Di-Jet Analysis of Polarized Proton-Proton Collisions at $\sqrt{s}$ =500GeV at STAR

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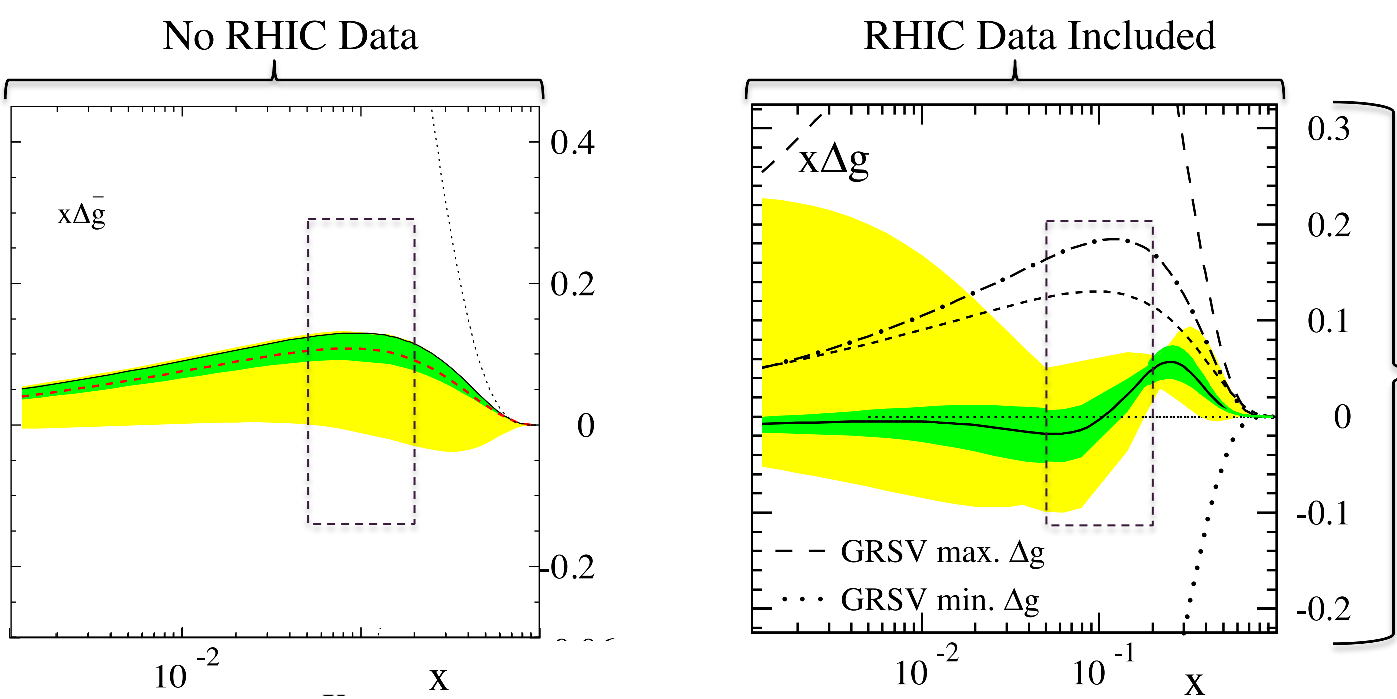
Motivation: Proton Spin Puzzle

Polarized DIS experiments determined the quark contribution to the spin of the proton is ~30%.

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



Inclusive jet and pion data from RHIC allowed for significant improvement but large uncertainties at low X remain

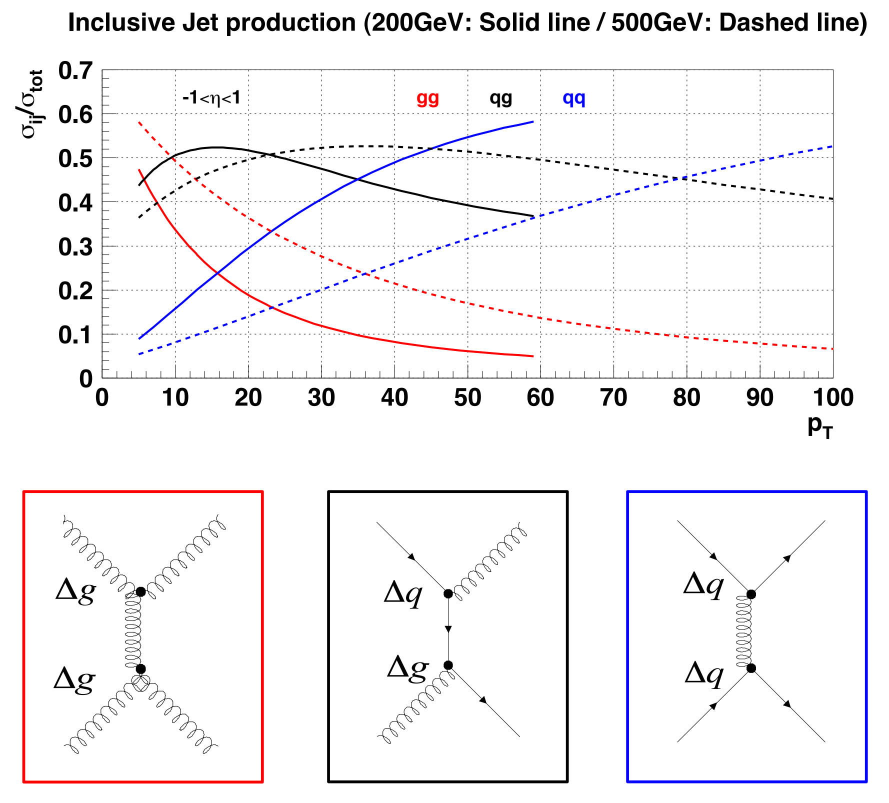
de Florian *et al*., Phys. Rev. D71, 094018 (2005).

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

Polarized pp collisions at RHIC

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

Δf: polarized parton distribution functions



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

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

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

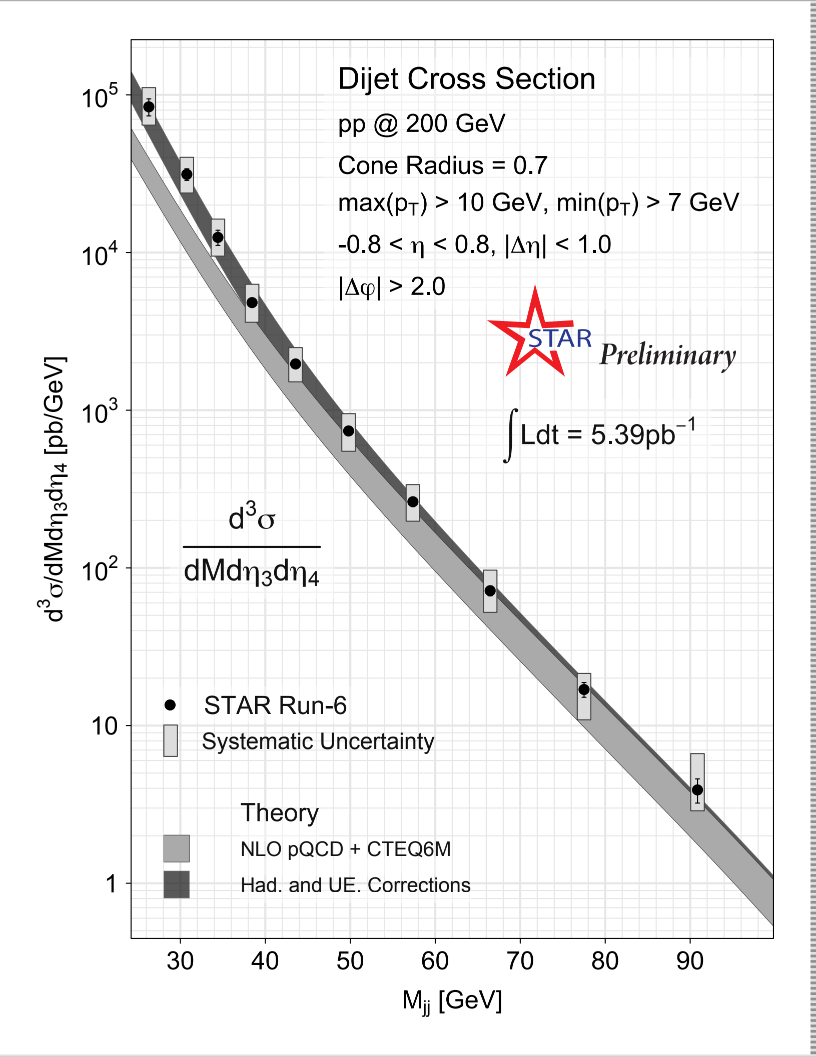
$$M = \sqrt{x_1 x_2 s}$$

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

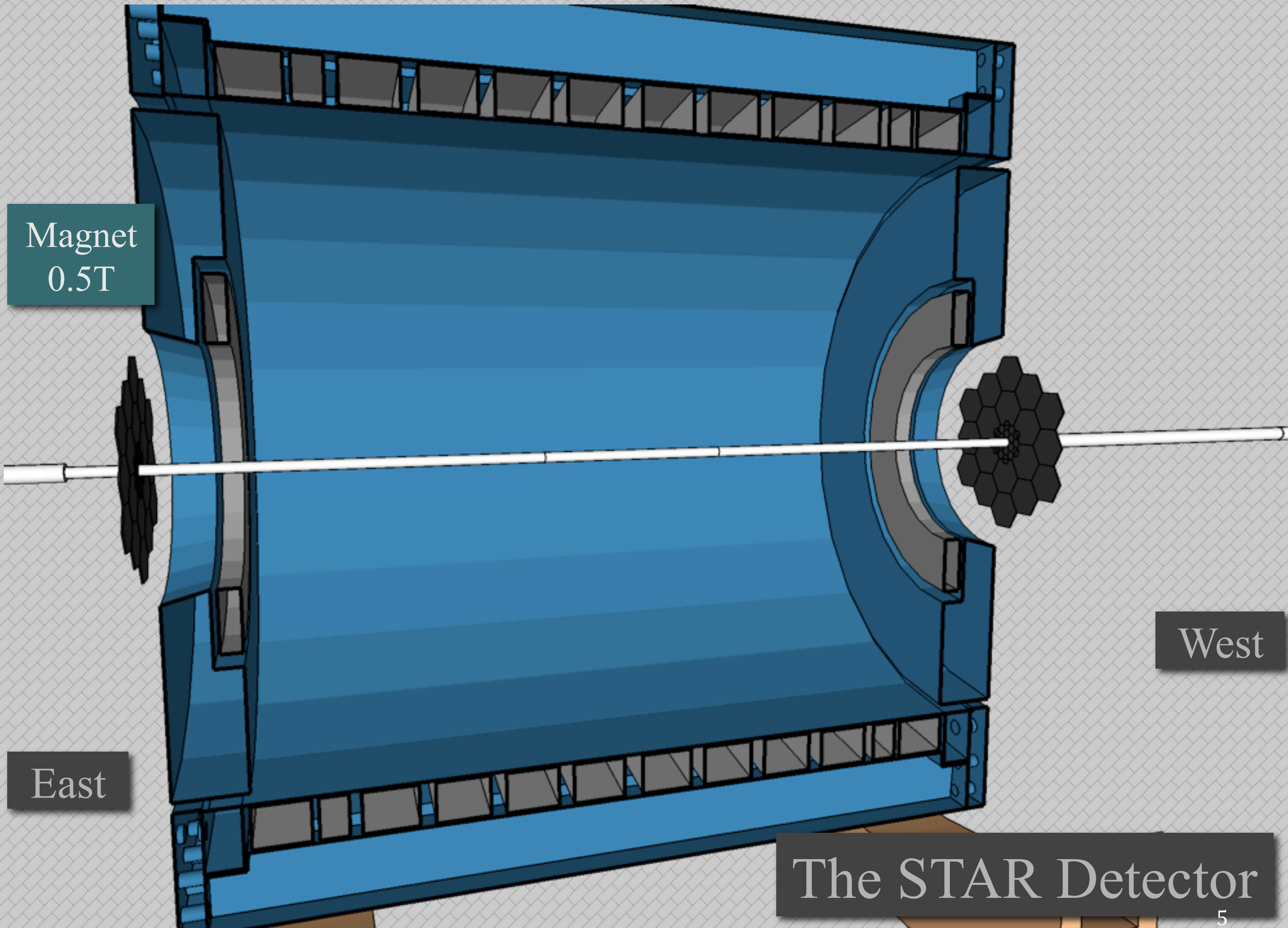
The Dijet A_{LL} at 500 GeV is sensitive to lower x values and therefore provides information on ΔG in a new kinematic regime

Dijet Cross Section at √s = 500 GeV

- The di-jet cross section provides an essential check for the experiment.
- The Dijet cross-section was found to be in good agreement with NLO pQCD theory at √s = 200 GeV
- Measuring the cross-section at 500 GeV will allow STAR to:
  - Test the behavior of a new Jet Algorithm (anti-Kt versus midpoint cone)
  - Study the effects of increased backgrounds and pileup
  - Understand trigger inefficiencies
  - Study detector response and calibration
  - Verify that we understand our observables and can use them in asymmetry measurements



Tai Sakuma, Thesis, MIT (2010)



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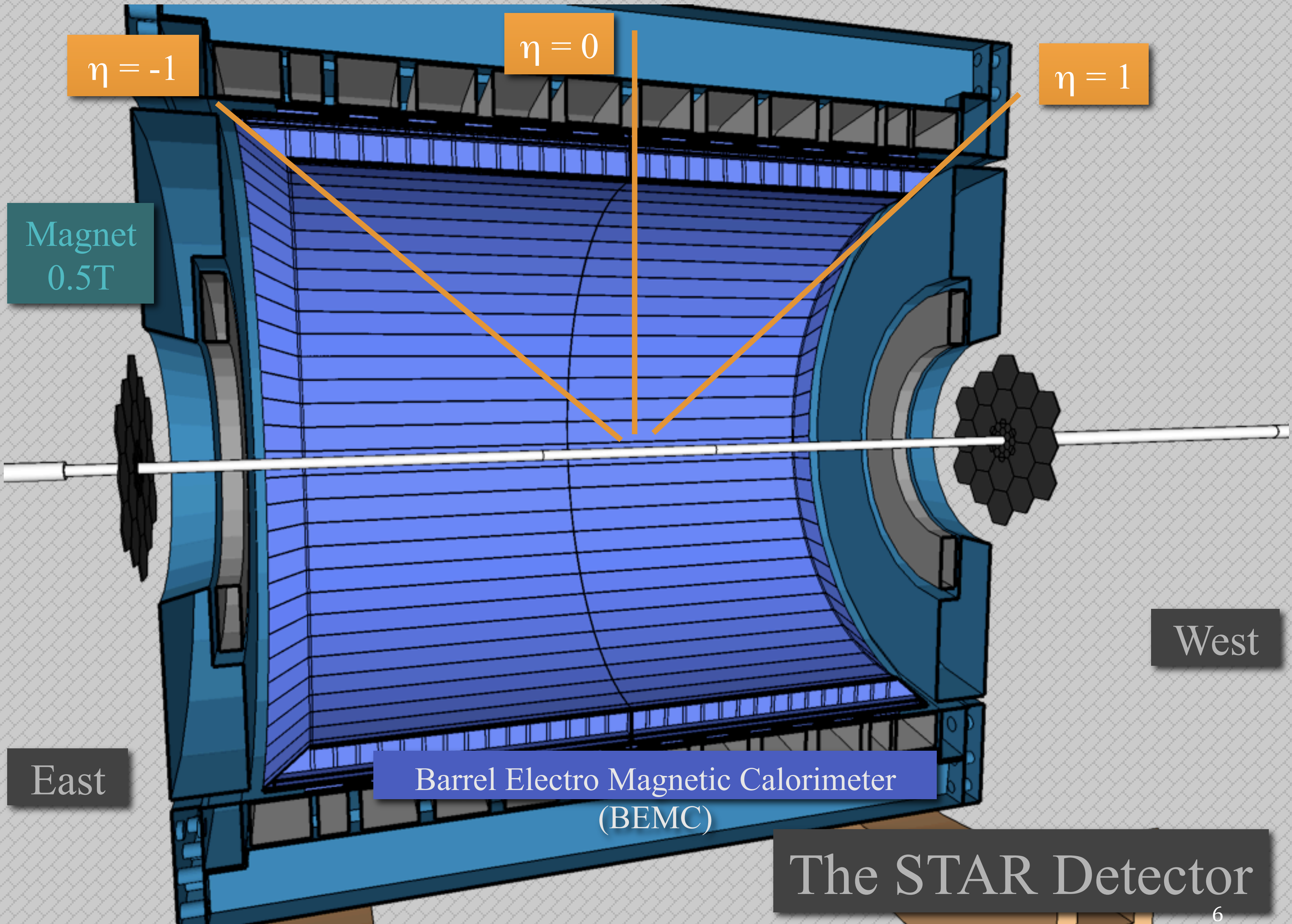
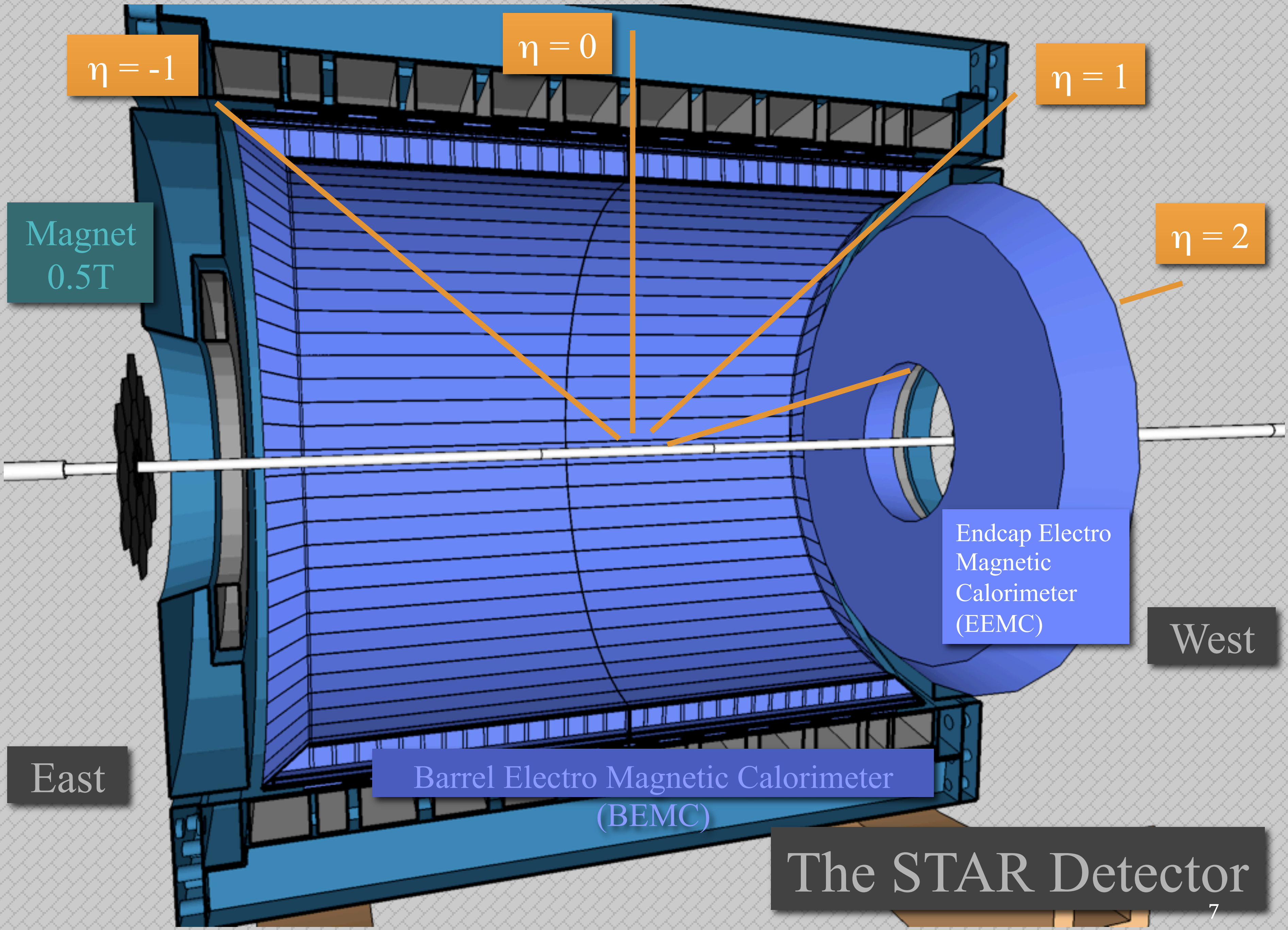


The STAR Detector

Tai Sakuma, Thesis, MIT (2010)



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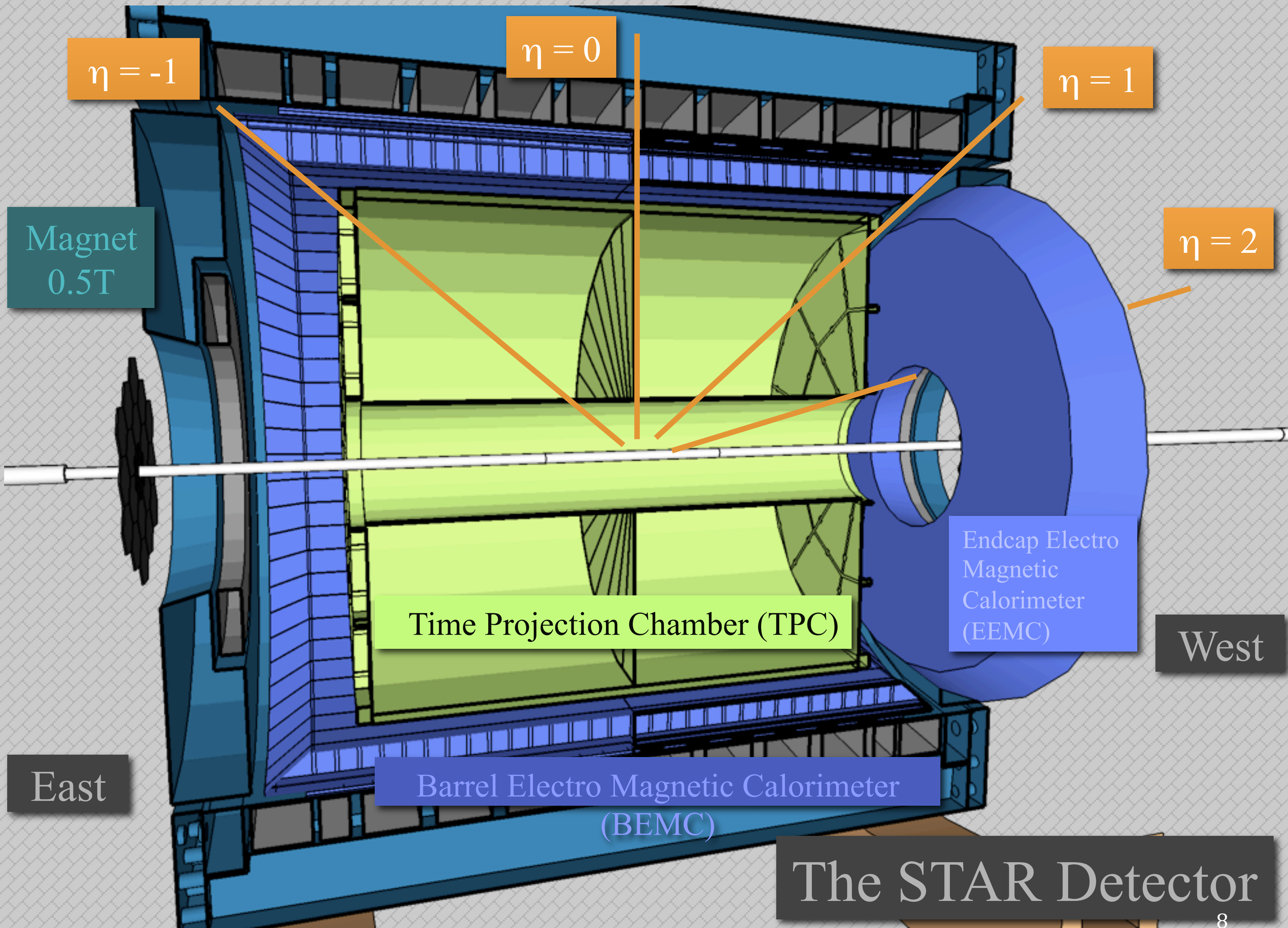

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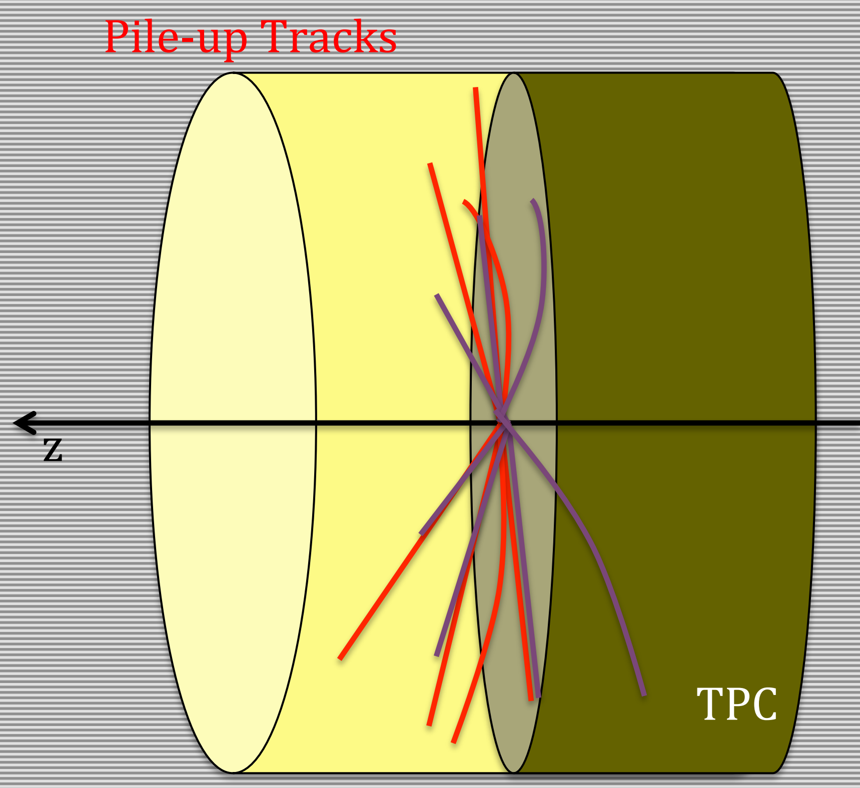
Run 9 pp500 MC Sample

- The goal of this MC sample is to properly account for
  - Inefficiencies
    - Trigger
    - Vertex
    - Fiducial
  - Resolutions

- An Embedding Simulation Sample of 83M thrown events
  - Embed pythia MC particles/tracks into zero bias triggered events from data
  - Perugia 0 TUNE 320

- Detector backgrounds (pile-up) are not capable of being properly simulated.

- Two Filters used:
  - Di-jet Pythia-level Filter
    - Improves signal extraction
  - Trigger Reconstruction level Filter
    - Reduced CPU time

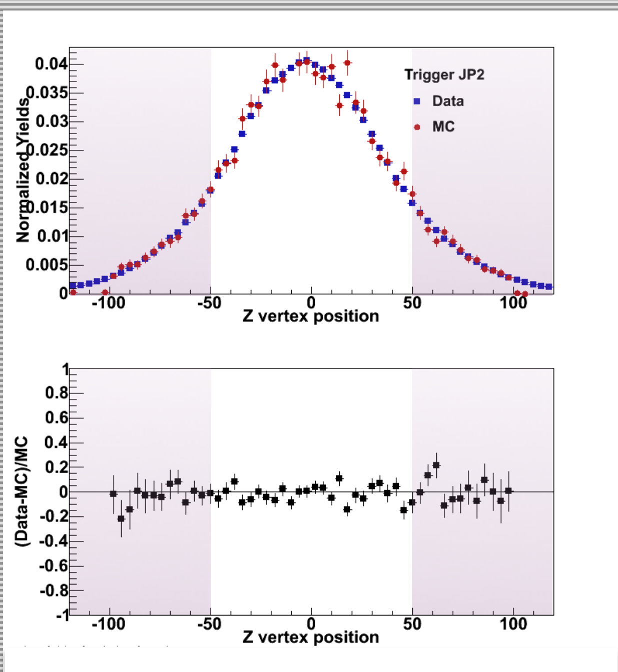


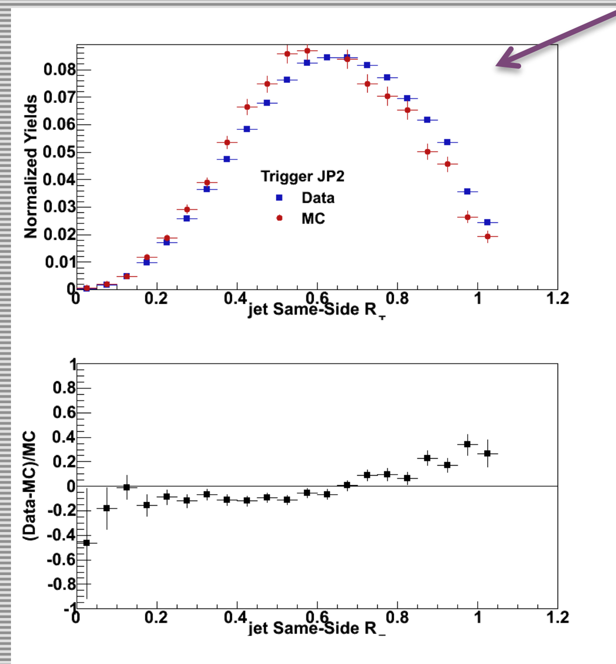
Event Selection

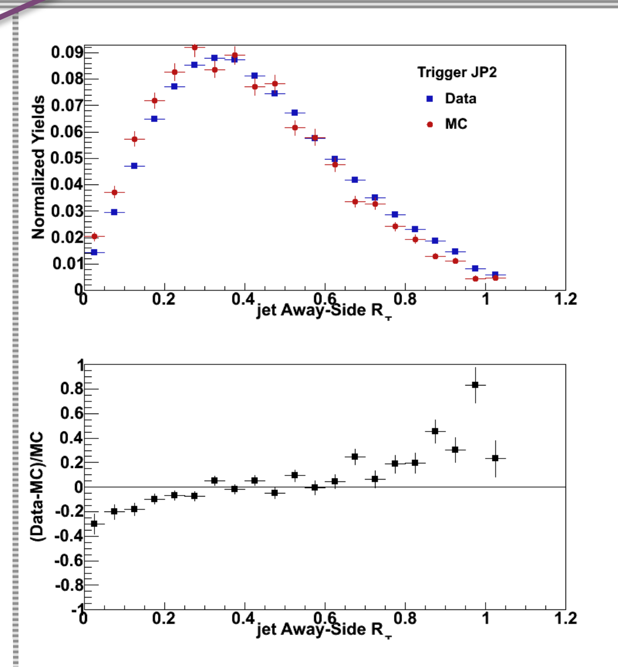
- 2009 Data collect ~10pb^{-1} with an average polarization of ~40%
- Jet Patch (JP): Division of the BEMC into 18 regions (1x1 in η×φ space) each containing 400 towers

- Triggers
  - Three Triggers examined:
    - JP1: $E_T \geq \sim 8.3$GeV
    - JP2: $E_T \geq \sim 13.0$GeV
    - AJP: $E_T \geq \sim 6.4$ GeV for two adjacent jet patches
  - Geometric Trigger:
    - Requiring a jet to be located near a JP

- Require # jets ≥ 2
- Require | Z vertex | ≤ 50 cm
- Same side jet demonstrates trigger bias

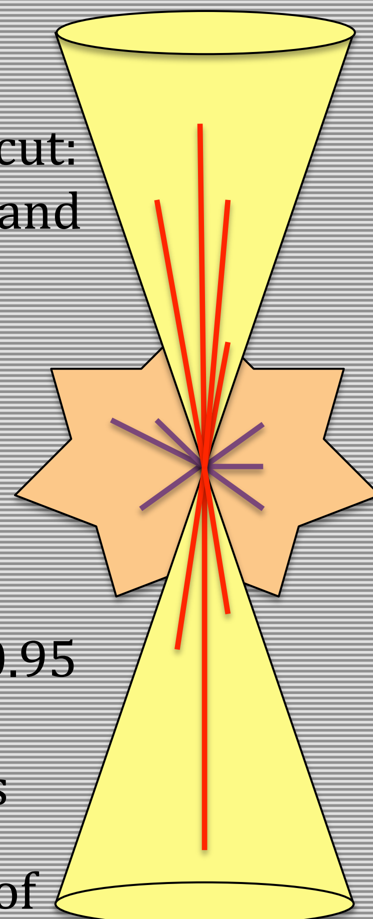


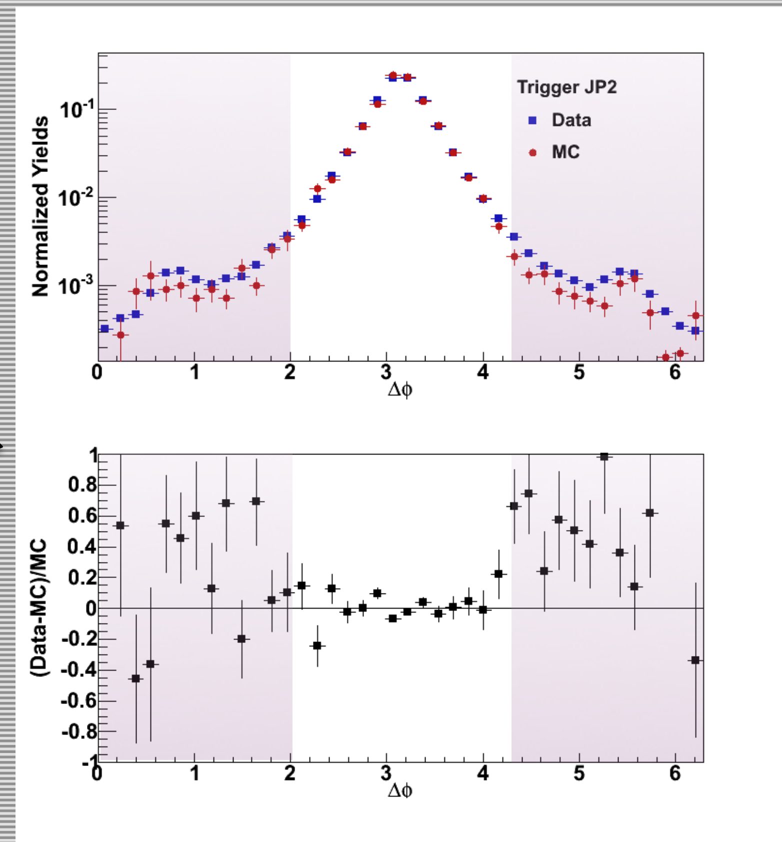




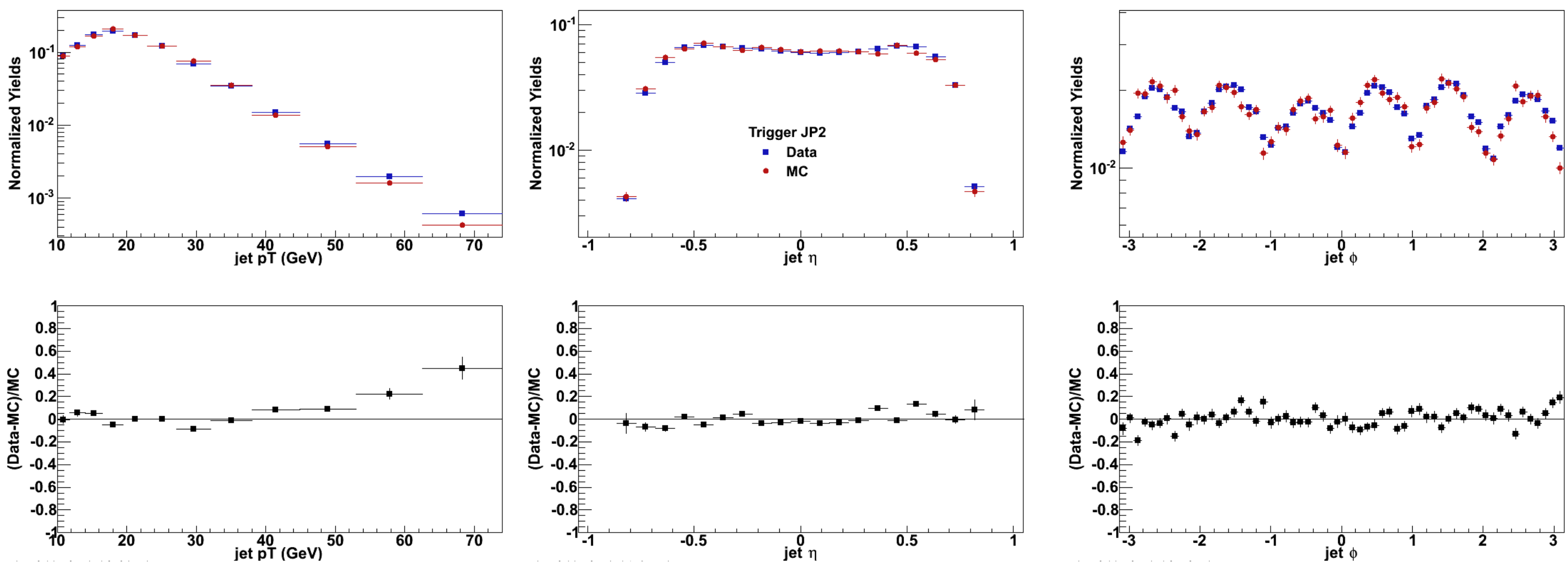
Selecting Di-jet Events

- Select the highest two pT jets
- Apply the asymmetric jet pT cut: max(pT1, pT2) > 13 (GeV/c) and min(pT1, pT2) > 10 (GeV/c)
- Require |jet η| < 0.8
- Require |det jet η| < 0.7
- Require one jet to have $R_T < 0.95$
- $\Delta\phi \geq 2.0$ for back to back jets
- Calculate the invariant mass of the two jets





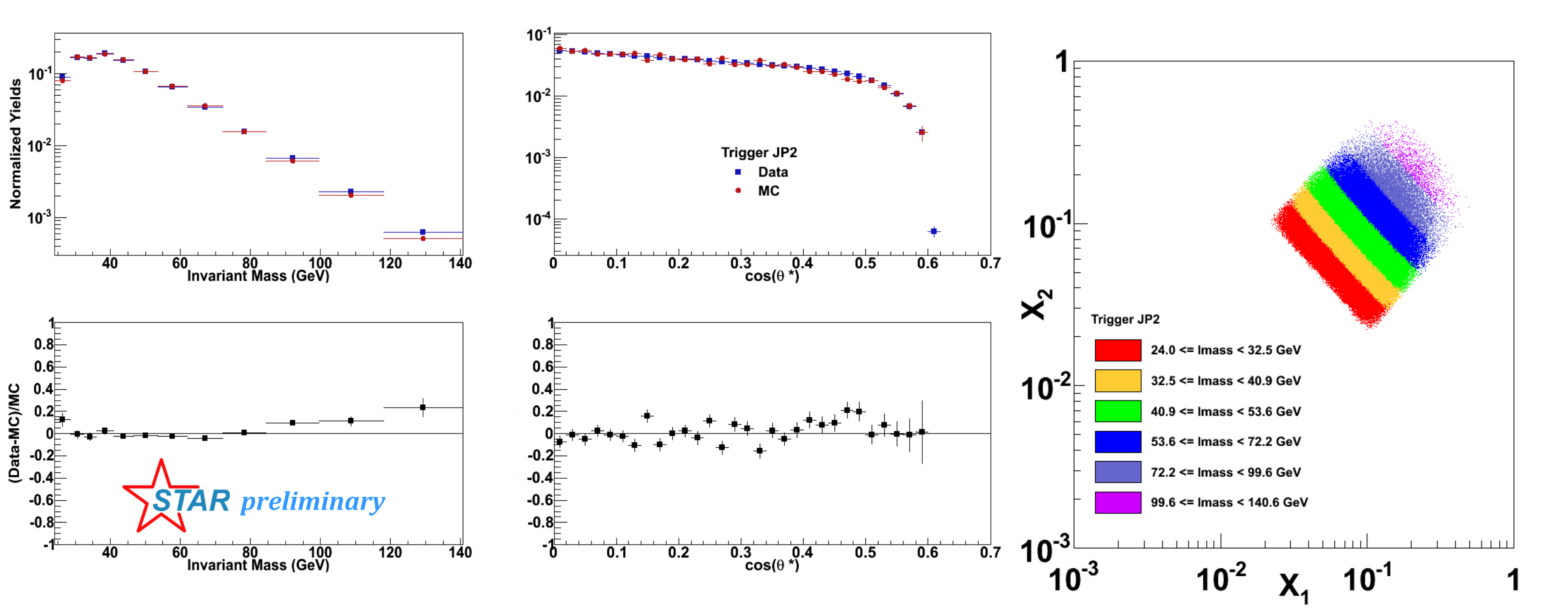
Run 9 500GeV Jet Data/Simulation Comparison



Nice agreement between data and simulation in Run 9

$$M_{inv} = \sqrt{2 p_{T3} p_{T4} \left(\cosh(\Delta\eta) - \cos(\Delta\phi)\right)}$$

*ignoring jet mass



Summary

- Constraint of the parton kinematics and the shape of $\Delta g(x)$ at lower x is provided by examining correlation measurements at $\sqrt{s}$ = 500 GeV

- The Di-jet cross-section analysis motivates STAR's abilities to measure asymmetries at this higher energy.

- The data/MC comparisons are well matched and can be used for data inefficiencies and resolutions corrections.

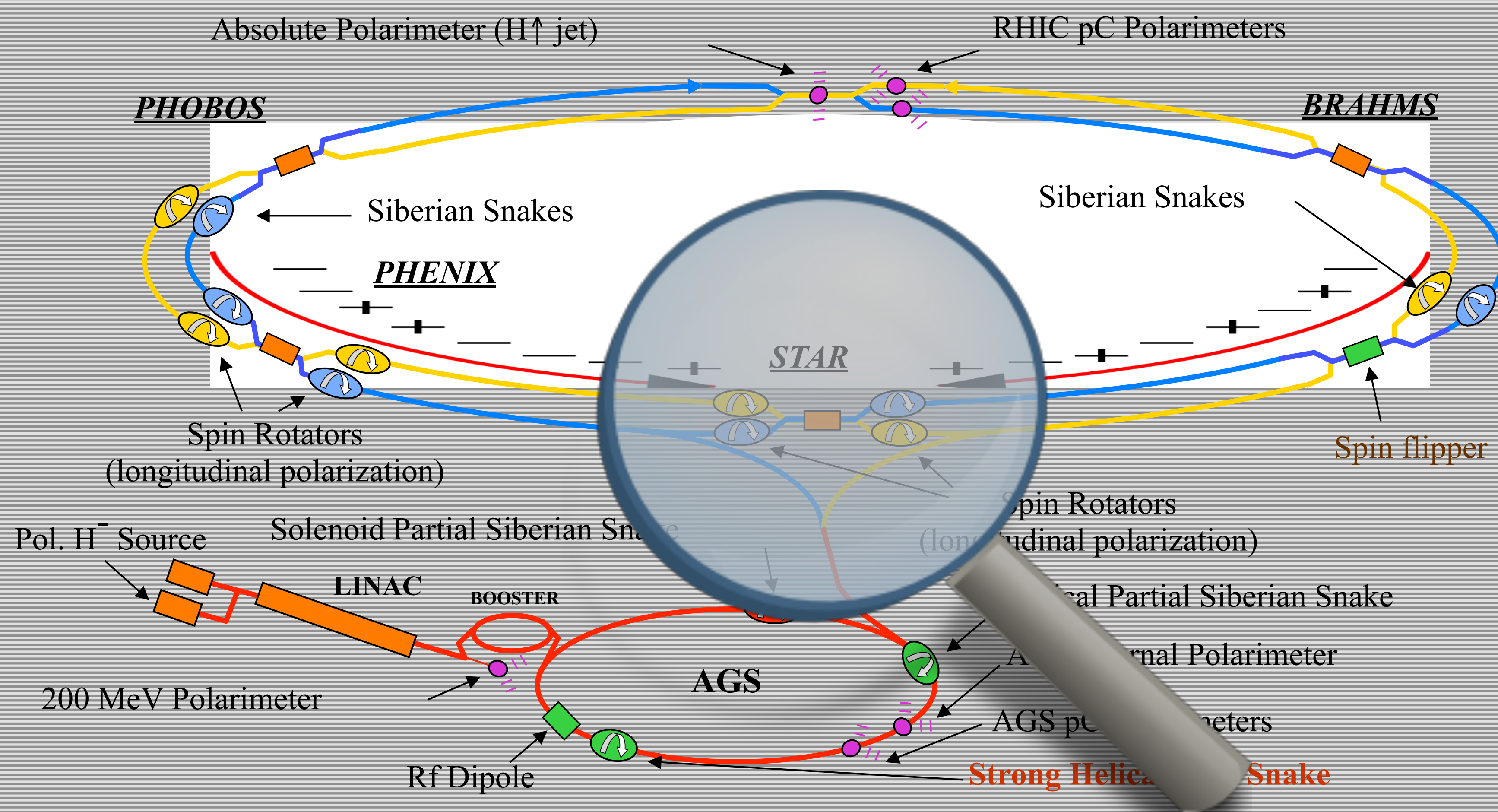
- Calculate the Dijet cross-section and evaluate the full systematics.

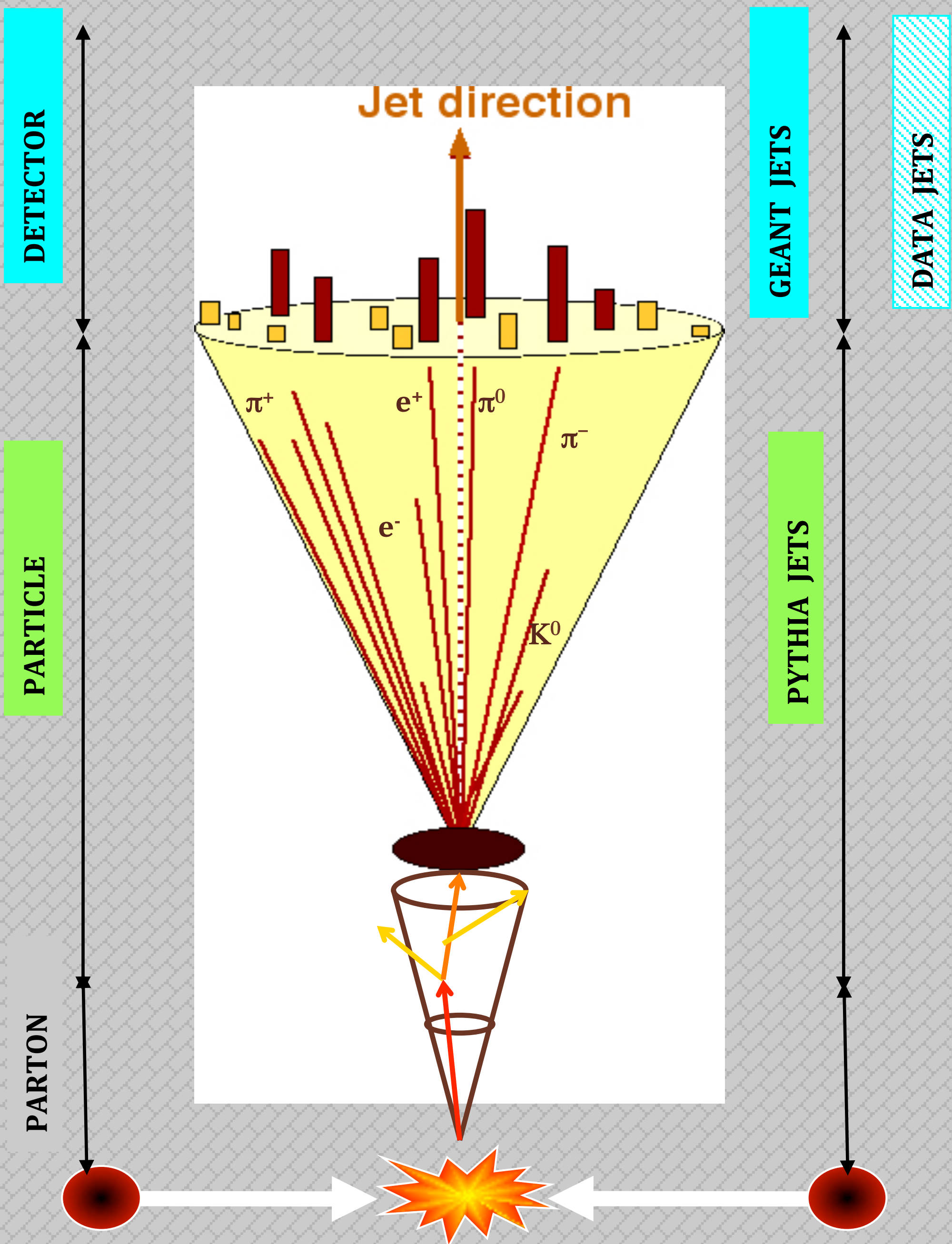
Back-up

Outline

- ✧ Concise Motivation
- ✧ BNL and the STAR experiment
- ✧ Di-Jet Cross-section Analysis
- ✧ Data/Simulation Comparisons

Relativistic Heavy Ion Collider (RHIC)





Anti-Kt Algorithm

Two Distances:

d_{ij} =distance between entities i and j

d_{iB} = distance between i and the beam

Then cluster proceeds by identifying the smallest of the distances. I

If it is a d_{ij} recombine entities i and j

If it is d_{iB} call i a jet and removing it from the list of entities.

The distances are recalculated and the procedure repeated until no entities are left.

$$d_{ij} = \min\left(\frac{1}{k_{ti}^2}, \frac{1}{k_{tj}^2}\right)\frac{\Delta_{ij}^2}{R^2} \qquad R = 0.6$$

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

$$\Delta_{ij}^2 = \left(y_i - y_j\right)^2 + \left(\phi_i - \phi_j\right)^2$$