Muon Identifier ALICE3

7th Workshop on Diffraction and Ultraperipheral Collisions in Děčín
19/09/2024
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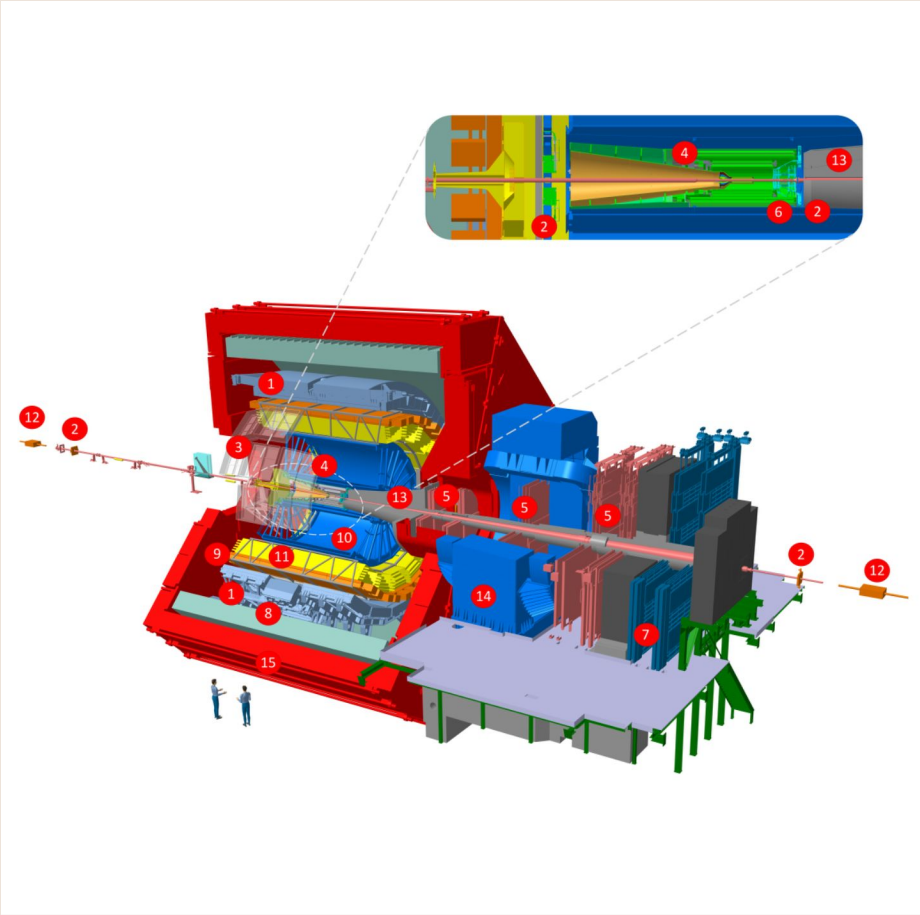
Solangel Rojas Torres

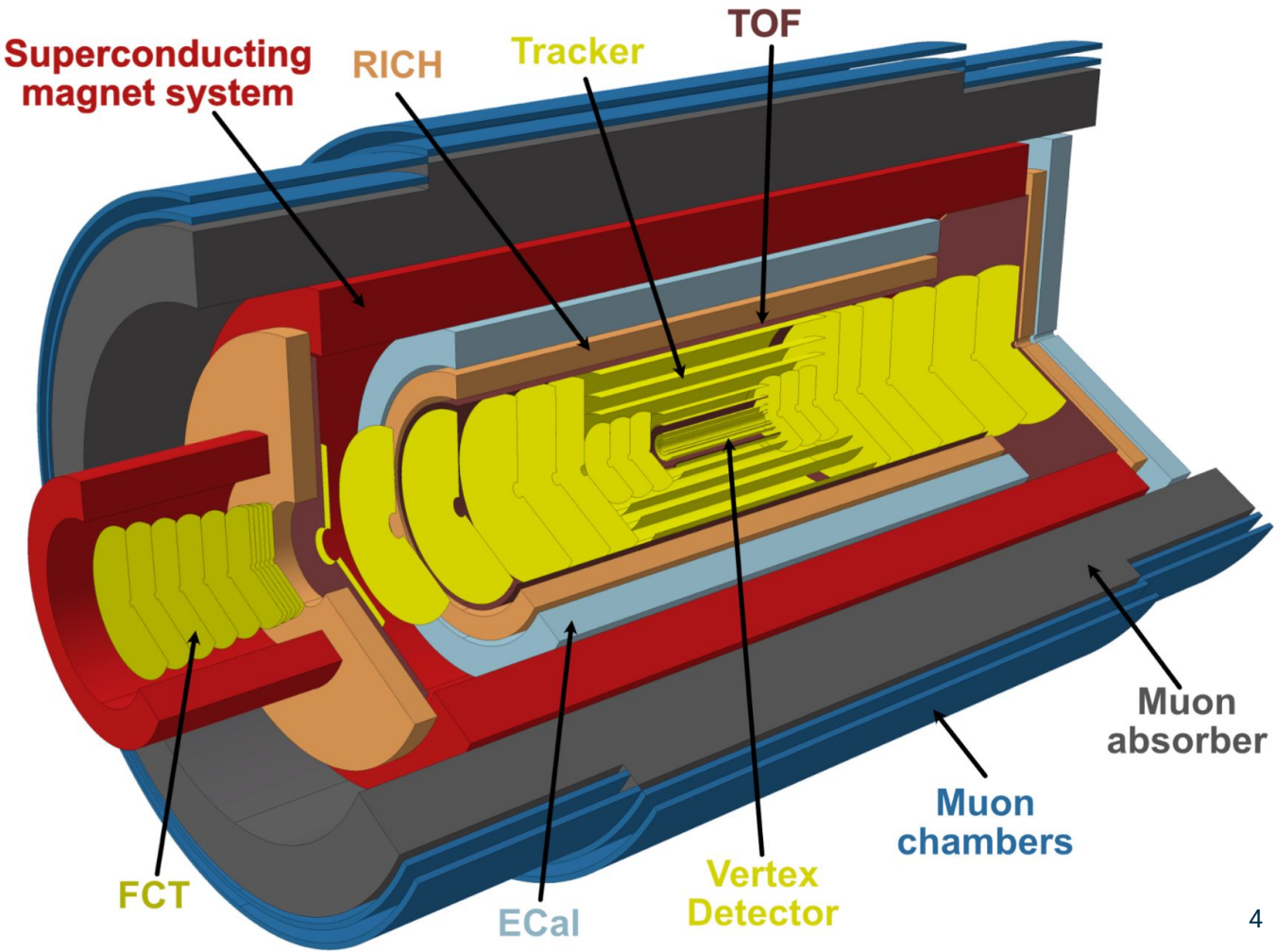
We all know ALICE

It’s a beautiful lady and we love her.

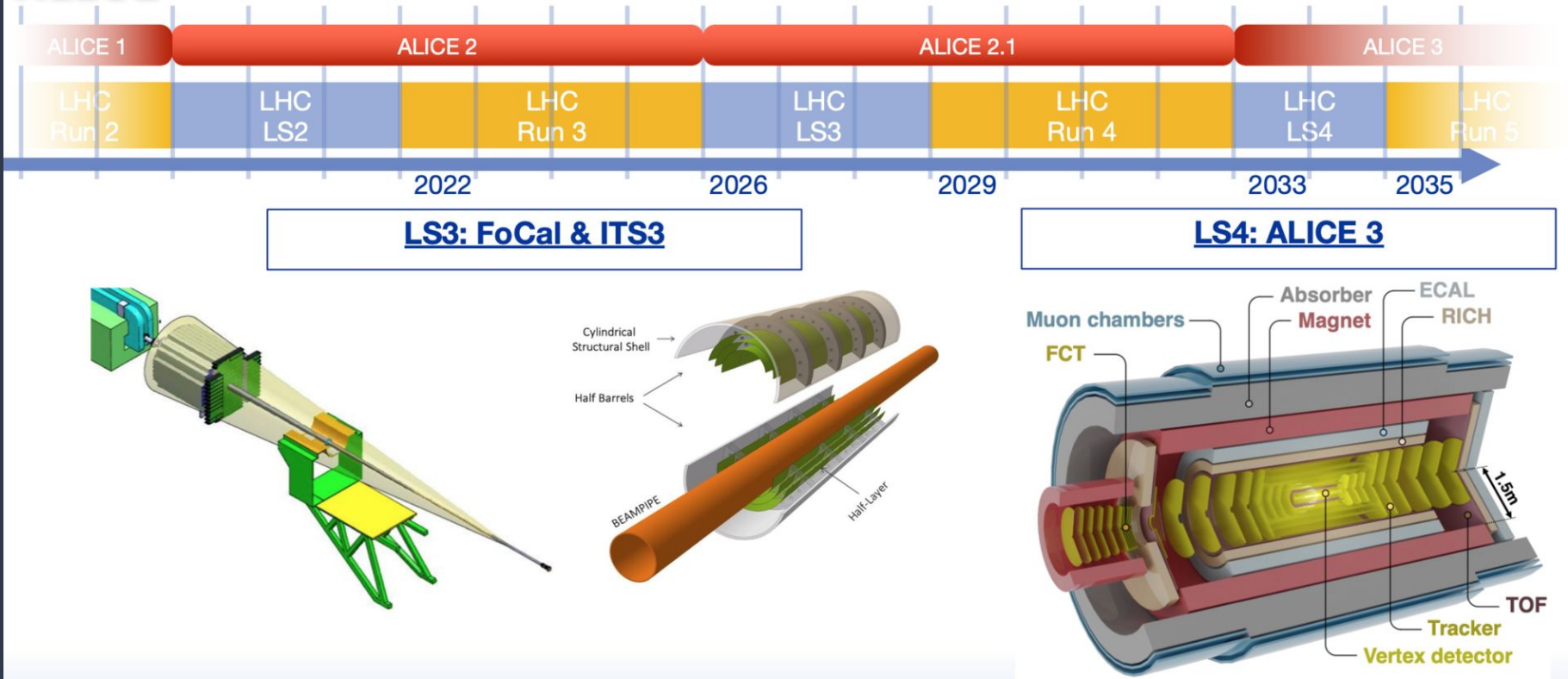


But do you know ALICE3?

ALICE3


Superconducting magnet system
RICH
Tracker
TOF
Muon absorber
Muon chambers
Vertex Detector
ECal
FCT

Timeline


ALICE 1
ALICE 2
ALICE 2.1
ALICE 3
LHC Run 2
LHC LS2
LHC Run 3
LHC LS3
LHC Run 4
LHC LS4
LHC Run 5
2022
2026
2029
2033
2035
LS3: FoCal & ITS3
LS4: ALICE 3
Cylindrical Structural Shell
Half Barrels
BEAMPIPE
Half-Layer
Muon chambers
FCT
Absorber
Magnet
ECAL
RICH
1.5m
TOF
Tracker
Vertex detector

ALICE3 Physics

A Large Ion Collider Experiment

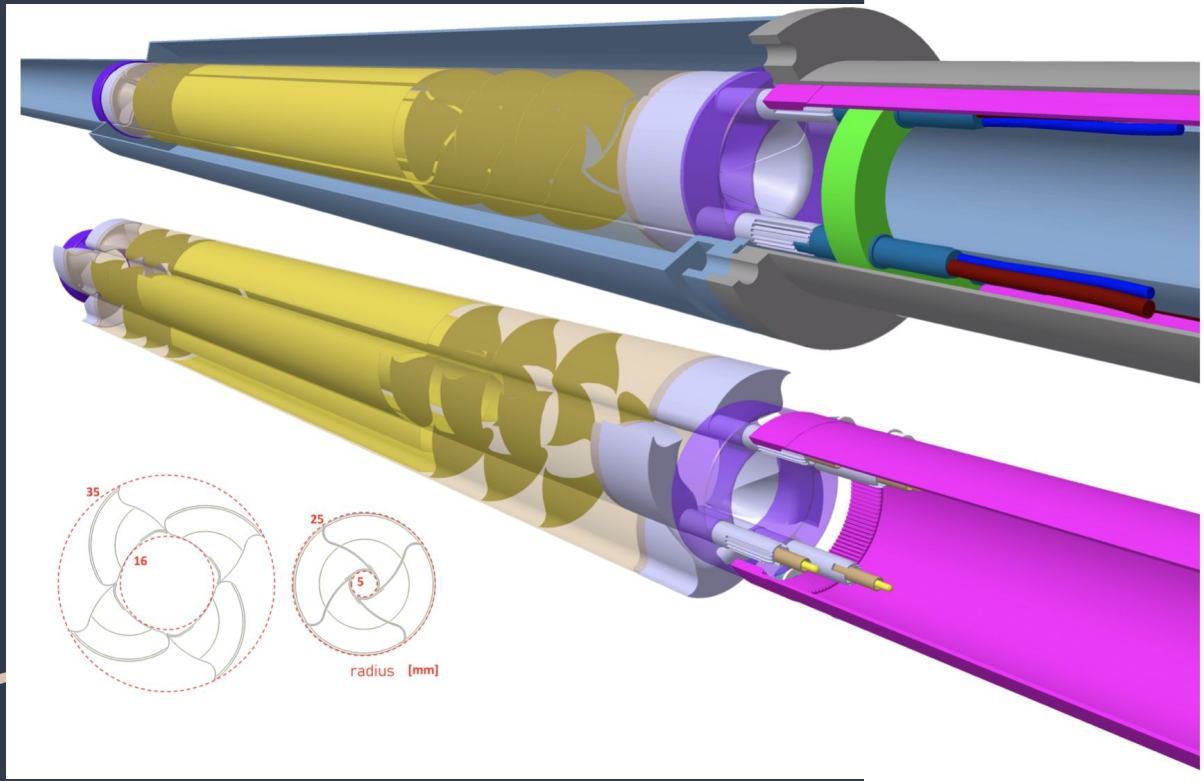
- time dependence of the temperature before hadronisation
  - more differential measurements
- chiral symmetry breaking
  - identification of electrons from heavy decays
- azimuthal correlations of charm-hadron pairs
- more QGP
- ϱ resonances
- axion-like particles and dark photons

… and a whole lot more!

- but we are mostly talking about the precision measurements

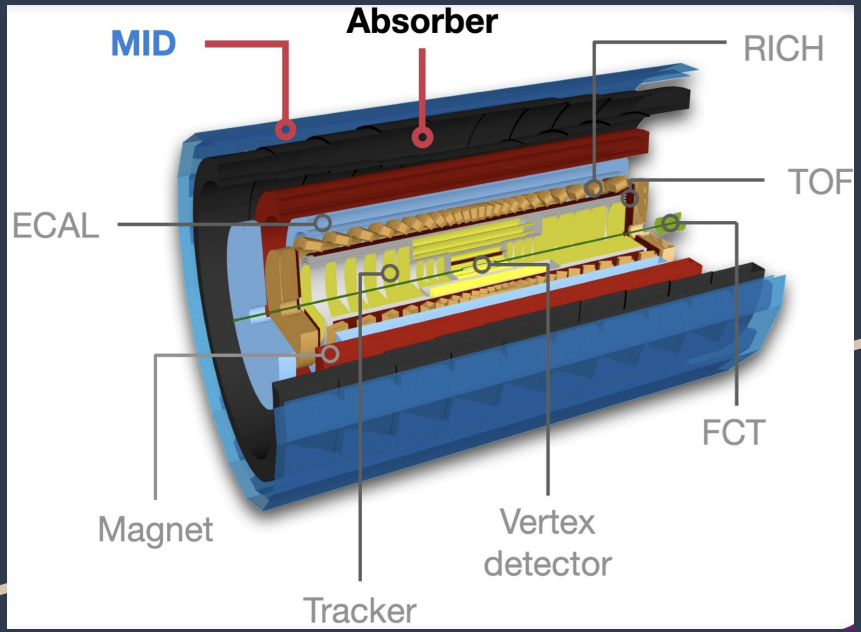
CERN COURIER: ALICE3 a heavy-ion detector of the 2030s
(Jochen Klein & Marco van Leeuwen, 01/03/2023)

ALICE3 detector remarks

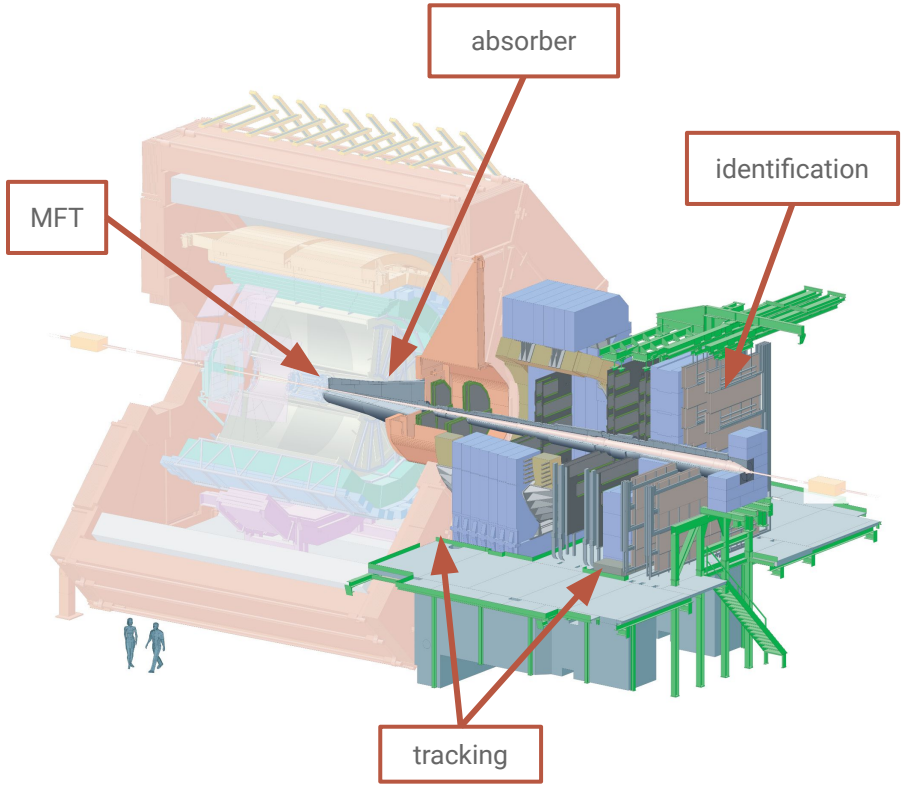


- no TPC but lots of silicon
  - CMOS technology already explored for the ITS3
  - TOF
- adjustable ITS
  - 5 mm from the interaction point

ALICE3 MID



ALICE2 MID



Detector development

NuviaTech cast plastic scintillator sample preparation.

- muons with low $p_T \approx 1.5$ GeV/c
  - resolution of $\Delta\varphi\Delta\eta = 0.02 \times 0.02$
  - reconstruction of J/ψ with p_T down to 0 GeV/c
- coverage of 360 m^2
  - acceptance $|\eta| < 1.24$
- non-magnetic absorber
  - 70 cm

Three options:

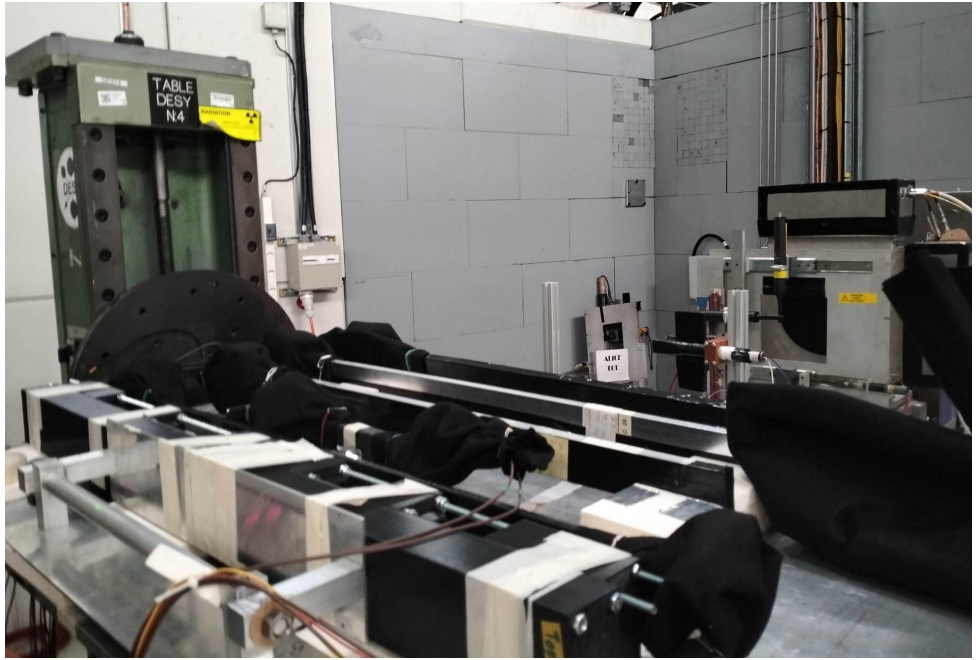
- **plastic scintillators + SiPMs**

  *(Mexico, **Prague**, Chicago)*
- MWPCs *(Budapest)*
- RPCs *(India)*

The first beamtest

June 2023

- scintillators & MWPCs
- hadrons from 0.5 to 6 GeV/c
- East area @CERN



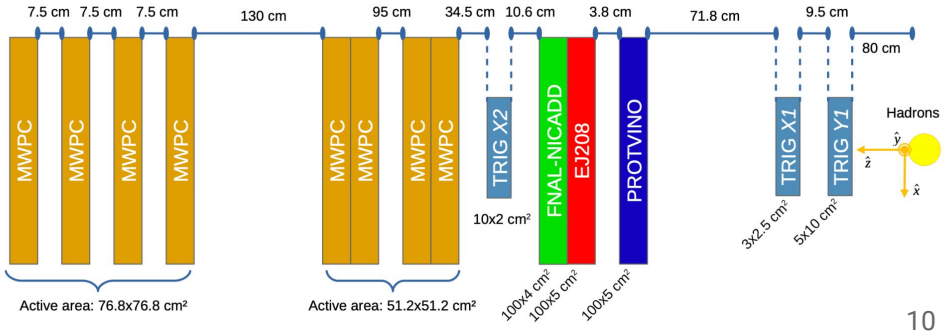
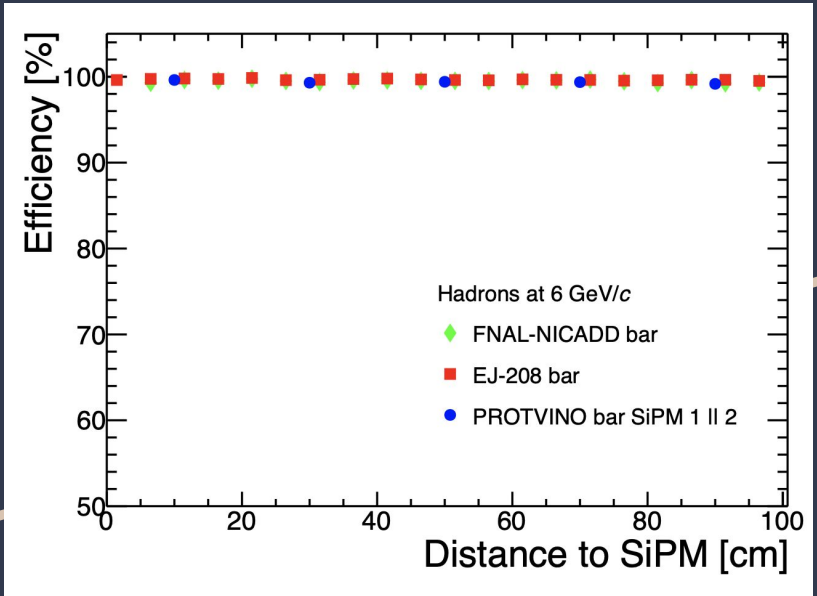


Photo from the beamtest with the scintillator samples, and the schematics of all modules placement.

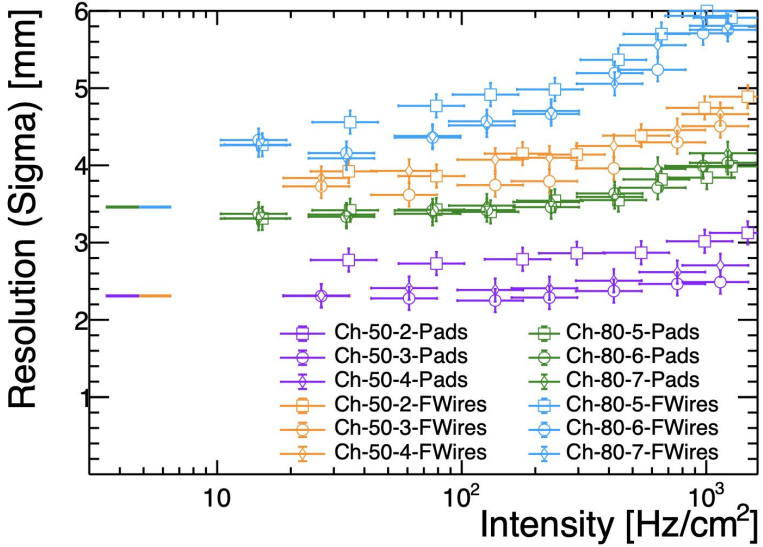
… and publication

JINST 19 (2024) T04006



Efficiencies of the plastic scintillator samples.

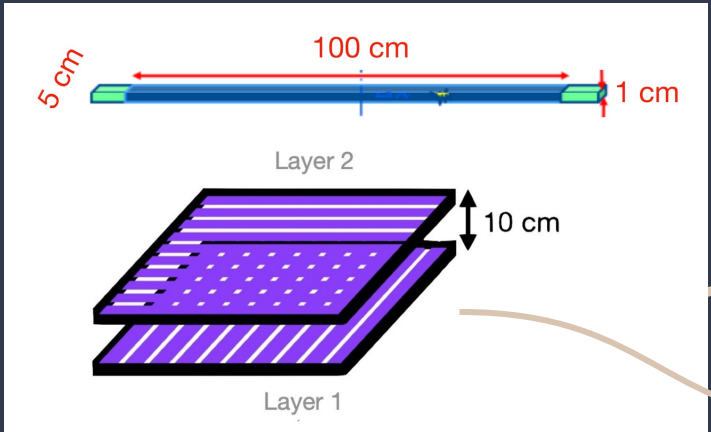
- several scintillator prototype bars tested
  - ELJEN, PROTVINO, FNAL
  - wavelength-shifting fiber
  - SiPMs
- MWPCs showed spatial resolution beyond requirements



Spatial resolution of the MWPCs.

The second beamtest

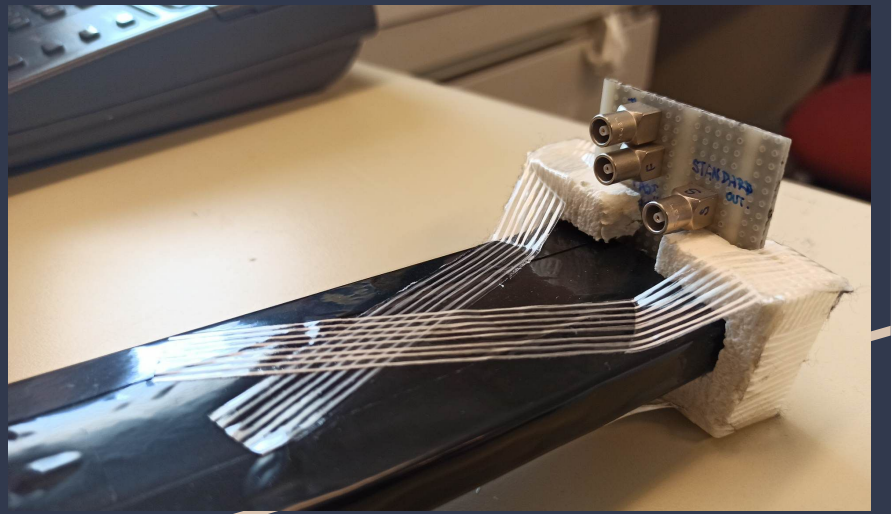
October 2024



- test with small plastic scintillator modules
  - 25x25 cm^2 instead of 100x100 cm^2
- further exploration of plastic options
- electronics testing
- validation of the muon tagging algorithms
- pion suppression measurements
  - realistic absorber

- improved MWPCs modules

MID at FNSPE



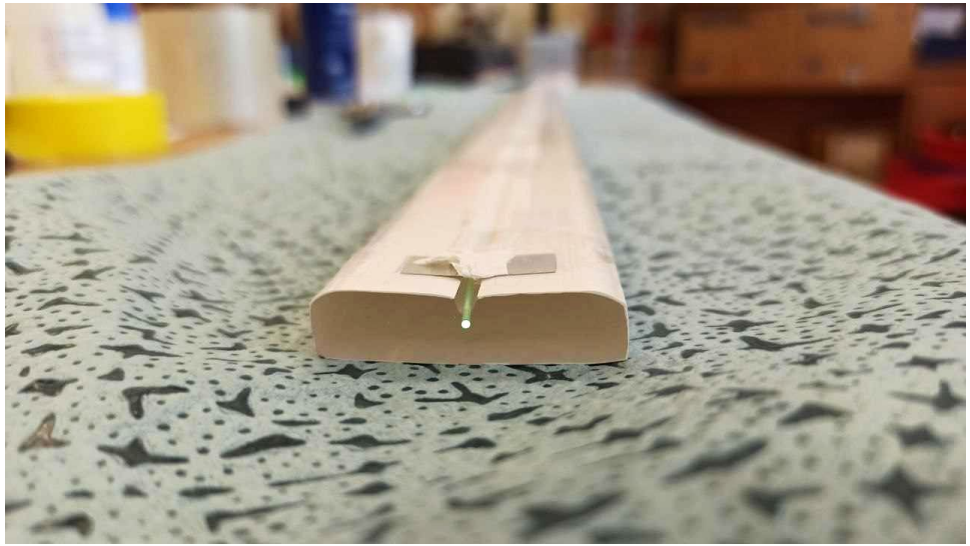
Scintillator bar with the SiPM attached ready for testing.

- further scintillator samples testing
- NuviaTech
  - **Czech company**
  - newly testing extrusion
    - competitiveness in price
- infrastructure for assembling and testing the modules in progress
  - CERN-CZ infrastructure project

Attenuation length measurements of the scintillator modules

Plastic scintillator samples:
extruded Nuviatech (left) and FNAL (right).

- FNAL + WLS fiber + 1 SiPM
  - extruded sample
- NuviaTech w/o WLS + 1 SiPM
  - extruded sample
  - cast sample

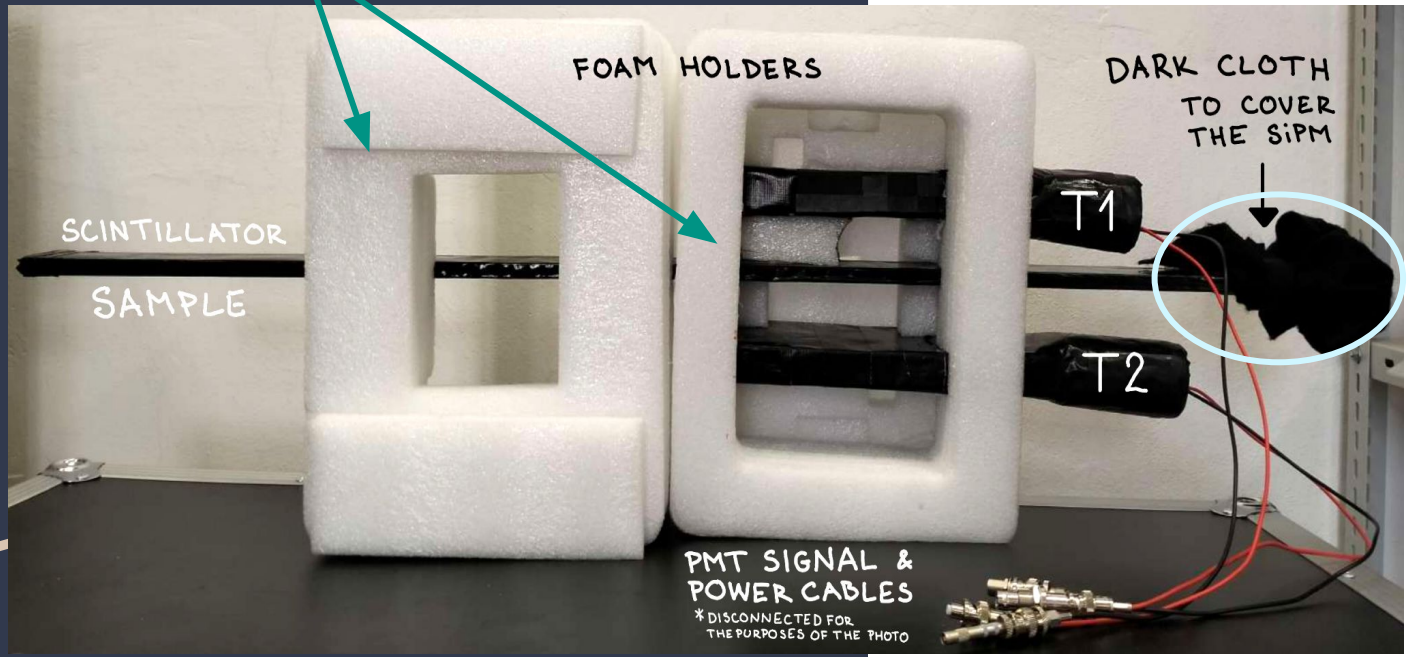


FNAL sample with wavelength-shifting fiber.

Cosmic–ray setup

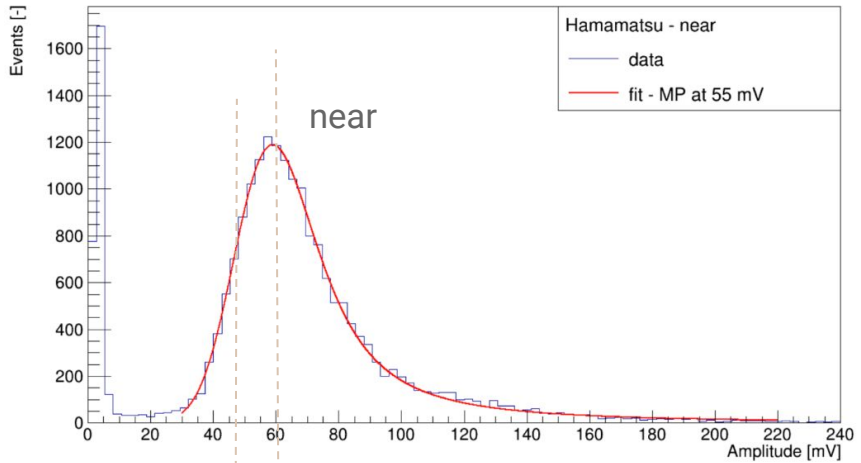
adjustable for different positions of the sample

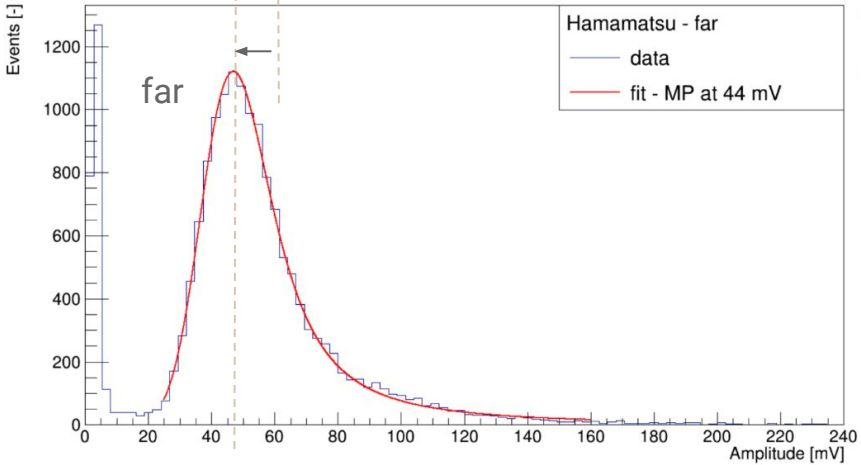
- foam holders for the triggering modules T1 and T1 (scintillator + PMT) and the scintillator sample
- multiple layers of the dark cloth to shield the SiPM from light leaks



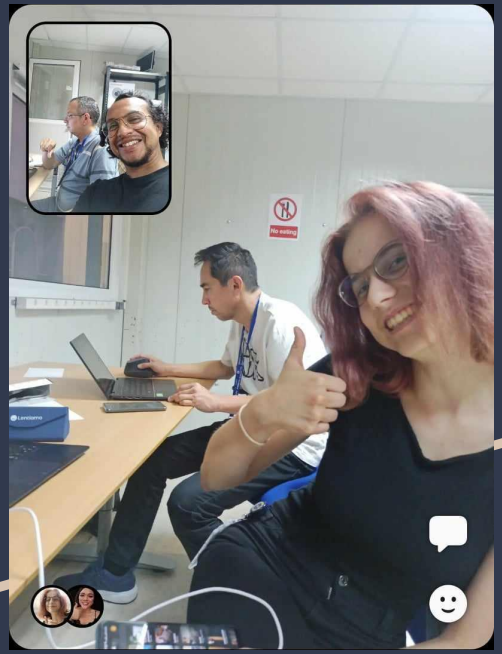
Work in progress

- initial measurements taking ratio from two positions
  - cast NuviaTech: μ = (260 ± 20) cm
- improvement of the method with more positions measured
  - exponential fits





Outlook and summary



- ALICE3 will replace the current ALICE after the LS4 (~2035)

- MID will be a barrel covering the area of 360 m^2
  - multiple detector options explored
  - plastic scintillators being cost-effective baseline
- prototype characterisation at FNSPE
  - NuviaTech

- successful beamtest in June 2023
  - JINST 19 (2024)
- next beamtest in October 2024

Backup

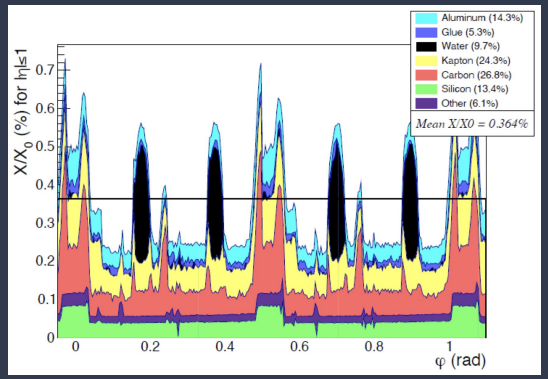
Budget

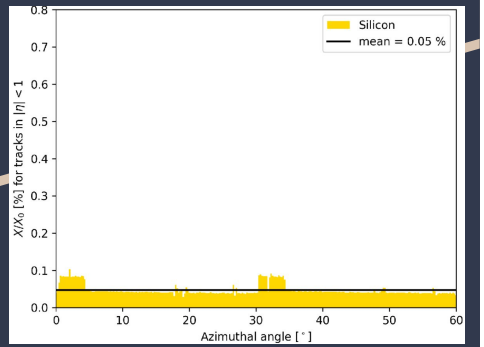
*Letter of Intent

System	Technology	Cost (MCHF)
Tracker	MAPS	30.5
TOF	Monolithic LGADs	14.8
	Hybrid LGADs[6]	26.4
RICH	Aerogel and monolithic SiPMs	20.9
	Aerogel, analogue SiPMs + readout[6]	34.0
ECal	Pb-scintillator + $PbWO_4$	17.0
MID	Steel absorber, scintillator bars, SiPMs	7.0
FCT	MAPS (solenoid + separate magnet)	5.3
	MAPS (solenoid + dipoles)	2.3
Magnet system	Superconducting solenoid + FCT magnet	25.0
	Superconducting solenoid and dipoles	40.0
Computing	Data acquisition and processing	6.0
Common items	Beampipe, infrastructure, engineering	15.0
Total		141.5

Table 19: Estimates of ALICE 3 core cost.

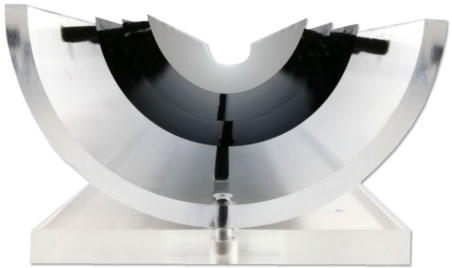
ITS3





Azimuthal distribution (averaged over the full barrel length) of the material budget of the Layer 0 for the current ITS2 (top) and the future ITS3 (right).

- 18 mm for the IP
- pure silicon
  - 20 - 40 μm thickness
  - dimensions of the whole stave
- carbon foam
- air cooling
- significant cost reduction



ITS ALICE 3

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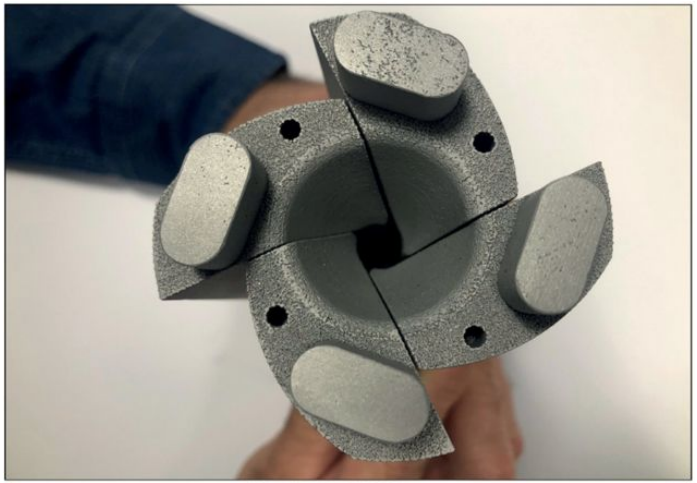
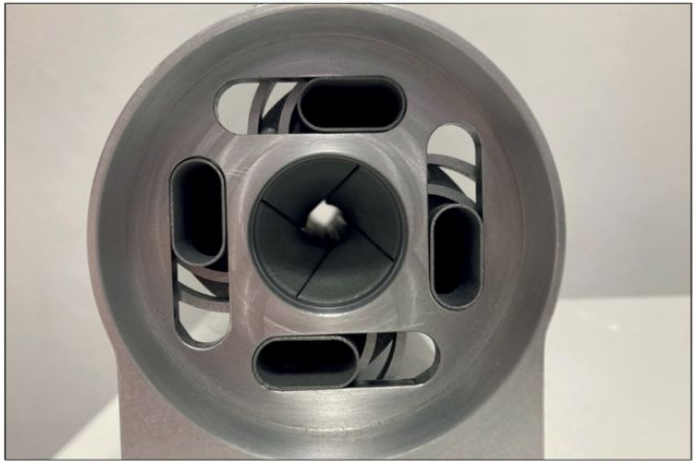
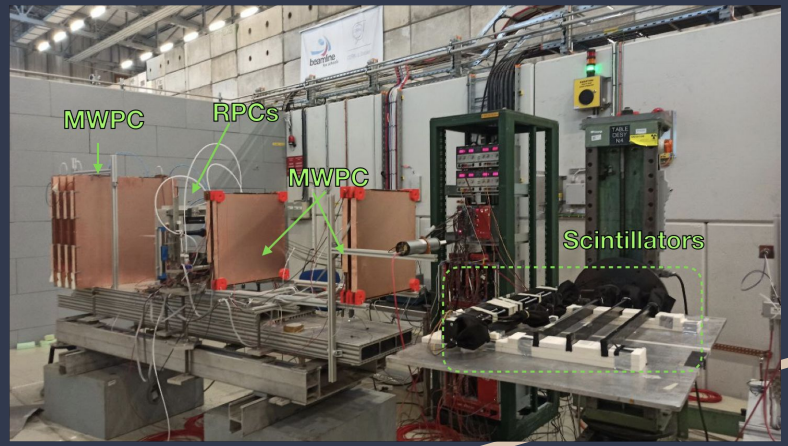




Beamtests



Beamtest in October 2024:

- test with small modules
  - 25x25 cm^2 instead of 100x100 cm^2
- further exploration of plastic options
  - FNAL
  - PROTVINO
  - Mexican manufacture
  - NuviaTech
    - no ELJEN due to the price
- electronics testing
- validate the muon tagging algorithms
- MWPCs based chamber
  - Test the dead zone reduction
  - Test with optimized electronic design
- Combined measurement
  - Measure pion suppression with realistic absorber