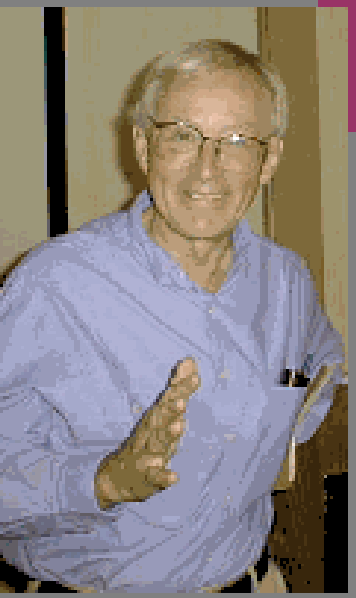
Forward Physics from RHIC to LHC

Thanks and a plea for guidance

Michael Murray
Kansas

Heavy Ions always data driven

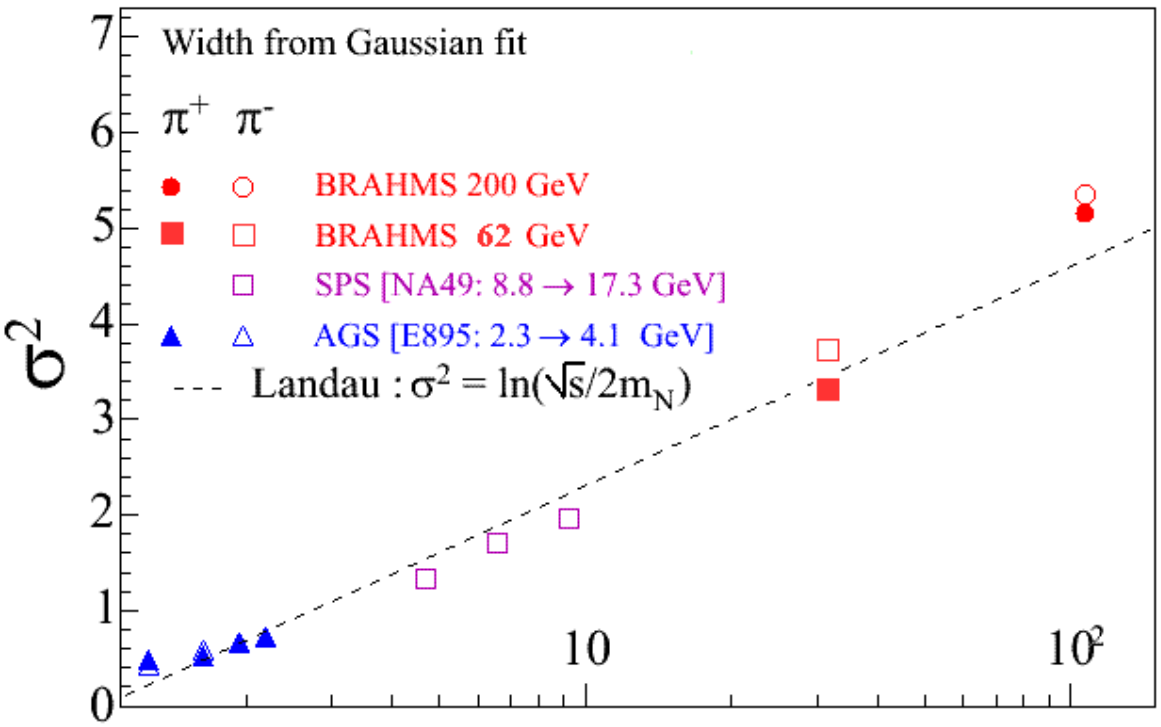


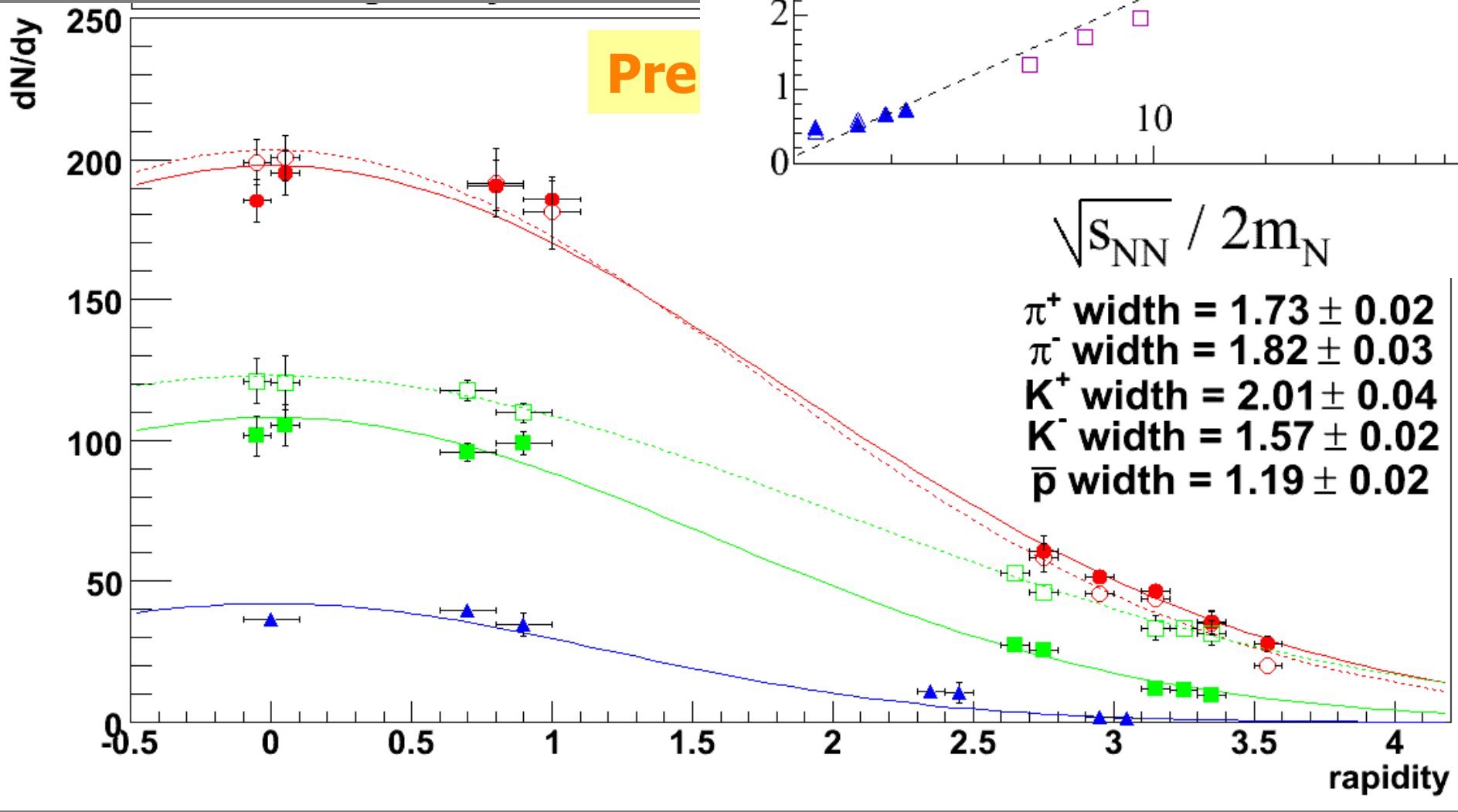
"These theories ain't worth a bucket of worm piss"

Bill Wi

Yields are not boost invariant

62GeV AuAu





Pre

Elliptic flow $V_2(p_T)$ changes slowly

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Suppression also changes very slowly

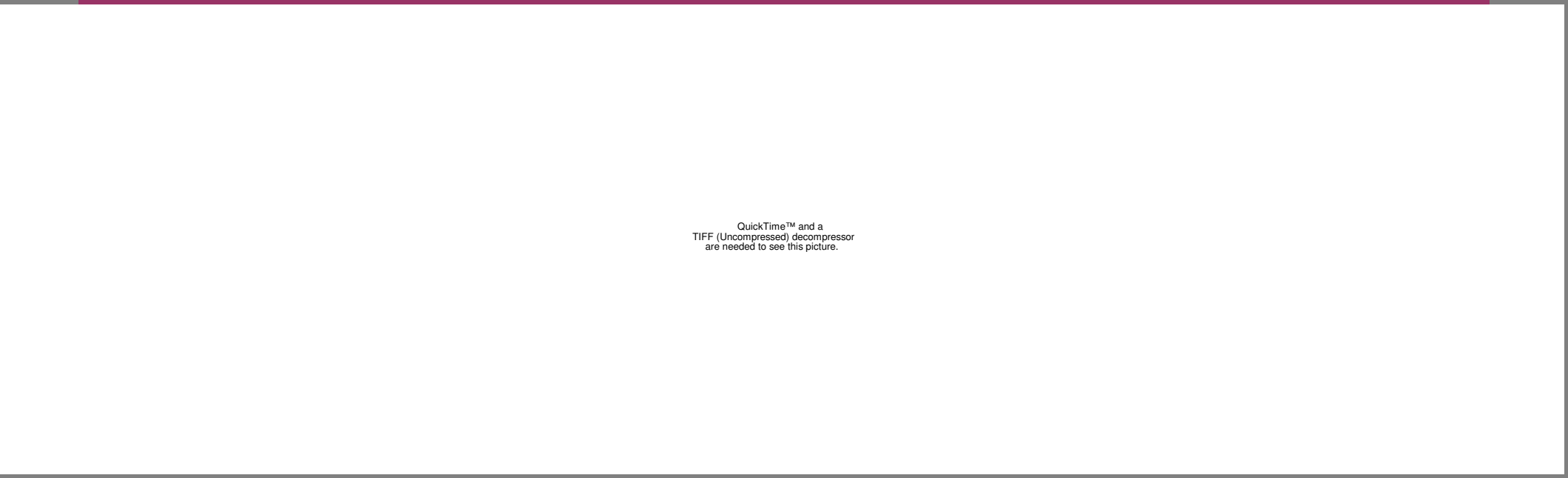
QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

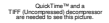
Lots of forward protons at high pT

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Saturation at forward y for d-Au





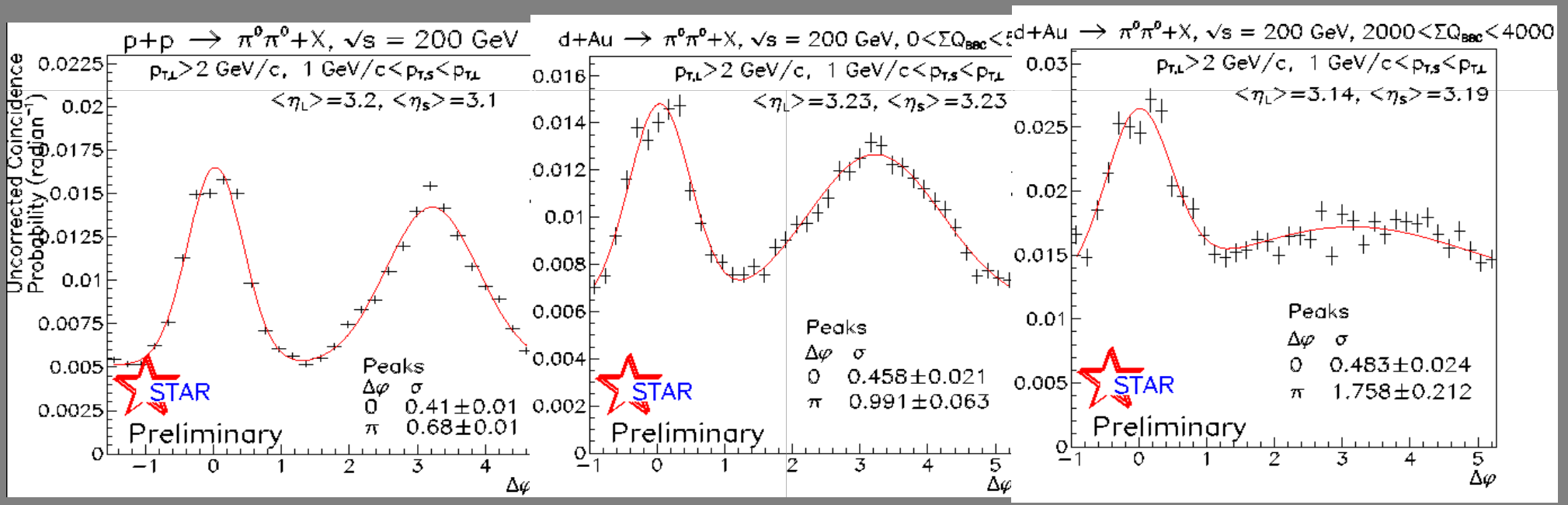
J/ψ also suppressed in dA

QuickTime™ and a
decompressor
are needed to see this picture.

Looks like limiting fragmentation not $x_{nucleus}$ scaling , Larry yesterday

Jet Suppression in dAu

200 GeV ***p+p*** and ***d + Au*** Collisions
Run8, STAR Preliminary

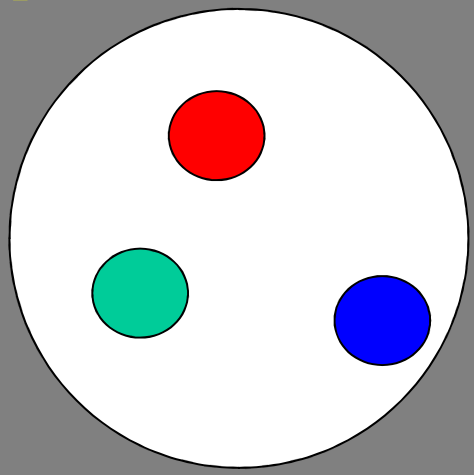


pp ***d+Au (peripheral)*** ***d+Au (central)***

Hawking Radiation in "QCD"

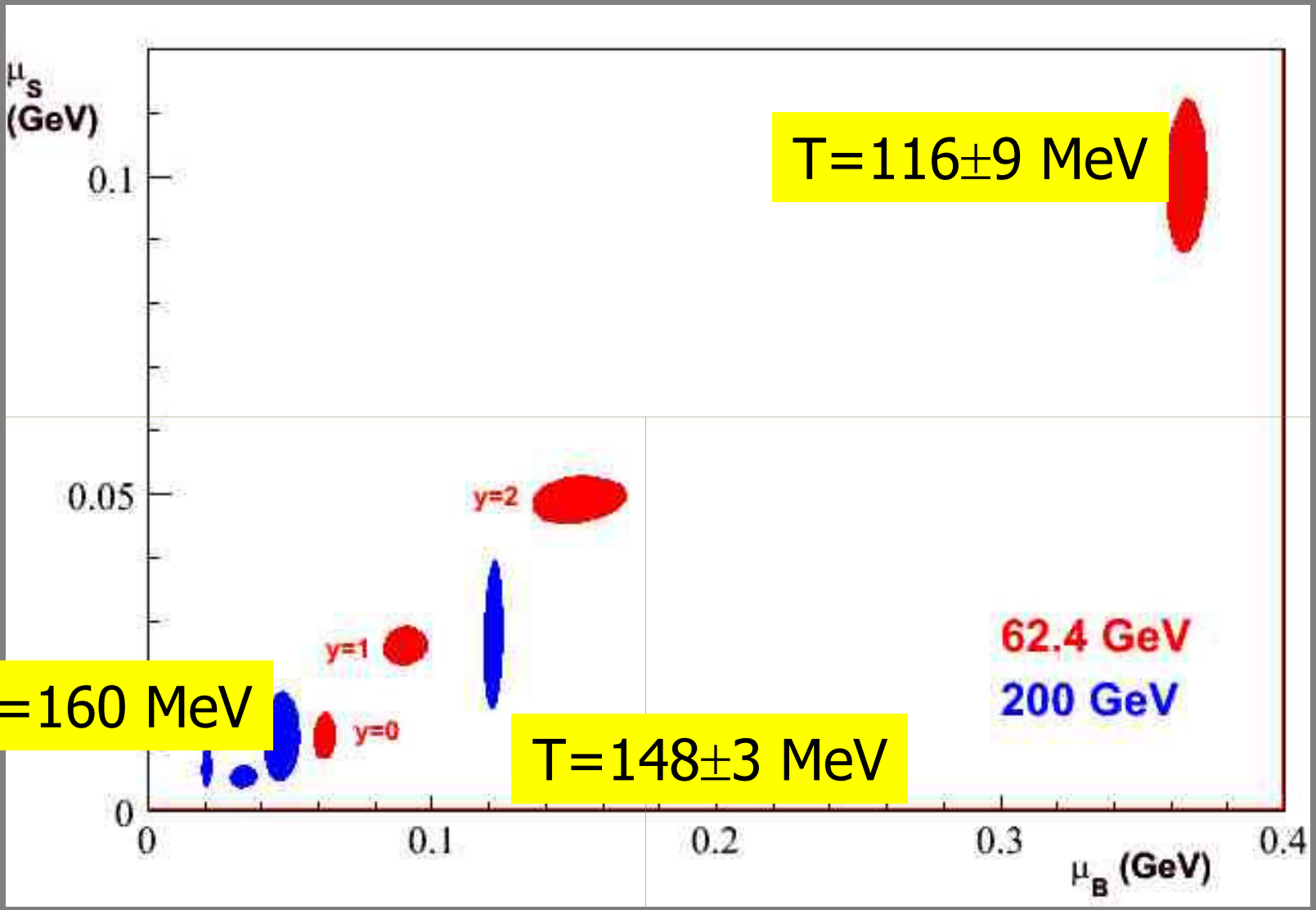
QCD gives quarks and gluons a "color" charge related to their strong interactions, Color Confinement causes the physical vacuum to create an "event horizon" like black holes…

→ Is a proton a "White Hole"?



1. "Thermal hadronization and Hawking-Unruh radiation in QCD." P. Castorina, D. Kharzeev and H. Satz

Fit $\pi^{\pm}$, $K^{\pm}$, $p^{\pm}$ => T, chemical potentials



2. "THERMUS -- A Thermal Model Package for ROOT", S. Wheaton and J. Cleymans, hep-ph/0407174

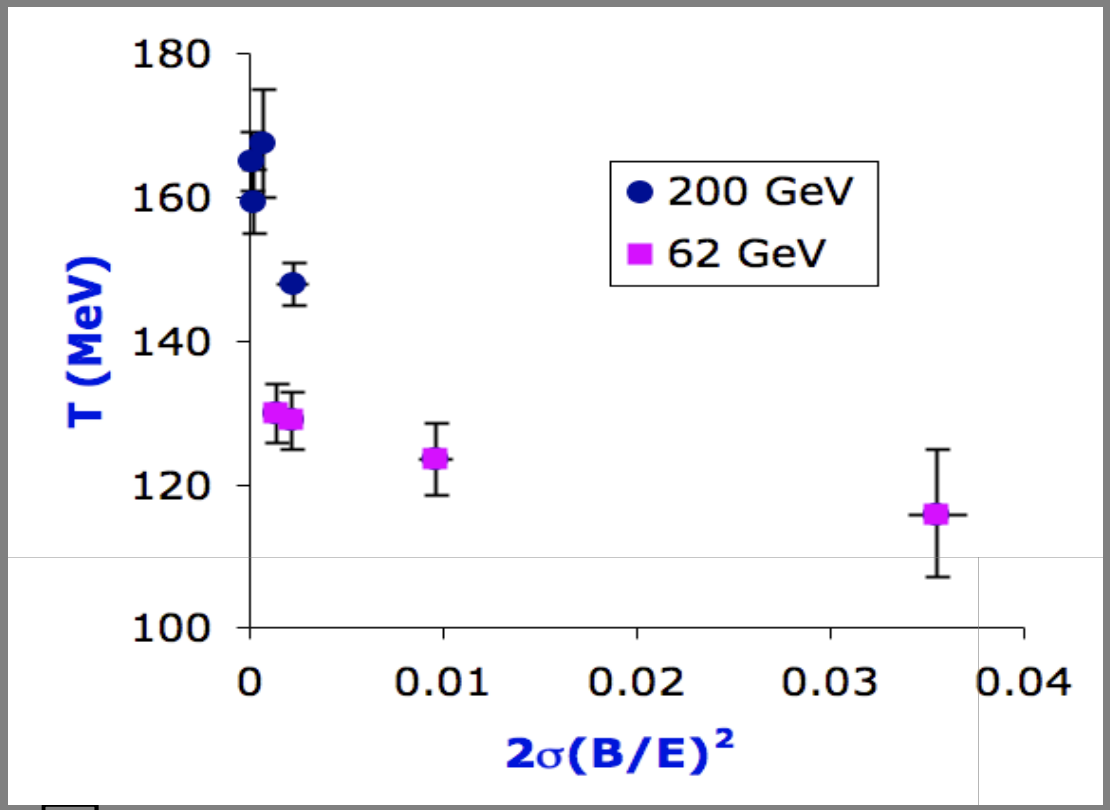
Gravity ⟺ "QCD"

Black Hole Mass	⟺	Energy
Charge	⟺	Baryon Number
Gravitational Constant	⟺	String tension

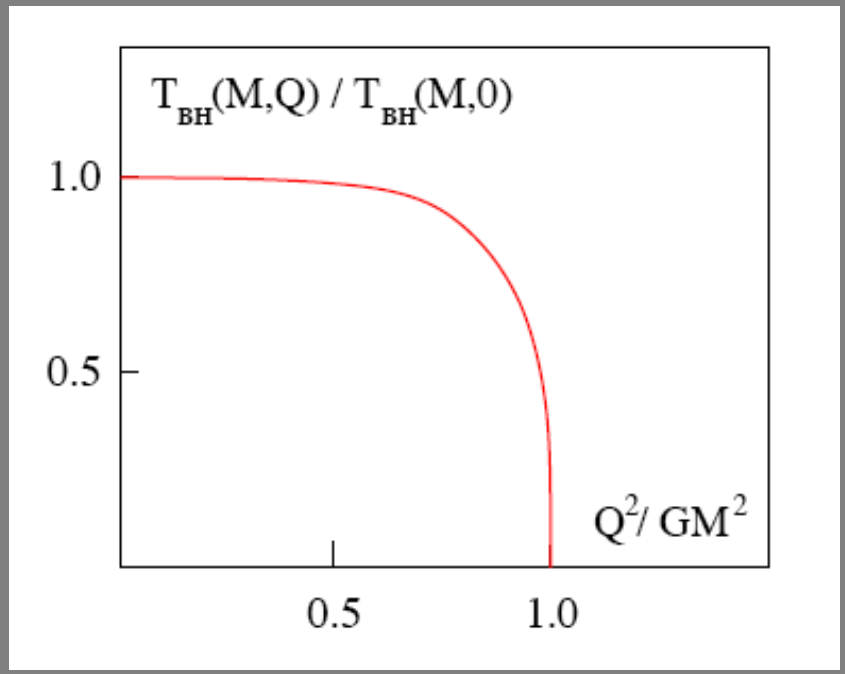
$$T_Q(B) = T_Q(B=0)\left\{\frac{4\sqrt{1-2\sigma\,B^2/E^2}}{(1+\sqrt{1-2\sigma\,B^2/E^2}\,)^2}\right\};$$

1. "Thermal hadronization and Hawking-Unruh radiation in QCD." P. Castorina, D. Kharzeev and H. Satz

First look for white holes

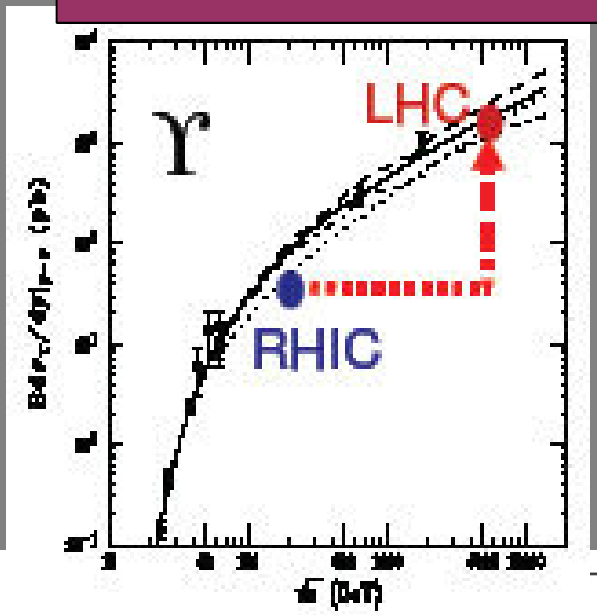


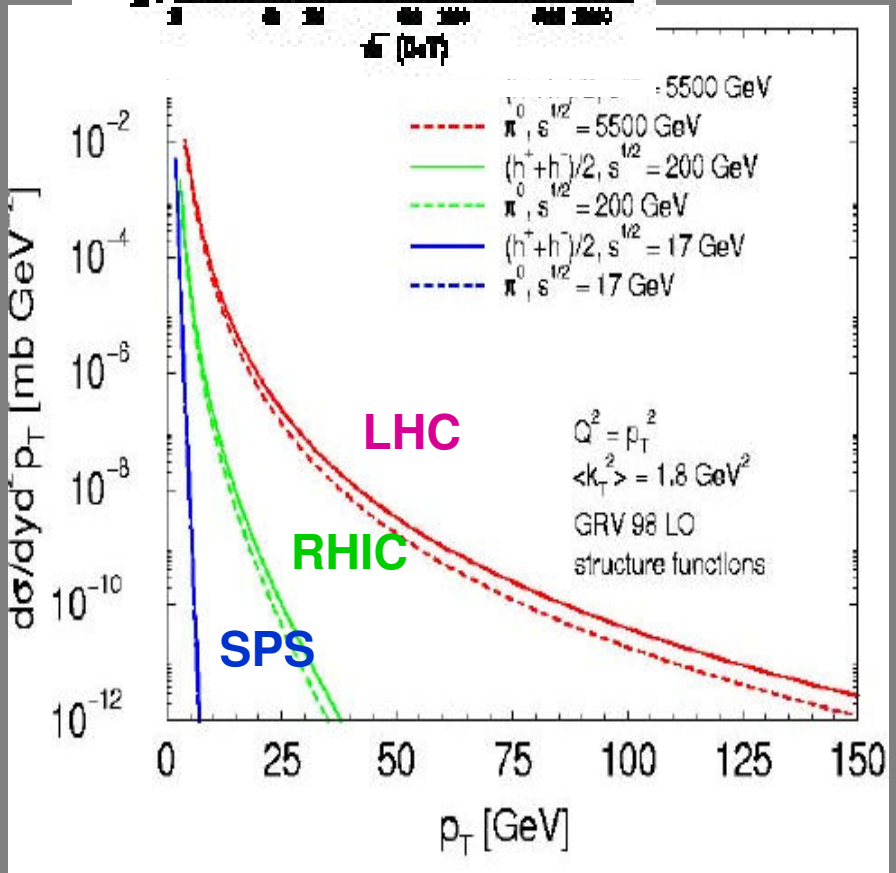
$$E_t = \sum_{\pi,k,p} \langle m_t \rangle \frac{dN}{dy}$$

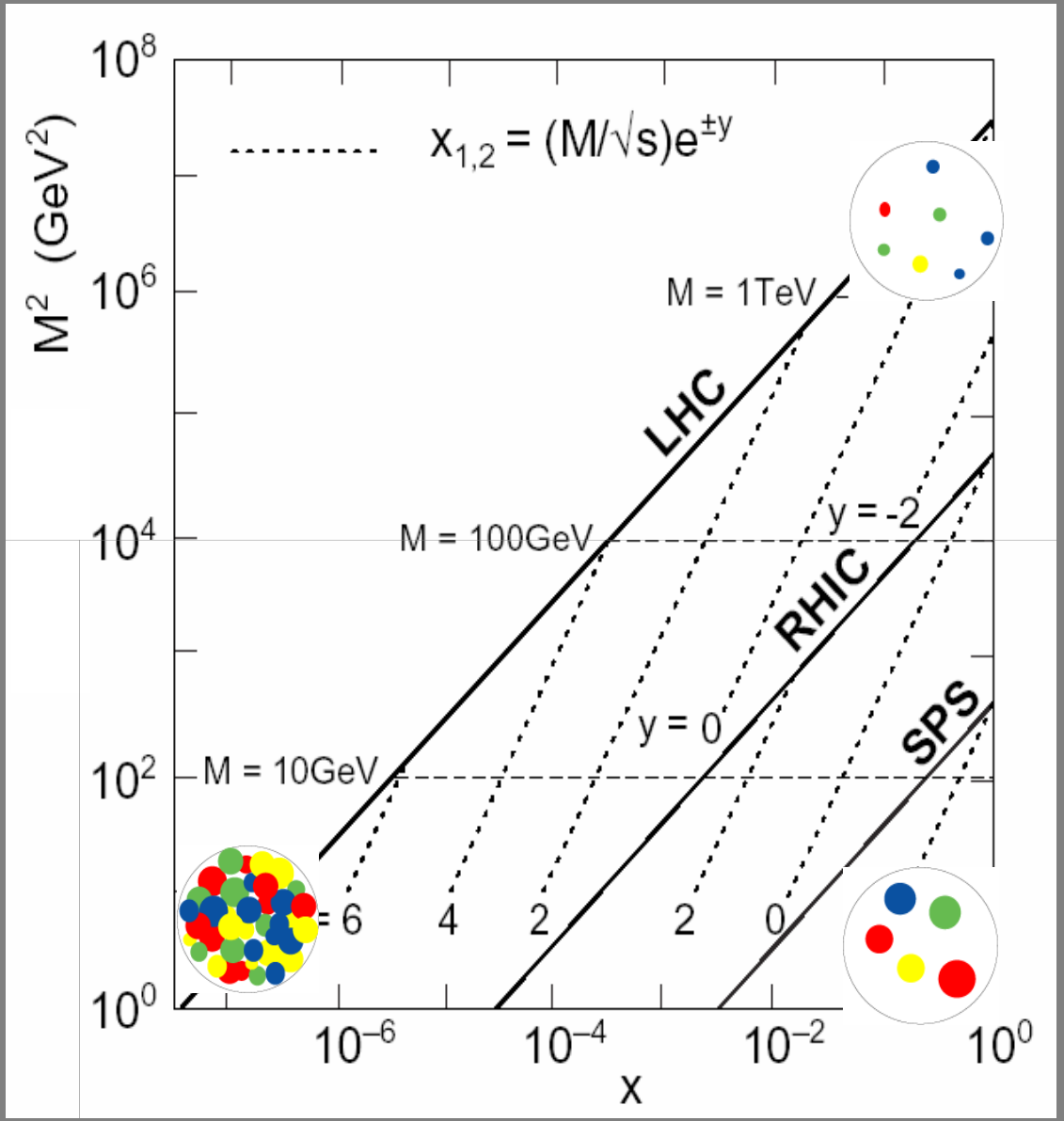


Temperature is dropping, but theory would predict no effect over such a range in (B/E)

What happens when energy goes up 28 times?

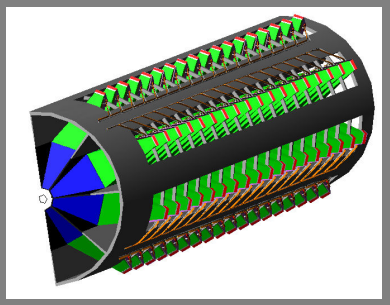




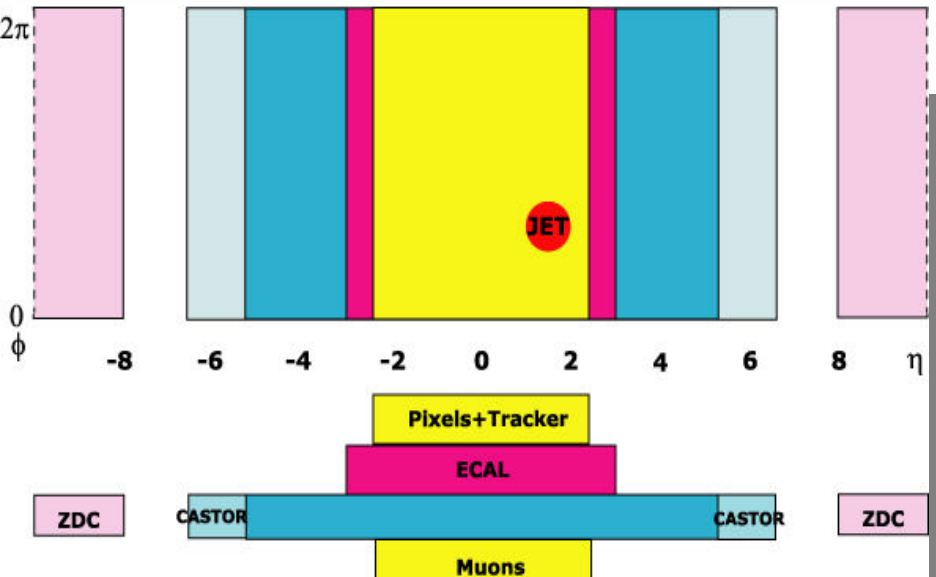


CMS

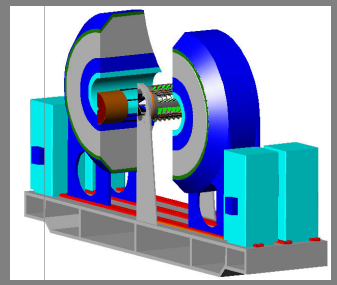
Castor $5.2 < \eta < 6.6$



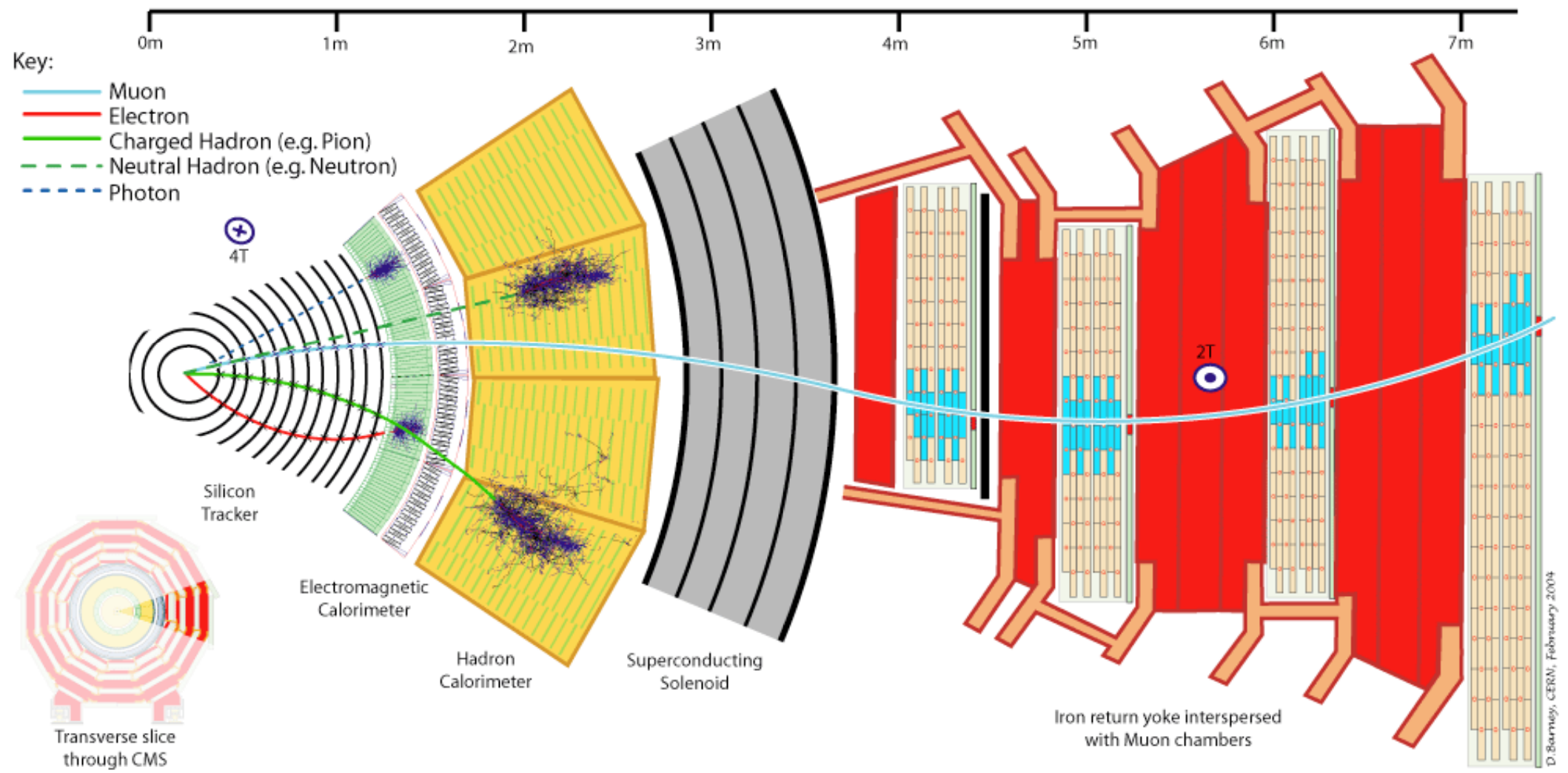
ZDC $\eta > 8.3$



Castor $5.3 < \eta < 6.7$

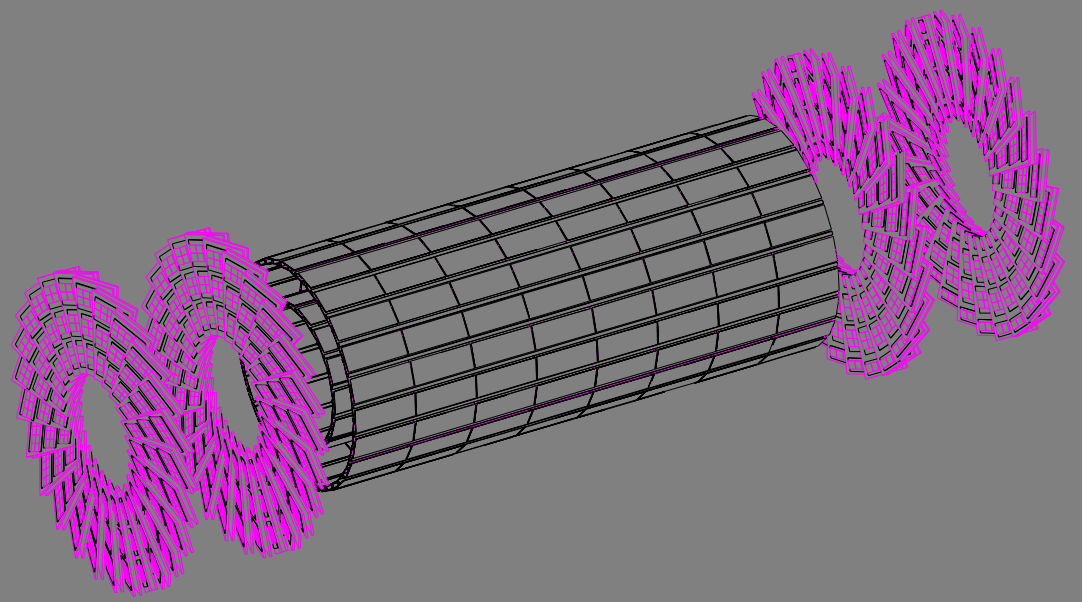


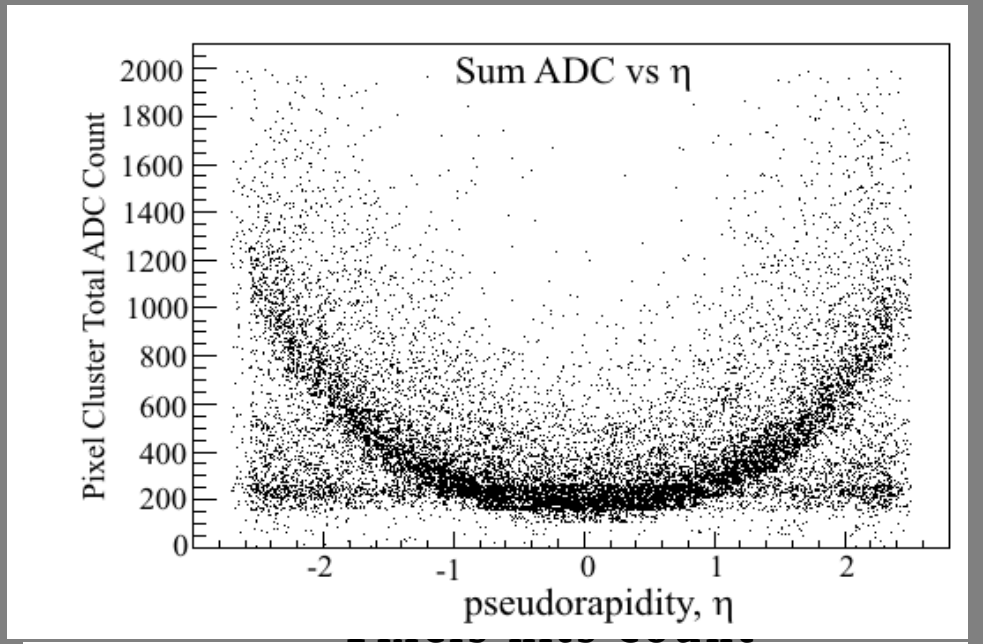
transverse slice through CMS

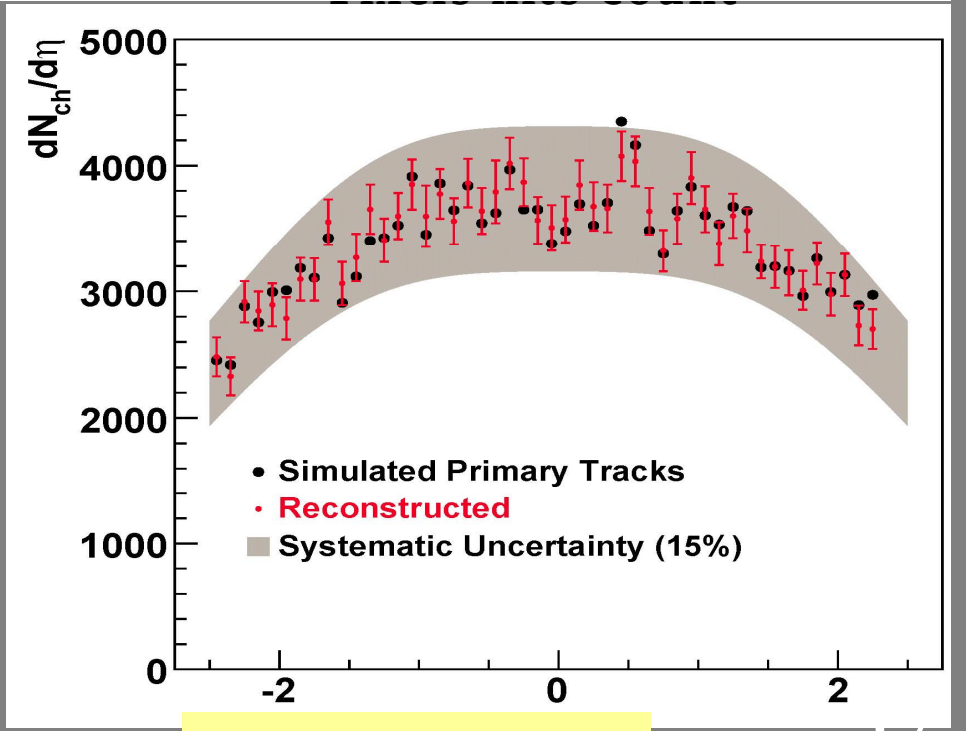


Multiplicity / event

Find hits in pixels, using an energy cut. We also have a tracklet analysis.



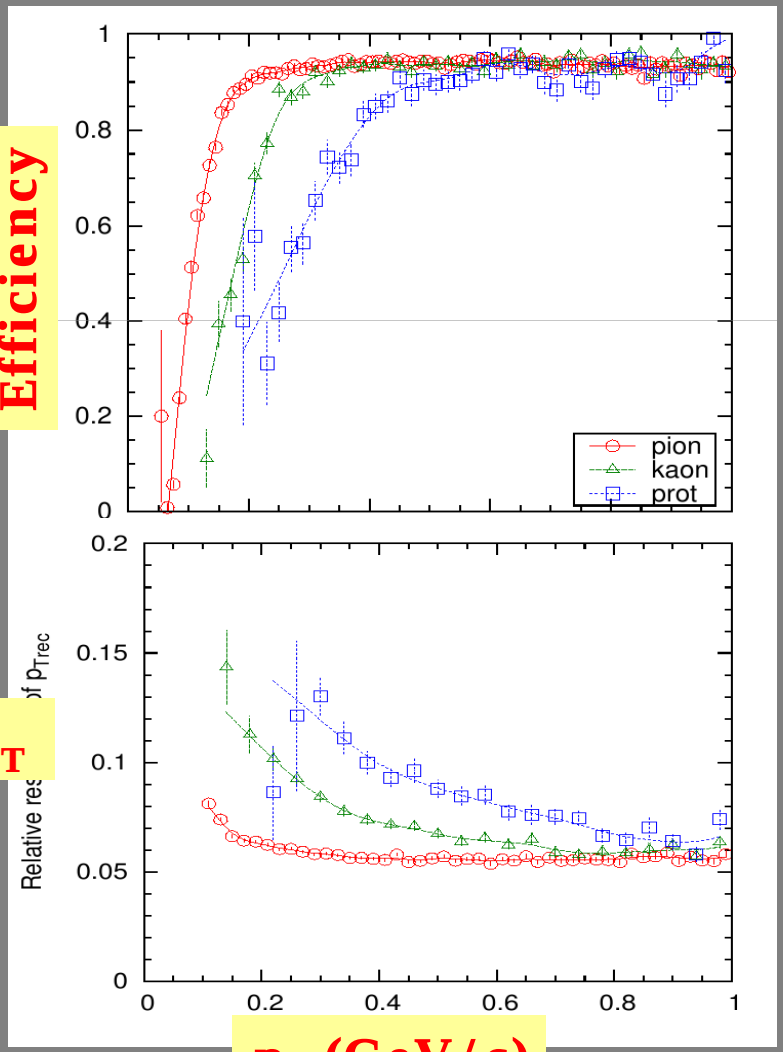


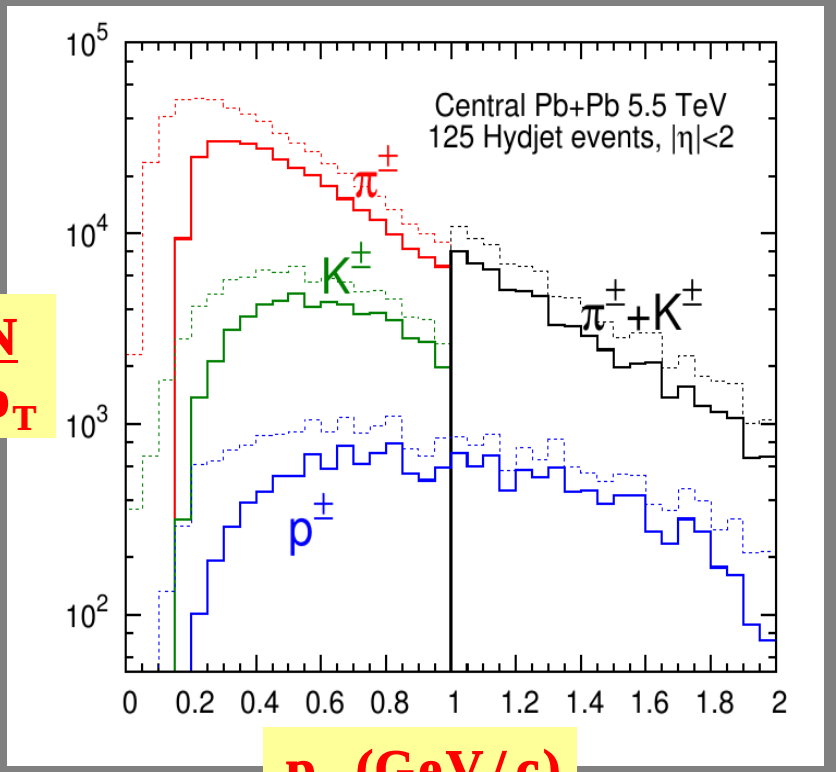


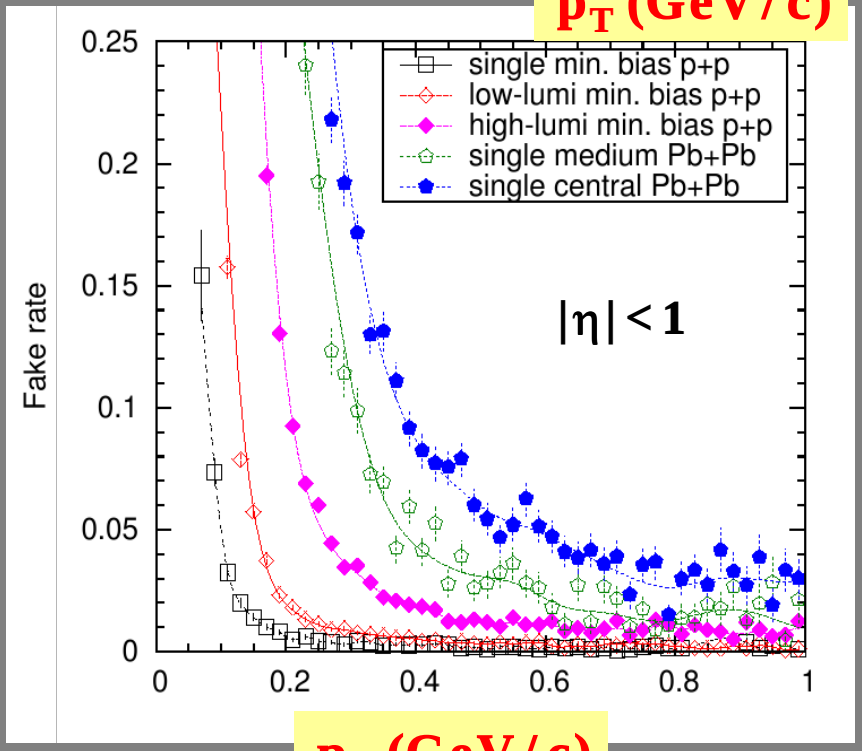
Pseudo rapidity

Low p_T hadrons

Find tracks in pixels and use energy loss vs momentum for particle ID

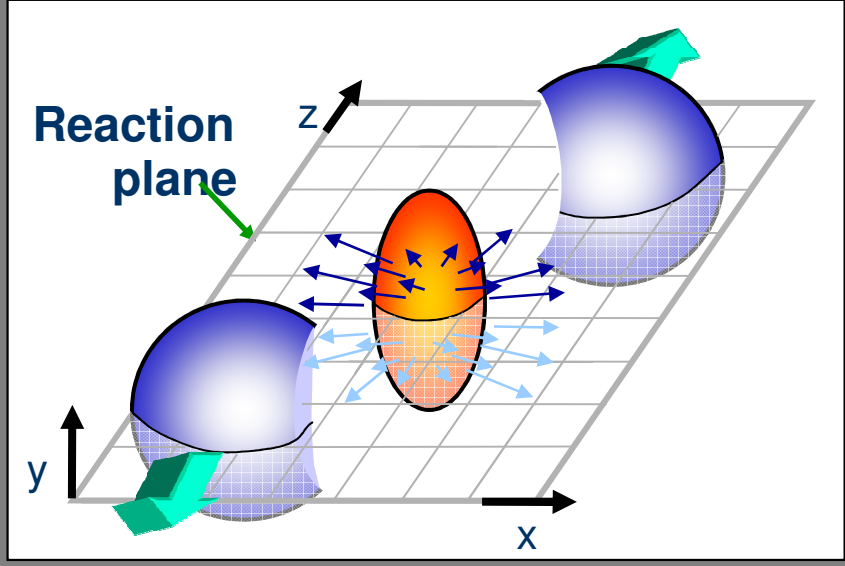


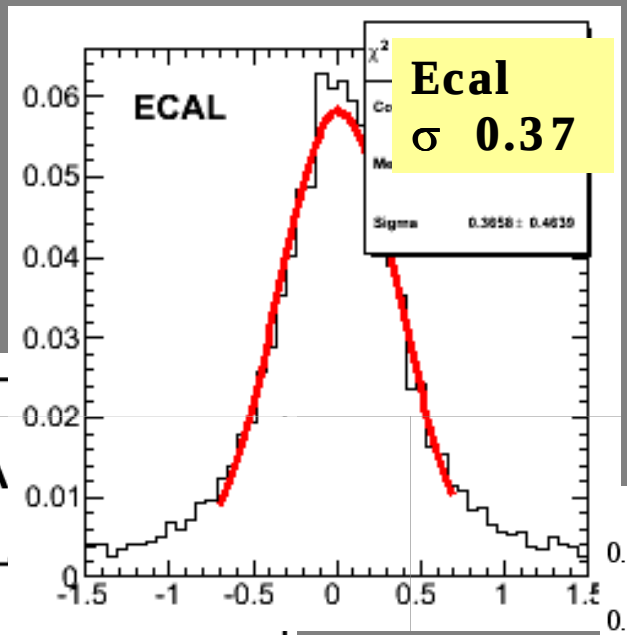




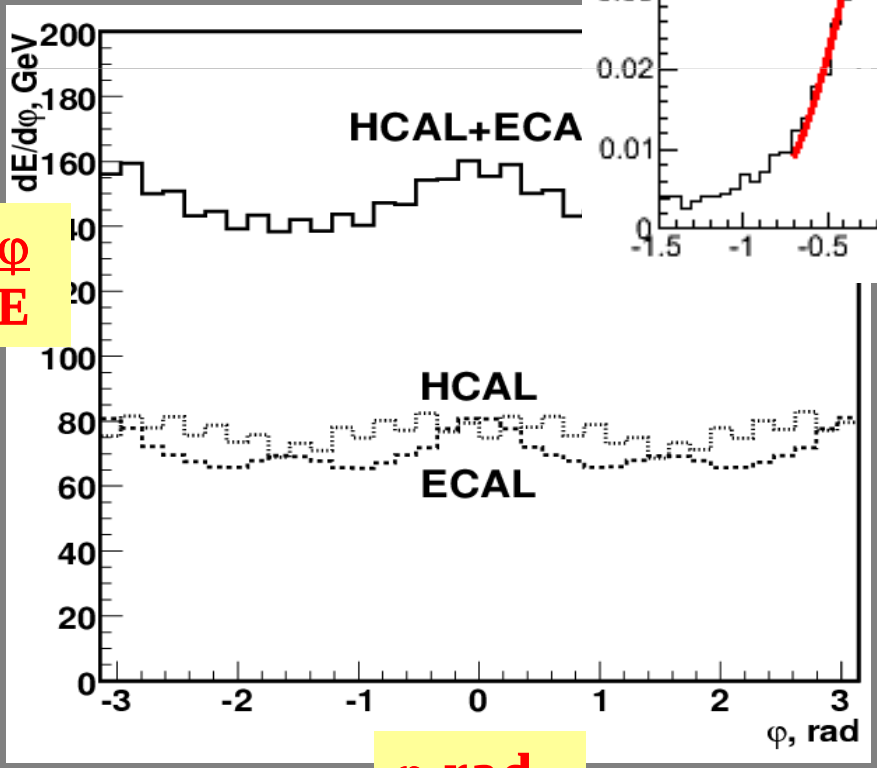
Elliptic Flow

1. Find the reaction plane calorimeters and tracker
2. Use two and multi particle correlations



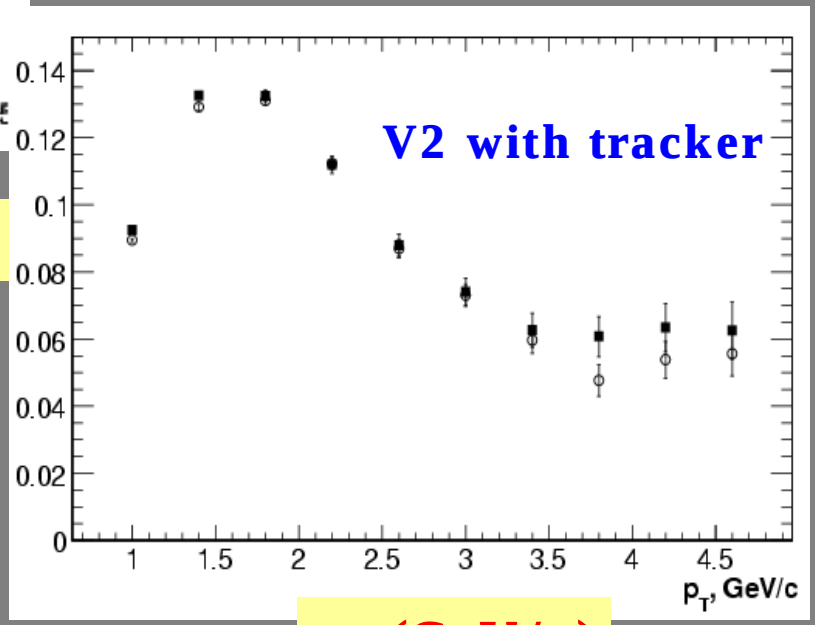


Ecal
σ 0.37



dφ
dE

φ rad

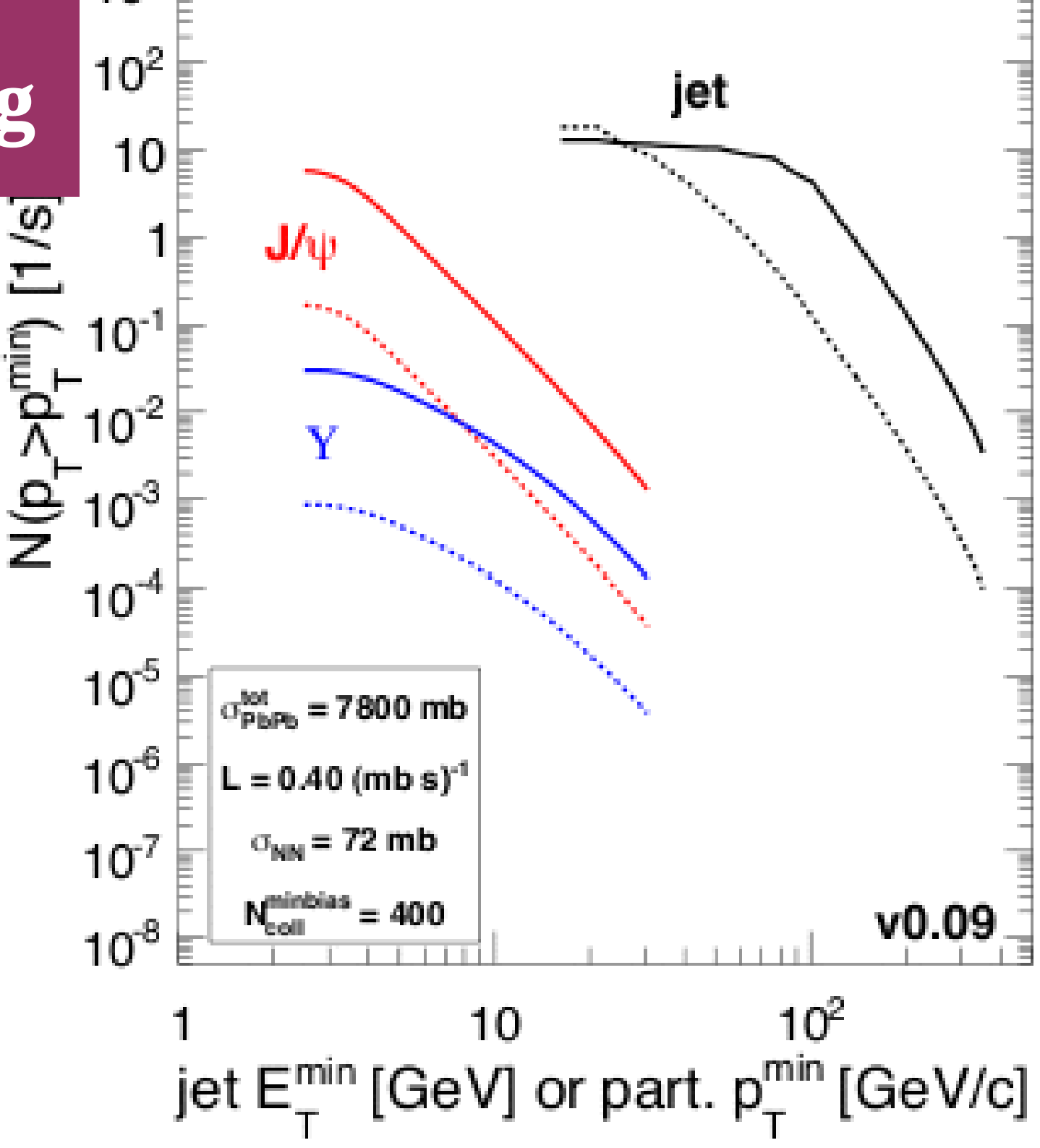


V_2

p_T (GeV/c)

Triggering

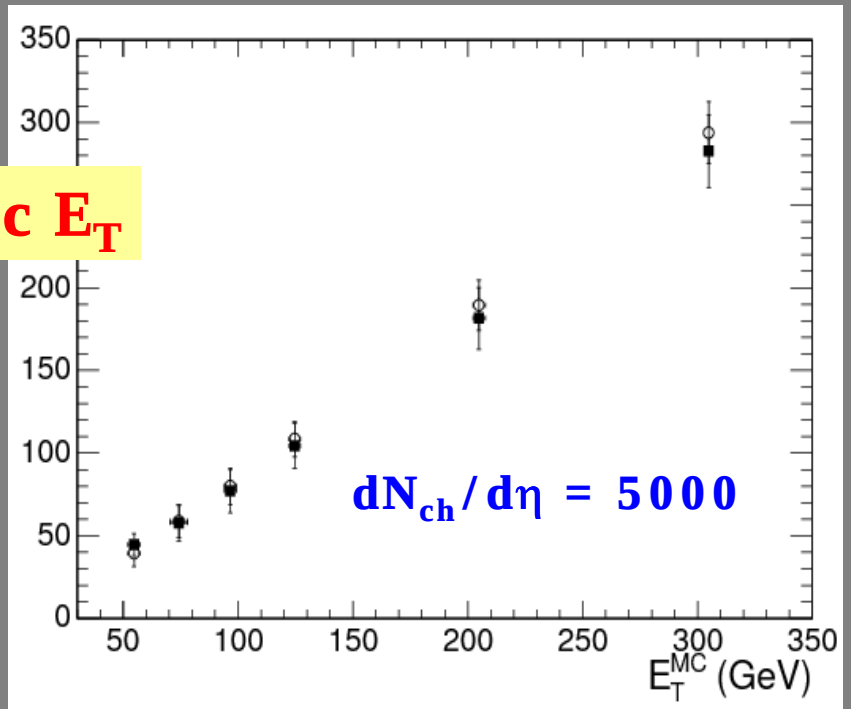
Trigger increases p_T range by > 2 for many probes

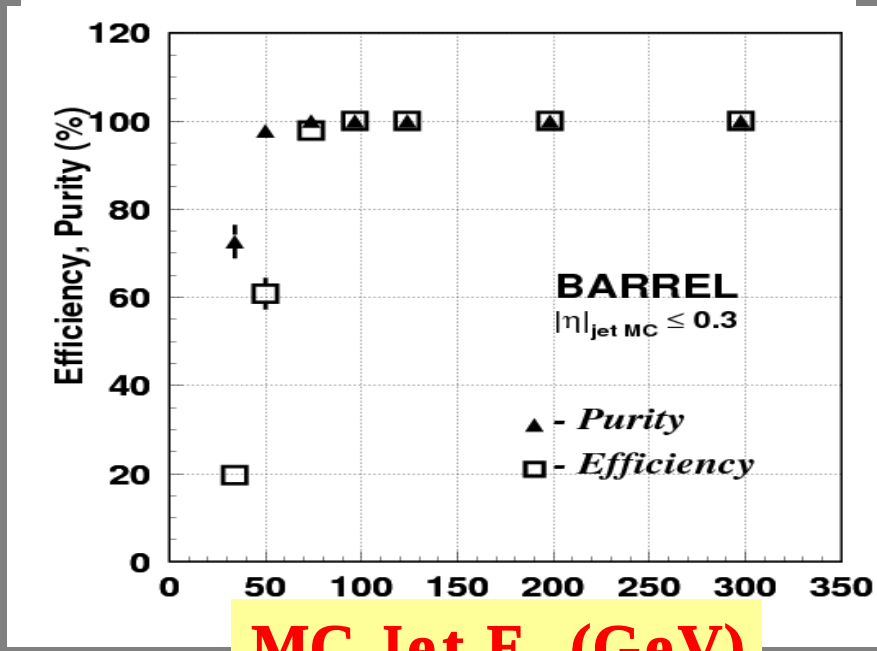


Finding Jets

Iterative cone (R>=0.5) with background subtraction:

- calculate average energy and dispersion in tower (in eta rings) for each event
- subtract average energy and dispersion from each tower
- find jets with a jet finder algorithm (any) using the new tower energies
- recalculate average energy and dispersion using towers free of jets
- recalculate jet energies
- ☺ **Done, but can do more iterations**

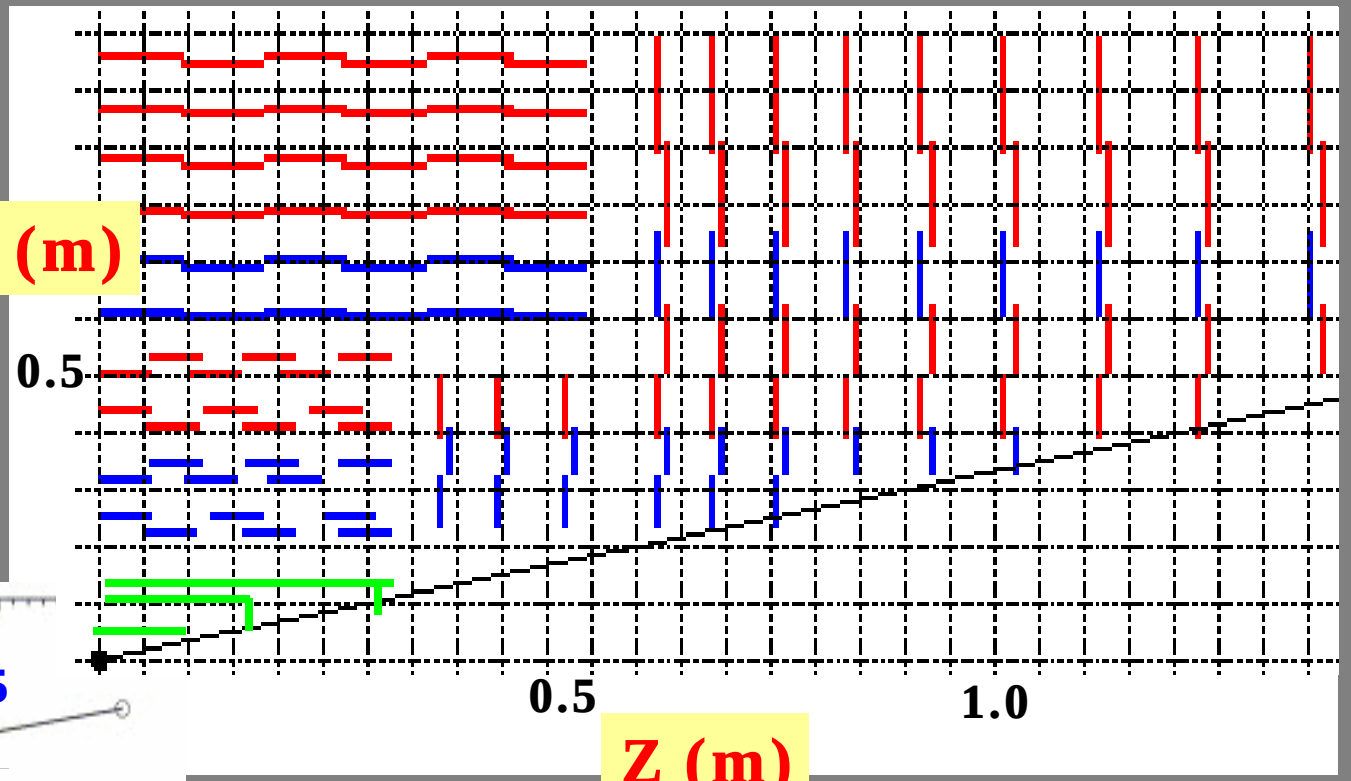


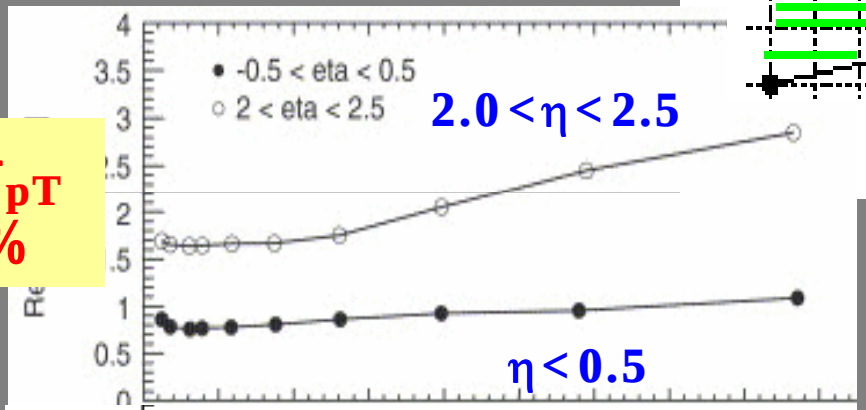


Space resolution is less then the tower size

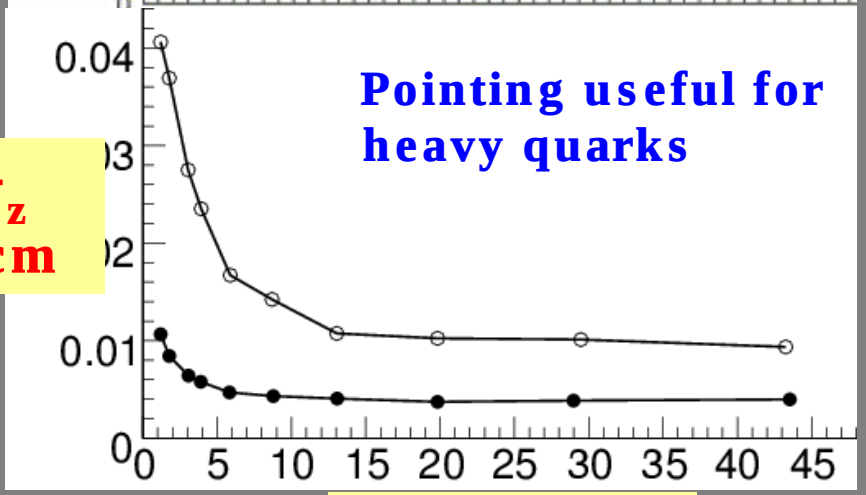
Tracking

Single strips
Double strips
Pixels



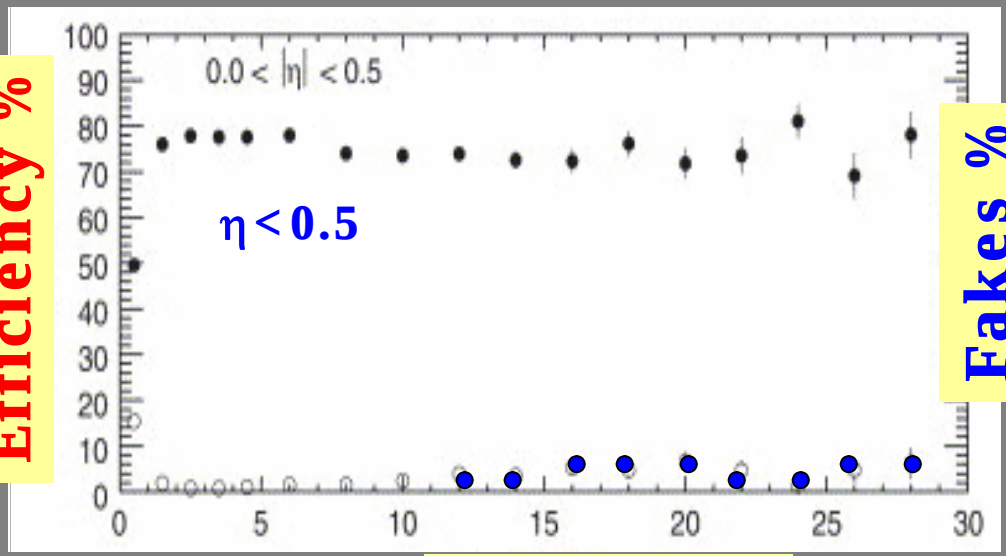


$\sigma\sigma_{pT}/\sigma$ %



$\sigma\sigma_z/\sigma$ cm

p_T (GeV/c)



Efficiency %

Fakes %

p_T (GeV/c)

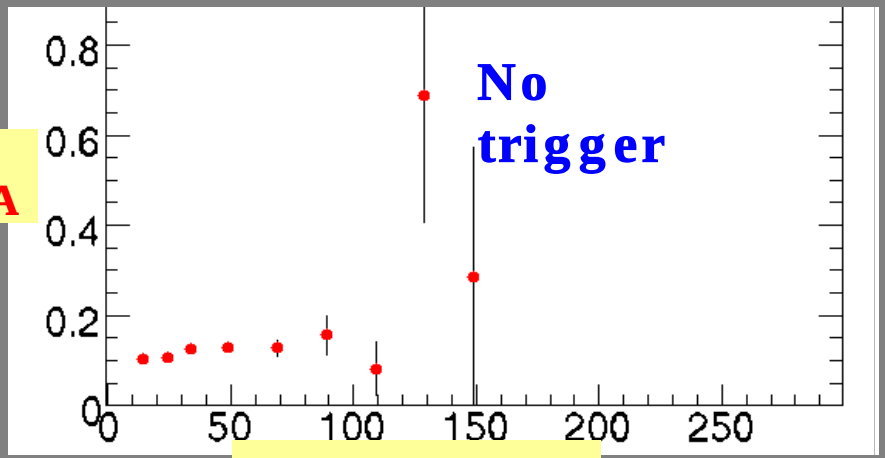
High Pt

Assume luminsity = 0.5 nb^{-1}

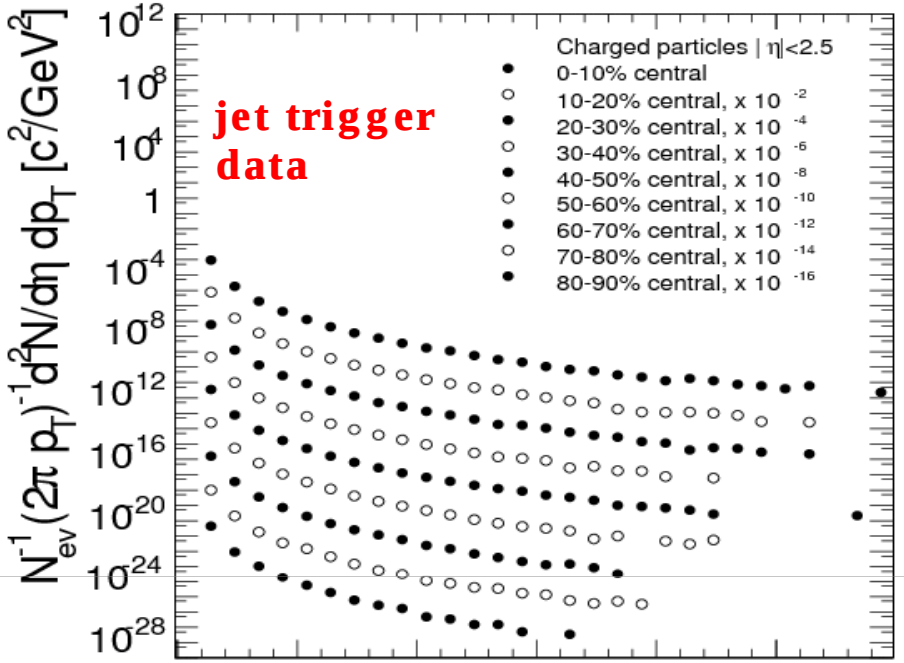
$$R_{AA} = \frac{\sigma_{pp}^{\text{inel}}}{\langle N_{\text{coll}} \rangle} \frac{d^2 N_{AA}/dp_T d\eta}{d^2 \sigma_{pp}/dp_T d\eta}$$

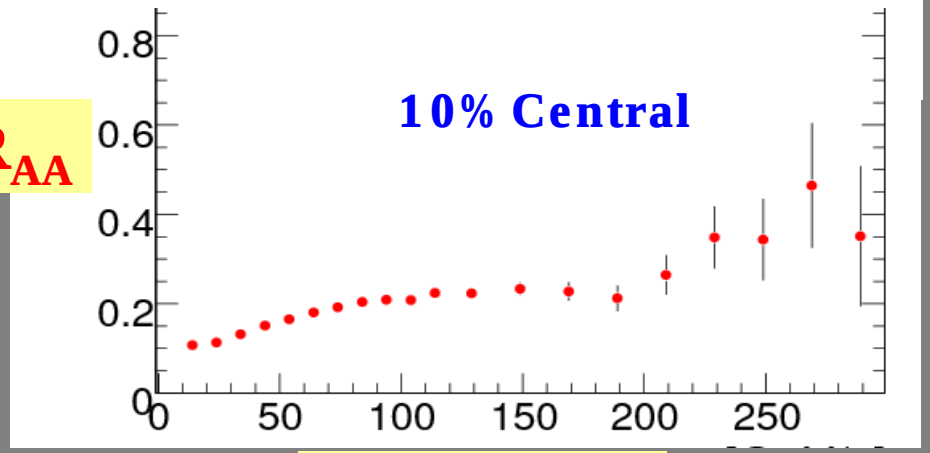
Energy loss from HYDJET

See Gabor Veres' talk Tuesday 4a

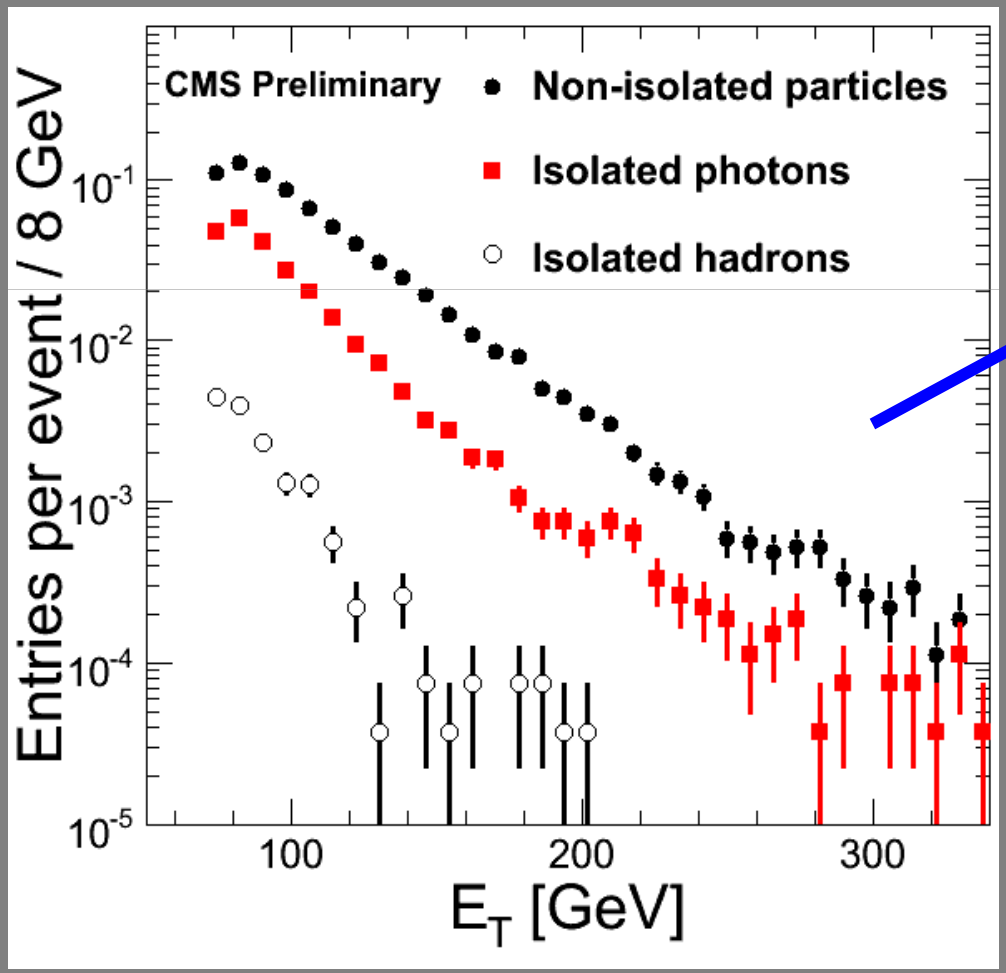


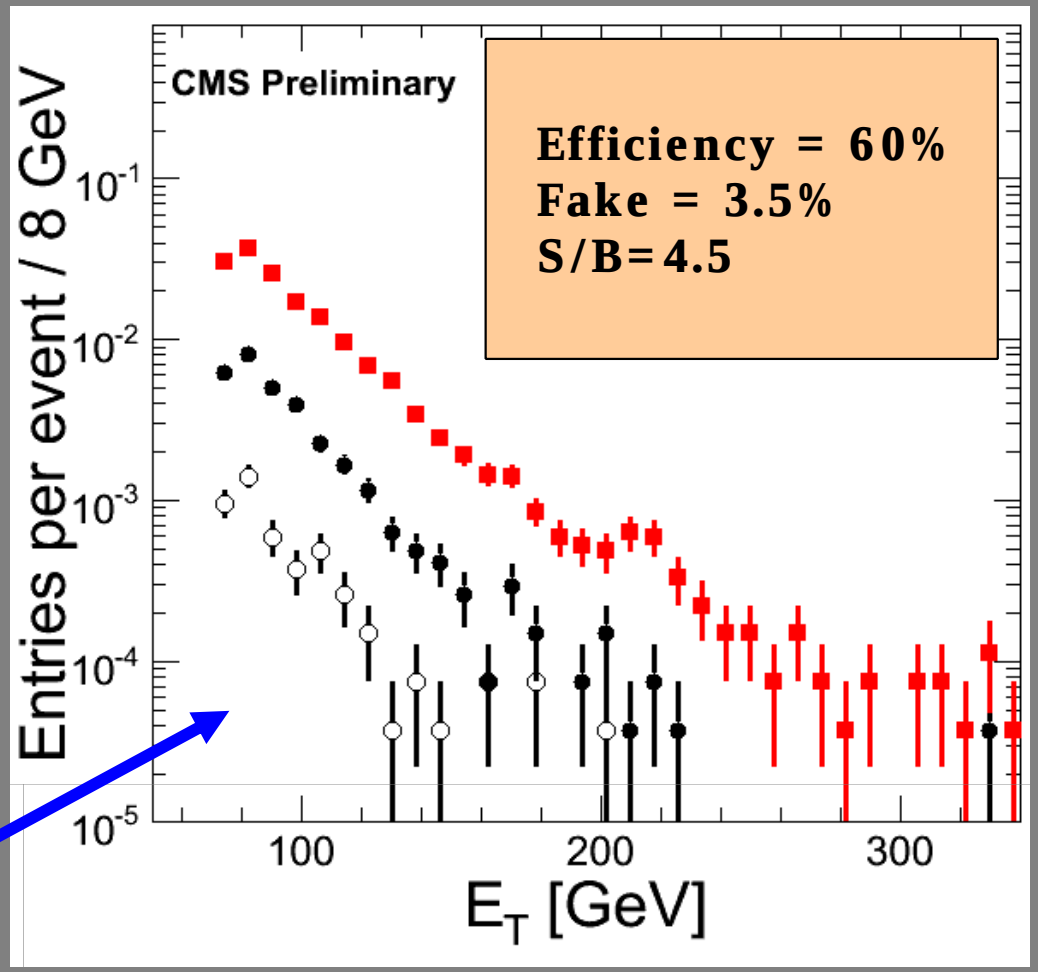
Charged particles $|\eta| < 2.5$





Photons

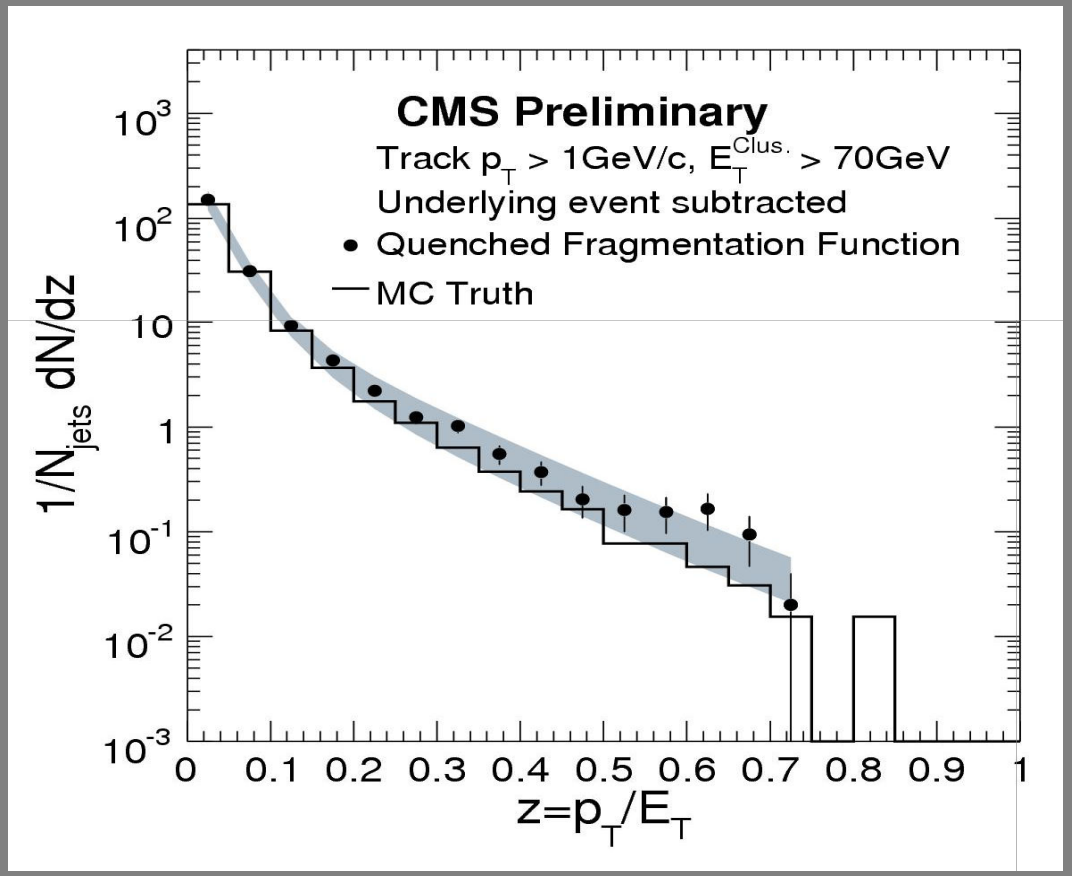


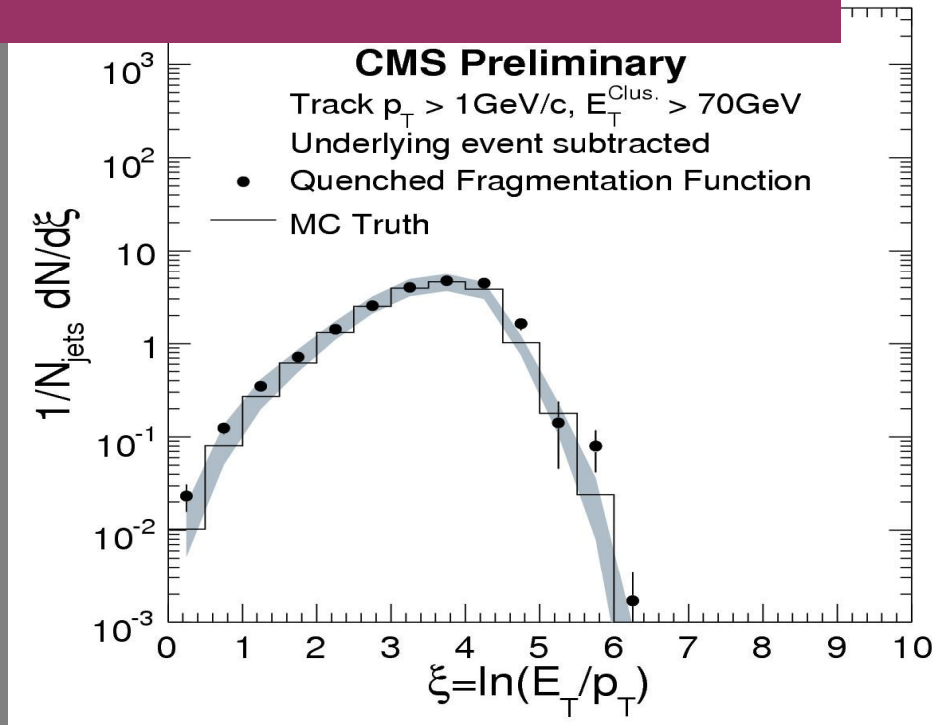


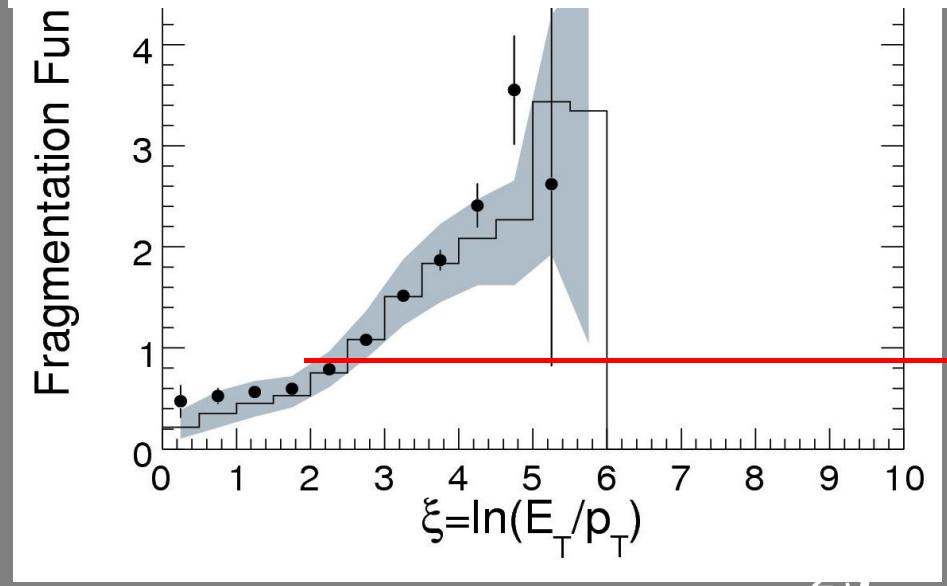
Photon ID based only on cluster shape and isolation cuts using a multi-variate analysis. We reconstruct photon energy with Island algorithm

Jet fragmention from γ jet events

Require photon E_T > 70GeV







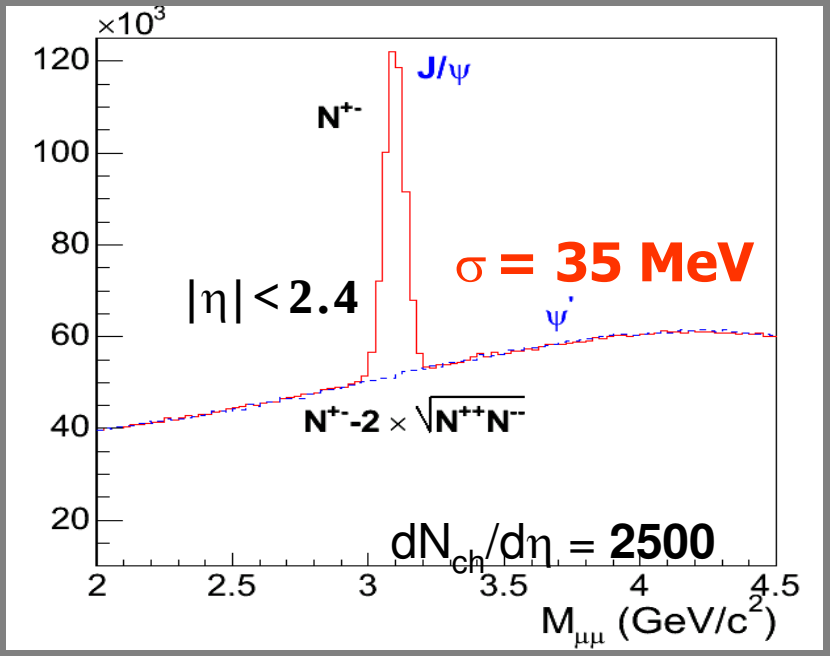
I = 0..5 nb^{-1}

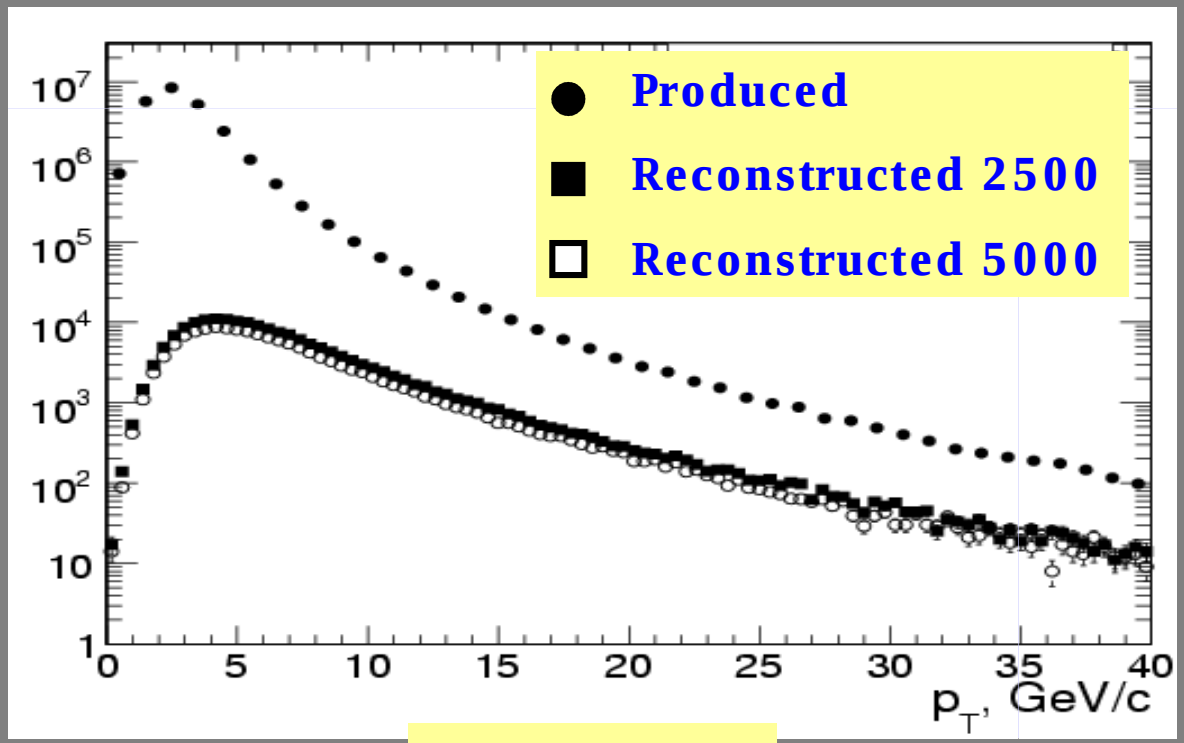
$J/\psi \to \mu^+\mu^-$

For 0.5 nb^{-1} we reconstruct 180K J/ψ

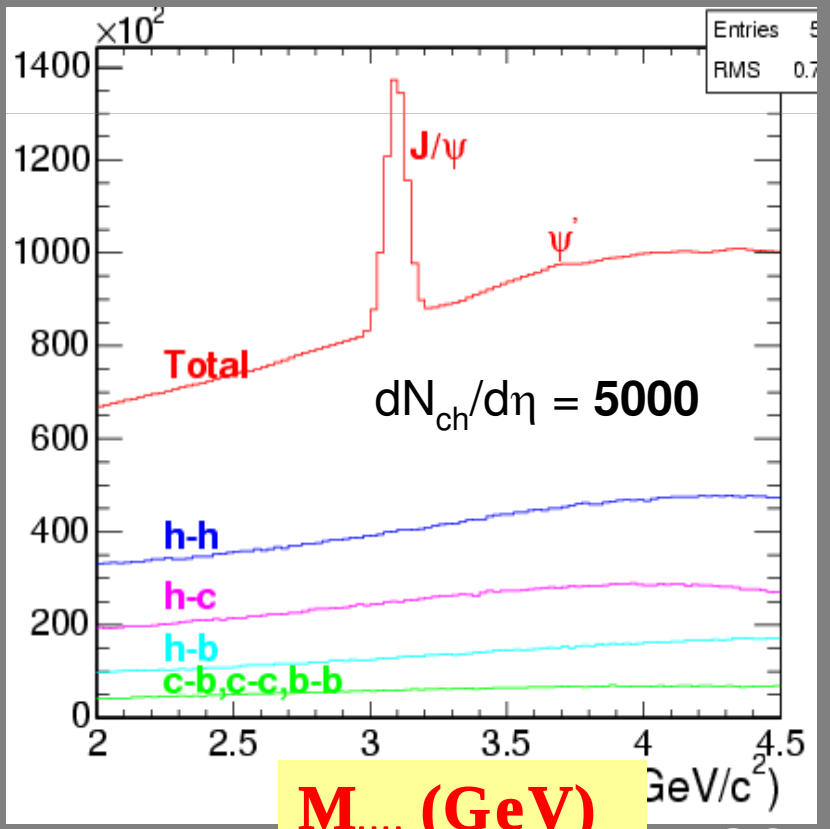
Signal/Background:

~5 for $|\eta|<0.8$, 1 for $|\eta|<2.4$





p_T (GeV/c)



$M_{\mu\mu}$ (GeV)

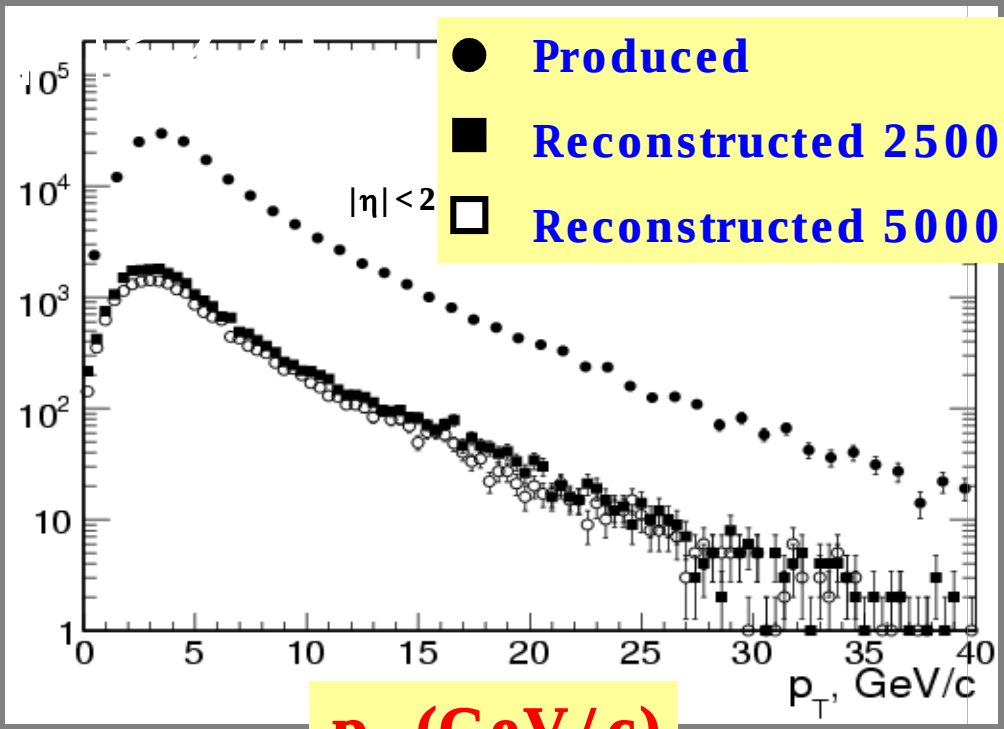
Υ → $\mu^+\mu^-$

Υ ~ 25 000,

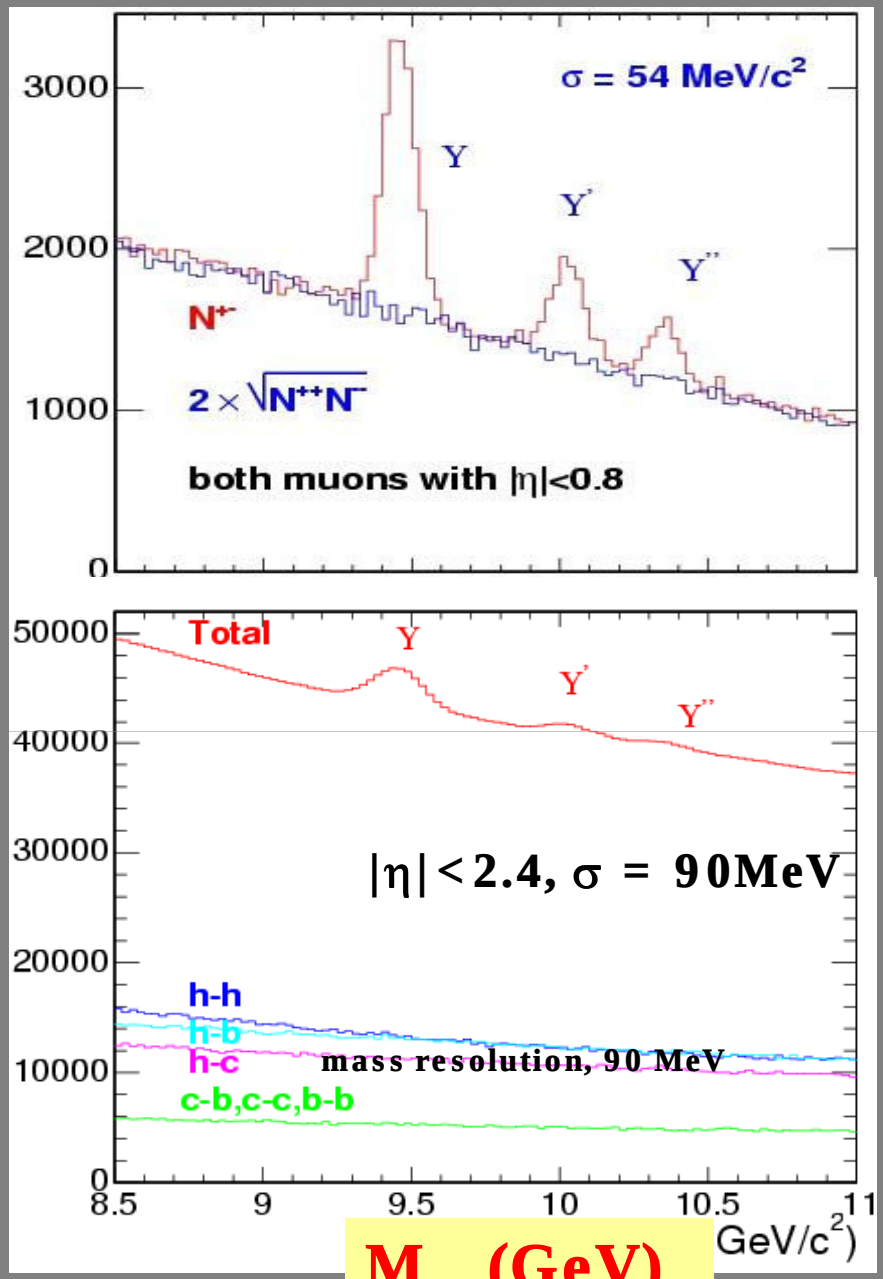
Υ' ~ 7 000,

Υ'' ~ 4 000

Signal/Background:
1 $|\eta| < 0.8$, 0.1 for



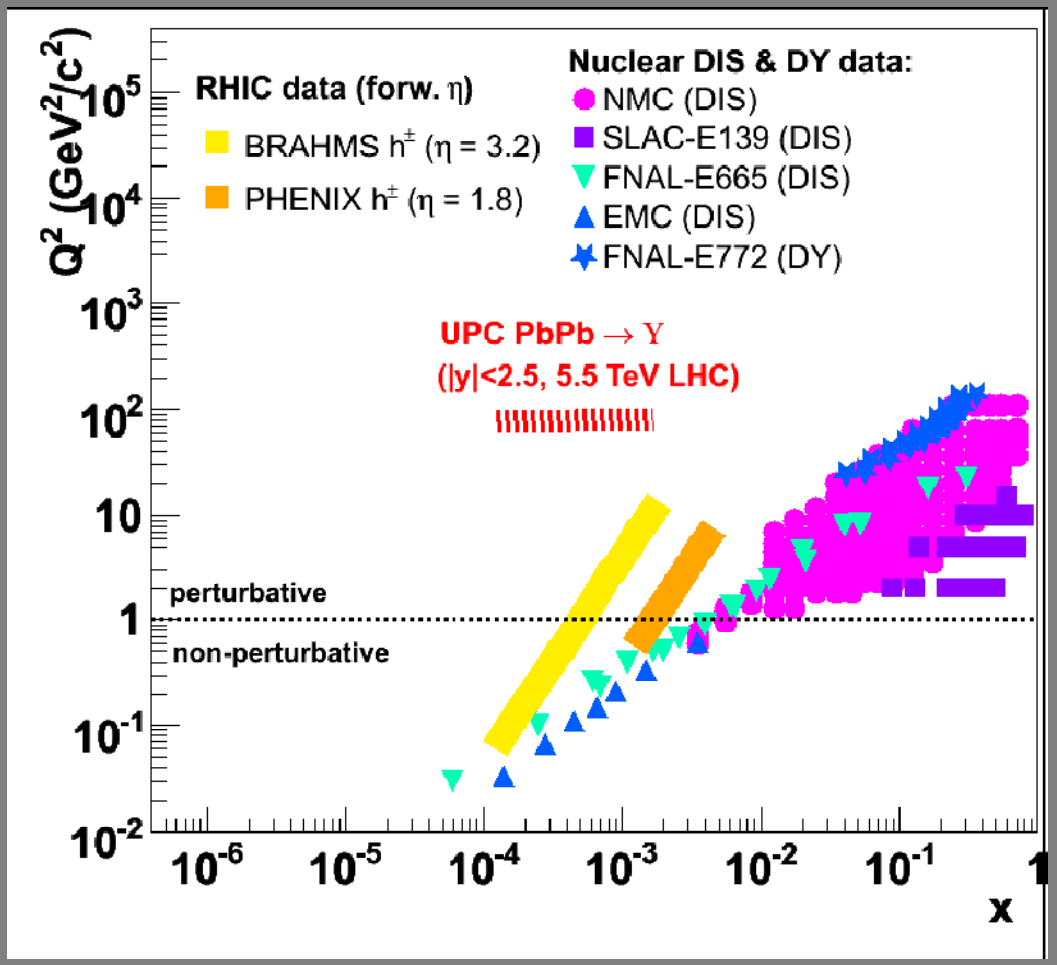
p_T (GeV/c)

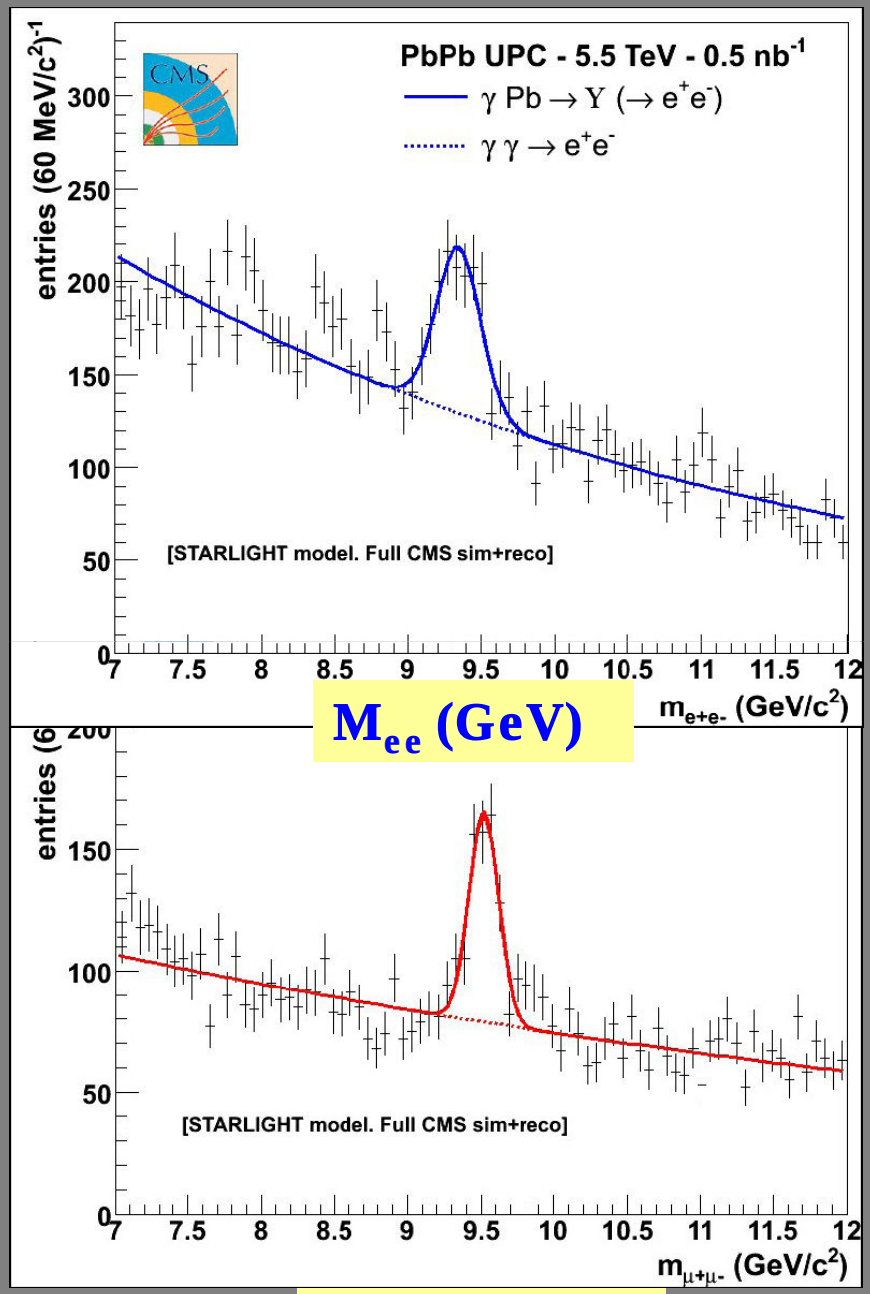


$M_{\mu\mu}$ (GeV)

Photon nucleus

Max photon energy ~ 80 GeV
γ+Pb: √S ≈ 1. TeV/n
γ+γ **√S ≈ 160 GeV**





Summary, Thanks

- Theory is a lot better than in the early days
- Thanks Al but don’t stop, we still need you

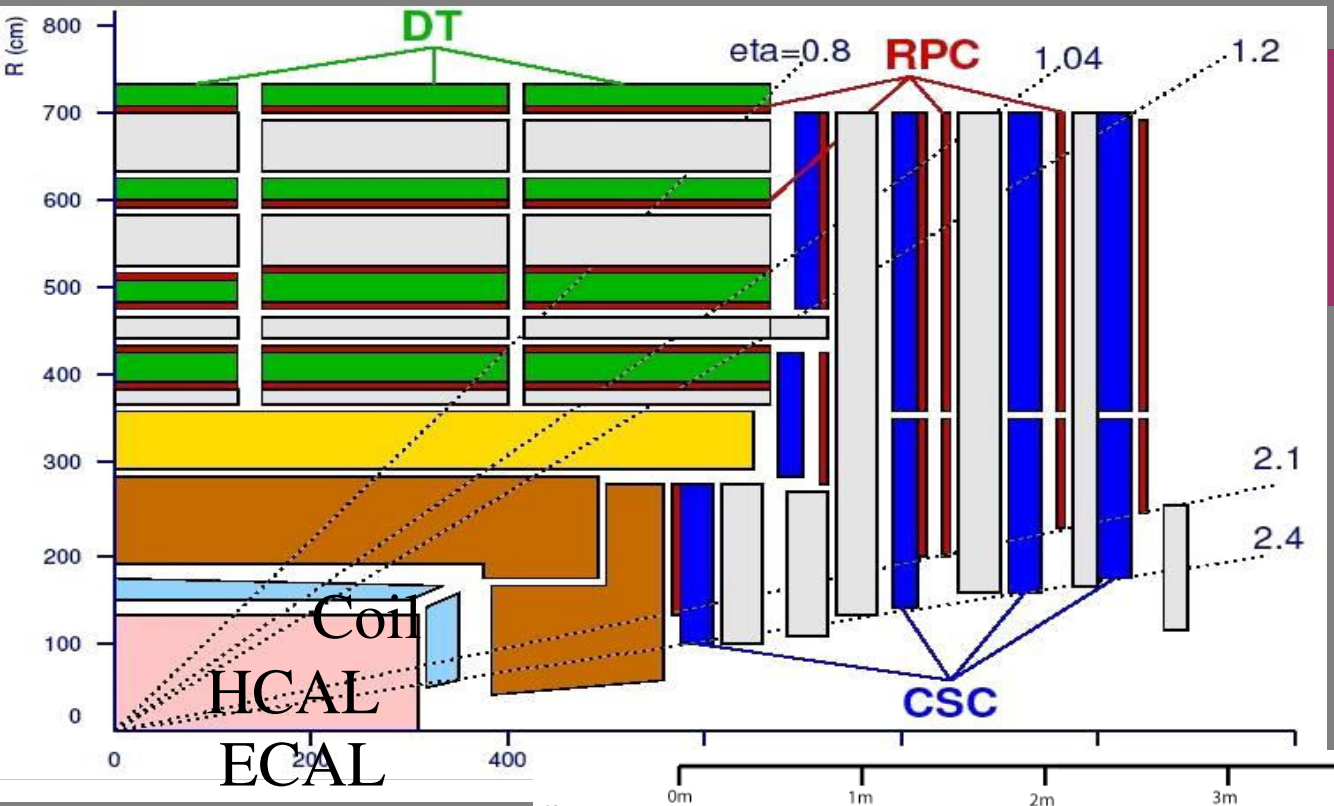
Backup slides

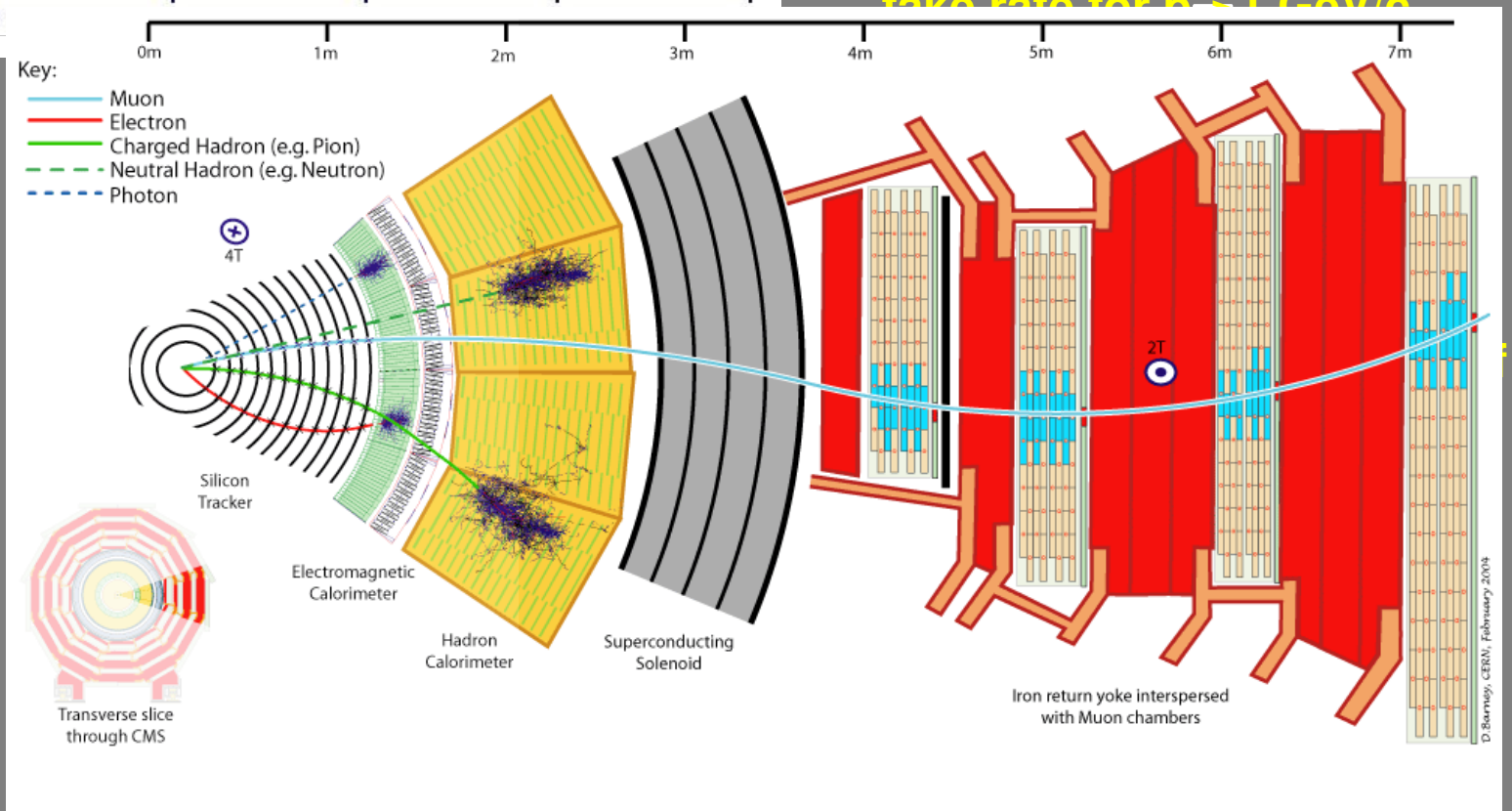
Slices of CMS

- **Silicon tracker:**

  Momentum resolution is ~2% for tracks with p_T <100 GeV

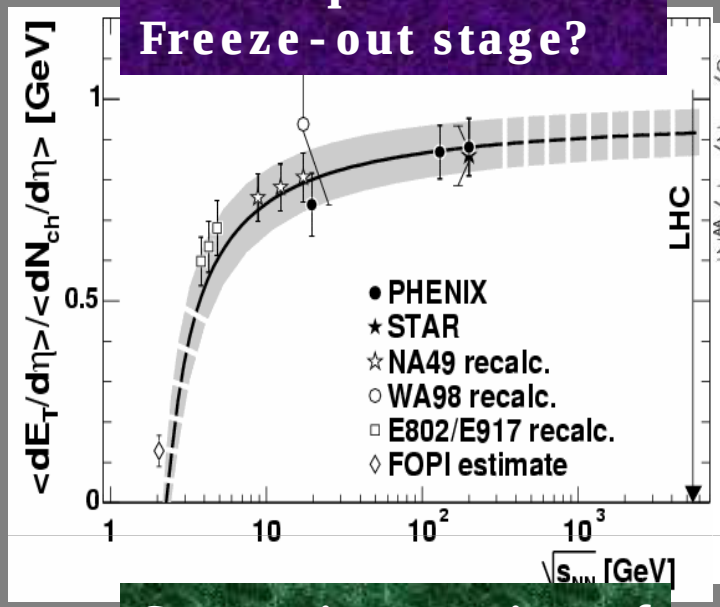
  Good efficiency and low fake rate for p_T >1 GeV/c



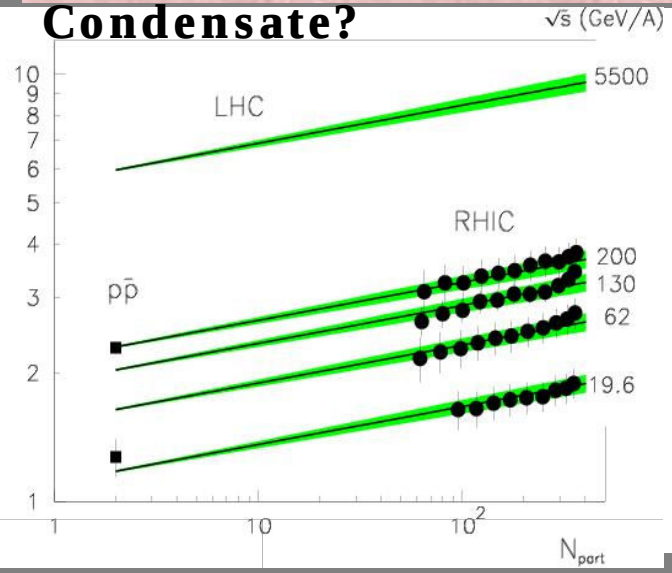


Some RHIC results

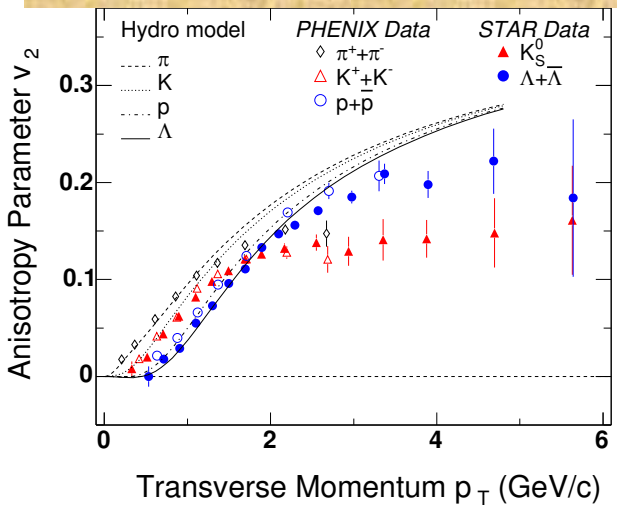
Local equilibrium in Freeze-out stage?



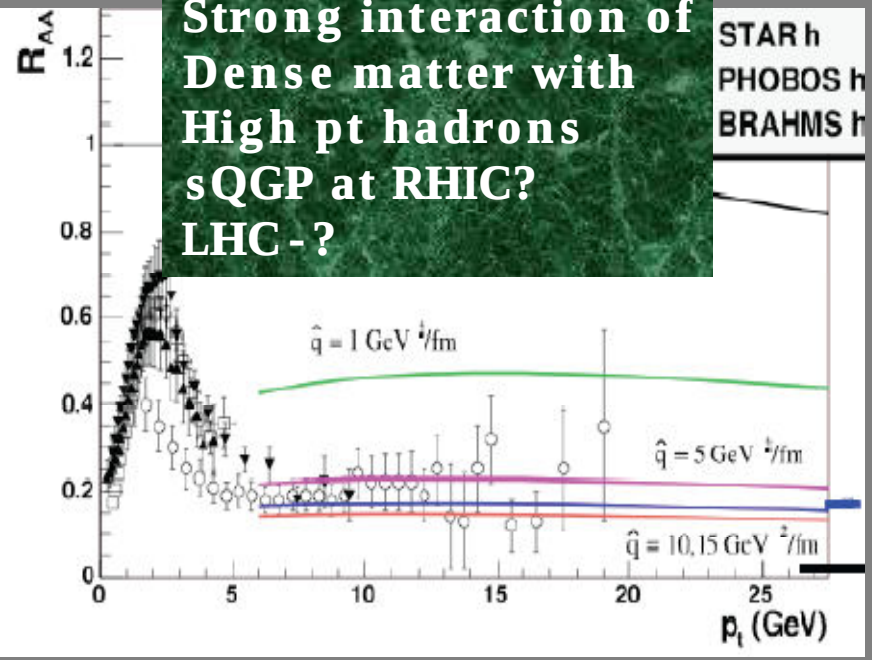
Calor Glass Condensate?



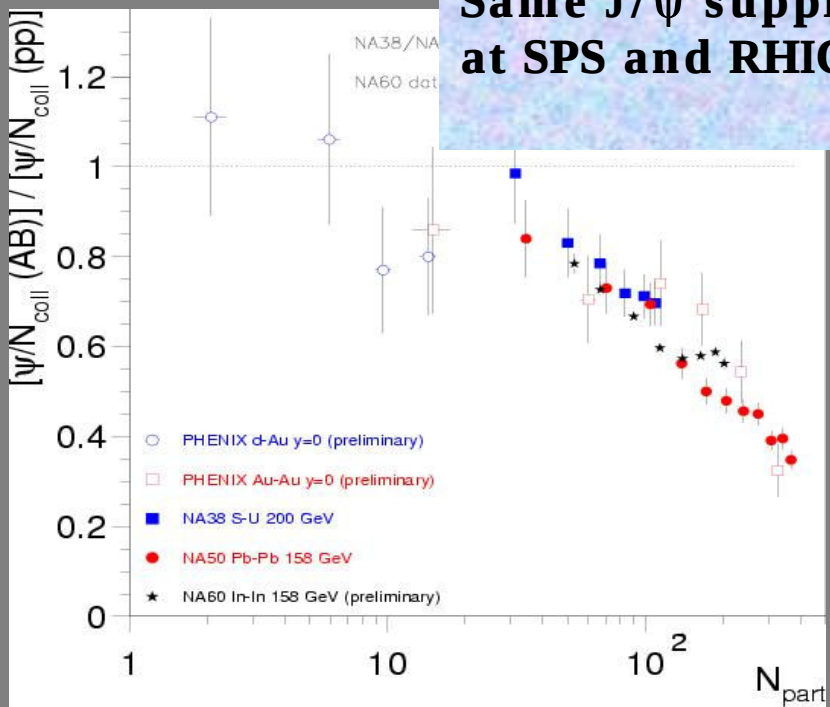
Deflection from Hydro – Viscosity?



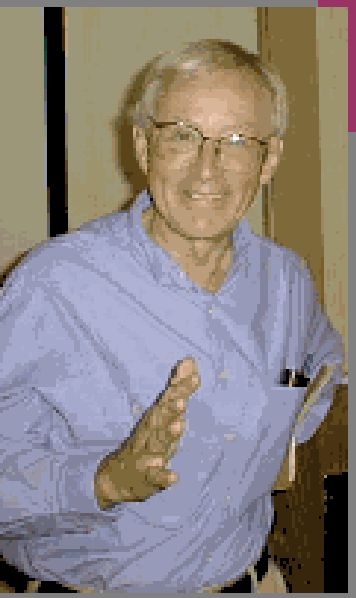
Strong interaction of Dense matter with High pt hadrons sQGP at RHIC? LHC -?



Same J/ψ suppression at SPS and RHIC



What does this all mean?



"These theories ain't worth a bucket of worm piss"
Bill Willis CERN Council 1982

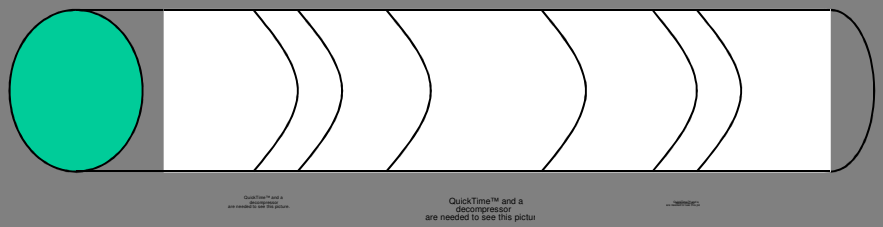
"There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things we know we don't know. But, there are also unknown unknowns. These are things we don't know we don't know."

Donald Rumsfeld Washington 2002

What should we concentrate on at LHC?

Long range correlations, early times

STAR



QuickTime™ and a
decompressor
are needed to see this picture.

QuickTime™ and a
decompressor
are needed to see this picture.