Shane Sweetman

Project update meeting
Week 4

A TMD-oriented analysis of $\pi^+\pi^-$ pairs in e^+e^- collisions

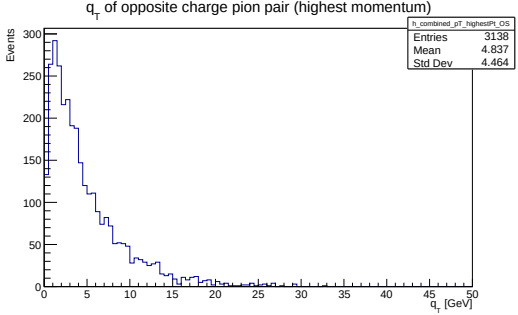
Outline

- Replace beam-axis transverse momentum with a **thrust-axis** definition.
- **Zoom** into the small-q_T region (focus plots on $q_T < 20$ GeV).
- Identify **Monte Carlo parameters** that change the low-q_T shape.

Before vs after: Highest OS (q_T beam-axis vs thrust-axis)

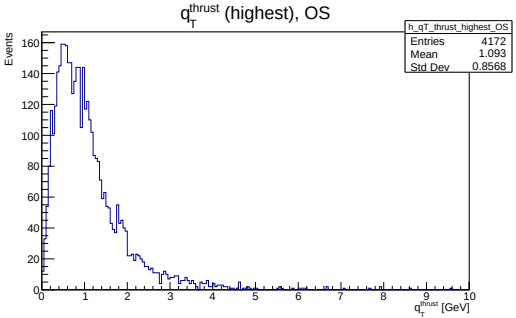
Before (beam axis) — Week 2

Highest-p_T OS spectrum (beam-axis q_T).



After (thrust axis) — 20k

Highest-p_T OS spectrum with thrust-axis q_T^{thrust} (20k events).



Thrust axis: the event's natural 2-jet direction

What thrust is

Thrust finds the axis $\hat{n}_T$ that makes the event look as "two-jet-like" as possible:

$$T \equiv \max_{\hat{n}} \frac{\sum_i |\vec{p}_i \cdot \hat{n}|}{\sum_i |\vec{p}_i|}.$$

If most momentum lies along one line (two back-to-back jets), then $T \to 1$. Because of the absolute value, $\hat{n}_T$ and $-\hat{n}_T$ describe the same axis.

What we use to compute it (in our analysis)

- Use **final, visible** particles from the event (no neutrinos).
- This is the same particle set used for jets, so the thrust axis is a **consistent event axis**.

Source: E. Farhi, Phys. Rev. Lett. 39 (1977) 1587.

How thrust fixes the "beam-q_T" problem

How the axis is found (high level)

We try many possible directions $\hat{n}$ on the sphere and pick the one that maximizes the thrust formula. Then we keep events with **large thrust** (e.g. $T > 0.8$) so the axis is stable and the event is truly 2-jet-like.

How we define transverse momentum

Once we have $\hat{n}_T$, "transverse" means *perpendicular to that axis*:

$$\vec{p}_T^{(T)} = \vec{p} - (\vec{p} \cdot \hat{n}_T)\hat{n}_T, \qquad q_T^{\text{thrust}} = \left| (\vec{p}_{\pi_0} + \vec{p}_{\pi_1})_T^{(T)} \right|.$$

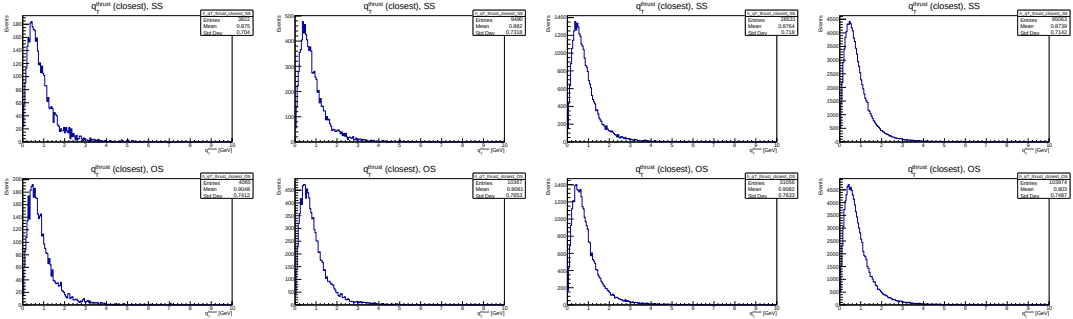
Takeaway

In e^+e^-, the 2-jet system is not aligned with the beam, so beam-axis transverse momenta can look artificially large. Using the **thrust axis** makes q_T measure the **imbalance inside the 2-jet event**, which is the TMD-motivated quantity.

Source: E. Farhi, Phys. Rev. Lett. 39 (1977) 1587; Z.-B. Kang *et al.*, arXiv:2007.14425.

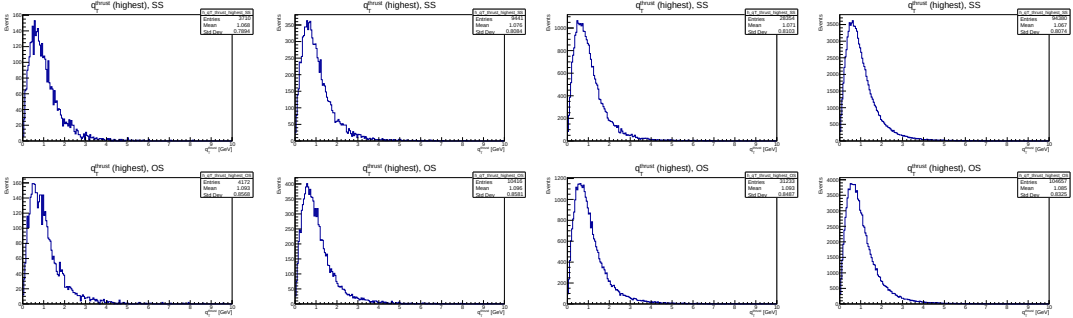
Event-number scan: closest selection (SS vs OS)

Columns: 20k 50k 150k 500k (top row = SS, bottom row = OS)



Event-number scan: highest-p_T selection (SS vs OS)

Columns: 20k 50k 150k 500k (top row = SS, bottom row = OS)



Monte Carlo parameters to vary

Shower (radiation)

- Radiation strength / scale choices (controls broadening).
- Shower cutoffs (controls how much soft/collinear activity is generated).

Hadronisation (string fragmentation)

- String transverse momentum width (controls intrinsic smearing).
- Lund fragmentation parameters (controls z and momentum sharing).

Questions?