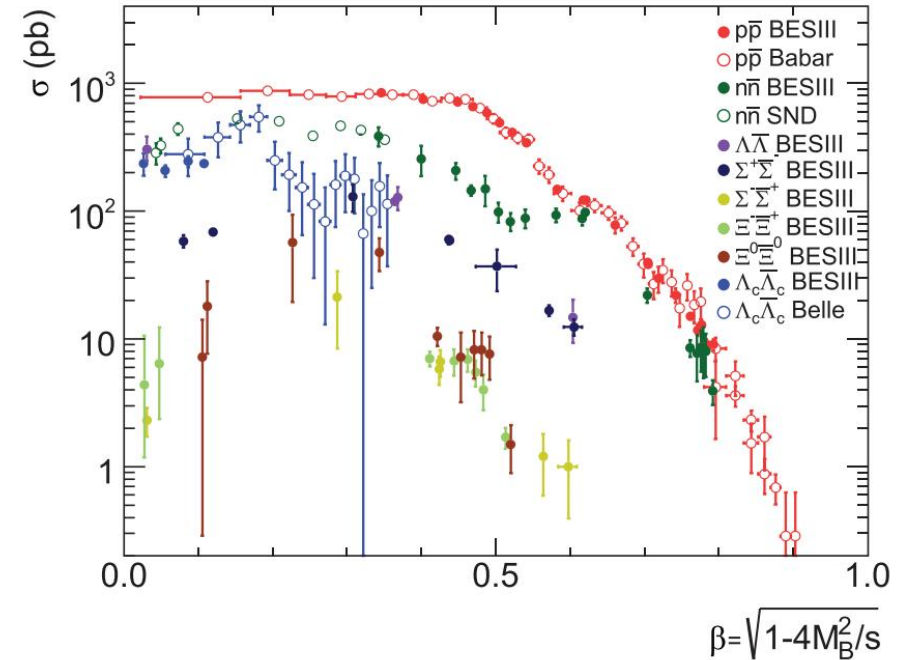


Measurement of the cross sections for

$$e^+e^- \rightarrow \Lambda\pi^+\bar{\Sigma}^- + c.c. \text{ and } e^+e^- \rightarrow \Lambda\pi^-\bar{\Sigma}^+ + c.c.$$

Motivation

1. Experimentally, the anomalous behavior of $e^+e^- \rightarrow p\bar{p}$, $n\bar{n}$, $\Lambda\bar{\Lambda}$ differing from the pQCD prediction around threshold is observed. The precision measurement of the e^+e^- cross section will be **very helpful for confirming the speculation** that whether or not there is an unexpectedly large cross section near threshold and **better understanding the decay dynamics**.



2. Until now, there is **the first** measurement of the decay $e^+e^- \rightarrow \Lambda\pi^+\bar{\Sigma}^- (\bar{\Lambda}\pi^-\Sigma^+)$ and $e^+e^- \rightarrow \Lambda\pi^-\bar{\Sigma}^+ (\bar{\Lambda}\pi^+\Sigma^-)$.
3. Searching for baryon decuplet $\Sigma^*(1385)$ and its related decays, such as $\Sigma\Sigma^*(1385)$ and $\Lambda\Sigma^*(1385)$.

Data and MC

➤ BOSS version : 665.p01

➤ Data samples :

The total luminosity is about 370 pb^{-1} ;

ten data samples : the center energy

between 2.6444 to 3.080 GeV ;

2.800 GeV: data of 2012 and 2015

years, respectively.

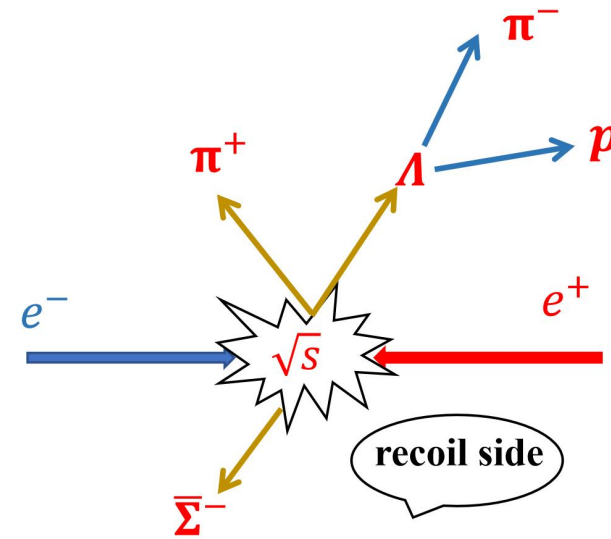
\sqrt{s} (GeV)	$\mathcal{L}(\text{pb}^{-1})$	Run No.	Boss version
2.6444	34.003	40128 ~ 40298	Boss665.p01
2.6464	33.722	40300 ~ 40435	Boss665.p01
2.7000	1.03	40436 ~ 40439	Boss665.p01
2.8000(2012)	3.753	28553 ~ 28575	Boss665.p01
2.8000(2015)	1.008	40440 ~ 40443	Boss665.p01
2.9000	105.253	39775 ~ 40069	Boss665.p01
2.9500	15.942	39619 ~ 39650	Boss665.p01
2.9810	16.071	39651 ~ 39679	Boss665.p01
3.0000	15.881	39680 ~ 39710	Boss665.p01
3.0200	17.290	39711 ~ 39738	Boss665.p01
3.0800	126.185	39355 ~ 39618	Boss665.p01

official Inclusive MC

Signal MC: $e^+e^- \rightarrow \Lambda\pi^+\bar{\Sigma}^-$ (PHSP), $\Lambda \rightarrow p\pi^-$ (PHSP), $\bar{\Sigma}^- \rightarrow anything$;

partial reconstruction method:

- (1) reconstruct **one** Λ with the clean process $\Lambda \rightarrow p\pi^-$;
- (2) combine **a** π^+/π^- produced by IP with Λ ;
- (3) check the **recoil mass of $\Lambda\pi$** system for $\bar{\Sigma}$ signal.



Event selection:

Good charged tracks :

➤ $|\cos\theta| < 0.93$

➤ tracks from Λ :

$$N_{track^+} > 1 \ \& \ N_{track^-} > 1$$

$$|V_z| < 20.0cm$$

➤ other tracks :

$$|V_{xy}| < 1.0cm \ \& \ |V_z| < 10.0cm$$

PID:

➤ $p: \text{prob}(p) > \text{prob}(\pi) \ \& \ \text{prob}(p) > \text{prob}(K)$

➤ $\pi: \text{prob}(\pi) > \text{prob}(p) \ \& \ \text{prob}(\pi) > \text{prob}(K)$

Reconstruct Λ :

➤ vertex fit and Secondary vertex fit successfully;

➤ $L/\sigma_L > 2$ and retain **one Λ with the maximum L/σ_L** ;

➤ $\chi^2 < 20$;

π^\pm from e^+e^- :

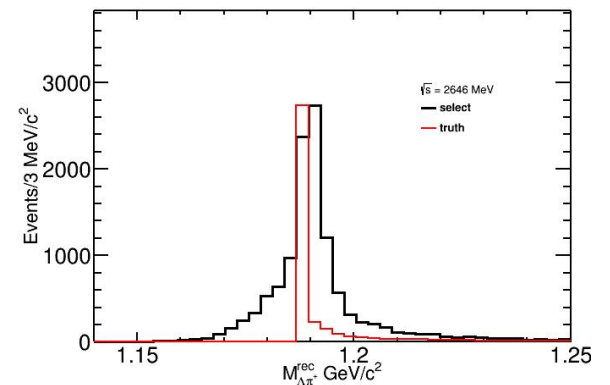
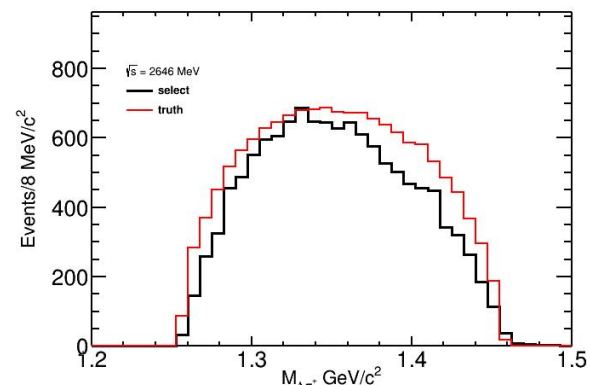
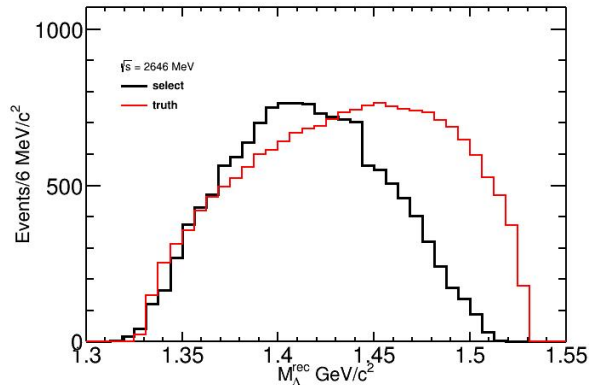
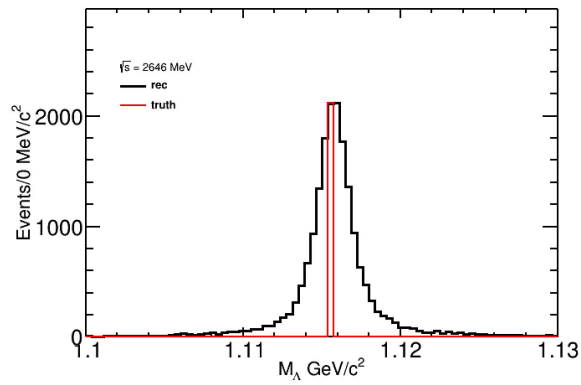
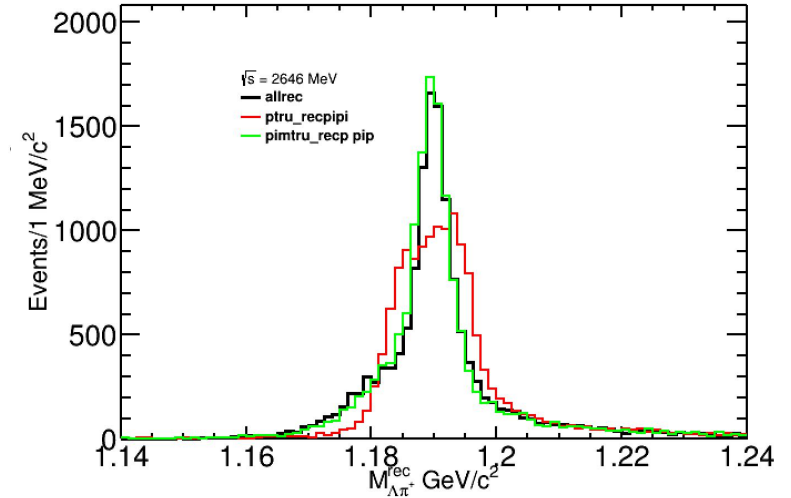
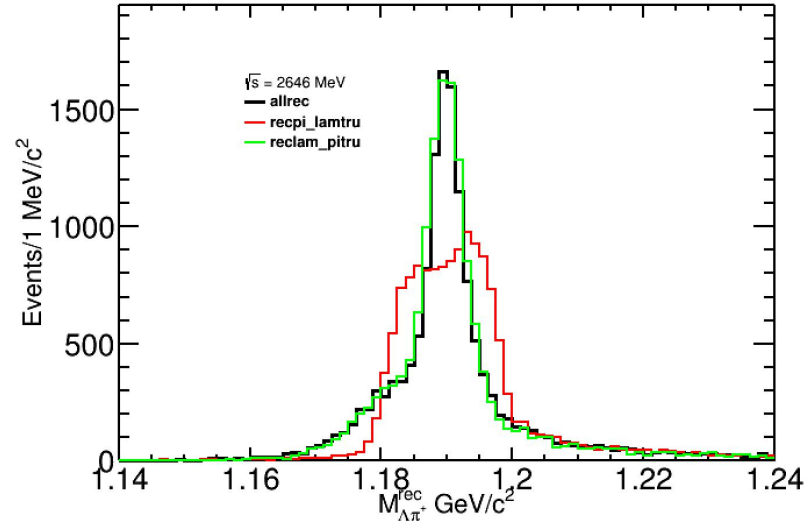
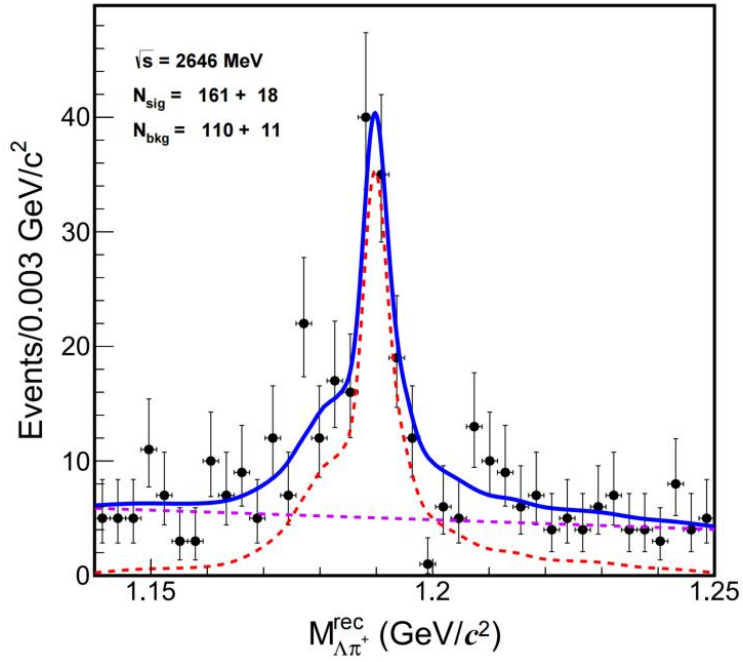
➤ **Skip** π^\pm that has been used to reconstruct Λ ;

➤ $|V_{xy}| < 1.0cm \ \& \ |V_z| < 10.0cm$

➤ $N_{\pi^+(\pi^-)} = 1$

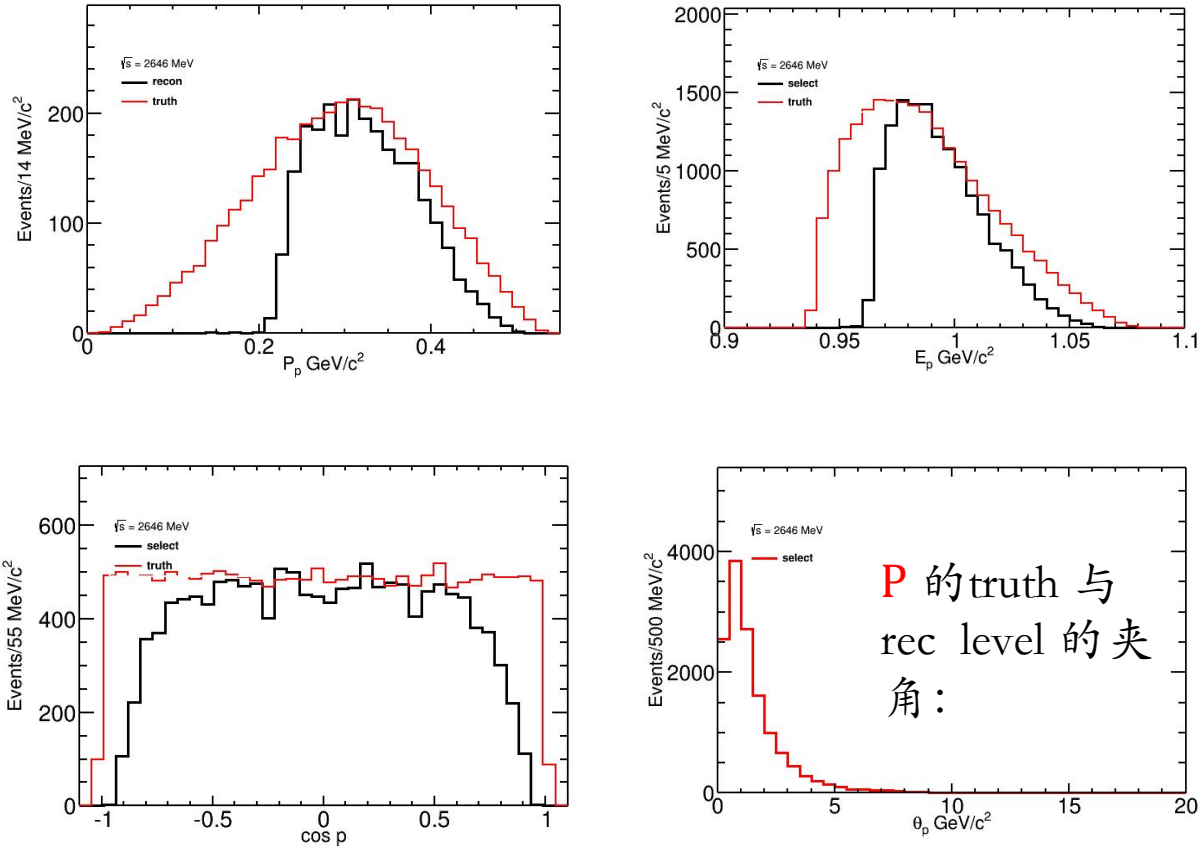
2.6464: $e^+e^- \rightarrow \Lambda\pi^+\bar{\Sigma}^-$

Mass:

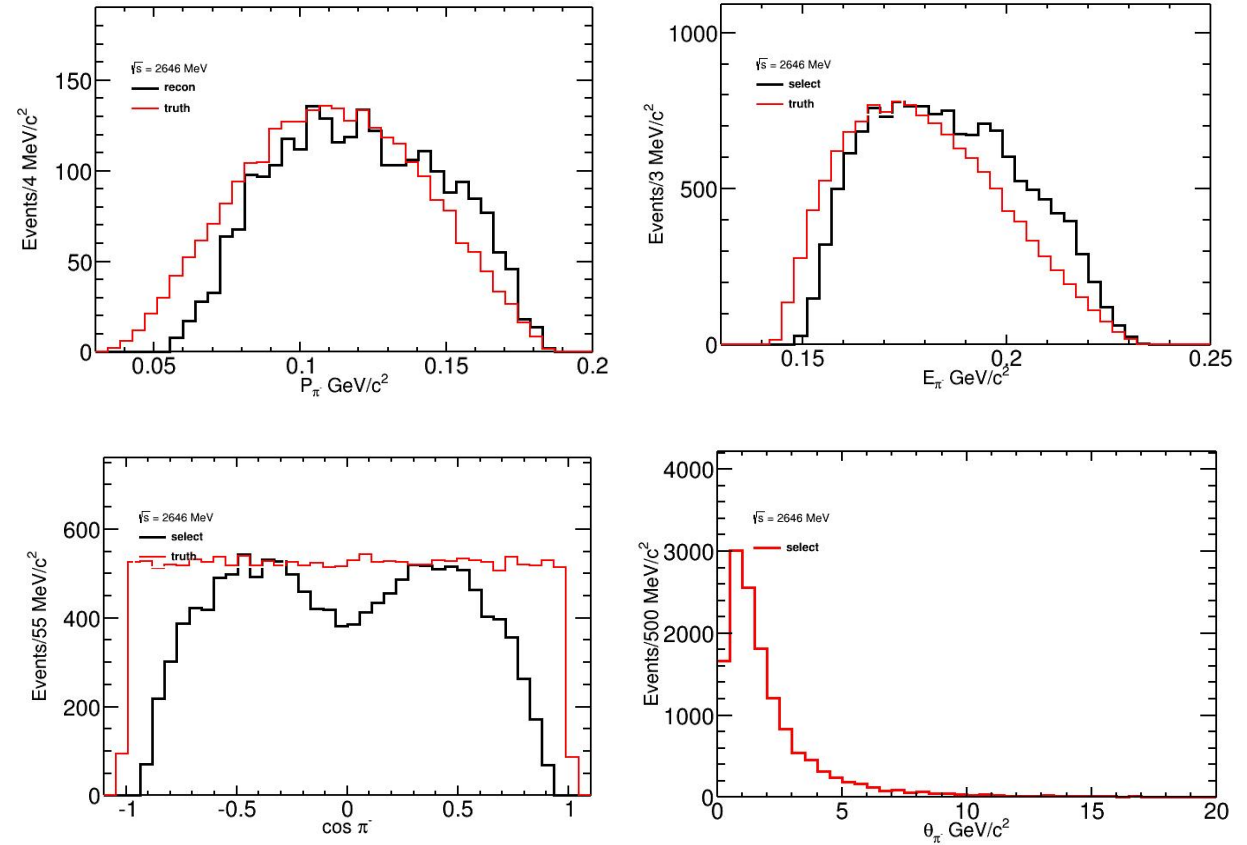


2.6464: $e^+e^- \rightarrow \Lambda\pi^+\bar{\Sigma}^-$

Λ 重建里的 p 的 truth 与 rec level :



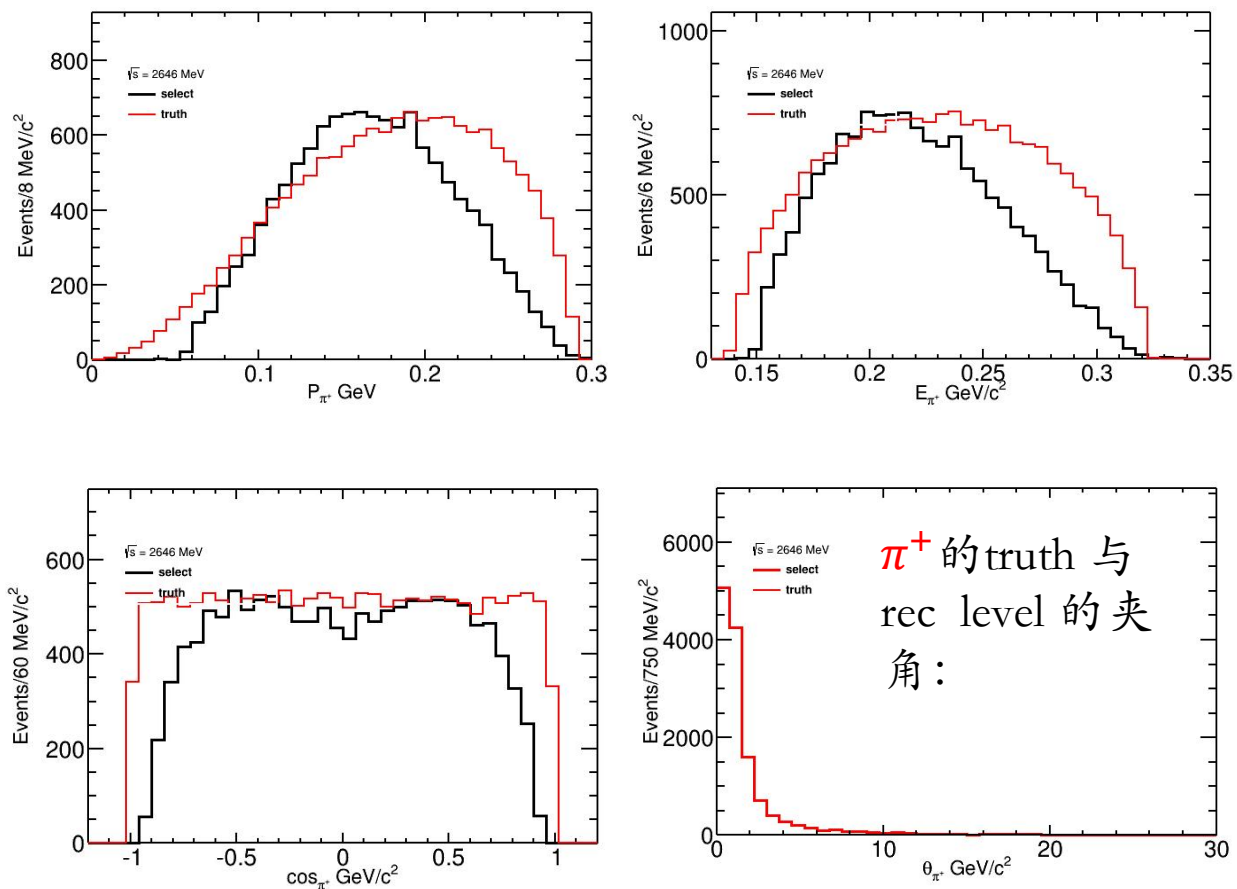
Λ 重建里的 π^- truth 与 rec level :



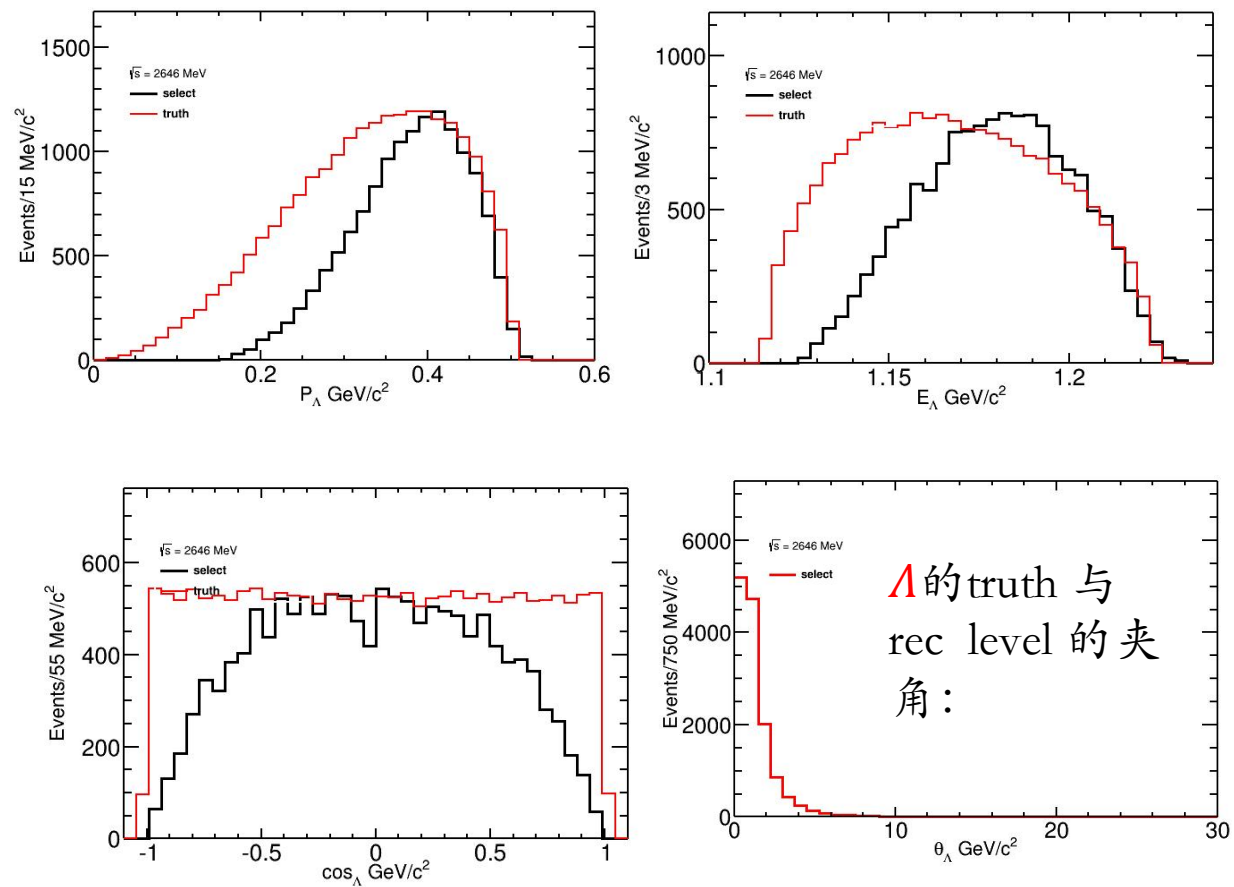
p 的 truth 与
rec level 的夹
角:

2.6464: $e^+e^- \rightarrow \Lambda\pi^+\bar{\Sigma}^-$

π^+ 的 truth 与 rec level 的四动量、角度对比:



Λ 的 truth 与 rec level 的四动量、角度对比:



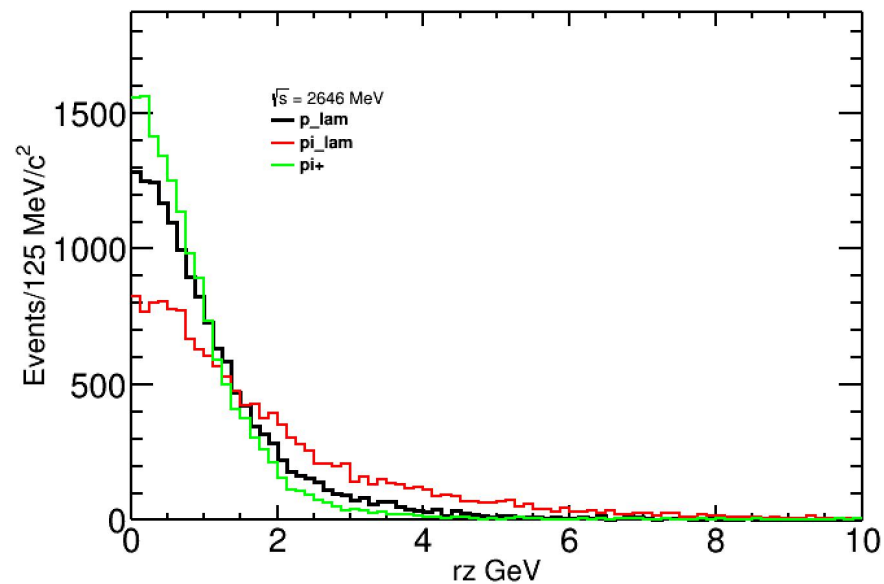
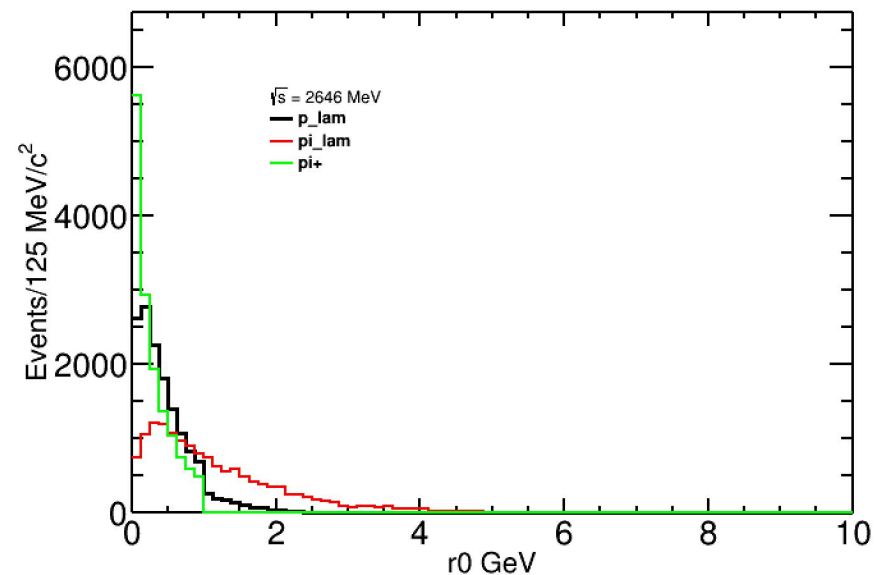
补充: DEC

```
noPhotos
Particle vpho 2.6464 0.0
Decay vpho
1.0000 gamma gamma* ConExc -2 3122 211 -3222;
Enddecay

Decay gamma*
1.0000 Lambda0 pi+ anti-Sigma- PHSP;
Enddecay

Decay Lambda0
1.0000 p+ pi- PHSP;
Enddecay

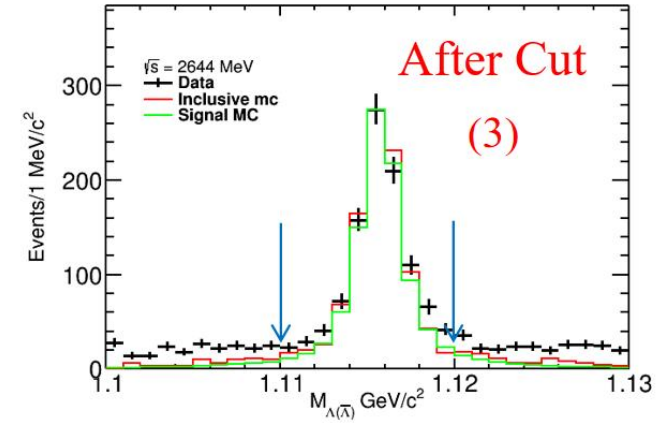
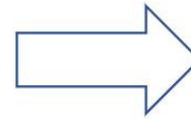
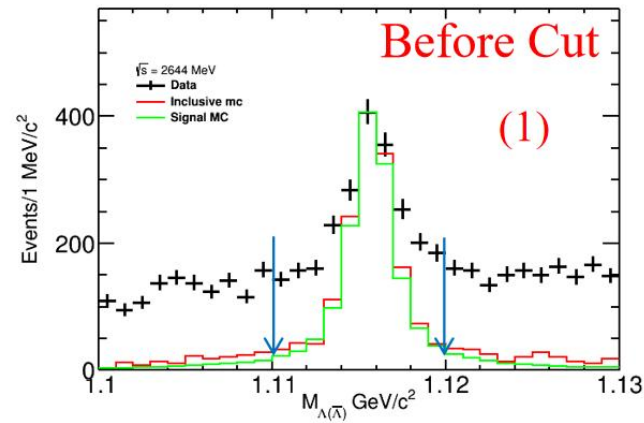
End
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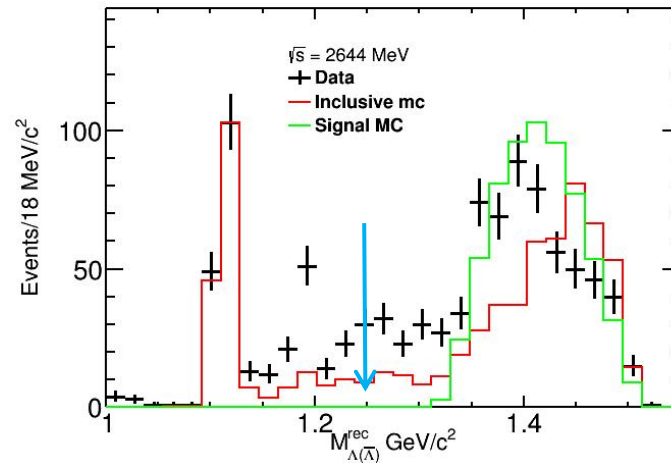
补充: BKG

- $1.11 < M_{\Lambda(\bar{\Lambda})} < 1.12 \text{ GeV}/c^2$

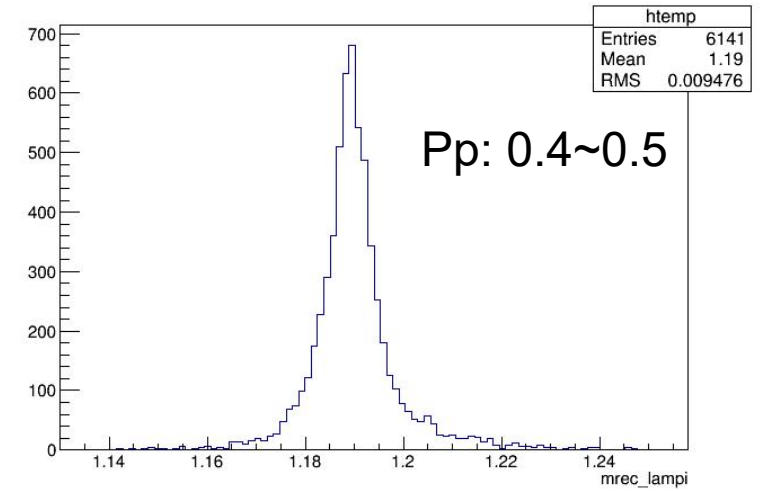
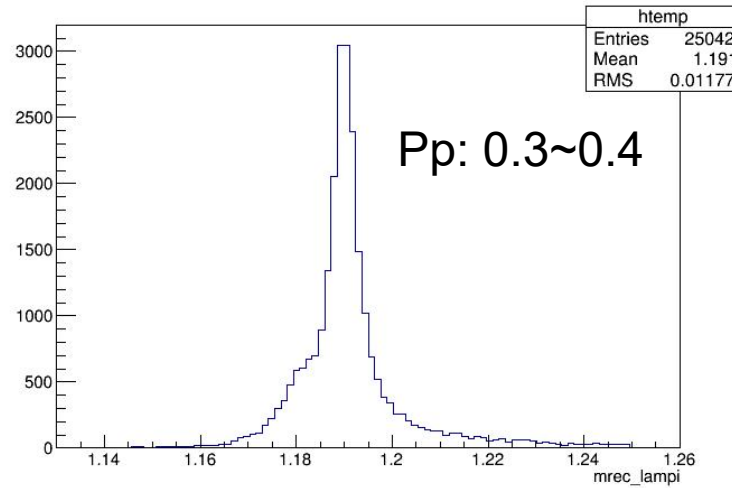
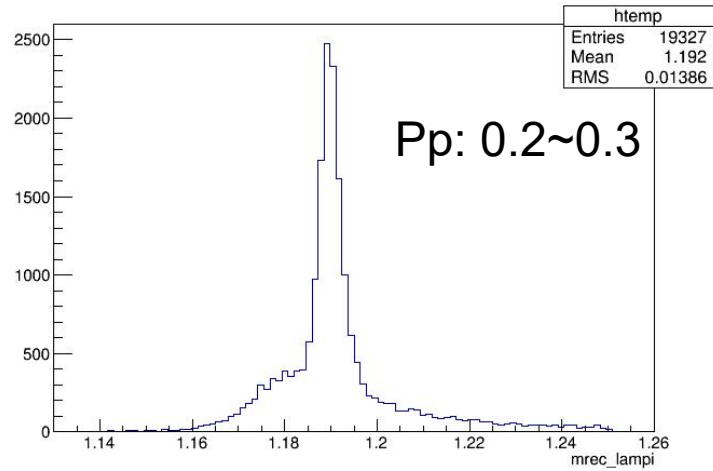
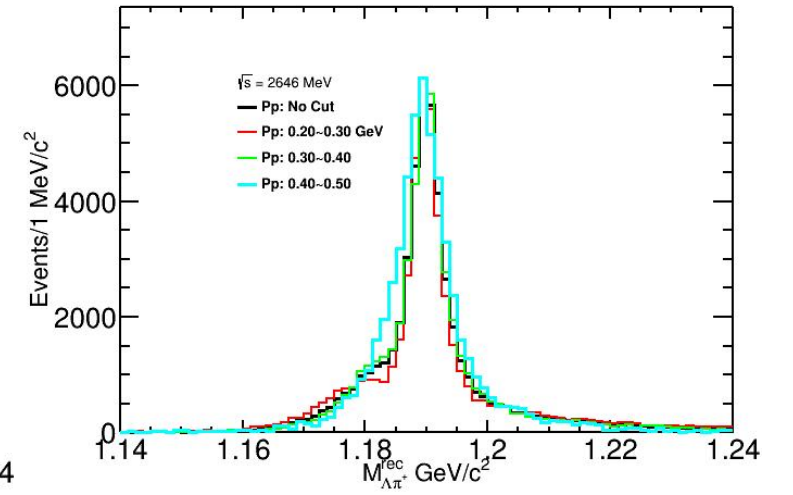
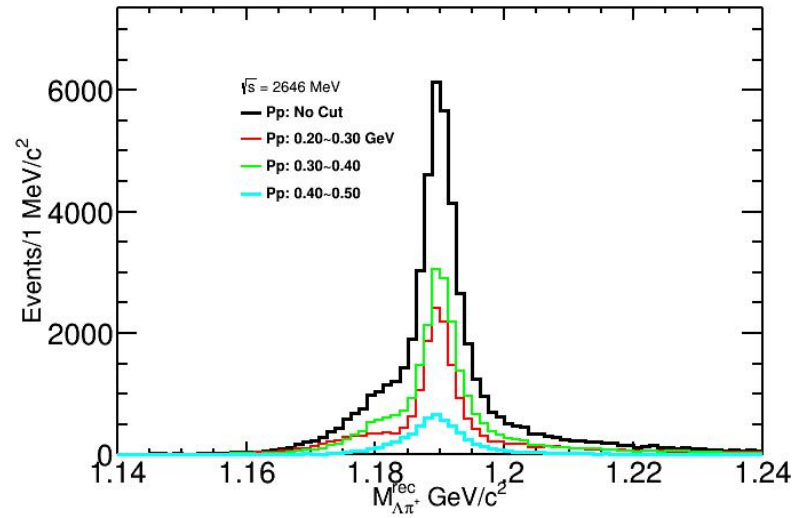
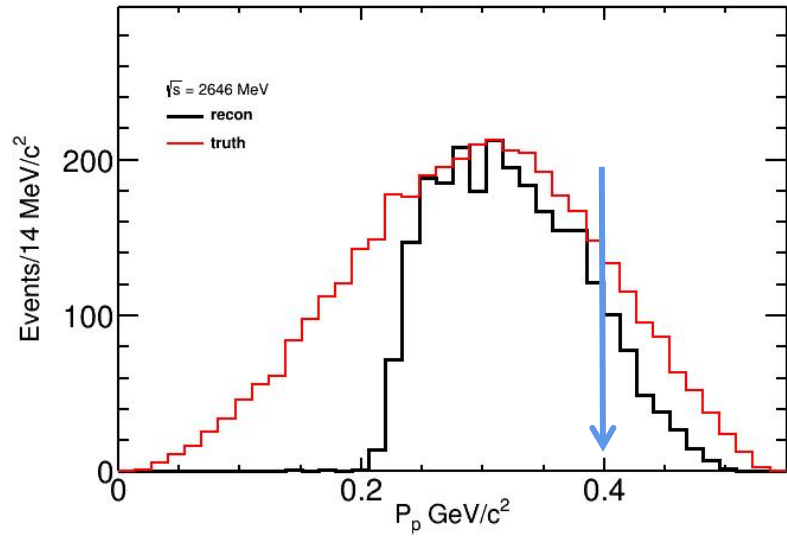
- $\chi^2 < 20$



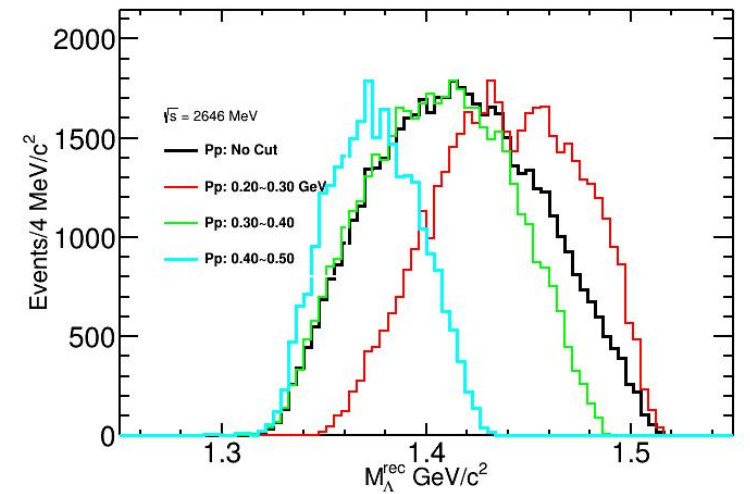
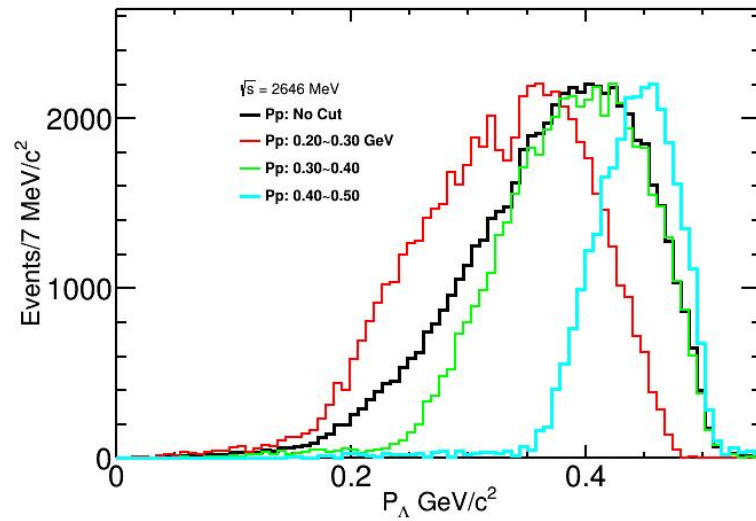
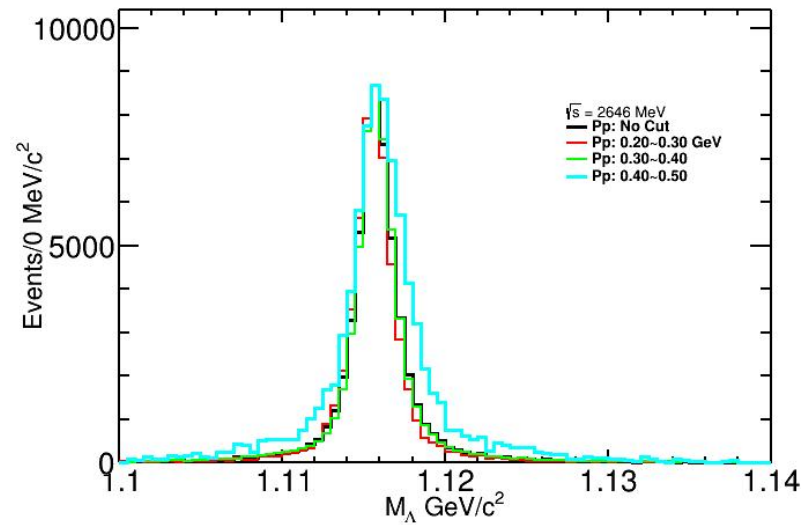
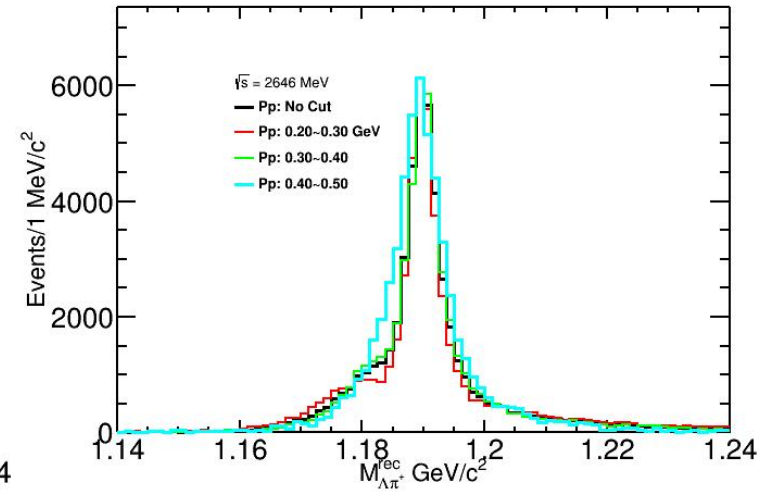
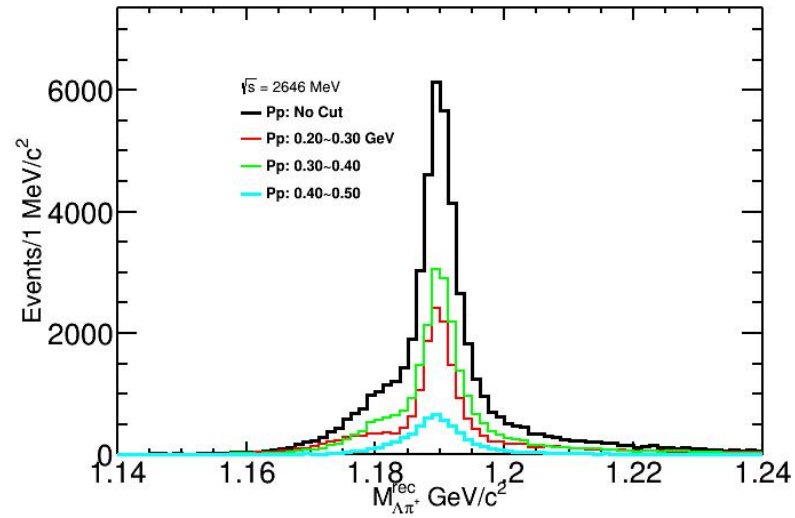
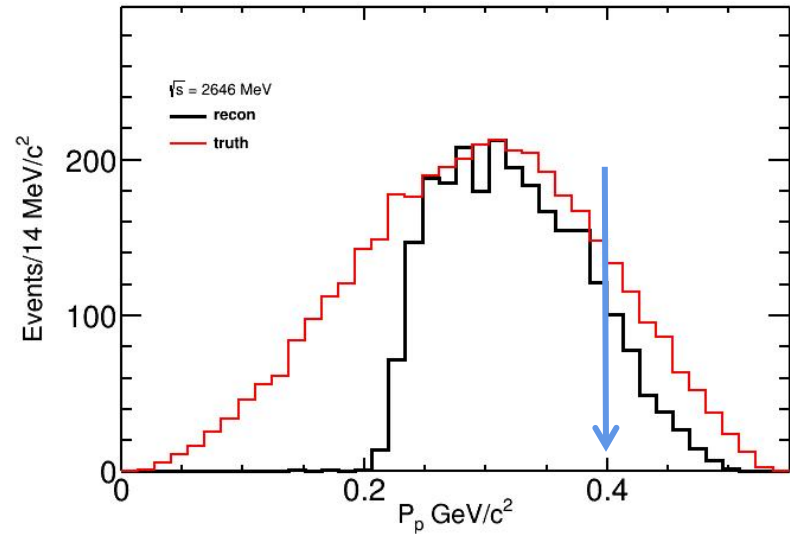
- $M_{\Lambda(\bar{\Lambda})}^{recoil} > 1.25 \text{ GeV}$



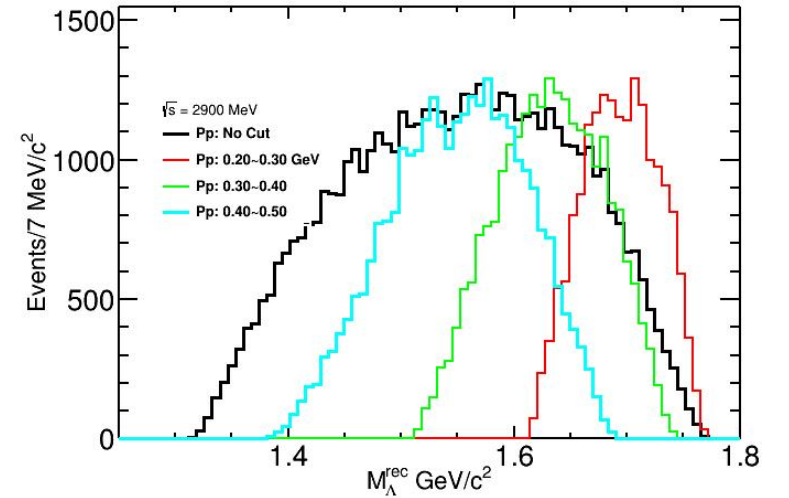
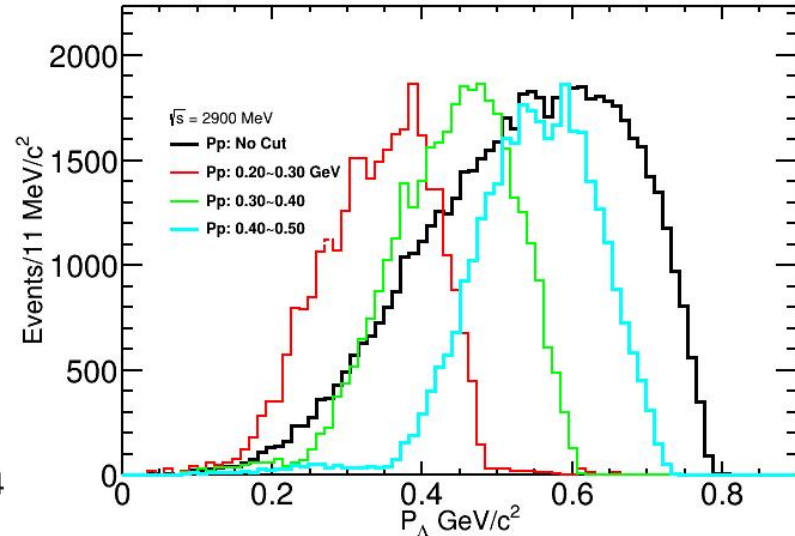
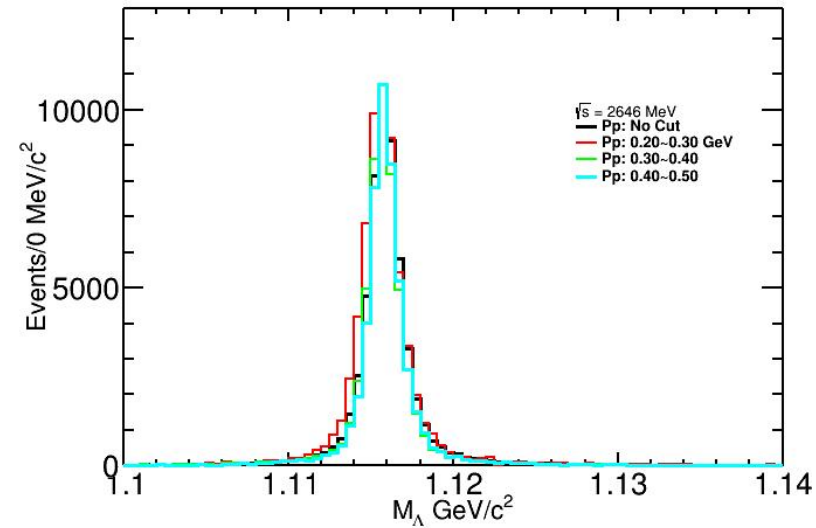
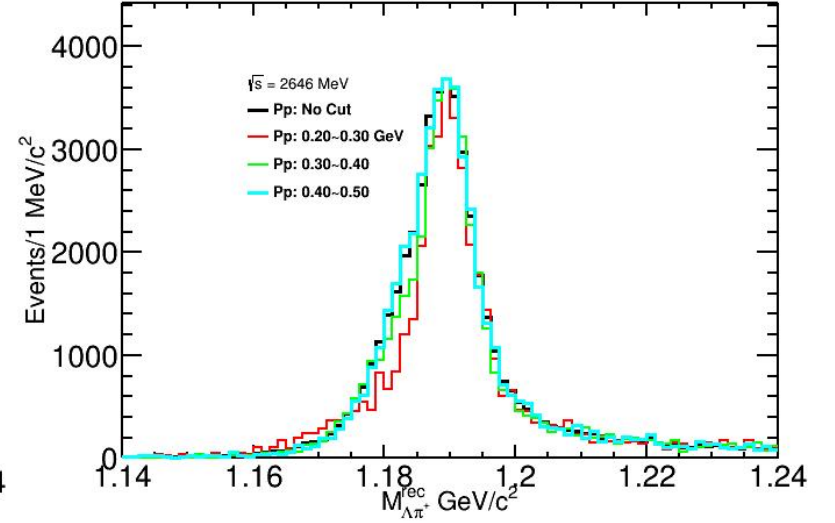
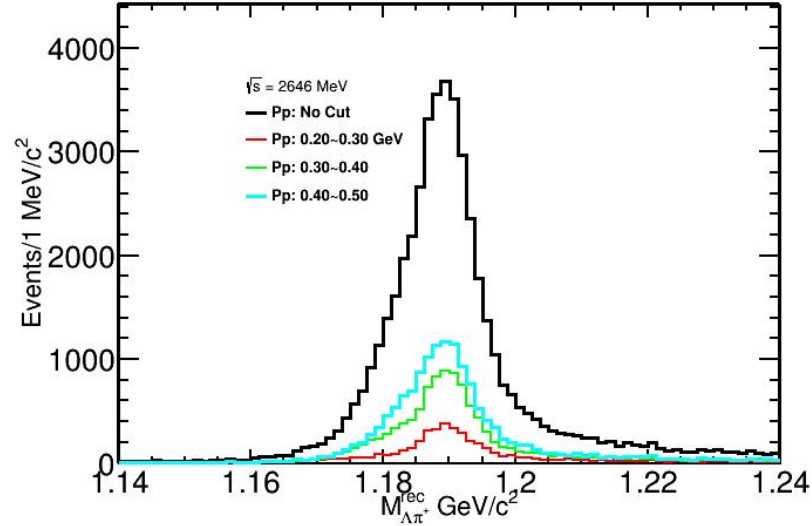
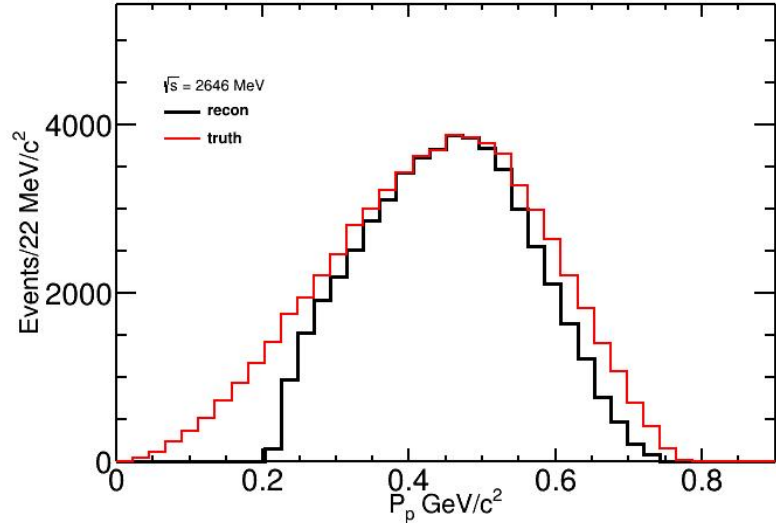
2.6464: $e^+e^- \rightarrow \Lambda\pi^+\bar{\Sigma}^-$

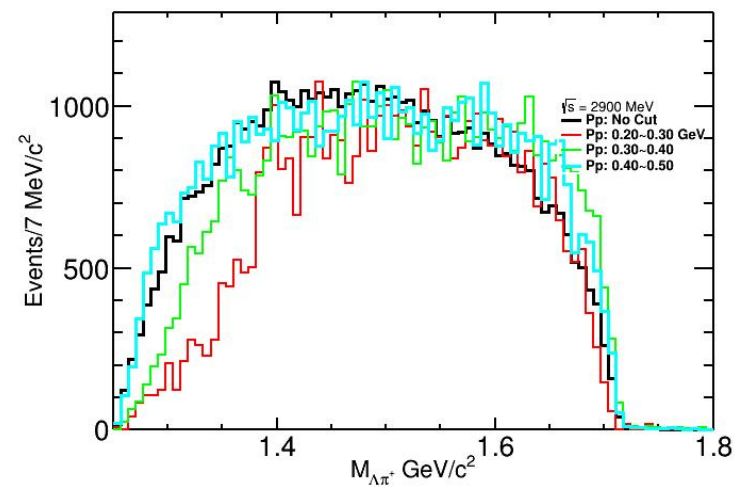
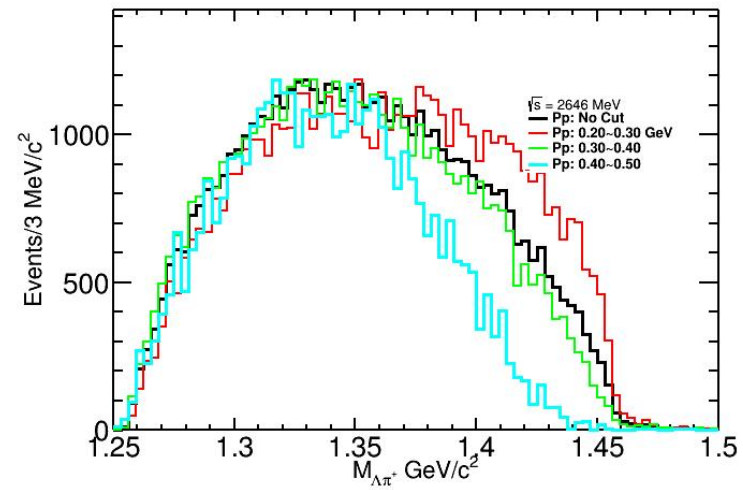
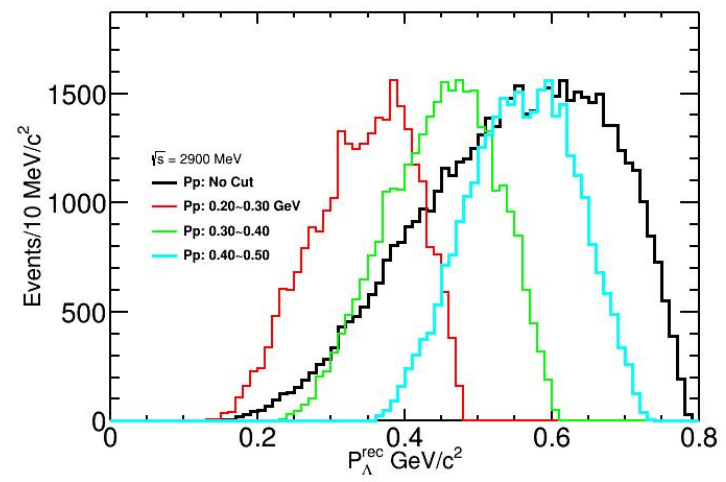
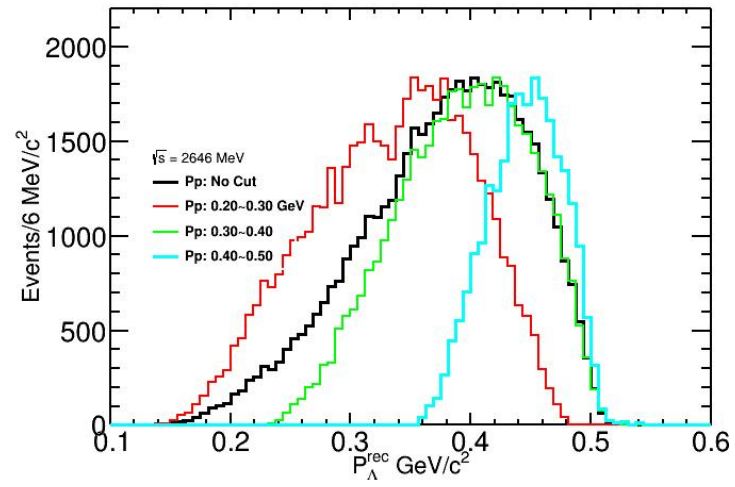


2.6464: $e^+e^- \rightarrow \Lambda\pi^+\bar{\Sigma}^-$

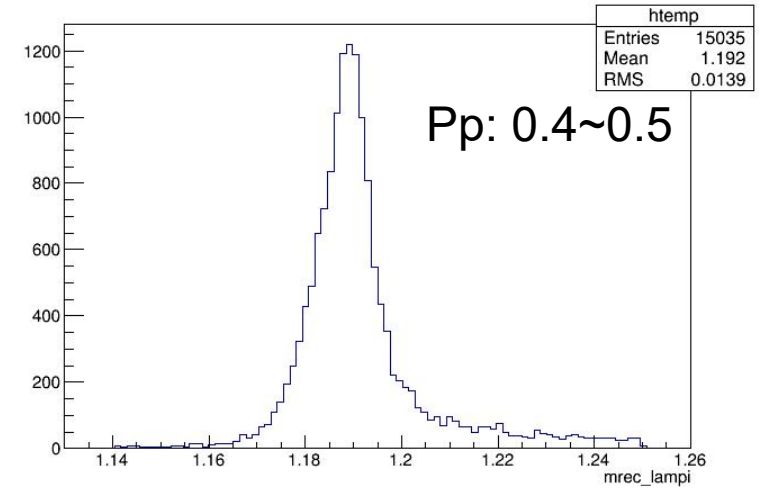
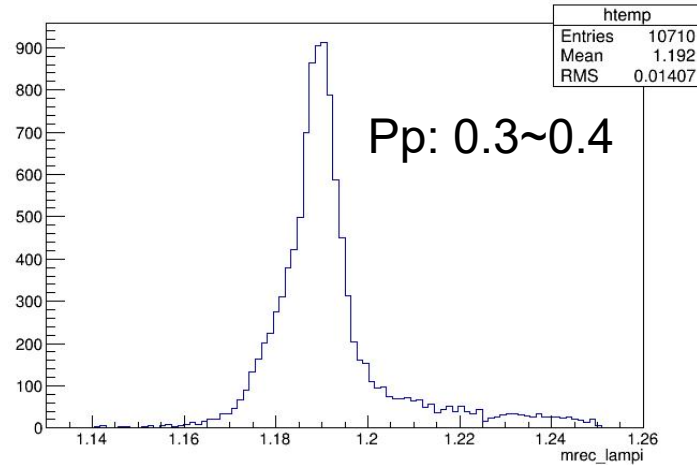
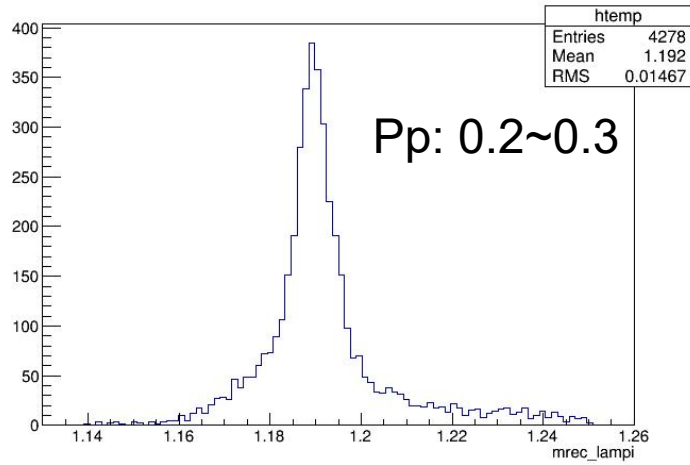
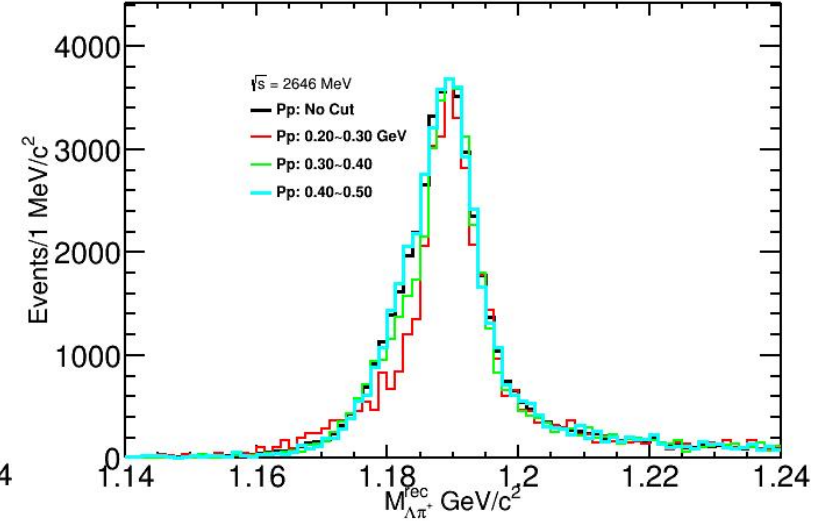
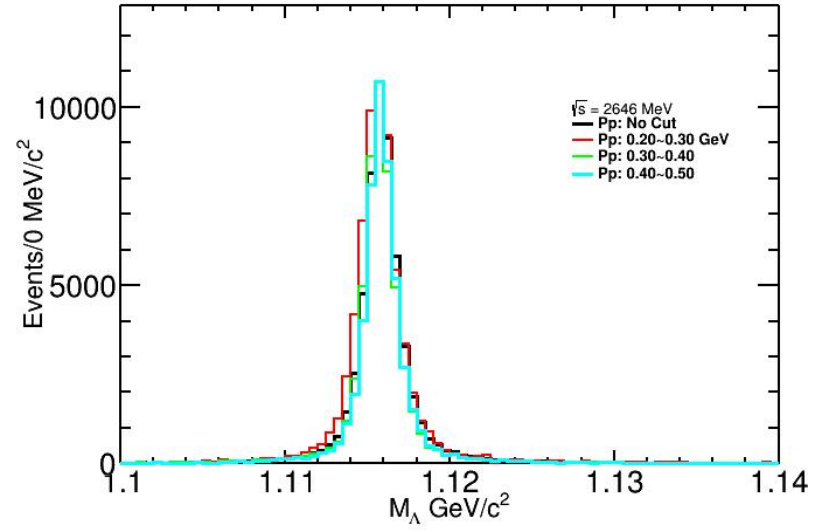
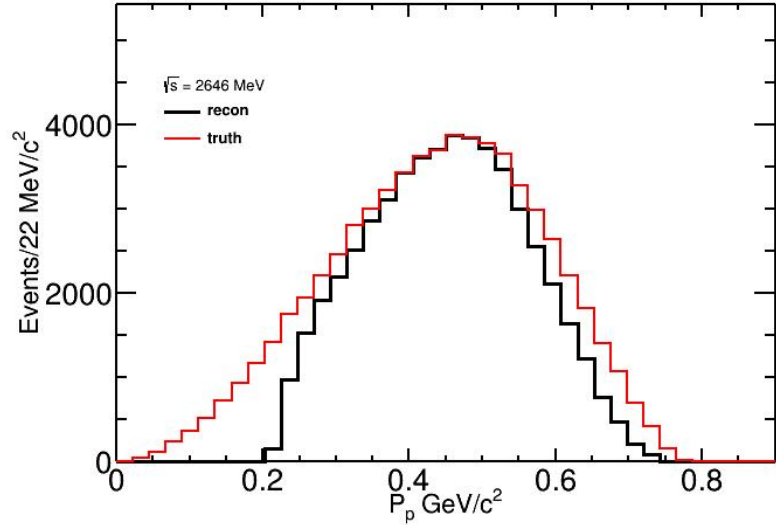


2.9000: $e^+e^- \rightarrow \Lambda\pi^+\bar{\Sigma}^-$

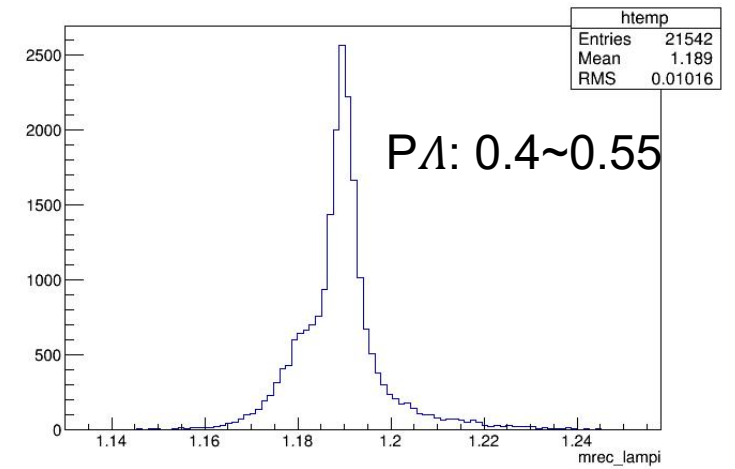
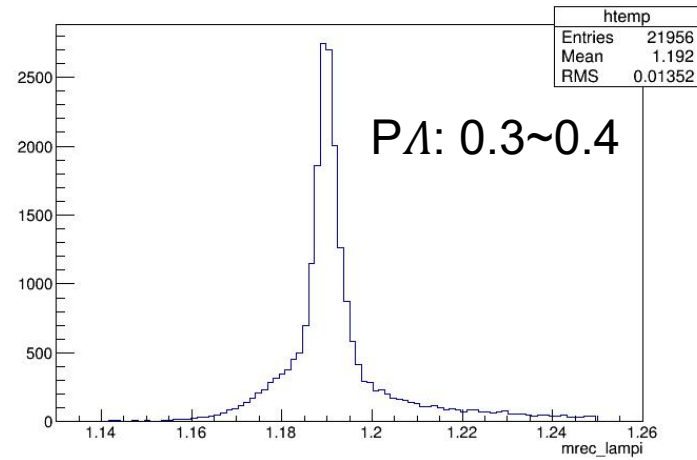
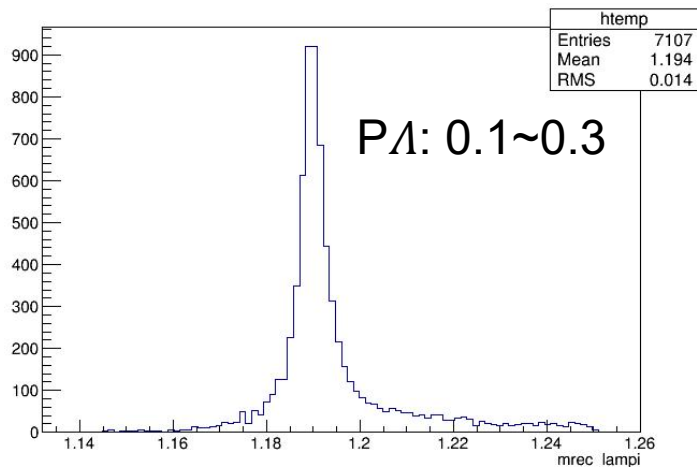
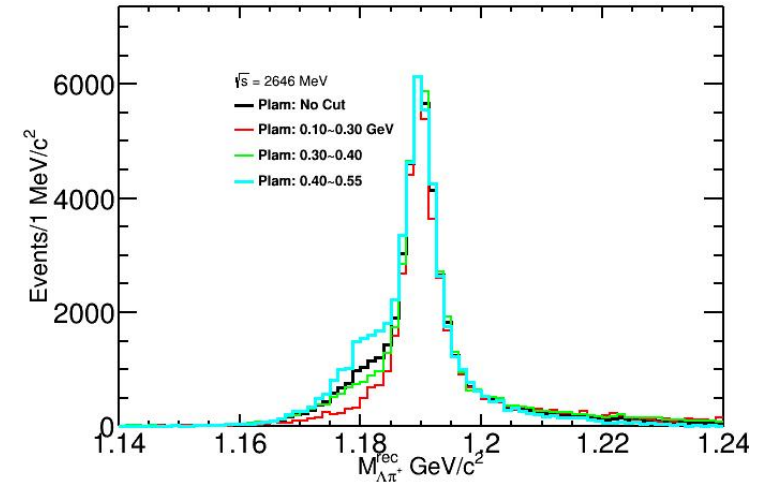
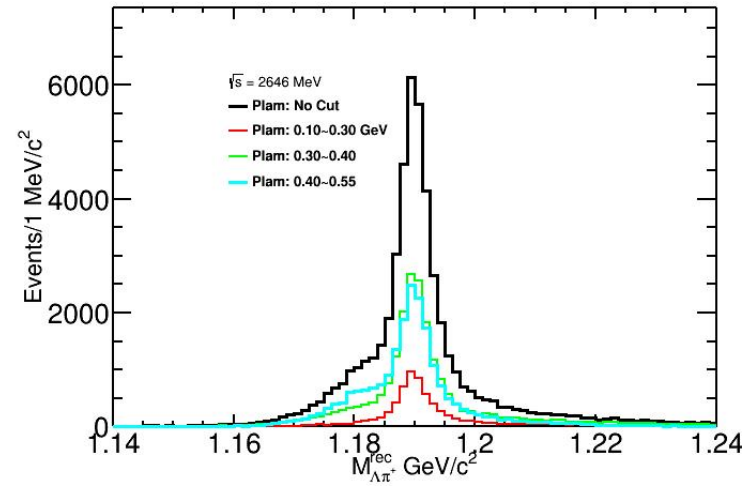
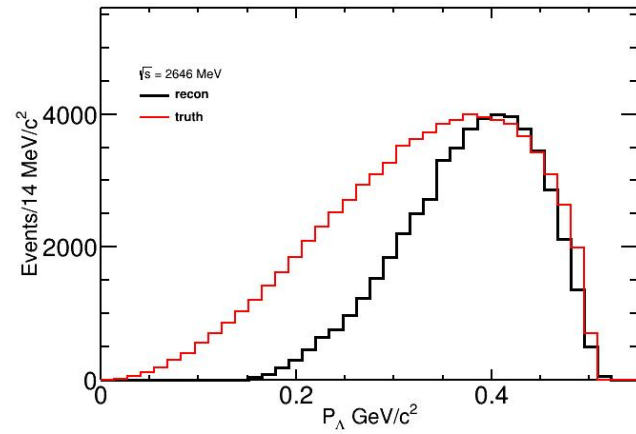




2.9000: $e^+e^- \rightarrow \Lambda\pi^+\bar{\Sigma}^-$



2.6464: $e^+e^- \rightarrow \Lambda\pi^+\bar{\Sigma}^-$



Distribution of $M_{\Lambda(\bar{\Lambda})}^{recoil}$ and $M_{\Lambda\pi}$

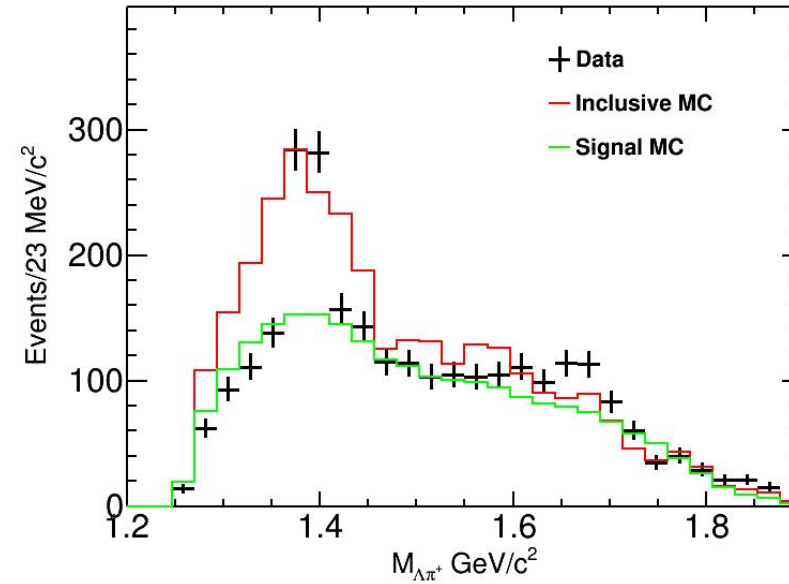
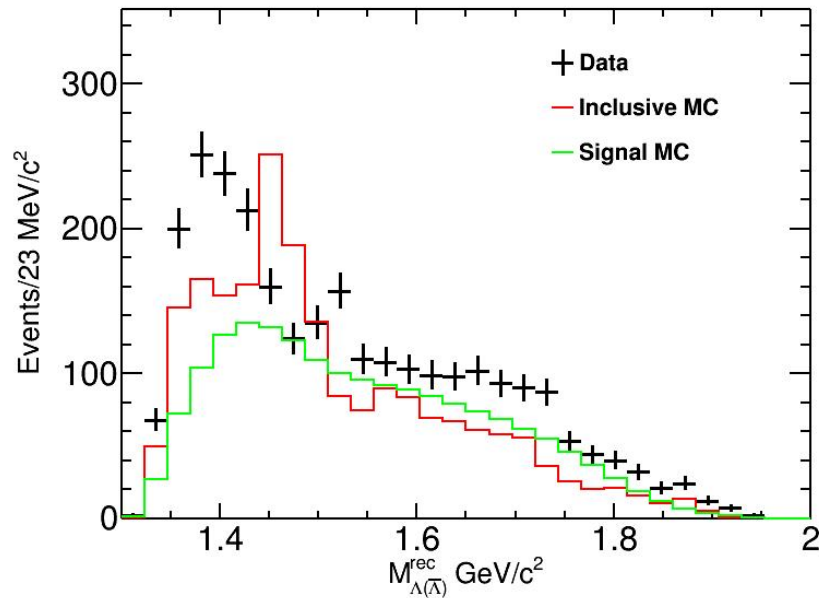
hadd all energy : 2644 ~ 3080 MeV

$$e^+e^- \rightarrow \Lambda\pi^+\bar{\Sigma}^-(\bar{\Lambda}\pi^-\Sigma^+)$$

$\Sigma(1385) \quad I(J^P) = 1(3/2^+)$

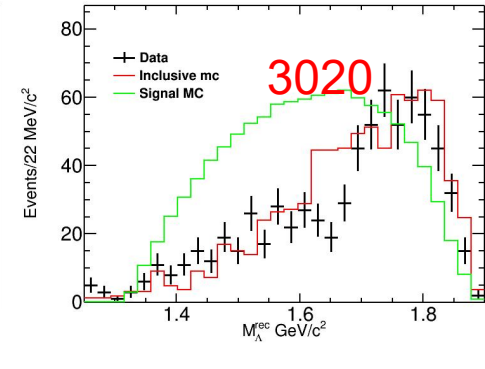
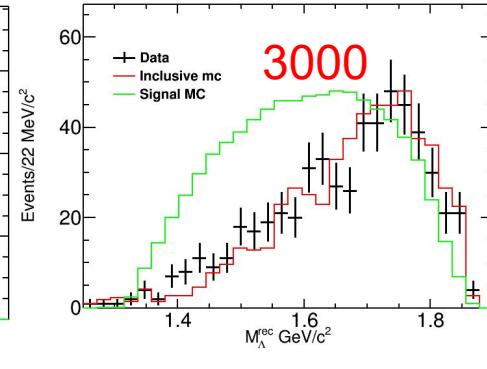
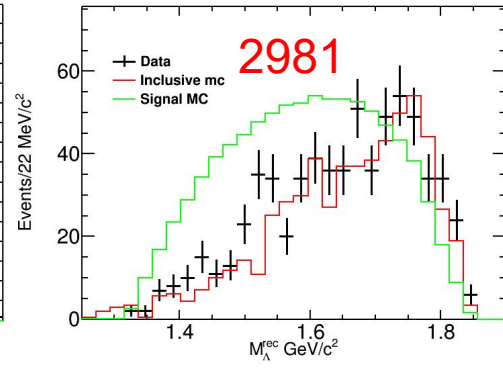
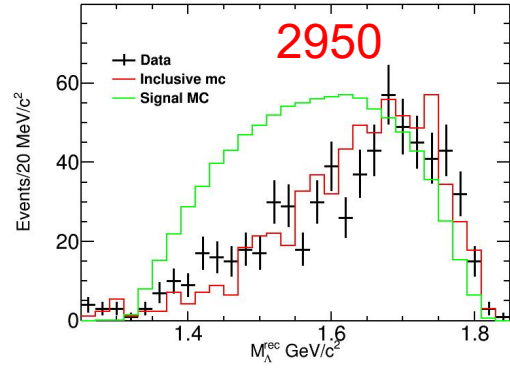
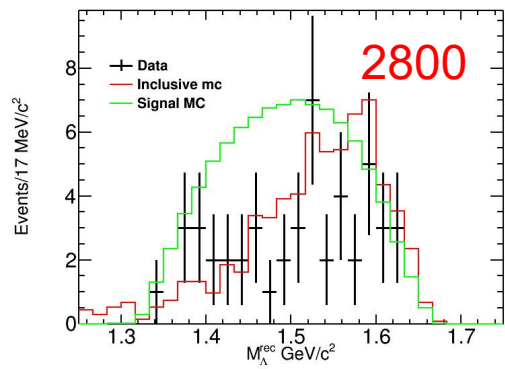
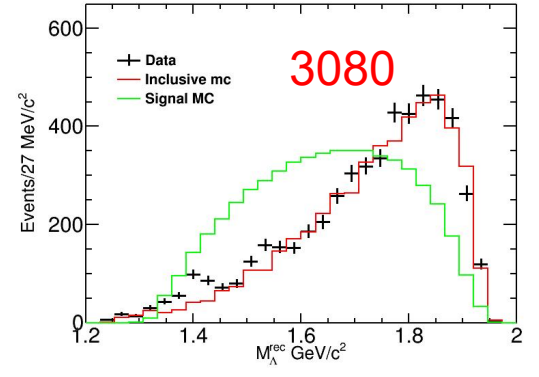
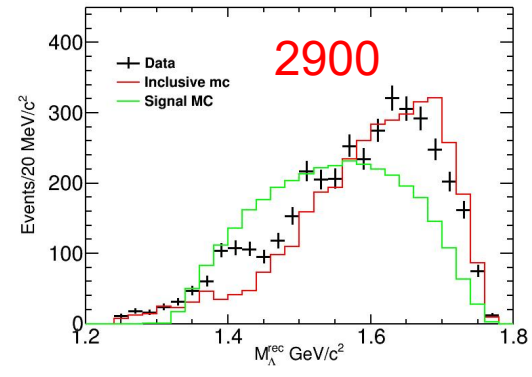
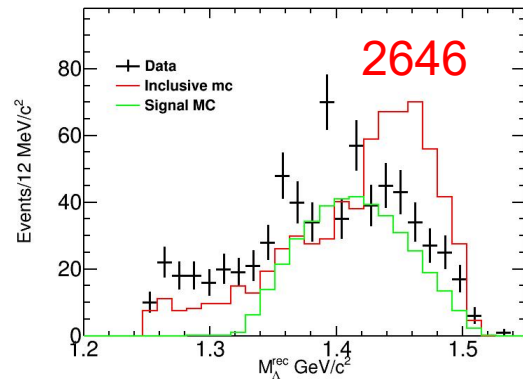
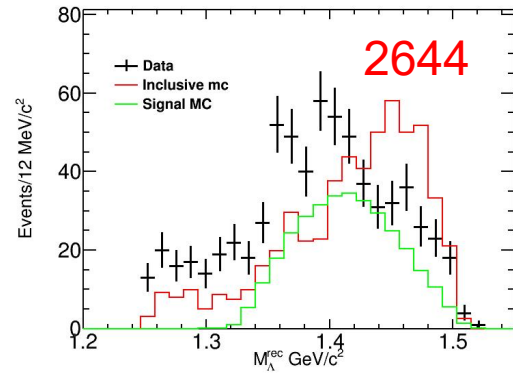
$$\Sigma_{(1385)} \rightarrow \Lambda\pi, \quad \Sigma_{(1385)} \rightarrow \Sigma\pi;$$

$$\Sigma_{(1385)} \rightarrow \Lambda\gamma, \quad \Sigma_{(1385)} \rightarrow \Sigma^+\gamma;$$

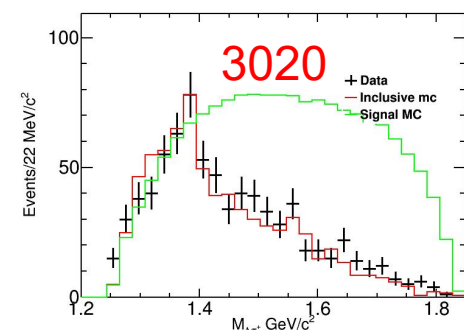
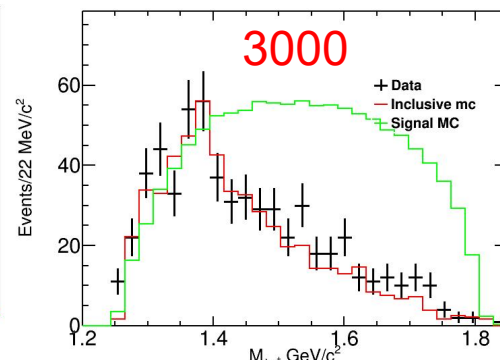
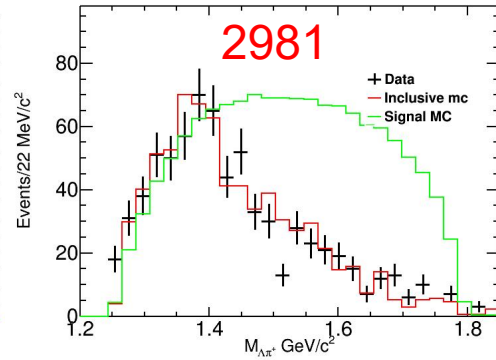
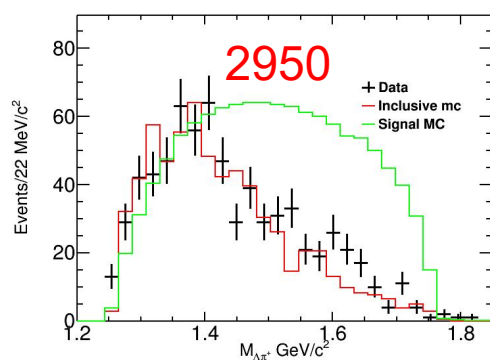
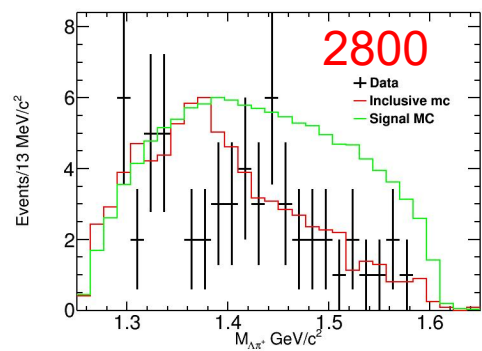
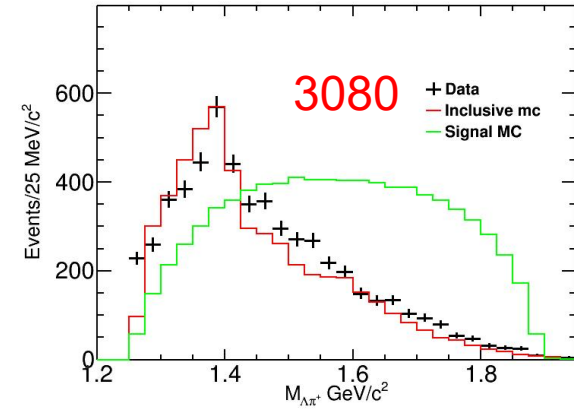
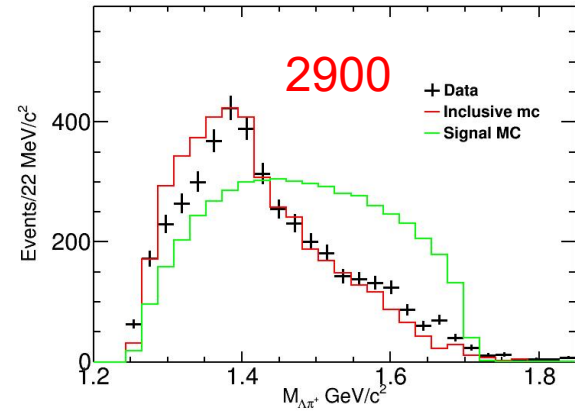
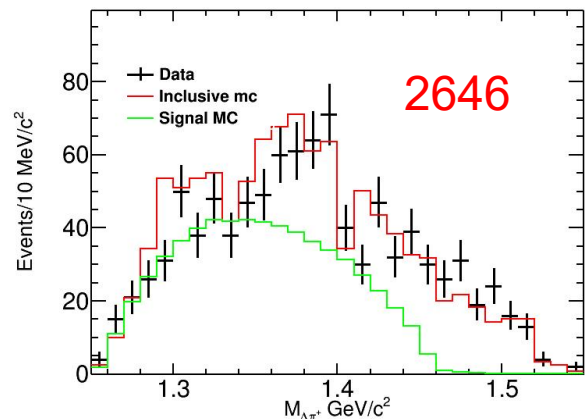
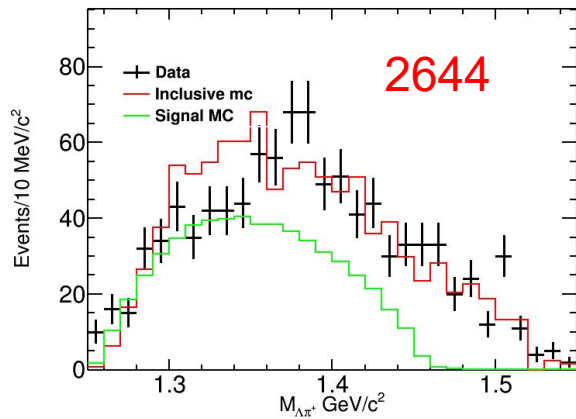


✓ a peaking around 1.4 GeV

$M_{\Lambda(\bar{\Lambda})}^{\text{recoil}}$



$M_{\Lambda\pi}$



Distribution of $M_{\Lambda(\bar{\Lambda})}^{recoil}$ and $M_{\Lambda\pi}$

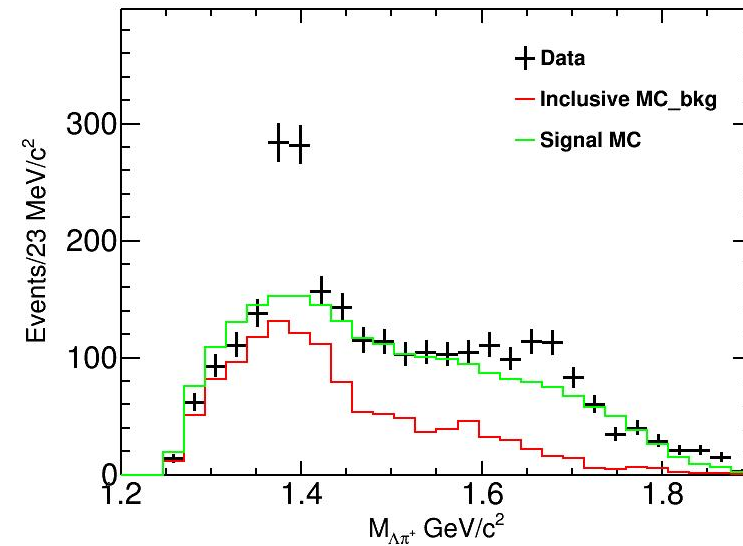
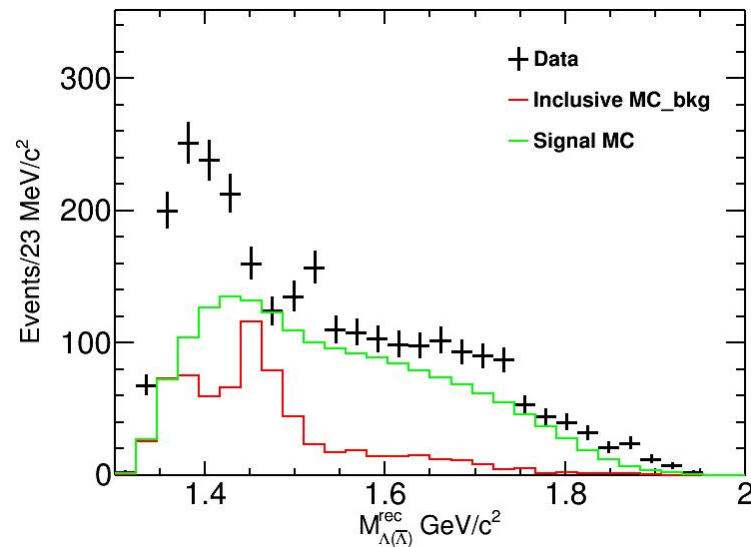
hadd all energy : 2644 ~ 3080 MeV

$\Sigma(1385) \quad I(J^P) = 1(3/2^+)$

$$e^+e^- \rightarrow \Lambda\pi^+\bar{\Sigma}^-(\bar{\Lambda}\pi^-\Sigma^+)$$

$$\Sigma_{(1385)} \rightarrow \Lambda\pi, \quad \Sigma_{(1385)} \rightarrow \Sigma\pi;$$

$$\Sigma_{(1385)} \rightarrow \Lambda\gamma, \quad \Sigma_{(1385)} \rightarrow \Sigma^+\gamma;$$



✓ a peaking around 1.4 GeV

Distribution of $M_{\Lambda(\bar{\Lambda})}^{recoil}$ and $M_{\Lambda\pi}$

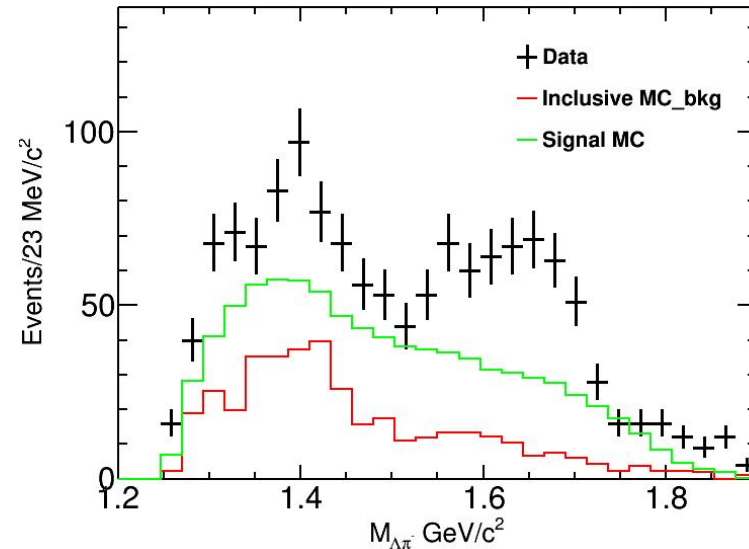
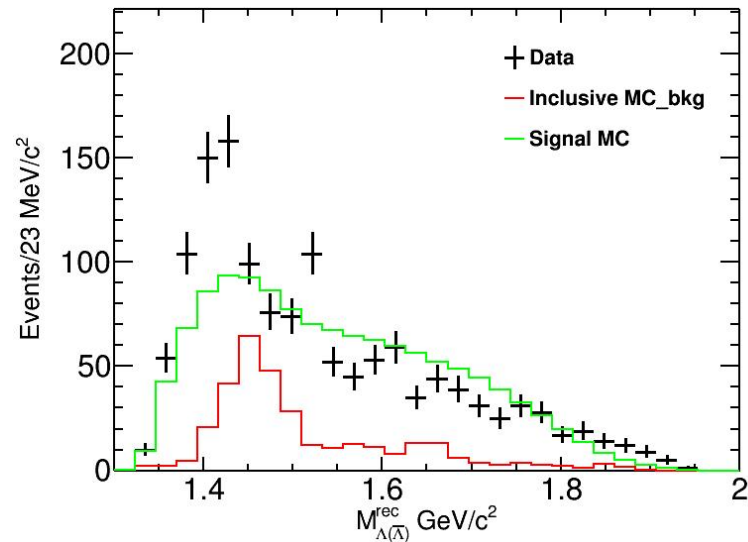
hadd all energy : 2644 ~ 3080 MeV

$\Sigma(1385) \quad I(J^P) = 1(3/2^+)$

$$e^+e^- \rightarrow \Lambda\pi^-\bar{\Sigma}^+(\bar{\Lambda}\pi^+\Sigma^-)$$

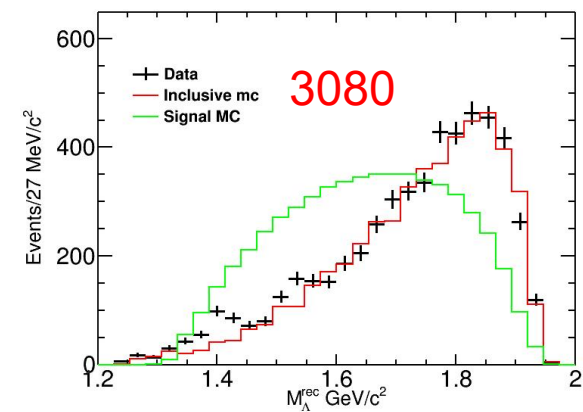
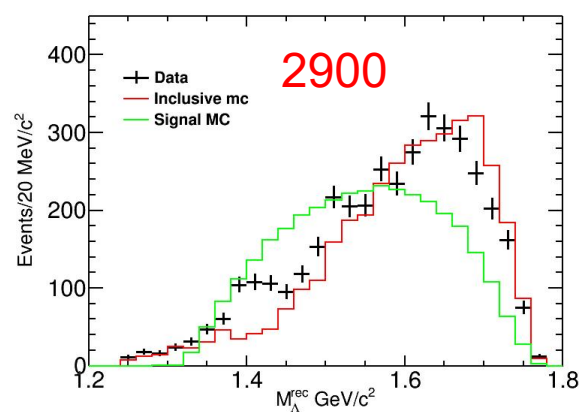
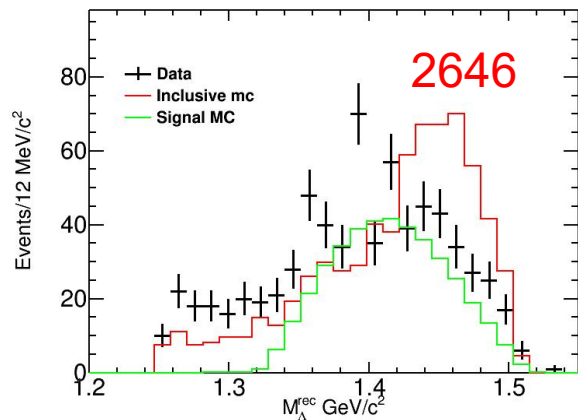
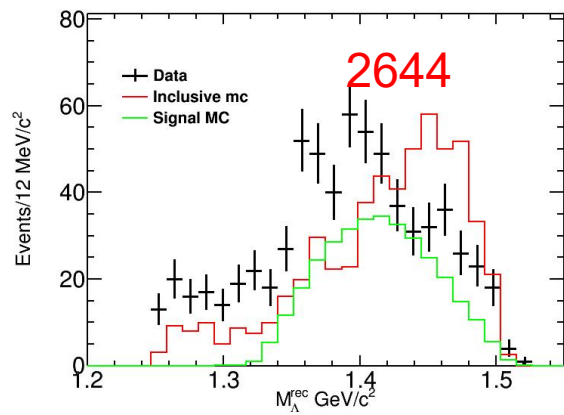
$$\Sigma_{(1385)} \rightarrow \Lambda\pi, \Sigma_{(1385)} \rightarrow \Sigma\pi;$$

$$\Sigma_{(1385)} \rightarrow \Lambda\gamma, \Sigma_{(1385)} \rightarrow \Sigma^+\gamma;$$

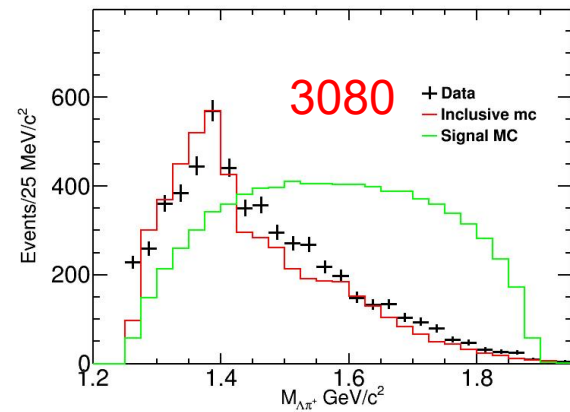
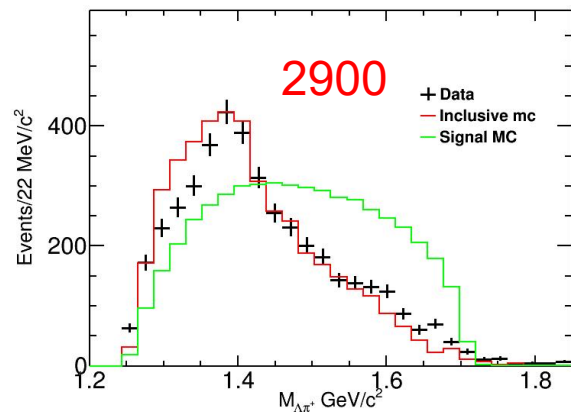
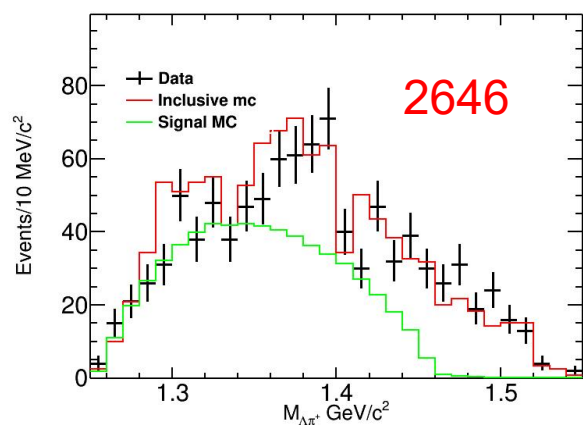
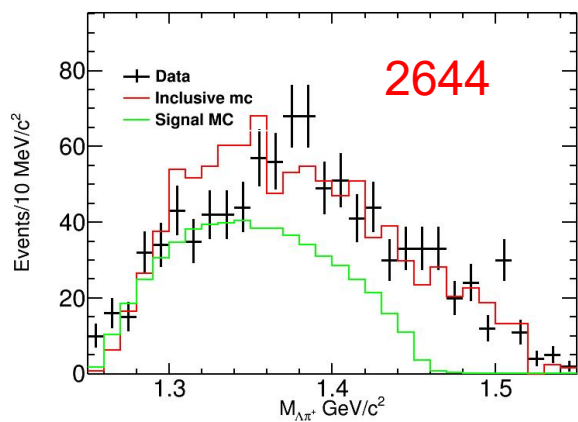


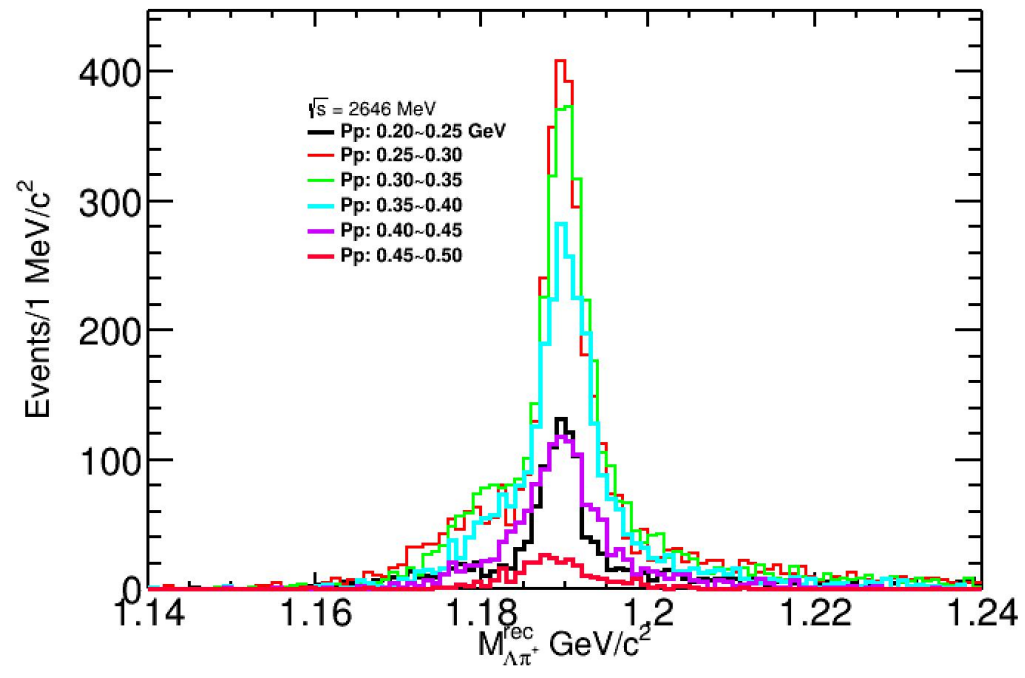
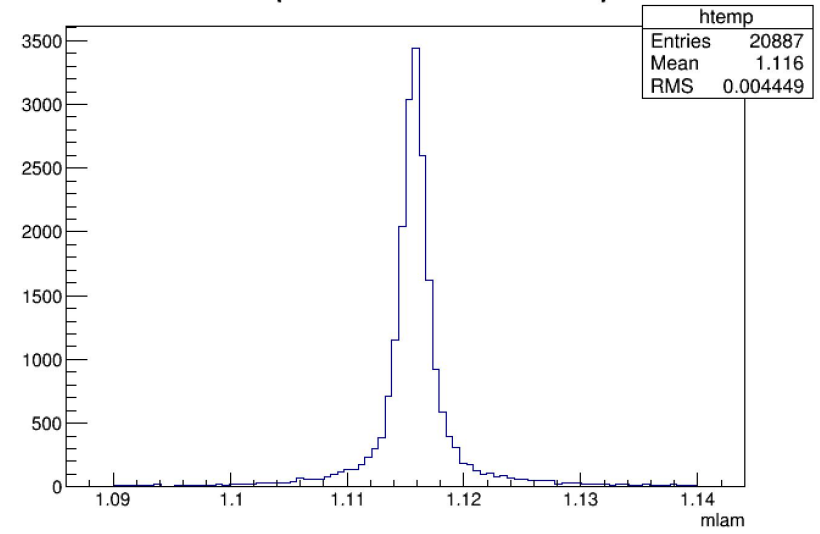
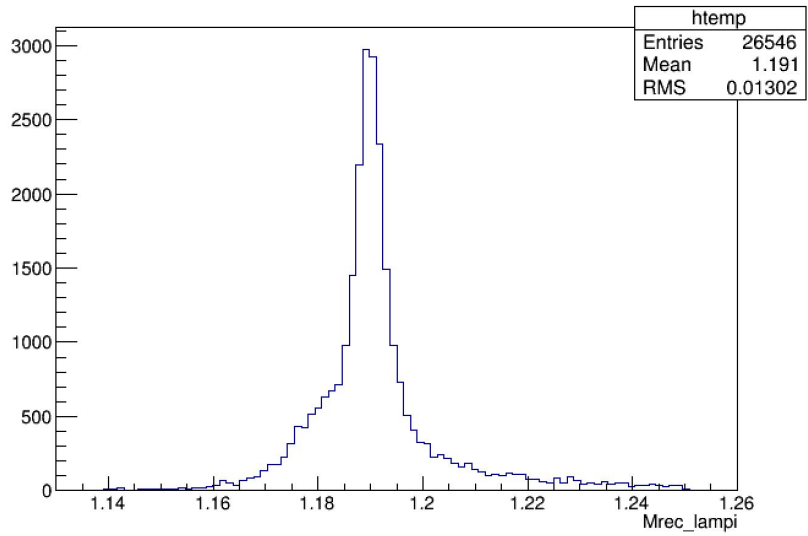
✓ a peaking around 1.4 GeV

$M_{\Lambda(\bar{\Lambda})}^{\text{recoil}}$

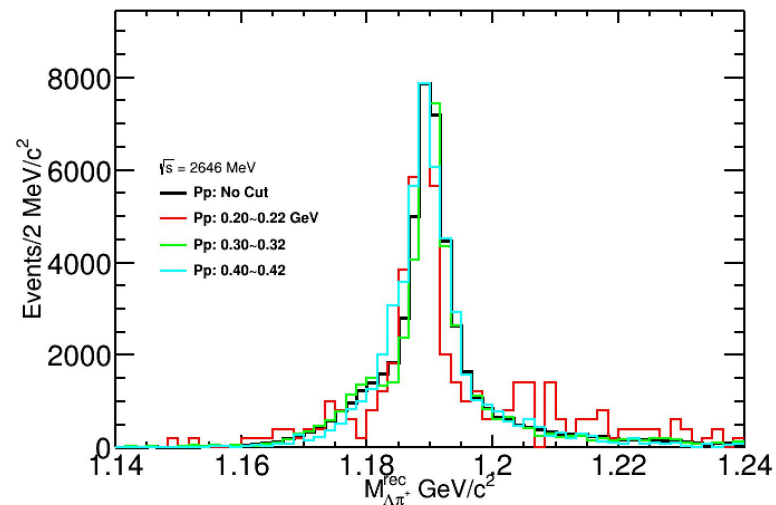
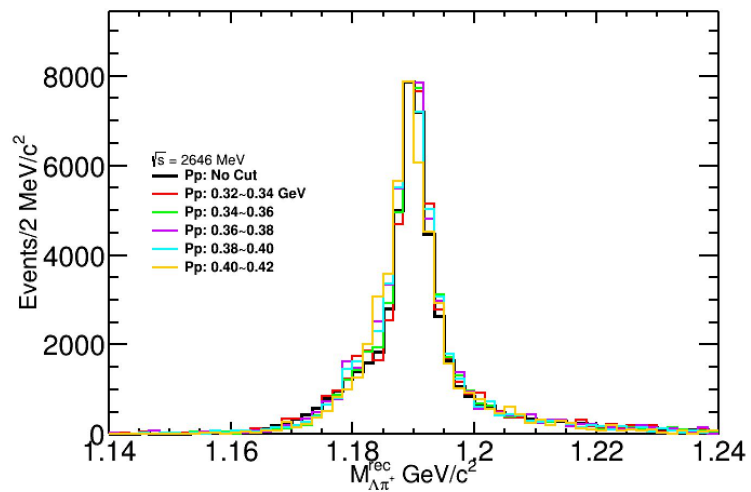
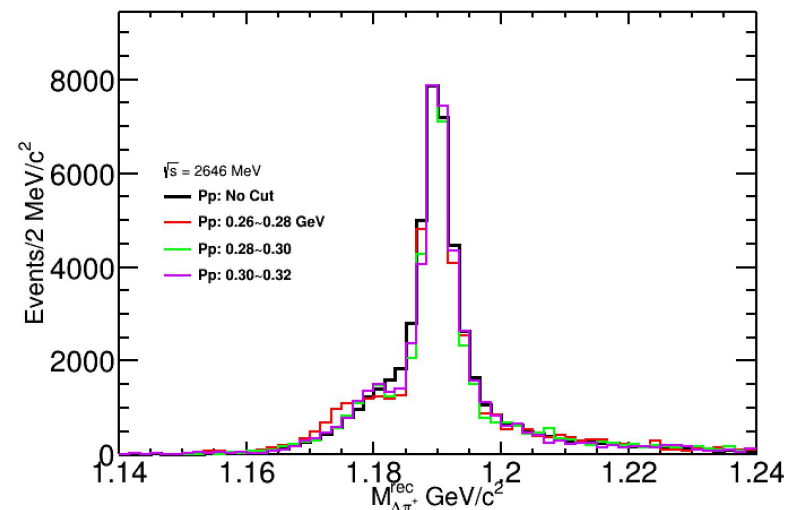
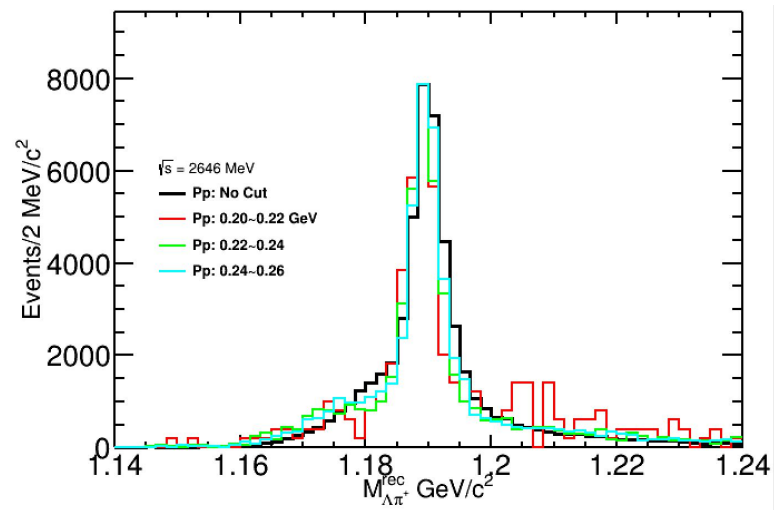
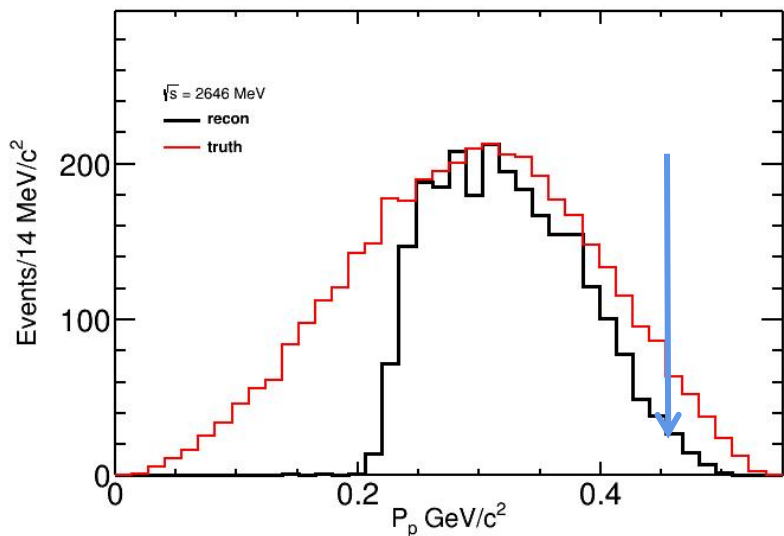


$M_{\Lambda\pi}$

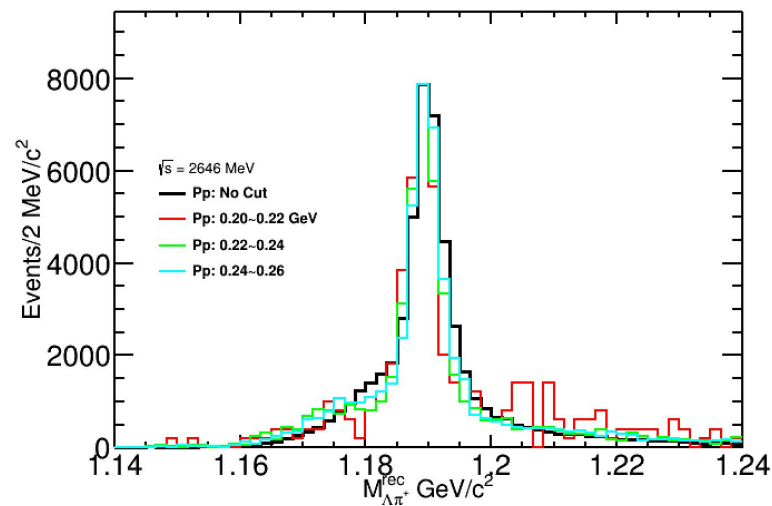
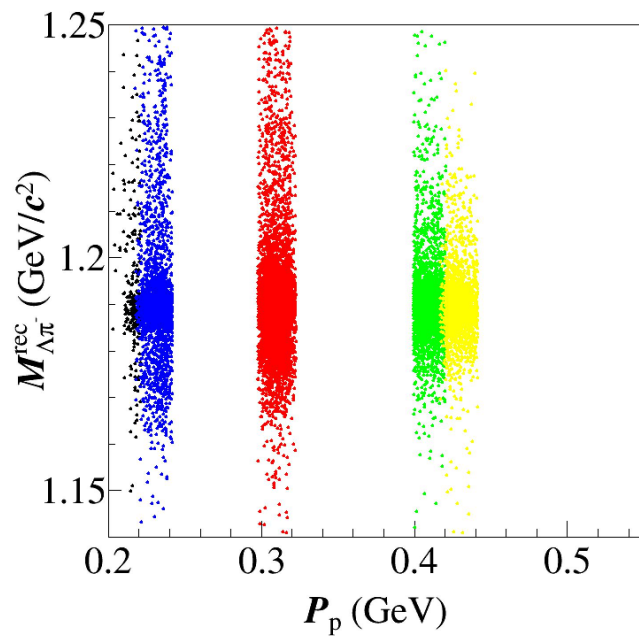
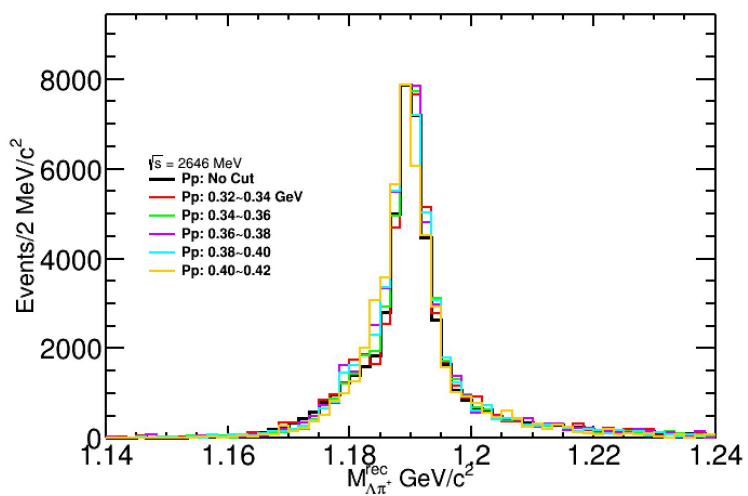
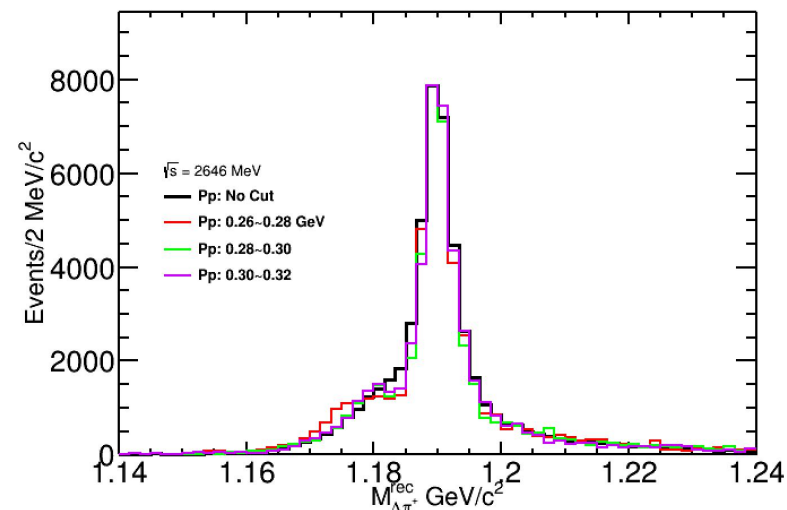
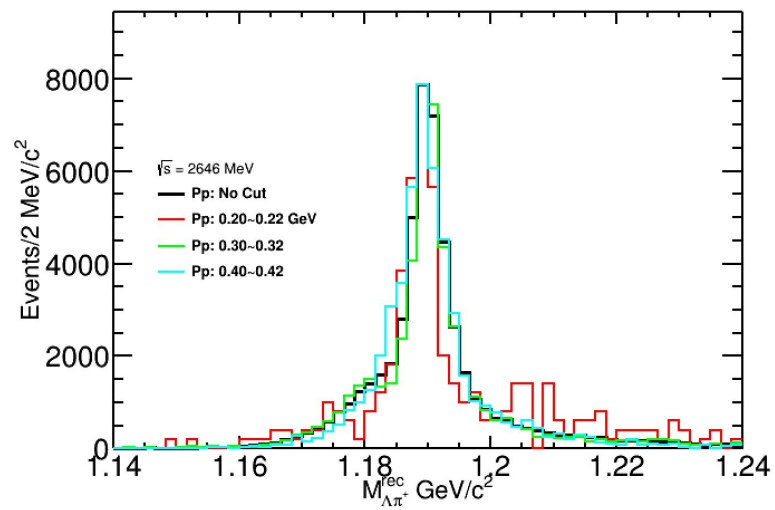
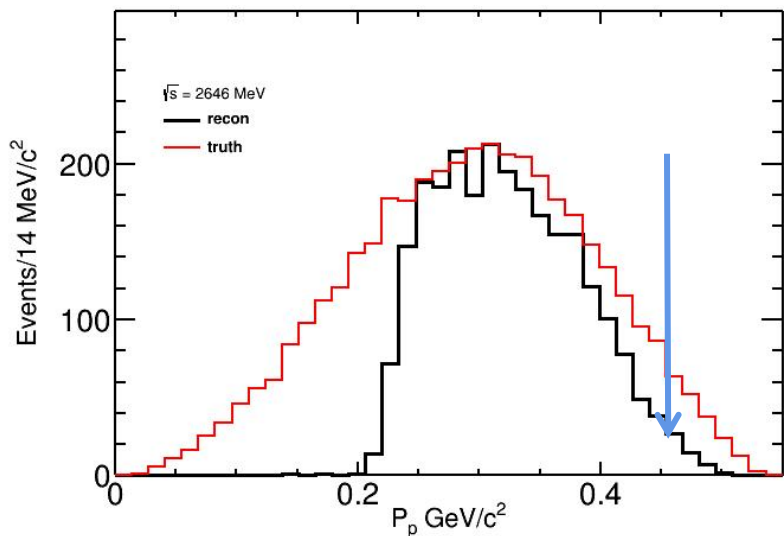




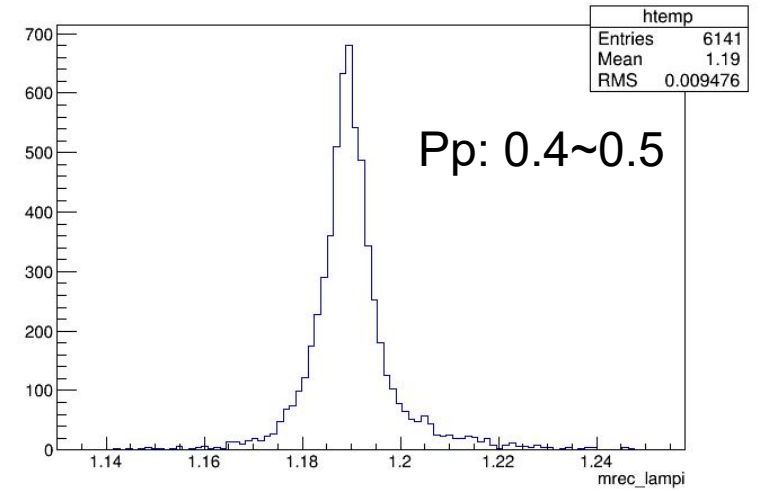
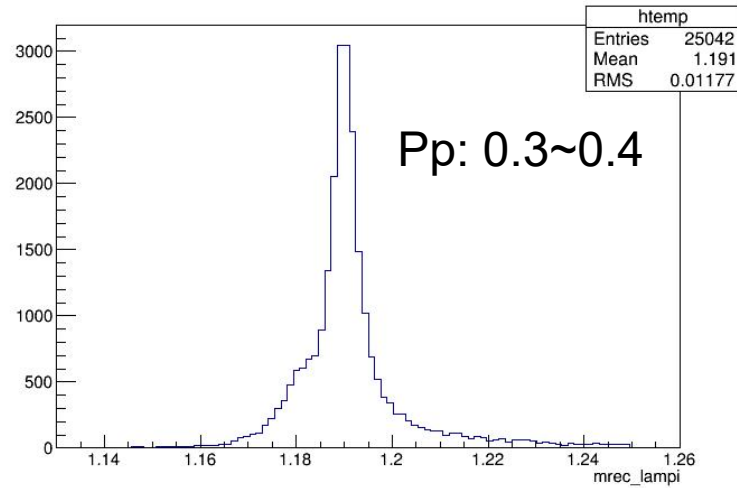
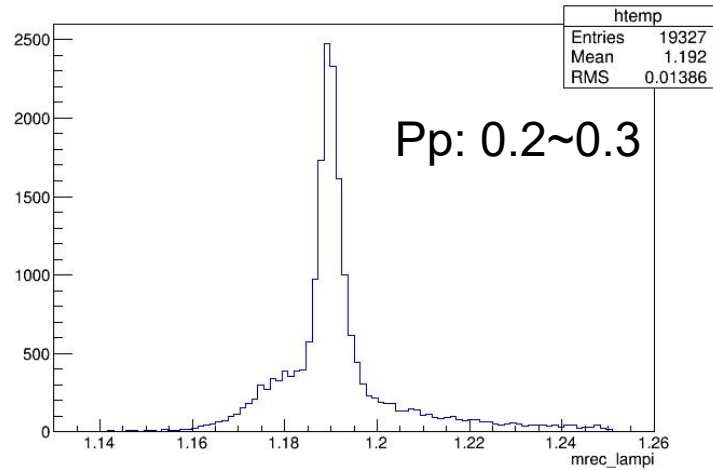
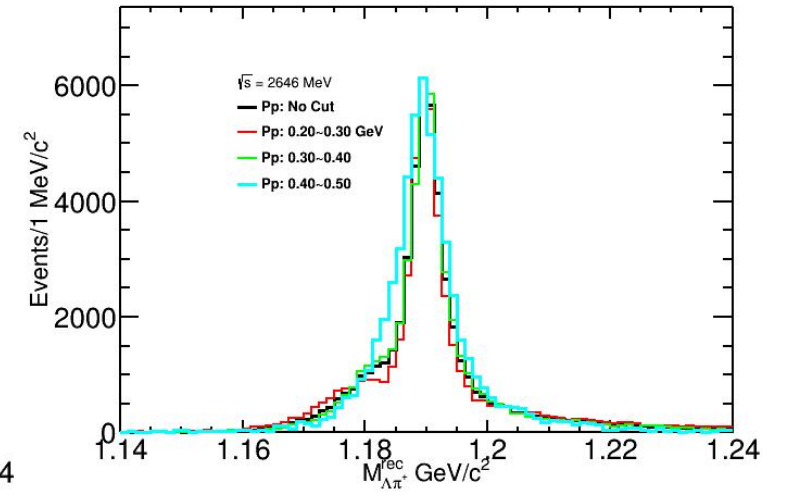
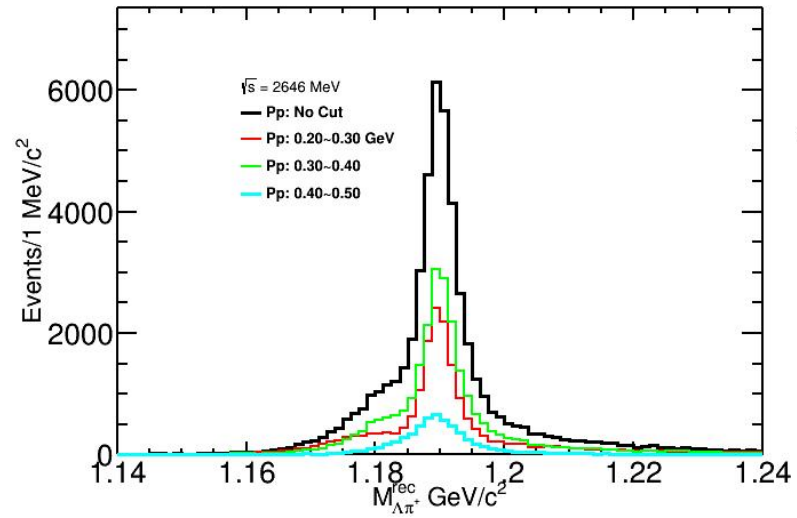
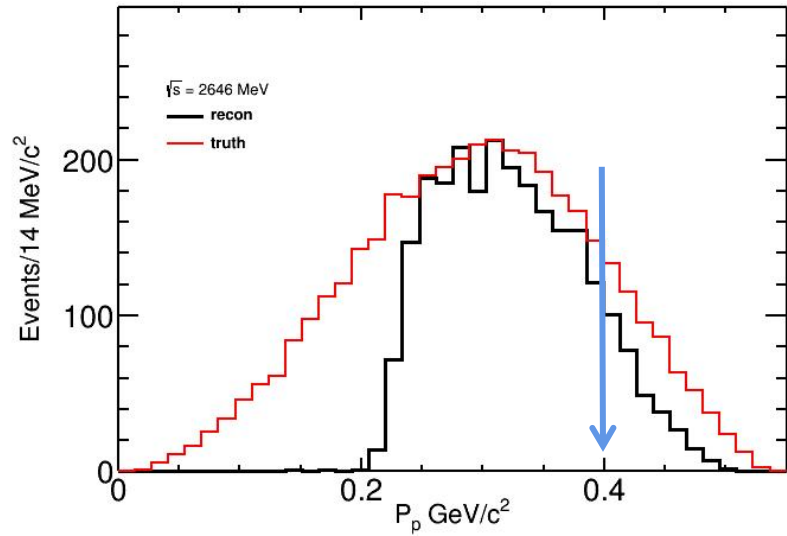
2.6464: $e^+e^- \rightarrow \Lambda\pi^+\bar{\Sigma}^-$



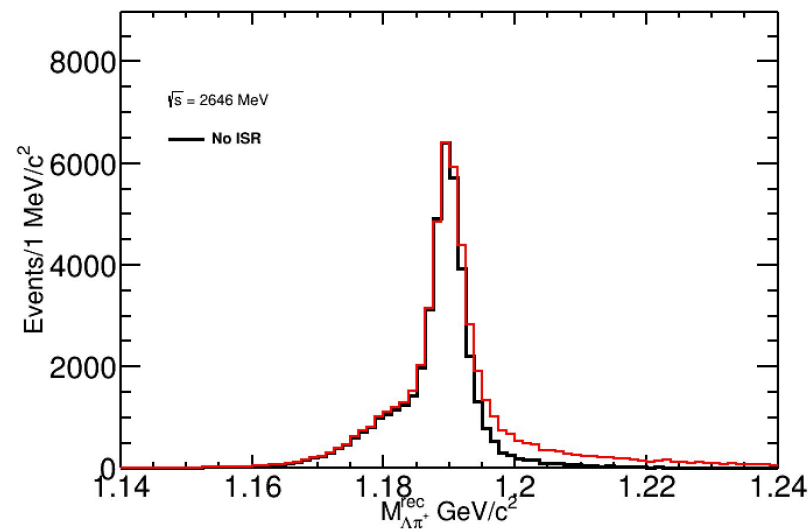
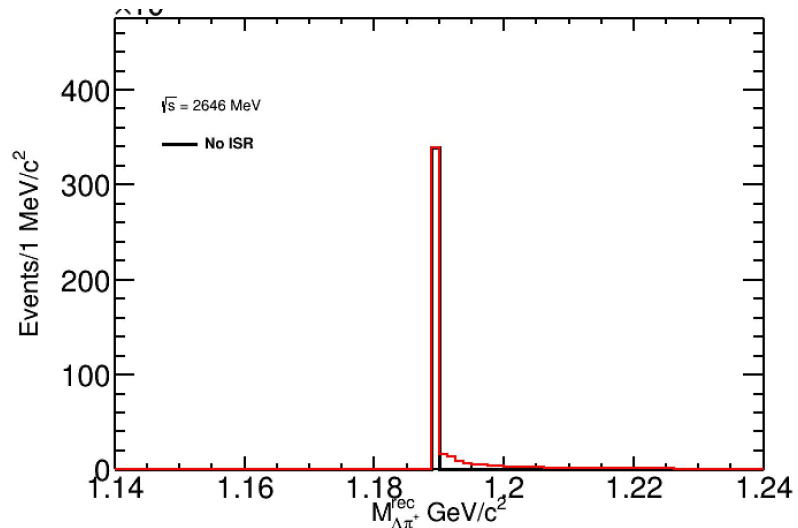
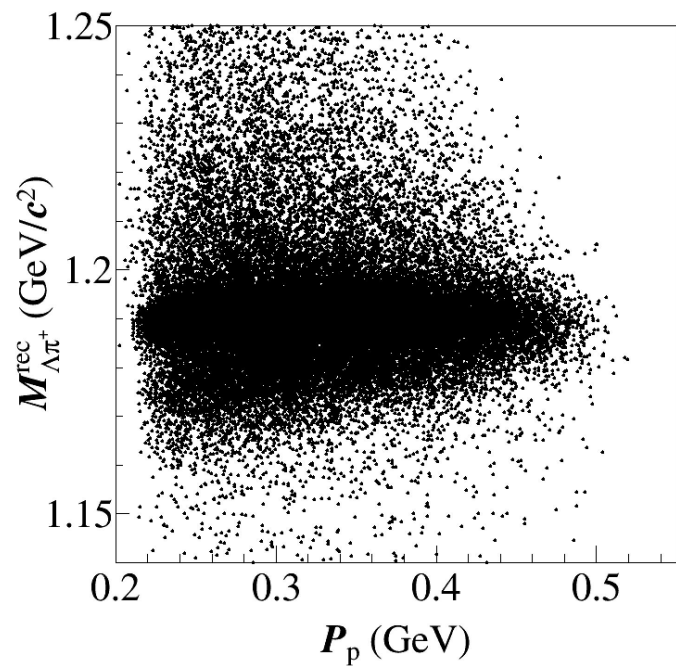
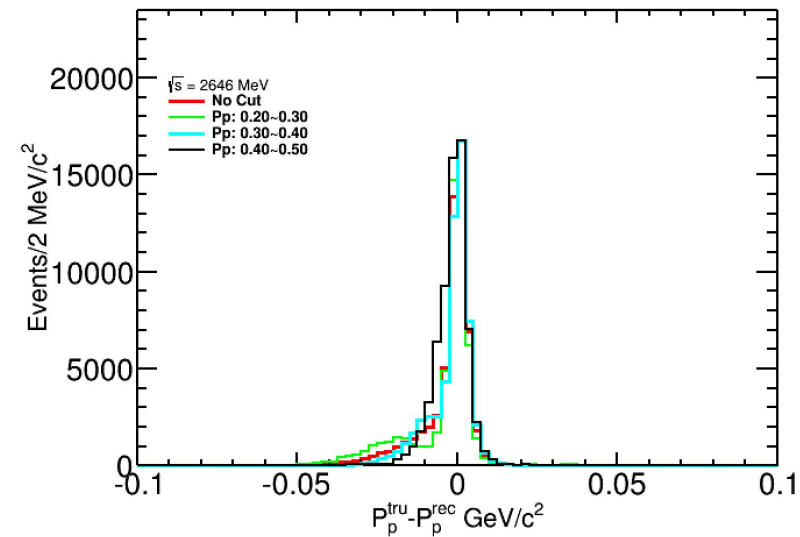
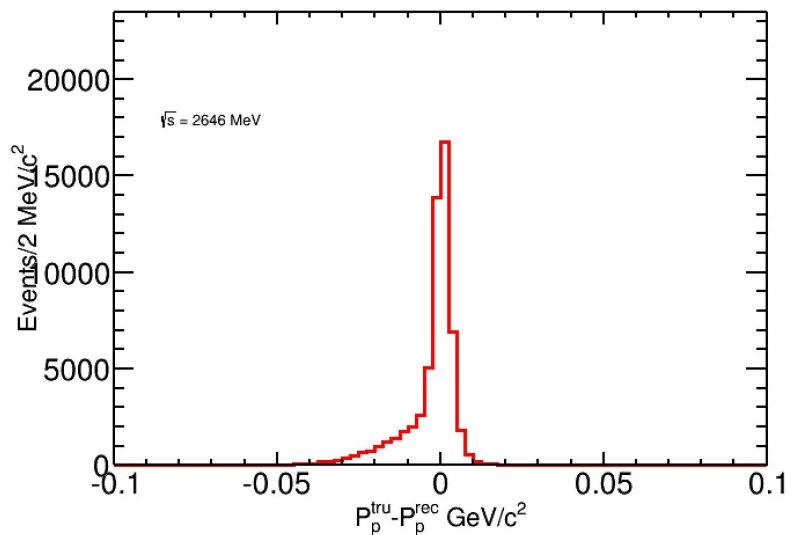
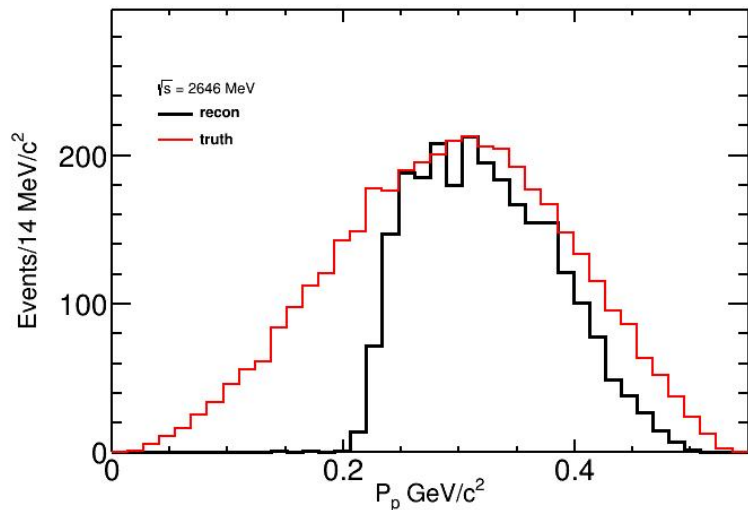
2.6464: $e^+e^- \rightarrow \Lambda\pi^+\bar{\Sigma}^-$



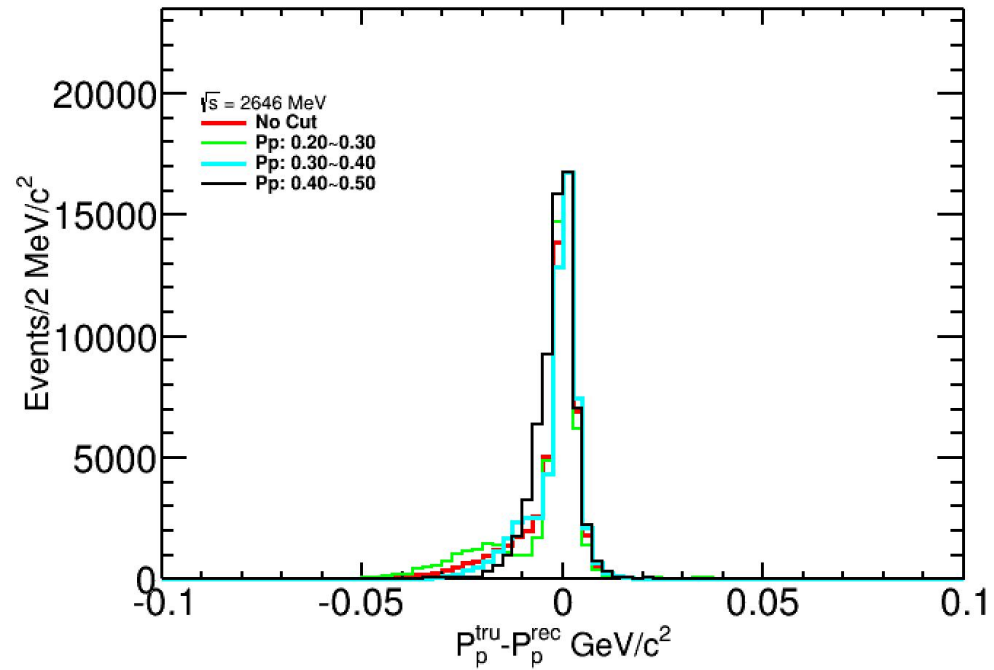
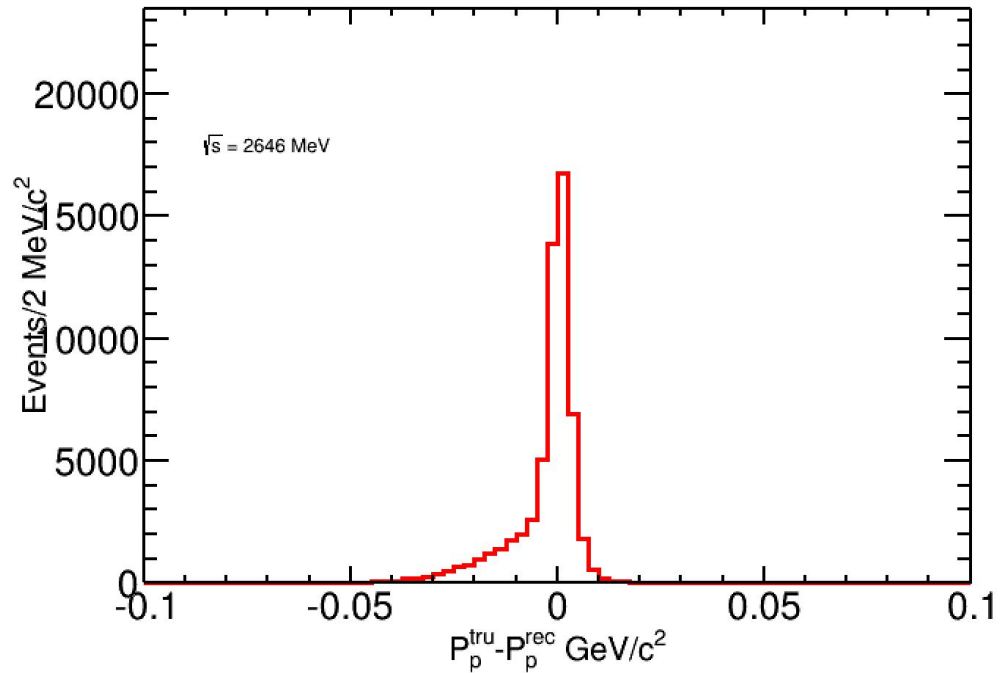
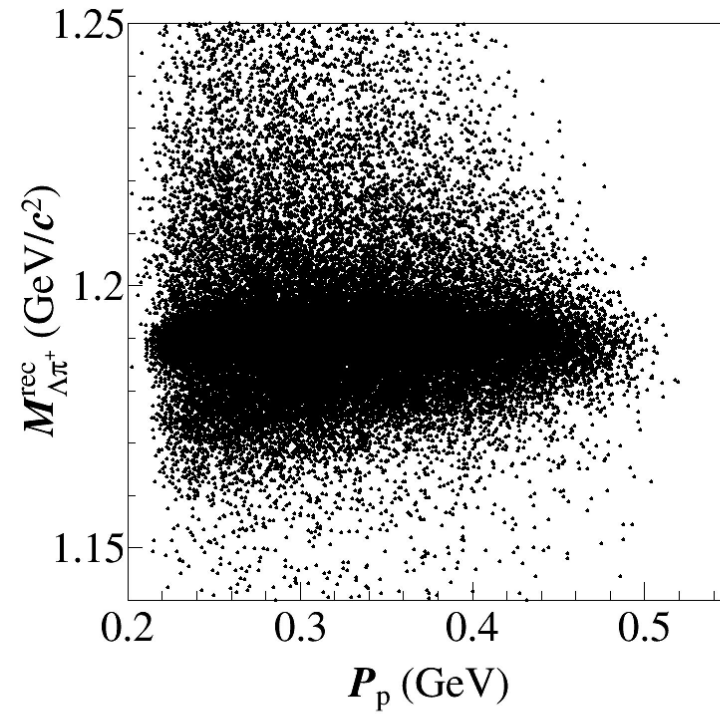
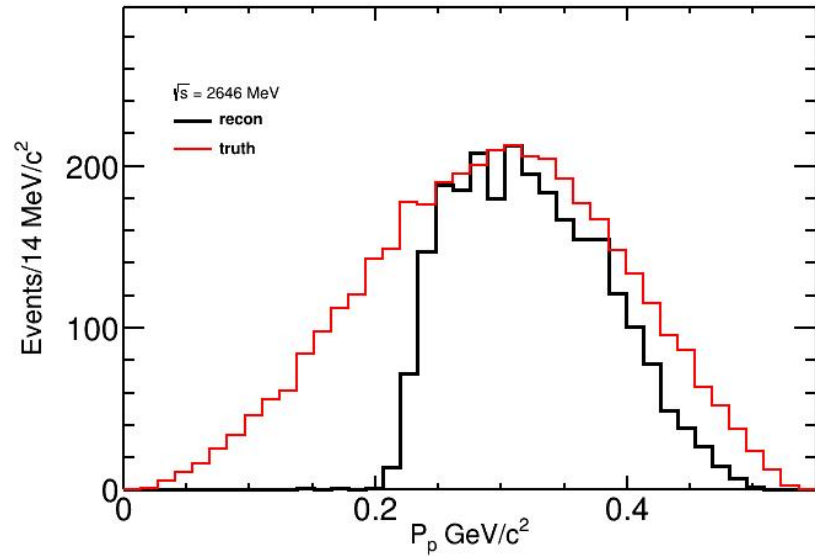
2.6464: $e^+e^- \rightarrow \Lambda\pi^+\bar{\Sigma}^-$



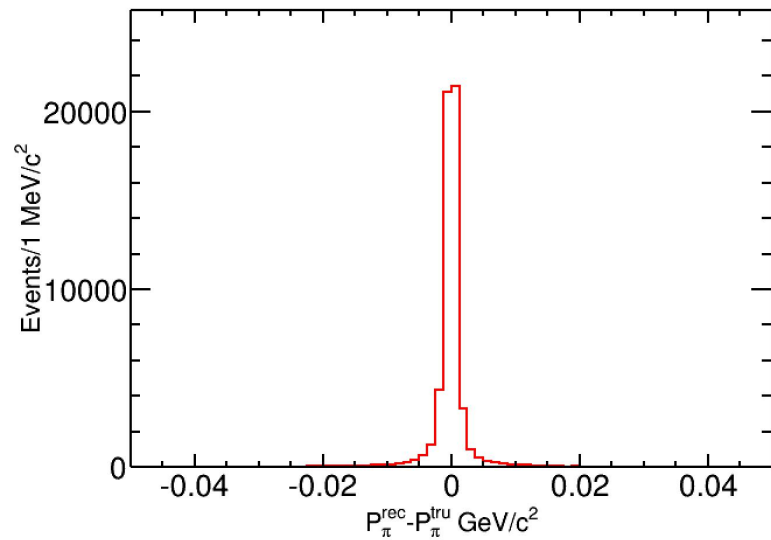
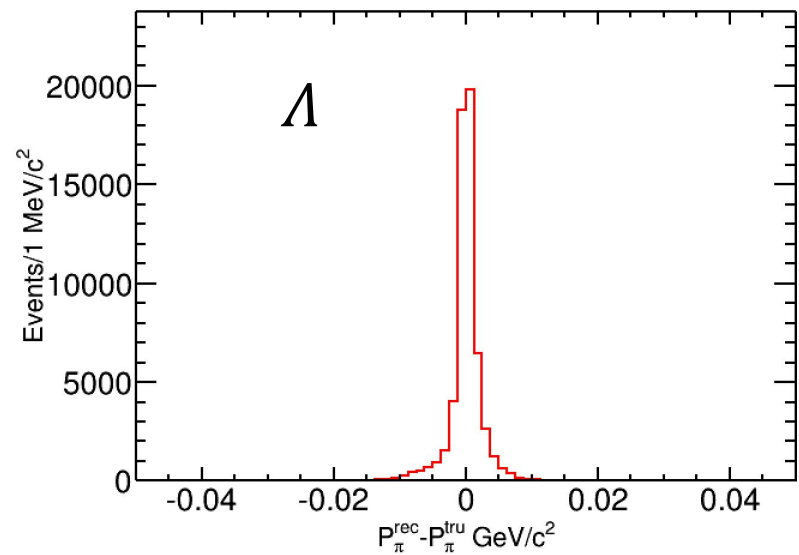
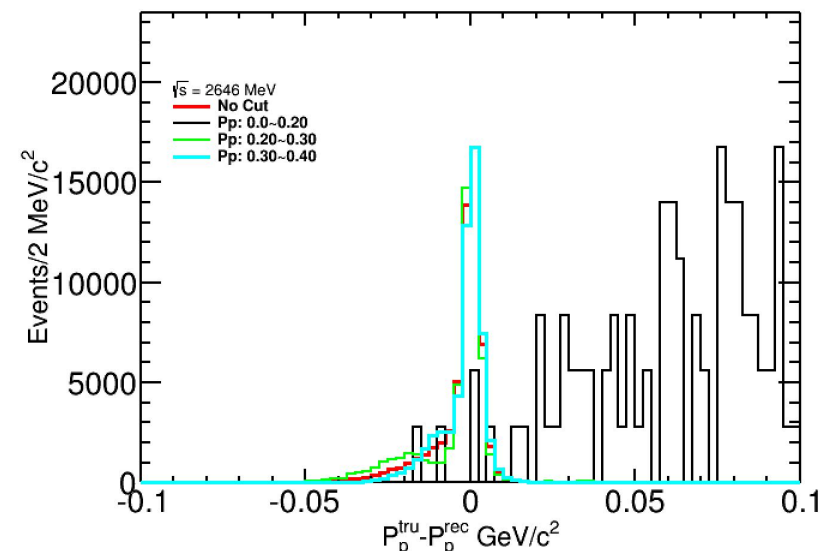
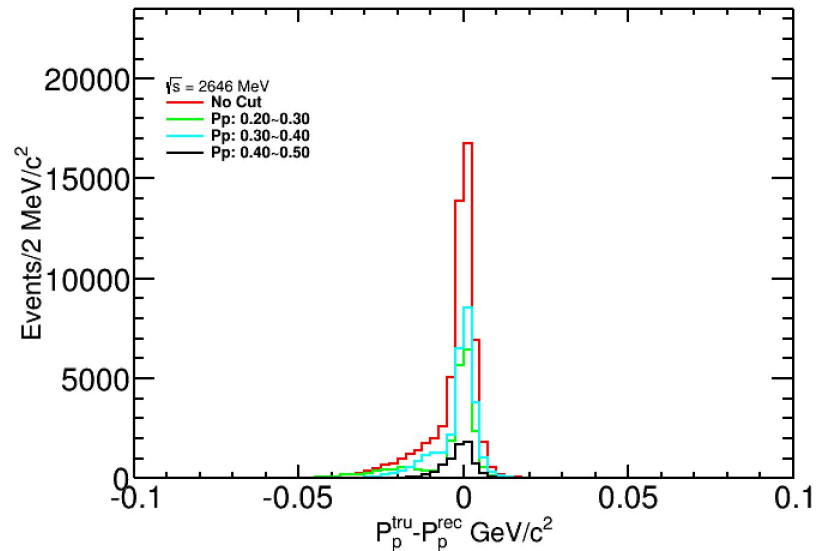
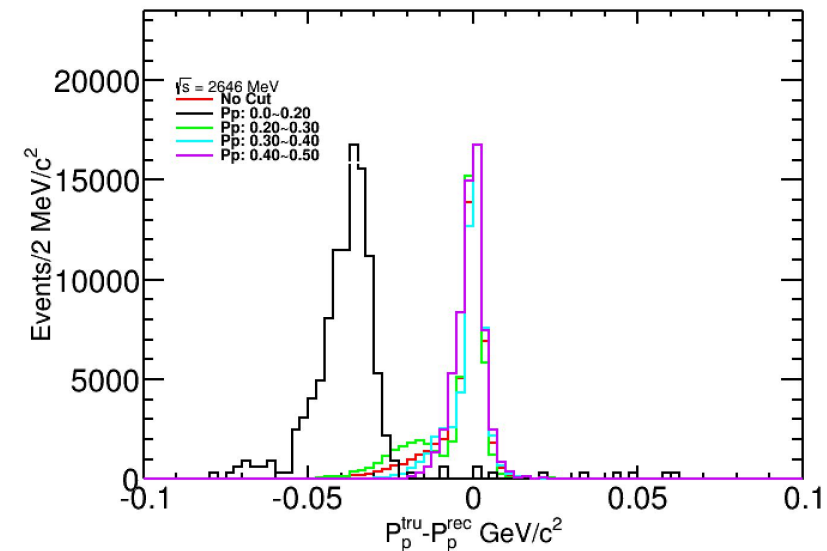
2.6464: $e^+e^- \rightarrow \Lambda\pi^+\bar{\Sigma}^-$



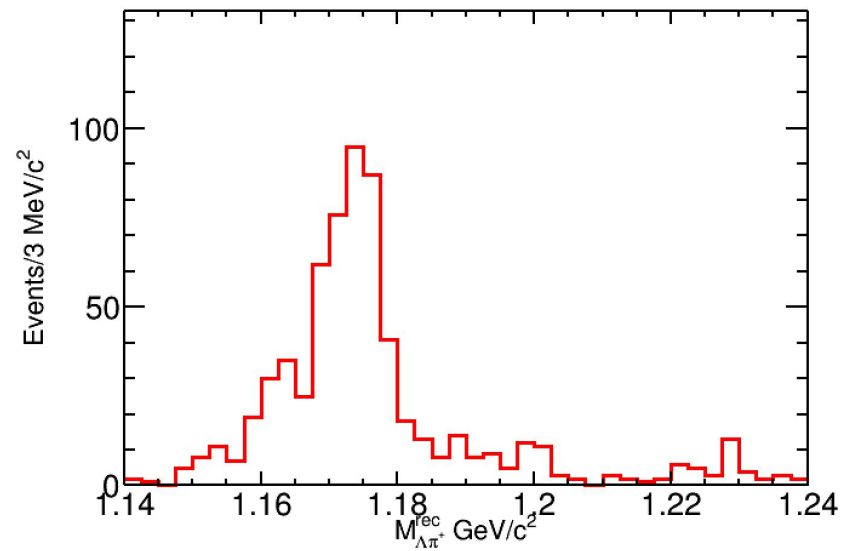
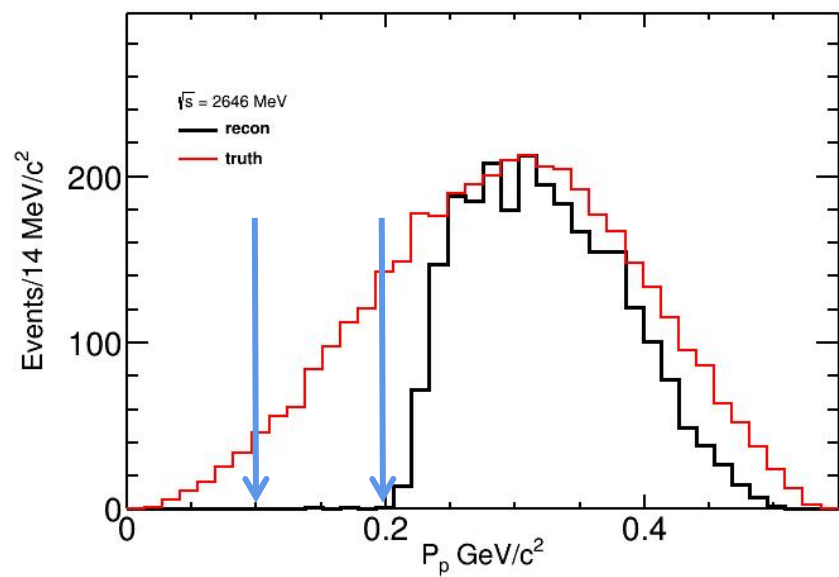
2.6464: $e^+e^- \rightarrow \Lambda\pi^+\bar{\Sigma}^-$



2.6464: $e^+e^- \rightarrow \Lambda\pi^+\bar{\Sigma}^-$



2.6464: $e^+e^- \rightarrow \Lambda\pi^+\bar{\Sigma}^-$



2580

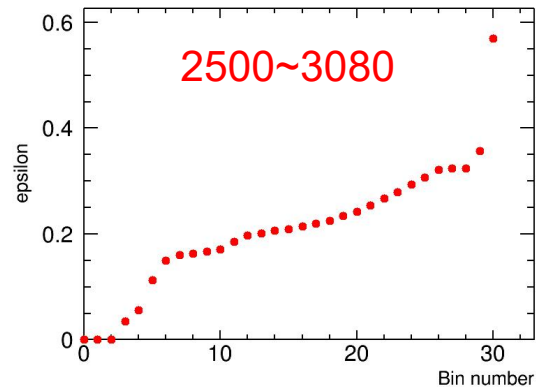
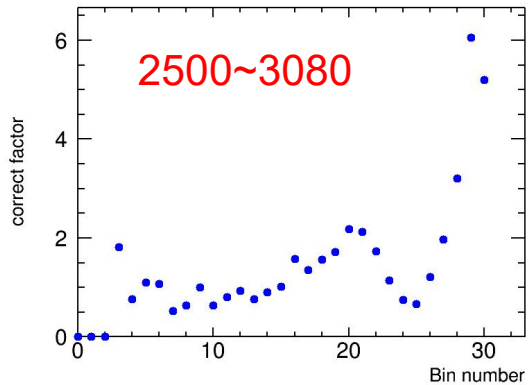
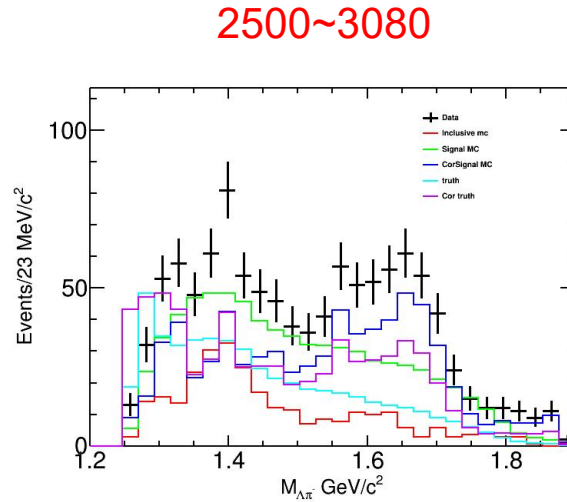
$$e^+e^- \rightarrow \Lambda\pi^-\bar{\Sigma}^+(\bar{\Lambda}\pi^+\Sigma^-)$$

$$1.18 < M_{\Lambda\pi^-}^{rec} < 1.21 \text{ GeV}$$

truth: no cut

$$f_{bin} = \frac{N_{data}^{bin} - N_{inclMC-sig}^{bin}}{N_{rec sigmc}^{bin}}$$

$$\epsilon_{cor} = \frac{\sum_{bin} (f_{bin} * N_{rec sigmc}^{bin})}{\sum_{bin} (f_{bin} * N_{tru sigmc}^{bin})}$$



$\epsilon_{\Lambda\pi^-\bar{\Sigma}^+(\bar{\Lambda}\pi^+\Sigma^-)}$	before correct (%)	After correct (%)
2644	14.1	11.9
2646	14.0	11.4
2700	18.5	13.7
2800 (hadd 2012)	24.0	18.8
2900	27.5	22.2
2950	28.6	22.6
2981	30.2	22.8
3000	30.3	22.2
3020	30.9	22.8
3080	31.6	21.8

Sys.

- ❑ Luminosity: 1 % (Chin. Phys. C 41,063001)
- ❑ Branching fraction ($\Lambda \rightarrow p\pi$): 0.78% (PDG)
- ❑ Photon tracking and PID: 2% per track (Phys. Rev. D 91, 112004)
- ❑ π tracking and PID: 3% per track (Phys. Rev. D 99, 011101)
- ❑ Fitting:

Background shape: Changing the background shape from the 1rd-order to 2rd-order **Chebyshev** polynomial;

Signal Shape: The signal shapes are modeled by the signal MC \rightarrow convolved with Gaussian functions;

❑ **ISR:**

❑ **Λ reconstruction: cited**

❑ **Mass window of $\Lambda(\bar{\Lambda})$, $M_{\Lambda(\bar{\Lambda})}^{recoil} > 1.25 \text{ GeV}/c^2$, $\chi^2 < 20$:**

Control sample, Compare the events changes before and after this cut;

❑ **weighted : 1、 N_{bin} 2、每个bin里数据的统计误差**

$$f_{bin} = \frac{N_{data}^{bin} - N_{inclMC-sig}^{bin}}{N_{rec\ sigmc}^{bin}}$$

$$\epsilon_{cor} = \frac{\sum_{bin} (f_{bin} * N_{rec\ sigmc}^{bin})}{\sum_{bin} (f_{bin} * N_{tru\ sigmc}^{bin})}$$

Source	Systematic uncertainty (%)
p tracking and PID	2.0
π tracking and PID	3.0
Luminosity	1.0
$\text{BF}(\Lambda \rightarrow p\pi)$	0.78
Background shape (chev)	--
Signal shape (gaus)	--
Λ reconstruction	
ISR	
Mass window of $\Lambda(\bar{\Lambda})$, $M_{\Lambda(\bar{\Lambda})}^{recoil} > 1.25 \text{ GeV}/c^2$, $\chi^2 < 20$,	
weighted :	