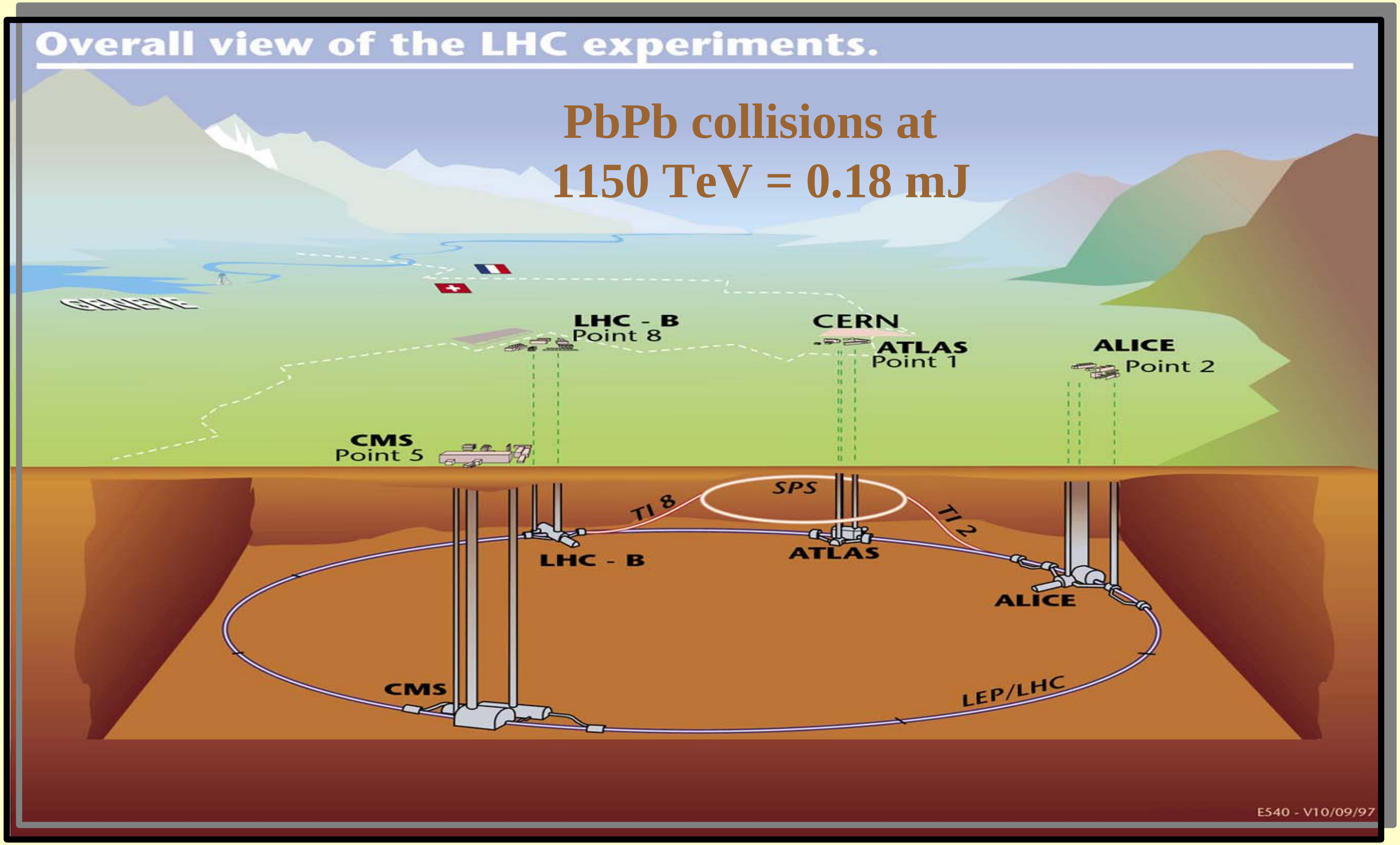
The ALICE experiment at LHC

- Experimental conditions at LHC
- The ALICE detector
- Some physics observables
- Conclusions

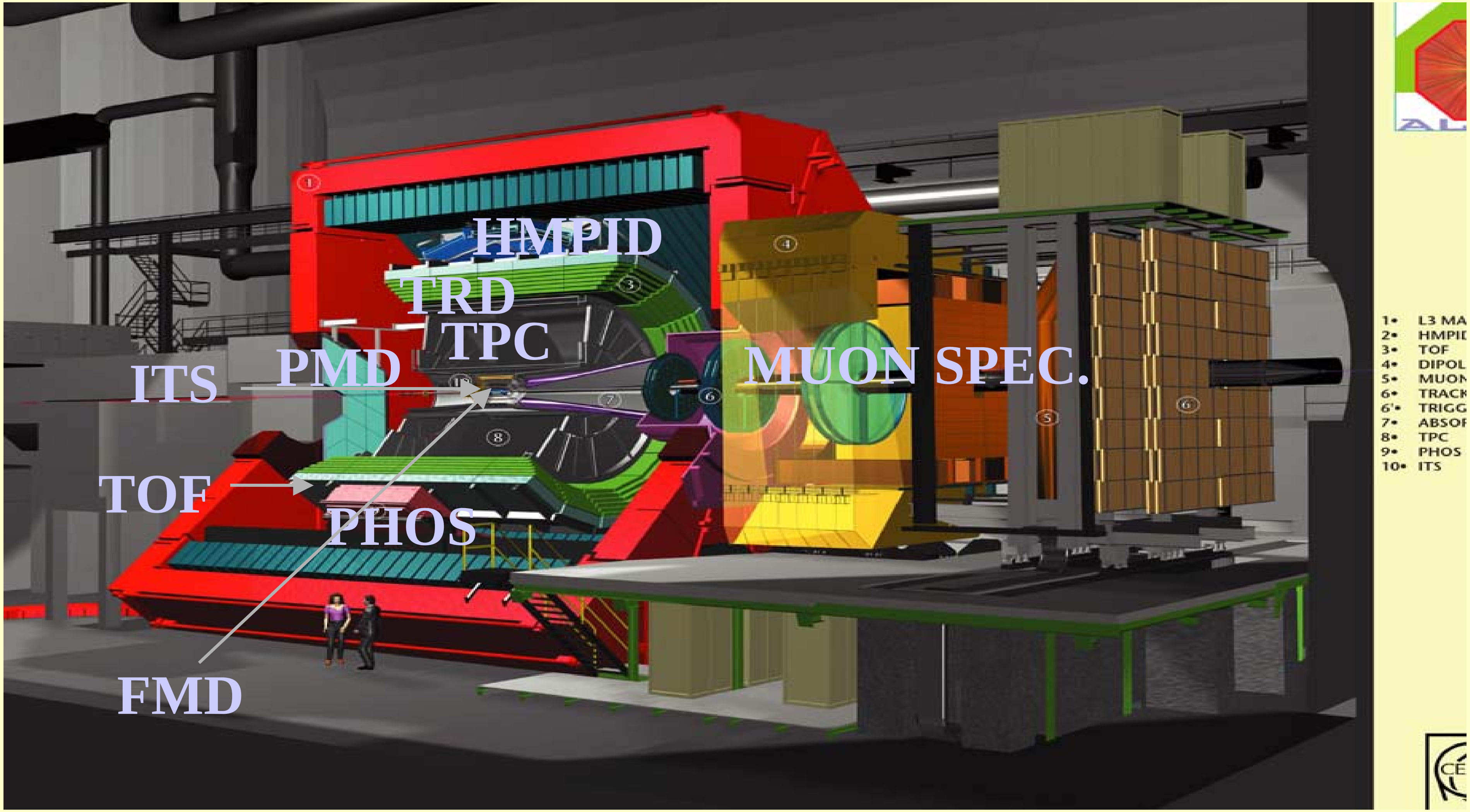
ALICE @ LHC


Overall view of the LHC experiments.
PbPb collisions at
1150 TeV = 0.18 mJ
GENEVE
LHC - B
Point 8
CERN
ATLAS
Point 1
ALICE
Point 2
CMS
Point 5
SPS
TI 8
TI 2
LHC - B
ATLAS
ALICE
CMS
LEP/LHC
E540 - V10/09/97

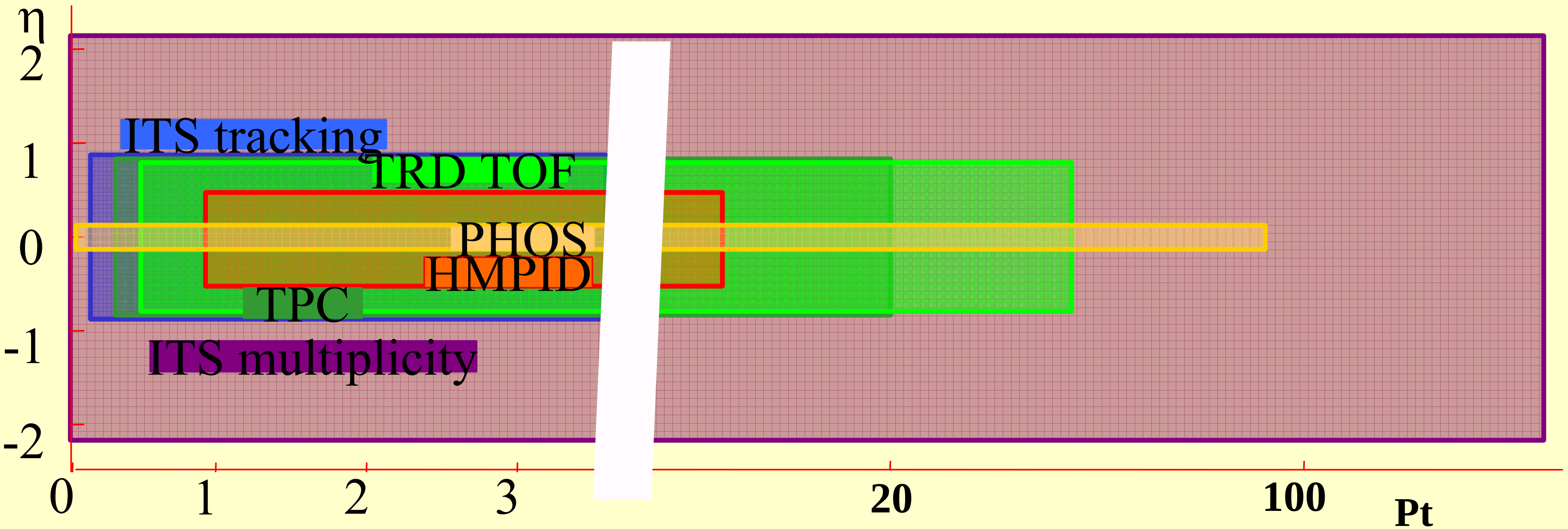
Experimental conditions @LHC

- 2007 start pp commissioning
- ALICE taking data in pp, pA and AA collisions
- ALICE programme at LHC, endorsed by LHCC
  - Initial few years (1HI 'year' = 10^6 effective s)
    - reg pp run at sqrt(s) = 14 TeV — L ~ 10^{29} and < $3x10^{30}$ cm^{-2} s^{-1}
    - 1-2 years Pb-Pb — L ~ 10^{27} cm^{-2} s^{-1}
    - 1 year p-Pb 'like' (p,d or α) — L ~10^{29} cm^{-2} s^{-1}
    - 1 -2 years light ions (eg Ar-Ar) — L ~ 10^{27} to 10^{29} cm^{-2} s^{-1}
- Heavy Ion running part of LHC initial programme, early pilot run expected by end of 2007 program

The ALICE experiment

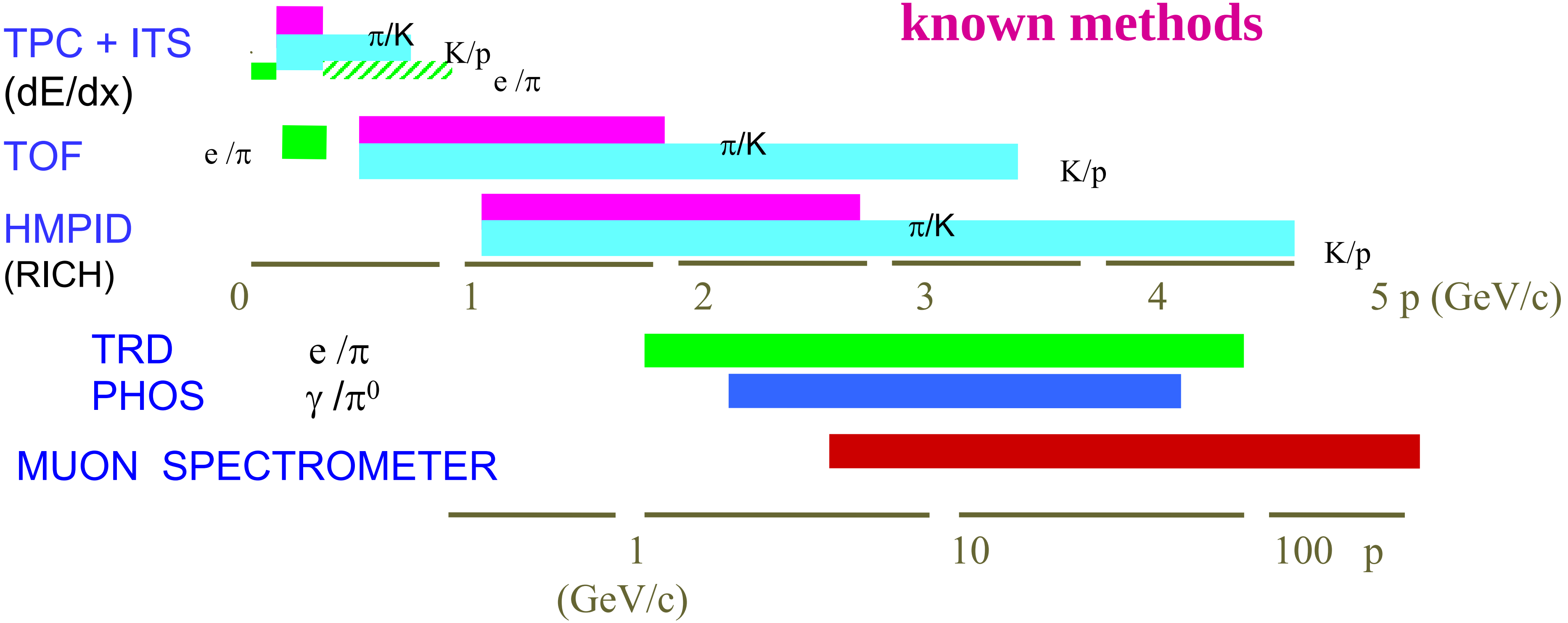


ALICE acceptance



Muon arm 2.4 < η < 4
PMD 2.3 < η < 3.5
FMD -5.4 < η < -1.6
1.6 < η < 3

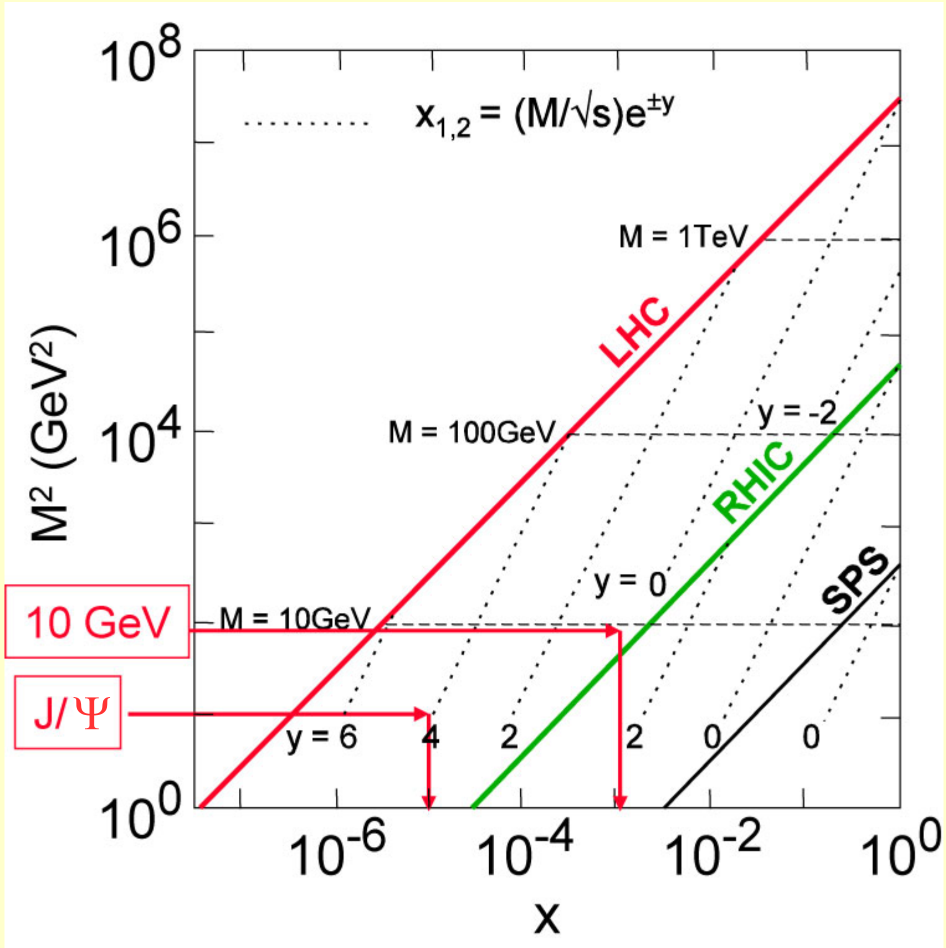
PID in ALICE


ALICE uses almost all known methods
TPC + ITS
(dE/dx)
π/K
K/p
e /π
TOF
e /π
π/K
K/p
HMPID
(RICH)
π/K
K/p
0
1
2
3
4
5 p (GeV/c)
TRD
e /π
PHOS
γ /π0
MUON SPECTROMETER
1
10
100 p
(GeV/c)

LHC new aspects I

-- probe initial partonic state
in a novel Bjorken-x range
(10^{-3} - 10^{-5})
--> nuclear shadowing
--> high density saturated
gluon distribution (CGC)

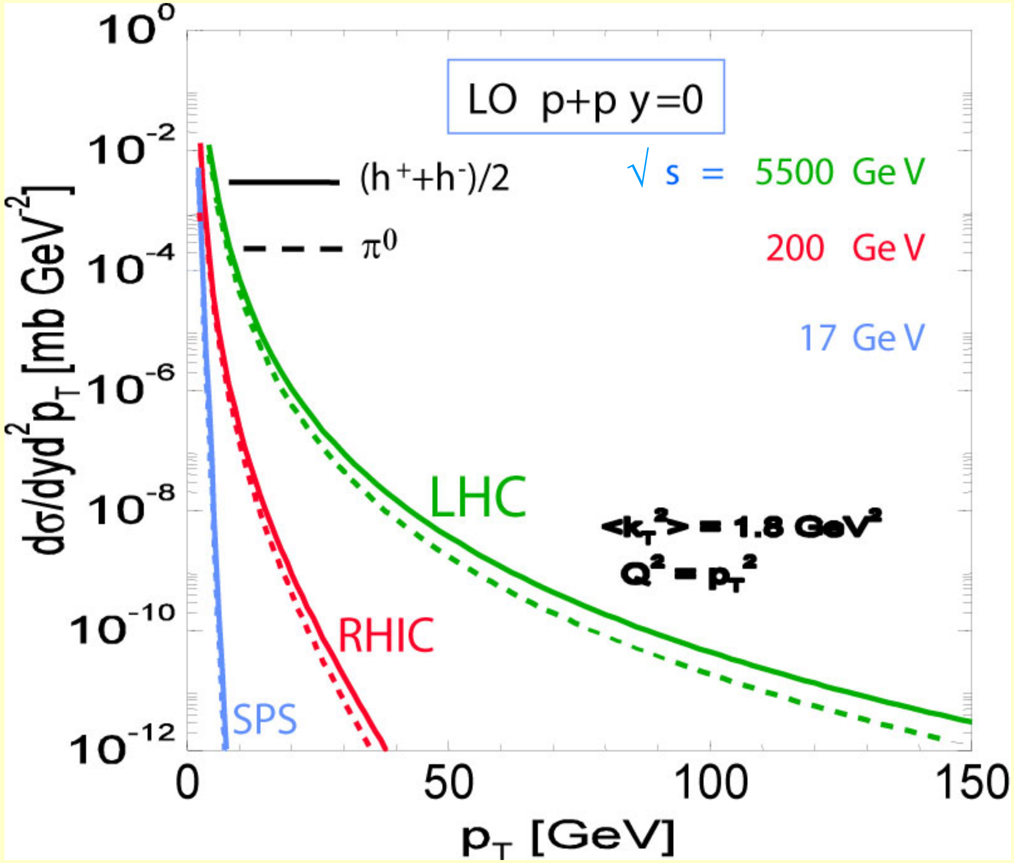
-- Larger saturation scale
($Q_s = 0.2\ A^{1/6}\ \sqrt{s}^{\ 0.2} = 2.7$ GeV)
particle production dominated
by saturation region



LHC new aspects II

-- Hard processes contribute significantly to the total AA cross section ($\sigma^{hard}/\sigma^{tot}$ = 98 %)
  --> bulk properties dominated by hard processes
  --> very hard probes are abundantly produced

-- Weakly interacting probes become accessible (γ, Z^0, W^{+-})



ALICE physics goals

Global observables: - *multiplicities, η-distributions*
Degrees of freedom as function T: - *hadron ratios and spectra, dileptons, direct photons*
Early state signal collective effects: - *elliptic flow*
Parton energy loss in deconfined state: - *jet quenching, high pt spectra, open charm & beauty*
Study of deconfinement: - *quarkonia spectroscopy*
Study of chiral symmetry restoration: - *neutral to charged ratio, resonance decays*
Fluctuation signals – critical behaviour: - *event by event particle composition, spectra*
Geometry of emitting source: - *HBT, impact parameter by zero degree energy flow*
Study of pp collisions in energy domain

-> Large acceptance
-> wide momentum coverage
-> good secondary vertex reconstr
-> good tracking capabilities
-> PID of hadrons and leptons
-> Photon detection

ALICE Collaboration 2004: Physics Performance Report, Vol I,
J. Phys. G: Nucl. Part. Phys. ***30*** *1517 - 1763*

Multiplicity AA

- Dimensional arguments: at saturation scale Q_S
- N = transverse particle density per rapidity unit
  - $N/R_A{}^2 = Q_S{}^2$, $R_A = A^{1/3}$ fm
- all particles produced by hard subprocesses
  - for central A-A collisions , at scale Q_S
  - $N = A^2/R_A{}^2 \times 1/Q_S{}^2 = Q_S{}^2 R_A{}^2$, $A^2/R_A{}^2 = T_{AA}$ (b=0fm)

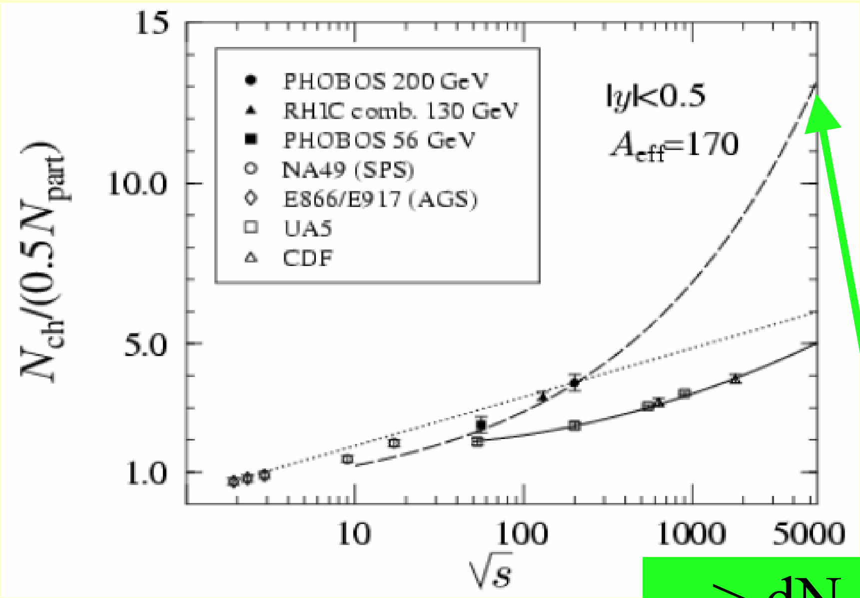
→$Q_S = 0.2 A^{1/6}$ GeV

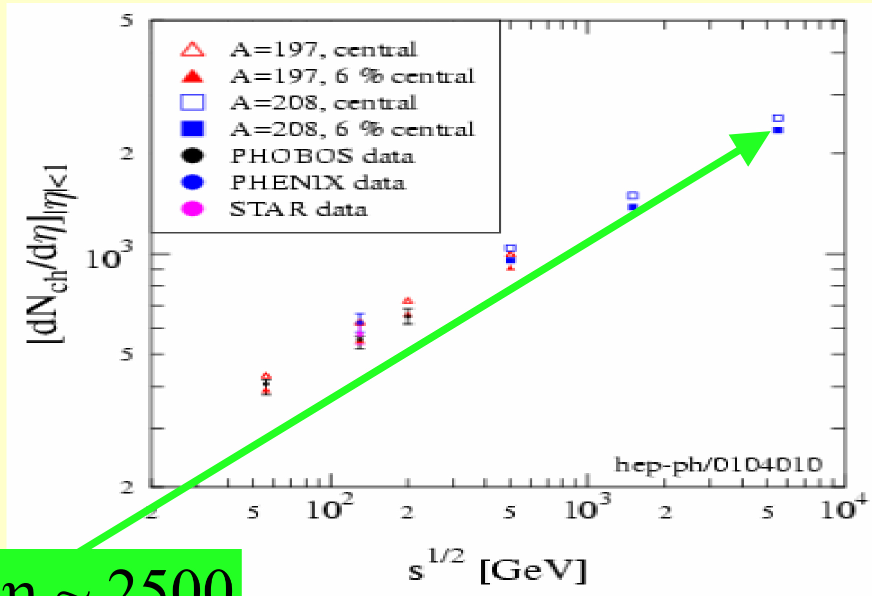
More accurate $Q_S = 0.2 A^{1/6} s^b$, $b \sim 0.1$

Which multiplicity at LHC ?

Former estimate: dN/dy = 2000 – 8000, extrapolation from RHIC data possible

uncertainties - shadowing/saturation (decrease)
- jet quenching (increase)
- A-scaling (important soft vs. hard changes with energy)





-> $dN_{ch}/d\eta \sim 2500$

(K.Kajantie, K.Eskola)

ALICE optimized for dN_{ch}/dy = 4000, checked up to 8000

Parton energy loss

- Parton energy loss in medium $<\Delta E> \propto \alpha_s C_R q L^2$
    - C_R Casimir coupling factor, 4/3 for quarks, 3 for gluons
    - q medium transport coefficient $\propto$ gluon density and momenta
    - L pathlength in medium
- Reduction of single inclusive high p_t particles
    - parton specific (stronger for gluons than quarks)
    - flavour specific (stronger for light quarks)
    - Identify hadrons (π,K,p,Λ) + partons (charm,beauty) at high p_t
- Suppression of mini-jets, same-side/away-side correlations
- Change of fragmentation function for hard jets (p_t >> 10 GeV/c)

Study parton energy loss

Compare p_t-distributions of leading particles in pp, pA and AA collisions

Nuclear modification factor:

$$R_{AA}(p_t) = \frac{1}{T_{AA}} \times \frac{dN_{AA}/dp_t}{dN_{pp}/dp_t}$$

Dead cone effect for heavy quarks with momenta < 20-30 GeV/c (v<<c)
- gluon radiation suppressed at angles < m_Q/E_Q
- Dokshitzer and Kharzeev: *dead cone implies lower energy loss*

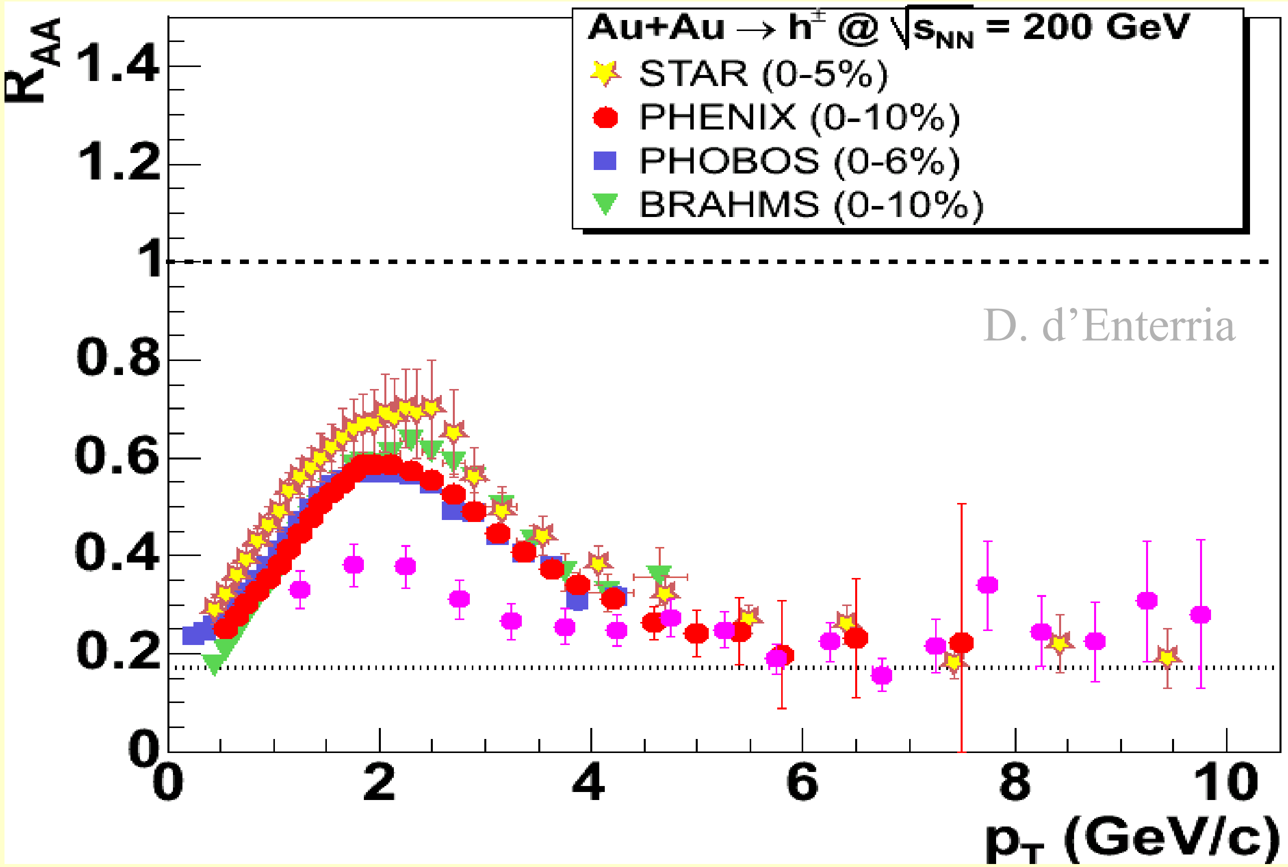
⇒ D meson quenching reduced
⇒ Ratio D/hadrons (D/π^0) enhanced and sensitive to medium properties

High Pt yield of particles

Results from RHIC experiments

D. d`Enterria

QM04`

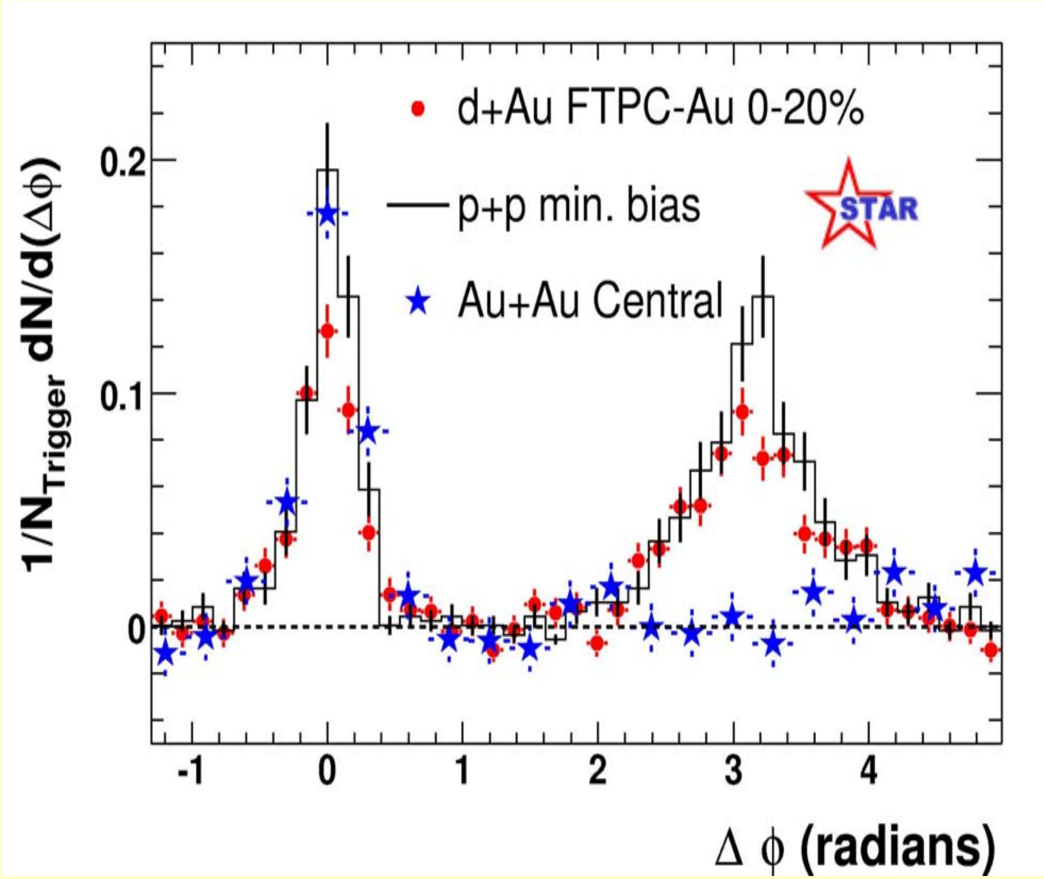


Jet quenching results

STAR at RHIC

Azimuthal jet correlation

- Established in:
  - p+p min. bias
  - d+Au
- suppressed in
  - Au-Au central



→ *See talk by Salgado, friday*

Quarkonia

- Quarkonia rates sensitive to nuclear absorption and secondary scattering, parton distributions, nuclear gluon shadowing
- Expect quarkonia in AA collisions reduced relative to pp or pA
- BUT copiously produced uncorrelated $\underline{q}q$-pairs may form final state quarkonium -> *Is there quarkonia enhancement at LHC ?*
- Reference: total charm/beauty cross section
- Quarkonia suppression as thermometer for deconfinement transition
- Charmonium ground state J/ψ, ηc (F.Karsch QM'04):
  - Still exist at 1.5 T_c, gradually disappear for T > 1.5 T_c, are gone at 3 T_c
  - Radial excitations disappear at T_c

Deconfinement and screening

Deconfinement ~ screening of the static potential between heavy quarks

T = 0: heavy quark bound states described by confining potential

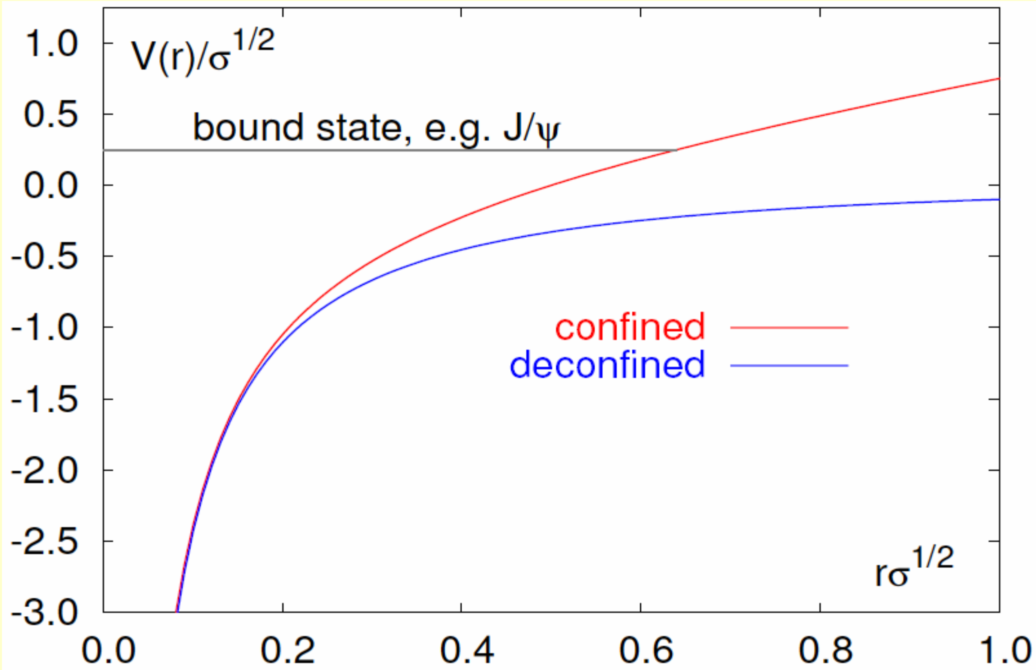
$V_{qq}(r) = -4\alpha/3r + \sigma r$

$\alpha = g^2(r)/4\pi$

T > Tc: no bound state in a Debye screened potential:

$V_{qq}(r,T) \sim -\alpha/r \exp(-\mu r)$

$\alpha = g^2(T)/4\pi$



$V_{qq}(r,T) \to \infty$ confinement

$V_{qq}(r,T) < \infty$ no confinement

Heavy quark free energy - heavy quark potential (Lattice QCD)

Singlet free energy $F_1(r,T)$
F.Karsch QM'04

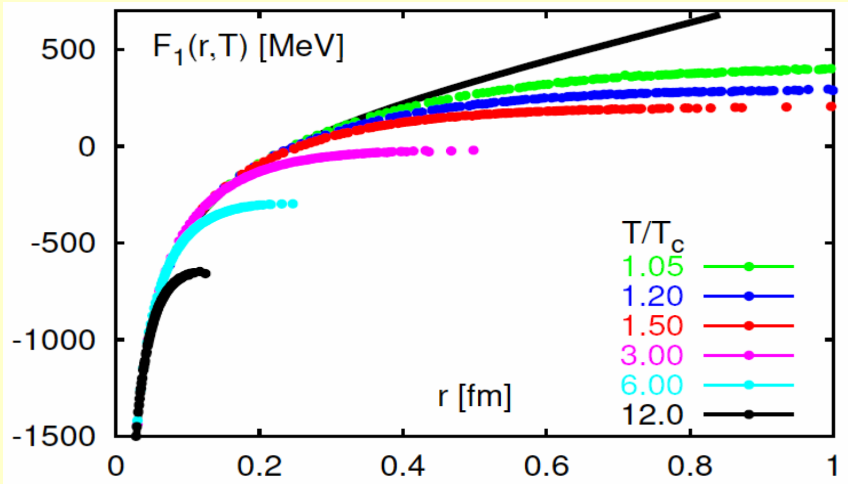
Singlet energy <=> “potential” energy

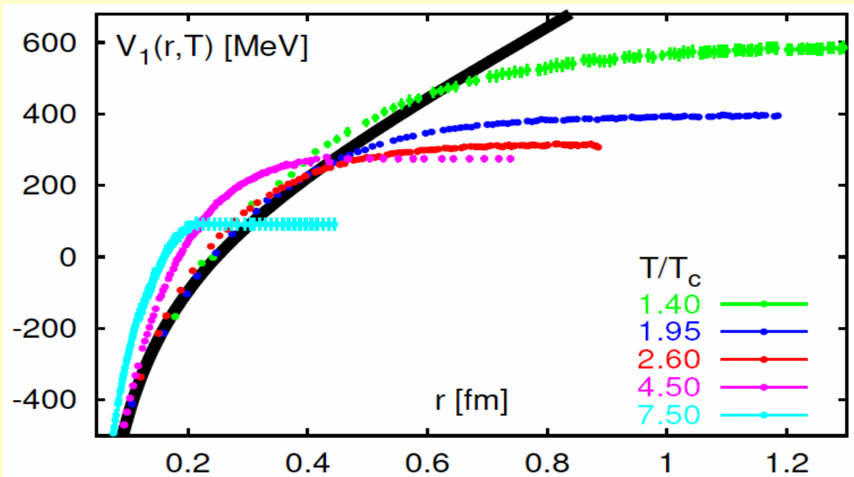
$$V_1(r,T) = -\,T^2 \frac{\partial F_1(r,T)/T}{\partial T}$$

- *potential is “deeper”: V(r,T) > F(r,T)*
- *potential “barrier” high above Tc*
- *“potential” screened at short distances*

At what temperature do heavy quark states really disappear ?

→ *See talk by Wong, friday*



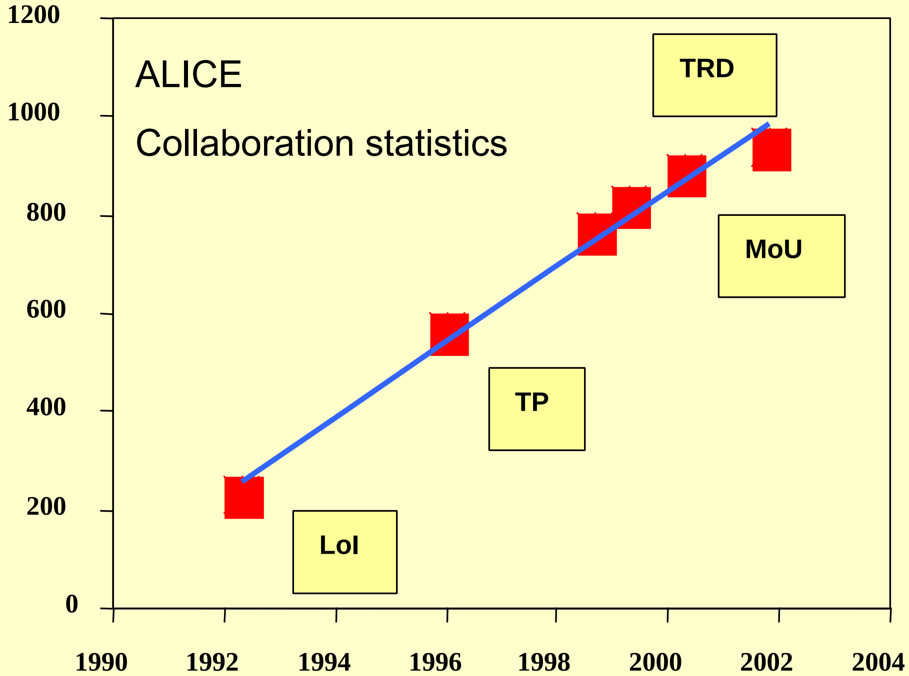


Conclusions

- LHC experiments will take data in two years
- ALICE measuring pp, pA, AA collisions
- rich and diverse physics program
- Exciting times ahead for experimentalist and theorists

The ALICE collaboration

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

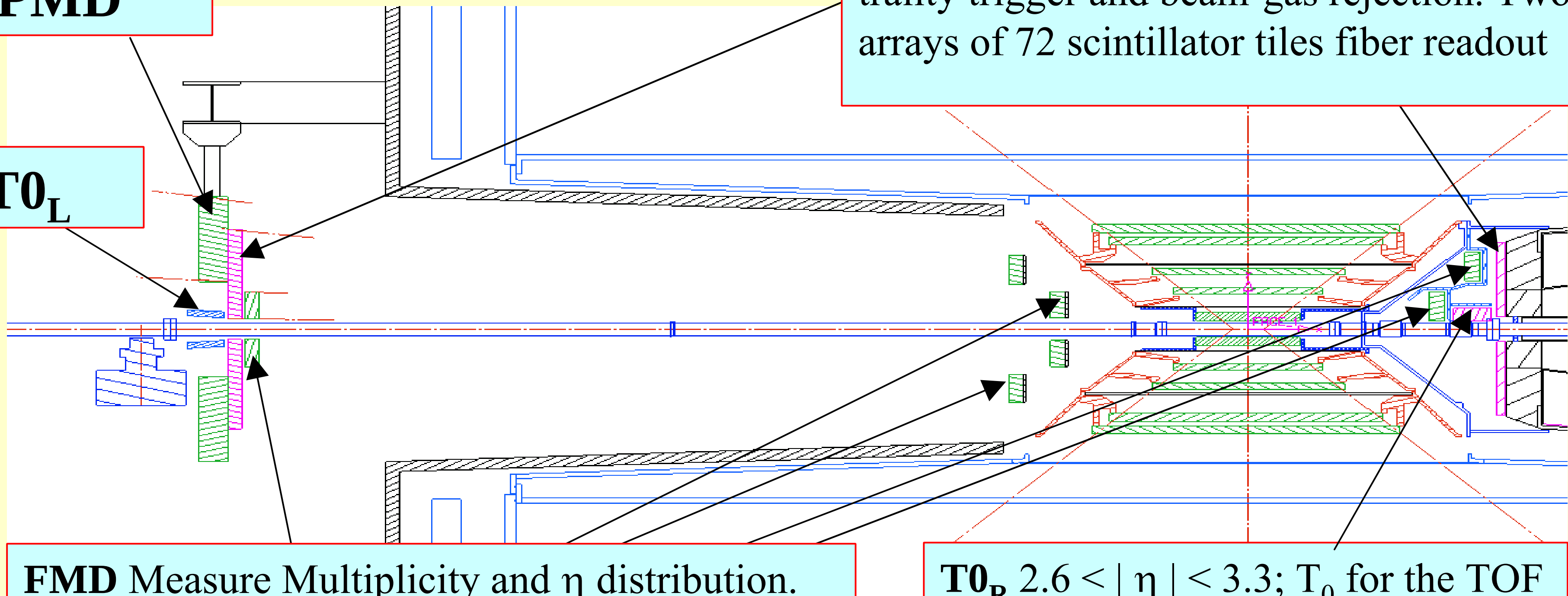


- 937 members
- 77 Institutions
- Discussion with China,Japan US

Forward Detectors

PMD

$T0_L$



V0 1.6 < | η | < 3.9 Interaction trigger, centrality trigger and beam-gas rejection. Two arrays of 72 scintillator tiles fiber readout

FMD Measure Multiplicity and η distribution. Over 1.6 < η < 3, -5.4 < η < -1.6 ; Silicon pad detector disks (slow readout) with 12k analog channels (occ.>1)

$T0_R$ 2.6 < | η | < 3.3; T_0 for the TOF (~ 50 ps time res.) Two arrays of 12 quartz counters. Also backup to V0