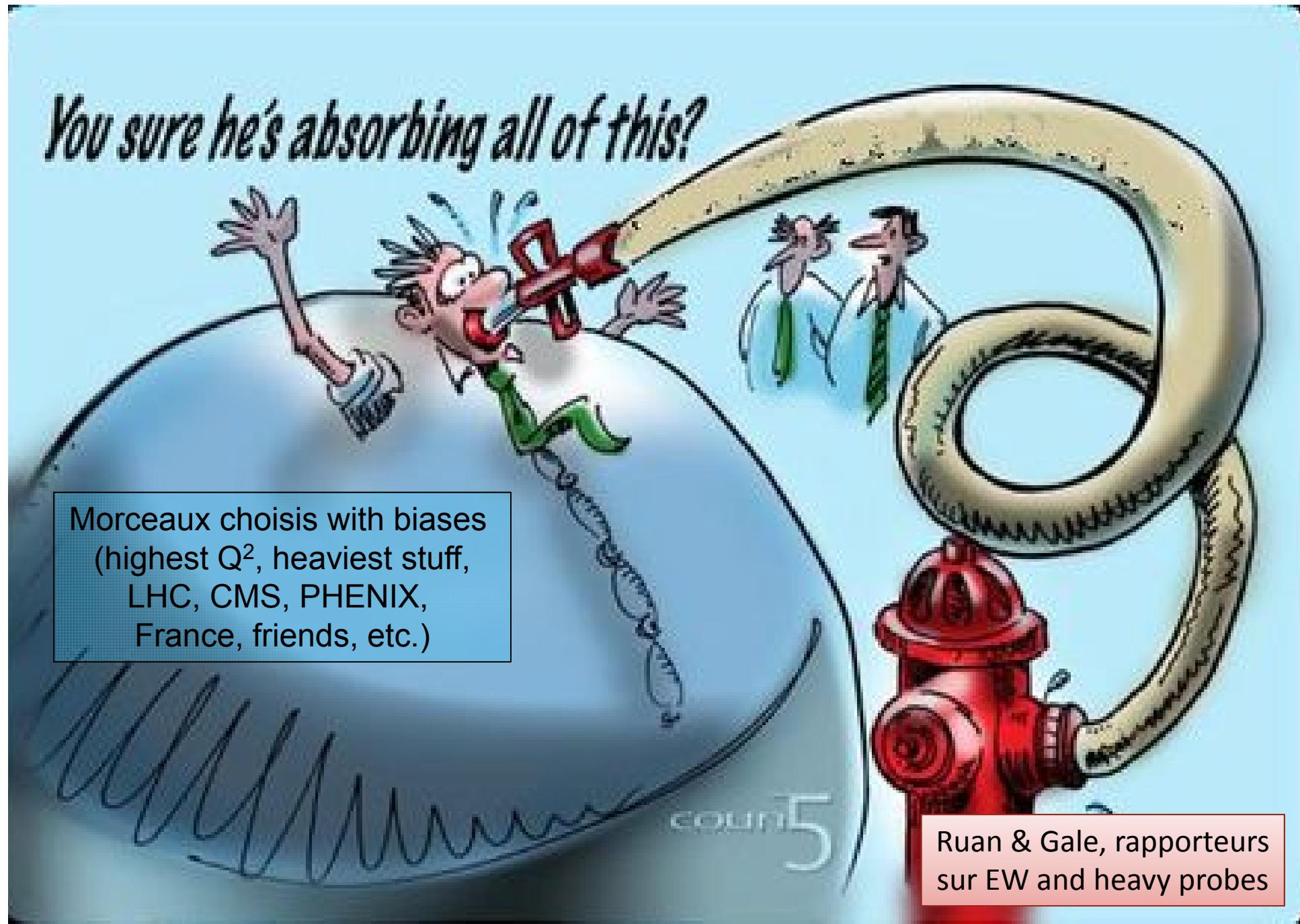


Quark Matter 2012 experimental highlights

Raphaël Granier de Cassagnac
LLR – École polytechnique / IN2P3
ERC grant “QuarkGluonPlasmaCMS”

Orsay, 2012, September 21st

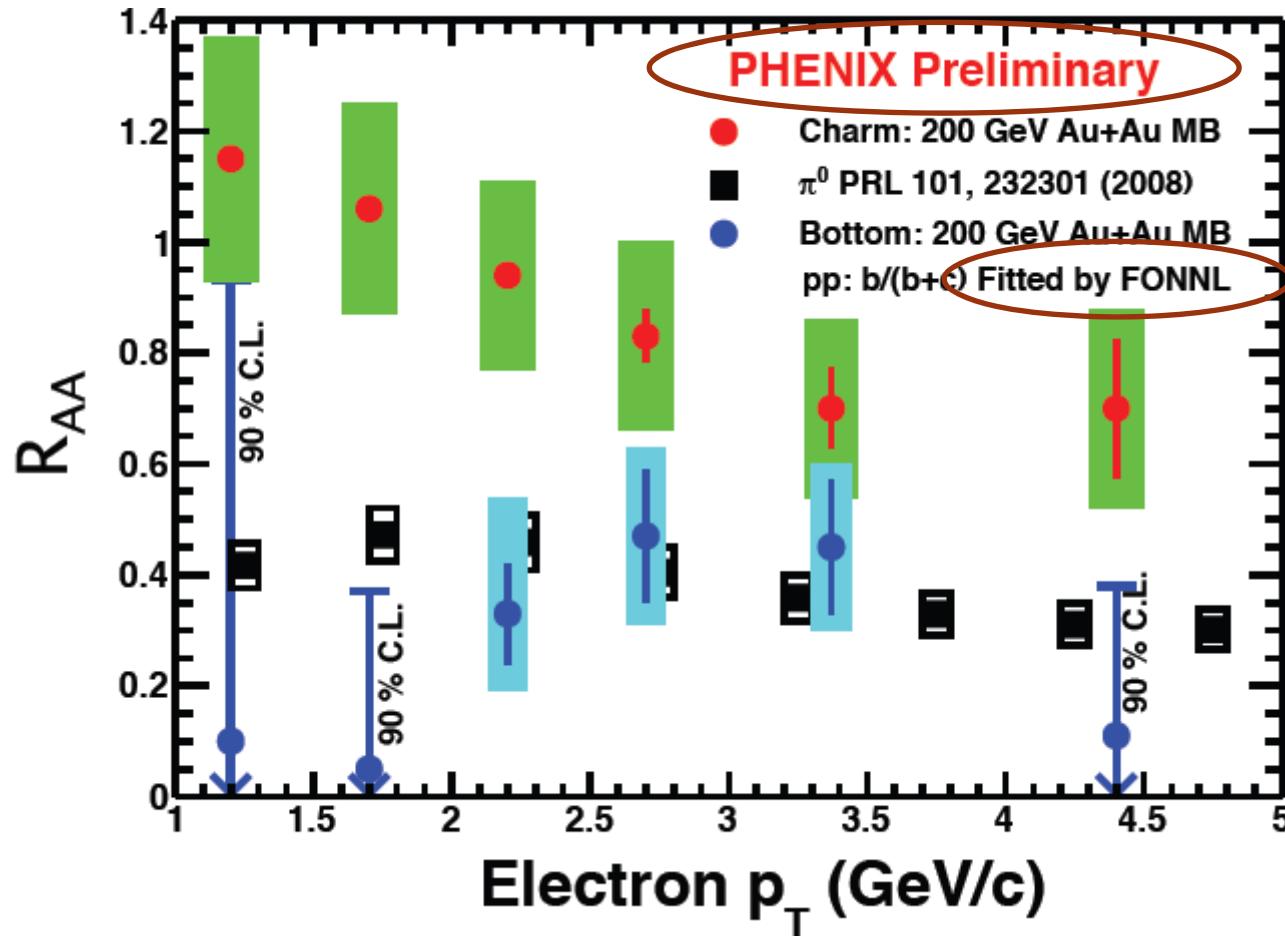




Since Annecy...

- From LHC: 20 x more PbPb data
 - But not more pp data, still corresponding to the first N_{coll} scaled PbPb run (e.g. 20 times more photons, Z or W in PbPb than pp @ 2.76 TeV)
- From RHIC:
 - First results from the Cu+Au, (U+U) runs
 - News from d+Au, energy scan...

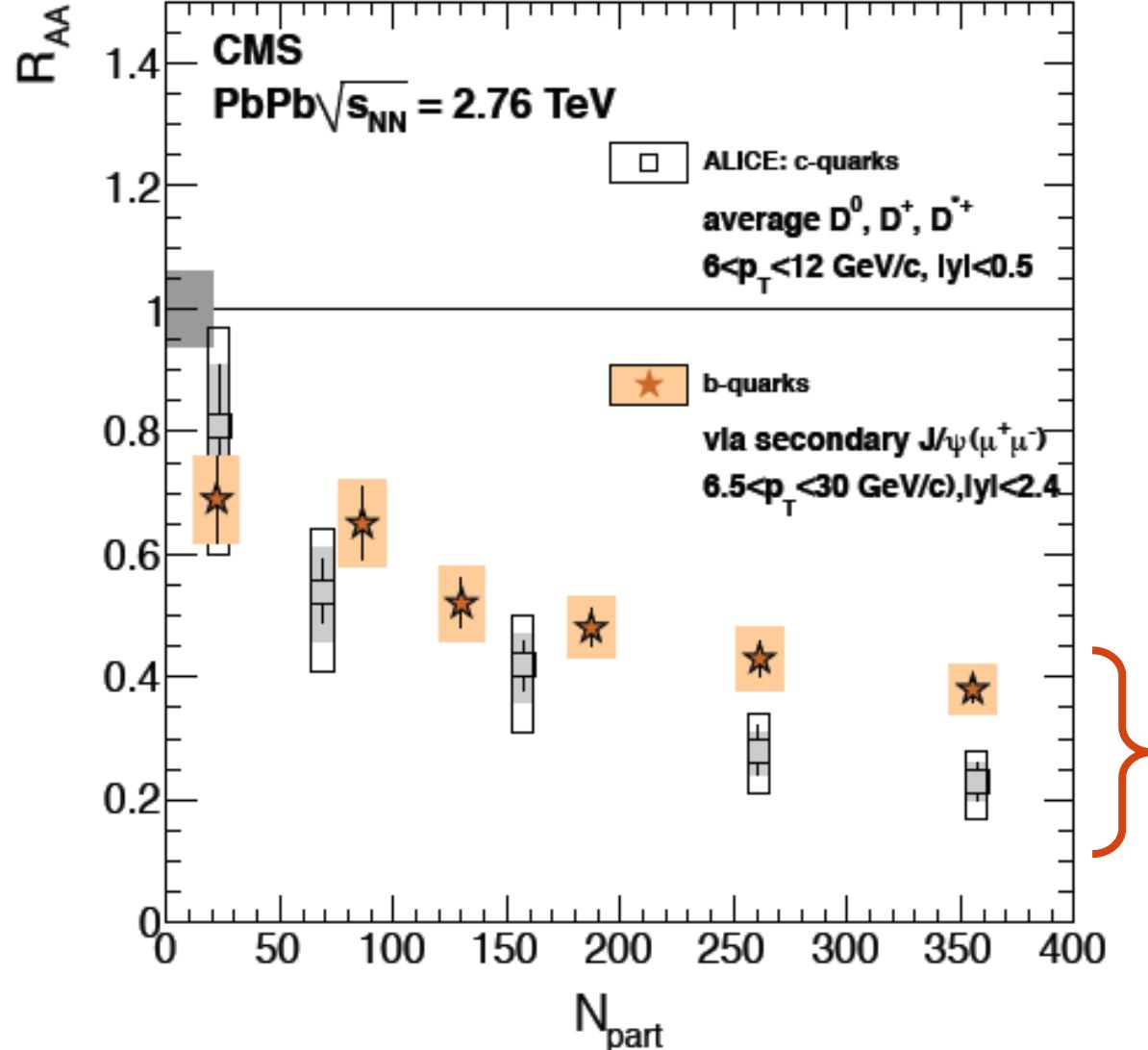
The big open surprise from RHIC...



PHENIX pretends that b's are more suppressed than c's
based on displaced electrons measured by the new VTX detector...

Nouicer et al.

... while LHC is kind with us



Several D's from Alice
 $B \rightarrow J/\psi$ from CMS

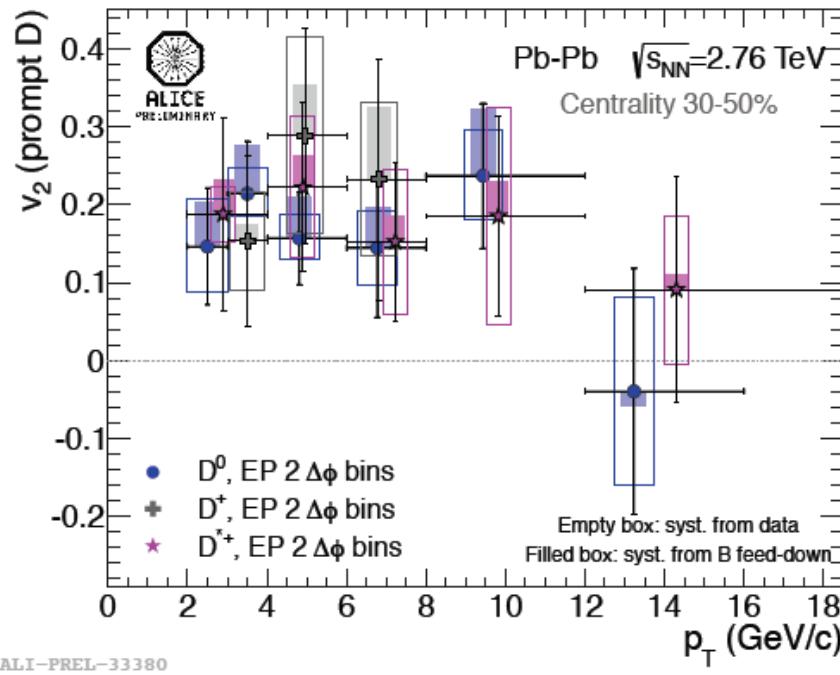
At LHC, we can
forget mixing flavours...

"There is order!"

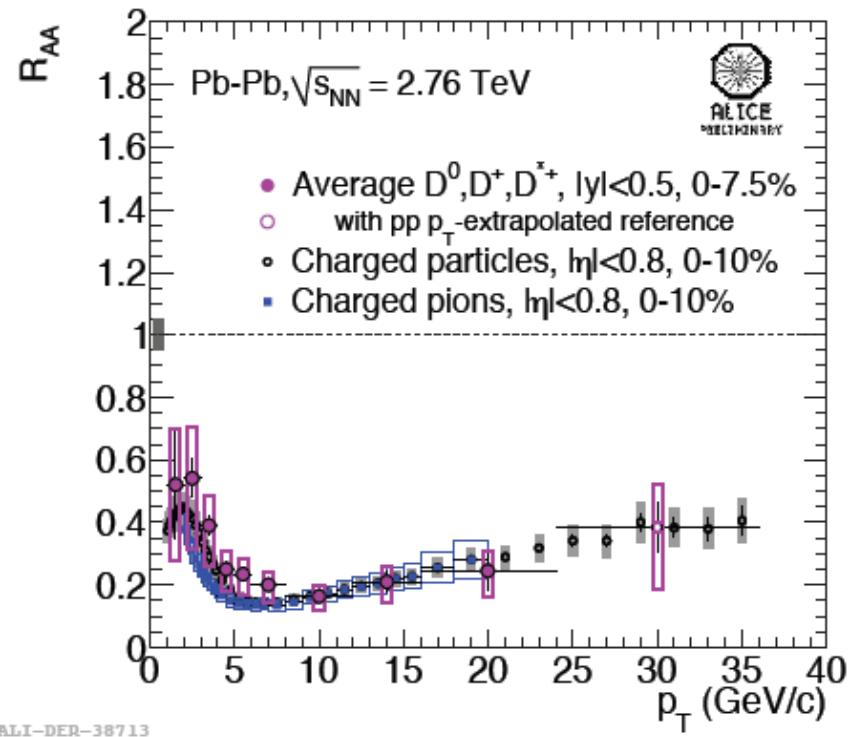
Plenary talks
by Zaida (ALICE)
and Camelia (CMS)

More from Alice

Elliptic flow



Nuclear modification factor



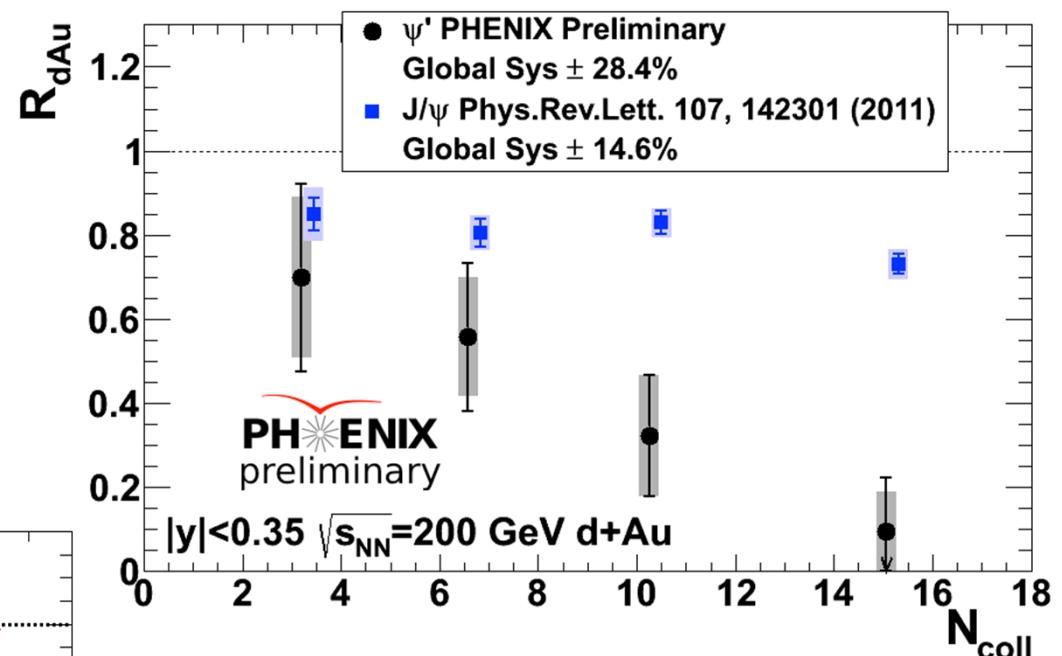
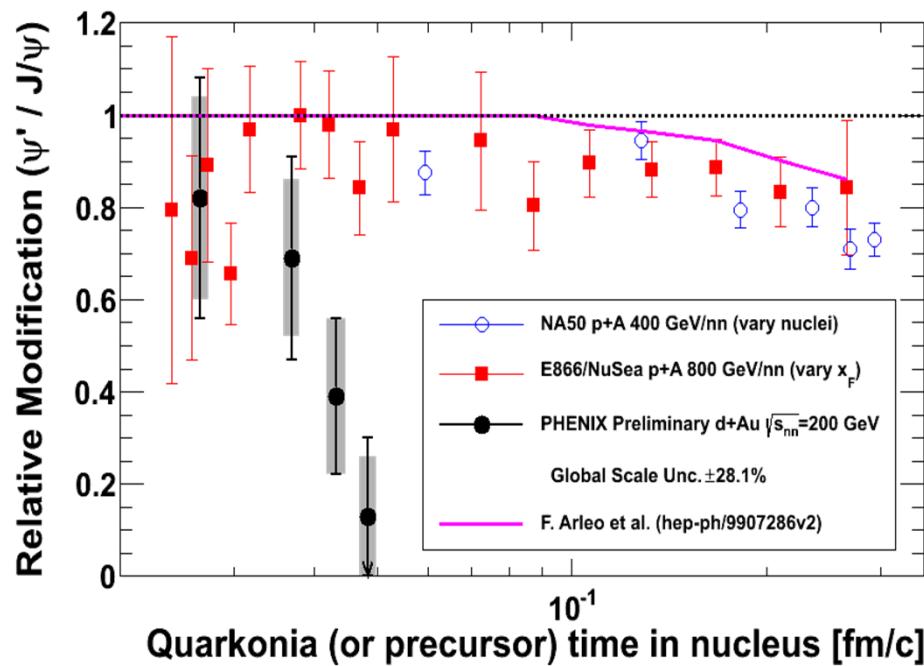
Also single electrons and muons, and pp measurements...
 $\sigma(\text{cc}) \approx 5 \mu\text{b}$ en pp@2.76 TeV x 1500 coll / 65 mb ≈ 115 pairs

Zaida

Surprising quarkonium: ψ' @ RHIC

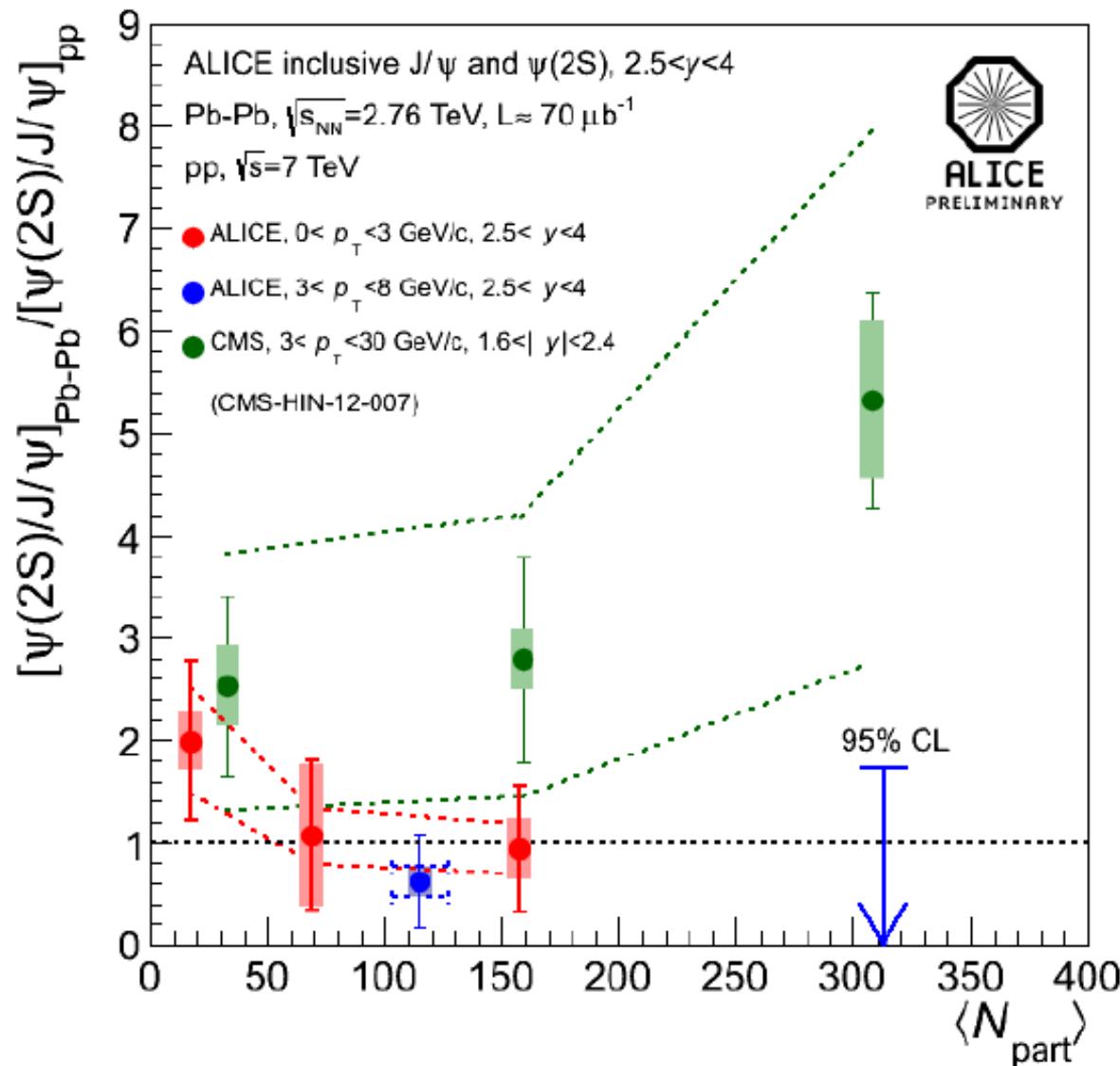
Enormous suppression
in dAu versus J/ψ

Such effects already seen
in various pA but much smaller



McGlinchey, Wysocki

The surprising quarkonium: ψ' @ LHC



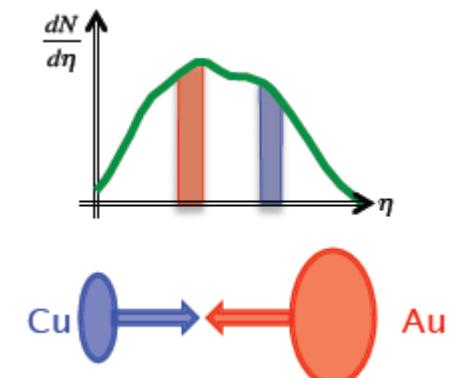
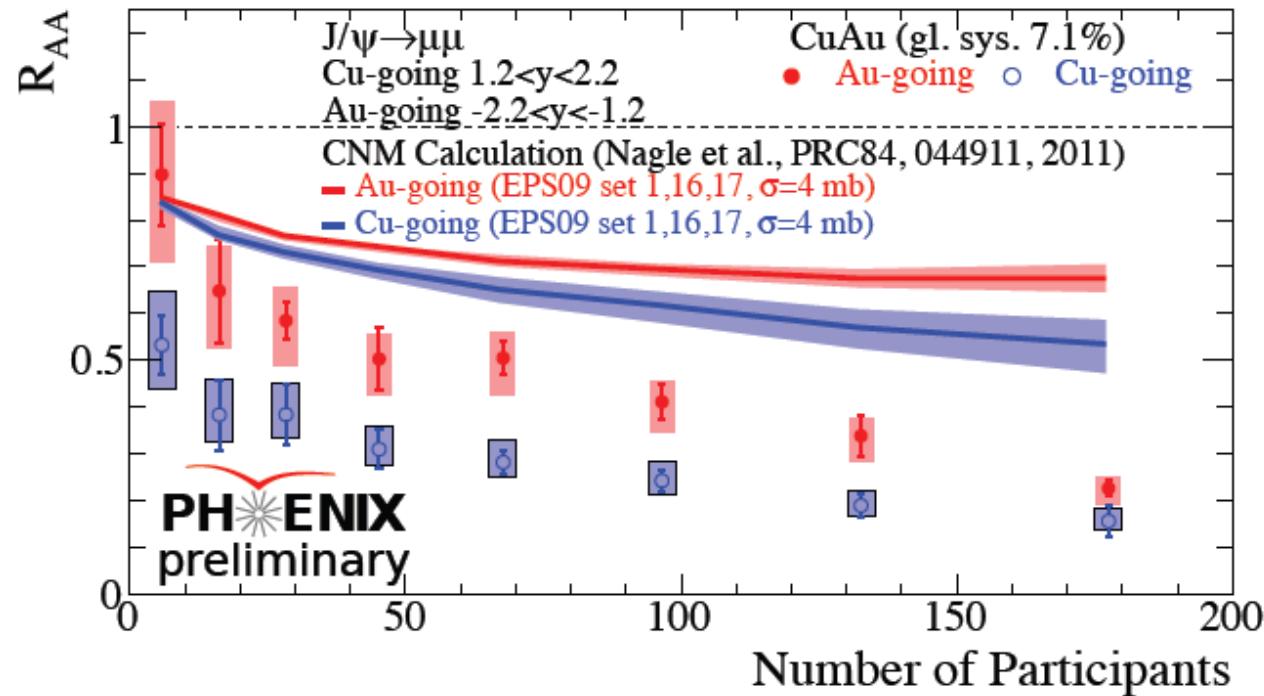
CMS had a hint (less than 2σ) of less suppression of the ψ' wrt to J/ψ at lower p_T (pp @ 2.76 TeV)

ALICE looked and does not see it... (pp @ 7 TeV)

No discrepancy!

Moon & Camelia
Scomparin & Arnaldi

J/ ψ in Cu+Au @ RHIC

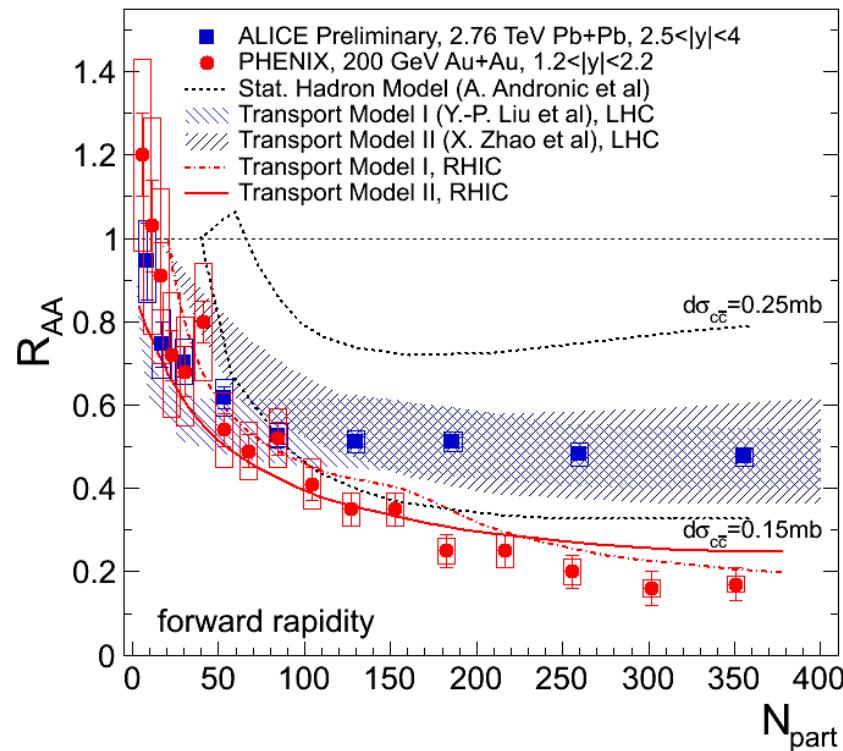


More suppression in the Copper going direction
Qualitatively expected from shadowing (lower x in the Au)
Quantitatively? Look in the peripheral region...

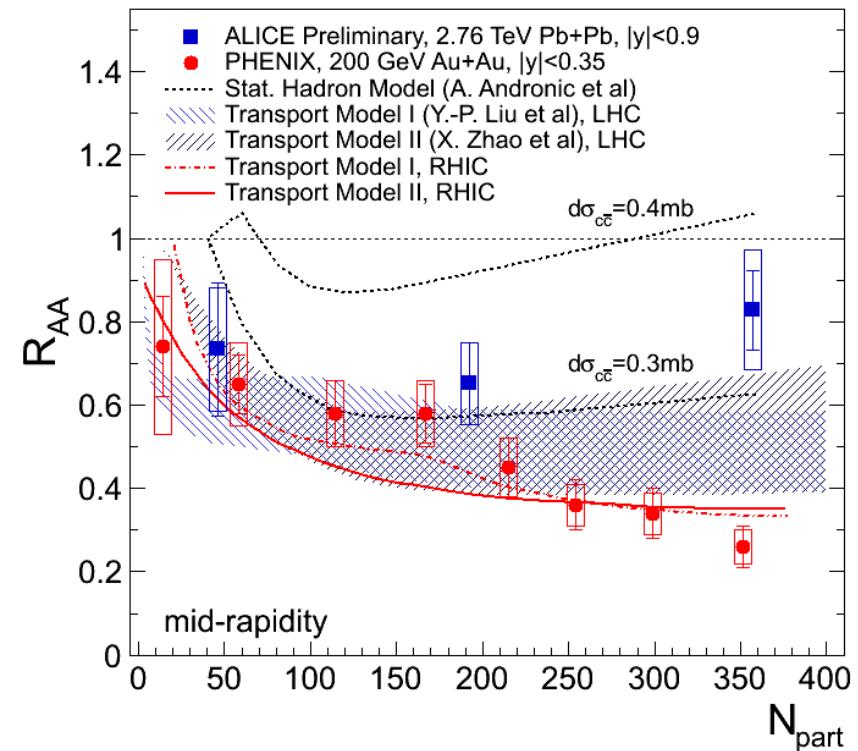
Rosati, Hollis

Low p_T J/ ψ less suppressed @ LHC

Forward rapidity



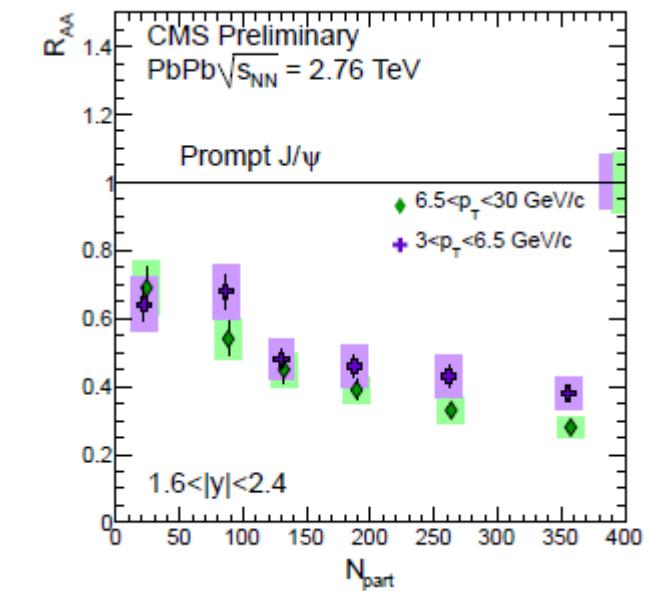
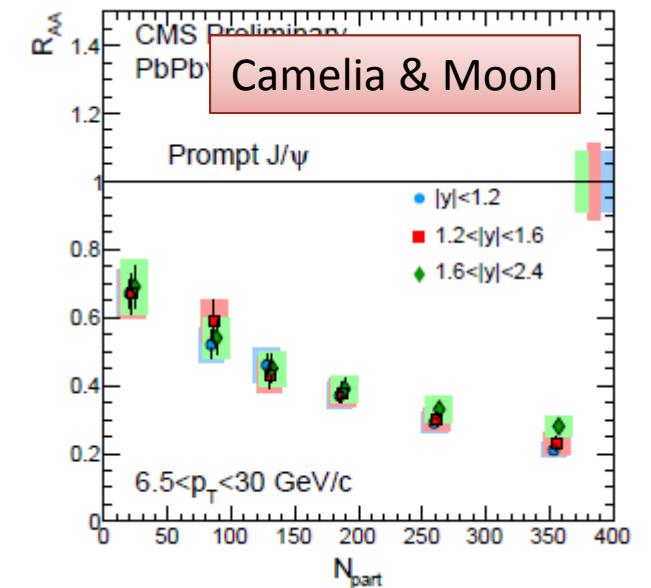
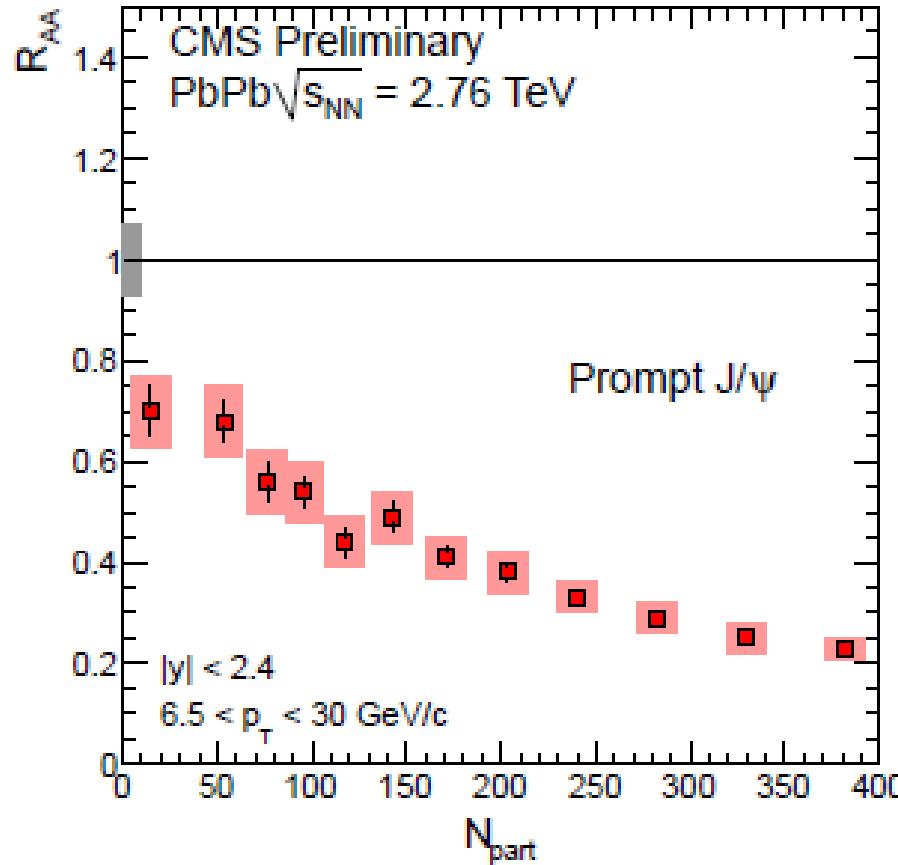
Mid rapidity



Less suppressed than at RHIC, in particular at mid-rapidity
Probably due to regeneration...

Scomparin,
Arnaldi & Arsene

High p_T J/ ψ more suppressed than at RHIC

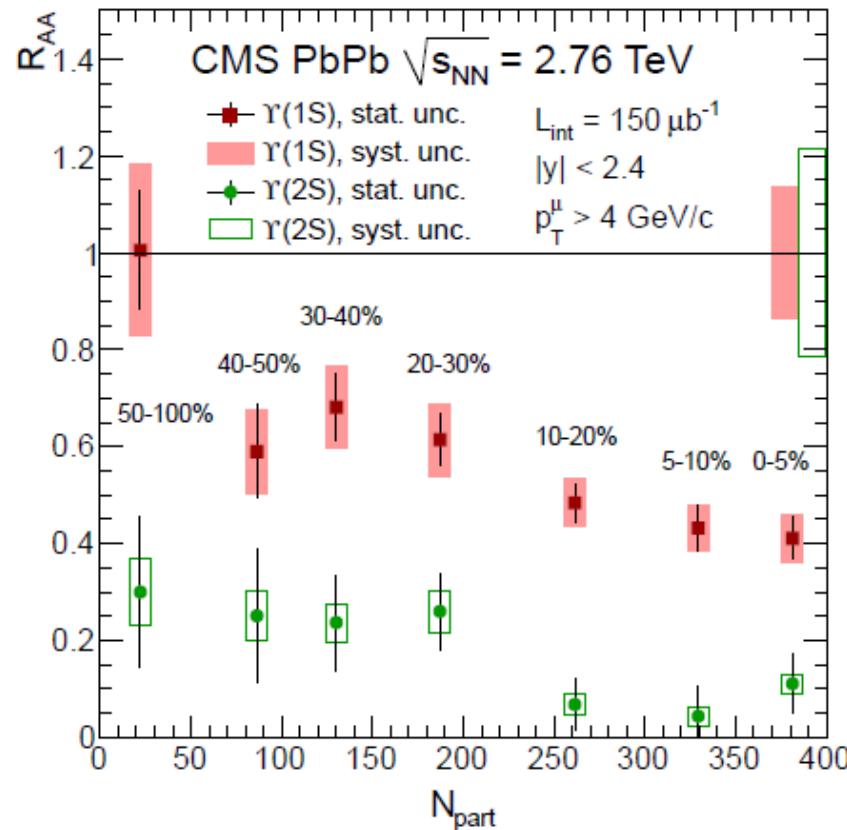


More data, more differential measurement
Alice and CMS seeing more suppression at higher pt
No room for strong rapidity dependence

Upsilons

Camelia, Rangel
Dong, Trzeciak, Xie

Upsilon(1S) and (2S) at LHC



Sequential disappearance of the 3 states

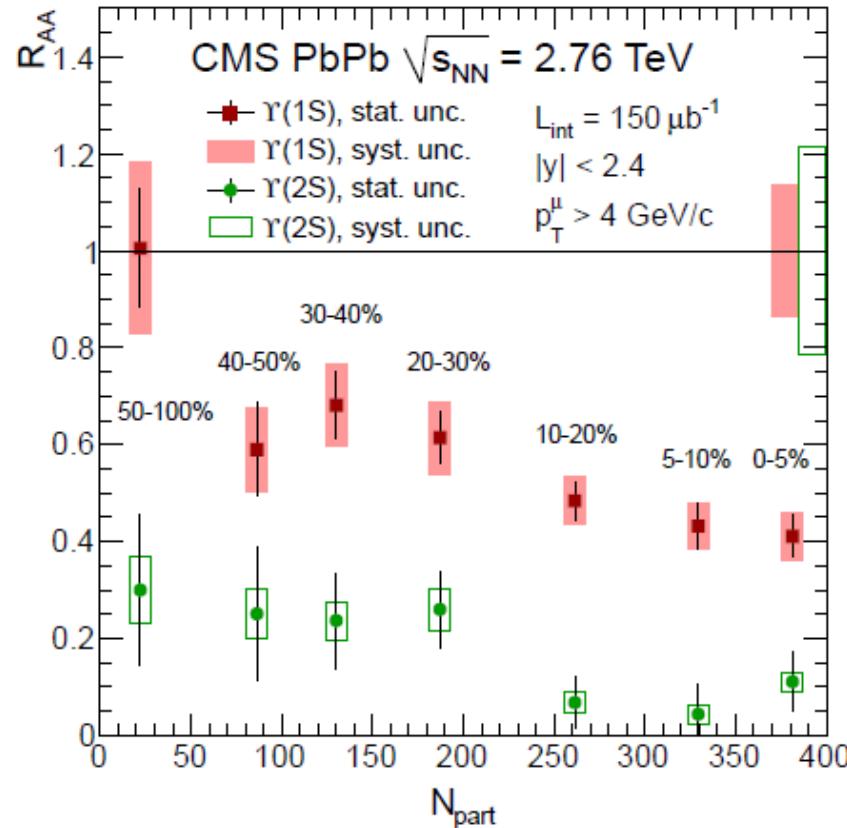
$$R_{AA} (\Upsilon(3S)) < 0.10 @ 95\% \text{ CL}$$

Check the behaviour in pA !

Upsilons

Camelia, Rangel
Dong, Trzeciak, Xie

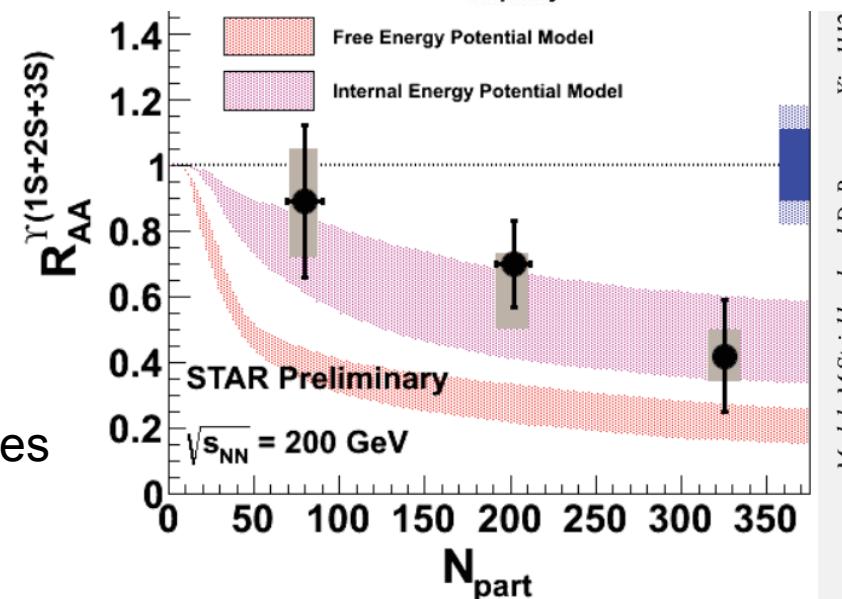
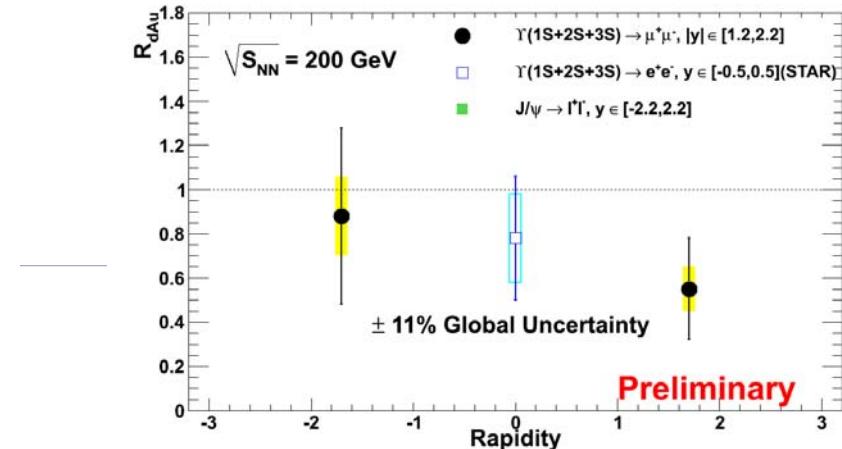
Upsilon(1S) and (2S) at LHC



Sequential disappearance of the 3 states
 $R_{AA}(\Upsilon(3S)) < 0.10$ @ 95% CL
 Check the behaviour in pA !

2012, September, 21th

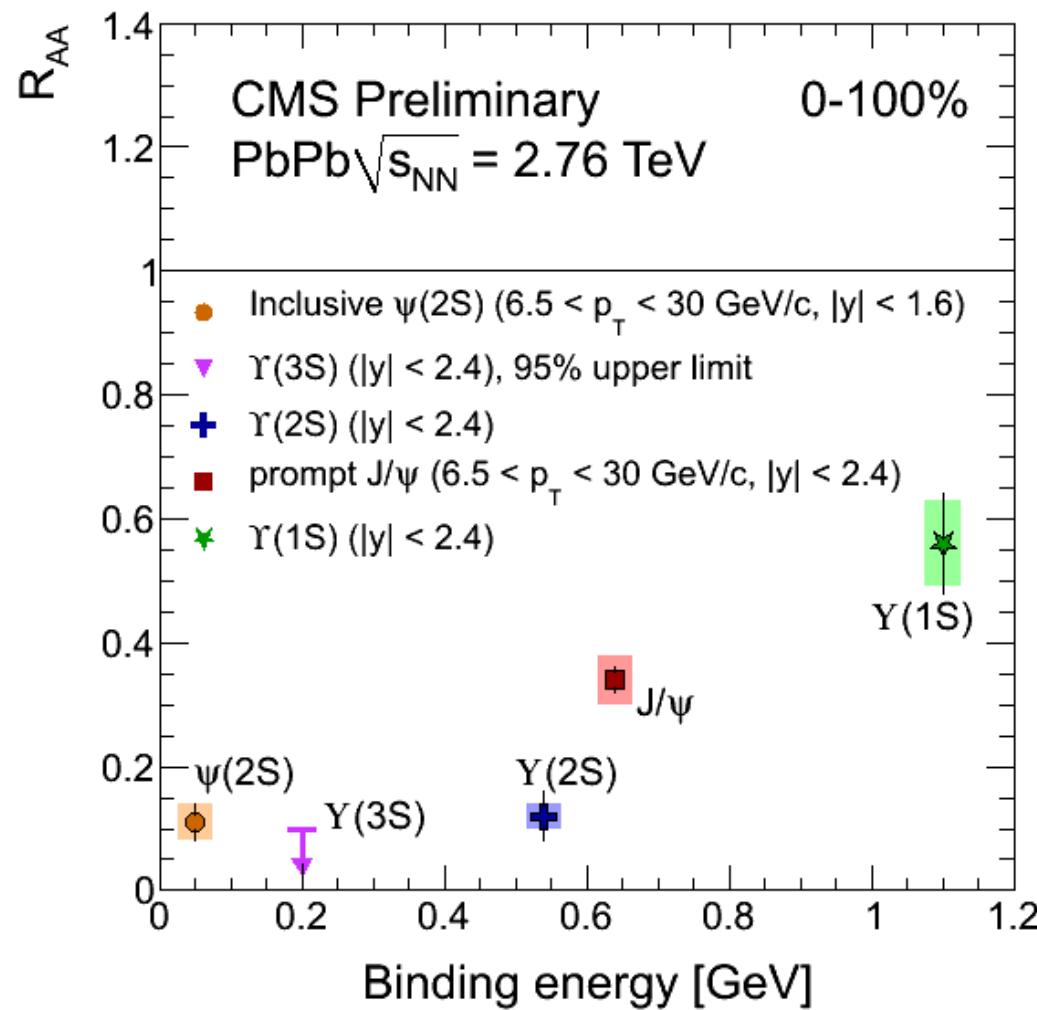
All Upsilon at RHIC



QM highlights - raphael@in2p3.fr

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Five states to bind them all



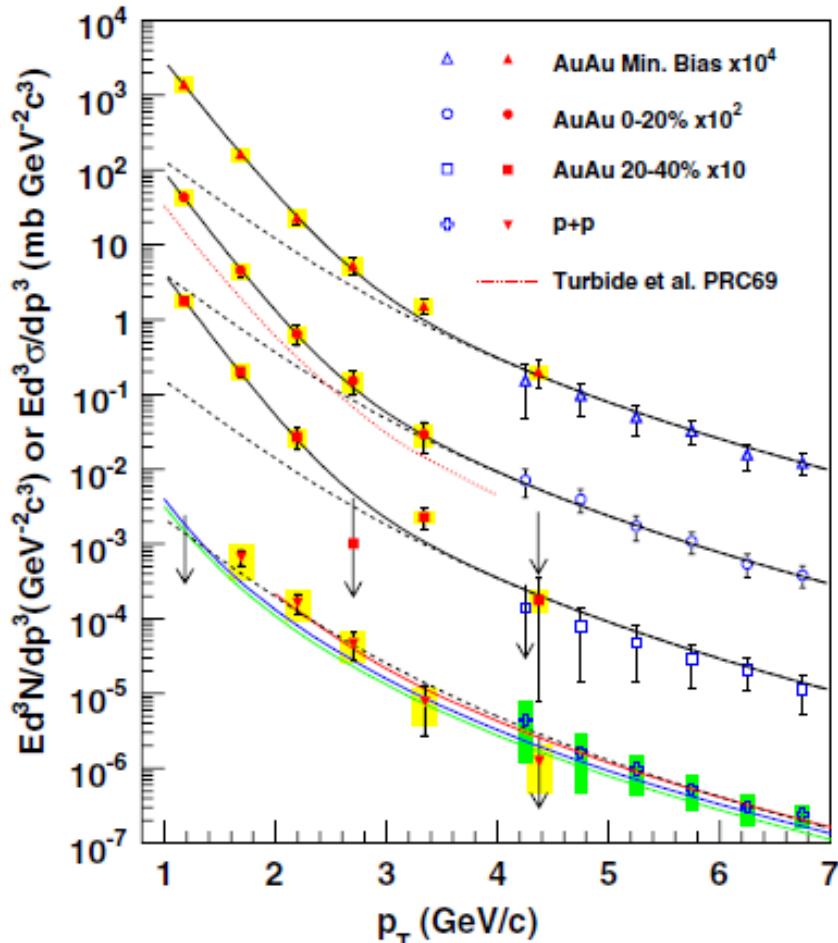
Forgetting low p_T J/ψ
(regeneration)

$R_{AA}(\text{MB})$ vs binding energy
looks ordered

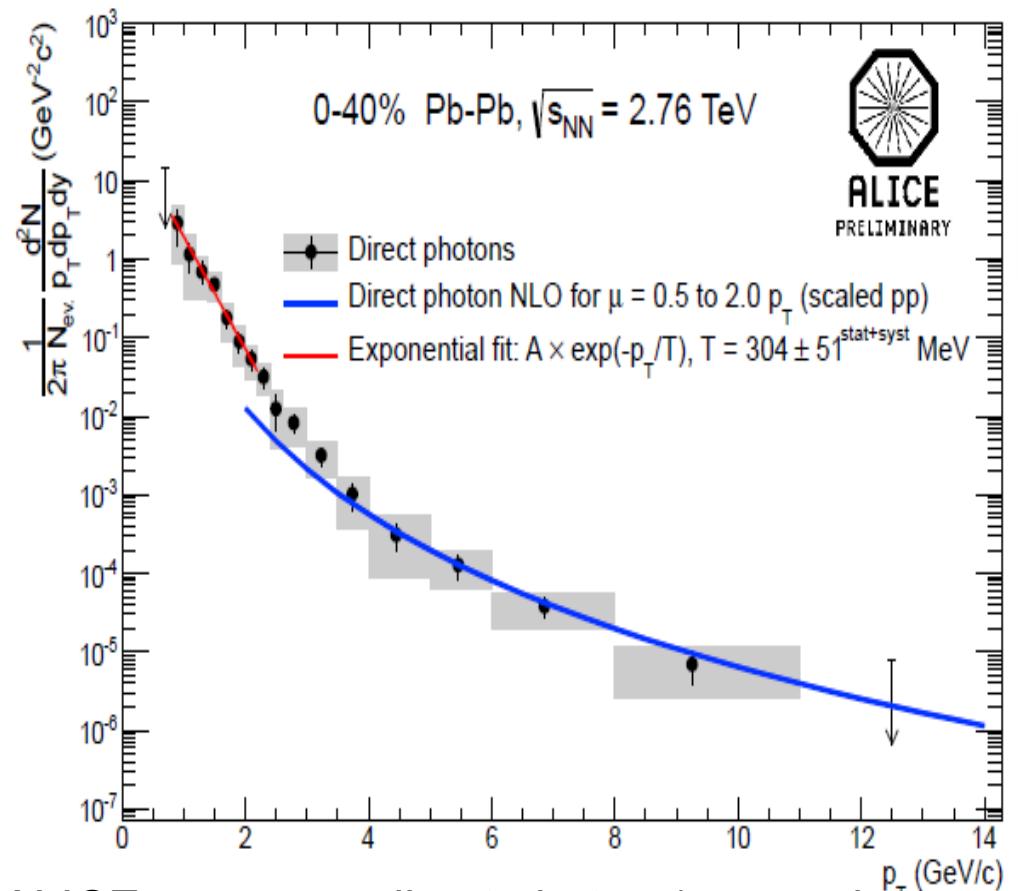
TBD with more data vs
centrality and unfolding
cold effects and feeddown
could start acting as a
thermometer?

Camelia

Speaking of temperature: low p_T photons!



PHENIX: PRL104 (2010)132301
ALICE: Wilde (best talk)



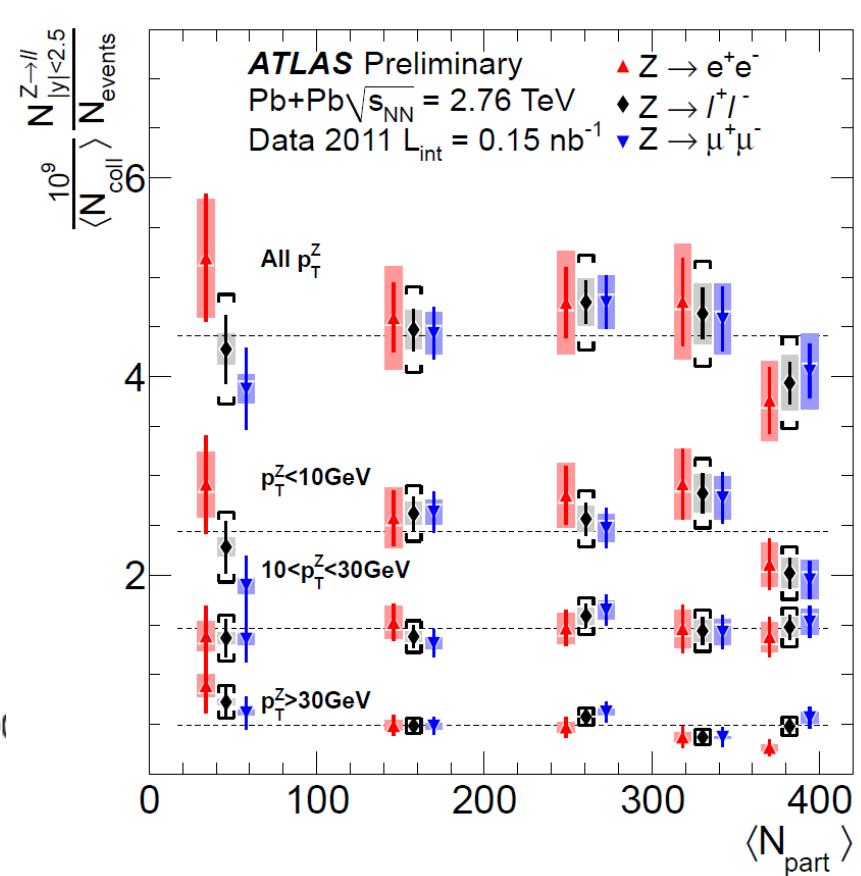
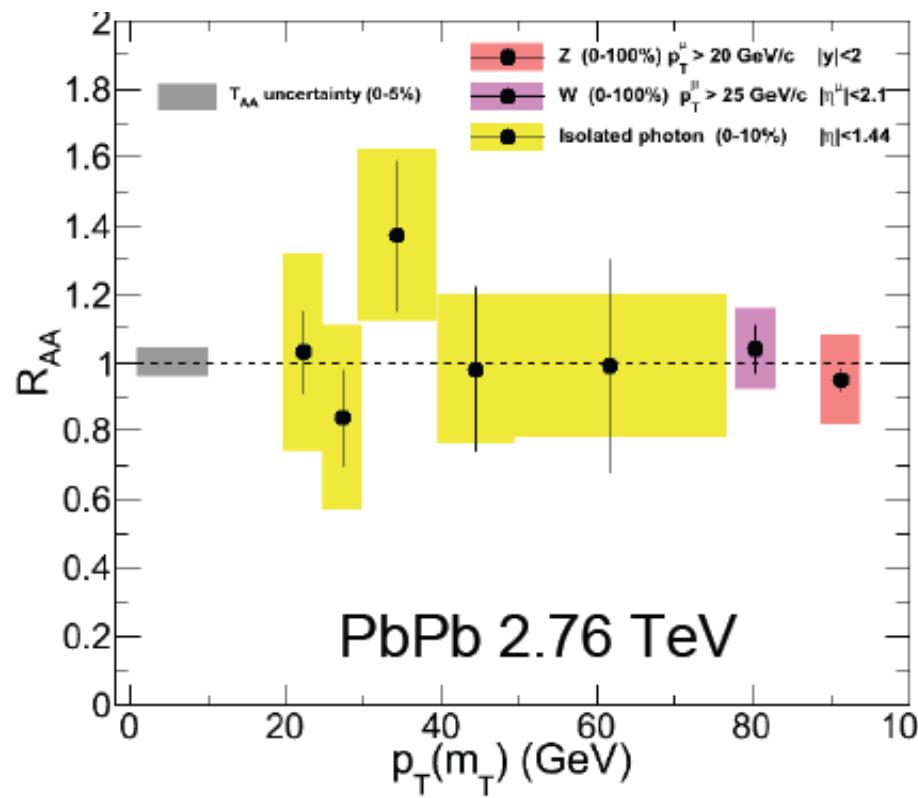
ALICE measures direct photon (conversion)
and fitting an (average) temperature
of (304 ± 51) MeV for 0–40%
PHENIX was $(221 \pm 19 \pm 19)$ MeV for 0–20%

<http://www.guinnessworldrecords.com/world-records/10000/highest-man-made-temperature>

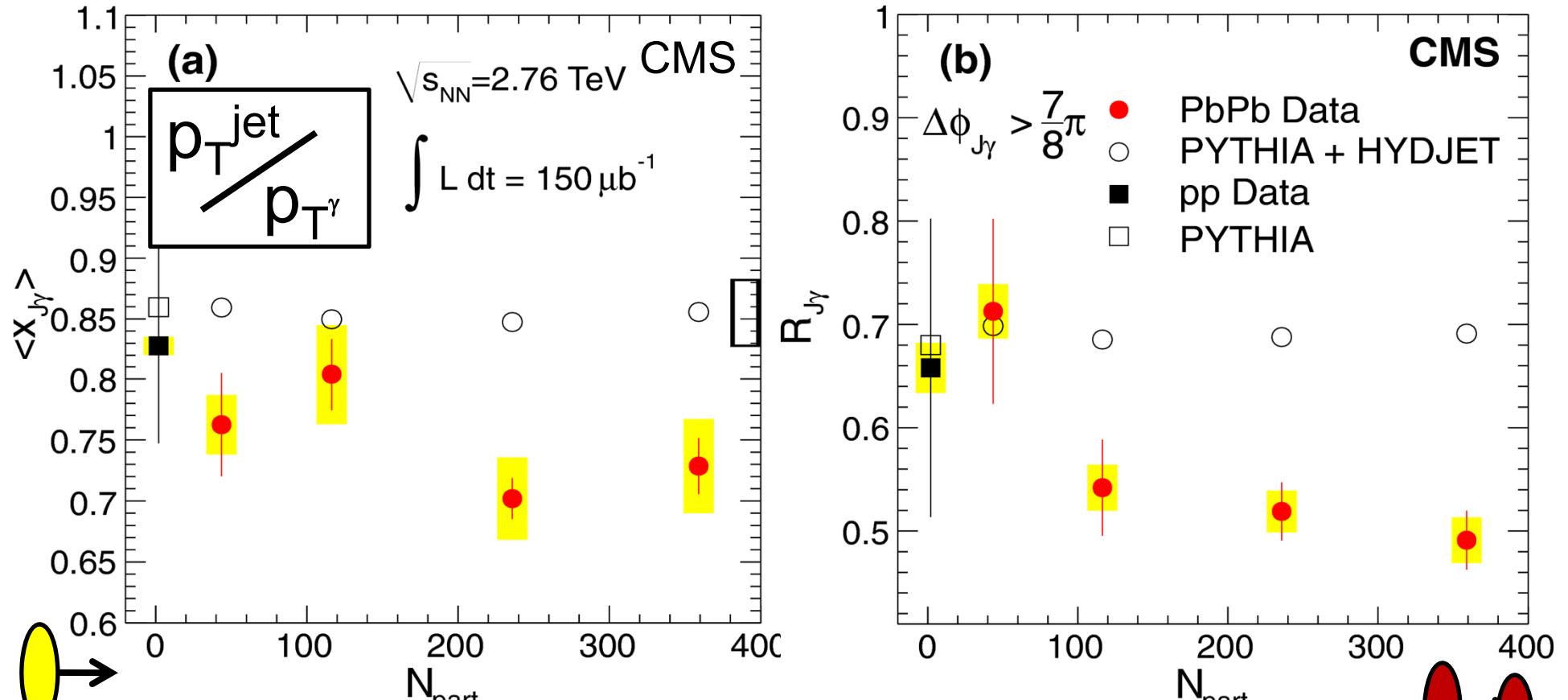
A word on electro+weak bosons

Apart from a strong expected isospin effect on the W^+ and W^- ,
no modification are seen for photons, Z and ($W^+ + W^-$)
A tension between ATLAS and CMS yields for the Z boson...

Plenary talks
by Steinberg (ATLAS)
and Raphael (CMS)
Lamia, Citron...



Correlating photons with jets

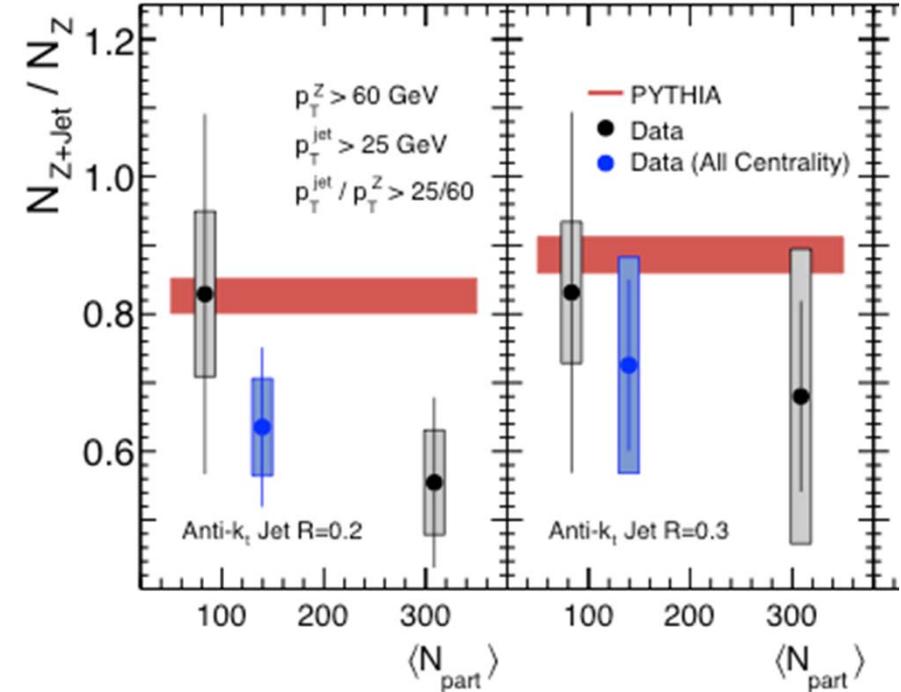
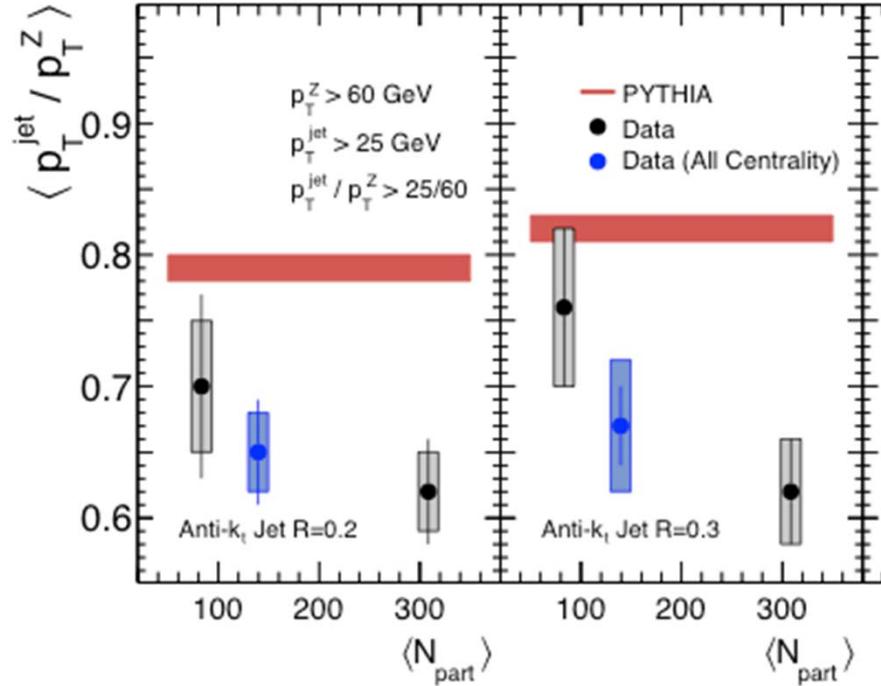


In CMS, for photon $p_T > 60$ and jet $p_T > 30$ GeV/c

- (a) Opposite jets are 14% less energetic in PbPb than pp
- (b) 20% more are not associated to a reconstructed jet
(very similar results in ATLAS, different cuts)

Veres, Raphael, Lai...
Steinberg, Citron...

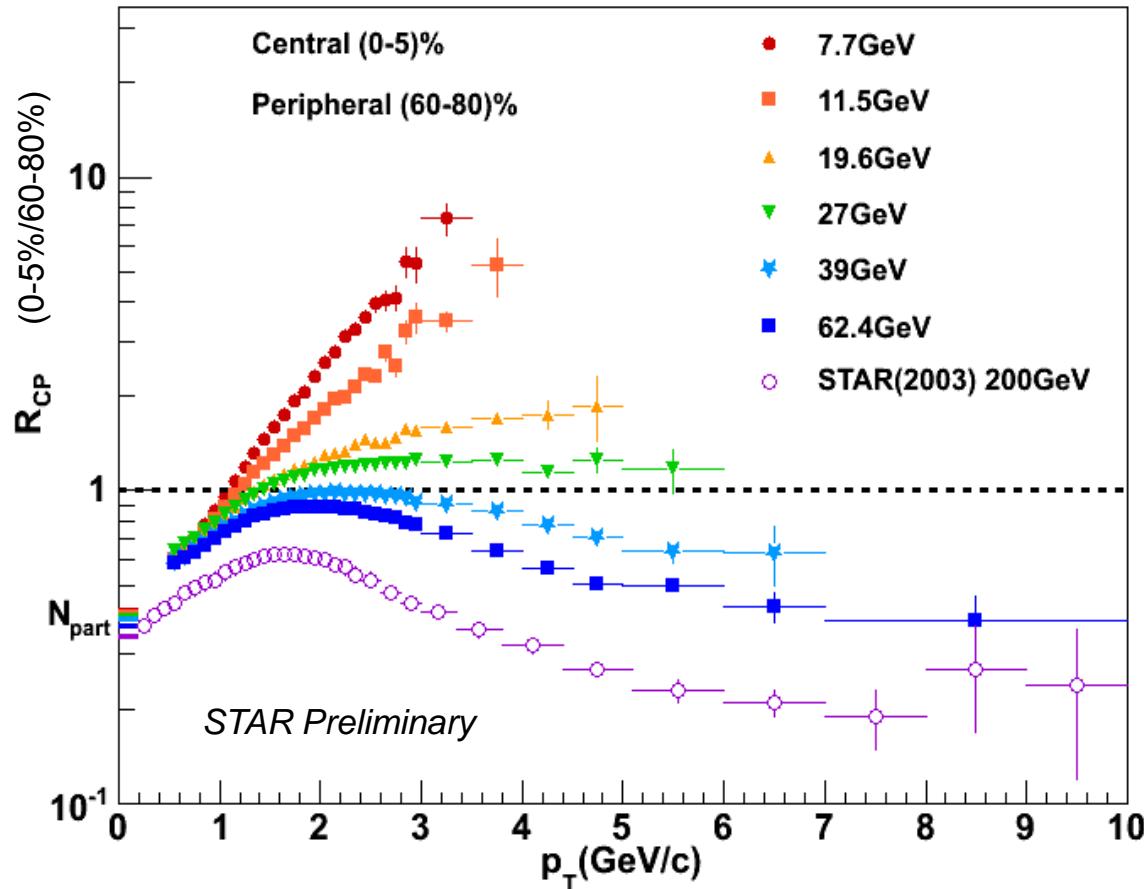
ATLAS correlates Z with jets!



(same quantities as previous slide)
36 Z + jet events with
 $p_T(Z) > 60 \text{ GeV}$ and $p_T(\text{jet}) > 25 \text{ GeV}$

Steinberg, Citron...

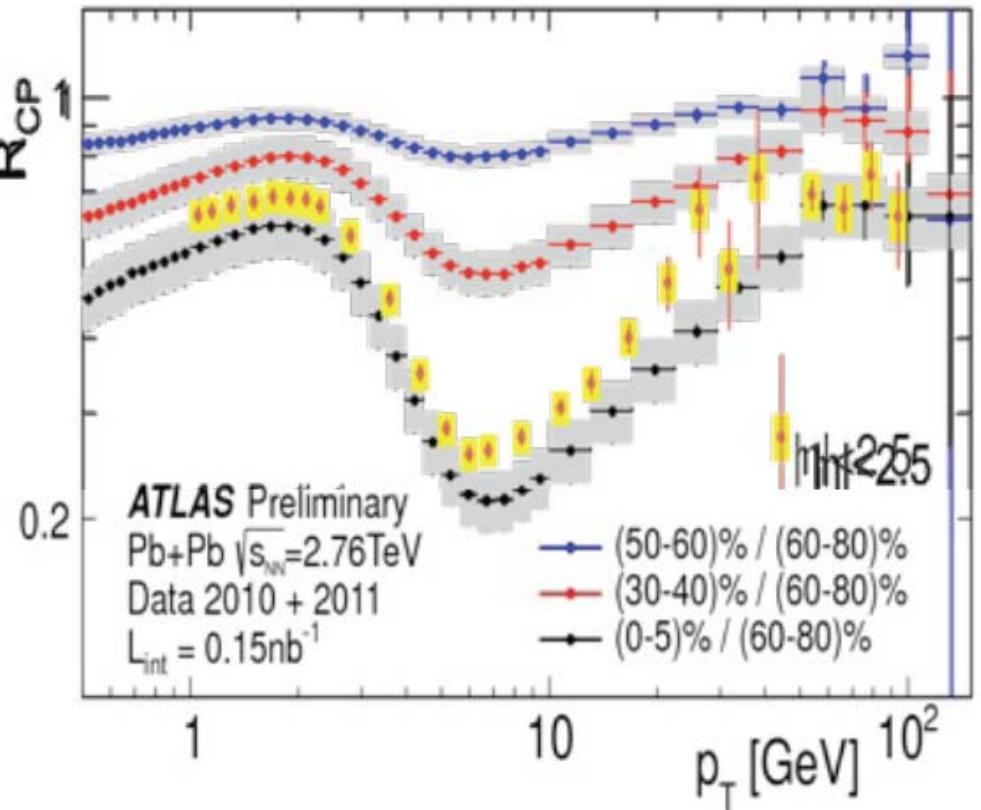
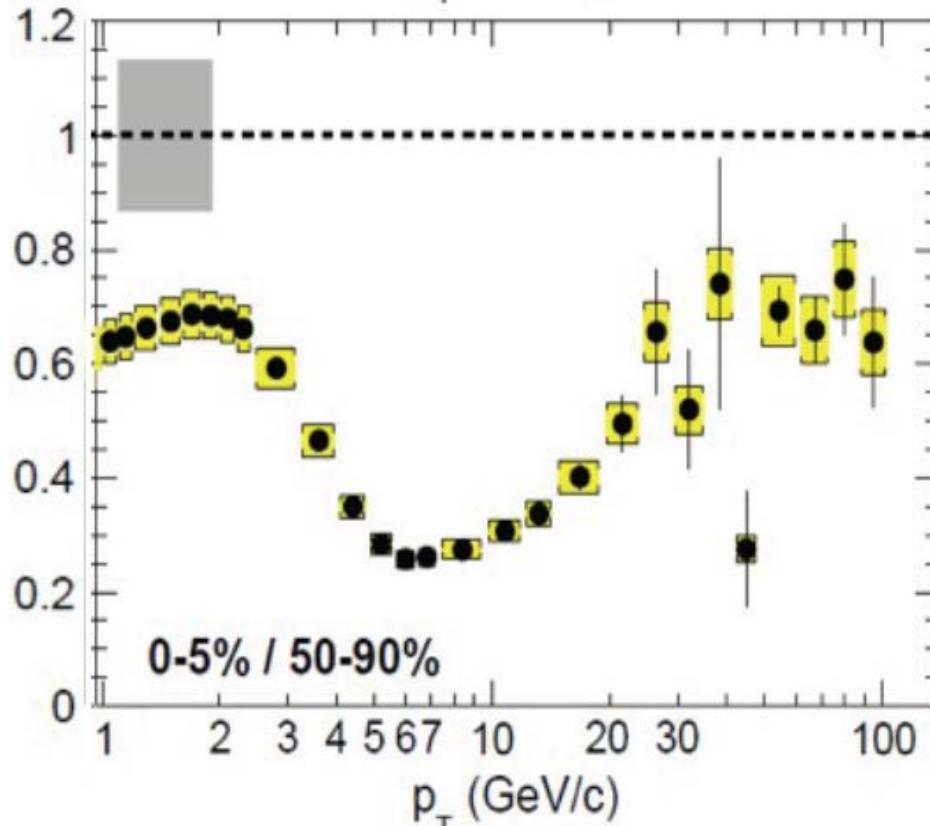
Charged particle R_{CP} @ low energy



Turning on the QGP ?
Cronin effect !

Sangaline

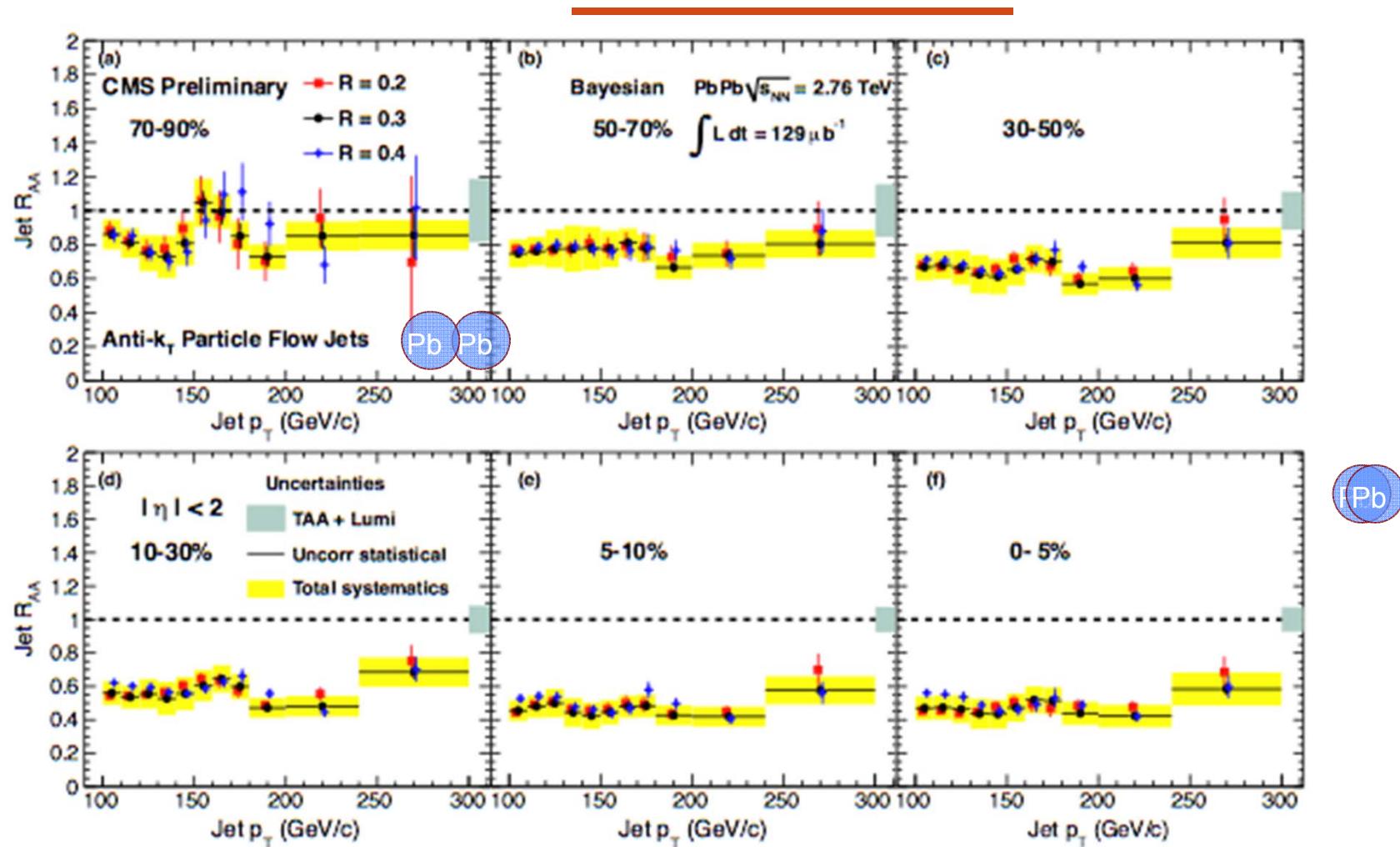
Charged particle R_{CP} @ high energy



RCP are comparable (though slightly different centrality)
(RAA also available from CMS)

Milov & Casalderrey-Solana
Veres, Spousta...

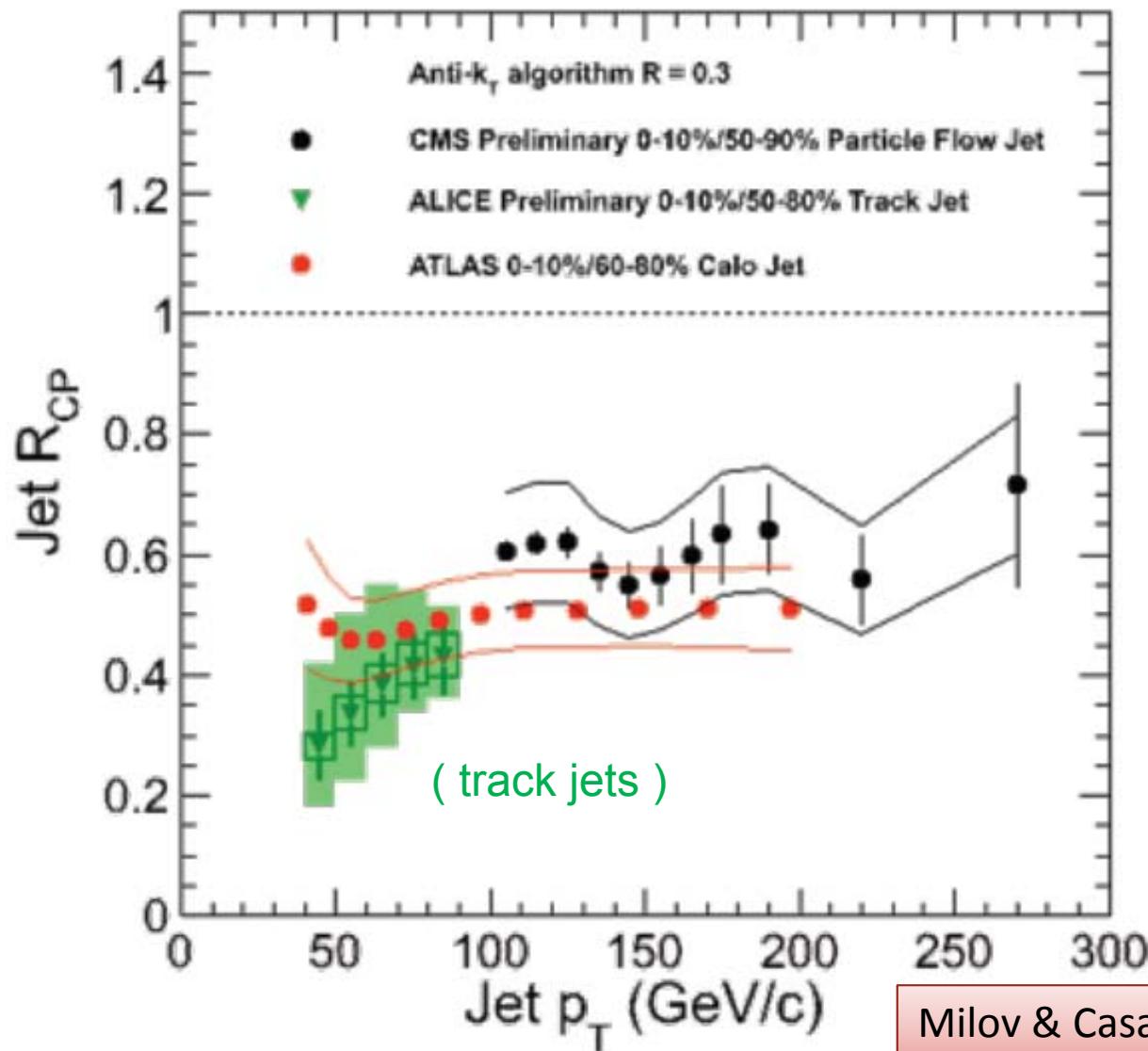
Jet RAA



Jet are quenched, little dependence on the radius (!)
(also Alice with track-jet and ATLAS R_{CP})

Veres, Tonjes

Comparing experiments



Milov & Casalderrey-Solana

Fragmentation functions

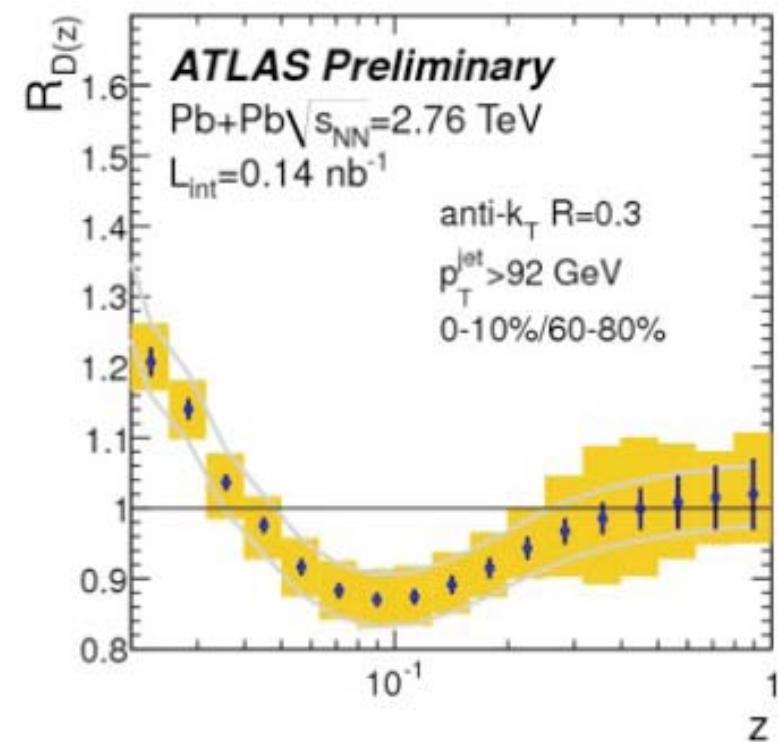
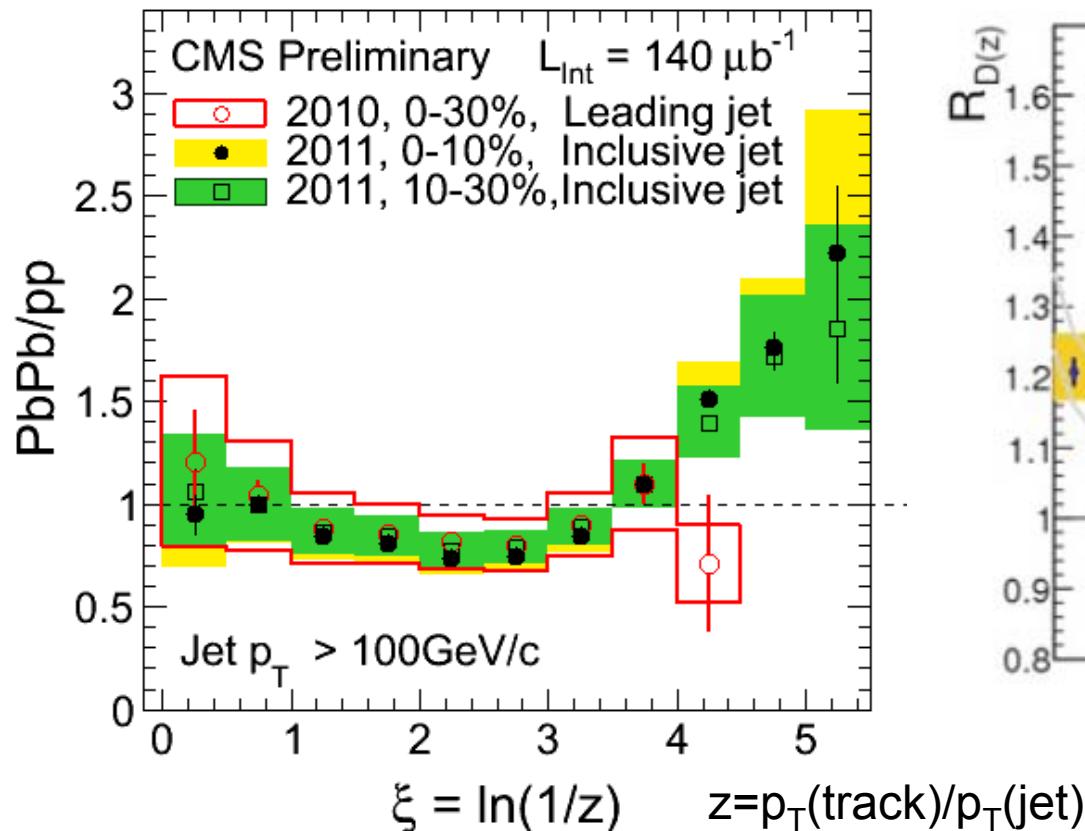
At QM'11, fragmentation functions of the surviving jet were unmodified

(p_T track > 4 GeV, p_T (jet) > 100 GeV)

At QM'12, we start seeing the modifications!

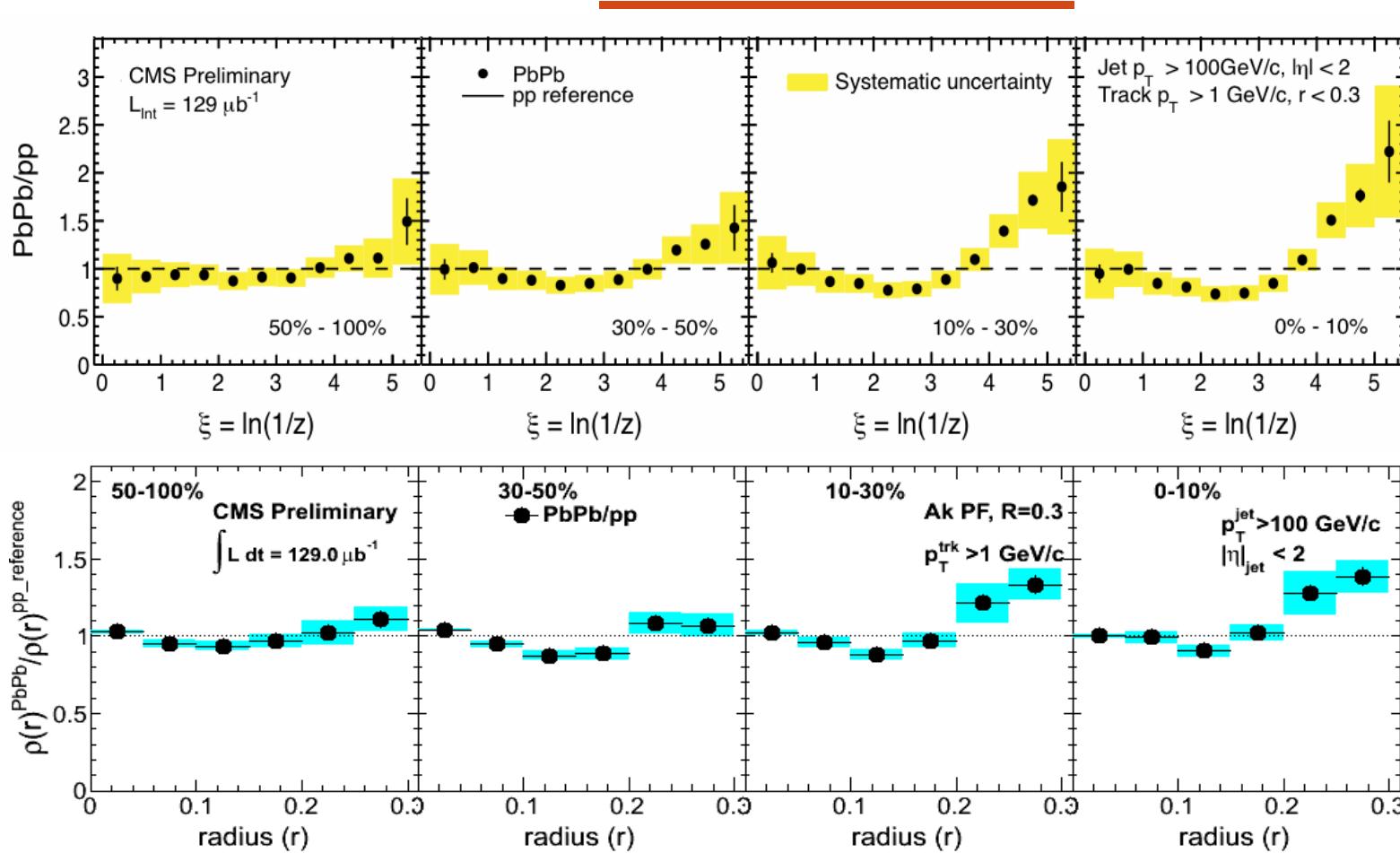
(p_T track > 1 GeV and higher p_T (jet) reach)

Veres, Spousta...
Ma, Rybar...



Similar in ATLAS, different variable, no pp...

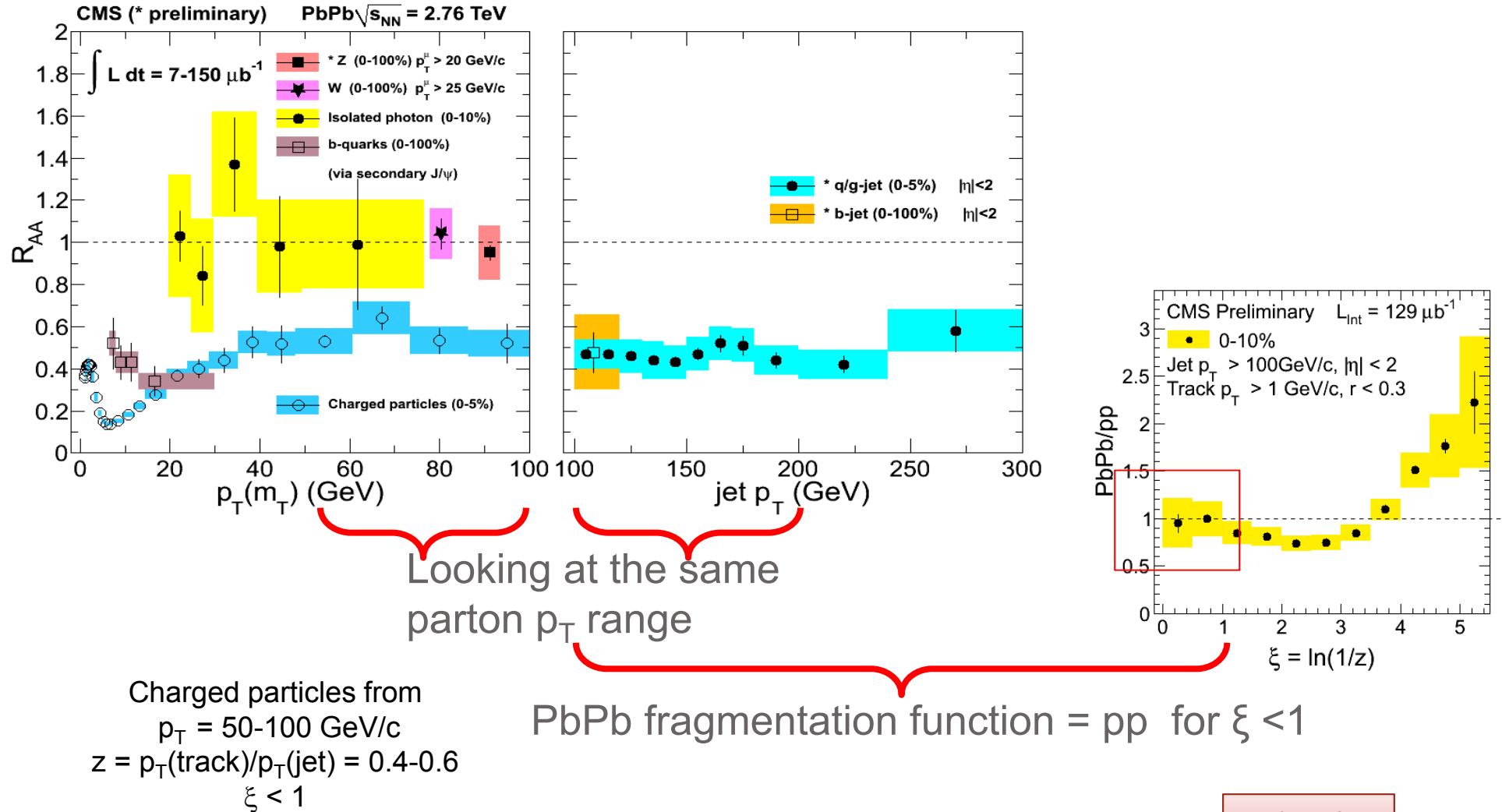
Fragmentation (energy) and shape (radius)



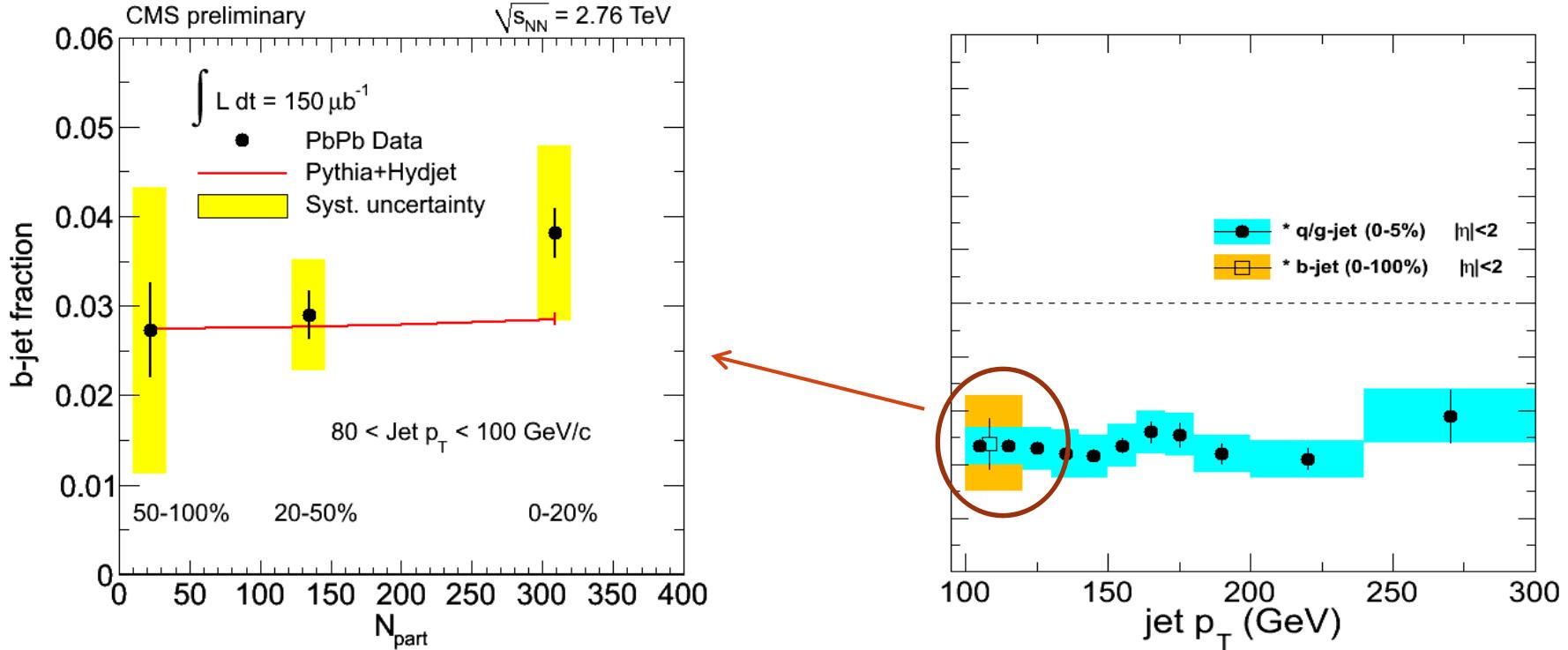
No change at small r , high p_T
 Narrowing/depletion at intermediate p_T
 Broadening/excess at large r low p_T

Veres, Ma, Kurt...

All together



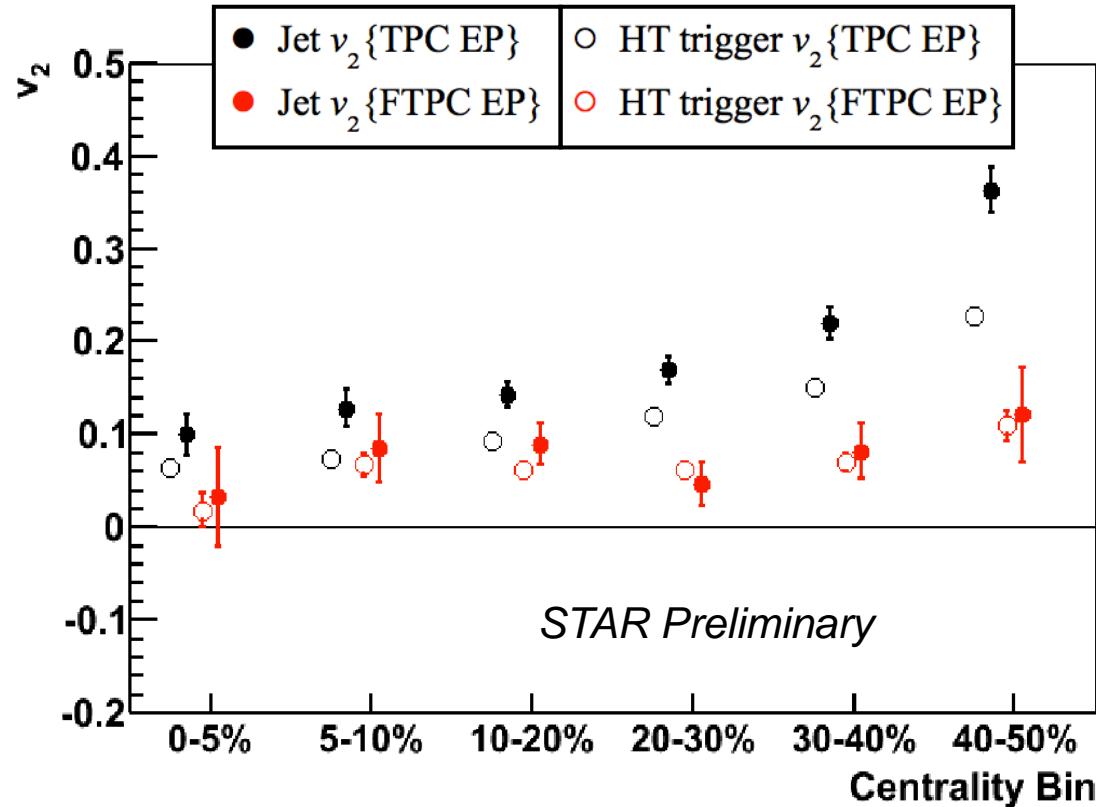
First b-jet identification



First b-jet identification in heavy-ion collisions
via various jet topologies (displaced tracks...)
Within large uncertainties, same b-jet proportion
as in pp $R_{AA}(b) \approx R_{AA}(\text{udsg})$
(also muon R_{CP} from ATLAS...)

Matt Nguyen, $\frac{1}{2}$ best talk

Path length, jet “ v_2 ” in STAR

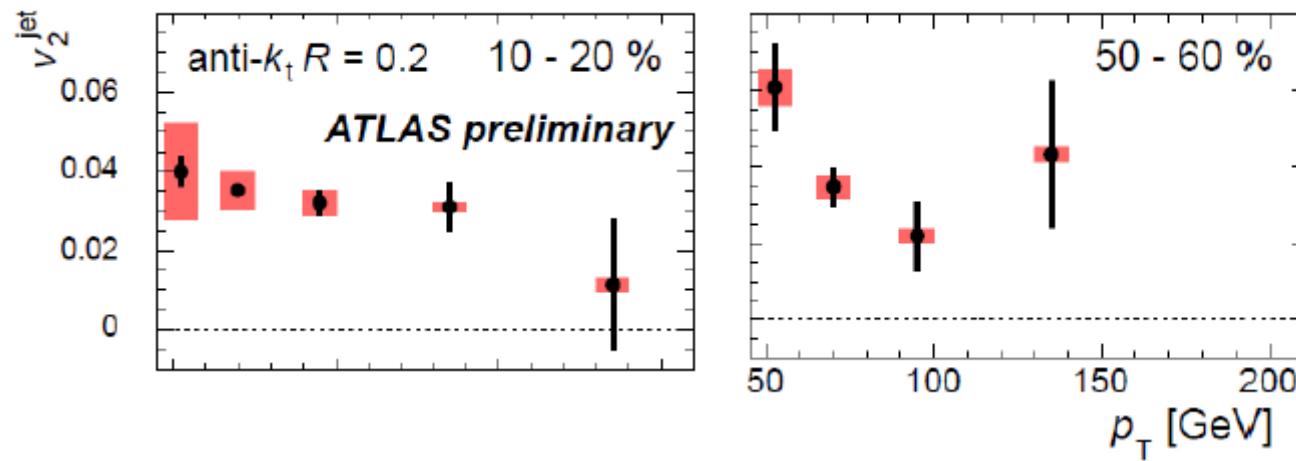
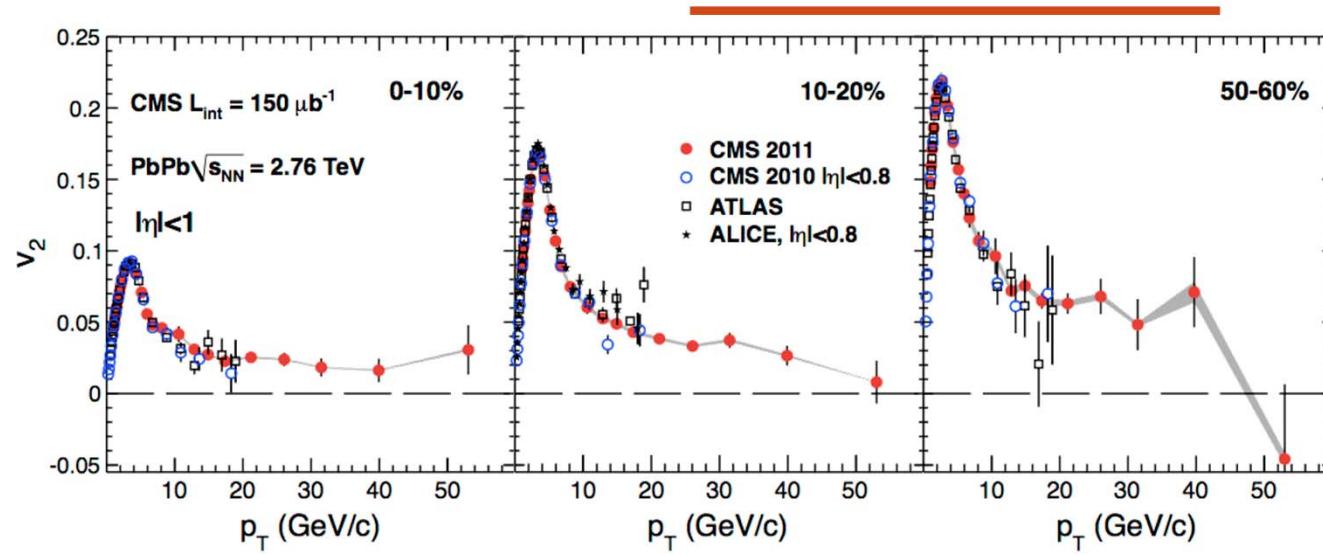


Non zero v_2 , especially in the forward direction

FTPC $2.8 < |\eta| < 3.7$ vs TPC $|\eta_{jet}| < 0.6$

Ohlson, ½ best talk

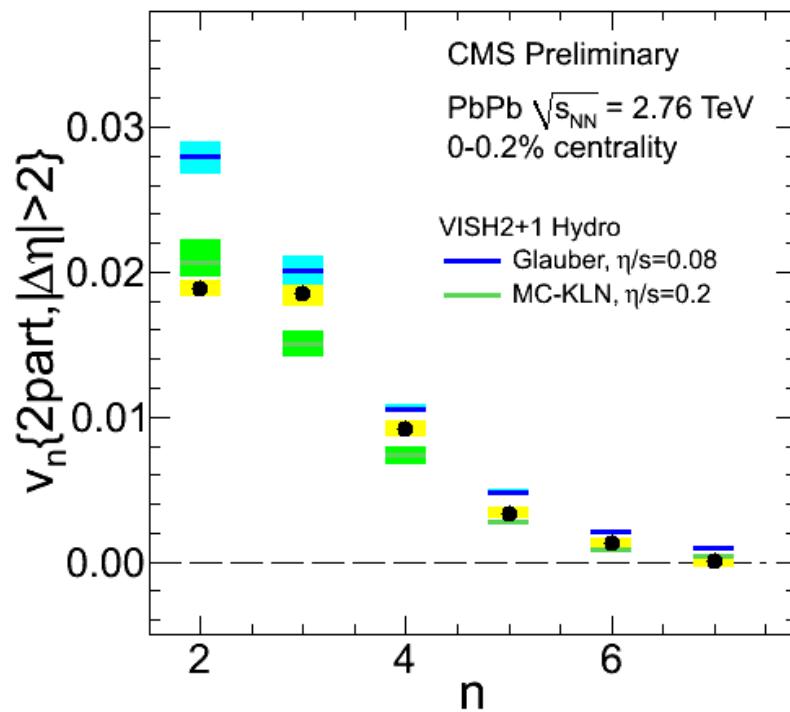
Path length, jet or hadron “ v_2 ” at LHC



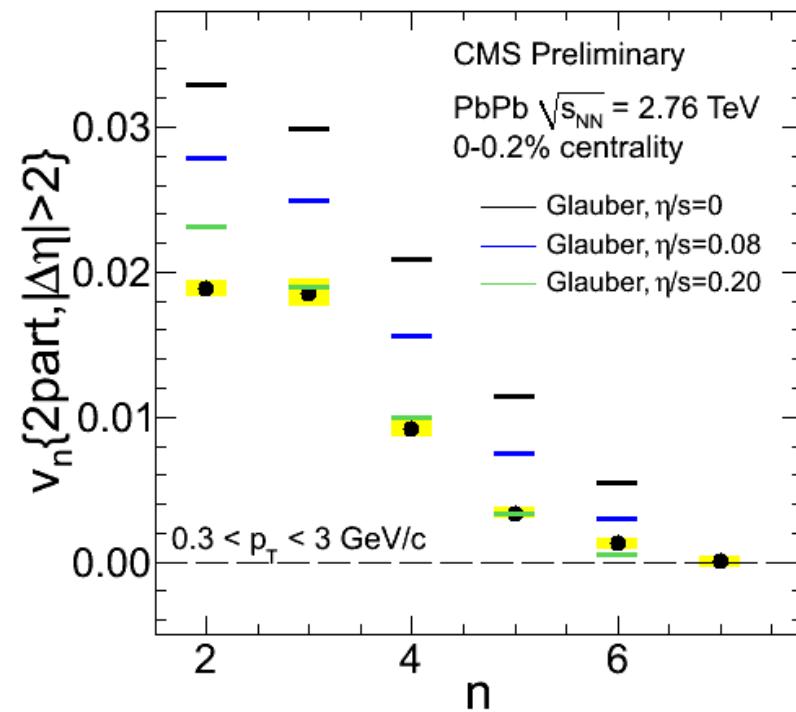
CMS: Zhukova
ATLAS: Spousta

A soft result: Ultracentral (0.2%) collisions

Calculation by Heinz et al.

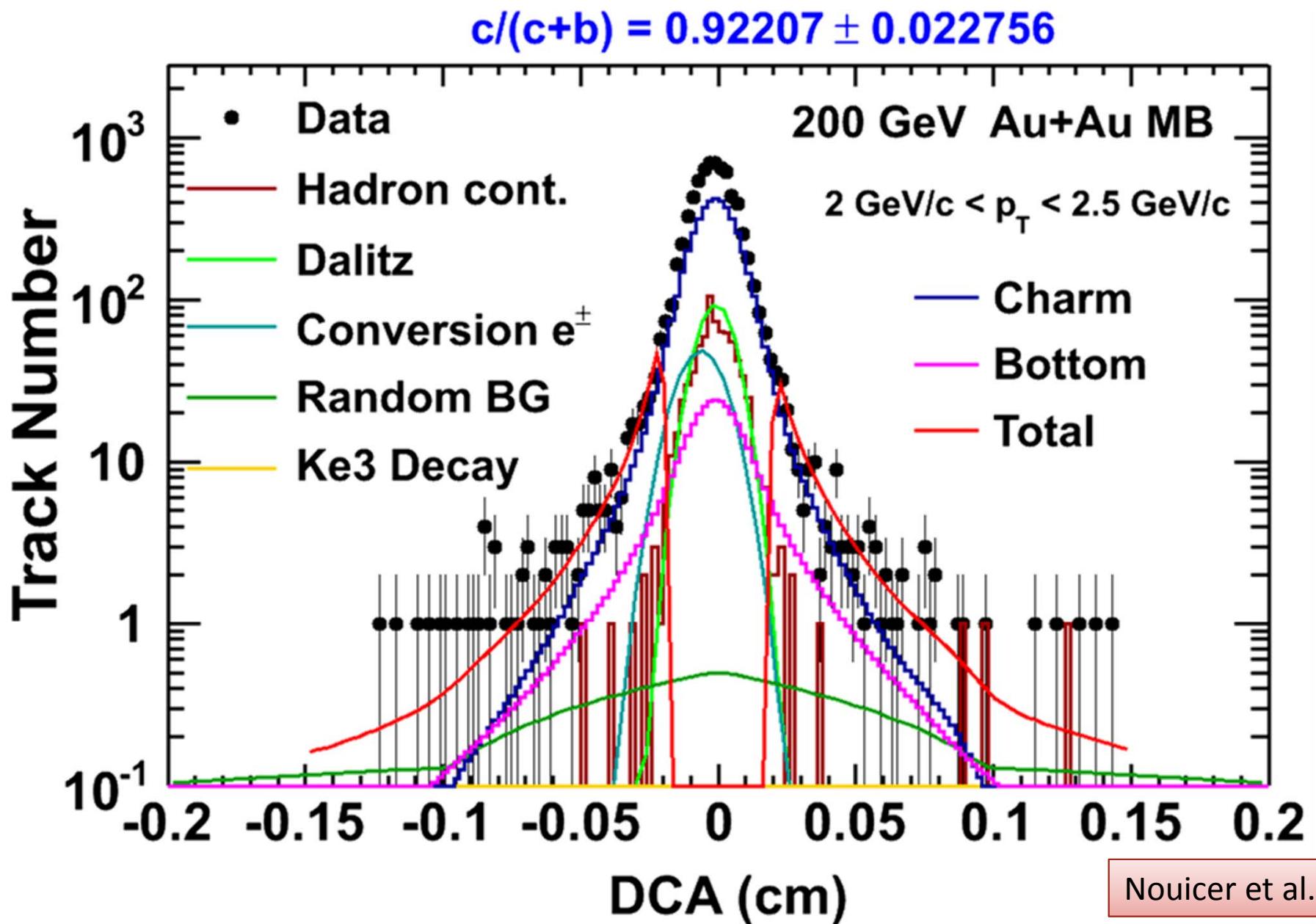


Calculation by Luzum et al.

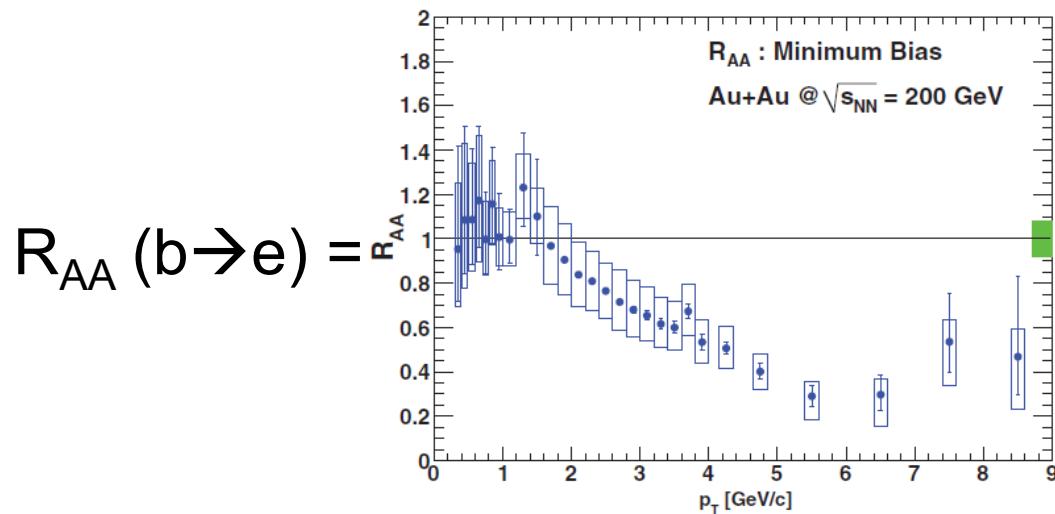


0.2% most central collisions
No almond = all fluctuations
 v_2 and v_3 vs models ?

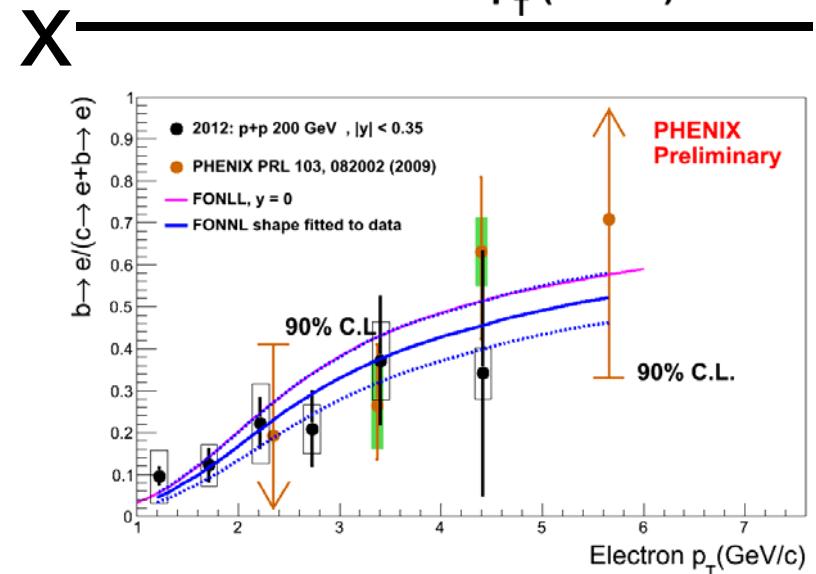
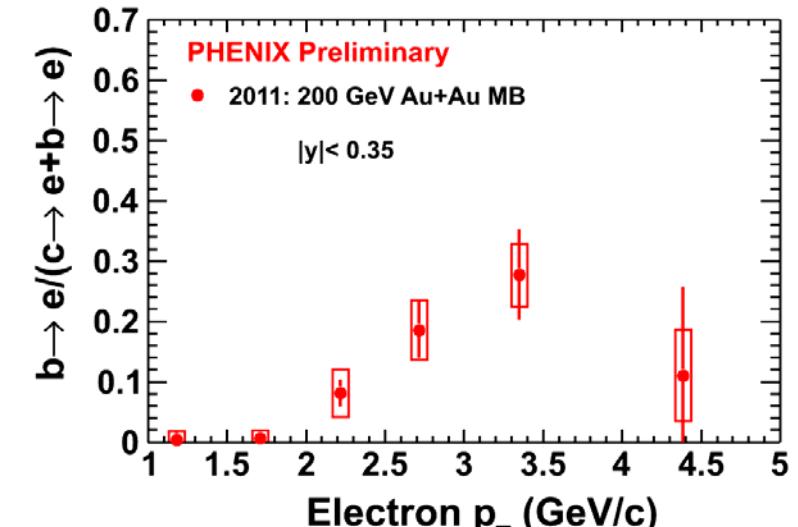
But there was much more...

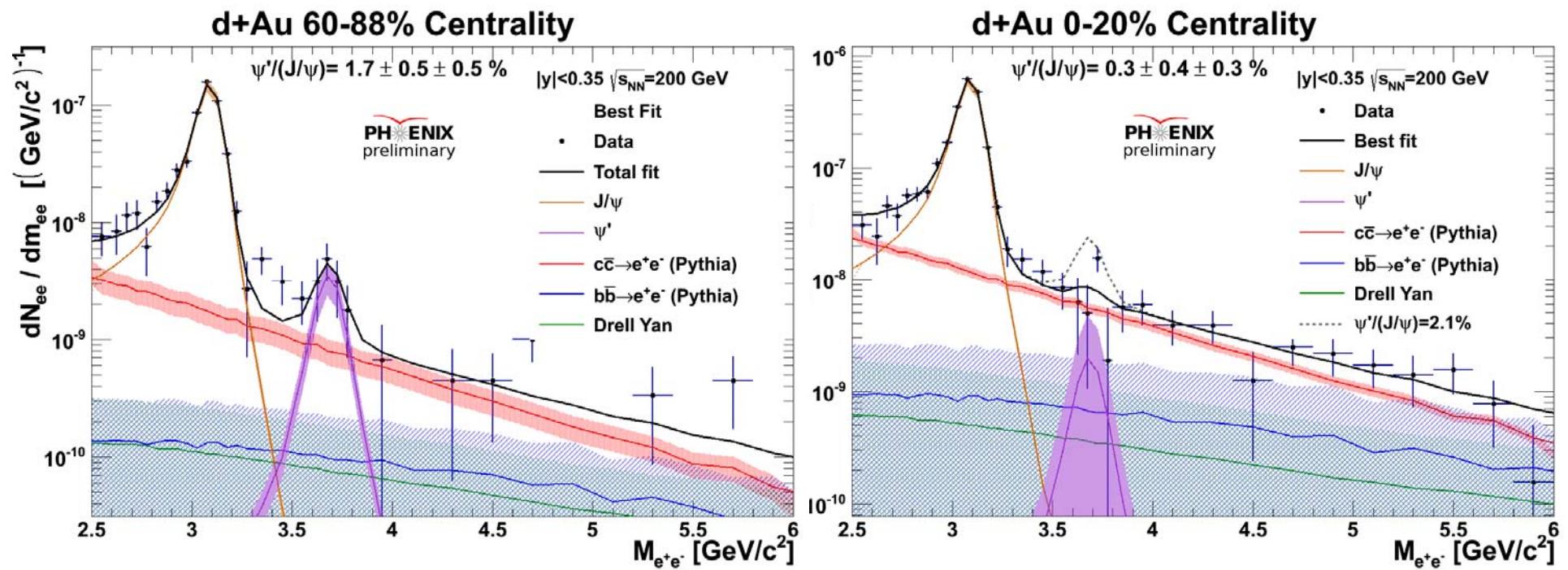


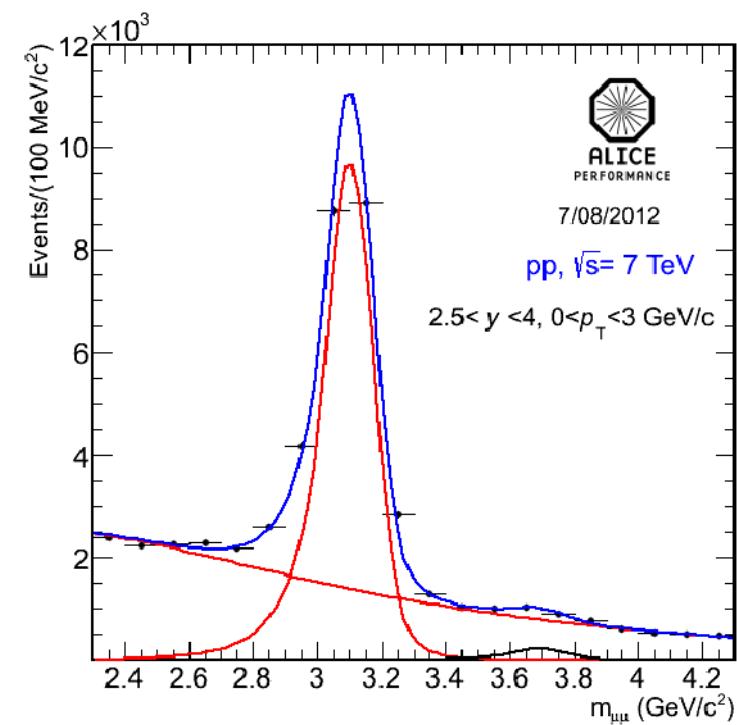
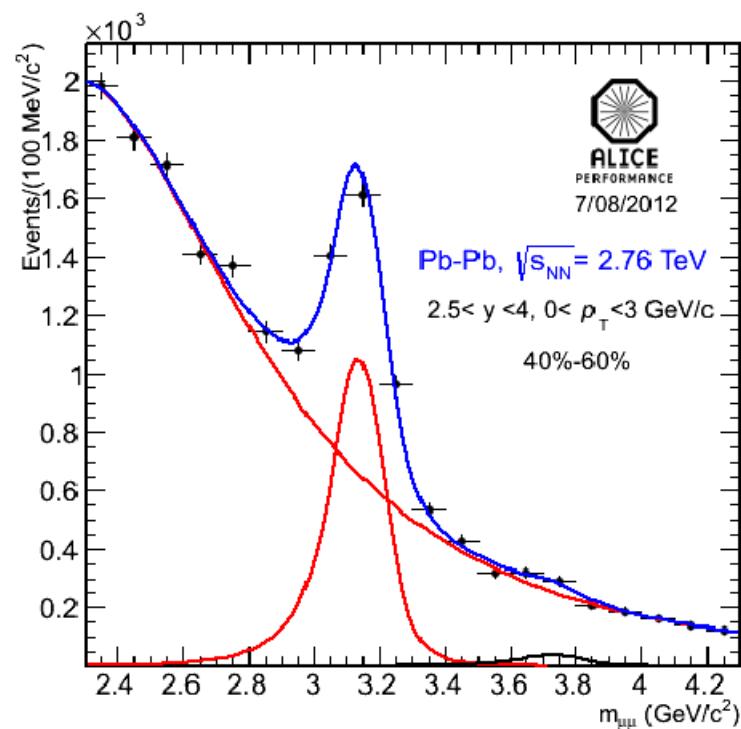
$$R_{AA}^{b \rightarrow e} = R_{AA}^{b+c \rightarrow e} \frac{\left(\frac{b \rightarrow e}{b + c \rightarrow e} \right)^{AA}}{\left(\frac{b \rightarrow e}{b + c \rightarrow e} \right)^{pp}}$$

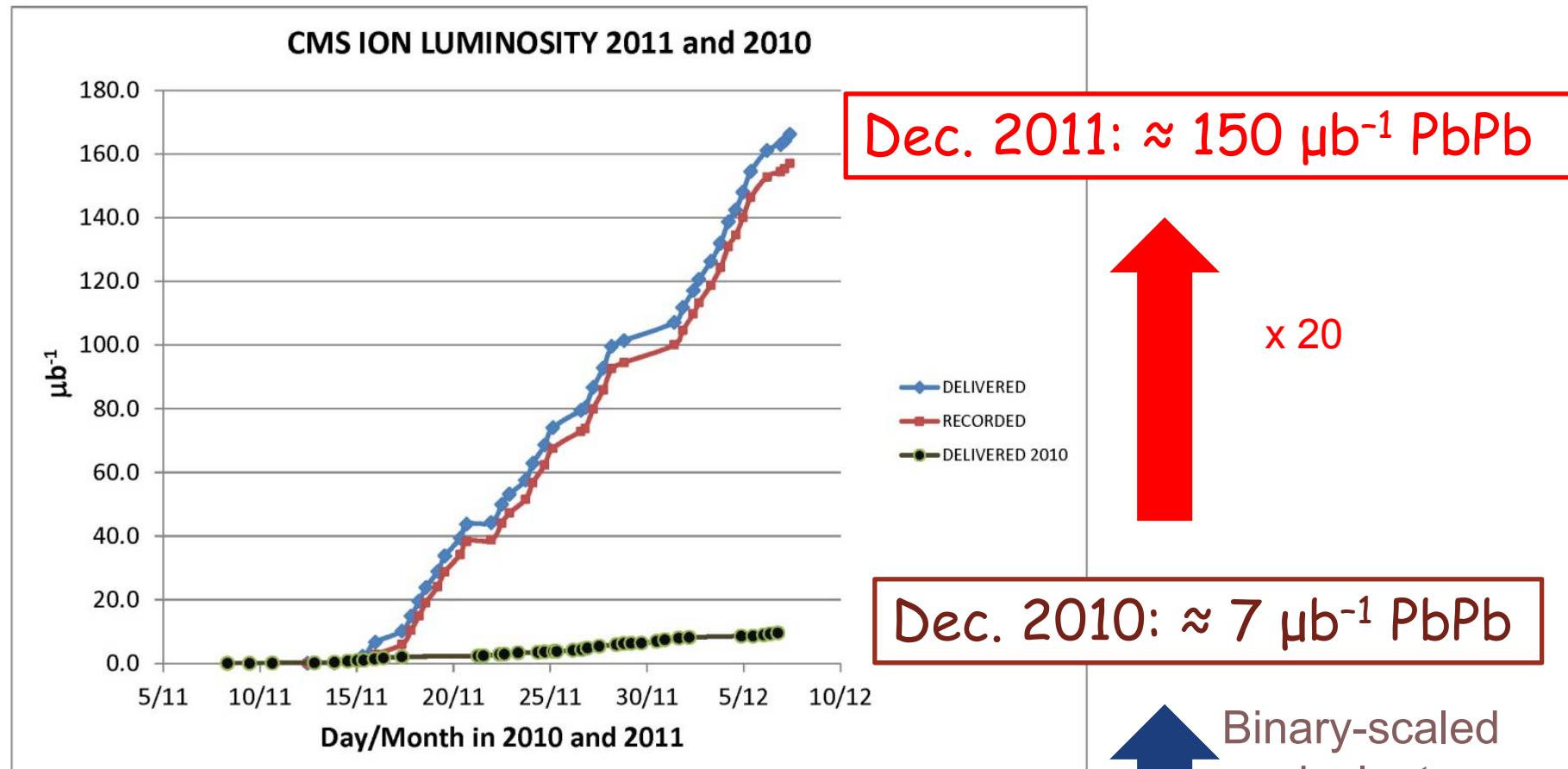


$$R_{AA}^{c \rightarrow e} = R_{AA}^{b+c \rightarrow e} \frac{1 - \left(\frac{b \rightarrow e}{b + c \rightarrow e} \right)^{AA}}{1 - \left(\frac{b \rightarrow e}{b + c \rightarrow e} \right)^{pp}}$$









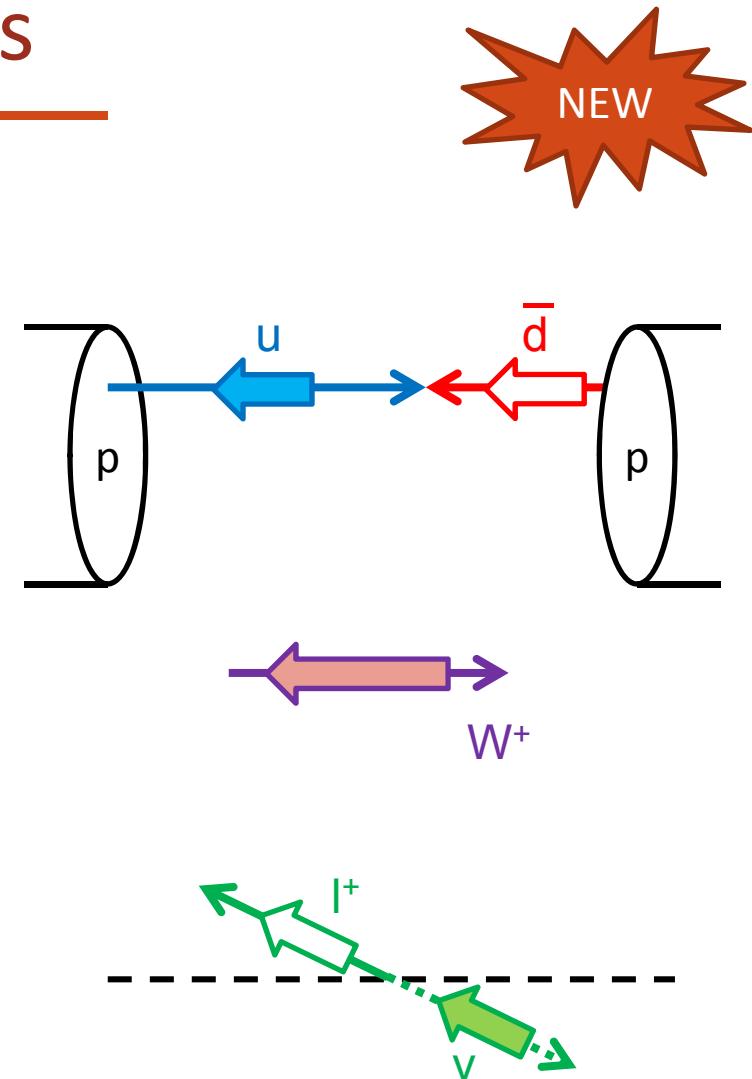
+ Mar. 2011 $\approx 230 \text{ nb}^{-1} \text{ pp at } 2.76 \text{ TeV}$

Binary-scaled
equivalent
→ as many
 Z , W , photons...

W bosons

@LO: $u\bar{d} \rightarrow W^+$ & $\bar{u}d \rightarrow W^-$

- Less W^+ and more W^- in PbPb than in pp (*isospin* effect)
 - Cancels for $W^+ + W^-$
 - W boosted towards the valence quark (higher rapidity)
 - Spin conservation $\rightarrow \mu^+$ (μ^-) boosted back to (away from) midrapidity
- A strong acceptance difference (not heavy-ion specific)

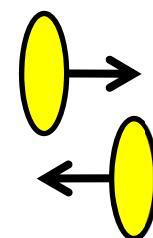
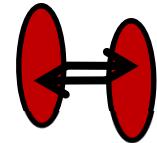


HIN-11-008

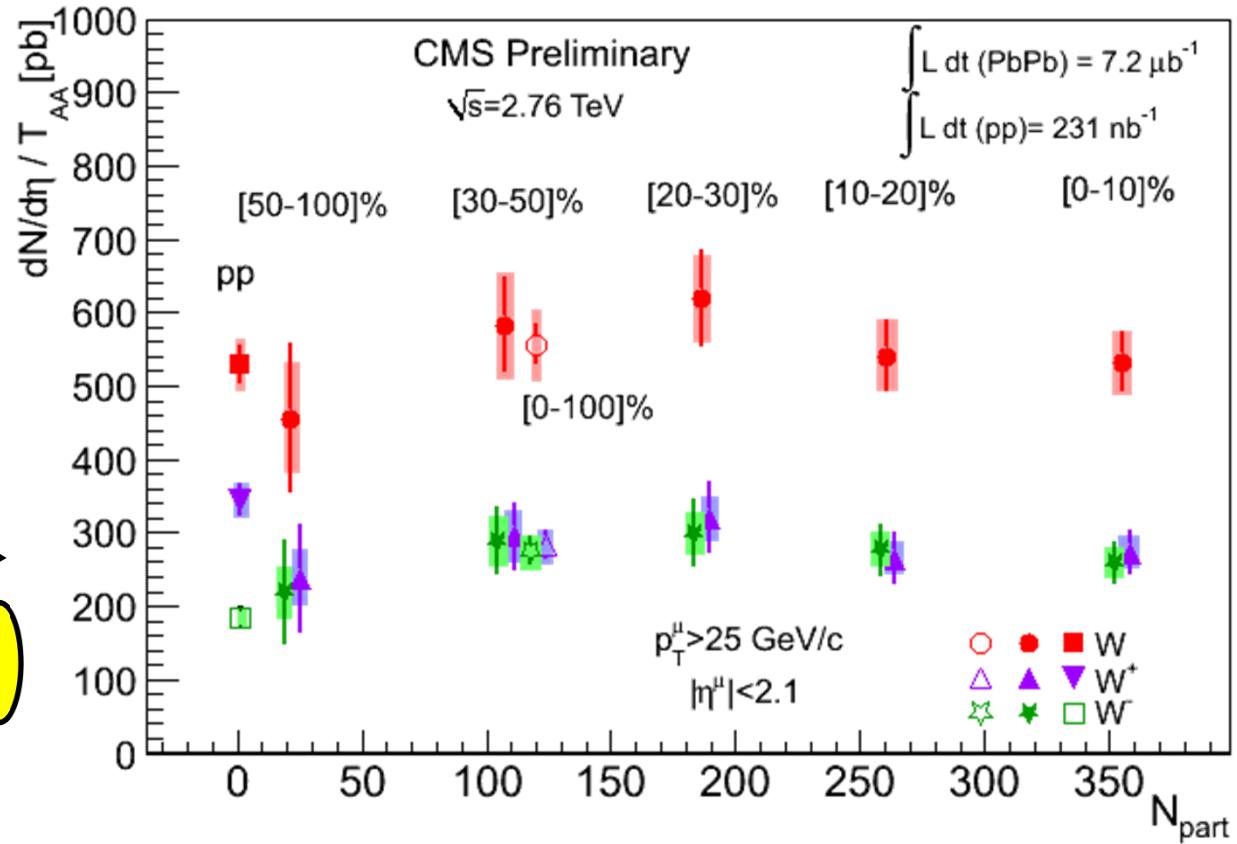


No centrality dependence

- $R_{AA}(W) = 1.04 \pm 0.07 \pm 0.12$
- $R_{AA}(W^+) \approx 0.7$
- $R_{AA}(W^-) \approx 1.3$



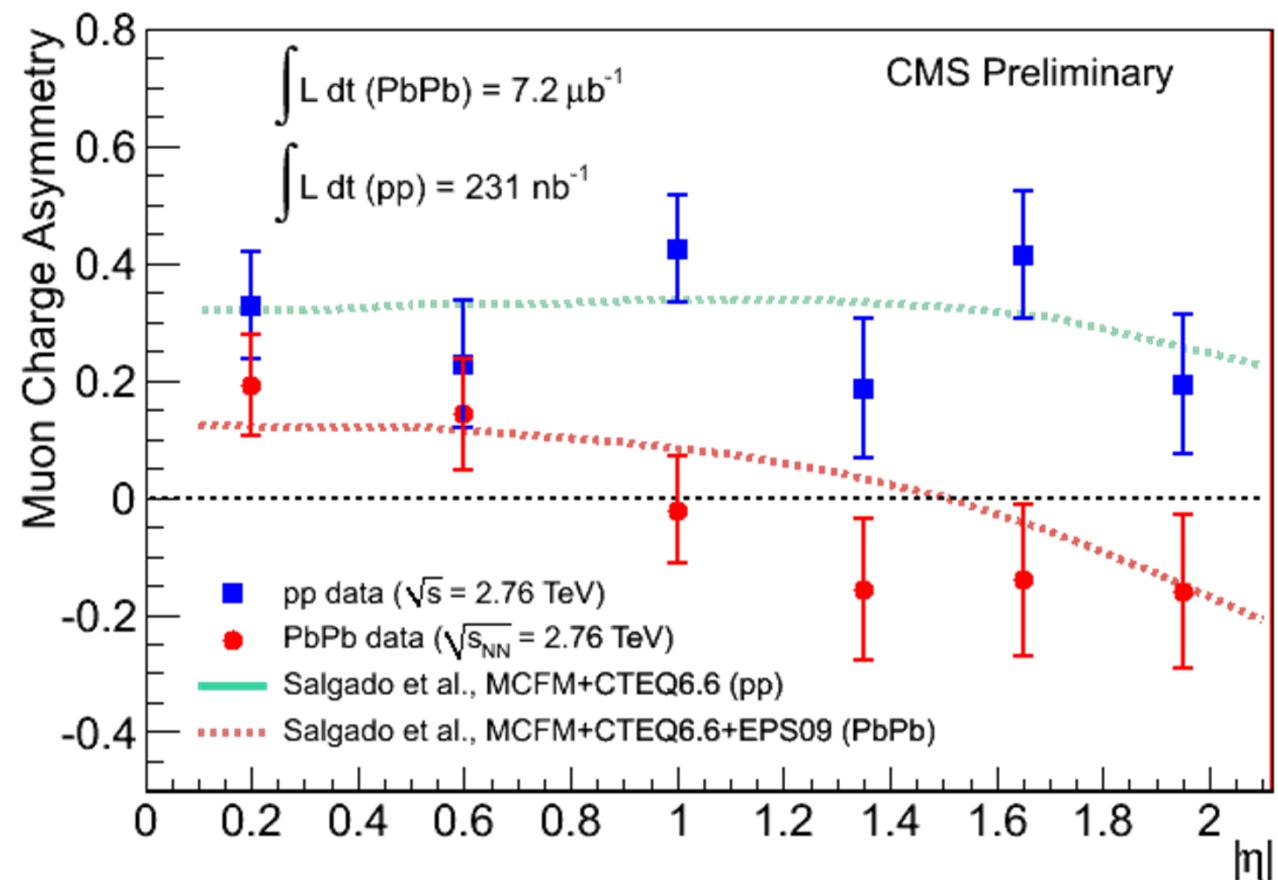
HIN-11-008





Muon charge asymmetry

- $(W^+ - W^-) / (W^+ + W^-)$
- Also matching predictions



HIN-11-008