

## Presentation

# The CERN Proton Irradiation Facility IRRAD during and after the CERN Long Shutdown 2

Brethoux, Damien (CERN) *et al*

14 January 2019



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# The CERN Proton Irradiation Facility IRRAD during and after the CERN Long Shutdown 2

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<sup>1</sup> CERN EN

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<sup>3</sup> EPFL

<sup>4</sup> MINES ParisTech

<sup>5</sup> CERN BE

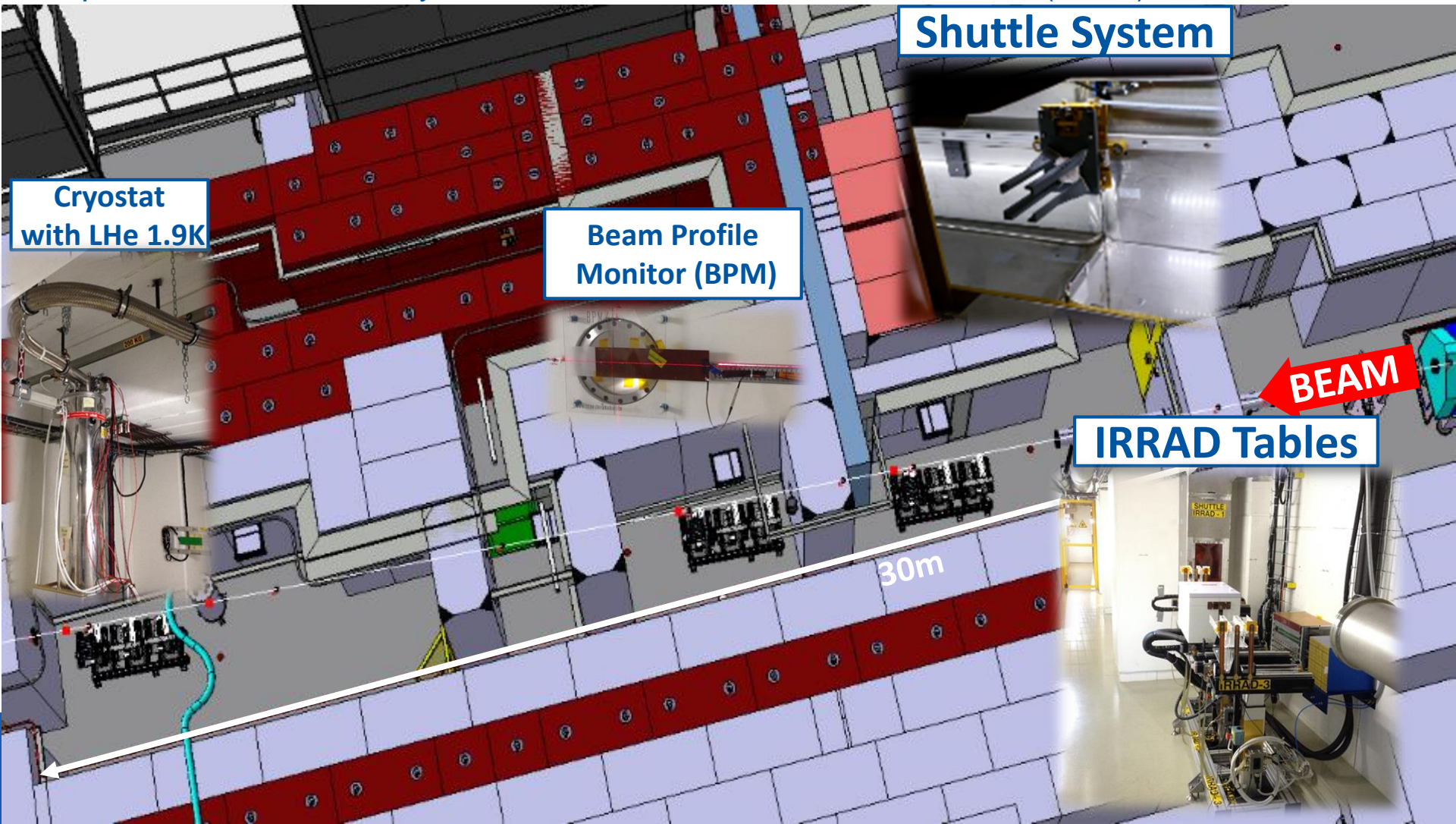


# Outline

- **IRRAD Facility & Summary Proton Run 2018**
- **IRRAD Data Manager**
- **IRRAD Infrastructure Upgrades (AIDA-2020 D15.7)**
- **Heavy Ions Run 2017-2018**
- **Activities during LS2**

# Proton Irradiation Facility IRRAD

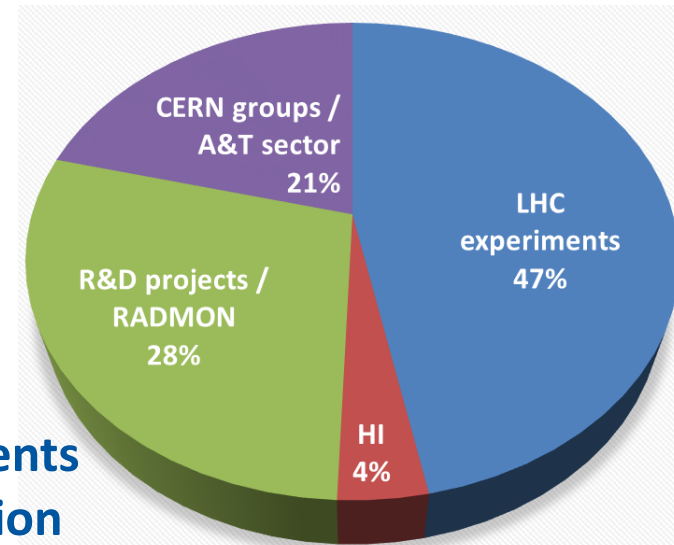
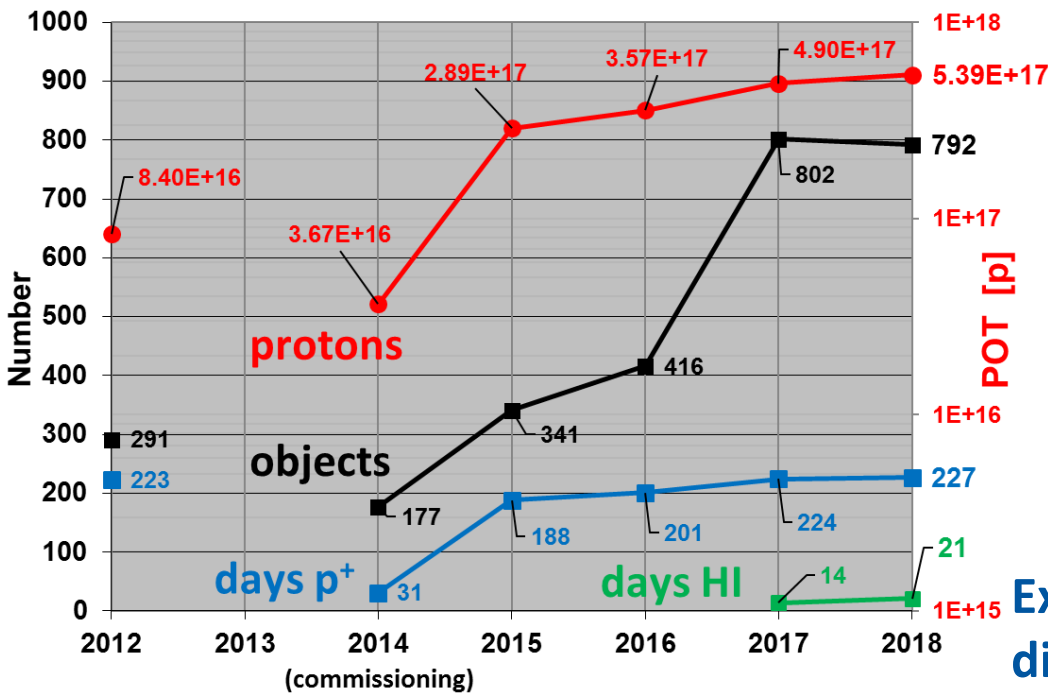
- Testing inner detector components of the HEP experiments
- Beam of 24 GeV/c and size of 12×12 mm<sup>2</sup>
- Spills of ~400 msec every ~10 sec
- Fluence of 1×10<sup>16</sup> p/cm<sup>2</sup> in 14 days
- Scanning up to dimensions of 10×10cm<sup>2</sup>
- Cryostat with LHe 1.9K
- Low T irradiations (-25°C)



# IRRAD: Summary Run 2018

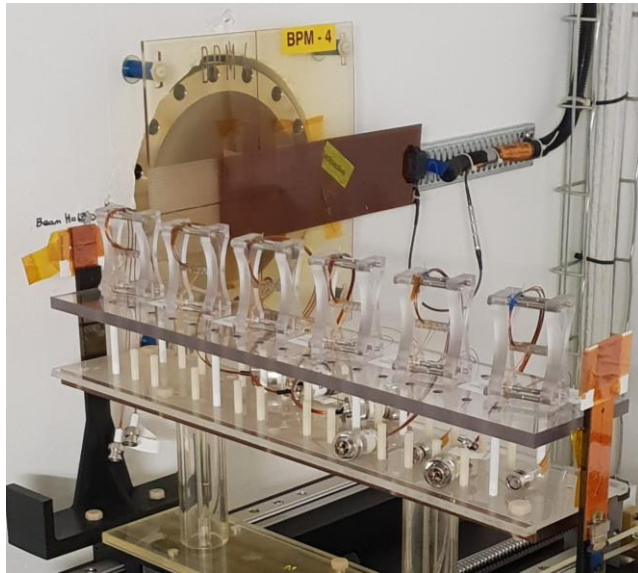
- 81 experiments completed in 2018:

- 92 users registered in the IRRAD Data Manager ([cern.ch/irrad-data-manager](http://cern.ch/irrad-data-manager))
- 996 objects declared by the users
- 792 objects irradiated



Experiments distribution

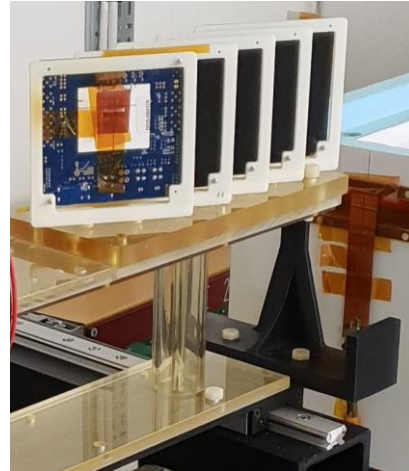
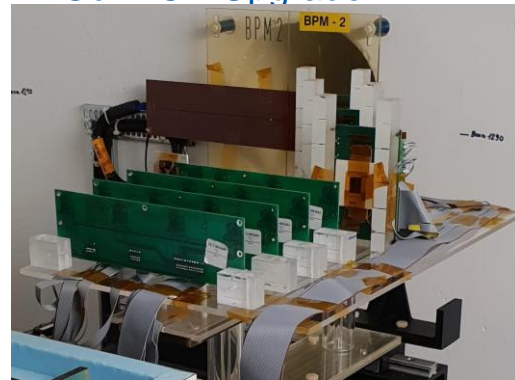
# IRRAD: Summary Run 2018



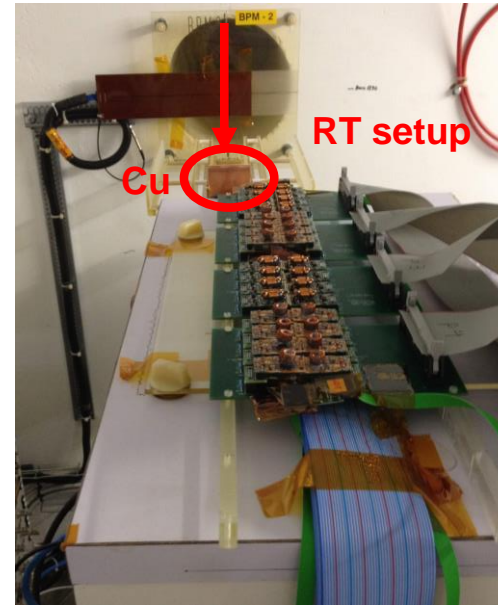
**Piezo actuators**  
for Crystal Collimation,  
Vacuum,  
Cryogenics,  
etc. (EN,TE)

**RD53A modules**  
for ATLAS ITk

**CLARO ASIC** for the  
LHCb RICH Upgrade

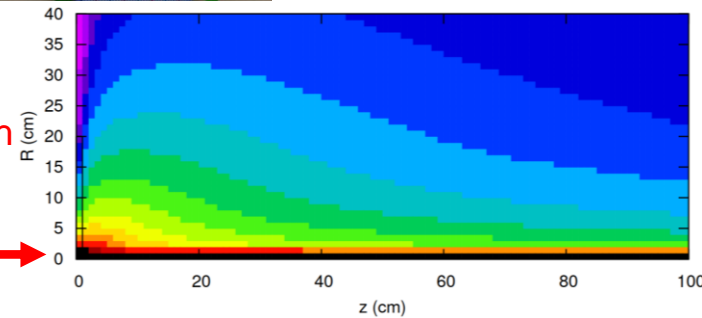


**2x FEAST2 DC/DC converters test**  
in cold-box & RT with “thin” 10mm Cu  
target (EP-ESE)



IRRAD 10mm Cu Target

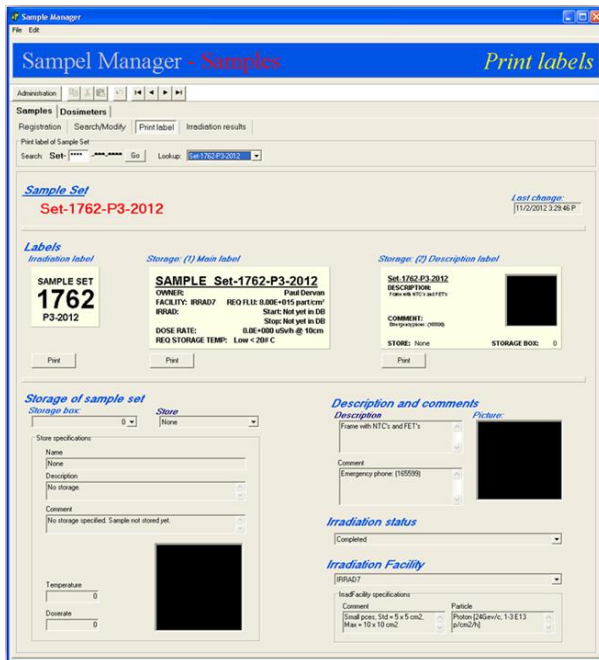
1MeV eq.  $\Phi$   
simulation with  
Cu-target



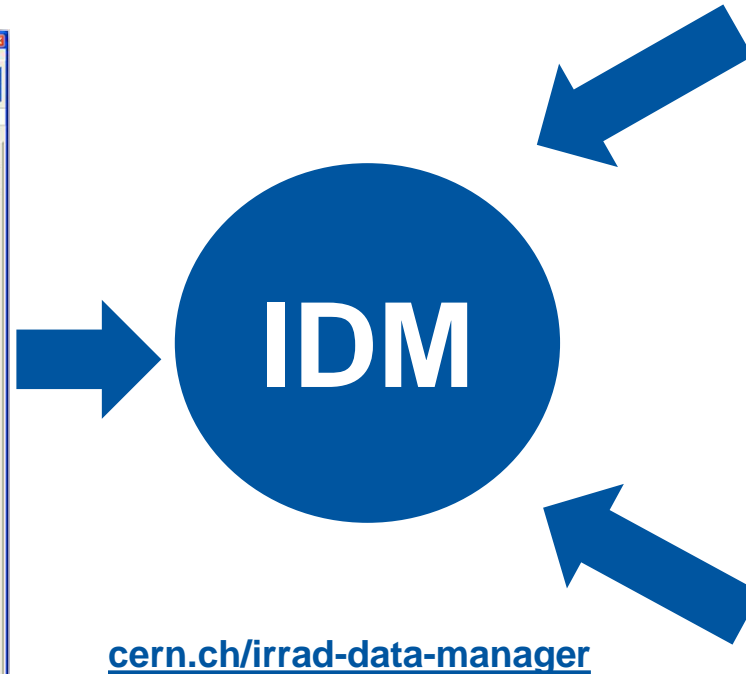
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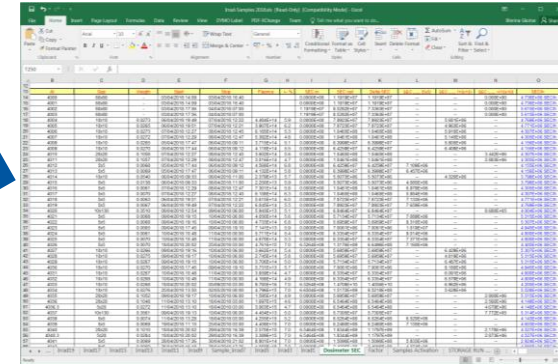
# IRRAD Data Manager (IDM)



Traceability  
(Before)



[cern.ch/irrad-data-manager](http://cern.ch/irrad-data-manager)



Facility Operation  
(During)



Dosimetry Results & Archive  
(After)



# IDM: Key Features

Before

- Experiments, samples, users and dosimeters registration
- Label printing

Old  
Sample  
Manager

During

- Real-time follow-up of irradiation experiments
- Computation of proton interaction parameters

After

- Display and archive of dosimetry result (~600 spectrometry measurements/year)

Extra

- User Interface preferences customization
- History and details of past experiments (with user permission)
- **Can be used also for irradiations in other facilities (PSI)**

New  
IDM

# IDM: Irradiation Experiments View

Before

CERN Accelerating science Signed in as: blerina.gkotse@cern.ch Sign out Directory

HOME EXPERIMENTS BPM IRRAD INFO PREFERENCES

IRRAD Data Manager

Welcome to IRRAD Data Manager, the all-in-one data management tool for IRRAD

My Experiments

IRRAD Data Manager

HOME EXPERIMENTS BPM IRRAD INFO PREFERENCES

IRRADIATION EXPERIMENTS

Search... [New Experiment]

Last update	Irradiation title	Availability	No. samples	No. users	Status	Actions
11/01/2019	<a href="#">Irradiation Test 2</a>	05/11/2018	1	0	Validated	[Edit] [Users] [Samples] [More]
11/01/2019	<a href="#">Irradiation Test 1</a>	05/11/2018	1	0	Validated	[Edit] [Users] [Samples] [More]

# IDM: Samples View

Before

The screenshot displays the IRRAD Data Manager interface. The top navigation bar includes 'HOME EXPERIMENTS BPM IRRAD INFO PREFERENCES' and logos for CERN, IRRAD, and AIDA 2020. The main content area is titled 'IRRAD Data Manager' and features a 'Back' button and a table of samples.

Last update	Sample ID	Sample Name	Category
11/01/2019	Not assigned	Sample NA2	Passive standard 10x10
10/01/2019	Not assigned	Sample NA1	Passive standard 10x10

The detailed view shows 'Sample dimensions' with a diagram of a sample stack. Below the diagram are input fields for 'Total height (mm) \*' (value: 25) and 'Total width (mm) \*' (value: 25). A table lists the layers:

Name *	Length (mm) *	Element/Compound	Delete
L1	0.13	kapton	x
L2	0.0006	Al(13)	x
L3	0.0006	SiO2	x

[cern.ch/irrad-data-manager](http://cern.ch/irrad-data-manager)

# IDM: Irradiation Status View

During

CERN Accelerating science Signed in as: blerina.gkotse@cern.ch [Sign out](#) [Directory](#)

HOME EXPERIMENTS BPM IRRAD INFO ADMIN PREFERENCES CERN IRRAD Proton Facility AIDA 2020

## IRRAD Data Manager

### Irradiation Status

[← Back](#) [+ New Irradiation](#) Select a table

Updated at	Sample	Dosimeter	Date IN - Date OUT	IRRAD table	Table position	Accumulated fluence	SEC	Updated by	Status	In Beam	Actions
15/11/2018	SET-003899	DOS-004211	15/11/2018 16:11 -	IRRAD19	Center		272851	irradiation.facilities@cern.ch	Registered	<input checked="" type="checkbox"/>	<a href="#">Edit</a> <a href="#">Status</a> <a href="#">Delete</a>
15/11/2018	SET-003900	DOS-004211	15/11/2018 16:11 -	IRRAD19	Center		272851	irradiation.facilities@cern.ch	Registered	<input checked="" type="checkbox"/>	<a href="#">Edit</a> <a href="#">Status</a> <a href="#">Delete</a>
15/11/2018	SET-003901	DOS-004211	15/11/2018 16:11 -	IRRAD19	Center		272851	irradiation.facilities@cern.ch	Registered	<input checked="" type="checkbox"/>	<a href="#">Edit</a> <a href="#">Status</a> <a href="#">Delete</a>
15/11/2018	SET-003902	DOS-004211	15/11/2018 16:11 -	IRRAD19	Center		272851	irradiation.facilities@cern.ch	Registered	<input checked="" type="checkbox"/>	<a href="#">Edit</a> <a href="#">Status</a> <a href="#">Delete</a>
15/11/2018	SET-003903	DOS-004211	15/11/2018 16:11 -	IRRAD19	Center		272851	irradiation.facilities@cern.ch	Registered	<input checked="" type="checkbox"/>	<a href="#">Edit</a> <a href="#">Status</a> <a href="#">Delete</a>

# IDM: Dosimetry Results View

After

CERN Accelerating science

Signed in as: blerina.gkotse@cern.ch Sign out Directory

HOME EXPERIMENTS BPM IRRAD INFO ADMIN PREFERENCES

Mat

< Back

Your experiment

	Last update	ID	Name	Category
<input type="checkbox"/>	07/08/2018	SET-003252	ULTEM1000	Passive standard
<input type="checkbox"/>	13/08/2018	SET-003253	PEEK	Passive standard
<input type="checkbox"/>	07/08/2018	SET-003254	Carbon Fiber	Passive standard
<input type="checkbox"/>	07/08/2018	SET-003255	Aluminum Lid	Passive standard

CERN Accelerating science

Signed in as: blerina.gkotse@cern.ch Sign out Directory

HOME EXPERIMENTS BPM IRRAD INFO ADMIN PREFERENCES

IRRAD Proton Facility AIDA<sup>202</sup>

## IRRAD Data Manager

### Dosimetry results for SET-003252 (ULTEM1000)

< Back

Search...

**Export**

Dosimeter	Dimensions (mm <sup>2</sup> )	Date In	Date Out	SEC	Accumulated fluence	Error(%)	Comments
DOS-004033	10×10	18/04/2018 20:02	05/09/2018 03:00	1.41e+10	9.79e+16	7	
DOS-004151	10×10	12/09/2018 13:25		0.00e+00		None	

Dosimeter dimensions (mm <sup>2</sup> )		Total accumulated fluence
10×10 mm <sup>2</sup>		9.790e+16 Protons/cm <sup>2</sup>

cern.ch/irrad-data-manager

# IDM: Experiments History View

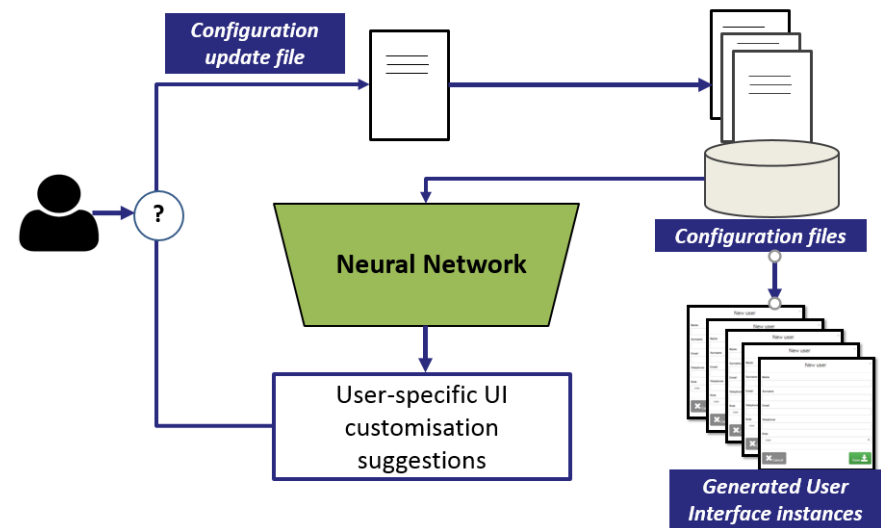
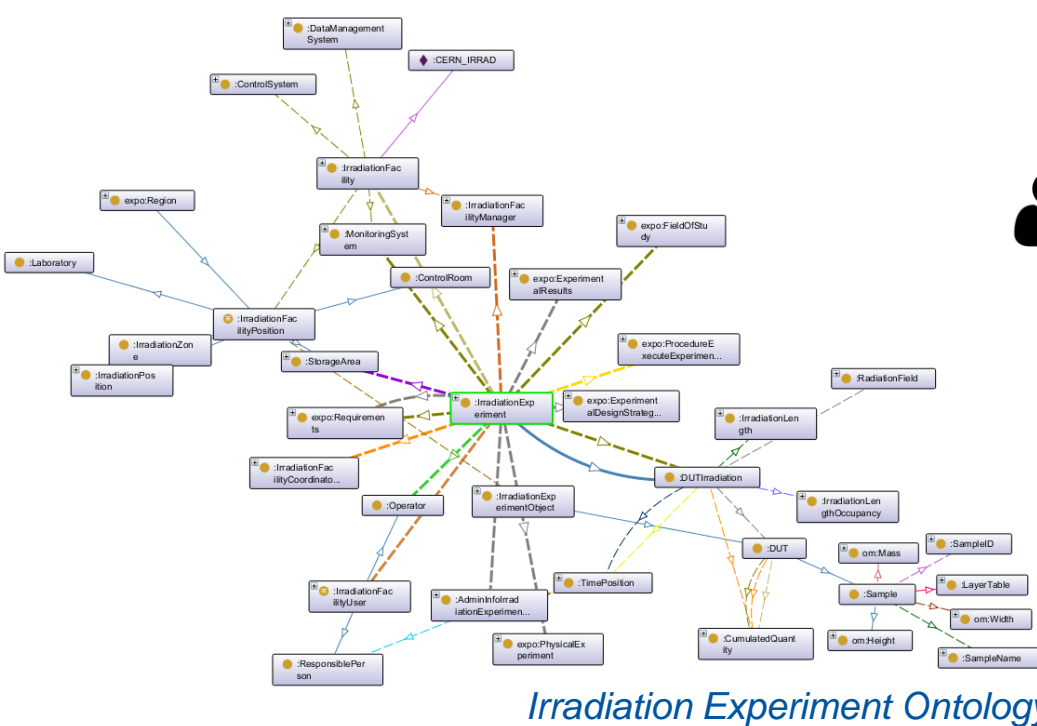
After

The screenshots illustrate the process of updating a comment on an experiment record. The first screenshot shows the 'Experiment Details' for the experiment '3D pixel for ATLAS ITk'. The second screenshot shows the 'Update Comment' dialog box, which prompts the user to 'Add additional comments (e.g. link to publications)' and provides a text input field. The third screenshot shows the 'Experiment Details' page with the 'Additional comments' field updated with the new comment: 'Important to characterise the new RD53A readout modules for ATLAS ITk pixel before the PS/SPS shutdown in 2019/20.'.

[cern.ch/irrad-data-manager](http://cern.ch/irrad-data-manager)

# Ontology-based Graphical User Interface Generation

- Purpose: Formalisation of knowledge gained from IDM and application to other irr. facilities
- Irradiation experiment model (ontology)\* → Automatic User Interfaces (UI) generation → Machine learning techniques for UI customisation



PhD Thesis  
with MINES  
ParisTech



\*Abstract and paper submitted to the European Web Semantics Conference 2019 (ESWC <https://2019.eswc-conferences.org/>)

# Outline

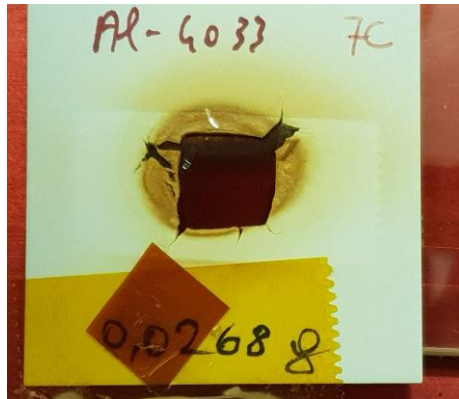
- IRRAD Facility & Summary Proton Run 2018
- IRRAD Data Manager
- **IRRAD Infrastructure Upgrades (AIDA-2020 D15.7)**
  - Damage and Degradation of equipment
  - Sample Holders for Higher Fluence Levels
  - RadHard Instrumentation for IRRAD ( $\mu$ -BPM)
- **Heavy Ions Run 2017-2018**
- **Activities during LS2**



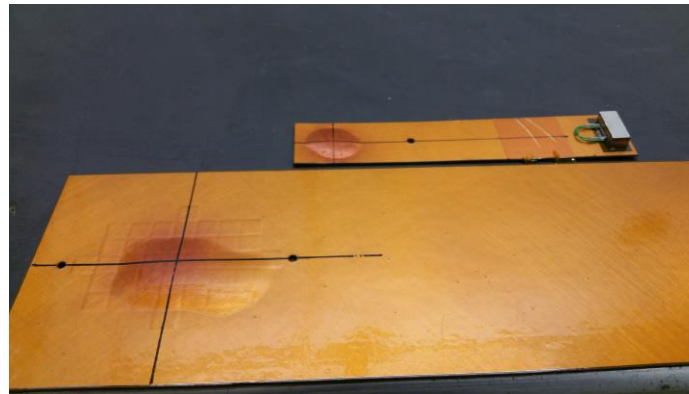
# Damage and Degradation Equipment

Infrastructure damage and degradation is accelerated due to the need of operating with always higher intensities (~ $2e18$  protons on target in 4 years and ~30% of experiments in the range of  $1e16-1e17$  protons/cm<sup>2</sup> in 2018)

See I. Mateu in AIDA-2020 WP15 satellite meeting



Sample Holder



Beam Profile Monitor (BPM) & mini-BPM



Support Frame



PCB Carrier



Irradiation Equipment



Cold Box Window

# Sample Holders for Higher Fluence Levels

(AIDA-2020 D15.7)

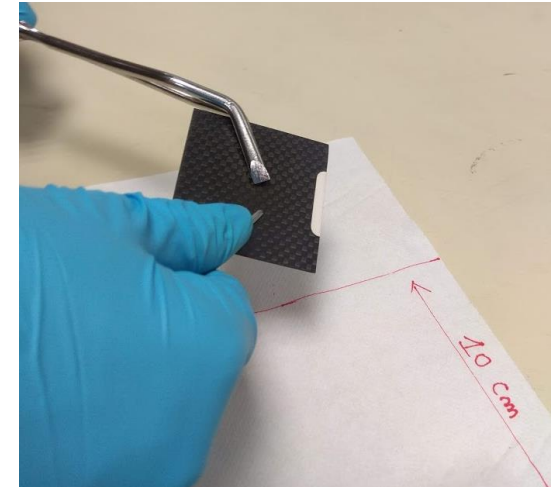
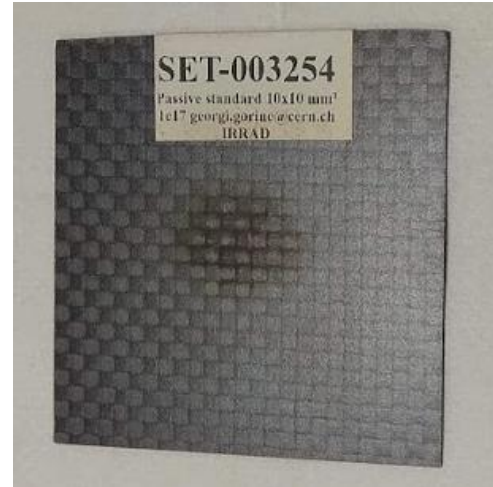
See I. Mateu in AIDA-2020 WP15 satellite meeting

Before Irradiation

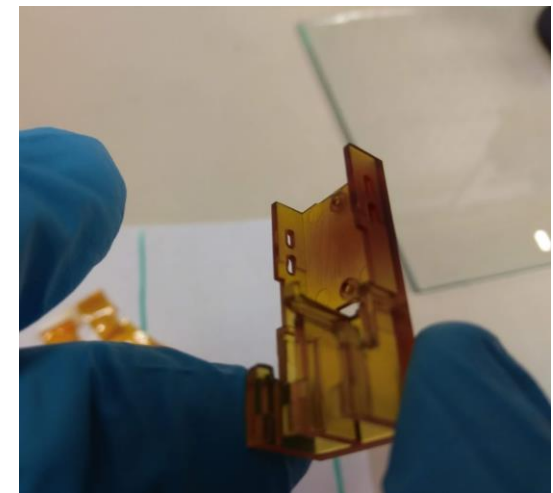
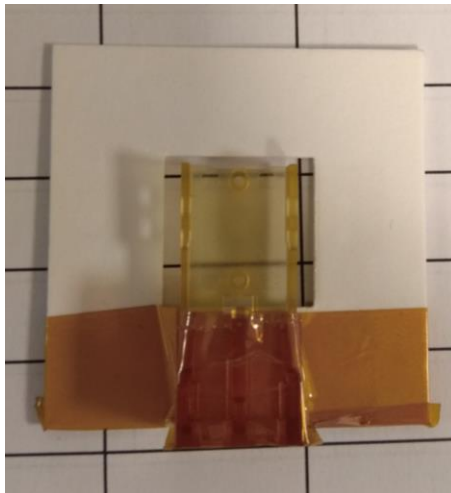
After Irradiation  $\sim 2 \times 10^{17}$  p/cm<sup>2</sup>

Stress Test

Carbon Fiber



ULTEM



# RadHard Instrumentation for IRRAD ( $\mu$ -BPM)

(AIDA-2020 D15.7)

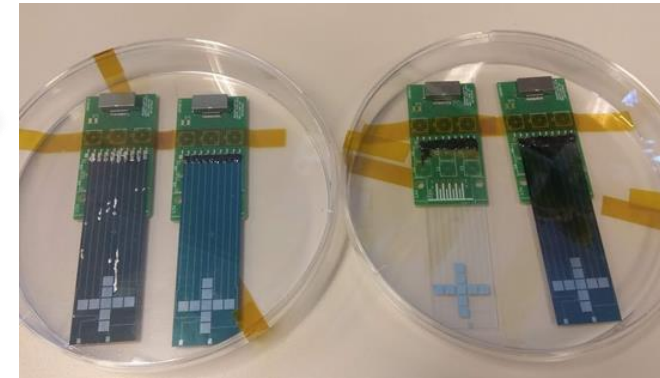
See I. Mateu in AIDA-2020 WP15 satellite meeting

■ Today's mini-BPMs are produced with standard PCB manufacturing techniques, and show:

- **big degradation** due to glue bubbling/burning
  - Need to change **INSULATING MATERIAL** without glue
- **(relatively) low "transparency"** to the beam
- **very radioactive** and long cool-down required
  - Need to reduce **THICKNESS OF METAL**



Current Beam Profile Monitor



Different stacks were produced and tested

■ This is possible using microfabrication techniques!

~15 $\mu$ m Copper	~80 $\mu$ m Kapton
~15 $\mu$ m Copper	~80 $\mu$ m Kapton
~15 $\mu$ m Copper	~80 $\mu$ m Kapton
~15 $\mu$ m Copper	~80 $\mu$ m Kapton
~15 $\mu$ m Copper	~80 $\mu$ m Kapton
~15 $\mu$ m Copper	~80 $\mu$ m Kapton
~15 $\mu$ m Copper	~80 $\mu$ m Kapton

2.5x thinner  
~200x less metal

100 nm Aluminium	100 nm Silicon Dioxide
100 nm Aluminium	100 nm Silicon Dioxide
100 nm Aluminium	100 nm Silicon Dioxide
100 nm Aluminium	100 nm Silicon Dioxide
100 nm Aluminium	100 nm Silicon Dioxide
100 nm Aluminium	100 nm Silicon Dioxide
100 nm Aluminium	100 nm Silicon Dioxide
100 nm Aluminium	~150 $\mu$ m Kapton

**CMi** EPFL Center of  
MicroNanoTechnology

**Mini-BPM:** 6 layers 0.5 mm thick ~100  $\mu$ m of Cu

**Micro-BPM:** 6 layers 0.2 mm thick, 0.6  $\mu$ m of Al

1. Accepted to the 7th International Conference on Radiation in Various Fields of Research (RAD2019: <http://www.rad2019.rad-conference.org/>);

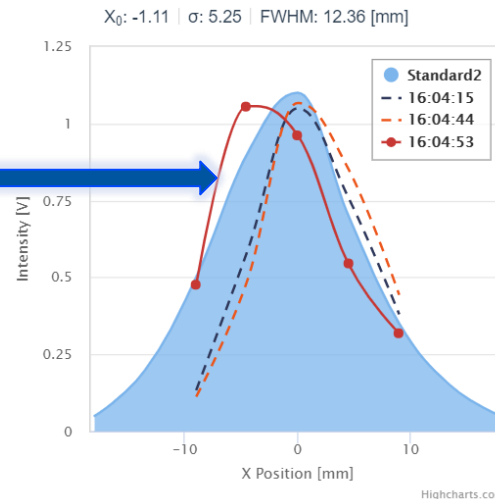
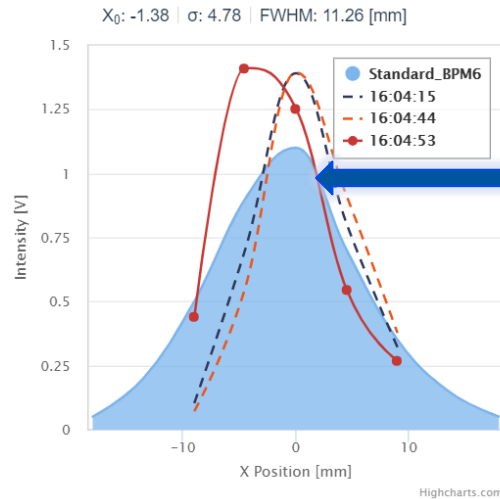
# RadHard Instrumentation for IRRAD ( $\mu$ -BPM)

(AIDA-2020 D15.7)

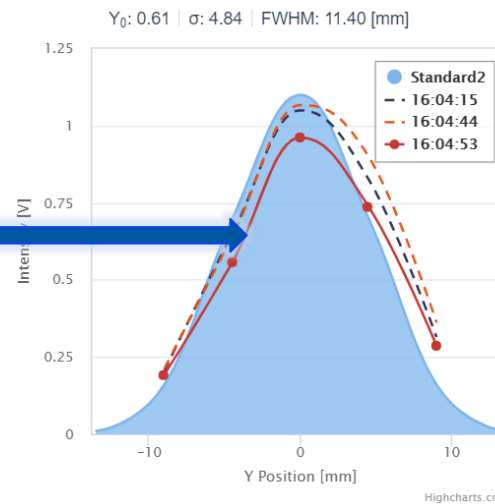
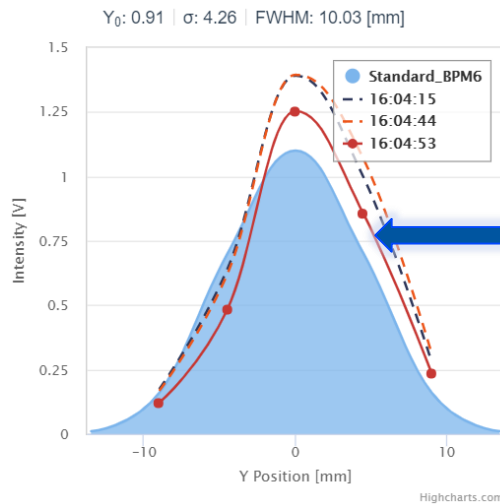
## Mini-BPM (Old)

## Micro-BPM (New)

X profile



Y profile



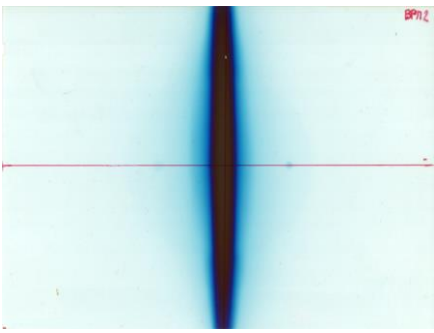
# Outline

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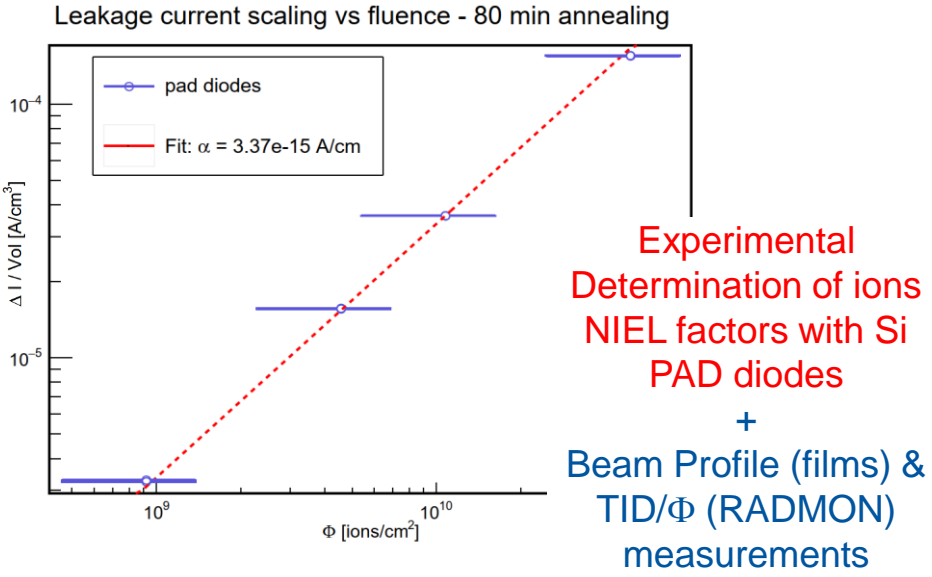
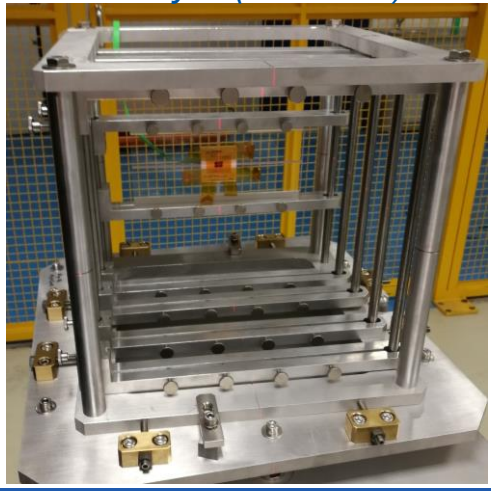
# Heavy Ion (HI) Runs 2017-18

- 2 weeks with  $^{54}\text{Xe}$  in 2017, 3 weeks with  $^{82}\text{Pb}$ 
  - Energy per nucleon:  $\sim 6 \text{ GeV/n}$
  - Ion flux:  $\sim 10^8$  to  $10^9$  ions/spill
- Radiation Hardness tests of Space Electronics Components (CHARM)
  - Highly penetrating (SEE testing)
  - Representative of Galactic Cosmic Ray spec.

*Samples on the CHARM conveyor (run 2018)*



*GafChromic film installed on the IRRAD BPM-2 (run 2017)*



- Ion dosimetry is a complex business!**
  - PS instrumentation not calibrated
  - Lack of experience & methodologies
- Promote HI tests in East Area after LS2**
  - Improve the dosimetry!
  - Build a use case with interested EP experiments?
  - Potential users in the Test-Beams community?

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# IRRAD during LS2

## ➤ East Area Consolidation Project

- Upgrade of East Area Beam Instrumentation
- Modification of EA water network
- ...

## ➤ IRRAD-specific improvements

- **Mandatory preventive maintenance of all irradiation systems**
  - Including the software infrastructure (Online display, BPM DAQ, control systems, etc...)
- **Refurbishment/upgrade of degraded irradiation equipment**
  - Repair/exchange one Huber chiller unit
  - Replace cooling boxes, setup VORTEX, etc..
- **Inventory of radioactive material in our storage areas (bld. 13/14/157)**
  - Contacting users for their samples

AIDA -2020  
D15.8



Cold box



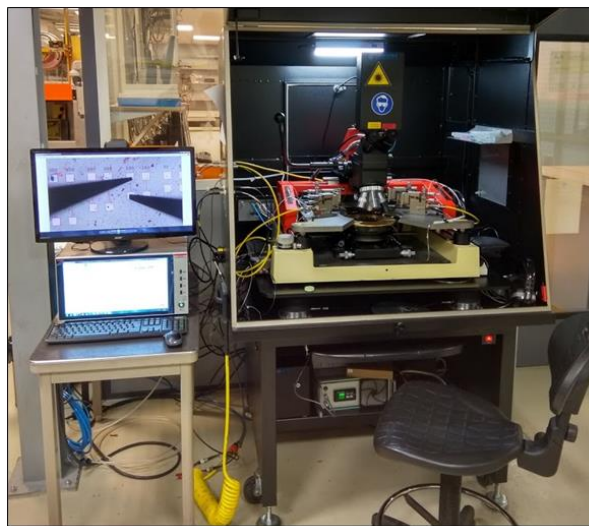
# IRRAD during LS2

## Instruments for measuring and characterizing radioactive material:

- Suss PM8 Probe Station (Available to the users)
- Keithley 4200A Semiconductor Parameter Analyzer (Available to the users)
- Climatic chamber (Purchased)
- $\gamma$ -spectrometer (To be installed)
- etc.



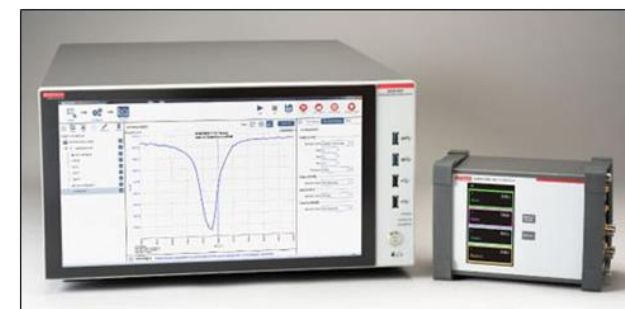
*$\gamma$ -spectrometer*



*Suss PM8 Probe Station*



*100Liters Temperature & Humidity Test Chamber*



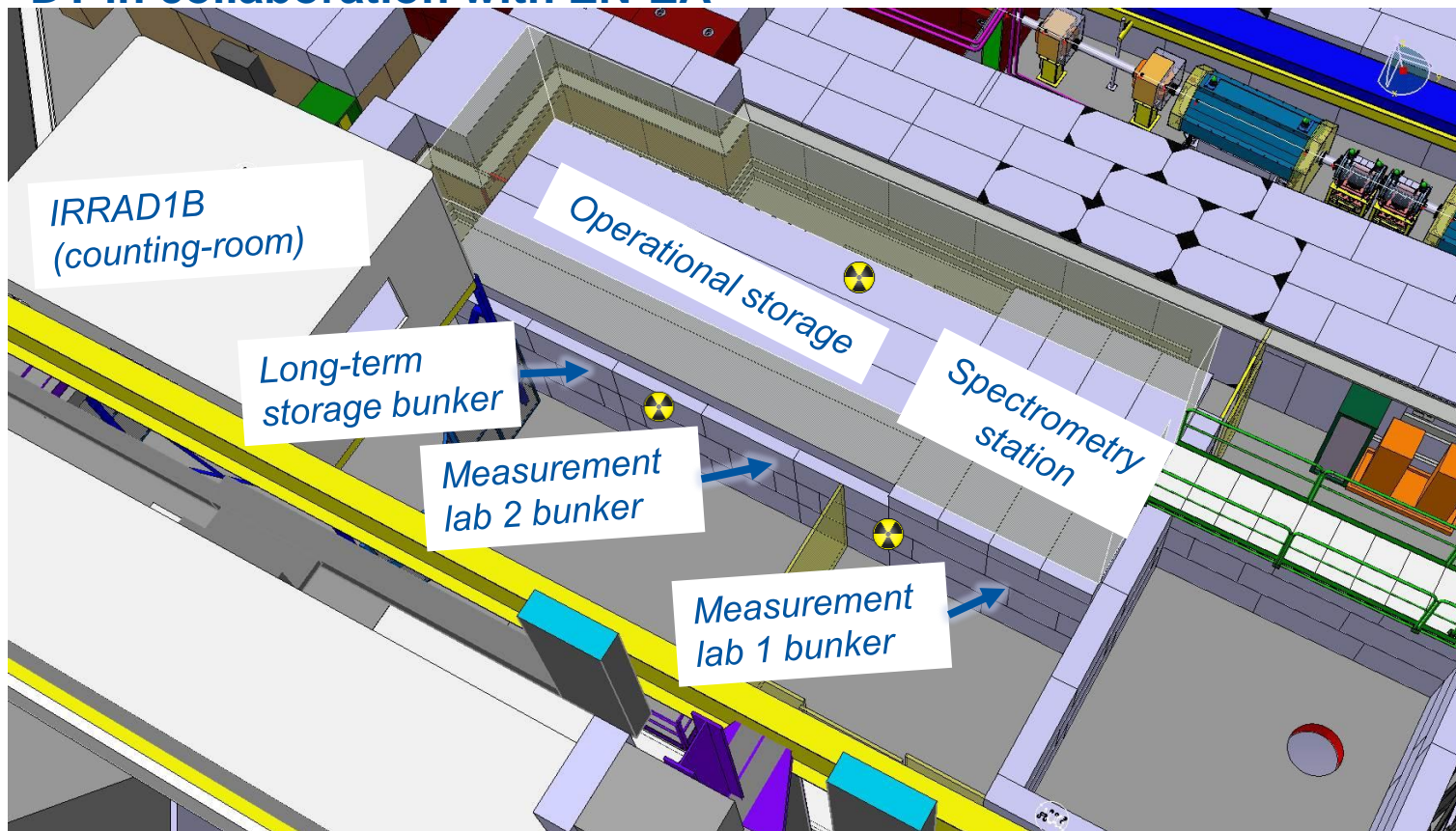
*Keithley 4200A Semiconductor Parameter Analyzer*

# IRRAD during LS2

- Setup a dedicated laboratory (for probe-station setup, climatic chamber,  $\gamma$ -spectrometer, etc.)
- Increase storage and material handling space

## Extension of the IRRAD Technical Area (Project under study),

### EP-DT in collaboration with EN-EA



# Pion Irradiations at PSI

- IRRAD not operational until spring 2021
- Possibility of pion irradiations at PSI under evaluation:
  - $\pi^+$  300 MeV/c
  - Typical max fluence level in the range of some  $1e15$   $n_{eq}/cm^2$
  - Variable beam spot along the beam axis
- Stay updated at [cern.ch/ps-irrad!](http://cern.ch/ps-irrad)

PS-IRRAD Proton Facility

Latest news

Registrations for the proton run 2018 are now closed!

AIDA-2020 Transnational Access

Irradiation runs 2019-2020

### Registration

The proton run of IRRAD will end on November 11th, 2018. Registration for active or special experiments are now closed. For passive experiments, the space left is very limited. In case of need please contact [ps.irrad@cern.ch](mailto:ps.irrad@cern.ch).

Read the call for application

Check the schedule

Register

### Facility description

The IRRAD proton facility is located on the TB beam-line at the CERN PS East Hall (building 157) where the primary proton beam with a momentum of 24GeV/c is extracted from the PS ring.

To irradiate small passive material sample at room temperature (RT):

- Learn more about the shuttle

To irradiate bigger samples and to perform active irradiation experiments at RT or -25°C:

- Learn more about the tables

### Beam parameters

IRRAD Beam Parameters

- Beam
- Beam description
- Beam intensity
- Beam profile
- Beam spot
- Beam size
- Beam position
- Beam stability
- Beam energy
- Beam energy spread
- Beam energy loss
- Beam energy loss rate
- Beam energy loss rate at the end of the beam line
- Beam energy loss rate at the end of the beam line at the target
- Beam energy loss rate at the end of the beam line at the target at the end of the beam line
- Beam energy loss rate at the end of the beam line at the target at the end of the beam line at the end of the beam line

### Contacts

Federico Ravotti	74280
Giuseppe Pezzullo	72058
IRRAD Control Room	63344
CCC-PS	76677

[ps.irrad@cern.ch](mailto:ps.irrad@cern.ch)

Learn more

### Access and safety

Two distinct ADaMS permissions are necessary to access IRRAD:

- Access to the Irradiation Area
- Access to the Control Room

You will also have to take safety into account.

Learn more about access and safety

### Dosimetry results

- You can check the last dosimetry results here
- You can access the archive of results back to 2001 here

Learn more

### Useful apps

- Beam Profile Monitor
- Data Manager
- OP Websites

Learn more

TB Beam Operation: The PS, SPS and AD Users

EP-DT Group: EPDT Irradiation Service

Other useful links: CERN Irradiation Facilities

E-group: [ps.irrad@cern.ch](mailto:ps.irrad@cern.ch)

# Conclusions

- First run (2014-2018) of the “new” IRRAD facility was successful
- Significant milestones achieved:
  - New IRRAD Data Manager System fully operational
  - Advancements in beam instrumentation and irradiation equipment R&D (AIDA-2020)
  - Possibility to perform experiments with Heavy Ions after LS2?
  - etc.
- IRRAD not operational during LS2 (2019-2021)
- Activities during LS2 for IRRAD:
  - Maintenance, upgrade and consolidation
  - Extension of the technical area (handling & measurement of irradiated samples)
- Possible pion irradiations in PSI organized by the IRRAD team in EP-DT