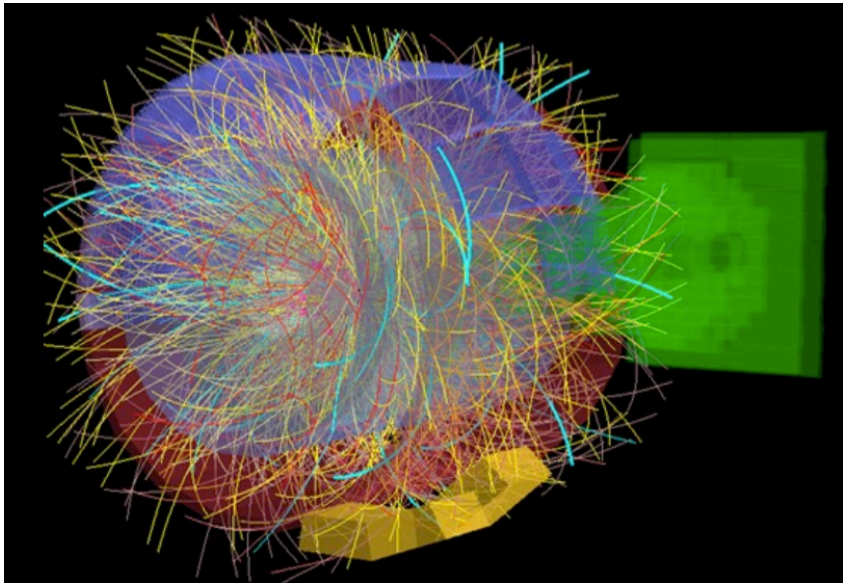
A Large Ion Collider Experiment



The ALICE Upgrade Program

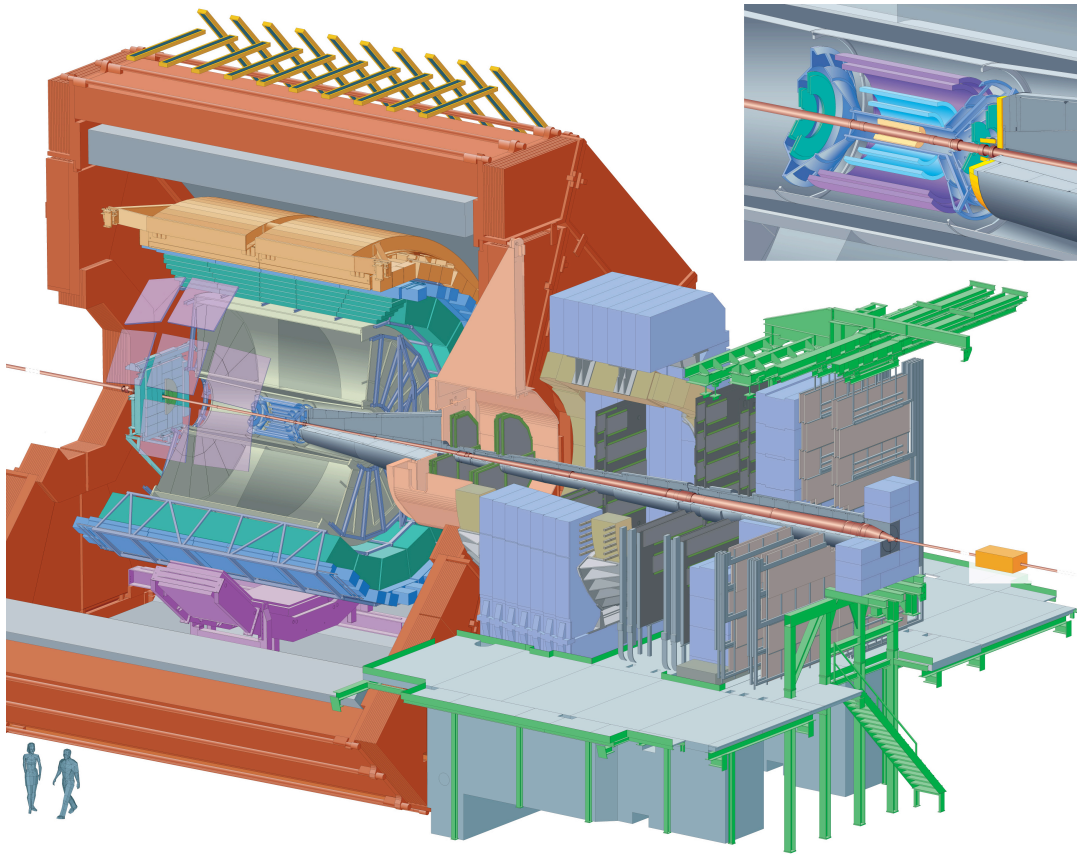
Ginés MARTINEZ – Subatech CNRS/IN2P3
for the ALICE Collaboration

IX FCPPL Workshop
March 31st 2016
Strasbourg, France

A Large Ion Collider Experiment

ALICE Detector (Run1 & Run2 2010-2018)

Avant propos



Integrated Luminosity (Run1 & Run2)
1 nb^{-1} in PbPb

- ✓ Devoted of the study of the Quark Gluon Plasma at the LHC
- ✓ Excellent (low pT) tracking performances (ITS+TPC +TRD)
- ✓ Excellent particle identification performances (TPC-TOF-TRD)
- ✓ Good secondary vertexing reconstruction (ITS-SPD)
- ✓ Electromagnetic calorimeter (EMCAL-DCAL)
- ✓ Muon spectrometer at 2.5<y<4
- ✓ MB Trigger and centrality measurement (V0-T0-ZDC)

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ALICE Physics Goals

Cabibbo & Parisi PLB 59 67 (1975)

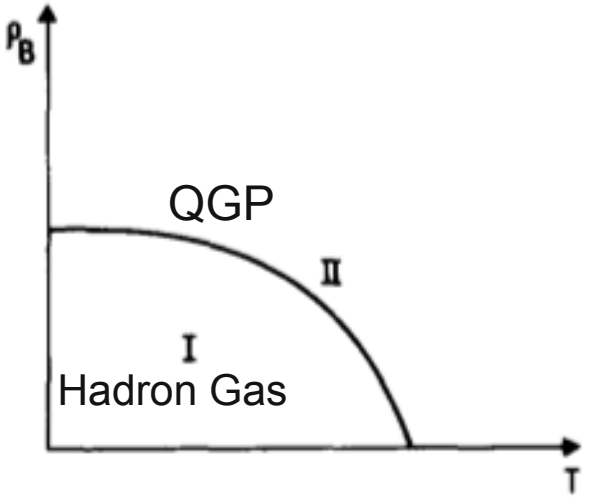
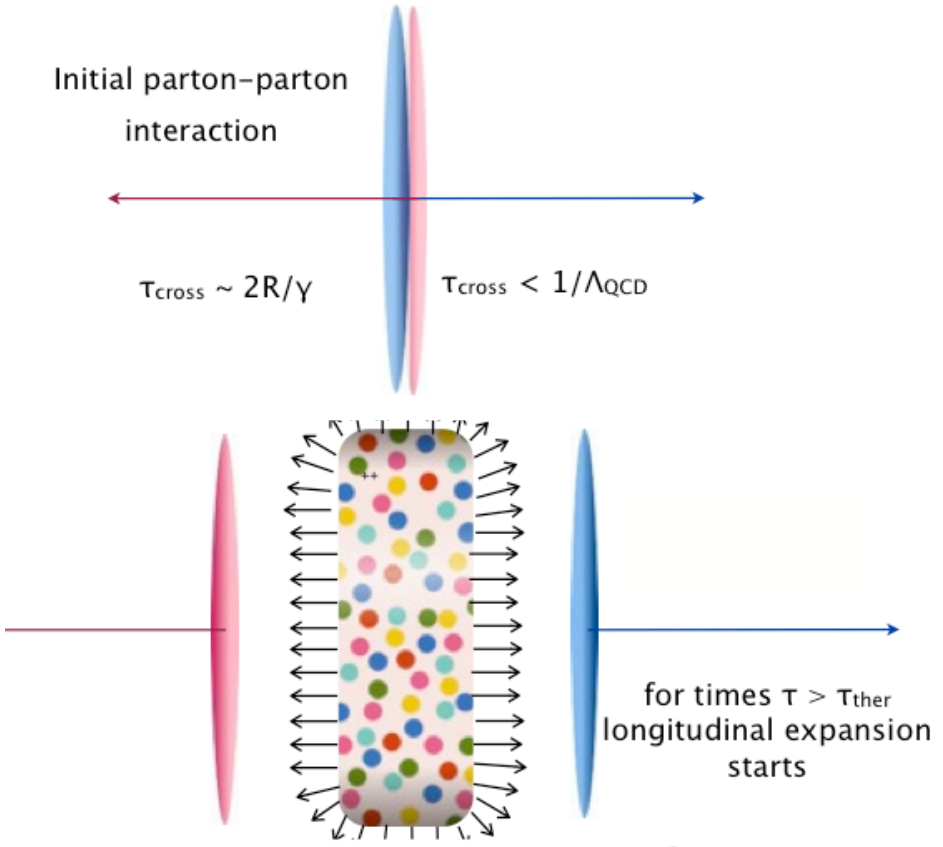


Fig. 1. Schematic phase diagram of hadronic matter. ρ_B is the density of baryonic number. Quarks are confined in phase I and unconfined in phase II.

Bjorken PRD27 140 (1983)



Characterisation of the Quark Gluon Plasma
by means of the heavy ion collisions at ultra relativistic energies.

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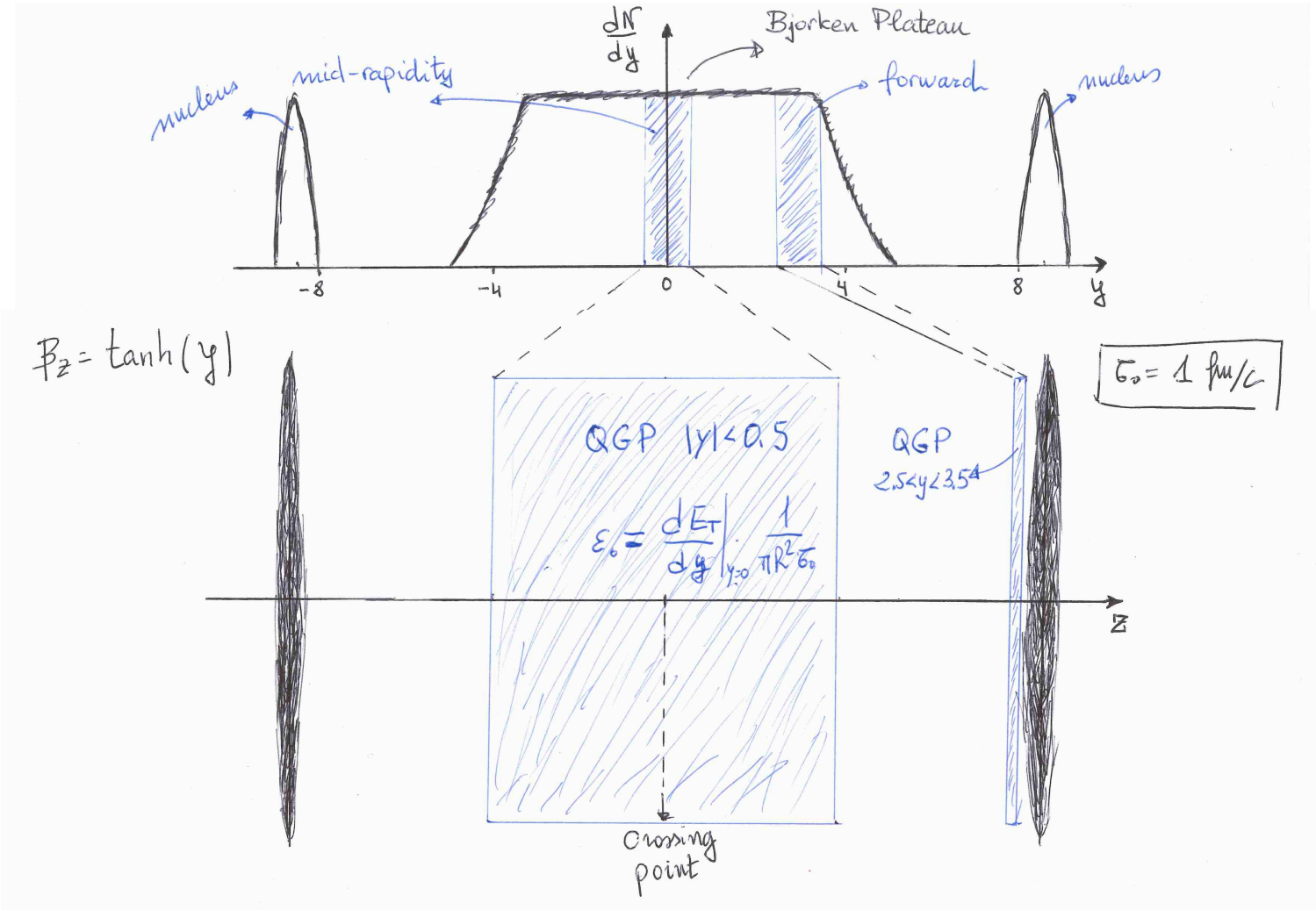
One particularity of ALICE Detector

Large Rapidity coverage



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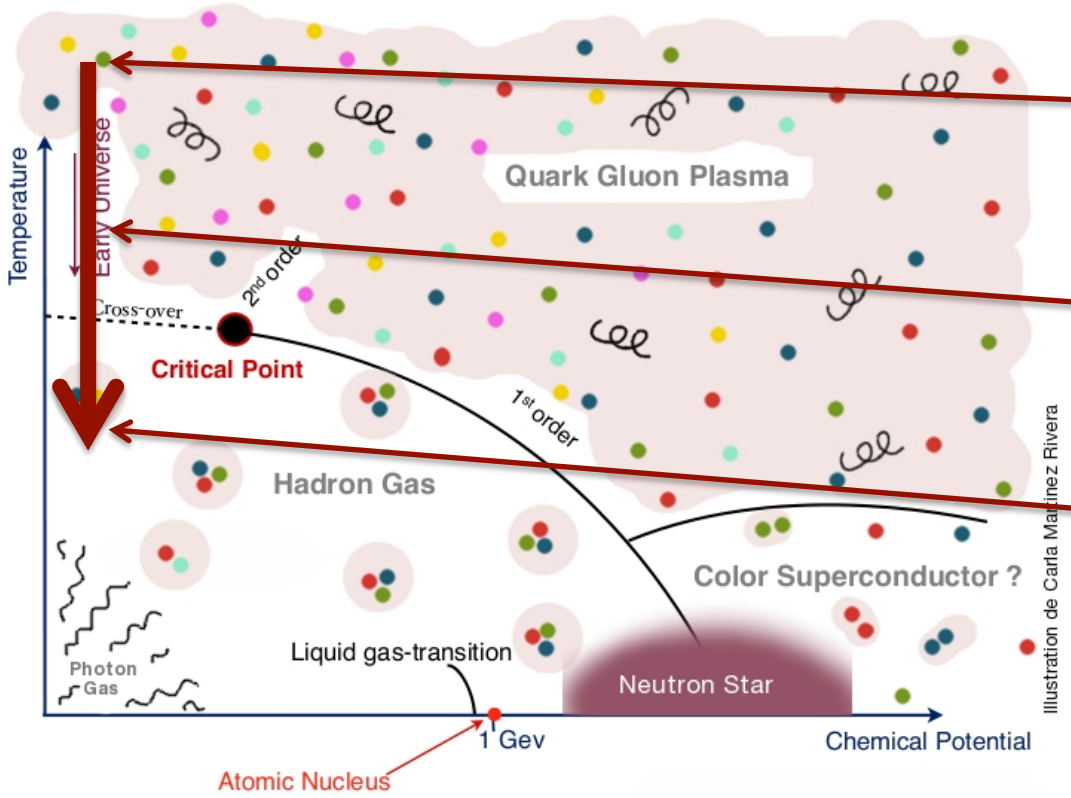
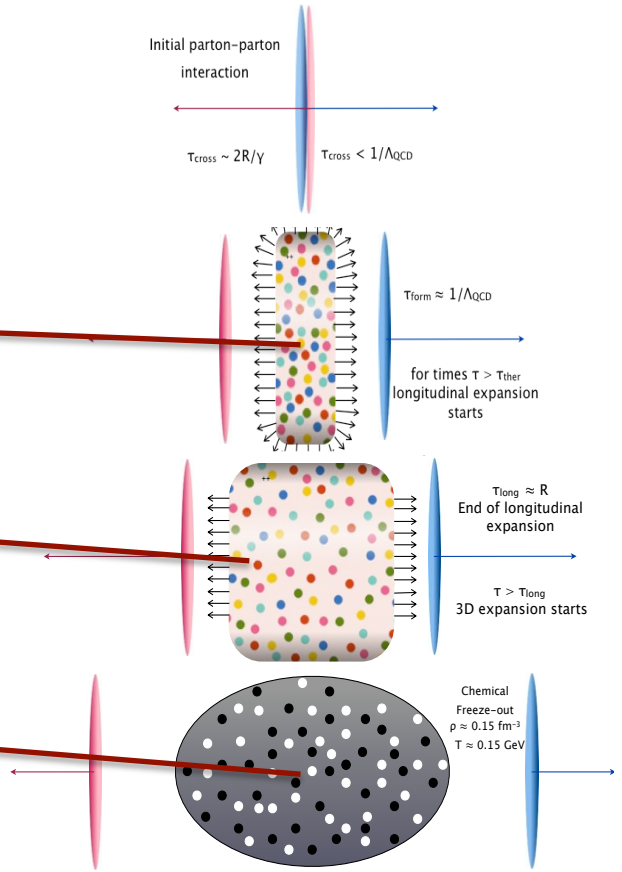
ALICE

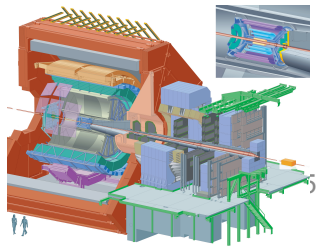
Heavy Ions at LHC

At the LHC μ_B~0

ε_0~10-40 GeV/fm^3 (T_i~350-550 MeV)







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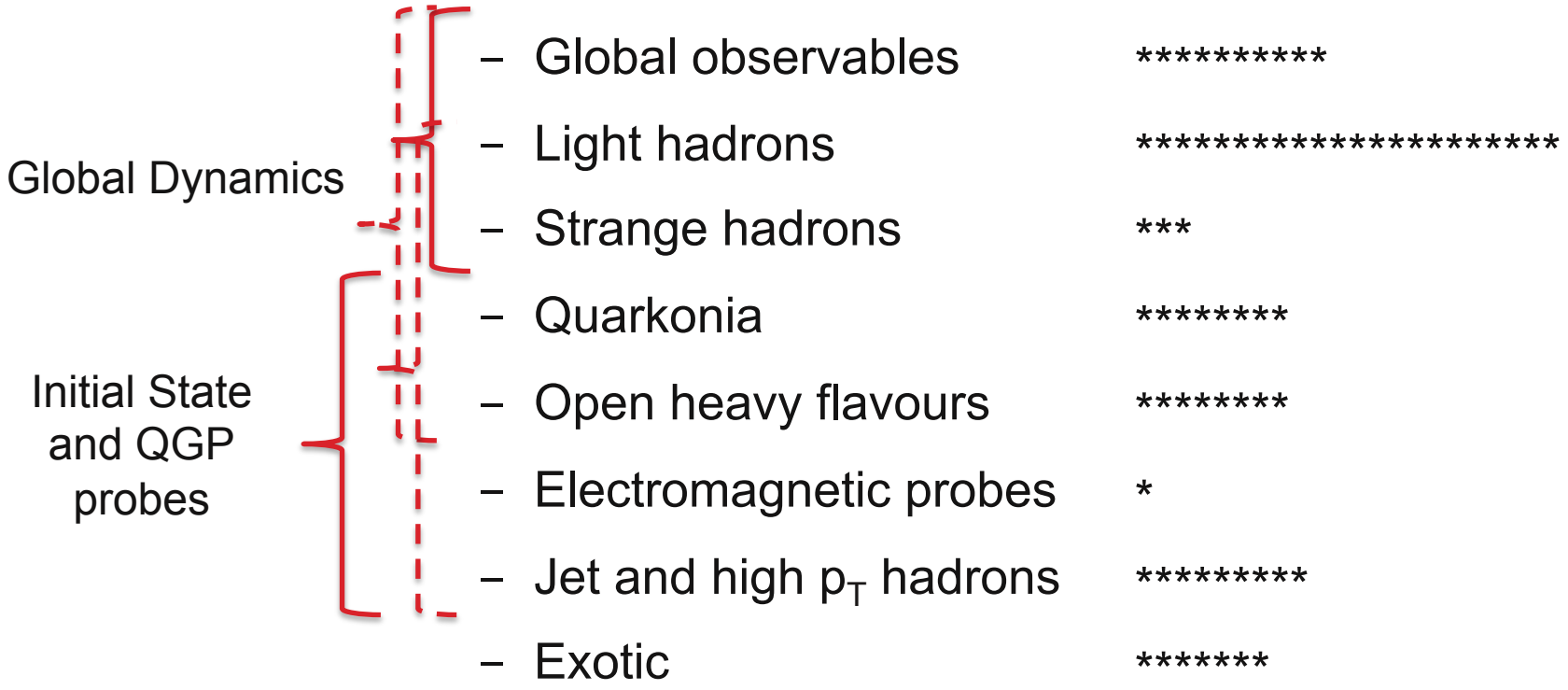
ALICE

QGP Observables



Rapidity, Transverse momentum, Azimuthal angle, centrality, centre of masse energy, reaction plane, correlations, fluctuations, small systems (pp and pA)

"*" number of ALICE publications (2010 - March 2016) for PbPb collisions

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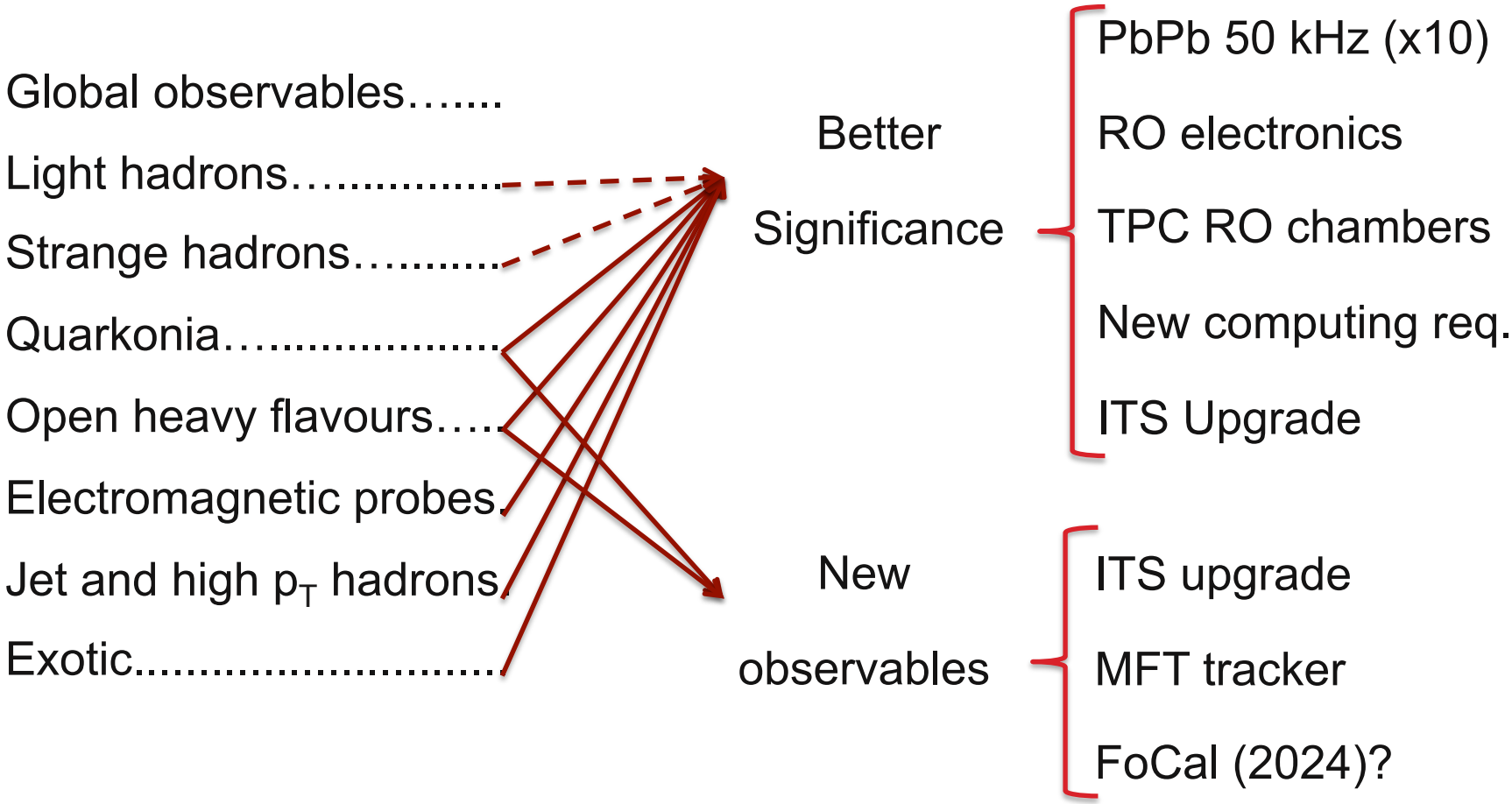
ALICE strategy for Run3 & Run4 2021-2028



Low signal over background: hardware trigger filtering impossible, namely at low pT

A Large Ion Collider Experiment

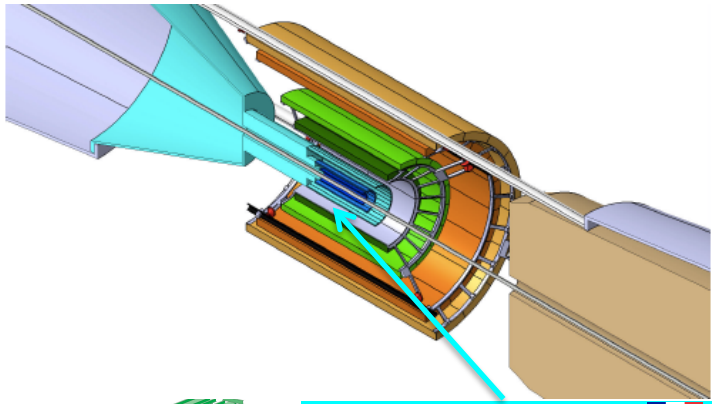
ALICE

ALICE Detector Upgrade for Run3

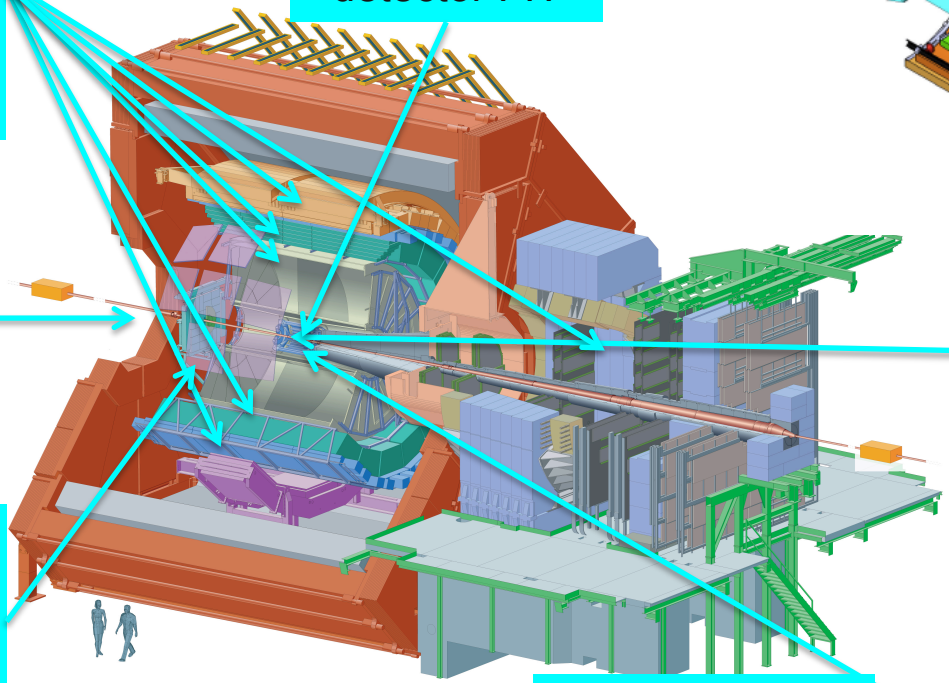
Increase of luminosity (50kHz IR) and improve vertexing and tracking at low p_T

TPC Muon Spectrometer, TRD, TOF, PHOS, EMCAL/ DCAL , ZDC, T0

New MB trigger detector FIT



New berilium beampipe smaller radius

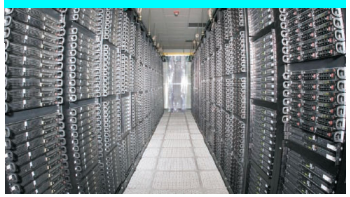


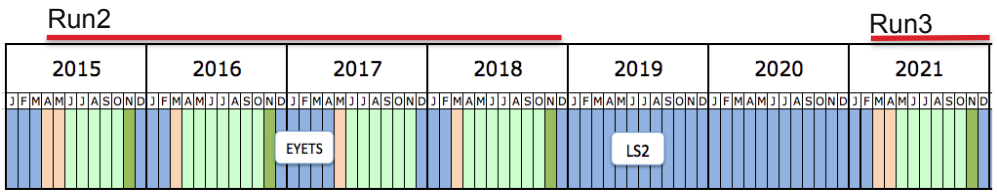
New Internal Tracking System, high resolution, low material budget

New TPC GEM Chambers (low ion backflow, continuous RO)

Muon Forward Tracker, high resolution, low material budget

Computing O^2





A Large Ion Collider Experiment

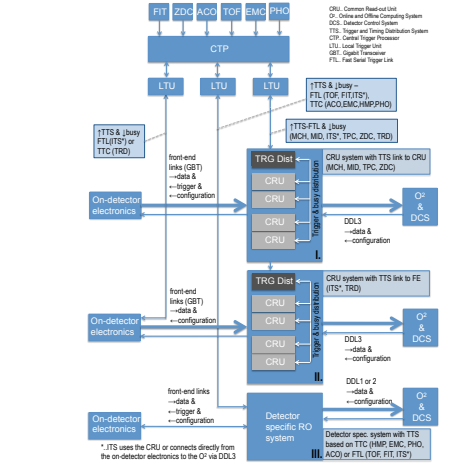
New Read-Out Architecture

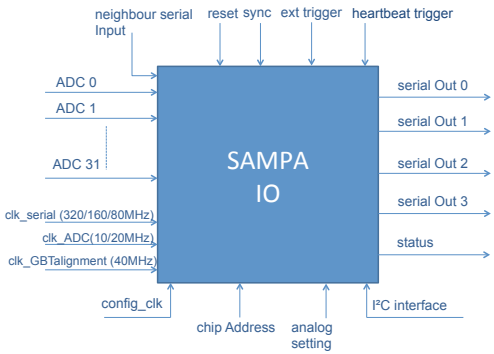
Goals

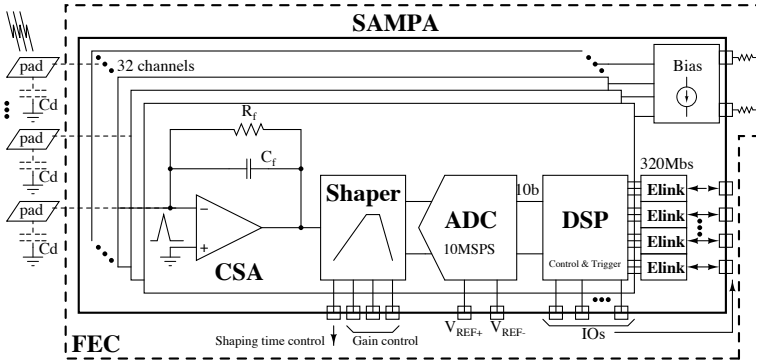
- Collecting more than 10 nb^{-1} in Pb-Pb collision during Run3 & Run4. Interaction rates ~50 kHz in Pb-Pb run; gain by a factor 100
- Equivalent nucleon integrated luminosity in pp and p-Pb at the same centre of mass energies.

Projects

- CTP
- CRU
- SAMPA: new ASIC for the TPC and muon tracking system
- MID
- TOF
- TDR
- ZDC



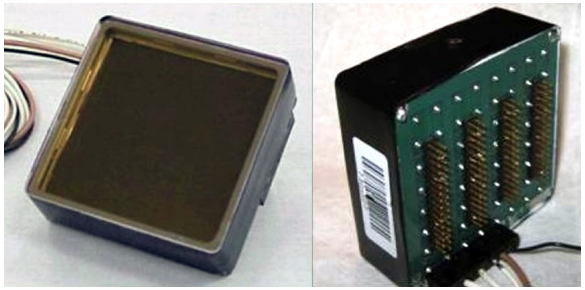


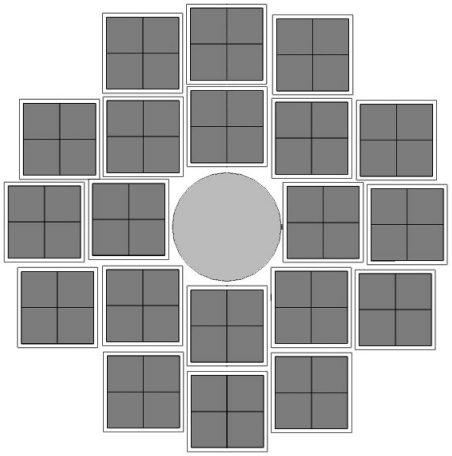


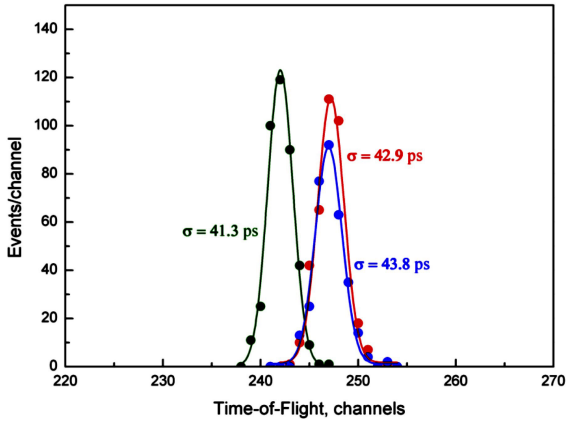
FIT: Fast Interaction Trigger for ALICE

Like a V0 and T0 in a single detector

- Efficiency ~83% (C&A) in pp collisions
- Centrality triggering (as V0)
- Vertex location (as T0)
- Time resolution <50 ps
- Event plane determination (as V0)
- No aging over Run3 and Run4 periods
- MCP-based detector
- XP85012 Planacon from Photonis (59x59x28 mm^3)



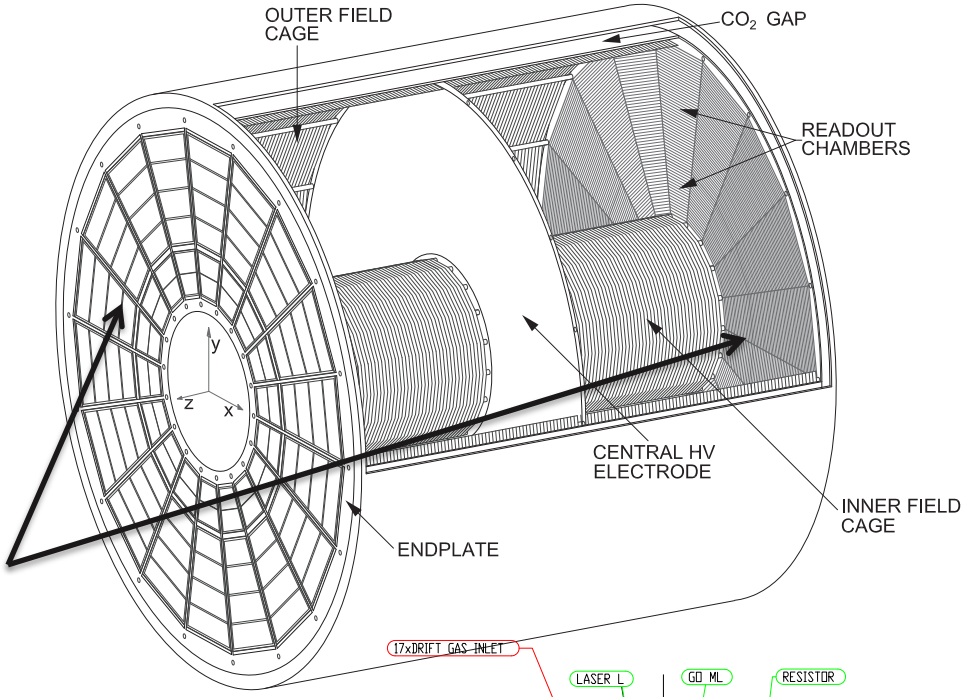


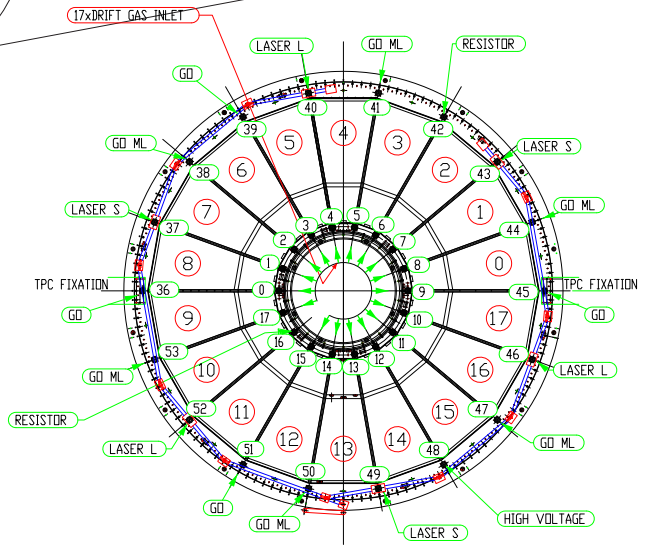


New TPC RO chambers

Limitation of the ion backflow

- Gating grid is not possible at 50 kHz IR
- Distortion at 1% for a 2000 gain
- Replacement of the read-out chambers is required.
- Continuous readout ➔ ~1 TByte/s. Online reconstruction needed (O2)

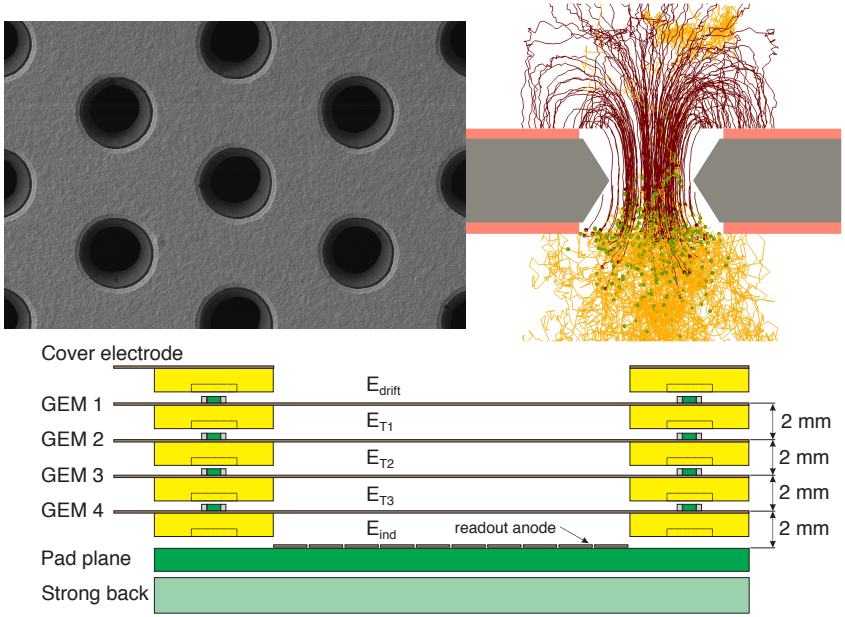


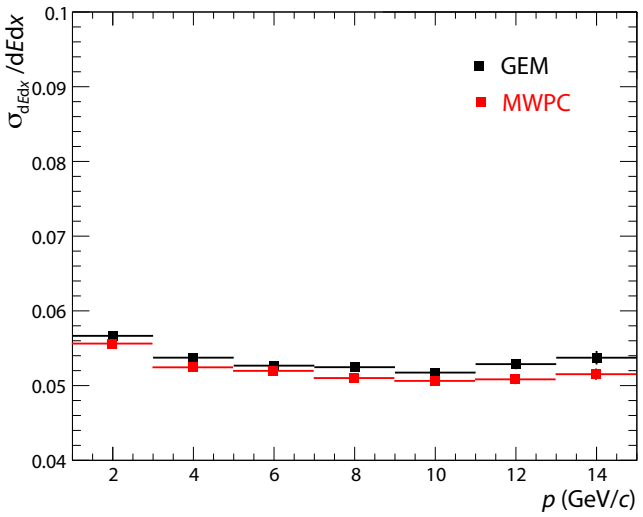


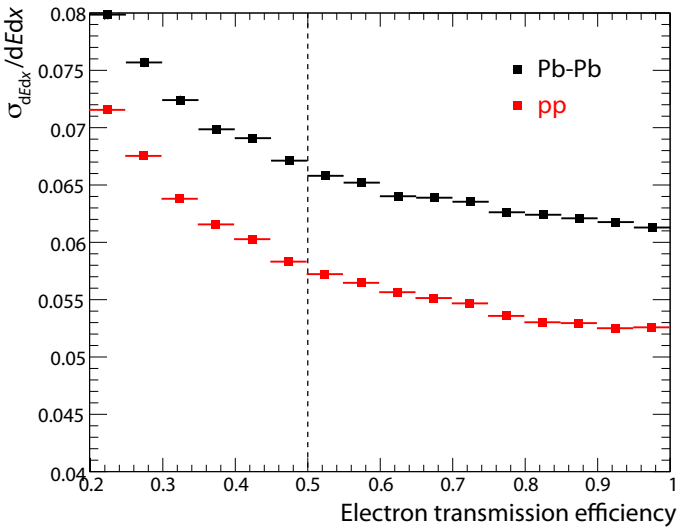
Quadruple GEM

Technology

- Quadruple GEM chambers
- GEMs technology intrinsically blocks ion backflow
- Similar performances to MWPC
- Good performance at high multiplicity (Pb-Pb at 50 kHz) and with pile-up.





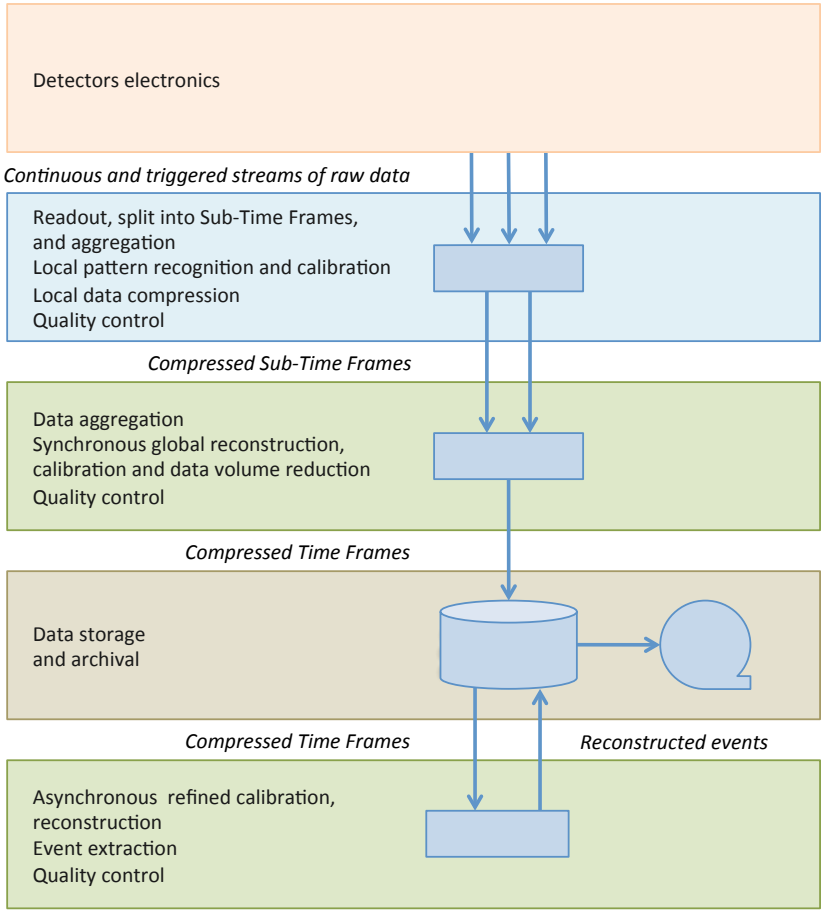


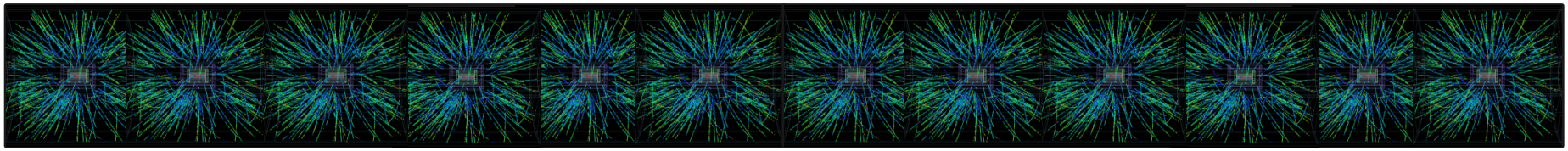
A Large Ion Collider Experiment

O2 project

Upgrade of the ALICE online and offline computing for Run3 & Run4

- Continuous read-out of ALICE detector, namely the TPC at 50 kHz IR ➔ more than 1 TByte/s data throughput from the detector
- New computing requirements ➔ O2 farm at LHC Point2 (ALICE) : 250 FLP and 1500 EPN
  - Online reconstruction and calibration. Parallelisation
  - High level trigger decision
  - Data compression
- Offline reconstruction and permanent data storage ➔ ~70 GByte/s





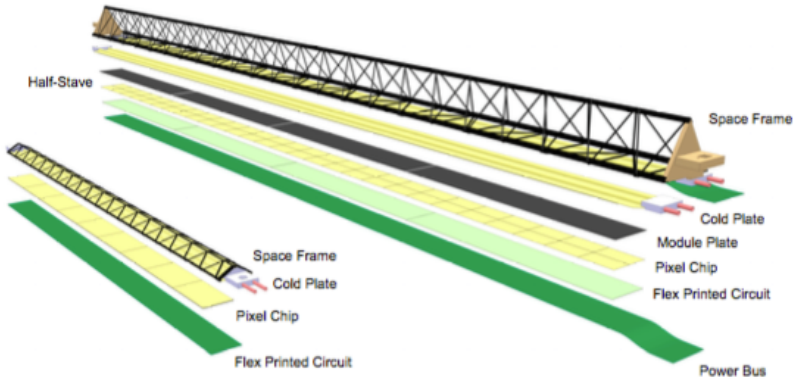
A Large Ion Collider Experiment

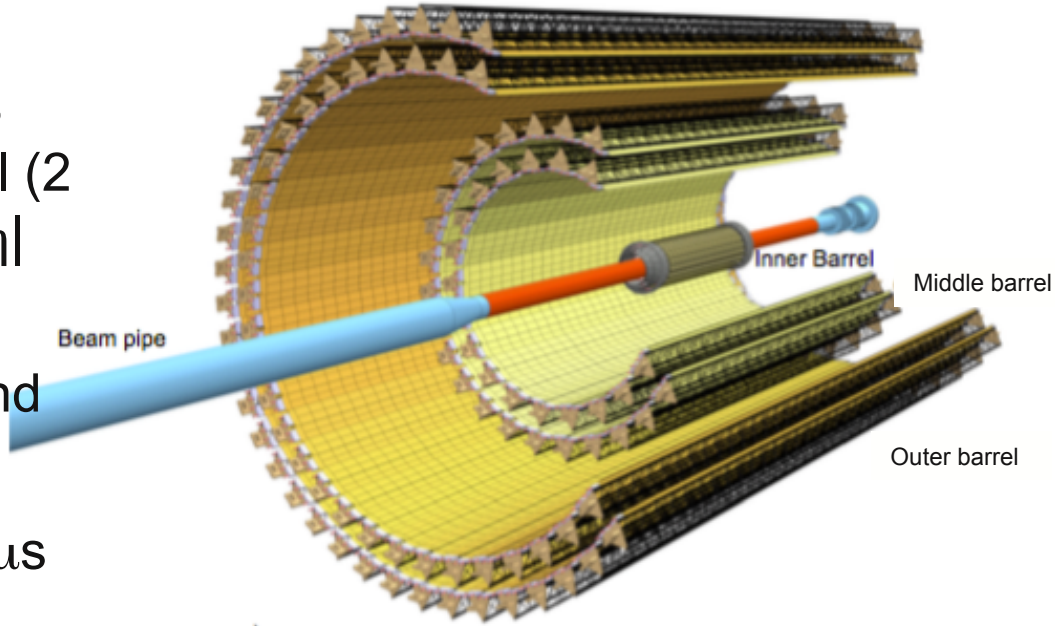
ALICE

Upgrade ALICE internal tracking system

Improving tracking performance, namely at low p_T

- Spatial resolution O(5 μm).
- First layer closer to IP (smaller beampipe)
- 0.3%X_0 per layer (light mechanical structure and MAPS sensors)
- 7 layers from R=22 mm to R=400 mm: Inner Barrel (3 layers $|\eta|<2$), Middle Barrel (2 $|\eta|<1.4$), Outter Barrel(2 $|\eta|<1.3$)
- Radiation: TID < 1 Mrad and $<10^{13}$ 1 MeV neq
- Event time resolution <10 μs

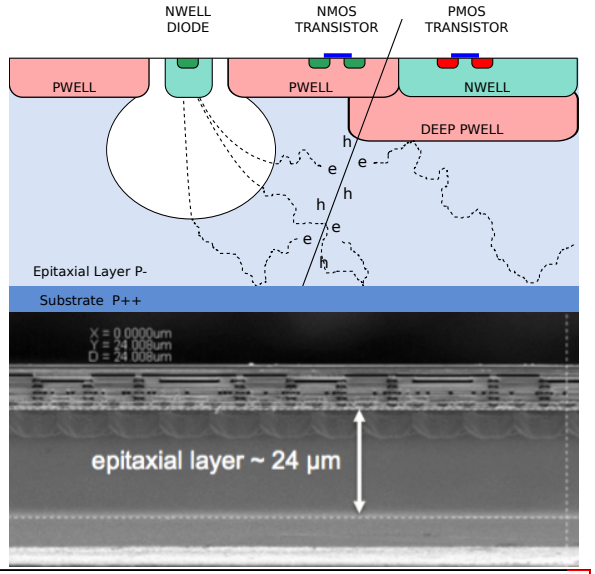


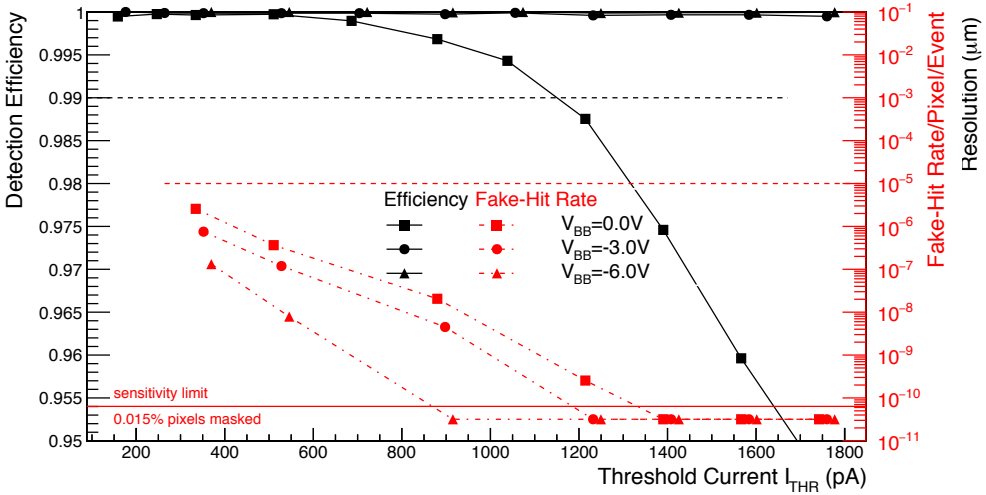


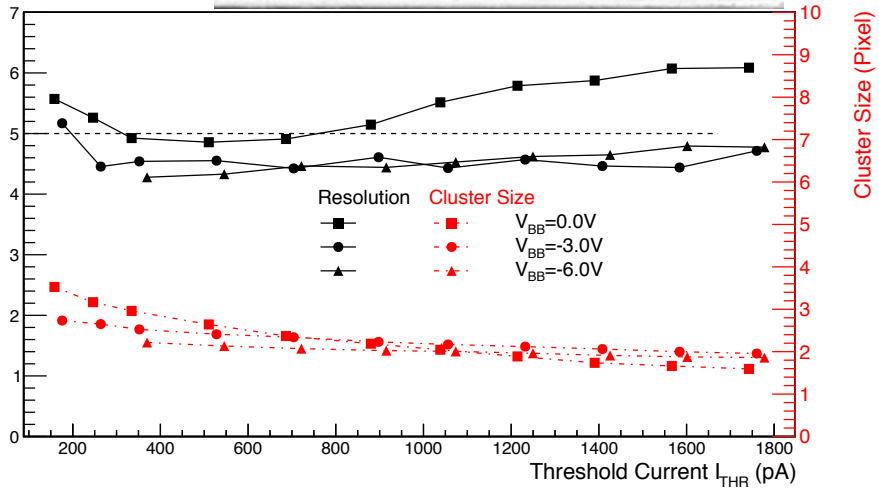
ALICE pixel sensor

CMOS Monolithic Active Sensors (MAPS), TowerJazz 0.18 μm technology

- Sensor Size 15 mm x 30 mm. Pixel size O(25x25 μm^2)
- Event time resolution <4 μs
- Low power consumption <50 mW/cm^2
- ITS: 25000 sensors, O(10^{10} pixels), 10 m^2 of silicon pixel surface, <6 kW.







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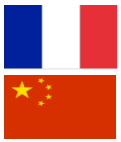
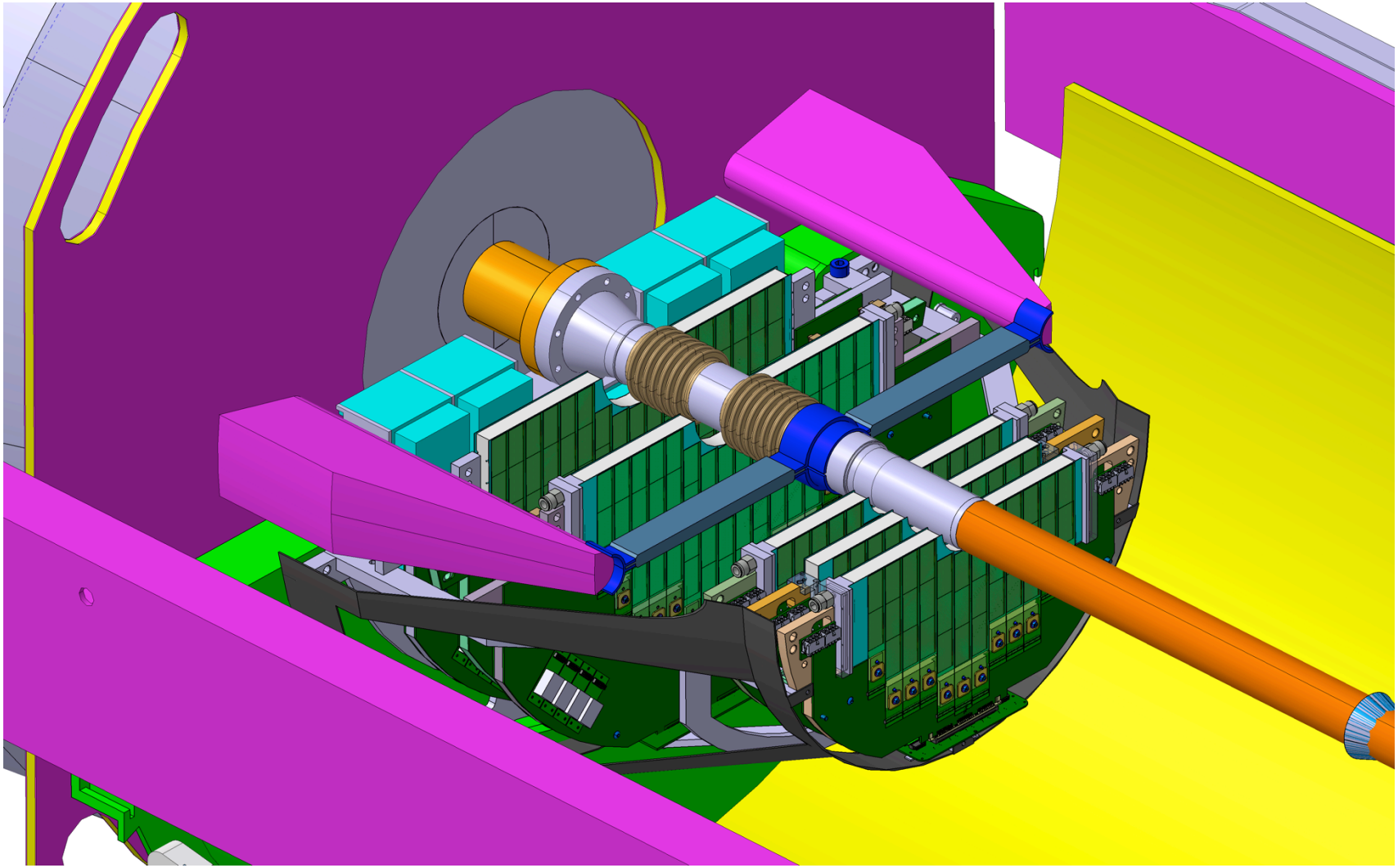


MFT: Silicon tracker at large rapidity

High precision vertexing in the Muon Spectrometer acceptance



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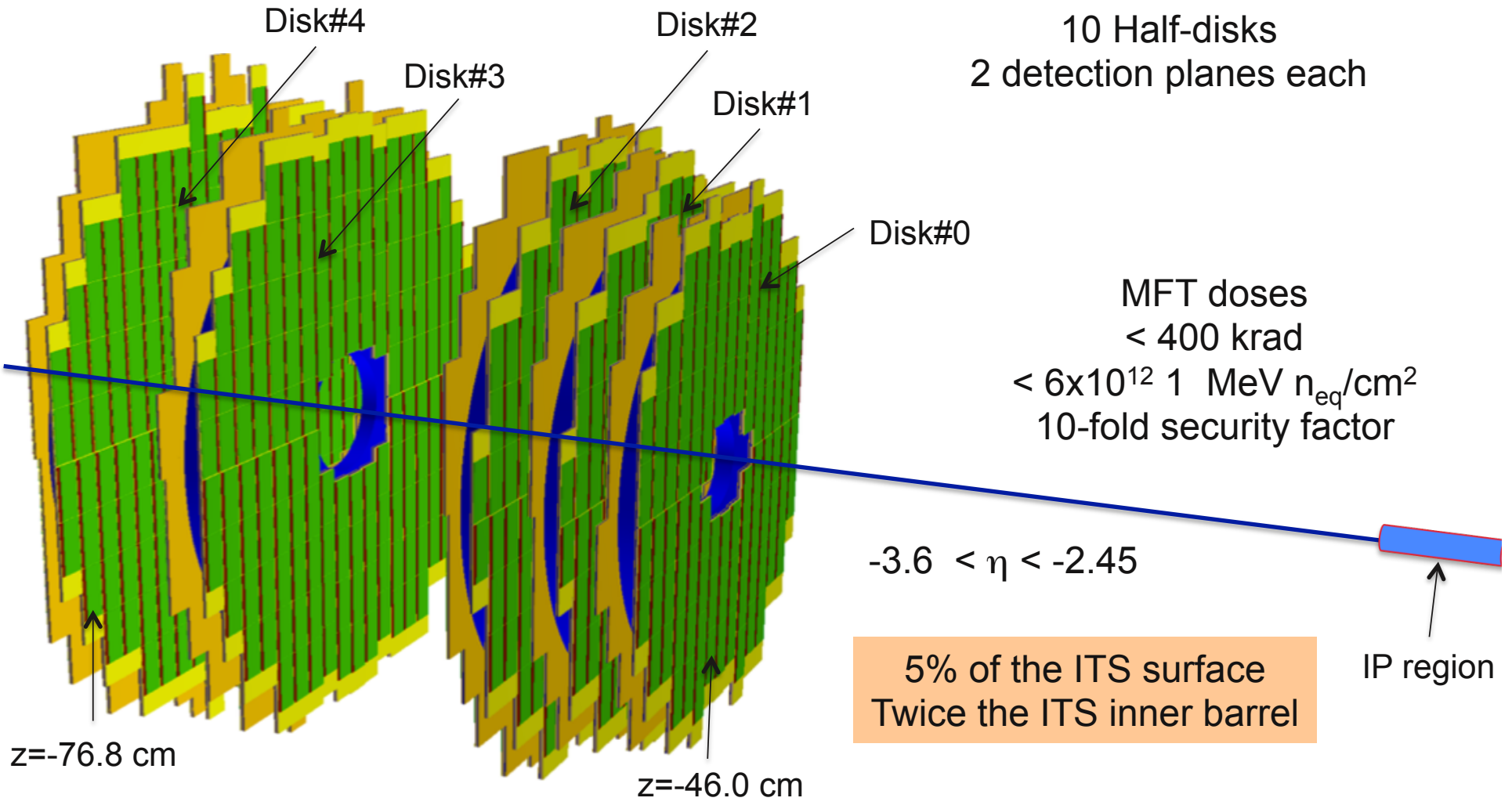
ALICE

MFT layout

920 silicon pixel sensors (0.4 m^2) in 280 ladders of 2 to 5 sensors each.



10 Half-disks
2 detection planes each

MFT doses
< 400 krad
< 6x10^{12} 1 MeV n_{eq}/cm^2
10-fold security factor

$-3.6 < \eta < -2.45$

5% of the ITS surface
Twice the ITS inner barrel

IP region

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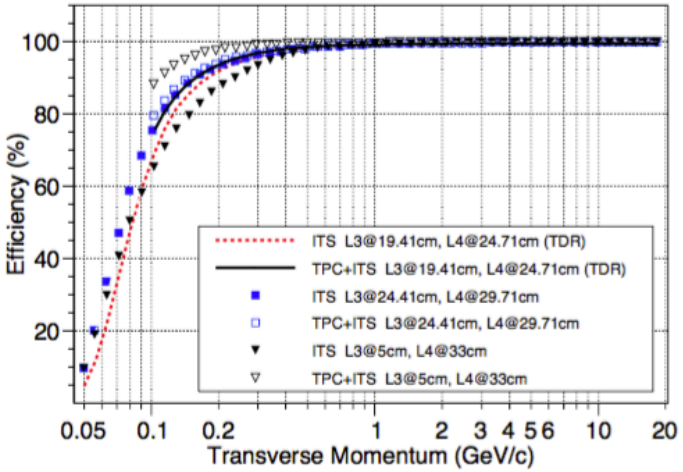
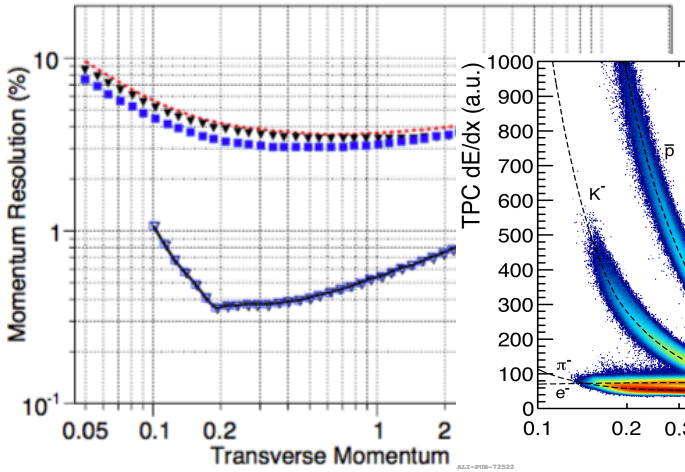
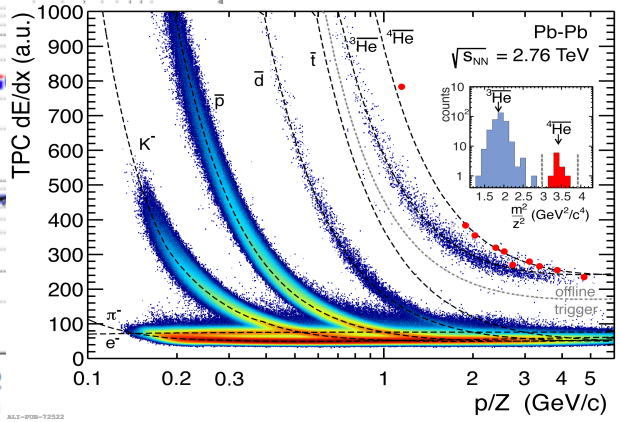
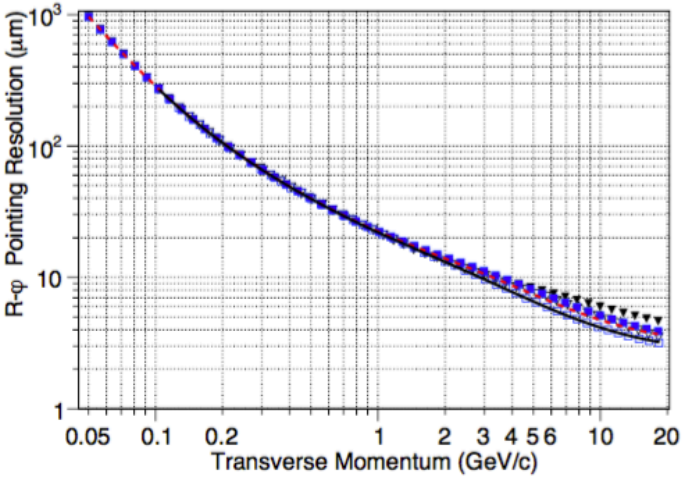
Upgraded ALICE tracking capabilities I

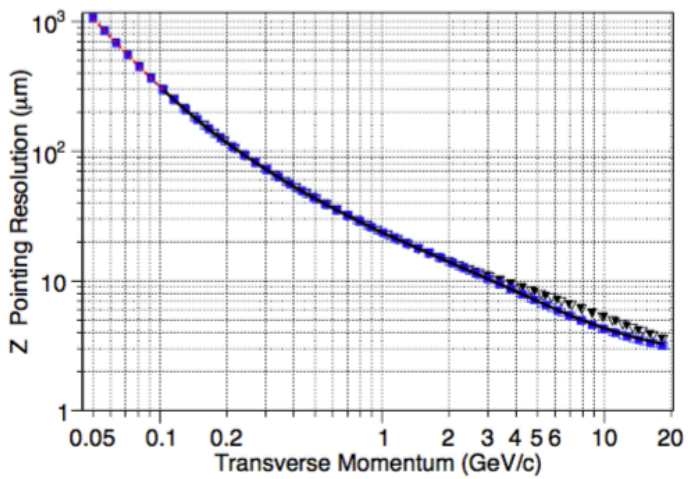
Central Barrel (|η|<1) ITS+TPC











Keeping present PID capabilities

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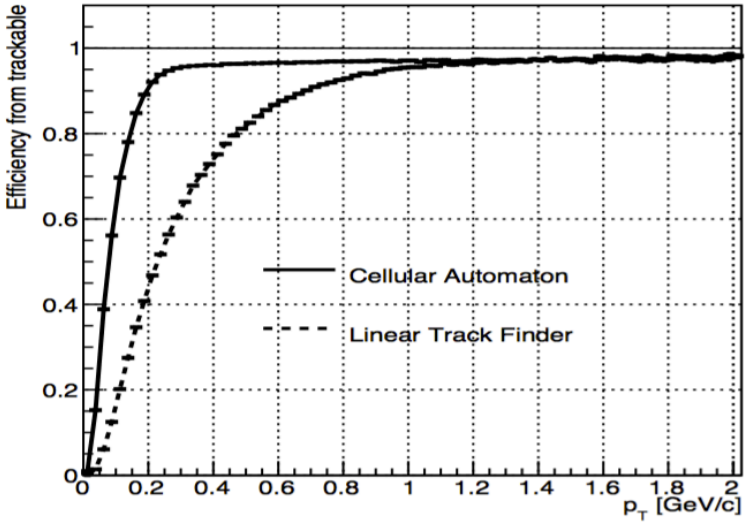
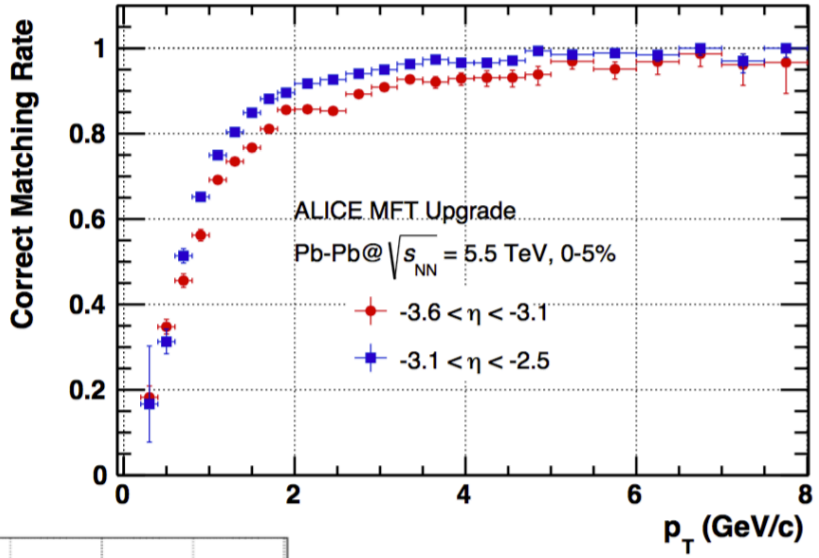
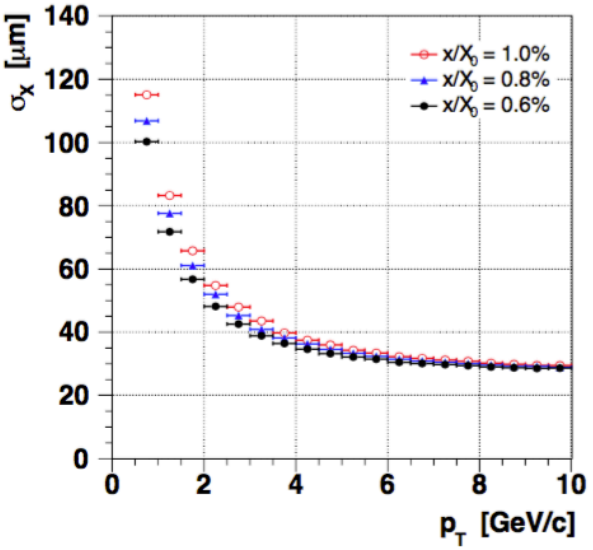
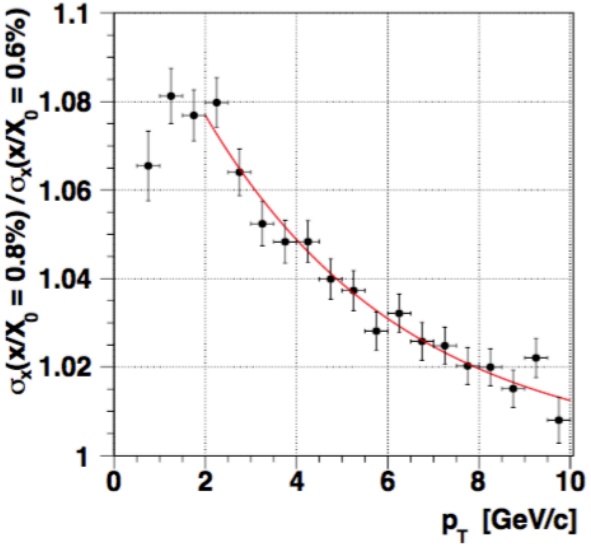
Upgraded ALICE tracking capabilities II

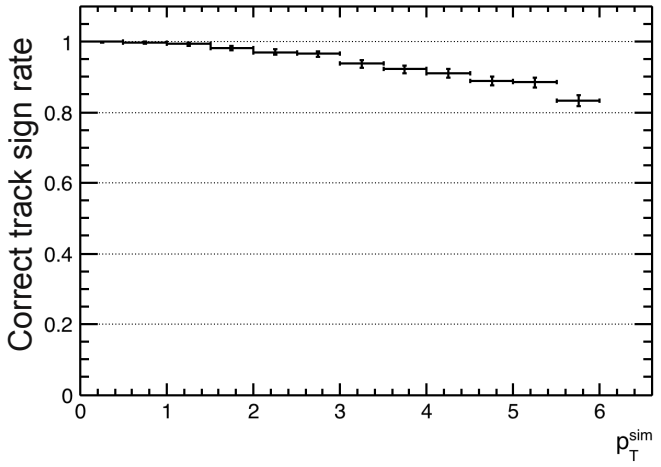
Muon Spectrometer (2.5<η<3.6) MFT+Muon











Caveat: Personal selection of physic performances with the upgraded ALICE detector

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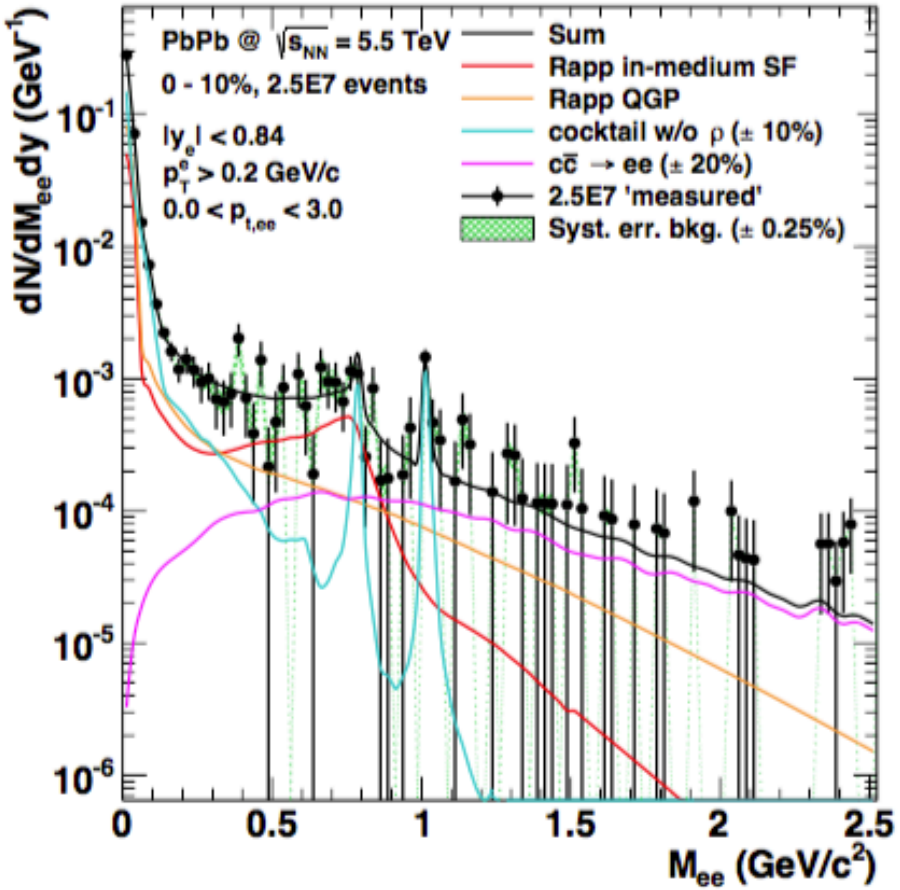
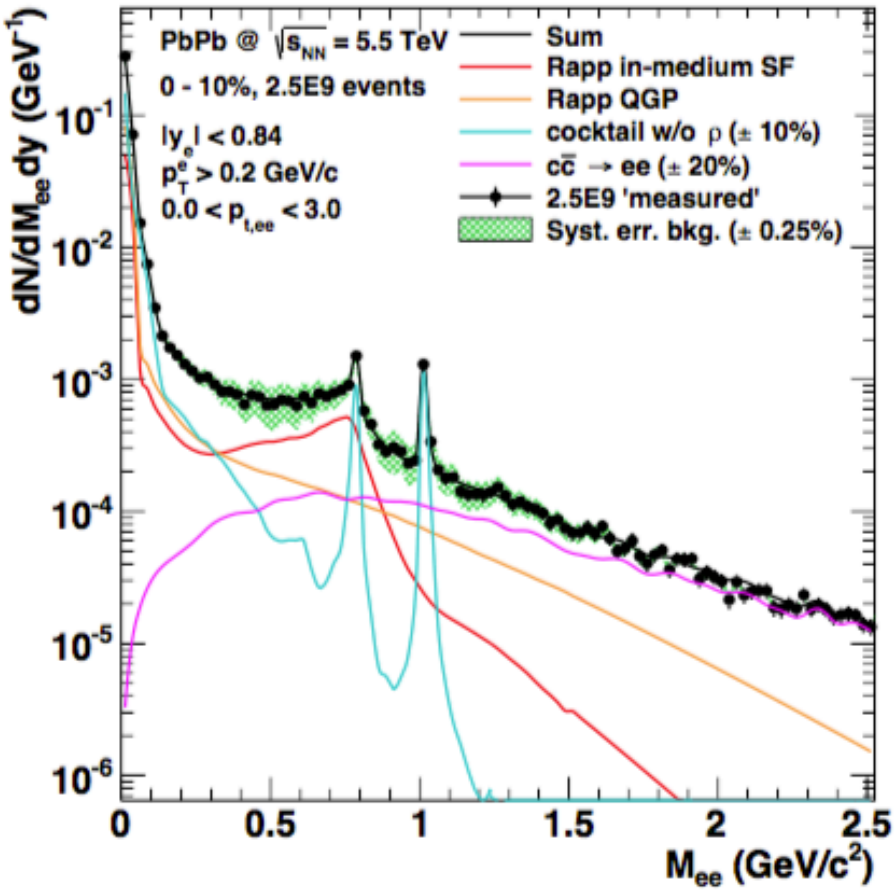
Physics Performance of the Upgraded ALICE

Low Mass dilepton $|\eta|<0.9$





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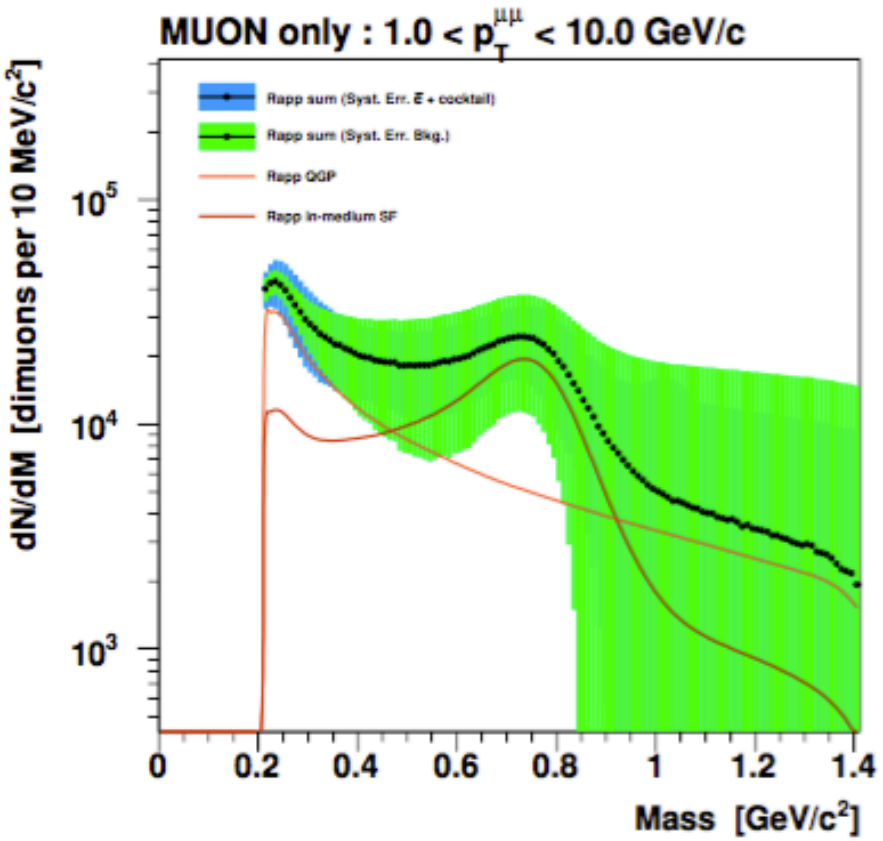
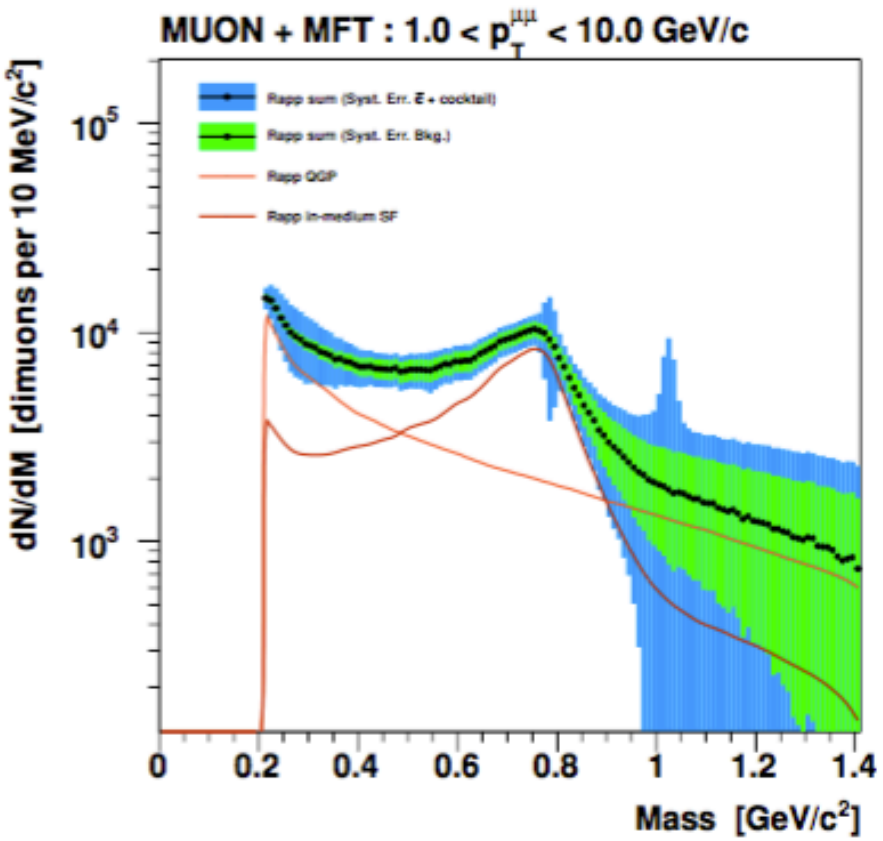
Physics Performance of the Upgraded ALICE

Low Mass dilepton 2.5<η<3.6

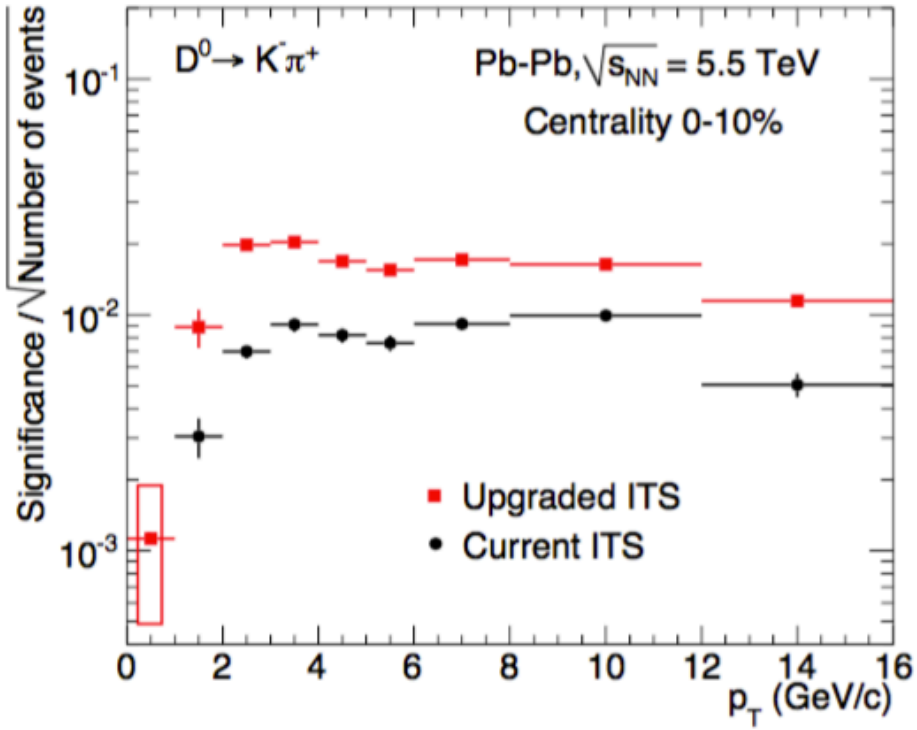


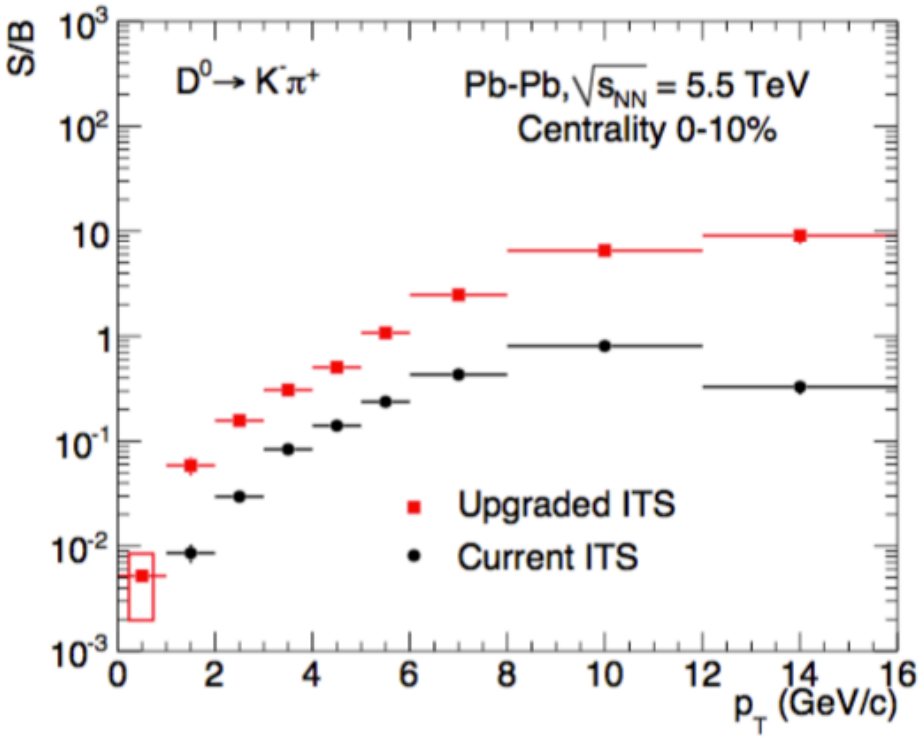


A Large Ion Collider Experiment

Physics Performance of the Upgraded ALICE

Charmed D0 mesons $|\eta|<0.9$





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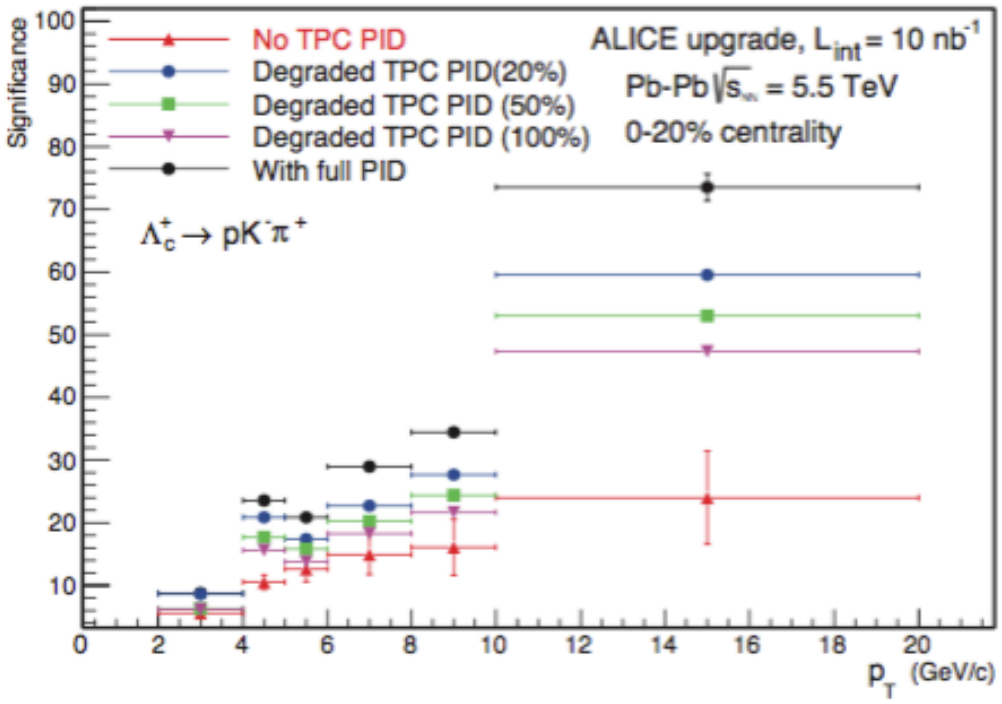
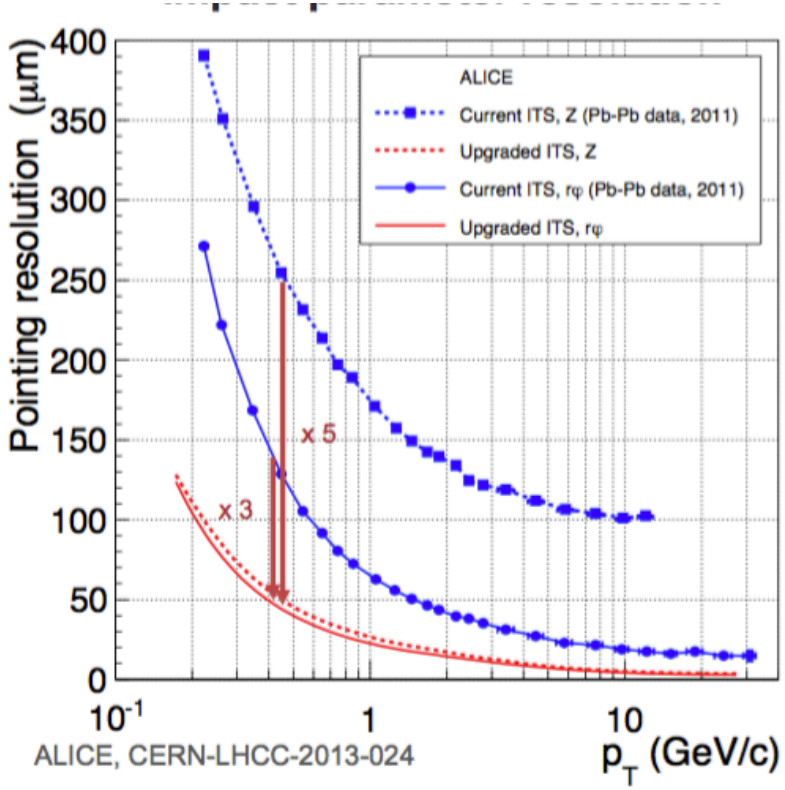
Physics Performance of the Upgraded ALICE

Charmed Λ_c baryons $|\eta|<0.9$





Λ_c became accessible for p_T~1-6 GeV thanks to the new ITS and increase of integrate luminosity

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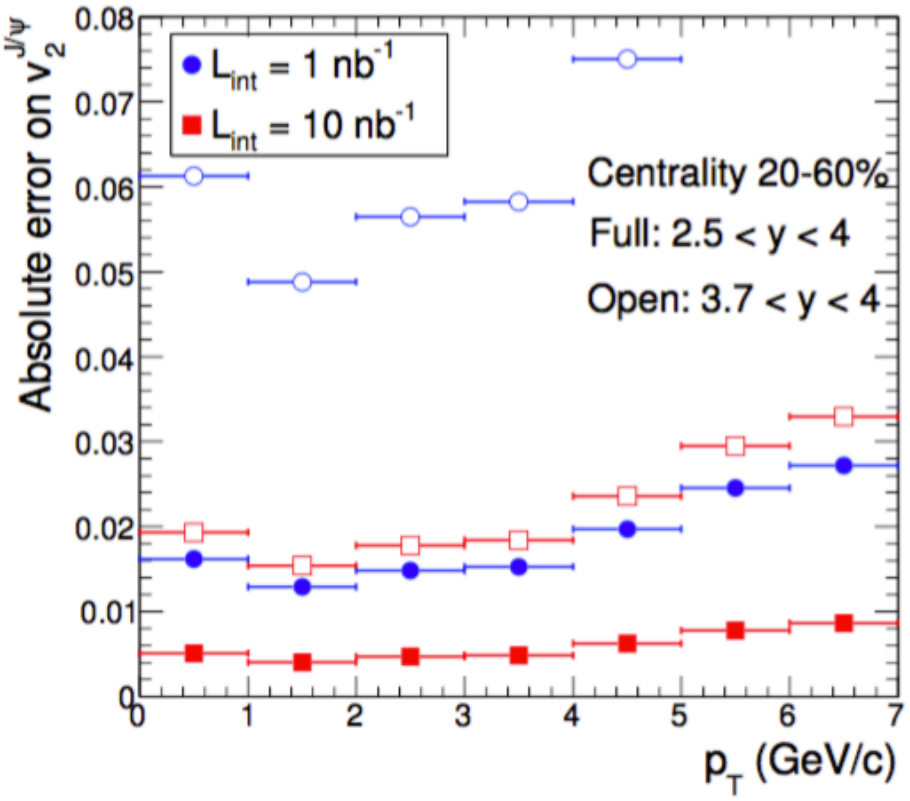
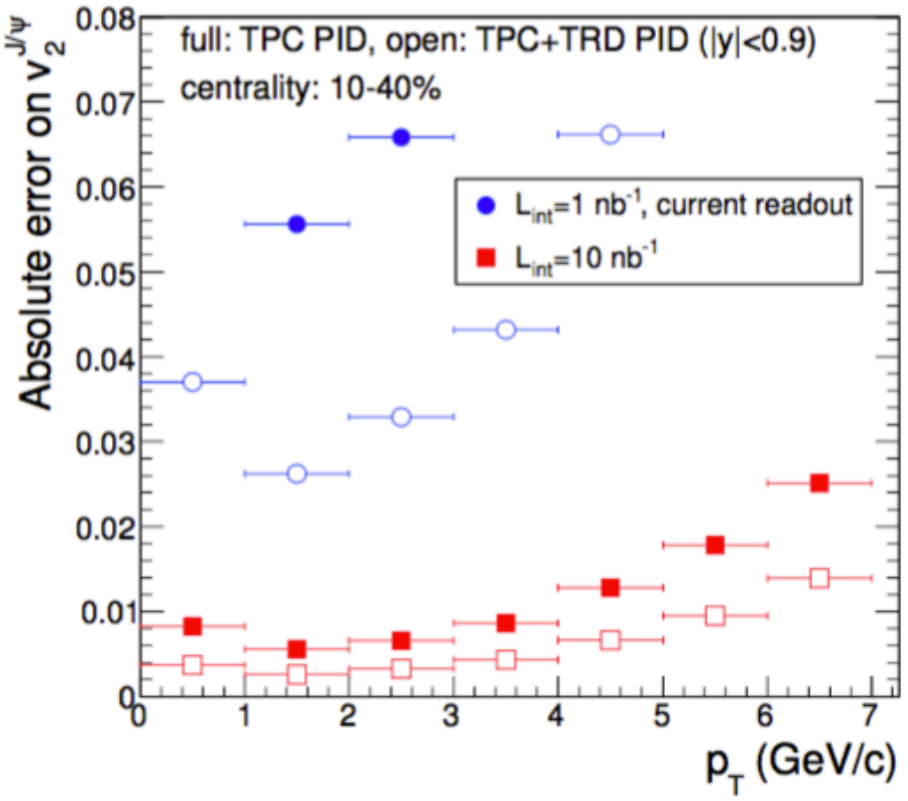
Physics Performance of the Upgraded ALICE

J/ψ elliptic flow |η|<0.9 and 2.5<η<4.0





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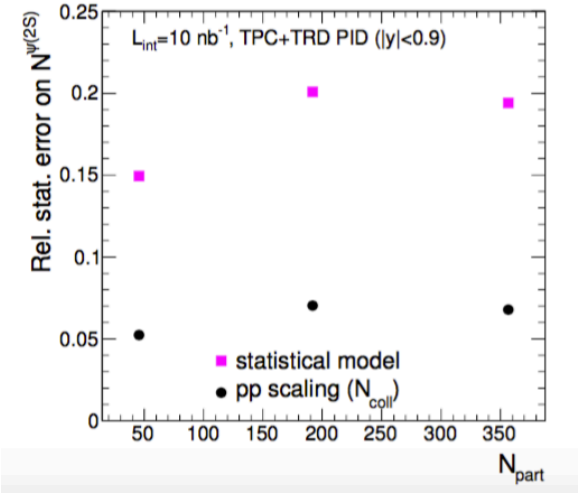
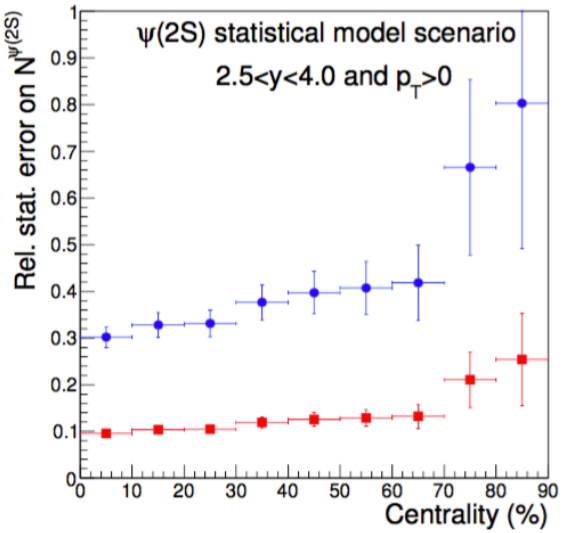
Physics Performance of the Upgraded ALICE

Ψ(2S) yields |η|<0.9 and 2.5<η<4.0





Inclusive ψ' $(3.40 < M_{\mu\mu} < 3.90\ \mathrm{GeV}/c^2)$: $R_{AA} = 0.3$, without the MFT					
p_T [GeV/c]	Signal [$\times 10^3$]	S/B	$S/\sqrt{S+B}$	Stat. Err. [%]	Sys. Err. [%]
0 – 1	12.8	0.0048	7.6	10.9	20.9
1 – 2	24.2	0.0039	9.7	9.5	26.5
2 – 3	20.4	0.0031	8.0	12.3	32.3
3 – 4	12.4	0.0026	5.6	17.7	39.0
4 – 5	6.9	0.0021	3.8	26.1	48.1
0 – 10	85.0	0.0030	16.1	6.0	33.3

Inclusive ψ' $(3.40 < M_{\mu\mu} < 3.90\ \mathrm{GeV}/c^2)$: $R_{AA} = 0.3$, with the MFT					
p_T [GeV/c]	Signal [$\times 10^3$]	S/B	$S/\sqrt{S+B}$	Stat. Err. [%]	Sys. Err. [%]
0 – 1	4.47	0.014	7.8	10.7	9.9
1 – 2	8.67	0.014	11	8.5	10.1
2 – 3	6.76	0.018	11	8.7	9.0
3 – 4	4.11	0.027	10	9.0	8.0
4 – 5	2.57	0.030	8.7	10.9	7.8
0 – 10	30.3	0.017	22	4.3	9.2

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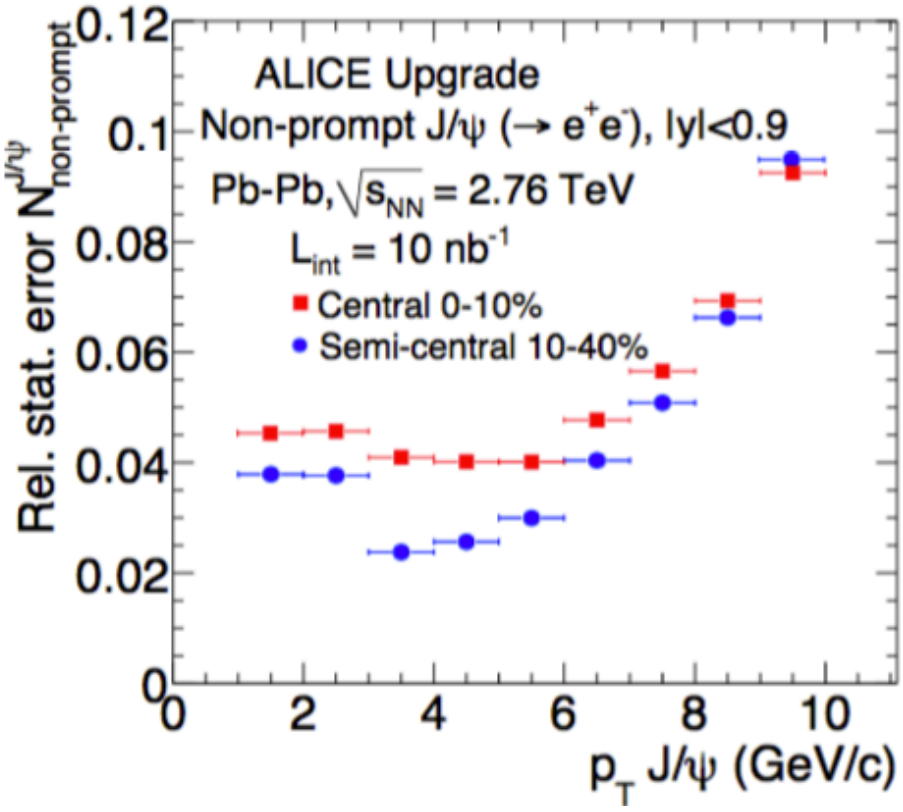
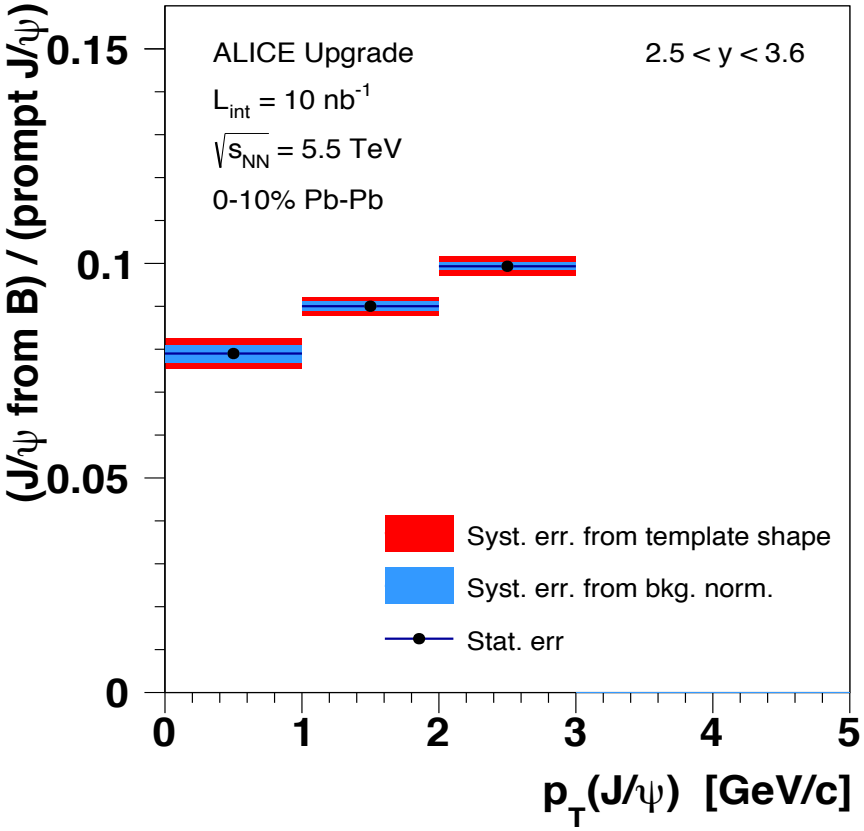
Physics Performance of the Upgraded ALICE

Beauty measurement in the golden J/ψ channel |η|<0.9 and 2.5<η<4.0

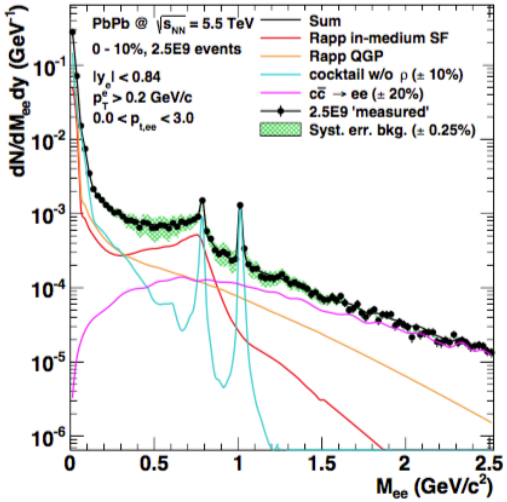


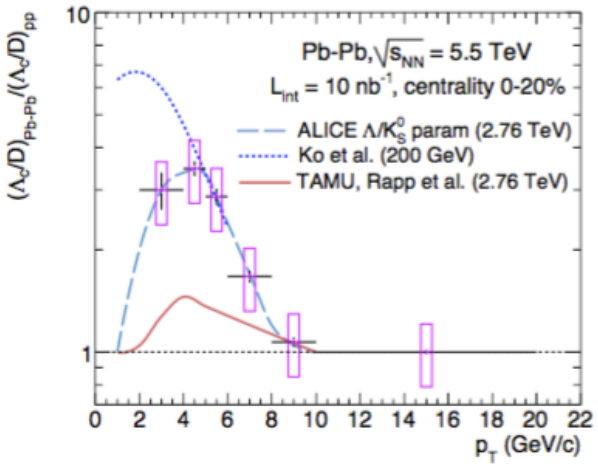


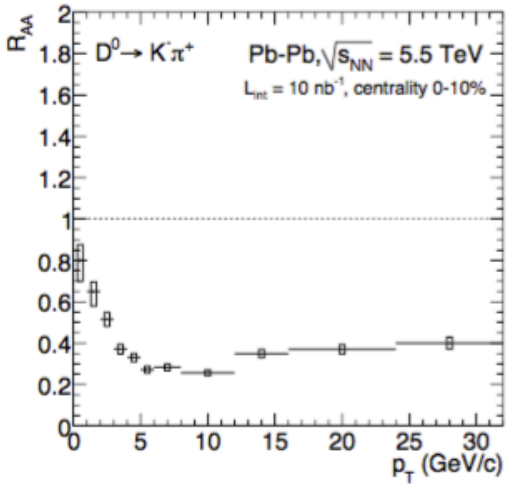
A Large Ion Collider Experiment

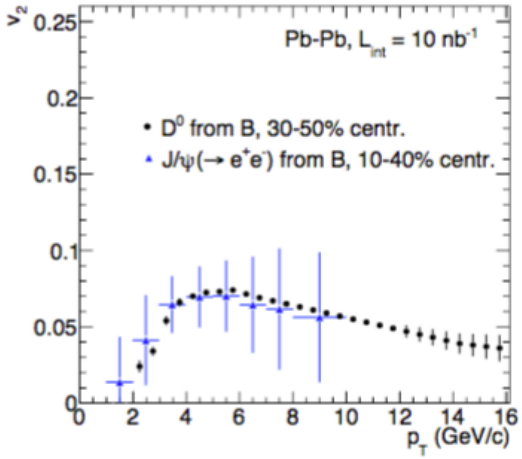
Physics Performance of the Upgraded ALICE

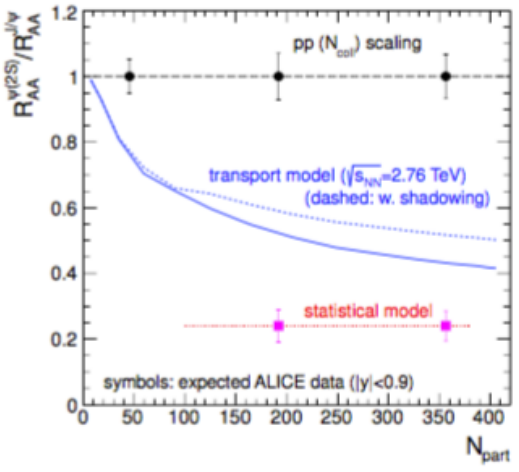
Many new physics results to be understood (+ jet, exotica …)

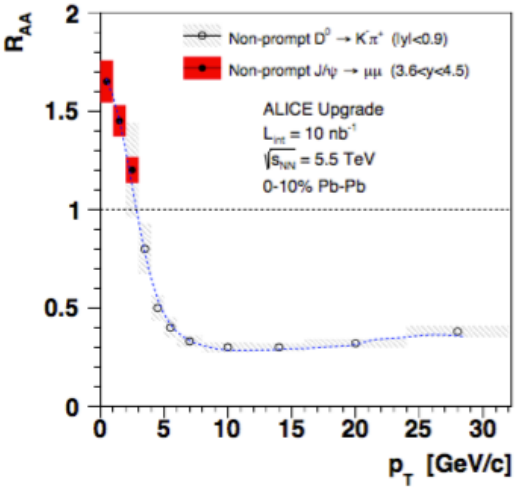












A Large Ion Collider Experiment

Bibliography

Letter of Intends and Technical Design Reports

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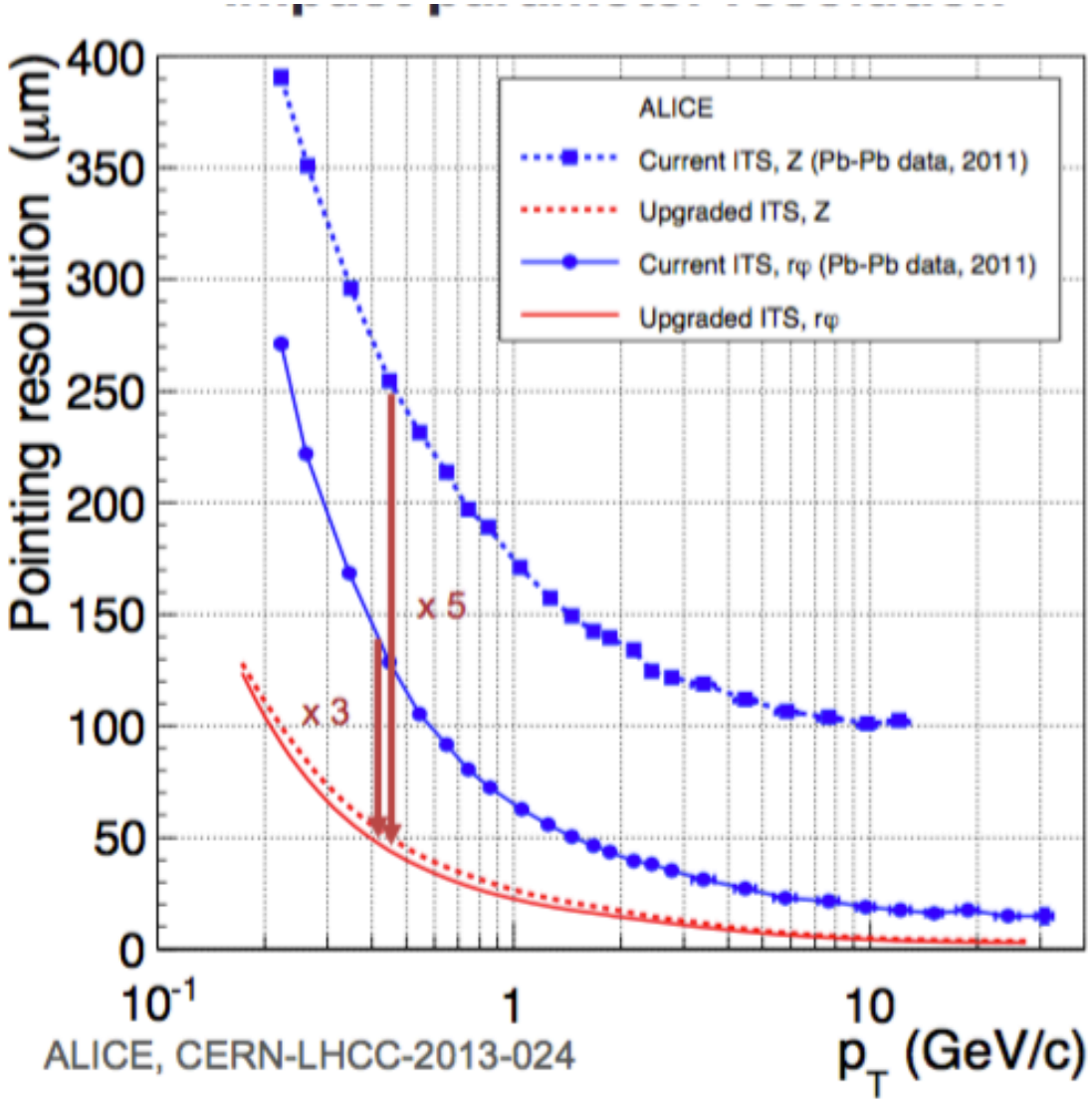
  - CERN-LHCC-2013-019 (System upgrade TDR)
  - CERN LHCC-2013-013 (TPC Upgrade TDR
  - CERN-LHCC-2013-023 (ITS Upgrade TDR)
  - CERN-LHCC-2015-001 (MFT TDR)
  - CERN-LHCC-2015-006 (O2 TDR)
- Alice Upgrade LoI and its addendum
  - CERN-LHCC-2012-012 (LoI)
  - CERN-LHCC-2013-014 (addendum)

Backup slides

Backup 1


ALICE
Current ITS, Z (Pb-Pb data, 2011)
Upgraded ITS, Z
Current ITS, rφ (Pb-Pb data, 2011)
Upgraded ITS, rφ
Pointing resolution (μm)
400
350
300
250
200
150
100
50
0
x 5
x 3
10^-1
1
10
p_T (GeV/c)
ALICE, CERN-LHCC-2013-024