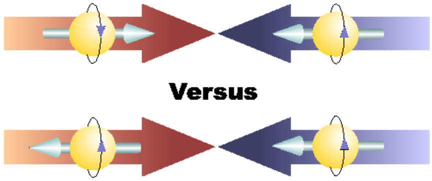
Updates on Run12 π^0 – jet A_{LL}

Yaping Wang (CCNU)
Siwei Luo, Zhenyu Ye (UIC)



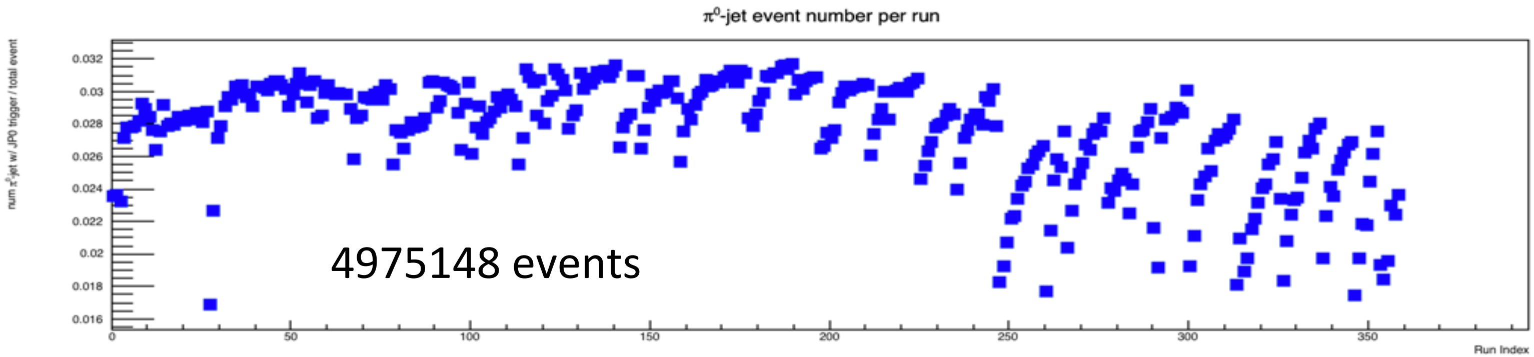
Comments/suggestions from last SPIN PWG discussion (5/7/2015)

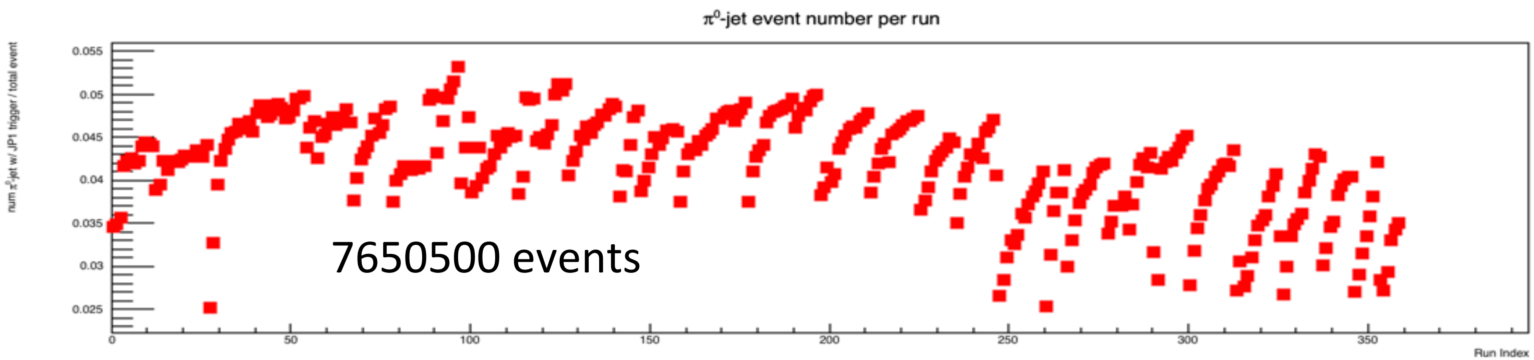
- ✓ Use Zilong's final run list (359 runs)
- ✓ Use events in which jet triggers are fired in BEMC with a matched jet (it was in A_{LL} calculations shown in my last week's slides, but confused description)
- ✓ Remove leading π^0 requirement
- ✓ Remove opening angle, daughter-photon distance, and $\Delta\eta$ cuts for π^0 selection
- ✓ Do signal + background fits for π^0 invariant mass distribution for each p_T bin to estimate the background fraction
- Adjust π^0 p_T cut

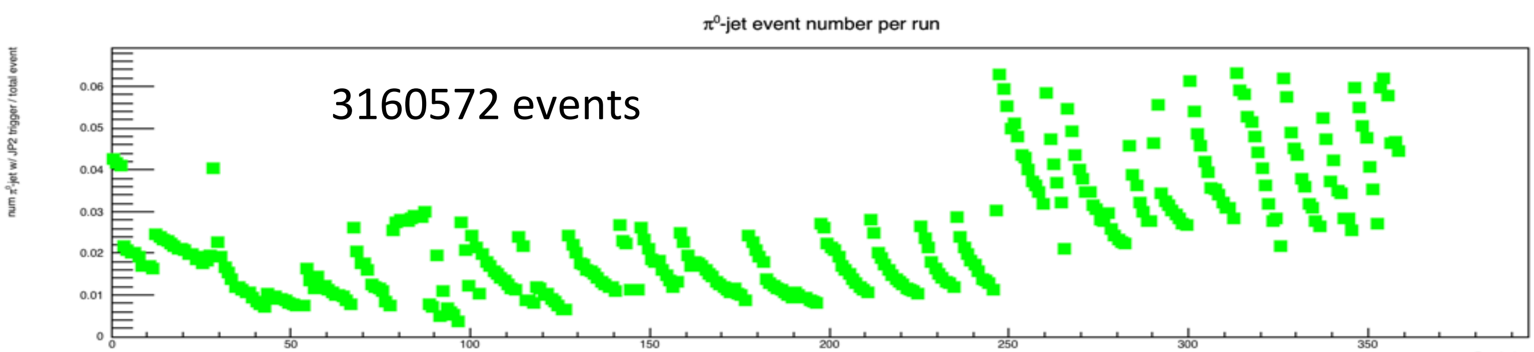
All the above suggestions in green are applied in today's updates!

New run list from Zilong

Ratio of JP0/JP1/JP2 triggered π^0-jet event to the total analyzed events (~174M events):







Triggers

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

Analysis cuts

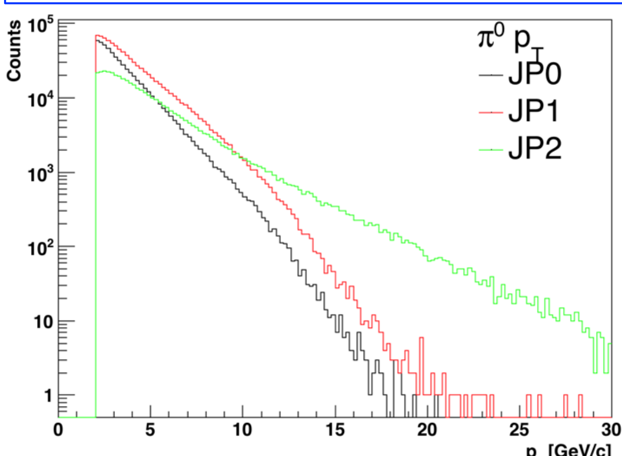
- π^0 p_T: > 2.0 GeV/c
- π^0 mass: (0, 0.6)
- π^0 physics eta: (1.086, 2.0)
- Decayed photon eta: (1.11, 1.96)
- Decayed photon 1 energy: > 2.0 GeV
- Decayed photon 2 energy: > 1.5 GeV
- Preshower energy for each photon: < 40 MeV
- SMD relative energy threshold for each photon
  $(E_{cluster1/2u}+E_{cluster1/2v})/E_{tower1/2}$: > 0.008
- ~~Photons opening angle (degree): (0.2, 3.0)~~
- ~~Photons distance on EEMC plane (cm): (4.0, 20.0)~~
- ~~Photons difference in eta (absolute value): < 0.15~~

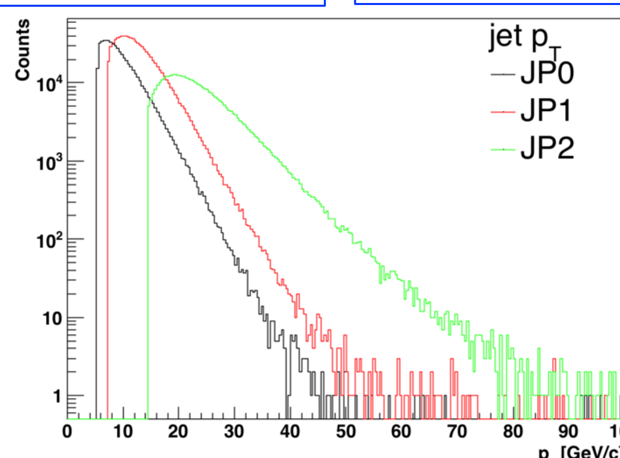
- Jet p_T > 5.0 GeV/c
- Jet physics eta: (-0.9, 0.9)
- Jet detector eta: (-0.7, 0.9)
- R_t < 0.95
- Using Anti-k_T algorithm with cone size R = 0.6
- Sum track p_T > 0.5 GeV/c

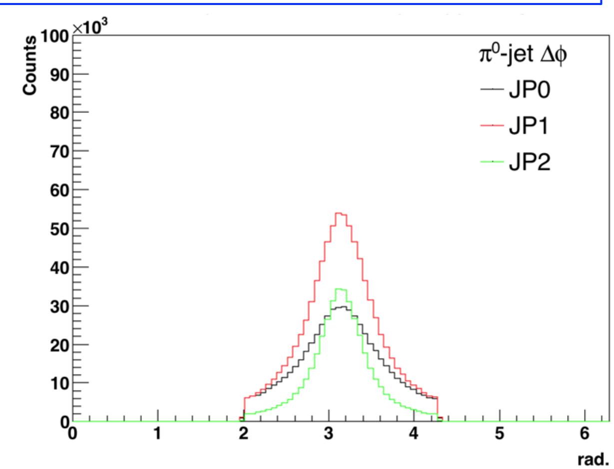
✧ $\Delta\phi$ > 2.0 (azimuthal angle between a forward π^0 opposite a barrel jet)

✧ ~~Only use leading π^0 to match a barrel jet~~

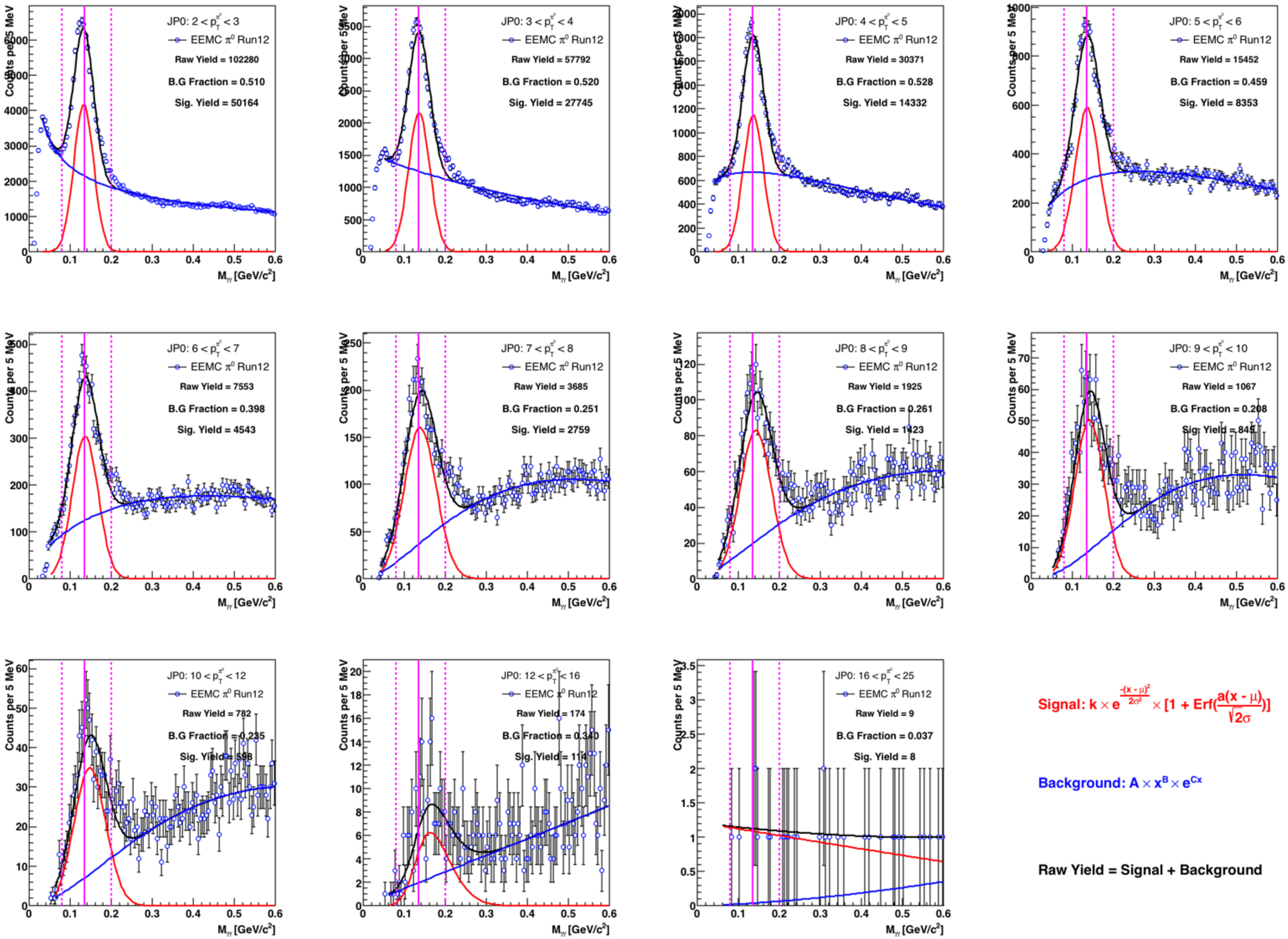
✧ π^0 mass region: (0., 0.6) GeV/c^2
restrict to (0.08, 0.20) for asymmetry calc.







Estimate π^0 background fraction via sig.+bkg. fit – JP0

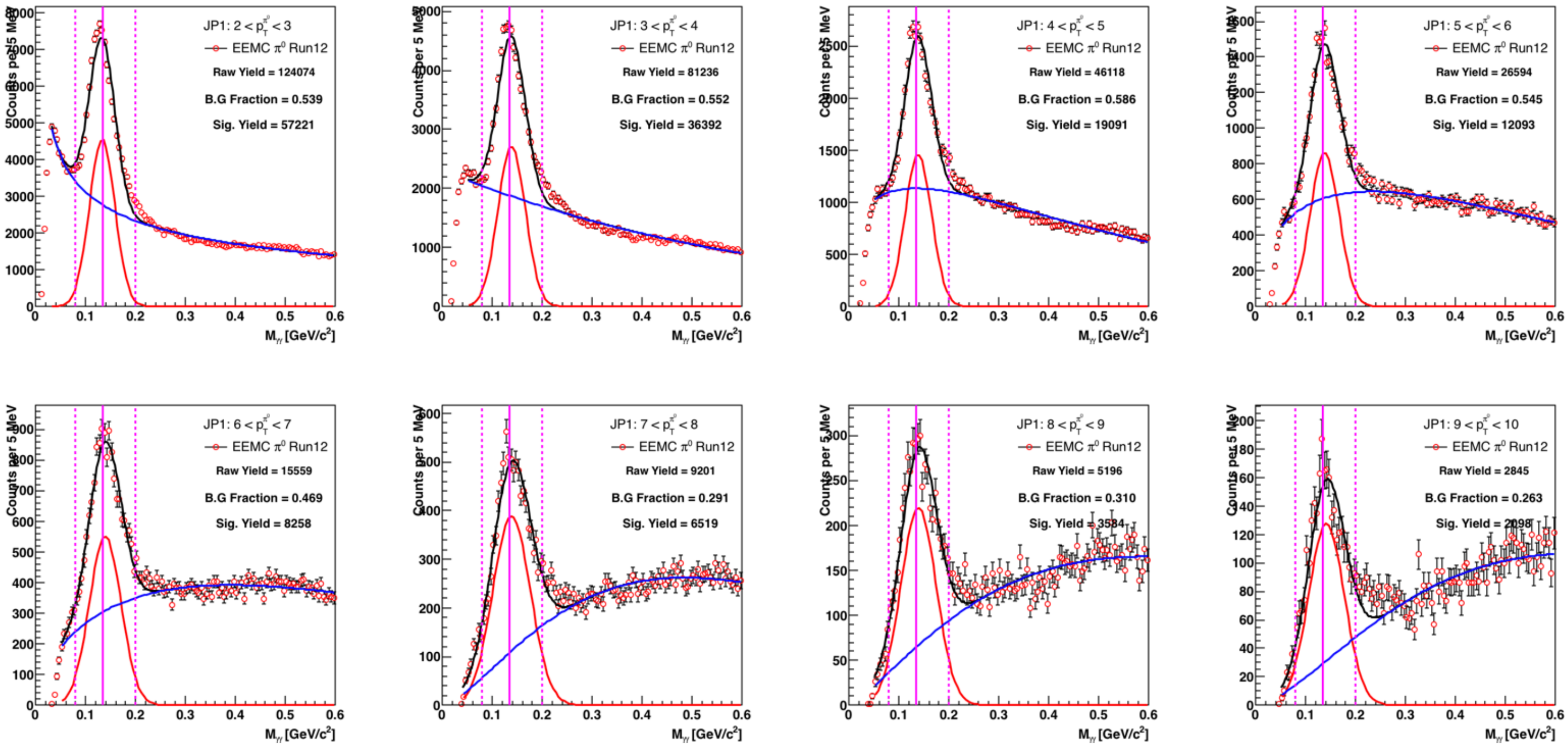


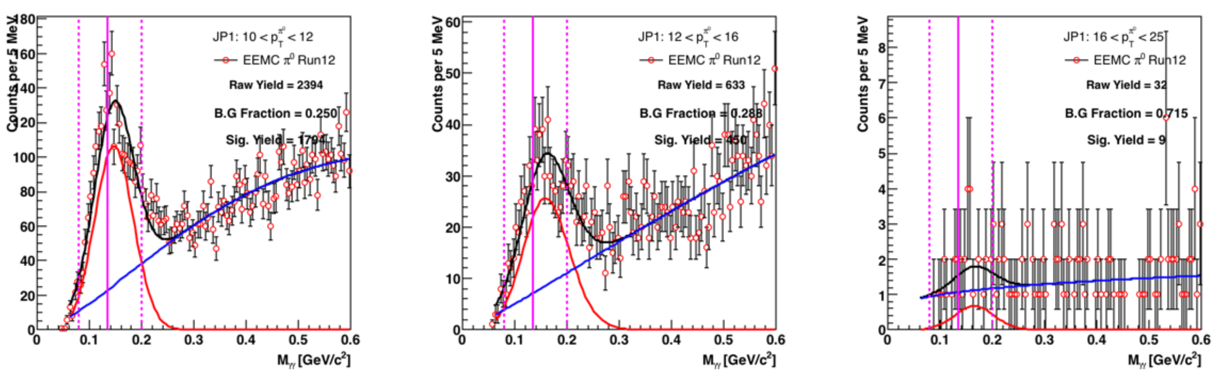
Signal: $k \times e^{\frac{-(x-\mu)^2}{2\sigma^2}} \times [1 + \mathrm{Erf}(\frac{a(x-\mu)}{\sqrt{2}\sigma})]$

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

Raw Yield = Signal + Background

Estimate π^0 background fraction via sig.+bkg. fit – JP1



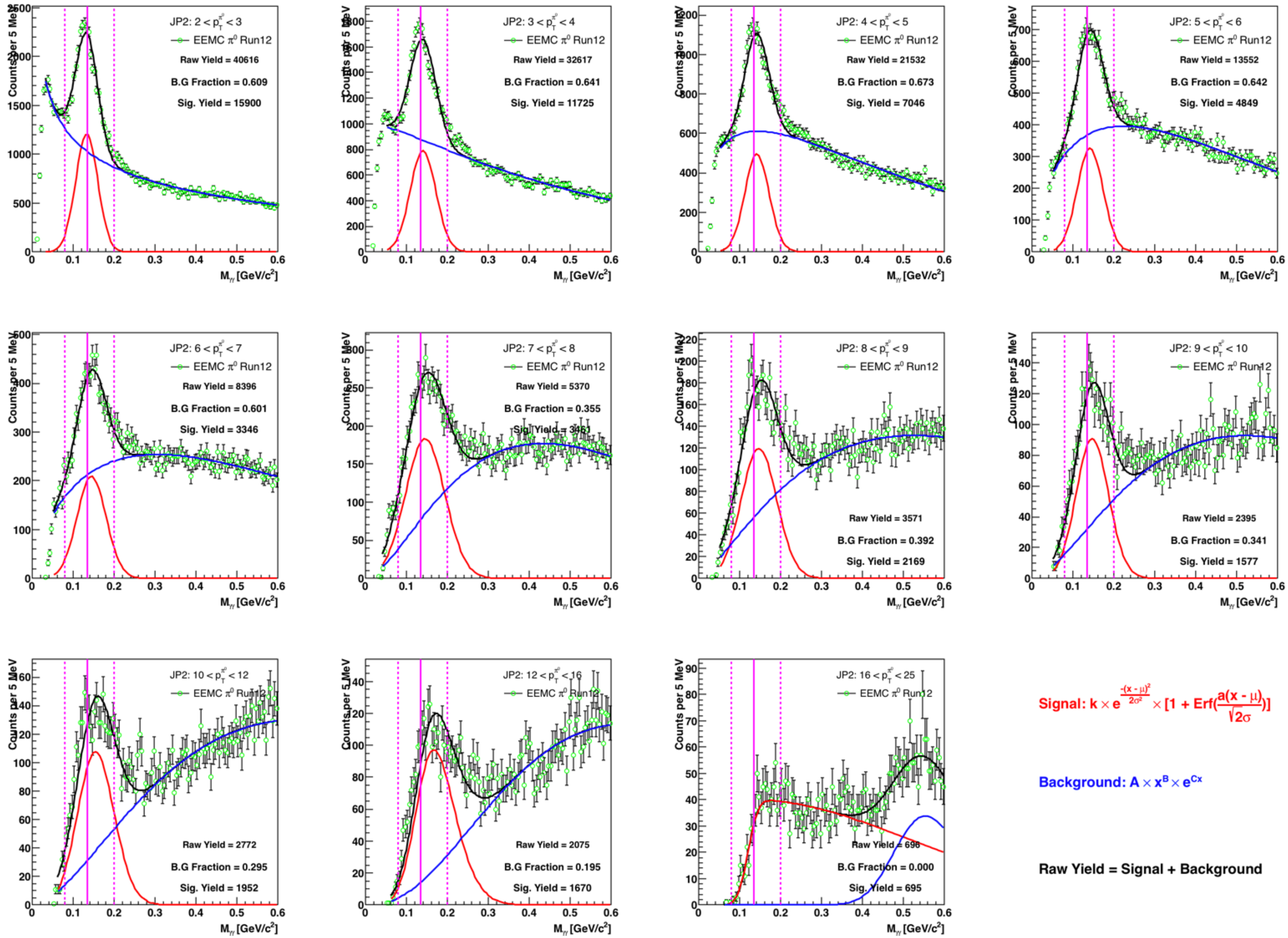


Signal: $k \times e^{\frac{-(x-\mu)^2}{2\sigma^2}} \times [1 + \mathrm{Erf}(\frac{a(x-\mu)}{\sqrt{2}\sigma})]$

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

Raw Yield = Signal + Background

Estimate π^0 background fraction via sig.+bkg. fit – JP2



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

π^0 background fraction estimations

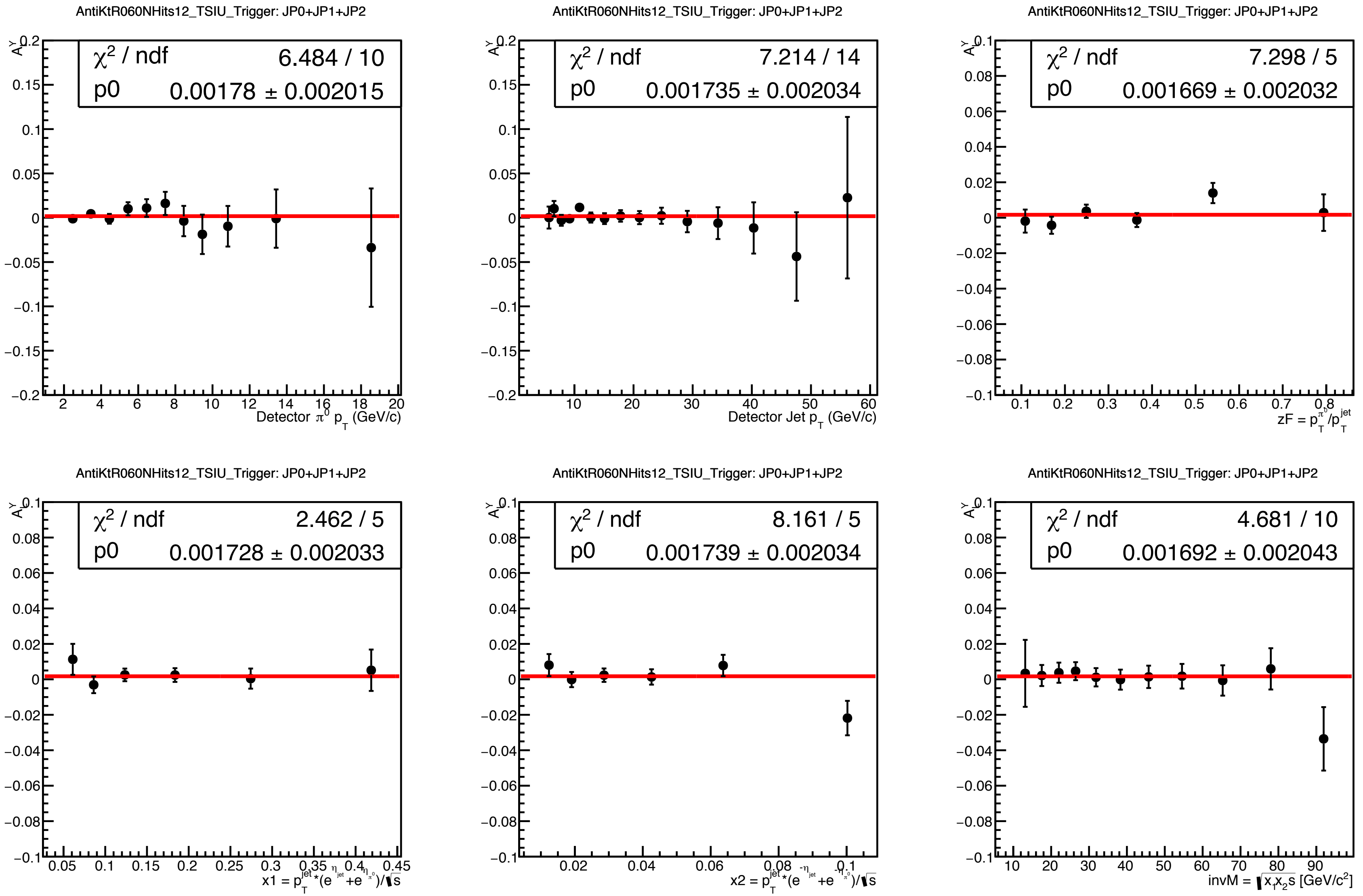
Background fraction estimations for π^0 – jet correlated events in each π^0 p_T bin in signal π^0 mass region (0.08, 0.2) GeV/c^2:

Bkg. Frac.	(2, 3)	(3, 4)	(4, 5)	(5, 6)	(6, 7)	(7, 8)	(8, 9)	(9, 10)	(10, 12)	(12, 16)	(16, 25)
JP0	0.510	0.520	0.528	0.459	0.398	0.251	0.261	0.208	0.235	0.340	1.0
JP1	0.539	0.552	0.586	0.545	0.469	0.291	0.310	0.263	0.250	0.288	0.715
JP2	0.609	0.641	0.673	0.642	0.601	0.355	0.392	0.341	0.295	0.195	0.000

These fractions were applied in A_{LL} calculations to subtract the background contributions.

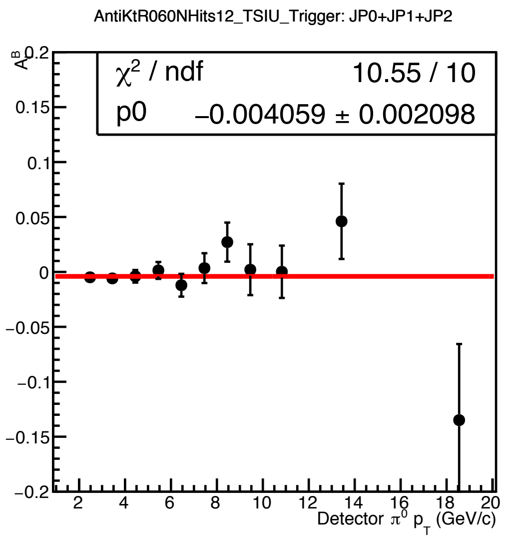
Asymmetry results – False asymmetries

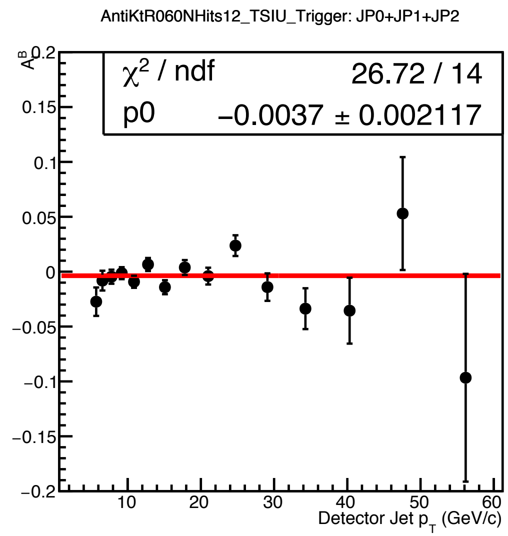
Longitudinal single-spin asymmetries (Yellow beam): combined triggers

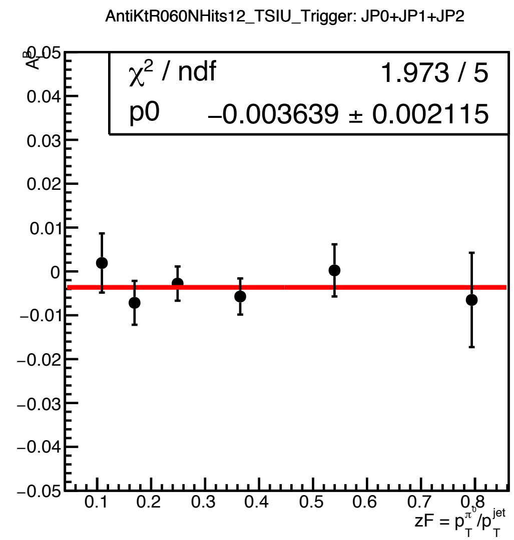


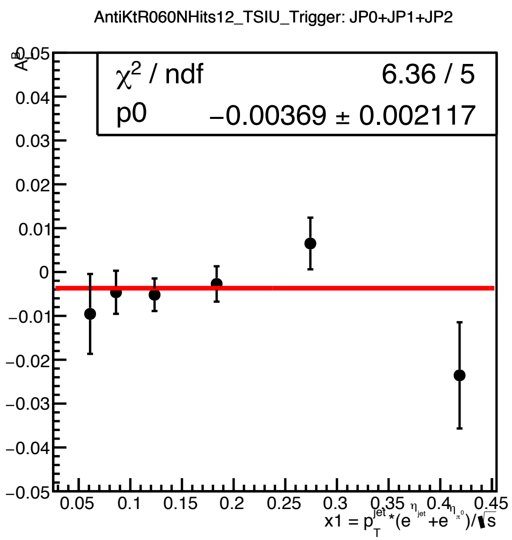
Asymmetry results – False asymmetries

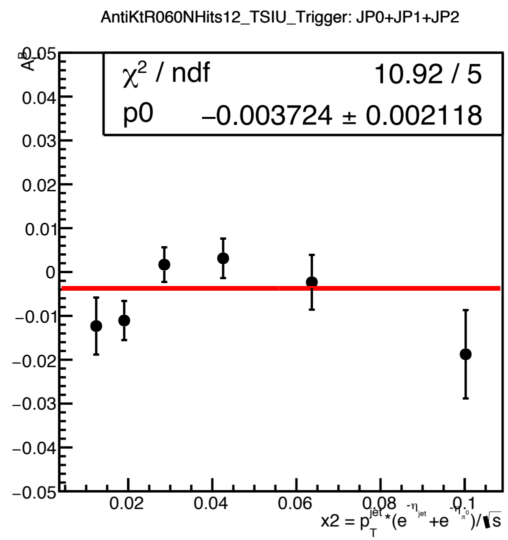
Longitudinal single-spin asymmetries (Blue beam): combined triggers

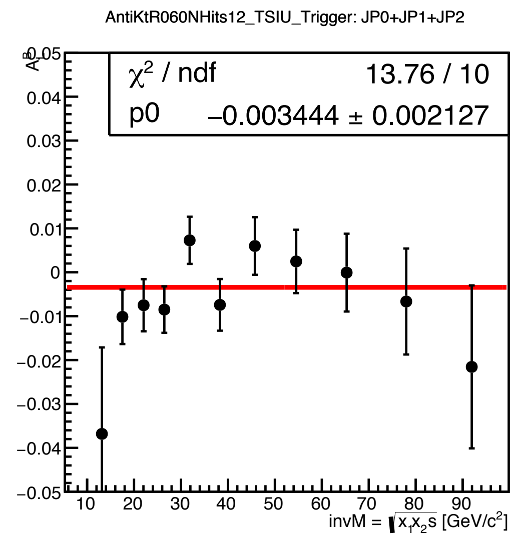






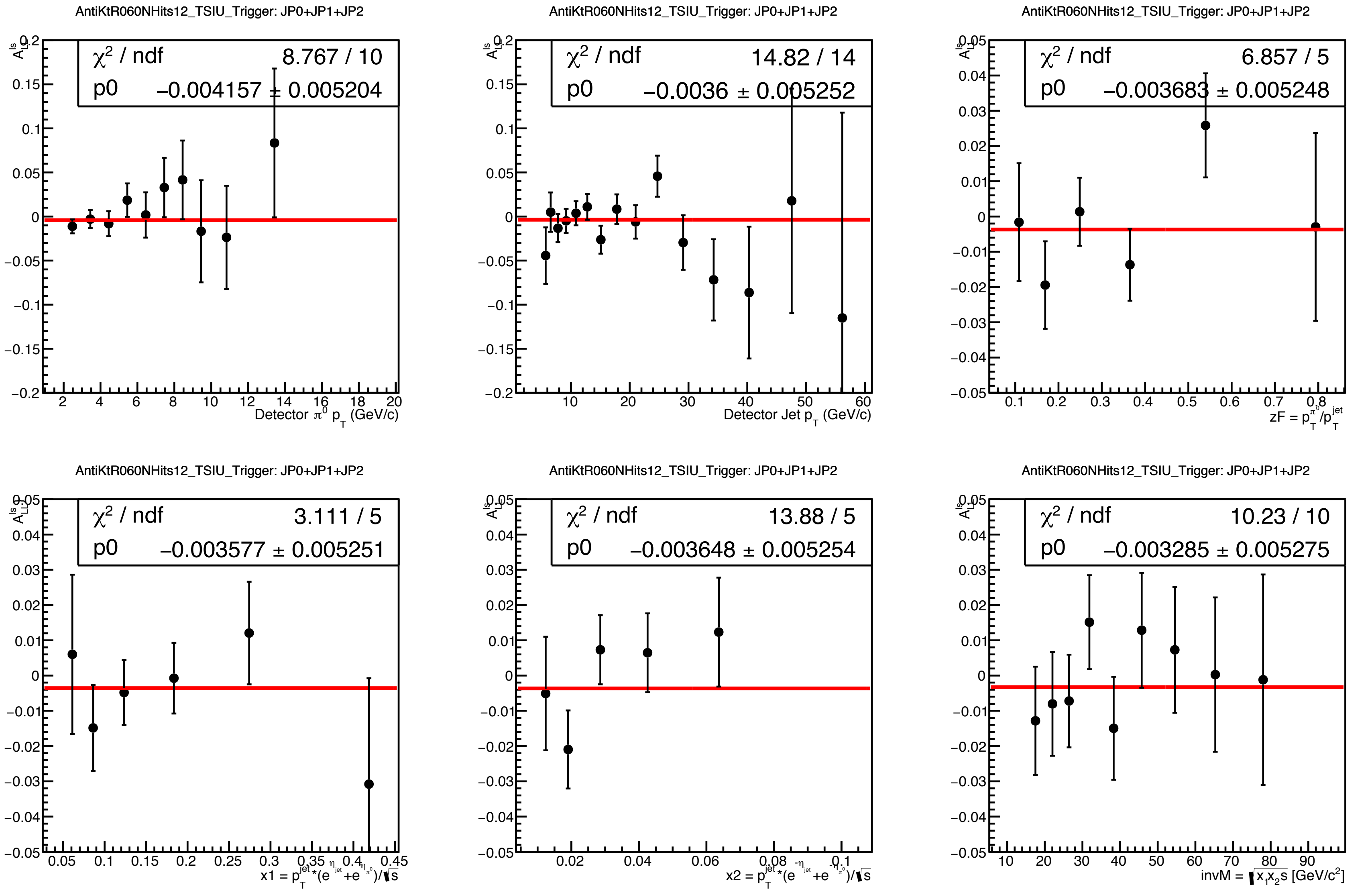






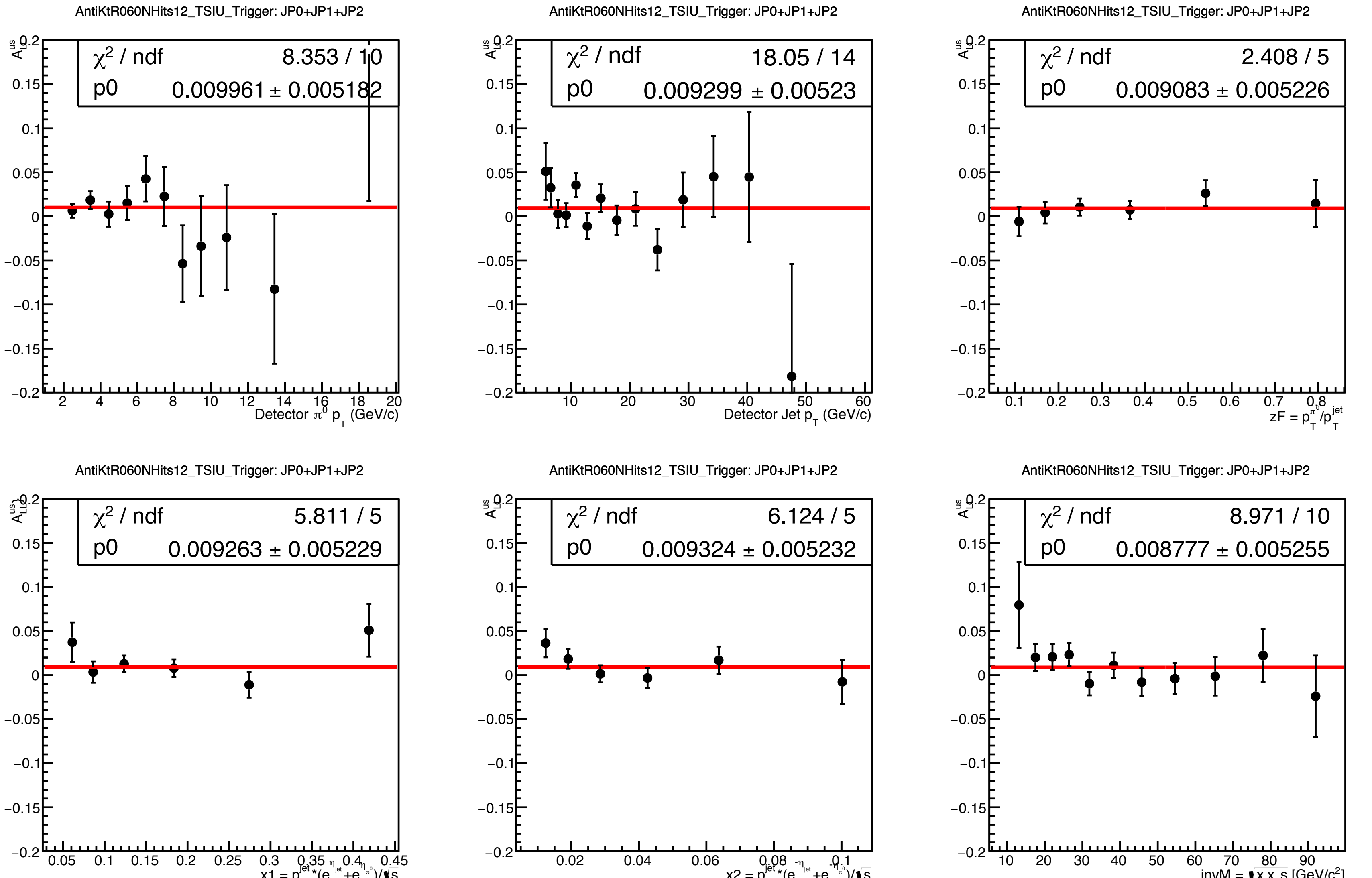
Asymmetry results – False asymmetries

Like-sign asymmetry: combined triggers



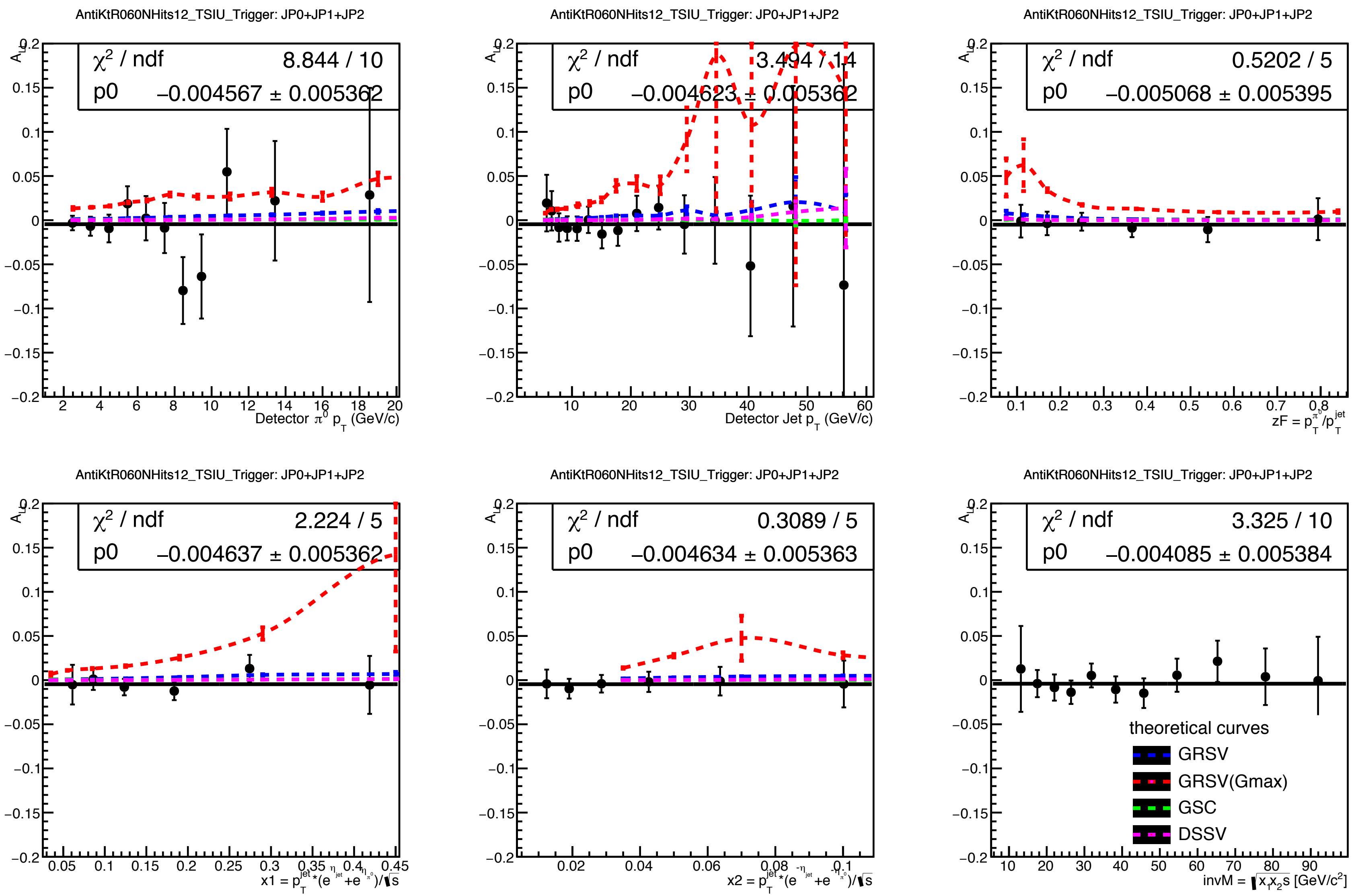
Asymmetry results – False asymmetries

Unlike-sign asymmetry: combined triggers



Asymmetry results – Longitudinal double spin asymmetry

Theoretical A_{LL} curves* are calculated to compare with data:



* Daniel de Florian, Phys. Rev. D79:114014,2009, arXiv:0904.4402v2

Backup Slides

Variable definitions

A_{LL} was measured as a function of jet or π^0 p_T.
To better determine Δg, A_{LL} as a function of x or z are used.

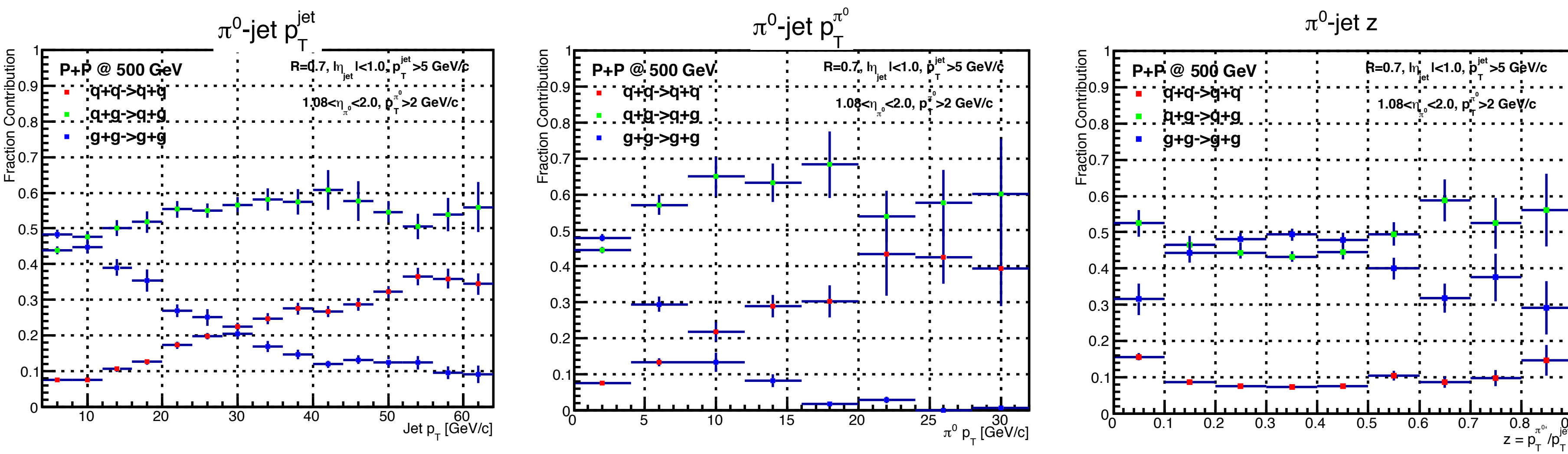
Variable definitions:

$$z = \frac{p_T^{\pi^0}}{p_T^{jet}},$$

$$x_1 = \frac{p_T^{jet}}{\sqrt{s}}\left(e^{\eta_{jet}} + e^{\eta_{\pi^0}}\right), \quad x_2 = \frac{p_T^{jet}}{\sqrt{s}}\left(e^{-\eta_{jet}} + e^{-\eta_{\pi^0}}\right)$$

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

Pythia simulation: sub-process fraction as a function of pT and z:



Variable binning

```
const Int_t nPi0PTbins = 11;
const Double_t mPi0PTbins[nPi0PTbins + 1] = { 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 12.0, 16.0, 25.0};

const Int_t nJetPTbins = 15; // jet pT bin 18% resolutions
const Double_t mJetPTbins[nJetPTbins + 1] = {5.0, 6.0, 7.1, 8.4, 10.0, 11.8, 13.9, 16.4, 19.4, 22.9, 27.0,
31.9, 37.6, 44.4, 52.3, 61.8};

const Int_t nPi0JetMassbins = 11;
const Double_t mPi0JetMassbins[nPi0JetMassbins+1] = {10.0, 14.0, 20.0, 24.0, 29.0, 35.0, 42.0, 50.0,
60.0, 72.0, 86.0, 100.0};

const Int_t nZFbins = 6; // zF 150% resolution
const Double_t mZFbins[nZFbins+1] = { 0.06, 0.135, 0.20, 0.30, 0.45, 0.675, 1.0};

const Int_t nXbins = 6; // x1/x2 150% resolution
const Double_t mX1bins[nXbins+1] = { 0.025, 0.070, 0.100, 0.150, 0.230, 0.35, 0.8};
const Double_t mX2bins[nXbins+1] = { 0.005, 0.015, 0.023, 0.035, 0.053, 0.08, 0.2};
```

Asymmetry results – Asymmetries

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:

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

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