Forward Diffractive Detector status and plans

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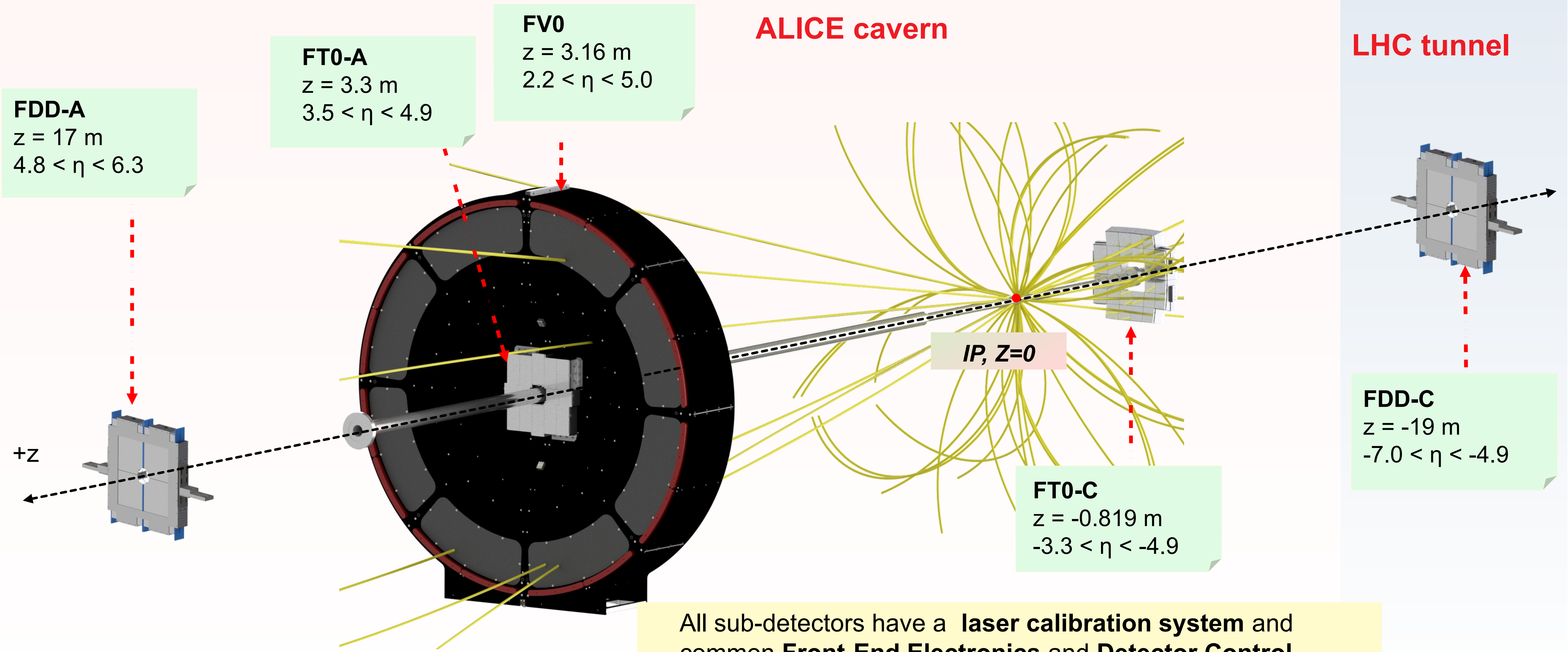
14.Sept.2023

FDD- Introduction

The **Forward Diffractive Detector** (FDD) is the **upgrade** of AD 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.

FIT layout

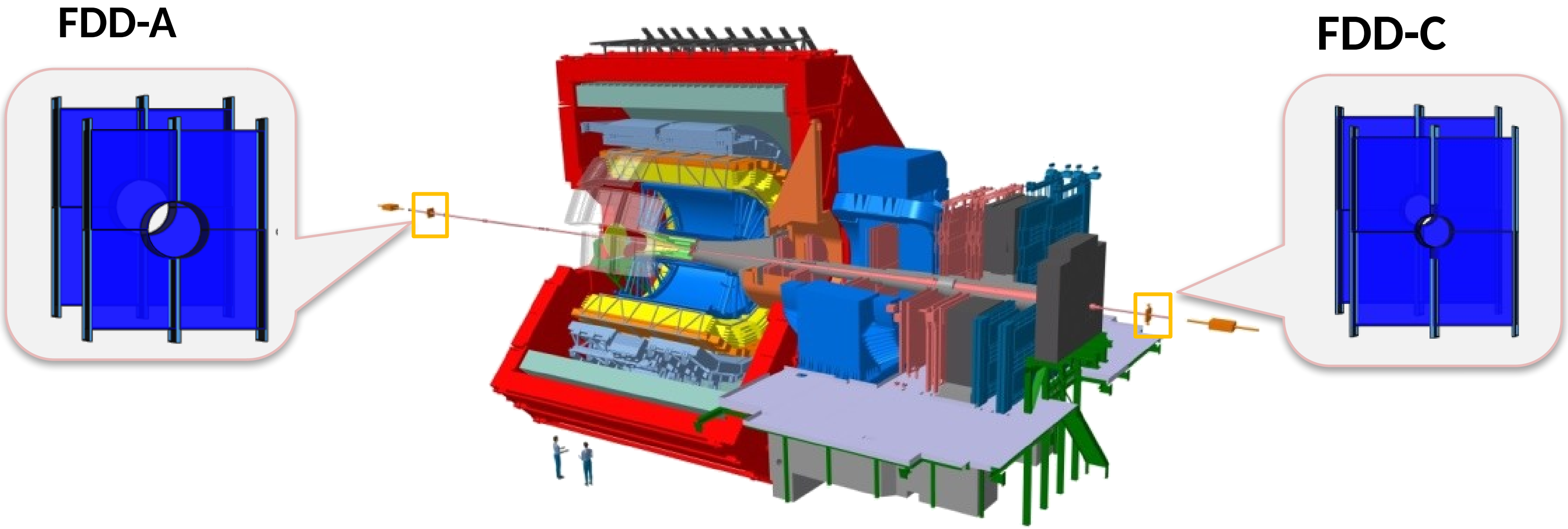


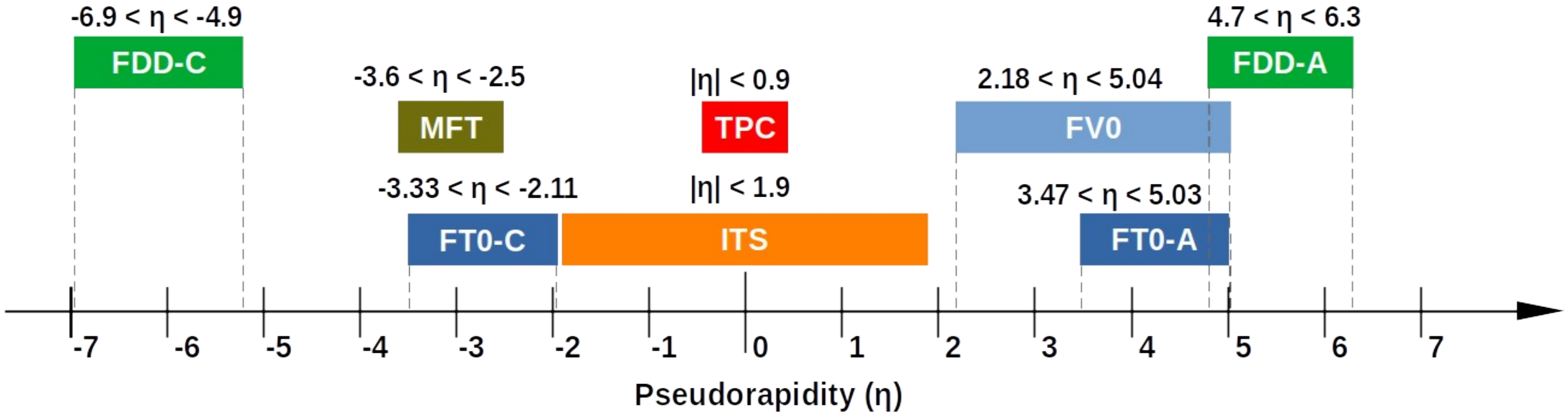
All sub-detectors have a **laser calibration system** and common **Front-End Electronics** and **Detector Control System**.

FDD placement

This forward coverage allows ALICE to:

- **Select diffractive events** down to diffractive masses of a few GeV/c².
- Veto particle production in the forward regions to obtain **clean samples of ultra-peripheral and diffraction events**.

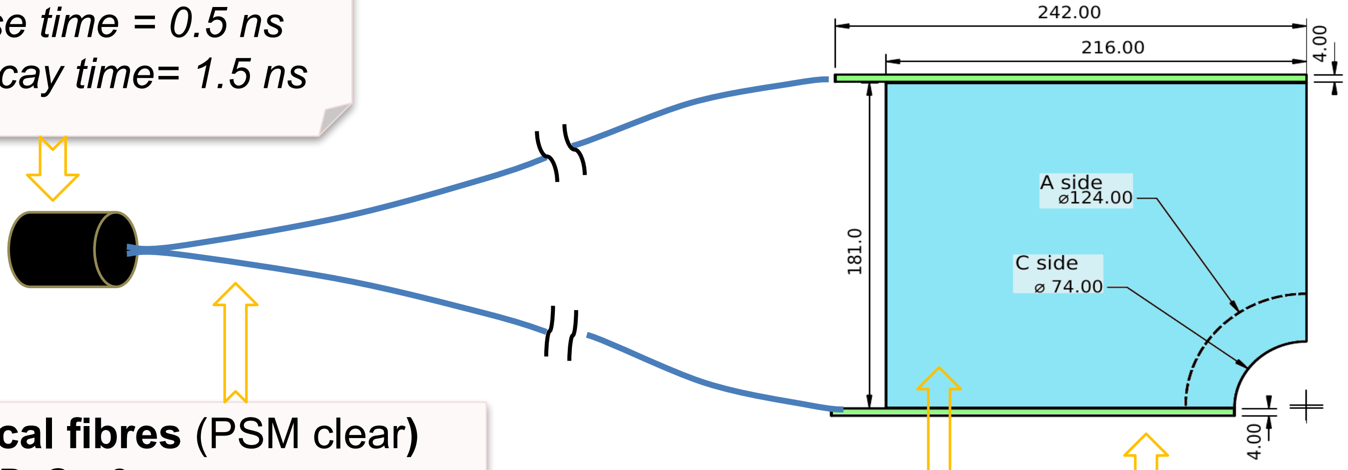


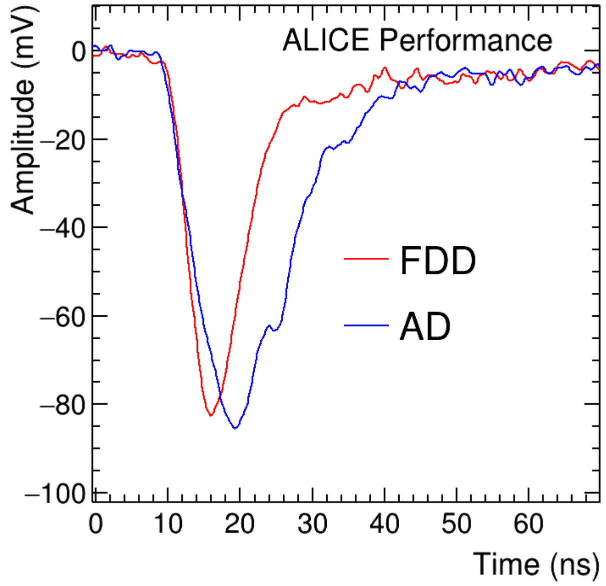


Materials

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*





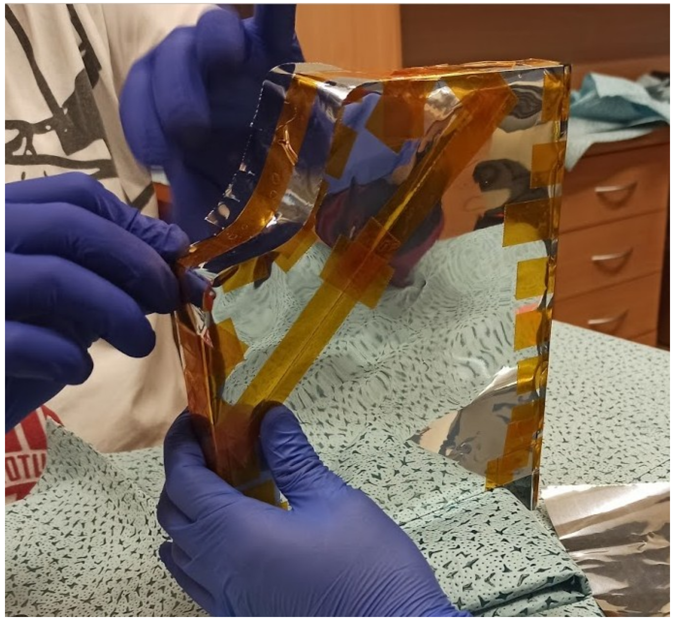
Optical fibres (PSM clear**)**
- *FDD-C : 3 m*
- *FDD-A : 1 m and 0.57 m*

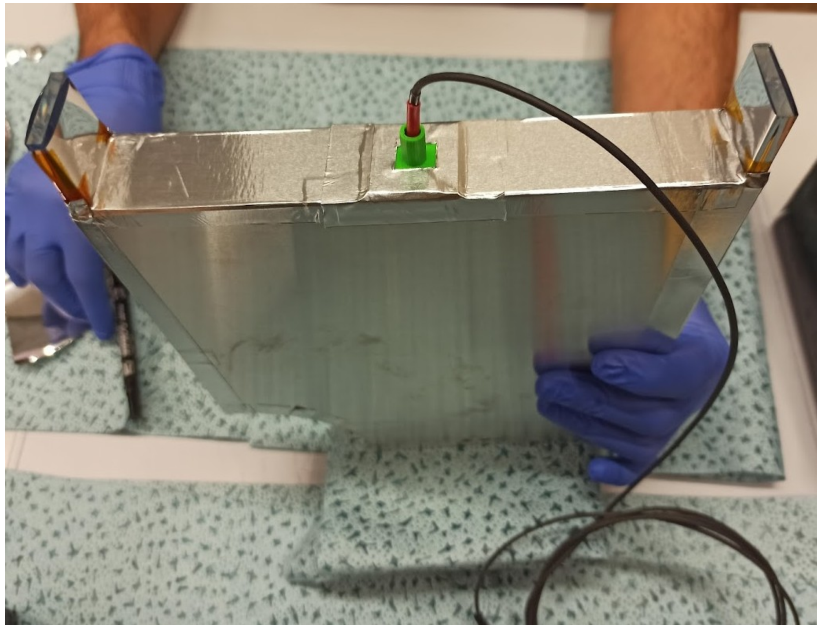
Plastic scint. (BC-420)
- *Rise time= 0.5 ns*
- *Decay time= 1.5 ns*

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

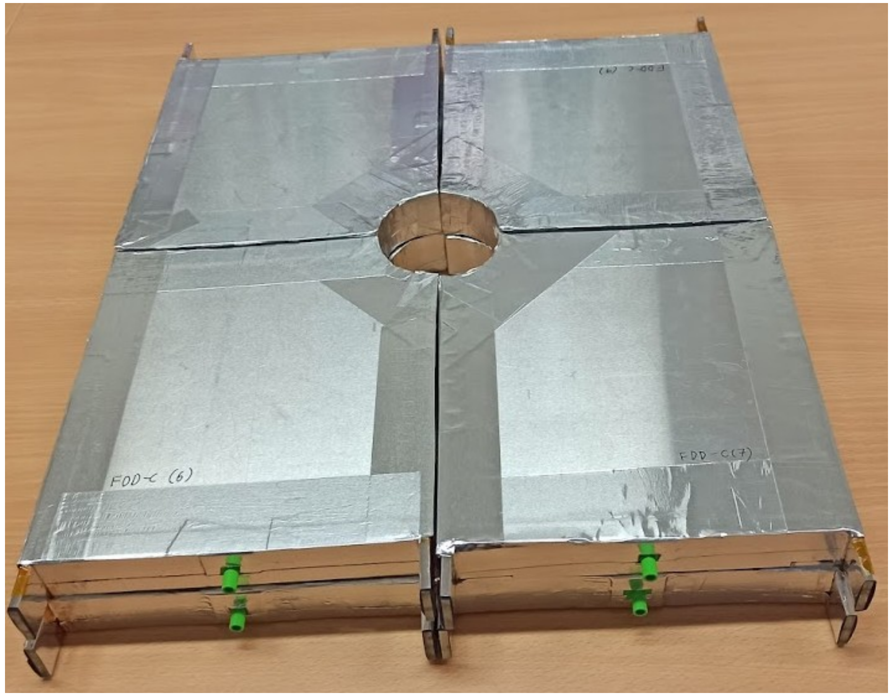
Pads Construction

Pads wrapping

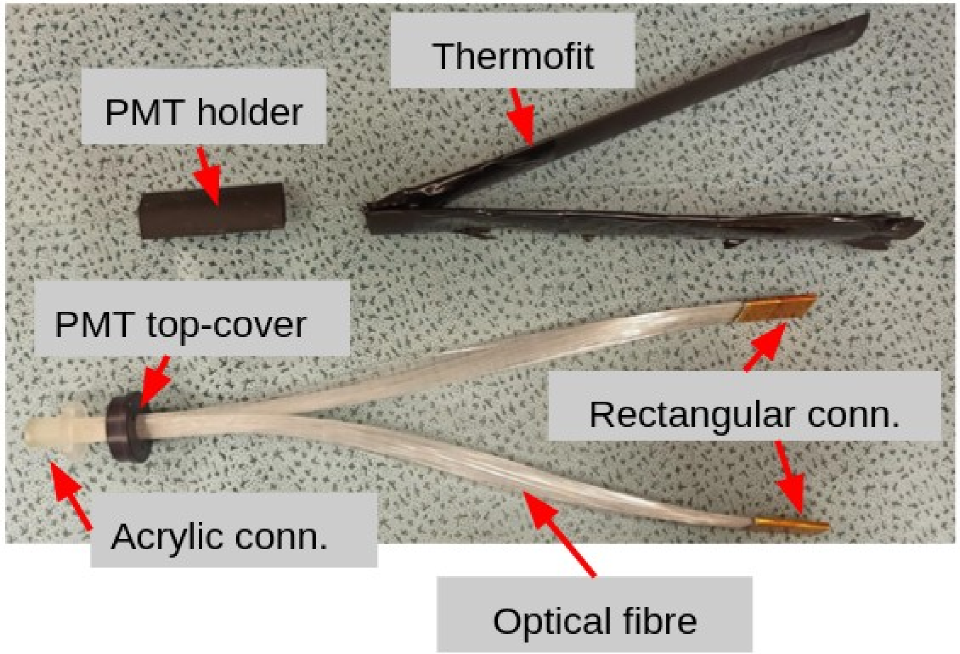


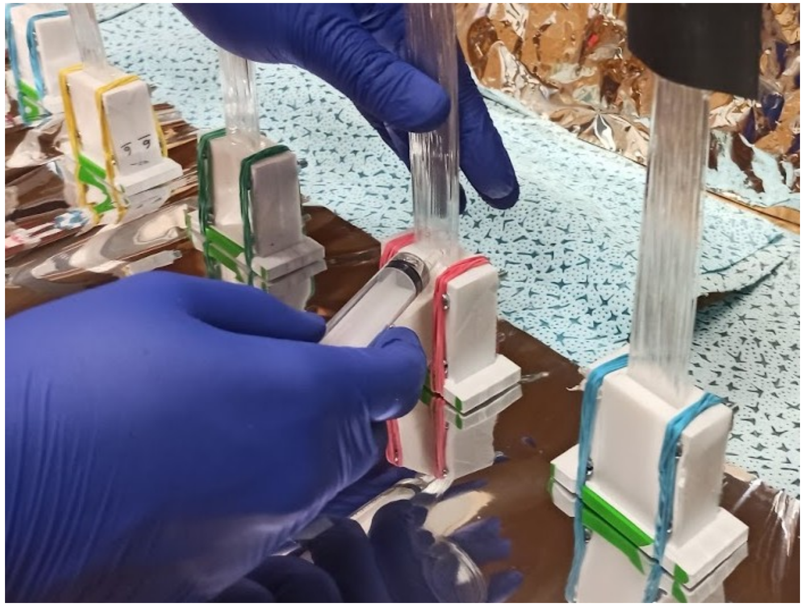


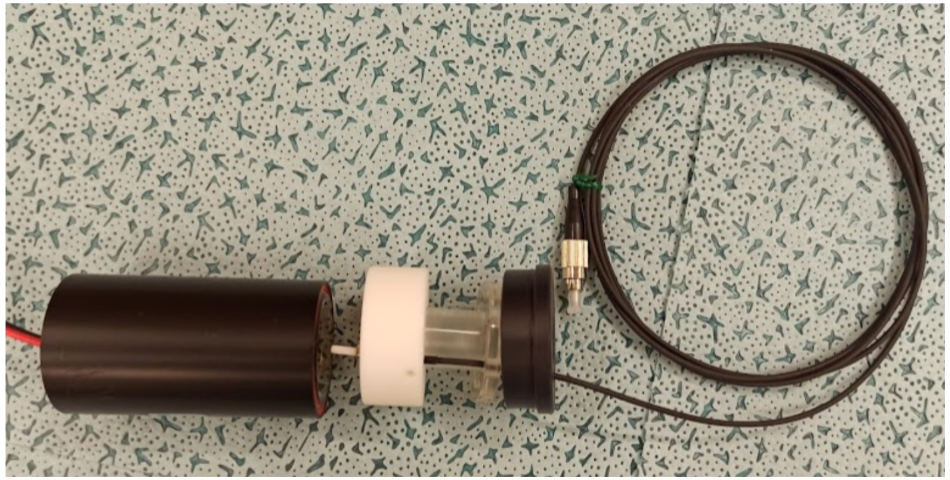
Module assembled

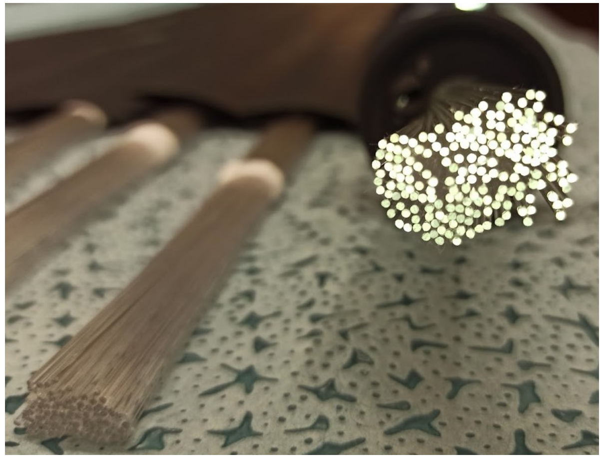


Fibre bundles





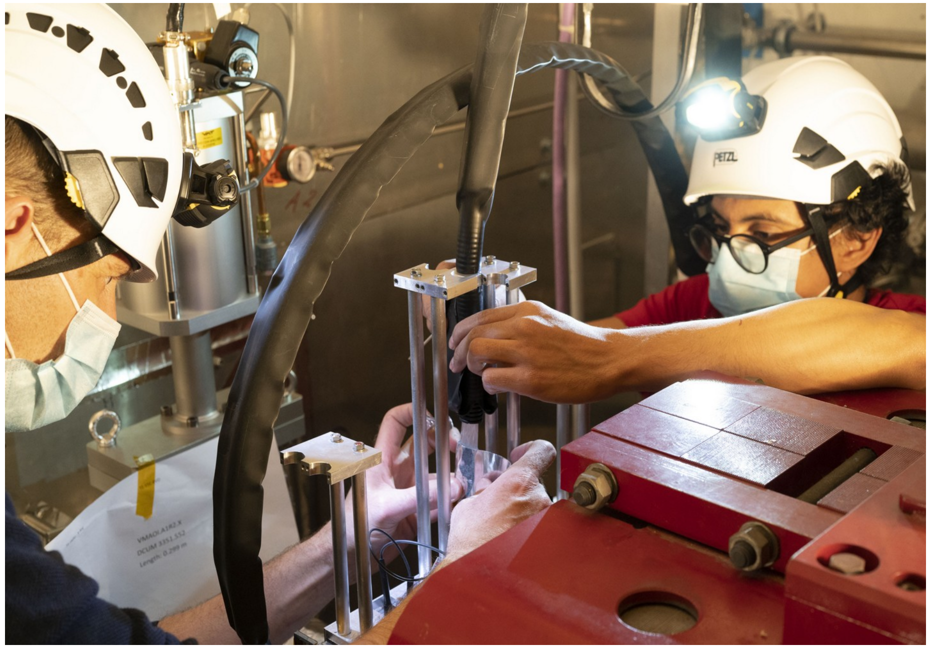




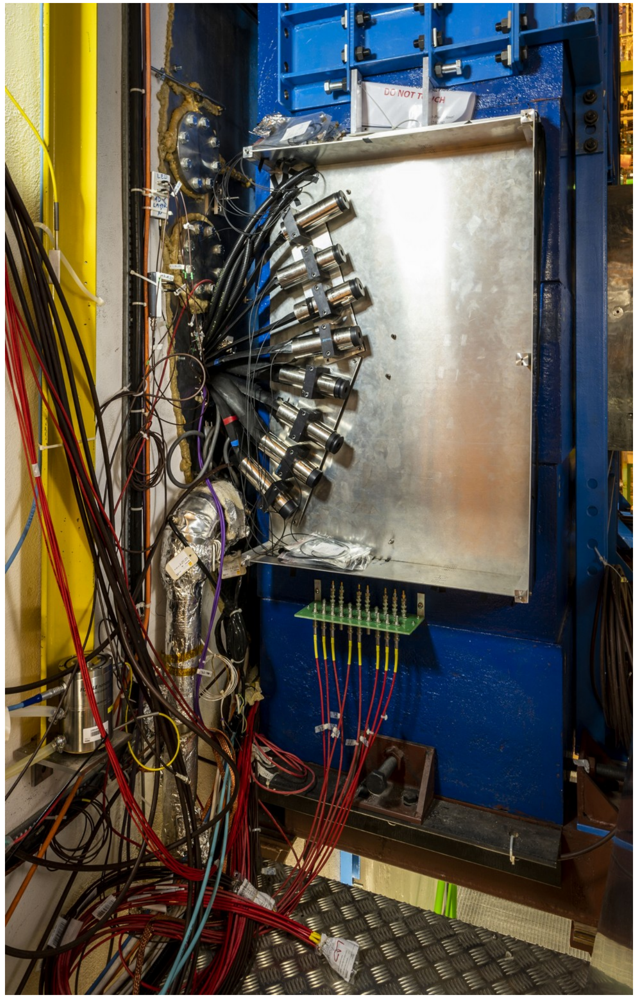
FDD-C installation

22.02.2021

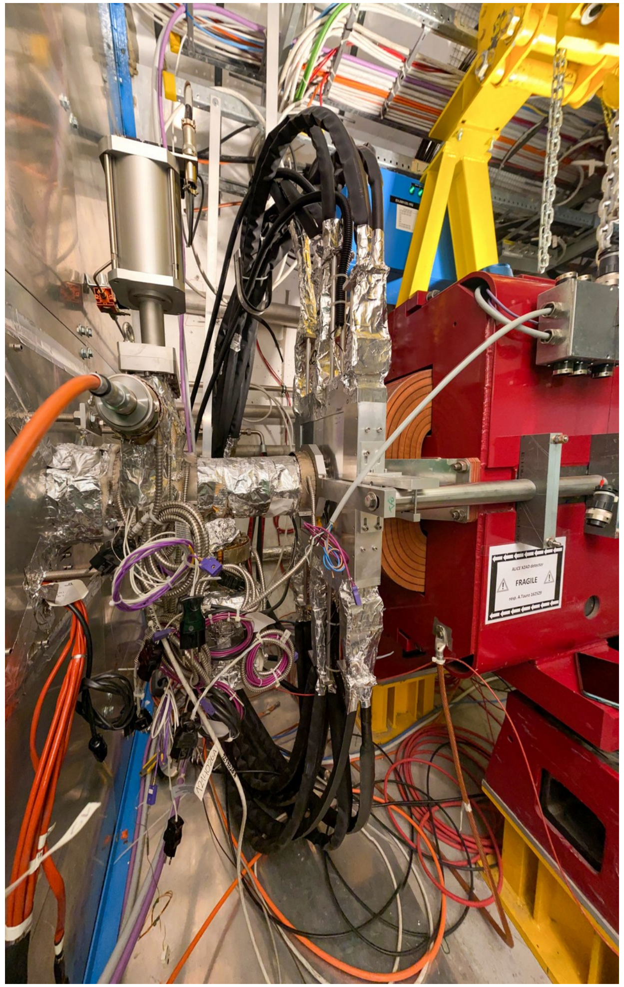
Fibre bundles installation



ALICE cavern - PMTs

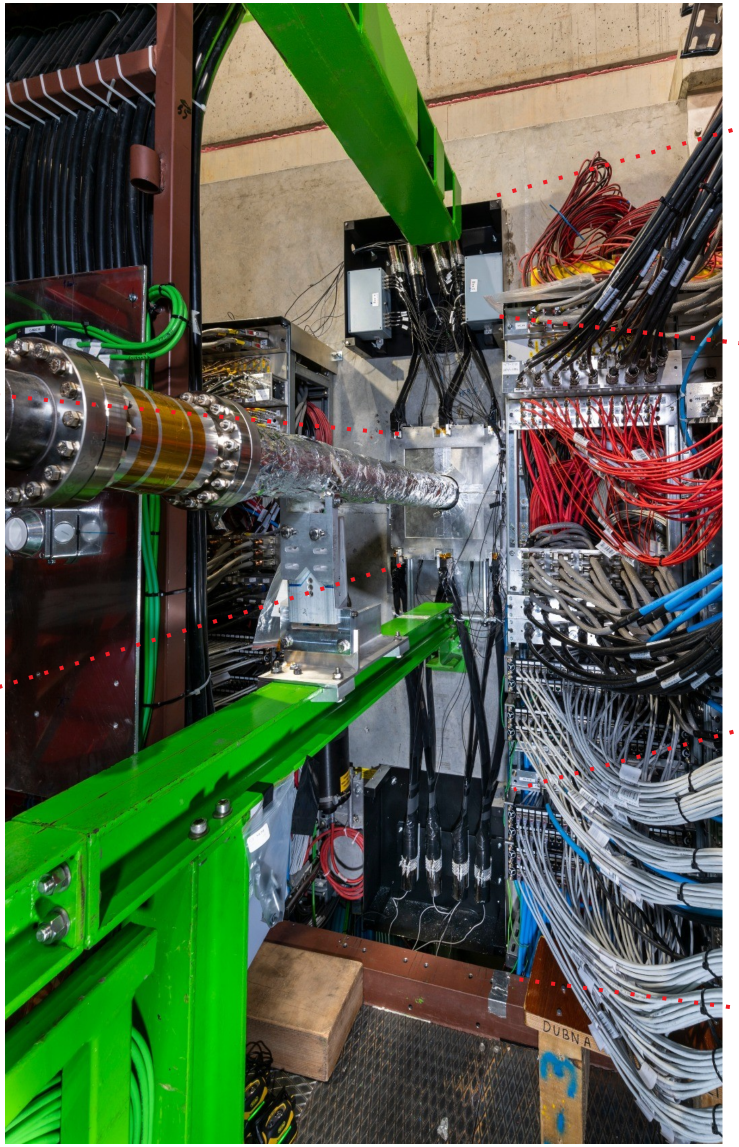


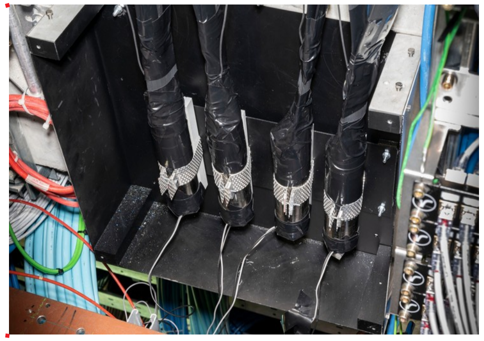
LHC tunnel – FDD-C



FDD-A installation

14.07.2021

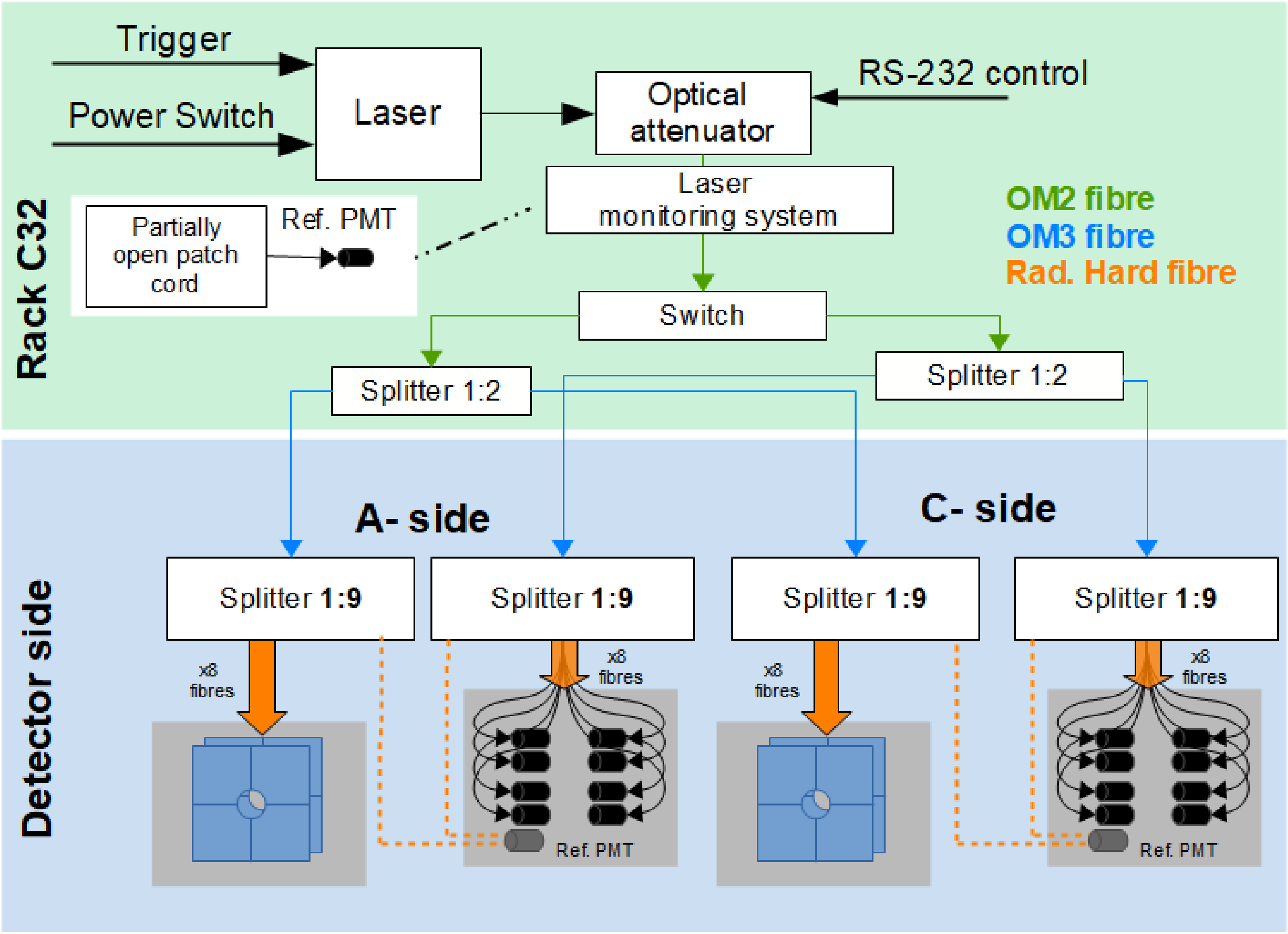




Laser calibration system

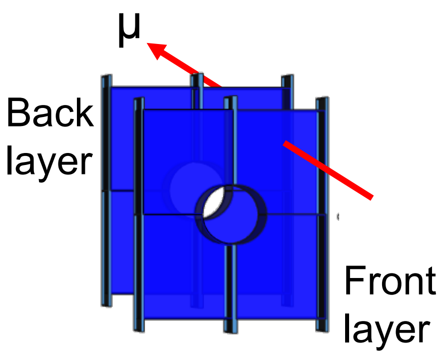
The laser calibration system will allow the monitoring of the detector to adjust parameters to guarantee the best performance.
In summary this system will be used to perform:

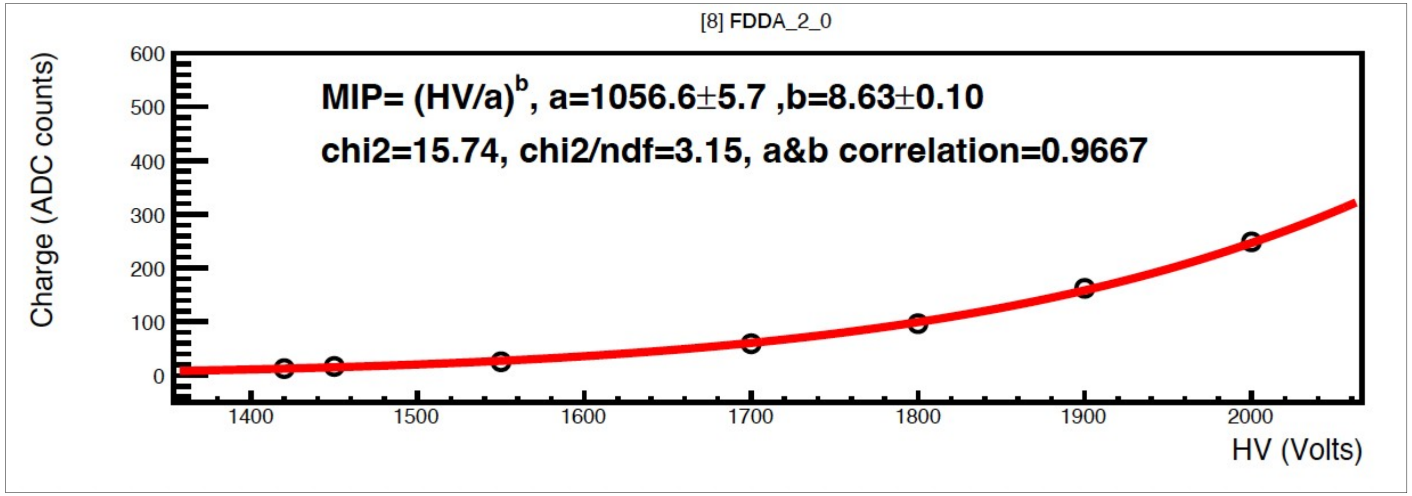
- Amplitude and time calibration
- Quality assurance
- Monitoring of the gain and aging of the components, such as the PMTs and plastic scintillators.

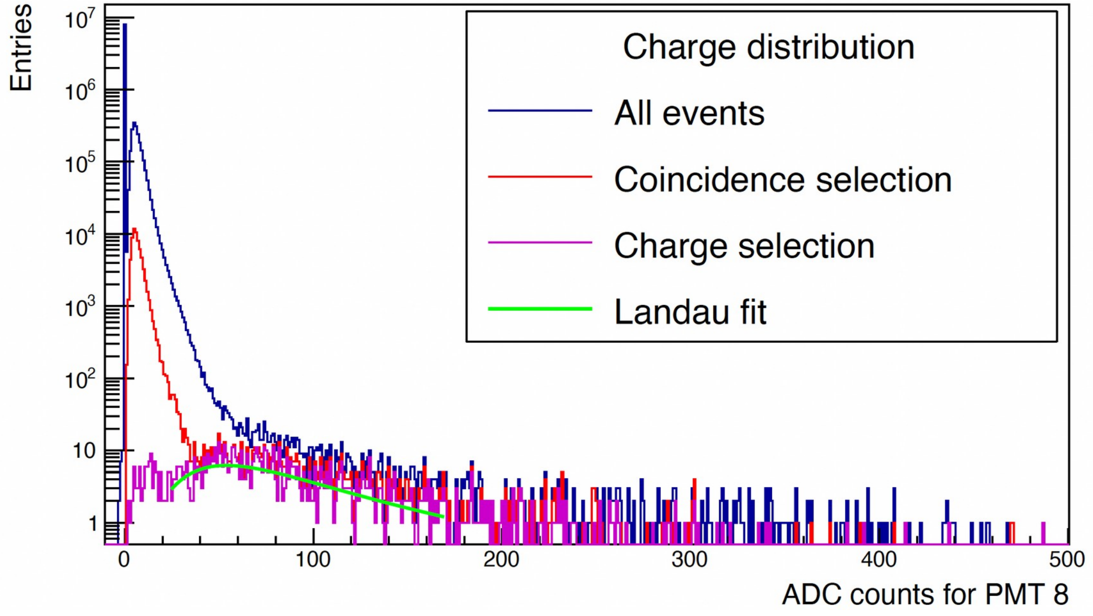


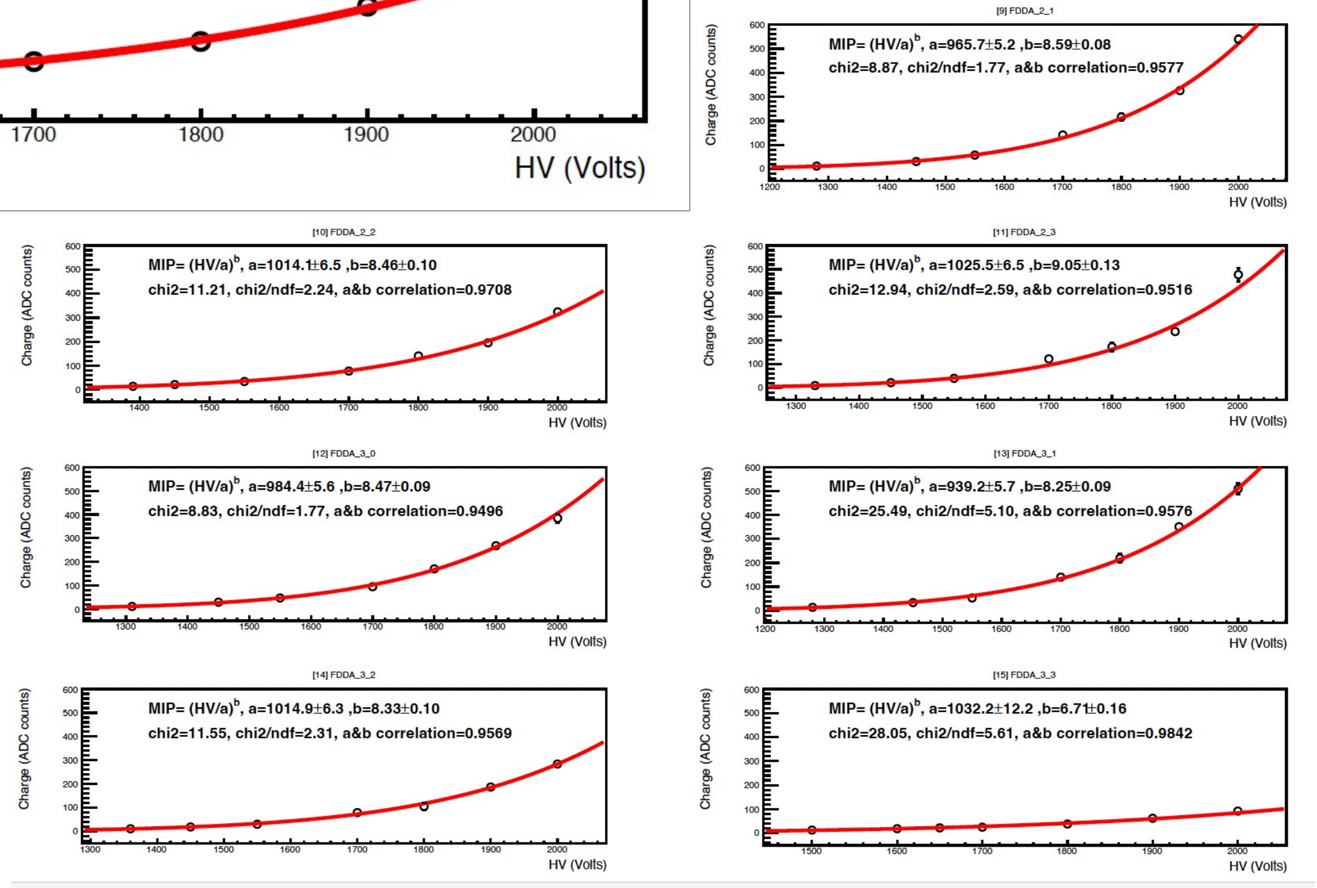
Wavelength = 405 nm

Calibration with cosmic muons





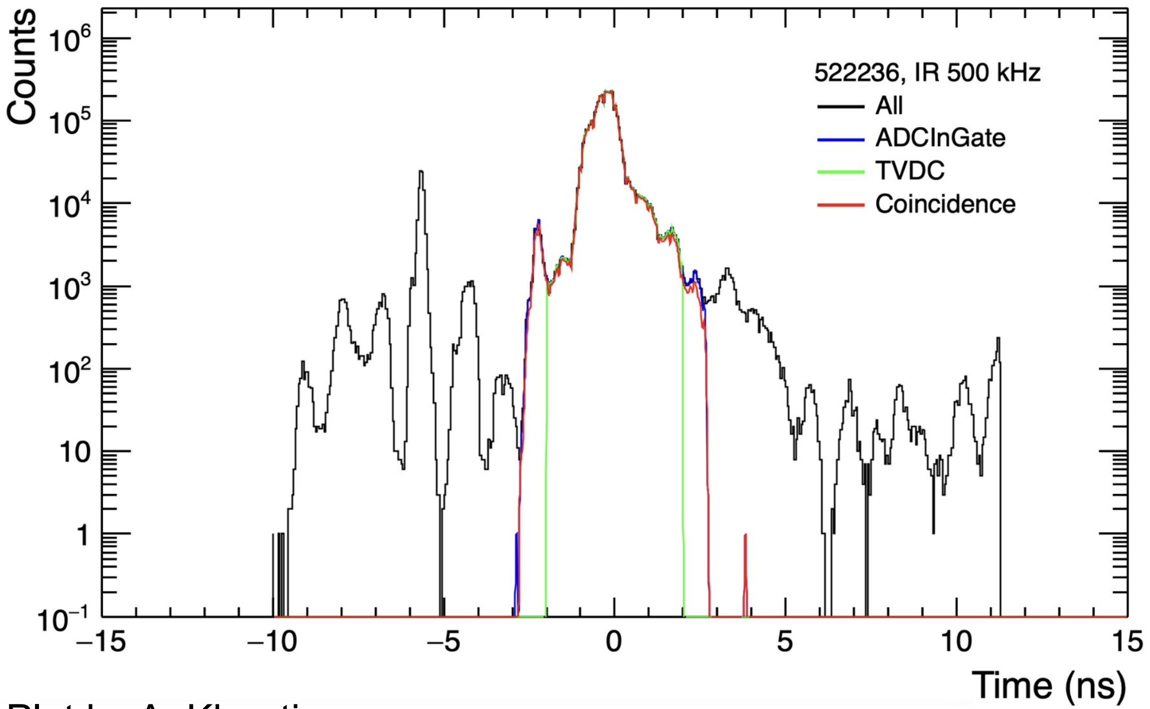




Plots by V. Zabloudil

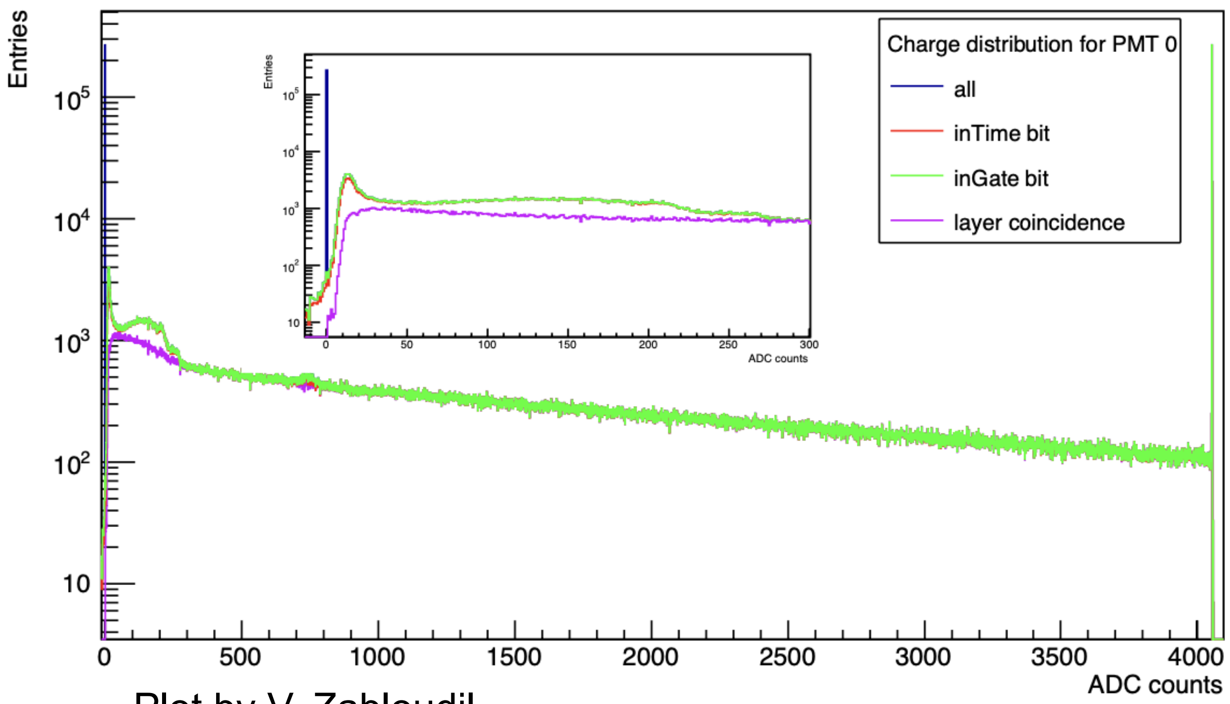
Time and Charge distributions
(old mezzanine boards)

Time distribution of one channel



Plot by A. Khuntia

Charge distribution of one channel



Plot by V. Zabloudil

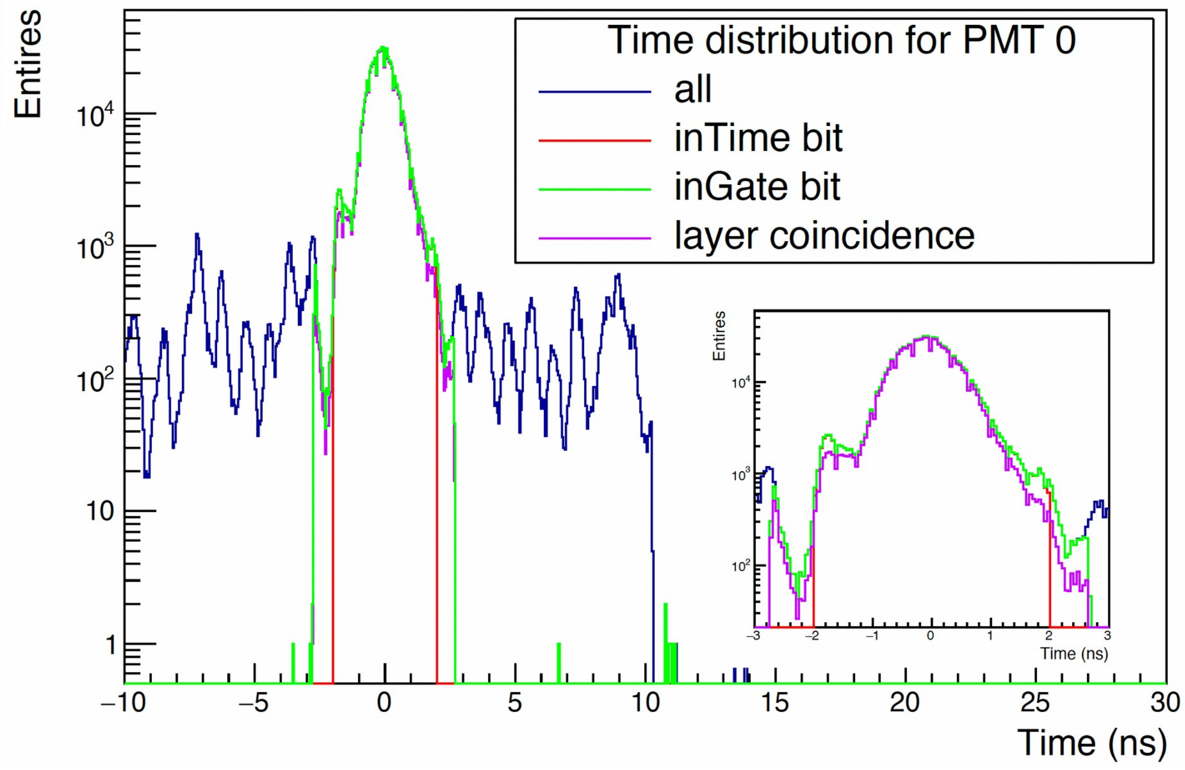
Not optimized time and charges for FDD with previous FEE electronics.

- New electronics installed on Monday (14.11.2022) to improve time distribution.

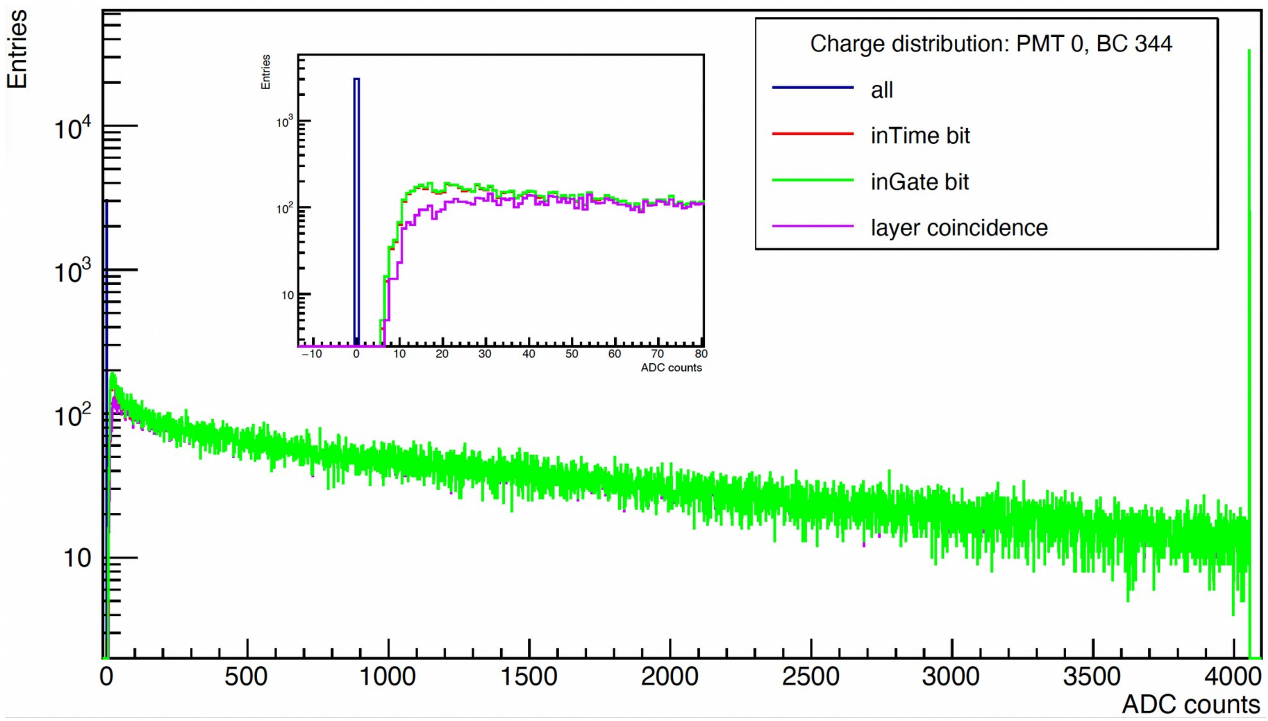
Time and Charge distributions
(new mezzanine boards)

Proton-Proton collision at 900 GeV, 8 colliding bunches in ALICE

Time distribution of one channel



Charge distribution of one channel



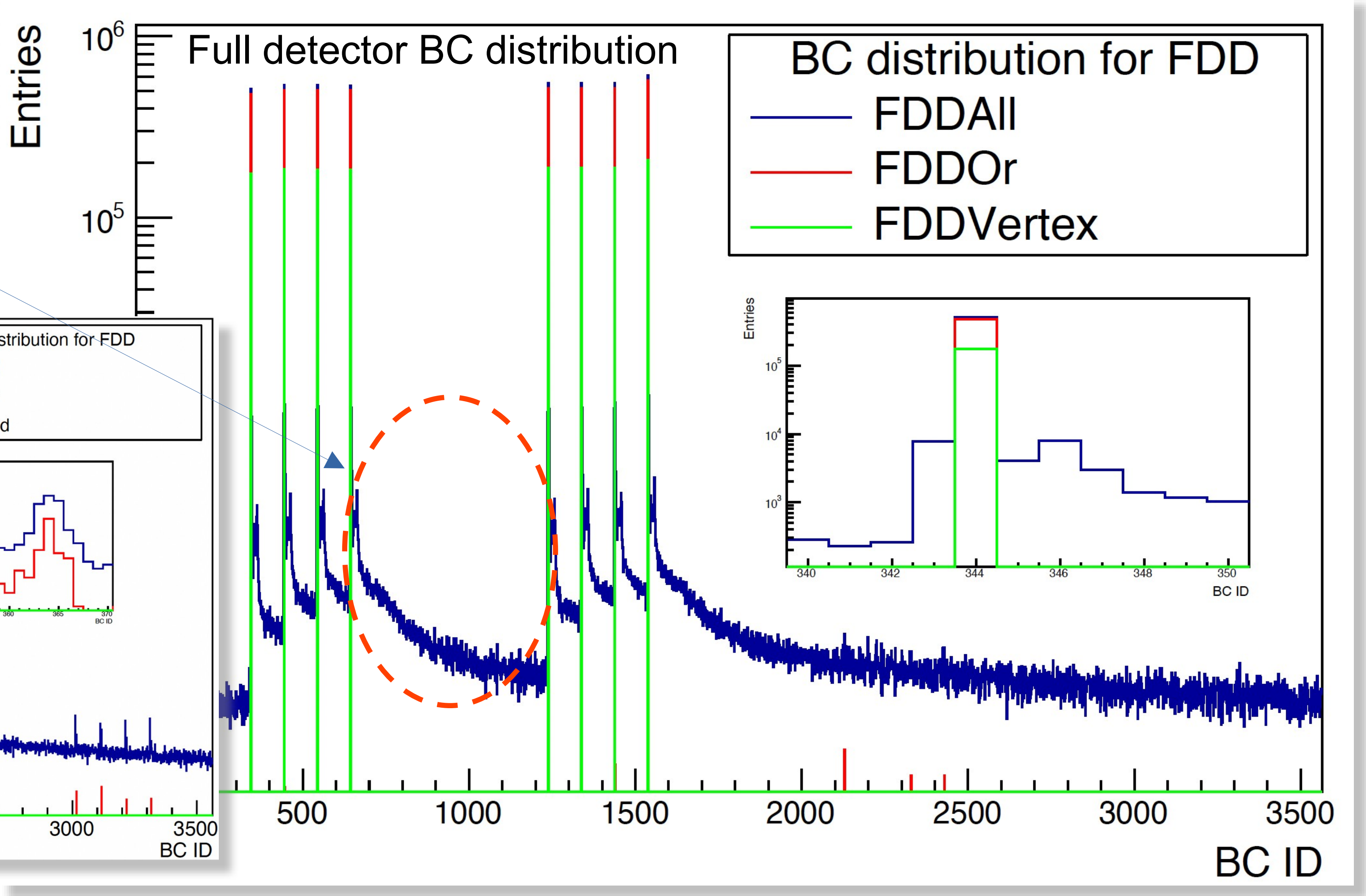
Plots by V. Zabloudil

Run 534265.

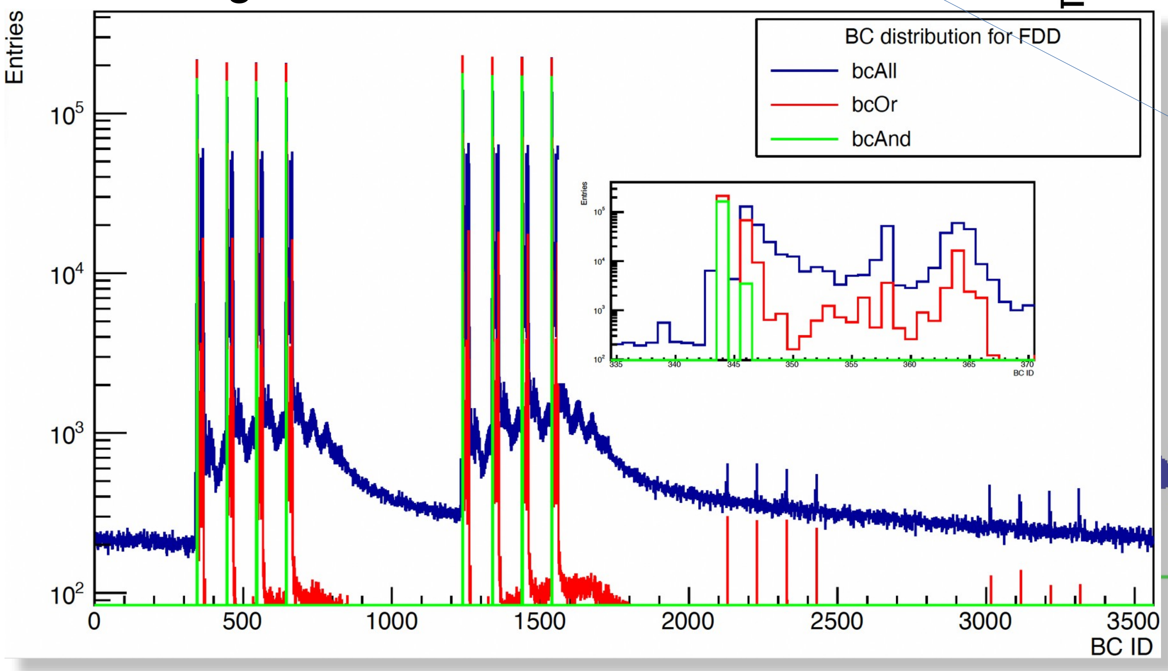
FDD BC distribution

To study the
- **after-pulses,**
- **signal reflections and**
- **dead time**

with the laser calibration system



Single channel

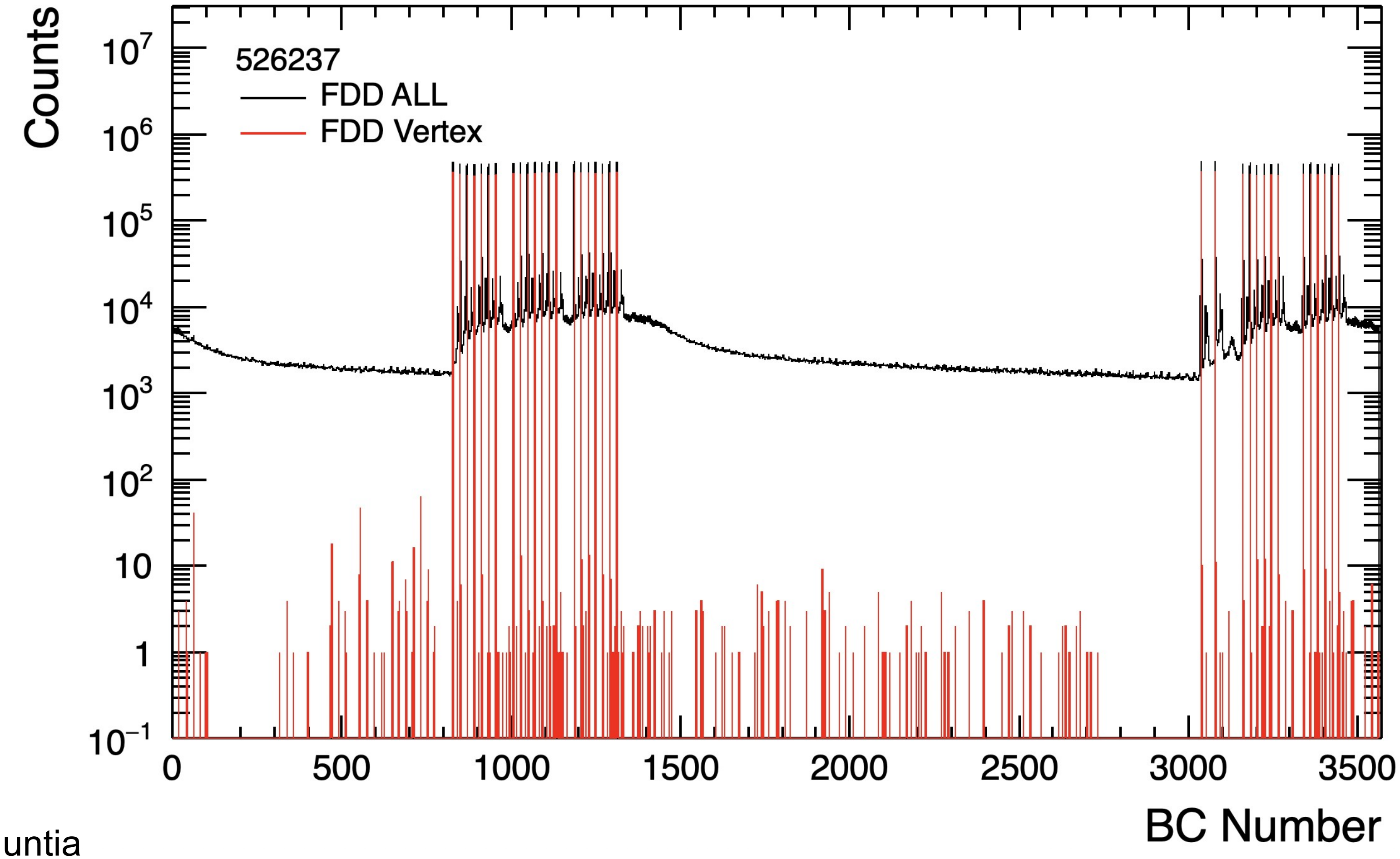


Plots by V. Zabloudil

FDD BC distribution

Vertex trigger clears the backgrounds very well.

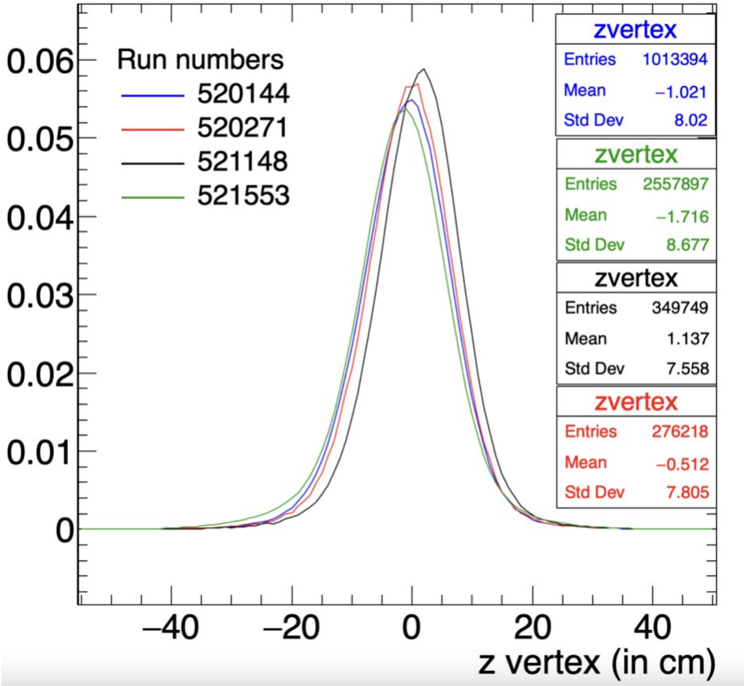
- ~0.1 % of background maximum at the highest interaction rate

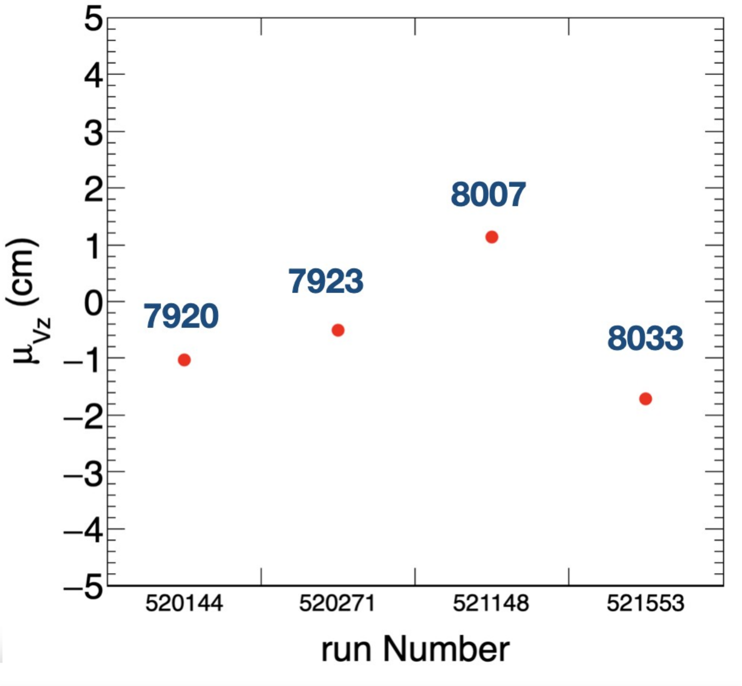


Plots by A. Khuntia

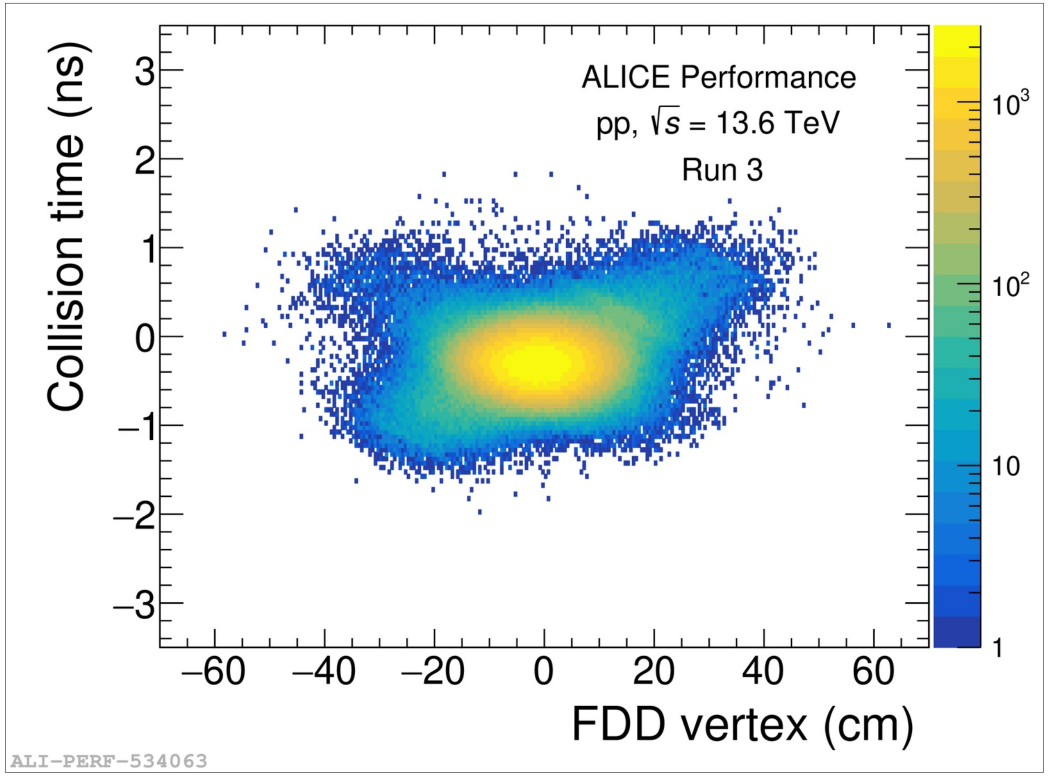
Vertex time

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





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

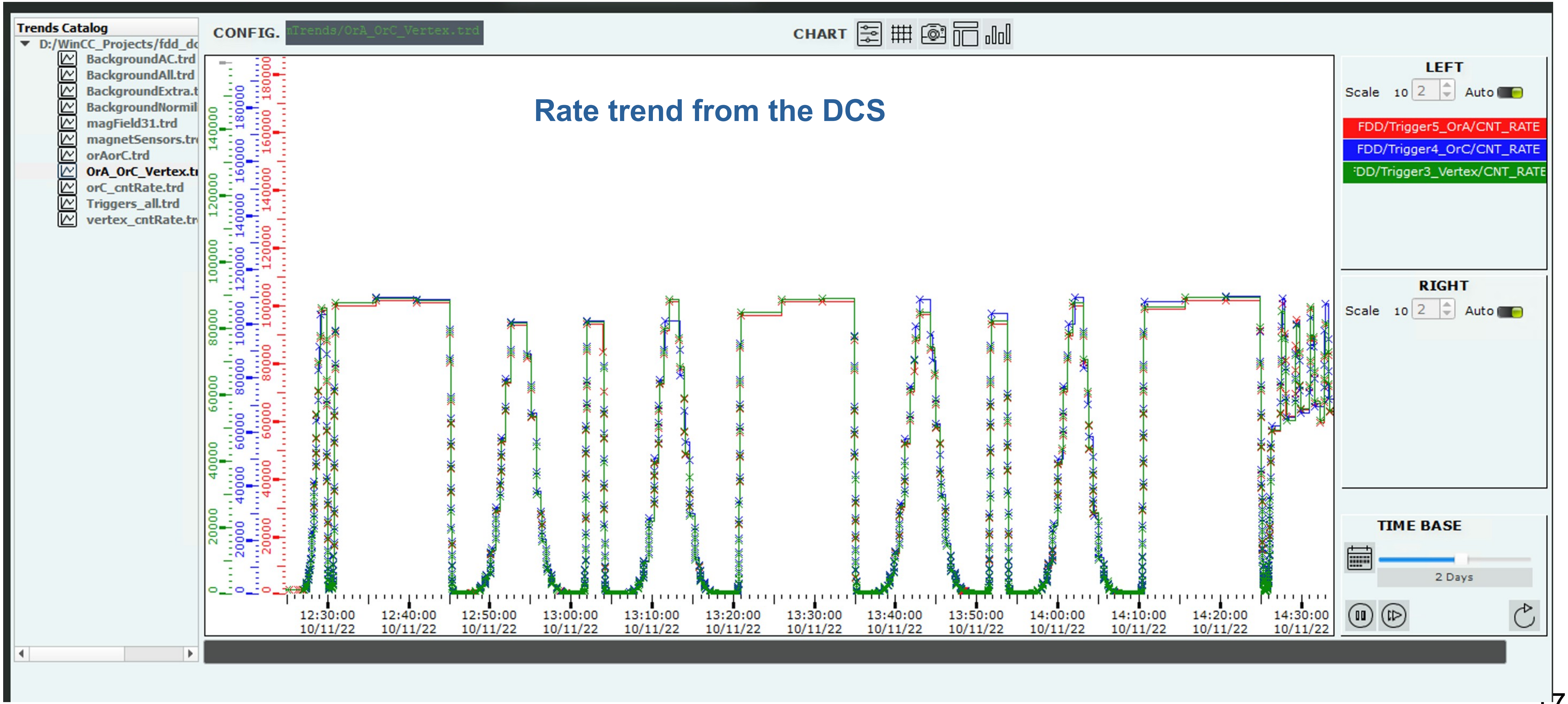


Plots by A. Khuntia

- FDD can reconstruct the primary vertex
- ALICE observed primary vertex shift in the z-direction by 1 cm towards ATLAS
- With FDD, we could able to see also the shift

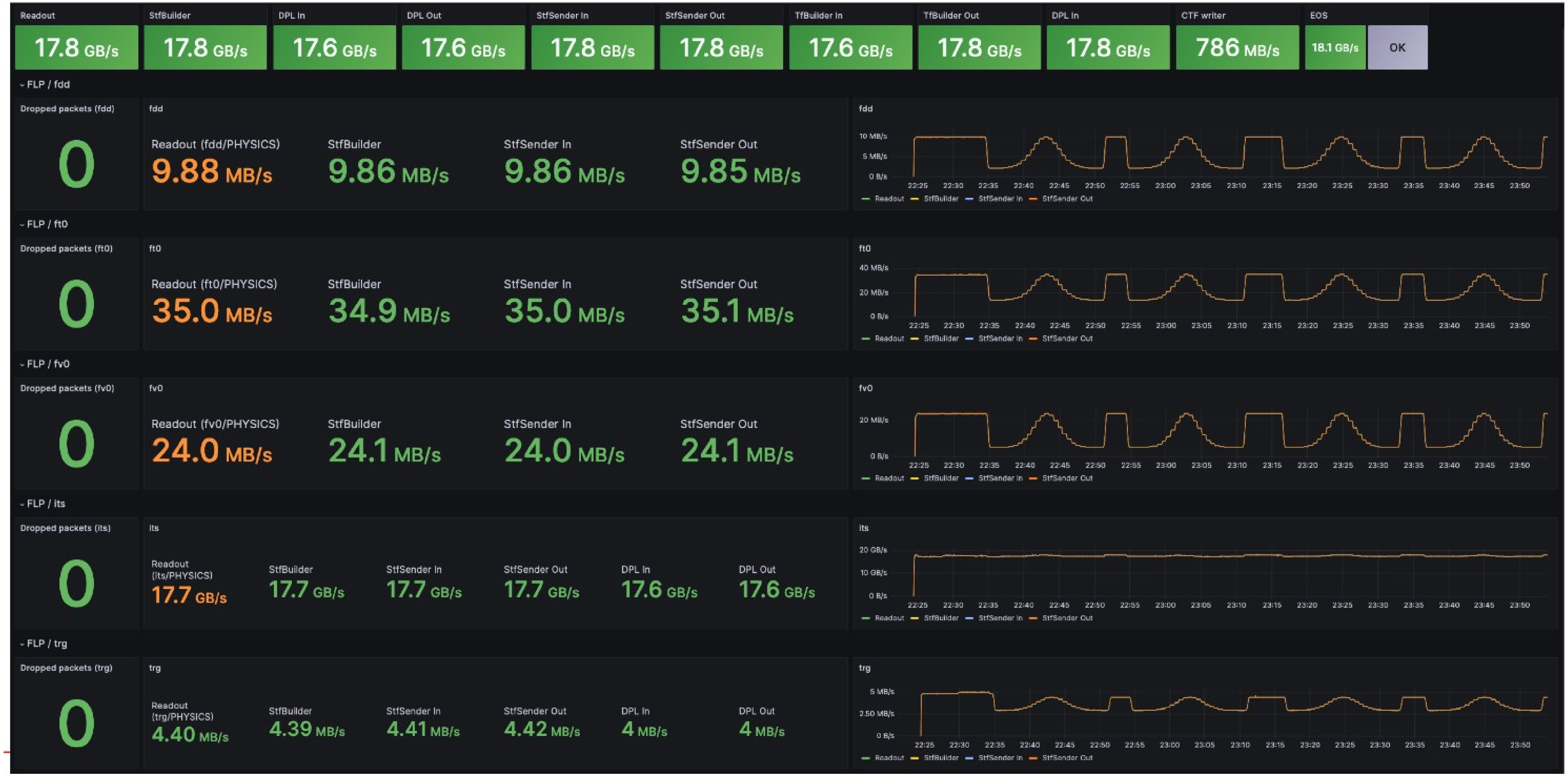
VdM scan

FDD participated in the last Thursday VdM scan (10.Nov.2022)

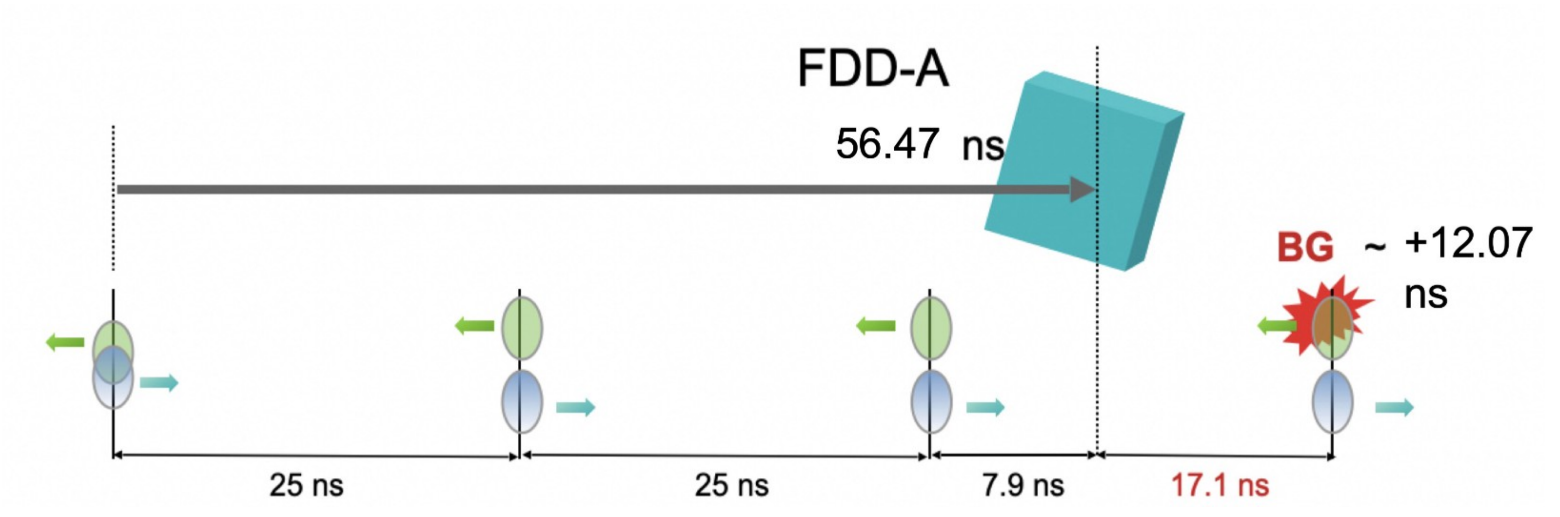


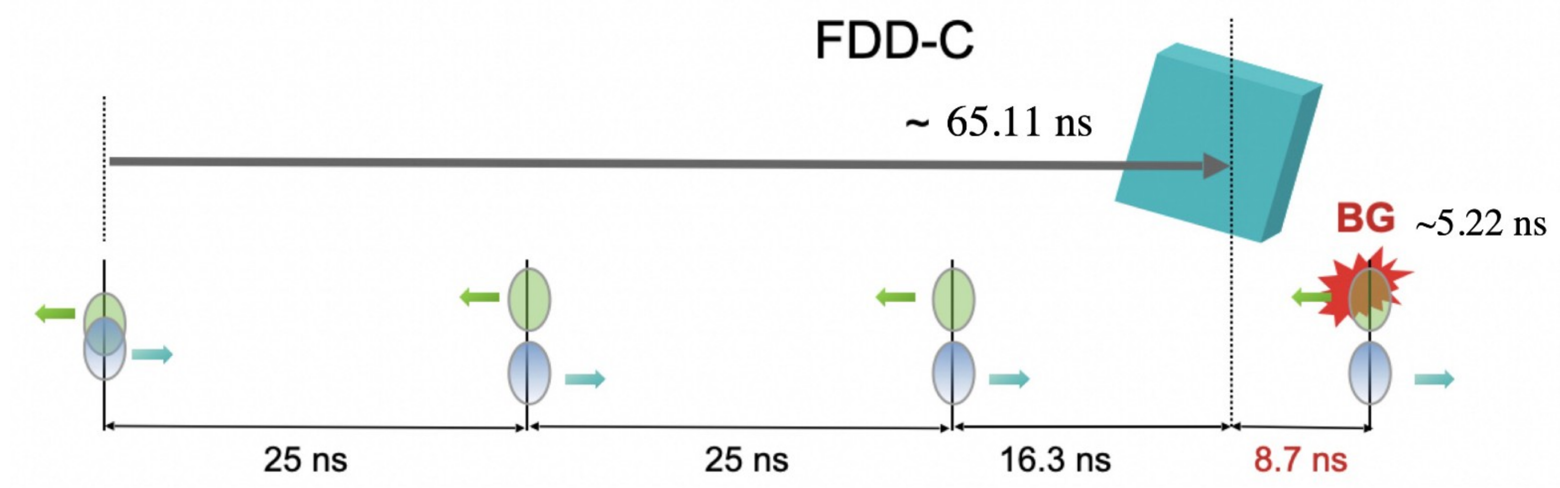
VdM scan

FDD participated in the last Thursday VdM scan (8-9.Sept.2023)



Beam Gas with FDD





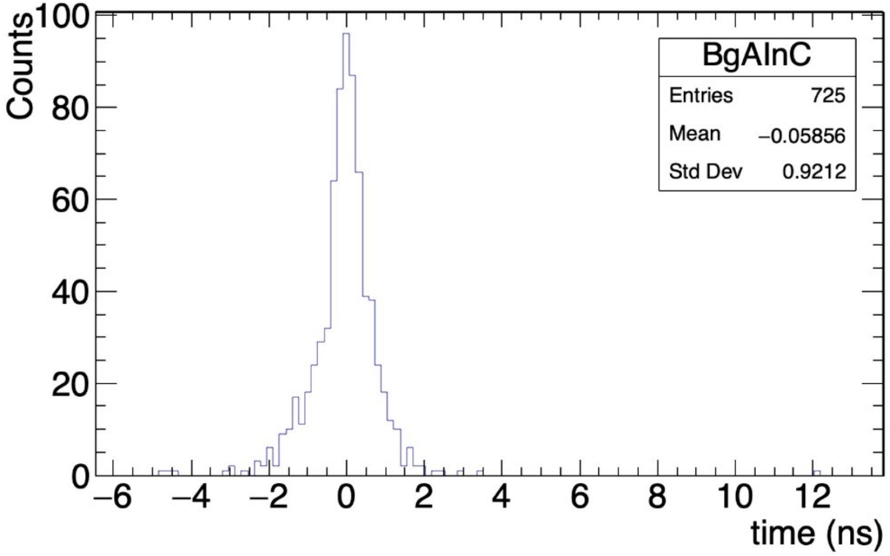
A-side

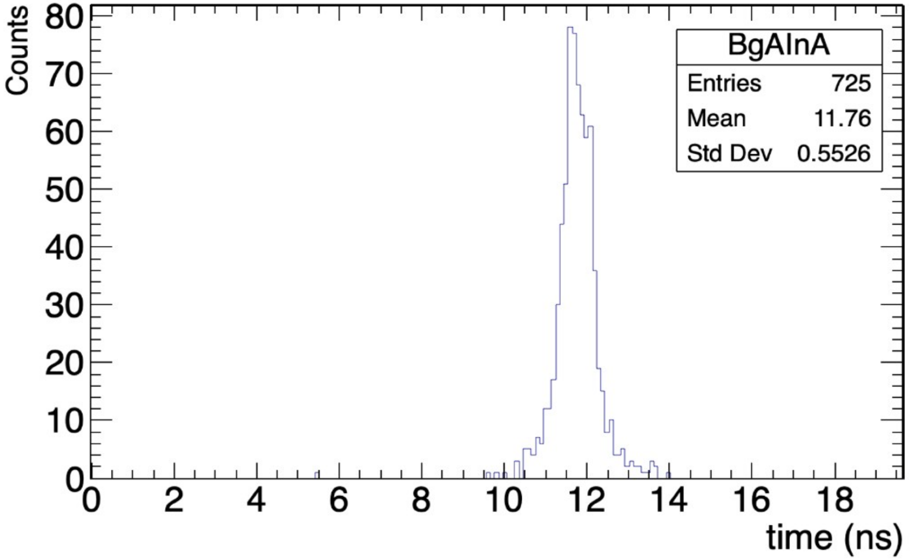
- Background coming from A-side will pass FDD-A **112.93 ns earlier** than the collision
- Events will be assigned to 5 BCs earlier, at time 25-12.93 = 12.07 ns

C-side

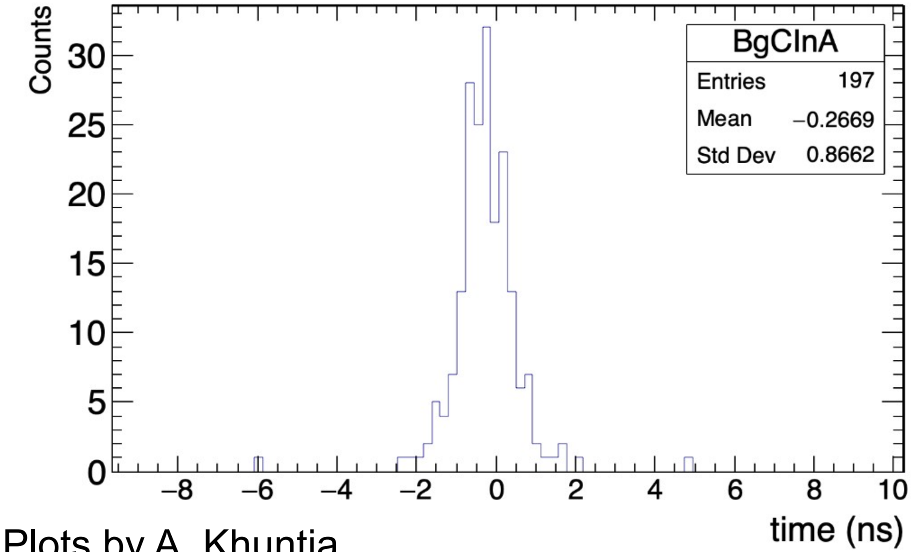
- Background coming from C-side will pass FDD-C **130.22 ns earlier** than the collision
- Events will actually be assigned to 5 BCs earlier, at time 25-30.22 = -5.22 ns

Beam Gas with FDD

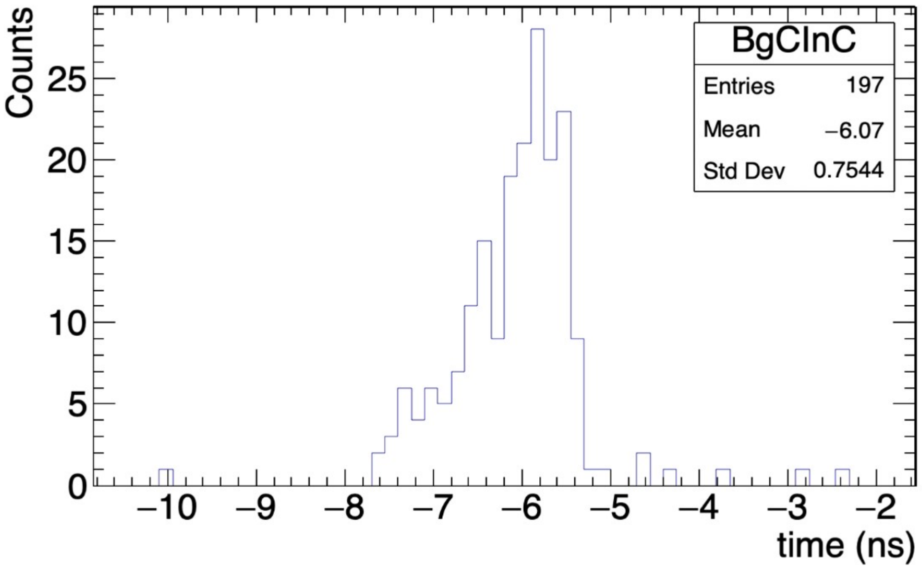




BGA



BGC



Plots by A. Khuntia

Plans and more about detectors

FDD:

- New detector concept to reduce the time width of the signal

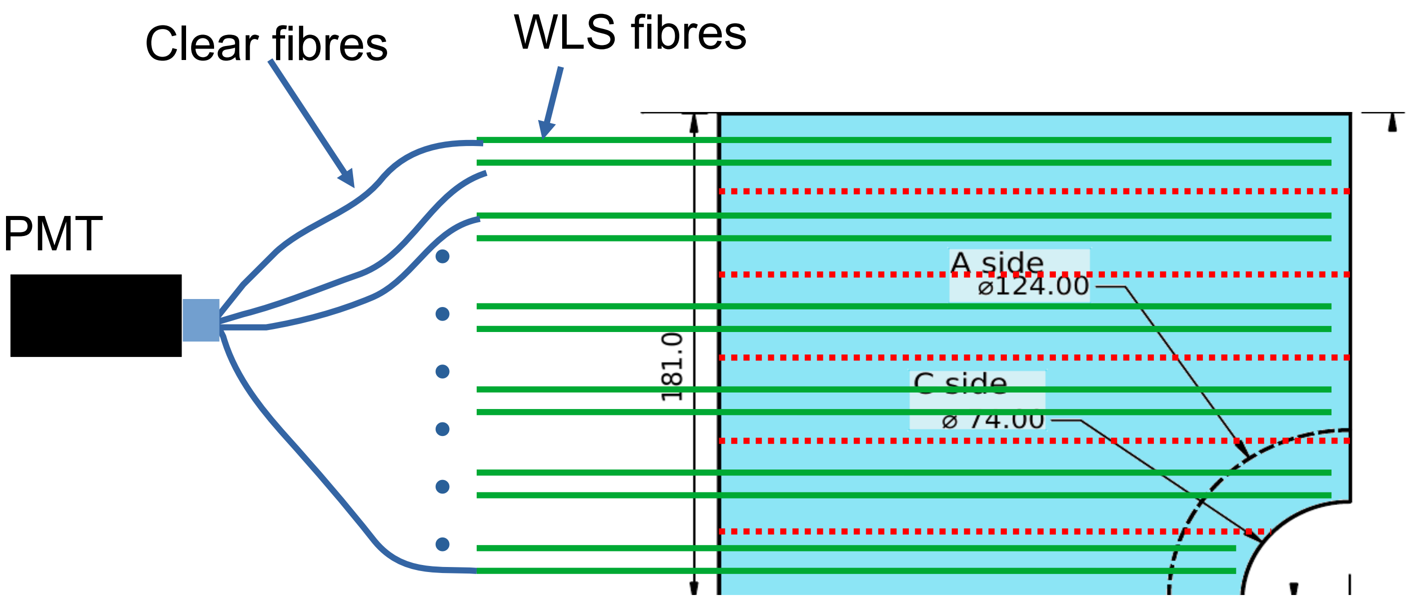
MuonID:

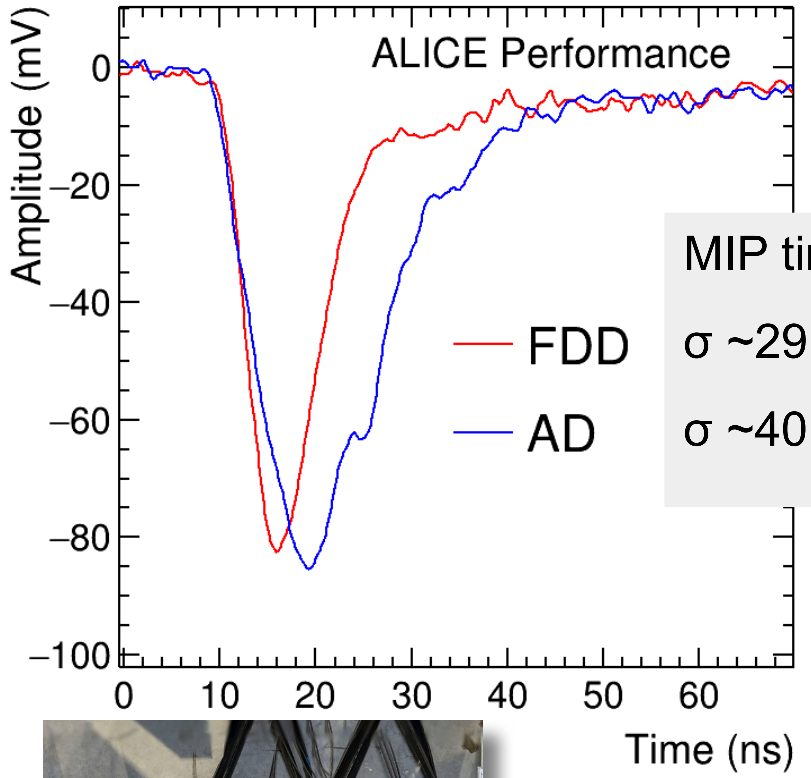
- Test scintillator bar prototypes
- Aiming to construct a full scale module to test next year

FDD new concept

Segment the FDD to reduce the pulse width of the signal output

- Produce **new prototype**
  - Wavelength shifting fibres readout
- **Geant4 simulation**
  - Evaluate the optimal segmentation and fibre density
- **Install a prototype in the ALICE** cavern, to prove the concept



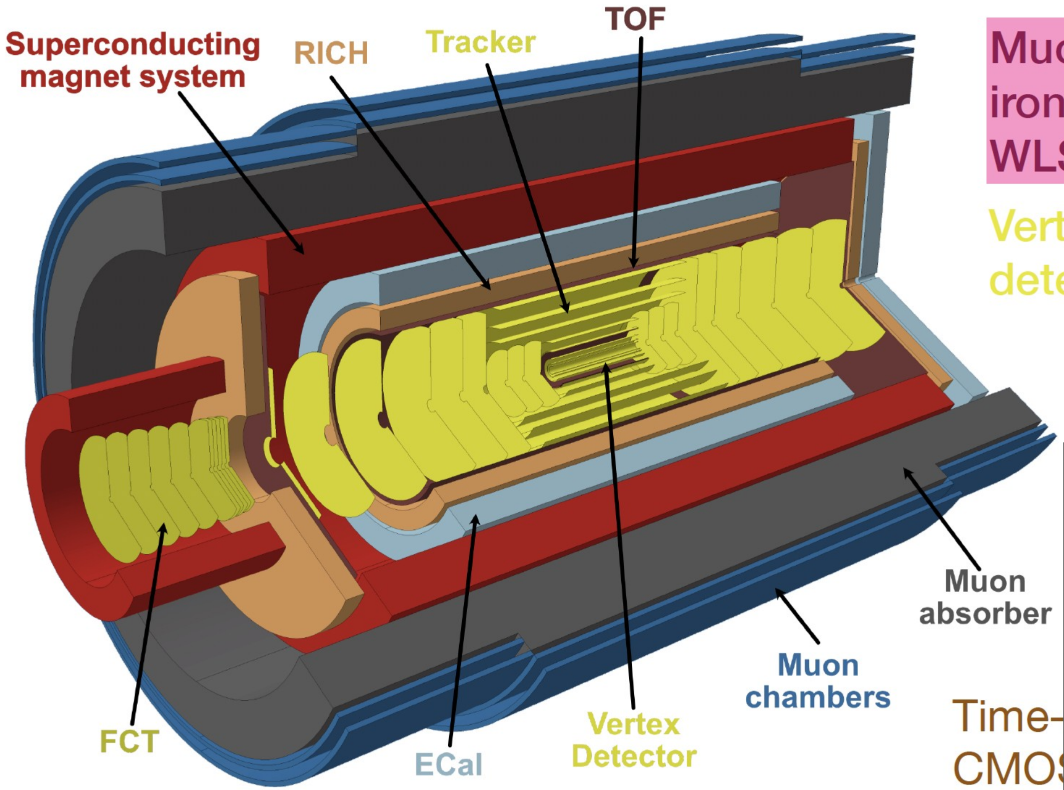


MIP time res.

σ ~29 ns

σ ~40 ns

MuonID for ALICE

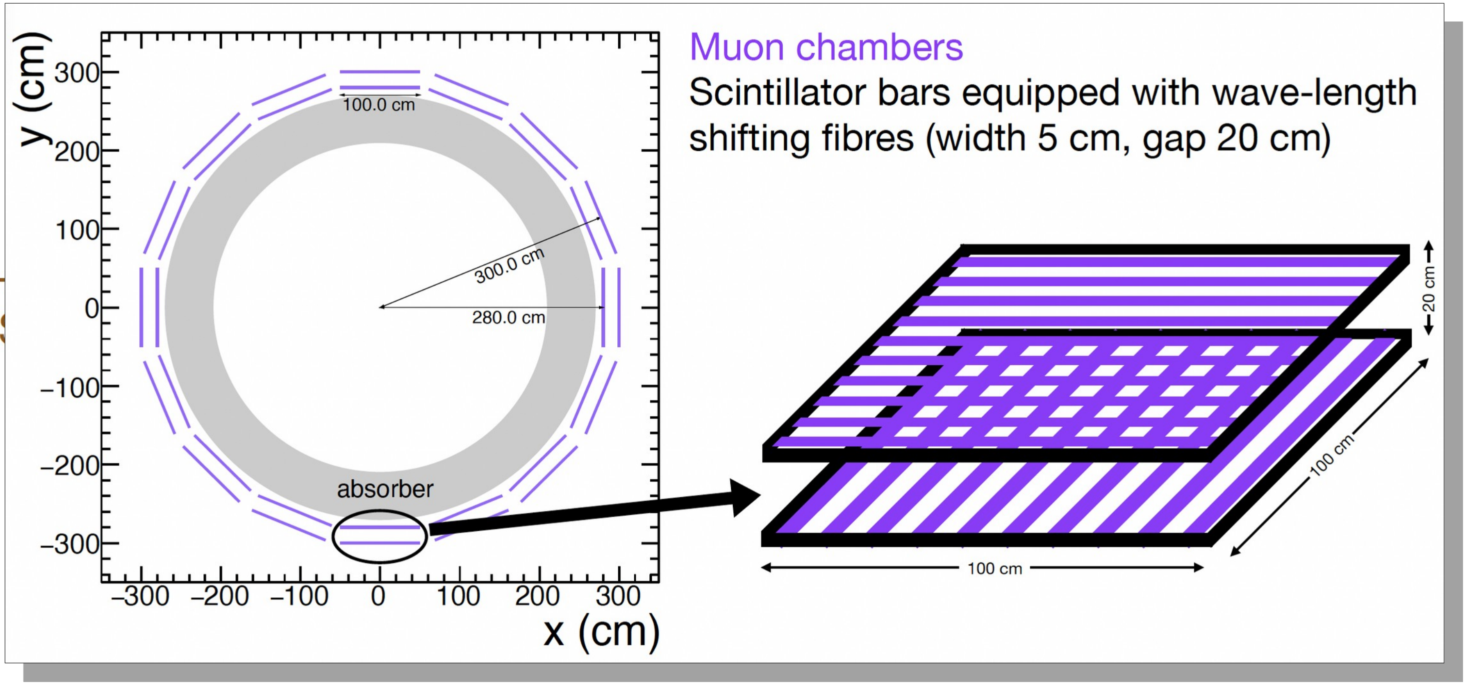


MuonID:
iron absorber, scintillating bars, WLS, SiPM

Vertexer detector: retractable detector, R_{in}~5mm

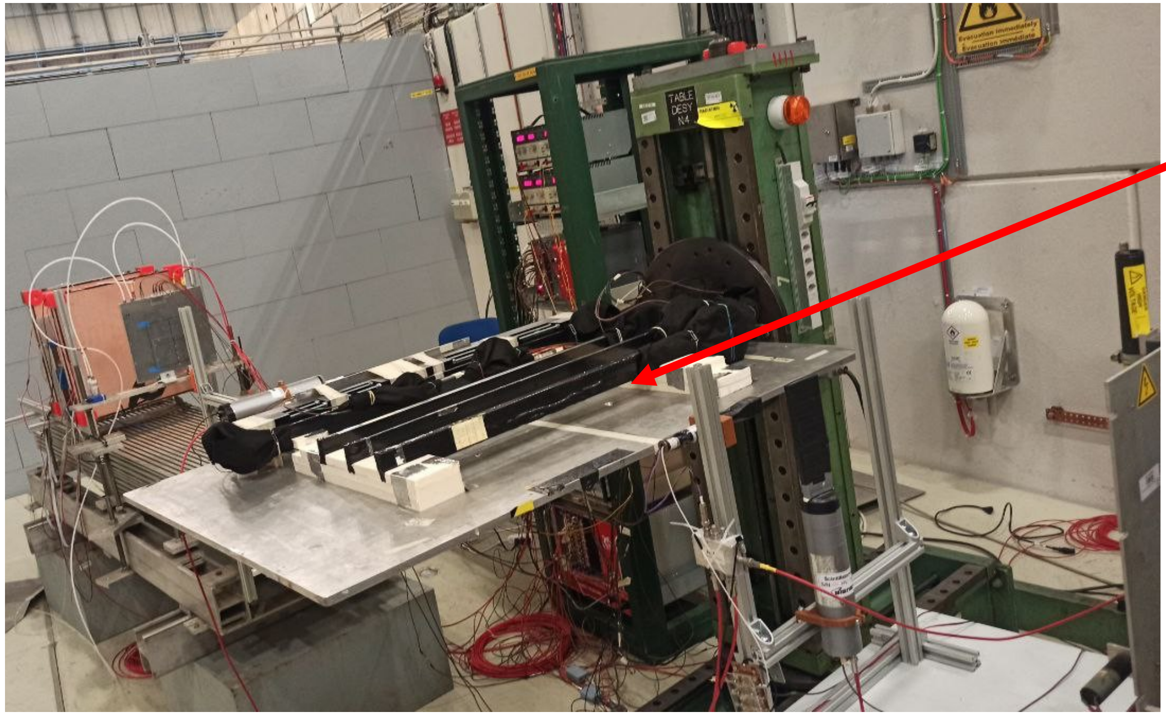
RICH: aerogel radiator, SiPM readout

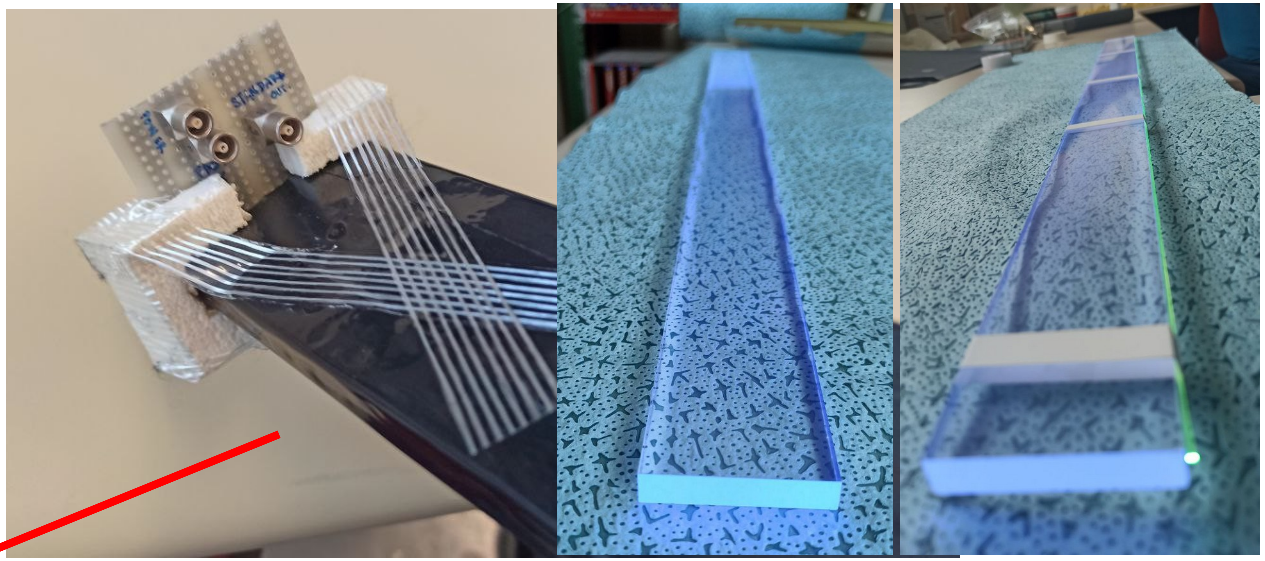
Time-
CMO

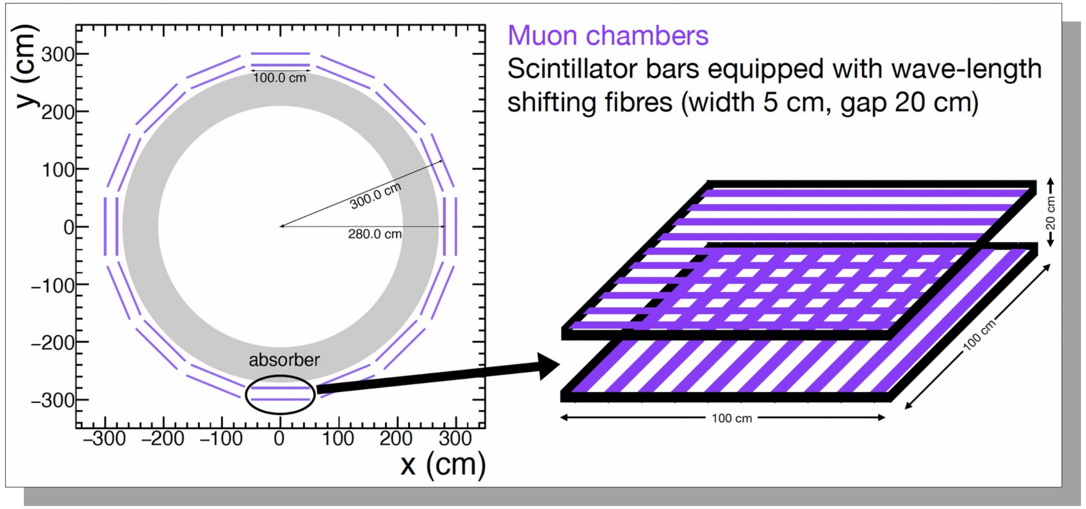


MuonID beam test and plans

- Beam test at CERN – June 2023
  - Two NuviaTech scintillator bars tested (with and w/o WLS fibre) – Analysis ongoing
  - To define scintillator and SiPM technologies
- Produce and test one chamber to test next year





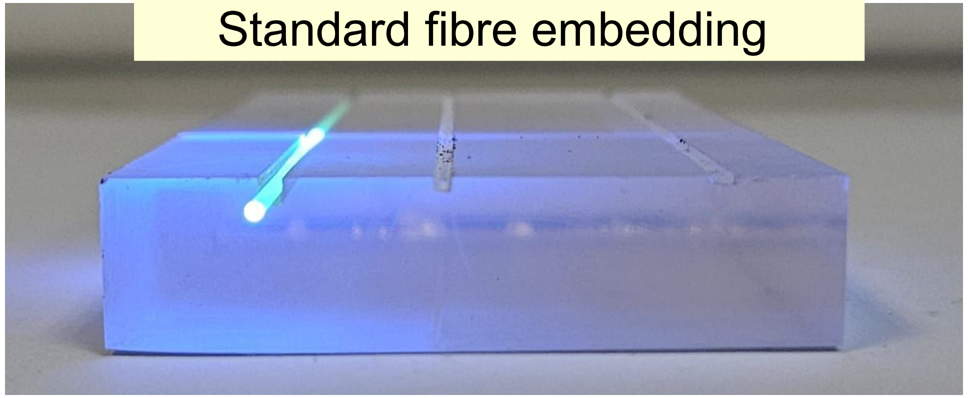


Scintillators for future detectors

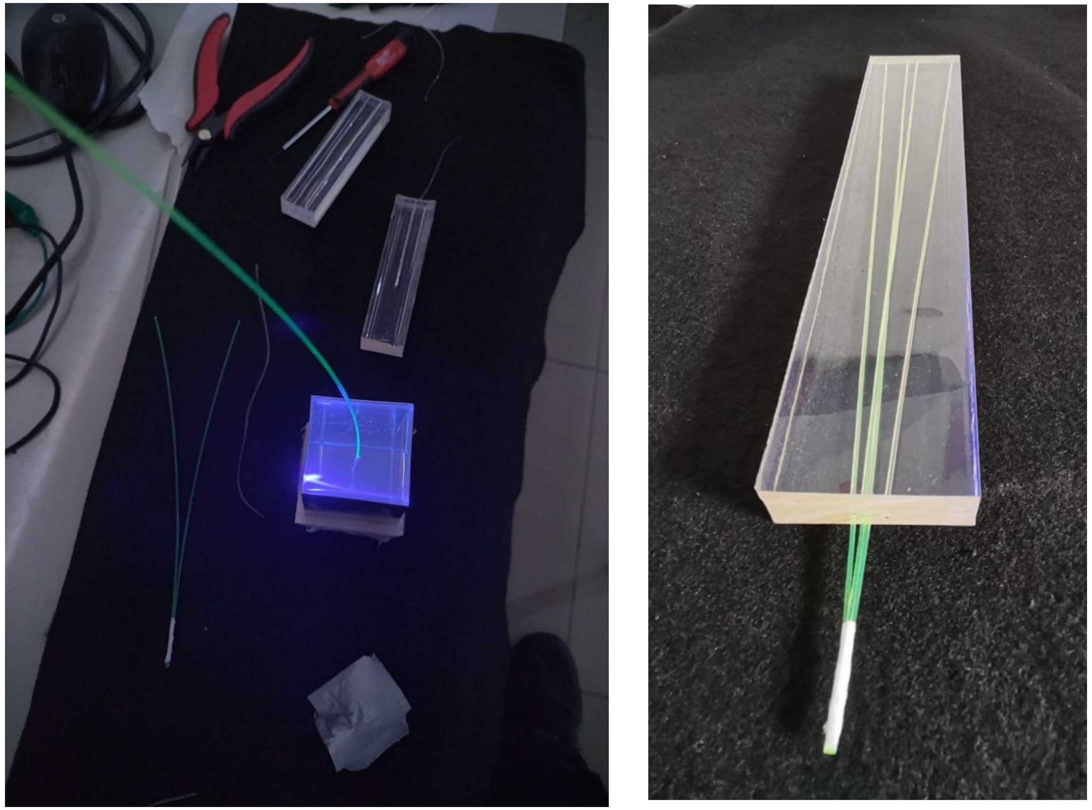
Development of
- new light readout techniques for scintillators
- novel scintillator materials

in cooperation with Universidad de Sinaloa in Mexico.

Standard fibre embedding



Embedded holes for fibres



Final comments

FDD

- Is stable and running close to 100% of the ALICE runs
- Research is ongoing to fully understand the FDD data
  - With pp collisions, cosmic rays and laser calibration system

New FDD concept

- Design and construct a new prototype to reduce the signal width of FDD

MuonID

- Analyze the beam test data
- Prepare and test full scale chamber

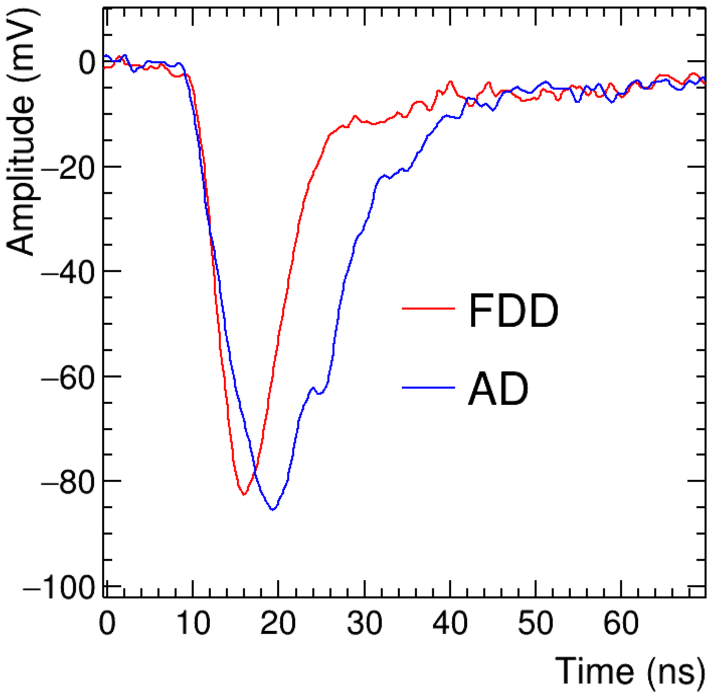
Thank you!

Backup

Performance – Time signal width

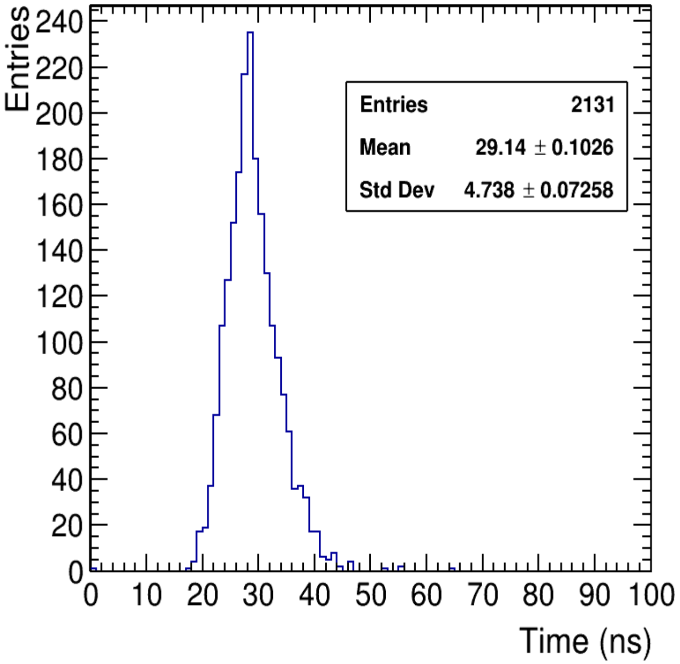
The **reduction of the signal time width** of FDD with respect to AD was achieved by using materials with a better timing response in the construction of the pads. Tests were performed with cosmic muons.

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

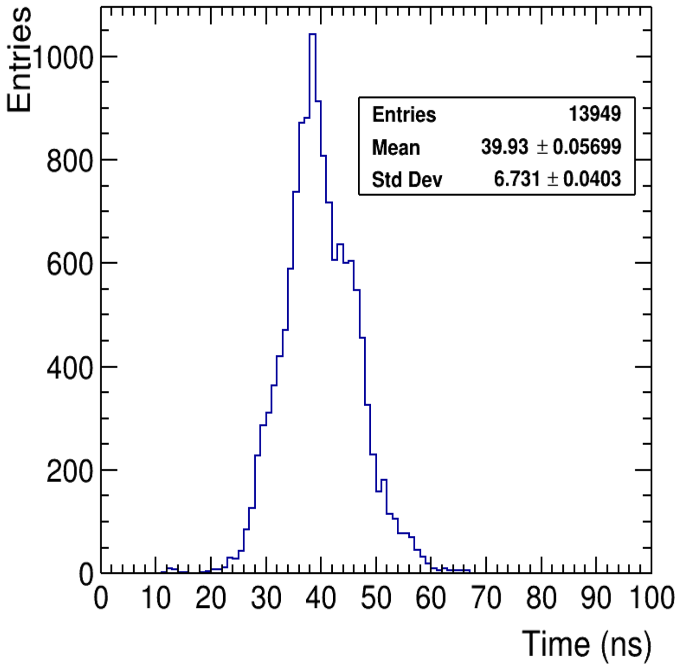


Distributions of the AD and FDD time width signals at 10% of the maximum amplitude.

FDD Width = 29.14 ns



AD Width = 39.93 ns



FIT - Front End Electronics