Coordinating the future challenging user needs and improvements of test beam and irradiation facility infrastructures at CERN

Pierre Pelissou (CERN – EP department), Eva Barbara Holzer, Federico Ravotti, Martin Schwinzerl, Martin Jaekel (CERN – EP department)

BTTB workshop - 15th April 2024

Agenda

1. **Introduction: a reminder of the test beam and irradiation facilities at CERN**
    A. CERN irradiation and test beam facilities
2. **Focus on the CERN test beam facilities**
    A. Test beam facilities team members
    B. Test beam facilities highlights of 2023
    C. Software Tool for Managing User Schedules Updates
3. **Focus on the CERN irradiation facilities**
    A. Irradiation facilities team members
    B. IRRAD and CHARM outlooks and activities in 2023
    C. Introduction to heavy ions activities
    D. GIF++ outlooks and activities in 2023
    E. Current R&D projects
    F. EUROLABS project summary

1. Introduction: a reminder of the test beam and irradiation facilities at CERN

A. CERN test beam and irradiation facilities

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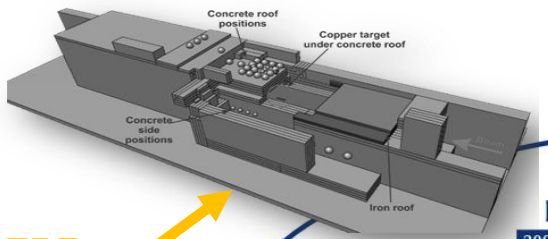
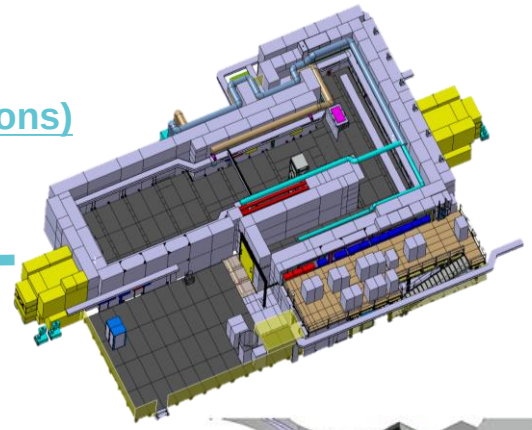
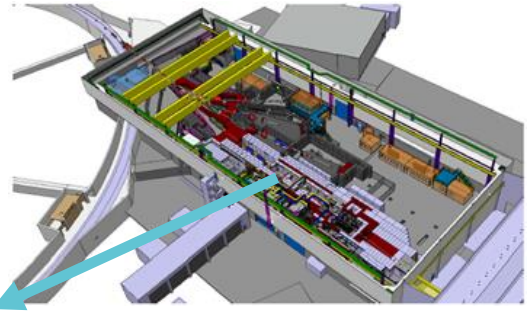


CERF (mixed field)



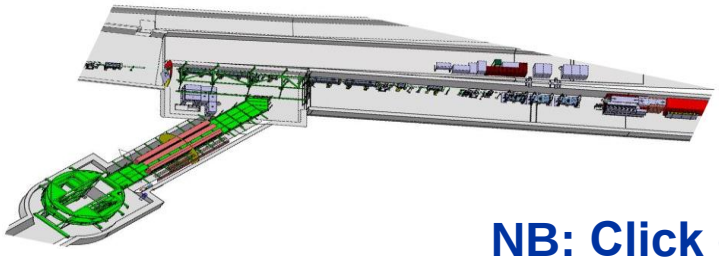
GIF++ (gamma & muons)



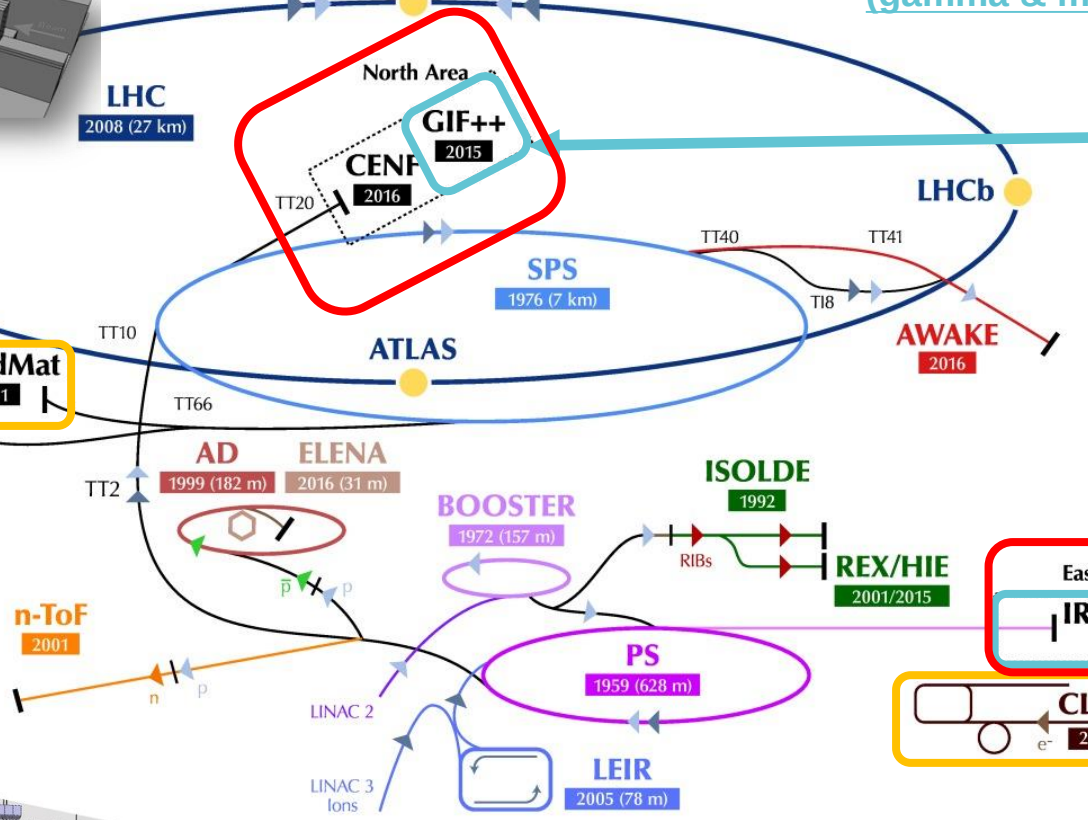
IRRAD (protons)

CHARM (mixed field)

HiRadMat (protons and ions beams)



CLEAR (electron beam)



NB: Click on each facilities' name to access their official websites

2. Focus on the CERN test beam facilities

A. Test beam facilities team members
B. Test beam facilities highlights of 2023
C. Software Tool for Managing User Schedules Updates

A. Test beam facilities team members

Eva Barbara Holzer

- PS/SPS Physics coordinator

Martin Jaekel

- Deputy of the PS/SPS Physics coordinator

Tetiana Shulha

- Administrative User Support for the PS/SPS Physics coordination
- EURO-LABS TA Support

Martin Schwinzerl

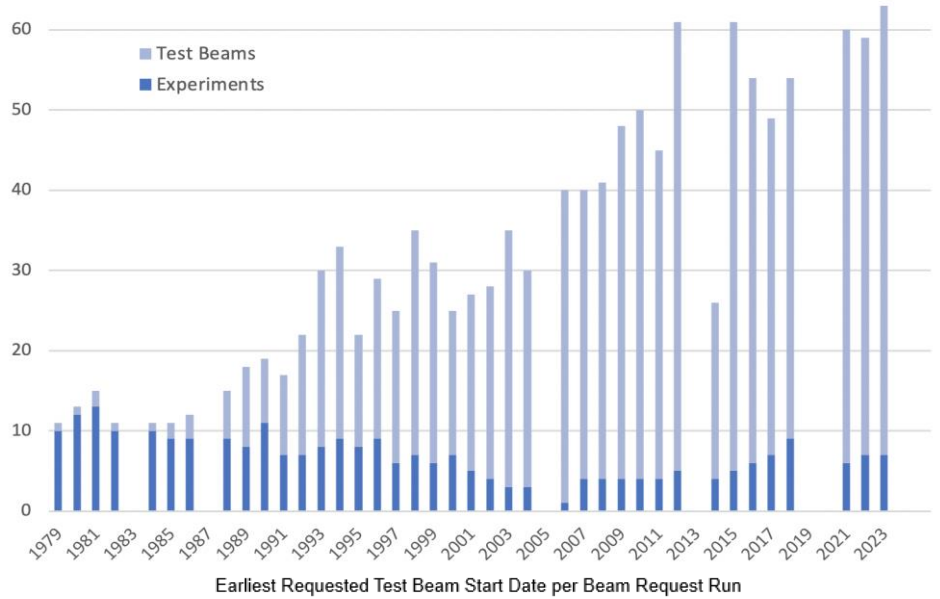
- Technical Support for the PS/SPS Physics coordination
- Software developer

B. Test beam facilities in 2024

➢ Call launched in 12/2023 for beam requests in 2024

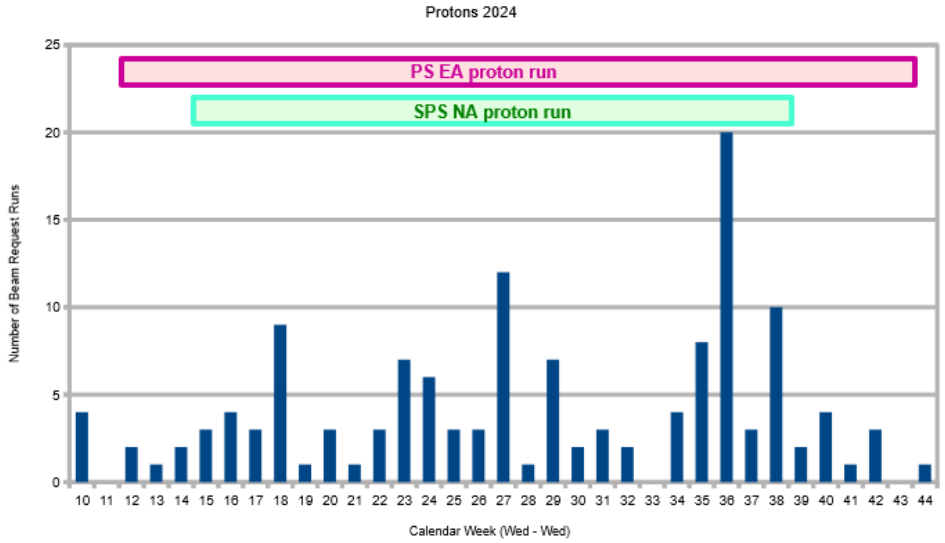
- Very high interest – **105 beam requests received**

2024	Number of weeks requested (main)		Weeks available	Number of weeks requested including parasitic tests	
PS T9 & T10	81.5	**132%**	62	32.5	**144%**
SPS H2, H4	66	**138%**	48	76	**158%**
SPS H6, H8	83	**173%**	48	155	**323%**



➢ Scheduling difficulty:

- High priority activities (project milestones, LS3)
- Hardware readiness and external constraints => demand for beam not uniform over the year



➢ Extension of the beam period by 5 weeks in 2024 approved

- Revision of schedule currently in progress => very challenging as test beam period has already started

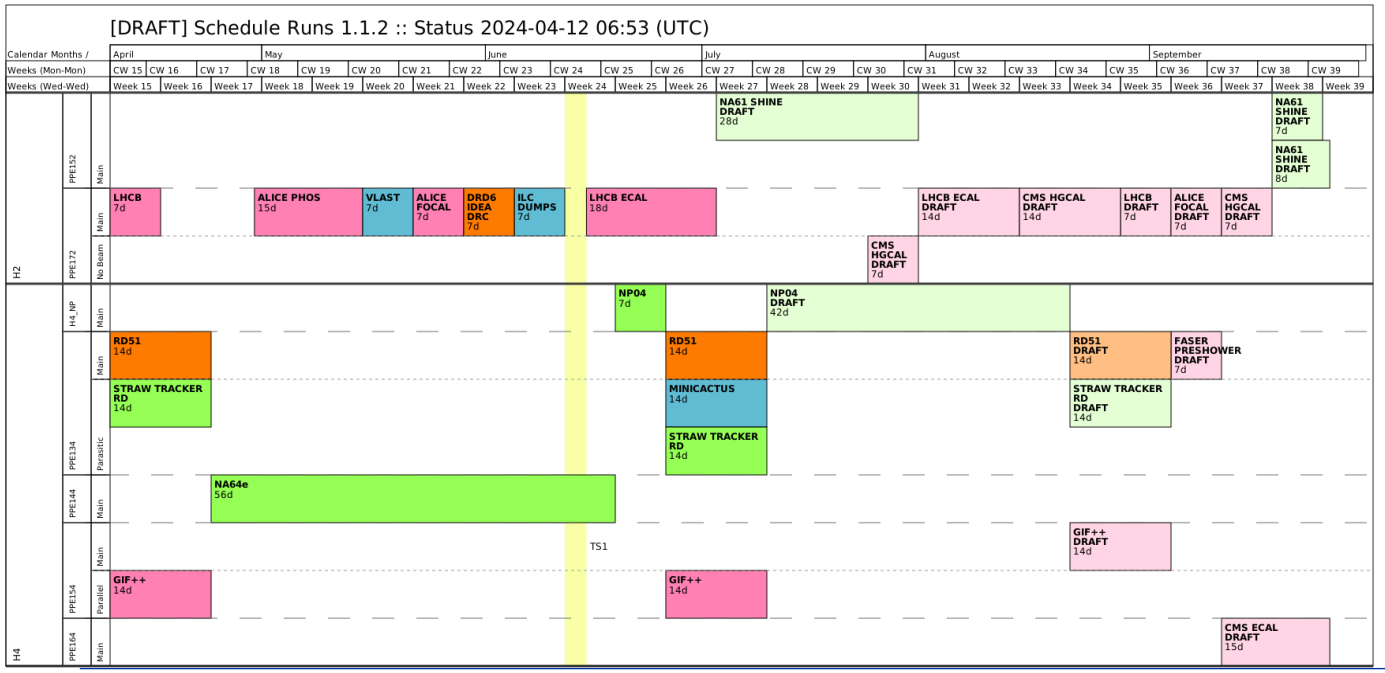
C. Software Tool for Managing User Schedules Updates

➢ Crucial to handle challenging situation for 2024

This project has received funding from the European Union's Horizon Europe Research and Innovation programme under Grant Agreement No 101057511.

➢ Scope & role of https://ps-sps-users.web.cern.ch:

- Collecting beam requests / automation of change requests
- Creation and maintenance of user schedules
- Managing and verification of constraints



Schedule Run "Run No. 2 for Activity "GIF++" and Beam Request (id: 1) ..." (Id: 5)

There are 3 Constraints available.

Check All Constraints

Actions	Id	Type	Relation	Other	Justification
X Ed	True	506	Location constraint	SPS[NA] / H4 / PPE154 (H4C)	Beam Request
X Ed	True	507	Usage	Main or parallel usage	Beam Request
X Ed	True	508	Duration	2 Week(s)	Beam Request

Test: Connection with runs of another activity [ScheduleRun]

Run Id	Activity	Begin Week	Begin	End	Run Duration	Run Usage	Run Location	Constr Type	Constraint					Check?	Fail?
9	ALICE ITS3	12	2024-03-22	2024-03-27	5 Days(s)	Main user	PS[EA]_T10	Time overlap constraint	should be scheduled	at the same time (i.e., concurrently)	runs from activity	[ALICE_FOCAL] ALICE FoCal		True	True
10	ALICE ITS3	19	2024-05-08	2024-05-15	1 Week(s)	Main user	PS[EA]_T10	Time overlap constraint	should be scheduled	at the same time (i.e., concurrently)	runs from activity	[ALICE_FOCAL] ALICE FoCal		True	True
11	ALICE ITS3	23	2024-06-05	2024-06-12	1 Week(s)	Main user	PS[EA]_T10	Time overlap constraint	should be scheduled	at the same time (i.e., concurrently)	runs from activity	[ALICE_FOCAL] ALICE FoCal		True	True
12	ALICE ITS3	31	2024-07-31	2024-08-07	1 Week(s)	Main user	PS[EA]_T10	Time overlap constraint	should be scheduled	at the same time (i.e., concurrently)	runs from activity	[ALICE_FOCAL] ALICE FoCal		True	True
13	ALICE ITS3	34	2024-08-21	2024-08-28	1 Week(s)	Main user	PS[EA]_T10	Time overlap constraint	should be scheduled	at the same time (i.e., concurrently)	runs from activity	[ALICE_FOCAL] ALICE FoCal		True	True
14	ALICE ITS3	37	2024-09-11	2024-09-18	1 Week(s)	Main user	PS[EA]_T10	Time overlap constraint	should be scheduled	at the same time (i.e., concurrently)	runs from activity	[ALICE_FOCAL] ALICE FoCal		True	False
15	ALICE ITS3	43	2024-10-23	2024-10-28	5 Days(s)	Main user	PS[EA]_T10	Time overlap constraint	should be scheduled	at the same time (i.e., concurrently)	runs from activity	[ALICE_FOCAL] ALICE FoCal		True	False

3. Focus on the CERN irradiation facilities

A. Irradiation facilities team members
B. IRRAD and CHARM outlooks and activities in 2023
C. Introduction to heavy ions activities in the East Area
D. GIF++ outlooks and activities in 2023
E. Current R&D projects
F. EUROLABS project summary

A. Irradiation facilities team members

Federico Ravotti

- EP-DT Facilities Team Responsible, IRRAD Facility Coordinator
- Irradiation Facilities EXSO

Pierre Pelissou - FELL

- Facilities R&D
- Engineering development
- RADNEXT EU-Project

Paolo Martinengo

- GIF^{++} Physics Coordinator

Martin Jaekel

- Responsible for the GIF++ facility upgrade

Jaroslaw Szumega – DOCT

- Machine Learning R&D
- Software development
- RADNEXT EU-Project

Giuseppe Pezzullo

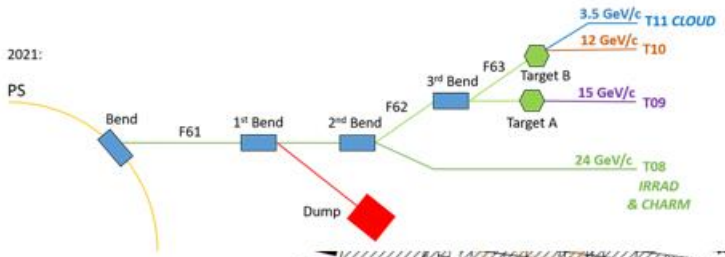
- GIF++ & IRRAD: users' supervisor
- First level expert and contact to CERN infrastructure teams
- Deputy EXSO

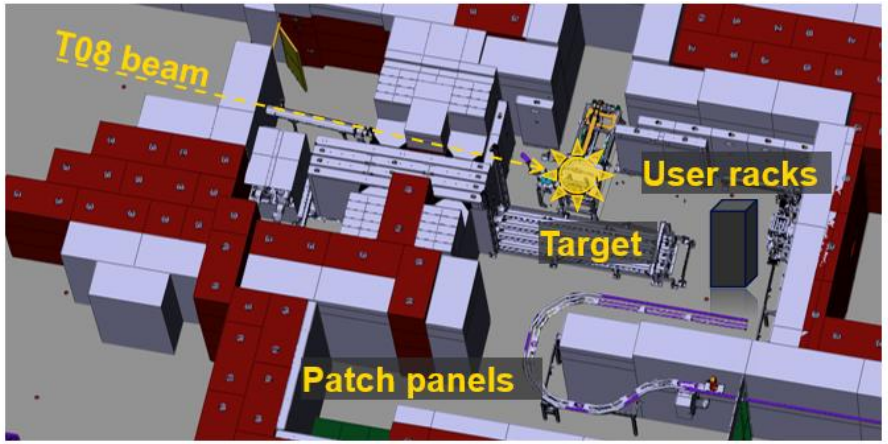
Blerina Gkotse – USER (Madison University)

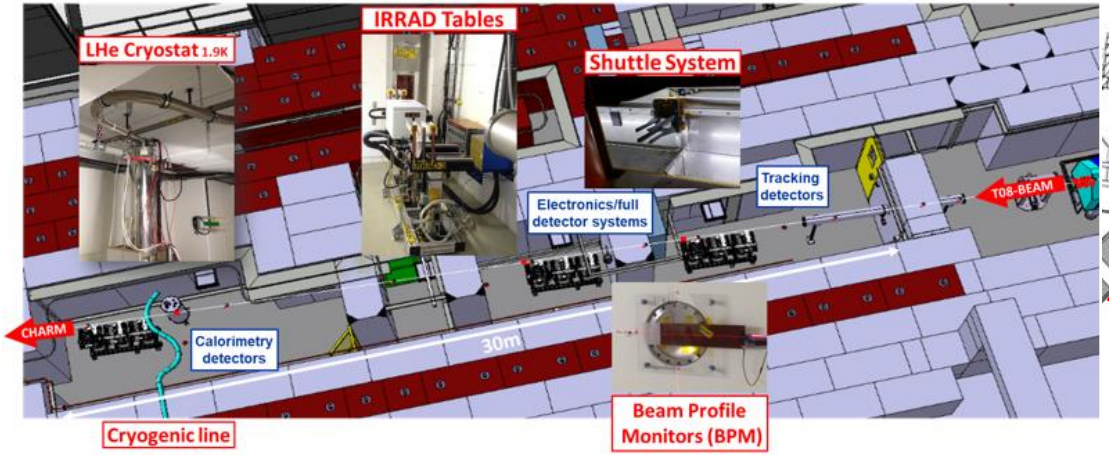
- Remote support to IT infrastructure: Controls, DAQ, Data Management

B. IRRAD and CHARM outlooks and activities in 2023

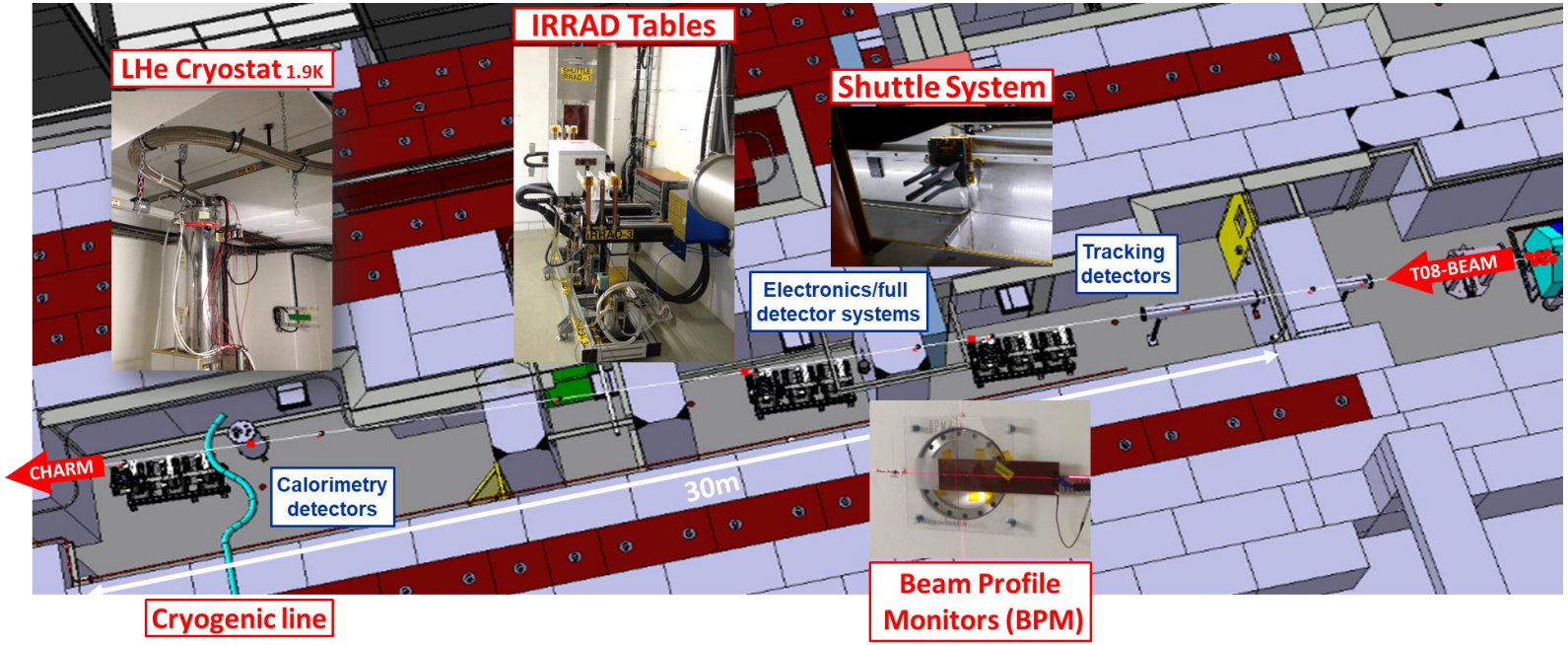
EAST AREA







Focus on IRRAD – managed by EP-DT-DD at CERN



Beam parameters

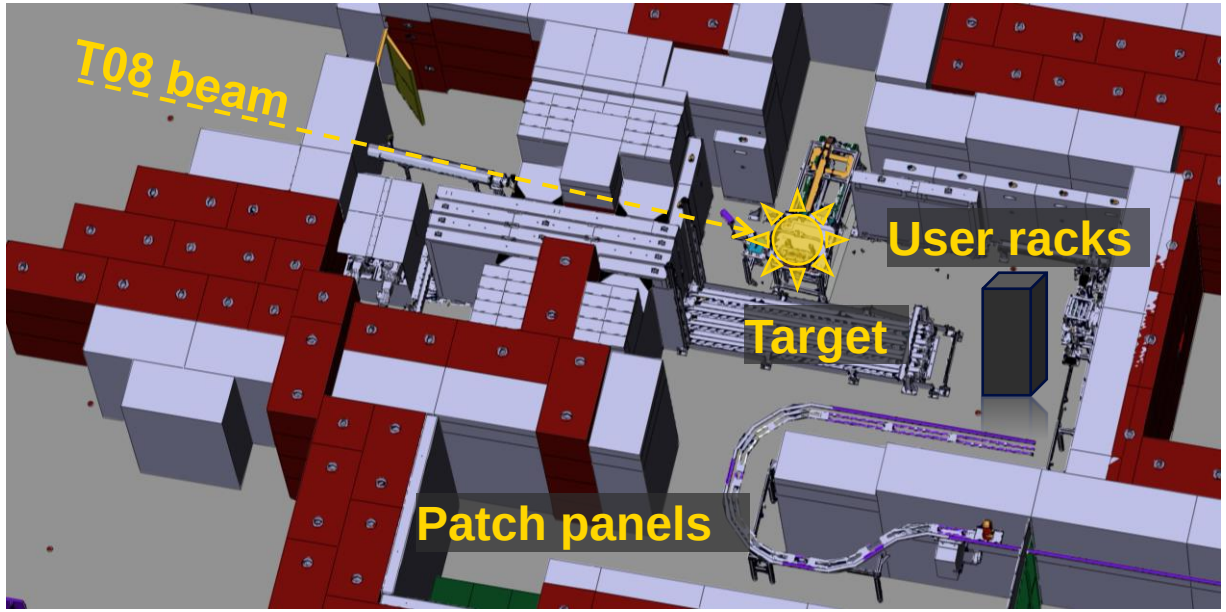
- Momentum: 24 GeV/c
- **Extracted intensity: $8*10^{11}$ p/spill**
- Spot size: ~12x12 mm^2 (FWHM)
- Spills of ~400 ms every ~10 s
- **Fluence: ~> 10^{17} p/cm^2 per year**

Equipment for users

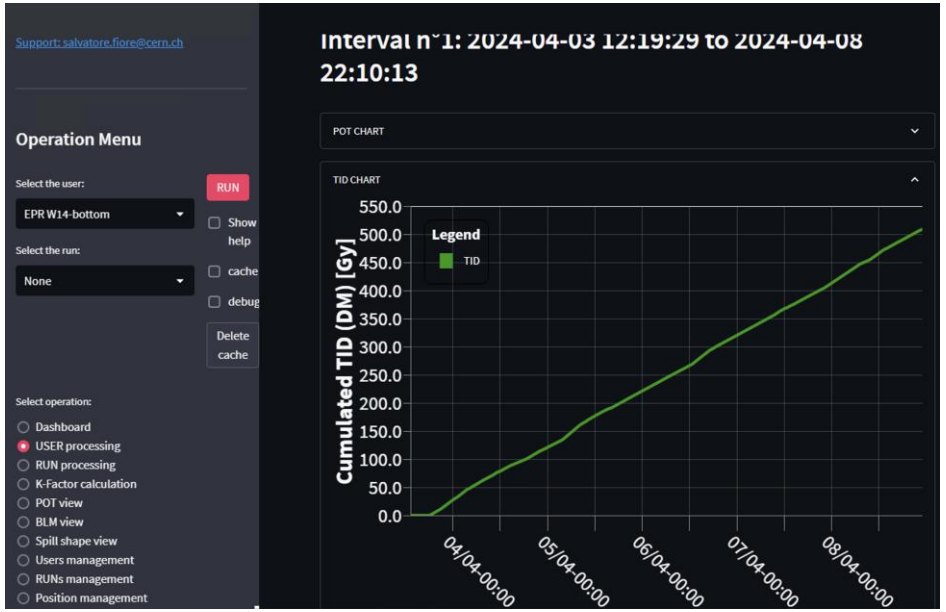
- Patch panels
- Beam monitoring (BPMs) and dosimetry infrastructure (HP-Ge gamma spectrometers)
- Dedicated post-irradiation storage areas, handling and characterization tools (see here)

Focus on CHARM managed by BE-CEM-EPR at CERN

CHARM irradiation facility



Online dosimetry for users



Equipment for users

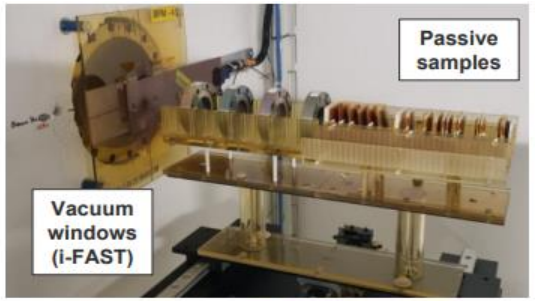
- User setup hosted in standard 21” rack, moved in irradiation position by robotic conveyor
- Full mock-up of user-provided cabling and connection in preparation room, for preparatory dry run
- Individual, time-wise dosimetry provided to each user in real time

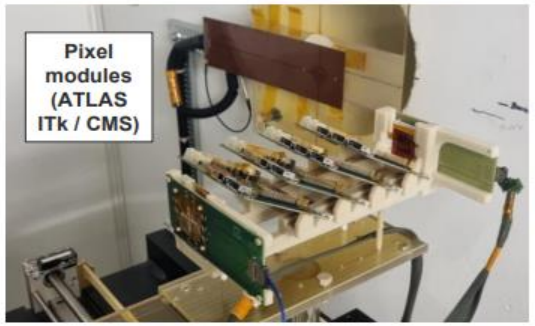
Courtesy of S. Fiore (CERN)

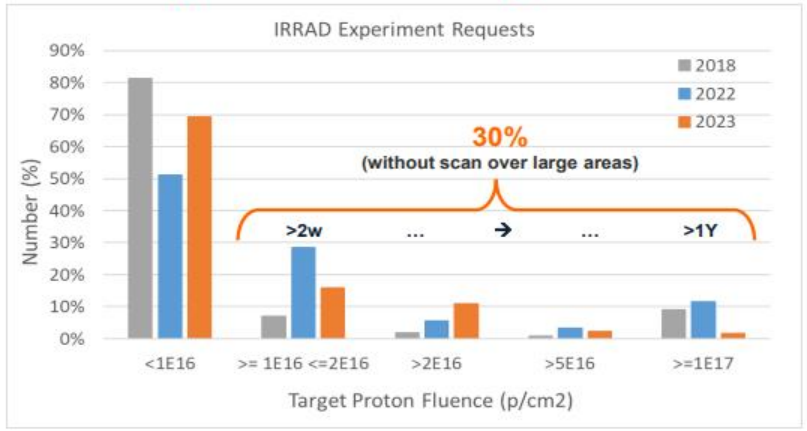
B. IRRAD and CHARM outlooks and activities in 2023

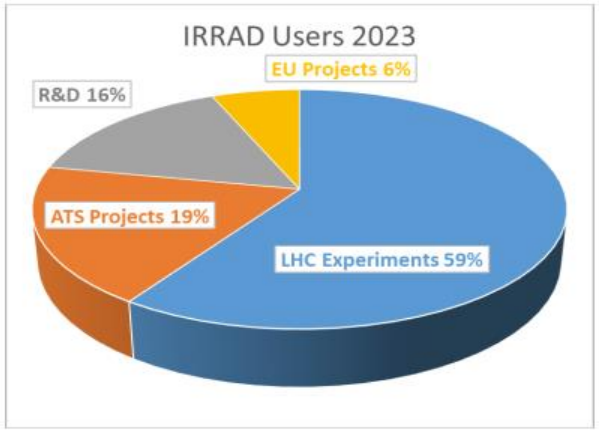
IRRAD in 2023

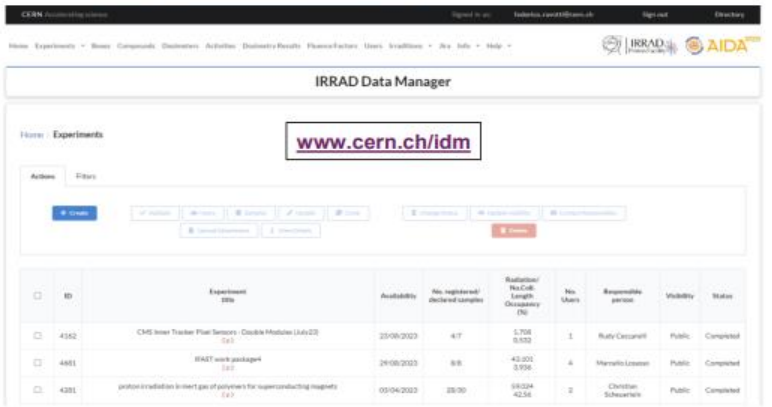
- **39 experiments registered:**
  - Room temperature, cold-boxes (-25ºC), cryogenic (4.2K), **scanning over large surfaces**, on-line monitoring, etc.
- **406 samples processed** (417 registered):
  - **LHC Experiments : ATLAS** (ITk Pixel, ITk RH/T, ITk Strips & HGTD), **CMS** (IT Pixel & BRIL), **LHCb** (PicoCal & ECAL)
  - **R&D & Expt. Support: RD53, RD50, EP-ESE, EP-DT**
  - **ATS Projects: TE-MSC, SY-BI**
  - **EU-projects: i-FAST** WP4, **AIDAinnova** WP4
- **~30% requests exceed 10^{16} p/cm^2**







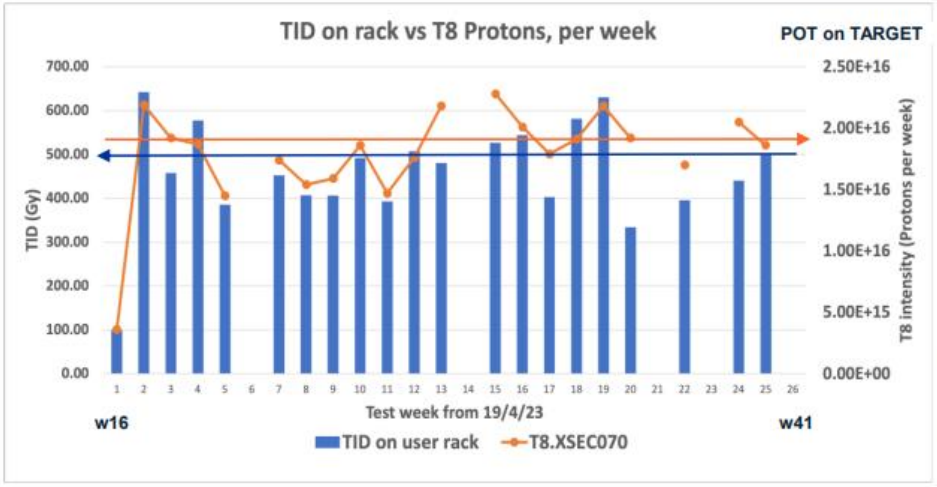




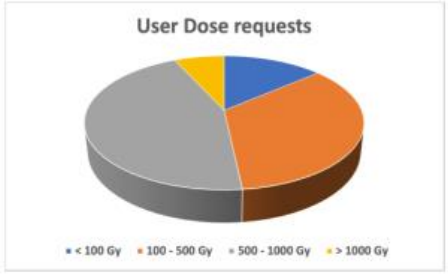
B. IRRAD and CHARM outlooks and activities in 2023

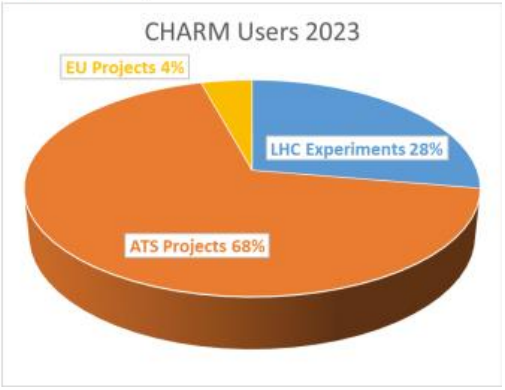
CHARM in 2023

- 47 radiation tests executed:
- 37 system-level & 10 component tests:
  - 32 ATS: SY-BI, SY-EPC, SY-STI, TE-MPE, TE-VSC, BE-CEM
  - 13 RCS: EP-DT, CMS, ATLAS, Caen, Wiener
  - 2 EU-projects: RADNEXT
- 2023 slots: 25 for protons (+2 for CHIMERA)
- 60% of the users require ≥500Gy (e.g. 2 slots in R13)
- All slot reserved in 2023! At least 1 user/slot



SYSTEM-LEVEL TESTS IN CHARM





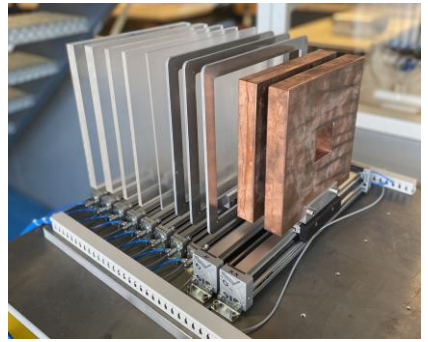
- TID on rack is compared with T8 p/w on TARGET: **TID variation mainly due to T8 proton yield**
- TID and Proton target values marked on the plot: **missing slots have special settings for beam/rack**

C. Introduction to heavy ions activities in the East Area

Main objective: study of radiation hardness assurance of electronics (**HEARTS project**)

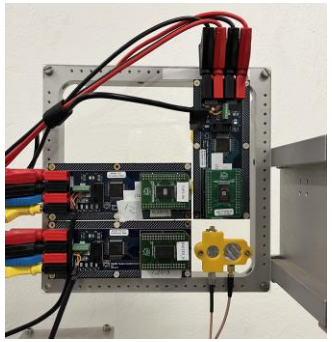
- **Pb ions are transferred to CHARM/IRRAD for single event effect testing (SEE testing)**

- **Electronics testing requirements:**
  - Broad Linear Energy Transfer (LET) range by variable energy extraction (**650 MeV/n - 3 GeV/n**) + passive energy degradation using LET booster: **10 - 100 MeVcm^2/mg**
  - Particle range **within silicon material > 1mm**
  - Large, homogeneous beam for board/system level testing
  - Low beam flux (to ensure single events): **10^2 - 10^5 ions/cm^2/s**



LET booster

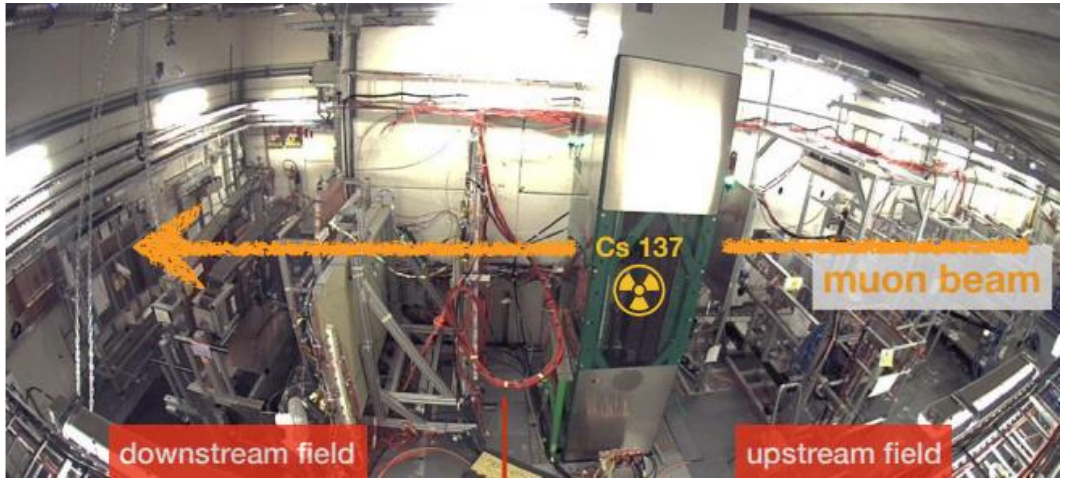
- **Ongoing challenges:**
  - Move from current test location in **CHARM** to **IRRAD**, improving beam quality/accessibility
  - Accommodate external users for **the 2.5-week test campaign** in November 2024
  - Explore feasibility of a separate dedicated beam line and use of lighter ions to reach **LETs lower than 10 MeVcm^2/mg**

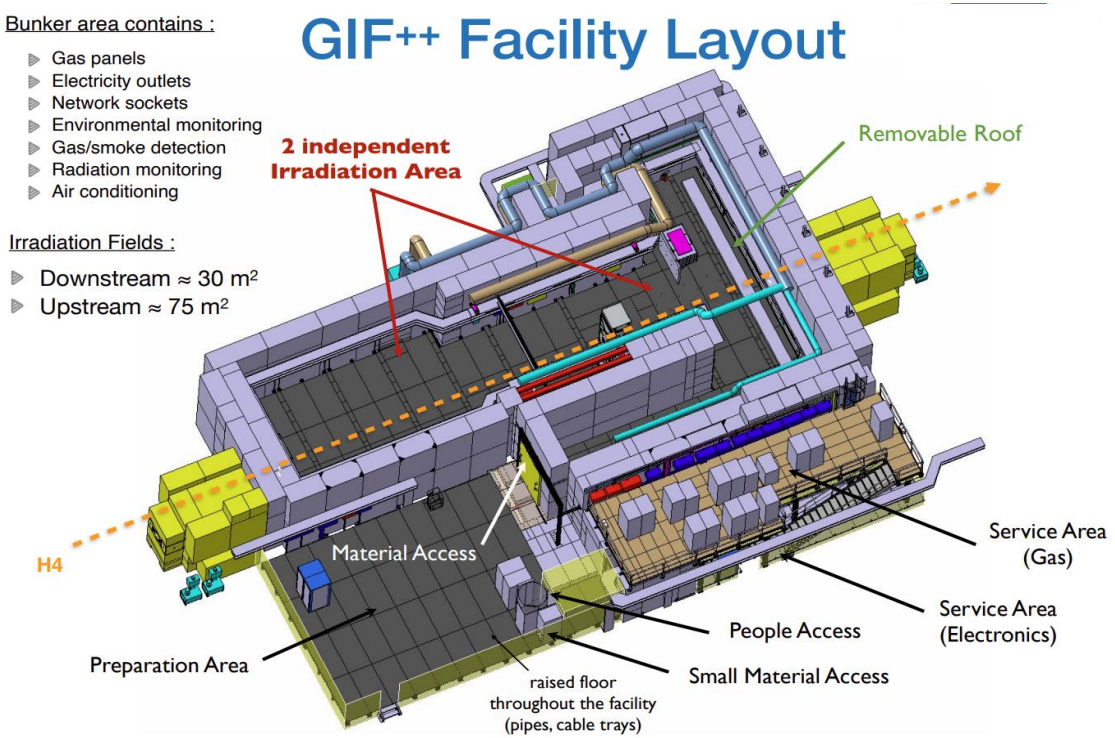


Electronic components under test

Courtesy of A. Waets (CERN)

D. GIF++ outlooks and activities in 2023





- Unique place, combining **a high energy muon beam** with a **12 TBq ^{137}Cs gamma source**
- GIF++ is a unique facility purpose-built for testing real size detectors in **realistic environment with LHC experiment readout systems & gas mixers**
- 2 identical attenuation systems with **12 custom shaped filters**: each consisting of **1 angular correction filter (Fe)** and **6 absorption filters**

D. GIF++ outlooks and activities in 2023

Successful year

- **48 weeks** of gamma irradiation to a wide community and **6 weeks** dedicated to muon beam
- **Extension of the gas area** planned in 2024 and **addition of 4 new supply gas** lines in 2025

User's applications

- Detector qualification with high radiation background & muon beam
- Radiation tests of electronics and optical components
- Search for eco-friendly gas mixtures for the RPCs and CSCs

Ongoing initiatives

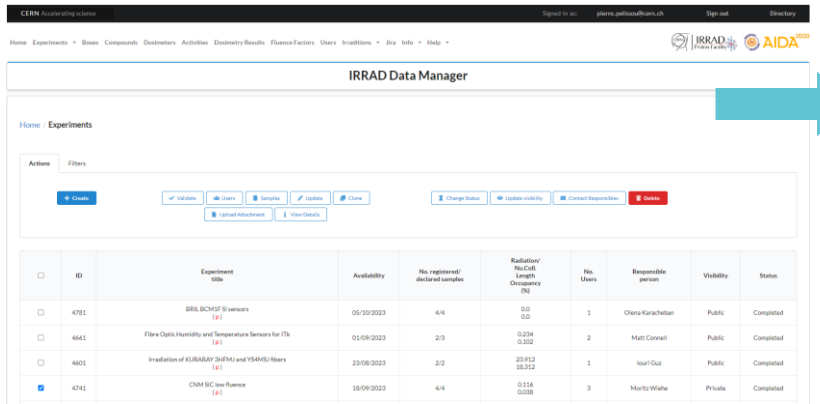
- Ongoing work regarding the extension of the experimental space
- A 10-year extension of the facility lifetime
- Possible upgrade of the source under investigation

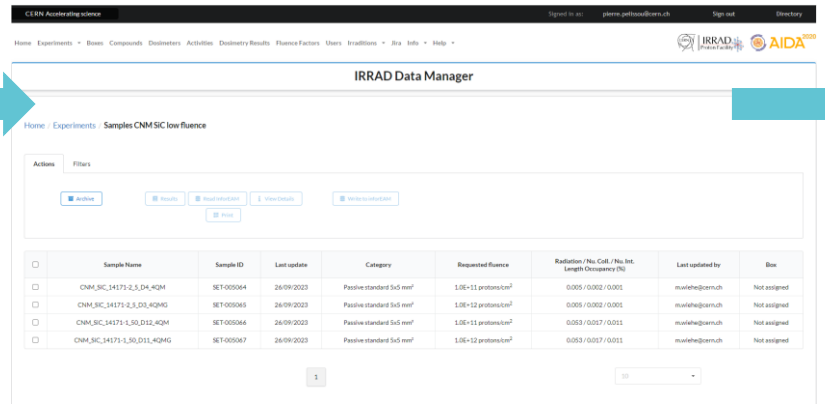
Activity	Resp.	Facility	Title	Description
216465	EP-UAT	GIF	RPC - BI production test	Production test of the BI gas gaps. This will include a setup going in and out from the bunker containing 24 gas gaps. Dimensions 300x100x60, weight 200 kG.
216137	EP-UAT	GIF	TGC prototype irradiation	TGC irradiation tests 2023
213815	EP-UAT	GIF	Test beam tracking MM detectors with Isobutane/ArCO2	Test beam tracking MM detectors with Isobutane/ArCO2
213813	EP-UAT	GIF	Test beam of MM production detectors with Isobutane/ArCO2	Test beam of MM production detectors with Isobutane/ArCO2
212816	EP-UCM	GIF	CMS HGCAL dry run at gIF++	Irradiation of HGCAL samples at GIF++
211132	EP-UCM	GIF	Consolidation of CMS RPC : Trolley 1	Operations and Modifications CMS RPC for Consolidation TR1. We are about to complete the program for 2 chambers.. We need to continue the charge accumulation for the other 2 chambers.
210614	EP-ADP	GIF	ProTov	Rate capability and aging test on gaseous detector with small form factors
210342	EP-UAT	GIF	ATLAS Legacy RPC Prototype	Setup for ageing test of an RPC detector with 50 cm x 50 cm size and 2 mm gas
208598	EP-UAT	GIF	Performance studies for sMDT detector prototype - MPI group	Performance studies for sMDT detector prototype - MPI group
208569	EP-UAT	GIF	Performance studies for RPC detector prototype - MPI group	Performance studies for RPC detector prototype - MPI group
205030	EP-UCM	GIF	CMS CSC longevity studies at GIF++ - ME11	CMS CSC (ME11) test beam and longevity studies at GIF++ (maintenance, measurements).
205028	EP-UCM	GIF	CMS CSC longevity studies at GIF++ - ME21	CMS CSC (ME21) test beam and longevity studies at GIF++ (maintenance, measurements).
204921	EP-UAI	GIF	Eco-friendly gas mixture tests - CMS RPC Trolley 3	Studies for an eco-frendly gas mixture for the RPC's
204544	EP-UCM	GIF	CMS-iRPC electronic test	CMS-iRPC chamber and electronics test
204305	EP-UCM	GIF	Rate capability for ME0 CMS GEM	Rate capability of GEM detector heavily irradiated
204304	EP-DT-FS	GIF	GIF++ EP-DT R&D 2	Test of RPC gaseous detectors under gas recirculation.
204283	EP-CMG	GIF	CMS DT MB2 chamber irradiation upstream	Irradiation and data taking of a DT MB2 chamber + monotubes at GIF++
204259	EP-UAT	GIF	RPC BIS78 Modul0 and Phase 2 prototype	Performance and ageing test of the ATLAS BIS78 Module 0 and Phase2 prototypes,
204254	EP-DT-DD	GIF	GIF User - upcoming installations	Allowing access to bunker area for selected user in preparation for upcoming installations.
203678	EP-UAT	GIF	Long Term Ageing of MM production detectors with Isobutane/ArCO2	Long Term Ageing of MM production detectors with Isobutane/ArCO2
203676	EP-UAT	GIF	Long Term Ageing for ATLAS-NSW MM	Long Term Ageing of MM production detectors with Isobutane/ArCO2

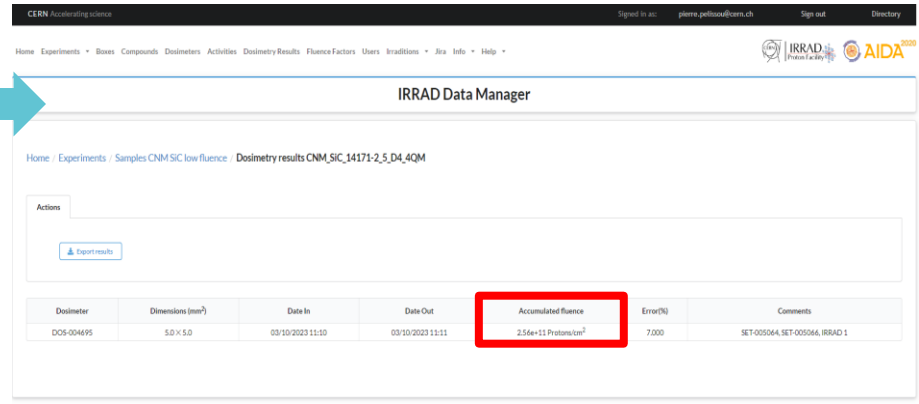
E. Current R&D projects

Example No.1: Deployment of a new version of the IRRAD facility Data Manager

- **Improvement achieved:** usability, sharing of irradiation experiment results and operational data
  - **Integration of an automatic computation of the proton fluence on IDM.**







- **Ongoing knowledge transfer about this application:** collaboration with Fermilab to implement IDM for the ITA facility

E. Current R&D projects

Example No.2: BPM DAQ Electronics Upgrade based on a new design

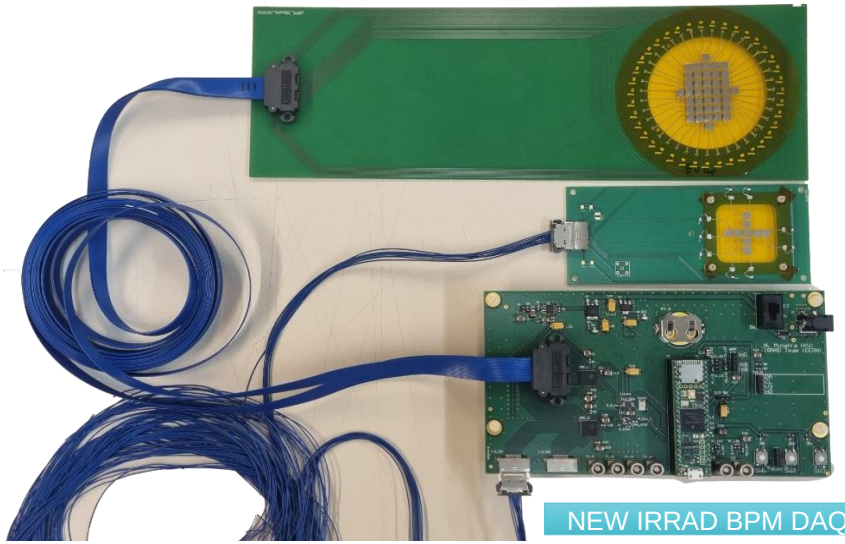
- Several limitations identified within the DAQ electronics after 10 years of operation:

  20ms sampling time, limited **number of channels** and **dynamic range** (matching with new detector technology), **longitudinal profile availability** (one channel only), etc.

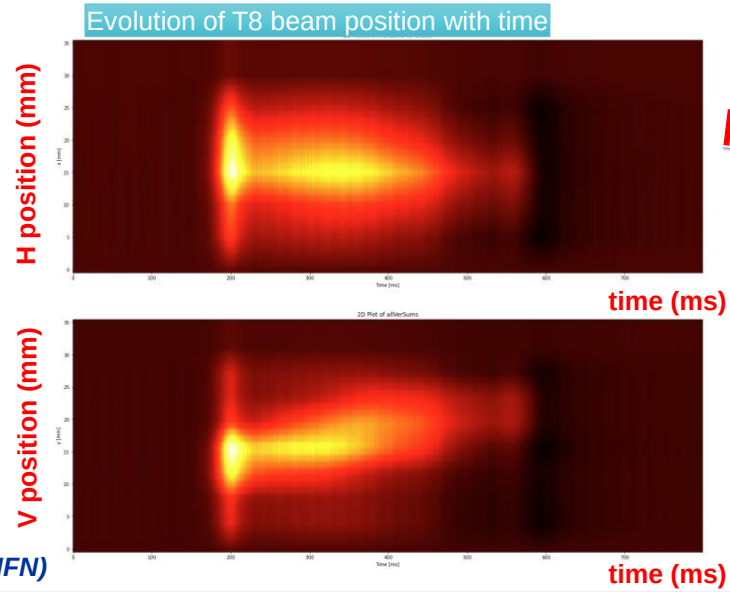
- New operational requirements to cope with:

  Slow- and **fast-extracted beams**, **heavy ion** beams, **new sensor technology**, increase information available for MD studies, etc.

- **Scalable system, sampling time down to 100's μs**, first prototype being tested



NEW IRRAD BPM DAQ *Courtesy of N. Minafra (KU) and S. Maiorano (INFN)*



Preliminary study

F. EUROLABS project summary

Access to Research Infrastructures for
Nuclear Physics - Accelerator R&D – Particle Physics

- **A 4-year project started in September 2022: https://web.infn.it/EURO-LABS/**
- **Transnational Access to a range of facilities – emphasis on students and post-docs**
  - Financial support available for beam times at CERN (IRRAD and GIF++) in 2024/2025
- **Several projects/improvements cited before have been supported by EURO-LABS**

Thank you for your attention

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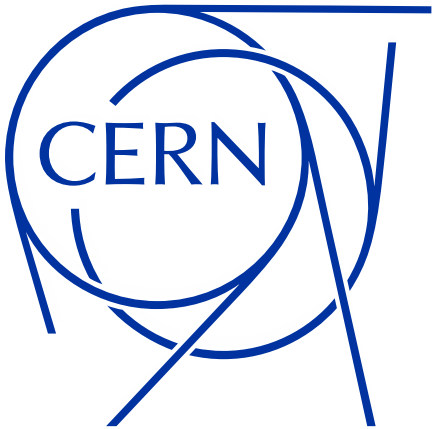


Appendix

A range of CERN facilities' useful information

CLEAR (CERN Linear Electron Accelerator for Research) is an electron facility aimed at developing instruments and components for existing and future accelerators, testing novel concepts as plasma and THz acceleration, investigating medical applications of electron beams including dosimetry and FLASH radiotherapy studying radiation hardness of electronics for aerospace and HE applications (**contact: CLEAR-Info@cern.ch**).

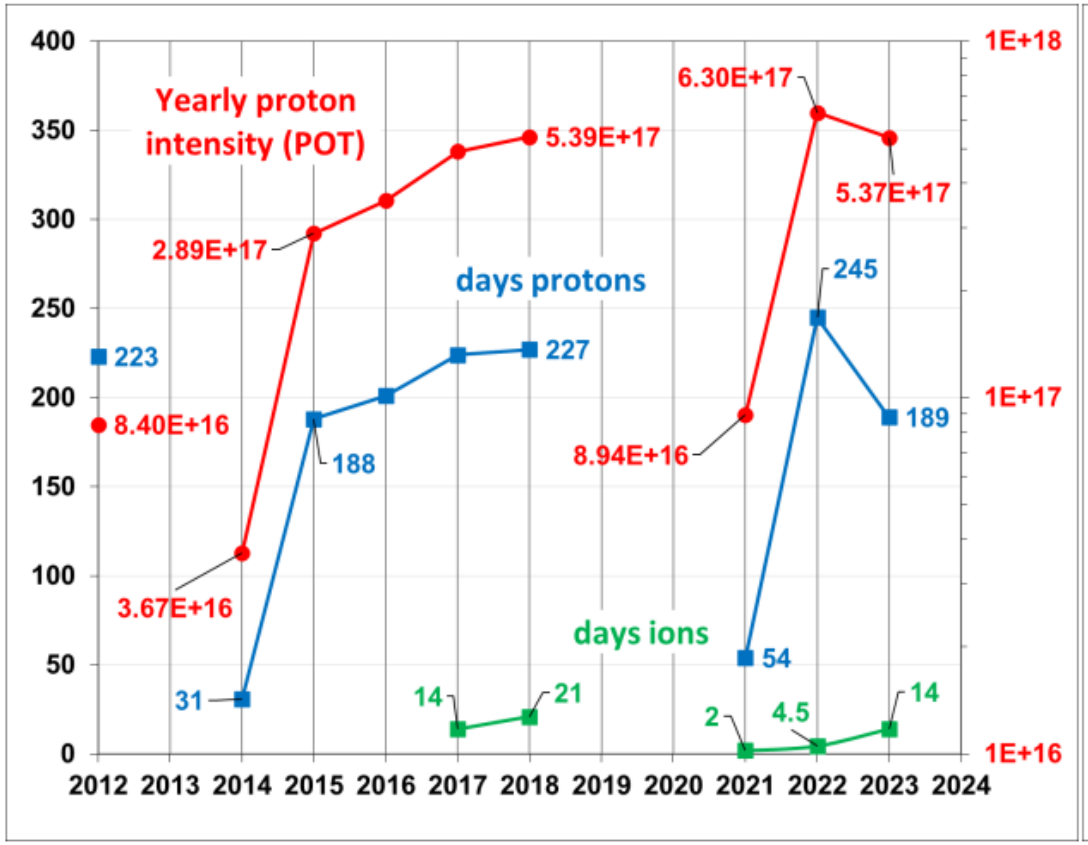
CERF (CERN-EU high-energy Reference Field) is a unique field calibration facility for radiation protection instrumentation used at high-energy accelerators, used to determine the response of detectors and dosimeters around high-energy accelerators and for air-crew dosimetry (**contact: fabio.pozzi@cern.ch**).

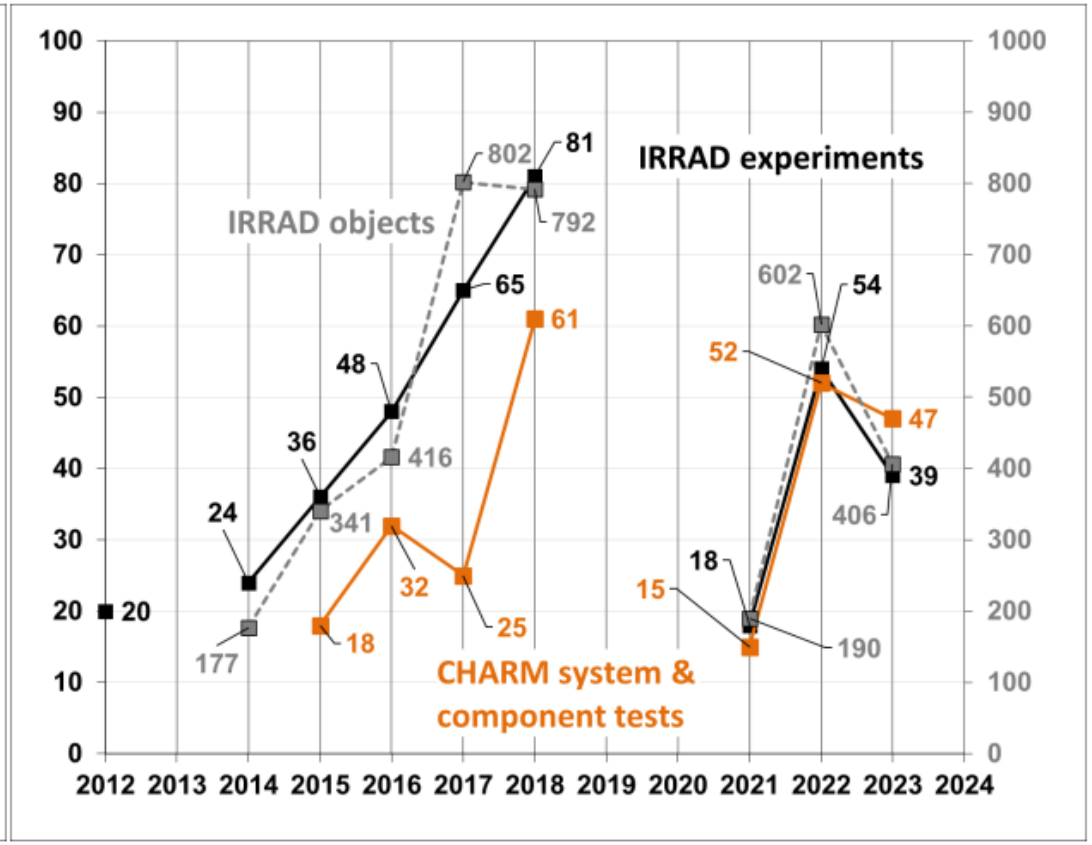
HiRadMat (High-Radiation to Materials) is a user facility designed to provide high-energy, high-intensity pulsed beams to an irradiation area where material samples as well as accelerator component assemblies can be tested (**contact: hiradmat-operation@cern.ch**).

Facilities beam parameters			
Facilities	**CLEAR**	**CERF**	**HiRadMat**
Beam time	32 weeks	1 week	4-5 experimental slots per year (~ 3 weeks)
Beam Momentum	220 MeV/c electrons	120 GeV/c positive hadron beam (2/3 π + and 1/3 p +)	440 GeV/c +- 0.3% protons / 173.5 GeV/n ions
Typical beam intensity	1×10^{8} e-/cm^{2}/s	From 10^{6} to 10^{8} particles/spill	3.5×10^{13} protons/spill / 3.64×10^{9} ions/spill
Upgrades foreseen	New beam line dedicated to medical applications and irradiations in 2025	Beam monitoring during set-up and run	Beam window limits

B. IRRAD and CHARM outlooks and activities in 2023

Statistics 2023





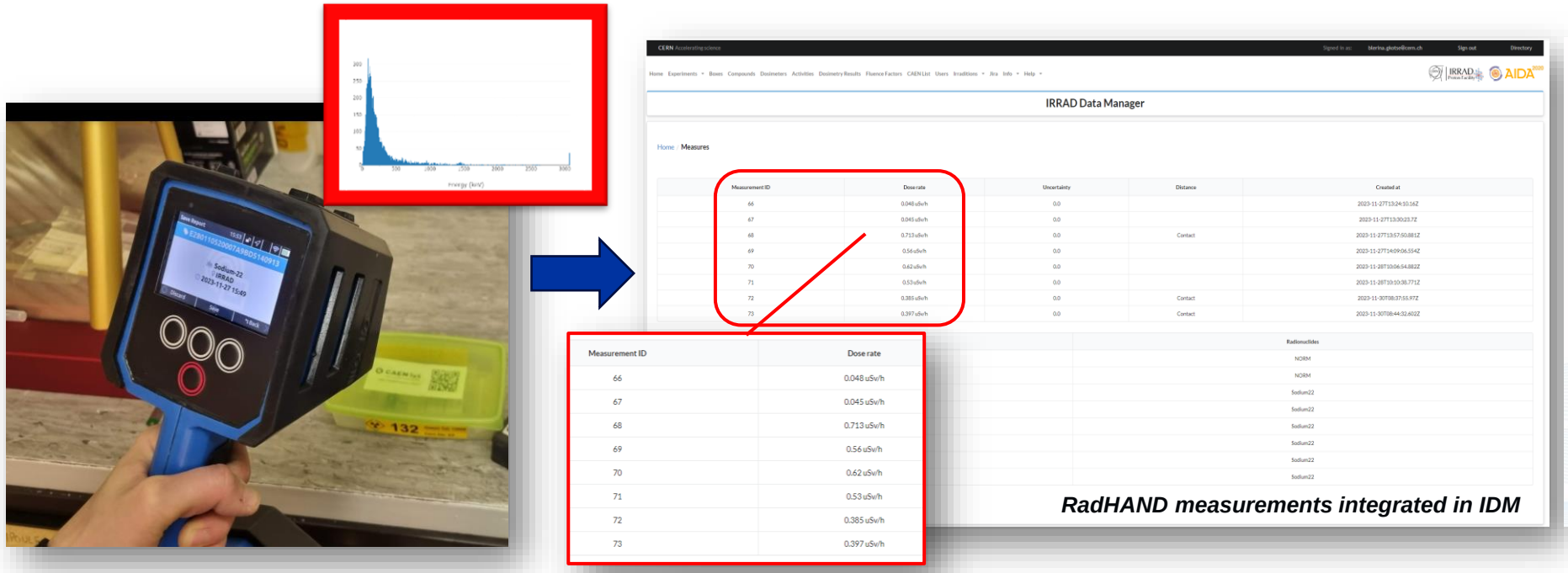
Up-to-date weekly beam performance of 2024 in IRRAD/CHARM

E. Current R&D projects

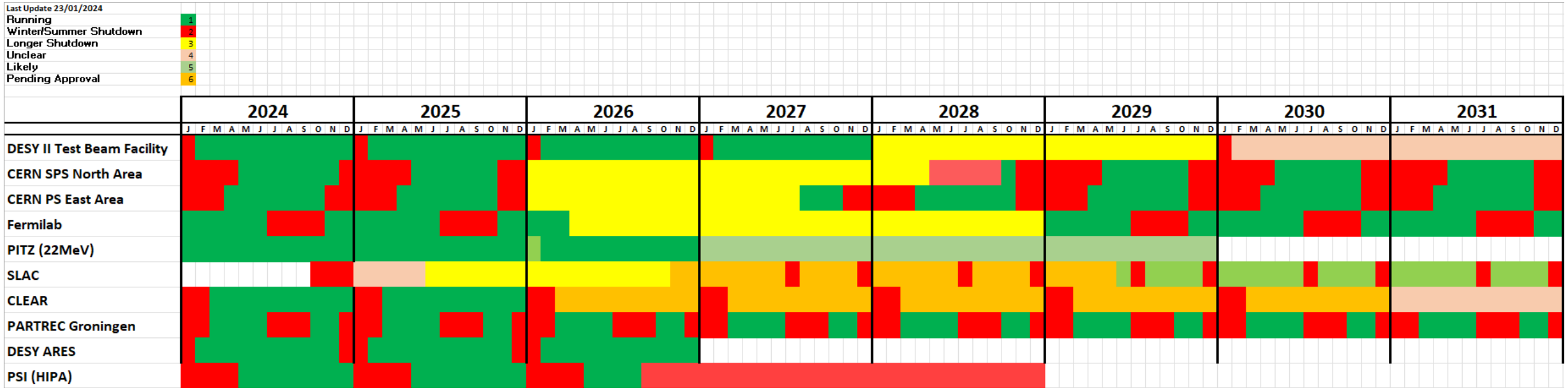
Example No.3: Spectrometry & Traceability Data Aggregation using a RFID-based integrated system

Project objective:

- Prototype being tested in IRRAD with **RadHAND device based on RFID tags**
- Successful communication between RadHAND device with IDM and proton fluence computation during irradiation campaigns performed in IRRAD (protons) and ENEA-FNG (neutrons)
- Upcoming test in CHARM in 2024 is already schedule



International test beam facilities schedule



Ack. M. Schwinzerl

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