Status of the ALICE Fast Interaction Trigger for the Run 3

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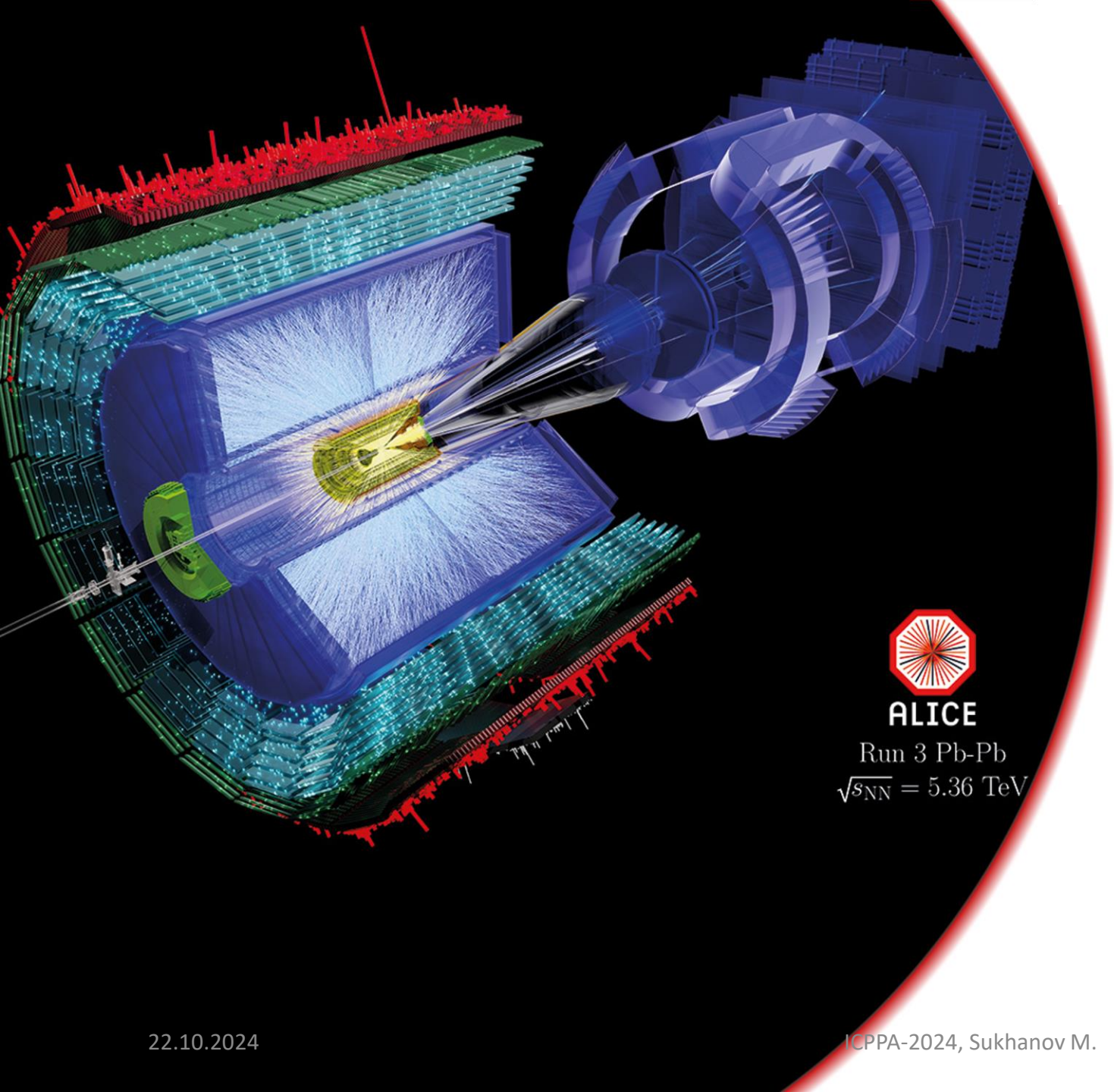
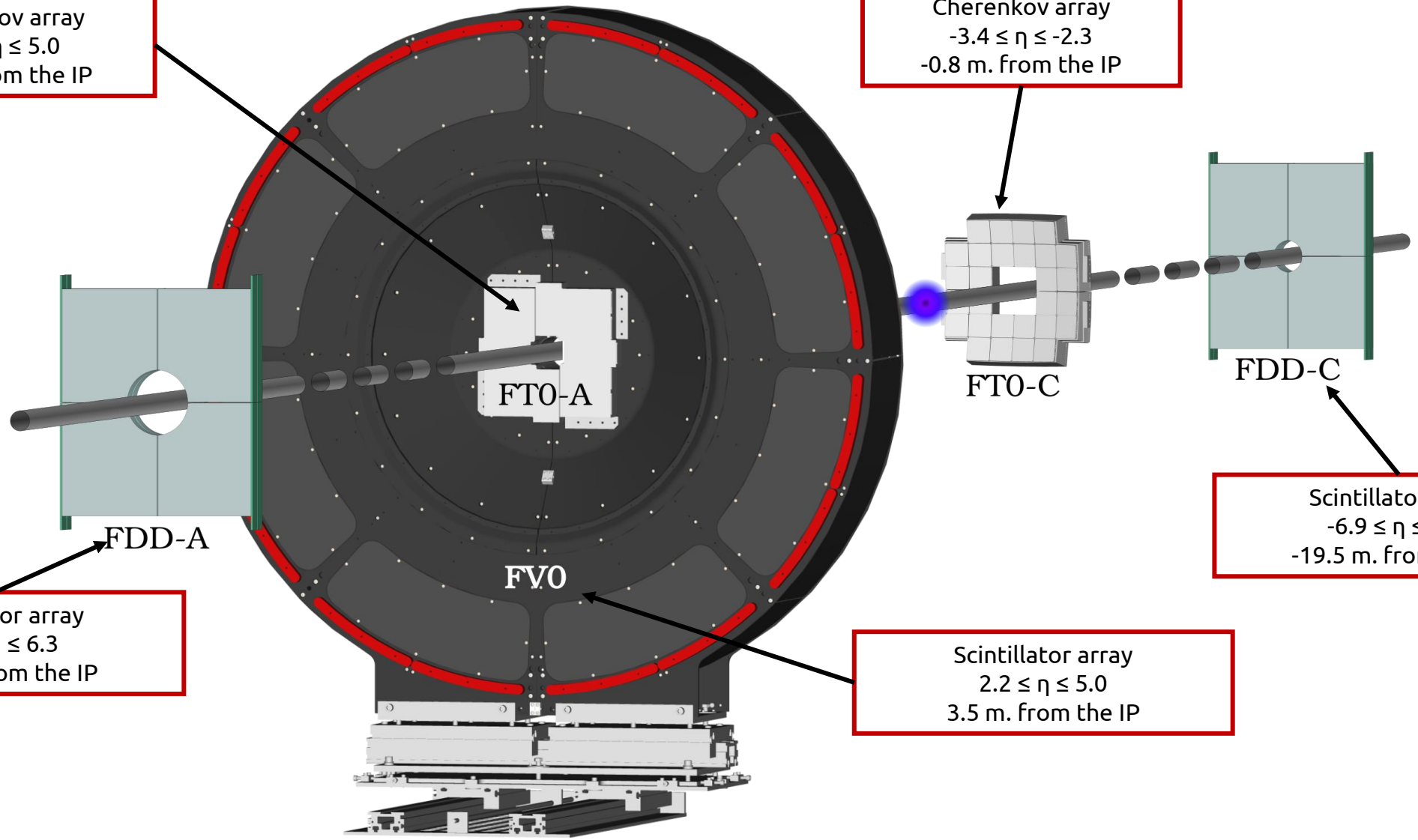
7th International Conference on Particle Physics and Astrophysics
Moscow 22 – 25 Oct 2024



Outline

- **F**ast **I**nteraction **T**rigger system (FIT)
  - FT0
  - FV0
  - FDD
- Front End Electronics (FEE)
- Detector Control System
- Luminosity and Background online monitoring
- Laser calibration system
- Run 3 experience
- FIT performance

Hybrid Forward detector Fast Interaction Trigger



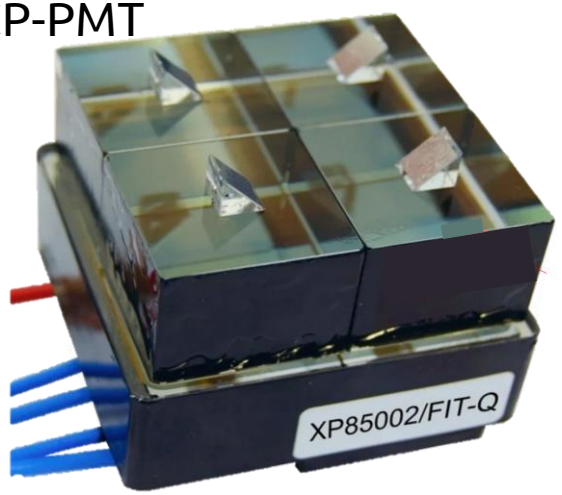
FT0

Purposes

- Collision time determination (used for TOF PID)
- Centrality and event plane determination
- Vertex and multiplicity trigger production
- Luminosity and background events online monitoring and feedback to LHC
- Ultra-peripheral collisions veto, used for diffractive physics

Construction

- One FT0 module is assembled with:
  - Modified MCP-PMT Planacon XP85012/FIT-Q
  - 4 quadrants quartz radiators optically coupled with MCP-PMT photocathodes
  - Quartz prisms for laser calibration system
- FT0-A
  - 24 modules – 96 analog channels
  - Flat surface
- FT0-C
  - 28 modules – 112 analog channels
  - Curved surface
- Time resolution of the signal for one channel ~13 ps



FV0

Purposes

- Centrality determination with corresponding trigger production
- Event plane determination

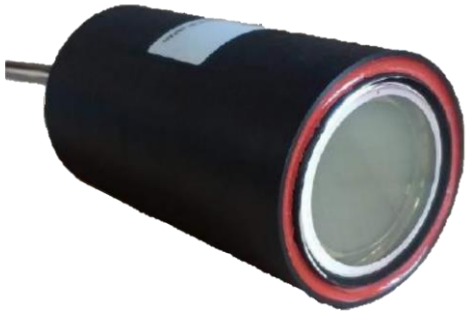
Construction

- 5 concentric EJ-204 scintillator rings 4 cm width
  - 4 inner rings are separated to 8 sectors
  - Outer one to 16 sectors
- Fine mesh PMT H6614-70-Y001 around for light collection
- Direct signal acquisition without light shift
- 48 analog channels
- Time resolution ~250 ps

FDD

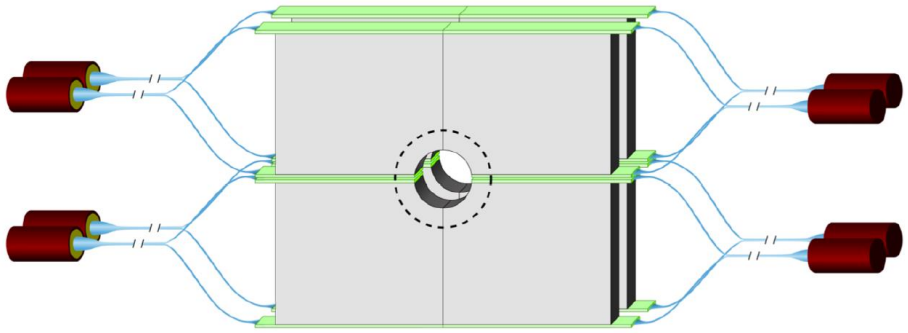
Purposes

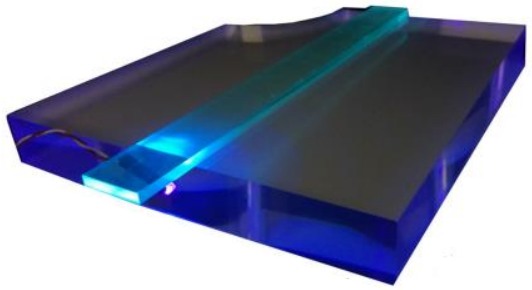
- Studying diffractive physics
- Luminosity monitoring and measurement

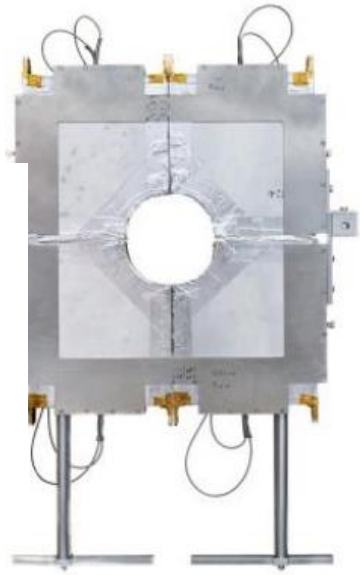


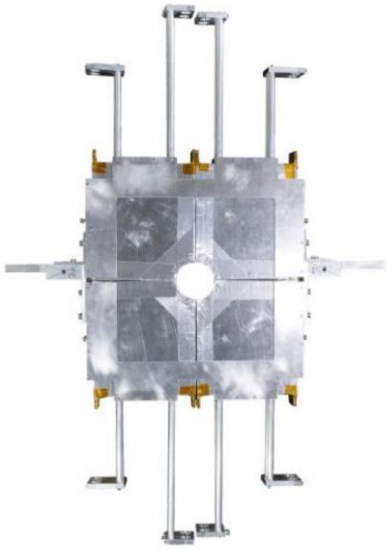
Construction

- 8 BC-420 scintillators on each side
  - One plane contains 4 scintillators
  - Two planes for each side
  - Signal acquisition with fine mesh PMTs H8409-70 with WLS plastic bars and optical fibers
- 16 analog channels

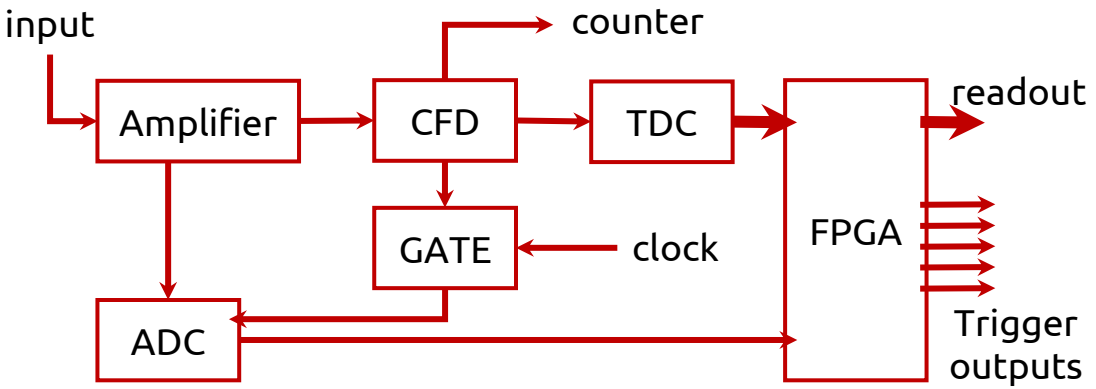








Front-End Electronics

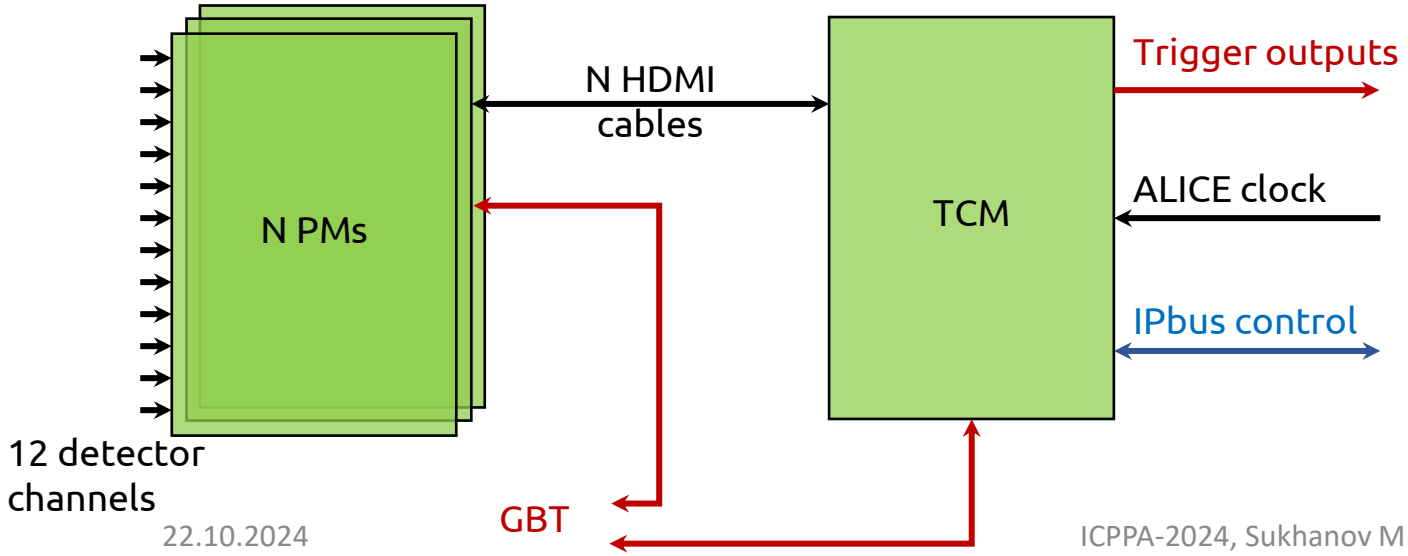


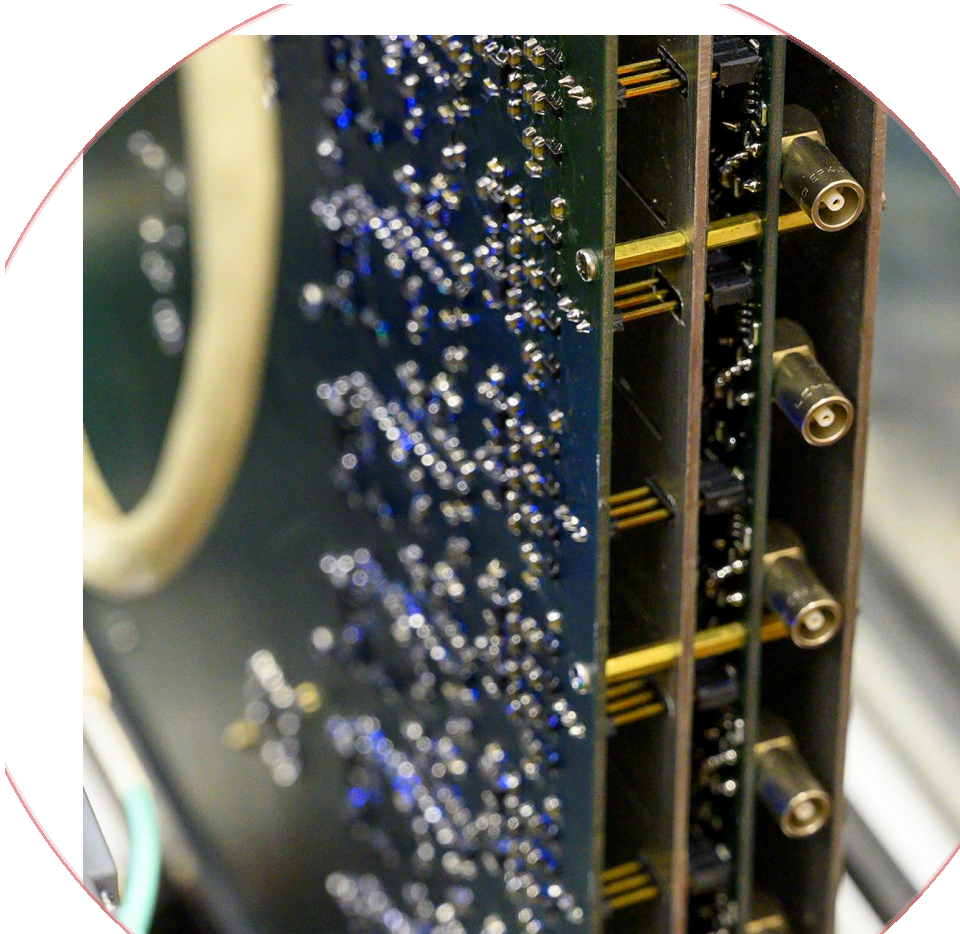
All FIT detectors have the same FEE modules

- Processing modules (PM)
- Trigger Clock and Control module **TCM**

- The number of PMs is determined by the number of analog channels (12 channel per PM)
- One TCM per detector – Trigger solution based on **digital signal**

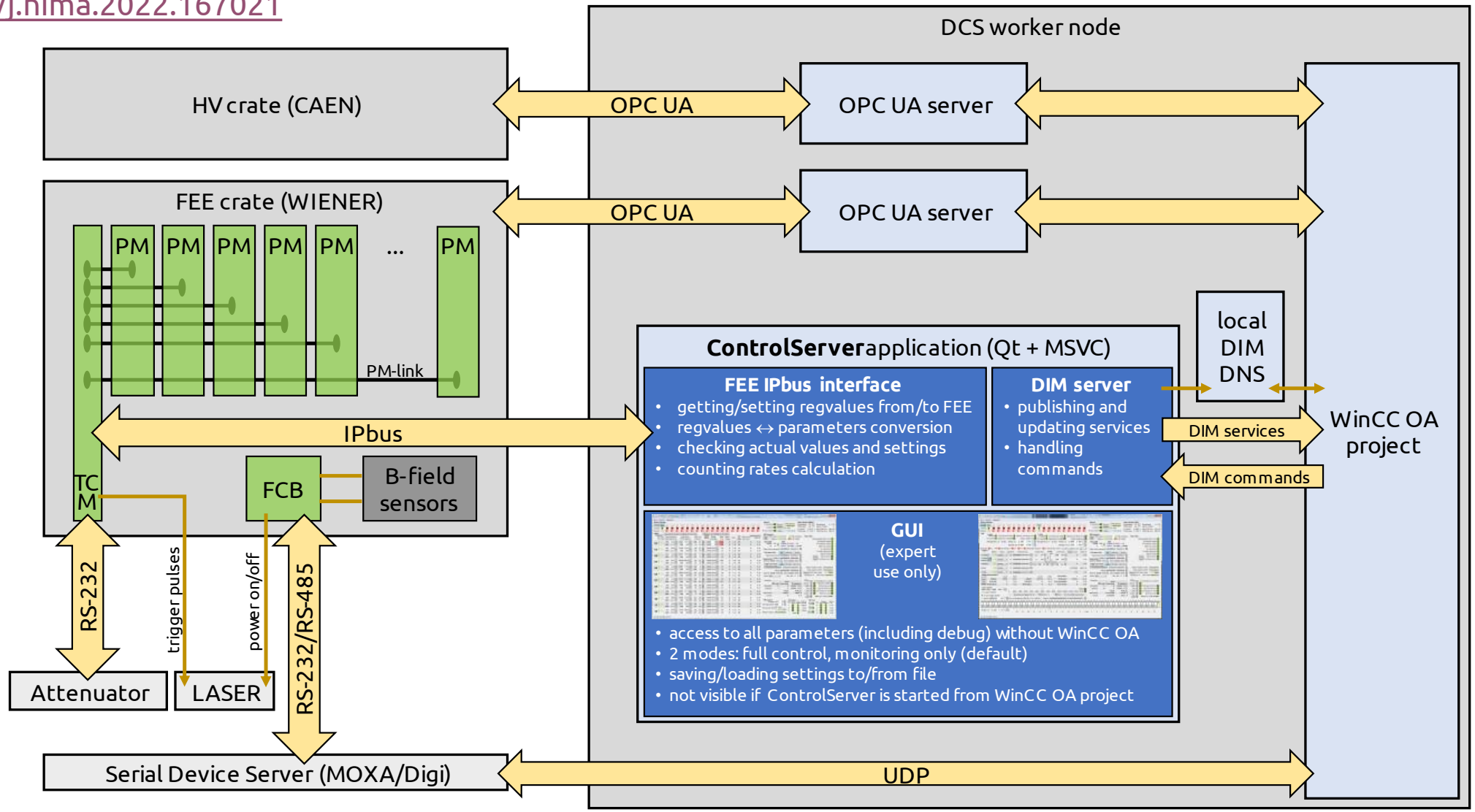
FEE structure:





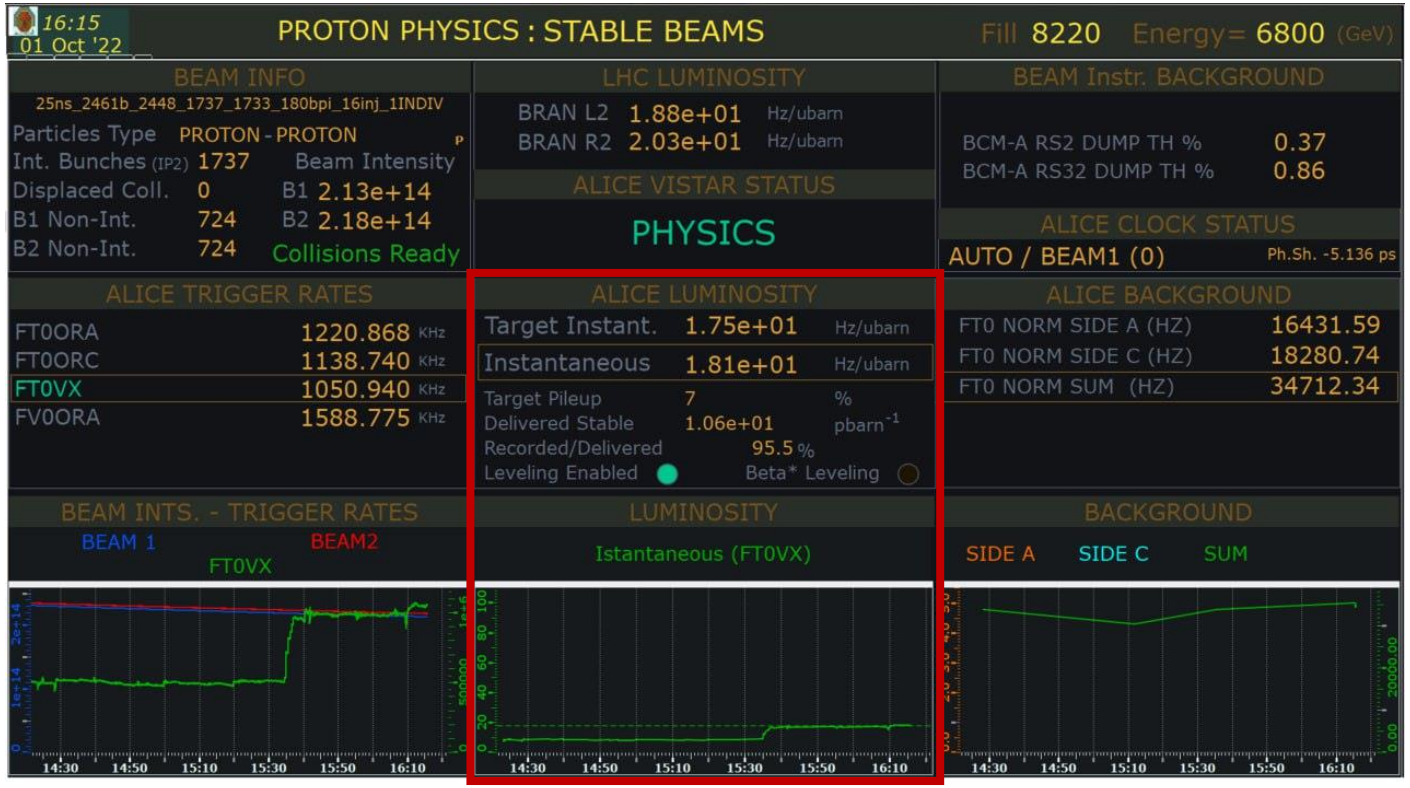
FIT Detector Control System

10.1016/j.nima.2022.167021



Instantaneous luminosity estimation

FT0 is the primary online luminometer of the ALICE during pp runs due to high time resolution and vertex insensitivity to background events



- **σ_{vis} auto adjustment depending on $\sqrt{s}$ or $\sqrt{s_{NN}}$ and FT0 full or peripheral mode**

Sources of luminosity:

- Vertex trigger for pp runs
- Vertex & (Central | Semi-Central) – Minimum bias trigger @Pb-Pb (optionally)

Online estimation:

$$L = -\frac{N_r N_b \ln\left(1 - \frac{R}{N_r N_b}\right)}{\sigma_{vis}}$$

R – source trigger rate

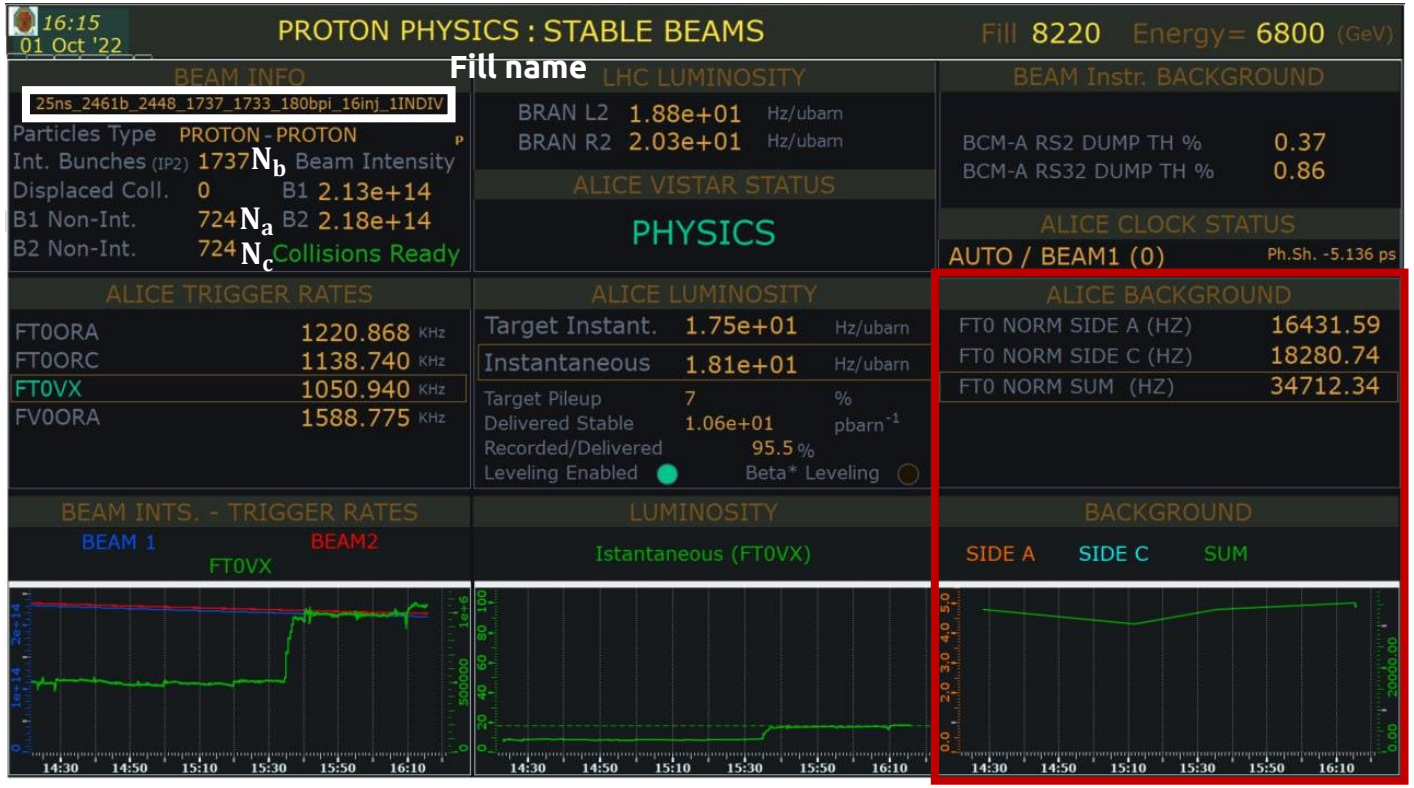
$\sigma_{vis} = a \cdot \eta \cdot \sigma$ — visible cross section including acceptance and efficiency.

N_r – number of LHC orbit revolutions per sec (11223 for pp @ $\sqrt{s} = 13.6$ TeV)

N_b – number of colliding bunches

Background events rate estimation

For the first time the orbit fill map is used by forward detector to trigger background events



Background events rate determination algorithm:

1. The numbers of buckets with injected bunches are transmitted to DCS
2. DCS calculate orbit fill map and send it to FEE through IPbus Control Server
3. Control Server calculates the rates of background counters and publishes ones by DIM for DCS

4. DCS algorithms normalize background rate and publish them for LHC interface:

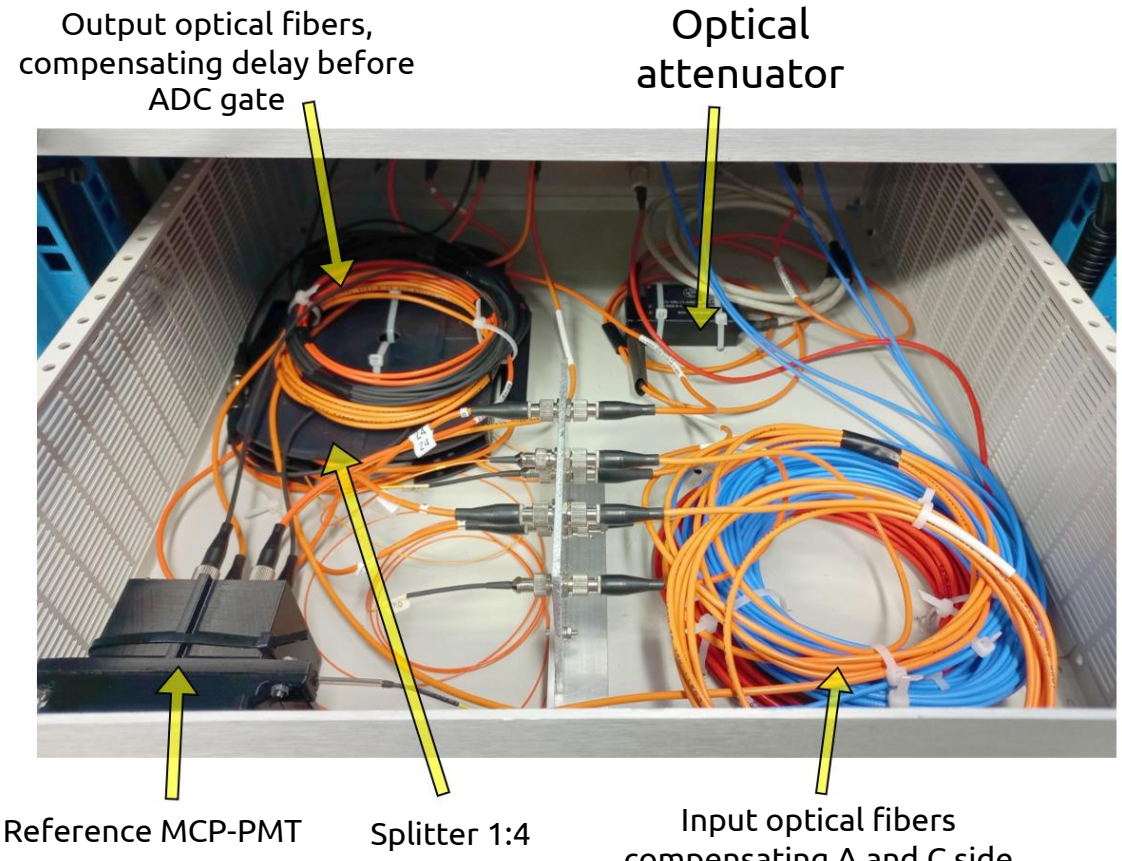
$$R_{bg} = R_{bg}^{a} \frac{(N_a+N_b)}{N_a} + R_{bg}^{c} \frac{(N_c+N_b)}{N_c}$$

$R_{bg}^{a(c)}$ –background rate from side A(C) given by Control Server
$N_{a(c)}$ – the number of single (non-colliding) bunches from A(C) side
N_b – the number of colliding bunches

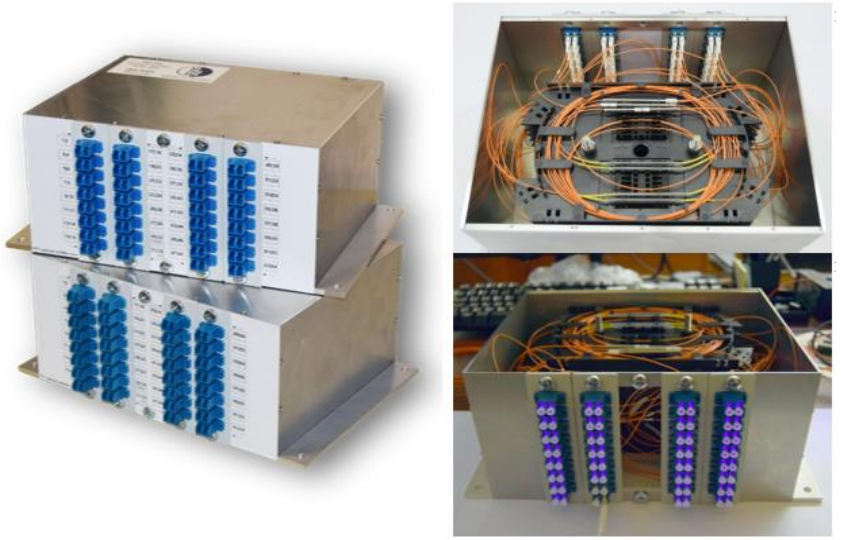
Laser calibration system

Purposes:

- Amplitude and time detector parameters adjustment
- Ageing control for PMT photocathodes and optical fibers
- Dead channels map measurement



Reference MCP-PMT



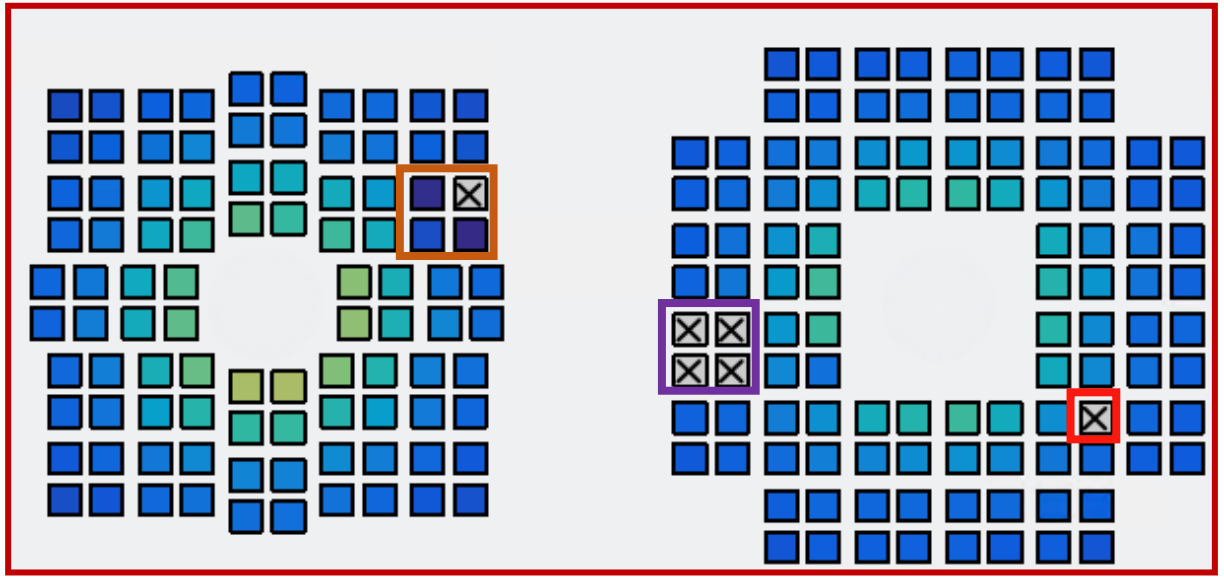
optical splitters

Run 3 experience

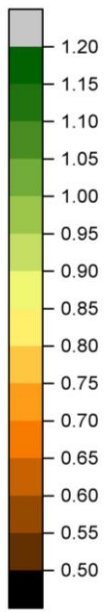
Since the beginning of Run 3 (July 2022):

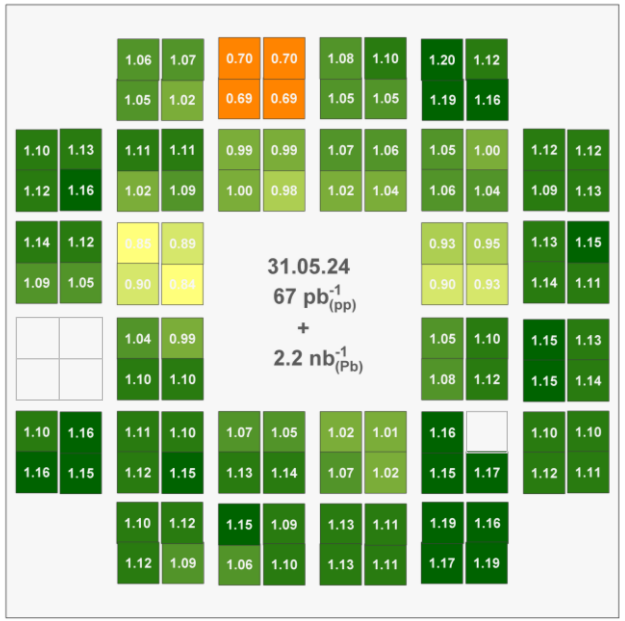
- Six channel of the FT0 were lost:
  - Vacuum microleak of the FTA-E2 MCP-PMT. 1 channel off since March 2024. Other channels experience significant rate drop.
  - FTC-A4 MCP-PMT HV breakdown. Could not be recovered since 2023.
  - Channel lost connection.
- Broken MCPs will be replaced after Run3

- Ageing:
  - Significant ageing for the innermost quadrants.
  - Up to 50% loss in gain and photocathode QE after collecting 1 C/cm^2.
  - Compensated by HV increase and “self-annealing” during YETSs.

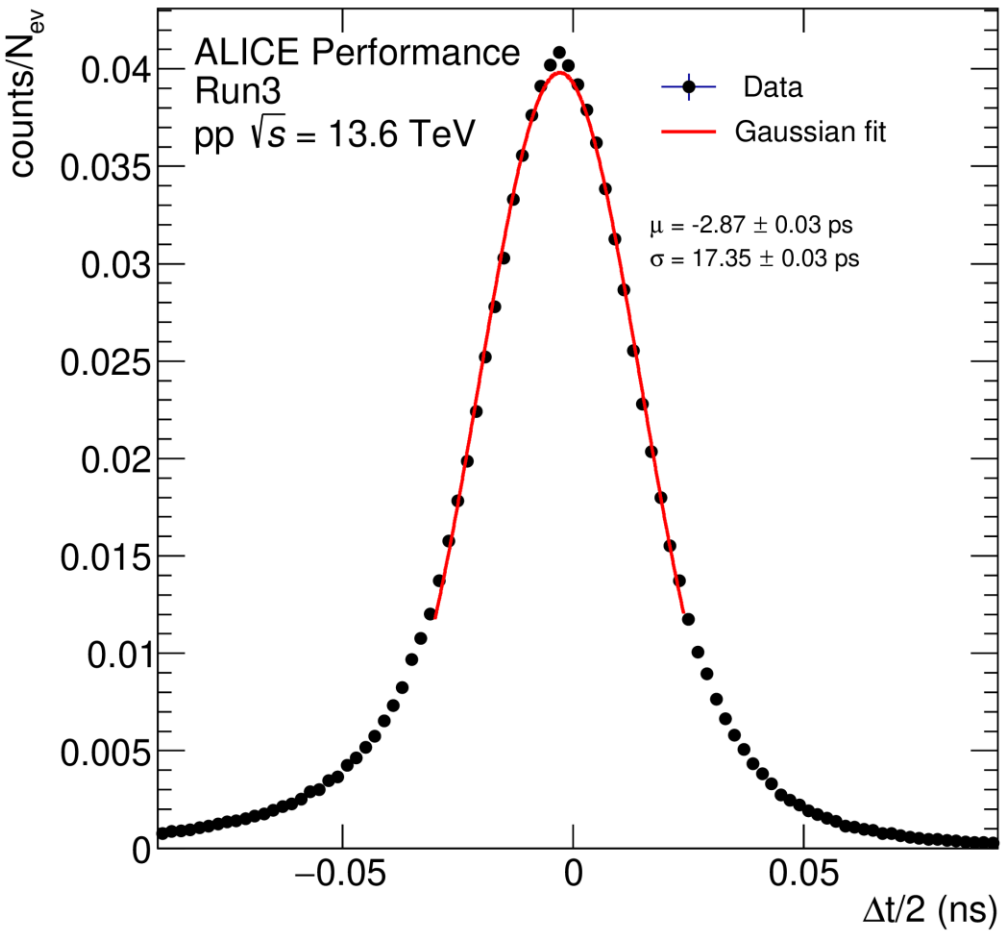


MCP-PMT response (June 2024 /start of RUN3)





FT0 time resolution for pp и Pb-Pb collisions



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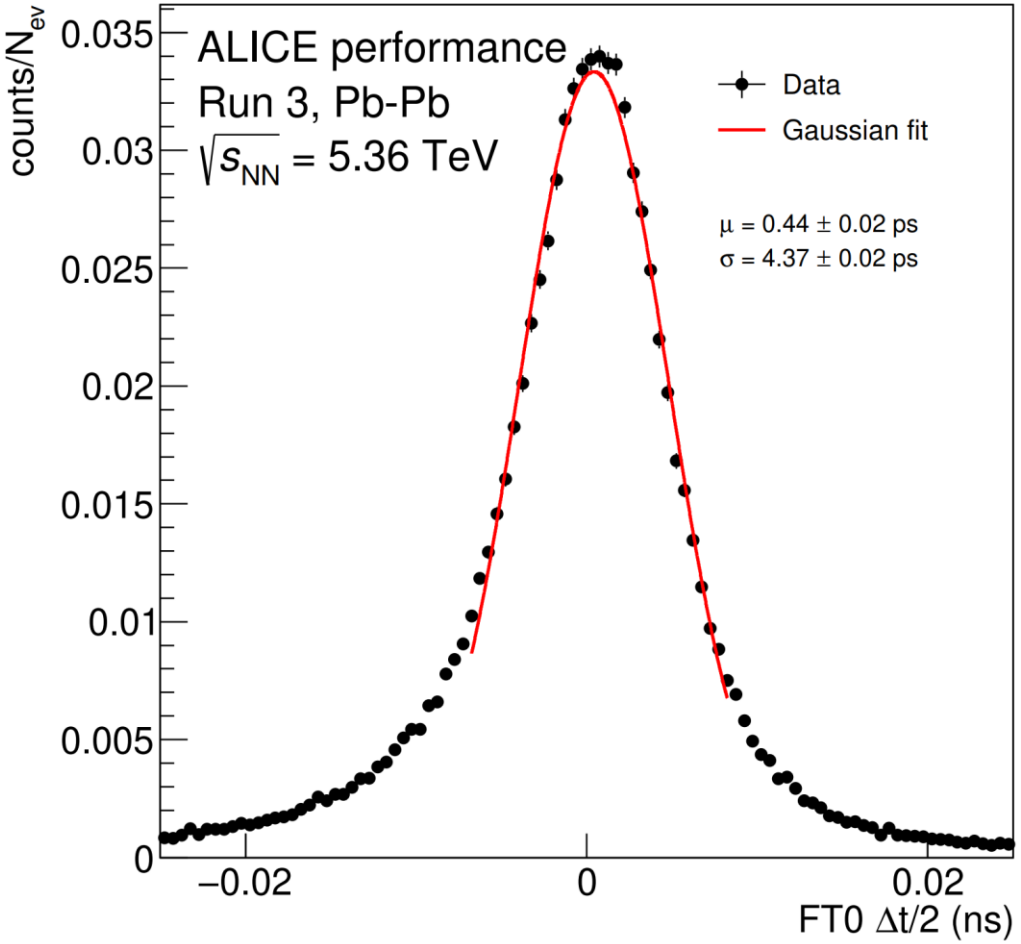

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Conclusion

- FIT provides collision time, multiplicity, centrality and event plane data, used for analysis
- FT0 shows outstanding collision time resolution (~17 ps. for pp and ~4 ps. for Pb-Pb)
- The FIT triggers are produced every BC event (25 ns) and could be propagated to other ALICE detectors
- Due to high resolution and other properties – FT0 is the primary luminometer during pp collisions for the LHC
- FIT will operate till the end of RUN 4 (at least until 2032)

Fast Interaction Trigger

ENG RU

Thank you for your attention!

Backup slides

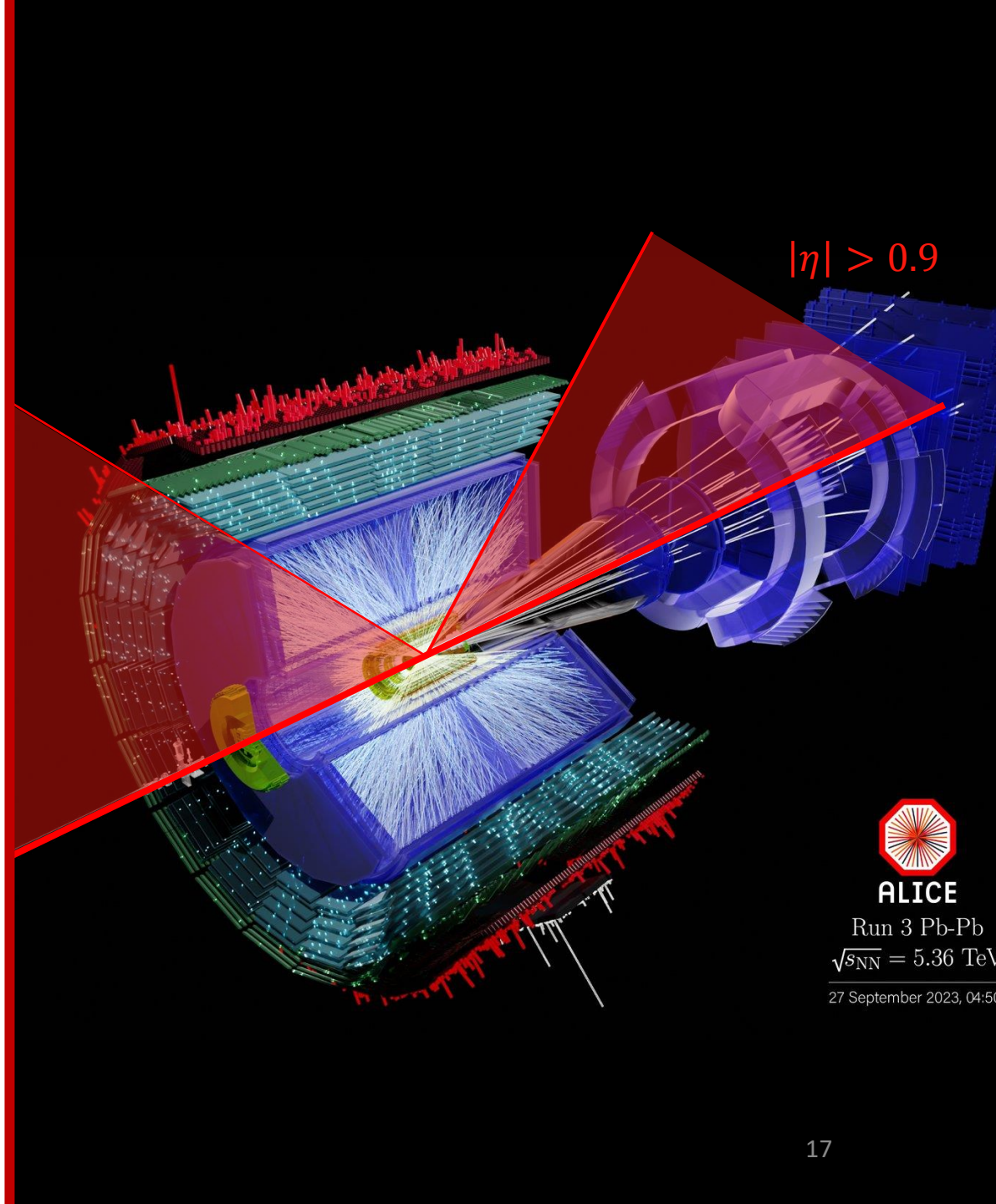
ALICE experiment

- **A L**arge **I**on **C**ollider **E**xperiment (**ALICE**) primary purpose is QGP properties research, induced by collision of ultra relativistic nucleus at LHC.

- ALICE at 2023 And 2024:
  - pp collisions up to 1MHz at $\sqrt{s} = 13.6$ TeV.
  - Pb-Pb collisions up to 50 KHz at $\sqrt{s_{NN}} = 5.36$ TeV.
  - Reference pp collision at $\sqrt{s} = 5.36$ TeV.

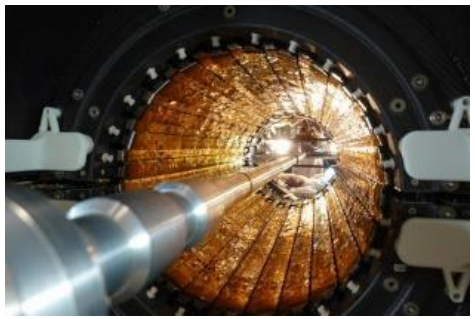
- Fast Interaction Trigger – one of the essential LS2 upgrades.

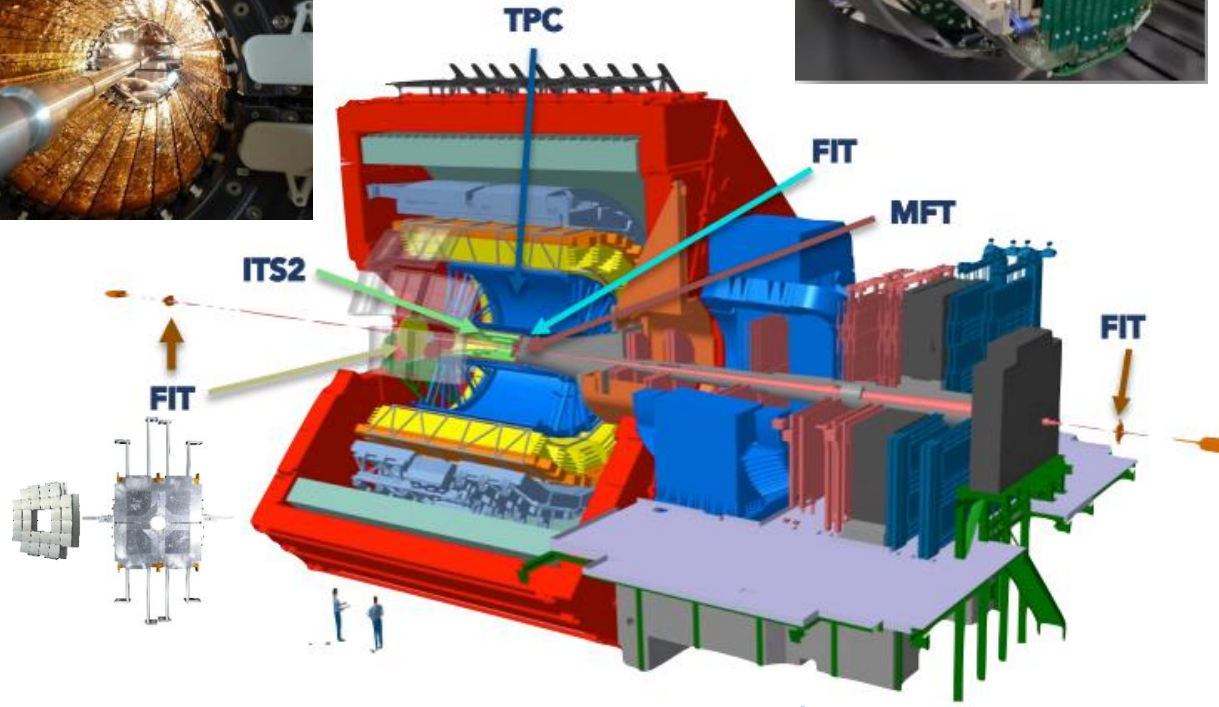
- FIT is a hybrid of three forward detectors (FD).



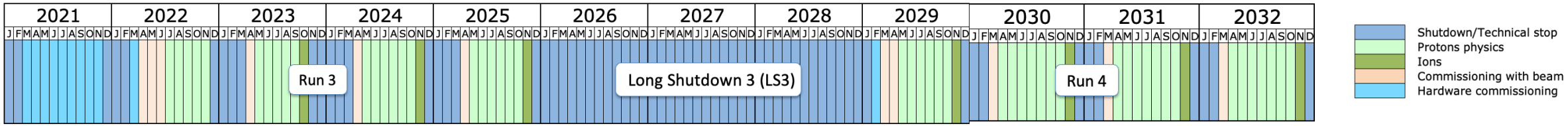
ALICE upgrade during LS2

- MFT – muon forward tracker
- ITS – new Inner tracking system
- New central trigger system
- New TPC readout with GEMs
- Online & offline framework for data acquisition and analysis - O^2
- Hybrid FD system Fast interaction Trigger





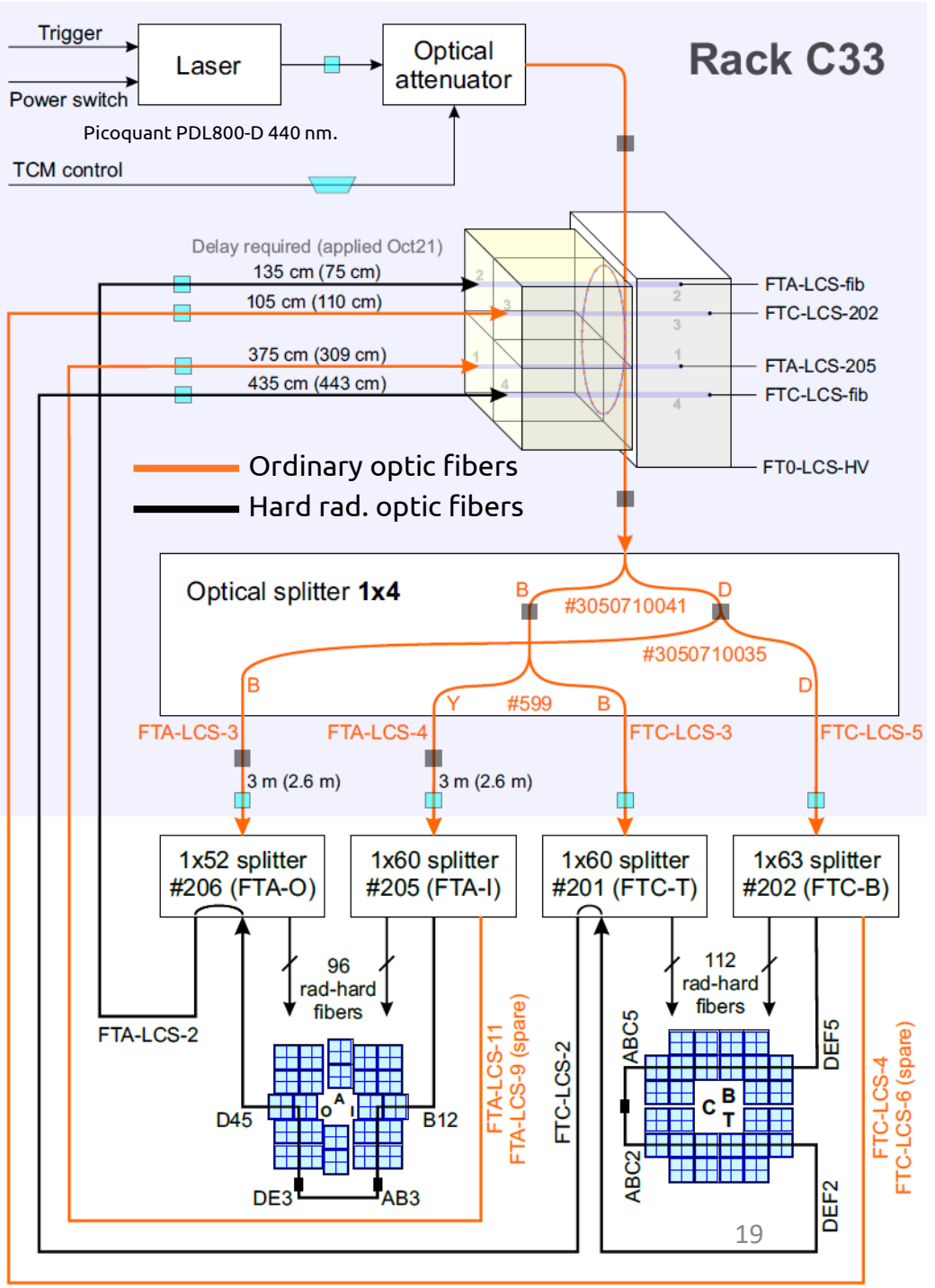
10.1016/j.nima.2019.04.070



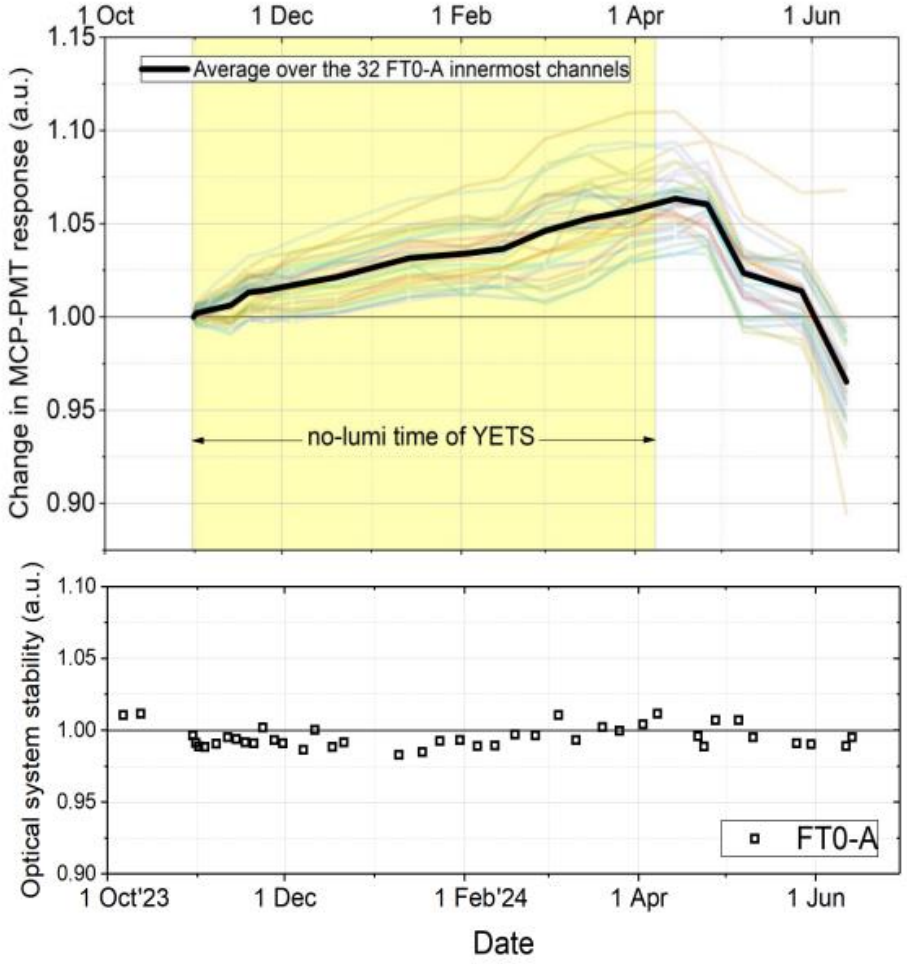
Laser calibration system (FT0)

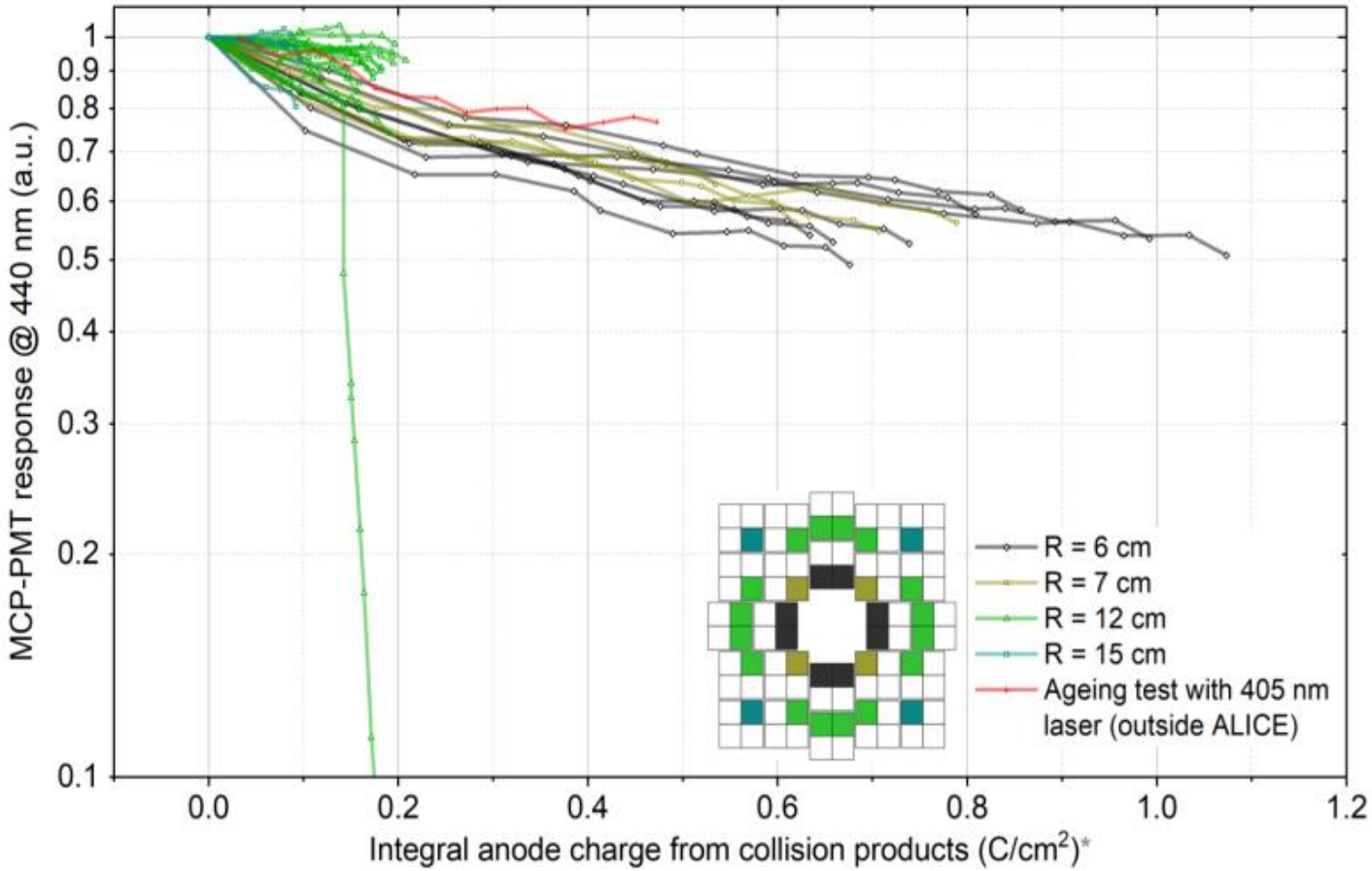
Construction:

- Picosecond laser flash split to the quadrants of reference FT0 module
- The signal reaches the quadrants by four ways
  - Two fibers through sides of detectors inside ALICE barrel
  - Other ones outside the barrel
- The time delay is compensated by the fiber length
- PMT photocathode ageing is determined as detector and ref. module amplitude ratio
- The fiber ageing is determined as ration of the amplitudes from fiber pairs.

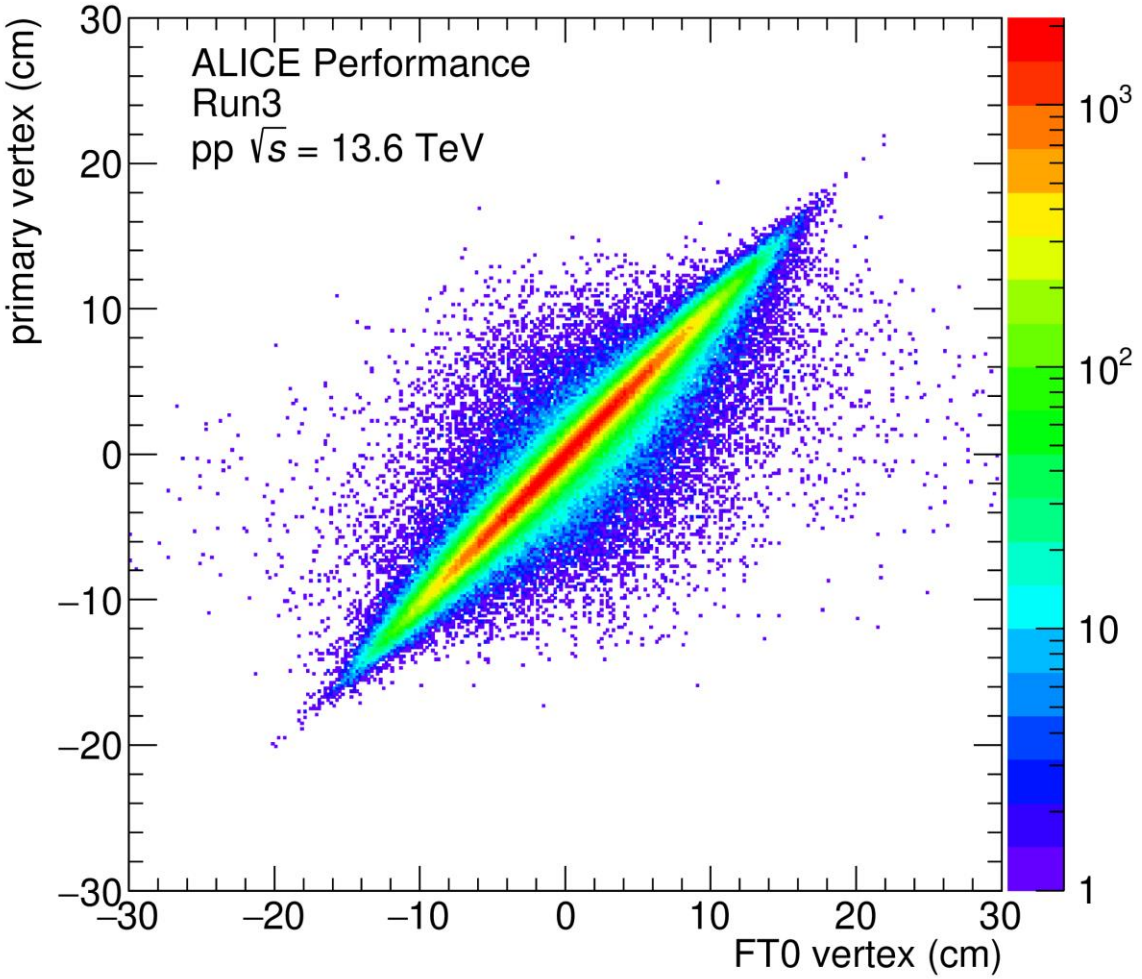


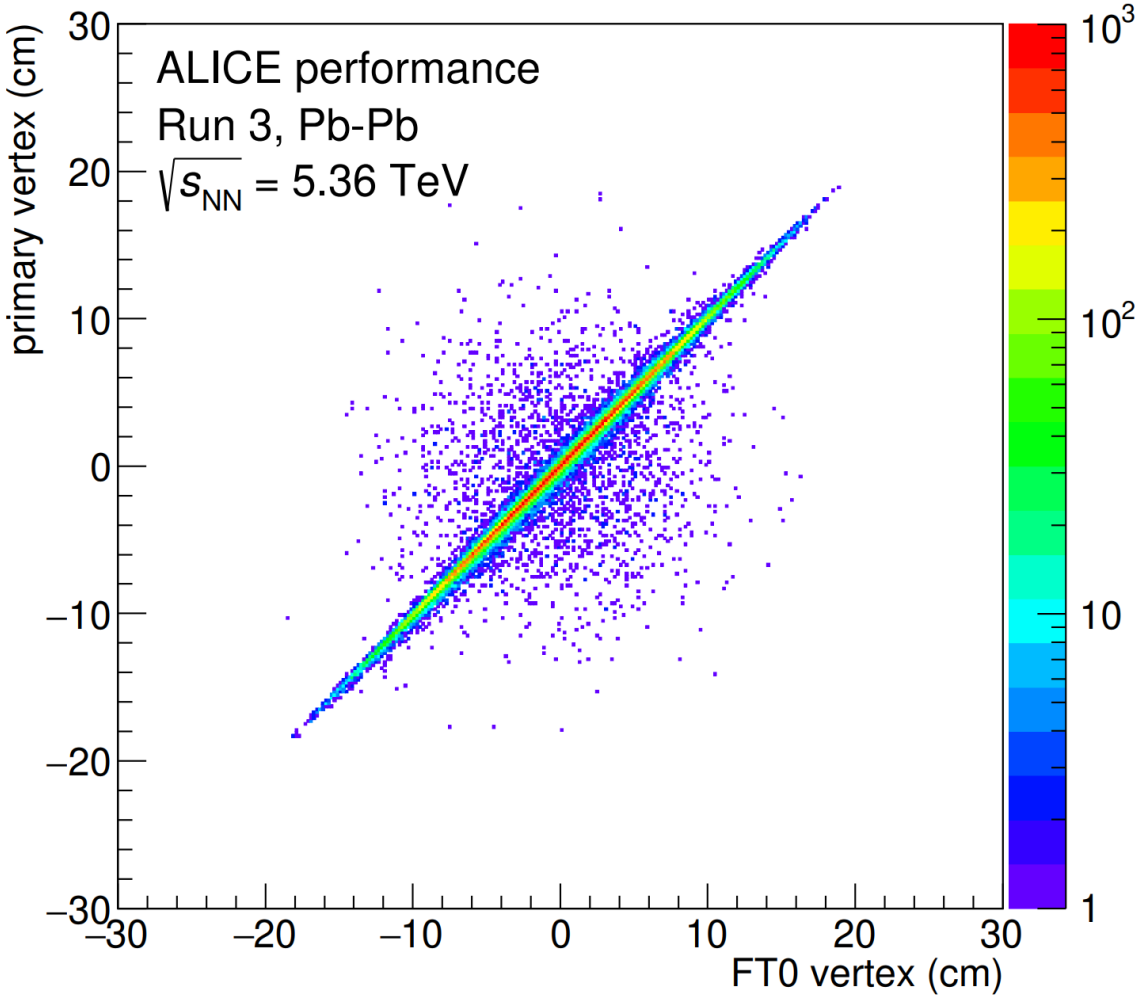
FT0 MCP-PMTs photocathode ageing and “self-annealing”



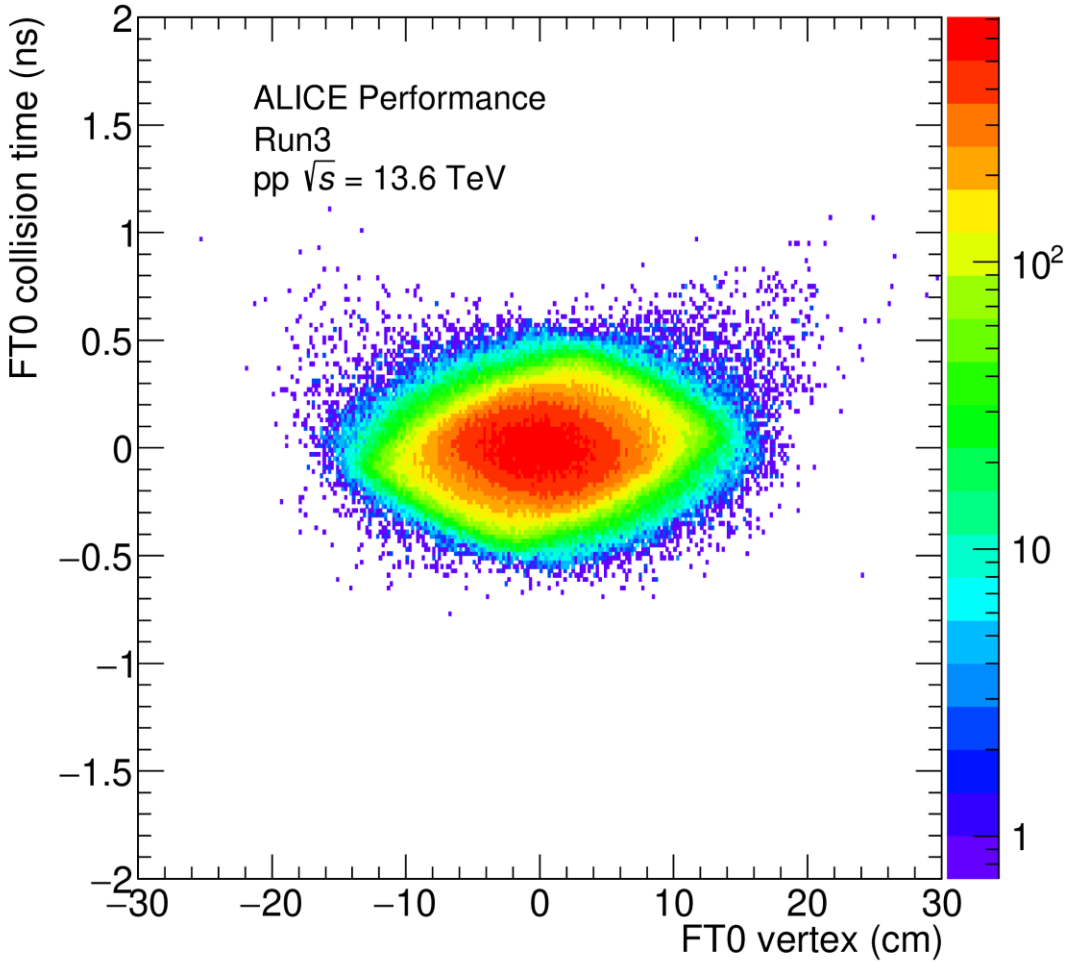


FT0 vertex vs Trackers PV correlation





FT0 vertex vs FT0 collision time



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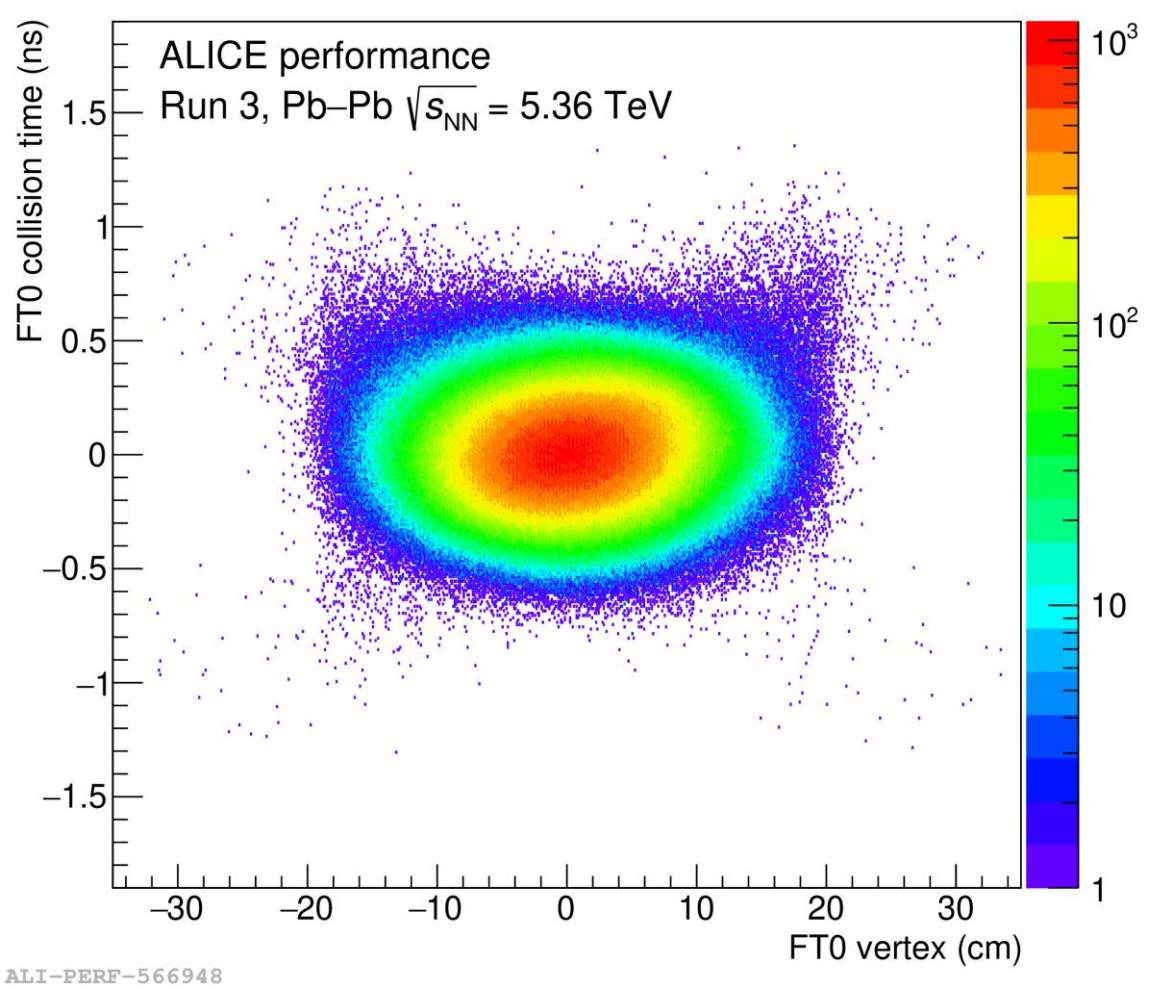

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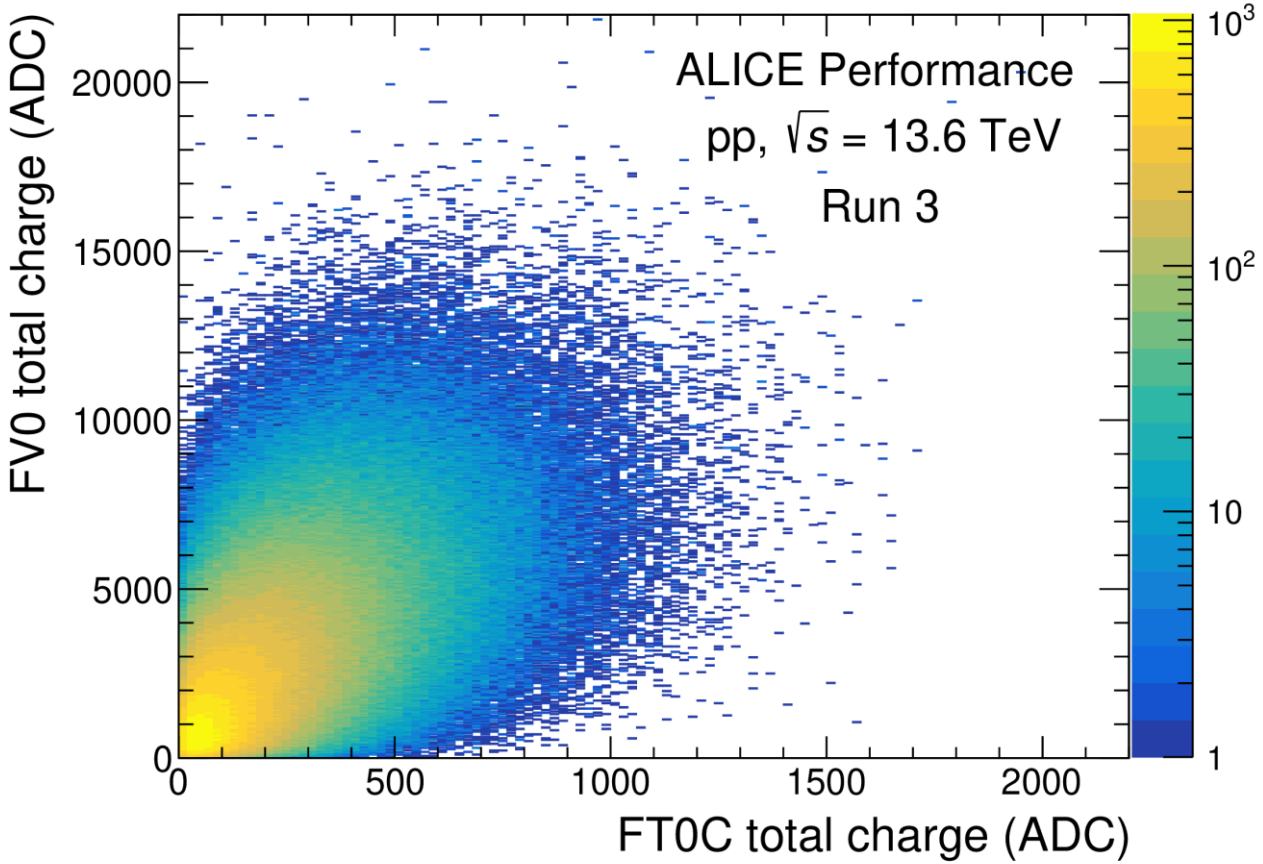
Corellation sum amplitude FV0 and FT0C



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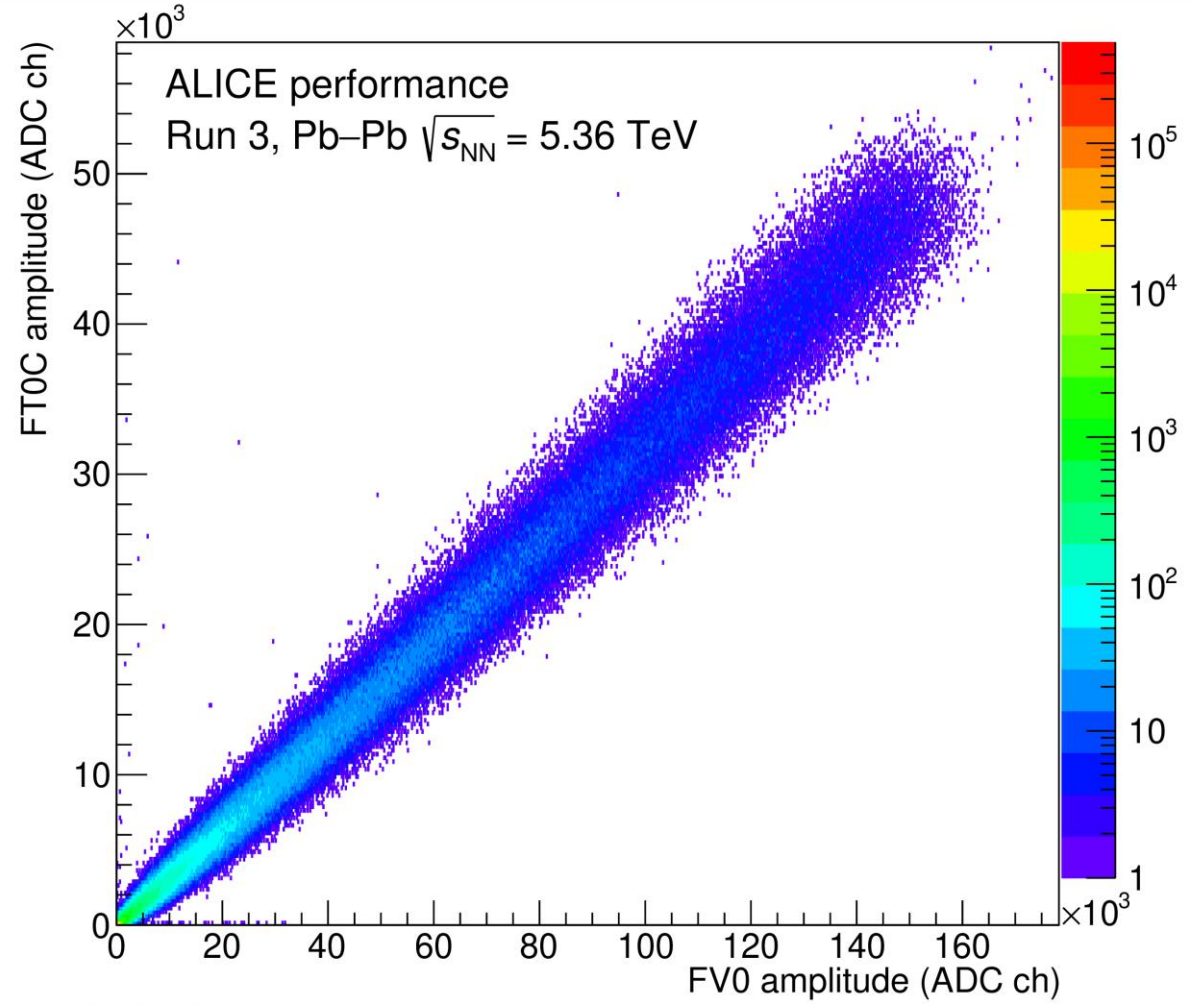

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