

# Collins

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# Introduction

- 碎裂函数是用来描述部分子碎裂到强子过程的函数，Collins函数则是考虑了部分子自旋的碎裂函数。
- 对Collins函数的测量能够检验目前人们对部分子碎裂过程的认识，是人们感兴趣的基本函数。
- 在没有极化束流的情况下， $\gamma^* \rightarrow q\bar{q}$ ，虚光子自旋为一，夸克反夸克自旋平行。可以通过观测夸克碎裂和反夸克碎裂整体带来的效应测量Collins。

# Like-sign, Unlike Sign

Like-sign 电荷相同的pion

Unlike-sign, 电荷相反的pion

NC= NU+ NL

$$R = \frac{N(2\phi_0)}{\langle N_0 \rangle}.$$

$$R = a \cos(2\phi_0) + b.$$

我们利用做比的方法消除探测器效应

$$N^U(2\phi_0) = \frac{d\sigma(e^+e^- \rightarrow \pi^\pm \pi^\mp X)}{d\Omega dz_1 dz_2} \approx \sum_q e_q^2 [(1 + \cos^2 \theta)(D_1^{fav} \bar{D}_2^{fav} + D_1^{dis} \bar{D}_2^{dis}) + \sin^2 \theta \cos(2\phi_0)(H_1^{fav} \bar{H}_2^{fav} + H_1^{dis} \bar{H}_2^{dis})] \quad (3.7)$$

$$N^L(2\phi_0) = \frac{d\sigma(e^+e^- \rightarrow \pi^\pm \pi^\pm X)}{d\Omega dz_1 dz_2} \approx \sum_q e_q^2 [(1 + \cos^2 \theta)(D_1^{fav} \bar{D}_2^{dis} + D_1^{dis} \bar{D}_2^{fav}) + \sin^2 \theta \cos(2\phi_0)(H_1^{fav} \bar{H}_2^{dis} + H_1^{dis} \bar{H}_2^{fav})] \quad (3.8)$$

$$N^C(2\phi_0) = \frac{d\sigma(e^+e^- \rightarrow \pi\pi X)}{d\Omega dz_1 dz_2} \approx \sum_q e_q^2 [(1 + \cos^2 \theta)(D_1^{fav} + D_1^{dis})(\bar{D}_2^{fav} + \bar{D}_2^{dis}) + \sin^2 \theta \cos(2\phi_0)(H_1^{fav} + H_1^{dis})(\bar{H}_2^{fav} + \bar{H}_2^{dis})], \quad (3.9)$$

$$\frac{R^U}{R^{L(C)}} = A \cos(2\phi_0) + B.$$

# 角度定义

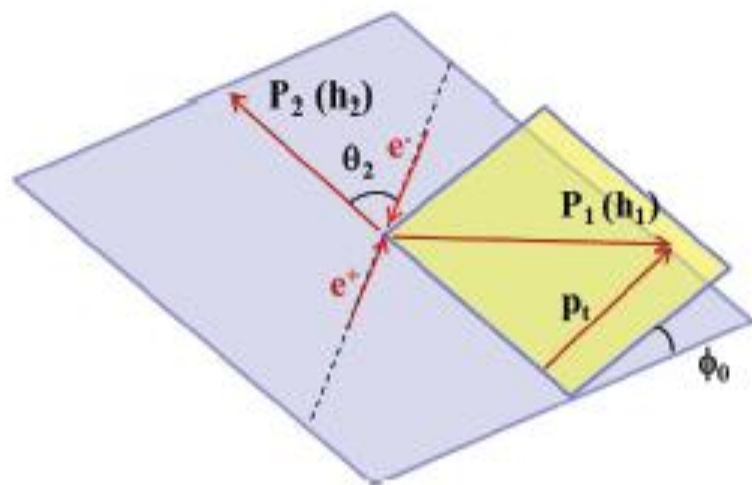


图 3.3: 同时考虑夸克和反夸克的碎裂, 在Gottfried-Jackson表达中, 极角 $\phi_0$ 的定义。

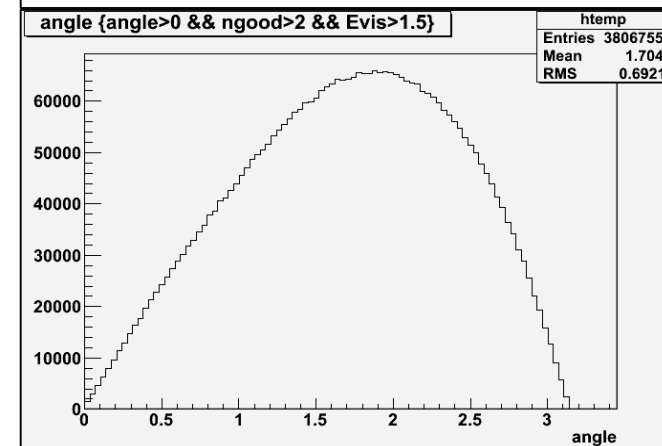
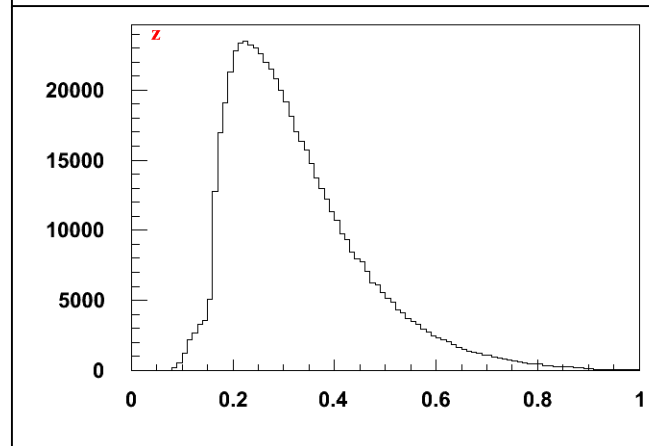
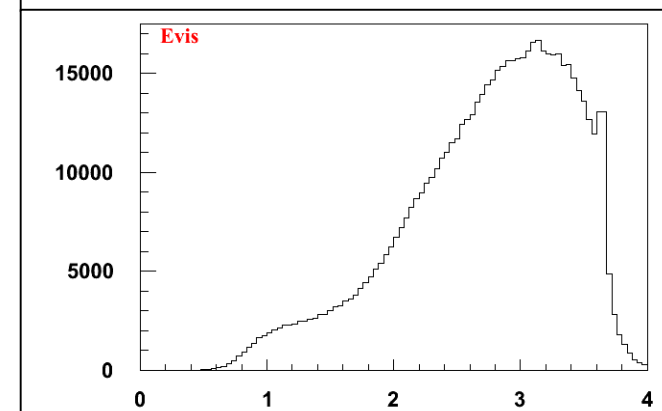
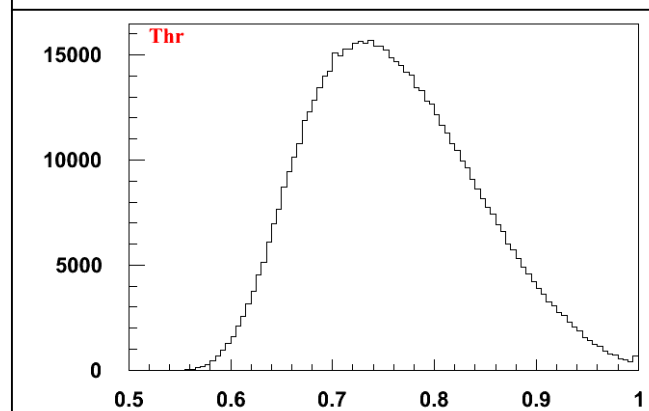
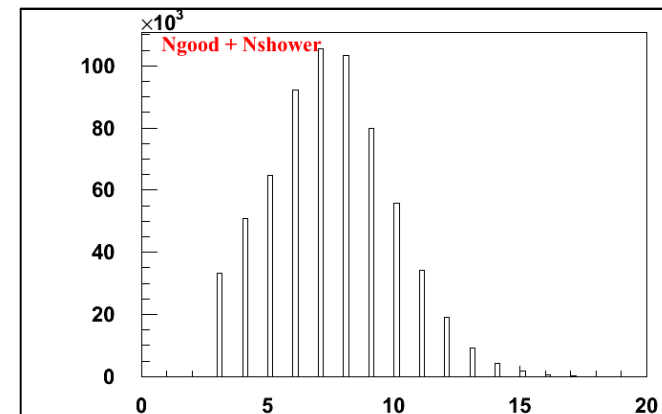
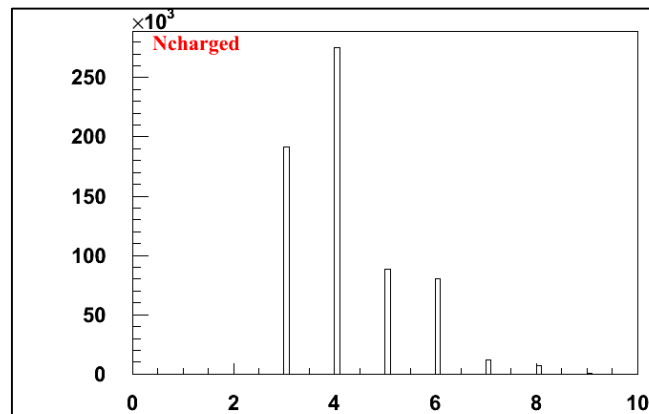
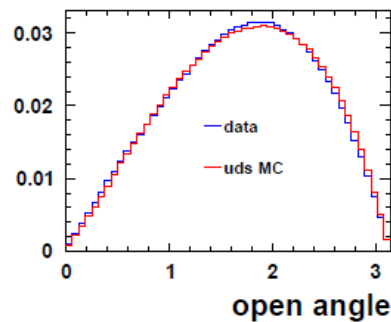
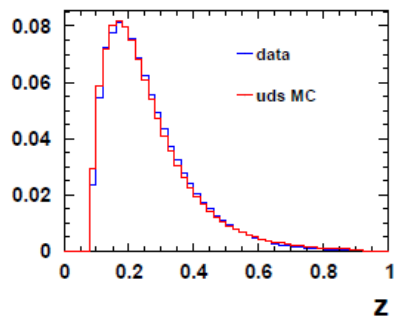
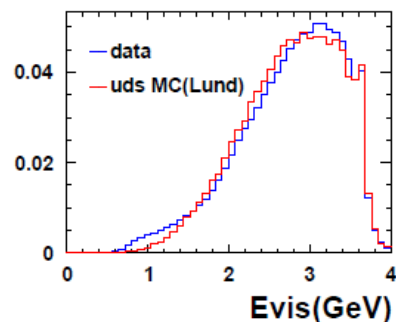
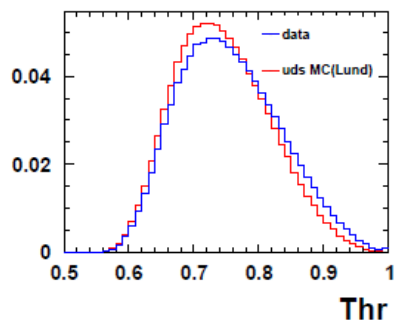
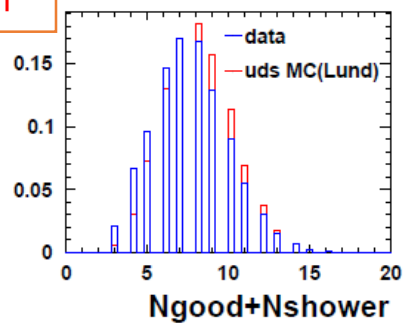
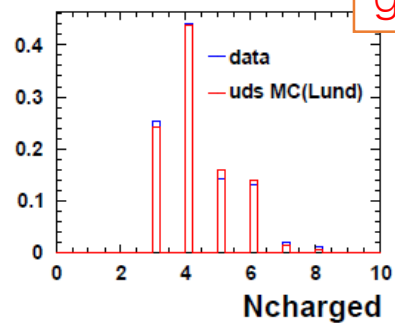
# Event selection

- 好径迹数  $\geq 3$
- 至少两个 pion
- 不存在电子
- 可观测的能量  $> 1.5 \text{ GeV}$
- 两个 pion 夹角  $> 120^\circ$
- $(z > 0.2) \quad z = E_\pi / E_{beam}$
- (高能区可能要考虑利用冲度条件 Thrust)
  - 冲度值分布在 0.5 到 1 之间，对于几乎各向同性的事例形状，冲度值接近 0.5，对于几乎背对背的两喷注事例，冲度值接近于 1

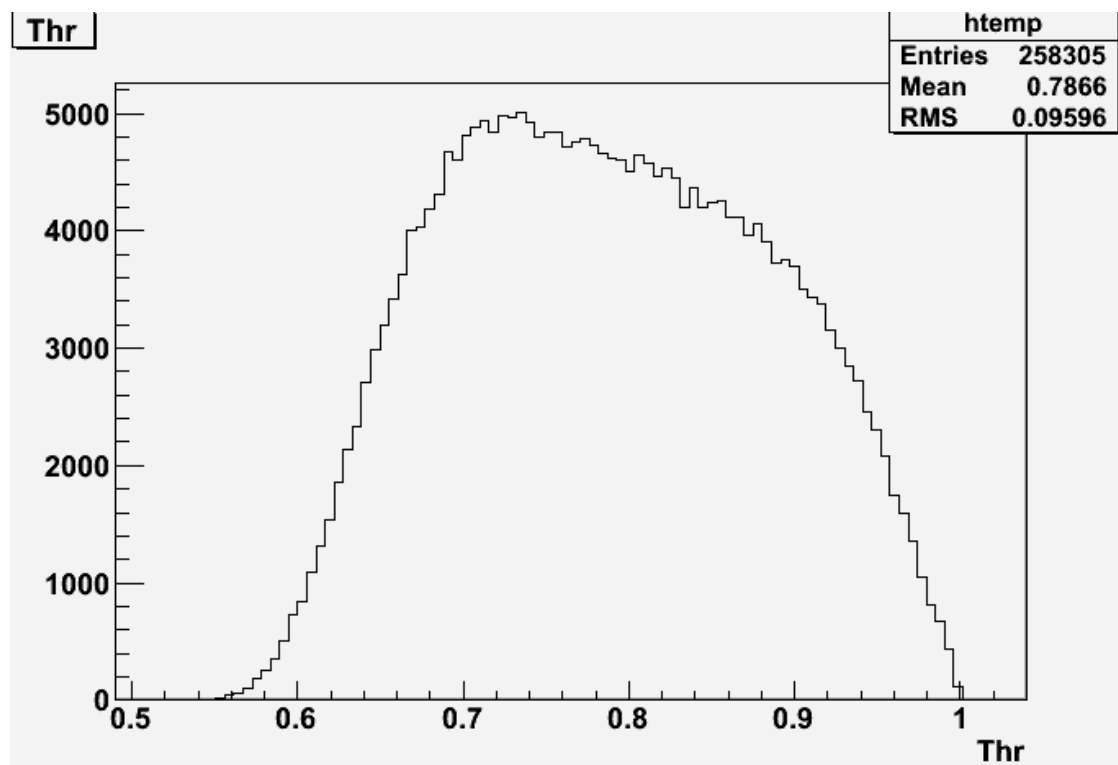
$$T = \text{Max} \left[ \frac{\sum_h |\mathbf{P}_h^{\text{CMS}} \cdot \hat{\mathbf{n}}|}{\sum_h |\mathbf{P}_h^{\text{CMS}}|} \right],$$

# Some plots

guan



Thrust MC 7GeV, 可能是我们的MC并没有很好的描述jet行为。



$$\phi_0$$

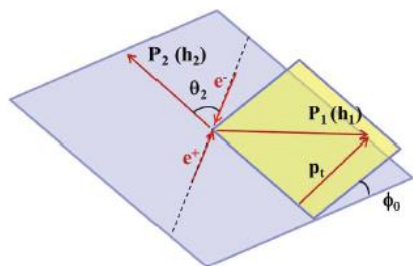


图 3.3: 同时考虑夸克和反夸克的碎裂, 在Gottfried-Jackson表达中, 极角 $\phi_0$ 的定义。

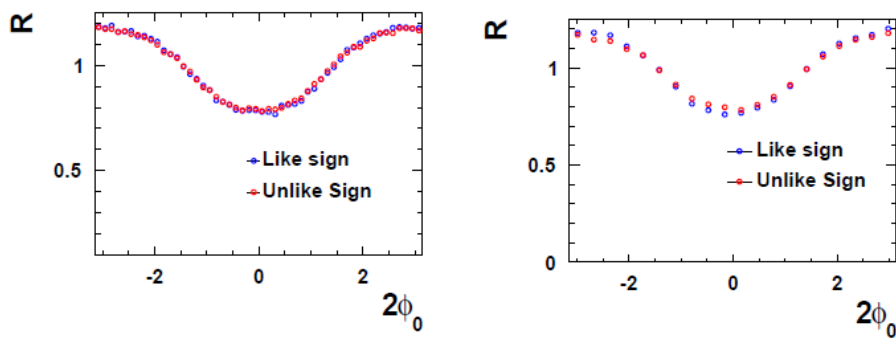
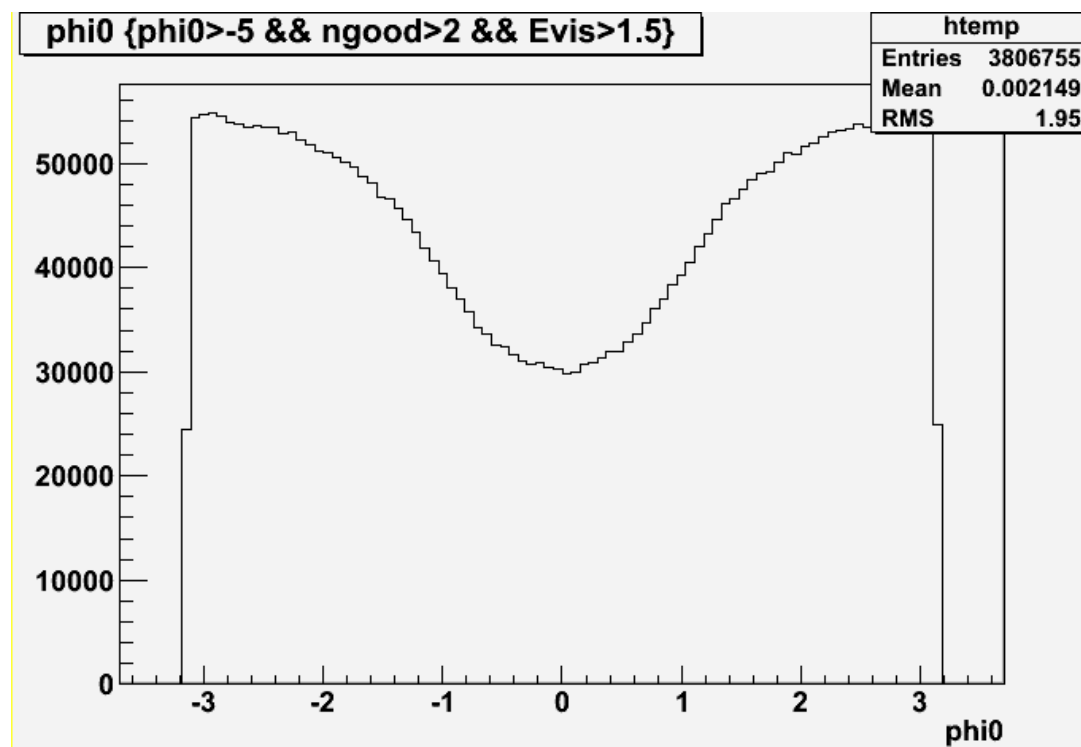


图 3.7: 数据和MC样本中归一化后的 $2\phi_0$ 分布, 这里“like-sign”表示电荷相同的 $\pi$ 对, “unlike-sign”表示电荷相反的 $\pi$ 对。





# bin

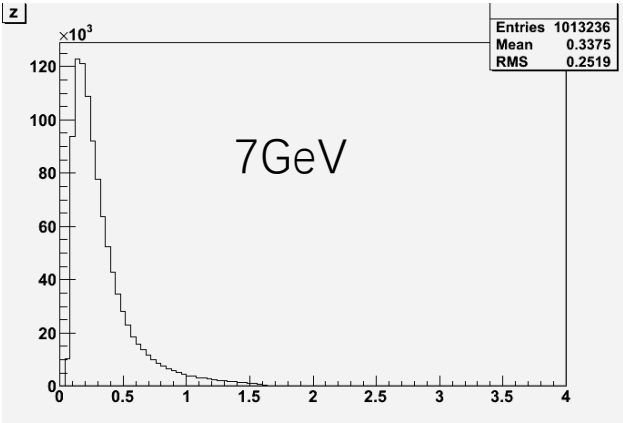
Table 5: All  $\pi$  pairs are grouped into 10 bins according  $z_1$  and  $z_2$ .

$z_2$						
0.9		4	7	9	10	
0.5		3	6	8	9	
0.3		2	5	6	7	
0.2		1	2	3	4	
0.15						
	0.15	0.2	0.3	0.5	0.9	$z_1$

he fractional energy  $z$  is divided into four bins:

- $[0.15,0.2]$ ,
- $[0.2,0.3]$ ,
- $[0.3,0.5]$ ,
- $[0.5,0.9]$ ,

0.5, 0.9	4	7	9	10
0.3, 0.5	3	6	8	9
0.2, 0.3	2	5	6	7
0.15,0.2	1	2	3	4
	0.15,0.2	0.2,0.3	0.3,0.5	0.5,0.9



因为在MC中我们用的Ebeam还是3.65/2， 所以出现了 $z>1$ 的情况

# Bins

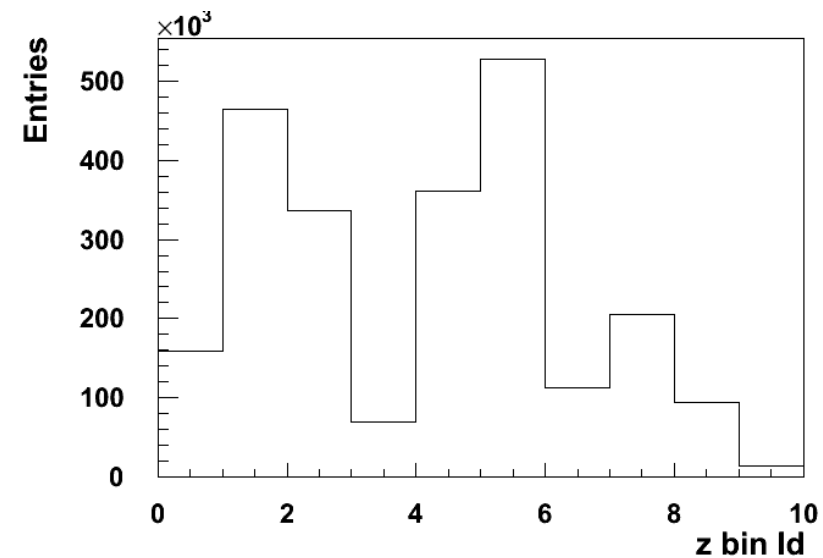
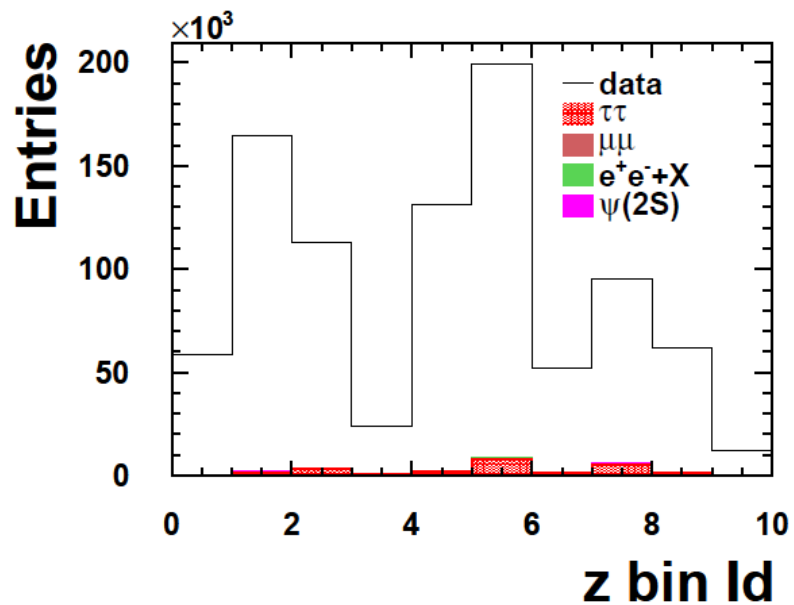


Figure 28: The number of pion pairs in data sample and the scaled contribution from ditau,  $e^+e^-X$ , dimu backgrounds and the  $uds$  MC sample.

$2\phi_0$

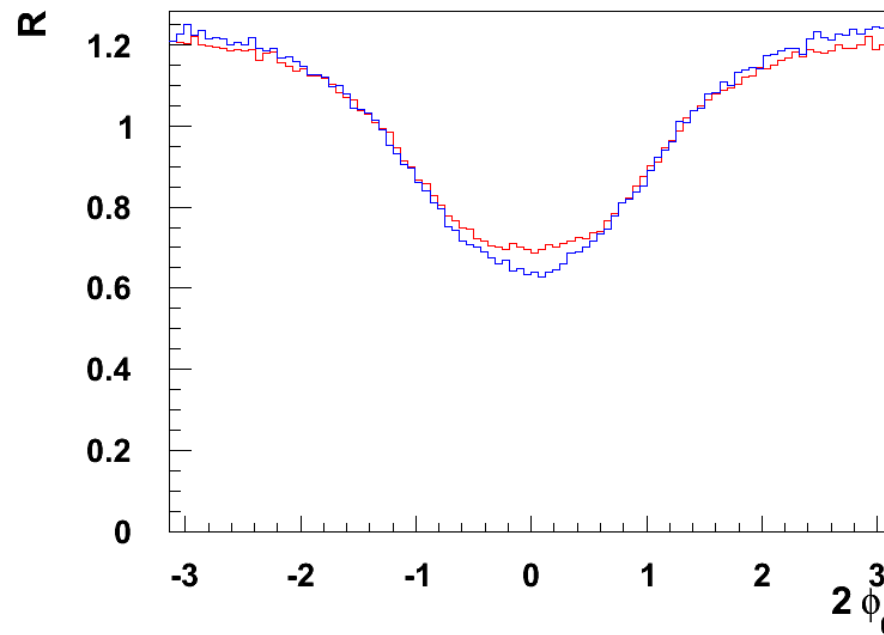
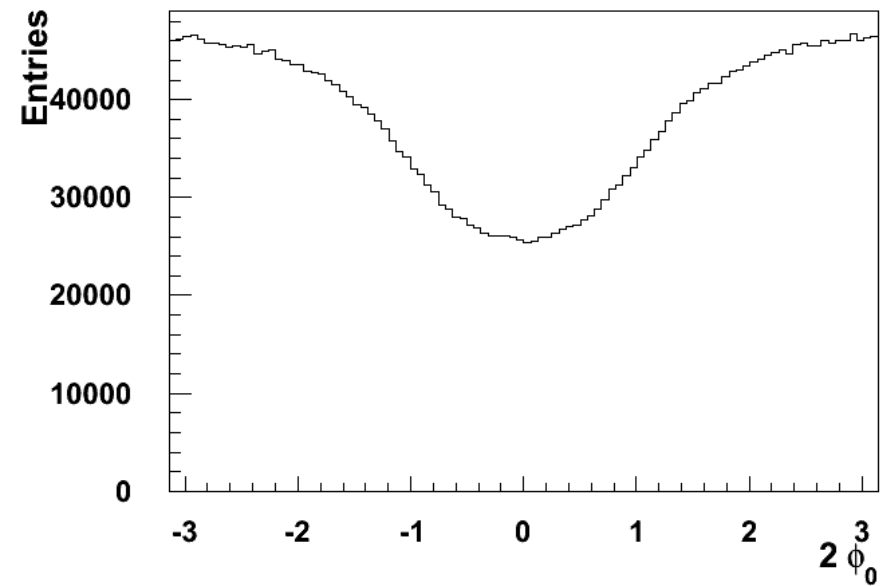
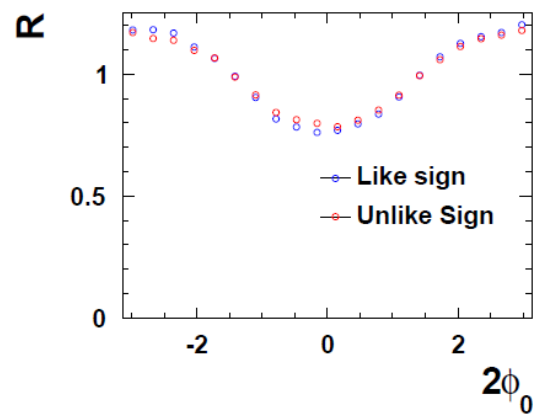
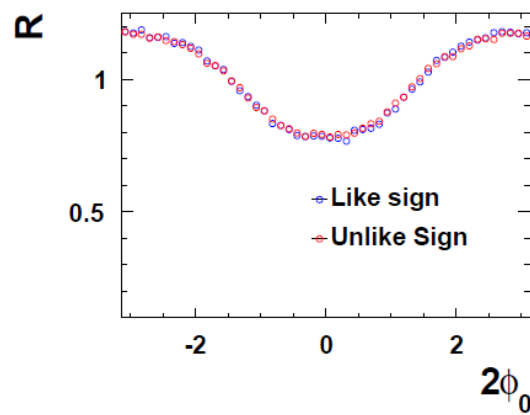
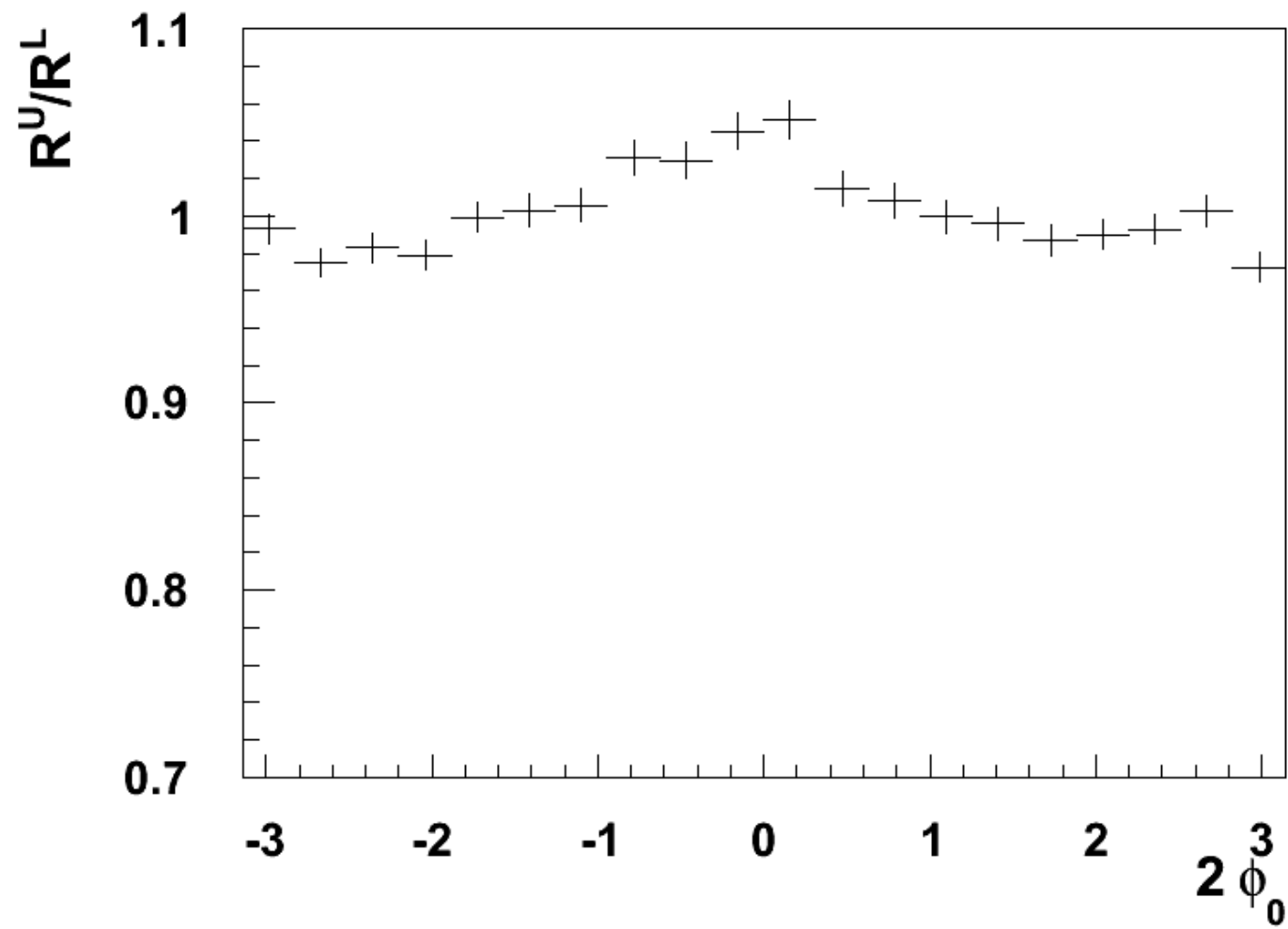
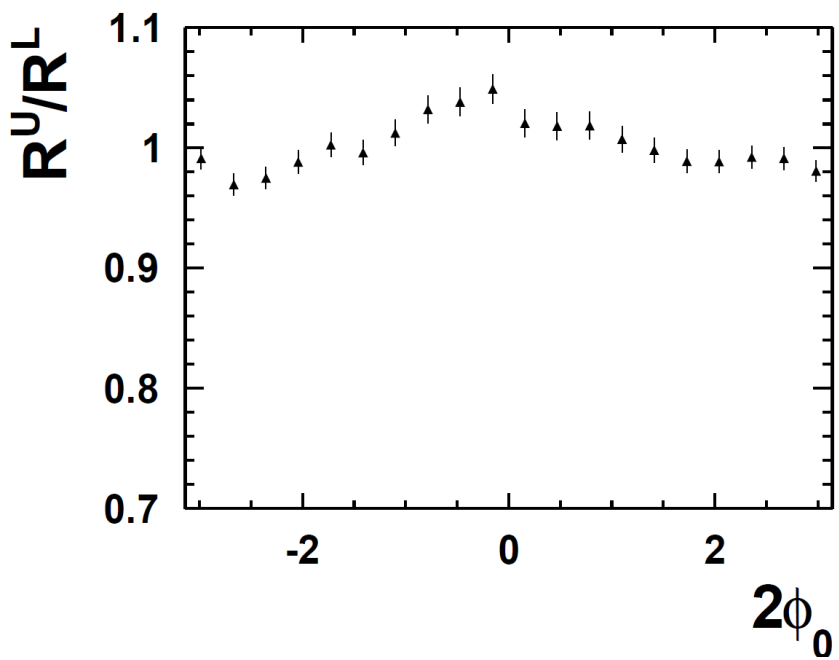
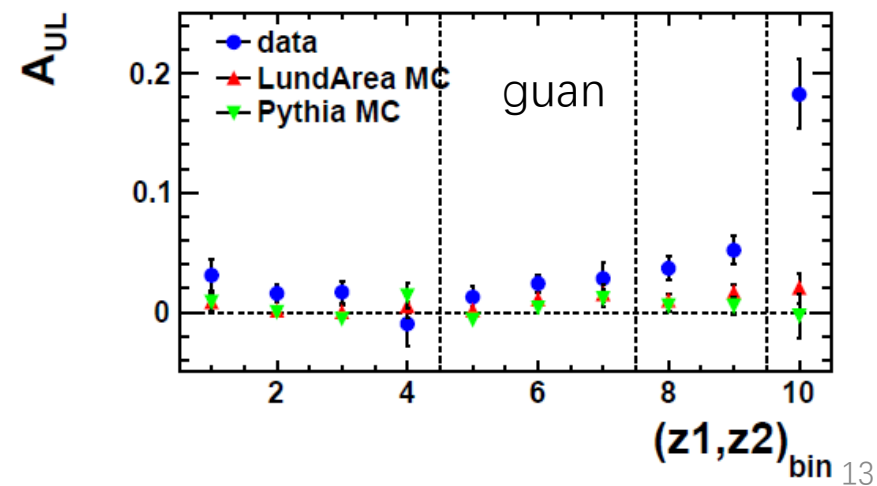
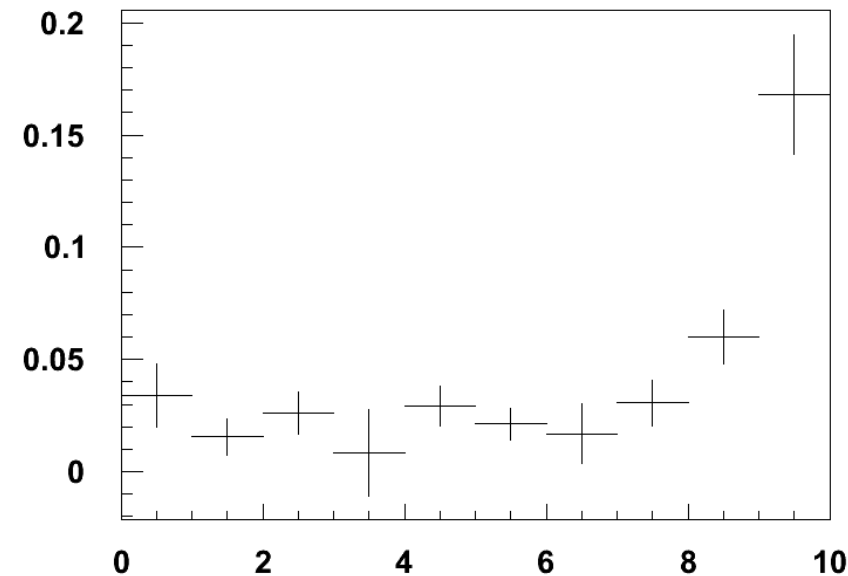
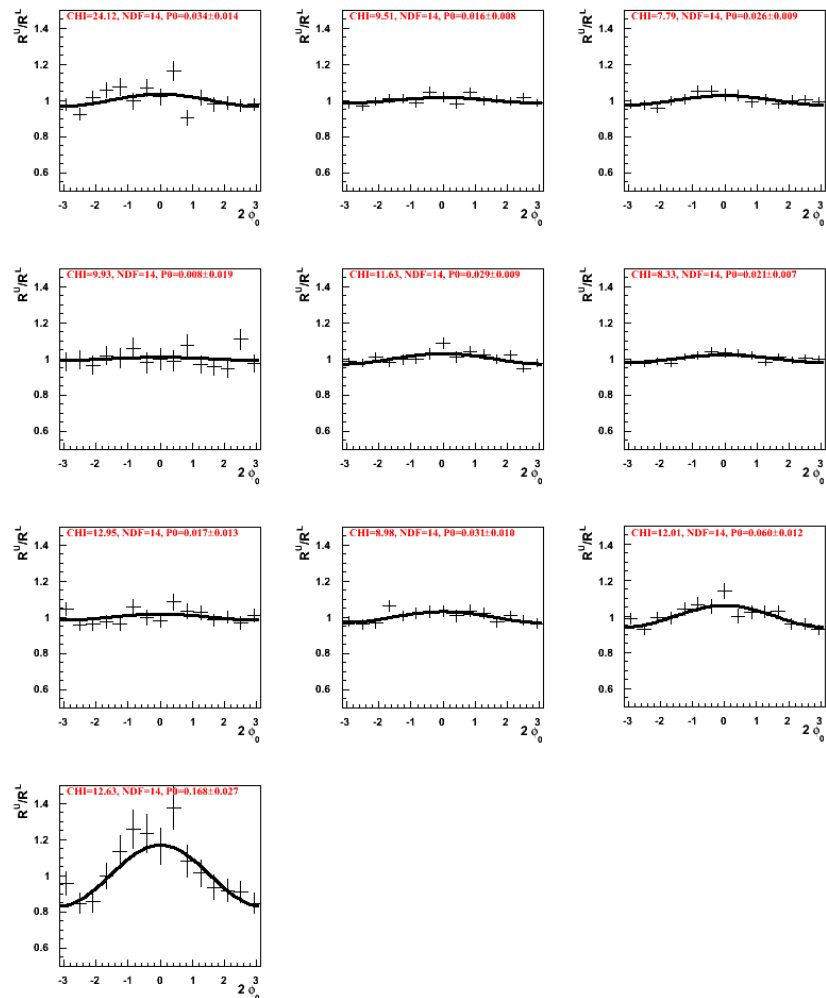


Figure 6: Normalized  $2\phi_0$  raw distribution for like-sign  $\pi$ -pairs and unlike-sign  $\pi$ -pairs in  $uds$  MC(left) and data(right).

# RU/RL



# RU/RL result for data



# $K \pi$ 误鉴别

- Data, 3.65GeV
- 我们预期 $K - K$ 对 $\pi - \pi$ 的污染是可以忽略的, 我们只考虑 $K - \pi$ 对 $\pi - \pi$ 的污染
- 通过MC样本, 我们可以得到 $K - \pi$ 对 $\pi - \pi$ 的污染率,

表 3.3: 通过MC样本拿到的 $\pi - K$ 污染 $\pi - \pi$ 组合的比例(%)。

Bin	1	2	3	4	5	6	7	8	9	10
$\pi - K$ 比份(%)	0.05	0.09	0.5	3.5	0.1	0.6	3.5	0.8	3.4	4.2

# Summary of K-pi误鉴别 (in %)

bin	1	2	3	4	5	6	7	8	9	10
3.65GeV	0.075415	0.09505	0.703521	3.61856	0.136384	0.935707	3.62093	1.7412	3.35928	4.48718
4GeV	0.170558	0.26956	1.36243	3.84245	0.411595	1.57369	3.98071	2.77459	3.6421	2.59548
5GeV	0.216667	0.308066	1.63059	4.73609	0.500723	1.68309	4.9946	3.1111	4.66132	4.81962
6GeV	0.318301	0.359657	1.78255	5.07545	0.596757	1.86081	5.25809	3.20022	5.40976	6.35558
7GeV	0.156986	0.323464	1.85564	5.86895	0.559083	2.02241	5.8388	3.32768	6.13588	7.3667

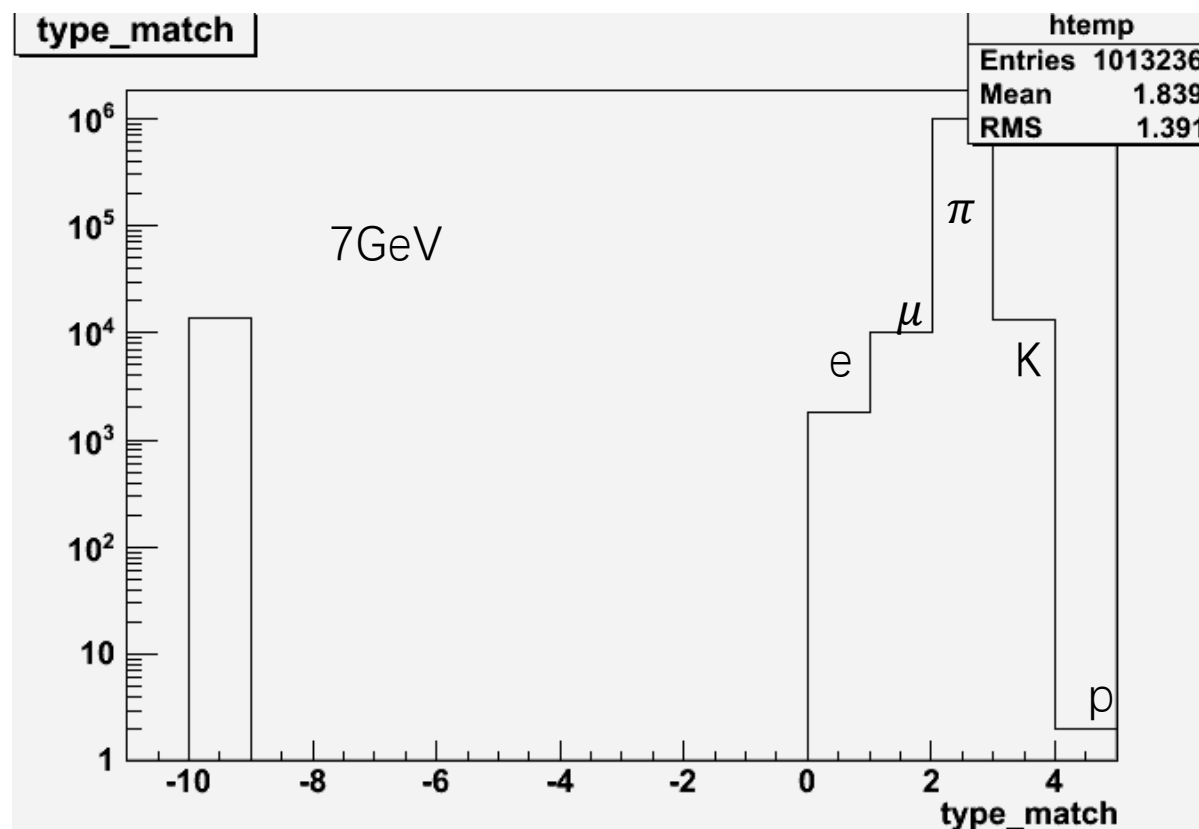
# 考虑到所有的误鉴别

bin	1	2	3	4	5	6	7	8	9	10
3.65GeV	1.34033	1.0598	1.11696	4.12942	1.1523	1.34551	3.88313	1.93906	3.67336	4.87179
4GeV	3.31974	3.49083	4.11974	4.53397	4.11595	4.16186	4.59575	4.37904	4.01762	2.92918
5GeV	3.3122	3.61121	4.08799	5.78461	4.15173	3.78995	5.97145	4.32797	5.45747	6.08794
6GeV	3.73584	3.77347	4.62632	6.17691	4.32469	4.51032	6.31934	4.98902	6.27936	7.26903
7GeV	3.97925	3.89966	5.08383	7.42007	4.54215	4.99283	7.35992	5.8142	7.34145	8.13819



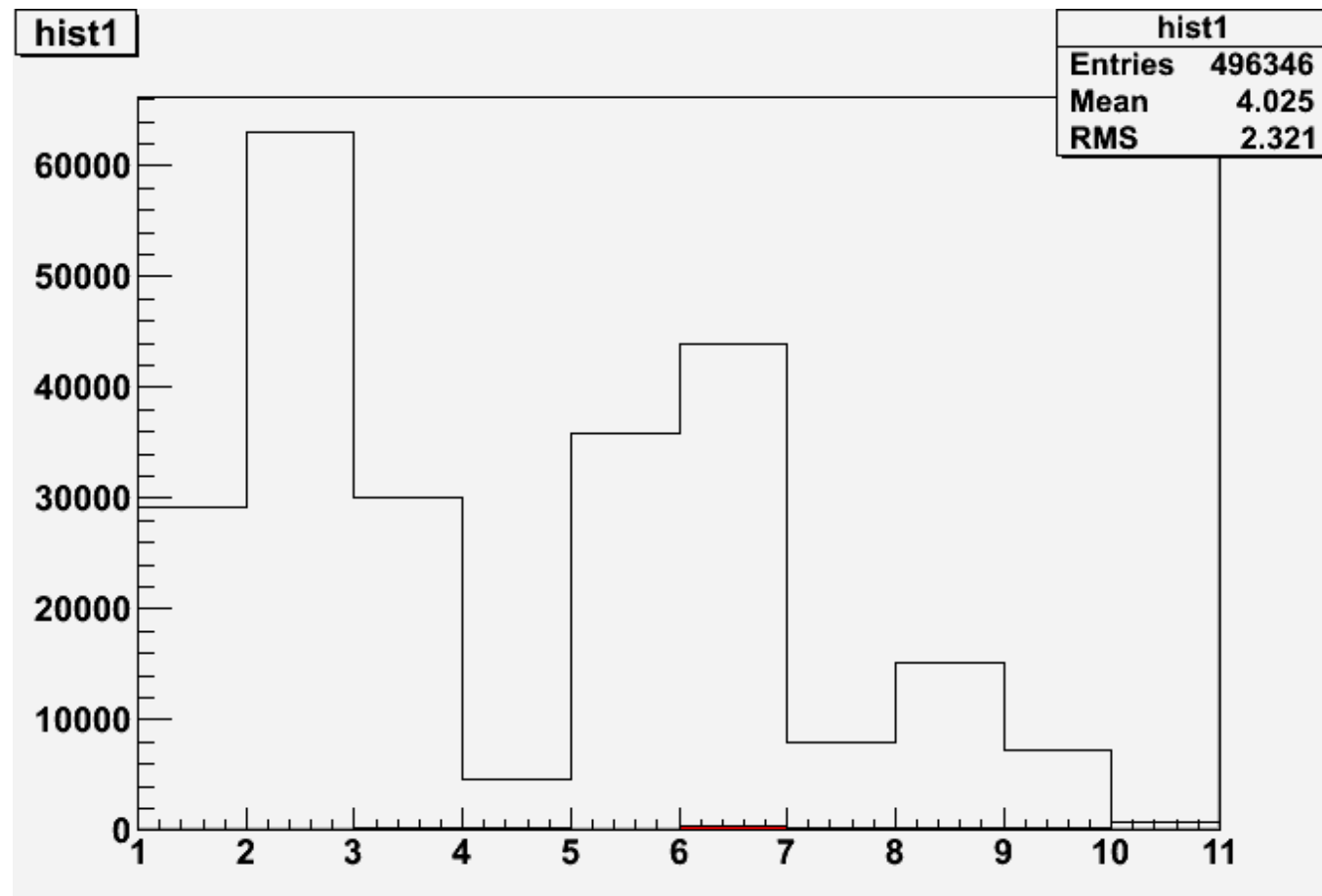
# 其他的误混来源

- 除了K以外， 其他的误混来源为 $\mu > e > p$

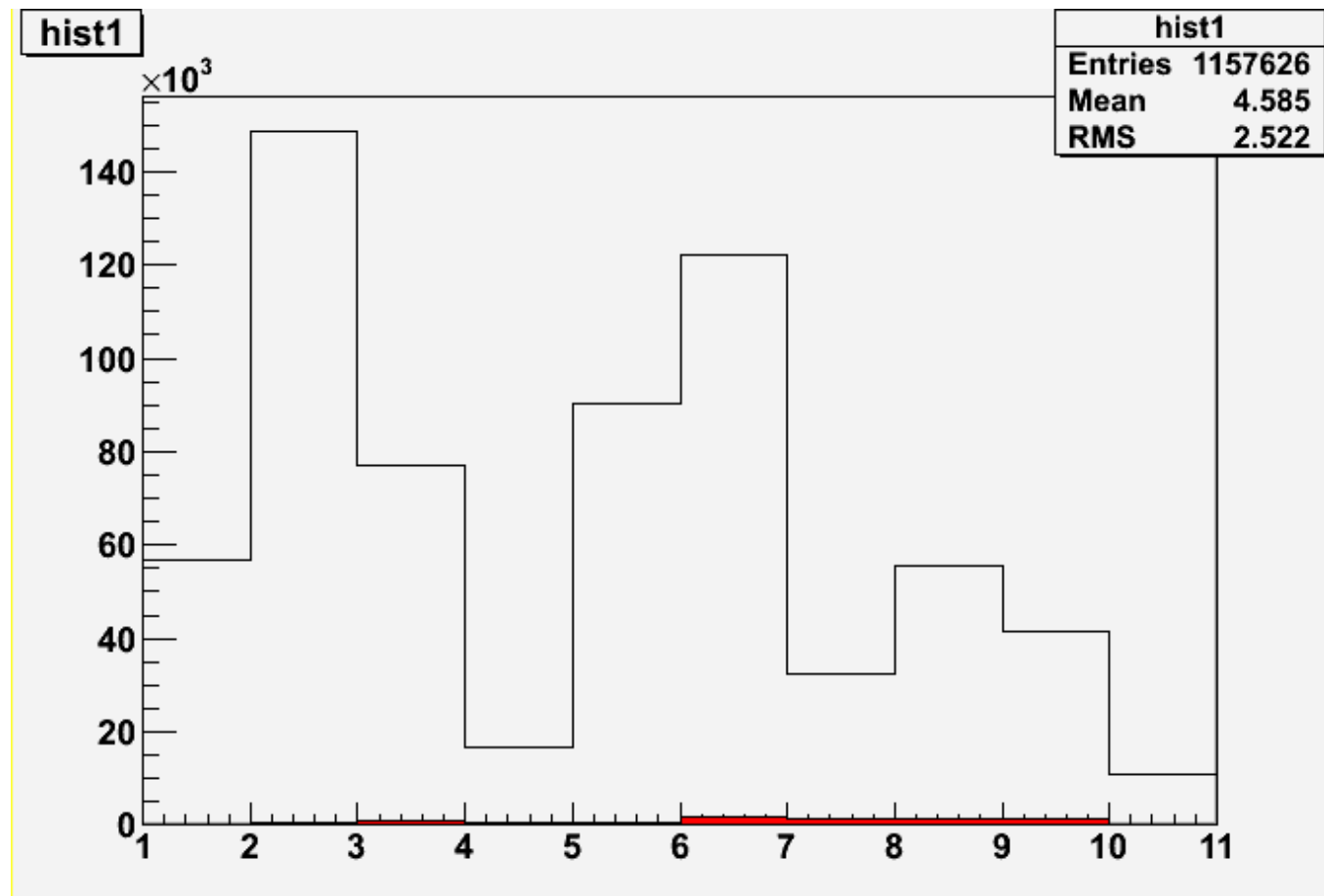




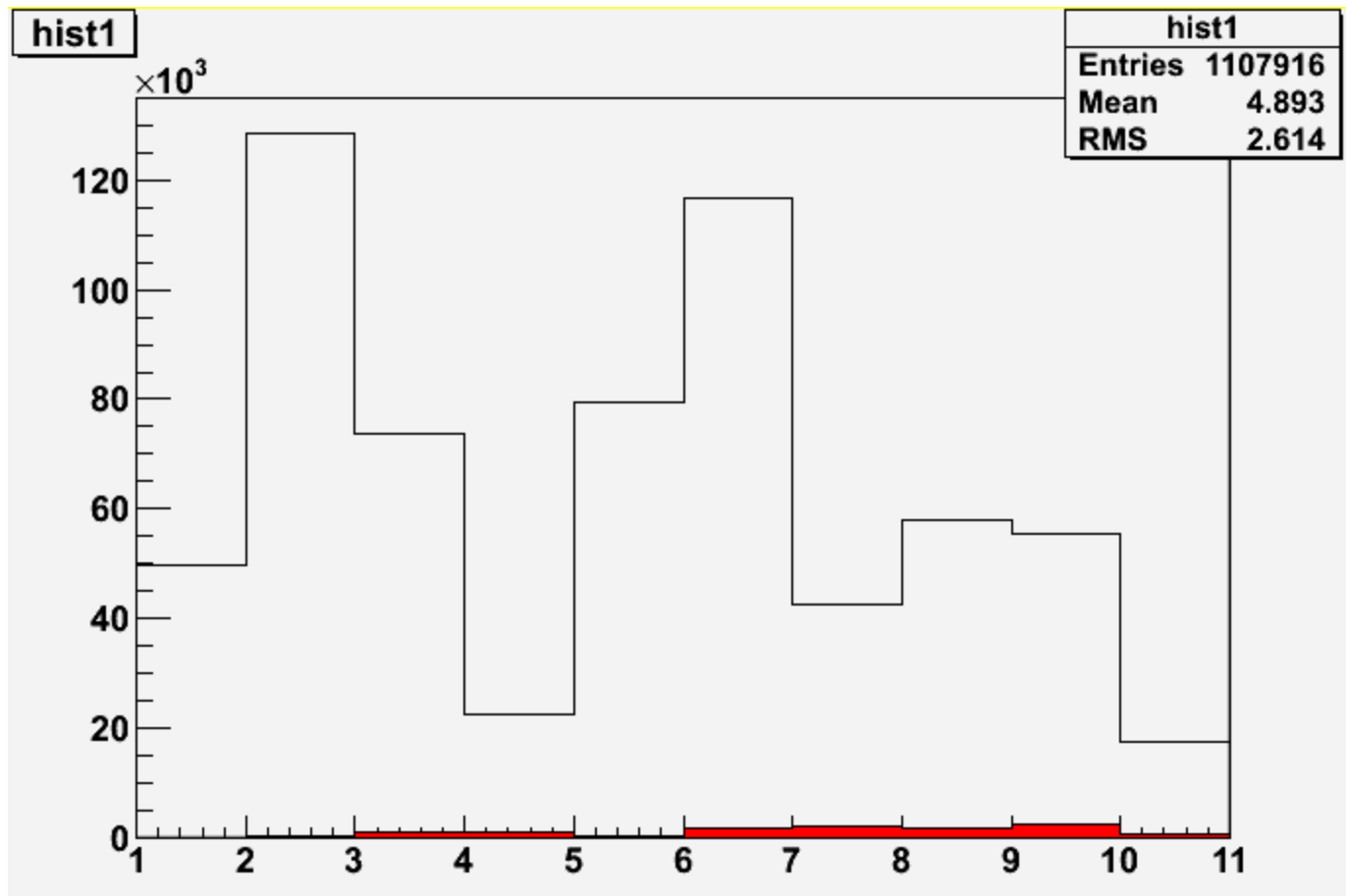
3.65GeV , kpi误混



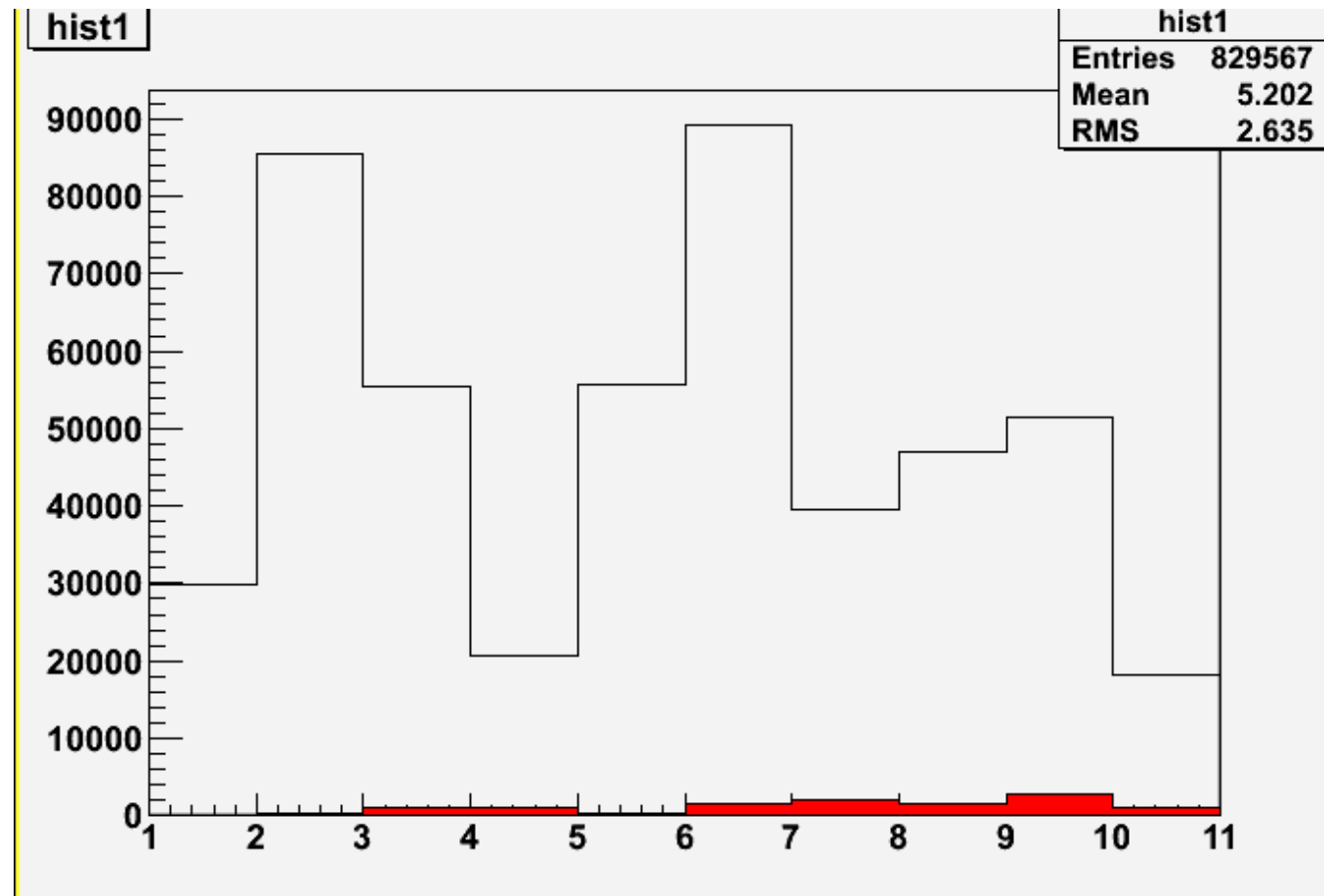
# 4GeV kpi误混



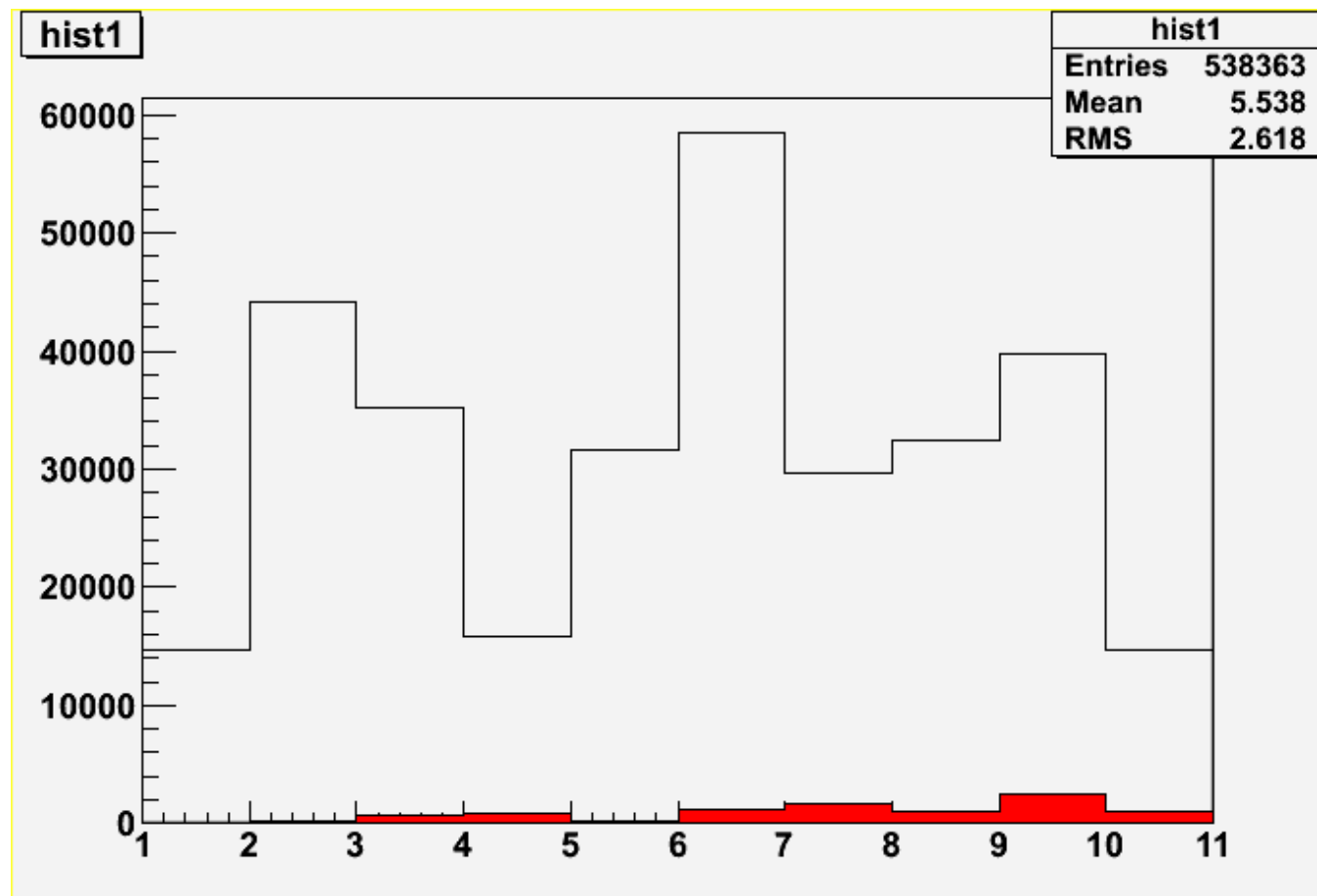
# 5GeV kpi误混



# 6GeV kpi误混



# 7GeV kpi误混



# Event Selection

- Good tracks:
  - $|\cos \theta| < 0.93 \ \&\& \ |dr| < 1 \text{ cm} \ \&\& \ |dz| < 10 \text{ cm}$
- Good gamma:
  - $|\cos \theta| < 0.8 \ \&\& \ E > 25 \text{ MeV}) \ || (0.84 < |\cos \theta| < 0.92 \ \&\& \ E > 50 \text{ MeV})$
  - $0 \leq T \leq 14$
- Num of good tracks  $\geq 3$
- Num of good tracks which are identified as pions  $\geq 2$
- No electrons are found
- Visible energy  $> 1.5 \text{ GeV}$
- Angle between two pions  $> 120$  degrees.
- 隐藏条件 ( $z > 0.2$ )  $z = E_{\pi}/E_{beam}$