EP-DT
Detector Technologies

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AIDA-2020 WP15.5

IRRAD facility beam profile monitors (BPM) and sample holders upgrades (D15.7) and GIF++ gas system upgrade (D15.10)

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IRRAD Proton Facility

Outline

- Beam Profile Monitors (BPM) system upgrade.
- BPM calibration and sensitivity study.
- New sample holders for extremely high fluences.

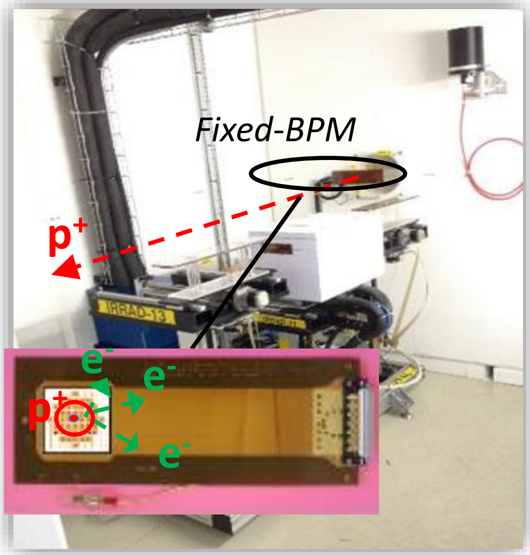
(D15.7)

- GIF ++ gas system. (D15.10)
- Conclusions

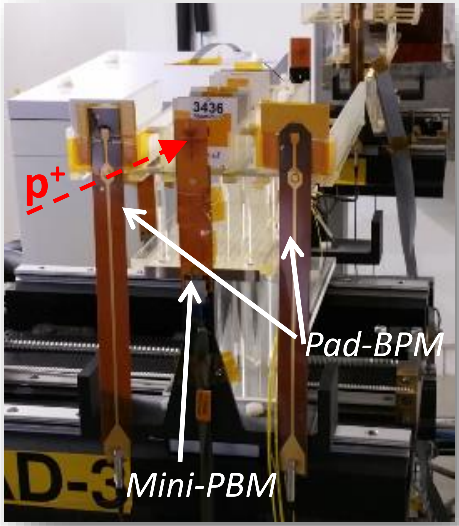
Beam Profile Monitors (BPM) system

- Patterned copper foils placed perpendicular to the beam. Interaction via secondary electron emission (SEE).
- 3 patterns
  - Fixed BPM: beam alignment (40 channels) – 2014.
  - Mini-BPM: Table alignment (9 channels) – 2017.
  - Single pad BPM: In beam/Out of beam detector (1 channel) – 2017.
- Dedicated BPM DAQ unit can read out 1 Fixed BPM or 4 x (1 Mini + 1 Pad).

DAQ unit



Fixed BPM



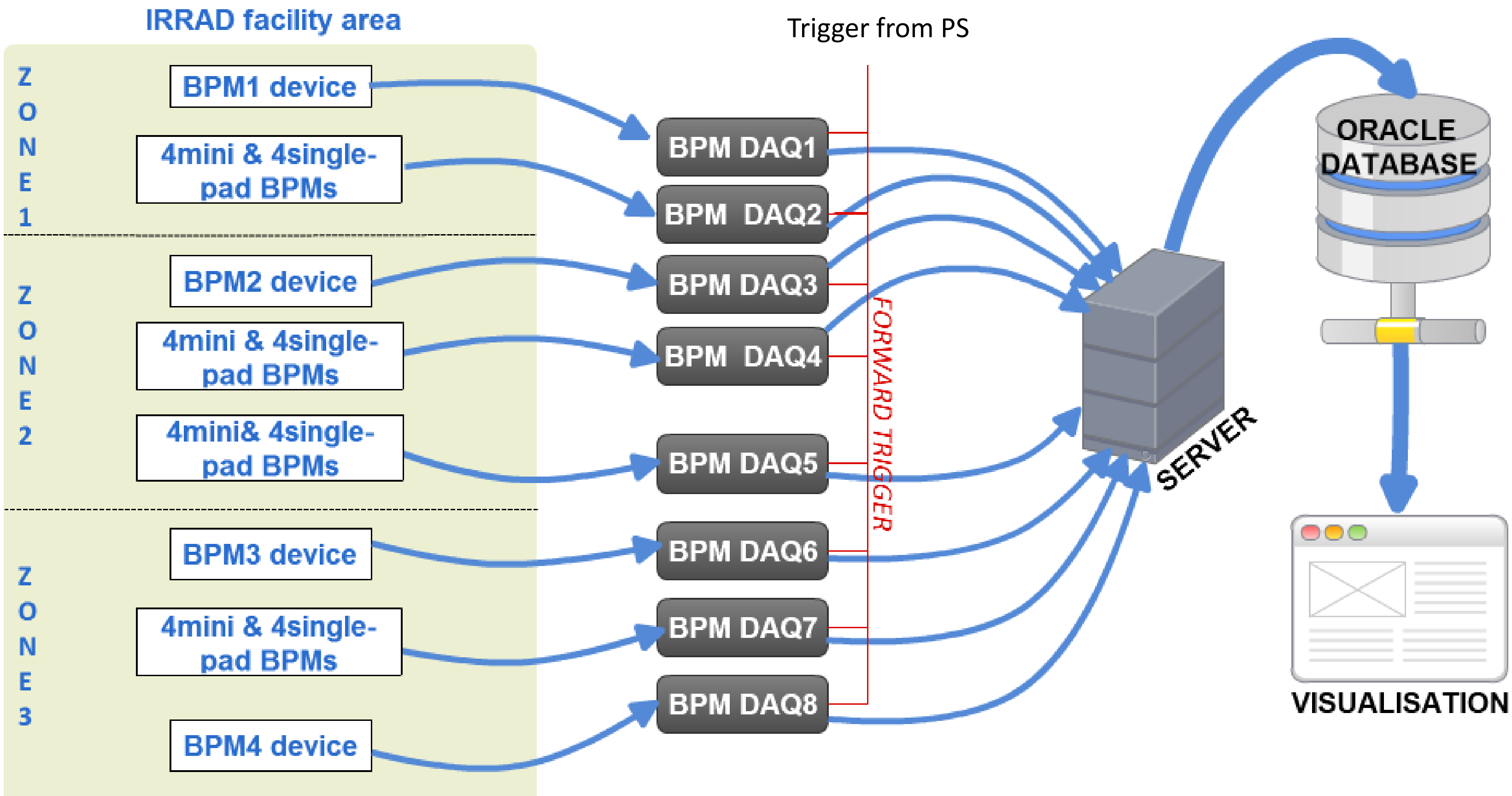
Mini and Single Pad BPM

See "F. Ravotti, *WP 15.5 - IRRAD and GIF^{++} Facilities Infrastructure Upgrade.* 1st AIDA-2020 Anual Meeting, DESY, June 2016"

AIDA 2020

BPM Architecture

IRRAD BPM infrastructure for 2017 & 2018 irradiation campaigns:



See "B. Gkotse, *System architecture and data processing capabilities of the Beam Profile Monitor for the CERN Proton IRRADiation Facility.* IEEE-NSS 2017"

BPM – Control System upgrades

All the BPM data is integrated in the Control System of the IRRAD facility, with handy visualizations serving different purposes

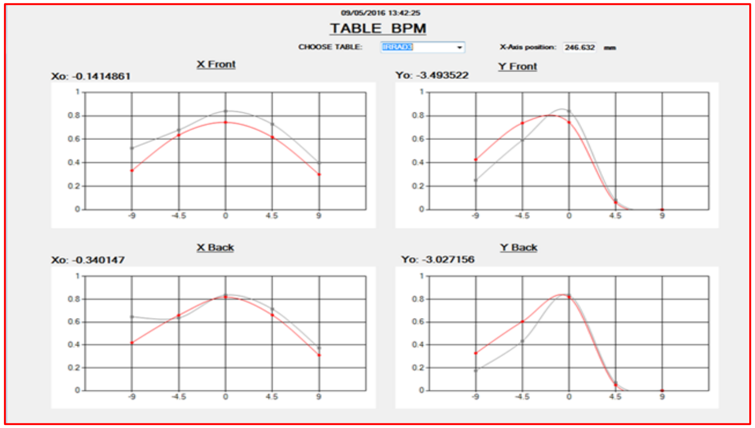


Table alignment (Mini-BPMs)

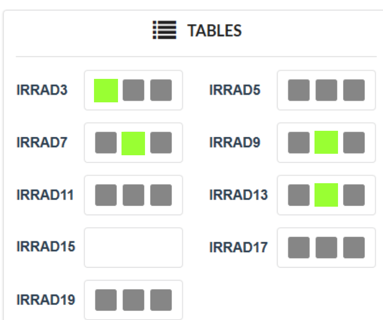
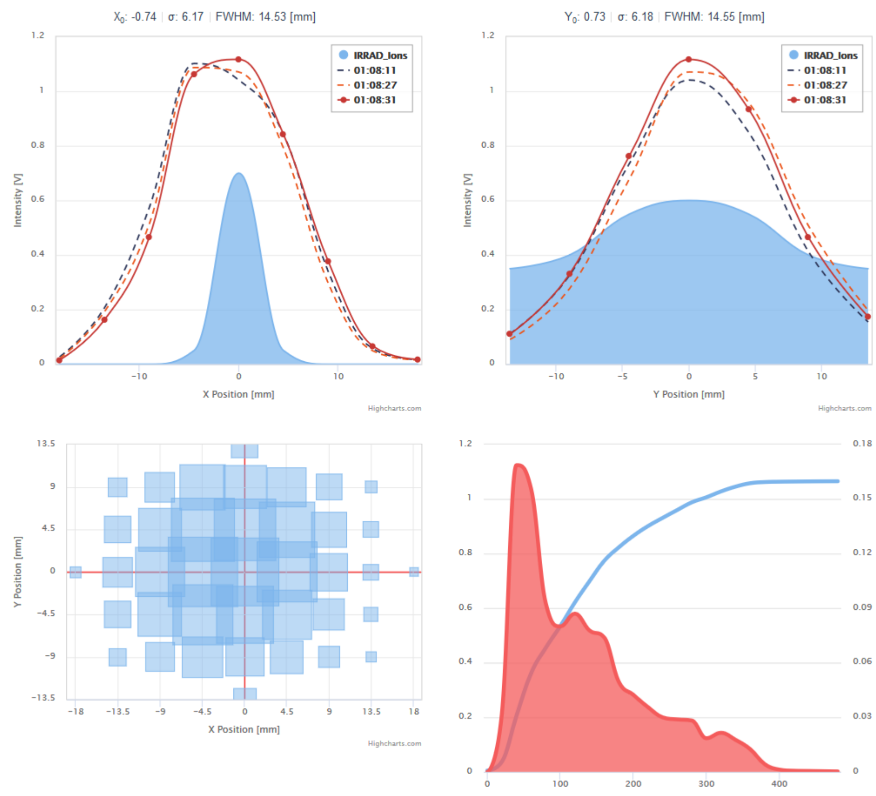


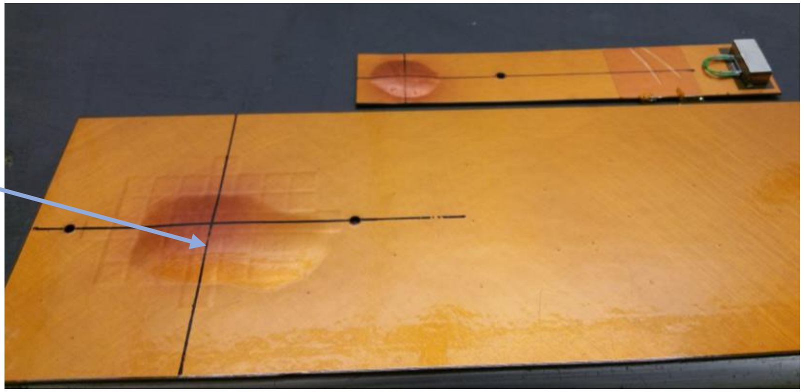
Table position (Pad BPMs)



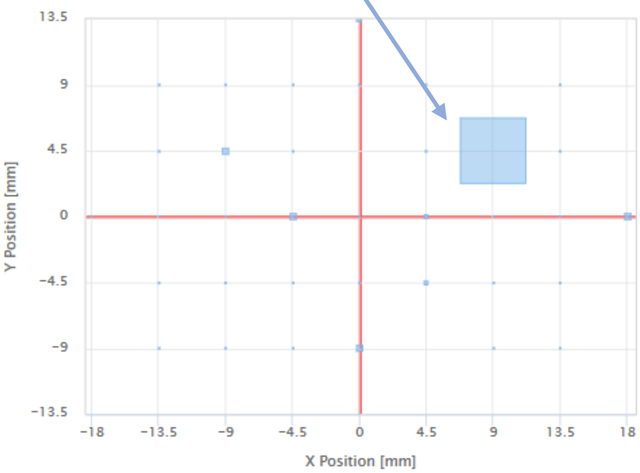
Beam Profile (Fixed BPMs)

Aging issues on BPMs

Apparition of "bubbles" under the polymide layers (due to swelling of the glue).



As a consequence, apparition of artifacts on the beam profiles.



- Several PBM had to be replaced during 2017 irradiation campaign.
- A new production is foreseen for 2018 to address this issue.
- Different patterns will be produced.

BPM Calibration and sensitivity study

- Objective: calibration of beam profile monitors (BPM) in terms of Secondary Electron Emission (SEE) yield

  How many electrons are generated per proton crossing the BPM surface

- Data is analysed spill per spill using the following method:

  1. Raw voltages of all BPM pads are fitted to a normalized 2D Gaussian function.

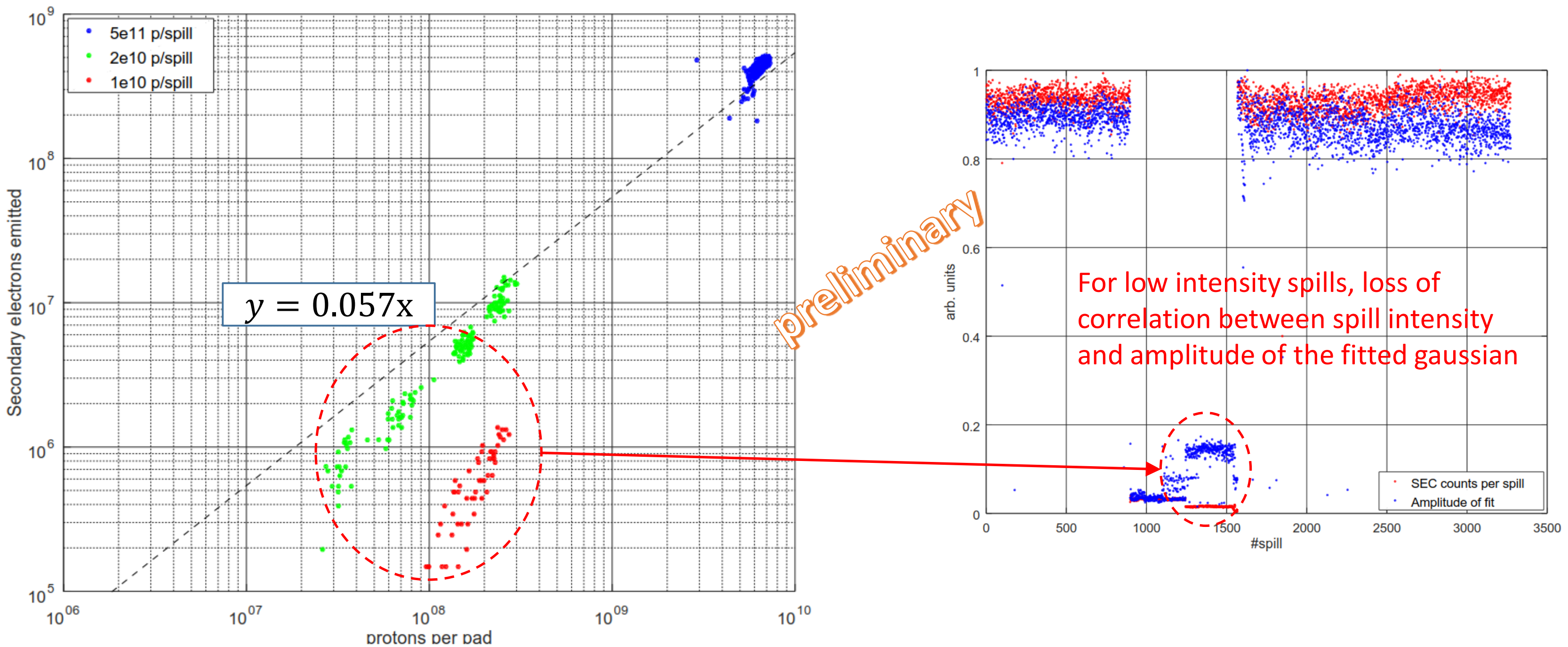
  $$f(x,y) = \frac{1}{2\pi\sigma_x\sigma_y} e^{-\left(\frac{(x-x_0)^2}{\sigma_x^2} + \frac{(y-y_0)^2}{\sigma_y^2}\right)}$$

  2. The number of protons crossing the central pad is obtained calculating the integral of *f(x,y)* over the pad surface and scaling it by the protons in the spill

  $$Protons = SEC \times Factor_{SEC} \times \iint_{pad} f(x,y)dxdy$$

  3. The number of secondary electrons emitted is obtained from the raw voltage measured on the central pad. The BPM electronics had been previously calibrated using a test current in order to obtain the conversion from raw voltage to injected charge.

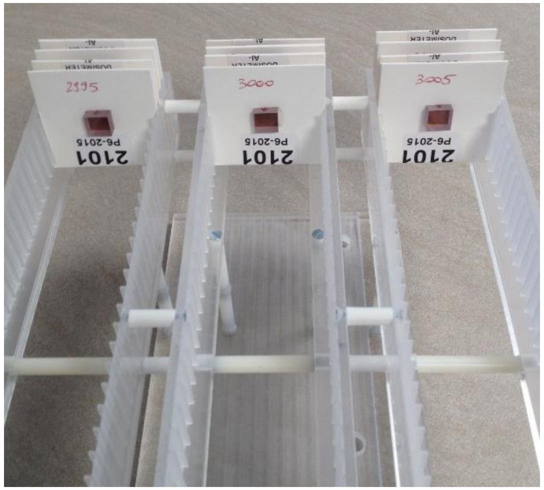
BPM Calibration and sensitivity study - Results

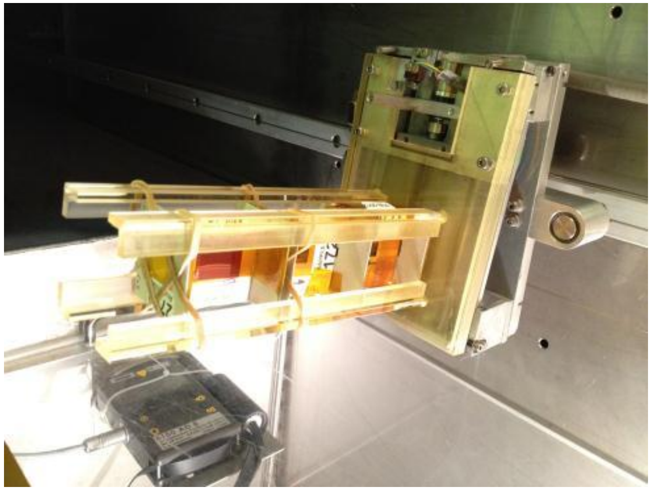


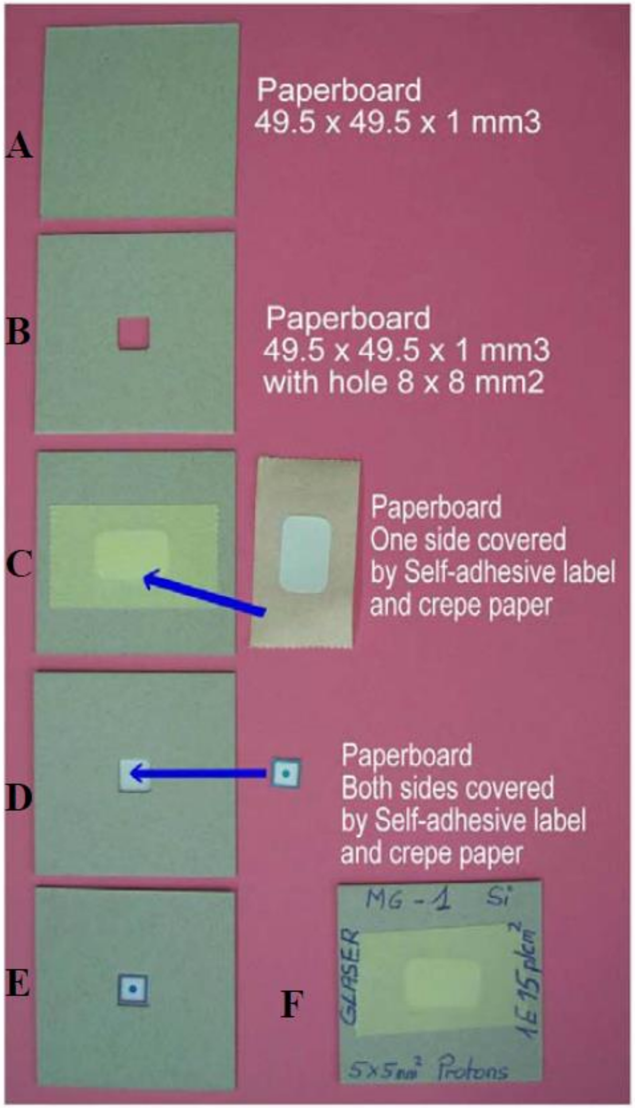
- Hint of linear response of SEE emission, as expected.
- Method fails as intensity of the spill is lowered → Probably not enough S/N, or non centred beam, for a good fit of the data .
- Analysis to be refined, and results compared to literature.
- Analysis for different conditions also to be included:
    - Fast extracted beam.
    - $Xe54^{+}$ ion run.

New sample holders for extremely high fluence

- Irradiation of small sensors in IRRAD.
- Replace current “paperboard” holders, which start to break at $\Phi > 10^{17}$ p/cm^2
- Evaluate new materials
  - Low activation (ALARA)
  - Mechanically resistant.
  - High availability, low cost, etc.







New sample holders for extremely high fluence

- 3 materials irradiated and tested (stress tests and activation) in 2017 in TRIGA reactor in JSI (different fluence values up to $3x10^{17}$ n/cm^2).
  - Cardboard (current sample holder) → Started breaking from $5x10^{16}$ n/cm^2.
  - 3D printing material → Started breaking from 10^{17} n/cm^2. Activation comparable to cardboard.
  - Carbon fibre → Best results.

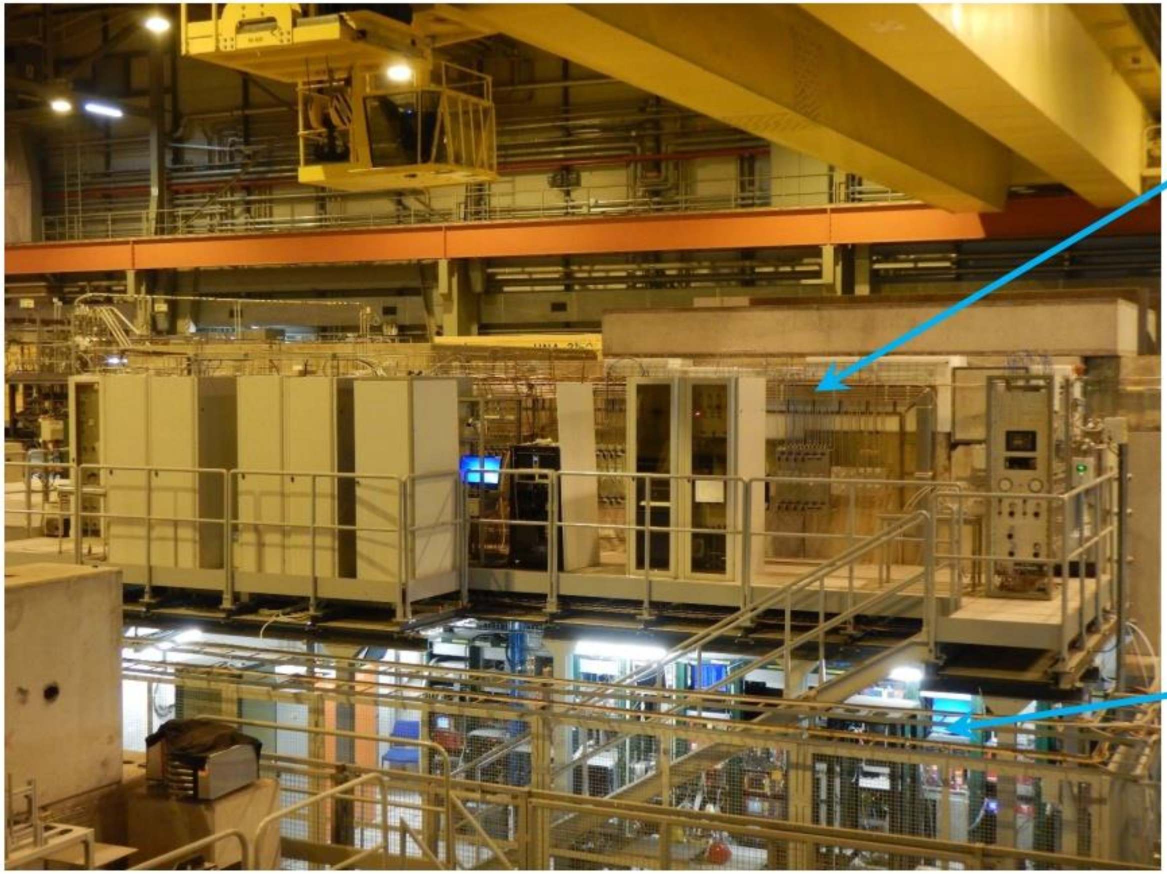
- New Carbon fibre samples irradiated in IRRAD, with stress and activation tests ongoing.
- Identic samples will be tested at JSI in 2018.
- Tests of PEEK plastic samples and eventually other materials are foreseen.

*(*Many thanks to I. Mandic, V.Cindro and JSI operation team for the support!)*

Stress tests on the samples irradiated at JSI

GIF++ Gas System upgrade (D15.10)

(From "R.Guida: *The gas systems infrastructure for the CERN Gamma Irradiation Facility.* AIDA-2020 Second Annual Meeting, Paris, 2017")



First floor: gas service area.
~ 20 gas racks and distribution panels (40 m^2 net area)

Ground floor: electronics area
~ 20 electronic racks hosting the irradiator controls, DCS, user equipment, fire detection ...

GIF++ Gas System upgrade (D15.10)

(From "R.Guida: *The gas systems infrastructure for the CERN Gamma Irradiation Facility.* AIDA-2020 Second Annual Meeting, Paris, 2017")

D15.10: GIF++ gas system :

The gas system has been equipped with additional distribution panels and mixers to allow for more parallel users. An IR analysis system has been installed. (Task 15.5).

All deliverables achieved (in blue). In addition to many other developments/achievements.

- New mixing units have been developed and build for GIF++.

  → Installed and operational.

- Additional gas distribution panels have been included at supply and in the gas systems.
- New gas recirculation modules have been developed and build for GIF++.

  →1 operational since beginning 2015, 1 since 2016 and one recently installed (commissioning will start in about one month).

- Further development are ongoing to have gas recirculation systems allowing operation of detectors requiring high gas filtering capacity.

  →New design for an automated purifier for GIF++ (first application for the ATLAS and CMS RPC R&D).

- Gas analysis and especially gas chromatography are available to all GIF++ users.

  →GC operational since beginning 2016.

  →IR analysers since 2015. A second installed 2016.

  →Automated O2/H2O analysis rack will be connected in September 2017.

- Design, components and construction procedures follow from experience and development of the gas systems for the LHC experiments .

Link to the AIDA-2020 D15.10 deliverable: http://cds.cern.ch/record/2266832/files/AIDA-2020-D15_10.pdf

Conclusions

- BPM system fully operational.
  - Different BPM patterns.
  - Control system upgrades.
  - New production for 2018.
- BPM calibration study is on the way.
- New sample holder materials for extreme fluence irradiations are being studied.
  - Carbon fibre most promising so far.
  - New tests foreseen in JSI and IRRAD this year.
- GIF++ gas system is completed (Deliverable 15.10 already produced).