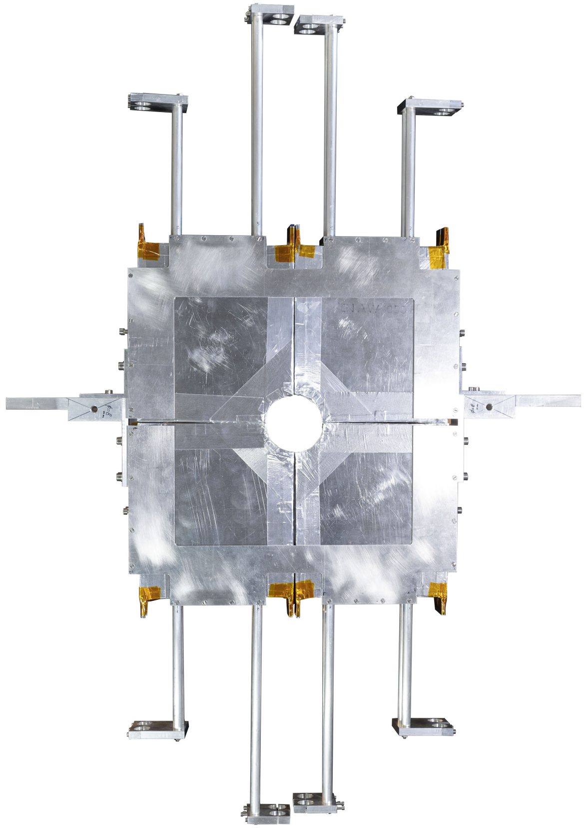
Desempeño del detector FDD en el experimento ALICE



Dr. Solangel Rojas Torres*

*Czech Technical University in Prague
Faculty of Nuclear Science and Physical Engineering

31.July.2024

solangel.rojas.torres@cern.ch

Introduction

The **Forward Diffractive Detector** (FDD) is the **upgrade** of **ALICE Diffractive (AD)** detector to fulfill the **new requirements** of the LHC conditions and fit in the new ALICE environment.

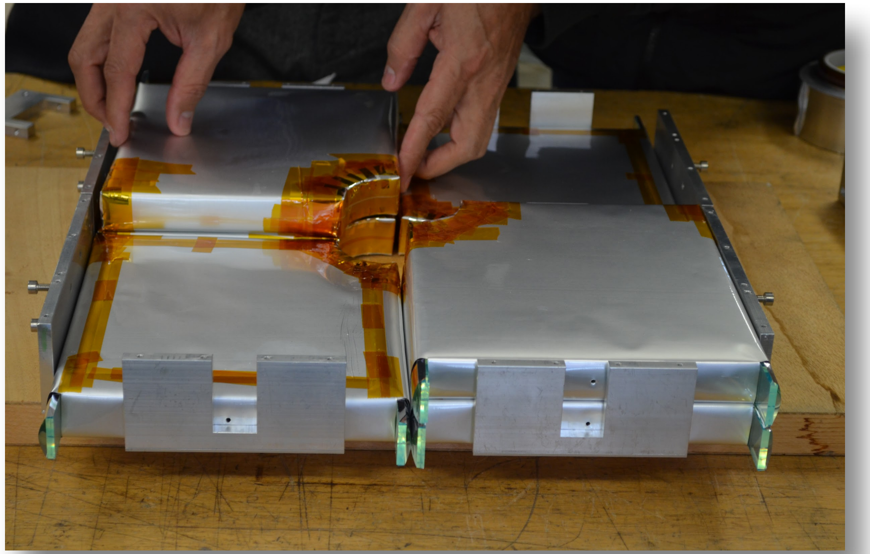
FDD keep the **same geometry** and **placement** of its predecessor but with **improvements in materials** used for its construction and is part of **Fast Interaction Trigger** system.

The FDD detector consists of two stations covering the pseudorapidity ranges of $\mathbf{4.7<\eta<6.3}$ and $\mathbf{-6.9<\eta<-4.9}$. This coverage allows to tag **diffractive** and **ultra-peripheral** events.

Precedent

Precedent - ALICE Diffractive detector

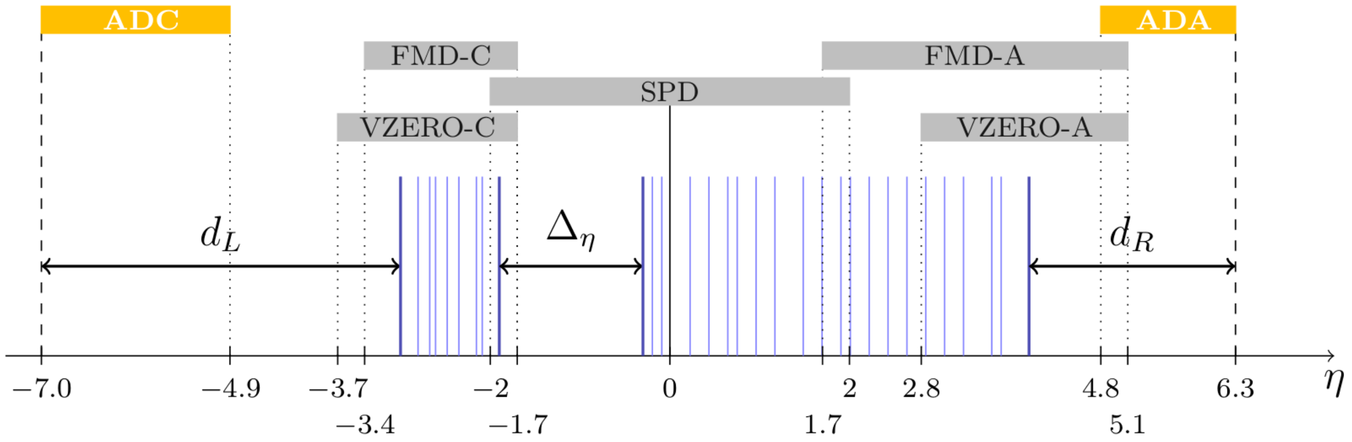
- Designed to **increase the forward coverage** to tag diffractive events produced in non frontal collision.
- It was designed, constructed and installed during **2014**.
- Consisted in two stations placed a both sides of the interaction point.



Pseudorapidity coverage of ALICE detectors in run 2

~19 meters from IP

~17 meters from IP

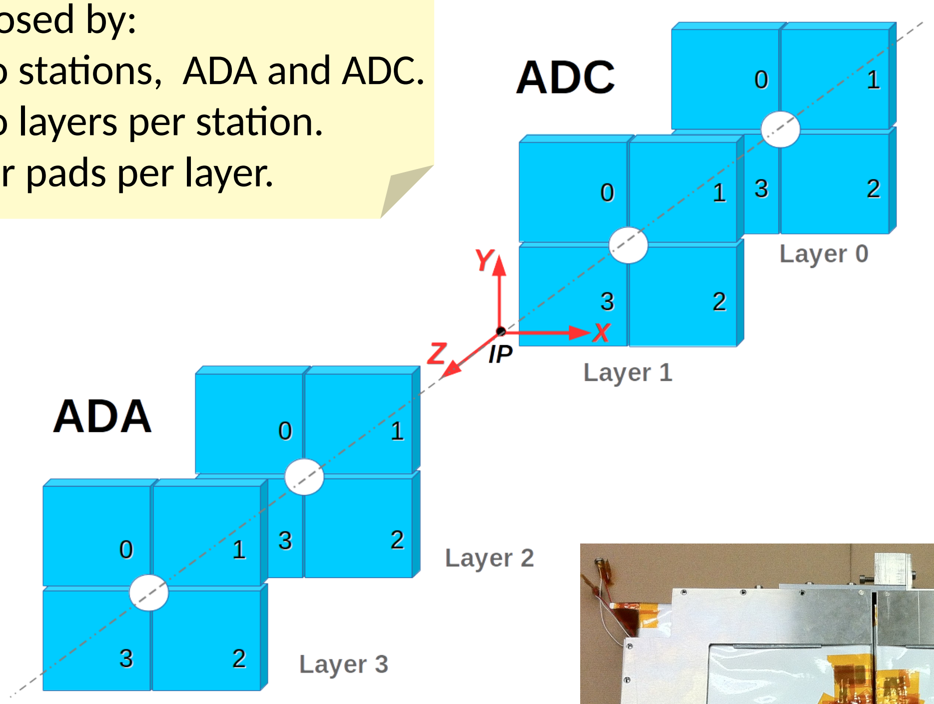


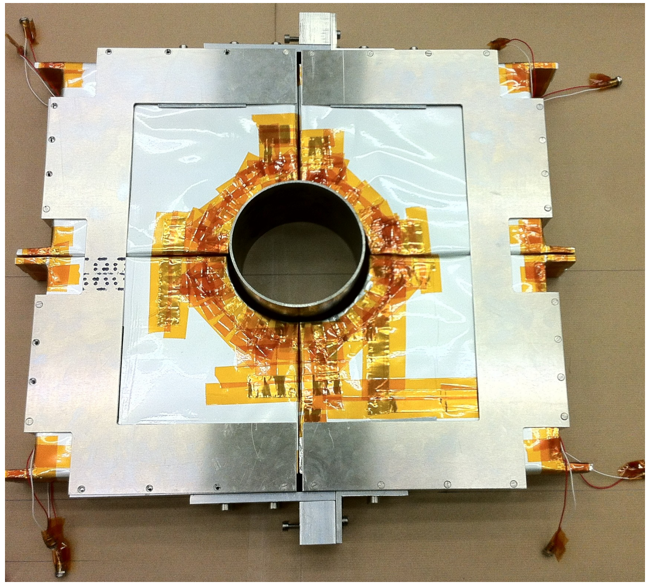
http://dx.doi.org/10.1088/1748-0221/16/01/P01017

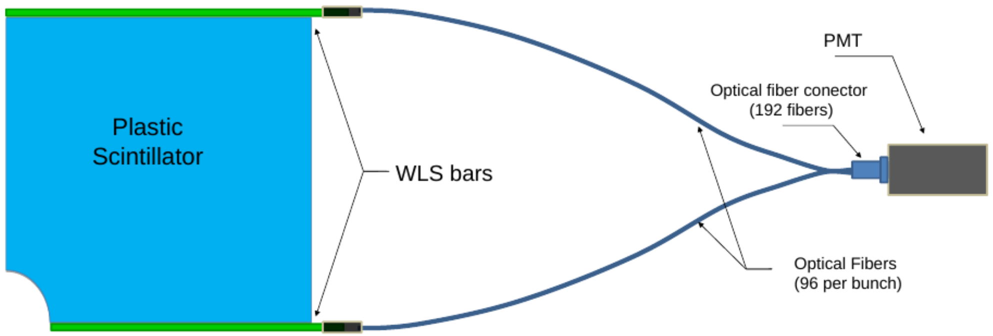
AD construction

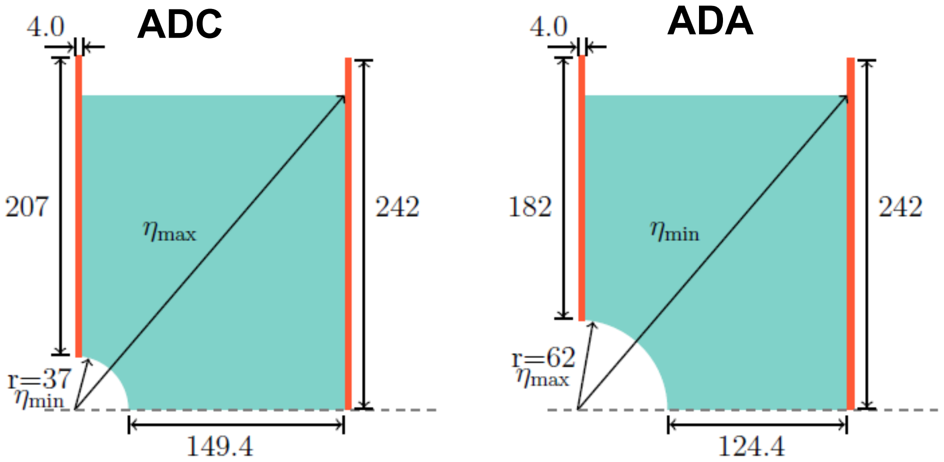
Composed by:
- Two stations, ADA and ADC.
- Two layers per station.
- Four pads per layer.

Materials:
- Plastic scintillator: ***BC-404***
- WLS bars: *ELJEN* (***EJ-280***)
- Optical fibers: *Kuraray* (***PSM-Clear***)
- PMTs: ***Hamamatsu R5946*** *(16 dinodes)*







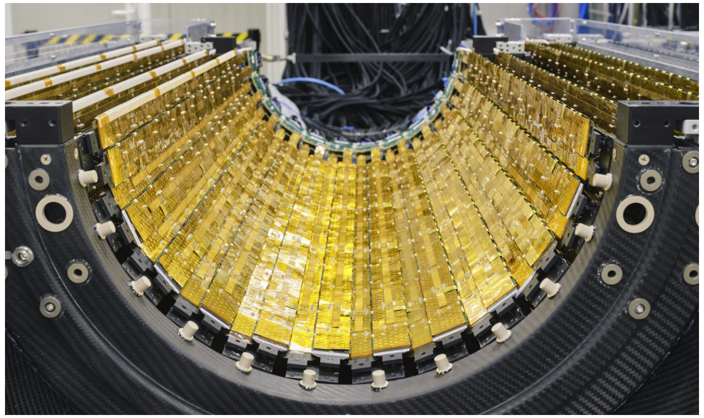


FDD in context

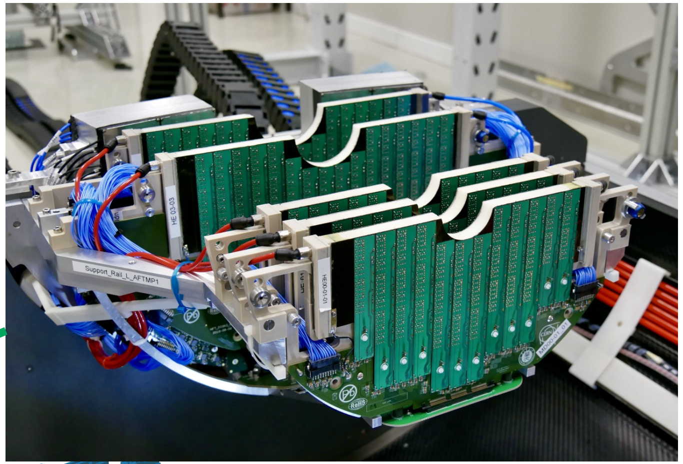
ALICE upgrades for Run-3

- Major upgrade of the **Time Projection Chamber (TPC)** detector.
- **New Online-Offline (O²) computing infrastructure**.
- Implementation of **continuous readout**

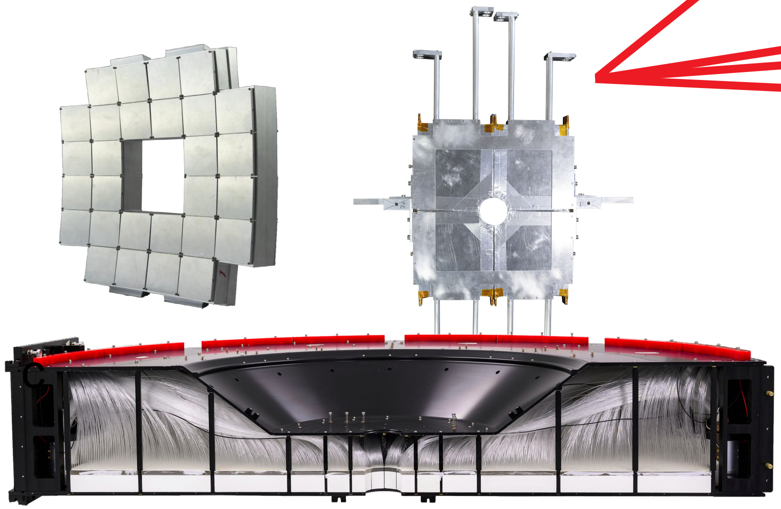
Inner Tracking System (ITS)

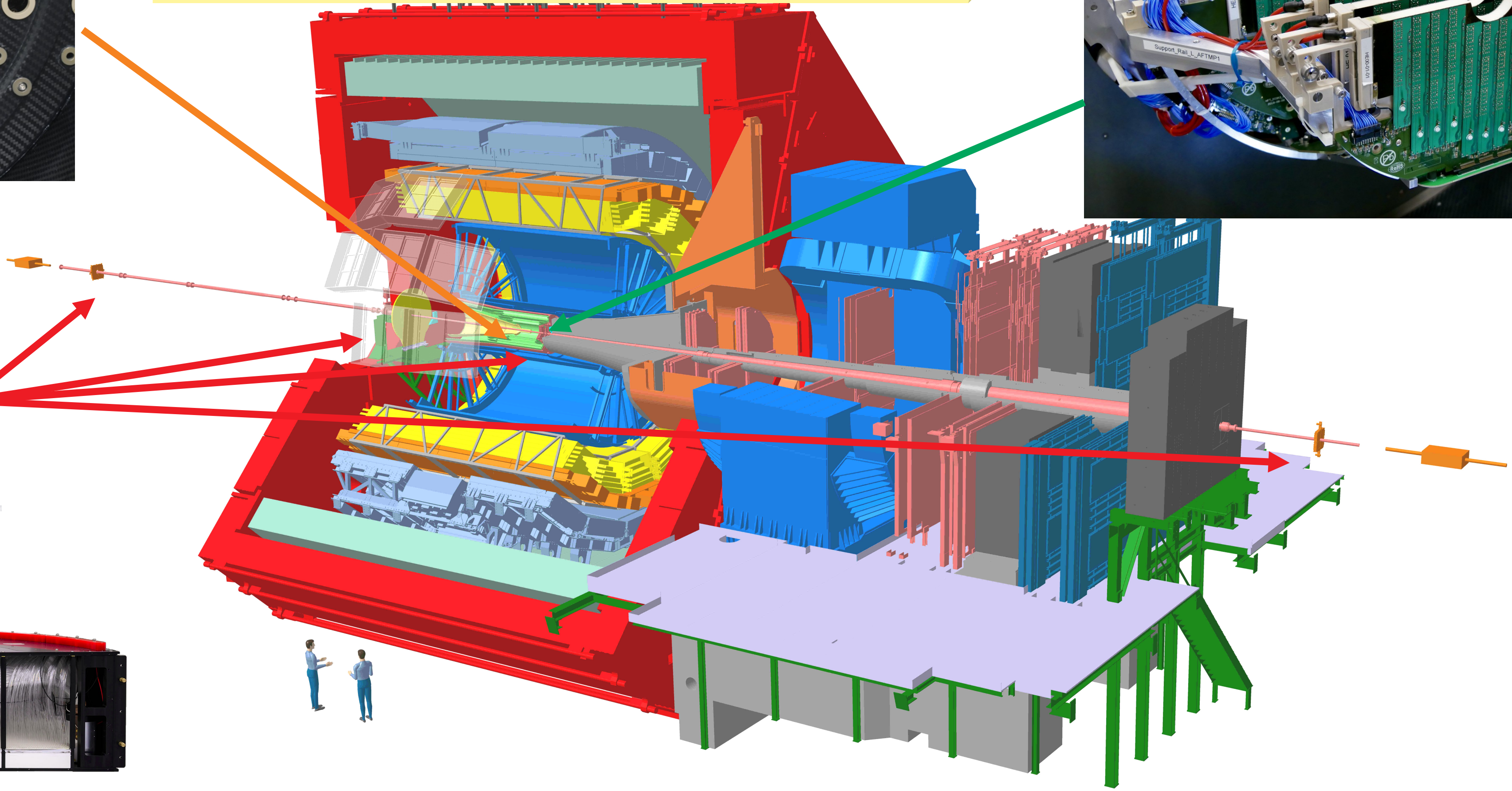


Muon Forward Tracker (MFT)



Fast Interaction Trigger (FIT)





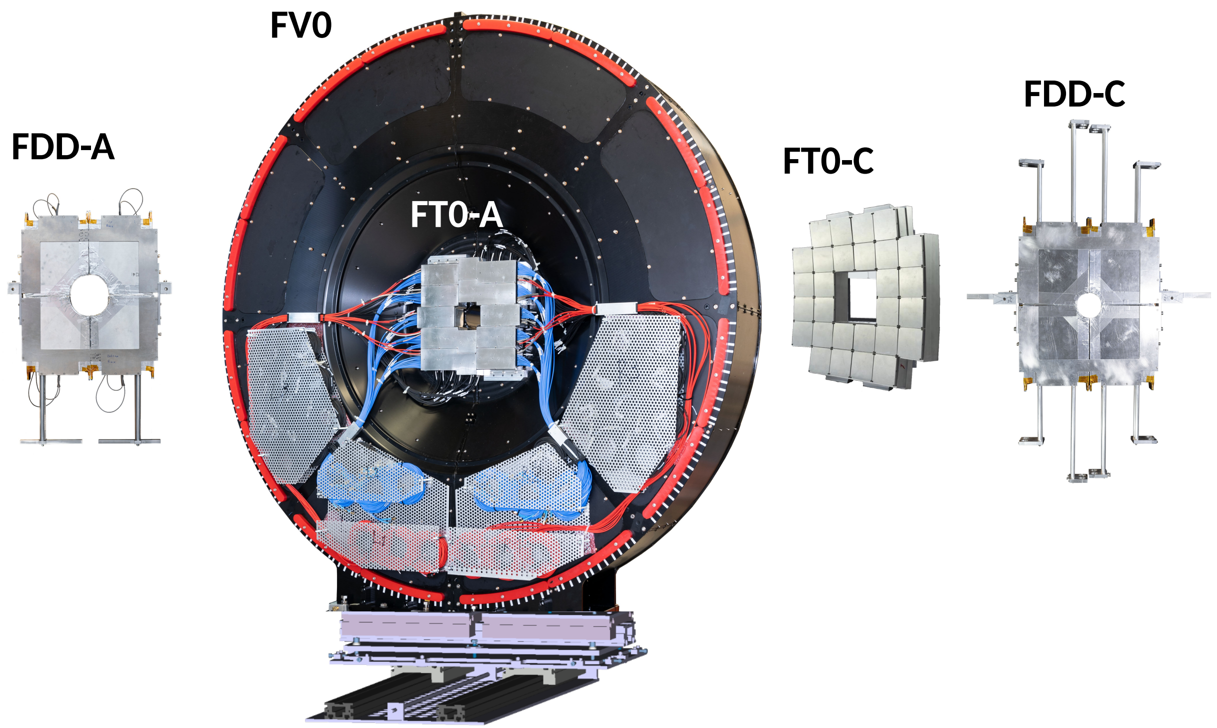
Fast Interaction Trigger

The FIT detector consists of three subsystems:

FV0, FT0 and **FDD**

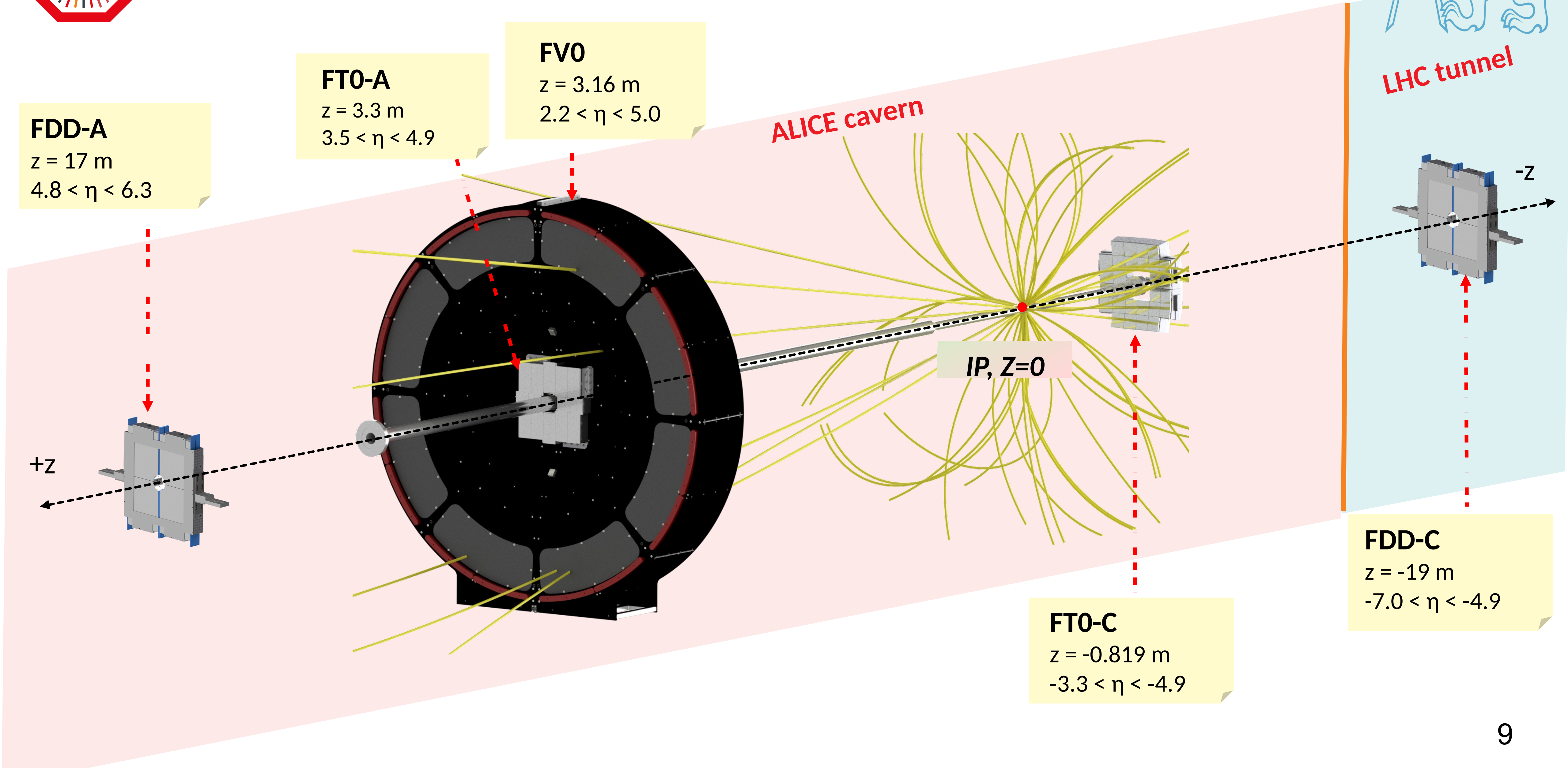
FIT will deliver:

- **Minimum latency** interaction trigger (**<425 ns**)
- **Luminosity**
- **Vertex position**
- Forward multiplicity
- Precise **collision time** for TOF-based particle ID
- **Centrality** and **reaction plane** for flow measurement
- Tags for **diffractive** and **ultra-peripheral** collisions



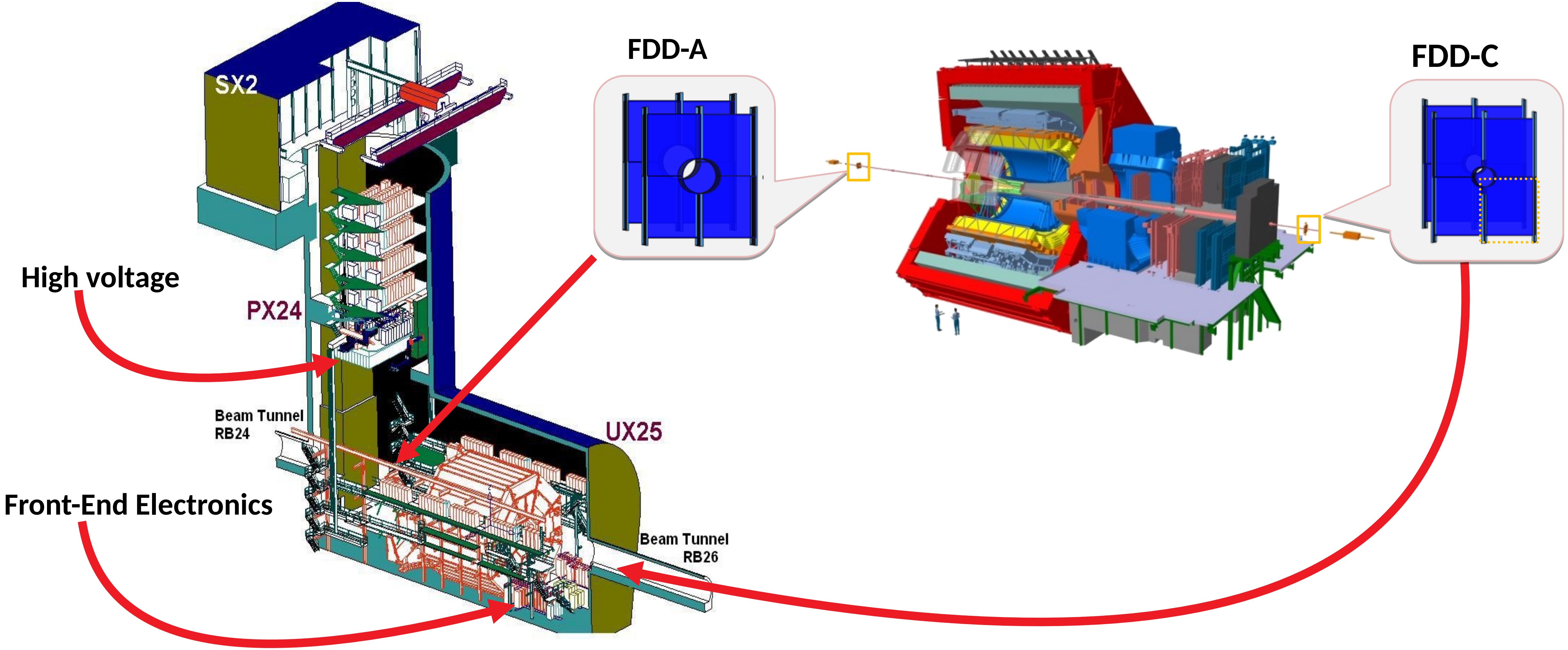
All sub-detectors have a **laser calibration system** and common **Front-End Electronics** and **Detector Control System**.

FIT layout



FDD-A
z = 17 m
4.8 < η < 6.3
FT0-A
z = 3.3 m
3.5 < η < 4.9
FV0
z = 3.16 m
2.2 < η < 5.0
ALICE cavern
LHC tunnel
-z
+z
IP, Z=0
FT0-C
z = -0.819 m
-3.3 < η < -4.9
FDD-C
z = -19 m
-7.0 < η < -4.9

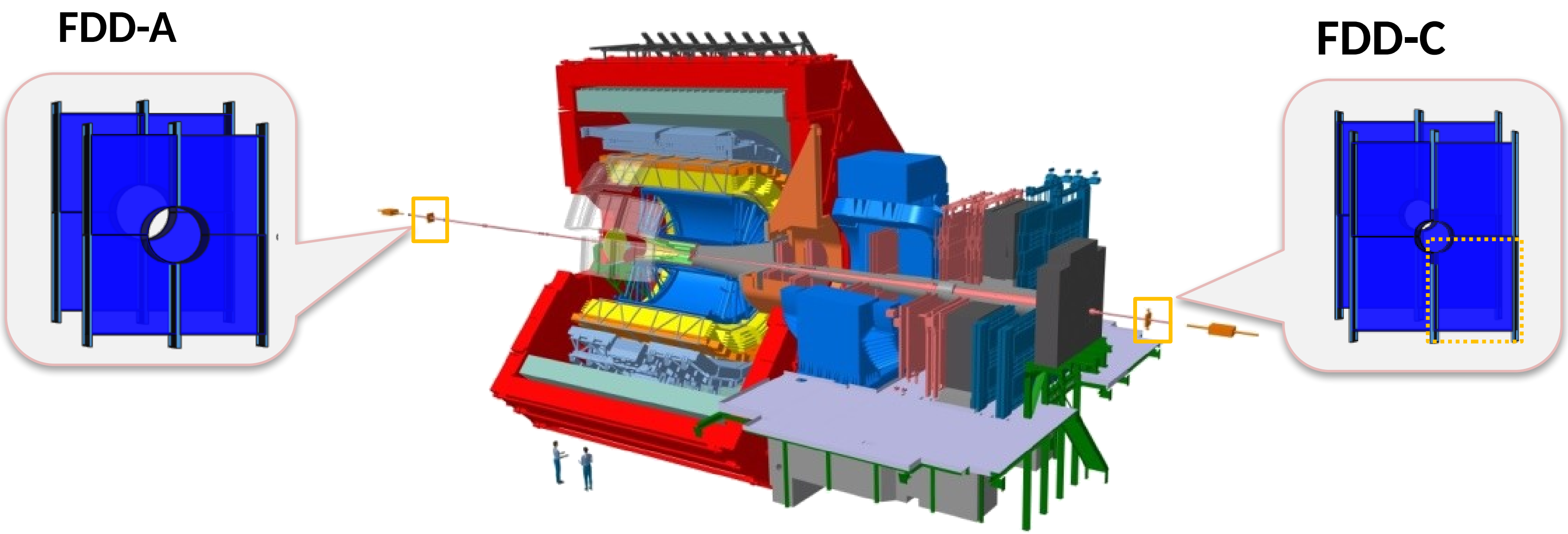
FDD placement

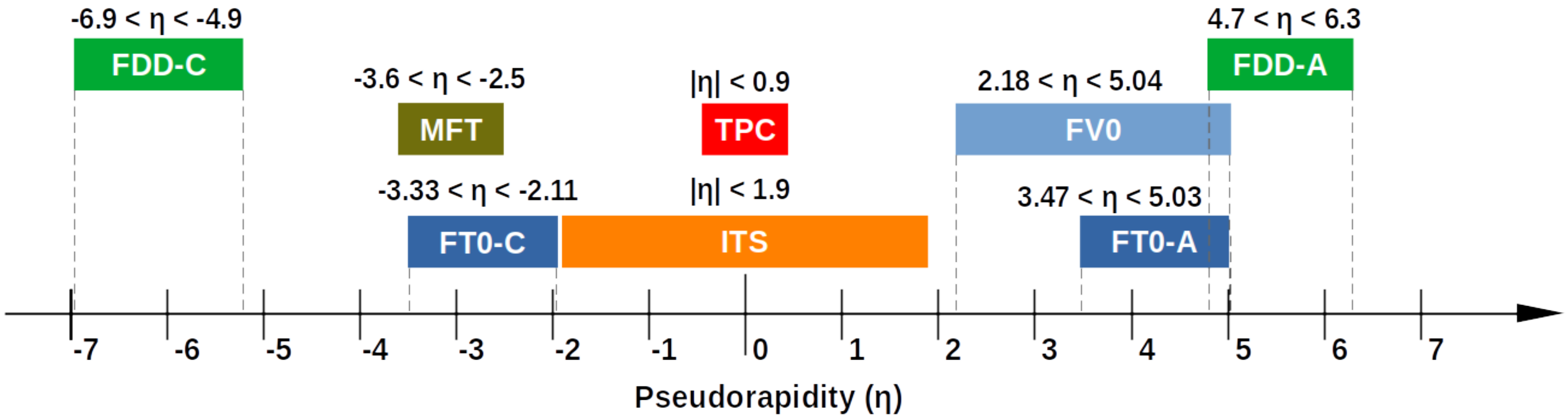


FDD coverage

This forward coverage allows ALICE to:

- **Select diffractive events** down to diffractive masses of a few GeV/c^2.
- Veto particle production in the forward regions to obtain **clean samples of ultra-peripheral and diffraction events**.

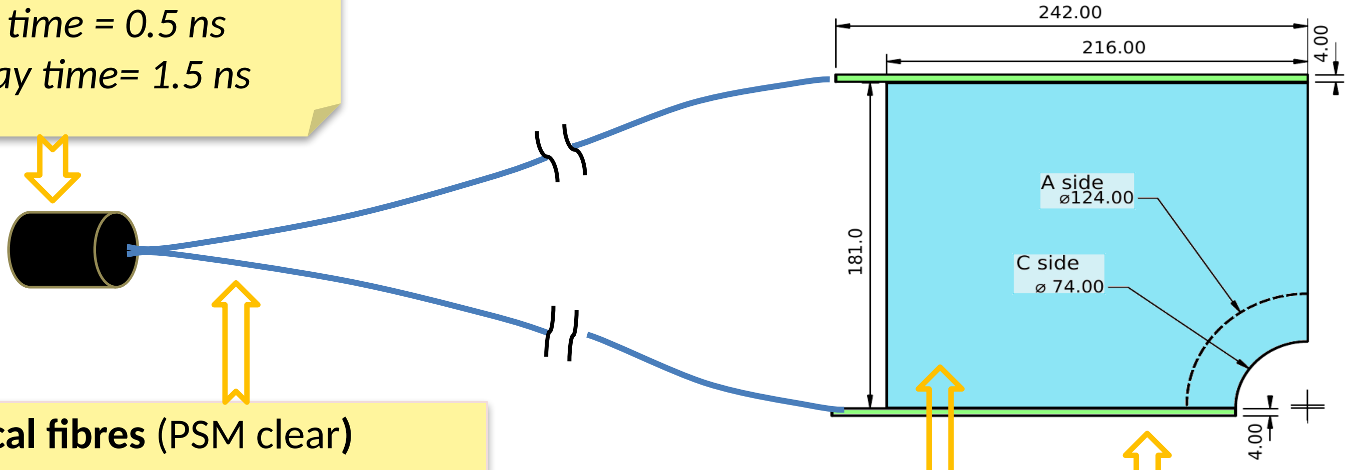




Materials

Each **pad** has two wavelength shifting (**WLS**) bars connected to individual **PMT** via a bundle of clear optical fibers.

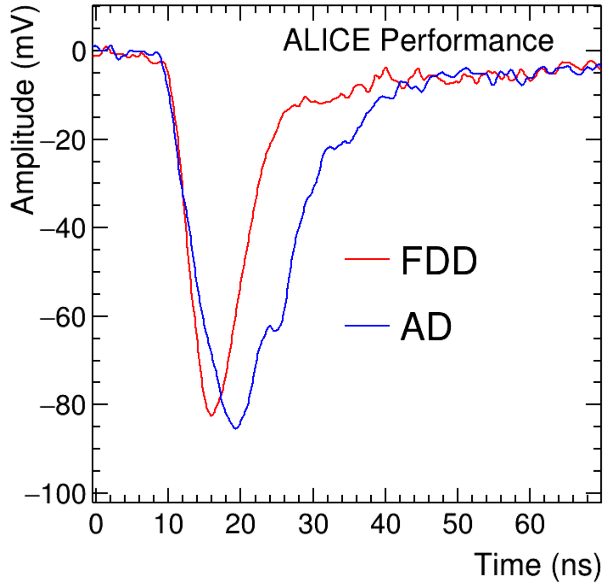
PMT (H8409-70)
- *Rise time = 0.5 ns*
- *Decay time= 1.5 ns*



Optical fibres (PSM clear)
- *FDD-C : 3 m*
- *FDD-A : 1 m and 0.57 m*

Plastic scint. (BC-420)
- *Rise time= 0.5 ns*
- *Decay time= 1.5 ns*

WLS bars (LuminnoTech: NOL-38)
- *Re-emission time = 0.95 ns*

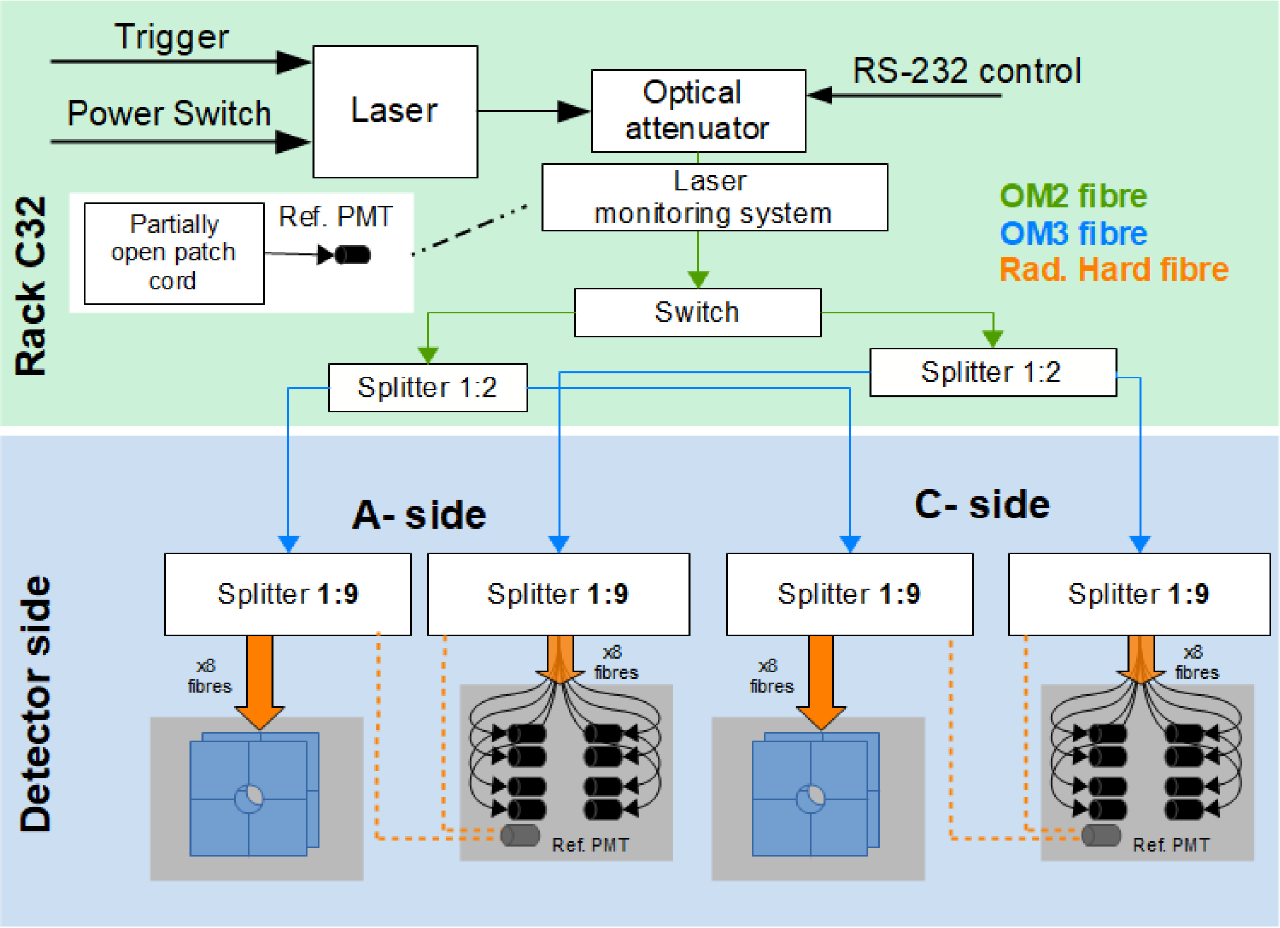


Laser calibration system

The laser calibration system will allow the monitoring of the detector to adjust parameters to guarantee the best performance. In summary this system will be used to perform:

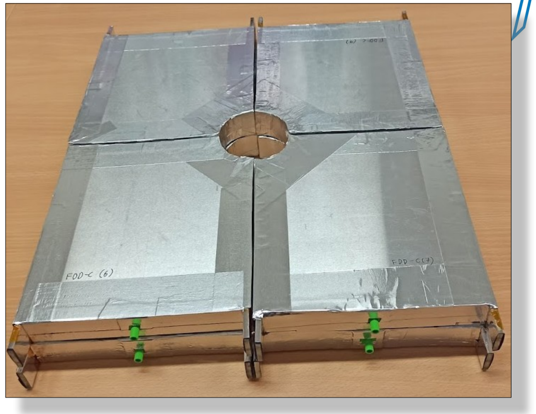
- Amplitude and time calibration
- Quality assurance
- Monitoring of the gain and aging of the components, such as the PMTs and plastic scintillators.

Wavelength = 405 nm



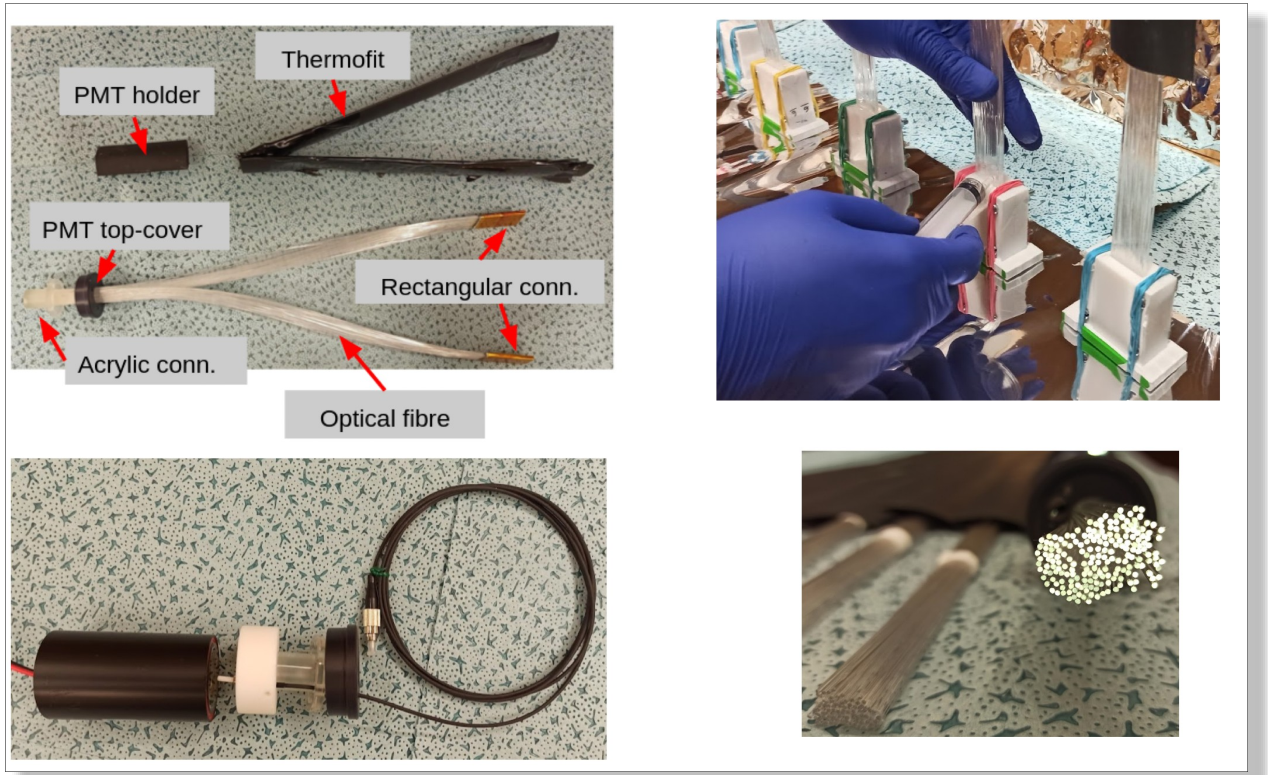
Pads Construction

Module assembled



Pads wrapping

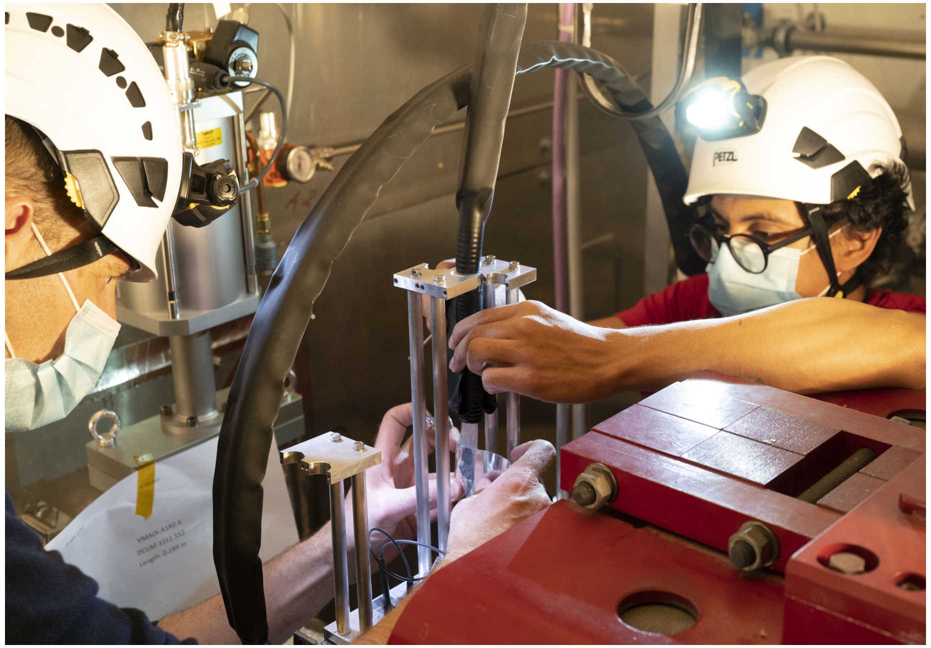
Fibre bundles



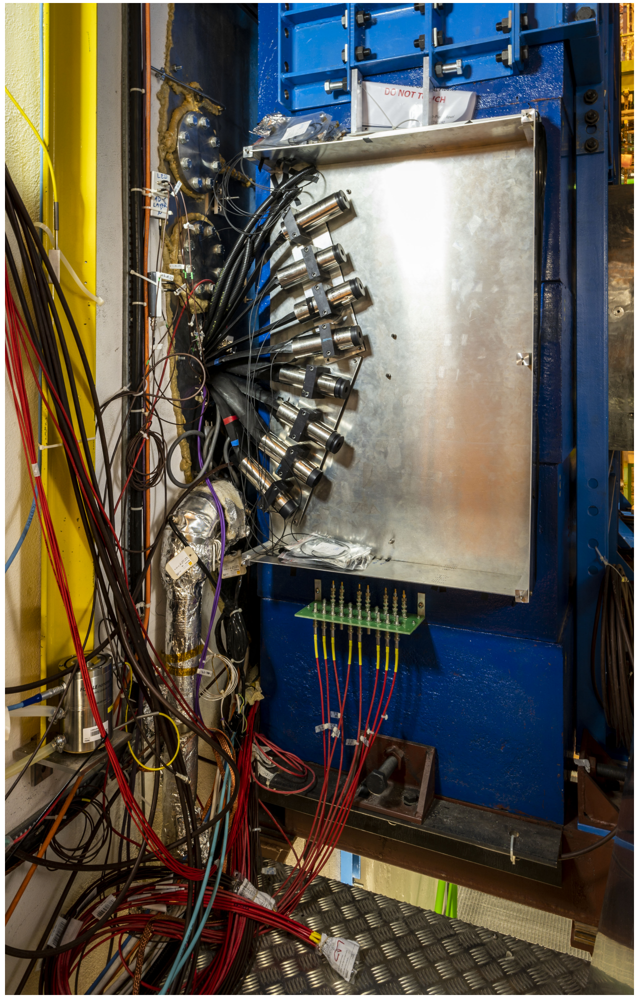
FDD-C installation

22.02.2021

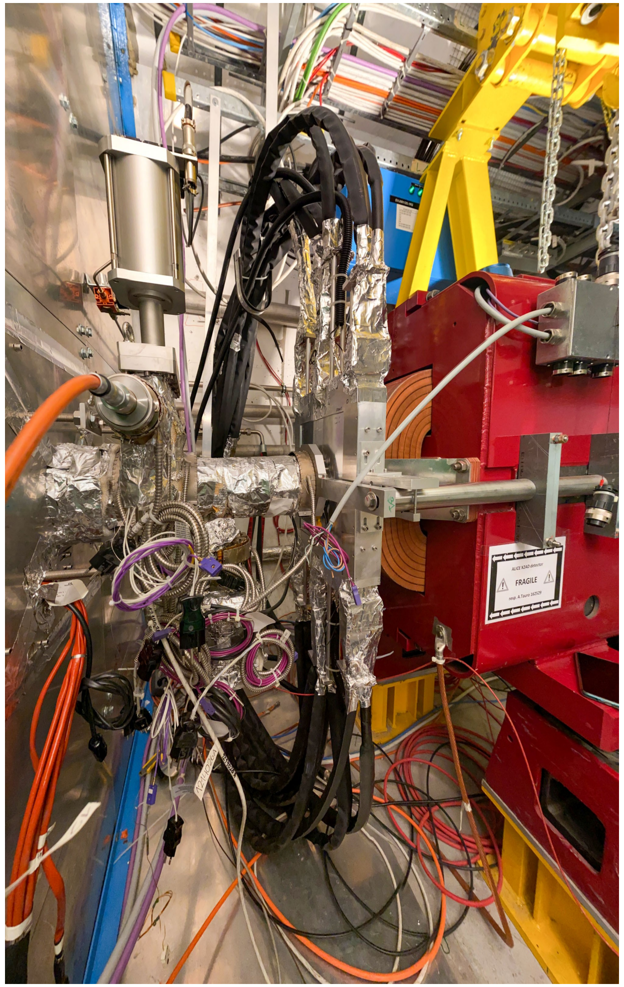
Fibre bundles installation



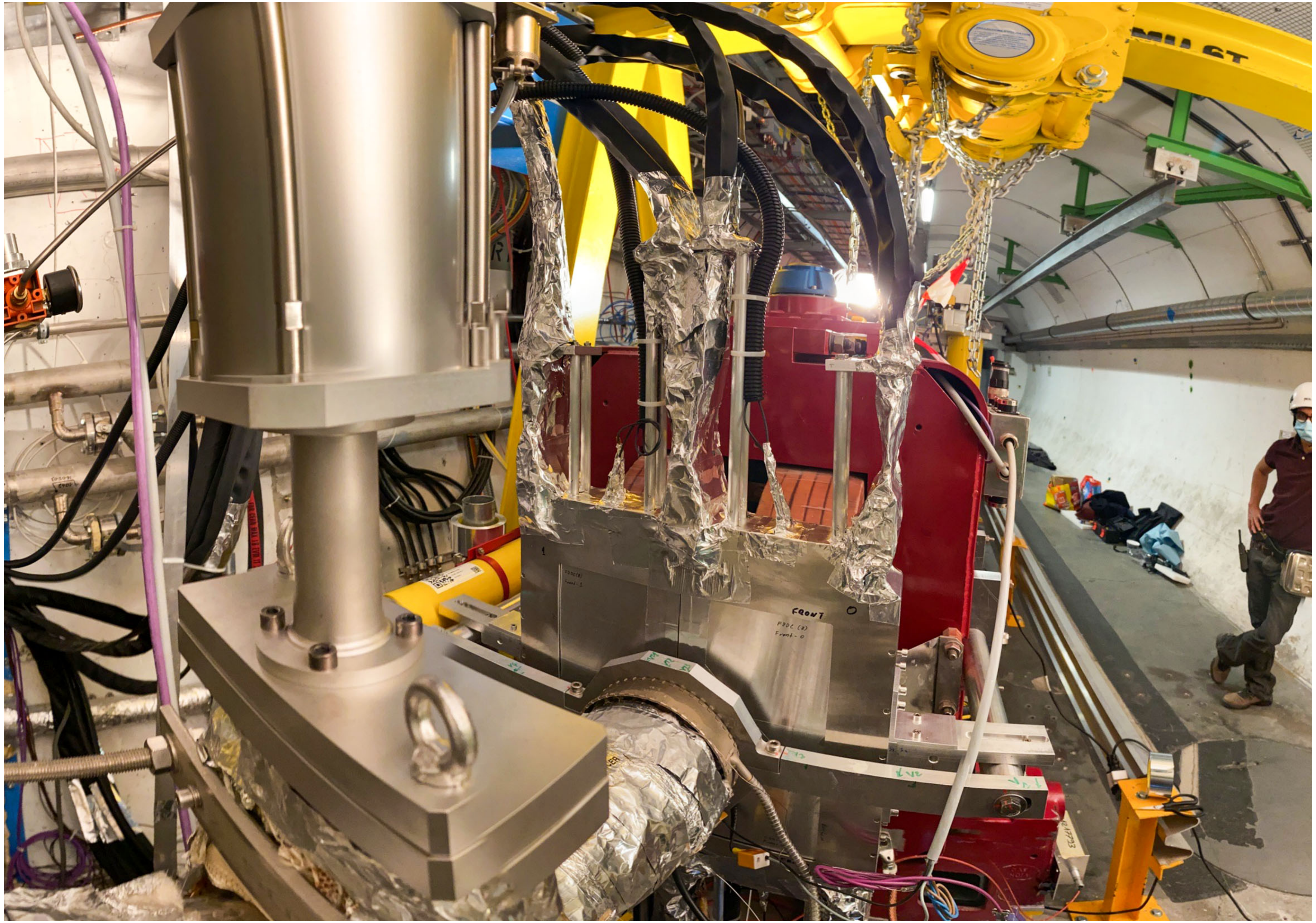
ALICE cavern - PMTs



LHC tunnel – FDD-C



Close up on the detector



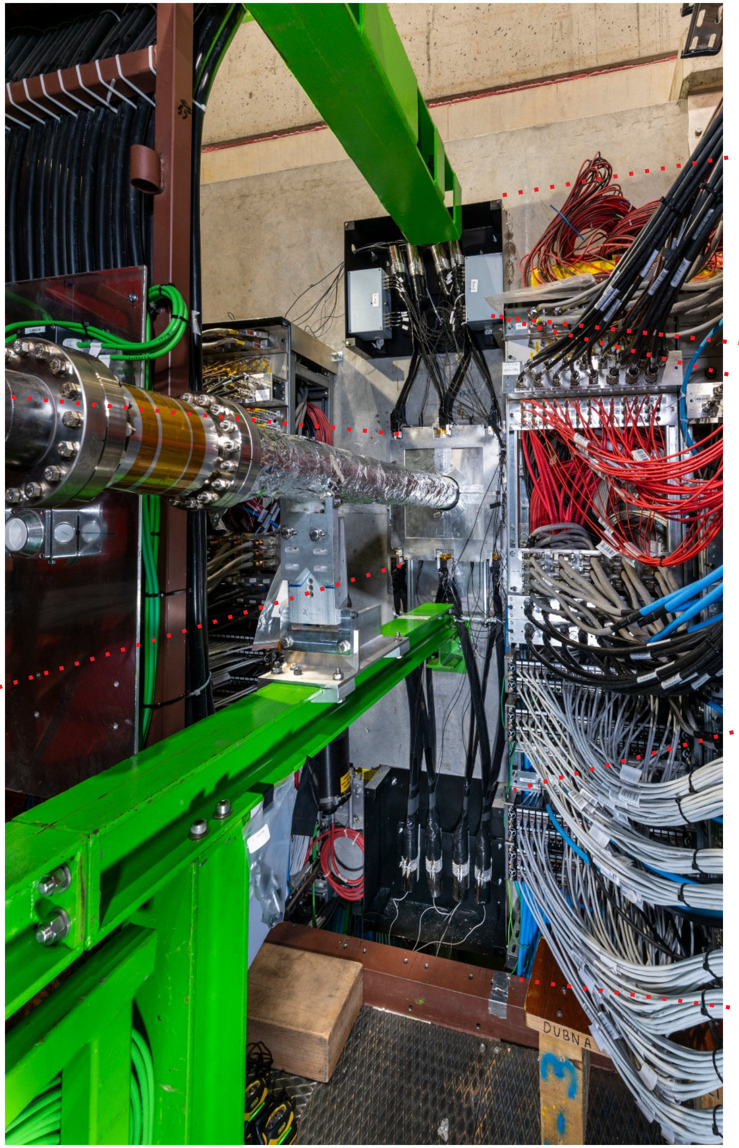
Optical fibres passing from the tunnel to the cavern

Tunnel side

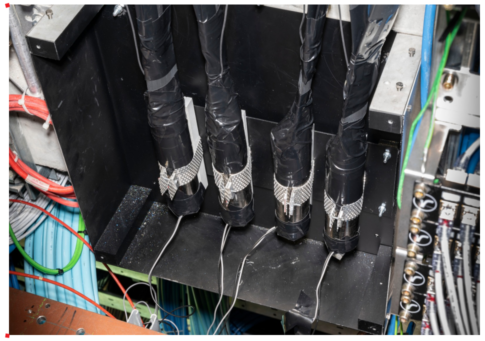
Cavern side

FDD-A installation

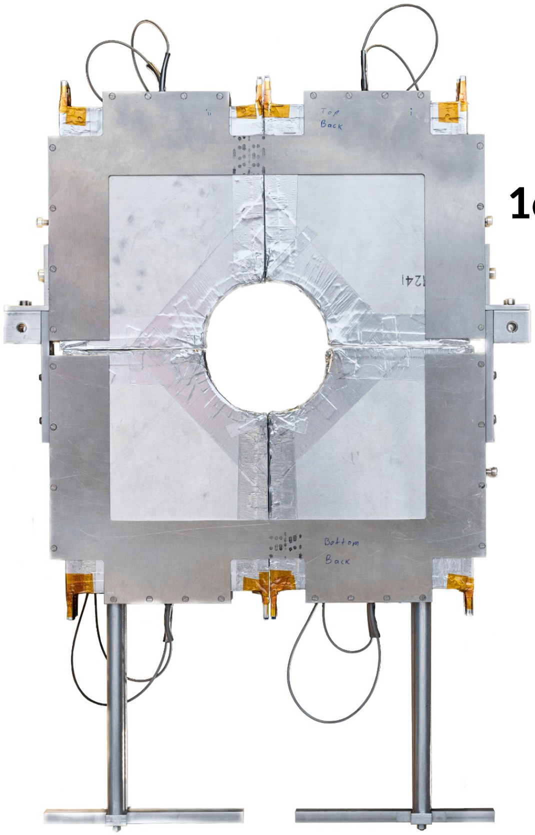
14.07.2021



Optical fibre laser light distribution boxes and PMTS

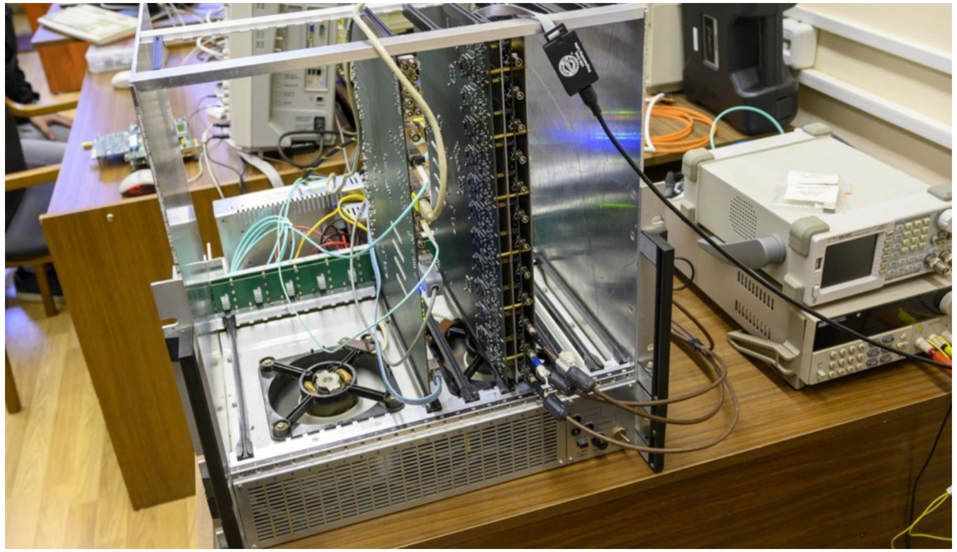


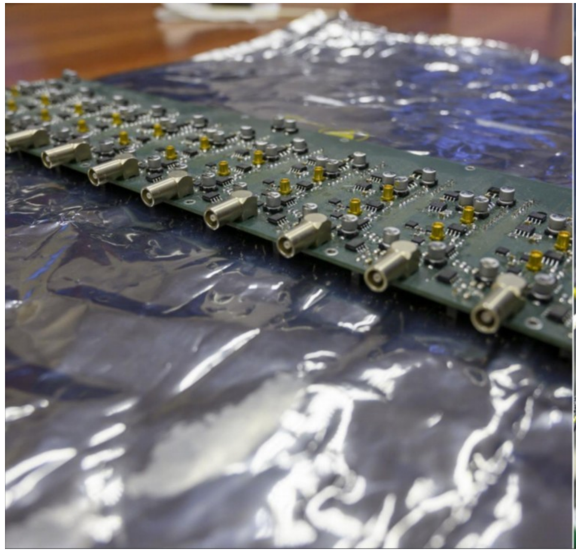
FIT - Front End Electronics

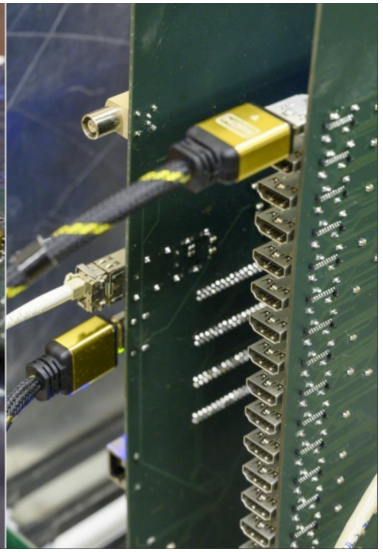


16 channels

Common FEE for all FIT







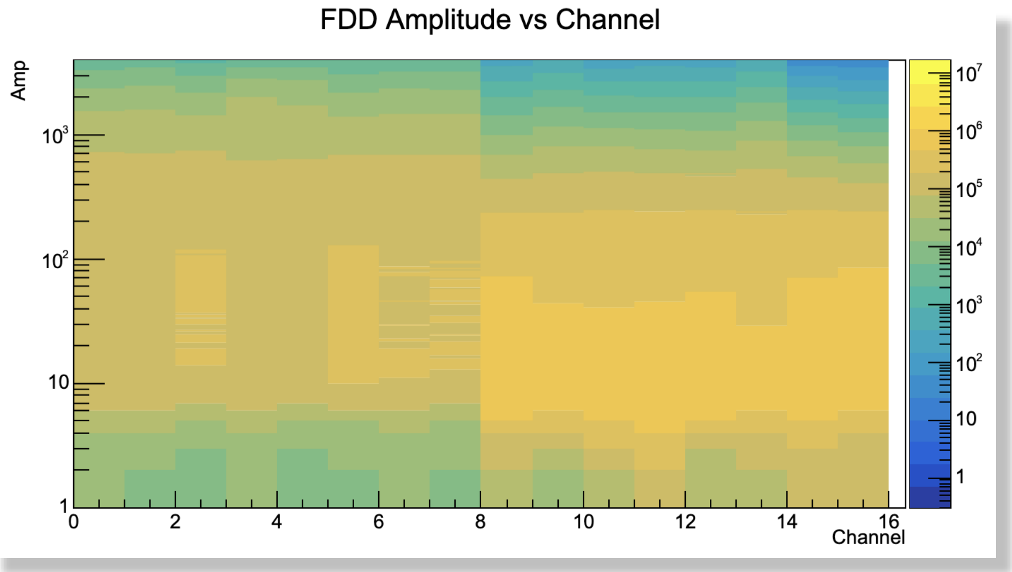
Costume crate:
- Power supply back plane

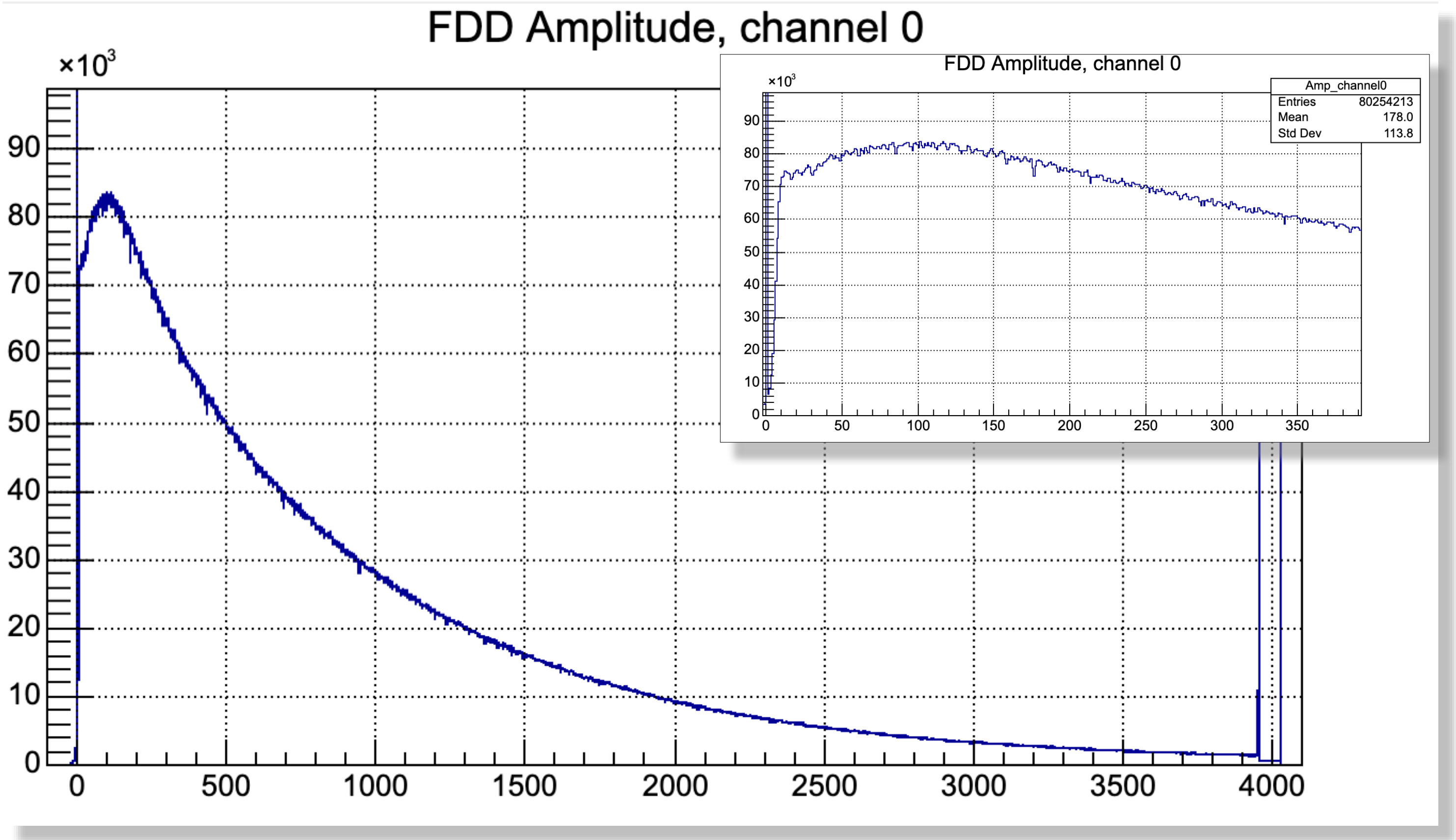
Processing module (PM):
- Charge
- CFD time
- Number of active channels

Trigger and Clock Module (TCM):
- OrA and OrC trigger (at least one trigger per side)
- Vertex Trigger
- Trigger based on amplitude

FDD performance

Charge distributions



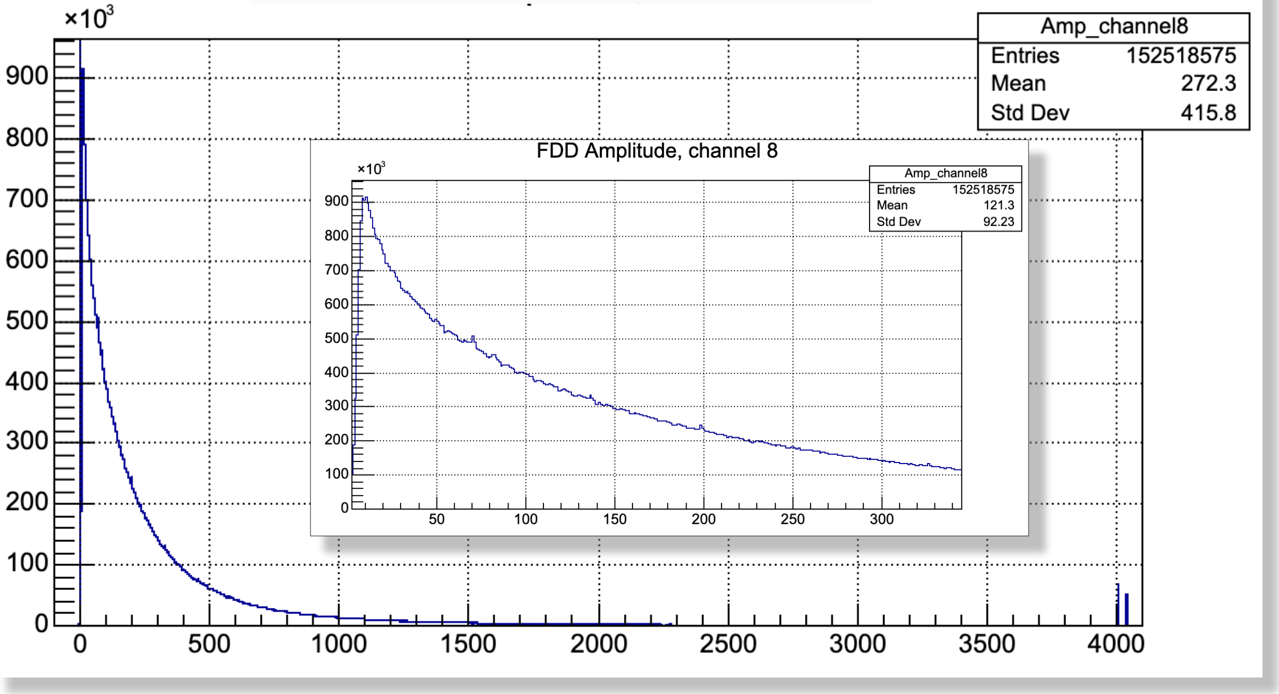


FEE electronics optimized for FDD and FV0

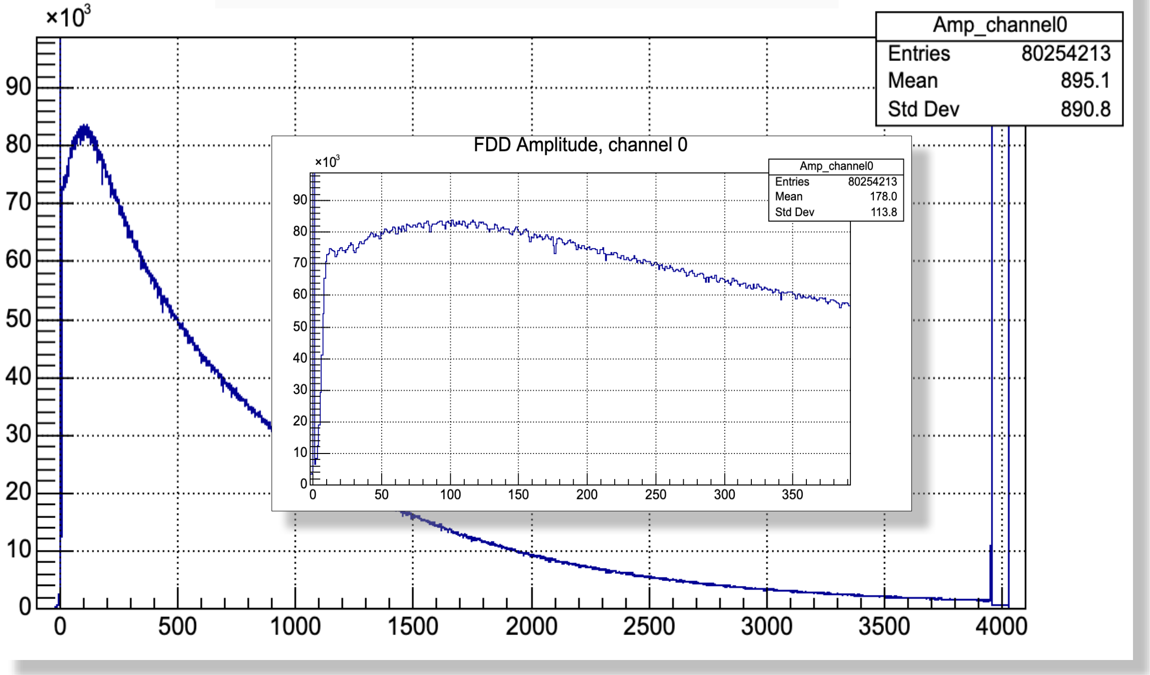
- New electronics installed on 2022 and being tested to improve time distribution.
- New mezzanine boards will reduce the noise and allow us to chose settings which will reduce the saturation.

Charge distributions for individual channels

FDD-A single channel charge

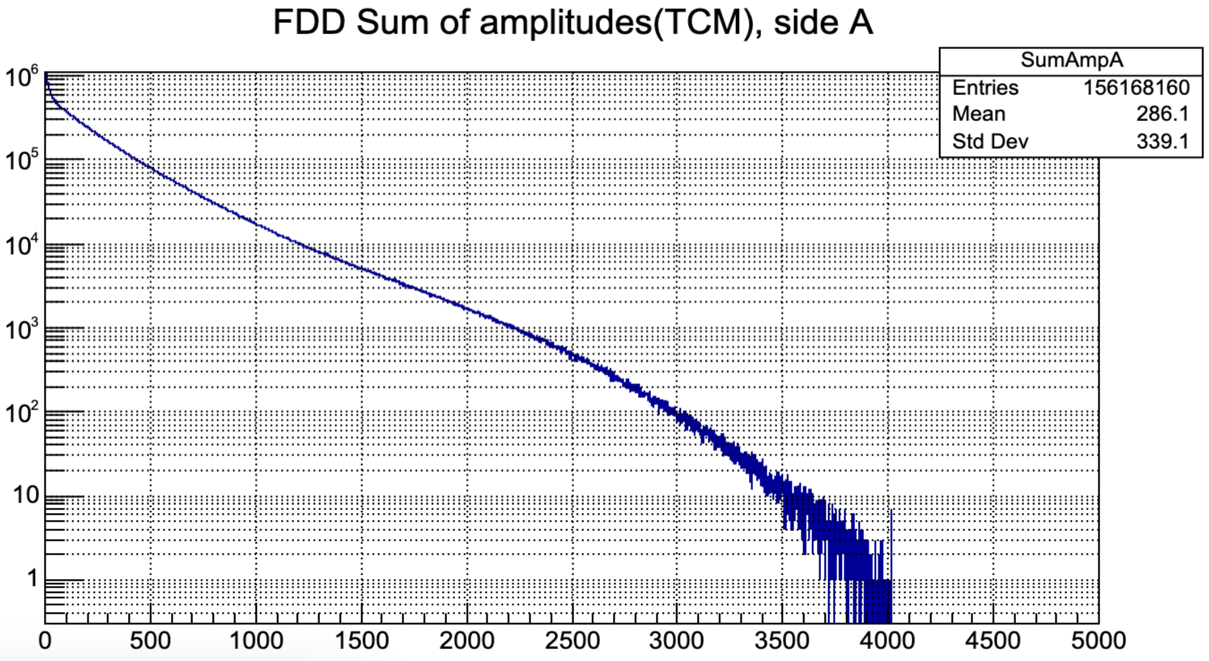


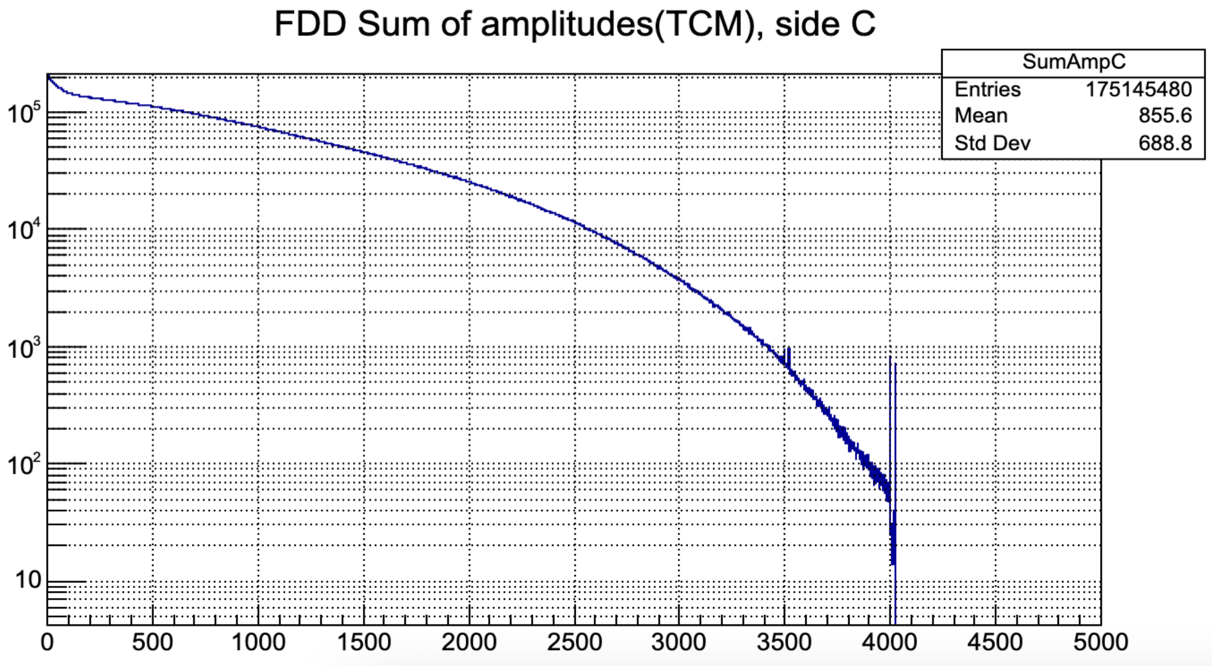
FDD-C single channel charge



The performance of the side-A and -C shows different amount of charge, i.e., multiplicity. The reason of the high multiplicity in C-Side has to be understood

Total charge distributions for A- and C-side



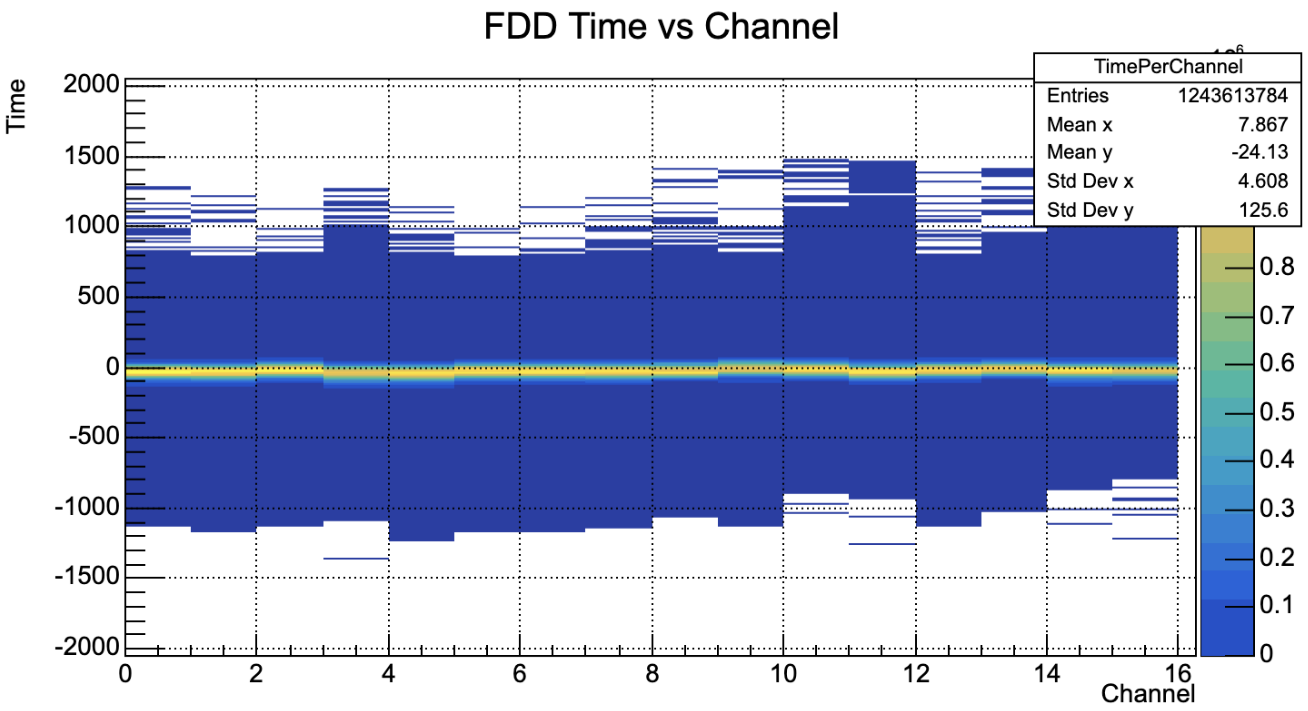


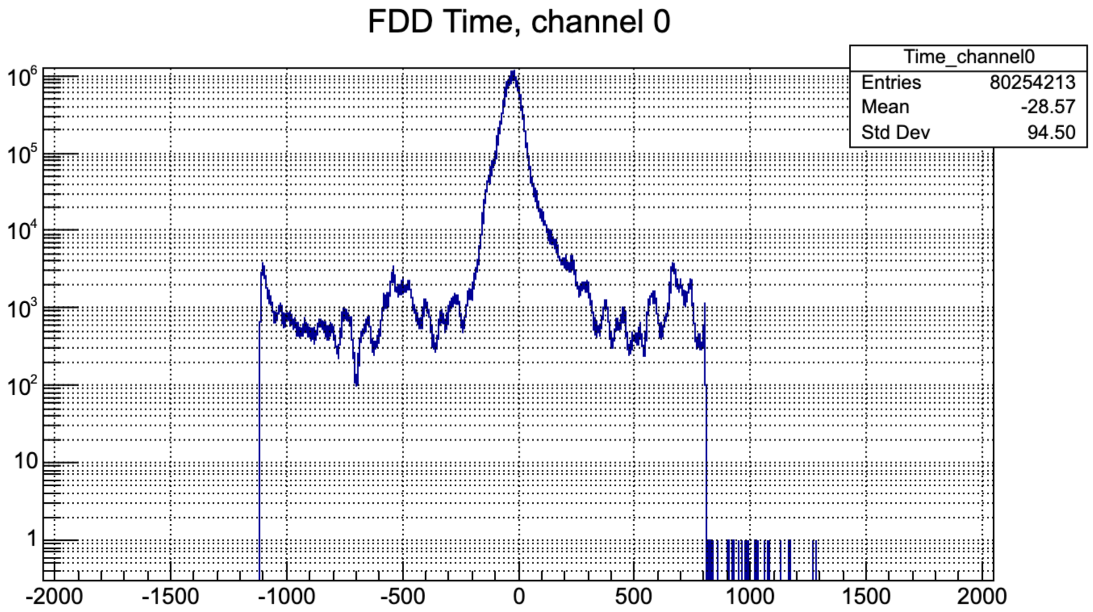
The performance of the side-A and -C shows different amount of charge, i.e., multiplicity. The reason of the high multiplicity in C-Side as well as the saturation has to be understood.

The MIP peak is visible

Time distributions

Time distribution of one channel



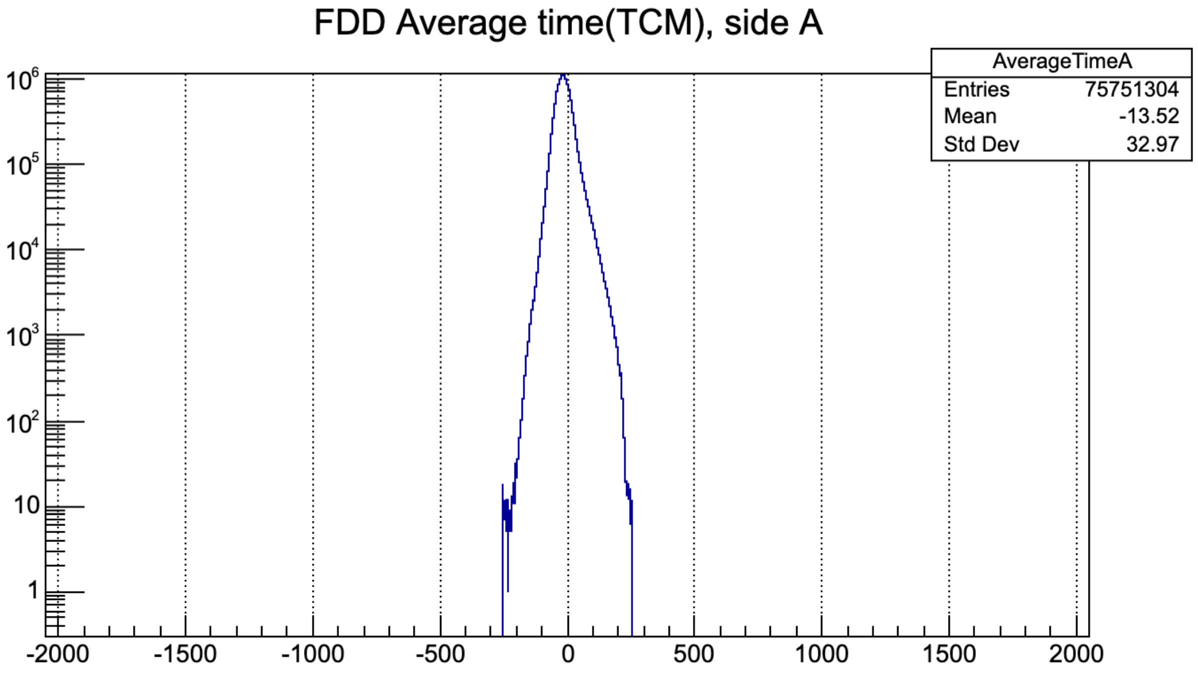


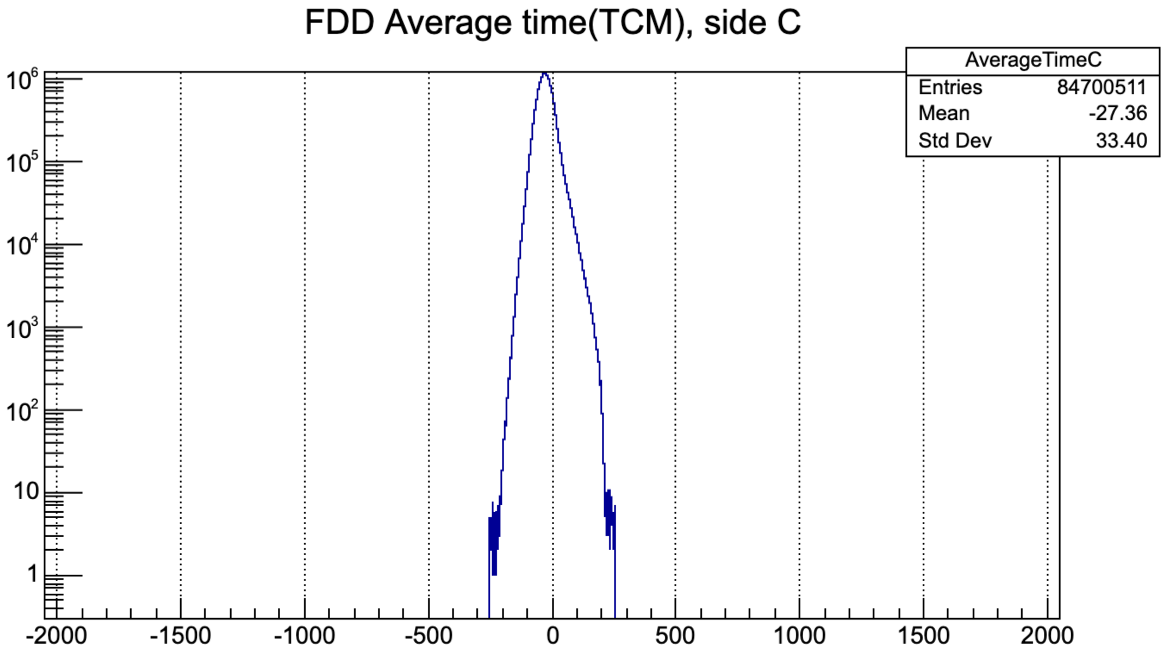
Not optimized time and charges for FDD with previous FEE electronics.

- New electronics installed on Monday (14.11.2022) and being tested to improve time distribution.
- New mezzanine boards will reduce the noise and allow us to chose settings which will reduce the saturation.

Time distributions

Time distribution of one channel



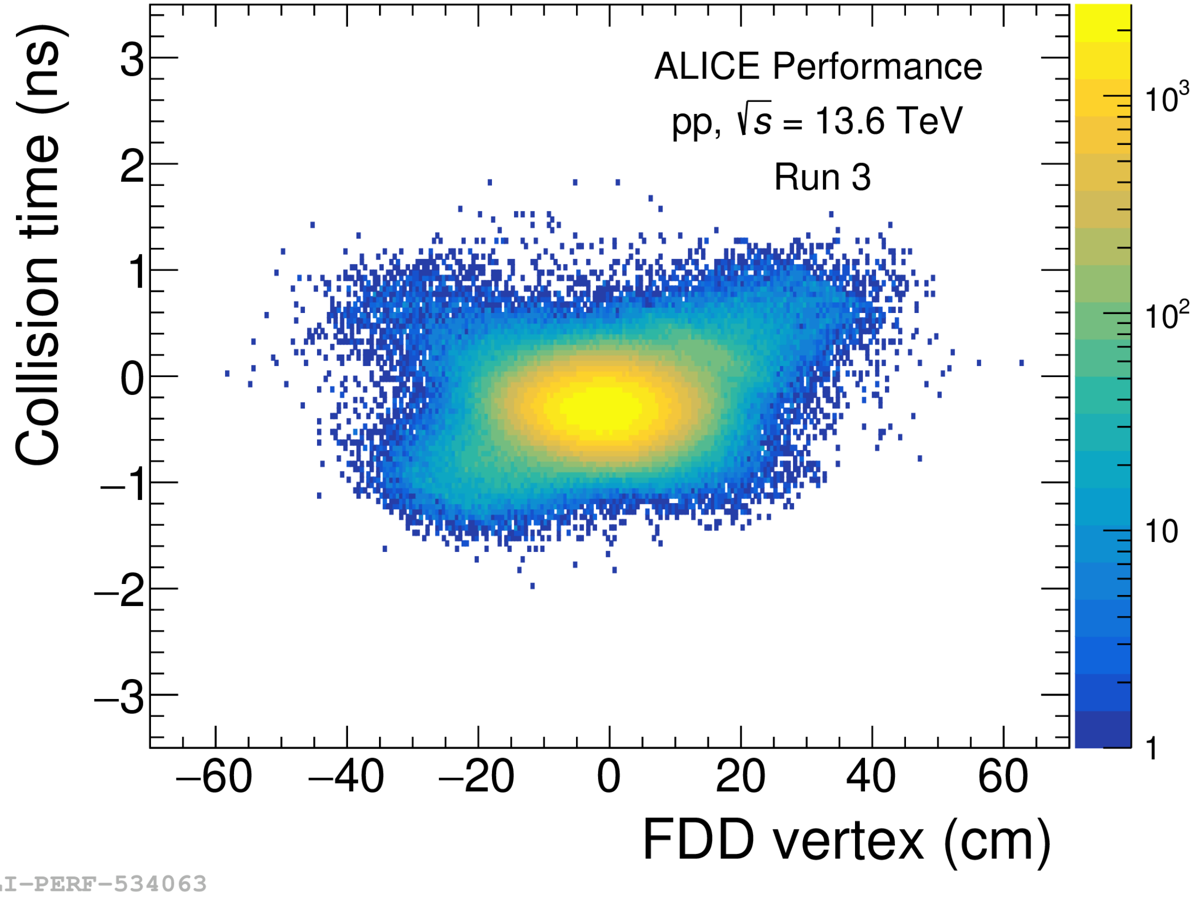


The position of the mean is dependent on the IP position vertex, which can variate on time.

FDD performance

Good vertex and collision time calculation at very forward pseudorapidity regions.

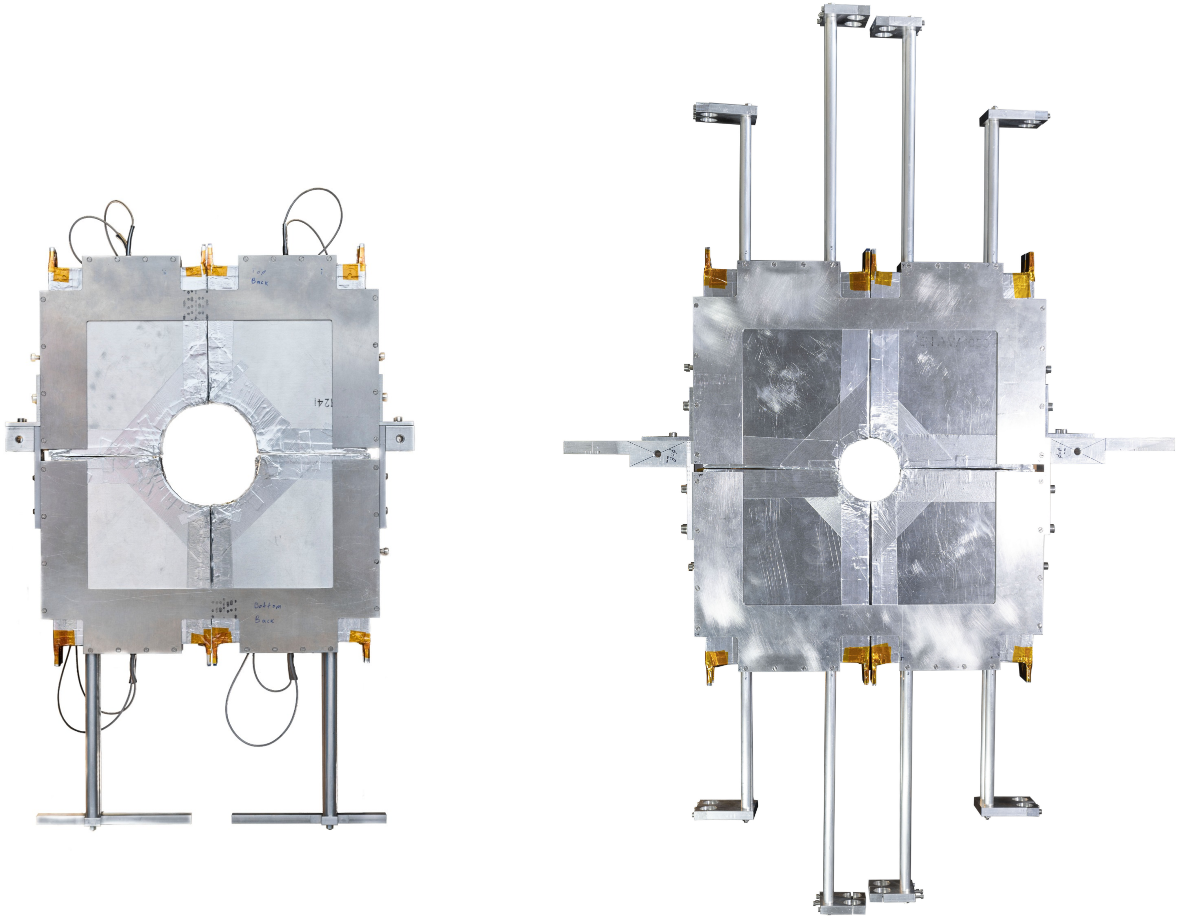
FDD vertex vs FDD collision time correlation in pp at 13.6 TeV



What we want to measure with FDD?

Physics studies:
- Luminosity
- Centrality
- Diffractive events
- Photon induced events

Technical:
- Beam monitoring
- Beam background
- Van der Meer scan

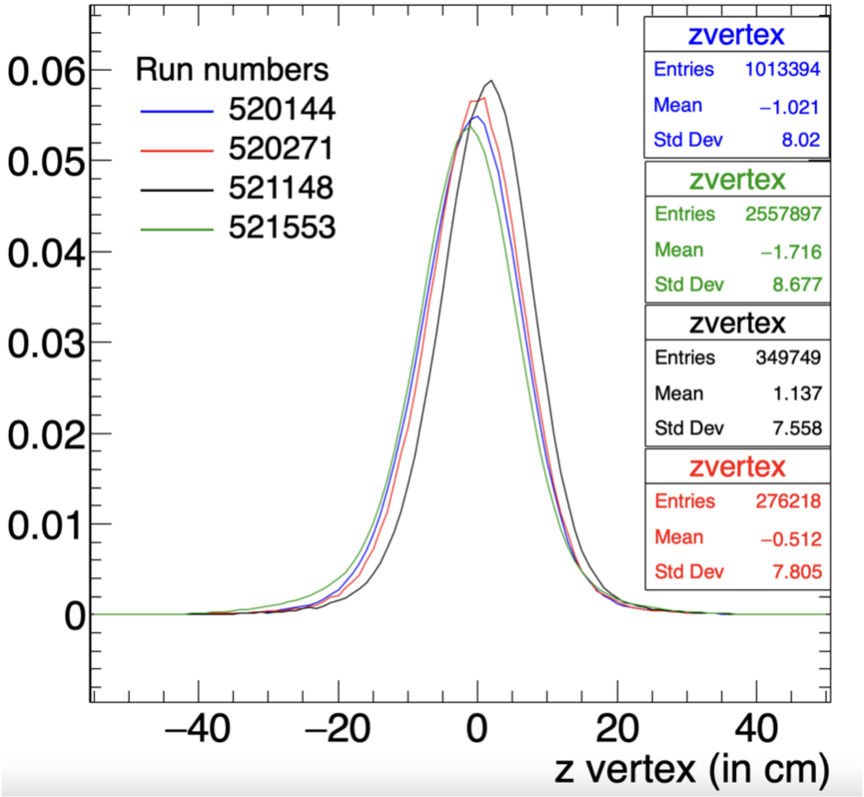


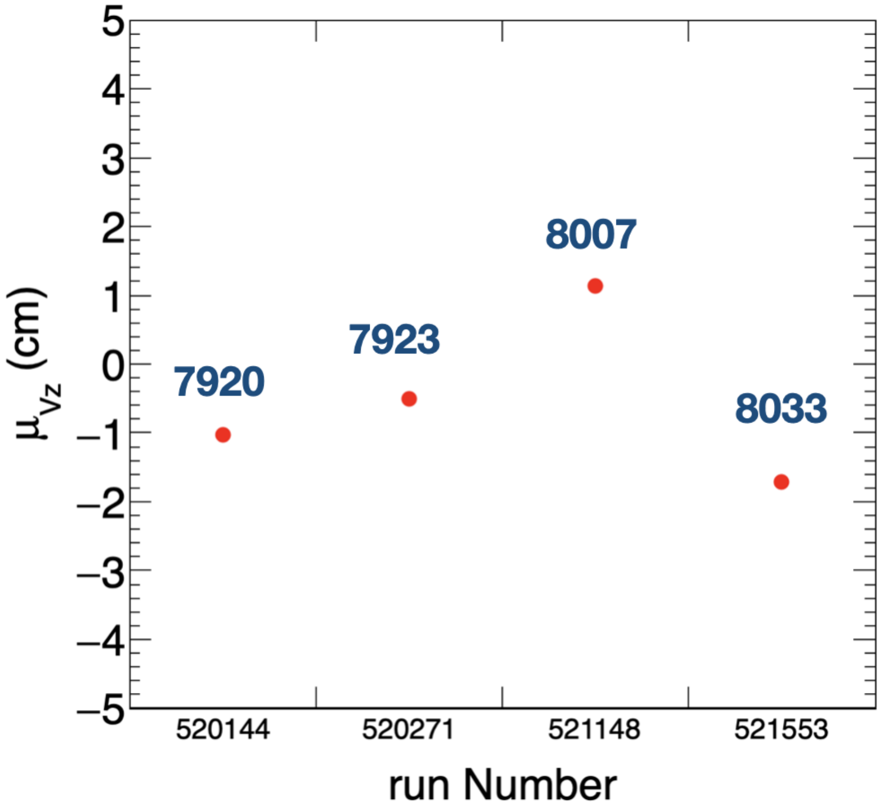
Technical measurement

Technical:

- Beam monitoring
- Beam background
- Van der Meer scan

Vertex time





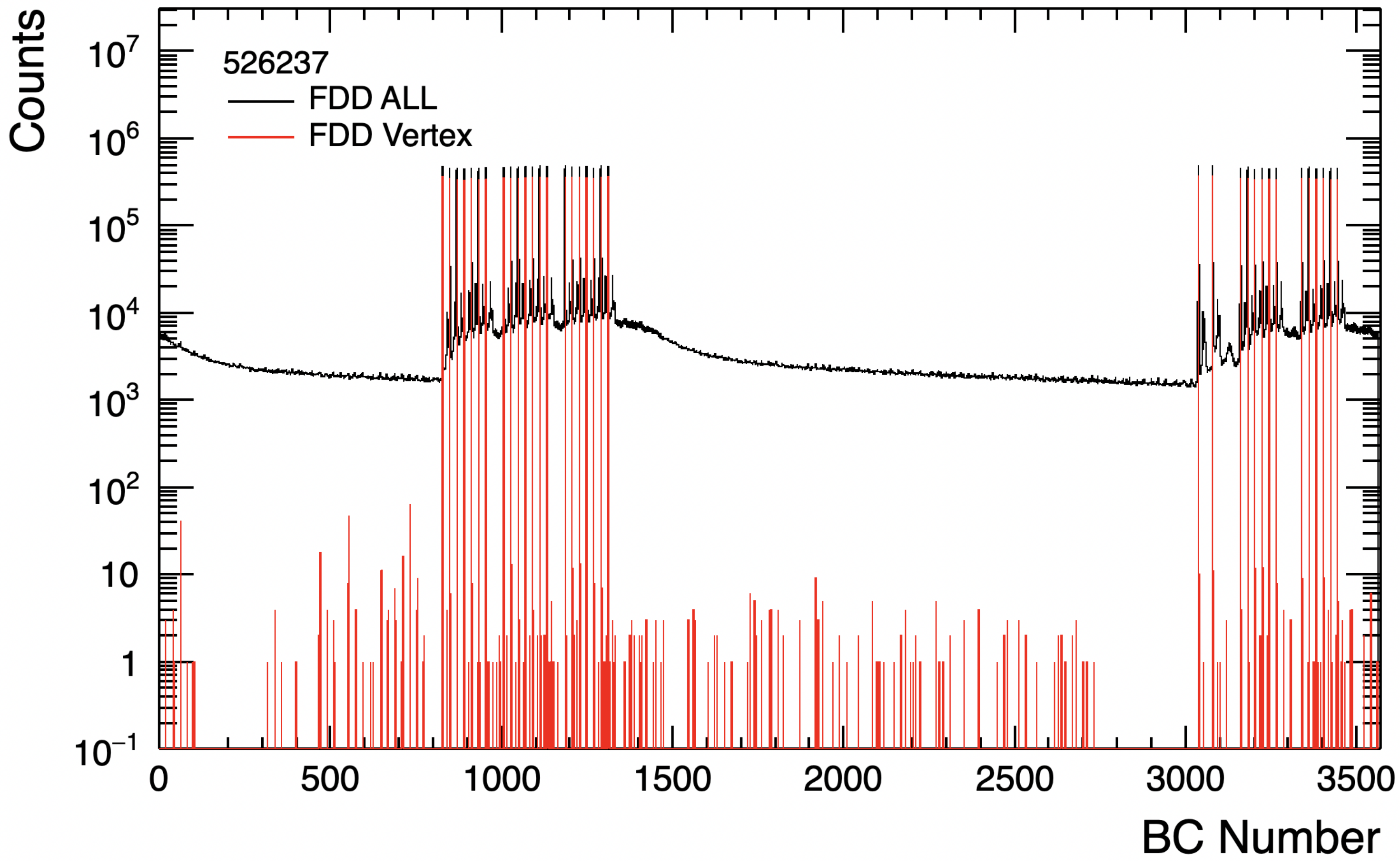
- FDD can reconstruct the primary vertex
- ALICE observed primary vertex shift in the z-direction
- With FDD, we could able to see also the shift

FDD BC distribution

Vertex trigger clears the backgrounds very well.

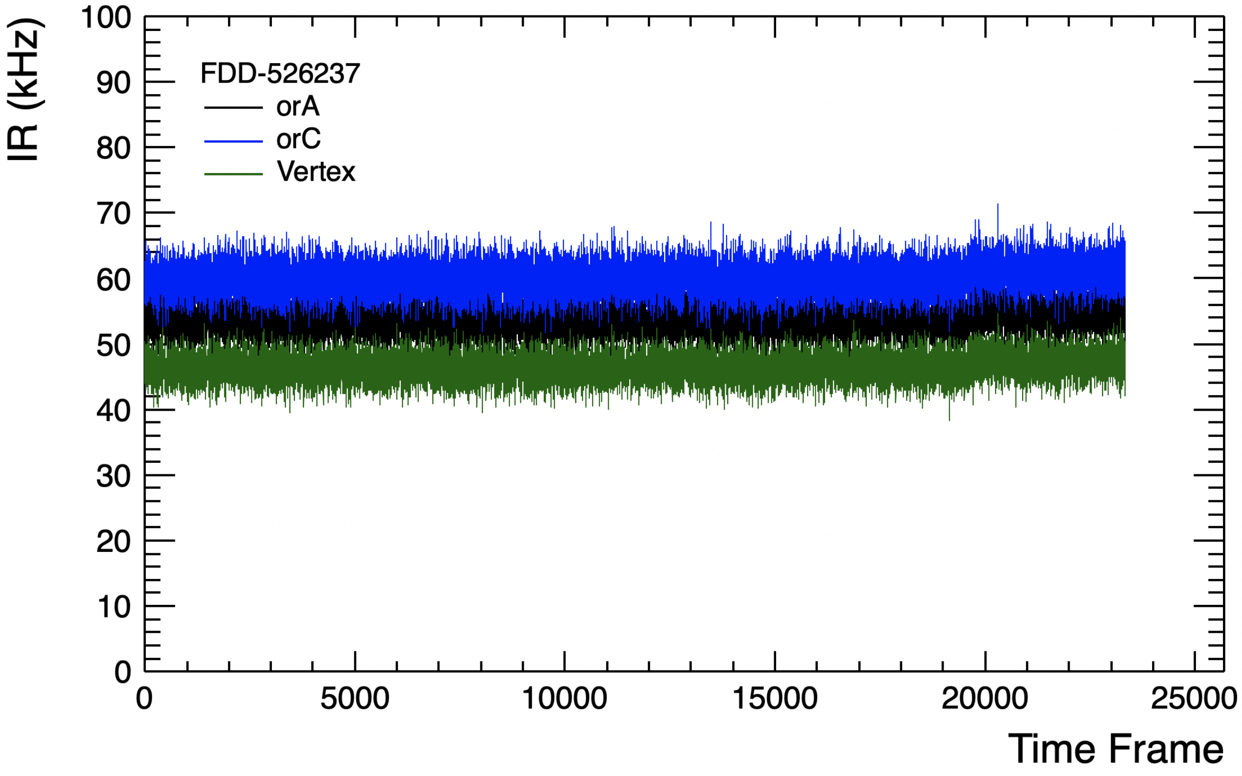
- ~0.1 % of background maximum at the highest interaction rate

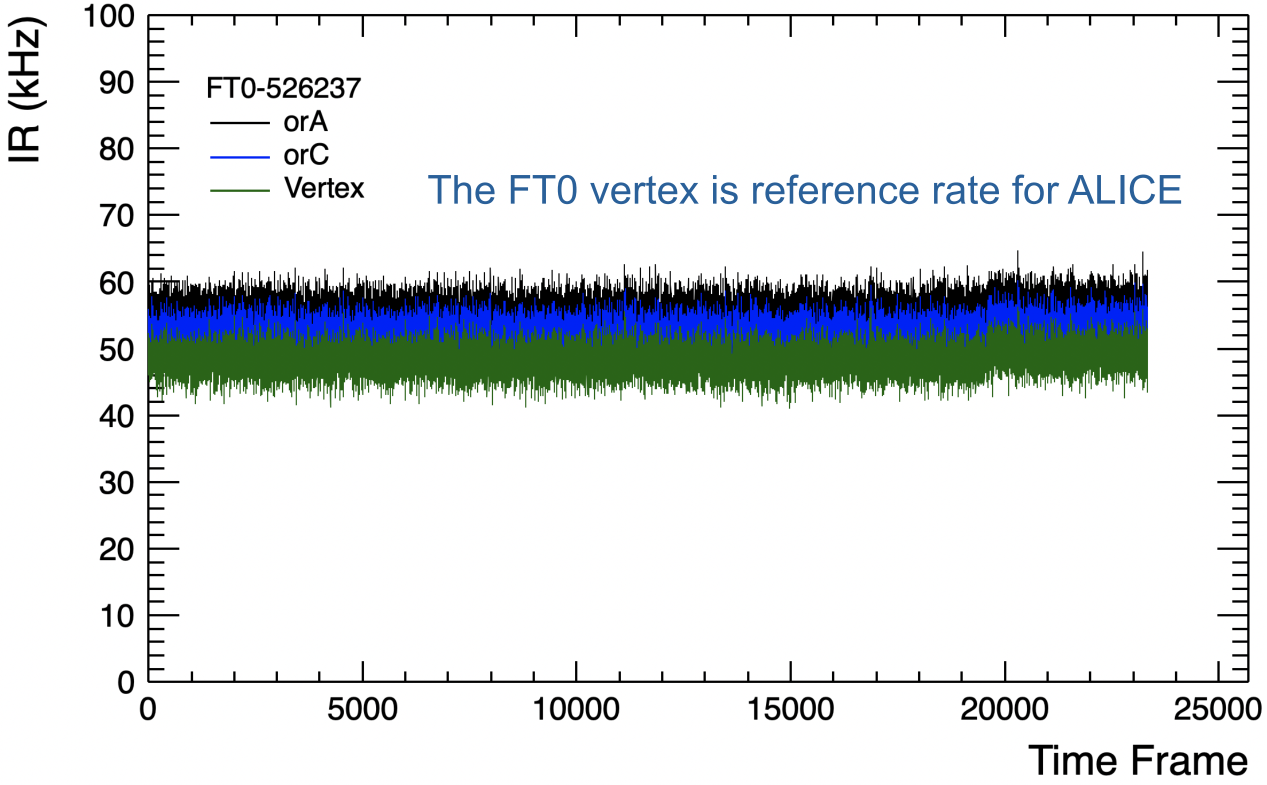
Additionally the coincidence of adjacent pads reduce the noise related triggered signals



FDD Interaction rate

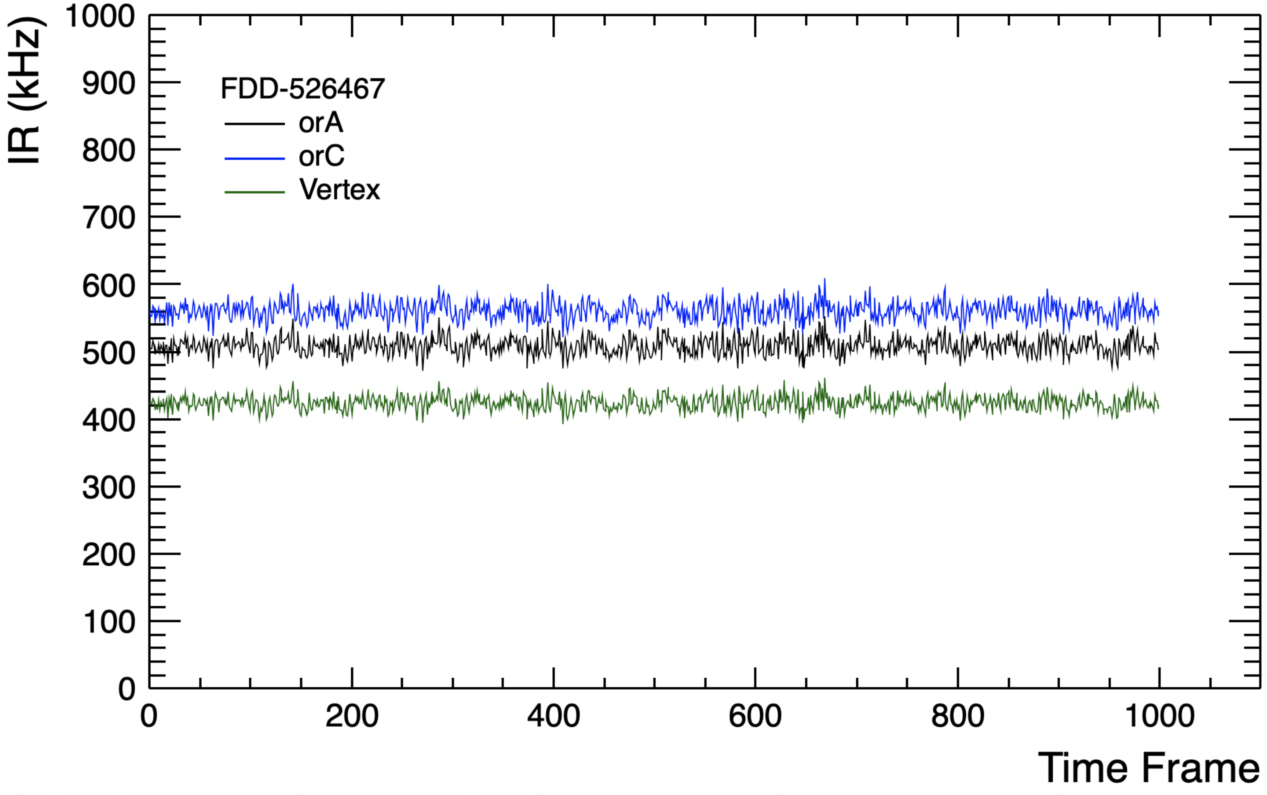
Comparable to FT0 at low rate.

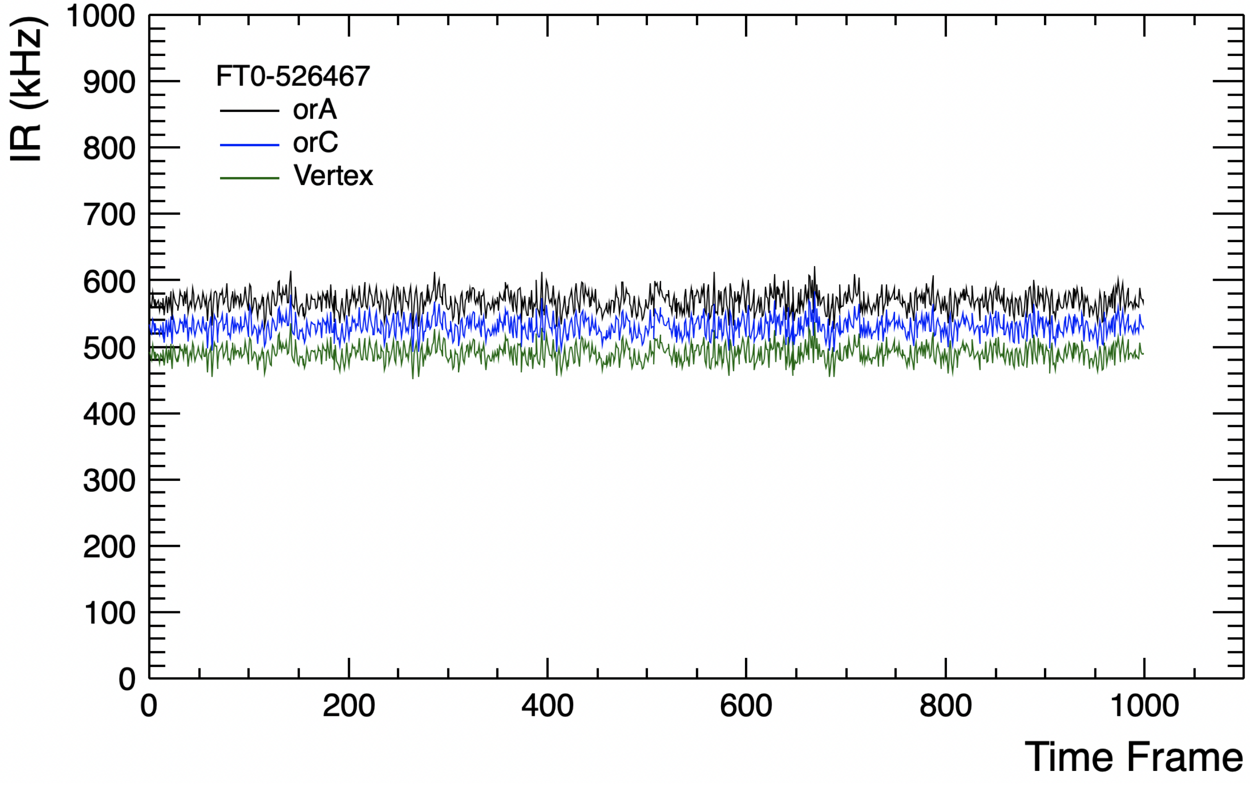




FDD Interaction rate

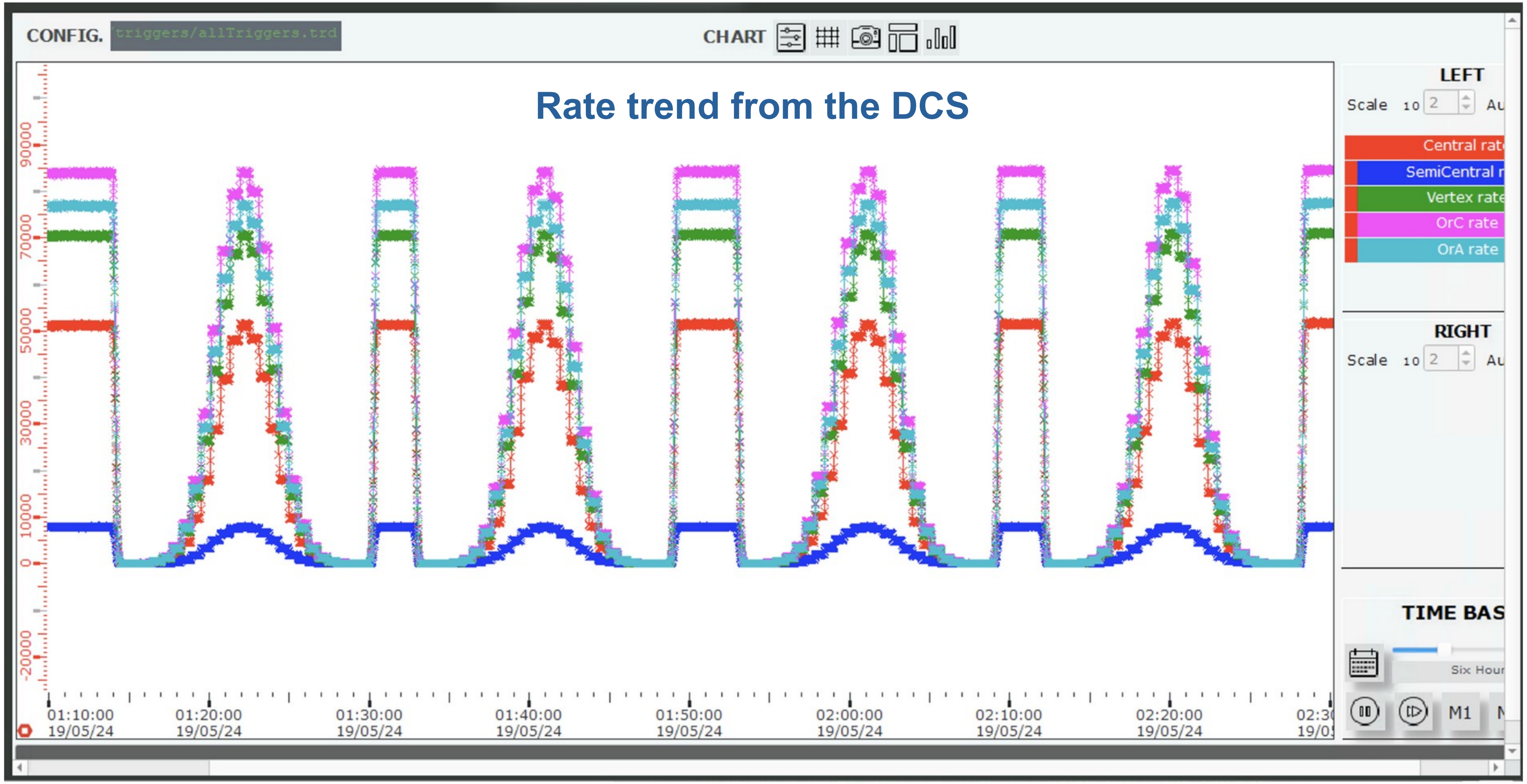
Lower rate w.r.t. FT0 at higher rate (to be understood)



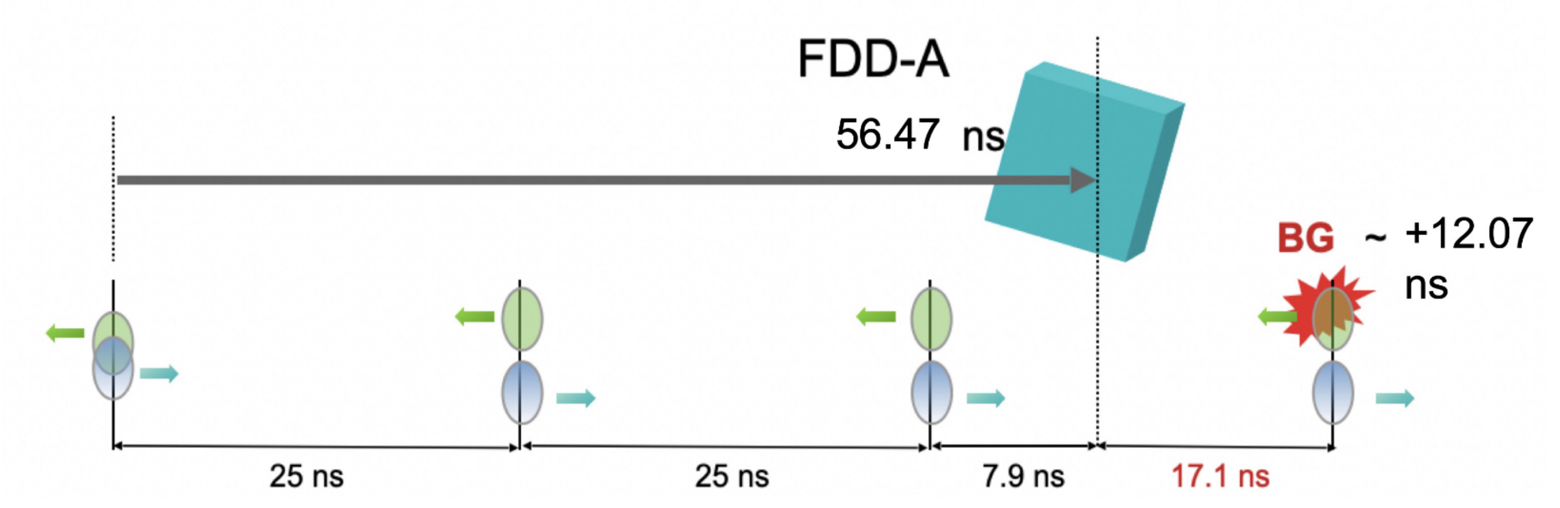


VdM scan

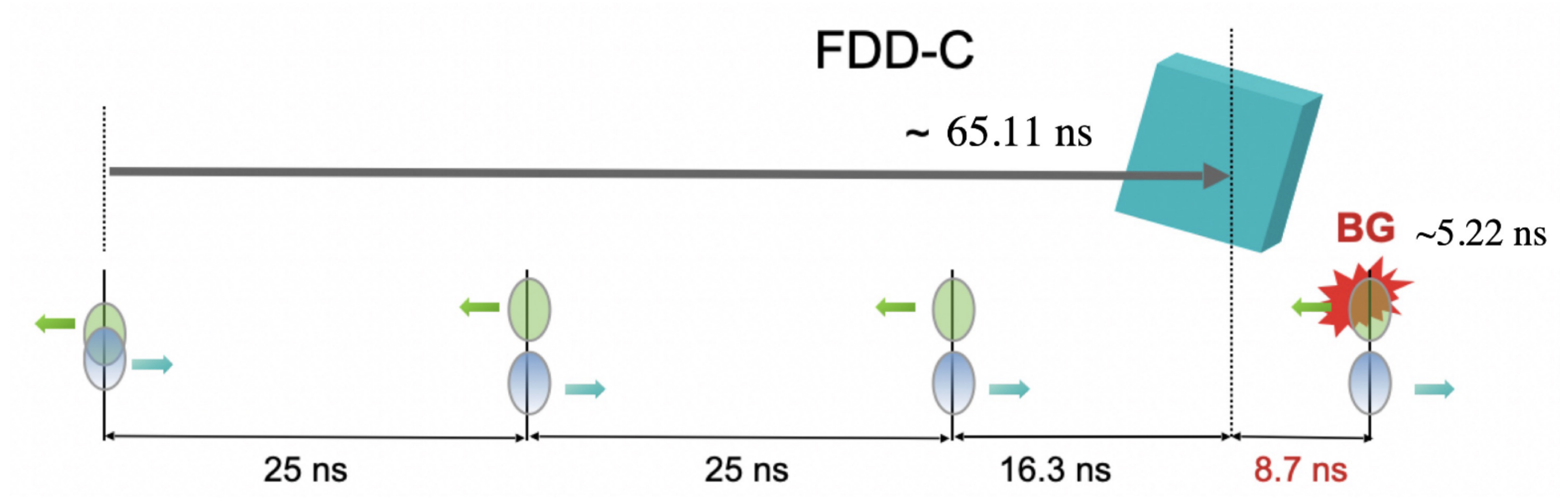
FDD participated in the 2024 VdM scan



Beam Gas with FDD

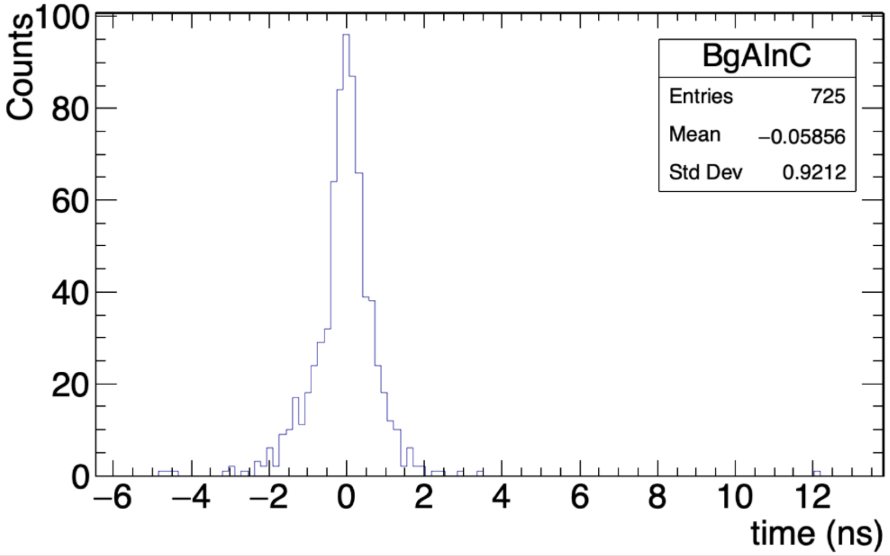


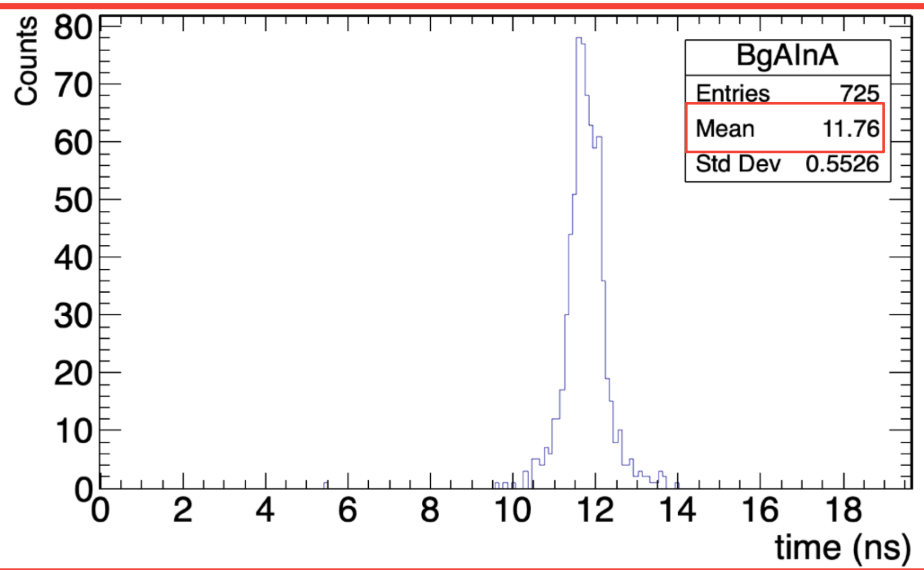
A-side
- Background coming from A-side will pass FDD-A **112.93 ns earlier** than the collision
- Events will be assigned to 5 BCs earlier, at time 25-12.93 = 12.07 ns



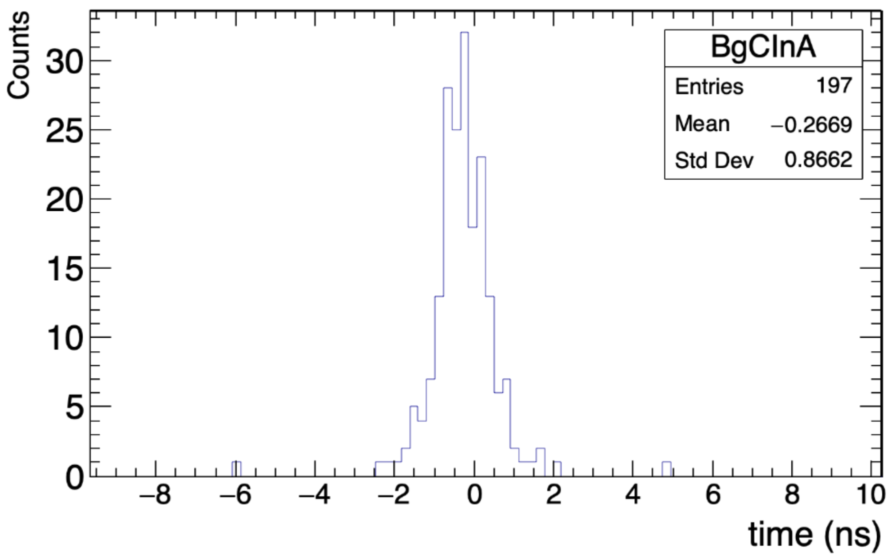
C-side
- Background coming from C-side will pass FDD-C **130.22 ns earlier** than the collision
- Events will actually be assigned to 5 BCs earlier, at time 25-30.22 = -5.22 ns

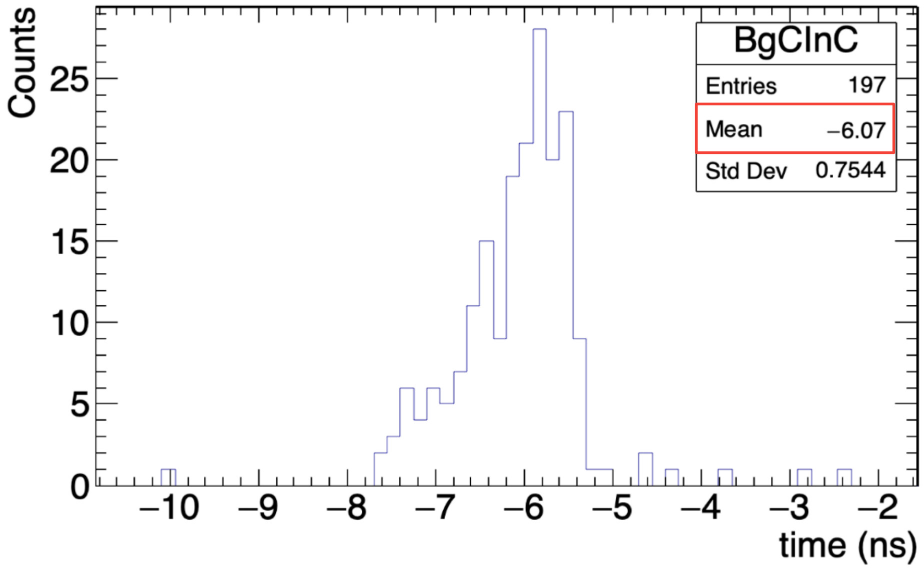
Beam Gas with FDD





BGA

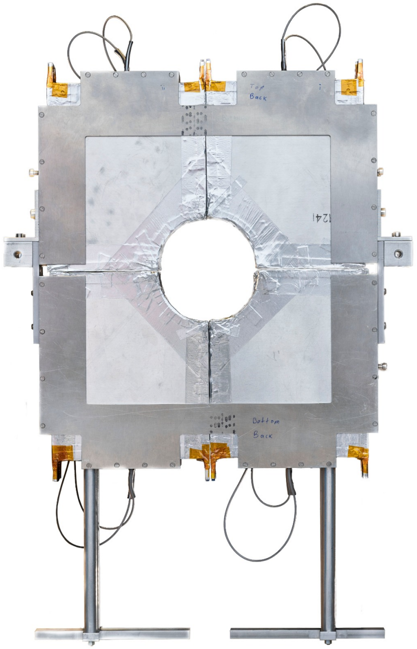


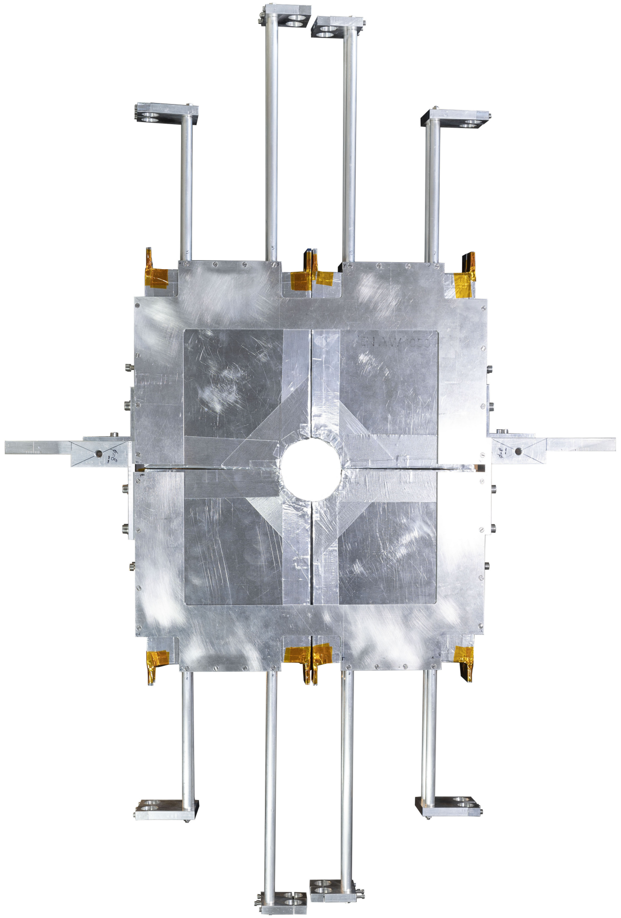


BGC

Physics studies

Physics studies:
- Luminosity
- Centrality
- Diffractive events
- Photon induced events





FDD can help to tag …

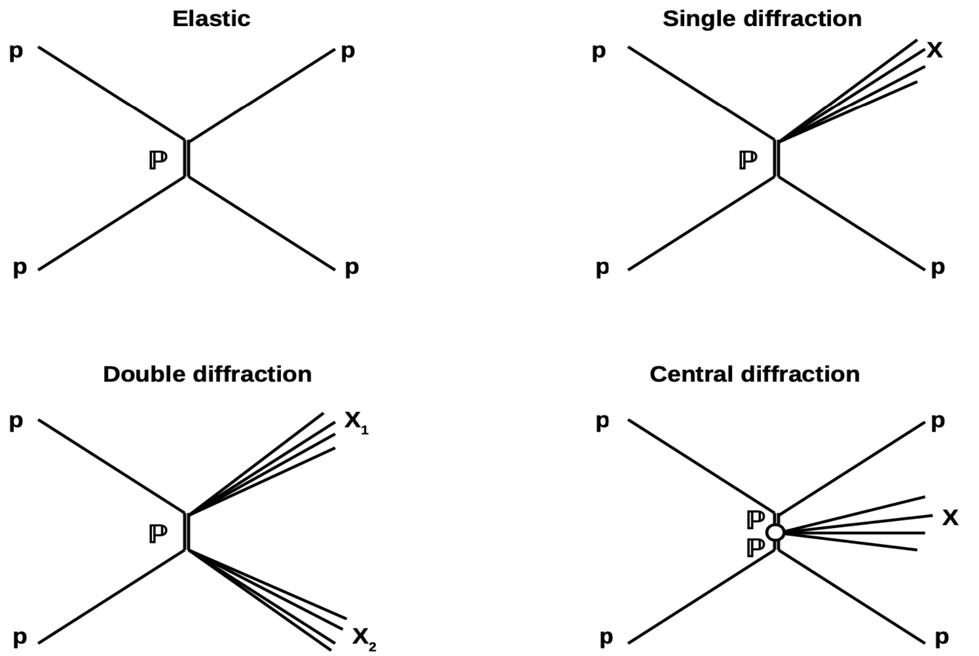
FDD can be used to tag activity or lack of it in the forward regions.

- **Diffraction events**
- **Photon induced events**

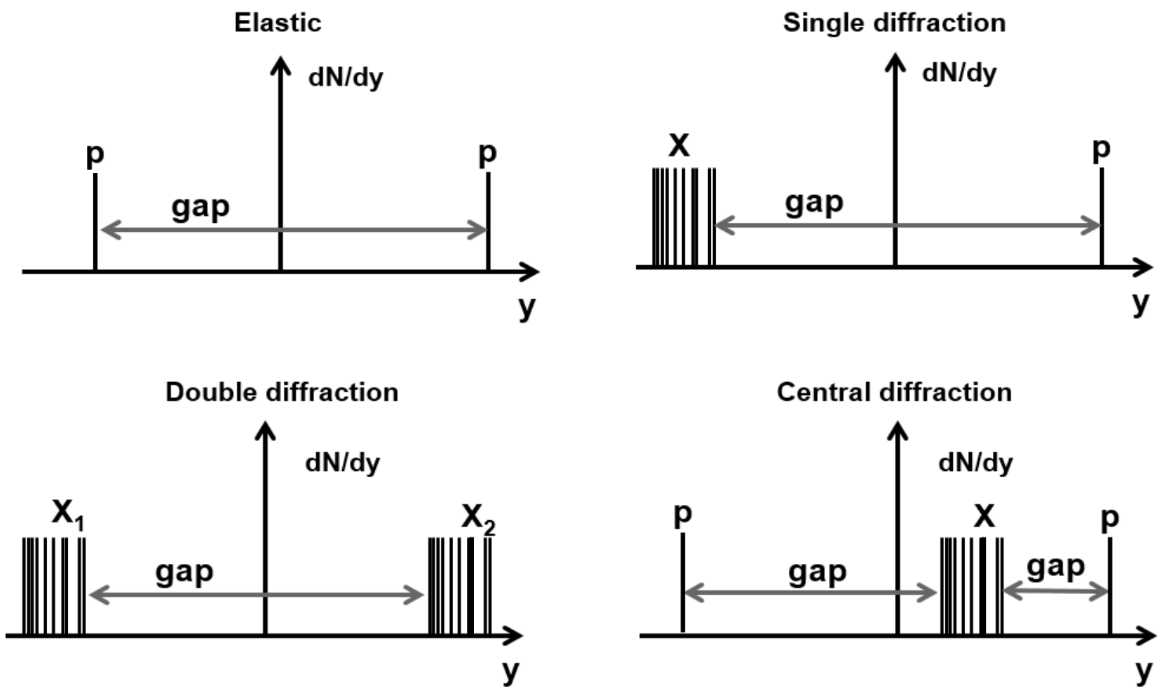
- Two particles passing close to each other …
- They **exchange a colorless object** and they can produce **remnant particles and activity gaps** in the central or forward regions depending on the topology of the interaction.

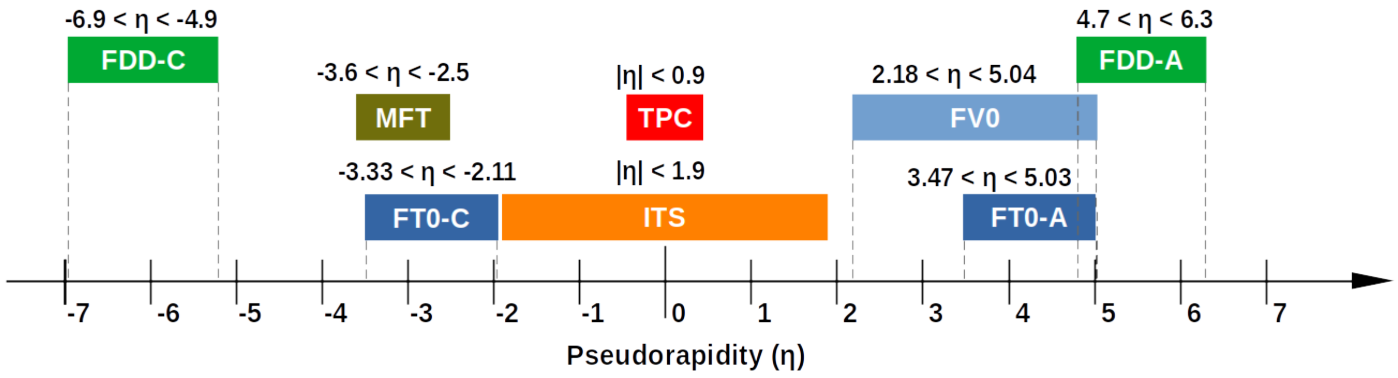
Diffractive events

Event topologies



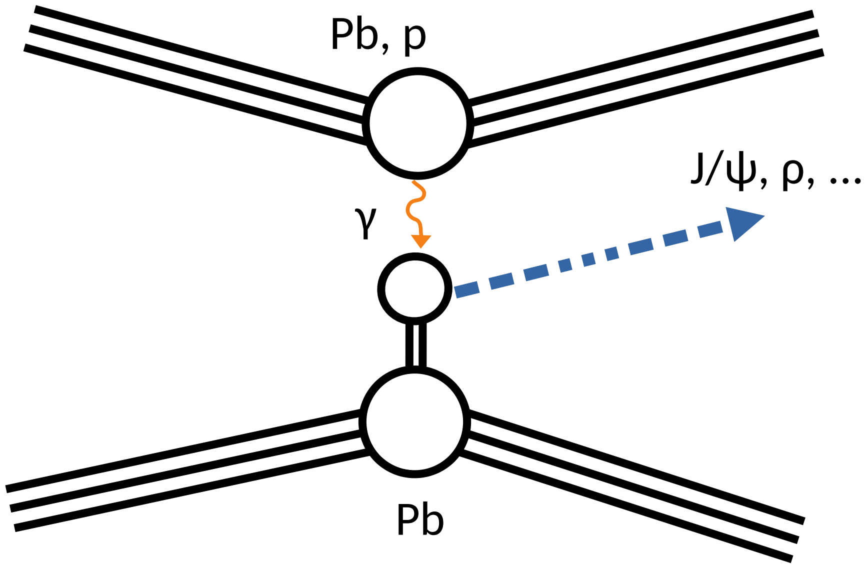
Rapidity gap distributions

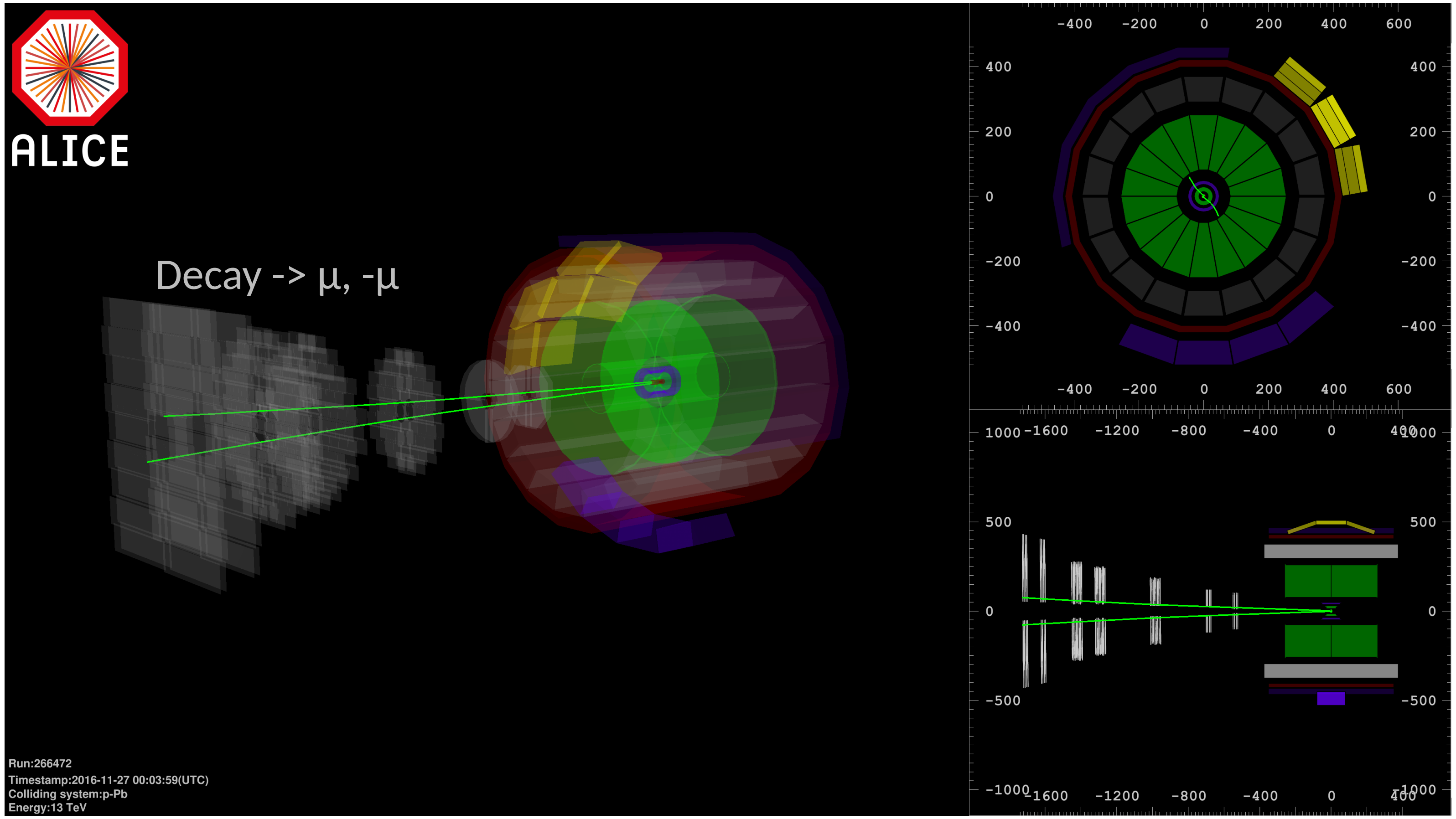




Photon induced events

A photon induced event produce a vector meson that decays in only two particles, producing a clear signal in ALICE.





Paper published with AD

JHEP

Published for SISSA by Springer

Received: *March 1, 2020*
Revised: *April 2, 2020*
Accepted: *May 11, 2020*
Published: *June 4, 2020*

Coherent photoproduction of ρ^0 vector mesons in ultra-peripheral Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV

https://doi.org/10.1007/JHEP06(2020)035

Physics Letters B 817 (2021) 136280

Contents lists available at ScienceDirect

Physics Letters B

www.elsevier.com/locate/physletb

ELSEVIER

First measurement of the $|t|$-dependence of coherent J/ψ photonuclear production

ALICE Collaboration *

https://doi.org/10.1016/j.physletb.2021.136280

Physics Letters B 798 (2019) 134926

Contents lists available at ScienceDirect

Physics Letters B

www.elsevier.com/locate/physletb

ELSEVIER

Coherent J/ψ photoproduction at forward rapidity in ultra-peripheral Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV

ALICE Collaboration *

https://doi.org/10.1016/j.physletb.2019.134926

Eur. Phys. J. C (2021) 81:712
https://doi.org/10.1140/epjc/s10052-021-09437-6

The European Physical Journal C

Regular Article - Experimental Physics

Coherent J/ψ and ψ' photoproduction at midrapidity in ultra-peripheral Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV

ALICE Collaboration*
CERN, 1211 Geneva 23, Switzerland

Received: 24 January 2021 / Accepted: 9 July 2021

https://doi.org/10.1140/epjc/s10052-021-09437-6

Paper published with AD

PHYSICAL REVIEW D **108,** 112004 (2023)

Exclusive and dissociative J/ψ photoproduction, and exclusive dimuon production, in p-Pb collisions at $\sqrt{s_{NN}} = 8.16$ TeV

S. Acharya *et al.*[*]
(ALICE Collaboration)

https://doi.org/10.1103/PhysRevD.108.112004

JHEP

Published for SISSA by Springer

Received: *June 7, 2023*
Revised: *August 8, 2023*
Accepted: *October 4, 2023*
Published: *October 20, 2023*

Energy dependence of coherent photonuclear production of J/ψ mesons in ultra-peripheral Pb-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV

https://doi.org/10.1007/JHEP10(2023)119

PHYSICAL REVIEW LETTERS **132,** 162302 (2024)

Editors' Suggestion

First Measurement of the $|t|$ Dependence of Incoherent J/ψ Photonuclear Production

S. Acharya *et al.*[*]
(ALICE Collaboration)

https://doi.org/10.1103/PhysRevLett.132.162302

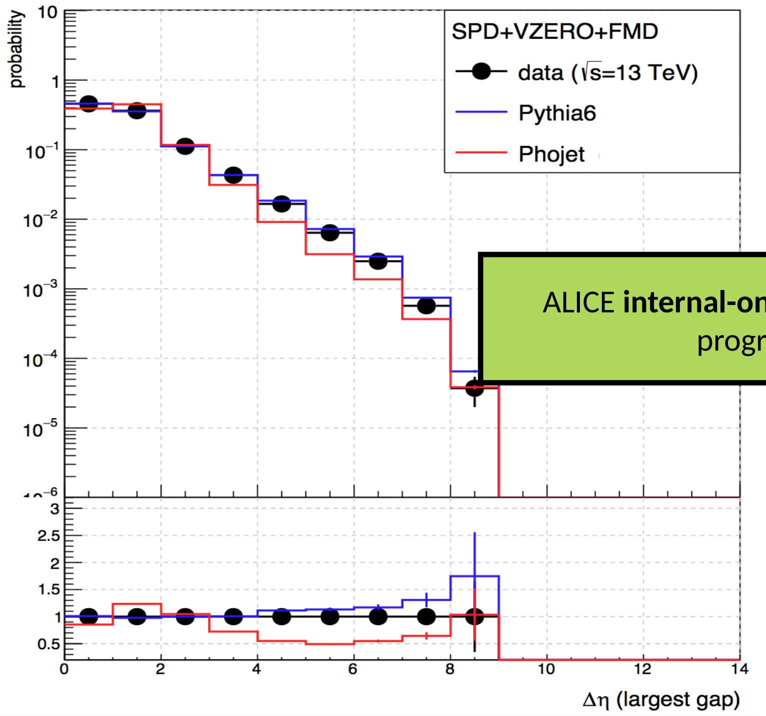
Final comments

- FDD is contributing to the **beam monitoring tasks**:
  - FDD is crucial to tag **beam-gas** events in high interaction collisions due to its **sensitivity from both direction (A and C sides)**.
- Show a good performance for **vertex time measurement**.
- Can contribute to the studies of **diffraction** and **ultra-peripheral collisions**.
- **VdM** data can be use to **calculate the cross section**.

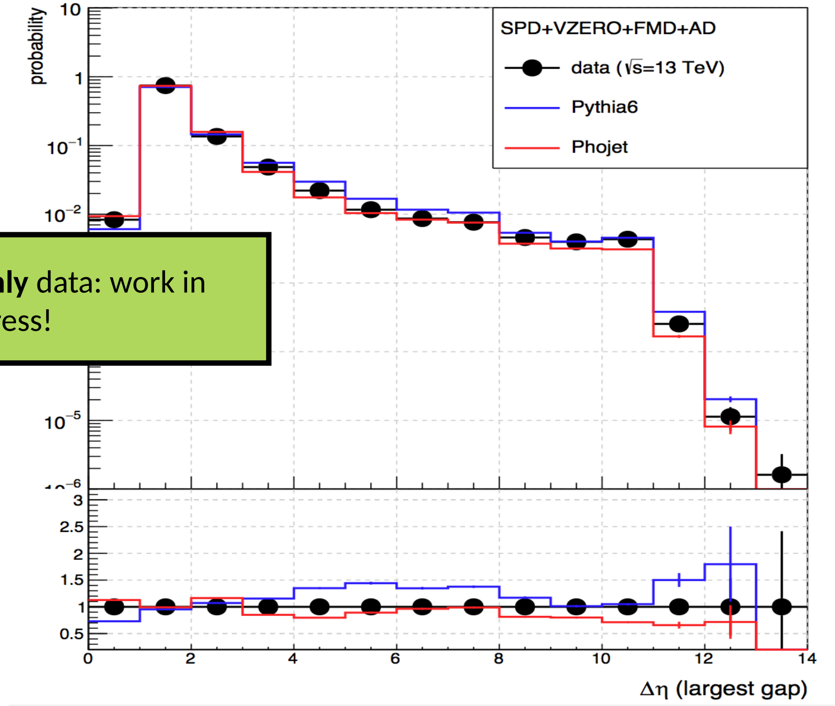
Backup

AD preliminaries

E. Calvo



ALICE **internal-only** data: work in progress!



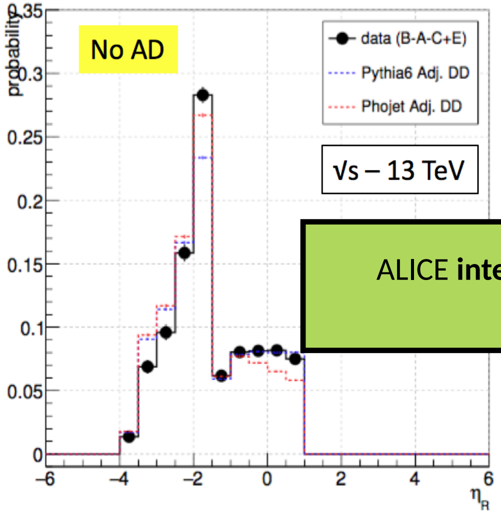
Same analysis as in
Eur. Phys. J. C 73 (2013) 2456

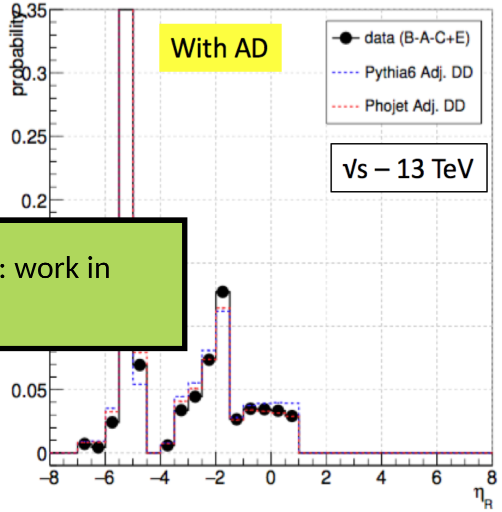
Distribution of the largest pseudorapidity gap in 2-arm events (DD), as defined in [Eur. Phys. J. C 73 (2013) 2456], showing on the **left the distribution without AD** and on the **right the distribution with AD**.

AD Upgrade for LHC Run 3 The ALICE Forward Diffraction Detector (FDD) DRAFT PROPOSAL, The FDD Collaboration.

AD preliminaries

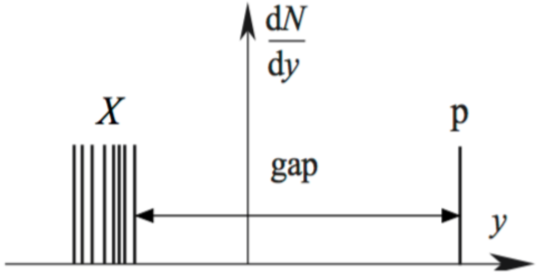
E. Calvo

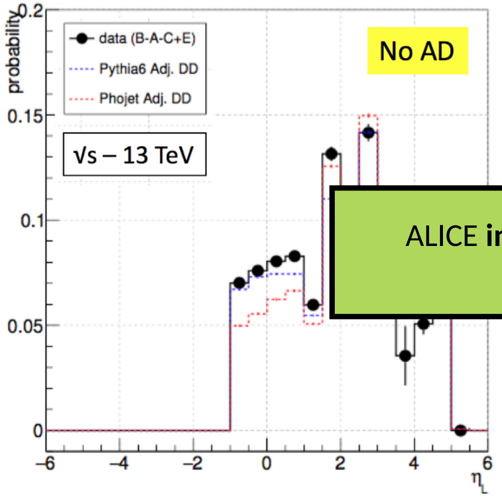


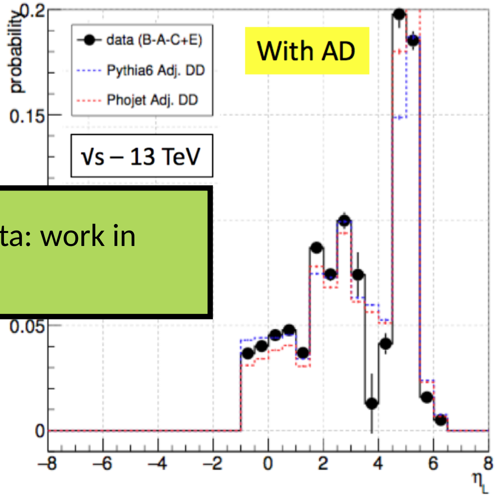


ALICE **internal-only** data: work in progress!

SD on C side







ALICE **internal-only** data: work in progress!

SD on A side

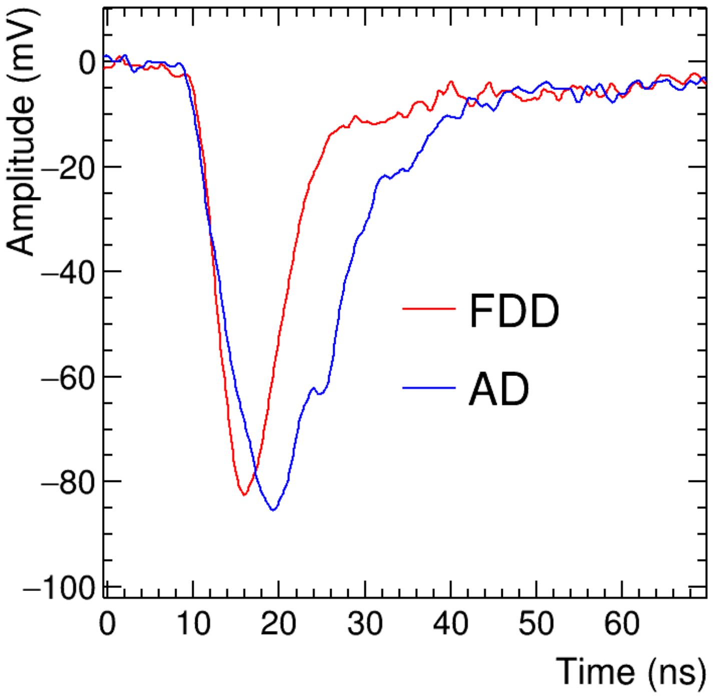
Same analysis as in
Eur. Phys. J. C 73 (2013) 2456

AD Upgrade for LHC Run 3 The ALICE Forward Diffraction Detector (FDD) DRAFT PROPOSAL, The FDD Collaboration.

Performance – Time signal width

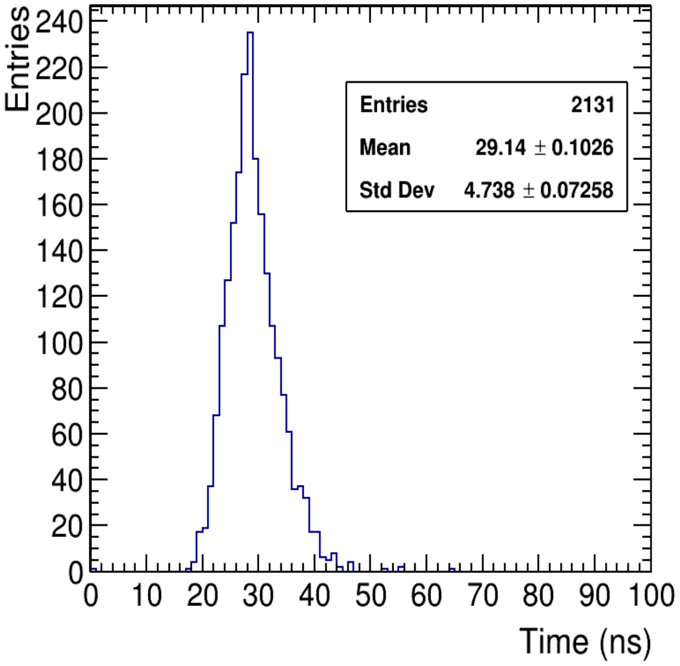
The **reduction of the signal time width** of FDD with respect to AD was achieved by using materials with a better timing response in the construction of the pads. Tests were performed with cosmic muons.

Example of two signals with similar amplitudes triggered by a cosmic muon.

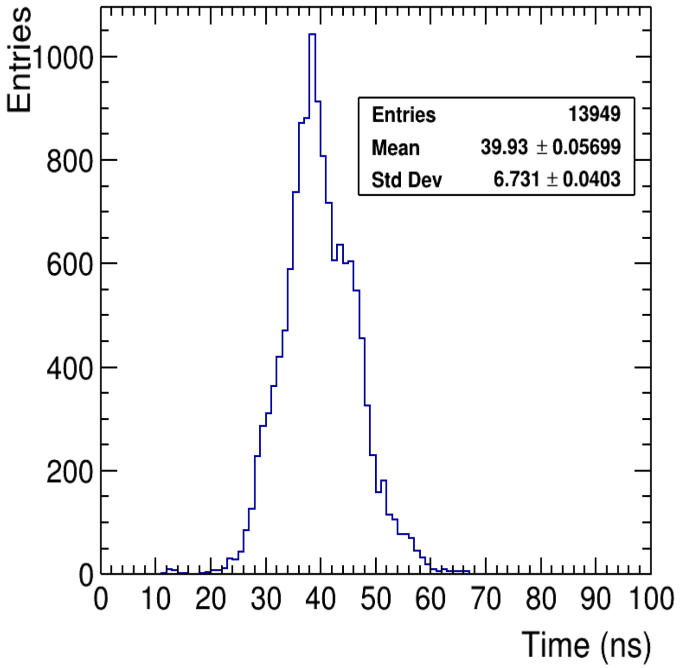


Distributions of the AD and FDD time width signals at 10% of the maximum amplitude.

FDD Width = 29.14 ns

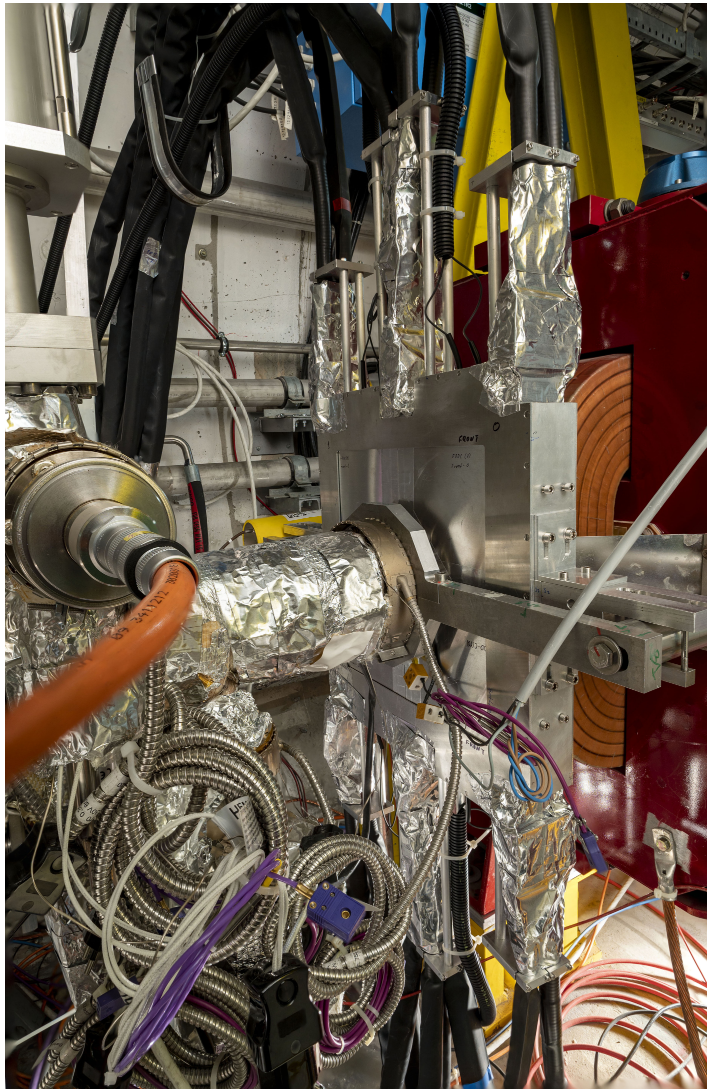


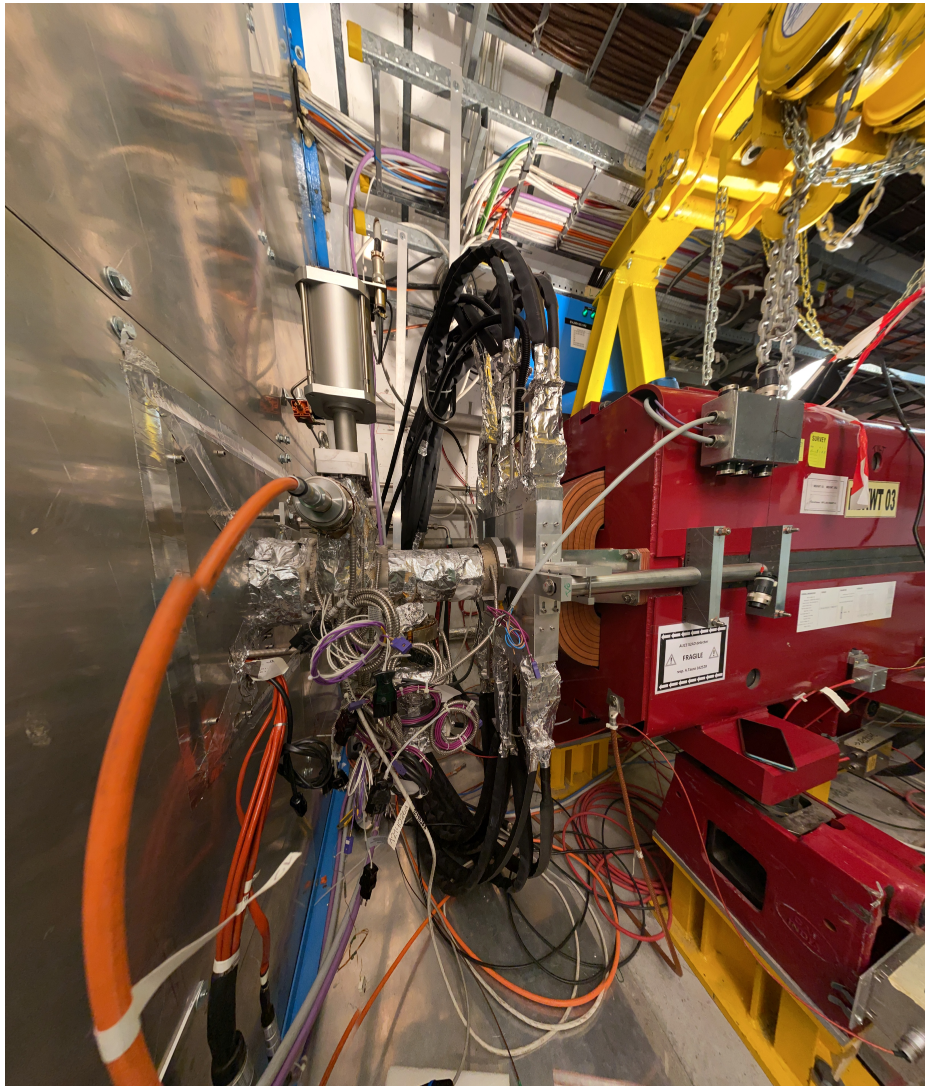
AD Width = 39.93 ns

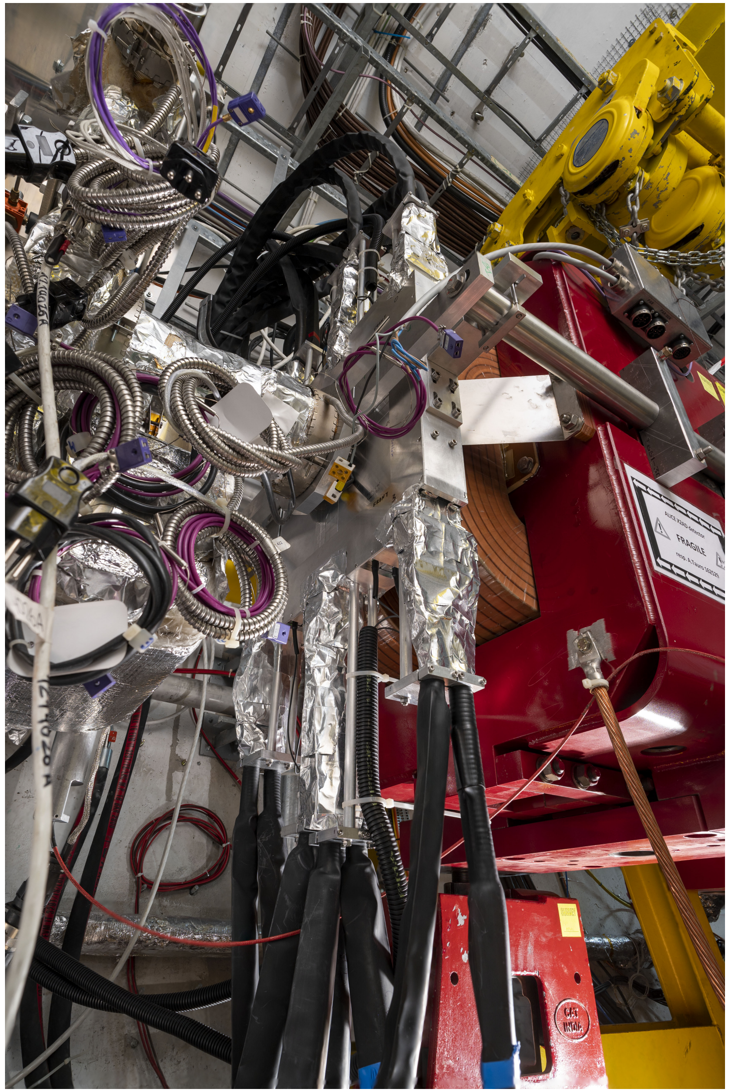


View form the tunnel

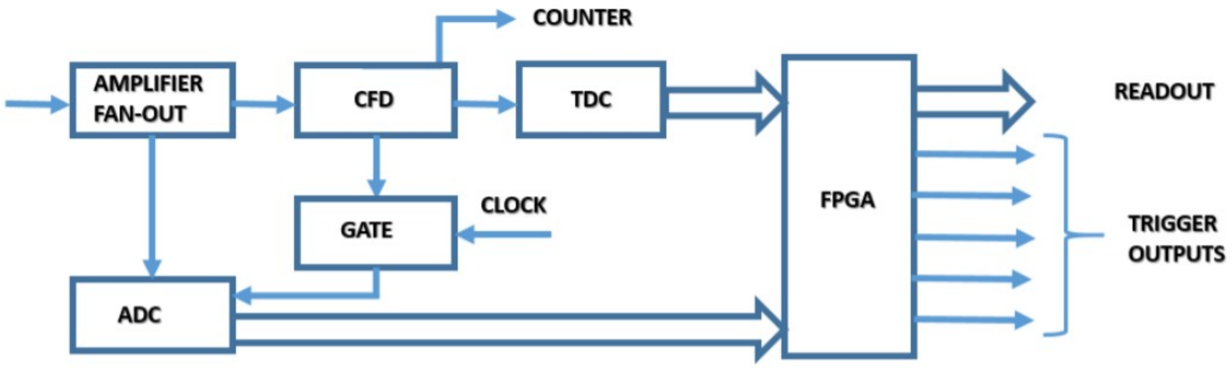
More pictures

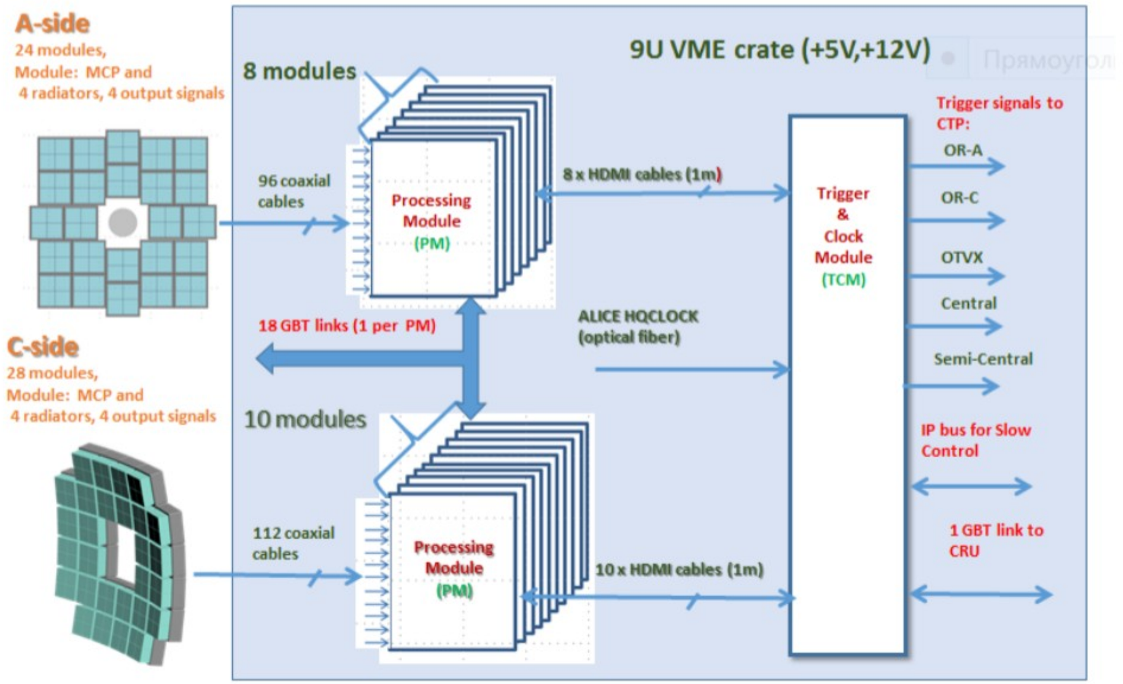


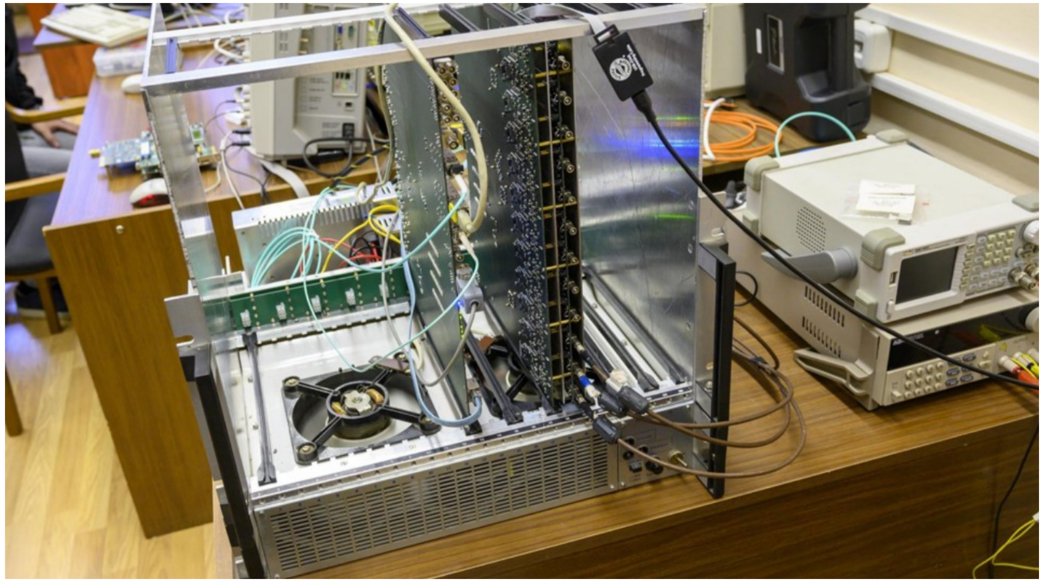


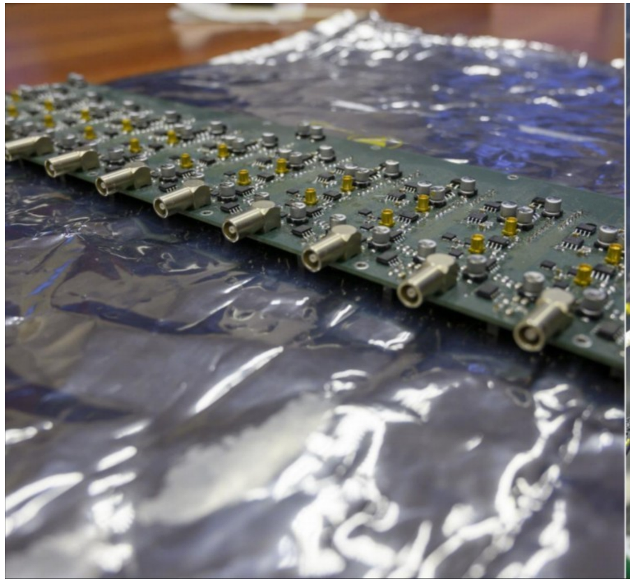


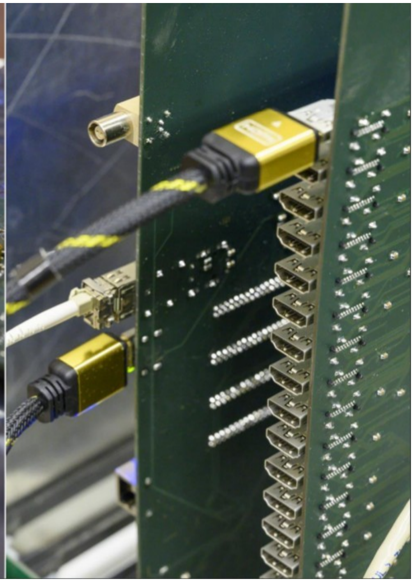
FIT - Front End Electronics





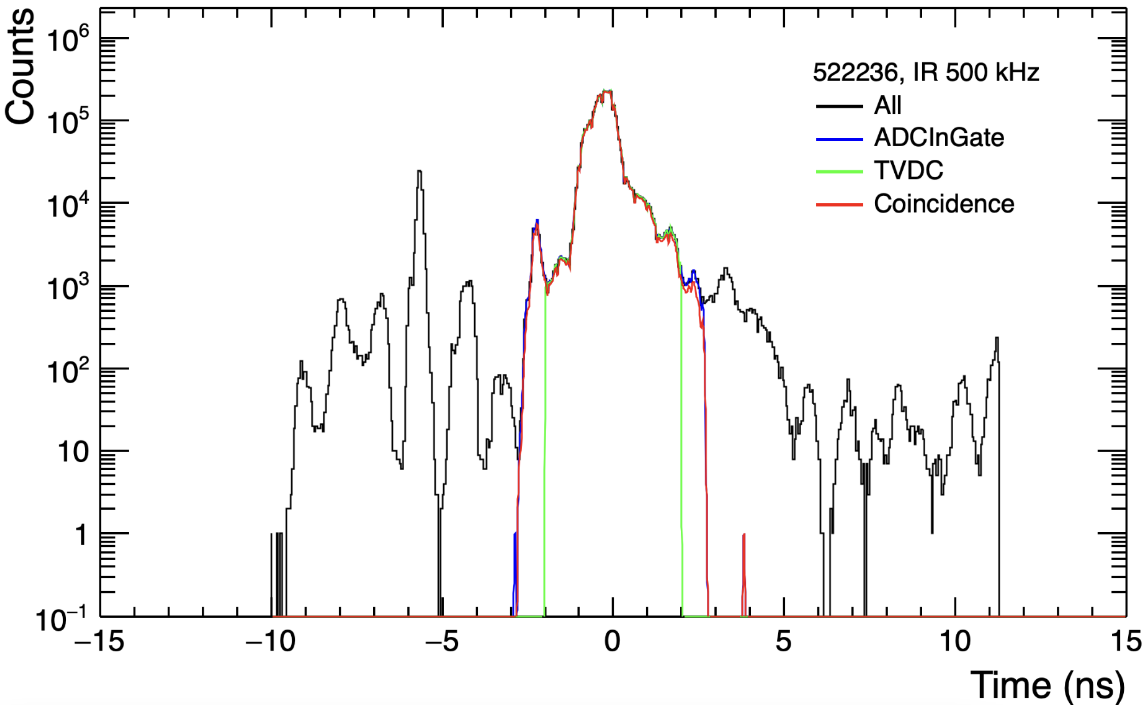




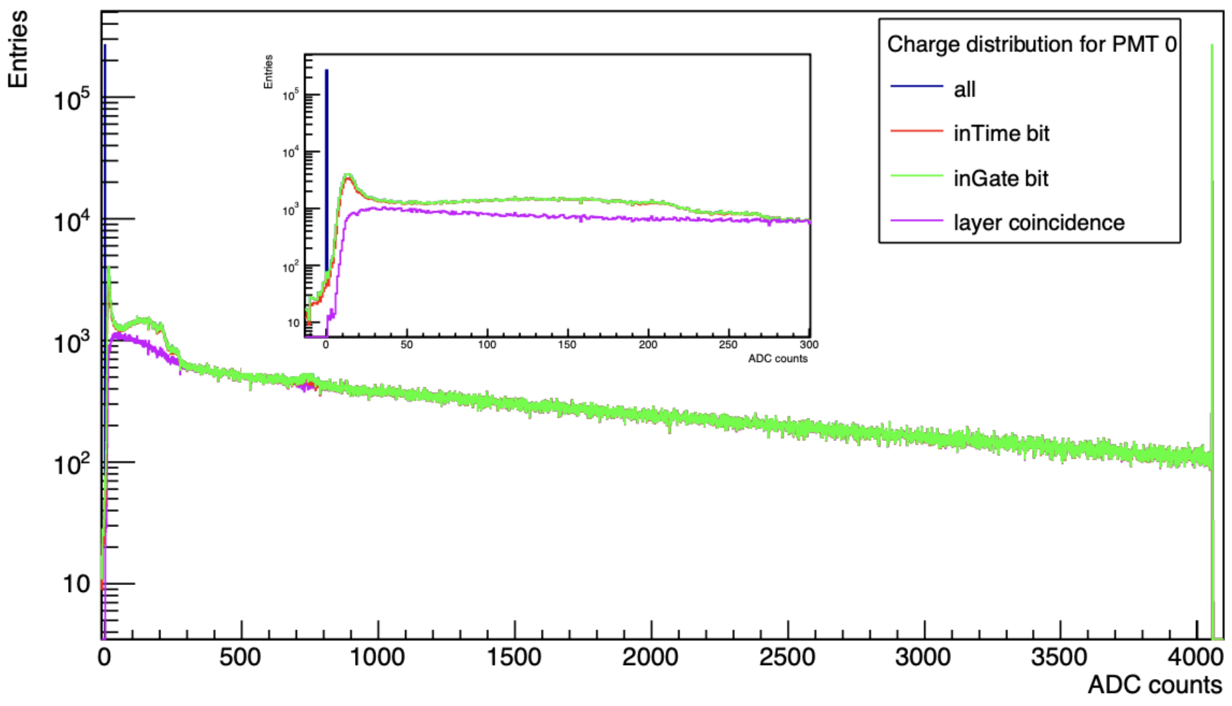


Time and Charge distributions

Time distribution of one channel



Charge distribution of one channel



Not optimized time and charges for FDD with previous FEE electronics.

- New electronics installed on Monday (14.11.2022) and being tested to improve time distribution.
- New mezzanine boards will reduce the noise and allow us to chose settings which will reduce the saturation.

Run number: 520296