

HAD_06: Probing extremely hot partonic matter properties via high precision muon measurements at the ALICE experiment

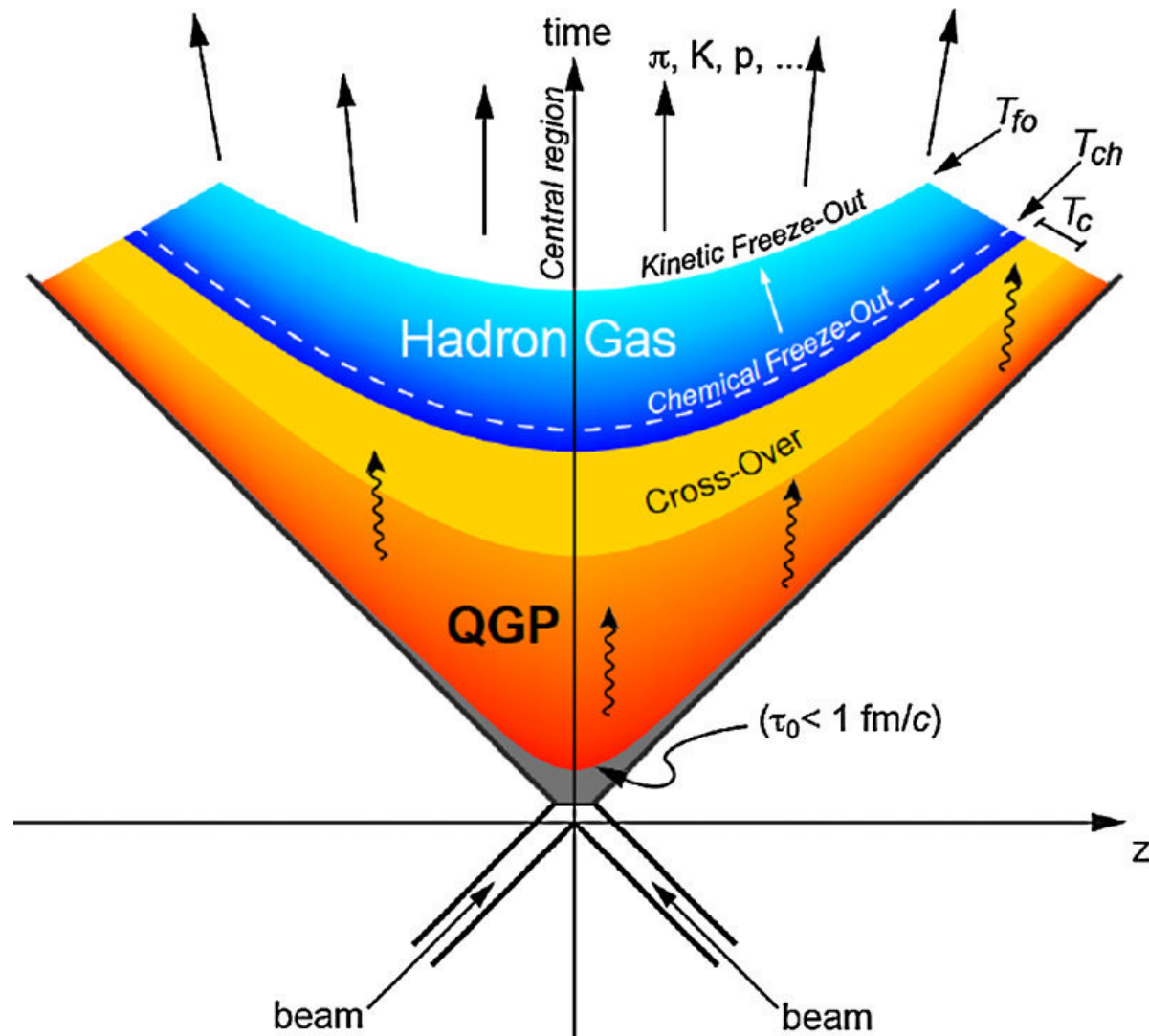
Yorito Yamaguchi

Hiroshima University

2024 Joint Workshop of FKPPN and TYL/FJPPN

May 8-11, 2024

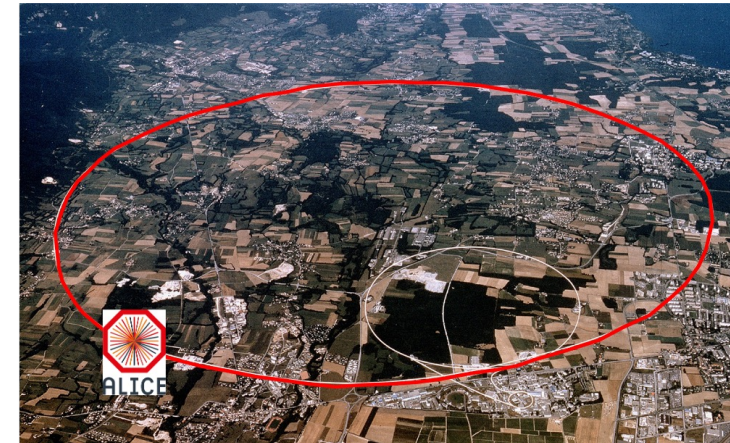
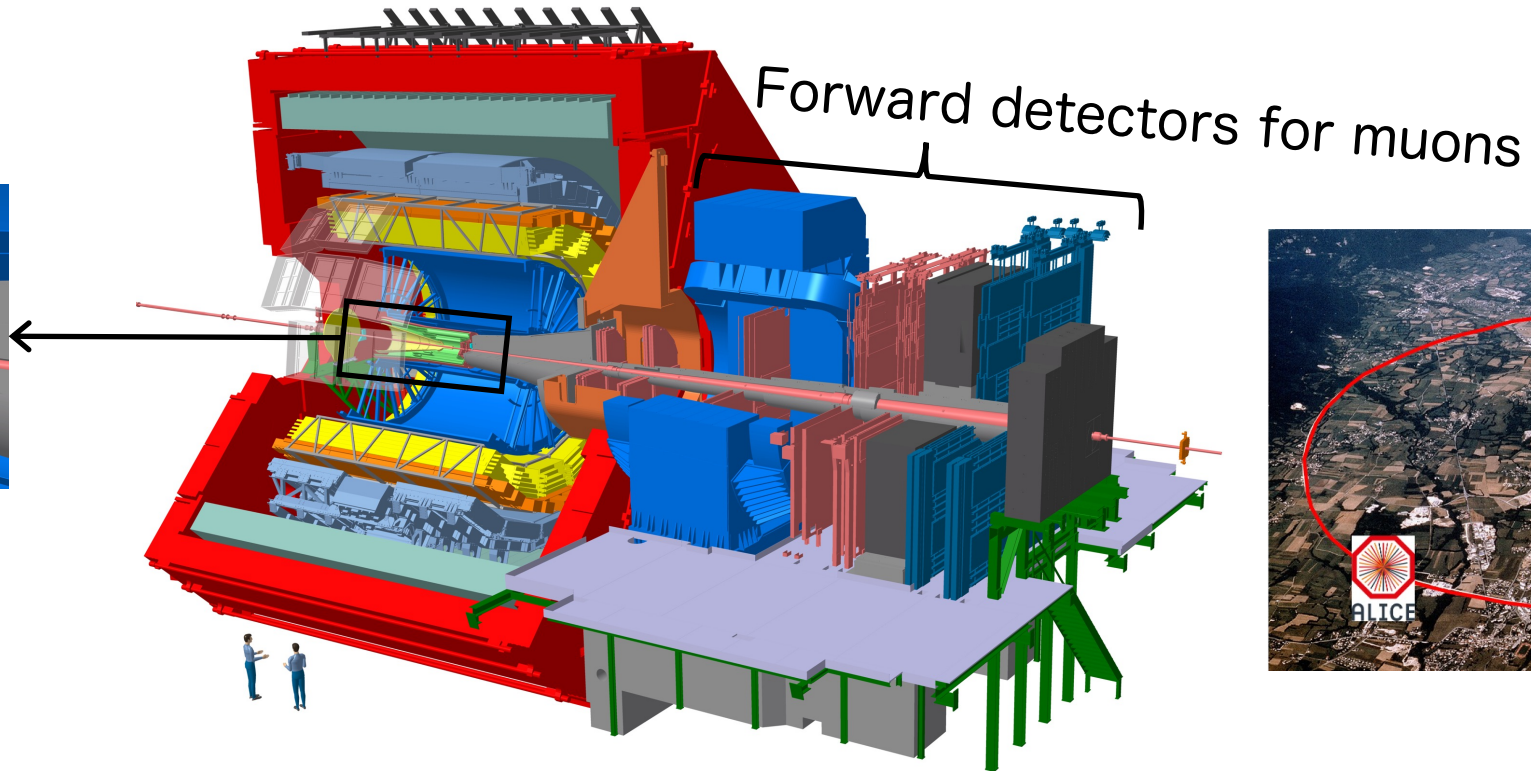
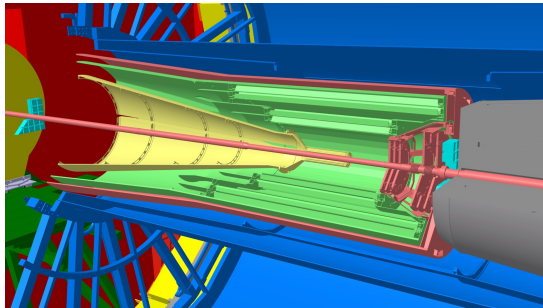
Heavy ion collisions



- Exploring extremely hot QCD matter
 - Deconfined state of quarks and gluons = Quark Gluon Plasma
 - Significant results in the last decades since 2000
 - ✓ QGP formation
 - ✓ Discovery of unique features of QGP
- Next decade: More focusing on early stages for further understanding
 - Key probes: Heavy quarks, thermal di-leptons

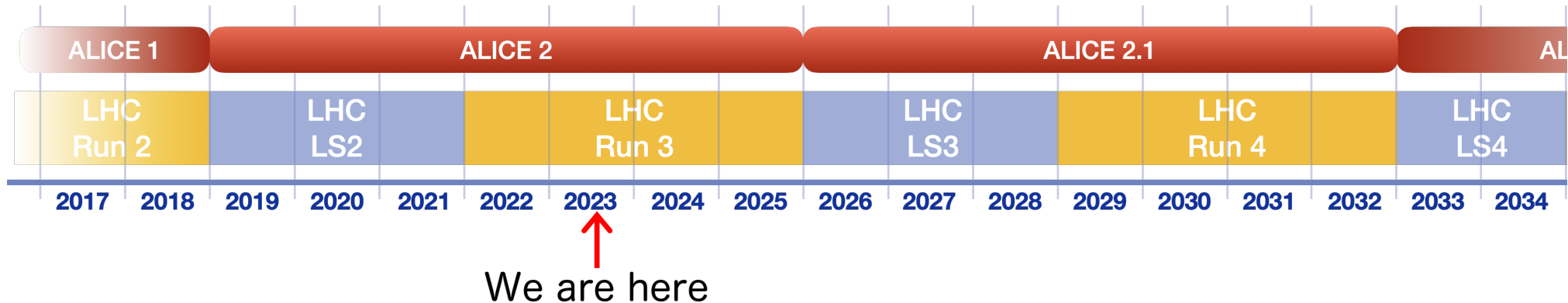
ALICE experiment

Vertex detectors



- Specially designed for heavy ion collisions at LHC
 - ~2000 collaborators from about 40 countries
 - Located in "French" side of CERN
 - Central ($|\eta| < 0.9$) : Silicon VTX + TPC + PID detectors + EMCal
 - Forward ($2.5 < \eta < 4$): Muon tracker + Muon ID

Upgrade programs for LHC-RUN 3



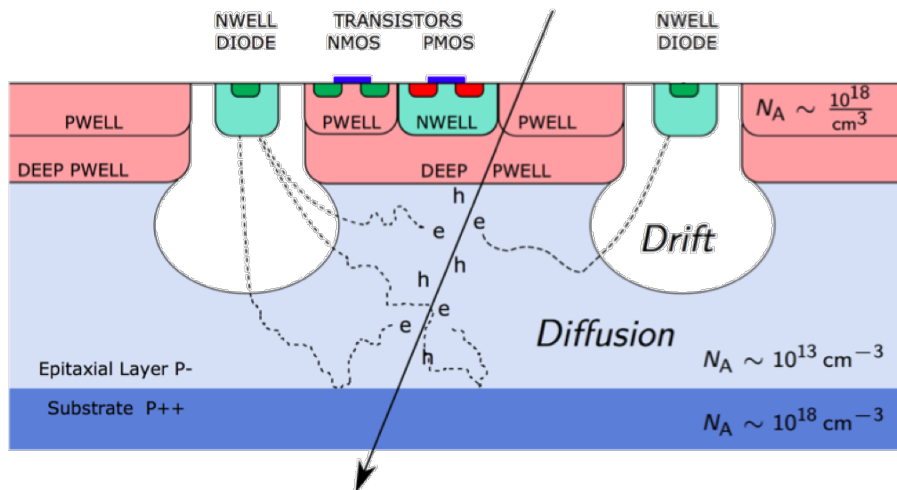
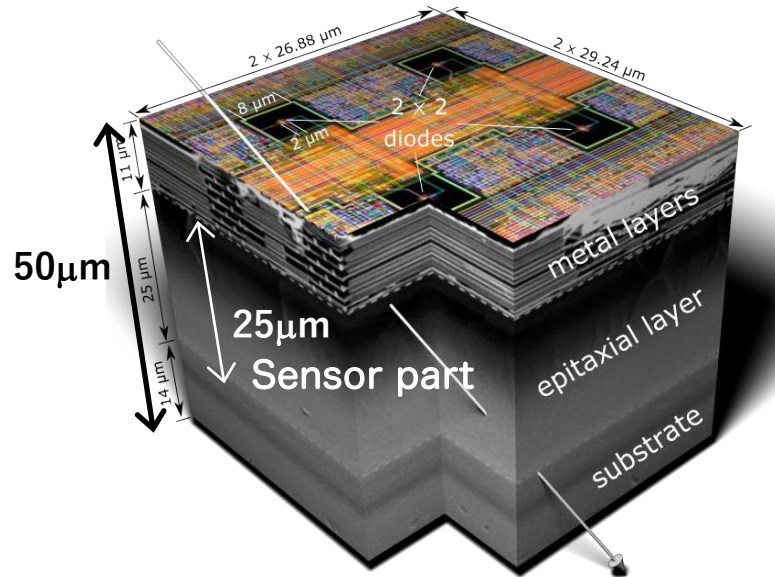
Major upgrades to focus on low/mid p_T phenomena and rare probes

→ More statistics & more accuracy on tracking

1. ITS2 (Inner Tracking System of silicon detectors)
 - 7-layer MAPS detectors for better vertexing & higher tracking efficiency
2. GEM-TPC
 - Continuous readout realized by GEM signal amplification
 - ~100 times higher rate of data-taking with 50kHz Pb-Pb collisions
3. New computing framework of online and offline data processing (O^2)
4. **MFT (Muon Forward Tracker)**
 - New MAPS detector in forward for better vertexing of muons

MAPS

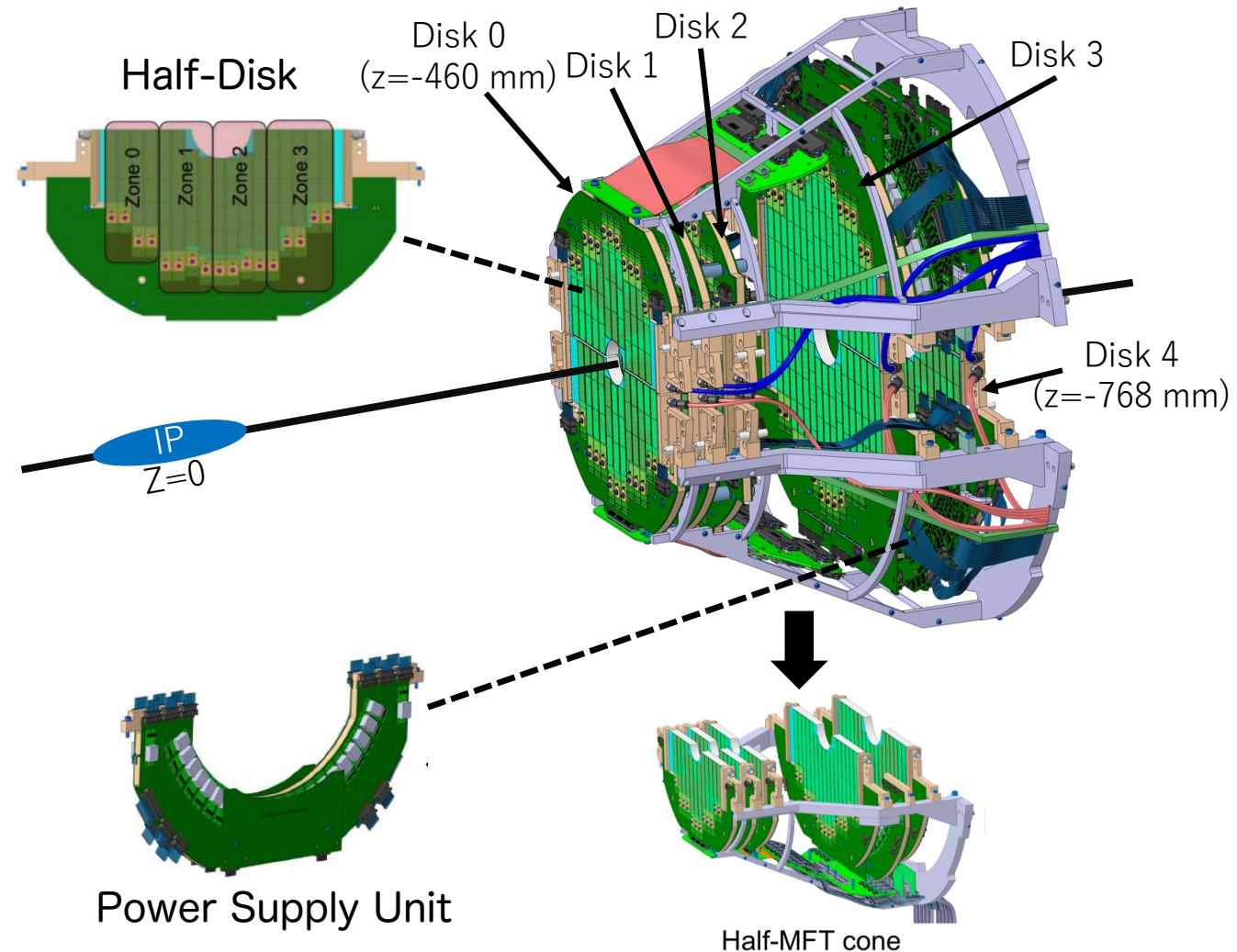
ALPIDE cross-section



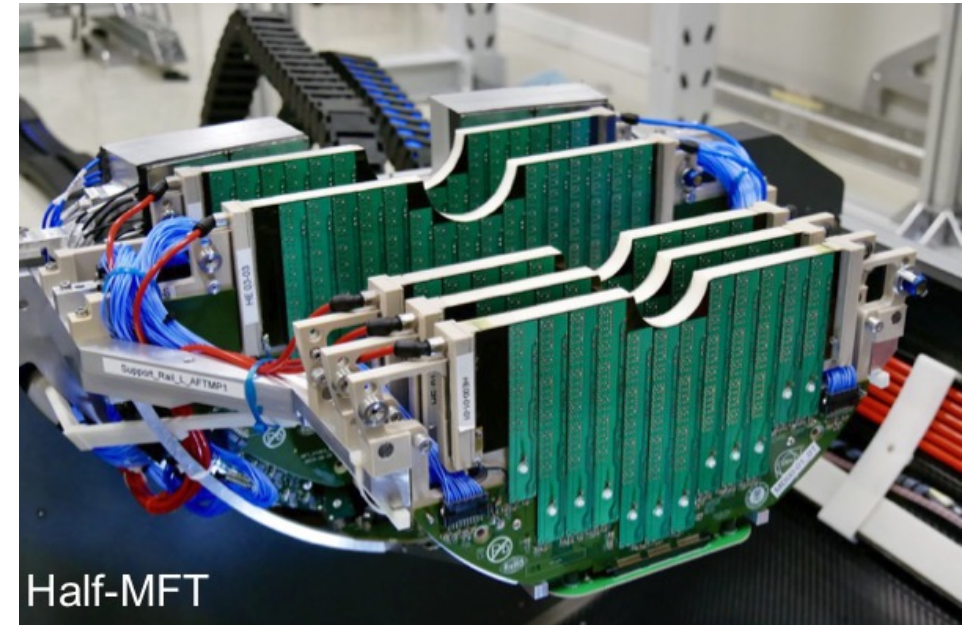
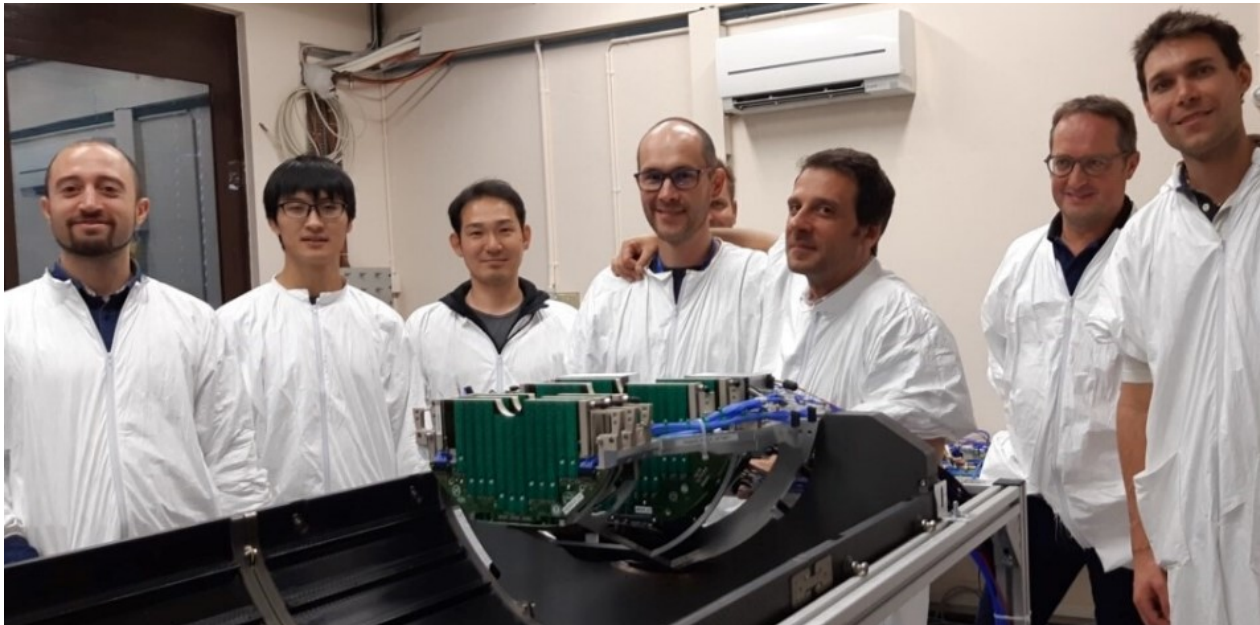
- Monolithic Active Pixel Sensor = MAPS
 - Cutting-edge silicon technology
 - ✓ Both sensor & readout on the same CMOS chip
 - ALPIDE = ALICE Pixel Detector developed by ALICE
 - ✓ T180nm-CMOS sensor technology
 - ✓ 1 pixel = $27 \times 29 \mu\text{m}^2 \rightarrow$ 1 sensor = $1.5 \times 3 \text{ cm}^2$
 - ✓ Good position resolution: $\sim 5 \mu\text{m}$
 - ✓ Integration time: $4 \mu\text{s}$
 - ✓ Low power consumption: 40 mW/cm^2

Muon Forward Tracker

- Installed in front of the hadron absorber
- Acceptance: $2.45 < \eta < 3.6$
- 5 double-sided disks at 460-768 mm from interaction point
 - $X/X_0 = 0.55\%$ per layer
 - 936 sensors in 280 ladders
- Development and assembly of MFT supported by TYL/FJPPL
 - HAD_02: 2017-2022

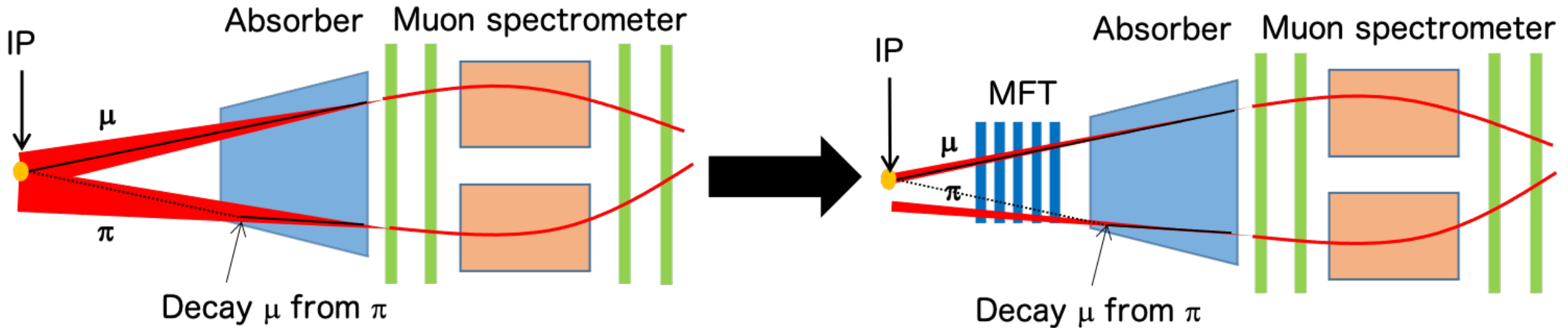


MFT assembly



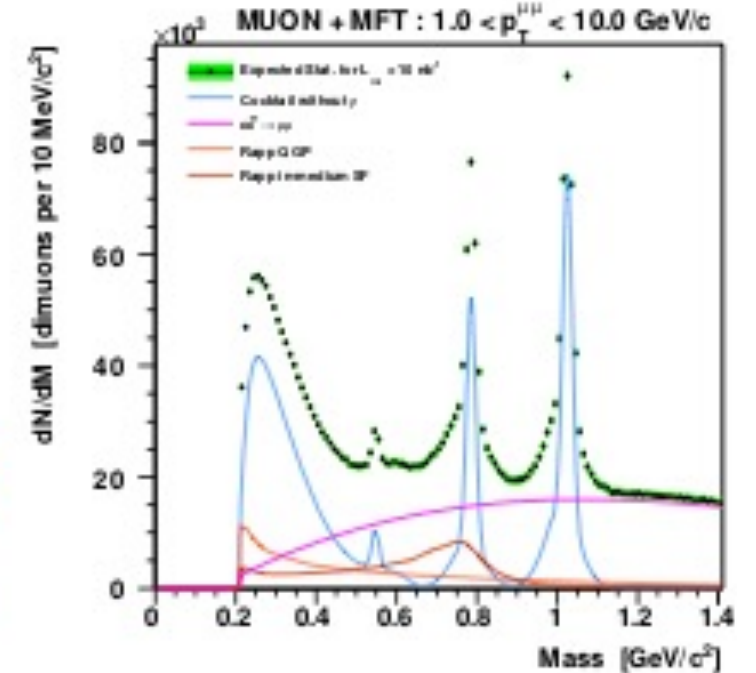
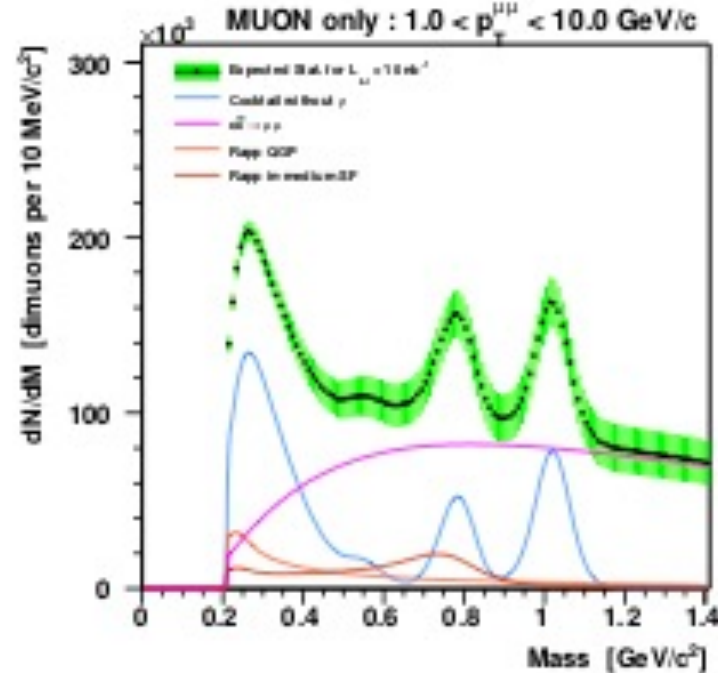
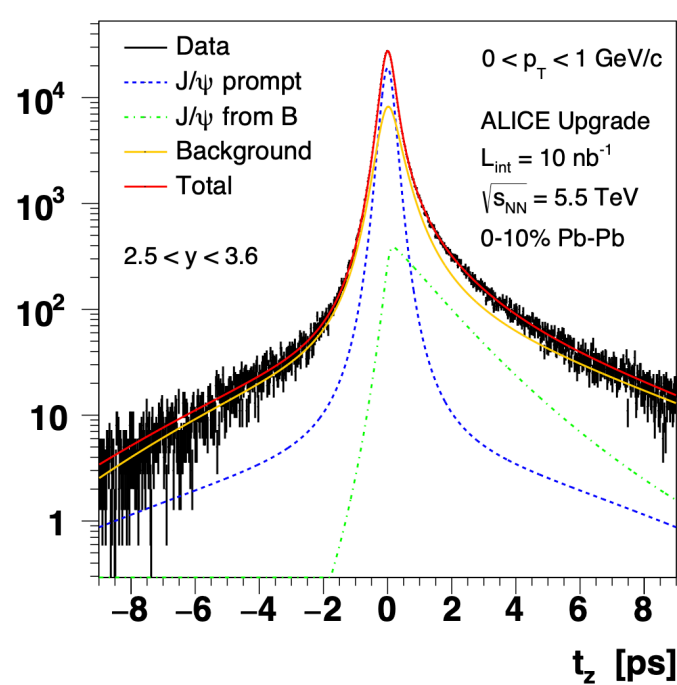
- MFT assembly has been done in 2019.
 - French group: Leading role of the MFT project
 - ✓ Sensor assembly on a ladder, Readout, Power supply, ...
 - Japanese group: Responsible to a control system development
 - ✓ Automatic slow control, power control, monitoring, ...

Benefits from MFT



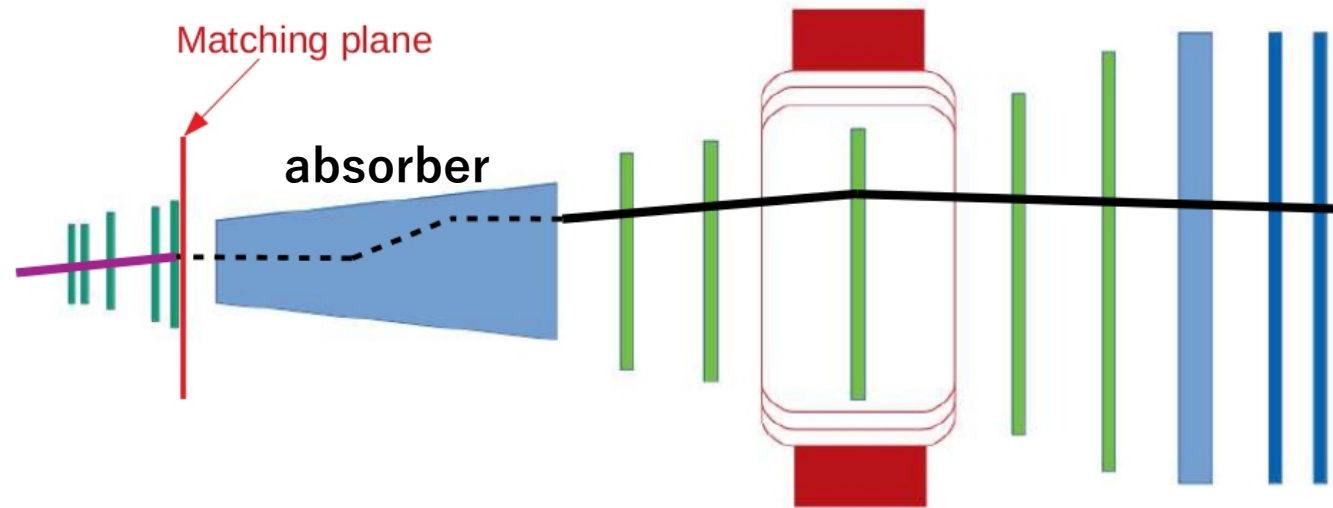
- Improvement of tracking precision around IP
 - Secondary vertex measurement
 - ✓ Rejection of decay μ from π/K
 - Improvement of mass resolution for di-muons

Ongoing measurements with MFT



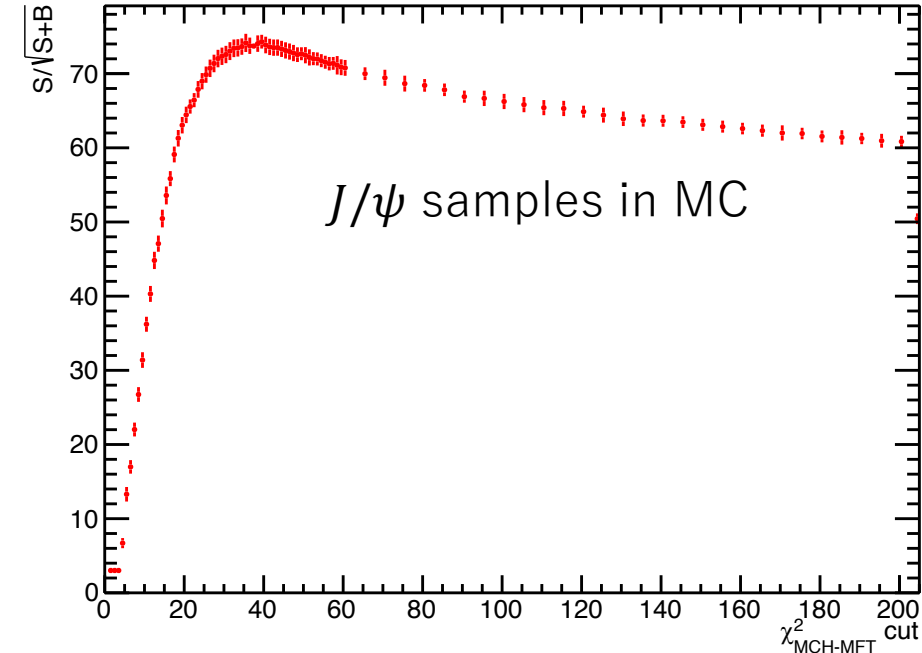
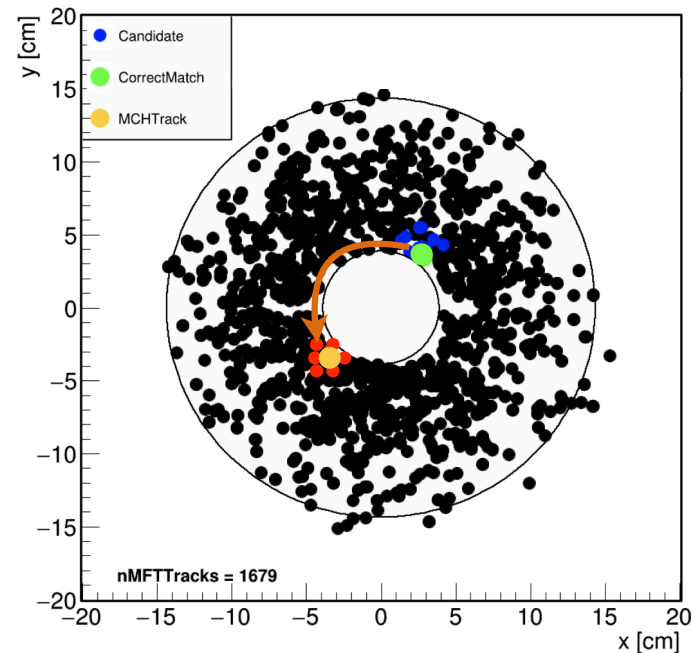
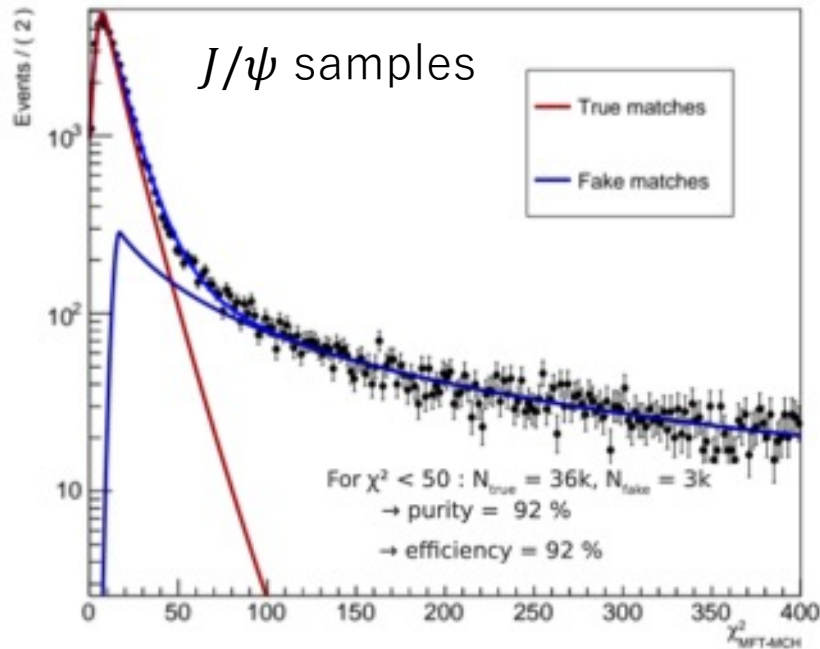
- Separation of B-decay J/ψ from inclusive J/ψ
- Quarkonia (J/ψ , 3 states of Y s)
 - Sequential melting in QGP
- Low mass vector mesons
 - Restoration of Chiral symmetry in hot partonic matter
- Thermal di-muons

MFT-MCH matching



- Crucial to make correct matching between MFT and Muon spectrometer (MCH)
 - Challenge with high occupancy near IP & disturbance by multiple scattering inside the absorber
- Matching procedure
 1. Associate MFT and MCH tracks compatible in time
 2. Compute a matching score and keep the best combination
 3. Refit the whole global track

Matching χ^2



- Matching χ^2 works well to find true track matches in pp data.
 - Clear difference in distribution for true and false matches
 - Full shape for false matches demonstrated by MCH track rotations
 - Possible to maximize purity & efficiency for signals
- Ongoing efforts with machine learning which helps to separate true and false matches with more charged particle multiplicity in Pb-Pb

Activities in 2024

- pp runs already started with smooth data-taking since the last April
 - Pb-Pb runs scheduled in November
- Assessment of track matching with ML for Pb-Pb data taken in 2023
 - Some Pb-Pb measurements as well
 - Track-matching and analysis fest in Japan
 - ✓ Effective in-person discussions together with main players both in France and Japan
- Expecting some final results from ongoing pp measurements
 - J/psi, heavy flavors and more ...

Summary

- Keeping a successful Japan-France collaboration in ALICE from MFT production stage to MFT operation stage
 1. HAD_02: ALICE forward upgrade for high precision high statistics single- and di-muon measurements at the LHC
 - PIs: K.Shigaki & G.Batigne
 2. HAD_06: Probing extremely hot partonic matter properties via high precision muon measurements at the ALICE experiment
 - PIs: Y.Yamaguchi & M.Guilbaud
- Staying active to get new exciting physics results with LHC-RUN 3 data in the next years