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

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

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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 mm²
- Spills of ~400 msec every ~10 sec
- Fluence of $1 \times 10^{16}$ p/cm² in 14 days
- Scanning up to dimensions of 10×10cm²
- 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)
  - **996 objects** declared by the users
  - **792 objects** irradiated
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)

1MeV eq. Φ simulation with Cu-target
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IRRAD Data Manager (IDM)

cern.ch/irrad-data-manager

Facility Operation (During)

Dosimetry Results & Archive (After)

Traceability (Before)
IDM: Key Features

- Experiments, samples, users and dosimeters registration
- Label printing
- Real-time follow-up of irradiation experiments
- Computation of proton interaction parameters
- Display and archive of dosimetry result (~600 spectrometry measurements/year)
- User Interface preferences customization
- History and details of past experiments (with user permission)
- Can be used also for irradiations in other facilities (PSI)
IDM: Irradiation Experiments View

Before
IDM: Samples View

cern.ch/irrad-data-manager
## IDM: Irradiation Status View

The image shows the interface of the IRRAD Data Manager for viewing irradiation status. The interface includes a table with the following columns:

- **IDM**: Irradiation Status View
- **Created at**: Date and time of the record
- **Sample**: Name of the sample
- **Dosimeter**: Type of dosimeter
- **DATE IN - DATE OUT**: Date range of irradiation
- **IRRAD Table**: Name of the irradiation table
- **Table Position**: Position of the sample in the table
- **Accumulated Fluence**: Total fluence received by the sample
- **SEC**: ID of the responsible person
- **Updated by**: Person who last updated the record
- **Status**: Current status of the sample (e.g., Registered)
- **In Beam**: Indicator of whether the sample is in the beam
- **Actions**: Options to edit or delete the record

### Example Entries

<table>
<thead>
<tr>
<th>Created at</th>
<th>Sample</th>
<th>Dosimeter</th>
<th>DATE IN - DATE OUT</th>
<th>IRRAD Table</th>
<th>Table Position</th>
<th>Accumulated Fluence</th>
<th>SEC</th>
<th>Updated by</th>
<th>Status</th>
<th>In Beam</th>
<th>Actions</th>
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<td>Center</td>
<td>272851</td>
<td><a href="mailto:irradiation.factories@cern.ch">irradiation.factories@cern.ch</a></td>
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<td>Registered</td>
<td>On</td>
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<td></td>
</tr>
</tbody>
</table>
IDM: Dosimetry Results View

cern.ch/irrad-data-manager
IDM: Experiments History View

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
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/cm² in 2018)

See I. Mateu in AIDA-2020 WP15 satellite meeting
Sample Holders for Higher Fluence Levels (AIDA-2020 D15.7)

Before Irradiation

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

Standard cardboard

Carbon Fiber

ULTEM

See I. Mateu in AIDA-2020 WP15 satellite meeting

Stress Test
RadHard Instrumentation for IRRAD ($\mu$-BPM)  
(AIDA-2020 D15.7)

- 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**

- This is possible using microfabrication techniques!

**Mini-BPM**: 6 layers 0.5 mm thick ~100 um of Cu

**Micro-BPM**: 6 layers 0.2 mm thick, 0.6 um of Al

RadHard Instrumentation for IRRAD (μ-BPM) (AIDA-2020 D15.7)

Mini-BPM (Old)   Micro-BPM (New)

X profile

Y profile
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Heavy Ion (HI) Runs 2017-18

- 2 weeks with $^{54}$Xe in 2017, 3 weeks with $^{82}$Pb
  - Energy per nucleon: ~ 6 GeV/n
  - Ion flux: ~ $10^8$ 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)"

- 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
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)
- γ-spectrometer (To be installed)
- etc.
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:
  - $\pi^+ 300 \text{ MeV/c}$
  - Typical max fluence level in the range of some $1 \times 10^{15} \text{n}_{\text{eq}}/\text{cm}^2$
  - Variable beam spot along the beam axis
- Stay updated at [cern.ch/ps-irrad](https://cern.ch/ps-irrad)!
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