Updates on Run12 π^0 – jet A_{LL}

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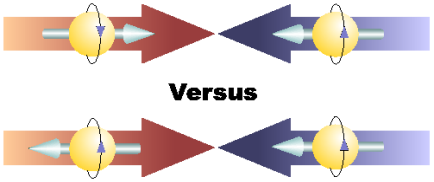


Outline

- 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

Asymmetry Analysis – Asymmetry definitions

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)

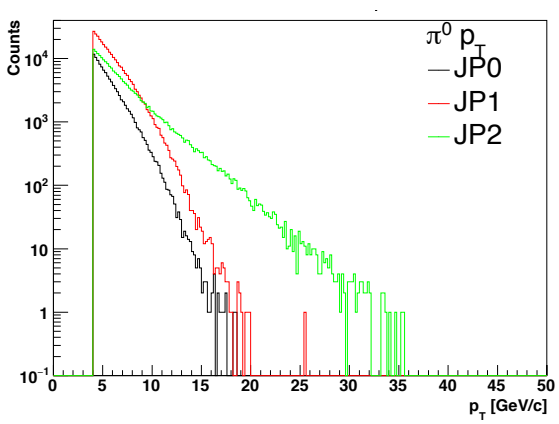
- π^0 p_T: > 4.0 GeV/c
- π^0 mass: (0, 0.6)
- π^0 physics eta: (1.086, 2.0)
- Decayed photon eta: (1.11, 1.96)
- Decayed photon 1 energy: > 2.0 GeV
- Decayed photon 2 energy: > 1.5 GeV
- Preshower energy for each photon: < 40 MeV
- SMD relative energy threshold for each photon $(E_{cluster1/2u}+E_{cluster1/2v})/E_{tower1/2}$: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

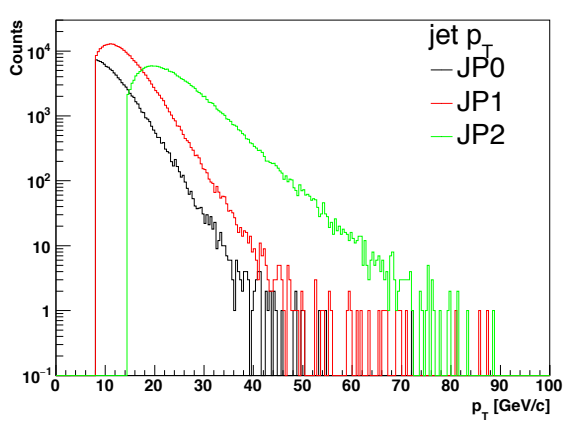
- Jet p_T > 8.0 GeV/c
- Jet physics eta: (-0.9, 0.9)
- Jet detector eta: (-0.7, 0.9)
- R_t < 0.95
- Using Anti-k_T algorithm with cone size R = 0.6
- Sum track p_T > 0.5 GeV/c

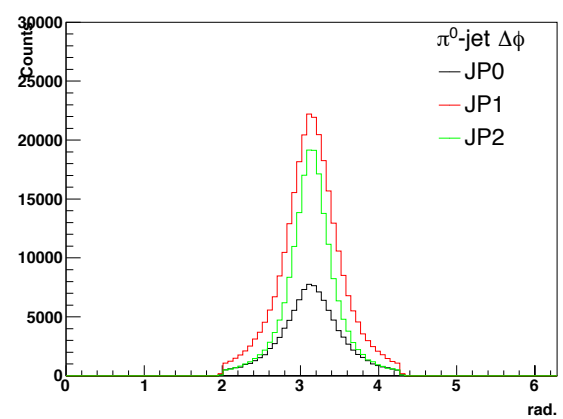
✧ $\Delta\phi$ > 2.0 (azimuthal angle between a forward π^0 opposite a barrel jet)

✧ Leading jet required (jet p_T > 8.0 GeV/c)

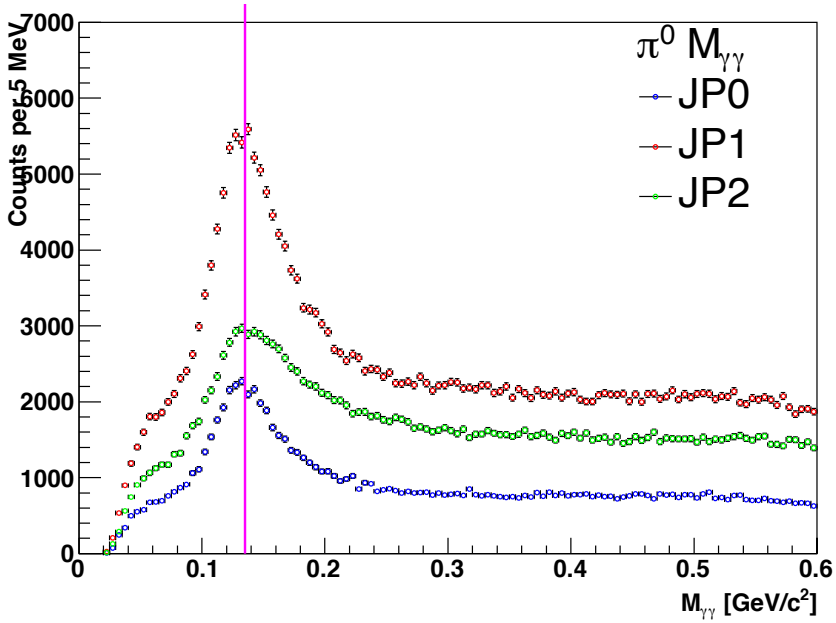
QA plots with all analysis cuts applied:

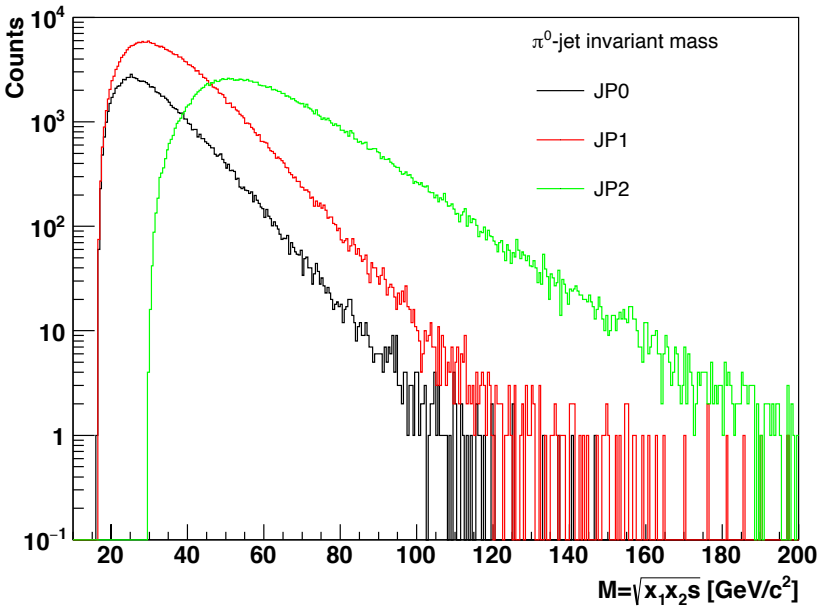


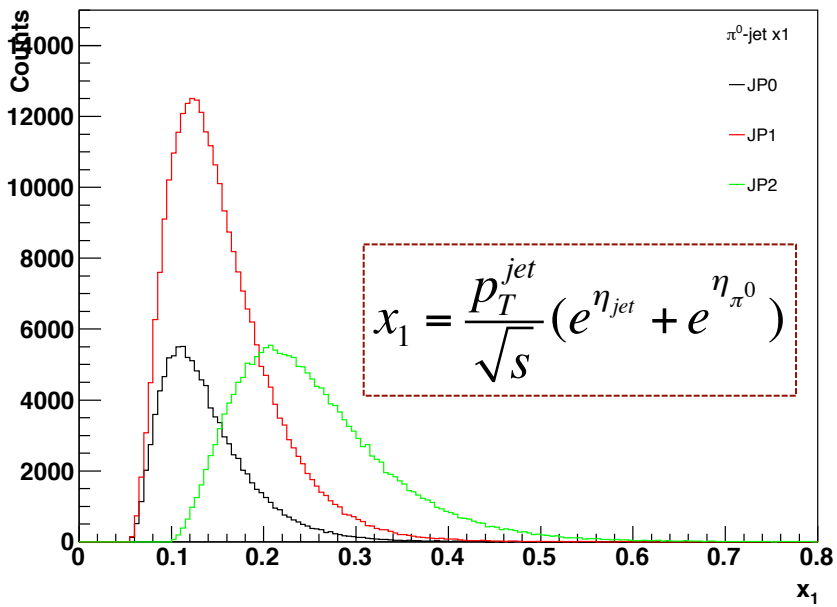


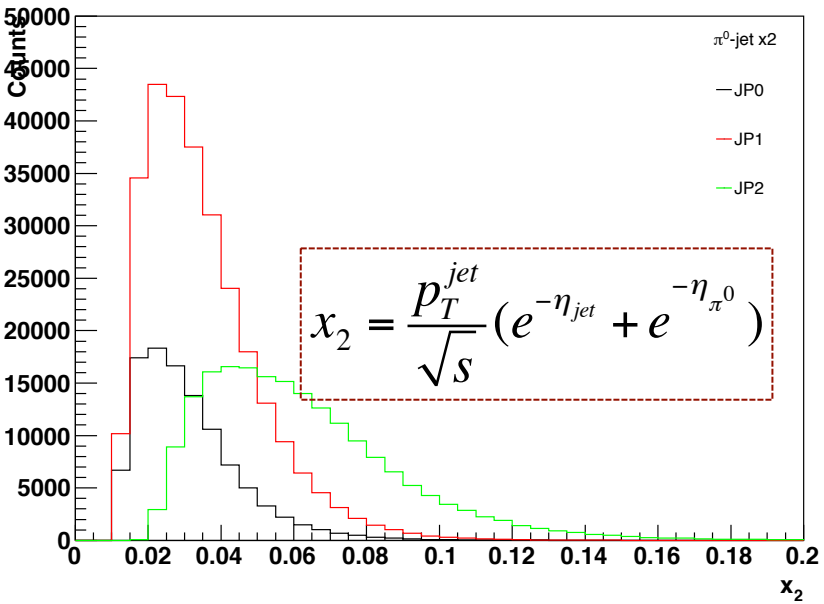


Asymmetry Analysis -- Analysis cuts updates

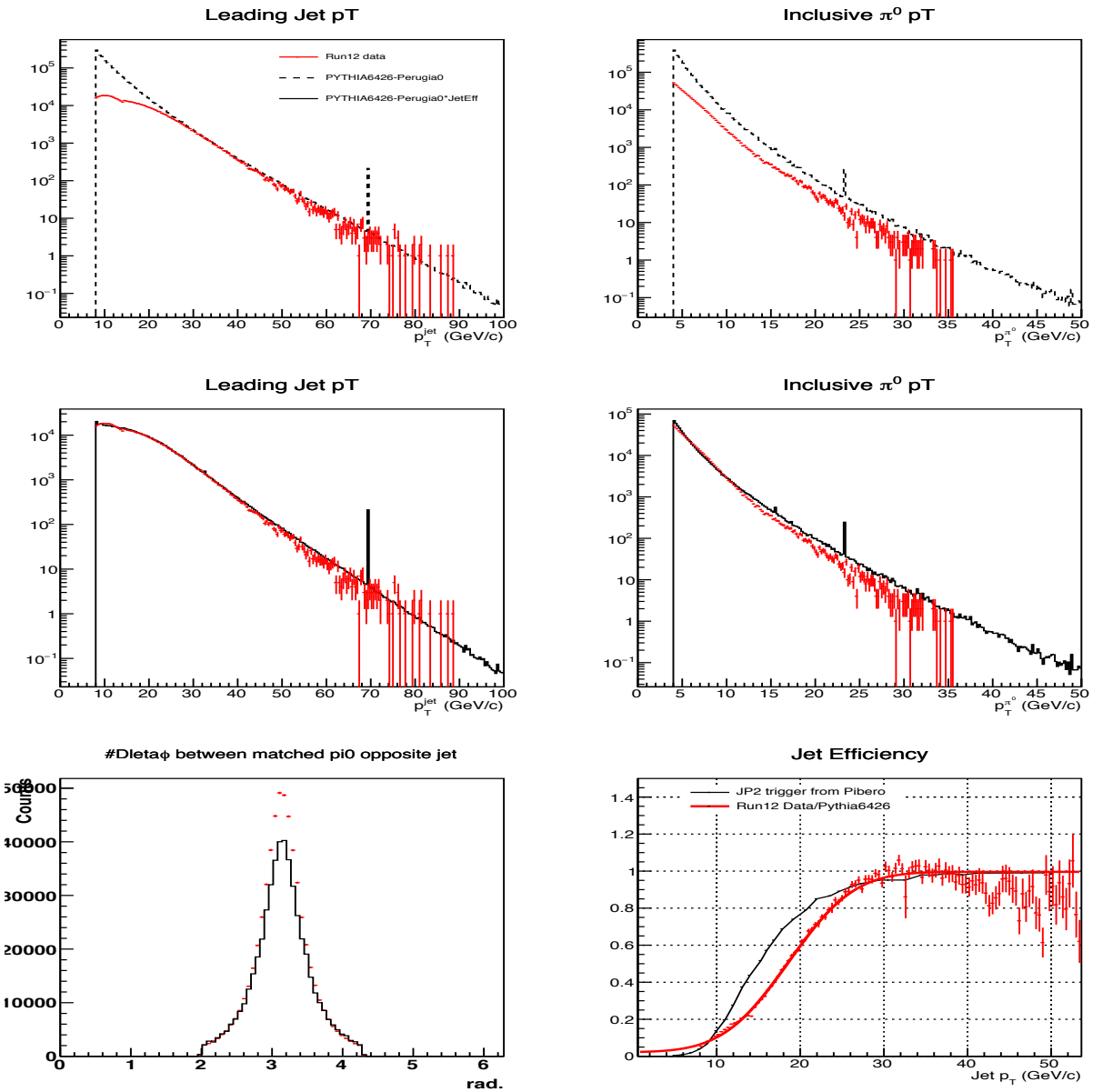






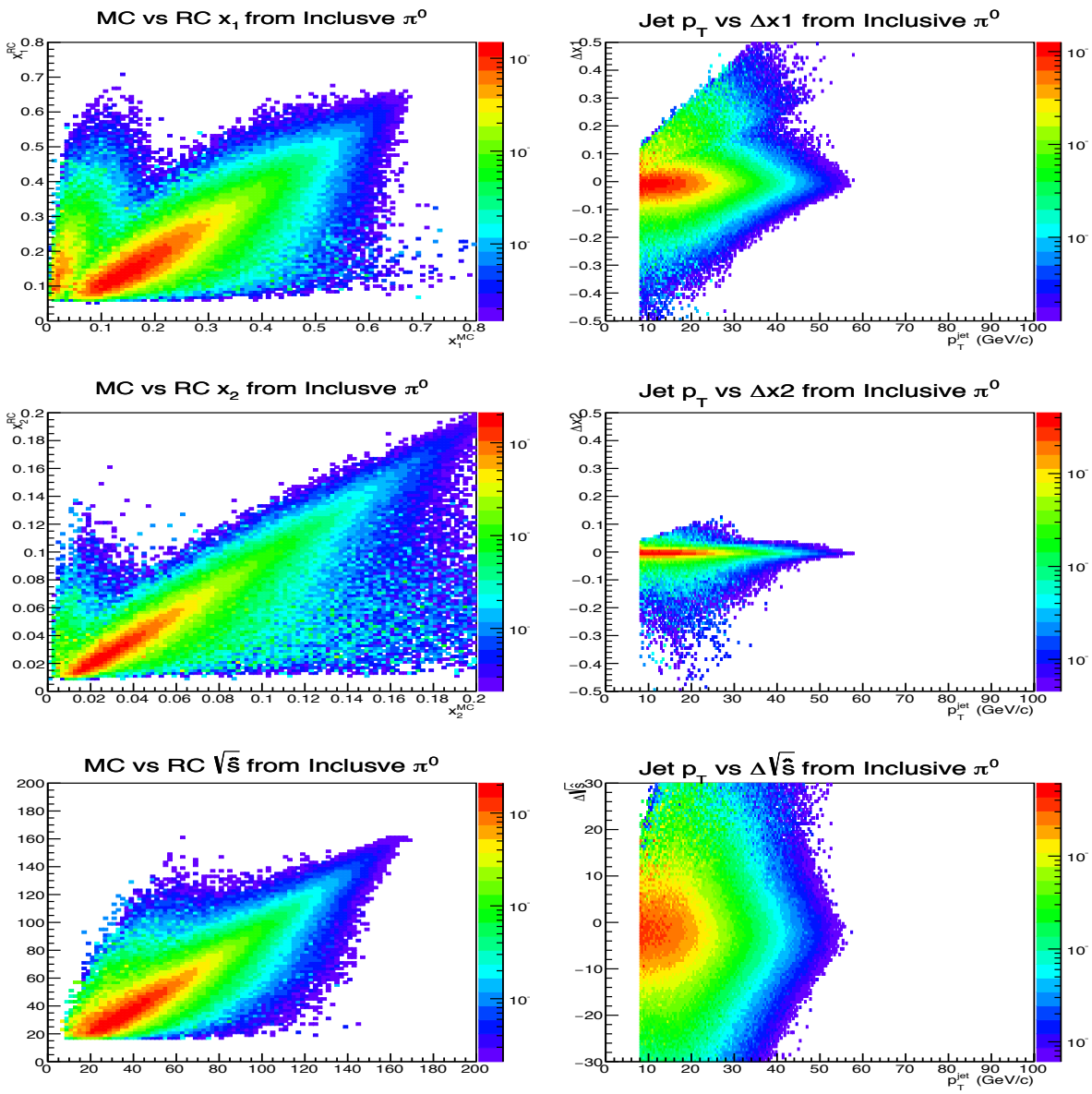


Asymmetry Analysis – Pythia Simulation Check



- With π^0 p_T > 4.0 GeV/c, leading jet p_T > 8.0 GeV/c, and $|\Delta\phi|$>2.0
- 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



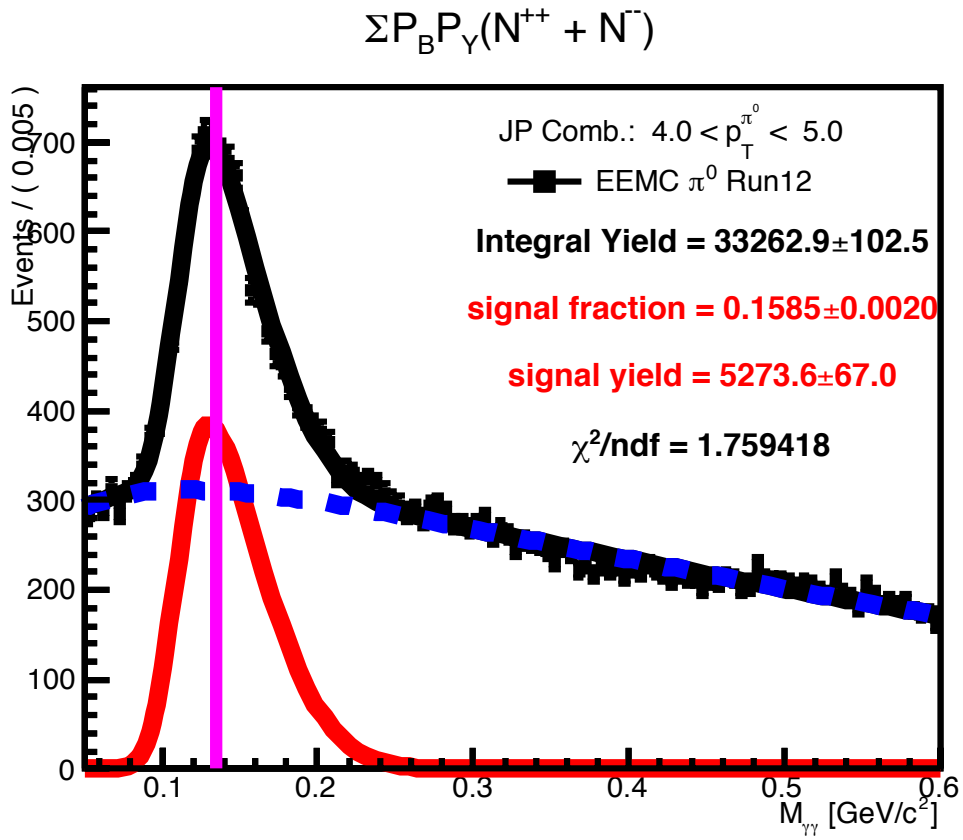
- Use leading jet p_T ratio of Run 12 data to MC to weight π^0-jet reconstruction efficiency;
- The reconstructed x_1, x_2, and invariant mass $\sqrt{x_1 x_2 s}$ of matched π^0-jet pair show a good linearity with MC (as shown in left plots).

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

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

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

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.

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

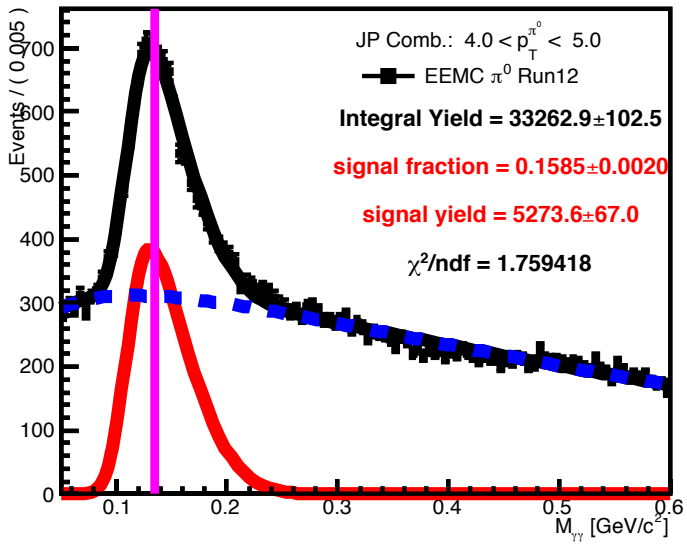
$$Background: A \times x^B \times e^{Cx}$$

$$Raw\ yield = Signal + Background$$

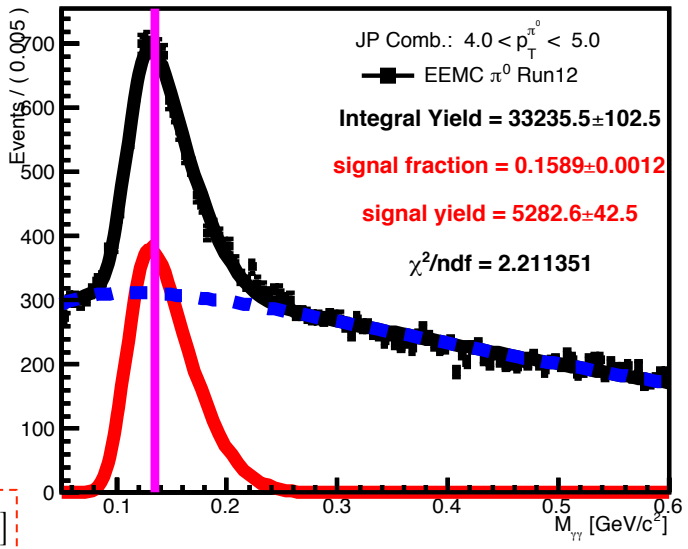
- The **raw yield** of π^0-jet are well fitted, in which the signal shape was described by **skewed Gaussian function**, and background shape was fitted by **Gamma function**;
- To estimate the ***signal yield***, fit range was set to [0.05, 0.6] GeV/c^2;
- Signal asymmetries, A_{LL}^S, estimated by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

Asymmetry Analysis – Signal extraction method update

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

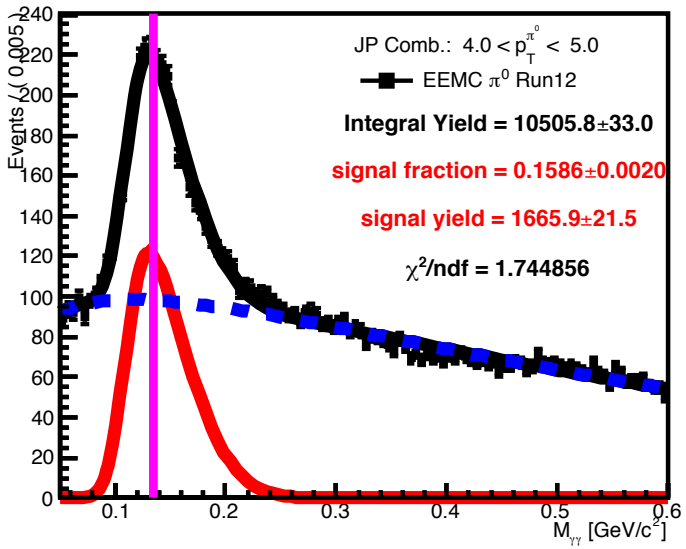


$\Sigma P_B P_Y R_3 (N^{+-} + N^{-+})$

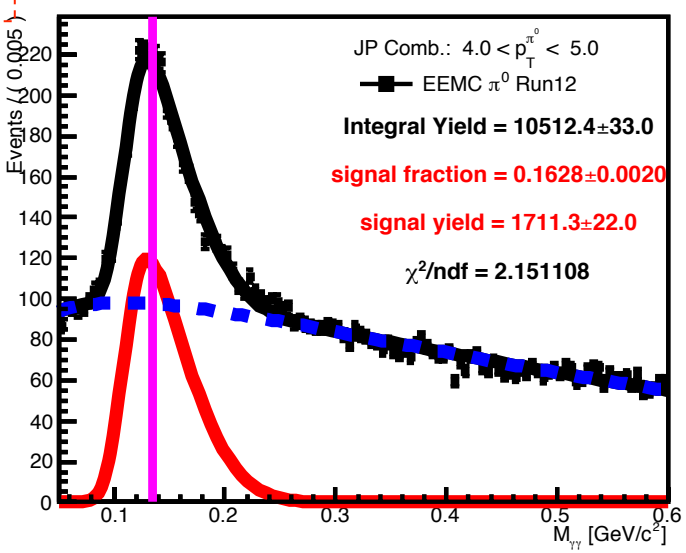


$$A_{LL} = \frac{\sum P_Y P_B [(N^{++} + N^{--}) - R_3 (N^{+-} + N^{-+})]}{\sum P_Y^2 P_B^2 [(N^{++} + N^{--}) + R_3 (N^{+-} + N^{-+})]}$$

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

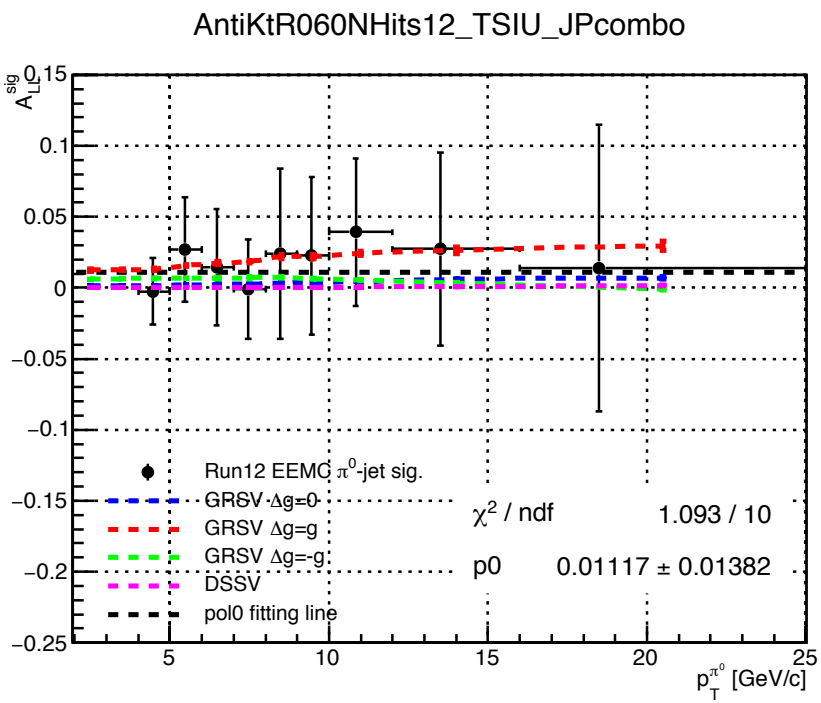


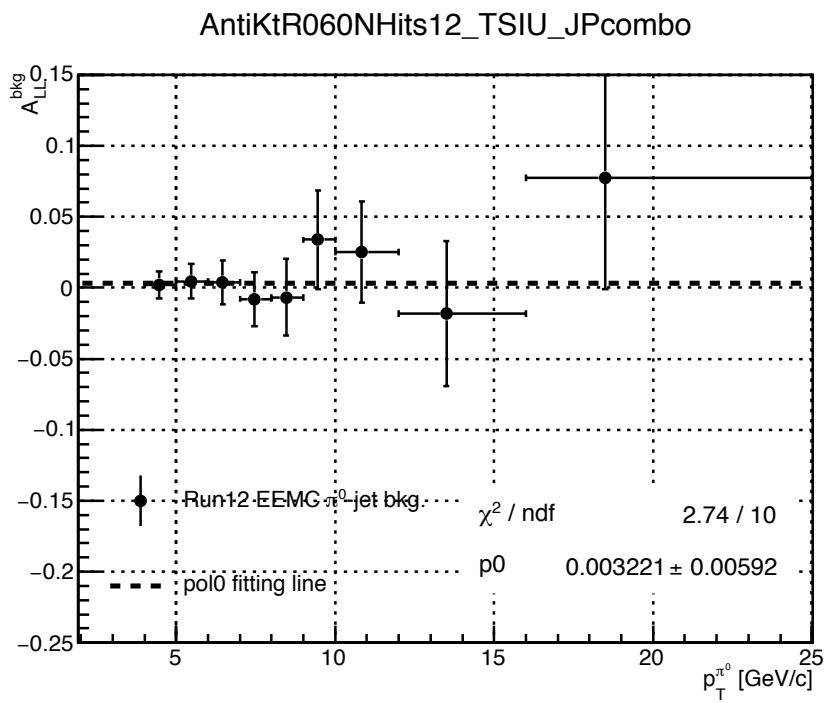
$\Sigma P_B^2 P_Y^2 R_3 (N^{+-} + N^{-+})$



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 :

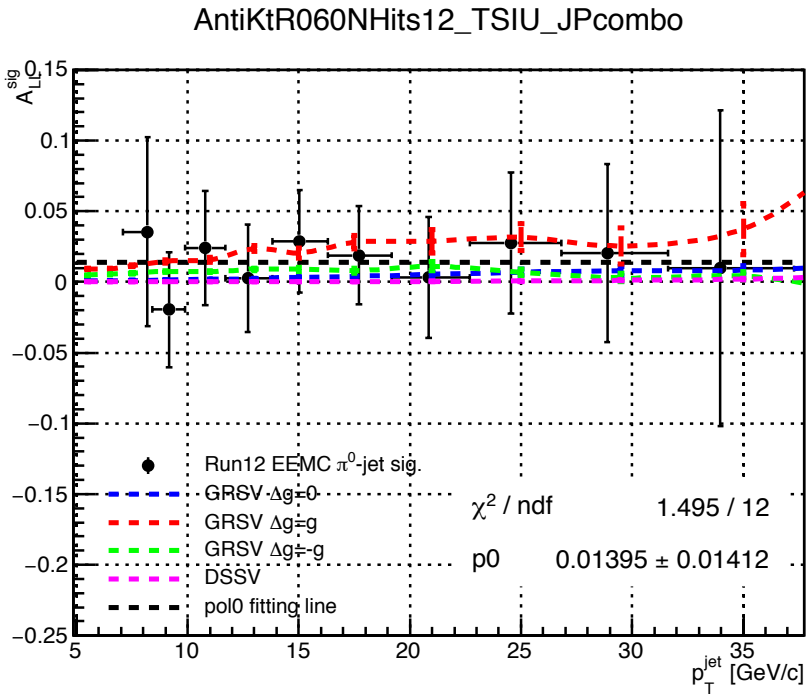


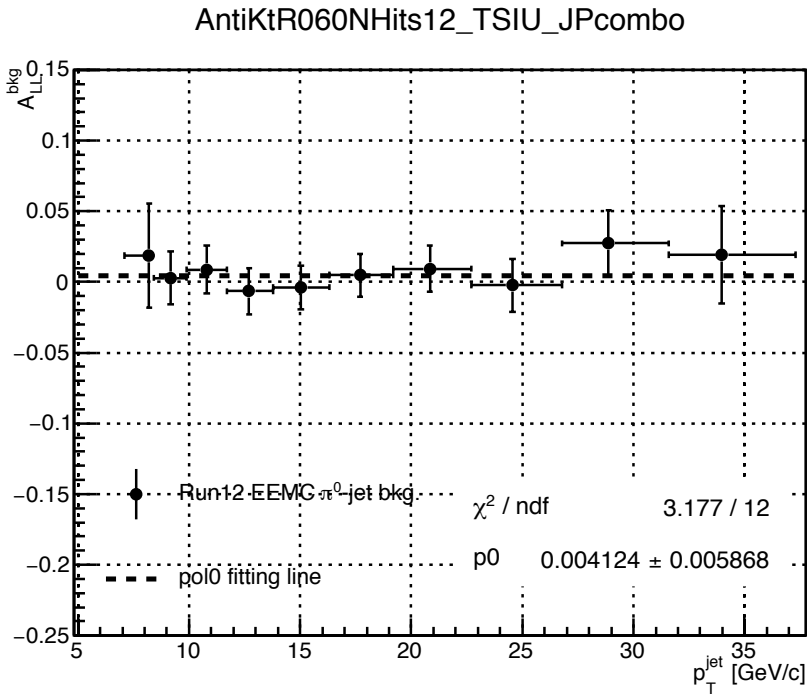


Error bar: Statistics errors only

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 :

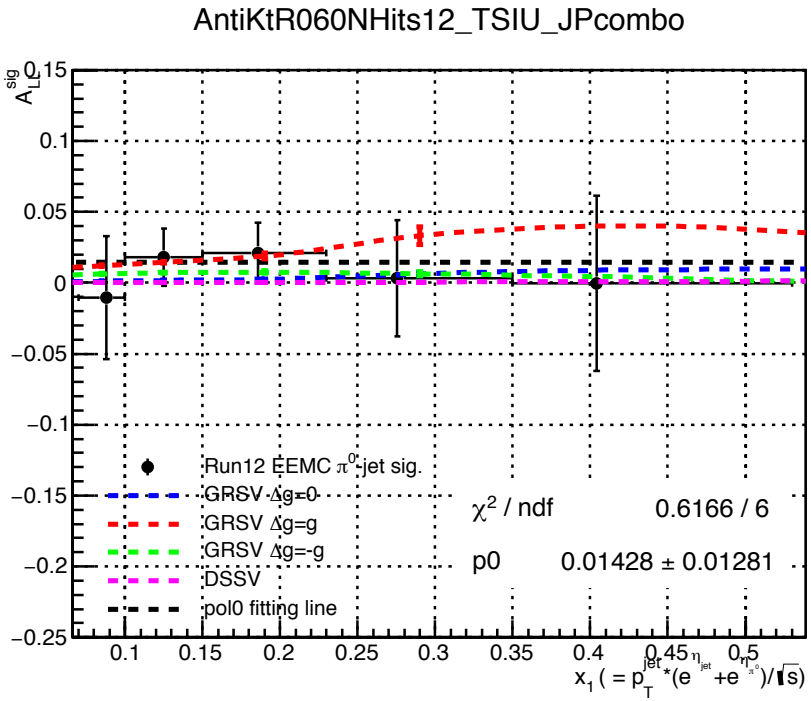


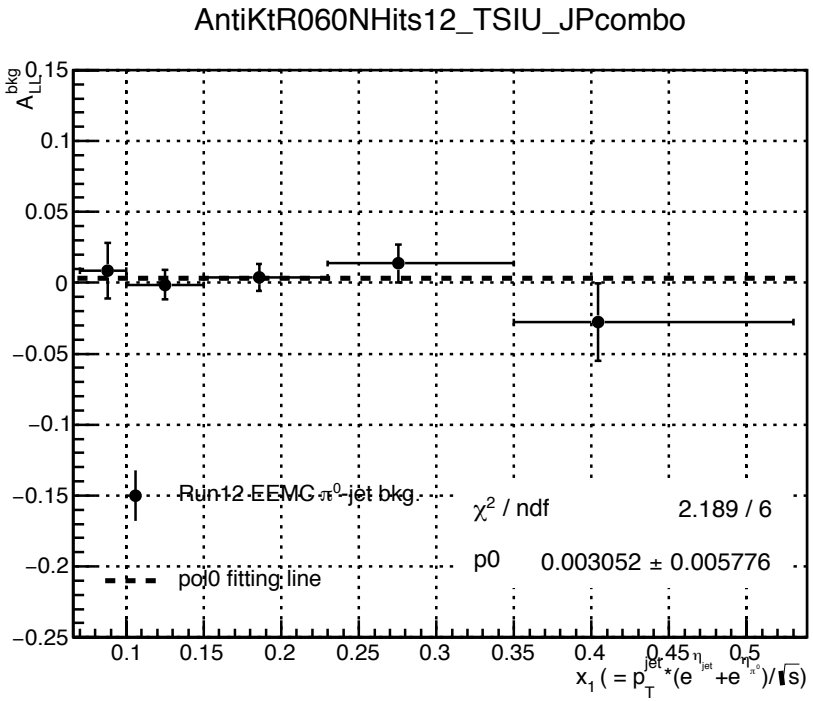


Error bar: Statistics errors only

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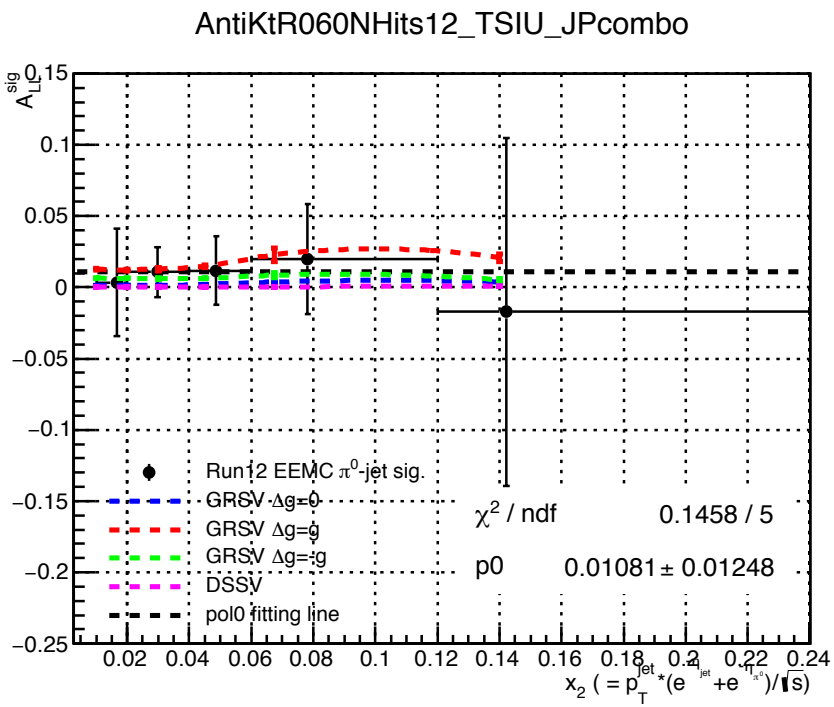
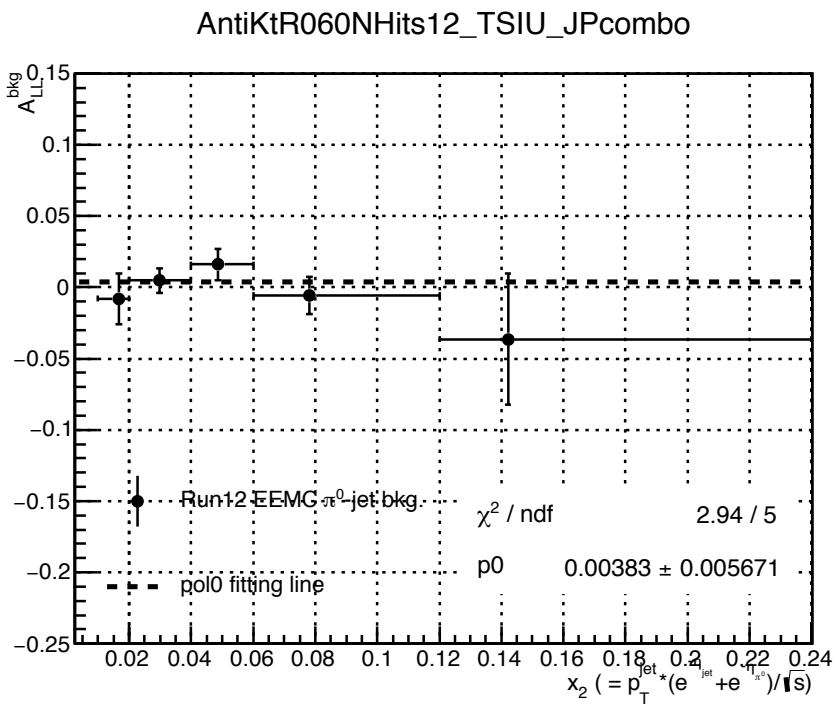
Asymmetry Results -- Updated longitudinal double asymmetry, A_{LL}

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





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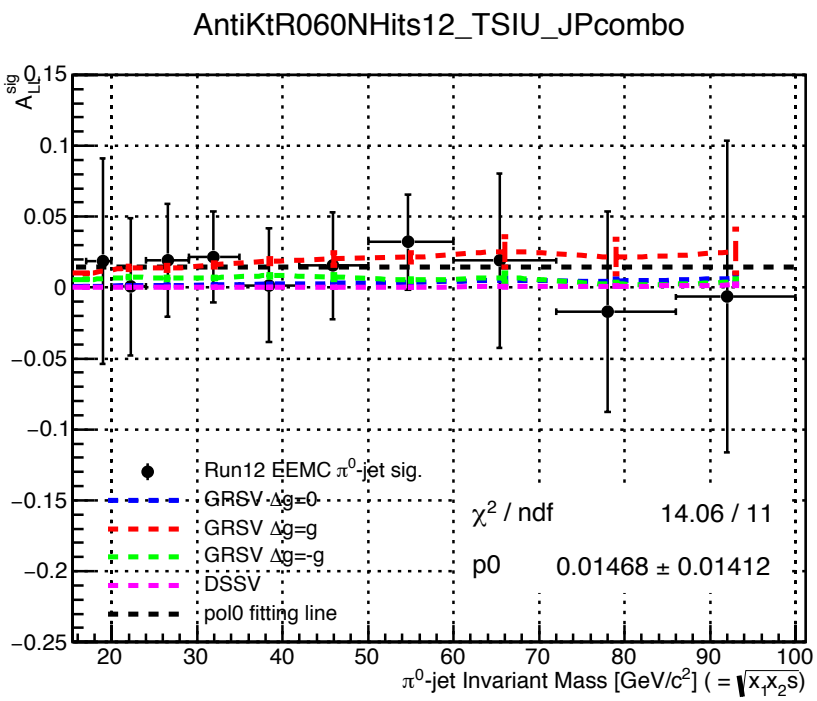
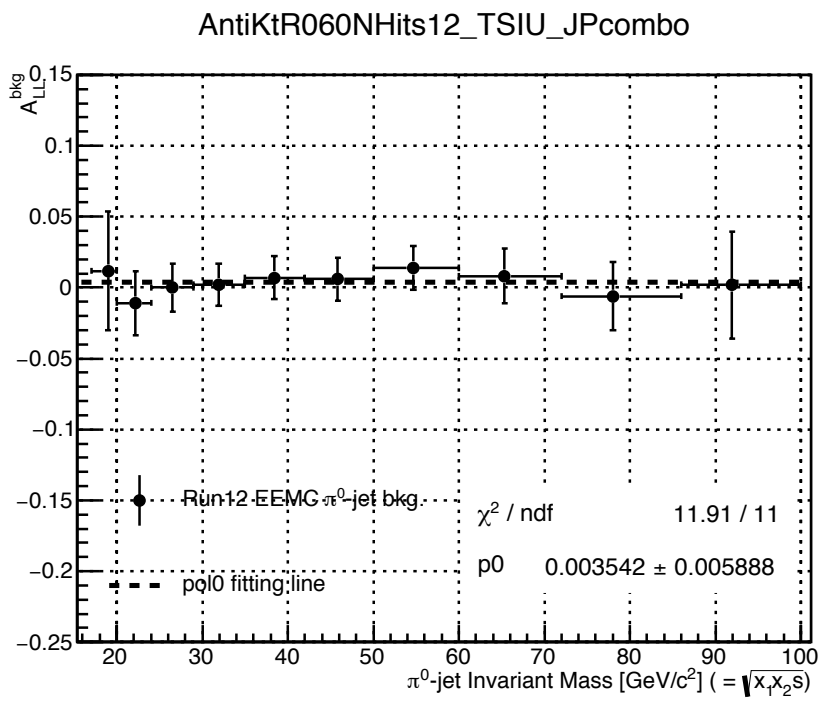
Asymmetry Results -- Updated longitudinal double asymmetry, A_{LL}

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





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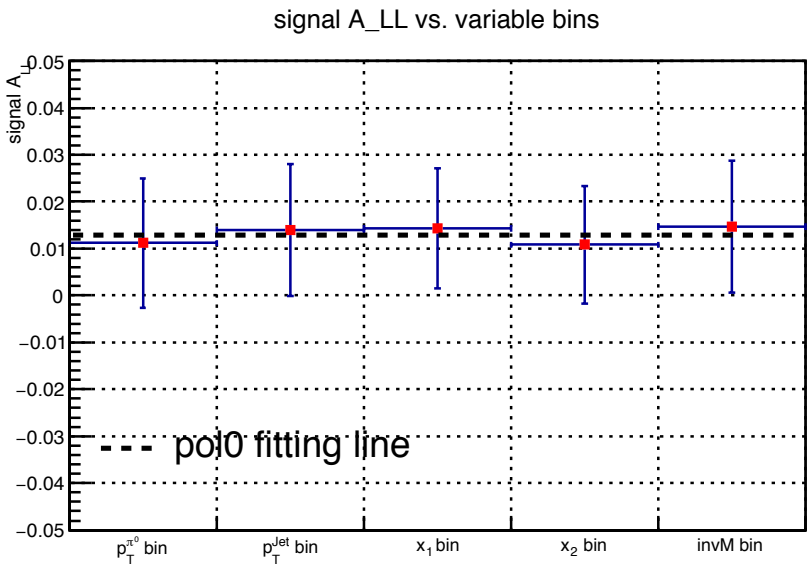
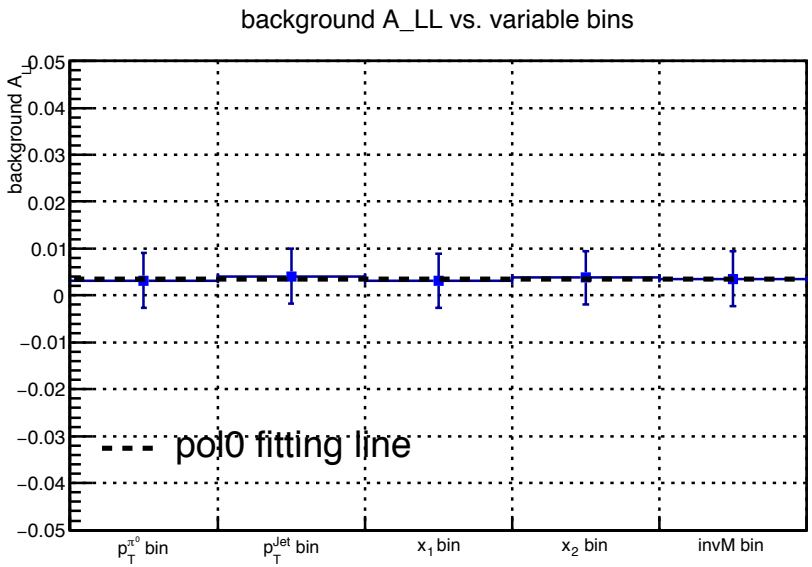
Asymmetry Results -- Updated longitudinal double asymmetry, A_{LL}

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





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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

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, and seems agree with the data.
5. Systematic uncertainties estimation is ongoing……

Plan:

1. Plan to submit an abstract for the SPIN2016!

Thanks!