Deciphering Jet Quenching Effects with Novel Reclustering Tools

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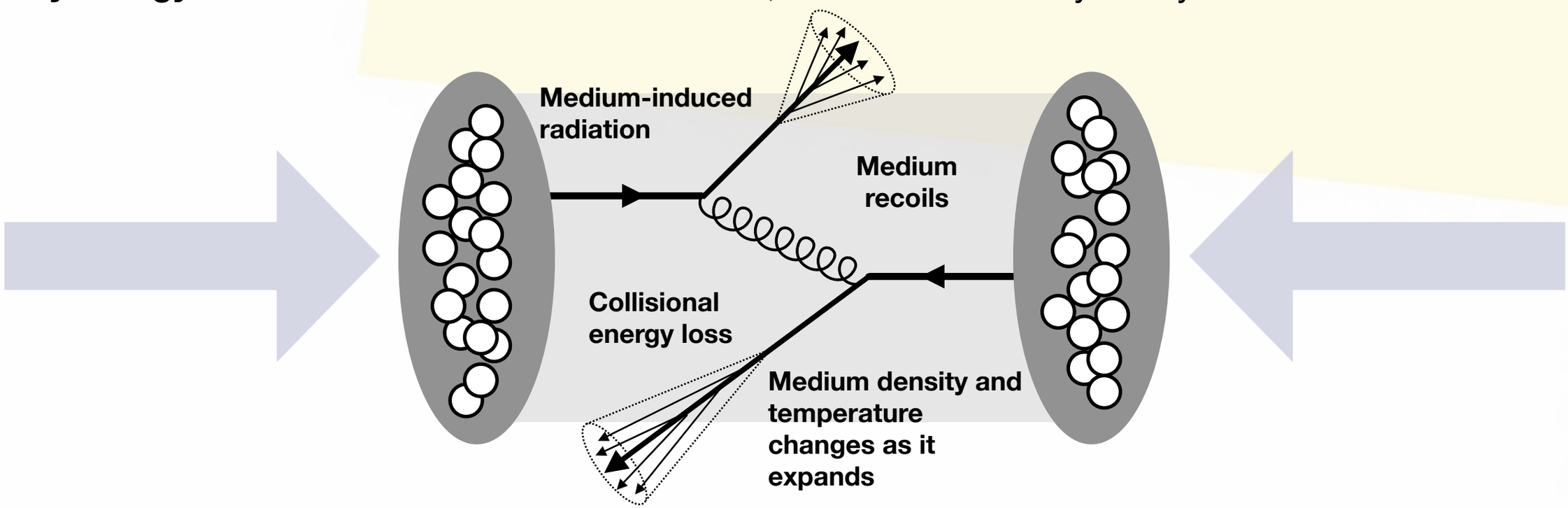
- **Jet Quenching**: one of the main signals of the formation of **Quark Gluon Plasma** in Heavy Ion Collisions.
- **Many energy loss mechanisms** to be considered, some of them not yet fully understood:

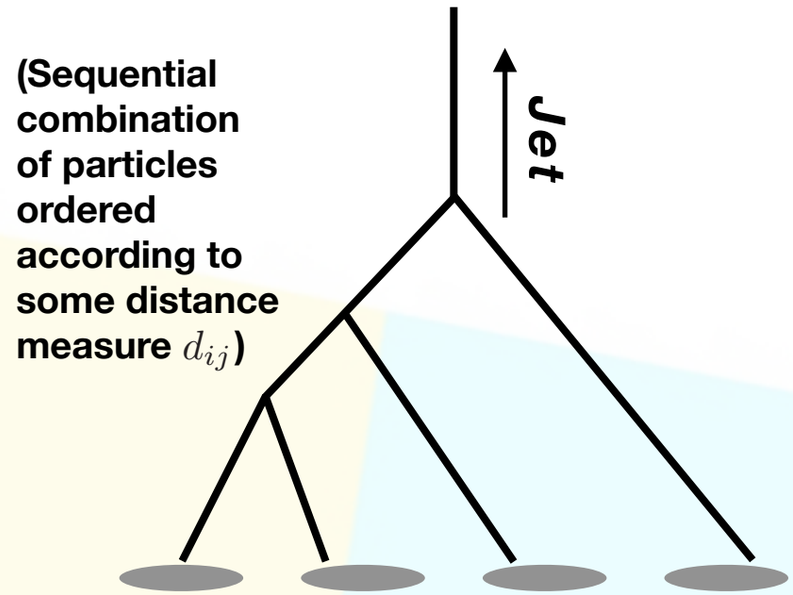


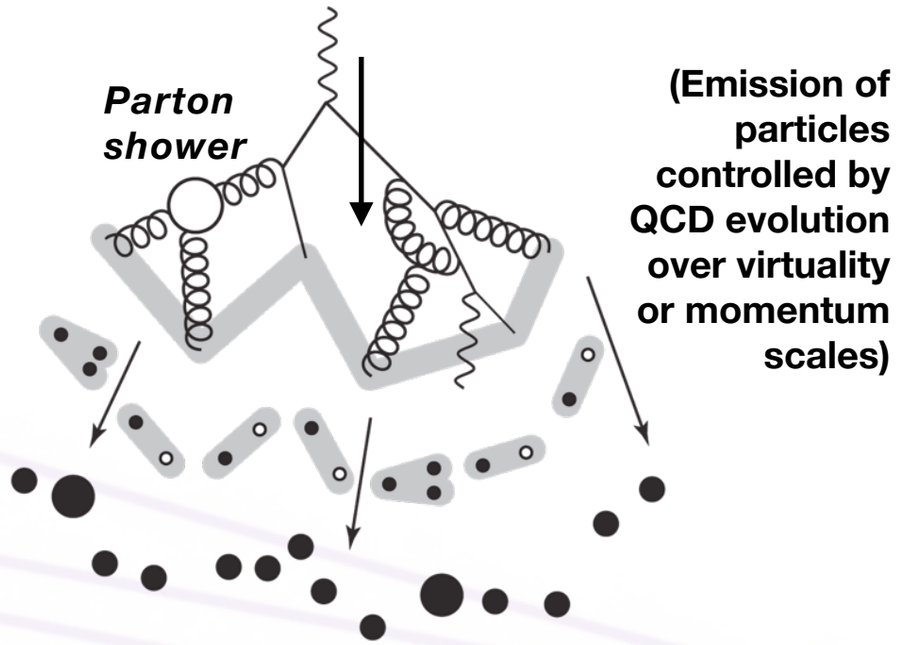
- In general, these effects depend on the **physical properties of the medium** (such as its density or its temperature).
- However, current Jet Quenching observables:

  - **don't** discriminate between different energy loss mechanisms
  - **don't** distinguish different degrees of quenching
  - **don't** take into account the fast time expansion of the QGP

- In addition, **jet selection biases** make the interpretation of jet measurements challenging.

- Possible solution: use of **Jet Substructure measurements**
- We use jet information to **reconstruct the parton shower** branching by branching:





- For this purpose we use the **generalized** k_t **algorithm:**

$$d_{ij} = \min(p_{t,i}^{2p}, p_{t,j}^{2p}) \frac{\Delta R_{ij}^2}{R^2} \qquad d_{iB} = p_{t,i}^{2p}$$

$$p = 0 \longrightarrow \text{C/A}$$
$$p = -1 \longrightarrow \text{Anti-}k_t$$
$$p = 1 \longrightarrow k_t$$

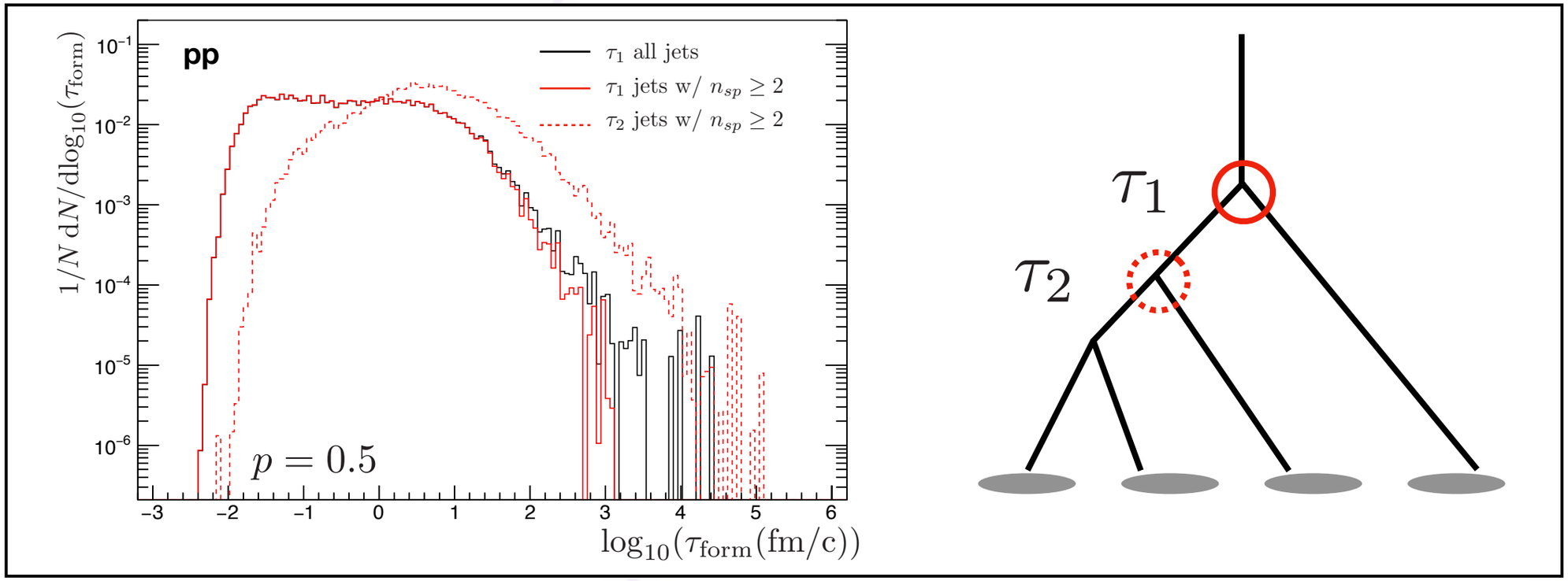
- Additionally, we apply **SoftDrop** to reduce contamination from uncorrelated underlying event activity

- We propose using $p = 0.5$. With this setup:

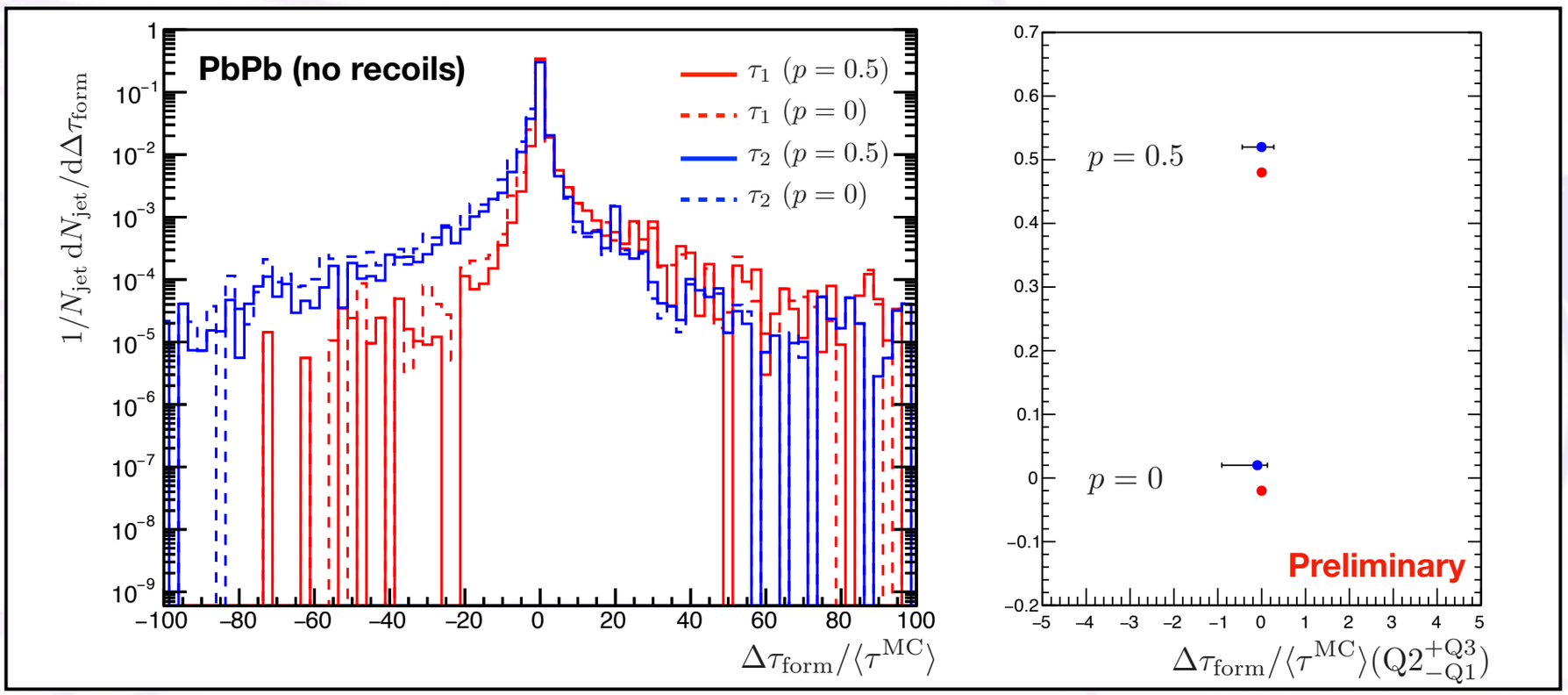
$$d_{ij} \sim p_{T,i}\theta^2 \sim \frac{1}{\tau_{\text{form}}} \quad \text{, with} \quad \tau_{\text{form}} \approx \frac{E}{Q^2} \overset{\text{(High energy limit)}}{\approx} \frac{1}{2Ez(1-z)(1-\cos\theta_{12})}$$

- **Can we use this** d_{ij} **as a proxy for the time scale at which each splitting takes place?**

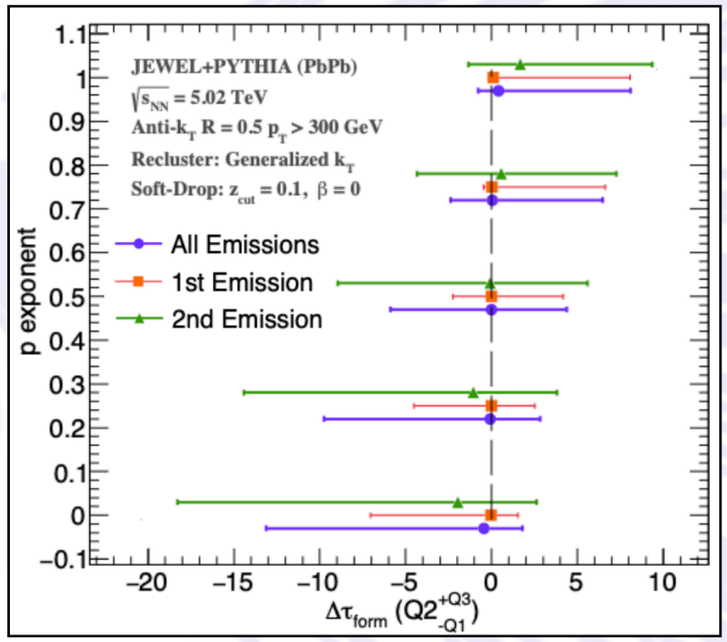
- We want to quantify the correlation between the values of τ_{form} obtained through our **unclustering** algorithm and those extracted from MonteCarlo-implemented parton showers.



- We look at $\Delta\tau = \tau_{\mathrm{form}}^{\mathrm{MC}} - \tau_{\mathrm{form}}^{\mathrm{Unclustering}}$:



Previous results:



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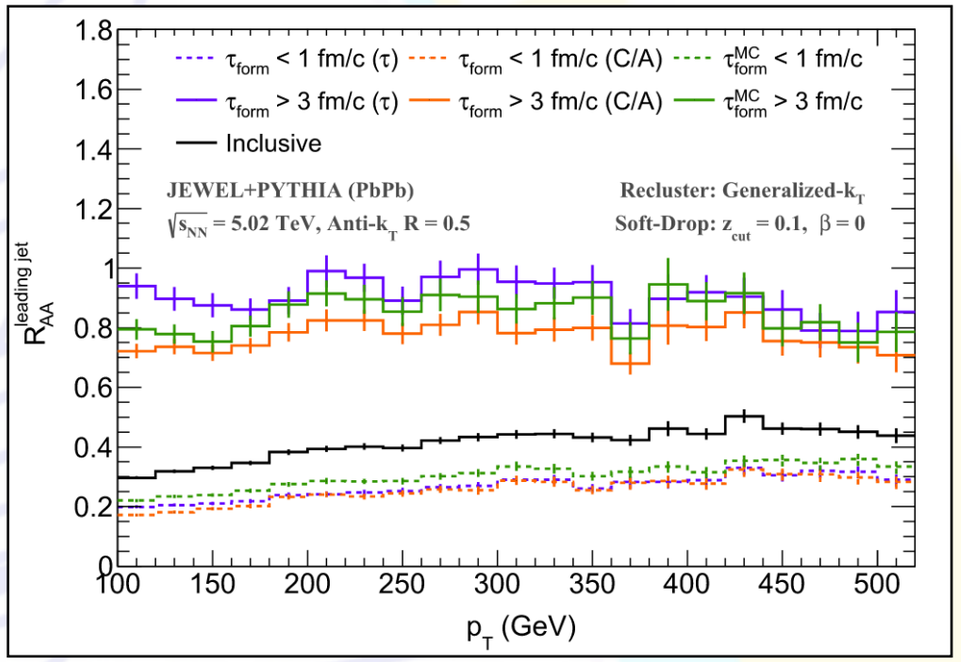
- Example of application of τ -algorithm: **Jet Classification**. We define two populations according to the value of $\tau_{\text{form}}^{\text{Unclustering}}$ for the first splitting: **early** (first 1 fm/c) and **late** jets (after 3 fm/c).

- Another possible classification: **pre-equilibrium** jets (first 0.6 fm/c), **QGP evolution** (between 0.6 and 5 fm/c), and outside the medium (after 5 fm/c).

- We examine the **groomed shared momentum fraction**:



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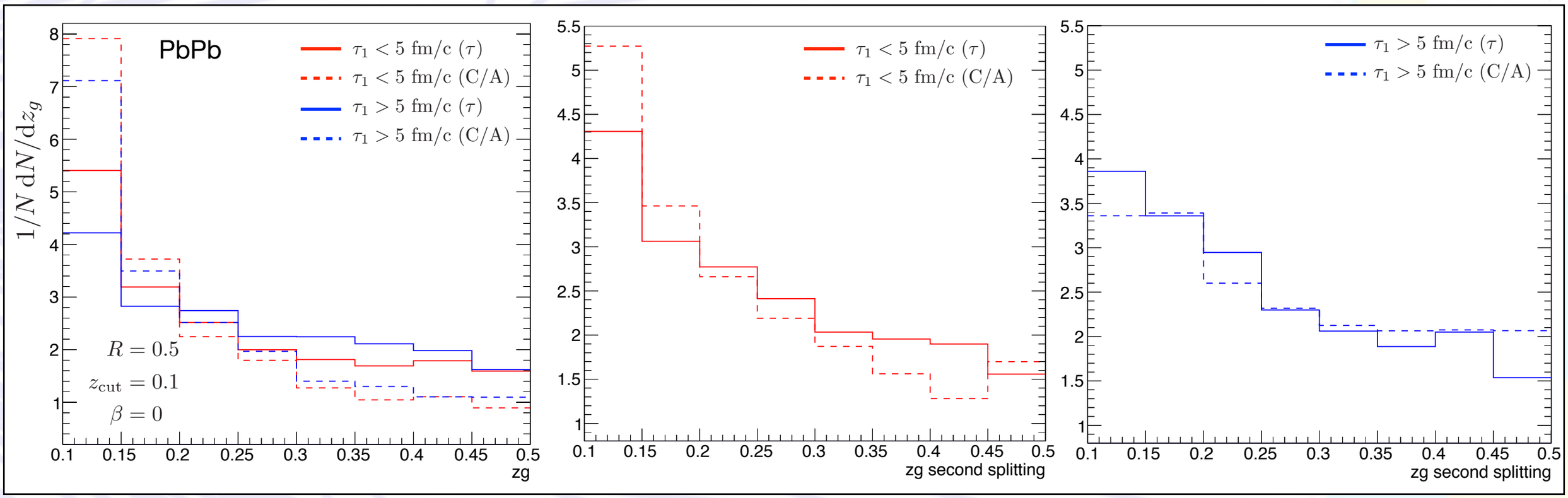
$$z_g = \frac{\min(p_{t1}, p_{t2})}{p_{t1} + p_{t2}}$$

With SoftDrop:

$$z_g > z_{cut} \left(\frac{\Delta R_{12}}{R_{jet}} \right)^{\beta}$$

Preliminary



Summary, future prospects

- In 'global' jet measurements we are implicitly averaging over **1)** all energy loss mechanisms, **2)** all jets, quenched to different degrees, and **3)** all stages of the QGP expansion.
- These averages, along with jet selection biases, obscure the interpretation of jet quenching results.
- A possible solution is having a **Jet classifier** that allows us to select quenched jets.
- We propose the τ_{form} of the first emission inside a jet reclustered with the τ-algorithm (i.e. generalized k_t-family with $p = 0.5$).
- This method allows us to identify jets formed at **early** or **late** times, as well as **inside** or **outside** the medium.
- This method **also** allows us to identify τ_{form} for the **second splitting** with reasonable IQR.
- *Work in progress:* Establishing the relation between our $\tau_{\mathrm{form}}^{\mathrm{Unclustering}}$ and the lifetime of the medium, repeating analysis for **photon+jet** events, including medium recoil…

A step towards QGP Tomography!