Jet physics in ALICE

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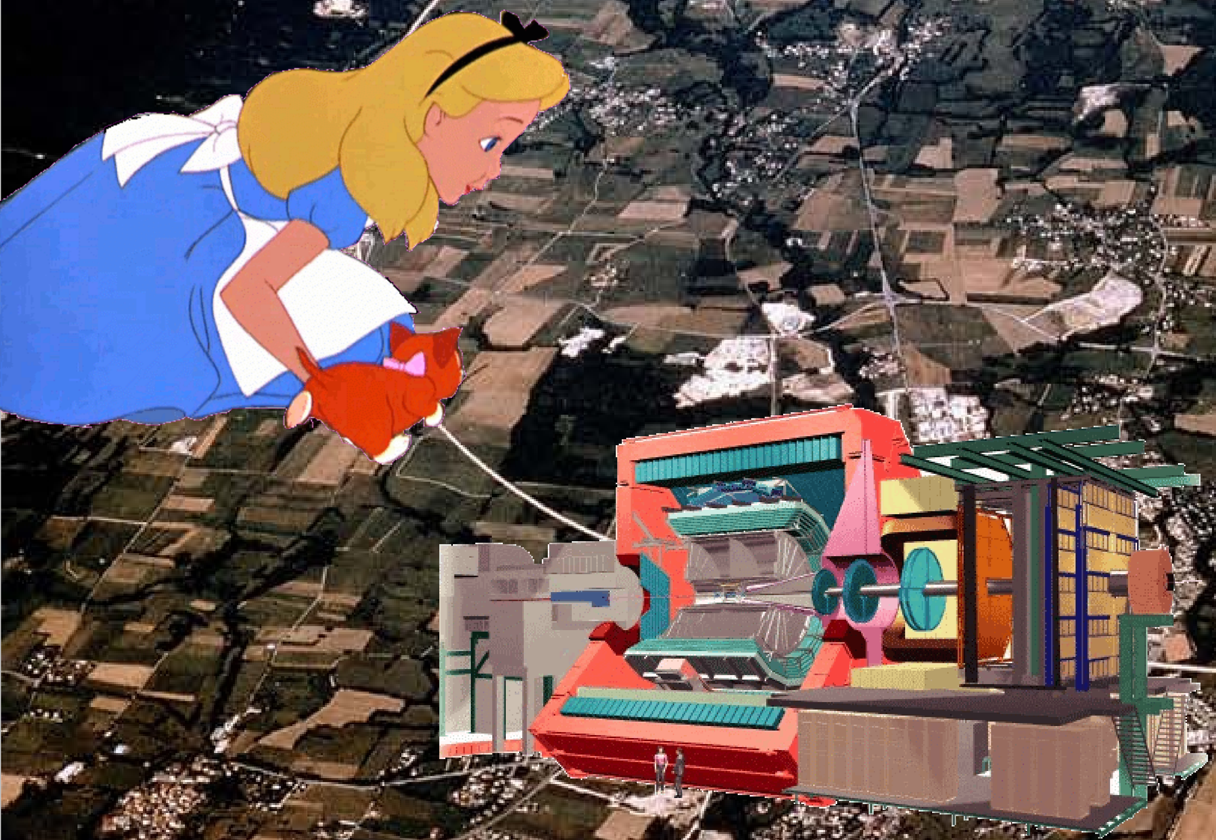
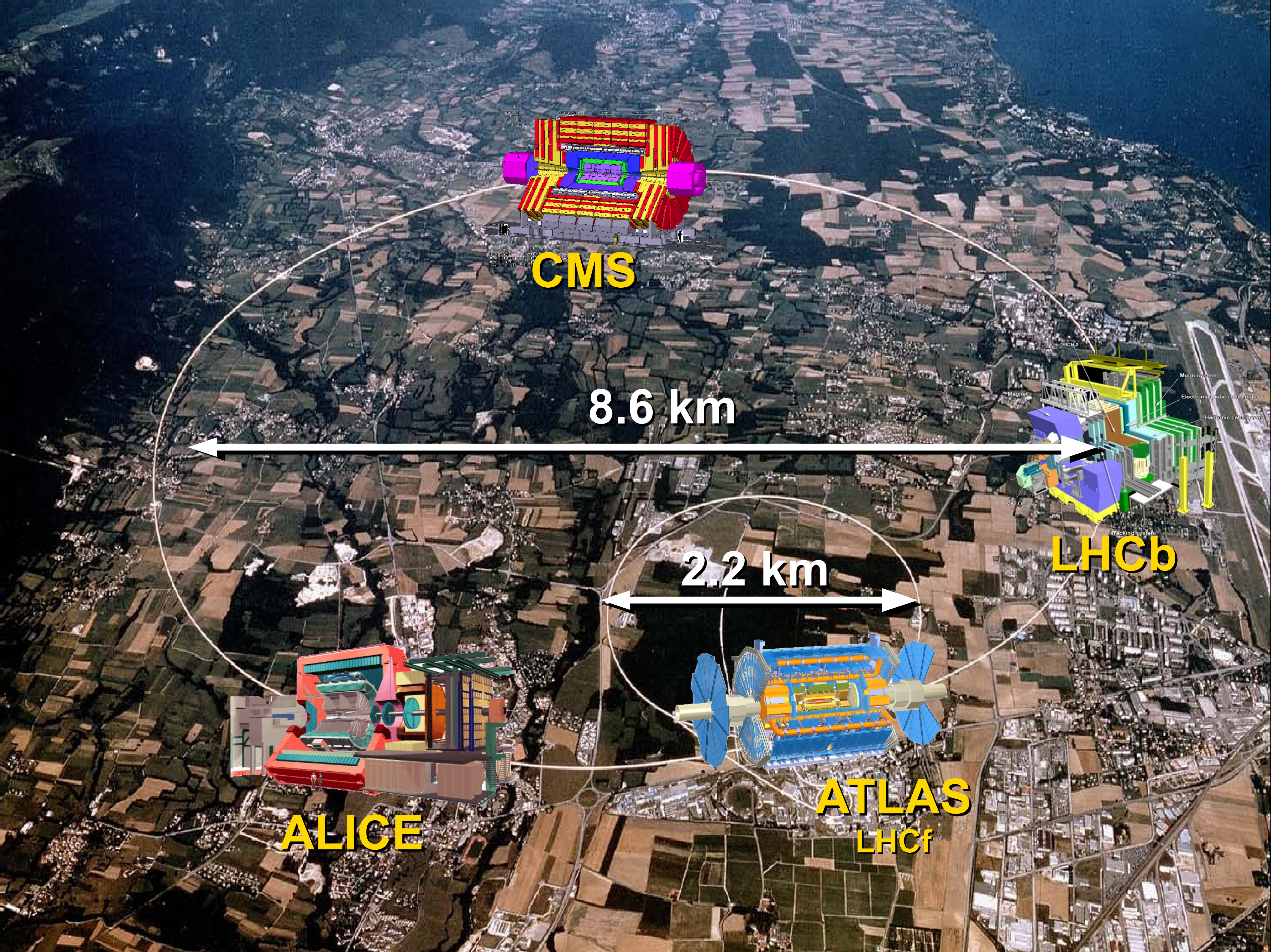
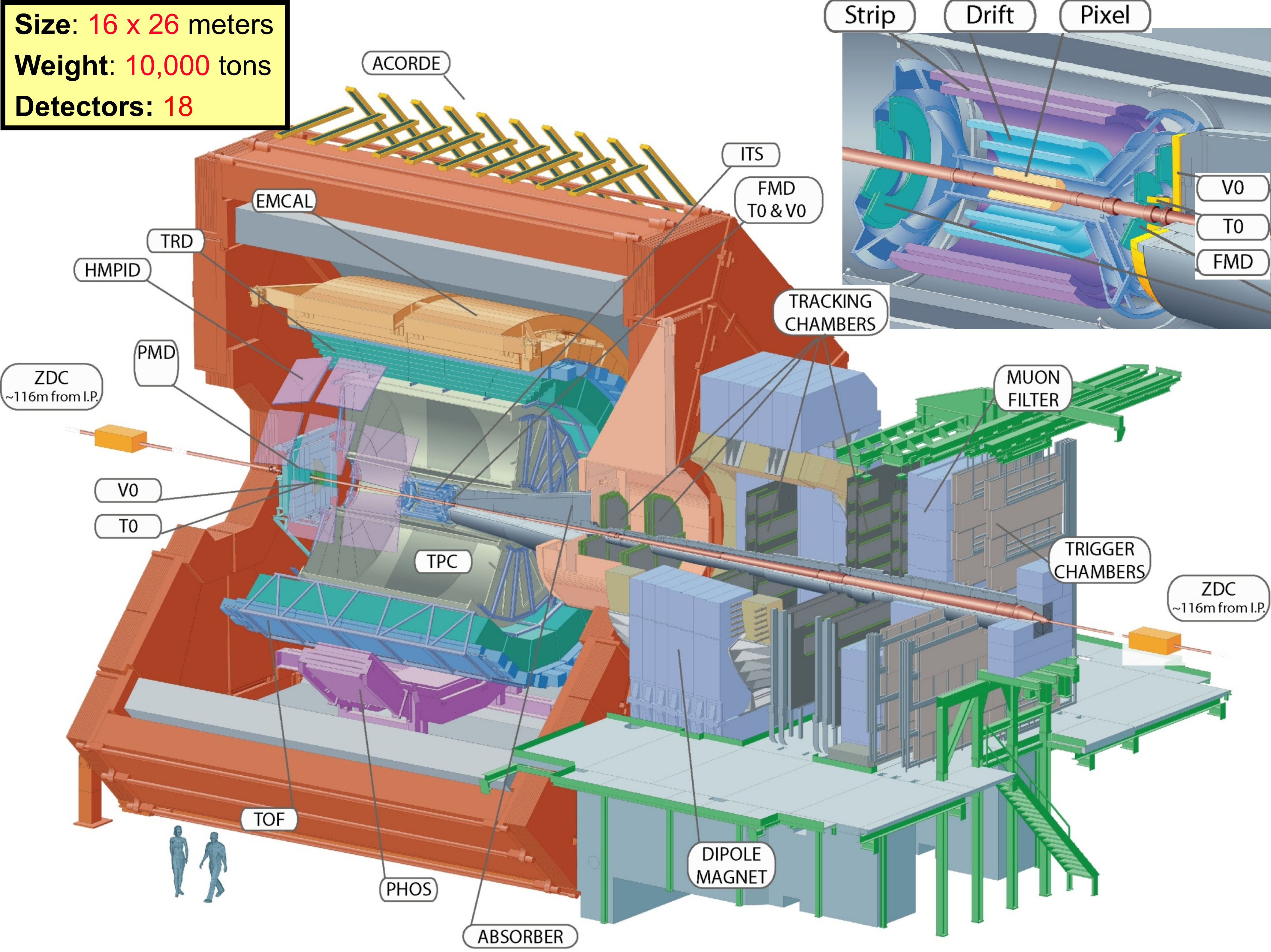



CMS
8.6 km
LHCb
2.2 km
ALICE
ATLAS
LHCf

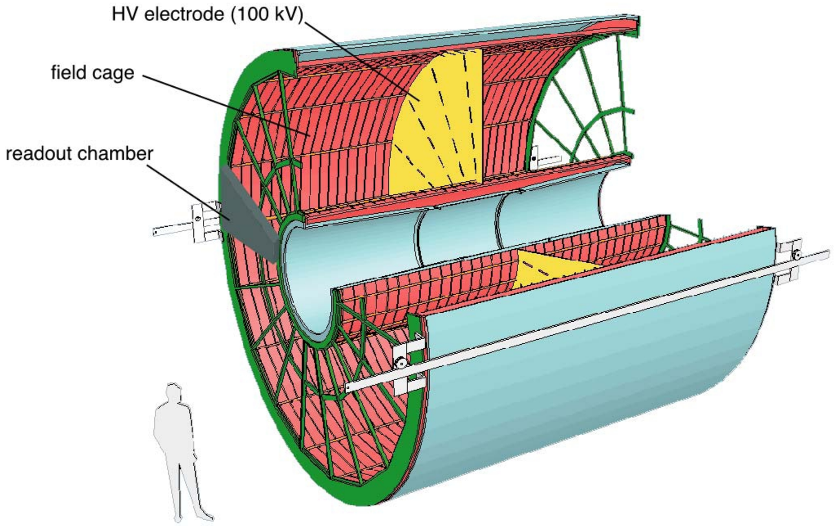


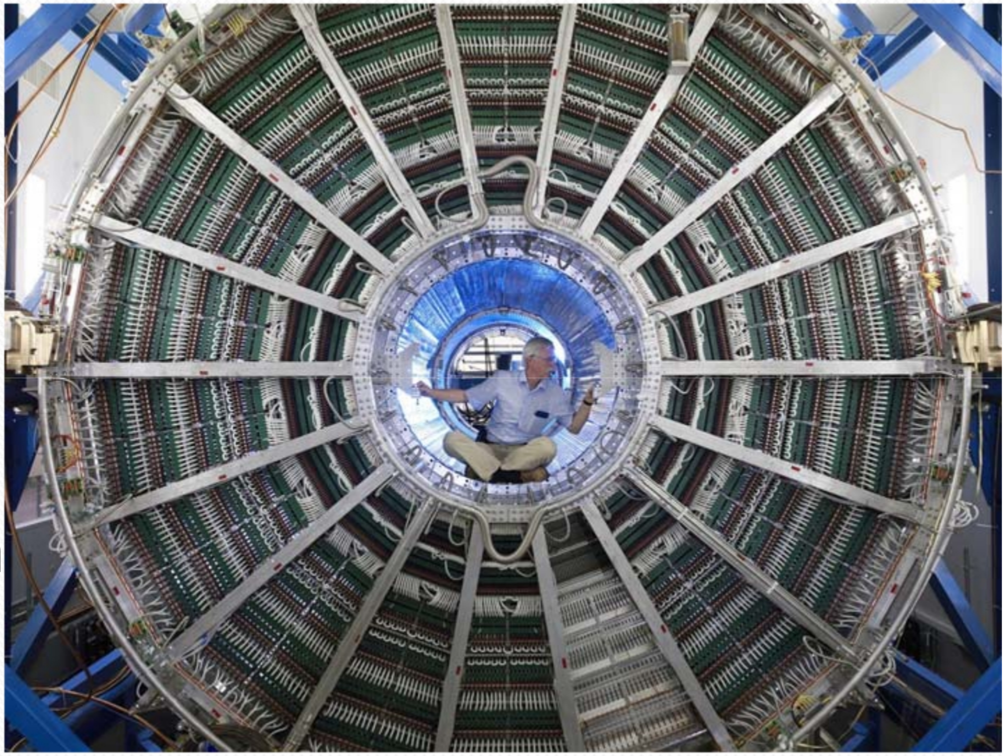
Size: 16 x 26 meters
Weight: 10,000 tons
Detectors: 18
ACORDE
Strip
Drift
Pixel
V0
T0
FMD
ITS
FMD
T0 & V0
EMCAL
TRD
HMPID
PMD
ZDC
~116m from I.P.
TRACKING
CHAMBERS
MUON
FILTER
V0
T0
TPC
TRIGGER
CHAMBERS
ZDC
~116m from I.P.
TOF
PHOS
ABSORBER
DIPOLE
MAGNET

The Time Projection Chamber

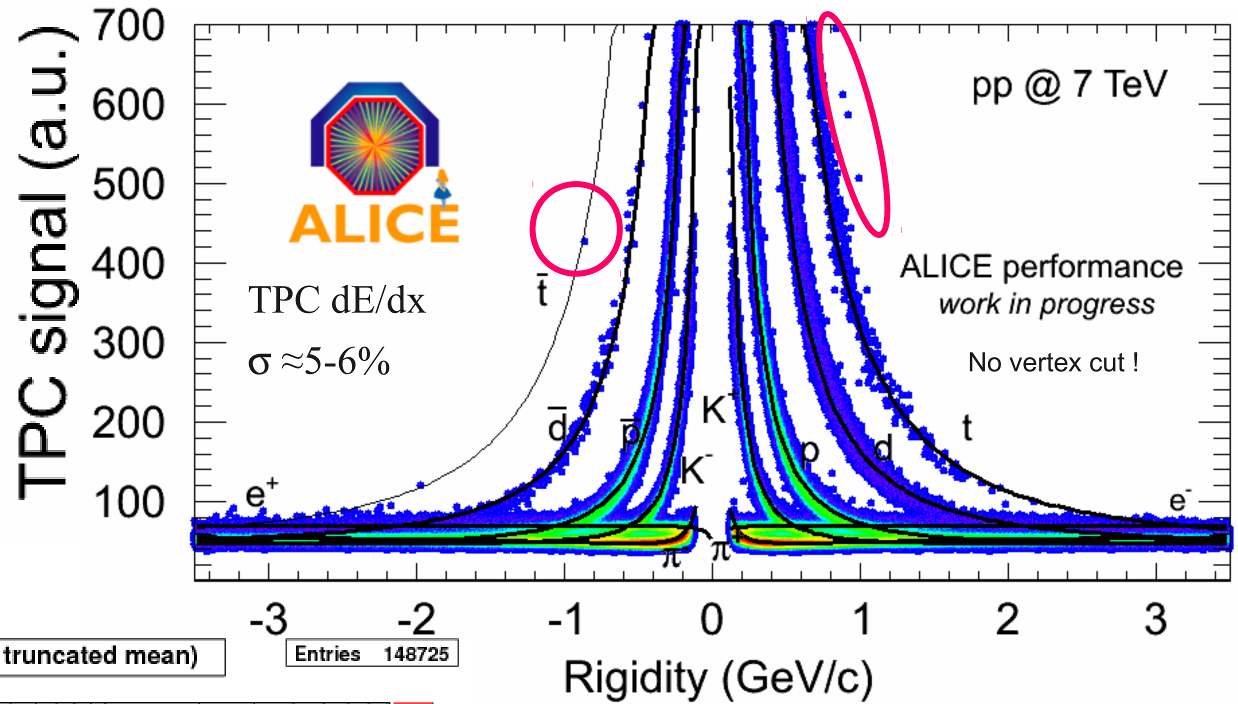
Specifications

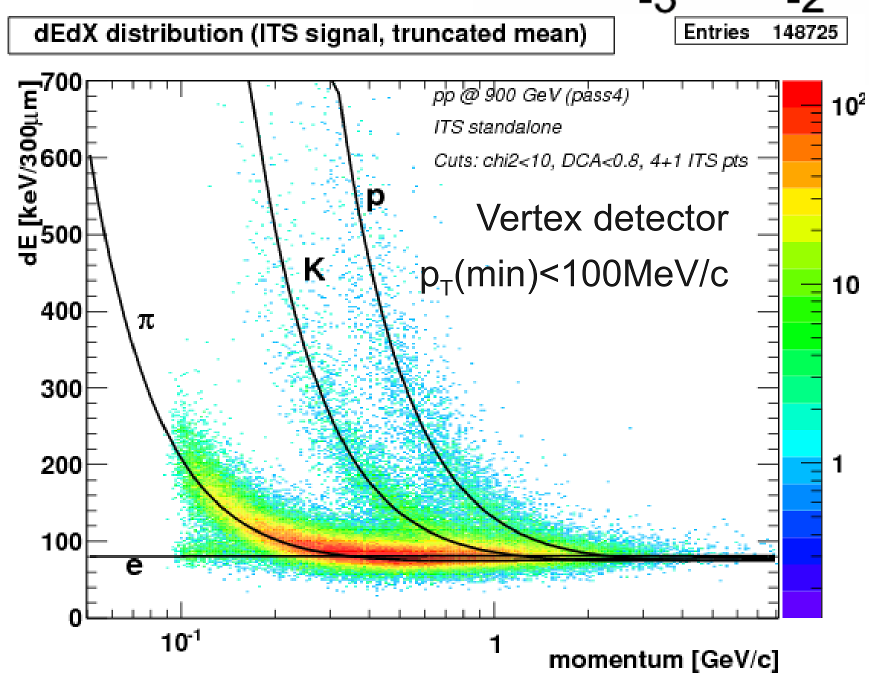
- Designed for $dN_{ch}/d\eta=8000$
- $|\eta|<0.9$, radius 0.9-2.5m
- In a 0.5 T Solenoidal Field
- 570k channels, 80MB/event
- 3% radiation length
- Outer diameter 5 m, Length 5 m
- Largest ever

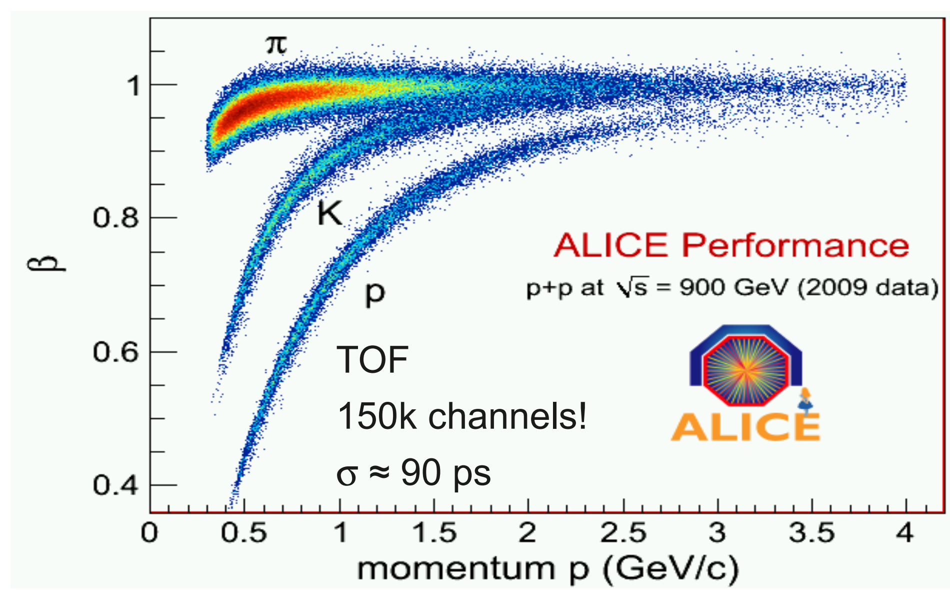




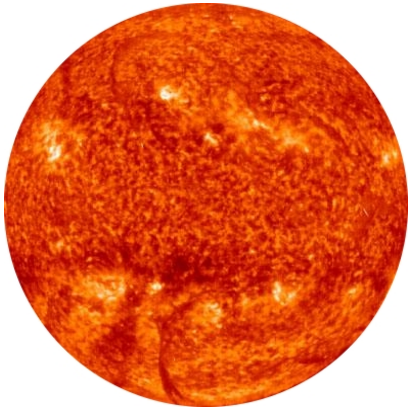
Particle identification



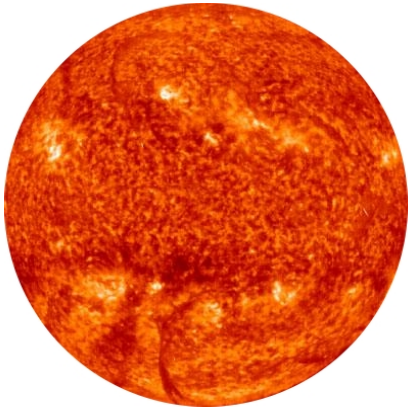




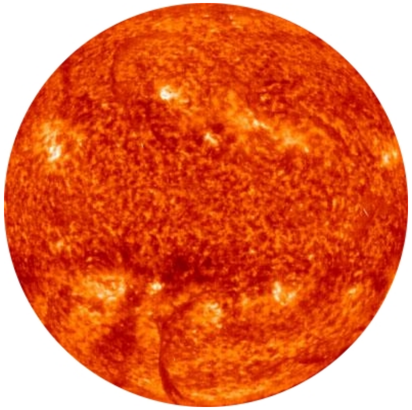
A simple picture of a heavy ion collision



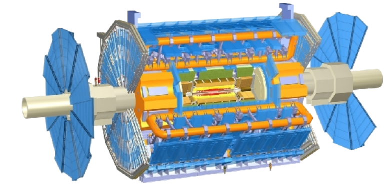
Jets as a probe of the quark gluon plasma



One jet "absorbed" by the medium

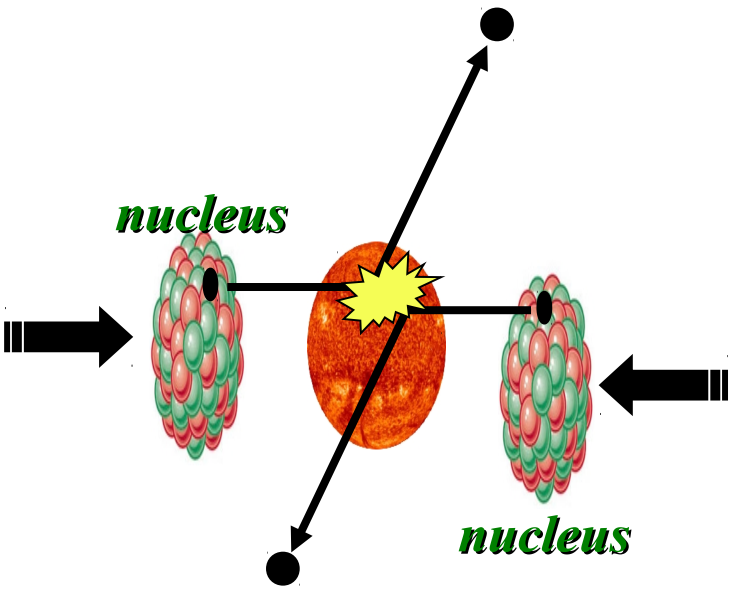


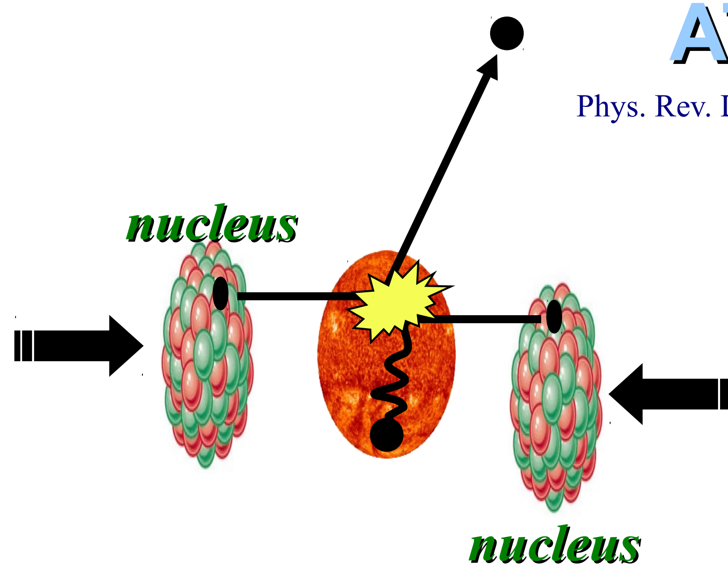
Jet quenching

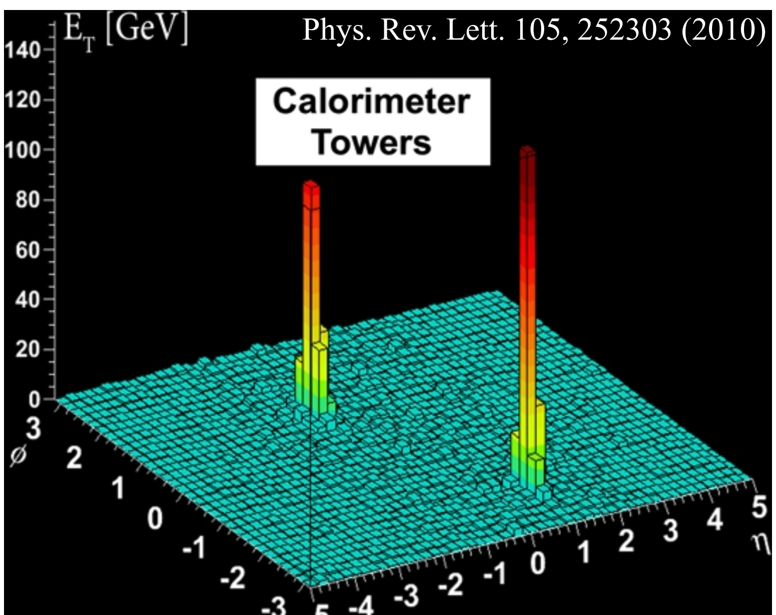


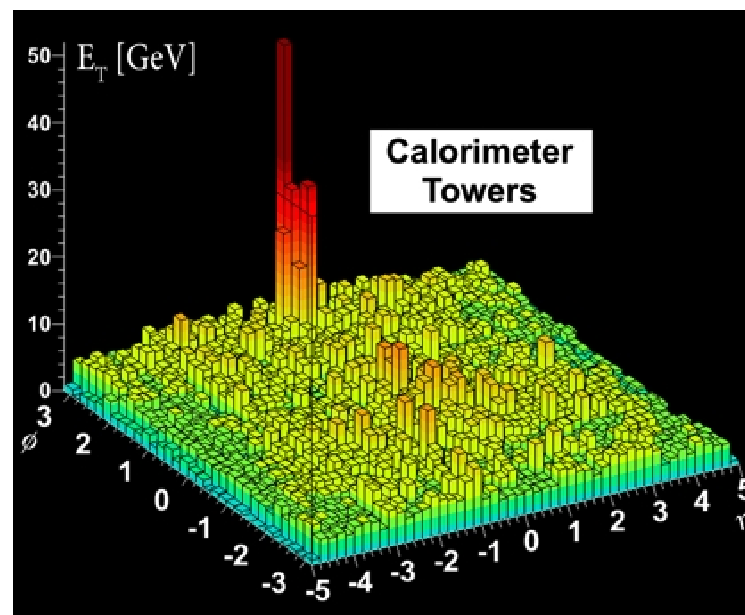
ATLAS

Phys. Rev. Lett. 105, 252303





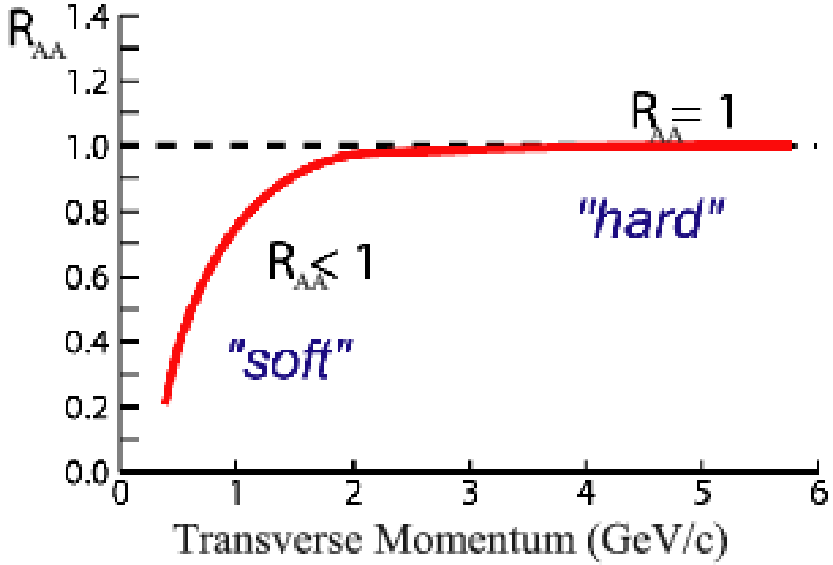




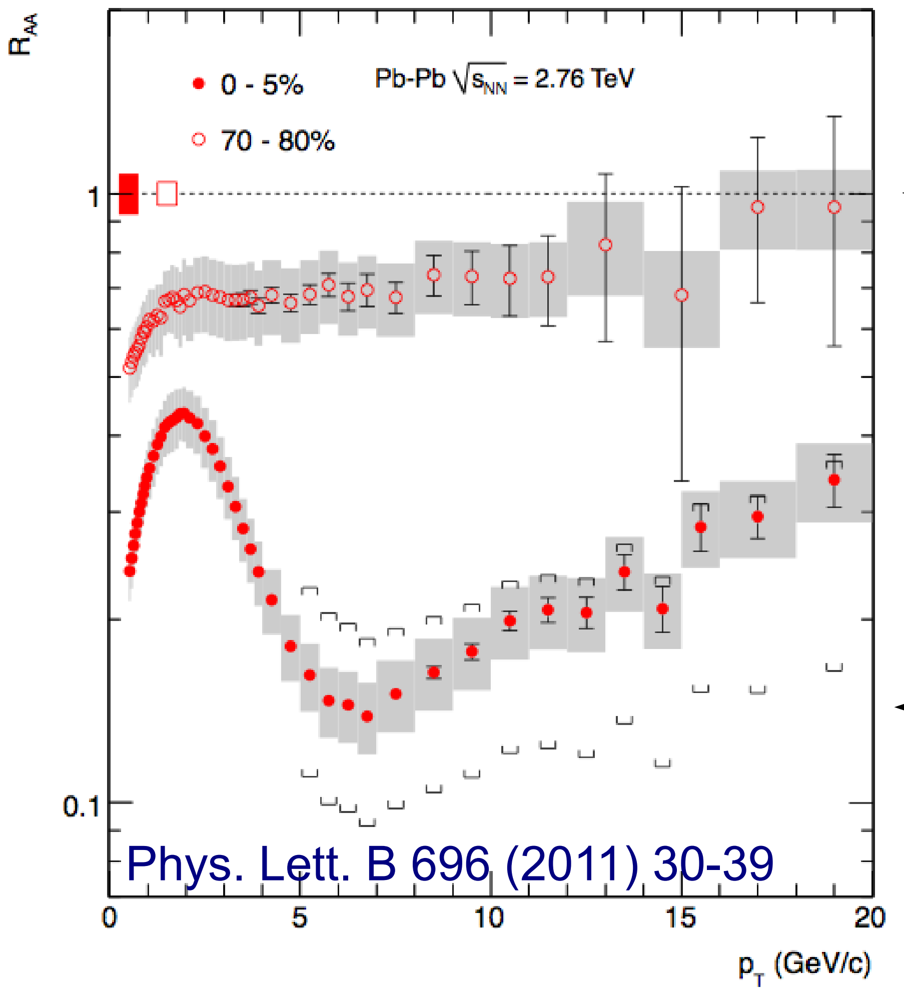
Single particles

- 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:

$$R_{AA} = \frac{d^2N_{AA}/dp_T d\eta}{T_{AA} d^2\sigma^{pp}/dp_T d\eta}$$

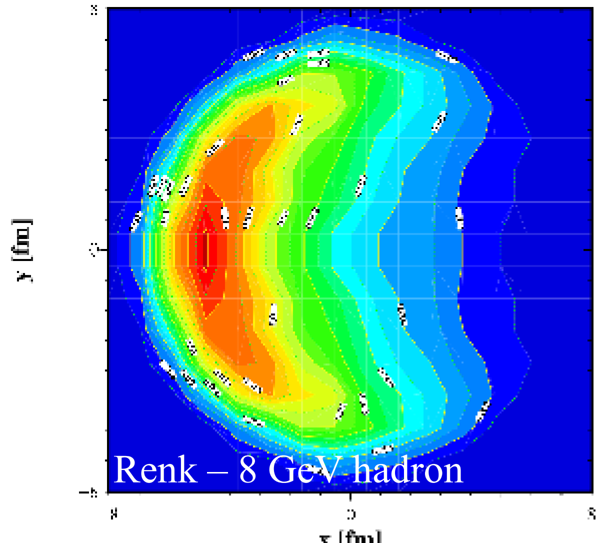


Experimental results

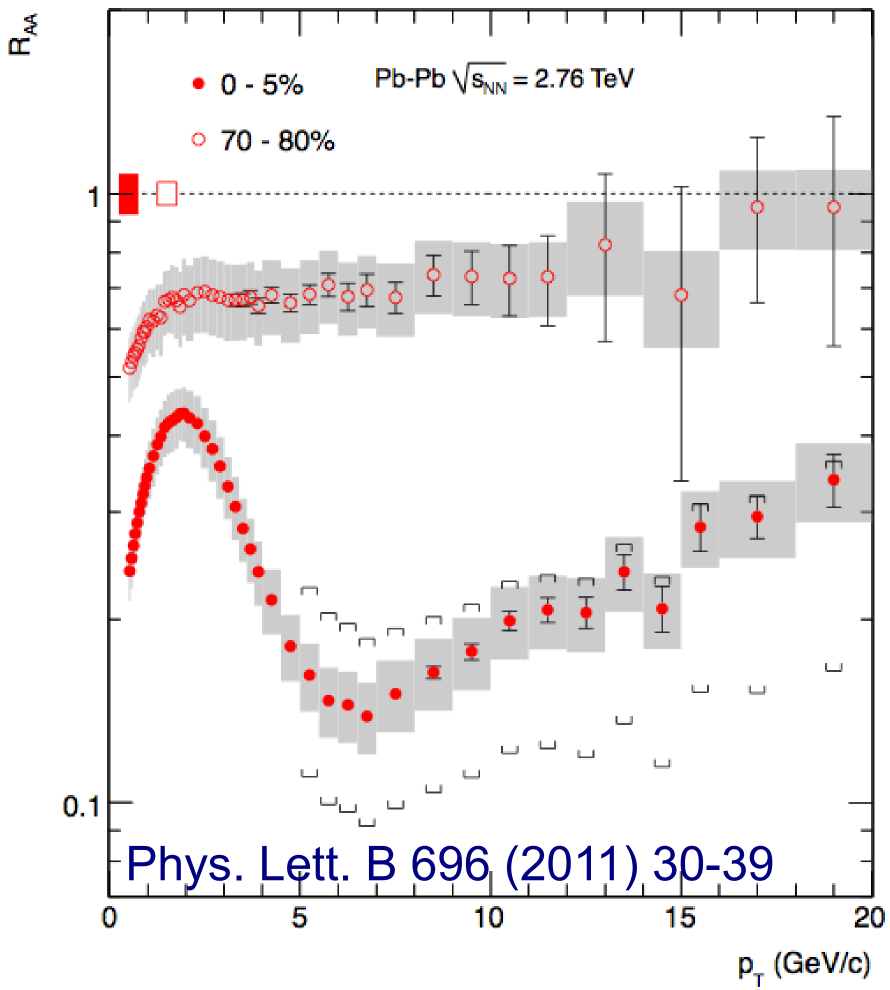


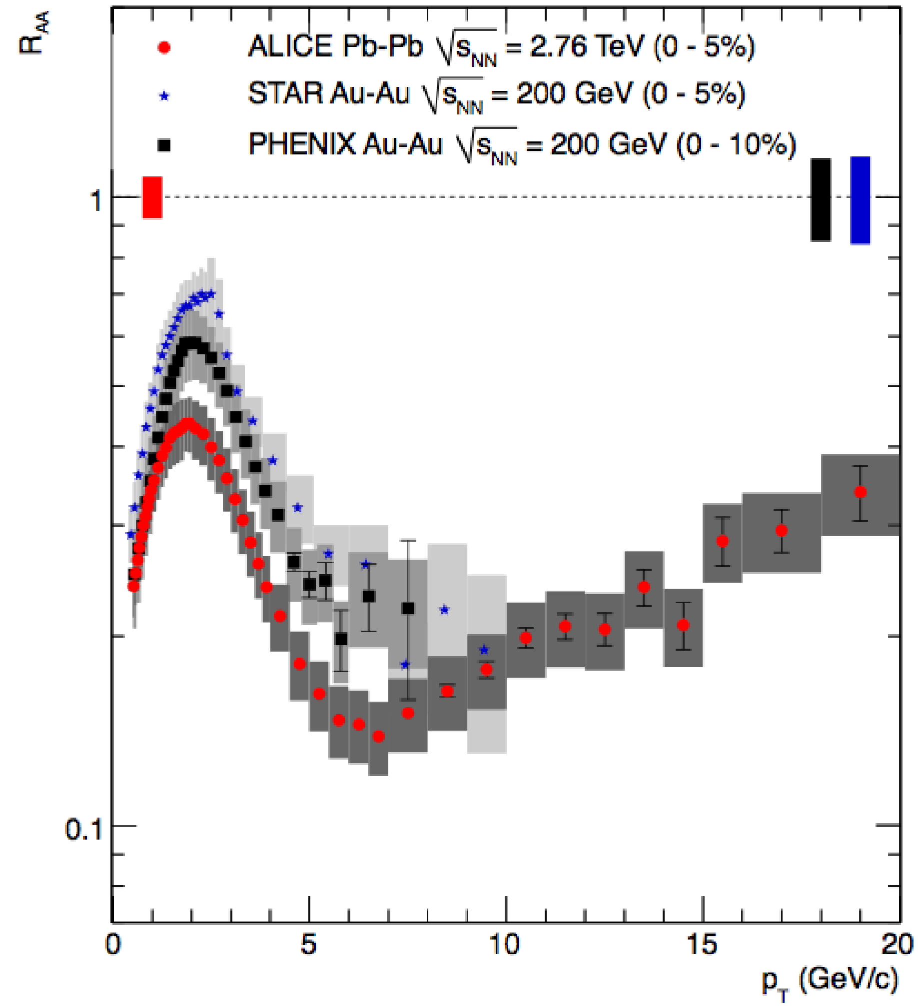
No suppression

Observed

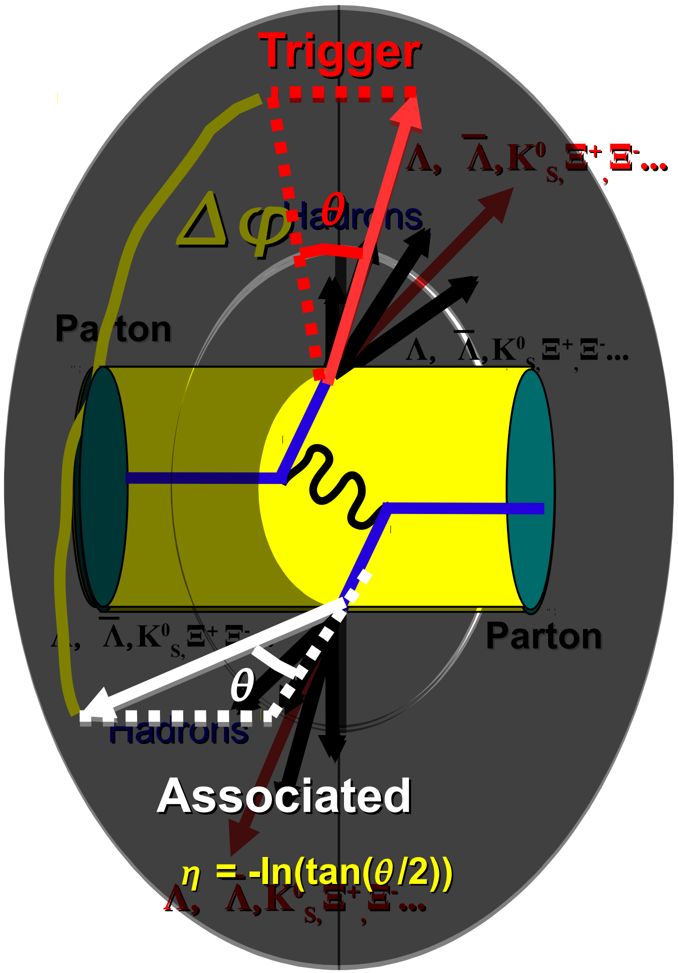


Experimental results

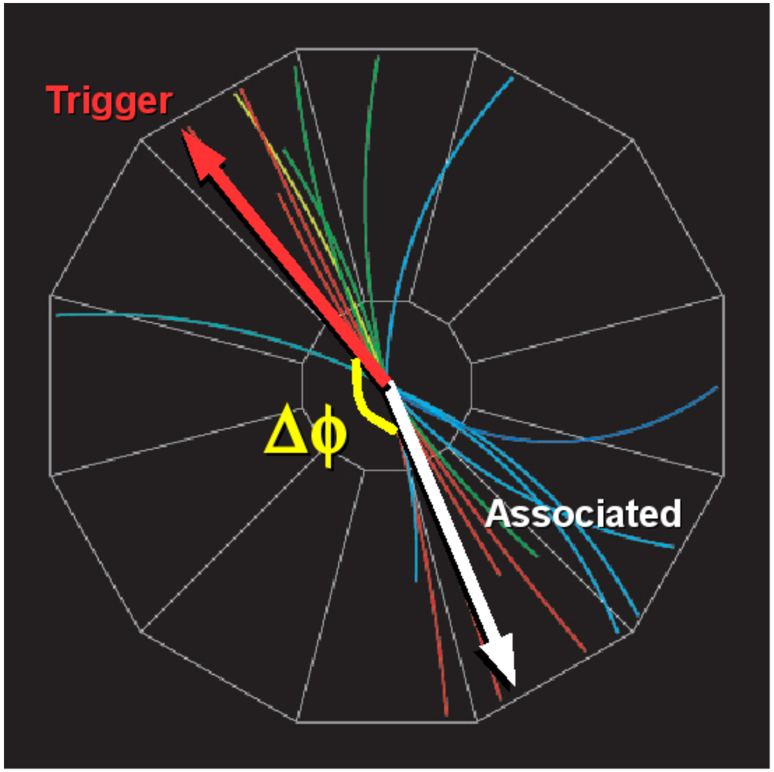


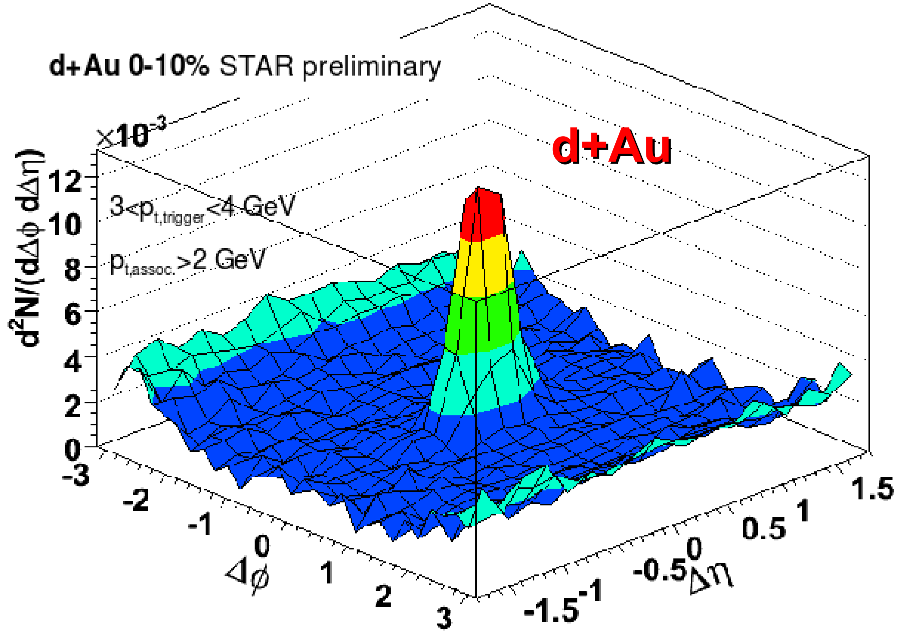


Look in two dimensions

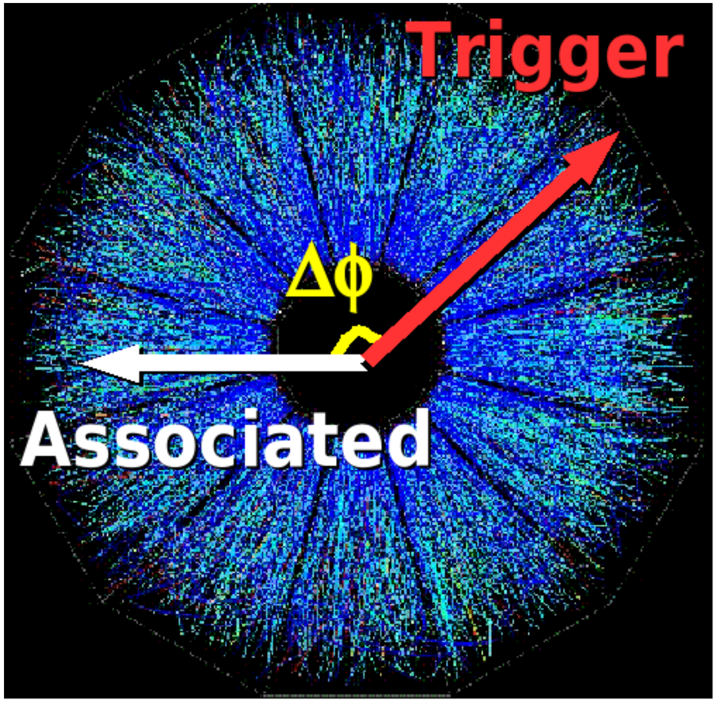


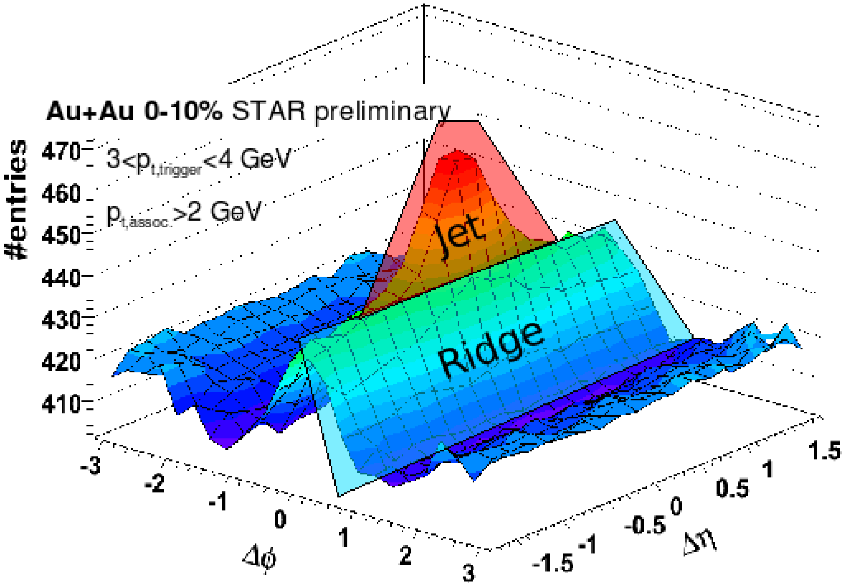
d+Au


Trigger
Δφ
Associated


d+Au 0-10% STAR preliminary
d+Au
$\times 10^{-3}$
$3<p_{t,trigger}<4$ GeV
$p_{t,assoc.}>2$ GeV
$d^2N/(d\Delta\phi\, d\Delta\eta)$
Δφ
Δη

In two dimensions in Au+Au



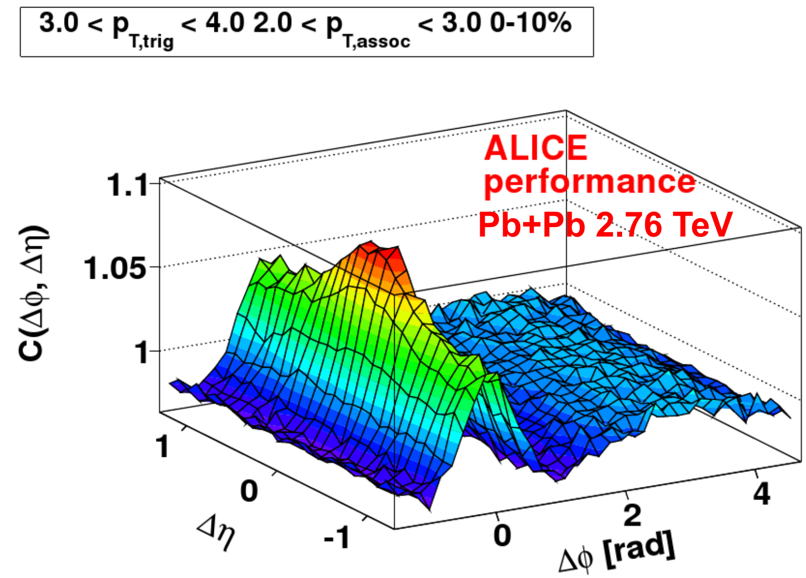


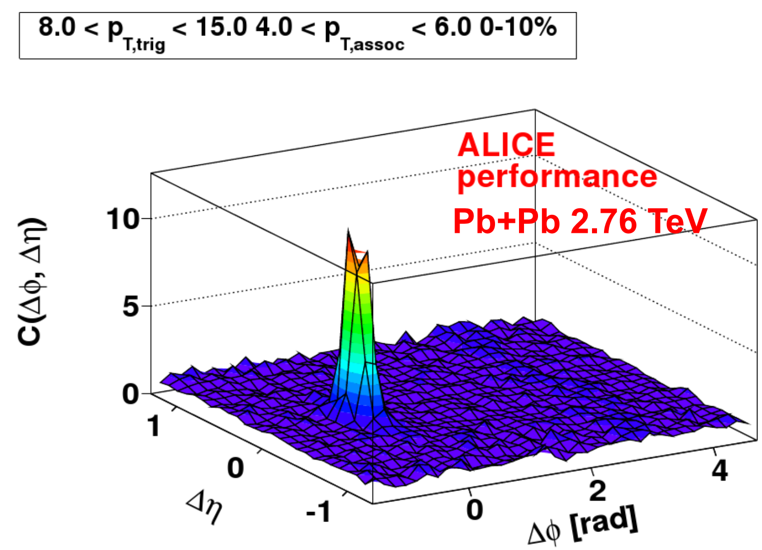
Dihadron Correlations

- Study two-particle correlations with per-trigger yields

$$\frac{1}{N_{trig}}\frac{dN_{assoc}}{d\Delta\varphi} \quad \textbf{and} \quad \frac{1}{N_{trig}}\frac{d^2N_{assoc}}{d\Delta\varphi d\Delta\eta}$$

- Lower p_T
  - Ridge
  - Hydrodynamics, flow
- High p_T
  - Quenching/suppression, broadening
- Calculate near side (around $\phi = 0$) and away side ($\phi = \pi$) yields
- Compare central and peripheral → I_{CP}
- Compare AA and pp → I_{AA}





Remaining slides gratuitously stolen from Jan Fiete Grosse-Oertringhaus at Moriond

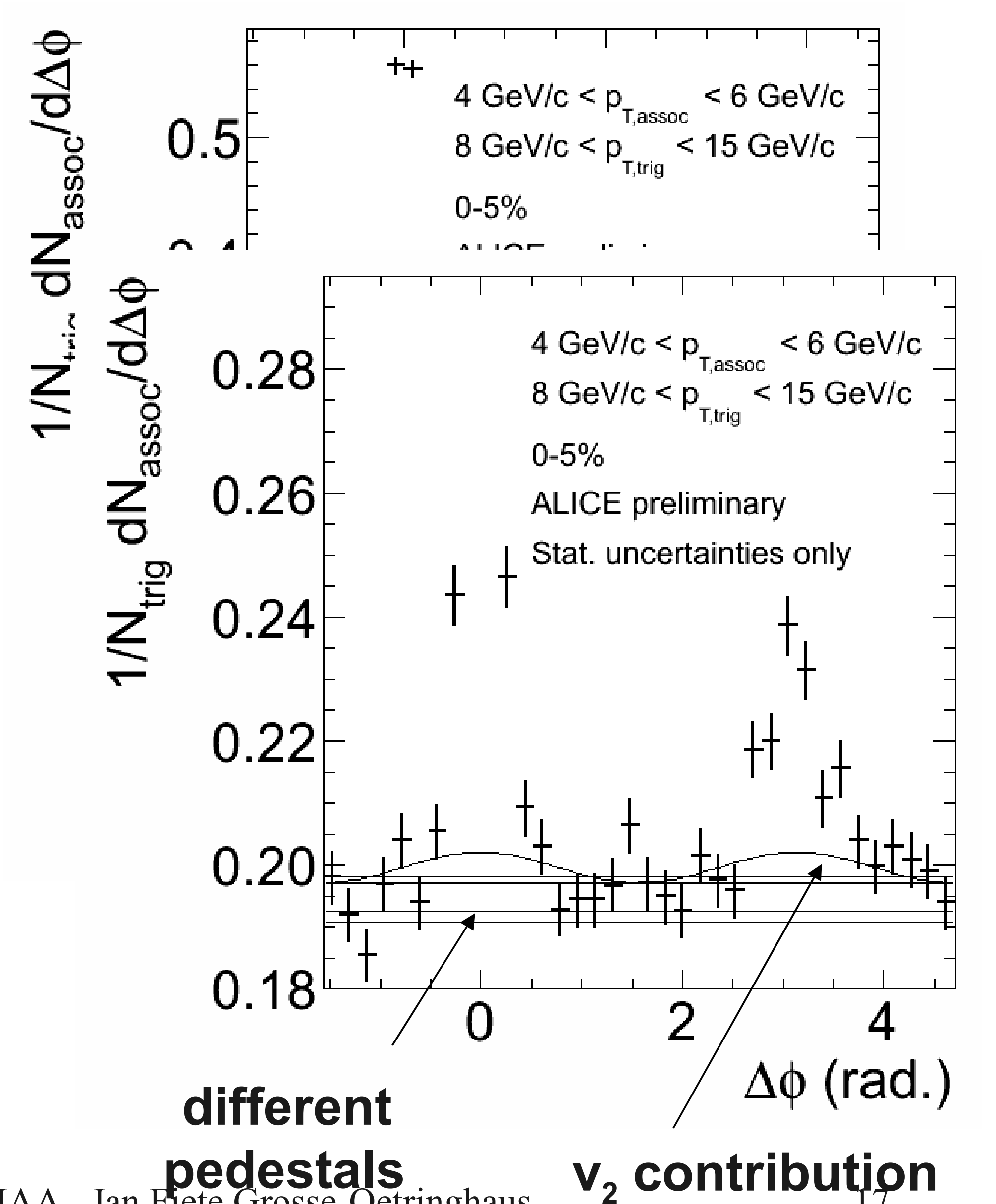
Measurement of ICP and IAA - Jan Fiete

Pedestal and Flow

- To calculate yields, pedestal needs to be determined
- Fit in region around π/2 (ZYAM)
  - Different ways to estimate uncertainty
- Estimate radial flow (v_2) contribution using ALICE flow measurement
  - Flow subtraction quite controversial

→ Measure in a region where the signal dominates over pedestal and v_2 modulation (8 GeV/c < $p_{T,trig}$ < 15 GeV/c)

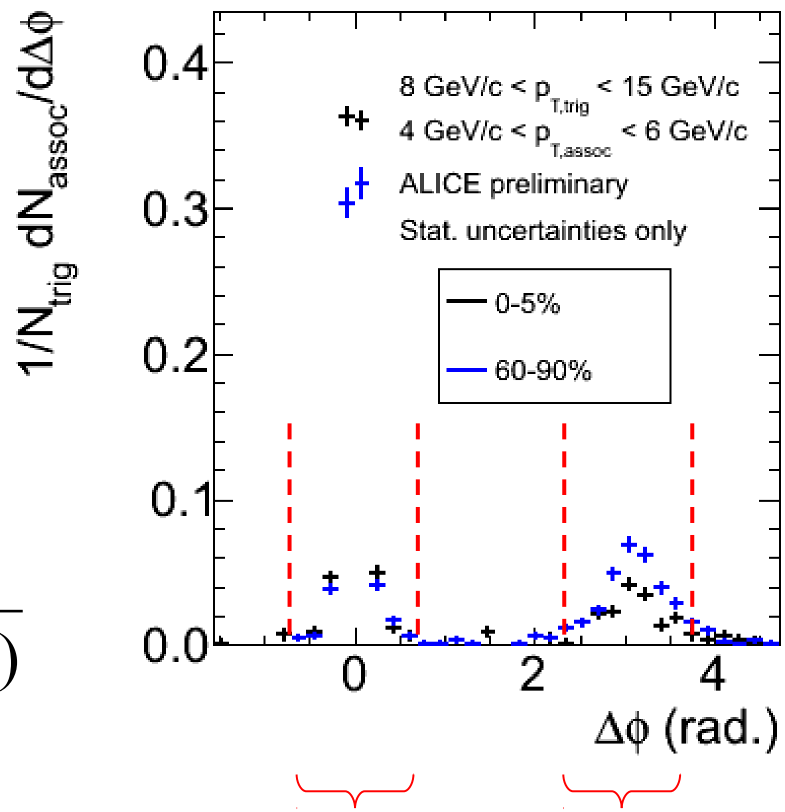
→ Indicate difference in measurement if v_2 was subtracted



Yield Extraction

- After pedestal (and optionally v_2) subtraction), integrate to obtain yield Y
  - Near side $-0.7 < \phi < 0.7$
  - Away side $-0.7 < \phi - \pi < 0.7$
- In bins of associated p_T: $p_{T,assoc}$
- Divide yields to obtain I_{CP} and I_{AA}

0-5%
60-90%

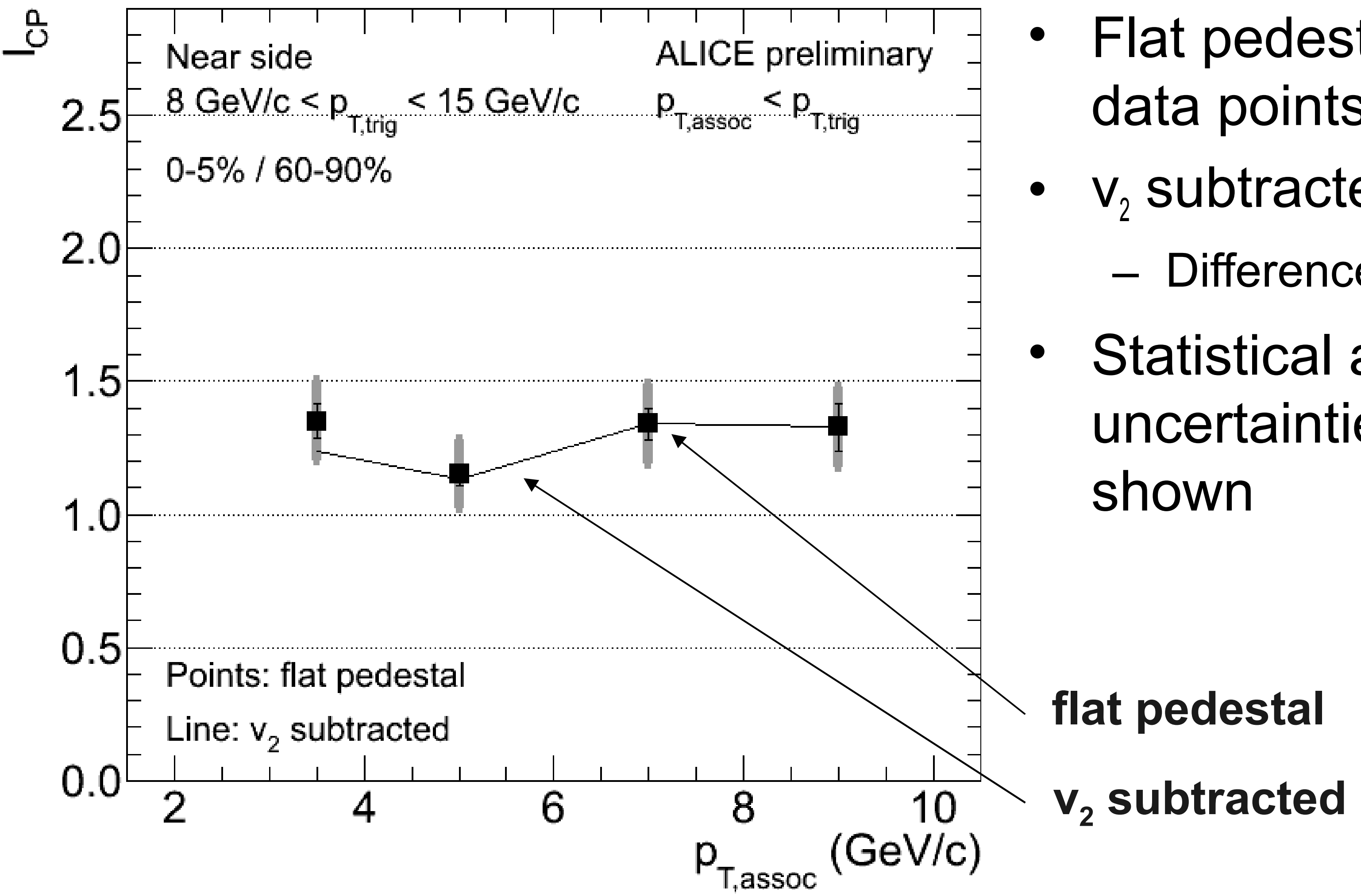


integration windows

$$I_{CP}(p_{T,trig};p_{T,assoc}) = \frac{Y^{AA}_{central}(p_{T,trig};p_{T,assoc})}{Y^{AA}_{peripheral}(p_{T,trig};p_{T,assoc})}$$

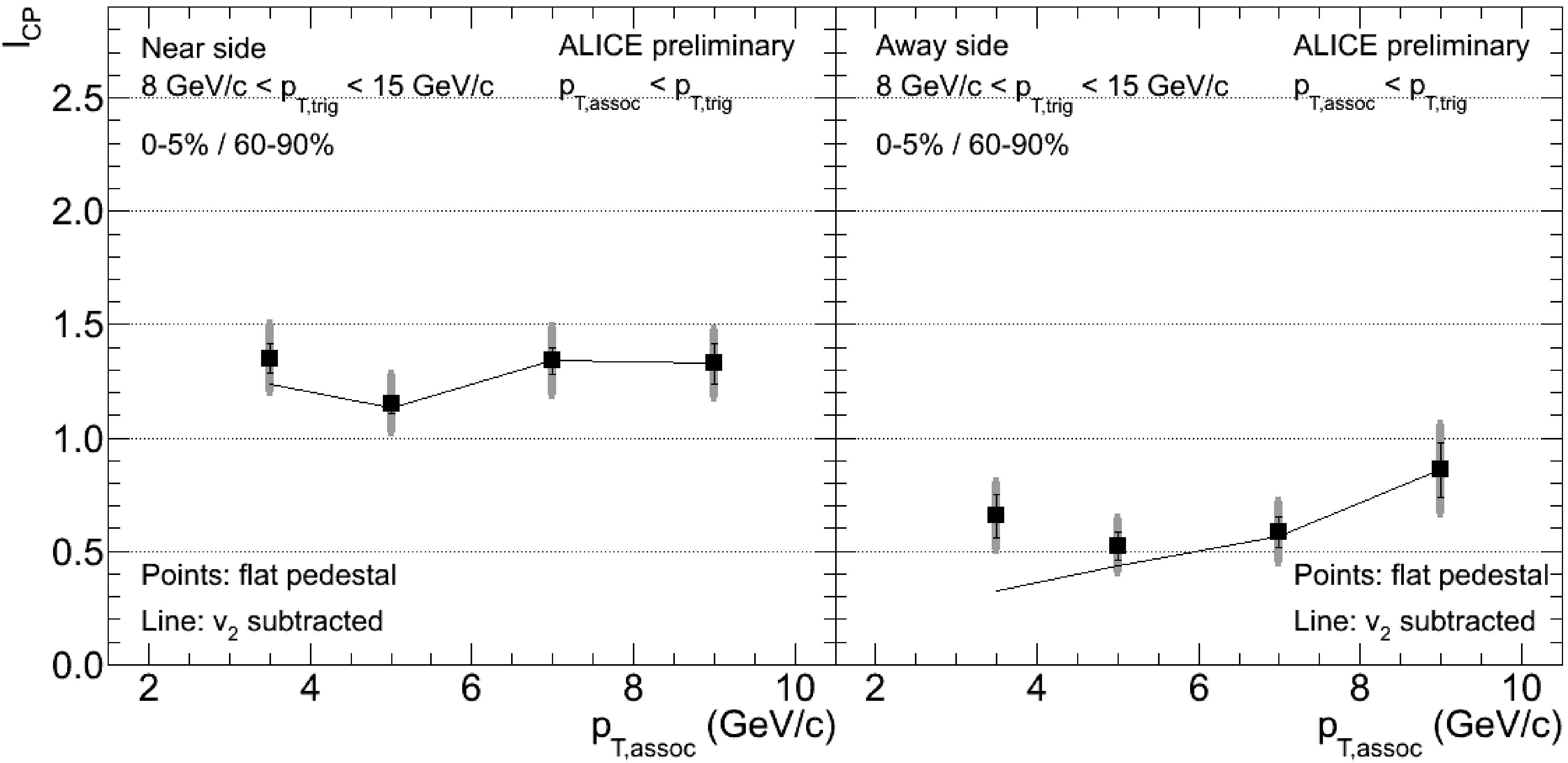
$$I_{AA}(p_{T,trig};p_{T,assoc}) = \frac{Y^{AA}(p_{T,trig};p_{T,assoc})}{Y^{pp}(p_{T,trig};p_{T,assoc})}$$

I_{CP}



- Flat pedestal subtraction → data points
- v_2 subtracted → line
  - Difference only at low p_T
- Statistical and systematic uncertainties (shaded area) shown

I_{CP} (2)

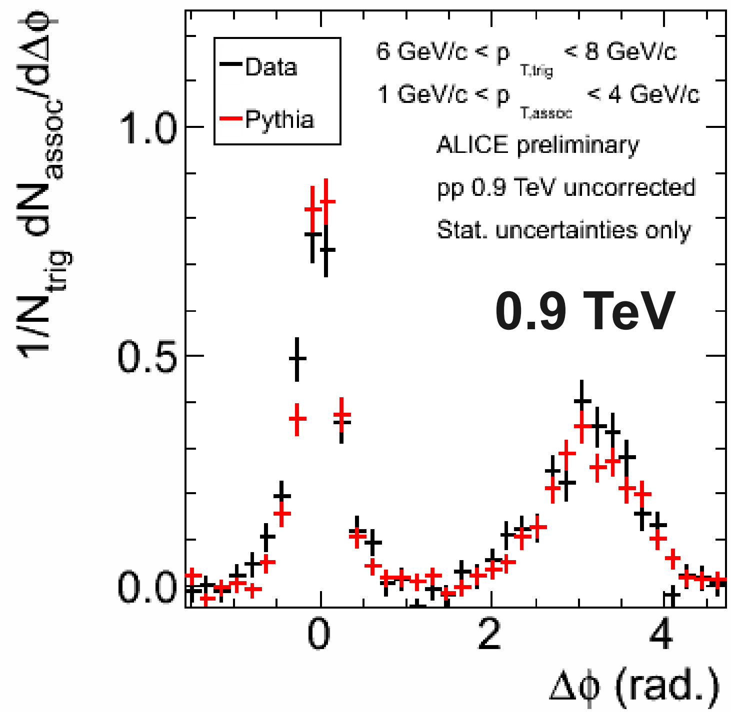


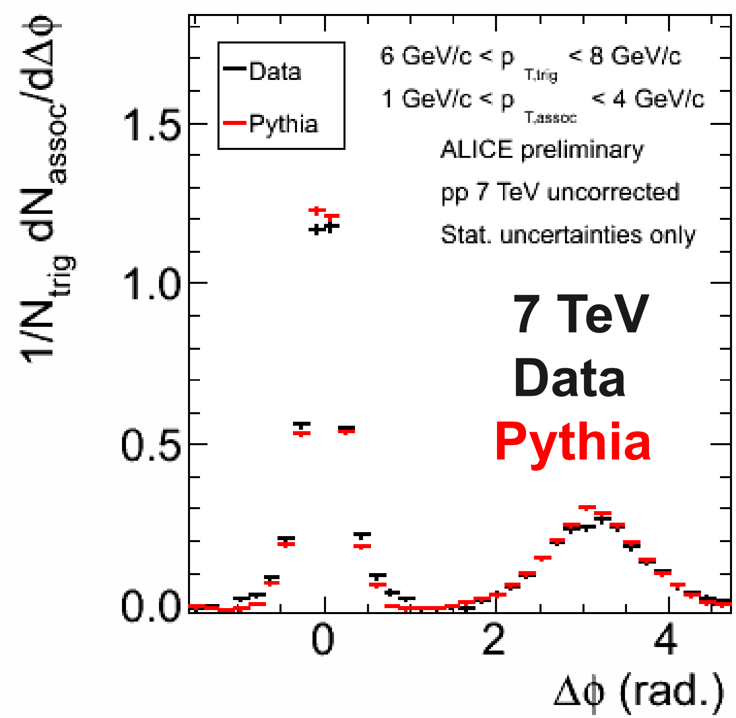
- **Slightly enhanced near-side: I_{CP} ~ 1.2 … unexpected and interesting**
- **Away side suppressed: I_{CP} ~ 0.6 … expected from in-medium energy loss**
- **v_2 contribution small except in lowest bin, there v_3 subtraction may be significant**

I_{AA} Reference

- Interesting to study yield with respect to unquenched (pp) case
  - No pp data taken at 2.76 TeV, yet
  - Use a MC
- Pythia6 tune Perugia-0 has been found to describe dihadron correlations at 0.9 and 7 TeV well
  - Using a scaling factor between 0.8 and 1
  - Interpolate to 2.76 TeV
    - Factor 0.93 ± 13% (stat/syst)

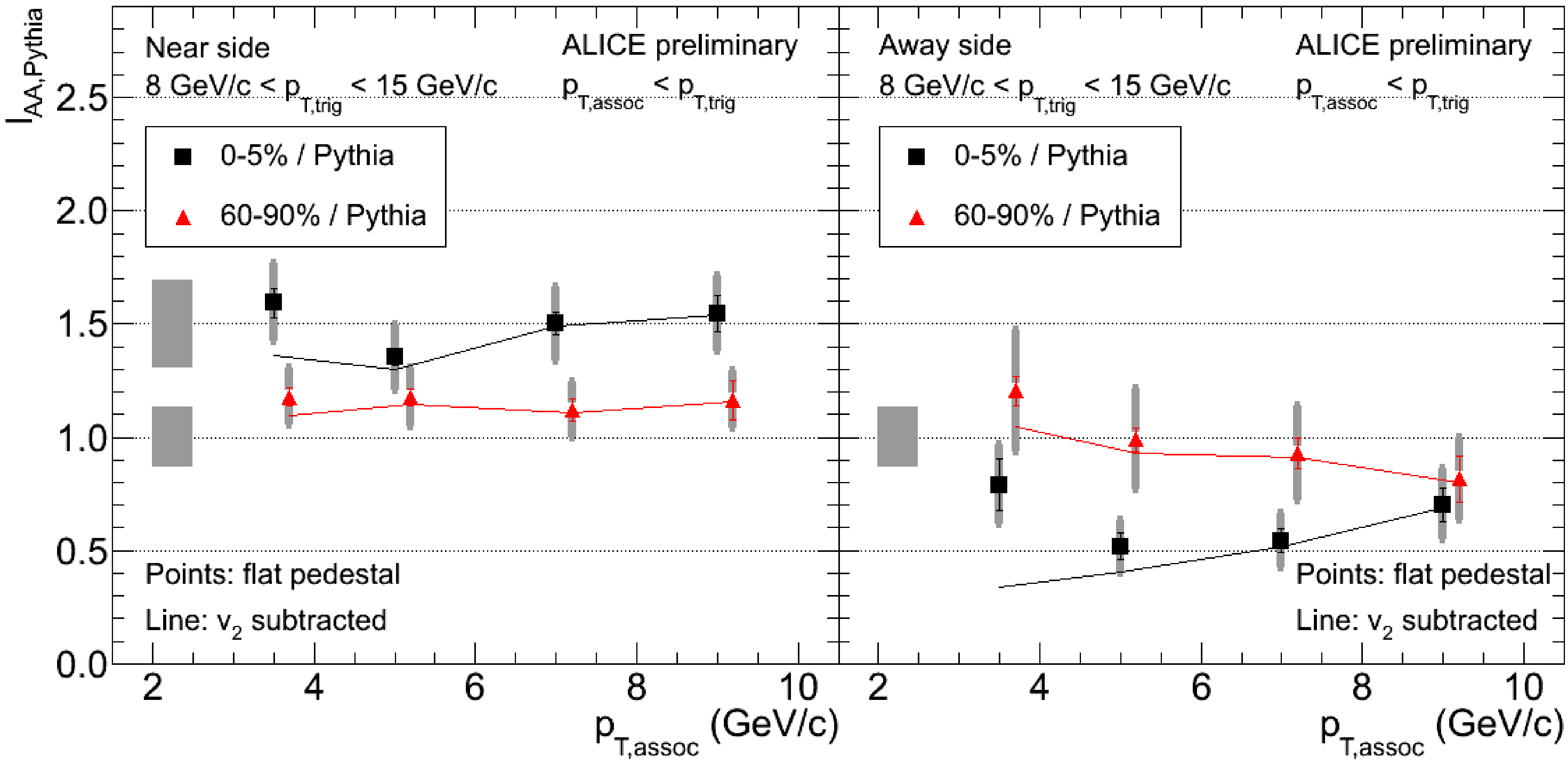
→ Use scaled Pythia reference to calculate $I_{AA,Pythia}$





Measurement of ICP and IAA - Jan Fiete

$I_{AA,Pythia}$



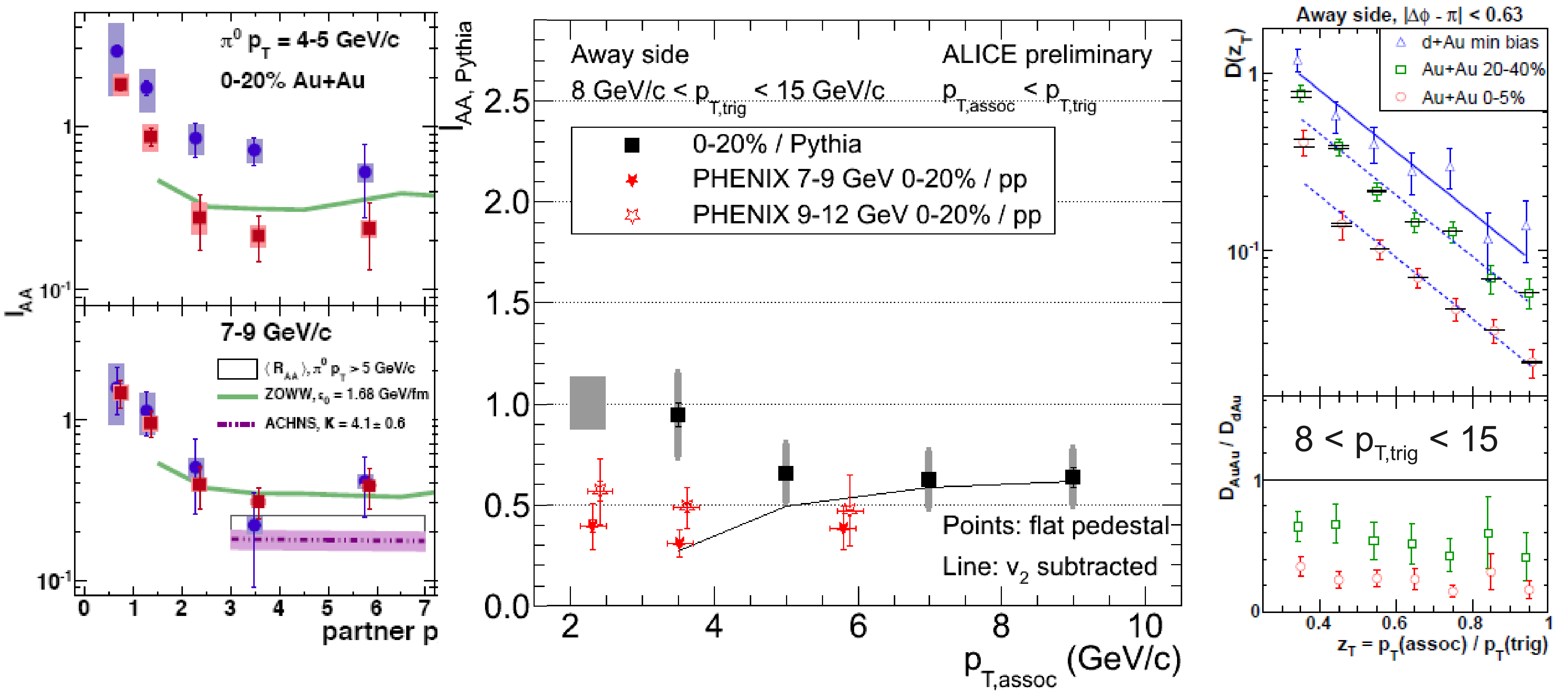
Central events

- Near side enhanced $I_{AA,Pythia}$ ~ 1.5
- Away side suppressed $I_{AA,Pythia}$ ~ 0.5 – 0.7

Peripheral events

- Near side enhanced $I_{AA,Pythia}$ ~ 1.2
- Away side $I_{AA,Pythia}$ consistent with 1

$I_{AA,Pythia}$: ALICE vs. RHIC



PHENIX, PRL 104, 252301 (2010)

STAR, PRL97,162301 (2006)

- **PHENIX subtracts v_2 → compare ALICE line with PHENIX**
- **STAR measurement in slightly different variable (z_T) and d+Au reference**

Conclusions

- Jet suppression at the LHC is greater than at RHIC
  - We will be able to quantify this better once we analyze the 2.76 TeV data
- The ridge is also at the LHC

More information on ALICE

- ALICE web site
- US LHC Blog posts

Backup slides

TRD, TOF, HMPID

Transition Radiation Detector

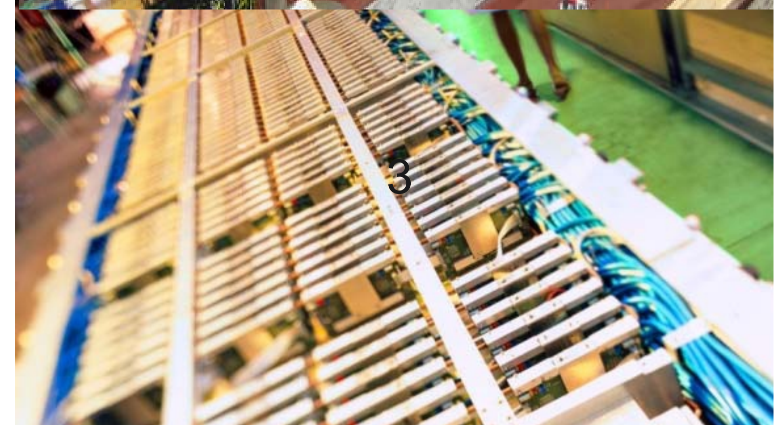
- p_T>1 GeV electron id, p_T>3 GeV trigger
- 540 modules, 4.8 cm radiator with 1.2M channels
- MWPC readout

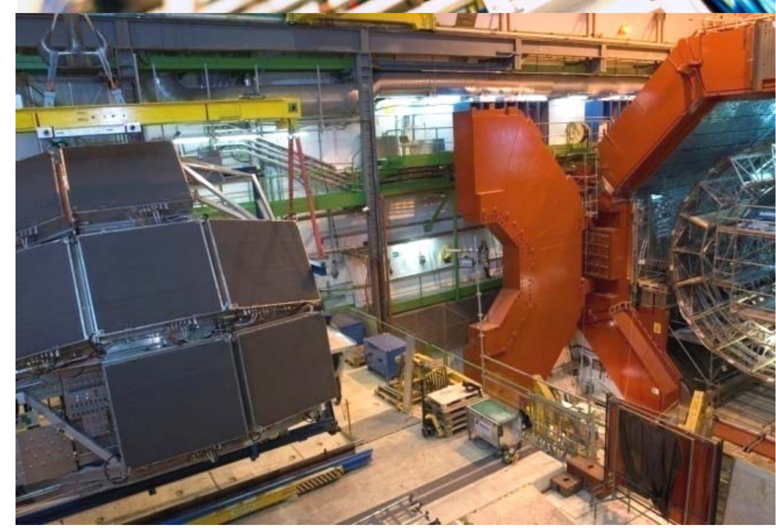
Time Of Flight

- Multi-gap Resistive Plate Chambers (MRPC)
- 50 ps resolution at ~5m
- $|\eta|<0.85$, $\Delta\varphi=2\pi$

High Momentum PID

- Proximity focused, Ring Imaging Cherenkov RICH
- $|\eta|<0.6$, $\Delta\varphi=\pi/3$
- PID 1<p<6 GeV

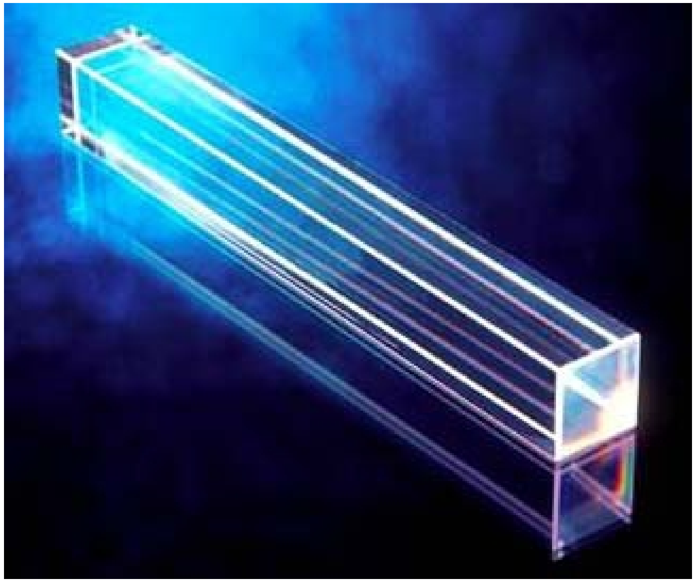




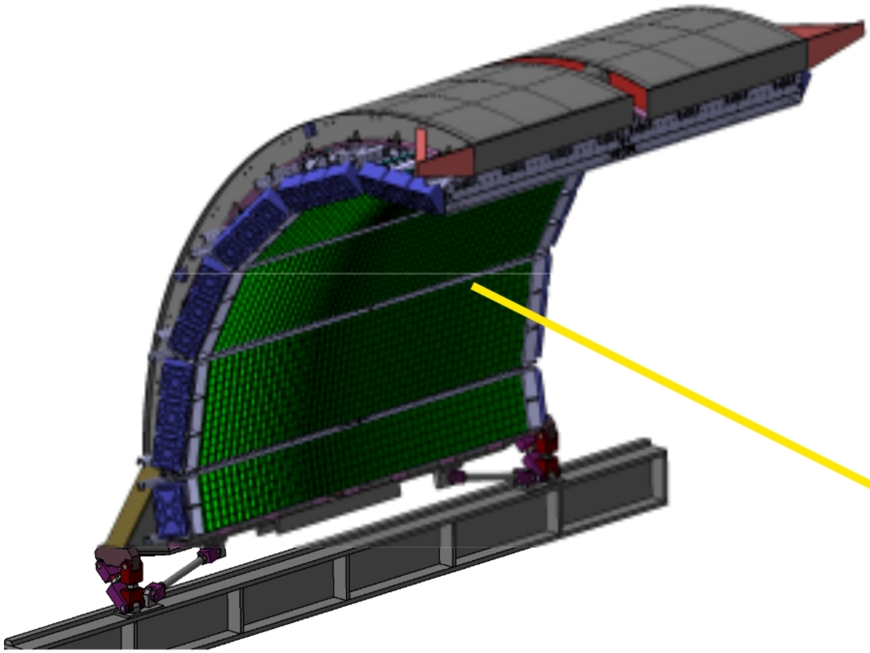
PHOS

PHOton Spectrometer

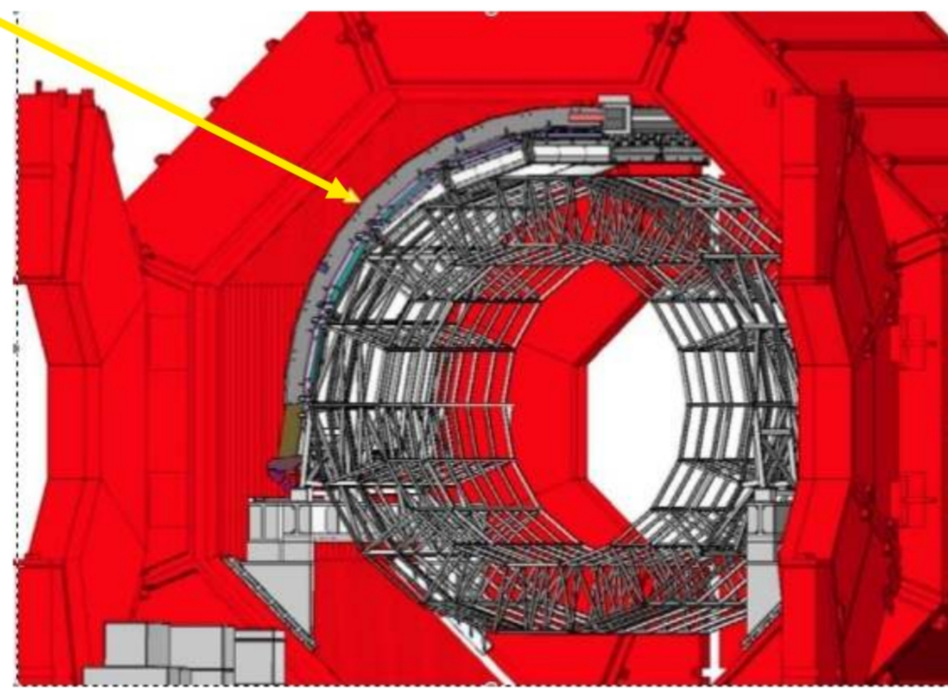
- PbO_4W crystal calorimeter
- γ,π^0,η for $1<p<100$ GeV
- $|\eta|<0.12$, $\Delta\phi=100^o$
- $\sigma(E)/E = 3\%$, $\sigma(x,y)=4$mm



EMCal



Funding approval: Feb. 2008
(~ALICE Upgrade: US, Italy, France, CERN, Finland)
– 7+2/3 US Super-Modules (SM)
– 3 EU SMs (Italy and France)
– Construct and Install 2008-2011



- Lead-scintillator sampling calorimeter
- 13 k towers
- Each tower $\Delta\eta X \Delta\varphi$= 0.014 X 0.014
- Shashlik geometry
- Avalanche phototodiodes
- $\Delta\eta=1.4, \Delta\varphi=107^{o}$
- $\sigma(E)/E=0.12/\sqrt{E} + 0.02$

EMCal Assembly

- 3072 identical modules, 2x2 towers
- 1.5^{o} taper in η
- Tower granularity $\delta\eta = \delta\varphi = 0.014$
- $20.1\ X_0$
- 77 layers Pb:Sc = 1.44 : 1.76 mm