

The Underlying Event at $\sqrt{s} = 500$ GeV at STAR

Grant Webb

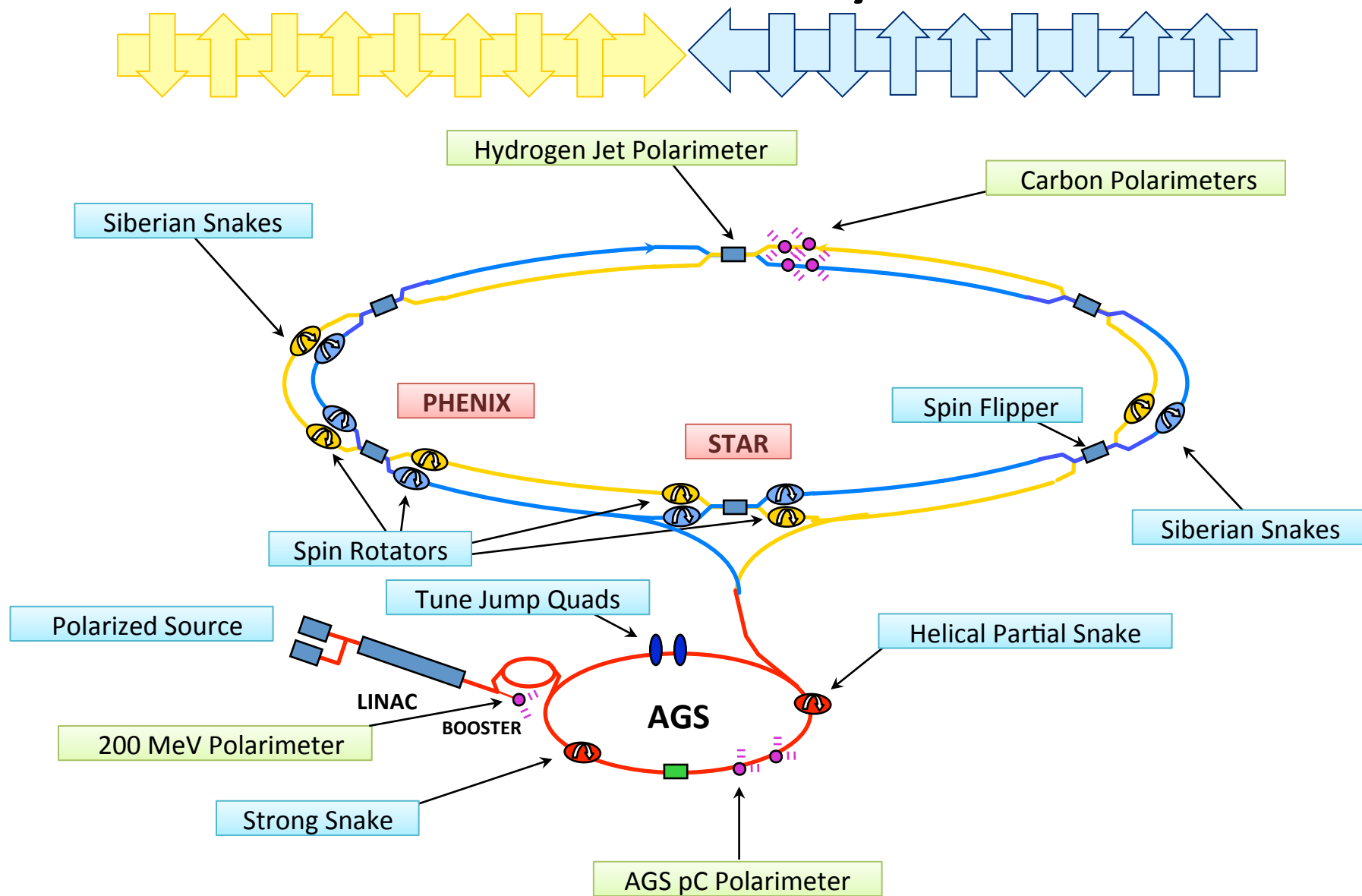
MPI 2015 - Trieste

November, 23 2015

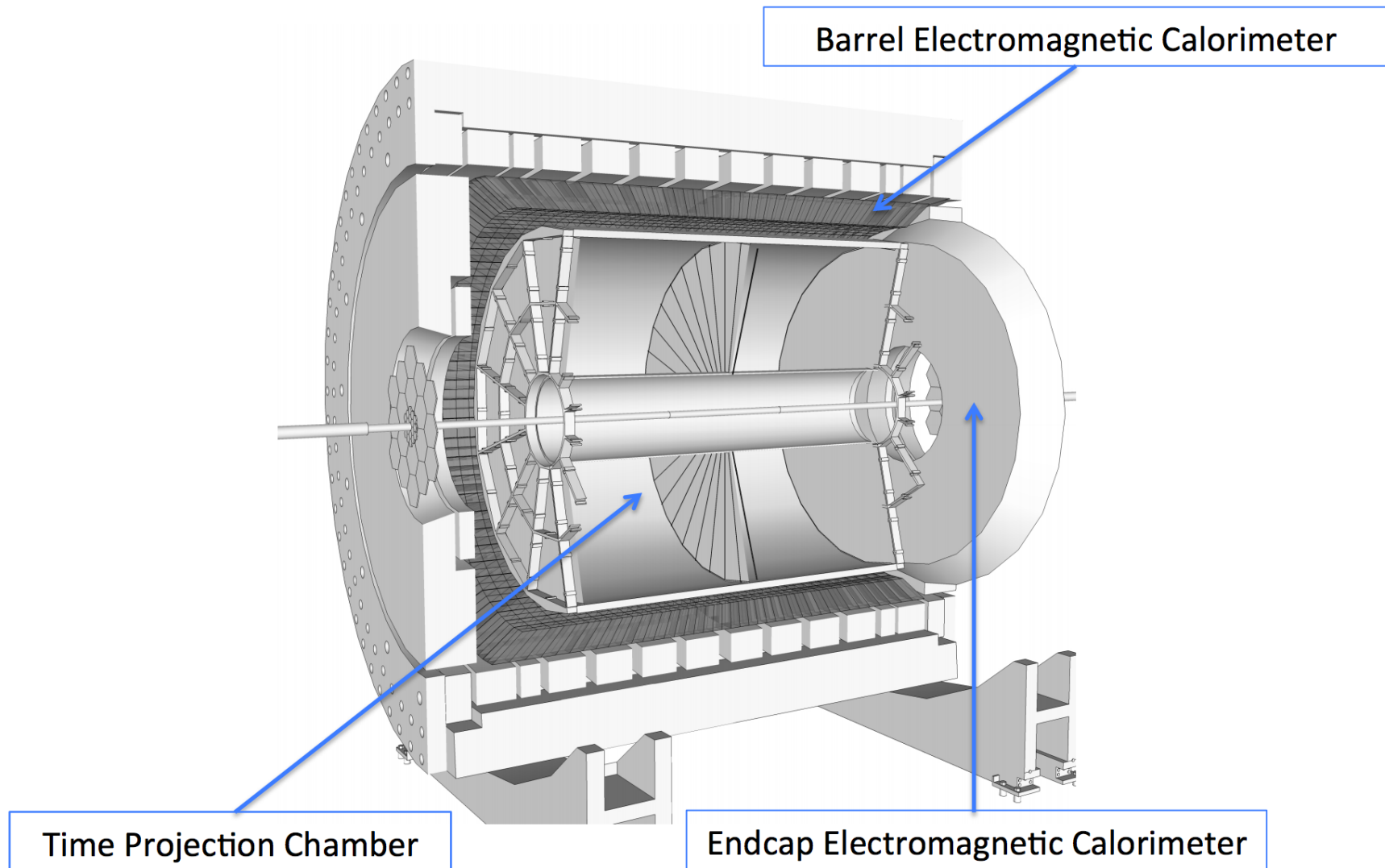
Outline

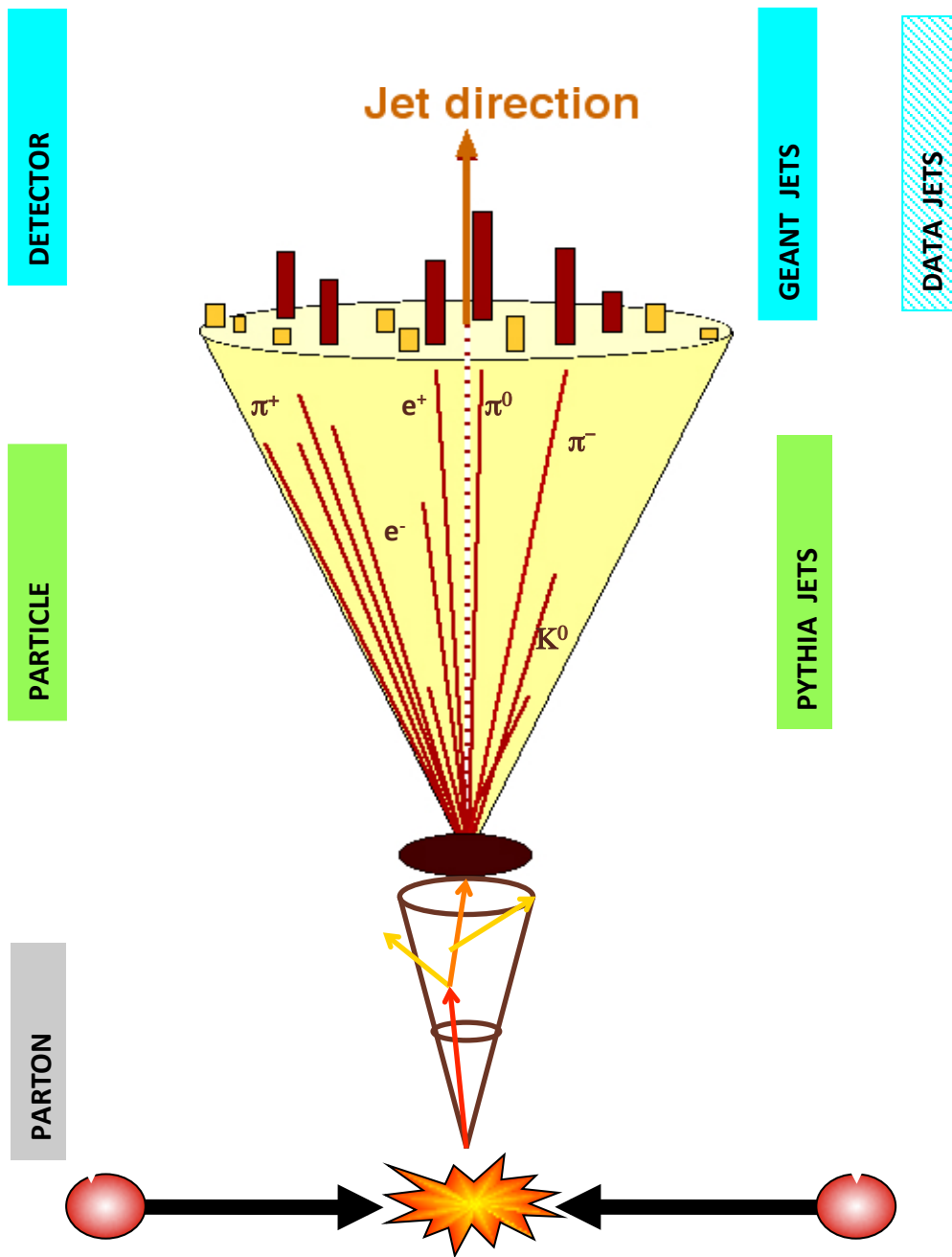
- RHIC/STAR review
- Event Selection
- Method to determine the Underlying Event
- Data/MC Comparisons
- Pythia Tune Study
- Spin Dependence of Underlying Event

The Relativistic Heavy Ion Collider



The Solenoid Tracker At RHIC





Jet Reconstruction

Anti- K_T algorithm

([arXiv:0802.1189])

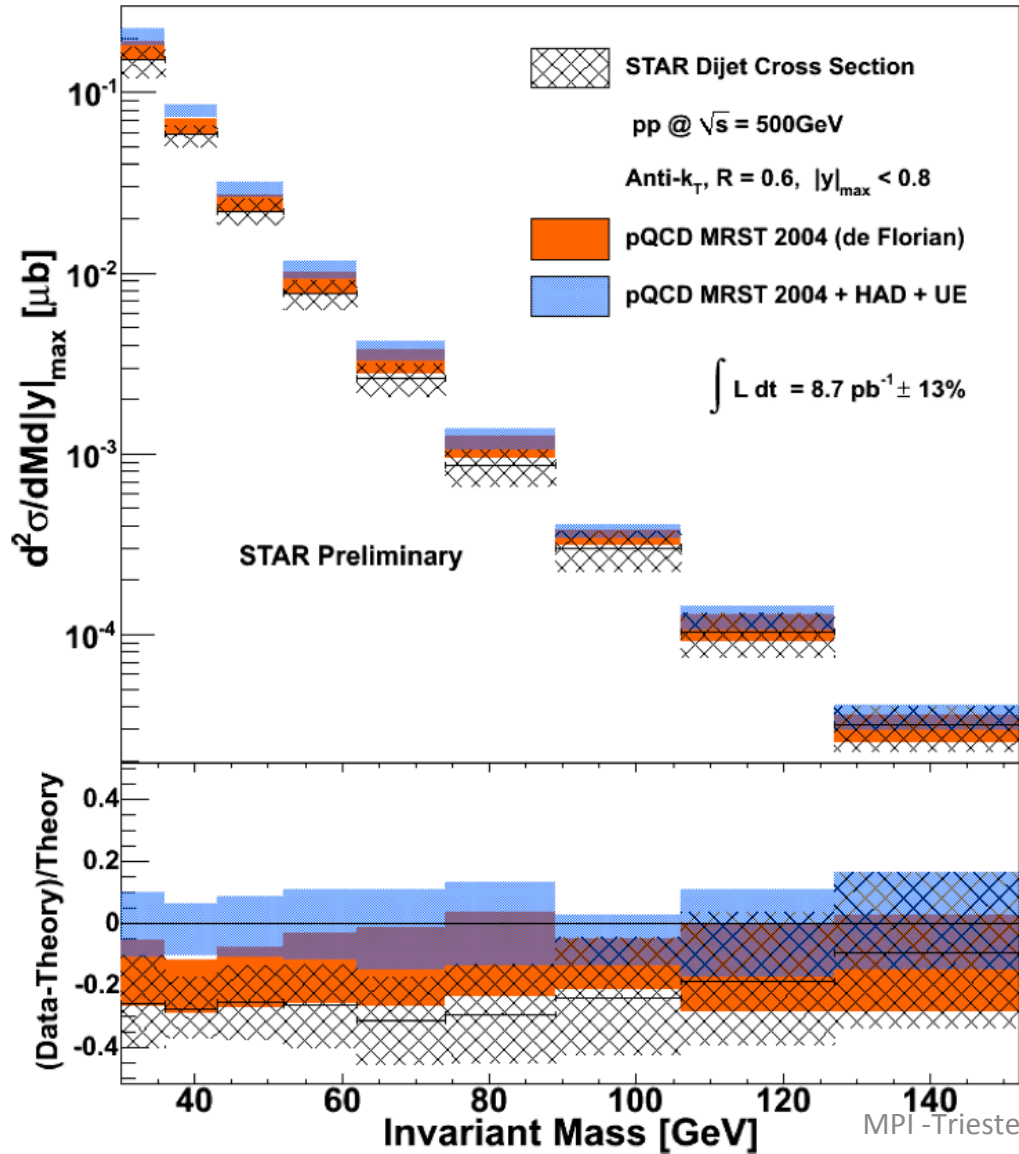
- Successive Combination
- Radius $R = 0.6$

$$d_{ij} = \min\left(\frac{1}{k_{Ti}^2}, \frac{1}{k_{Tj}^2}\right) \frac{\Delta R_{ij}^2}{R^2}$$

$$d_{iB} = \frac{1}{k_{Ti}^2}$$

Use **PYTHIA + GEANT** to quantify detector response

STAR Dijet Cross Section at 500 GeV



$$x_1 = \frac{1}{\sqrt{s}} \left(p_{T3} e^{\eta_3} + p_{T4} e^{\eta_4} \right)$$

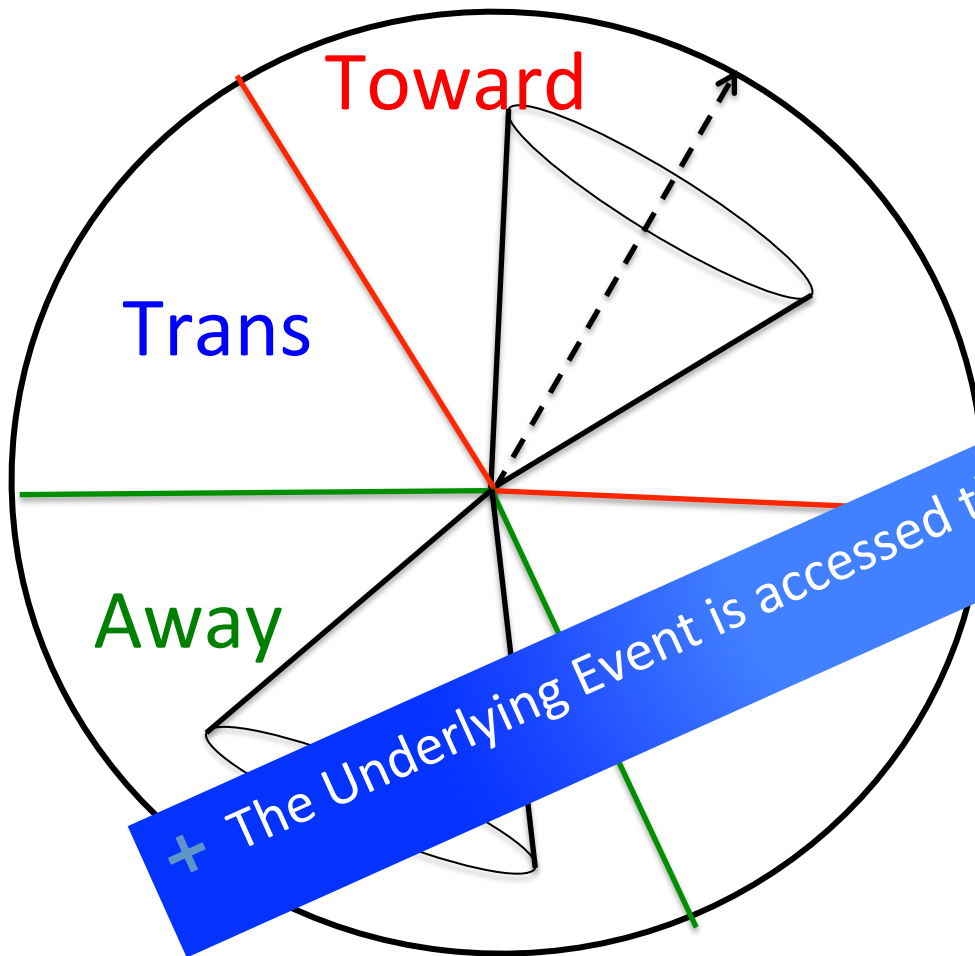
$$x_2 = \frac{1}{\sqrt{s}} \left(p_{T3} e^{-\eta_3} + p_{T4} e^{-\eta_4} \right)$$

$$M = \sqrt{x_1 x_2 s}$$

$$\cos \theta^* = \tanh \left(\frac{\eta_3 + \eta_4}{2} \right)$$

Reconstructing Di-jets
provide access to the initial
partonic kinematics at LO

Defining the Regions to Access the UE



- Track p_T and Tower $E_T > 200$ MeV
- Detector jet $\eta < 0.5$
- JP Trigger (JP2) with threshold > 13 GeV
- Leading JP Trigger fired JP

$$|\Delta\phi| = |\phi_{\text{jet}} - \phi_{\text{track/tower}}|$$

Toward:

$$|\Delta\phi| < 60$$

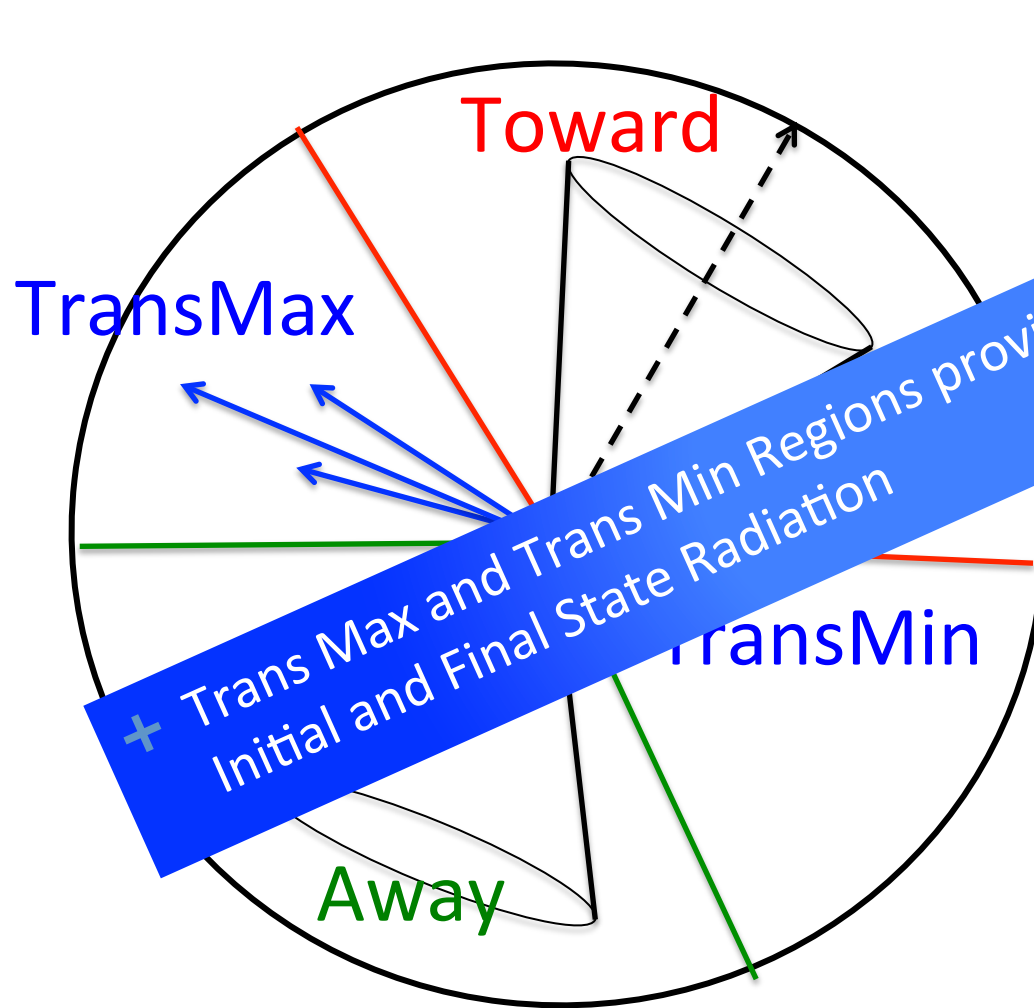
Away:

$$|\Delta\phi| > 120$$

Transverse:

$$60 < |\Delta\phi| < 120$$

Separating the Transverse Regions



Trans Plus:

$60 < \Delta\phi$

Trans Min:

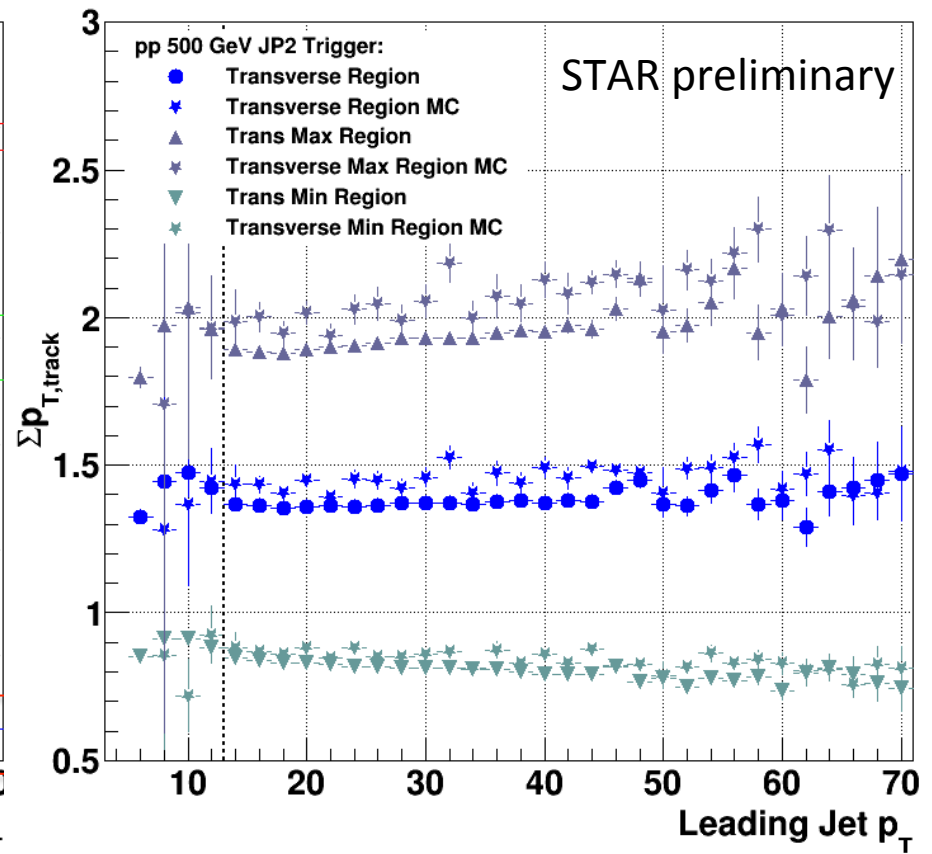
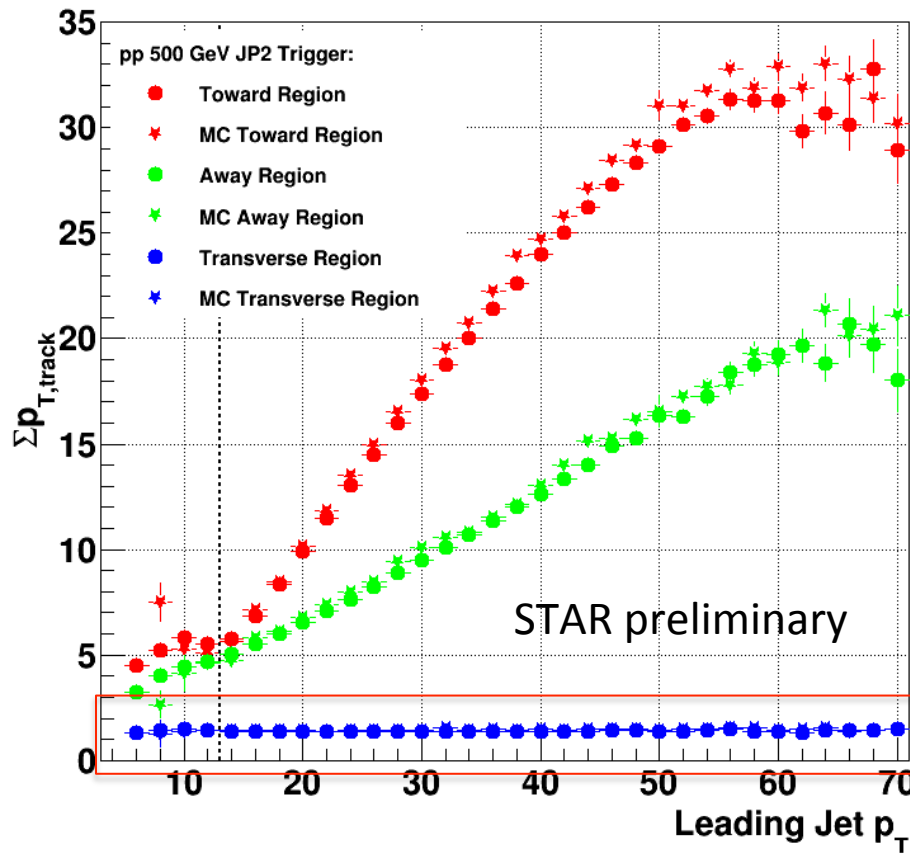
$\Delta\phi > -120$

Trans Max and Min:

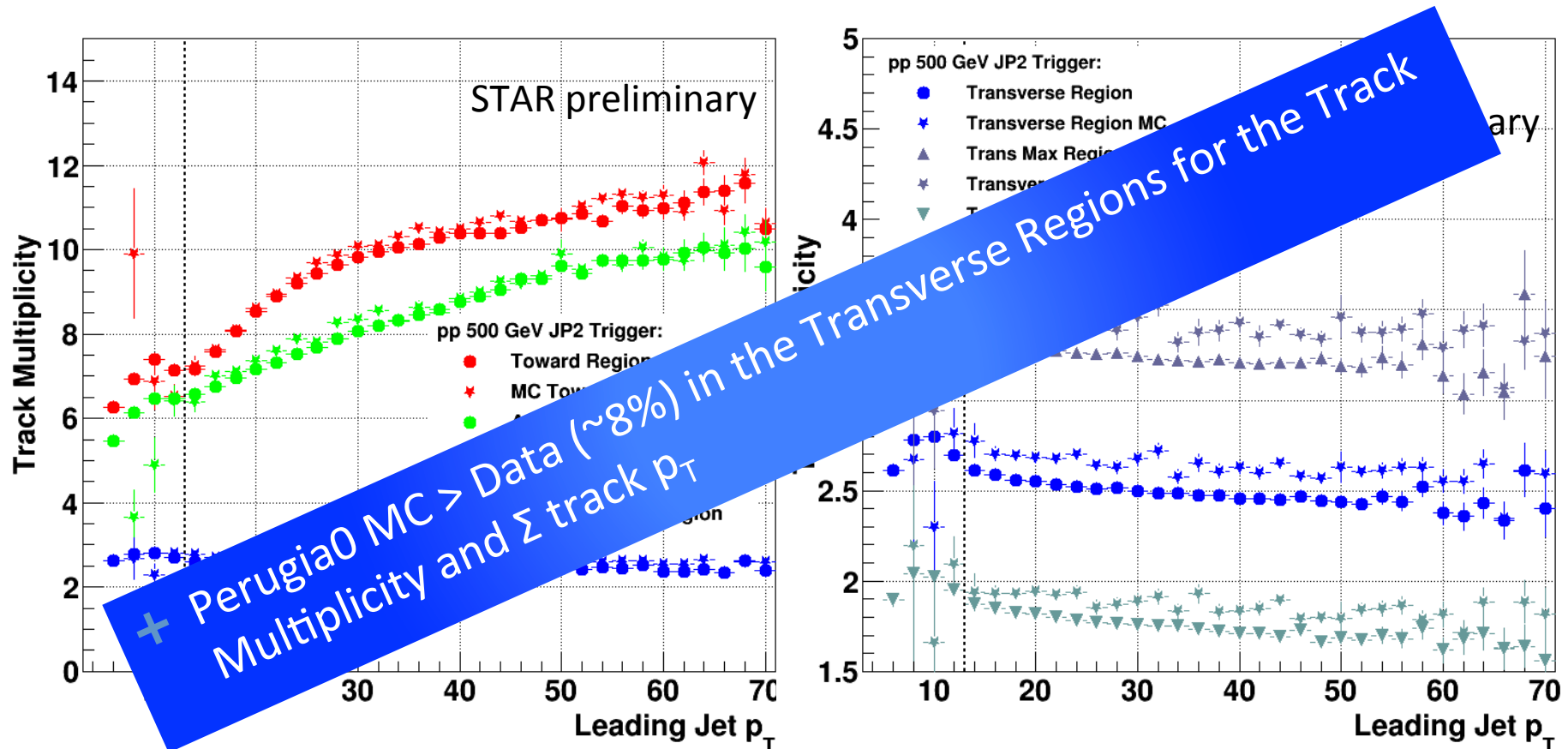
Find Σ track p_T for
TranP and TranM

The region with higher
 Σ track p_T is trans Max
and the other is trans
Min

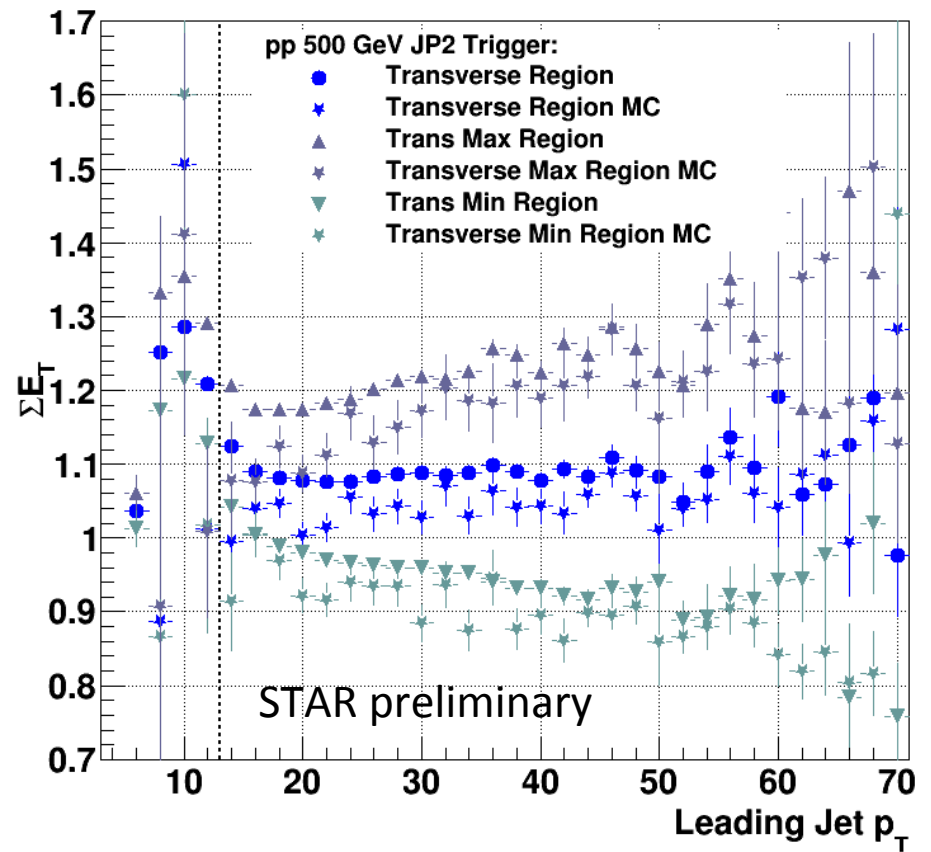
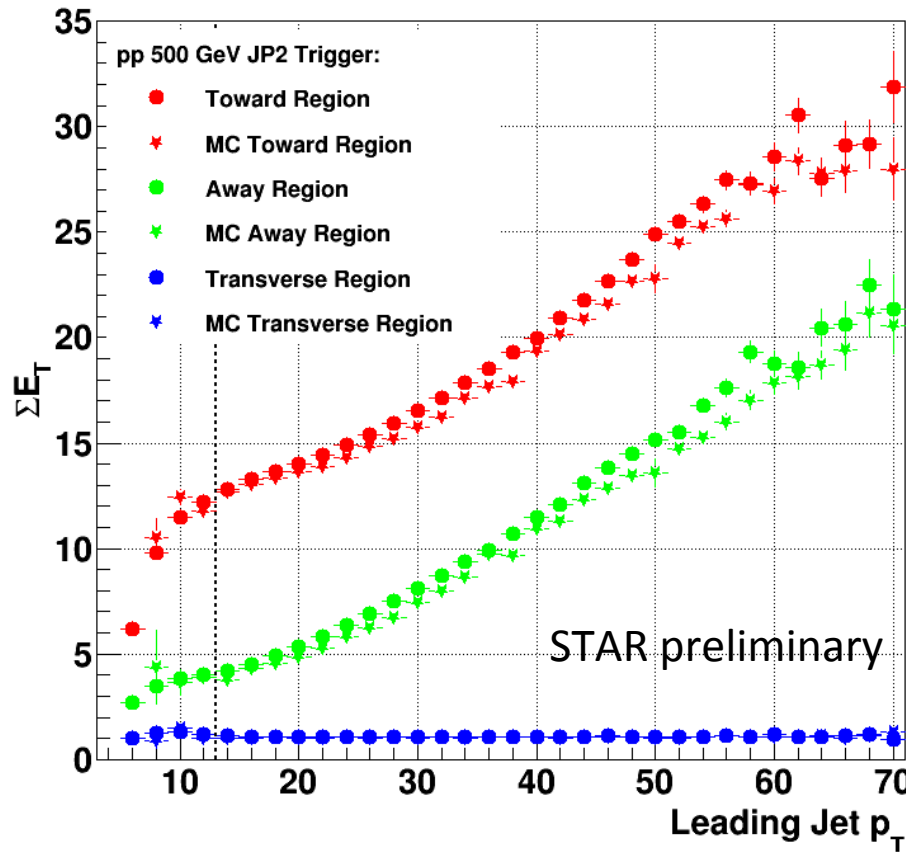
Data/MC Comparison: Σ Track p_T



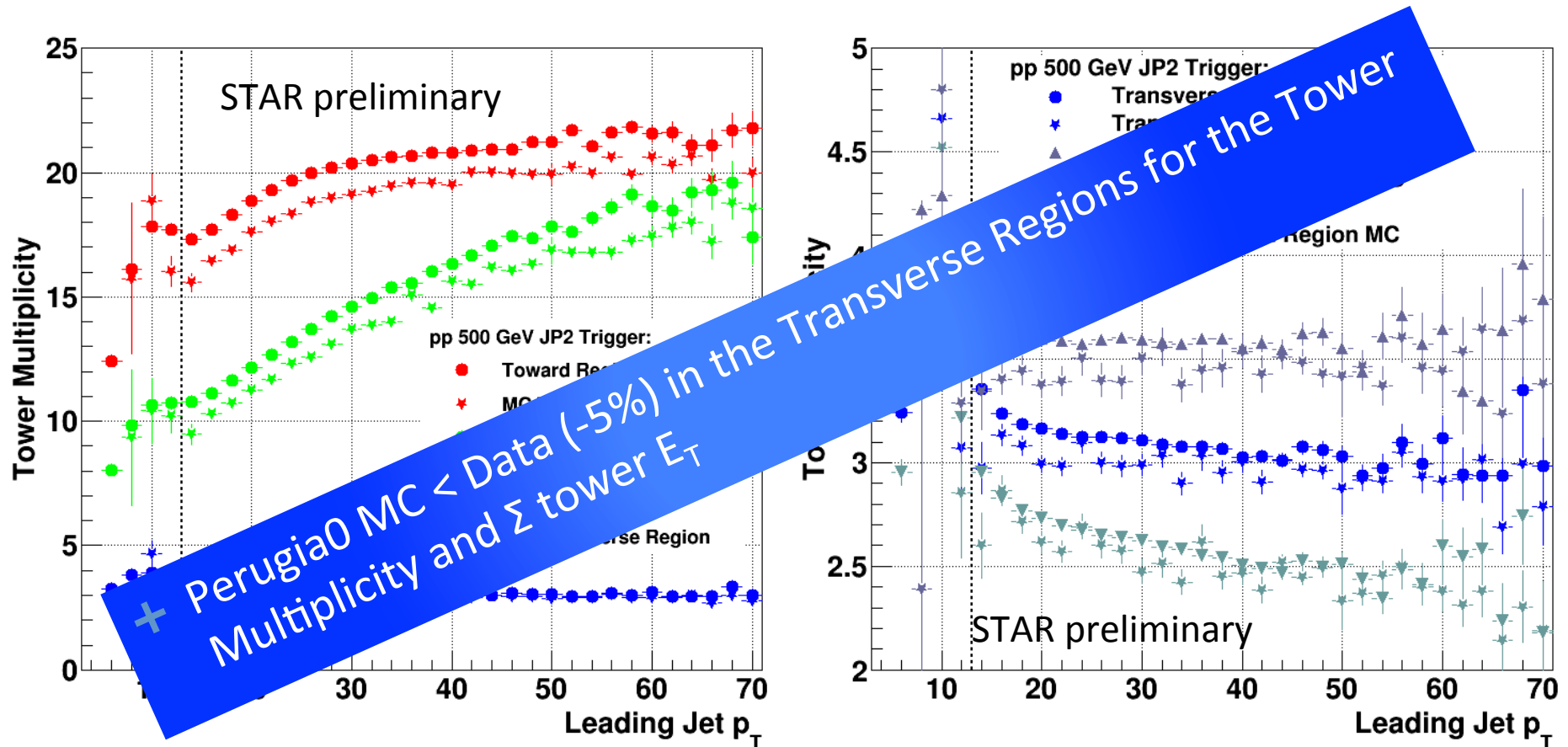
Data/MC Comparison: Track Multiplicity



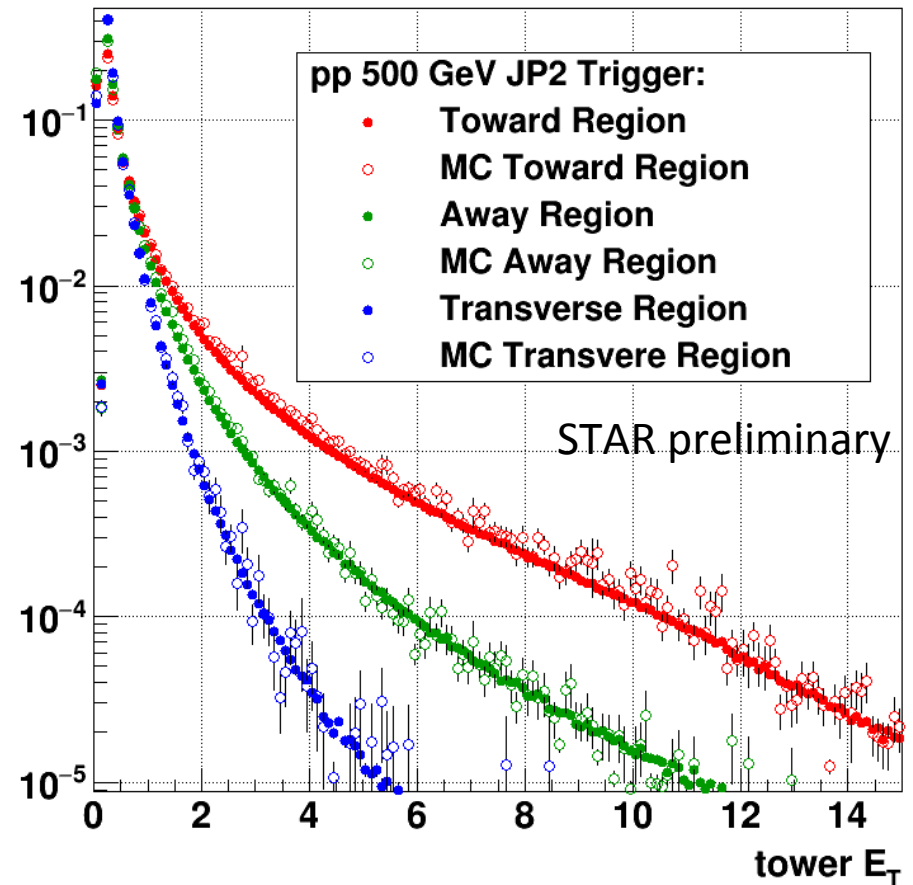
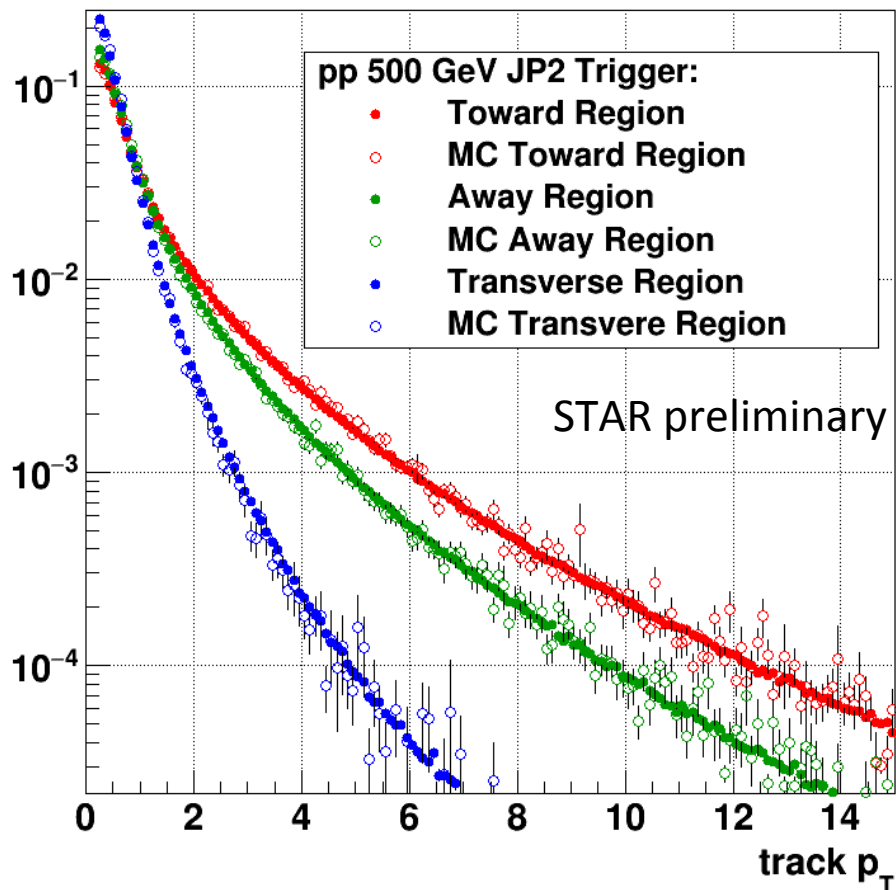
Data/MC Comparison: Σ Tower E_T



Data/MC Comparison: Tower Multiplicity



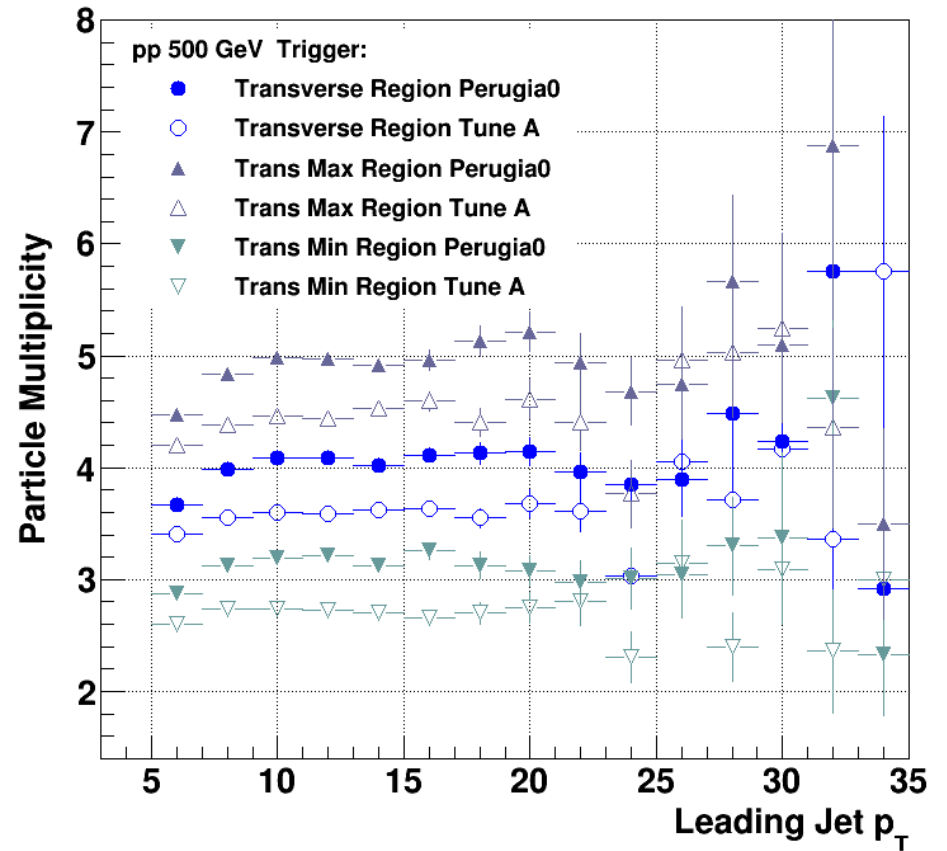
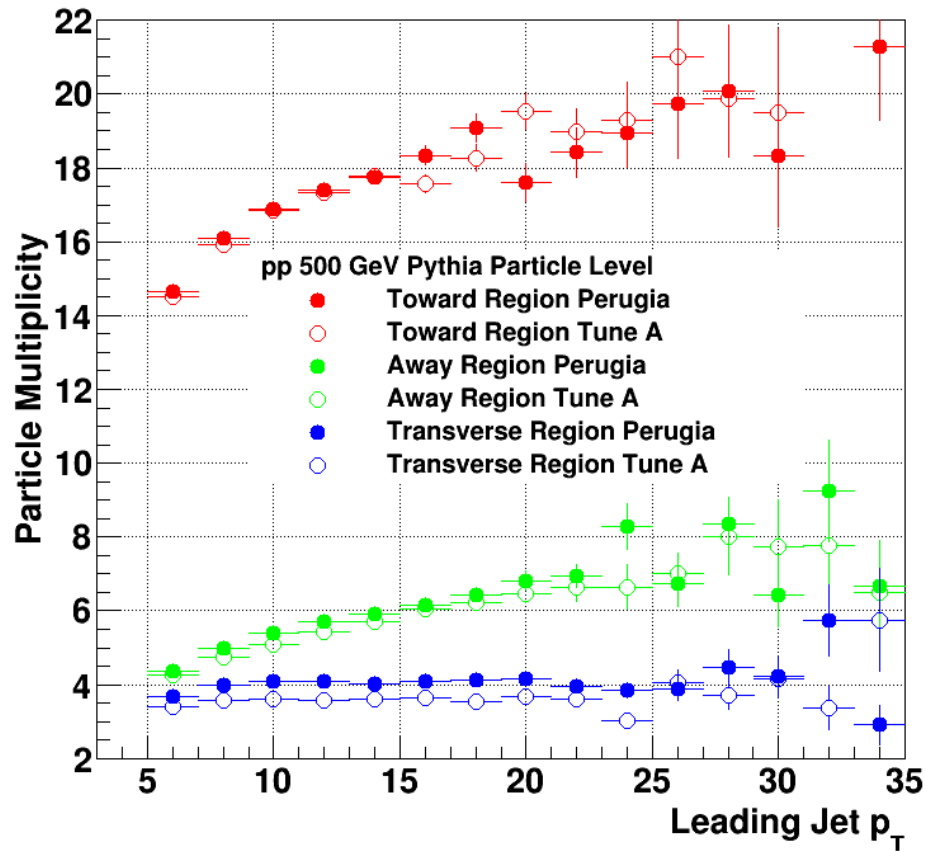
Data/MC Comparison: Track p_T and Tower E_T



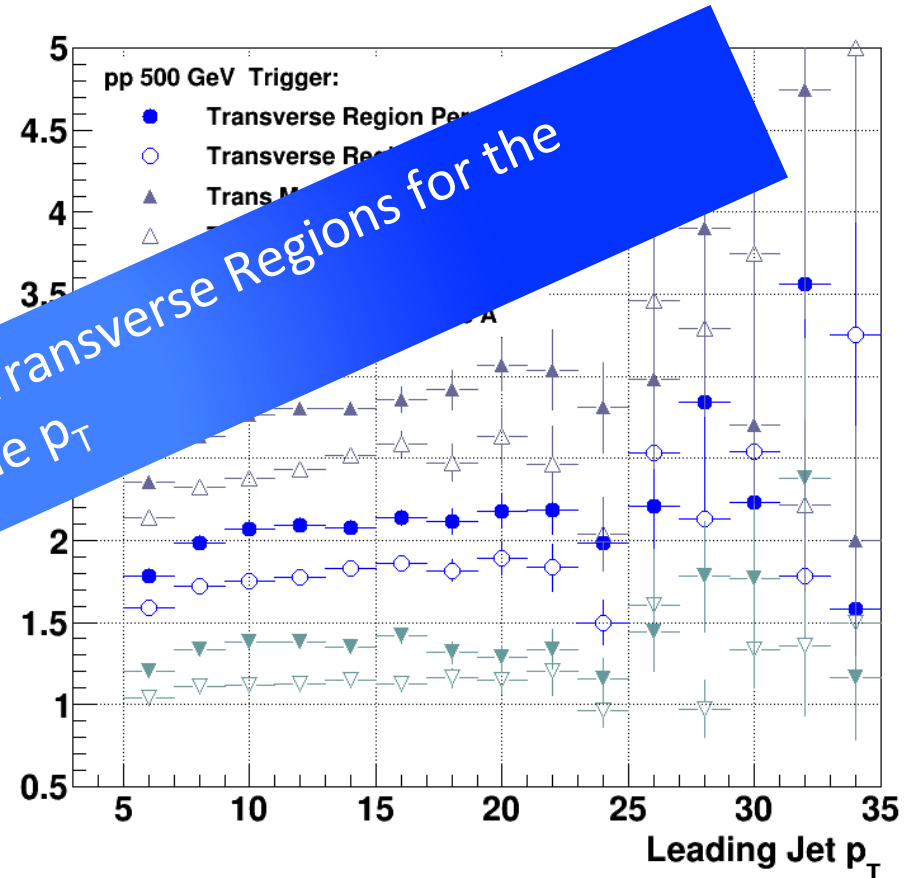
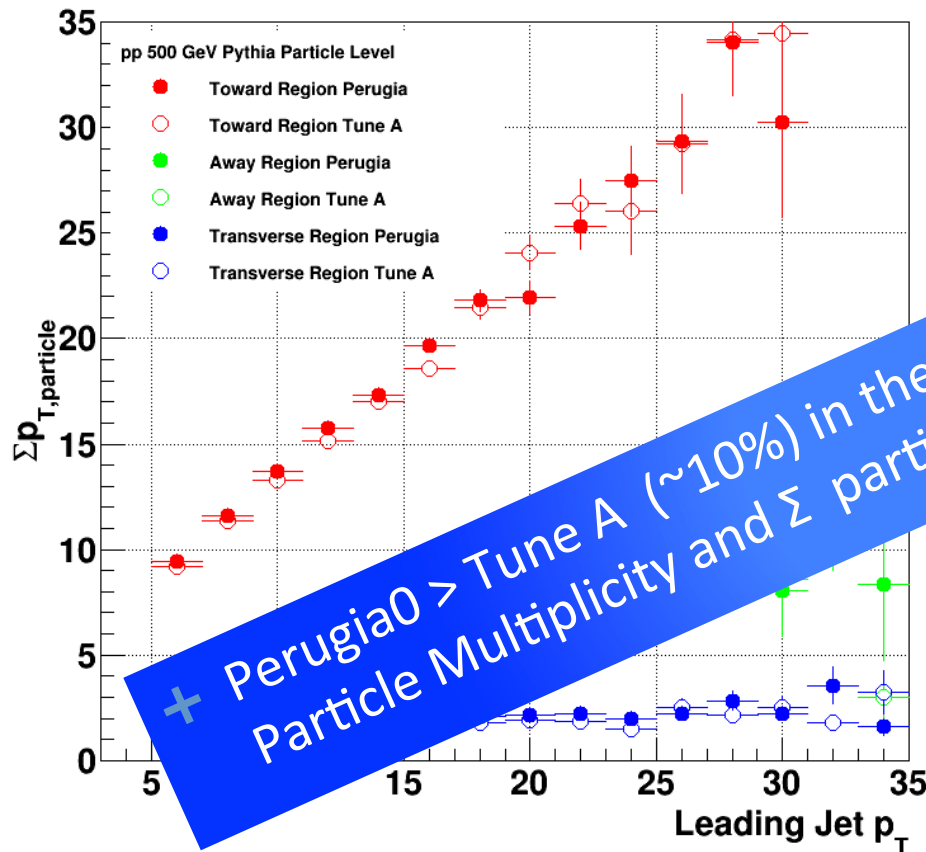
Pythia Tune Analysis

- Produced 1 M events of Perugia0 and 1M events of TuneA
- The tune was the only parameter changed in the analysis
- Performed the Underlying Event analysis on both tunes and compared.

Pythia Tune Comparison



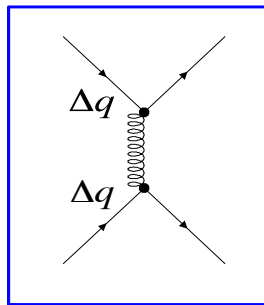
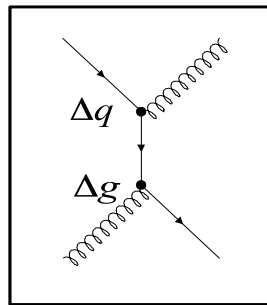
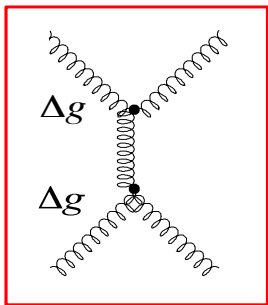
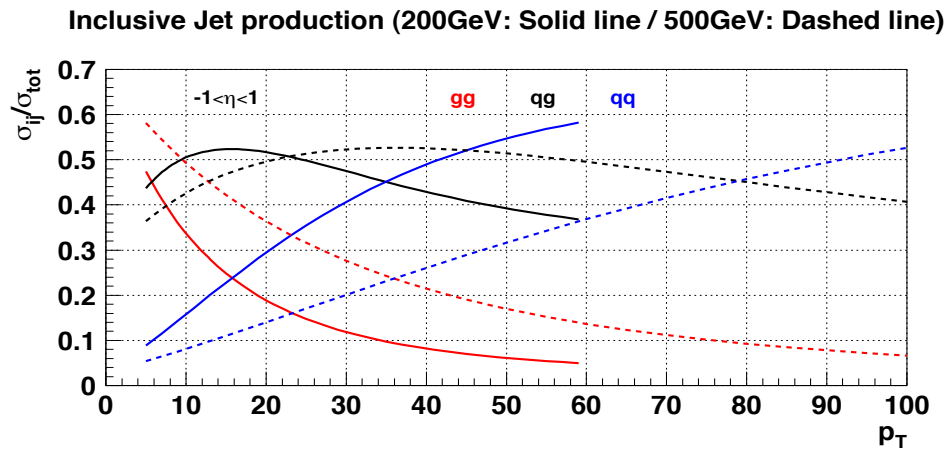
Pythia Tune Comparison



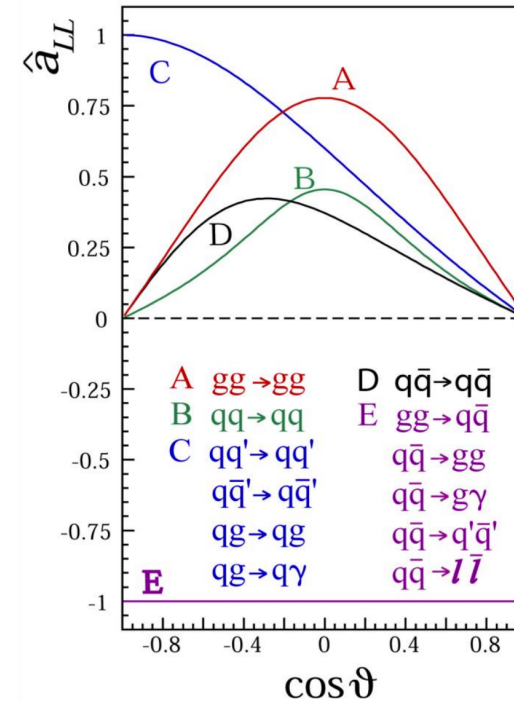
The Double Spin Asymmetry

$$A_{LL} = \frac{\sigma^{++} - \sigma^{+-}}{\sigma^{++} + \sigma^{+-}} \propto \frac{\Delta f_a \Delta f_b}{f_a f_b} \hat{a}_{LL}$$

Δf : polarized parton distribution functions



MPI-Trieste



$$A_{LL} = \frac{1}{P_Y P_B} \frac{N^{++} - N^{+-}}{N^{++} + N^{+-}}$$

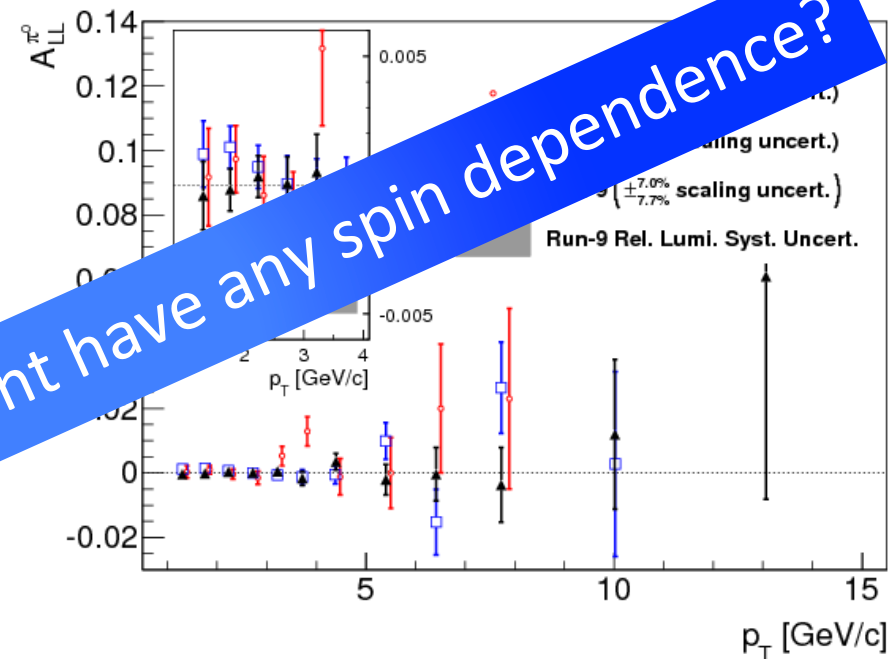
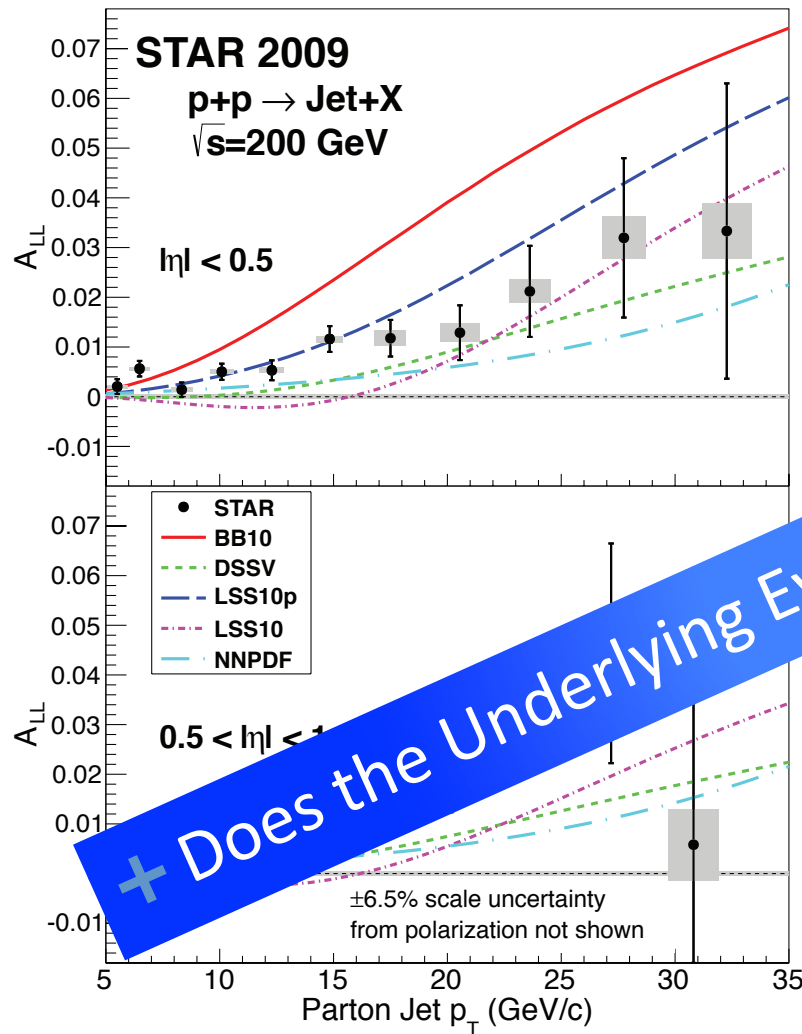
Observables:

Inclusive Jets

Dijet

Inclusive π^0 's

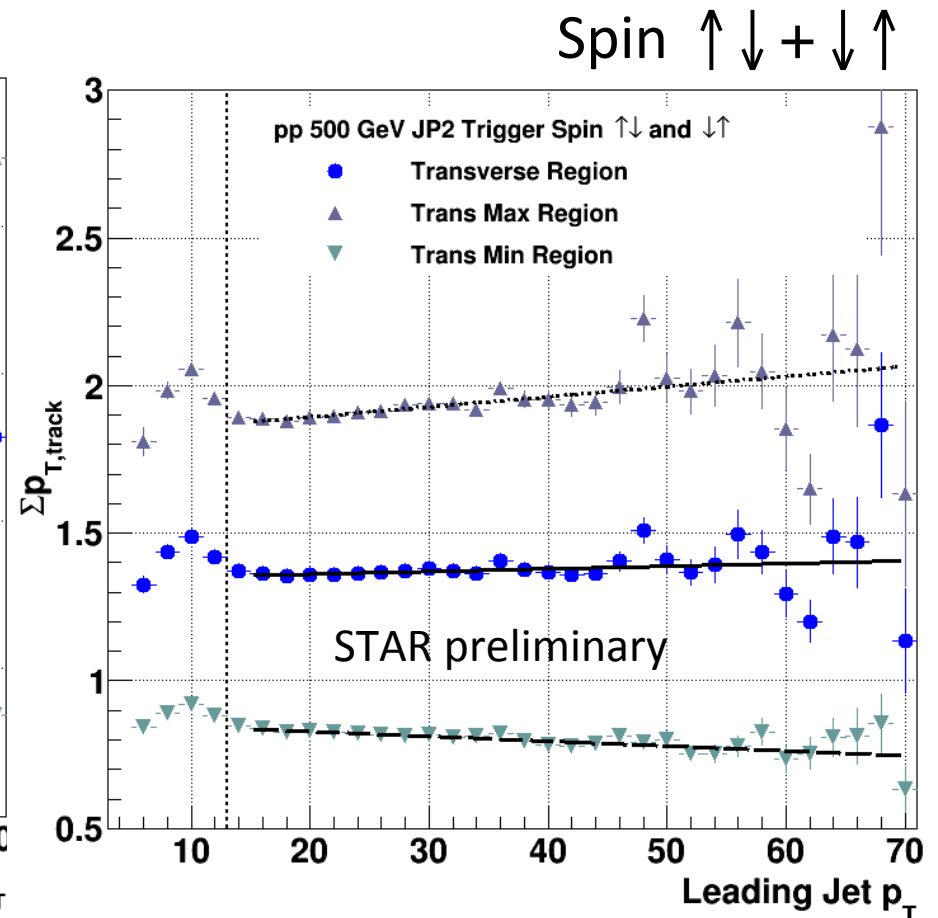
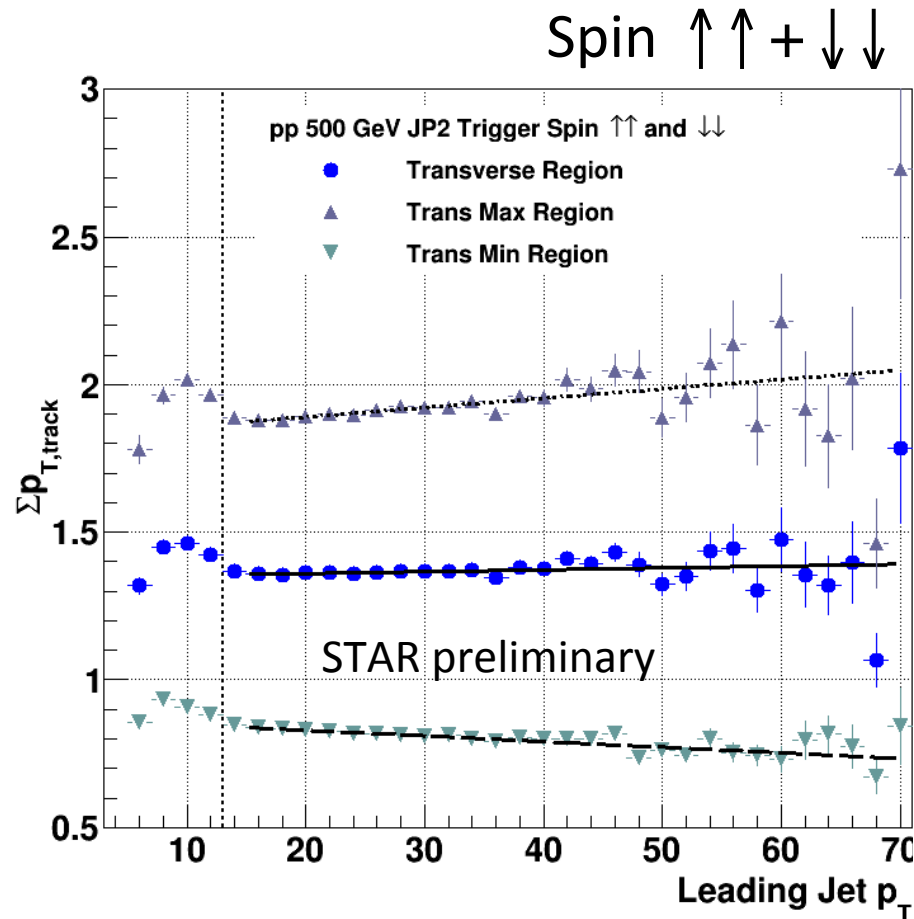
High Precision 2009 RHIC DATA $\rightarrow \int \Delta g(x)$



+ Does the Underlying Event have any spin dependence?

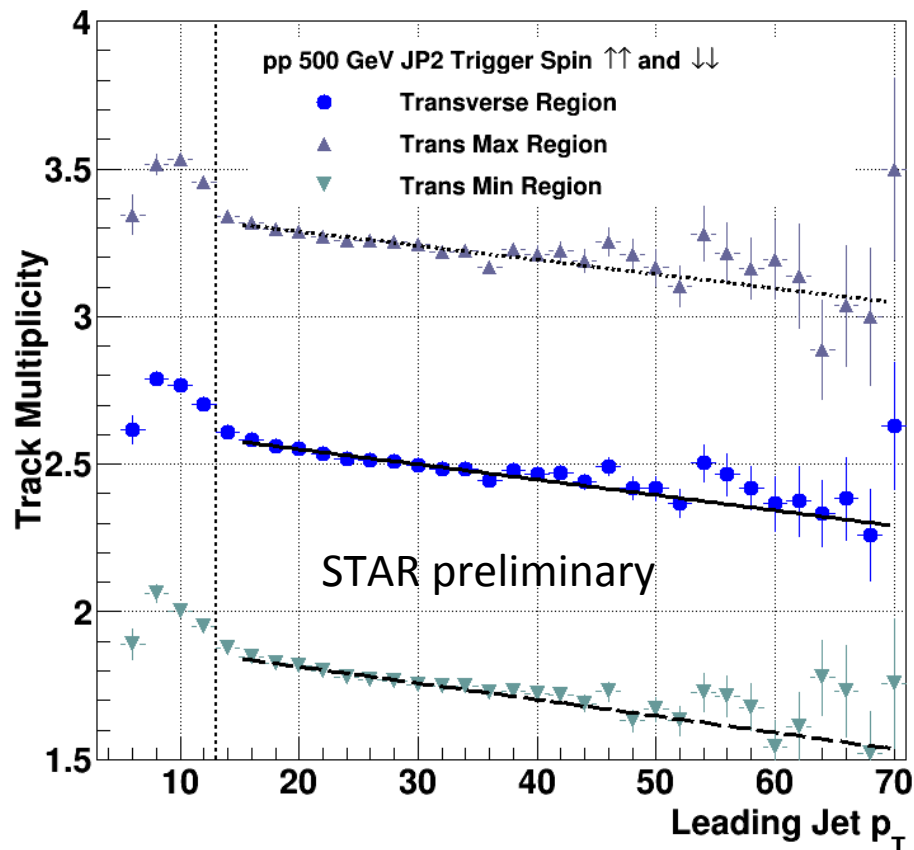
$$A_{LL} = \frac{\sigma^{++} - \sigma^{+-}}{\sigma^{++} + \sigma^{+-}} \propto \frac{\Delta f_a \Delta f_b}{f_a f_b} \hat{a}_{LL}$$

Spin Dependent UE Analysis: Σ Track p_T

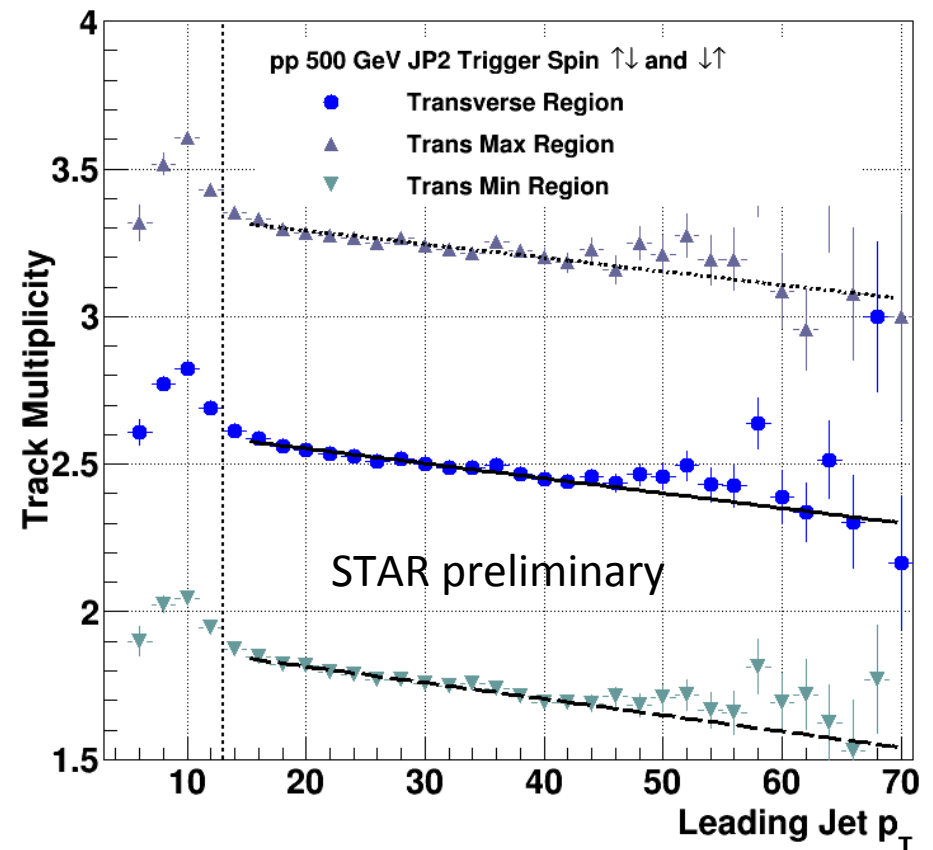


Spin Dependent UE Analysis: Track Multiplicity

Spin $\uparrow\uparrow + \downarrow\downarrow$



Spin $\uparrow\downarrow + \downarrow\uparrow$

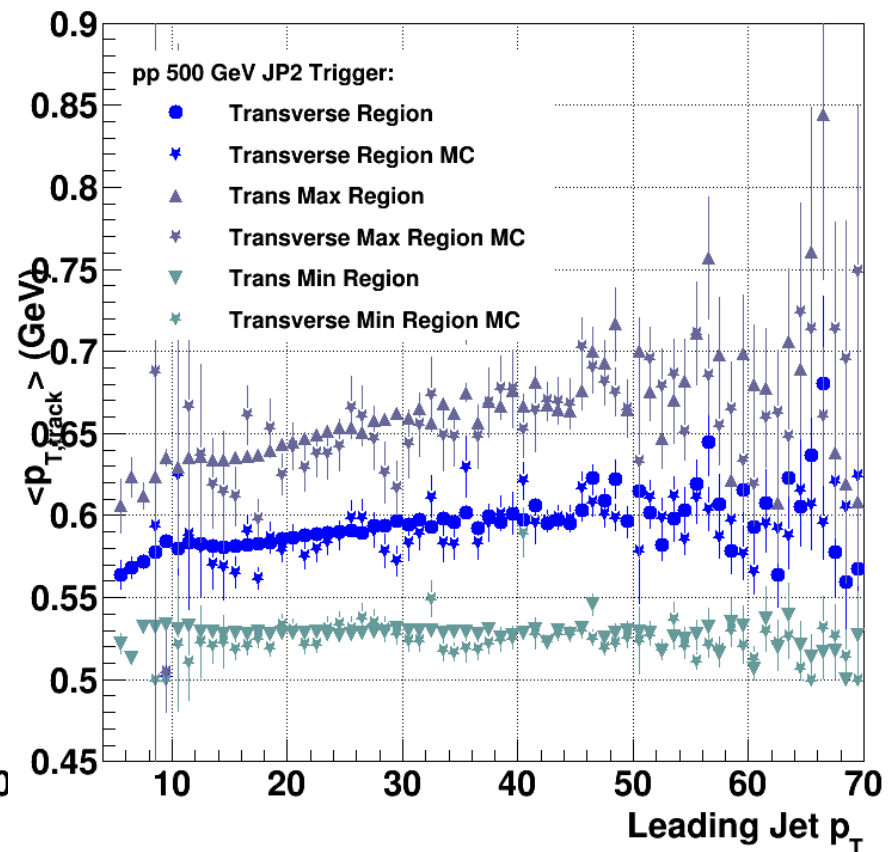
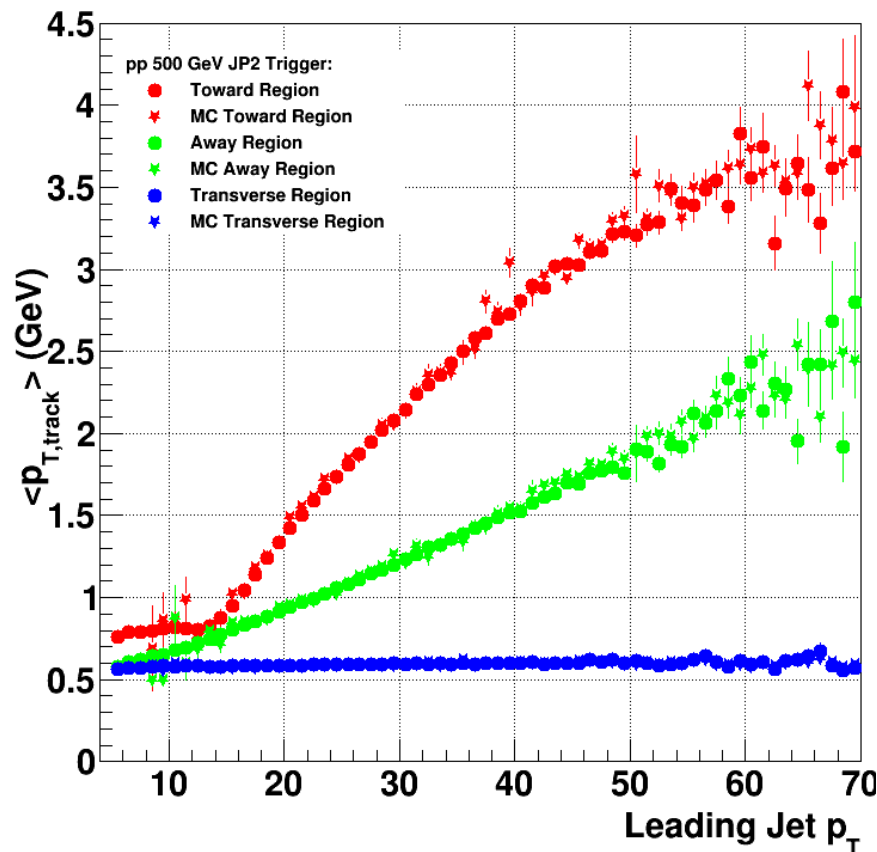


Conclusions

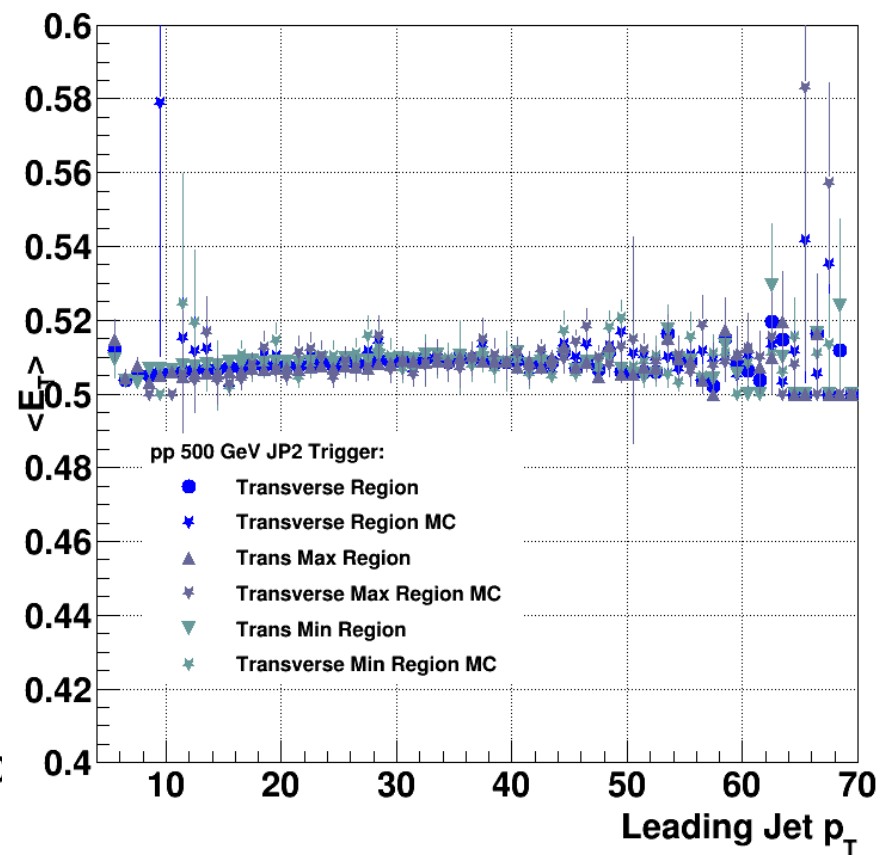
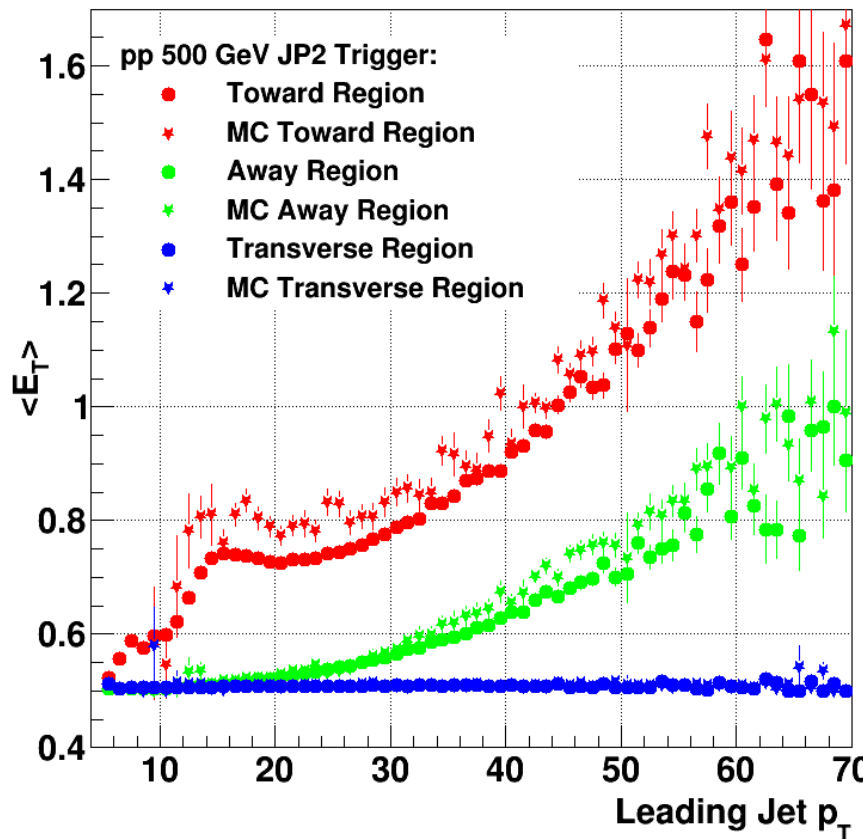
- Data/MC Comparisons agree extremely well for all 3 Regions
 - Slight discrepancies in the track and tower multiplicities and sum p_T and sum E_T
- The UE analysis can also be used to determine the agreement of different pythia tunes.
- Spin Dependence of the Underlying Event can be determined for the first time at STAR!

Back Up

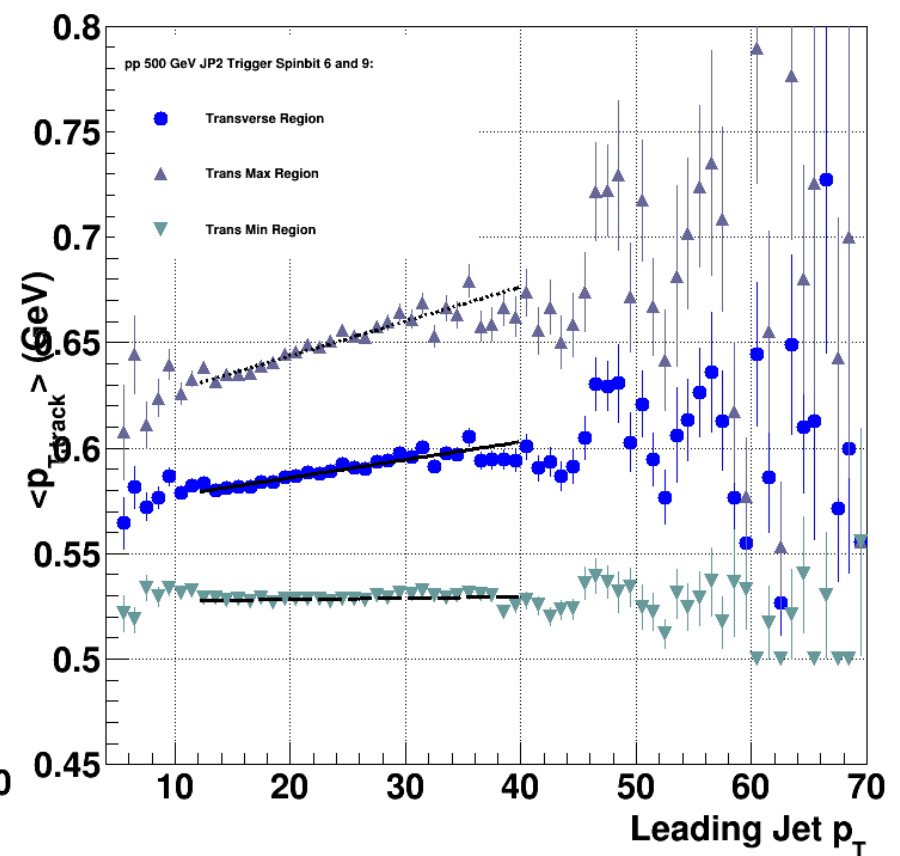
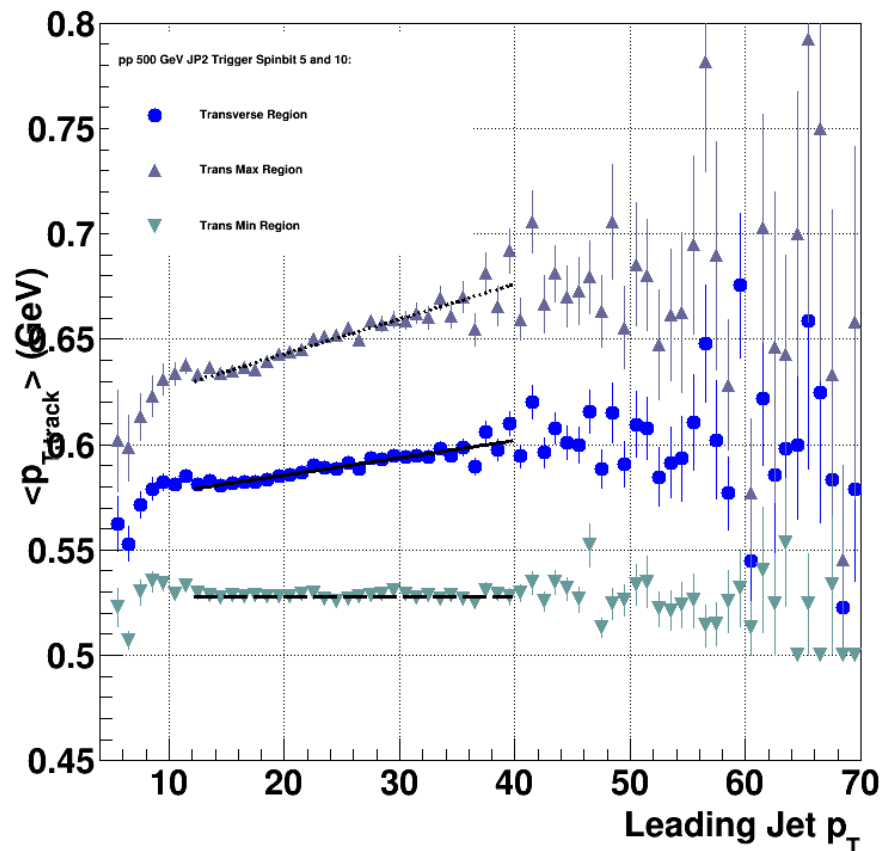
Data/MC Comparisons: Track $\langle p_T \rangle$



Data/MC Comparison: Tower $\langle E_T \rangle$

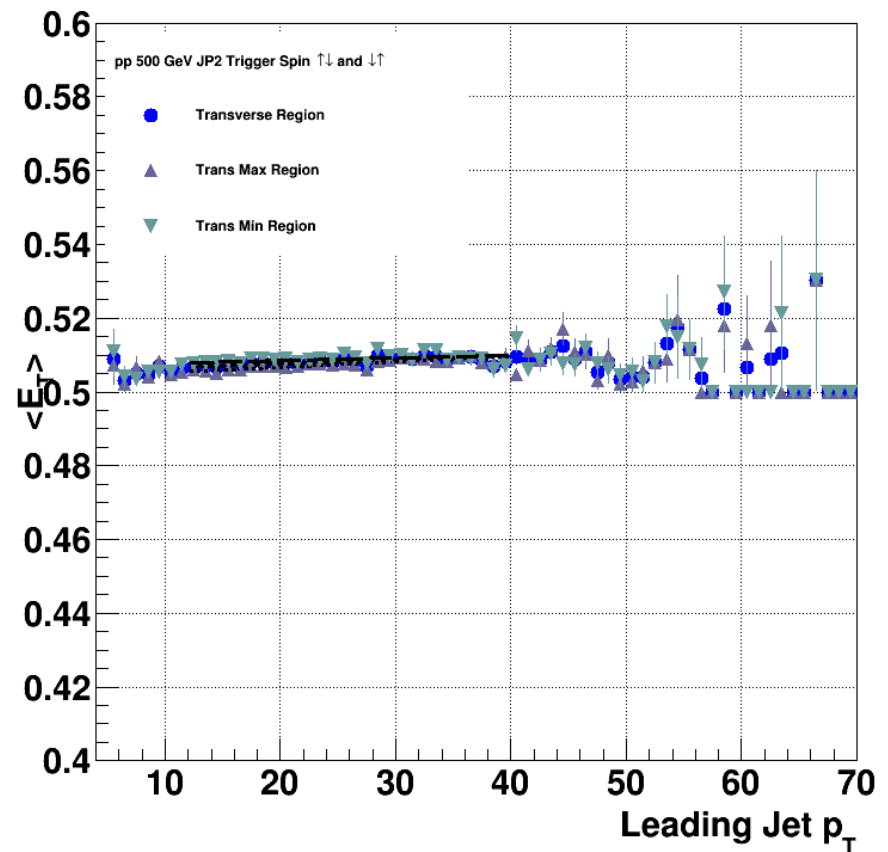
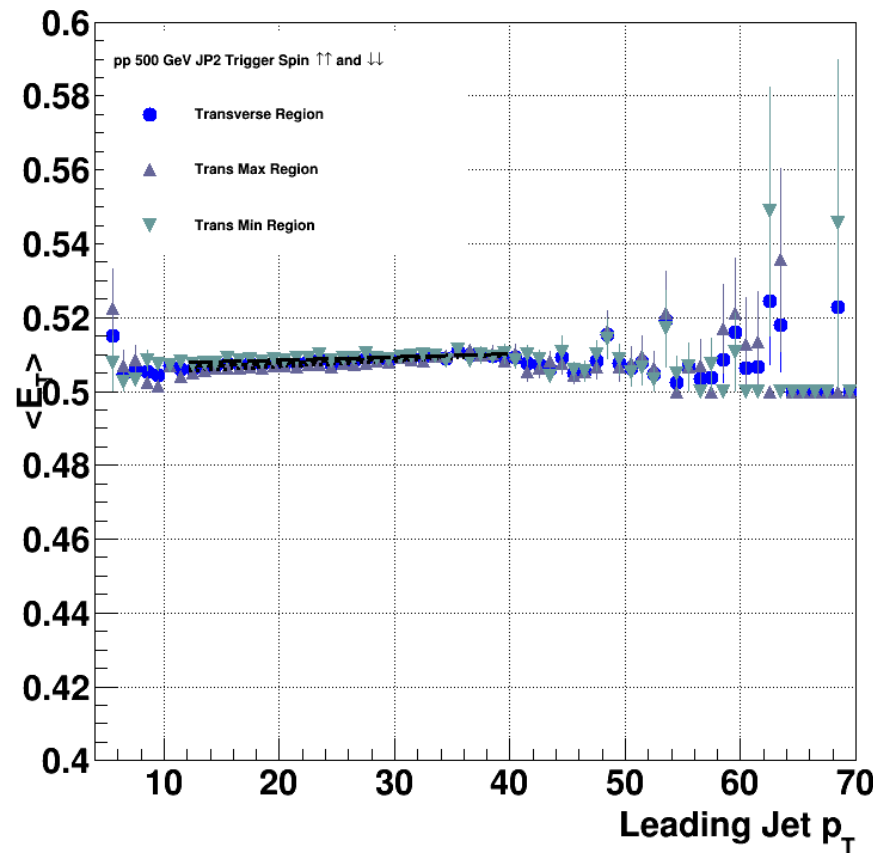


Spin Dependent UE Analysis: Track $\langle p_T \rangle$

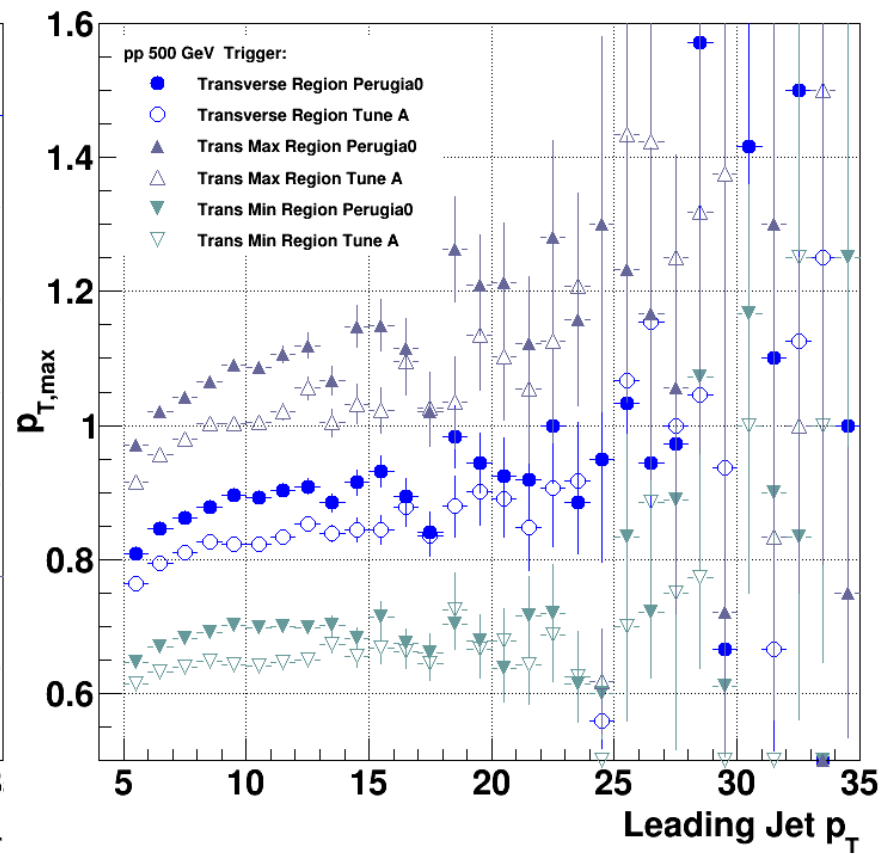
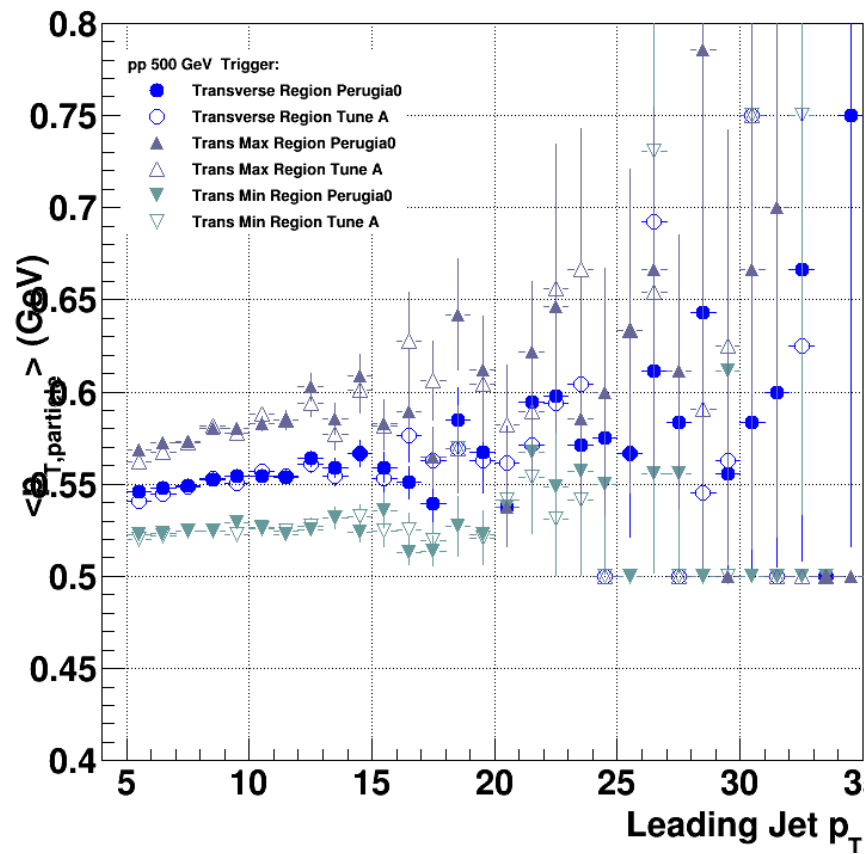


Spin Dependent UE Analysis: Tower

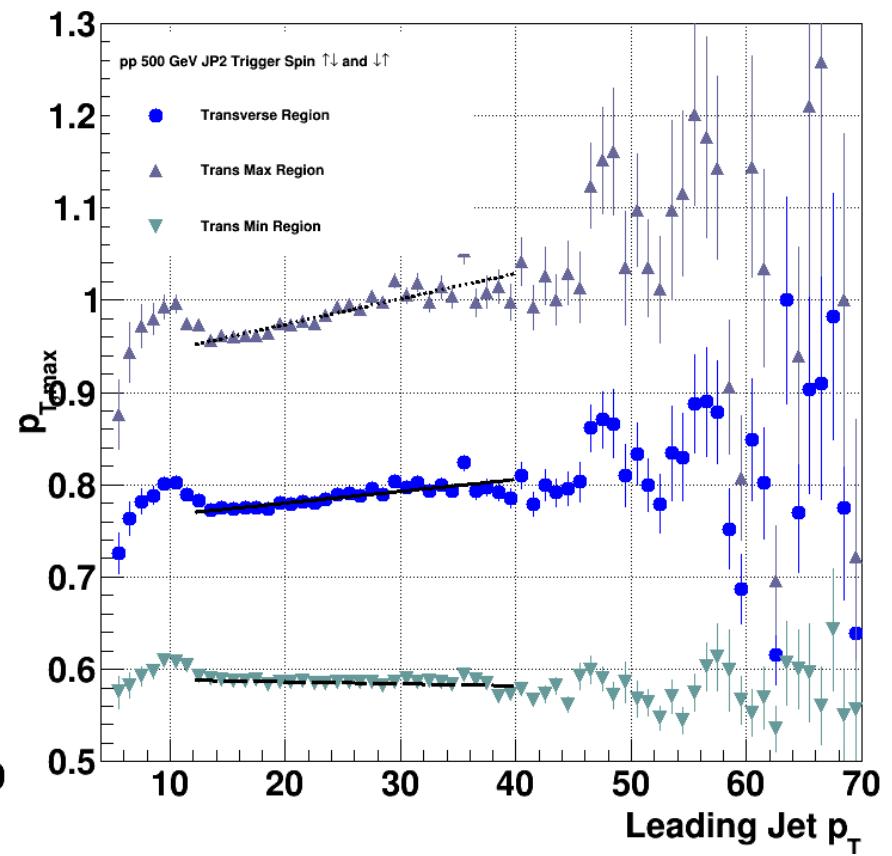
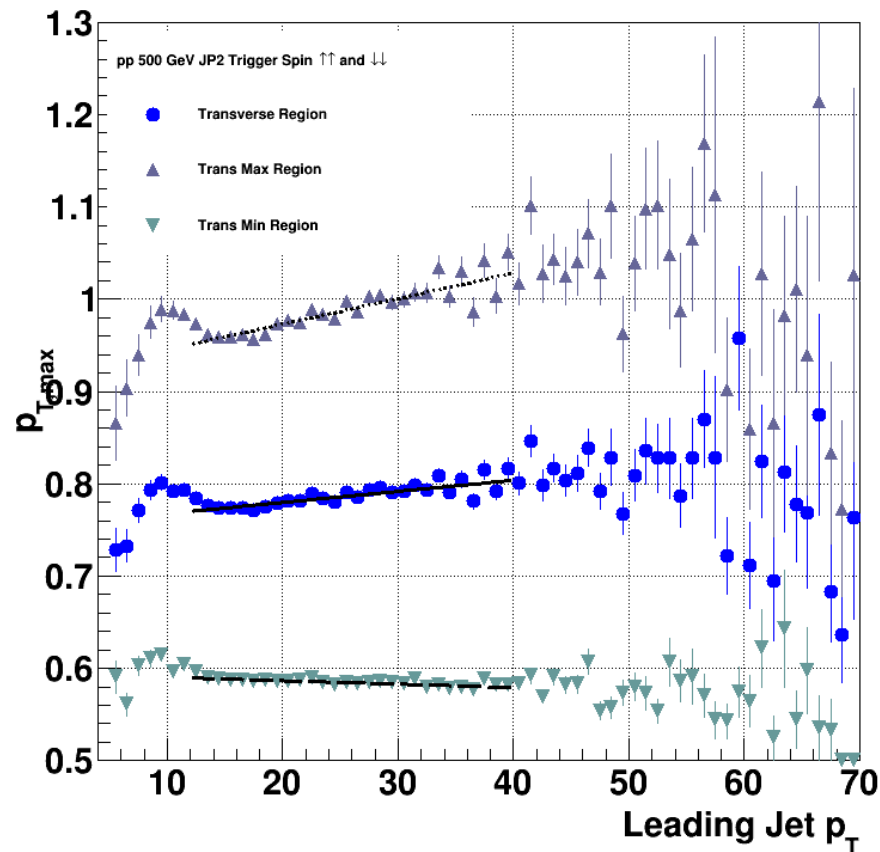
$$\langle E_T \rangle$$



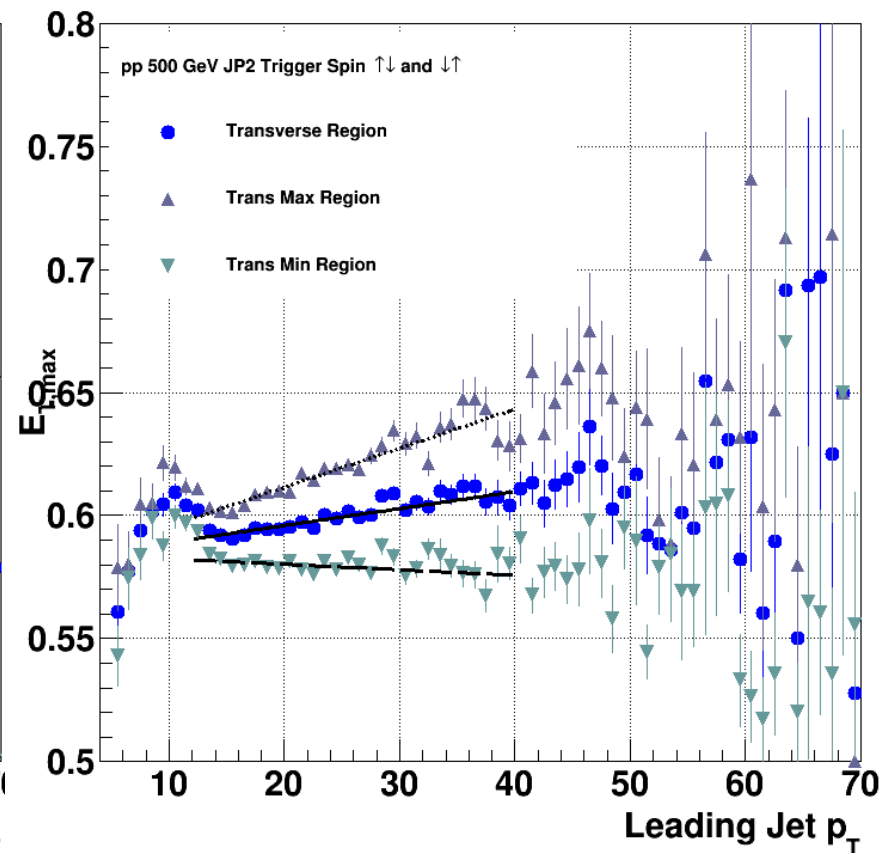
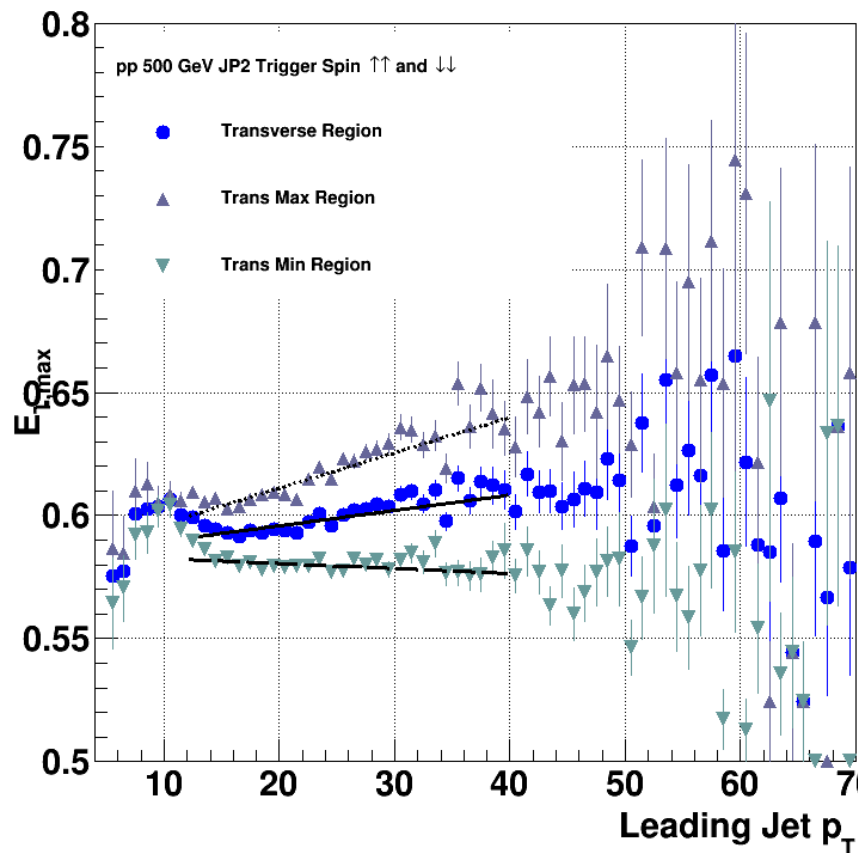
Pythia Tune Comparison



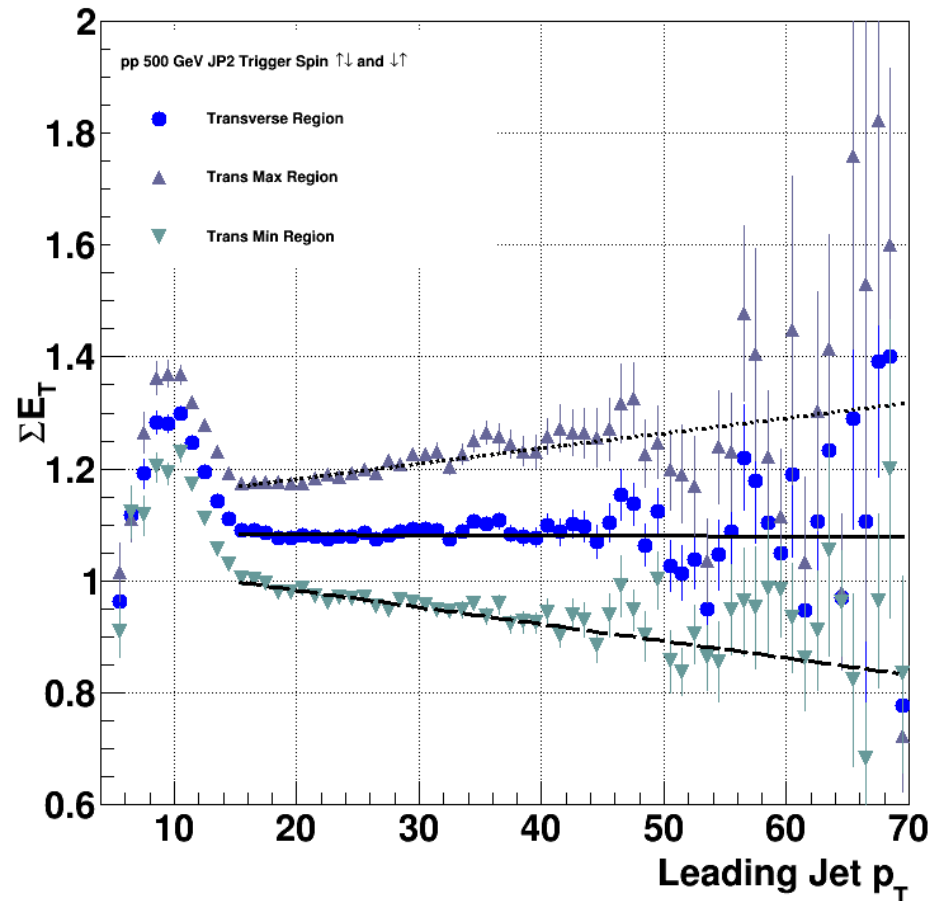
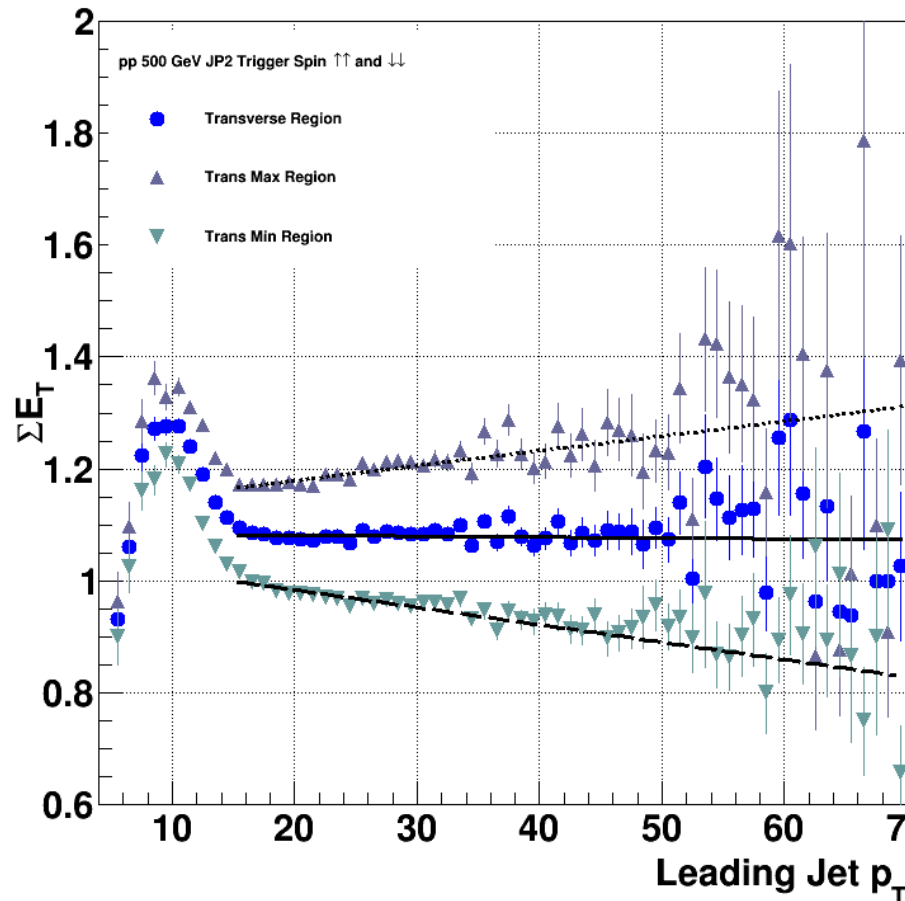
Spin Dependent UE Analysis: Max Track p_T



Spin Dependent UE Analysis: Max Tower E_T



Spin Dependent UE Analysis: Σ Tower E_T



Spin Dependent UE Analysis: Tower Multiplicity

