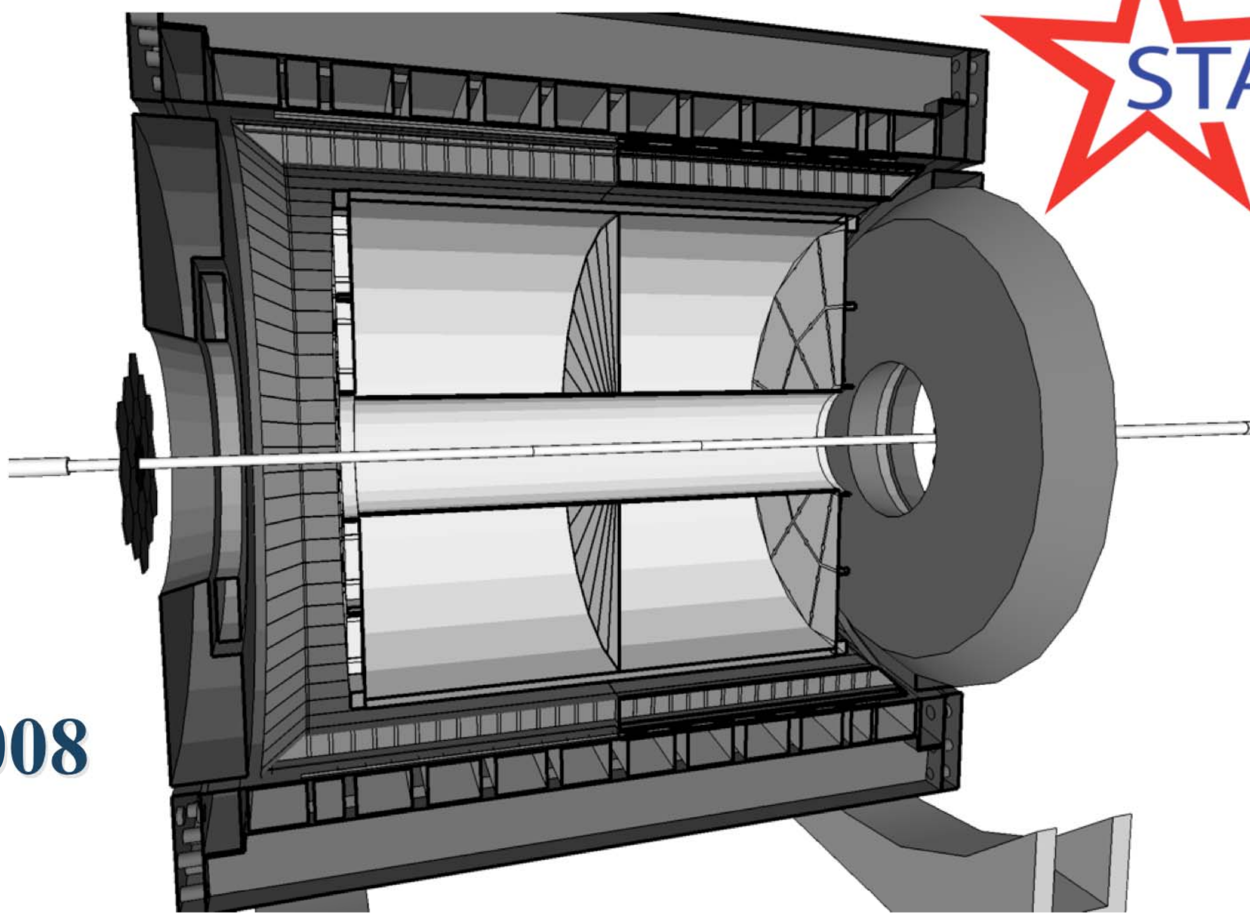
Status of Dijet Cross Section and Double Longitudinal Spin Asymmetry Measurement in 200 GeV Proton+Proton Collisions at RHIC

Tai Sakuma
MIT



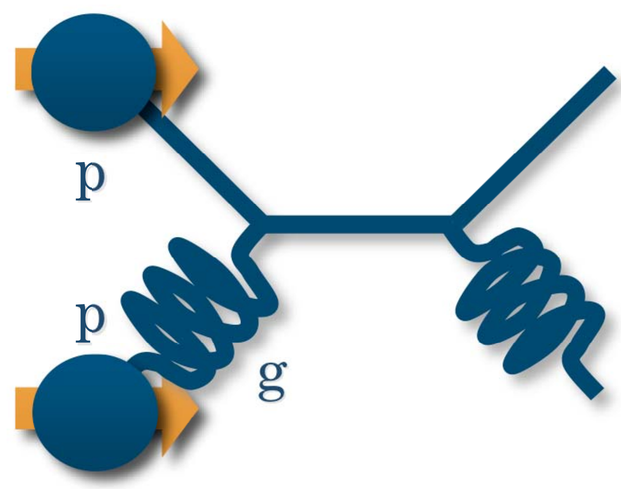
10/10/2008

Contents

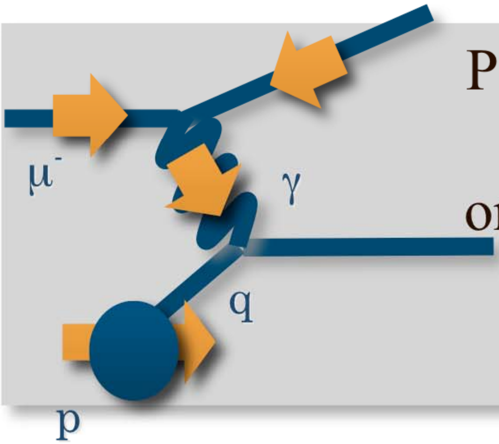
1. ΔG measurement at STAR

$$\frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + \langle L_q \rangle + \langle L_g \rangle$$

2. The status and projections of the dijet analysis



ΔG measurement at STAR



Polarized DIS found that quarks carry only a small fraction of the proton spin

$\Delta\Sigma \approx 0.3$

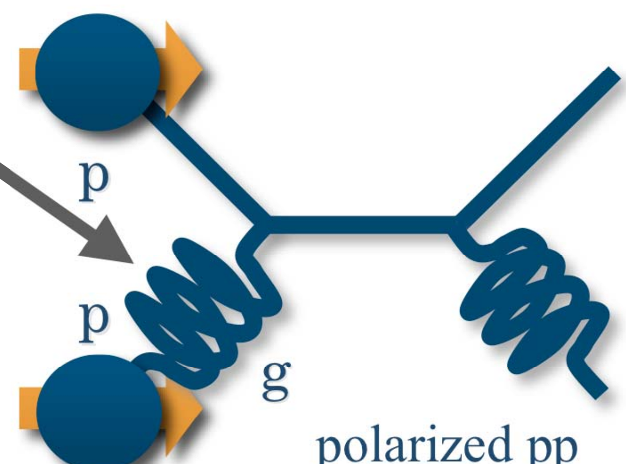
ΔG is only loosely constrained from polarized DIS data.

$$\frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + \langle L_q \rangle + \langle L_g \rangle$$

proton spin — quarks — gluons — orbital motions

$$\Delta G = \int_0^1 \Delta g(x) \mathrm{d}x$$

$$\Delta g(x) = g^+(x) - g^-(x)$$

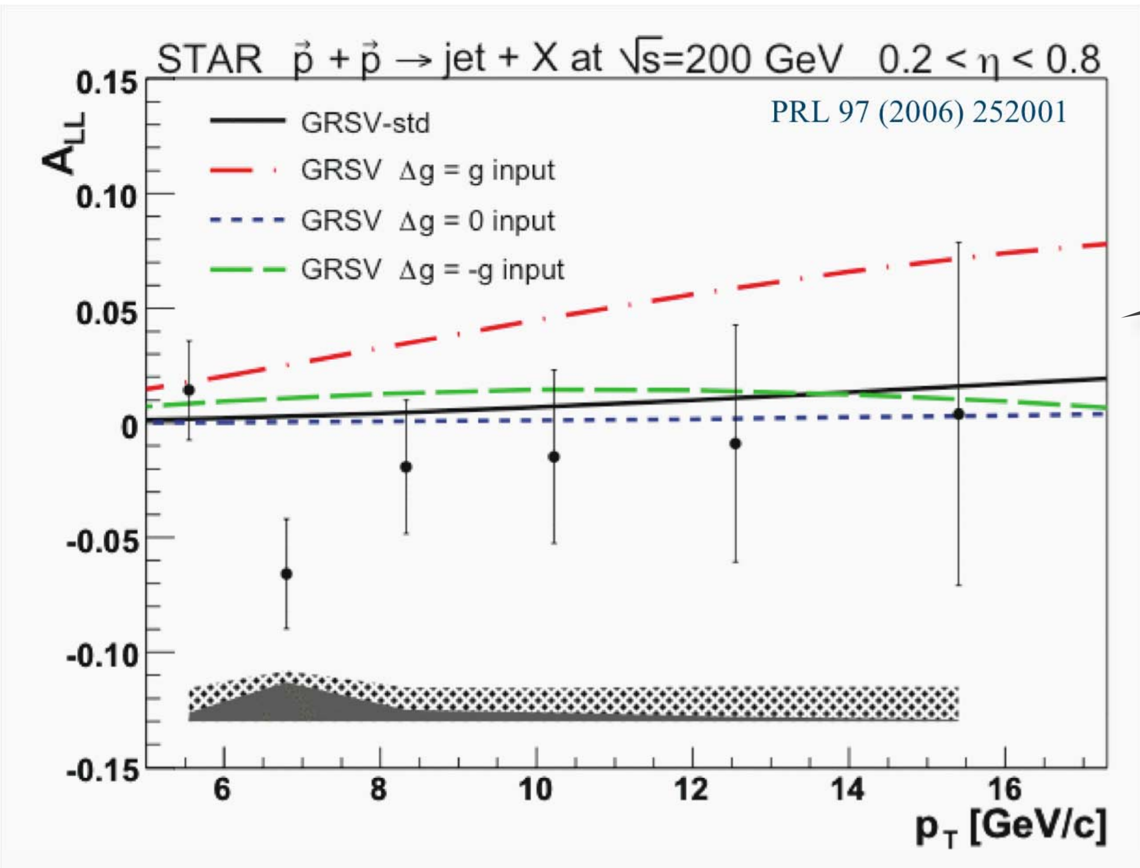


In polarized pp collisions, A_{LL} is the most important quantity to measure to determine ΔG.

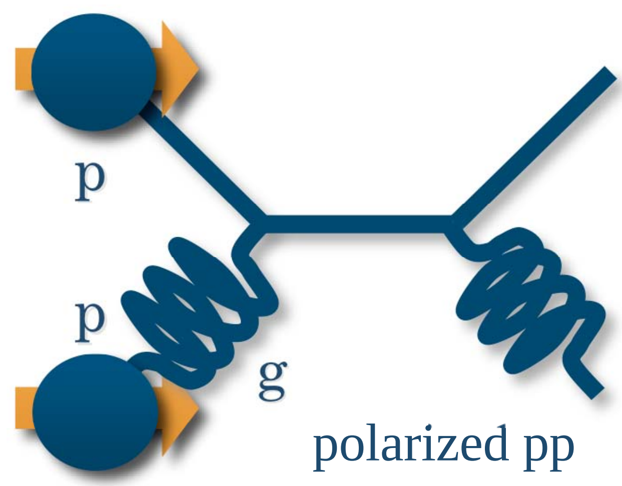
A_{LL} - the double longitudinal spin asymmetry

$$A_{\rm LL} = \frac{\sigma_{++} - \sigma_{+-}}{\sigma_{++} + \sigma_{+-}}$$

- sensitive to ΔG

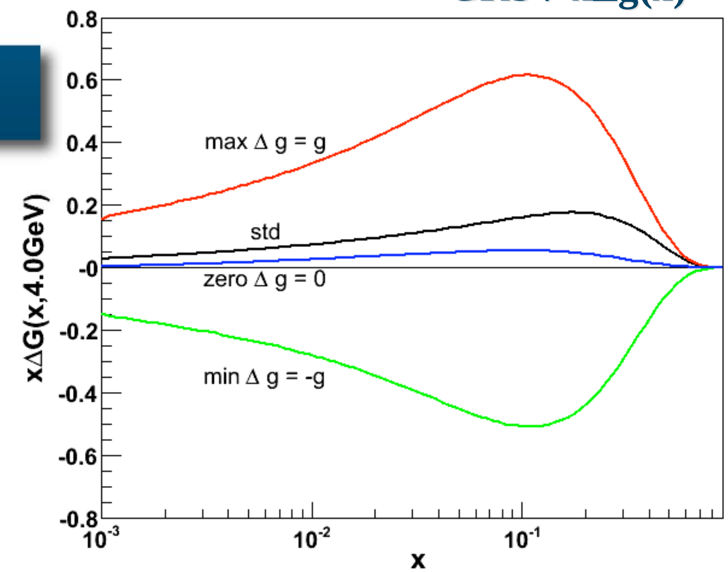


As an example of A_{LL}, this is one of the early results from STAR.



A_{LL} is sensitive to ΔG

GRSV xΔg(x)

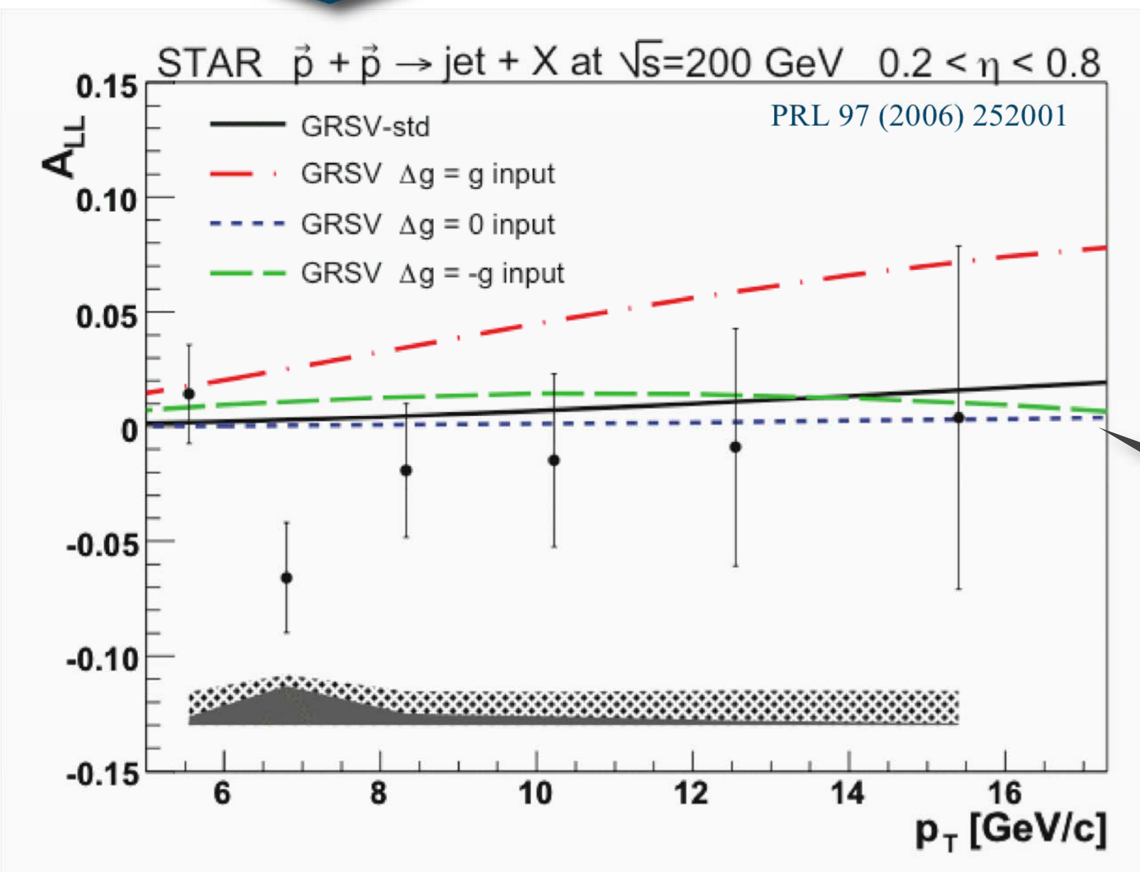


Perturbative QCD

$$A_{\rm LL} = \frac{\sum_{i,j}\int {\rm d}x_1 \int {\rm d}x_2 \Delta f_i(x_1,Q^2)\Delta f_j(x_2,Q^2)\hat{\sigma}(\cos\theta^*)\hat{a}_{\rm LL}(\cos\theta^*)}{\sum_{i,j}\int {\rm d}x_1 \int {\rm d}x_2 f_i(x_1,Q^2) f_j(x_2,Q^2)\hat{\sigma}(\cos\theta^*)}$$

$$\Delta g(x) = \Delta f_i(x)|_{i=g}$$

Polarized Gluon Distribution Functions



A_{LL} is sensitive to polarized gluon distribution

The cross section measurement is to confirm pQCD framework

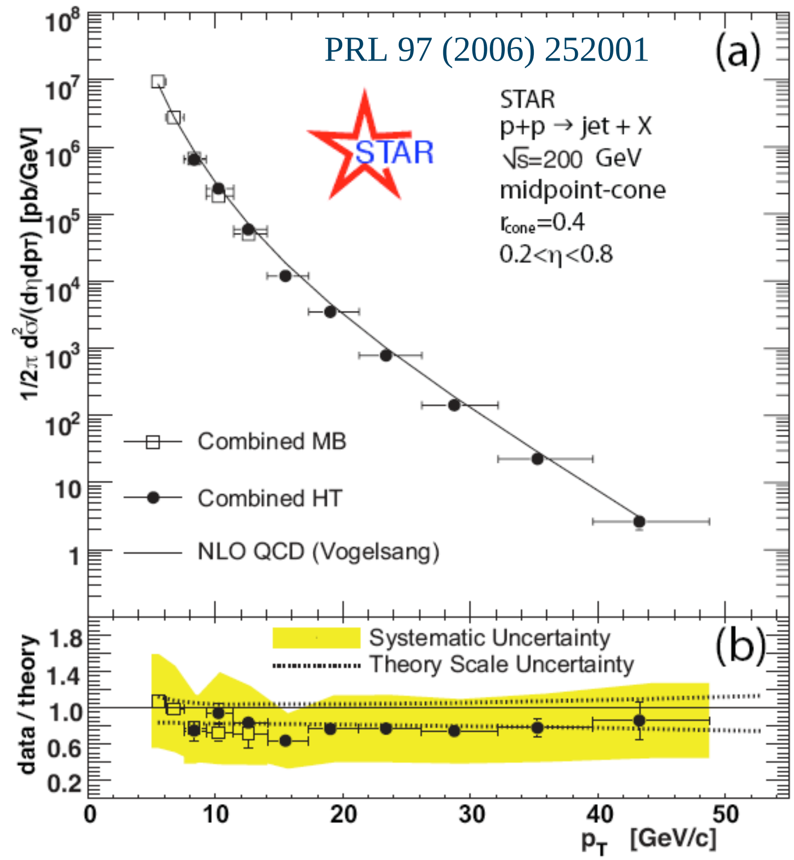
Perturbative QCD

$$A_{\rm LL} = \frac{\sum_{i,j} \int \mathrm{d}x_1 \int \mathrm{d}x_2 \Delta f_i(x_1, Q^2) \Delta f_j(x_2, Q^2) \hat{\sigma}(\cos\theta^*) \hat{a}_{\rm LL}(\cos\theta^*)}{\sum_{i,j} \int \mathrm{d}x_1 \int \mathrm{d}x_2 f_i(x_1, Q^2) f_j(x_2, Q^2) \hat{\sigma}(\cos\theta^*)}$$

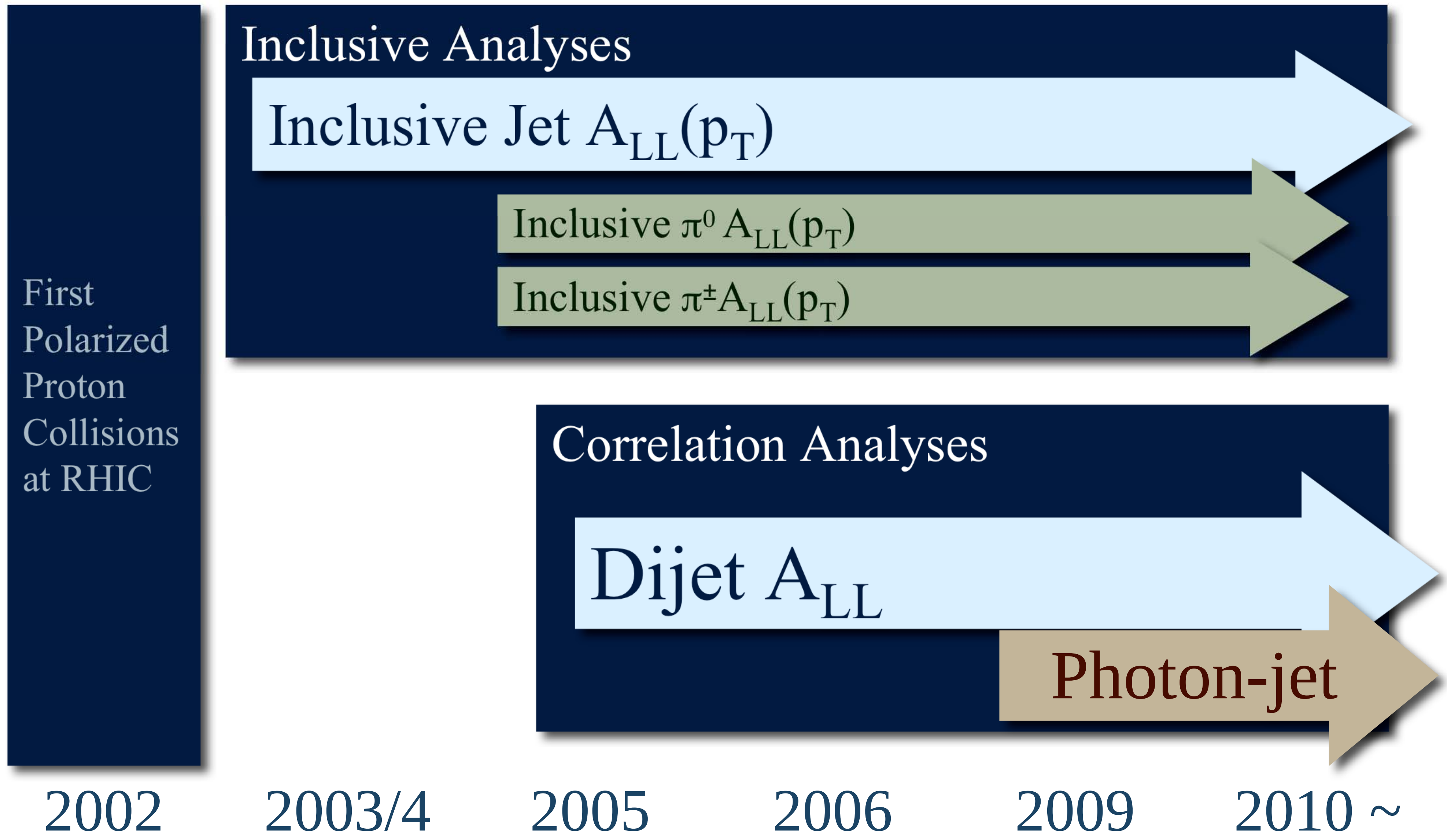
$$\Delta g(x) = \Delta f_i(x)|_{i=g}$$

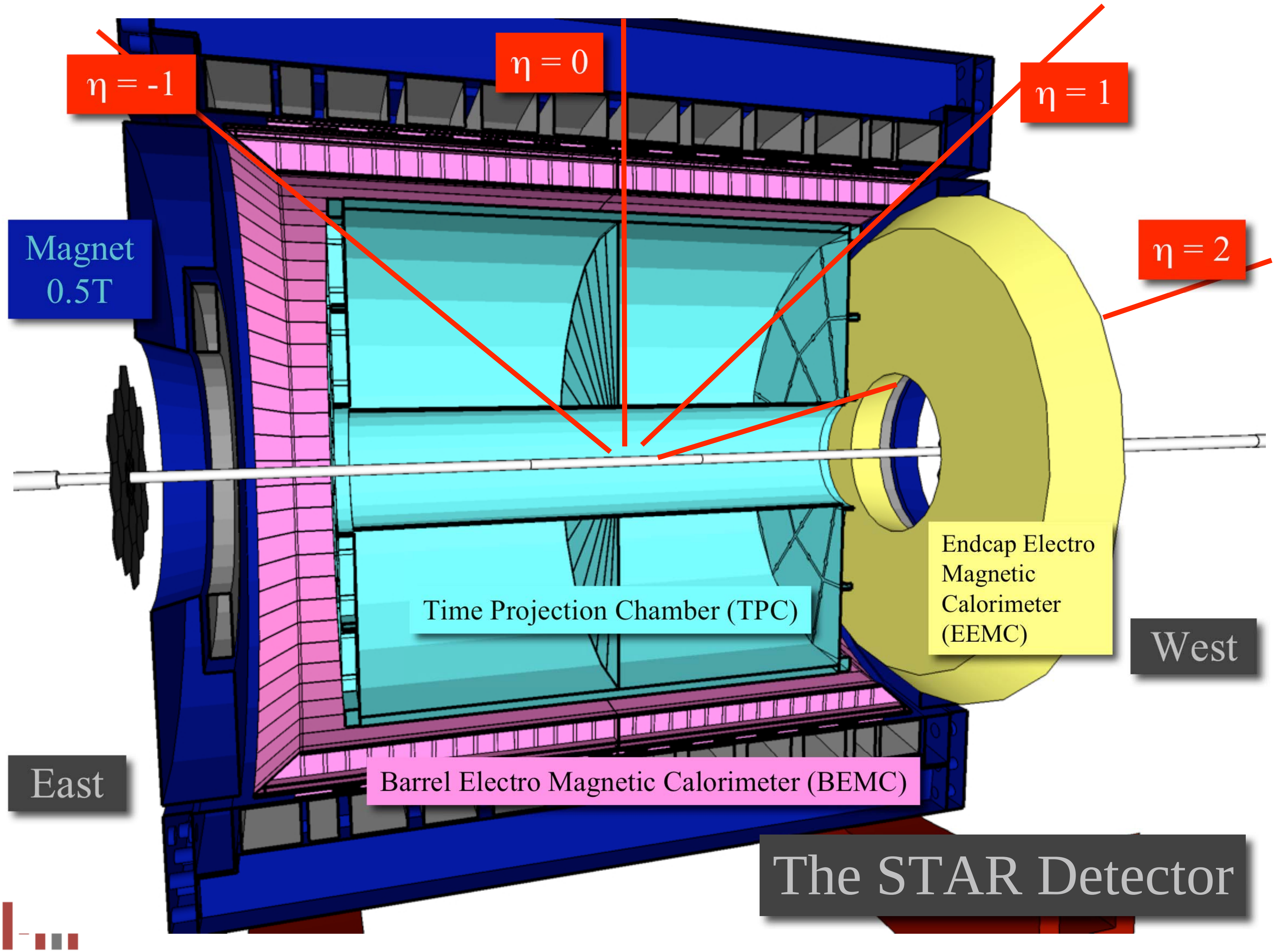
verify the framework

$$\sigma = \sum_{i,j} \int \mathrm{d}x_1 \int \mathrm{d}x_2 f_i(x_1, Q^2) f_j(x_2, Q^2) \hat{\sigma}(\cos\theta^*)$$



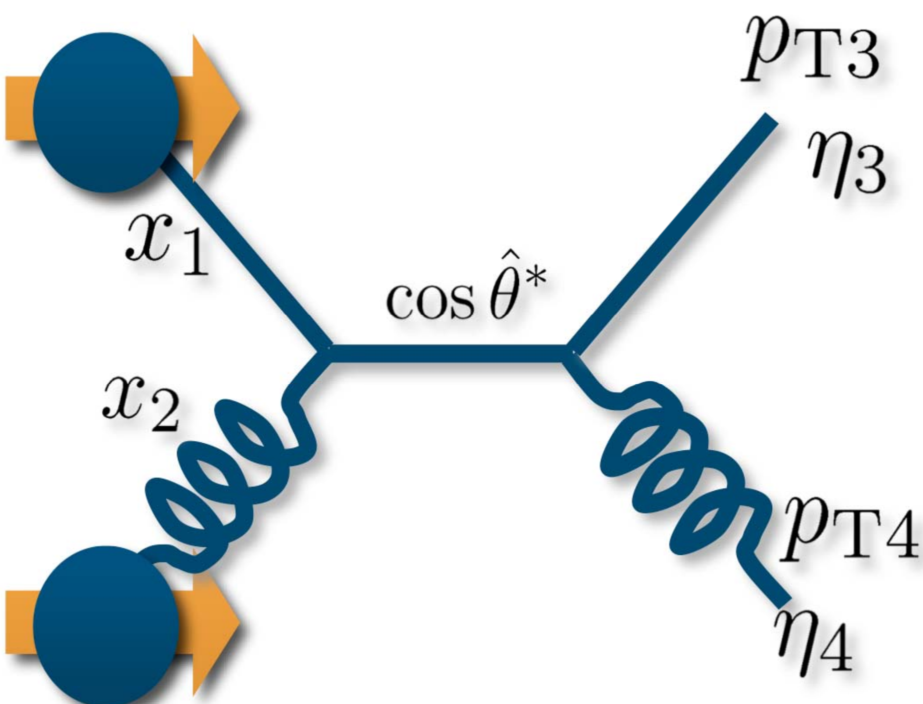
STAR measures A_{LL} for various final states.





η = -1
η = 0
η = 1
η = 2
Magnet 0.5T
Time Projection Chamber (TPC)
Endcap Electro Magnetic Calorimeter (EEMC)
West
East
Barrel Electro Magnetic Calorimeter (BEMC)
The STAR Detector

Motivation for Dijet A_{LL} is to constrain ΔG with initial event kinematics



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

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

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

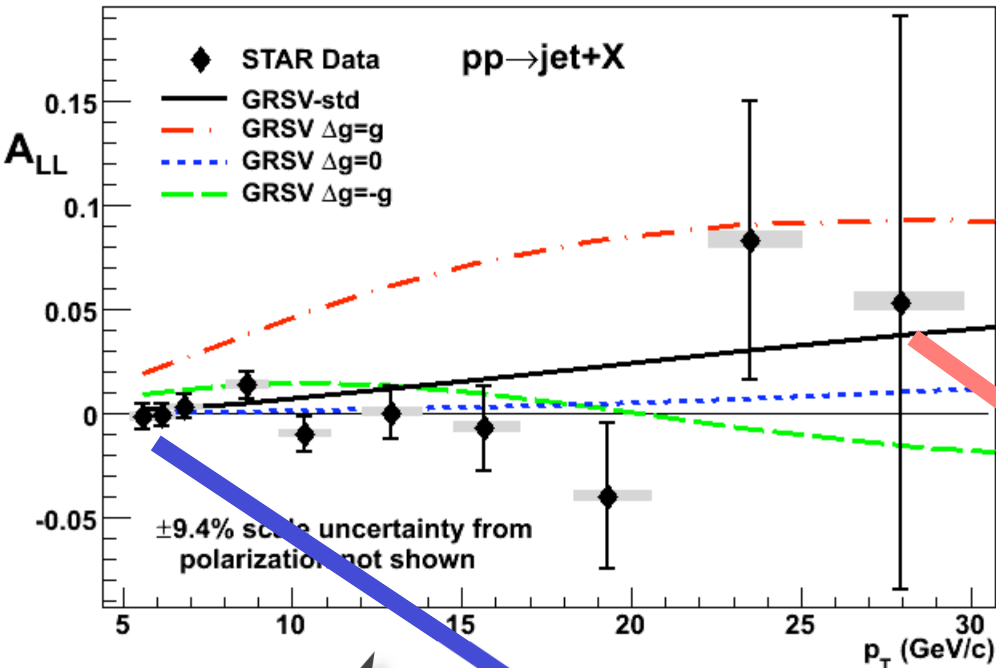
$$\eta_3 + \eta_4 = \log\frac{x_1}{x_2}$$

$$\tanh\frac{\eta_3 - \eta_4}{2} = \cos\theta^*$$

The initial state variables can be written in terms of the final state variables

Compared to the inclusive jet A_{LL}

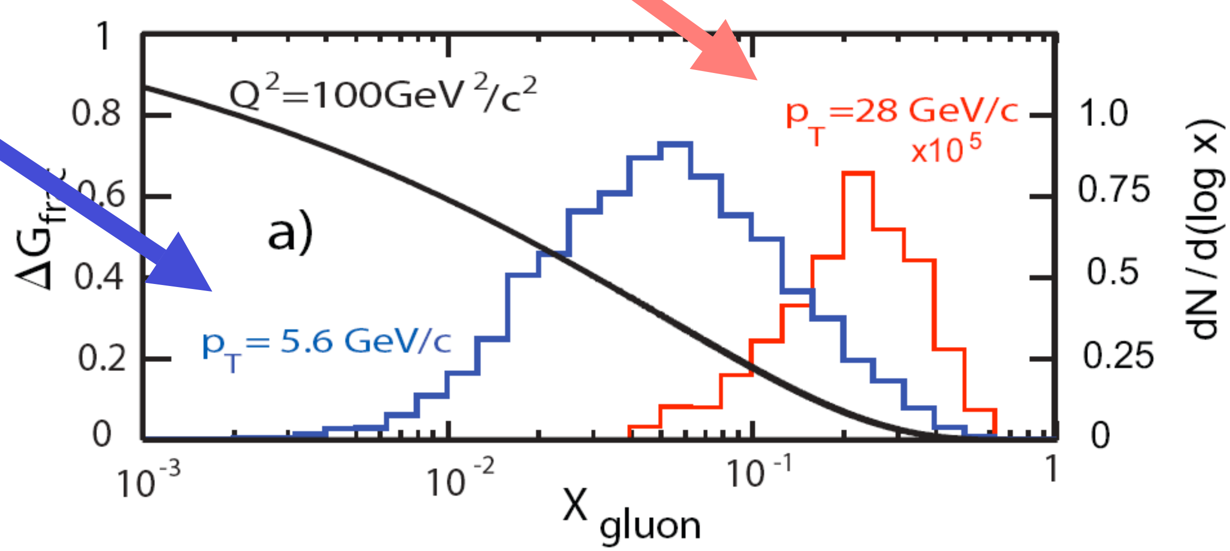
PRL **100**, 232003 (2008)



$$x \sim \frac{2p_T}{\sqrt{s}}$$

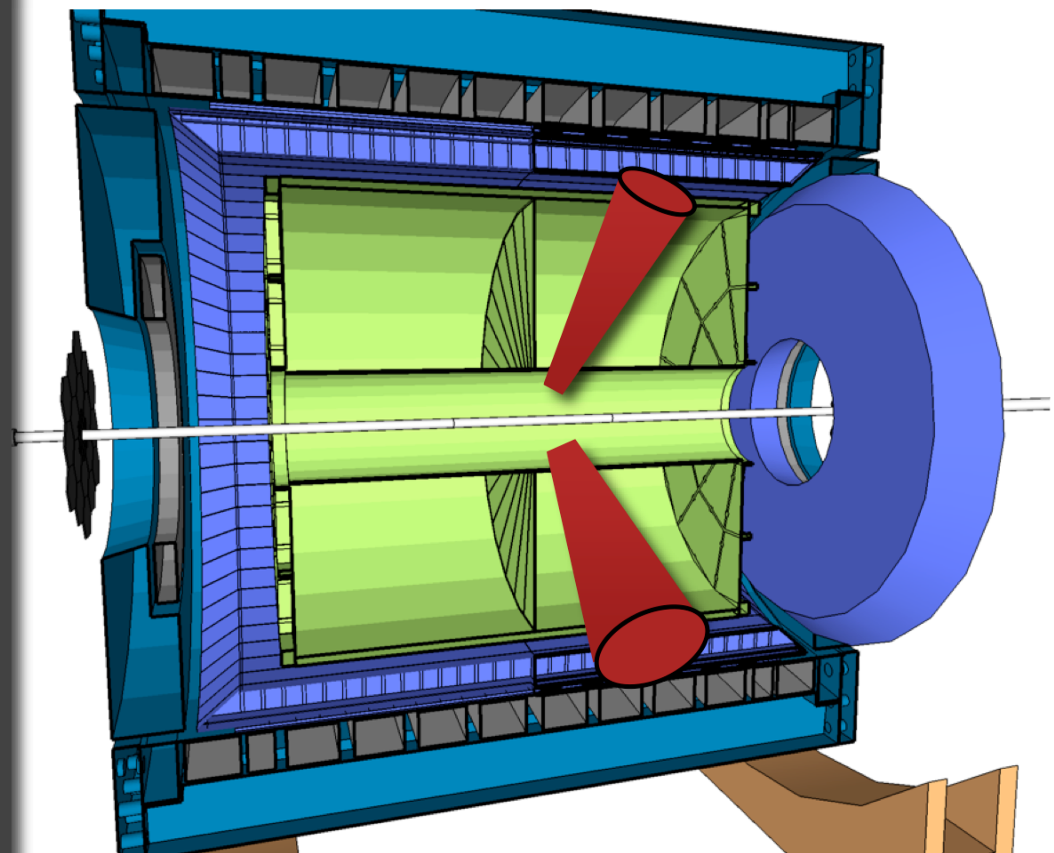
Each bin is integral over a range of x

A_{LL} as a function of p_T



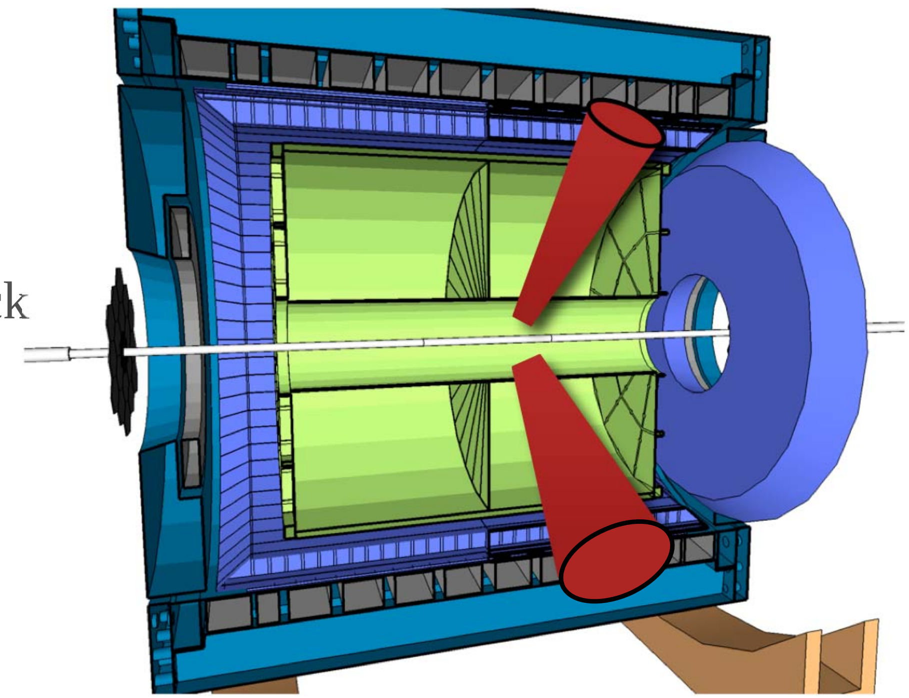
Evolution of STAR Dijet program

- 2005
  - First cross section measurement
  - west barrel - west barrel dijets
- 2006
  - First A_{LL} measurement
  - barrel - barrel dijets,
    barrel - endcap dijets
- 2009
  - May provide better constraint on ΔG than inclusive jets
  - Wide acceptance including endcap - endcap dijets



Dijet Definition

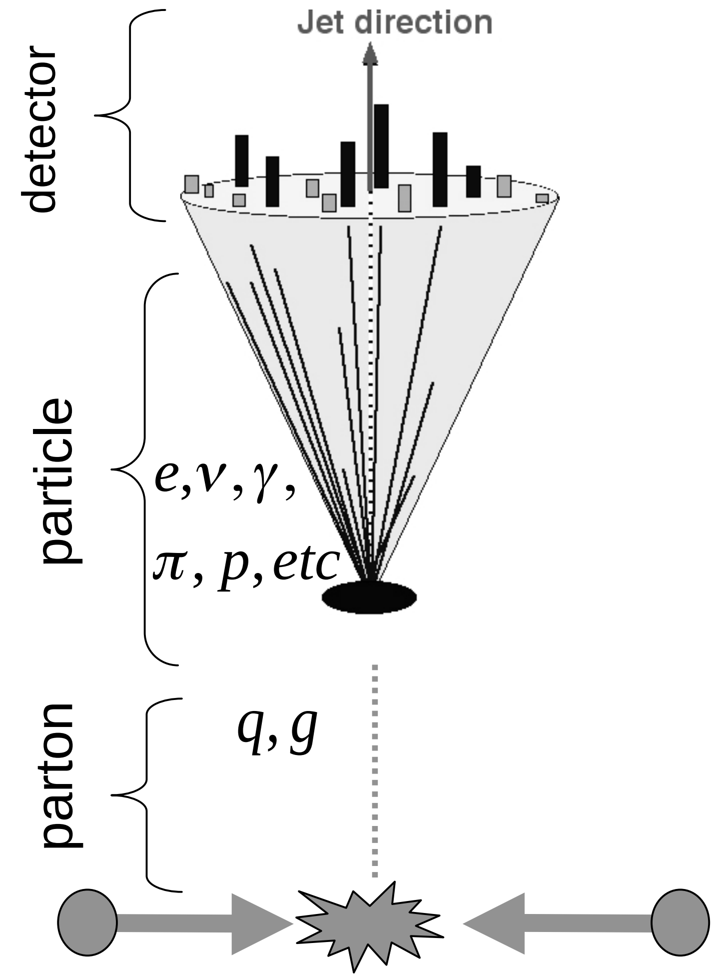
- Jet Definition
  - Collection of charged tracks and tower energy deposits in a circle in η x ϕ plane
    - Charged Tracks
      - TPC
      - Pion mass assumption
    - Tower Energy Deposits
      - BEMC
      - Photon mass assumption
      - MIP energy subtraction for track
  - Midpoint Cone Algorithm
    hep-ex/0608030
    - Cone Radius: 0.4(2005), 0.7(2006)
- Dijet Definition
  - Two leading pT jets



Cross Section Measurement

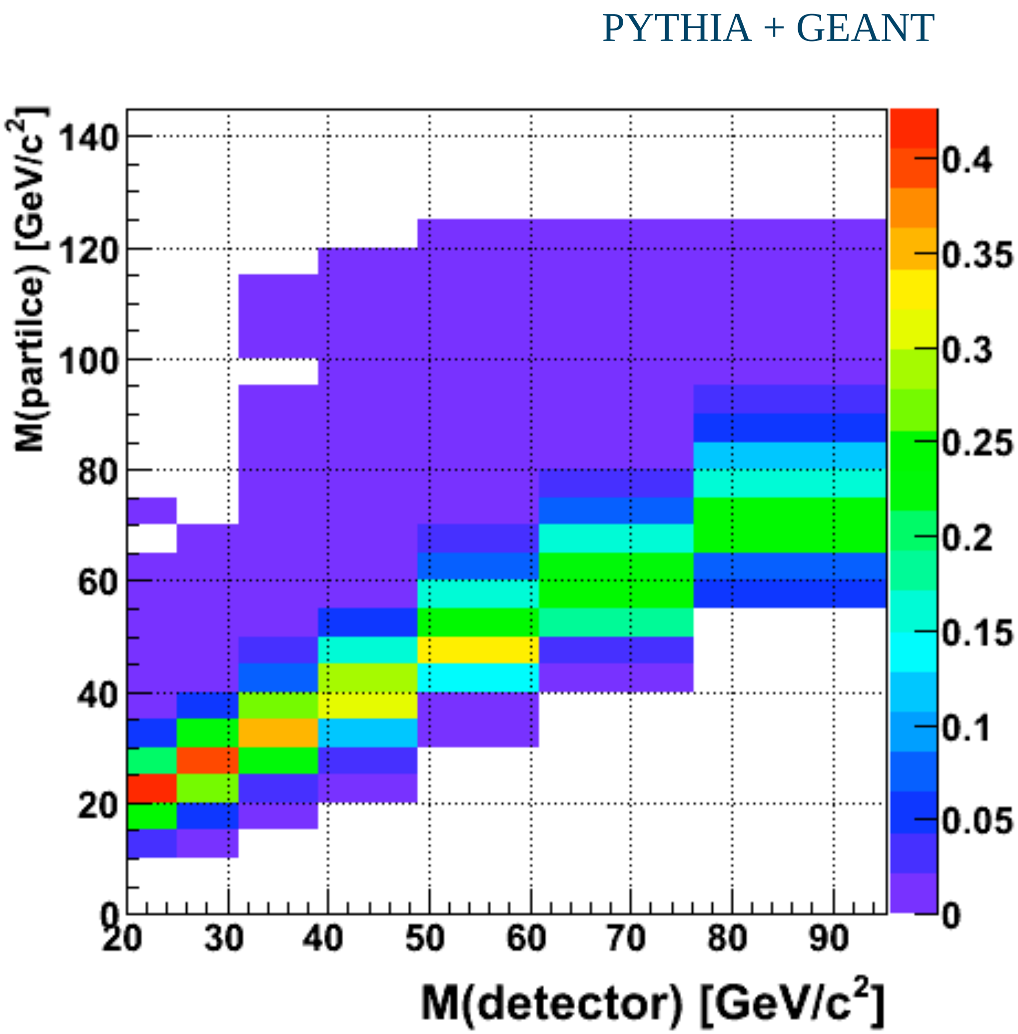
$$\frac{d\sigma}{dM\, d\eta_3\, d\eta_4} = \frac{N_{\text{dijet}}}{dM\, d\eta_3\, d\eta_4} \cdot \frac{1}{\int \mathcal{L} dt} \cdot \frac{1}{c}$$

- Data Collection
  - RHIC 2005 Run
  - 200 GeV, $2.2 pb^{-1}$
- Phase Space
  - $\min(p_T) > 7$ GeV, $\max(p_T) > 10$ GeV
  - $-0.05 < \eta < 0.95$, $|\Delta\eta| < 0.5$
  - $|\Delta\varphi| > 2.0$
- Data - NLO comparison
  - The comparison is made at particle level.
    - Detector jets are corrected to particle jets with Pythia
    - The corrections for hadronization and underlying events on NLO calculation are evaluated with Pythia

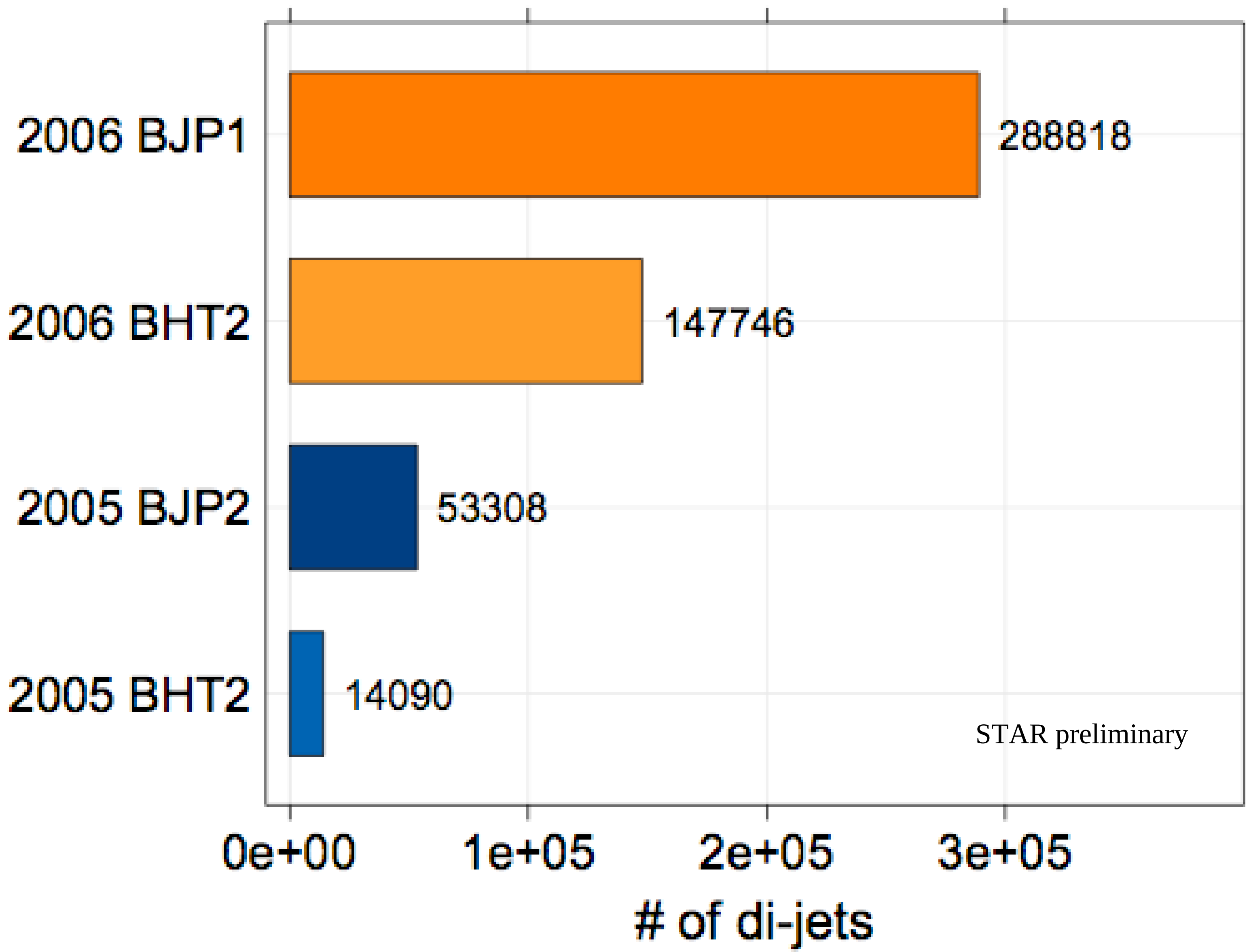


Unfolding dijet cross section with Pythia MC sample

- The particle level distribution is different from the detector level distribution due to the detector response.



Dijet Yield

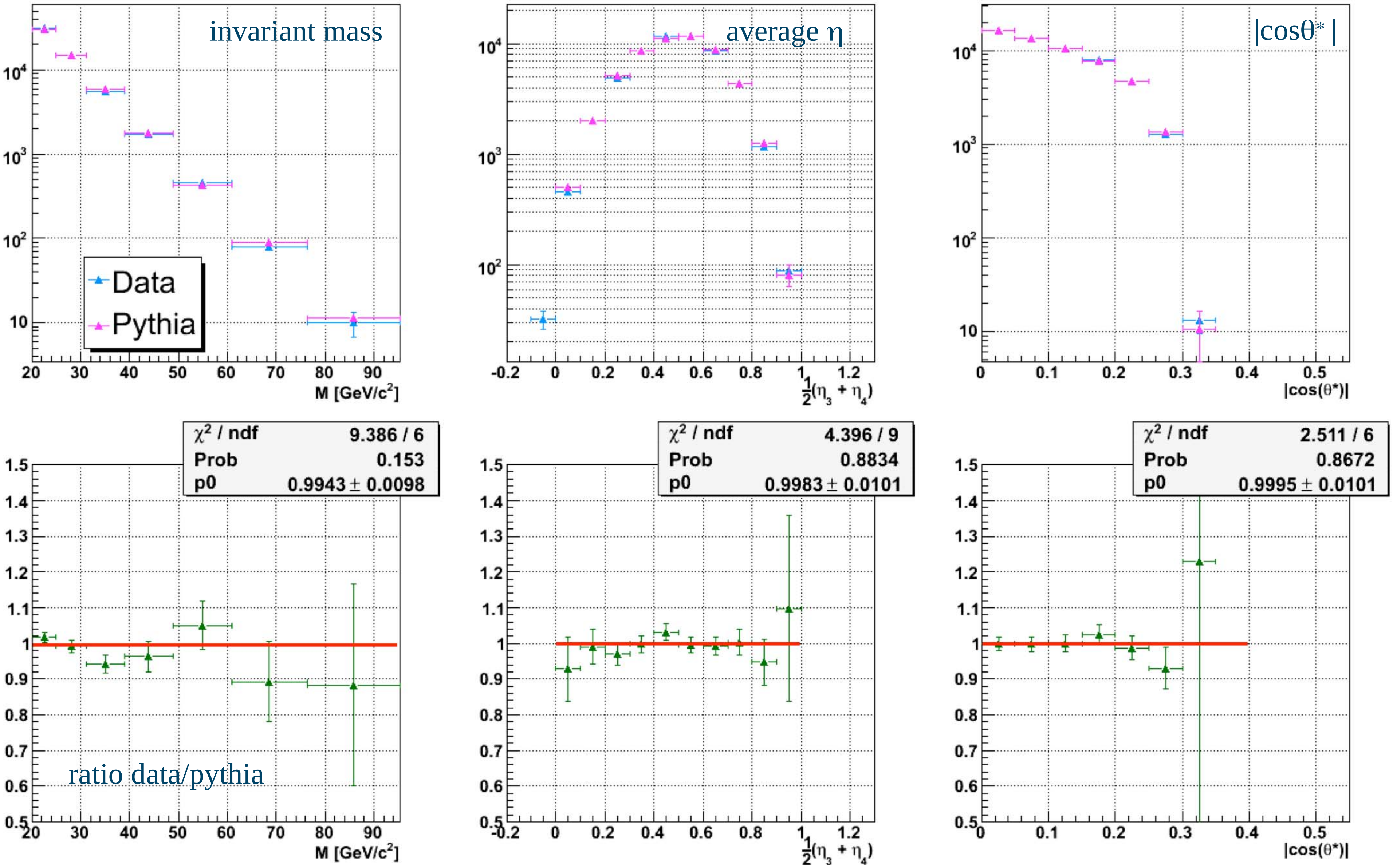


2006 BJP1
288818
2006 BHT2
147746
2005 BJP2
53308
2005 BHT2
14090
STAR preliminary
0e+00
1e+05
2e+05
3e+05
# of di-jets

Dijet distributions are well described by MC

(One normalization factor fixed by M distribution)

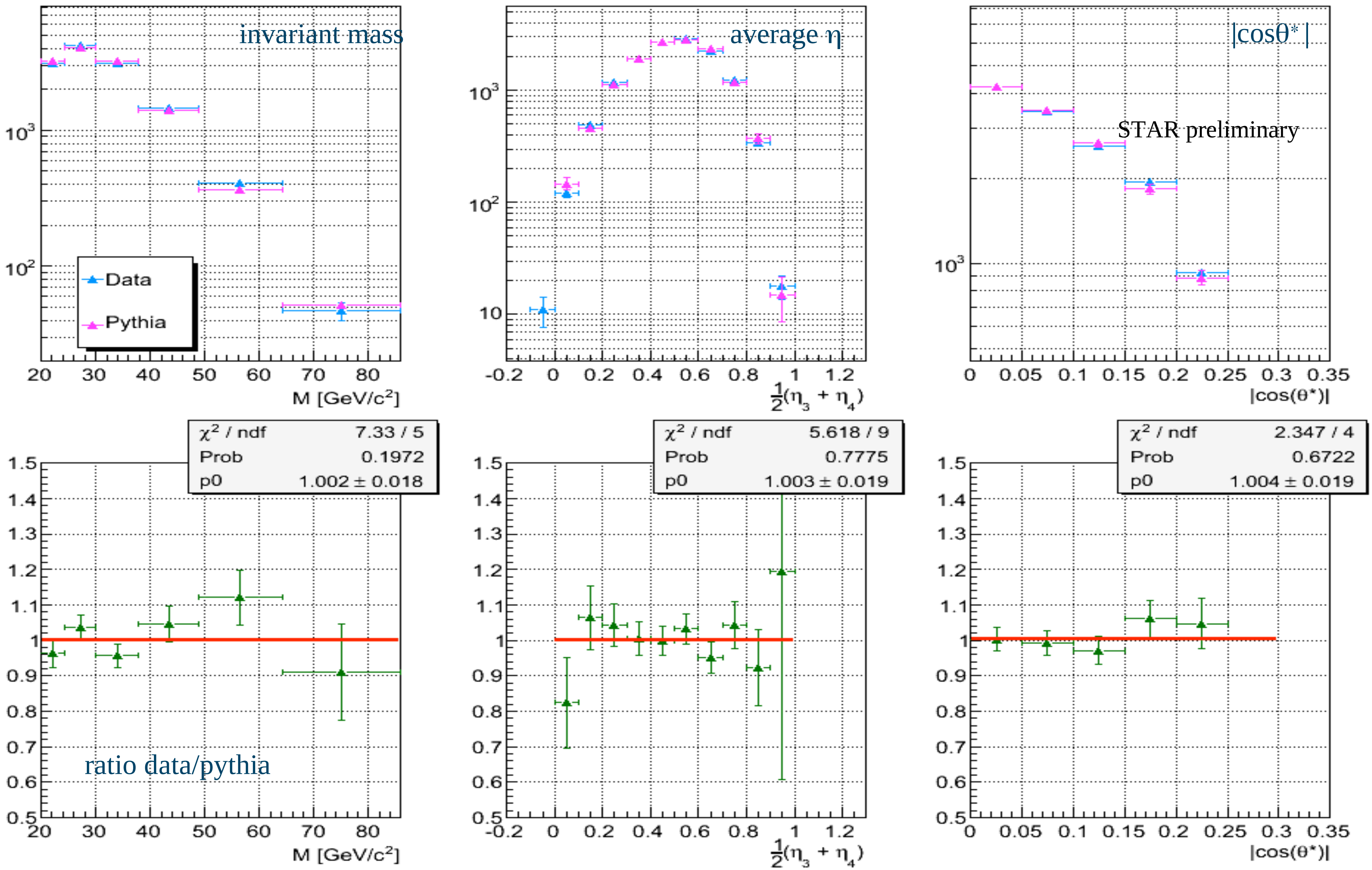
2005 BJP2



$$\sqrt{s} = 200\ \mathrm{GeV},\ 0.2 \leq \eta \leq 0.8,\ p_{\mathrm{T}} \geq 5.0\ \mathrm{GeV/c},\ M \geq 20\ \mathrm{GeV/c^2}$$

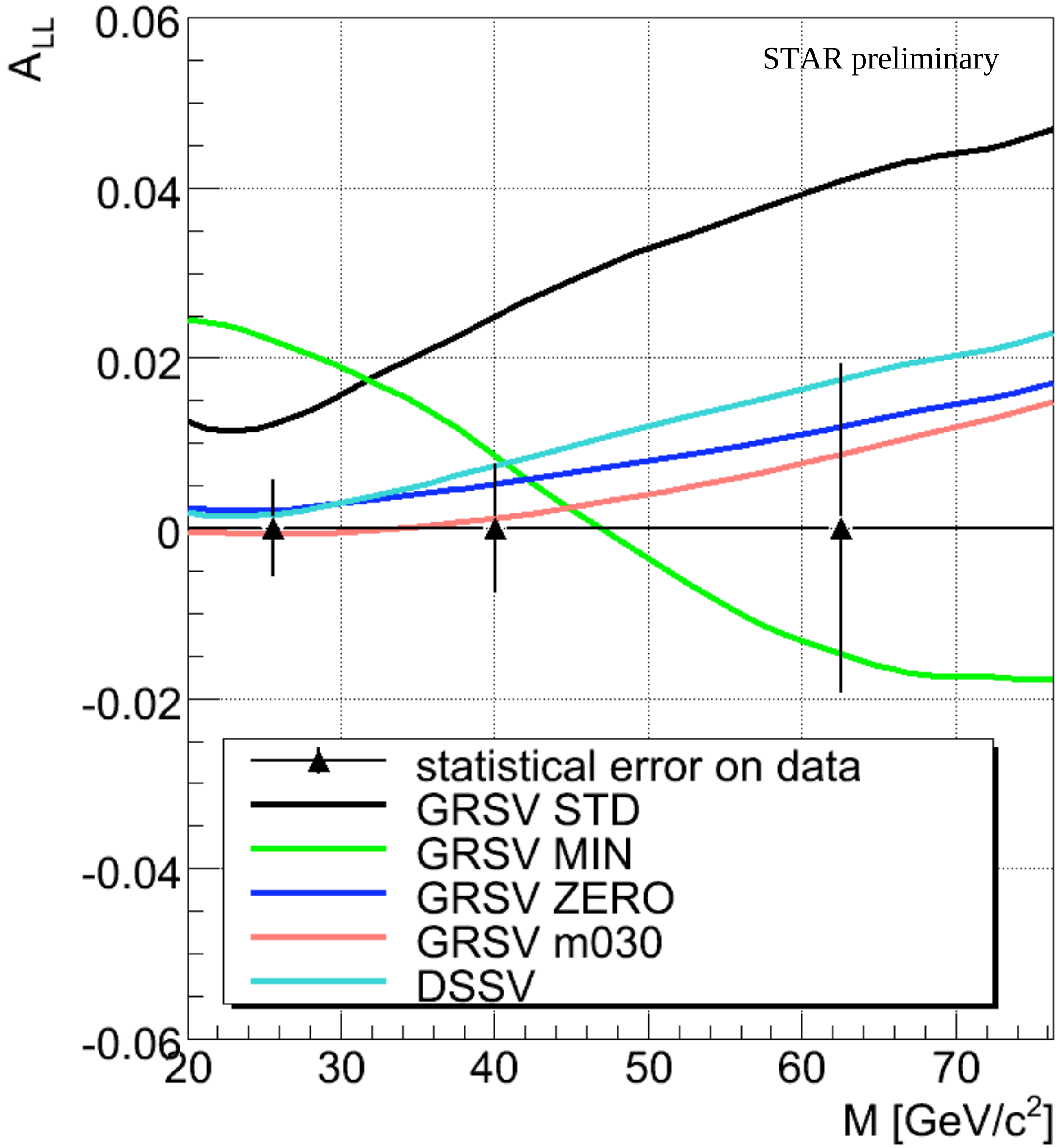
Dijet distributions with asymmetric p_T cuts more appropriate for NLO comparisons - Direct comparisons require full evaluation of hadronization and underlying event corrections ⇒ Next steps full comparison of absolute cross-sections!

2005 BJP2



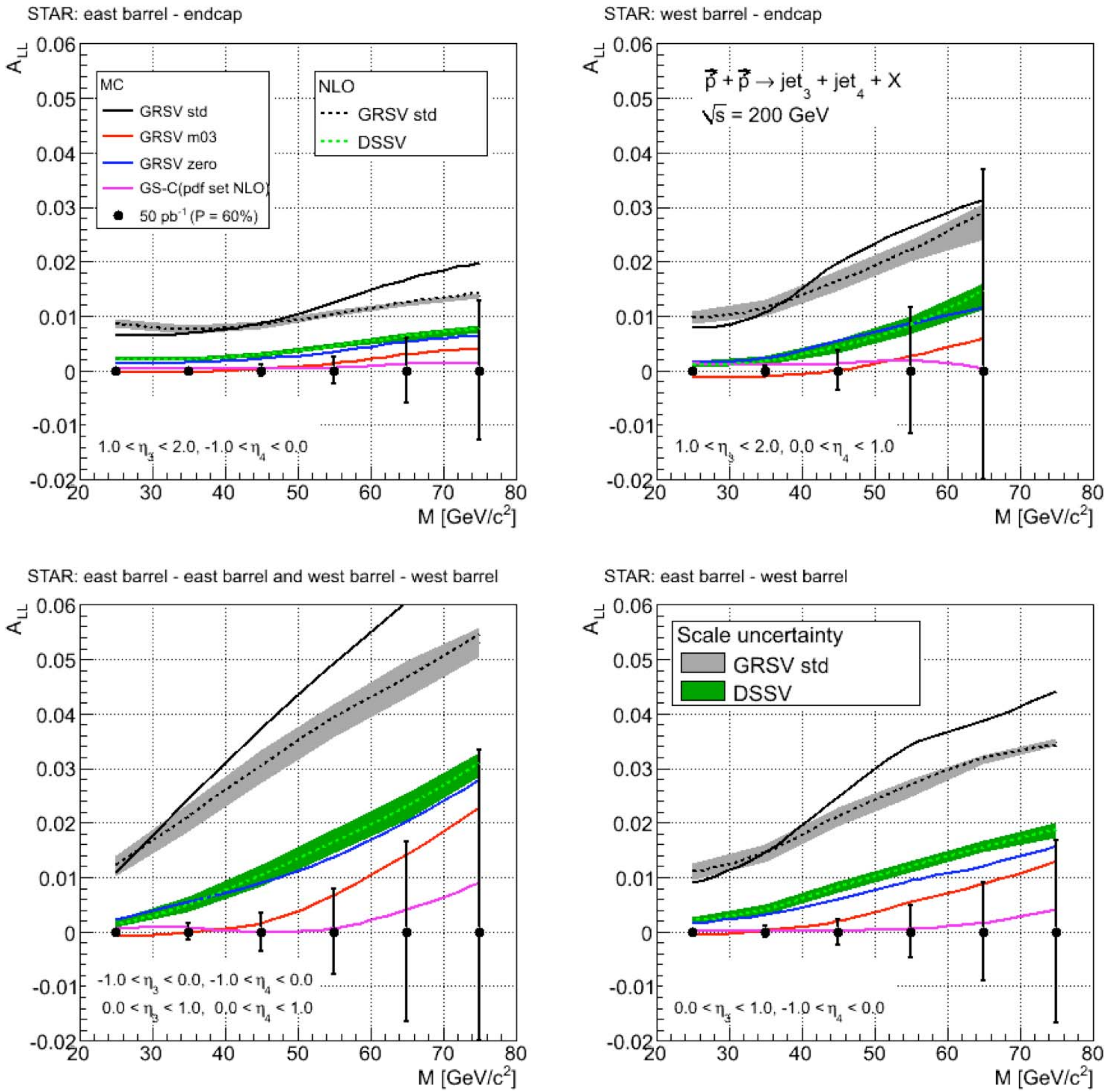
$\sqrt{s} = 200$ GeV $\min(p_T) \geq 7.0$ GeV/c, $\max(p_T) \geq 10.0$ GeV/c $-0.05 \leq \eta \leq 0.95$ $|\Delta\eta| < 0.5$ $|\Delta\varphi| > 2$

Size of reconstructed statistical errors on dijet A_{LL} (2006)



$\sqrt{s} = 200$ GeV, $-0.7 \leq \eta \leq 0.9$, $p_T \geq 5.0$ GeV/c, $M \geq 20$ GeV/c^2 BJP1

2009 STAR Beam Use Request dijet A_{LL} Projections ($50pb^{-1}$, P=60%)



Summary

- The dijet A_{LL} allows us to constrain $\Delta g(x)$ with initial parton kinematics (x).
- The dijet cross section measurement in pp collisions at 200 GeV are in progress.
  - Data - NLO comparison will be made at the particle level jets.
  - The effects of, e.g. underlying events and hadronization are being evaluated.
- The first dijet A_{LL} will come from 2006 data
- With 2009 data, the dijet A_{LL} is expected to put further constraint on $\Delta g(x)$ with the event kinematics.