# Radiation Monitoring:
# Run 2 Overview and Run 3 Outlook

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https://indico.cern.ch/event/971222/

# Outline

- Introduction:
  - Mandate of the Monitoring and Calculation Working Group (MCWG),
  - MCWG's activities,
  - MCWG as a service,
- Run 2 highlights:
  - Milestone: improvement of the LHC BLM analysis framework
  - Automated Reporting
  - Selected studies on Radiation Environments
- Run 3 outlook:
  - MCWG's objectives,
  - Updates on the analysis framework
  - Injectors/Transfer Lines Automated Monitoring
  - LHC Automated Monitoring and Watchdogs
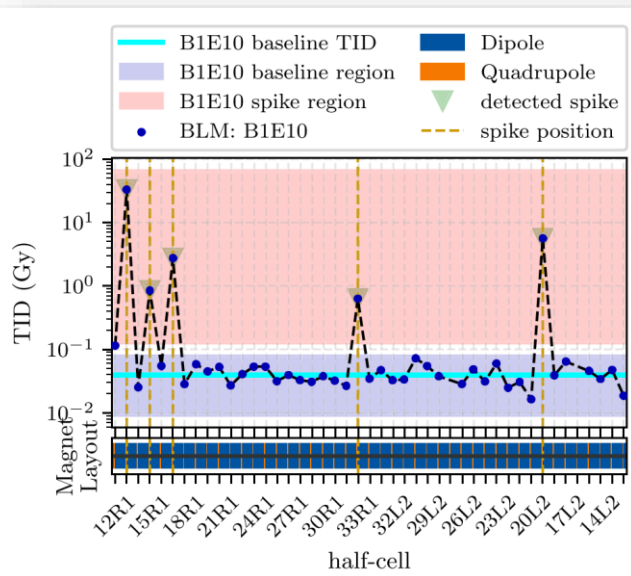- Conclusions

# Introduction: Radiation Levels at CERN

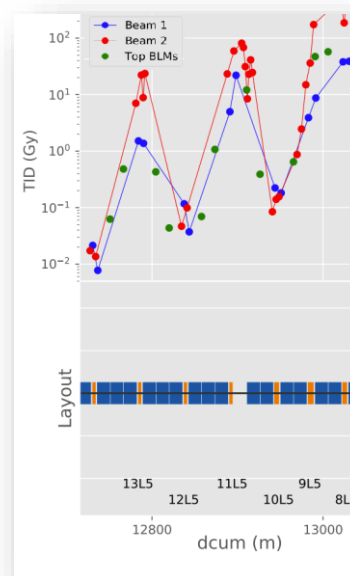**Annual Radiation Levels**

~tens of mGy (~$10^7$ HEH/cm$^2$ )
SEEs

~ tens of Gy
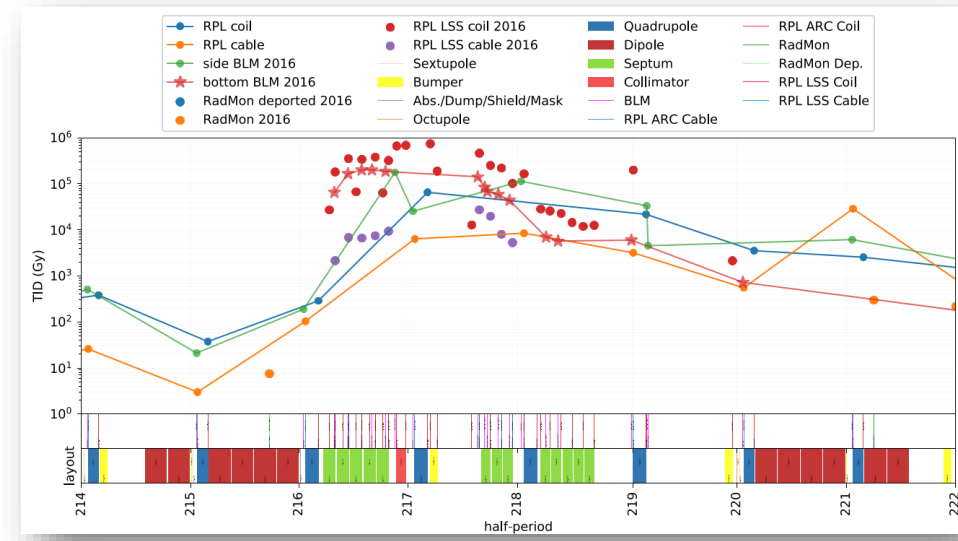+Cumulative effects (TID,DDs)

~MGy
+Material damages
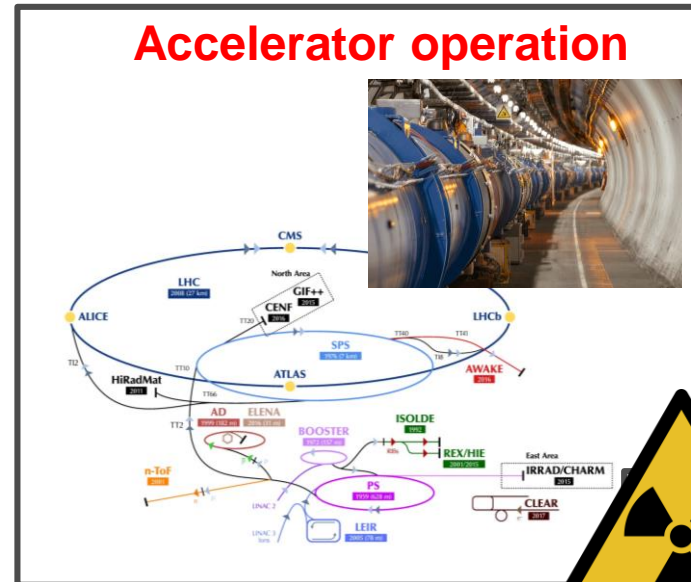
## LHC ARCs
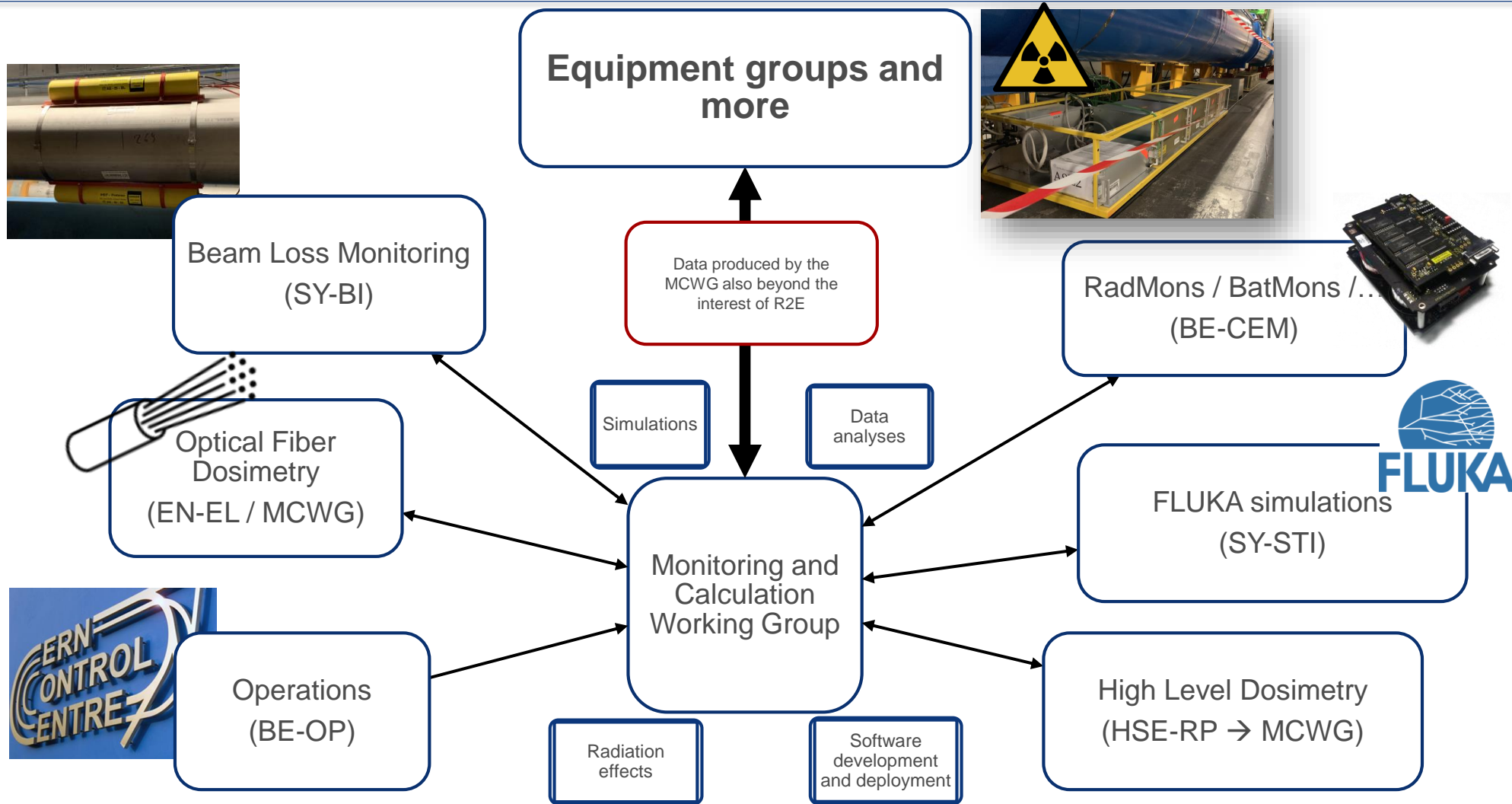


## LHC DSs



## SPS LSS2 – North Area extraction

# Introduction: MCWG mandate

- Evaluation and analysis of distribution and evolution of the radiation fields across CERN's accelerator complex.


**Accelerator operation**

- Assessment of potential radiation risks resulting in requirements for dealing with existing equipment and future installations.


**Equipment**

# Introduction: Monitoring And Calculation Working Group activities



**Equipment groups and more**

Data produced by the MCWG also beyond the interest of R2E

Beam Loss Monitoring (SY-BI)

Optical Fiber Dosimetry (EN-EL / MCWG)

Operations (BE-OP)

Simulations

Data analyses

Monitoring and Calculation Working Group

Radiation effects

Software development and deployment

RadMons / BatMons /... (BE-CEM)

FLUKA simulations (SY-STI)

High Level Dosimetry (HSE-RP → MCWG)

# Introduction: MCWG as a service

- Provides a service: mcwg-request@cern.ch:

  - Assessment of the past, present, and future radiation levels,

  - More than 20 requests over LS2:

    - **expected increase** over the accelerator operation,

- Meetings on the monthly basis:

  - Updates on Radiation Levels,

  - Addressing requests,

  - Milestones (reports, new tools, analyses)



MCWG Requests over time
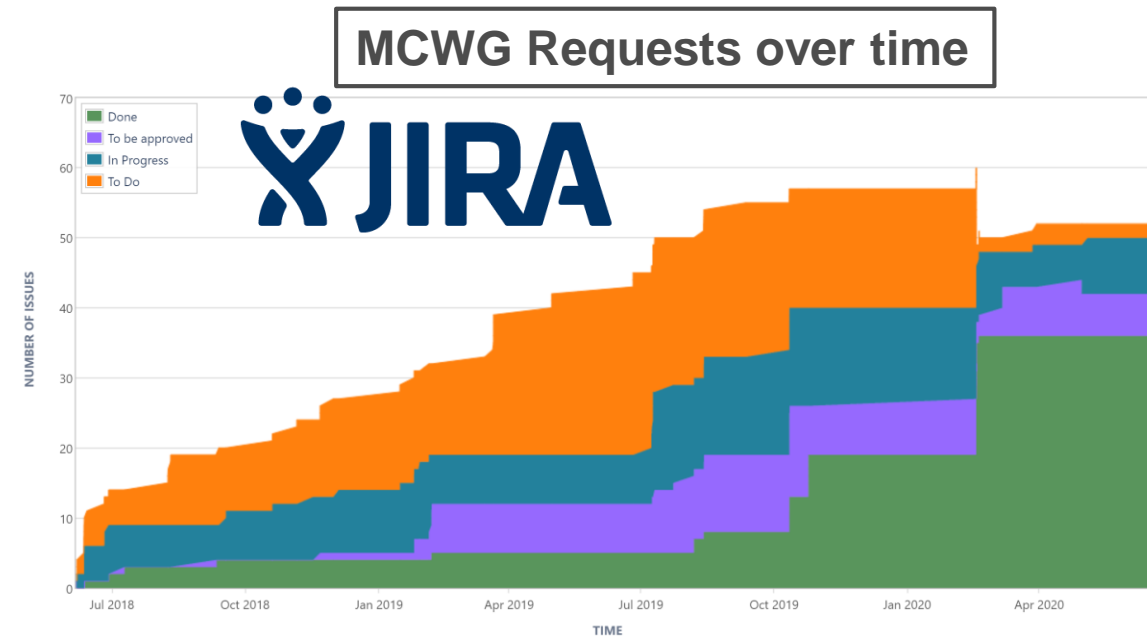
# Run 2 highlights

# Run 2 highlights: improvement of LHC BLMs analysis

| Manual, slow, time-consuming, potentially inconsistent |
| :---: |

↓

| **Not efficient!** |
| :---: |

↓

| How to **improve** it? |
| :---: |

↓

| The only **solution**: AUTOMATION |
| :---: |

## Limitations in the past…

- Every radiation request handled **manually**

> *Took ages* to obtain results

- **Slow access** to CERN Accelerator Logging Service (CALS) via Timber

- Usage of the **non-offset corrected data**
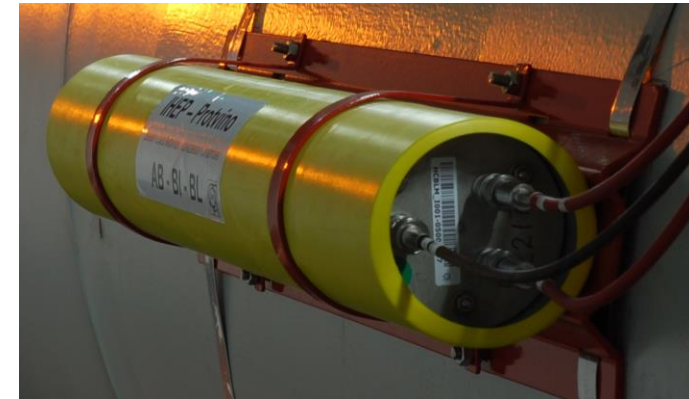
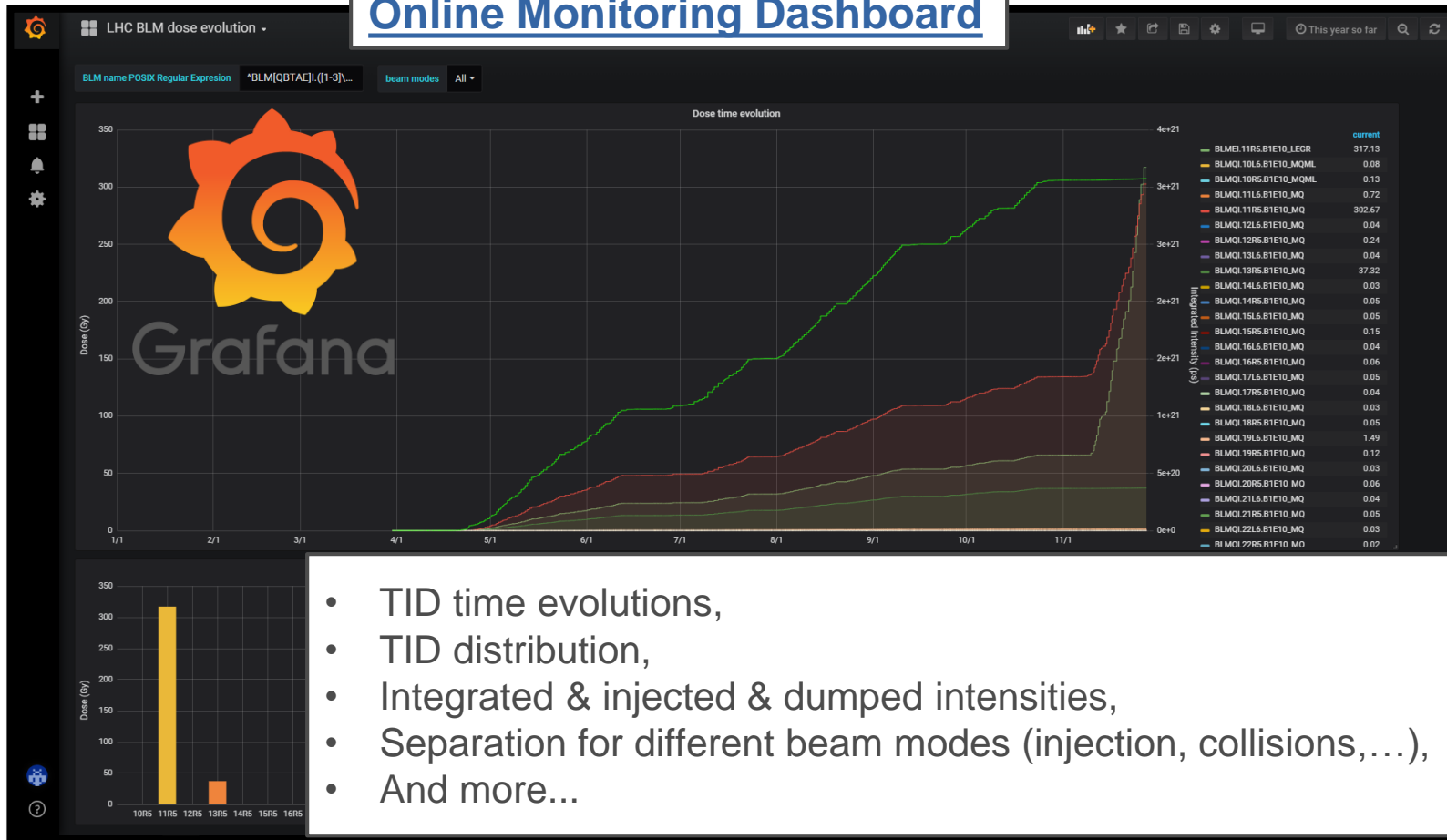> **Overestimations for low dose** environments (ARC sections)

## At the end of Run 2…

- Fully **automated** BLM data analysis for R2E proposes,

- Automated reporting,

- Online access to processed measurement,

# Run 2 highlights: automated reporting from LHC BLMs

**Weekly radiation reports distributed via the mailing list**
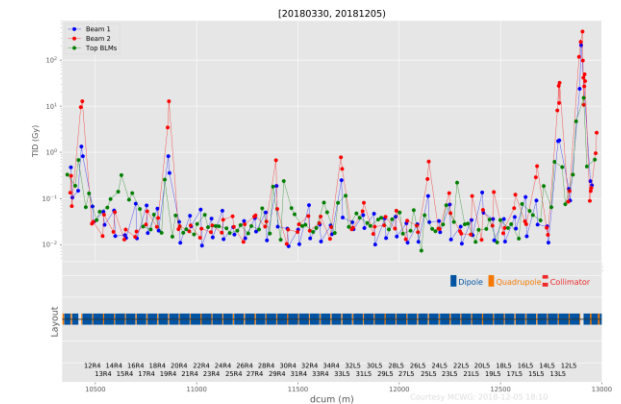
**Online Monitoring Dashboard**



- TID time evolutions,
- TID distribution,
- Integrated & injected & dumped intensities,
- Separation for different beam modes (injection, collisions,…),
- And more...

# Run 2 highlights: selected studies on the radiation environment

**Report on the Prompt Dose Distribution Along the LHC Based on BLM Data for proton-proton operation in Run 2**

- TID measurements along LHC based on the > 3500 BLMs,
- Localized radiation maxima highlighted,

**RADIATION LEVEL SPECIFICATIONS FOR HL-LHC**

- Run2 BLM TID measurements + FLUKA simulations → HL-LHC specification,

**Measurements = CRITICAL input**

## Radiation Environment in the LHC Arc Sections During Run 2 and Future HL-LHC Operations

- Analysis of the residual-gas induced radiation levels and their evolution,
- BLM TID + FLUKA + intensity measurements vs. RadMon measured HEH-eq-fluence,
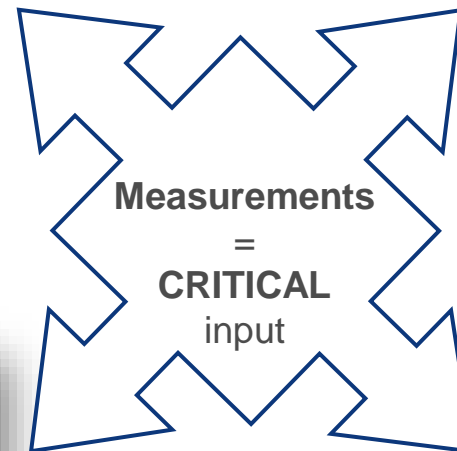
**Radiation levels in the SPS during the 2015-2018 operation**

- TID/HEH-fluence measurements along SPS based on BLMs and RadMons,
- Complementary passive measurements (NMOS, RPL) included,

# Run 3 outlook

# Run 3: MCWG objectives

- **Synthesis** of the information from **all available radiation monitors** (BLMs, RadMons, Fibres) into the MCWG **automated monitoring**:
  - Comprehensive picture of the radiation levels,
  - Benchmarks and cross checks of the detectors,
  - Forecasting the evolution → alarms if tolerance to be exceeded → R2E failures mitigation,

- Providing **regular updates on the radiation levels** across CERN accelerator complex:
  - Reports at the MCWG monthly meetings,
  - PDF reports sent to the mailing list,
  - Online monitoring for LHC, SPS, …, PSB, + transfer lines
    - → https://mcwg-monitoring.web.cern.ch/

- Addressing dedicated **requests** (continuation)
  - Equipment owners,
  - FLUKA team for simulations scaling & benchmarks,
  - Other (RP, Operations)…



MCWG analyses
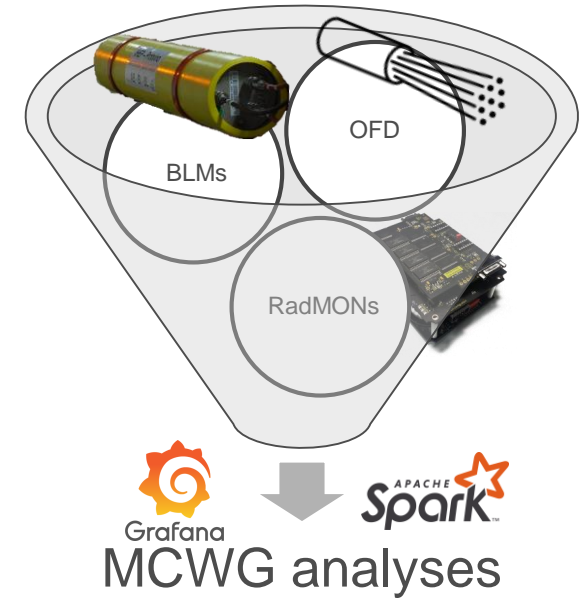
# Run 3: Updates on the analysis framework
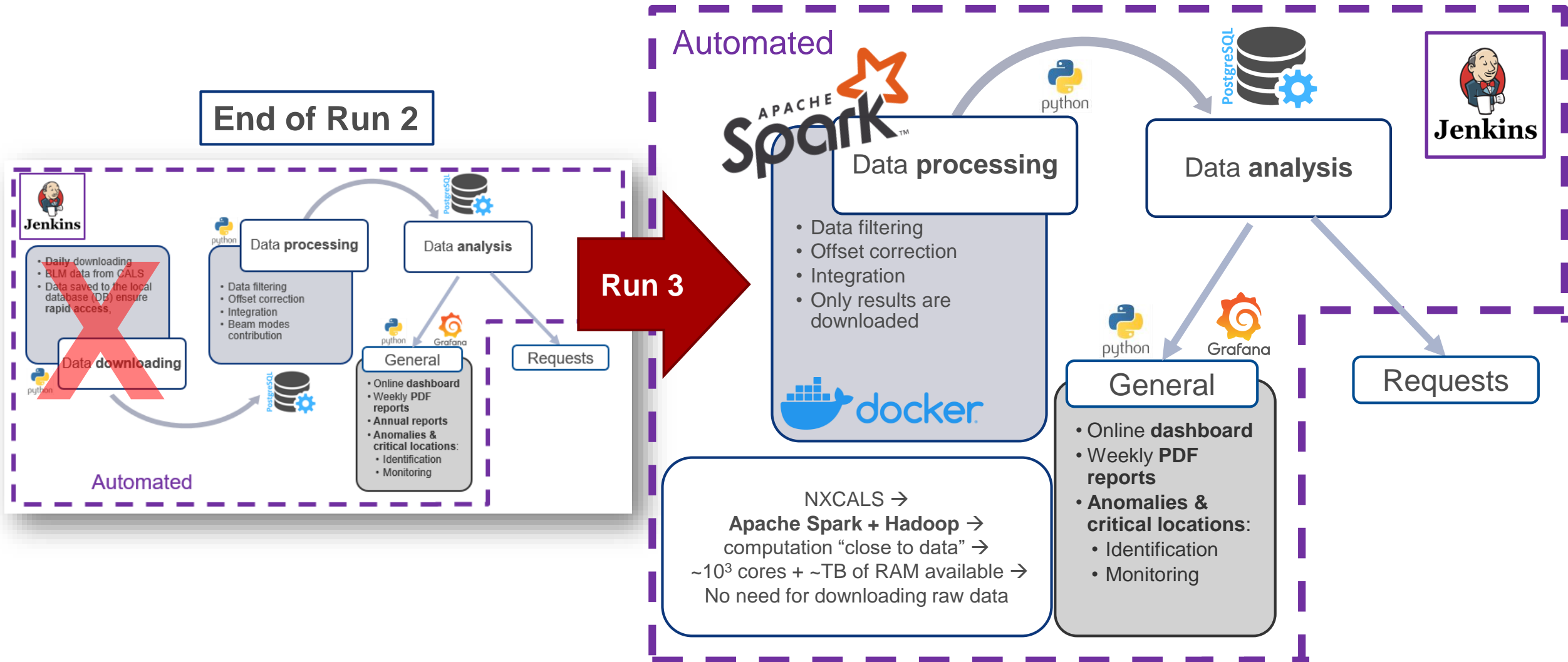
# Run 3: Injectors/Transfer Lines Automated Monitoring

- Intensity statistics:
  - Intensity tracking (injected, extracted, lost)
- BLMs analysis
  - High-Frequency data (if available) to perform a detailed analysis of TID,
    - ~20 GB/day to process in case of PSB
    - ~60 GB/day for PS
- Distributed Optical Fiber Dosimetry
  - PSB/PS/SPS entirely covered,
  - High spatial resolution of TID measurements,
- RadMons
  - TID / HEH-eq-fluence monitoring (other quantities to be included in the nearest future),
- Online monitoring preview:
  - https://mcwg-monitoring.web.cern.ch/



Example from the monitoring dashboard
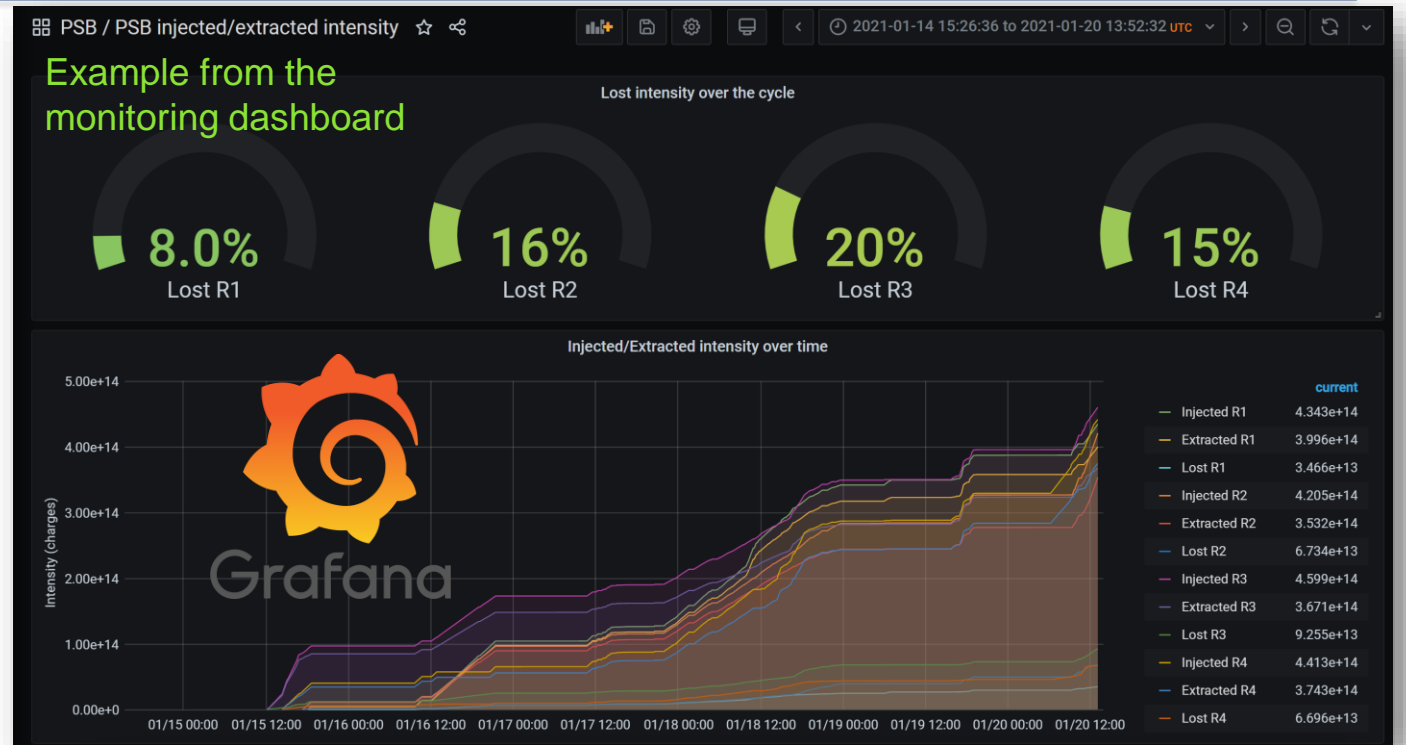
Largest accelerators covered

Automation server
→ Analysis on the hourly basis

# Run 3: LHC Automated Monitoring and Watchdogs

- Integration of existing monitoring tools with the NXCALS:
  - Monitoring dashboard → https://mcwg-monitoring.web.cern.ch/

- Anomalies detection:
  - **LSSs+DSs:** discrepancies from scaled Run 2 behavior,
  - **ARCs** → dedicated algorithm → deviations from the baseline,

- Automated extrapolation of the current behavior:
  - notifications when **tolerance** for a given region is going to be **exceeded** → **prevention** of R2E failures and prediction of mitigation actions,

- Validation of the past studies:
  - ARC levels evolution,
  - Scaling of the radiation levels (e.g. IR3, IR7),
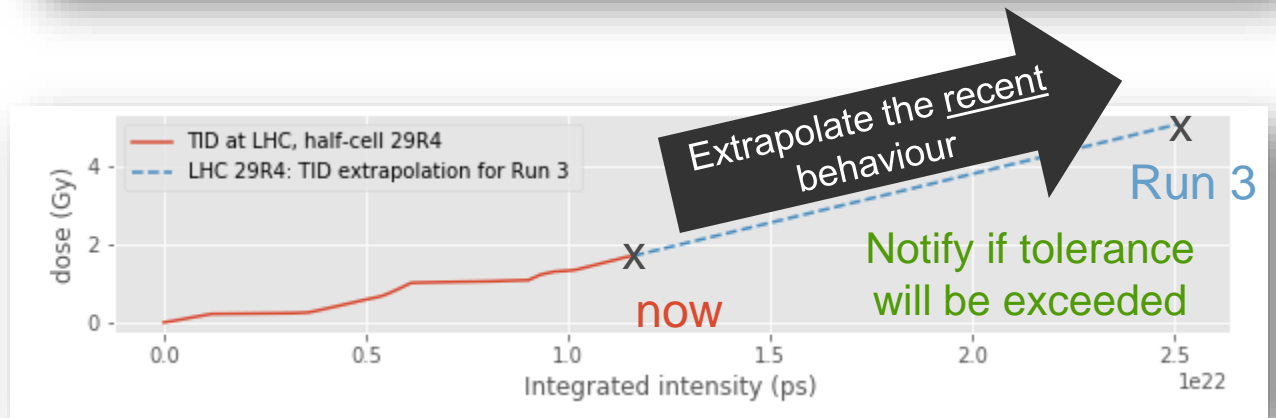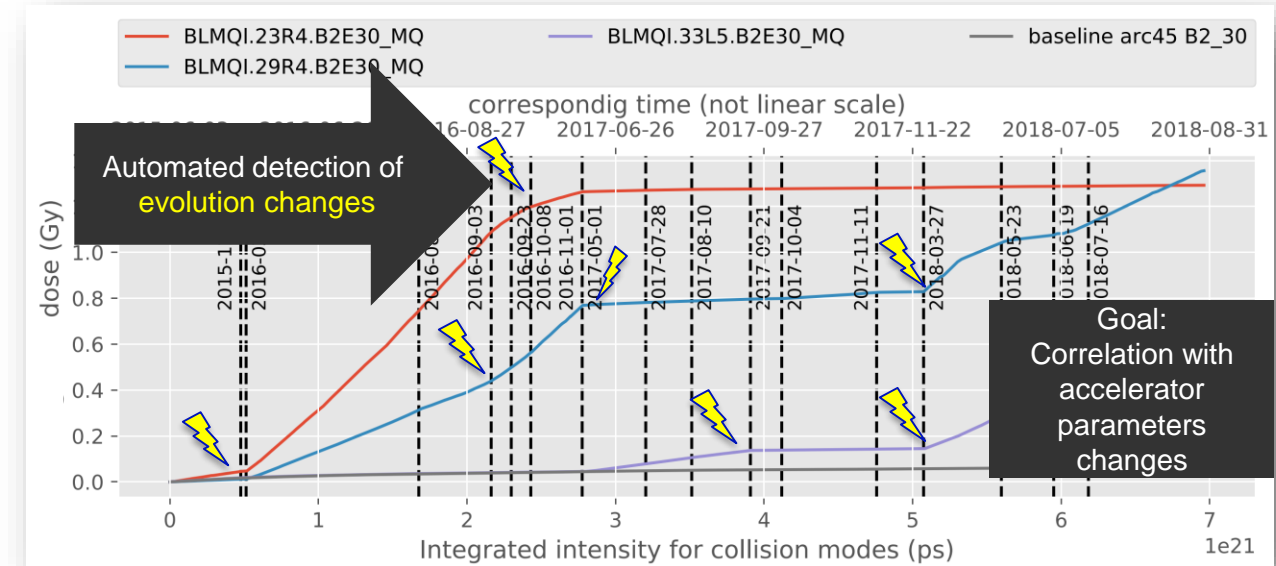
# Conclusions

- User service:
  - Requests: mcwg-request@cern.ch ,
  - Assessment of past/present/future radiation levels and their impact on the concerned equipment,
  - Over the past years, thanks to various developments and automation, mission of the MCWG has changed:
    - ~~reacting to R2E failures~~ → preventing the R2E failures,

- MCWG's Run 3 goal:
  - Provide the level of **support in injectors/experimental areas** as in the LHC by the end of Run 2,
    - New radiation monitors available (mainly OFD) → integration with the existing monitoring,

- Online monitoring available: https://mcwg-monitoring.web.cern.ch/
  - Great tool for quick inspection of radiation levels,

- Various internal projects and software developments to ensure quality of service along the operation:
  - Anomalies & critical locations → detection & monitoring,
  - Evolution tracking,

Thank you for
your attention!
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# Appendix: MCWG Run2/LS2 contributions

**Papers:**

- *Radiation Environment in the LHC Arc Sections during Run 2 and Future HL-LHC Operations,* K. Bilko et. al., IEEE TNS vol. 67, 2020

- *LHC and HL-LHC: Present and Future Radiation Environment in the High-Luminosity Collision Points and RHA Implications,* R. Garcia Alia et. al., IEEE TNS vol. 65, 2018

- *Distributed Optical Fiber Radiation Sensing in the Proton Synchrotron Booster at CERN,* D. Di Francesca et. al., IEEE TNS vol. 65, 2018

**Proceedings:**

- *Detailed analysis of the baseline dose levels and localized radiation spikes in the arc sections of the Large Hadron Collider during Run 2*, K. Bilko et. al., IPAC2019

- *Run 2 prompt dose distribution and evolution at the Large Hadron Collider and implications for future accelerator operation*, O. Stein et. al., IPAC2019

- *A Systematic Analysis of the Prompt Dose Distribution at the Large Hadron Collider*, O. Stein et. al., IPAC2018

- *Identification and Analysis of Prompt Dose Maxima in the Insertion Regions IR1 and IR5 of the Large Hadron Collider*, O. Stein et. al., IPAC2017

- *Radiation Levels at the LHC: 2012, 2015 and 2016 Proton Physics Operations in View of HL-LHC requirements*, C. Martinella et. al., IPAC2017

**Reports:**

- *Radiation Environment in the SPS during the 2015-2018 operation,* K. Bilko and R.G. Alia, CERN - EDMS 2471368

- *HL-LHC Radiation level specification document,* G. Lerner et. al., EDMS 2302154

- *Report on the Prompt Dose Distribution Along the LHC Based on BLM Data for proton-proton operation in Run 2*, O. Stein and K. Bilko, CERN-ACC-NOTE-2019-0040

- *High Energy Hadrons Fluence Measurements in the LHC during 2015, 2016 and 2017 Proton Physics Operations*, C. Martinella et. al., CERN-ACC-NOTE-2018-088

- *Radiation levels in the LHC during the 2015 Pb-Pb and 2016 p-Pb run and mitigation strategy for the electronic systems during HL-LHC operation*, C. Martinella et. al., CERN-ACC-NOTE-2018-073