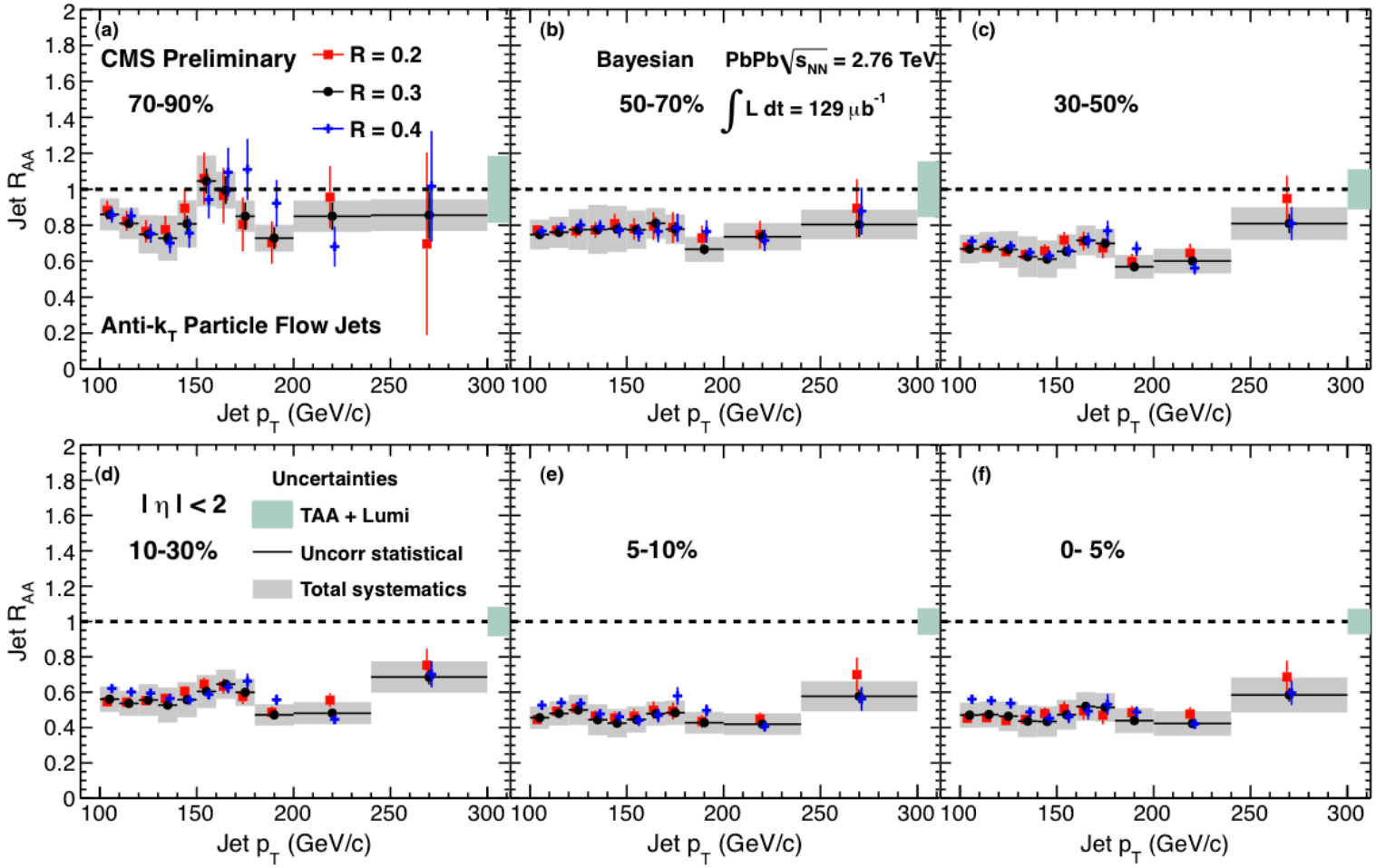
Dijet results from CMS

Yetkin Yilmaz

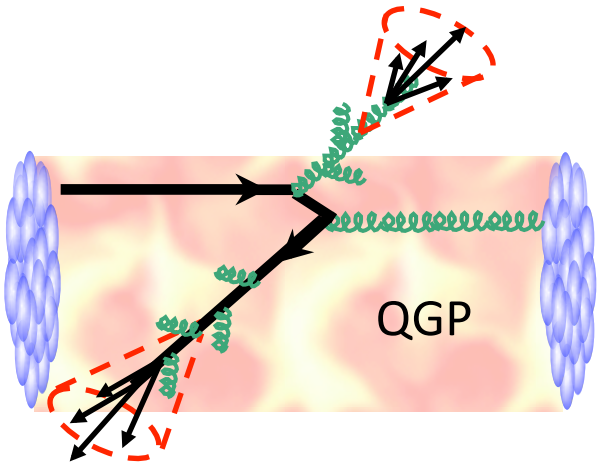
Previously in Sevil's talk: Jet R_{AA}

How much E does a typical jet lose?

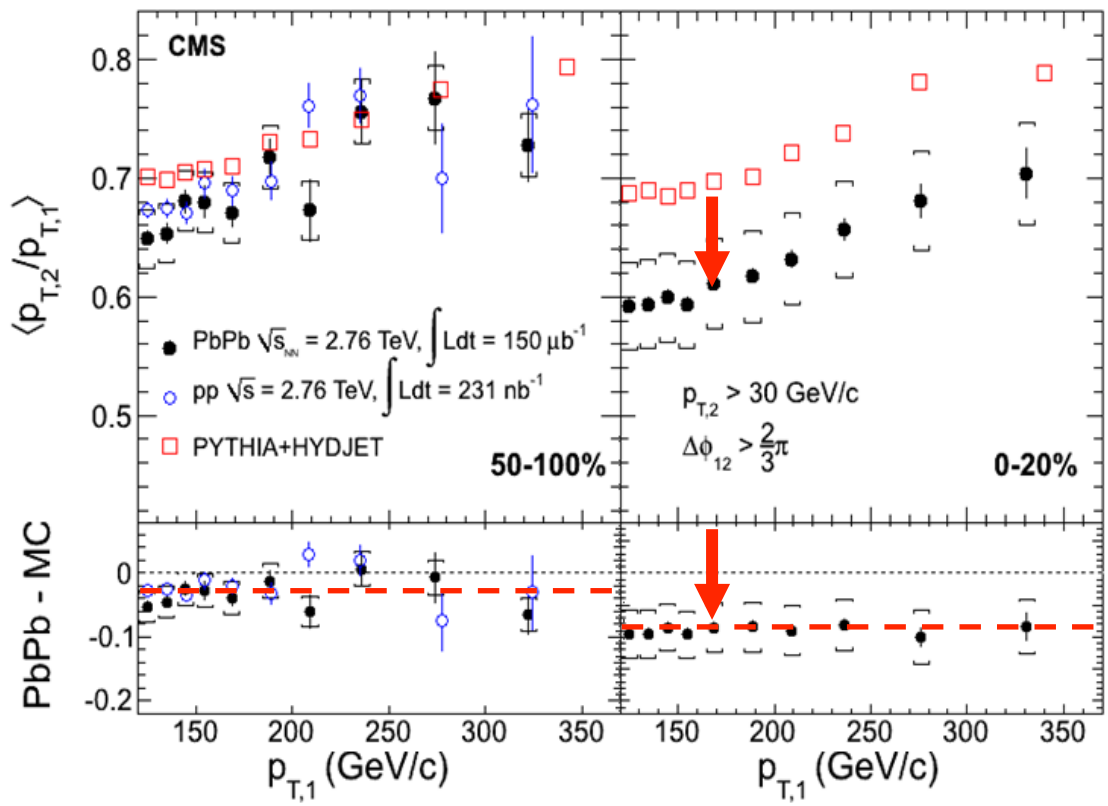


CMS-PAS-HIN-12-004

Dijet imbalance

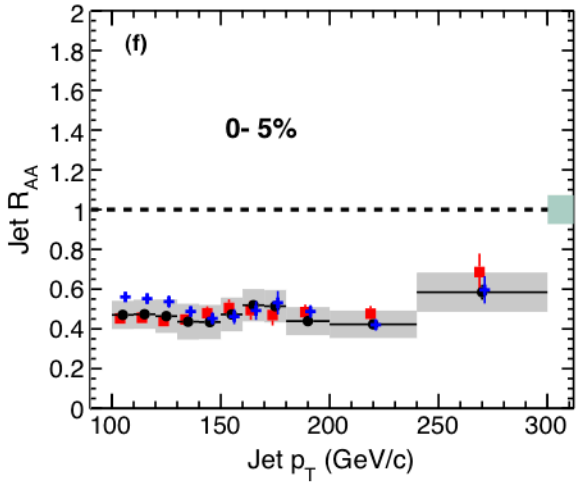


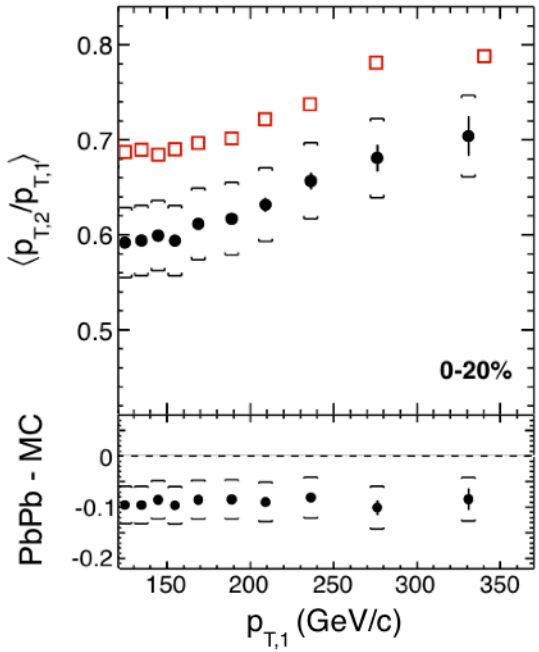
PLB 712 (2012) 176

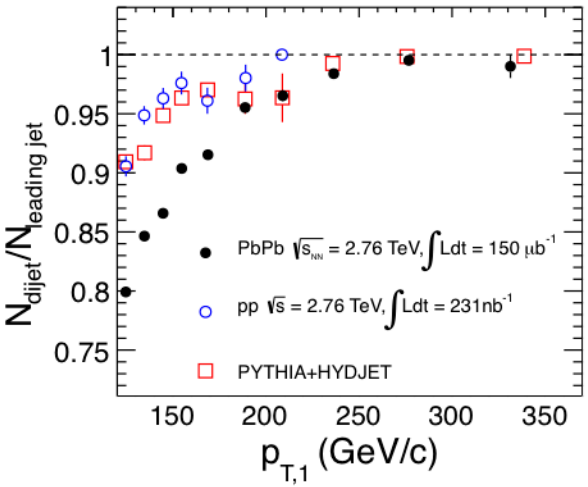


- How much energy lost on average?
- How much does it vary?
- What is the path-length dependence?

Putting results together*





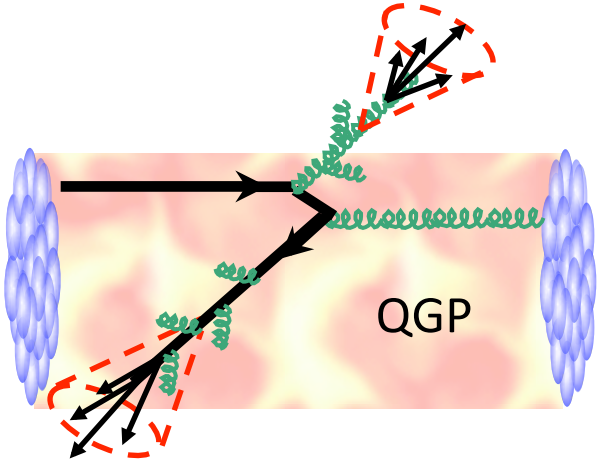


- With information from many dimensions, we can learn about more than a single parameter of the quenching mechanism.
- Only missing ingredient is the factorization of effects from a nuclear initial state.

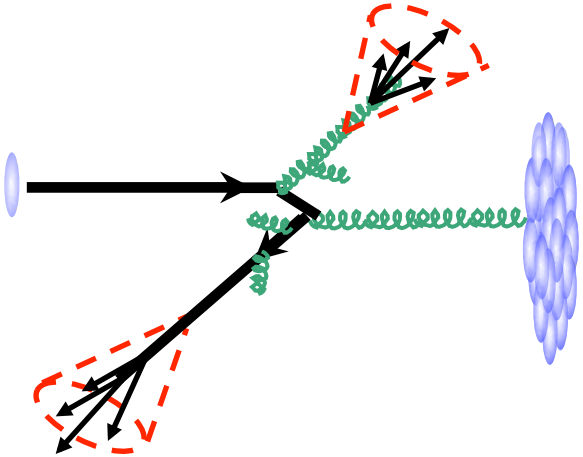
(* keep in mind the detector smearing effects)

Dijets in pPb

PbPb collisions

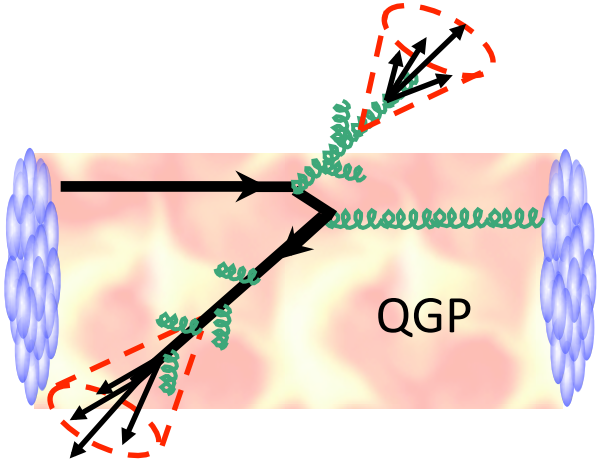


pPb collisions

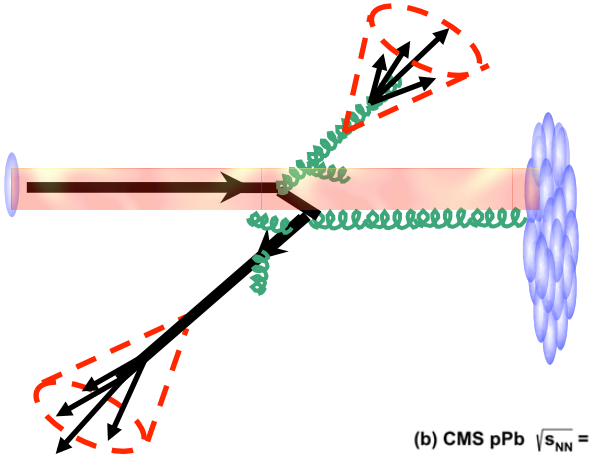


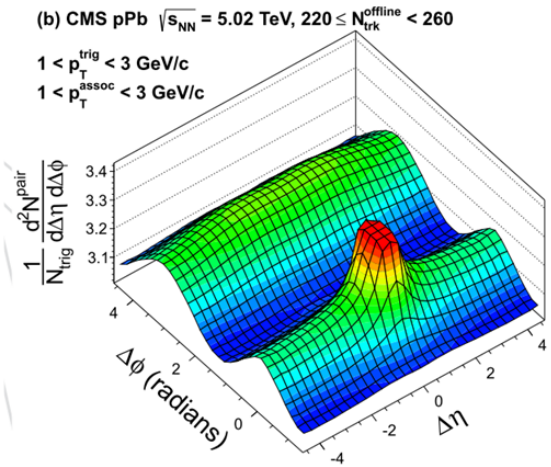
- Baseline for PbPb collisions
  - Cold nuclear effects, nPDFs

PbPb collisions



pPb collisions



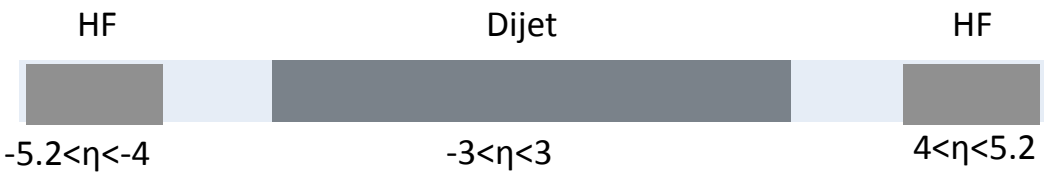


- Baseline for PbPb collisions
  - Cold nuclear effects, nPDFs

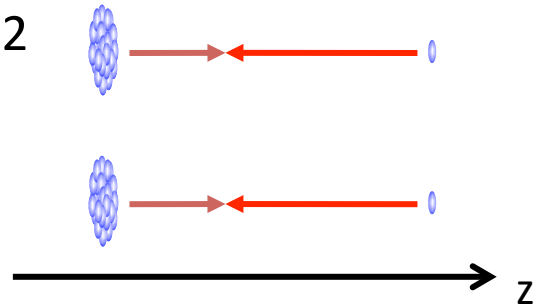
Do we ALSO see an onset of density effects in pPb already?

Event characterization

- ZDC based variables (spectators)
  - Not very well-correlated to the energy density at mid-rapidity
- Mid-rapidity based variables
  - Significant auto-correlation with jet configuration
- Forward calorimeter based variables:
  - Single side?
  - Two sides together?



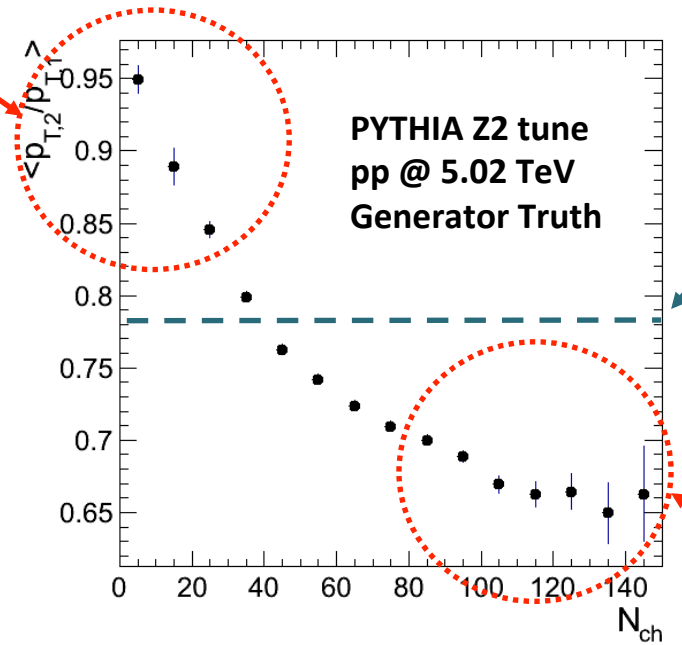
Final choice: E_T measured in $4<|\eta|<5.2$



Tracker based variables

- Introduce bias on number of jets and their fragmentation:

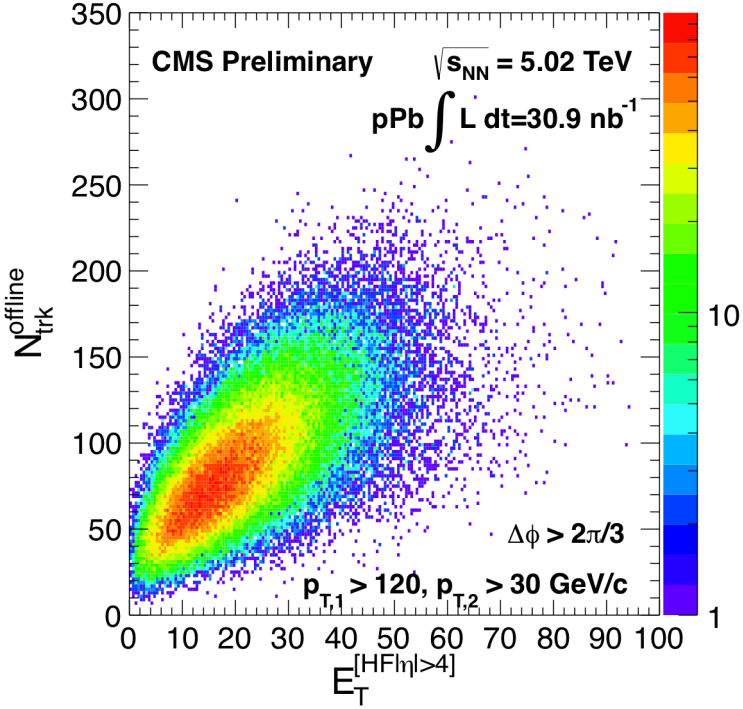
Event less likely to have 3 (or more) jets

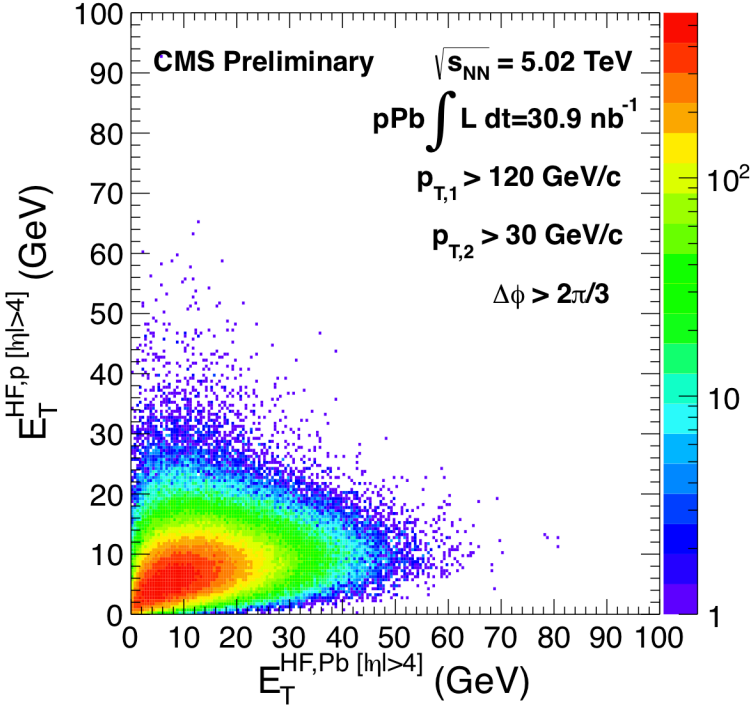


Mean value for all generated dijets

Event more likely to have 3 (or more) jets
Each jet means additional N_{ch} ~ 10.

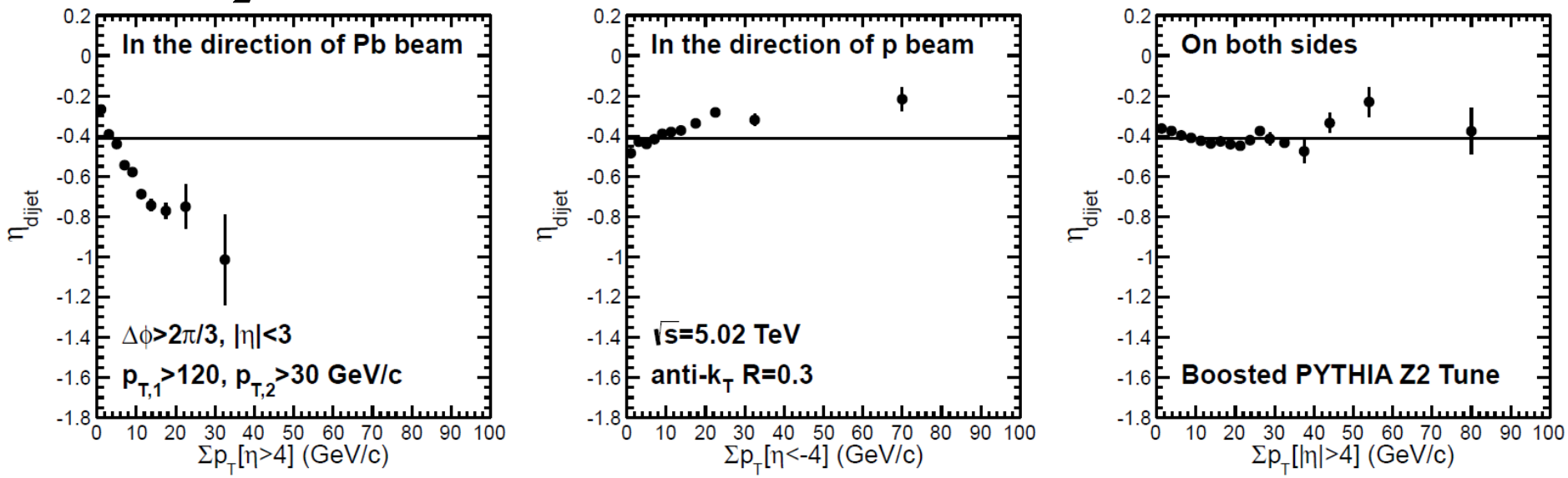
Forward energy based variables

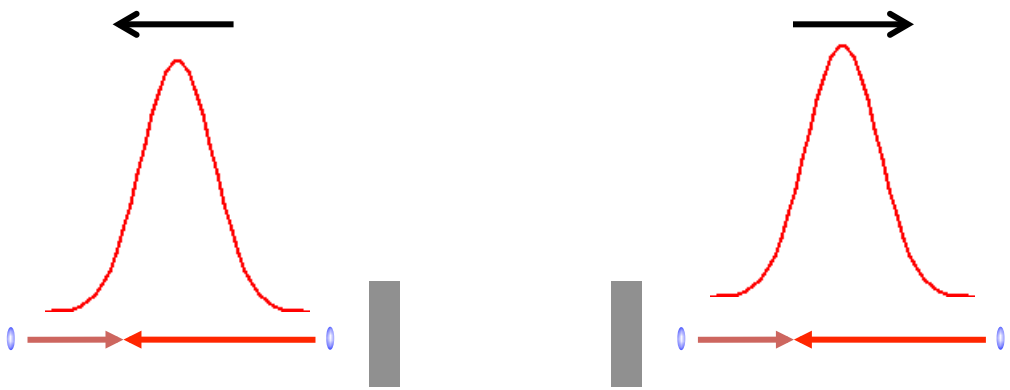




Forward energy based variables

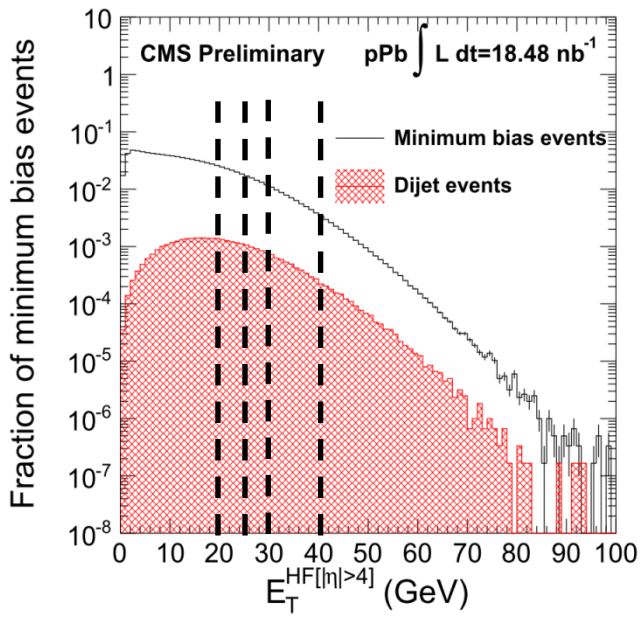
$$\eta_{dijet} = \frac{\eta_1+\eta_2}{2}$$

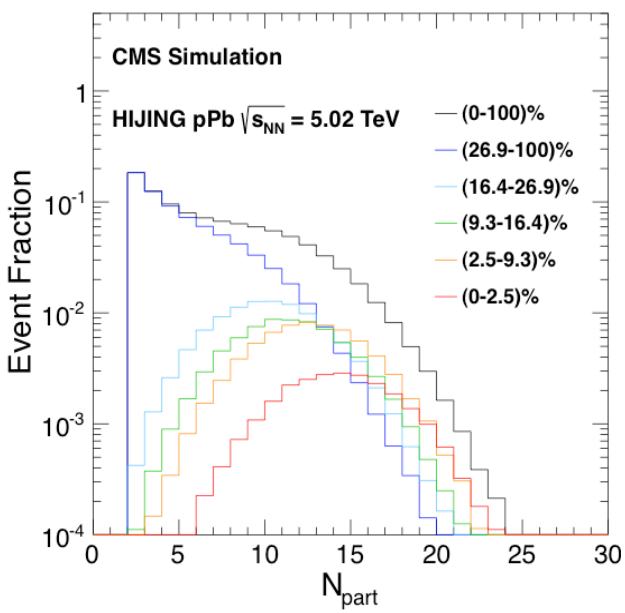




Energy momentum conservation:

When a large deposit on one side is required the dijet pseudorapidity shifts towards the other direction.

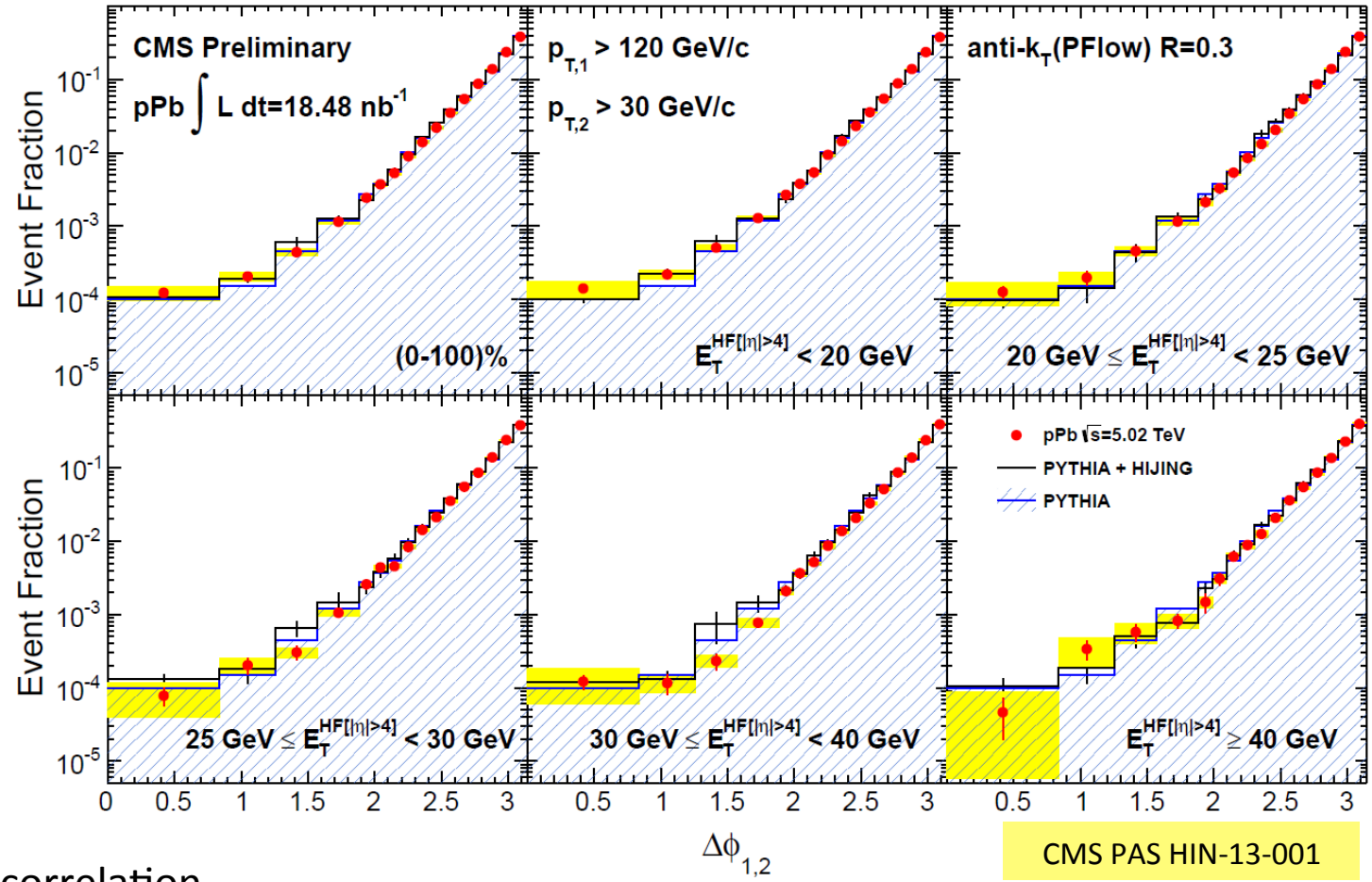




$E_T^{HF[\|\eta\|>4]}$ range (GeV)	Fraction of DS events	Fraction of dijet events	$\langle N_{trk}^{corrected} \rangle$ in DS events
0-20	73.1%	52.6%	33±2
20-25	10.5%	16.8%	74±3
25-30	7.1%	12.7%	88±4
30-40	6.8%	13.0%	106 ±5
40-100	2.5%	4.9%	135 ±6

N_{part} has a weak dependence on forward calorimeter energy in pPb.

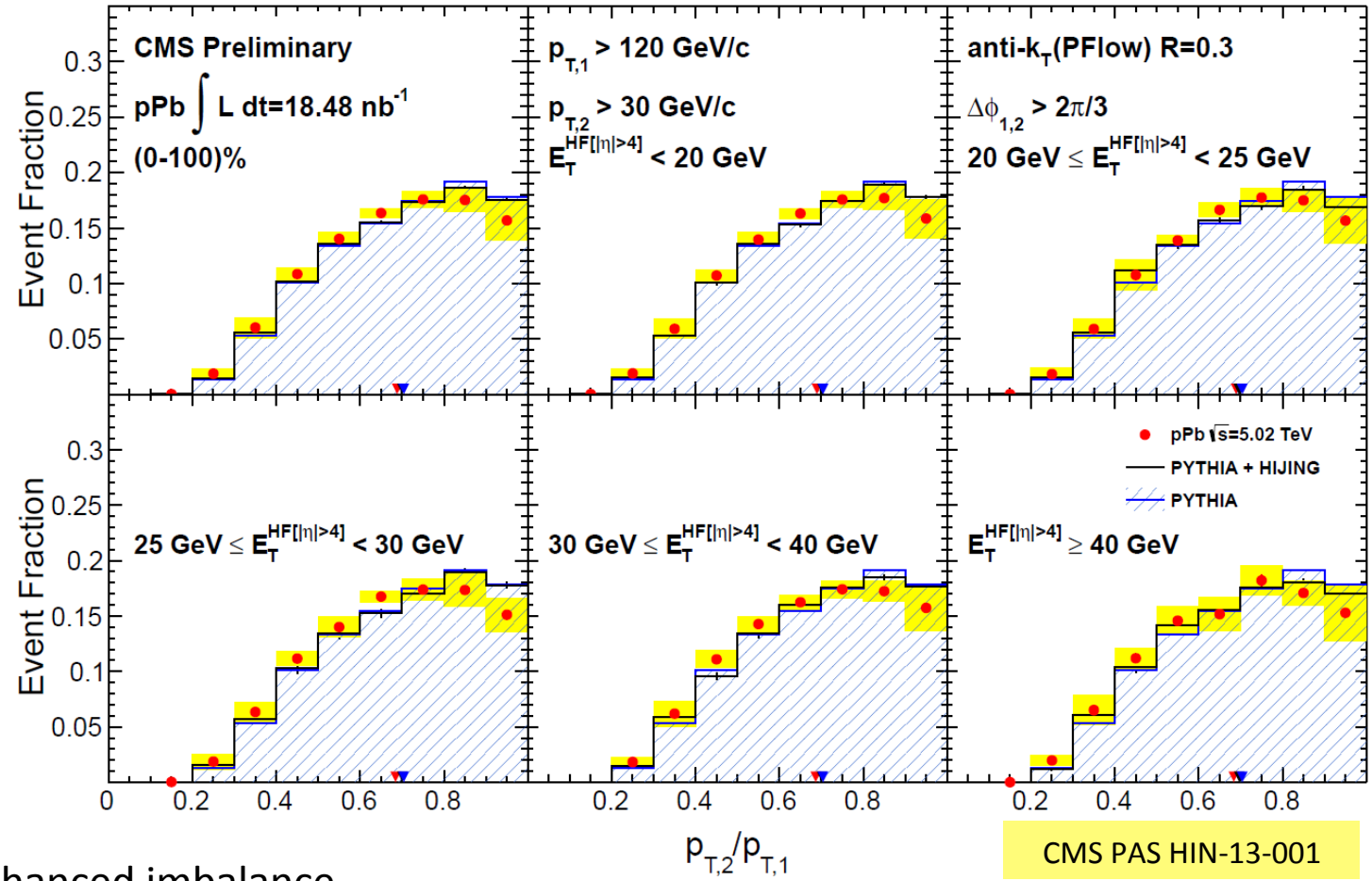
Dijet angular correlations



CMS PAS HIN-13-001

Cannot see a decorrelation.

Dijet momentum balance



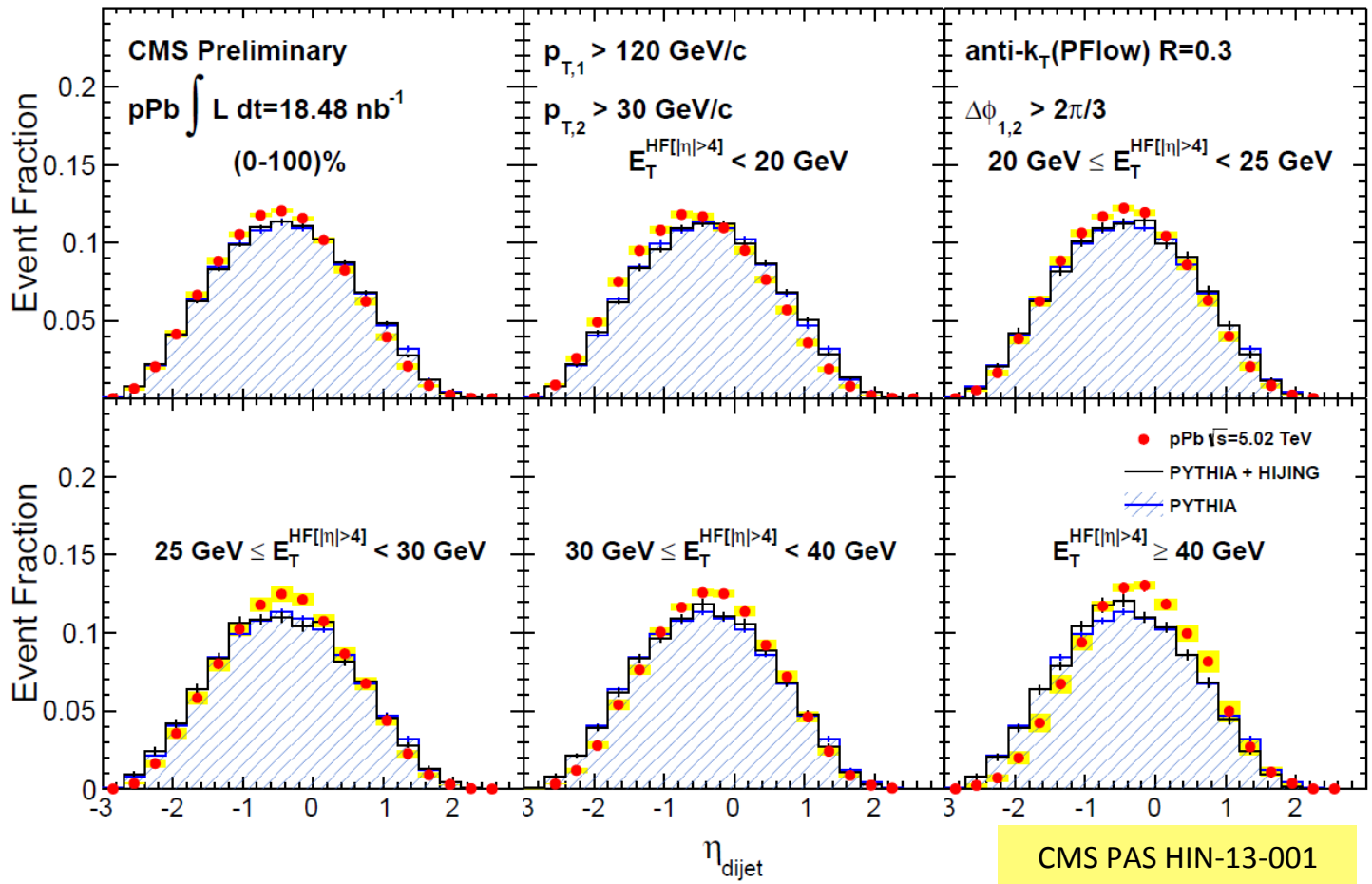
CMS PAS HIN-13-001

Cannot see an enhanced imbalance

Dijet system pseudorapidity

$$\eta_{dijet} = \frac{\eta_1 + \eta_2}{2}$$

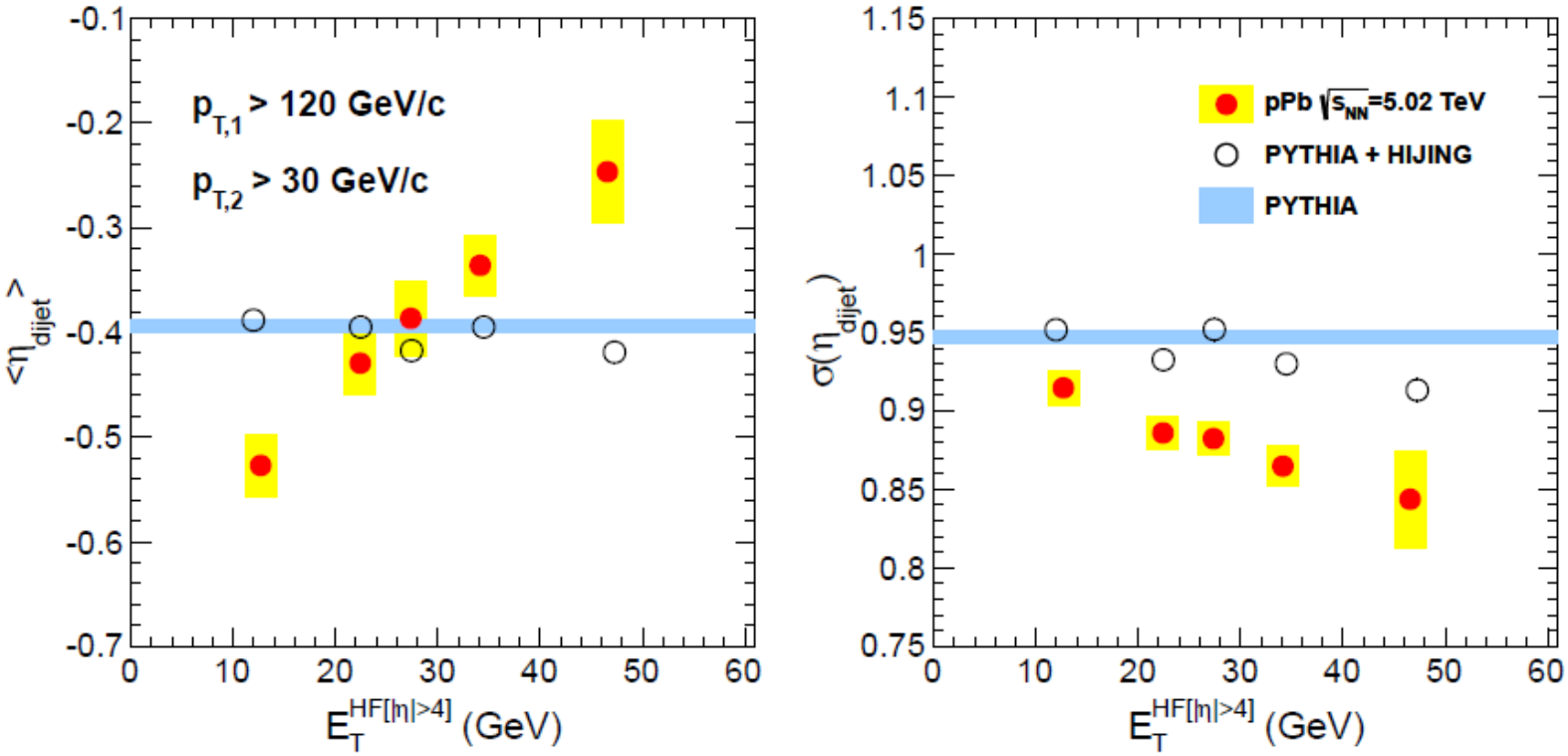
(an approximation to rapidity of the parton system)



CMS PAS HIN-13-001

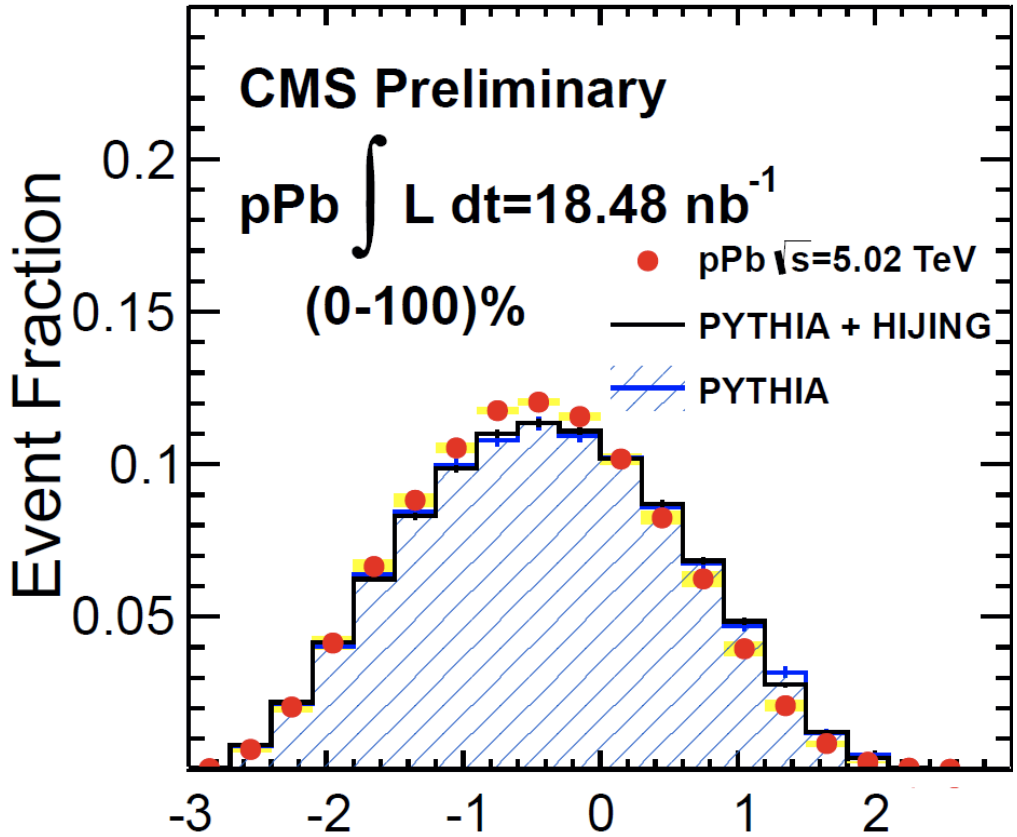
Observation of modification to the pseudorapidity distribution

Summary of dijet eta vs HF



- Mean of η_{dijet} increases v.s. forward calorimeter energy
- Width of η_{dijet} decreases v.s. forward calorimeter energy (also in MC reference)

Dijet eta for 0-100%

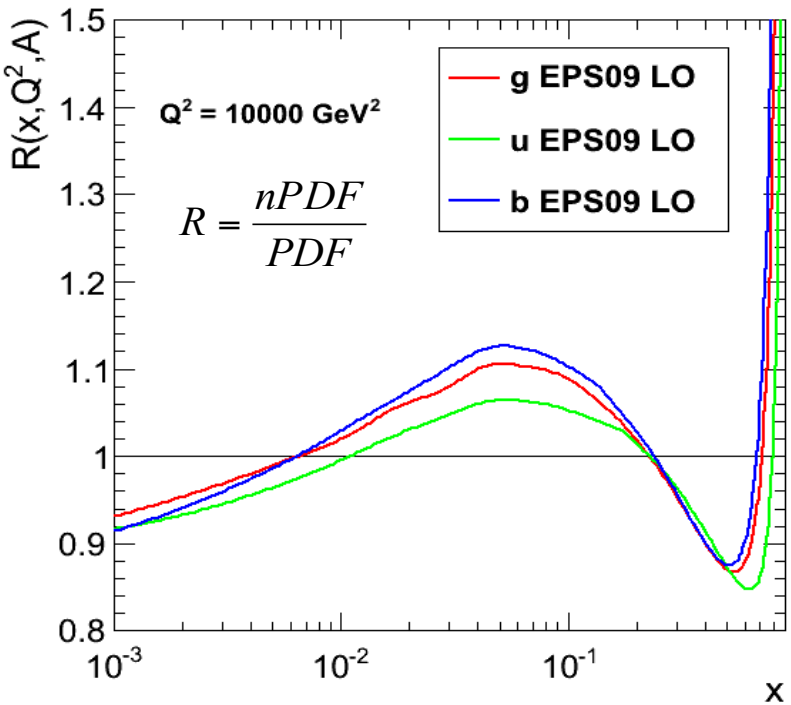


$$\eta_{dijet} = \frac{\eta_1 + \eta_2}{2}$$

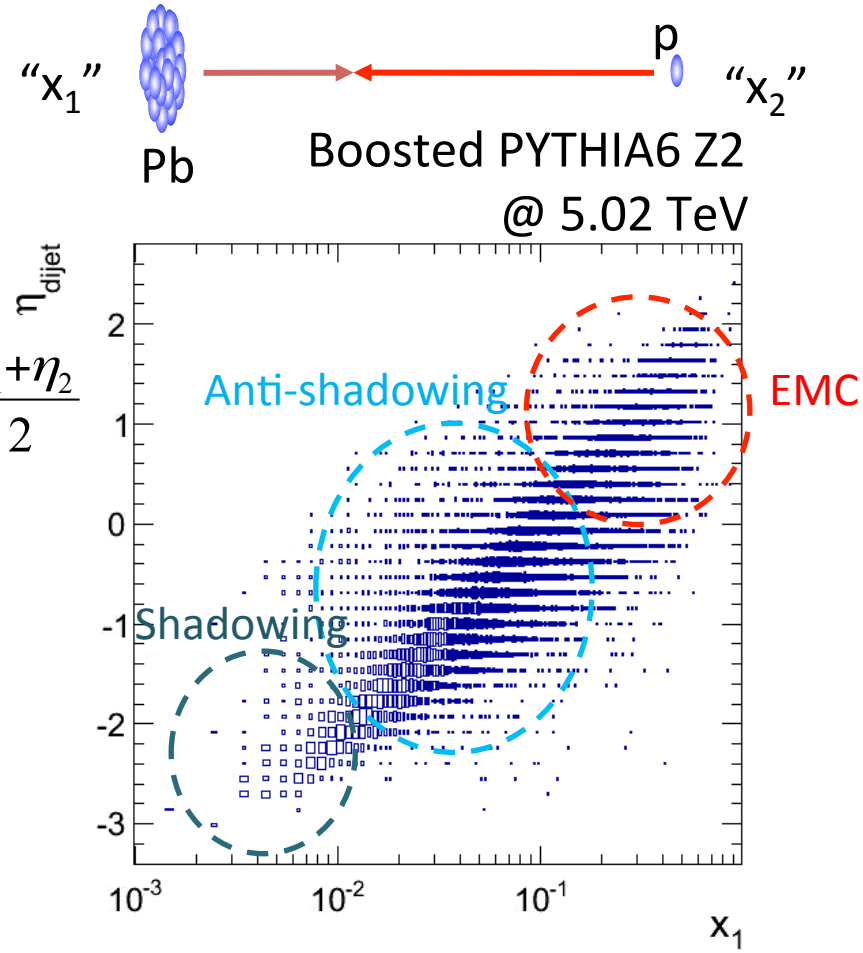
- The modification in eta is significant in 0-100% selection, without any bias.

Dijet η ←→ x

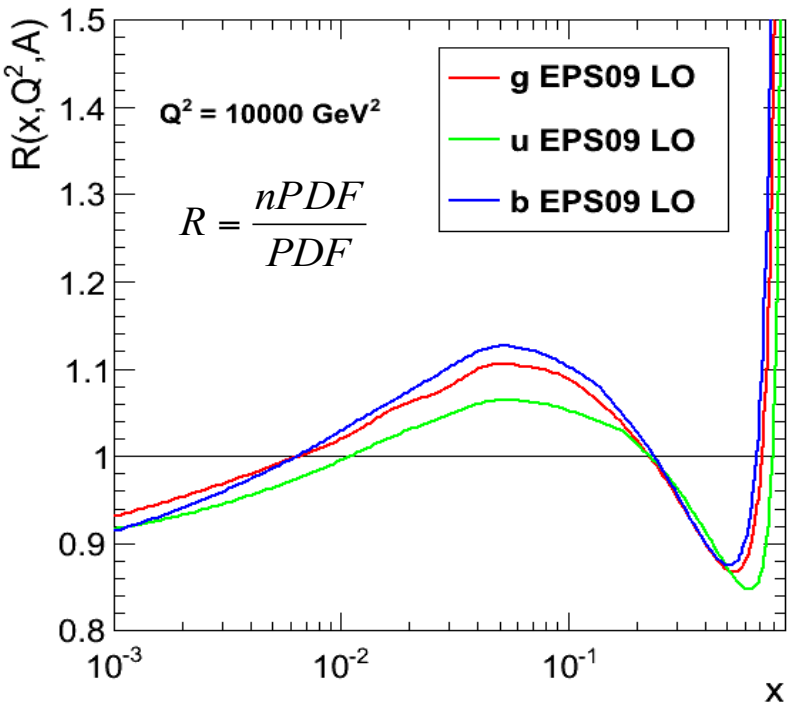
François Arleo and Jean-Philippe Guillet
http://lapth.cnrs.fr/npdfgenerator/



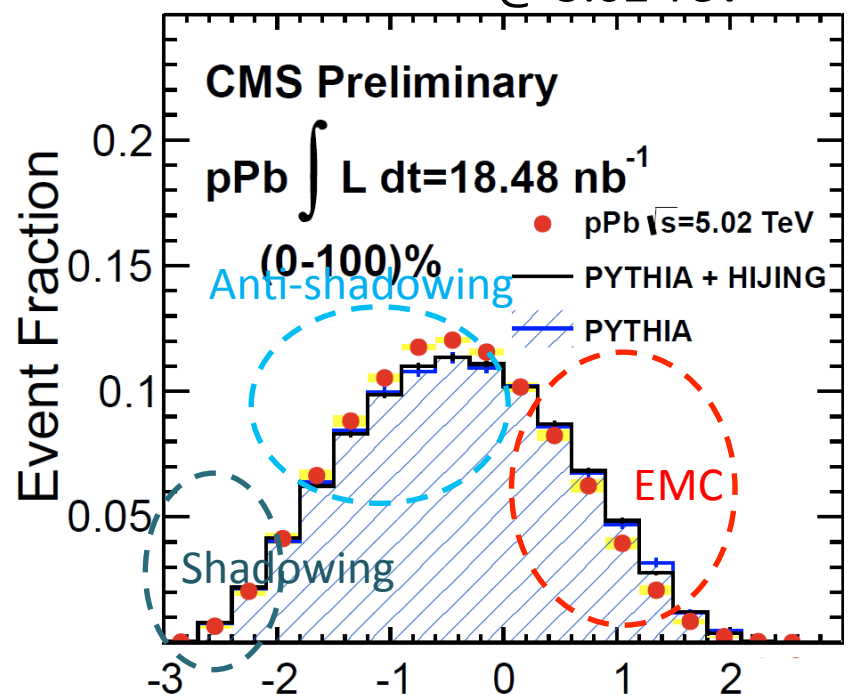
$$\eta_{dijet} = \frac{\eta_1 + \eta_2}{2}$$



Expected nPDF effects



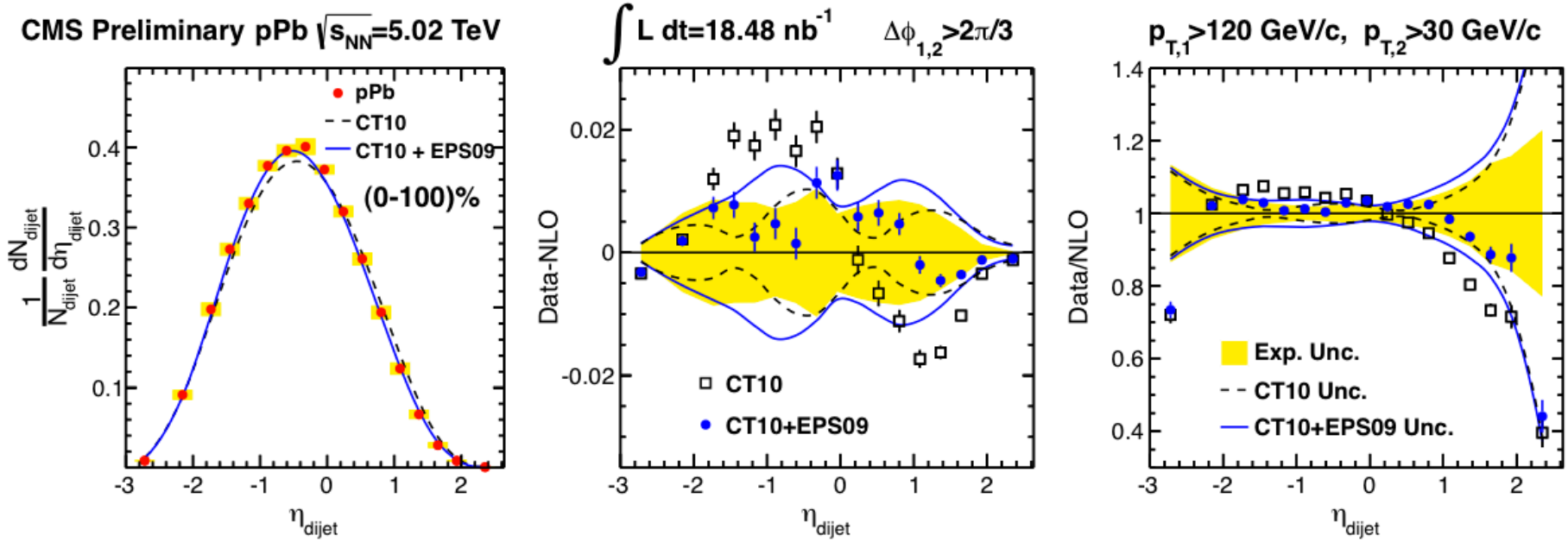
Boosted PYTHIA6 Z2 @ 5.02 TeV



- Observe similar enhancement/suppression in dijet η as predicted for parton x by EPS09 collaboration.

$$\eta_{dijet} = \frac{\eta_1 + \eta_2}{2}$$

Comparison to NLO calculations

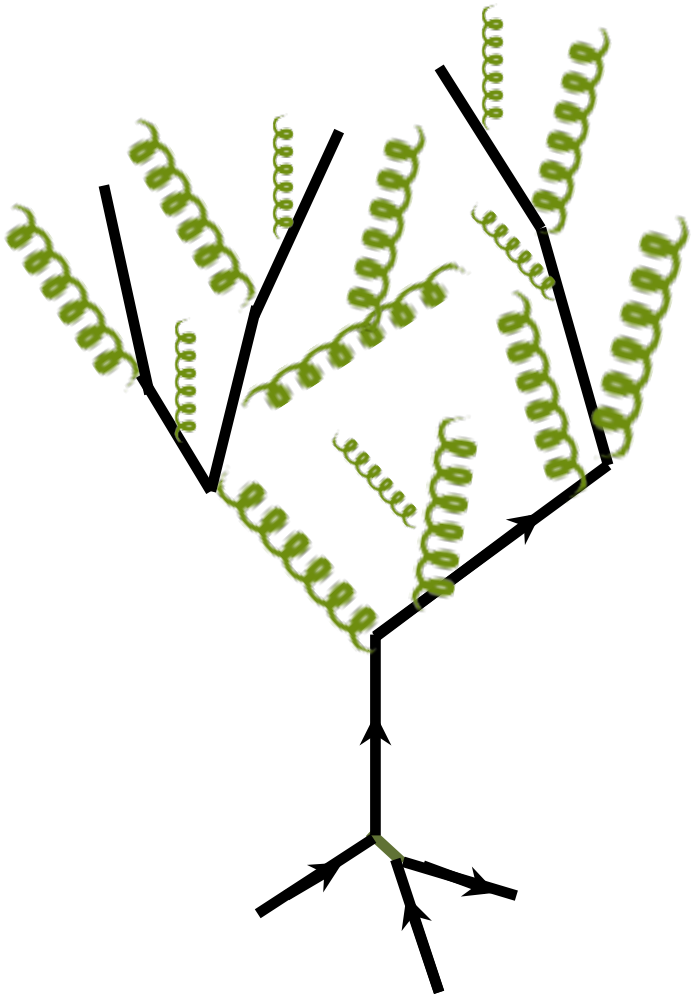


- Results are compatible with EPS09 prediction
- Not compatible without EPS09

Conclusions

- pPb data is rich in physics
- The classification of dijet events in terms of their bulk properties is a challenging task
- No quenching effects observed
- Possibly initial-state effects observed in dijet kinematics
- The dijet rate in the negative eta is slightly enhanced
  - Similar to anti-shadowing expectation

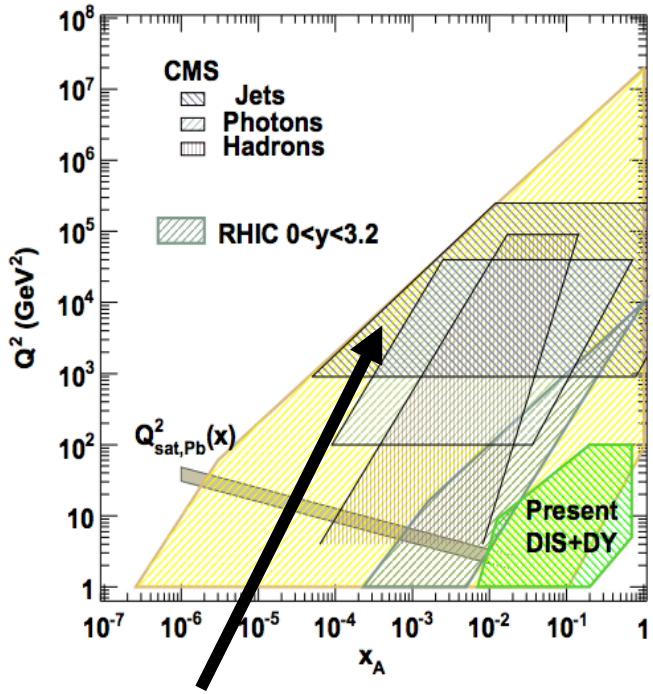
Thanks

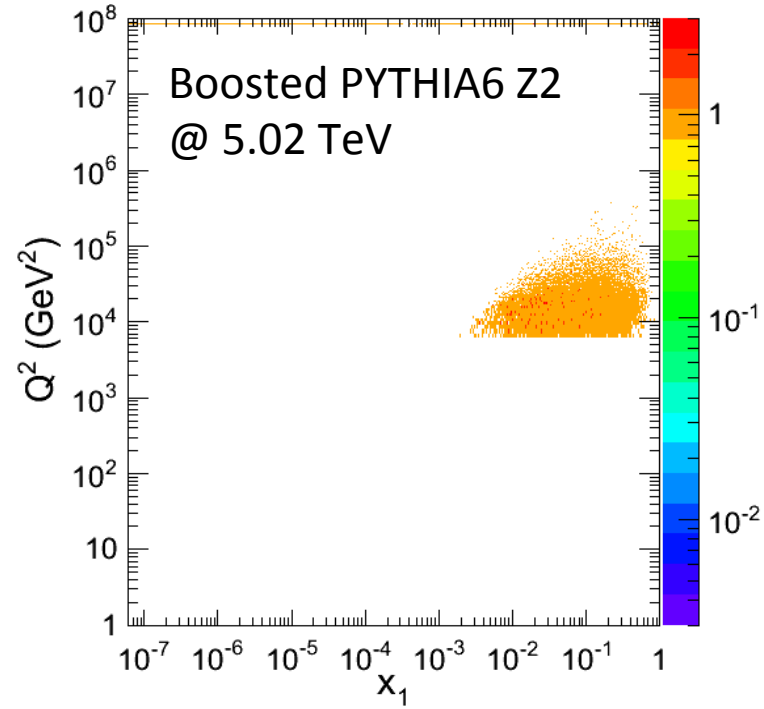


Back-up slides

Probing PDFs

Kinematic reach for CMS, pPb @ $\sqrt{s}$ = 8.8 TeV (0.1 pb^{-1})





Jets cover high Q^2 and $10^{-4}<x<1$.

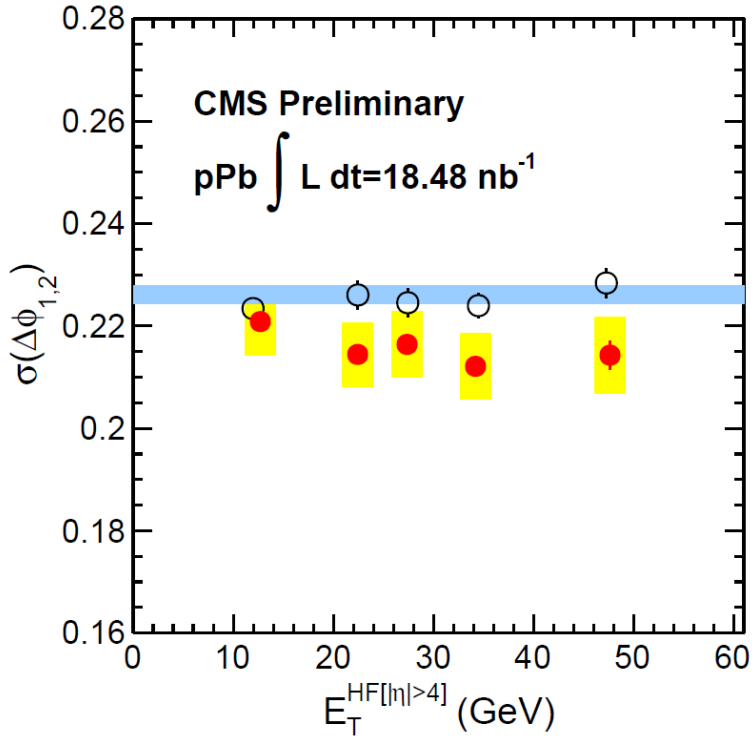
With the dijet selection of the analysis:

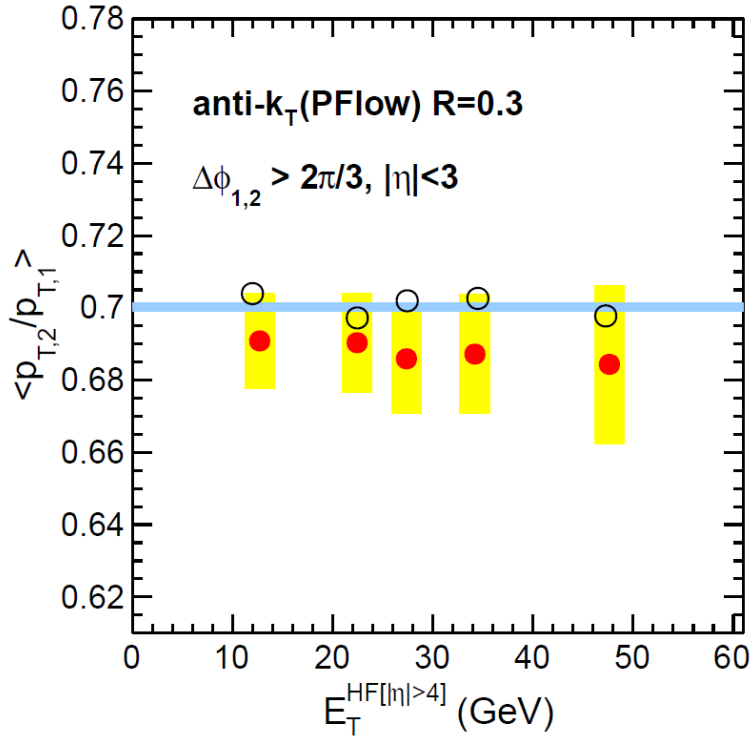
$p_{T,1} > 120$ GeV/c, $p_{T,2} > 30$ GeV/c, $\Delta\phi_{12} > 2\pi/3$

C.A. Salgado, et. al. J.Phys. G39 (2012) 015010

Summary of p_T ratios and $\Delta\phi$

CMS PAS HIN-13-001

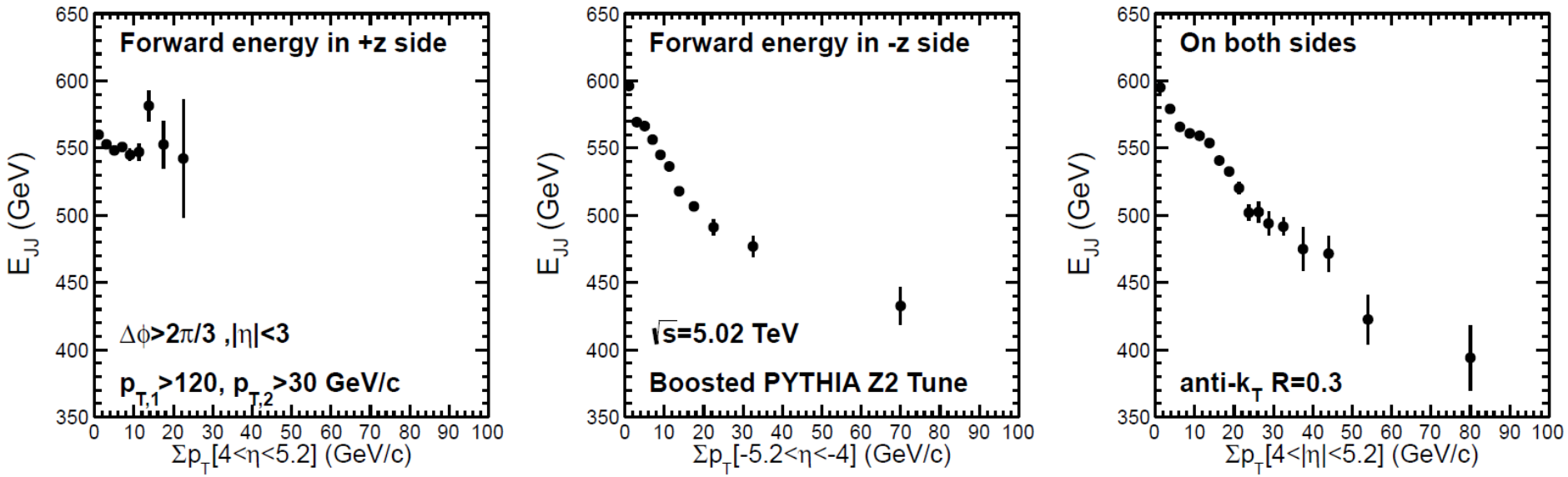




- With the current systematic uncertainty, no detectable change in $\langle p_{T,2}/p_{T,1}\rangle$ and $\Delta\phi$ width larger than 2% as a function of forward calorimeter energy,
- **These results allow us to use jets for nPDF determination.**

Bias due EM conservation?

Why does the dijet pseudorapidity get narrower by increasing forward energy?



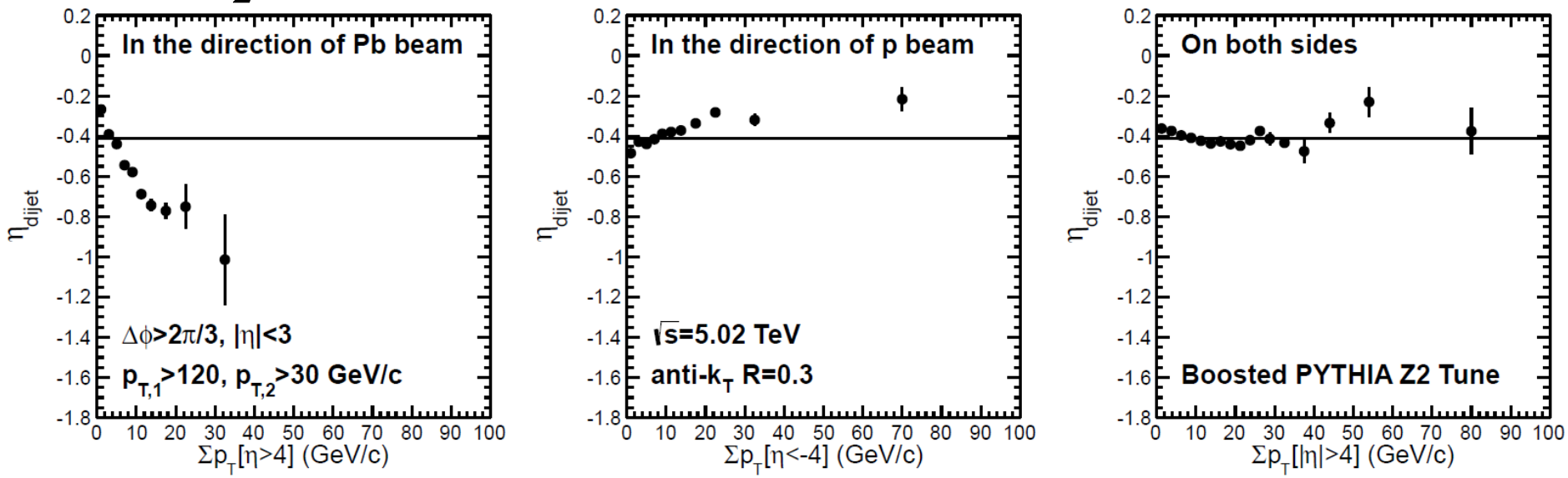
$$E_{JJ} = p_{T,1} \cosh(\eta_2) + p_{T,1} \cosh(\eta_2)$$

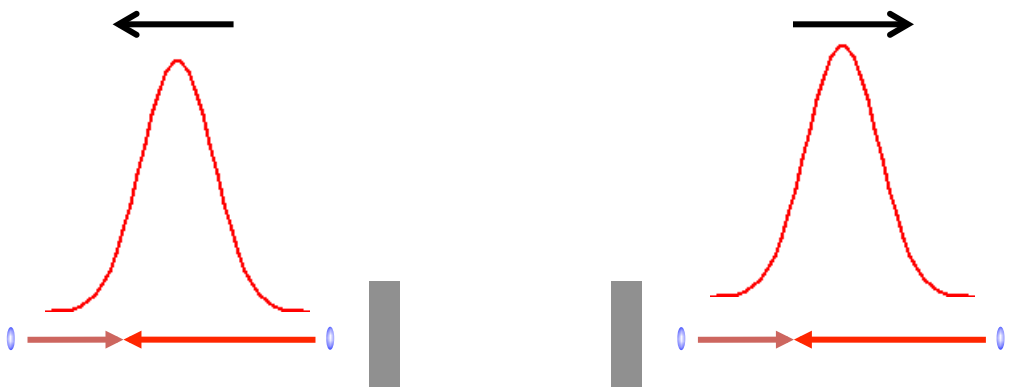
As forward energy in the event increases the energy that is left to dijet pair decreases.

This trend is smaller if you look at +z side. Why ?

Forward energy deposit

$$\eta_{dijet} = \frac{\eta_1+\eta_2}{2}$$



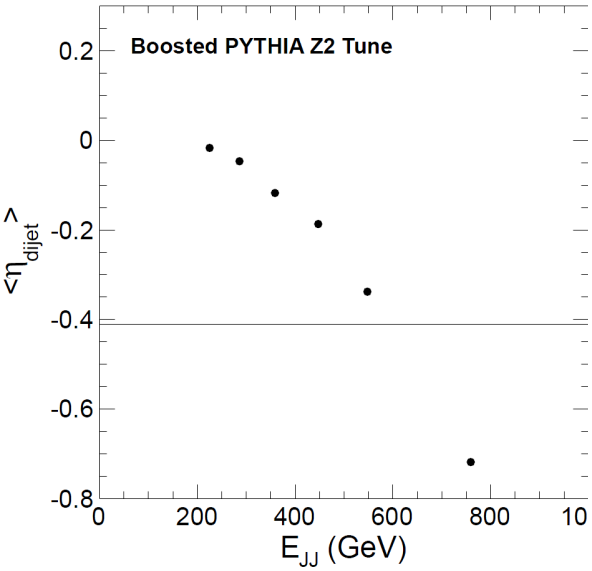


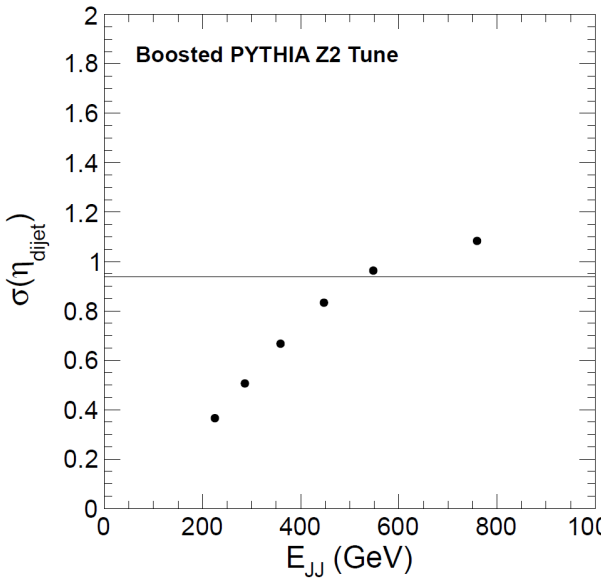
Energy momentum conservation:

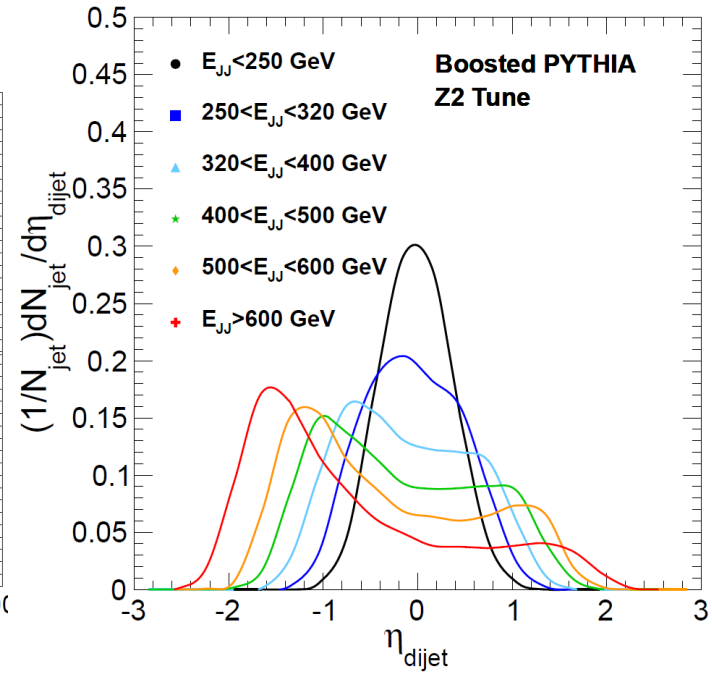
When a large deposit on one side is required the dijet pseudorapidity shifts towards the other direction.

Bias due EM conservation?

Does this also result in a shift?

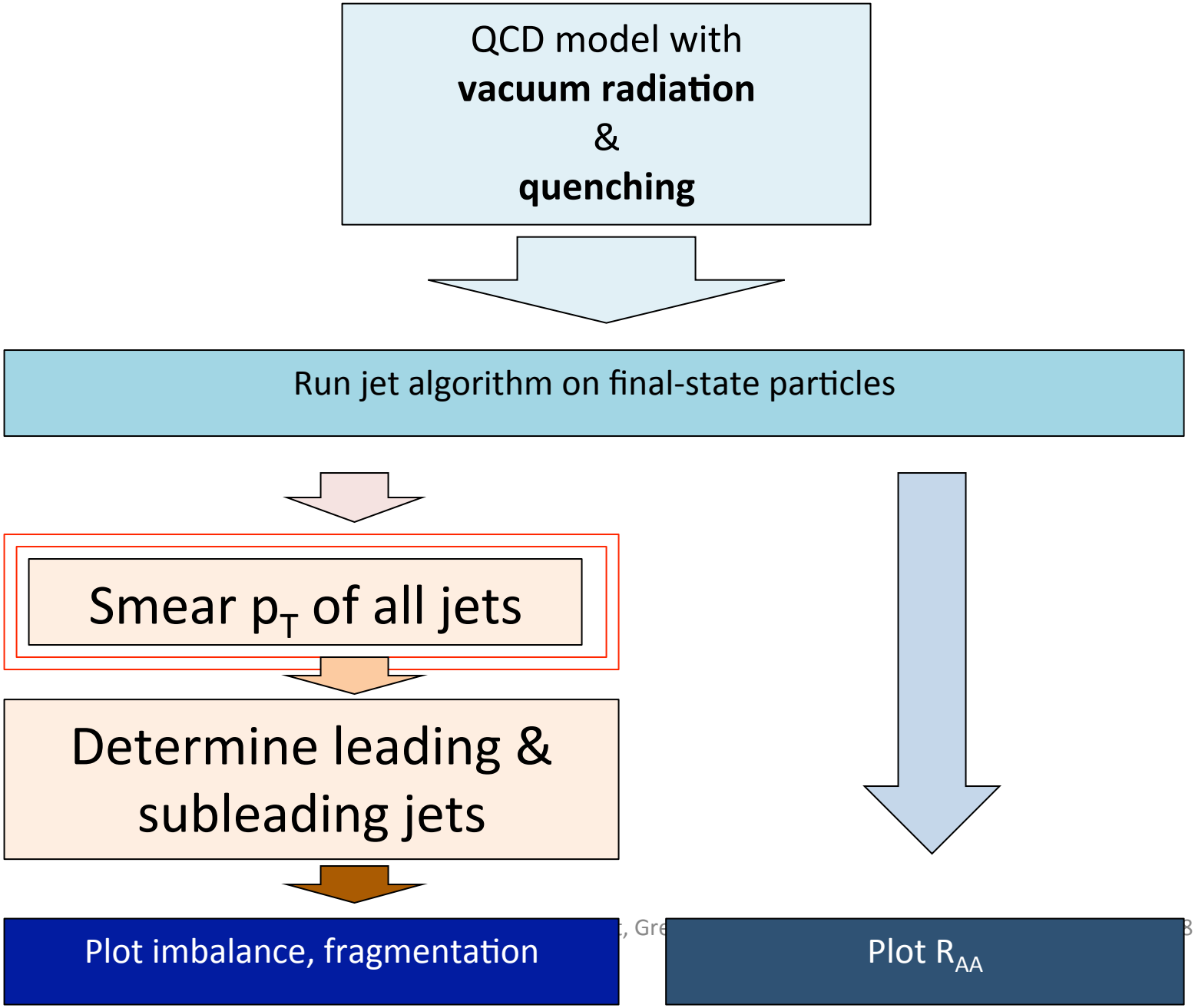






$$E_{JJ} = p_{T,1}\cosh(\eta_2) + p_{T,1}\cosh(\eta_2)$$

Could be the case? How much of an effect?


QCD model with
vacuum radiation
&
quenching
Run jet algorithm on final-state particles
Smear p_T of all jets
Determine leading & subleading jets
Plot imbalance, fragmentation
Plot R_{AA}

Resolution effects

The model calculation has to take
into account the resolution effects
by smearing all jets,
BEFORE selecting leading and subleading jets.

$$\sigma\left(\frac{p_{\mathrm{T}}^{\mathrm{Reco}}}{p_{\mathrm{T}}^{\mathrm{Gen}}}\right) = C \oplus \frac{S}{\sqrt{p_{\mathrm{T}}^{\mathrm{Gen}}}} \oplus \frac{N}{p_{\mathrm{T}}^{\mathrm{Gen}}},$$

C	S	N (pp)	N (50–100%)	N (30–50%)	N (10–30%)	N (0–10%)
0.0246	1.213	0.001	0.001	3.88	5.10	5.23

photon-tagged jets, Phys. Lett. B 718 (2013) 773