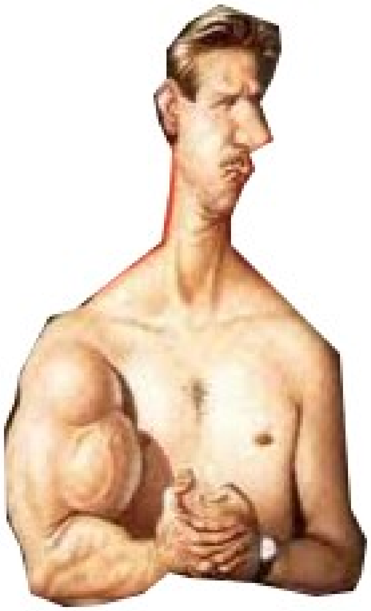
A hybrid strong/weak coupling approach to jet quenching



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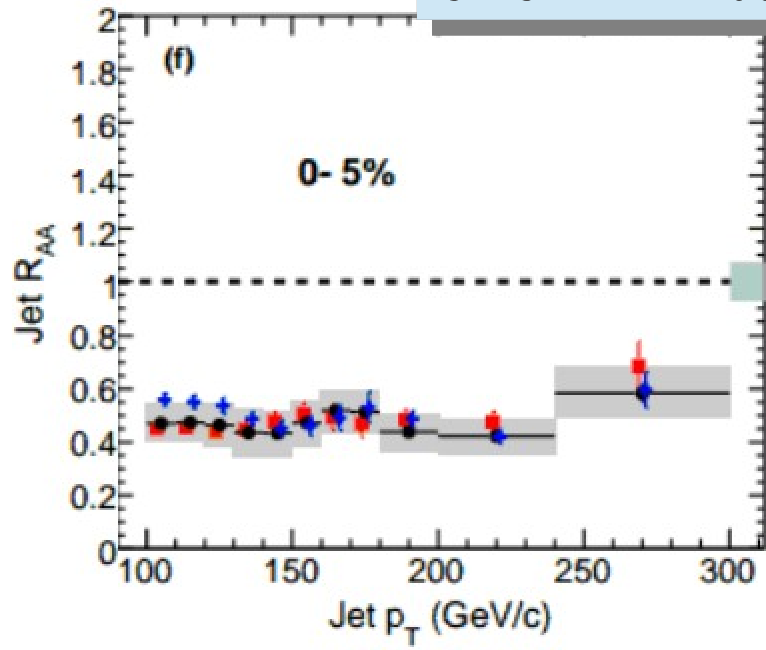
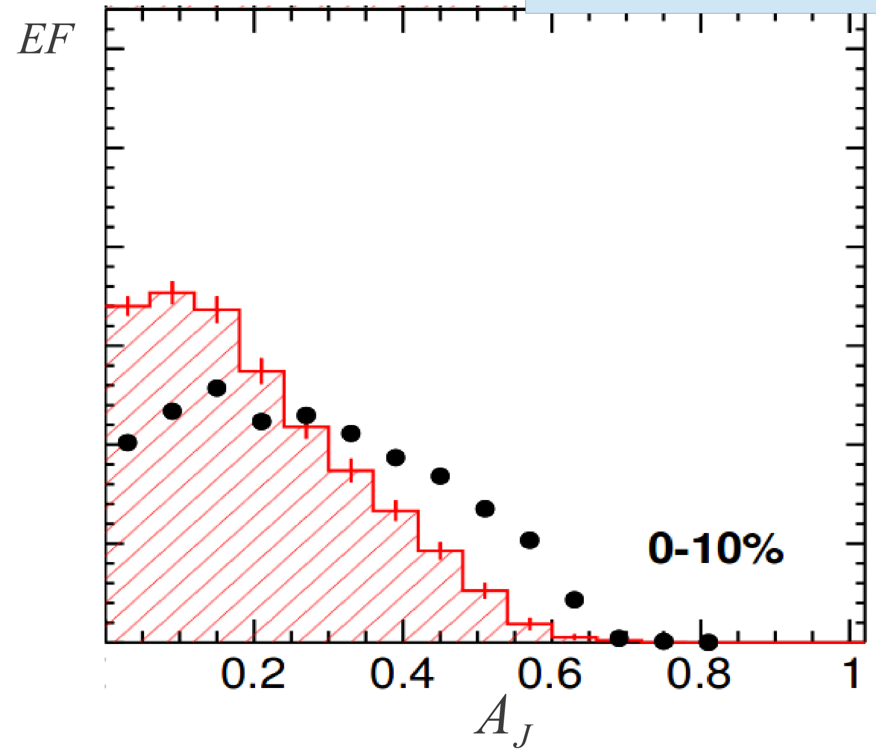
Jorge Casalderrey and Krishna Rajagopal

Motivation

CMS-HIN-12-004



arXiv:1202.5022



- Jets get modified: Energy Loss
- Many models include:
  - Radiative Energy Loss (perturbative) plus
  - Collisional Energy Loss (soft momentum energy transfer of order μ_D ~ T < 1 GeV)
- We explore strongly coupled models

Quin et al, 1012.5280

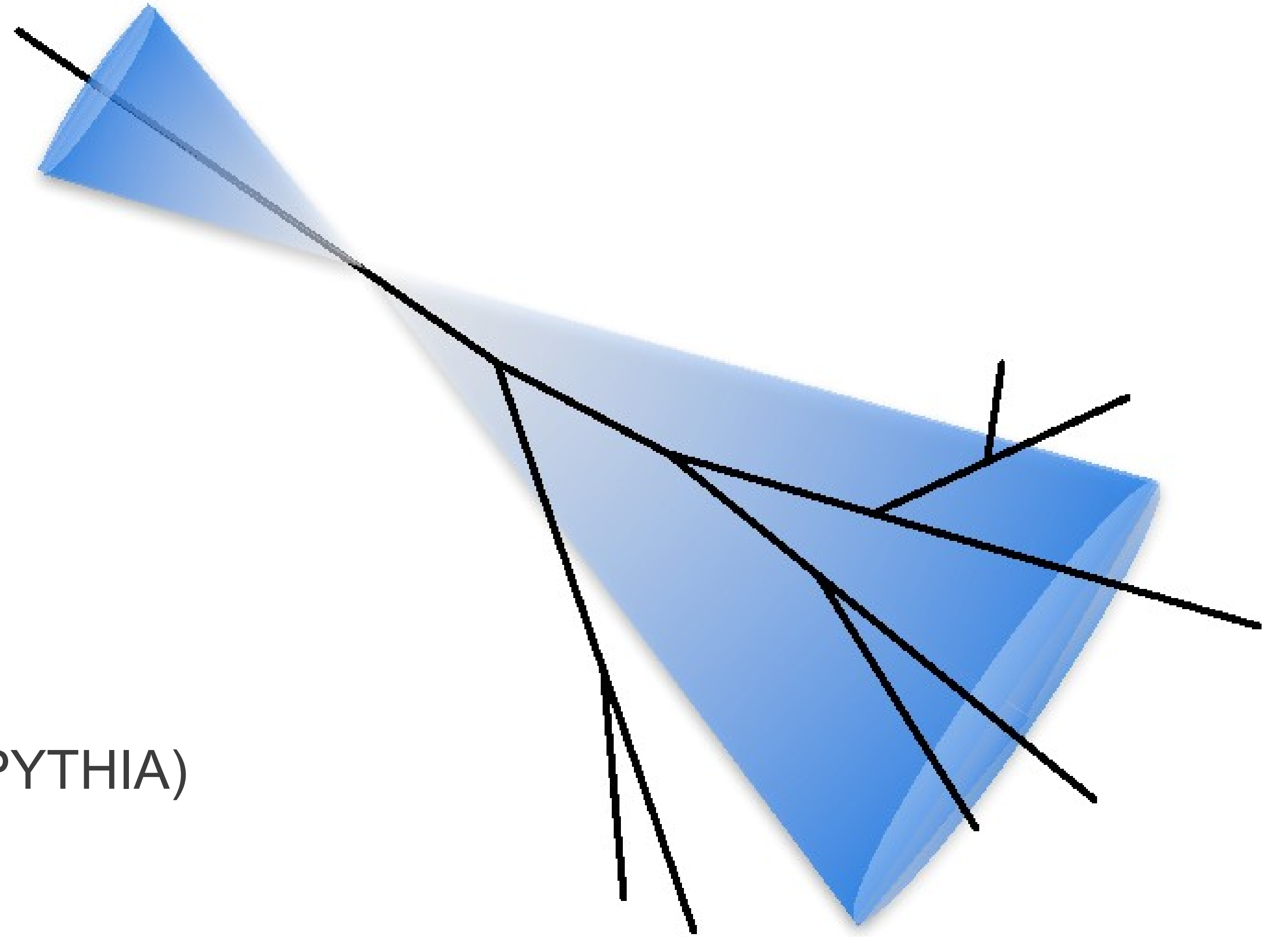
Young et al 1103. 5769

Y. He et al 1105.2566

Renk 1112.2503

Zapp et al 1212.1599

Hybrid Model



- Jet shower perturbative (PYTHIA)
- Additional loss in rungs → strongly coupled, non-perturbative
- Assign lifetime to every rung $\tau_f = \frac{2E}{Q^2}$. Final partons fly until critical temperature is reached.
- We always stay at parton level !

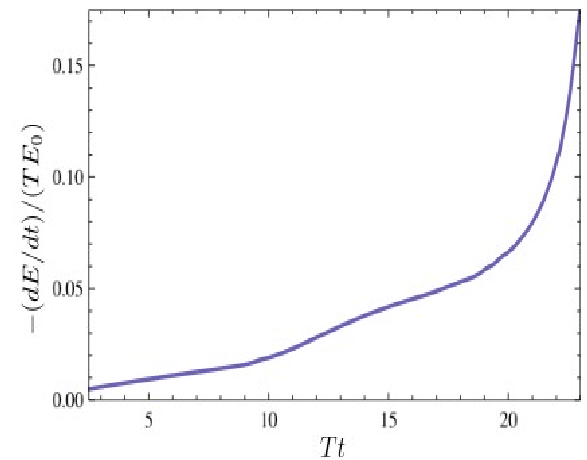
Plasma Modelling

- Woods-Saxon density profile
- Entropy and Temperature related by ideal gas E.O.S
- Entropy density is assumed to be proportional to number of participants
- Bjorken hydro for time dependence (neglecting transverse expansion)
- No quenching before 0.5 fm (transverse frame)
- Initial temperature at zero impact parameter is 0.4 GeV. Stop quenching when T reaches 0.175 GeV

Three Models

- Light → $\frac{dE}{dt} \sim \frac{1}{\sqrt{(t-t_s)}} \rightarrow \frac{dE(t)}{dt} = -(\frac{C_R}{C_F})^{\frac{1}{3}} \alpha_L \frac{E_i^{5/3} T^{4/3}}{E(t)}$

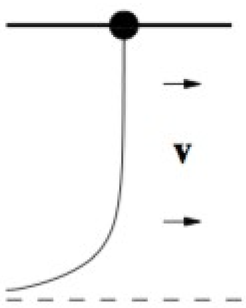
Chesler et al 0810.1895



- Heavy → $\frac{dE(t)}{dt} = -\frac{C_R}{C_F} \alpha_H E(t) T \qquad \gamma < (\frac{M}{T\sqrt{(\lambda)}})^2$

(out of the validity range)

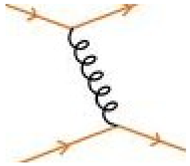
Herzog et al 0605158



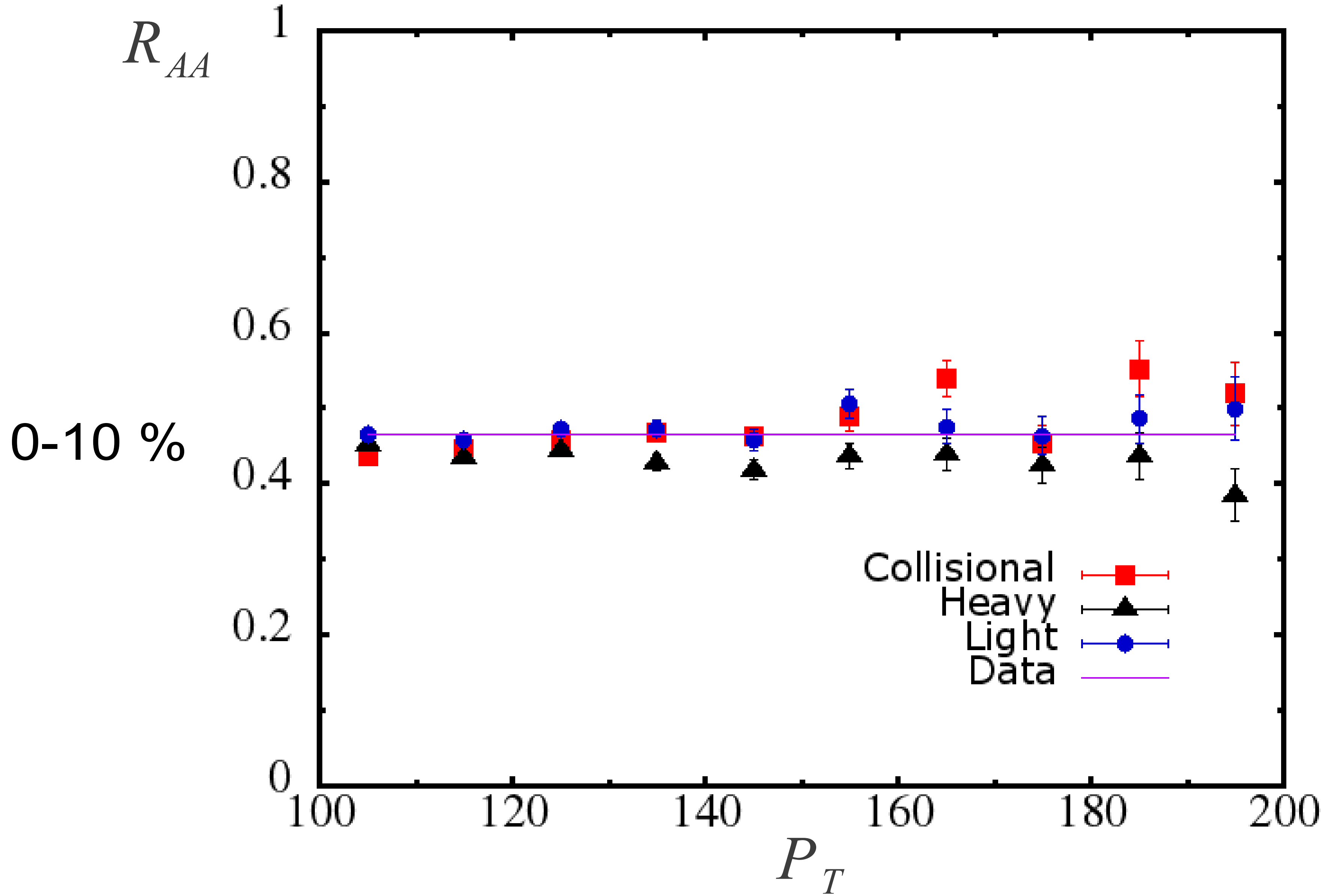
as control also:

- Collisional → $\frac{dE(t)}{dt} = -\frac{C_R}{C_F} \alpha_C T^2$

Wicks et al. nucl-th/0512076

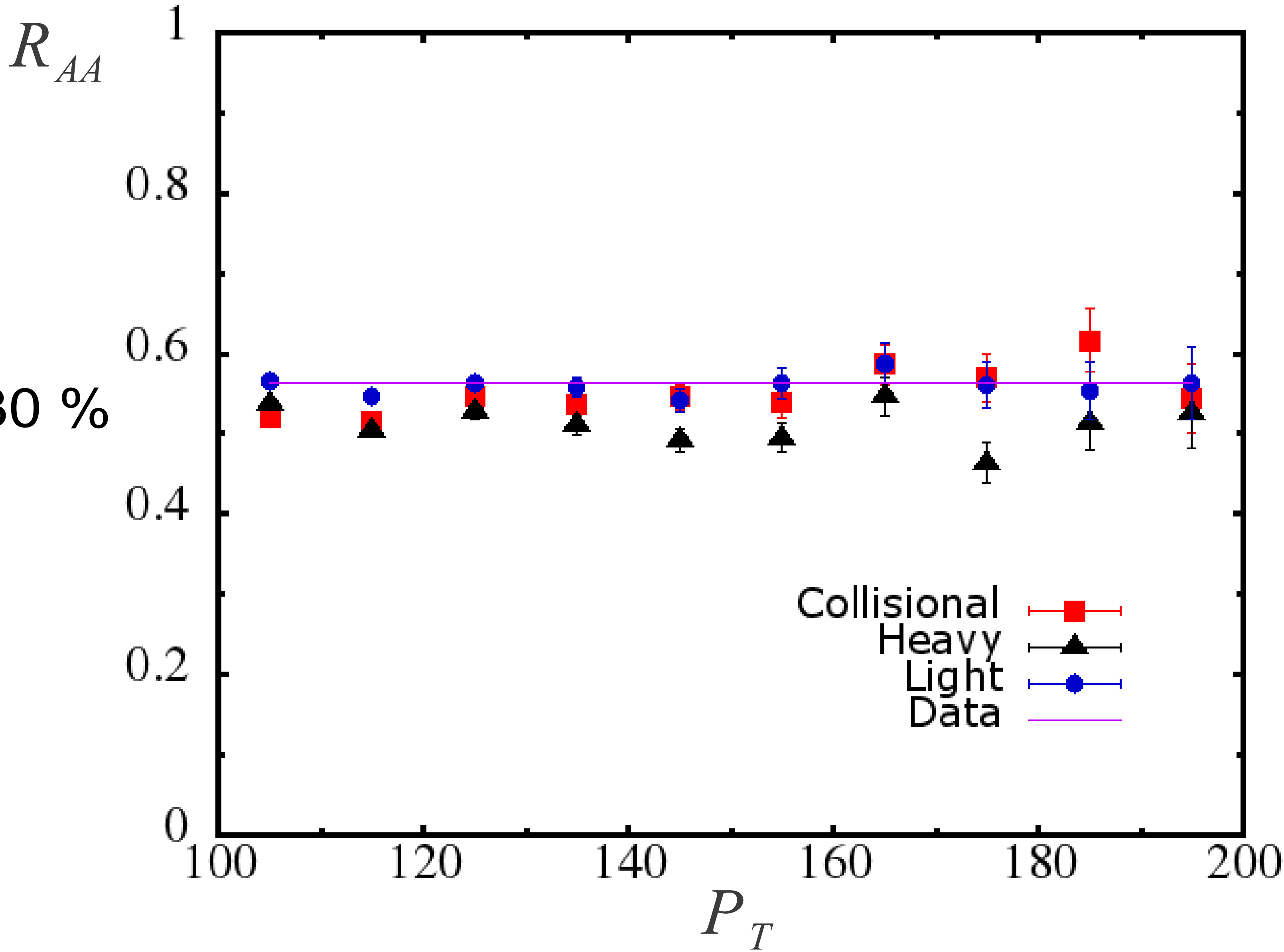


$\alpha_i \equiv$ *fitting parameter*

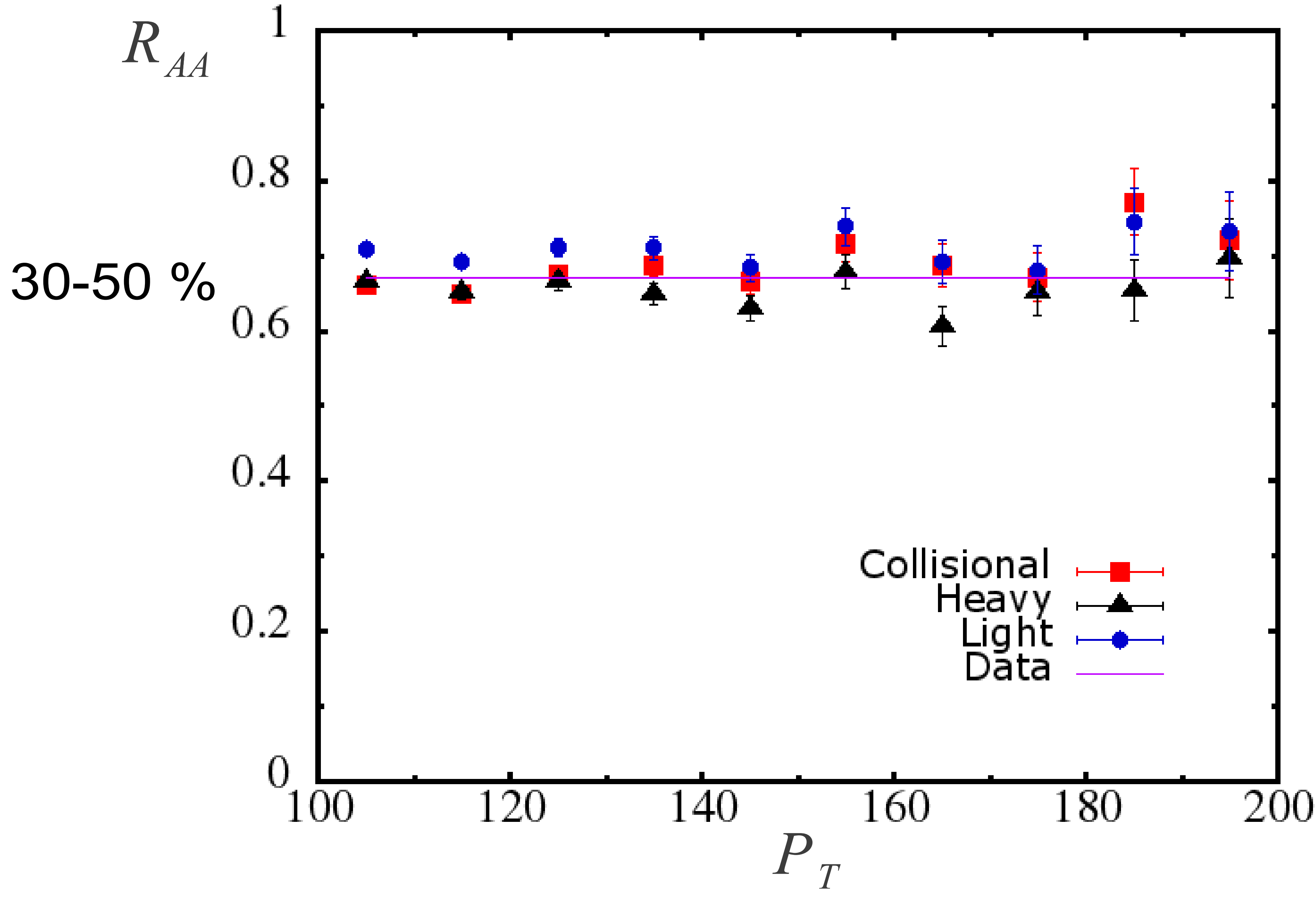


Fit R_{AA} to match data at central collisions

10-30 %

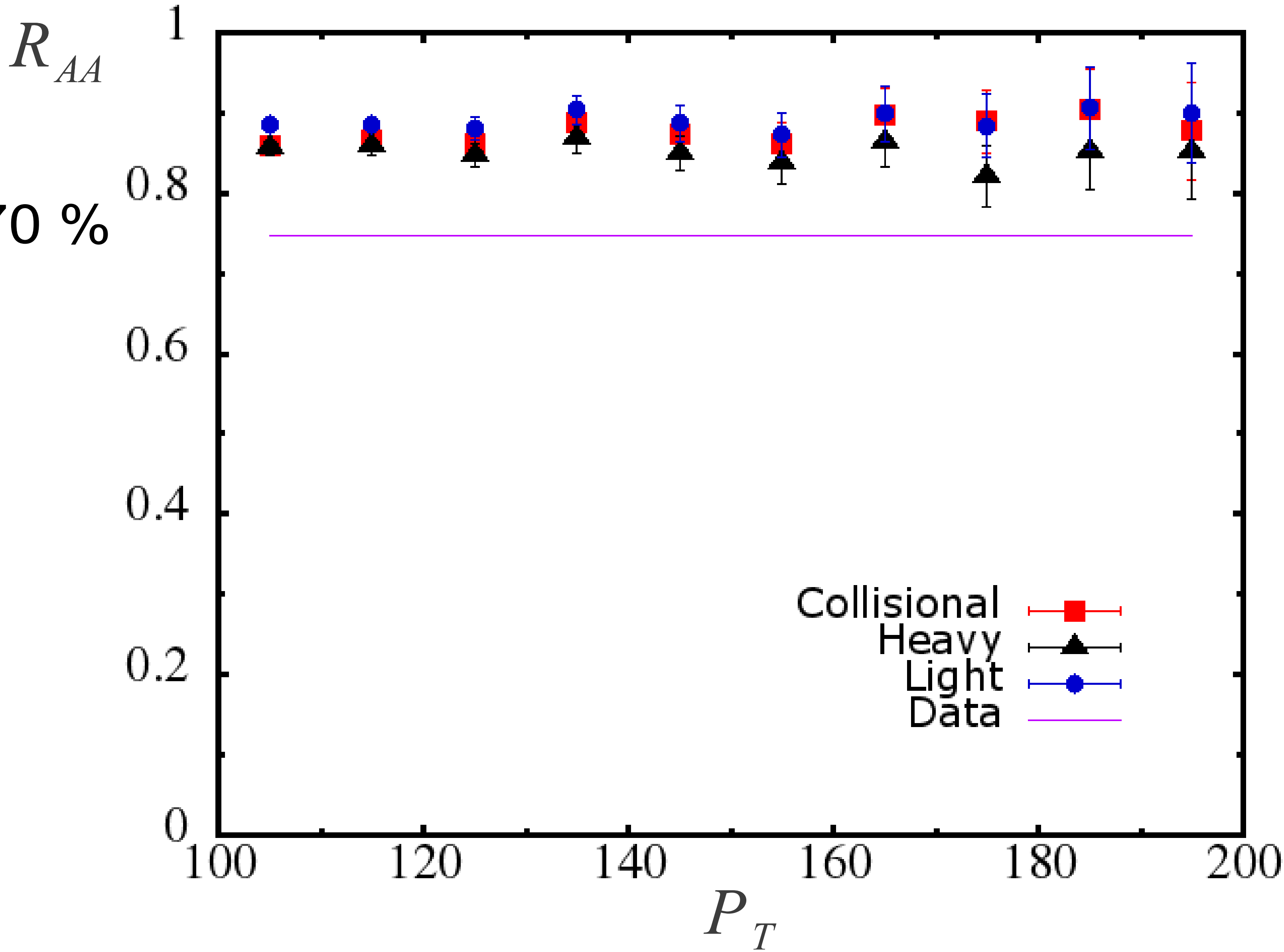


We let it evolve with centrality



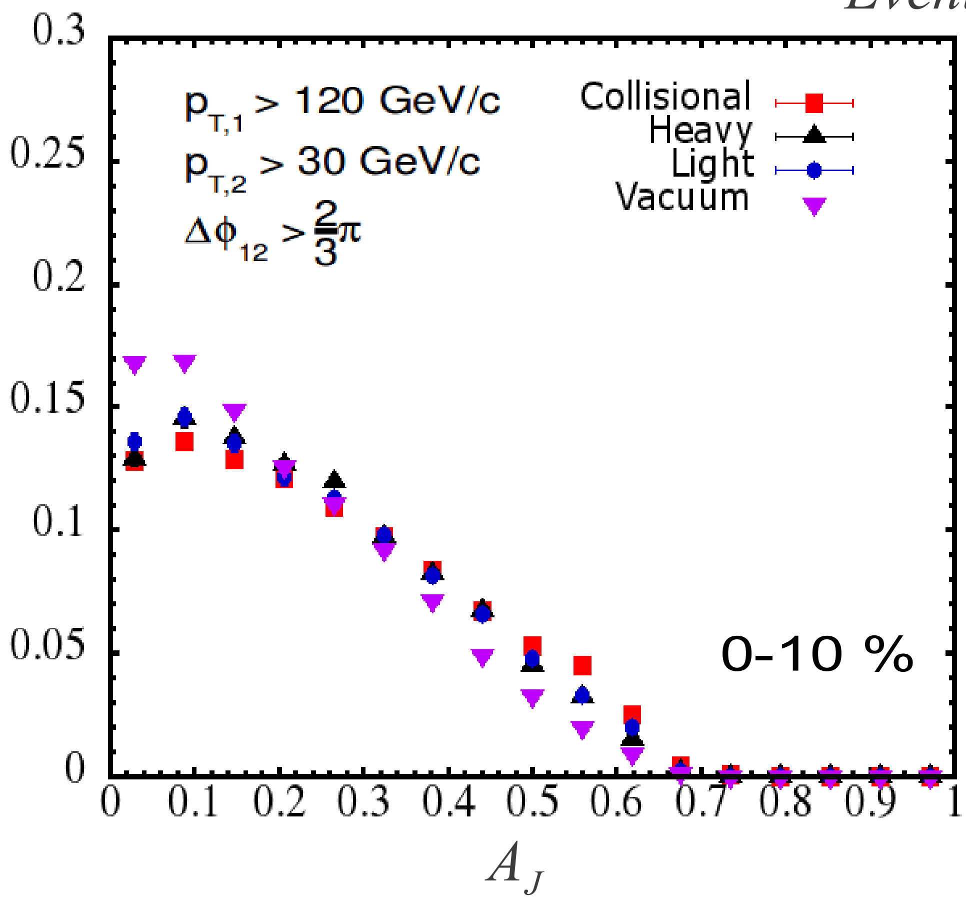
R_{AA}
30-50 %
1
0.8
0.6
0.4
0.2
0
100
120
140
160
180
200
P_T
Collisional
Heavy
Light
Data

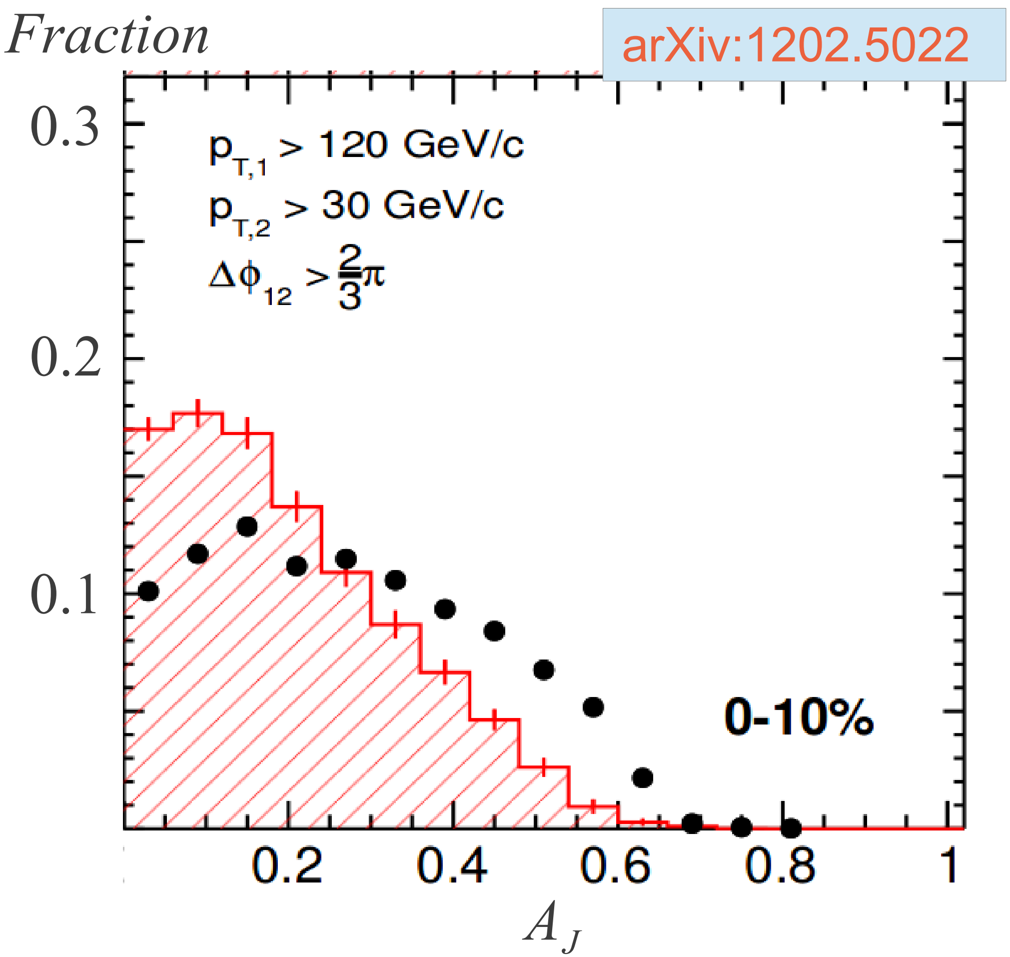
50-70 %



The model describes R_{AA} dependence on centrality at central and mid-peripheral bins, but deviates at most peripheral.

Asymmetry



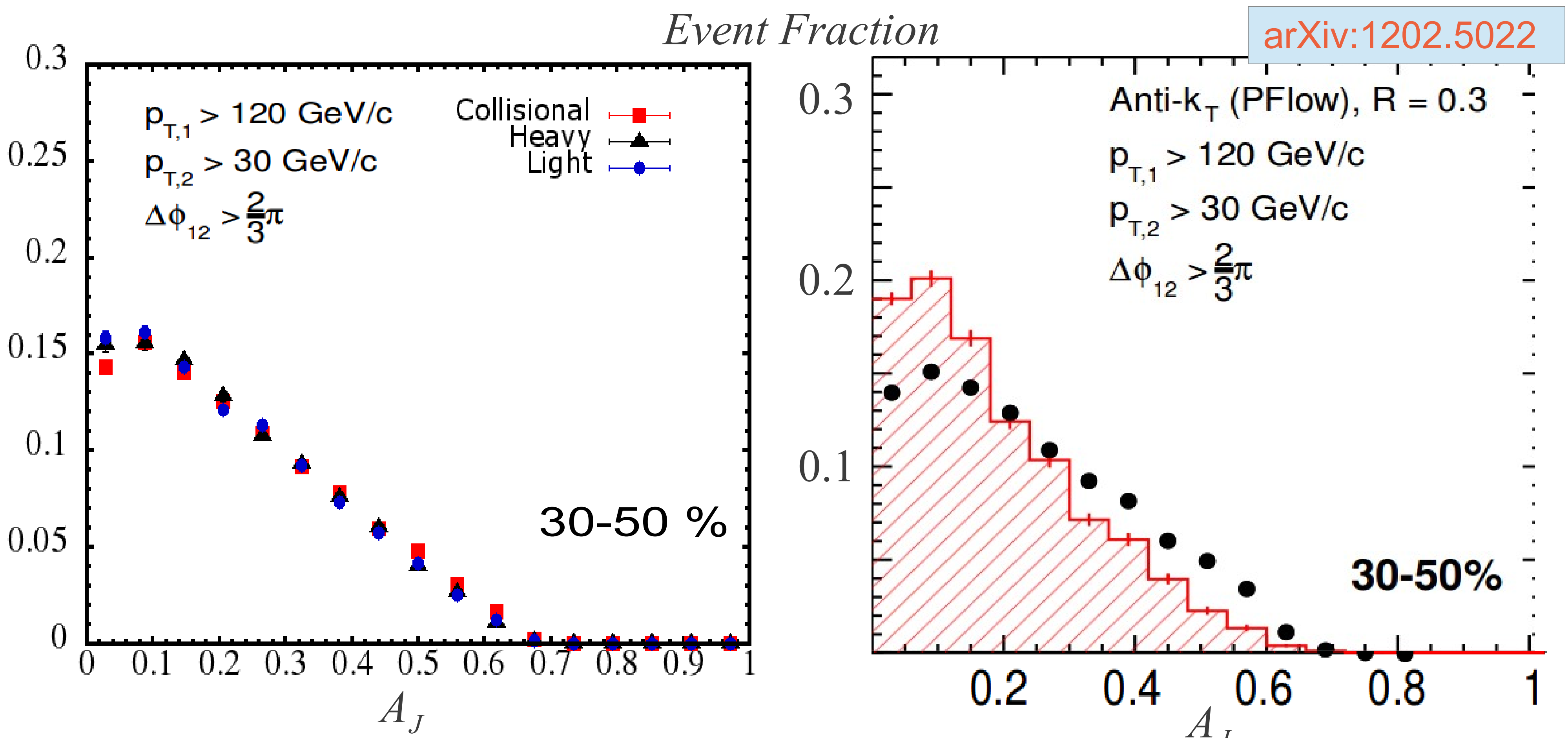


arXiv:1202.5022

$$A_J \equiv \frac{P_{T1} - P_{T2}}{P_{T1} + P_{T2}}$$

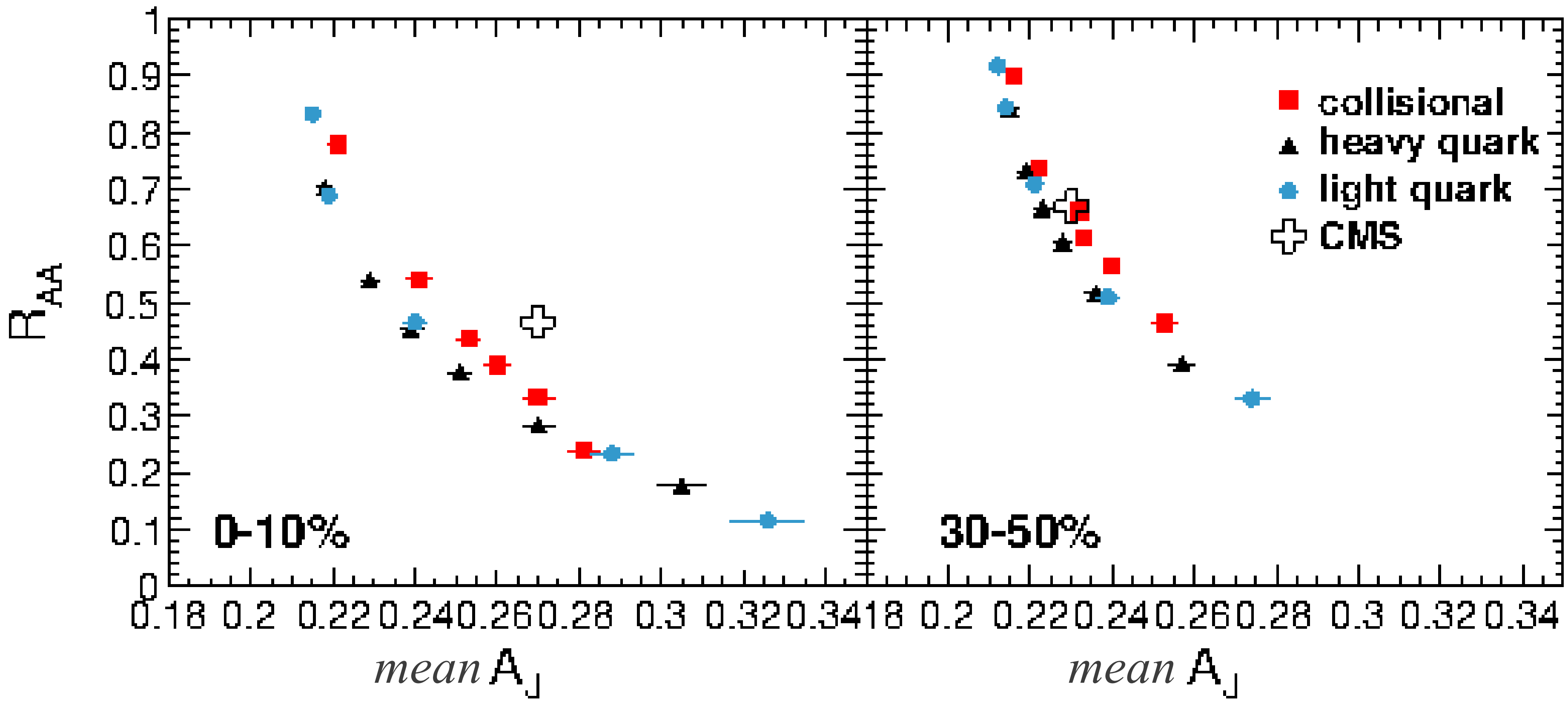
Dijet imbalance not quite strong enough

Asymmetry



$$A_J \equiv \frac{P_{T1} - P_{T2}}{P_{T1} + P_{T2}}$$

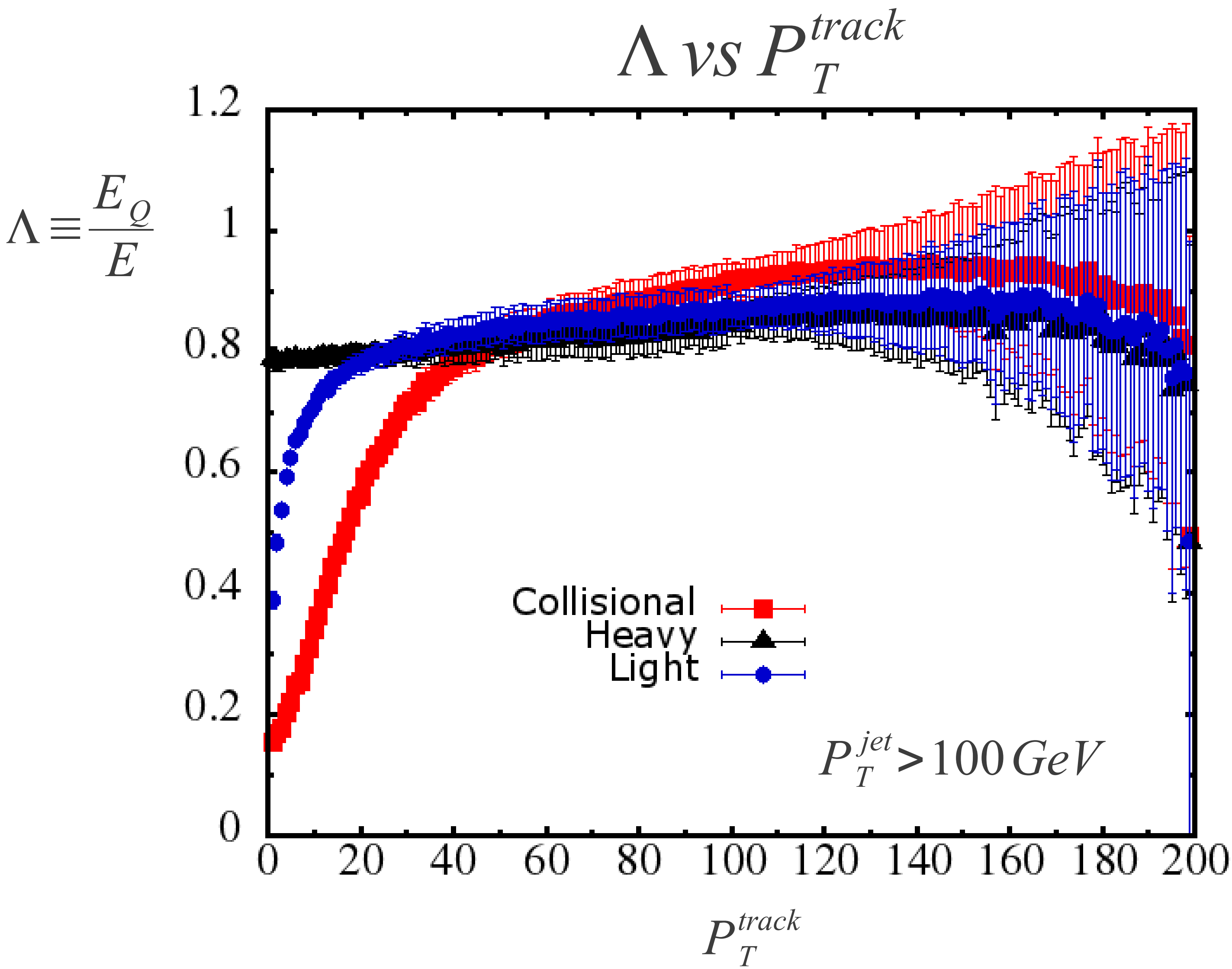
Scanning Parameter Space : R_{AA} *vs mean* A_J



The models don't show significant differences

Mild disagreement in most central bin may point to an additional source of energy loss... (Radiative?)

How can we distinguish between models?

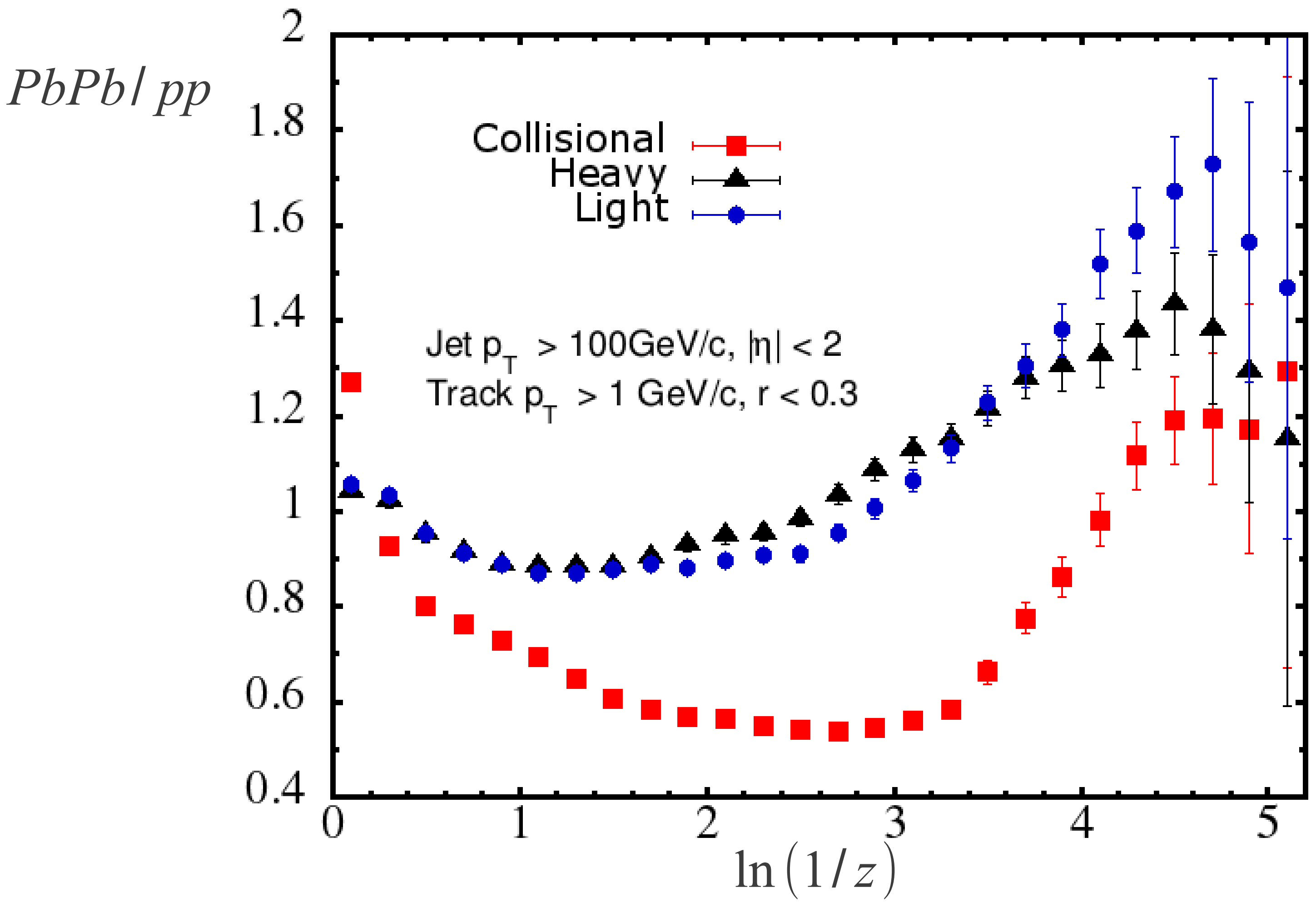


0-10 %

The mean quenching factor that a track belonging to a jet gets is different for different models.

Directly related to Fragmentation Functions

Fragmentation Functions



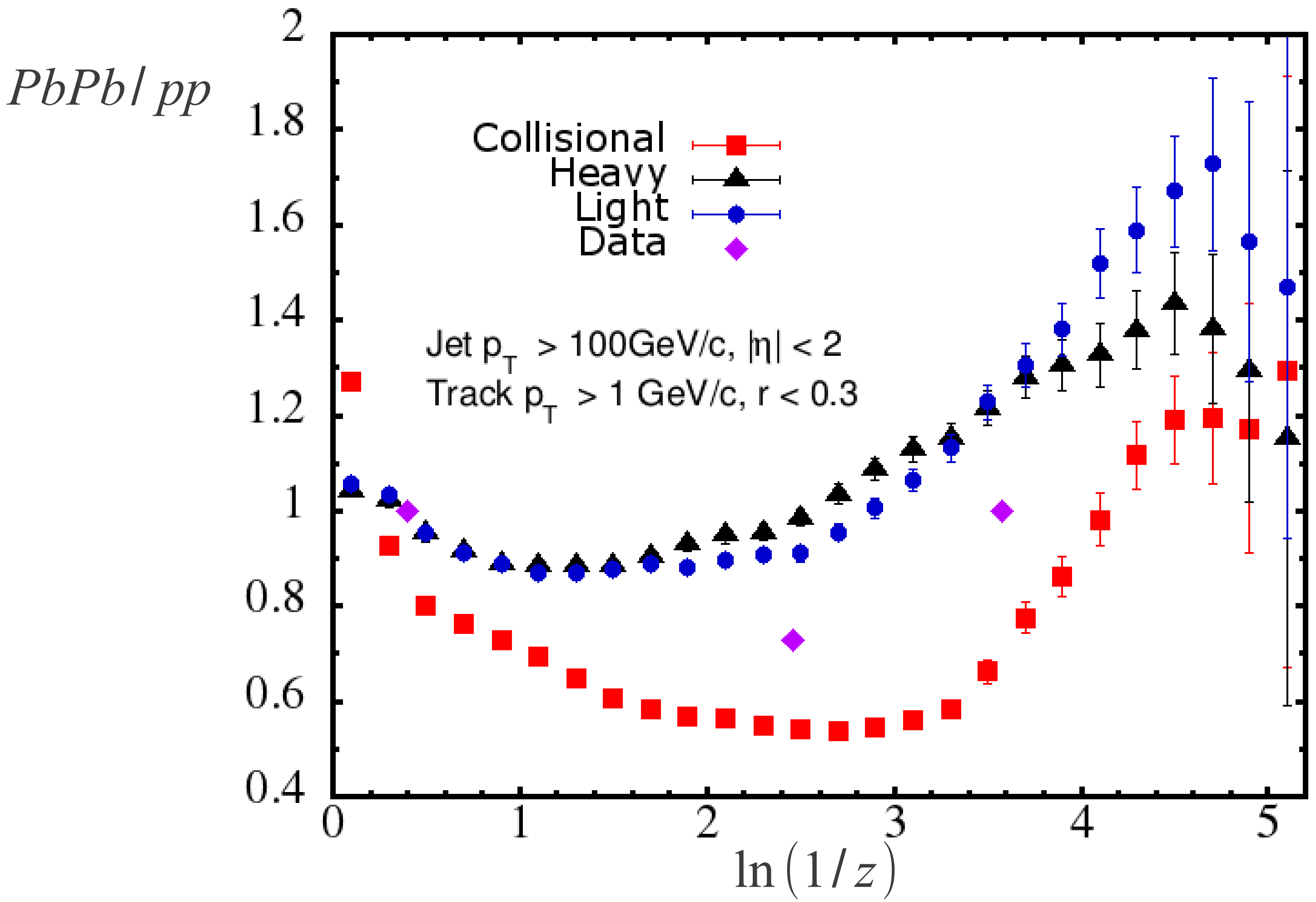
0-10 %

PARTONIC LEVEL!

Collisional→ too strong, soft particles suppression

Heavy and Light → mild behaviour: more "consistent" with data

Fragmentation Functions



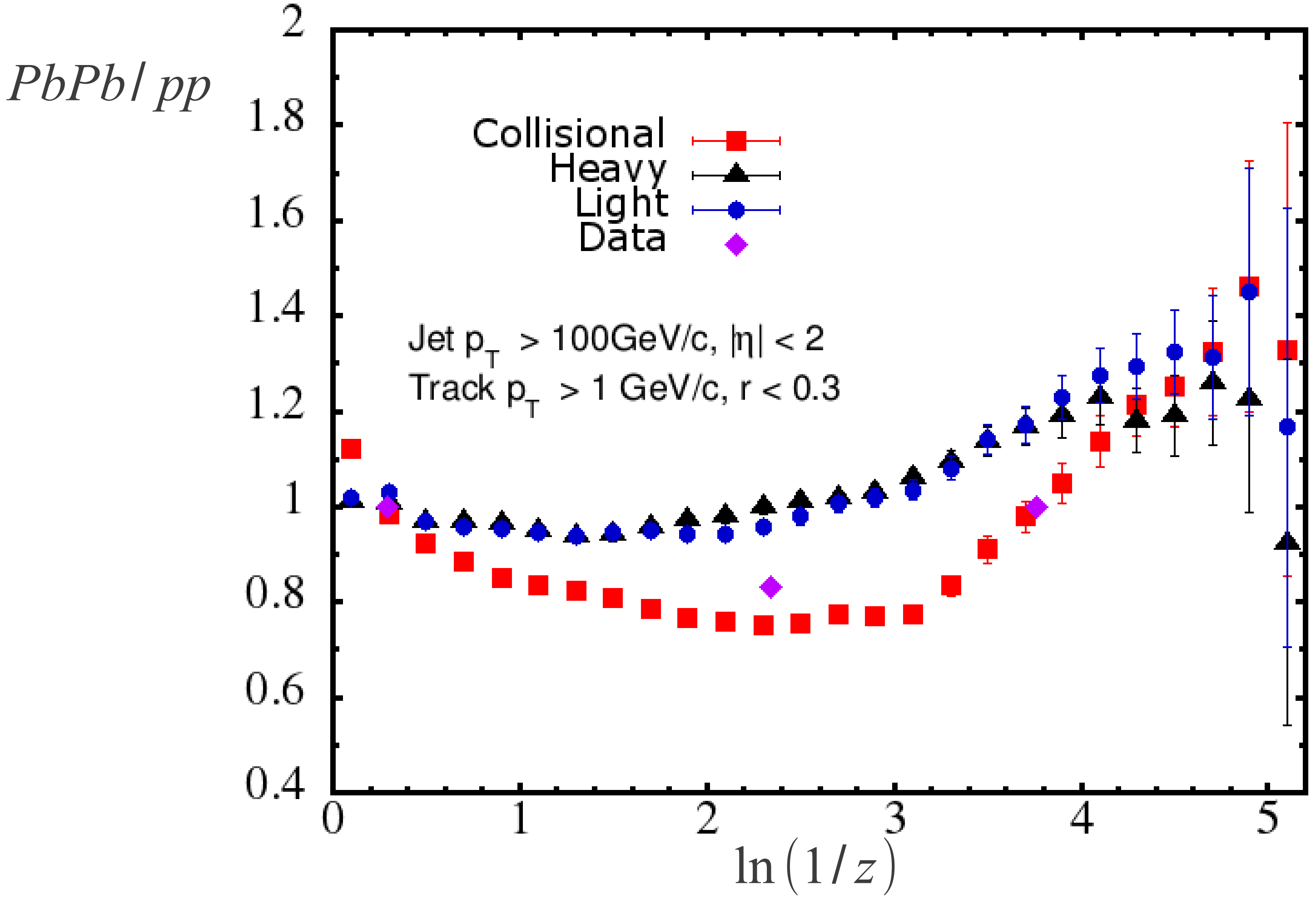
0-10 %

PARTONIC

LEVEL!

One would expect that for the hadronic version the curve should shift to the right

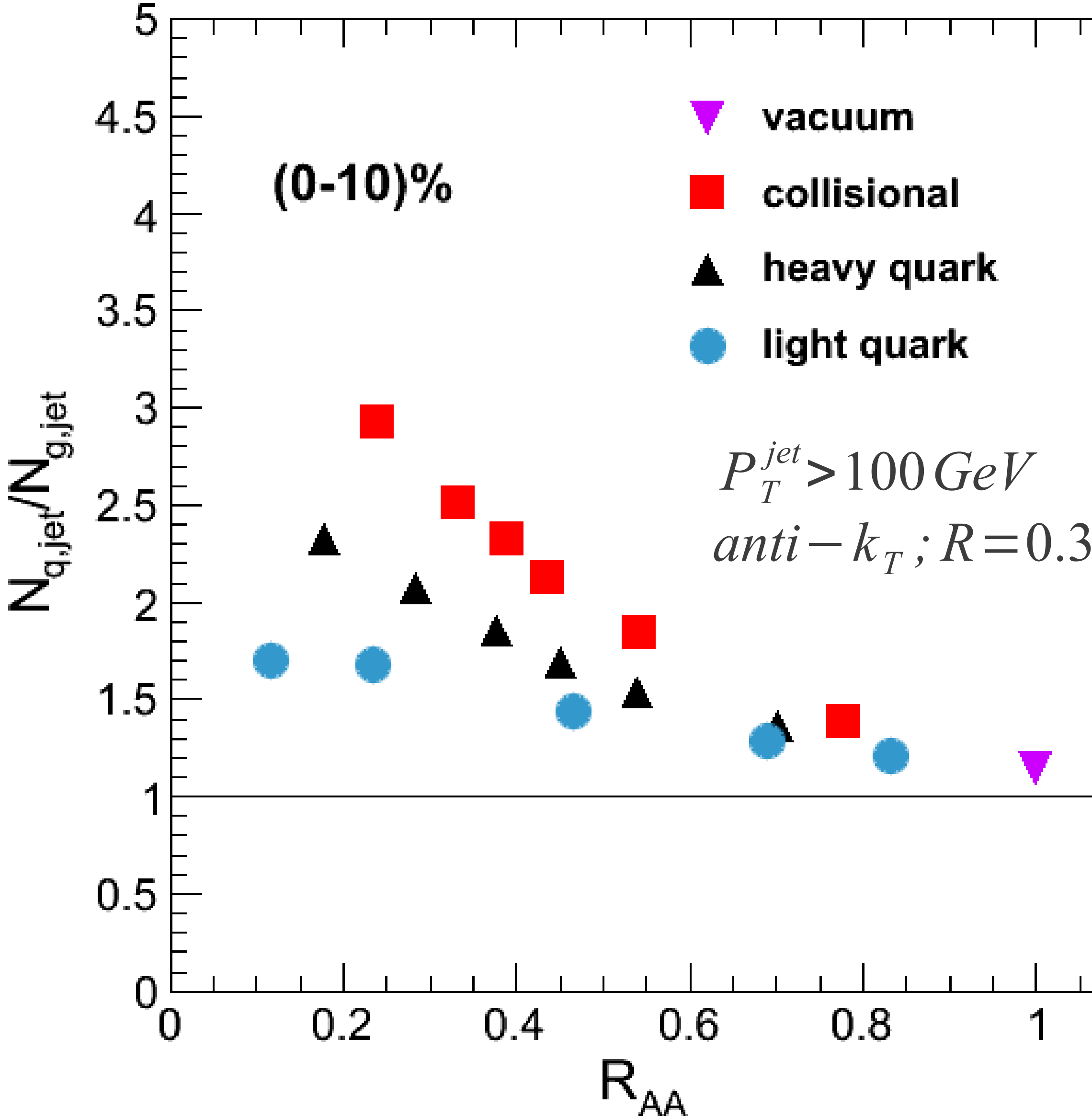
Fragmentation Functions



30-50 %

PARTONIC LEVEL!

Colour charge dependence



Non-trivial C_R dependence yields change of species

An additional discriminant between models

To be studied:

b to inclusive jet yield as a potential observable

Conclusions

- Hybrid model describes qualitatively (and in some cases quantitatively) many of the features of jet quenching

- Simultaneous description of R_{AA} and dijet asymmetry points towards additional source(s) of energy loss

- The momentum dependence of quenching favours strongly coupled models for the non-radiative component of energy loss

- The non-trivial C_R dependence could be used to further discriminate the origin of such a component

Thank you!!!!

Backup

Alpha Values

- Heavy: 0.025
- Light: 0.2
- Coll.: 9