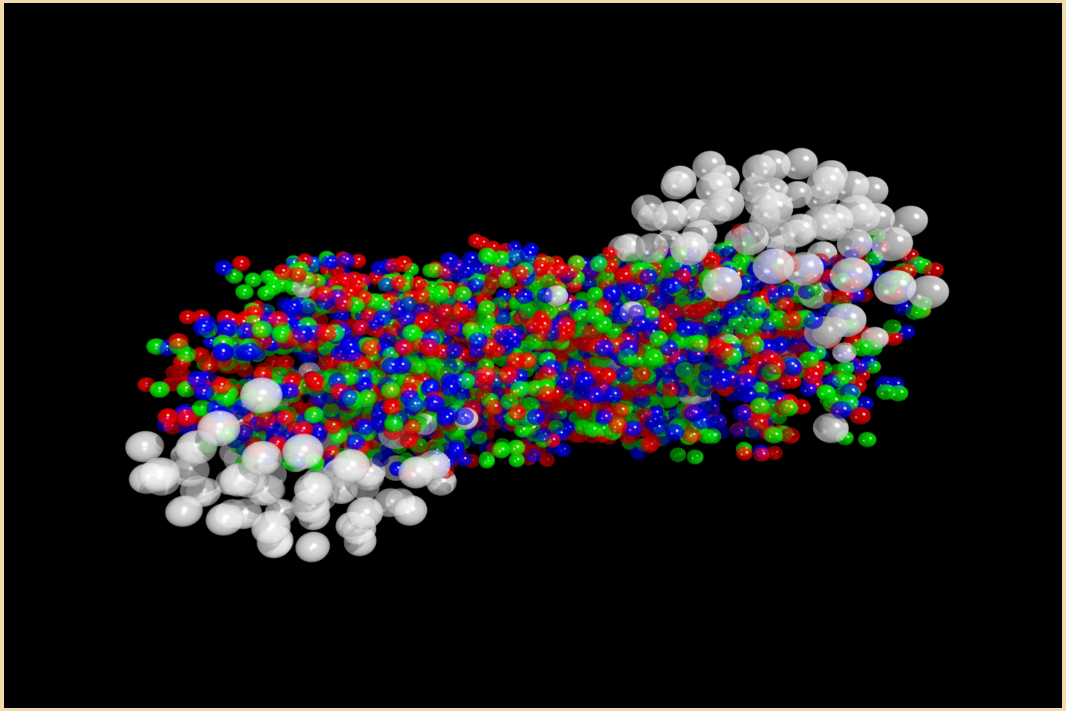
Physics Performance of ALICE

- Overview
  - The LHC as Ion collider
  - SPS-RHIC-LHC
  - Global properties in the LHC regime
- ALICE and its experimental strategy
  - Suite of detectors
  - Performance
  - Status

Heavy Ion Collisions



LHC as Ion Collider

- Running conditions:

Collision system	$\sqrt{s_{NN}}$ (TeV)	$\mathcal{L}_0$ (cm^{-2}s^{-1})	$\langle\mathcal{L}\rangle/\mathcal{L}_0$ (%)	Run time (s/year)	σ_{geom} (b)
pp	14.0	10^{34} *		10^{7}	0.07
PbPb	5.5	10^{27}	70-50	10^{6} **	7.7

$\mathcal{L}_{max}$(ALICE) = 10^{31}** * $\mathcal{L}_{int}$(ALICE) ~ 0.7 nb^{-1}/year**

- \+ other collision systems: pA, lighter ions (Sn, Kr, Ar, O) & energies (pp @ 5.5 TeV).

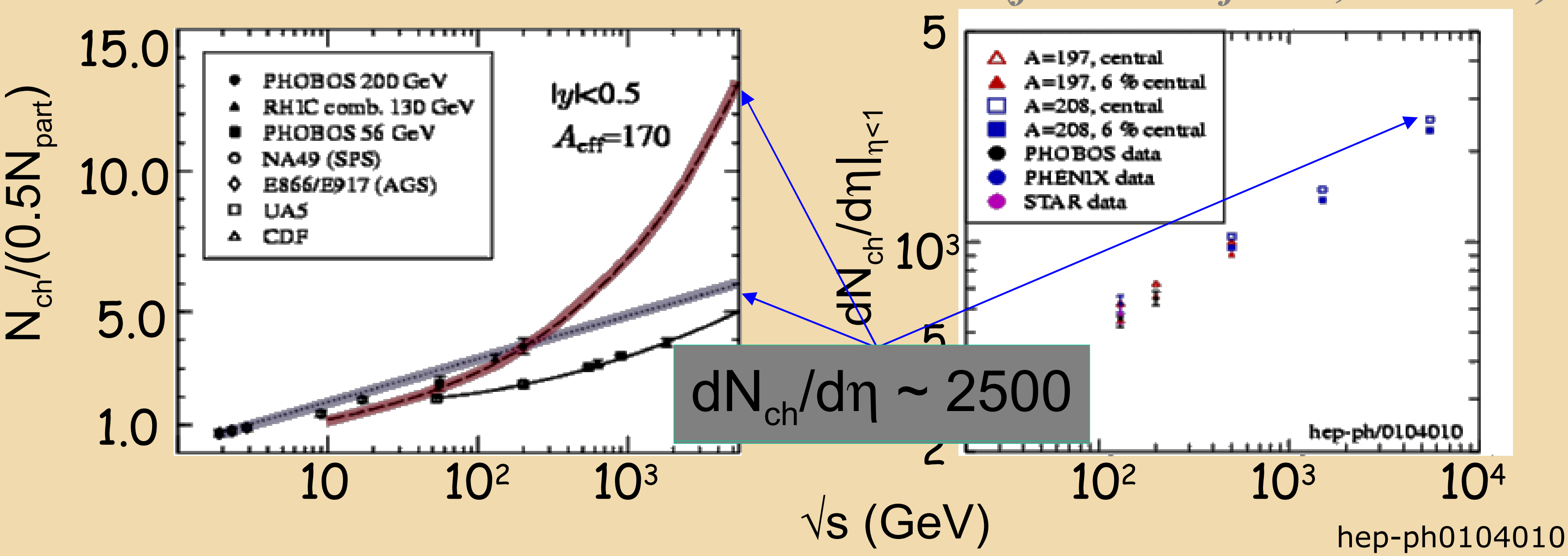
From SPS to RHIC to LHC
‘hotter – bigger – longer lived’

Formation time τ_0 3 times shorter than RHIC
Lifetime of QGP τ_{QGP} factor 3 longer than RHIC
Initial energy density ε_0 3 to 10 higher than RHIC

Central collisions	SPS	RHIC	LHC
$s^{1/2}$(GeV)	17	200	5500
dN_{ch}/dy	500	850	2–8 $\times 10^3$
ε (GeV/fm^3)	2.5	4–5	15–40
V_f(fm^3)	10^3	7×10^3	2×10^4
τ_{QGP} (fm/c)	<1	1.5–4.0	4–10
τ_0 (fm/c)	~1	~0.5	<0.2

Novel aspects… Multiplicity

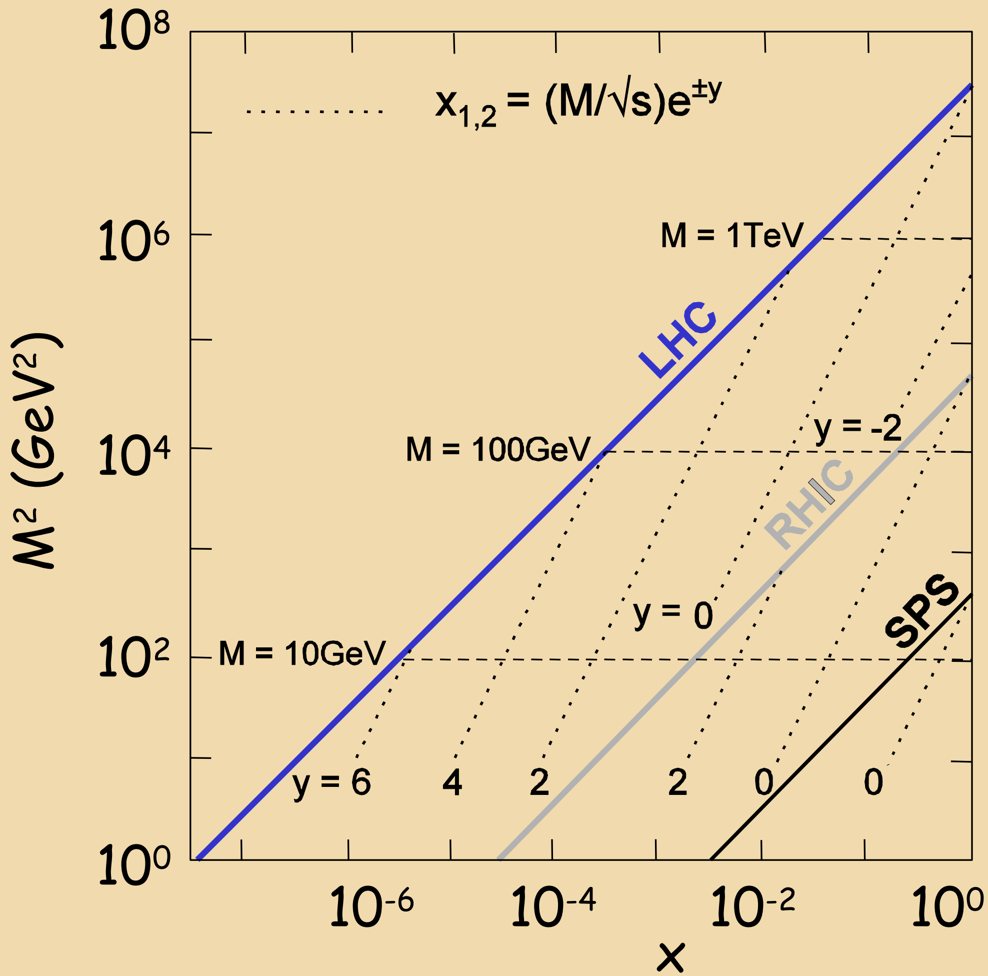
(from K.Kajantie, K.Eskola)



Even with RHIC data extrapolation to LHC uncertain
Expect multiplicity in range dN/dy (charged) ~ 1500 to 6000
ALICE optimized for dN/dy(charged) 4000; operational up to ~ 8000

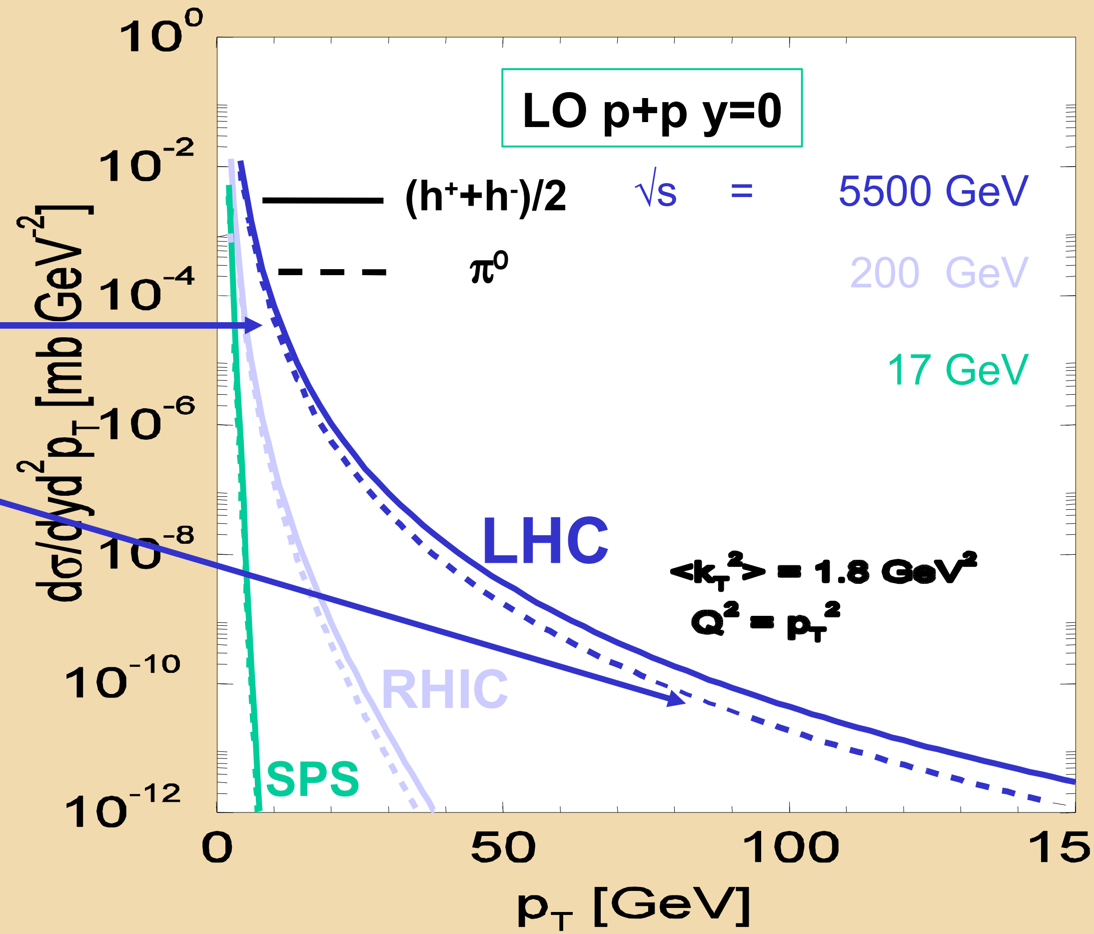
Novel Aspects… soft processes

- Probe initial partonic state in a novel Bjorken-x range (10^{-3} - 10^{-5}):
  - nuclear shadowing,
  - high-density saturated gluon distribution.
- Larger saturation scale ($Q_s = 0.2A^{1/6}\sqrt{s}^{\delta} = 2.7$ GeV): particle production dominated by the saturation region.

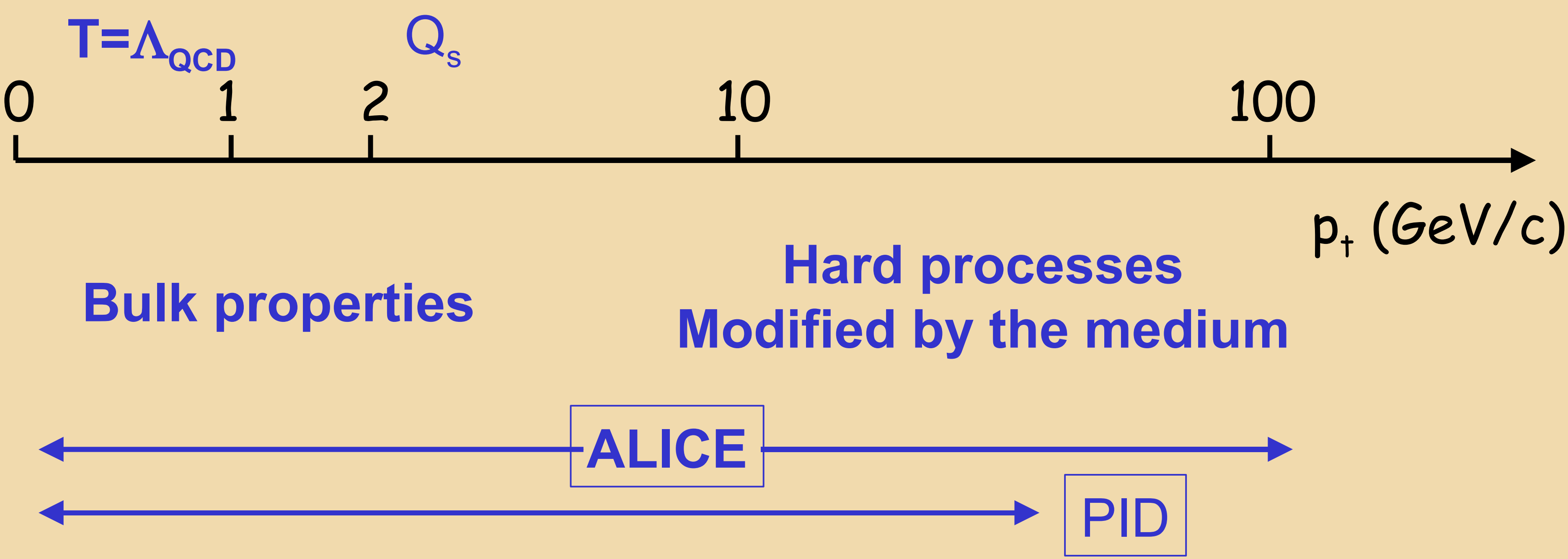


Novel Aspects…Hard processes

- Hard processes contribute significantly to the total AA cross-section (σhard/σtot = 98%)
  - ⇨ Bulk properties dominated by hard processes
  - ⇨ Very hard probes are abundantly produced
- Weakly interacting probes become accessible (γ, Z^0, $W^{\pm}$)



Alice : required p_T reach



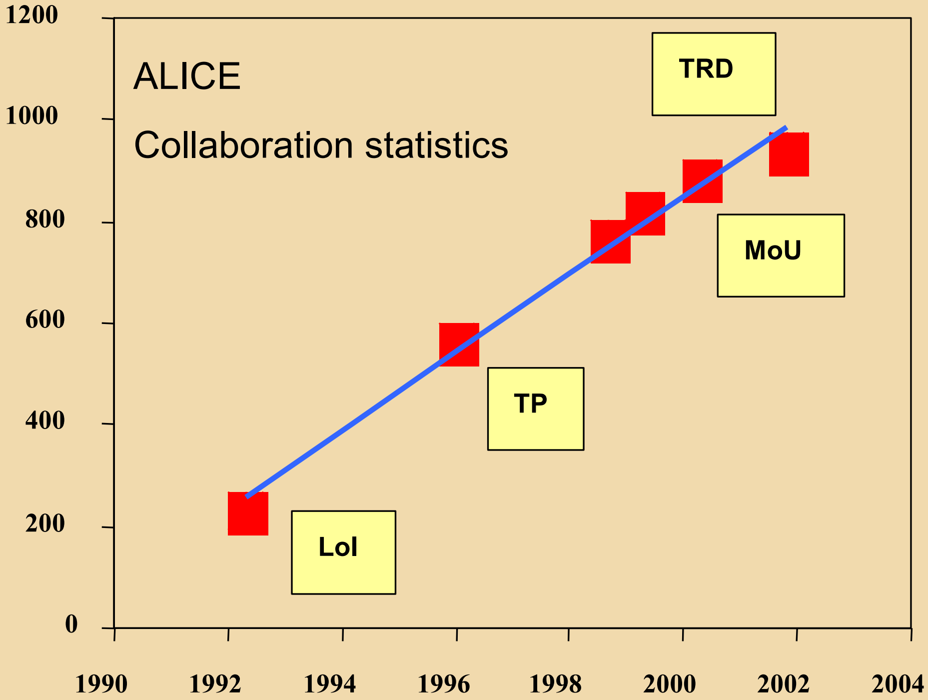
ALICE Physics Reach…

- **Global properties**
  - **Multiplicities, η distributions**
- **Degrees of Freedom vs Temperature**
  - **Hadron ratios and spectra**
  - **Dilepton continuum**
  - **Direct photons**
- **Collective effects**
  - **Elliptic flows**
- **De-confinement**
  - **Charmonium, bottonium spectroscopy**
- **Chiral symmetry restoration**
  - **Neutral to charge ratio**
  - **Resonance decays**
- **Partonic energy loss in QGP**
  - **Jet quenching, high p_T spectra**
  - **Open charm and beauty**
- **Geometry of emission**
  - **HBT, zero-degree energy flow**
- **Fluctuations and critical behavior**
  - **Event-by-event particle composition and spectroscopy**

...and experimental consequences for ALICE

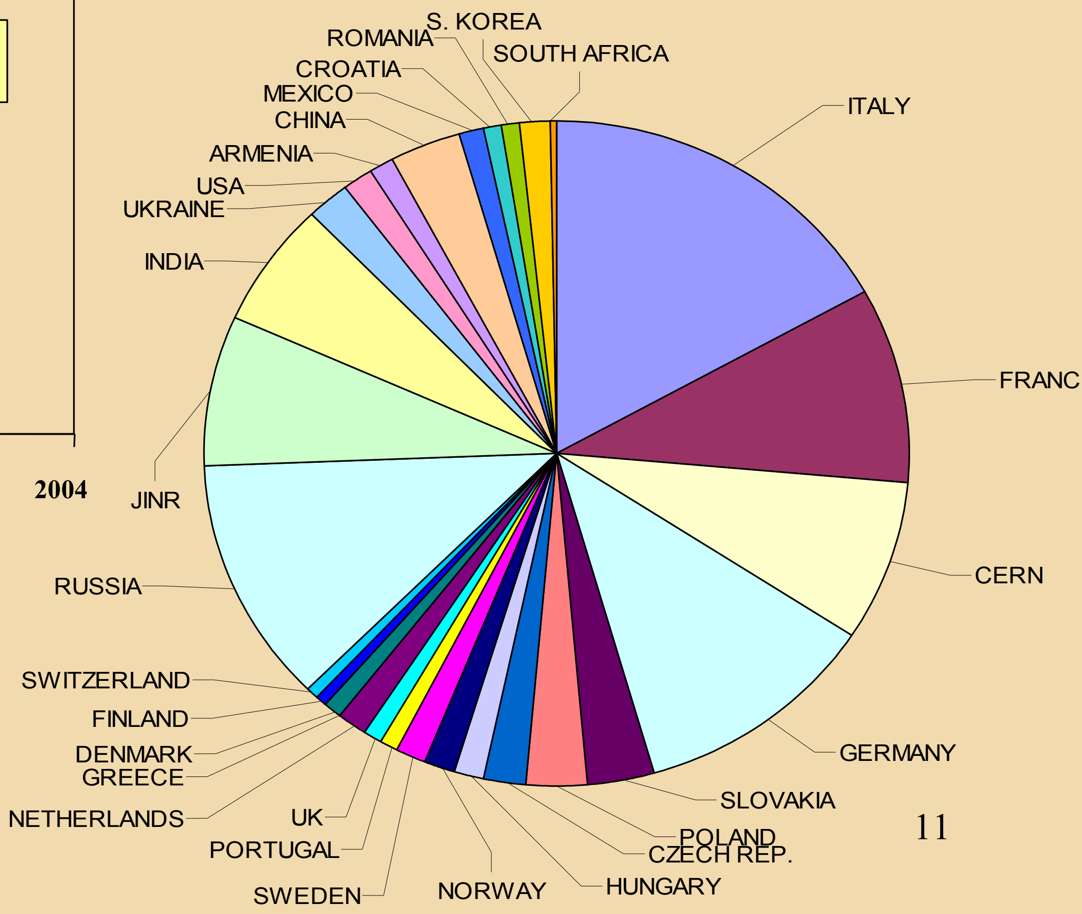
- Large Acceptance Coverage
- Large Momentum Coverage (from 100 MeV/c to > 100 GeV/c)
- High Granularity (designed for dN/dy ~ 8000,
  i.e. 15 000 particles in acceptance)
  - Spectroscopy and Identification of
    - hadrons and leptons
- c-, b- vertex recognition
- Excellent photon detection (in $\Delta\varphi = 45^0$ and $\eta = 0.1$)
- Large acceptance em calorimetry very desirable, for which only the infrastructure exists, but not yet the detector

ALICE collaboration

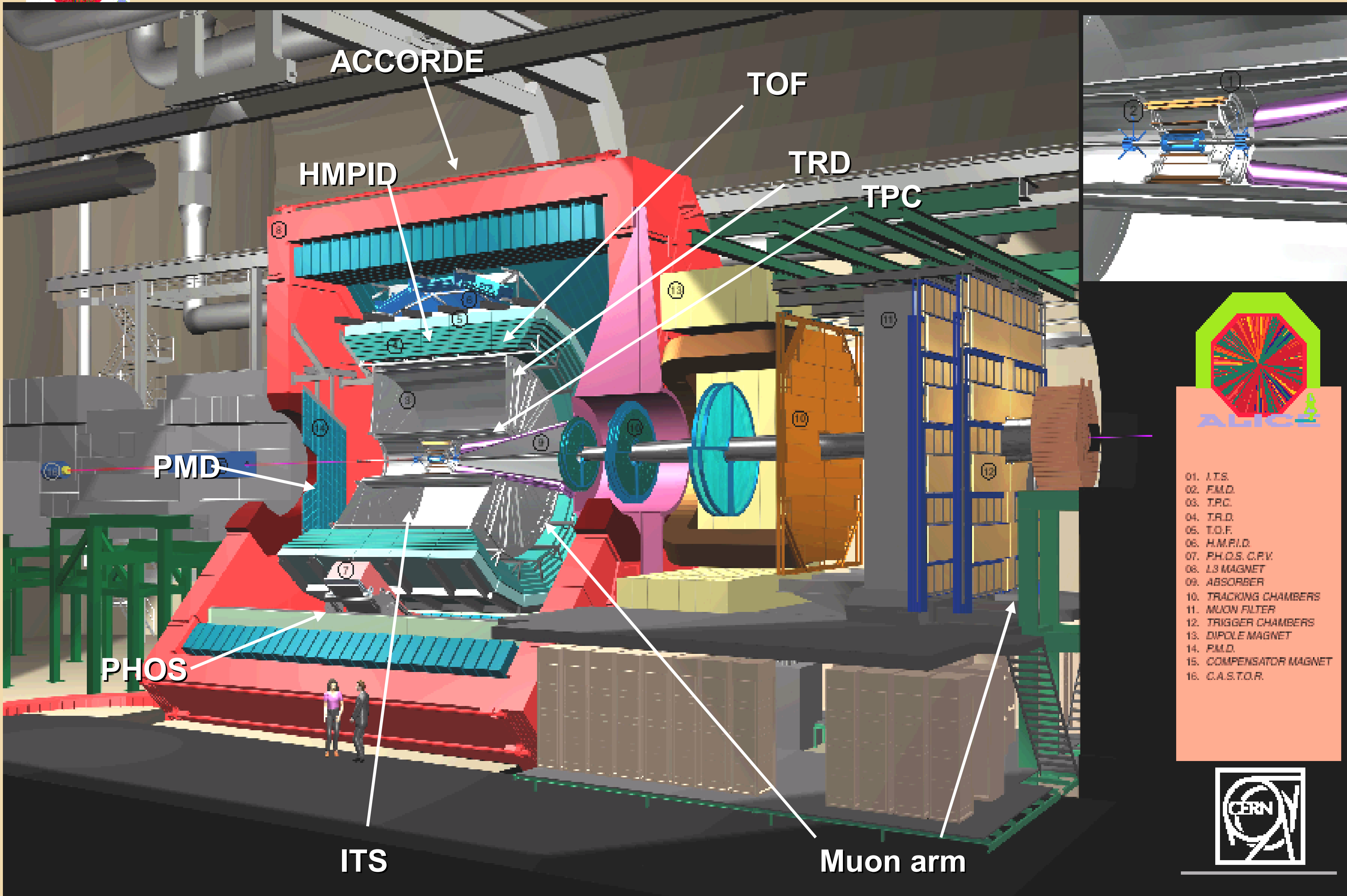


- 937 members
- 77 Institutions
- Discussion with China, Japan, US

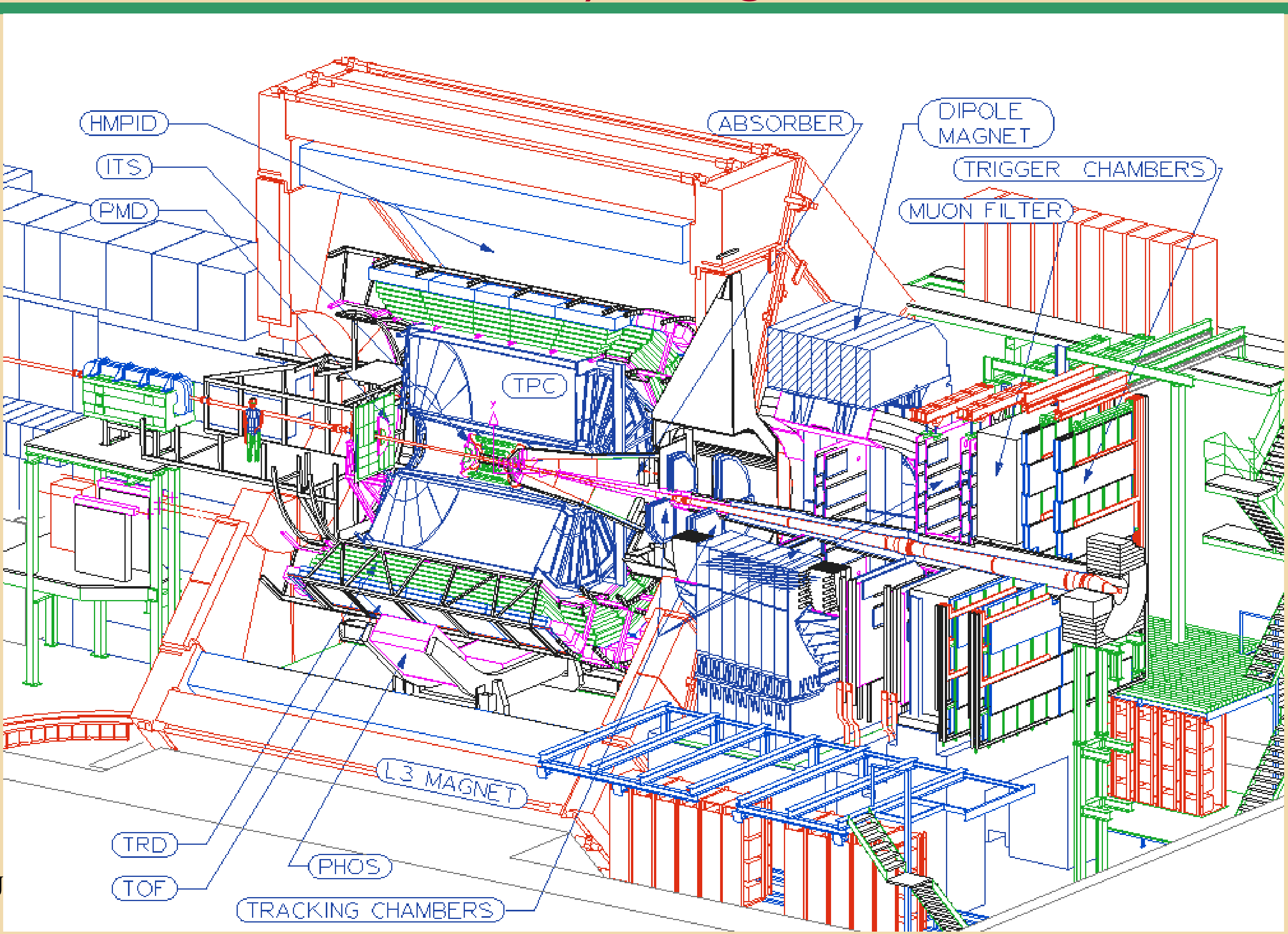
After more than 10 years of life, still healthy and growing!



ALICE Detector



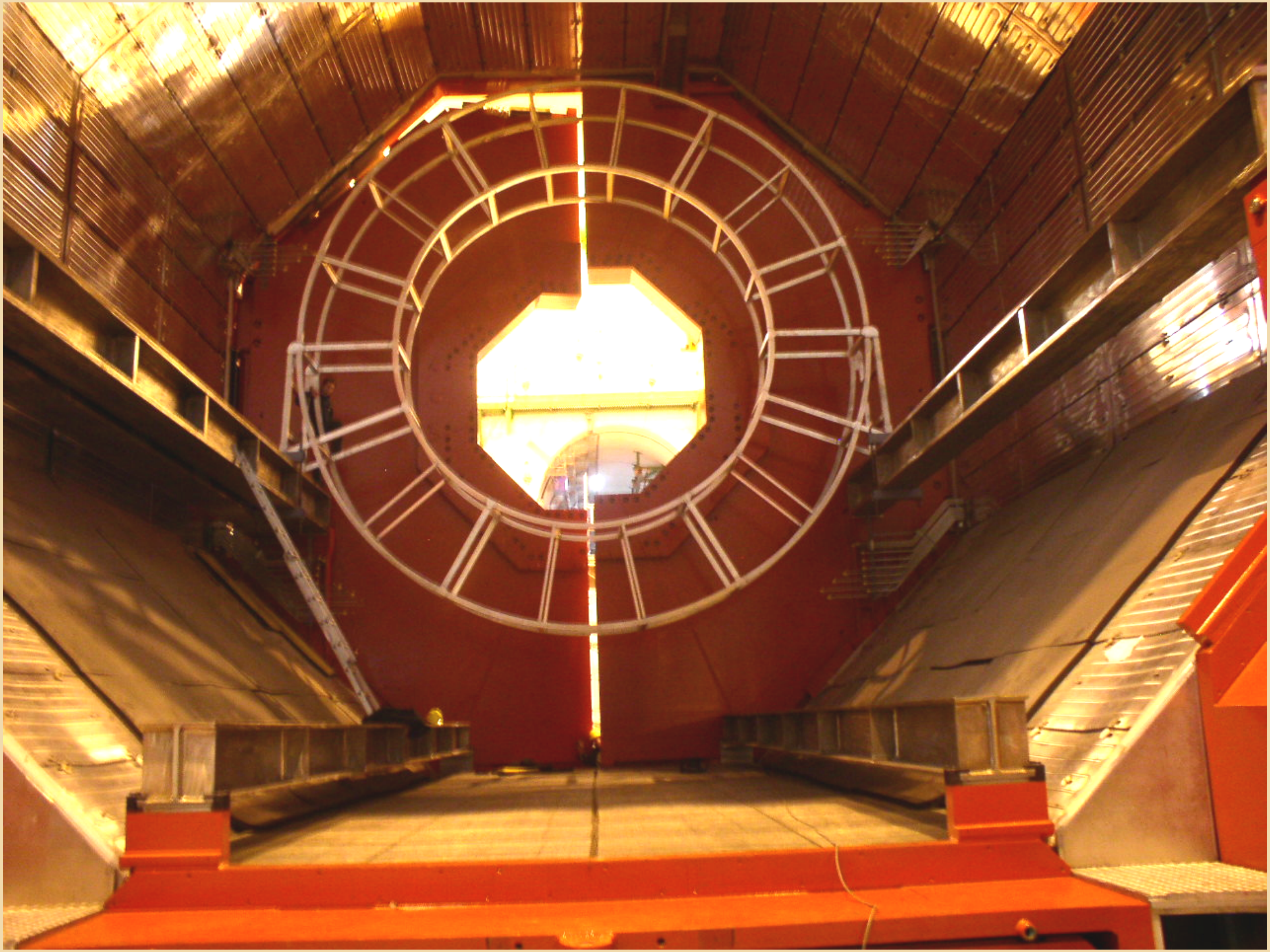
Stable Layout; Services (Cables, Cooling, Gas…)being installed



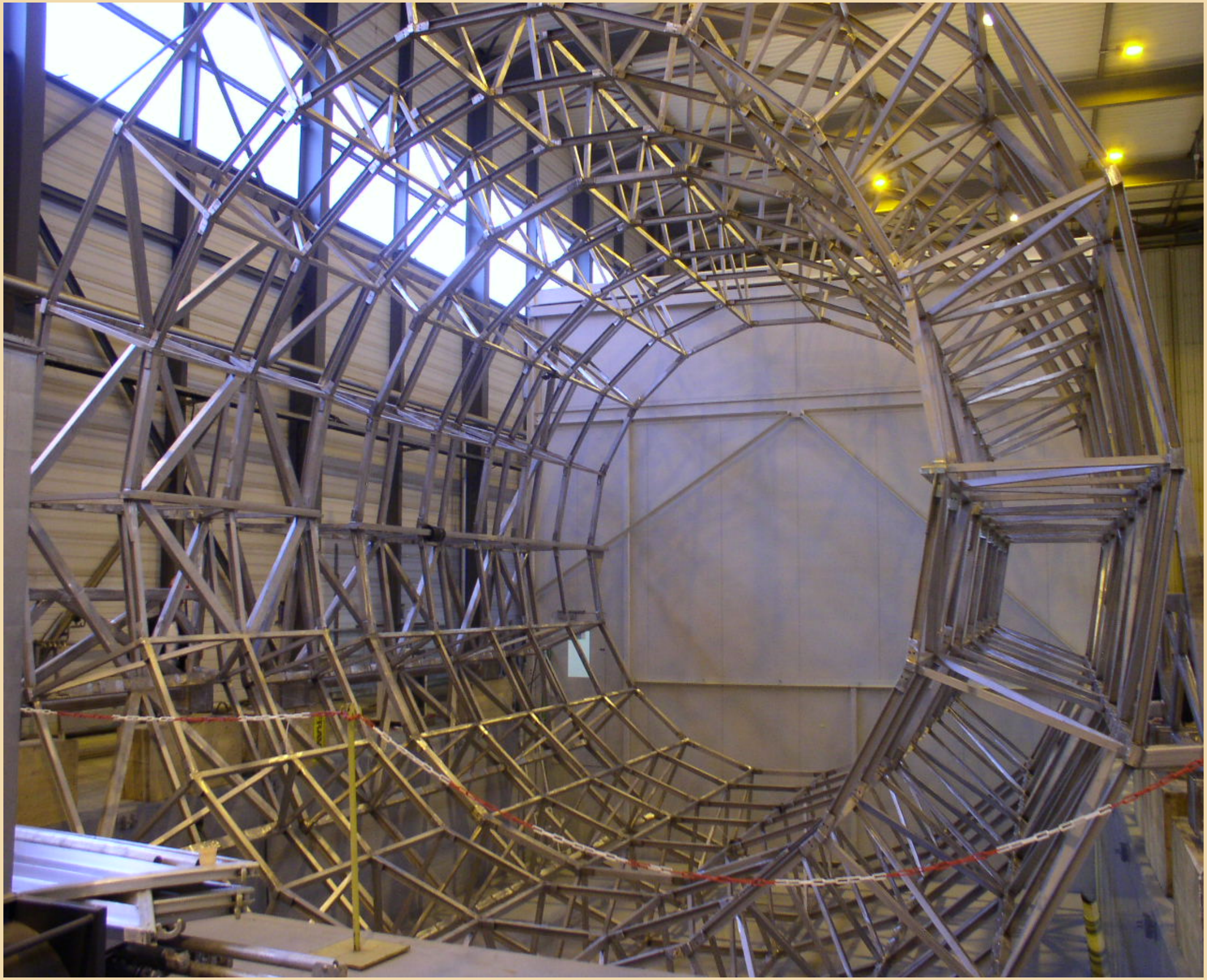
ALICE Detector Suite: selected highlights

- **Inner Silicon Tracker**
  - **Pixels, Si- Drift, Si- strips**
- **TPC : the world's largest**
  - **Very ambitious performance specifications**
  - **Highly integrated readout electronics**
- **Transition radiation detector**
  - **$1.2*10^6$ channels; trigger capability; (need collaborators for completion; discussions with Japan)**
- **HMPID : large area RICH with CsI photo-cathodes**
- **FMD: large area Si- multiplicity detector array to complement central tracking**
- **PHOS : a 20 000 $PbWO_4$ crystal calorimeter (need collaborators for completion; discussions with China and Japan)**
- **Muon Spectrometer**
  - **with the world's largest warm dipole**
  - **Advanced $1.2*10^6$ channel precision tracker**
- **Infrastructure for large EM Calorimeter installed**
  - **In discussion with US groups**
- **And, and … arrays of specialized detectors**

Inside the Solenoid for the central detectors; L3 legacy of LEP



Preparing Space Frame for TPC/ITS/TRD/TOF Pre-Integration

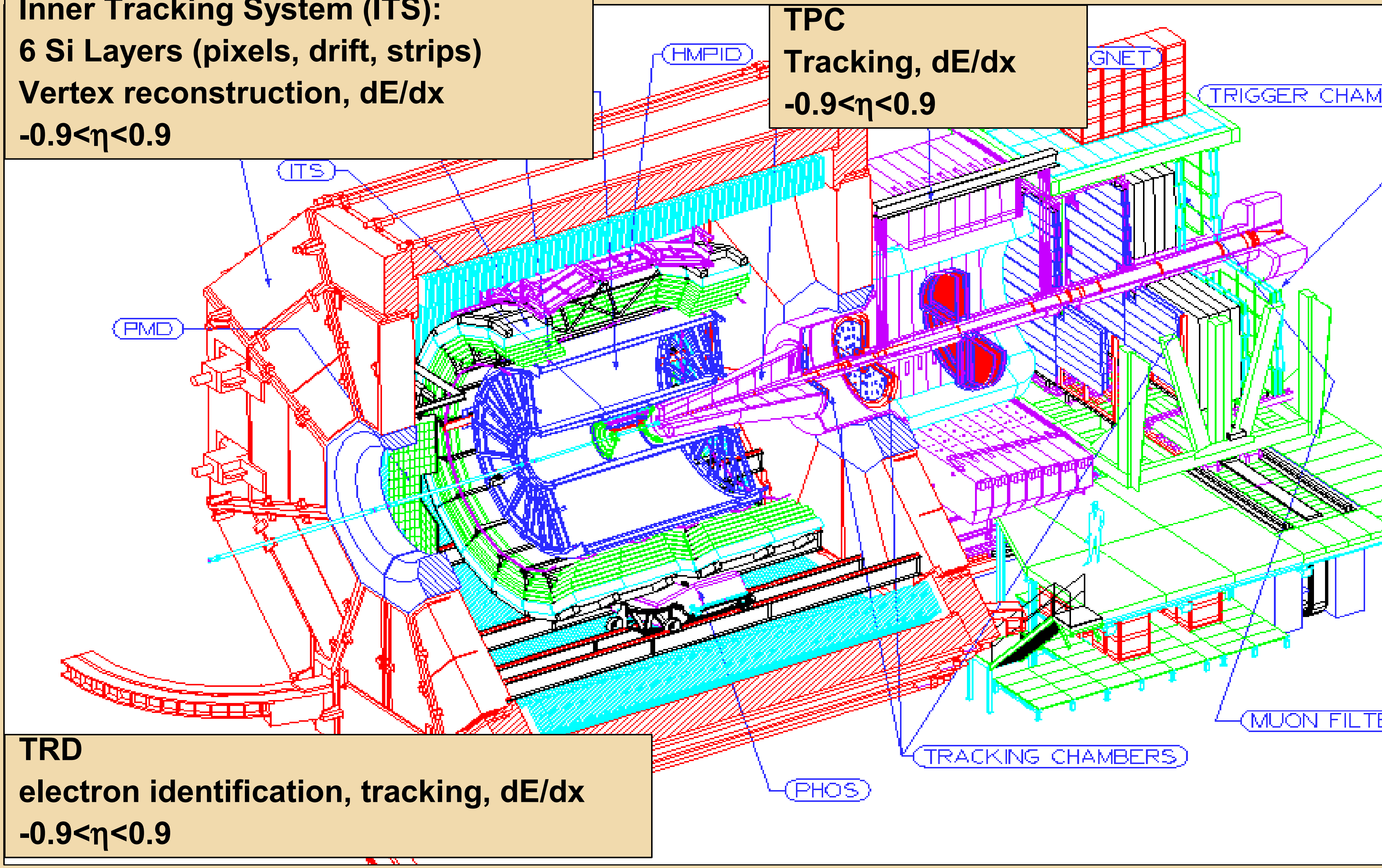


Pre-Integration of ITS/TPC/TRD/ TOF ongoing at present moment

ALICE Layout: Tracking (and event characterization)

Inner Tracking System (ITS):
6 Si Layers (pixels, drift, strips)
Vertex reconstruction, dE/dx
-0.9<η<0.9

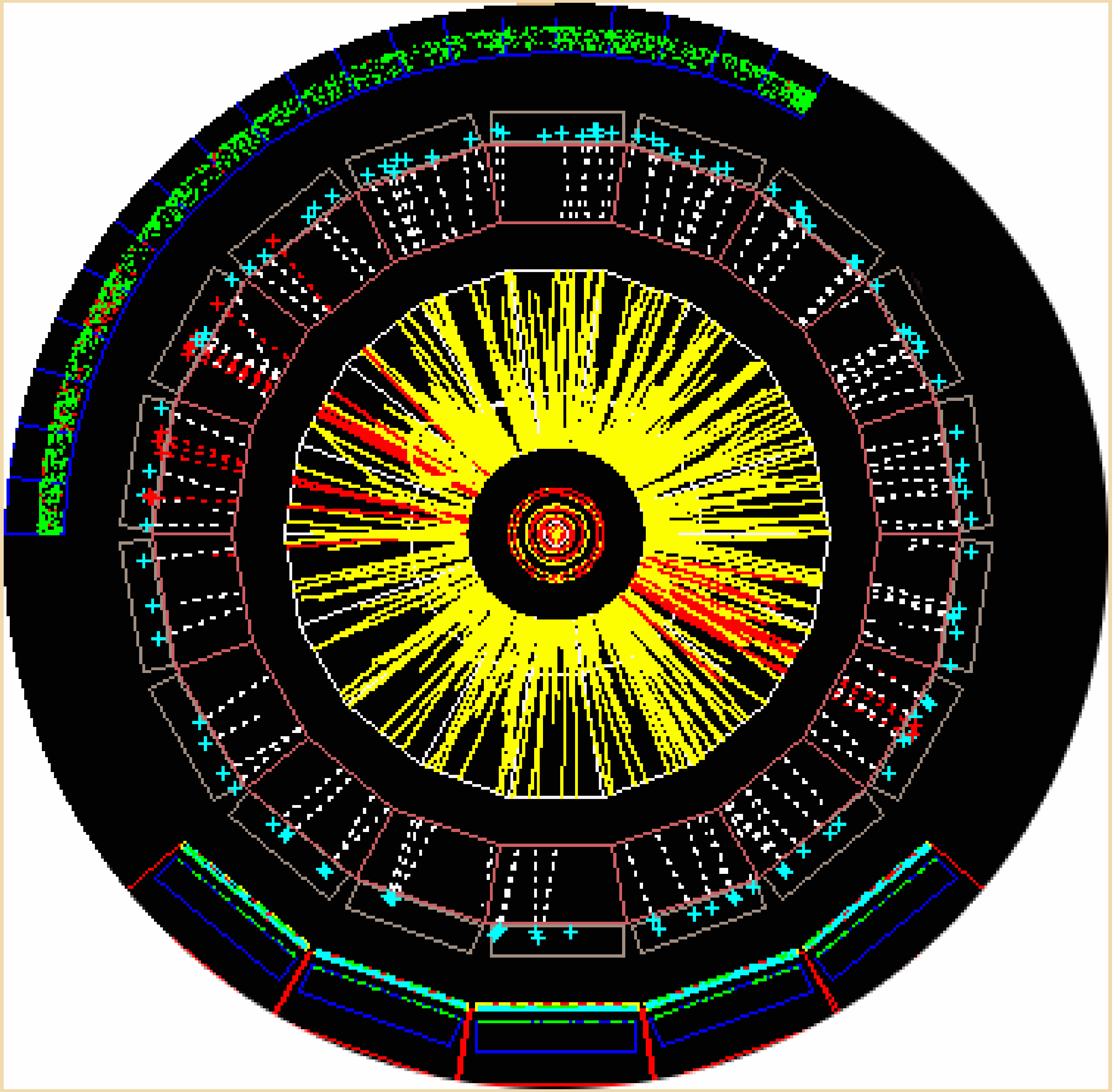
TPC
Tracking, dE/dx
-0.9<η<0.9



TRD
electron identification, tracking, dE/dx
-0.9<η<0.9

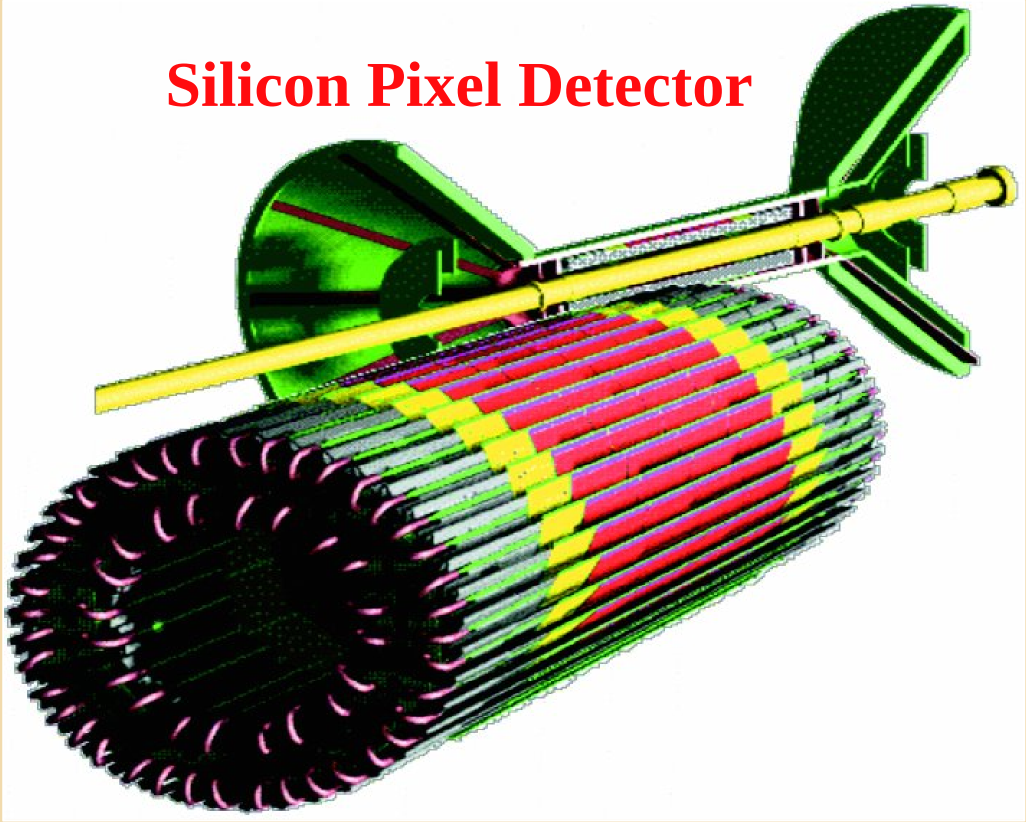
ALICE Tracking

Combine :
ITS + TPC + TRD

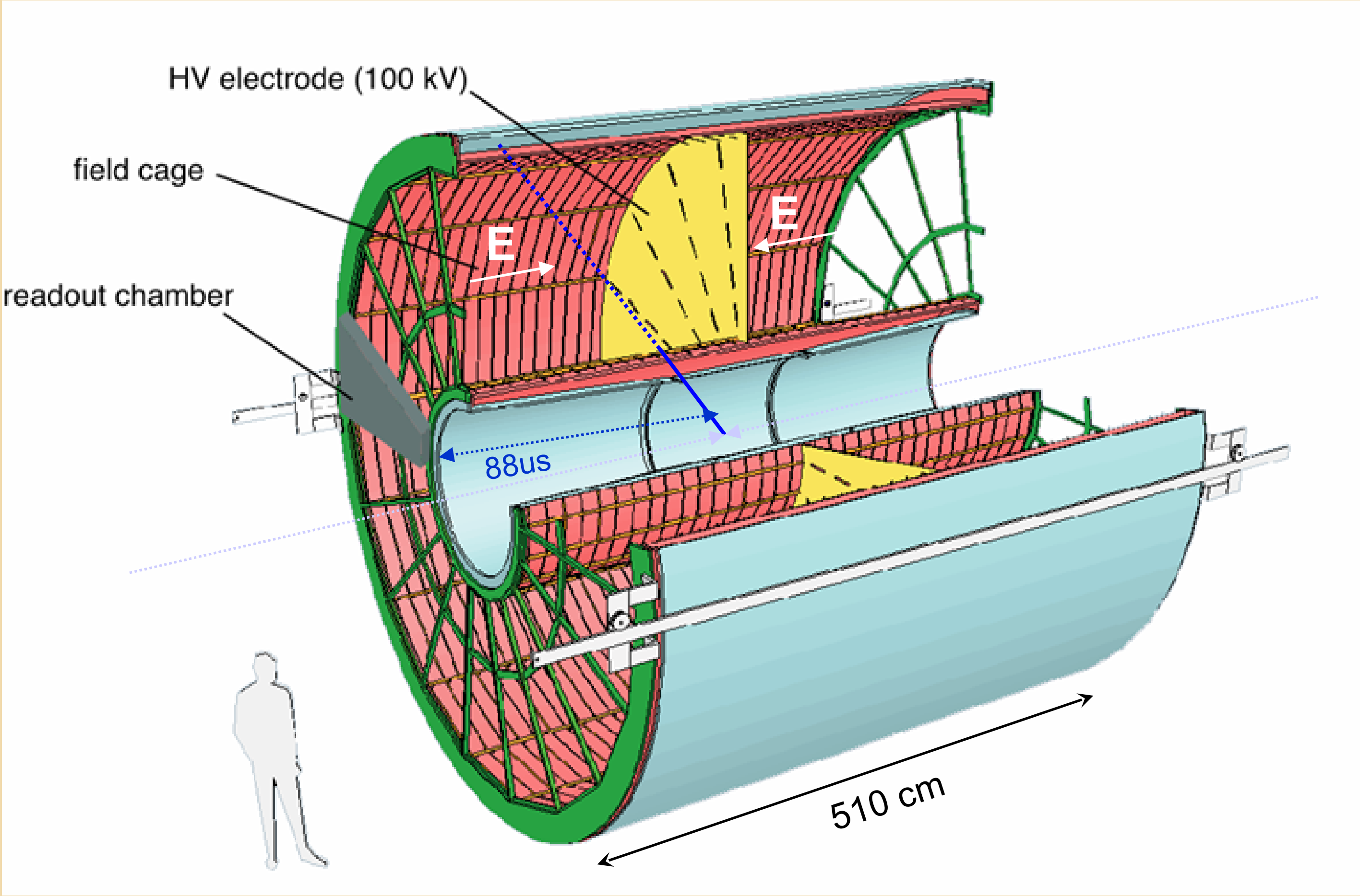


Inner Traking System

ITS = SPD + SSD + SDD



TPC layout



GAS VOLUME
88 m^3

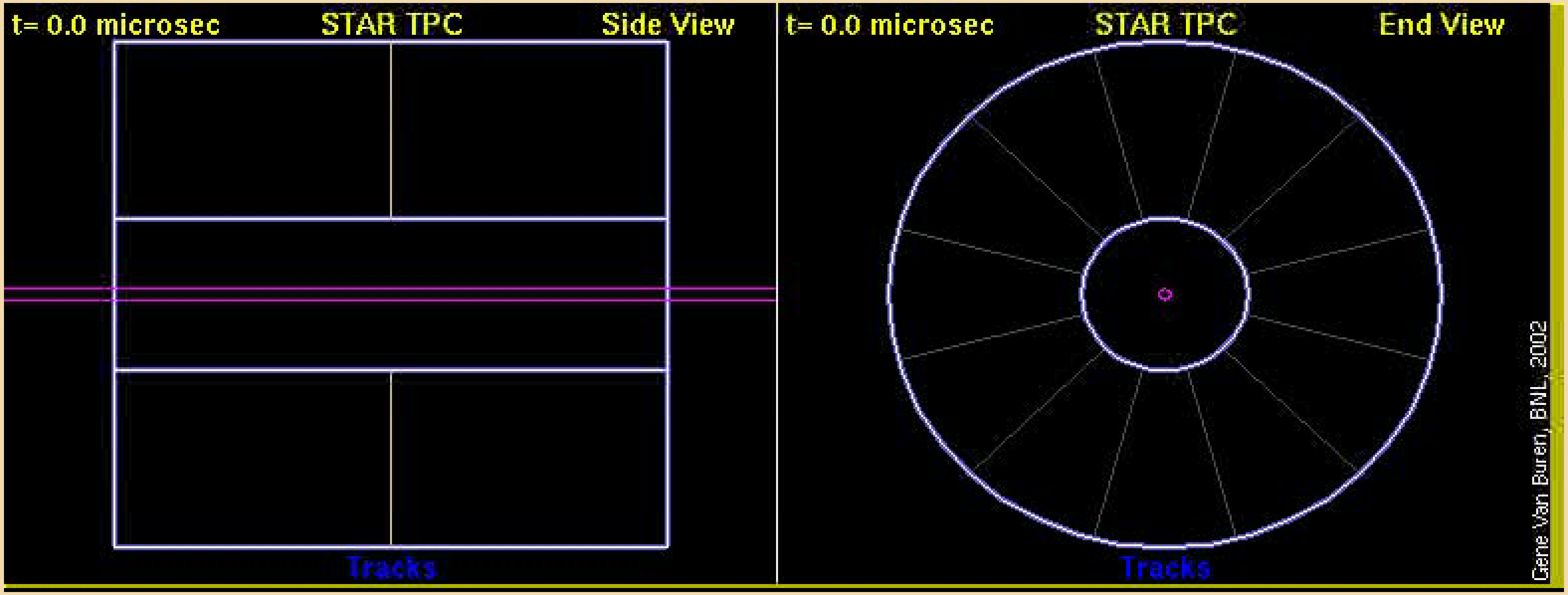
DRIFT GAS
90% Ne - 10%CO_2
Field cage finished
FEE finished
Read out chamber finished
At present pre-integration of field cage into experiment

Readout plane segmentation

18 trapezoidal sectors

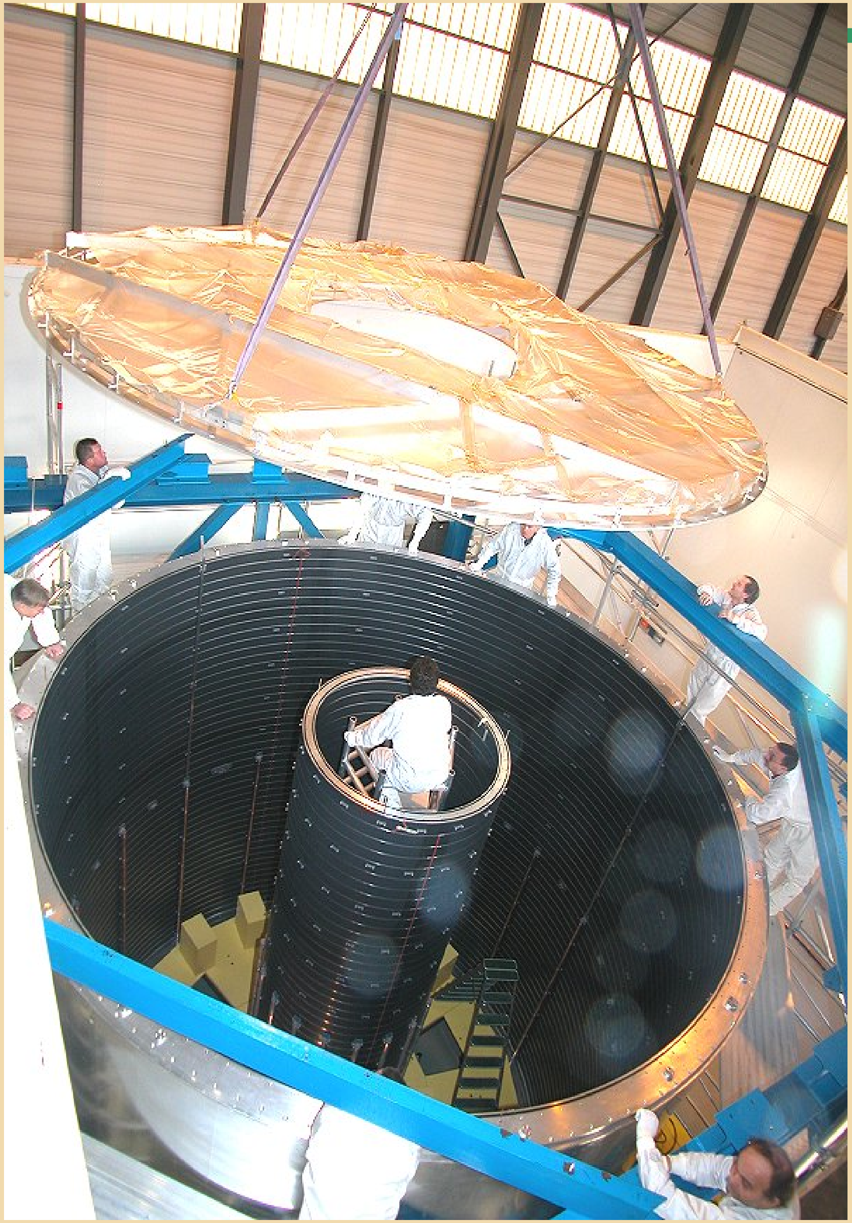
each covering 20 degrees in azimuth

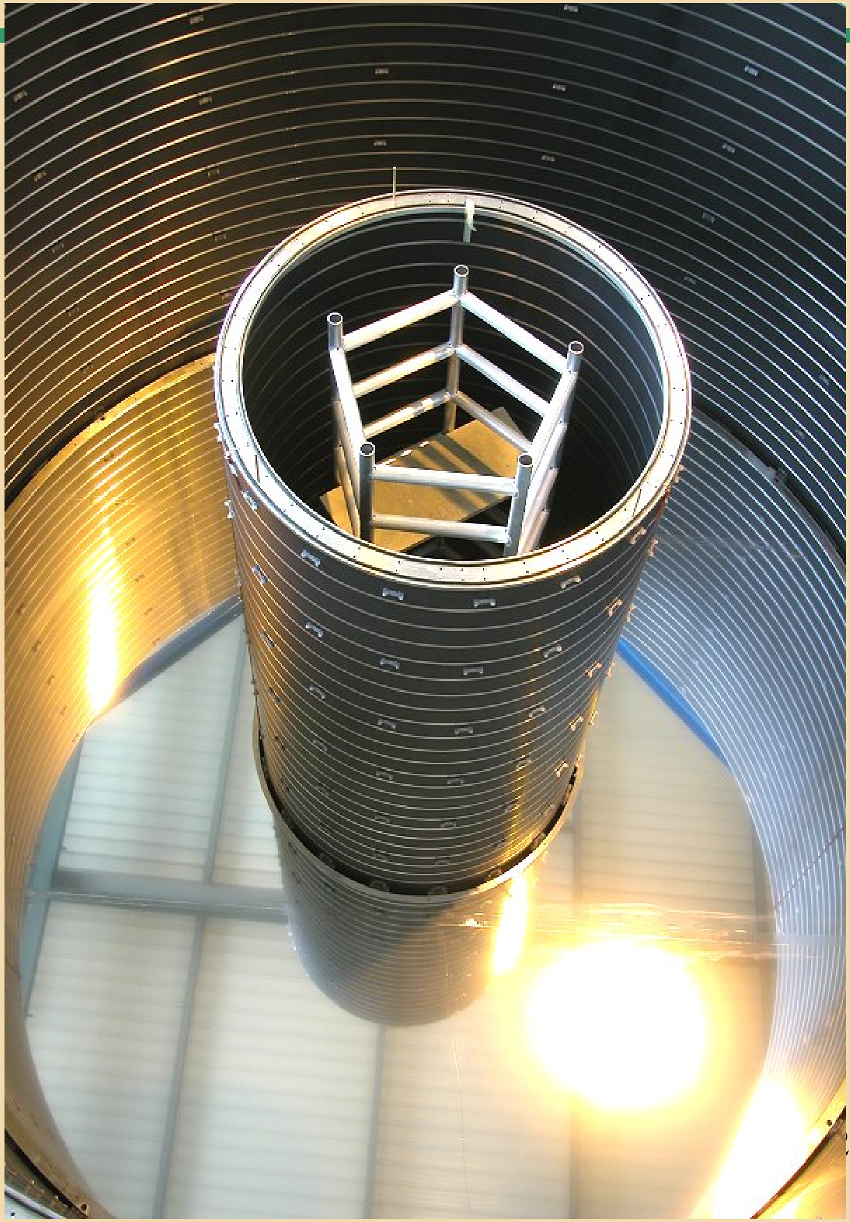
TPC principle



ALICE TPC has 88 μs drift time
TRD (2 μs drift only) can serve as trigger for TPC

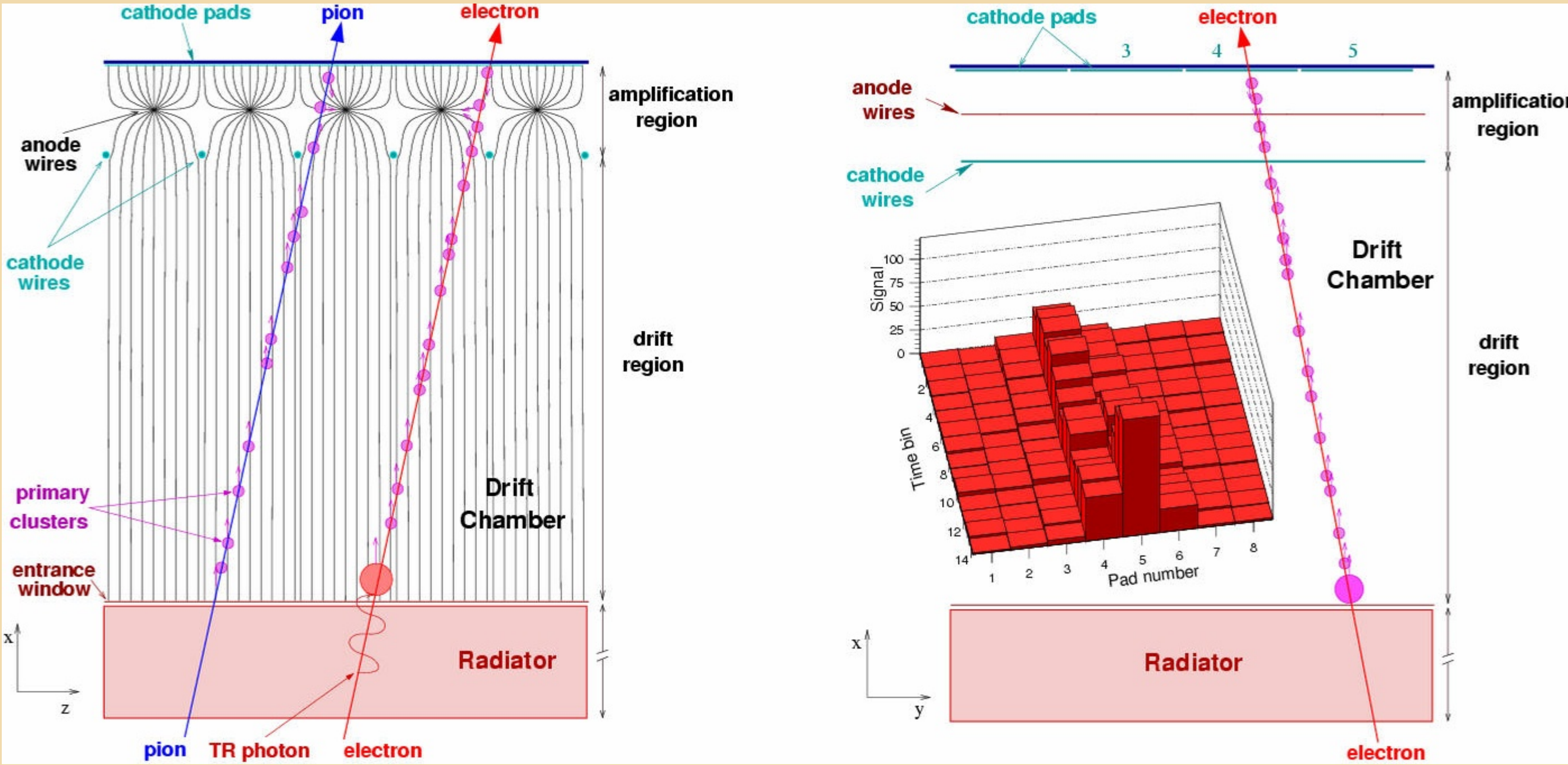
Mounting the TPC Central Electrode
With 10^{-4} parallelism to readout chambers





ALICE TRD : Ionization, Tracklet, Triggering

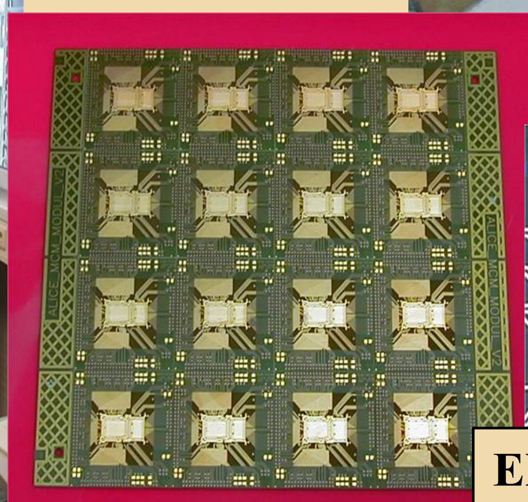
Pad chambers with a total of 1 200 000 channels

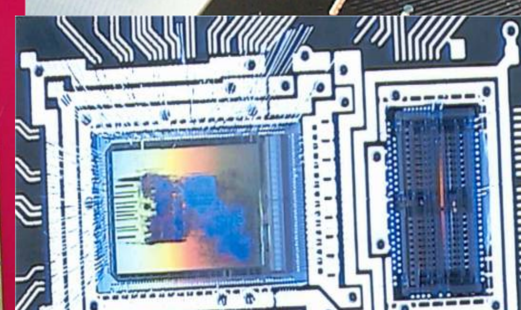


TRD ; Chamber production in Heidelberg,GSI, Dubna, Bucharest

Chamber production in Heidelberg

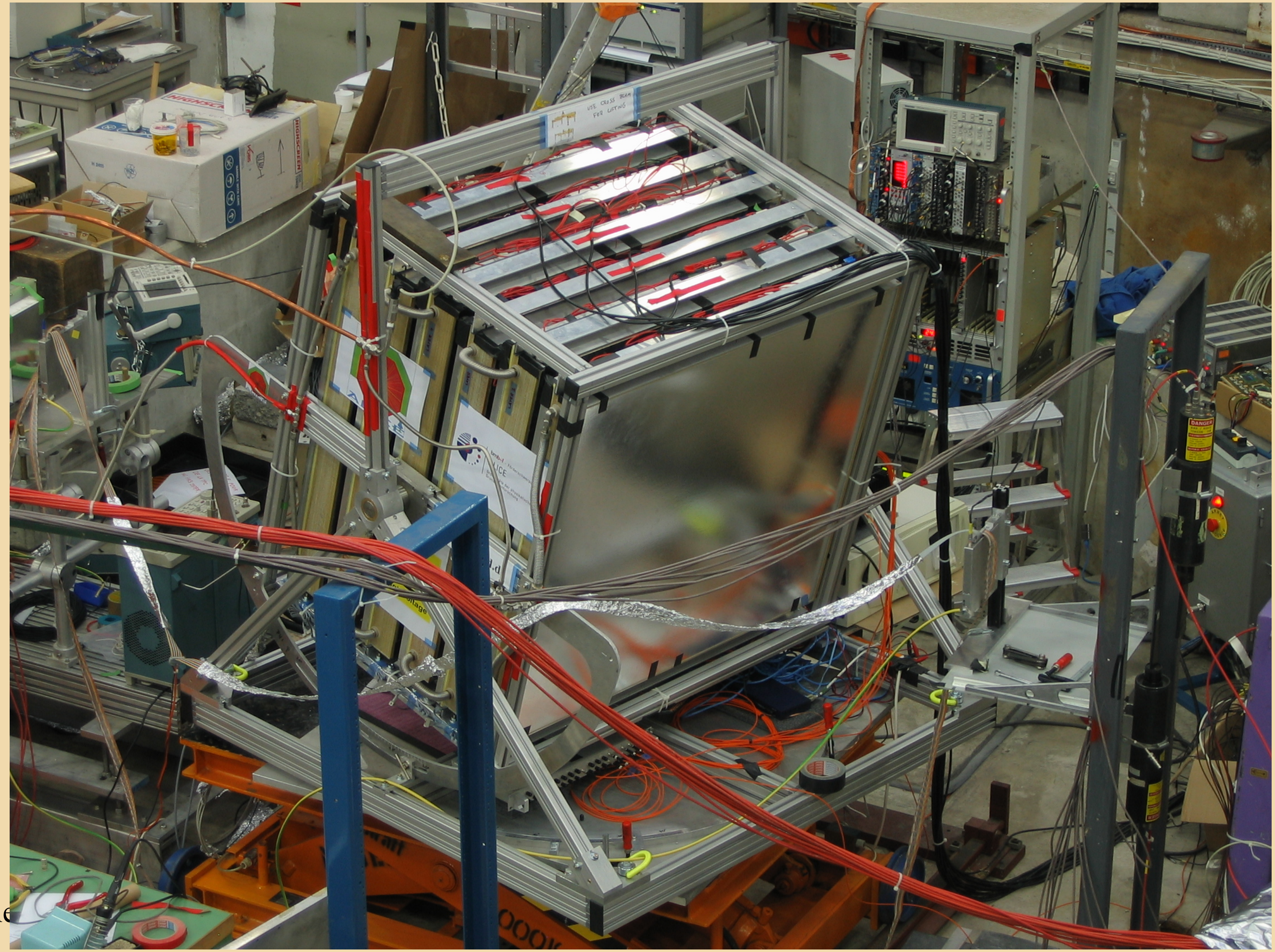
Chamber production lab in JINR





Electronics and MCM bonding at FZ Karlsruhe

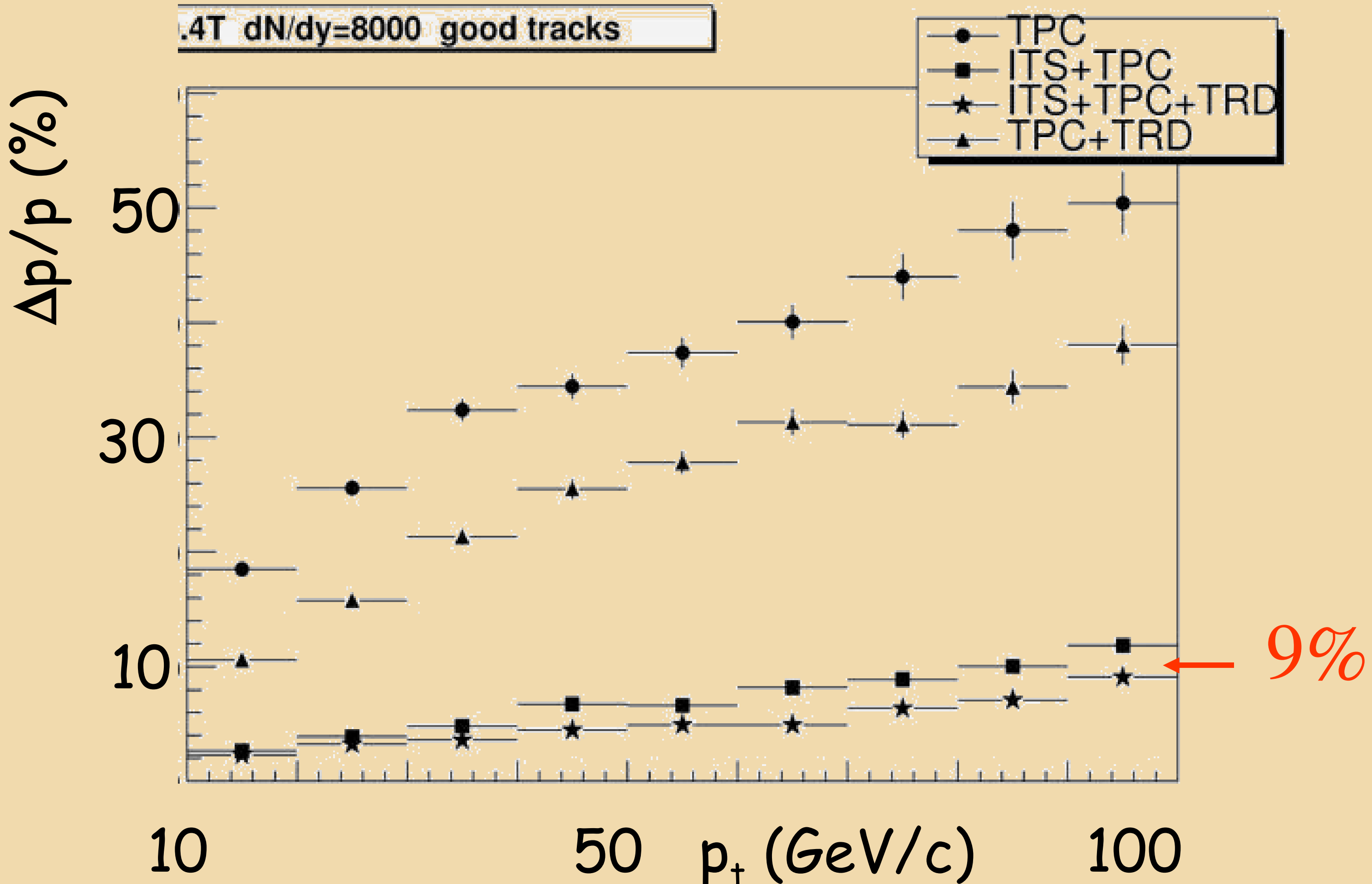
TRD prototype



TRD properties

- TRD will incerase the pion rejection by a factor 100 for e above 3 GeV/c
- TRD's momentum resolution of 5% at 5 Gev/C will be combied with TPC and ITS
- TRD needs a high granularity in order to cope with the high multiplicity and thus have an acceptable occupancy of about 34% at dN/dy=8000
- Radiation thickness of TRD will be ~ 15% X/X0

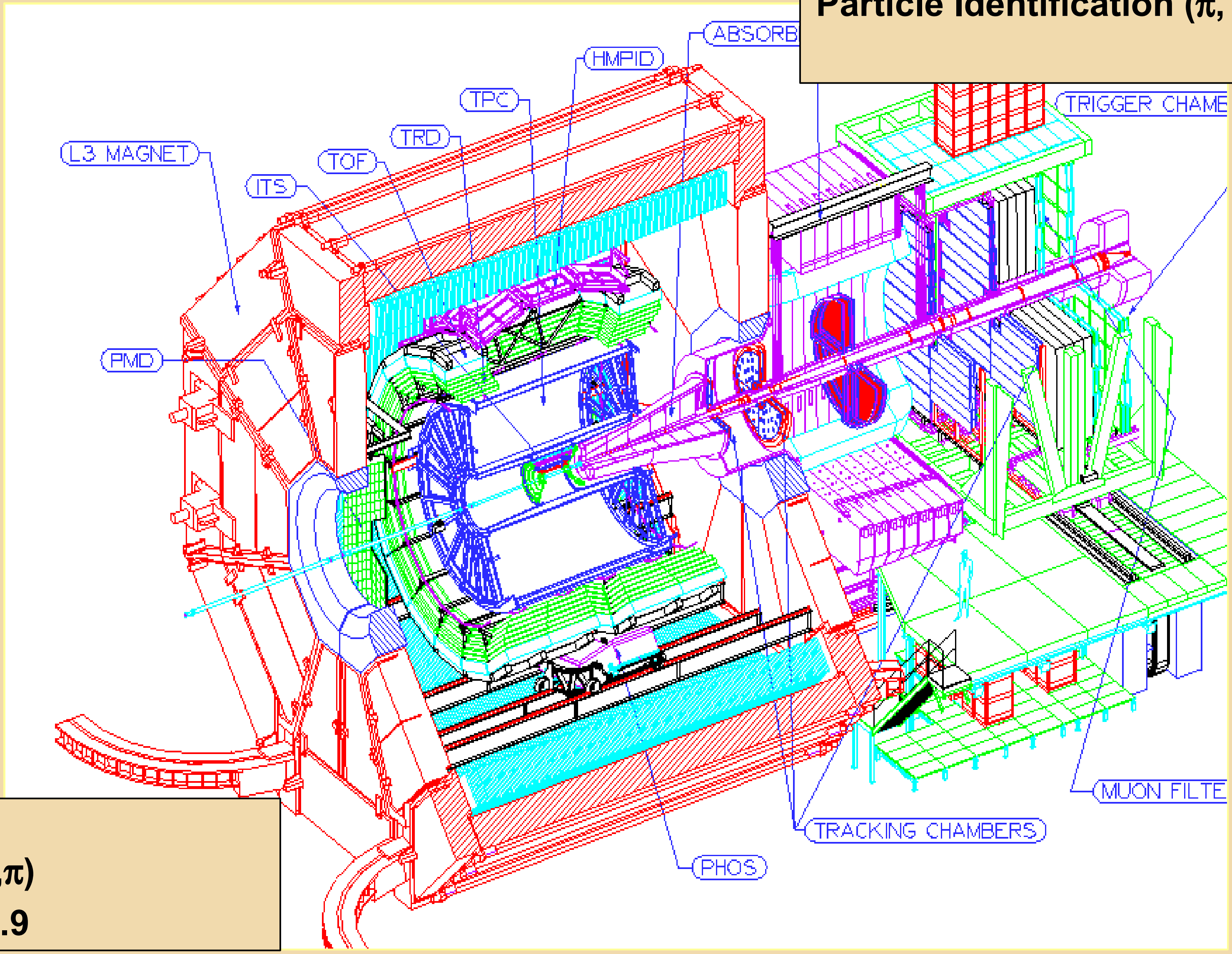
Combined Momentum Resolution



resolution ~ 9% at 100 GeV/c
excellent performance in hard region!

ALICE LAYOUT: PID

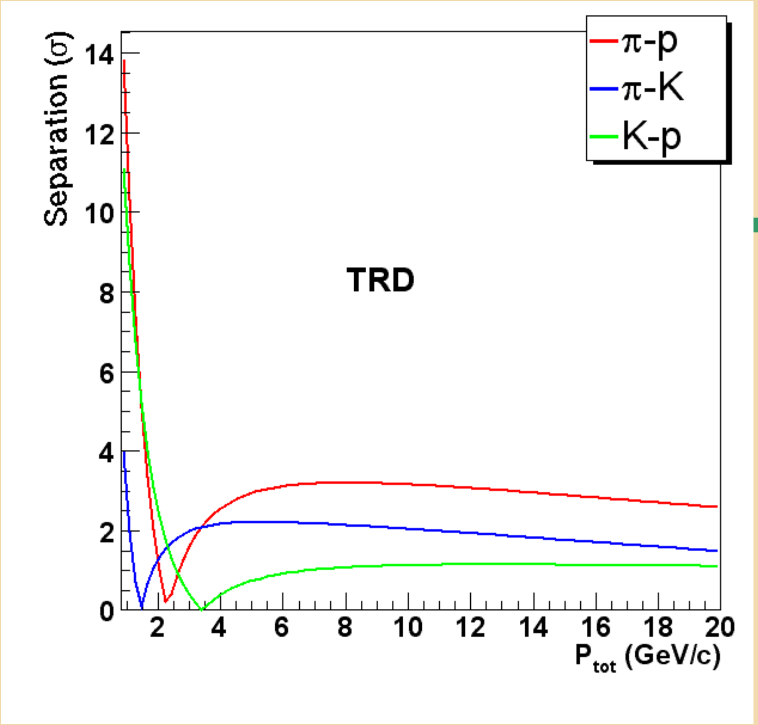
HMPID: High Momentum Particle Identification (π, K, p)



TOF

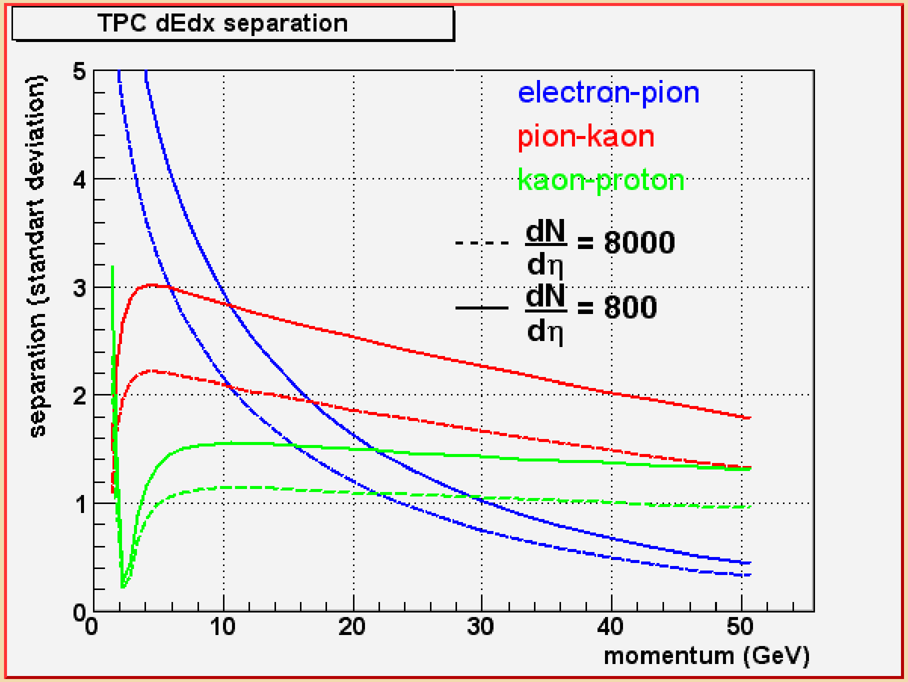
PID (K,p,π)

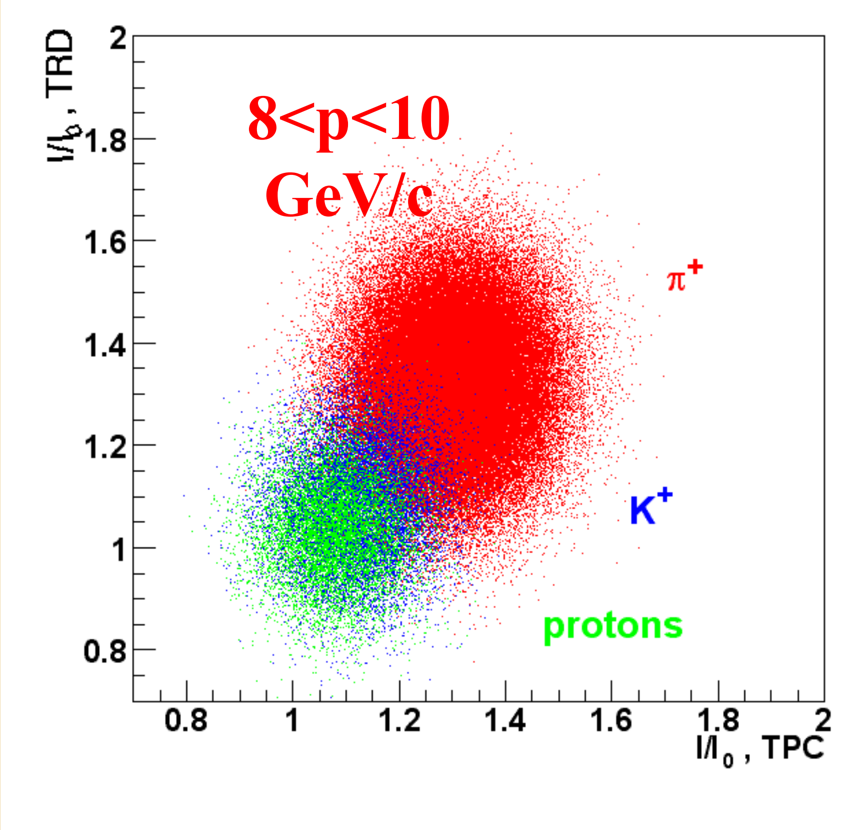
$-0.9<\eta<0.9$



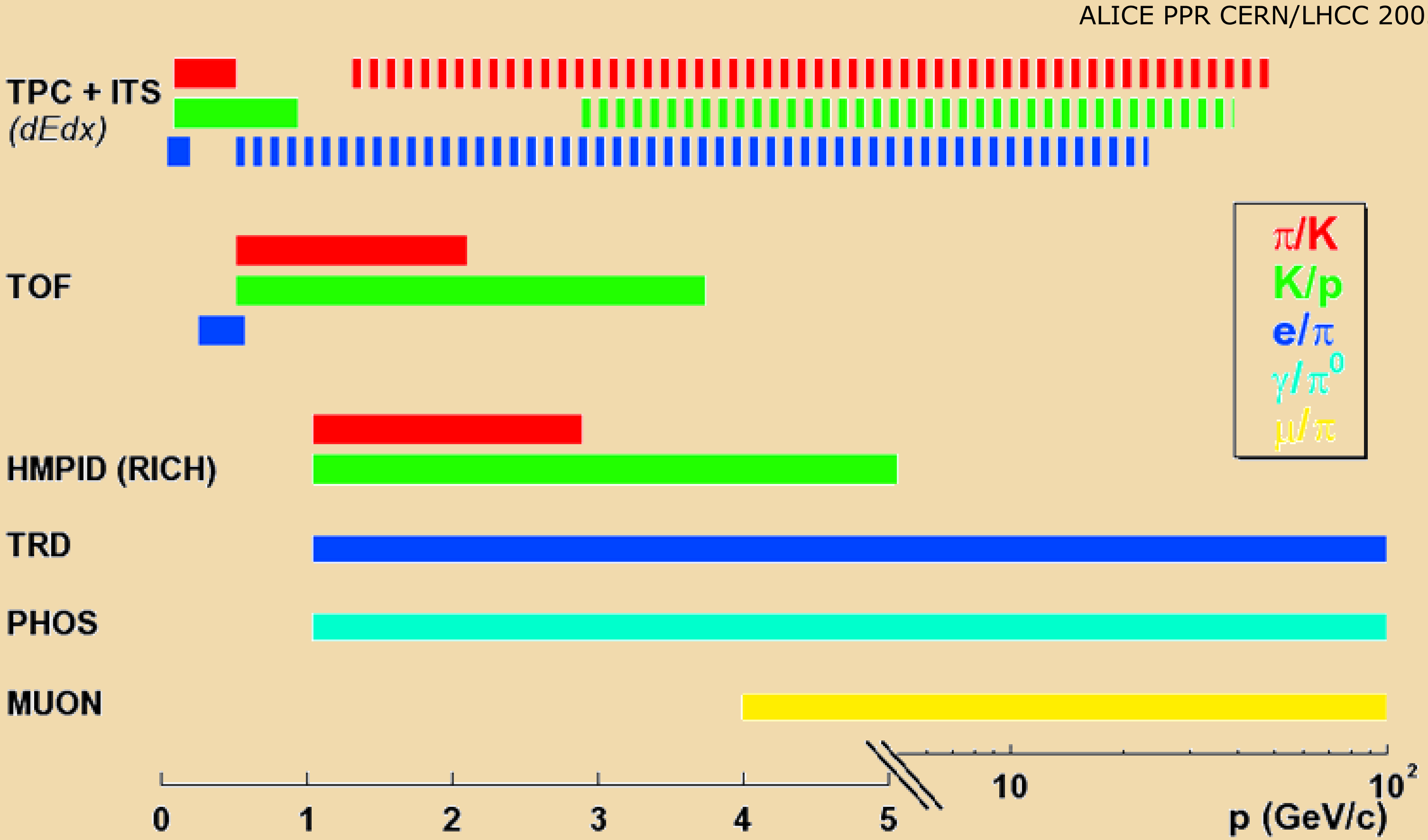
Under study: extension of PID to higher momenta

- Combine TPC and TRD dE/dx capabilities (similar number of samples/track) to get statistical ID in the relativistic rise region



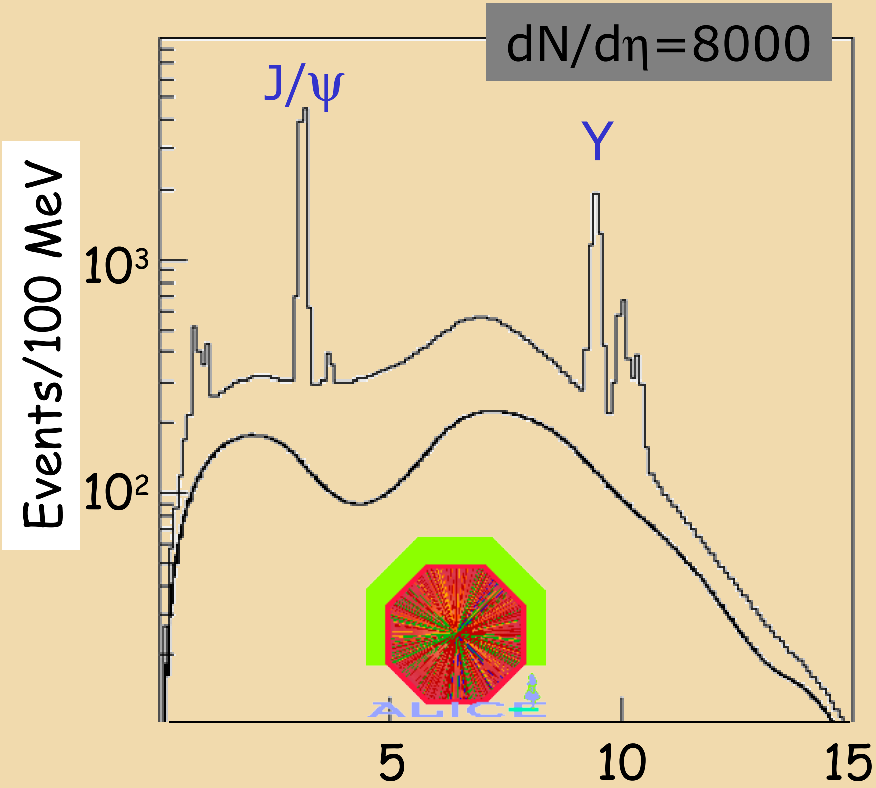


Hadron and Lepton Identification



c/b Quarkonia

- 1 month statistics of PbPb √sNN=5.5 TeV



Looking forward to first operation

- to a timely completion of LHC and experiments construction in April 2007;
  - Accelerators and experiments are in the production phase.

- For an exciting decade of HI physics in a new regime physics
  - Detailed physics program is taking shape (Physics Performance Reports, Yellow Report,..)

- The 2005 – 2007 challenge:
  - Keep the detector construction on its rather tight time scale
  - Continue preparation and bring to ready-state the physics analysis programs
  - demonstrate world-wide distributed Monte-Carlo production and data analysis.

Thank you !