# Updates on Run12 $\pi^0$ – jet $A_{LL}$

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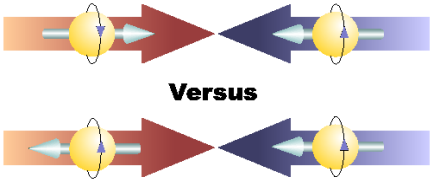


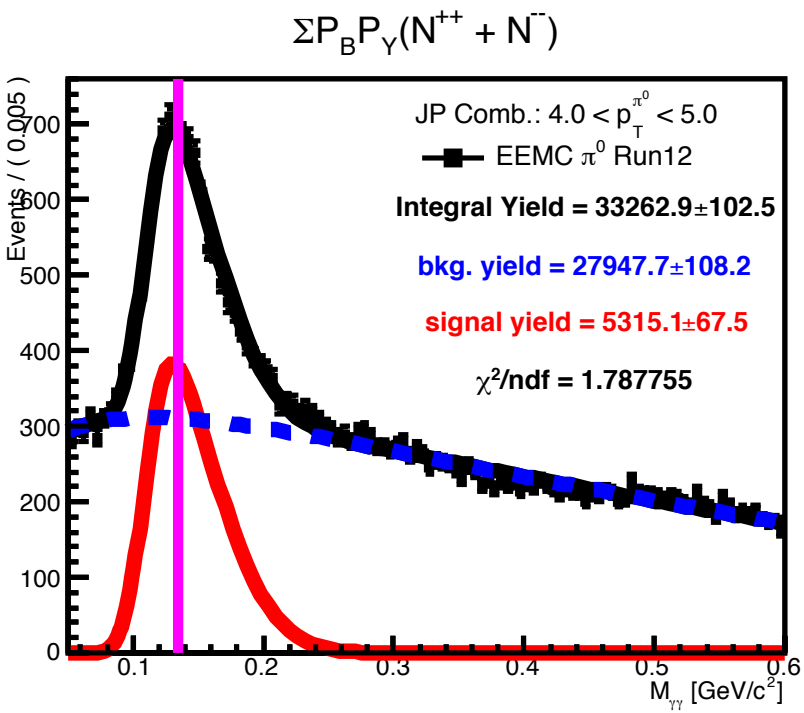
# Outline

- Updates on variable binning
- Updates on signal yield estimation method
- Updated asymmetry results

# Asymmetry Analysis -- Variable re-binning

```
const Double_t mPi0PTbins_rebin[8]={ 4.0, 5.0, 6.0, 8.0, 10.0, 12.0, 16.0, 36.0};

const Double_t mJetPTbins_rebin[8] = {7.1, 9.9, 13.8, 19.2, 26.8, 37.3, 51.9, 100.0};

const Double_t mPi0JetMassbins_rebin[7] = {17.0, 24.0, 35.0, 50.0, 72.0, 100.0, 200.0};

const Double_t mX1bins_rebin[6] = { 0.07, 0.10, 0.15, 0.23, 0.35, 0.53};

const Double_t mX2bins_rebin[6] = { 0.01, 0.02, 0.04, 0.06, 0.12, 0.24};
```

# Asymmetry Analysis – Signal yield estimation 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.

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

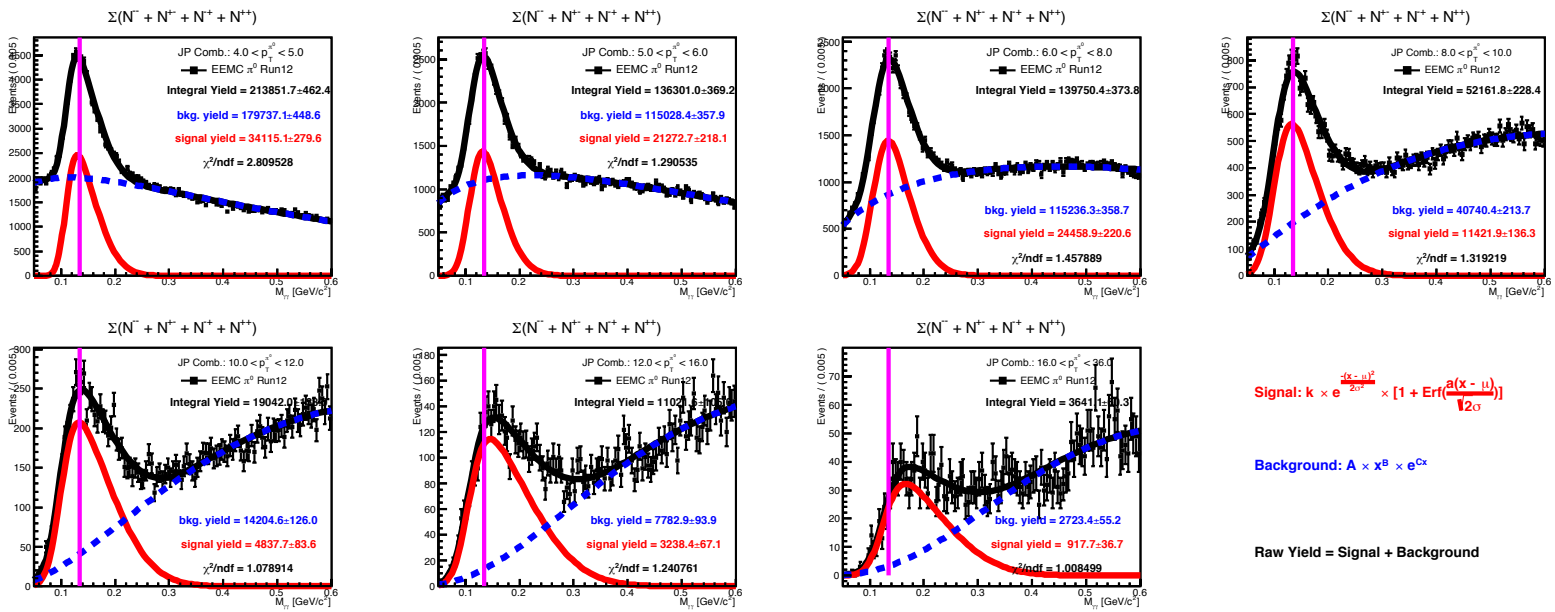
$$bkg(x):\ A \times x^B \times e^{Cx}$$

$$model(x) = \frac{n_{sig}}{n_{sig} + n_{bkg}} * sig(x) + \frac{n_{bkg}}{n_{sig} + n_{bkg}} * bkg(x)$$

$$n_{raw} * model(x) = n_{sig} * sig(x) + n_{bkg} * bkg(x)$$

- The **raw yield** ($n_{raw}$)of $\pi^0$-jet are well fitted by *model(x)*, in which the signal shape was described by **skewed Gaussian function** *sig(x)*, and background shape was fitted by **Gamma function** *bkg(x)*;
- The shapes of *sig(x)* and *bkg(x)* were determined by fitting the spectrum summed over spin states.
- ***Signal yield*** **($n_{sig}$)** and **background yield ($n_{bkg}$)** are estimated by fitting over [0.05, 0.6] GeV/c$^2$ with the fixed *sig(x)* and *bkg(x)* shapes, according $n_{raw} * model(x) = n_{sig} * sig(x) + n_{bkg} * bkg(x)$
- Signal (background) asymmetries, $A_{LL}^S$ ($A_{LL}^B$), are calculated by the fitted yields $n_{sig}$ ($n_{bkg}$).

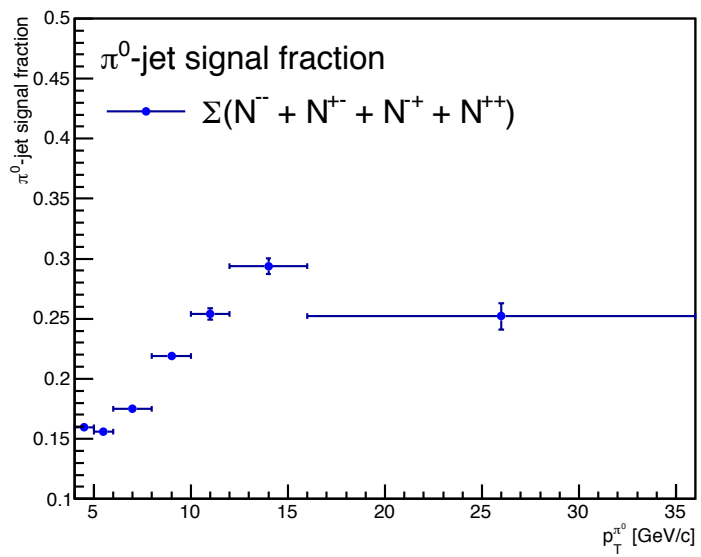
# Asymmetry Analysis – determine *sig(x)* & bkg(x) shapes for $\pi^0$ $p_T$ bins

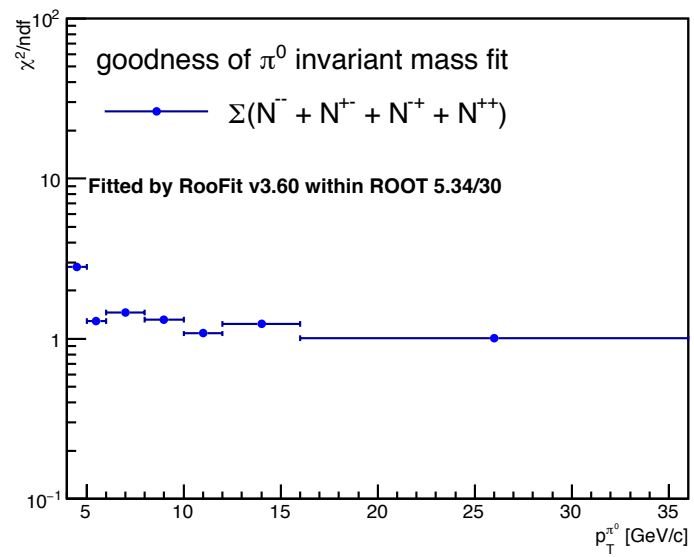



Signal: $k \times e^{\frac{-(x-\mu)^2}{2\sigma^2}} \times [1 + \mathrm{Erf}(\frac{a(x-\mu)}{\sqrt{2}\sigma})]$

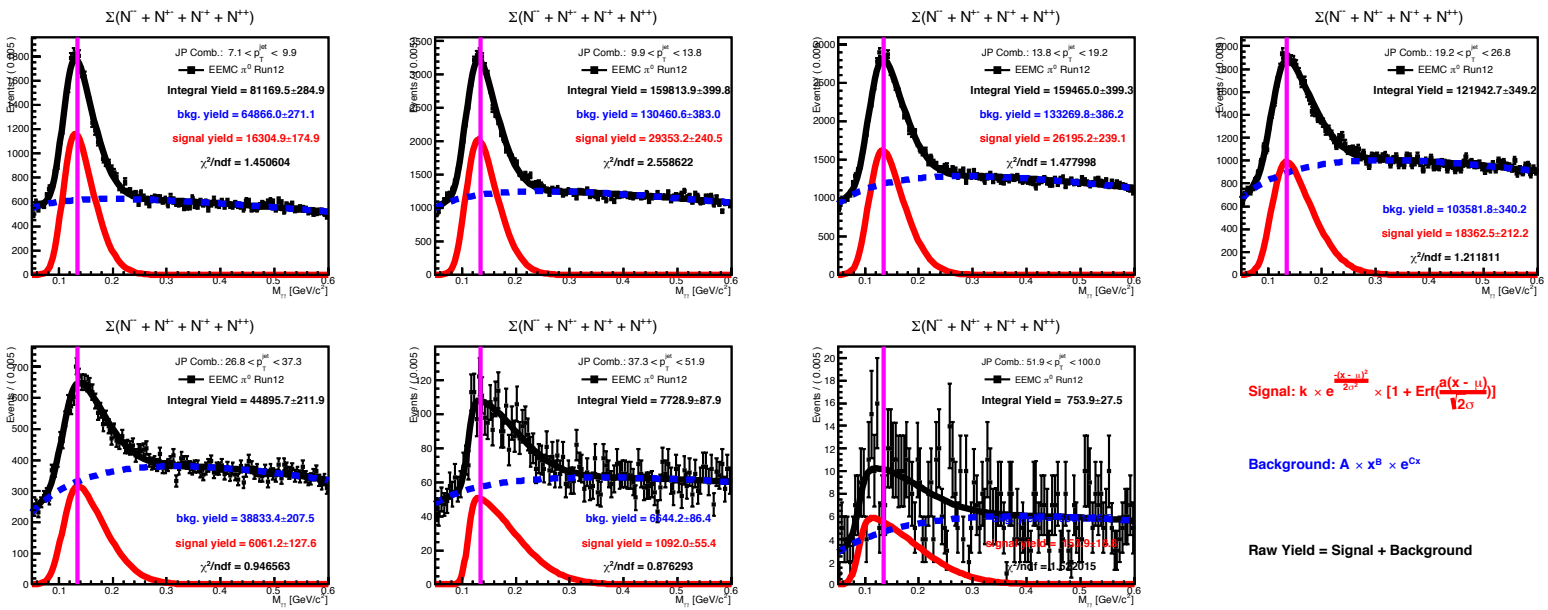
Background: $A \times x^B \times e^{Cx}$

Raw Yield = Signal + Background



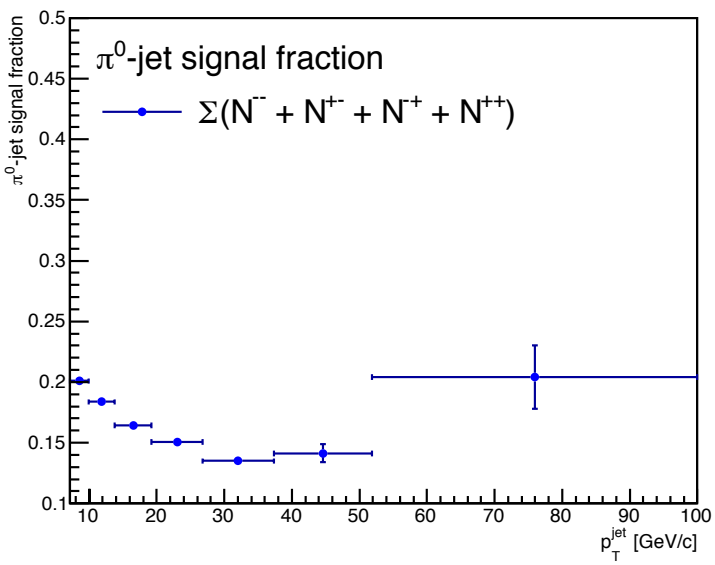
# Asymmetry Analysis – determine *sig(x)* & bkg(x) shapes for jet $p_T$ bins

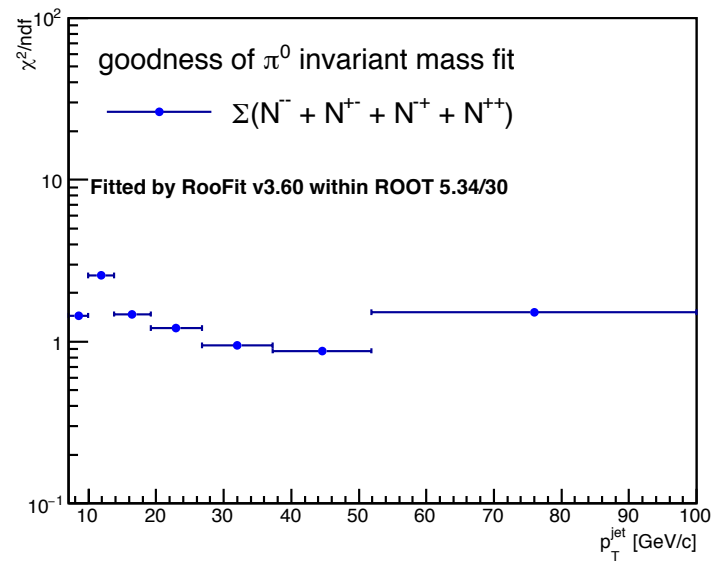



**Signal:** $k \times e^{\frac{-(x-\mu)^2}{2\sigma^2}} \times [1 + \mathrm{Erf}(\frac{a(x-\mu)}{\sqrt{2}\sigma})]$

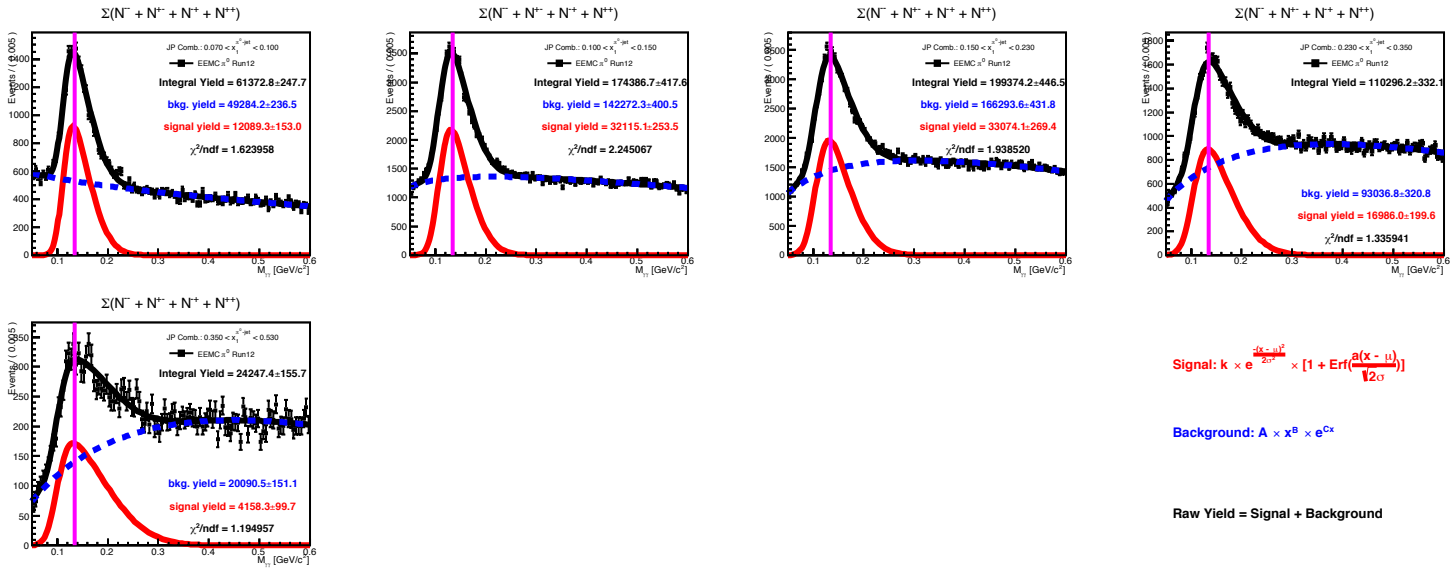
**Background:** $A \times x^B \times e^{Cx}$

**Raw Yield = Signal + Background**



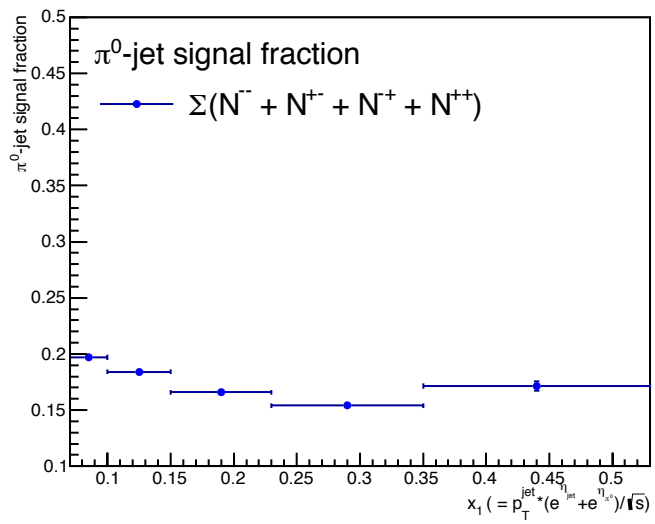
# Asymmetry Analysis – determine *sig(x)* & bkg(x) shapes for $x_1$ bins

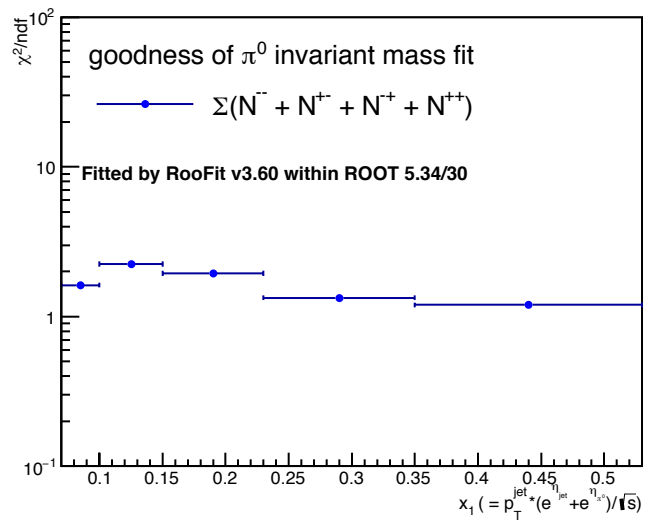



Signal: $k \times e^{\frac{-(x-\mu)^2}{2\sigma^2}} \times [1 + \mathrm{Erf}(\frac{a(x-\mu)}{\sqrt{2}\sigma})]$

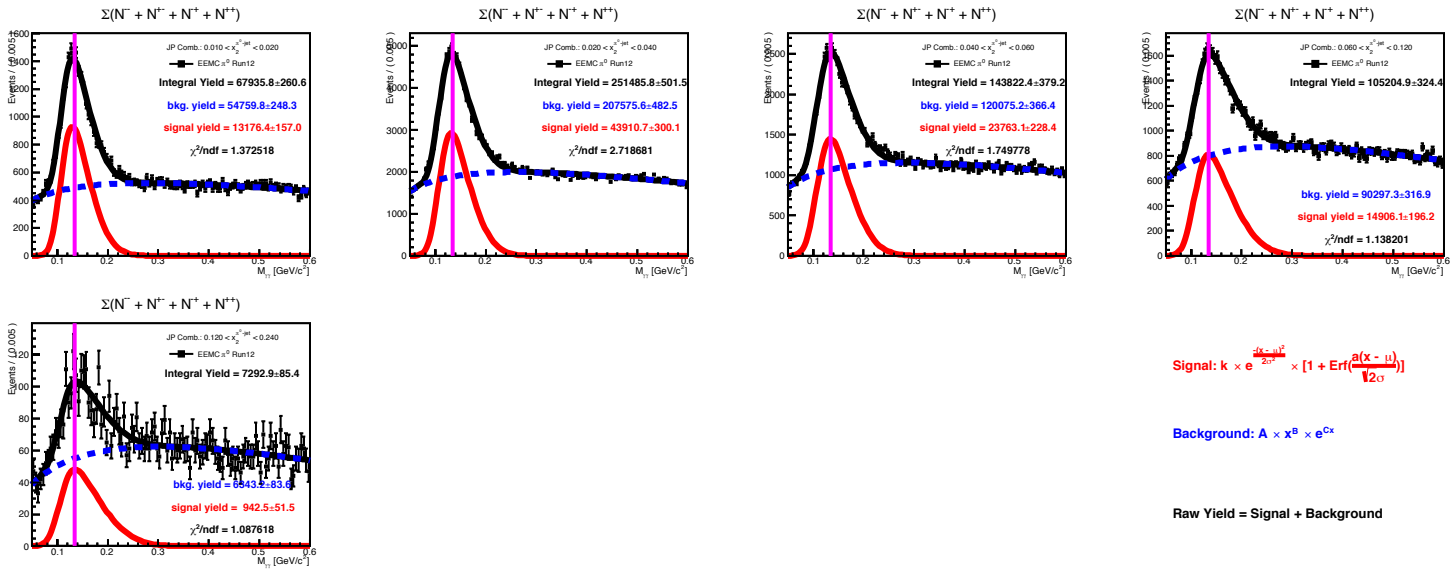
Background: $A \times x^B \times e^{Cx}$

Raw Yield = Signal + Background



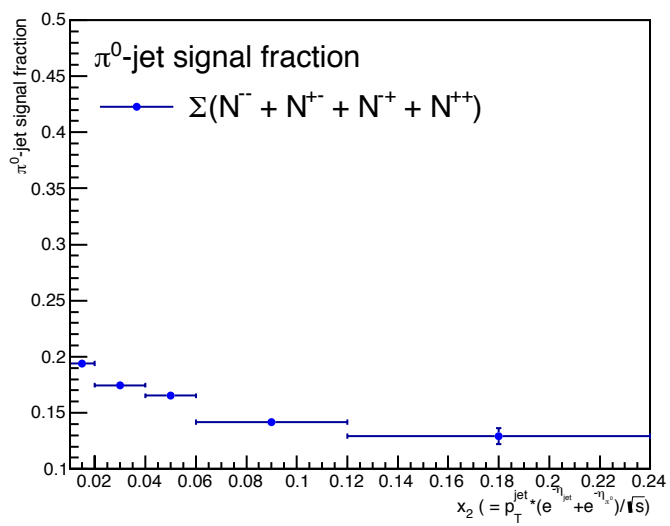
# Asymmetry Analysis – determine *sig(x)* & bkg(x) shapes for $x_2$ bins

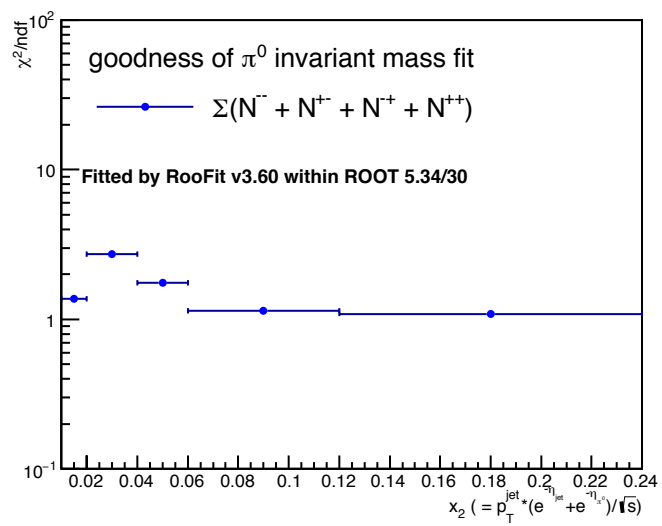



Signal: $k \times e^{\frac{-(x-\mu)^2}{2\sigma^2}} \times [1 + \mathrm{Erf}(\frac{a(x-\mu)}{\sqrt{2}\sigma})]$

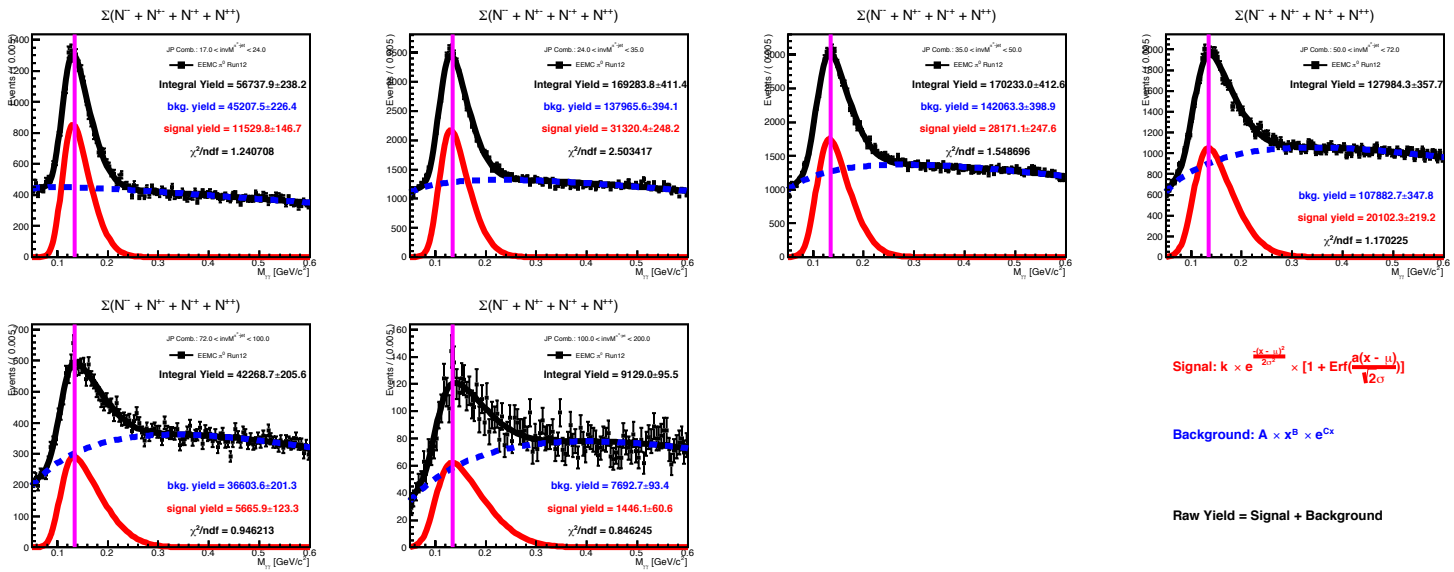
Background: $A \times x^B \times e^{Cx}$

Raw Yield = Signal + Background



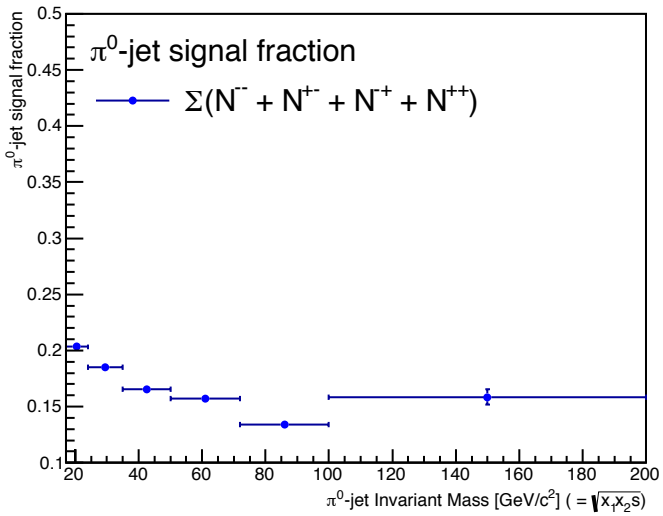
# Asymmetry Analysis – determine *sig(x)* & bkg(x) shapes for *inv. mass* bins

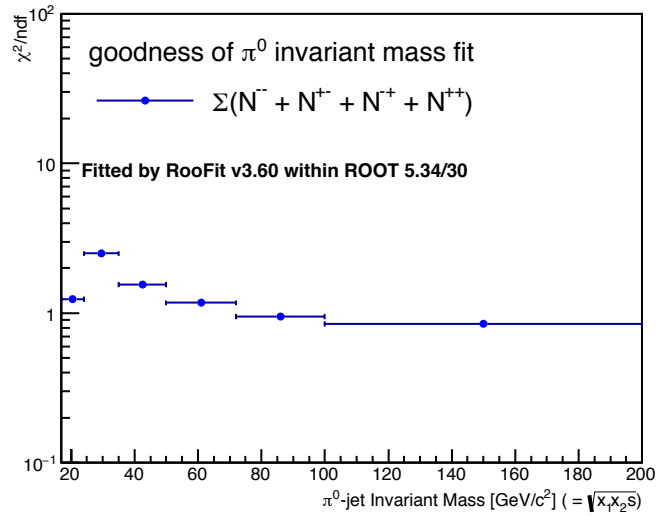



Signal: $k \times e^{\frac{-(x-\mu)^2}{2\sigma^2}} \times [1 + \mathrm{Erf}(\frac{a(x-\mu)}{\sqrt{2}\sigma})]$

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

Raw Yield = Signal + Background

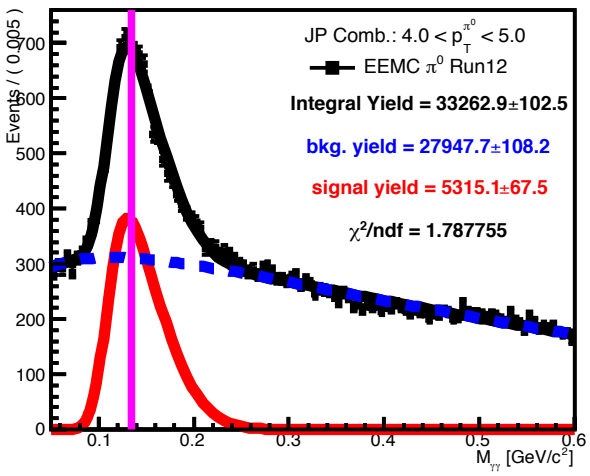


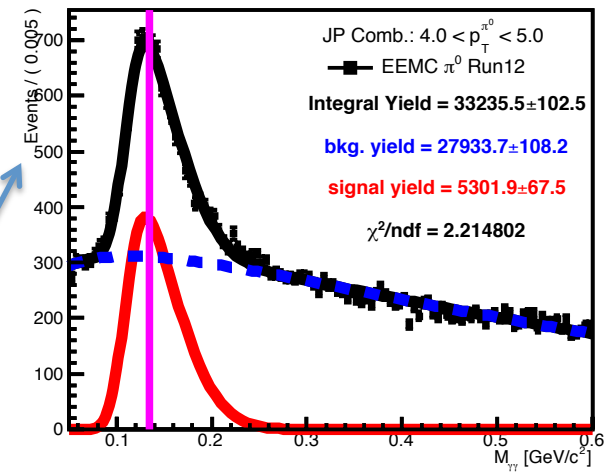
# Asymmetry Analysis – Calculate the signal asymmetry $A_{LL}$

- $n_{sig}$ and $n_{bkg}$ were estimated by fitting for all kinds of weighted spin state combinations and variable bins (eg. ).

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

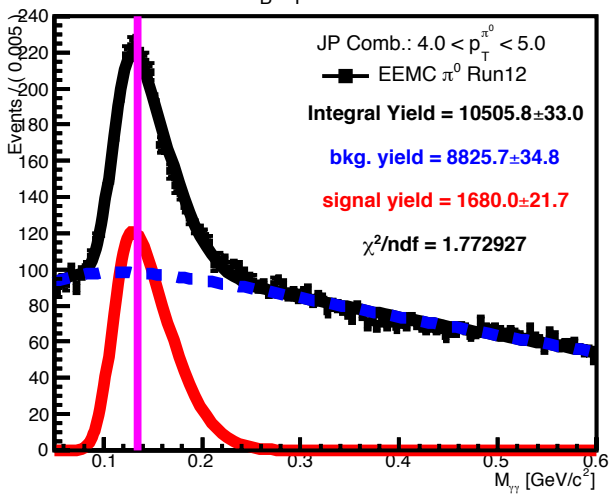



$\Sigma P_B P_Y R_3 (N^{+-} + N^{-+})$

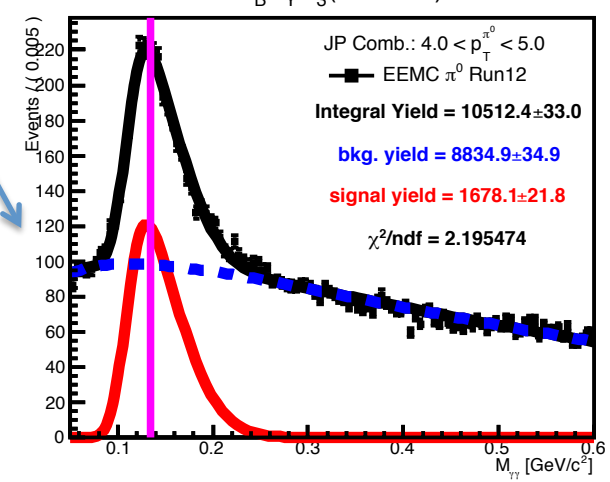



$$A_{LL} = \frac{\sum P_Y P_B [(N^{++} + N^{--}) - R_3 (N^{+-} + N^{-+})]}{\sum P_Y^2 P_B^2 [(N^{++} + N^{--}) + R_3 (N^{+-} + N^{-+})]}$$

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

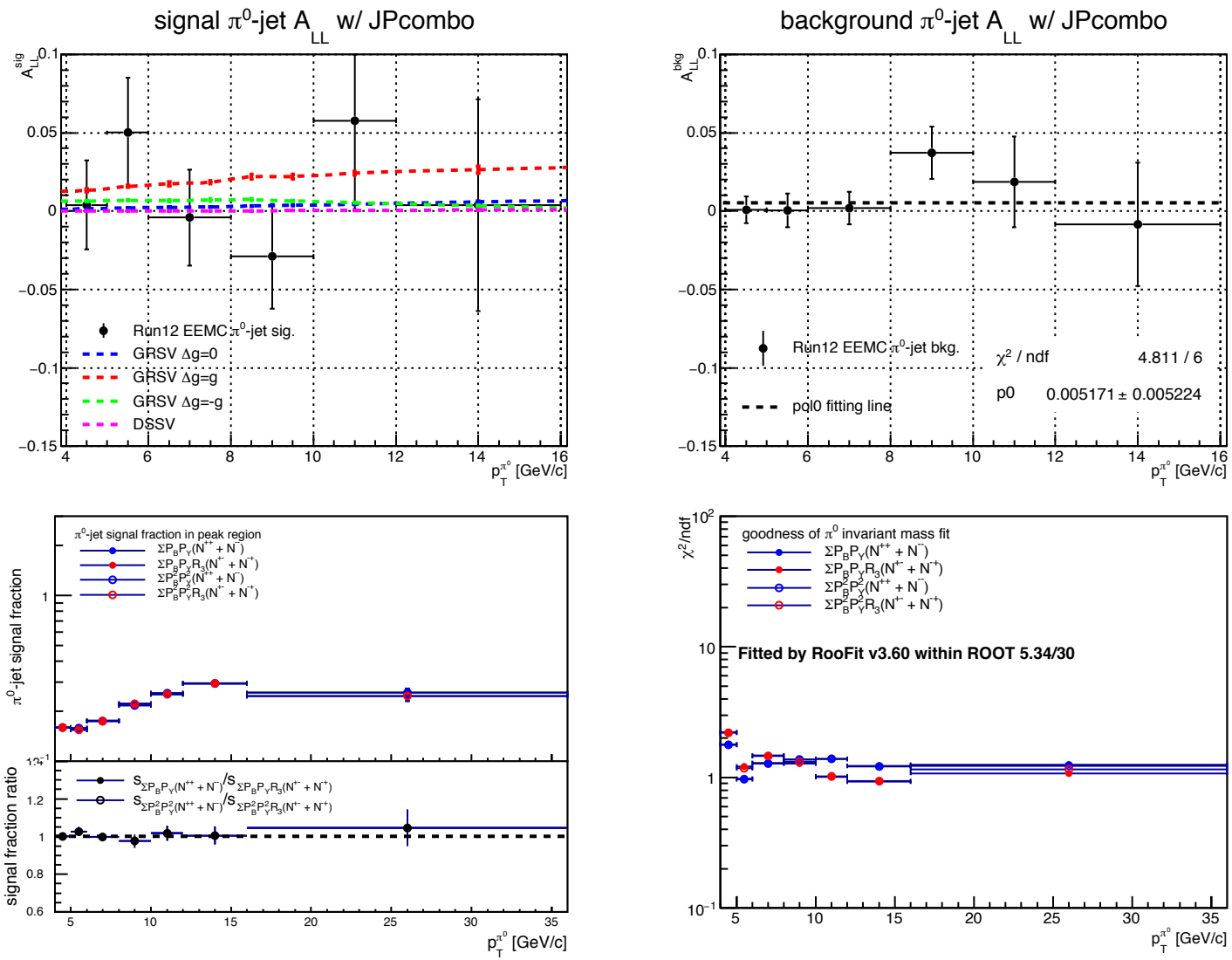



$\Sigma P_B^2 P_Y^2 R_3 (N^{+-} + N^{-+})$



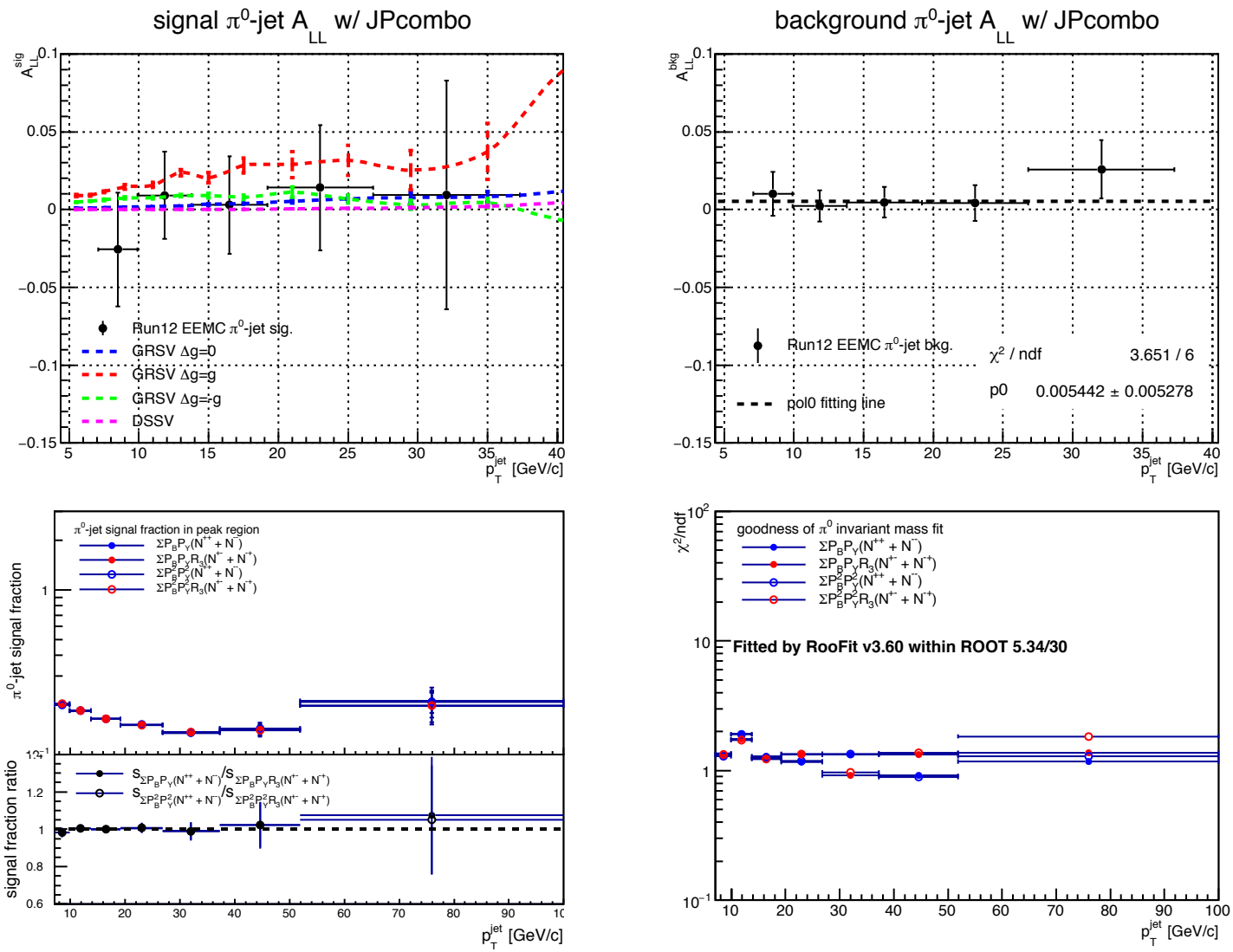
# Asymmetry Results -- Updated longitudinal double asymmetry, $A_{LL}$

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



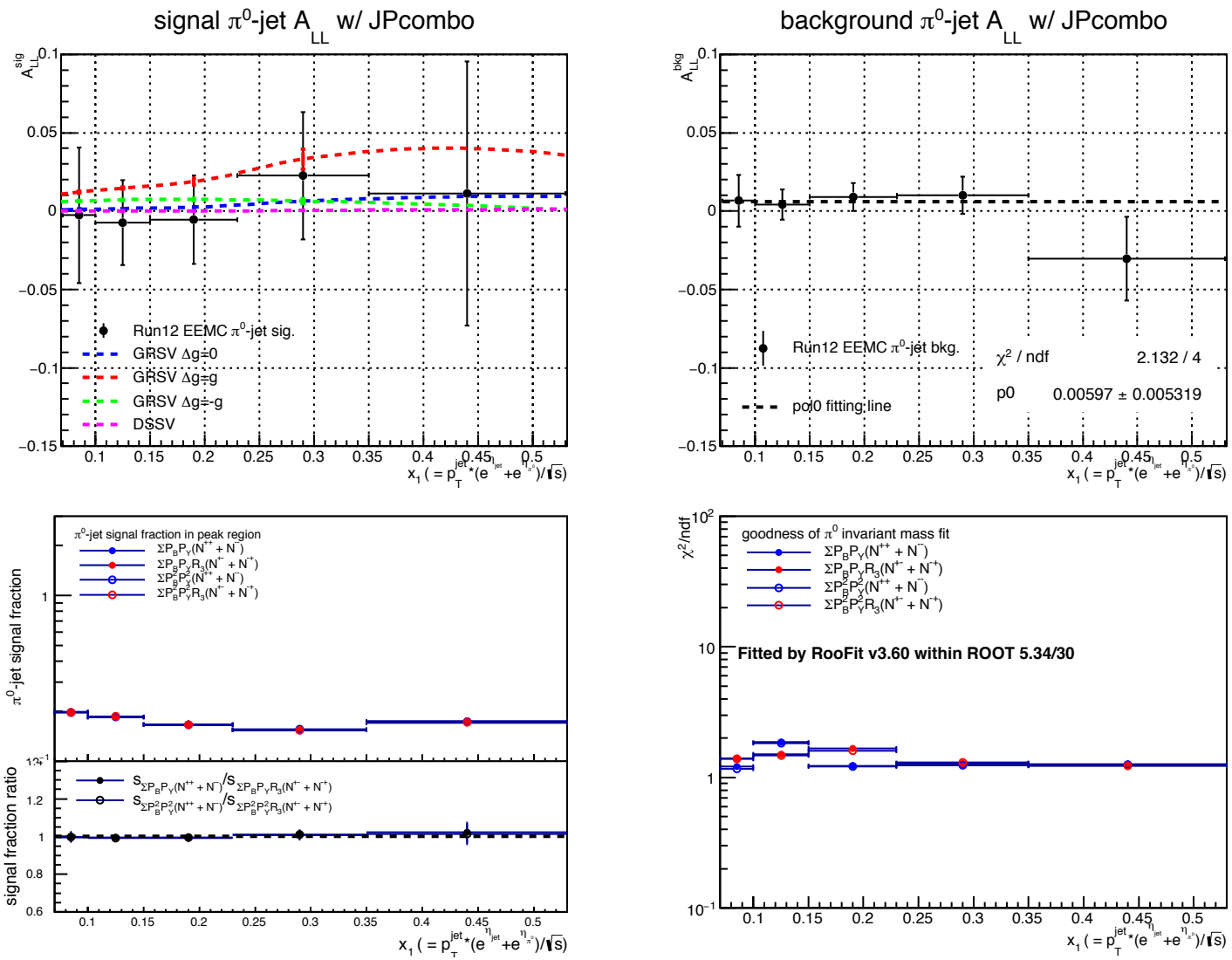
# Asymmetry Results -- Updated longitudinal double asymmetry, $A_{LL}$

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



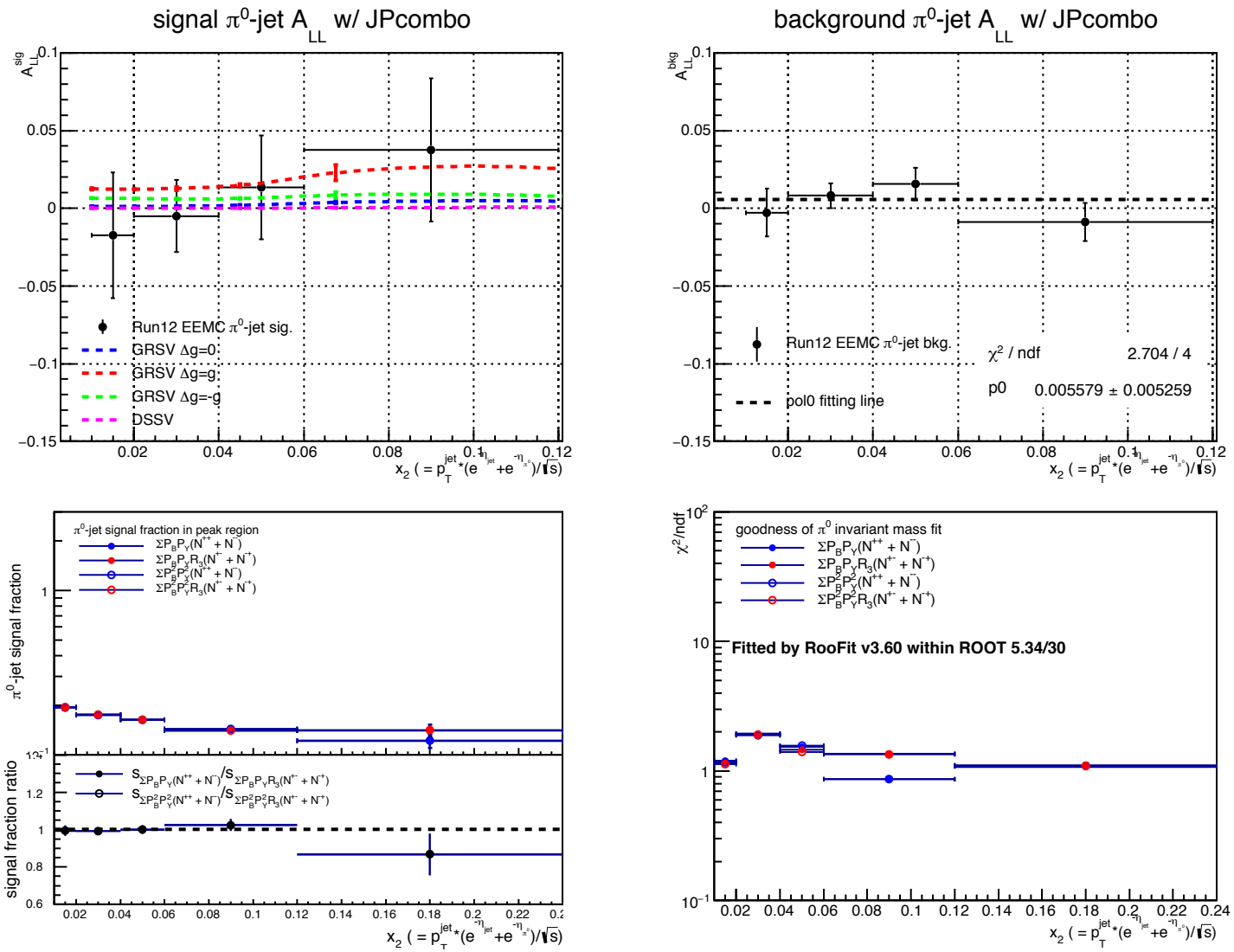
# Asymmetry Results -- Updated longitudinal double asymmetry, $A_{LL}$

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



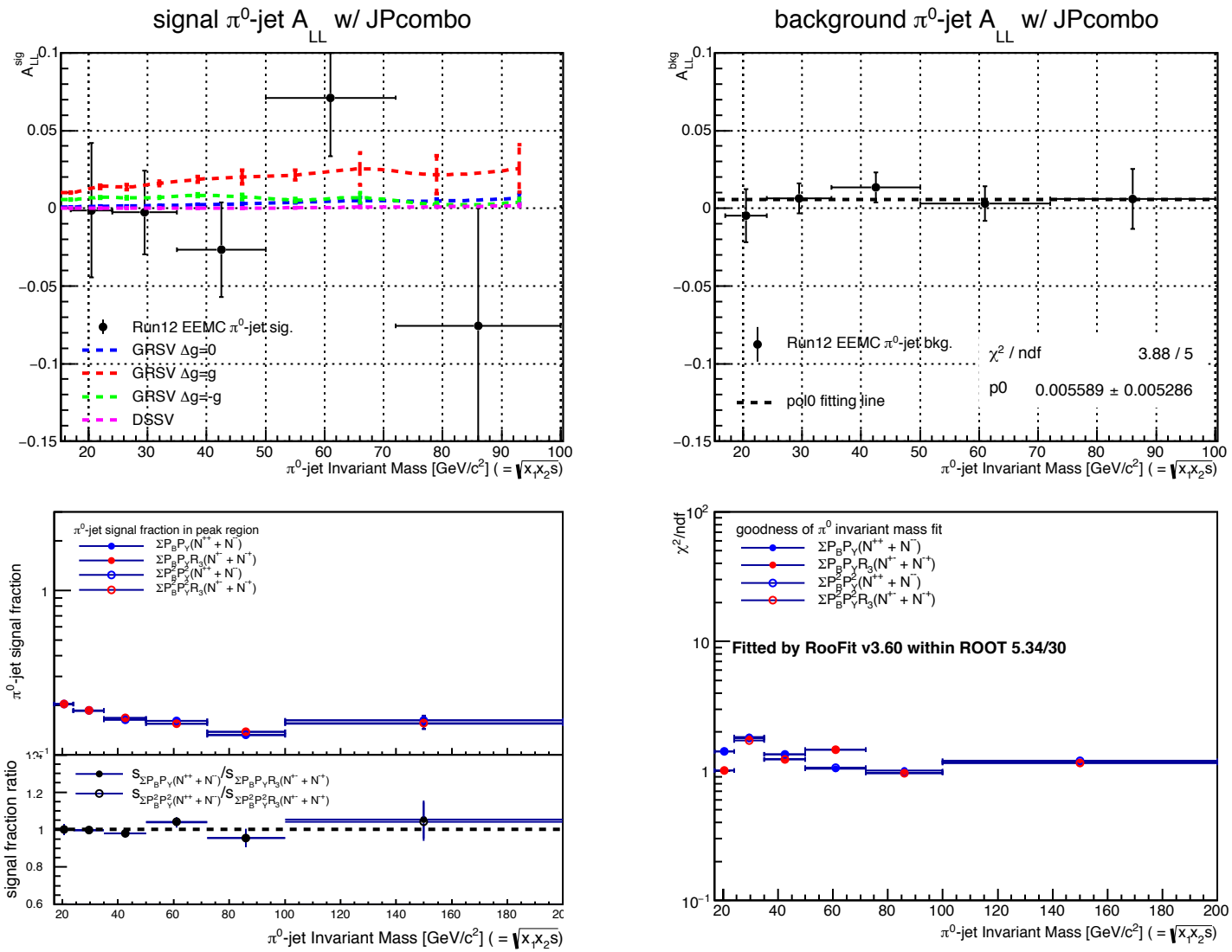
# Asymmetry Results -- Updated longitudinal double asymmetry, $A_{LL}$

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



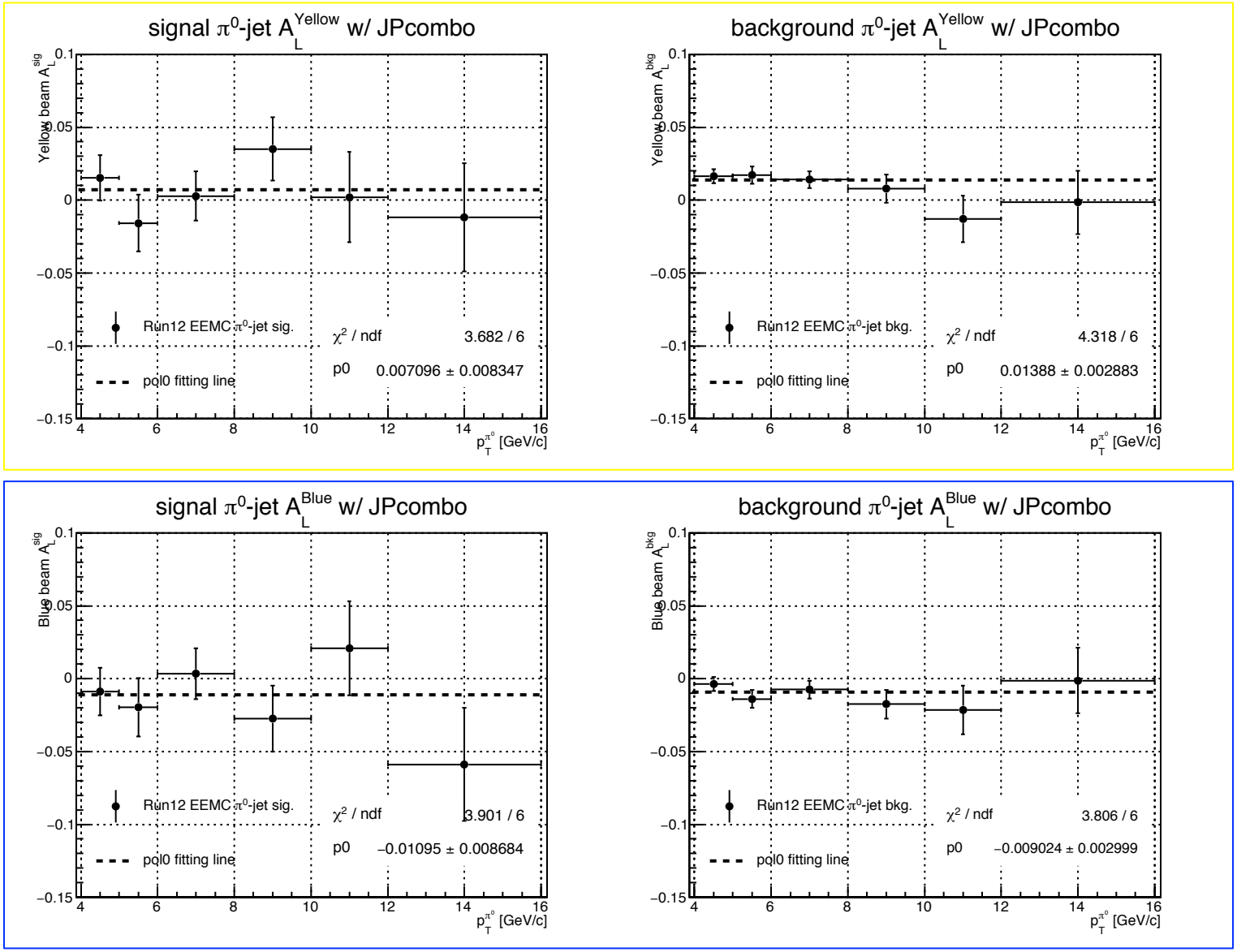
# Asymmetry Results -- Updated longitudinal double asymmetry, $A_{LL}$

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



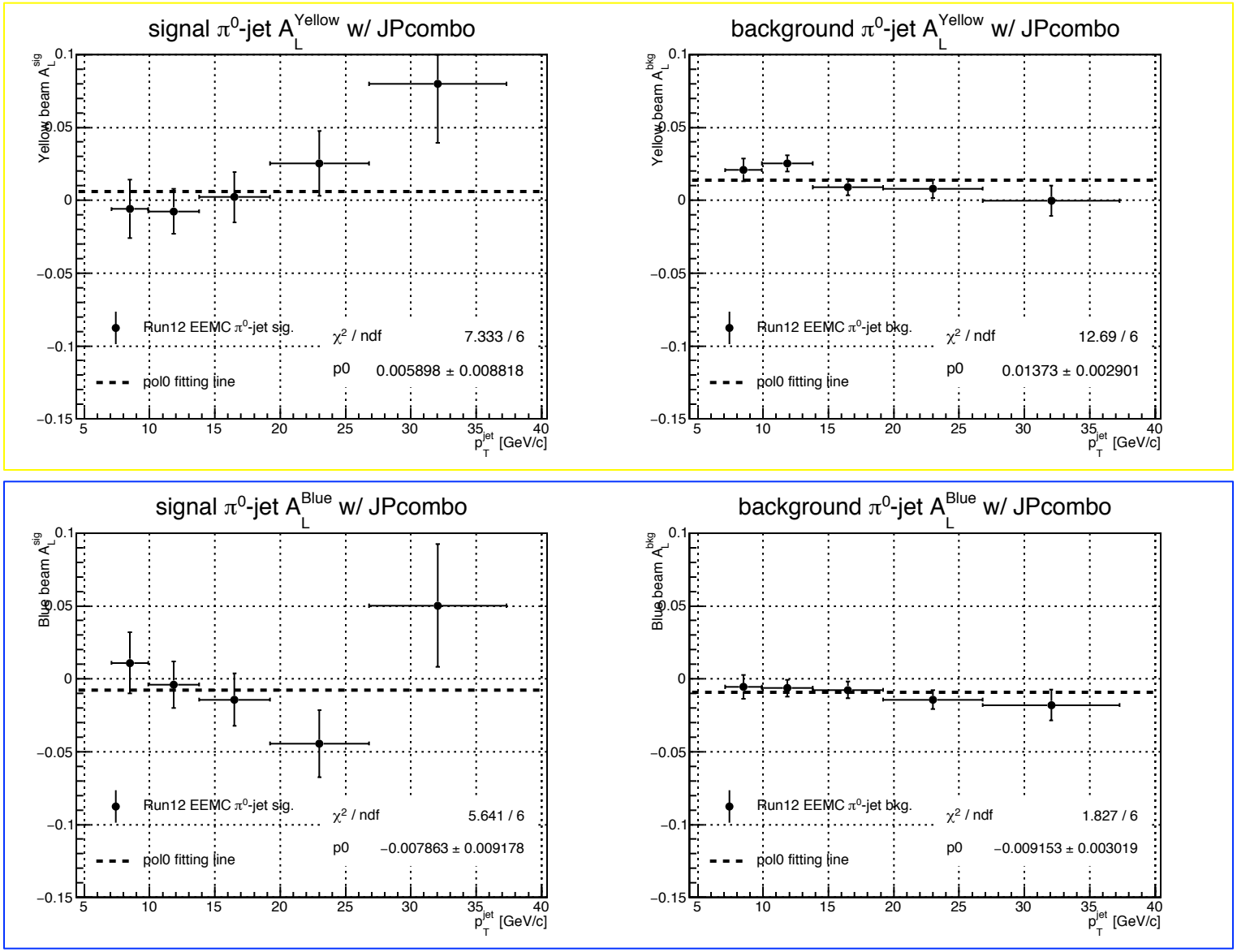
# Asymmetry Results – Updated single asymmetries, $A_L^Y$, $A_L^B$

$\pi^0$ $p_T$ bins



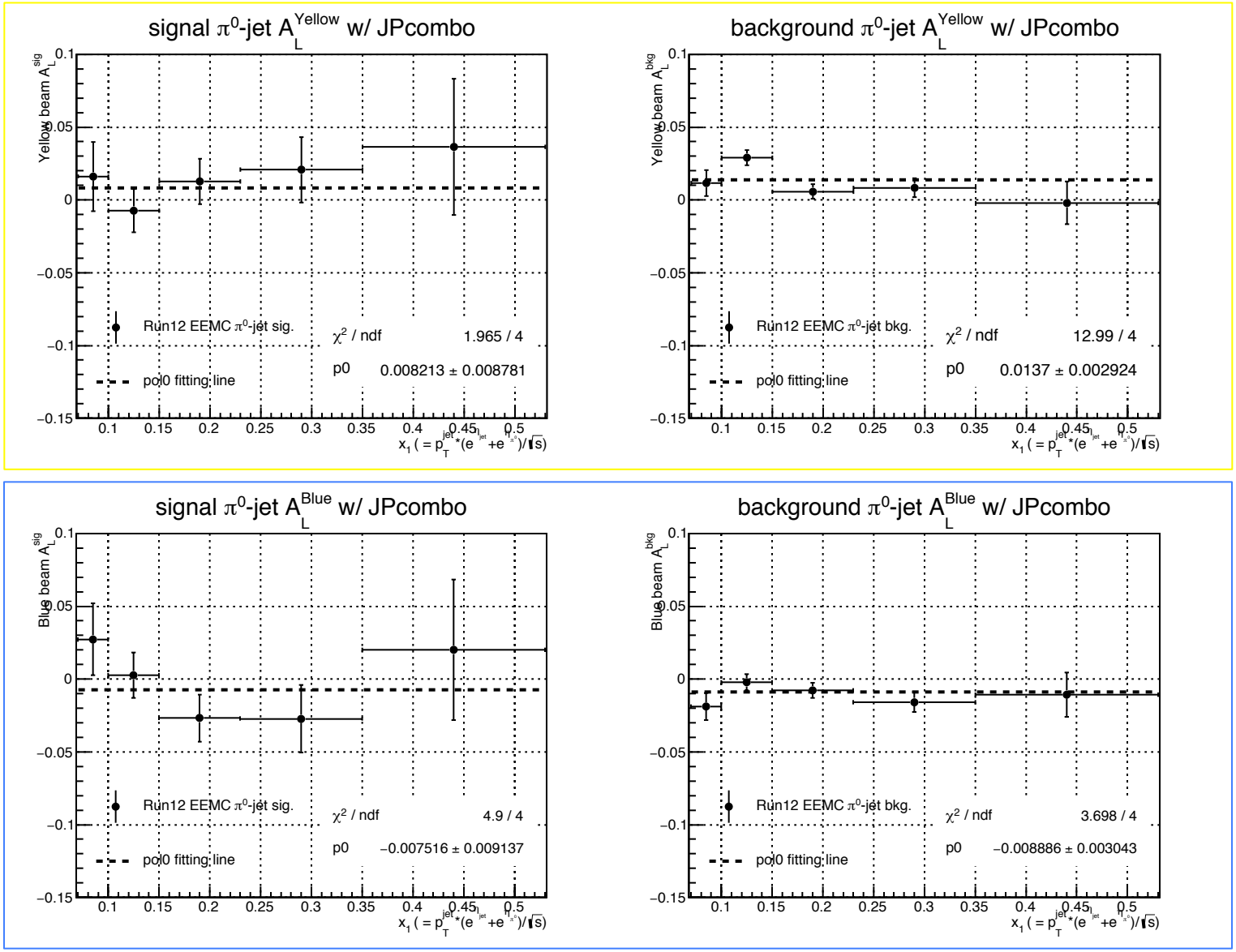
# Asymmetry Results – Updated single asymmetries, $A_L^Y$, $A_L^B$

jet $p_T$ bins



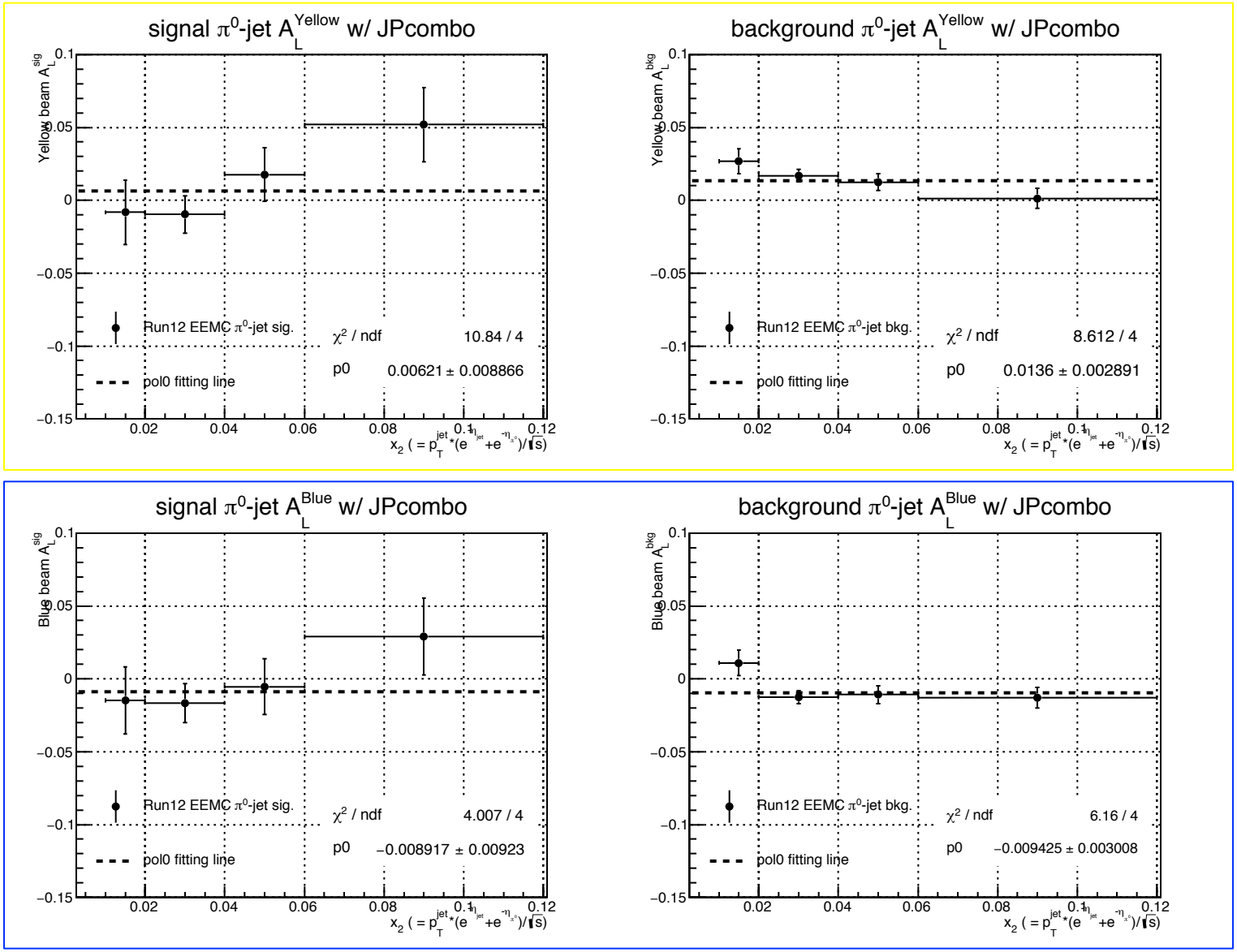
# Asymmetry Results – Updated single asymmetries, $A_L^Y$, $A_L^B$

$x_1$ bins



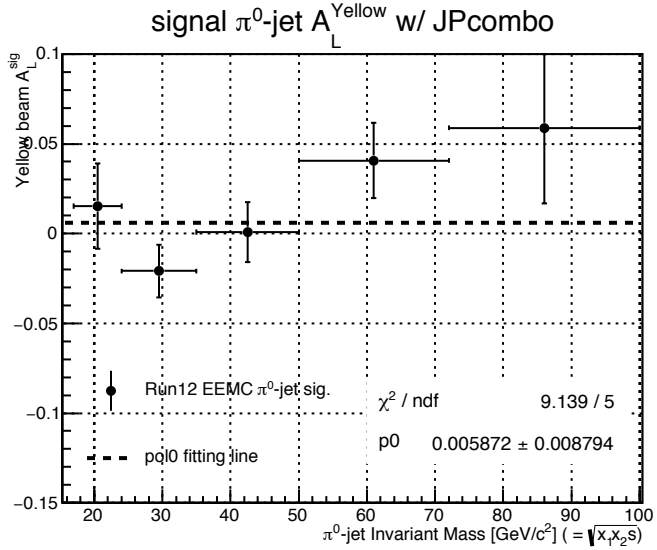
# Asymmetry Results – Updated single asymmetries, $A_L^Y$, $A_L^B$

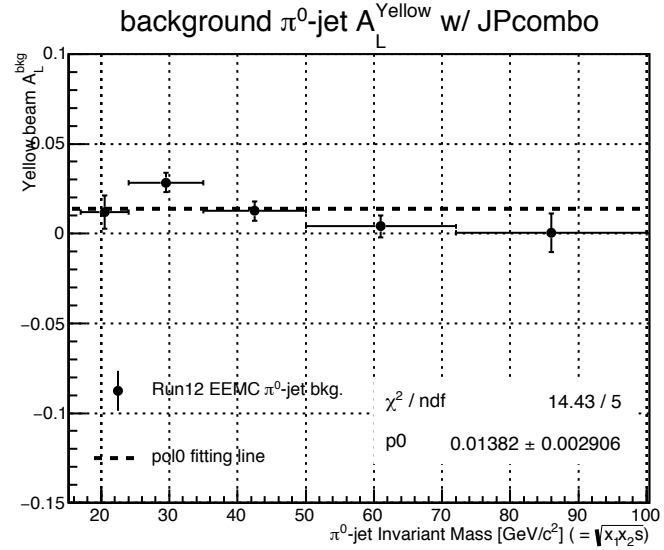
$x_2$ bins

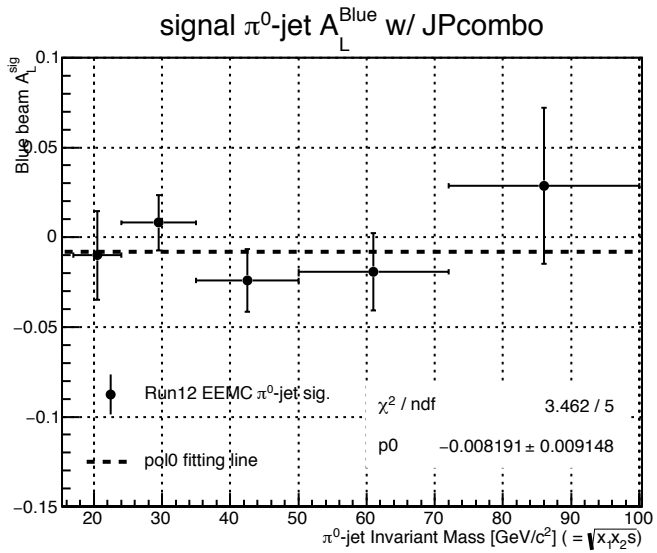


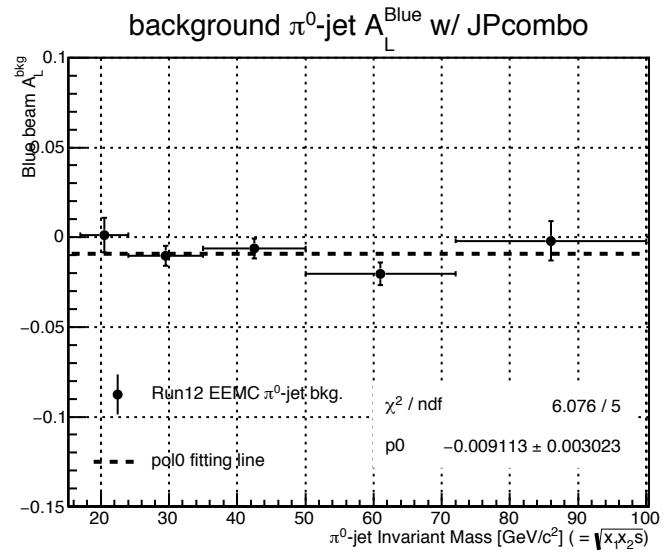
# Asymmetry Results – Updated single asymmetries, $A_L^Y$, $A_L^B$

inv. mass bins

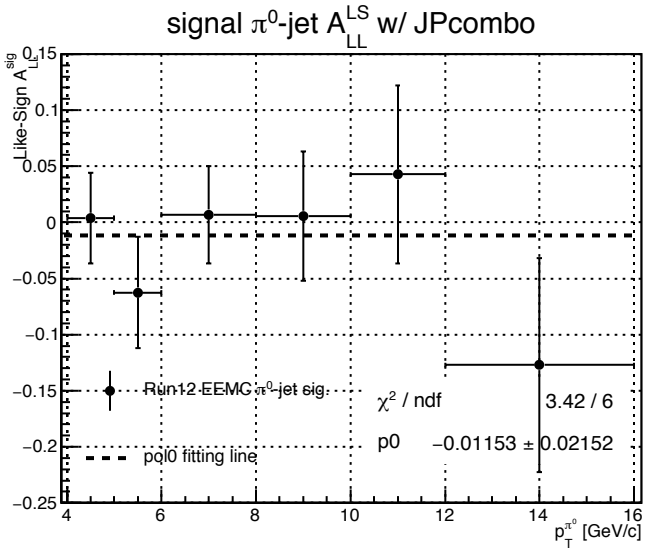


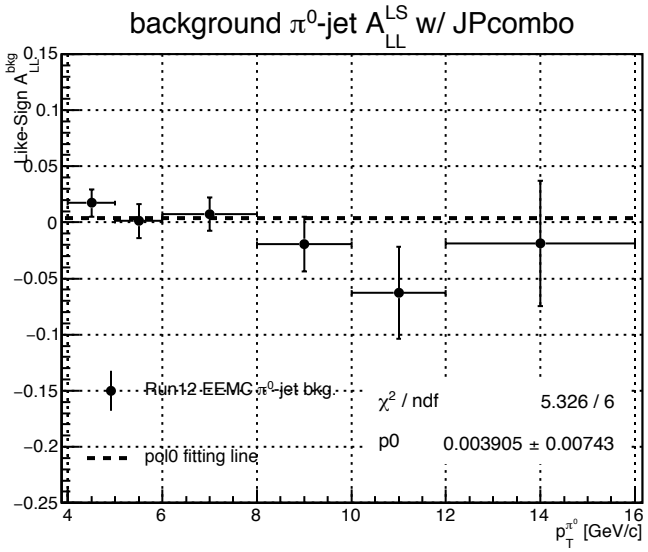



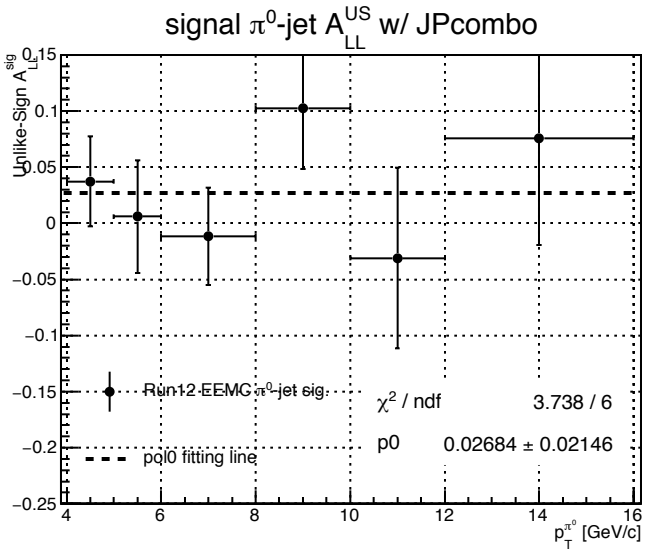



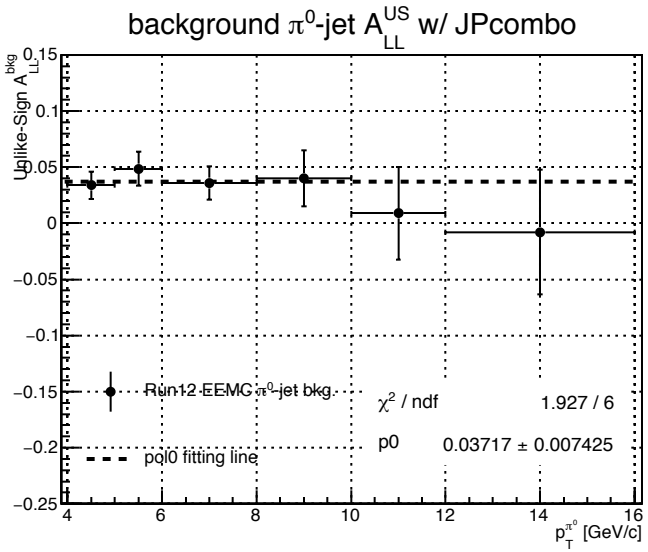



# Asymmetry Results – Updated false asymmetries, $A_{LL}^{LS}$, $A_{LL}^{US}$ $\pi^0$ $p_T$ bins



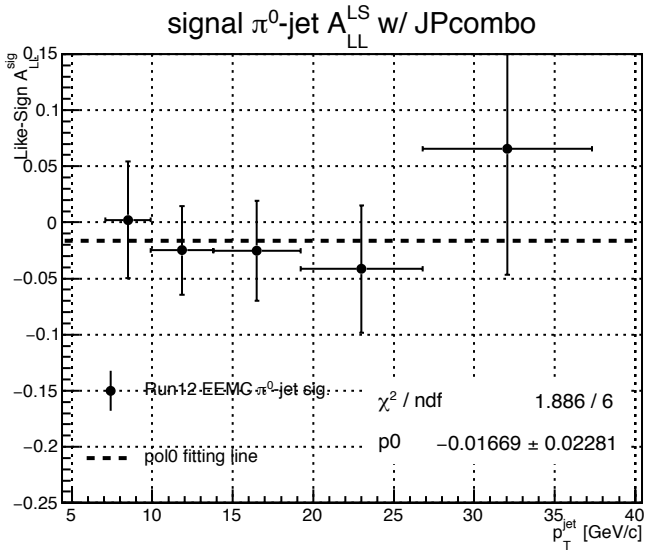



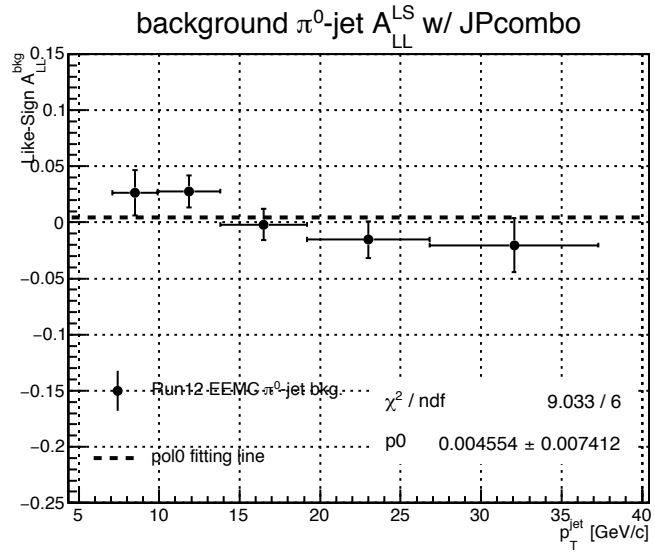



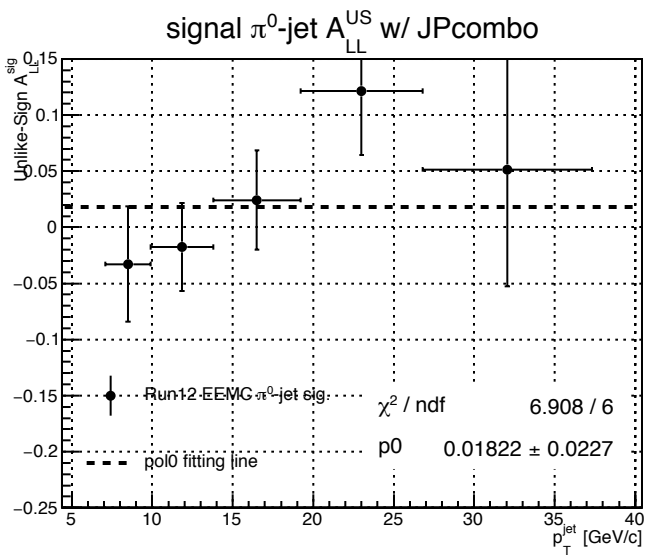



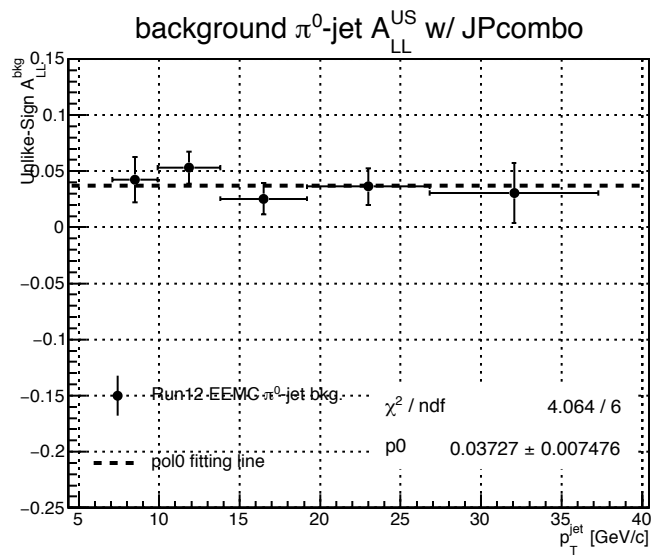
# Asymmetry Results – Updated false asymmetries, $A_{LL}^{LS}$, $A_{LL}^{US}$

jet $p_T$ bins



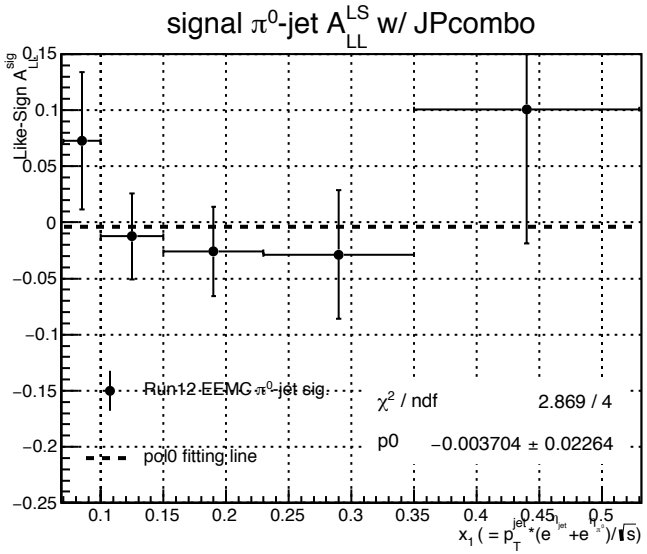



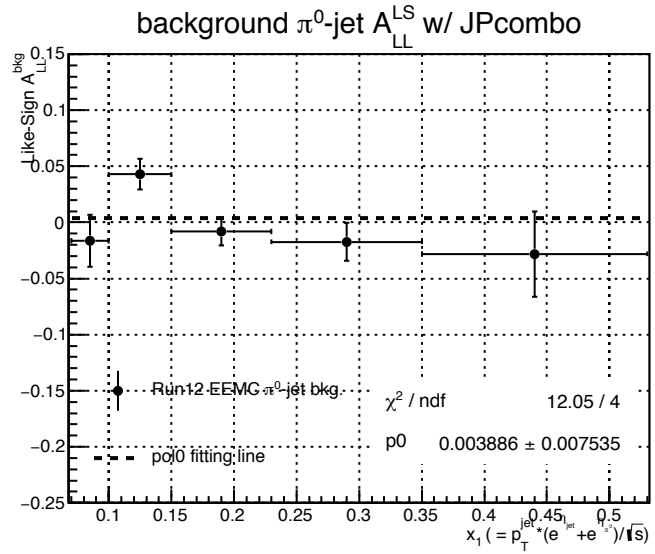



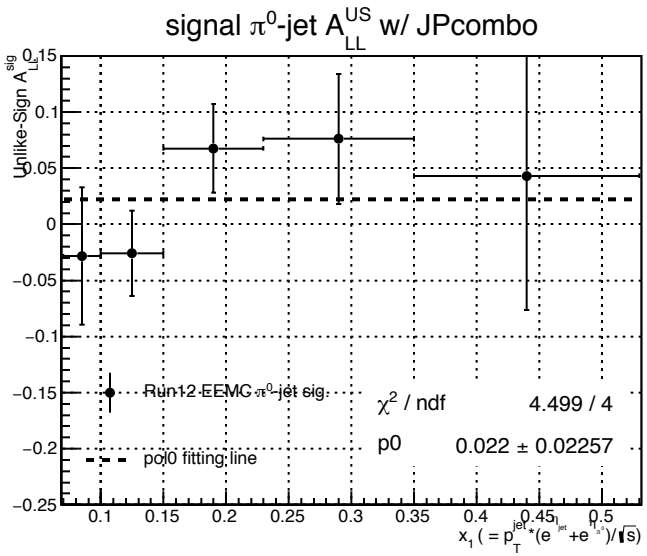



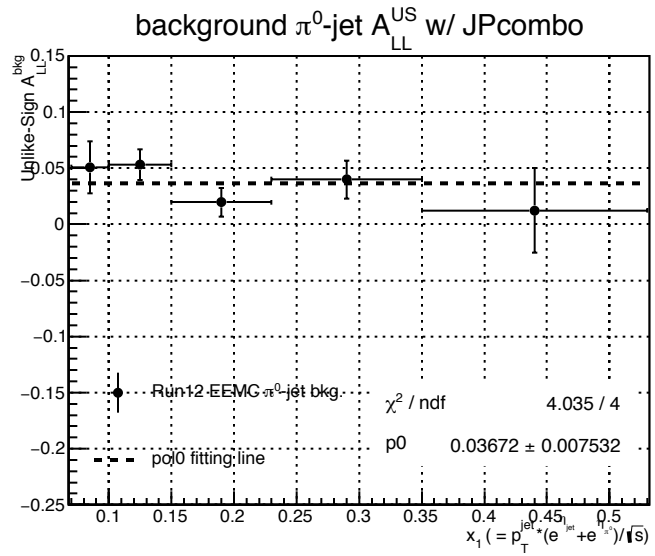
# Asymmetry Results – Updated false asymmetries, $A_{LL}^{LS}$, $A_{LL}^{US}$

$x_1$ bins



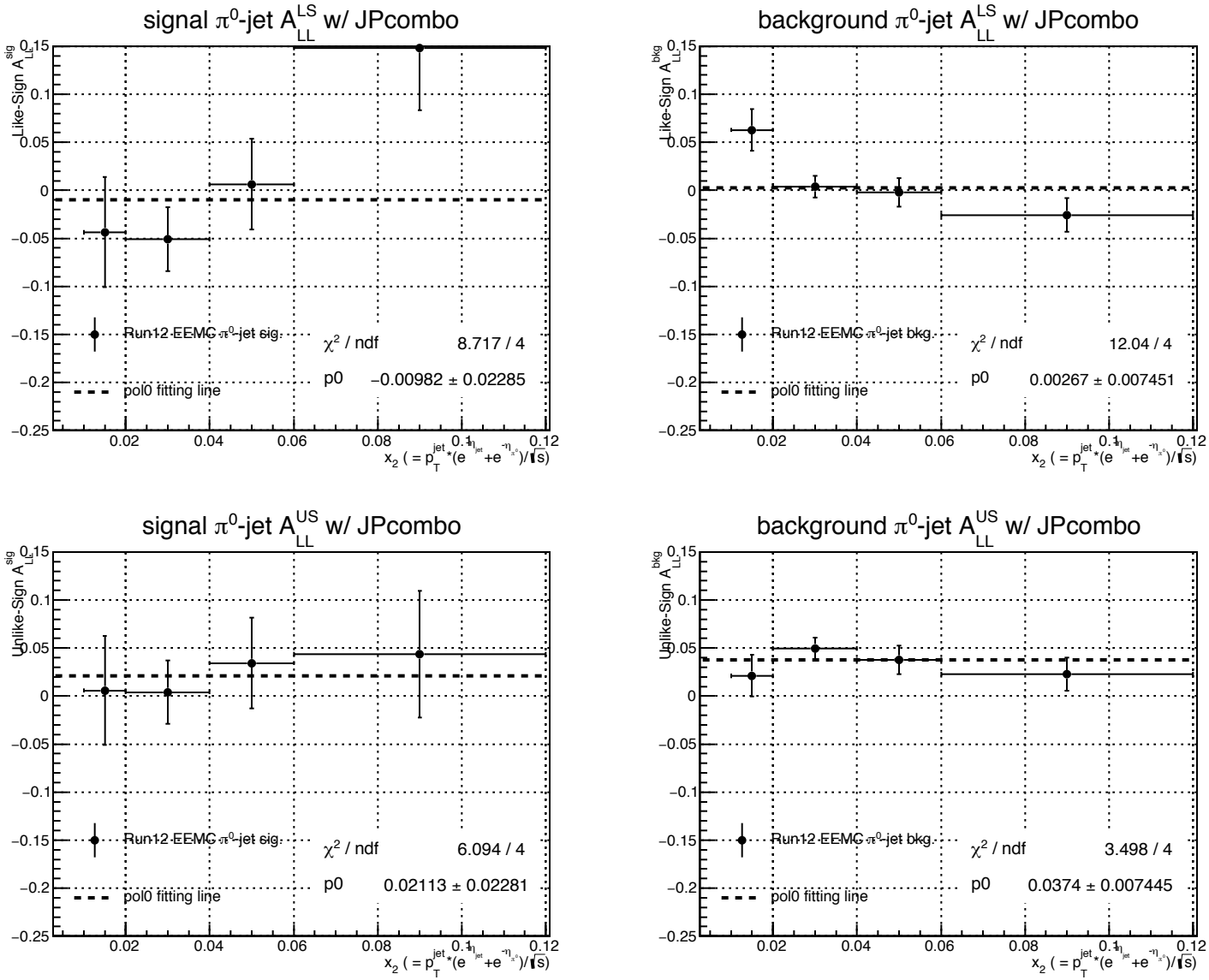
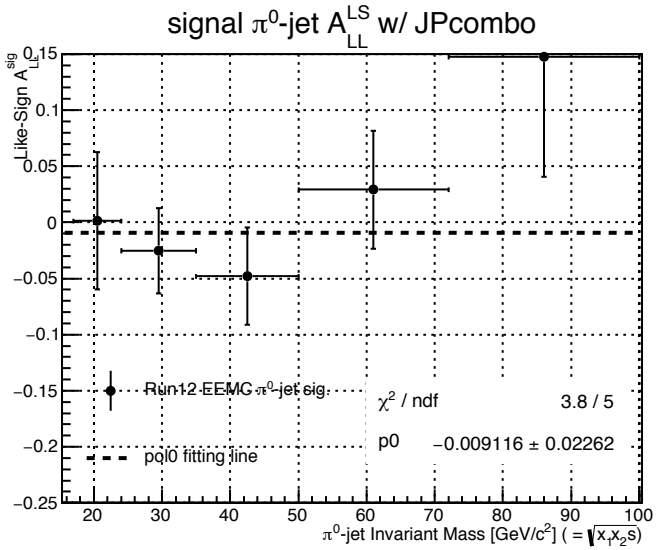
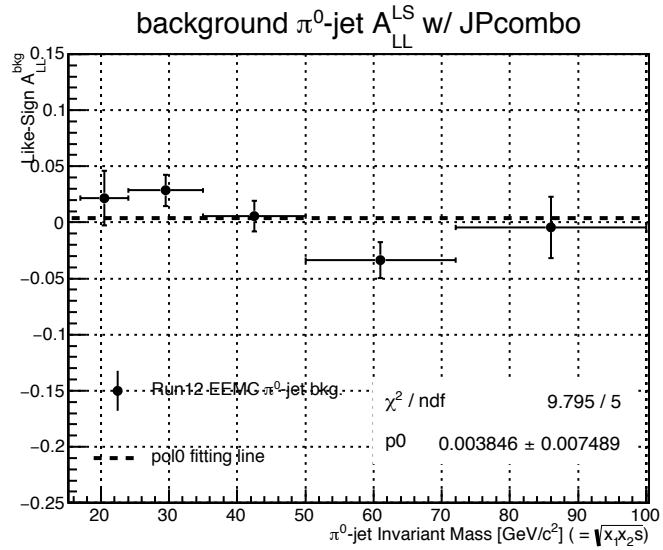
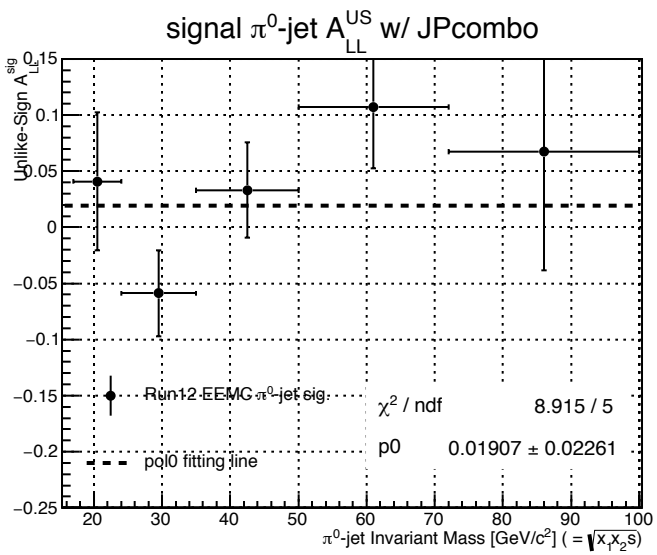
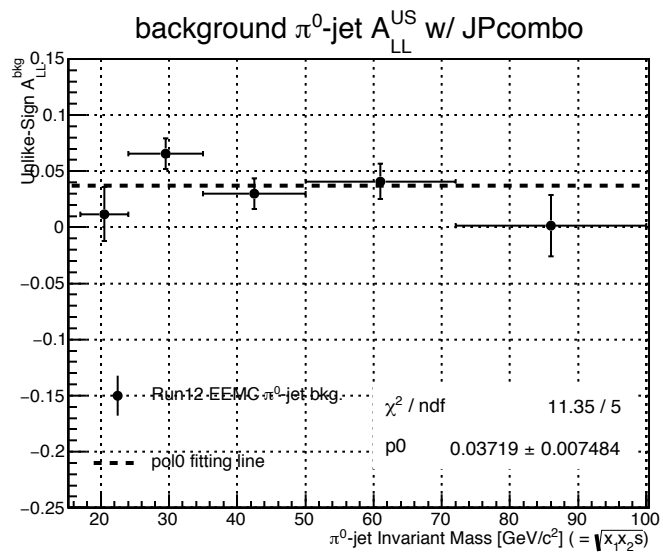



# Asymmetry Results – Updated false asymmetries, $A_{LL}^{LS}$, $A_{LL}^{US}$

$x_2$ bins



# Asymmetry Results – Updated false asymmetries, $A_{LL}^{LS}$, $A_{LL}^{US}$ inv. mass bins