ALICE: detector status and upgrade

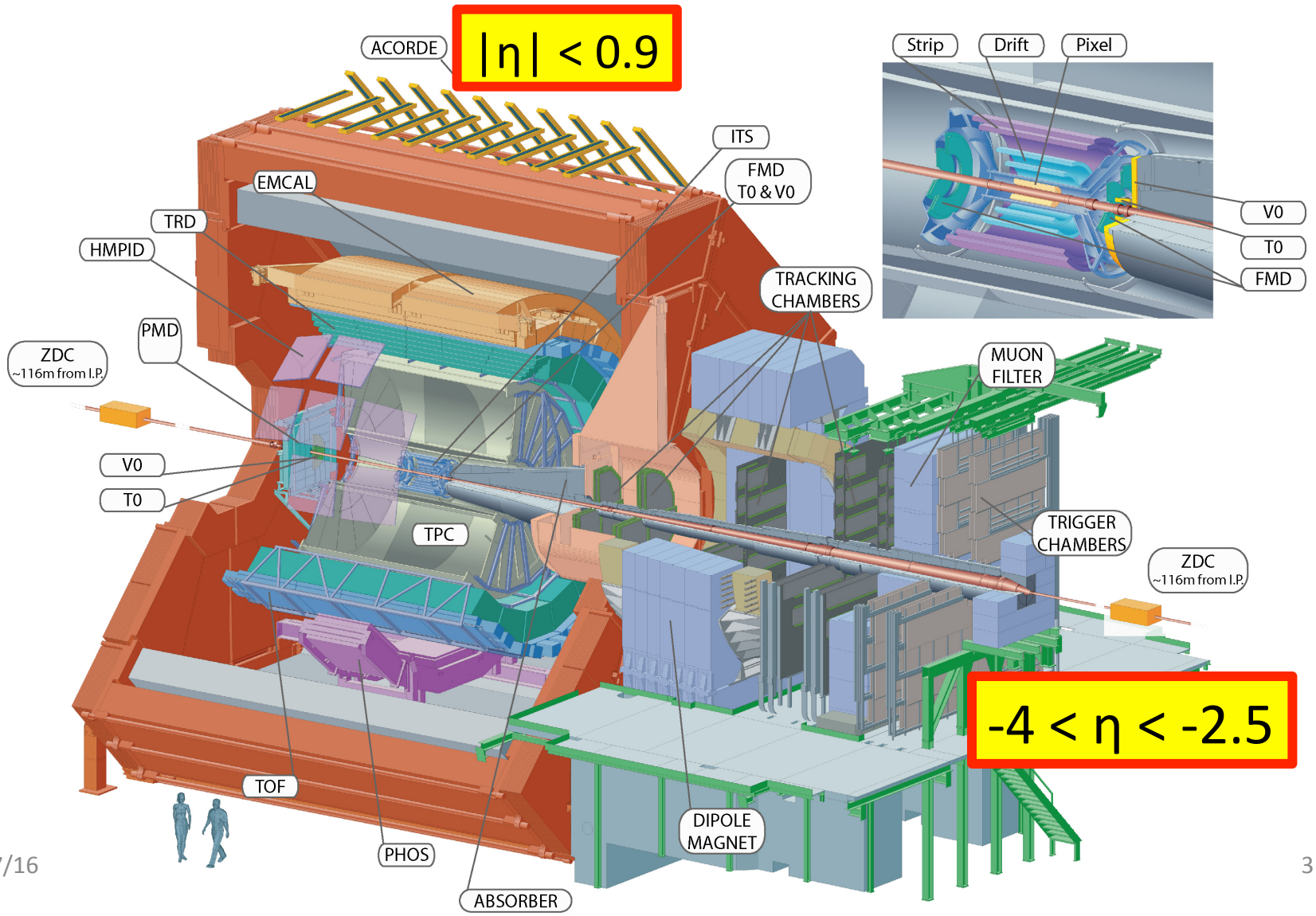
XXII Cracow Epiphany Conference
7 – 9 Jan 2016

C. Mayer – Instytut Fizyki Jądrowej PAN, Krakow
on behalf of the ALICE collaboration

Overview

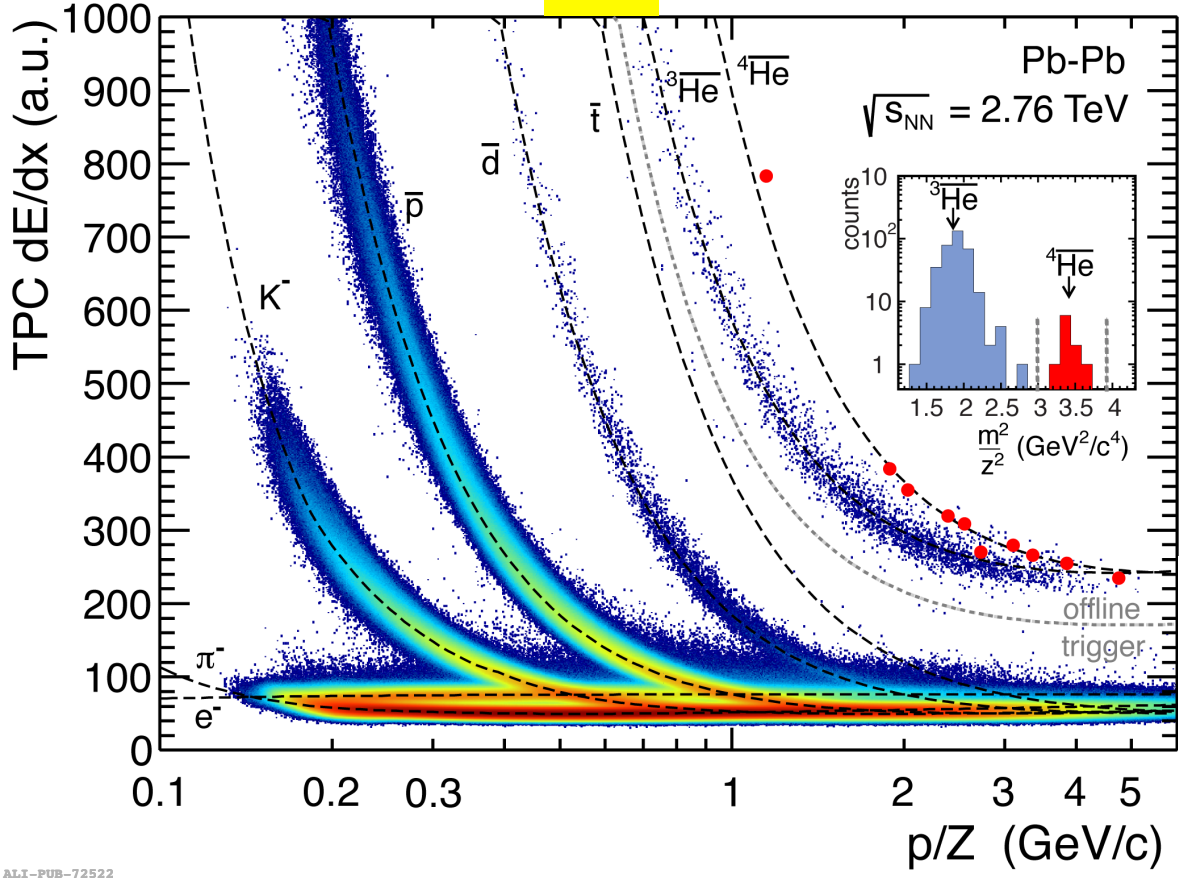
- ALICE detector overview
- ALICE PID performance
- ALICE Upgrades
  - Inner Tracking system (ITS)
  - Fast Interaction Trigger (FIT)
  - Muon Forward Tracker (MFT)
  - Time Projection Chamber (TPC)
  - Online-offline computing (O^2)
- Summary

The ALICE Detector

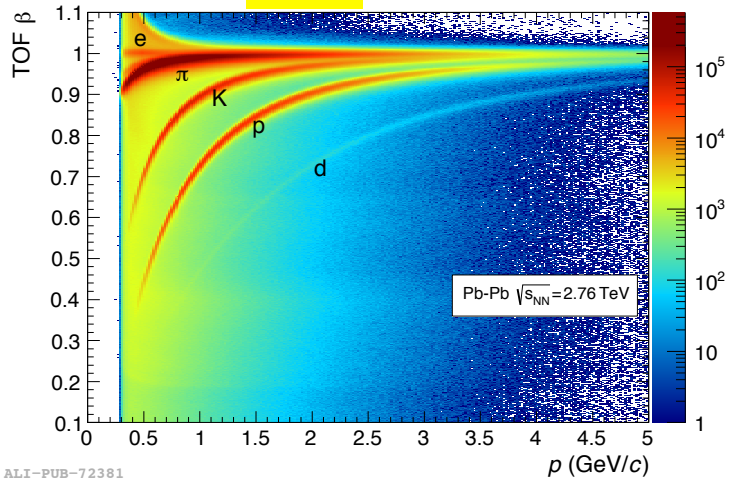


ALICE PID performance – Pb-Pb

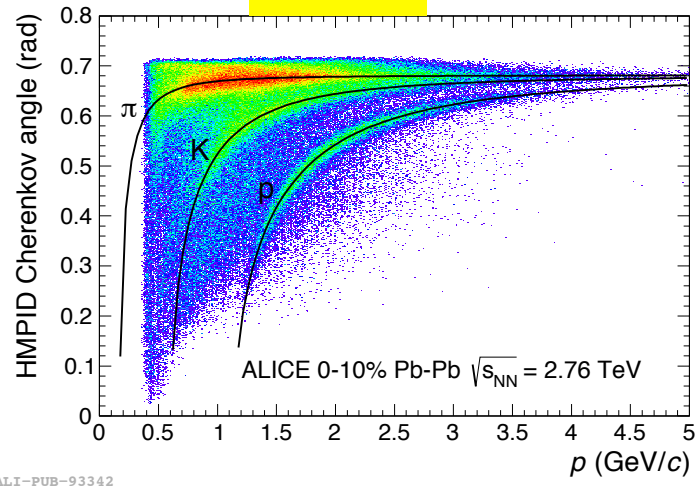
TPC



TOF



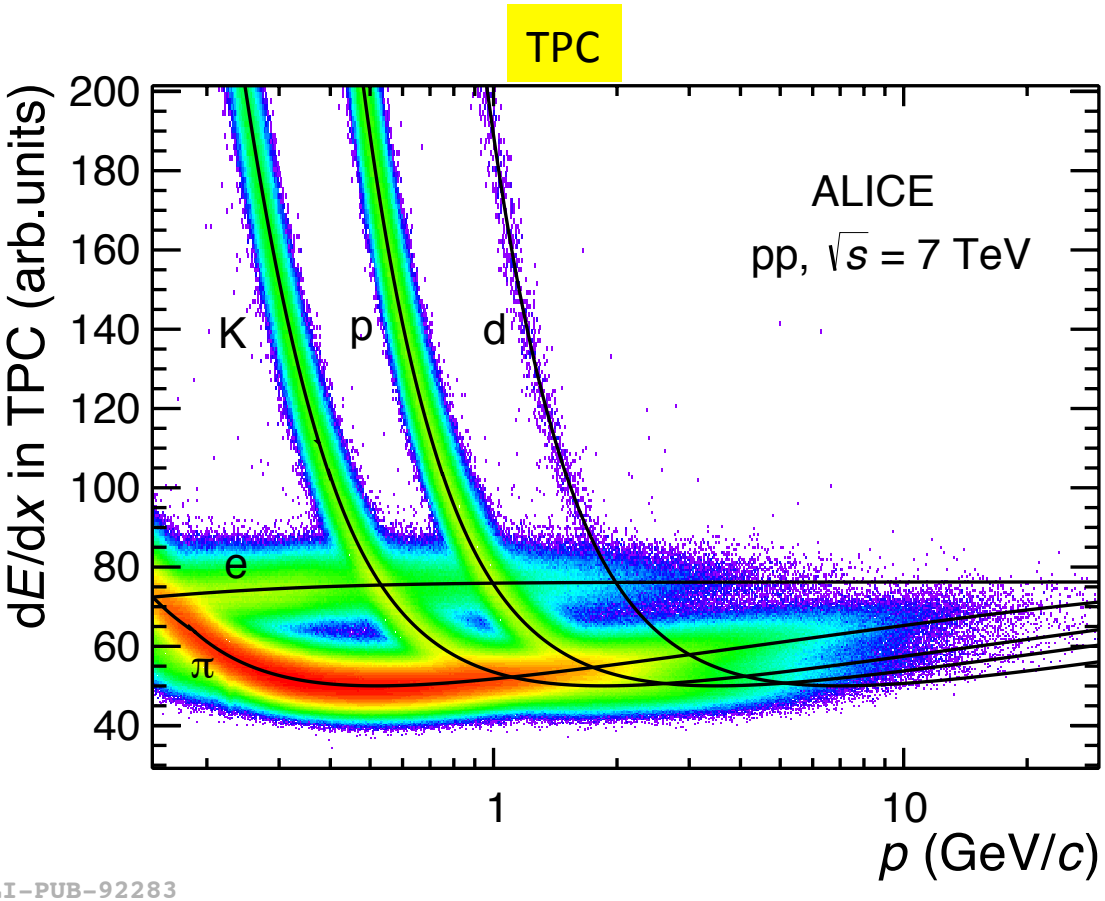
HMPID

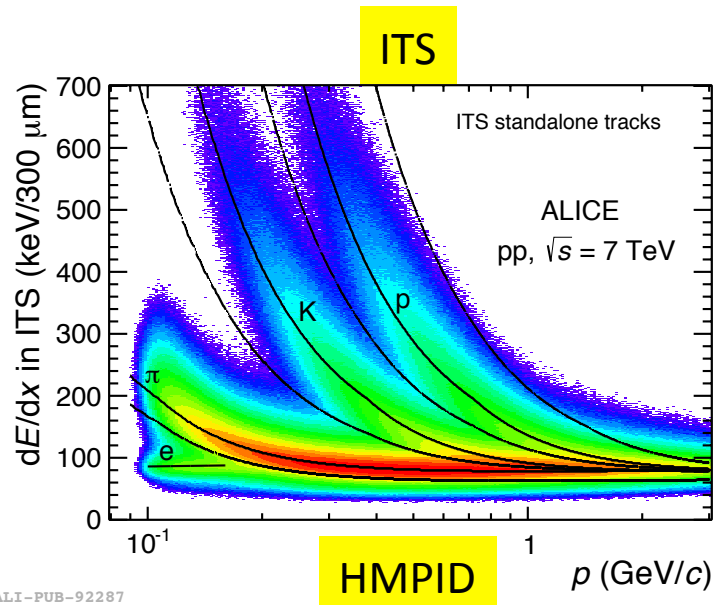


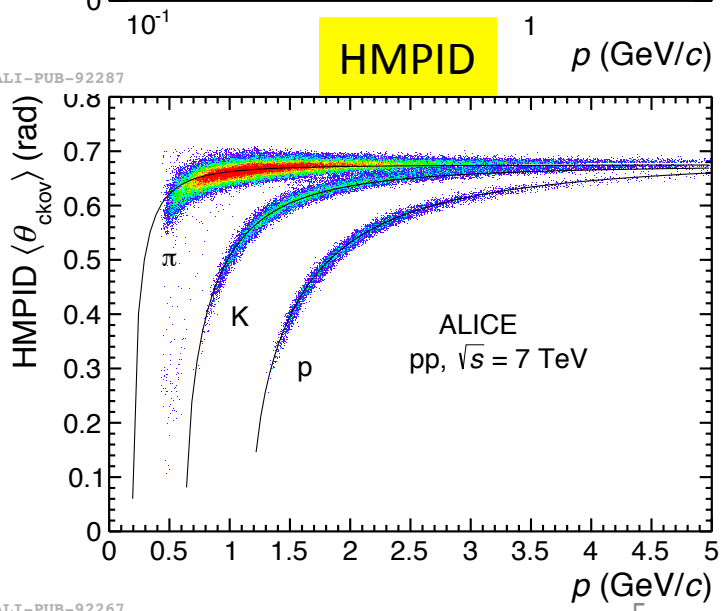
Excellent PID capability over a wide range in momentum. Not shown: ITS,TRD, …

Performance of the ALICE Experiment at the CERN LHC
Int. J. Mod. Phys. A 29 (2014) 1430044

ALICE PID performance – pp







Excellent PID capability over a wide range in momentum. Not shown: ITS,TRD, …

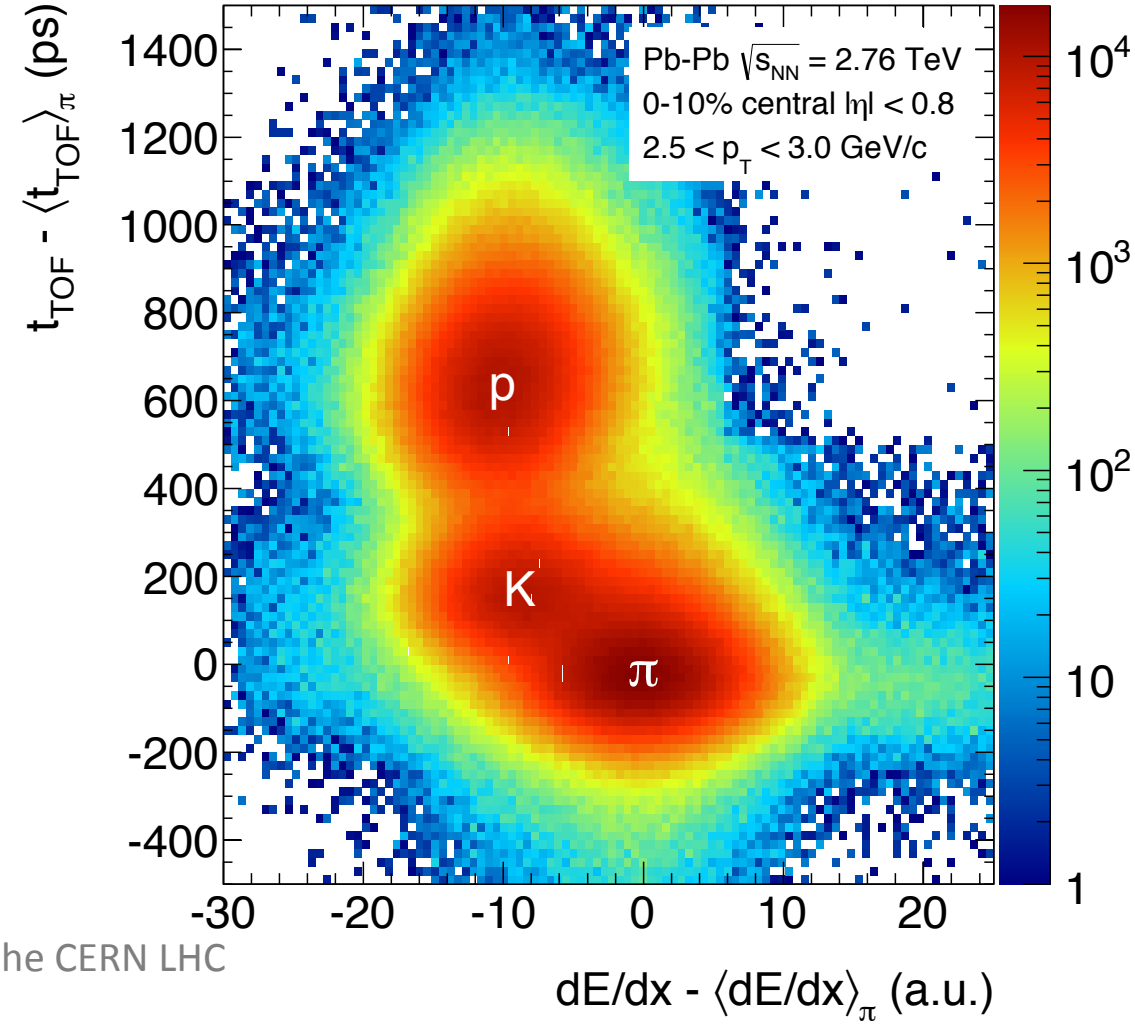
Measurement of pion, kaon and proton production in proton-proton collisions at √s=7 TeV, EPJC 75 (2015) 226

ALICE PID performance – Bayesian PID

Soft classification of tracks based on Bayesian statistics

All detectors with PID information can be used

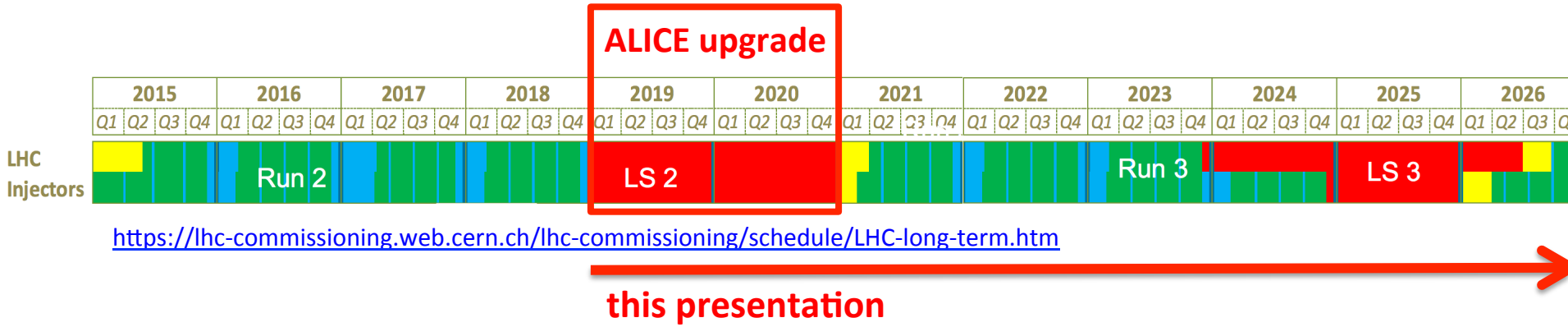
Right: Combined pion identification with TOF and with dE/dx in the TPC



Performance of the ALICE Experiment at the CERN LHC
Int. J. Mod. Phys. A 29 (2014) 1430044

ALI-PUB-72494

LHC Schedule



Running conditions after LS2:

foreseen Pb-Pb $L \approx 6\times10^{27}\ cm^{-2}s^{-1}$ (2011: $5\times10^{26}\ cm^{-2}s^{-1}$)

ALICE data to be collected in runs 3 and 4:

Pb-Pb: $L^{int} > 10\ nb^{-1}$

pp: $L^{int} > 6\ pb^{-1}$

ALICE upgrade physics goals

- Heavy quarks as probes of the quark-medium interaction and of the QGP transport coefficients
- Heavy quark in-medium energy loss and its dependence on quark mass
  - Charm and beauty hadrons production and dynamics to lowest p_T
- Charmonium dissociation and possible regeneration as a tool to study de-confinement
  - J/ψ and ψ(2S) ratio and prompt/non-prompt J/ψ separation to lowest p_T and in the widest rapidity domain
- Target are probes with very small S/B -> minimum-bias trigger

ALICE upgrade physics goals

- Chiral symmetry restoration, space-time evolution and equation of state of the QGP
  - Vector mesons and virtual thermal photons in via low-mass di-electrons and di-muons
- Jet quenching and fragmentation
- PID of jet particle content
- Light nuclei production
- …

ALICE upgrade strategy

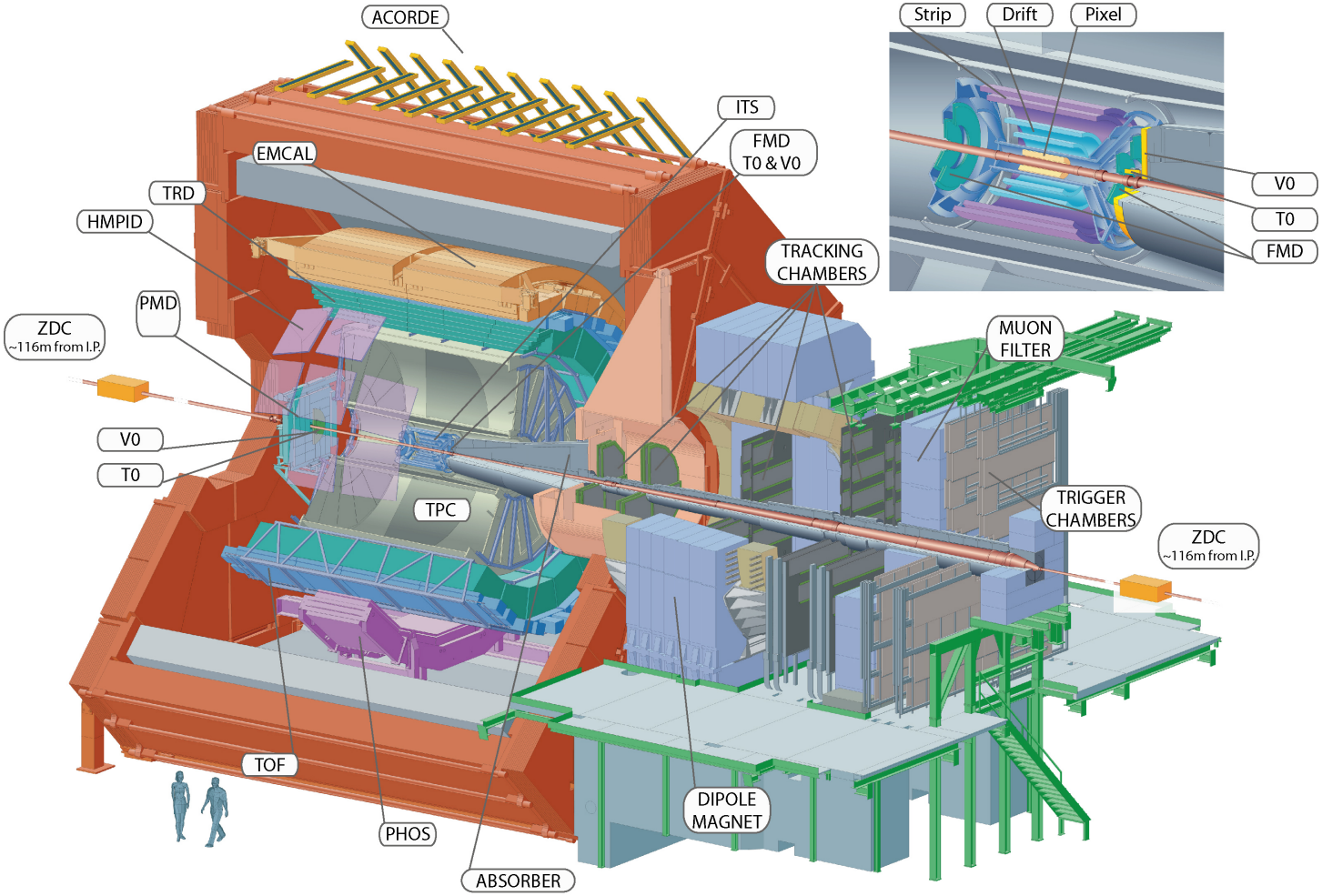
Requirements

- Excellent tracking efficiency and resolution at low p_T down to < 100 MeV/*c*
  - Increase tracking detector granularity and reduce material thickness
- Impact parameter resolution
  - detectors as close as possible to the IP
- Large statistics in minimum-bias mode
  - Increase readout rate, reduce data size
- Preserve PID capabilities at high rate
  - Consolidate PID detectors and speed-up their read-out

ALICE upgrade strategy

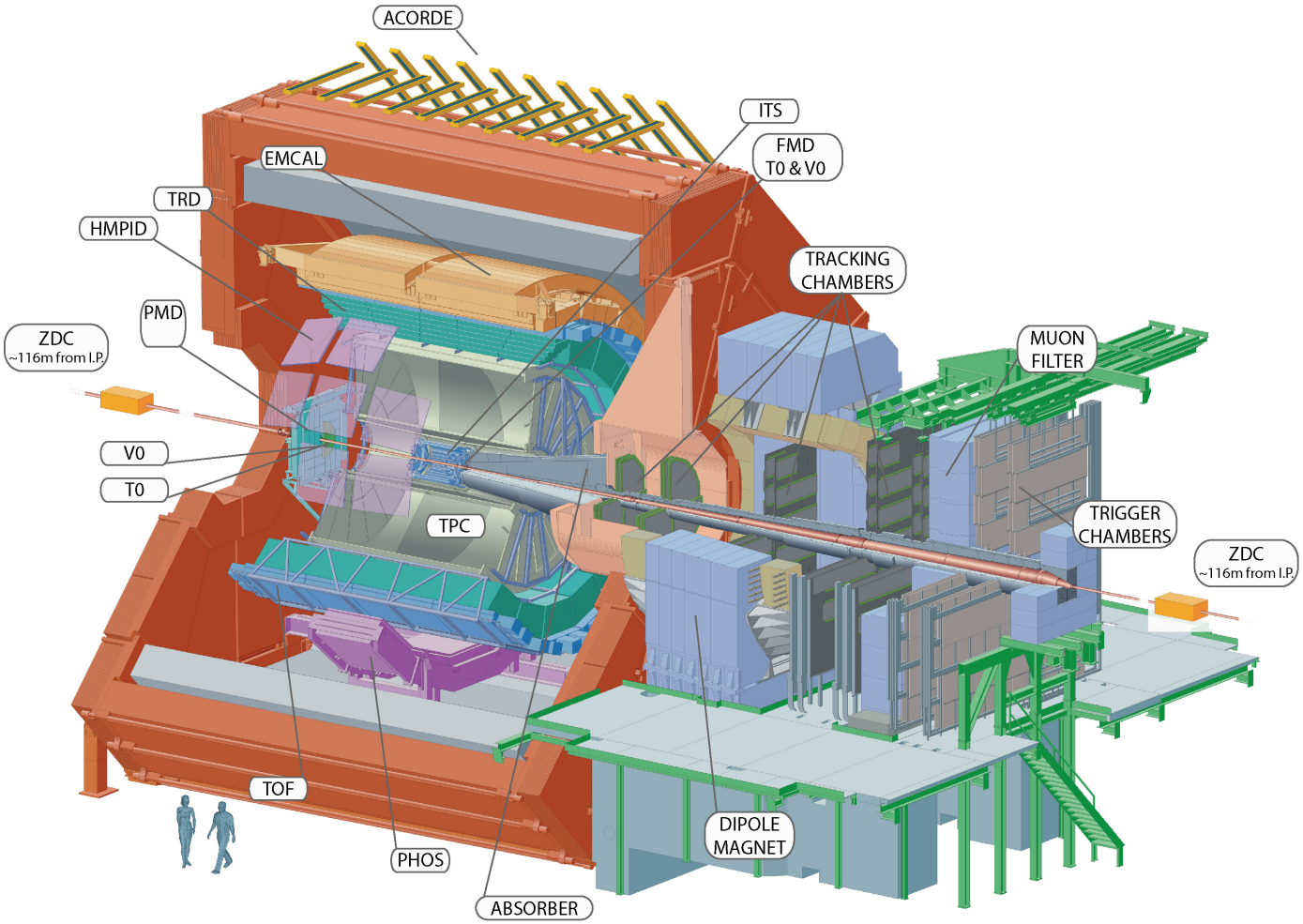
New silicon pixel tracker at central and forward rapidities

CMOS MAPS pixels ⇒ Improved tracking resolution, less material, faster read-out



ALICE upgrade strategy

Upgrade read-out for MUON, ZDC, TPC, TOF, TRD, EMCal, PHOS

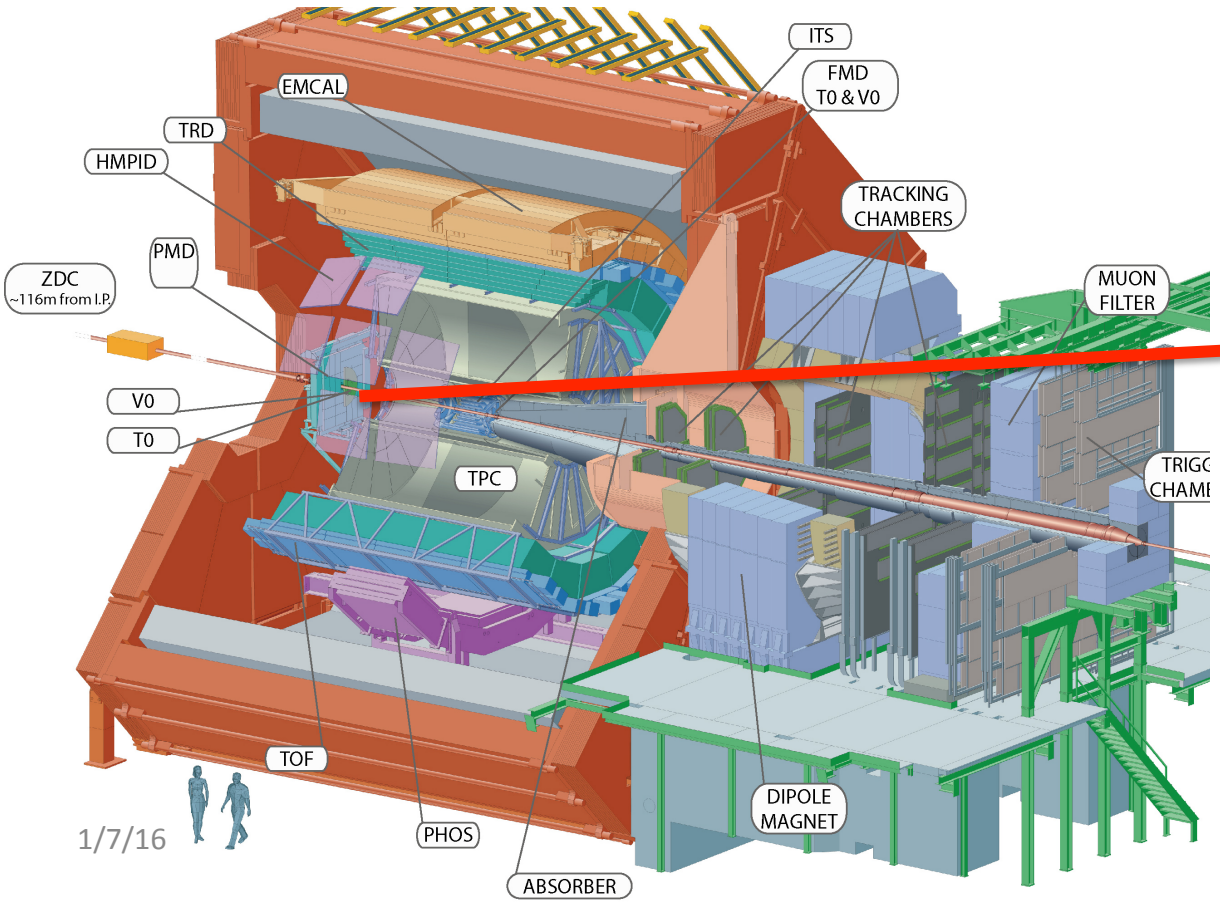


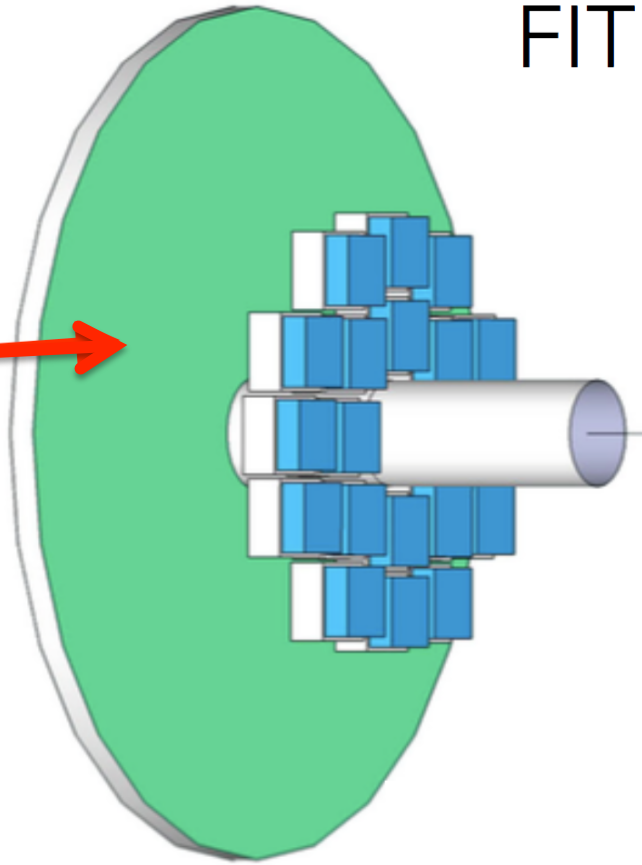
ALICE upgrade strategy

New Min. Bias trigger detector (Fast Interaction Trigger)

Integrated Online-Offline system (O^2)

Record min. bias Pb-Pb collisions at 50 kHz (×100 Run1 acquisition rate)

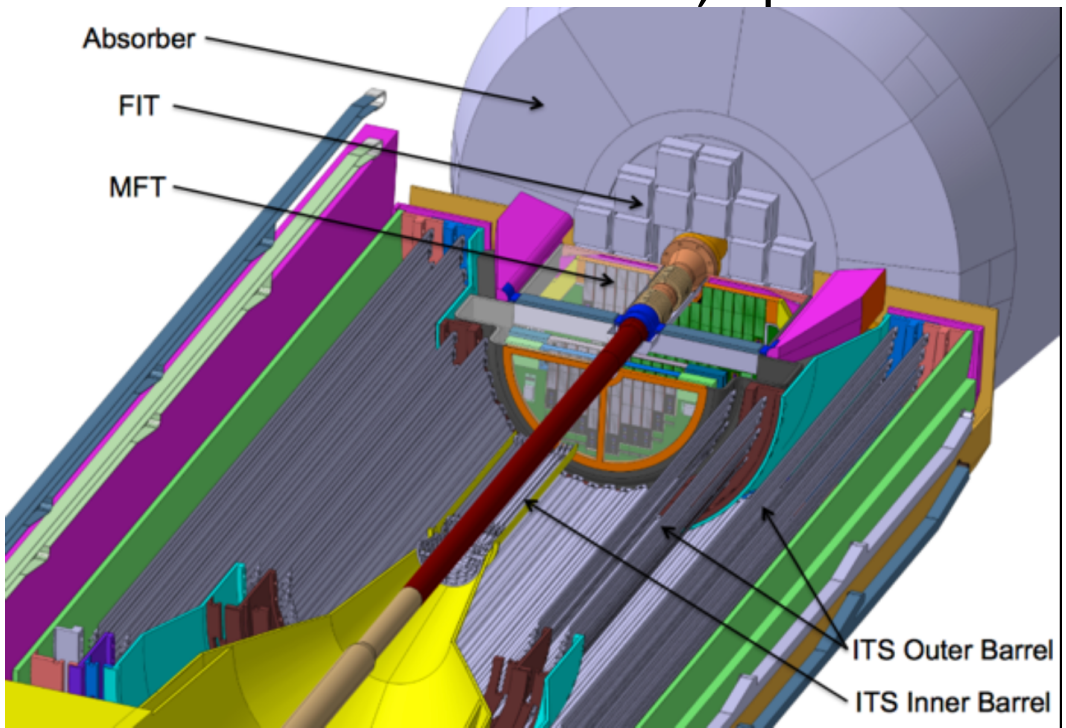




LS2 Upgrade Overview

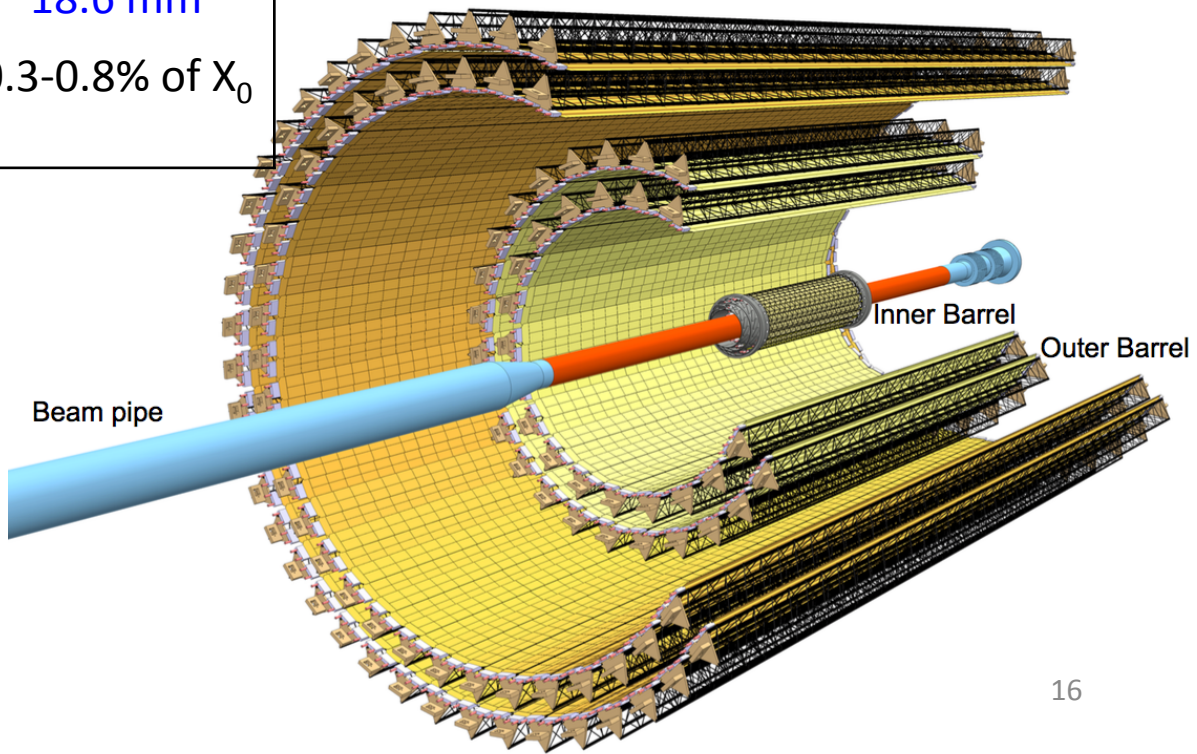
Inner Silicon Trackers

- Rapidity coverage: $|\eta| < 1.5$ (ITS) and $-3.6 < \eta < -2.3$ (MFT)
- All-Pixel trackers
- Based on CMOS Monolithic Active Pixel Sensor technology
- Spatial hit resolution ≈5 μm (pixel size ≈ 28 x 28 μm^2)
- Max. Pb-Pb read-out rate = 100 kHz, up to 400 kHz in pp

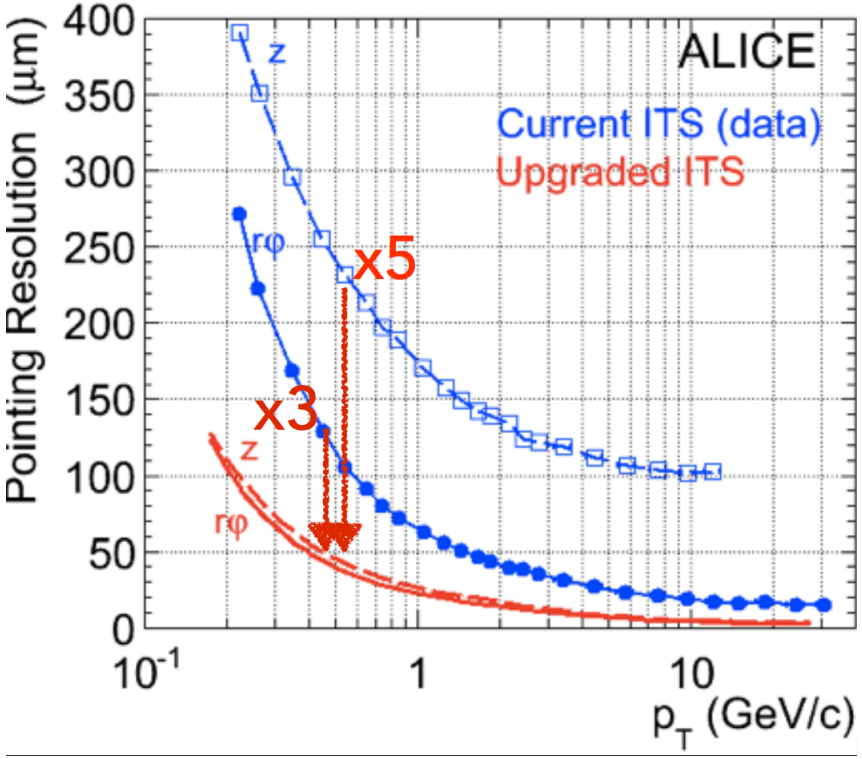


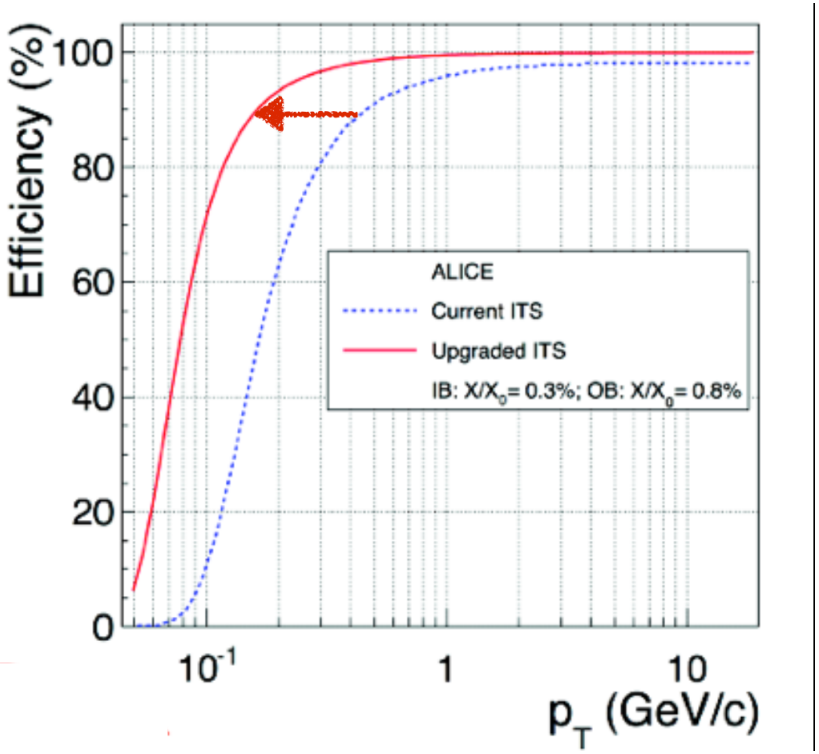
New ITS at mid-rapidity

	Current ITS	New ITS
# layers	6	7
Rapidity coverage	$\|\eta\| < 0.9$	$\|\eta\| < 1.5$
First layer radius	3.9 cm	2.3 cm
Beam Pipe radius	29.4 mm	18.6 mm
Material budget per layer	1.1% of X_0	0.3-0.8% of X_0



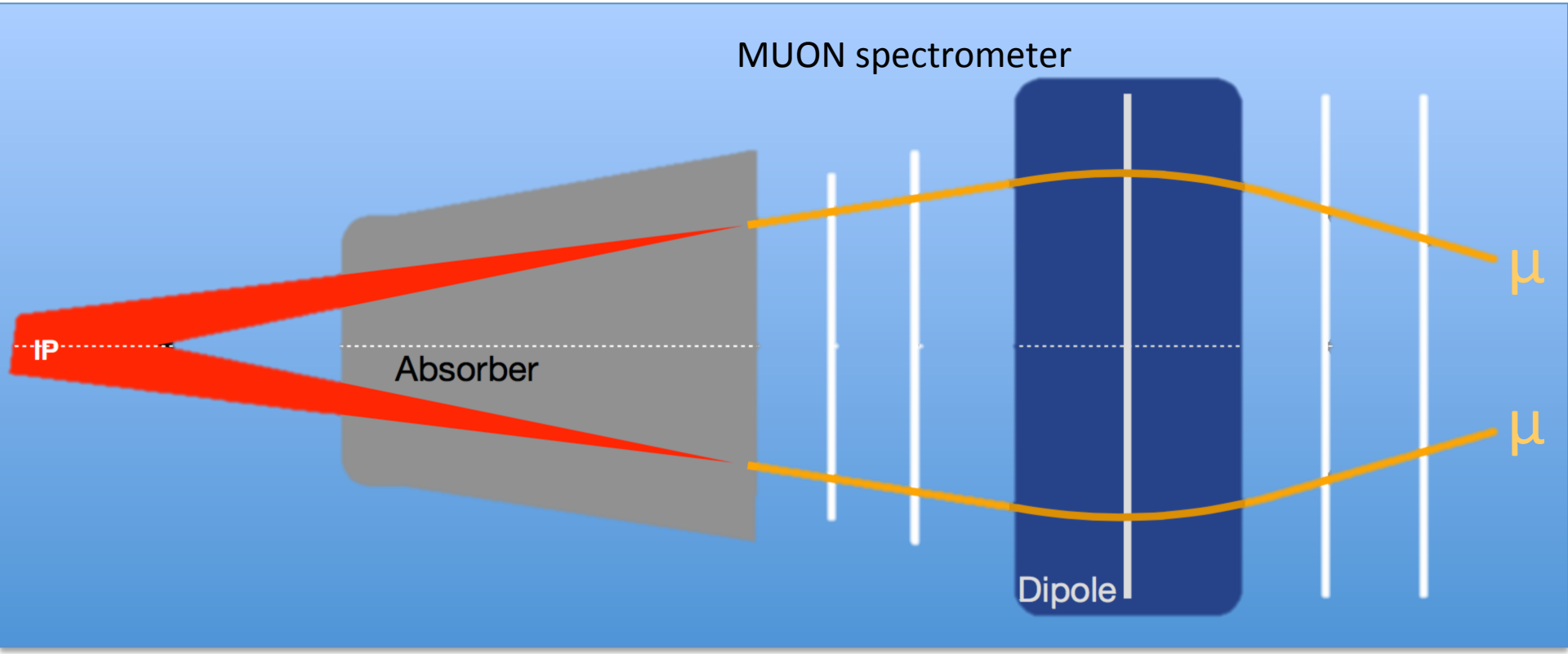
New ITS at mid-rapidity





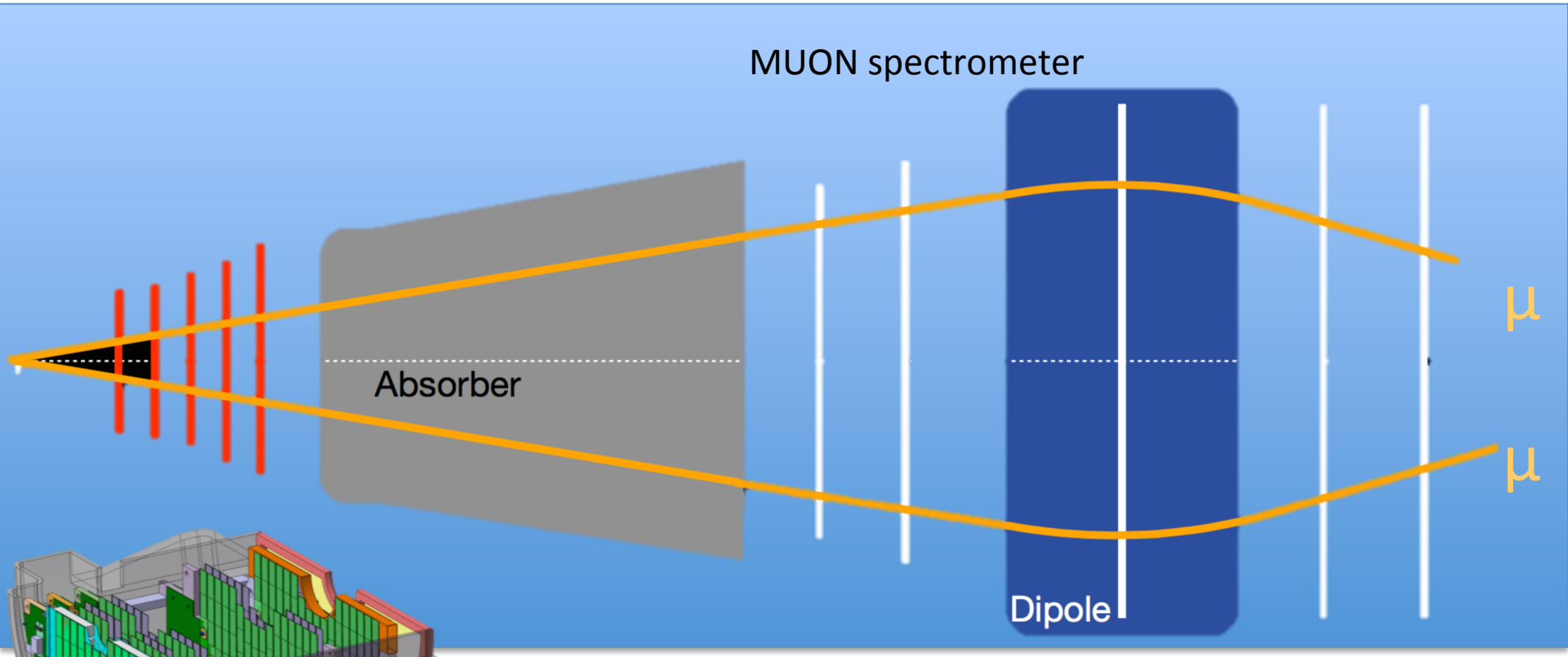
- Impact parameter resolution ×3 in transverse plane (×5 along beam)
- 90% track reconstruction efficiency down to $p_T \approx 0.1$ - 0.2 GeV/c

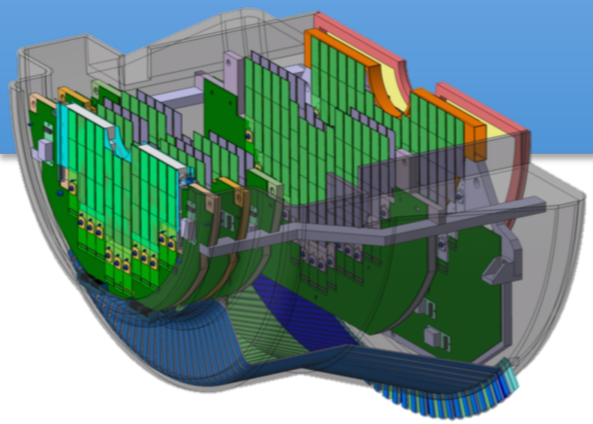
Muon Forward Tracker



- Present MUON spectrometer blurred in muon track extrapolation
- No constraint in the primary vertex region (no charm/beauty separation)

Muon Forward Tracker





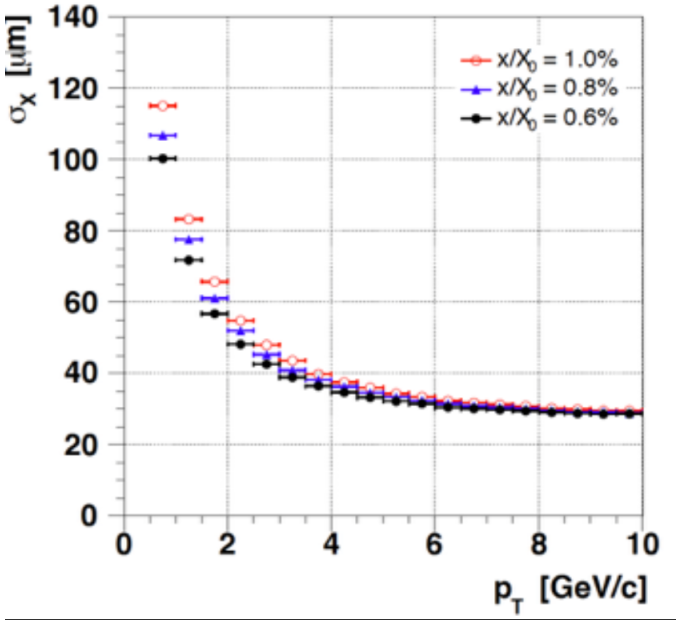
Match MUON tracks with MFT tracks

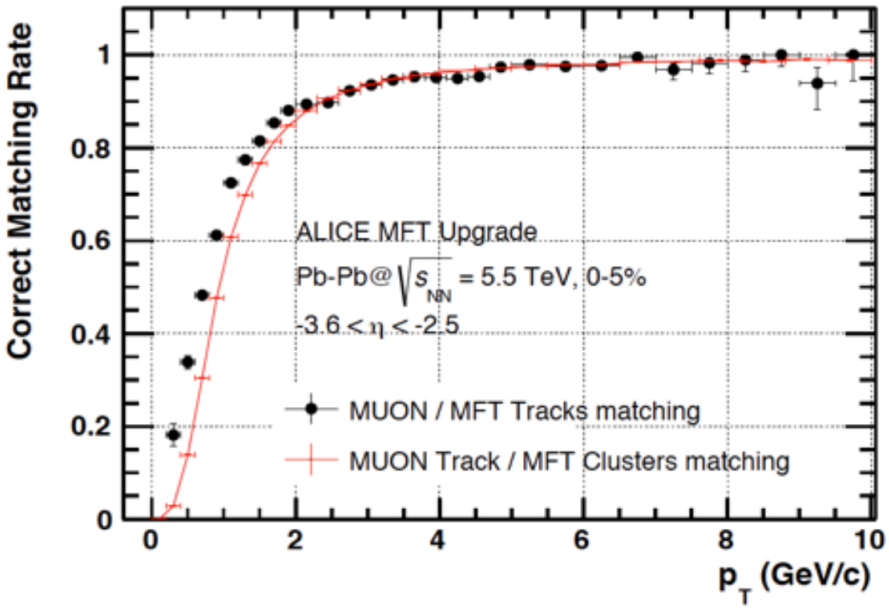
- Increase MUON track pointing accuracy

Detector Layout

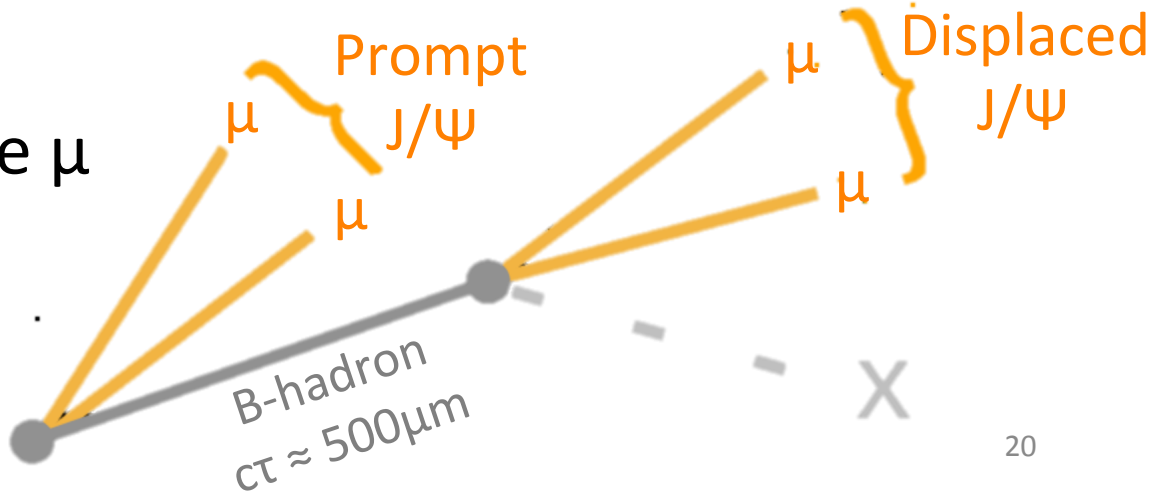
- 5 Disks with 2 detection planes each
- 0.6% of X0 per disk
- $-3.6 < \eta < -2.3$

Muon Forward Tracker





Possibility to separate charm/beauty in single μ and J/ψ analysis



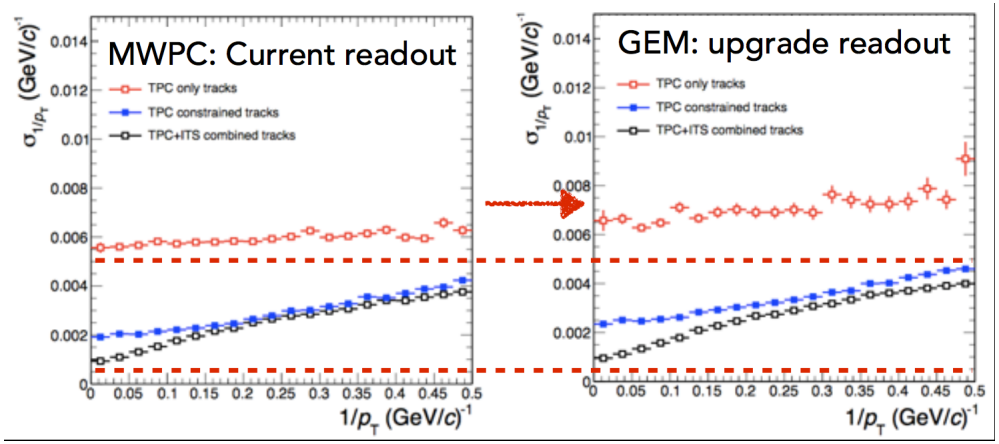
TPC Upgrade

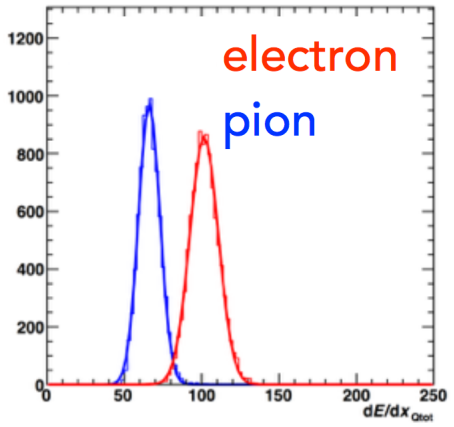
Current Readout = MWPC

- limits event readout rate to ≈3 kHz

New readout chambers based on GEM tech.

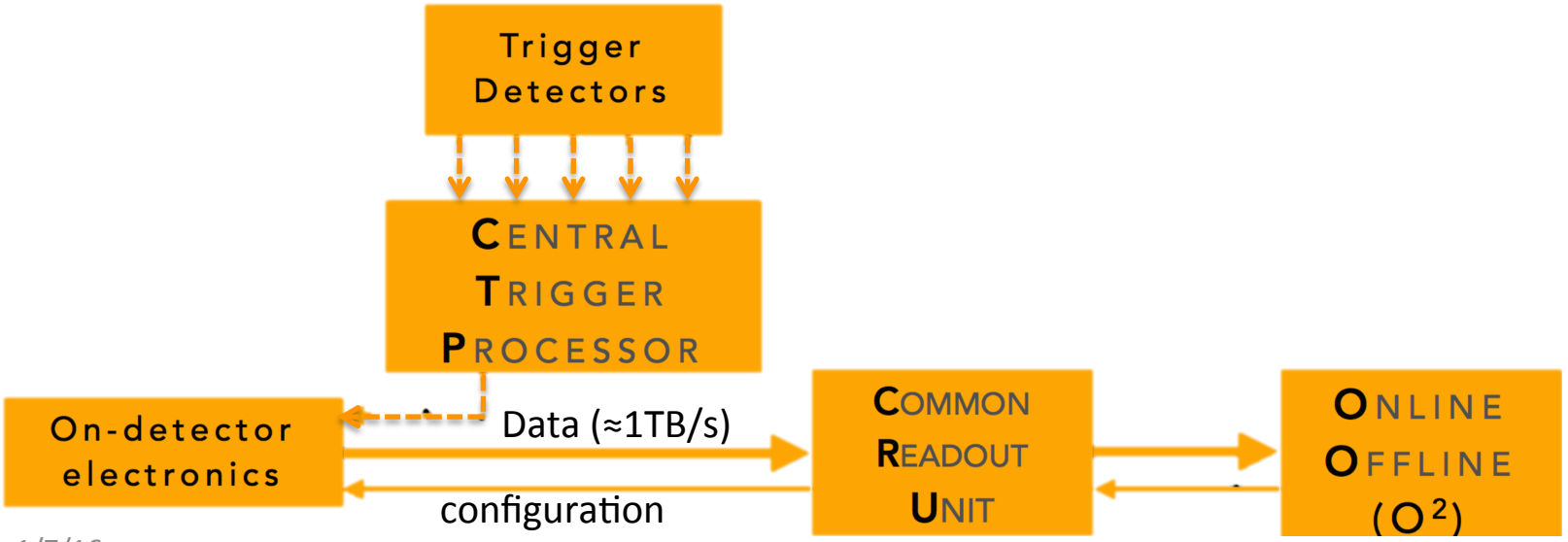
- Reduced ion back-flow
- Continuous readout up to 50 kHz Pb-Pb int. rate
- Momentum resolution preserved for ITS+TPC tracks
- PID efficiency via dE/dx measurement preserved





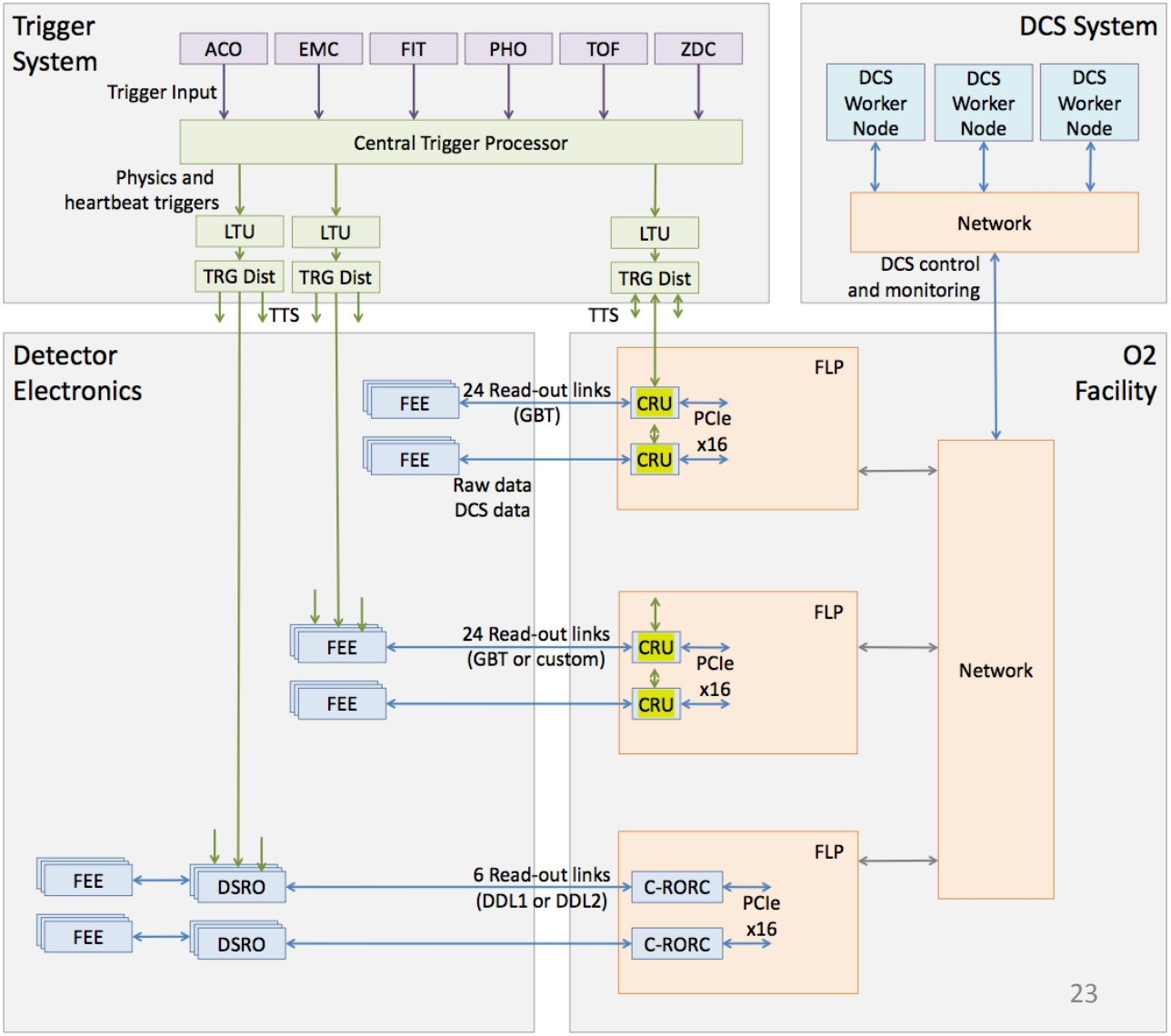
Readout and Trigger

- Goal: record each collision (@50 kHz)
- Minimum Bias trigger or self-triggered,
- Continuous readout GBT links between FEE and CRU
- Data throughput ≈1 TB/s in Pb-Pb
  (×100 compared to Runs 1-2)



Online and Offline (O^2)

- O^2: new facility at LHC Point 2
- ≈100k CPU cores
- 60 PB of storage

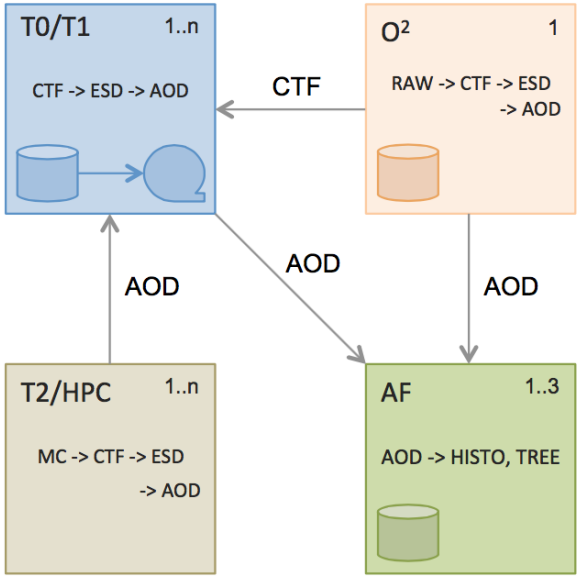


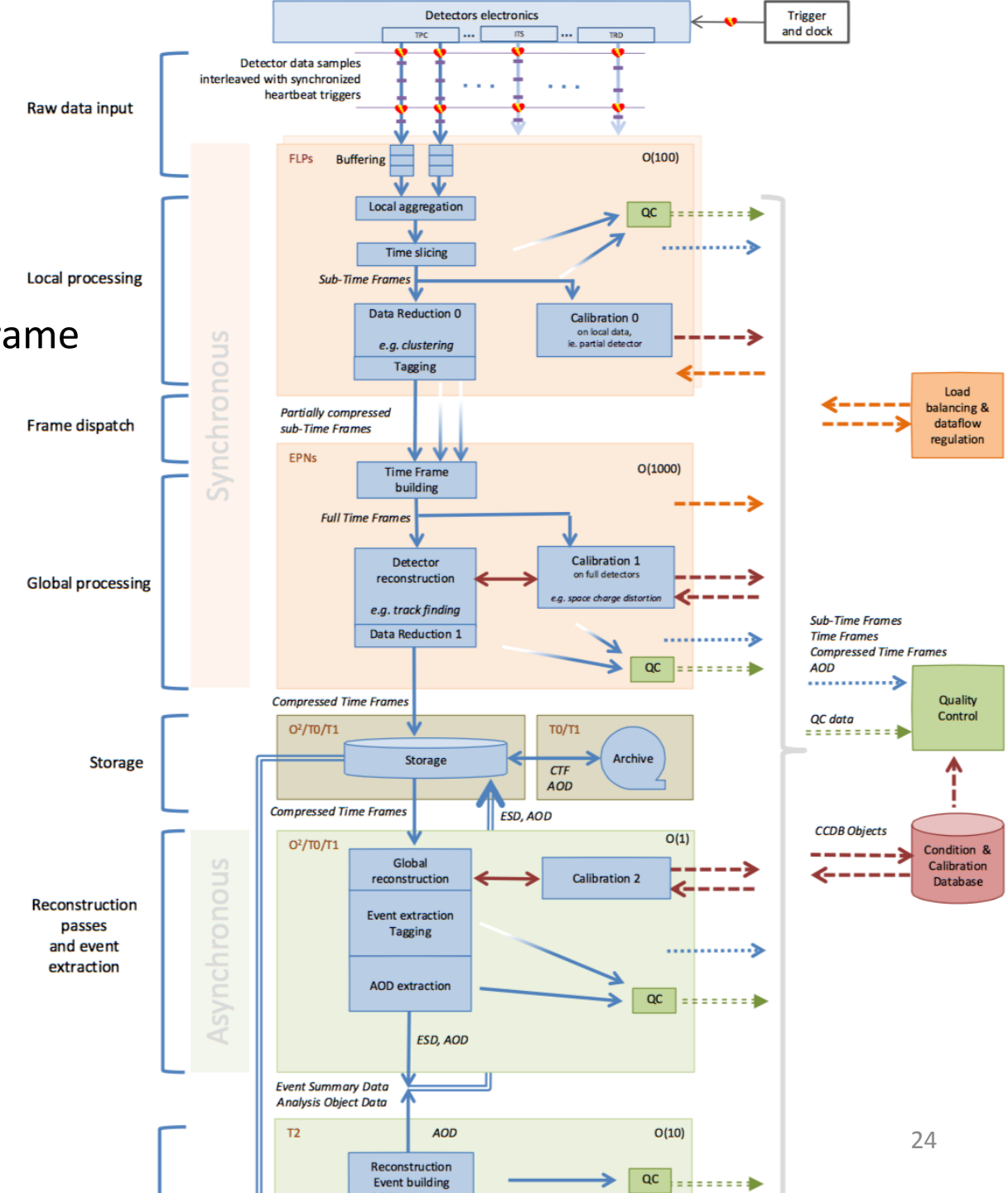
O^2

CTF … compressed time frame

T0/T1/T2 … grid sites

AF … analysis facility





Online and Offline (O^2)

Number of reconstructed collisions and
storage requirements for different systems and scenarios.

Example schedule (to be shifted by +1 year)

Year	System	Collisions	Storage CTF (PB)	Storage Calibration (TB)	Storage ESD/AOD (PB)	Required CPU seconds (single CPU core)
2020	pp	$2.7 \cdot 10^{10}$	1.5	5	0.6	$1.7 \cdot 10^{10}$
	Pb–Pb	$2.3 \cdot 10^{10}$	37	23	15	$2.8 \cdot 10^{11}$
2021	pp	$2.7 \cdot 10^{10}$	1.5	5	0.6	$1.7 \cdot 10^{10}$
	Pb–Pb	$2.3 \cdot 10^{10}$	37	23	15	$2.8 \cdot 10^{11}$
2022	pp	$4.3 \cdot 10^{11}$	23	76	9.2	$2.7 \cdot 10^{11}$
2025	pp	$2.7 \cdot 10^{10}$	1.5	5	0.6	$1.7 \cdot 10^{10}$
	Pb–Pb	$2.3 \cdot 10^{10}$	37	23	15	$2.8 \cdot 10^{11}$
2026	pp	$2.7 \cdot 10^{10}$	1.5	5	0.6	$1.7 \cdot 10^{10}$
	Pb–Pb	$1.1 \cdot 10^{10}$	18	11	7.2	$1.3 \cdot 10^{11}$
	p–Pb	$1.0 \cdot 10^{11}$	10	20	4.0	$7.2 \cdot 10^{10}$
2027	pp	$2.7 \cdot 10^{10}$	1.5	5	0.6	$1.7 \cdot 10^{10}$
	Pb–Pb	$2.3 \cdot 10^{10}$	37	23	15	$2.8 \cdot 10^{11}$

Summary

- Major ALICE detector/readout/computing upgrades
  - Improved tracking performance
  - Enable Pb-Pb collisions readout rate at 50 kHz
- Unique Physics program with × 100 larger statistics
- Focused on

  Heavy-Flavour and Charmonium

  + much more:
    - low-mass di-leptons
    - light-nuclei,
    - jets
    - …

ALICE
UPGRADE