Aggiornamento ALICE ITS3 2023-24

S. Beolé

19 Luglio 2024

OUTLINE

- ITS organization and INFN responsibilities
- ITS status and plans
- ITS3 status and plans

ITS Project Organization

Institute Board

Team Leaders, Project Leader, Deputy Project Leader, ITS3 sub-project leaders, Technical Coordinator

Project Leader

F. Reidt

Deputy Project Leader

Giacomo Contin

ITS3 sub-project

Sub-project Leaders

A. Kluge, M. Mager

Work Packages Conveners

Physics and Performance/F.Grosa, **A. Rossi**

Chip Design/G. Aglieri, W. Snoeys

Chip Characterization/M. Suljic, S. Senyukov, H.Hillemmans, M. Keil, **V. Sarritzu**

Thinning, Bending and Interconnection/ **G. Contin**, **D.Colella**

Mechanics and Cooling/C. Gargiulo, M. Angeletti

Readout electronics, Power supply and Services/ O.Bourrion, **S. Siddhanta, P. Giubilato**

ITS2

Technical Coordinator

M.Keil

System Run Coordinator

N. Valle - *A. Isakov – J. Sonneveld*

Electronics Coordinator

G. Aglieri

Software Coordinator

M. Concas

Sub-system Coordinators

DCS/M. Keil

ITS2S/P. Martinengo

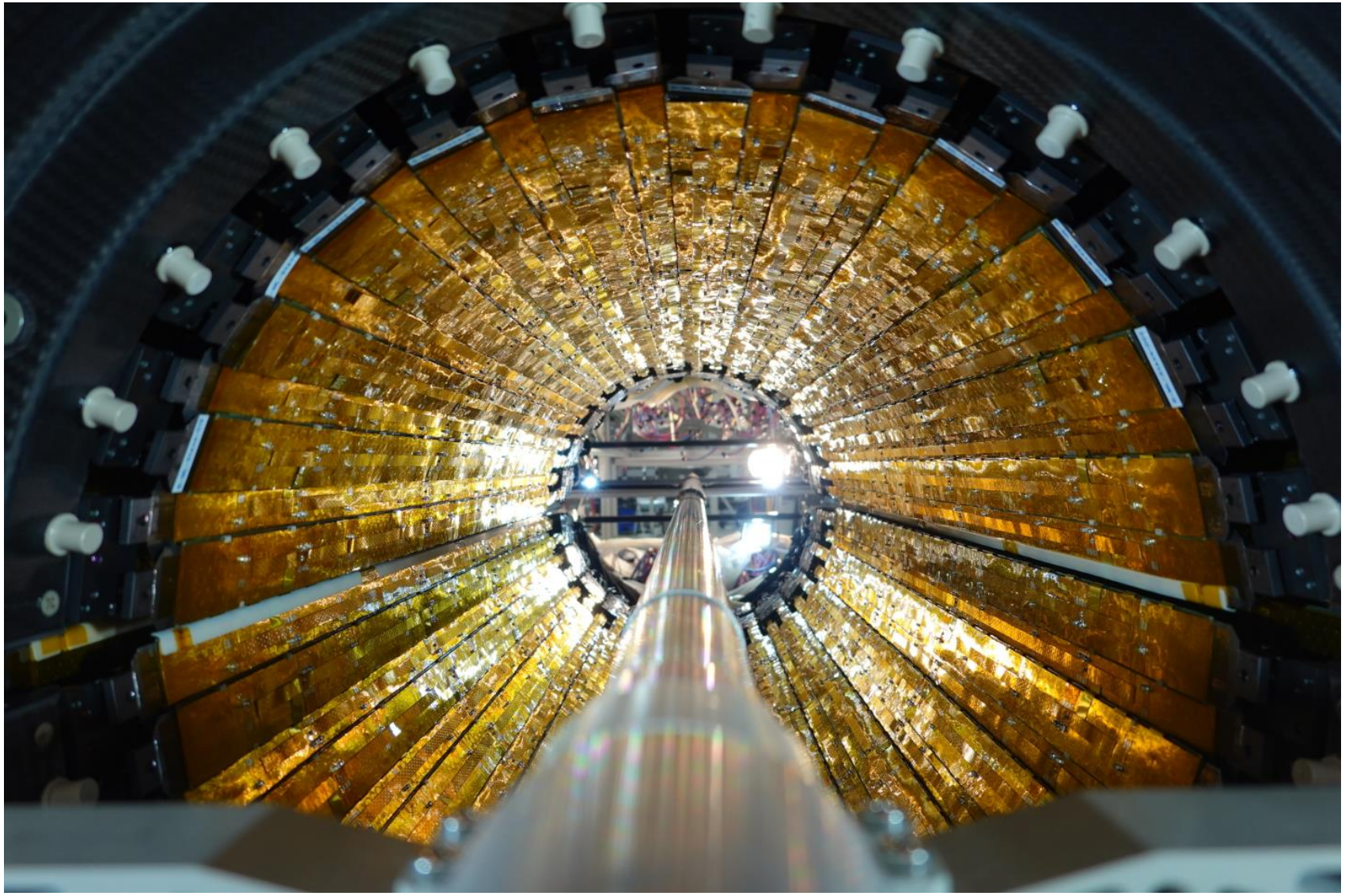
Cooling/S. Senyukov

ITS2

Slide da:

Artem Isakov

Matteo Concas



Presa dati 2023

ottimizzazione tools di QC, in-run recovery, soglie

Main topics

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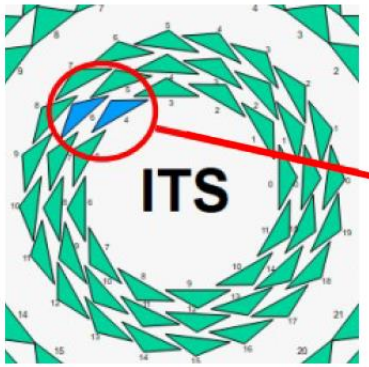
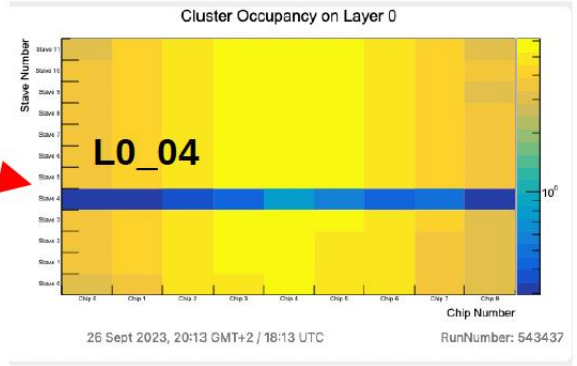
- Lessons learned from Pb–Pb run
- ITS in 2024 data taking of pp collisions
- Status of the ITS track reconstruction
- Outlook

Beam induced background in Pb-Pb

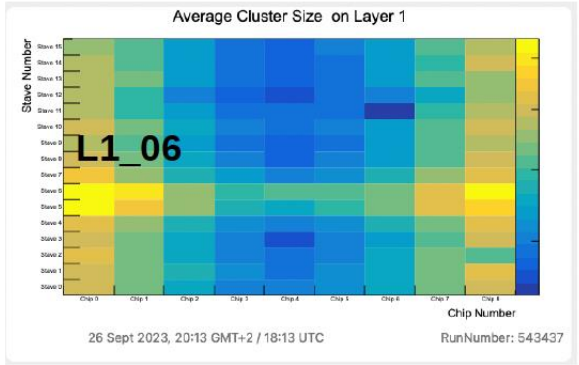
ITS reported problematic region at φ = 2.4, and r = 2 to 3 cm

This region was not approachable by previous generation of ITS where L0 of SPD started at r ~ 4 cm

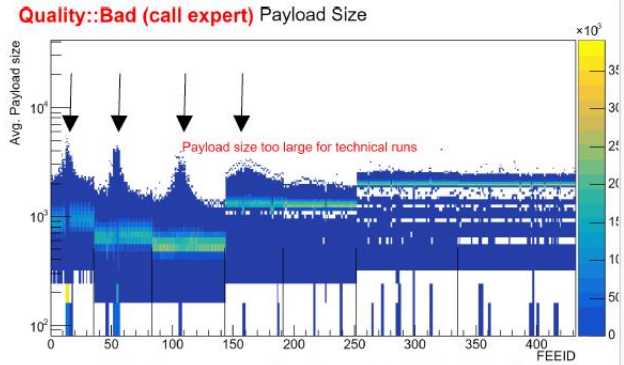




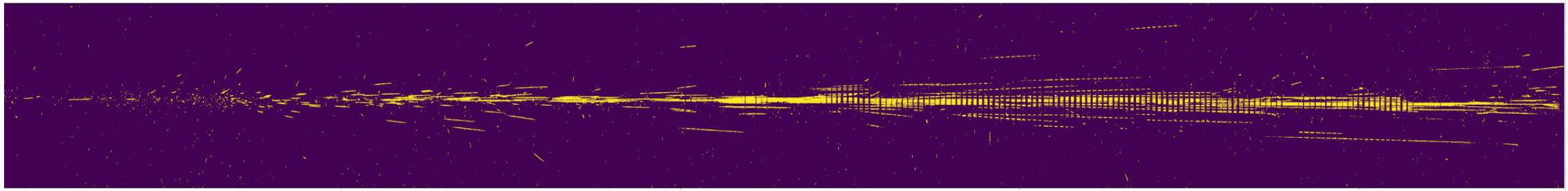
Low cluster occupancy
On affected staves



Larger cluster sizes
on affected staves

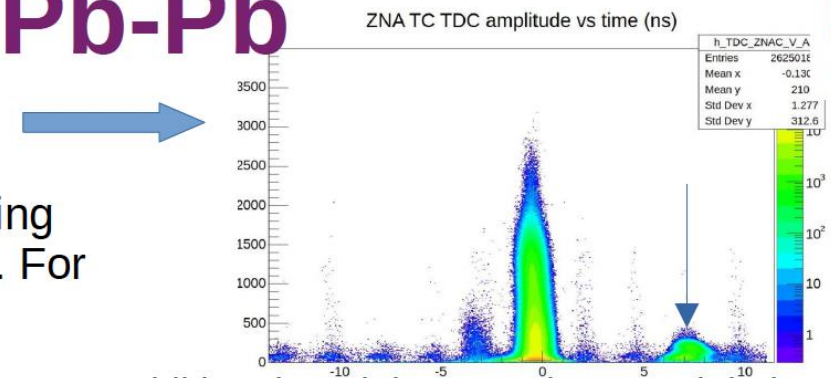


Background also visible in the data rate of the neighboring staves and reaching L3



LHC background effect in Pb-Pb

Confirmed by MFT and ZDC via off-time signals from Beam 1

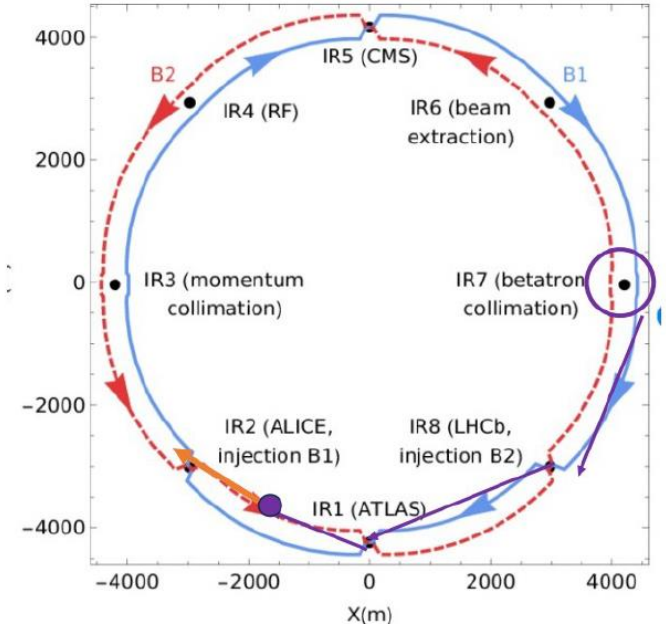


Additional peak in ZDC Time-to-Digital Coverter signal at 7.2 ± 1.5 ns correspond to time of flight for particles from the background spot

Explanation: Muon shower created from ion fragments traveling inside the beam, hitting IP2 TCT collimators, ~114 m from IP2. For more details, follow

Mitigated on October 4th by adding an orbit bump at the ALICE TCTs

The inflicted radiation damages due to the background was estimated to ~1.5% of the entire lifetime dose



ITS activities after the Pb-Pb background:

- Prepared a new Readout Unit (RU) firmware with improved tolerance against large events → already installed at P2

- Participating in beam background study group organized by RC:
  - Develop tagging/identification of background events
  - Correlation of signals in MFT, ZDC and ITS
  - Estimation of remaining background signal
  - Comparison fo FLUKA simulation results

https://indico.cern.ch/event/1342872/contributions/5653271/attachments/2761673/4809489/2023.11.29--LHCC--Status_of_accelerator.pdf

ITS performance in 2024

In 2024, ITS participated in >700 hours of physics data-taking

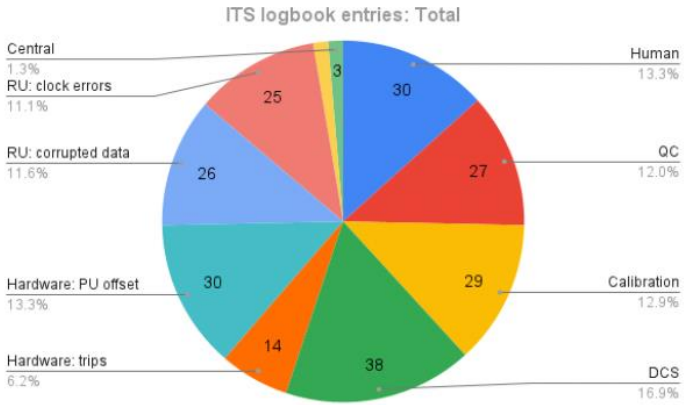
The leading causes why was ITS contacted are
Readout Unit issues and **low voltage trips** →
both are subjects of radiation effects

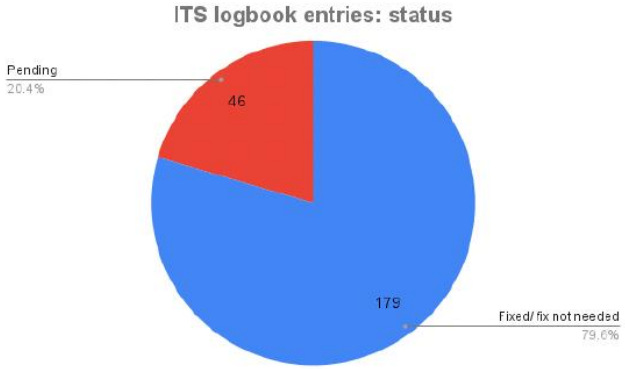
Impact of RU-related issues reduced:

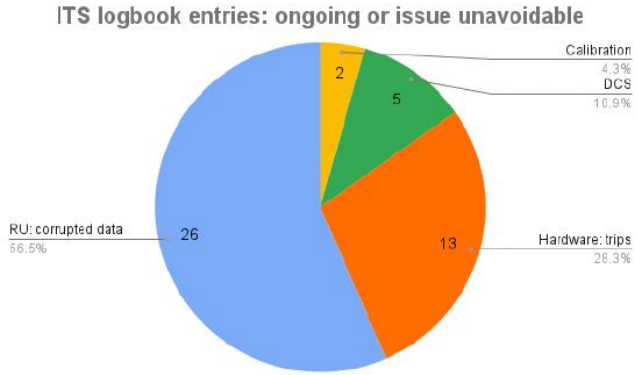
- **Protection against corrupted data**
  - New CRU firmware to filter out corrupted data
  - New checks on bad data in ITS Decoder

- **Improved detection:**
  - Improved CRU monitoring of RU errors
  - New QC plots to check chip status

- **Better recovery:**
  - Established procedure to recover RU issues during data-taking
  - Next step: automation of the RU recovery using CRU monitoring

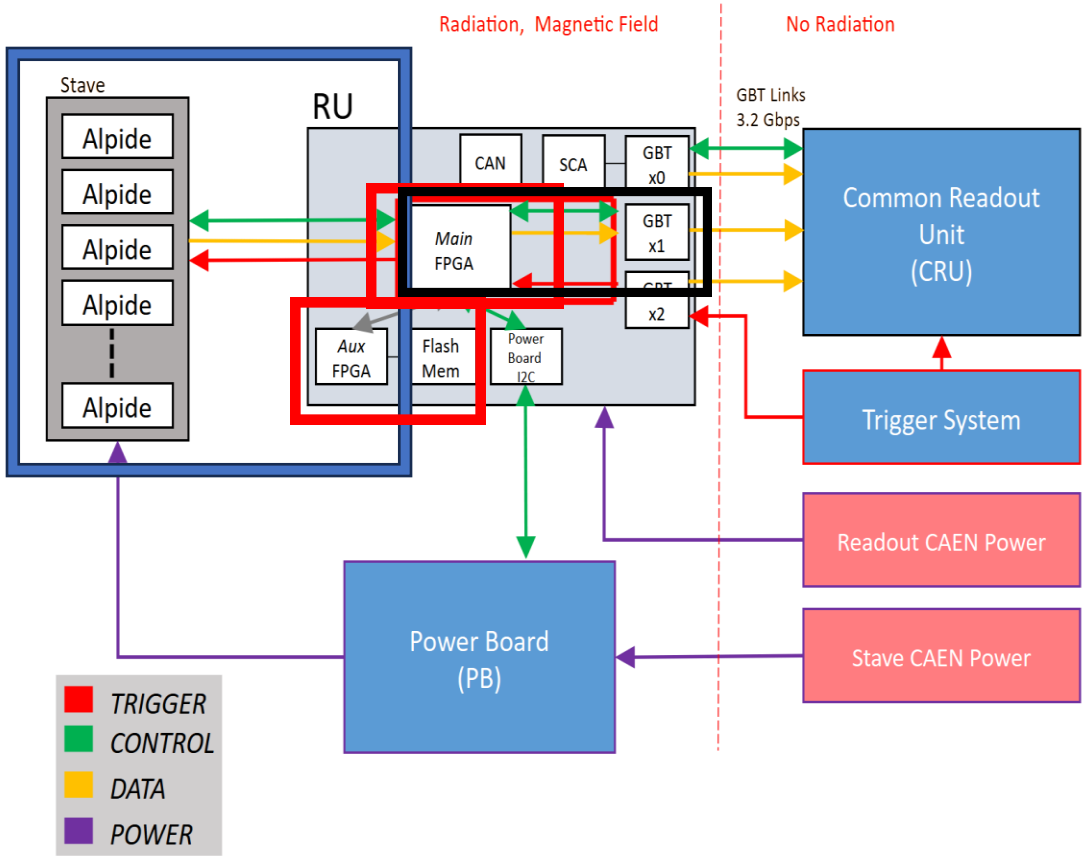






In-run recovery and radiation effects mitigation

ITS RU racks are located at ~7m from Interaction Point -> exposed to radiation



Different approaches targeting specific issues:

1) Lane recovery: reconfiguration of a chip and lane

2) RU scrubbing : regular update of the Main FPGA configuration controlled by the Aux FPGA

3) [New] RU + GBT link issue: radiation-induced corruption of the output data of the RU

Solution for in-run recovery:

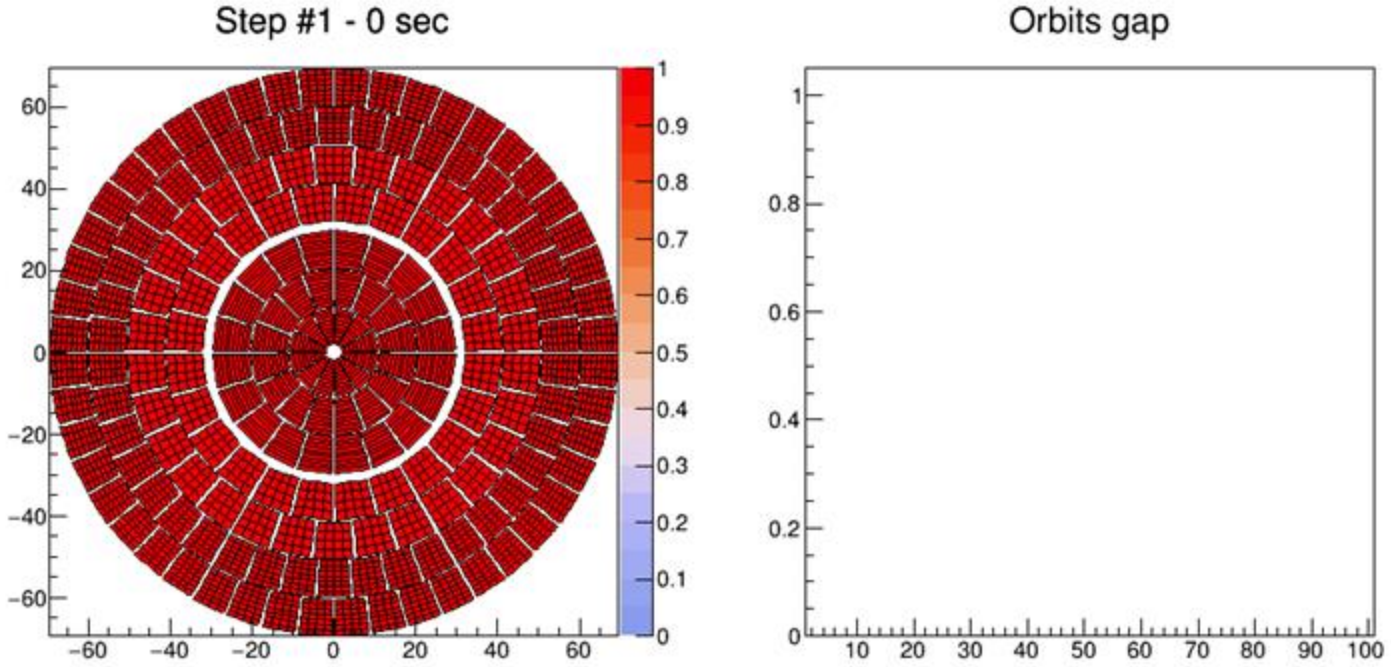
✓ Tests of manual recovery procedure with expert tools

✓ Developed a list of commands for DCS back-end

- [ongoing] Implementation of user-friendly operator tools

- [under preparation] Full automation of issue detection and recovery

Chip status monitoring



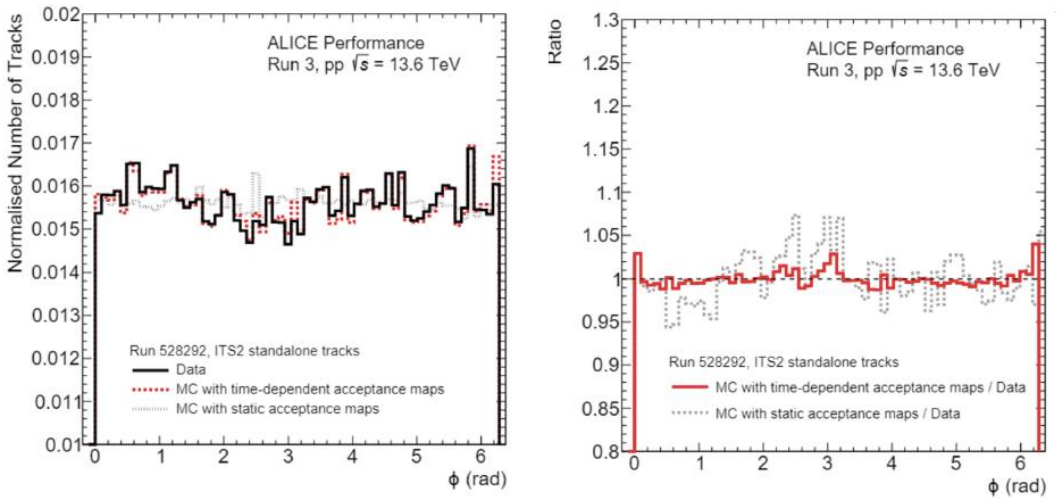
Calibration workflow with time-dependent chip status maps:

- MC anchoring → help to reproduce changes in lane status with precision of ~1 sec → sensitive to lane recovery (~10-20 sec)
- Online monitoring with QC → low-level performance of the readout and processing → could be used to quickly detect Single Event Upset issue with data from RU

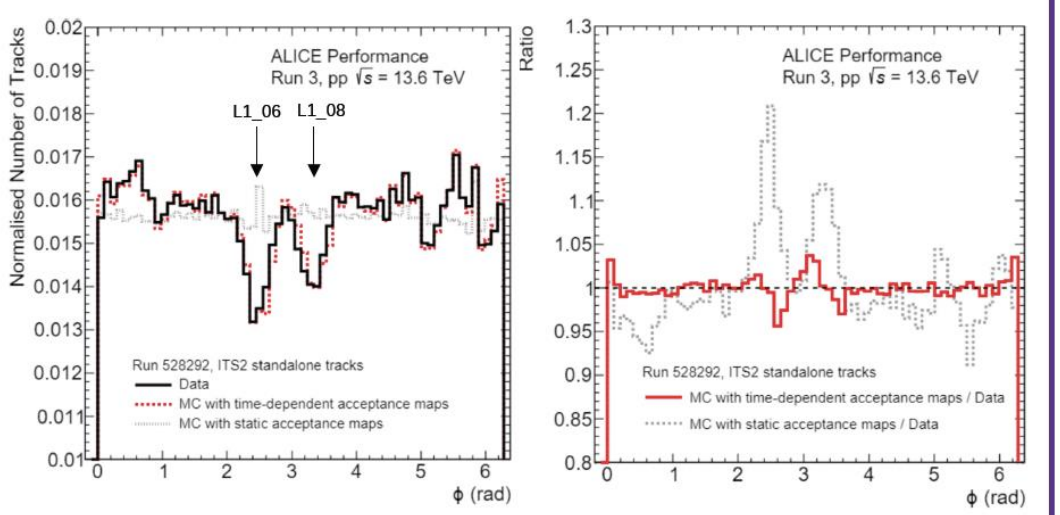
MC anchoring to chip status map

The new workflow gives important input for MC anchoring -> Major improvement of MC anchoring performance

Example of MC anchoring for good run



Run with limited acceptance for ITS
(2 missing IB staves)



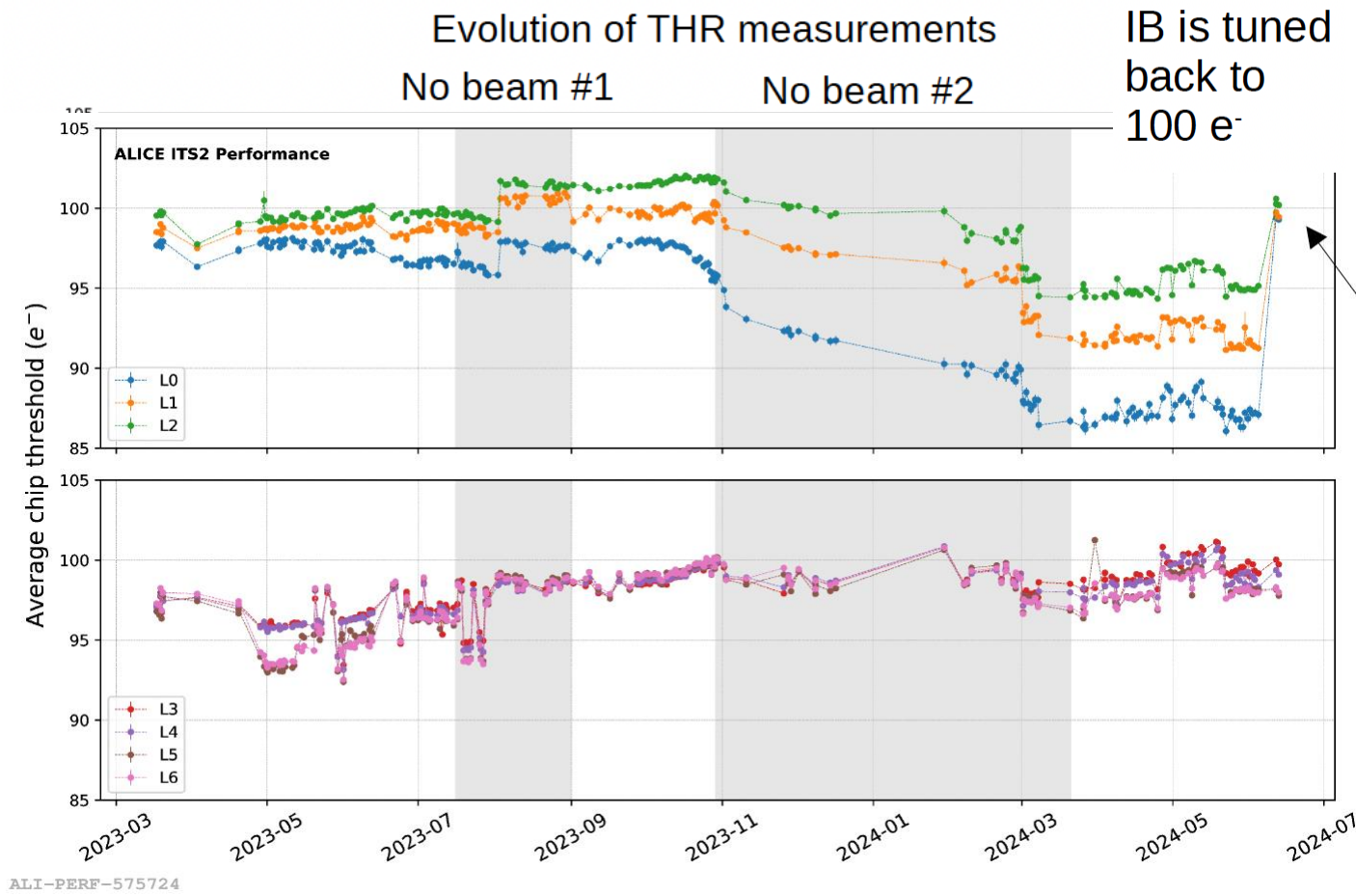
Calibration

ITS performs calibration during each ramp down by measuring charge threshold (THR)

December 2022: Detector was tuned to 100e-

Middle of Pb-Pb Run: observed a mild decrease in the average THR:

- Effect visible in innermost layers, magnitude depends on radial distance to the interaction point: THR(L0)<THR(L1)<THR(L2)
- THR decrease continued during no-beam time and leveled off in February.
- Total THR decrease of 5-15 e^-

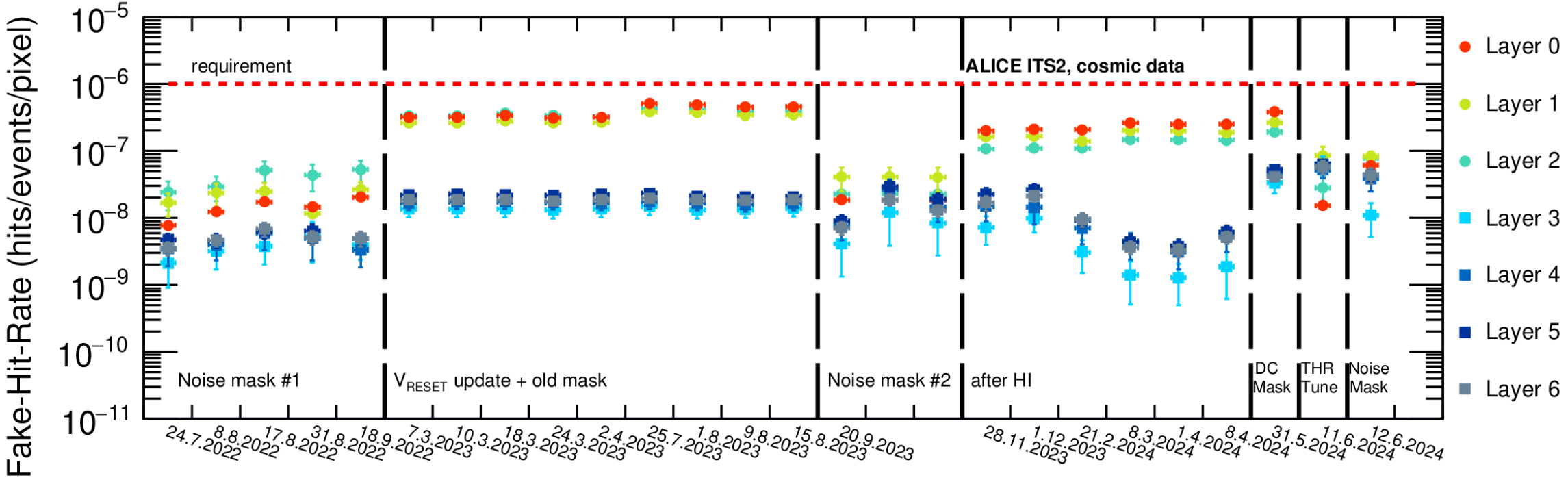


Threshold very sensitive to analogue voltage: 1 mV ~ 1 e^-

Fake hit rate

FHR Level was always below at least by factor of 10 from project requirement

- After re-tuning IB to 100 e- and performing new noise scan to mask noise pixels, the FHR level is back to values from 2023 before the Pb-Pb Run!
- Note: OB has stricter masking of noise pixels. For IB, we prioritize efficiency of detection



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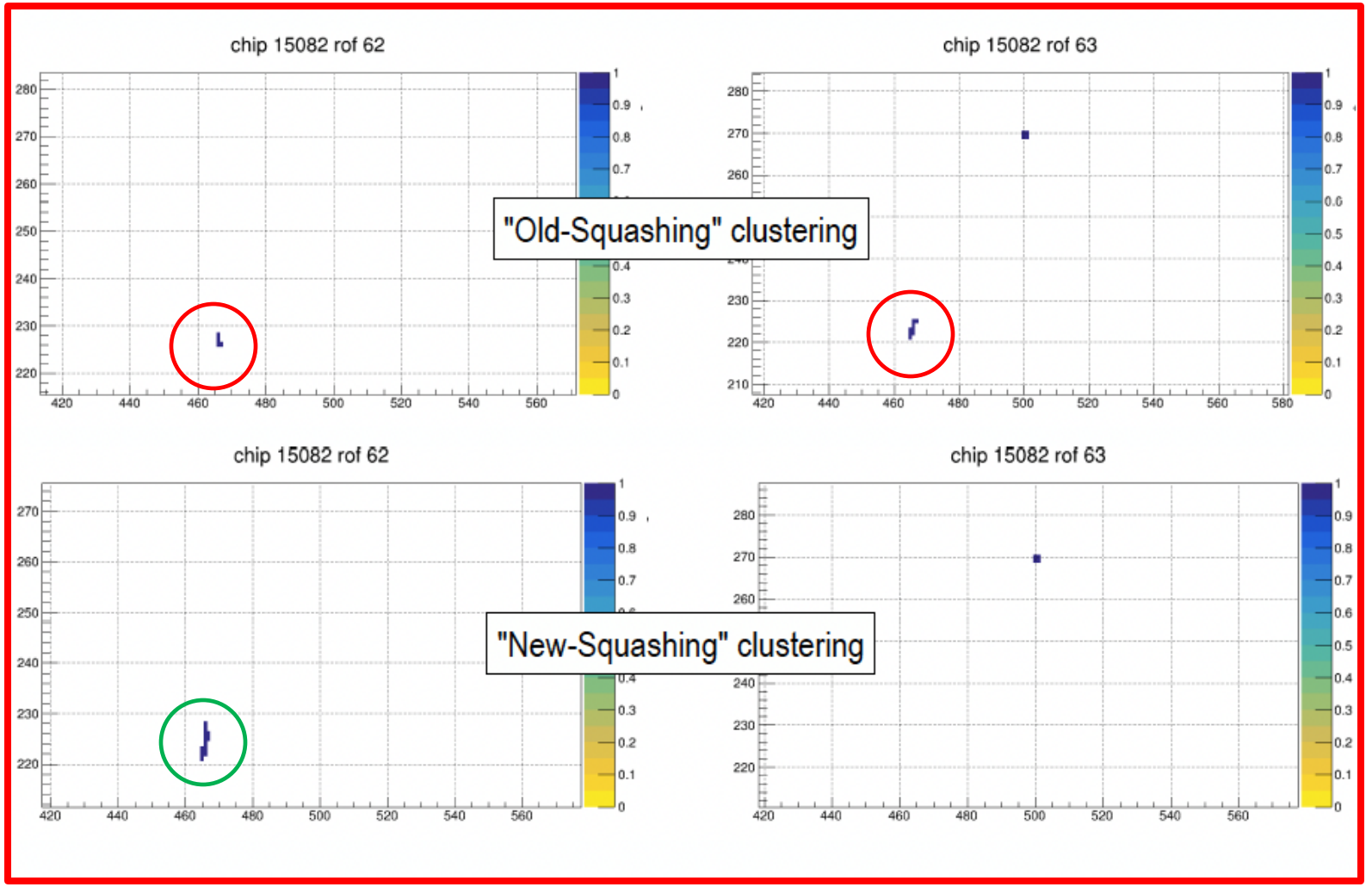
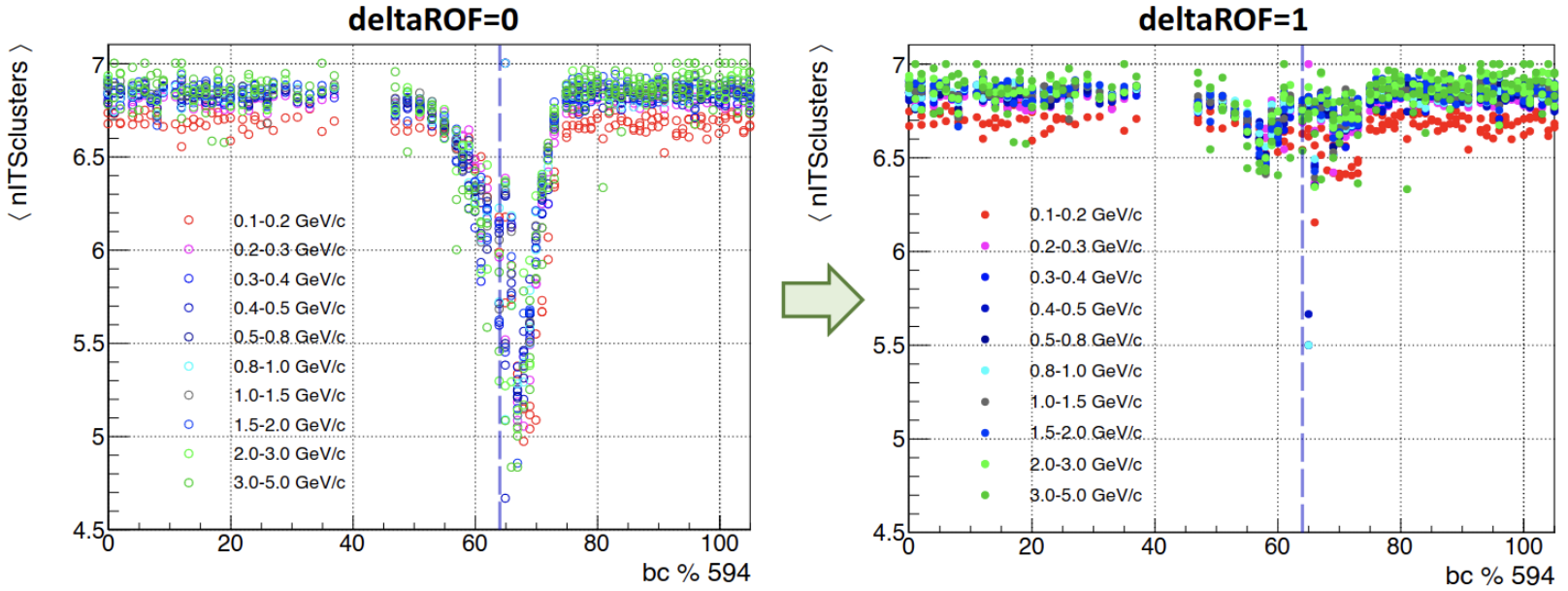
ITS tracking: cluster squashing



Multi-ROF tracking

PbPb_LHC23zzh_544122, 12k events



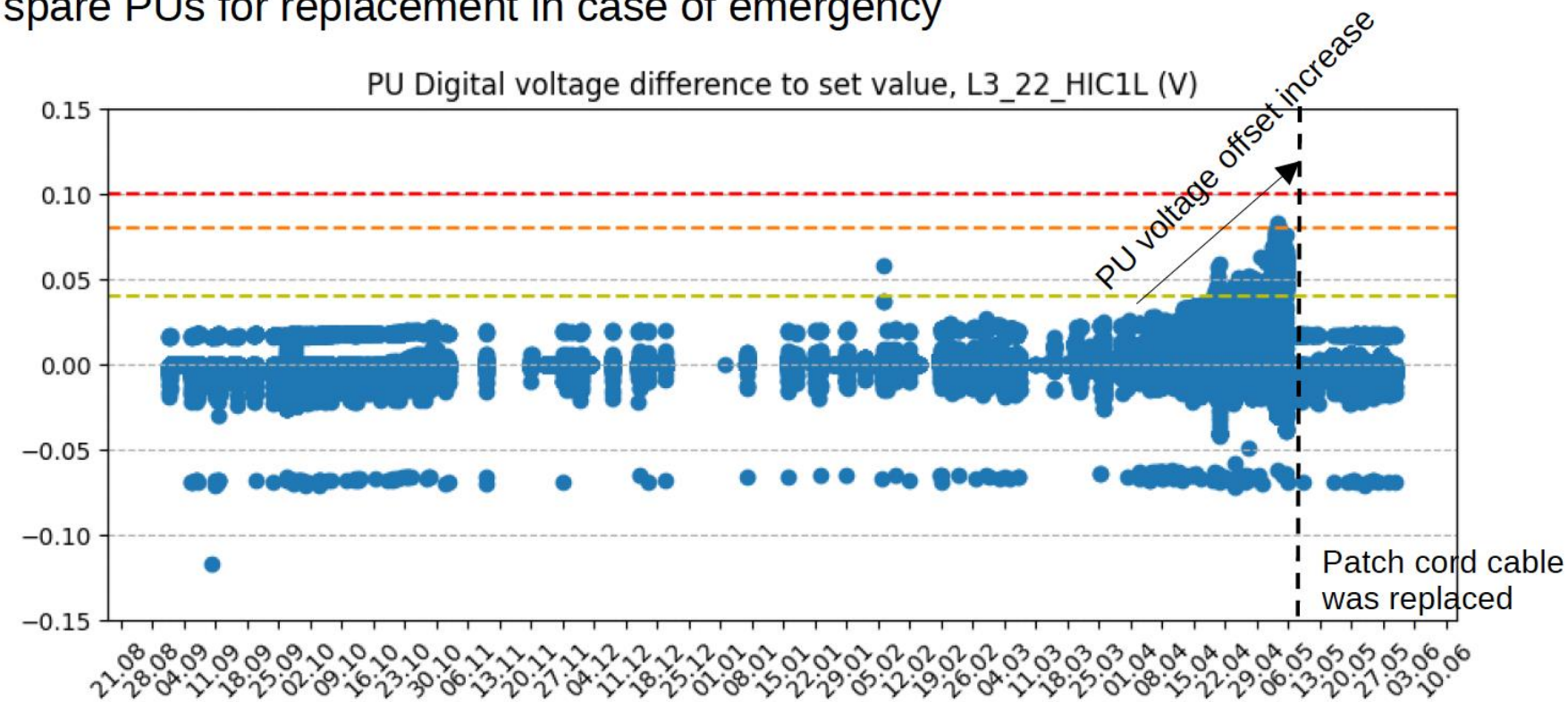
- Decrease in tracking efficiency at the boundary of the ITS strobes
  - Expected and known behaviour due to the sum of different effects, observed in data
  - not all clusters belonging to the same track are detected in the same ROF
- Method Tested on a convenient filling scheme in PbPb 22s
  - Collisions happening close to the ROF boundary
  - Efficiency vs BC_Id increasing moving out of the boundary (+- 1 ROF)

Health monitoring of Power Units (PU)

Known issue: upward drift of the PU output voltage → we need to perform monitoring of the long-term trends of *PU voltage offset* and Trimmer Offset to detect problematic PUs

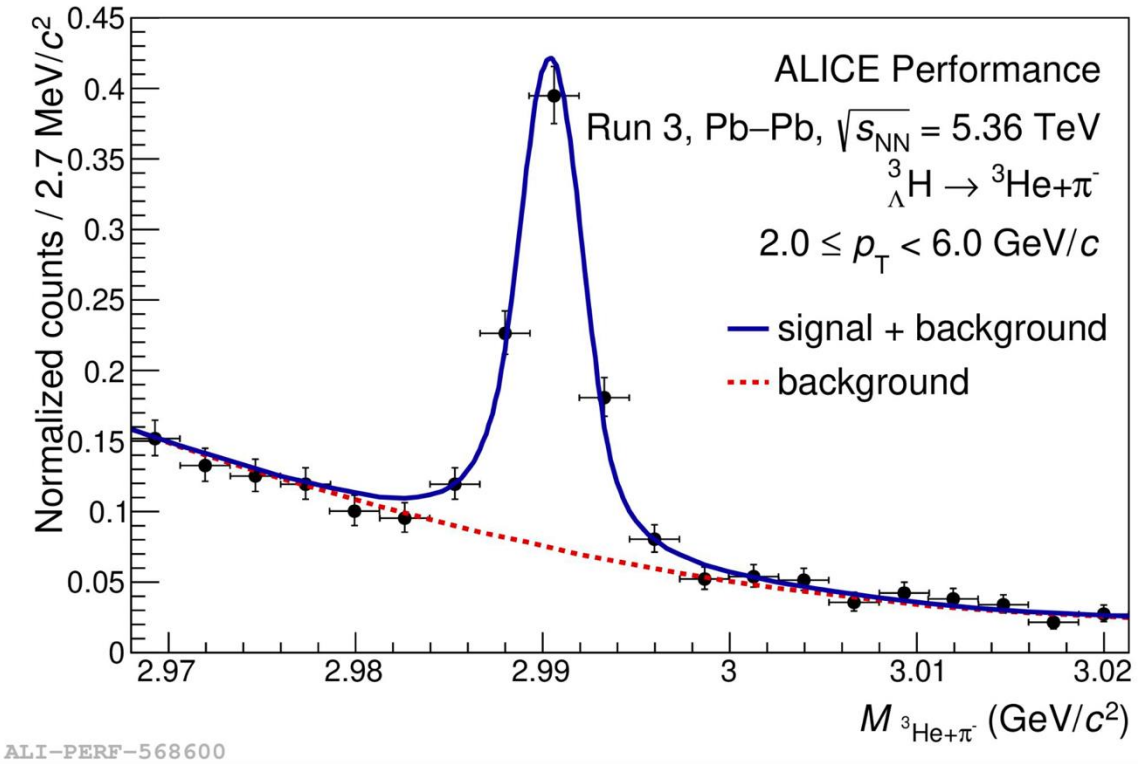
Solutions:

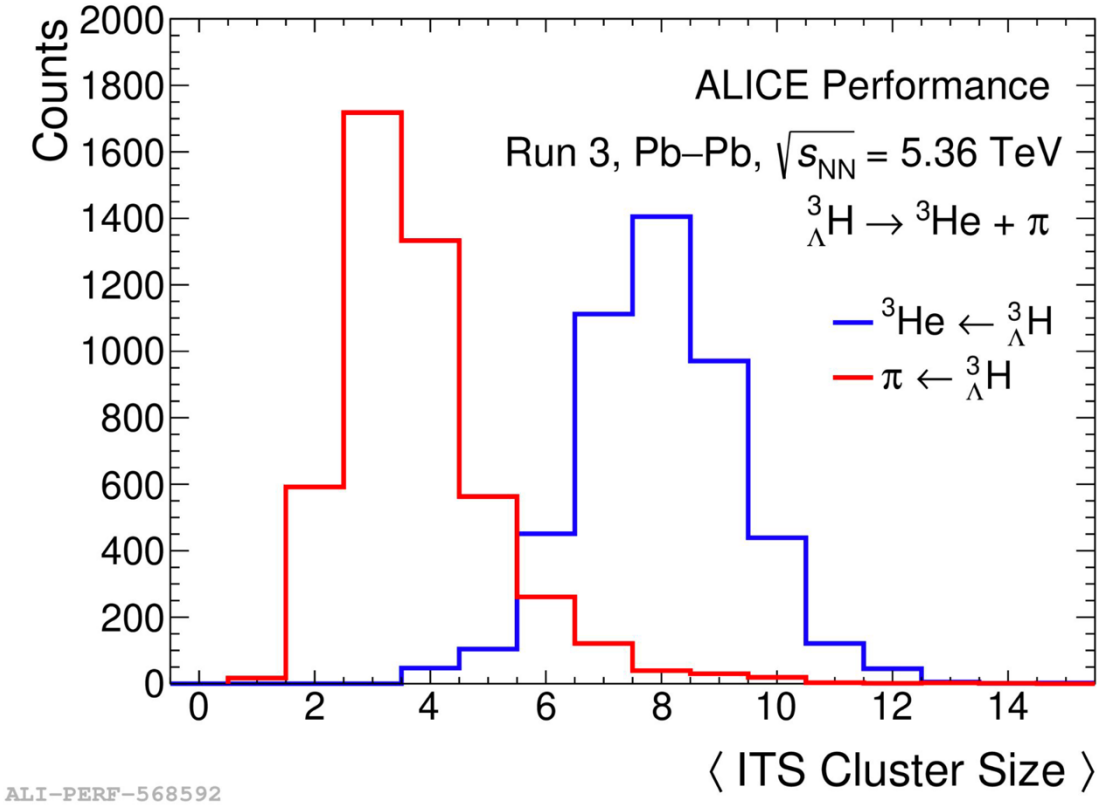
- [short term] Increase of CAEN supply voltage from 3.3 to 3.4 V
- [access needed] Replacement of patch cords
- We still have spare PUs for replacement in case of emergency



ITS PID from cluster size

- Hypertriton two-body decay channel reconstruction
  - Use of ITS cluster size to tag ^{3}He daughter track and reduce ITS-TPC fake matchings (π vs ^{3}He)
  - PID capabilities of a silicon digital detector !





Outlook

ITS successfully ran in the Pb-Pb run in 2023: Developed monitoring tools like QC and DCS worked well in detecting problematic situations

The background spot was quickly detected and brought under control in a common effort with RC/ZDC/MFT and LHC

ITS performing well in pp in 2024:Mitigation strategies for beam induced issues are being put in place

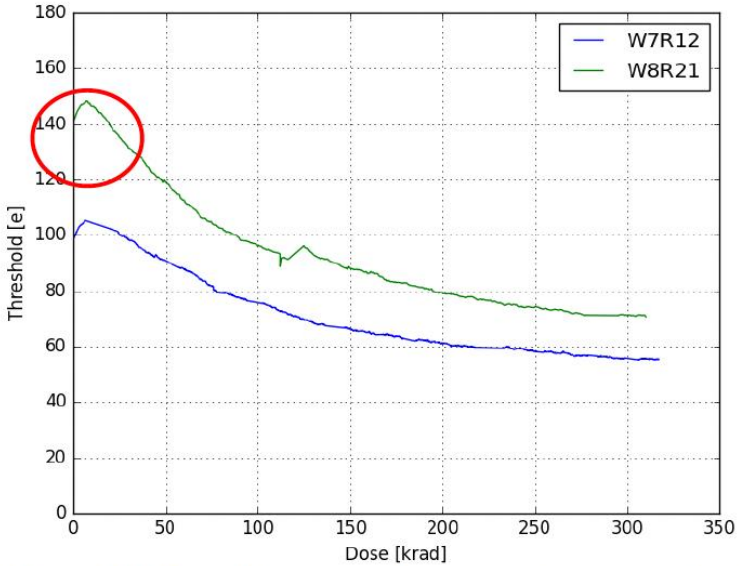
Calibration Toolkit is working very well and detector performance is closely monitored with new tools of CRU monitoring and Chip Status calibration workflow

ITS Reconstruction and QA software being further improved

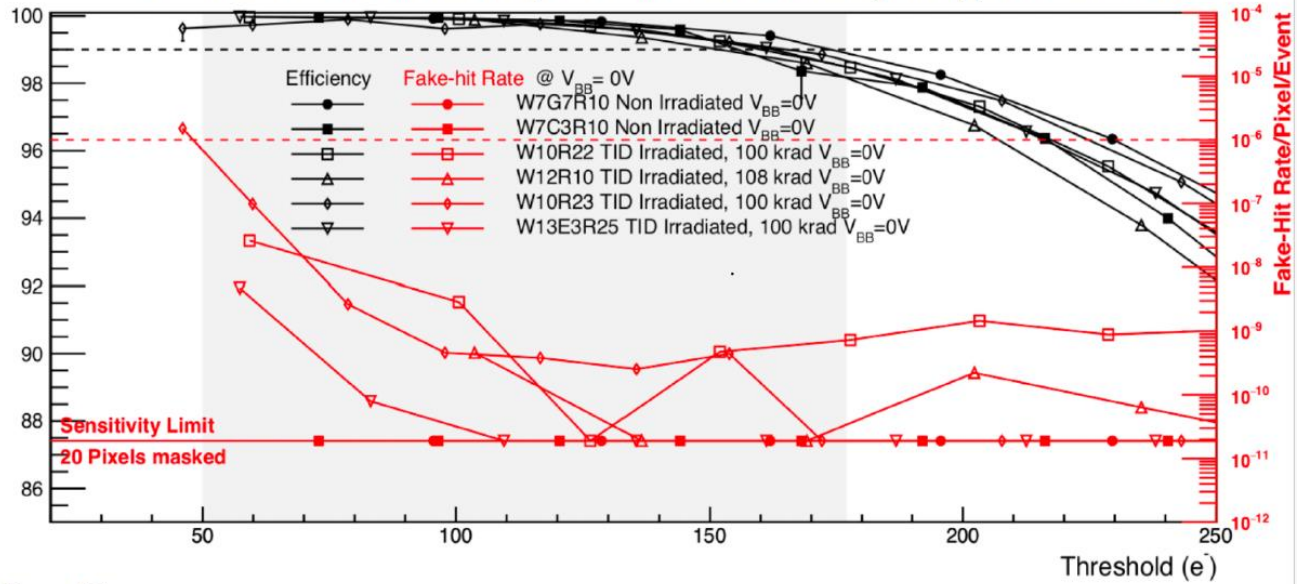
BACKUP SLIDES

Reminder: ALPIDE working point and sensitivity to radiation

Threshold changes during X-ray radiation of ALPIDE chip at V_{BB} = -3 V. Taken from



Measurements of detection efficiency and fake-hit rate (FHR) level as a function of Threshold charge for different ALPIDE prototypes. Taken from



2022 + 2023 preliminary dose estimations for L0: 30 – 40 kRad / 3.8 – 5 to 10^{11} 1 MeV n_{eq}/ cm^2. Taken from

THR behavior during Pb-Pb period corresponds to the R&D observations:

- **R&D**: Initial increase in threshold followed by its decay with increase of absorbed TID
- **P2:** IB shows a decrease of THR (higher dose), OB has slight rise of THR (smaller dose)

Choice of operational margins for THR is driven by **FHR level** (< 10^{-6}/pixel/event) and **detection efficiency** >99%

- Minimal observed THR of 85 e^- on L0 still lies within optimal ranges → no effect on physics data taking
- We target to 100 e^- THR → **detector was re-tuned** at TS1

https://indico.cern.ch/event/1081887/contributions/5129292/attachments/2544752/4382013/20221110_TB_ITS2_freidt.pdf