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Study of Pion Tracking Efficiency via $e^+e^- \to \gamma^{\mathrm{ISR}}\pi^+\pi^-\pi^+\pi^-$ process

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Outline

- BOSS Version & Data Sets
- Event Selection
- Background Study
- Summary

BOSS Version & Data Sets

- Physical Process: $e^+e^- \to \gamma^{\rm ISR}\pi^+\pi^-\pi^+\pi^-$
- BOSS Version: 7.0.3
- Data: 4180 dataset is used now

$\sqrt{s}$(GeV)	$\mathcal{L}$(pb^{-1})	RunNo
4.1780	3194.5	43716 ~ 47066

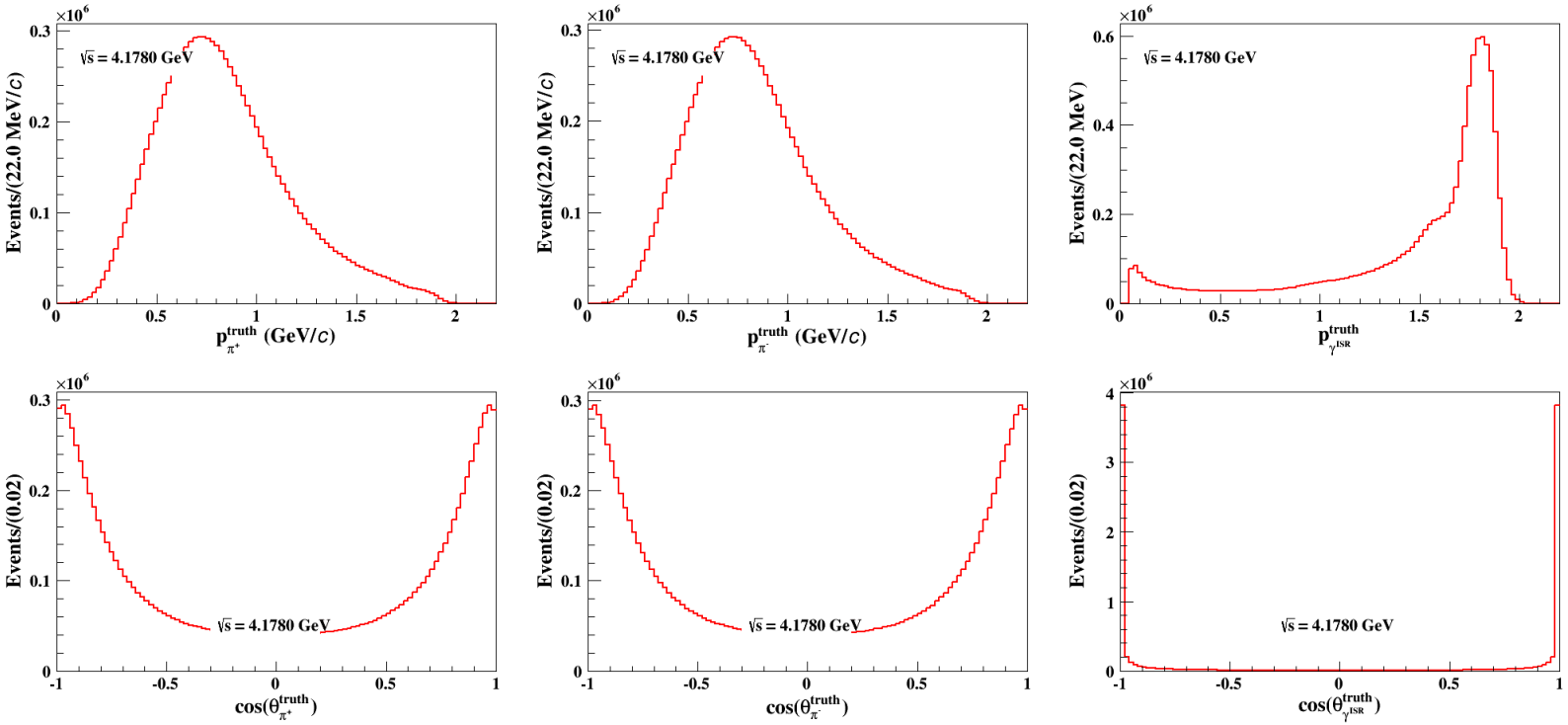
  - Final: both old 3770 (2.9 fb^{-1}) and 4180 data sets

- MC samples:

Process	Generator	Samples
$e^+e^- \to \gamma^{\rm ISR}\pi^+\pi^-\pi^+\pi^-$	PHOKHARA	10M~15.8 ×
$e^+e^- \to$ hadrons	HYBRID	80M~1×
$e^+e^- \to (\gamma^{\rm ISR})e^+e^-$	BABAYAGANLO	542M~0.4×
$e^+e^- \to (\gamma^{\rm ISR})\mu^+\mu^-$	BABAYAGA v3.5	17M~1×
$e^+e^- \to (\gamma^{\rm ISR})\tau^+\tau^-$	KKMC	11M~1×
$e^+e^- \to e^+e^-X$	BESTWOGAM	5M~1×

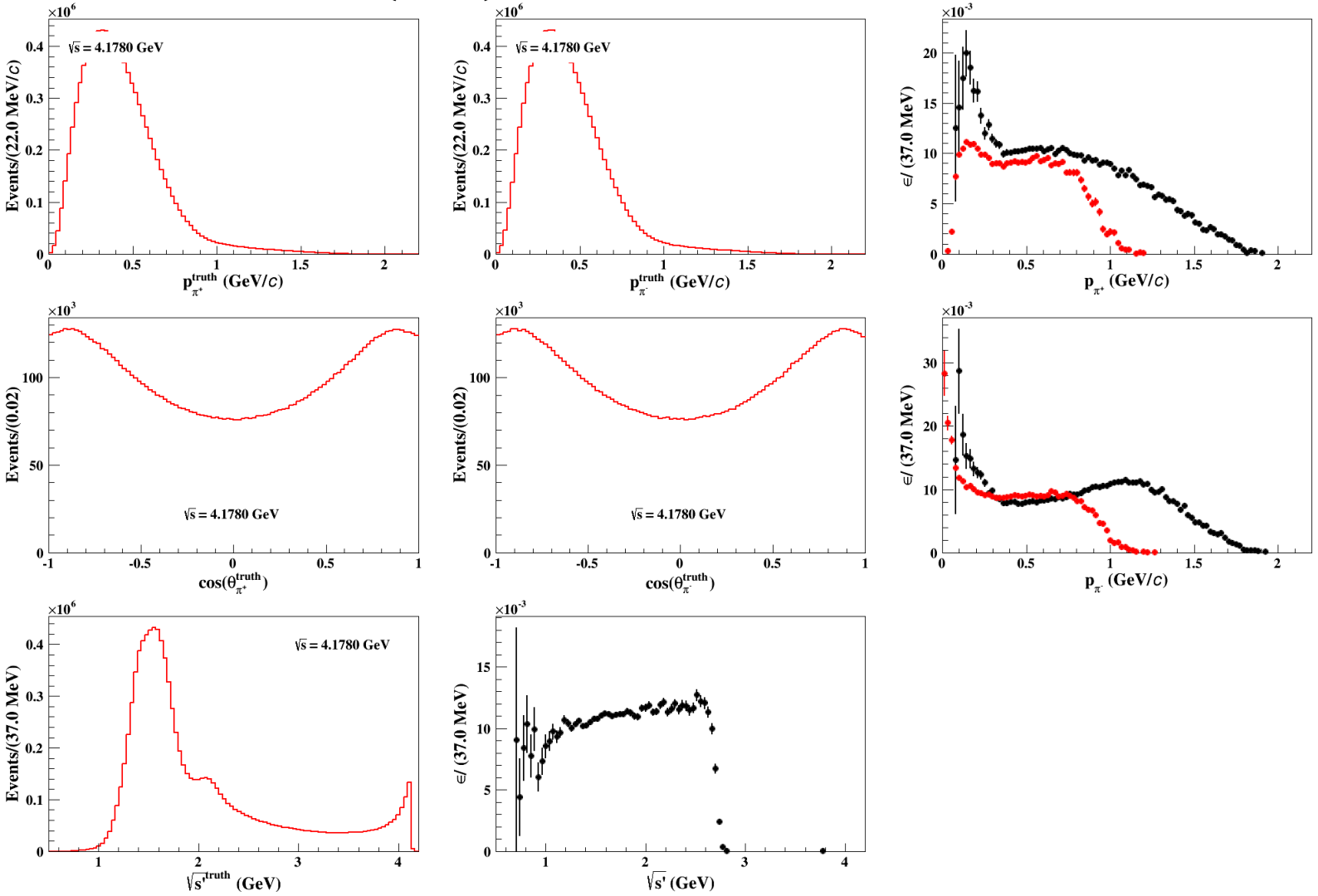
Signal MC

- The signal MC of $e^+e^- \to \gamma^{\mathrm{ISR}}\pi^+\pi^-\pi^+\pi^-$ generated by PHOKHARA
  - ScanMode: ISR
  - NLO: Yes
  - FSR: ISR only
- MC truth distributions (higher)



MC Truth

- MC truth distributions (lower)

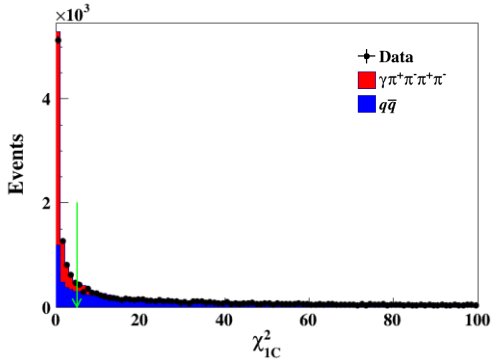


Event Selection

- Good neutral tracks:
  - Barrel: $E_\gamma \geq 0.025\text{GeV}, |\cos\theta| < 0.8$
  - Endcaps: $E_\gamma \geq 0.05\text{GeV}, 0.86 < |\cos\theta| < 0.92$
  - $0 \leq \text{TDC} \leq 700\text{ns}$
  - The most energetic photon is regarded as the ISR photon and required $E_\gamma \geq 0.4$ GeV
- Good charged tracks:
  - $V_r < 1$ cm, $|V_z| < 10$ cm, $|\cos\theta| < 0.93$
  - $N_{\text{Good}} = 3$ or 4
  - PID (dE/dx + TOF): prob(π) > prob(K) & prob(π) > prob(p)
- Missing a charged track:
  - Successful 1C kinematic fit required $m_{\text{missingtrack}} = m_\pi$
  - $\chi^2_{\text{1C}} \leq 5$

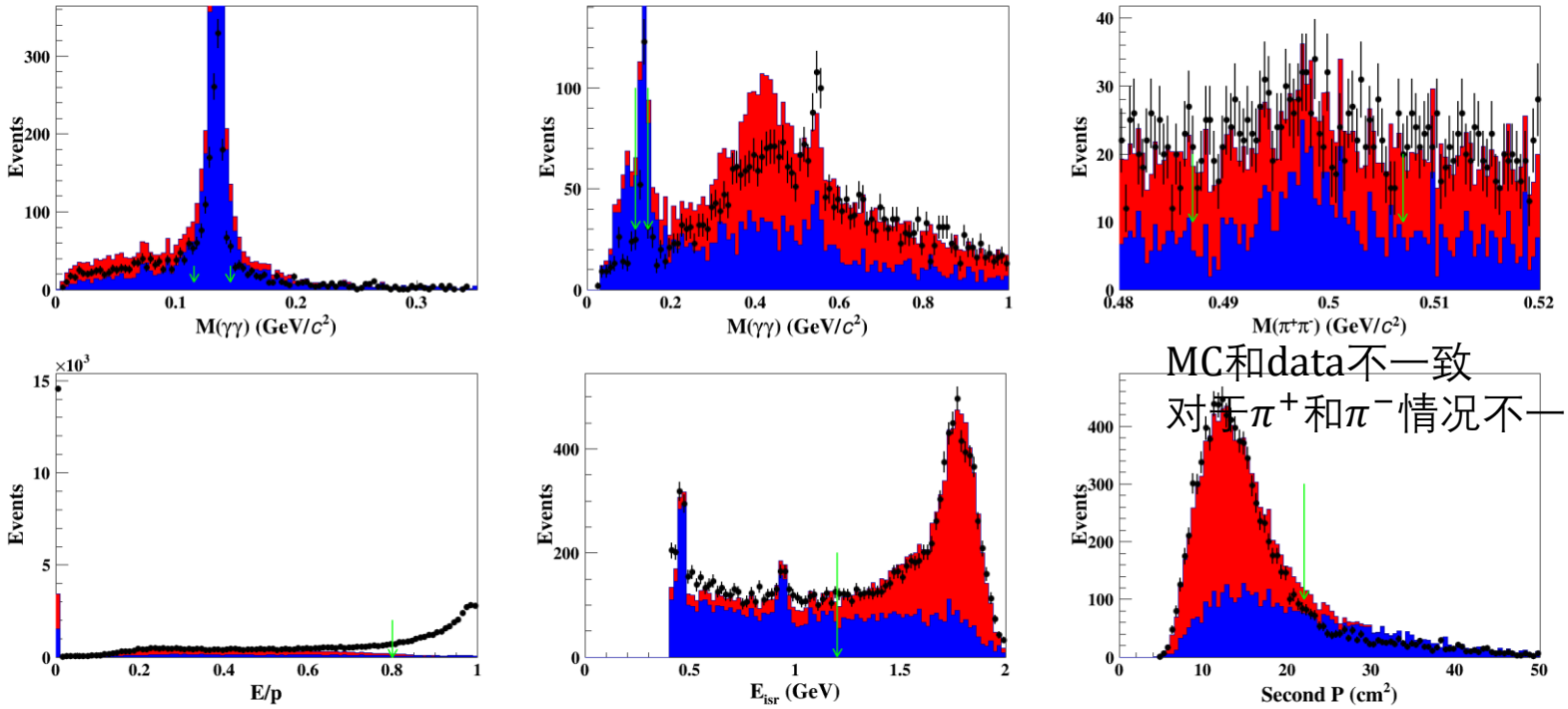
- Missing π^+

如何判断miss的径迹
不会重复被计算



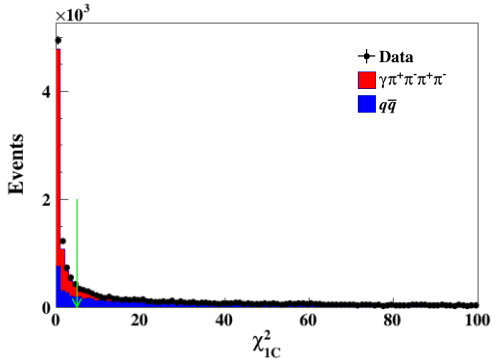
Further Selection

- Further requirments
  - π^0 veto: $M_{\pi^0} \leq 0.115$ || $M_{\pi^0} \geq 0.145$
  - K_S veto: $M_{K_S} \leq 0.487$ || $M_{K_S} \geq 0.507$
  - Bhabha veto: $E/p \leq 0.8$
  - $E_{\gamma \mathrm{ISR}} > 1.2$ 对动量范围的影响，主要为了排除本底
  - Neutron veto: the second moment of neutral cluster smaller than 22 cm^2



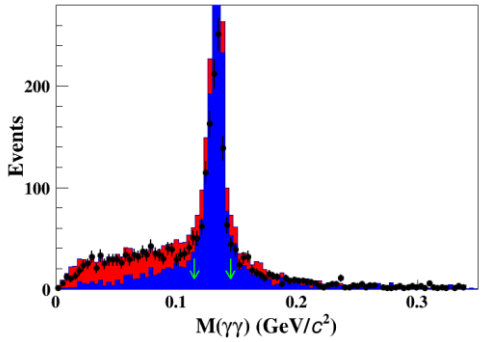
MC和data不一致
对于π^+和π^-情况不一样的原因

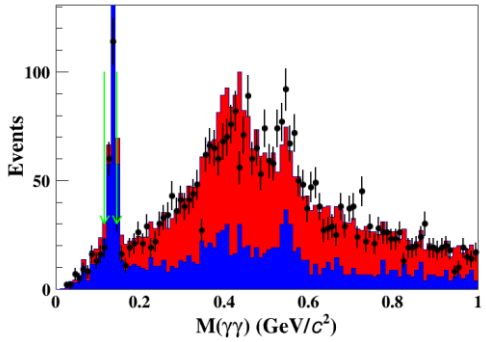
Further Selection

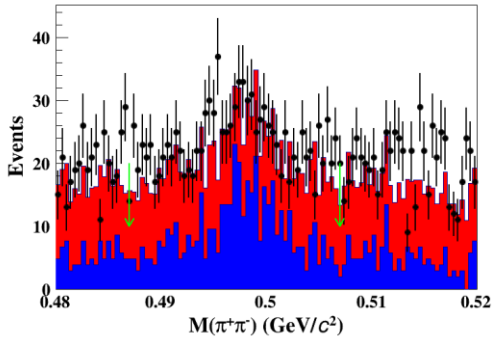


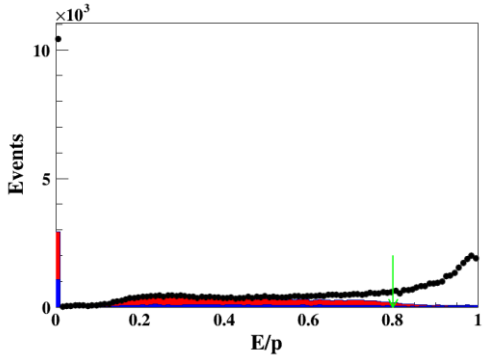
- Missing π^-

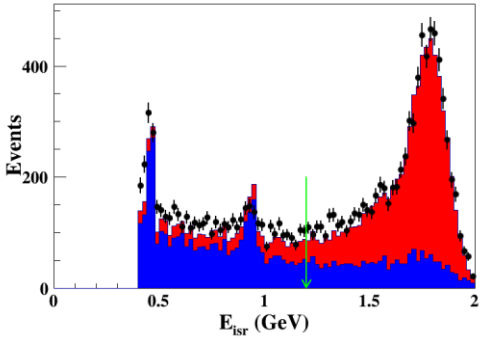
$\pi^{\pm}$	Situation	Signal purity
π^+	$N_{\text{Good}} = 3$	1418/5985
	$N_{\text{Good}} = 4$	1281/2297
π^-	$N_{\text{Good}} = 3$	1320/5761
	$N_{\text{Good}} = 4$	402/2112

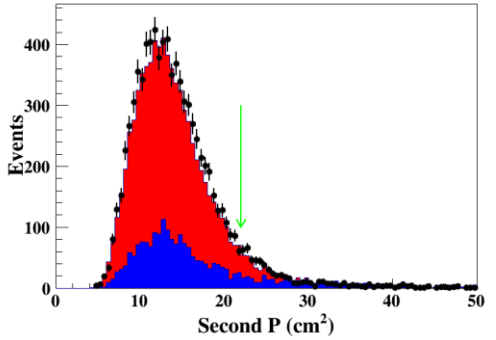












Background Analysis

- Hadronic topology analysis
  - Main hadronic channels → with π^0

$e^+e^- \to (\gamma^{\mathrm{ISR}})\pi^+\pi^-\pi^+\pi^-\pi^0$
$e^+e^- \to \pi^+\pi^-\pi^+\pi^-\eta$
$e^+e^- \to \pi^+\pi^-\omega, \omega \to \pi^+\pi^-\pi^0$
$e^+e^- \to (\gamma^{\mathrm{ISR}})\pi^+\pi^-\pi^0\pi^0$
…

  - Signal purity

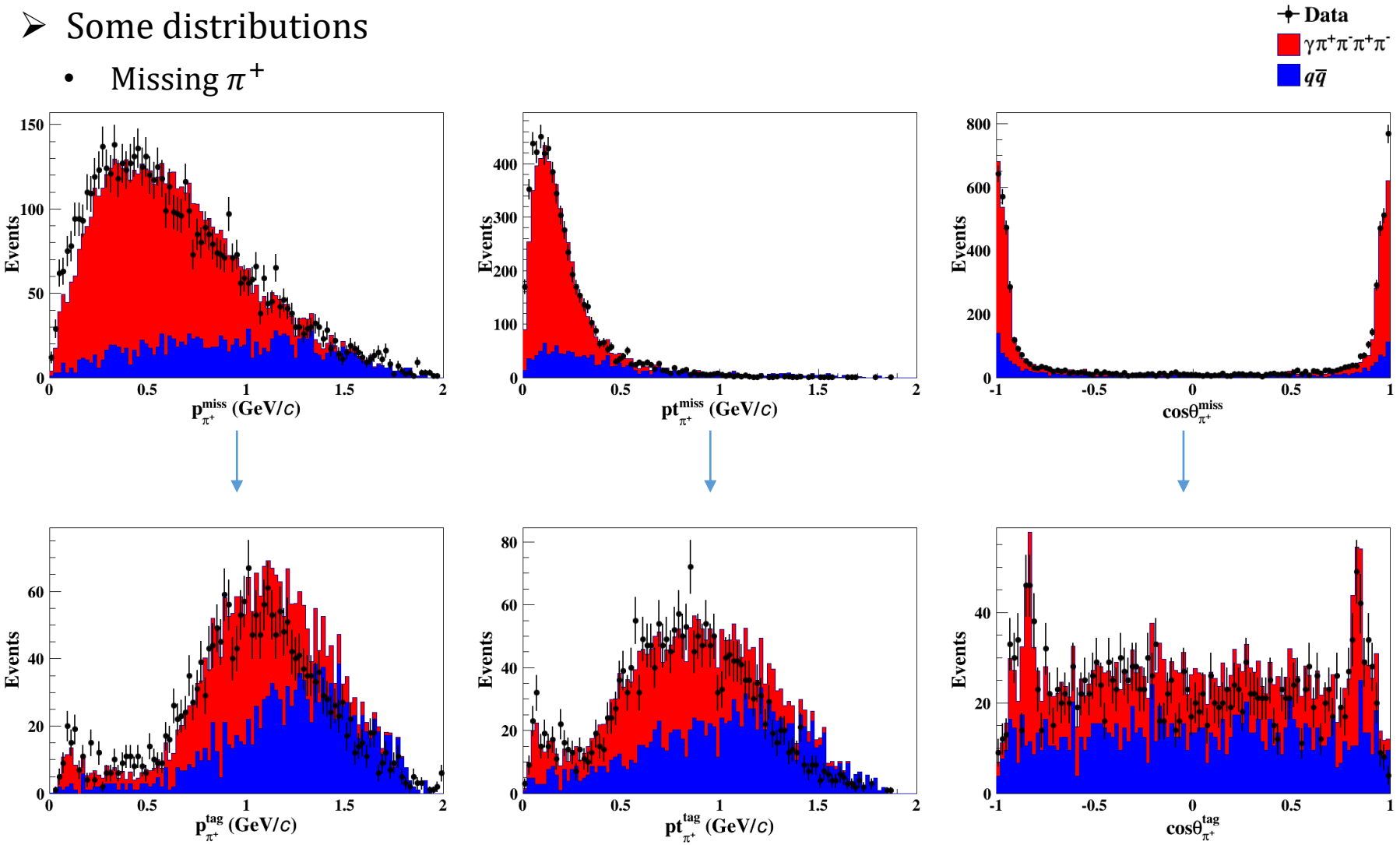
$\pi^{\pm}$	Situation	Background ratio
π^+	$N_{\mathrm{Good}} = 3$	23.7%
	$N_{\mathrm{Good}} = 4$	55.8%
π^-	$N_{\mathrm{Good}} = 3$	22.9%
	$N_{\mathrm{Good}} = 4$	19.0%

Cutflow检查原因

Why so different?
More check

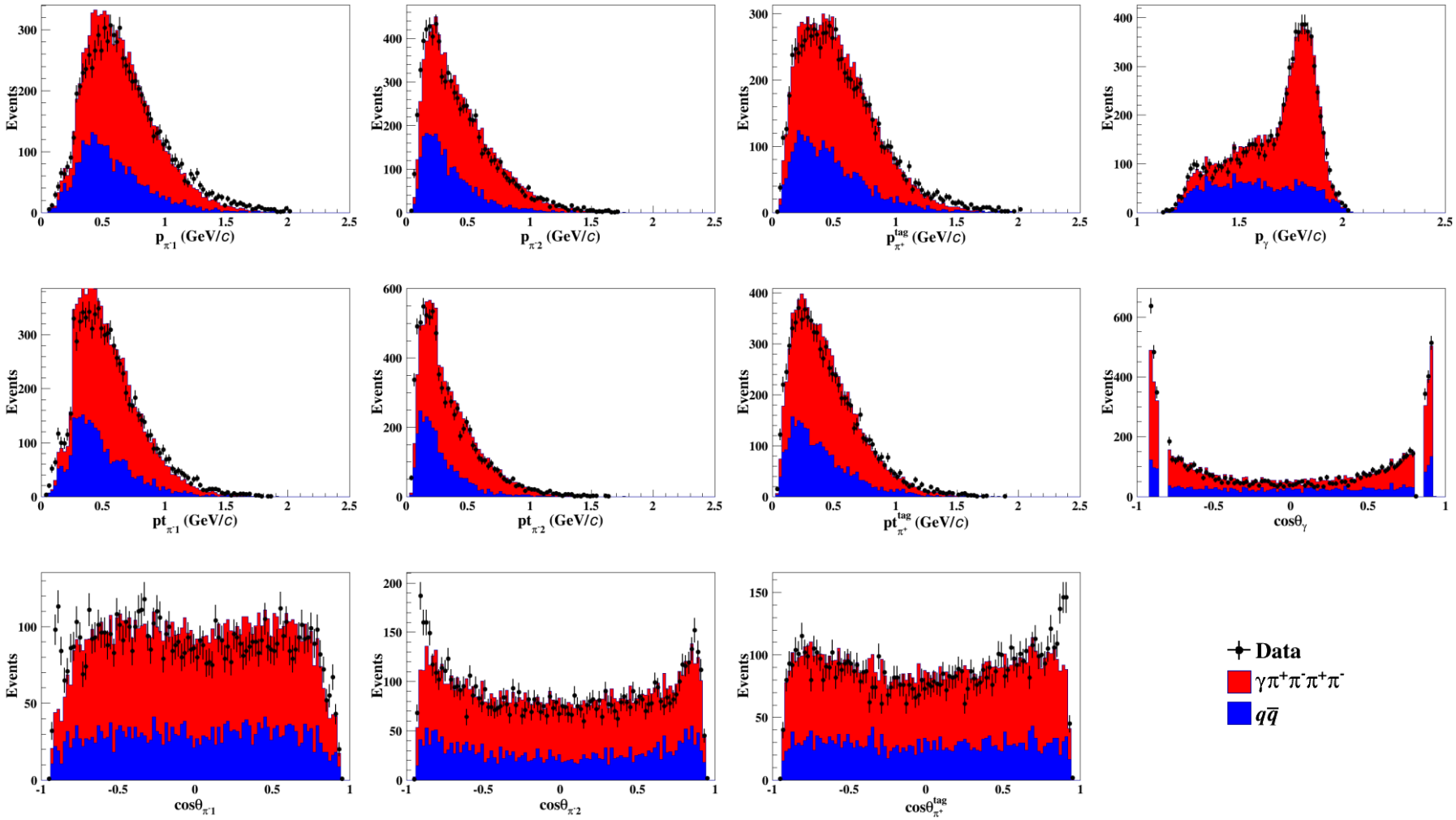
Comparisons: data and MC

- Some distributions
  - Missing π^+



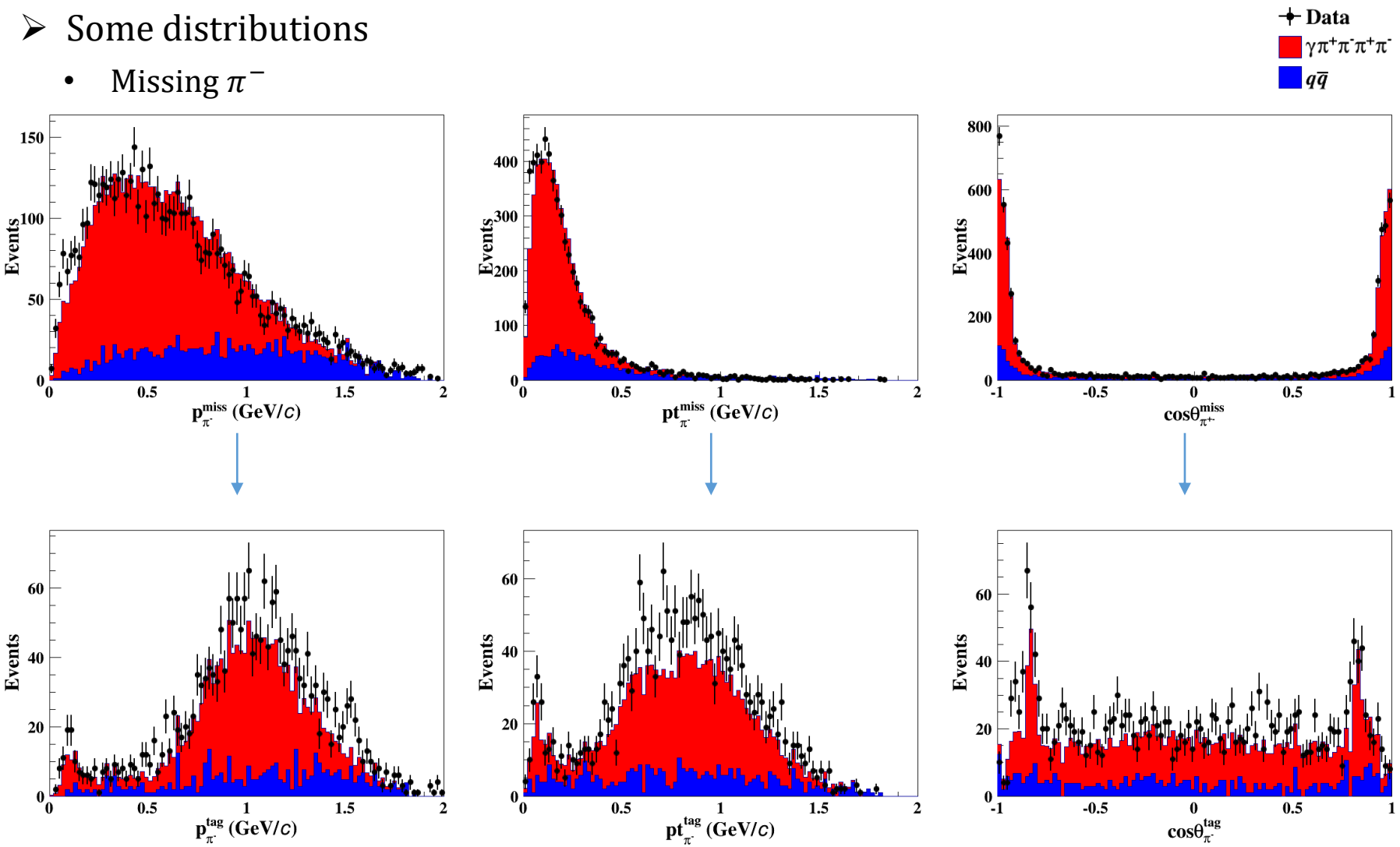
Comparisons: data and MC

- The tagged particles in Missing π^+



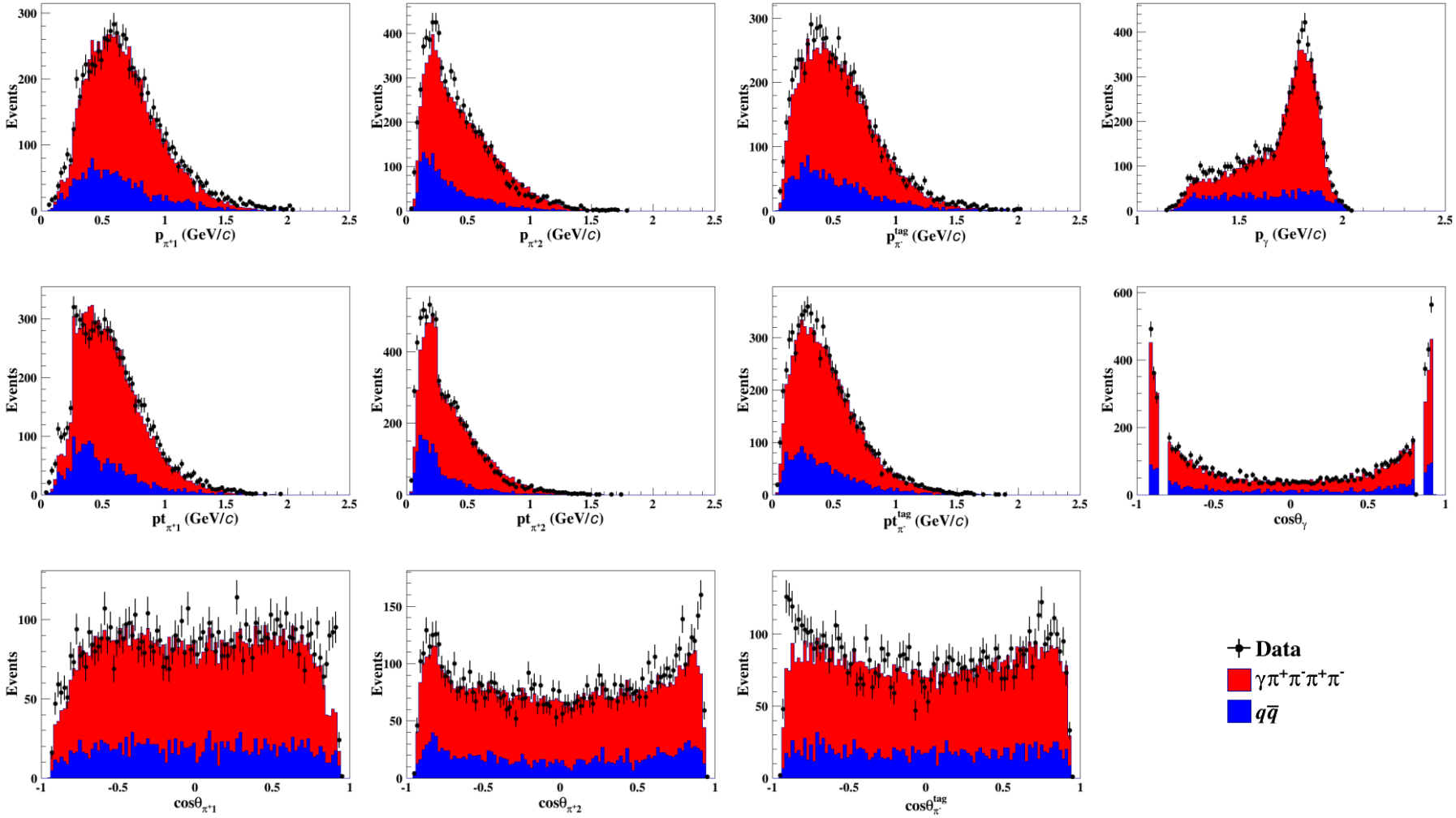
Comparisons: data and MC

- Some distributions
  - Missing π^-



Comparisons: data and MC

- The tagged particles in Missing π^-



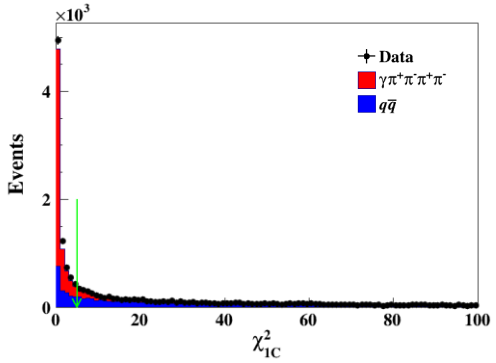
Summary

- Summary
  - The preliminary event selection has been used
  - The main backgrounds are from hadronic channels with π^0
  - There is good agreement with data and MC
  - The momenta of missing tracking is low
- Next to do
  - Try to suppress the backgrounds and improve the signal purity
  - Find another control samples to do the pion tracking efficiency
  - The strategy will used in old 3773 dataset

Thank you !

Back up

Further Selection



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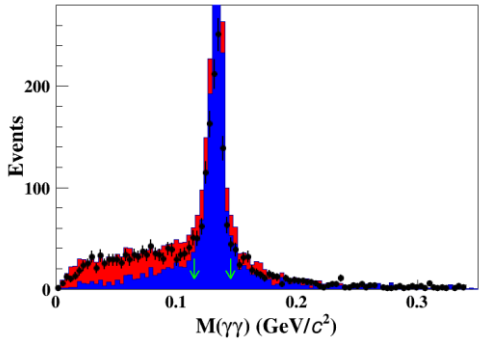

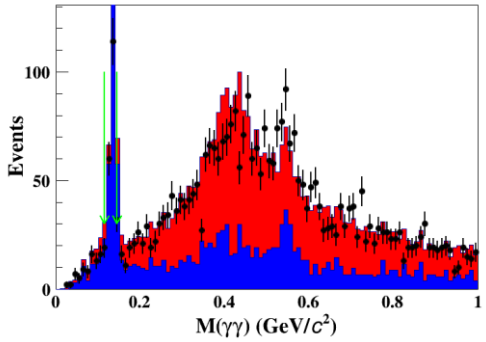

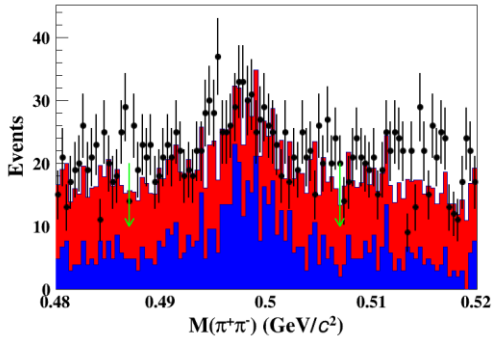

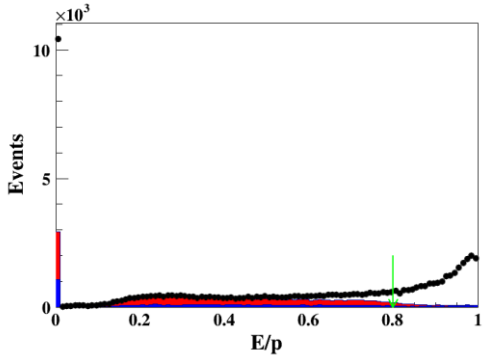

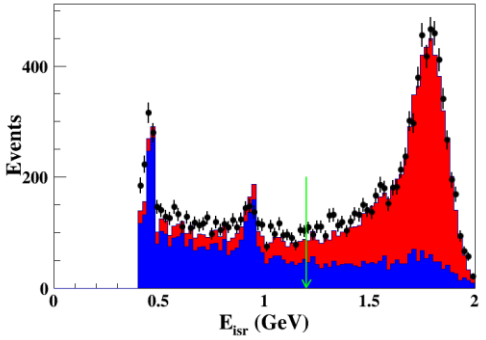

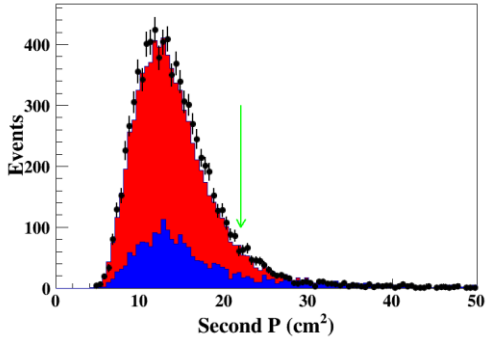

CutFlow Signal MC

	Tagpip				Tagpim		
total number	10000000				10000000		
nGam>=1	5504899	55.0%	55.0%		5504899	55.0%	55.0%
ISR photon	1375268	13.8%	25.0%		1375268	13.8%	25.0%
nGood==3||nGood==4	1261860	12.6%	91.8%		1261860	12.6%	91.8%
npip>=1&&npim>=1	1238241	12.4%	98.1%		1238241	12.4%	98.1%
Mode	257017	2.6%	20.8%		255655	2.6%	20.6%
chi2Tagpip<5	153013	1.5%	59.5%		153390	1.5%	60.0%
isrphoene>1.2	129845	1.3%	84.9%		130227	1.3%	84.9%
M2gg_Noisr	124101	1.2%	95.6%		124582	1.2%	95.7%
M2gg_Isr	123488	1.2%	99.5%		123966	1.2%	99.5%
Mks	112336	1.1%	91.0%		112873	1.1%	91.1%
Isrphosecmom	107755	1.1%	95.9%		108331	1.1%	96.0%
E/p	91667	0.9%	85.1%		89922	0.9%	83.0%

CutFlow Inclusive MC

	Tagpip				Tagpim		
total number	80000000						
nGam>=1	75175469						
ISR photon	34898659						
nGood==3||nGood==4	16188142						
npip>=1&&npim>=1	14460273						
Without fourpion	14372029						
Mode	3310425	4.1%	23.0%		3047143		21.2%
chi2Tagpip<5	32466	0.04%	0.98%		19642		0.64%
isrphoene>1.2	18568	0.02%	57.2%		8608		43.8%
M2gg_Noisr	8652	0.01%	46.6%		4531		52.6%
M2gg_Isr	7754	0.01%	89.6%		3986		88.0%
Mks	6715	0.01%	86.6%		3295		82.7%
Isrphosecmom	4047	0.01%	60.3%		2709		82.2%
E/p	2807	0.004%	69.4%		1791		66.1%

CutFlow Data


```
************************ data **********************
***
DTtotal     =16497920
DTmode      =3896171
DTchi2      =118801
DTEisr      =40944
DTm2ggNoisr =37343
DTm2ggIsr   =36841
DTmks       =33724
DTisr       =30343
DTeop       =8282
************************ qqba **********************
***
QQtotal     =14372029
QQmode      =3310425
QQchi2      =32466
QQEisr      =18568
QQm2ggNoisr =8652
QQm2ggIsr   =7754
QQmks       =6715
QQisr       =4047
QQeop       =2807
************************ kpkm **********************
***
MCtotal     =1238241
MCmode      =257017
MCchi2      =153013
MCEisr      =129845
MCm2ggNoisr =124101
MCm2ggIsr   =123488
MCmks       =112336
MCisr       =107755
MCeop       =91667
```

Tagpip

```
 8 ************************ data **********************
   ***
 9 DTtotal     =16497920
10 DTmode      =3681745
11 DTchi2      =88653
12 DTEisr      =31097
13 DTm2ggNoisr =28818
14 DTm2ggIsr   =28366
15 DTmks       =25818
16 DTisr       =23962
17 DTeop       =7873
18 ************************ qqba **********************
   ***
19 QQtotal     =14372029
20 QQmode      =3047143
21 QQchi2      =19642
22 QQEisr      =8608
23 QQm2ggNoisr =4531
24 QQm2ggIsr   =3986
25 QQmks       =3295
26 QQisr       =2709
27 QQeop       =1791
28 ************************ kpkm **********************
   ***
29 MCtotal     =1238241
30 MCmode      =255655
31 MCchi2      =153390
32 MCEisr      =130227
33 MCm2ggNoisr =124582
34 MCm2ggIsr   =123966
35 MCmks       =112873
36 MCisr       =108331
37 MCeop       =89922
```

Tagpim

Tracking Efficiency

- Tracking efficiency calculated by
  - Calculated by

$$\epsilon_{\pi}^{\text{tracking}} = \frac{N_{\text{nGood}=4}}{N_{\text{nGood}=3} + N_{\text{nGood}=4}}$$