Resolution in charge channel

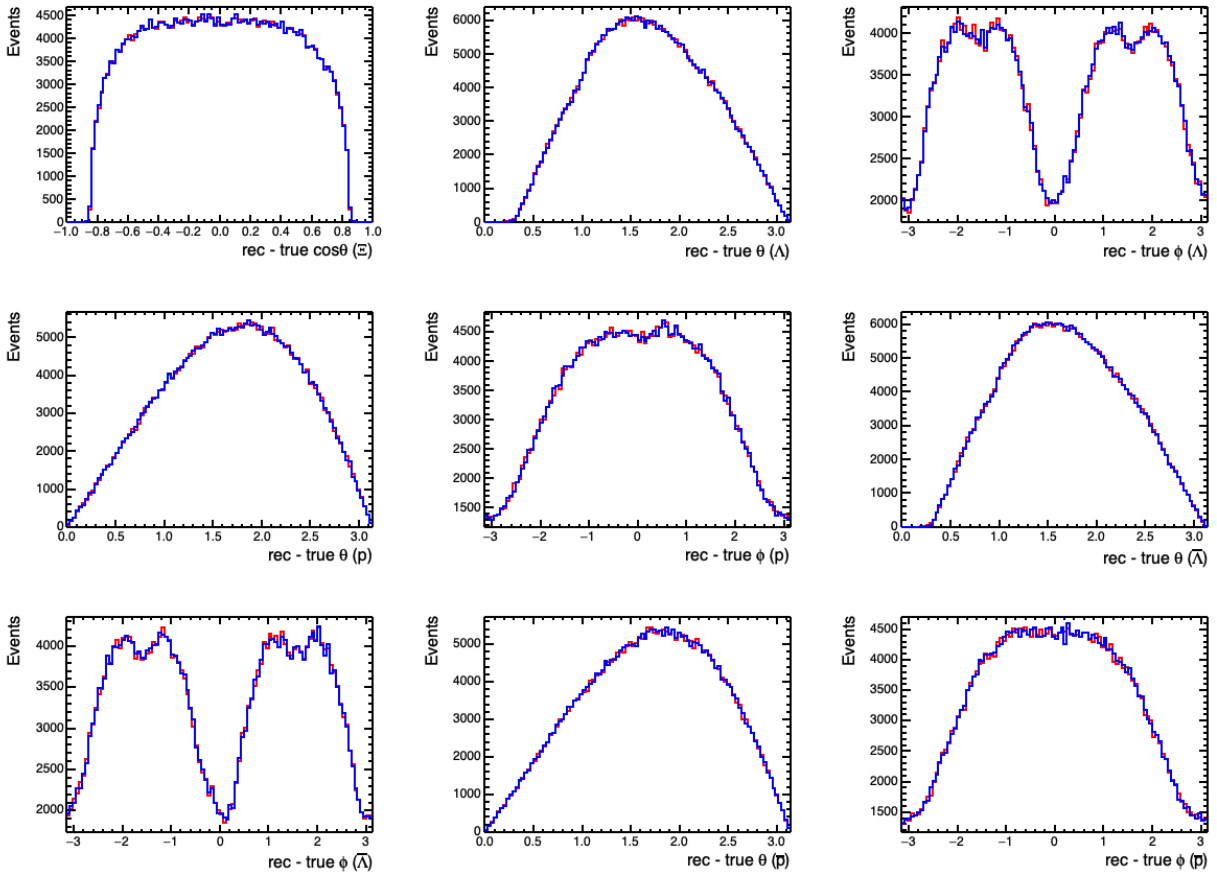
Brief Introduction

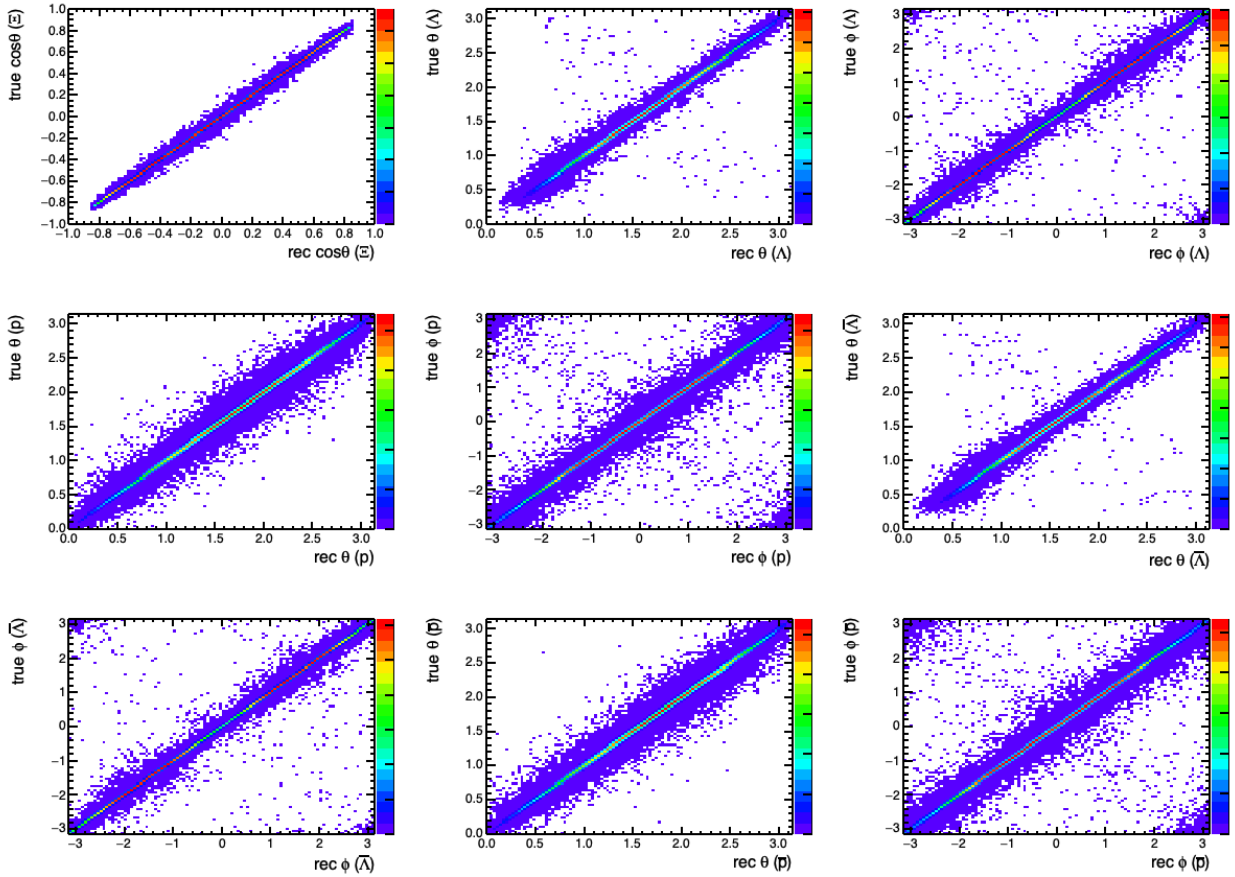
- Statistic of MC sample

	mDIY	PHSP
2009	16577	353063
2012	93012	1971946
2018	197055	6055122
2019	174929	5504992

- I plot the helicity angle distribution for each year separately.

Distribution of nine variables (2009)




true cosθ (Ξ)
rec cosθ (Ξ)
true θ (Λ)
rec θ (Λ)
true ϕ (Λ)
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rec ϕ (p)
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true ϕ ($\bar{\Lambda}$)
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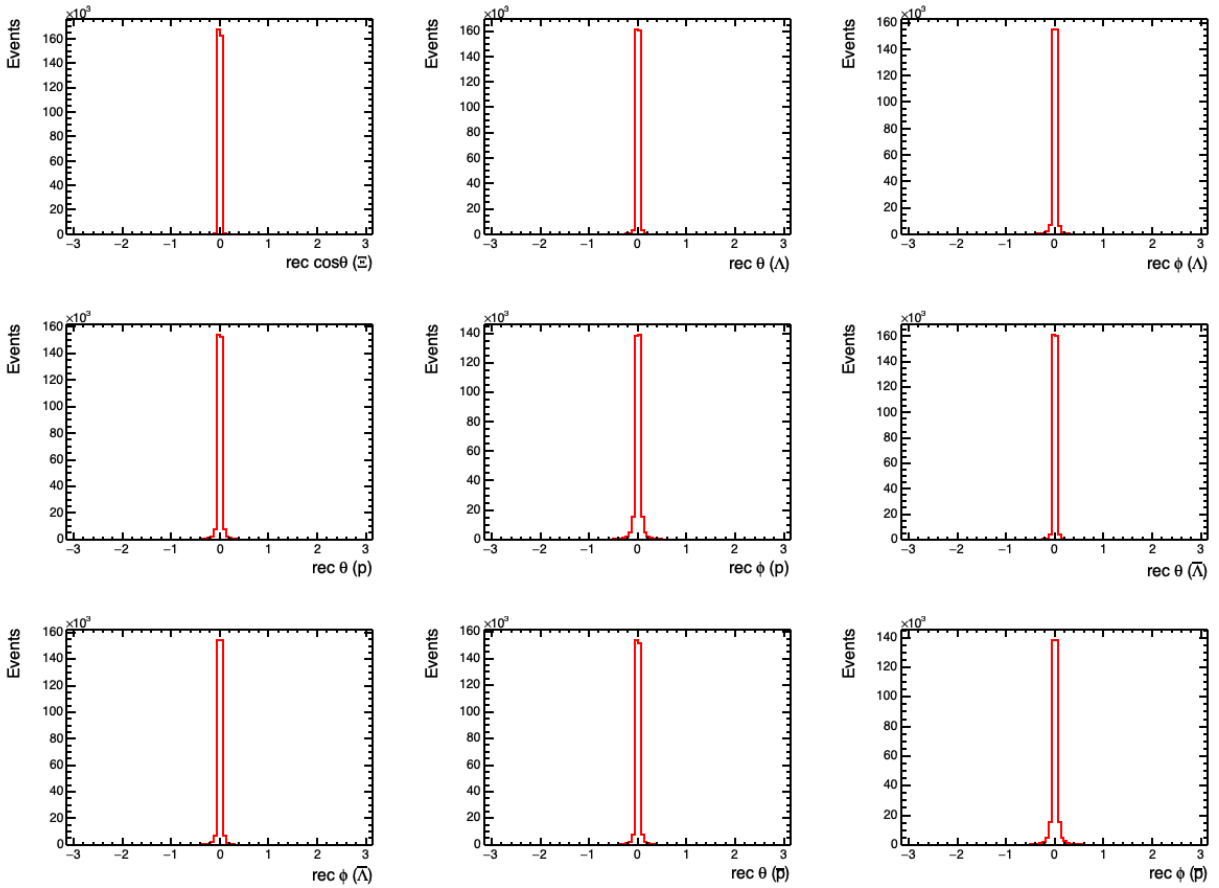
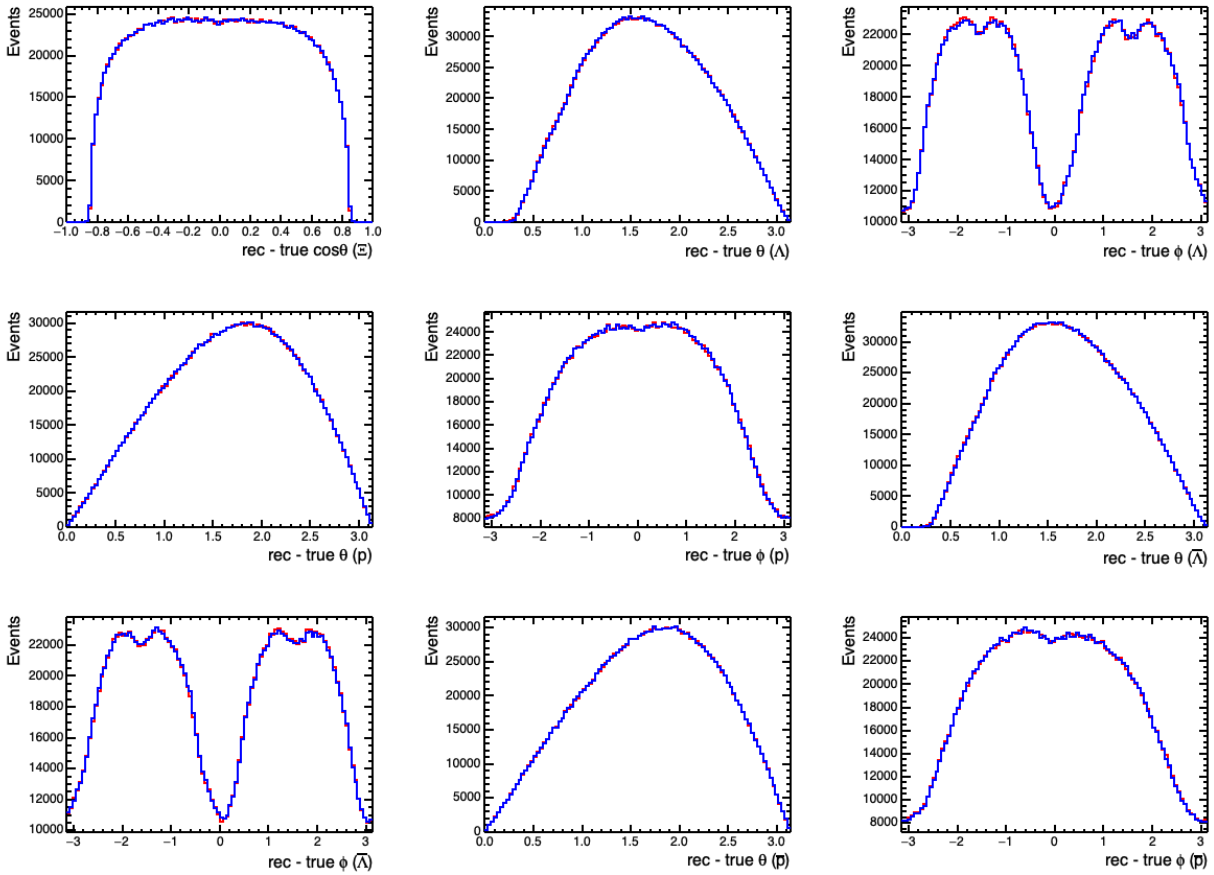
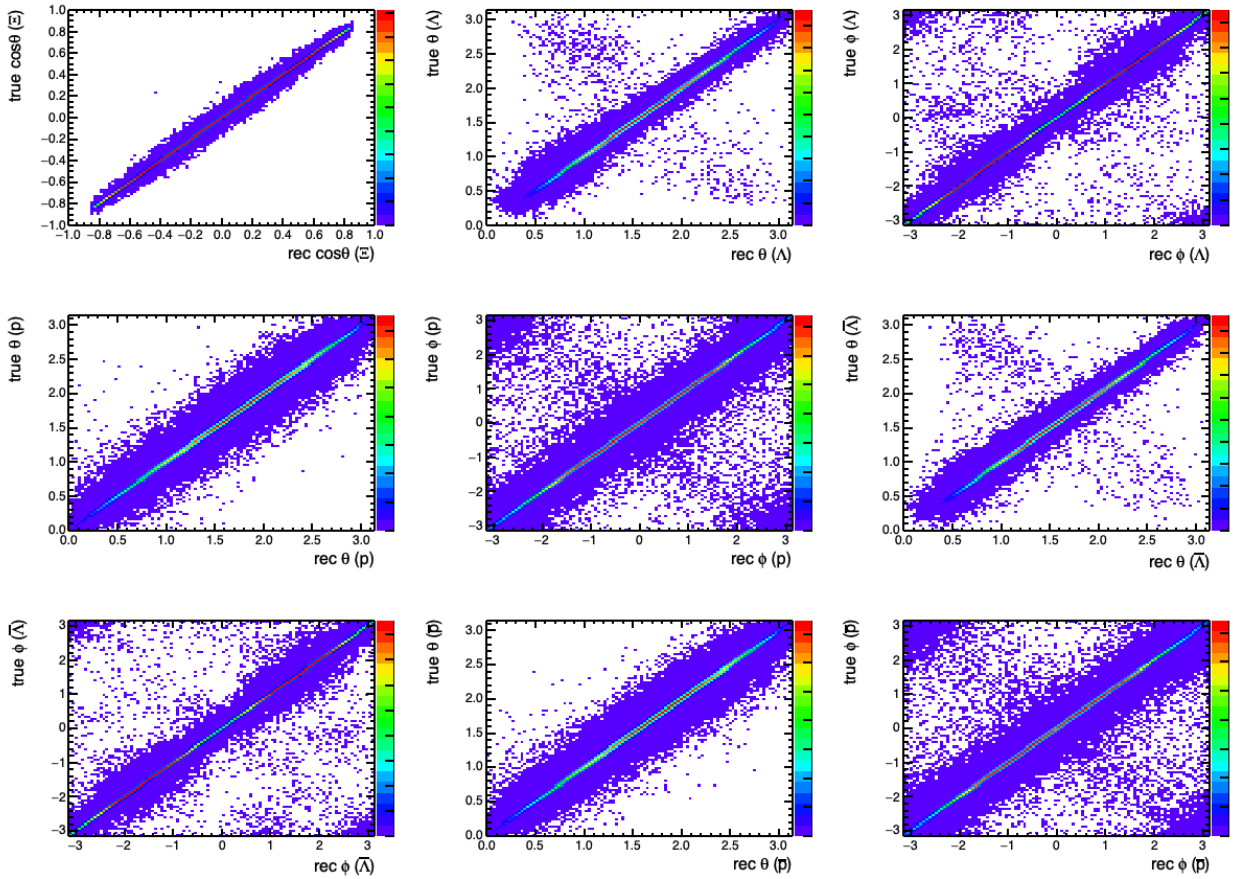
rec ϕ ($\bar{p}$)

$$Value = Rec - True$$



Distribution of nine variables (2012)

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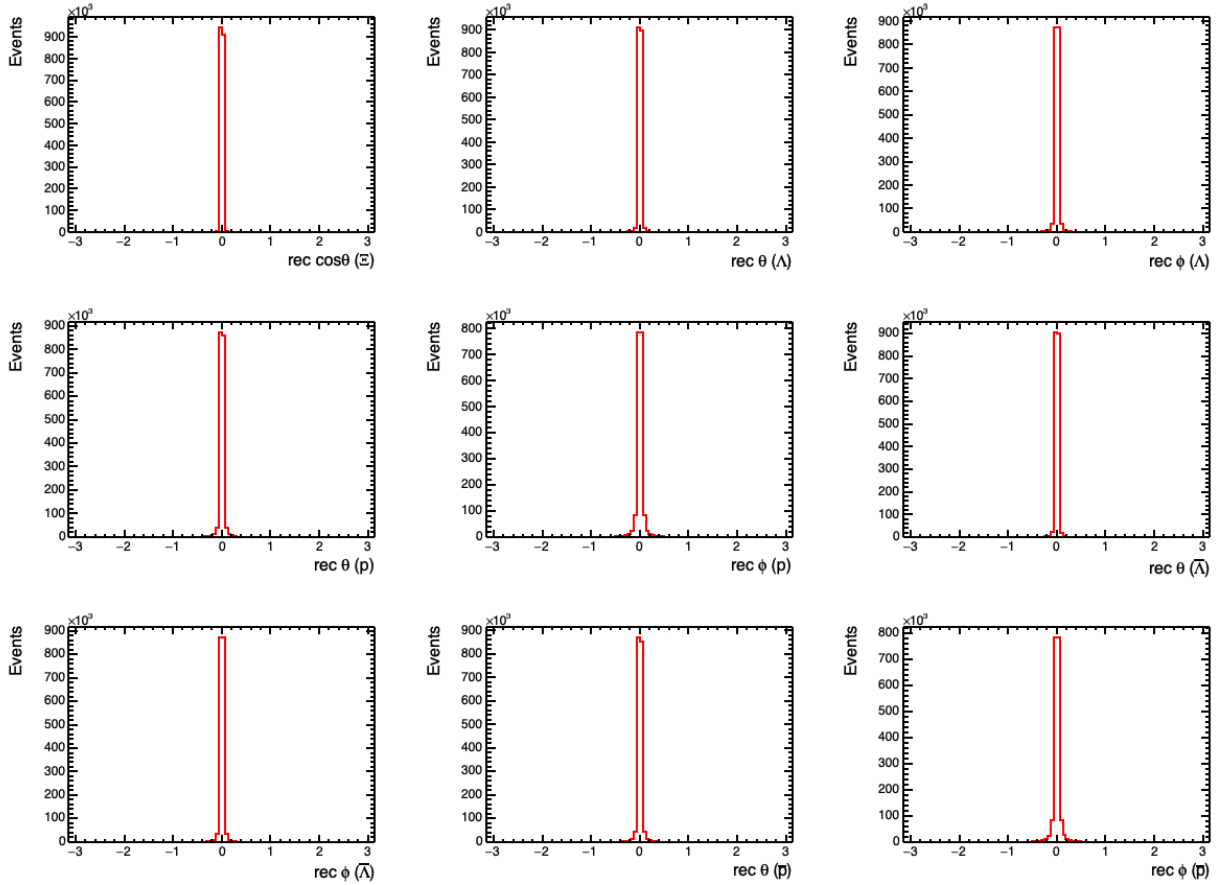
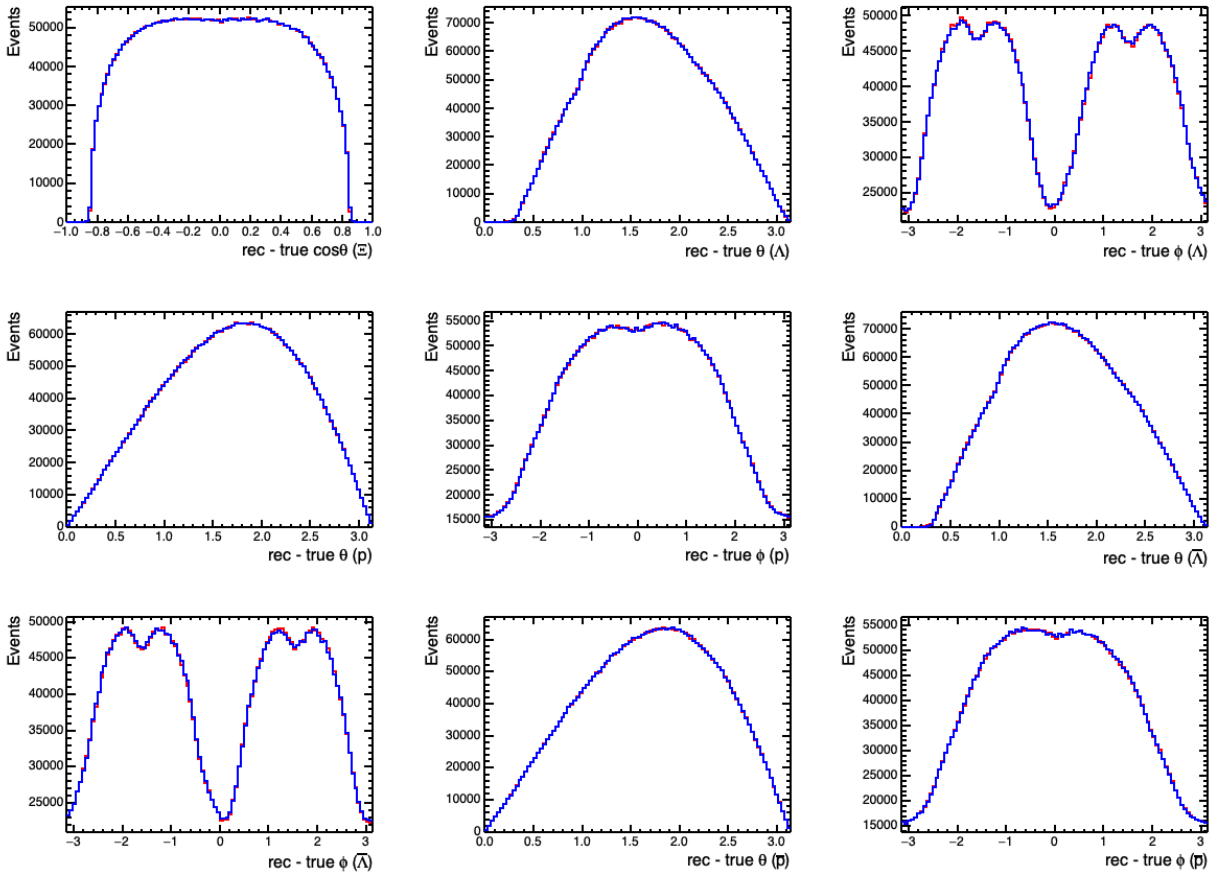
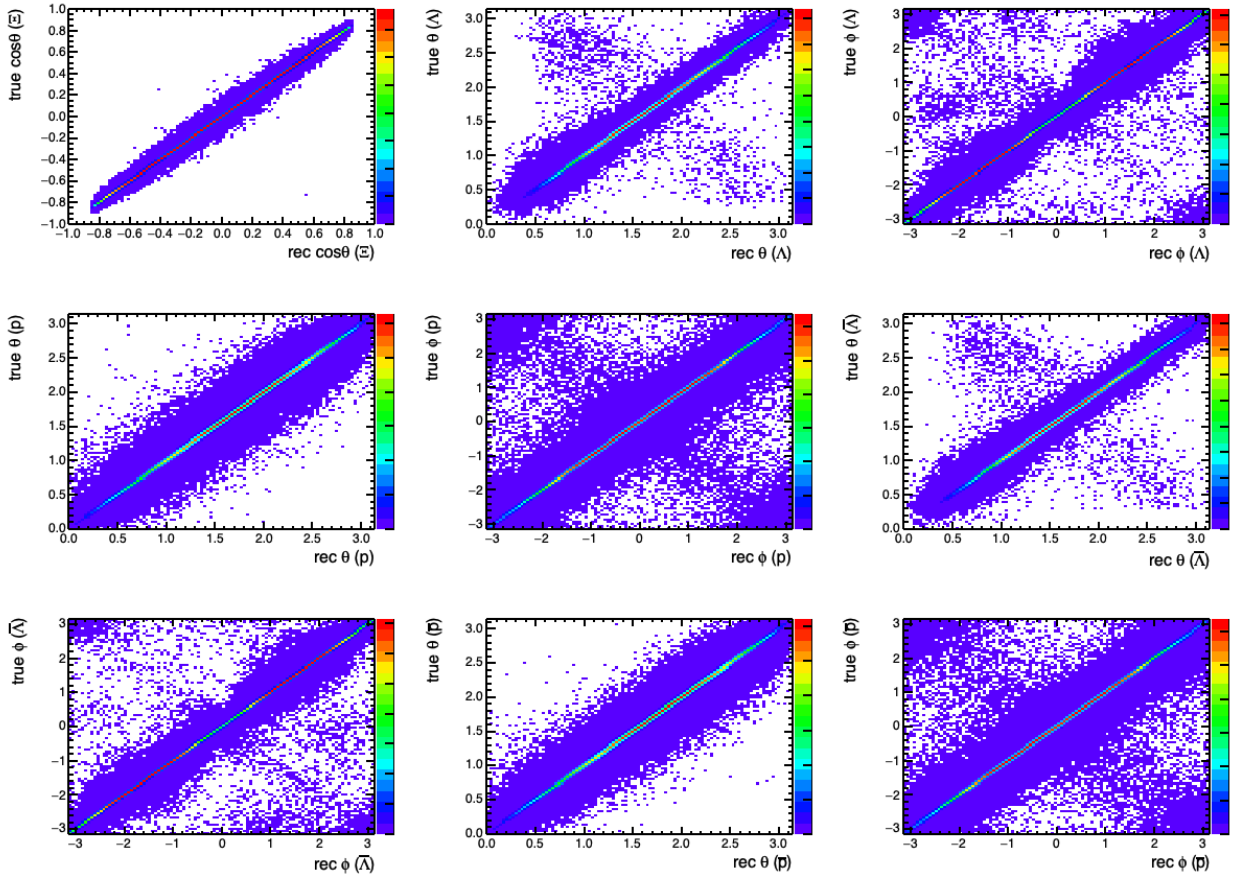


Distribution of nine variables (2018)

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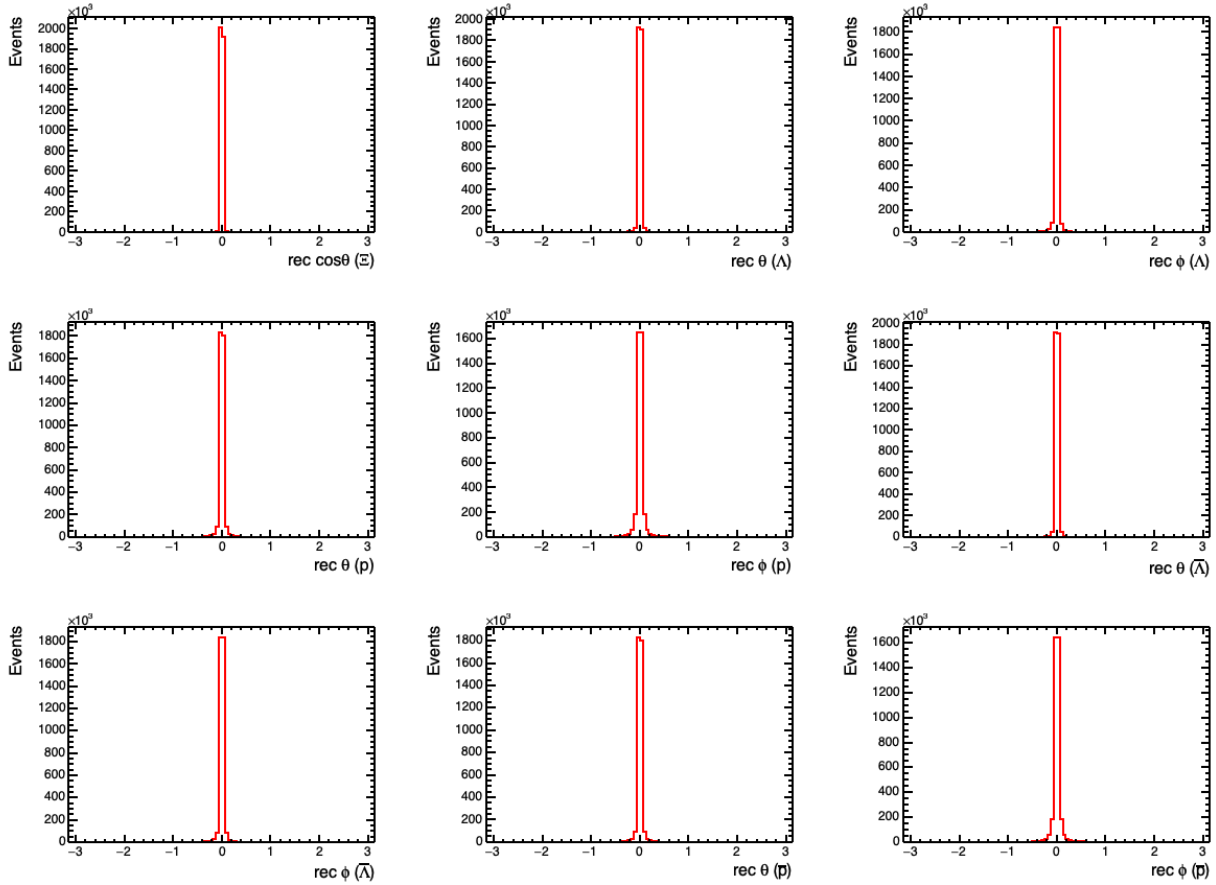
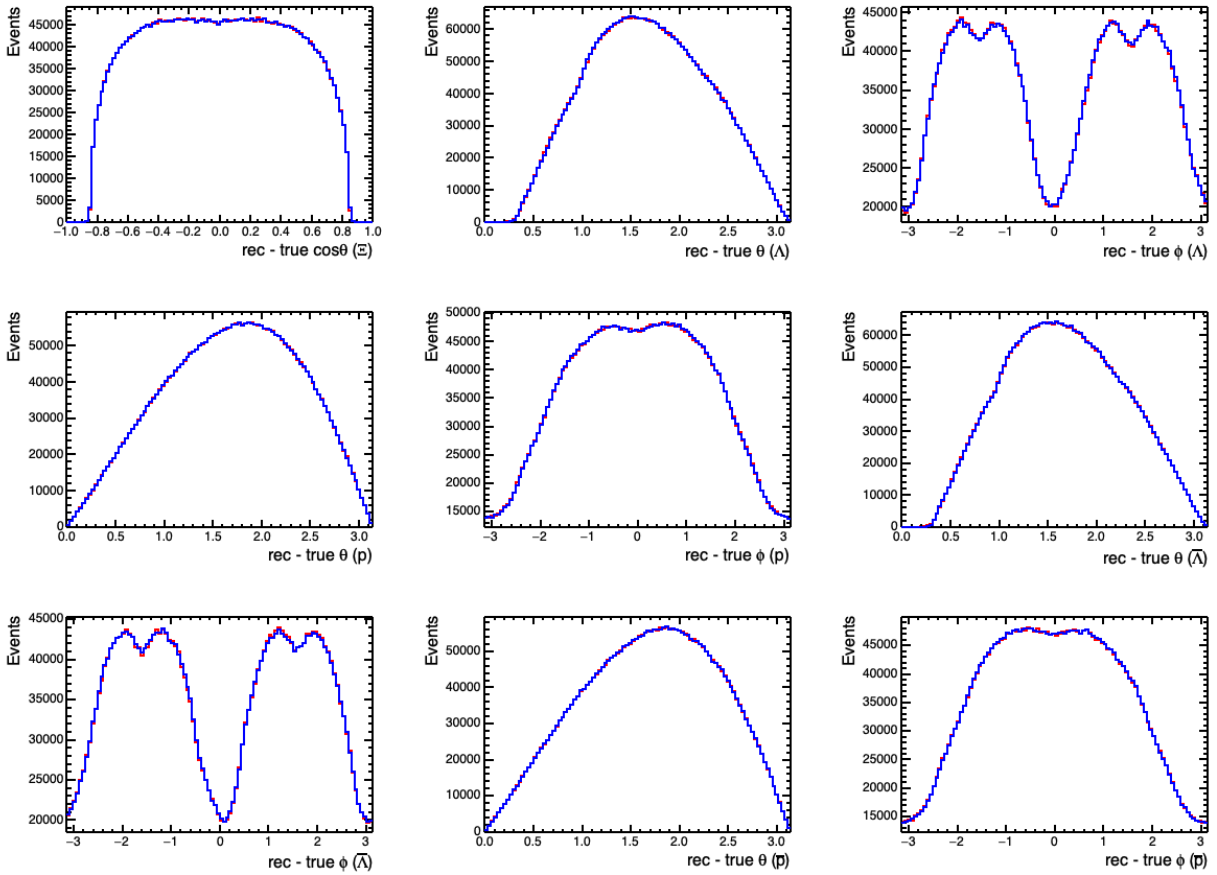
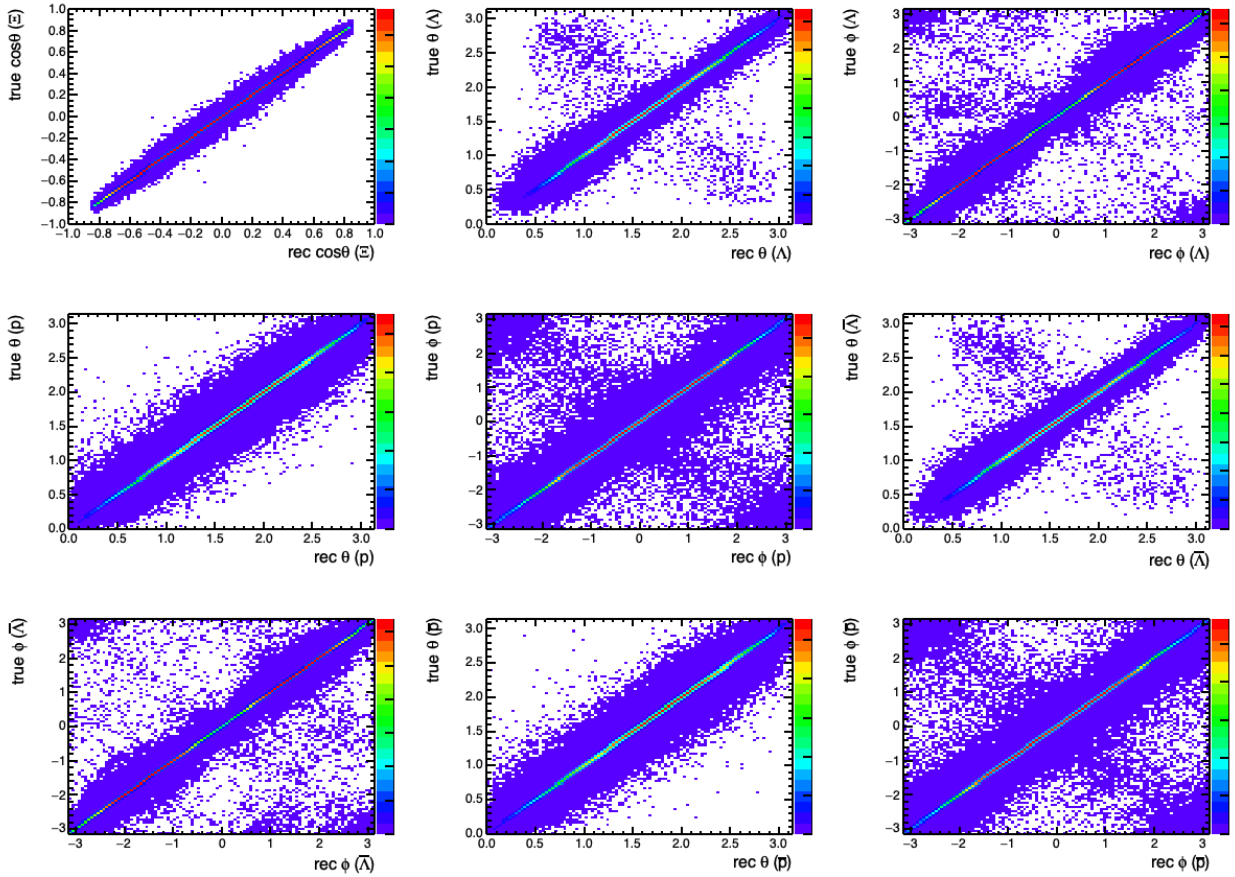


Distribution of nine variables (2019)

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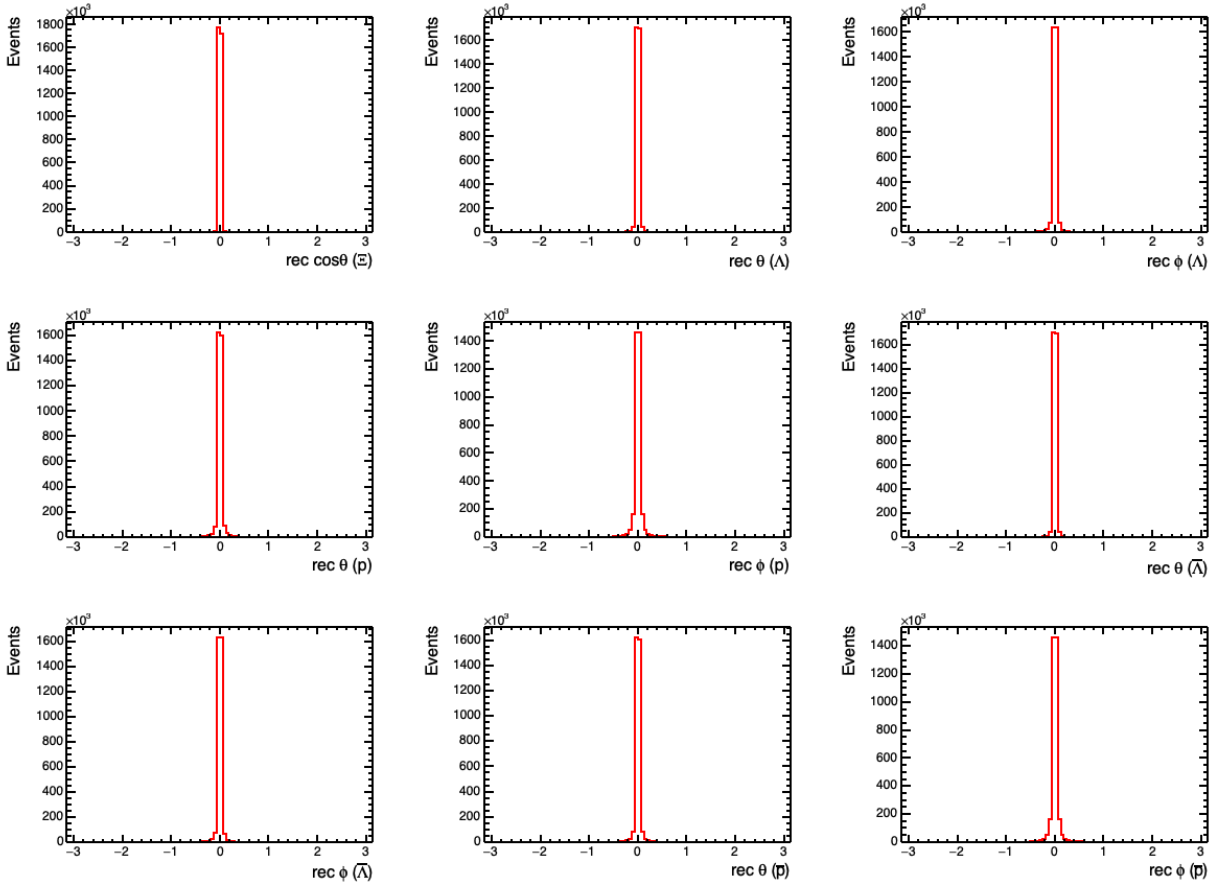
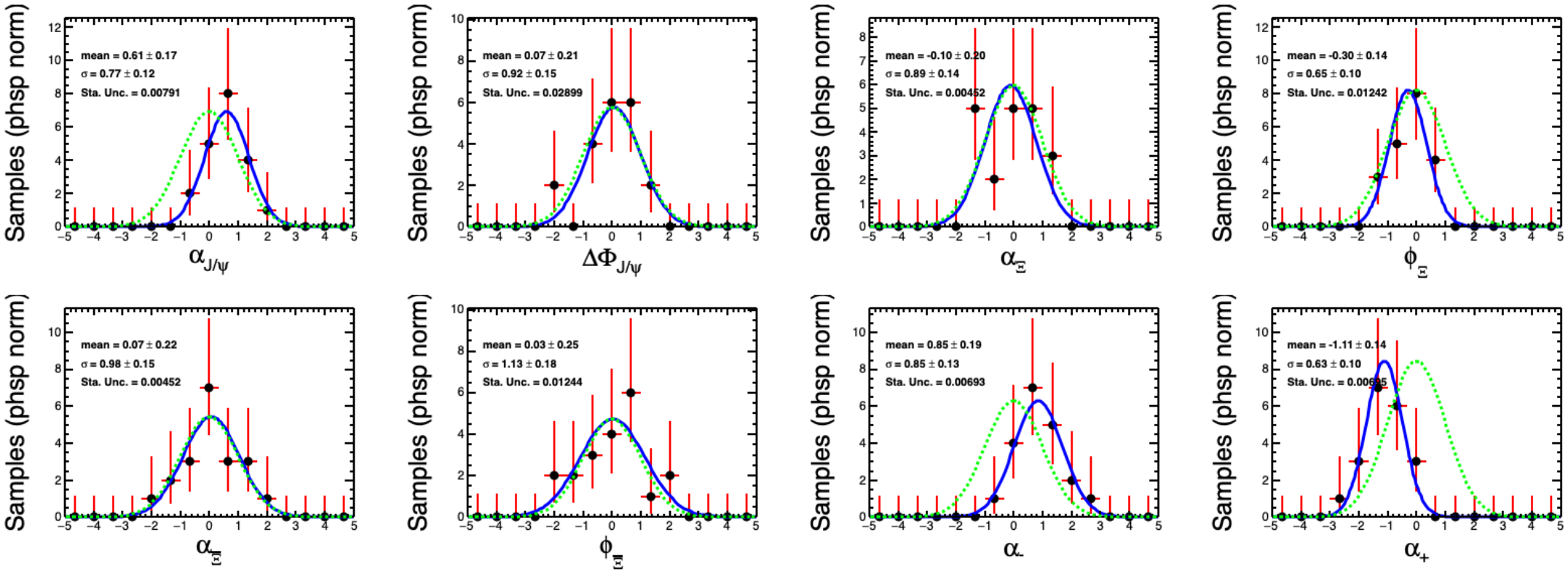
rec ϕ ($\bar{p}$)

$$Value = Rec - True$$



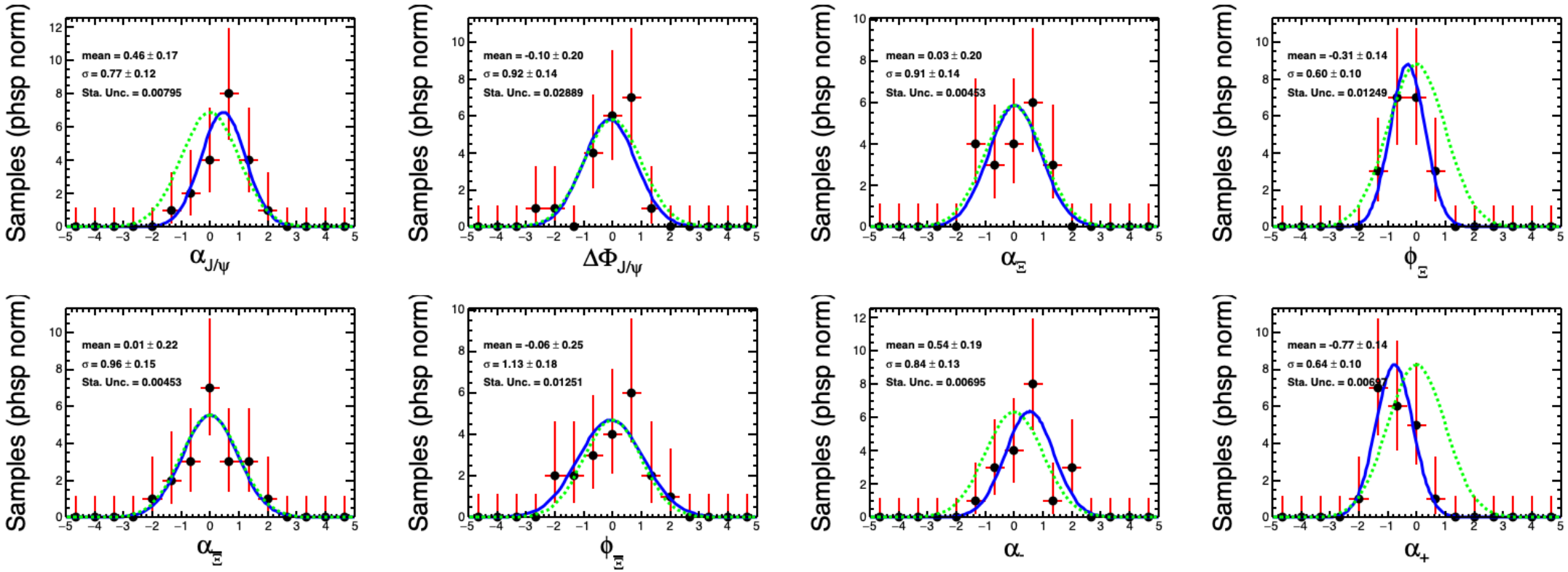
Input-Output Check

Using PHSP MC to calculate the normalization factor
The result of fitting the true distribution



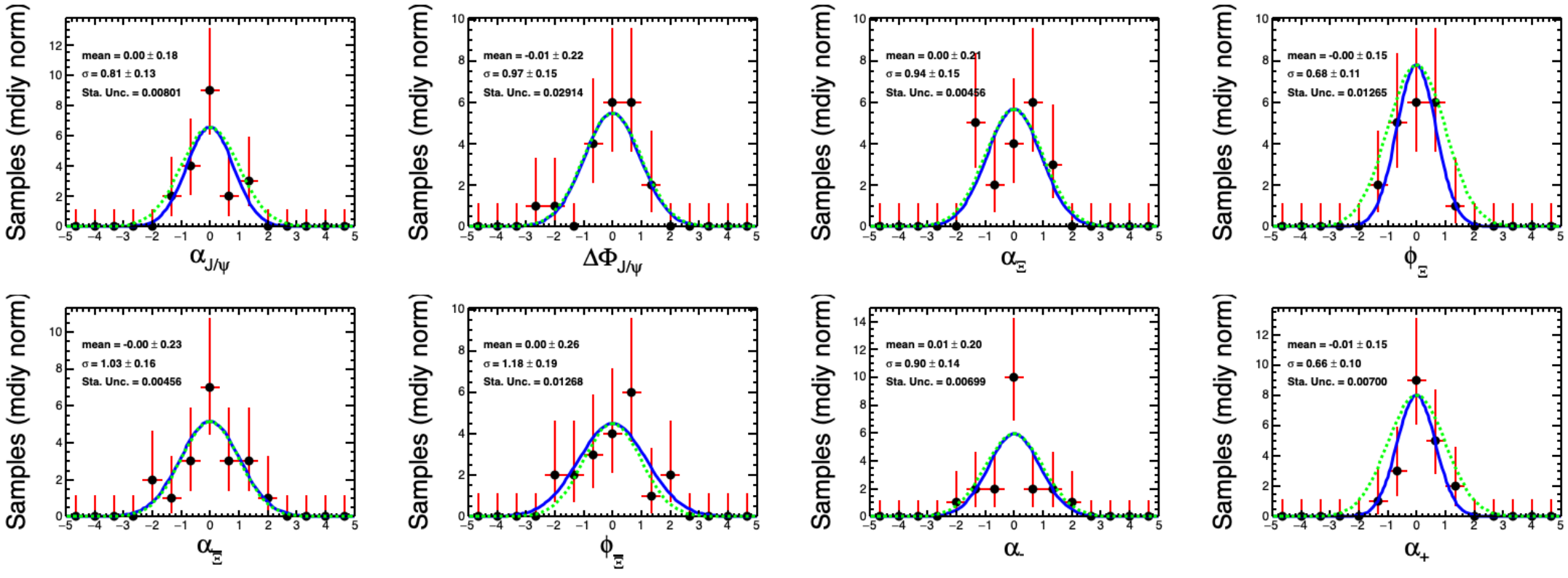
Input-Output Check

Using PHSP MC to calculate the normalization factor
The result of fitting the reconstruction distribution



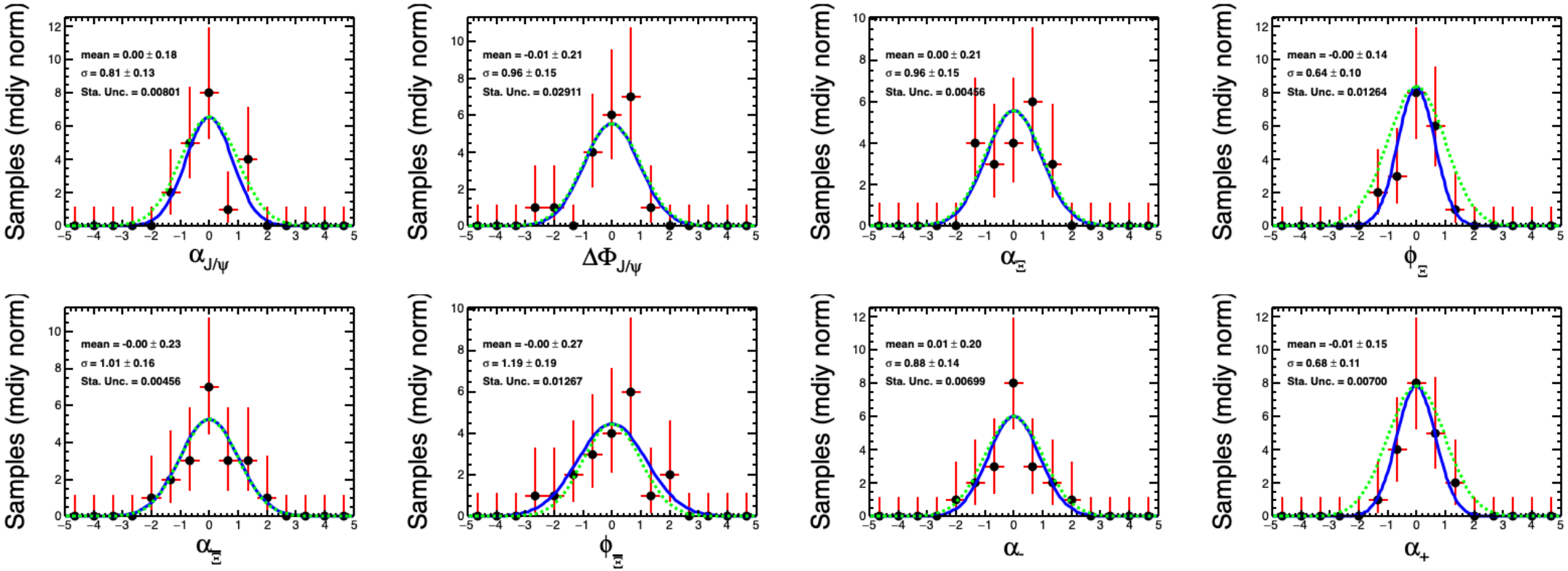
Input-Output Check

Using mDIY MC to calculate the normalization factor
The result of fitting the true distribution



Input-Output Check

Using mDIY MC to calculate the normalization factor
The result of fitting the reconstruction distribution



A reference for the mDIY normalization

- Cowan, Glen. *Statistical data analysis*. Oxford university press, 1998.
- https://www.sherrytowers.com/cowan_statistical_data_analysis.pdf
- Page 157

Although $s(x|y)$ and $\varepsilon(y)$ are by construction independent of the probability that a given value y occurs (i.e. independent of $f_{\text{true}}(y)$), they are not in general completely model independent. The variable y may not be the only quantity that influences the probability to obtain a measured value x. For the example of beta decay where y represents the true and x the measured energy of the emitted electron, $s(x|y)$ and $\varepsilon(y)$ will depend in general on the angular distribution of the electrons (some parts of the detector may have better resolution than others), and different models of beta decay might predict different angular distributions.

Background Estimation

- Sideband method
- sWeight method

Brief introduction

- Decay Channel

  $J/\psi \to \Xi^-\bar{\Xi}^+ \to \Lambda(\to n\pi^0)\pi^-\bar{\Lambda}(\to \bar{p}^-\pi^+)\pi^+$ (neutron channel)

  $J/\psi \to \Xi^-\bar{\Xi}^+ \to \Lambda(\to p^+\pi^-)\pi^-\bar{\Lambda}(\to \bar{n}\pi^0)\pi^+$ (anti-neutron channel)

- Single Tag: reconstruct the charged leg

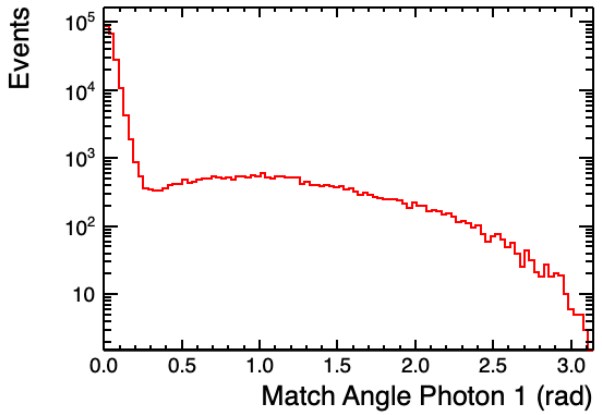
$$\bar{\Xi} \to \bar{\Lambda}(\to \bar{p}^-\pi^+)\pi^+$$
$$\Xi \to \Lambda(\to p^+\pi^-)\pi^-$$

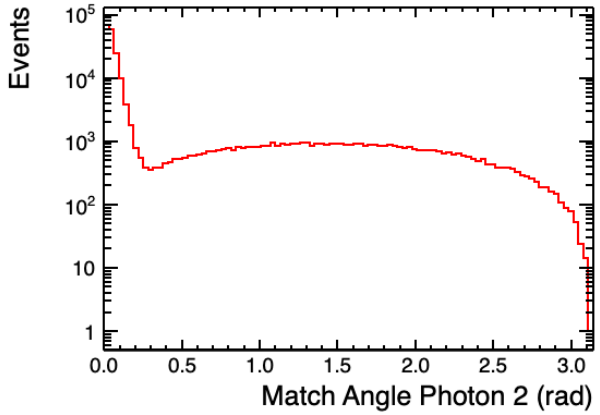
- Double Tag: reconstruct π^0 from EMC showers, obtain four momenta of $n/\bar{n}$ from

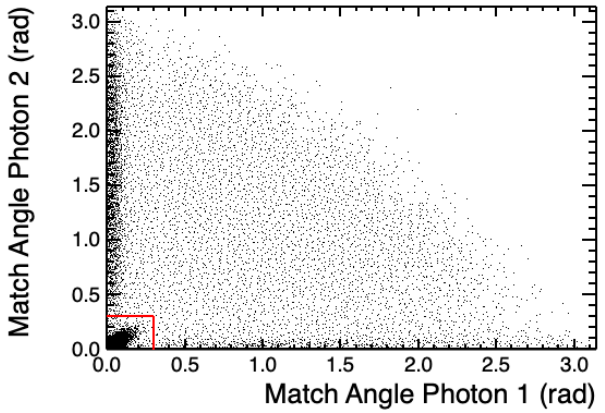
$$P_n = P_{J/\psi} - P_{\bar{\Xi}} - P_{\pi^-} - P_{\pi^0}$$
$$P_{\bar{n}} = P_{J/\psi} - P_{\Xi} - P_{\pi^+} - P_{\pi^0}$$

Photon Contamination

- π^0 reconstructed from Photon 1 and Photon 2
- Match angle is open-angle between true and reconstruction.
- To distinguish the signal and background in MC
  - Angle(photon 1) < 0.3 rad
  - Angle(photon 2) < 0.3 rad

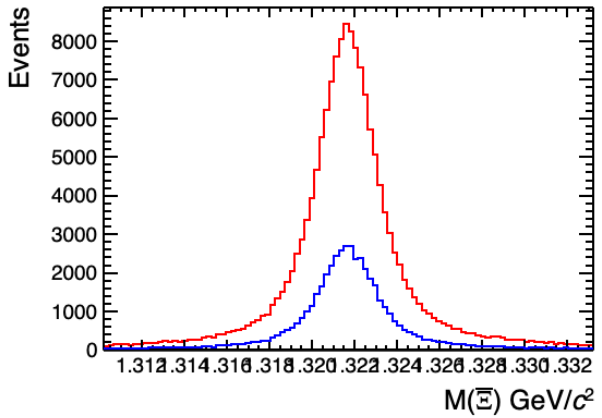


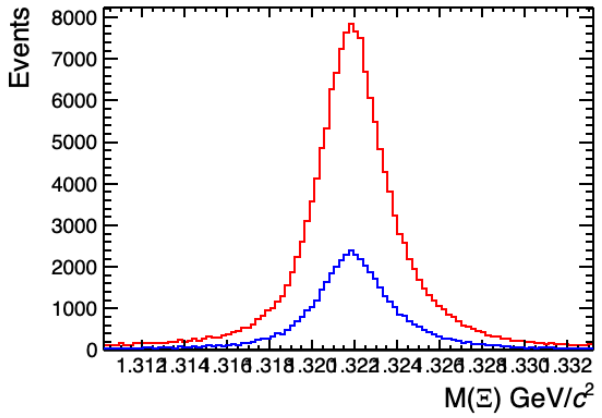


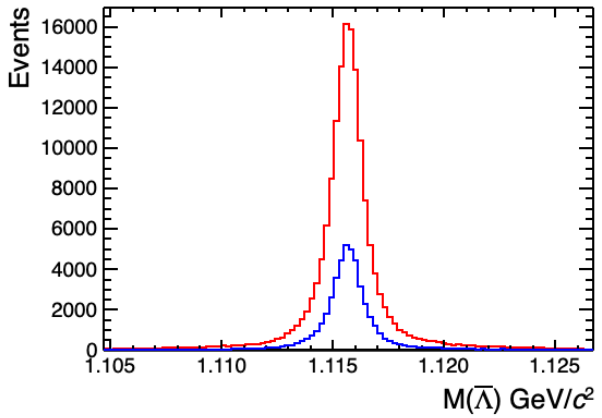


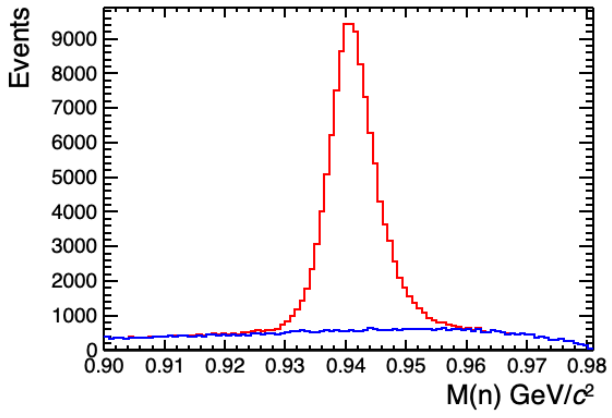
Photon Contamination

- Using the invariant mass of neutron as the observable to distinguish the signal and background
  - Red line: signal + background
  - Blue line: background







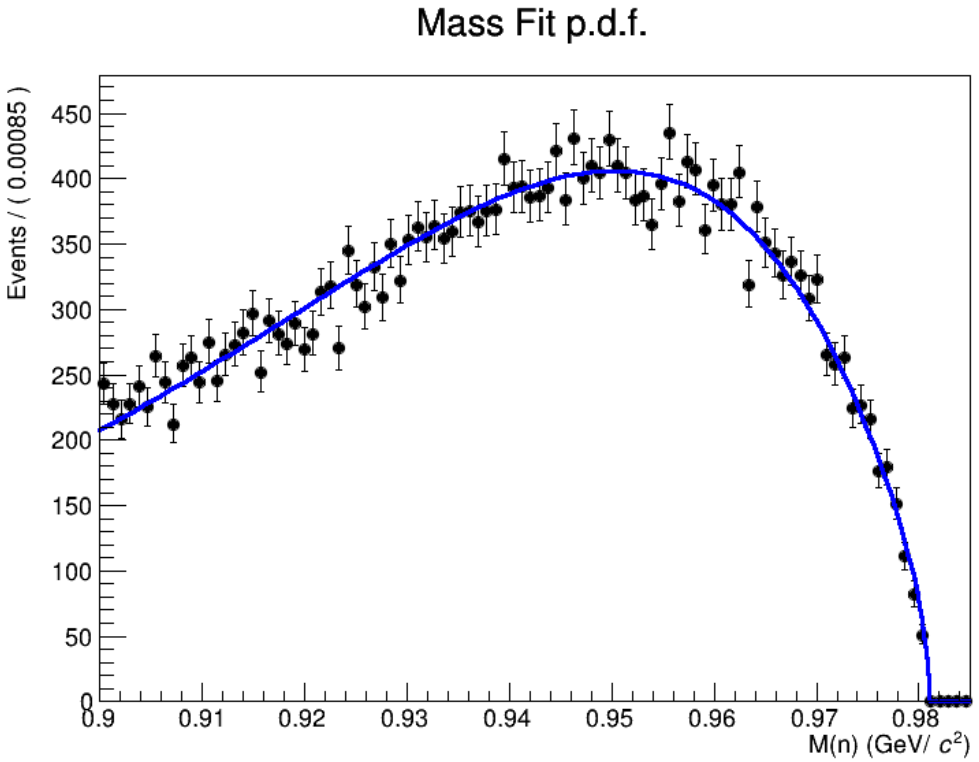


Fitting of Neutron Invariant Mass

- Model background

$$\text{P. D. F.} = \text{Argus}(m; m0, c, p) \times f(m; p0, p1, p2, p3)$$

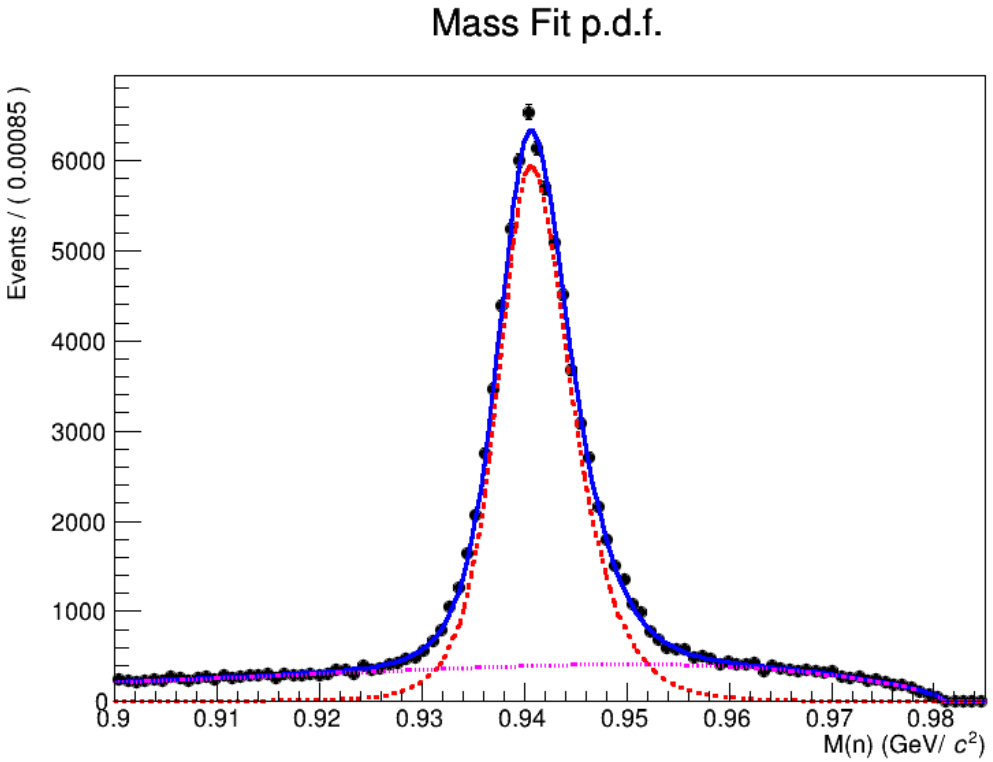
Parameters	Fit values
m0	0.981 (fix)
c	-6.18 ± 0.05
p	5.0 (fix)
p0	0.496 ± 0.017
p1	0.496 ± 0.018
p2	-1.493 ± 0.018
p3	0.495 ± 0.018



Fitting of Neutron Invariant Mass

- Using RooKeysPdf to model the signal shape
- Fix the background shape

Parameters	Fit values
nEvt Signal	$(6.87 \pm 0.03)\times10^4$
nEvt background	$(3.04 \pm 0.02)\times10^4$



Example: 2018 neutron channal.

Fitting of Neutron Invariant Mass

		2009		2012		2018		2019	
		Fit value $\times 10\text{^}3$	true value	Fit value $\times 10^3$	true value	Fit value $\times 10^4$	true value	Fit value $\times 10^4$	true value
xixipm	nEvt signal	3.54 ± 0.07	3466	12.3 ± 0.12	12210	6.87 ± 0.03	68452	6.86 ± 0.03	68360
	nEvt background	1.54 ± 0.05	1620	4.79 ± 0.09	4912	3.05 ± 0.02	30786	3.05 ± 0.02	30860
xixipp	nEvt signal	3.97 ± 0.07	3724	19.9 ± 0.016	19756	7.10 ± 0.03	70718	6.93 ± 0.03	68867
	nEvt background	1.57 ± 0.05	1635	8.45 ± 0.12	8593	3.16 ± 0.02	31892	3.01 ± 0.02	30552

All the Fit value and true value are consistent within 1 sigma.

Remove neutron shower in π^0 reconstruction

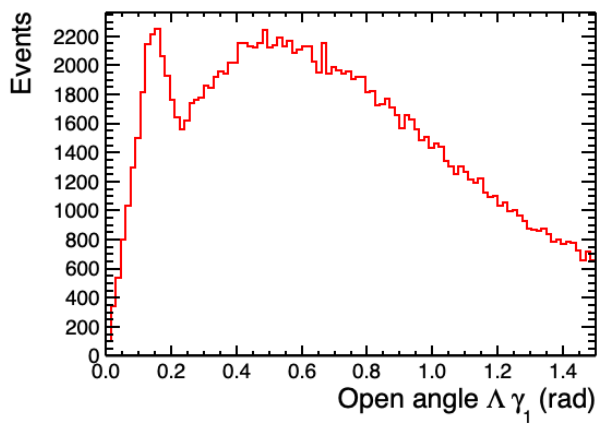
After single tag

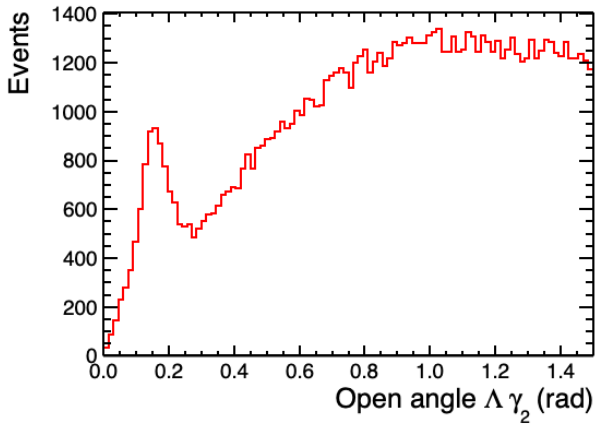
- π^0 reconstruction
  - Using standard procedure to select good photon from EMC.
  - Double loop good photon to do a 1C kinematic fit
    $M(\pi^0) = M(\gamma_1 + \gamma_2)$
  - π^0 candidates with $\chi^2_{1C} < 25$

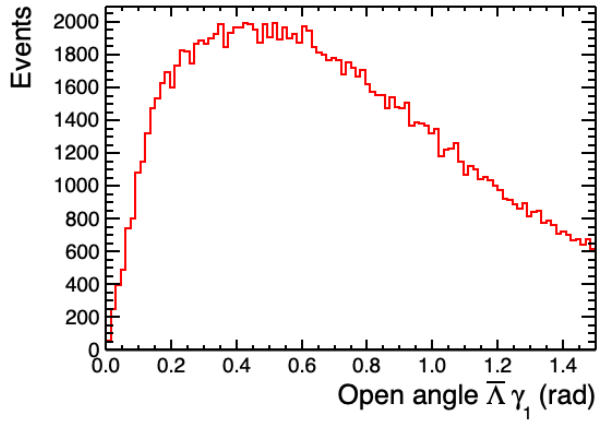
- Kinematic Fit
  - $P_{J/\psi} = P_{\Xi} + P_{\pi^{\mp}} + P_{\gamma 1} + P_{\gamma 2} + P_{n/\bar{n}}$
  - $M(\pi^0) = M(\gamma_1 + \gamma_2)$
  - $M(\Lambda/\bar{\Lambda}) = M(\gamma_1\gamma_2 n/\bar{n})$
  - $\chi^2_{kmf} < 200$
- $P_{n/\bar{n}} = P_{J/\psi} - (P_{\Xi} + P_{\pi^{\mp}} + P_{\gamma 1} + P_{\gamma 2})$

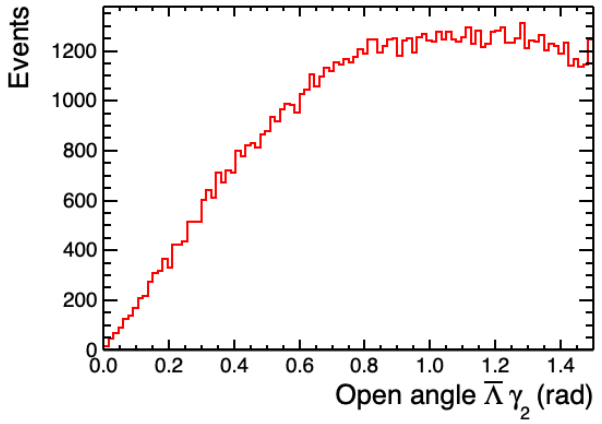
Remove neutron shower in π^0 reconstruction

- The opening angle between Lambda and photon.
- Peak in neutron channel come from neutron shower.



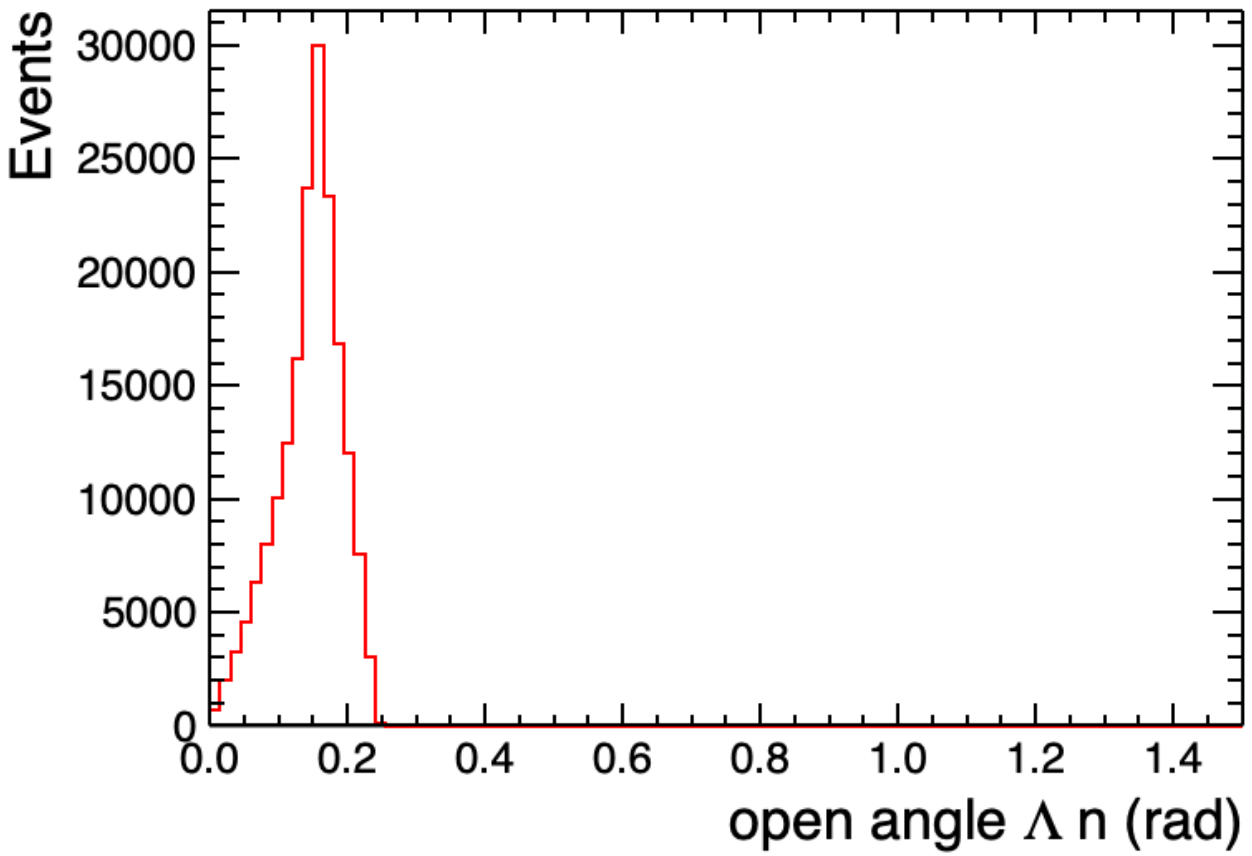






Remove neutron shower in π^0 reconstruction

- The true value of the opening angle between Λ and n
- The opening angle is less than 0.25 rad (~15°)



Remove neutron shower in π^0 reconstruction

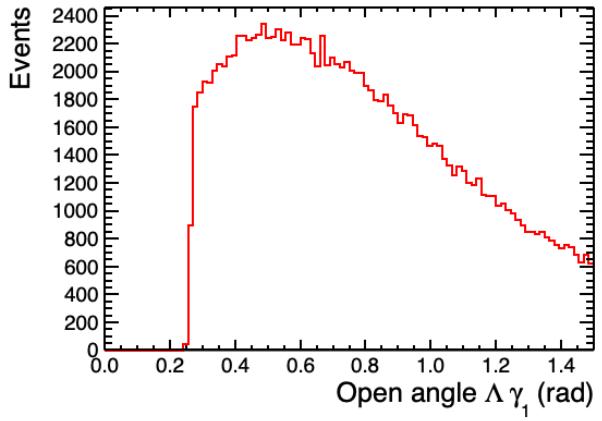
After single tag

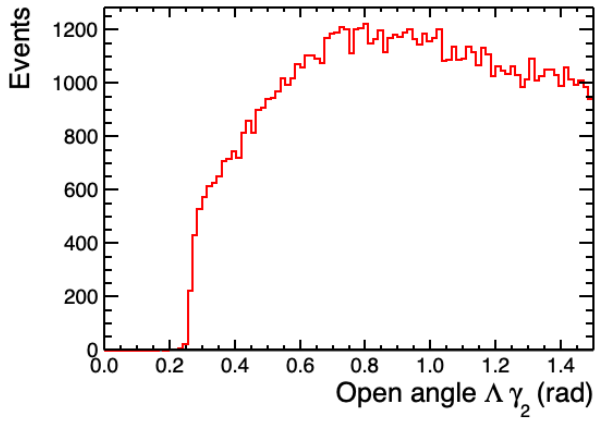
- $P_{\Lambda/\bar{\Lambda}} = P_{J/\psi} - (P_{\Xi} + P_{\pi^{\mp}})$
- π^0 reconstruction
  - An additional requirement to standard procedure of photon selection
    $\mathrm{Angle}(P_{\Lambda/\bar{\Lambda}}, \gamma) > 15°$
  - Double loop good photon to do a 1C kinematic fit
    $M(\pi^0) = M(\gamma_1 + \gamma_2)$
  - π^0 candidates with $\chi^2_{1C} < 25$

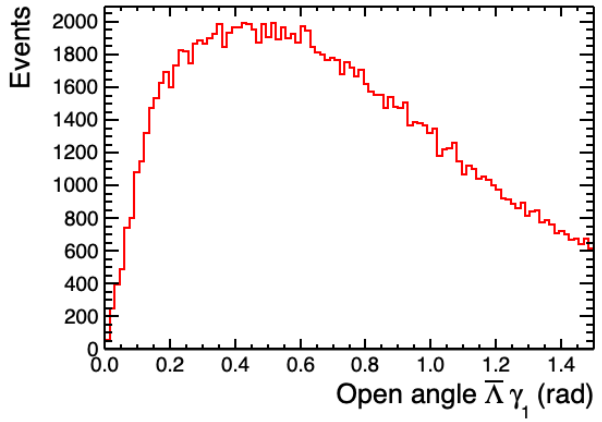
- Kinematic Fit
  - $P_{J/\psi} = P_{\Xi} + P_{\pi^{\mp}} + P_{\gamma 1} + P_{\gamma 2} + P_{n/\bar{n}}$
  - $M(\pi^0) = M(\gamma_1 + \gamma_2)$
  - $M(\Lambda/\bar{\Lambda}) = M(\gamma_1 \gamma_2 n/\bar{n})$
  - $\chi^2_{kmf} < 200$
- $P_{n/\bar{n}} = P_{J/\psi} - (P_{\Xi} + P_{\pi^{\mp}} + P_{\gamma 1} + P_{\gamma 2})$

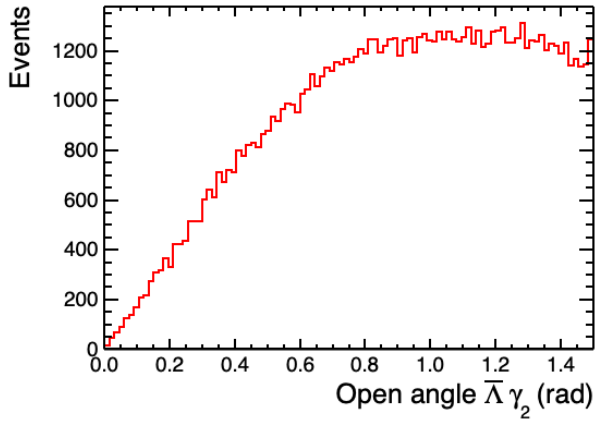
Remove neutron shower in π^0 reconstruction

- The opening angle between Lambda and photon.

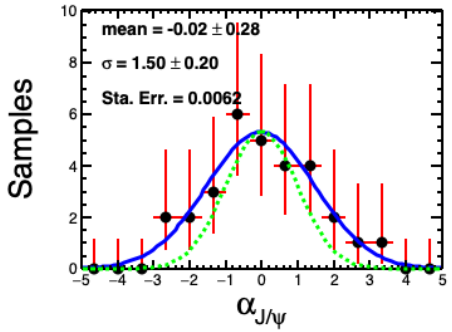


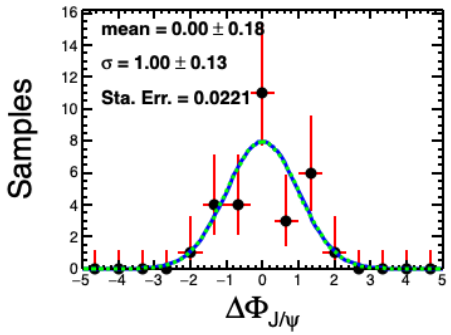


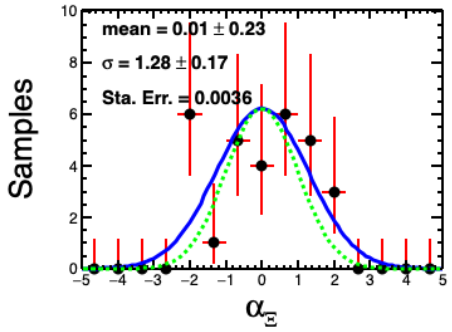


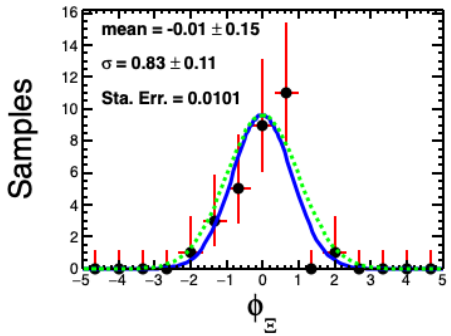


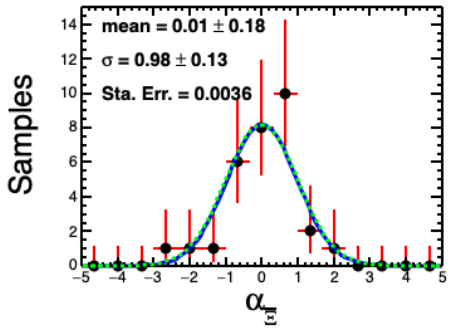
Using mDIY MC to estimate the background

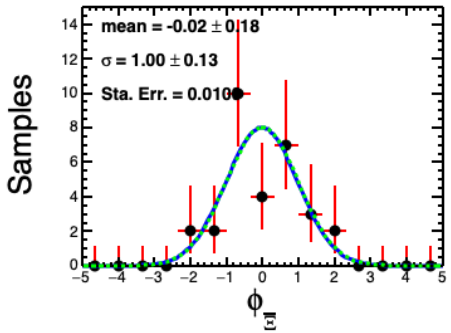


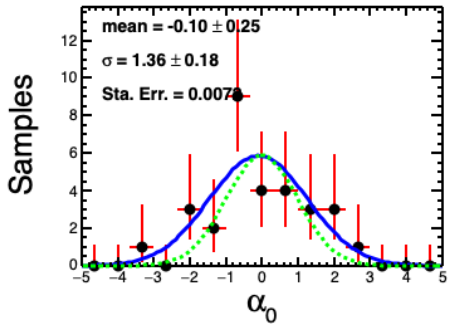


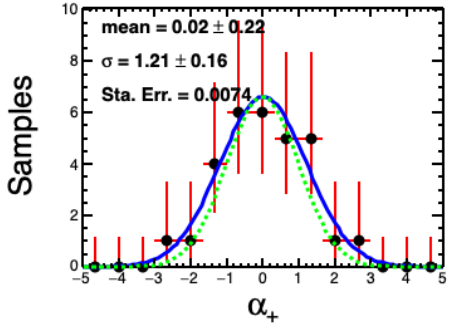


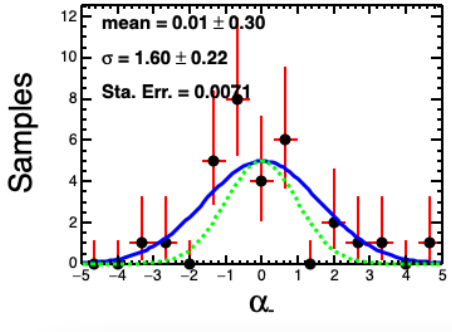


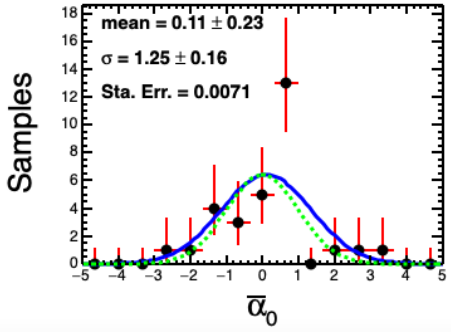






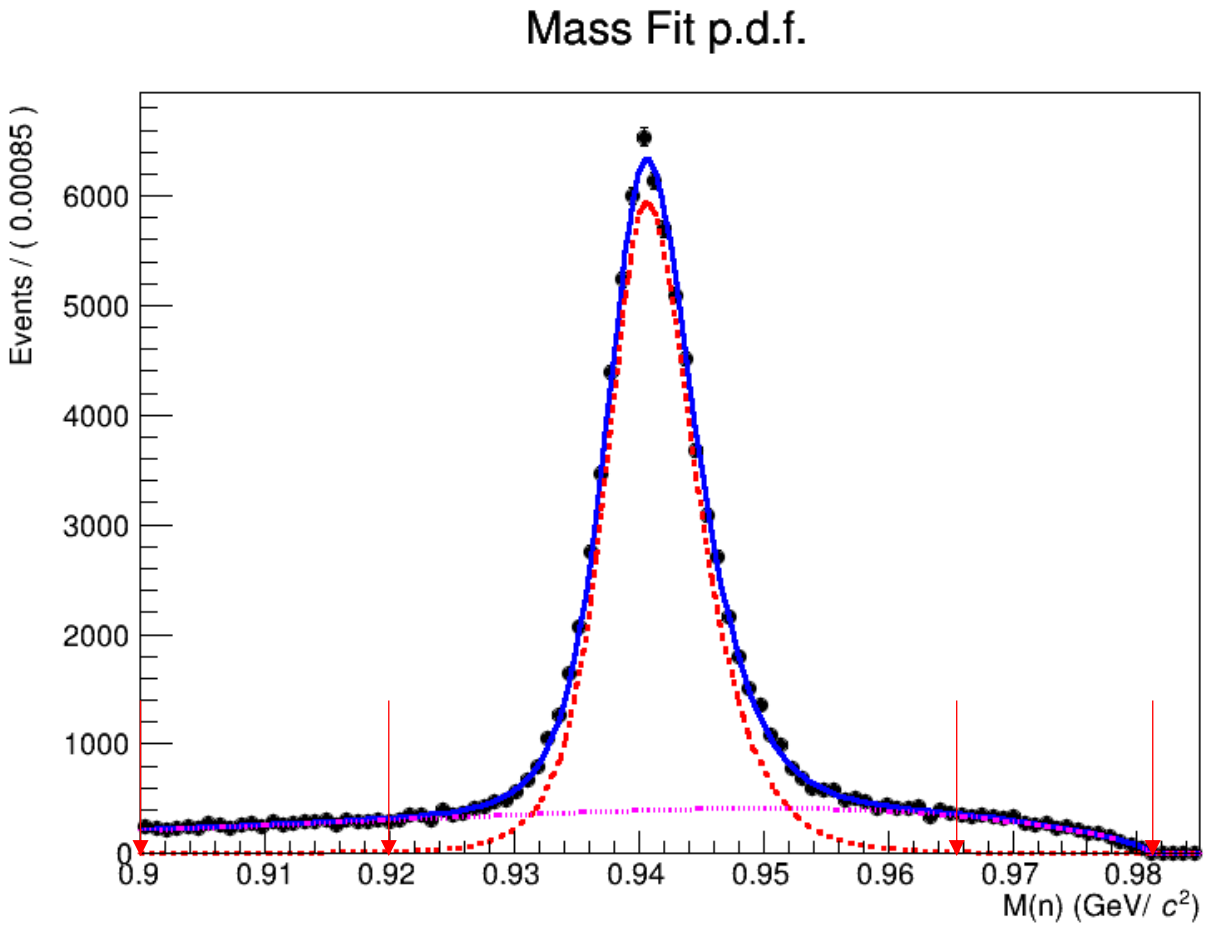




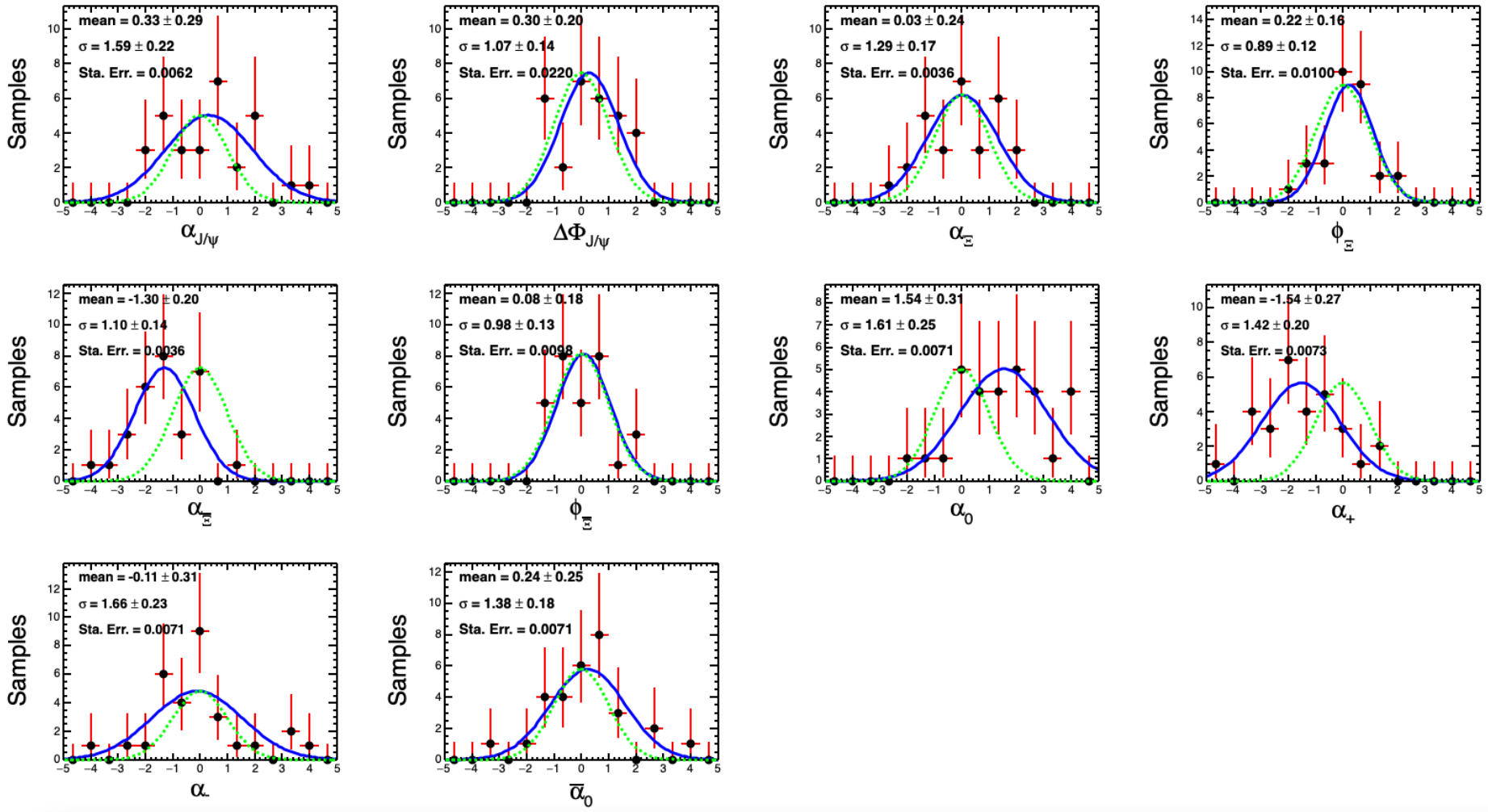


Using sideband method to estimate the background

- Definition of sideband
  $0.90 < M(n) < 0.92$
  $0.965 < M(n) < 0.981$



Using sideband method to estimate the background



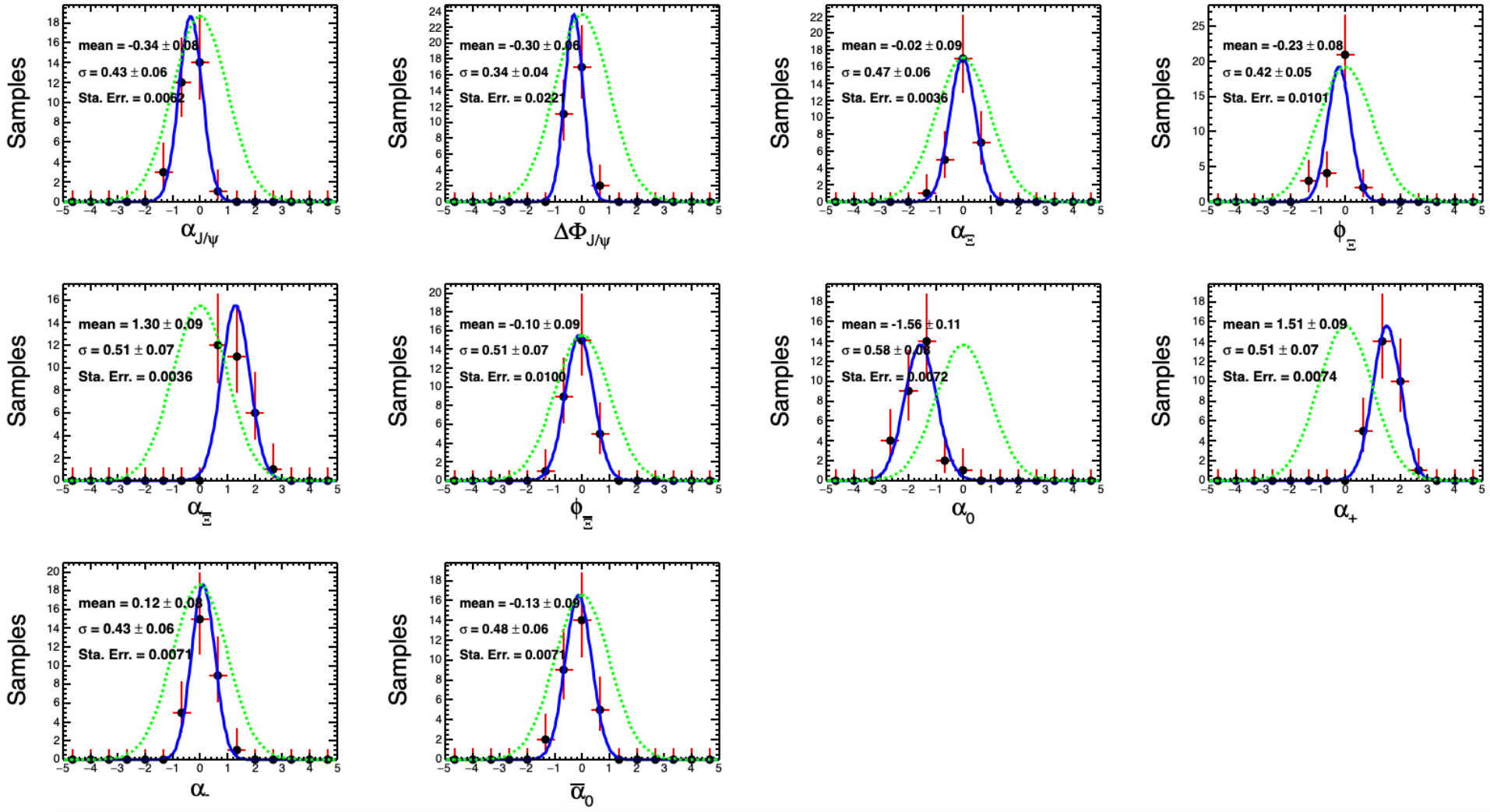
Difference between mDIY and sideband

In each sample

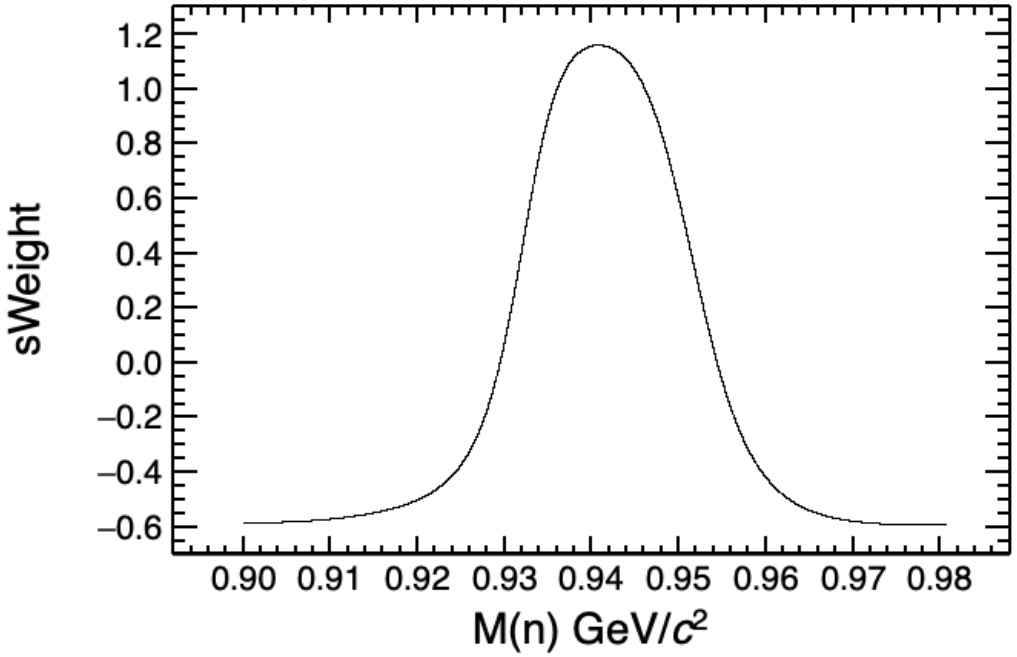
$$diff = \frac{V_1 - V_2}{err_1}$$

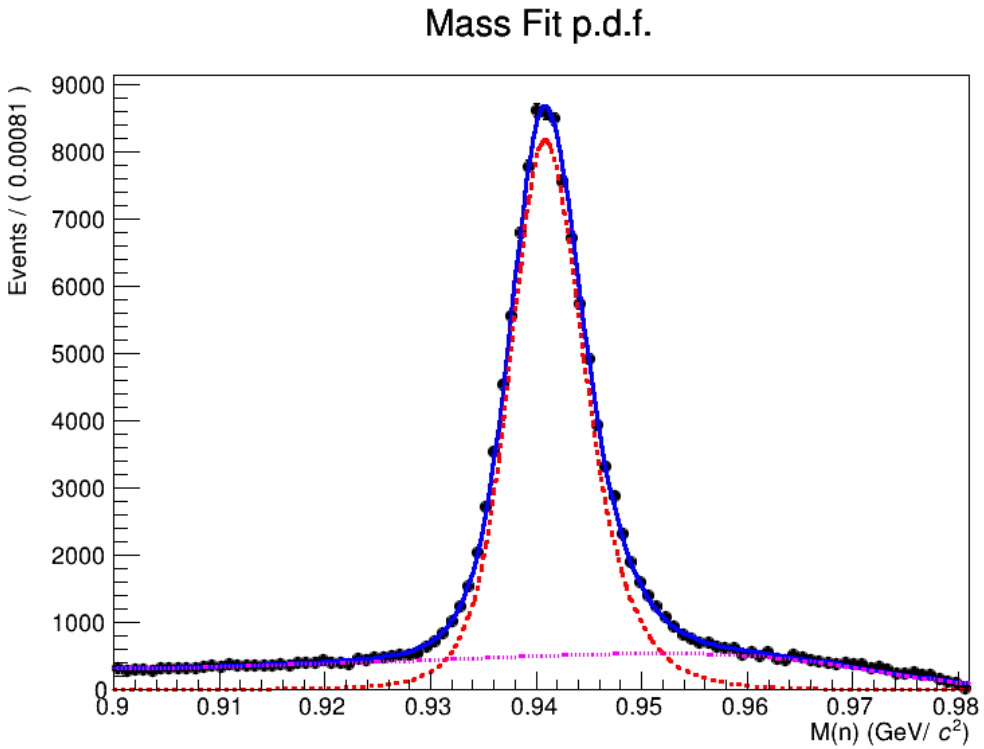
V1 is mDIY results

V2 is sideband results

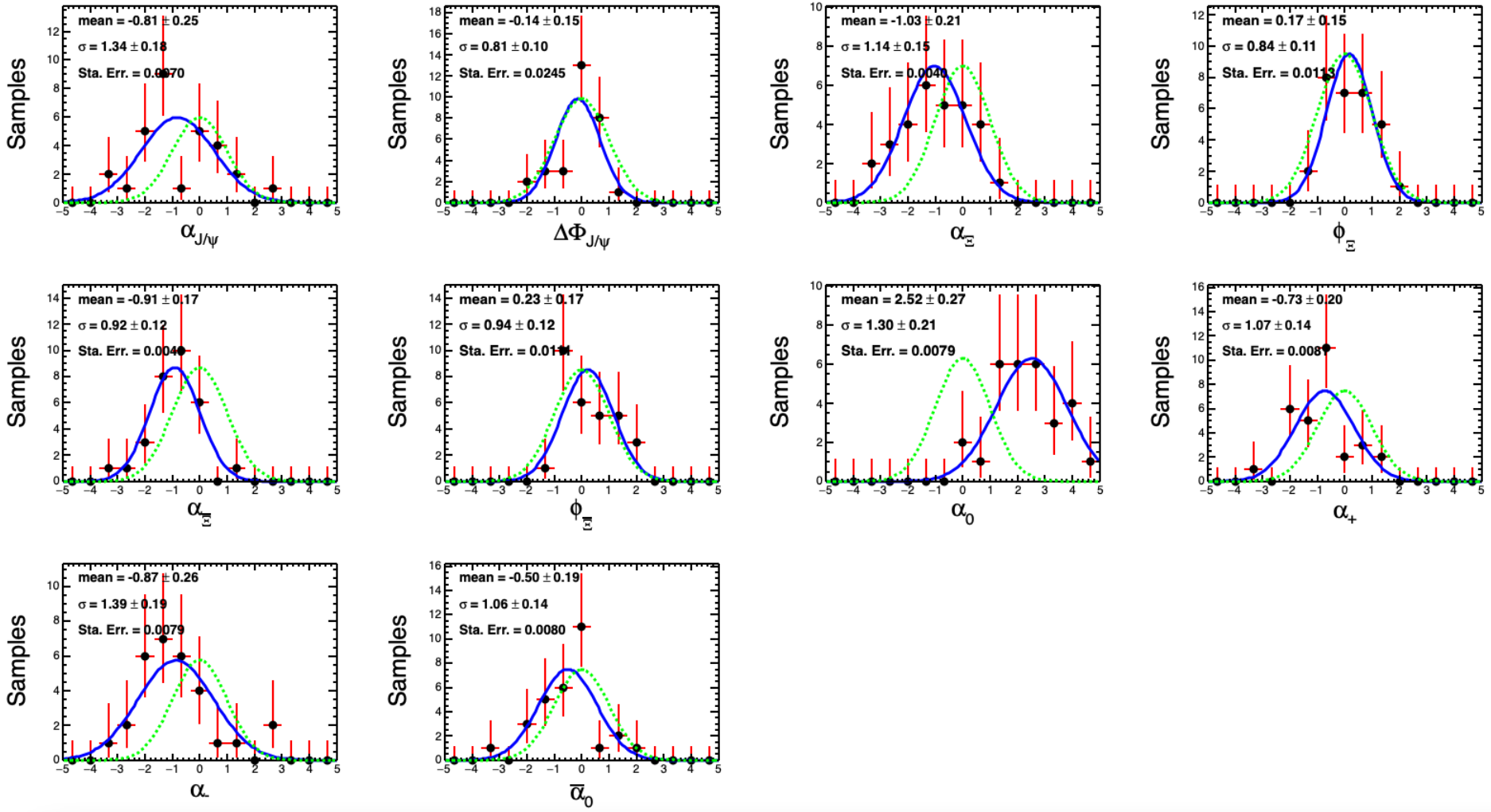


Using sWeight to estimate the background

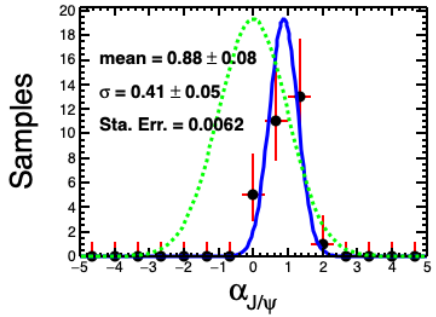


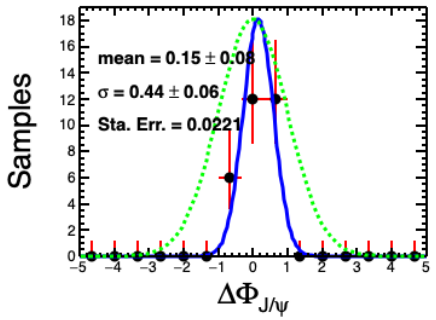


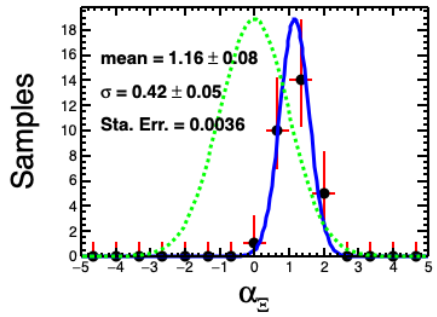
Using sWeight to estimate the background

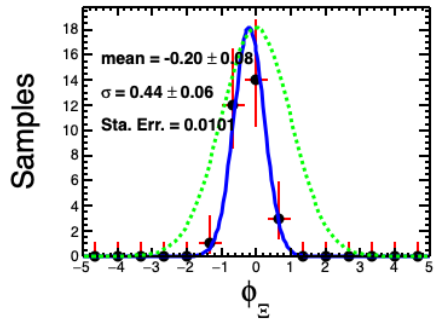


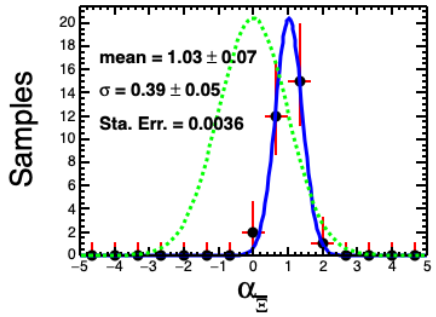
Difference between mDIY and sWeight

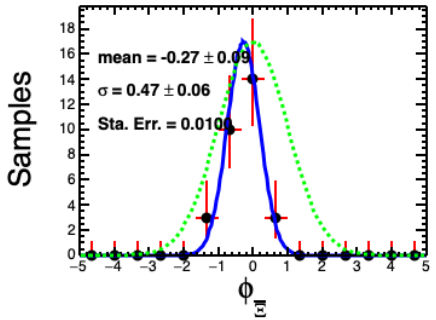


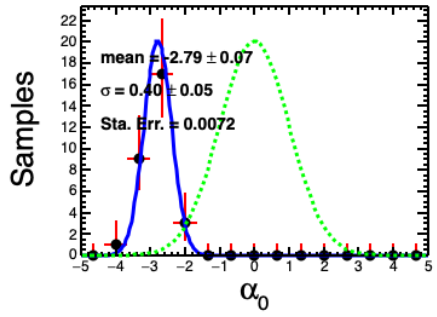


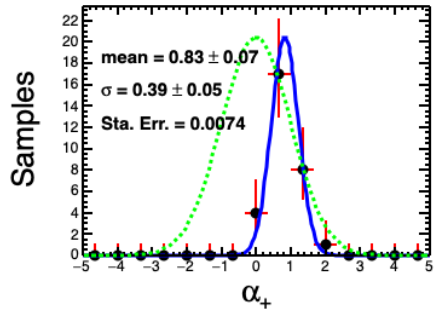


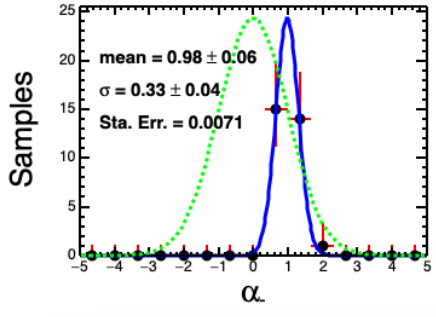


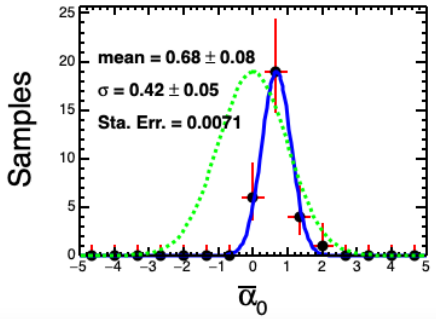












Backup

Using sideband method to estimate the background