I/O Check of Angular Fit of $J/\psi \to \Lambda\bar{\Lambda}$

$$J/\psi \to \bar{\Lambda}(\to \bar{p}\pi^{+})\Lambda(\to n\pi^{0}), \qquad Measure\ \alpha_0$$

$$J/\psi \to \Lambda(\to p\pi^{-})\bar{\Lambda}(\to \bar{n}\pi^{0}), \qquad Measure\ \bar{\alpha}_0$$

裴宇鹏

Simply Introduction (4 Parameter)

- **Measure $A_{CP} = \frac{\alpha_0+\bar{\alpha}_0}{\alpha_0-\bar{\alpha}_0}$ to do CP test**
- **Production Parameter of spin-1/2 baryon at $c\bar{c}$:** Angular distribution parameter α_ψ and relative phase $\Delta\Phi$
- **Decay Parameter for 2-body decays:** Decay parameter α_0 and $\bar{\alpha}_0$
- Joint angular distribution: $(\xi = (\theta, \theta_n, \phi_n, \theta_{\bar{n}}, \phi_{\bar{n}}))$

Unpolarised part　Polarised part　Spin correlated part

$$W(\xi) = \mathcal{T}_0(\xi) + \alpha_\psi \mathcal{T}_5(\xi) - \alpha\bar{\alpha}\left[\mathcal{T}_1(\xi) + \sqrt{1-\alpha_\psi^2}\cos(\Delta\Phi)\,\mathcal{T}_2(\xi) + \alpha_\psi \mathcal{T}_6(\xi)\right] + \sqrt{1-\alpha_\psi^2}\sin(\Delta\Phi)\left[\alpha\mathcal{T}_3(\xi) - \bar{\alpha}\mathcal{T}_4(\xi)\right]$$

Table 1 | Summary of the results

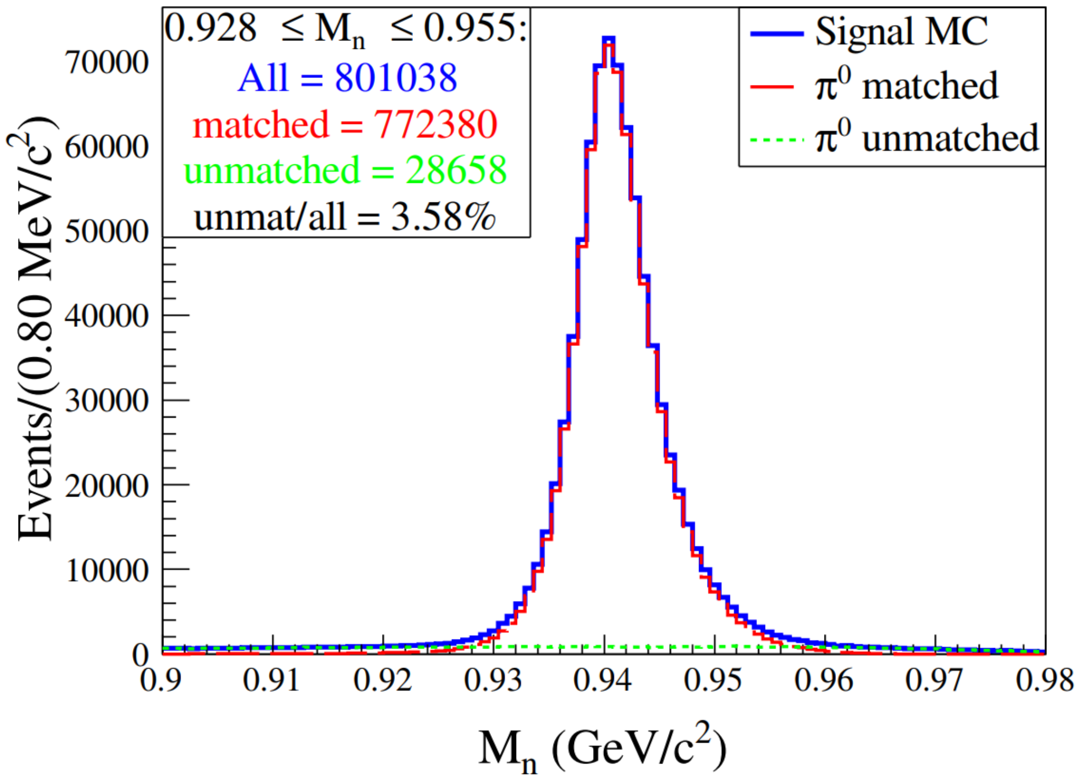
Parameters	This work	Previous results
α_ψ	$0.461 \pm 0.006 \pm 0.007$	0.469 ± 0.027 (ref. [14])
$\Delta\Phi$	$42.4 \pm 0.6 \pm 0.5°$	-
α_-	$0.750 \pm 0.009 \pm 0.004$	0.642 ± 0.013 (ref. [6])
α_+	$-0.758 \pm 0.010 \pm 0.007$	-0.71 ± 0.08 (ref. [6])
$\bar{\alpha}_0$	$-0.692 \pm 0.016 \pm 0.006$	-
A_{CP}	$-0.006 \pm 0.012 \pm 0.007$	0.006 ± 0.021 (ref. [6])
$\bar{\alpha}_0/\alpha_+$	$0.913 \pm 0.028 \pm 0.012$	-

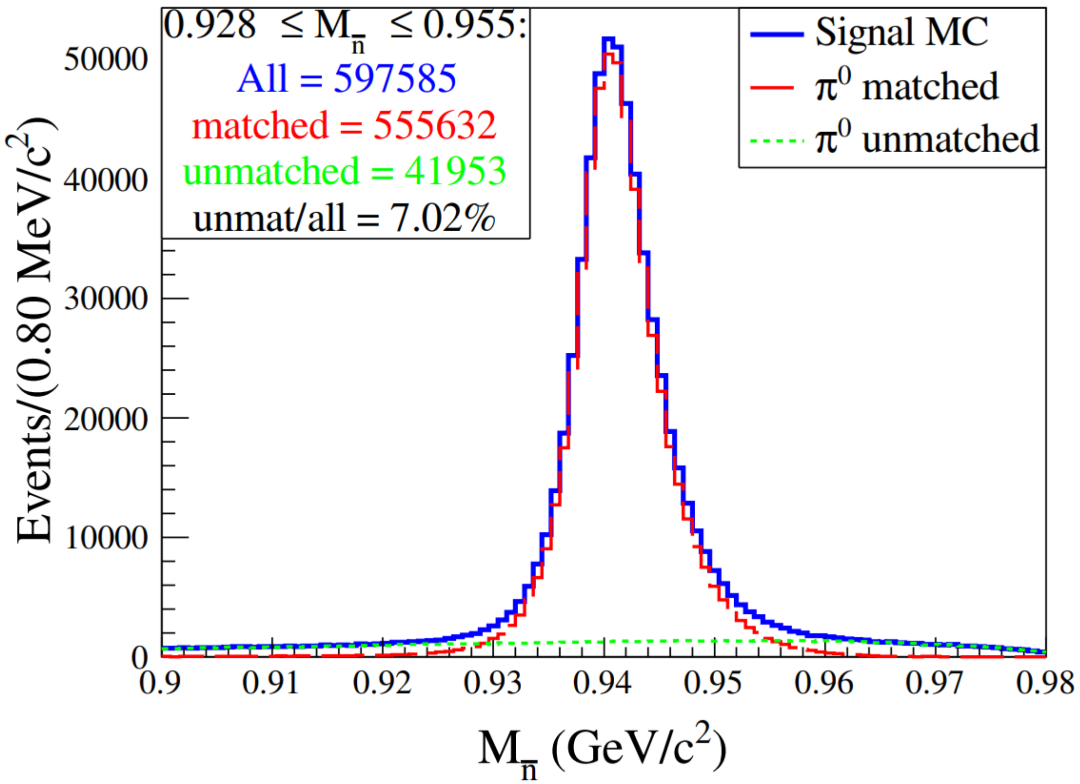
Parameters: $J/\psi \to \Lambda\bar{\Lambda}$ angular distribution parameter α_ψ, helicity phase $\Delta\Phi$, asymmetry parameters for the $\Lambda \to p\pi^-$ (α_-), $\bar{\Lambda} \to \bar{p}\pi^+$ (α_+) and $\bar{\Lambda} \to \bar{n}\pi^0$ ($\bar{\alpha}_0$) decays, CP asymmetry A_{CP} and ratio $\bar{\alpha}_0/\alpha_+$. The first uncertainty is 1 s.d. statistical, and the second is systematic, calculated as described in the Methods.

	A_{CP}	Value
Λ	$\frac{\alpha(\Lambda \to n\pi^0) + \alpha(\bar{\Lambda} \to \bar{n}\pi^0)}{\alpha(\Lambda \to n\pi^0) - \alpha(\bar{\Lambda} \to \bar{n}\pi^0)}$	Not be measured
	$\frac{\alpha(\Lambda \to p\pi^-) + \alpha(\bar{\Lambda} \to \bar{p}\pi^+)}{\alpha(\Lambda \to p\pi^-) - \alpha(\bar{\Lambda} \to \bar{p}\pi^+)}$	$-0.0025 \pm 0.0046 \pm 0.0011$ $-0.006 \pm 0.012 \pm 0.007$
Σ^+	$\frac{\alpha(\Sigma^+ \to p\pi^0) + \alpha(\bar{\Sigma}^- \to \bar{p}\pi^0)}{\alpha(\Sigma^+ \to p\pi^0) - \alpha(\bar{\Sigma}^- \to \bar{p}\pi^0)}$	$-0.004 \pm 0.037 \pm 0.011$
	$\frac{\alpha(\Sigma^+ \to n\pi^+) + \alpha(\bar{\Sigma}^- \to \bar{n}\pi^-)}{\alpha(\Sigma^+ \to n\pi^+) - \alpha(\bar{\Sigma}^- \to \bar{n}\pi^-)}$	$-0.049 \pm 0.054 \pm 0.030$
Ξ^-	$\frac{\alpha(\Xi^- \to \Lambda\pi^-) + \alpha(\bar{\Xi}^+ \to \bar{\Lambda}\pi^+)}{\alpha(\Xi^- \to \Lambda\pi^-) - \alpha(\bar{\Xi}^+ \to \bar{\Lambda}\pi^+)}$	$-0.004 \pm 0.012 \pm 0.007$
Ξ^0	$\frac{\alpha(\Xi^0 \to \Lambda\pi^0) + (\bar{\Xi}^0 \to \bar{\Lambda}\pi^0)}{\alpha(\Xi^0 \to \Lambda\pi^0) - (\bar{\Xi}^0 \to \bar{\Lambda}\pi^0)}$	$0.0022 \pm 0.0061 \pm 0.0013$

Simply Introduction

- Event selection of $J/\psi \to \bar{\Lambda}(\to \bar{p}\pi^+)\Lambda(\to n\pi^0)$ and $J/\psi \to \Lambda(\to p\pi^-)\bar{\Lambda}(\to \bar{n}\pi^0)$ is performed and the optimization have done.
- The main background comes from **self-mis-combined background,** but some different:
  - $n\pi^0$ channel: Mis-identification of **neutron showers**;
  - $\bar{n}\pi^0$ channel: **Secondary shower** related of anti-neutron.
- After event selection, the self-BKG is **3.58%** and **7.02%** of $n\pi^0$ and $\bar{n}\pi^0$ in signal region.





Parameter Estimation

- Maximum likelihood fit method is used to estimate the decay parameters.

$$\mathcal{S} = -ln\mathcal{L} = -\sum_{i=1}^{N_{sig}} ln\mathcal{W}(\xi_i,\alpha) + \frac{N_{bkg}}{N_{BKG}} \sum_{i=1}^{N_{BKG}} ln\mathcal{W}(\xi_i,\alpha) + (N_{sig} - N_{bkg})lnC^{-1}$$

$$C^{-1} = \int d\xi \mathcal{W}(\xi,\alpha)\epsilon(\xi) = \int d\xi \frac{\mathcal{W}(\xi,\alpha)}{\mathcal{W}(\xi,\alpha')} \boxed{\mathcal{W}(\xi,\alpha')\epsilon(\xi)} = E[\frac{\mathcal{W}(\xi,\alpha)}{\mathcal{W}(\xi,\alpha')}] = \frac{1}{N_{Toy}} \sum_{i=1}^{N_{Toy}} \frac{\mathcal{W}(\xi,\alpha)}{\mathcal{W}(\xi,\alpha')}$$

- N_{sig}: Events of data
- N_{bkg}: Events of background in signal region
- N_{BKG}: Events of a sample to estimate the background (mDIY exclusive MC or Sideband)
- $\mathcal{W}(\xi_i,\alpha)$: angular distribution
- $\mathcal{C}$: Normalization factor, estimated by mDIY Toy MC

- N_{Toy}: Events of mDIY toy MC
- α: Pending decay parameters of data
- α': Known decay parameters of toy MC

Outline

- Background Estimation
    - Exclusive MC to estimate BKG
    - Sideband Method to estimate BKG
- Simultaneous Fit
- A problem: Fit error in RooFit

Outline

- Background Estimation
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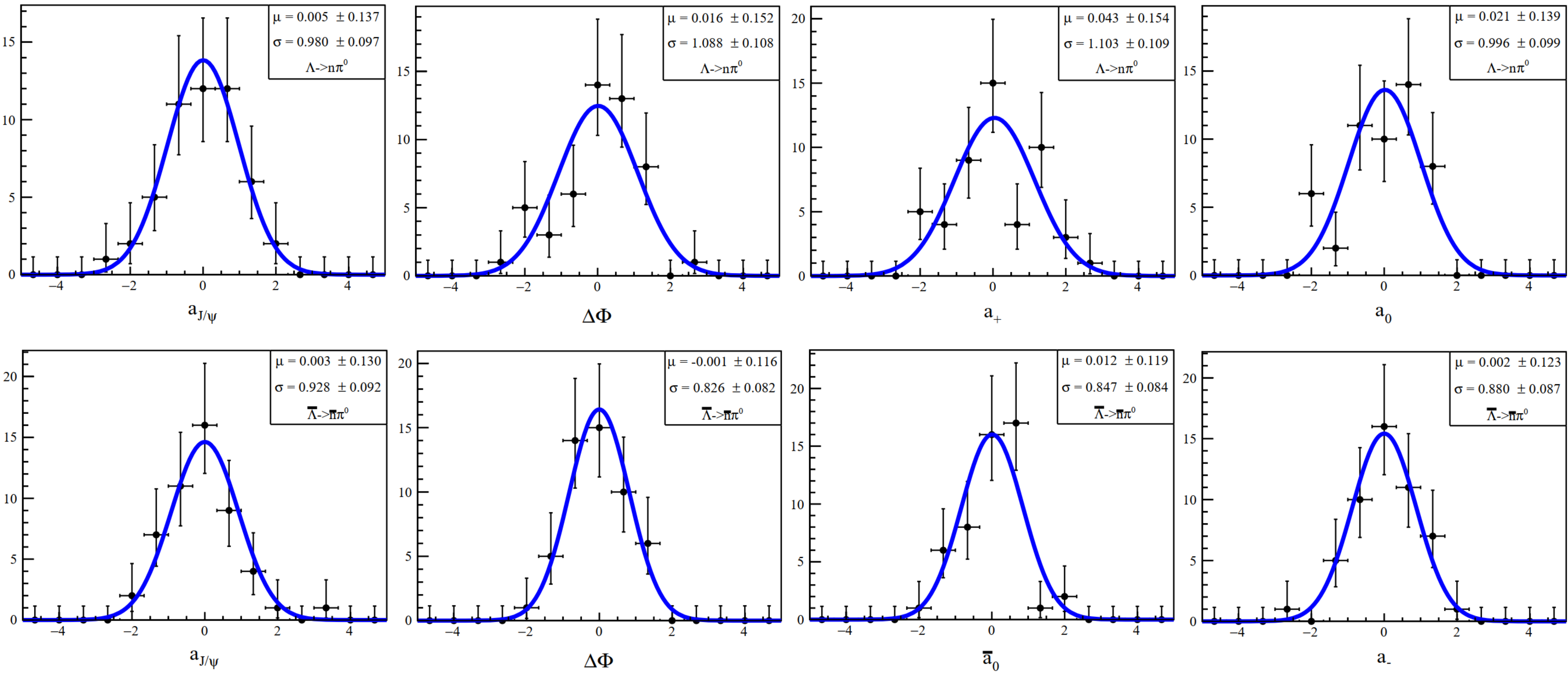
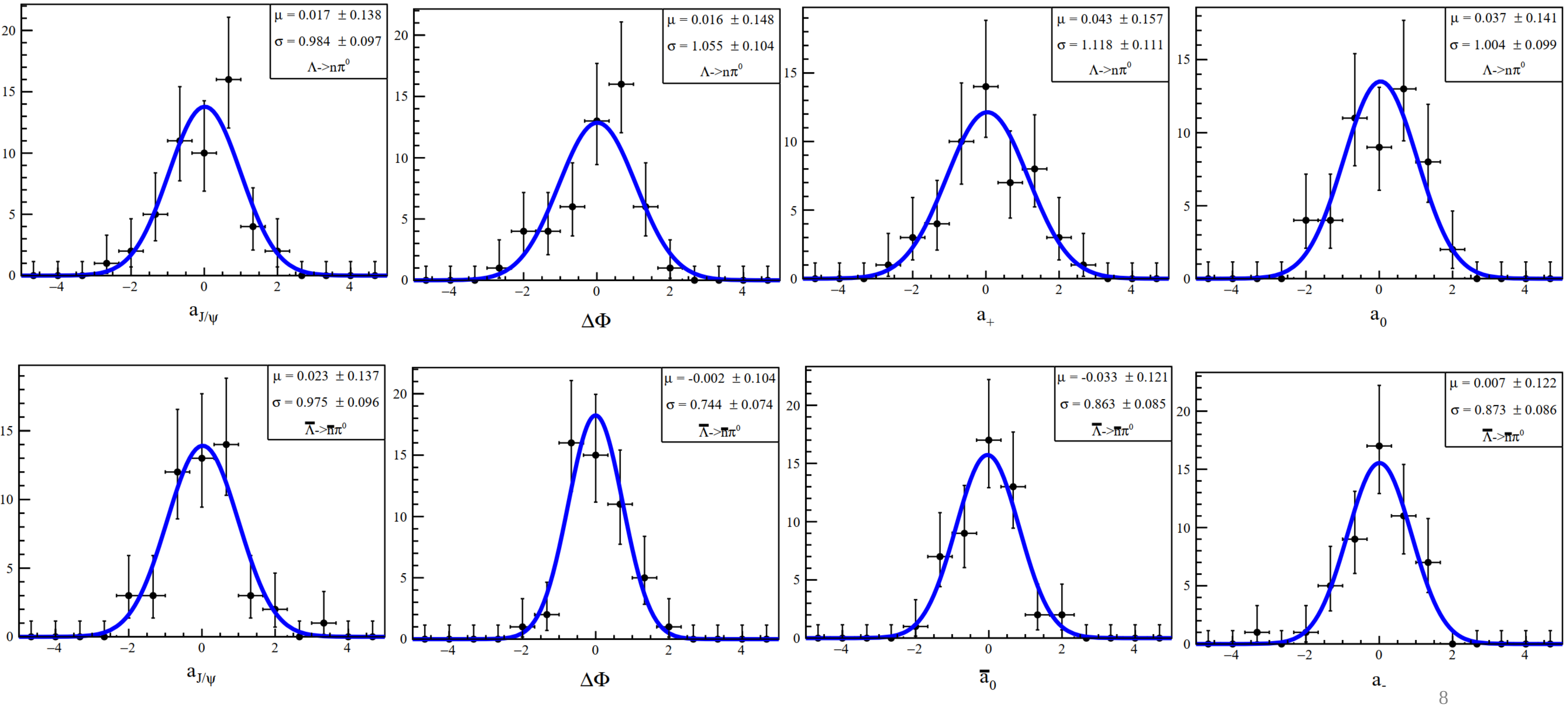
IO Check | No BKG (use matched MC)

50 independent samples (1x data) + 1 share mDIY integral MC (50x data)



IO Check | With BKG, use exclusive MC to estimate BKG

50 independent samples (1x data) + 1 share mDIY integral MC (50x data)



Outline

- Background Estimation
  - Exclusive MC to estimate BKG
  - Sideband Method to estimate BKG
- Simultaneous Fit
- A problem: Fit error in RooFit

Sideband Check (Just $\Lambda \to n\pi^0$)

16 moment distribution

3 regions in mass of n/n̄:

[0.9, 0.928] (Left Sideband), 4829

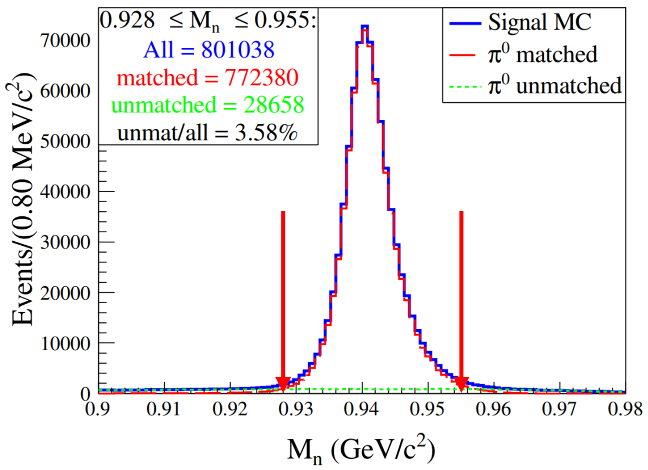
[0.928, 0.955] (Signal Region), 28195

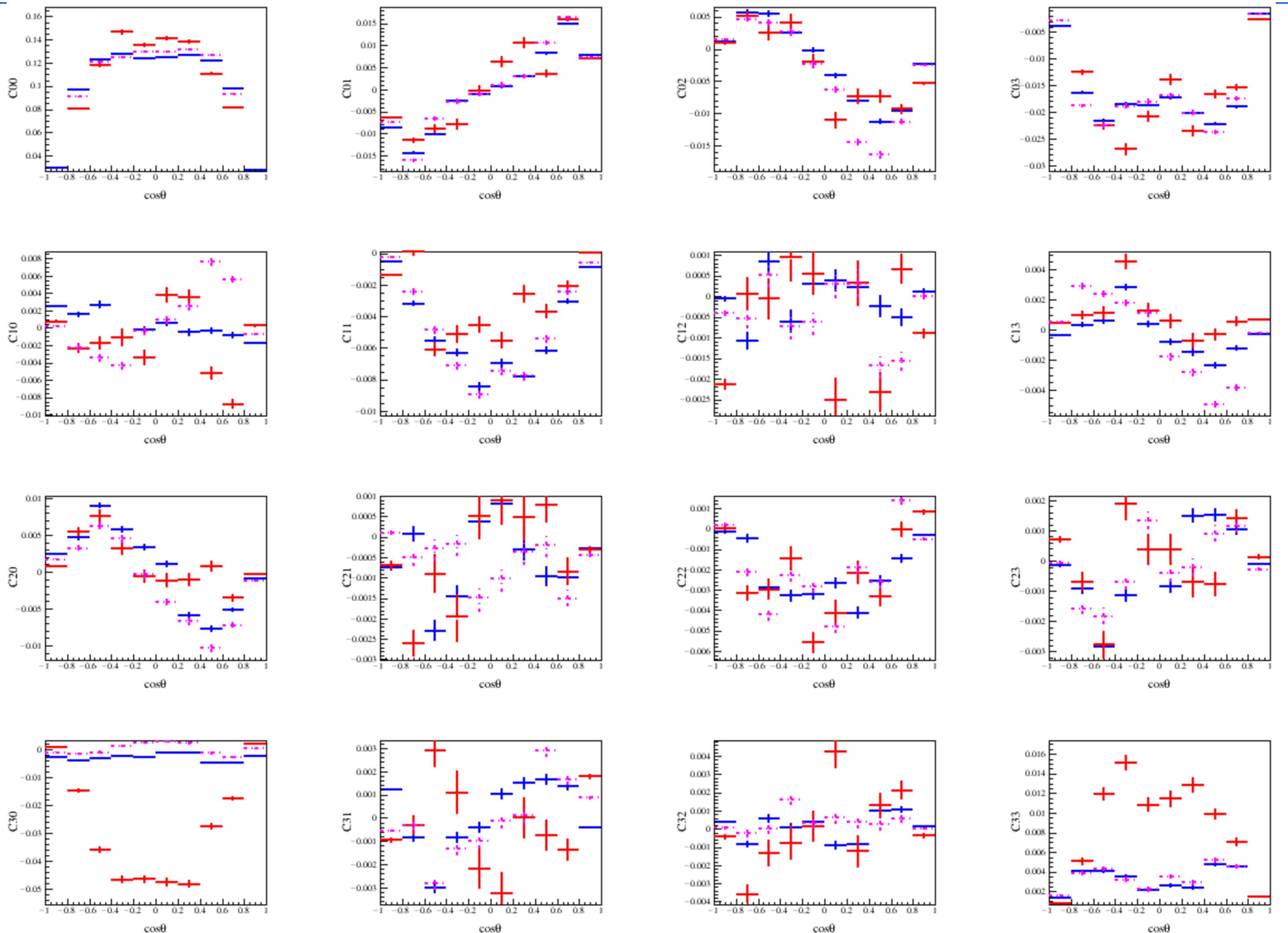
[0.955, 0.98] (Right Sideband). 19416

Left Sideband: Red

Signal Region: Blue

Right Sideband: Pink





Check 16 Moment of Signal and BKG in M_n

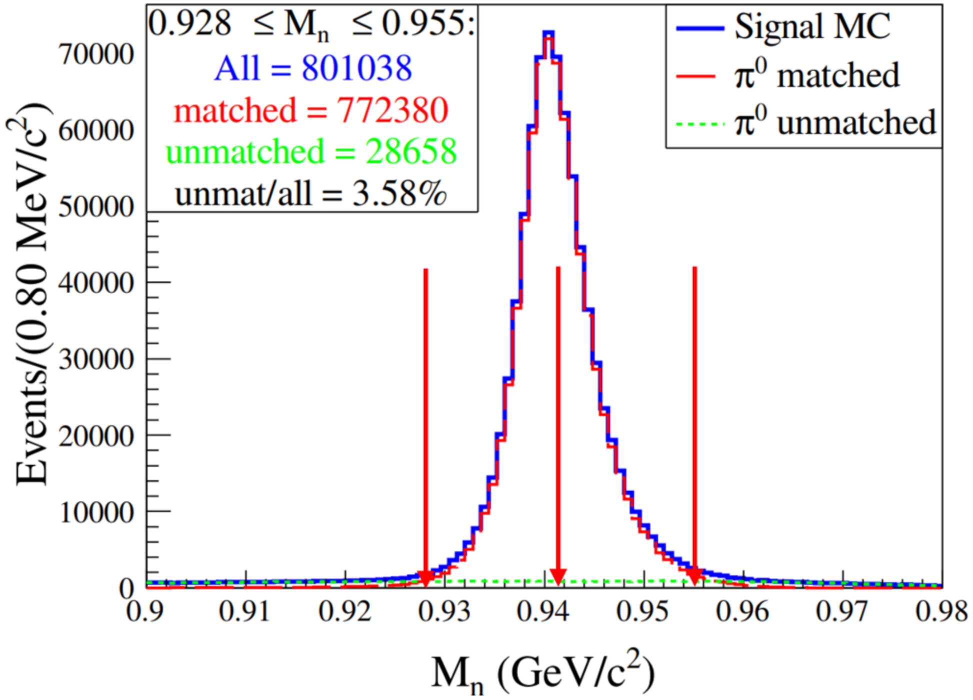
4 regions in mass of n/n̄:

[0.9, 0.928] (Left Sideband)

[0.928, 0.942] (Left Signal Region)

[0.942, 0.955] (Right Signal Region)

[0.955, 0.98] (Right Sideband).



	Left Sideband	Left Signal Region	Right Signal Region	Right Sideband
N_{sig}	4829	437806	336090	6547
N_{bkg}	26052	14050	14145	19416

SIG 16-mom

4 regions in mass of n/$\bar{n}$:

[0.9, 0.928] (Left Sideband)

[0.928, 0.942] (Left Signal Reg

[0.942, 0.955] (Right Signal Re

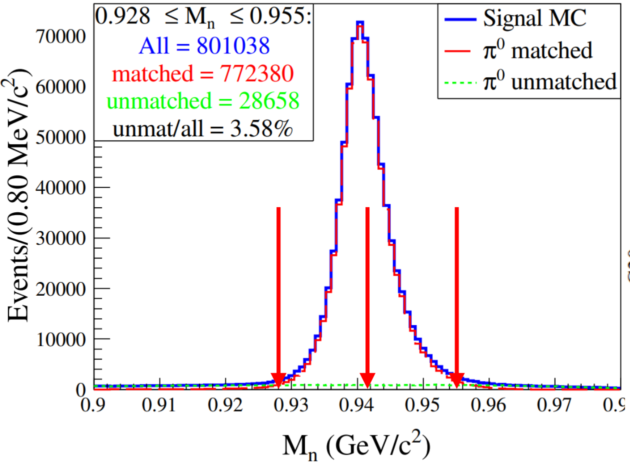
[0.955, 0.98] (Right Sideband).

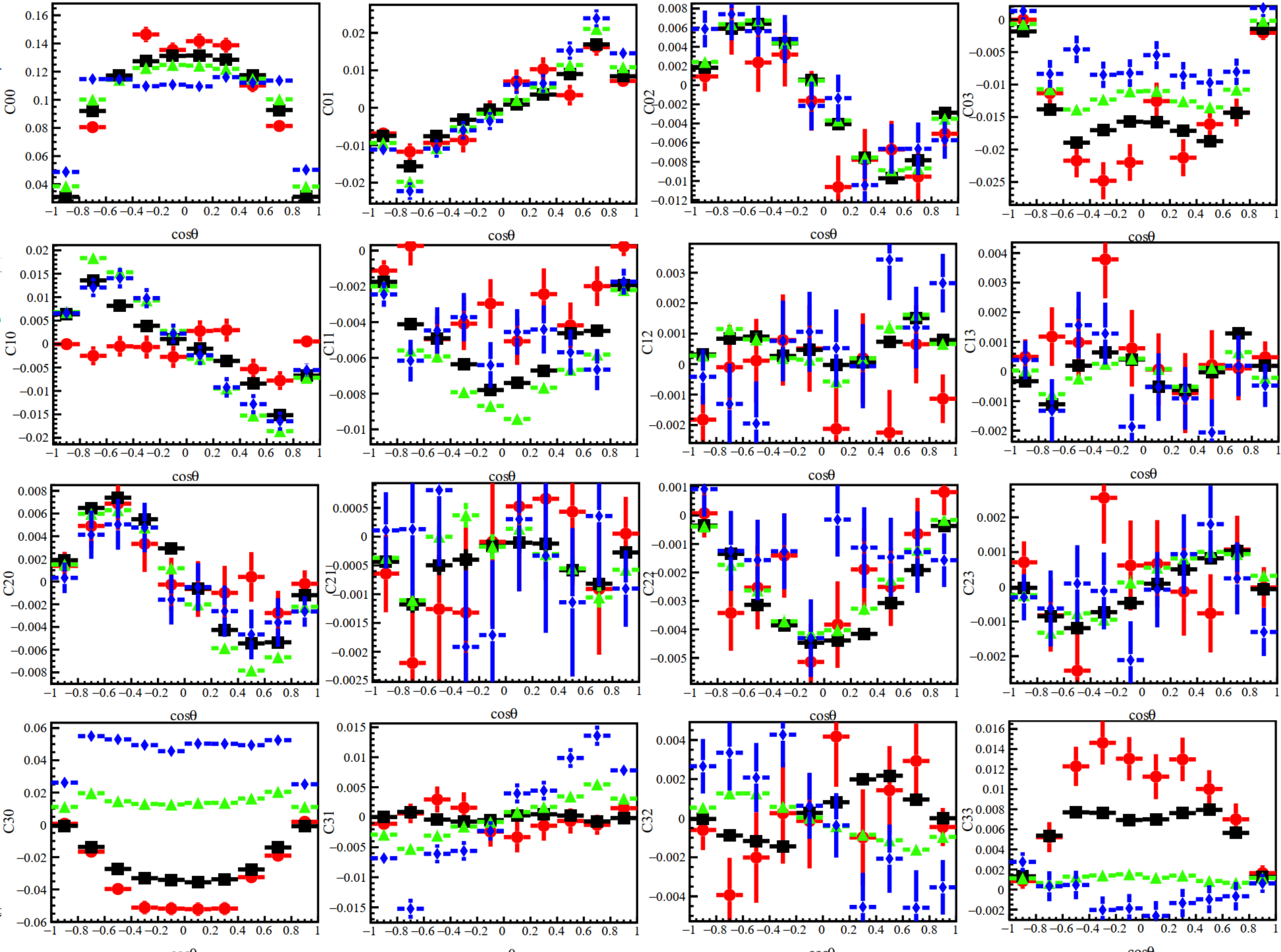
Left Sideband: Red

Left Signal Region: Black

Right Signal Region: Green

Right Sideband: Pink





BKG 16-mom

4 regions in mass of n/n̄:

[0.9, 0.928] (Left Sideband)

[0.928, 0.942] (Left Signal Regi

[0.942, 0.955] (Right Signal Re

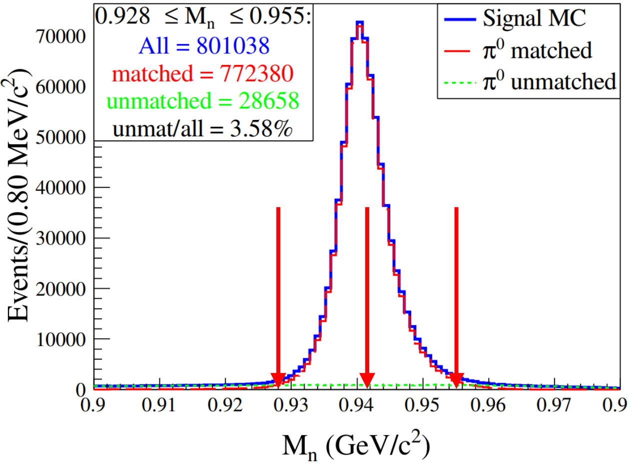
[0.955, 0.98] (Right Sideband).

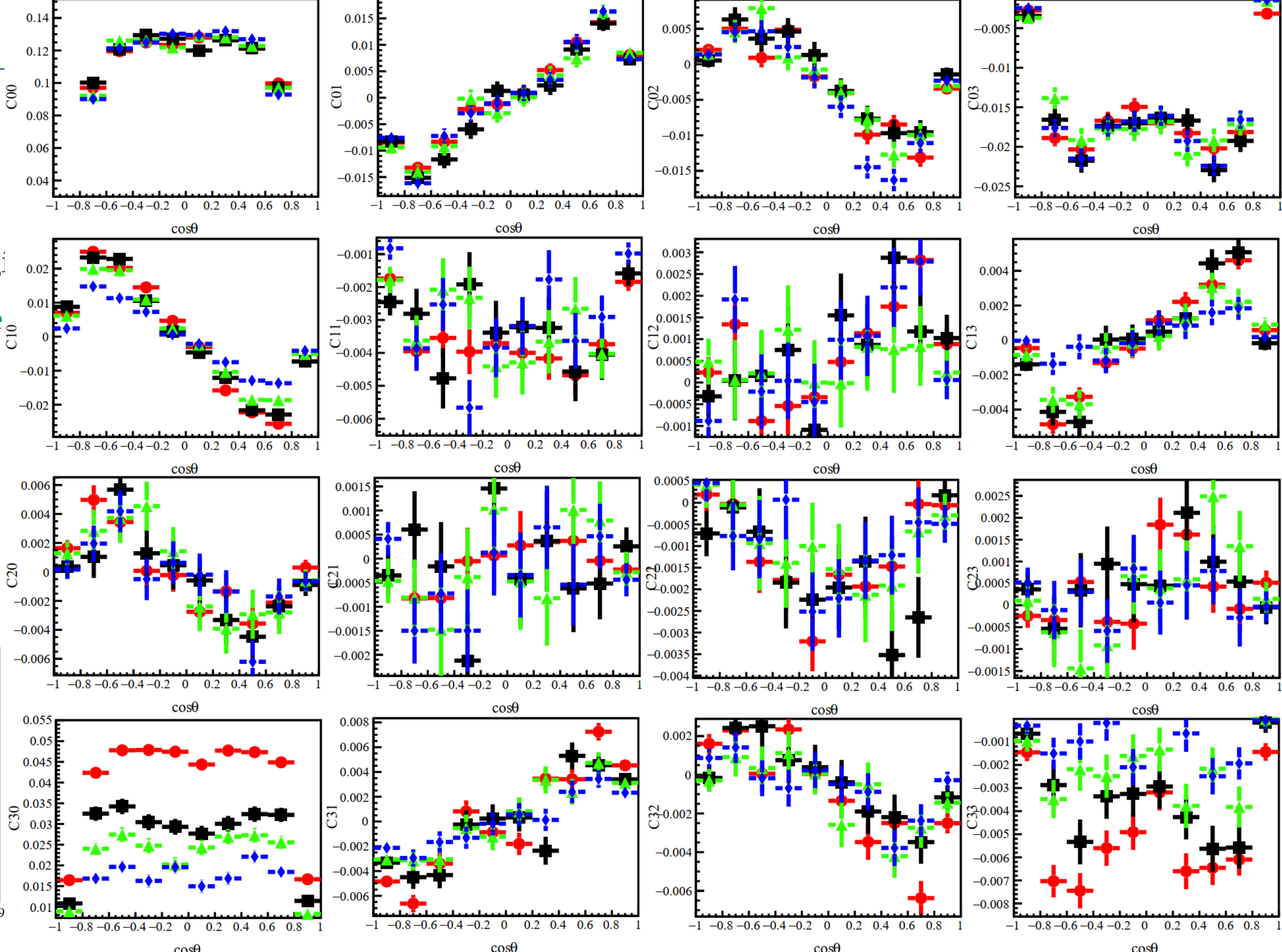
Left Sideband: Red

Left Signal Region: Black

Right Signal Region: Green

Right Sideband: Pink





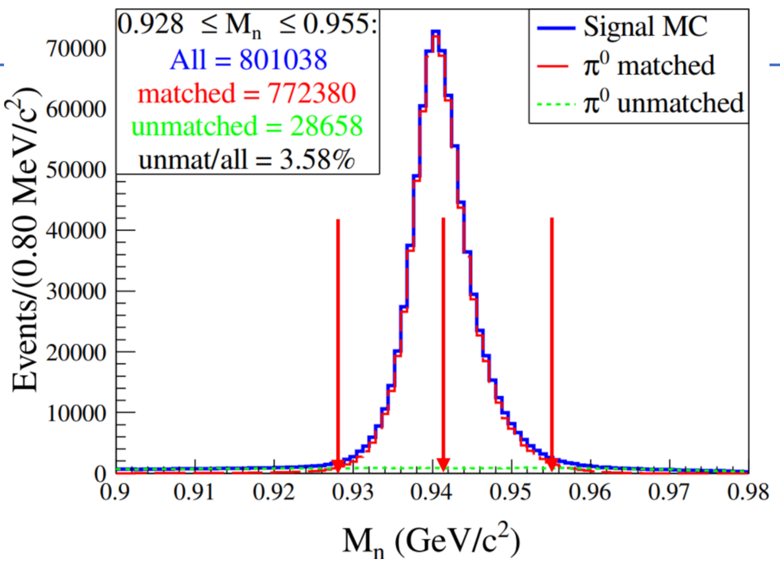
Neutron Truth Match Angle

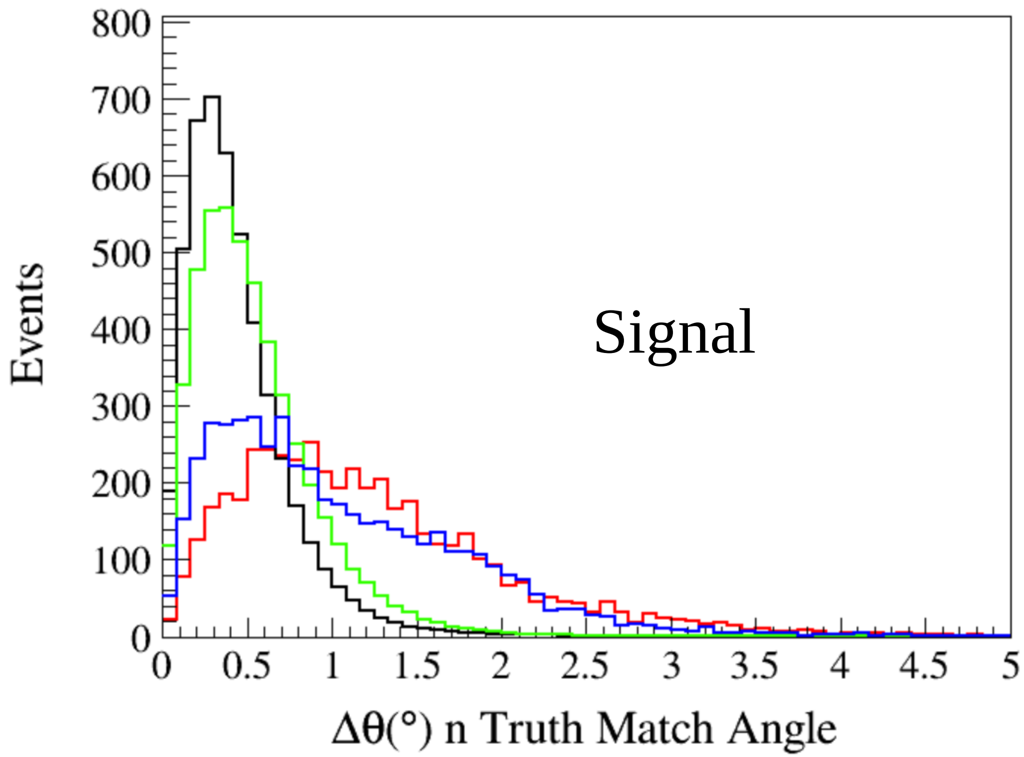
Left Sideband: Red

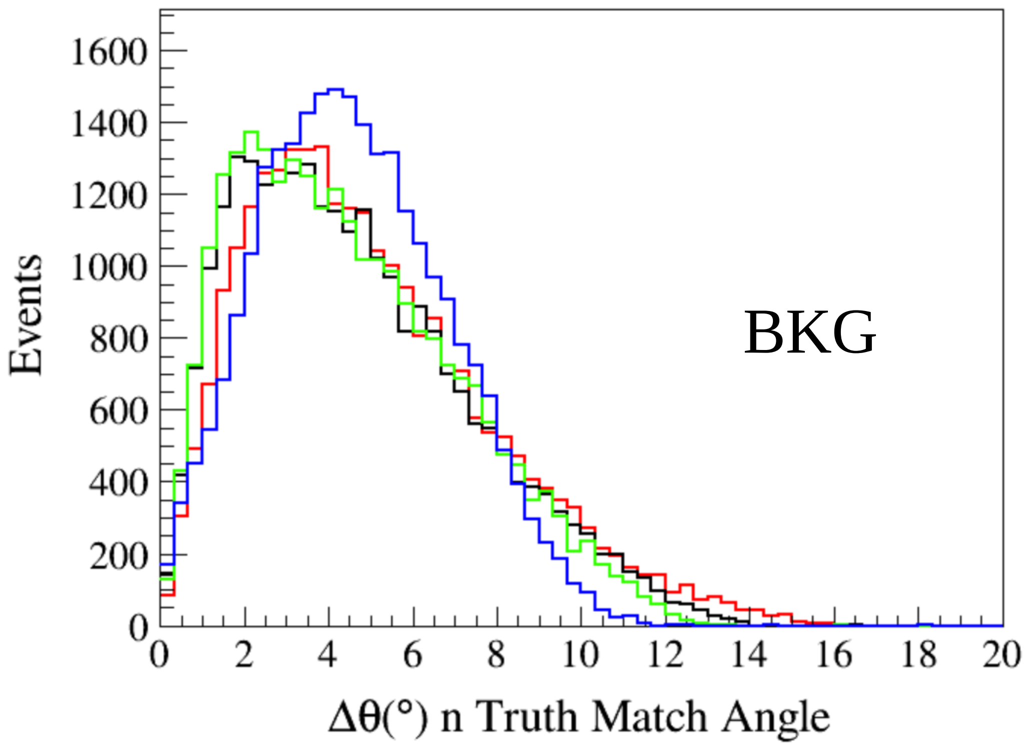
Left Signal Region: Black

Right Signal Region: Green

Right Sideband: Pink

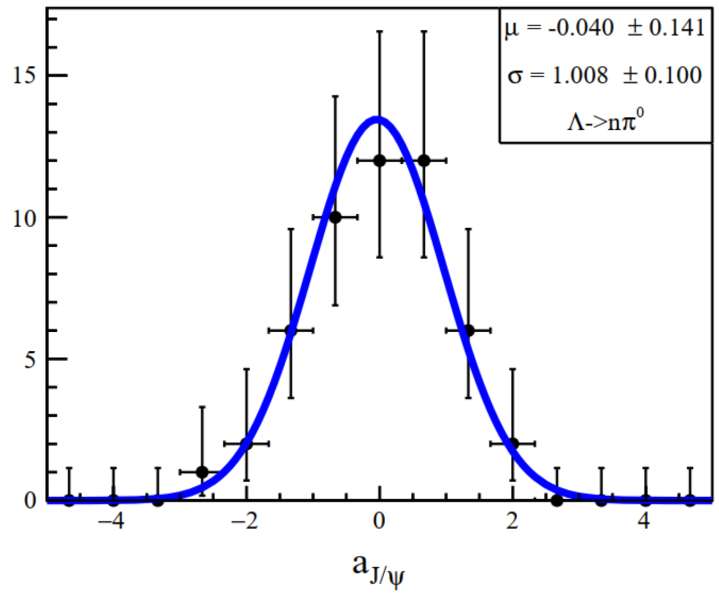


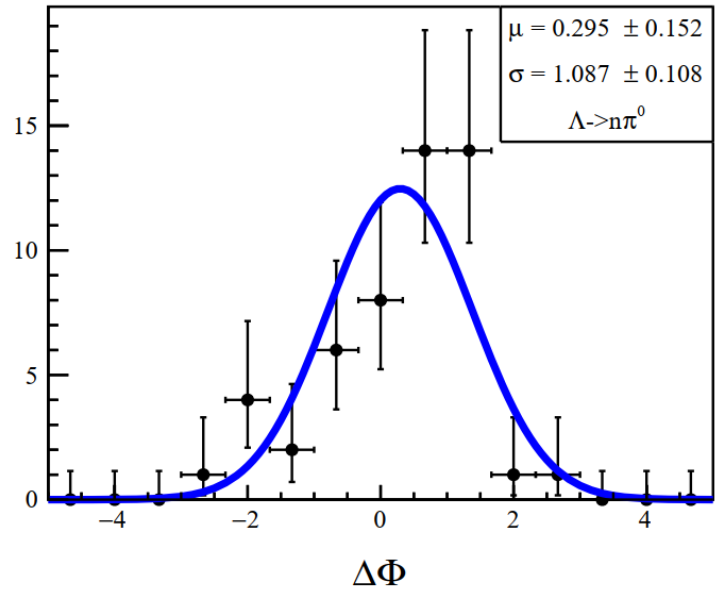


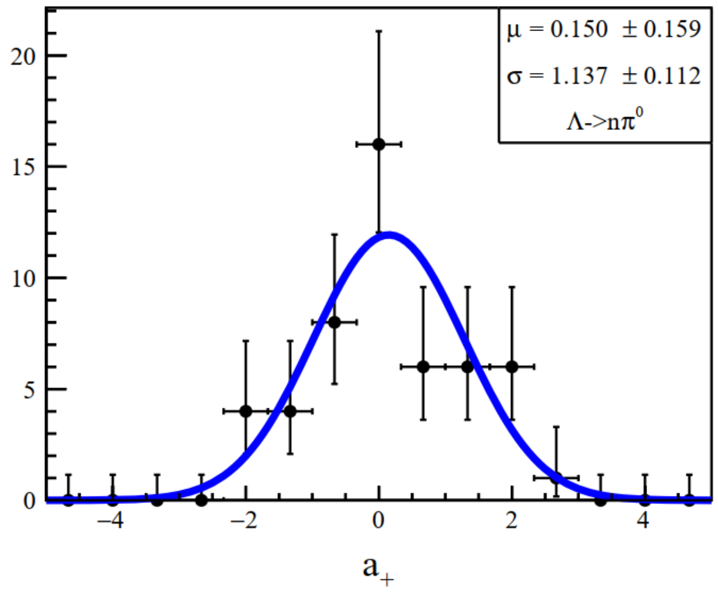


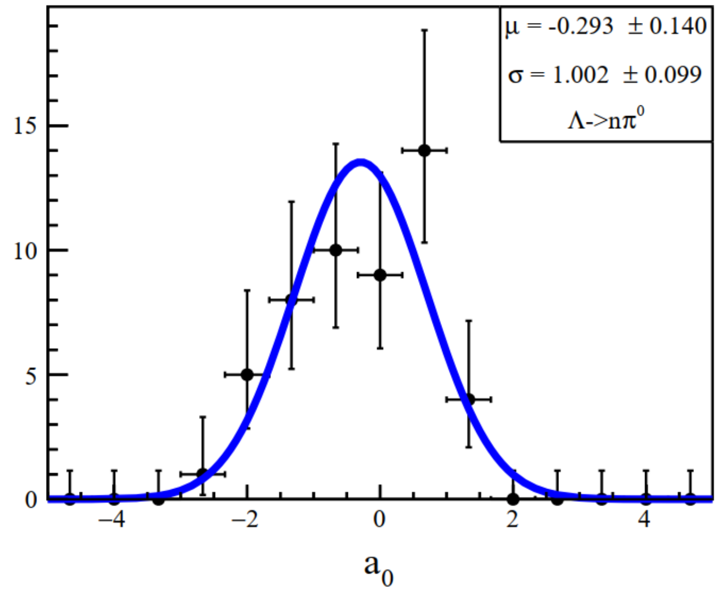
Fit Result (Use left and right sideband to estimate BKG)

50 independent samples (1x data) + 1 share mDIY integral MC (50x data)









Outline

- Background Estimation
  - Exclusive MC to estimate BKG
  - Sideband Method to estimate BKG
- Simultaneous Fit
- A problem: Fit error in RooFit

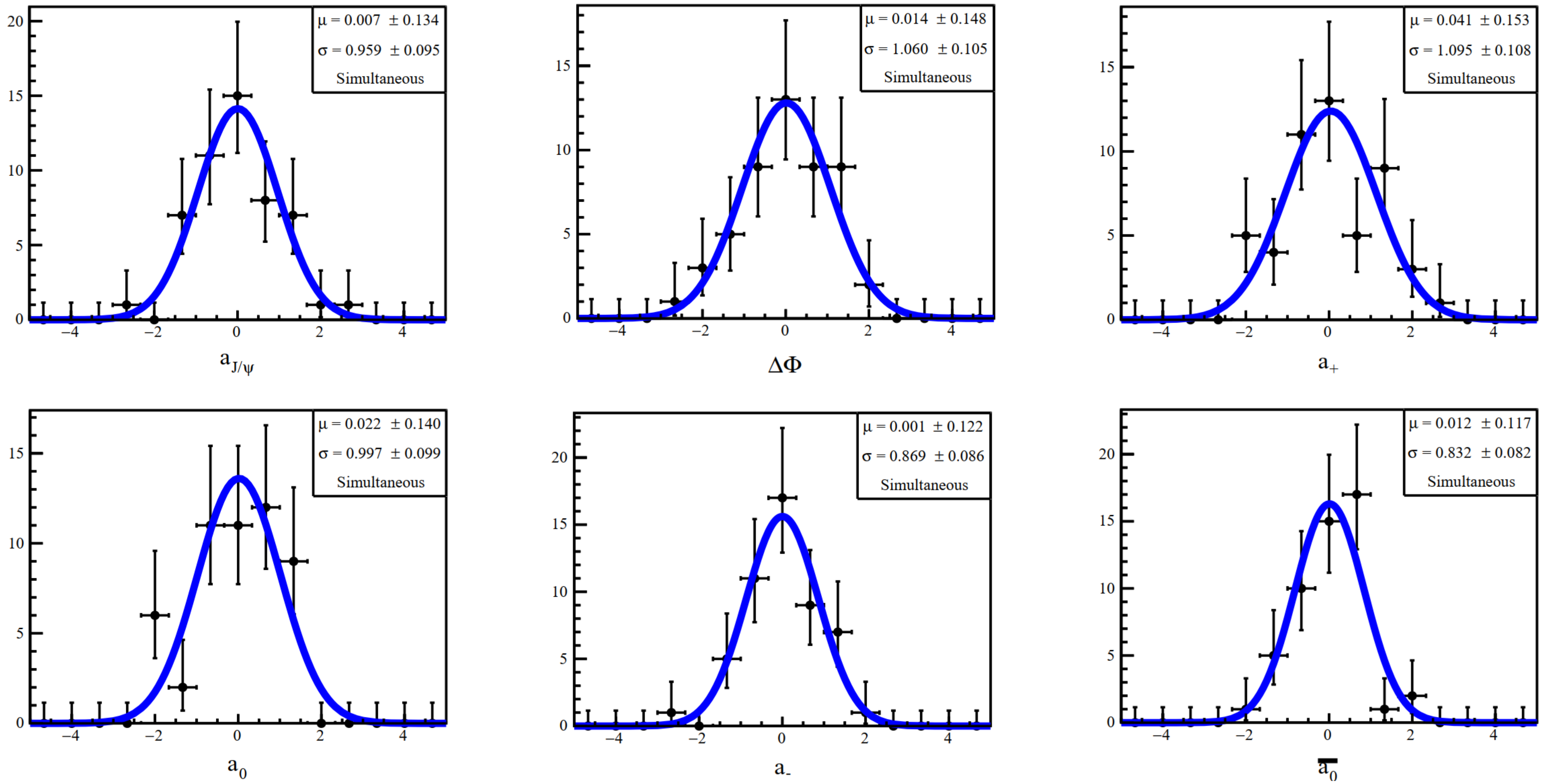
$J/\psi \to \bar{\Lambda}(\to \bar{p}\pi^+)\Lambda(\to \mathrm{n}\pi^0)$ use the angular Function $\mathcal{W}(\xi; \alpha_{J/\psi}, \Delta\Phi, \alpha_+, \alpha_0)$

$J/\psi \to \Lambda(\to p\pi^-)\Lambda(\to \bar{\mathrm{n}}\pi^0)$ use the angular Function $\mathcal{W}(\xi; \alpha_{J/\psi}, \Delta\Phi, \alpha_-, \bar{\alpha}_0)$

Share the $\alpha_{J/\psi}$ and $\Delta\Phi$

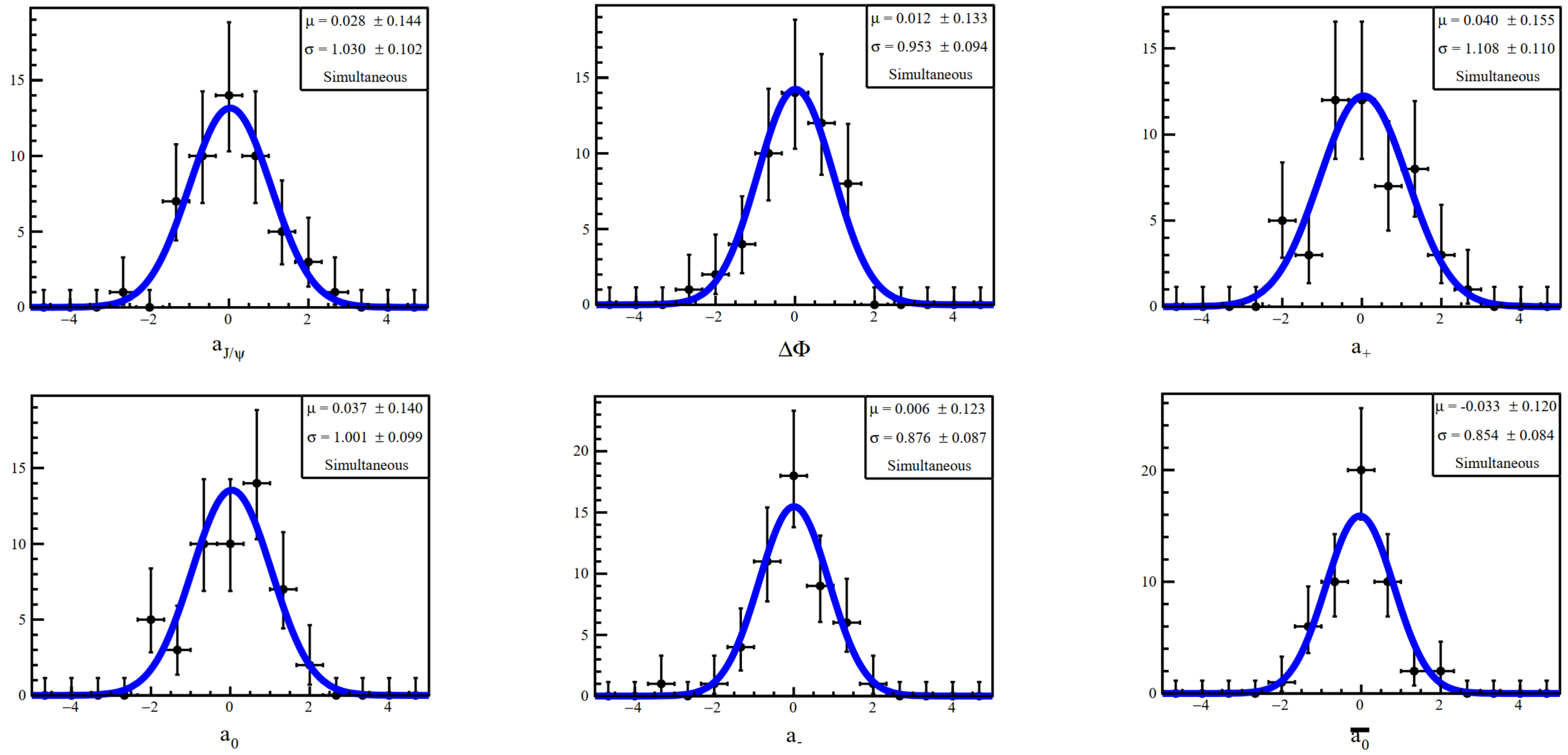
IO Check | Simultaneous Fit (No BKG)

50 independent samples (1x data) + 1 share mDIY integral MC (50x data)



IO Check | Simultaneous Fit (With BKG, use exclusive MC to estimate)

50 independent samples (1x data) + 1 share mDIY integral MC (50x data)



Outline

- Background Estimation
  - Exclusive MC to estimate BKG
  - Sideband Method to estimate BKG
- Simultaneous Fit
- A problem: Fit error in RooFit (How to calculate the fit error in a sub-range ?)

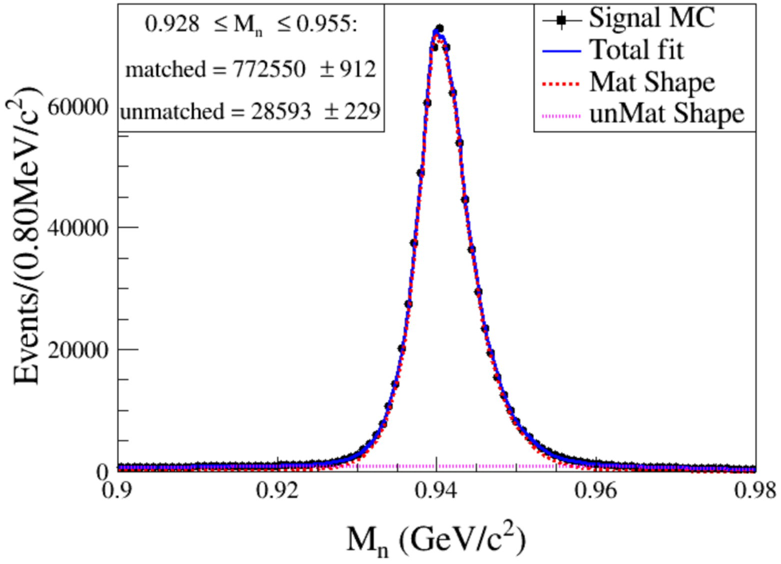
Fit Mass Check

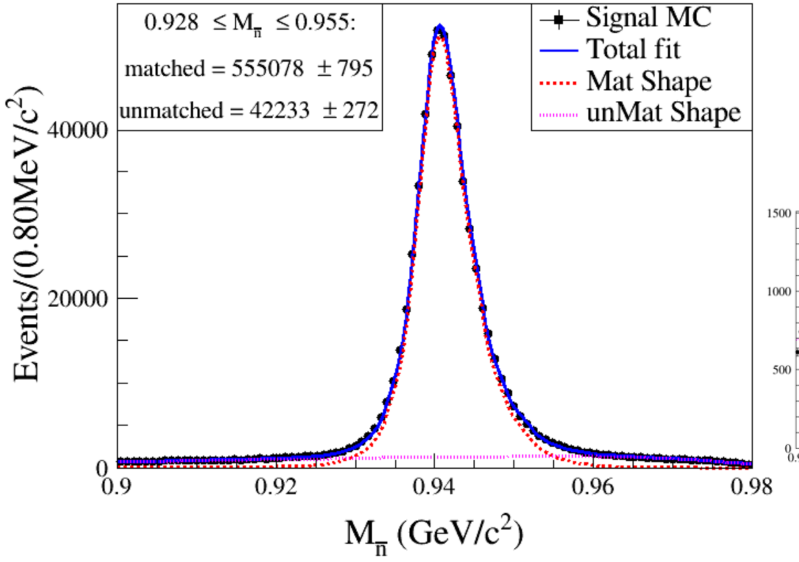
- Exclusive MC:
  - $J/\psi \to \bar{\Lambda}(\to \bar{p}\pi^+)\Lambda(\to n\pi^0)$ (use mDIY, 1×data)
  - $J/\psi \to \Lambda(\to p\pi^-)\bar{\Lambda}(\to \bar{n}\pi^0)$ (use mDIY, 1×data)

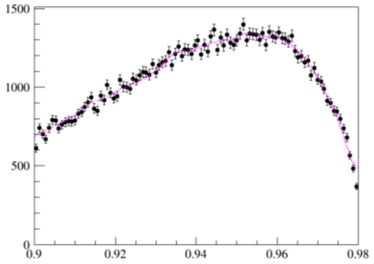
Difference just in random seed

- Signal MC:
  - $J/\psi \to \bar{\Lambda}(\to \bar{p}\pi^+)\Lambda(\to n\pi^0)$ (use mDIY, 1×data)
  - $J/\psi \to \Lambda(\to p\pi^-)\bar{\Lambda}(\to \bar{n}\pi^0)$ (use mDIY, 1×data)
- Fit Formular:

$$\boldsymbol{PDF} = \boldsymbol{Signal}\ (matched\ exclusive\ MC\ shape) + \boldsymbol{BKG}\ (unmatched\ exclusive\ MC\ shape)$$

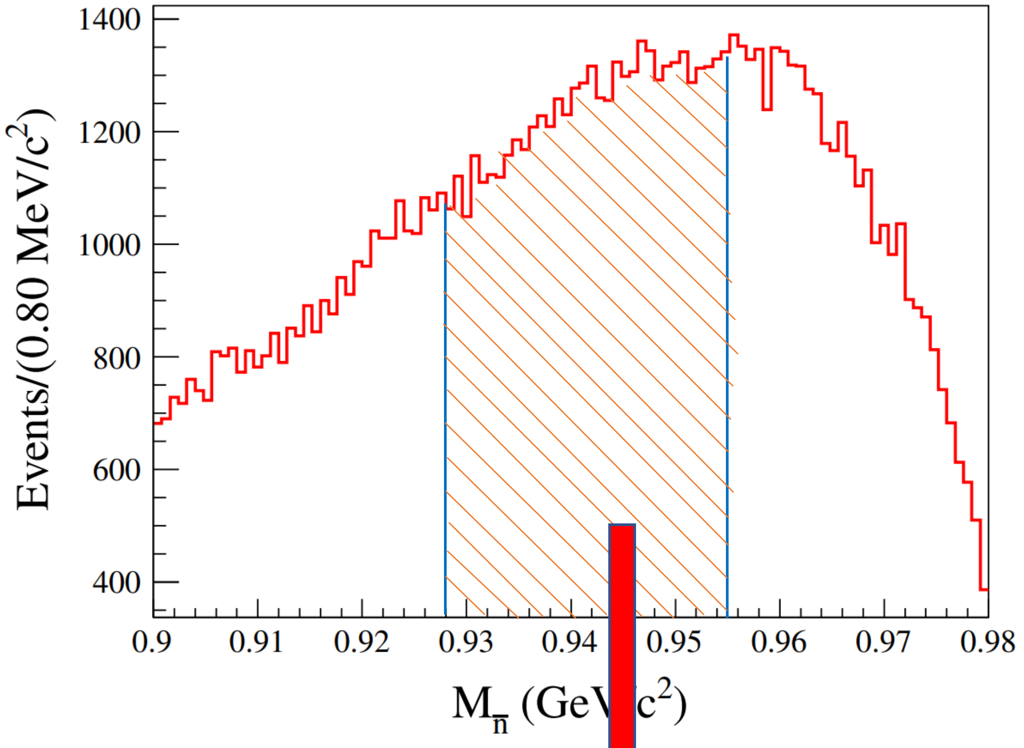






Signal Region	$\Lambda \to n\pi^0$		$\bar{\Lambda} \to \bar{n}\pi^0$	
	Matched	**Unmatched**	**Matched**	**Unmatched**
Truth Match	772380	28658	555632	41953
Fit	772550 ± 912	28593 ± 229	555078 ± 795	42233 ± 272
disparity	0.19σ	0.28σ	0.70σ	1.03σ

Error in Signal Region



Use a RooFIt error propagation function

https://root-forum.cern.ch/t/roofit-integral-error-and-manual-question/45864/5

```
RooRealVar *xxx = w->var("mnbar");
xxx->setRange("myrange", lo_count, up_count);

RooAbsReal *sigint = sig->createIntegral(*xxx, *xxx, "myrange");
RooProduct sig_yield{"signal_yield", "signal_yield", {*sigint, nsig}};
double Nmat_sig = sig_yield.getVal();
double NmatErr_sig = sig_yield.getPropagatedError(*result, x);

RooAbsReal *bkgint = bkg->createIntegral(*xxx, *xxx, "myrange");
RooProduct bkg_yield{"Background_yield", "Background_yield", {*bkgint, nbkg}};
double Nmat_bkg = bkg_yield.getVal();
double NmatErr_bkg = bkg_yield.getPropagatedError(*result, x);
```

$$frac_{BKG} = \int_{SigReg} pdf_{BKG} = 0.4$$

$$42233 \pm 172$$

$$172 < \sqrt{42233} = 205.5$$

$$42233 \pm 272$$

$$N_{SigReg}^{BKG} = frac_{BKG} \times N_{Fit}^{BKG}$$

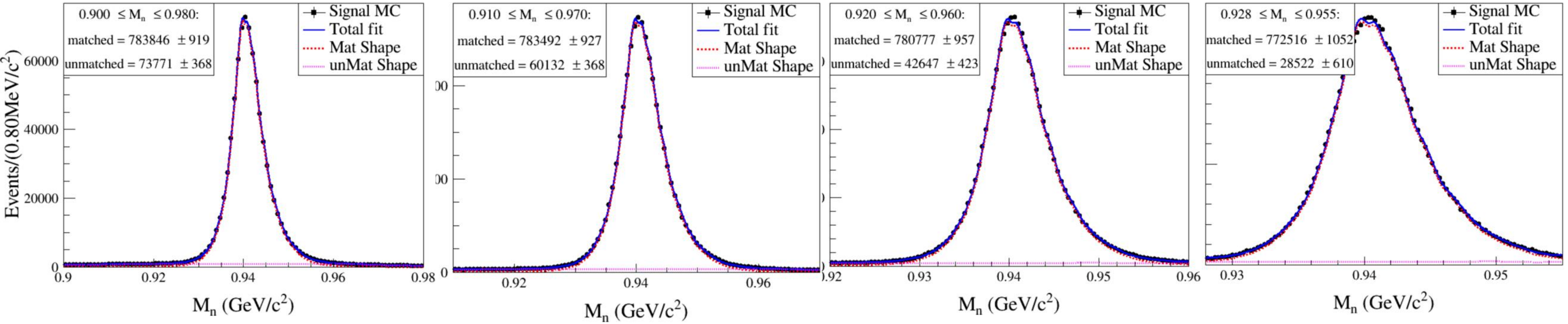
$$\sigma_{SigReg}^{BKG} = frac_{BKG} \times \sigma_{Fit}^{BKG}$$

$$\sigma_{SigReg}^{BKG} = \sqrt{frac_{BKG}} \times \sigma_{Fit}^{BKG}$$

N_{Fit}^{BKG} 与 σ_{Fit}^{BKG} 是拟合得到的本底事例数与误差

Fit Check 改变拟合范围，看看BKG事例误差的变化 (以npi0为例)

Fit Range	Matched		Unmatched	
	N	Nerr	N	Nerr
[0,9 0,98]	783846	919	73771	369
[0.91, 0.97]	783492	927	60132	368
[0.92, 0.96]	780777	957	42647	423
[0.928, 0.955]	772516	1052	28522	610



Summary

Parameters	$\Lambda \to n\pi^0$		$\bar{\Lambda} \to \bar{n}\pi^0$	
	Pull $\boldsymbol{\mu}$	Pull $\boldsymbol{\sigma}$	Pull $\boldsymbol{\mu}$	Pull $\boldsymbol{\sigma}$
$\boldsymbol{\alpha_{J/\psi}}$	0.017 ± 0.138	0.984 ± 0.097	0.023 ± 0.957	0.957 ± 0.096
$\boldsymbol{\Delta\Phi}$	0.016 ± 0.148	1.055 ± 0.104	0.002 ± 0.104	0.744 ± 0.074
α $(\boldsymbol{\Lambda \to n\pi^0}\ or \boldsymbol{\Lambda \to p\pi^-})$	0.037 ± 0.141	1.004 ± 0.099	0.007 ± 0.122	0.873 ± 0.086
$\bar{\alpha}$ $(\boldsymbol{\bar{\Lambda} \to \bar{p}\pi^+}\ or \boldsymbol{\bar{\Lambda} \to \bar{n}\pi^0})$	0.043 ± 0.157	1.118 ± 0.111	-0.033 ± 0.121	0.863 ± 0.085

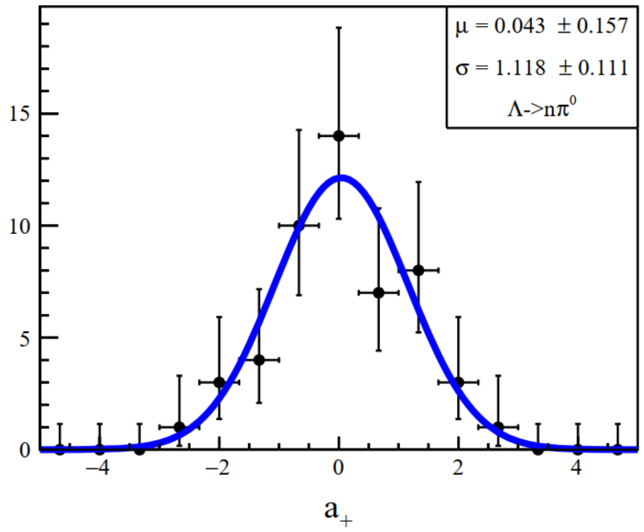
Simultaneous Fit		
Parameters	Pull $\boldsymbol{\mu}$	Pull $\boldsymbol{\sigma}$
$\boldsymbol{\alpha_{J/\psi}}$	0.028 ± 0.144	1.030 ± 0.102
$\boldsymbol{\Delta\Phi}$	0.012 ± 0.133	0.953 ± 0.094
$\boldsymbol{\alpha_+(\bar{\Lambda} \to \bar{p}\pi^+)}$	0.040 ± 0.155	1.108 ± 0.110
$\boldsymbol{\alpha_0(\Lambda \to n\pi^0)}$	0.037 ± 0.140	1.001 ± 0.099
$\boldsymbol{\alpha_-(\Lambda \to p\pi^-)}$	0.006 ± 0.123	0.876 ± 0.087
$\boldsymbol{\bar{\alpha}_0(\bar{\Lambda} \to \bar{n}\pi^0)}$	-0.033 ± 0.120	0.854 ± 0.084

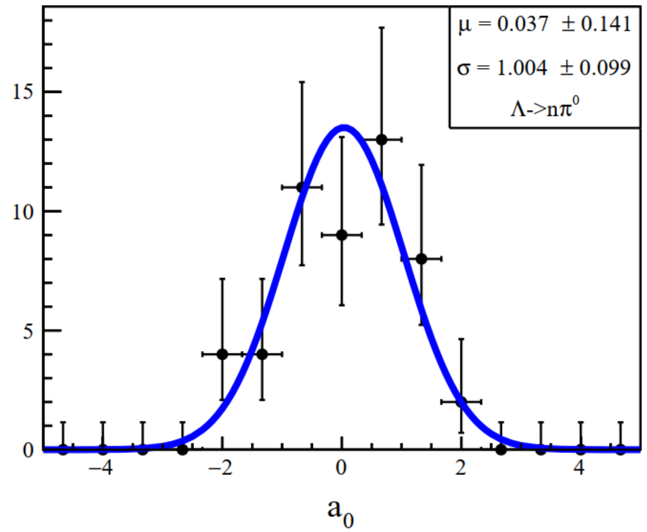
Next to do(2022-09-05)

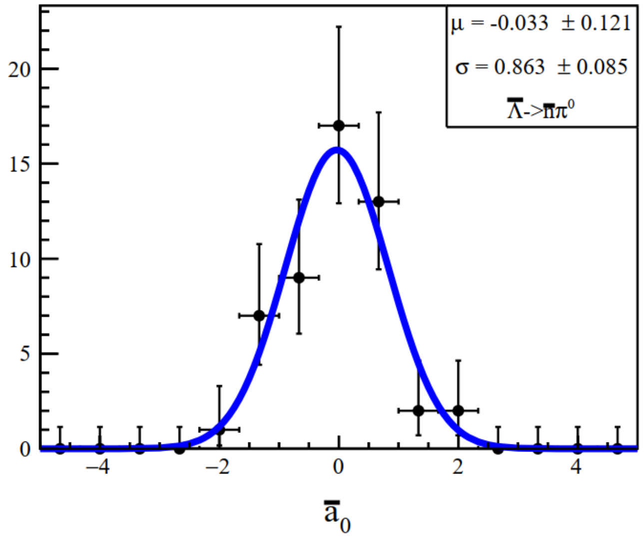
- Truth有偏 和 重建无偏的理解
  - 彭老师：中心值可能无变化，turth统计量大，误差小
  - *可以看truth->效率->分辨，误差的变化*
- Npi0与nbarpi0为何不对称，有差别？（nbarpi0）
  - Truth这俩应该无任何差别
  - *可以将MC积分分成两份(x25)，分别拟合，看两次的结果*
- 16矩的差别：
  - 左右看着还行，和中间有差别？
  - C03和C30应该对称，但是不对称
  - *将信号区间分为左右，看差别，要理解sideband无法描述的原因*
- Sideband方法与exclusive的比较
  - Sideband的BKG事例与信号区间同量级，但exclusive是50倍，二者不在一个量级
  - 可将exc只用1data的本底，看情况
  - 也可用x1 x10 x25看看变化
- Simultaneous Fit与单独拟合需要比较的是拟合出来的绝对结果，有怎样改善
  - 从目前看，alpha_jpsi和DeltaPhi变好对于alpha和alphabar影响不太大
- Sideband的理解很重要，精确测量如果用exclusive描述，如何补全data和MC的差别？ Sideband的理解对于将来理解data和MC很重要
- 子区间误差用系数传递没有问题，因为在取子区间事例数时，pdf的形状已经确定，从大到小，传递误差时，按照线性传递即可
- 改变拟合范围，谱范围越来越小，拟合误差越来越大，因为随着谱变小，信号和本底关联越来越强，区分度越来越小，本底的约束变弱，误差变大

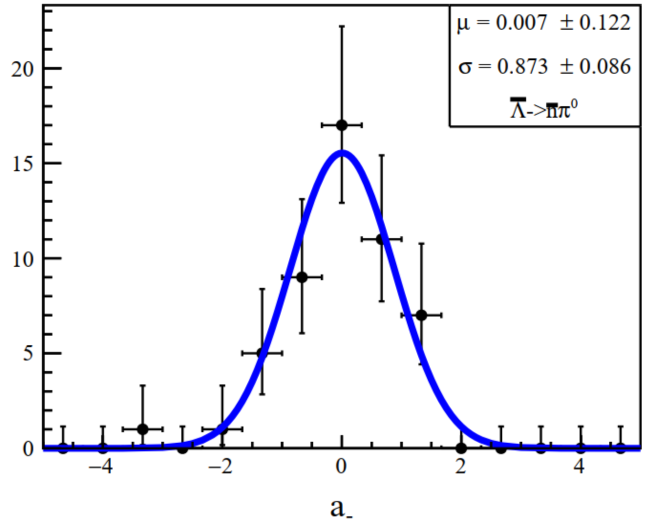
- Truth的IO的pull的中心值是0.2，也可以接受，但需要理解加上效率和分辨之后，IO还变好了？仅仅是数凑上了罢了
- 图还是有点小。。。。。

Q1: npi0与nbarpi0的不对称



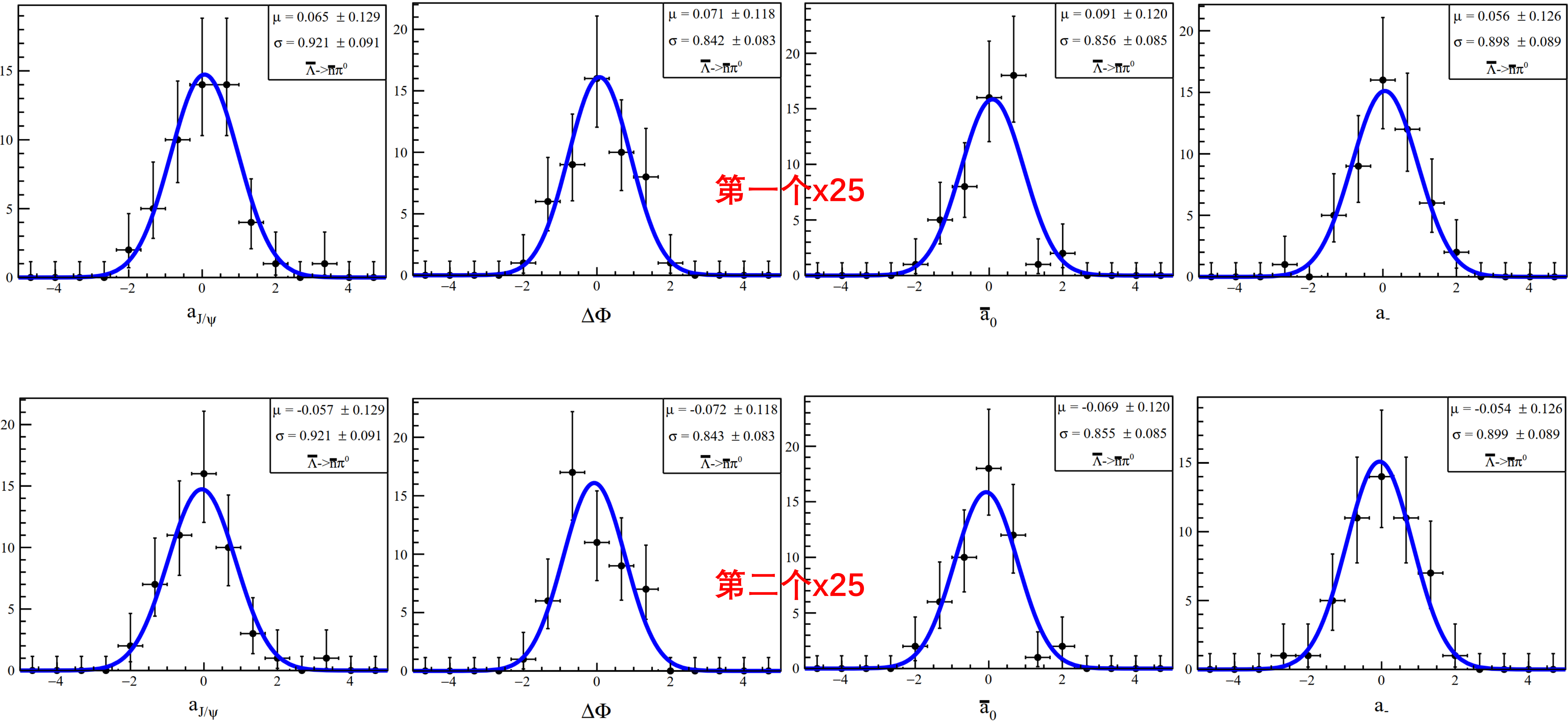






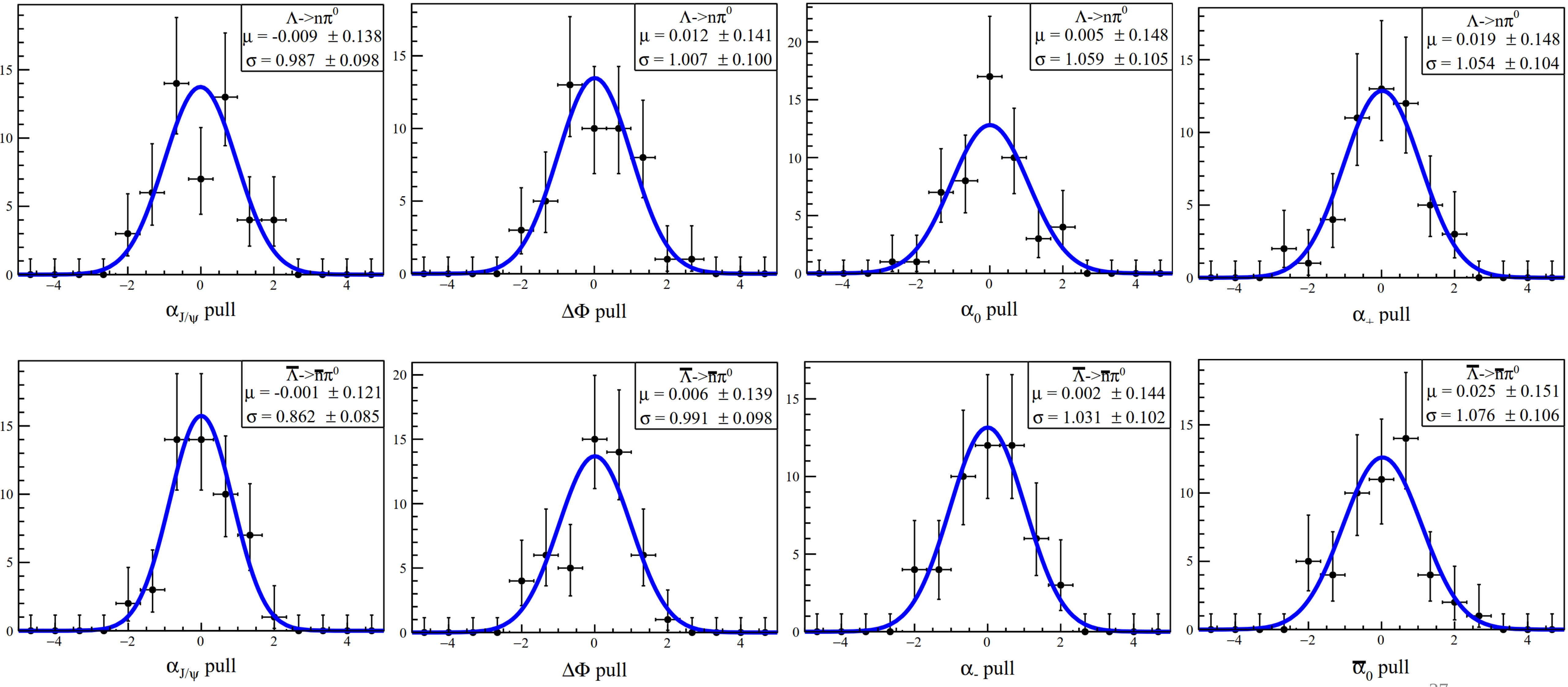
IO Check | nbarpi0 Truth with Efficiency (MC积分拆为两个25x)

pull误差在两个sample中都偏小



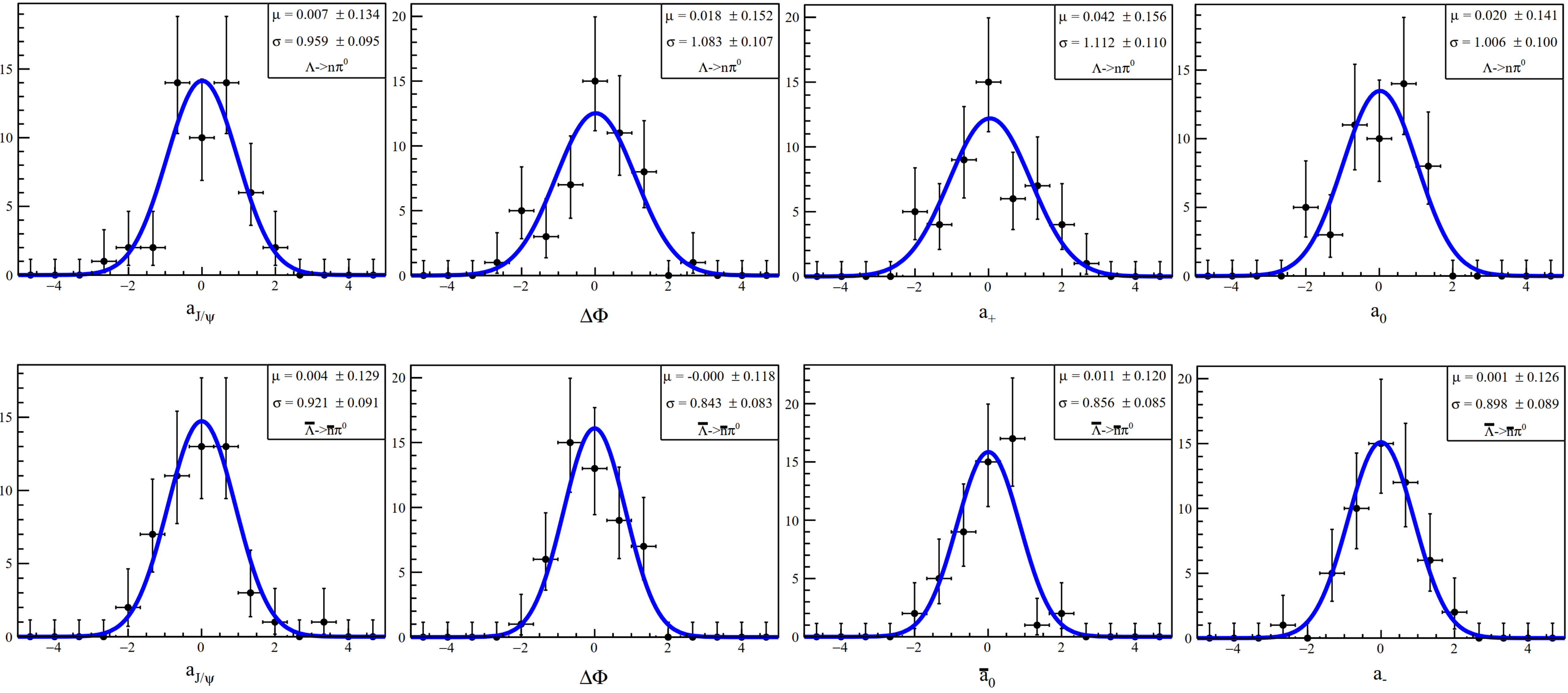
IO Check | Truth (统计量与重建相同)

50 independent samples (1x data) + 1 share mDIY integral MC (50x data)



IO Check | Truth with Efficiency

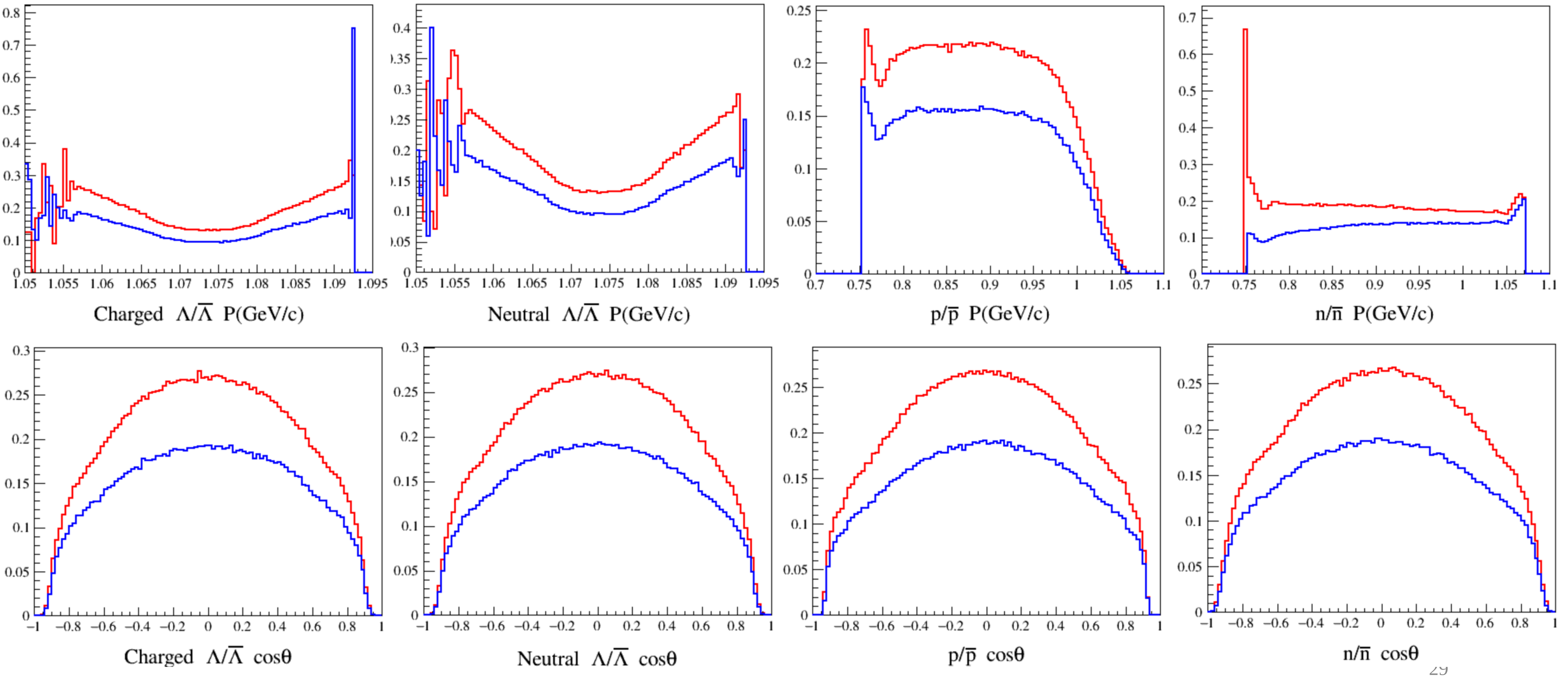
50 independent samples (1x data) + 1 share mDIY integral MC (50x data)



Efficiency Curve

-- Red Line: $\Lambda \to n\pi^0$ -- Blue Line: $\bar{\Lambda} \to \bar{n}\pi^0$

Charged $\Lambda/\bar{\Lambda}$: 由带电径迹重建，对应于$\Lambda \to p\pi^-, \bar{\Lambda} \to \bar{p}\pi^+$



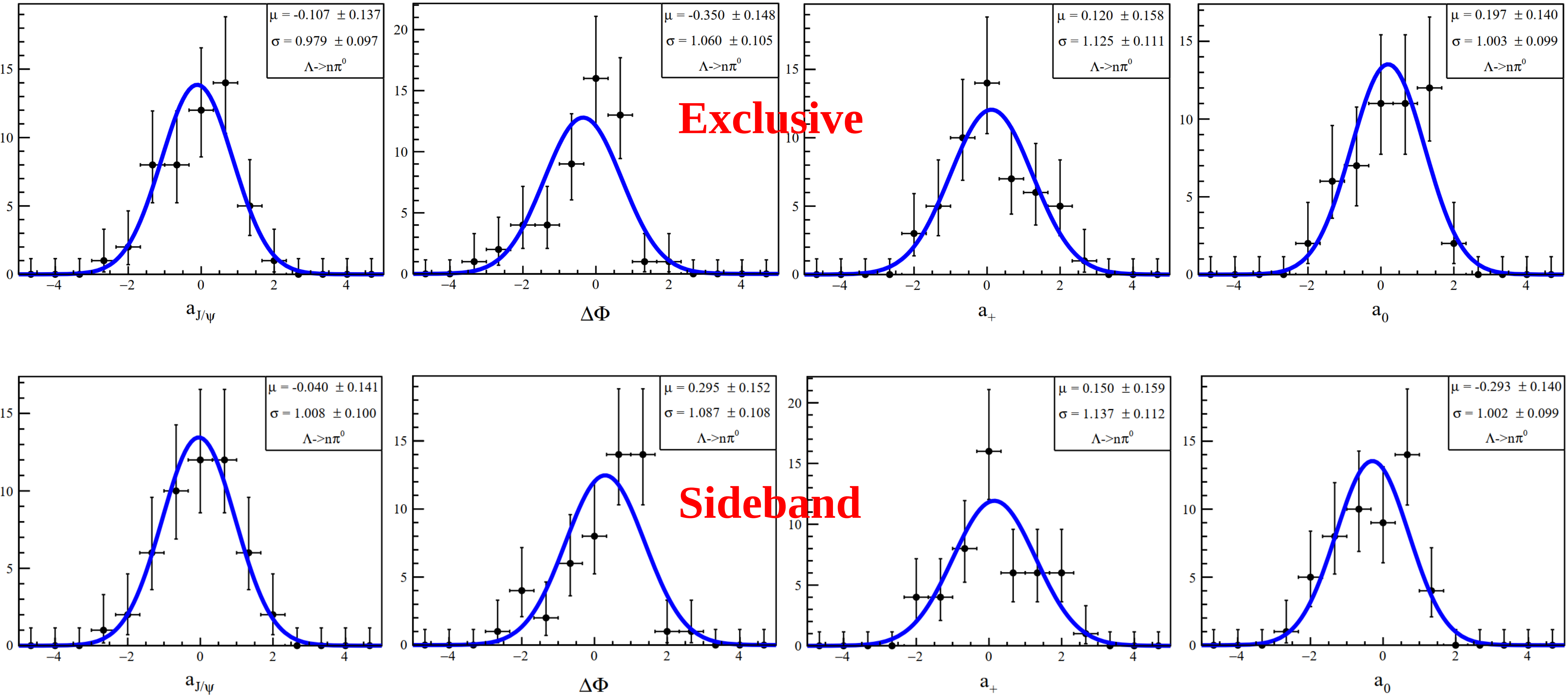
Q2: Excluxive与sideband比较

Exclusive MC为 x50 data，而Sideband仅有x1，无法将二者直接比较

- 用x1的Exclusive MC比较
- 分别x1 x10 x25 x50的Exclusive MC，看结果有何变化

Exclusive and Sideband (均用1x的NBKG)

二者差不多



Exclusive MC (用 1x 10x 25x 49x 的NBKG)

Pull Value		1x	10x	25x	49x
$\alpha_{J/\psi}$	μ	-0.107 ± 0.137	-0.066 ± 0.138	0.017 ± 0.138	0.017 ± 0.138
	σ	0.979 ± 0.097	0.984 ± 0.097	0.984 ± 0.097	0.984 ± 0.097
$\Delta\Phi$	μ	-0.350 ± 0.148	-0.053 ± 0.148	-0.012 ± 0.148	0.016 ± 0.148
	σ	1.060 ± 0.105	1.054 ± 0.104	1.054 ± 0.104	1.055 ± 0.104
α_+	μ	0.120 ± 0.158	0.046 ± 0.157	0.052 ± 0.156	0.043 ± 0.157
	σ	1.125 ± 0.111	1.119 ± 0.111	1.117 ± 0.111	1.118 ± 0.111
α_0	μ	0.197 ± 0.140	0.052 ± 0.140	0.069 ± 0.140	0.037 ± 0.141
	σ	1.003 ± 0.099	1.003 ± 0.099	1.002 ± 0.099	1.004 ± 0.099

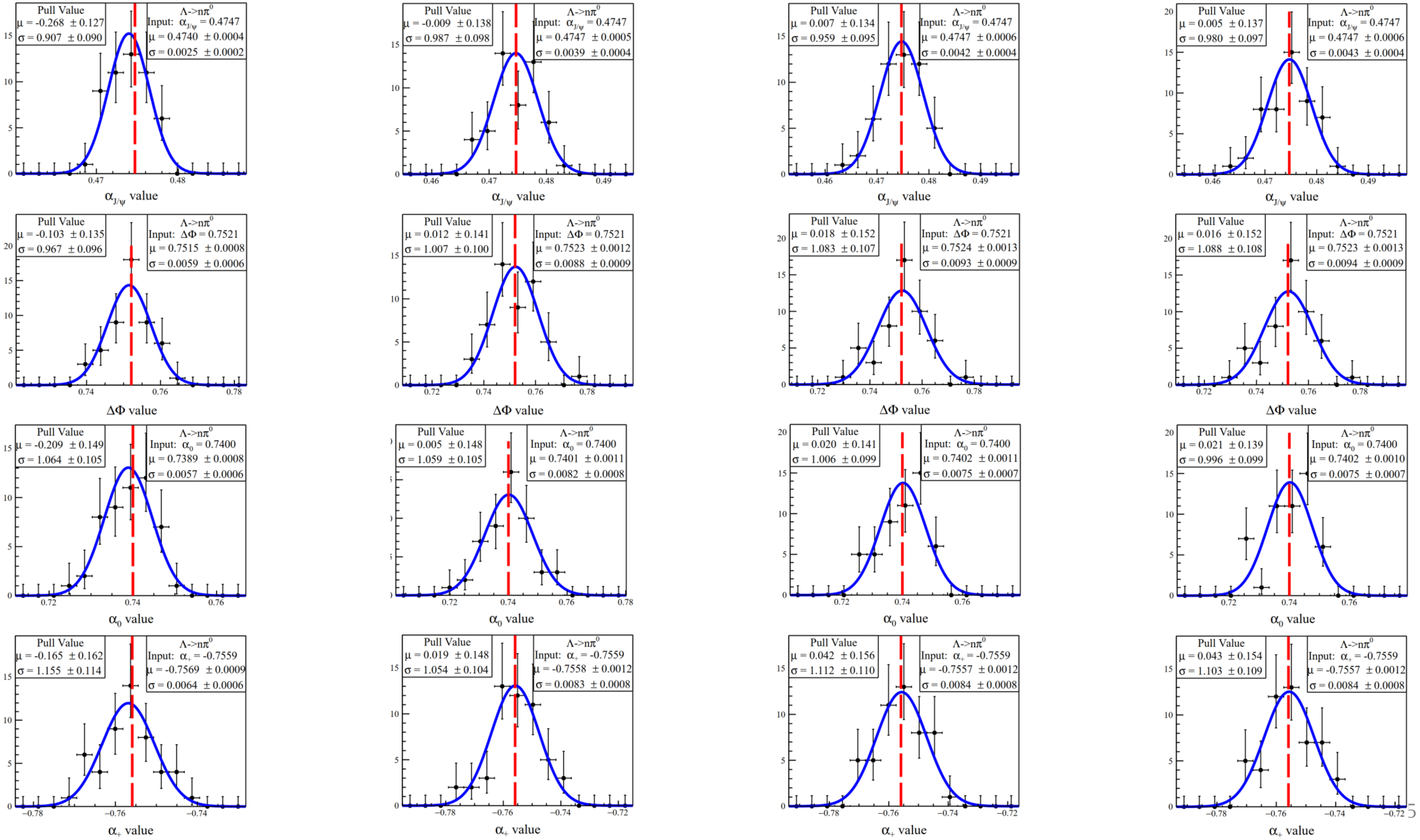
Q3: 之前大统计量IOCheck不ok?

周一组会说起Truth不是很好，这里给出展示

误差变化(Truth 157W → Truth 77W → EffTruth → RecNoBKG)

Fit Value		Truth(157w)	Truth(77w)	Efficiency	Resolution
$\alpha_{J/\psi}$ 0.4747	μ	0.4740	0.4747	0.4747	0.4747
	σ	0.0025	0.0039	0.0042	0.0043
$\Delta\Phi$ 0.7521	μ	0.7515	0.7523	0.7524	0.7523
	σ	0.0059	0.0088	0.0093	0.0094
α_+ -0.7559	μ	-0.7569	-0.7558	-0.7557	-0.7557
	σ	0.0064	0.0083	0.0084	0.0084
α_0 0.74	μ	0.7389	0.7401	0.7402	0.7402
	σ	0.0057	0.0082	0.0075	0.0075

误差变化(Truth 157W → Truth 77W → EffTruth → RecNoBKG)



Q4: Sideband 分布

Check 16 Moment of Signal and BKG in M_n

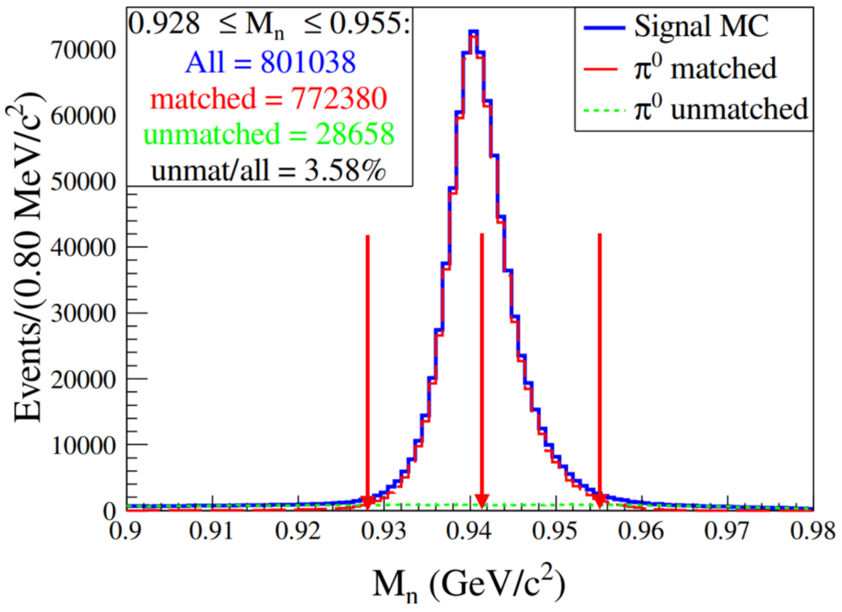
4 regions in mass of n/n̄:

[0.9, 0.928] (Left Sideband)

[0.928, 0.942] (Left Signal Region)

[0.942, 0.955] (Right Signal Region)

[0.955, 0.98] (Right Sideband).



		Left Sideband	Left Signal Region	Right Signal Region	Right Sideband
$n\pi^0$	N_{sig}	-	437806	336090	-
	N_{bkg}	26052	14050	14145	19416
$\bar{n}\pi^0$	N_{sig}	-	299528	255854	-
	N_{bkg}	30876	20116	22016	33191

BKG 16-mom $\Lambda \to n\pi^0$

Left Sideband: Red

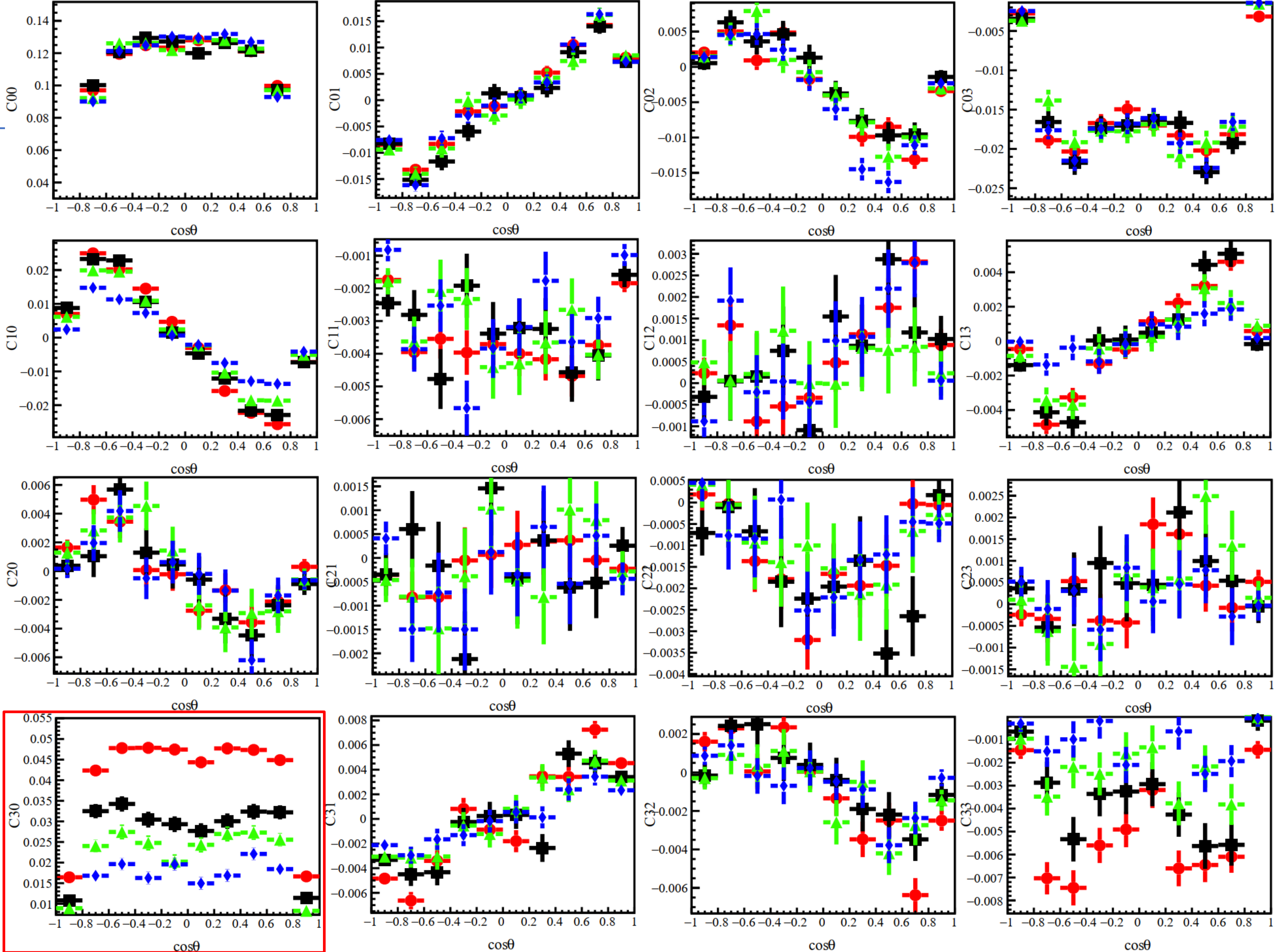
Left Signal Region: Black

Right Signal Region: Green

Right Sideband: Blue

C30->Fill(cos, $\hat{P}_z^n$)

$\hat{P}_z^n$:中子动量单位矢量于z轴的投影



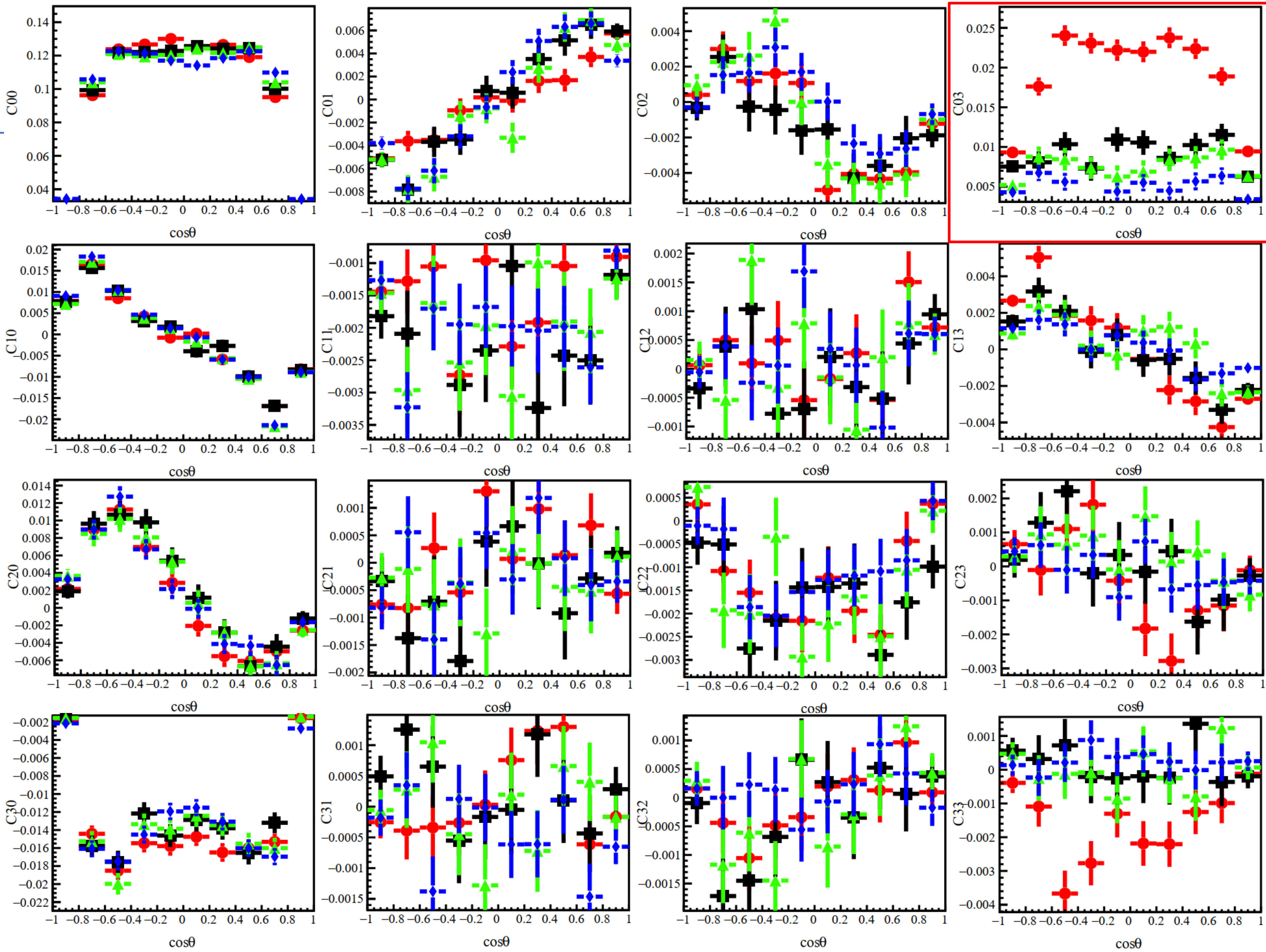
BKG 16-mom $\bar{\Lambda} \to \bar{n}\pi^0$ Channel

Left Sideband: Red

Left Signal Region: Black

Right Signal Region: Green

Right Sideband: Blue



C03->Fill(cos, $\hat{P}_z^{\bar{n}}$)

$\hat{P}_z^{\bar{n}}$:反中子动量单位矢量于z轴的投影

BKG Truth Match Angle

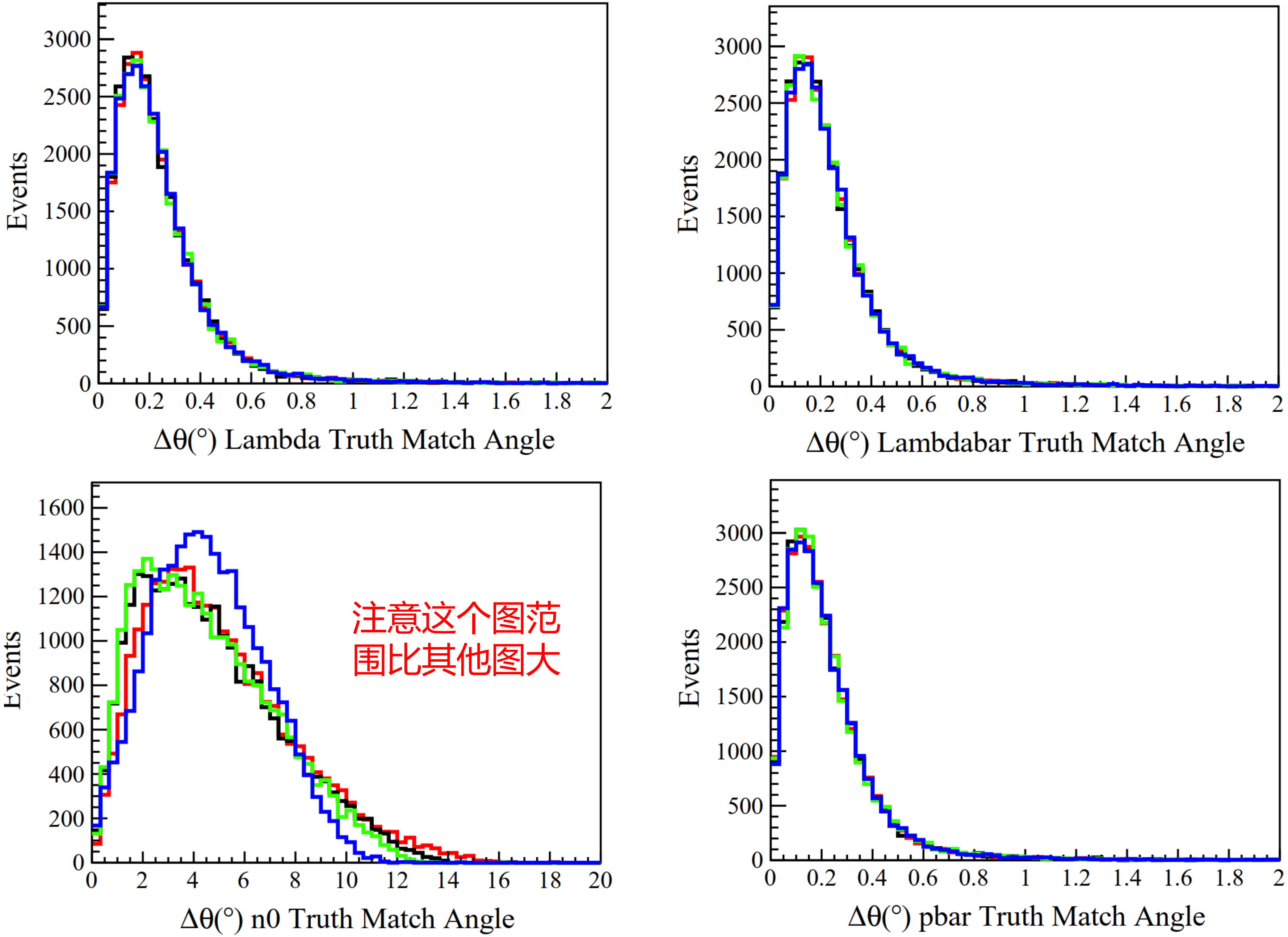
$\Lambda \to n\pi^0$

Left Sideband: Red

Left Signal Region: Black

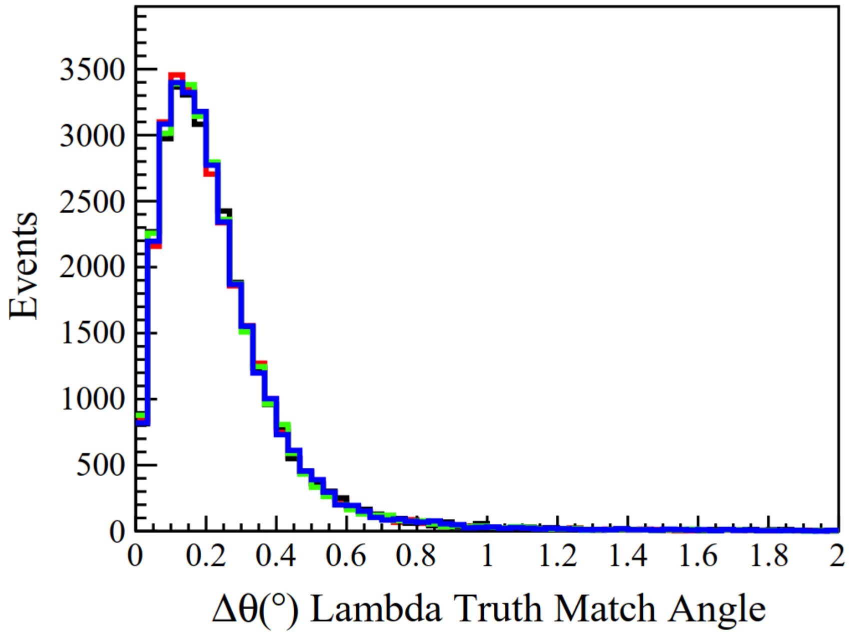
Right Signal Region: Green

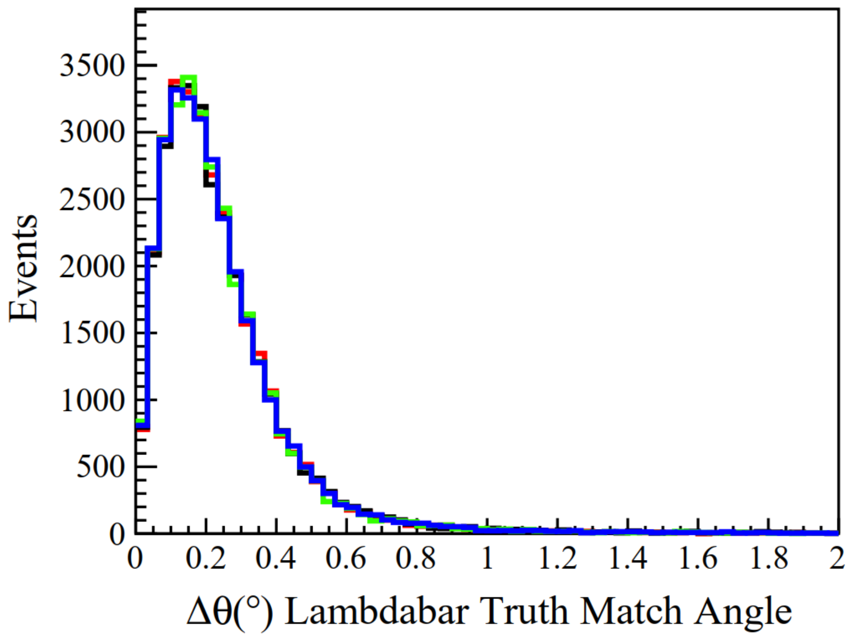
Right Sideband: Blue



BKG Truth Match Angle

$\bar{\Lambda} \to \bar{n}\pi^0$



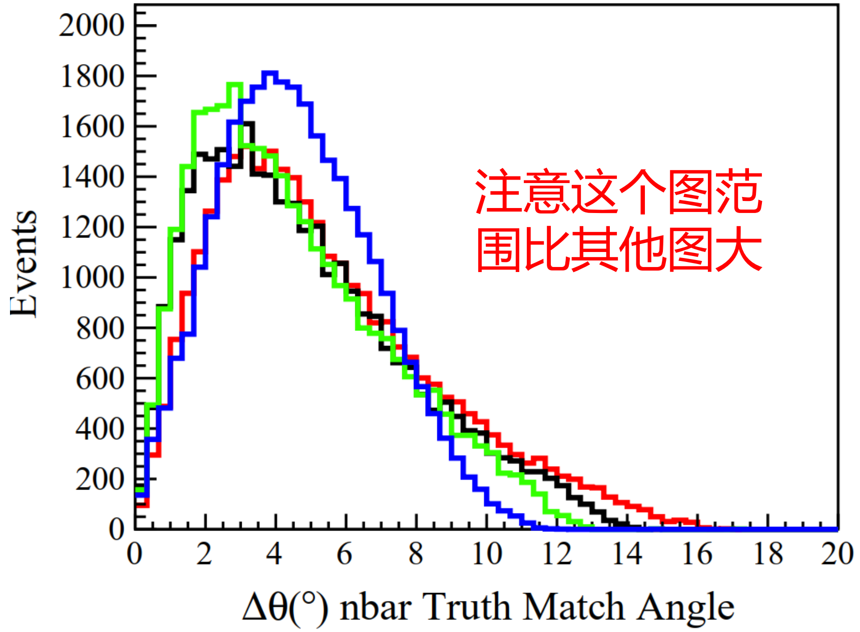


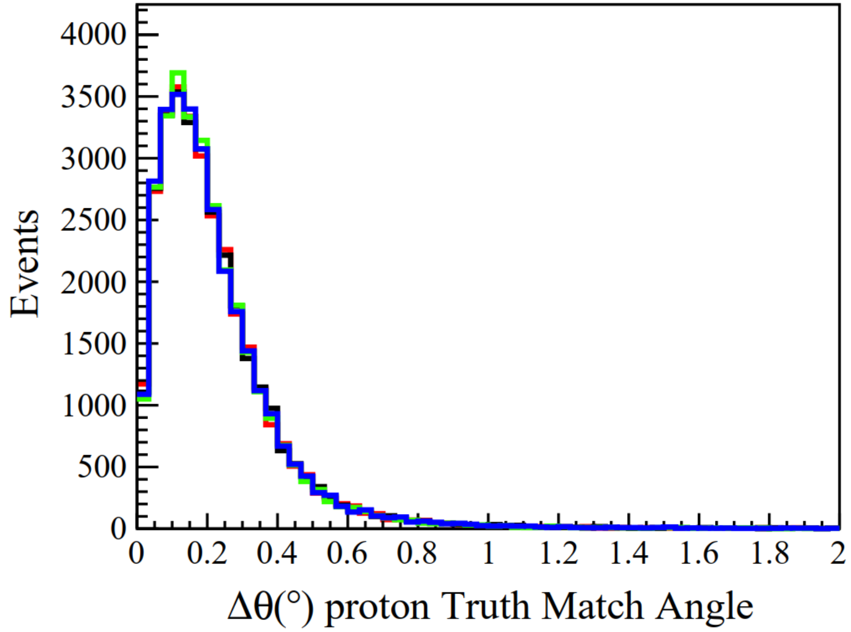
Left Sideband: Red

Left Signal Region: Black

Right Signal Region: Green

Right Sideband: Blue





SIG 16-mom
$\Lambda \rightarrow n\pi^0$ Channel

Left Signal Region: Black

Right Signal Region: Green

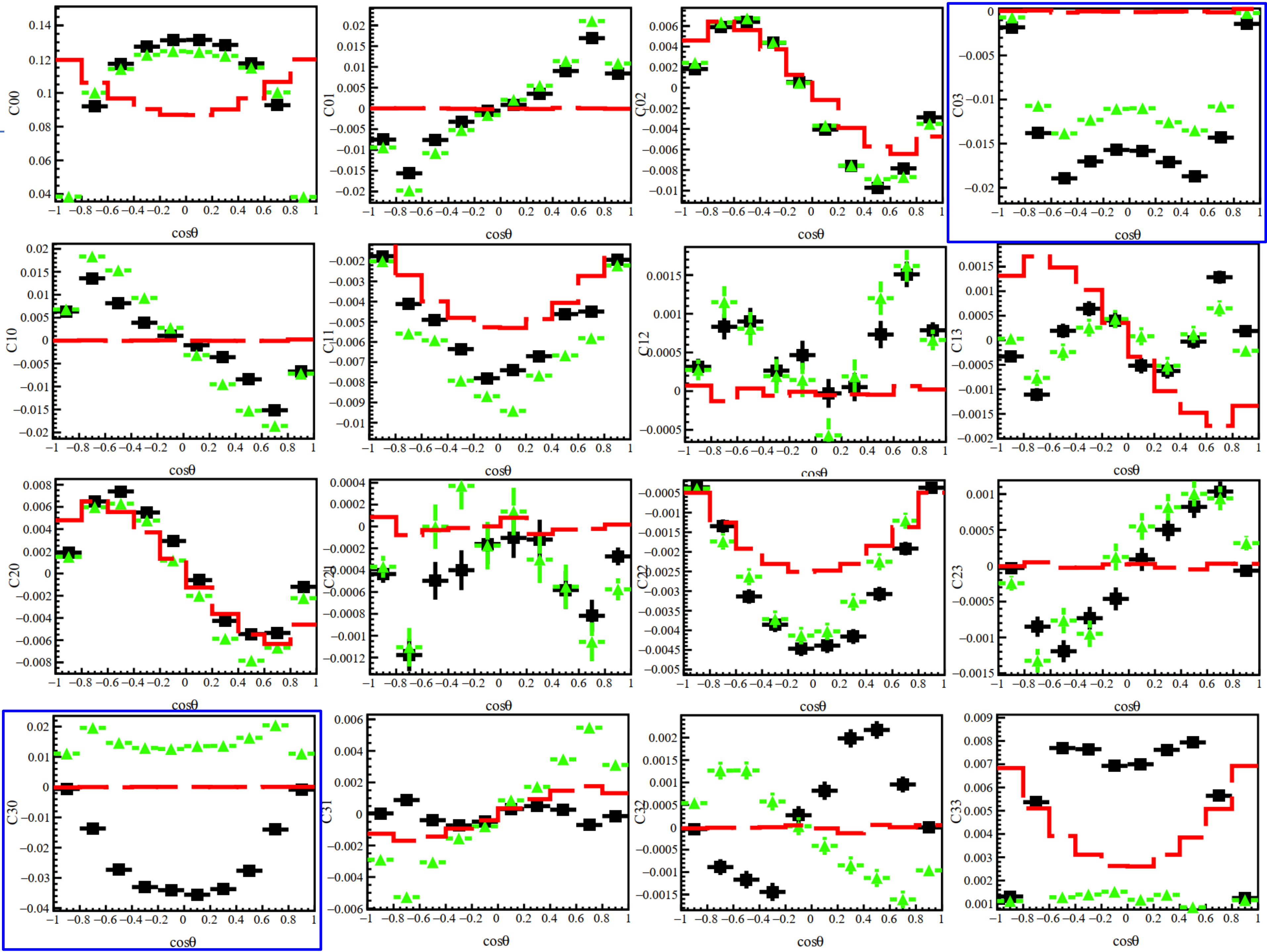
Truth: Red Dashed

C03->Fill(cos, $\hat{P}_z^{\bar{p}}$)

$\hat{P}_z^{\bar{p}}$:反质子动量单位矢量于z轴的投影

C30->Fill(cos, $\hat{P}_z^{n}$)

$\hat{P}_z^{n}$:中子动量单位矢量于z轴的投影



SIG 16-mom
$\bar{\Lambda} \rightarrow \bar{n}\pi^0$ Channel

Left Signal Region: Black

Right Signal Region: Green

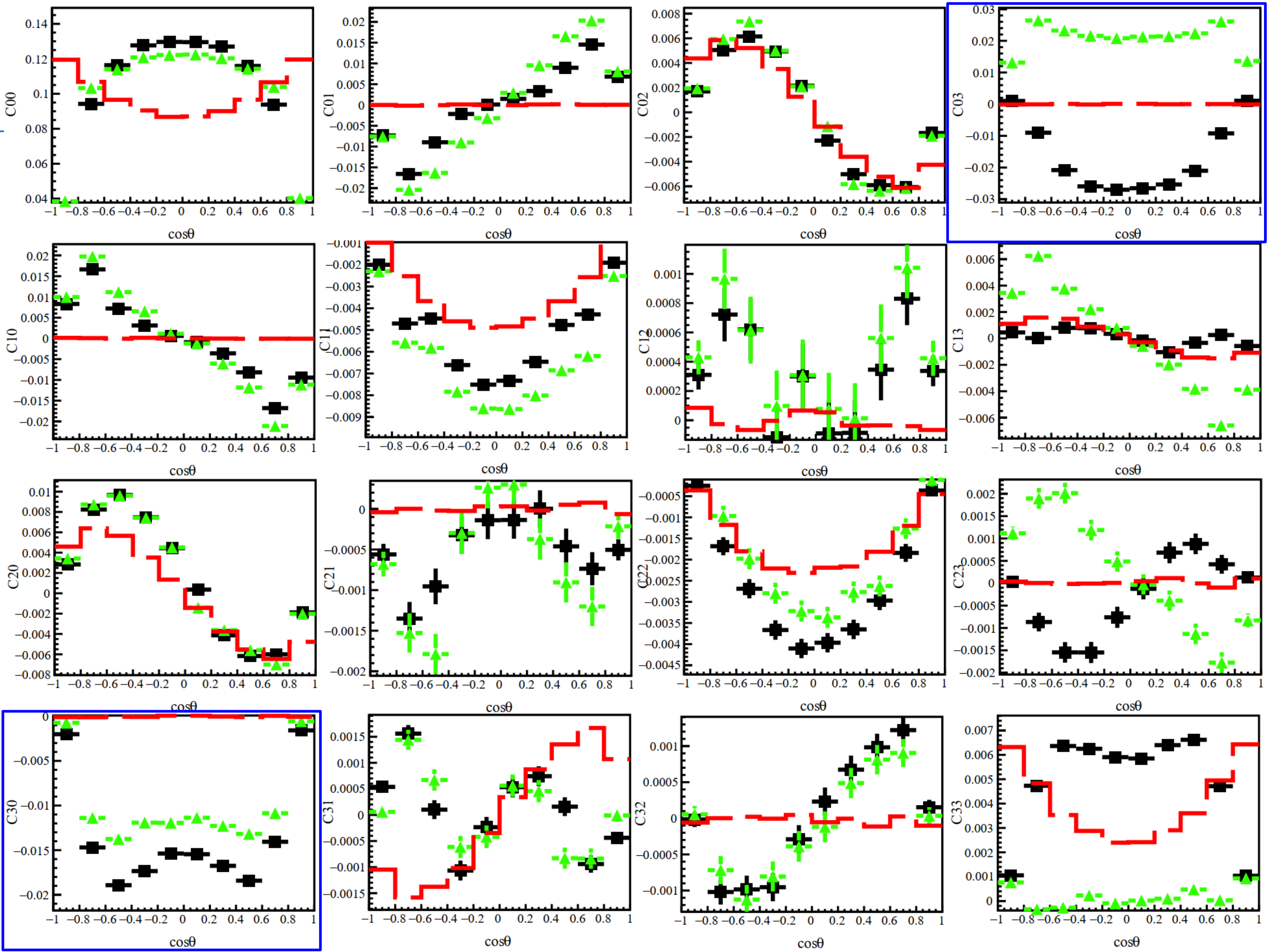
Truth: Red Dashed

C03->Fill(cos, $\hat{P}_z^{\bar{n}}$)

$\hat{P}_z^{\bar{n}}$:反中子动量单位矢量于z轴的投影

C30->Fill(cos, $\hat{P}_z^{p}$)

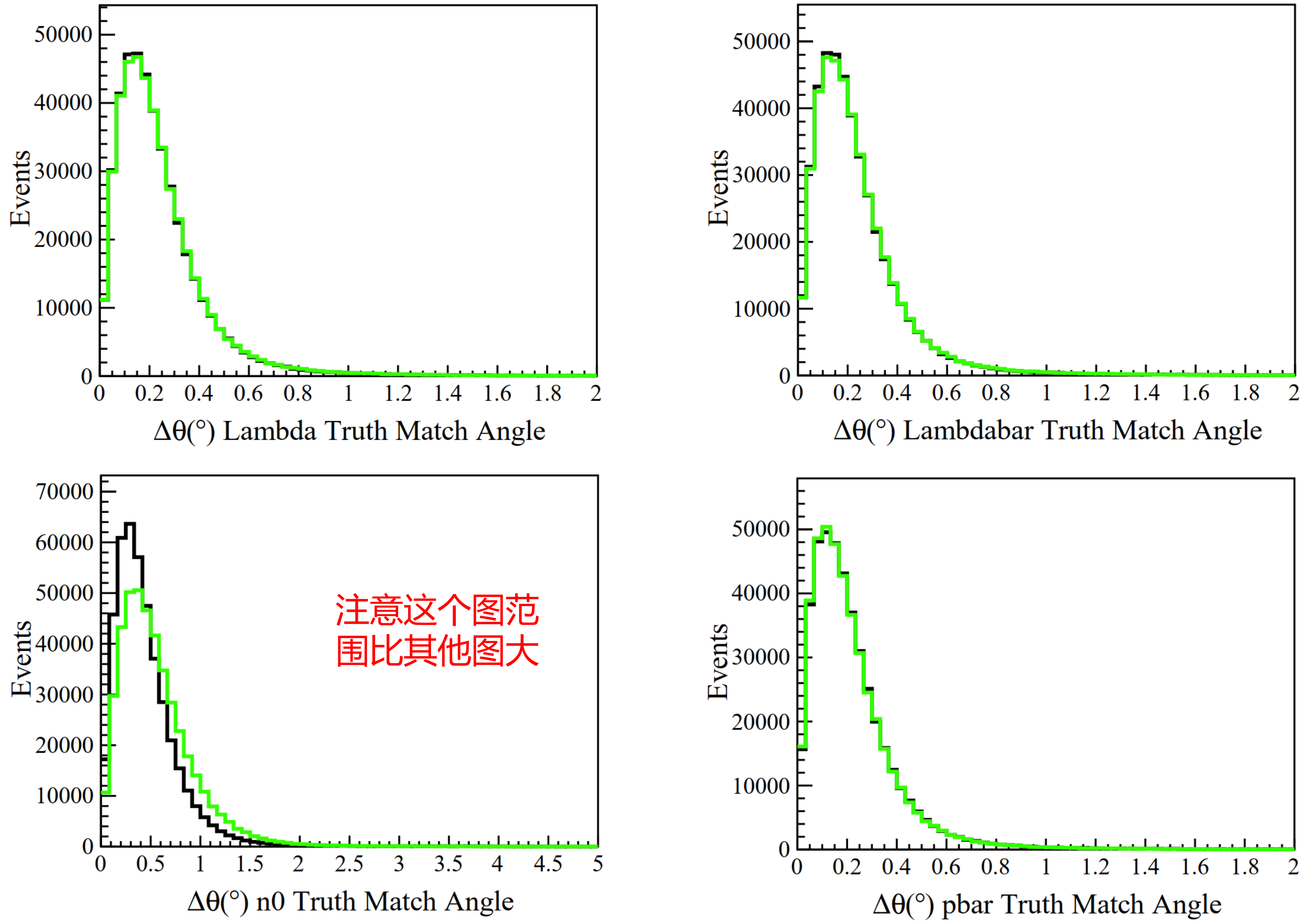
$\hat{P}_z^{p}$:质子动量单位矢量于z轴的投影



SIG Truth Match Angle $\Lambda \rightarrow n\pi^0$

Left Signal Region: Black

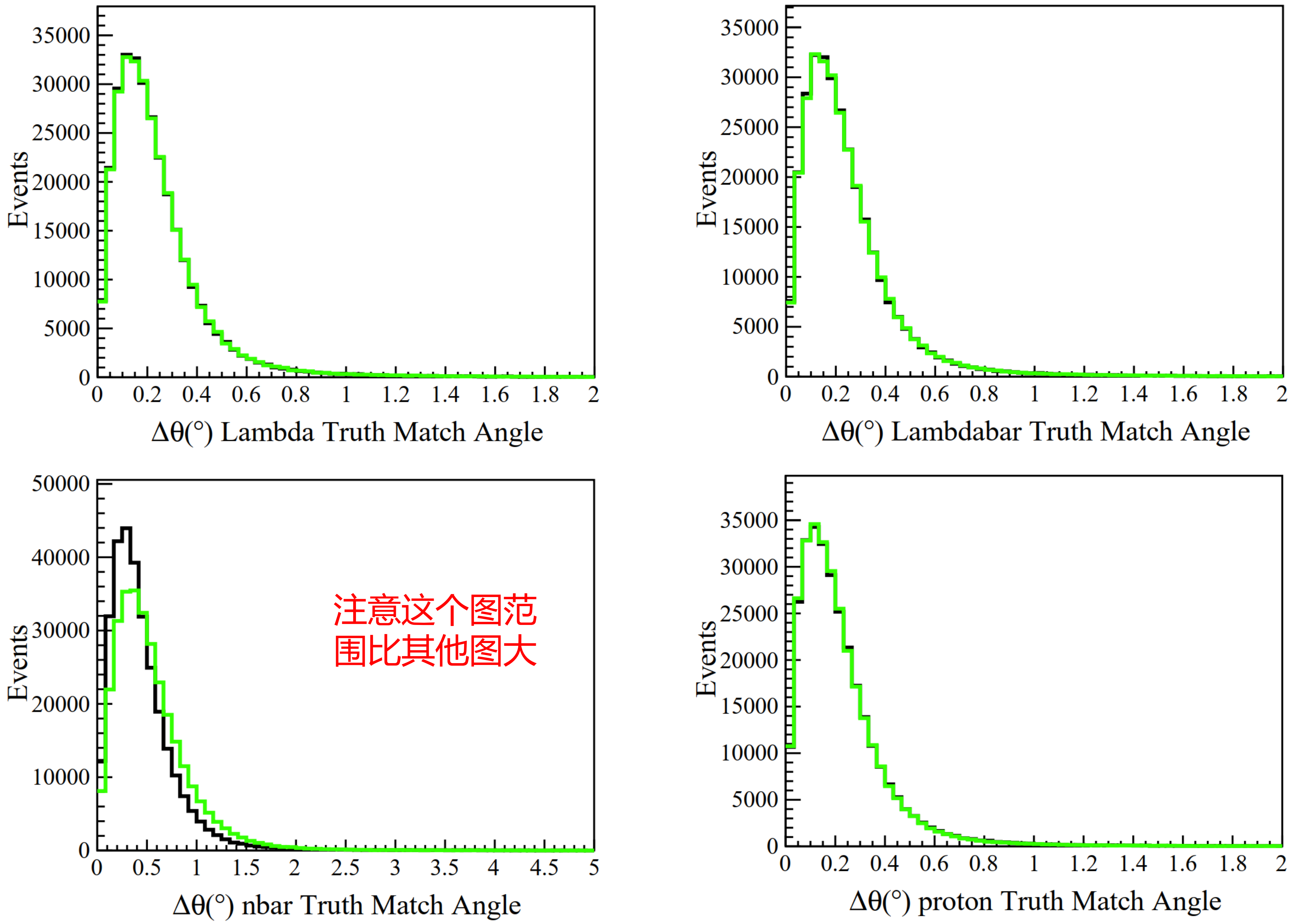
Right Signal Region: Green



SIG Truth Match Angle $\bar{\Lambda} \to \bar{n}\pi^0$

Left Signal Region: Black

Right Signal Region: Green



BKG 16-mom
$\Lambda \to n\pi^0$ Channel

Left Sideband: Red

Left Signal Region: Black

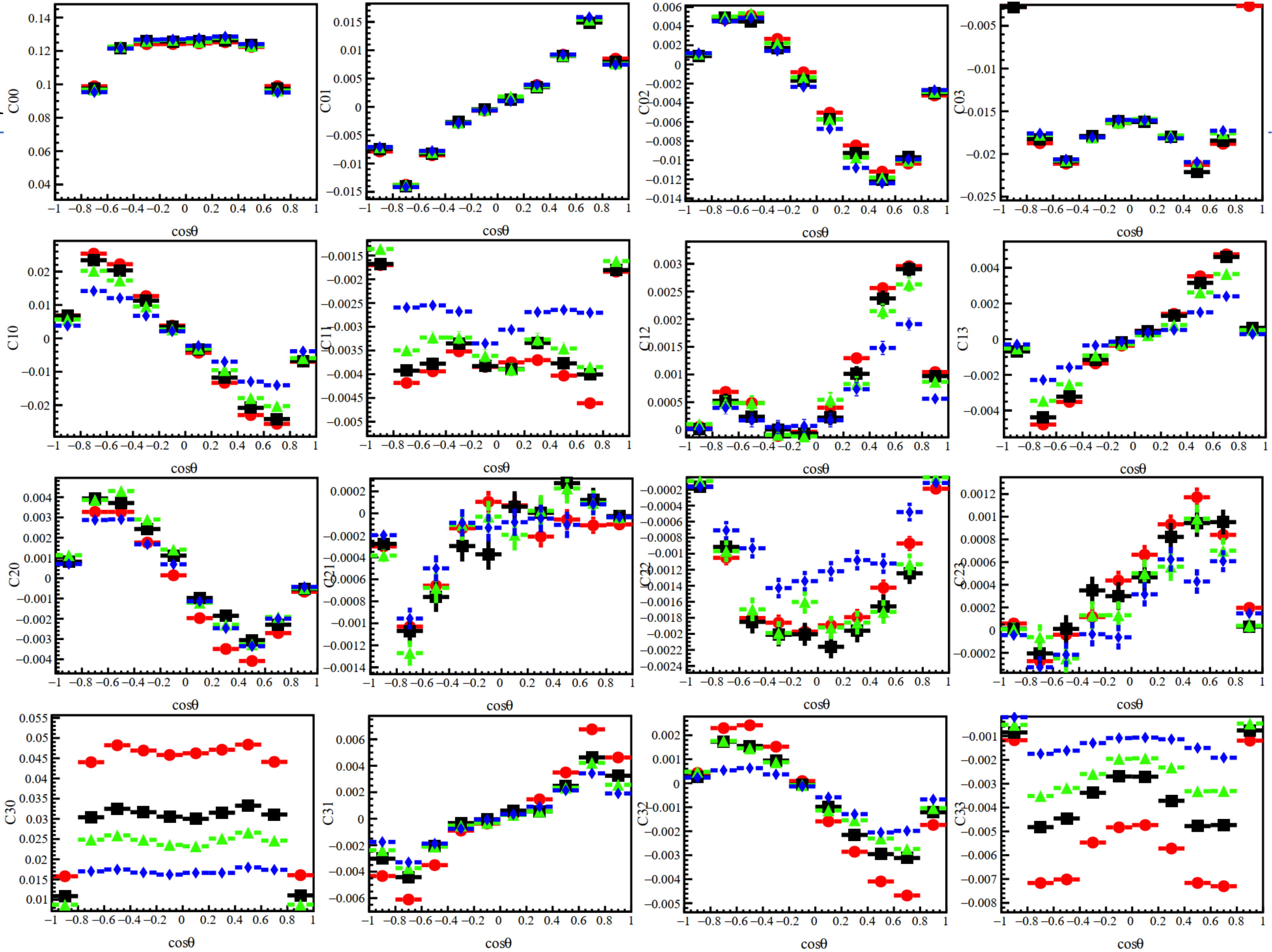
Right Signal Region: Green

Right Sideband: Blue

x50 更大统计量

C30->Fill(cos, $\hat{P}_z^n$)

$\hat{P}_z^n$:中子动量单位矢量于z轴的投影



SIG 16-mom $\Lambda \to n\pi^0$ Channel

2 regions in mass of n/n̄:

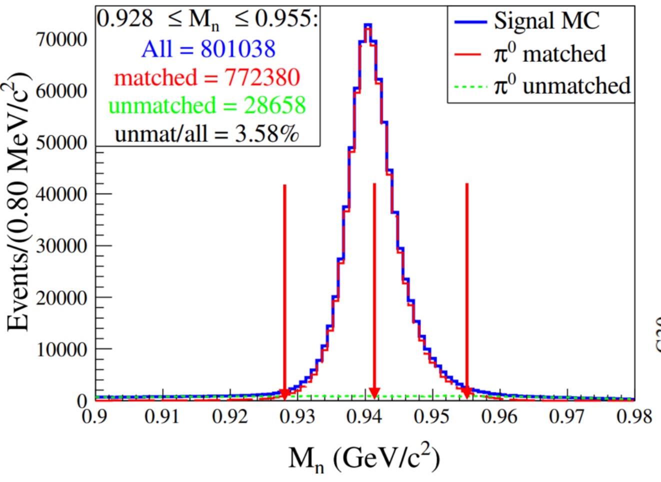
[0.928, 0.942] (Left Signal Regic

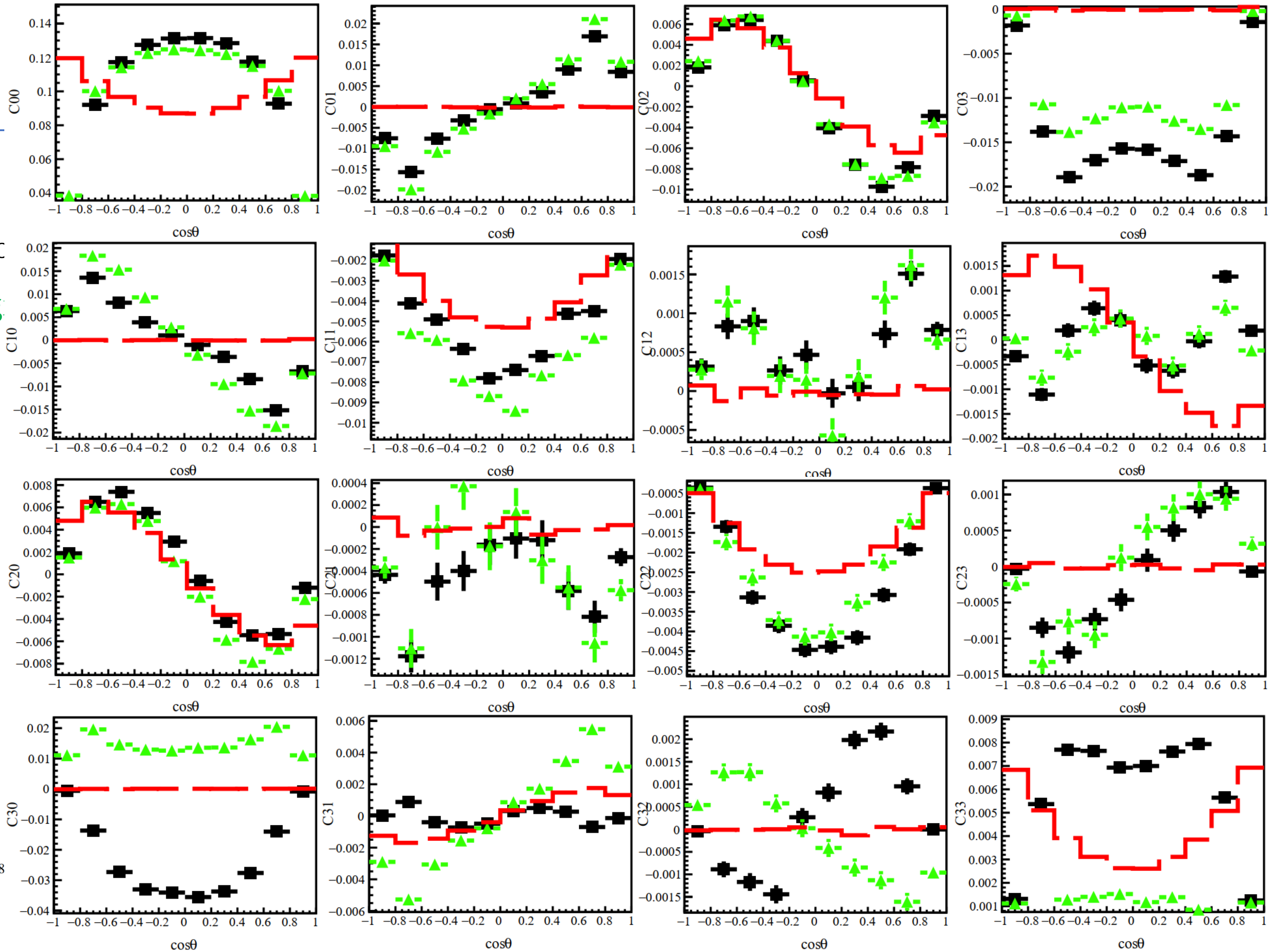
[0.942, 0.955] (Right Signal Reg

Left Signal Region: Black

Right Signal Region: Green

Truth: Red Dashed





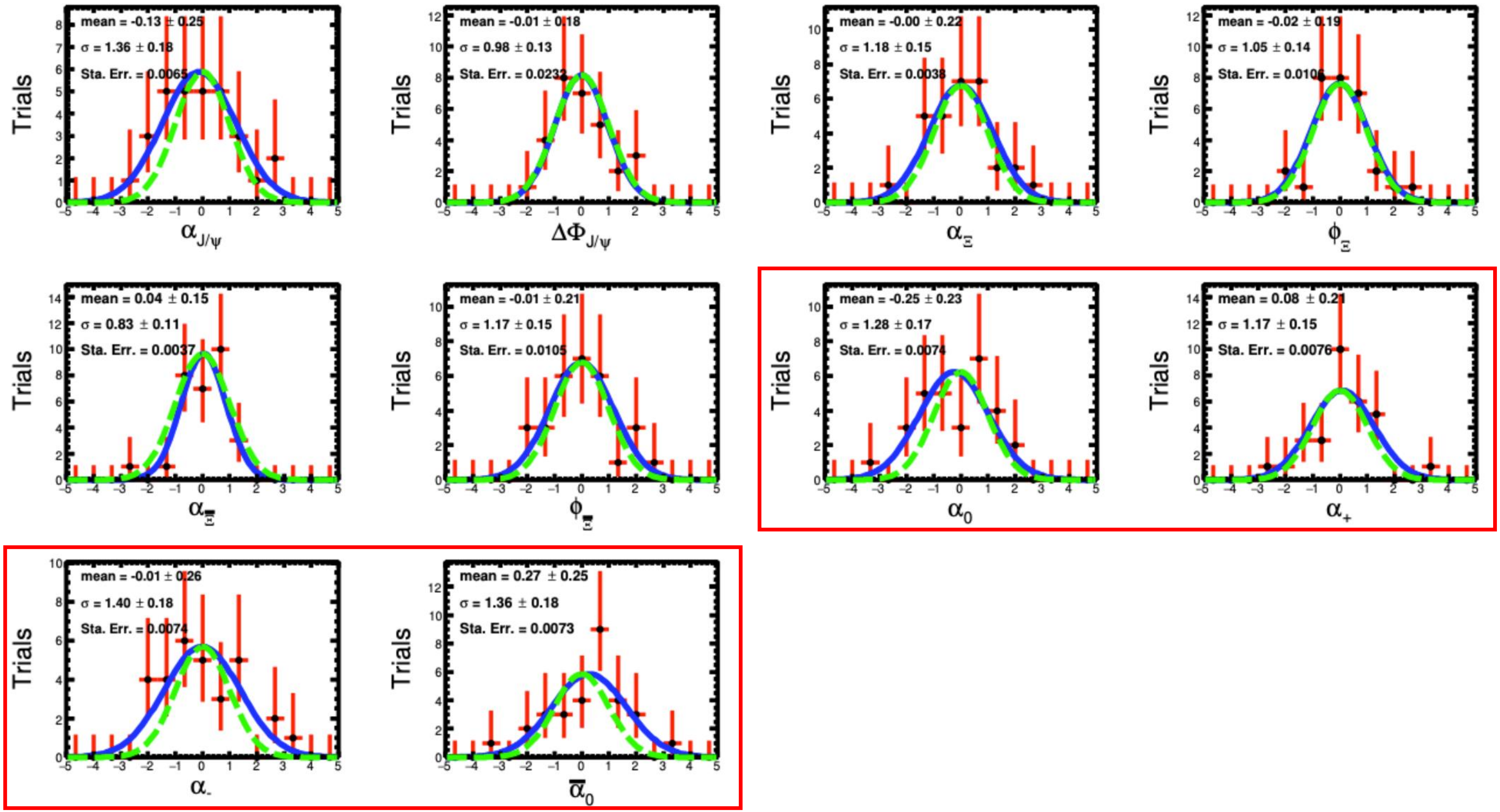
Back up

```
===> cat *.err
/etc/condor/wrapper/wrapper.sh: line 26:  5853 Killed                  /usr/bin/timeout $JobLimit ${UserExe} "$@"
/etc/condor/wrapper/wrapper.sh: line 26:  5844 Killed                  /usr/bin/timeout $JobLimit ${UserExe} "$@"
/etc/condor/wrapper/wrapper.sh: line 26:  5910 Killed                  /usr/bin/timeout $JobLimit ${UserExe} "$@"
/etc/condor/wrapper/wrapper.sh: line 26:  5886 Killed                  /usr/bin/timeout $JobLimit ${UserExe} "$@"
/etc/condor/wrapper/wrapper.sh: line 26:  6017 Killed                  /usr/bin/timeout $JobLimit ${UserExe} "$@"
/etc/condor/wrapper/wrapper.sh: line 26:  6029 Killed                  /usr/bin/timeout $JobLimit ${UserExe} "$@"
/etc/condor/wrapper/wrapper.sh: line 26:  6038 Killed                  /usr/bin/timeout $JobLimit ${UserExe} "$@"
```

```
 1 #!/bin/bash
 2
 3 ## The handler of signals
 4 trap stop_user_job 2 3 15
 5 stop_user_job() {
 6     #echo "Job ${_CONDOR_IHEP_JOB_ID} is stopped by signal"
 7     kill -TERM $JobPid
 8 }
 9
10 ## execute user's job with maximum (JobLimit) wall time
11 JobWallTime=`grep -E '^AcctGroup ' $_CONDOR_JOB_AD |awk -F'"' '{print $2}'`
12 JobLimit=28800  # 8 hours
13 if [[ "$JobWallTime" == "long" ]]; then
14     JobLimit=1209600  # 14 days
15 fi
16 UserExe=$1
17 shift
18 /usr/bin/timeout $JobLimit ${UserExe} "$@" &
19
20 ## Capture the pid of the job to kill later, if needed
21 JobPid=$!
22 ## Wait for the job to exit of own accord
23 wait $JobPid
24 ExitCode=$?
25 if [ $ExitCode -eq 124 ]; then
26     echo "Job is KILLED: exceeds the time limit ("$JobLimit" secondes). " >&2
27 fi
28
29 exit $ExitCode
```

Slides From Liu Liang

30 independent samples (1x data) + 1 share mDIY integral MC (30x data)



SIG 16-mom

4 regions in mass of n/$\bar{n}$:

[0.9, 0.928] (Left Sideband)

[0.928, 0.942] (Left Signal Reg

[0.942, 0.955] (Right Signal Re

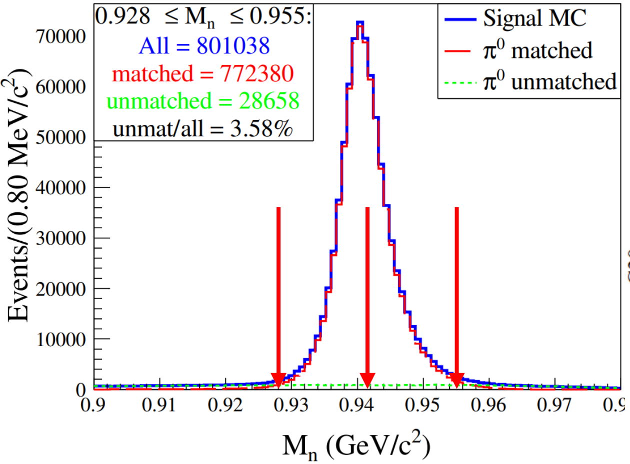
[0.955, 0.98] (Right Sideband).

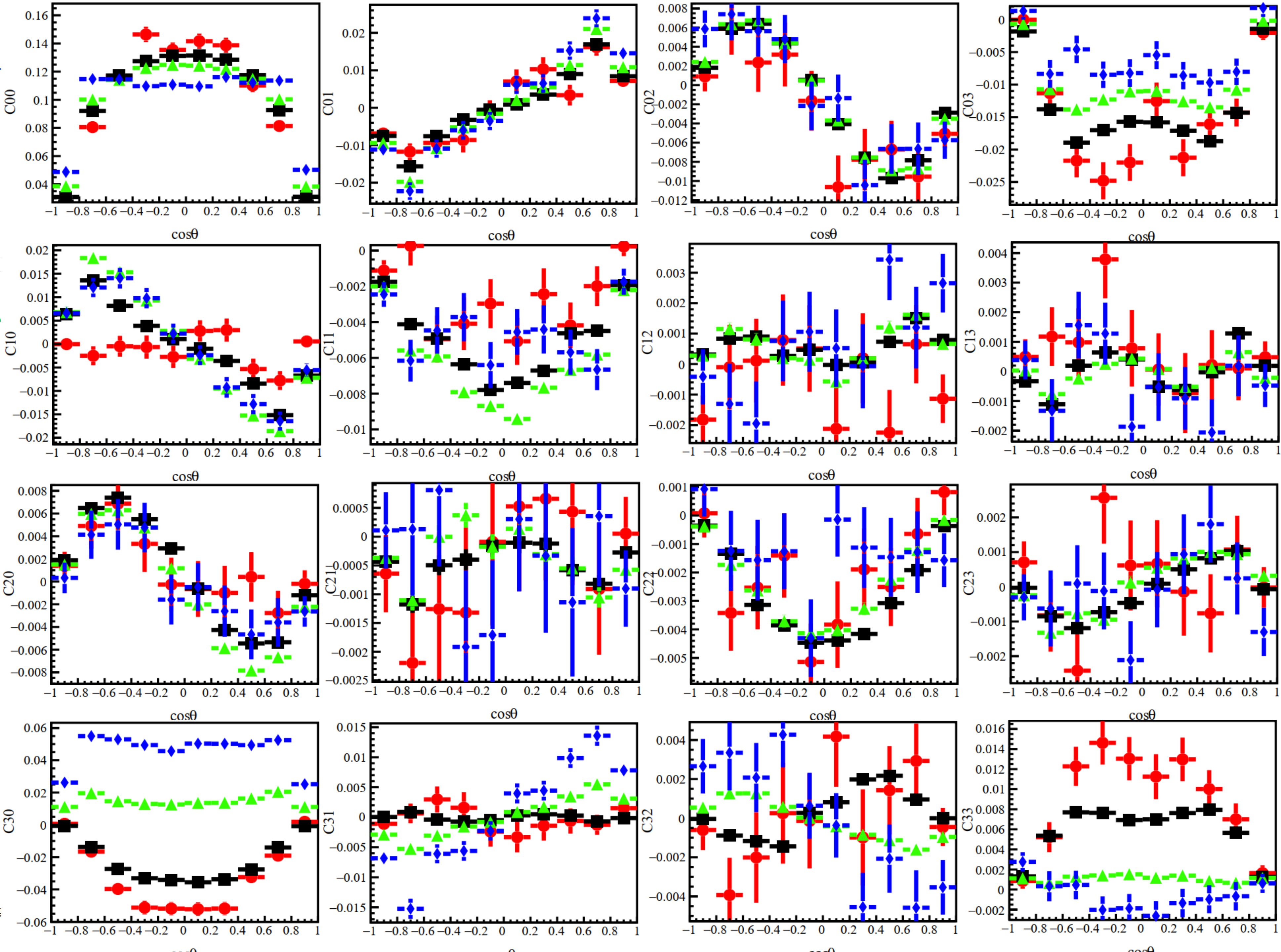
Left Sideband: Red

Left Signal Region: Black

Right Signal Region: Green

Right Sideband: Pink





IO Check | Exclusive MC Method Details

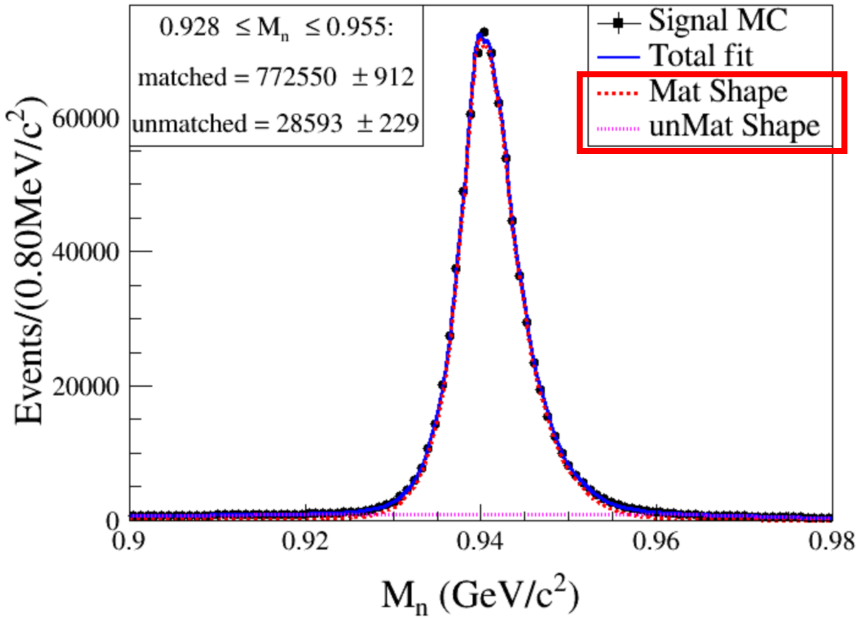
50 independent samples (1x data) + 1 share mDIY integral MC (50x data) Some Details

- **Nsig:** 产生50份mDIY MC (1x data), (每个 mDIY 含有 match 和 unmatch)
- **NBKG:** 描述本底的 Exclusive MC，由上述50份 mDIY MC得到：
  - 50 mDIY MC得到unmatch部分
  - 对于拟合 sample i, 将除i之外其他 mDIY MC unmatched 加在一起，作为sample i 的exclusive mc
- **Nbkg:** 用 match 和 unmatched 的形状拟合mDIY MC，得到Nbkg， 50个样本都用同样的 match 和 unmatch 形状拟合
- **NToy:** 将50份 mDIY MC mached 合起来作为MC积分的 Toy MC

$$N_{BKG}(sample\_i) = \sum_{k\neq i}^{50} N_{sig}^{unMatch}(sample\_i)$$

$$N_{Toy} = \sum_{i=1}^{50} N_{sig}^{Match}$$

$$\mathcal{L} = -\sum_{i=1}^{N_{sig}} ln\mathcal{W}(\xi_i,\alpha) + \frac{N_{bkg}}{N_{BKG}}\sum_{i=1}^{N_{BKG}} ln\mathcal{W}(\xi_i,\alpha) + (N_{sig}-N_{bkg})lnC^{-1}$$



IO Check | Sideband Method Details

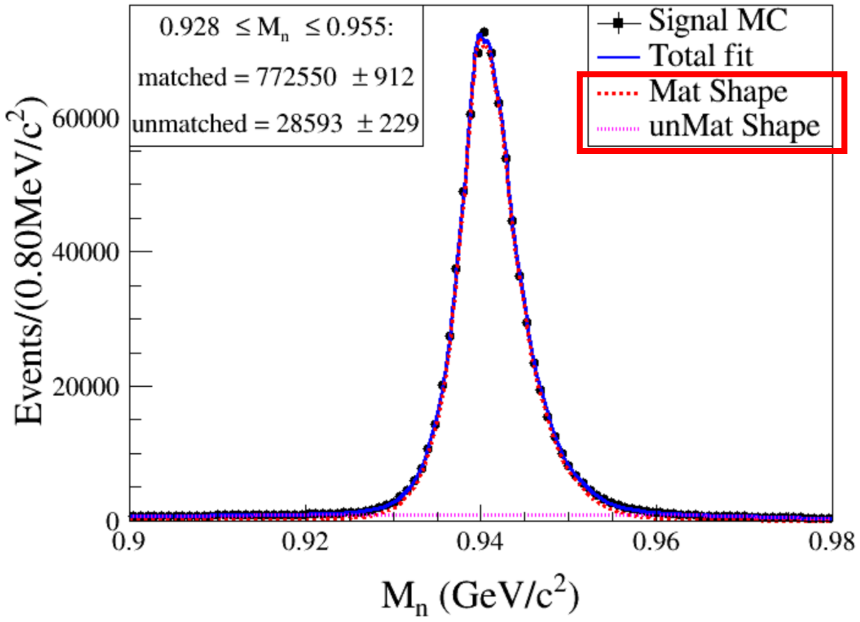
50 independent samples (1x data) + 1 share mDIY integral MC (50x data)   Some Details

- **Nsig:** 产生50份mDIY MC (1x data), (每个 mDIY 含有 match 和 unmatch)
- **NBKG:** 取左右sideband的事例数，左右sideband贡献，除以NBKG为归一化
- **Nbkg:** 用 match 和 unmatched 的形状拟合mDIY MC，得到Nbkg， 50个样本都用同样的 match 和 unmatch 形状拟合
- **NToy:** 将50份 mDIY MC mached 合起来作为MC积分的 Toy MC

$$N_{BKG} = \sum_{k}^{50} N_{sig}^{Left\ Sideband} + \sum_{k}^{50} N_{sig}^{Right\ Sideband}$$

$$N_{Toy} = \sum_{i=1}^{50} N_{sig}^{Match}$$

$$\mathcal{L} = -\sum_{i=1}^{N_{sig}} ln\mathcal{W}(\xi_i, \alpha) + \frac{N_{bkg}}{N_{BKG}} \sum_{i=1}^{N_{BKG}} ln\mathcal{W}(\xi_i, \alpha) + (N_{sig} - N_{bkg}) lnC^{-1}$$



About 16 moment

$$C_{\alpha\beta} = \bar{n}_\alpha n_\beta$$

$\bar{n}_\alpha$: $\bar{\Lambda}$ 衰变的重子动量于给定参考系中的分量

n_β: Λ衰变的重子动量于给定参考系中的分量

Figure 12 shows the distribution of moment versus $\cos\theta$, the $\cos\theta$ is divided by 10 bins. For main value it is normalized by total number of events of the average value in i-th bin, which means:

$$T_i = \frac{1}{N_{total}} \sum_{k=1}^{N_i} C_{\alpha\beta}, \qquad (13)$$

here $N_{total} = 1934$ is the number of events of data sample and N_i is the number of events in the i-th bin. For the corresponding uncertainty, it is estimated by the formula below:

$$\sigma = \frac{T_i}{\sqrt{N_i}} + \sqrt{\frac{N_i}{N_{total}} \sum_{k=1}^{N_i} C_{\alpha\beta}^2 - \frac{1}{N_{total}^2} [\sum_{k=1}^{N_i} C_{\alpha\beta}]^2} \qquad (14)$$

Event Selection of $\bar{p}\pi^+n\pi^0$

- Good Charged Tracks
  - $V_r \leq 10cm,\ \ |V_z| \leq 30cm$
  - $|cos\theta| < 0.93$
  - nGood = 2
- PID (Use dedx+TOF)
  - **Proton**: $p > 0.5$ GeV/c && PID:
    Prob(p) > Prob(K/π)
  - **Pion**: $p < 0.5$ GeV/c && PID:
    Prob(π) > Prob(K/p)
- Good Shower Selection
  - $|cos\theta| \leq 0.8\ ,\ E > 25MeV$
  - $0.86 \leq\ |cos\theta| \leq 0.92\ , E > 50MeV$
  - $0 \leq TDC \leq 14$
  - Nshower ≥ 2
  - $Ang_{shower,ChgTrk} \geq 10°$ (for $\bar{p} \geq 20°$)
- $\bar{\Lambda}$ Reconstruction
  - Primary and Secondary vertex fit
  - $L/\sigma_L\ > 2.0$
  - $\chi^2_{sec} < 15$
  - $|M_{\bar{p}\pi^+} - 1.1157| < 0.008\ (GeV/c^2)$
  - $M^{recoil}_{\bar{p}\pi^+} \in [1.069, 1.152]\ GeV/c^2$
- 2C Kinematic fit
  - On the hypothesis of $\bar{\Lambda}n\gamma\gamma$
  - Loop all γ pairs, perform:
    - $75 < M_{\gamma\gamma} < 175$ (MeV/c^2)
    - $\frac{|E_1 - E_2|}{p_{\pi^0}} < 0.9$
    - $\theta_{\gamma,\Lambda} > 10°$, Λ direction is recoiled from $\bar{\Lambda}$
    - BDT Response > 0.15
  - $\bar{\Lambda}$ is from secondary vertex fit
  - Neutron is treated as a missing particle
  - Constrain $M_{n\pi^0} = M^{PDG}_{\Lambda}$ and $M_{\gamma\gamma} = M^{PDG}_{\pi^0}$
  - $\chi^2_{kmfit} < 50$
  - $M_n \in [0.90, 0.98] GeV/c^2$

Event Selection of $p\pi^-\bar{n}\pi^0$

- Charged Tracks
  - $V_r \leq 10cm,\ \ |V_z| \leq 30cm$
  - $|cos\theta| < 0.93$
  - nGood = 2
- PID (Use dedx+TOF)
  - **Proton**: $p > 0.5$ GeV/c && PID:
    Prob(p) > Prob(K/π)
  - **Pion**: $p < 0.5$ GeV/c && PID:
    Prob(π) > Prob(K/p)
  - nProton ≥ 1; nPion ≥ 1
- Shower Selection
  - $|cos\theta| \leq 0.8\,,\ E > 25MeV$
  - $0.86 \leq\ |cos\theta| \leq 0.92\,, E > 50MeV$
  - $0 \leq TDC \leq 14$
  - Nshower ≥ 2
  - $\theta_{Trk,\gamma} \geq 10°$
- Λ Reconstruction
  - Primary and Secondary vertex fit
  - $L/\sigma_L > 2.0$
  - $\chi^2_{sec} < 15$
  - $|M_{p\pi^-} - 1.1157| < 8$ MeV/c^2
  - $M^{recoil}_{p\pi^-} \in [1.069, 1.152]\ GeV/c^2$
- 2C Kinematic fit
  - on the hypothesis of $\Lambda\bar{n}\gamma\gamma$
  - Loop all γ pairs, perform:
    - $75 < M_{\gamma\gamma} < 175$ (MeV/c^2)
    - $\frac{|E_1 - E_2|}{\pi^0} < 0.8$
    - $\theta_{\gamma,\Lambda} > 15°,$ $\bar{\Lambda}$ direction is recoiled from Λ
    - BDT Response > 0.15
  - Λ is from secondary vertex fit
  - Anti-neutron is treated as a missing particle
  - Constrain $M_{\bar{n}\pi^0} = M^{PDG}_{\bar{\Lambda}}$ and $M_{\gamma\gamma} = M^{PDG}_{\pi^0}$
  - $\chi^2_{kmfit} < 50$
  - $M_{\bar{n}} \in [0.9, 0.98]\ \ GeV/c^2$

	$\bar{p}\pi^+ n\pi^0$		$p\pi^- \bar{n}\pi^0$	
	eff	(%)	eff	(%)
Total	100%		100%	
Good Charged	65.6%		64.3%	
PID	63.6%	97.0%	62.6%	97.3%
Good Shower	56.2%	88.4%	60.3%	96.4%
Vertex Fit $(L/Lerr > 2$ && $\chi^2_{sec} < 15$ $\bar{\Lambda}/\Lambda$ 5σ mass window $\bar{\Lambda}/\Lambda$ 3σ recoil mass)	44.7%	79.5%	47.8%	79.3%
Kinematic Fit $(\theta_{\Lambda,\gamma} > 10°/ \theta_{\bar{\Lambda},\gamma} > 15°$ $Asy < 0.8$ $BDT > 0.15)$	26.4%	59.1%	20.5%	42.8%
$\chi^2_{kmfit} < 50$	23.0%	87.2%	17.4%	84.8%
$0.90 < M_n/M_{\bar{n}} < 0.98$	20.2%	87.6%	15.8%	91.0%
γ Truth Match	18.4%	91.4%	13.3%	84.3%

Online Cut