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

Blerina Gkotse, Martin Jaekel, Pierre Jouvelot, Isidre Mateu, Viktoria Meskova, Alexander Smith Moelholm, Alfredo Nunez, Giuseppe Pezzullo, Federico Ravotti, Ourania Sidiropoulou

Current Team Members

- Team Responsible
- IRRAD Coordinator, Facilities EXSO

Federico, STAFF

- GIF^{++} Physics Coordinator

Martin, STAFF

- Facilities Manager, GIF^{++} EXSO
- Users Supervisor

Giuseppe, STAFF

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

Blerina, FELL (Jan. 21)

- Data Management
- AIDAinnova EU-project

Alfredo, TECH (Oct. 20)

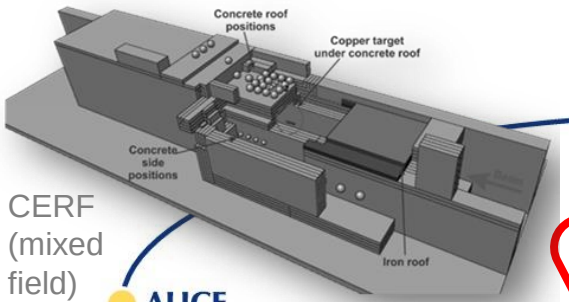
- u-BPM project (EPFL-CMi)
- R&D on Beam Instrumentation

Ourania, FELL (ATLAS, Feb. 20)

Outline

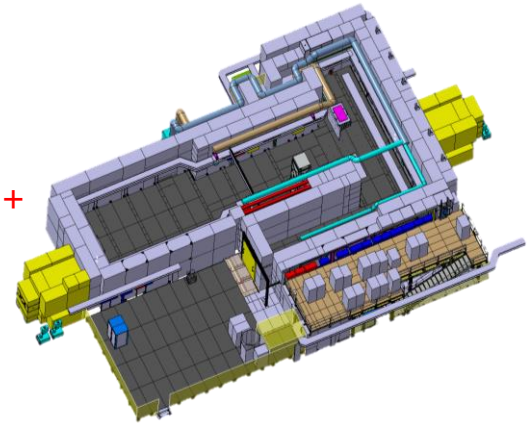
- IRRAD
- GIF^{++}
- Irradiation and Test Beam Facilities DBs
- Summary

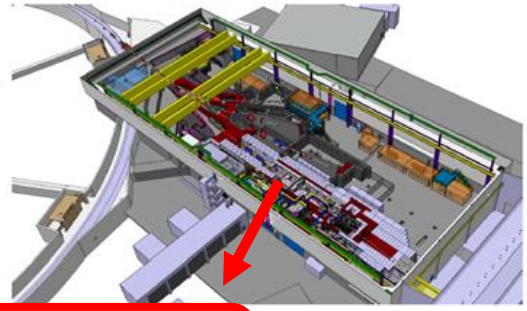
CERN Irradiation Facilities



CERF (mixed field)

GIF++ (gamma + muons)



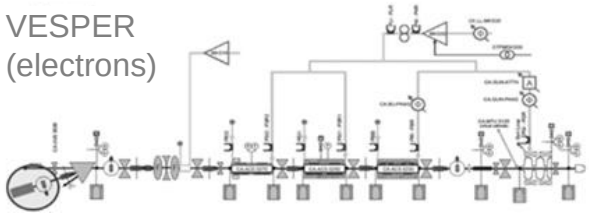


CALLAB (irradiation sources)

IRRAD (protons)

CHARM (mixed field)

VESPER (electrons)



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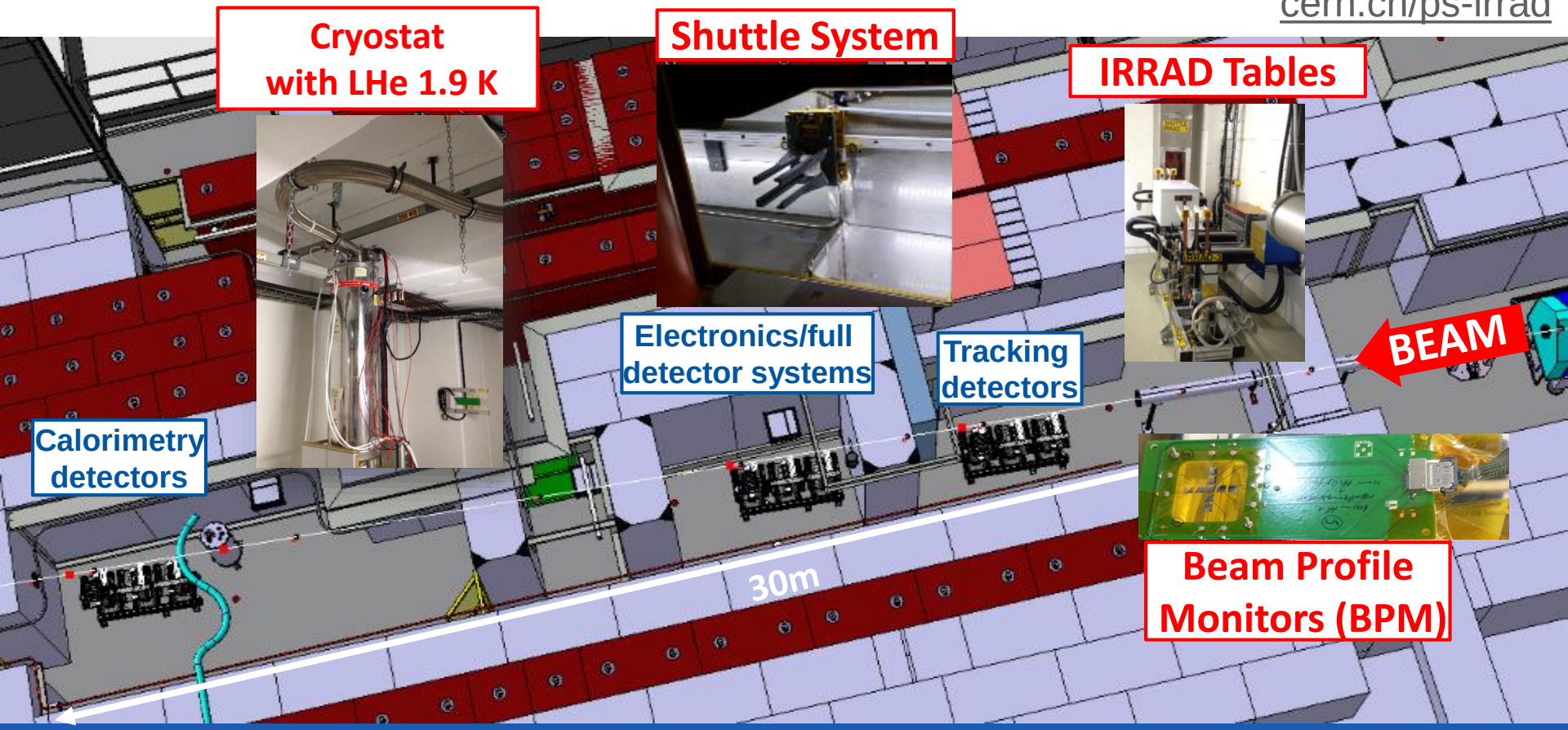
CERN Proton Irradiation Facility (IRRAD)

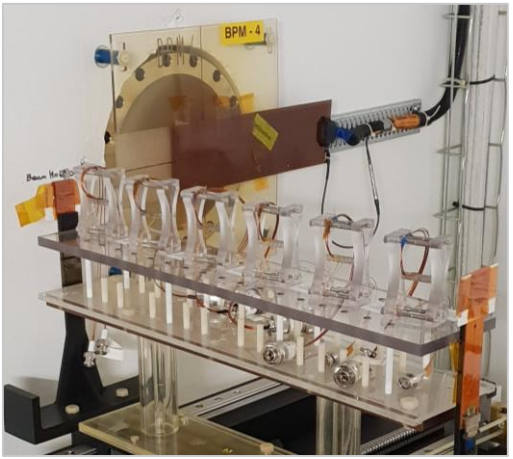
- Testing components of HEP experiments
- 24 GeV/c, Gaussian 12×12 mm^2 FWHM
- Spills of 400 ms every ~10 s
- Fluence of 1×10^{16} p/cm^2 in 14 days
- Scanning also in dimensions of 10×10 cm^2
- Low-temperature irradiation (-25°C)

cern.ch/ps-irrad



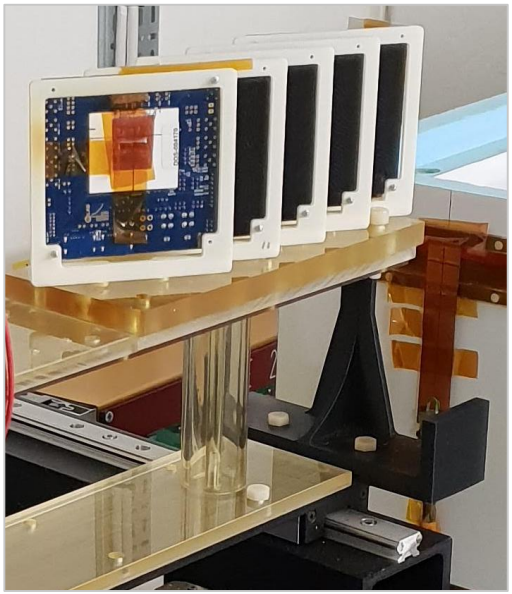
IRRAD Experiments in 2018

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

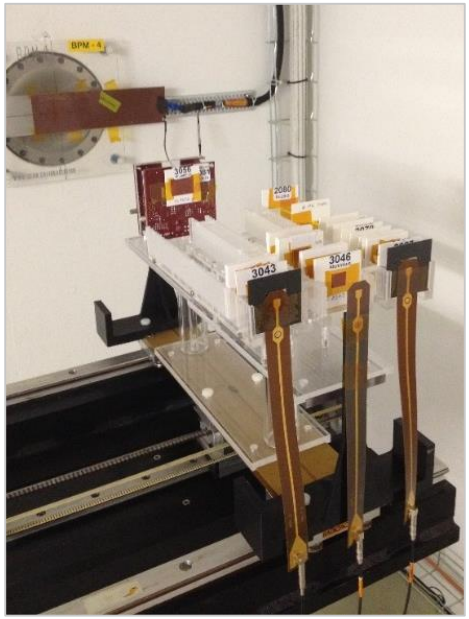


Piezo actuators

ECAL crystal



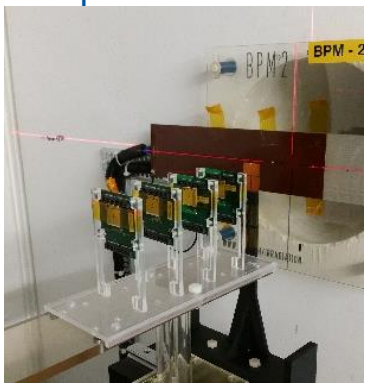
RD53A modules

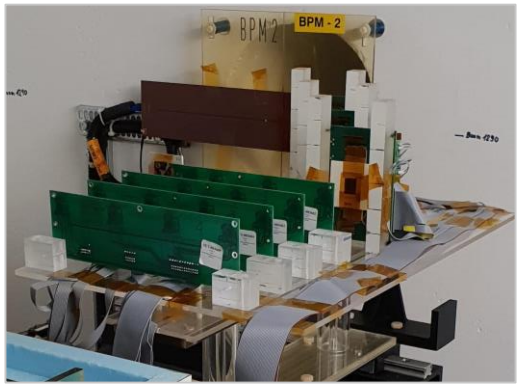


Si pad diode

Full-tracking detector module

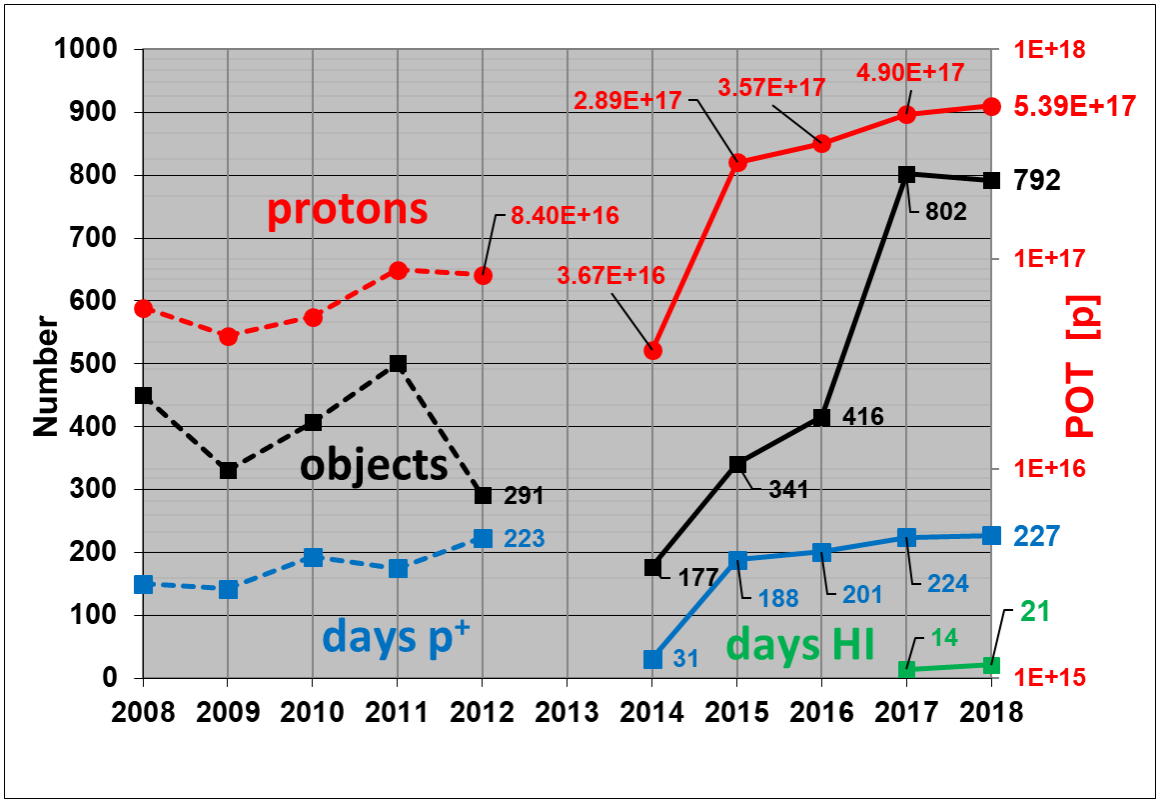
Samples on shuttle

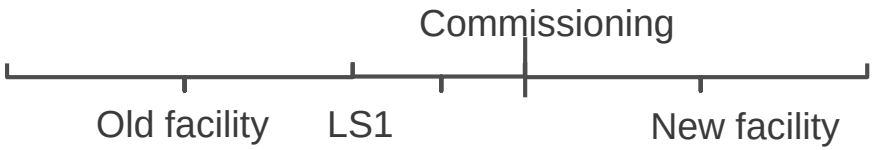


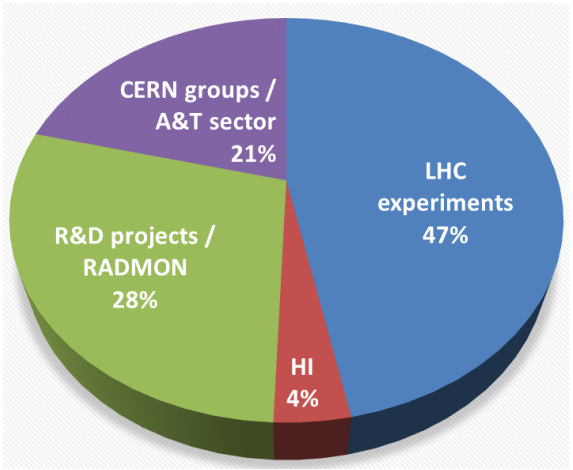


CLARO ASIC

IRRAD Statistics for the Last 10 Years

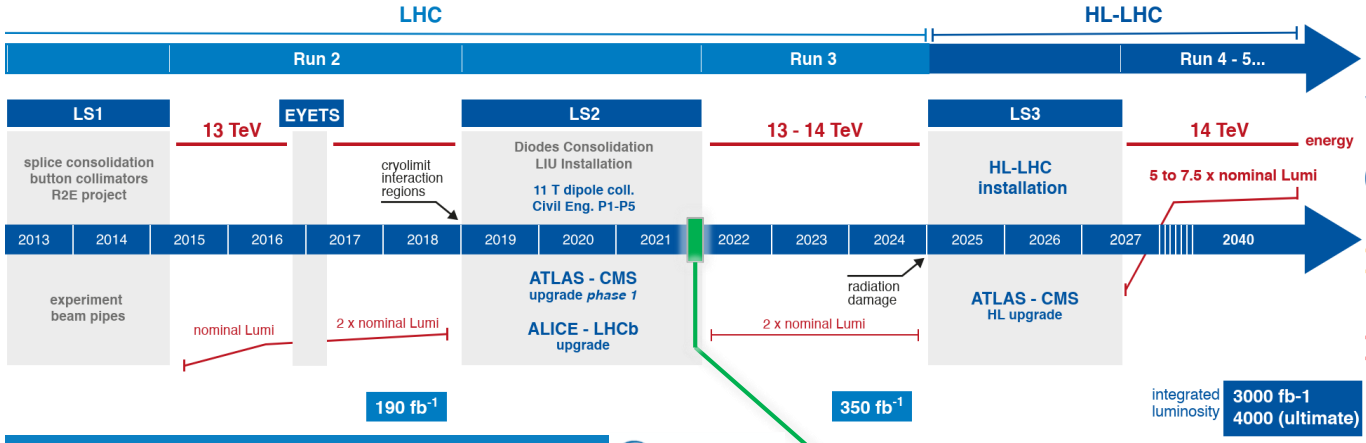






Repartition of the users in 2018

IRRAD Towards Phase II Upgrade



Semiconductor/inner detectors will face

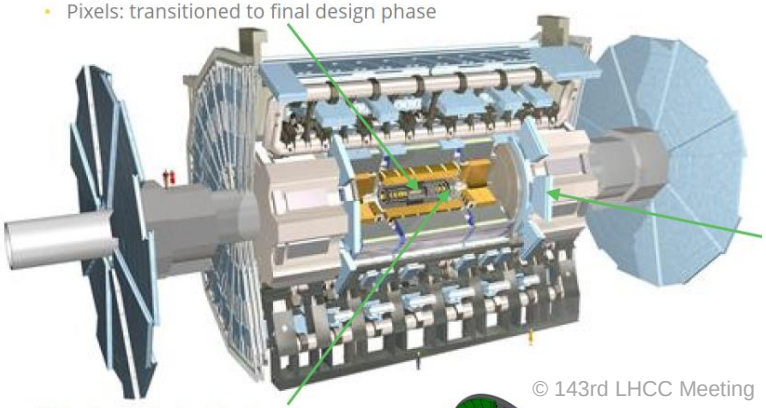
>10^{16} n_{eq}/cm^2 (HL-LHC)

>$7x10^{17}$ n_{eq}/cm^2 (FCC-hh)

Phase-II upgrade

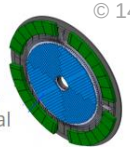
ATLAS EXPERIMENT

- 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



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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

Registration
- Users
- Experiments
- Samples

Planning
- Schedule
- Beam interaction quantities
- Capacity
- Dosimeter/sample assignment

Operation
- Irradiation status
- Control system
- Beam Instrumentation

Dosimetry
- Gamma spectrometry
- Proton fluence calculations

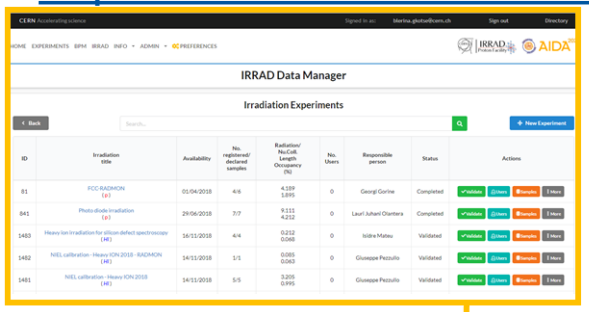
Traceability
- Logistics/Infrastructure
- Transport

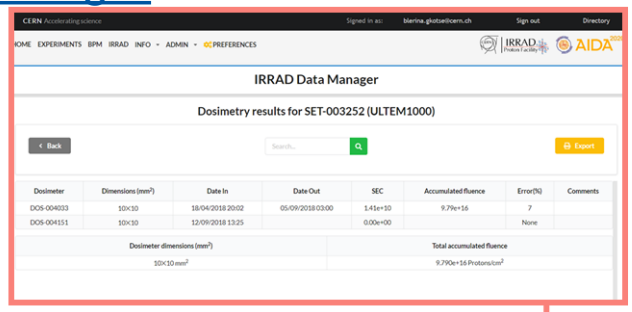
History
- Reproducibility
- Dissemination

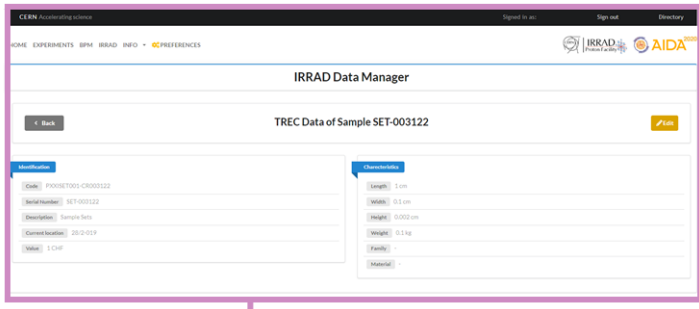
Before | During | After

IRRAD Data Manager (IDM)

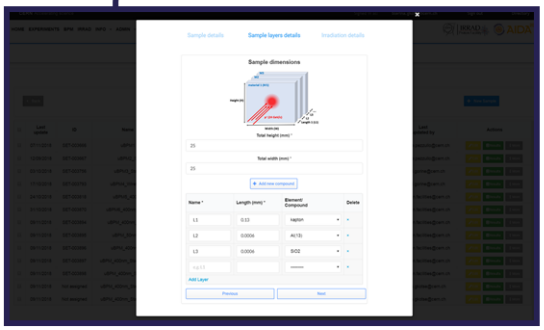
A **unified data management tool** for Irradiation Experiments follow-up
http://cern.ch/irrad-data-manager

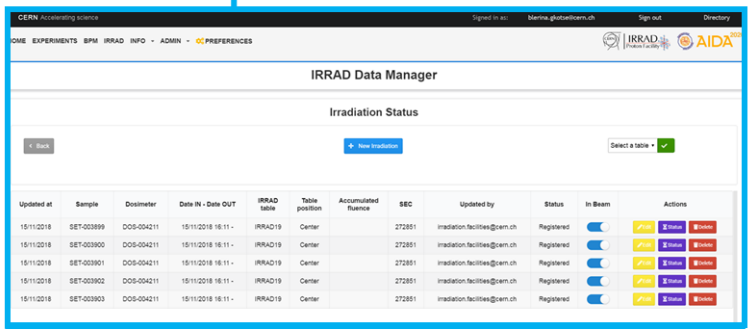


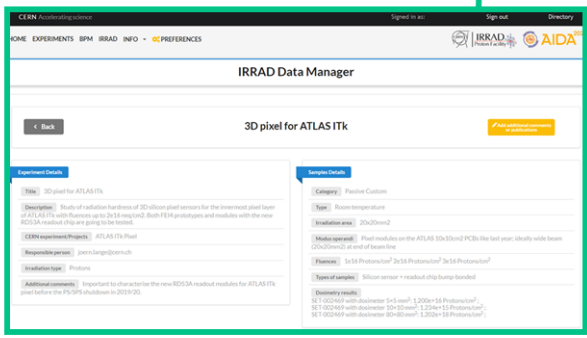




Registration → **Planning** → **Operation** → **Dosimetry** → **Traceability** → **History**







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

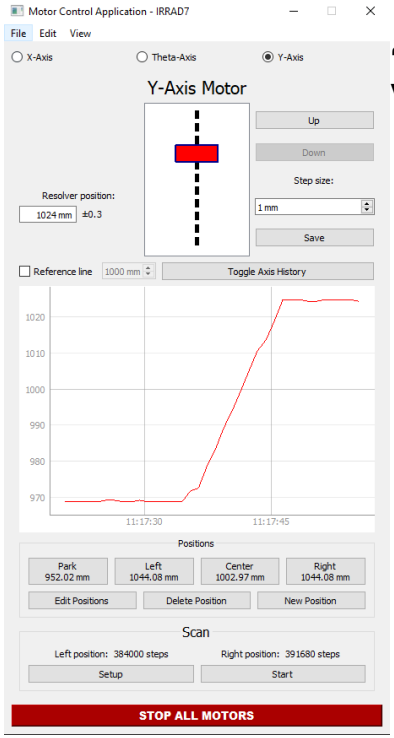
IRRAD Control System

- **P**ython-based **I**RRAD **M**otor **C**ontrol **A**pplication (**PIMCA**)
- based on pyQT (python) – no license required
- compatible with Windows and Linux
- database in the backend

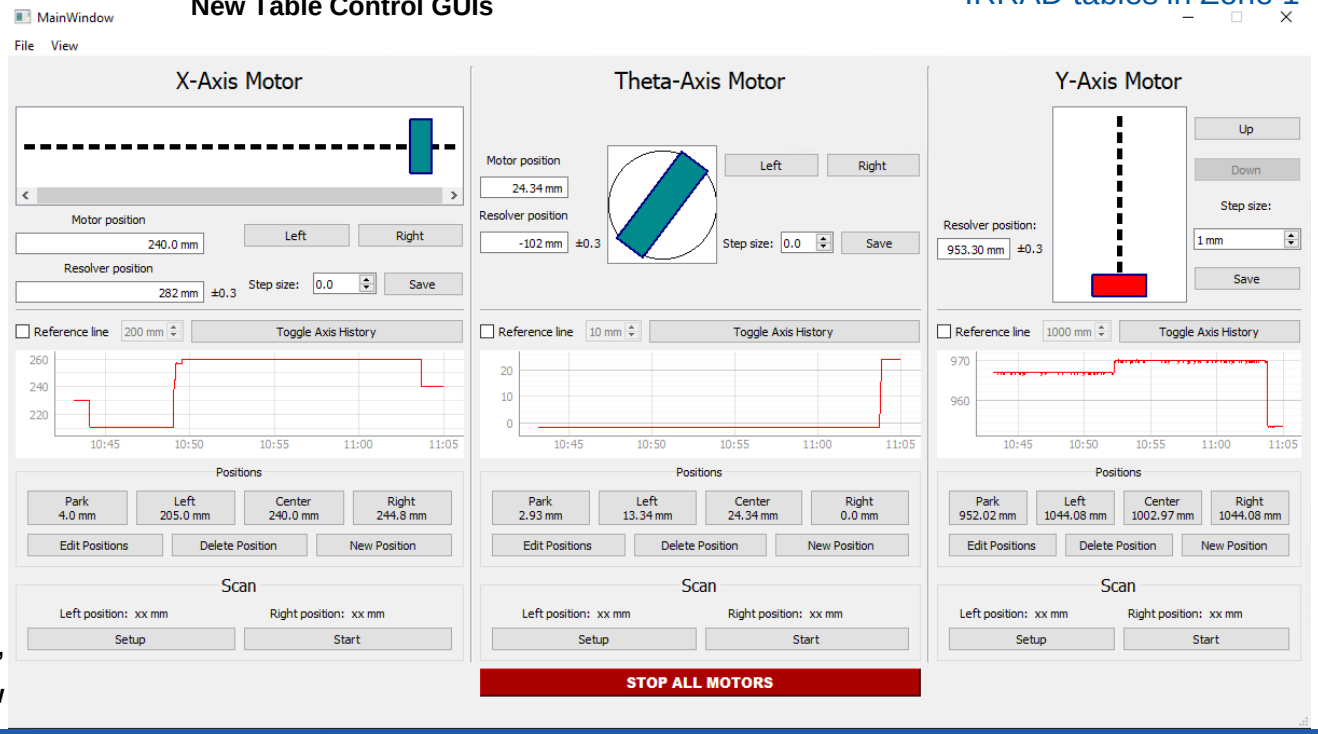
IRRAD tables in Zone 1

New Table Control GUIs

"single-axis" view

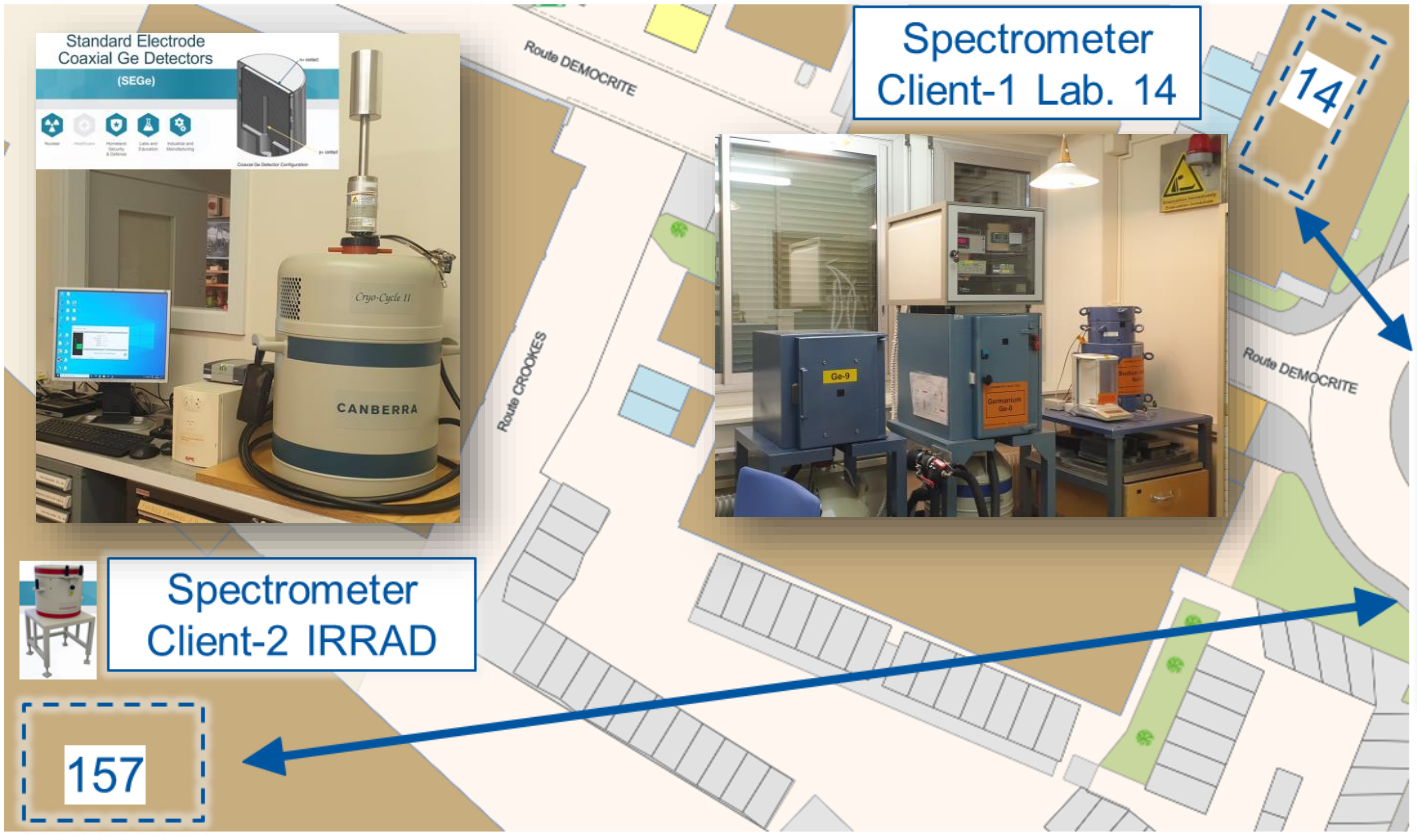


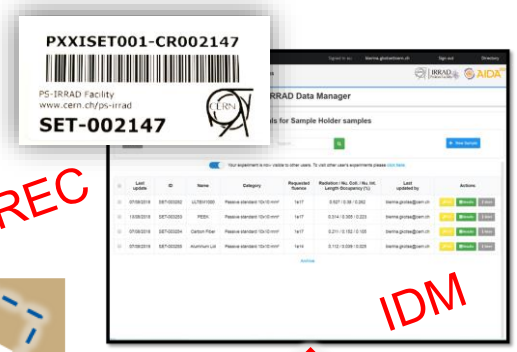
"dashboard" view



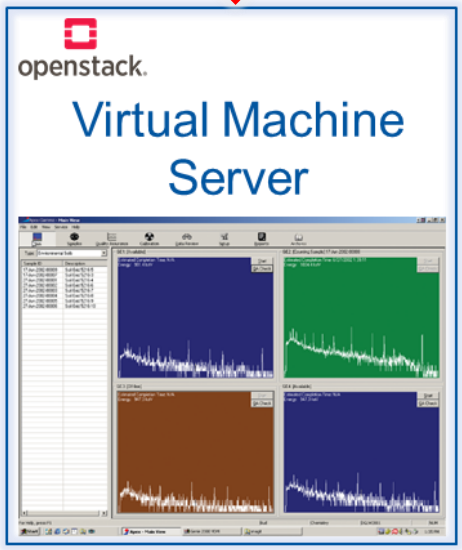
IRRAD γ-Spectrometry

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



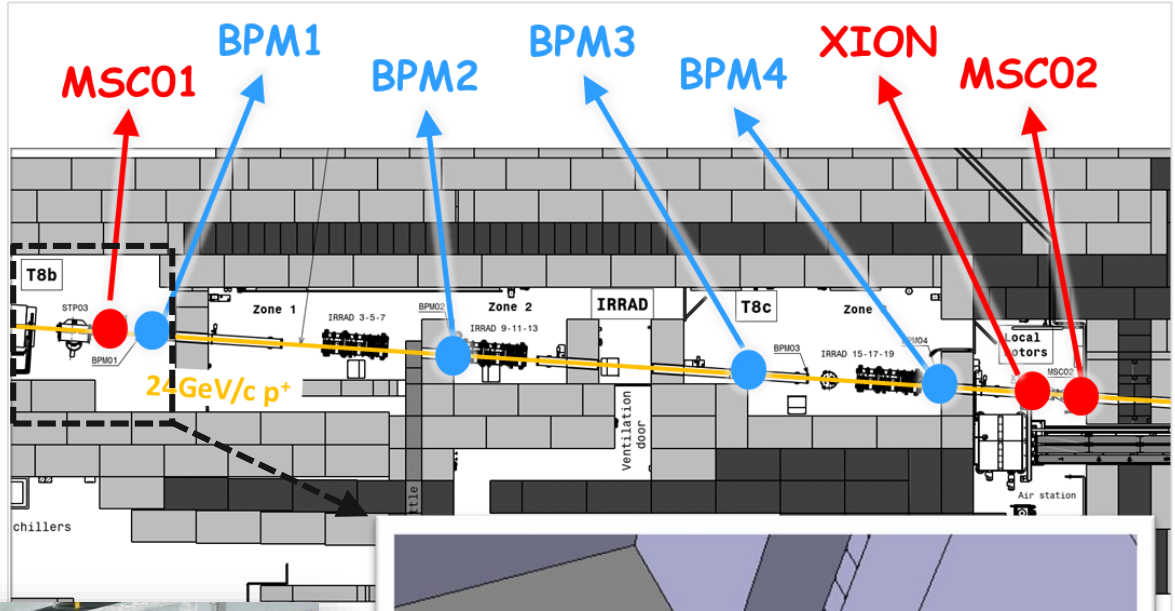


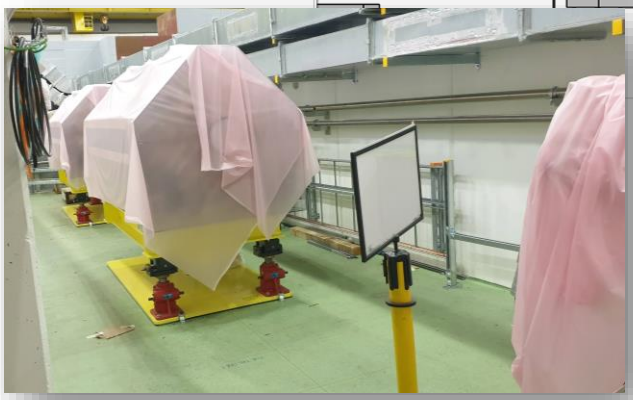
ARAMIS

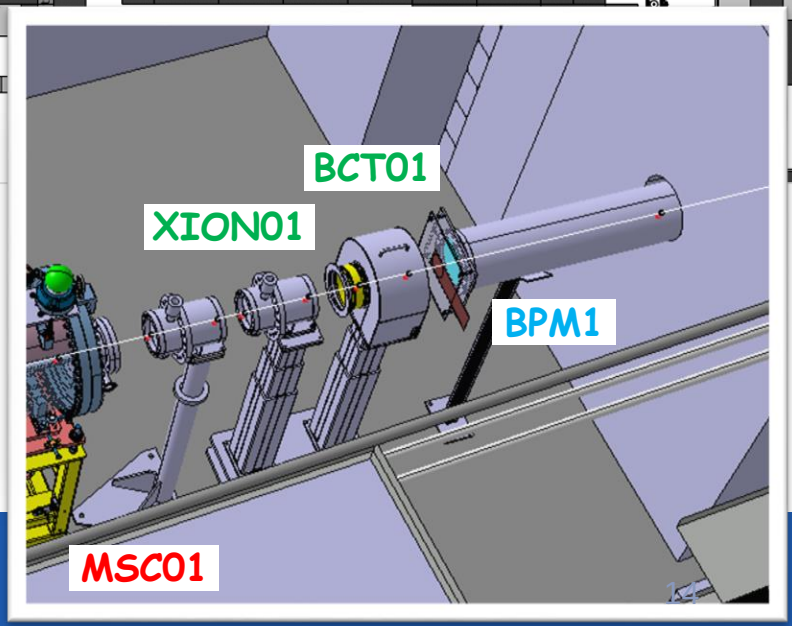


IRRAD Beam Instrumentation

- 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





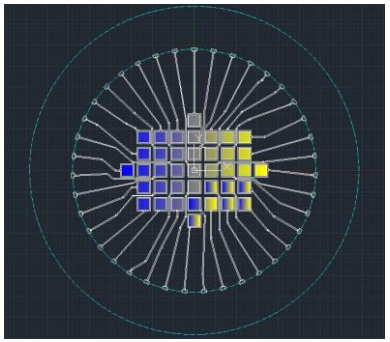


Ultra High-level Radiation Monitoring with Thin Metal Nano-layers: ***NanoRadMet***

- **Understand the SEE proprieties of ultra-thin (nm) metal layers exposed to ultra-high particle Φ**

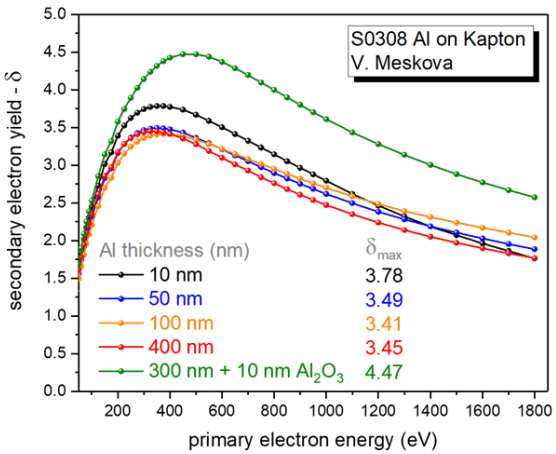
- **Engineer a new Beam Profile Monitor device: u-BPM**
  - usable with **low E particles** (MeV)
  - simple operation (IRRAD) & **radhard**
  - higher sensitivity
  - lower activation
  - **non-invasive (X_0<1% vs 30%)**

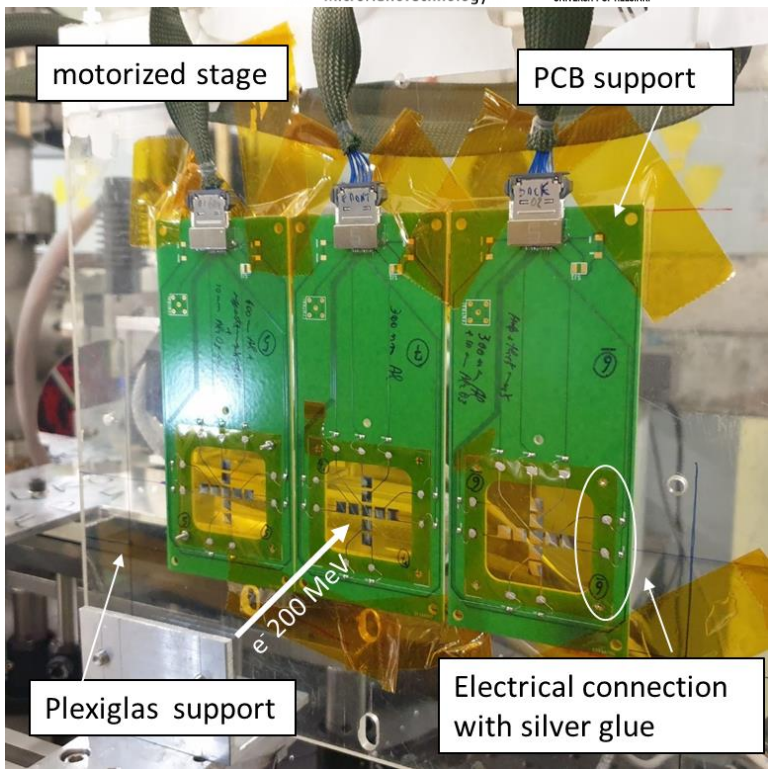
O. Sidiropoulou EP-DT Seminar "Beam Profile Monitors based on thin-film nanolayers for the IRRAD Proton Facility



39 ch. BPM device

SEY measurements (TE-VSC)



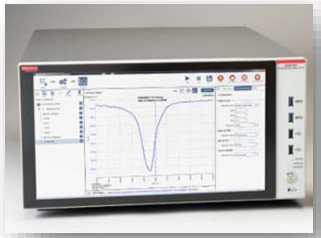


Prototypes of **new full u-BPM devices** being tested at VESPER facility (200 MeV electrons)

IRRAD Technical Area

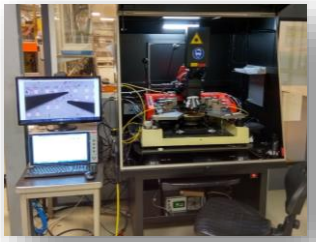
- reduce transport of irradiated material
- increase samples storage / handling capabilities
- provide users with a **laboratory** & advanced **characterization tools**

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



Keithley 4200A SPA

Keithley 2657A Extension
HV SMU up to 3kV



Suss PM8 Probe Station

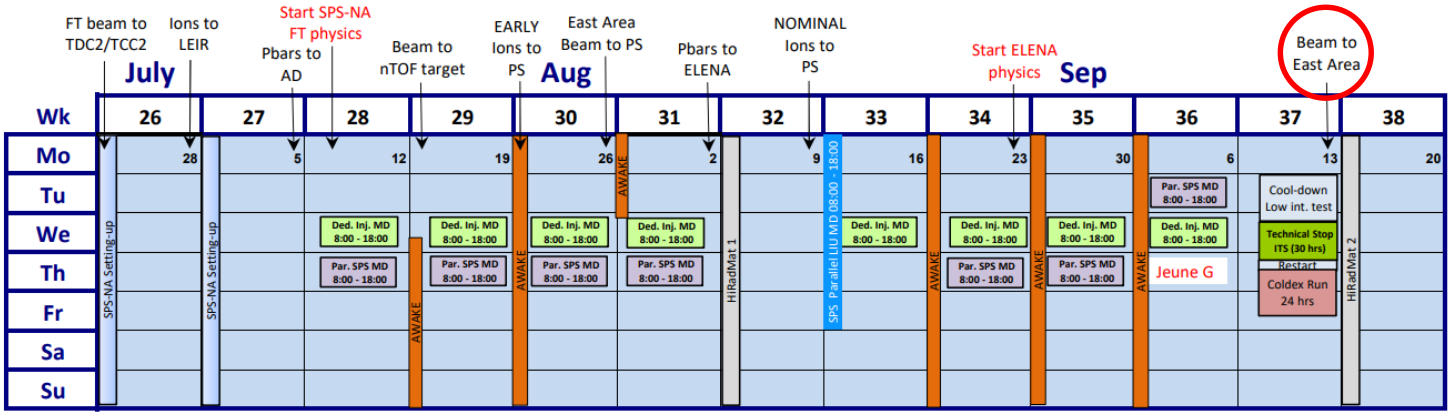
TH100-C Climatic Chamber

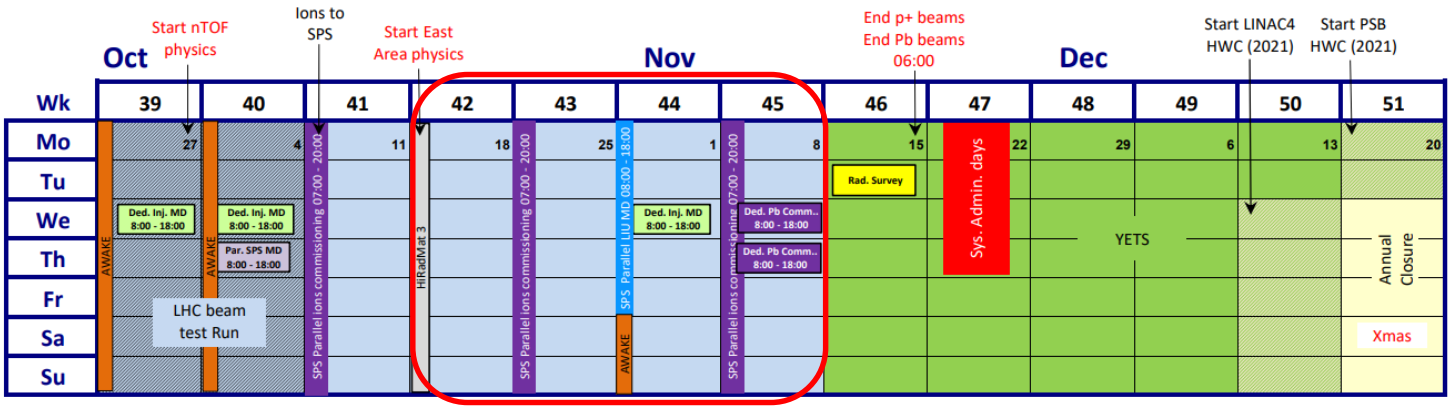
IRRAD Restart Schedule

- 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 ...





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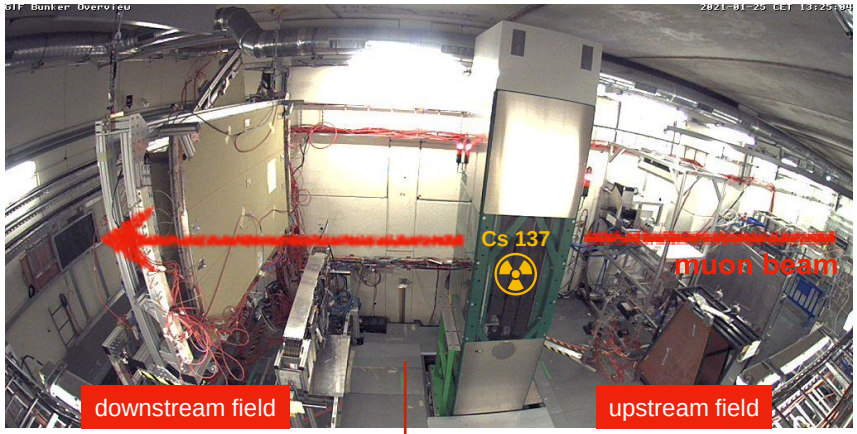
GIF++ @ EHN1

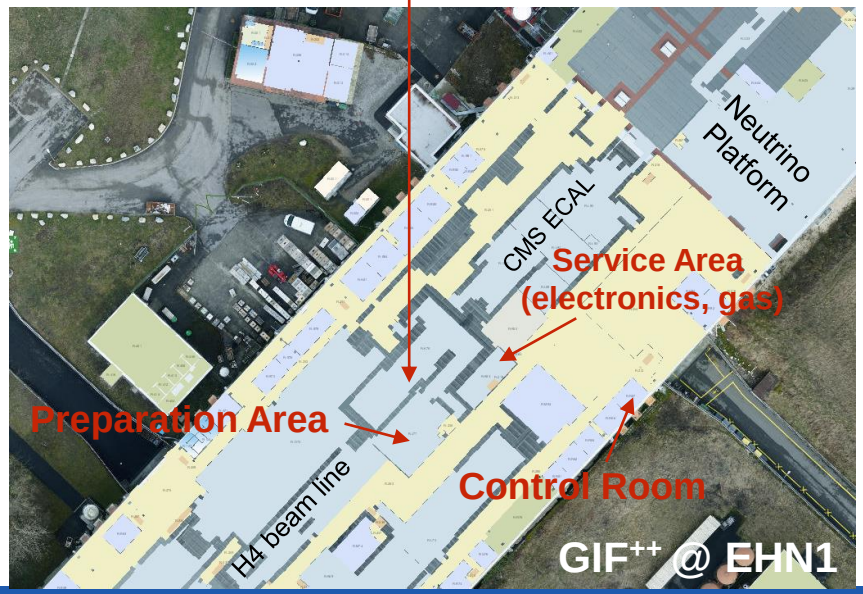
EP-DT Detector Technologies

Beams Department

Irradiator operation throughout the whole year

Irradiation Bunker





- Joint facility, operated by EP-DT and BE-EA
- Unique place, combining a high-energy muon beam with a 12 TBq ^{137}Cs gamma source
- Designed for testing real-size detectors, of up to several m^2, as well as a broad range of smaller prototype detectors and electronic / optical components.
- 160 m^2 irradiation bunker with 2 independent irradiation zones (≈ 30+75 m^2), 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++ Facility Layout

GIF++ Main R&D :

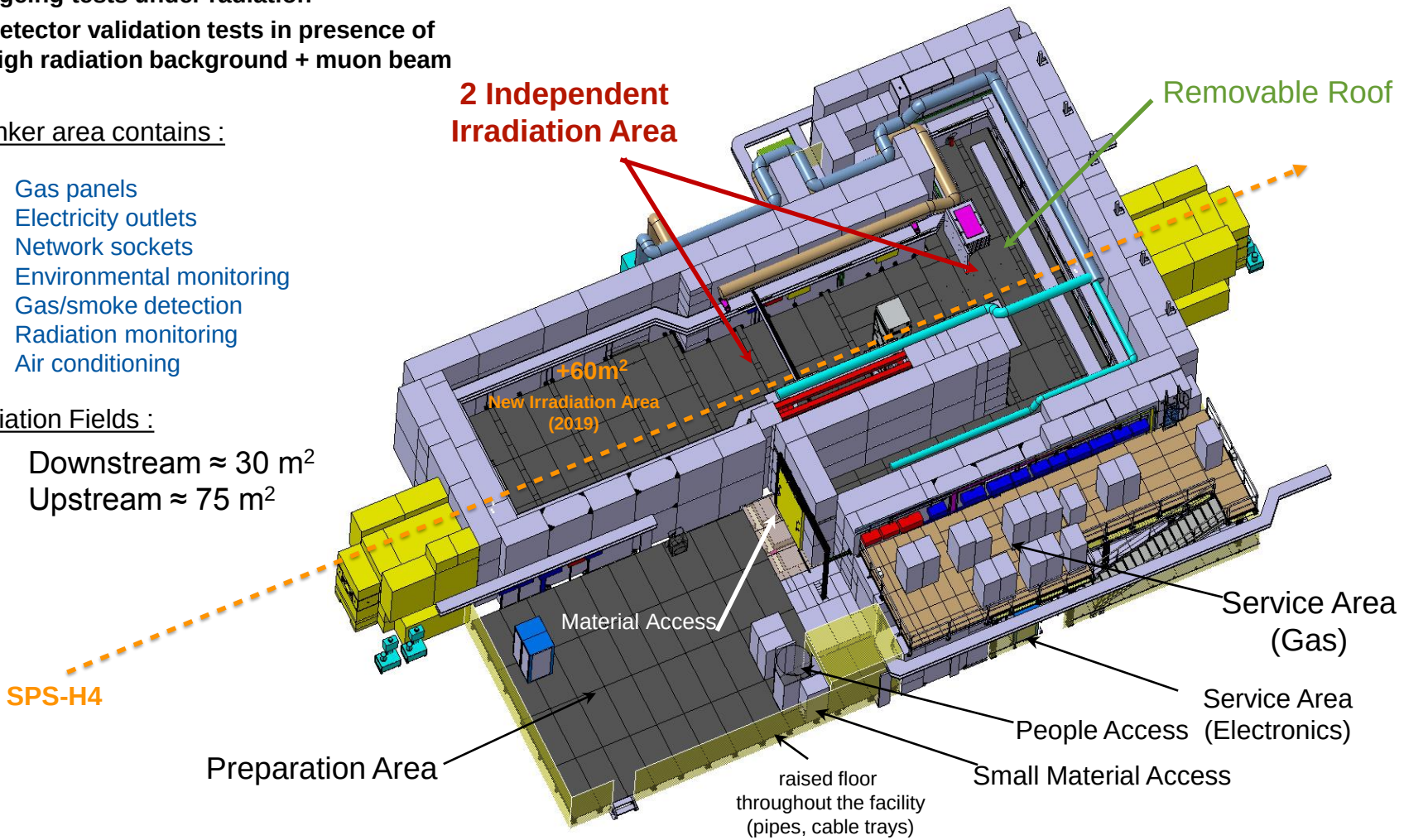
- **Ageing tests under radiation**
- **Detector validation tests in presence of high radiation background + muon beam**

Bunker area contains :

- Gas panels
- Electricity outlets
- Network sockets
- Environmental monitoring
- Gas/smoke detection
- Radiation monitoring
- Air conditioning

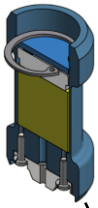
Irradiation Fields :

- Downstream ≈ 30 m^2
- Upstream ≈ 75 m^2

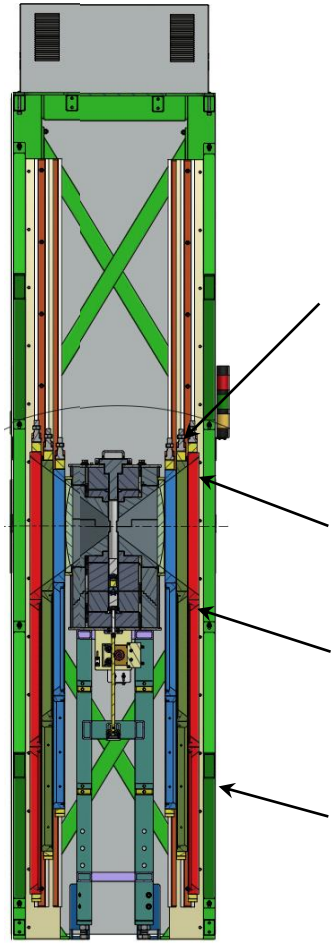


GIF++ Irradiator & Attenuation Filters

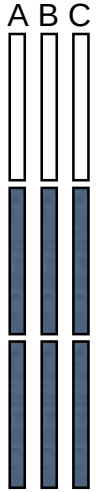
One ^{137}Cs source, two identical attenuation systems, each consisting of one angular correction filter (Fe) and 6 absorption filters - a total of 14 custom shaped filters



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



Angular correction filter provides uniform photon distribution for large area detectors

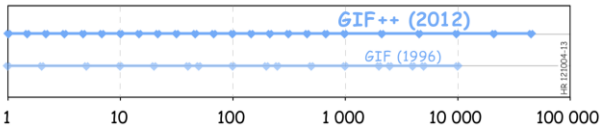


Filter System :

Absorption factor		
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

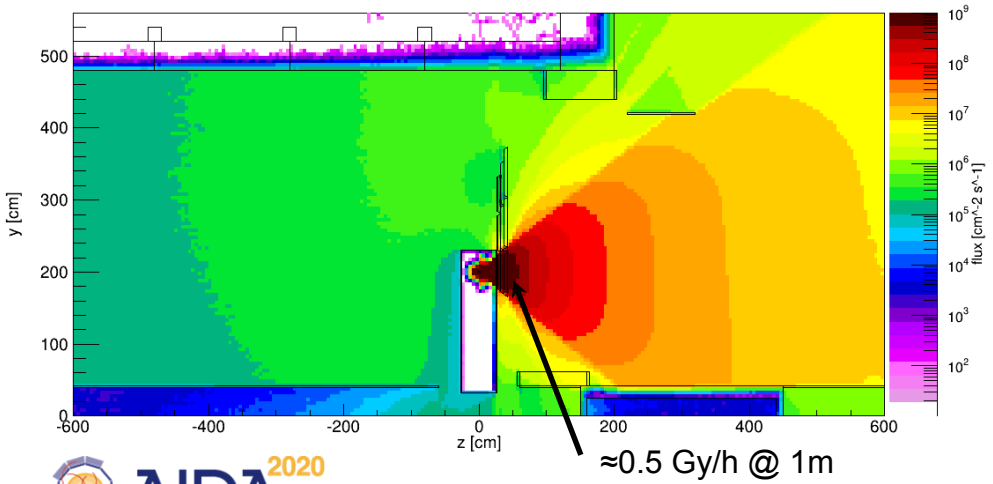


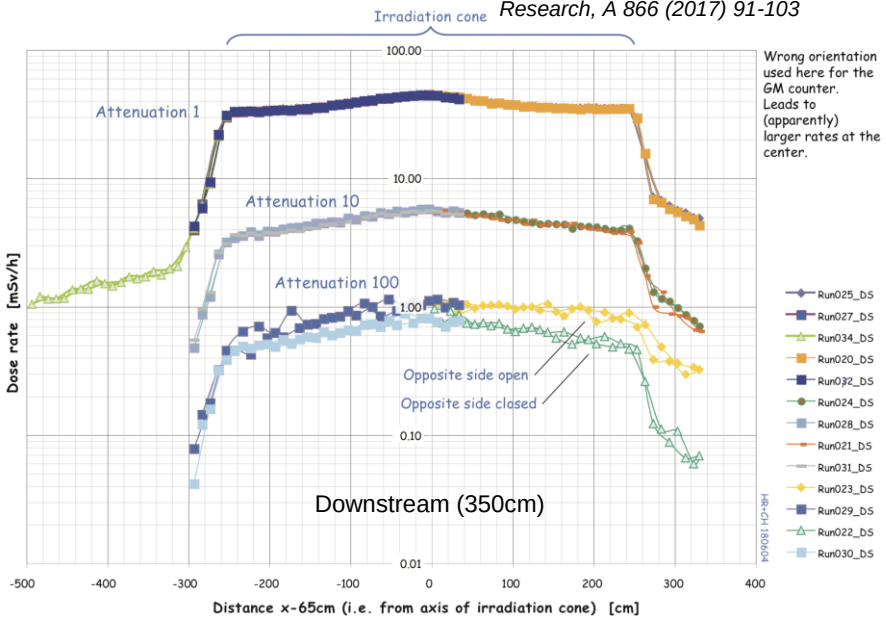
(calculated values for un-scattered gammas)

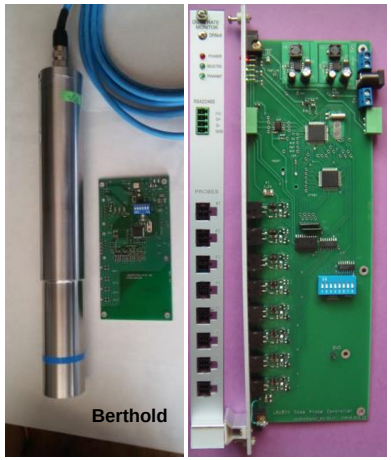
GIF++ Radiation Field & Monitoring

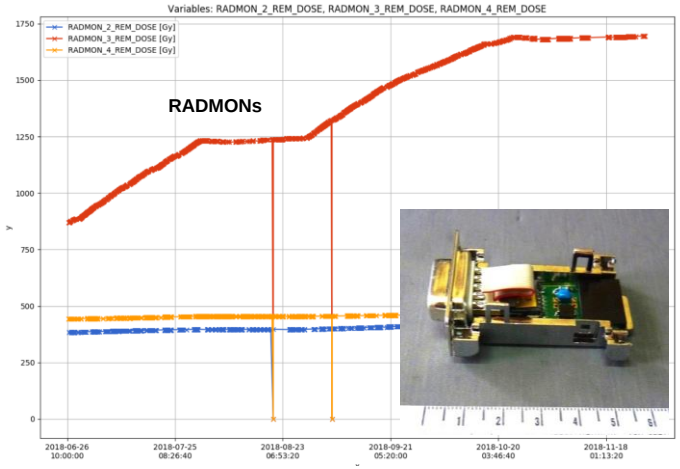
The Radiation Field in the New Gamma Irradiation Facility (GIF++) at CERN
Nuclear Inst. and Methods in Physics Research, A 866 (2017) 91-103

Total flux, one field, without filters







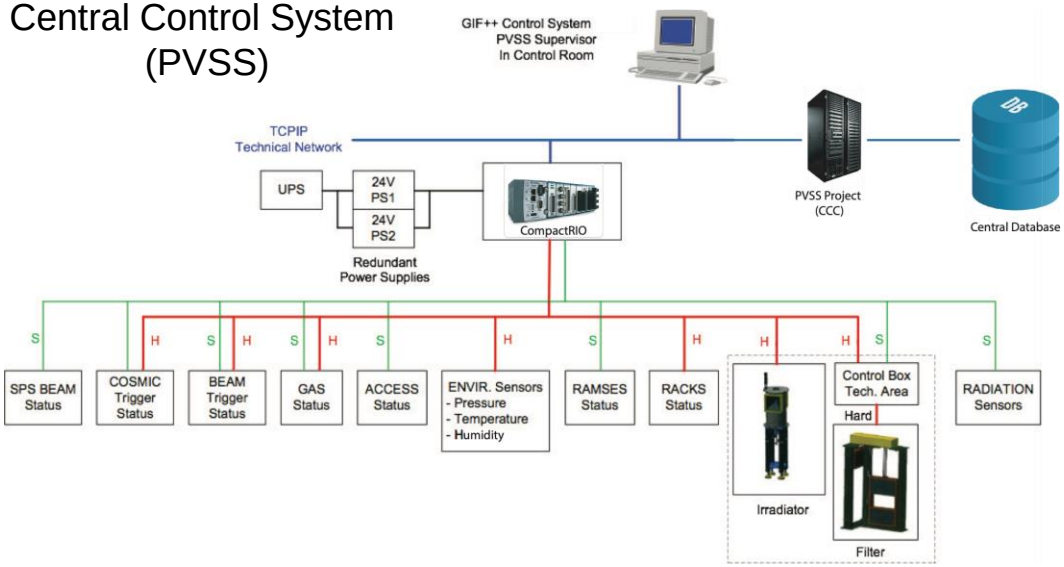


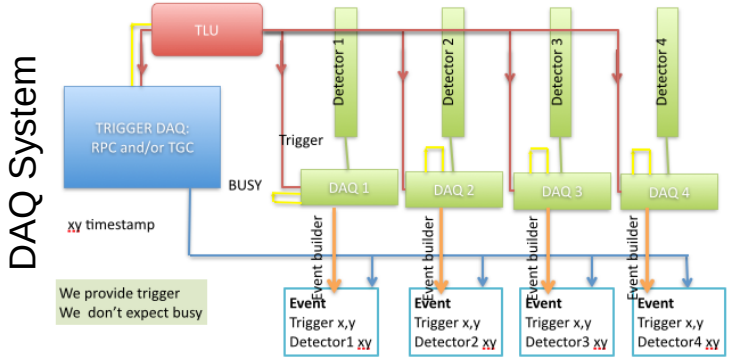
- 12 x RADMON "movable" sensors
- 2 REMUS detectors, on DIP & TIMBER
- 2 Berthold counter GM LB6500
- Automess AD6 with external probe
- 3.2m translation stage for field mapping

Optional Half Filter

GIF++ Available Infrastructure

Central Control System (PVSS)

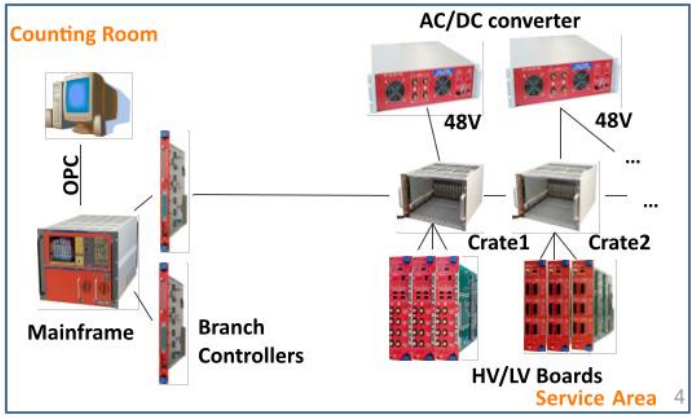




Monitoring (for both atmospheric and gases): p, T, rH
Baseline: 4 gas and 6 atmospheric sampling points

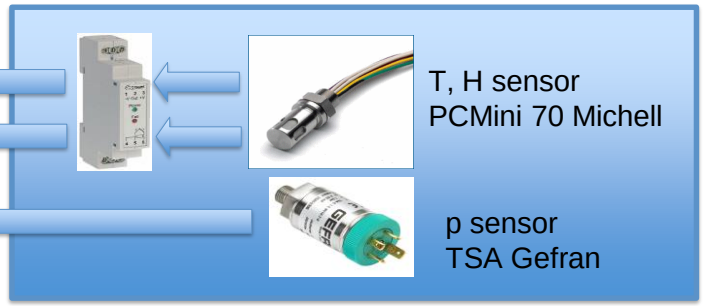
Beam Trigger
(2 pairs of scintillators)

DCS System



Gas and Environmental sensors

CAEN
ADC 3801



Central Gas System

EP-DT-FS

R.Guida, B. Mandelli et al

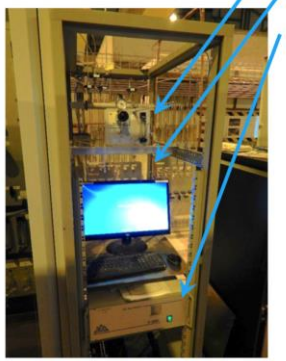
The gas system infrastructure is a key element of the successful R&D programs performed at the GIF++

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

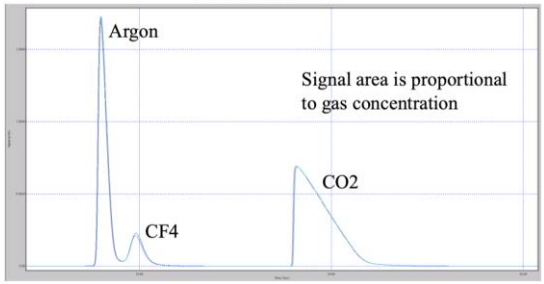
Wide range of gases available
Possibility to use pre-mixed bottles (local gas point)

AIDA 2020 **Partial funding of the gas system equipment and two CERN technical students**

Gas recirculation module



Gas chromatogram



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

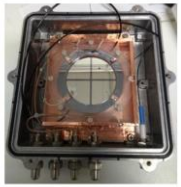
GIF++ Operation 2020

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.

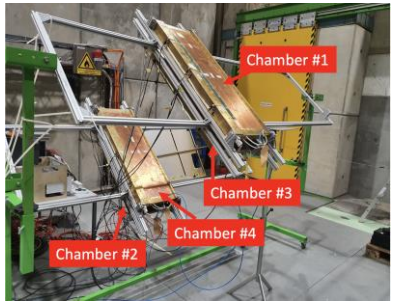
- **Mass testing of chamber very demanding on the overall coordination, with multiple access / chamber exchange per week from both MM and sTGC**
- **In addition a high-priority long-term study (several months) had to be started at the end of 2020 to test the feasibility of using Isobutane in the NSW 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!

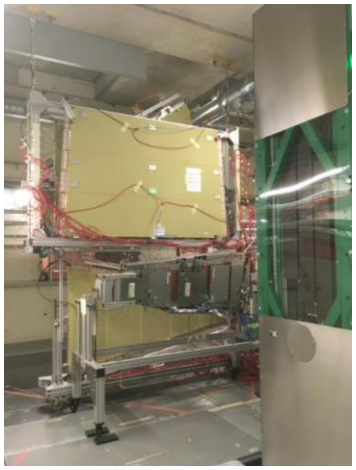


ProTOV-RPC R&D

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



MWPC Based Muon Trigger



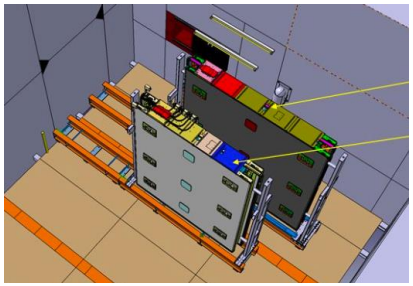
ATLAS MM

ATLAS sMDT

EP - DT

CMS - RPC

ATLAS-RPC



CMS - DT

CMS - CSC

EcoGas

ATLAS - sTGC

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

*) 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 !

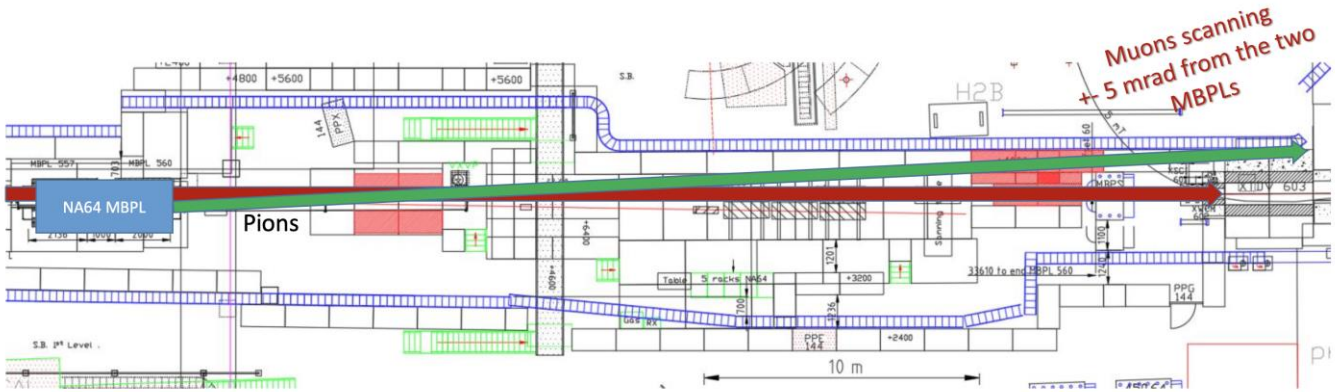
EP-DT Detector Technologies

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.

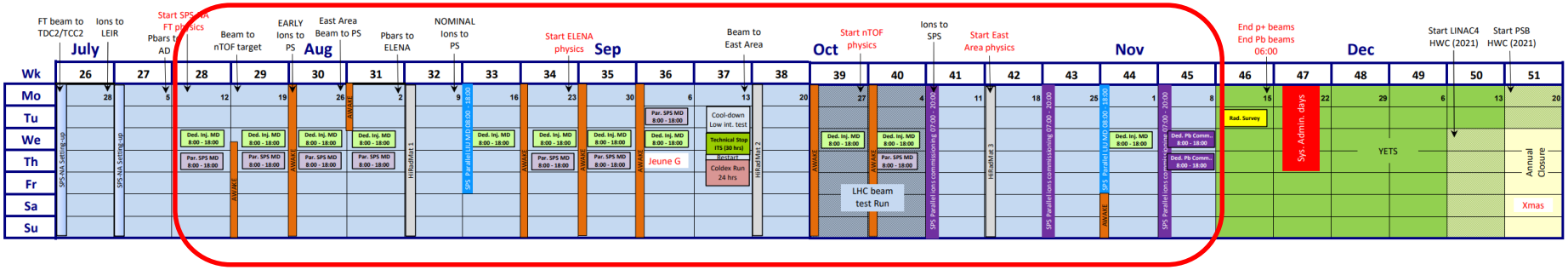
Now (!) under construction. Available for 2021 beam (hopefully)



- Two deflection magnets will allow a moderate (≈ 25cm) 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 ?)

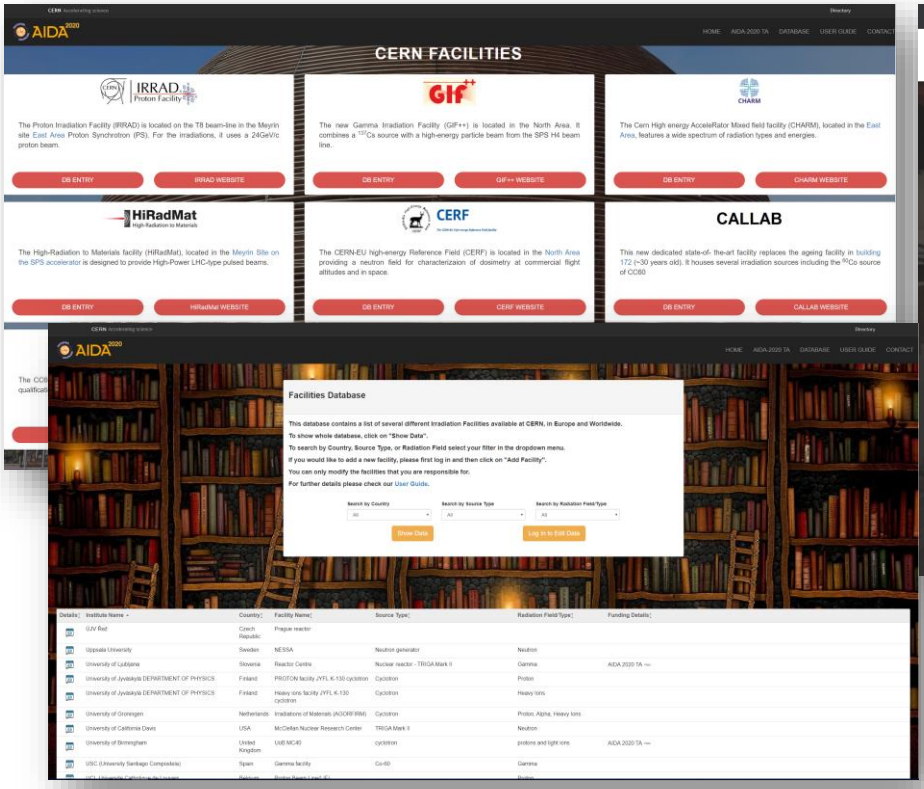
Outline

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

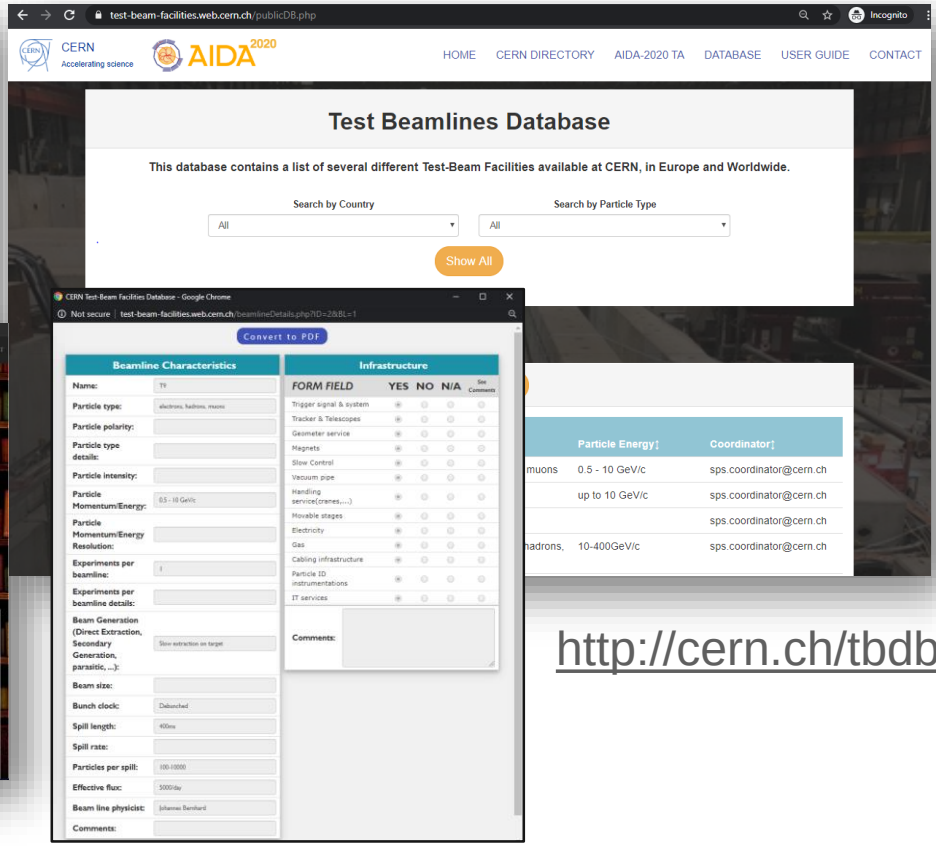
Irradiation and Test Beam Facilities DBs

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



http://cern.ch/irradiation-facilities



http://cern.ch/tbdb

Summary

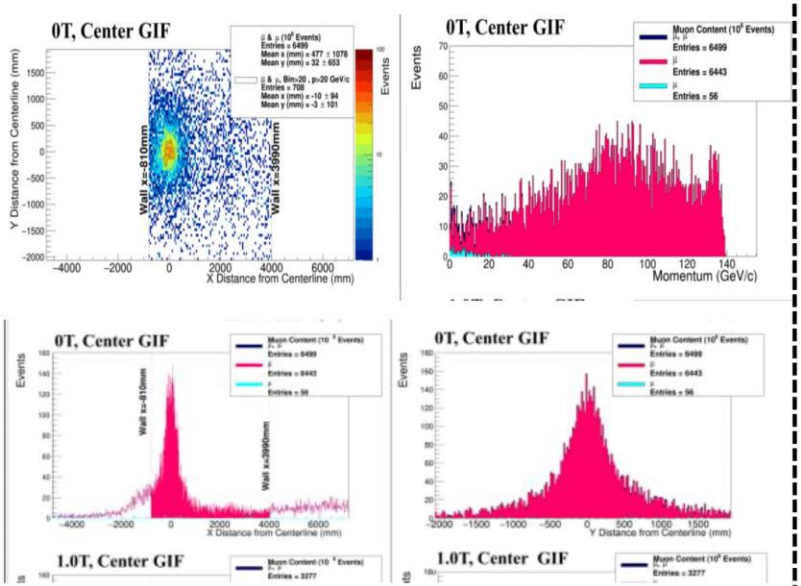
- IRRAD:
  - In maintenance since 2018
  - Upgrades on technical area in 2020
  - Hardware and software upgrades
  - Beam commissioning in Autumn 2021 (and maybe experiments?)

- 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

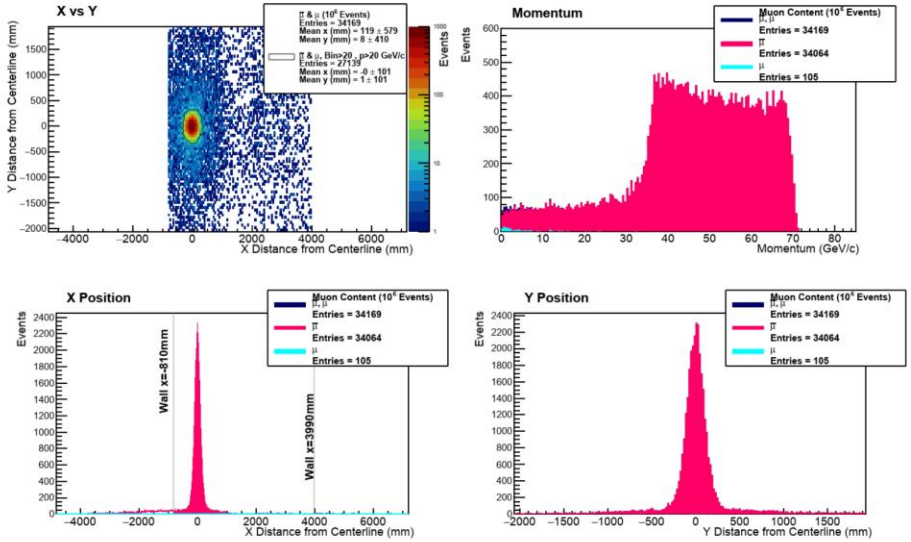
- Old Configuration



6.5k muons per 10^6

Cost: negligible

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



35 k muons per 10^6

Better defined momentum and more 'focused' beam