Updates on Run12 π^0 – jet A_{LL}

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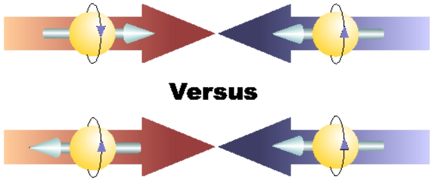


Outline

- Update on Asymmetry Analysis cuts
- Update on Signal Extraction Method
- Updated Asymmetry Results
- Summary and Plan

Asymmetry Analysis -- Dataset and Triggers

- **Dataset: 2012 pp longitudinal at √s=510 GeV**
  - Reconstructed EEMC trees location (~2.6 T): /star/u/ypwang/disk05/Run12Pi0s_EEMC
  - Reconstructed jet trees location: /star/data05/scratch/zchang/Run12Jets_new
    /star/data05/scratch/zchang/Run12Jets_new_new
  - Use Zilong's final run list (359 runs)

- **Use events in which jet triggers are fired in BEMC with a matched jet:**
  - Hardware, software and geometric trigger conditions applied
  - Triggers (threshold: JP0 5.4 GeV/c, JP1 7.3 GeV/c, JP2 14.4 GeV/c):

★If(JP2 hardware & JP2 software & geometric match JP2 & pT>14.4) JP2 triggered

★If(JP1 hardware & JP1 software & geometric match JP1 & pT>7.3) JP1 triggered

★If(JP0 hardware & JP0 software & geometric match JP0 & pT>5.4) JP0 triggered

Spin pattern @ Run 12:

Spin4	Yellow	Blue
5	-	-
6	+	-
9	-	+
10	+	+

Longitudinal double spin asymmetries:

$$A_{LL} = \frac{\sum P_Y P_B[(N^{++} + N^{--}) - R_3(N^{+-} + N^{-+})]}{\sum P_Y^2 P_B^2[(N^{++} + N^{--}) + R_3(N^{+-} + N^{-+})]}$$

$$\delta A_{LL} = \frac{\sqrt{\sum P_Y^2 P_B^2[\delta(N^{++} + N^{--})^2 + R_3^2\delta(N^{+-} + N^{-+})^2]}}{\sum P_Y^2 P_B^2[(N^{++} + N^{--}) + R_3(N^{+-} + N^{-+})]}$$

Longitudinal single-spin asymmetries:

$$A_L^Y = \frac{\sum P_Y[(N^{++} + N^{+-}) - R_1(N^{--} + N^{-+})]}{\sum P_Y^2[(N^{++} + N^{+-}) + R_1(N^{--} + N^{-+})]}$$

$$A_L^B = \frac{\sum P_B[(N^{++} + N^{-+}) - R_2(N^{--} + N^{+-})]}{\sum P_B^2[(N^{++} + N^{-+}) + R_2(N^{--} + N^{+-})]}$$

Like-sign/Unlike-sign asymmetry:

$$A_{LL}^{ls} = \frac{\sum P_Y P_B(N^{++} - R_4 N^{--})}{\sum P_Y^2 P_B^2(N^{++} + R_4 N^{--})}$$

$$A_{LL}^{us} = \frac{\sum P_Y P_B(R_6 N^{+-} - R_5 N^{-+})}{\sum P_Y^2 P_B^2(R_6 N^{+-} + R_5 N^{-+})}$$

* Indices on the N's are for yellow beam first and for blue beam second.

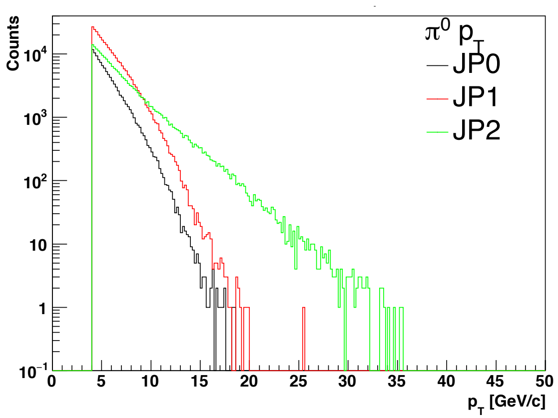
Asymmetry Analysis – Analysis cuts update (highlight in red color)

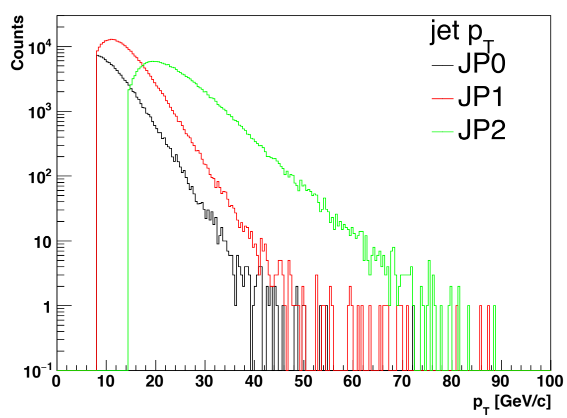
- π^0 p_T: > 4.0 GeV/c
- π^0 mass: (0, 0.6)
- π^0 physics eta: (1.086, 2.0)
- Decayed photon eta: (1.11, 1.96)
- Decayed photon 1 energy: > 2.0 GeV
- Decayed photon 2 energy: > 1.5 GeV
- Preshower energy for each photon: < 40 MeV
- SMD relative energy threshold for each photon $(E_{cluster1/2u}+E_{cluster1/2v})/E_{tower1/2}$: > 0.008

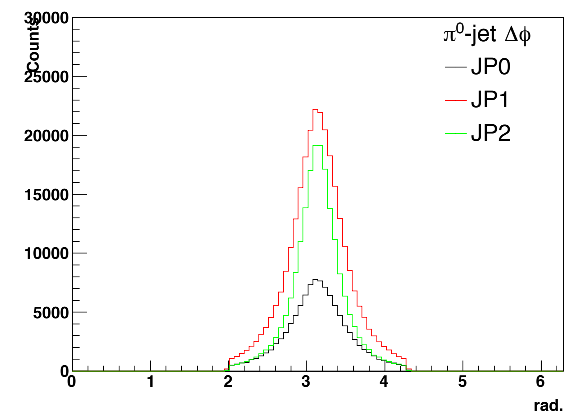
- Jet p_T > 8.0 GeV/c
- Jet physics eta: (-0.9, 0.9)
- Jet detector eta: (-0.7, 0.9)
- R_t < 0.95
- Using Anti-k_T algorithm with cone size R = 0.6
- Sum track p_T > 0.5 GeV/c

- ✧ $\Delta\phi$ > 2.0 (azimuthal angle between a forward π^0 opposite a barrel jet)
- ✧ Leading jet required (jet p_T > 8.0 GeV/*c*)

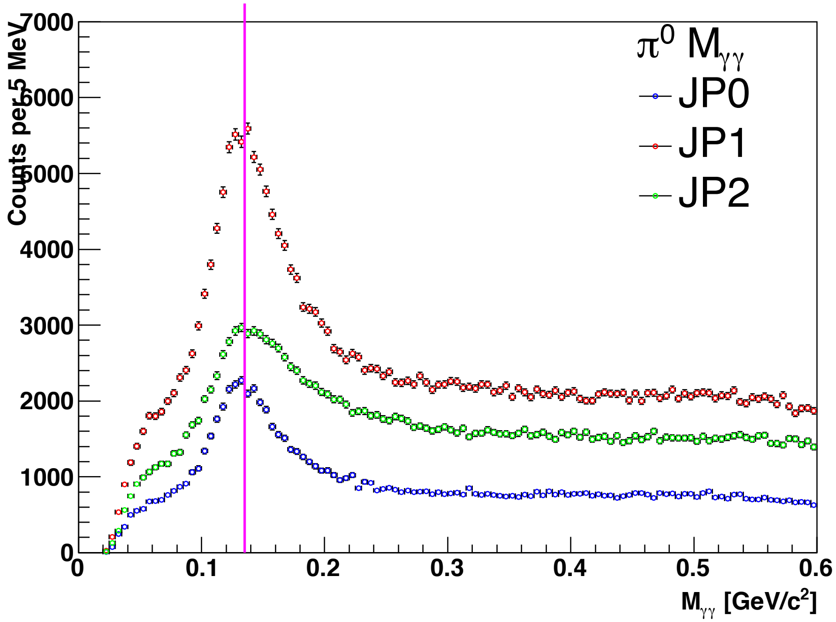
QA plots with all analysis cuts applied:

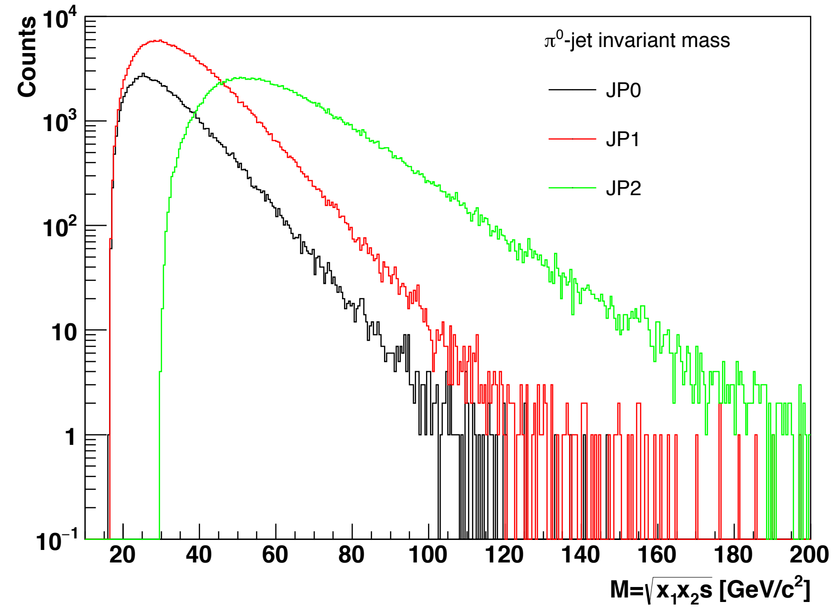


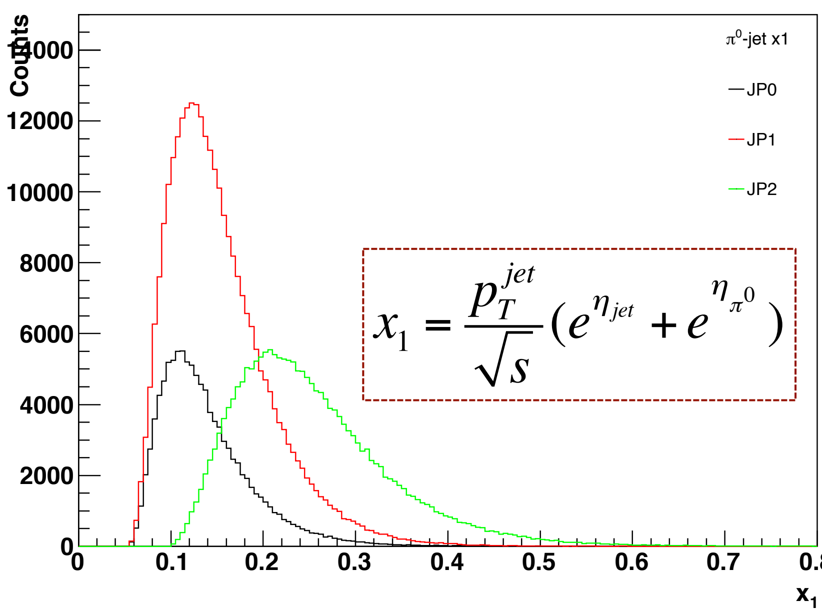




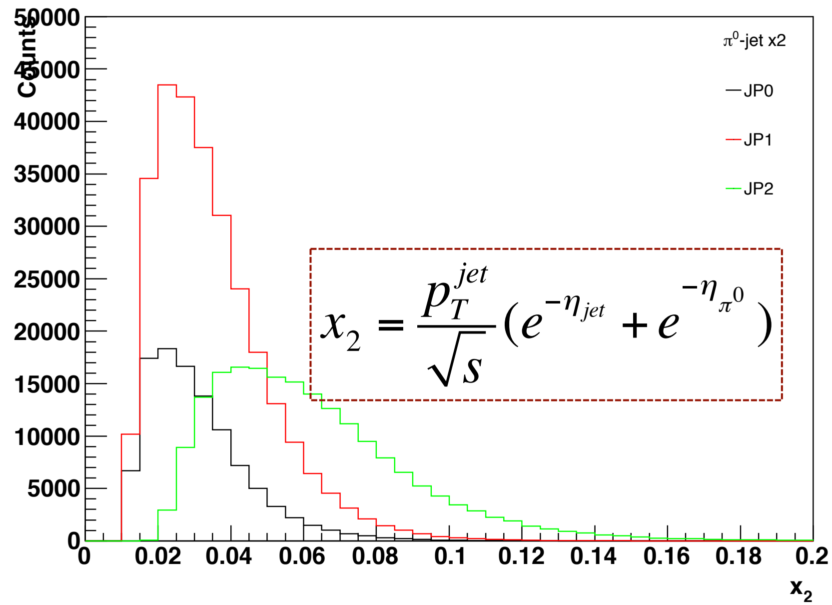
Asymmetry Analysis -- Analysis cuts updates





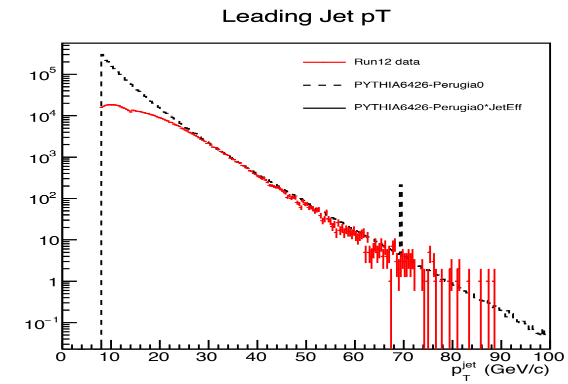


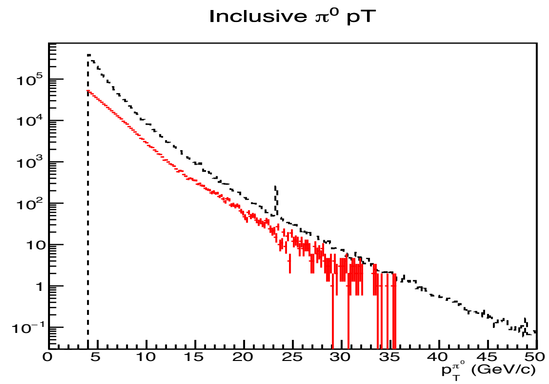
$$x_1 = \frac{p_T^{jet}}{\sqrt{s}}\left(e^{\eta_{jet}} + e^{\eta_{\pi^0}}\right)$$

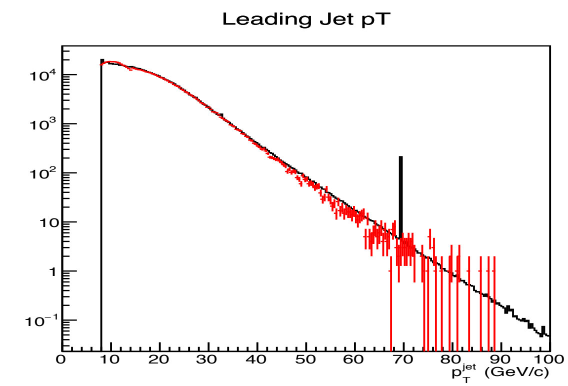


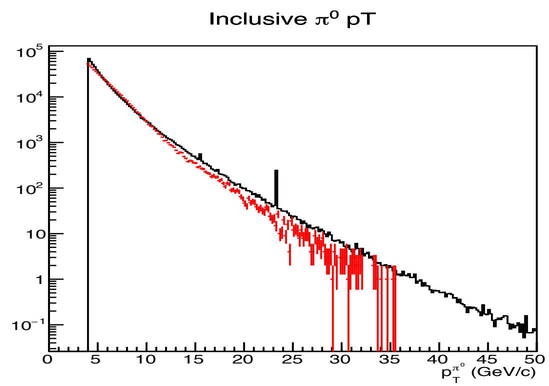
$$x_2 = \frac{p_T^{jet}}{\sqrt{s}}\left(e^{-\eta_{jet}} + e^{-\eta_{\pi^0}}\right)$$

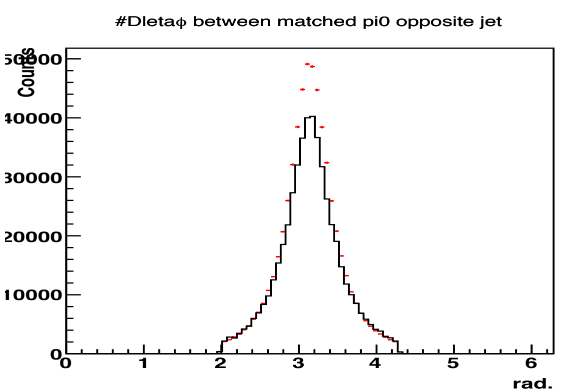
Asymmetry Analysis – Pythia Simulation Check

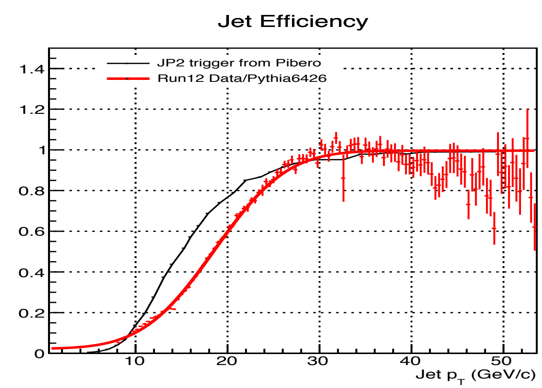






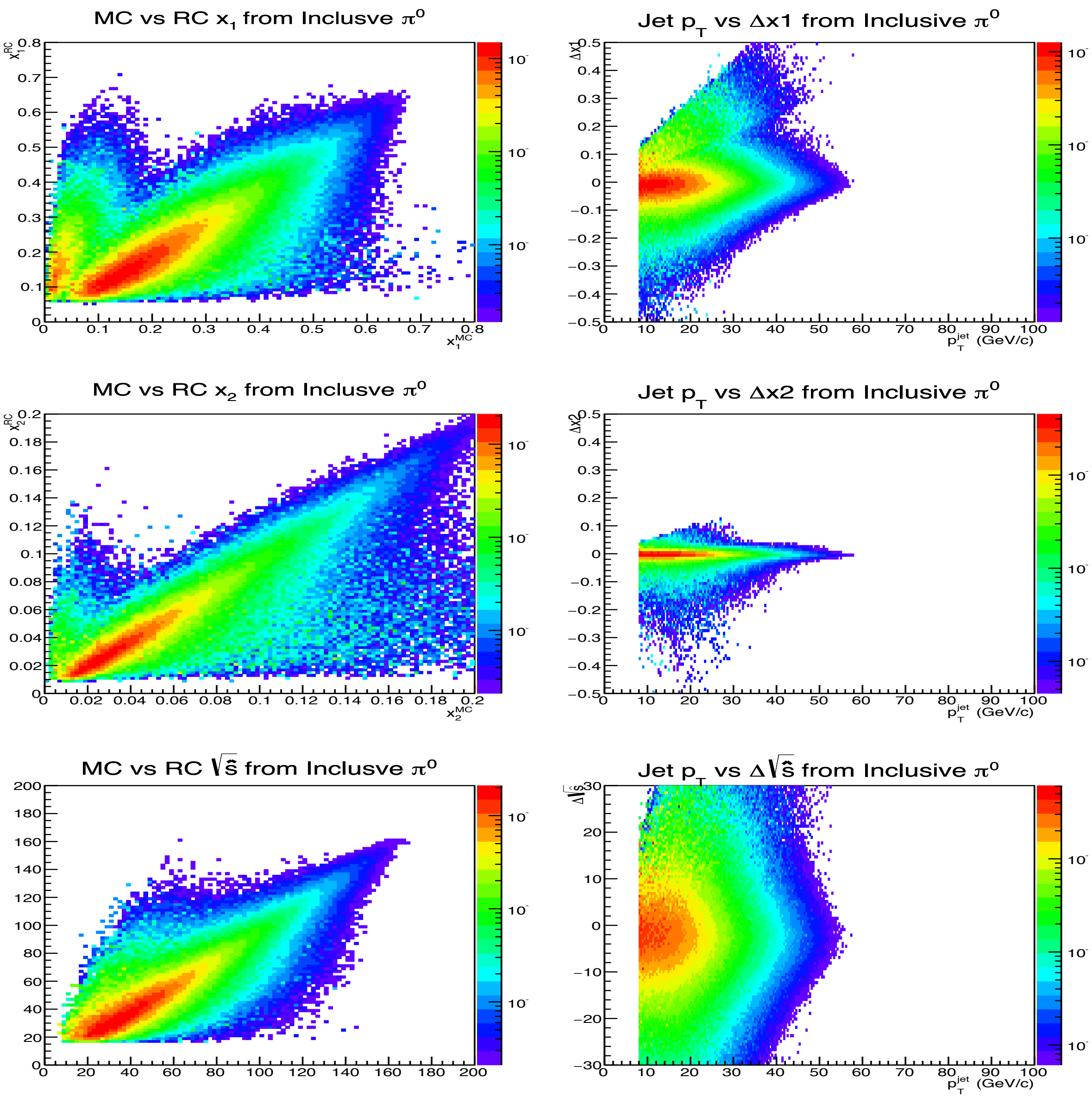






- Require π^0 $p_T > 4.0$ GeV/c, leading jet $p_T > 8.0$ GeV/c, and $|\Delta\phi|>2.0$ (data: JP comb.)
- Use leading jet p_T ratio of Run 12 data to MC to weight π^0-jet reconstruction efficiency (as shown in bottom right plot);
- The weighted π^0/jet p_T spectrum from MC are consistent well with data (as shown in middle plots);
- The weighted $\Delta\phi$ between matched π^0 and opposite leading jet from MC agree well with data (as shown in bottom left plot).

Asymmetry Analysis – Pythia Simulation Check



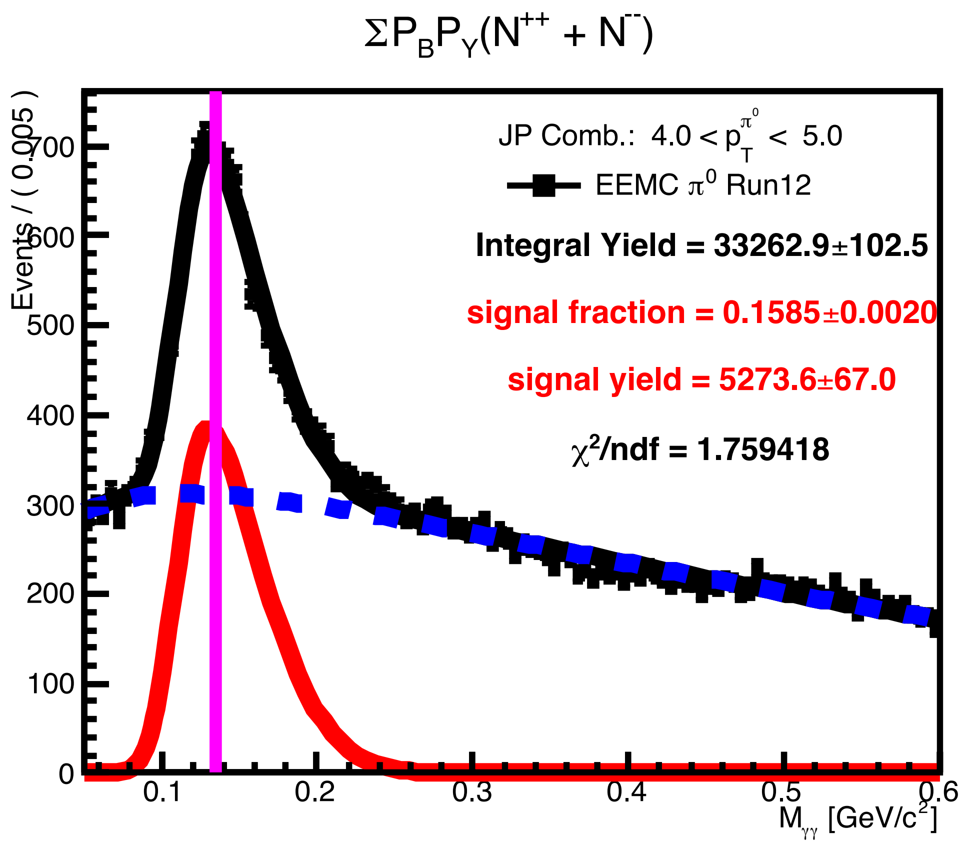
- Use leading jet p_T ratio of Run 12 data to MC to weight π^0-jet reconstruction efficiency;
- The reconstructed x_1, x_2, and invariant mass of matched π^0-jet pair show a good linearity with MC (as shown in left plots).

$$x_1 = \frac{p_T^{jet}}{\sqrt{s}}\left(e^{\eta_{jet}} + e^{\eta_{\pi^0}}\right)$$

$$x_2 = \frac{p_T^{jet}}{\sqrt{s}}\left(e^{-\eta_{jet}} + e^{-\eta_{\pi^0}}\right)$$

$$M_{\pi^0-jet} = \sqrt{x_1 x_2 s}$$

Asymmetry Analysis – Signal extraction method update



The invariant mass spectrum (weighted by relative luminosities and beam polarizations), are fitted to estimate signal yield for each kinematic variable bin, respectively.

$$Signal: \; k \times e^{\frac{-(x-\mu)^2}{2\sigma^2}} \times [1 + \mathrm{Erf}(\frac{a(x-\mu)}{\sqrt{2}\sigma})]$$

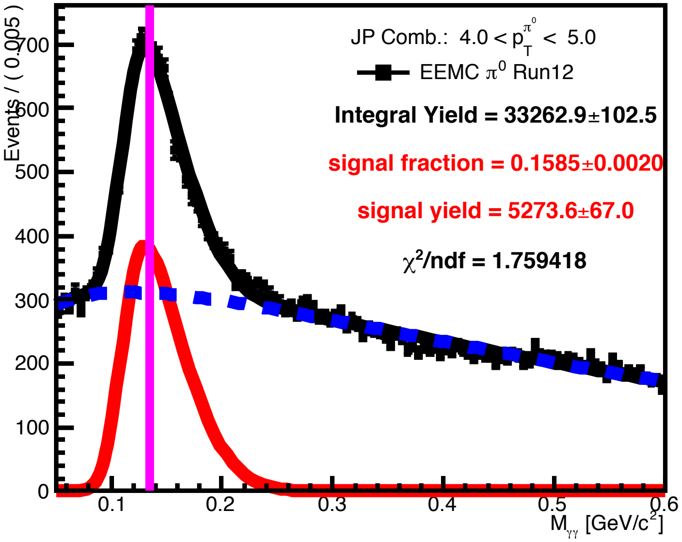
$$Background: \; A \times x^B \times e^{Cx}$$

$$Raw \;\; yield = R \times Signal + (1-R) \times Background$$

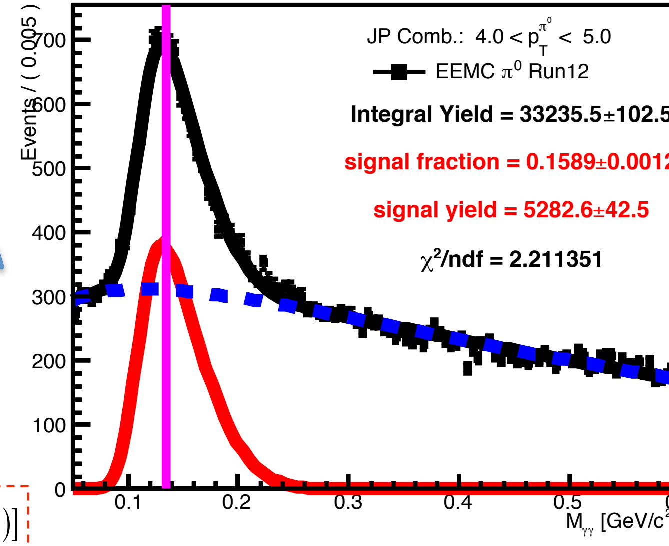
- The **raw yield** of π^0-jet are well fitted, in which the signal shape was described by **skewed Gaussian function**, and background shape was fitted by **Gamma function**;
- To estimate the ***signal yield***, fit range was set to [0.05, 0.6] GeV/c^2;
- Signal asymmetries, A_{LL}^{Sig}, estimated by the fitted yields of the skewed Gaussian function.

Asymmetry Analysis – Signal extraction method update

$\Sigma P_B P_Y (N^{++} + N^{--})$

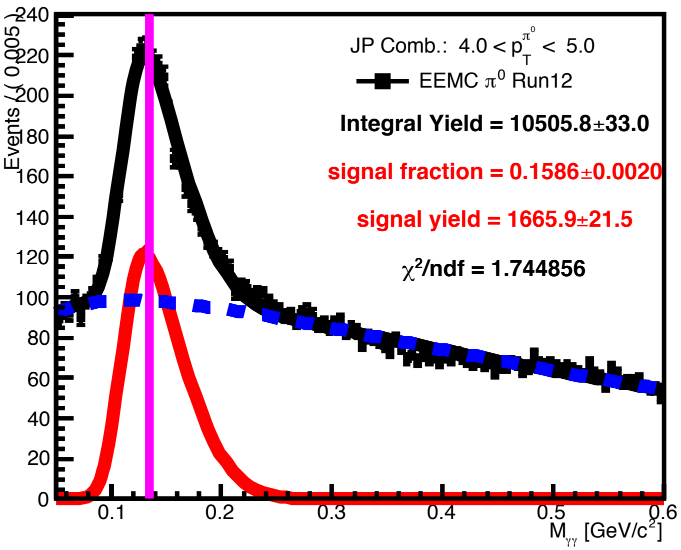


$\Sigma P_B P_Y R_3 (N^{+-} + N^{-+})$

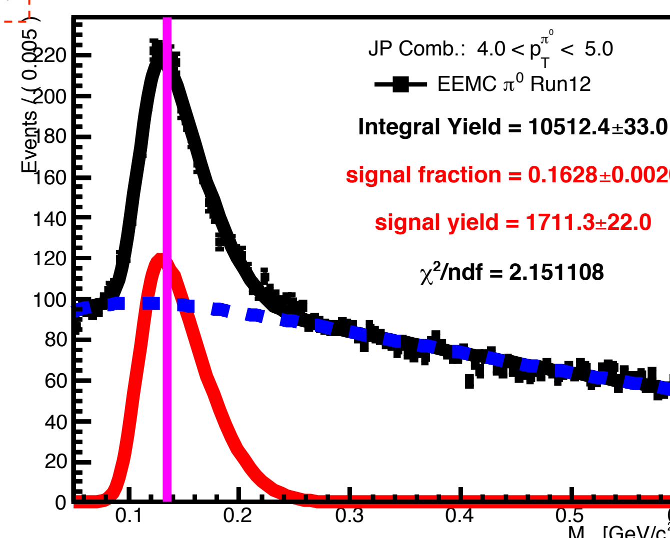


$$A_{LL} = \frac{\sum P_Y P_B[(N^{++}+N^{--}) - R_3(N^{+-}+N^{-+})]}{\sum P_Y^2 P_B^2[(N^{++}+N^{--}) + R_3(N^{+-}+N^{-+})]}$$

$\Sigma P_B^2 P_Y^2 (N^{++} + N^{--})$

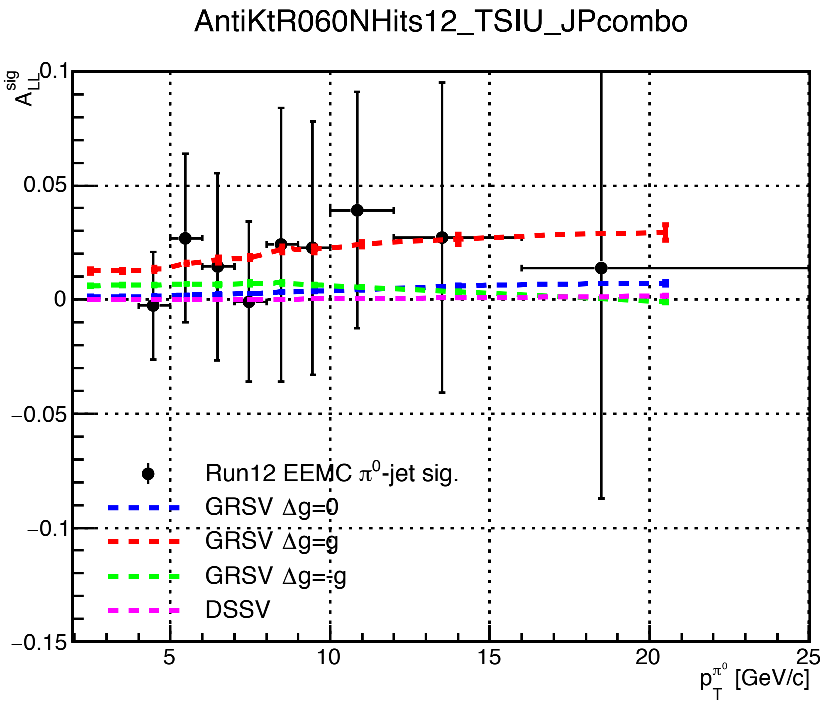


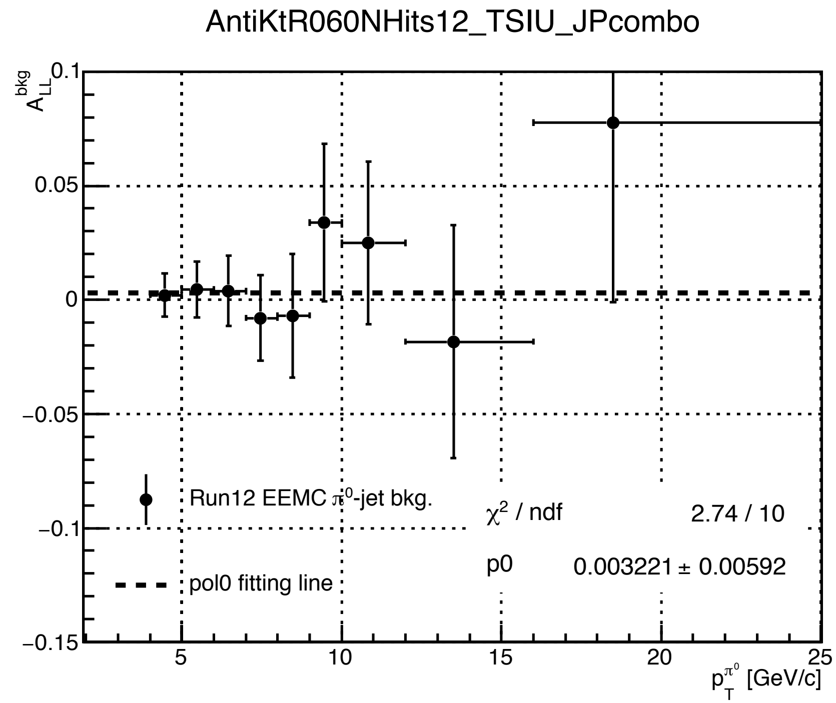
$\Sigma P_B^2 P_Y^2 R_3 (N^{+-} + N^{-+})$



Asymmetry Results -- Updated longitudinal double asymmetry, A_{LL}

Longitudinal double asymmetry, A_{LL}^{Sig} (left) and A_{LL}^{Bkg} (right), as a function of π^0 p_T :





Error bar: Statistics errors only

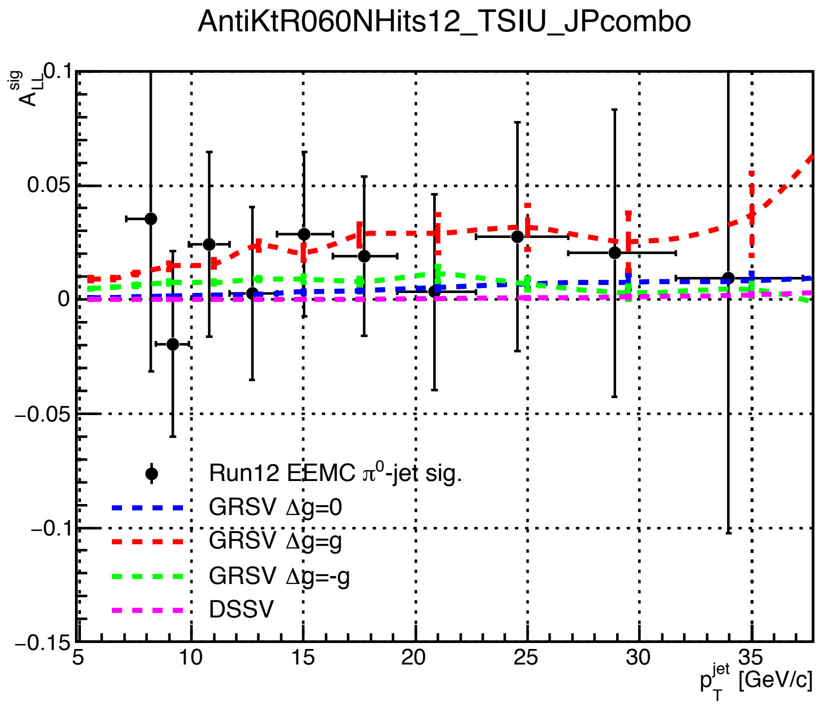
Average asymmetries (by pol0 fit):

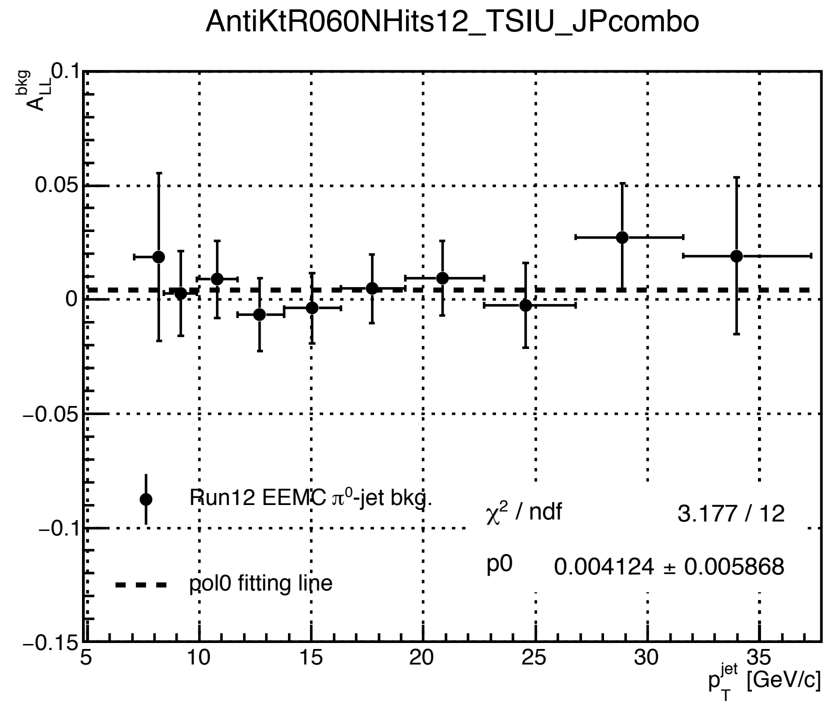
$\langle A_{LL}^{Sig} \rangle$: 0.01117±0.01382 ($\chi^2$/ndf = 1.093/10)

$\langle A_{LL}^{Bkg} \rangle$: 0.003221±0.00592 ($\chi^2$/ndf = 2.74/10)

Asymmetry Results -- Updated longitudinal double asymmetry, A_{LL}

Longitudinal double asymmetry, A_{LL}^{Sig} (left) and A_{LL}^{Bkg} (right), as a function of jet p_T :





Error bar: Statistics errors only

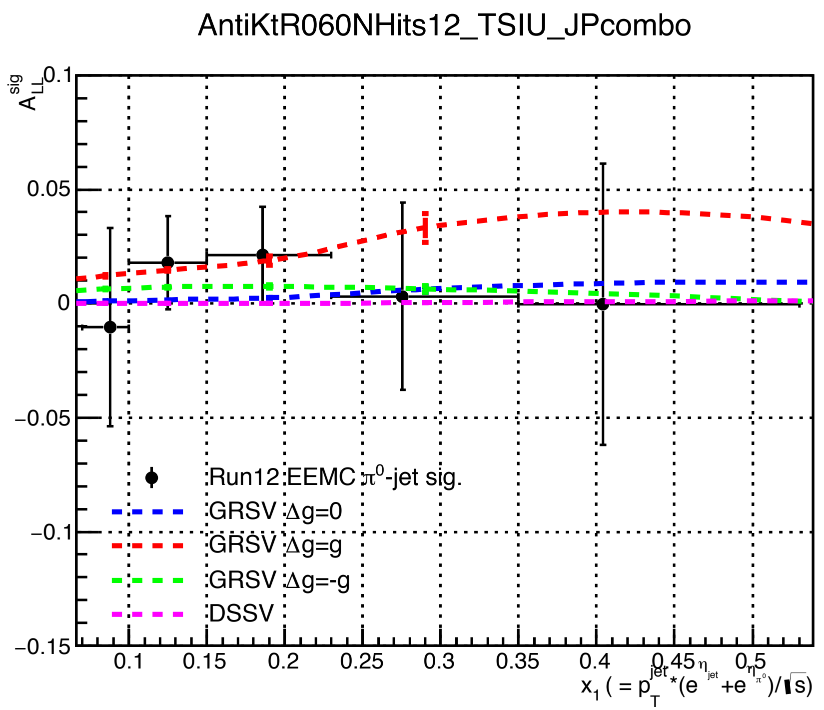
Average asymmetries (by pol0 fit):

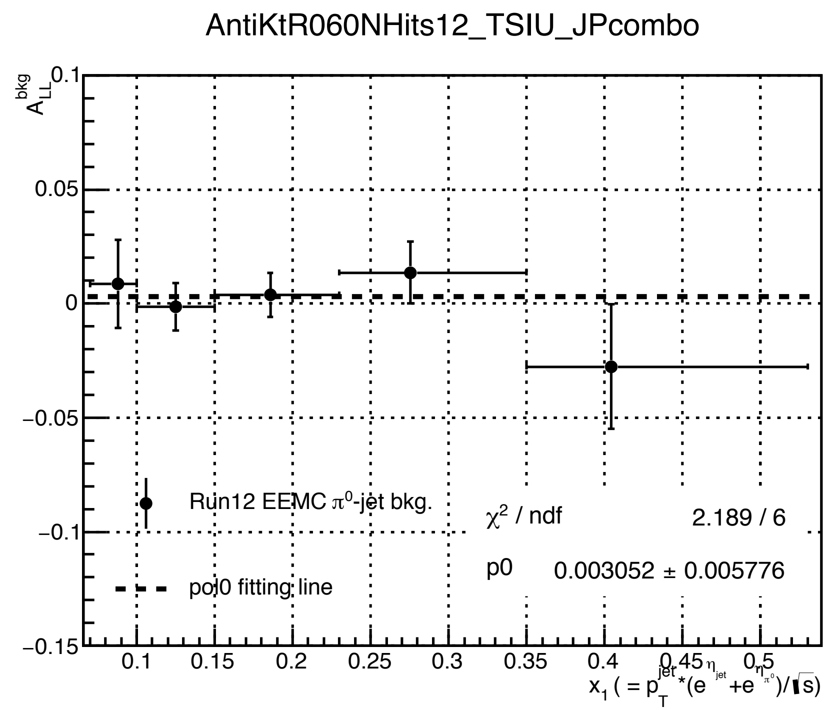
$\langle A_{LL}^{Sig} \rangle$: 0.01395±0.01412 ($\chi^2$/ndf = 1.495/12)

$\langle A_{LL}^{Bkg} \rangle$: 0.004124±0.005868 ($\chi^2$/ndf = 3.177/12)

Asymmetry Results -- Updated longitudinal double asymmetry, A_{LL}

Longitudinal double asymmetry, A_{LL}^{Sig} (left) and A_{LL}^{Bkg} (right), as a function of π^0-jet x_1 :





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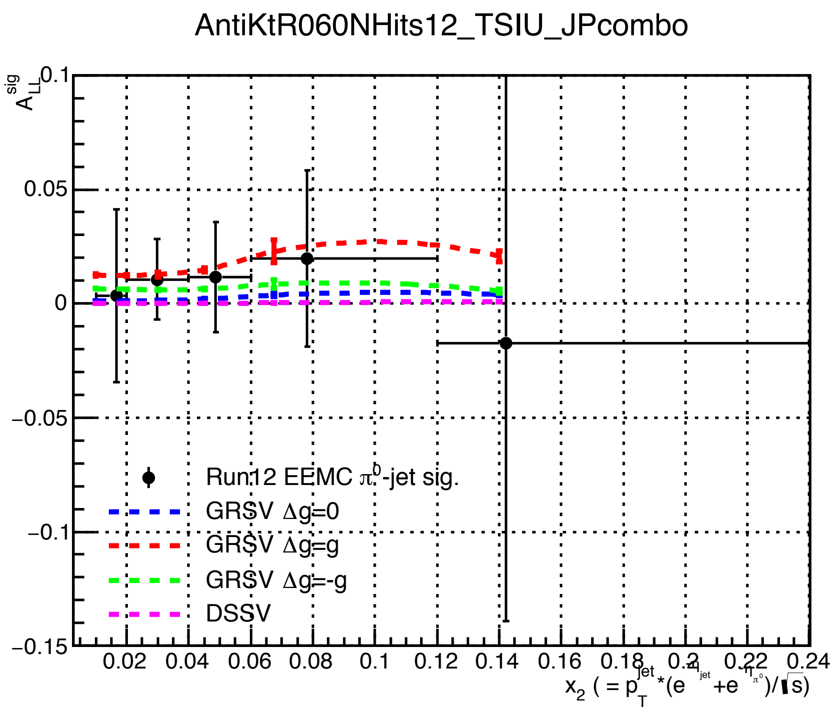
Average asymmetries (by pol0 fit):

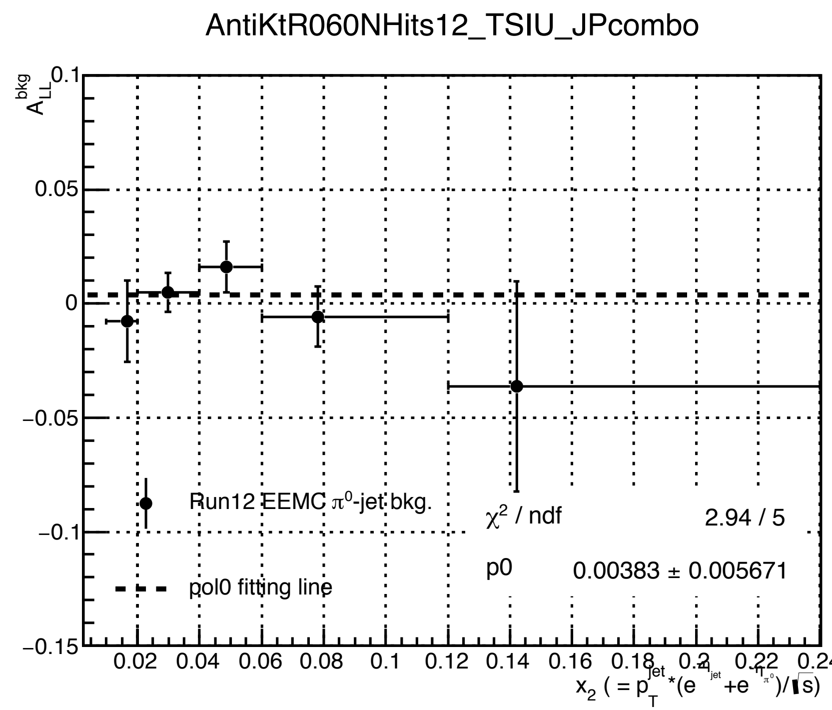
$\langle A_{LL}^{Sig} \rangle$: 0.01428±0.01281 ($\chi^2$/ndf = 0.6166/6)

$\langle A_{LL}^{Bkg} \rangle$: 0.003052±0.005776 ($\chi^2$/ndf = 2.189/6)

Asymmetry Results -- Updated longitudinal double asymmetry, A_{LL}

Longitudinal double asymmetry, A_{LL}^{Sig} (left) and A_{LL}^{Bkg} (right), as a function of π^0-jet x_2 :





Error bar: Statistics errors only

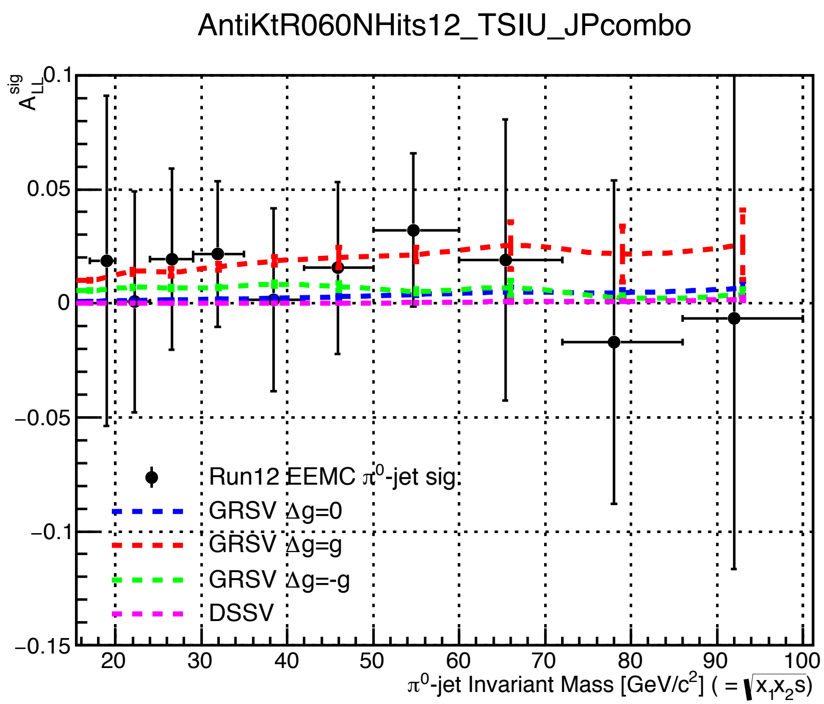
Average asymmetries (by pol0 fit):

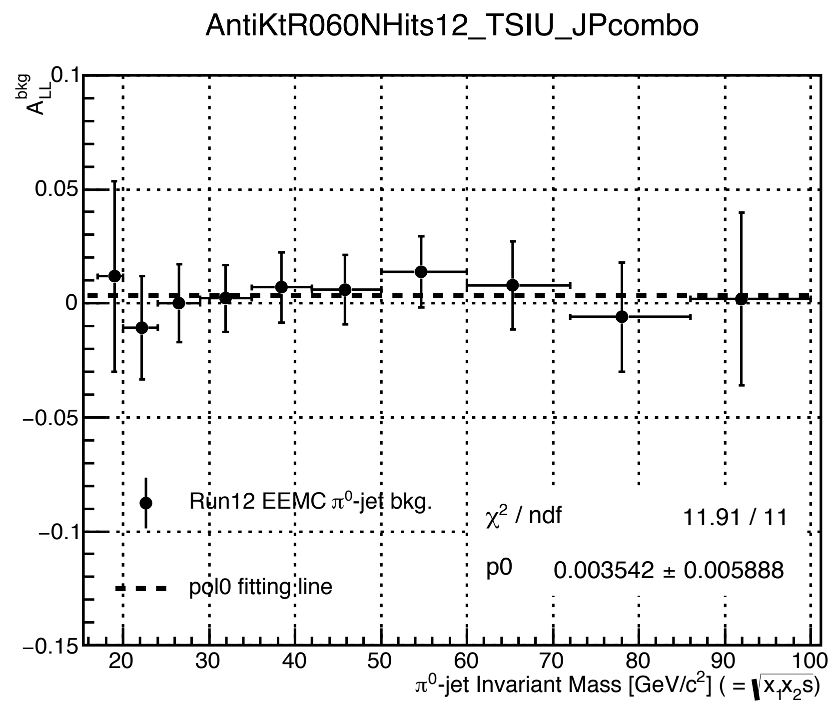
$<A_{LL}^{Sig}>$: 0.01081±0.01248 (χ^2/ndf = 0.1458/5)

$<A_{LL}^{Bkg}>$: 0.00383±0.005671 (χ^2/ndf = 2.94/5)

Asymmetry Results -- Updated longitudinal double asymmetry, A_{LL}

Longitudinal double asymmetry, A_{LL}^{Sig} (left) and A_{LL}^{Bkg} (right), as a function of π^0-jet *inv. Mass*:





Error bar: Statistics errors only

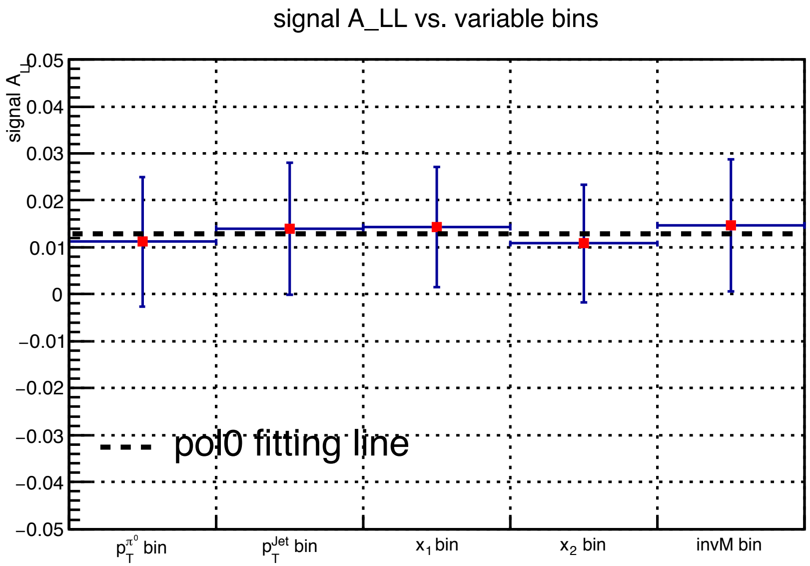
Average asymmetries (by pol0 fit):

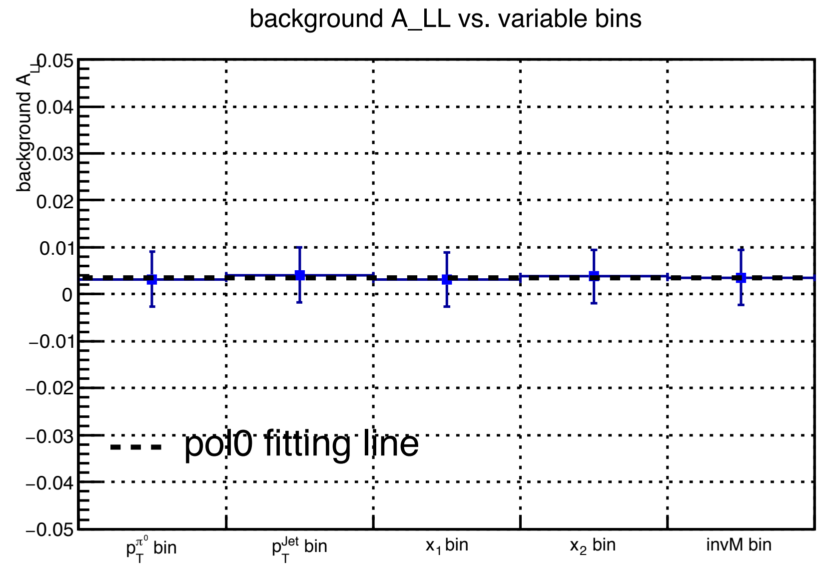
$\langle A_{LL}^{Sig} \rangle$: 0.01468±0.01412 ($\chi^2$/ndf = 14.06/11)

$\langle A_{LL}^{Bkg} \rangle$: 0.003542±0.005888 ($\chi^2$/ndf = 11.91/11)

Asymmetry Results -- Updated longitudinal double asymmetry, A_{LL}

Average longitudinal double asymmetry, A_{LL}^{Sig} (left) and A_{LL}^{Bkg} (right):





************************************				
Minimizer is Linear				
Chi2	=	0.0767421		
NDf	=	4		
p0	=	0.0129046	+/-	0.00599958

************************************				
Minimizer is Linear				
Chi2	=	0.0225257		
NDf	=	4		
p0	=	0.00355563	+/-	0.00260388

The average longitudinal double-spin asymmetries show consistent between different kinematic variables.

Summary and Plan

Summary:

1. Analysis cuts were optimized by Pythia simulation checks;
2. The signal yields were estimated by fitting function in a direct way.
3. The statistical uncertainties have been estimated only, and the re-calculated asymmetries are around 0.013 and 0.0035 for signal and background, respectively.
4. Theoretical curves were updated with higher iterations (arXiv: 0904.4402v2).
5. Systematic uncertainties estimation is ongoing……

Plan:

1. Plan to submit an abstract for the SPIN2016! -- see next slide

Thanks!

Longitudinal Double Spin Asymmetries with π^0 - Jet Correlations in Polarized Proton Collisions at $\sqrt{s}$ = 510 GeV at STAR

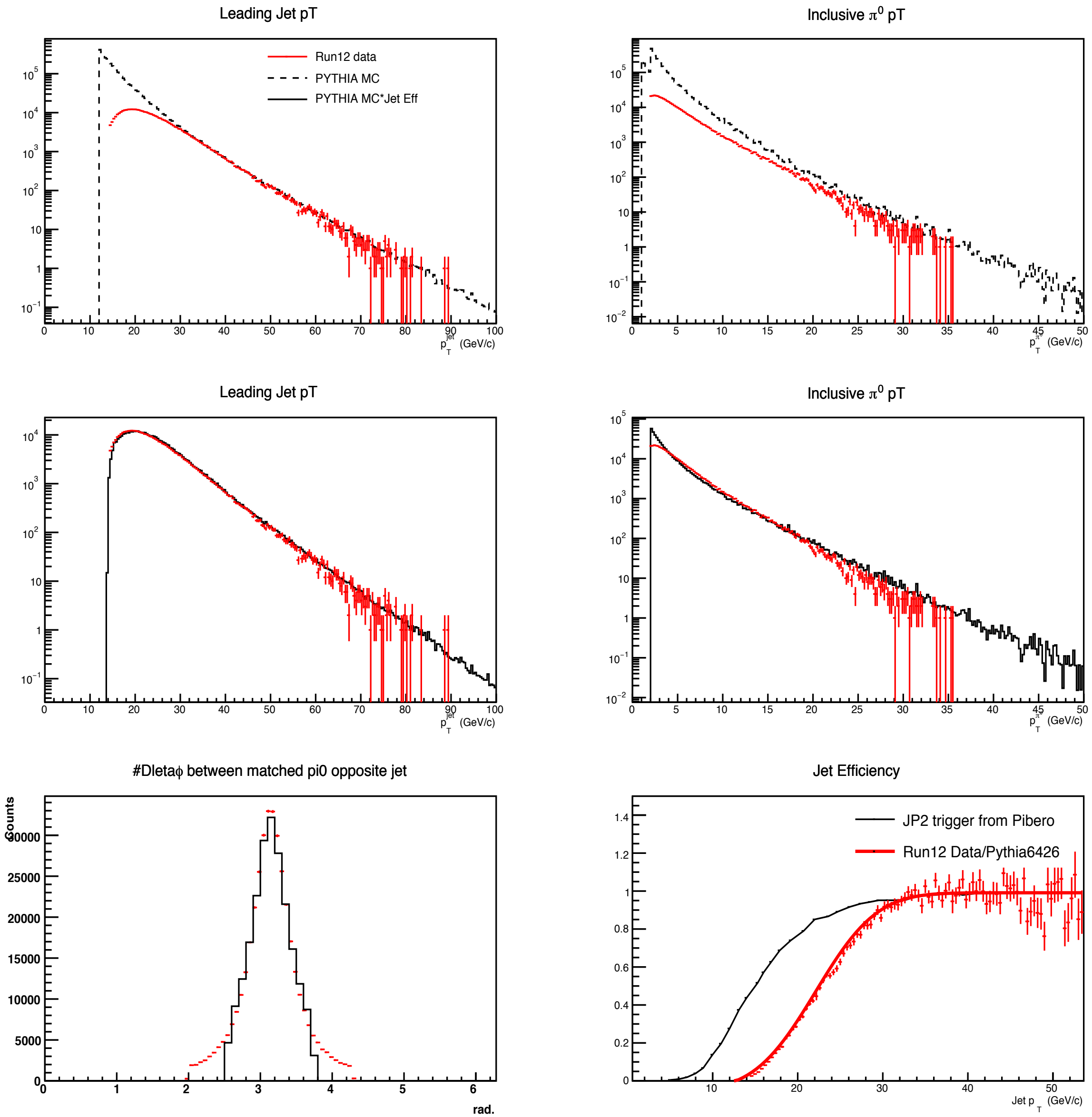
Yaping Wang for the STAR Collaboration

One of the primary goals of the spin physics program at STAR is to constrain the polarized gluon distribution function, $\Delta G(x)$, by measuring the longitudinal double-spin asymmetry (A_{LL}) of various final-state channels. Using jet in the mid-rapidity region correlated with an opposite-side neutral pion in the forward rapidity region $0.8 < \eta < 2.0$ in the STAR endcap provides a new tool to access the $\Delta G(x)$ distribution at Bjorken-x down to 0.01. Compared to inclusive jet measurements, this channel also allows to constrain the initial parton kinematics, such as x_1, x_2 and invariant mass.

the results of

In this talk, we will present ~~the status of the analysis of~~ the π^0-jet A_{LL} in longitudinally polarized proton-proton collisions at $\sqrt{s}$ =510 GeV, extracted from 80 pb^{-1} of data taken during the 2012 RHIC run. The measured A_{LL} are compared with at next-to-leading order (NLO) model calculations with different polarized parton distribution functions.

Backup – Pythia Simulation Check



- JP2 trigger data only
- Use leading jet p_T ratio of Run 12 data to MC to weight π^0-jet reconstruction efficiency (as shown in bottom right plot);
- The weighted π^0/jet p_T spectrum from MC are consistent well with data (as shown in middle plots);
- The weighted Δϕ between matched π^0 and opposite leading jet from MC agree well with data (as shown in bottom left plot).