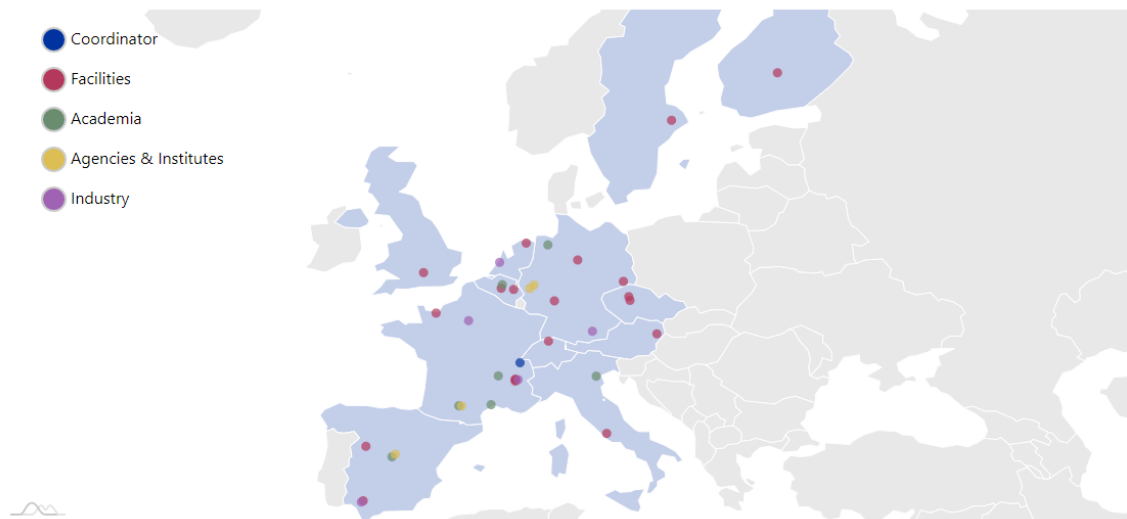
❑ <https://radnext.web.cern.ch/>

❑ Includes list and map of partners and supporters, and links to their websites

❑ Blog entries, including also events and career opportunities

❑ **Provides the means to get in touch with us**

Partners & Associates



RADNEXT partners

Coordinator: CERN (Int.)

Facilities:

- GSI (DE)
- UMCG PARTREC (NL)
- GANIL (FR)
- RADEF (FI)
- UCLouvain (BE)
- PSI (CH)
- CNA (ES)
- NPI CAS (CZ)
- TRIUMF (CA)
- STFC-ISIS (GB)
- ENEA-FSN (IT)
- CNRS LPSC (FR)
- UU NESSA (SE)
- ILL (Int.)
- Centre Spatial Liege (BE)
- HZDR (DE)
- ESRF (Int.)
- ELI Beamlines (CZ)
- CLPU (ES)
- PTB (DE)
- Seibersdorf Laboratories (AT)

Academia:

- University of Montpellier (FR)
- KU Leuven (BE)
- Padova University (IT)
- Saint-Etienne University (FR)
- Oldenburg University (DE)
- University Carlos III of Madrid (ES)
- ISAE-SUPAERO (FR)
- MINES ParisTech, PSL University (FR)

Agencies & Institutes:

- CNES (FR)
- DLR (DE)
- INTA (ES)
- Fraunhofer INT (DE)

Industry:

- Airbus (Int.)
- 3D-Plus (FR)
- IROC Technologies (FR)
- ALTER (ES)
- Datzmann interact & innovate (DE)

RADNEXT supporters

Facilities:

- UAM CMAM (ES)
- INFN TIFPA (IT)
- IFJ PAN (PL)

Academia:

- UOW CMRP (AU)
- SUAI (RU)
- Universidad Nebrija (ES)
- University of Piraeus (GR)
- University of Valencia (ES)
- ETH Zurich AEIL (CH)
- UiO (NO)
- Politecnico di Torino (IT)
- CRISMAT (FR)

Agencies & Institutes:

- Egyptian Space Agency (EG)
- RADECS Association (Int.)
- ESS Bilbao (ES)

Industry:

- STMicroelectronics (Int.)
- Radiosity Solutions (US)
- CAEN (IT)
- Radtest (GB)
- Micro-Cameras (CH)
- Systheia (FR)
- Cobham Gaisler (SE)
- Tecnobit - Grupo Oesia (ES)
- RedCat Devices (IT)
- Teledyne e2v (FR)
- RAKON (FR)
- IDEAS (NO)
- Spin.Works (PT)
- SkyLabs (SI)
- ARQUIMEA (ES)
- Cypress Semiconductor (US)
- Syderal Swiss (CH)
- ICEYE (FI)
- Puli Space Technologies (HU)
- UNITES Systems (CZ)
- TRAD (FR)
- Thales Alenia Space (Int.)

Project structure

Work packages

WP No.	Work Package Title	Lead Participant
WP1-MGT	Project management	CERN, UM
WP2-NA1	Communication, Dissemination, Exploitation and Training	KUL, ESRF
WP3-NA2	Transnational Access Management and Harmonization	ENEA, INT
WP4-NA3	Roadmap and pre-design of future irradiation facilities	CERN, ELI
WP5-JRA1	Radiation monitors, dosimeters and beam characterization	UJM, TRIUMF
WP6-JRA2	Standardization of system level radiation qualification methodology	UM, UC3M
WP7-JRA3	Cumulative radiation effects on electronics	UM, ISAE
WP8-JRA4	Complementary modelling tools	UM, CERN
WP9-TA1	Neutron, muon and mixed-field spallation facilities and irradiation	UKRI, TRIUMF
WP10-TA2	Proton, heavy ions and alternative beams and irradiation	CNES, JYU

Joint Research Activities

WP5: radiation monitors, dosimeters and beam characterization

- ❑ Definition of the correlation matrix between RADNEXT facilities needs and established or innovative sensing solutions
- ❑ Definition and standardization of relevant beam parameters
- ❑ Innovative measurement techniques applied to the RADNEXT facilities
- ❑ Development of low-cost dosimetry systems accessible to RADNEXT users



Sylvain Girard
(Jean Monnet University)
WP leader



Cornelia Hoehr
(TRIUMF)
Deputy WP leader



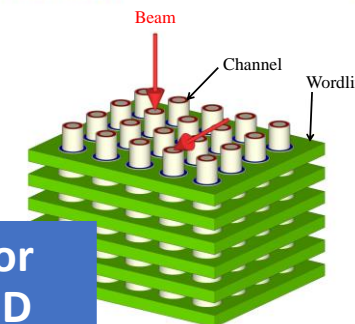
Andreas Pflaum
(University of Oldenburg)
PhD student



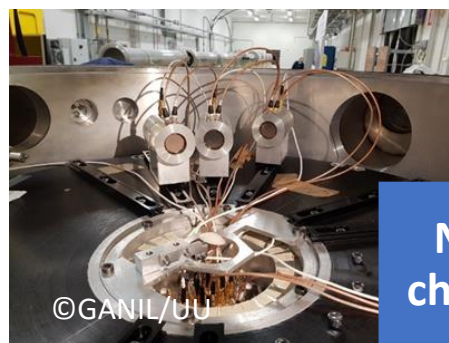
Luca Weninger
(Jean Monnet University)
PhD student



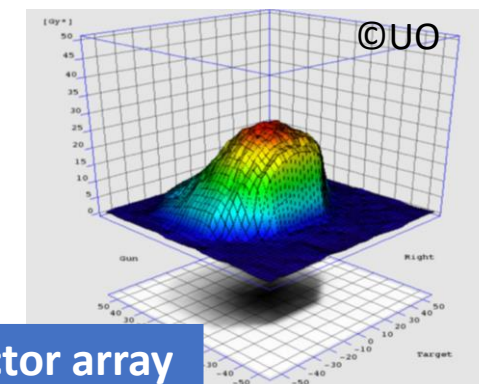
**Fiber-based
Dosimetry**



**SEU monitor
based on 3D
NAND Flash**



**Neutron field
characterization**



Detector array

WP6: standardization of system-level testing radiation qualification

- ❑ Radio frequency integrated circuits (RFIC) and agile RF transceiver
- ❑ System in Package (SiP) architectures (for RF Systems)
- ❑ Machine learning for failure detection
- ❑ Distributed on-board-computer (OBC) architecture for satellite systems
- ❑ Stimuli definition
- ❑ Pass/fail test for black box
- ❑ Enhanced observability



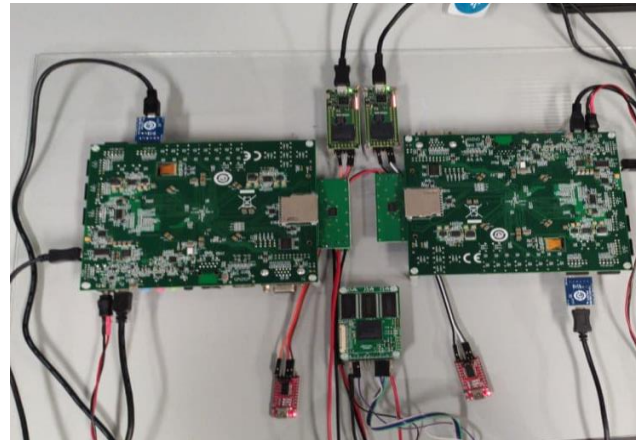
Luigi Dilillo
(University of Montpellier)
WP leader



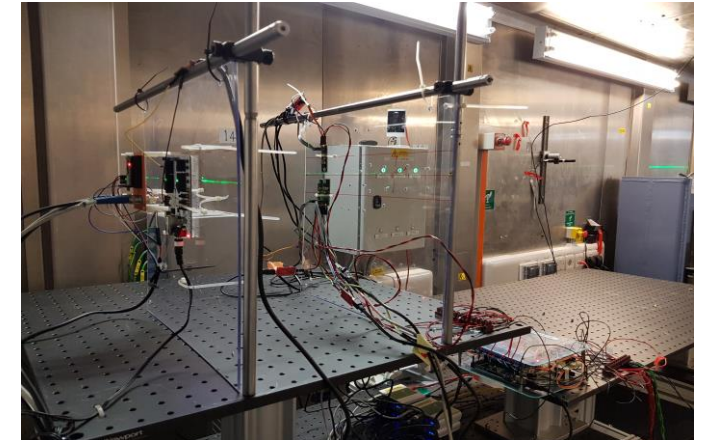
Luis Entrena Arrontes
(University Carlos III of Madrid)
Deputy WP leader



André Mattos
(University of Montpellier)
PhD student



Multi-system setup for P/F test
(img. LIRMM)



Experiment from remote, in
ChipIR (img. LIRMM)

WP7: cumulative radiation effects on electronics

☐ TID effects:

- Comparison of Co-60 and X-ray sources
- Beam comparison and filtering
- Dosimeters to be used
- Charge yield

☐ TNID effects:

- Test procedures and facilities
- Basic mechanisms of leakage current (dark current)
- CMOS image sensors



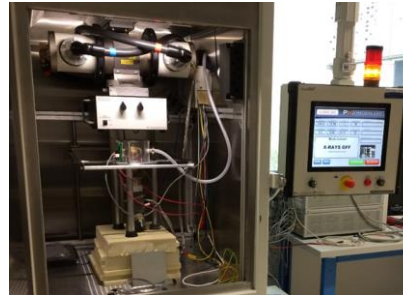
Jérôme Boch
(University of Montpellier)
WP leader



Vincent Goiffon
(ISAE-SUPAERO)
Deputy WP leader

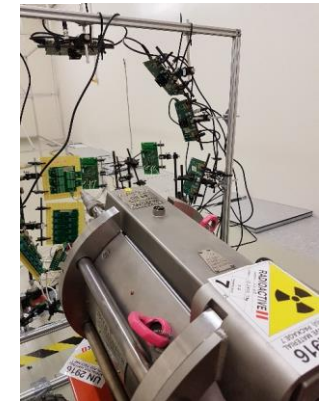


Vincent Girones
(University of Montpellier)
PhD student



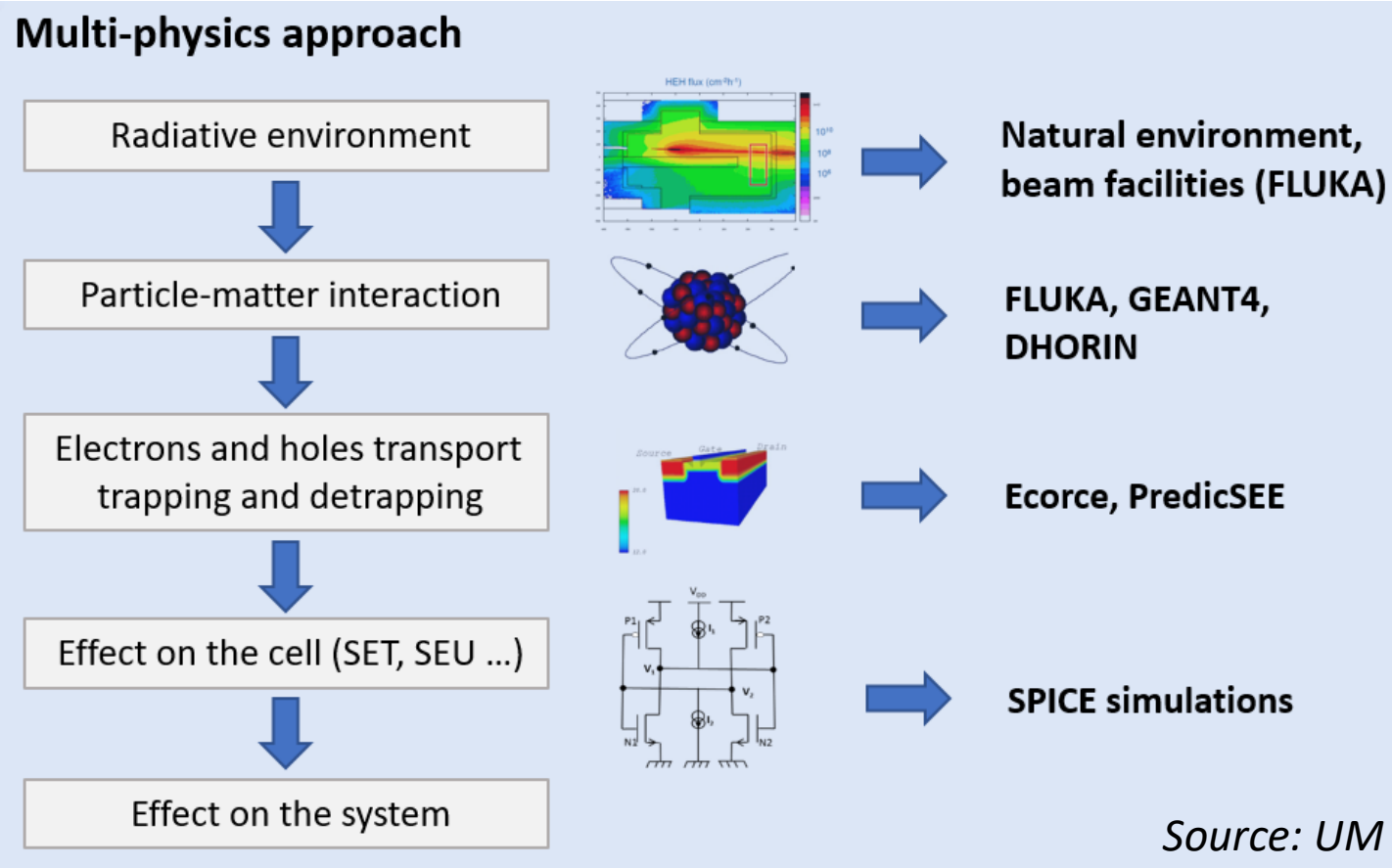
320 kV X-Ray generator
Source: UM

*3.5 MeV e-beam
Accelerator
Source: ATRON*



Cobalt 60 Irradiator
Source: UM

WP8: complementary modeling tools



□ And facility modelling



Frédéric Wrobel
(University of Montpellier)
WP leader



Giuseppe Lerner
(CERN)
Deputy WP leader



Cleiton Magano Marques
(University of Montpellier)
PhD student



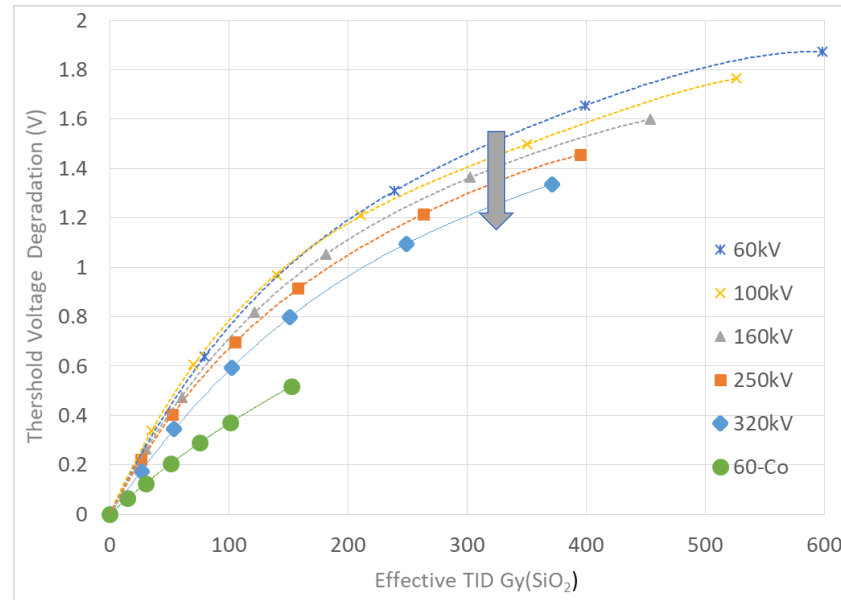
Tim Wagner
(GSI)
Postdoc researcher



Illia Zymak
(ELI Beamlines)
Postdoc researcher

X-ray generator vs Co-60 source

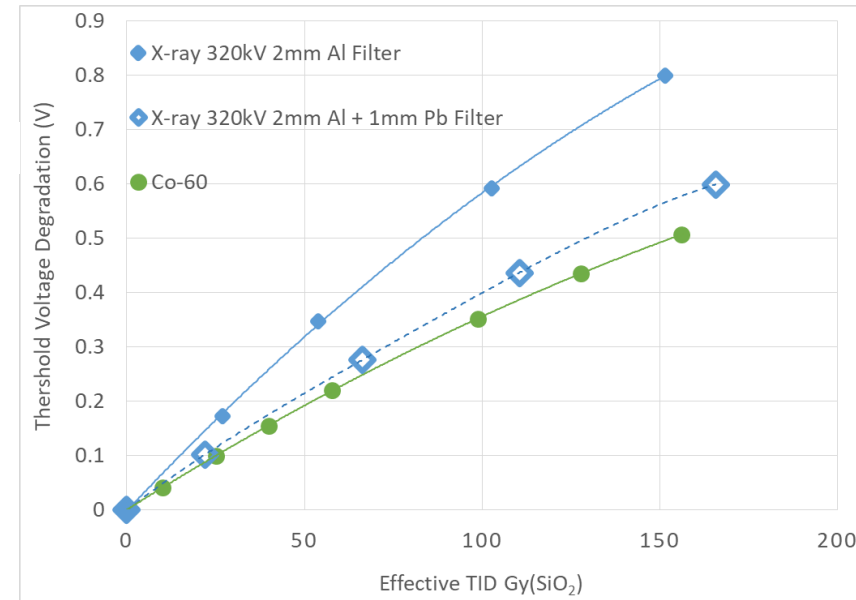
The use of high energy X-rays generator



NMOS transistors

The use of filters

Source: UM



□ Voltage and filter can have an impact on the degradation of the device that can make X-ray more or less comparable to Co-60

- Best fitting for high voltage for the generator
- And for filtering technique that removes the low-energy part of the X-ray spectra

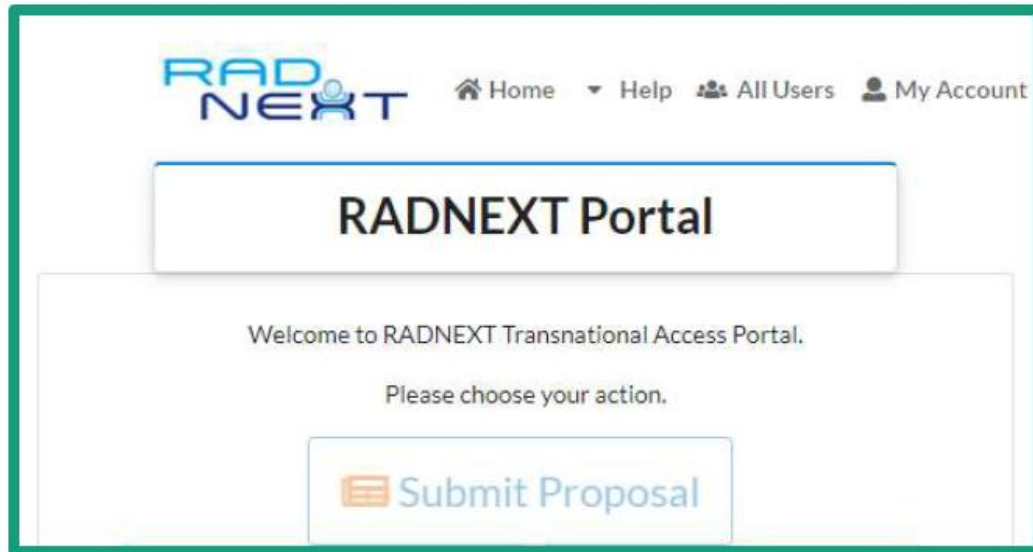
Transnational access

RADNEXT TA

- ❑ More than **6000h of free-of-cost beam time** to be awarded via **competitive selection process** to radiation effects researchers worldwide
- ❑ Transnational = you can apply for beam time only outside your home country
- ❑ Funding for (partially) supporting travel and other test related expenses (e.g., accommodation) also possible, as managed by each of the participating facilities
- ❑ Industry (and in particular SMEs) are eligible and strongly encouraged to submit their proposals
 - Detailed eligibility conditions available on website
- ❑ Main counterpart from RADNEXT TA users: **test results need to be published!!**

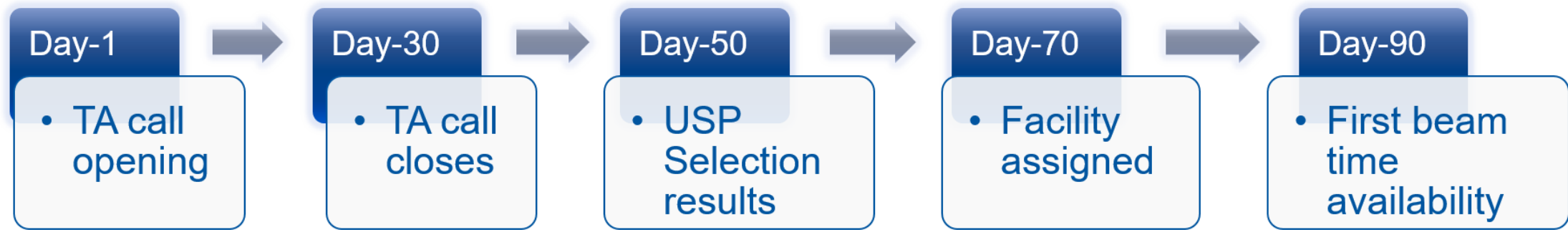
RADNEXT TA: guideline for proposals

<https://radnext-ta-portal.web.cern.ch/>



- ☐ Proposal title
- ☐ Beam type
- ☐ Abstract (<1200 characters)
- ☐ Project description (<4500 characters)
 - Excellence (test objectives, innovation)
 - Impact (community, societal)
 - Implementation (test setup, irradiation plan)
- ☐ Amount of irradiation
- ☐ User availability
- ☐ Group leader
- ☐ Team members
- ☐ Remember that when you apply for beamtime you're committing yourself to share the results

RADNEXT TA: proposal evaluation and facility assignment



Actual beam delivery depends on beam type, facility availability and user readiness

Some evaluation criteria...

- ☐ Commercial vs. scientific goals
- ☐ Level of detail and readiness
- ☐ Convincing and justified test plan
- ☐ Innovation, ambition, expected output
- ☐ Requested amount vs. availability

...and some tips

- ☐ Alignment with RADNEXT activities and goals
- ☐ Target curiosity of reviewers
- ☐ Provide a clear picture of your project
- ☐ Explain what sets you apart from the other
- ☐ Ask for reasonable beam time

Seems to complicated? Contact the User Support Expert team for free (radnext-use@cern.ch)!

RADNEXT TA

- ❑ TA submission process → keep a close eye on the website!
- ❑ So far, 150 proposals received in 6 calls (58% acceptance)
- ❑ 7th call for proposals will open soon, until January 31st, 2023 → make sure to submit your proposal!!

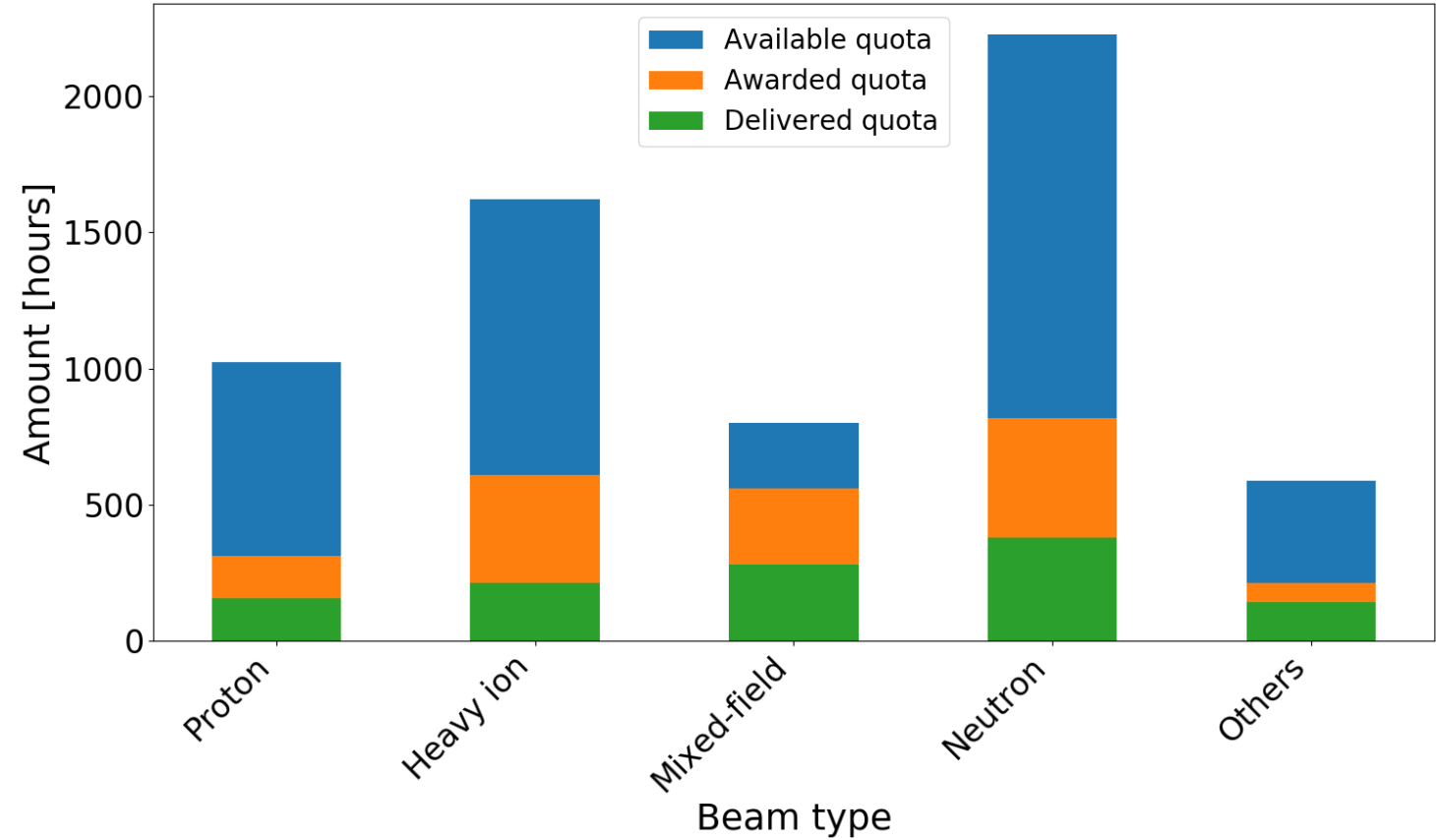
Transnational Access

Transnational Access to irradiation facilities is the cornerstone of the RADNEXT project. More than 6000 beam time hours are awarded during the four years of the project, in more than 20 different facilities in Europe and beyond.

Both academic and industrial groups are eligible for beam time as potential RADNEXT users, and in particular small and medium-sized enterprises (SMEs) are strongly encouraged to submit their proposals. Beam time awarded for RADNEXT users is free of charge, funded by EU European Union's Horizon 2020 research and innovation programme under grant agreement No 101008126.

The next Call For Proposals will be opened in January 2023.

RADNEXT TA: status at 30.11.2022



Facilities in the network

Where they stand in the world



Neutron



Proton



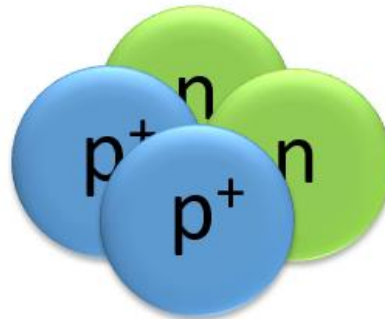
Electron



Q: which is the most important radiation source for SEE characterization?



Photon

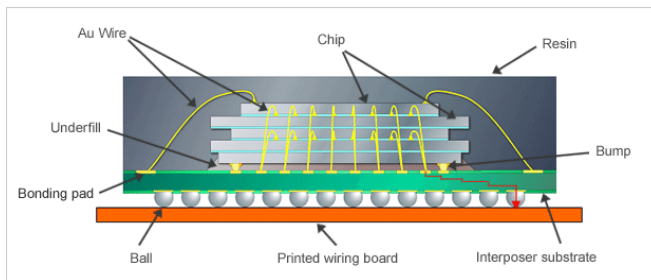
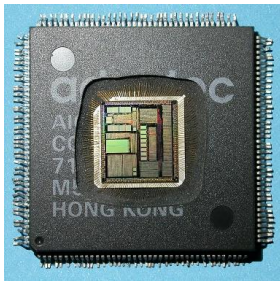
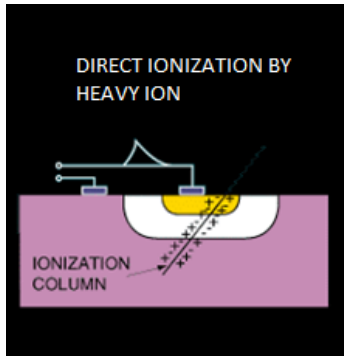


Ions



Muon

Heavy ions: what standards recommend



Heavy ion characteristics

- Defined in terms of their linear energy transfer (LET) and forgetting their atomic number

$$LET = \frac{1}{\rho} \frac{dE}{dx}$$

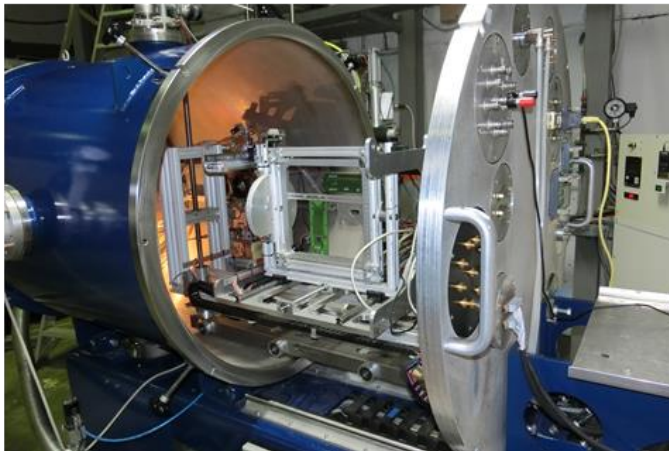
- Ion energies < 100 MeV/n and more typically about 10 MeV/n
- Standard test energy ions have **short ranges**
 - LET may not be constant in the sensitive volume
 - Need to use vacuum chambers
 - Need to decapsulate the device prior to irradiation
- High-energy ions (> 100 MeV/n) are desirable
 - For some devices it is simply impractical to expose the SV

Heavy ions: rare and precious

Institute / Organisation	Facility	Country	Beam type
UCLouvain - Cyclotron Resource Centre	HIF	Belgium	Heavy ions
University of Jyväskylä, Department of Physics	RADEF	Finland	Heavy ions
University Medical Center Groningen (UMCG)	PARTREC/AGOR cyclotron	Netherlands	Heavy ions
Grand Accélérateur National d'Ions Lourds (GANIL)	GANIL	France	Heavy ions
GSI Helmholtzzentrum	UNILAC	Germany	Heavy ions
GSI Helmholtzzentrum	SIS-18	Germany	Heavy ions
CERN	CHARM	Switzerland	Heavy ions
CERN	SPS North Area	Switzerland	Heavy ions

Contact: Nancy Postiau

- ☐ Cyclotron
- ☐ Heavy ion cocktail with 9.3 MeV/n energy
- ☐ Vacuum irradiation
- ☐ Available all year long
- ☐ 280 hours (112 remaining)



Ion	Energy [MeV]	Range [μm]	LET [MeV/(mg/cm ²)]
$^{13}\text{C}^{4+}$	131	269,3	1,3
$^{22}\text{Ne}^{7+}$	238	202	3,3
$^{27}\text{Al}^{8+}$	250	131,2	5,7
$^{36}\text{Ar}^{11+}$	353	114	9,9
$^{53}\text{Cr}^{16+}$	505	105,5	16,1
$^{58}\text{Ni}^{18+}$	582	100,5	20,4
$^{84}\text{Kr}^{25+}$	769	94,2	32,4
$^{103}\text{Rh}^{31+}$	957	87,3	46,1
$^{124}\text{Xe}^{35+}$	995	73,1	62,5

RADEF

Contact: Heikki Kettunen

☐ Cyclotron

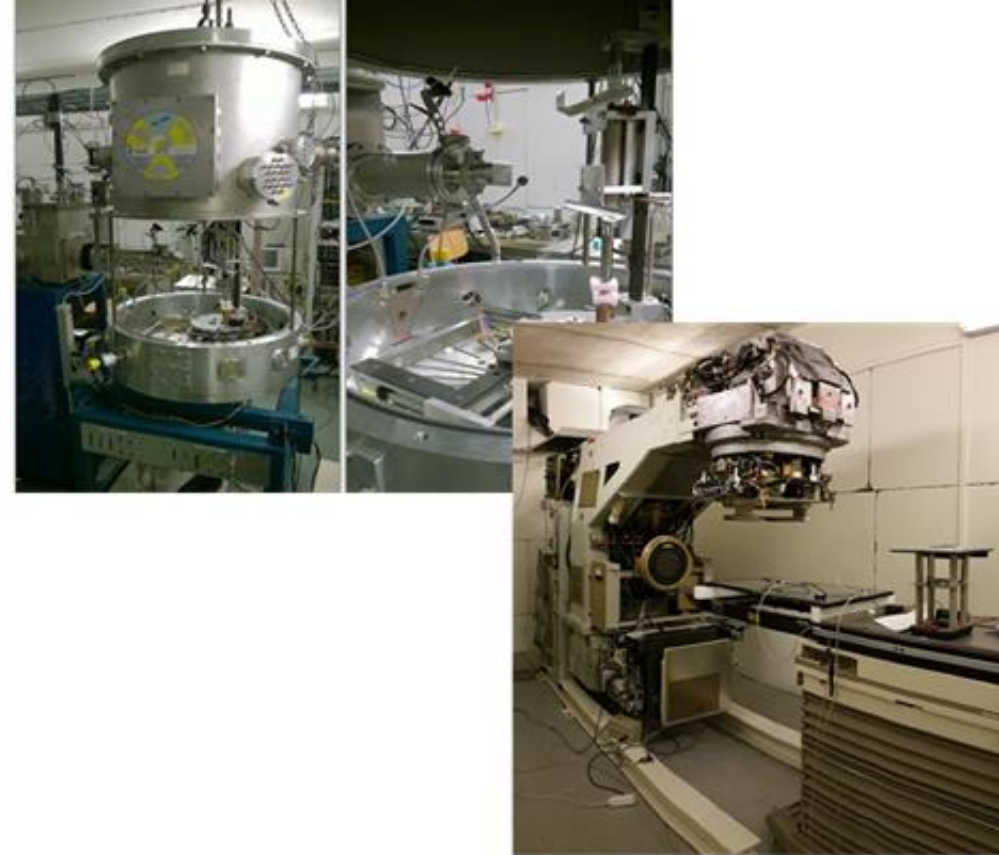
☐ Heavy ion cocktails

- 9.3 MeV/n: N, Ne, Ar, Fe, Kr, Xe
- 10 MeV/n: Ar, Kr, Au
- 16.3 MeV/n: O, Ne, Ar, Fe, Kr, Xe
- 22 MeV/n: O, Fe, Kr

☐ Vacuum and in-air irradiation

☐ Available all year long

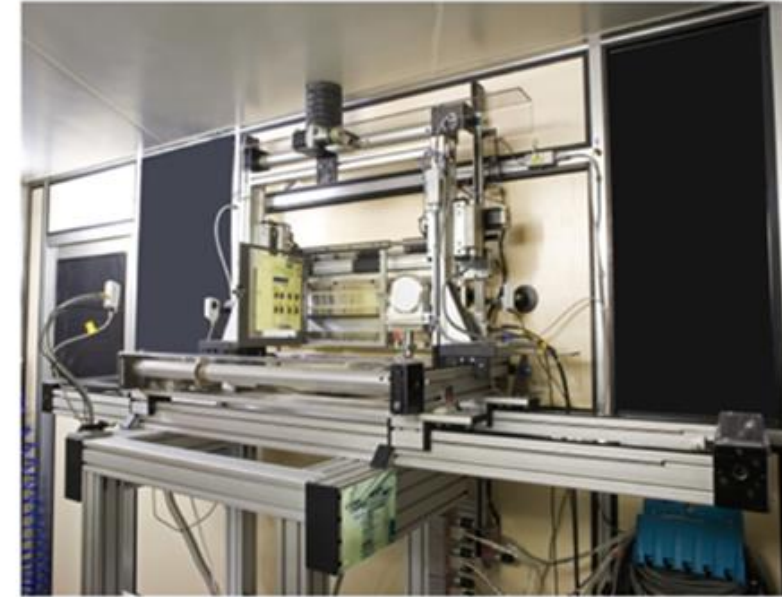
☐ 300 hours (105 remaining)



GANIL

Contact: Eloïse Dessay

- ☐ Cyclotron
- ☐ Only one ion per test campaign
- ☐ Variable range and LET obtained through degradation
- ☐ In-air irradiation
- ☐ Available only between April and June
- ☐ 158 hours (102 remaining)



Standard sample holder

Ion	Energy [MeV/n]	Range [μm]	Min LET [MeV/(mg/cm ²)]
³⁶ Ar	27	445	5,4
⁸⁶ Kr	60	1223	11
¹²⁹ Xe	50	685	26,5
²⁰⁸ Pb	29	258	72,7

PARTREC

Contact: Brian Jones

☐ Cyclotron

☐ Ion cocktails

- 30 MeV/n: O, Ne, Ar, Kr, Xe
- 90 MeV/n: He, C, O, Ne

☐ Variable range and LET also obtained through degradation

☐ In-air irradiation

☐ Available all year long

☐ 237 hours (> 200 remaining)

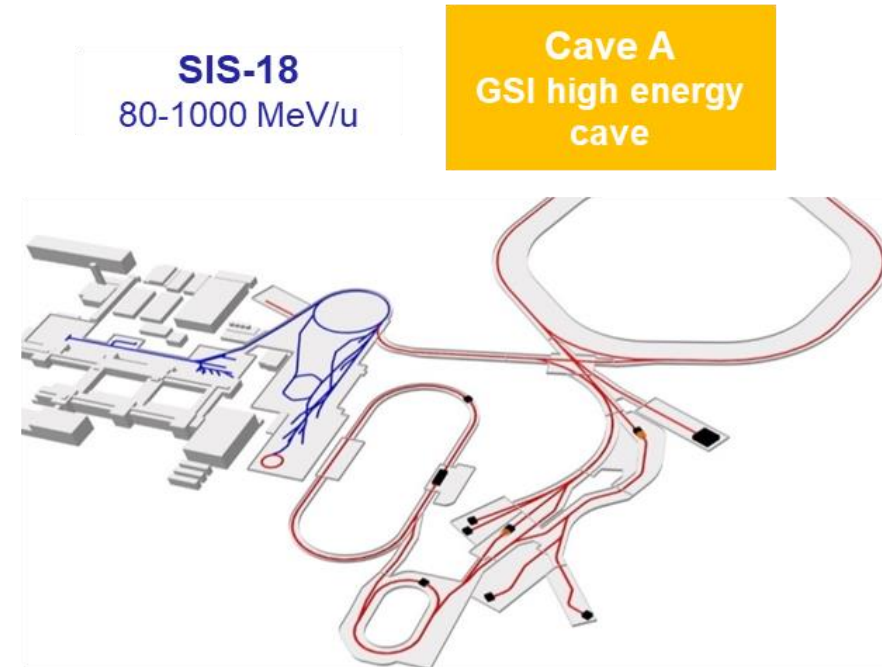


partrec

GSI UNILAC & SIS18

Contact: Marco Durante

- ☐ Synchrotron
- ☐ Almost all ions possible, though only few available for test campaign
 - Typically C, Ca, Fe, U
- ☐ Vacuum and in-air irradiation
- ☐ UNILAC provides micro-probe beam (1 μm precision) and single-ion mode
- ☐ Available only 1-2 months per year
- ☐ SIS18 64 hours (48 remaining)
- ☐ UNILAC 128 hours (88 remaining)



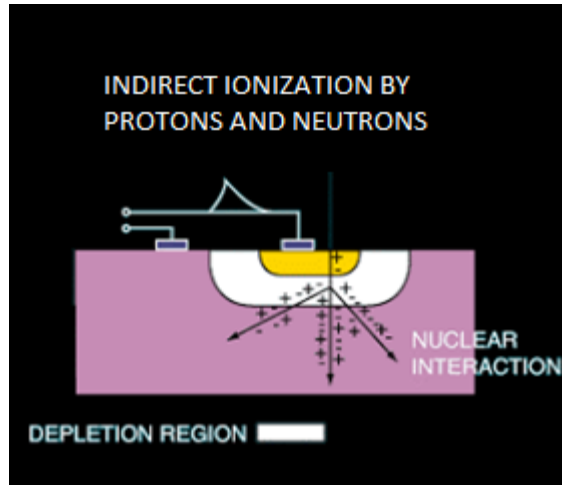
CERN CHARM and North Area

Contact: Rubén García Alía

- ❑ Synchrotron
- ❑ Only one ion per test campaign (Pb)
- ❑ Variable LET and range through acceleration tuning or degradation
- ❑ In-air irradiation
- ❑ Available only 1 month per year
- ❑ 500 hours (404 remaining)



Neutrons: wide spectrum

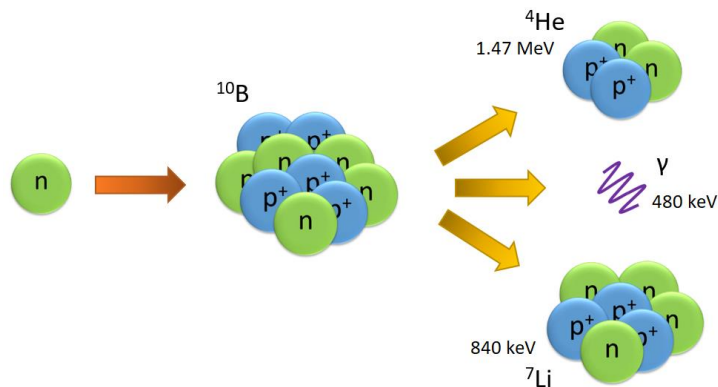


Atmospheric neutrons (>10 MeV)

- ☐ Require high-energy proton accelerators
- ☐ Important for any terrestrial application

Intermediate-energy neutrons (0.1-20 MeV)

- ☐ Do not require high-energies to be produced
- ☐ Important for nuclear fusion and CERN accelerators



Thermal neutrons (25 meV)

- ☐ Only in presence of Boron-10
- ☐ Important wherever shielding is involved

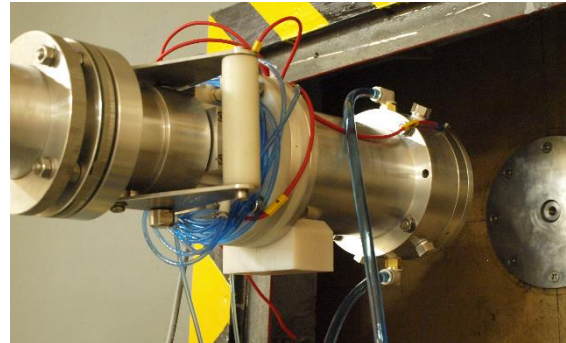
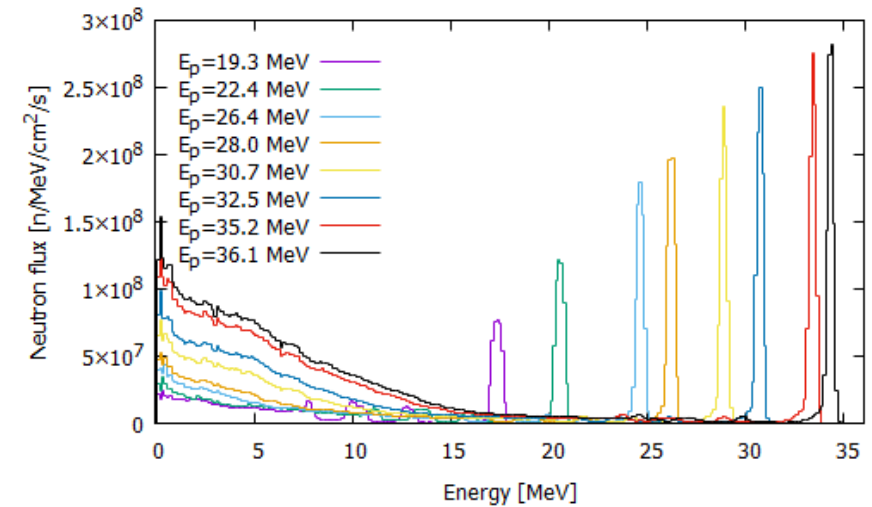
Neutrons: wide spectrum -> plenty of beam types and facilities

Institute / Organisation	Facility	Country	Beam type
Nuclear Physics Institute of the CAS	CANAM	Czech Republic	Neutrons
UKRI-STFC	Chiplr	United Kingdom	Neutrons
UKRI-STFC	EMMA	United Kingdom	Neutrons
Physikalisch-Technische Bundesanstalt (PTB)	PIAF	Germany	Neutrons
TRIUMF	TNF	Canada	Neutrons
Grand Accélérateur National d'Ions Lourds (GANIL)	SPIRAL2-NFS	France	Neutrons
Institut Laue Langevin (ILL)	TENIS	France	Neutrons
CNRS/LPSC	GENESIS	France	Neutrons
ENEA	FNG	Italy	Neutrons
Helmholtz-Zentrum Dresden-Rossendorf (HZDR)	nELBE	Germany	Neutrons (+ Gamma)

CANAM – NPI-CAS

Contact: Daniil Koliadko

- ❑ Quasi mono-energetic neutron spectrum
- ❑ Generated by interaction of protons with Li and Be targets
- ❑ Adapt to SEE and displacement damage testing (high flux)
- ❑ Available 8 months per year
- ❑ Up to 80 hours (58 remaining)



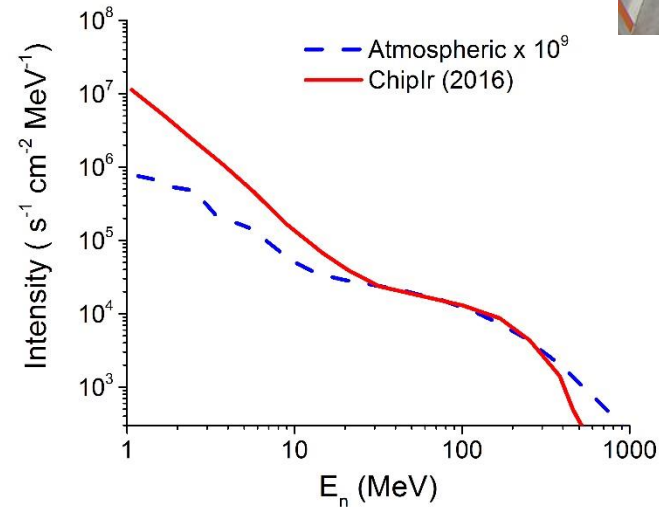
p+Be (0.5mm) neutron source
installed in front of collimator



CHIPIR - STFC

Contact: Carlo Cazzaniga

- ❑ Atmospheric neutron spectrum
- ❑ Generated by interaction of synchrotron protons with W target
- ❑ Adapt to SEE
- ❑ Available all year long
- ❑ 620 hours (368 remaining)

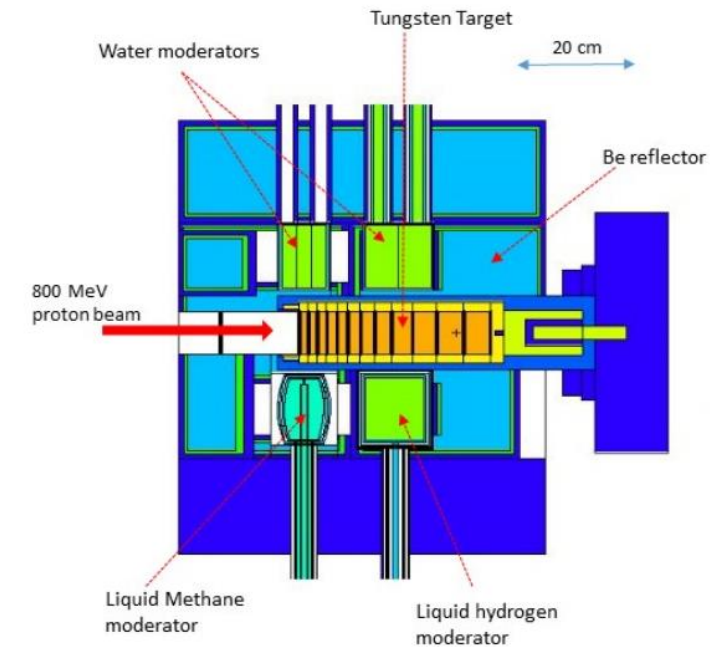
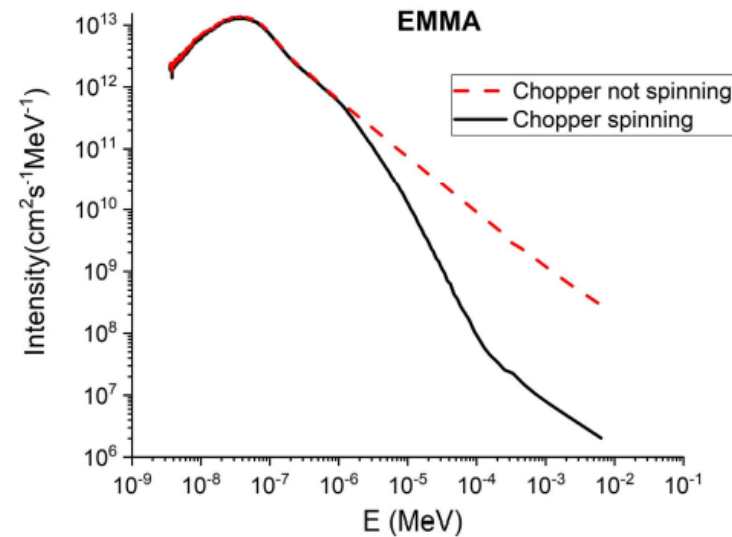


Science and
Technology
Facilities Council

EMMA - STFC

Contact: Carlo Cazzaniga

- ❑ Thermal neutron spectrum
- ❑ Generated by interaction of synchrotron protons with W target and H₂O moderators
- ❑ Adapt to SEE
- ❑ Available all year long
- ❑ 150 hours (78 remaining)



Science and
Technology
Facilities Council

PIAF - PTB

Contact: Benjamin Lutz

- ❑ Mono-energetic neutrons
- ❑ Generated by interaction of various beams with various targets
- ❑ Adapt to SEE
- ❑ Available all year long
- ❑ 175 hours (28 remaining)

Monoenergetic Neutrons

$^{45}\text{Sc} (p,n) ^{45}\text{Ti}$: 8, 27 keV

$^7\text{Li} (p,n) ^7\text{Be}$: 0.03 – 0.7 MeV

T (p,n) ^3He : 0.7 – 4 MeV

D (d,n) ^3He : 4 – 15 MeV

T (d,n) ^4He : 14 – 19 MeV

$\phi_{1\text{m}} = 2.5 \cdot 10^2 \text{ to } 1.9 \cdot 10^4 \text{ cm}^{-2}\text{s}^{-1}$

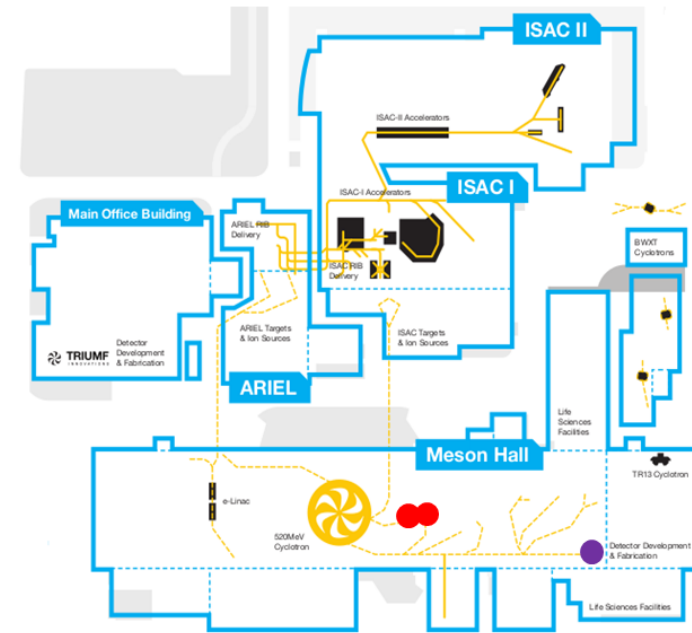
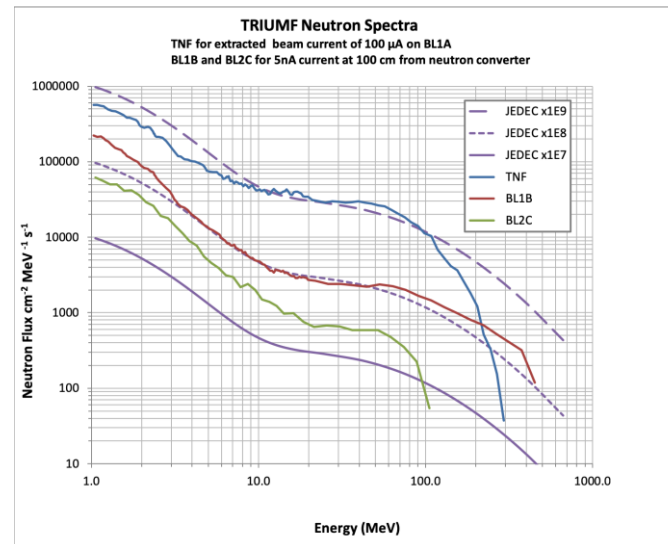
$\phi_{\text{max}} = 5 \cdot 10^5 \text{ to } 5 \cdot 10^6 \text{ cm}^{-2}\text{s}^{-1}$



TRIUMF - TNF

Contact: Camille Belanger-Champagne

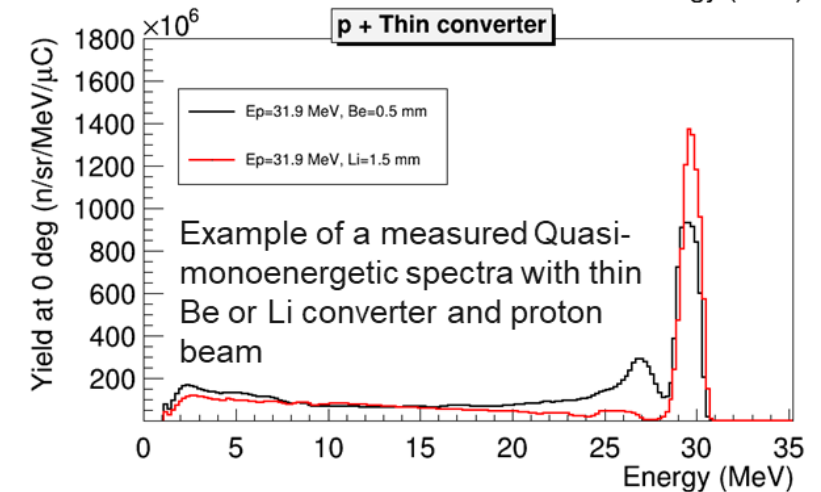
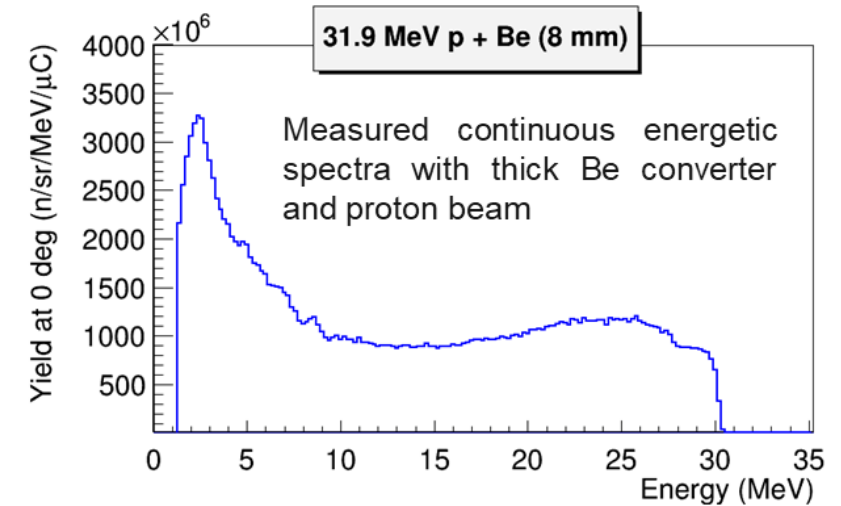
- ❑ Atmospheric neutron spectrum from a cyclotron
- ❑ Generated by proton beam with Al target
- ❑ Adapt to SEE
- ❑ Available May-December
- ❑ 92 hours (68 remaining)



NFS - GANIL

Contact: Xavier Ledoux

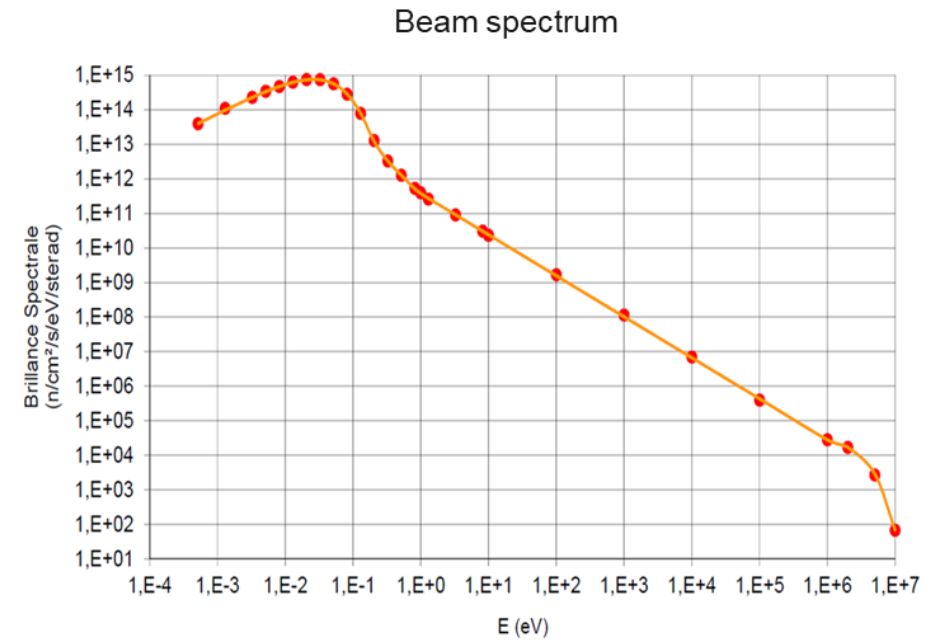
- ❑ White neutron spectrum < 40 MeV
- ❑ Quasi-mono energetic neutron beams also possible up to 31 MeV
- ❑ Produced by interaction of protons with Li and Be targets
- ❑ Facility currently under characterization
- ❑ Available October-December
- ❑ 90 hours (78 remaining)



TENIS - ILL

Contact: Manon Letiche

- ☐ Thermal neutron spectrum
- ☐ Produced by nuclear fission reactor
- ☐ Adapt to SEE
- ☐ Available 9 months per year
- ☐ 100 hours (75 remaining)

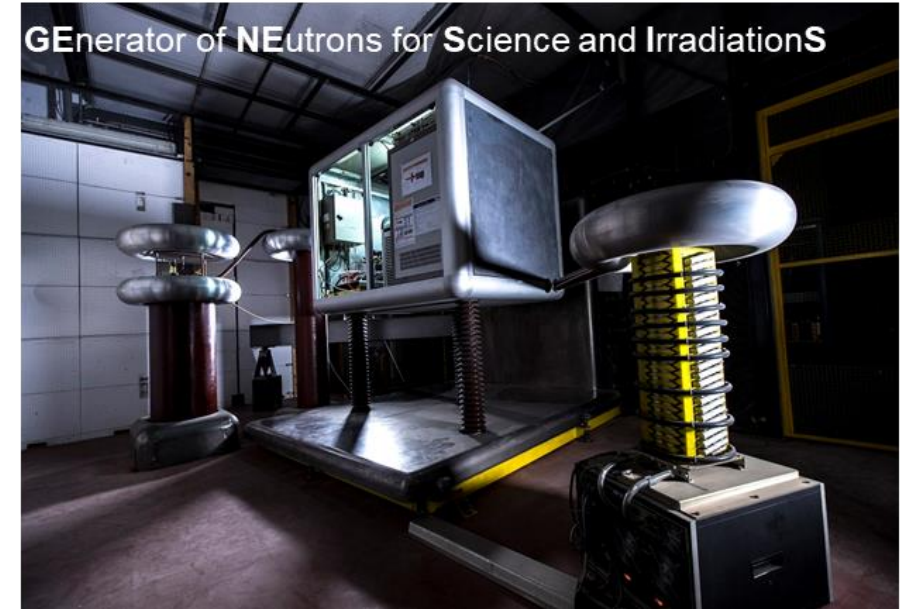


GENESIS - LPSC

Contact: Annick Billebaud

- ❑ Mono-energetic neutrons
- ❑ Produced by colliding deuteron with deuterium and tritium targets
- ❑ Adapt to SEE
- ❑ Available all year long
- ❑ 160 hours (136 remaining)

GEnerator of NEutrons for Science and IrradiationS



Energy	Max. beam current	Absolute intensity	Max Flux (at 1 cm)
14.2 MeV	150 $\mu\text{A} \pm 2\%$	$8 \times 10^9 \text{ n.s}^{-1}$	$5.10^7 \text{ n.cm}^{-2}.\text{s}^{-1}$



FNG - ENEA

Contact: Salvatore Fiore

- ❑ Mono-energetic neutrons
- ❑ Produced by colliding deuteron with deuterium and tritium targets
- ❑ Adapt to SEE
- ❑ Available all year long
- ❑ 530 hours (306 remaining)

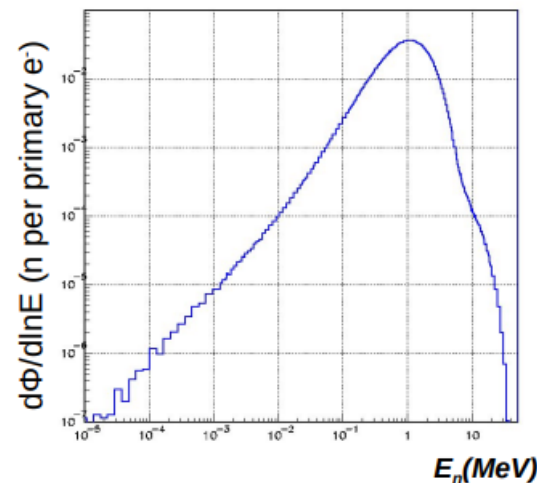
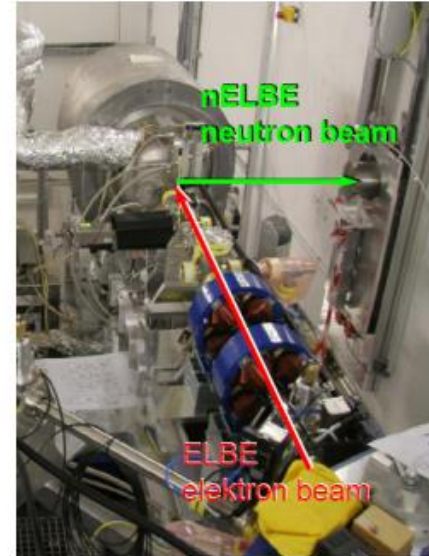


Agenzia nazionale per le nuove tecnologie,
l'energia e lo sviluppo economico sostenibile

nELBE - HZDR

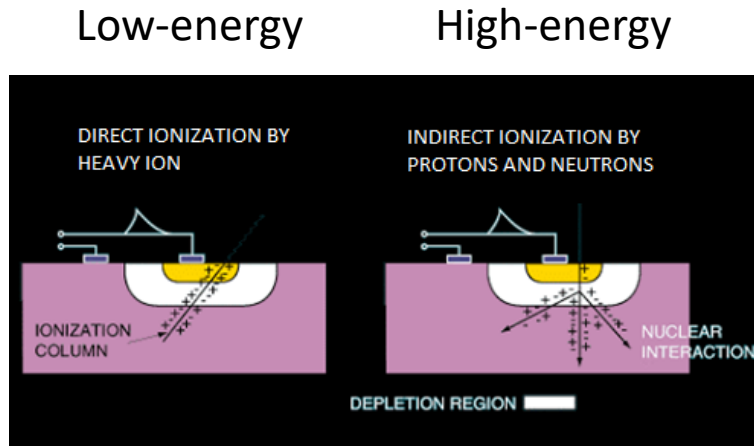
Contact: Anna Ferrari

- ❑ White neutron spectrum
- ❑ Produced by colliding electrons with liquid Pb target
- ❑ To be characterized
- ❑ Available a few months per year
- ❑ 150 hours (150 remaining)



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Protons: two-way interaction



20-200 MeV protons needed

- ❑ Space, accelerator, atmospheric

> 200 MeV needed for high-Z fission

- ❑ Still feasible with a cyclotron

Low-energy (< 20 MeV)

- ❑ Feasible with LINAC or cyclotron

- ❑ Require decapsulation

- ❑ Or use of controlled straggling techniques

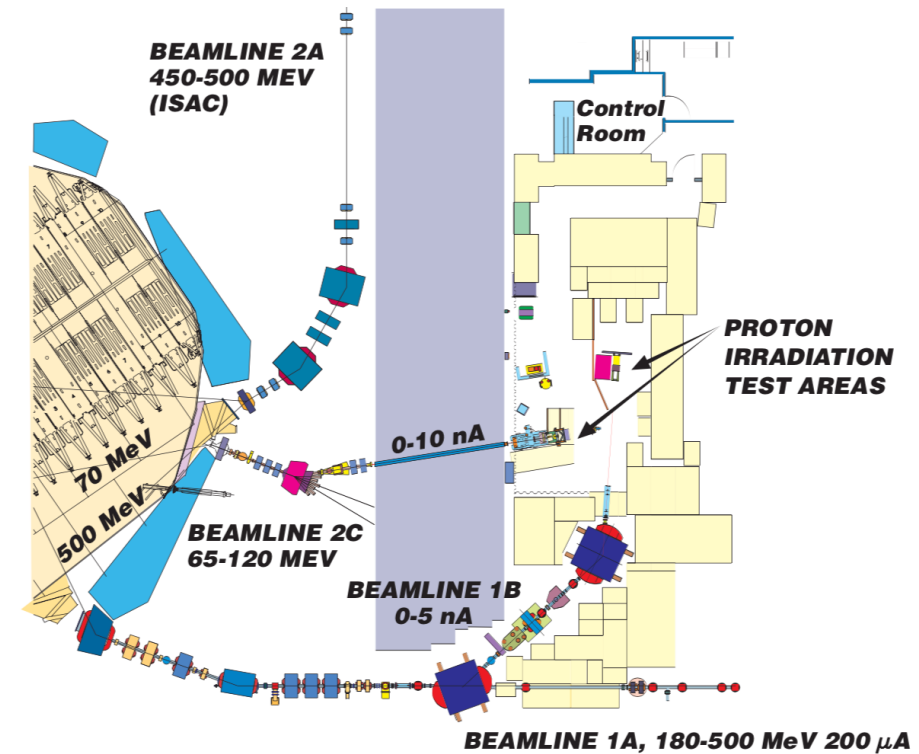
Protons: a bit ions, a bit neutrons

Institute / Organisation	Facility	Country	Beam type
TRIUMF	BL1B	Canada	Protons
University Medical Center Groningen (UMCG)	PARTREC/AGOR cyclotron	Netherlands	Protons
Centro Nacional de Aceleradores (CNA)	Tandem / Cyclotron	Spain	Protons
Paul Scherrer Institut (PSI)	PIF	Switzerland	Protons
Consorcio del Centro de Láseres Pulsados (CLPU)	VEGA	Spain	Protons (laser)
Helmholtz-Zentrum Dresden-Rossendorf (HZDR)	DRACO	Germany	Protons (laser)
Nuclear Physics Institute of the CAS	CANAM	Czech Republic	Protons

TRIUMF – BL1B

Contact: Camille Belanger-Champagne

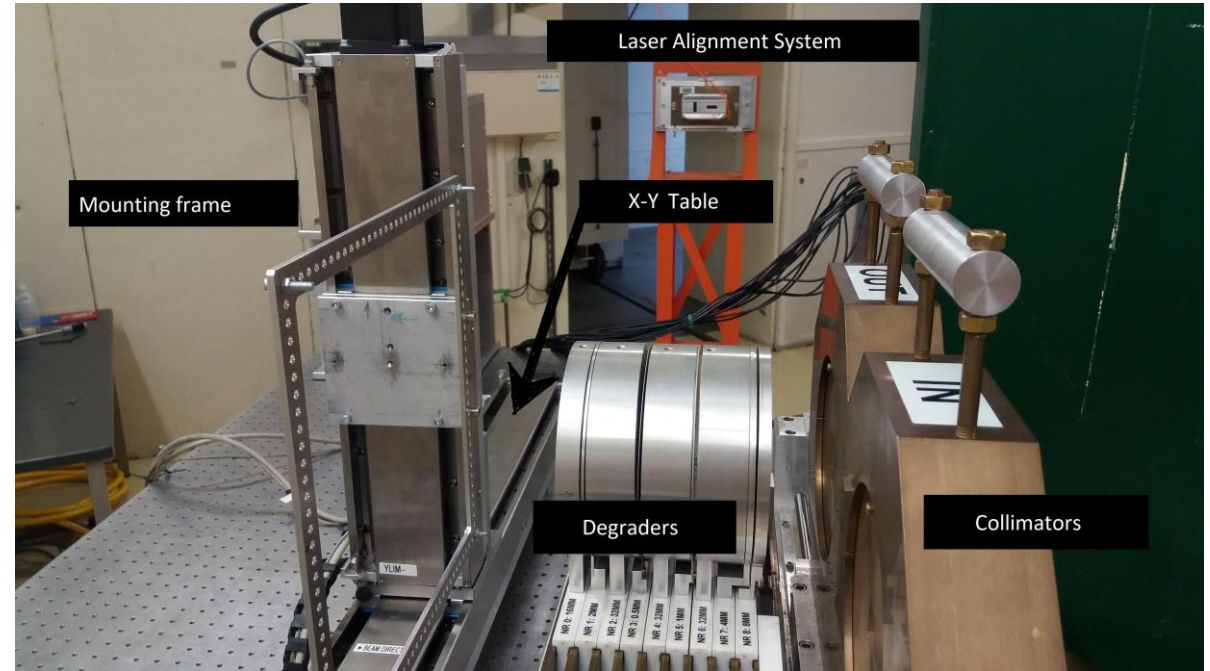
- ☐ Cyclotron
- ☐ Highest energy protons (up to 500 MeV)
- ☐ In-air irradiation
- ☐ Available May-December
- ☐ 100 hours (88 remaining)



PARTREC

Contact: Brian Jones

- ❑ Cyclotron
- ❑ 190 MeV or 66.5 MeV max
- ❑ Intermediate and lower energies through degradation
- ❑ In-air irradiation
- ❑ Available all year long
- ❑ 238 hours (102 remaining)



umcg



university of
groningen

partrec

CNA

Contact: Yolanda Morilla

☐ 3MV Tandem VdG

- 600 keV – 6 MeV
- Vacuum irradiation

☐ Cyclotron

- 10-18 MeV
- In-air irradiation

☐ Adapt to SEE and TNID

☐ Available all year long

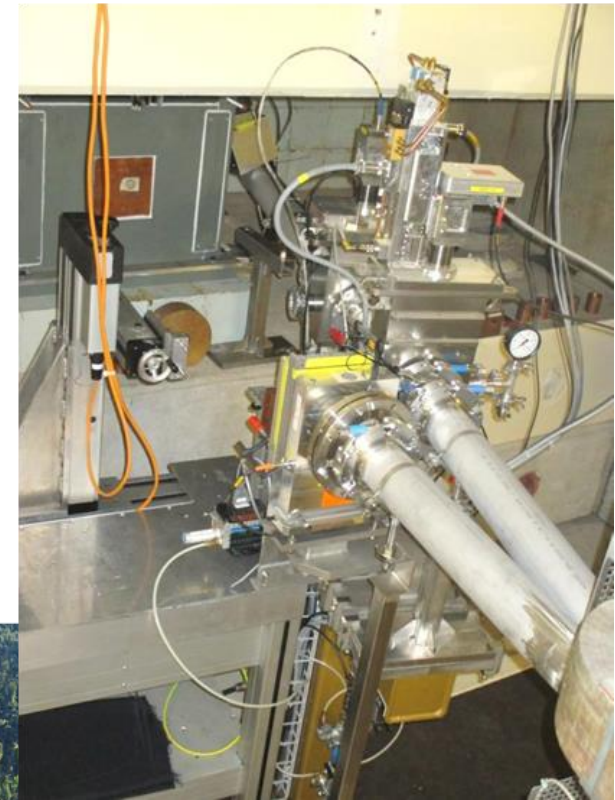
☐ 200 hours (160 remaining)



PIF - PSI

Contact: Wojciech Hajdas

- ❑ Cyclotron
- ❑ Up to 230 MeV
- ❑ Lower energies available through degradation
- ❑ Available all year long
- ❑ 130 hours (83 remaining)

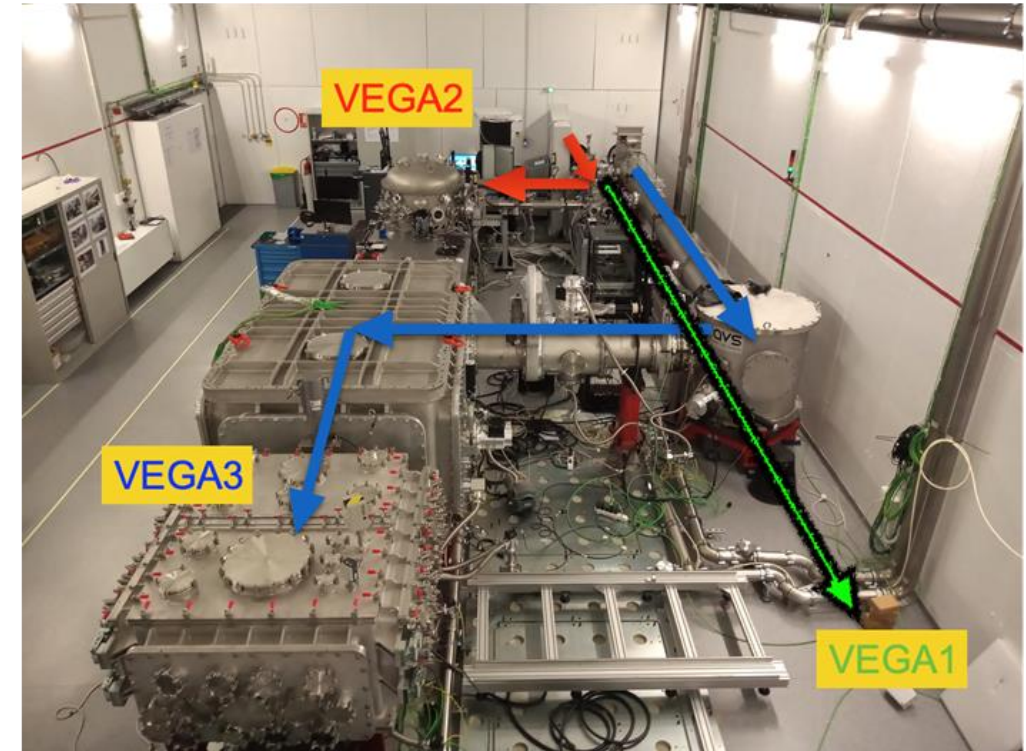


PAUL SCHERRER INSTITUT
PSI

VEGA - CLPU

Contact: Ana Santa Cruz

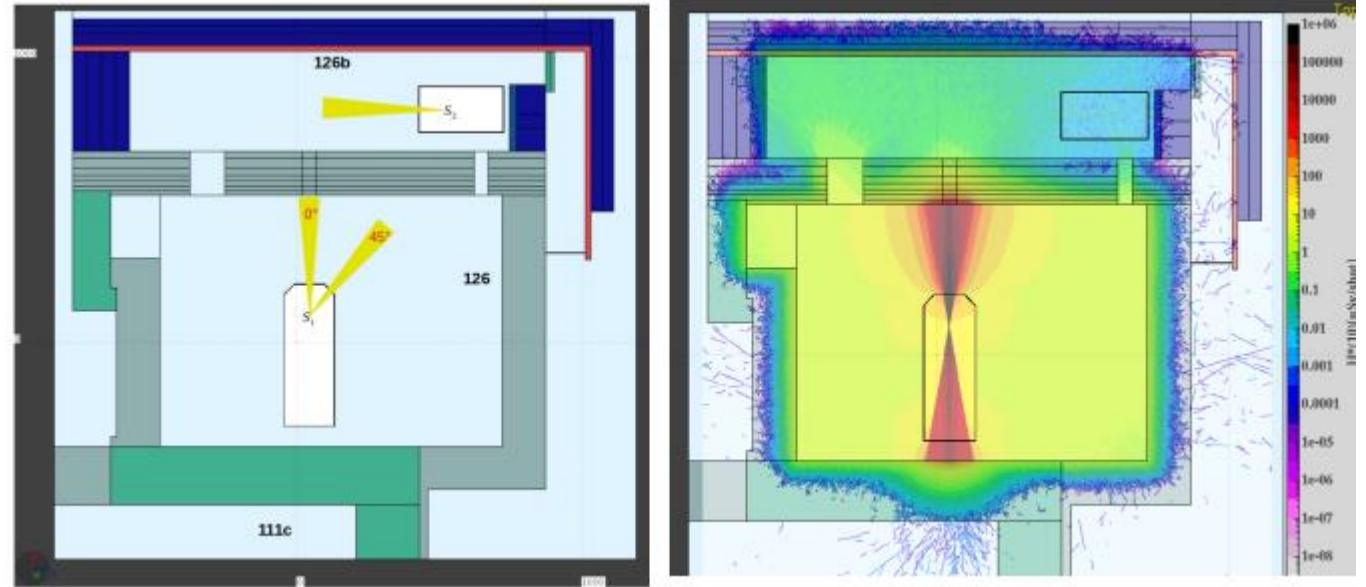
- ❑ Laser-driven acceleration
- ❑ Variable laser power and frequency
- ❑ Spectrum in the 10-20 MeV range
- ❑ To be characterized
- ❑ Available a few months per year
- ❑ 150 hours (118 remaining)



DRACO - HZDR

Contact: Anna Ferrari

- ☐ Laser-driven acceleration
- ☐ Variable laser power and frequency
- ☐ Up to 200 MeV
- ☐ To be characterized
- ☐ Available a few months per year
- ☐ 120 hours (120 remaining)



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CANAM – NPI-CAS

Contact: Daniil Koliadko

- ☐ Cyclotron
- ☐ 6-35 MeV mono-energetic
- ☐ Adapt to SEE and displacement damage testing (high flux)
- ☐ Available 8 months per year, activity just started
- ☐ Up to 80 hours (58 remaining)



*Cyclotron U120M
(under reconstruction until October 2022)*



Other beams: diversity to tackle specific needs

Mixed-field

- ❑ Needed to tackle the specific needs of artificial radiation fields like those at CERN
 - Representativeness for SEEs, but also for TID and TNID in terms of particle composition and spectra
 - Includes protons, neutrons, pions, electrons, photons, muons

Muons

- ❑ Similar behavior as low-energy protons
- ❑ Very abundant at ground level

High-energy X-rays

- ❑ Can be used to replicate ionization track of ions

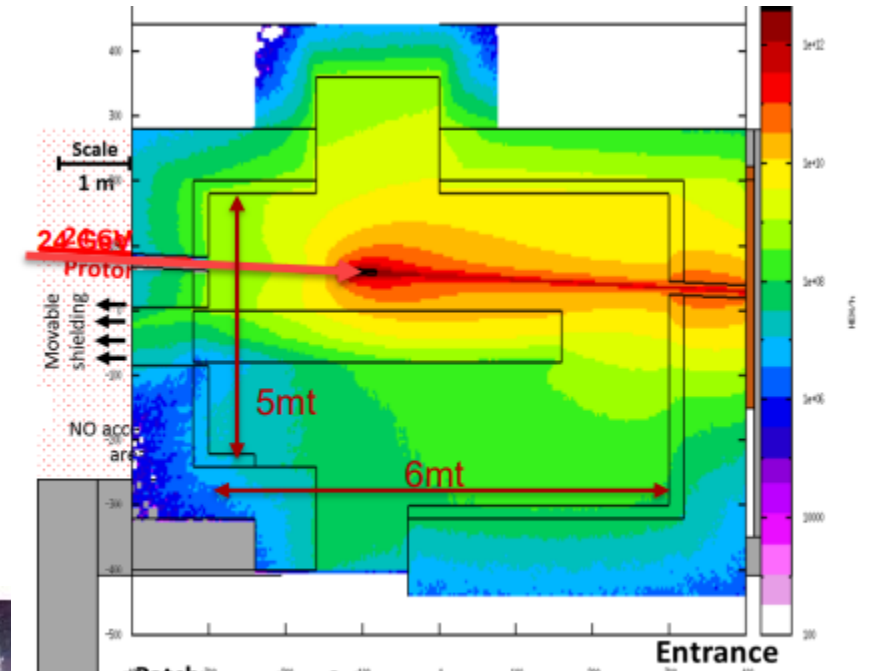
Other beams: diversity to tackle specific needs

Institute / Organisation	Facility	Country	Beam type
CERN	CHARM	Switzerland	Mixed Field
UKRI-STFC	RIKEN-RAL	United Kingdom	Muons
European Synchrotron Radiation Facility (ESRF)	ESRF	France	X-rays (synchrotron)
Helmholtz-Zentrum Dresden-Rossendorf (HZDR)	eELBE	Germany	Electrons
Helmholtz-Zentrum Dresden-Rossendorf (HZDR)	gELBE	Germany	Gamma

CERN CHARM

Contact: Salvatore Danzeca

- ☐ Synchrotron
- ☐ Mixed-field (p , n , π , K , e , μ , γ) produced by protons colliding on a Cu target
- ☐ In-air irradiation
- ☐ One week irradiation
- ☐ Largest beam uniformity
- ☐ Available April-October
- ☐ 800 hours (240 remaining)



RIKEN-RAL - STFC

Contact: Carlo Cazzaniga

- ❑ Mono-energetic muons up to 30 MeV
- ❑ Generated by interaction of synchrotron protons with W target
- ❑ Adapt to SEE
- ❑ Available all year long
- ❑ 140 hours (70 remaining)

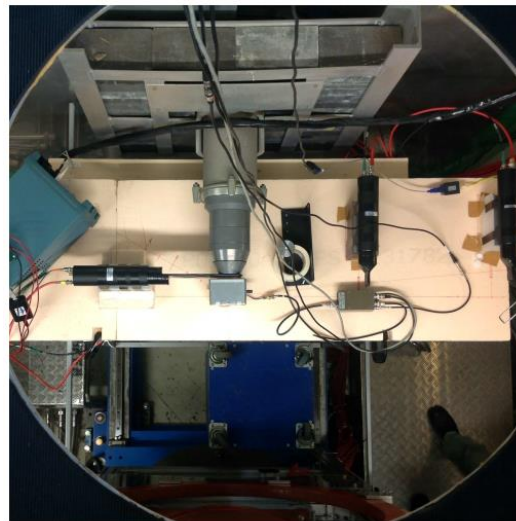


Figure 1: RIKEN-RAL Port4 dosimetry system. Two detectors used for positron counting are located to right of beam exit. The scintillator sits between the exit window and enclosed surface barrier detector.



Science and
Technology
Facilities Council

Contact: Ennio Capria

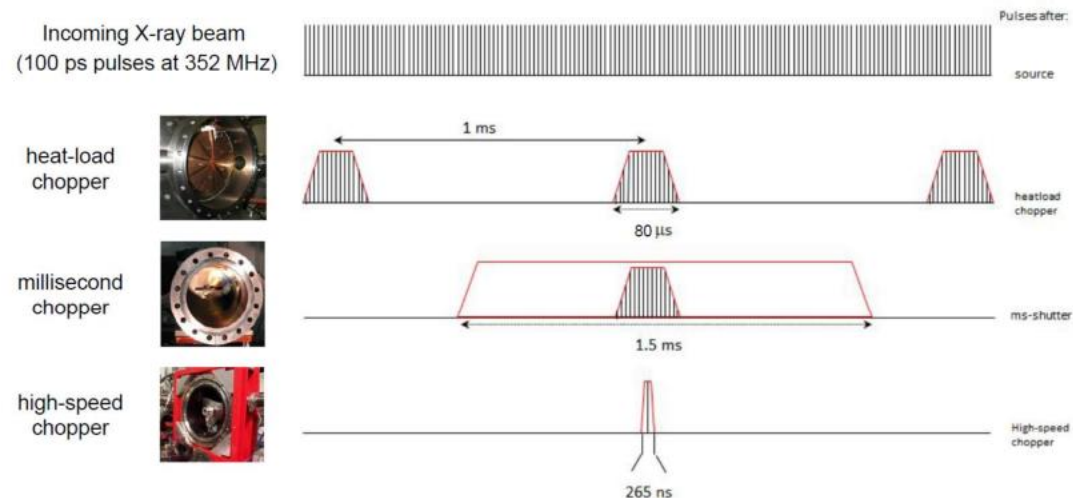
☐ Synchrotron

☐ High-energy X-rays to simulate heavy ion strikes

☐ Available all year long

☐ Requires a second proposal to be submitted directly to the local PAC

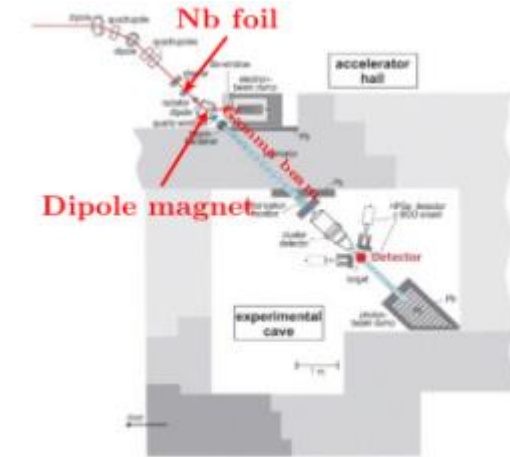
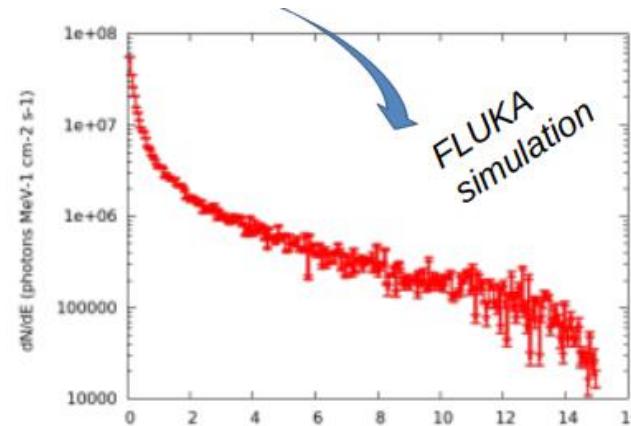
☐ 288 hours (216 remaining)



gELBE - HZDR

Contact: Anna Ferrari

- ☐ Photon spectrum
- ☐ Produced with a 15 MeV electron beam interacting with a Nb target
- ☐ To be characterized
- ☐ Available a few months per year
- ☐ 80 hours (8 remaining)



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Getting involved

Ways to get involved

- ❑ As a **beam time user**: just prepare and submit your proposal!
- ❑ As a **project supporter**: contact us and we will provide you a support letter template
- ❑ As a **project partner**: let us know how you think you/your research group or company can contribute to RADNEXT, and if considered relevant, we can prepare the related application to be evaluated by the RADNEXT Project Consortium Board
 - Note: no further budget is available for extra RADNEXT partners, hence any additional involvement needs to be through in-kind contributions (still, all partners are considered equally in the project in terms of proposing ideas, taking decisions, etc.)

SERESSA 2022

5th to 9th of December at CERN, Geneva



The RADNEXT irradiation facility network

Andrea Coronetti, CERN, UM on behalf of the RADNEXT network



Reasons why 'yes'

- ❑ *Need to demonstrate reliability of operation under radiation*
- ❑ *Continuous evolution of technology*
 - ❑ *Ex. Below the 90 nm node the SEL mechanism disappeared, but reappeared at < 20 nm*
- ❑ *Sensitivity phase space changing*
 - ❑ *Ex. Traditionally SEEs induced by ions, then high-energy protons (below 500 nm), now low-energy protons (below 90 nm)*
- ❑ *Models often needs experimental data as a starter*
 - ❑ *Ex. Critical charge, sensitive volume unknown*
- ❑ *Every device is (almost) unique*
 - ❑ *Ex. Part-to-part variability and traceability, data portability*
- ❑ *Data available is often outdated or partial*
 - ❑ *Ex. Unspecified bias, temperature, stimuli in test report*
- ❑ *We live in a competitive world*
 - ❑ *Proprietary data*
 - ❑ *There are plenty of things that the manufacturer won't tell you*