

Upgrades for the CERN EP Irradiation Facilities (IRRAD, GIF++) and Plans beyond the Long Shutdown 2

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Current Team Members



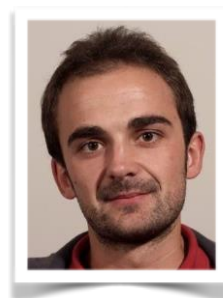
Federico, STAFF

- Team Responsible
- IRRAD Coordinator, Facilities EXSO



Martin, STAFF

- GIF++ Physics Coordinator



Giuseppe, STAFF

- Facilities Manager, GIF++ EXSO
- Users Supervisor



Blerina, FELL (Jan. 21)

- AIDAinnova, RADNEXT EU-projects
- Computing M&O / R&D



Alfredo, TECH (Oct. 20)

- Data Management
- AIDAinnova EU-project



Ourania, FELL (ATLAS, Feb. 20)

- u-BPM project (EPFL-CMi)
- R&D on Beam Instrumentation

Outline

- IRRAD
- GIF⁺⁺
- Irradiation and Test Beam Facilities DBs
- Summary

Outline

➤ IRRAD

➤ GIF⁺⁺

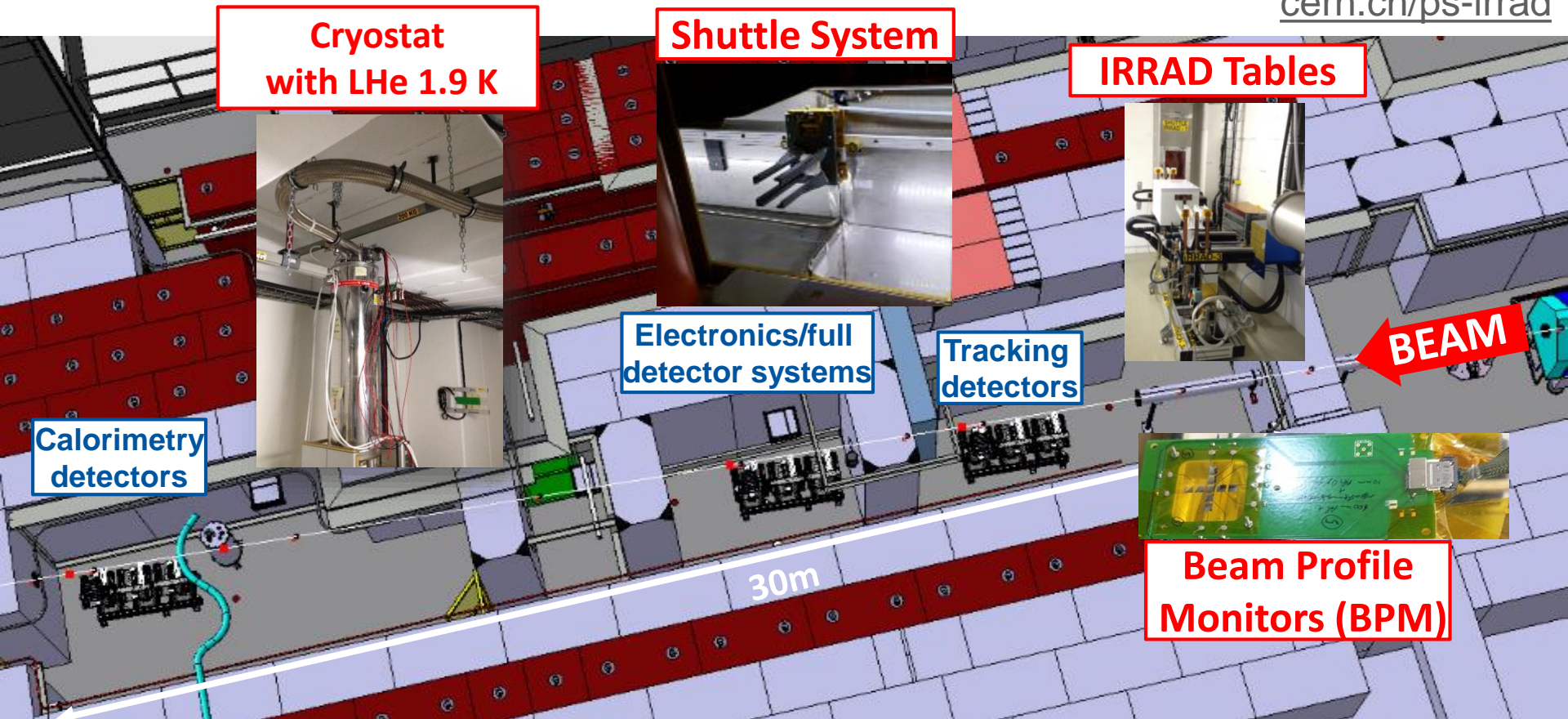
➤ Irradiation and Test Beam Facilities DBs

➤ Summary

CERN Proton Irradiation Facility (IRRAD)

- Testing components of HEP experiments
- 24 GeV/c, Gaussian 12×12 mm² FWHM
- Spills of 400 ms every ~10 s
- Fluence of 1×10^{16} p/cm² in 14 days
- Scanning also in dimensions of 10×10 cm²
- Low-temperature irradiation (-25°C)

cern.ch/ps-irrad



IRRAD Experiments in 2018

81 experiments, 97 users, 792 samples, 405 dosimeters, 2056 dosimetry measurements

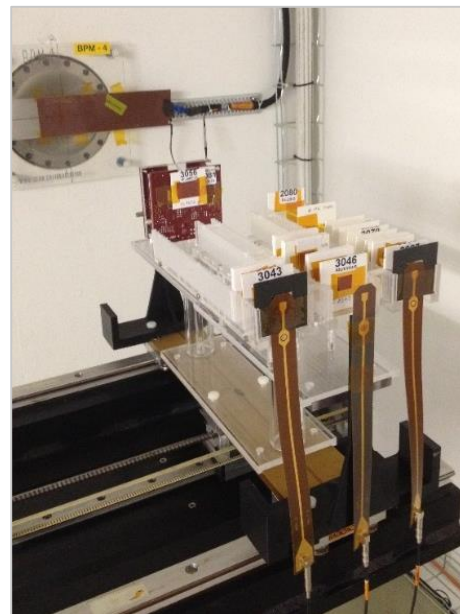
© ps-irrad.cern.ch



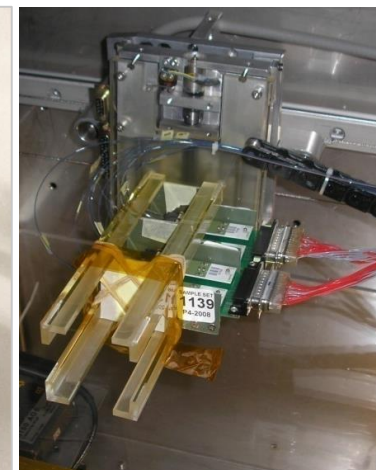
Piezo actuators



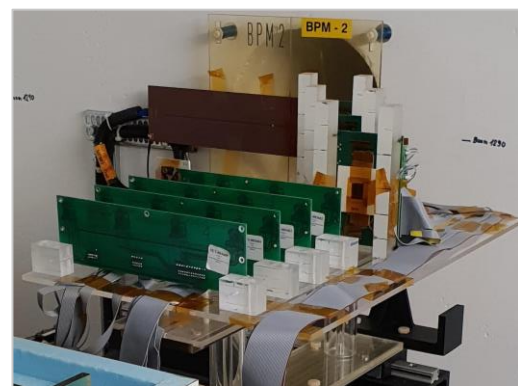
ECAL crystal



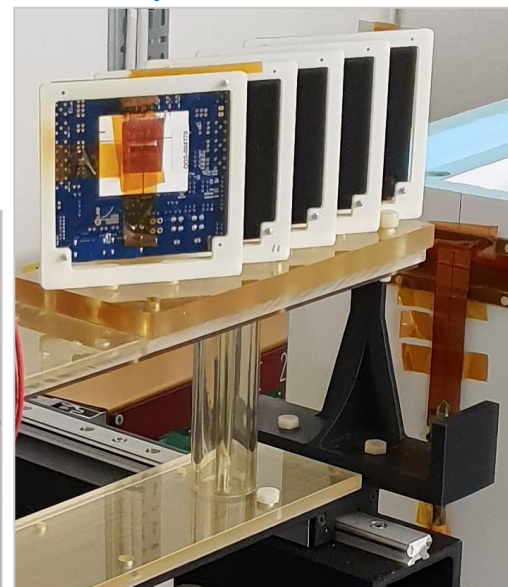
Si pad diode



Samples on shuttle



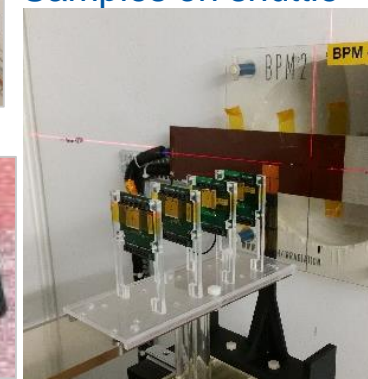
CLARO ASIC



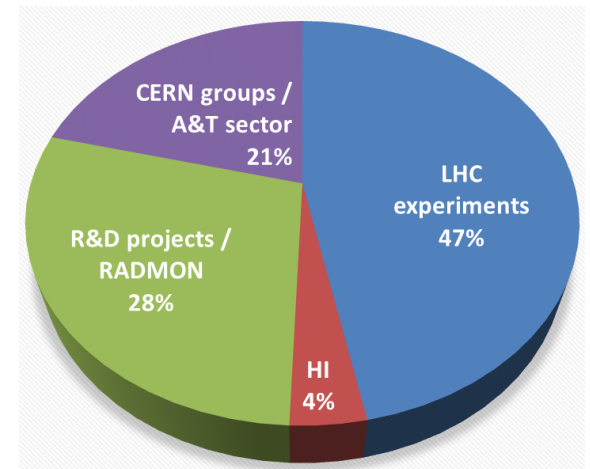
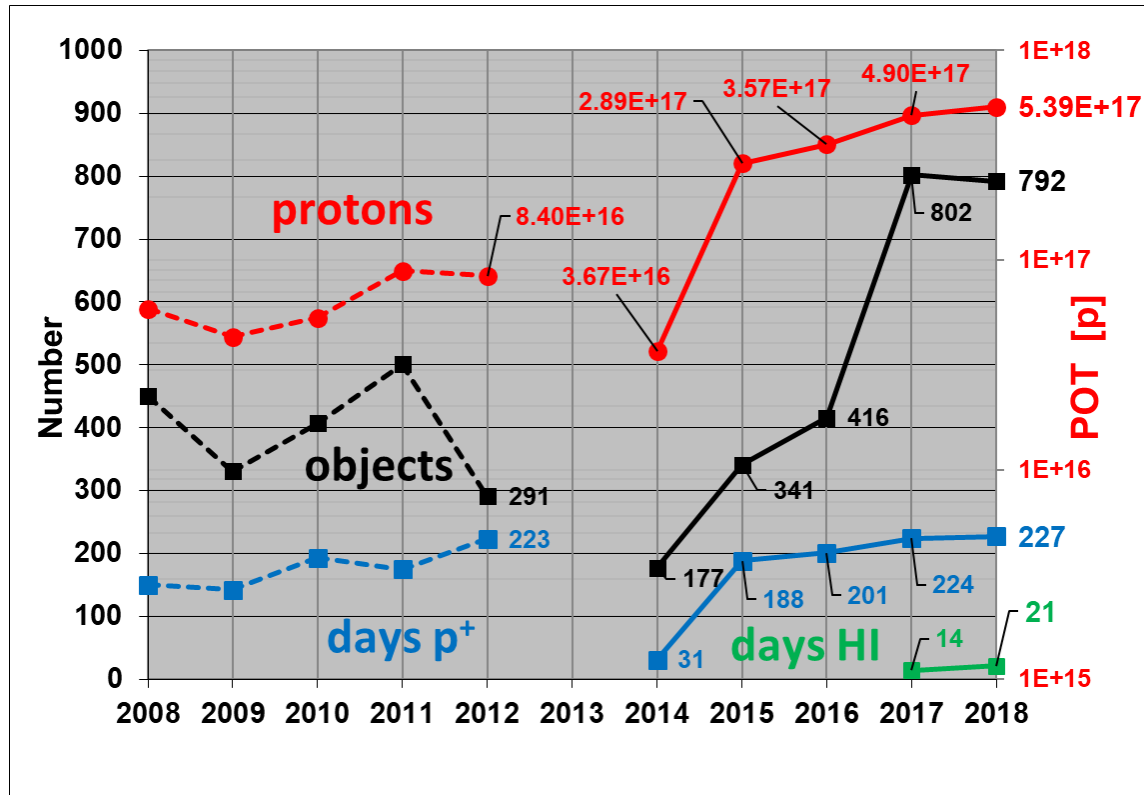
RD53A modules



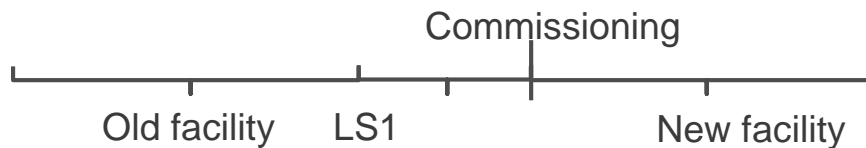
Full-tracking detector module



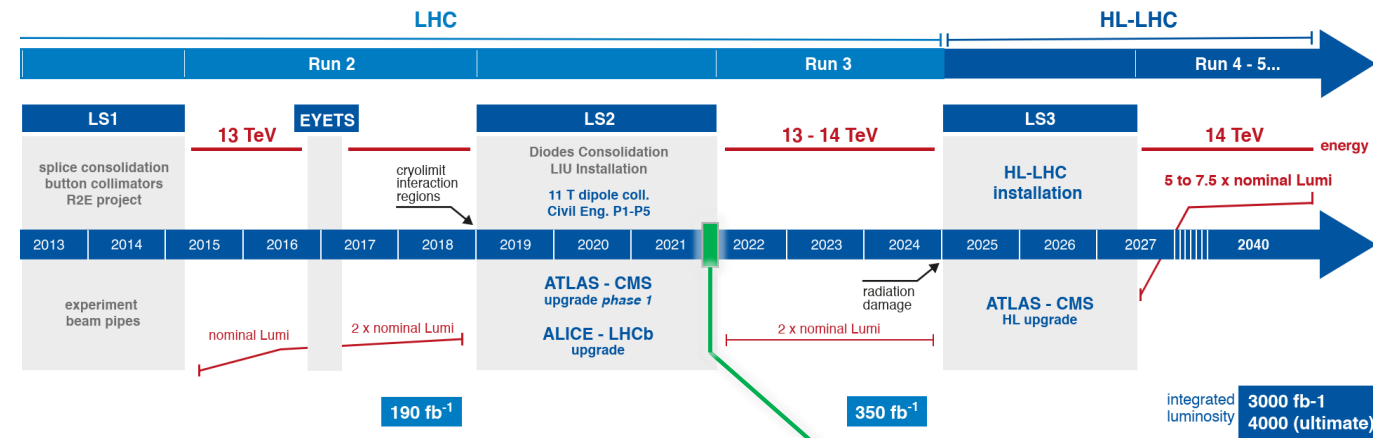
IRRAD Statistics for the Last 10 Years



Repartition of the users in 2018



IRRAD Towards Phase II Upgrade



Semiconductor/inner detectors will face

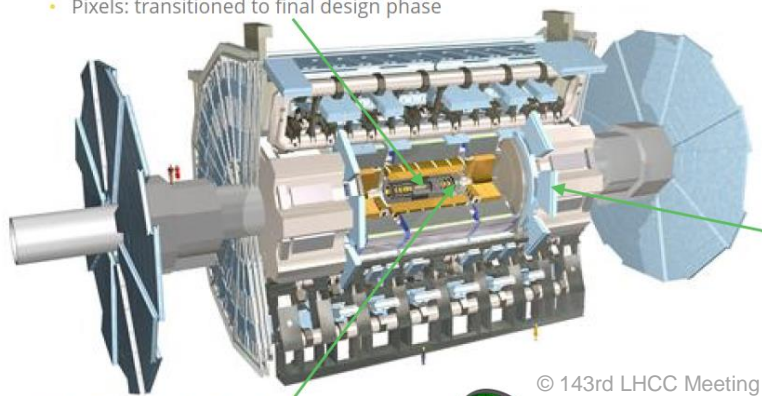
$>10^{16} n_{eq}/cm^2$ (HL-LHC)

$>7 \times 10^{17} n_{eq}/cm^2$ (FCC-hh)

Phase-II upgrade

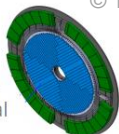


- New all-silicon Inner Tracker (ITk)
 - Strips: preproduction
 - Pixels: transitioned to final design phase



© 143rd LHCC Meeting

- High Granularity Timing Detector
 - TDR preliminarily approved
 - Upgrade cost group review this week → last step before research board approval



IRRAD-RUN2 from 18/10/2021

Experiments R&D on for Phase II upgrade:

- 3D pixels, SiPM, LGADs, HV-CMOS, ...
- CMS pixel, ATLAS ITk strips, CMS Timing Detector, ATLAS HGTD, ...

Electronic developments: RD53, DC/DC, etc.

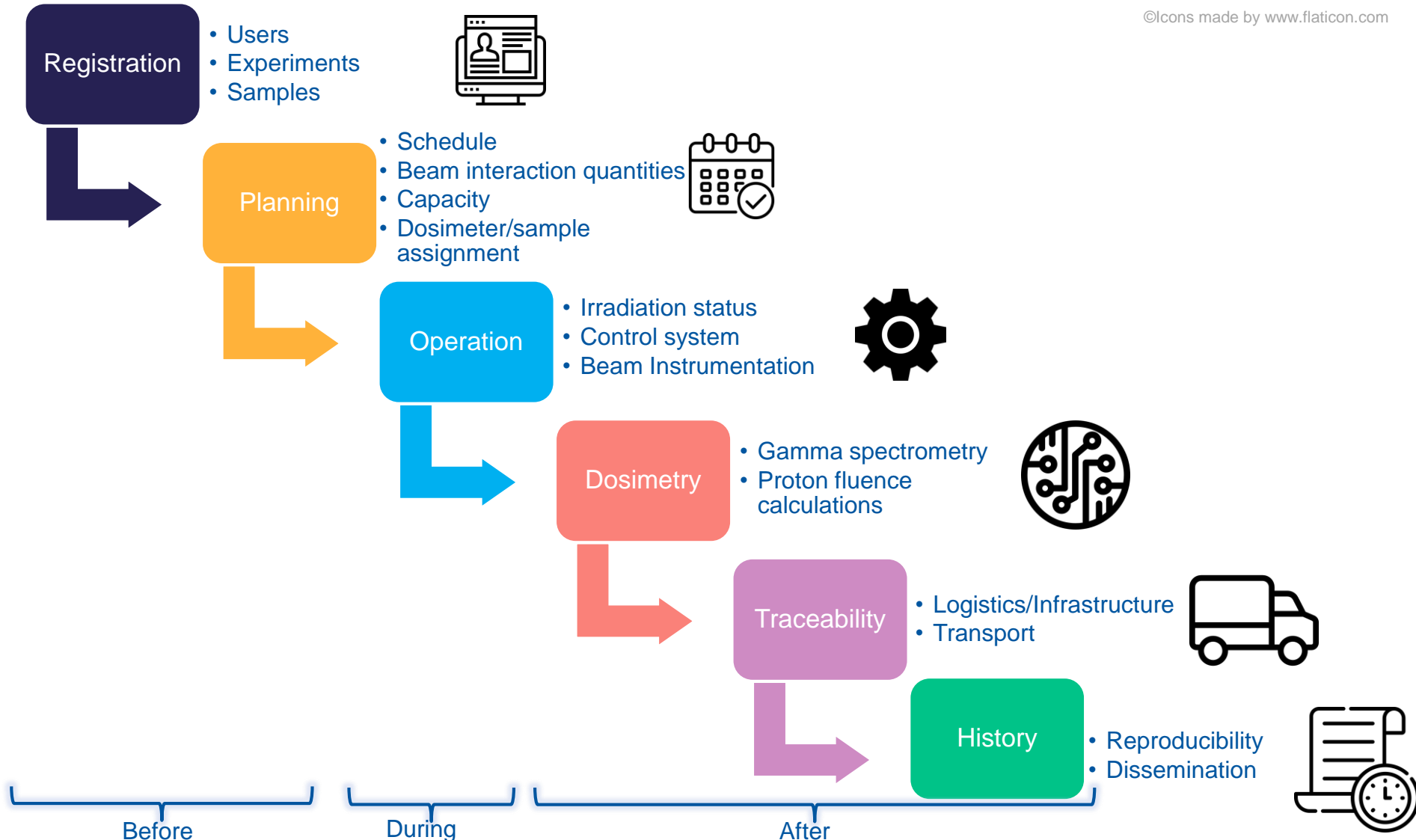
Accelerator components:

- Vacuum/Magnet parts, collimator actuators, ...

Increasing number of requests for IRRAD-RUN2!

Irradiation Experiment Workflow in IRRAD

©Icons made by www.flaticon.com



IRRAD Data Manager (IDM)

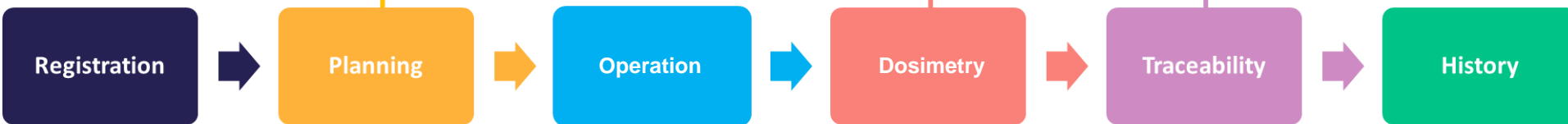


A unified data management tool for Irradiation Experiments follow-up

<http://cern.ch/irrad-data-manager>

The top row shows three screenshots of the IRRAD Data Manager interface:

- Left (Yellow border):** 'IRRAD Data Manager - Irradiation Experiments' view showing a table of experiments with columns for ID, Irradiation site, Availability, No. registered/defined samples, Radiation No./UK Length, Occupancy (%), No. Users, Responsible person, Status, and Actions.
- Middle (Red border):** 'IRRAD Data Manager - Dosimetry results for SET-003252 (ULTEM1000)' view showing a table of dosimetry results with columns for Dosimeter, Dimensions (mm²), Date In, Date Out, SEC, Accumulated fluence, Error(D), and Comments.
- Right (Purple border):** 'IRRAD Data Manager - TREC Data of Sample SET-003122' view showing details for a specific sample, including characteristics like Length, Width, Height, Weight, Family, and Material.



This screenshot shows the 'Sample details' view, featuring a 3D diagram of a rectangular sample and a table with columns for Name, Length (mm), and Diameter (mm).

This screenshot shows the 'Irradiation Status' view, displaying a table with columns for Updated at, Sample, Dosimeter, Date In - Date Out, IRRAD table, Table position, Accumulated fluence, SEC, Updated by, Status, In Beam, and Actions.

This screenshot shows the '3D pixel for ATLAS ITK' view, providing detailed information about a specific irradiation setup, including a description, responsible person, irradiation type, and dosimetry results.

to get notifications and sign in, join the e-group *irrad-ps-users*

IRRAD Control System

- Python-based IRRAD Motor Control Application (PIMCA)
- based on pyQT (python) – no license required
- compatible with Windows and Linux
- database in the backend



IRRAD tables in Zone 1

Motor Control Application - IRRAD7

File Edit View

X-Axis Theta-Axis Y-Axis

Y-Axis Motor

Up Down

Step size: 1 mm

Save

Resolver position: 1024 mm ±0.3

Reference line: 1000 mm

Toggle Axis History

Positions

Park	Left	Center	Right
952.02 mm	1044.08 mm	1002.97 mm	1044.08 mm

Edit Positions Delete Position New Position

Scan

Left position: 384000 steps Right position: 391680 steps

Setup Start

STOP ALL MOTORS

“single-axis” view

“dashboard” view

New Table Control GUIs

MainWindow

File View

X-Axis Motor

Motor position: 240.0 mm

Resolver position: 282 mm ±0.3

Step size: 0.0

Save

Reference line: 200 mm

Toggle Axis History

Positions

Park	Left	Center	Right
4.0 mm	205.0 mm	240.0 mm	244.8 mm

Edit Positions Delete Position New Position

Scan

Left position: xx mm Right position: xx mm

Setup Start

Theta-Axis Motor

Motor position: 24.34 mm

Resolver position: -102 mm ±0.3

Step size: 0.0

Save

Reference line: 10 mm

Toggle Axis History

Positions

Park	Left	Center	Right
2.93 mm	13.34 mm	24.34 mm	0.0 mm

Edit Positions Delete Position New Position

Scan

Left position: xx mm Right position: xx mm

Setup Start

STOP ALL MOTORS

Y-Axis Motor

Motor position: 952.02 mm

Resolver position: 953.30 mm ±0.3

Step size: 1 mm

Save

Reference line: 1000 mm

Toggle Axis History

Positions

Park	Left	Center	Right
952.02 mm	1044.08 mm	1002.97 mm	1044.08 mm

Edit Positions Delete Position New Position

Scan

Left position: xx mm Right position: xx mm

Setup Start

IRRAD γ -Spectrometry

- CANBERRA APEX-Gamma installations
- new SW architecture (collaboration with HSE-RP)
 - **Openstack Virtual Machine (VM) Server**
 - **ARAMIS tool** for data exchange across platforms



ID	Name	Category	Acquisition Status	Processed (All Data, No. of Length (Percentage))	Link	Actions
07000010	07000001	07000001	Passive standard 100-Event	10/17	0.0/0.0 (0.00/0.00%)	View
10000010	07000001	10000001	Passive standard 100-Event	10/17	0.0/0.0 (0.00/0.00%)	View
10000010	07000001	10000002	Passive standard 100-Event	10/17	0.0/0.0 (0.00/0.00%)	View
07000010	07000001	07000001	Calibration	10/17	0.0/0.0 (0.00/0.00%)	View
07000010	07000001	07000002	Calibration	10/17	0.0/0.0 (0.00/0.00%)	View

TREC

IDM

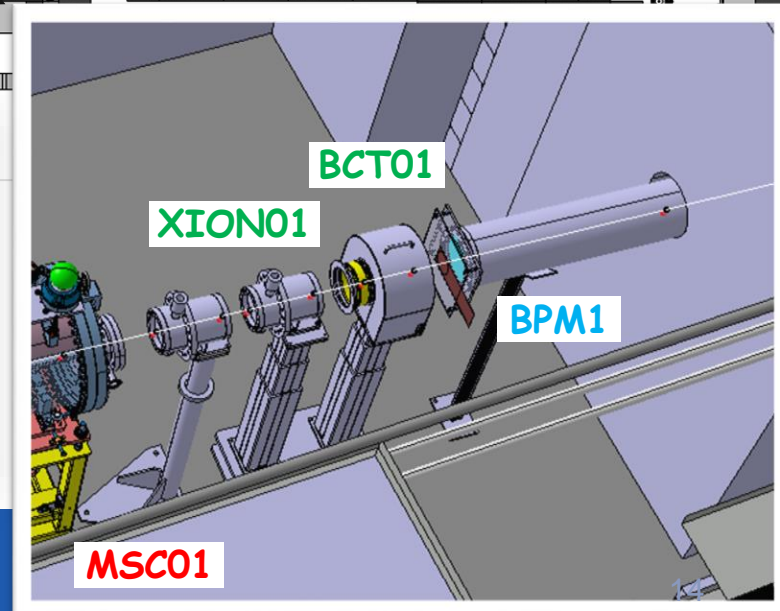
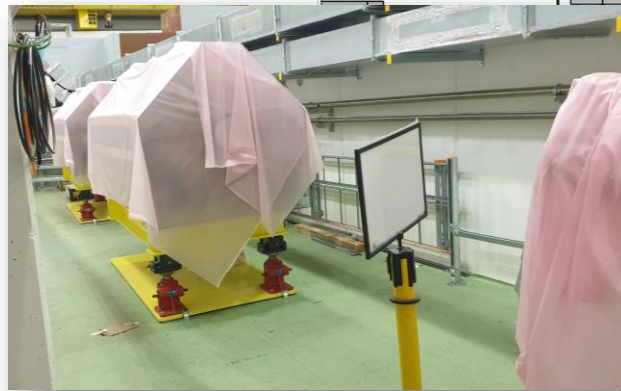
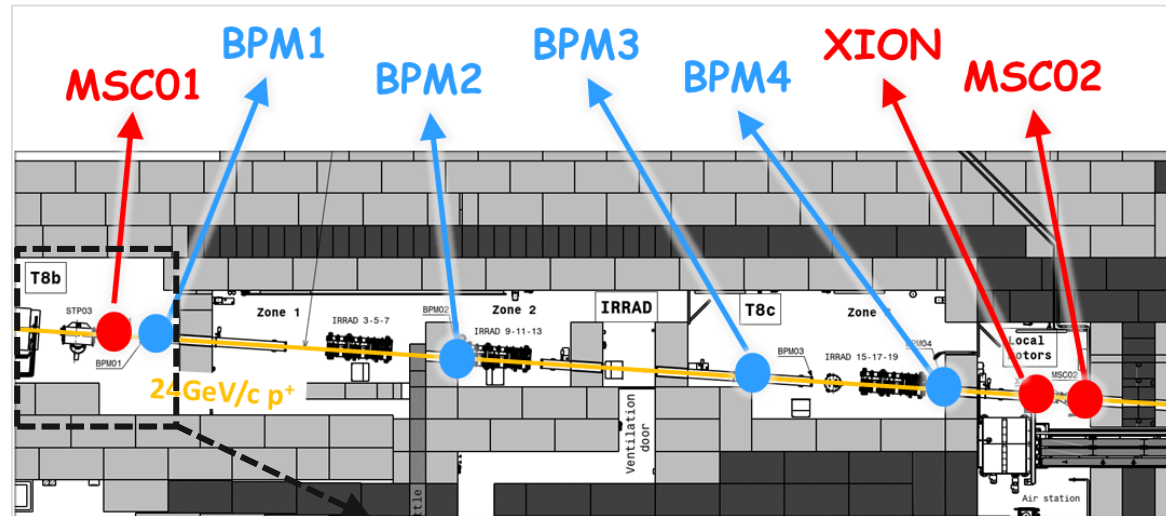
ARAMIS \updownarrow

openstack.
Virtual Machine Server



IRRAD Beam Instrumentation

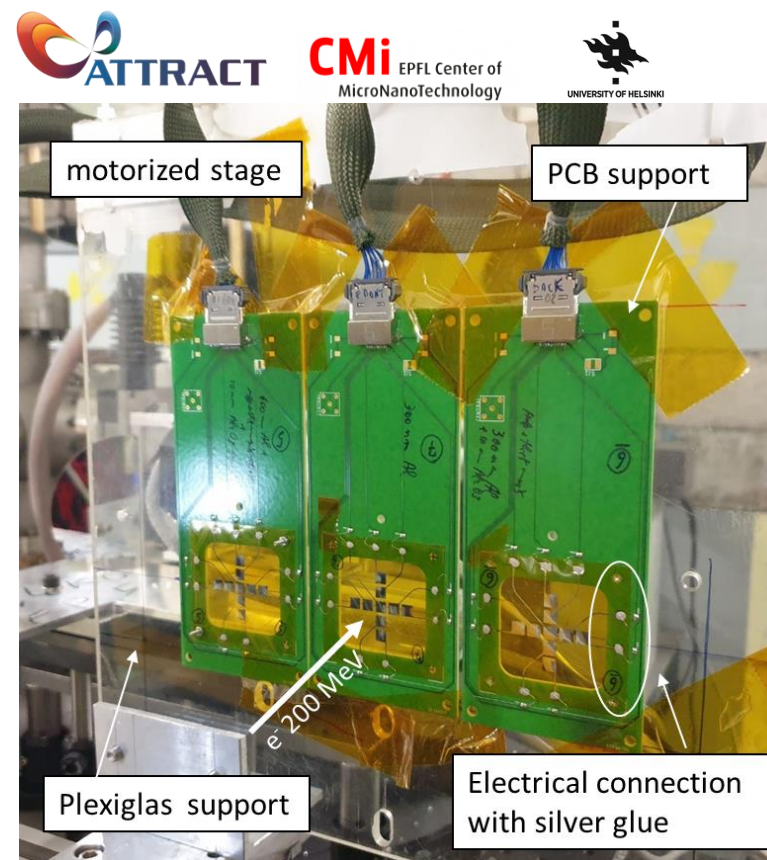
- better understanding of proton beam intensity:
 - T8 transport, calibrations, etc. (10^{11} p/spill)
 - Low intensity (10^9 - 10^{10} p/spill)
 - Heavy Ion runs
- new **XION02** downstream
- new measurement point **upstream IRRAD** on telescopic feet :
 - XION01
 - BCT01
- collaboration with BE-EA, BE-SEM and SY-BI



Ultra High-level Radiation Monitoring with Thin Metal Nano-layers: *NanoRadMet*

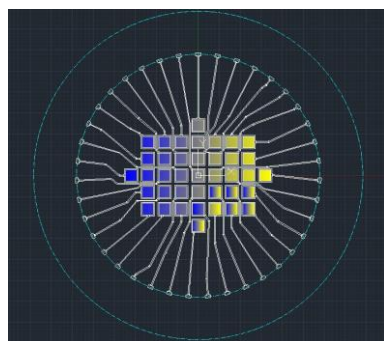
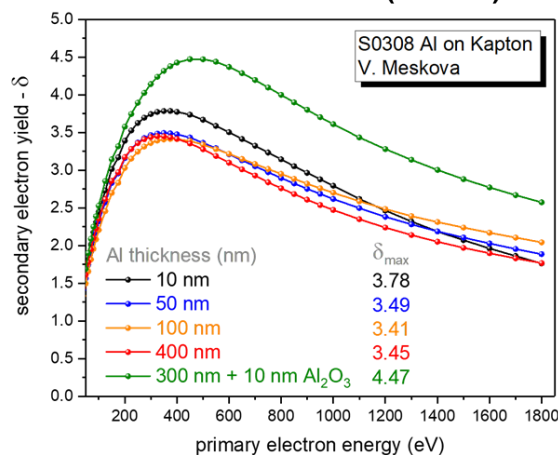
- Understand the SEE properties of ultra-thin (nm) metal layers exposed to ultra-high particle Φ
- Engineer a new Beam Profile Monitor device: **u-BPM**
 - usable with **low E particles** (MeV)
 - simple operation (IRRAD) & **radhard**
 - higher sensitivity
 - lower activation
 - **non-invasive** ($X_0 < 1\%$ vs 30%)

O. Sidiropoulou EP-DT Seminar "Beam Profile Monitors based on thin-film nanolayers for the IRRAD Proton Facility"



Prototypes of **new full u-BPM devices** being tested at VESPER facility (200 MeV electrons)

SEY measurements (TE-VSC)

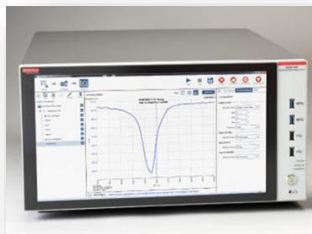


39 ch. BPM device

IRRAD Technical Area

Services
(electricity, AC,
lighting, network,
etc.) installation is
ongoing with BE-EA

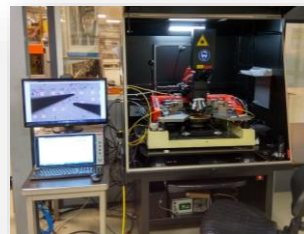
- reduce transport of irradiated material
- increase samples storage / handling capabilities
- provide users with a **laboratory** & advanced **characterization tools**



Keithley 4200A SPA

Keithley 2657A Extension

HV SMU up to 3kV



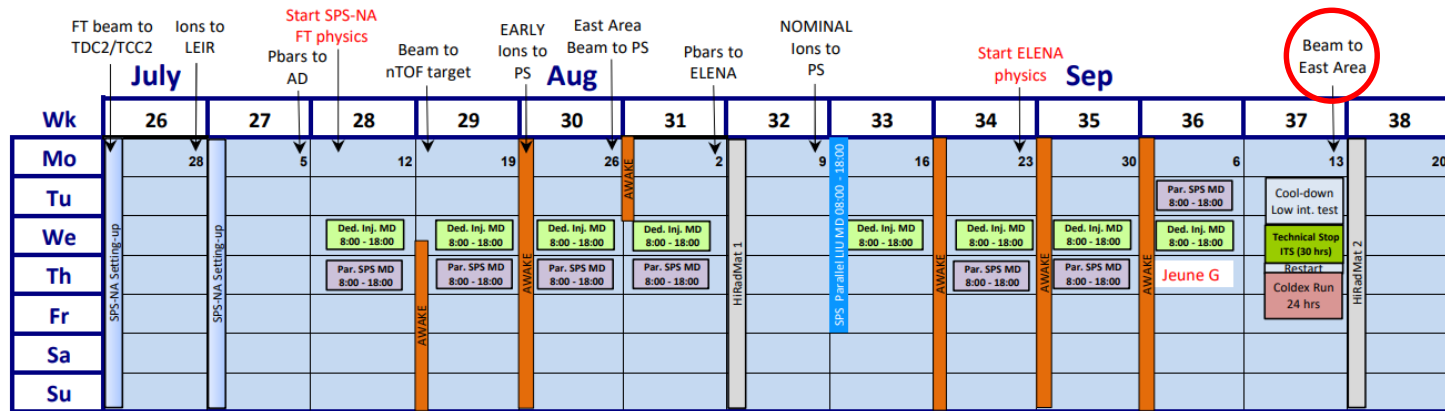
**Suss PM8
Probe
Station**



**TH100-C
Climatic
Chamber**

IRRAD Restart Schedule

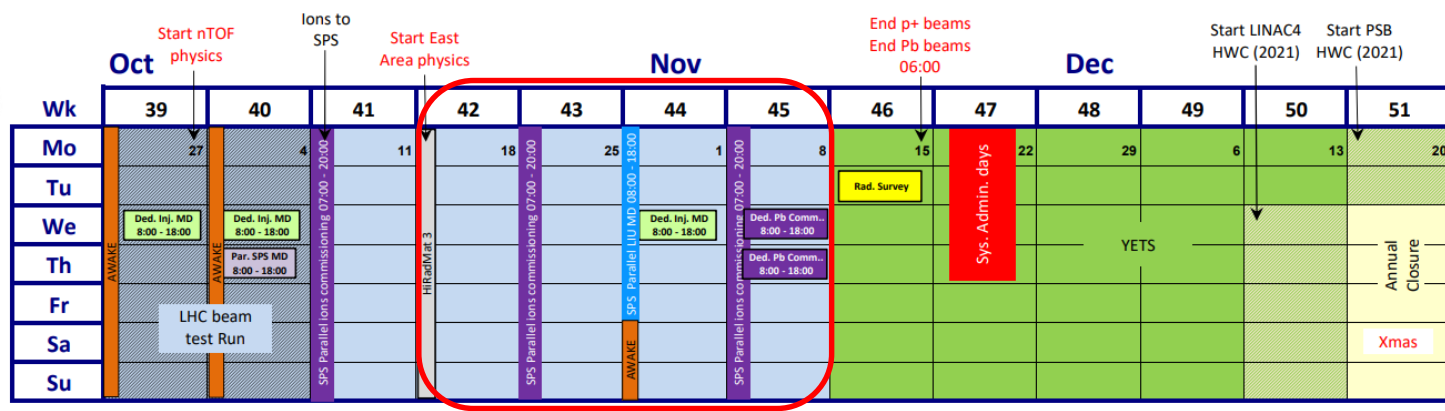
- EA Consolidation project is ongoing: some **delays due to COVID-19**
- goal is to **complete EA-T8 with priority**: hand over to BE-OP ASAP!
- current schedule: beam (Sep. 21), physics + IRRAD commissioning (Oct. 21) + **irradiations?**



Injector Accelerator Schedule 2021

Approved by Research Board on 02.12.2020

... will be re-discussed in March 2021 after update about readiness of LHC experiments ...



Outline

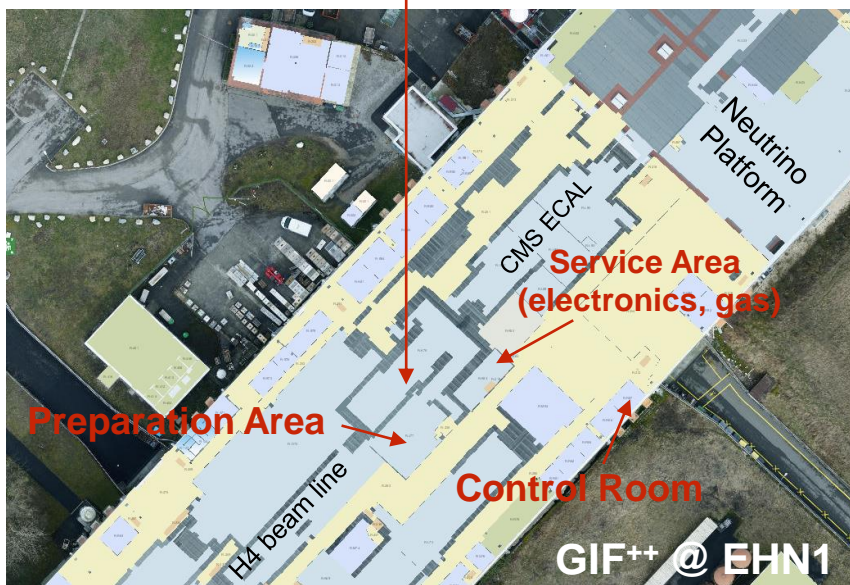
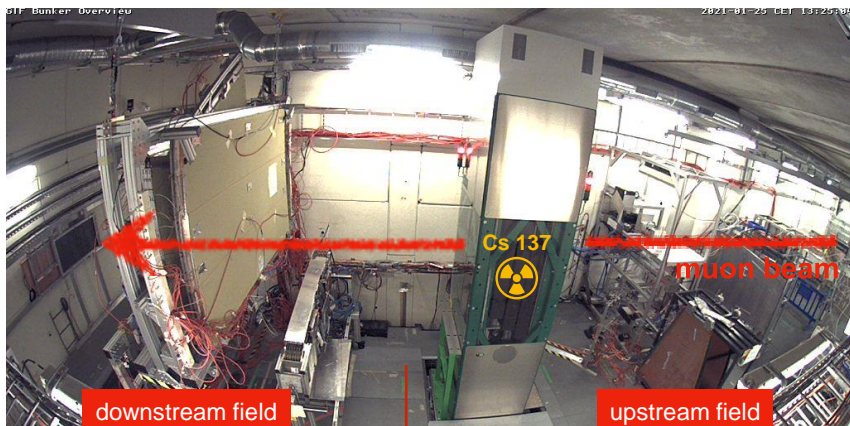
➤ IRRAD

➤ GIF⁺⁺

➤ Irradiation and Test Beam Facilities DBs

➤ Summary

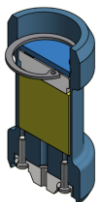
Irradiation Bunker



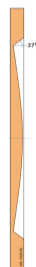
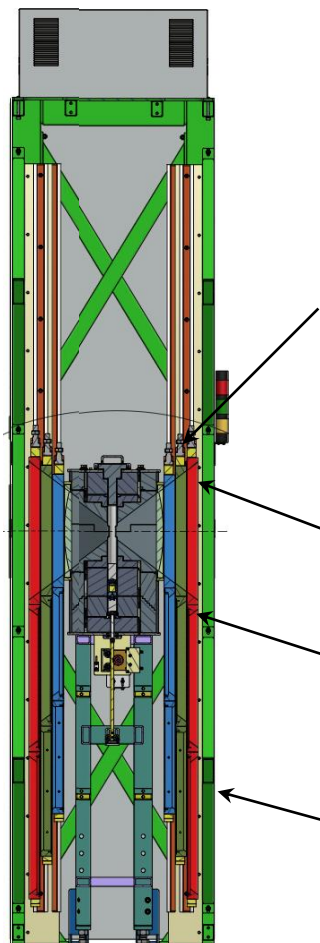
- Joint facility, operated by EP-DT and BE-EA
- Unique place, combining a **high-energy muon beam** with a **12 TBq ¹³⁷Cs gamma source**
- Designed for testing **real-size detectors**, of up to several m², as well as a broad range of **smaller prototype** detectors and electronic / optical components.
- 160 m² irradiation bunker with 2 independent irradiation zones (≈ 30+75 m²), with separated attenuation systems
- “All year” operation** from Cs-Irradiator
- High-energy Muon beam at H4 beam line - 7 weeks dedicated beam in 2018
- Central Control System, recording all relevant parameters and providing interlocks
- Wide range of available gases (+ custom gases) in bunker & service zone
- <https://gif-irrad.web.cern.ch/>

GIF++ Irradiator & Attenuation Filters

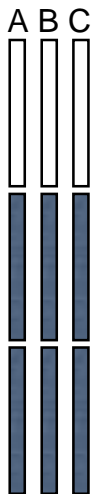
One ^{137}Cs source, two identical attenuation systems, each consisting of one angular correction filter (Fe) and 6 absorption filters - a total of 14 custom shaped filters



14 TBq
 ^{137}Cs
(as of 2014)



Angular correction filter provides uniform photon distribution for large area detectors

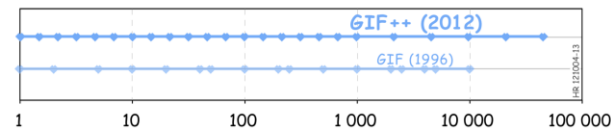


Filter System :

Absorption factor		
A	B	C
0	0	0
10	1.47	2.15
100	100	4.64

24 possible attenuation factors:

1	21.54	464.2
1.47	31.62	681.3
2.15	46.42	1000
3.16	68.12	2154
4.64	100	4642
6.81	146.8	10000
10	215.4	21544
14.68	316.2	46415

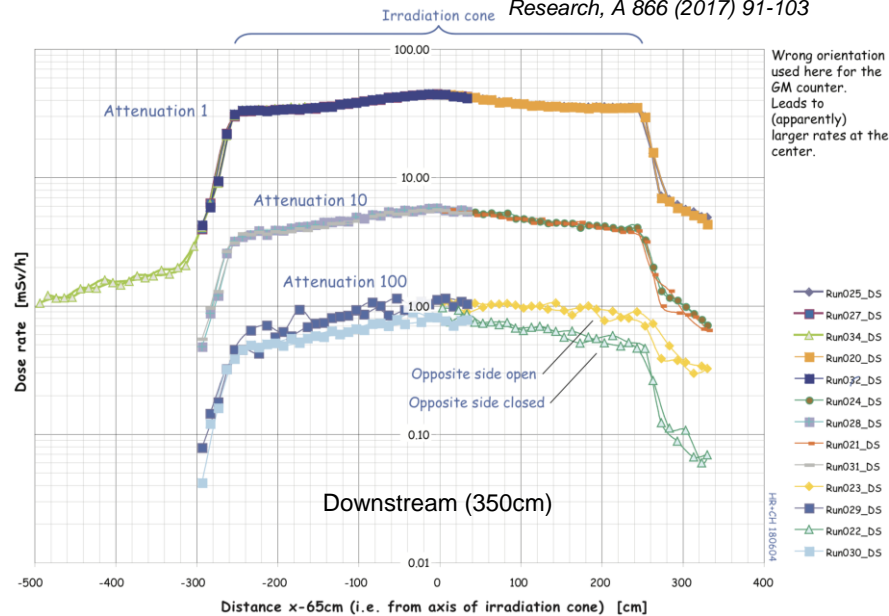
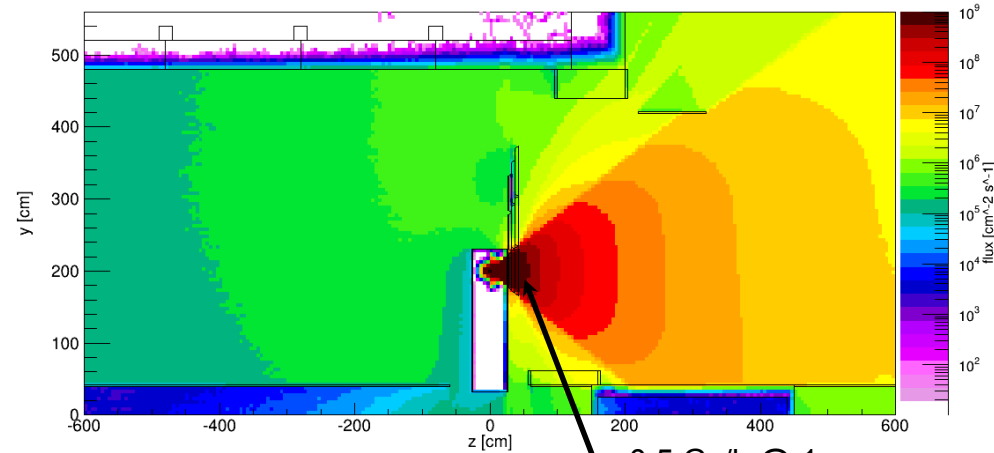


(calculated values for un-scattered gammas)

GIF++ Radiation Field & Monitoring

The Radiation Field in the New Gamma Irradiation Facility (GIF++) at CERN
Nuclear Inst. and Methods in Physics Research, A 866 (2017) 91-103

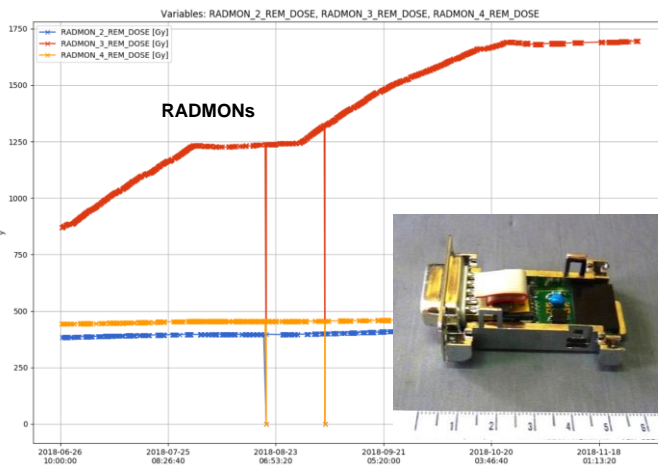
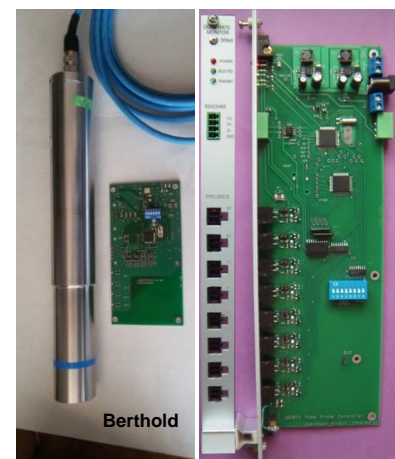
Total flux, one field, without filters



Wrong orientation used here for the GM counter. Leads to (apparently) larger rates at the center.

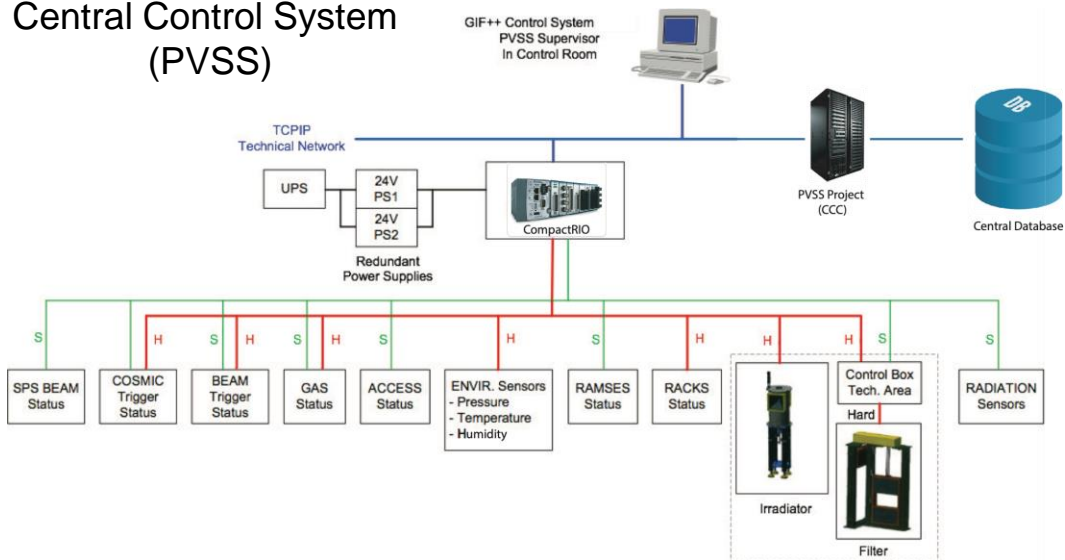
- ▶ 12 x RADMON “movable” sensors
- ▶ 2 REMUS detectors, on DIP & TIMBER
- ▶ 2 Berthold counter GM LB6500
- ▶ Automess AD6 with external probe
- ▶ 3.2m translation stage for field mapping

Optional Half Filter



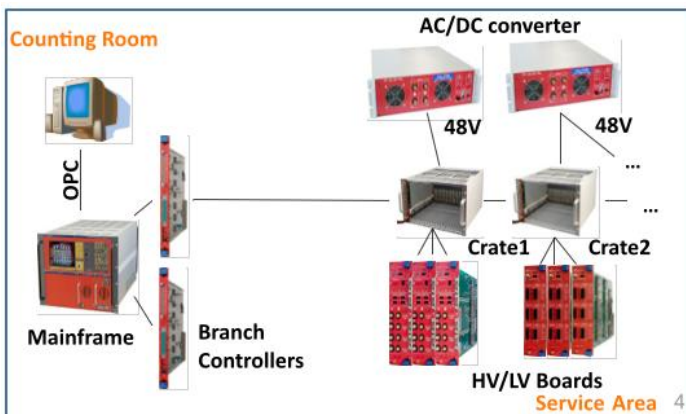
GIF++ Available Infrastructure

Central Control System (PVSS)

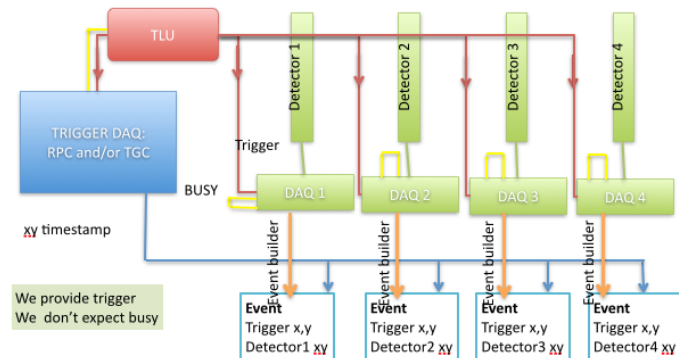


Monitoring (for both atmospheric and gases): p, T, rH
 Baseline: 4 gas and 6 atmospheric sampling points

DCS System

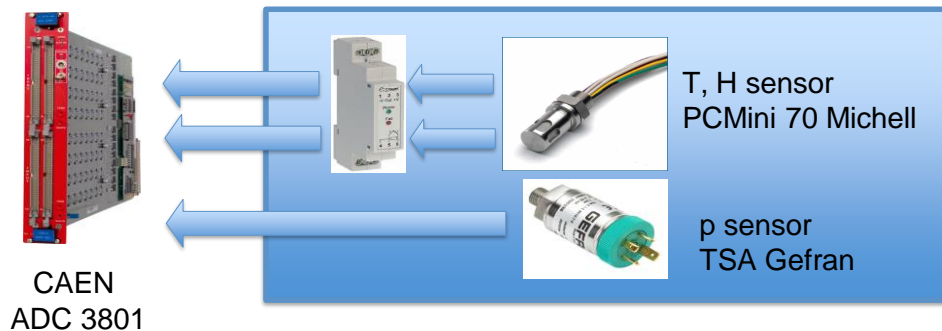


DAQ System



Beam Trigger
 (2 pairs of scintillators)

Gas and Environmental sensors



CAEN
 ADC 3801

Central Gas System

The gas system infrastructure is a key element of the successful R&D programs performed at the GIF++



Mixing units, gas recirculation systems and gas analysis module are used for detector R&D studies

Wide range of gases available

Possibility to use pre-mixed bottles (local gas point)



AIDA 2020

Partial funding of the gas system equipment and two CERN technical students



Mixture distribution

Monitoring of pressure, O₂/H₂O, temperature, atmospheric pressure

Additional software controlled pressure regulation for very low flow regimes

Gas mixing unit

Gas recirculation module

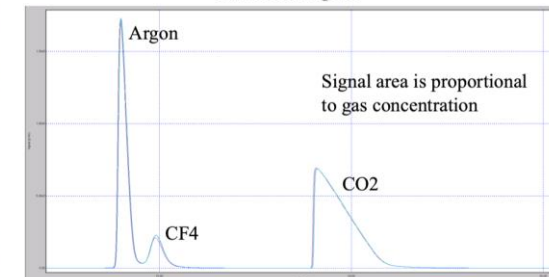


Sampling manifold

PC for GC software controls

GC analyser (3 modules for large spectra gas separation)

Gas chromatogram



Gas chromatographic analysis: allows monitoring gas mixture composition and presence of impurities on return from detectors under test

GIF++ Operation 2020

After the major upgrades in 2019, priority was given to the ongoing mass-production tests for the ATLAS NSW while providing irradiation to a wide variety of setups

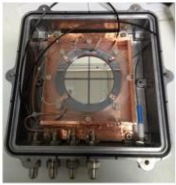
⇒ 17 registered setups served during 2020.

- Mass testing of chamber very demanding on the overall coordination, with multiple access / chamber exchange per week from both MM and sTGC
- In addition a **high-priority long-term study** (several months) had to be started at the end of 2020 to test the feasibility of using Isobutane in the NSW MM detectors
 - To provide the best - unshadowed - irradiation conditions, we suspend the 3-chamber MM trolley from the ceiling, allowing a continuous exchange of the regular MM test chambers below in parallel to the long term study
 - 4 mounting points (each rated at 500kg) are now available
- Increased shadowing, due to the increased number of setups in the upstream (extended) area will be one of the challenges in the coming years.
 - Please consider this when designing your support frames!

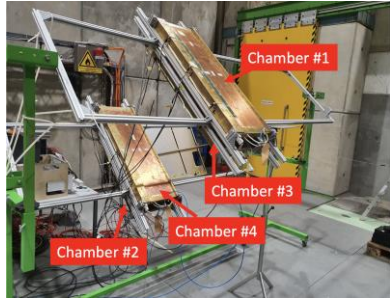


Successful Year 2020!

Annual User Meeting : <https://indico.cern.ch/e/GIF-AUM-2020>



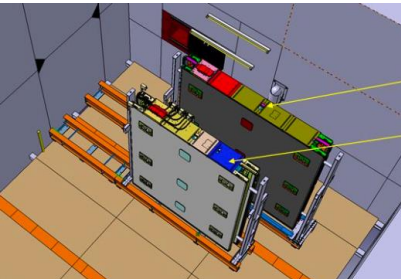
ProTOV-RPC R&D



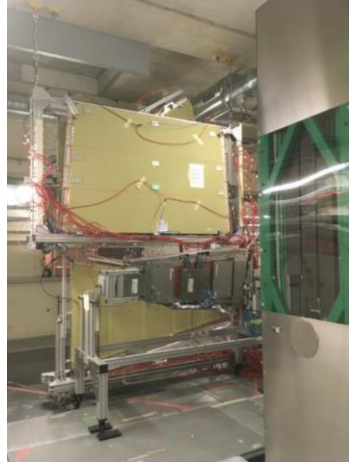
MWPC Based Muon Trigger



ATLAS-RPC



CMS - DT



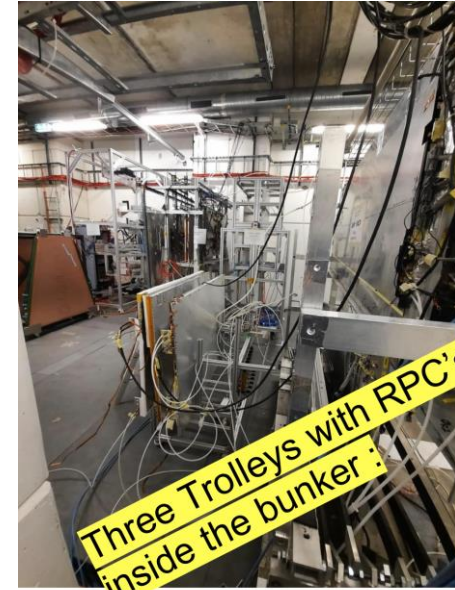
ATLAS MM



ATLAS sMDT



EP - DT

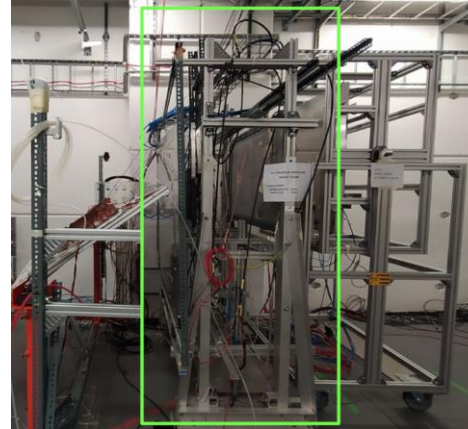


Three Trolleys with RPC's inside the bunker :

CMS - RPC



CMS - CSC

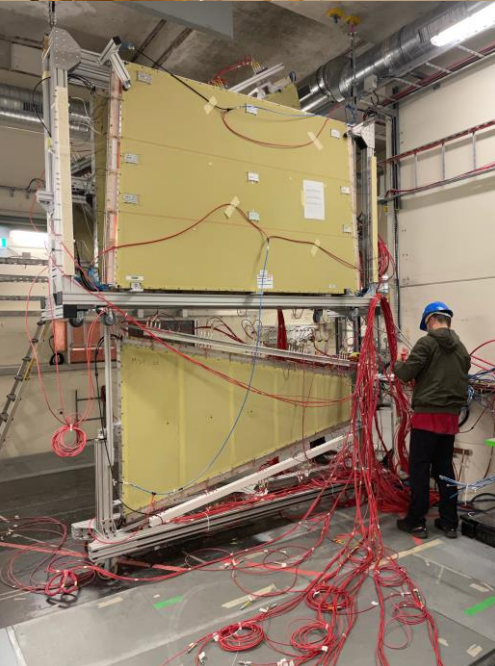


EcoGas



ATLAS - sTGC

Unshadowed long-term / high-field position provided to ATLAS Micro-Megas



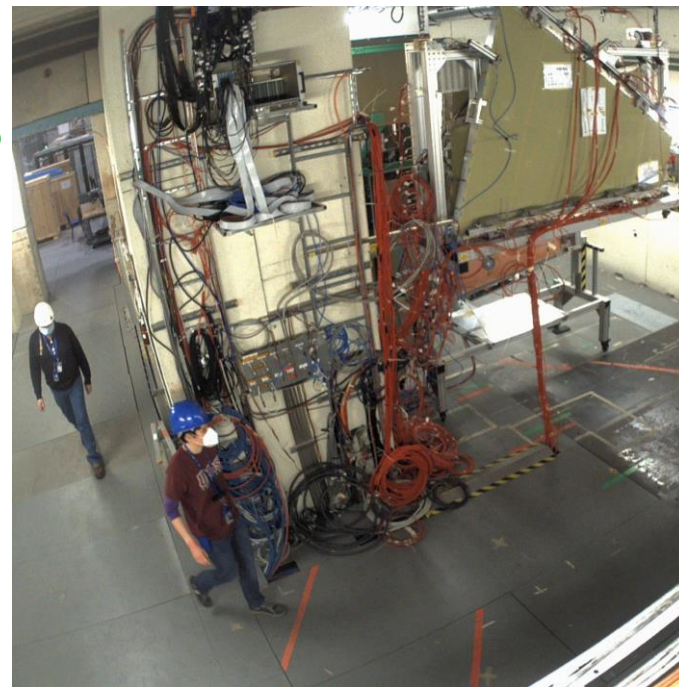
We always* find a solution!

*) within reasonable demands / conditions

GIF++ Operation 2020 & 2021 (?)

Challenging year with CoVid-19 pandemic

- GIF++ only closed during CERN lockdown **16.03-18.05**
- restarting as early as the LHC experiments
- **Operational otherwise the whole year**,
after implementing necessary CoVid measures
- However, **several installations postponed**
due to travel restrictions of essential people.
Annual irradiator maintenance postponed.
- Several delays in shipment of chambers, etc.



**Thanks to everyone (incl. users) who helped to
make it possible to keep operating GIF++!**

Challenges will continue for several months!

Upcoming Control Room usage during beam time needs to be defined

An outlook in the facility's restart in 2021 with enhanced flexibility for more physics !



EP-DT
Detector Technologies

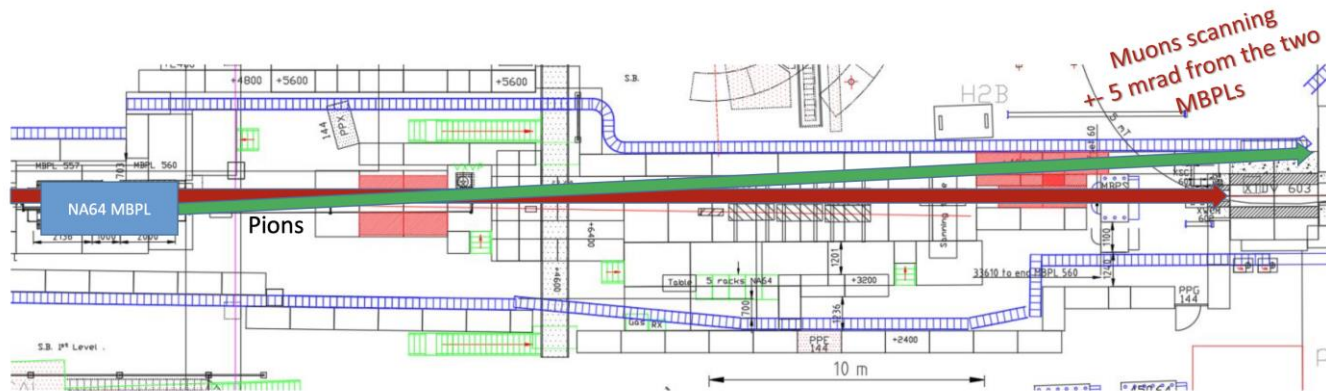
BE Beams Department

based on slides from N. Charitonidis (BE-EA)



- Two new beam dumps will be installed to allow for alternative creation of muons from a pion beam, potentially allowing the GIF⁺⁺ to run as secondary instrument
- Existing beam creation (upstream) will stay the default during dedicated H4 beam time until system is fully commissioned and more experience is collected. Also default when running in parallel with RD51.

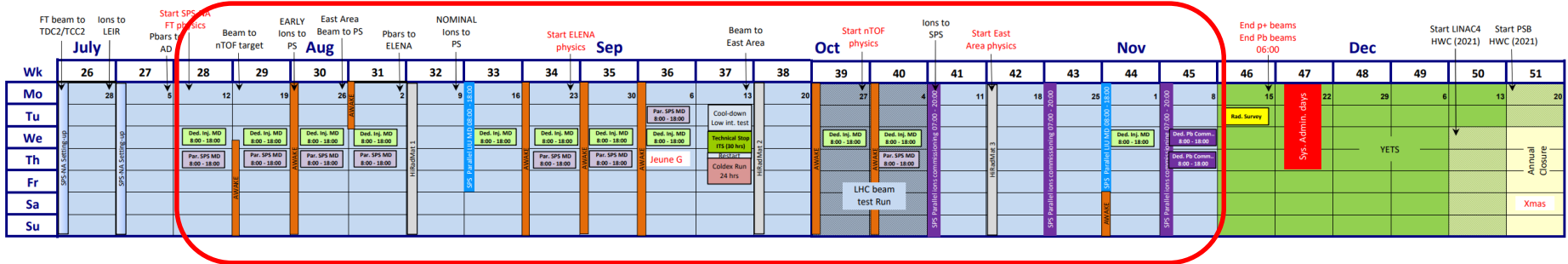
Now (!) under construction. Available for 2021 beam (hopefully)



- Two deflection magnets will allow a moderate ($\approx 25\text{cm}$) steering of the beam away from the bunker wall

GIF++ Beam Schedule

- ▶ Operation with Gamma Irradiator will continue without mayor stops foreseen
- ▶ Except 1 week irradiator maintenance (March or May)
- ▶ Current beam schedule: NA Physics from Jul. 12 until 14. Nov.



Nr.	Setup / Week
1	ATL NSW MM
2	ATL NSW sTGC
3	ATL RPC M0
4	ATL RPC Phase2
5	ATL sMDT
6	CMS CSC
7	CMS DT
8	CMS RPC
9	EP DT2
10	iRPC
11	ProToV-RPC
12	RER21/CBM
13	RHUM
14	RPC ECOGAS

- 14 dedicated muon beam requests in GIF++ received so far
- 7 weeks requested to SPS. We will have to see what is possible in this short beam year
- Dedicated beam time will be allocated by SPS Physics coordinator (around end of April)
- Allocation of space / beam-time inside the GIF++ will then be optimised by GIF Physics Coordinator
- First test of how expanded bunker will allow increased number of setups to participate in simultaneous beam time (up to 12 ?)

Outline

- IRRAD
- GIF⁺⁺
- Irradiation and Test Beam Facilities DBs
- Summary

Irradiation and Test Beam Facilities DBs

Two separate online database platforms for searching **irradiation facilities** and **test beams** at CERN and worldwide

- **Filtering** by radiation field/particle type, source or country
- **Entering and maintaining** the data by facility coordinators

CERN FACILITIES

IRRAD
The Proton Irradiation Facility (IRRAD) is located on the TB beam-line in the Meyrin site East Area Proton Synchrotron (PS). For the irradiations, it uses a 24GeV/c proton beam.

GIF
The new Gamma Irradiation Facility (GIF++) is located in the North Area. It combines a ^{60}Co source with a high-energy particle beam from the SPS H4 beam line.

CHARM
The Cern High energy Accelerator Mixed field facility (CHARM), located in the East Area, features a wide spectrum of radiation types and energies.

HiRadMat
The High-Radiation to Materials facility (HiRadMat), located in the Meyrin Site on the SPS accelerator is designed to provide High-Power LHC-type pulsed beams.

CERF
The CERN-EU high-energy Reference Field (CERF) is located in the North Area providing a neutron field for characterization of dosimetry at commercial flight altitudes and in space.

CALLAB
This new dedicated state-of-the-art facility replaces the ageing facility in building 172 (>30 years old). It houses several irradiation sources including the ^{60}Co source of ECDB.

Test Beamlines Database

This database contains a list of several different Test-Beam Facilities available at CERN, in Europe and Worldwide.

Search by Country: [All] Search by Particle Type: [All]

Show All

Facilities Database

This database contains a list of several different Irradiation Facilities available at CERN, in Europe and Worldwide.

To show which database, click on "Show Data".
To search by Country, Source Type, or Radiation Field/Type, select your filter in the dropdown menu.
If you would like to add a new facility, please first log in and then click on "Add Facility".
You can only modify the facilities that you are responsible for.
For further details please check our User Guide.

Search by Country: [All] Search by Source Type: [All] Search by Radiation Field Type: [All]

Installs:	Institute Name	Country	Facility Name	Source Type	Radiation Field/Type	Funding Details
0/0	Geneva Republic	Switzerland	Proton Irradiation Facility	Proton	Proton	
0/0	Uppsala University	Sweden	MESAS	Neutron generator	Neutron	
0/0	University of Lugano	Slovenia	Reactor Centre	Nuclear reactor	Gamma	AIDA 2020 TA
0/0	University of Jyväskylä DEPARTMENT OF PHYSICS	Finland	PROTON facility JYFL K-150 cyclotron	Cyclotron	Proton	
0/0	University of Jyväskylä DEPARTMENT OF PHYSICS	Finland	Radioisotope facility JYFL K-150 cyclotron	Cyclotron	Radioisotope	
0/0	University of Groningen	Netherlands	Irradiation of Materials (ANDORF) ring	Cyclotron	Proton, Alpha, Heavy ions	
0/0	University of California Davis	USA	McClain Nuclear Research Center	TRIGA Mark II	Neutron	
0/0	University of Birmingham	United Kingdom	UM-BMG40	Cyclotron	proton and light ions	AIDA 2020 TA
0/0	USC (Assembly Santiago Compostela)	Spain	Gamma facility	Co-60	Gamma	
0/0	University of Cambridge	United Kingdom	Radioisotope facility	Radioisotope	Radioisotope	

Test Beam Characteristics and Infrastructure

Beamline Characteristics	Infrastructure
Name: TB	FORM FIELD YES NO N/A See Comments
Particle type: electrons, hadrons, muons	Trigger signal & system
Particle polarity:	Tracker & Telescopes
Particle type details:	Geometer service
Particle intensity:	Magnets
Particle Momentum/Energy: 0.5 - 10 GeV/c	Slow Control
Particle Momentum/Energy:	Vacuum pipe
Particle Momentum/Energy:	Handling services (cranes,...)
Particle Momentum/Energy:	Module stages
Particle Momentum/Energy:	Electricity
Particle Momentum/Energy:	Gas
Experiments per beamline:	Cabling infrastructure
Experiments per beamline details:	Particle ID instruments
Beam Generation (Direct Extraction, Secondary Generation, parasitic, ...):	IT services
Beam size:	Comments:
Bunch clock:	
Spill length:	
Spill rate:	
Particles per spill:	
Effective flux:	
Beam line physics:	
Comments:	

<http://cern.ch/tbdb>

<http://cern.ch/irradiation-facilities>

Summary

➤ IRRAD:

- In maintenance since 2018
- Upgrades on technical area in 2020
- Hardware and software upgrades
- Beam commissioning in Autumn 2021 (and maybe experiments?)

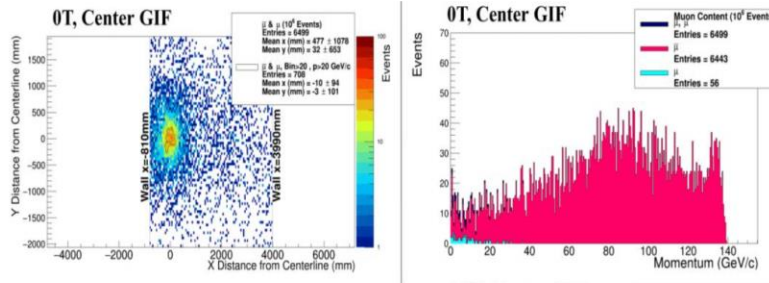
➤ GIF++:

- In 2020, despite COVID19, GIF++ operational (several new setups)
- Bunker upgrade in 2019
- Improved muon beam in 2021
- Beam time will be allocated between July and November 2021

BACKUP

Monte-Carlo comparison

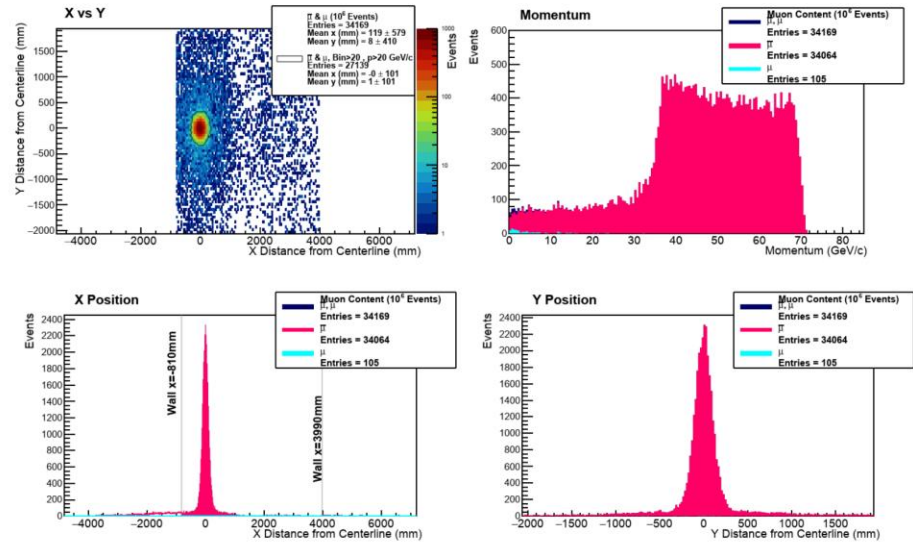
- Old Configuration



6.5k muons per 10⁶

Cost: negligible

- * New Configuration (80 GeV) **from 2021**



35 k muons per 10⁶

Better defined momentum and more 'focused' beam

26/1/2021



N. Charitonidis - GIF++ Annual Meeting

4