WP15 Report
Upgrade of beam and irradiation test infrastructure

Federico Ravotti (CERN) & Marcel Stanitzki (DESY)

AIDA-2020 3rd Annual Meeting
Bologna, 26/04/2018

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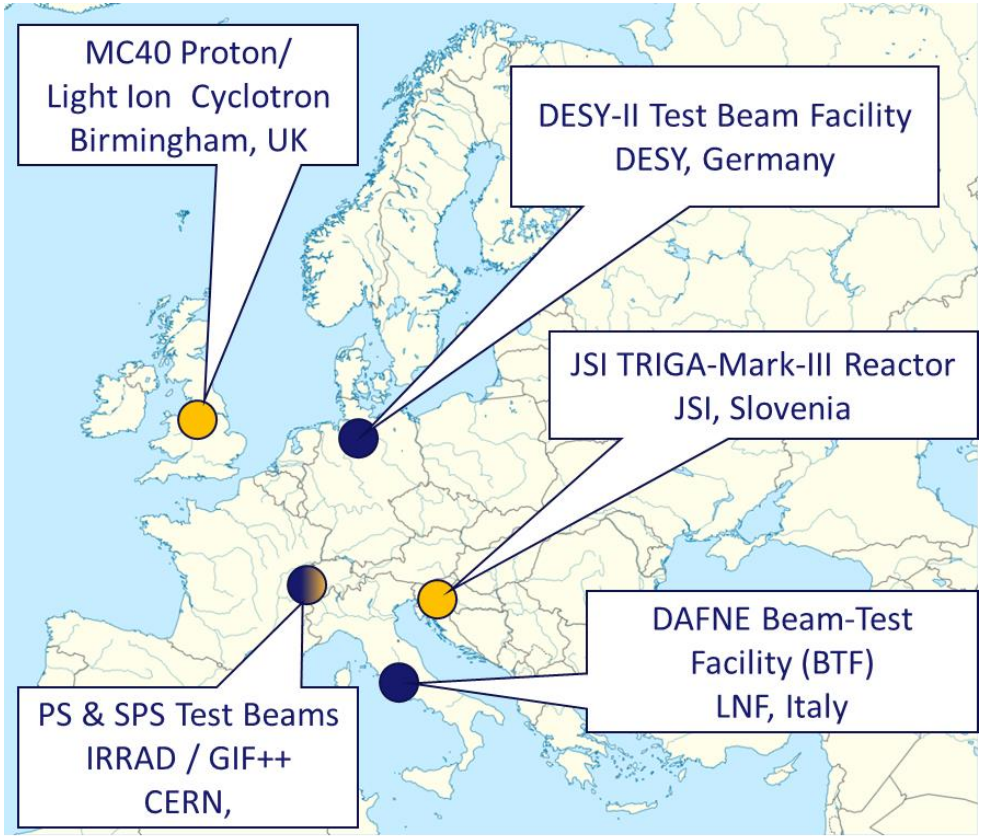
WP 15 Structure, Lab's & Facilities

- **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



Test Beam Facility
Irradiation Facility

WP15.1 Scientific Coordination

- **WP15 Satellite Meeting @ 6th BTTB Workshop (16/1/2018)**
  - https://indico.cern.ch/event/683891
- 2nd event after Barcelona in 2017
  - https://indico.cern.ch/event/591285/
- WP15 has a large overlap of activities and participants with BTTB
  - in particular within Tasks 15.2, 15.3 and 15.4
  - irradiation facilities upgrade activities (Task 15.5) are driven by user requirements …
- **Chasing people for slides, milestone & deliverable reports and publications**

WP15 Status @ M36

- Milestones due in M36
  - MS85 *Installation and commissioning of instantaneous dose rate monitoring system*
    - **Already online**
  - MS86 *Test of the different software modules as event display, camera position tracking and user interface*
    - **Already online**
- Deliverables due in M36
  - D15.2 *Silicon strip reference tracker at DESY*
    - **Extension of scope -> M45**
  - D15.8 Cold irradiations at Birmingham
    - **Already online**
- Publications : 49 Records in CDS
  - 17 are Milestone & Deliverable Reports

AIDA-2020 Extension: Proposal from WP15 (D15.4 & D15.5)

- **D15.4 New Frascati beamline: now M44, postpone to M50**
  - the delay of the Frascati beam line upgrade results from a **re-allocation of resources in the machine division of the laboratory**, which was dictated by external constraints and recommended by an independent advisory body.
  - the presently estimated date for completion leave **little safety margin** and almost **no time to support initial usage** within the project duration, while **an extension would allow for optimizing the facility for the maximum benefit of users**.
- **D15.5 Frascati photon tagging system: now M42, postpone to M52**
  - the **photon tagging facility requires the new beam line to be operational** and would be **commissioned right after the beamlines have gone operational**.

AIDA-2020 Extension: Proposal from WP15

- **Other activities within WP15 (achieved or being achieved) could be further followed-up or extended for the benefit of our users community:**
  - Beam telescope support (D15.1)
  - User support at test-beam area (D15.2 & D15.3)
  - Test-beam areas online database (D15.6)
  - Exploit the demonstrator of augmented reality at GIF++ (D15.11)
  - …

- **AIDA-2020 and WP15 in particular provided the "glue" to bring together activities and people from many EU laboratories/institutes in realizing tasks which would not have been necessarily funded otherwise**
  - Strong argument to **continue the project for another year**!

Annual Meeting in Bologna

- Parallel Session Summary
  - Heard updates on all our activities
  - Reports on all Milestones and Deliverables
  - Interesting discussions on
    - Interplay with WP5
    - Plans for our main facilities
  - Plans for the AIDA2020 Extension
- Lots of great slides
  - [Check it out]

Print | PDF | Full screen | Detailed view | Filter

14:00	WP15.1 - Welcome & Introduction	Federico Ravotti et al.	14:30 - 14:40
	Aula 6		
	WP15.2 - Improvements of test beam infrastructure for high precision tracking	Dimitra Tsionou	14:40 - 15:00
	Aula 6		
15:00	WP15.3 - Improvements of the DESY test beam infrastructure	Dimitra Tsionou	15:00 - 15:20
	Aula 6		
	News about WP15.4 - Improvements of the test beam infrastructure at INFN-LNF	Paolo Valente	15:20 - 15:40
	Aula 6		
	WP15.5 - Transport system for large objects at Ljubljana JSI TRIGA reactor	Marko Mikuz et al.	15:40 - 16:00
	Aula 6		
16:00	Coffee Break		
	Aula 6		16:00 - 16:30
	WP15.5 - IRRAD Facility Infrastructure Upgrade	Blerina Gkotse	16:30 - 16:50
	Aula 6		
	WP15.5 - Si for large fluence irradiation monitoring	Juozas Vaitkus	16:50 - 17:10
17:00	Aula 6		
	News about WP15.5 - Cold irradiations at Birmingham Proton Facility	Richard French	17:10 - 17:30
	Aula 6		
	WP15.5 - GIF++ Gas System Upgrade	Roberto Guida	17:30 - 17:50
	Aula 6		
	WP15.5 - Cosmic-rays tracker improvements & augmented reality event-display for GIF++	Davide Boscherini et al.	17:50 - 18:10
18:00	Aula 6		
	WP15.5 - Istantaneous dose-rate monitor for GIF++ Facility	Plamen Stoianov Iaydjiev	18:10 - 18:30
	Aula 6		

WP15 Structure

WP15.2	WP15.3	WP15.4	WP15.5
J. Dreyling-Eschweiler DESY	M. Stanitzki 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

EUDET-type Beam Telescopes

A common tool used by many different users from various experiments

Today & User interfaces
A workhorse for various (HEP) test beams: 7 copies at 5 different test beam facilities (CERN PS/SPS, DESY, SLAC, ELSA)

WP10 connections

•3 pillars of EUDET-type telescope package: from data to results

EUDET-type hardware ⇔ **EUDAQ** DAQ software → **EUTelescope** Track Reconstruction SW

.Defined Interfaces

–DUT integration e.g. in µm-precise stages

–TLU communication

.Starting point: *beam-telescopes.github.io*

.Defined Interfaces

–Producer for DUT-DAQ communication

–Converter for data proc.

.Starting point: *eudaq.github.io*

Strong WP5 connections

.Interfaces

–To EUDAQ 1 events

–DUT implementation

.Starting point: *eutelescope.github.io*

Telescope Status

Deliverables achieved

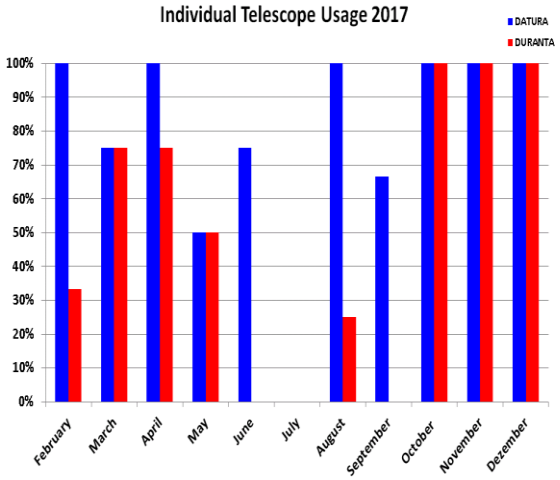
AIDA2020 inputs

- FTE: 10% (05/15-06/16) and 40% (07/16-today)
- For AZALEA: 80k
- For 10x Mimosa spares: 30k

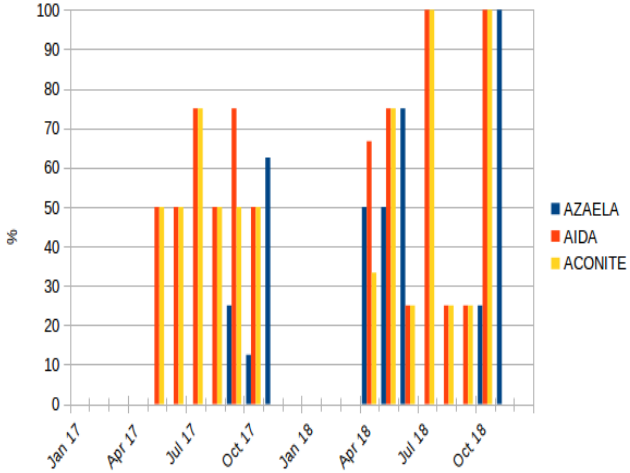
AIDA2020 results

- AZALEA was installed at PS T10, CERN, in September 2016
- Milestone (MS32) and Delivery (D15.1) already achieved in 2016/7
- Starting point of documentation: telescopes.desy.de
- Usage of AIDA supported telescopes

DESY (two telescopes)



CERN (one telescope at PS, two at SPS)



Reviews for the Future Steps

In 2017/18: Reviews of the last decade and future needs

•Dedicated workshop "Future opportunities for Test Beams at DESY"
Hamburg, 5-6 October 2017, https://indico.desy.de/indico/event/17998/

•During the POF review appearance in MT and MU contributions
Hamburg, 5-9 February 2018, https://indico.desy.de/indico/event/19128/

•Asking the community in the "Beam Telescope 2025" Forum at BTTB6
Zurich, 16-19 January 2018, https://indico.desy.de/indico/event/18050/

Main results and outlooks:

•***"EUDET-type beam telescopes are a common tool (hardware, DAQ, reconstruction software) used by many different users from various experiments"***

•Continuous development (hardware and software) and support are needed

•Specific needs and started collaborative efforts:

1)Better time resolution

2)Test beam database

Breaking News: BTTB7 at CERN in the week 14-18 January 2019

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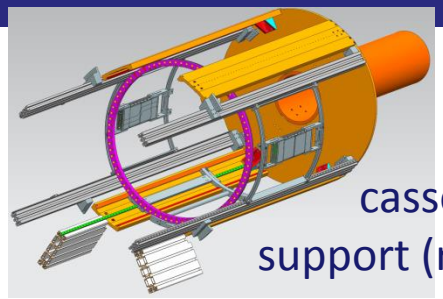
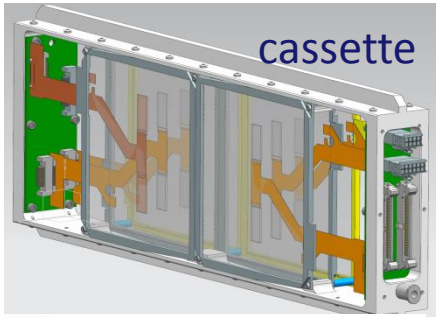
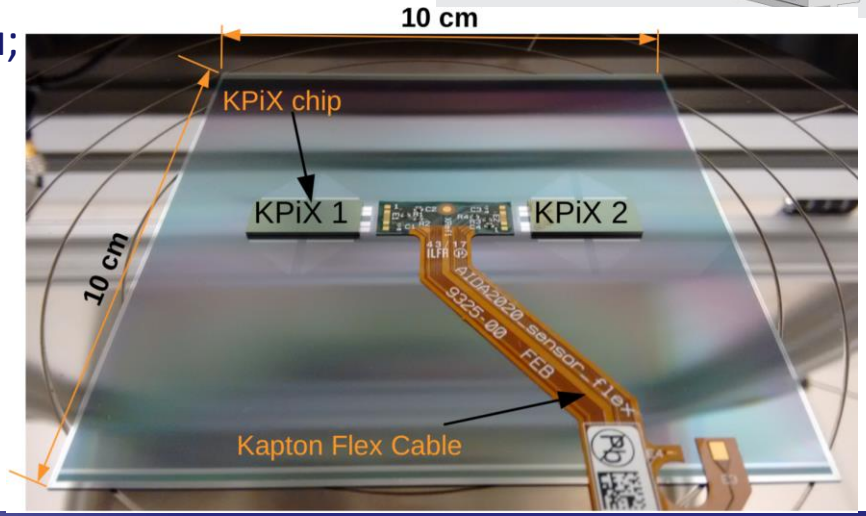
WP15.3 Improvements of the DESY test beam infrastructure





WP15.3.1: External silicon tracker for 1T magnet in the DESY test beam

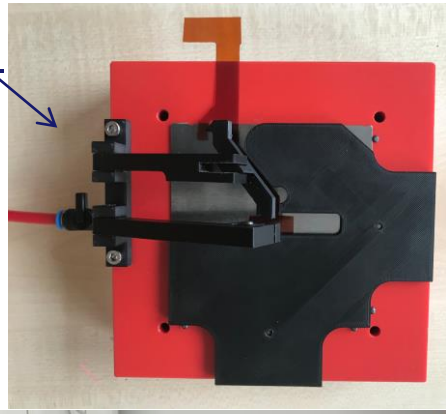
- Design requirements: large activate area with spatial resolution <10 µm, limited space for large user case.
- 6 layers of SiD strip sensor with 2 KPiX readout chips bump-bonded chosen to fulfil the requirements; hold by mechanical support (cassettes) with movable rails.
- SiD Sensor:
  - **Nov 2016**: 25 sensors ordered at Hamamatsu;
  - **July 2017**: Sensor arrived;
  - **Sep 2017**: All sensor quality verified; send to IZM
  - **Feb 2018**: Start final assembly -> glue & wire-bond Kapton flex cable.

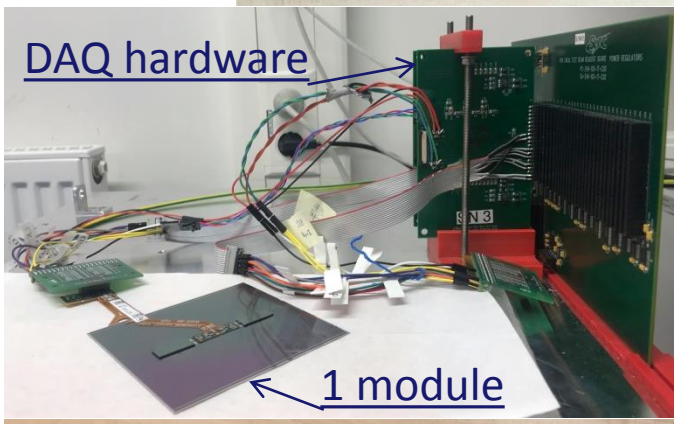


WP15.3 Improvements of the DESY test beam infrastructure

- Module assembly status:
  - 3 modules assembled but none up to spec
    → many tests to qualify the components & assembly process.
    → confident on every single component functioning
    → suspect assembly process -> e.g. glue or gluing tool
- DAQ hardware and software ready:
  - DAQ well studied from an identical setup (KPiX on an Ecal sensor): including beam tests in May & Oct 2017.
  - Transfer knowledge to ongoing Module tests.
- EUDAQ2 integration: close collaboration w/ WP5
  - Ready: run control, data collector, data conversion.
- Other components:
  - mechanical support: cassette ready, sensor frame and rails in production;
  - Power supply system ready at DESY.

Gluing tool example





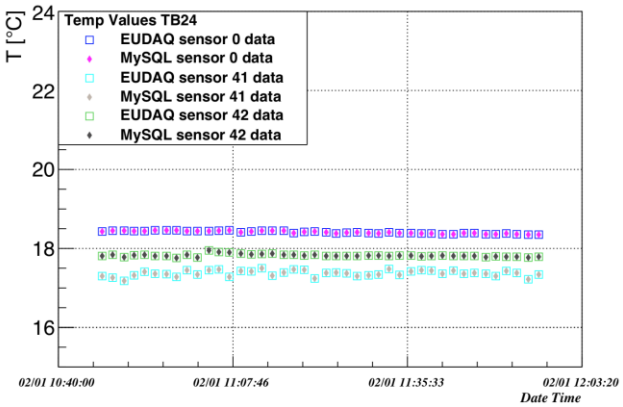
WP15.3 Improvements of the DESY test beam infrastructure

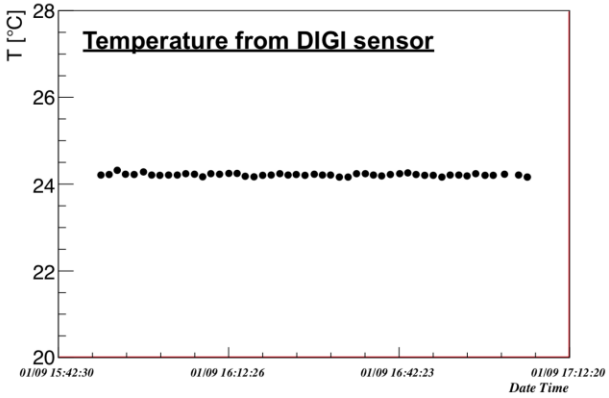
- Sensors delivered on time, and other hardware/software on time, thus **MS59 on time in M30**.
- **Sensor assembly is more problematic than expected**
  - first module tests started from Feb 2018, partially work → slow down assembly process → tests to inspect assembly process and components.
  - Will take more time than expected
- **Extension of scope request**
  - Lesson learn from BTTB6 and latest DESY Test Beam User workshop:
    - better deliver telescope in a complete package: hardware, TLU, DAQ and a reconstruction suite like EUTelescope for the EUDET-type pixel telescopes.
  - Move to M45 with extended scope
    - 1 or 2 test beam weeks needed in fall 2018 at DESY;
    - Additional software development and time to perform a 1st full telescope analysis;
    - Extra point: integrating the recently delivered (15/12/2017) AIDA2020-type TLU.

WP15.3 Improvements of the DESY test beam infrastructure

WP15.3.2: Environmental slow control system

- A central monitoring system maintained by DESY
- Commercial Rack-based data logger with data stored in MySQL DB, integrated to EUDAQ2
- 1st user operations by interns, finished by 01/2018
- MS33 on time in M18; D15.3 on time in M30
- Status & plan:
  - Ready for internal/external users;
  - As part of foreseen upgrade/maintain: deploy DQM4HEP for monitor once it is integrated to EUDAQ2.





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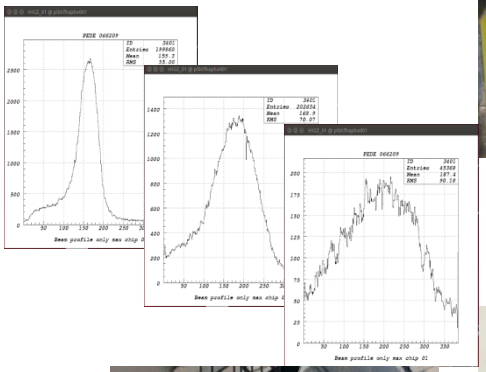
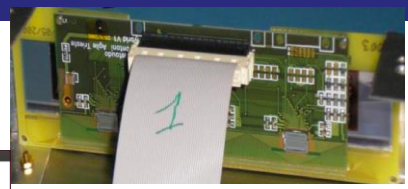
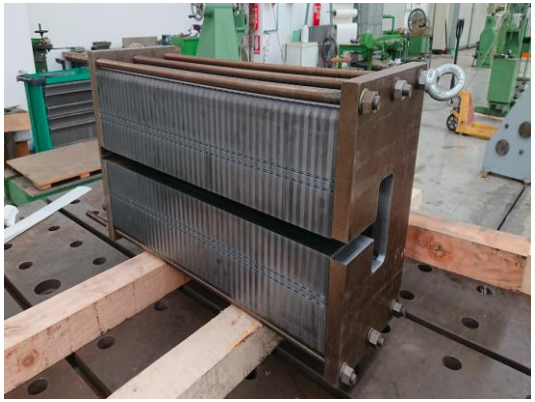
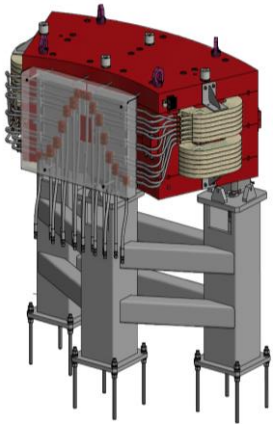
Improvements of the test beam infrastructure at INFN-LNF

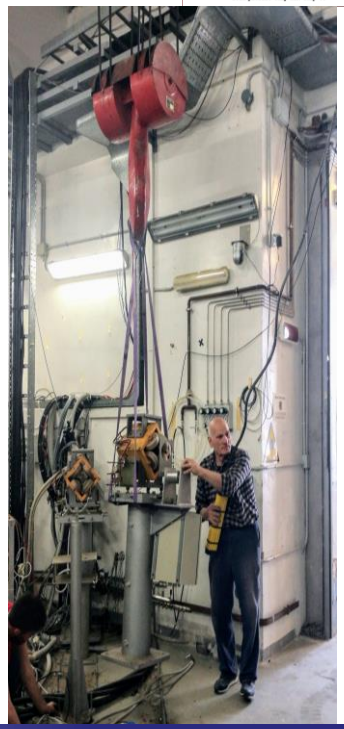
- MS70 – photon tagging components: achieved
  - Hardware, firmware and software fully tested, also with (electron) beam
  - Final commissioning and D15.5: Photon tagging will be operational after the new beam-lines installation
- MS34 – new beam line components: delayed, but:
  - Full funding now available
  - Infrastructural work well advanced: old line dismantled, building modifications and hall preparation on-going
  - New magnets design completed and production started
  - New power supplies in production
  - Vacuum, supports, services advancing in parallel











WP15.4 Summary

- The BTF upgrade is a **complex project and a huge effort**
  - Schedule and delays influenced by:
    - Funding timing
    - Administrative overhead
    - Interference of infrastructural work with accelerator complex operations
- The main uncertainty comes from the construction of the new magnets
  - All projects started and almost all productions on-going
- Civil engineering on track
- Upgrade of cooling, power, services also proceeding
- Updated schedule for new beam-lines
  - BTF-1 expected restart: June 2018
  - BTF-2 installation and commissioning: first months of 2019
  - **Move D15.4 (New Frascati beam line) to M50**
  - **Enables use of BTF by AIDA2020 users**
- Photon tagging ready, need to be installed on new line
  - **Move D15.5 (Photon tagging) to M52**

WP15 Structure

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Task 15.5: Improvements of the infrastructure for irradiation tests

all Milestones achieved!

- **D15.6 – CERN Proton Facility Upgrade** — **M24**
  - **contactless fluence monitor (VU)**
  - **IRRAD samples & users management sw. / storage area equipment (CERN)**
  - **CERN online database on irradiation facilities of interest for HEP (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 — **M48**
  - instantaneous dose-rate monitor (INRNE)
  - improved cosmic-rays tracker & demonstrator of augmented reality (INFN)

Task 15.5: Contactless Fluence Monitor (VU)

J. Vaitkus

- Investigation of **Si and GaN sensors for large fluence irradiation monitoring**
- Combining results from various measurement techniques: TDTL, DLTS, PPIS, PIL, etc.

c-Si

Type of irradiation	Electrons		Protons		Pions	
Energy	6.6 MeV		24 GeV/c		300 MeV/c	
Fluence range	10^{16}-5×10^{16} e/cm^2		10^{12}-10^{16} p/cm^2		10^{11}-3×10^{15} π^+/cm^2	
Si material	CZ n-Si	CZ p-Si	FZ n-Si	CZ p-Si	CZ n-Si	FZ n-Si
Dopant concentration	10^{15} cm^{-3}	3×10^{15}cm^{-3}	10^{12} cm^{-3}	10^{12} cm^{-3}	10^{12} cm^{-3}	10^{12} cm^{-3}

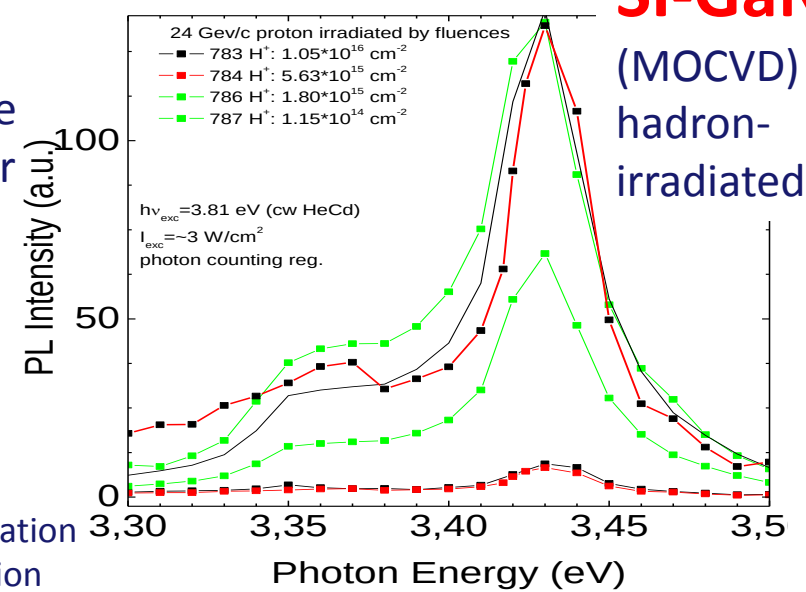
mc-Si

Type of irradiation	Protons
Energy	8 MeV
Fluence range	10^{12}-10^{16} p/cm^2
Si material	p-Si
Dopant concentration	10^{15} cm^{-3}

inexpensive material for mass production

SI-GaN

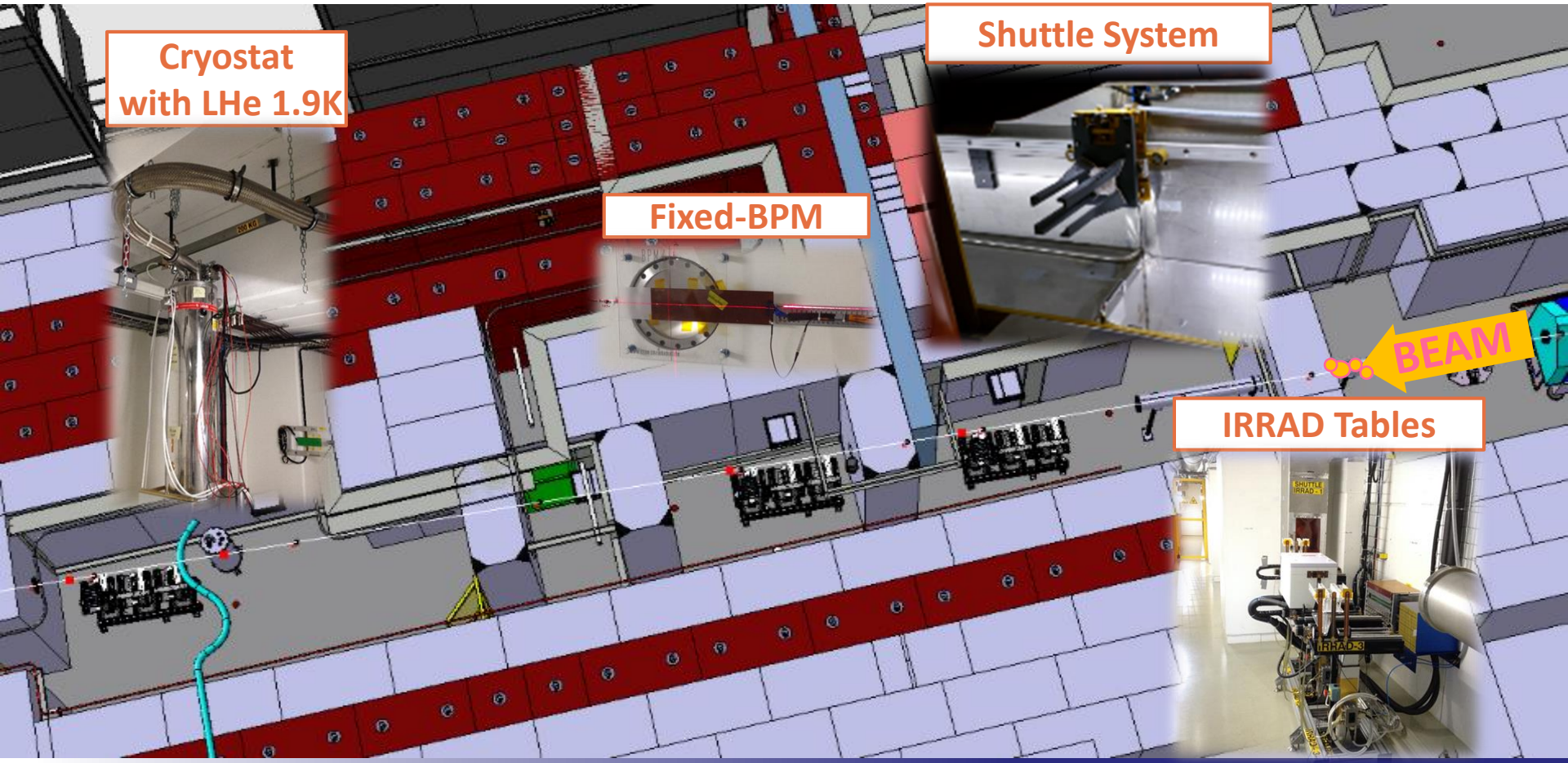
(MOCVD) hadron-irradiated



- **Semi-Insulating GaN** is a promising material for particle/imaging detectors
  - lack of detailed studies of radiation-induced defects
  - The **AT-GaN** showed insignificant changes after neutron irradiation
  - **GaN LED sensors** can be used for detection of hadron irradiation

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 msec** 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)

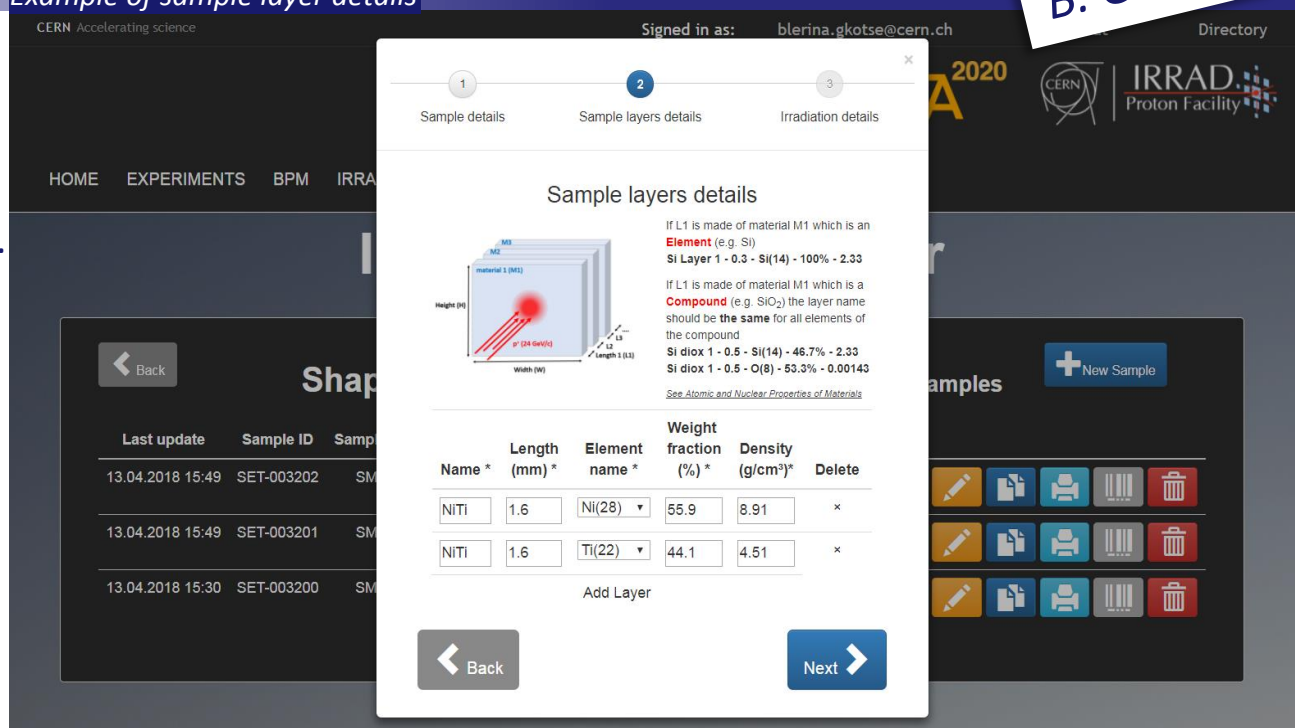


Task 15.5: IRRAD Data Manager

B. Gkotse

- **Registration** of samples, users, experiments, dosimeters, etc.
  - edit, clone, delete, print, etc.
- Printing **traceability labels**
- Different views for admin and users
- **Interaction lengths estimation** based on the elements/compounds of the samples
- **Continuously improved**
  - users feedback
  - ML and automatic UI generation (Blerina' s PhD)

Example of sample layer details

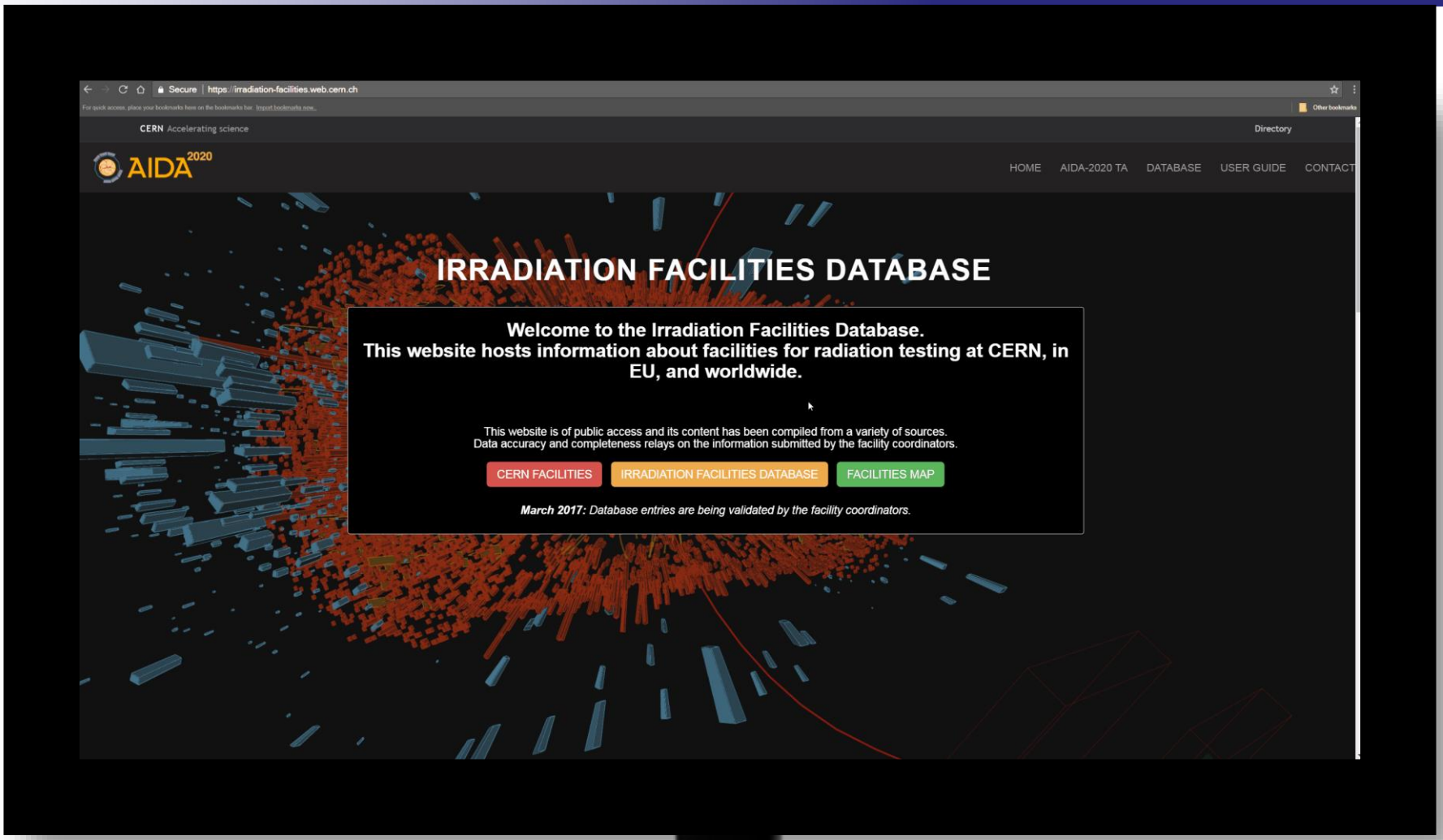


Sample label

Registered experiments	25
Users	28
User projects	15
Registered samples	361
Irradiated samples	73

Usage Statistics since April 11th 2018

Task 15.5: CERN Proton Facility Irradiation Facilities Database



Task 15.5: CERN Proton Facility Irradiation Facilities Database

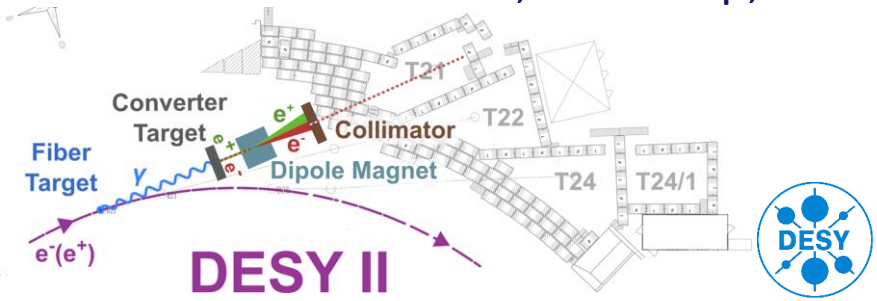
Statistics

- **209** irradiation facilities
- **377** visits in 2018

Visitor countries for 2018

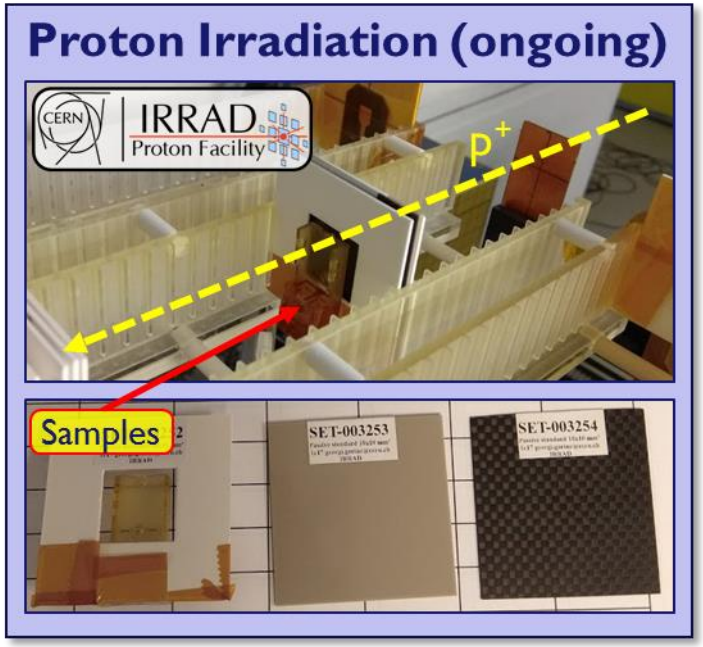
Follow-up

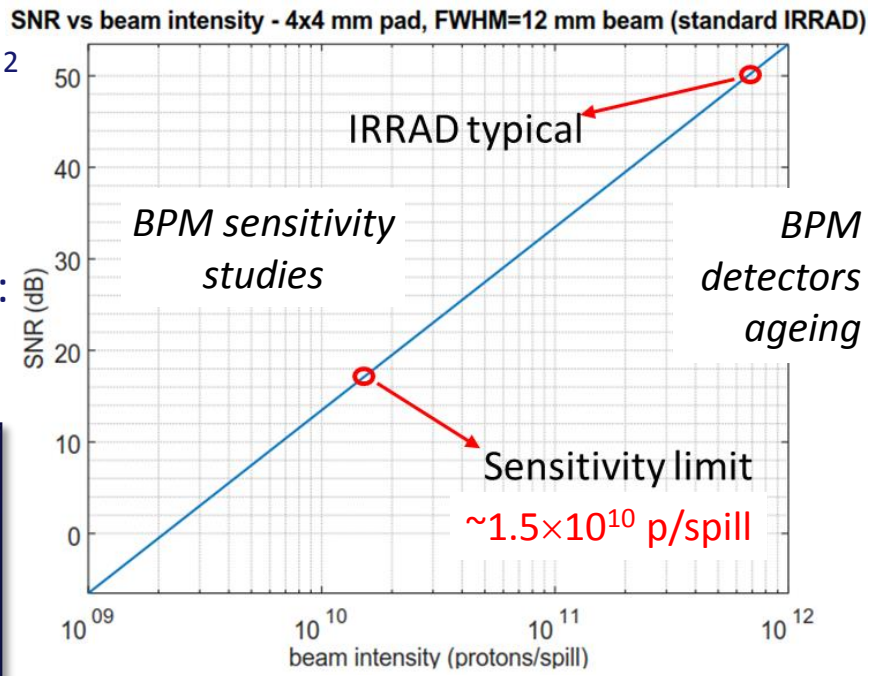
- Interest from the **test-beam users community** for equivalent web application on **worldwide test-beam areas** (forum discussions @ BTTB6)
- CERN team can adapt the SW infrastructure (http://cern.ch/test-beam-facilities), **but it is necessary** to:
  - define the **relevant information**
  - input the **first dataset**
  - appoint a **responsible person** (knolegible for data validation, follow-up, reminders)



Task 15.5: RadHard instrumentation for IRRAD

- Need to replace **cardboard sample holders** above 10^{16} p/cm^2
  - activation
  - material deterioration
  - radioactive waste
- Material tested in **IRRAD** and **JSI**: Cardboard, Nylon, Carbon fibre, PEEK, ULTEM1000





- Study the **sensitivity** and **time response** for optimizing BPM instr. w.r.t. the beam conditions
- BPM and mini-BPMs detectors replaced in 2018
- New BPM detectors: **production by the end of LS2** to address **radiation damage** issues and need of **new patterns** adapted to IRRAD beam optics

Task 15.5: Cold Irradiations at Birmingham Facility – LN_2 Cooling

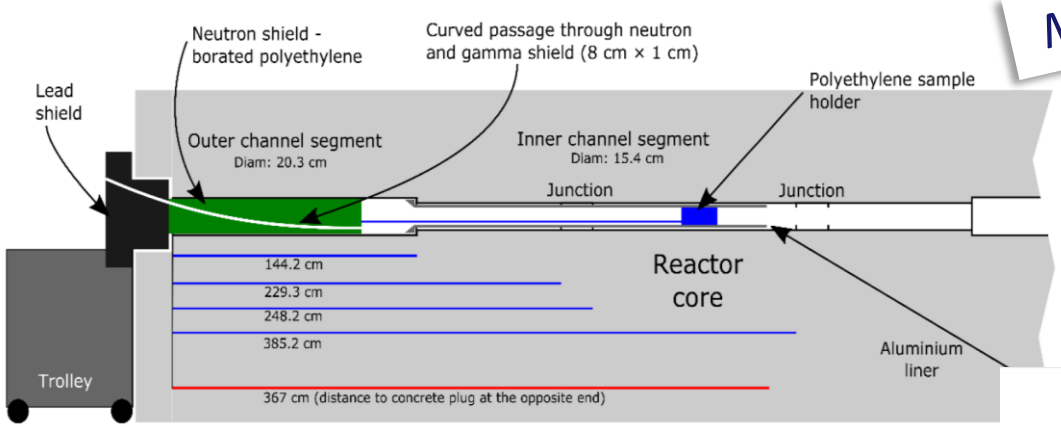
P. Kemp-Russell

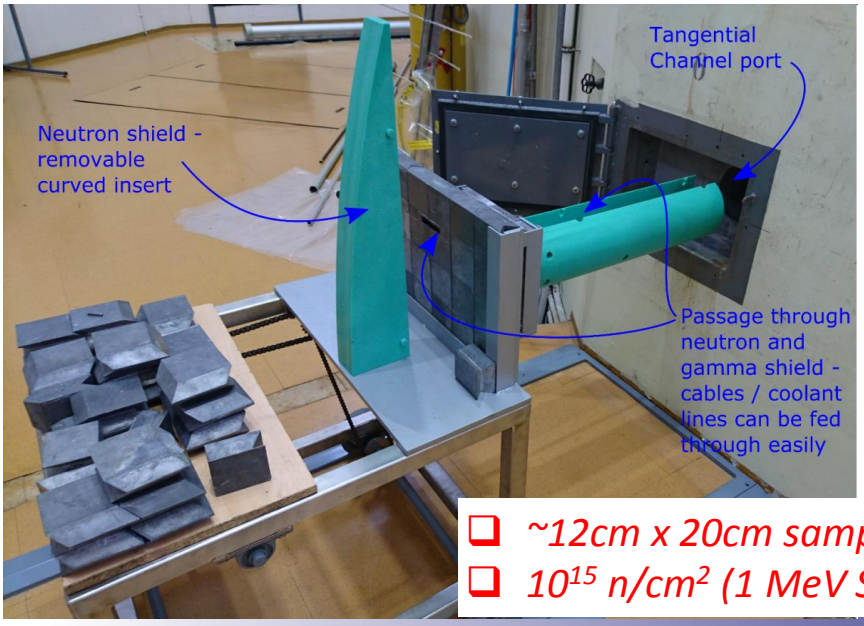
READY TO GO

- New design LN_2 box: **construction completed** by Sheffield April 2018
- Improved Z-support (**new pillar**) for better movement control
- Cooling stable to operational irradiation temperatures at Birmingham (measured)
- Scanning system and software **testing at Sheffield Robotics** (2nd LN_2 cooling unit)
- Ready for **installation at Birmingham during next operational shut down** in 2018

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

TRIGA reactor Tangential channel fitted with irradiation device





- *~12cm x 20cm samples*
- *10^{15} n/cm^2 (1 MeV Si eq.) < 1h*

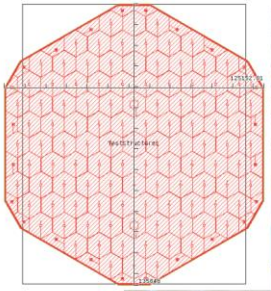
M. Mikuz

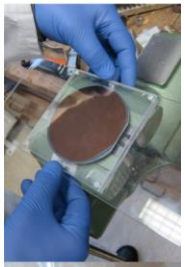
1st Irradiations

- ATLAS - silicon wafers (DESY)
  - thermo-mechanical studies (2e15 n/cm^2)
- Atlas Tile calorimeter upgrade
  - shaper/digitizer card (8e12 n/cm^2)

More Kids on the Block

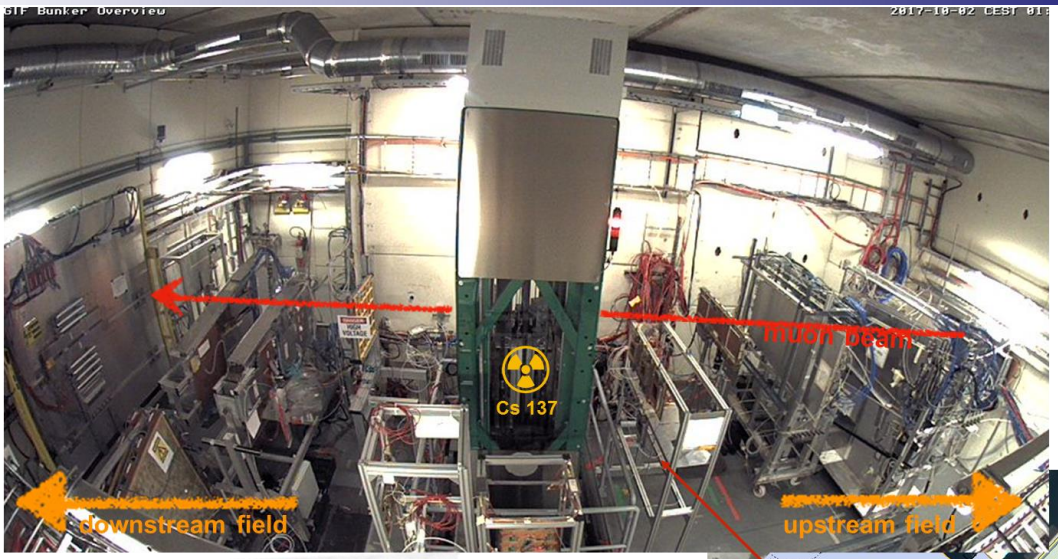
- CMS calorimeter upgrade – Si sensors
  - hexagonal sensor coming from an 6" wafer with the dimensions of 12.6 x 13.6 cm (and a thickness of 320micron)
  - 18 sensors, 2 pieces each of 3 types and 3 fluences (2*3*3)
  - up to 1e15 n/cm^2
- ATLAS full sensor QA
  - square sensors out of 6" wafers
  - up to 2e15 n/cm^2





Task 15.5: GIF++

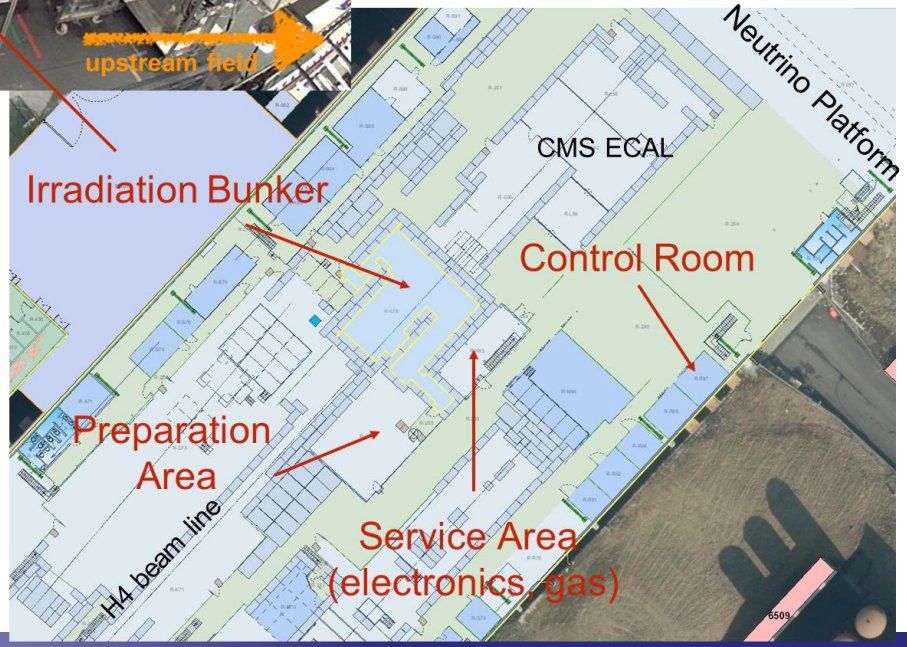
M.R. Jaekel



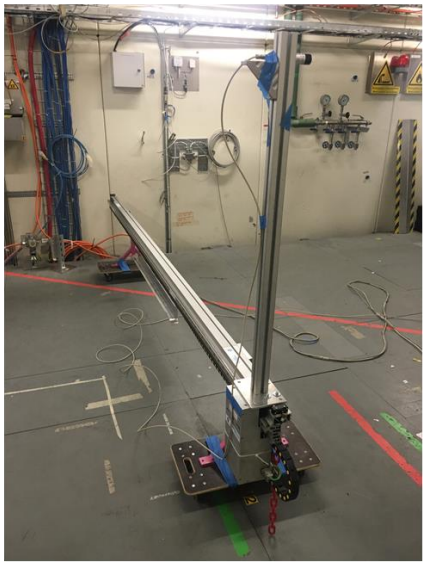
Main R&D :

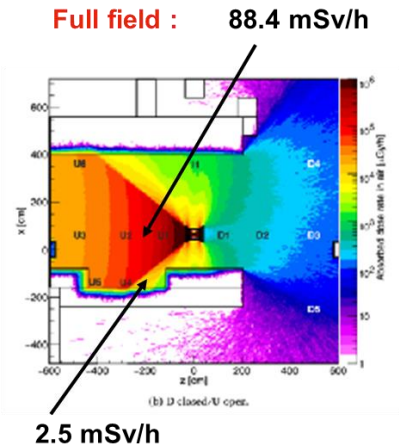
- Ageing tests under radiation
- Detector validation tests in presence of high radiation background + muon beam

- Joint facility, operated by EN-EA and EP-DT
- Unique place, combining a high energy muon beam (≈100 GeV/C, 10^4 muons per spill) with a 14 TBq ^{137}Cs gamma source (2014)
- 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.
- 100 m^2 irradiation bunker with 2 independent irradiation zones, separated attenuation systems
- All year round operation from Cs-Irradiator
- Central Control System, wide range of available gases (+ custom gases) in bunker & service zone



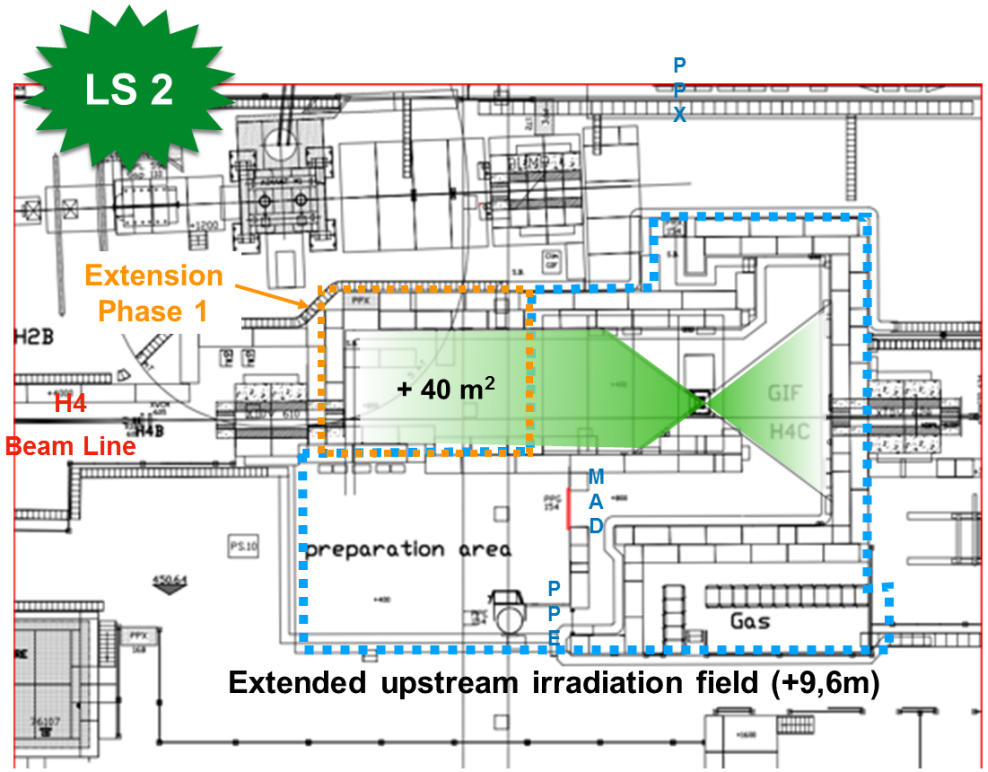
Task 15.5: GIF++ Recent Completed Upgrades





- Material Access Door (MAD) installed, allowing fast installation/removal of setups (access no longer requires a transport request to remove concrete blocks)
- 3.2m translation stage installed (thanks to H.Reithler, Univ.Aachen). First full field mapping completed with Automess AD-6 with external probe 15/H. Results to be distributed soon, including measurements with half-filter. System available for further measurements on request.
- One shielded rack installed in upstream alcove, outside of main irradiation cone. Dose rate in this rack significantly influenced by scattered gammas. At an attenuation factor of 6.9, we reach ≈ 0.1 mSv/h inside rack.

Task 15.5: GIF++ a possible way forward …



Possible extension of the Irradiation bunker during LS2, currently under consideration

- Currently investigation ongoing if **irradiation zone can be extended upstream** (+40 m²) ,
  - Compatible with new PPE-144 zone proposal
  - More space for placing set-ups in muon beam, already during Run 3
  - Lower radiation zone, due to increased distance (up to ≈ 15 m from source). Reduced need of attenuation.
  - More space for mass production tests

ECR approved,
IEFC approval & budget pending

- **Part of broader long term plan** to cope with future requirements for a gas detector test fa LS3 (sideways extension, source upgrade etc.)
  - Will depend on the future needs for R&D, currently under discussion
  - Cs-Source certified until LS3 (14->11 TBq). Needs to be re-certified or exchanged during LS3.

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

- The gas systems infrastructure is a key element of the successful R&D programs performed at GIF++
  - Mixing units, gas recirculation systems and gas analysis modules are used for detector R&D studies
- Commissioning of the new second generation gas recirculation system will probably start in autumn (when new resources will be finally available)

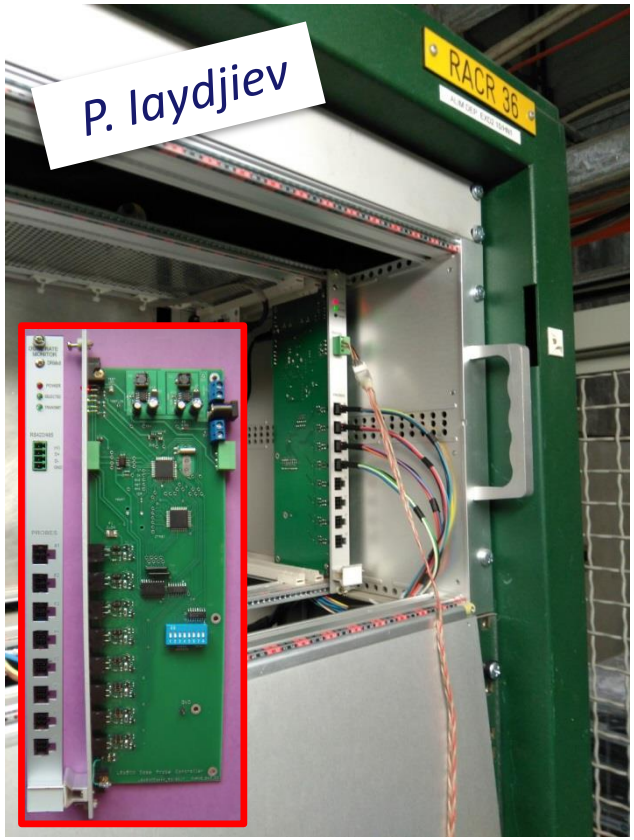
Gas recirculation module

AIDA 2020 D 15.10 (M24)

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

M.R. Jaekel
R. Guida

Task 15.5: GIF++ Facility Upgrade (Instantaneous Dose-rate monitor)



- The first version of the 2–channel counter board designed at INRNE, Sofia tested at GIF++ in June 2016;
- Final design (8-channel) board **designed and tested in November 2017** (supported by AIDA-2020 TA);
- Integration of the Berthold data in GIF++ DCS is ongoing.

MS85 (M36)

Final board installed at GIF++, 2017

Berthold probe installed at GIF++ (upstream)

Comparison RADMON vs. Berthold Probes, 2017

	Total dose Gy	Irradiation time hours	Dose per hour (RADMON) mGy/h	Probe counts cps	Probe cps (dead time correction)	Dose per hour (probe) mGy/h	Maximum cps per probe for the correct dose estimation
RADMON2 + probe2	15.9	96	166	18500	25342	178	45500

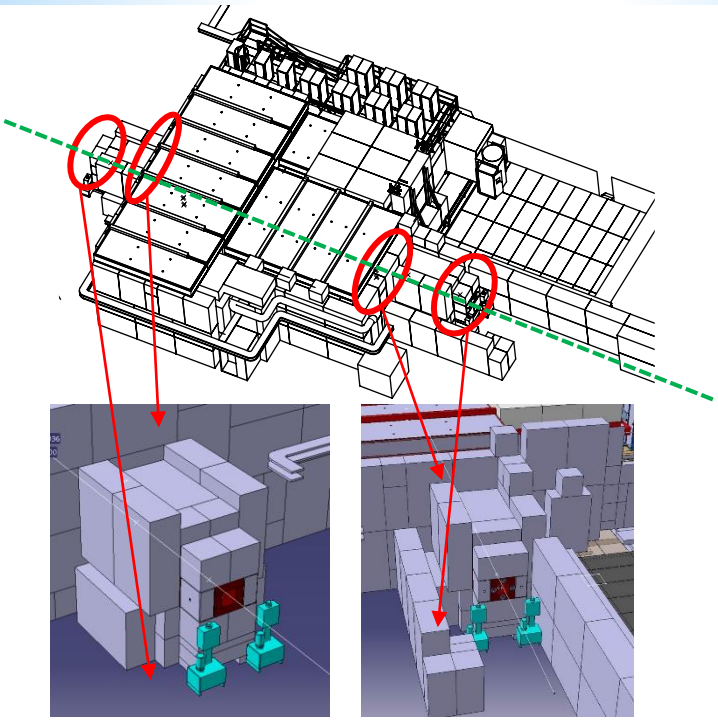
D15.11 (M48)

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

2018 First Half
At material arrival, produce chambers:
- gas volumes
- readout panels
- front-end electronics

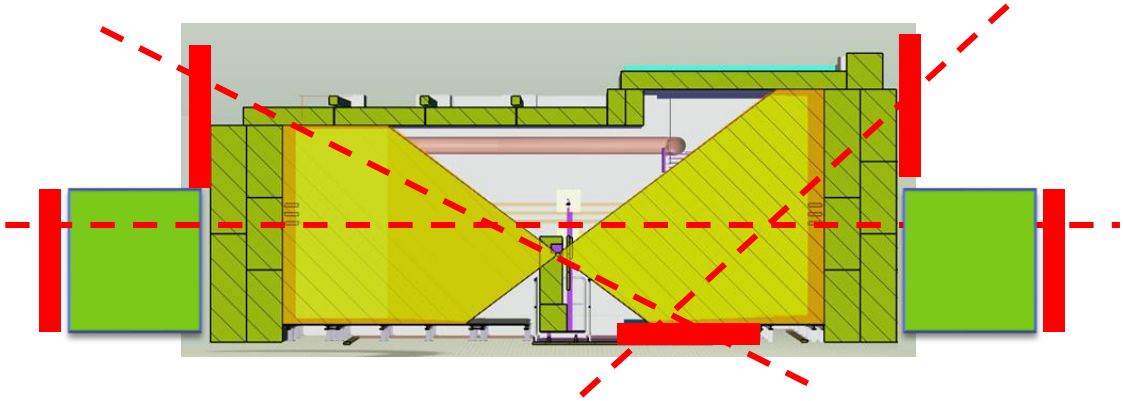
G. Alberghi

2018 Second Half
Downstream chambers can be installed
Upstream chambers waiting for news on bunker extension



Upstream Downstream

- Mechanics of new chambers is available
- Need to produce some of the active elements of the detectors:
  - gas volumes
  - readout panels available
  - Front-end electronics to be tested
- Chambers test stand at CERN-BB5 area;
- Discussions with EP-DT and EN-EA groups at CERN to define **chambers installation details & schedule**.



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

Milestone MS86 in M36:
Test of the different software modules as event display, camera position tracking and user interface

Present status of the infrastructure software:

GIF++ Cosmic rays tracker DAQ and event reconstruction

* Software in development as a C program on a Linux machine, reading VME timing pattern readout modules
* Event reconstruction is a module of the DAQ generating the track vectors. The simulated tracks generator is ready
* Tracks are available on an UDP port

GIF++ DCS

* Software developed as a WinCC software on a Windows machine, connected to a CAEN mainframe and receiving gas system data form the gas DCS.
* DCS module publishing DCS data for the ARtDeCo (Augmented Reality to DCS) module is in development. It will associate virtual instruments tags and monitoring data

Software Platform for Augmented Reality:

* **ARToolKit** chosen as software platform
* The software has been tested in the INFN Labs of Roma Tor Vergata
* The software is able to recognize black&white markers and to show superimposed text above instruments and detectors
* Next steps: test the communication between DCS and ARToolKit; survey GIF++ area in order to define the set of markers needed

Funding:

* 20 kEUR used to finance a 1-year Post Doc contract with INFN - Rome Tor Vergata

MS86 (M36)

D15.11 (M48)

WP15 Milestones Summary

WP 15.2	WP15.3		WP15.4		WP15.5						
DESY-II & CERN Test Beam Facility	DESY-II Test Beam Facility		BTF		CERN IRRAD		JSI Triga	CERN GIF++			U.o.B Cyclot. Facility
MS32	MS33	MS59	MS34 (M18) ⬇ (M42)	MS70	MS16	MS35	MS17	MS37	MS85	MS86	MS36

BTF components installed

WP15 Deliverables Summary

WP 15.2	WP15.3	WP15.4	WP15.5			
DESY-II & CERN Test Beam Facility	DESY-II Test Beam Facility	BTF	CERN IRRAD	JSI Triga	CERN GIF++	U.o.B Cyclotr. Facility
D15.1	D15.2 (M36) ⬇ (M45)	D15.4 (M30) ⬇ (M50)	D15.6	D15.7 (M44)	D15.9	D15.10
	D15.3	D15.5 (M42) ⬇ (M52)				D15.11 (M48)
						D15.8

Scope Extension

New BTF beamline

Summary

- **WP15 is delivering improvements to Test Beam and Irradiation Facilities**
  - Improve capabilities and user experience
- **AIDA2020 is providing the "glue" to make activities happen, that may not have happened otherwise**
  - Every task leader gave a clear overview of the impact of AIDA-2020 in his activity in terms of material and or manpower support (see parallel session talks)
- **WP15 has several activities that would benefit from an AIDA2020 extension**
  - Will allow to have real user operation at Frascati (D15.4)
  - Few other activities where we could build on things we already achieved in AIDA2020
  - AIDA2020 is crucial forum for "us facility people" to meet and exchange ideas
- Thanks to the team from Bologna for hosting us at this fantastic place