Extracting the beam asymmetry Σ from data (bins in $(E_\gamma,\cos\theta)$)

Event yield asymmetries (binned in ϕ)

$$A(\phi) = \frac{N^\perp - N^\parallel}{p_\gamma^\parallel N^\perp + p_\gamma^\perp N^\parallel} = \Sigma\cos(2(\alpha^\parallel - \phi))$$

Event based fit (unbinned in ϕ)

$$-\ln\mathcal{L} = \sum_{i=1}^{n} -\ln(p_{\text{prompt}}(\phi_i, p_{\gamma,i}, \Sigma, a_1 \dots a_4, b_1 \dots b_4)) +$$
$$\sum_{j=1}^{m} -\ln\left(p_{\text{sideband}}(\phi_j, p_{\gamma,j}, \Sigma^{\text{bkg}}, a_1^{\text{bkg}} \dots a_4^{\text{bkg}}, b_1^{\text{bkg}} \dots b_4^{\text{bkg}})\right)$$

toy MC: generate events that follow pdfs $(\frac{\mathrm{d}\sigma}{\mathrm{d}\Omega})$ of $N^\parallel, N^\perp$ and $p_{\text{prompt}}, p_{\text{sideband}}$

Investigating toy MC fit results

χ^2 **fits**: investigate *normalized residuals* $\xi = \frac{\Sigma_{\text{estimated}} - \Sigma_{\text{true}}}{\text{err}(\Sigma_{\text{estimated}})}$,
$\rightarrow$ "good" fit yields $\xi \sim \mathcal{N}(0, 1)$
bayesian fits:

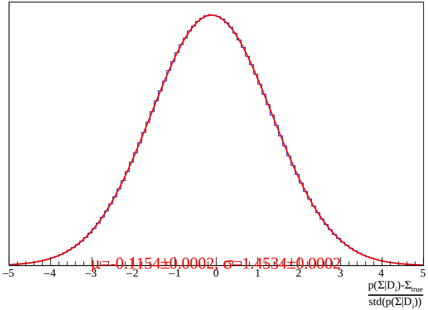
a. add up posteriors $p(\Sigma|y_i)$ to combined posterior $P(\Sigma|y_0, \ldots, y_{9999})$ (mixture model)
   $\rightarrow$ expect $P(\Sigma|y_0, \ldots, y_{9999}) \sim \mathcal{N}(\Sigma_{\text{true}}, \sigma)$
b. build "normalized residuals" $\Xi = \sum_{i=0} \frac{p(\Sigma|y_i) - \Sigma_{\text{true}}}{\text{std}(p(\Sigma|y_i))}$
   $\rightarrow$ expect $\Xi \sim \mathcal{N}(0, \mathcal{O}(1))$

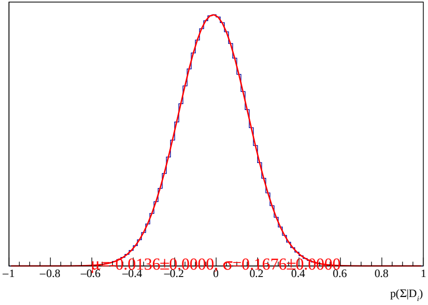
also check χ^2 distribution and MCMC diagnostics

Fit results (event yield asymmetries with BAYES)

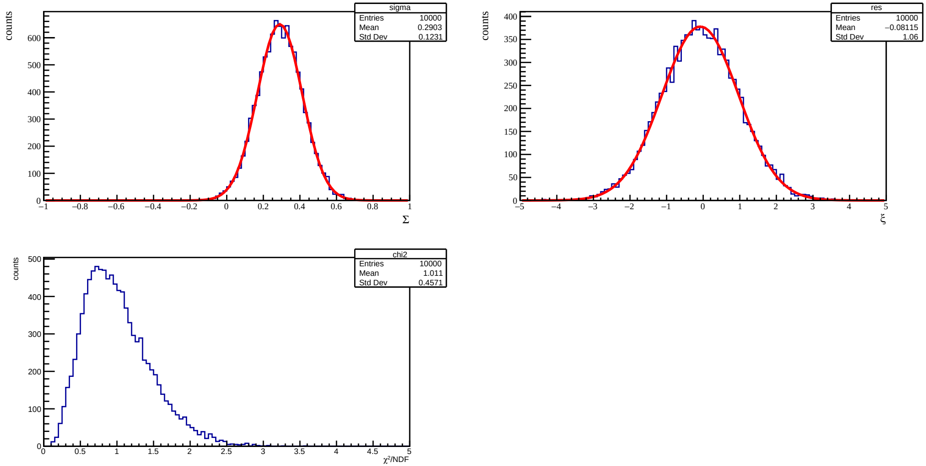
statistics of η final state: (12 bins in ϕ)

- 10000 toy bins
- $p_\gamma^{\parallel} = 0.25, p_\gamma^{\perp} = 0.3$, $\Sigma = 0.3$
- $n_{\text{events}}^{\parallel} \sim \text{Pois}(800)$, $n_{\text{events}}^{\perp} \sim \text{Pois}(1000)$





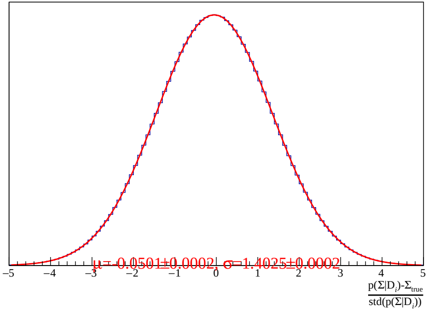
Fit results (event yield asymmetries with χ^2 fit)

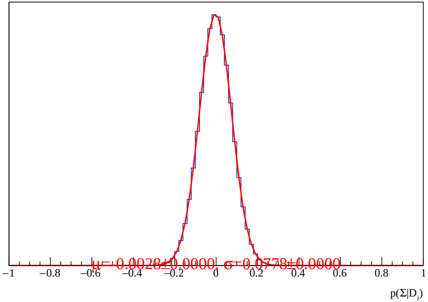


Fit results (event yield asymmetries with BAYES)

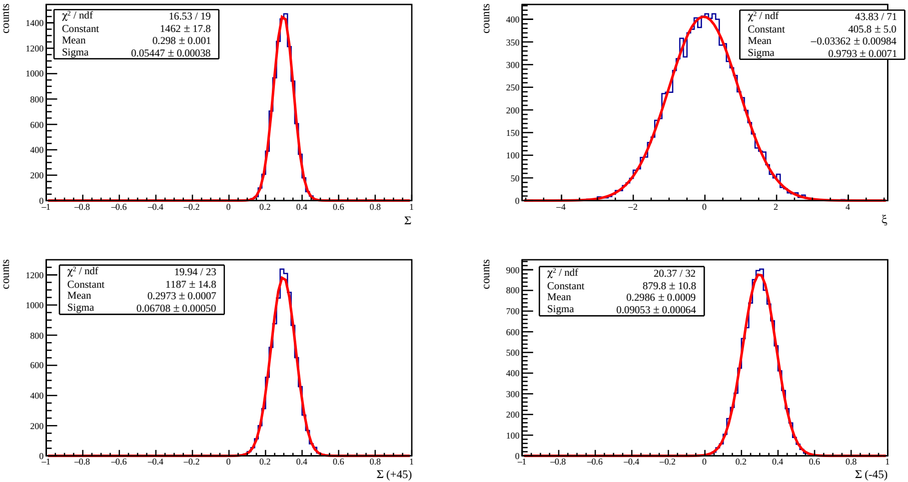
statistics of π^0 final state: (24 bins in ϕ)

- 10000 toy bins
- $p_\gamma^{\parallel} = 0.25, p_\gamma^{\perp} = 0.3,\ \Sigma = 0.3$
- $n_{\text{events}}^{\parallel} \sim \text{Pois}(4000),\ n_{\text{events}}^{\perp} \sim \text{Pois}(5000)$





Fit results (event yield asymmetries with χ^2 fit)

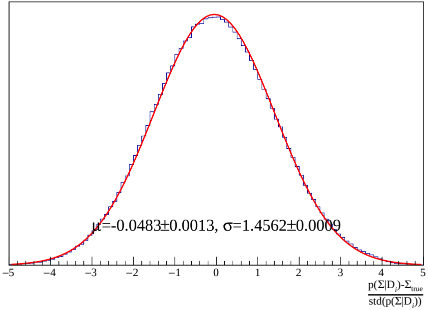


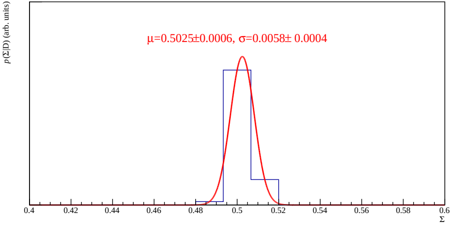
Event yield method okayish, but binning and statistics affect the fit siginificantly!

Fit results (Event-based fit)

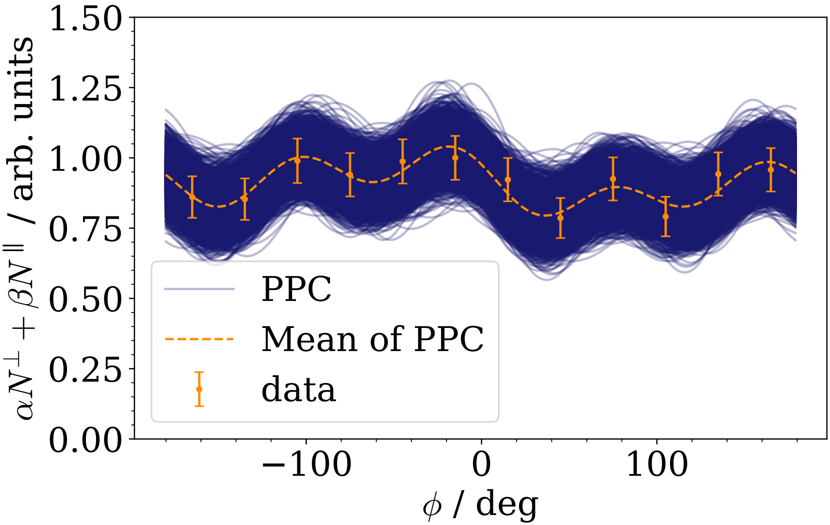
- 300 toy bins (fit takes very long)
- $p_\gamma^{\|} = 0.25, p_\gamma^{\perp} = 0.3$, $\Sigma = 0.3$, sideband events and weights similar to data, Eff. func: $f(\phi) = \frac{1}{10.5}(9.3 + 0.28\cos\phi + 0.24\sin 3\phi)$
- $n_{\text{events}}^{\|} \sim \text{Pois}(800)$, $n_{\text{events}}^{\perp} \sim \text{Pois}(1000)$
- either build "normalized residuals" Ξ or "independent likelihood pool" $P(\Sigma|y_0 \dots y_{300}) \propto \frac{\prod_i p(\Sigma|y_i)}{\pi(\Sigma)^{300-1}}$

Fit results (Event-based fit)





Fit results (Event-based fit)



Fit results (Data), now "justified" :)