

The Fast Interaction Trigger for ALICE LHC Run 3 and 4



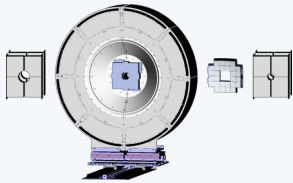
ALICE
A JOURNEY OF DISCOVERY

LXX International Conference 'NUCLEUS - 2020'
Online, 11 - 17 October 2020

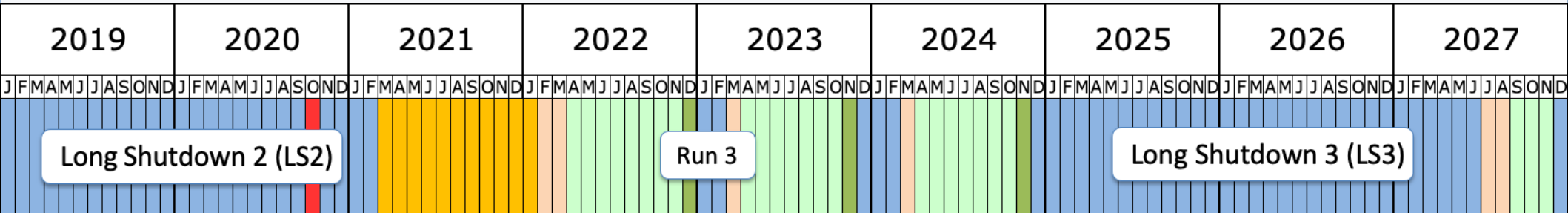


Maciej Słupecki
on behalf of the ALICE Collaboration



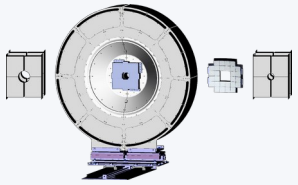


LHC schedule



The LHC entered the Long Shutdown 2 (**LS2**) in 2019 → major implications for ALICE

- Increase in luminosity (number of collisions per s per cm²)
- Sustained pp operation at 25 ns bunch crossing time
- Minimum-bias **Pb-Pb** at the target interaction rate of **50 kHz**
 - in Run 1 and 2 it was < 1 kHz; downgraded from available 8 kHz



ALICE upgrades



Time Projection Chamber (TPC)

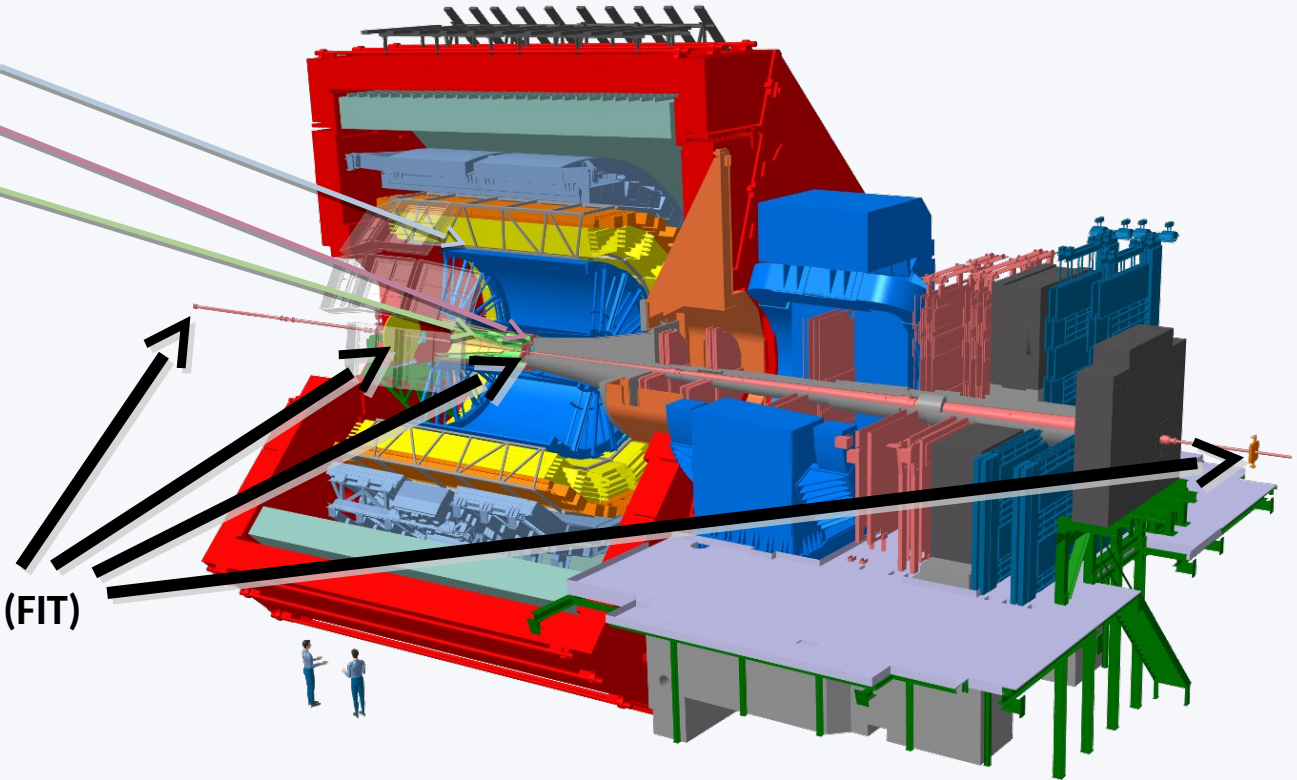
Muon Forward Tracker (MFT)

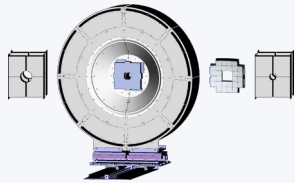
Inner Tracking System (ITS)

New Online-Offline (O²)
computing infrastructure

New Fast Interaction Trigger (FIT)

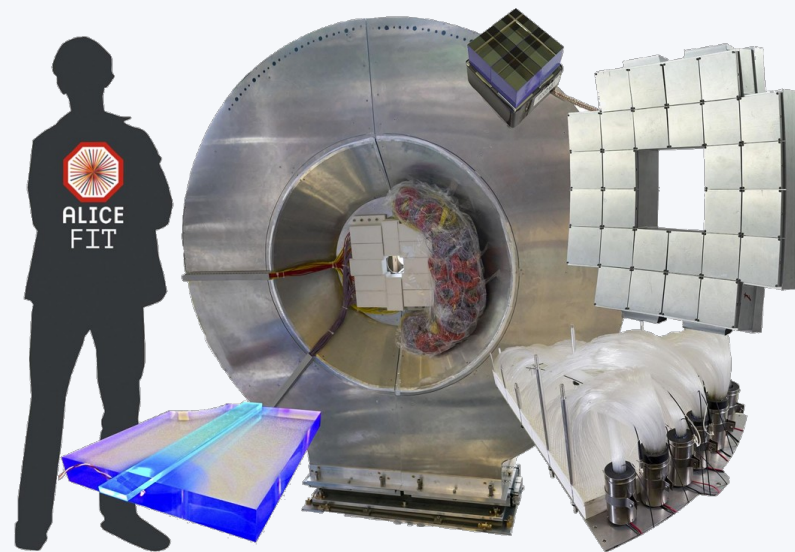
- Cherenkov arrays
- Plastic scintillators

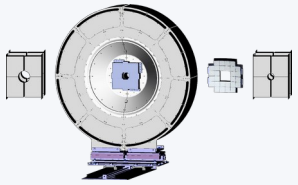




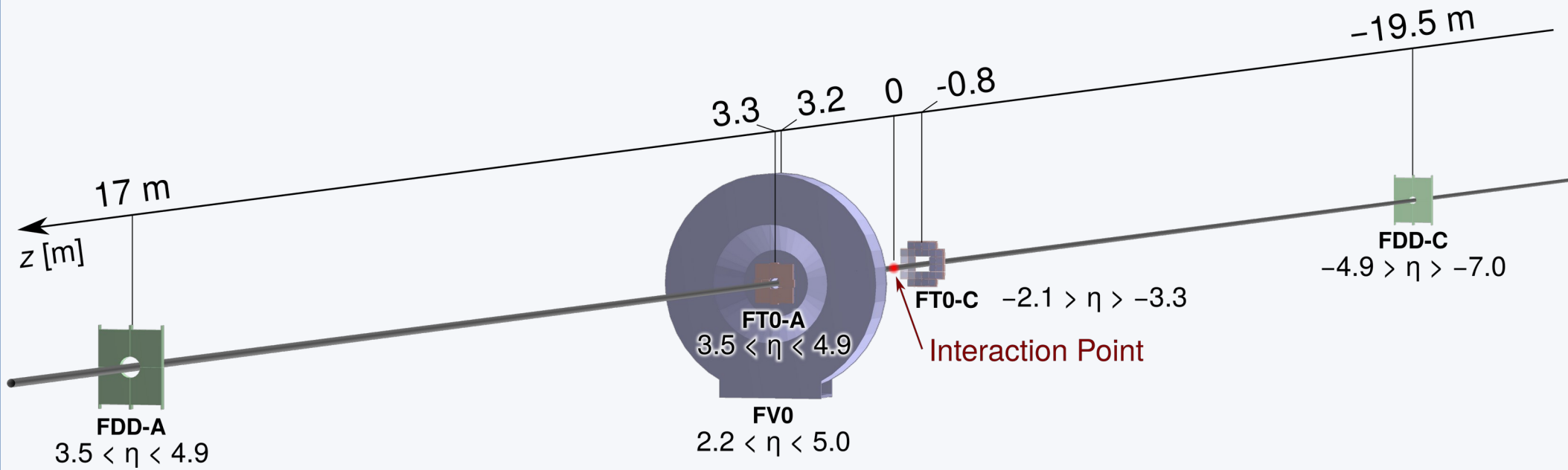
Functionalities of FIT

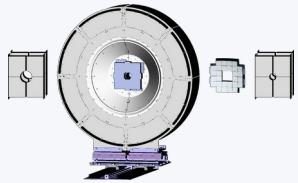
- **Luminosity** monitoring & feedback to LHC
 - Essential for the operation of ALICE
- **Fast Interaction Trigger**
 - Online vertex determination
 - Minimum bias and centrality selection
 - Rejection of beam-gas events
 - Veto for ultraperipheral collisions
- **Multiplicity** → **centrality** and **event plane**
- **Collision time** for Time-Of-Flight particle ID
- **Diffraction physics**





FIT layout

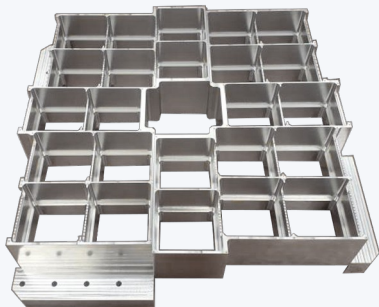




FIT subdetectors

FT0

- ✱ 2 **Cherenkov** arrays
→ with quartz radiators
- ✱ low latency → LM trigger
- ✱ time resolution < 20 ps
- ✱ background rejection
→ MB trigger, **luminosity**



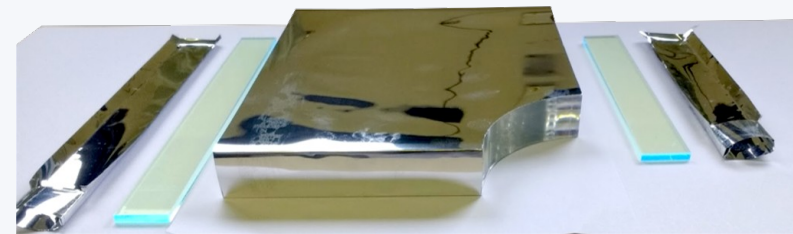
FV0

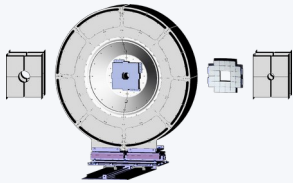
- ✱ 5 **scintillator** rings, 8 sectors
- ✱ low latency → LM trigger
- ✱ time resolution ~ 250 ps
- ✱ background monitoring
- ✱ **large area** → **multiplicity trigger**



FDD

- ✱ 2 **scintillator** arrays,
2 layers each
- ✱ very forward rapidity
→ diffractive physics
- ✱ background monitoring





FIT subdetectors

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- ✱ 2 **Cherenkov** arrays
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FDD

- ✱ 2 **scintillator** arrays,
2 layers each
- ✱ very forward rapidity
→ diffractive physics
- ✱ background monitoring

- ✱ **Common custom-designed front-end electronics**

→ sustained pp operation at 25 ns bunch crossing, high dynamic range

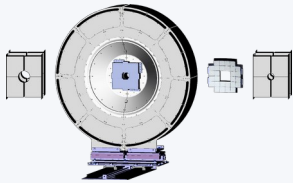
- ✱ **Radiation hard**

→ FIT survives Run 3 and 4 without major component replacements

→ no active electronics at the detector

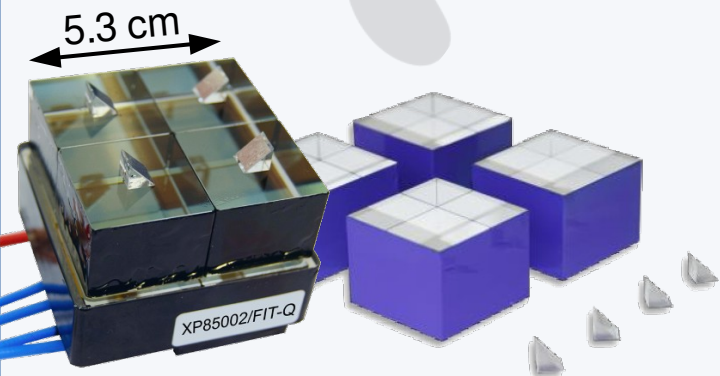


FIT subdetectors – FT0



Detector module

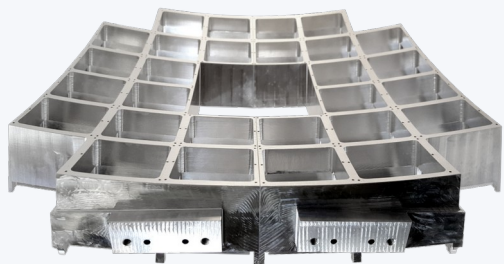
- ✱ MCP-PMT PLANACON XP85002/FIT-Q
- ✱ 4 quartz radiators & 4 readout channels



17.10.2020

FT0-C

- ✱ 28 modules
→ 112 channels
- ✱ concave shape

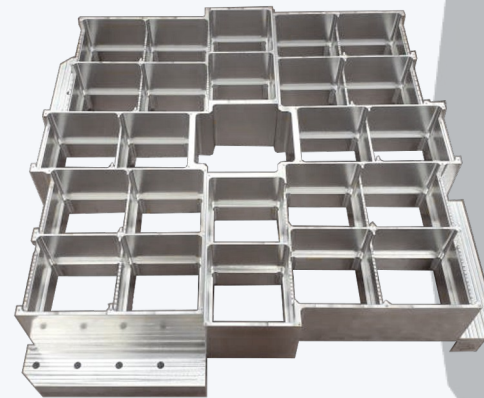


35 cm

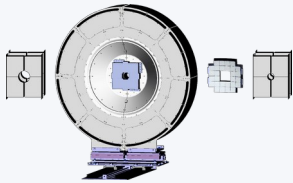
Maciej Slupecki

FT0-A

- ✱ 24 modules
→ 96 channels
- ✱ planar shape



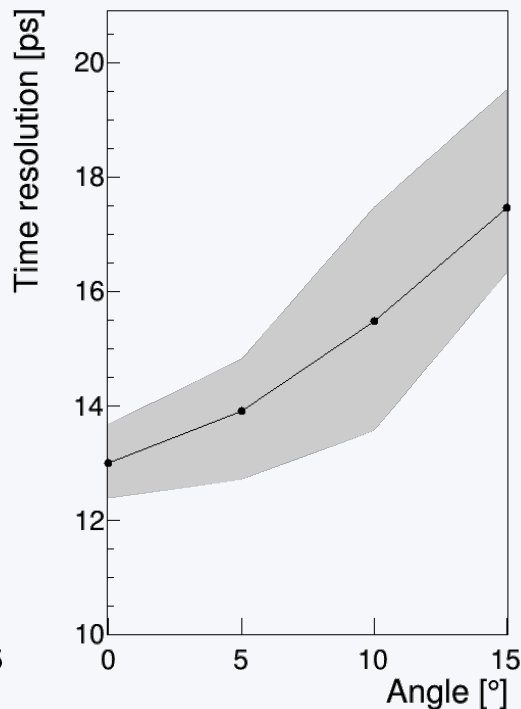
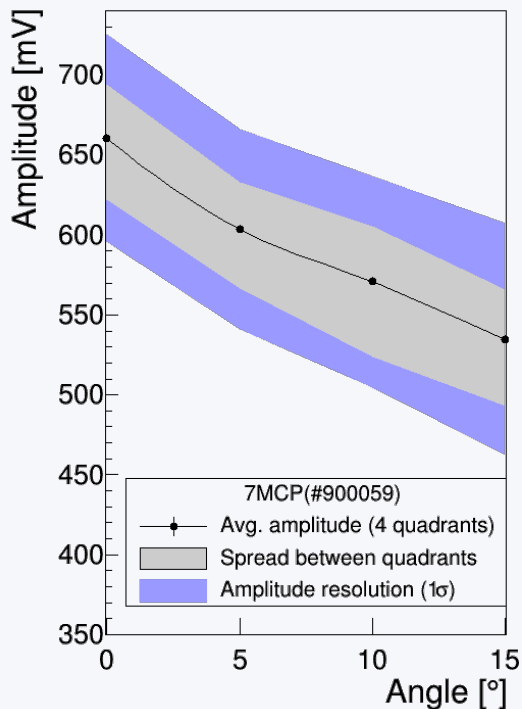
33 cm

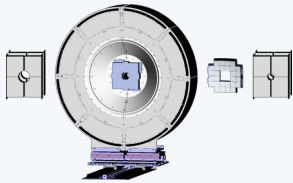


FIT subdetectors – FT0

Detector module tests at CERN PS – few examples

Confirmation of importance of concave shape on the C-side

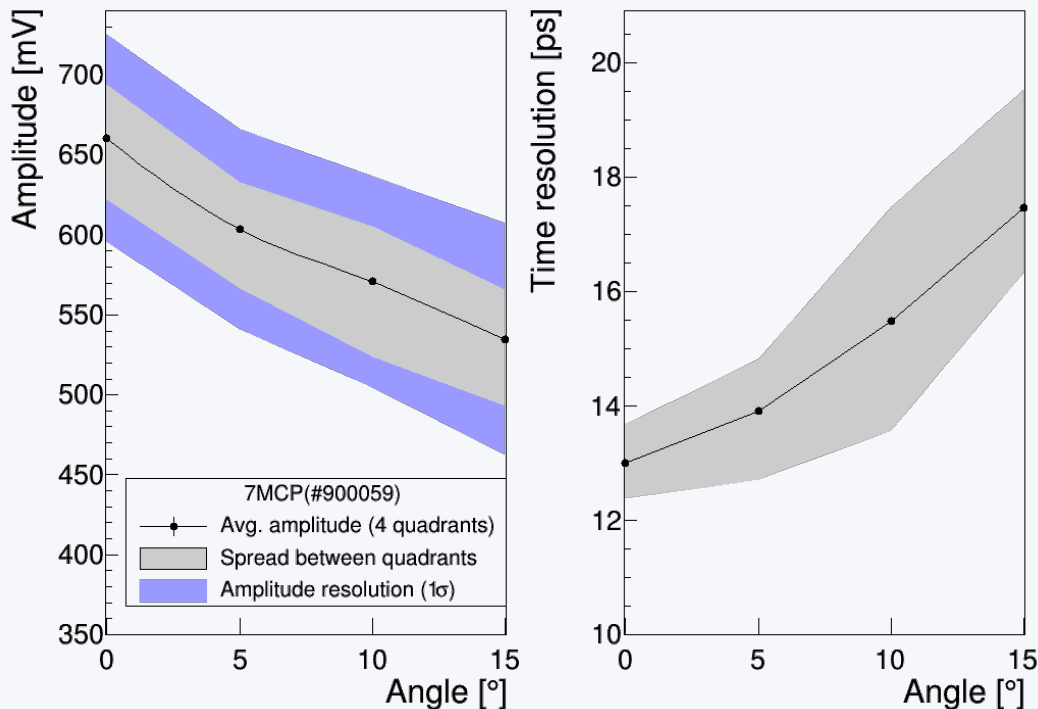




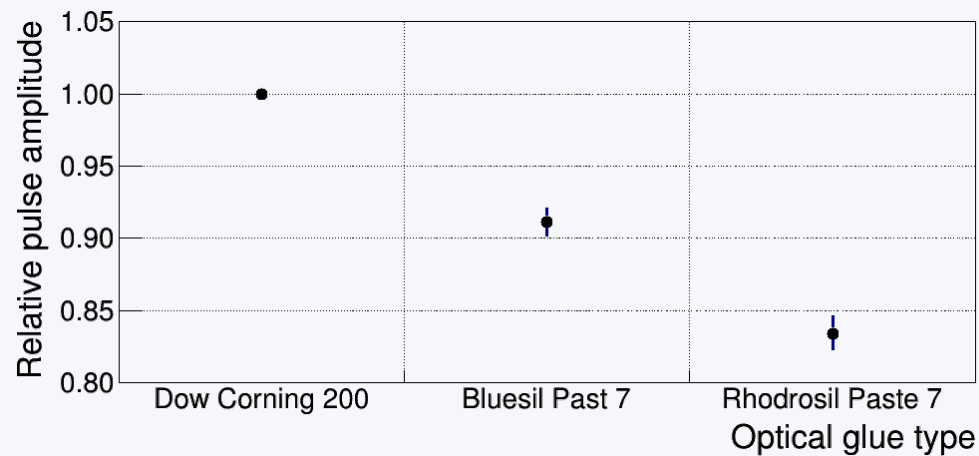
FIT subdetectors – FT0

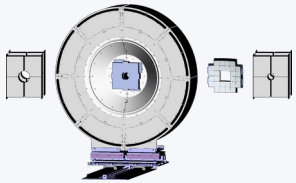
Detector module tests at CERN PS – few examples

Confirmation of importance of concave shape on the C-side



Selection of the optimal optical grease, most transparent for Cherenkov light





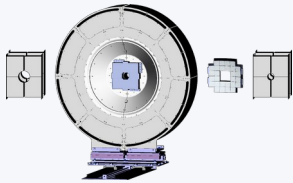
FIT subdetectors – FT0

Comprehensive photosensor acceptance tests

66 units were tested

- ✱ Pulse shape
- ✱ Gain scan
- ✱ Anode current saturation limit
- ✱ Resistance
- ✱ Afterpulses and dark count rate
- ✱ Long term HV stress-test



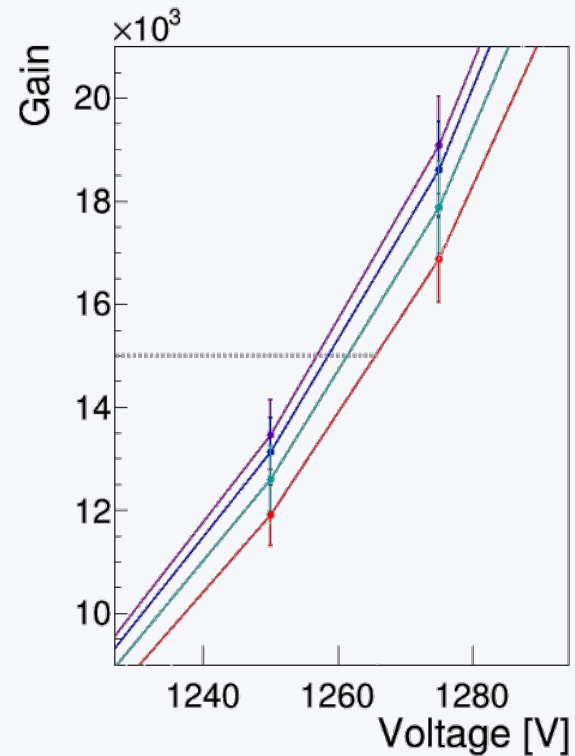
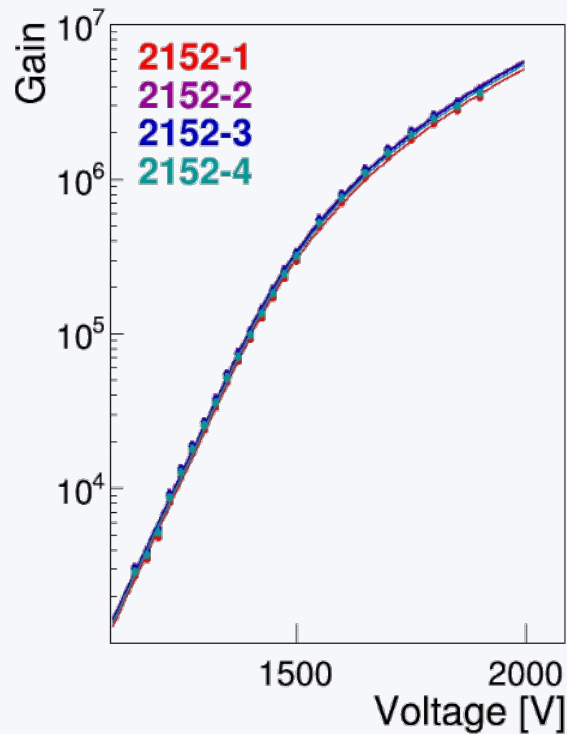


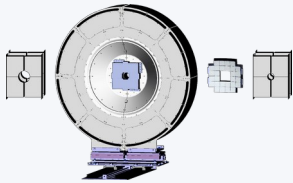
FIT subdetectors – FT0

Comprehensive photosensor acceptance tests

66 units were tested or retested

- ☀ Pulse shape
- ☀ **Gain scan**
- ☀ Anode current saturation limit
- ☀ Resistance
- ☀ Afterpulses and dark count rate
- ☀ Long term HV stress-test



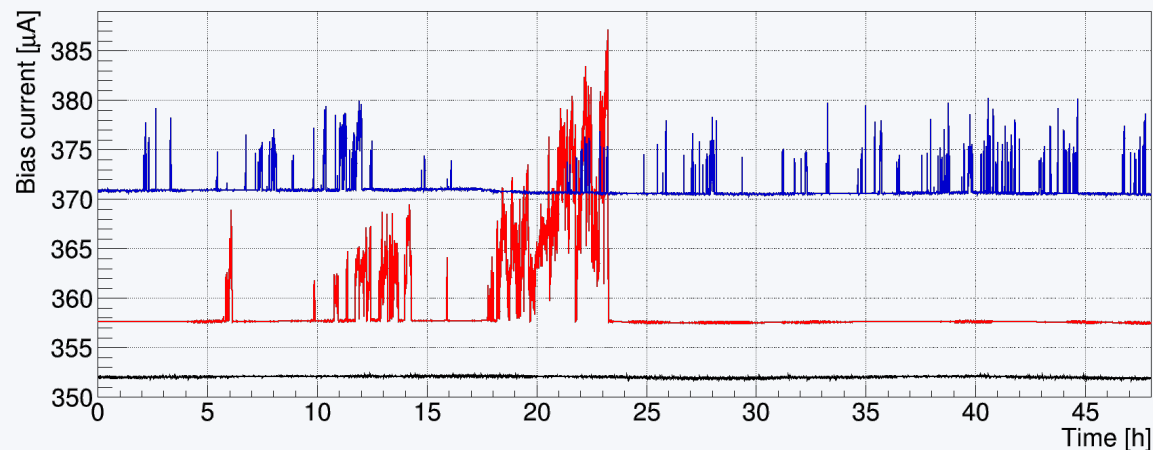


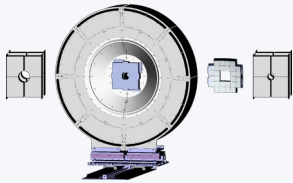
FIT subdetectors – FT0

Comprehensive photosensor acceptance tests

66 units were tested or retested

- ☀ Pulse shape
- ☀ Gain scan
- ☀ Anode current saturation limit
- ☀ Resistance
- ☀ Afterpulses and dark count rate
- ☀ **Long term HV stress-test**





FIT subdetectors – FT0

Comprehensive photosensor acceptance tests

66 units were tested or retested

- ✱ Pulse shape
- ✱ Gain scan
- ✱ Anode current saturation limit
- ✱ Resistance
- ✱ Afterpulses and dark count rate
- ✱ Long term HV stress-test

✱ **Operation within magnetic field**

See the following publications:

[1] <https://arxiv.org/pdf/1807.03804.pdf>

[2] Yu.A. Melikyan, Performance of the cost-effective Planacon® MCP-PMTs in strong magnetic fields, in final review stage in NIMA



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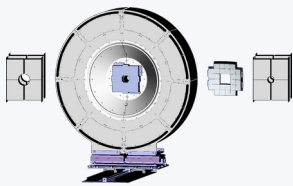
FIT subdetectors – FV0

- ✱ 40 scintillator cells
- ✱ 48 readout channels
→ 2 ch, for every 5th-ring-cell
- ✱ **novel light-collection system**
→ keep **pulse width** < 25 ns
→ no wavelength-shifting fibers

V. Grabski, (2019). *New fibre read-out design for the large area scintillator detectors: providing good amplitude and time resolutions.*
<https://arxiv.org/abs/1909.01184v1>

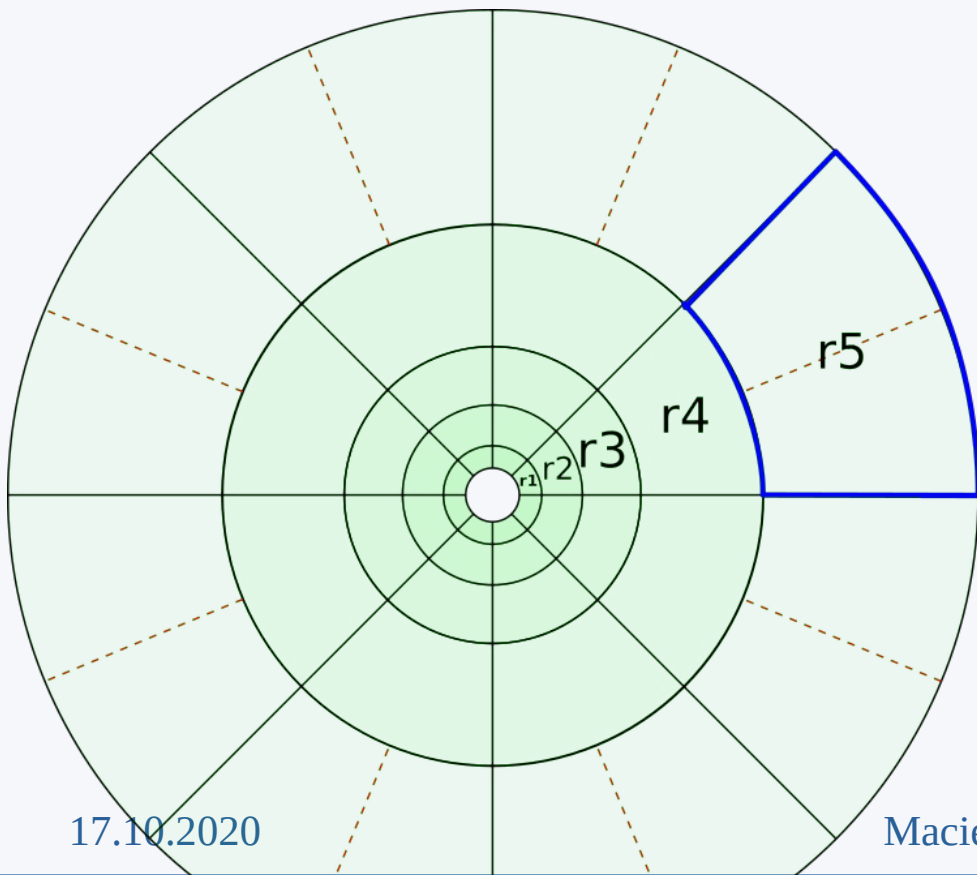


144 cm

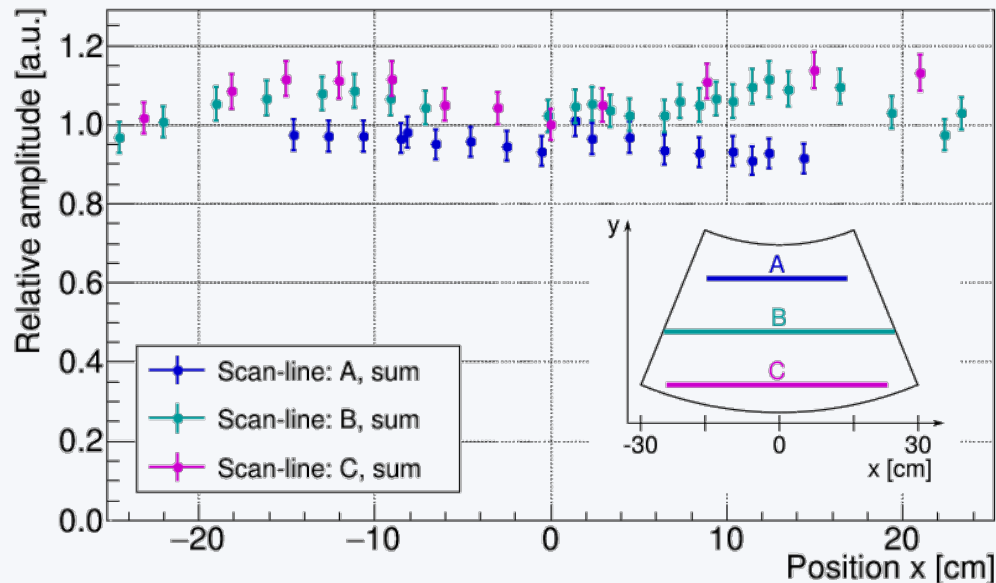


FIT subdetectors – FV0

Uniformity of ring 5 in single-sector prototype tested at CERN PS



Sum of both ring-5 readout channels is uniform



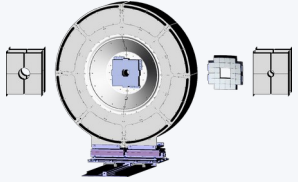
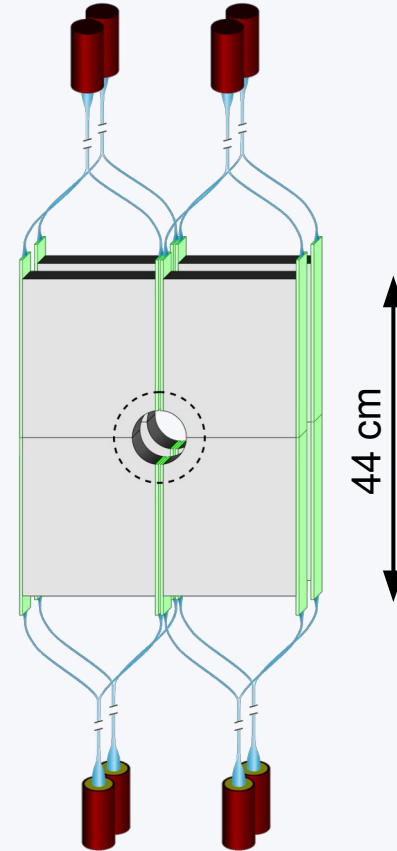


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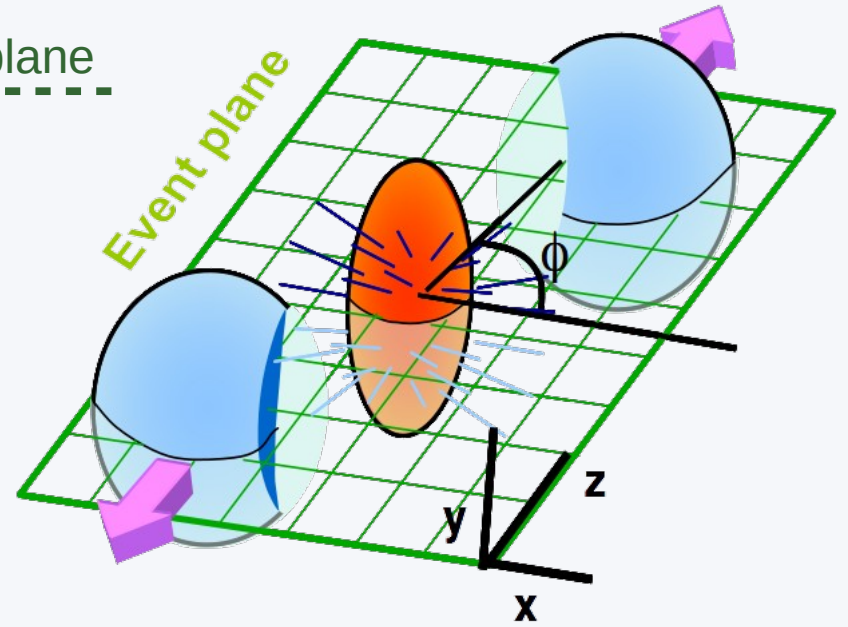
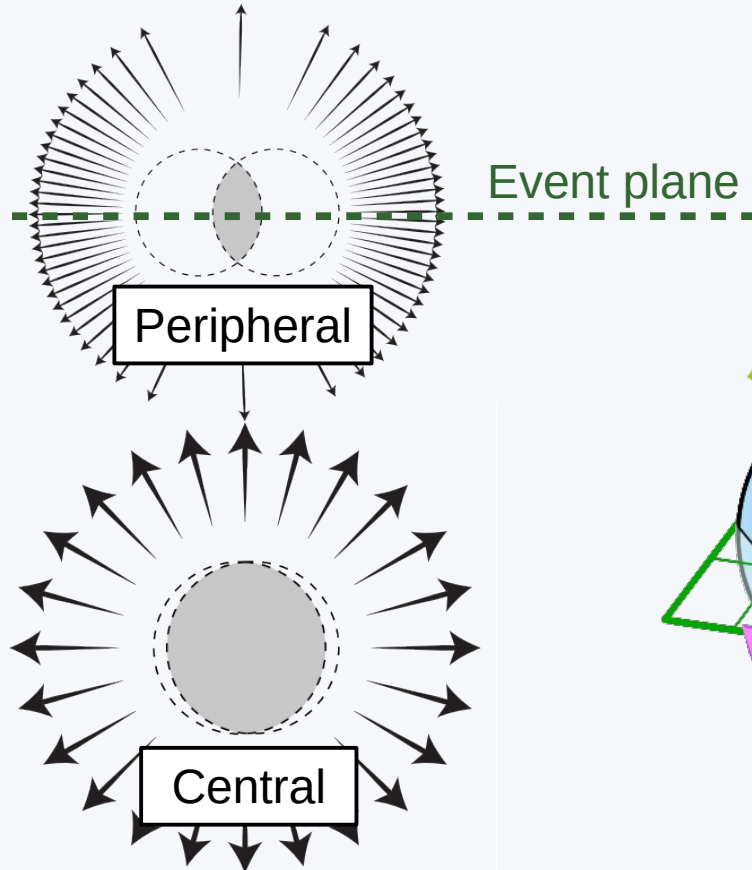
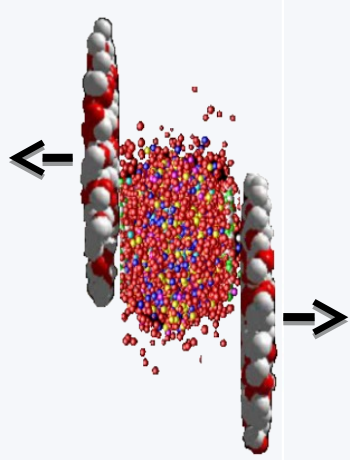
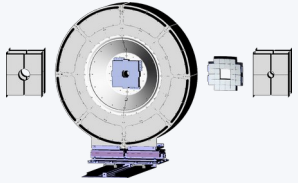
FIT subdetectors – FDD

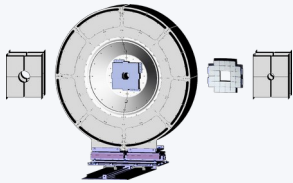
- ✱ 2 arrays of 2-layered scintillators, 4 cells per layer
→ 16 readout channels in total
- ✱ Light is collected through plastic bars doped with very fast wavelength shifter (NOL-38), and transported through clear fiber bundles to PMTs
- ✱ Studies diffractive or photon-induced processes
→ tags absence of activity in the forward direction





Centrality and event plane



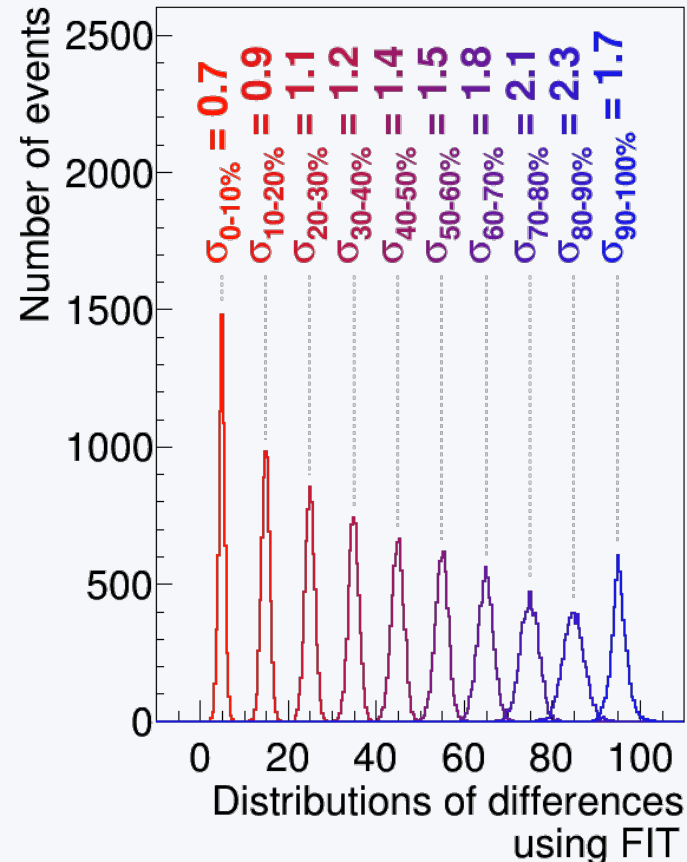
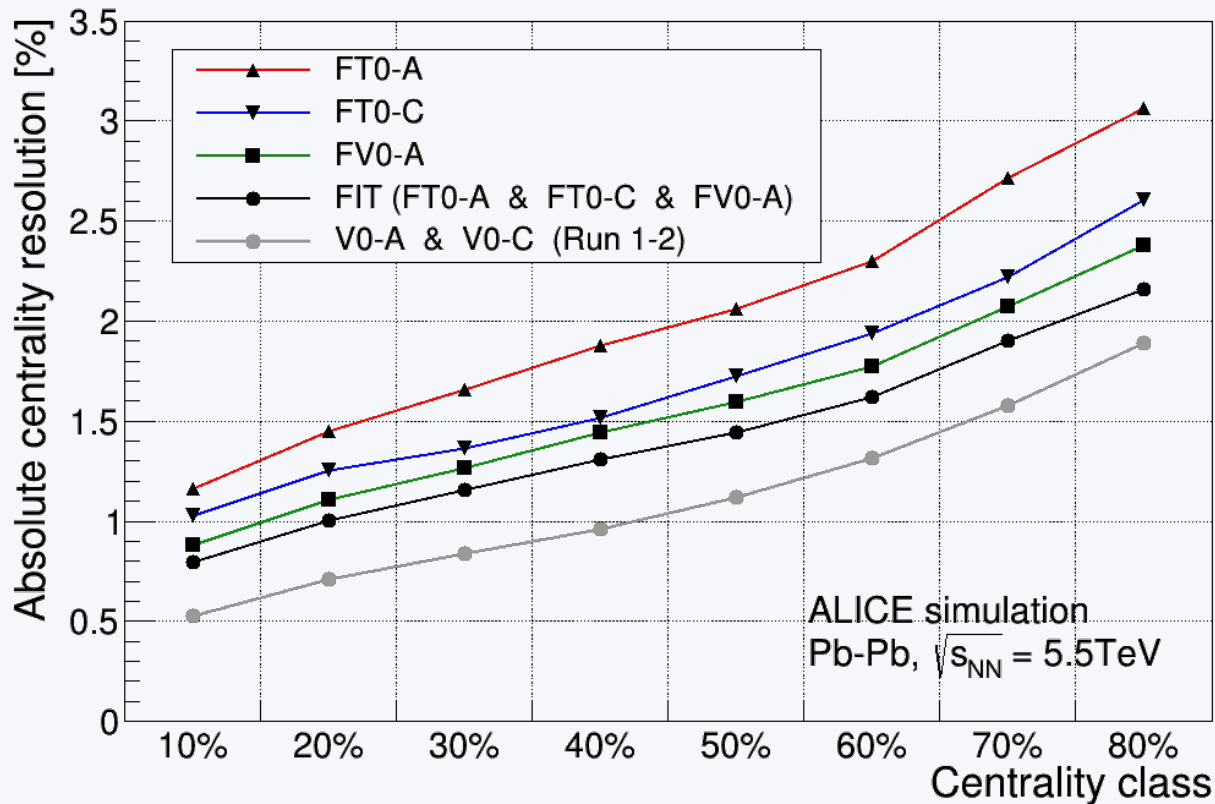


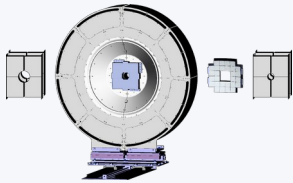
Simulated physics performance

Centrality resolution



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Simulated physics performance

Event-plane resolution

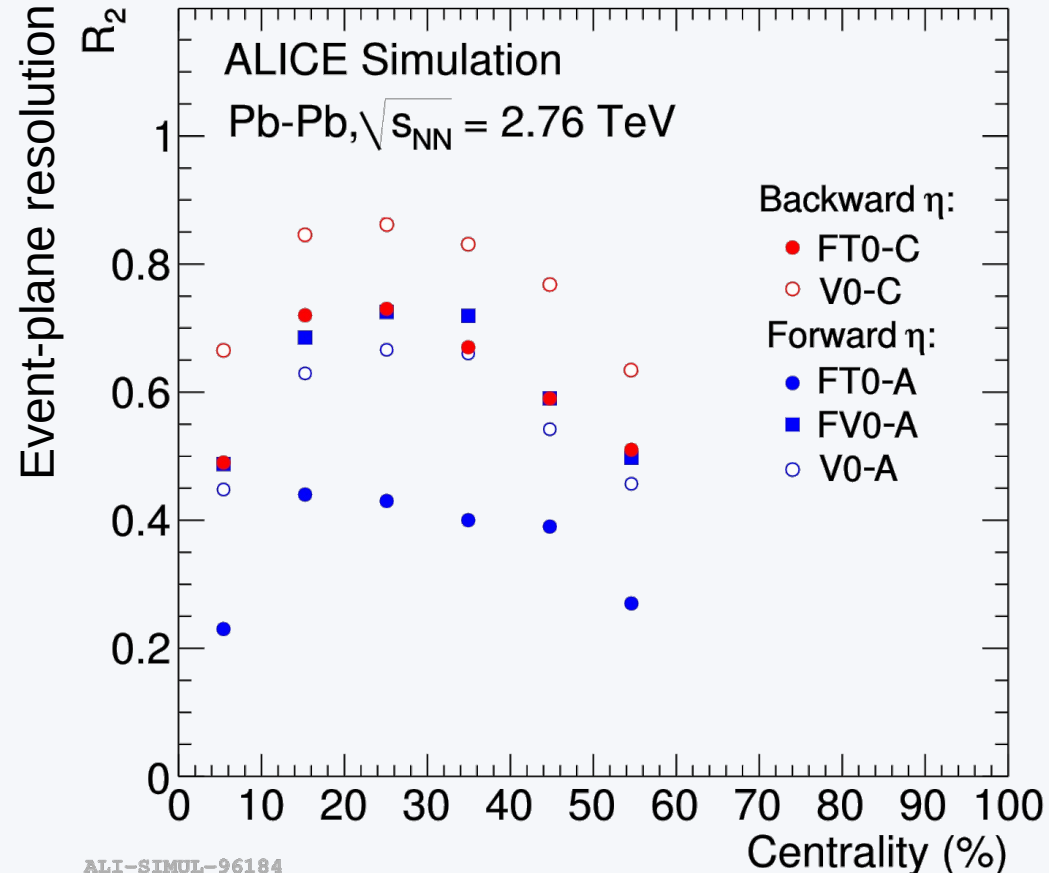
Event-plane resolution – definition

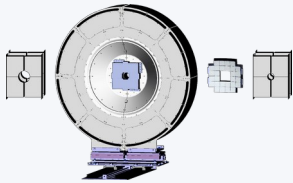
$$\mathcal{R}_n = \langle \cos [n (\Psi_n - \Psi_{RP})] \rangle$$

Harmonic number
(for elliptic flow $n = 2$)

Measured event plane

Reference
(simulated) plane

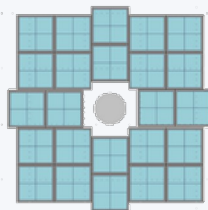




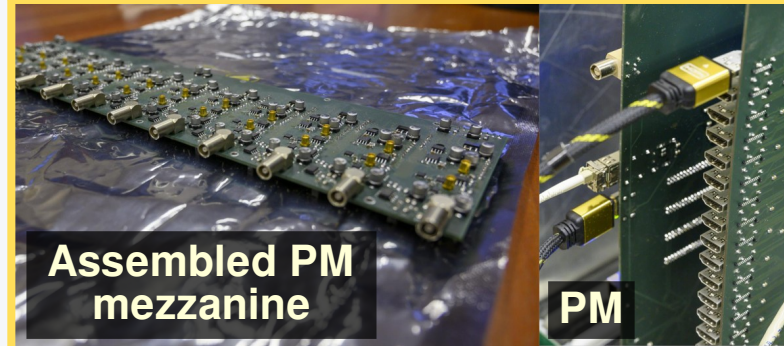
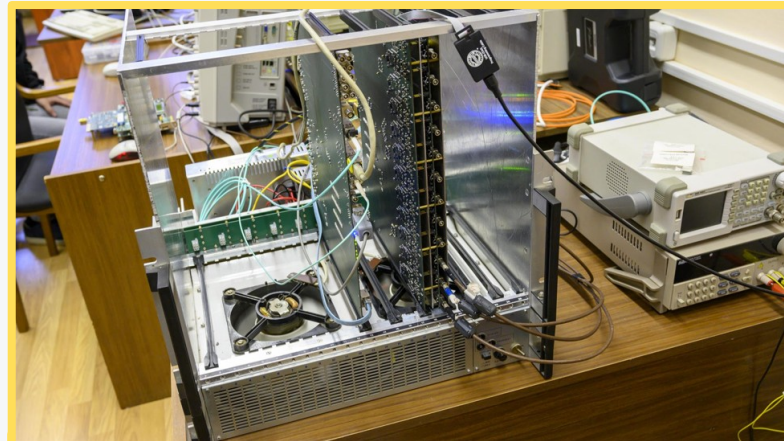
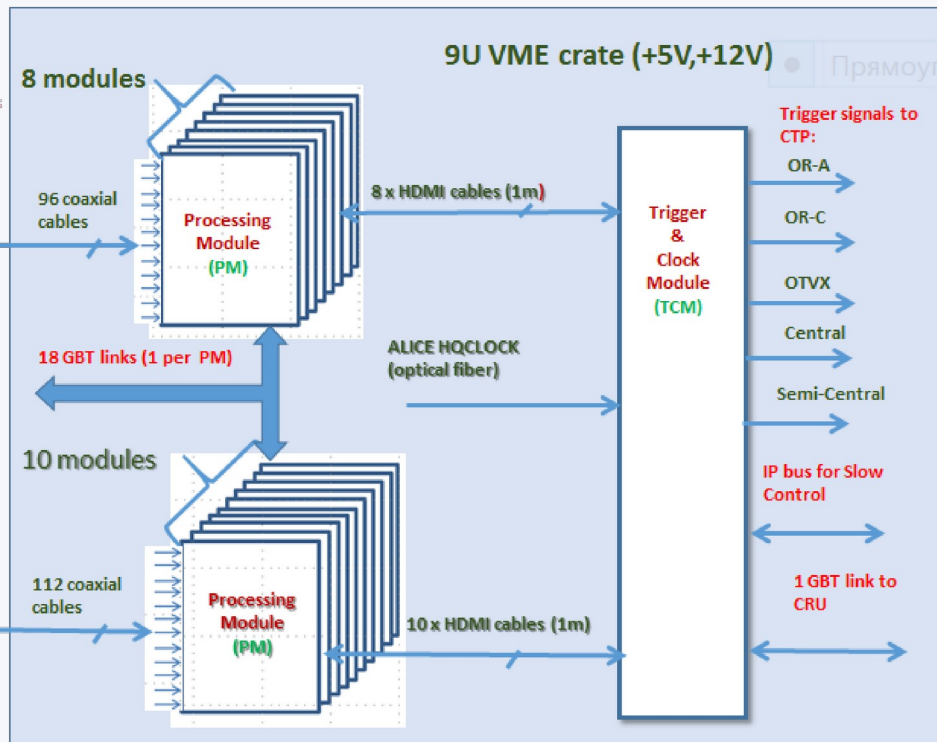
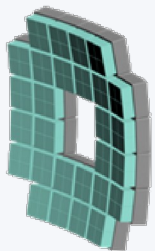
FIT electronics

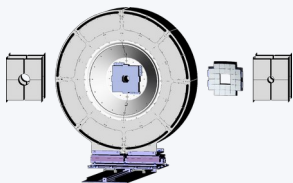
Showing FT0 part only

A-side
24 modules,
Module: MCP and
4 radiators, 4 output signals



C-side
28 modules,
Module: MCP and
4 radiators, 4 output signals

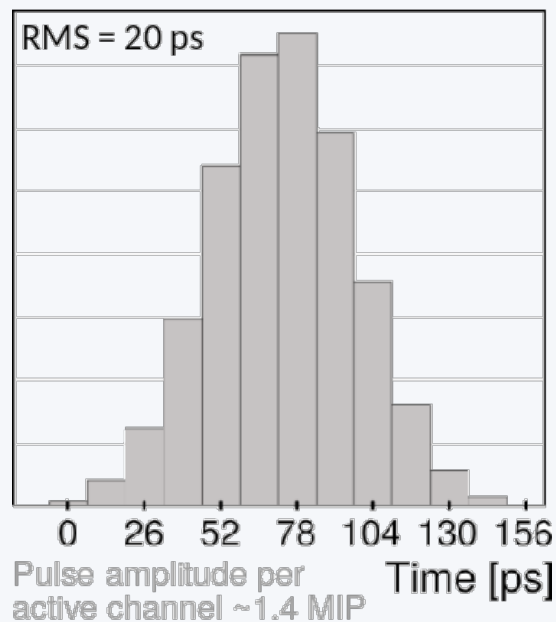




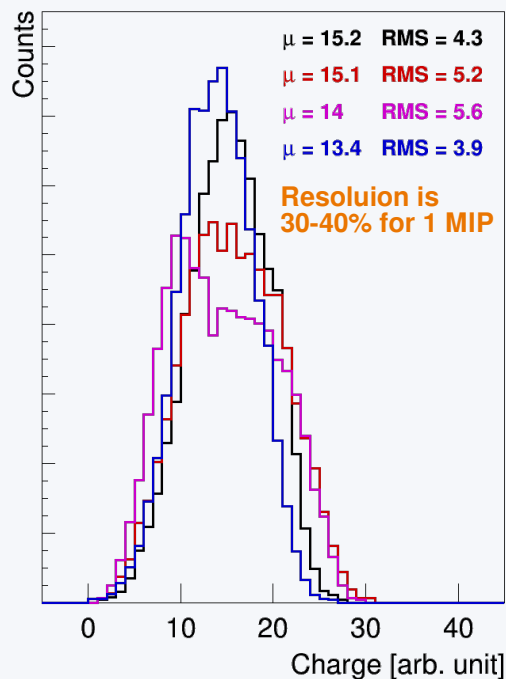
FIT electronics

Latest test results

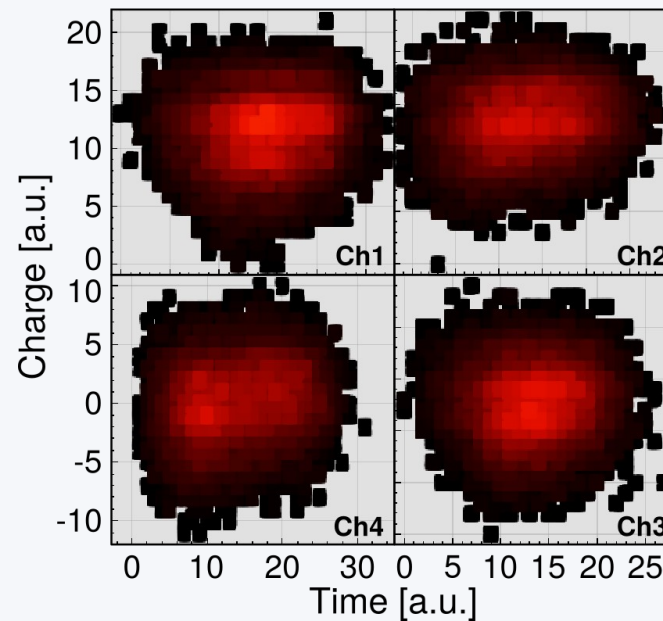
Vertex trigger resolution
at low channel multiplicity (2 & 3)

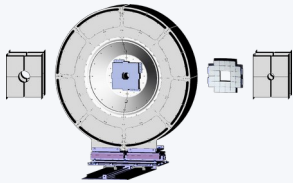


Charge of 4 random channels from
the partly assembled FT0-A detector
and final version of FEE using laser

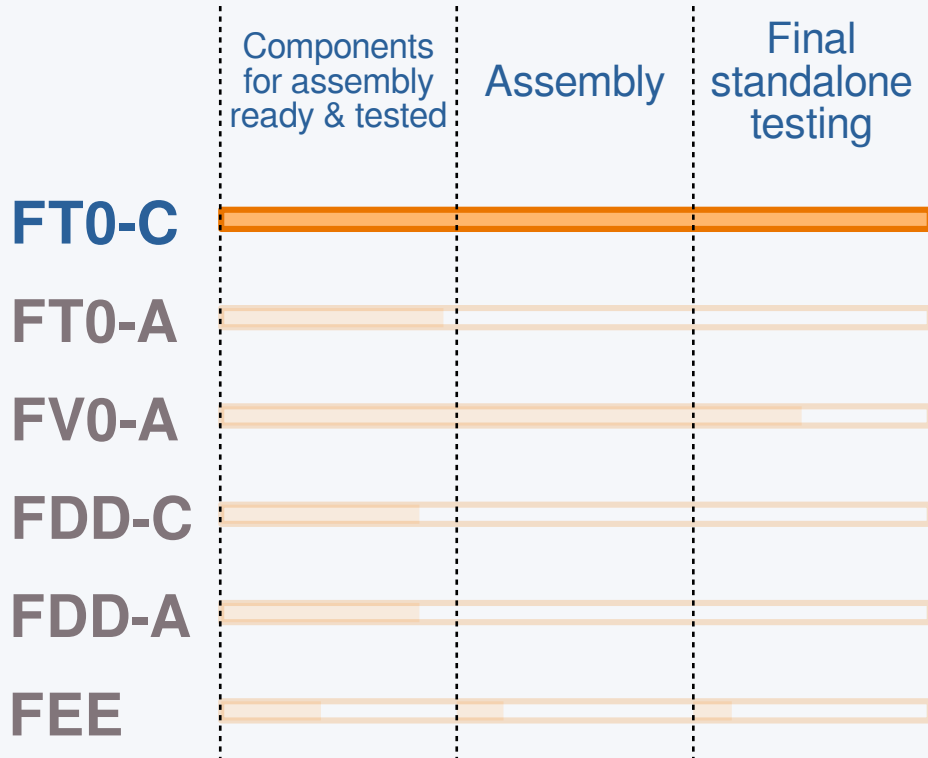


Time vs. charge shows no correlation
→ CFD works correctly

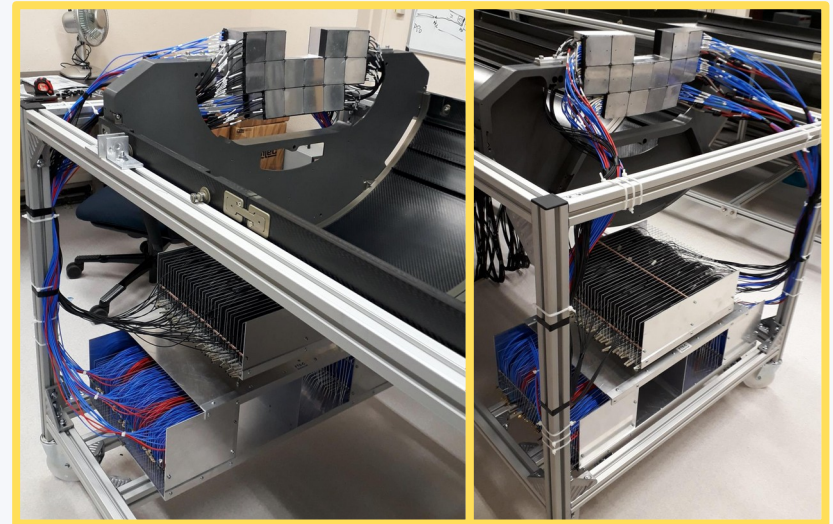


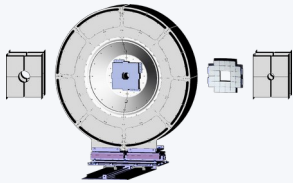


Status of FIT subsystems

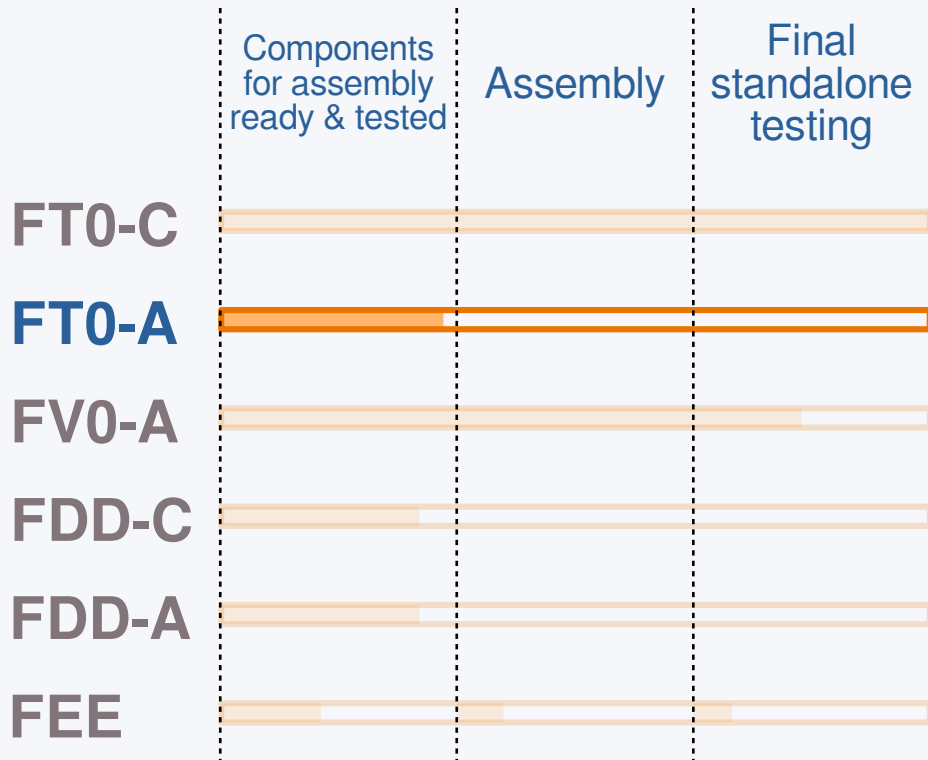


- ✱ Assembled, integrated within the common structure with MFT, all connections tested → ready for installation

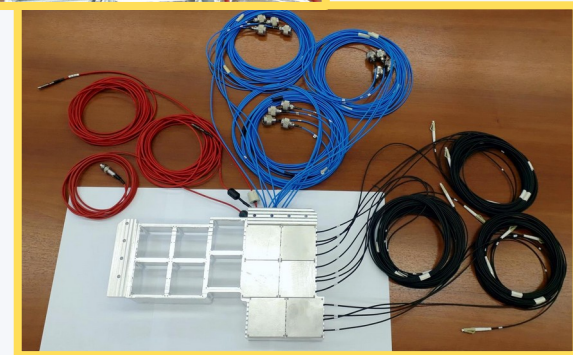
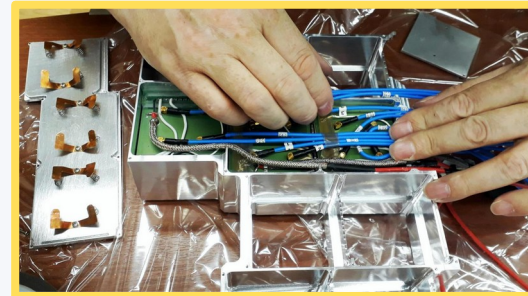


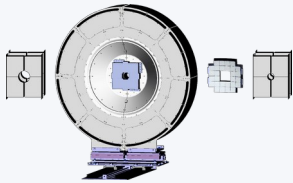


Status of FIT subsystems

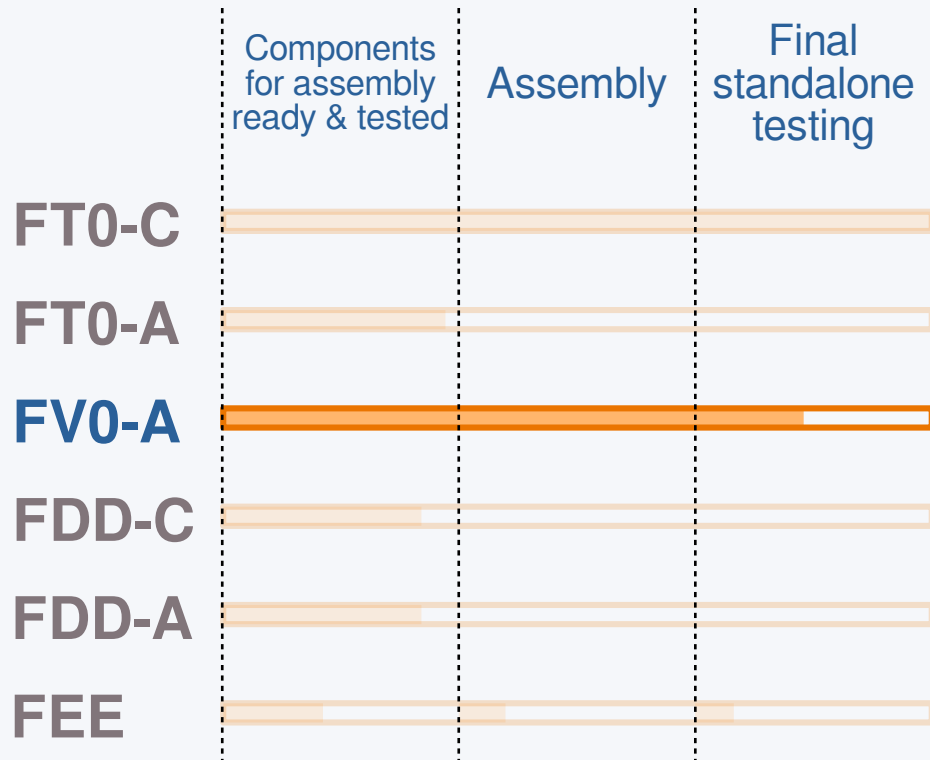


- ✱ Used for final FEE tests
- ✱ Ongoing simple modification of metal structure
- ✱ Expected assembly time: <2 weeks



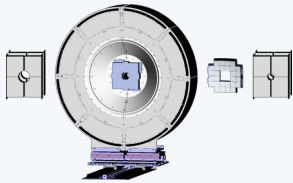


Status of FIT subsystems

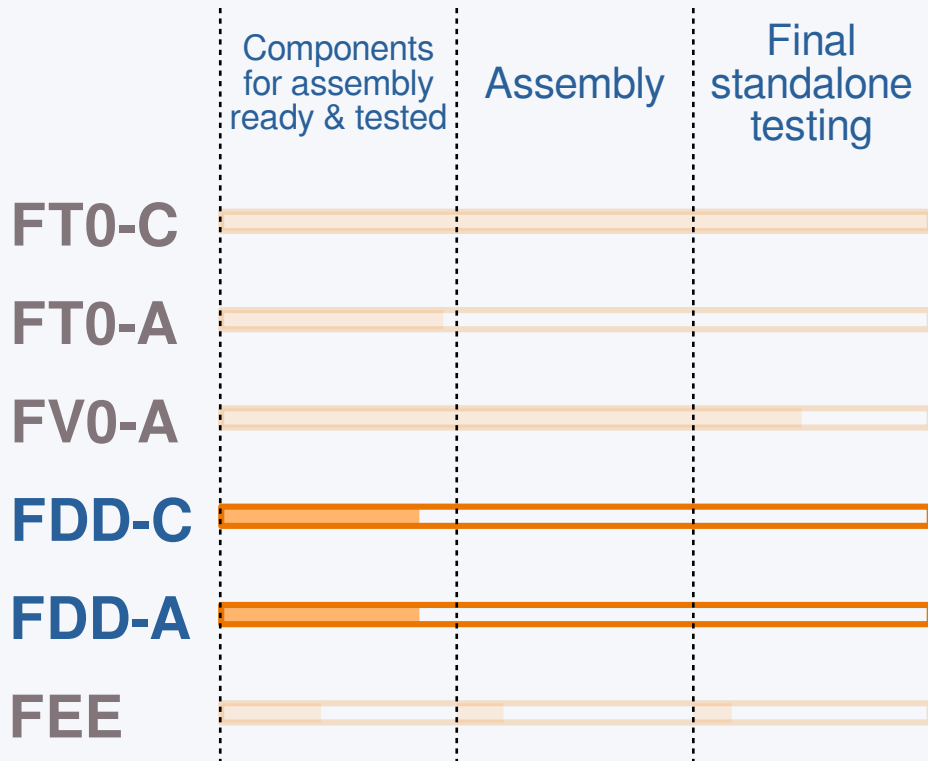


- ✱ Measurements to be completed:
 - pulse-shape verification
 - tests with final FEE, tuning for FV0
 - charge measurement with cosmic muons

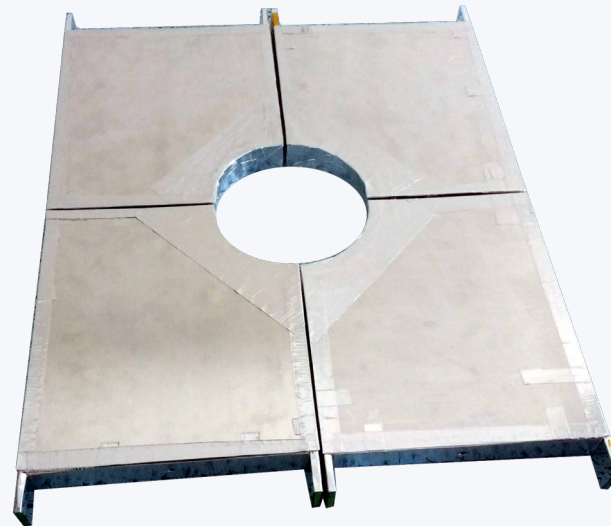


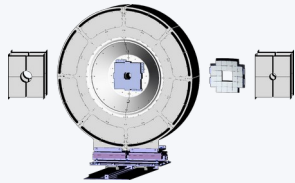


Status of FIT subsystems

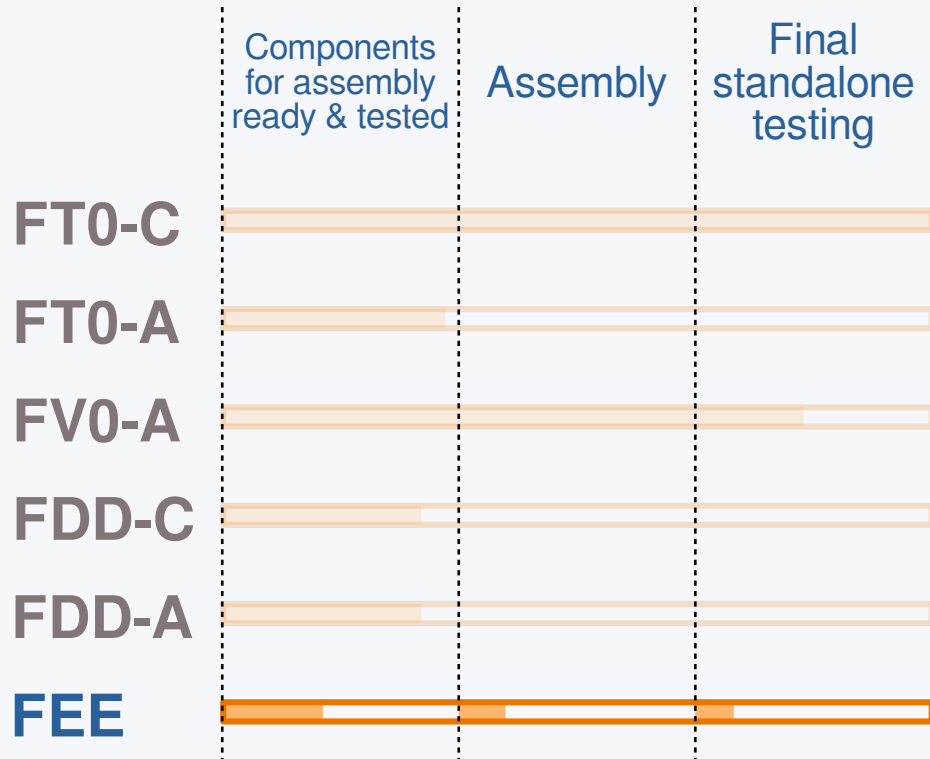


- ✱ Characterization of photosensors is completed
- ✱ Assembly of scintillator modules takes 60 h
- ✱ Assembly of fiber bundles takes 2-3 weeks

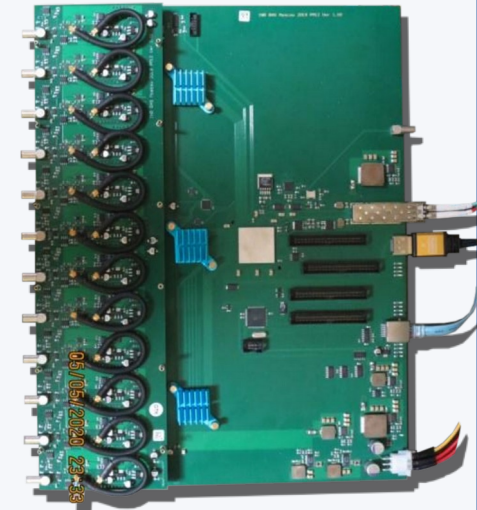
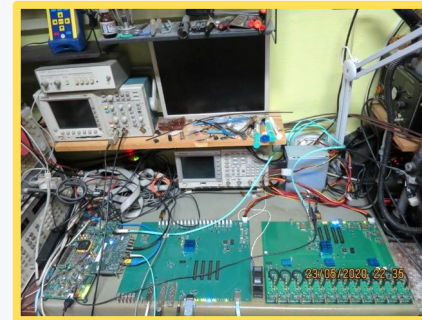


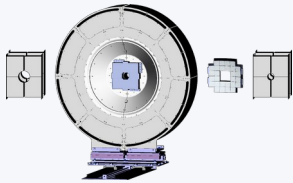


Status of FIT subsystems



- ✱ Components are tested in parallel with assembly
- ✱ Electronics designed for FT0
→ need to be tested and tuned for FV0 and FDD
- ✱ Mass production will start after all tests completed
→ in January 2021



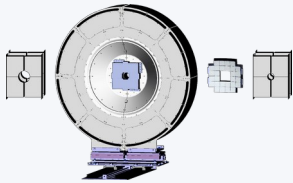


Status of FIT subsystems



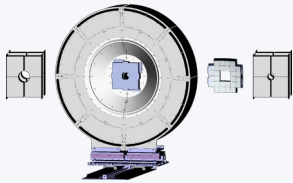
	Components for assembly ready & tested	Assembly	Final standalone testing	Scheduled for installation in ALICE*	Remaining time
FT0-C				30.11.2020 – 22.01.2021	2 months
FT0-A				24 – 28.05.2021	7 months
FV0-A				24 – 28.05.2021	7 months
FDD-C				1-26.02.2021	3-4 months
FDD-A				1-26.02.2021	3-4 months
FEE				Before 06.2021 (global commissioning)	7.5 months

*According to v42, subject to change, depending on COVID-19 effects

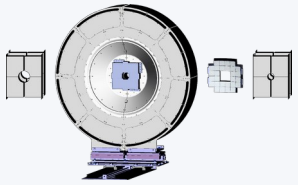


Summary

- FIT is essential for the operations in ALICE in Run 3 and 4
 - Trigger, luminometer
 - Diffractive physics, collision time for PID, centrality and event-plane
- FIT consists of 3 very different, and therefore, complimentary subdetectors
- FIT detectors are partly assembled and tested
 - Entire detector assembly should be completed by December 2020
- Installation will be started in December 2020 and will end in April 2021
 - FIT is on time for installation



Thank you for your attention



Backup

