Mid-Rapidity Di-jet Cross Section Measurement at $\sqrt{s}$ = 200 GeV at STAR

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for the

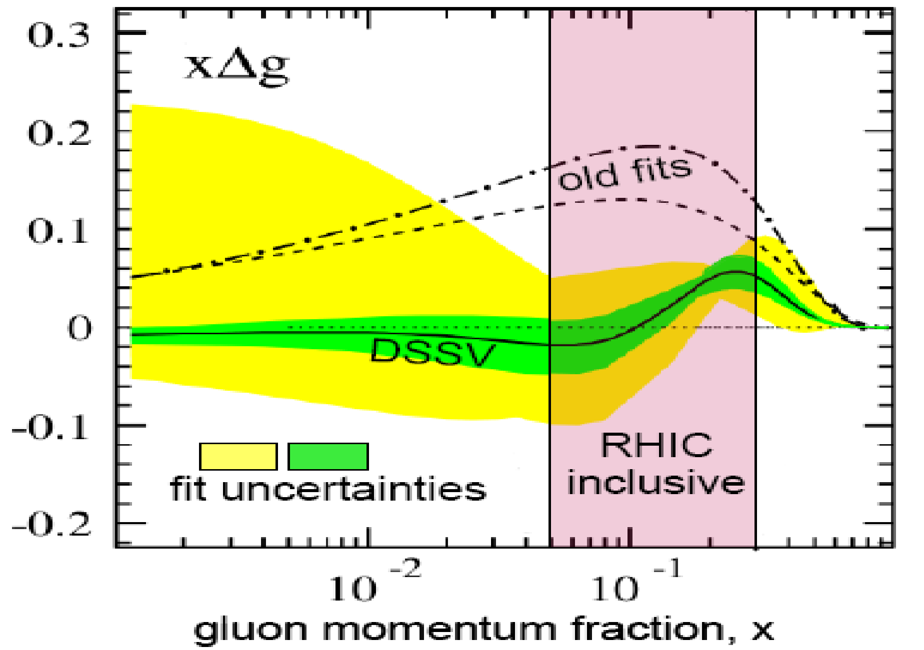
STAR Collaboration

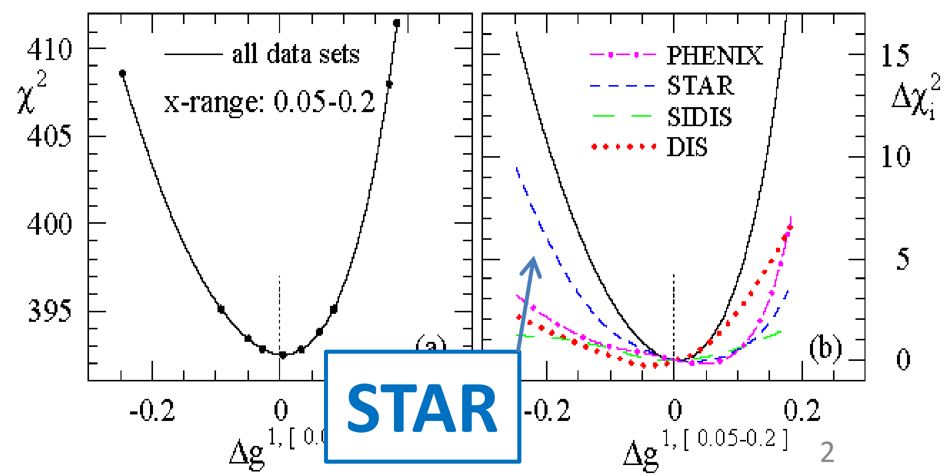
Goal: Understanding Di-jets at STAR

$$S = \frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + L$$

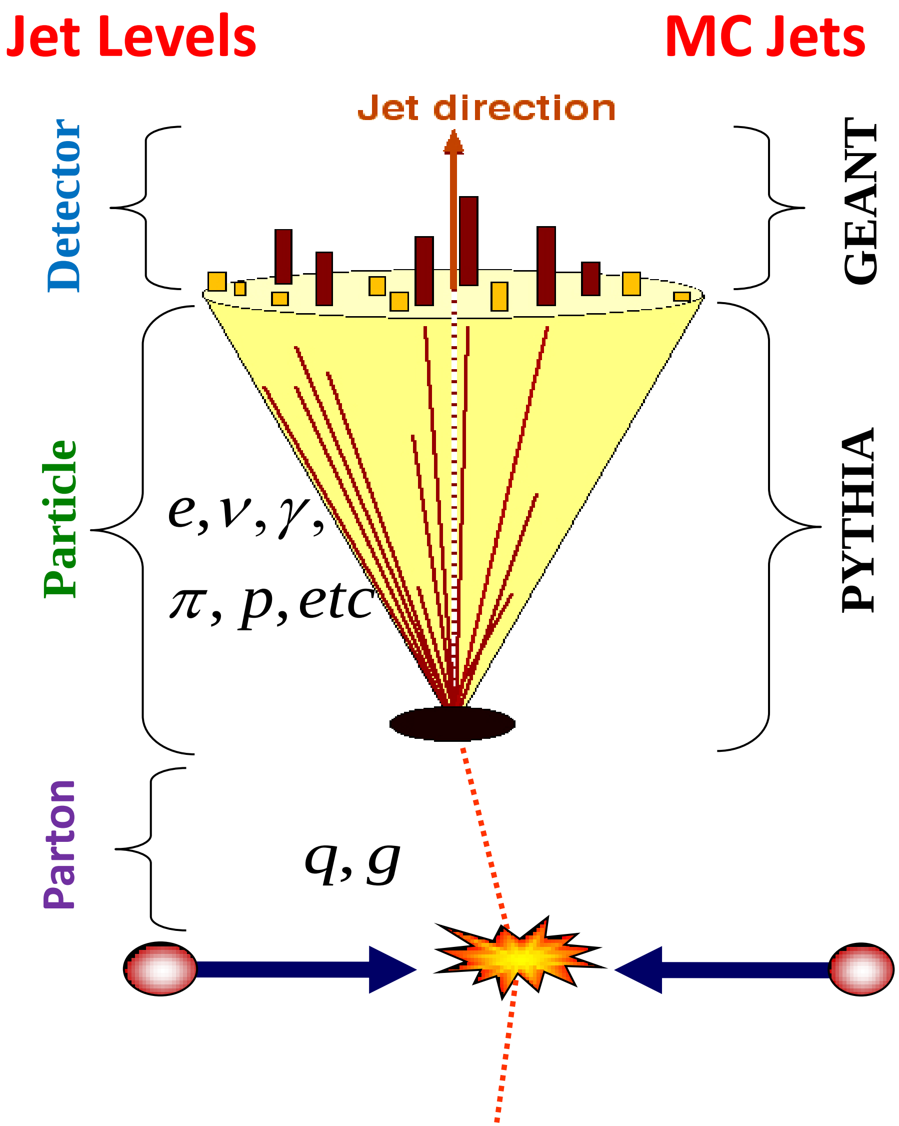
- Want to better constrain x dependence of ΔG by using correlation measurements such as di-jet asymmetries
- Need to show that the di-jet observable is well understood at STAR
- Agreement between measured di-jet cross section and NLO pQCD predictions would give confidence that di-jets can be used in asymmetry measurements

de Florian *et al.*, PRL **101**, 072001 (2008)





Jet Reconstruction



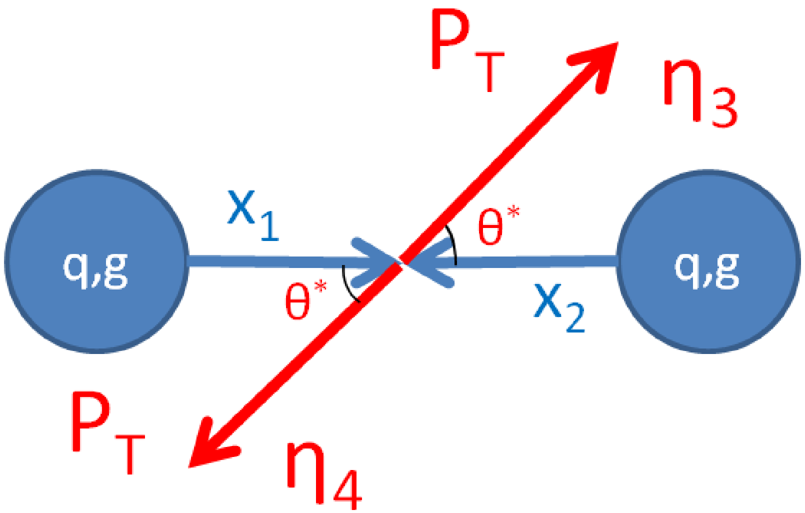
Anti-K_T Algorithm:

- Radius = 0.6
- Less sensitive to underlying event and pile-up effects
- Implemented using FastJet
- Used in both data and simulation

Three Simulation Jet Levels:

- Parton – Jets produced from hard scattered partons as well as ISR and FSR
- Particle – Jets produced from stable particles arising from fragmenting partons including beam remnants
- Detector – Jets produced from simulated detector response to final state particles

Di-jet Selection



$$x_1 = \frac{P_T}{\sqrt{s}}(e^{\eta_3} + e^{\eta_4})$$

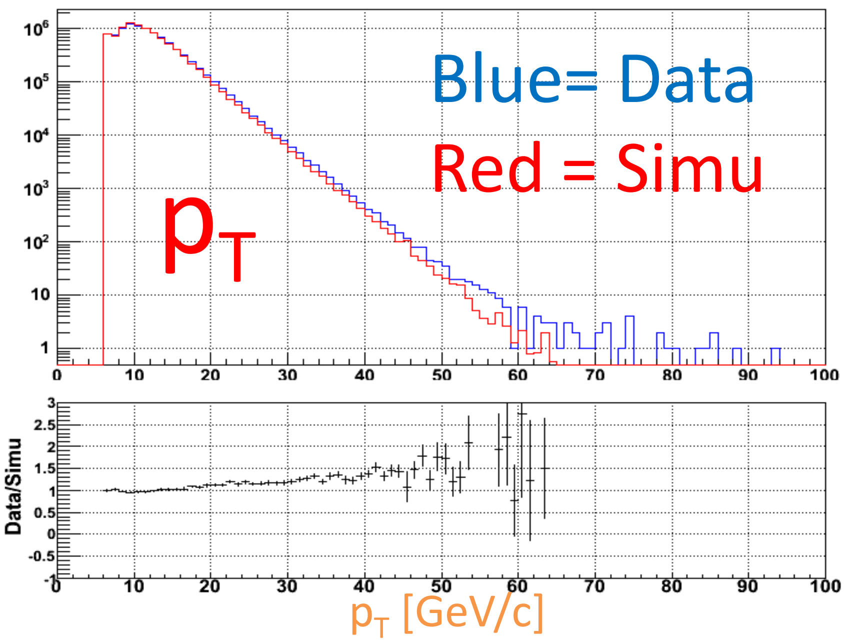
$$x_2 = \frac{P_T}{\sqrt{s}}(e^{-\eta_3} + e^{-\eta_4})$$

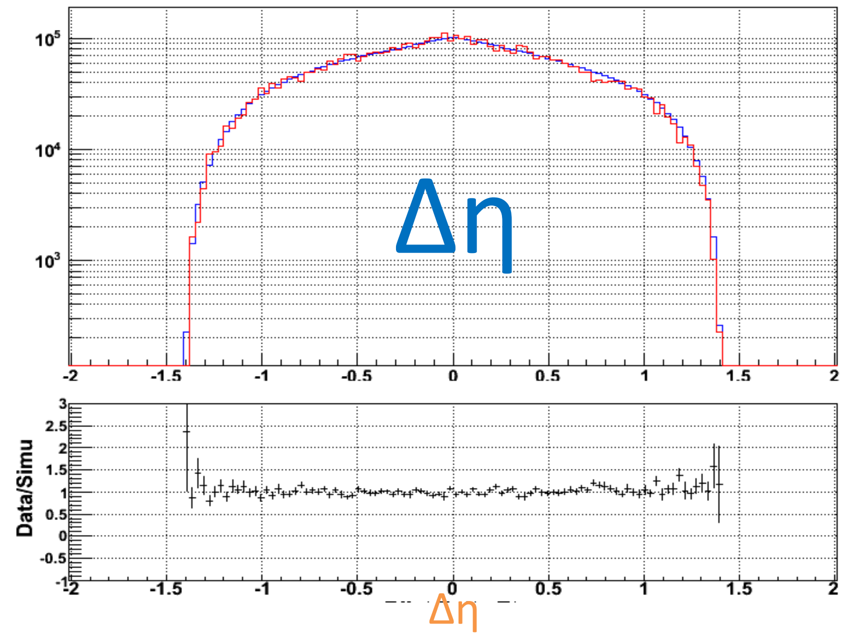
1. Require Z-Vertex to be within ± 90 cm
2. Select all jets with -0.8 ≤ η ≤ 1.8 and -0.7 ≤ det η ≤ 1.7
3. Select 2 highest p_T jets
4. Require at least one jet fired the trigger

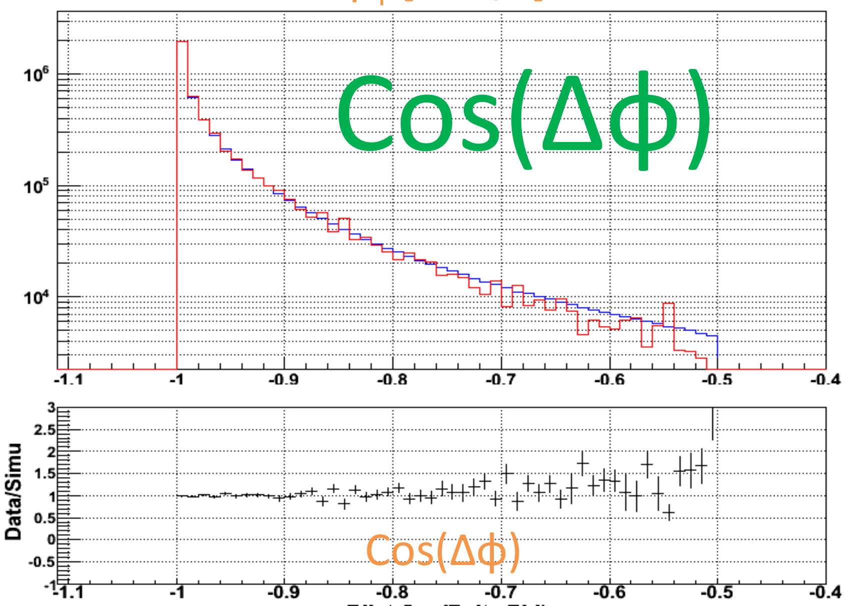
After Di-jet is found, apply following cuts:

- Cos(Δϕ) ≤ -0.5
- One jet neutral fraction < 1.0
- Jet p_{T_high} ≥ 8.0 Jet p_{T_Low} ≥ 6.0
- |η| ≤ 0.8, |det η| ≤ 0.7
- Track p_T ≤ 30 GeV or jet p_T Balance

Data – Simulation Comparisons



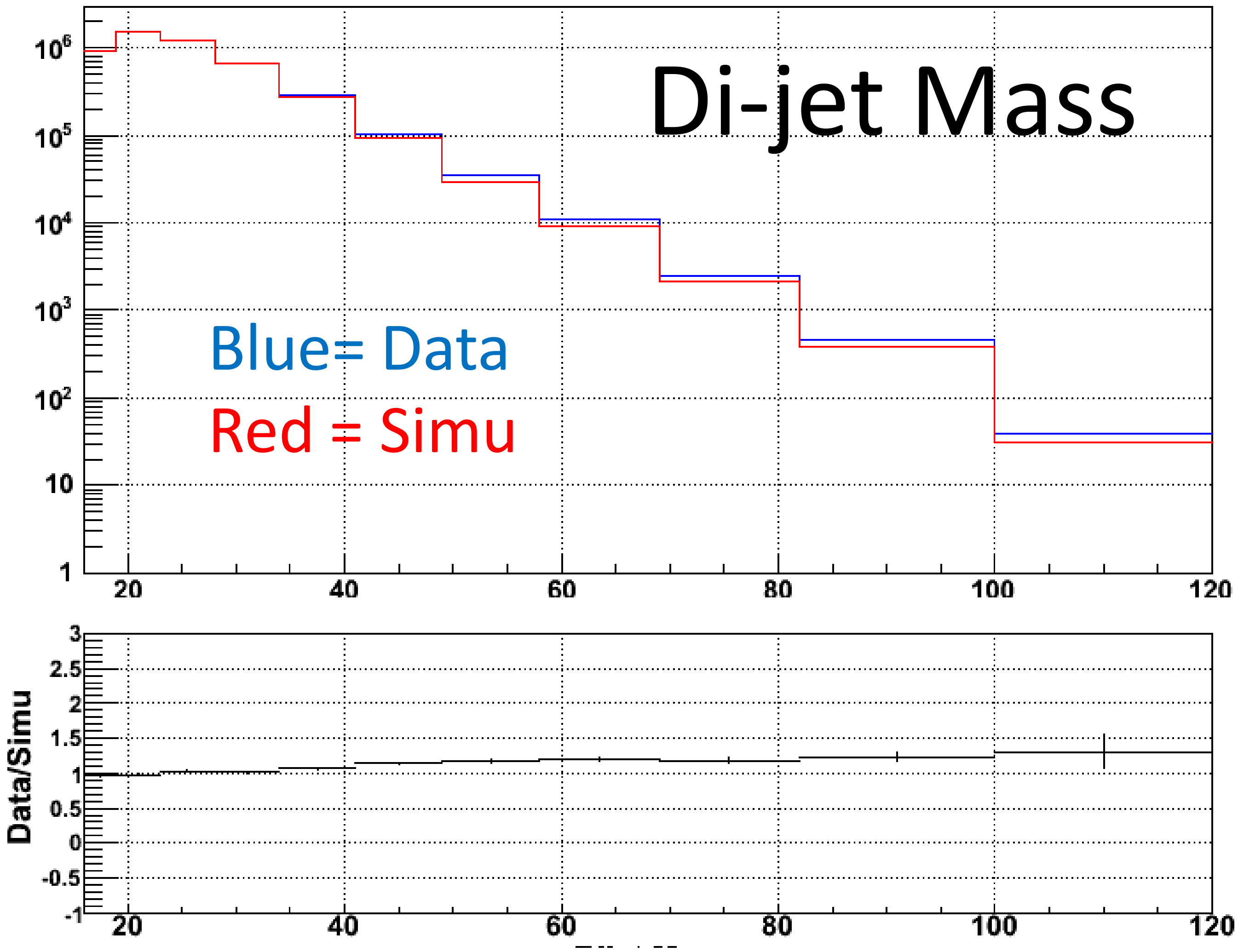




$$M \approx \sqrt{2 p_{T3} p_{T4} [\cosh(\Delta\eta) - \cos(\Delta\phi)]}$$

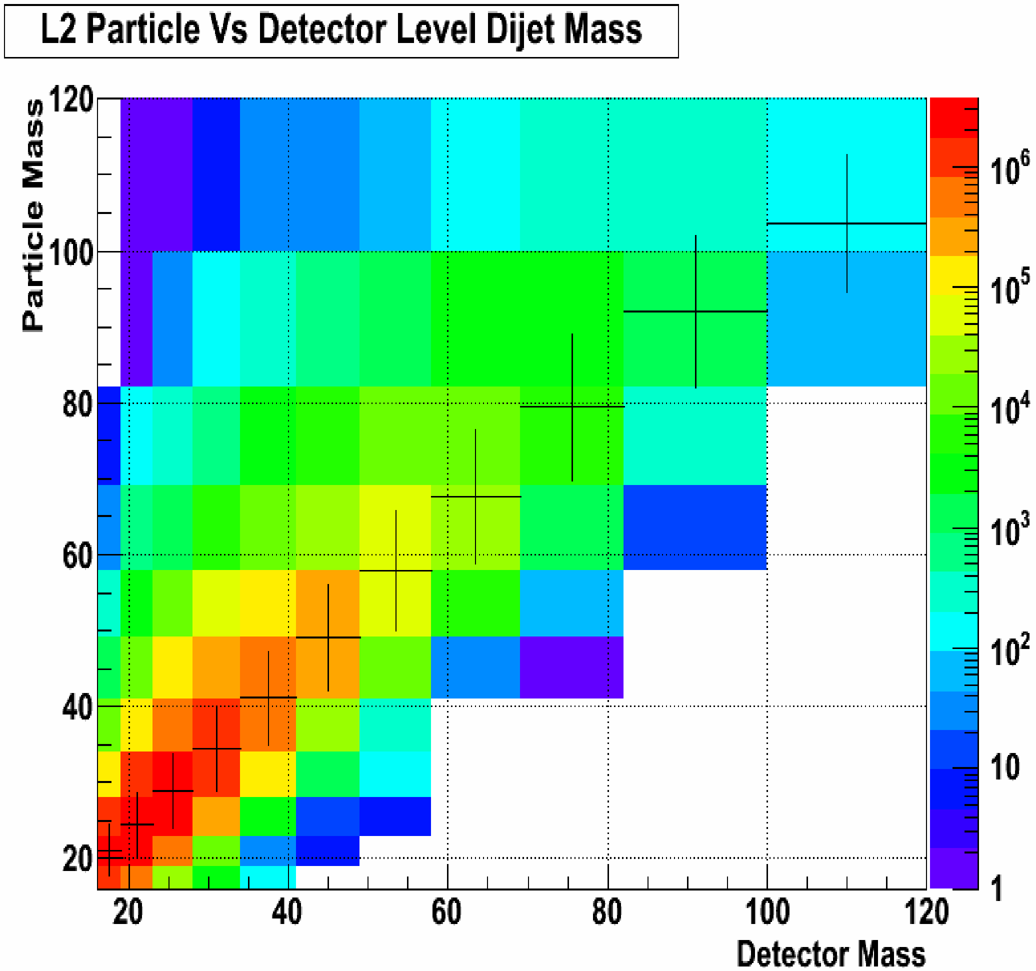
- Simulation sample needed to unfold and correct raw data yields
- Ignoring jet mass, di-jet mass depends on jet p_T, jet pseudorapidity difference, and jet azimuthal angle difference
- These quantities must match well in data and simulation to match di-jet mass

Data – Simulation Comparison



Di-jet Mass [GeV/c^2]

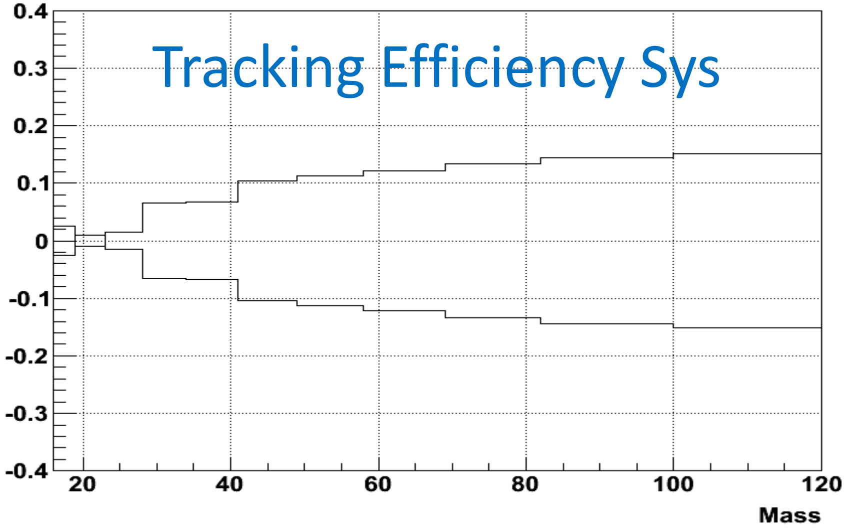
Unfolding Raw Yields

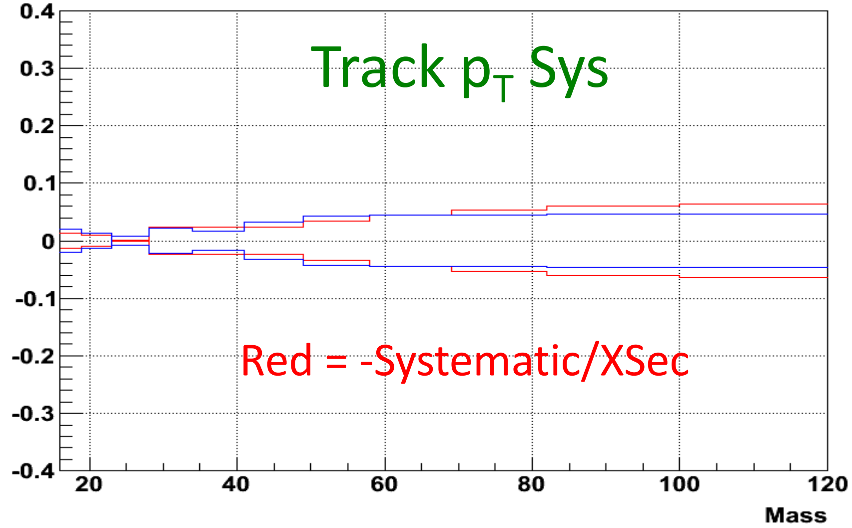


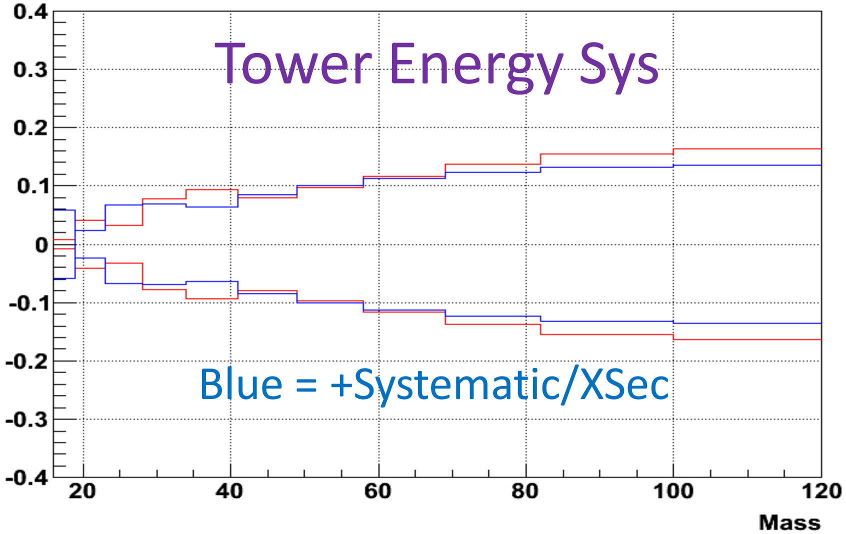
http://hepunx.rl.ac.uk/~adye/software/unfold/RooUnfold.html

- Raw di-jet yield must be corrected for detector resolution and acceptance effects – Unfolding
- Utilize the Singular Value Decomposition (SVD) method ito unfold raw yield [arXiv:hep-ph/9509307]
- Use ‘Response Matrix’ to relate detector response to thrown particles
- SVD a way of solving the linear system in a regularized way
- SVD method implemented in RooUnfold package

Systematic Errors: Detector Response

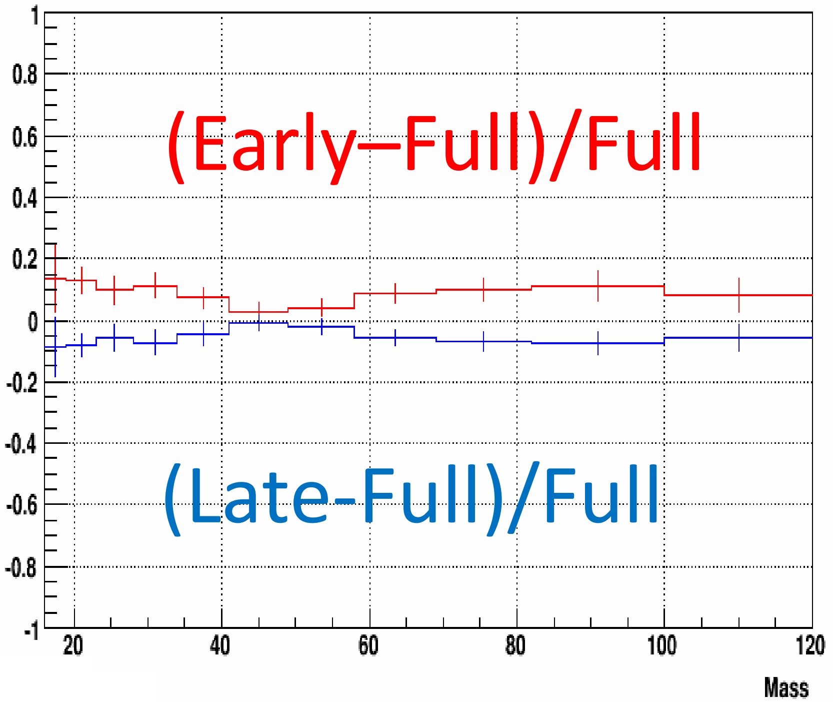




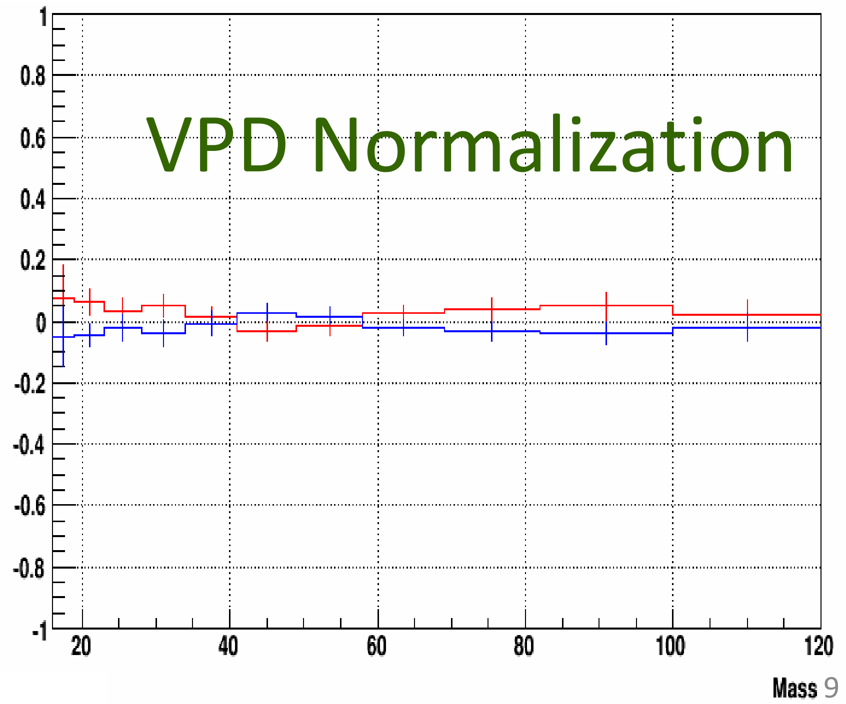


- Evaluated three 'Detector' Systematics
  - Tracking Efficiency: 4%
  - Track p_T Uncertainty: ± 1%
  - Tower Energy Scale Uncertainty: ± 3.7%
- Systematic in each bin is the average between + and – systematic
- These three and next systematic are added in quadrature to obtain final systematic band

Systematic Errors: Time Variation

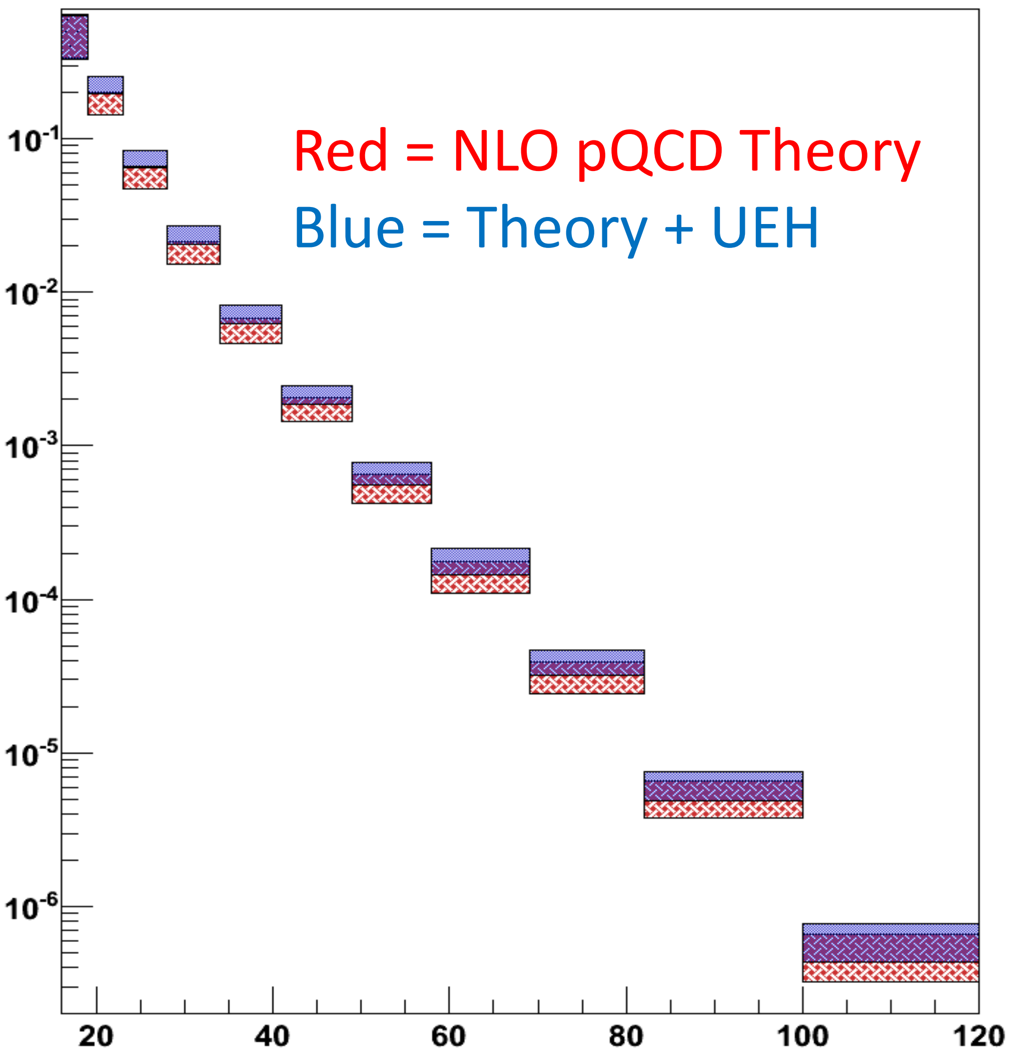


- Cross Section appears to change over course of run
- Extracting cross section from early and later in run gives different results
- Difference between early and late used as systematic
- Still under investigation but indications point to time variation in BBC luminosity monitor
- VPD seems more stable but need absolute cross section in order to use as luminosity monitor



Underlying Event and Hadronization

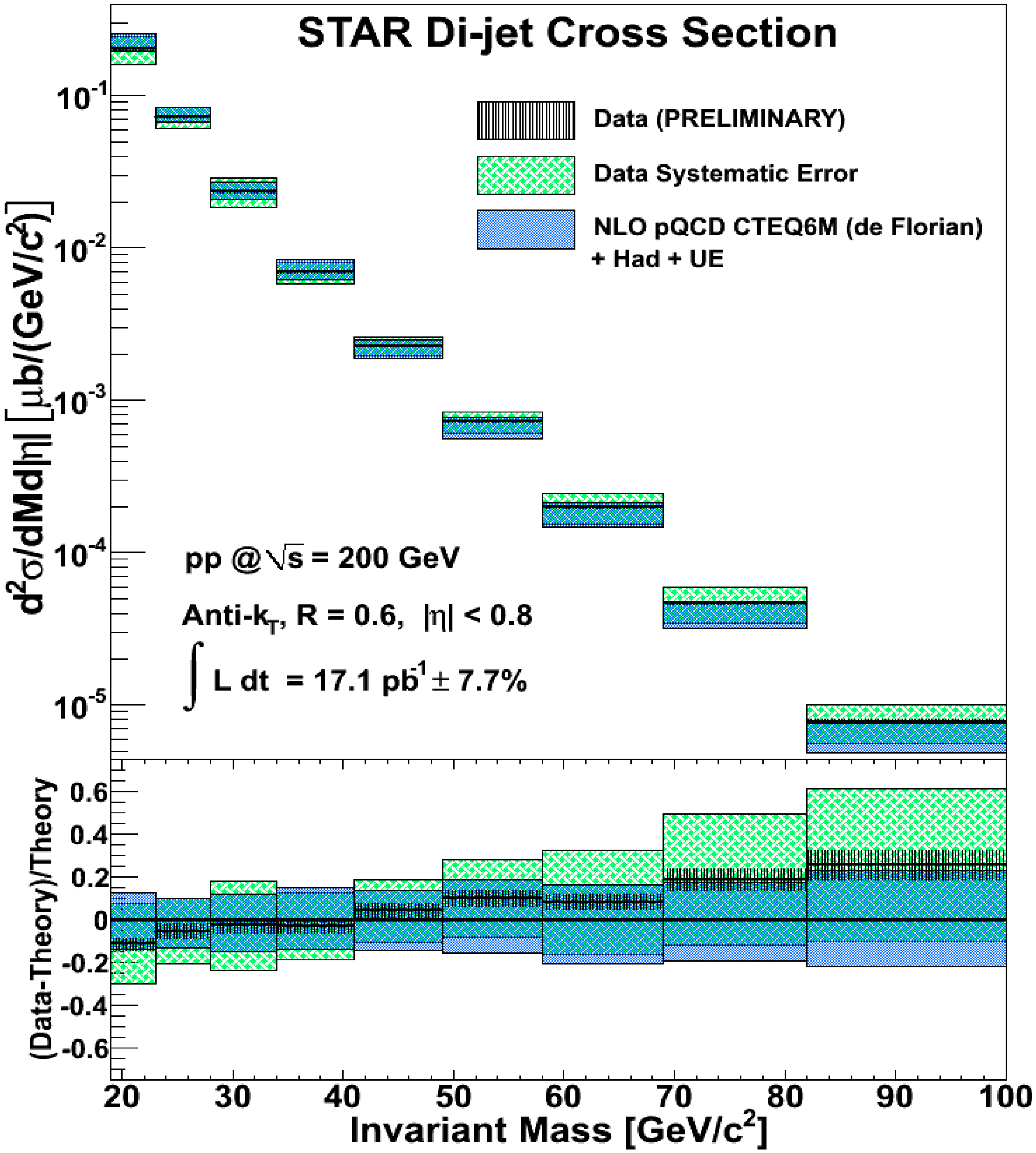
Theoretical Cross Section



Di-jet Mass [GeV/c^2]

- Extracted data cross section is compared to NLO pQCD theoretical calculation from deFlorian et al using CTEQ6M PDF
- Theory calculations do not take into account underlying event or hadronization effects
- Use difference between data cross section corrected to particle level and cross section corrected to parton level as contribution from UEH
- Add this UEH contribution to theoretical cross section

Di-jet Cross Section Result



Thickness of vertical black hashing represents size of statistical error on the measurement

Green hatched box is symmetric about data point and is the quadrature sum of all systematic errors

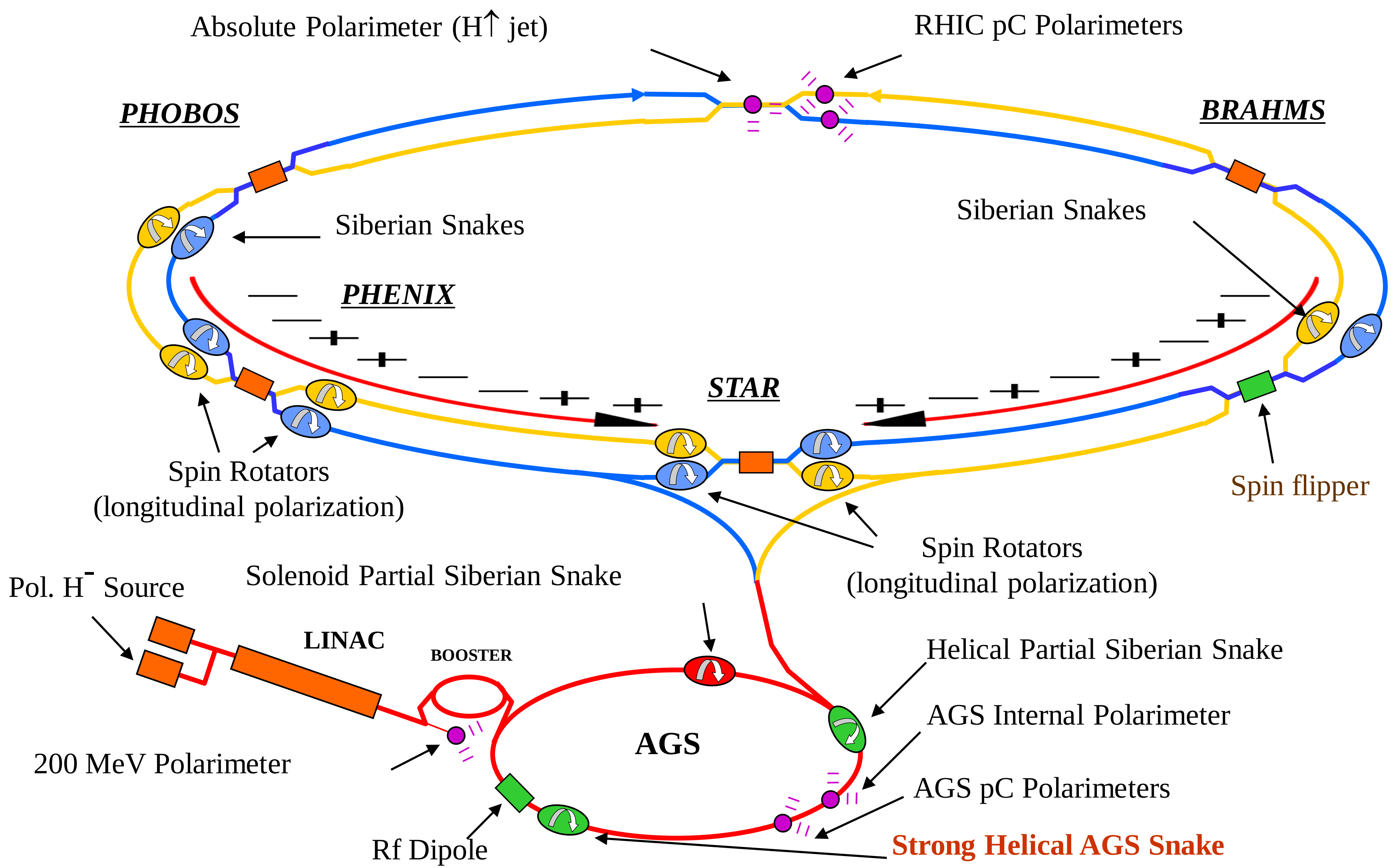
Thickness of blue box represents error on theory determined by changing factorization and renormalization scales by factor of 0.5 and 2

Conclusions

- STAR has measured the mid-rapidity di-jet cross section at $\sqrt{s}$ = 200 GeV using the Anti-k_T jet algorithm
- The measured cross section is in agreement with NLO pQCD theoretical predictions
- Work continues on investigating and mitigating the time variation of the cross section due to changes in the luminosity monitor
- The good agreement between data and theory gives confidence in future di-jet asymmetry measurements

Back-Up

RHIC

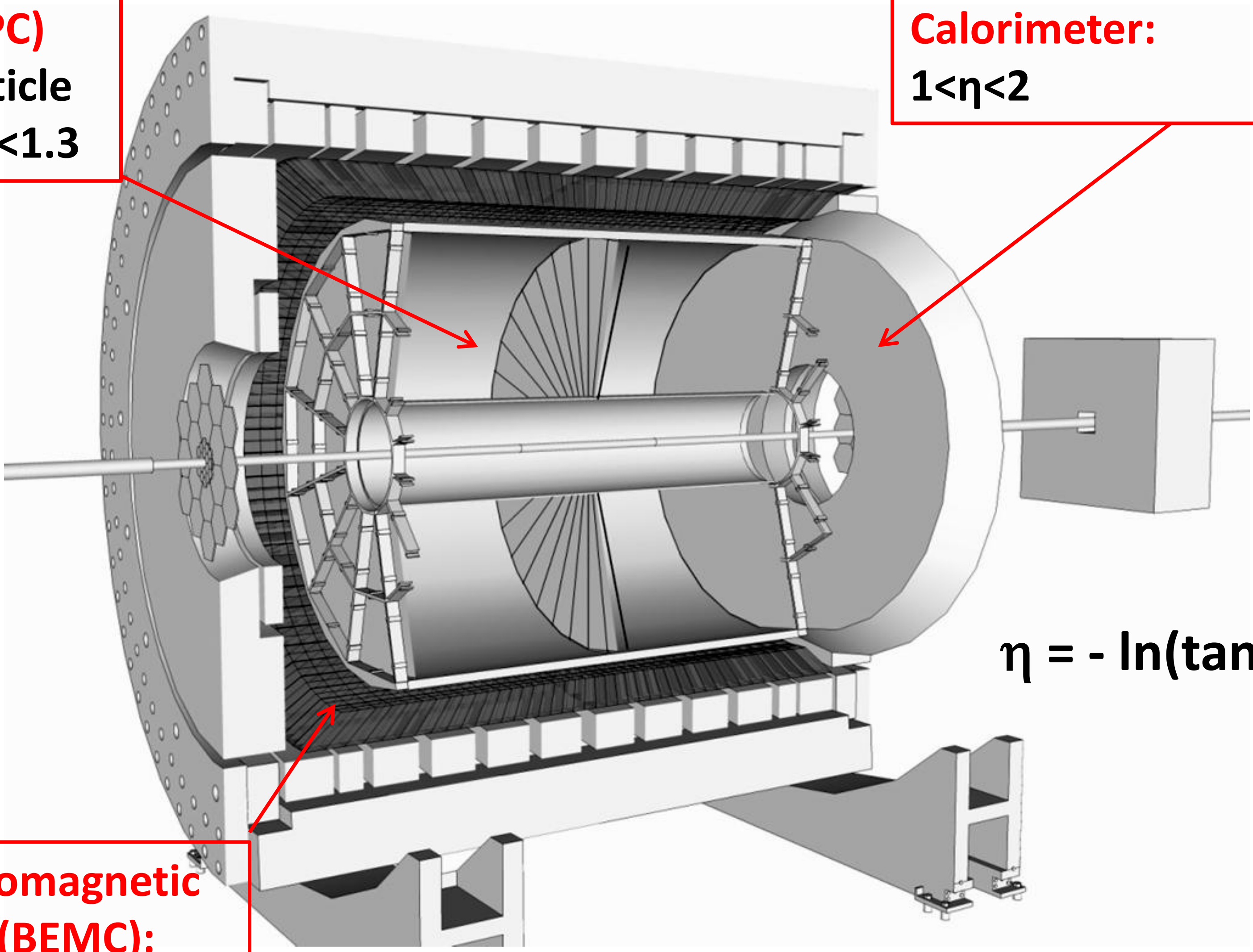


Absolute Polarimeter (H↑ jet)
RHIC pC Polarimeters
PHOBOS
BRAHMS
Siberian Snakes
Siberian Snakes
PHENIX
STAR
Spin Rotators
(longitudinal polarization)
Spin flipper
Spin Rotators
(longitudinal polarization)
Pol. H$^-$ Source
Solenoid Partial Siberian Snake
LINAC
BOOSTER
Helical Partial Siberian Snake
AGS Internal Polarimeter
AGS
200 MeV Polarimeter
AGS pC Polarimeters
Rf Dipole
Strong Helical AGS Snake

STAR Detector

Time Projection Chamber (TPC)
Charged Particle Tracking $|\eta|<1.3$

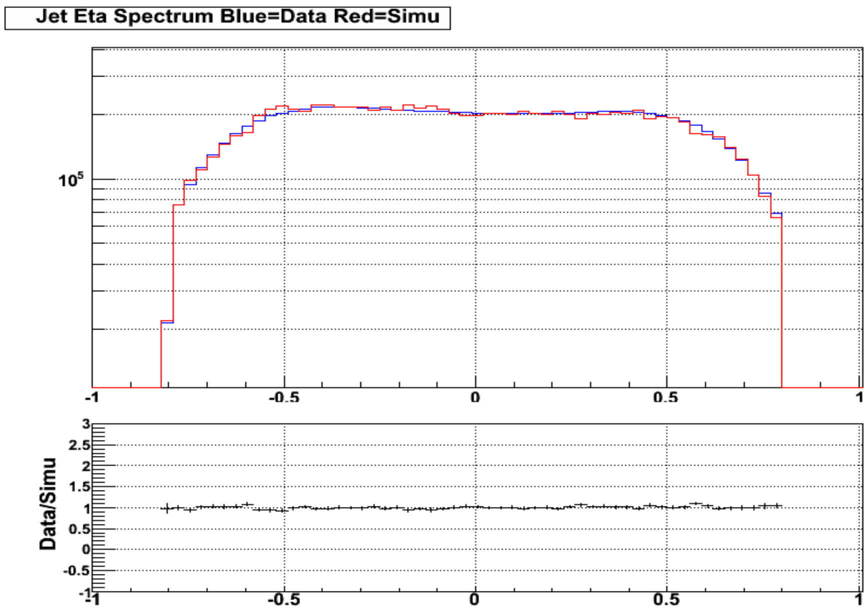
Endcap Electromagnetic Calorimeter:
$1<\eta<2$

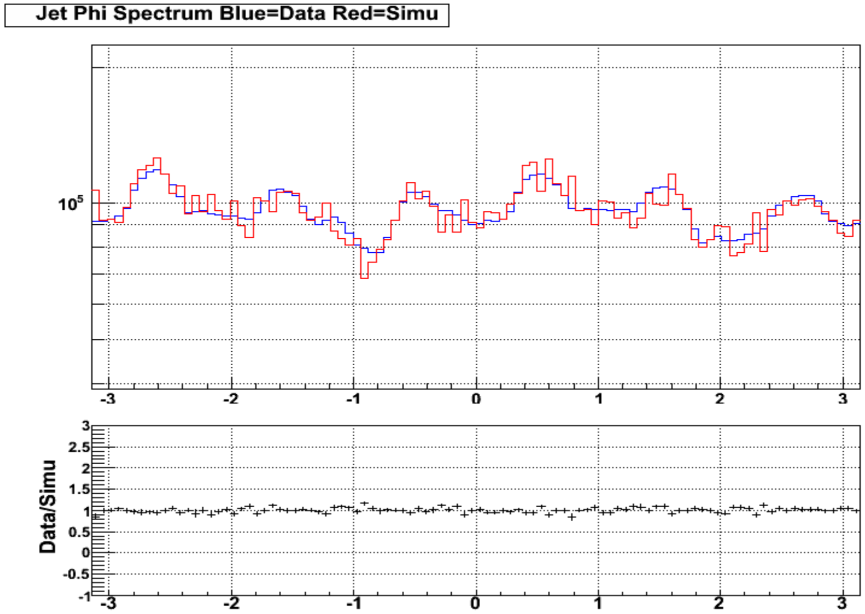


$$\eta = -\ln(\tan(\theta/2))$$

Barrel Electromagnetic Calorimeter (BEMC):
$|\eta|<1$

Data - Simulation Comparisons





Effect of Time Variation Systematic