Interfacing Pythia with URQMD – a hadronic rescattering framework

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With:
da Silva, Serenone, Chinellato, & Takahashi
arXiv:2002.10236

The what and the why?

What?

Interface Pythia8/Angantyr with a model for hadronic rescatterings.

Why?

Well established effect, solid physics basics – is it reasonable to sweep it under the rug?

Why MCnet?

The results were quite surprising! And might be interesting for non-HI physicists.

Current Pythia efforts (pp: Sjöstrand & Utheim, 2005.05658, HI: WiP)

Outline:

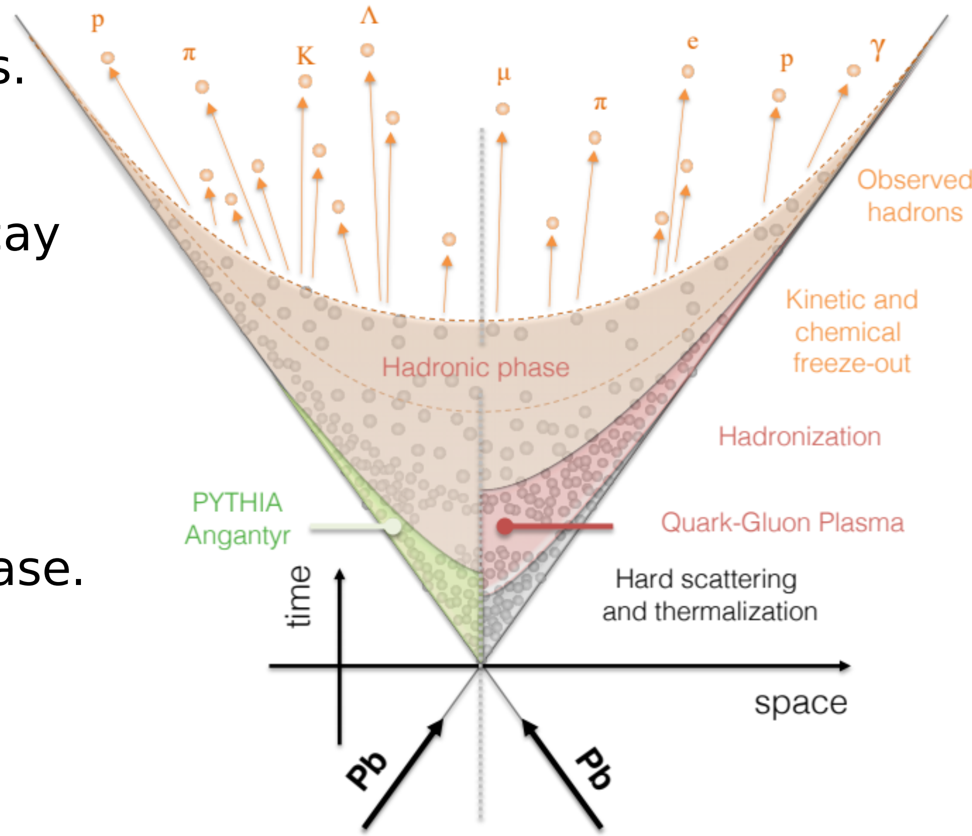
1. Hadrons hit each other in the final state.

2. This has larger effects than we thought.

The big picture

Side-by-side view of two different realities.

Note in particular:
- String decay faster than plasma decay
- A Pb-Pb collision is very large!



But!
- Hard scatterings are the same.
- So is the physics of the hadronic phase.

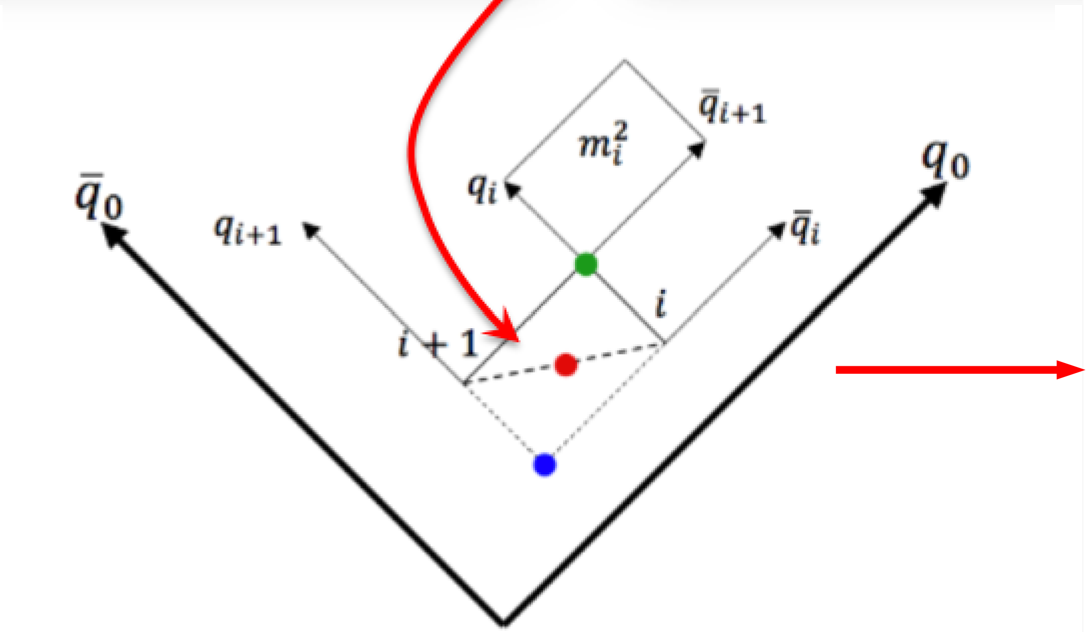
And peripheral Pb-Pb collisions are comparable to pp collisions.

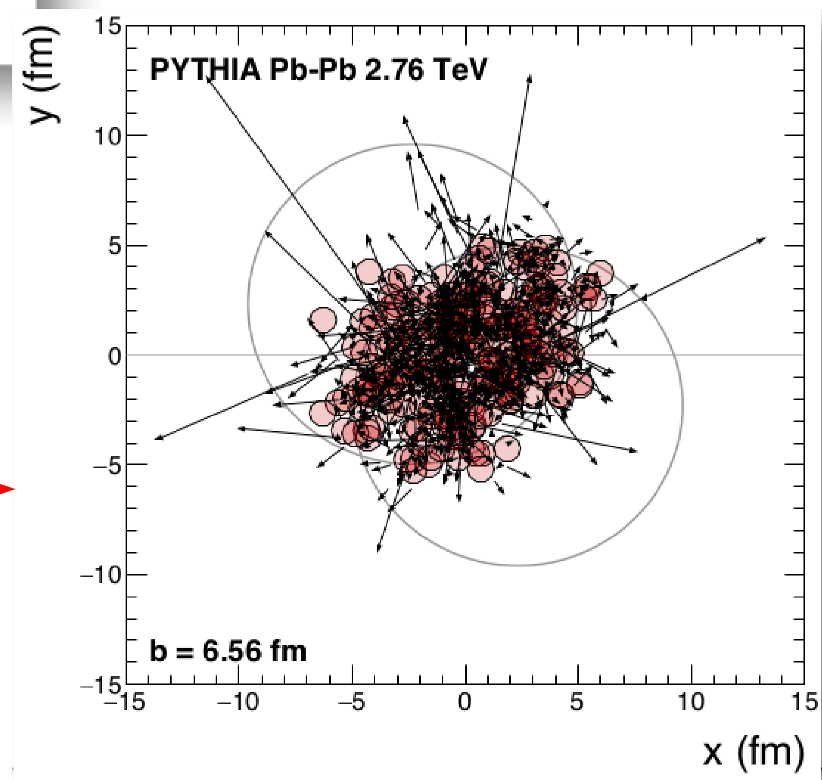
Hadron production: Where and when?

Key input, *hadron production vertices*. (Ferreres-Solé & Sjöstrand, 1808.04619)

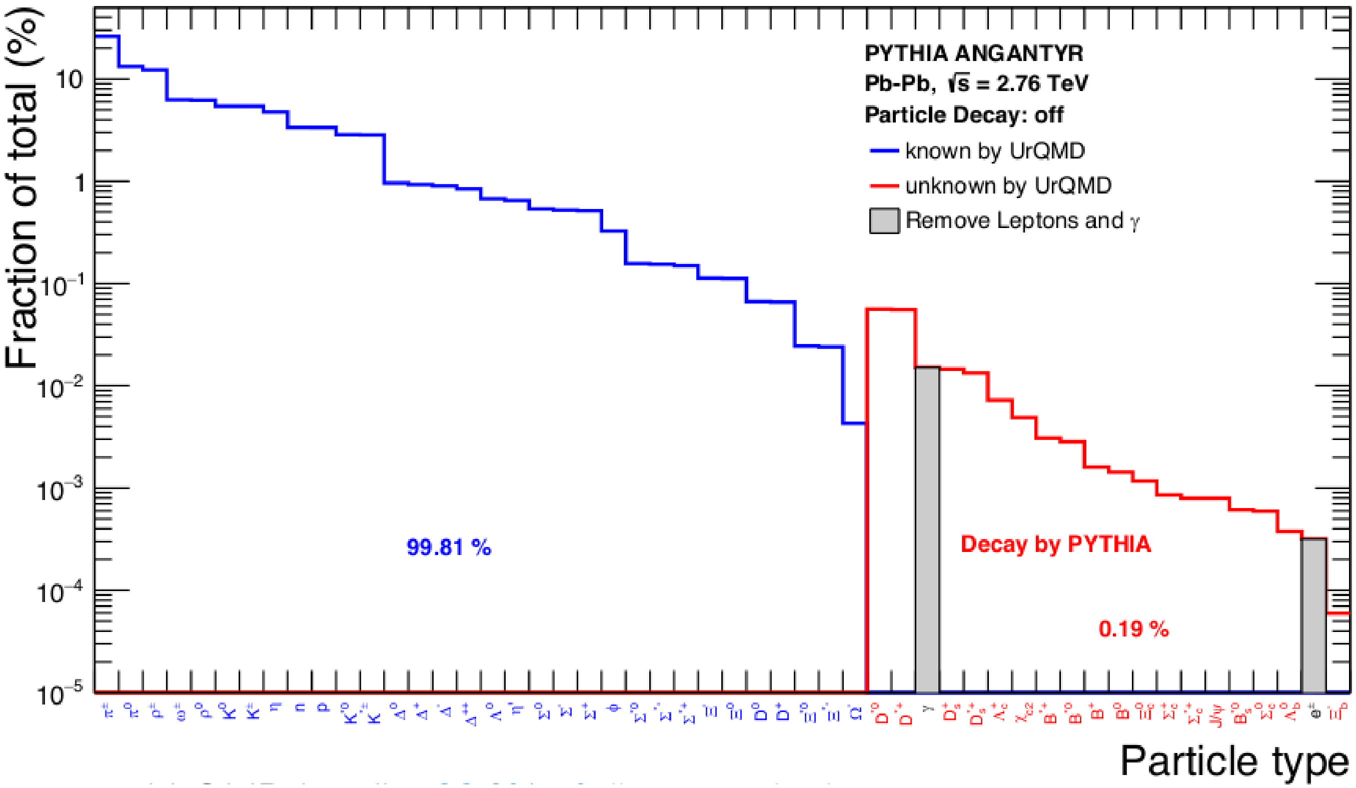
$$v = \frac{x^+p^+ + x^-p^-}{\kappa}$$

$$v^h = \frac{v_1 + v_2}{2}$$





Some details about the interface



Heavy flavours, leptons and photons **unknown to URQMD.**

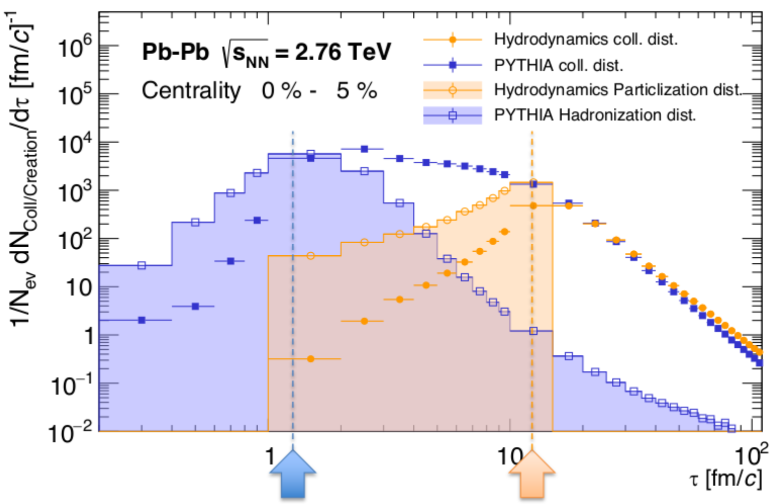
URQMD handles **99.8%** of all decays, and **100%** of all rescatterings.

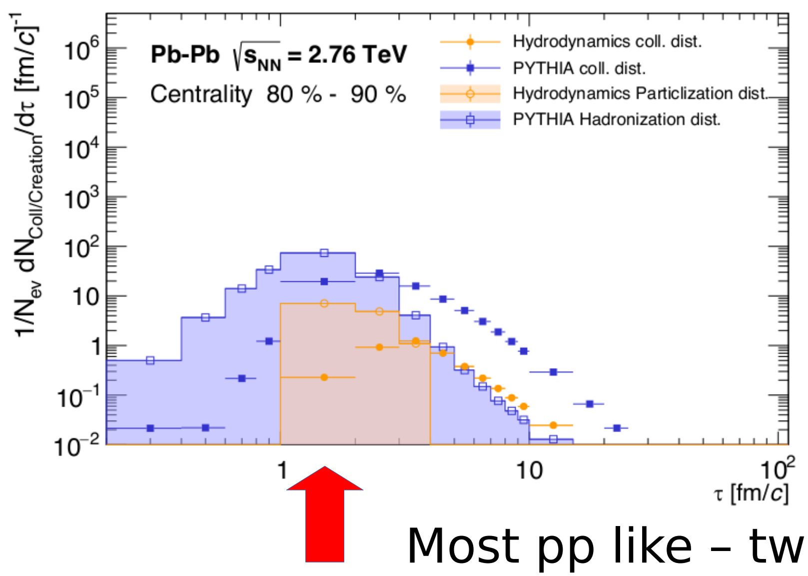
Simple ascii-based interface, could be improved.
This could be a job for HepMC3.

A very dense hadron-soup

Earlier fragmentation means **denser final state**.

A normal heavy ion treatment of pp would give little effect.

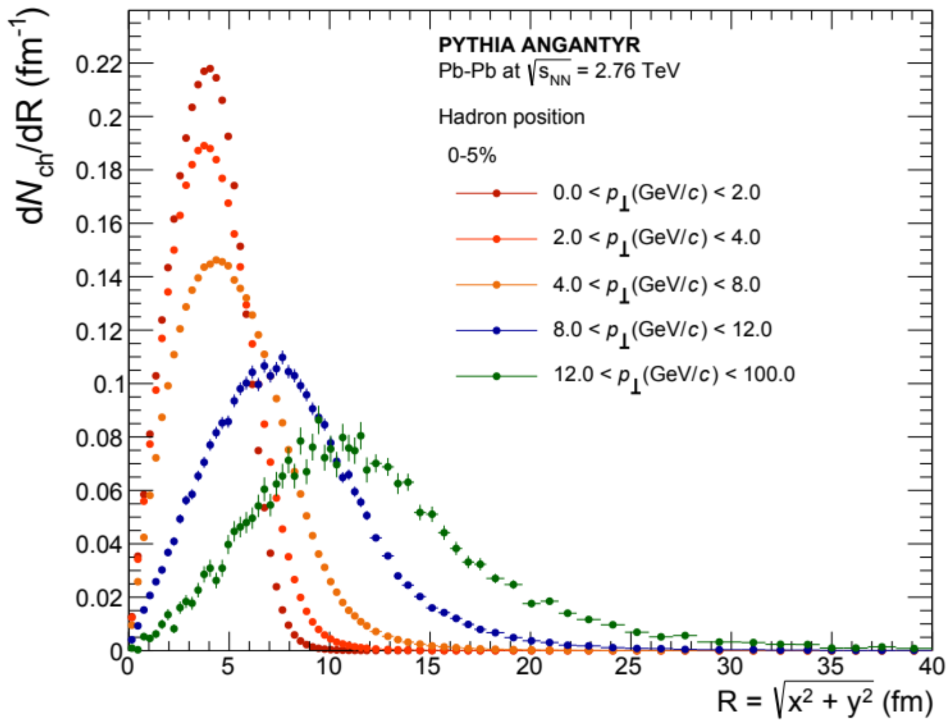




Most pp like – two peaks collapse, but Pythia + URQMD last longer

Harder particles fragment further away

Hard particle production vertices are **far away** from the rest.



Mostly affects soft physics

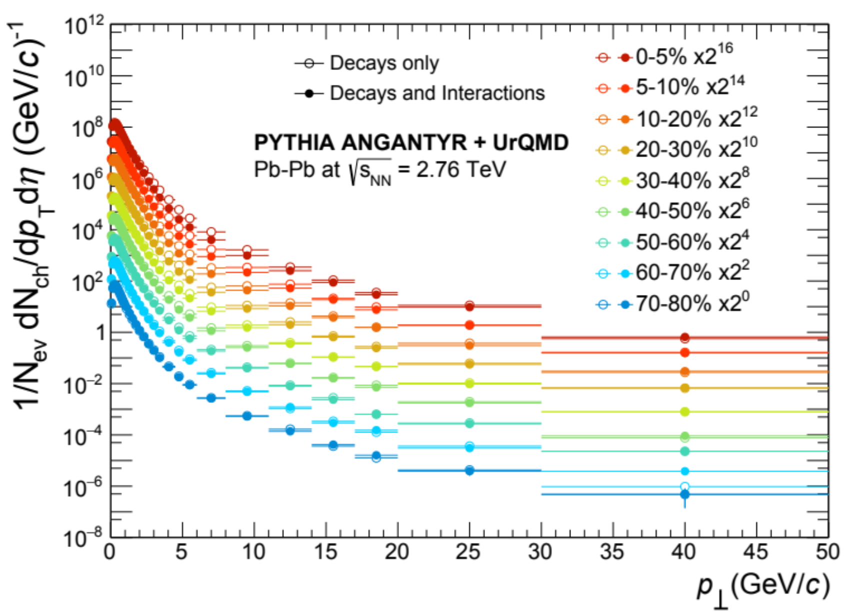
For larger collision systems, relevant R becomes larger.

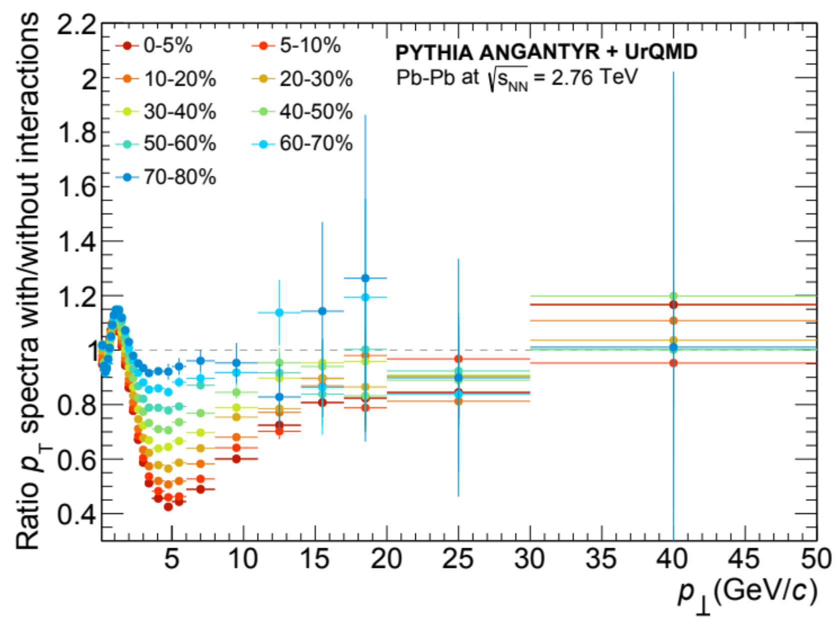
Charged particle spectra

Harder particles (~ 5 GeV) pushed to lower pT.

Effect up to **10-20% in most periferal** (pp like) Pb-Pb.
Up to **60 % in central** Pb-Pb.

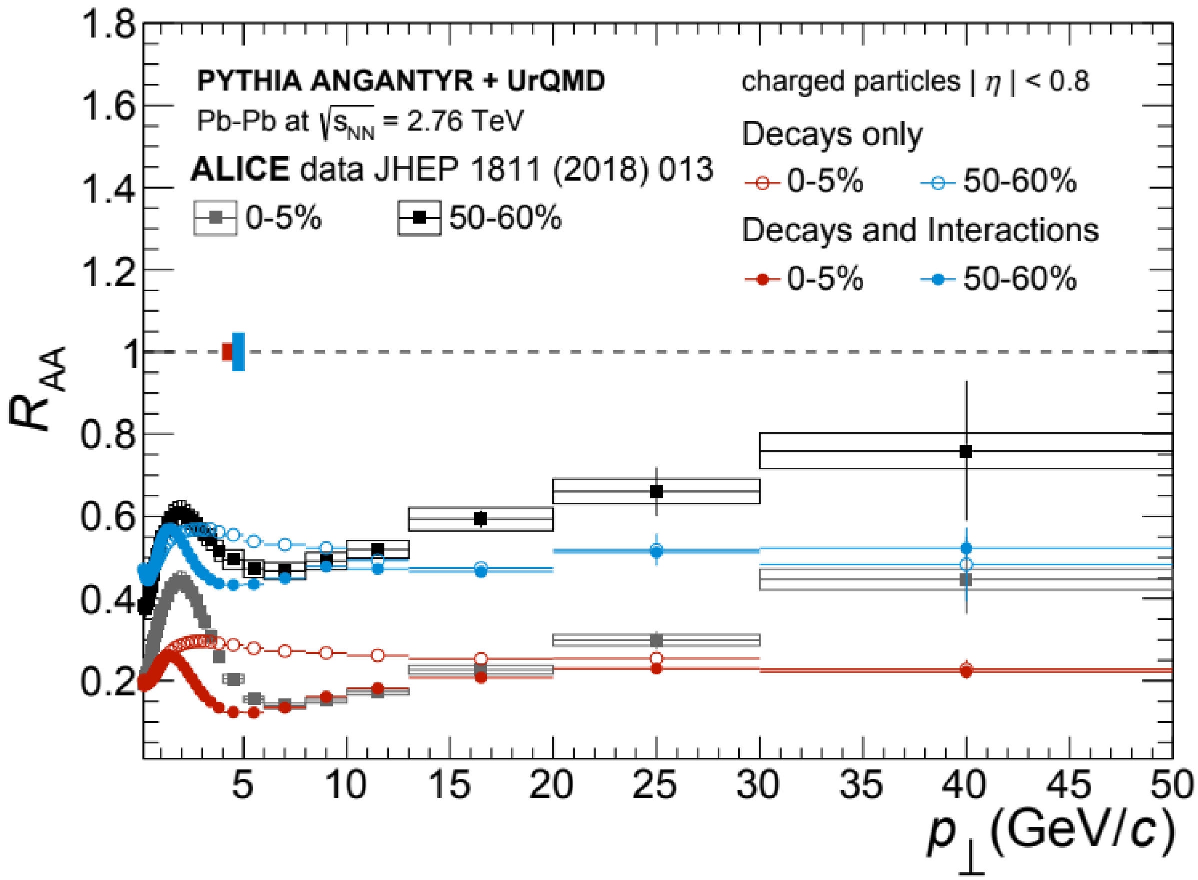
Clearly non-negligible for heavy ion physics.





Nuclear modification factor

In heavy ion physics, this is usually quantified as the modification vs. pp

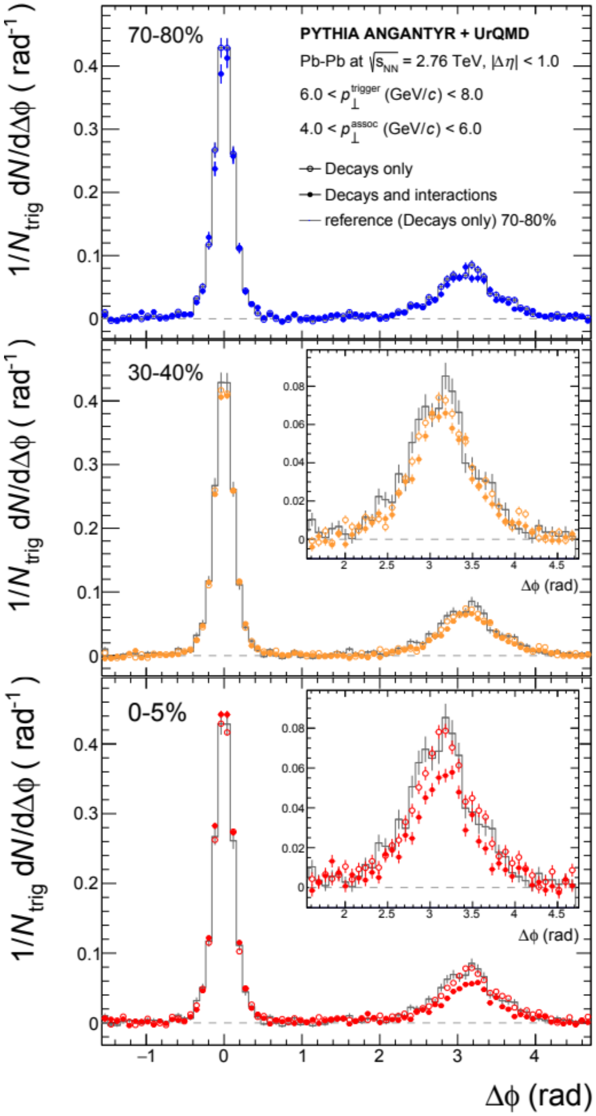


$$R_{AA} = \frac{\mathrm{d}^2 N_{\mathrm{ch}}/\mathrm{d}p_\perp \mathrm{d}y|_{AA}}{N_{\mathrm{coll}}\ \mathrm{d}^2 N_{\mathrm{ch}}/\mathrm{d}p_\perp \mathrm{d}y|_{pp}},$$

The high-pT behavior not produced well by the model.

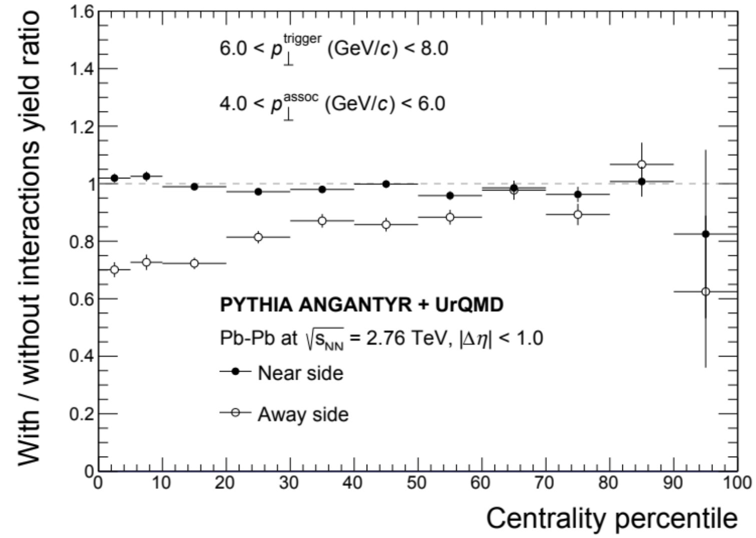
The **good agreement at intermediate pT** is worth studying further.

Looking closer at the modification



In particular the **yields on the away-side of jets are modified**.

Probably difficult to find a similar signature in pp – but similar to effects from Quark-Gluon Plasma models.

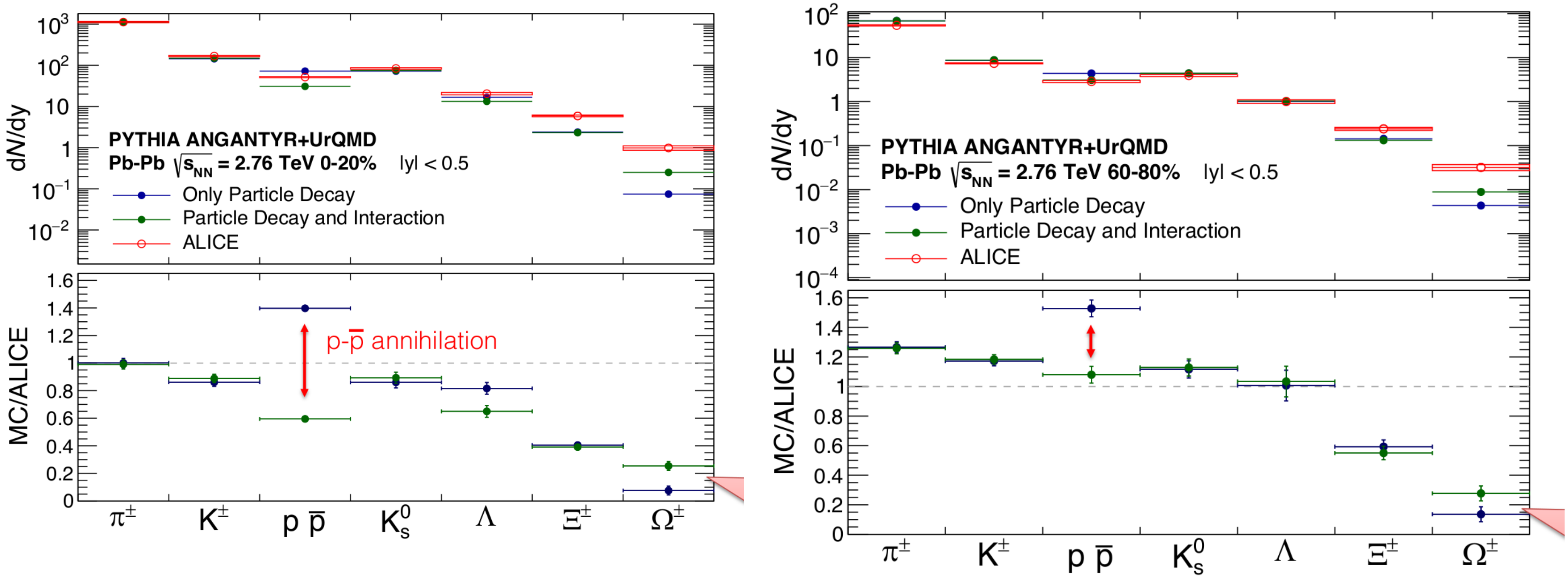


Hadrochemistry

Different rescatterings have different cross sections.

Some modeling, but **mostly parameterized data**.

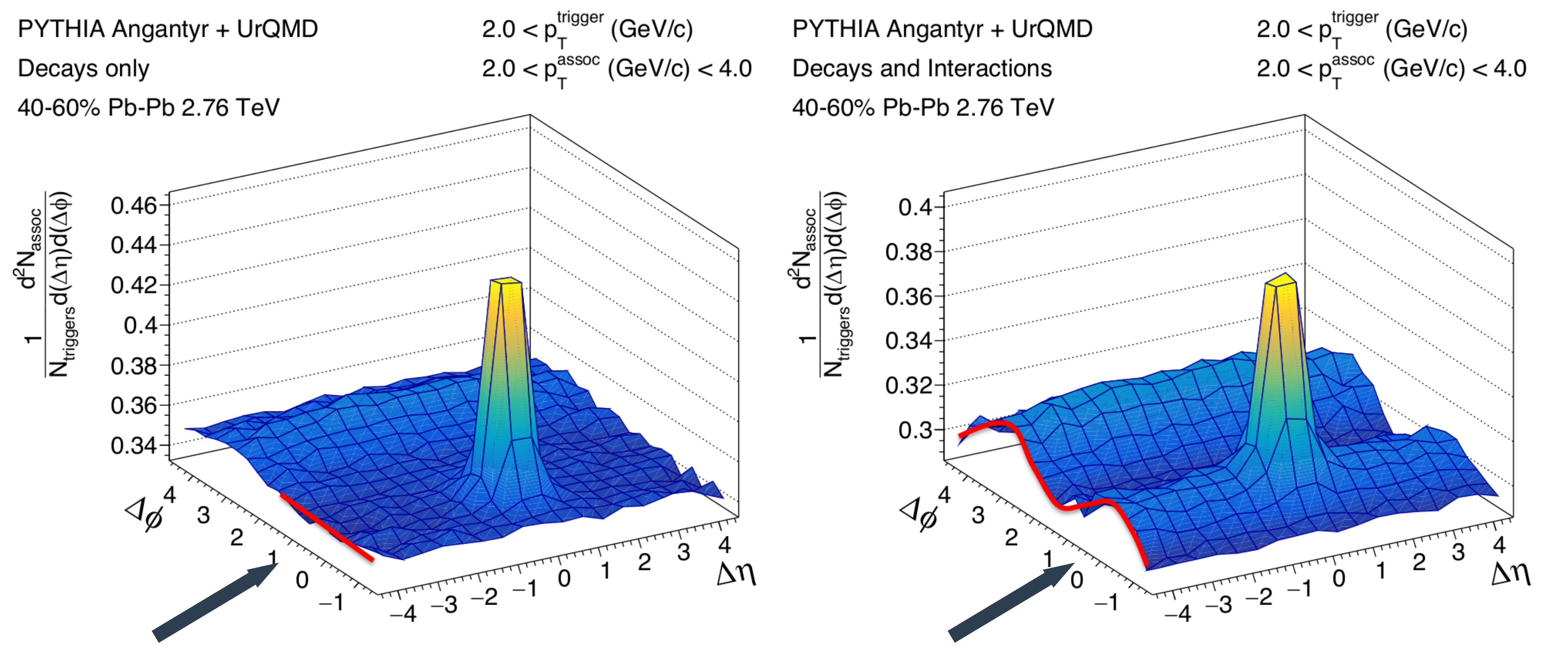
Quite **interesting for hadronization models**, also in pp



Flow

Clear **double ridge** from hadronic rescatterings.

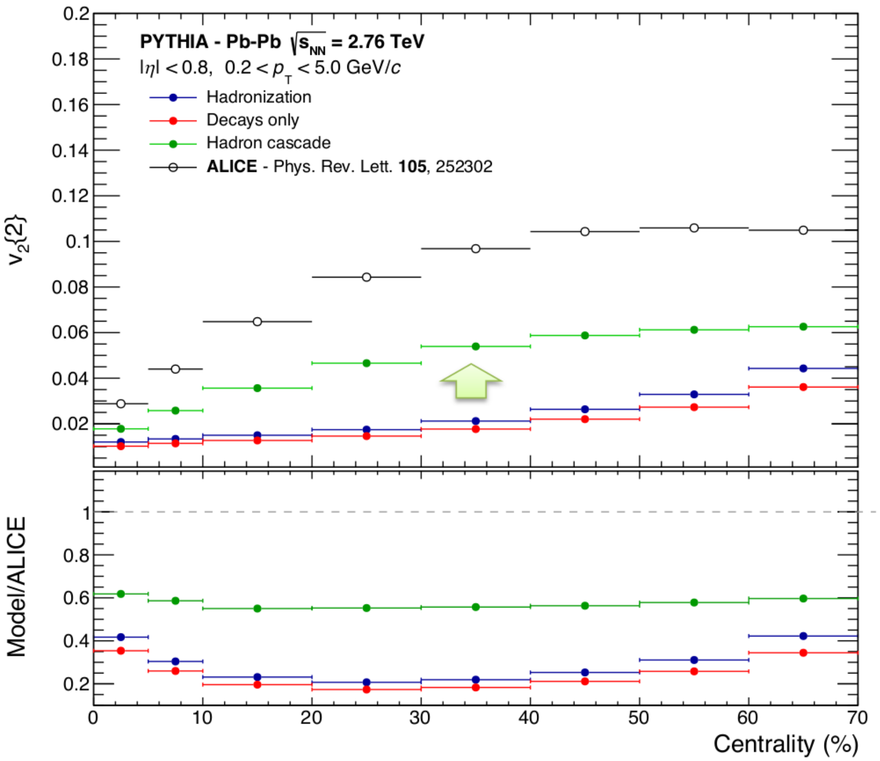
Quantitative argument against “long range in η ~ early times”.

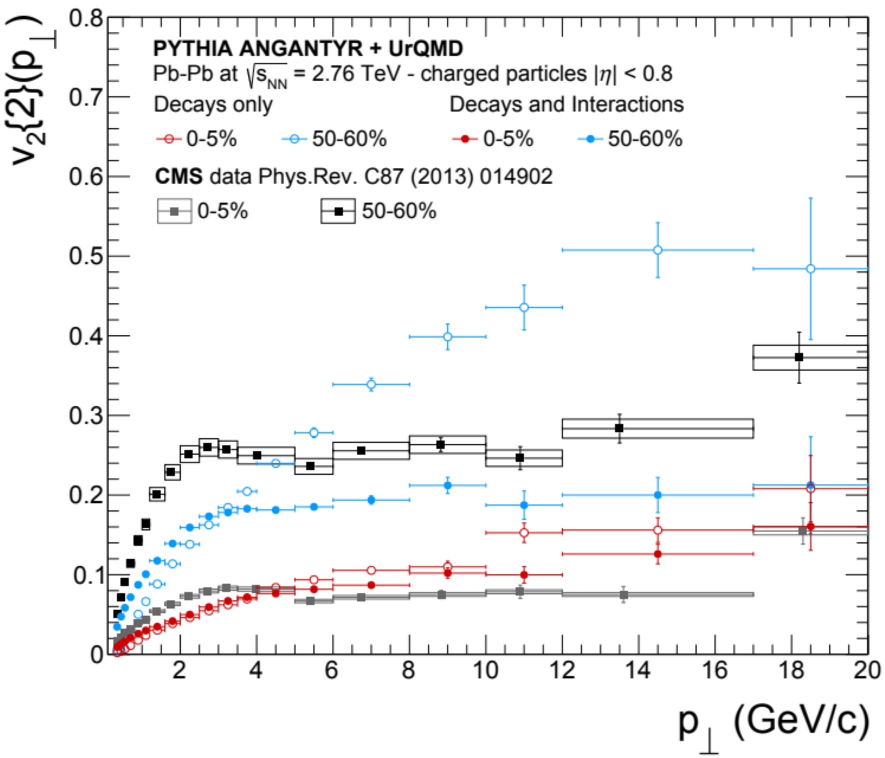


Flow II

Not enough to describe data…

But leaves **significantly more room for other models** to play!





Summary

Well known physics effect **non-negligible in heavy ions**...
...**will it continue to be negligible in pp**?

My guess: *People interested in soft QCD will need to start thinking about this!*

A MC venturing into the heavy ion world will need to take this into account.

Also a project made possible by the existence of Open Source code!

For the future: Cleaner interfaces are needed, many codes (URQMD, SMASH, PYTHIA) already exist – perhaps more will come.

Thank you for the attention!