Background Subtraction Methods on Recoil Jets from Proton-Proton Collisions

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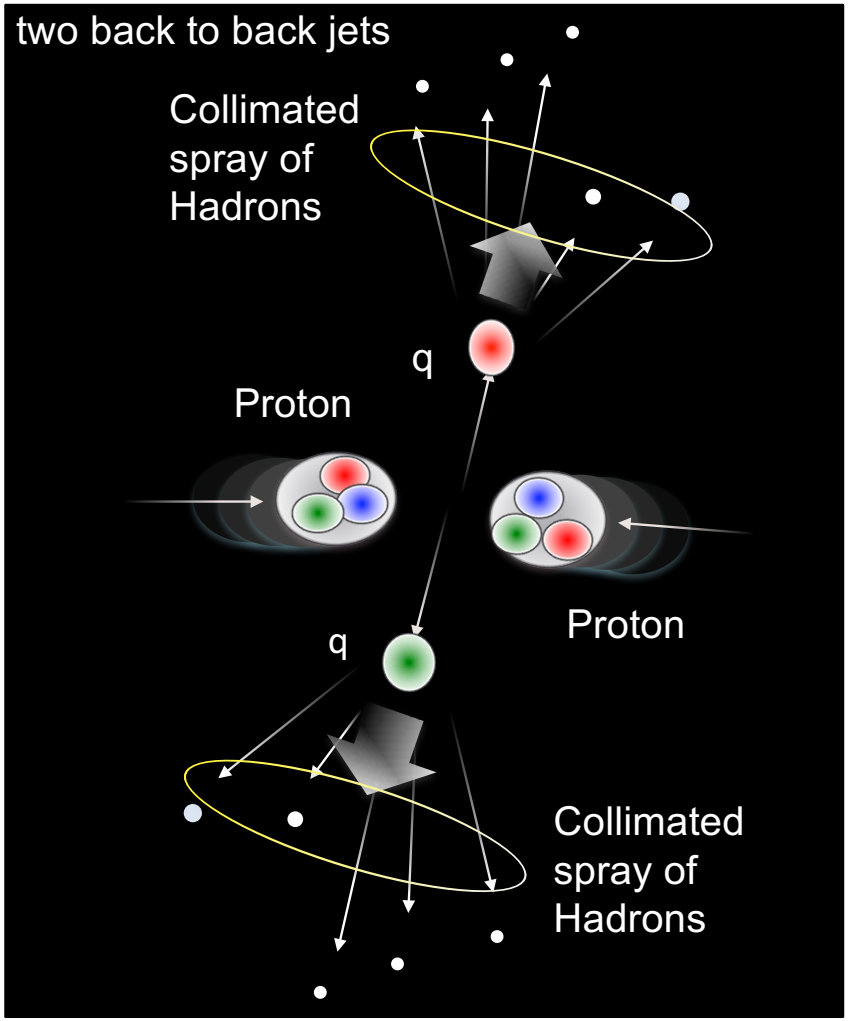
Motivation

- At the RHIC, heavy ions collide at high energies creating “jets” of hadrons.
- These collisions also create a medium of Quark Gluon Plasma (QGP) which the jets travel through.
- Jets are used as a probe of QGP, proton-proton collisions provide a baseline reference since there is no medium present.

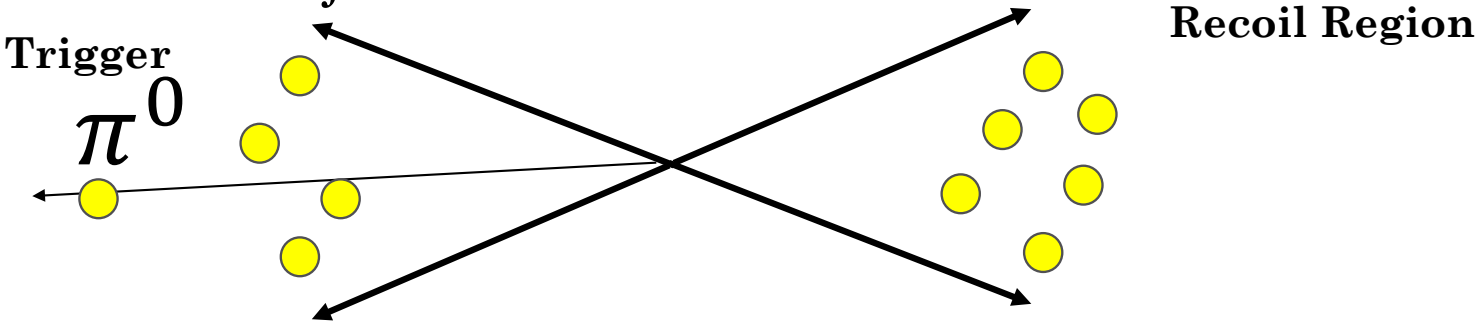
What is a Jet?

- The result of partons interacting in high energy collisions.
- Strong force energy creates partons which then pair, due to confinement, to form hadrons.
- All collision energy does not go towards jets, uncorrelated particles are also produced, and appear in jet data.
- These uncorrelated particles are what is referred to as the background, and must be subtracted.



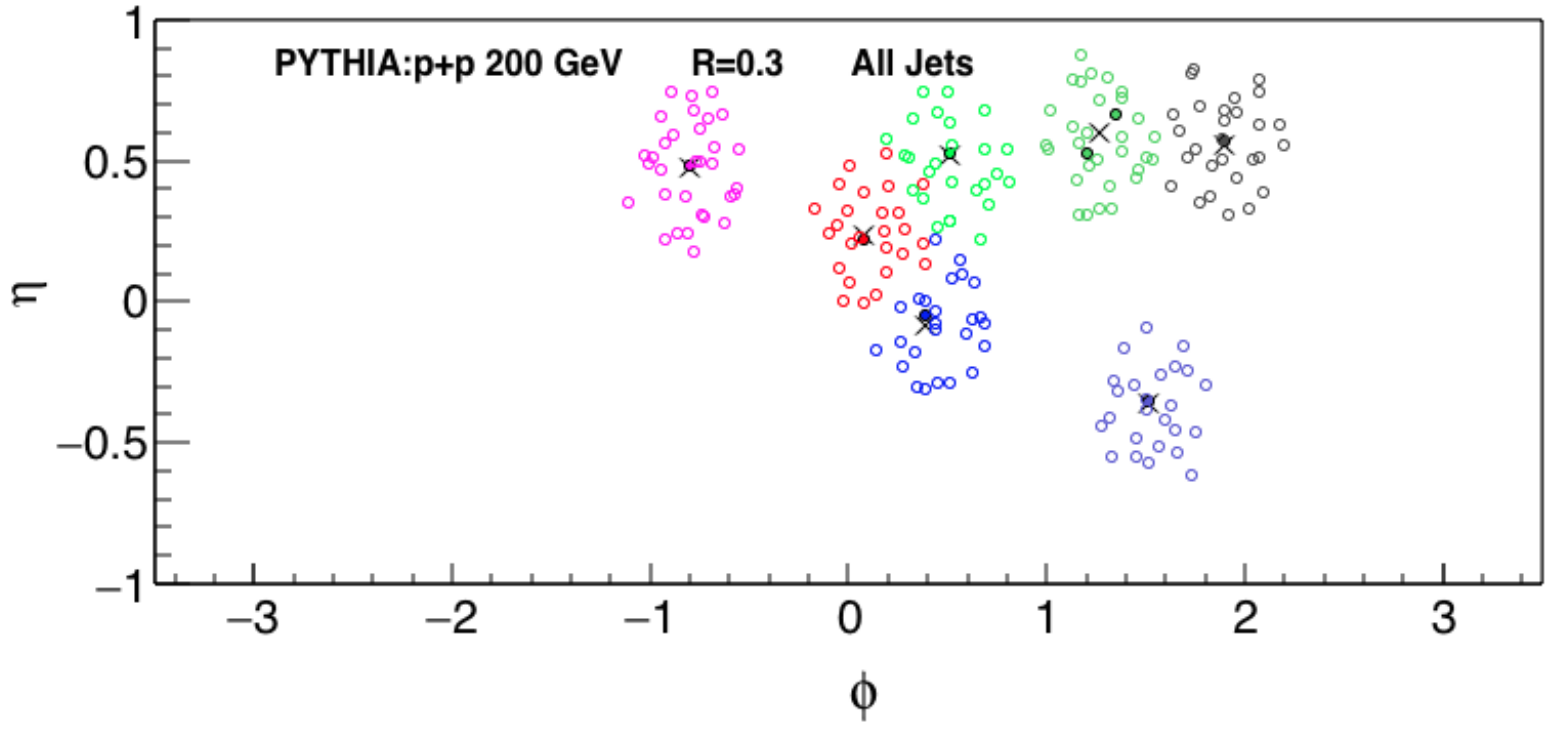
Specifics about data

- Proton-proton collisions with center of mass energy of 200 GeV, from runs at the RHIC in 2009
- Only focused on π^0 trigger recoil jets
- Trigger P_T range: 9 GeV < P_T Trigger < 30 GeV
- "Anti-kt" algorithm with the Jet Cone parameter, $R = \sqrt{\Delta\varphi^2 + \Delta\eta^2}$ = 0.3 (small radius = less background)
- Only charged particles of 0.2 GeV < P_T < 20 GeV used in reconstruction of jets



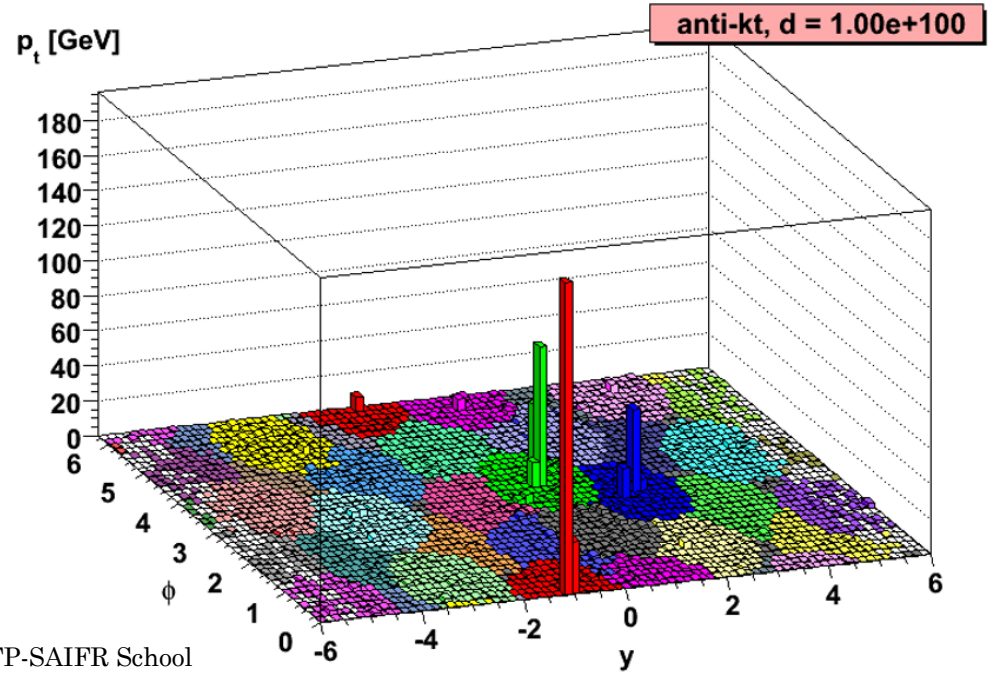
What jets look like in p+p collisions

Jet areas are not equal, R varies



Two types of background

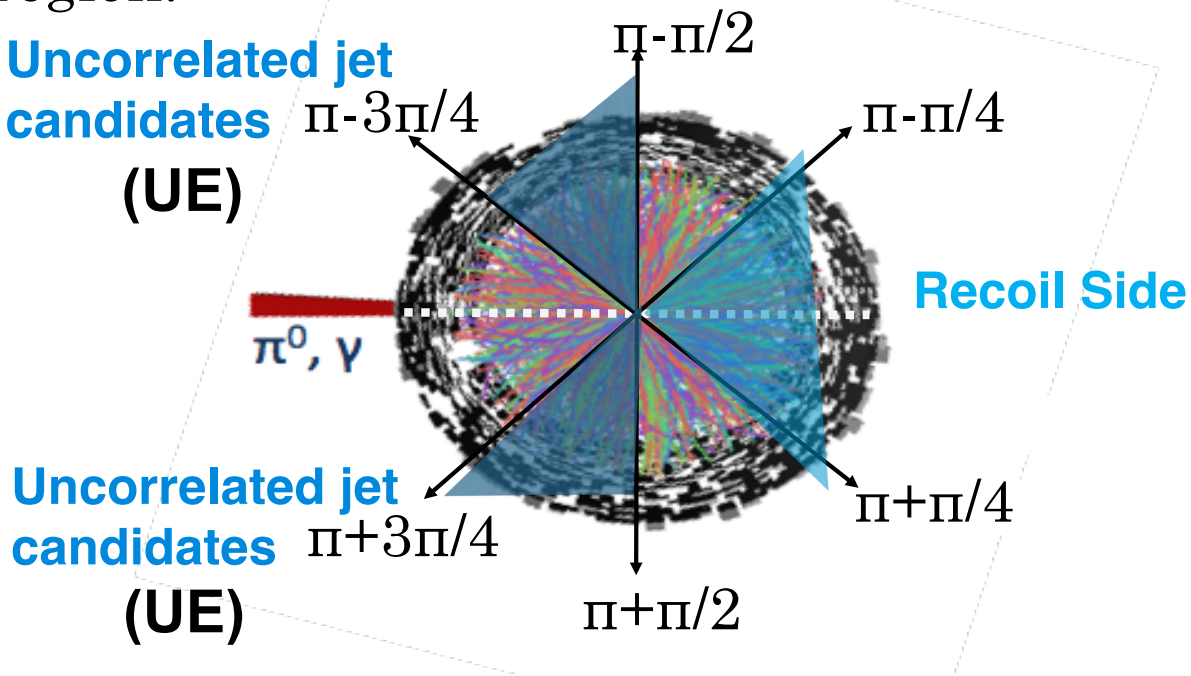
- "Combinatorial" jets: which consist of only uncorrelated "soft" (low energy) particles not related to hard jets
- Underlying event energy: soft particles that are found within reconstructed recoil jets



Method 1

(combinatorial subtraction)

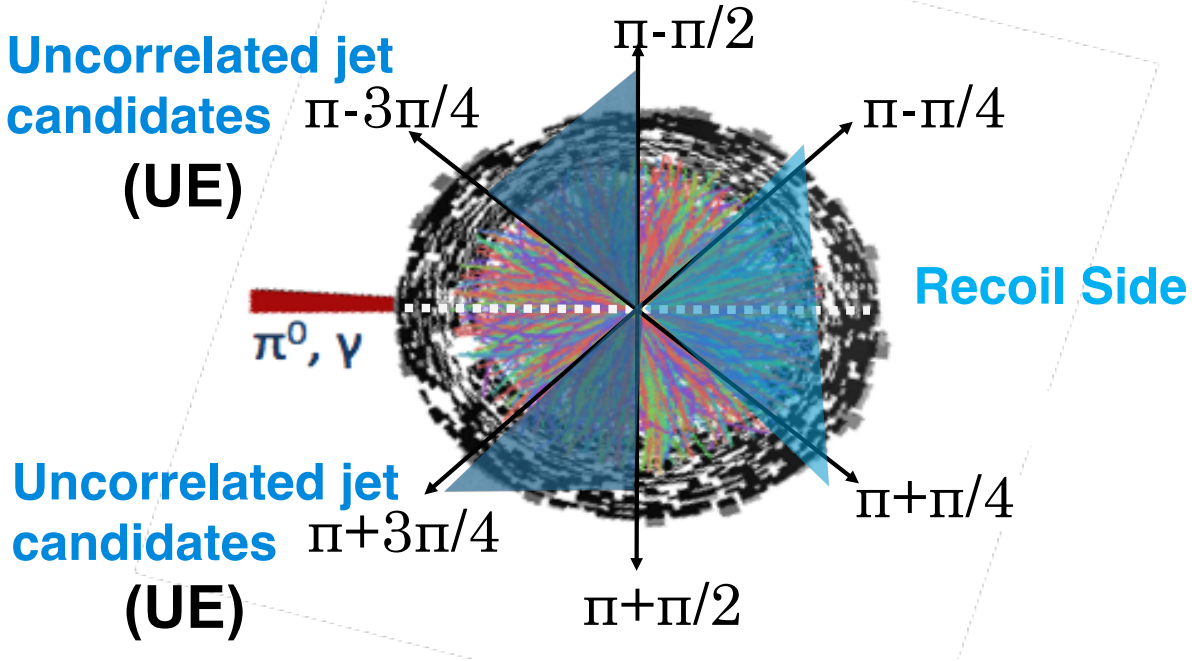
- A statistical subtraction where the energy distribution of combinatorial jets in the Uncorrelated Event (UE) region is subtracted from the energy distribution of jets in the recoil region.



Method 2

(Underlying energy subtraction)

Calculate the average P_T (Transverse Momentum) of reconstructed jets in the UE region as an estimate of the underlying energy. Then subtract from reconstructed jets in the Recoil region on a jet-by-jet basis.

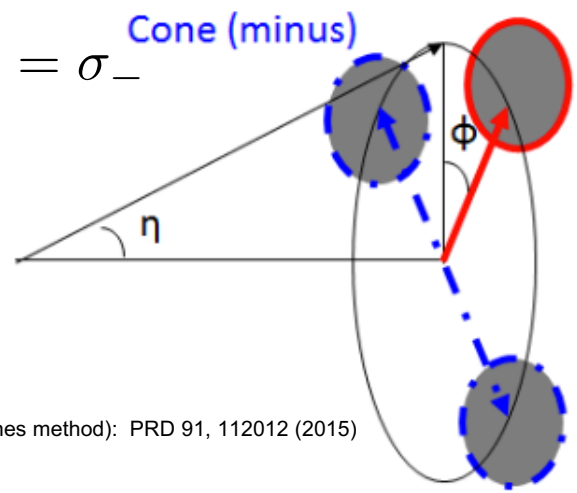


Method 3

(Underlying energy subtraction)

Calculate the average P_T of tracks in circular areas (πR^2 with R = 0.3) at φ +/- π/2 in respect to the recoil jet's φ. Subtract from recoil jet P_T on a jet by jet basis. (as in Zilong Chang's thesis and an ALICE paper)

$$\frac{\sum p_T^{trk}}{A_{con}} = \sigma_-$$

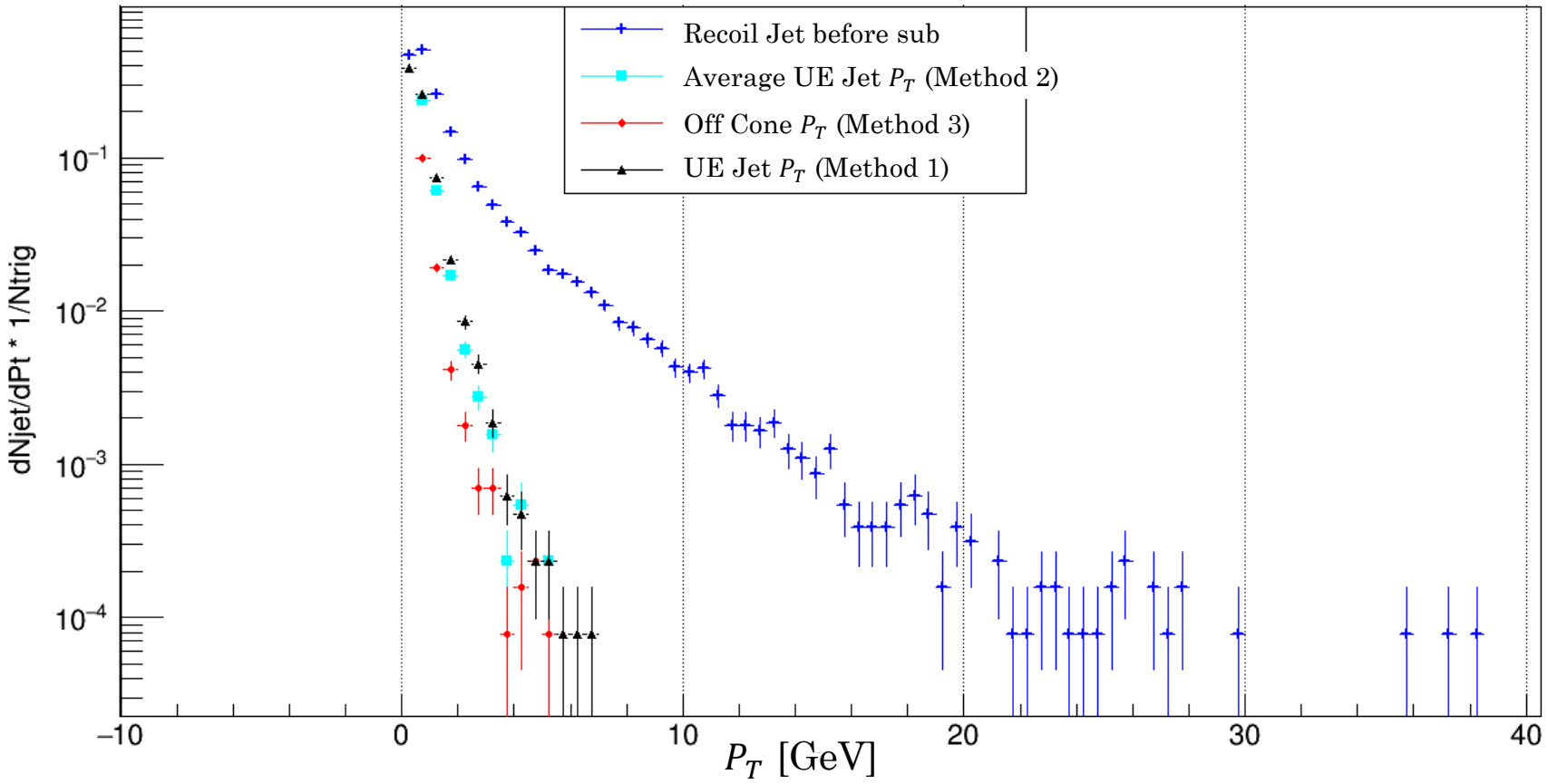


$$\frac{\sum p_T^{trk}}{A_{con}} = \sigma_+$$

ALICE (perpendicular cones method): PRD 91, 112012 (2015)

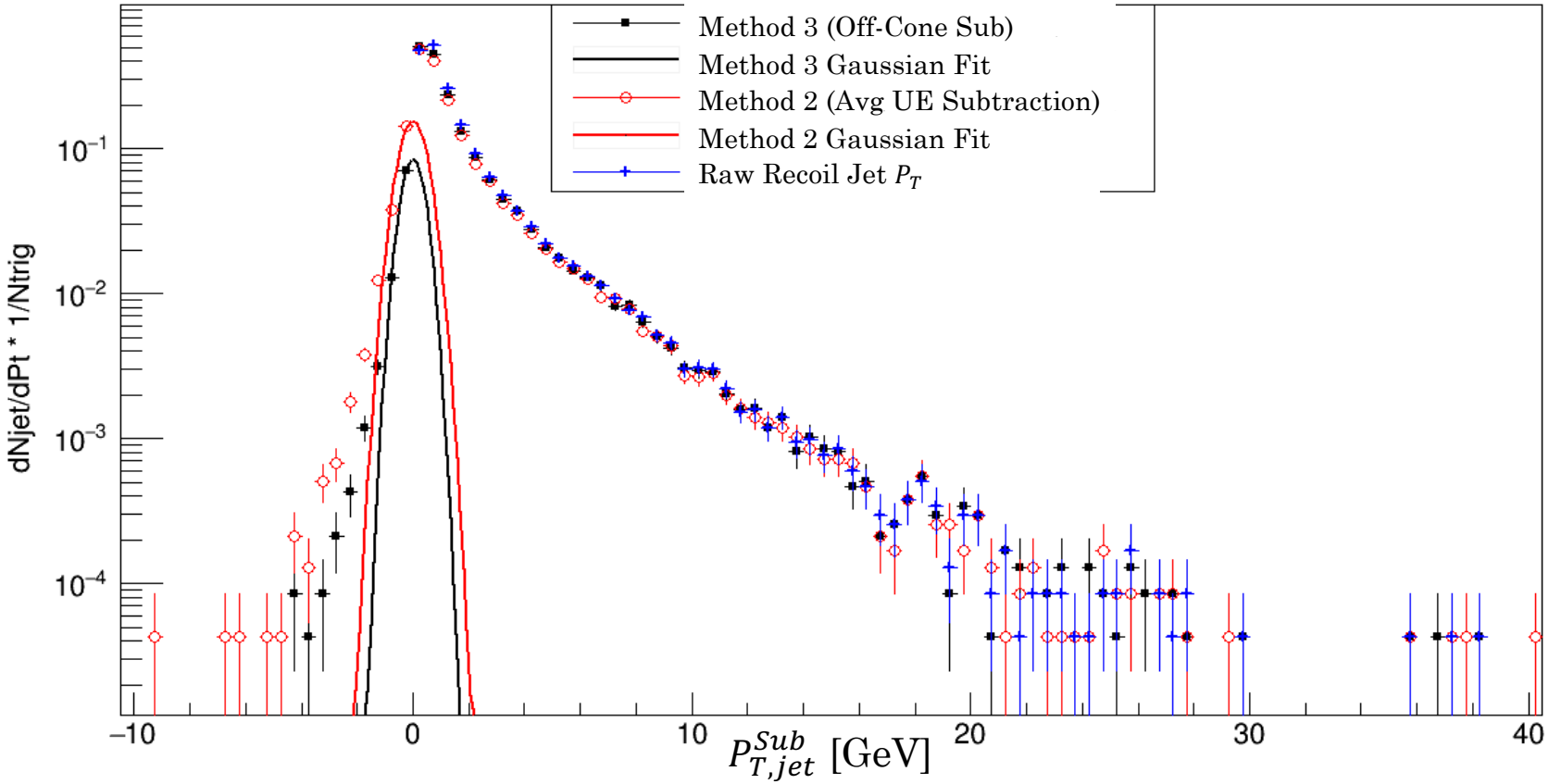
$$\sigma_{ave} = \frac{1}{2}(\sigma_- + \sigma_+) \qquad p_T^{bg} = \sigma_{ave} \times A_{jet}$$

P_T Distribution of Reconstructed Recoil Jets and Three Methods of Subtraction

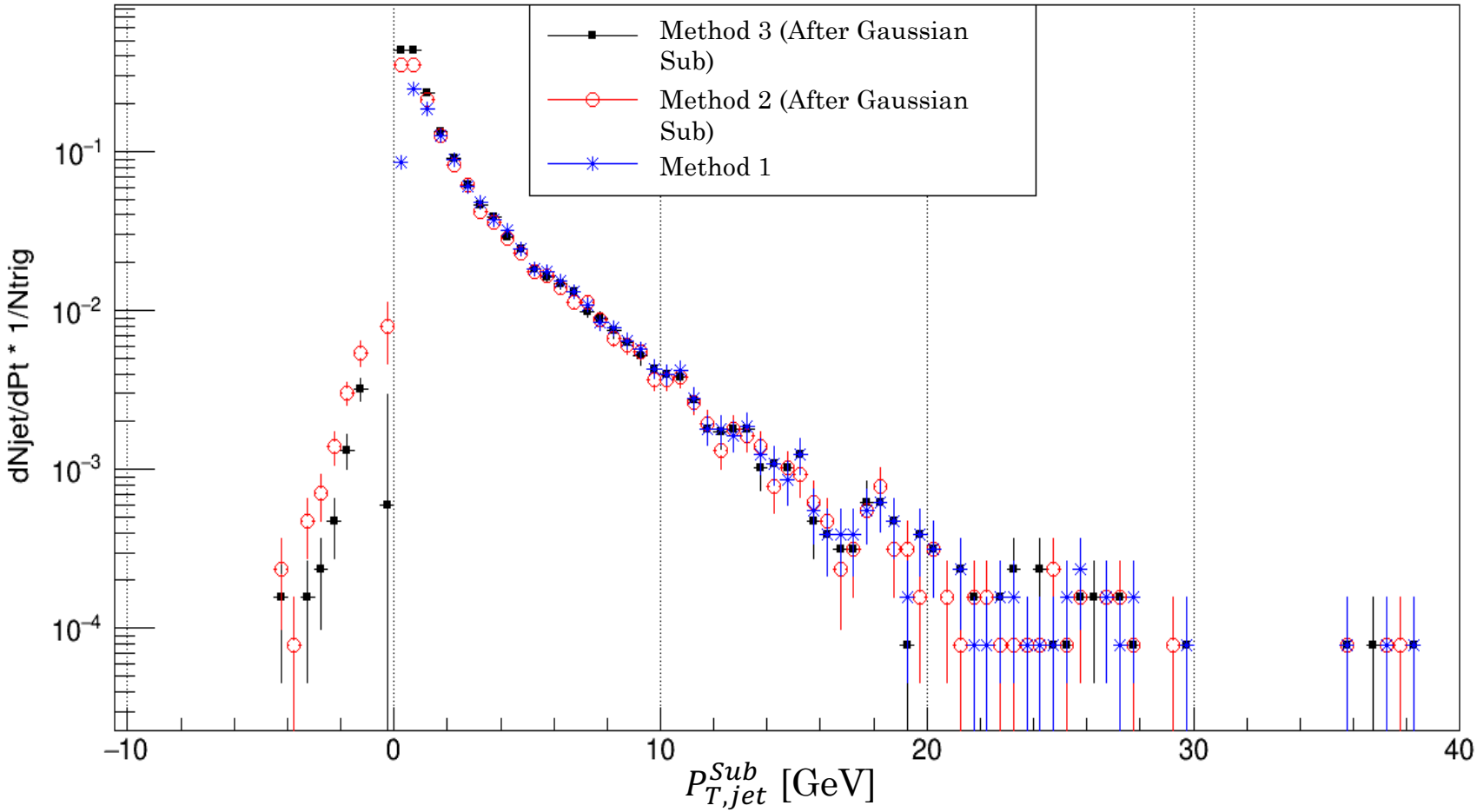


Method 2 & 3: After Underlying Event Subtraction

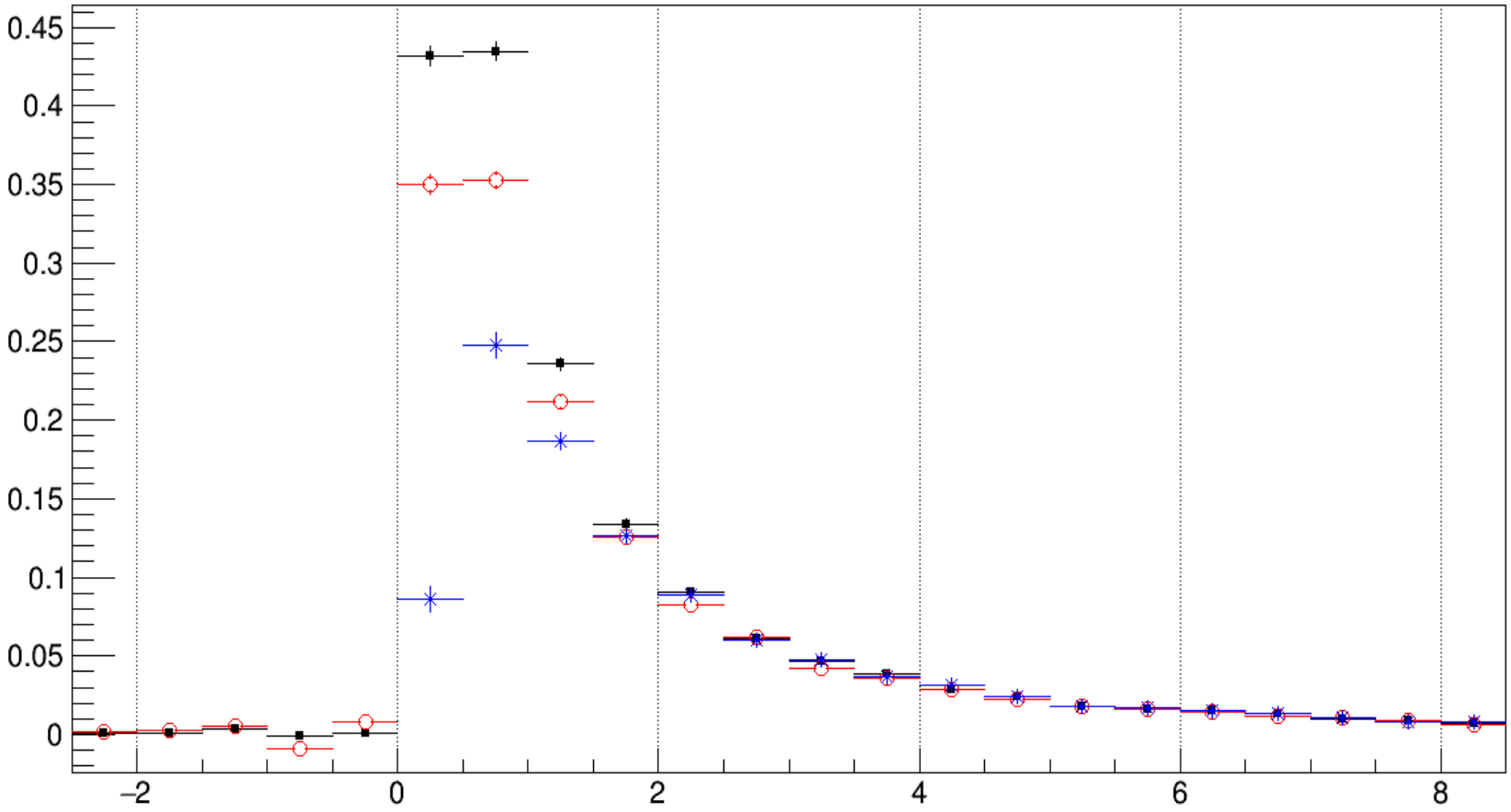
The points in the negative region are due to combinatorial jets which are dominated by background particles.



All Methods Compared After Gaussian Subtraction



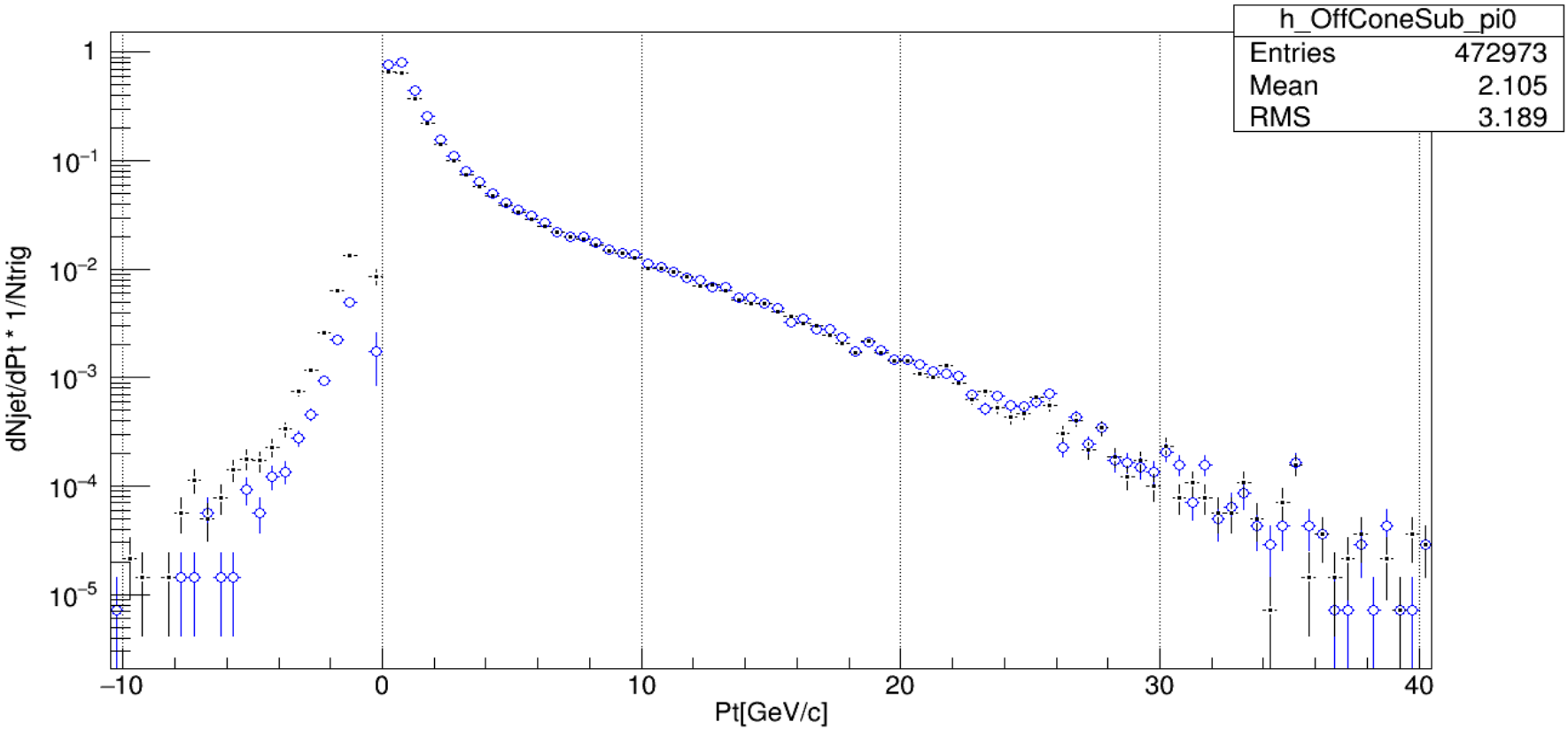
A zoom of the low P_T regime of all three methods



Methods used on Pythia simulation results

This compares methods 2 & 3

Plot displays same trend of low pT inconsistencies.



Conclusions

- 3 different methods were implemented in attempt to subtract the background from a jet energy spectrum.
- All methods are consistent within ~10% for P_T jet energy > ~1 GeV
- Methods 2 and 3 agree within 25%, and both agree with Method 1 within 50%, at energies down to ~0.5 GeV.
- Greater differences are seen at energies lower than 0.5 GeV, but jet spectra cannot be accurately measured below 1-2 GeV (Theory does not produce accurate calculations below 1-2 GeV).
- These results provide an estimate of the systematic uncertainties caused by background subtraction of jet spectra of proton-proton collisions .

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