ALICE forward rapidity upgrades

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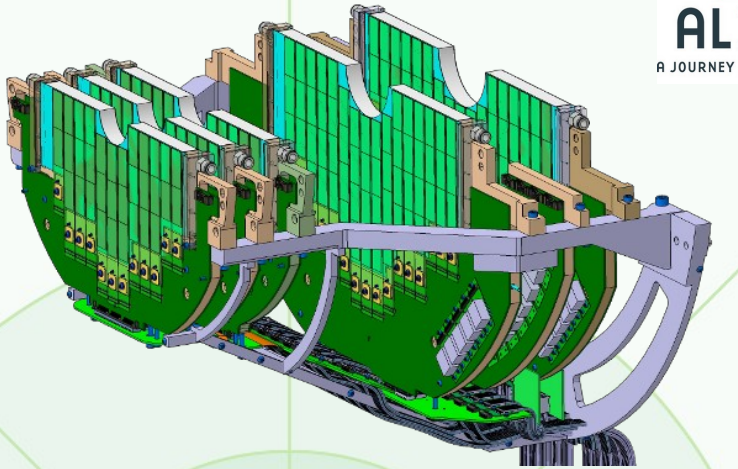
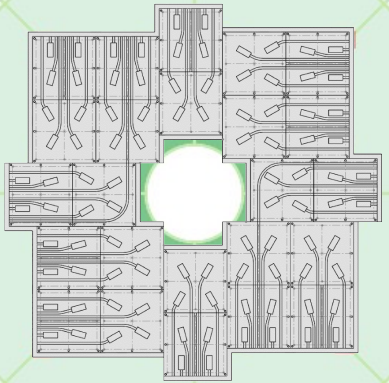
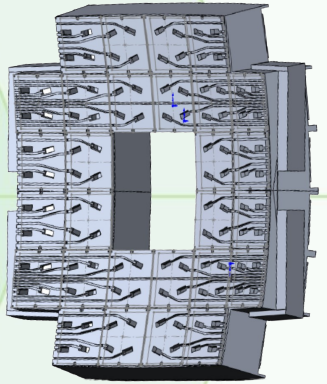
on behalf of the ALICE Collaboration

Outline

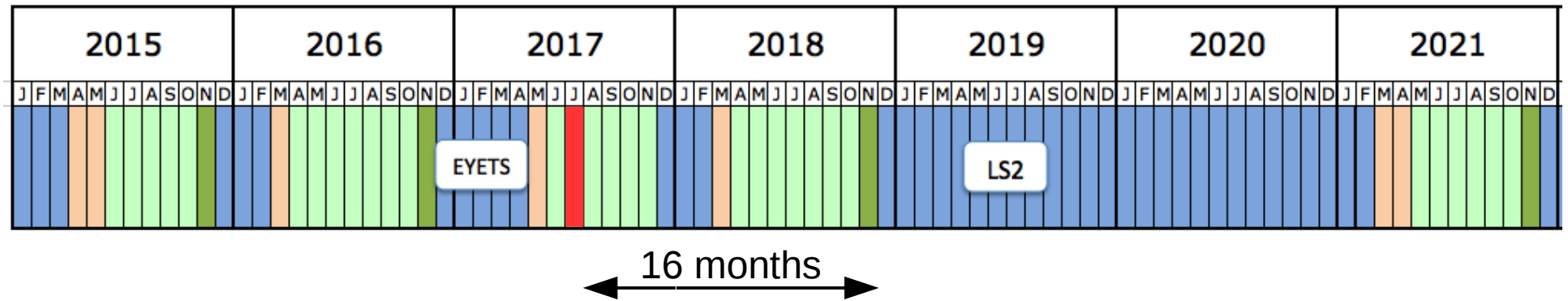
- **LHC schedule**
- **Overview of ALICE upgrades**
- **Muon Forward Tracker (MFT)**
  - Principle of operation
  - Design & layout
  - Simulated performance
- **Fast Interaction Trigger (FIT)**
  - Layout and geometry
  - Test results of the prototype detector module
  - Simulated performance







LHC schedule



The LHC will enter the Long Shutdown 2 (**LS2**) in 2019 – in 16 months

- Increase in luminosity (number of collisions per s per cm^2)
- Sustained p-p operation at 25 ns bunch crossing time
- Minimum-bias **Pb-Pb** at the target interaction rate of **50 kHz**
  - (now <1 kHz; downgraded from available 8 kHz)

Overview of ALICE upgrades

8.07 (Sat) 10:00 by Christian Lippmann

Time Projection Chamber (TPC)
- New GEM technology for readout chambers
- Faster electronics & continuous readout

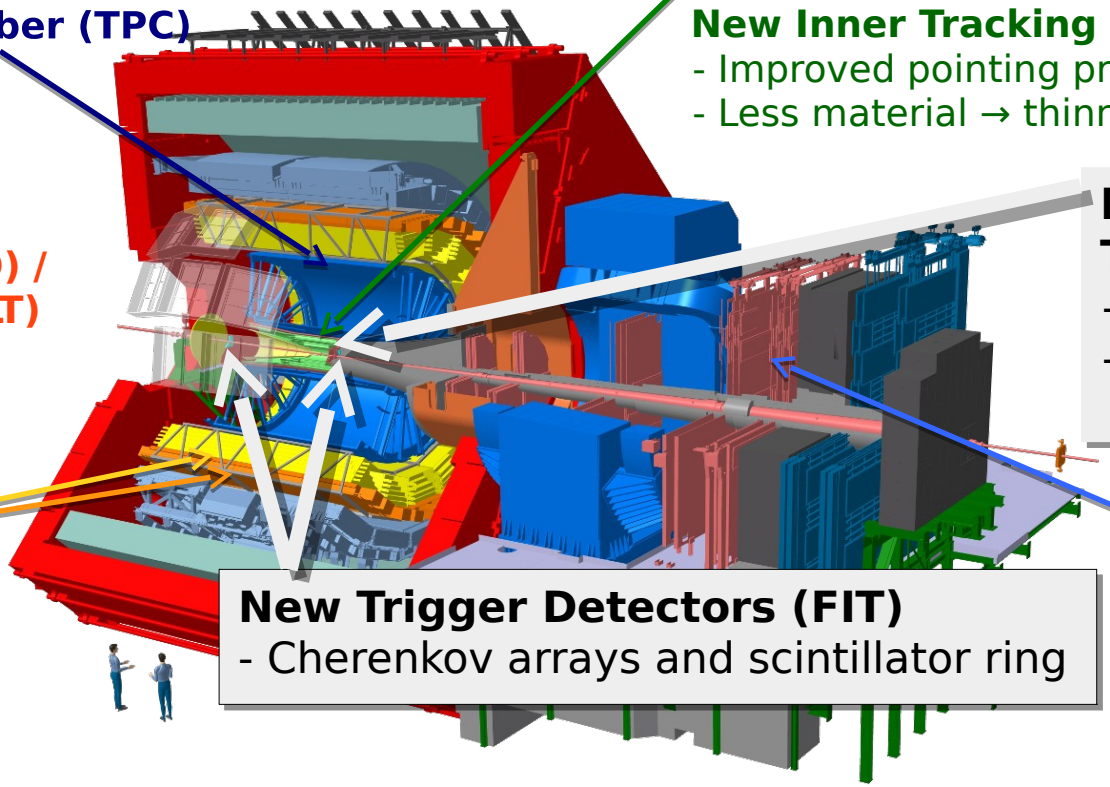
Data Acquisition (DAQ) / High Level Trigger (HLT)
- New architecture
- Online tracking and data compression
- 50 kHz Pb-Pb event rate

TOF, TRD
- Faster readout

New Central Trigger Processor

8.07 (Sat) 9:45 by Paolo Camerini

New Inner Tracking System (ITS)
- Improved pointing precission
- Less material → thinnest tracker @ LHC

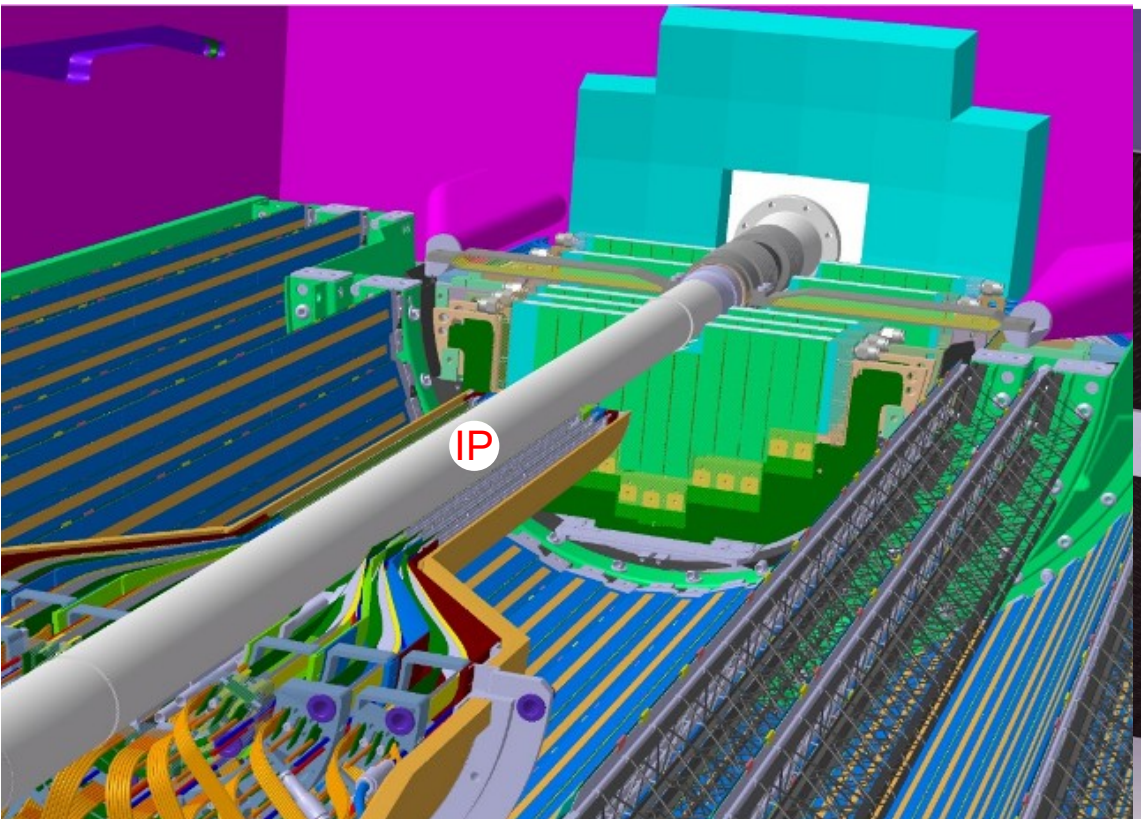


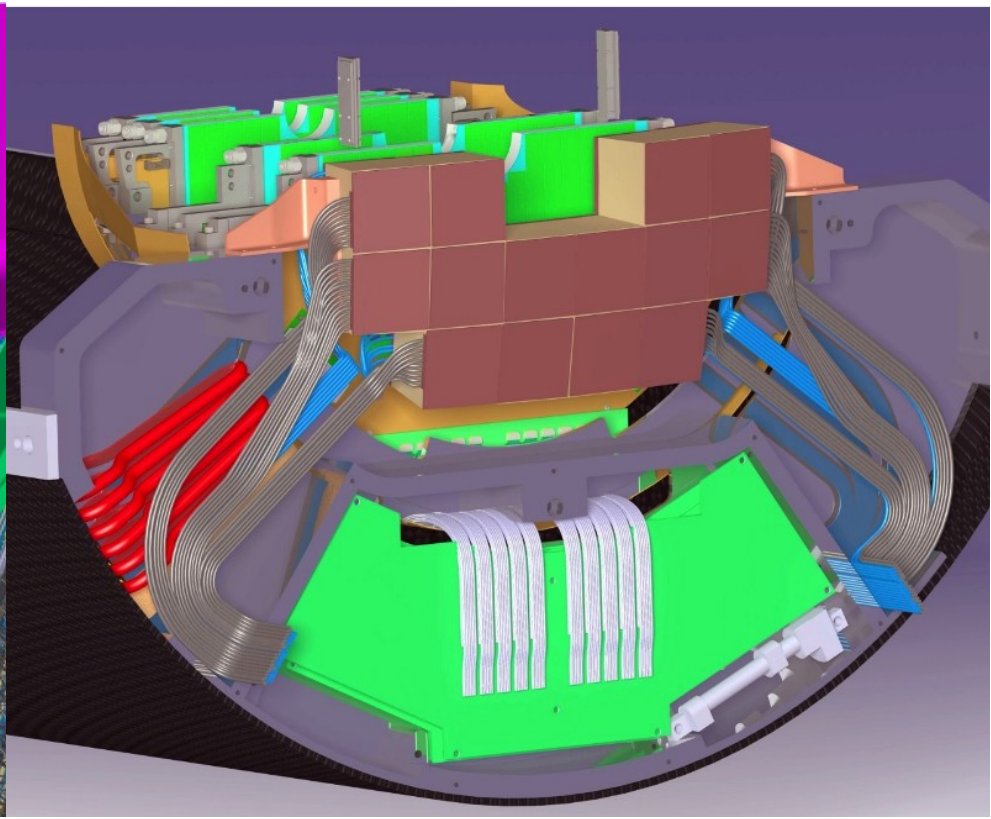
Muon Forward Tracker (MFT)
- New Si tracker
- Improved muon vertex position

New Trigger Detectors (FIT)
- Cherenkov arrays and scintillator ring

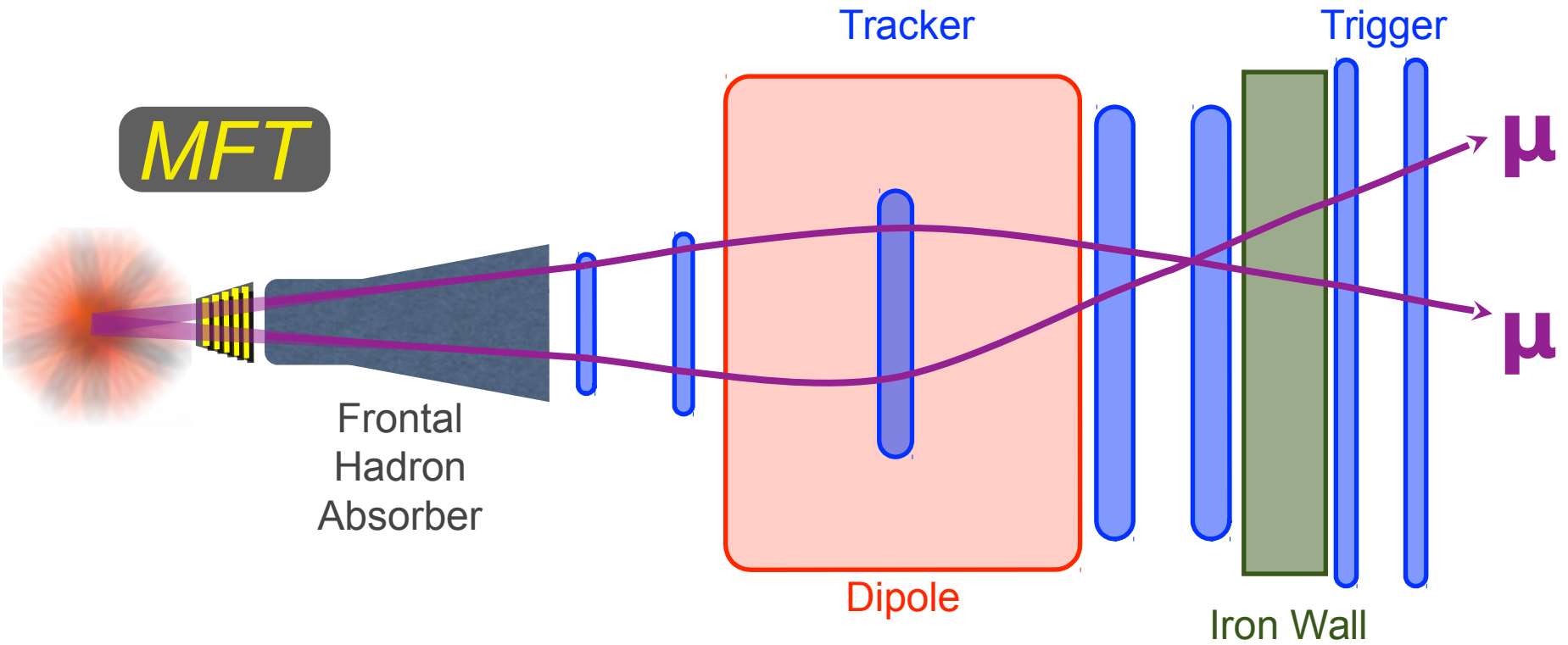
MUON ARM
- Continuous readout electronics

Location of the forward upgrades in the vicinity of the interaction point





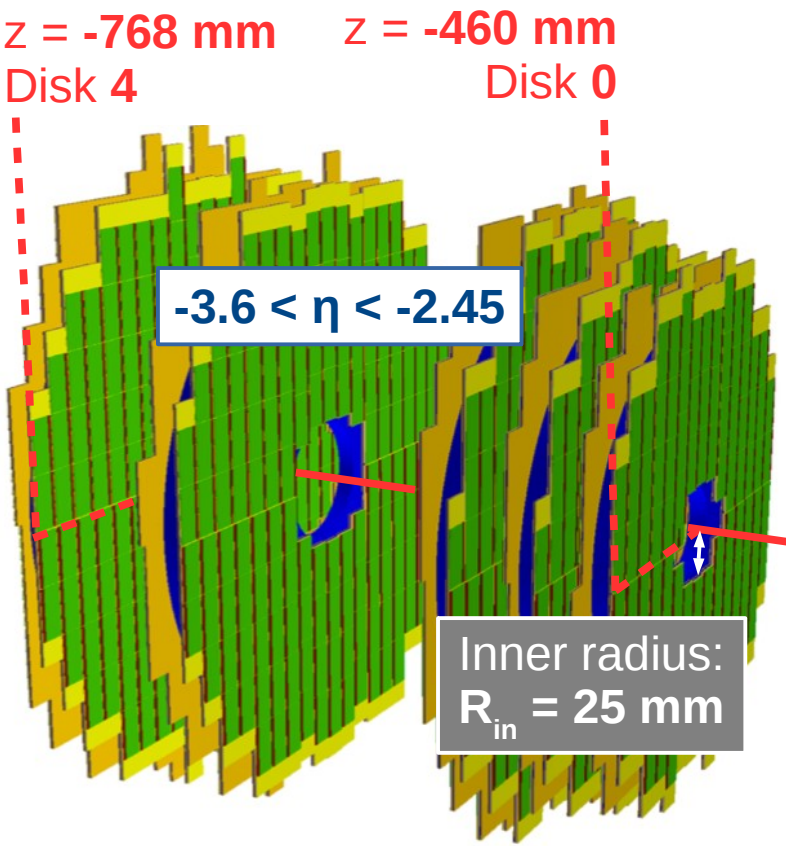
Muon Forward Tracker (MFT)
Principle of operation (1/2)



Muon Forward Tracker (MFT)
Principle of operation (2/2)

- Muon tracks are matched between the Muon Spectrometer and MFT
- **MFT adds high pointing accuracy for muon tracks**
  - Measurement of **displaced vertex position**
    → due to heavy flavour semi-muonic decays
  - Strong Lorentz boost effect at forward rapidity, even for $p_T = 0$
  - Measurement of **beauty** down to $p_T = 0$ from displaced J/ψ vertices
  - Measurement of **ψ(2S)**

MFT design and layout



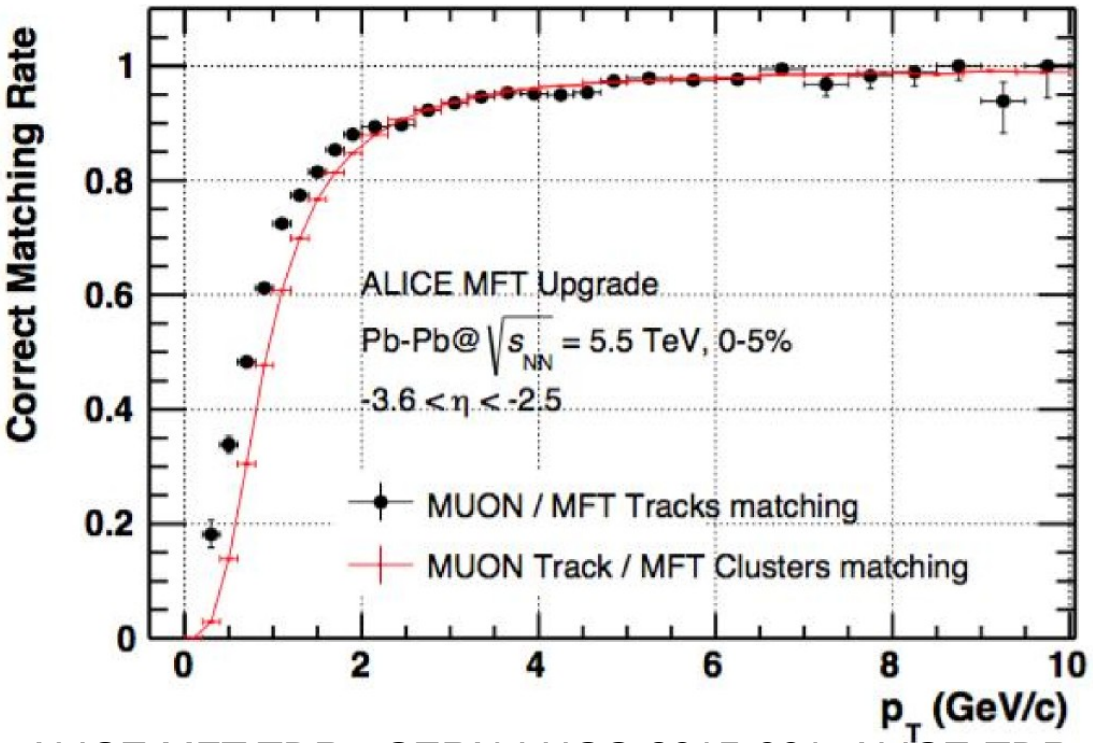
- **920** silicon pixel sensors (0.4 m^2) on **280** ladders of 2 to 5 sensors each
- 10 Half-disks, 2 detection planes each
- Sensor type: ALPIDE → O(25 mm x 25 mm)
  - See *The ALICE ITS upgrade* by Paolo Camerini *(on 8.07 at 9:45)* → description of sensors
- Good matching efficiency between MFT and Muon Tracker

MFT doses:
< 400 krad
→ 10-fold safety margin

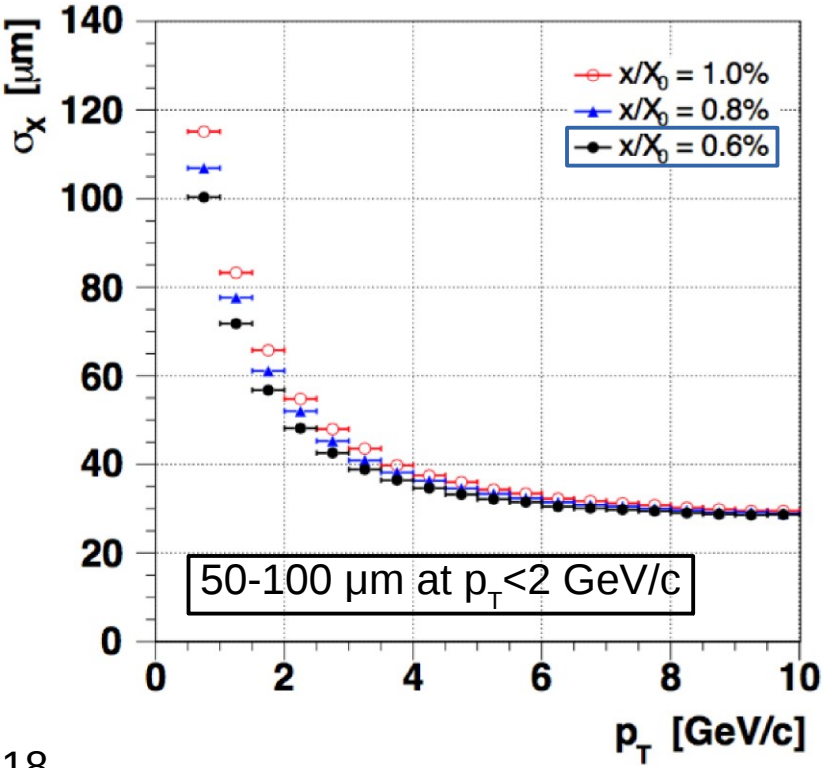
- Fast electronics readout capable of operating with:
  - **Pb-Pb** interaction rate **~50 kHz** and
  - **p-p** interaction rate **~200 kHz**

MFT performance

Muon track matching probability



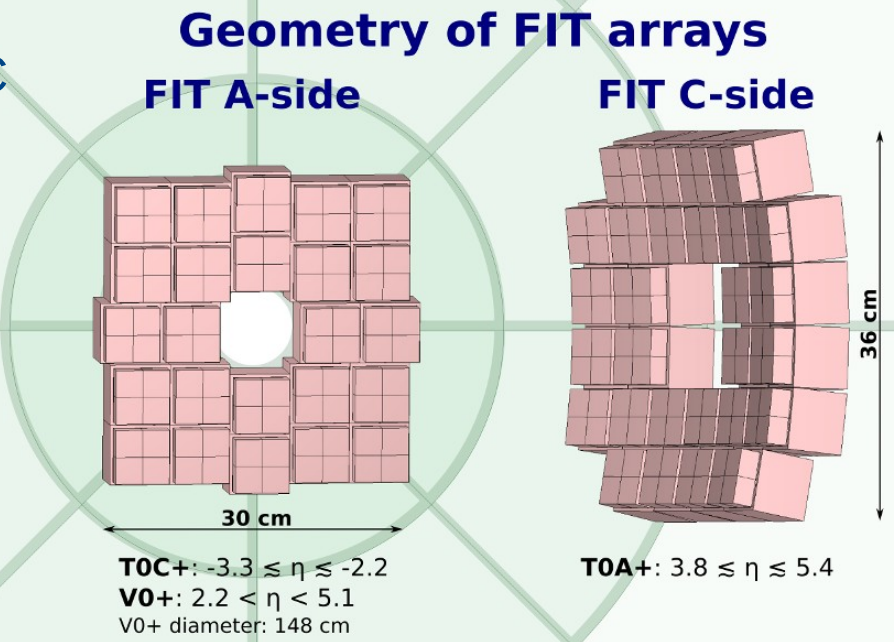
Offset resolution of muon track



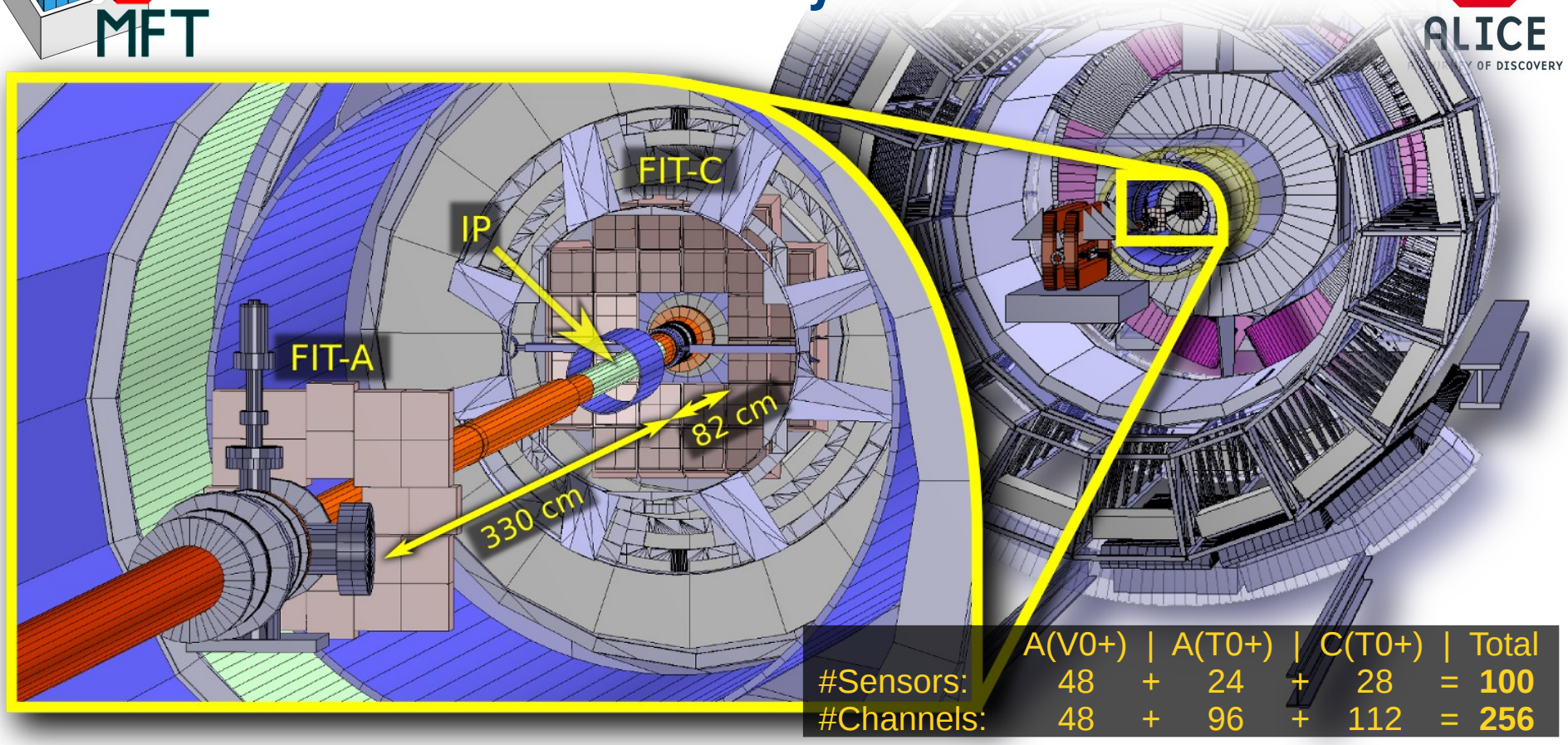
ALICE MFT TDR - CERN-LHCC-2015-001, ALICE-TDR-018

Why ALICE needs Fast Interaction Trigger (FIT)?

- **Luminosity** monitoring & feedback to LHC
  - Essential for the operation of ALICE
- Fast Interaction **Trigger**
  - Online Vertex determination
  - Minimum Bias and centrality selection
  - Rejection of beam/gas events
  - Veto for Ultra Peripheral Collisions
- Collision time for Time-Of-Flight particle ID
- **Multiplicity** → **Centrality** and **Event Plane**



FIT layout

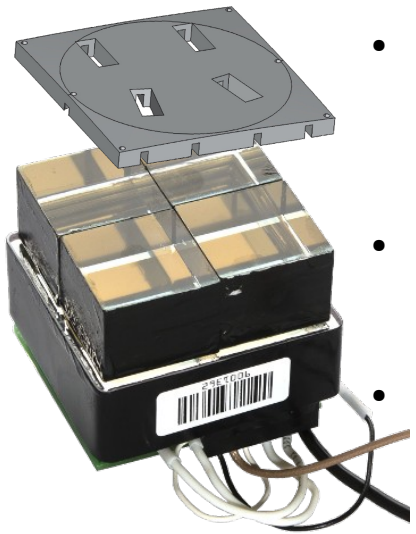


	A(V0+)		A(T0+)		C(T0+)		Total
#Sensors:	48	+	24	+	28	=	**100**
#Channels:	48	+	96	+	112	=	**256**

Detector technology (1/2)

How to make FIT fast? → T0+

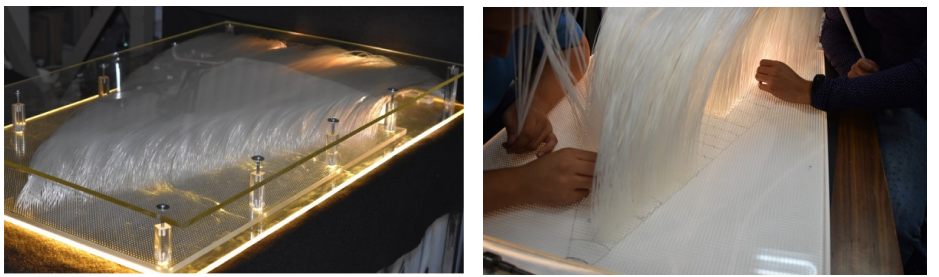
- Cherenkov detector modules
- ΔT ~ 20 ps



- Adapter holding prisms for the laser calibration system
- 4 quartz radiators (26.5 x 26.5 x 20) mm^3
- Photosensor: MCP-PMT PLANACON XP85012

How to make FIT large? → V0+

- Sectored scintillator ring
- ΔT ~ 200 ps
- No wavelength shifting fibers

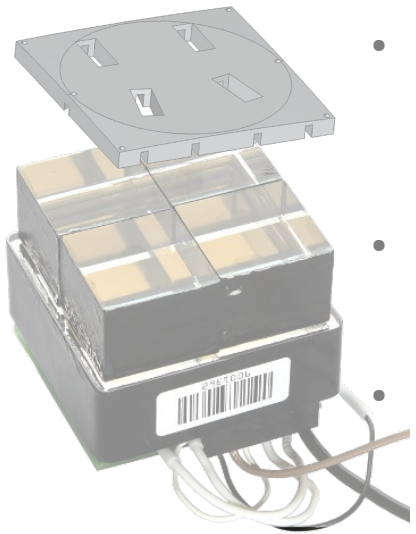


Real scale mock-up of one sector of V0+

Detector technology (2/2)

FIT = T0+ & V0+

Both elements must be well integrated with each other
→ use the same readout electronics



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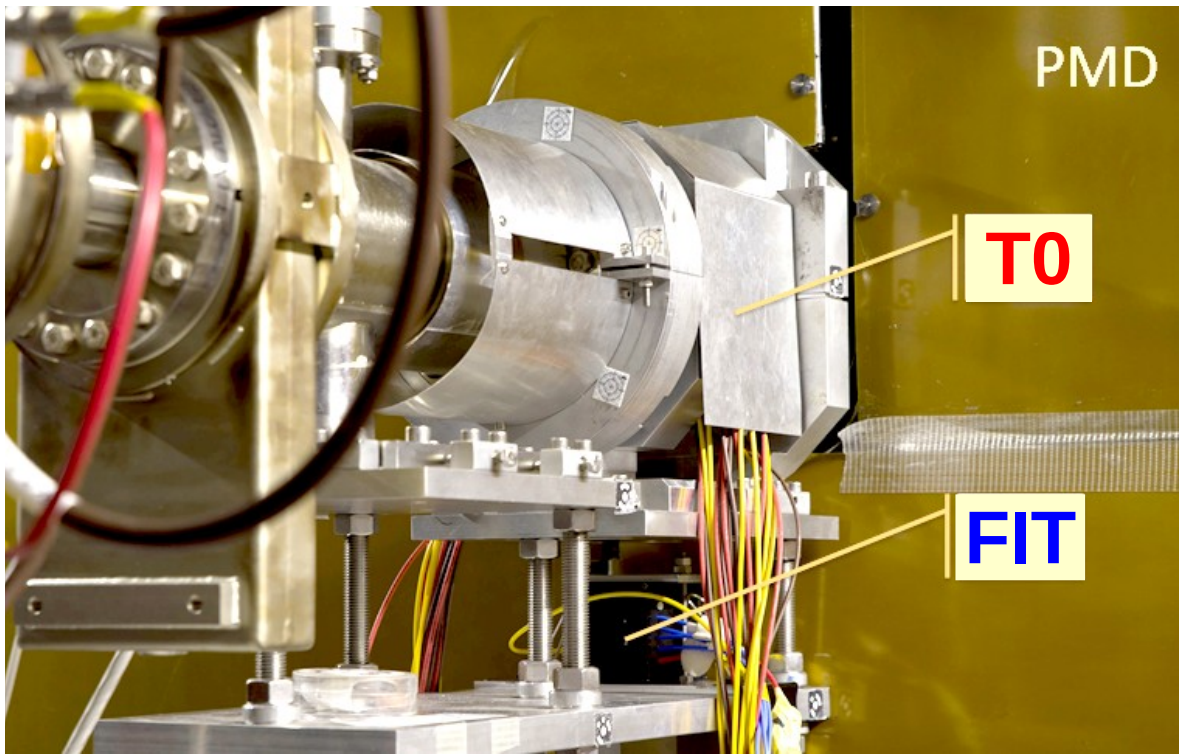
- Photosensor: MCP-PMT PLANACON XP85012

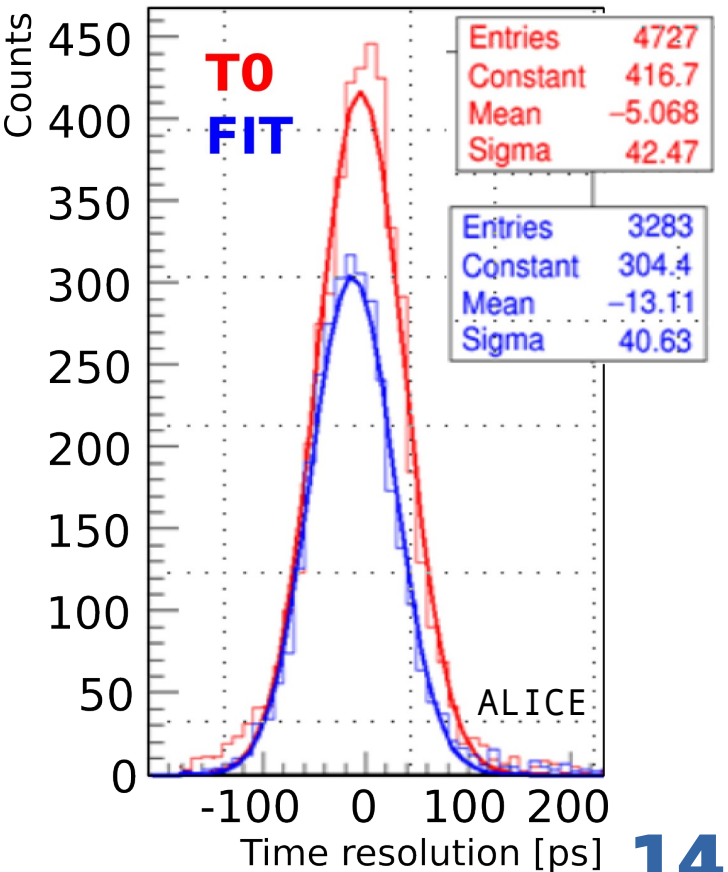
- No wavelength shifting fibers

Real scale mock-up of one sector of V0+

FIT prototype tests at ALICE (1/2)

→ Cherenkov detector module (T0+)

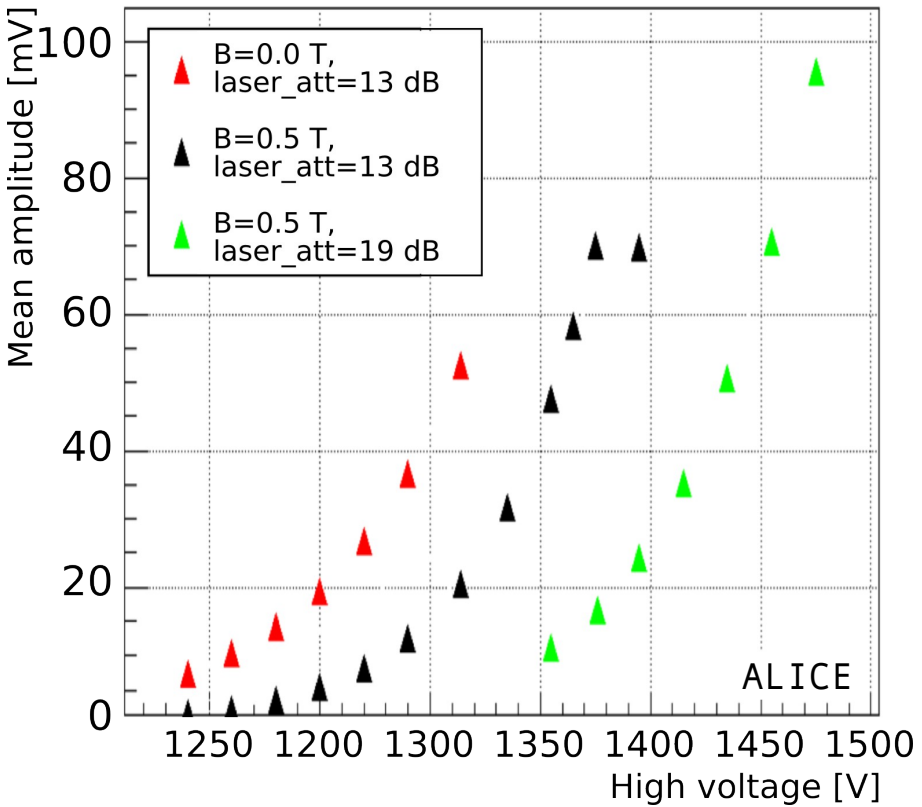




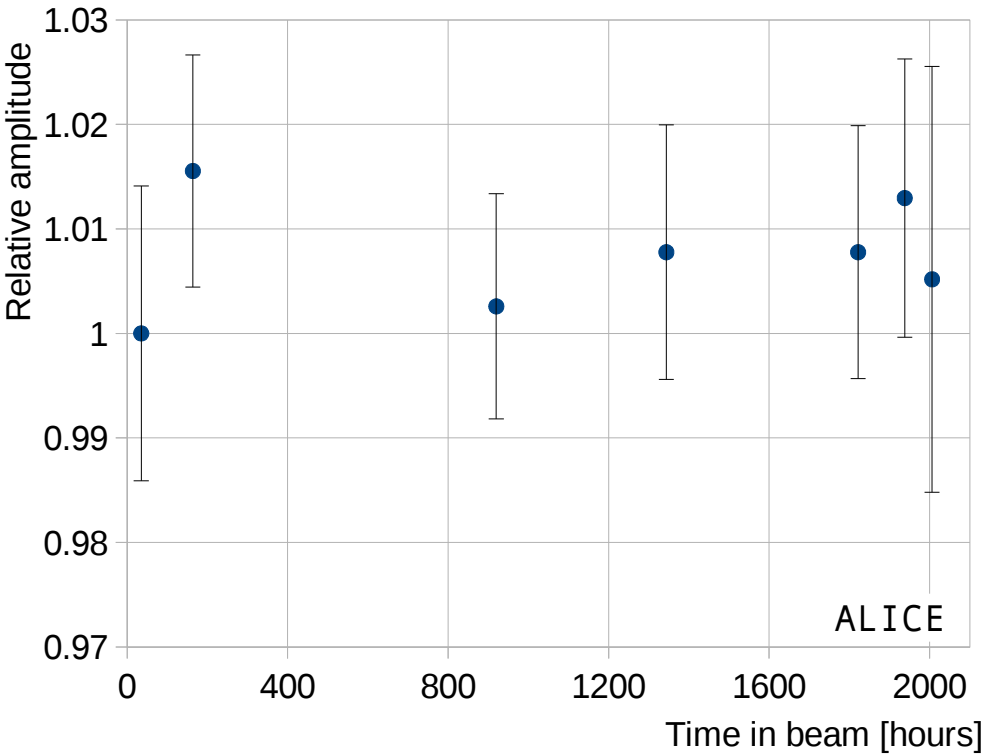
FIT prototype tests at ALICE (2/2)

→ Cherenkov detector module (T0+)

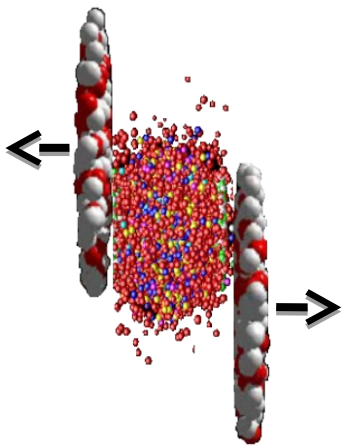
MCP gain in magnetic field

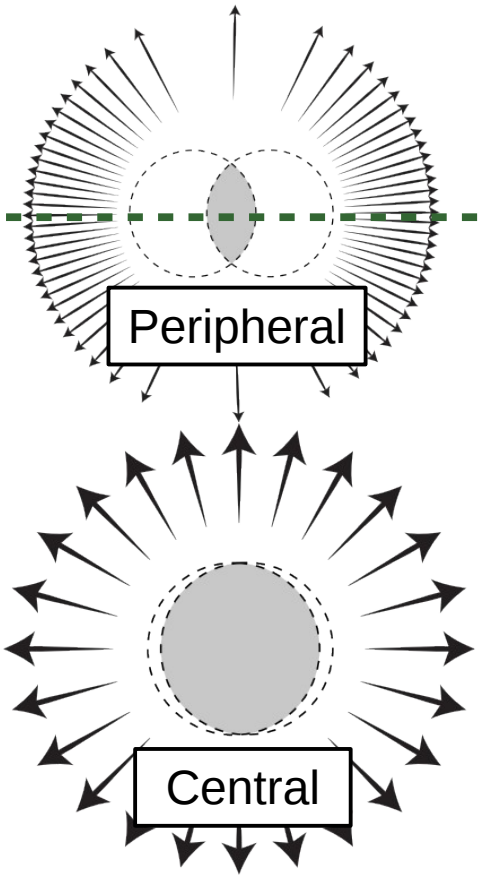


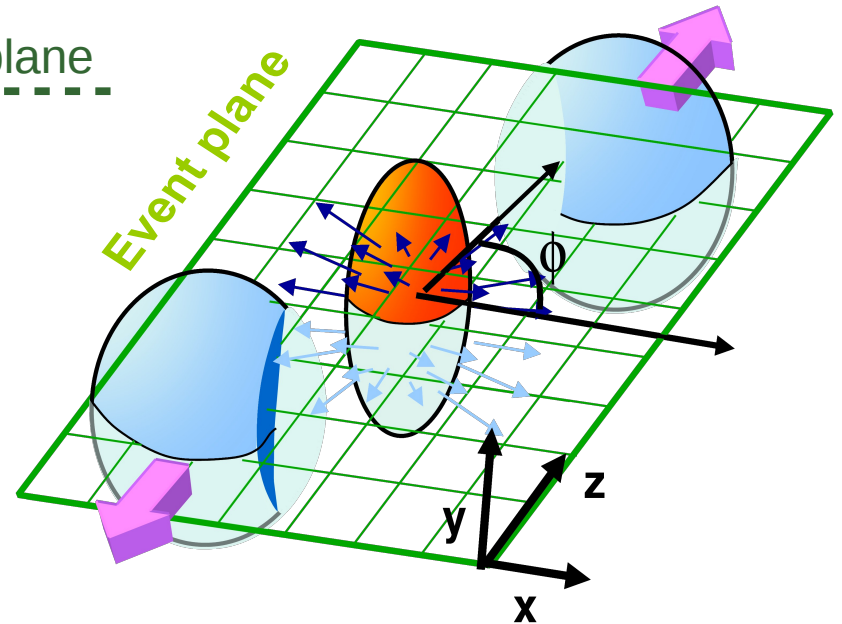
No visible ageing
of MCP detector module prototype for FIT



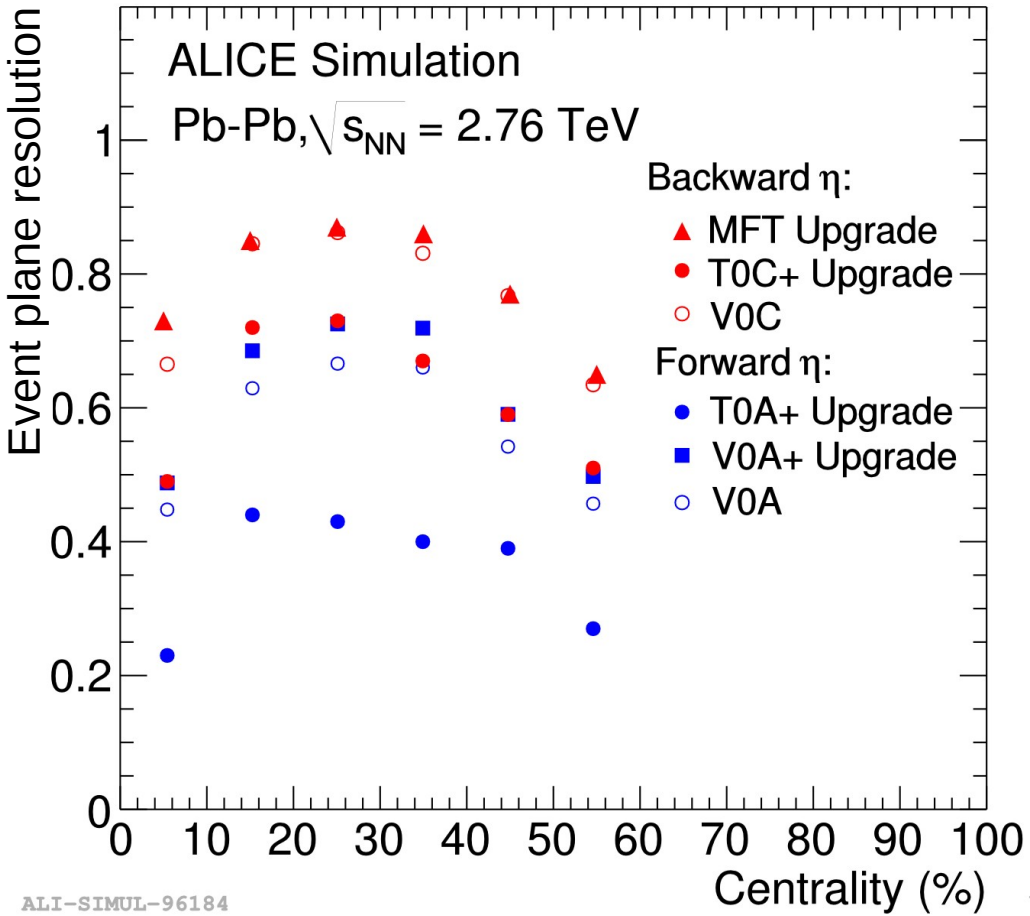
Importance of the V0+ scintillator ring
Centrality and event plane

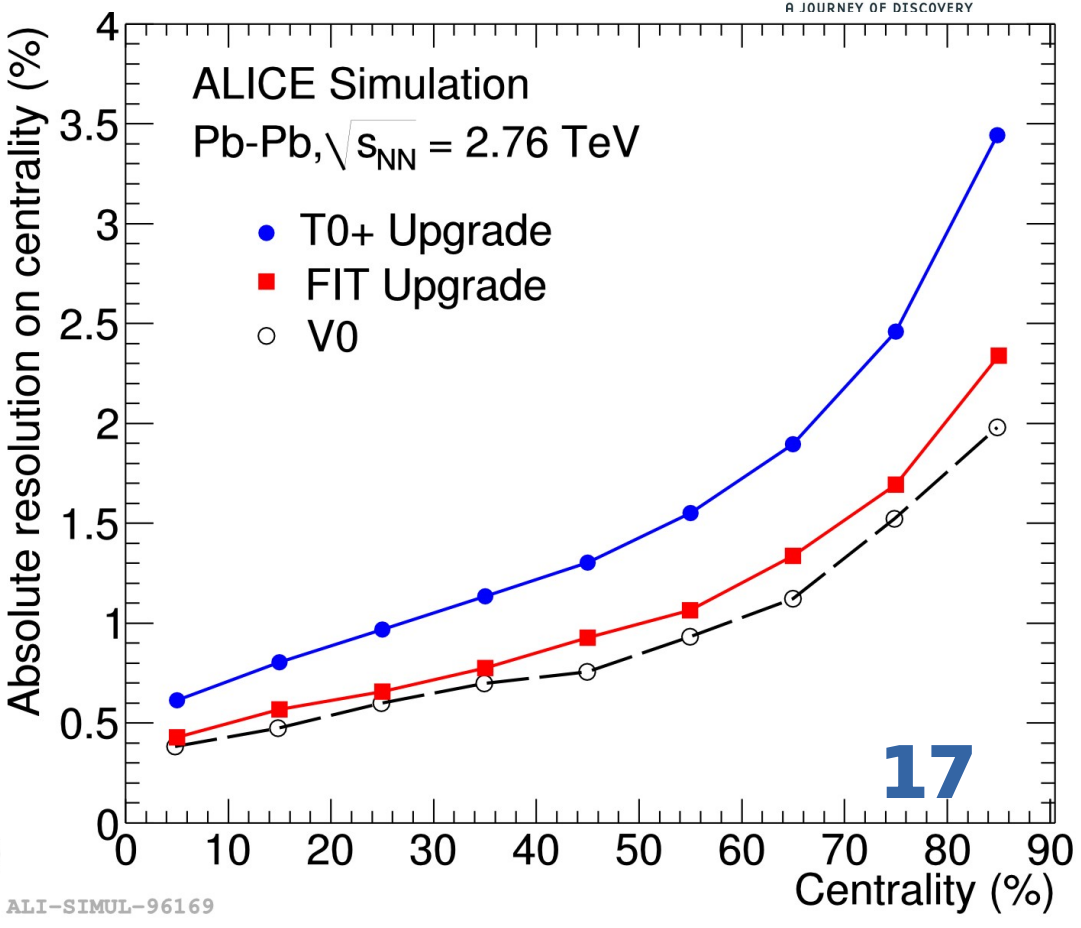






Importance of the V0+ scintillator ring
Simulated physics performance of FIT





Conclusions and outlook

- The R&D of the new forward detectors: MFT and FIT at ALICE is well advanced.
- The detector prototypes reach the operational parameters required at the LHC Run 3 on the laboratory test benches and in simulations.
- The components of both projects are undergoing an internal ALICE review process.
- The mechanical integration of inner parts of ALICE, including the beam pipe, ITS, MFT and FIT will be tested using the mock-up setup in September 2017.