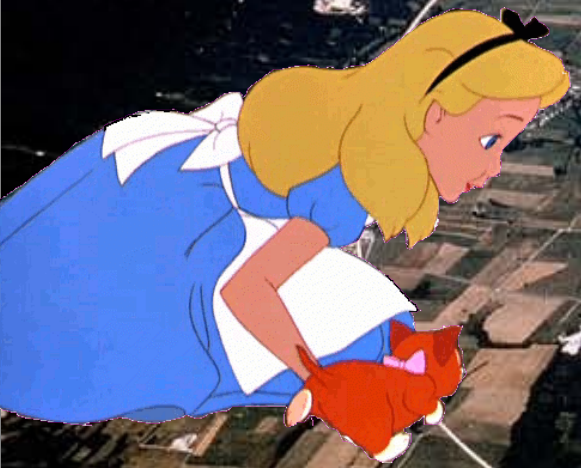
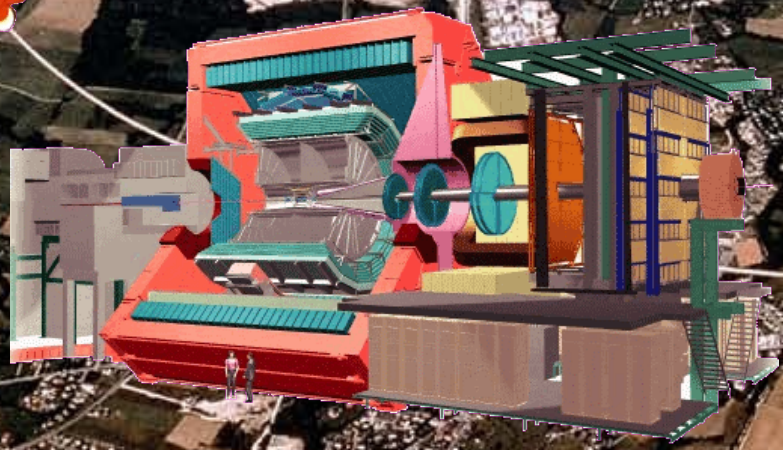
Results from ALICE

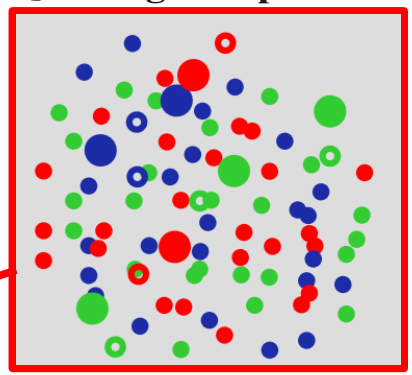
Christine Nattrass
for the ALICE collaboration
University of Tennessee at Knoxville





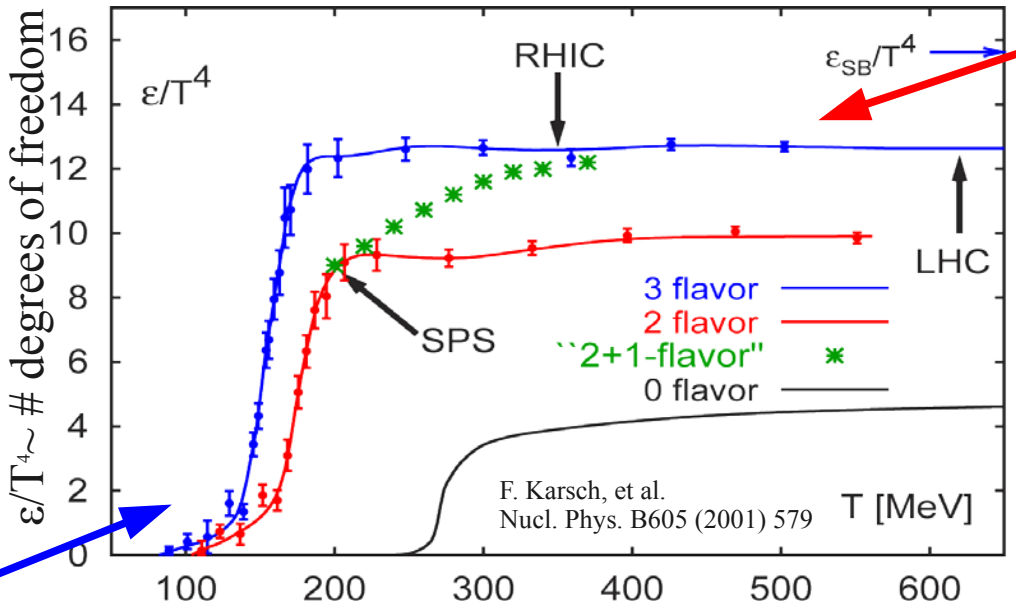
Exploring QCD at high temperatures

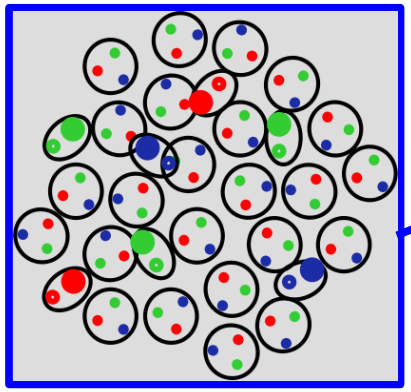
Quark-gluon plasma



Deconfined - more degrees of freedom

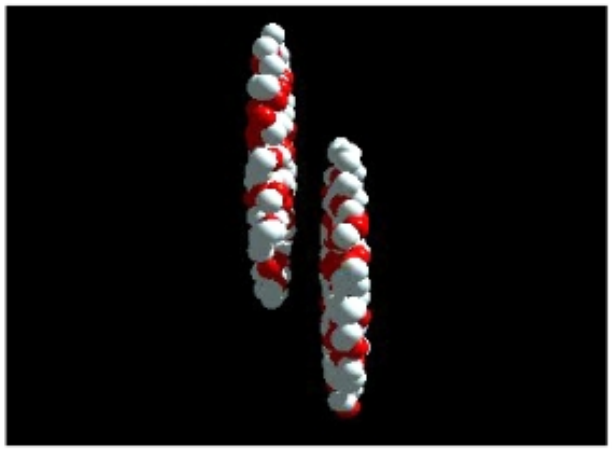
$T_c \sim 175 \pm 8$ MeV $\rightarrow \varepsilon_c \sim 0.3$ -1 GeV/fm^3

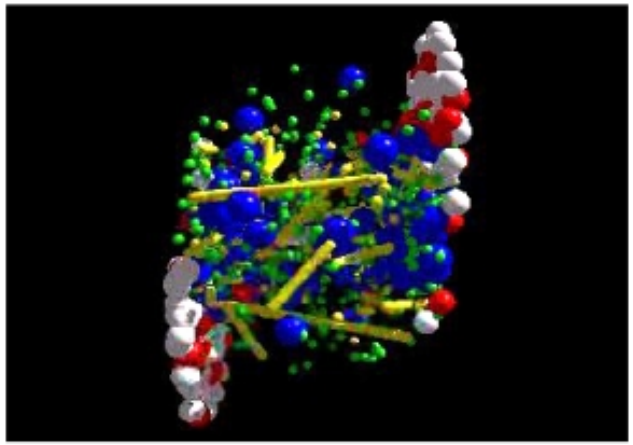


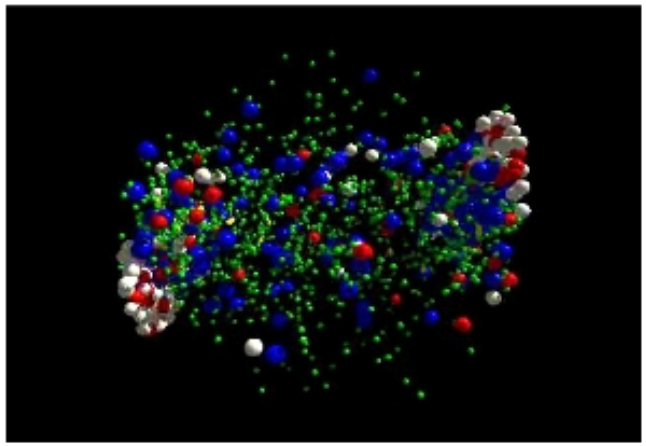


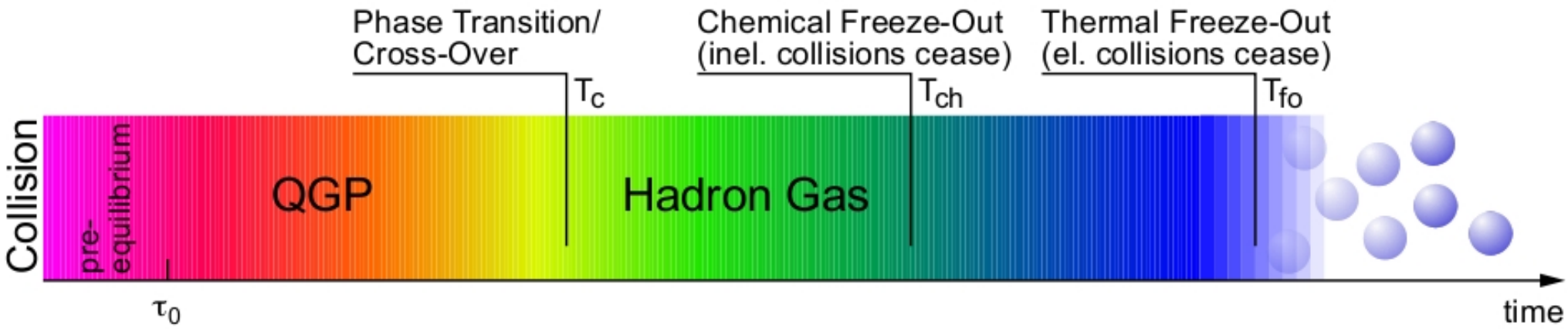
Confined - fewer degrees of freedom

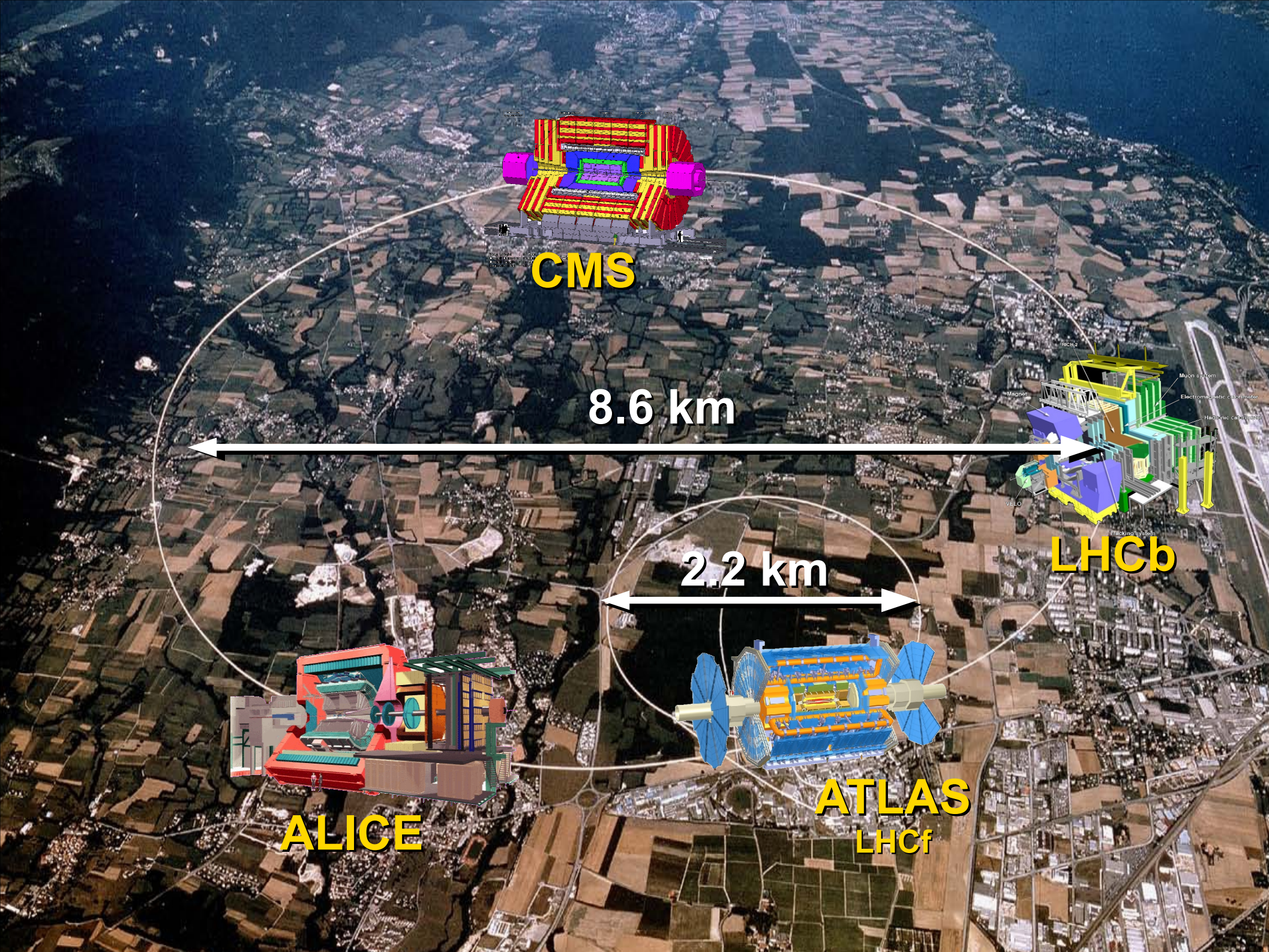
The phase transition in the laboratory

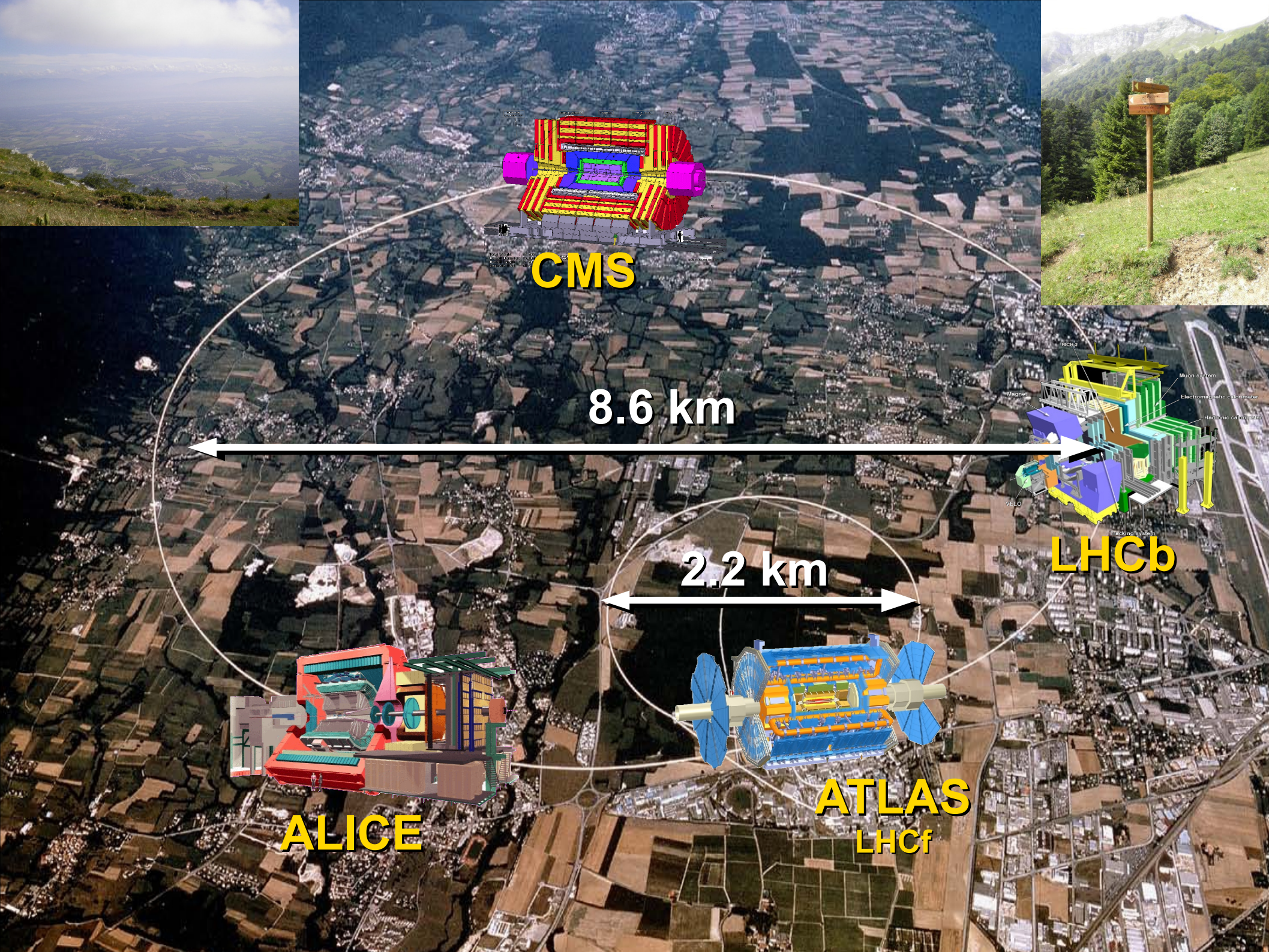









CMS
8.6 km
LHCb
2.2 km
ALICE
ATLAS
LHCf


CMS
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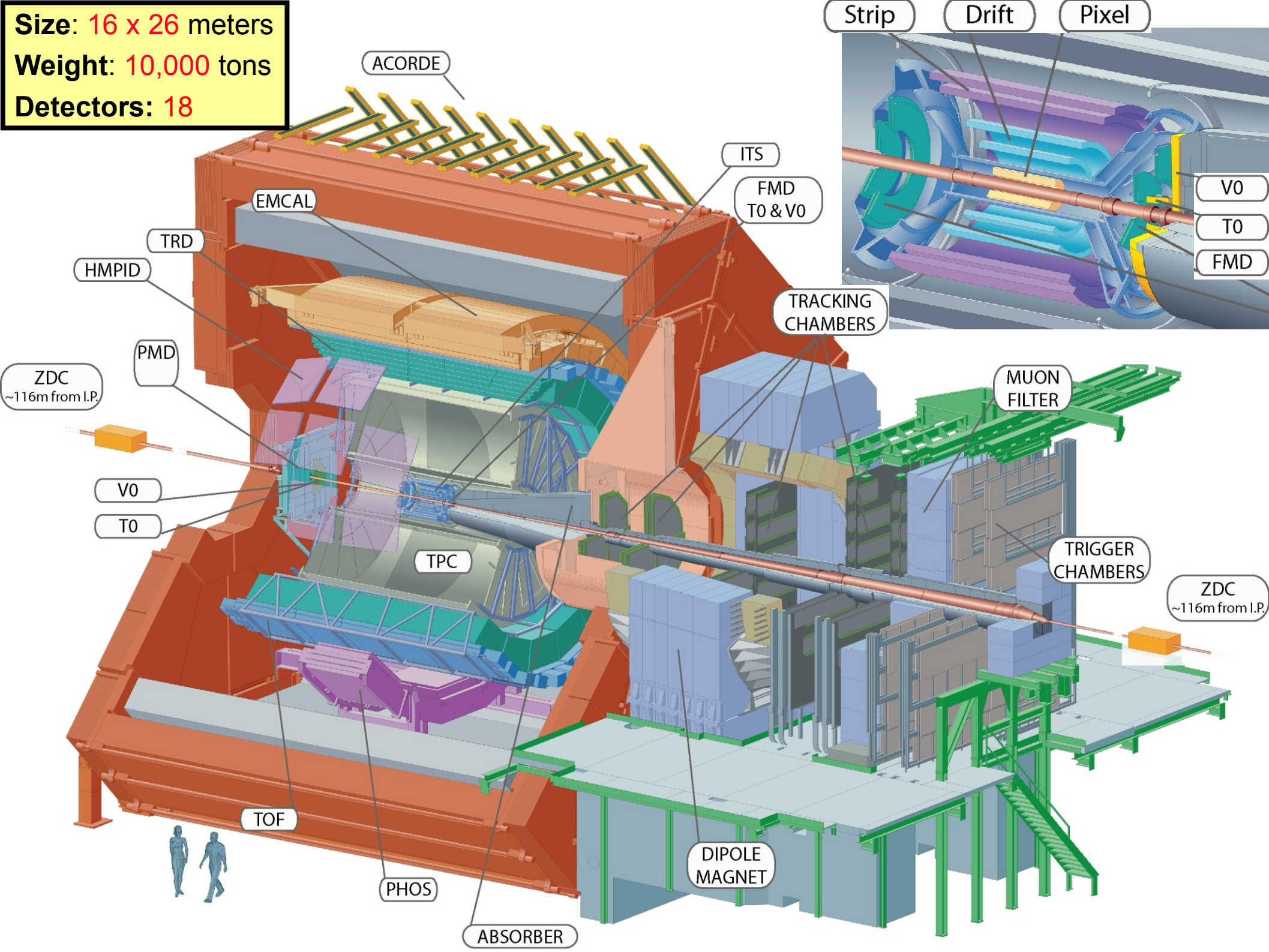
ALICE
ATLAS
LHCf


ALICE
~1000 members
~30 countries
~100 institutes


Size: 16 x 26 meters
Weight: 10,000 tons
Detectors: 18
ACORDE
ITS
FMD
T0 & V0
EMCAL
TRD
HMPID
TRACKING
CHAMBERS
PMD
ZDC
~116m from I.P.
MUON
FILTER
V0
T0
TPC
TRIGGER
CHAMBERS
ZDC
~116m from I.P.
TOF
PHOS
DIPOLE
MAGNET
ABSORBER
Strip
Drift
Pixel
V0
T0
FMD

Size: 16 x 26 meters
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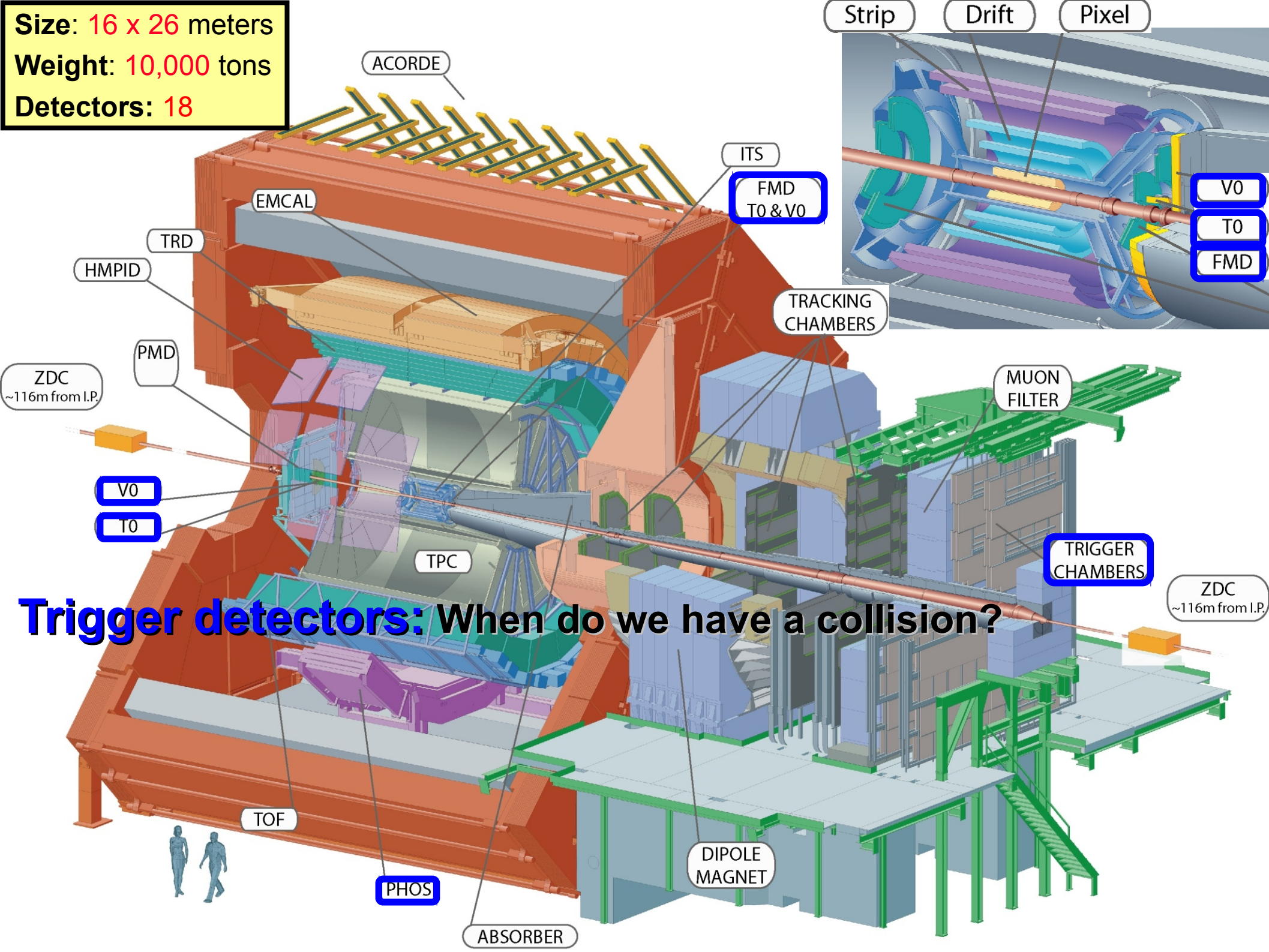

Trigger detectors: When do we have a collision?

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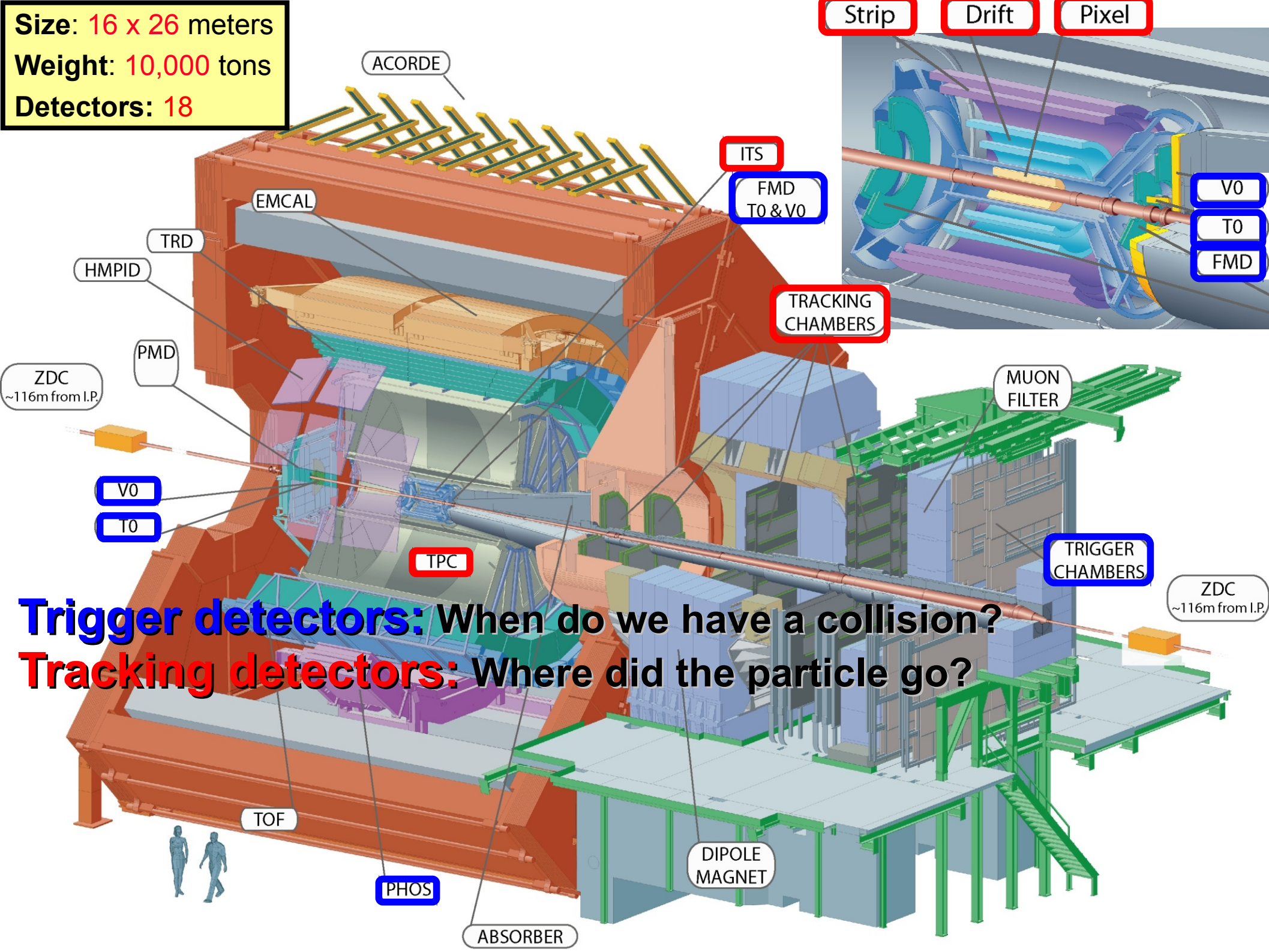

Trigger detectors: When do we have a collision?
Tracking detectors: Where did the particle go?

Size: 16 x 26 meters
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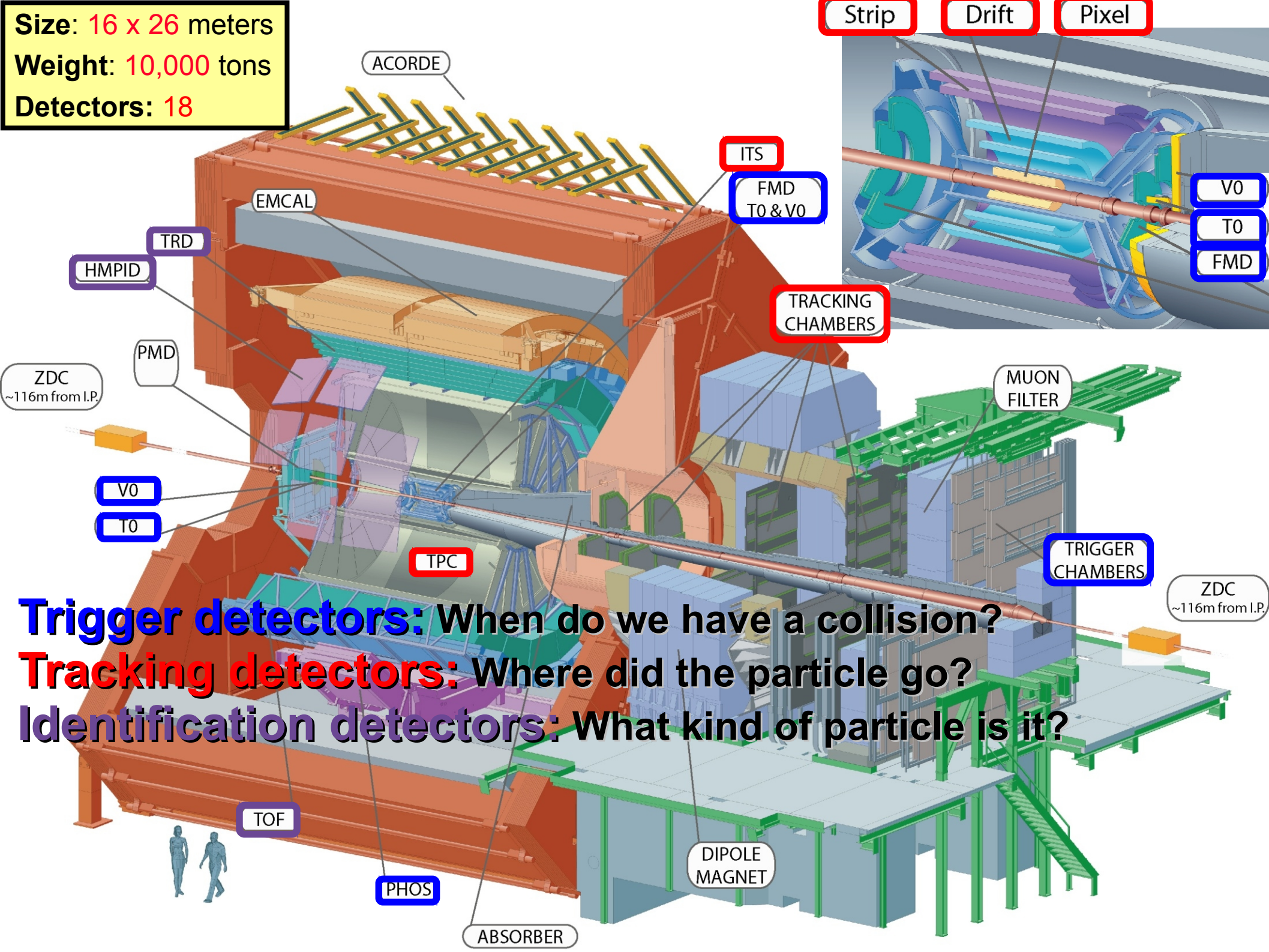
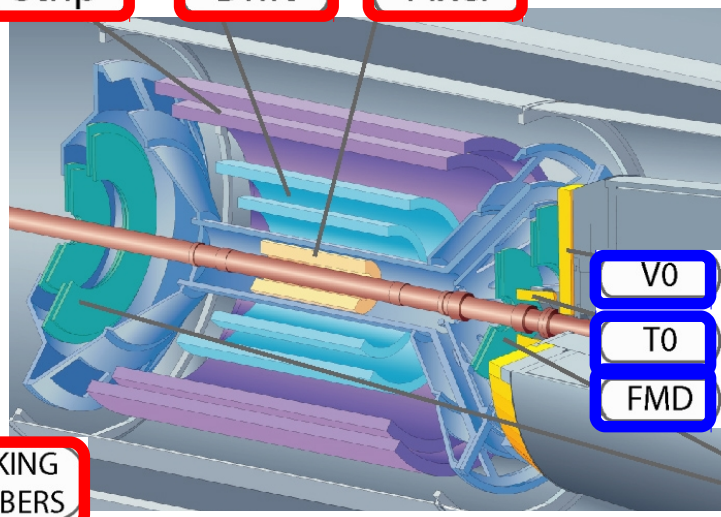


Trigger detectors: When do we have a collision?
Tracking detectors: Where did the particle go?
Identification detectors: What kind of particle is it?

Size: 16 x 26 meters
Weight: 10,000 tons
Detectors: 18



ACORDE
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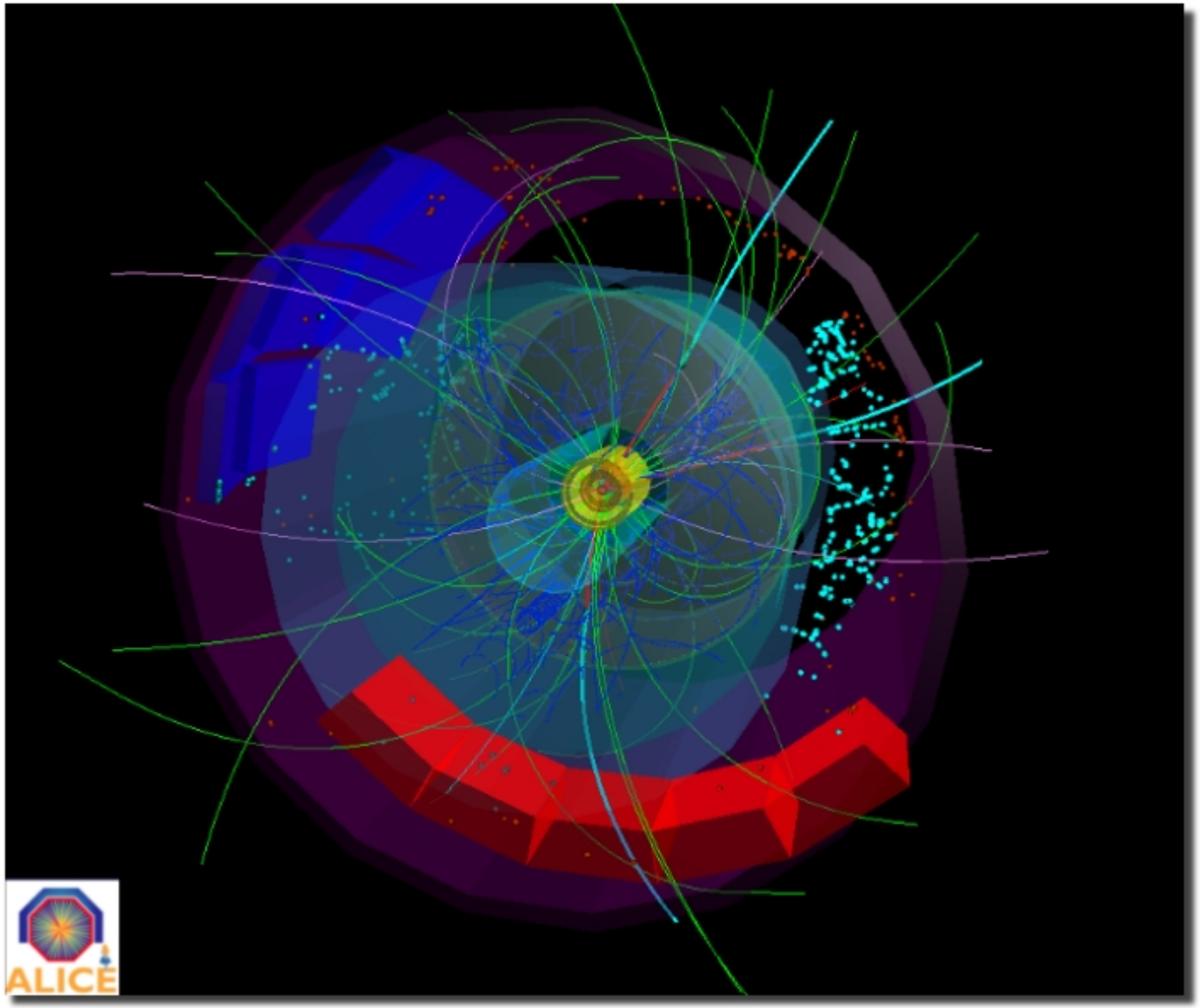
PMD
ZDC
~116m from I.P.
MUON
FILTER
V0
T0
TPC
TRIGGER
CHAMBERS
ZDC
~116m from I.P.

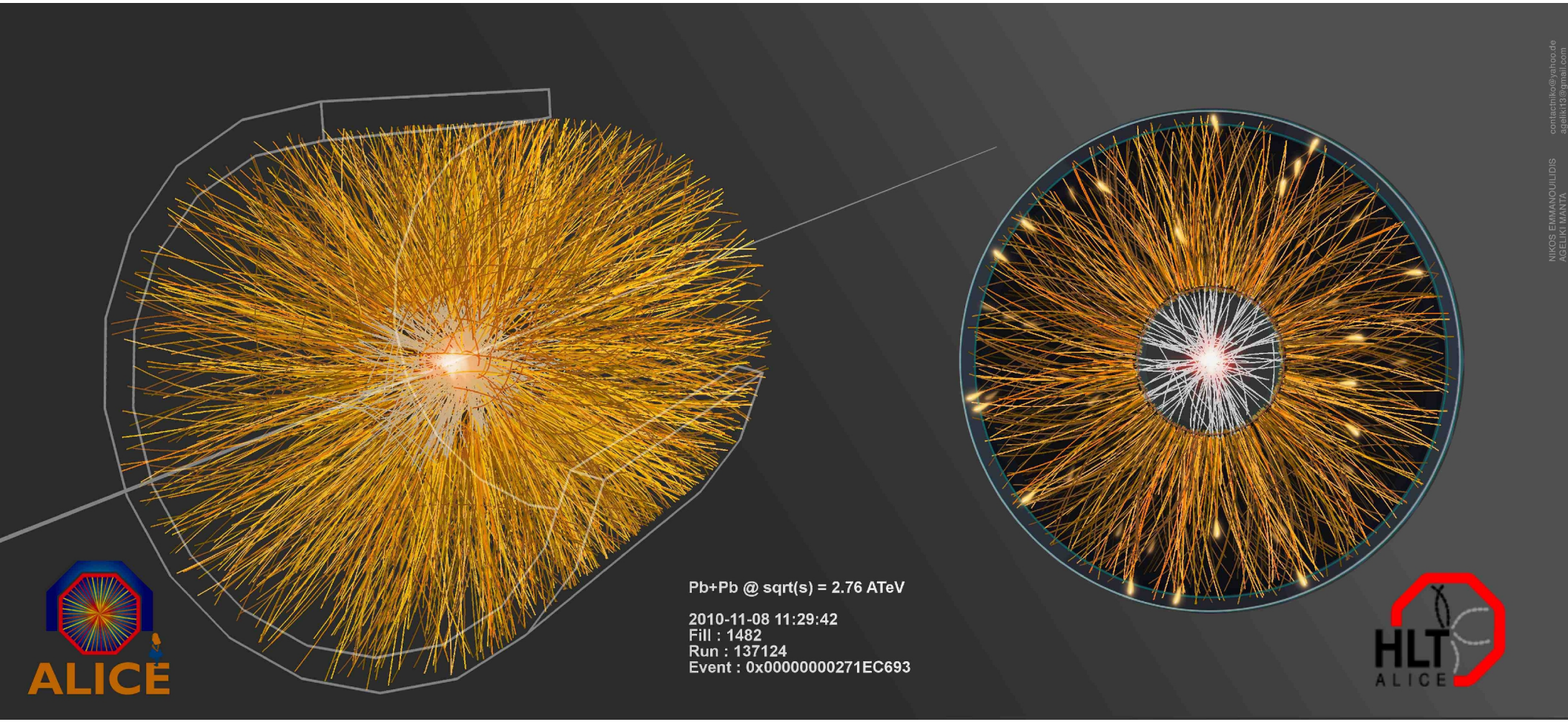
Trigger detectors: When do we have a collision?
Tracking detectors: Where did the particle go?
Identification detectors: What kind of particle is it?
Calorimeters: How much energy does the particle have?

TOF
PHOS
DIPOLE
MAGNET
ABSORBER

p+p collisions

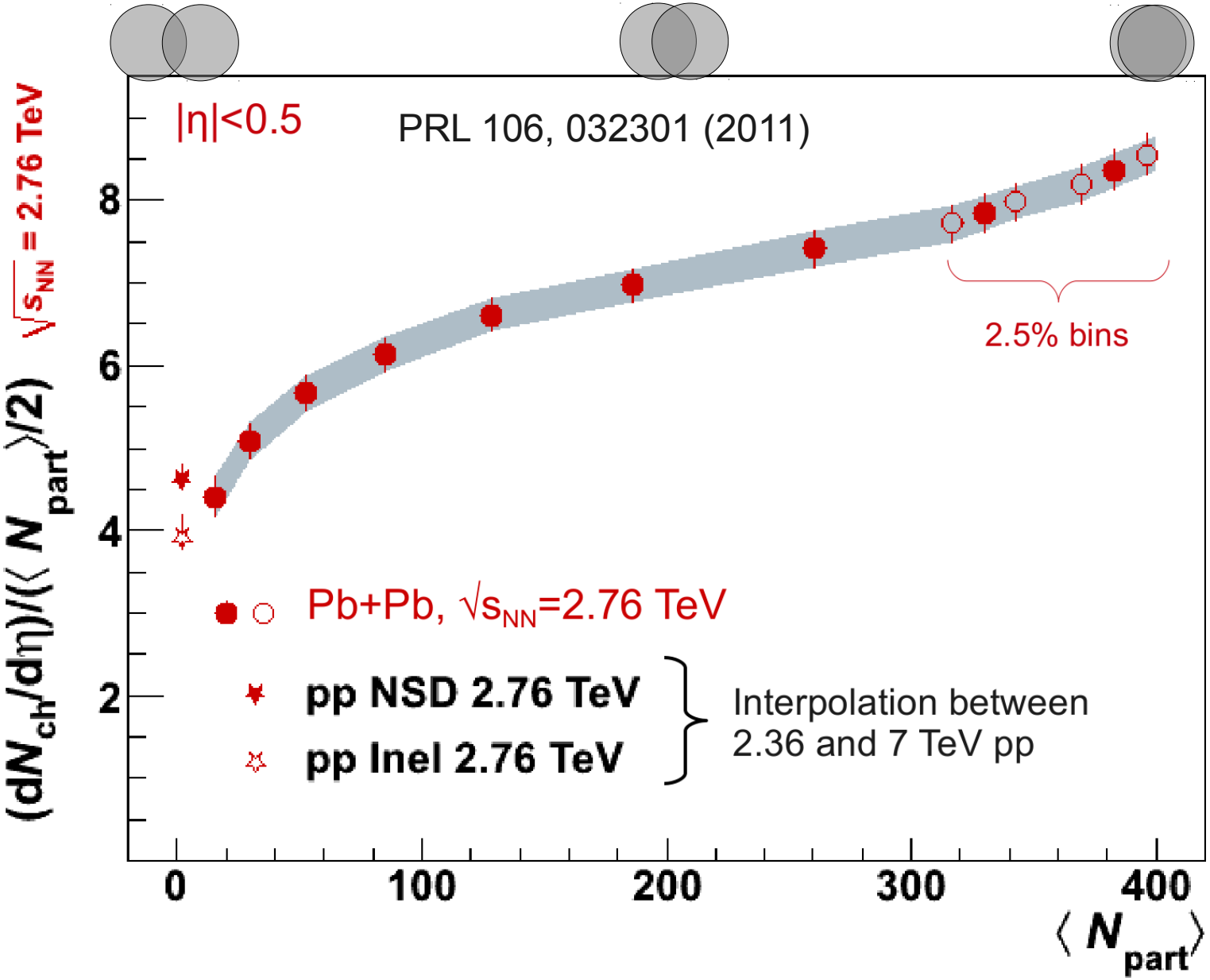


Pb+Pb collisions



Bulk properties

Centrality dependence of $dN_{ch}/d\eta$

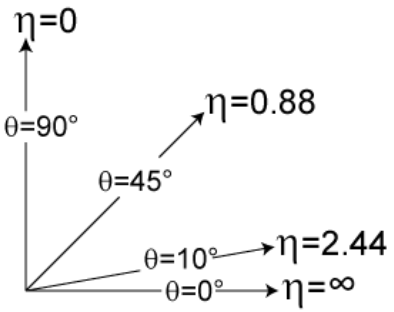


RHIC data scaled by 2.1

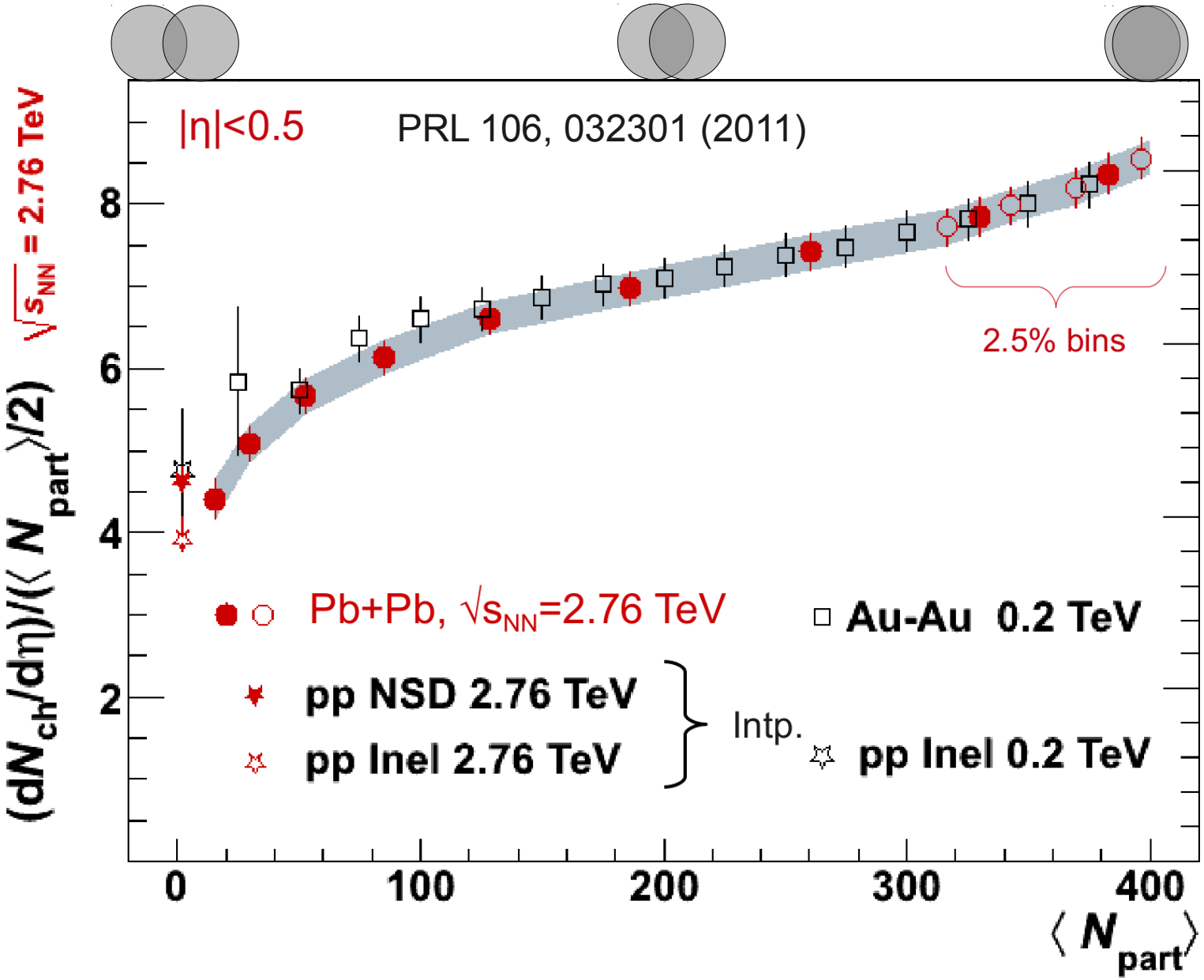
PHENIX
PRC 71, 034908 (2005)

$dN_{ch}/d\eta$ = Number of charged tracks per unit pseudorapidity

η = pseudorapidity
= - ln[tan(θ/2)]



Centrality dependence of $dN_{ch}/d\eta$



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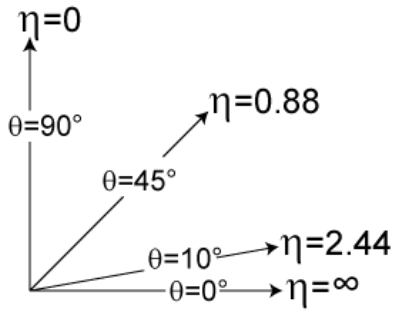
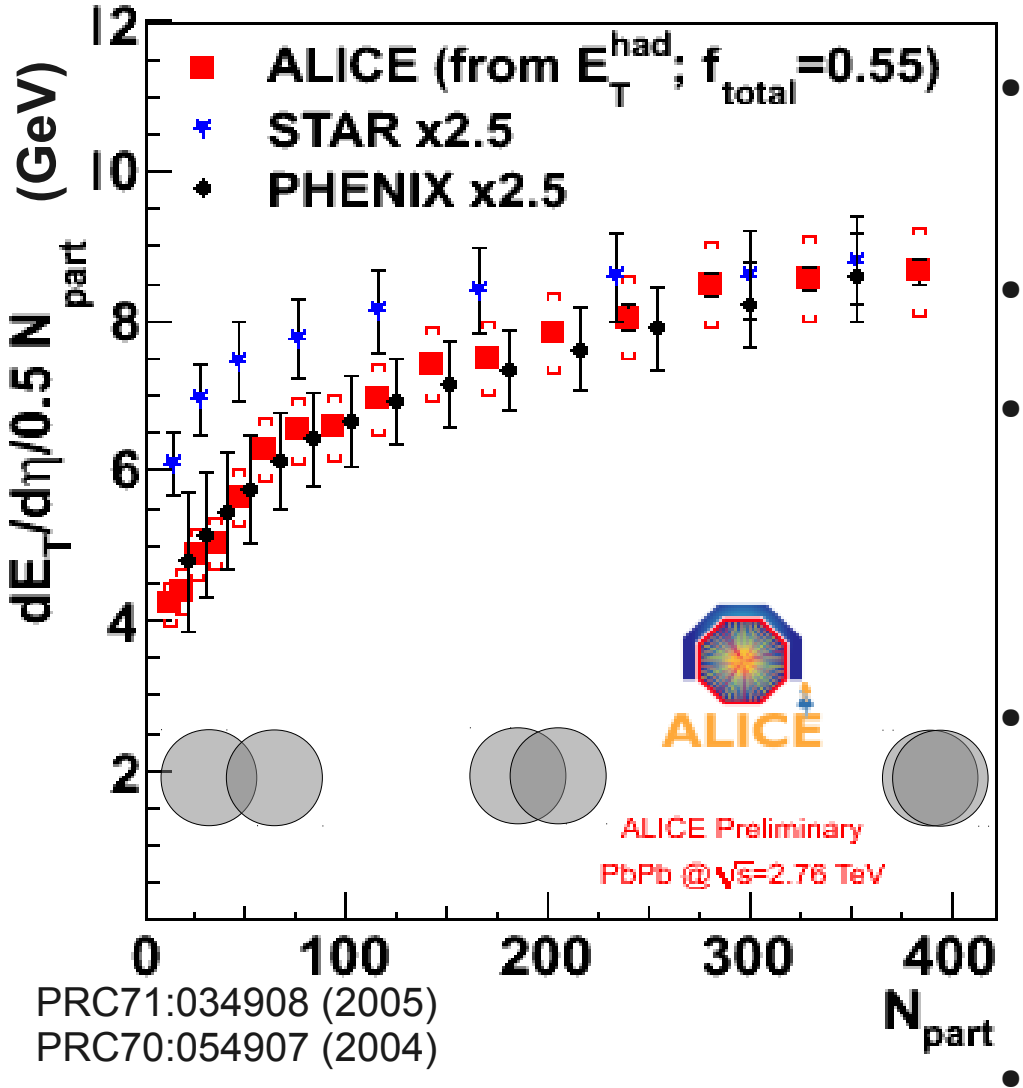


N_{part} = number of participating nucleons

Transverse Energy



PRC71:034908 (2005)
PRC70:054907 (2004)

Centrality dependence similar to RHIC (PHENIX)

- E_T^{had} from charged hadrons directly measured by the tracking detectors
- f_{total} from MC to convert into total E_T
- From RHIC to LHC
  - ~2.5 increase $dE_T/d\eta/(0.5*N_{part})$
- Energy density (Bjorken)

$$\varepsilon = \frac{1}{\pi R^2 \tau}\frac{dE_t}{dy} \qquad R = 1.12\,A^{1/3}\,fm$$

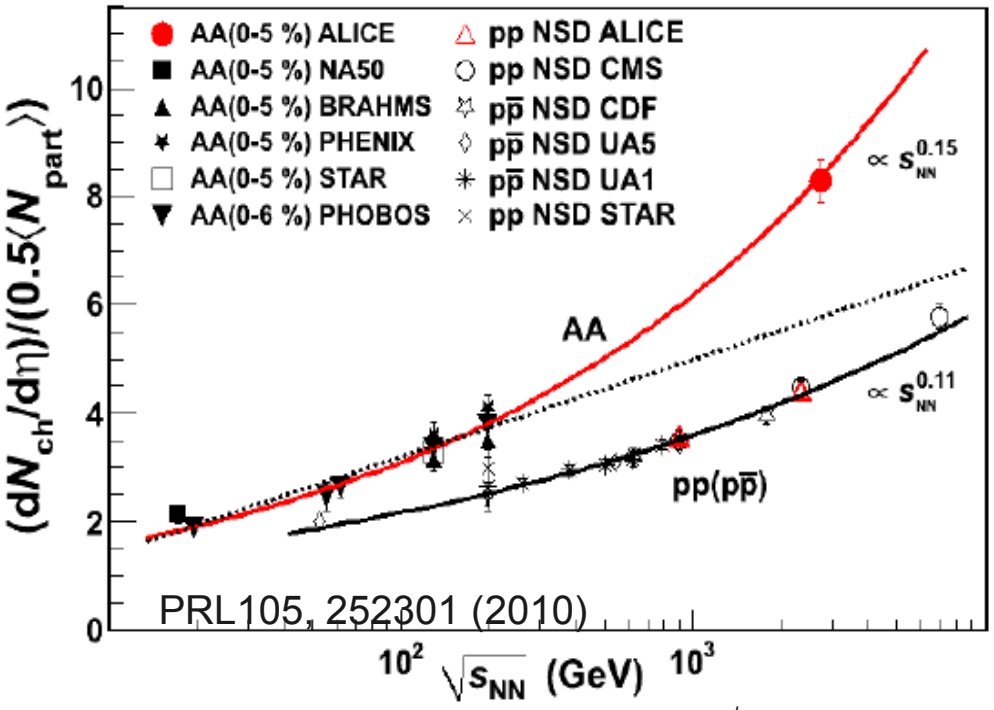
- $\varepsilon\tau \sim 16$ GeV/(fm^{2}c)
  RHIC: $\varepsilon\tau = 5.4 \pm 0.6$ GeV/(fm^{2}c)

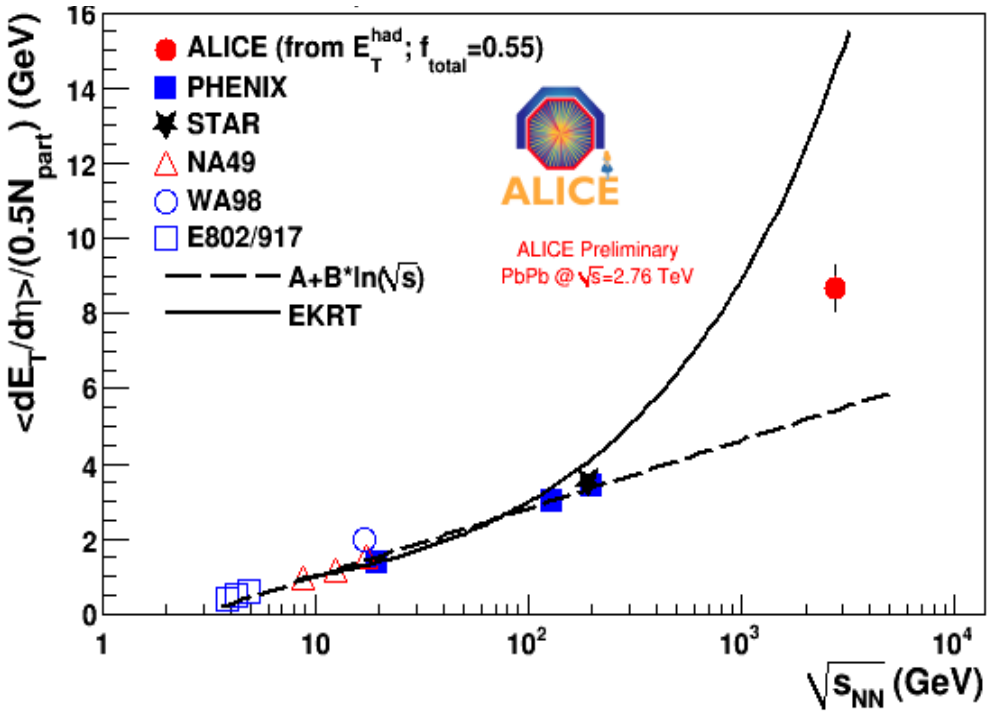
$\sqrt{s_{NN}}$ dependence

- $dN_{ch}/d\eta/(0.5*N_{part}) \sim 8$
- **2.1 x RHIC**
  1.9 x pp (NSD) at 2.36 TeV
- growth with $\sqrt{s}$ faster in AA than pp

- $dE_T/d\eta/(0.5*N_{part}) \sim 9$ in 0-5%
- ~5% increase of N_{part} (353 → 383)
  → **2.7 x RHIC**
  (consistent with 20% increase of $\langle p_T \rangle$)

Grows faster than simple logarithmic scaling extrapolated from lower energy

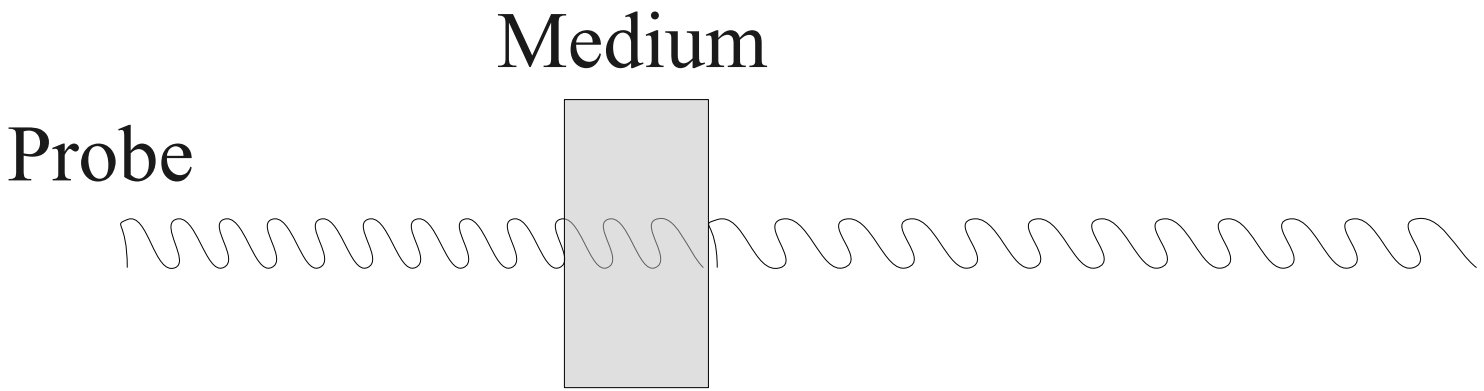




$\sqrt{s_{NN}}$ = Center of mass energy per nucleon

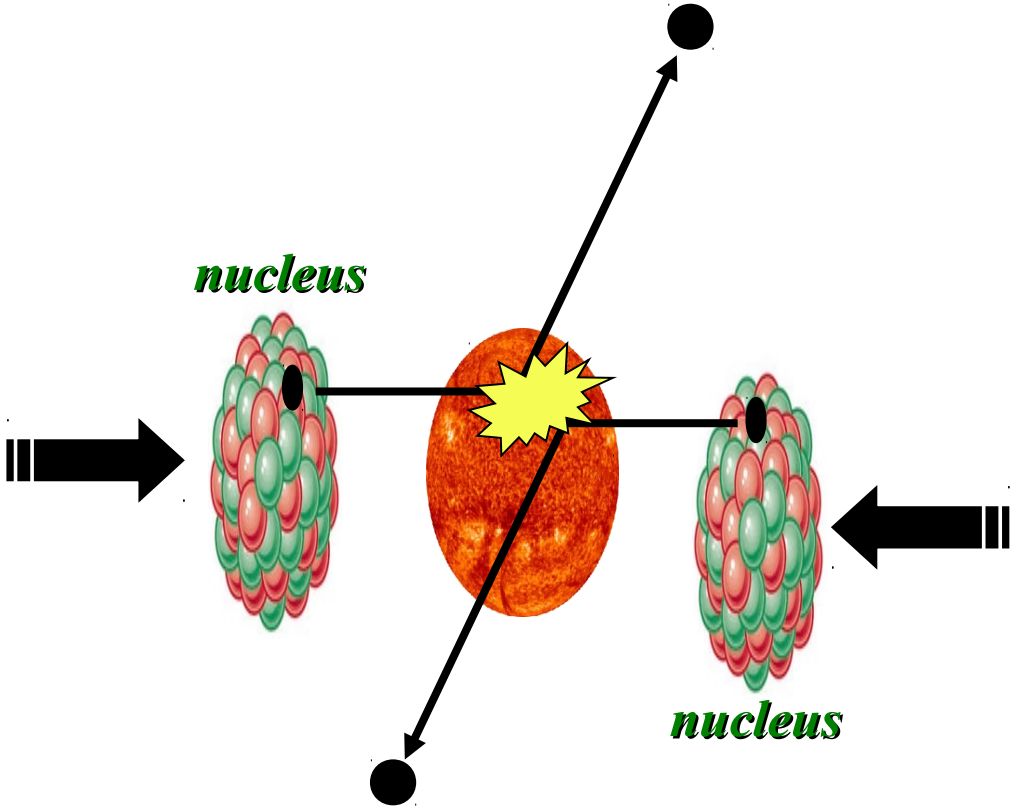
Probes of the Quark Gluon Plasma

Probes of the Quark Gluon Plasma



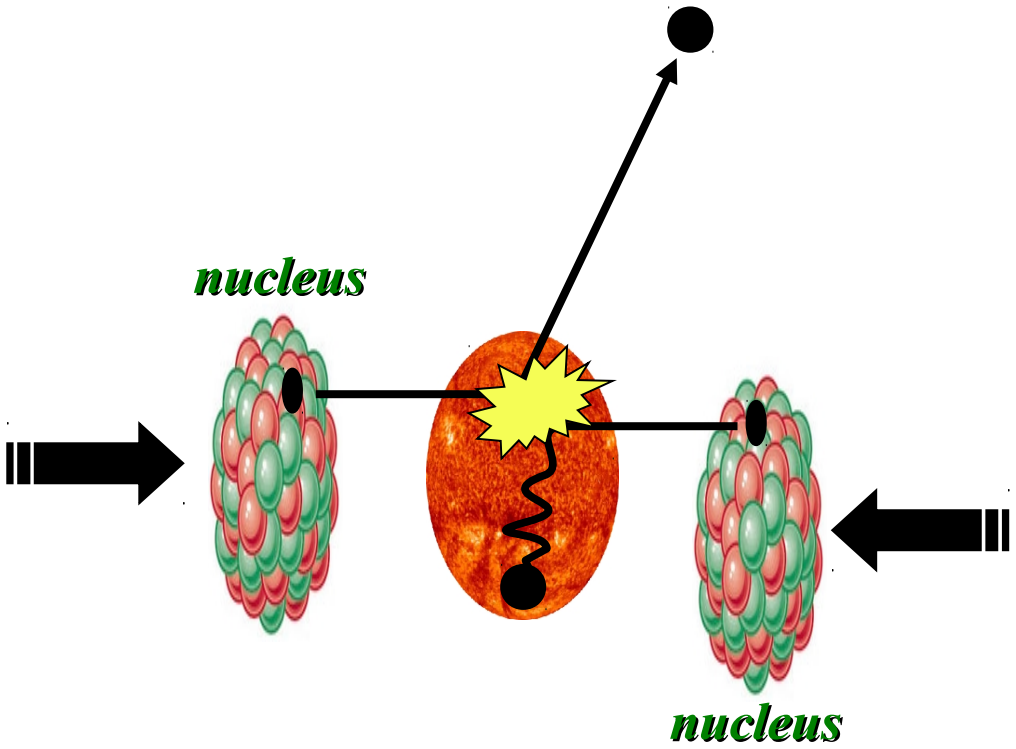
Want a probe which traveled through the collision

Probes of the Quark Gluon Plasma



Want a probe which traveled through the collision
QGP is short lived → need a probe created in the collision

Probes of the Quark Gluon Plasma



Want a probe which traveled through the collision
QGP is short lived → need a probe created in the collision
We expect the medium to be dense → absorb probe

Single particles

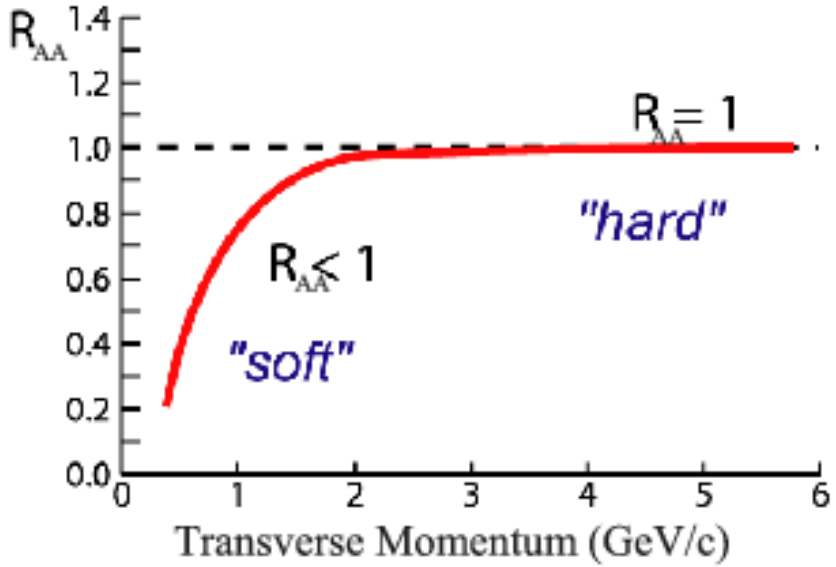
Measure spectra of hadrons and compare to those in p+p collisions or peripheral A+A collisions

If high-p_T hadrons are suppressed, this is evidence of jet quenching

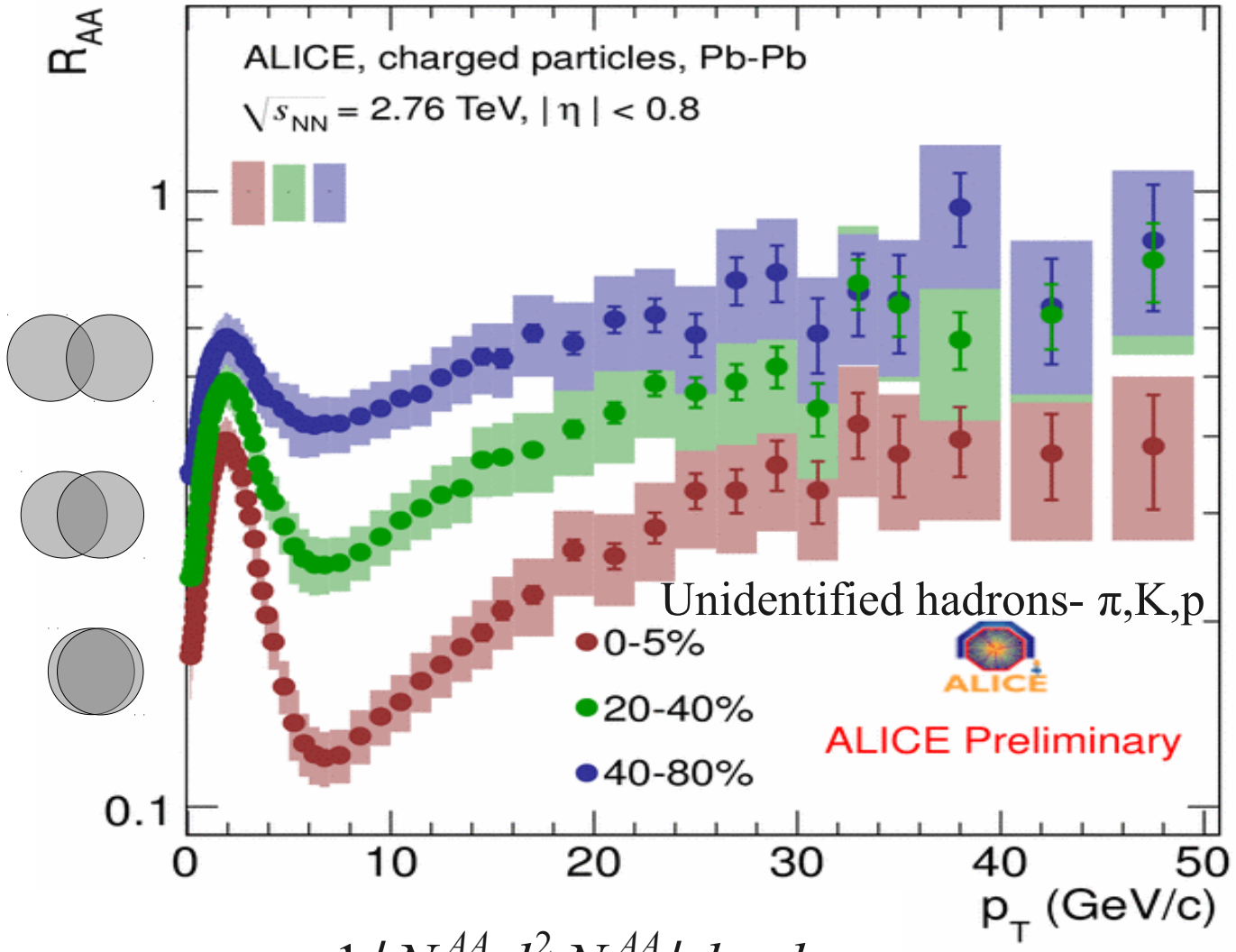
Assumption: sufficiently high-p_T hadrons mostly come from jets

Unmodified spectra:

$$R_{AA} = \frac{1/N_{evt}^{AA}\, d^2 N_{ch}^{AA}/d\eta\, dp_T}{\langle N_{coll}\rangle (1/N_{evt}^{pp})\, d^2 N_{ch}^{pp}/d\eta\, dp_T}$$



Nuclear modification factor (R_{AA})



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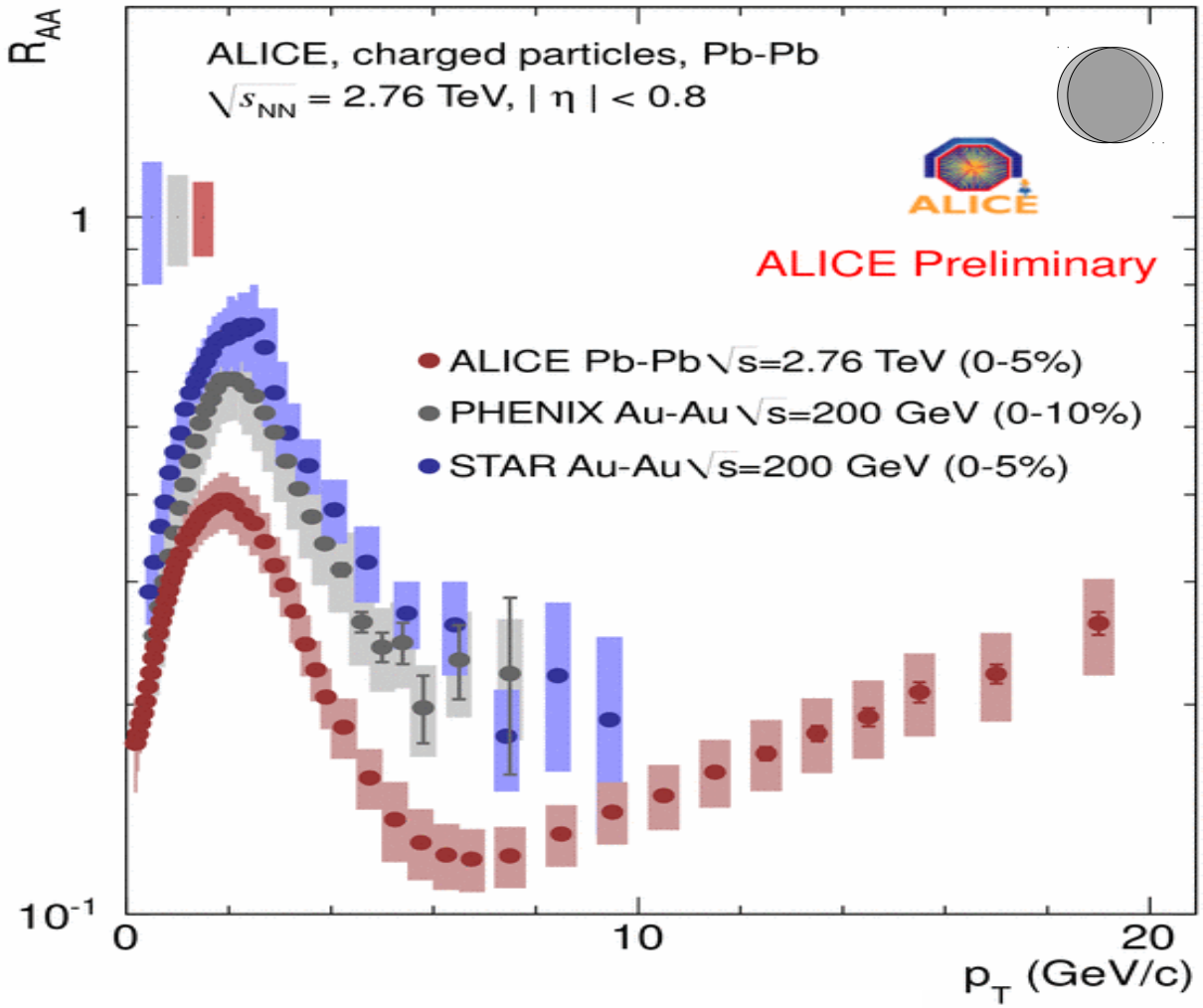

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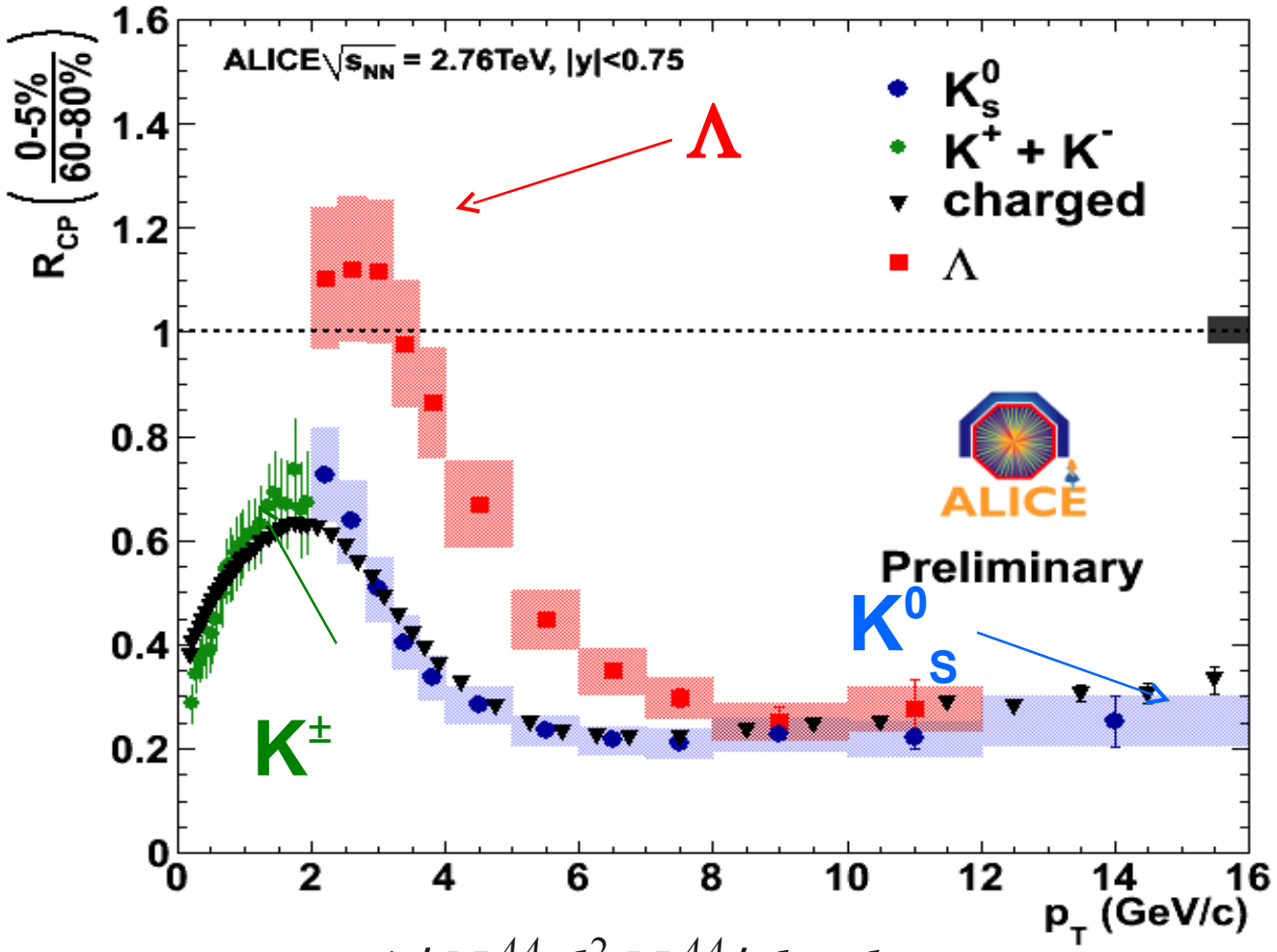

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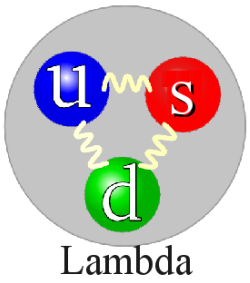
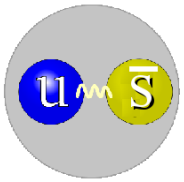
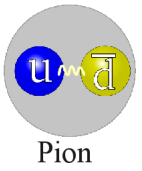


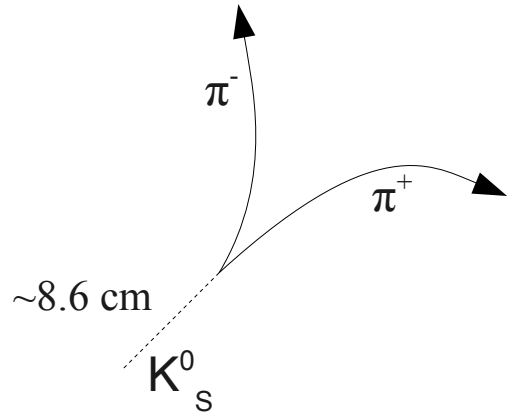
~1116 MeV/c^2



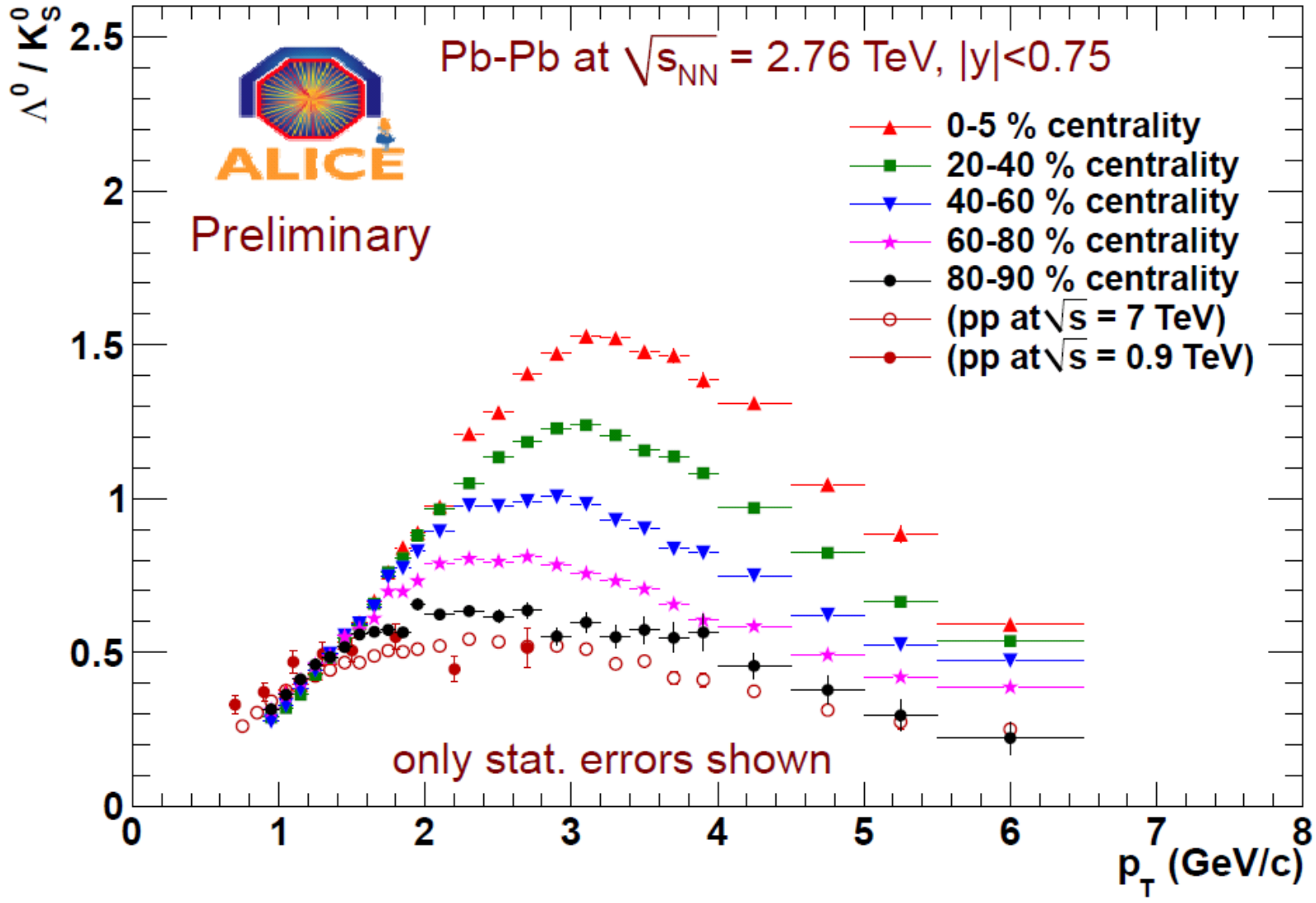
~494 MeV/c^2



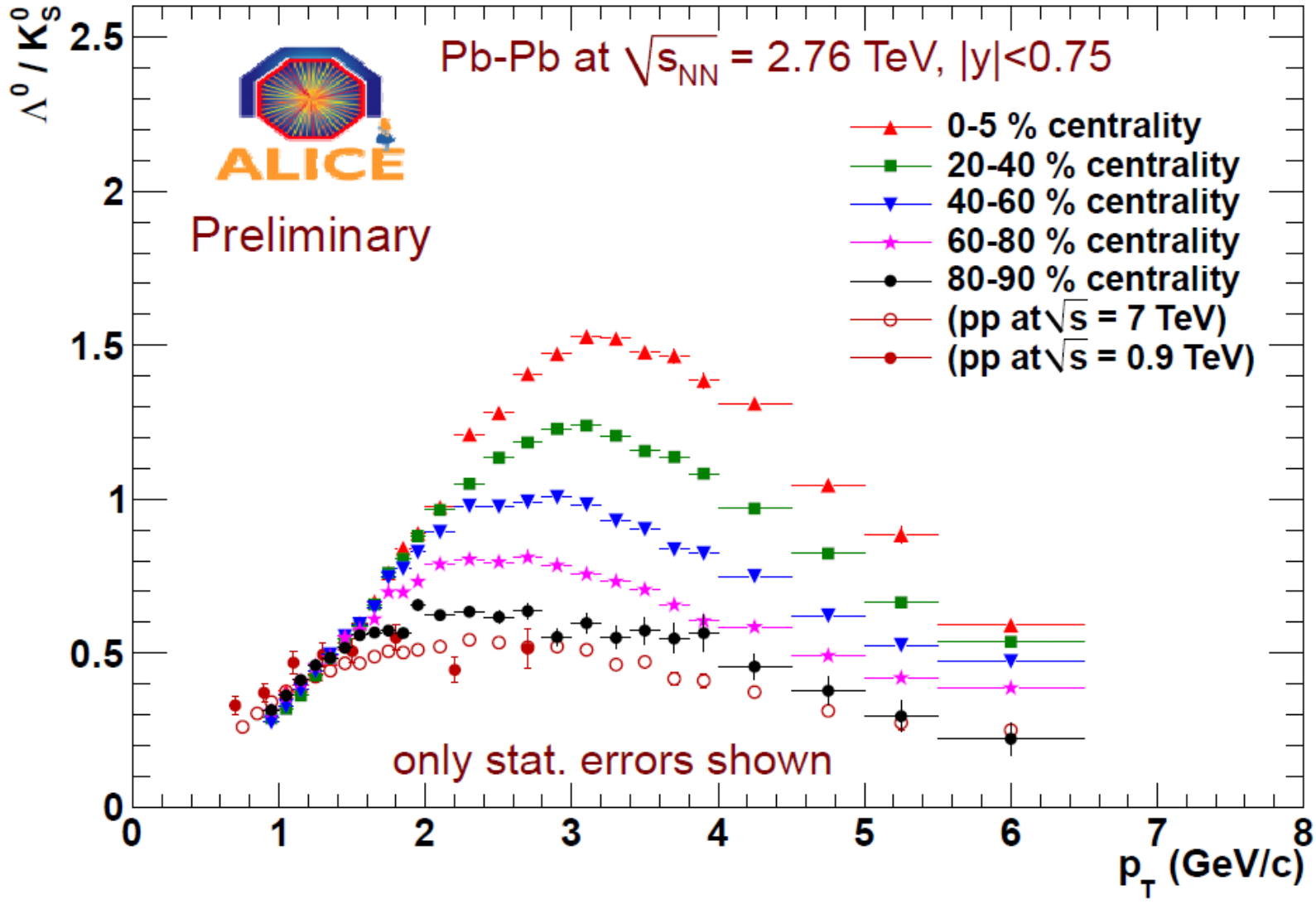
~140 MeV/c^2

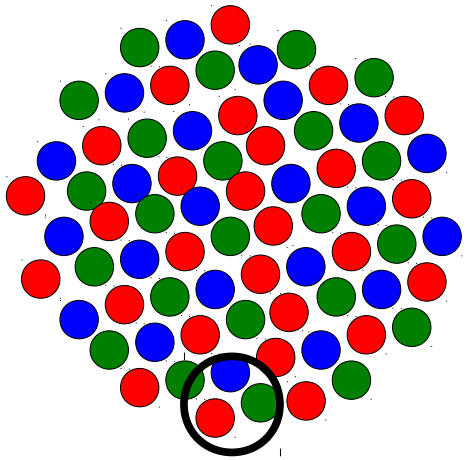


Baryon anomaly: Λ/K^0_S



Baryon anomaly: Λ/K^0_S

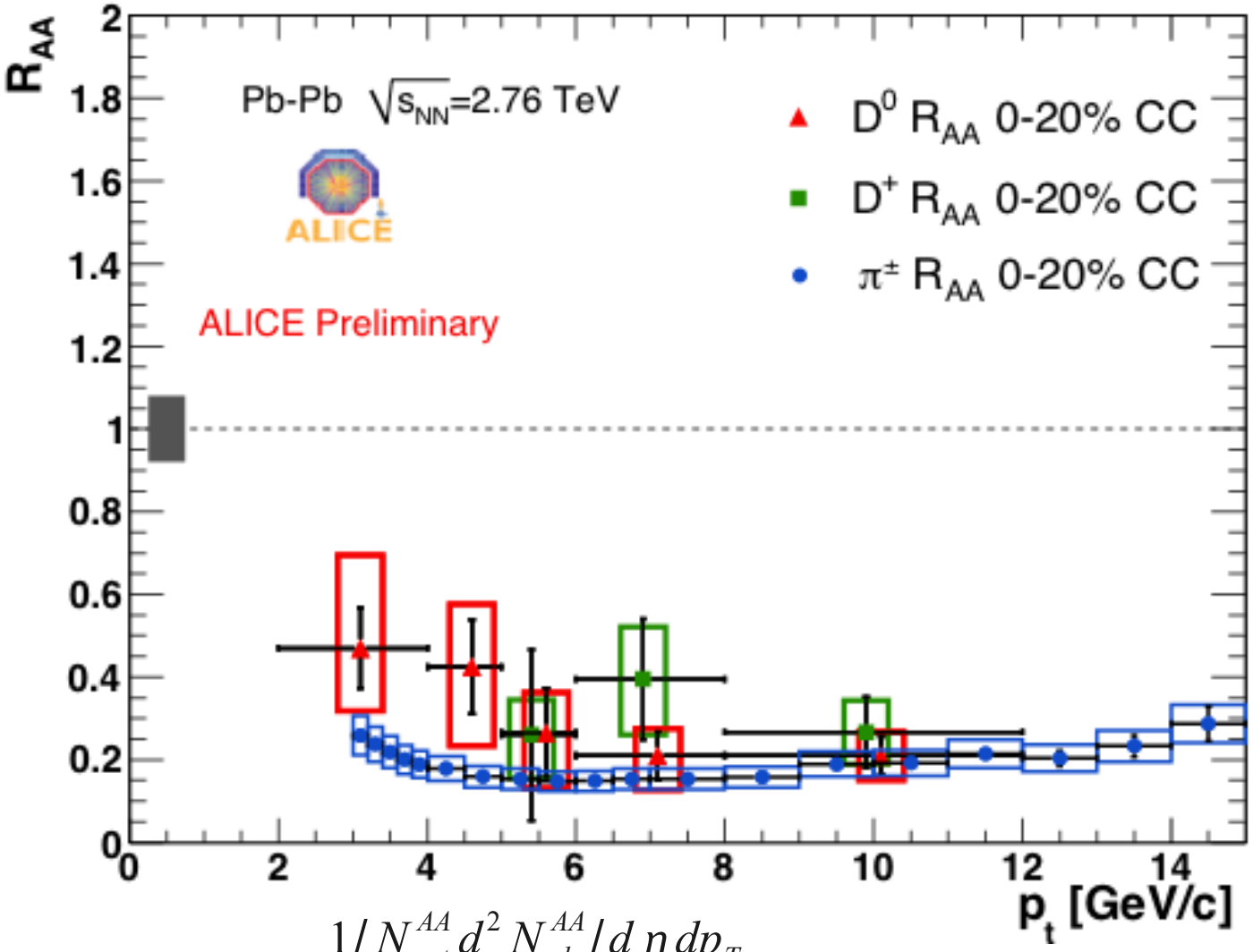




Recombination

Ann.Rev.Nucl.Part.Sci.58:177-205,2008

Charm nuclear modification factor



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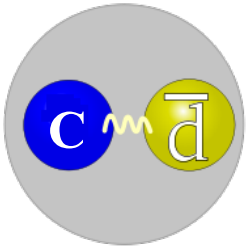
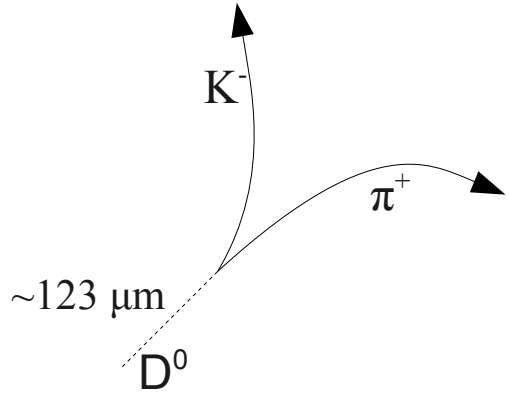
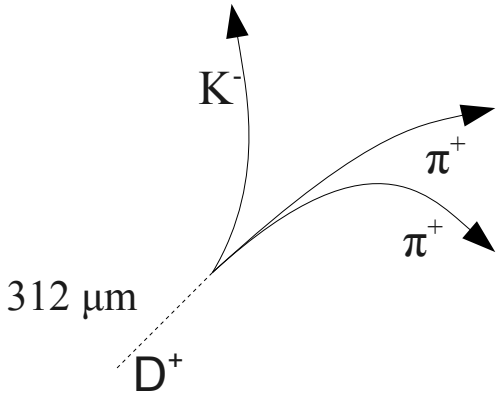


D meson

~1865 MeV/c^2





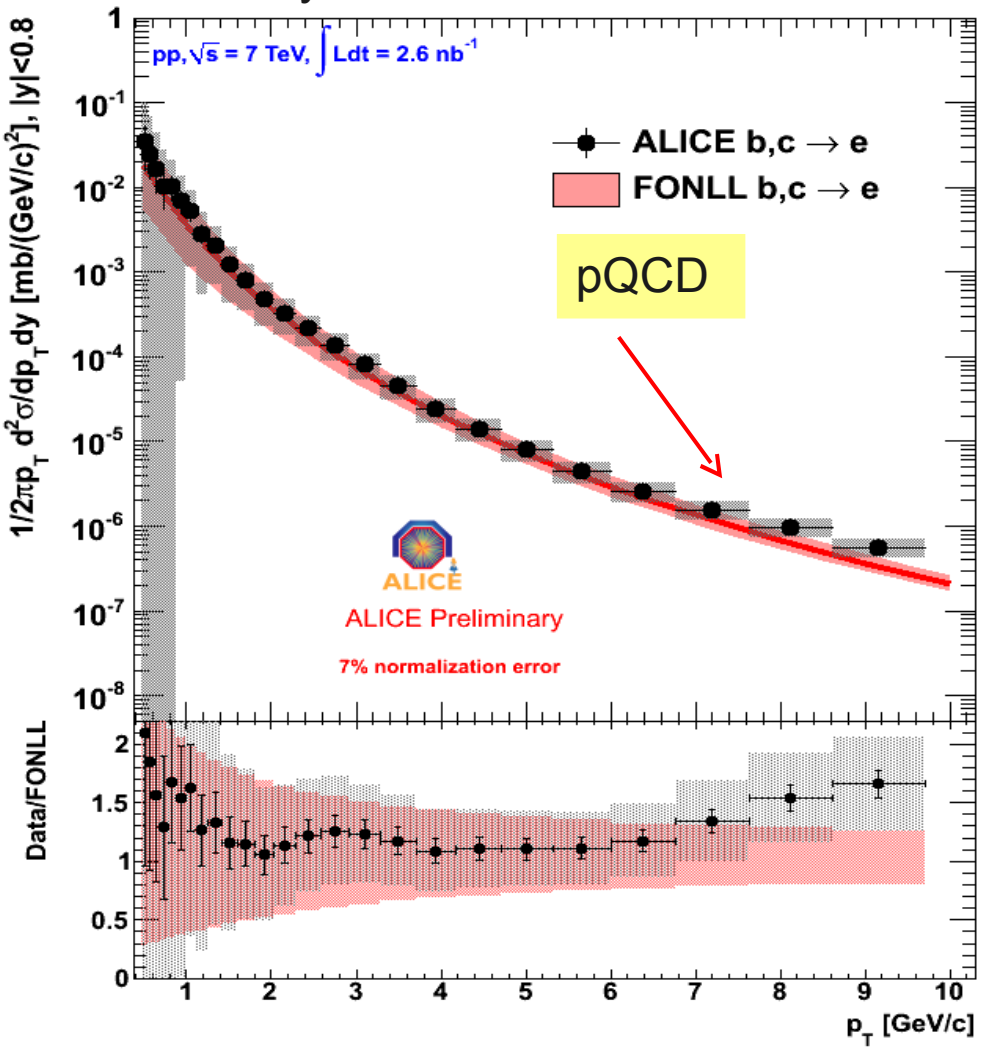
Conclusions

- Charged particle production and transverse energy follow same trends as seen at RHIC
- Energy higher than experimental extrapolation, lower than many models
- High p_T particle production suppressed to ~0.15 of what we would expect from scaling p+p collisions → hot, dense medium produced
- Significant suppression observed even for heavy quarks

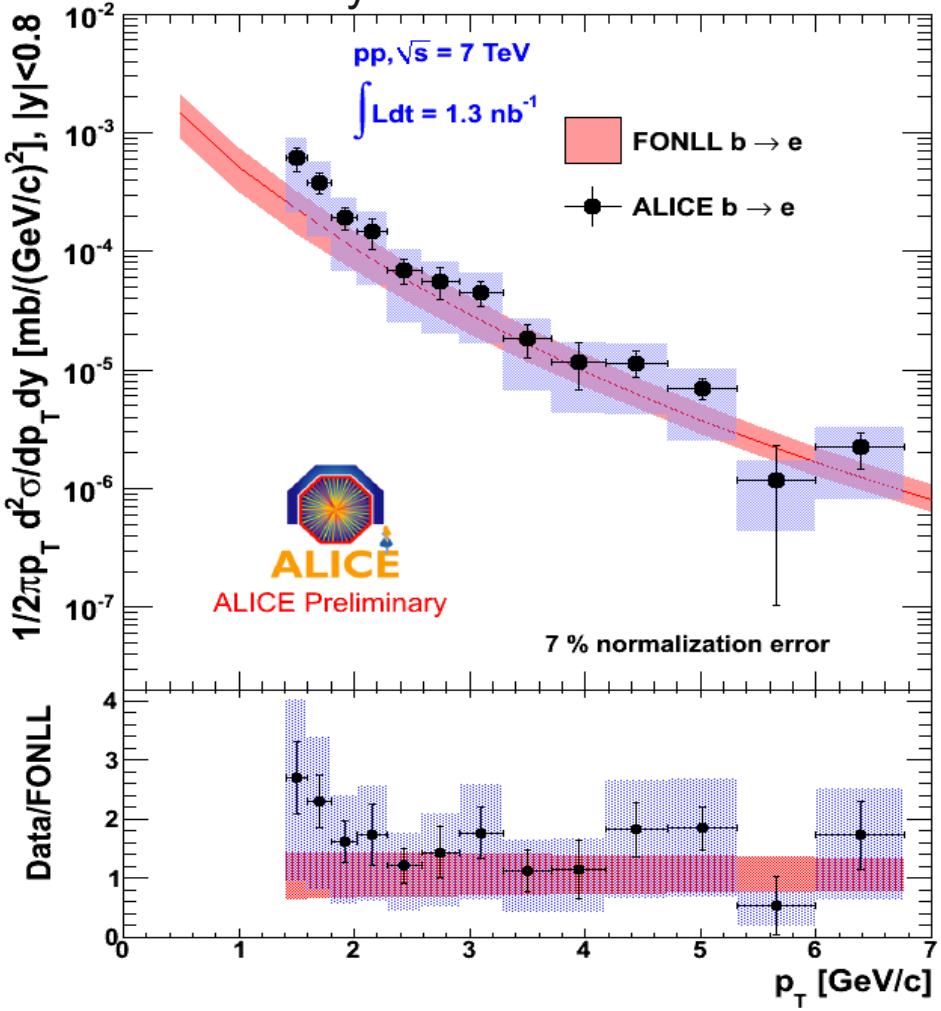
Backup slides

Non-photonic electrons

Beauty + Charm



Beauty Electrons



Charm cross section