WP15 Report
Upgrade of beam and irradiation test infrastructure

Federico Ravotti (CERN) & Marcel Stanitzki (DESY)

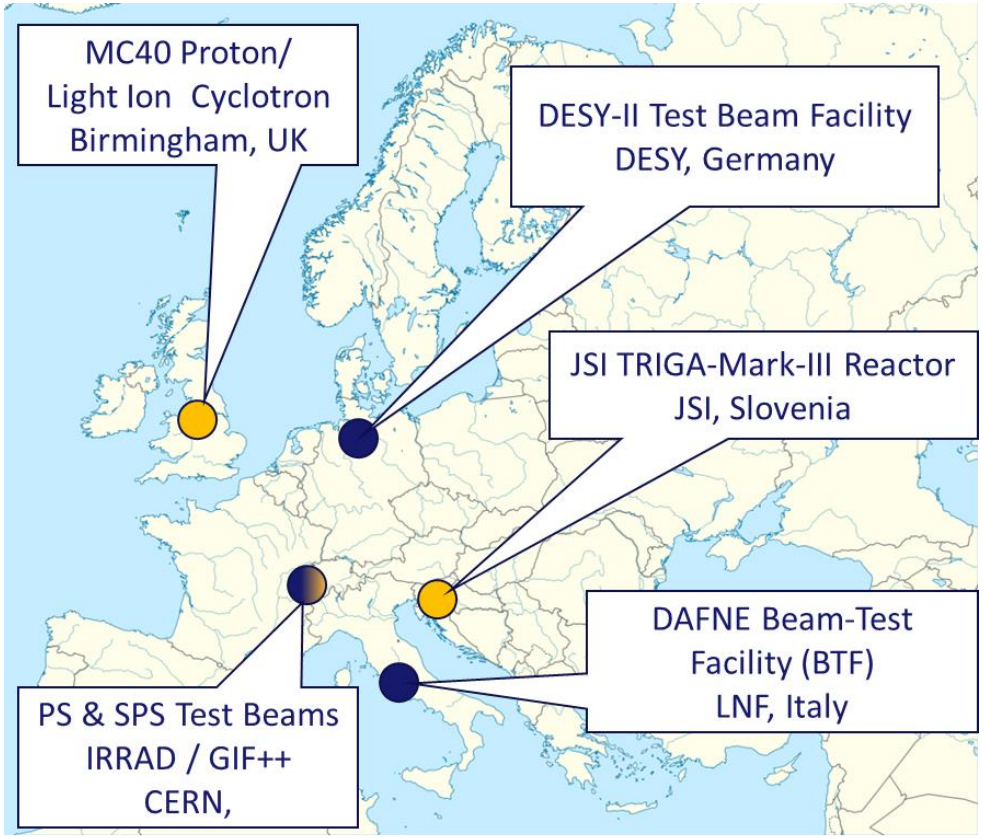
AIDA-2020 Final Annual Meeting

Vidyo, 29 April 2020

WP 15 Structure, Lab's & Facilities

- **Task 15.1**: Scientific coordination (CERN, DESY)
- **Task 15.2**: Improvements of test beam infrastructure for high precision tracking (CERN, DESY)
- **Task 15.3**: Improvements of the DESY test beam infrastructure (DESY)
- **Task 15.4**: Improvements of the test beam infrastructure at LNF (INFN)
- **Task 15.5**: Improvements of the infrastructure for irradiation tests (CERN, INFN, VU, INRNE, JSI, USFD*)

*associated partner linked to CERN



WP15.1 Scientific Coordination

- Chasing people for slides, Milestone & Deliverable reports and publications
- **WP15 Satellite Meetings @ BTTBs**
  - large overlap of activities and participants, moreover facilities upgrade activities were driven by user requirements …
  - Barcelona, 2017: https://indico.cern.ch/event/591285/
  - Zurich, 2018: https://indico.cern.ch/event/683891
  - Geneva, 2019: https://indico.cern.ch/event/731649/



- From 2019: gather, give consistency and formalize community ideas for AIDAinnova proposal!

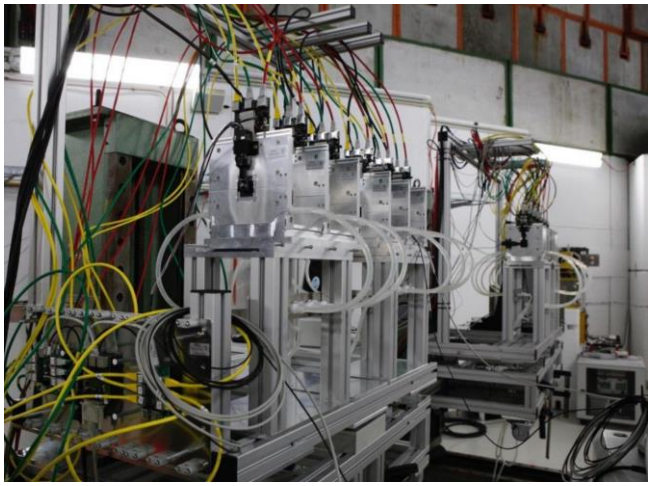
WP15 Status @ M60

- **Milestones:**
  - **all achieved!**
- **Deliverables:**
  - **all achieved!**
  - **INFN-LNF (D15.5)** and **GIF++ upgrade (D15.11)** reports being reviewed
- **Publications:**
  - 81 records in CDS (including 21 official reports)
  - http://cds.cern.ch/collection/AIDA-2020?ln=en
  - several other in the pipeline

WP15 Structure

WP15.2	WP15.3	WP15.4	WP15.5
J. Dreyling-Eschweiler DESY	*M. Wu* DESY	*P. Valente* Frascati	*F. Ravotti et al.* CERN, INFN, VU, INRNE, JSI, USFD
DESY-II Test Beam Facility; CERN PS & SPS Test Beam Areas	DESY II Test Beam Facility	BTF @ LNF	IRRAD; GIF++; JSI Triga Reactor; U.o.B. Cyclotron Facility

WP15.2: Azalea is coming home...

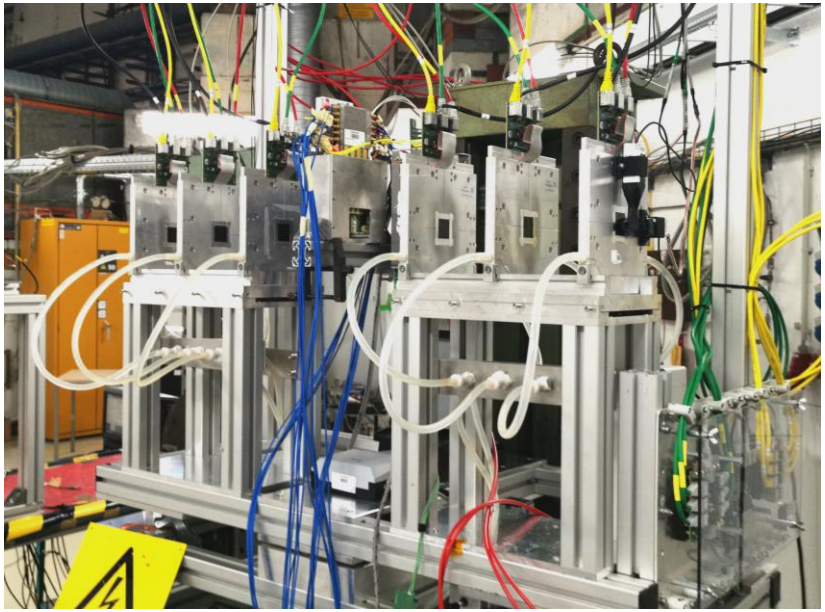


Testing in TB22 DESY, July 2016

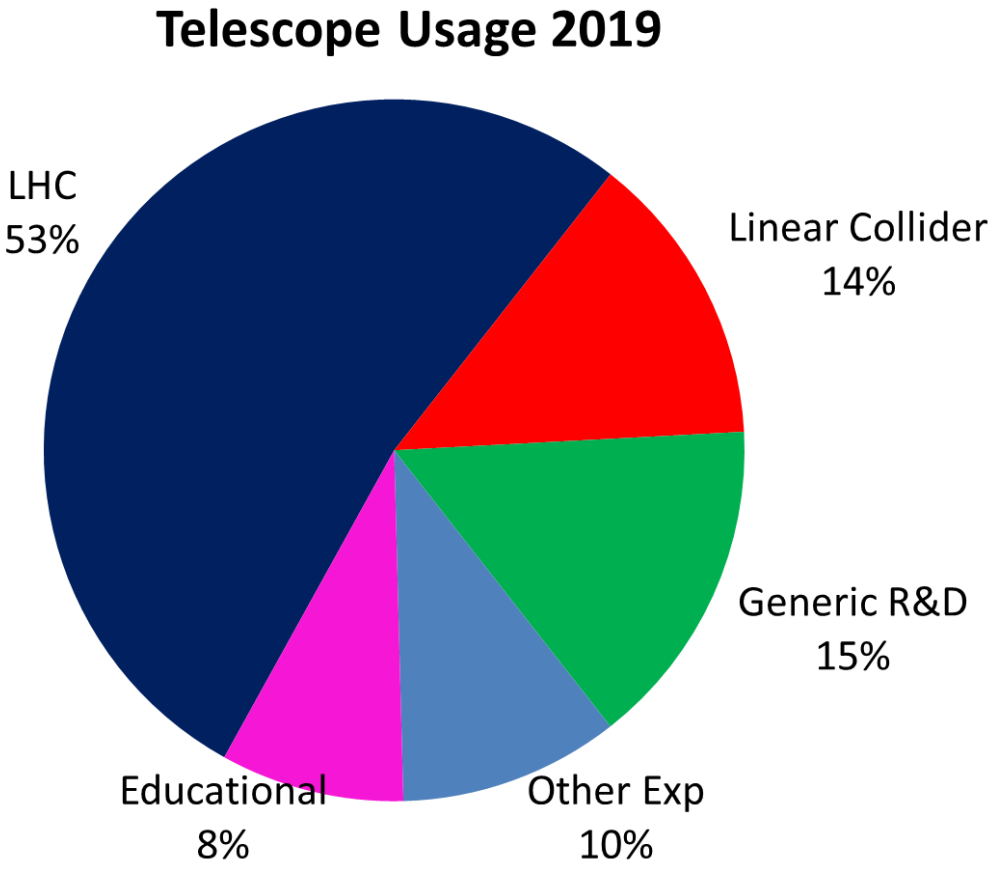
Packed and shipped from CERN to DESY, in Dec. 2018/Jan. 2019

Flying through the DESY Test Beam hall

WP15.2: Telescopes at DESY in 2019



TOTEM @TB24



WP15.2 follow-up: Common Beam Telescopes 2025

- Current Status
  - We have 7 telescopes operating
  - In operation since approximately a decade: **AZALEA is the youngster being already four years old!**
  - We will keep them running for as long as possible, but we'll reach end-of-life
- Active Discussion also with WP5
  - Improve timing information,
  - Maintain spatial resolution,
  - Keep material budget low, etc.
- Many of our ideas went into the AIDAinnova proposal
  - Stay tuned!

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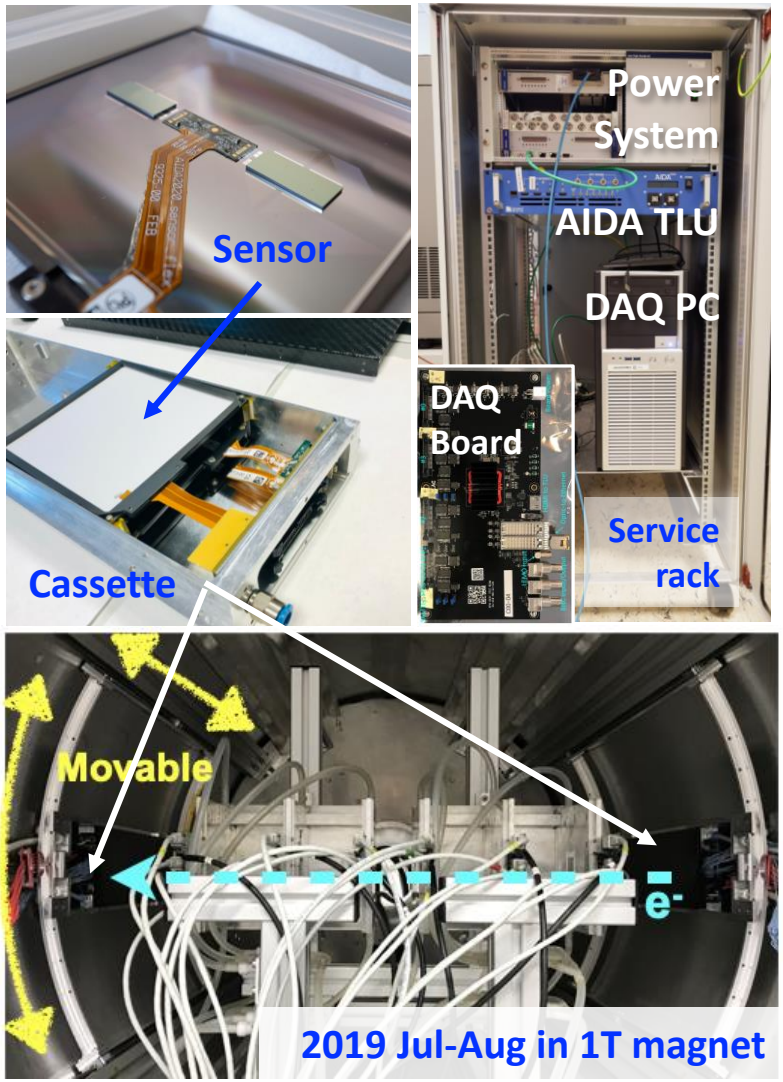
WP15.3: Improvements of the DESY test beam infrastructure

Task 15.3.1: External silicon tracker for 1T magnet in the DESY test beam

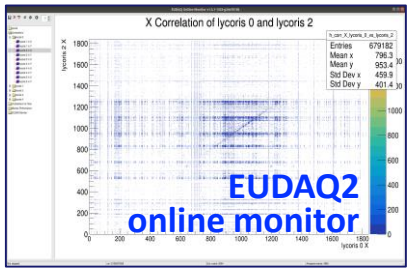
- Delivered a 6-layer large active area (10x10cm^2) telescope of novel hybrid-less sensor
  - with better spatial resolution than required: dy~7.4 um (< 10 um), dx~0.17 mm (< 1 mm)
- Highlight milestones:
  - July 2017 – sensor arrived
  - Oct 2018 – assembly quality validated
  - Feb 2019 – prototype's first beam commissioning test succeeded
  - May 2019 – production's first beam commissioning succeeded
  - July 2019, Mar 2020 – production performance measurements with EUDET telescope **done**

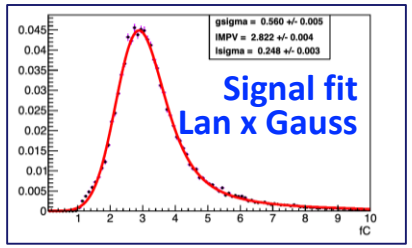


M. Wu

WP15.3: Improvements of the DESY test beam infrastructure

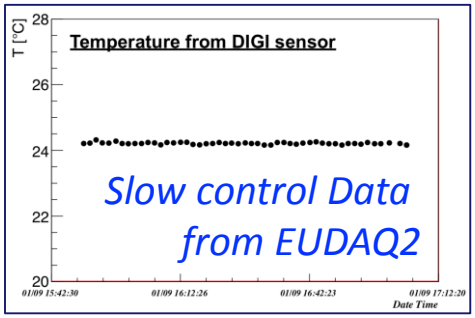
- A full telescope package: integrated to EUDAQ2 + AIDA TLU, providing a full chain data analysis framework;
- Well documented as a long-life project: numerical manuals available online.
- Publications: Journal paper progressing (first draft exp. May 2020), 2 IEEE proceedings, 1 VCI proceeding (doi:10.1016/j.nima.2019.162864)
- Status: waiting for the first "benevolent" user.

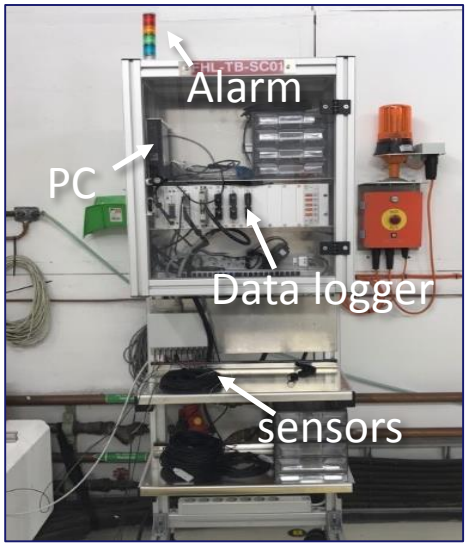




Task 15.3.2: Environmental slow control system

- Commercial rack-based data logger, polling by EUDAQ2 via MySQL database – simple plugin for user
- Delivered on time: MS33 and D15.3
- Documentation: 2 user manuals available online as AIDA tech reports.
- **Status**: Available for all users at DESY , full system now upgraded to Win10.





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WP15.4: External Constraints

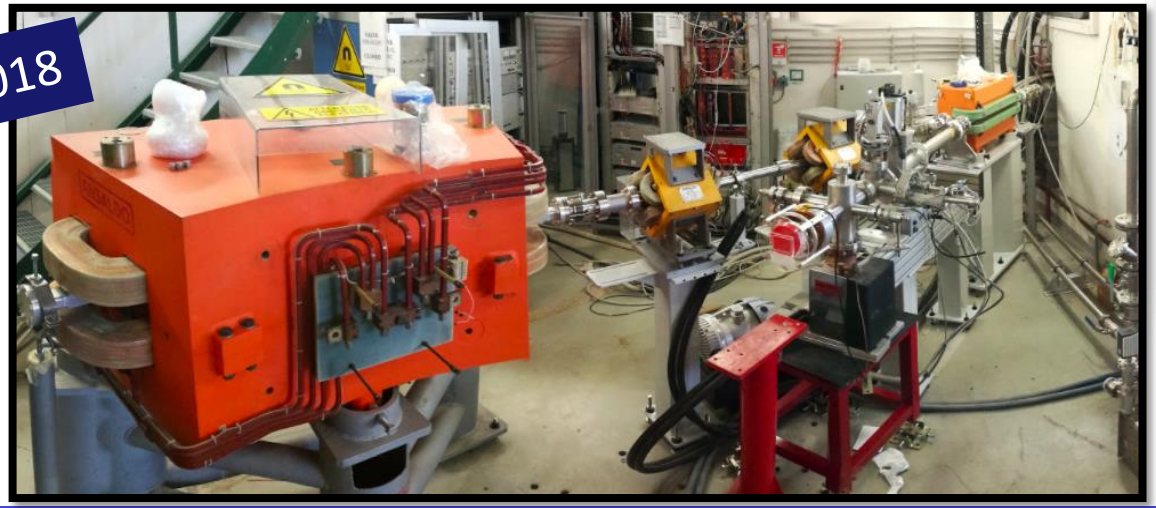
- Delay of project start
  - LNF MAC recommended shift of priorities
  - Delay of procurement of essential components
- Major Vacuum Incident in Early Fall 2019
  - Beam pipe broke
  - Beryllium contamination
  - Major effort required for clean-up
- Latest Plan (pre COVID-19)
  - April 2020: beam for Padme
  - November 2020: test beam for users
  - 2021: installation of photon tagging
- From a AIDA WP15 perspective
  - Really beyond our control …

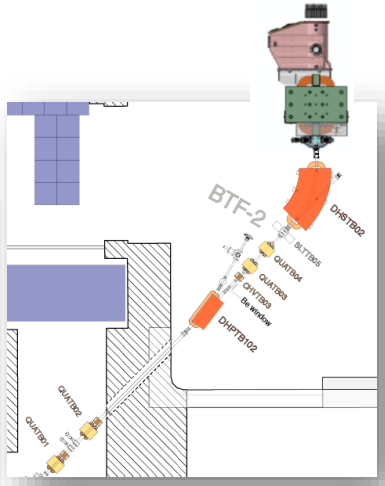
WP15.4: BTF-1 & BTF-2 beam-lines ready

- Old beam-line dismantling
- Cables re-routing
- BTF-1 and BTF-2 branches installation
- New experimental hall control room
- New power supply hall
- Cooling, power, controls connection operative

April 2018

→ Long time based experiment (PADME) and external users





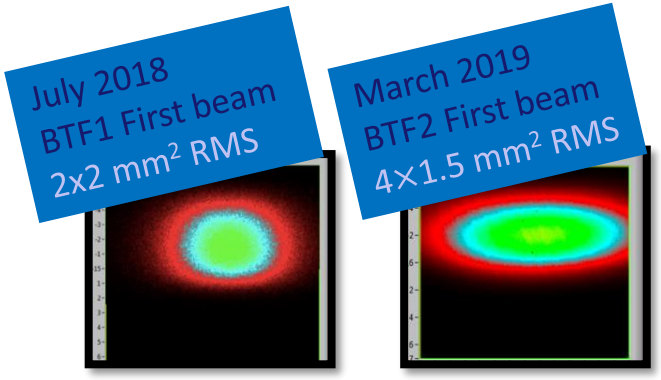
September 2018

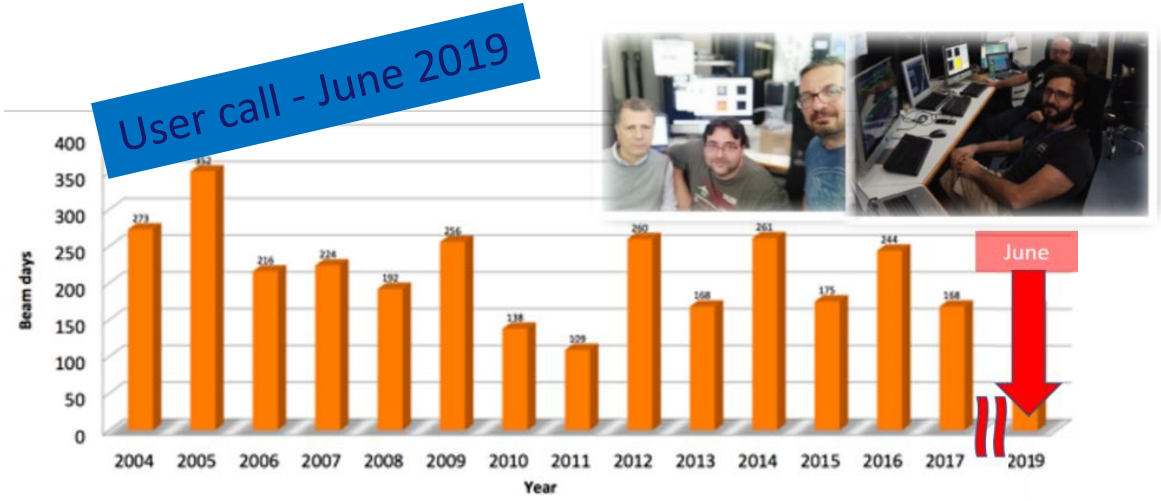
D15.4 – New Frascati beam line components installed, delayed from M18 to M44 due to postponed funding → achieved (report submitted)

P. Valente
B. Buonomo

WP15.4: BTF-1 & BTF-2 beam-lines ready

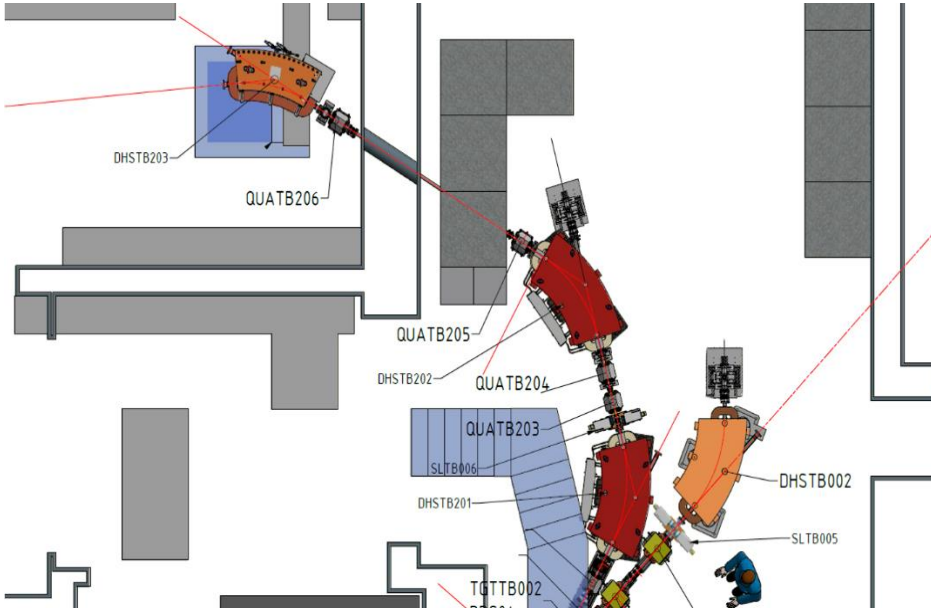
- Commissioning with secondary electron beam (450 MeV): July 2018
- Commissioning with secondary positron beam (545 MeV): Sep. 2018
- First user on new BTF-1 line, PADME (dark photon searches) experiment: Oct. 2018 - Feb. 2019
- First users call for beam time: Jan. 2019
- User Beam Time open in June 2019: Pixel and Gas detectors tests.
- 2018/2019 Good publication number of BTF related activities (>50)





WP15.4: Photon Tagging

- BTF2 Extension to second hall delayed after COVID and PADME data taking
- Time scale now **2021**
- BTF2 components (Magnets, vacuum pipes, mechanics, pumps scrapers…) in final test/shipping (5%) or ready to be mounted (95%)



D15.5 – New Frascati photon tag components installed, due to vacuum event now moved off, next installation after PADME users run and COVID19 delay → **achieved** (report submitted)

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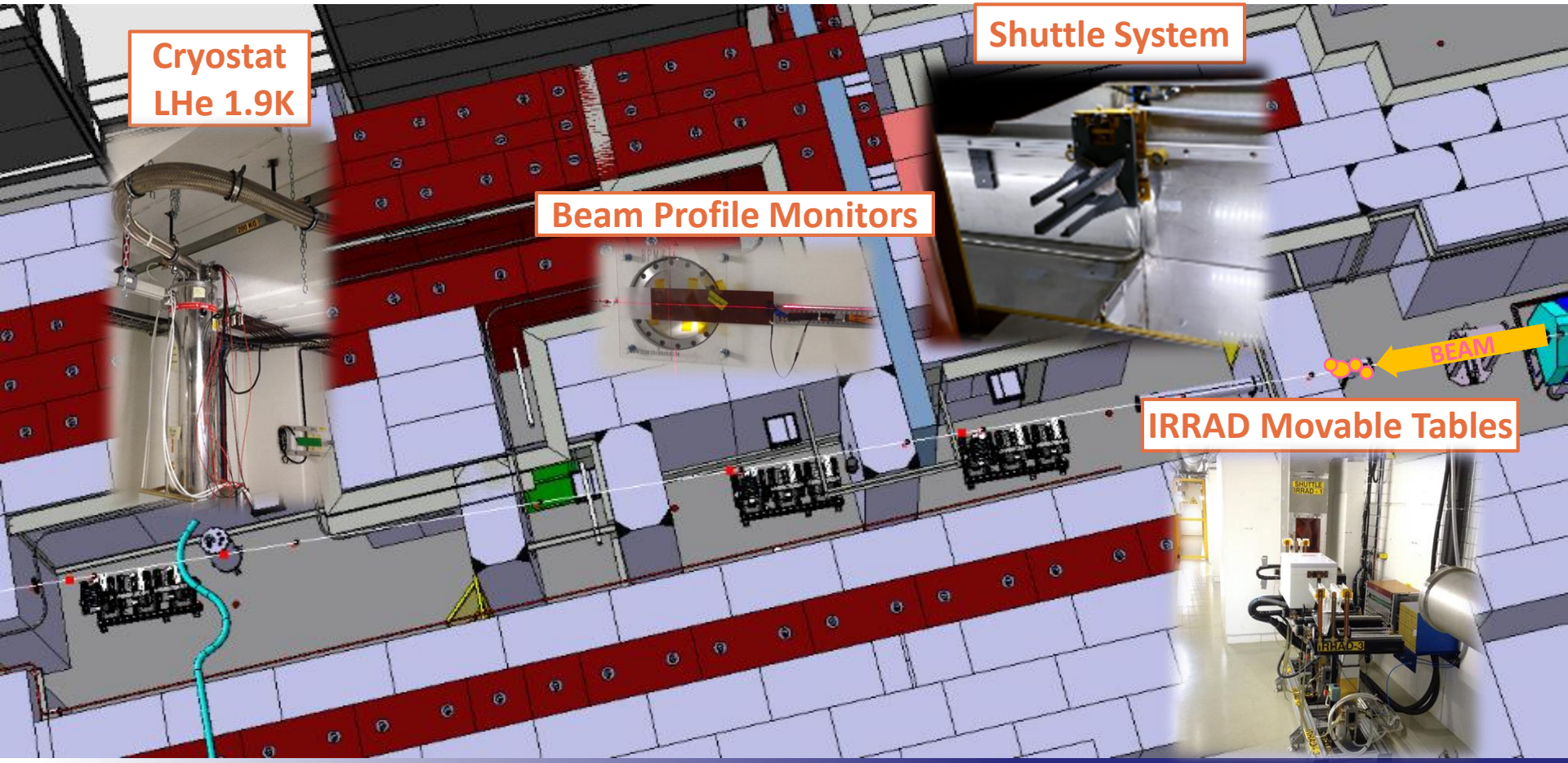
Task 15.5: Improvements of the infrastructure for irradiation tests

Milestones: all achieved!

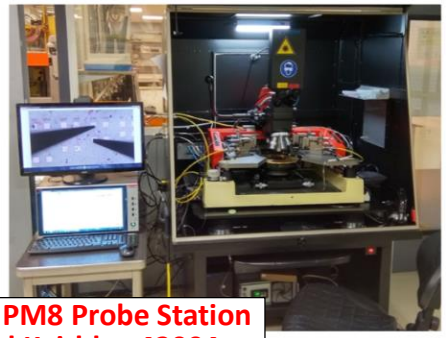
- **D15.6 – CERN Proton Facility Upgrade** — M24
  - contactless fluence monitor (VU)
  - IRRAD data manager software tool / storage area equipment (CERN)
  - irradiation facilities on-line database (CERN)
- **D15.7 – RadHard Instrumentation for CERN Proton Facility (CERN)** — M44
- **D15.8 – Cold Irradiations at Birmingham Facility (USFD)** — M36
- **D15.9 – Large Objects Transport System for Neutron Irradiations (JSI)** — M18
- **D15.10 – Upgrade of GIF^{++} Facility Gas System (CERN)** — M24
- **D15.11 – GIF++ Facility Upgrade** — M54
  - instantaneous dose-rate monitor (INRNE)
  - improved cosmic-rays tracker & demonstrator of augmented reality (INFN)

Task 15.5: IRRAD Proton Facility

- **Testing components of the HEP experiments**
- Beam of **24 GeV/c** and size of **12×12 mm²**
- Spills of **400 ms** every **~10 sec**
- Fluence of **1×10¹⁶ p/cm² in 14 days**
- Scanning also in dimensions of 10×10 cm²
- Low temperature irradiation (-25°C)



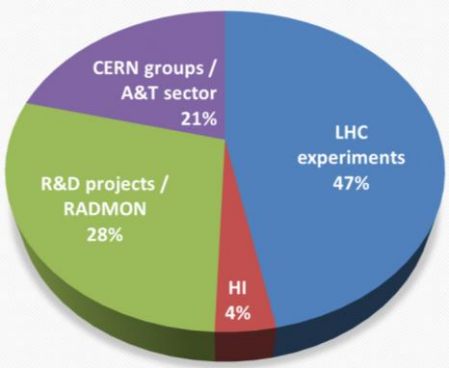
Task 15.5: IRRAD Proton Facility



NEW IRRAD Technical Area after LS2 (end 2020 ?)

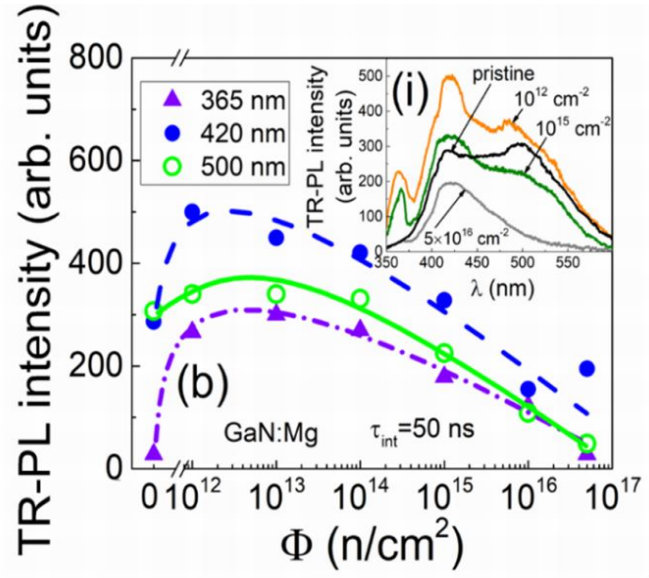
AIDA 2020 partial funding of equipment (D15.6)

Task 15.5: IRRAD Proton Facility

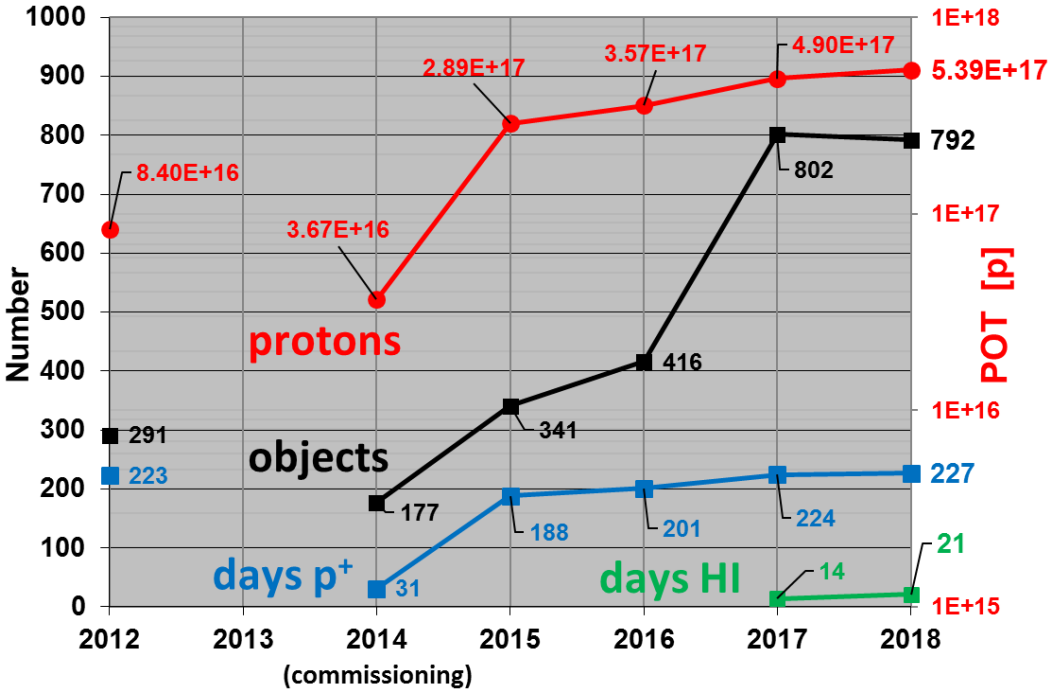


Experiments distribution during run 2018

Contactless Fluence Monitor



Variations of the predominant TR-PL spectral peaks with neutron irradiation fluence. In the inset (*i*) variations of TR-PL spectra are depicted.

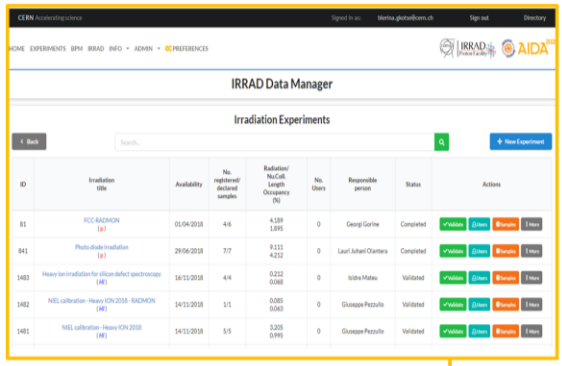


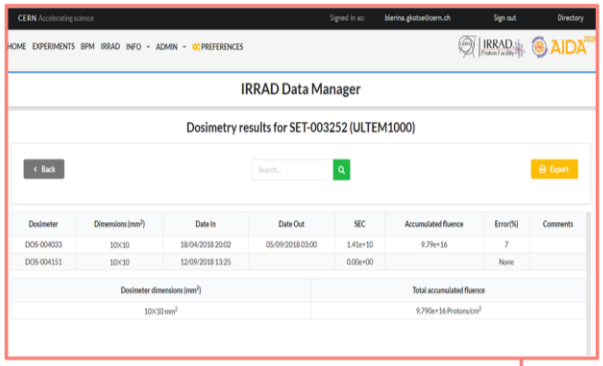
within AIDA-2020: improvement of characterization techniques for irradiated semiconductor materials: GaN, a-Si

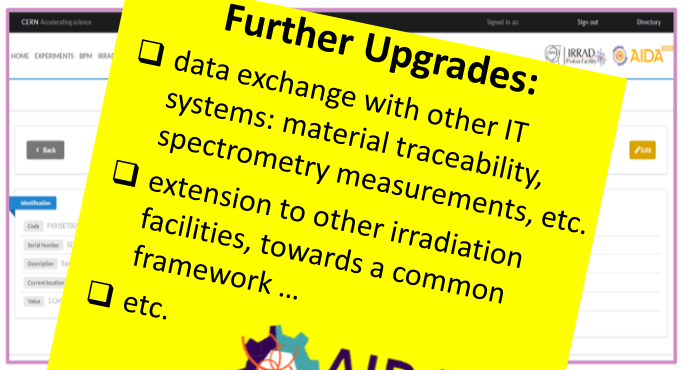
J. Vaitkus (VU)

D15.6 (M24)

Task 15.5: CERN IRRAD Task - IRRAD Data Manager (IDM)





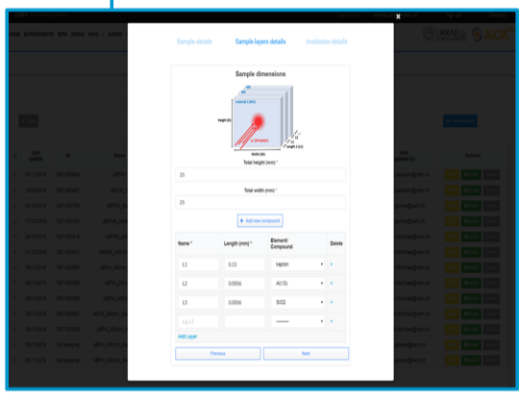


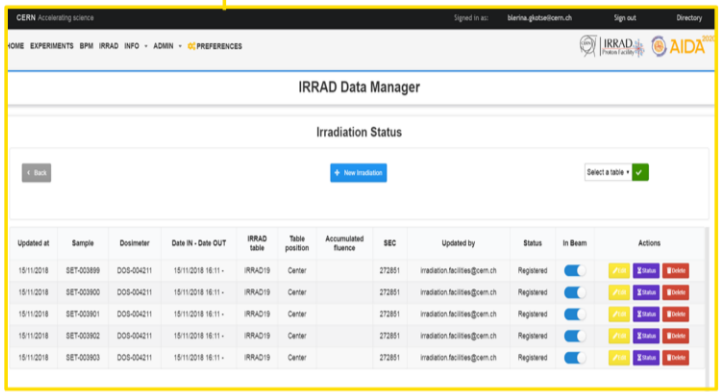
Further Upgrades:

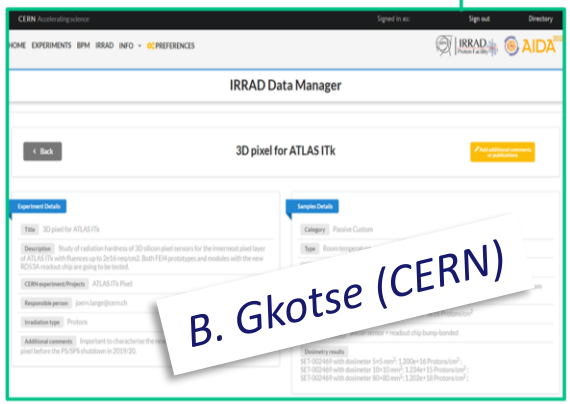
- ❑ data exchange with other IT systems: material traceability, spectrometry measurements, etc.
- ❑ extension to other irradiation facilities, towards a common framework …
- ❑ etc.

AIDA innova

Registration → **Planning** → **Follow-up** → **Dosimetry Results** → **Traceability** → **History**





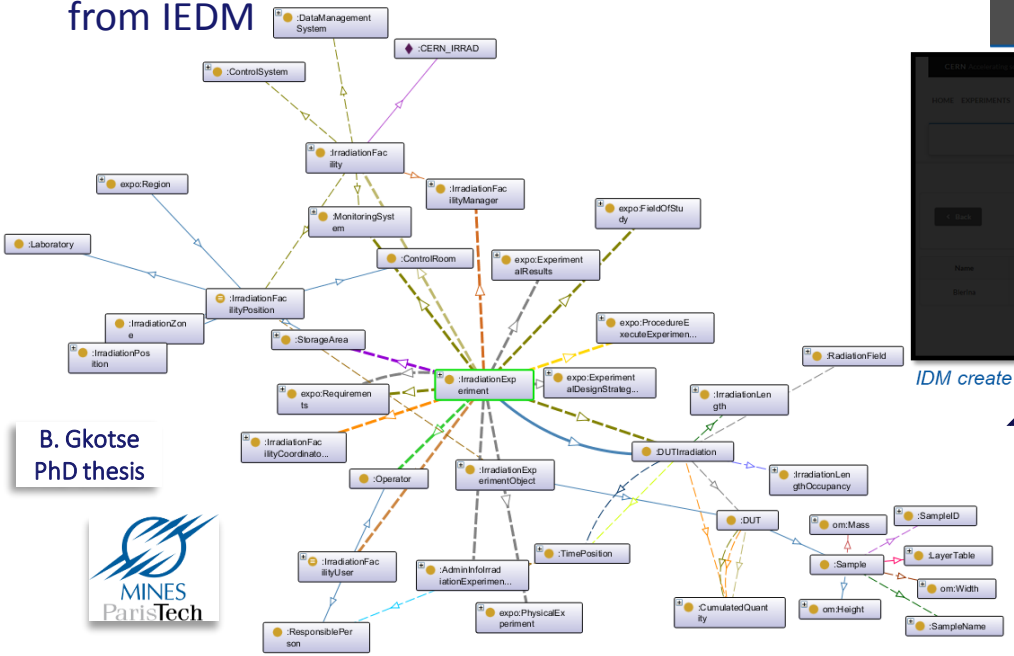


B. Gkotse (CERN)

Task 15.5: CERN IRRAD Task - Beyond the IDM Tool …

Irradiation Experiments Data Management Ontology (IEDM)

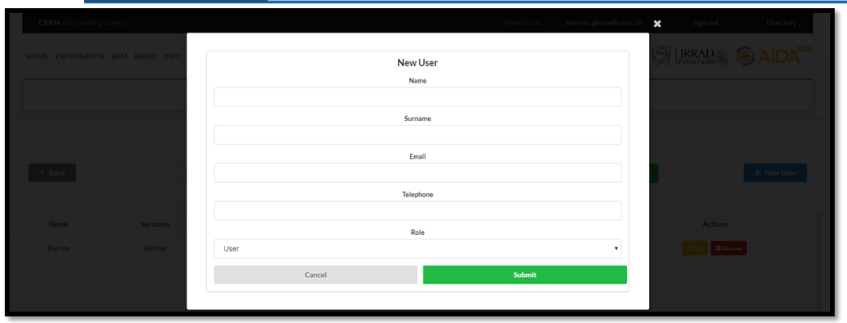
- Key entities & relations of an irradiation experiment
- Fundamental step for generalizing software tools
- Enabling ML-related applications
- Web application code "automatically" generated from IEDM



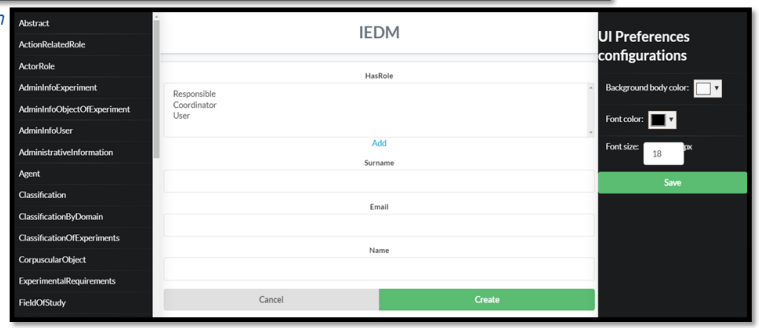
B. Gkotse PhD thesis

MINES ParisTech

	IDM	Generated Web Application
Purpose	IRRAD facility data management	any domain
Software infrastructure	CERN	free and open source
Storage	Oracle database	SQLite3 database, ontology or triple store
Web Semantic technologies	No	Yes, allowing for data integration
Functionalities	more complex functionalities (e.g., interaction lengths calculation)	CRUD operations



IDM create instance form



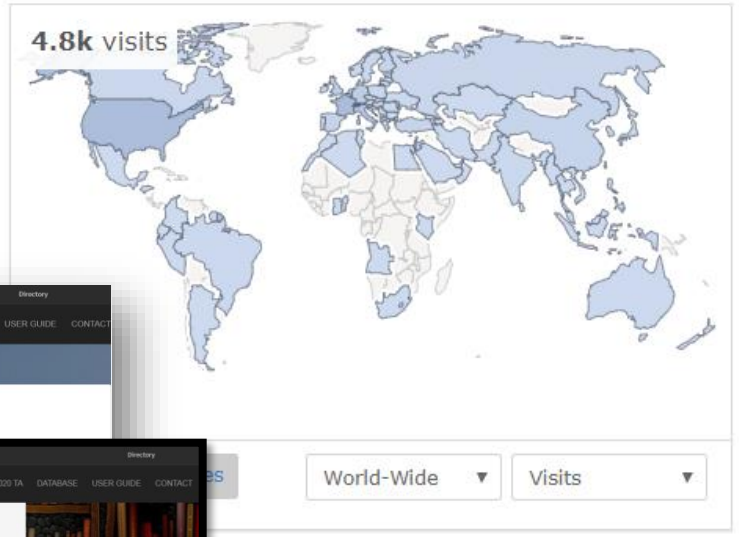
Generated application create instance form

during Y5 …

Task 15.5: CERN IRRAD Task - Irradiation Facilities Database

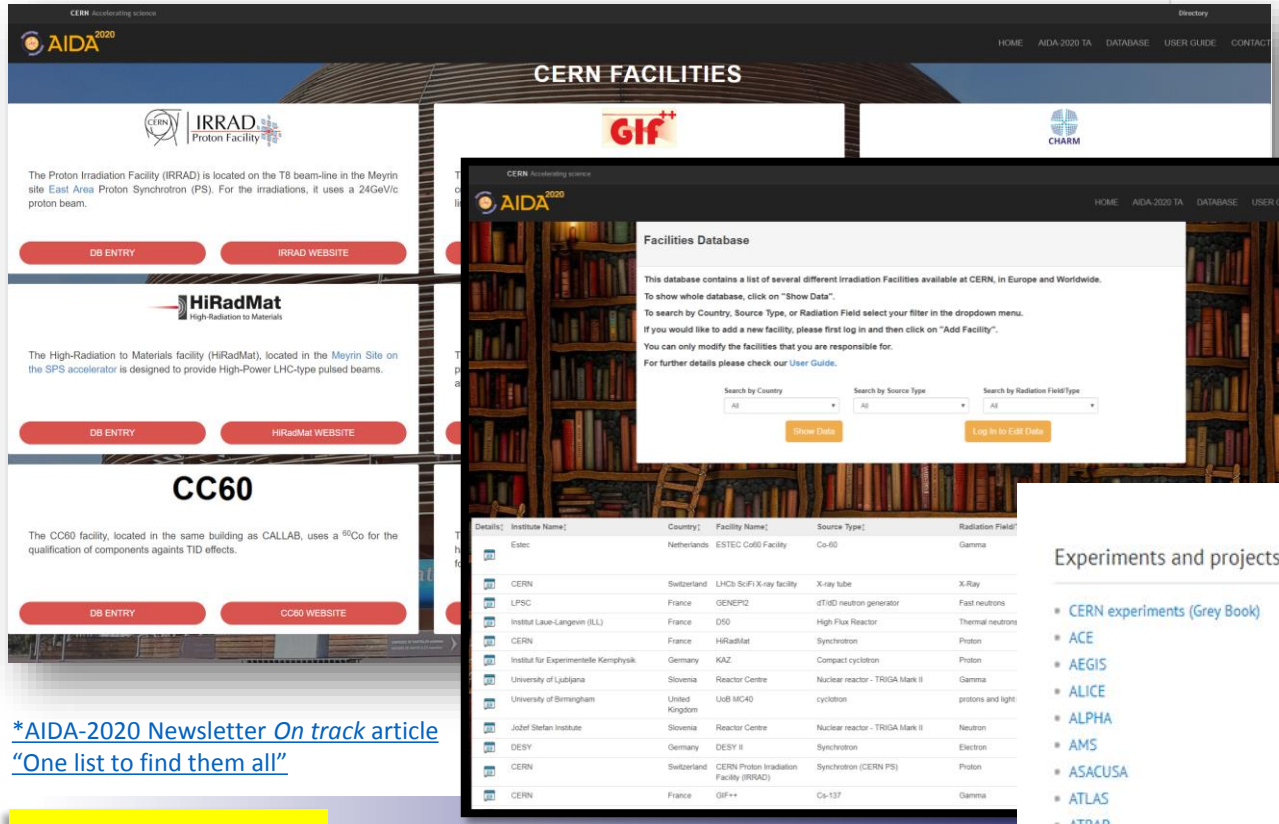
An online platform for finding suitable facilities for irradiation experiments*, **very important during LS2**!

- **217** irradiation facilities
- **4800** visits since first launched (February 2017)
- automatic reminders to facility coordinators



cern.ch/irradiation-facilities

B. Gkotse (CERN)



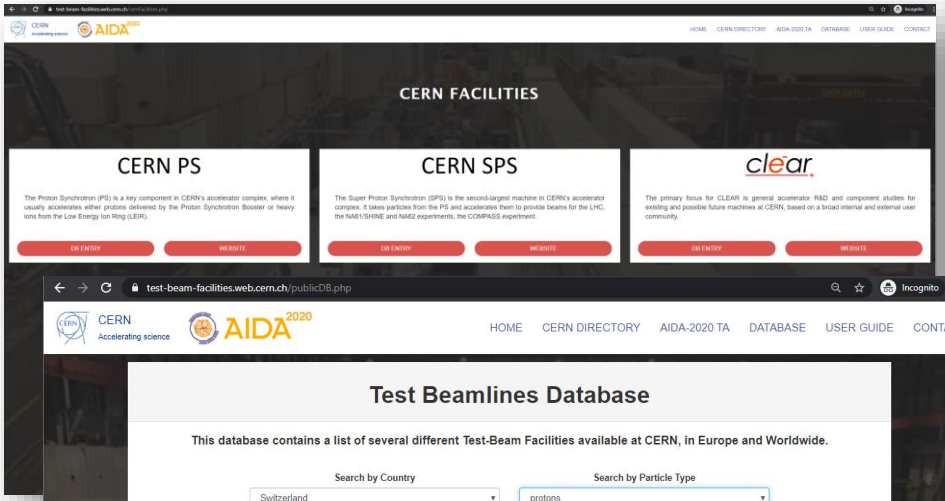
*AIDA-2020 Newsletter *On track* article "One list to find them all"

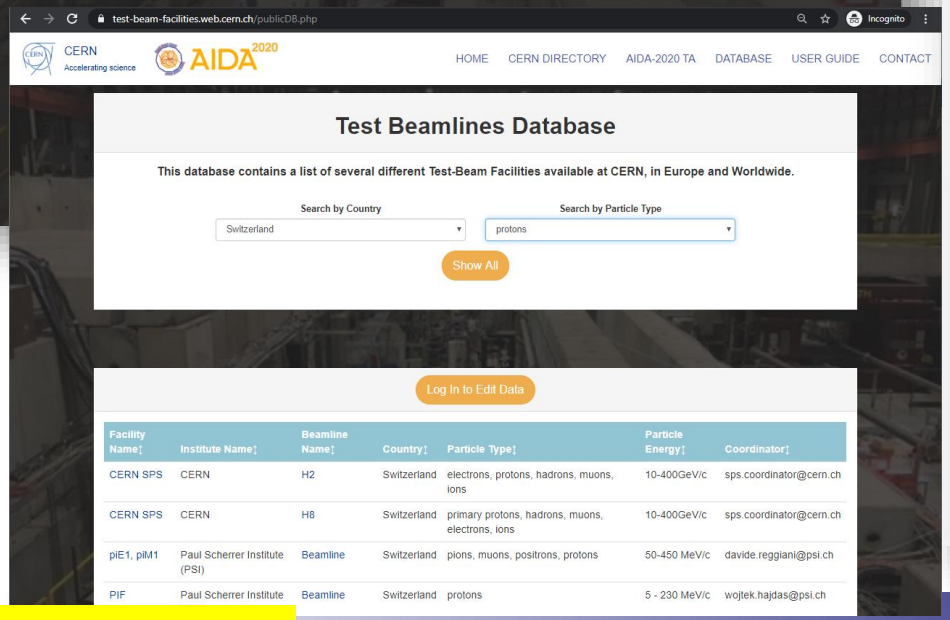
Task 15.5: CERN IRRAD Task - Test-beam Facilities Database

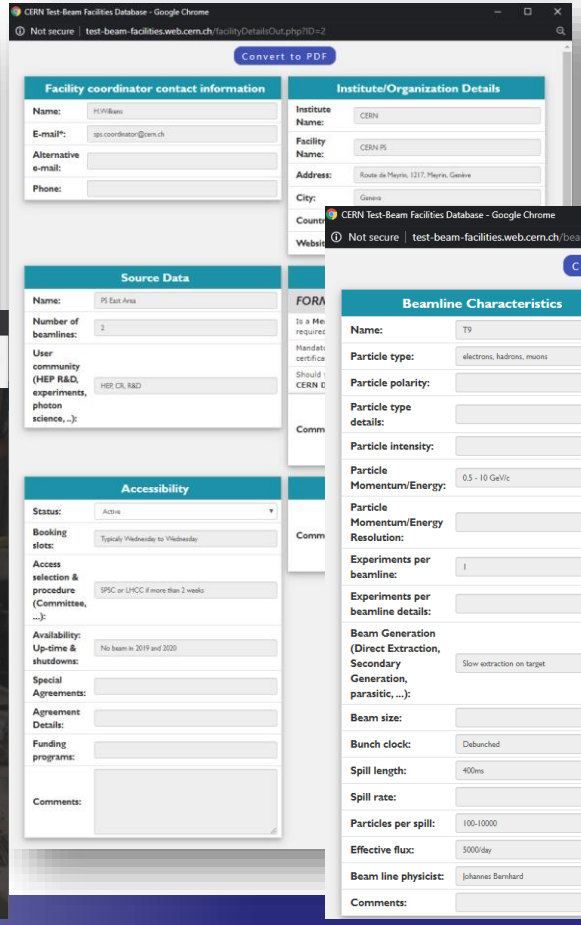
A unified database and platform for test beam facilities at CERN, in EU and worldwide

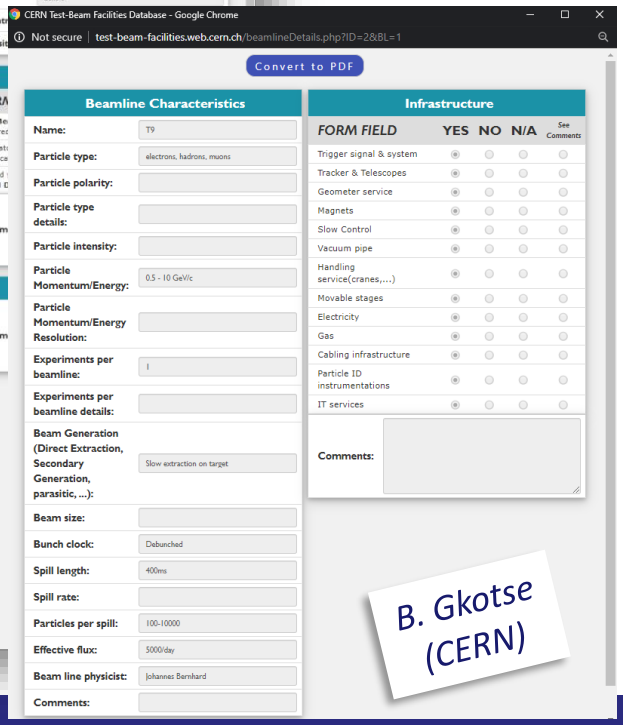
- **16** facilities, **27** beamlines
- presented at BTTB in 2020; user guide: http://cds.cern.ch/record/2706474
- automatic reminders to facility coordinators

http://www.cern.ch/tbdb









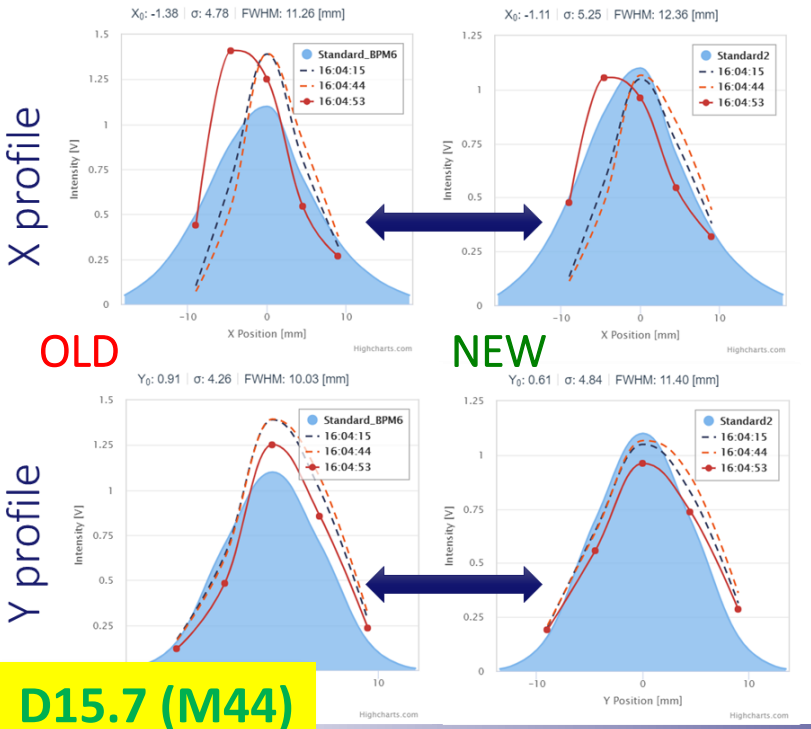
B. Gkotse (CERN)

during Y5 …

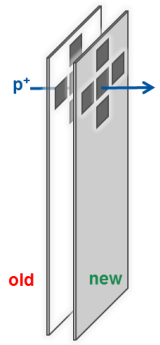
Task 15.5: CERN IRRAD Task - RadHard instrumentation

- **Sample Holder Material**
  - Carbon Fibre and ULTEM good candidates after assessment of various materials
- **Beam Profile Monitor (BPM):**
  - detailed performance analysis with different beam conditions
  - engineering of BPM detectors with different patterns/granularity
  - proof of concept of a RadHard μ-BPM based on microfabrication technologies

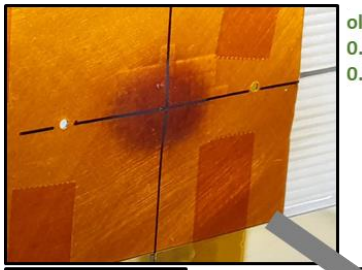
CMi EPFL Center of MicroNanoTechnology



Tested in IRRAD during 2018!

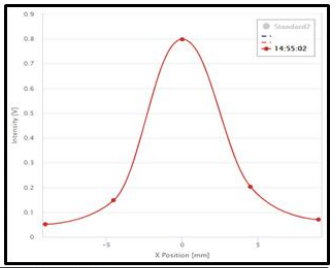


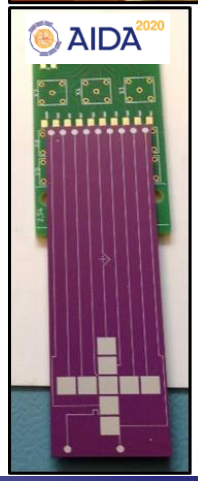
I. Mateu, G. Pezzullo, G. Gorine, J. Bronuzzi (CERN)



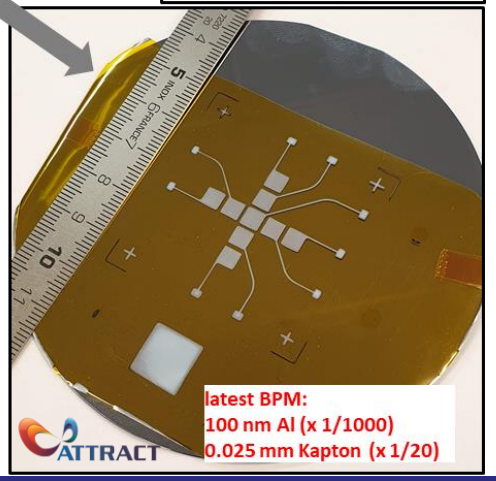
old BPM:
0.1 mm Cu
0.5 mm Kapton

new BPM:
200 MeV electrons irradiation (2019)





new BPM:
400 nm Al
0.5 mm Si/SiO_2



latest BPM:
100 nm Al (x 1/1000)
0.025 mm Kapton (x 1/20)

D15.7 (M44) during Y5 …

Task 15.5: Cold Irradiations at Birmingham Facility – LN_2 Cooling

- Aims of WP15.5: Improvements to infrastructure for Irradiation tests
- Milestones and deliverables required and achieved for WP15.5

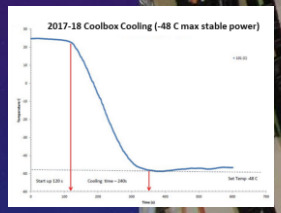
MS: 15.8. Concept of cold box to be evaluated and a design fixed

DEL: 15.8. Cold irradiations at Birmingham cyclotron enabled

The University Of Sheffield.

2014-2017 system
Small window, Flimsy pillar.

- Improvements made in new design
- Greater thermal performance
- Sensor annealing well understood / avoided
- Larger sample capacity
- Reduced fan and heatsink size proportional to box
- Reduction of internal heat-load from fan.
- Cooling stable to operational (measured) irradiation temperatures at Birmingham
- Reduced service channel count
- Simplified control system
- Increased scan area
- New improved support (Z) pillar for better movement control (new).
- Robust robotic communication



Installed U.o.B. Sept. 2018, very positive feedback from OP team!

To be installed in IRRAD (2 boxes, STD cooling) before end of 2020!

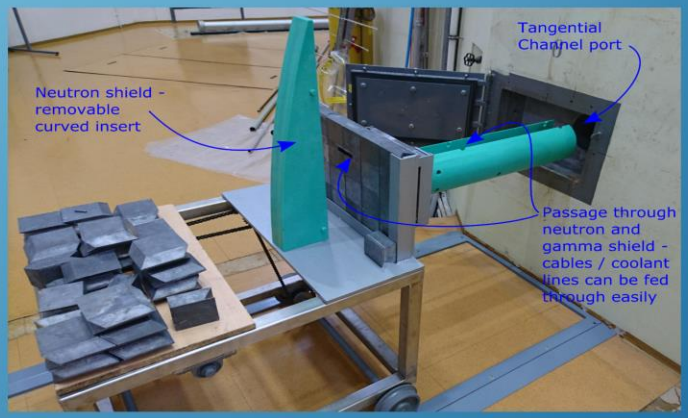
2017-2020 system
Large window, Robust pillar

2

Task 15.5: Transport System for Large Objects at TRIGA Reactor (JSI)

- new irradiation facility at JSI reactor installed and commissioned in 2016
- allows irradiation of ~ 12 x 25 cm^2 samples
  - services possible
- 10^{15} $n_{eq}cm^{-2}$ in less than one hour
- 8 irradiation projects completed (electronics, sensors), 3 during last year
- ATLAS pixel module - 10^{16} n_{eq}
- CMS calorimeter, 7 irradiations up to 10^{16} n_{eq} cm^{-2}
- ATLAS full size sensor
- AIDA funds exhausted by end of 2018
- limited amount of irradiations offered for half price

V. Cindro (JSI)



Task 15.5:

- **Typically for muon systems of HEP experiments**
- **E_γ = 0.66 MeV**; max. dose-rate **~0.5 Gy/h** @ 1m from source (±37º angle) and **2.5 Gy/h** @ glass contact
- Several **attenuation factors** available (up to ~50'000)
- **μ-beam** from T2 on H4 beam-line (100 GeV; ~10^4 /spill)

ENGINEERING DEPARTMENT

EP-DT
Detector Technologies

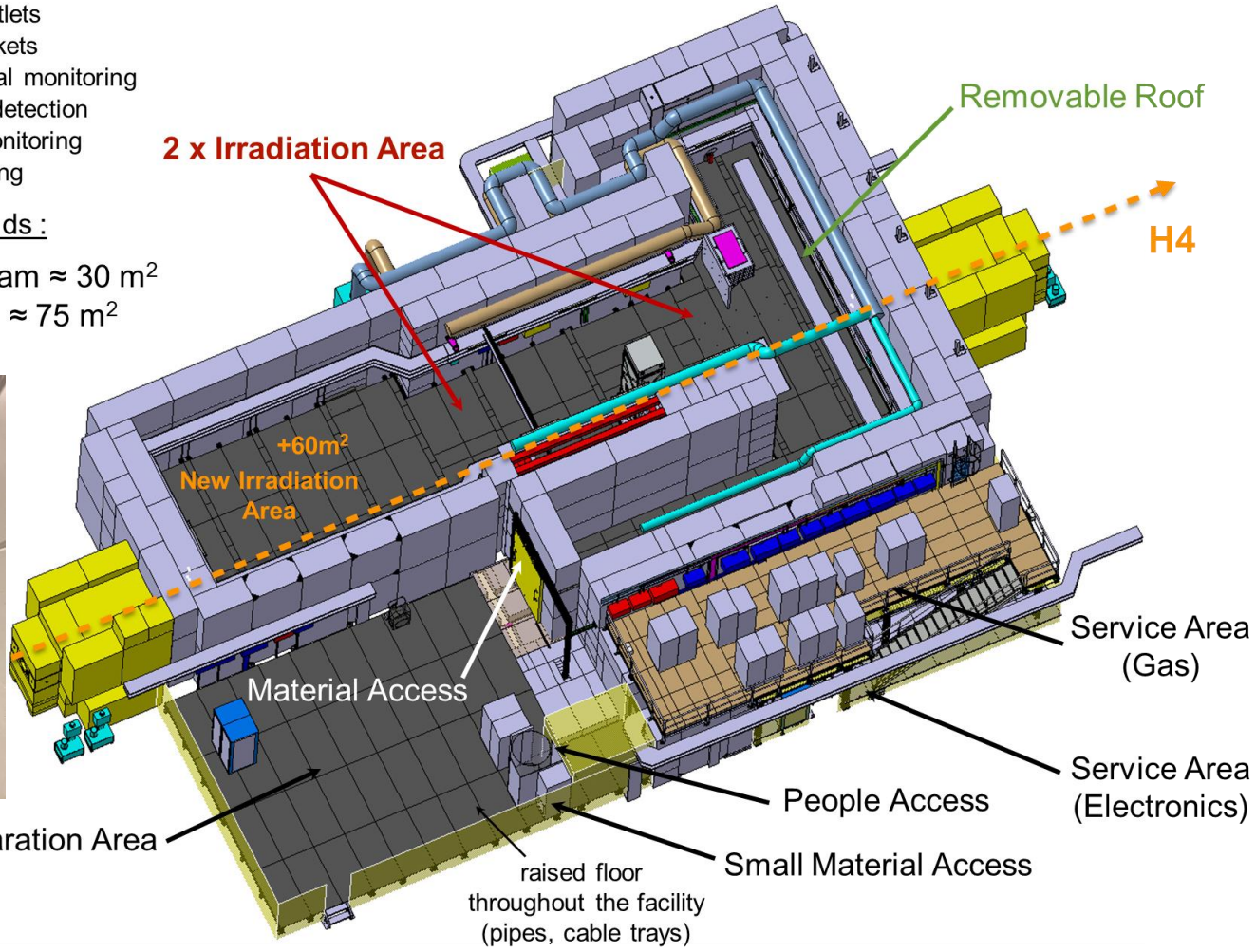
Task 15.5:

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



After LS2 (July 2019)

Task 15.5: GIF++ Facility Upgrade (Gas System)

R. Guida (CERN)

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 available 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**

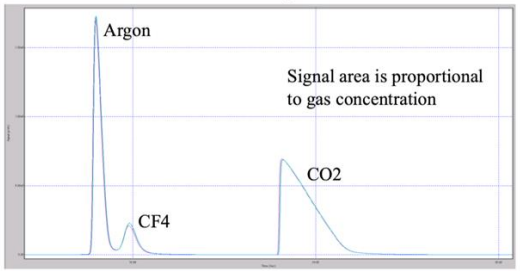
Mixture distribution

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

Additional software controlled pressure regulation for very low flow regimes

Gas mixing unit

Gas recirculation module

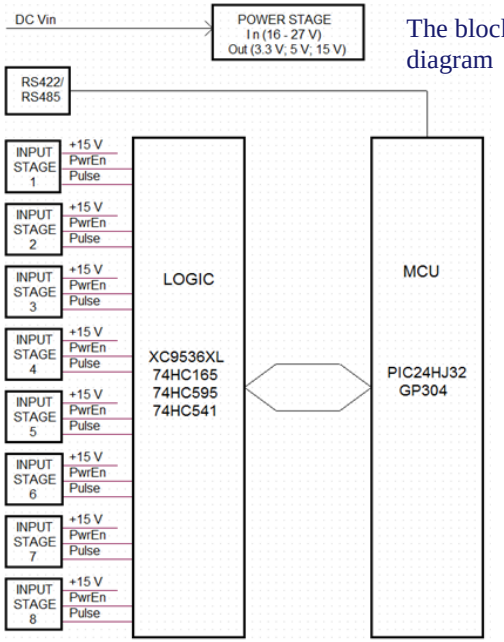


Gas chromatographic analysis : allows monitoring gas mixture composition and presence of impurities on return from detectors under test

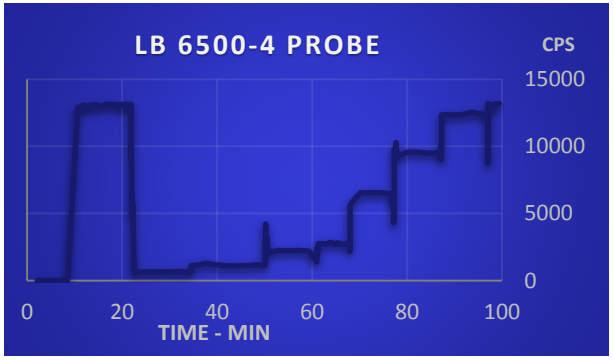
Task 15.5: GIF++ Facility Upgrade (Instantaneous Dose-Rate Monitor)

Instantaneous DRM for GIF++ and test of SiPM + scintillator as a DRM for Gif++

Berthold LB 6500 Geiger-Mueller Dose Rate Probe for 2 and 8 channel DRM



The block diagram

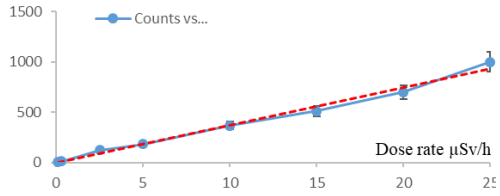


Test configuration

SiPM - Hamamatsu S13360-1325CS (57.28V)
Photosensitive area: 1.3 x 1.3 mm, Pixel pitch: 25 µm, reduced crosstalk and dark count, Gain (typ.) - 7.0×10^5

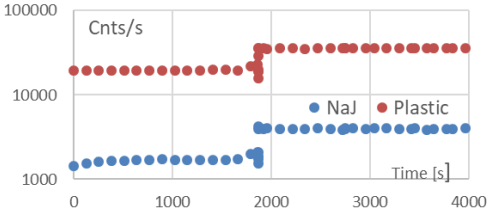
Scintillator
- 250x10x7 mm^3 , extruded polystyrene bar supplemented with 1.5% paraterphenyl (PTP) and POPOP 0.01%;
- 30-100 micron layer Uniplast actng as a diffusive reflector; Light shifter WLS Y11 KURARAY Φ 1 mm

Amplifier - Canberra 2024, shaping time 2 µs, **ADC** – 4k, custom made



Counts vs Dose rate measurements

DRM with a NaI(Tl) scintillator and photomultiplier FEU-35 was assembled at INRNE for the test. The spectra of Caesium-137 measured with it is shown on the plot:



Comparison for NaI(Tl) and plastic scintillators for two attenuations at GIF++

during Y5 …

The light yield and decay time for NaI and plastic scintillators differ significantly. The test and comparison between these 2 DRM's at Gif++ (from 10 to 10000 mGy/h) could give an information for the possible use of the DRM's at substantially different dose rate conditions.

P. Iaydjiev, L. Dimitrov, I. Vankov, G. Mitev, L. Ratchev

Test of the Berthold LB 6500 Geiger-Mueller Dose Rate Probes at several attenuations at Gif++

MS85 (M36)

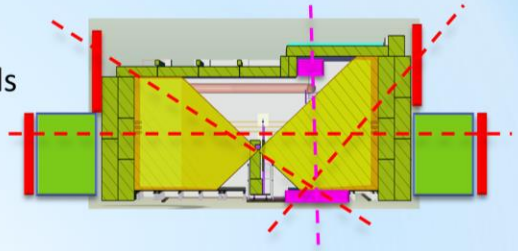
Task 15.5: GIF++ Facility Upgrade (Cosmic-ray Tracker Upgrade)

Project description

Extension of the present GIF++ cosmic tracker
via installation of new RPC chambers on the bunker endcap walls

Benefits:

- Extended coverage
- Selection of harder momentum muons
- Triggering on beam-halo muons



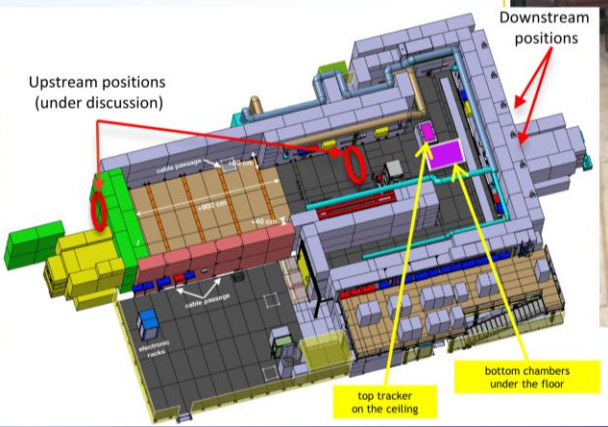
Project deliverable

4 RPC chambers have been constructed

- mechanics + front-end electronics + gas volumes

Chambers positioning:

- defined for the downstream region
- upstream region under discussion taking into account:
  - bunker extension
  - improved muon beam proposal (new pion dump)

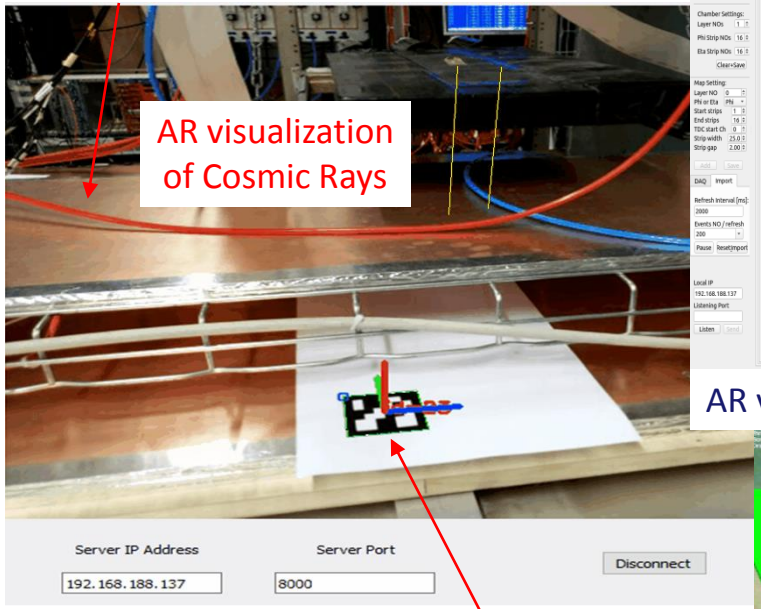


D. Boscherini

Task 15.5: GIF++ Facility Upgrade (Augmented Reality Event-display)

Cosmic-ray test setup at BB5

- RPC detector

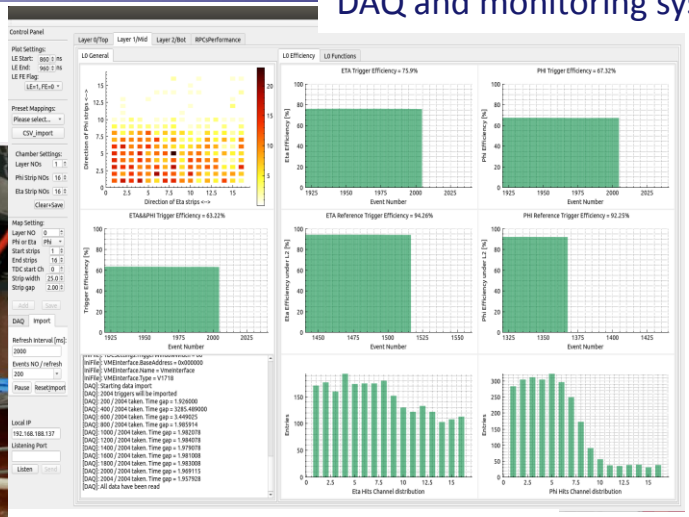


- Marker and AR reference frame

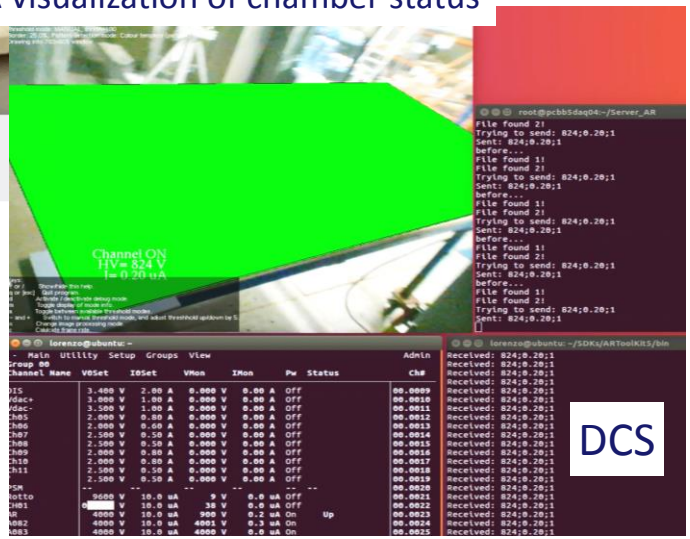
Software Platforms:

- ARToolKit 5.4 for AR
- WinCC for DCS
- Qt (for porting AR on Android)
- Data acquisition & monitoring custom application

DAQ and monitoring system



AR visualization of chamber status



This application has been developed for demonstrating the concept

For a real use:

- Port the software on an android system
- Enable the possibility to orient the system in a complex environment using multiple markers
- Enable the possibility to increase the precision of the information localization
- Making the tracking interactive
- Making the detector interactive
- Making the DCS interactive

G. Aielli

INFN Istituto Nazionale di Fisica Nucleare

WP15 Deliverables Summary

Summary & Outlook

- **WP15 has delivered improvements to Test Beam and Irradiation Facilities**
  - people working together, meeting & exchanging ideas, providing common infrastructures and services for the community, …
  - **all Milestones completed**
  - **all Deliverables completed** (D15.5 and D15.11 **reports on-line soon**)
  - several of our **activities continued in Y5 beyond the Deliverables** with good results!

- ***We'd like to thank our task leaders and all contributors for making it really a pleasure to lead WP15. As in any large projects, we went through ups and downs, but at the end we all achieved everything we aimed for, and more!***

- **… and beyond AIDA-2020?**
  - WP15 has build bridges and communities and this network will probably "stay alive" beyond AIDA-2020
  - several ideas born within WP15 evolved into full AIDAinnova EoI's in key areas (development of new common tools, beam telescopes upgrade, etc.)
  - "crossing fingers" for the new proposal and looking forward to restart working together soon!