

Overview of Run 2 LHC radiation level monitoring and Run 3 Outlook

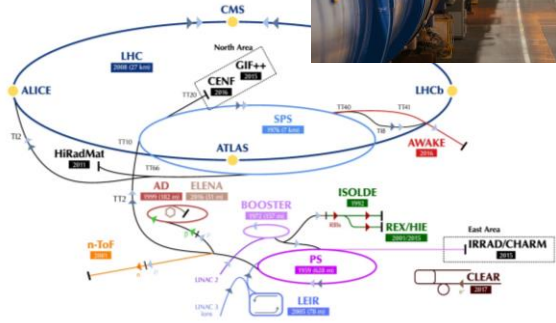
Kacper Bilko
Ruben Garcia Alia
Yacine Kadi

On Behalf of Monitoring and Calculation Working Group (MCWG)



Radiation levels monitoring...

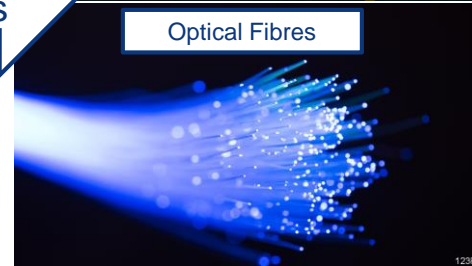
Accelerator operation



Radiation field assessment



Beam Loss Monitors

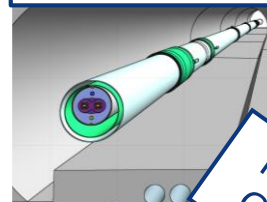


Optical Fibres

RadMons



FLUKA simulations



And others...

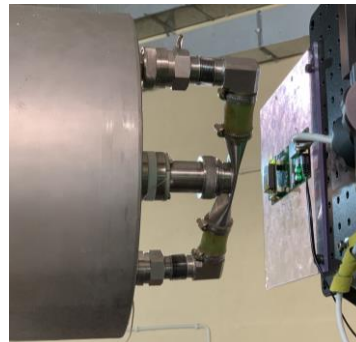
Hundreds of GBs of data

Equipment owners



Data produced by MCWG also beyond the interest of R2E (RP, operation)

Qualification of electronics



Monitoring and analysis (MCWG)

- Data analysis
- Simulations
- Software development and deployment
- Accelerator Physics
- Radiation effects

Run 2 highlight: improvement of LHC BLMs analysis

Manual, slow,
time-consuming,
inconsistent



Not efficient!
Reliable analysis
impossible...



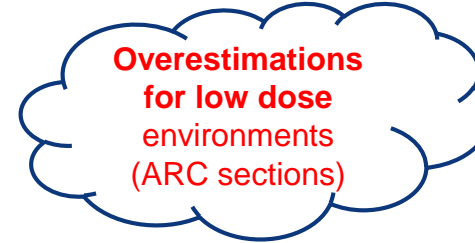
How to
improve it?



The only **solution**:
AUTOMATION

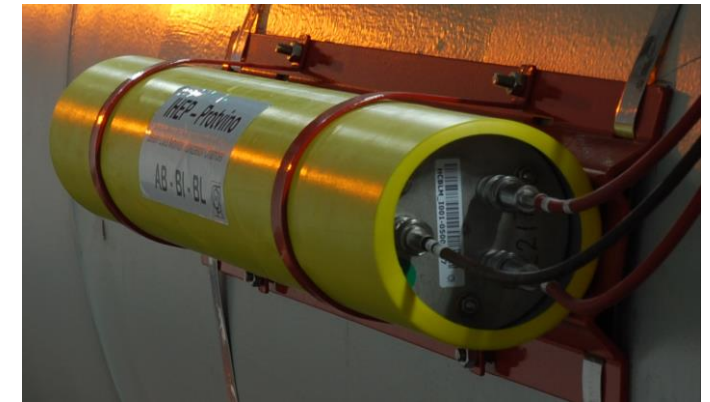
Limitations in the past...

- Every radiation request handled manually
- Slow access to CERN Accelerator Logging Service (CALs) via Timber
- Usage of the non-offset corrected data

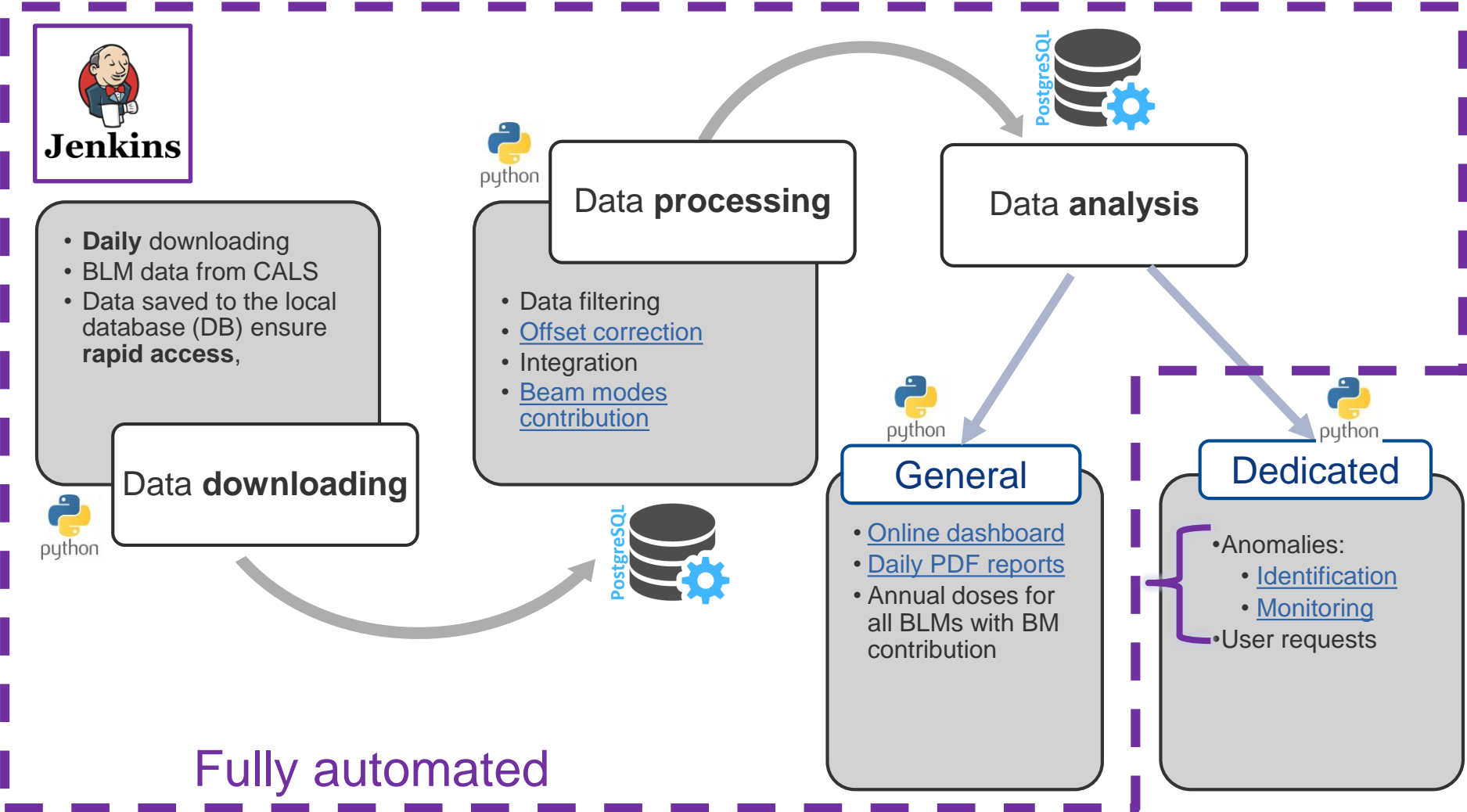


At the end of Run 2...

- Fully **automated** BLM data analysis,
- Automated reporting,
- Online access to processed measurement,

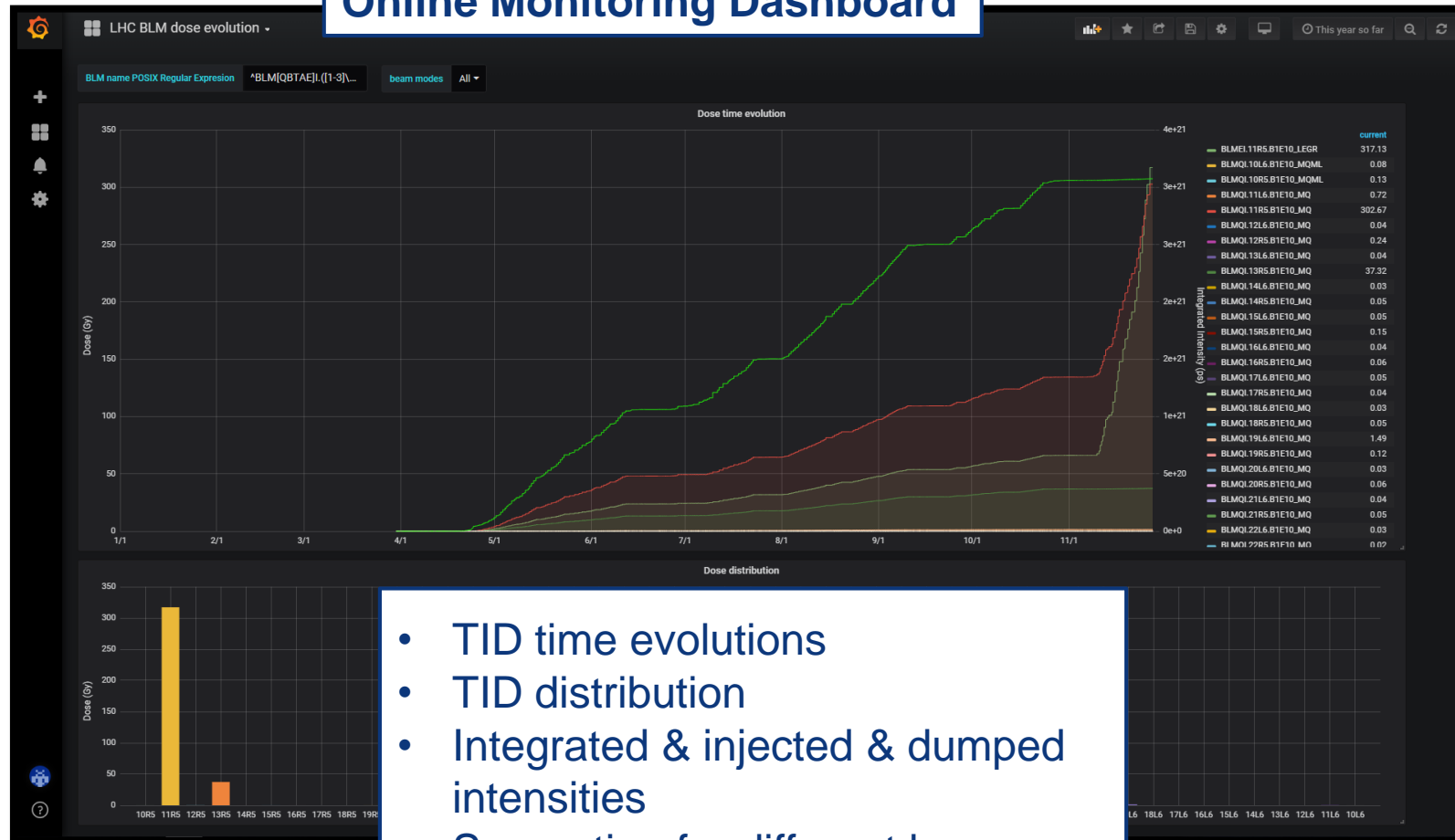


Run 2 milestone: automation of the BLM analysis



Run 2 Automation → New ways of results distribution

Online Monitoring Dashboard

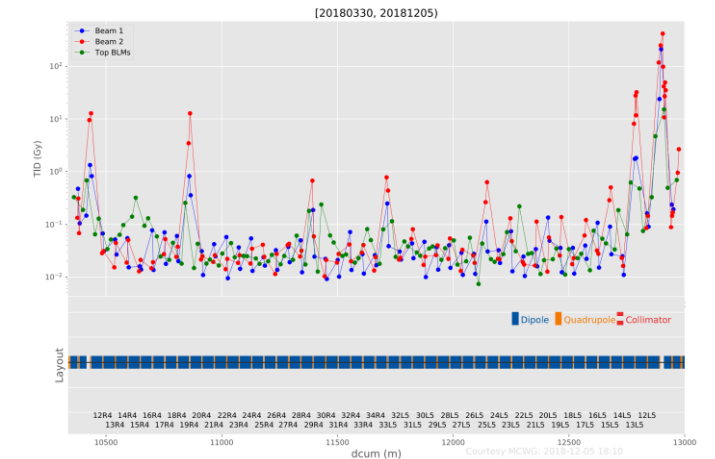


- TID time evolutions
- TID distribution
- Integrated & injected & dumped intensities
- Separation for different beam modes (injection, collisions,...)
- And more...

Weekly radiation reports

3.4 ARC45

3.4.1 Plot



3.4.2 Top 10 hottest BLMs

| | dcum | tid |
|-----------------------|----------|----------|
| BLMEI.11L5.B2E22.LEFL | 12904.80 | 4.17e+02 |
| BLMQI.11L5.B2E10.MQ | 12895.70 | 2.49e+02 |
| BLMQI.11L5.B1I30.MQ | 12898.20 | 2.11e+02 |
| BLMQI.11L5.B2E30.MQ | 12887.95 | 1.18e+02 |
| BLMEI.11L5.B2E21.LEFL | 12906.90 | 9.83e+01 |
| BLMAI.11L5.B2E22.MBA | 12915.30 | 4.94e+01 |
| BLMEI.11L5.B2E30.LEFL | 12909.00 | 4.16e+01 |
| BLMAI.11L5.B2E21.MBA | 12917.40 | 3.52e+01 |
| BLMAI.13L5.B2E21.MBA | 12791.70 | 3.23e+01 |
| BLMQI.13L5.B2E10.MQ | 12787.55 | 2.78e+01 |

Run 2 Automation → Rapid Data Access → more time for detailed analysis

Example of detailed studies:
ARC baseline and spike analysis

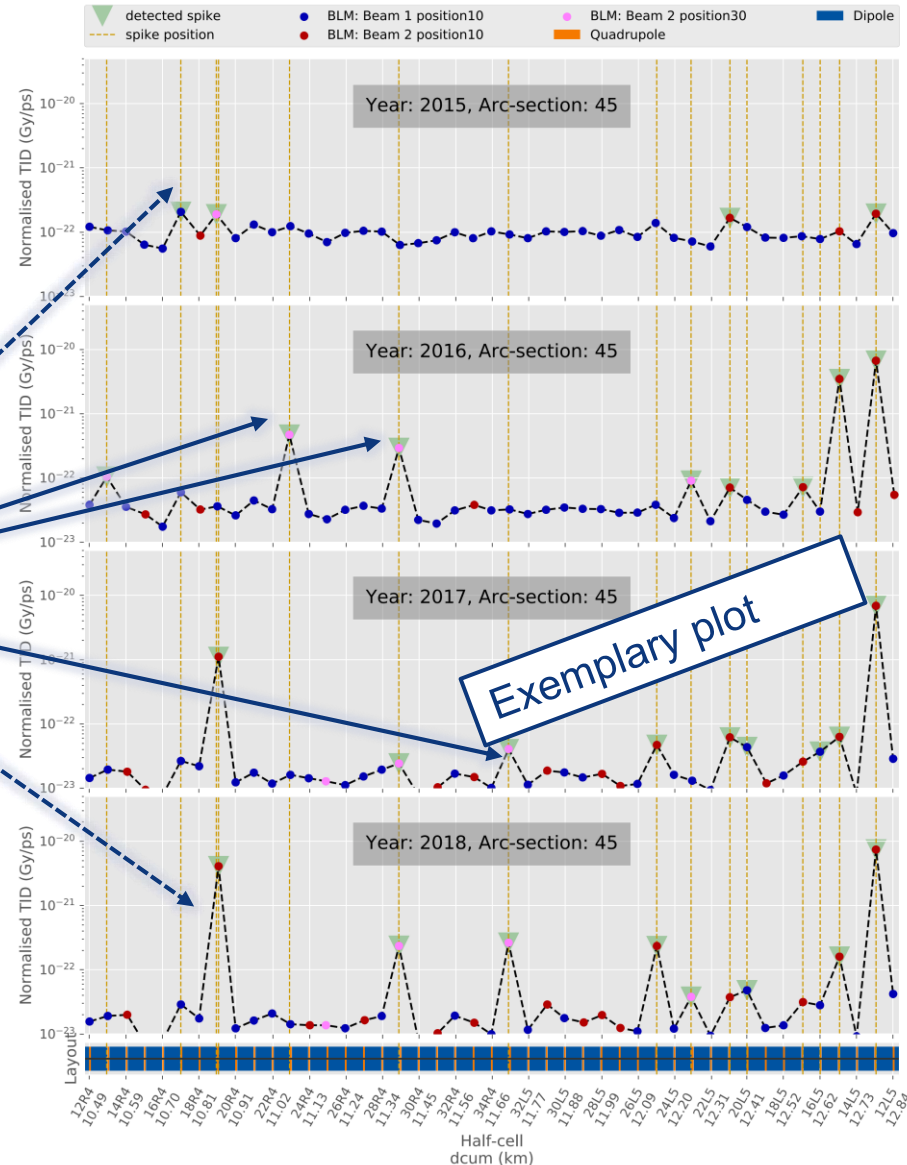
Spikes exceed baseline
up to 3 orders of
magnitude

Potentially dangerous

Identification
and monitoring is critical

ARC spikes
identification
algorithm

Future:
Automation of
the detailed analysis



Run 2: MCWG LHC related contributions

Papers:

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

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:

- *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

Theses:

- *Detailed analysis of the evolution and distribution of the total ionising dose in the LHC arc sections during the accelerator operation*, K. Bilko, CERN-THESIS-2018-307

LS2 & Run 3 outlook

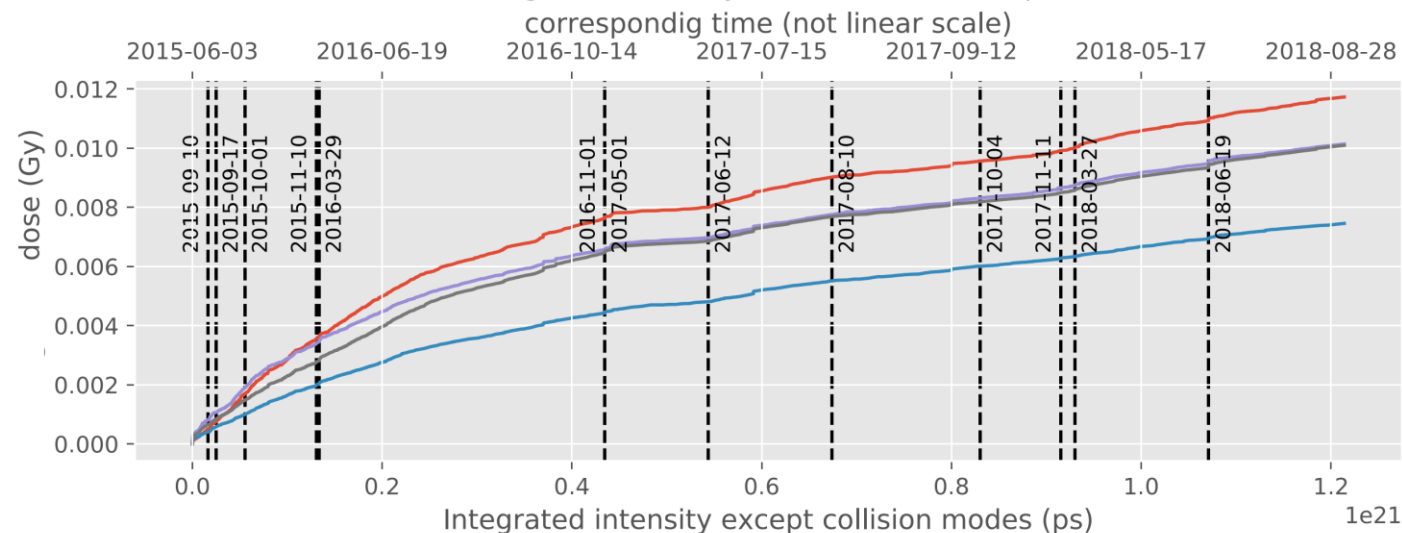
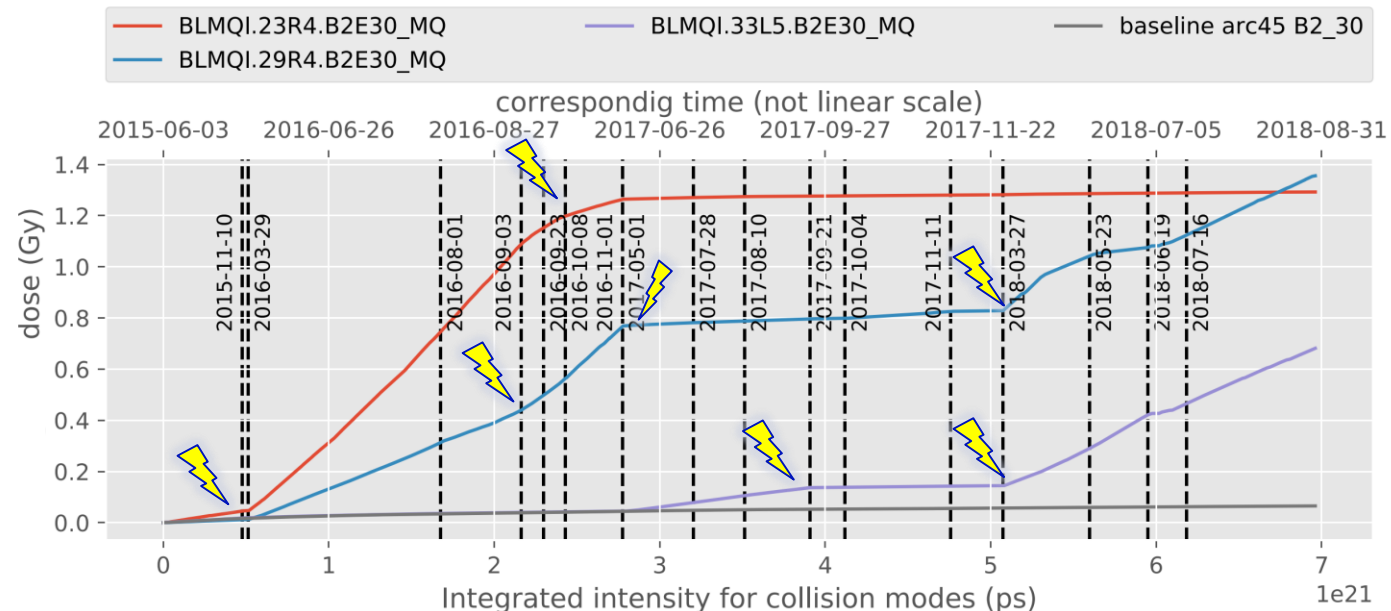
- **Maintenance** of already existing features (BLM analysis, Online monitoring, Weekly reporting),
- Implementation of **NXCALS compatibility** for the existing tools.
- **Full automation of analysis for other radiation monitors** (RadMons, BatMons, Distributed Optical Fiber Radiation Sensor (DOFRS)),
- Continuous **validation of expected radiation levels + automated anomalies detection** and monitoring,
- Through available measurements and simulations → **online monitoring** of radiation levels not only at monitor but also **at equipment locations**.
- **Full automation of radiation monitoring in Injector Chain and Transfer Lines,**

Run 3 outlook: Anomalies detection in the Total Ionizing Dose evolution

Detailed spikes analysis

Automated
detection of
evolution changes

Correlation with the
accelerator
parameters changes



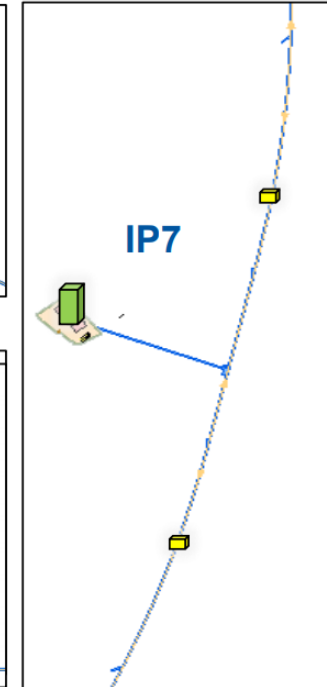
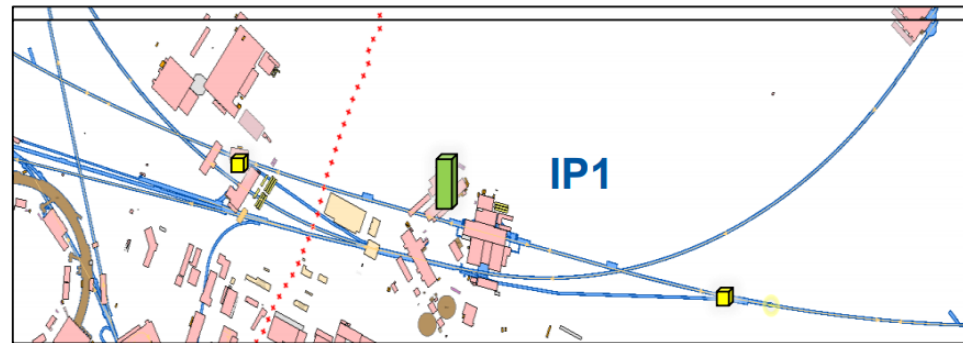
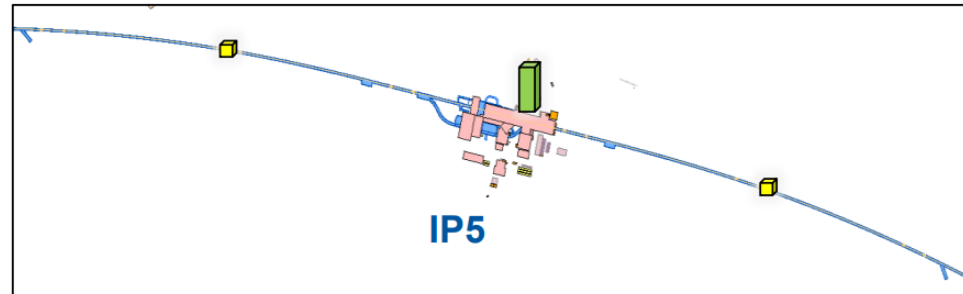
Run 3 outlook: Distributed Optical Fiber Radiation Sensor (DOFRS) in the LHC

Future installations: LHC

Courtesy D. Di Francesca

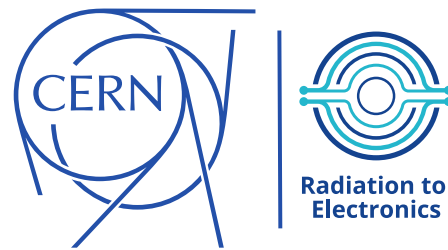
ECR (EDMS 1978574)

- It will be completed during LS2 and **operational in Run 3**
- **DS regions of IP1, IP5 and IP7**



11-12 December 2018

R2E Annual Meeting – Optical Fiber Dosimetry 12



Thank you for your attention!