XIII Зимняя школа « Физика тяжёлых ионов: от LHC к NICA «

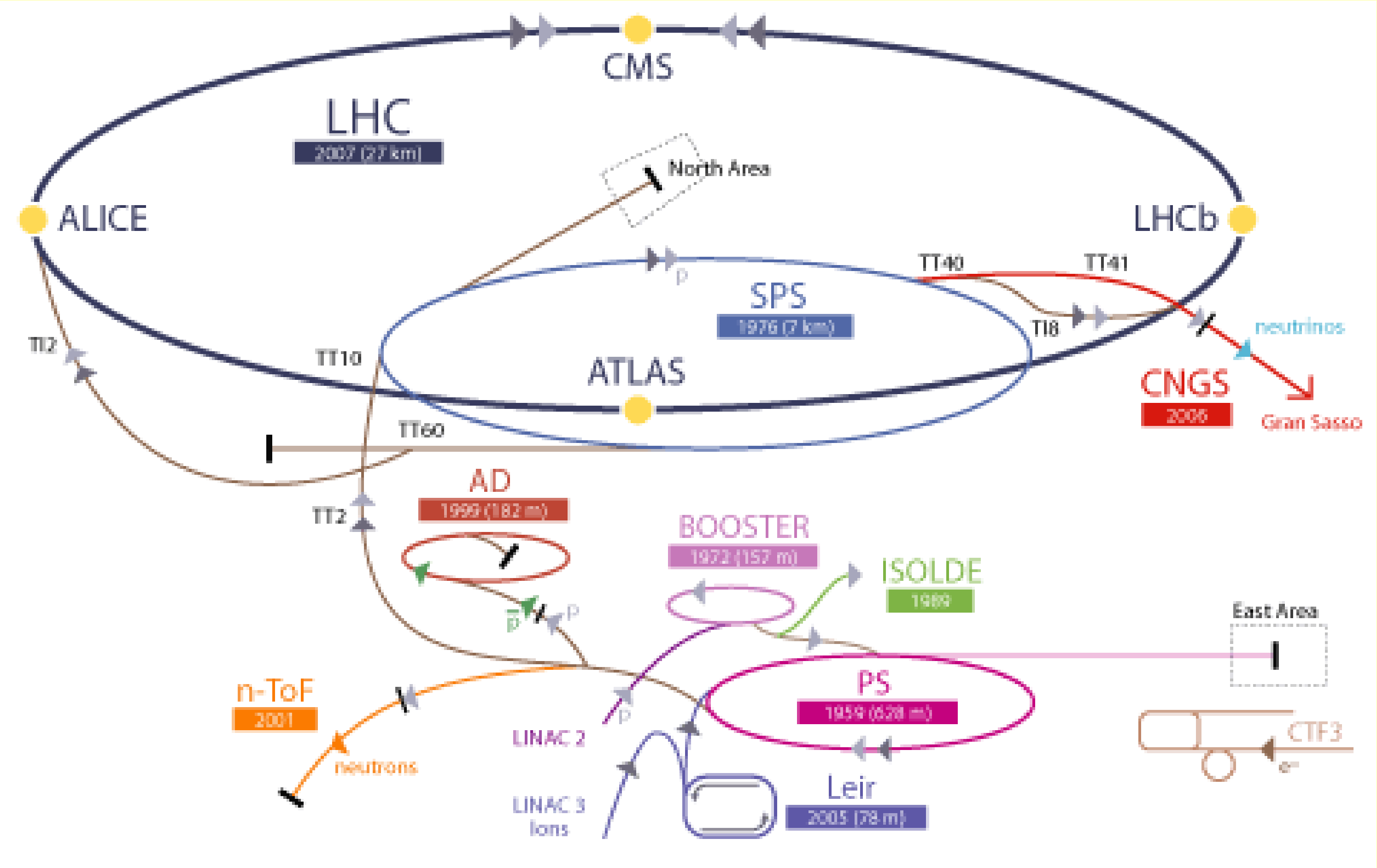
Февраль 3, 2017, Дубна

ALICE (A Large Ion Collider Experiment) на LHC

(часть 1, установка ALICE)

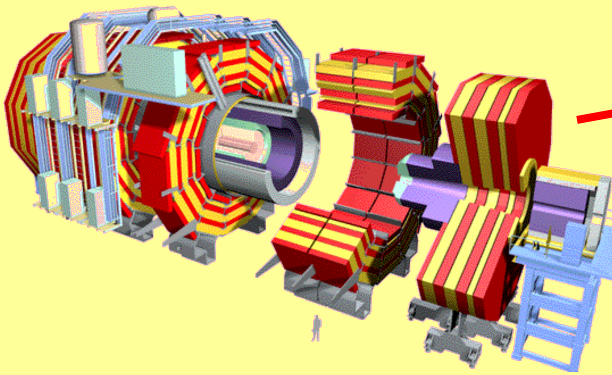
Б. В. Батюня (ОИЯИ)

CERN (European Organization for Nuclear Research) accelerator complex

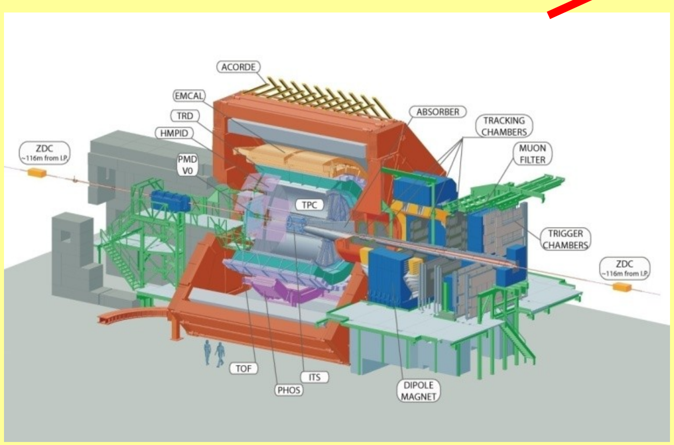


LINAC2- BOOSTER-PS-SPS-LHC (the sircle length is 27 km)

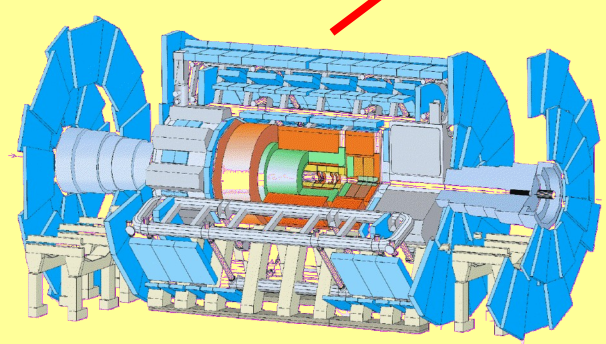
p+p @ 13 TeV
p+Pb @ 5.02 TeV (for NN)
Pb+Pb @ 5.02 TeV (for NN)



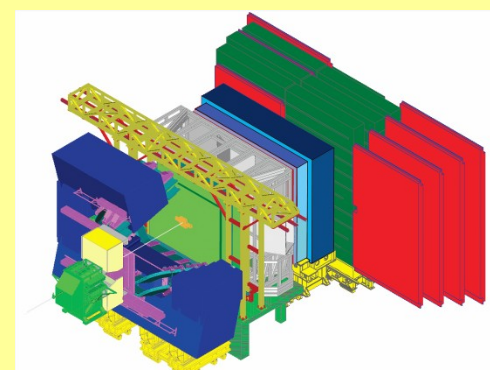
CMS



ALICE



ATLAS



LHCb

What's the main Physics Questions might be answered at the LHC

- ***ALICE:***

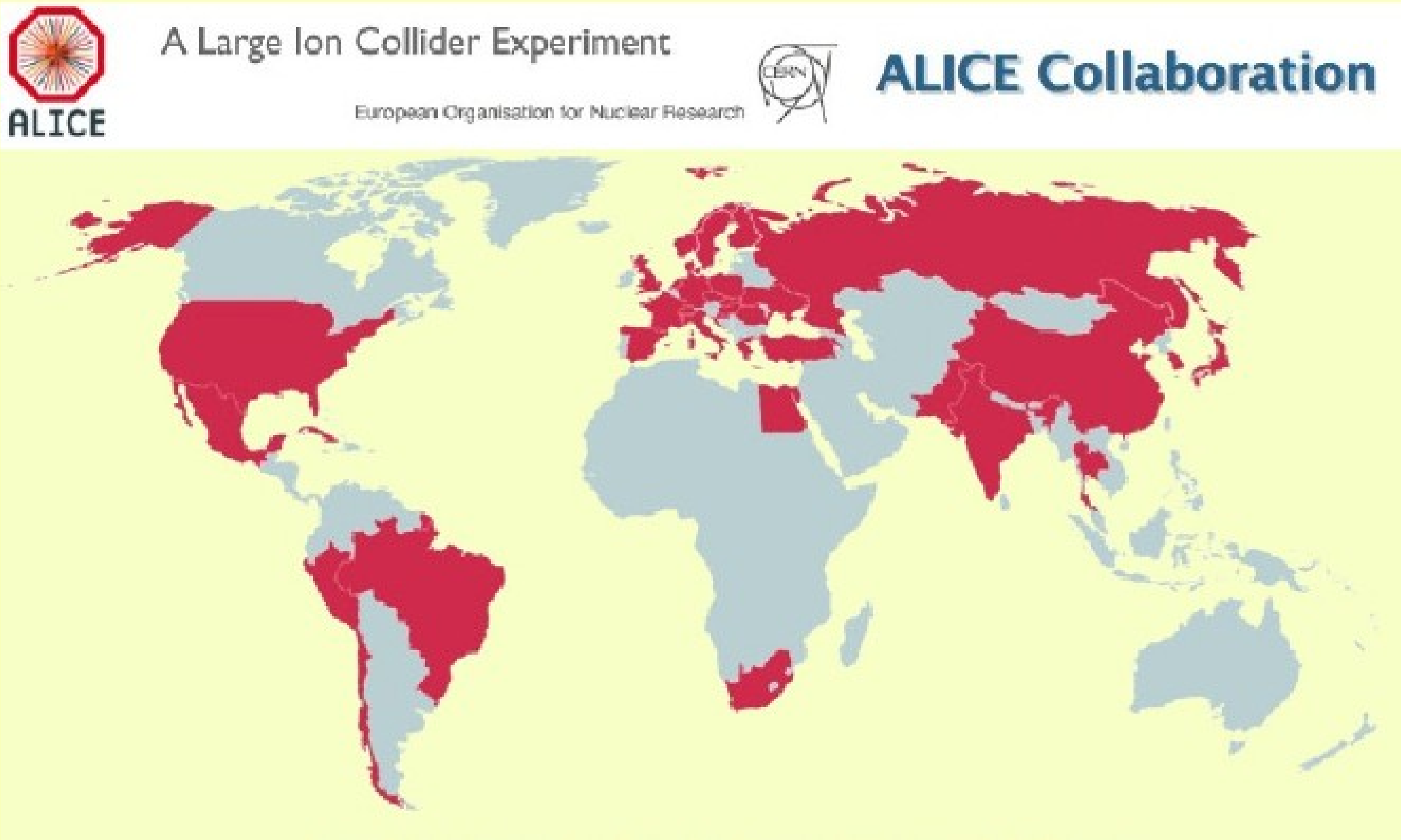
- Quark-gluon plasma;

  - ***Chiral Symmetry; restoration;***
  - ***Deconfinement;***
  - ***Hadronization;***

- ***ATLAS, CMS, LHCb:***
  - ***Higss mechanism;***
  - ***Supersymmetry;***
  - ***CP violation;***

Accelerators using for Heavy-Ion collisions

Acceleratos	Energy $(s_{NN})^{1/2}$ (GeV)	Collision systems	Running status
LHC (CERN, Collider)	2760-5020	Pb-Pb	Now
RHIC (Brookhaven, Collider)	20-200	Au-Au	Now
SPS (CERN, Fixed-target)	8-17	Pb-Pb	Now
FAIR (GSI, Fixed-target)	4-8	Au-Au	2020-2021
NICA (Dubna, Collider)	4-11	Au-Au	2020



42 countries, 174 institutes, 1800 members

Particle classification using a life time

The stable particles/antiparticles:

e-(e+), proton/antiproton;
photon(γ), neutrino(ν_e, ν_μ, ν_τ)/antineitrino.

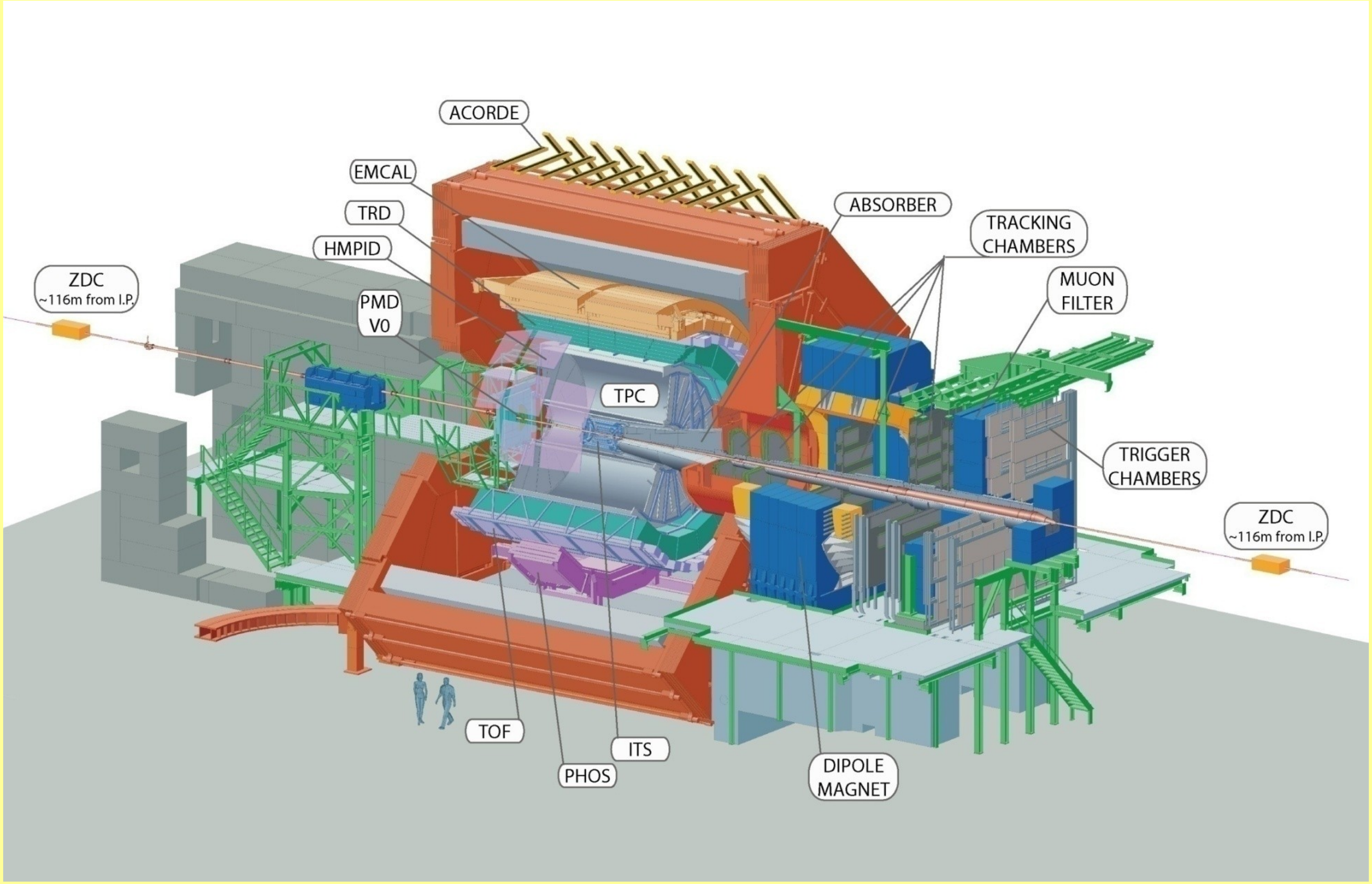
All other particles are unstable (decay to the daughter ones) and are called by a convention of the physicists:

– particles (mean pass lenth > 1 cm): n, μ, π, $K^{\pm 0}$, Λ, Σ, Ξ, Ω

– long lived resonances :
the mean pass length ($\geq$ 100 μm) may be fixed in the detector (the mean life time $\tau > 10^{-13}$ s).

– short lived resonances with typical life time $\leq 10^{-22}$ s, the pass can't be detected.

ALICE setup

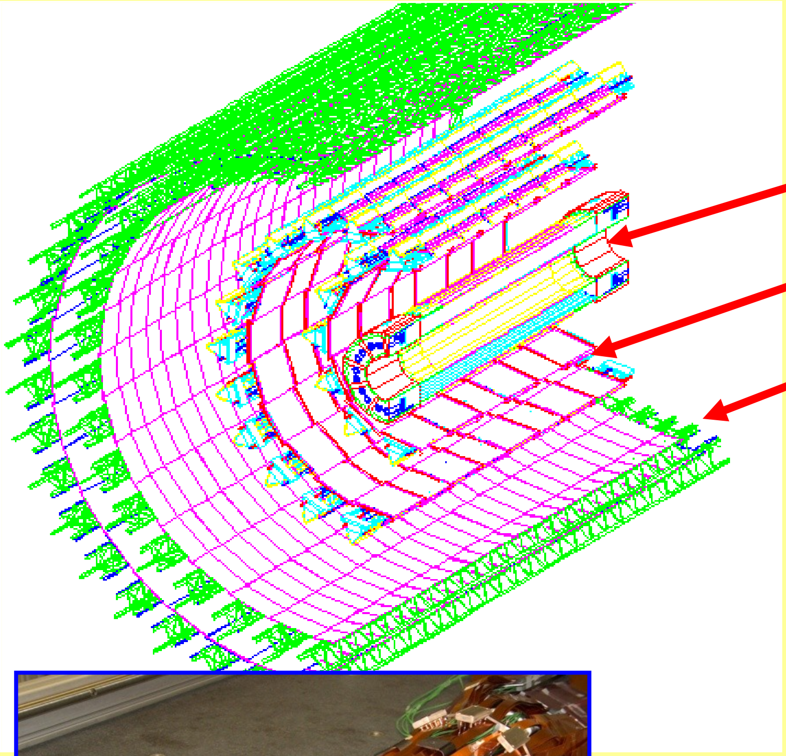


Length: 26 m, Height: 16 m, Weight: 10,000 tons

The Inner Tracking System:

Primary vertex, Secondary vertex, Particle identification, Standalone reconstruction

~ 12.5M channels

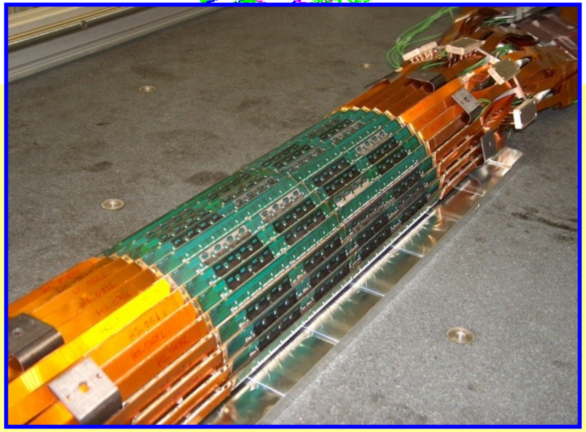


SPD-Silicon Pixel

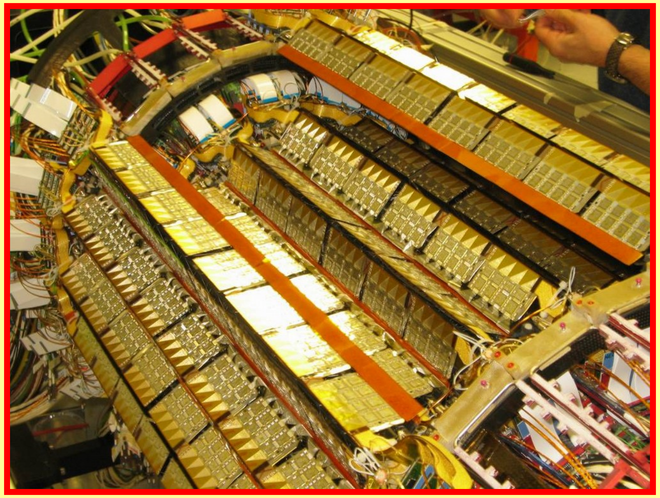
SDD-Silicon drift

SSD –Silicon Strip

Strips



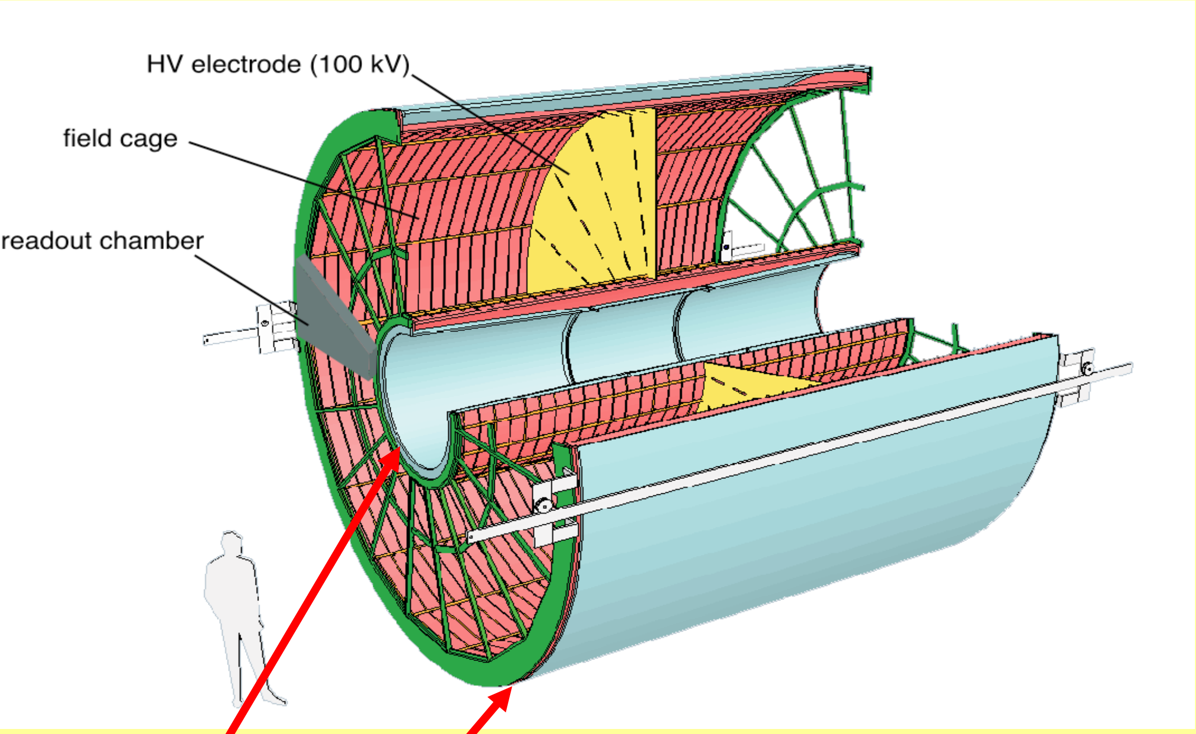
Pixels



Drift

The Time Projection Chamber:

Main tracking detector (charged particles) of the ALICE Central Barrel

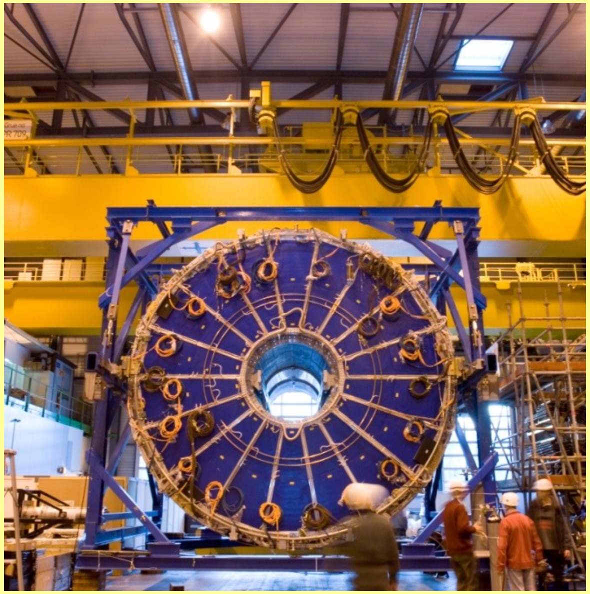


845 < r < 2466 mm
Drift length 2 x 2500 mm
Drift gas Ne-CO_2-N_2 (86/9/5)
Gas volume 95 m3
557568 readout pads

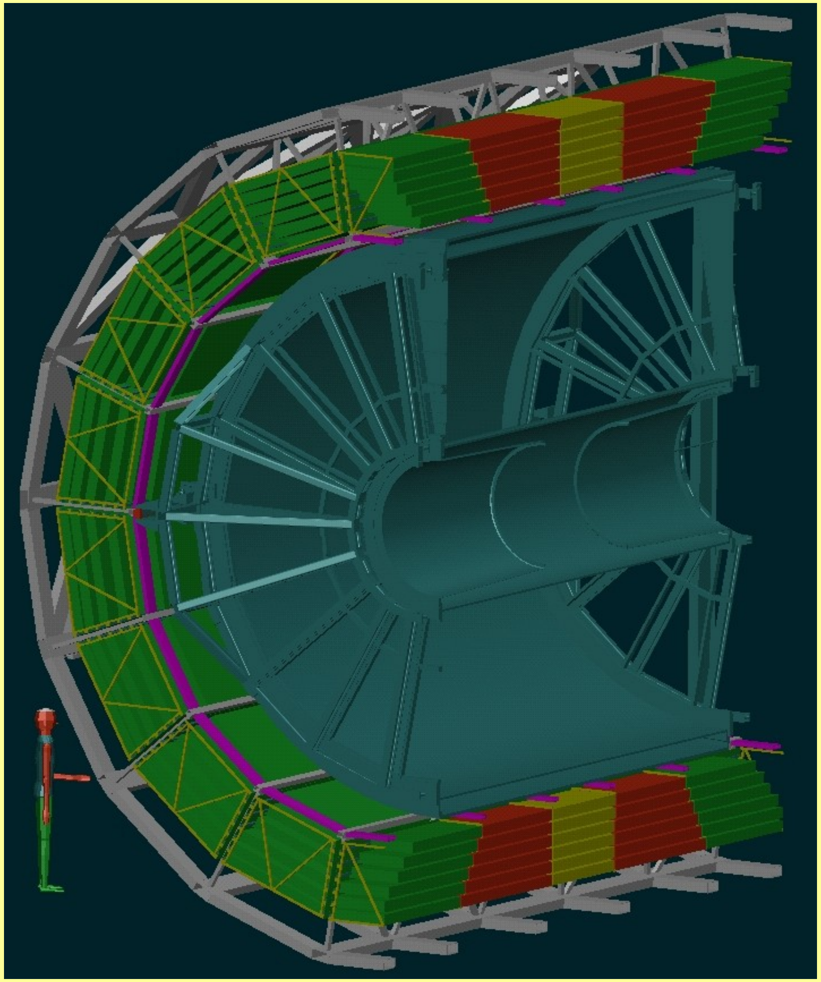
Inner and Outer Vessels

TPC

installation



The Transition Radiation Detector:
e - identification

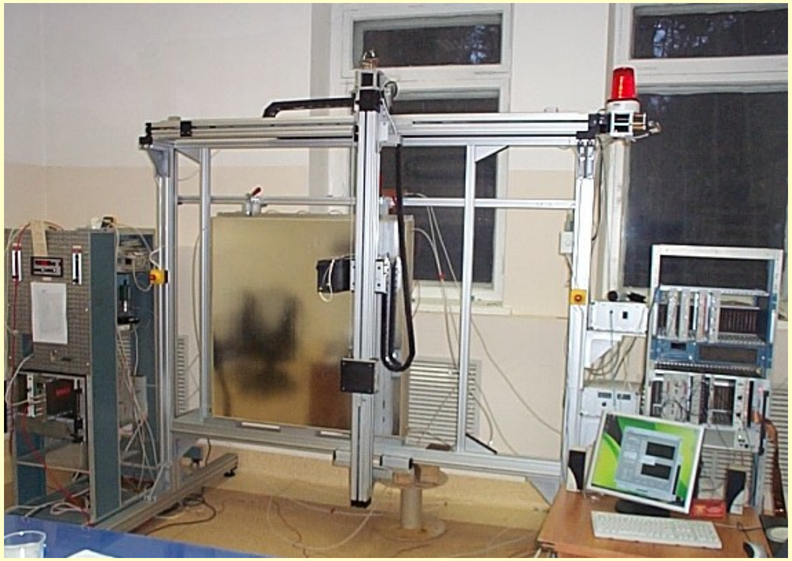


- 18 supermodules
- 6 radial layers
- 5 longitudinal stacks

540 chambers
750m^2 active area
28m^3 of gas

Each chamber:
≈ 1.45 x 1.20m^2
≈ 12cm thick
(incl.Radiators
and electronics)

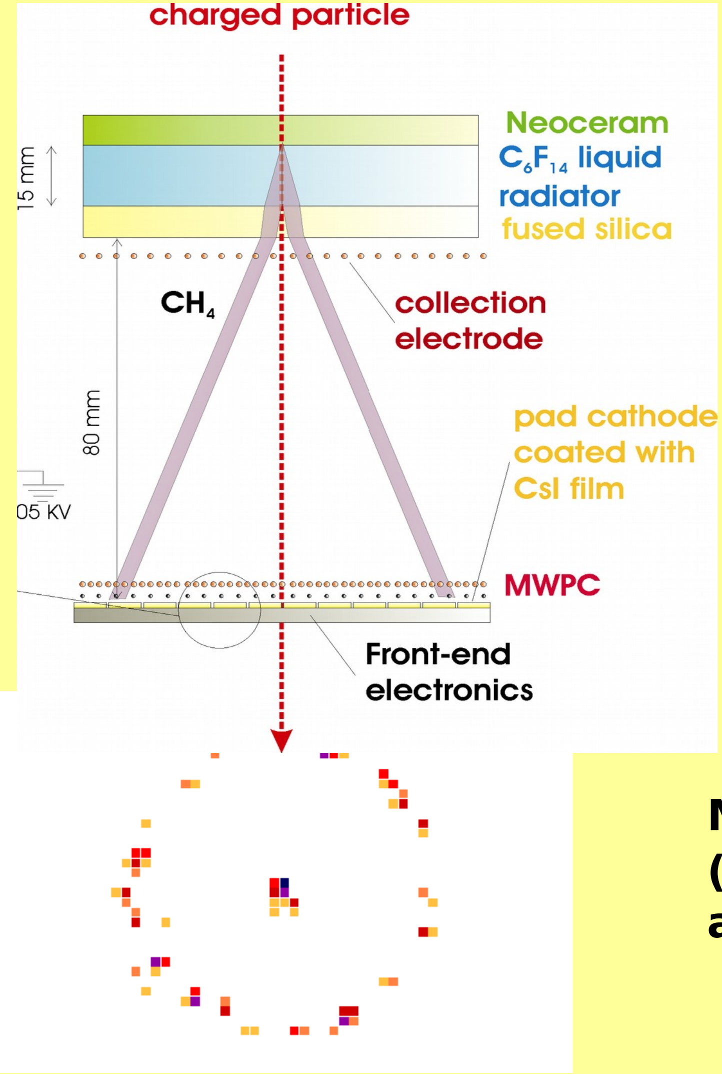
Transition Radiation Detector Drift Chambers Construction



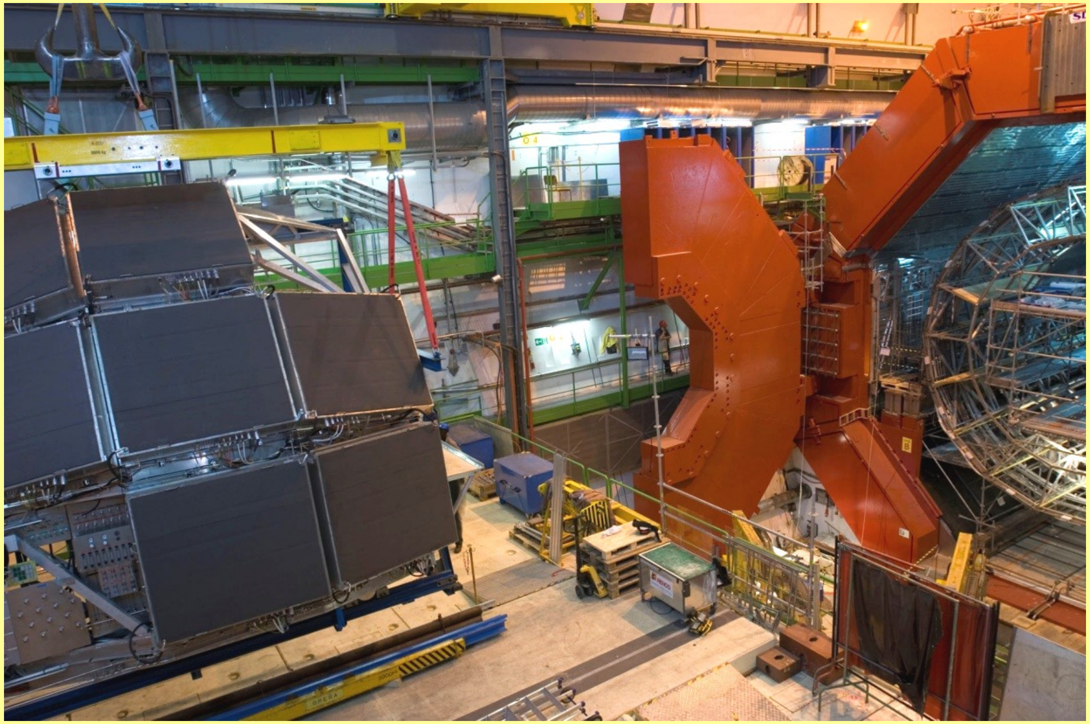
The High Momentum Particle Id Detector

Ring Cherenkov detector (RICH), active surface ~ 11 m^2 at R ~ 4.7 m

Principal scheme



Installation of HMPID

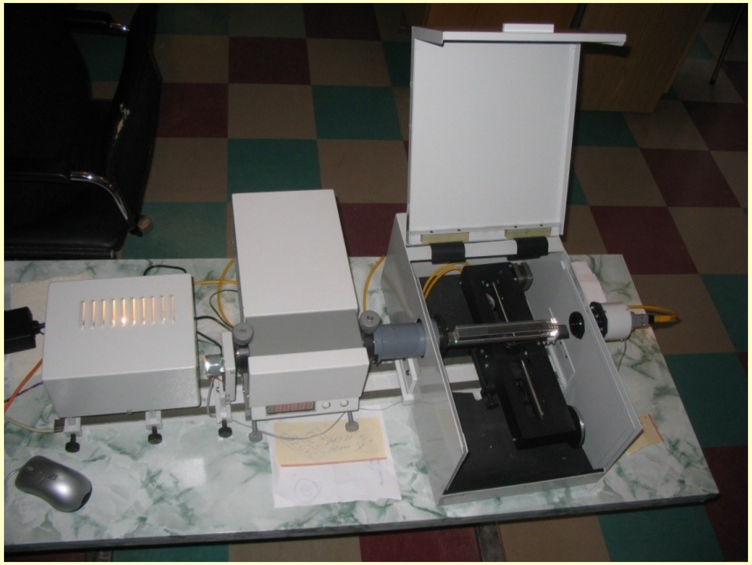


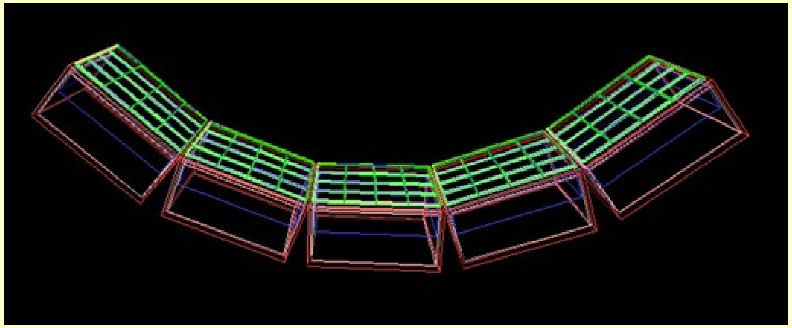
MWPC with CH_4 with analogue pad r/o ($\sim 160\times10^3$ channels), photon conversion on a layer of CsI (Q.E. ≈ 25% @ 175 nm)

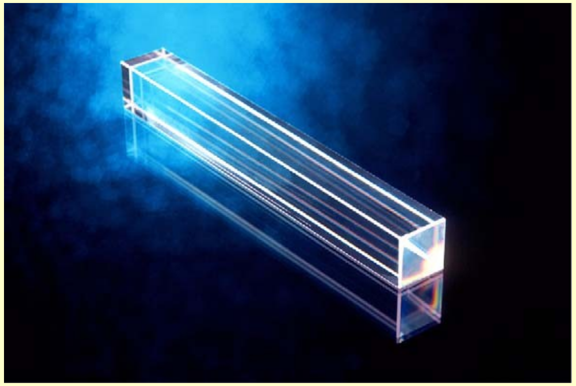
Photon Spectrometer

$PbWO_4$ crystal (17920 cristals in total):

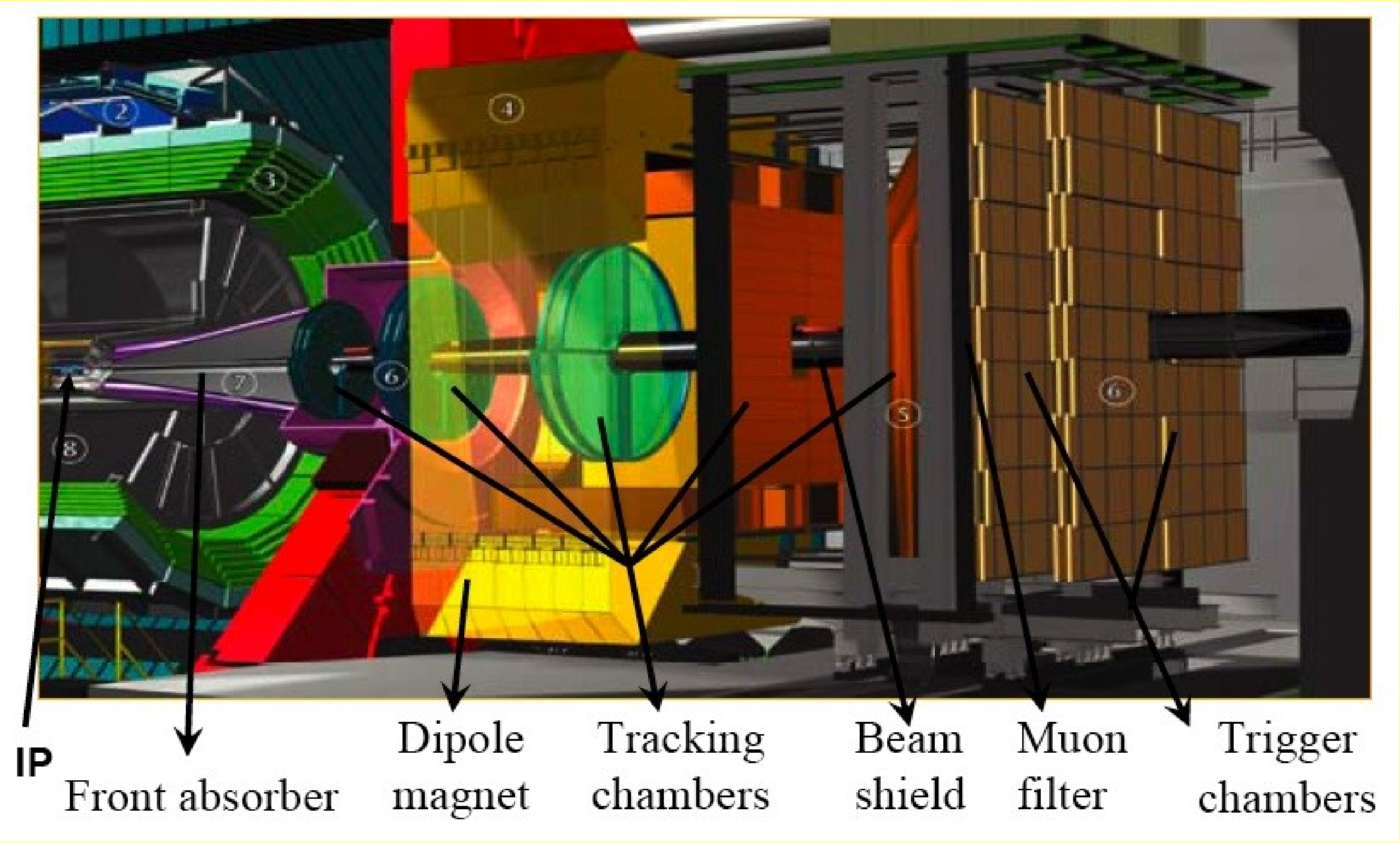
R_M=2.2 cm, X_0=8.9 mm, ρ=8.28 g/cm^3, n=2.16, size: 22×22×180 mm^3







Forward Muon Spectromneter

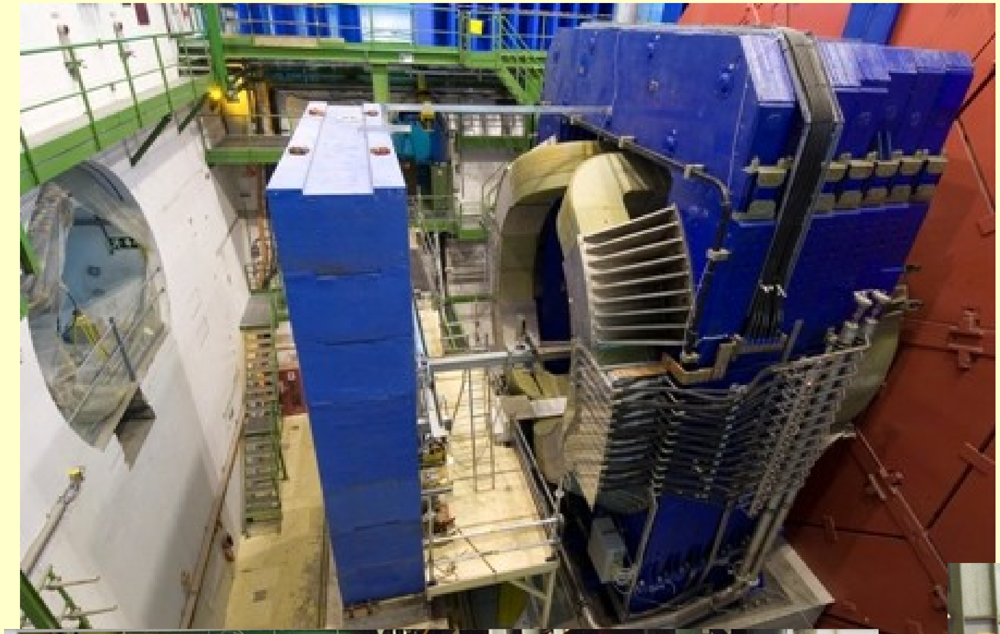


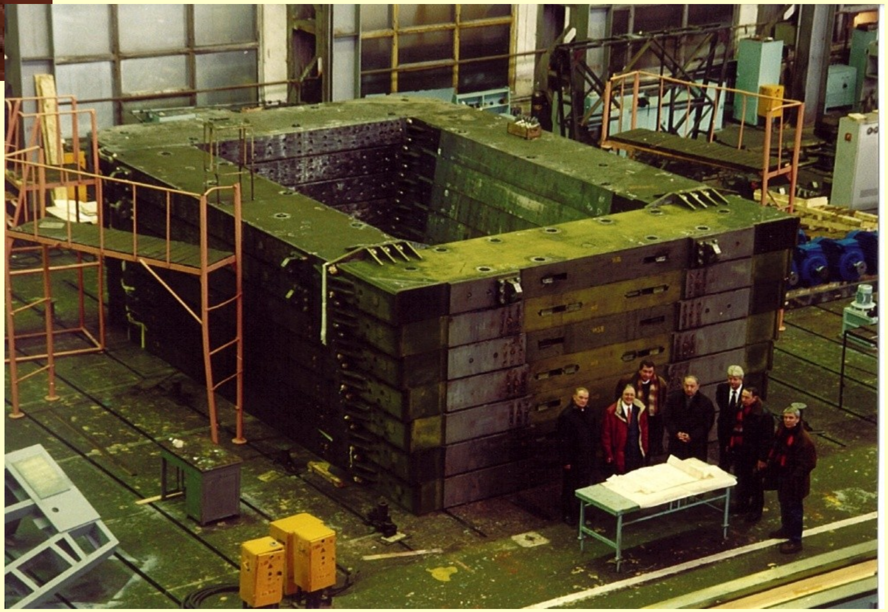
Acceptance on single m:

- p>4 GeV/c
- $-4.0 < \eta < -2.5$

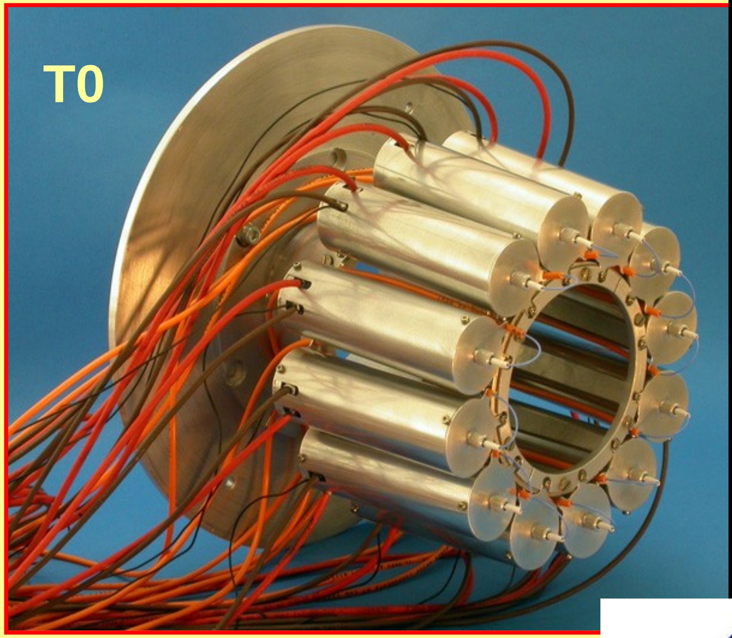
$\Delta M/M \sim 1\%$ at Y- mass

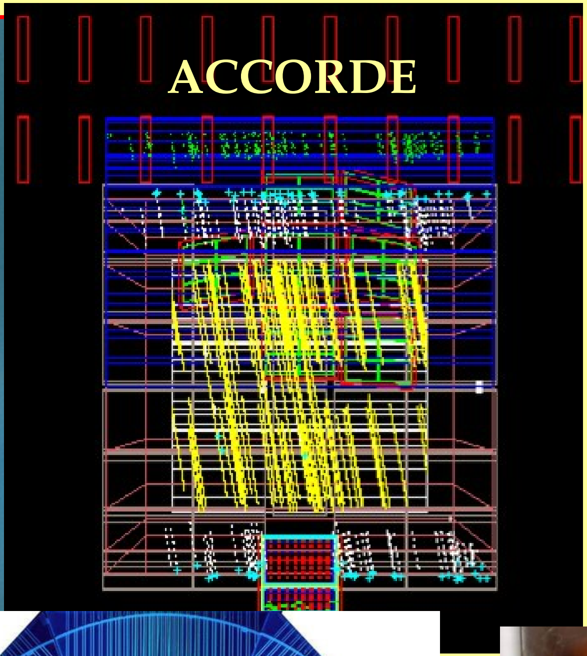
Large Dipole Magnet for Dimuon Spectrometer
(850 ton, 9 x 7 x 4.5 m)

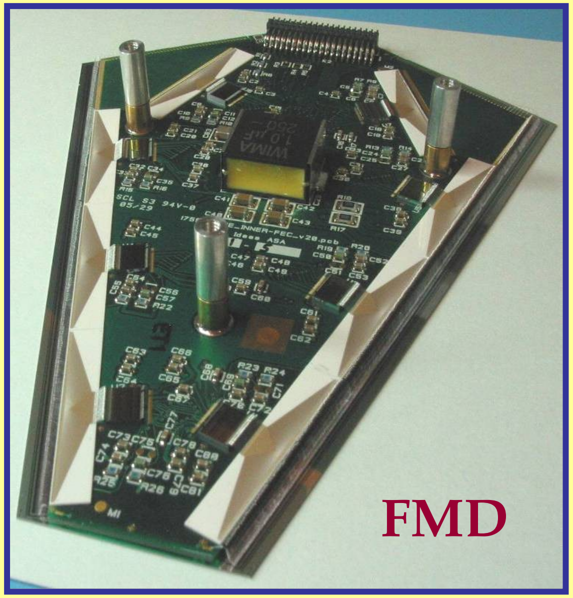


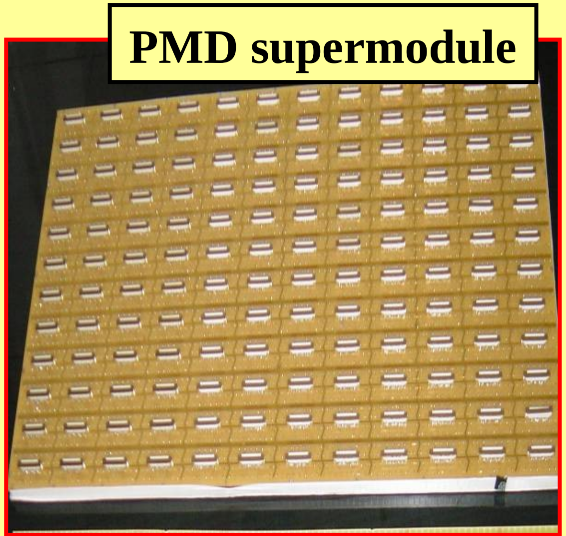



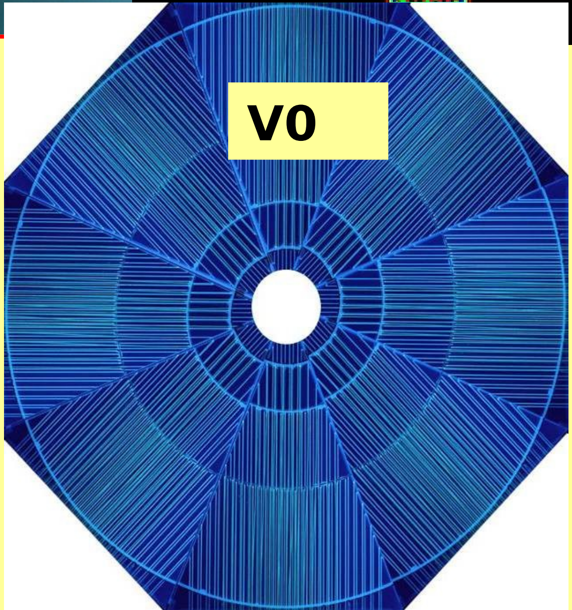
Forward Detectors

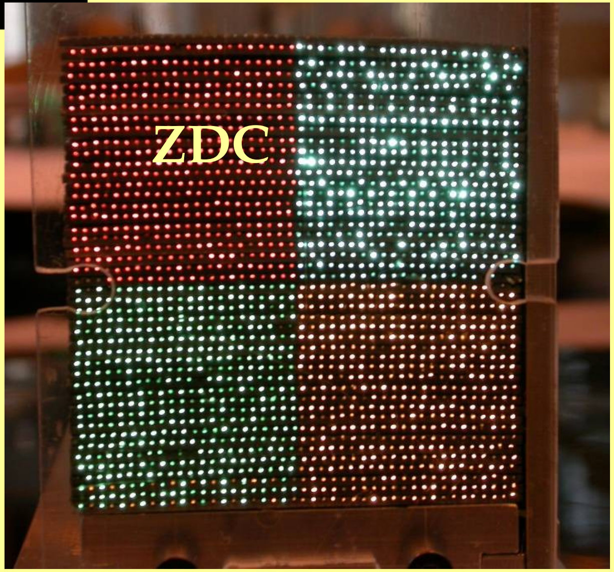






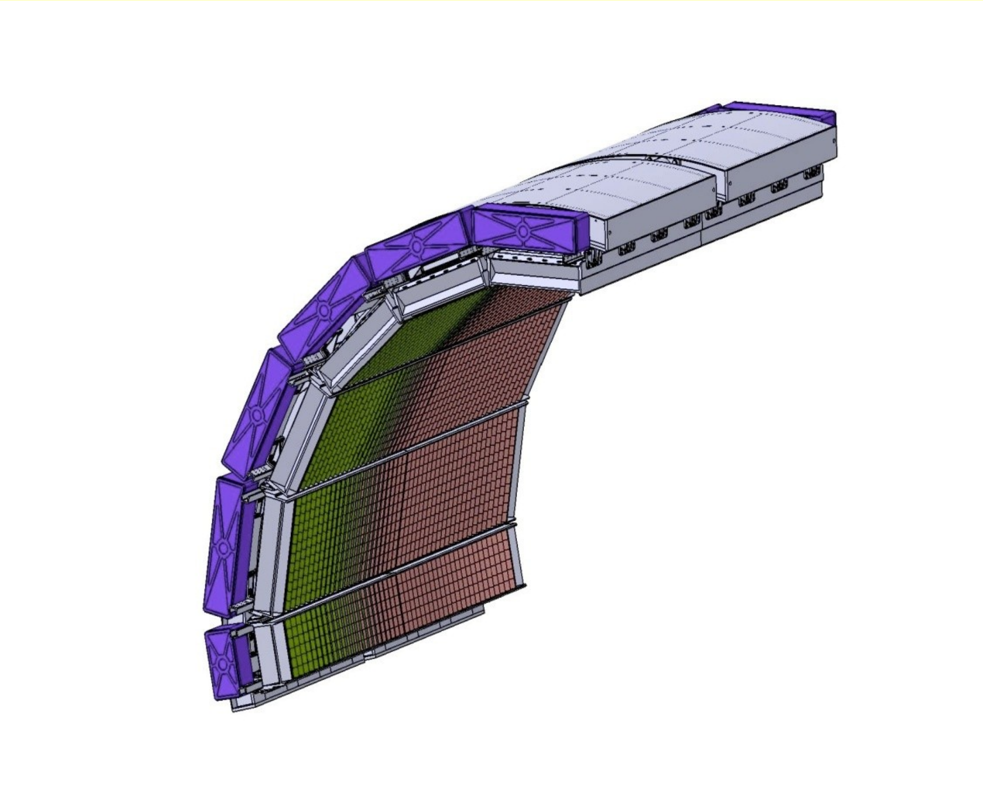






ALICE Electromagnetic Calorimeter

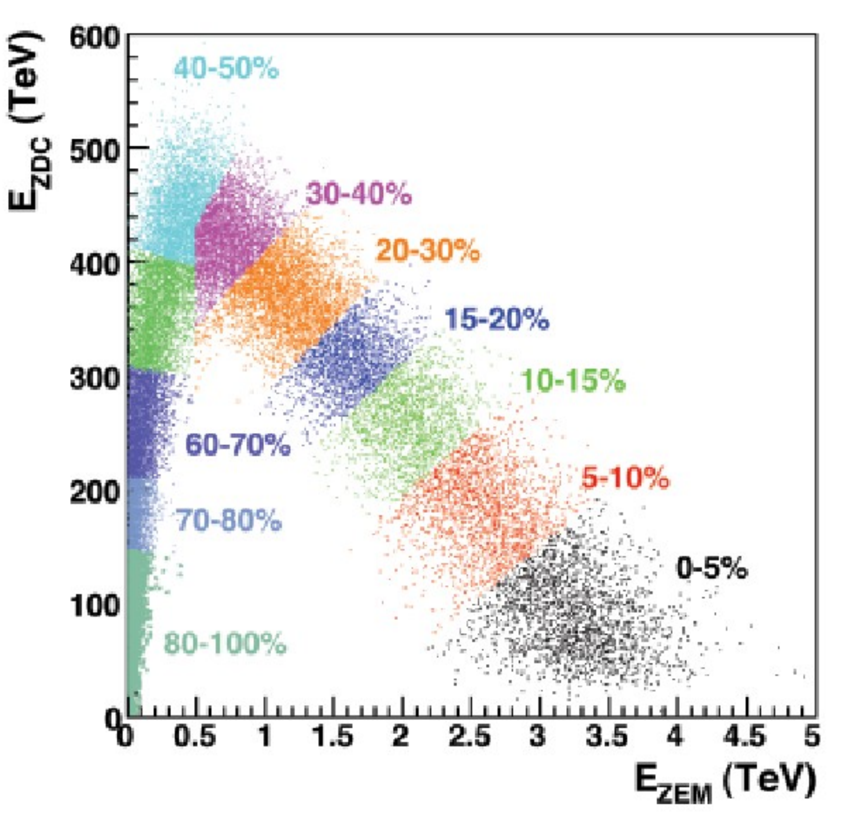
US + Italy + France contribution

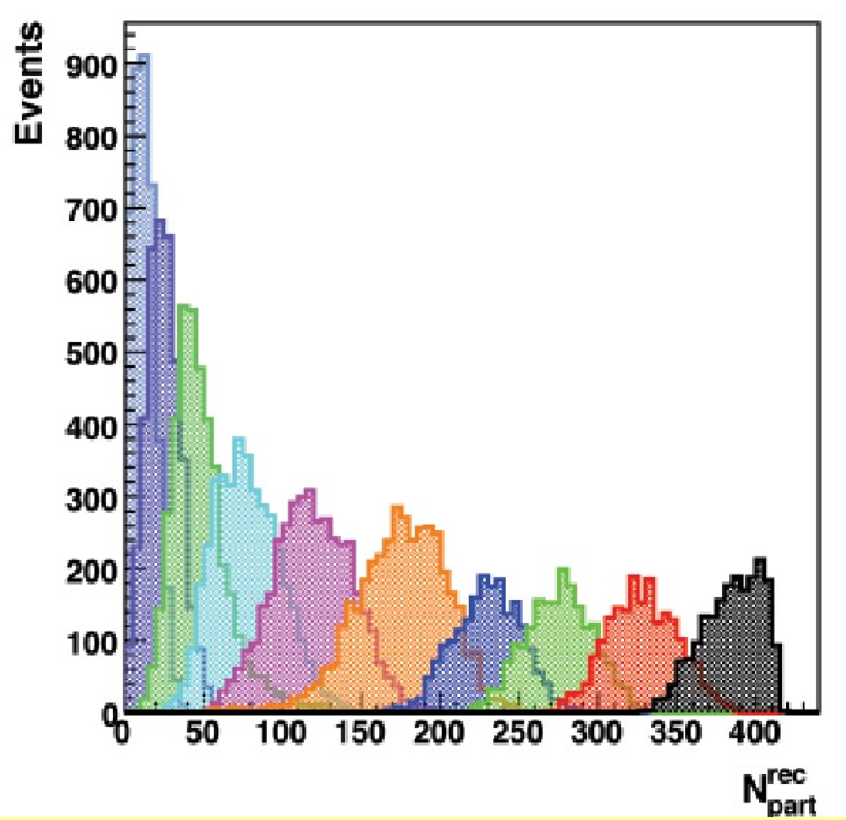


Lead scintillator sampling calorimeter
$\Delta\phi = 110^o$
$|\Delta\eta| = 0.7$
Number of towers is about 13 000

It will enhance the ALICE capabilities for jet measurement. It enables triggering on high energy jets (enhancement factor 10-15), reduces the bias for jet studies and improves the jet energy resolution.

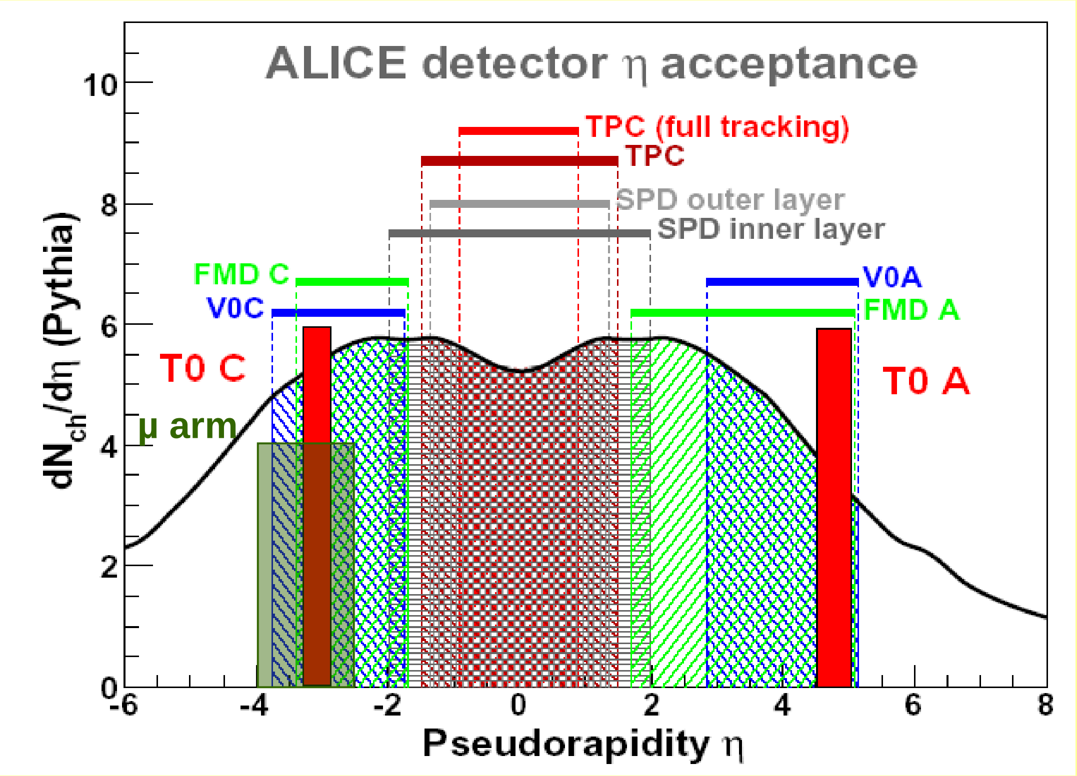
Centrality determination in ALICE





Event by event determination of the centrality :
Zero degree hadronic calorimeters (ZDC) +
electromagnetic calorimeters (ZEM)
EZDC , ZEM → Nspec → Npart → Impact parameter (b)

Charged particle acceptance

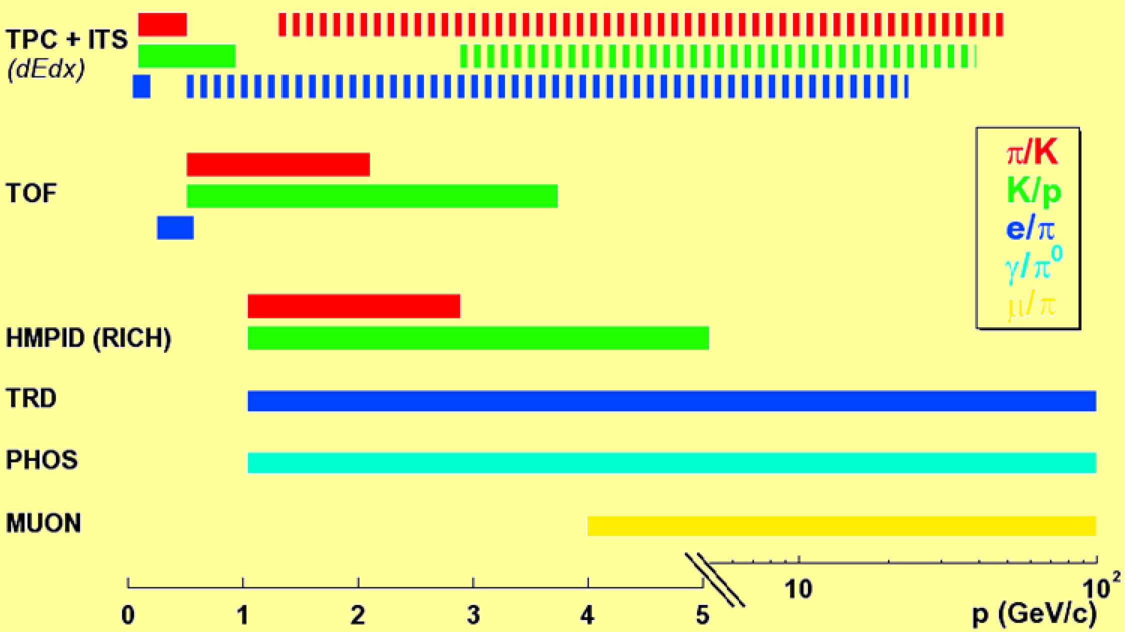


- Minimum Bias trigger provided by a coincidence between the V0 counters and the ITS-pixel layers.

η = -ln(tg(θ/2)), θ is polar angle

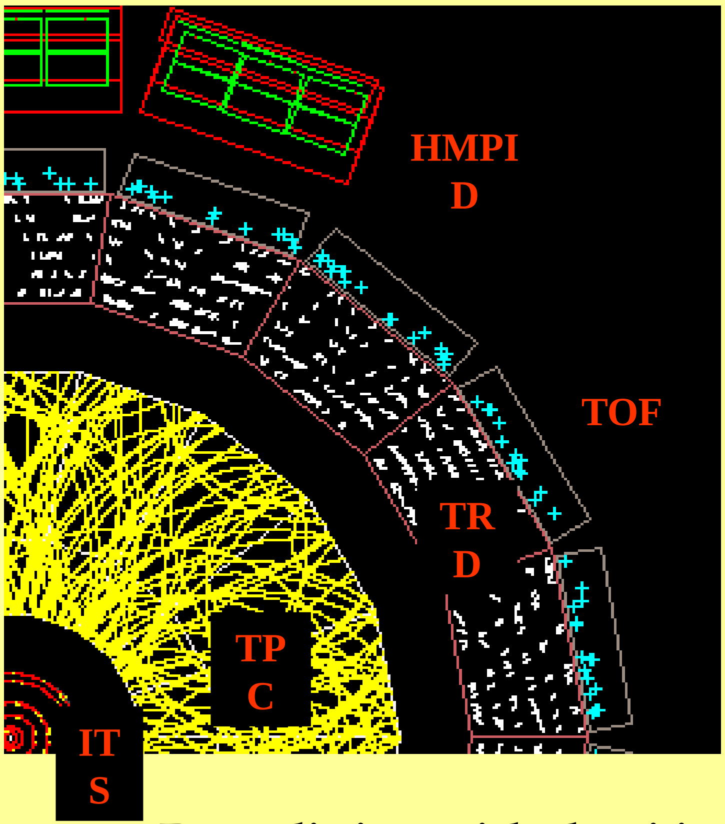
Particle Identification

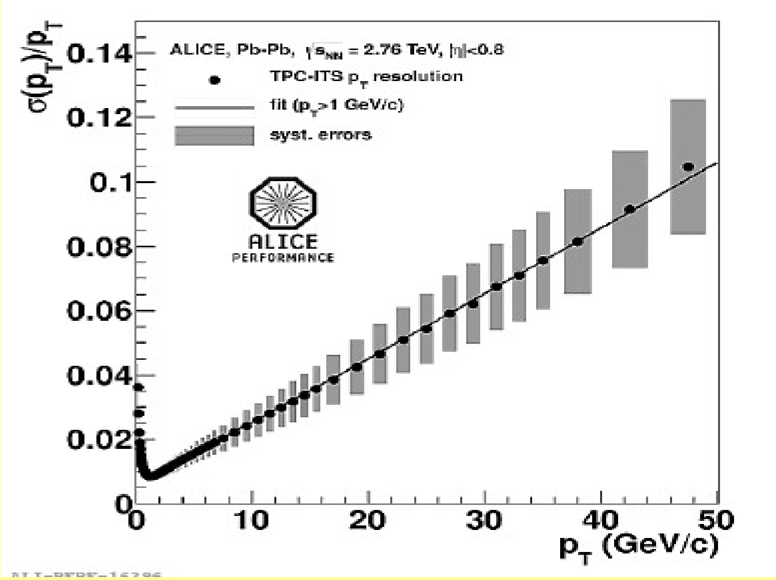
excellent particle ID up to ~ 50 to 60 GeV/c

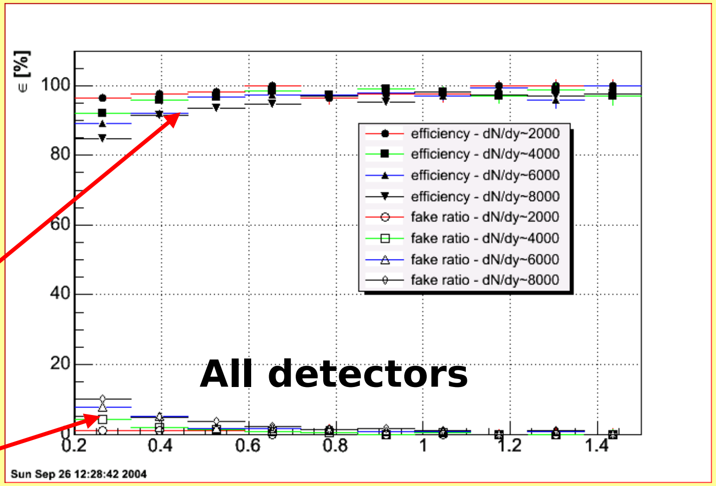


- Identification short lived particles (hyperons, D/B meson) through secondary vertex detection
- Hadrons (dE/dx + ToF), leptons (dE/dx, TOF, transition radiation) and photons (high resolution EM calorimetry, conversions);

Tracking efficiency







For realistic particle densities
dN/dy ~ 2000
combined efficiency well above 95%
and fake track probability below 5%

Заключение

Установка ALICE включает набор требуемых детекторов, позволяющих изучать процессы образования различных элементарных частиц и резонансных состояний при взаимодействии самых тяжёлых ядер при рекордно больших энергиях, необходимых при изучении механизма рождения кварк-глюонной плазмы.

Thanks
for your attention

Спасибо
за внимание