Centrality dependence of highly energetic jets in p+Pb collisions at the LHC

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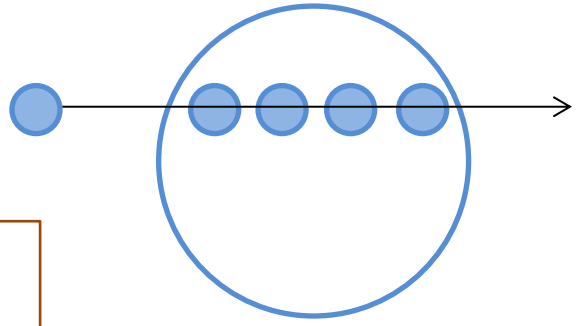
based on:
AB, V. Skokov, S. Bathe, arXiv:1408.3156

R_{pA}
ATLAS data
Explanation
Experimental test
Conclusions

p+A collisions

Number of collisions scaling:

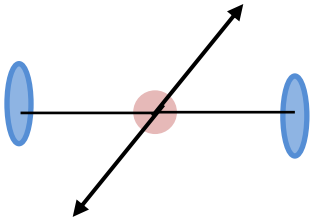


$$\langle N_{pA}(p_t)\rangle = \frac{\langle N_{pp}(p_t)\rangle}{1} N_{coll}$$

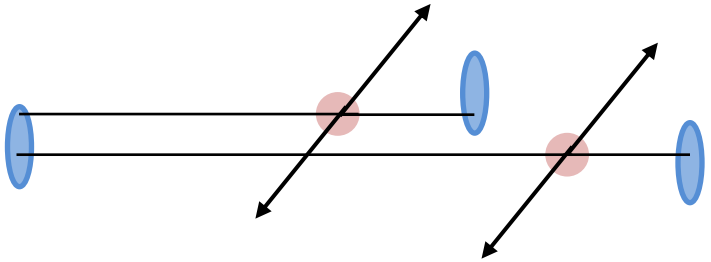
$N_{coll} = 4$

$N_{part} = 4 + 1$

Easy to understand in pQCD

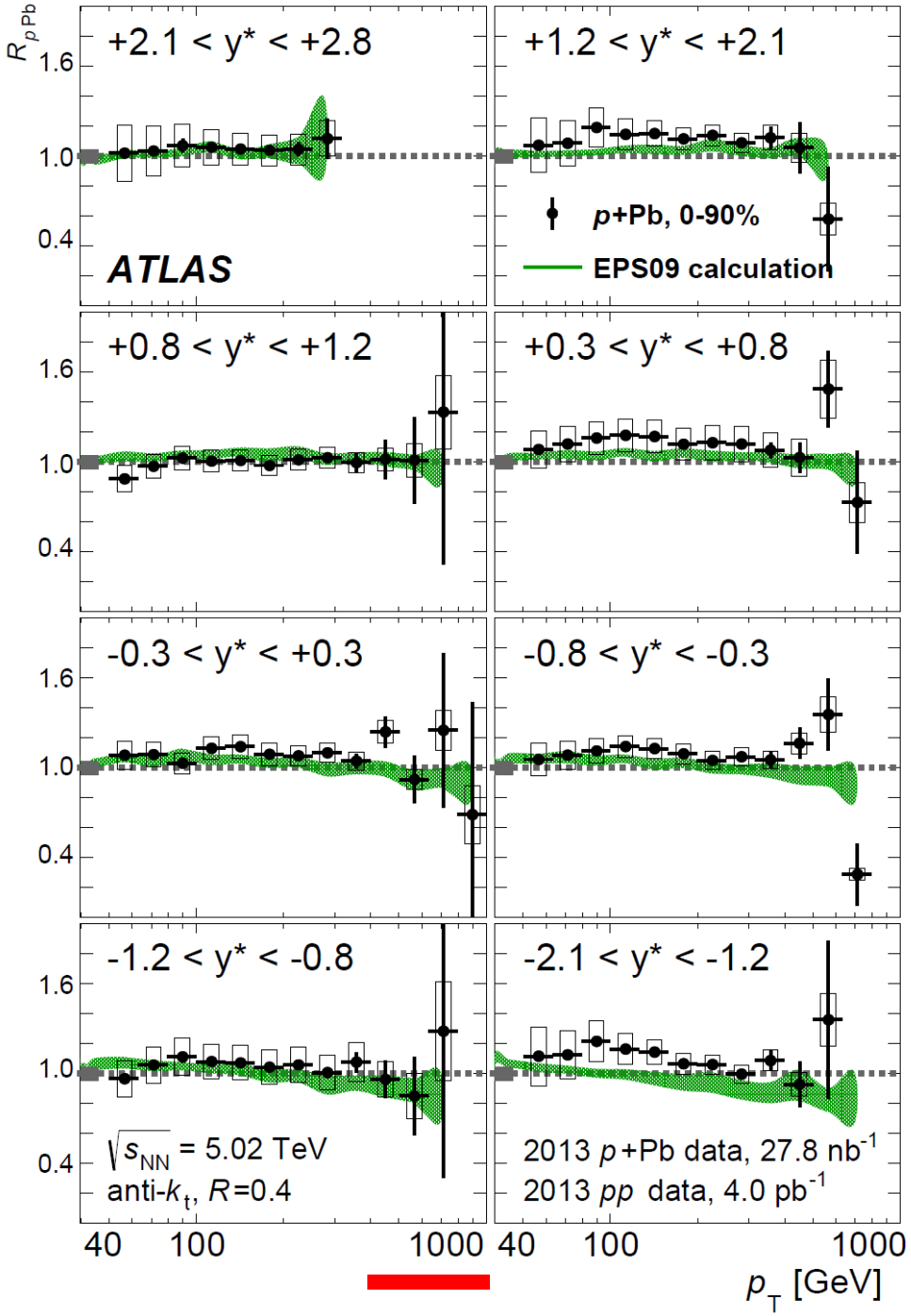


pp



$pA, N_{coll} = 2$

It should work for high p_t particles (but not for low p_t)



$$R_{pA} = \frac{1}{\langle N_{\rm coll} \rangle} \frac{dN^{pA}_{\rm jet}/dp_\perp dy}{dN^{pp}_{\rm jet}/dp_\perp dy}$$

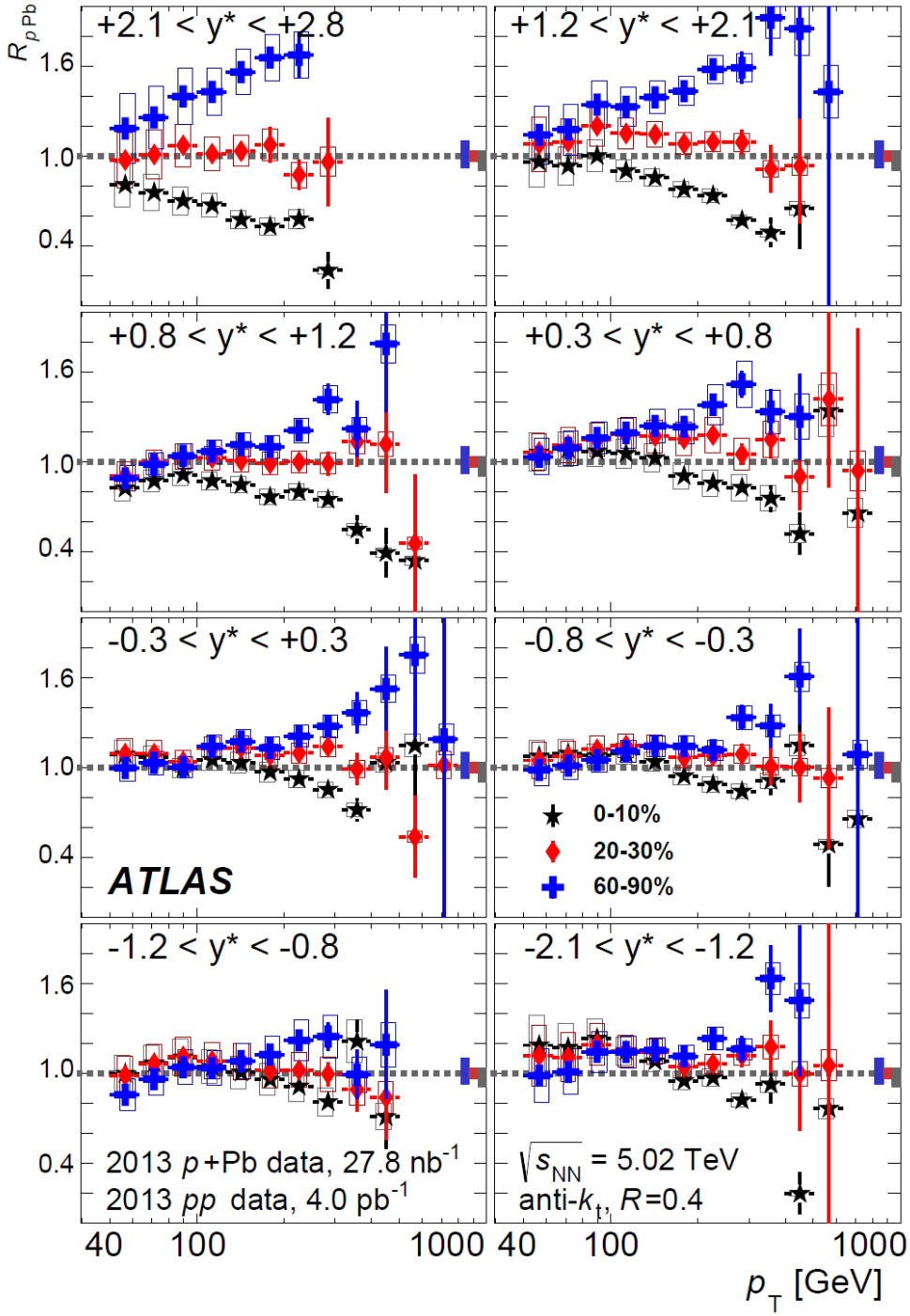
Results for $0 - 90\%$ centrality class – almost min. bias.

$$R_{pA}(\text{mbias}) \cong 1$$

No surprises!

But what about different centrality classes?

ATLAS, arXiv:1412.4092



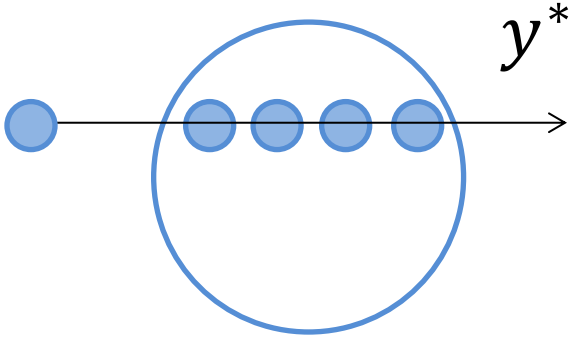
Surprise:

$$R_{pA}(\text{central}) < 1$$

$$R_{pA}(\text{peripheral}) > 1$$

Closer look:

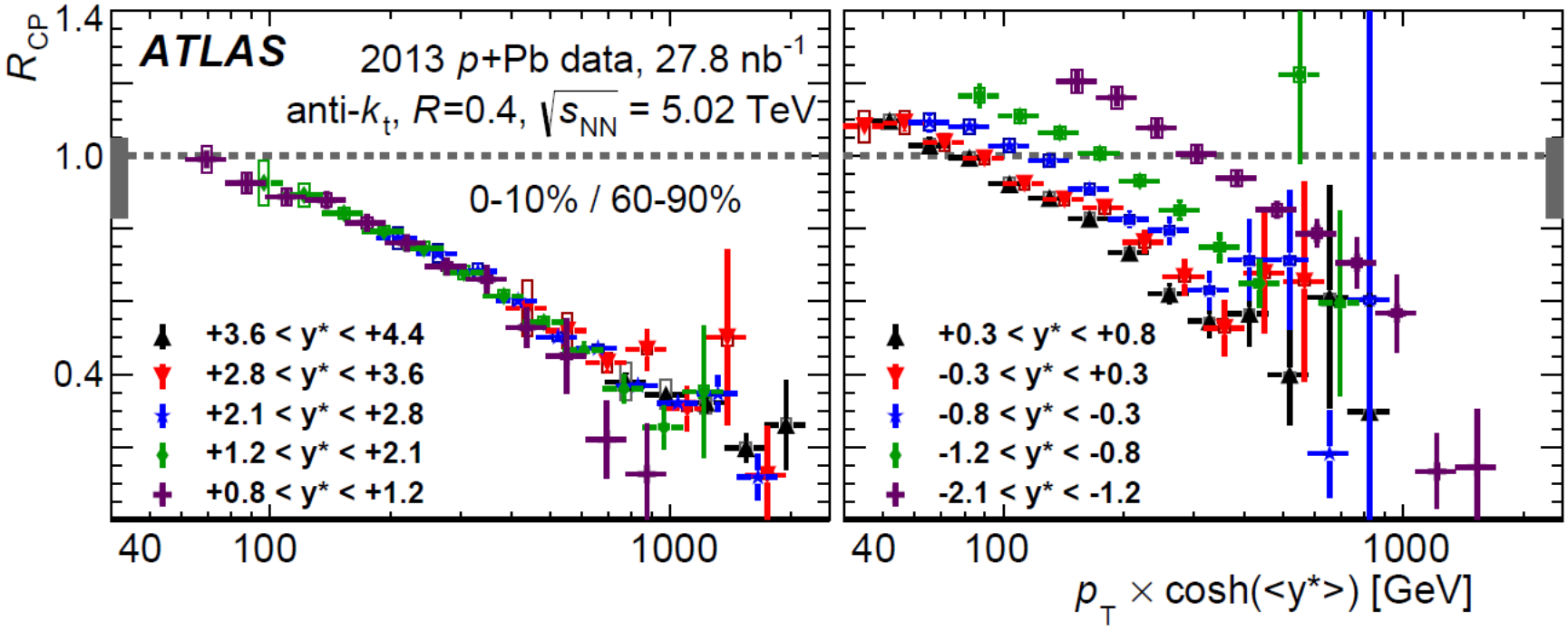
- strong at forward y^*
- weak (absent) at backward y^*



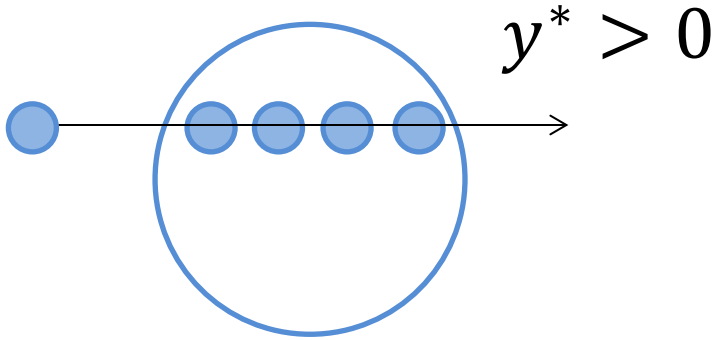
ATLAS, arXiv:1412.4092

Scaling with jet energy

ATLAS, arXiv:1412.4092



$$R_{cp} = \frac{R_{pA}|_{\text{cent.}}}{R_{pA}|_{\text{periph.}}}$$



Scaling for $y^* > 0$

AB, V. Skokov, S. Bathe, arXiv:1408.3156

Conjecture

Jets of very high energy are characterized by a suppressed number of soft particles

To see how it works let's consider an extreme case:

- suppose that events with high energy jets are characterized by a strong suppression of soft particle production, so that the number of soft particles is of the order of 1
- all those events will be classified as peripheral
- and consequently no jet events in central collisions, thus

$$R_{pA}(\text{cent}) = 0, \quad R_{pA}(\text{peri}) > 1, \quad R_{pA}(\text{mbias}) = 1$$

if no other physics

AB, V. Skokov, S. Bathe, arXiv:1408.3156

Model

MC-Glauber model to evaluate N_{coll} in each event

In each N+N collision a jet can be produced with probability $p \ll 1$, p dependent on jet energy

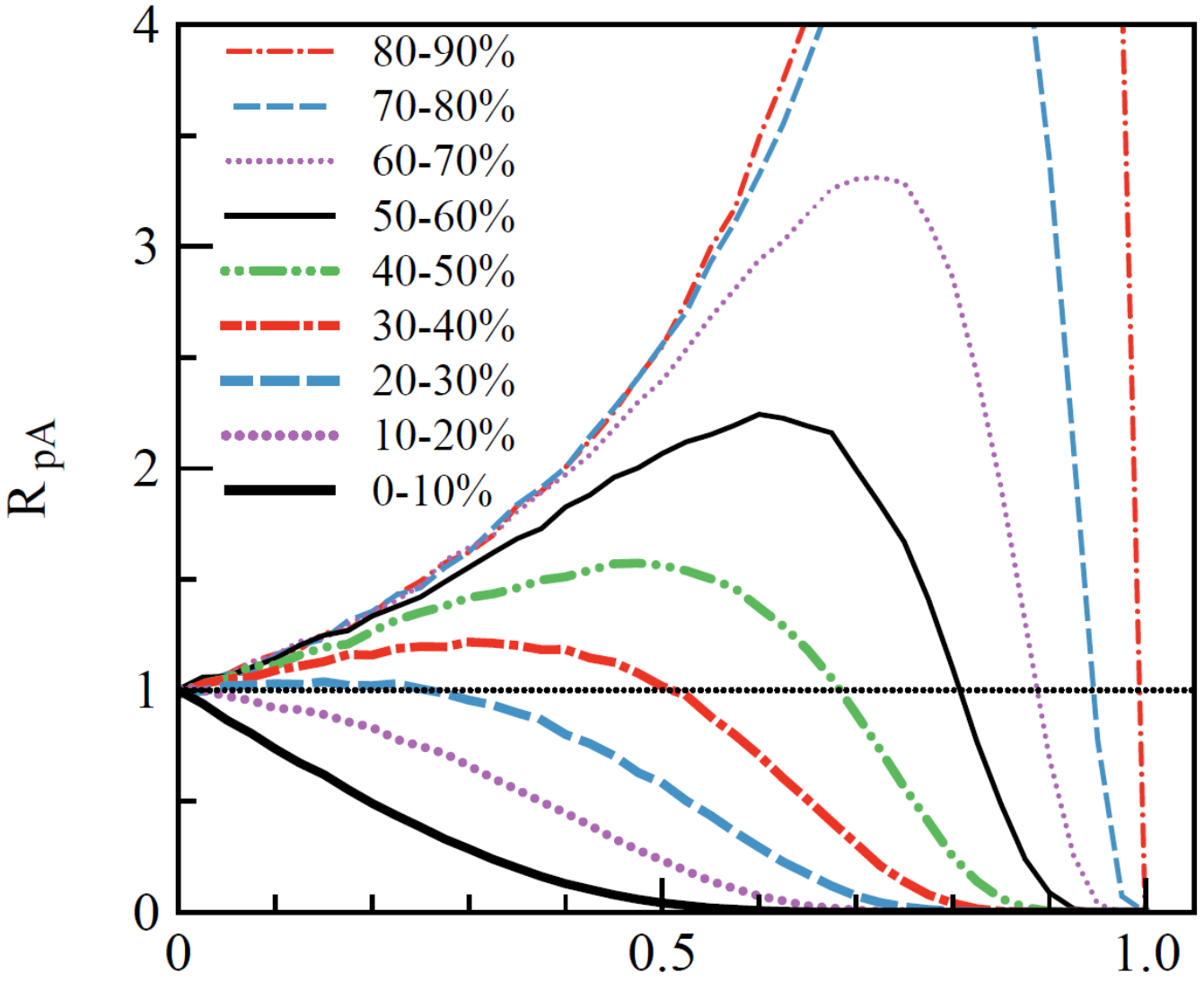
Soft particle production is proportional to $\langle N_{\mathrm{part}} \rangle$ convoluted with NBD with $\langle n_{pp} \rangle$ and k_{pp}

Suppression, $\boxed{\langle n_{pp} \rangle \rightarrow \langle n_{pp} \rangle (1 - s),}$ in events with jets

s depends on jet energy

Result

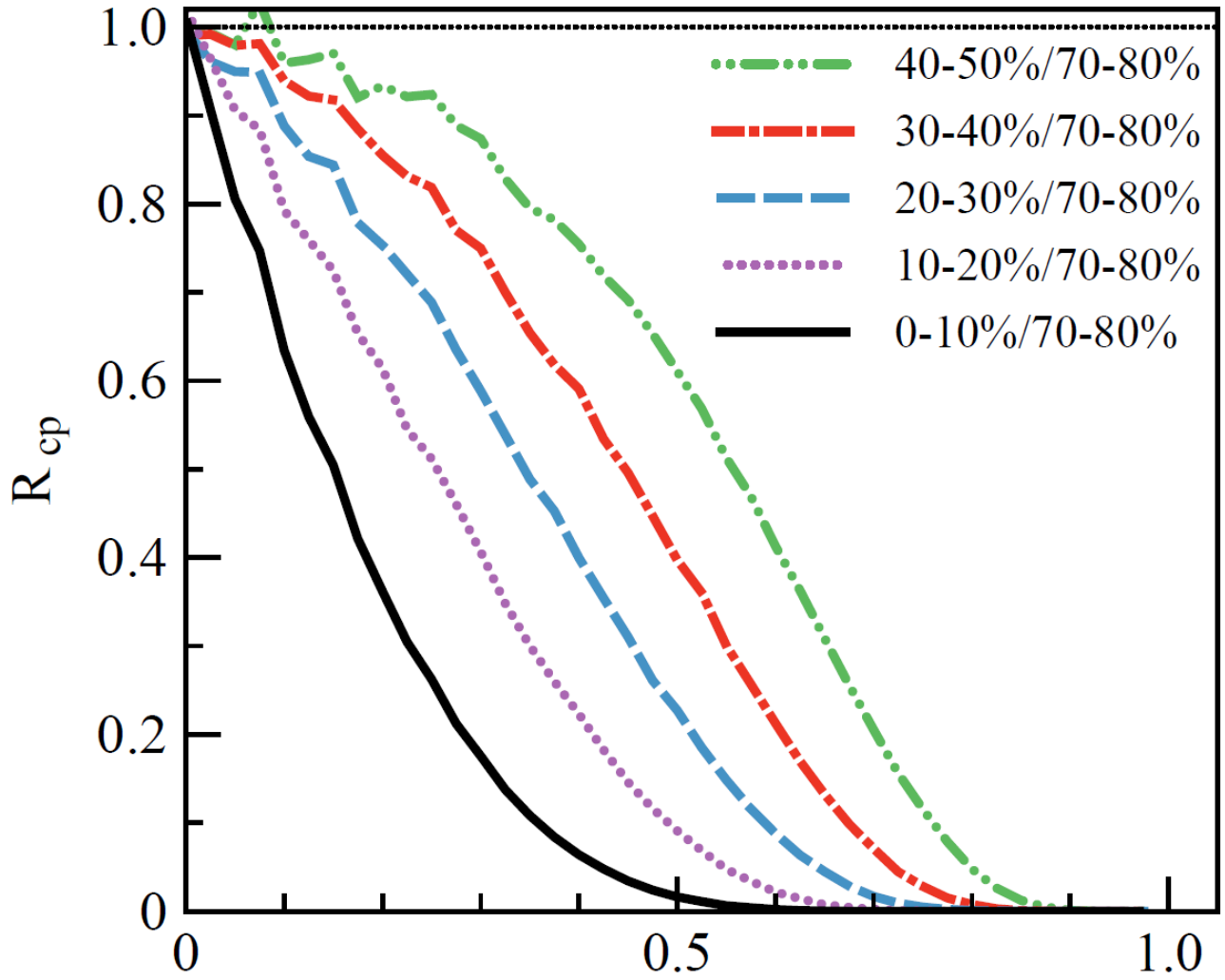
AB, V. Skokov, S. Bathe, arXiv:1408.3156



s - suppression of soft particles

Result

AB, V. Skokov, S. Bathe, arXiv:1408.3156



s - suppression of soft particles

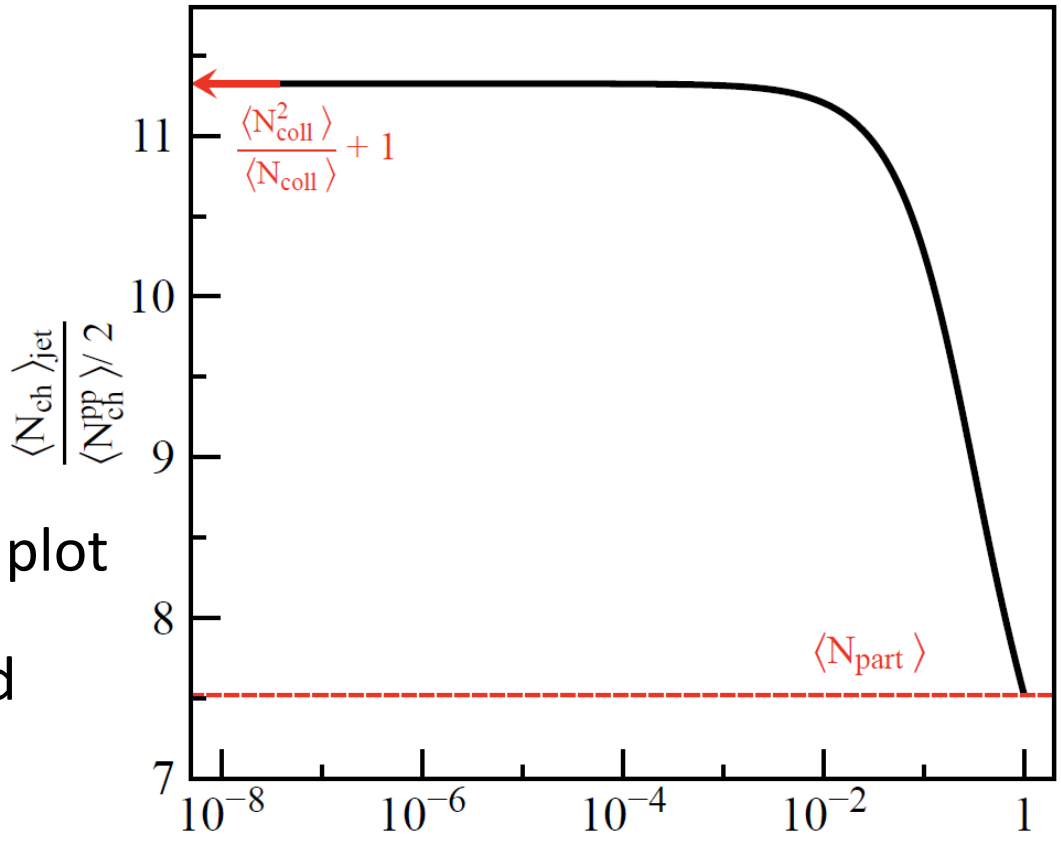
$s \sim 0.2$ for 1000 GeV jets

Experimental test

Measure the number of soft particles in events with jets

Suppression not active in this plot

If suppression, $\langle N_{\rm ch}\rangle_{\rm jet}$ should decrease with decreasing p (increasing E)



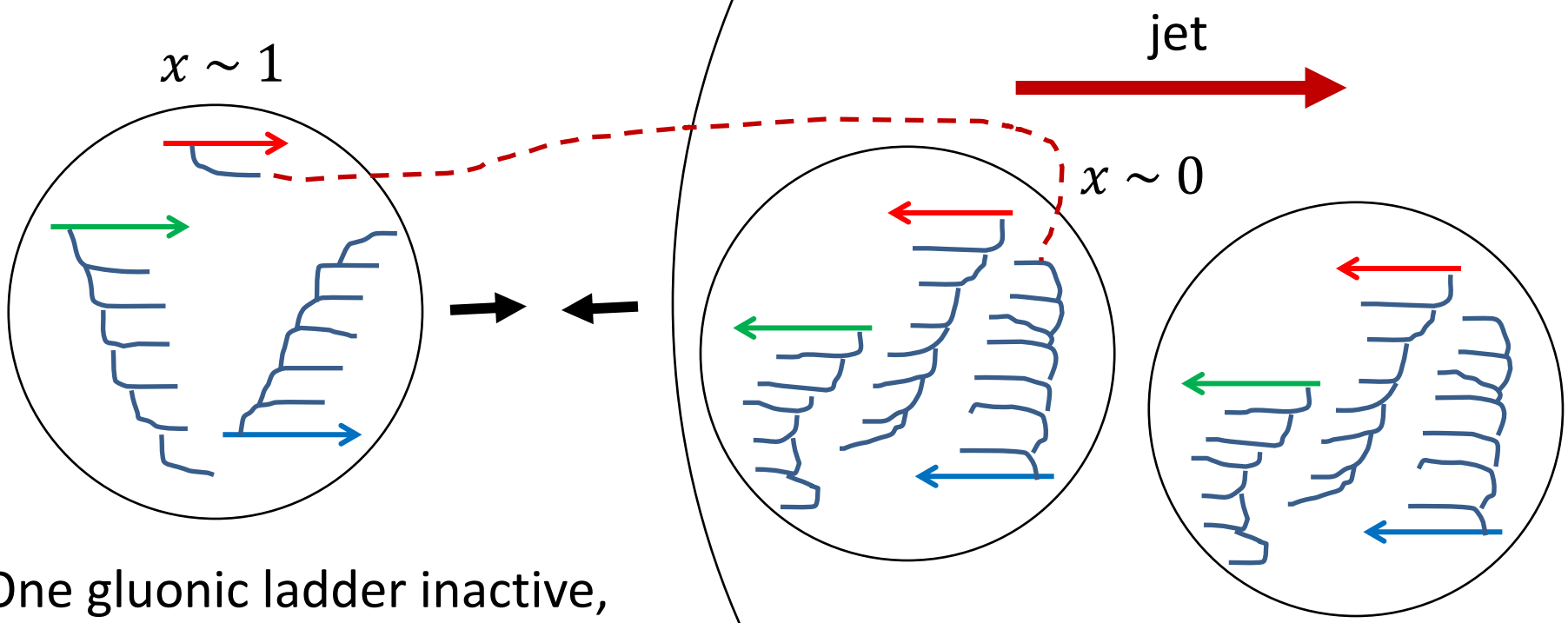
p - probability to produce a jet in N+N, depends on jet energy

$$\langle N_{\rm part}\rangle_{\rm jets} = \frac{\sum_{N_{\rm part}} P(N_{\rm part}) N_{\rm part}\left[1-(1-p)^{N_{\rm part}-1}\right]}{\sum_{N_{\rm part}} P(N_{\rm part})\left[1-(1-p)^{N_{\rm part}-1}\right]}$$

$$\langle N_{\rm part}\rangle_{\rm jets} \simeq \frac{\langle N_{\rm part}^2\rangle - \langle N_{\rm part}\rangle}{\langle N_{\rm part}\rangle - 1} = \frac{\langle N_{\rm coll}^2\rangle}{\langle N_{\rm coll}\rangle} + 1$$

$p \ll 1$

Possible mechanism



One gluonic ladder inactive, suppression of soft particles roughly by 1/3 ?

Jet with high energy in the forward direction

Opposite situation ($x \sim 1$ in Pb and $x \sim 0$ in p) does not work (negligible suppression)

Conclusions

Interesting centrality dependence of highly energetic jets in p+Pb at the LHC

$$R_{pA}(\text{central}) < 1$$

$$R_{pA}(\text{peripheral}) > 1$$

$$R_{pA}(\text{mbias}) \cong 1$$

Conjecture:
Jets of very high energy are characterized by a suppressed number of soft particles

Can be easily tested experimentally

Source of nontrivial information about nucleon wave function

More theoretical work needed