Table 2: The results of fitting and branching fractions of χ_{cJ}.

Decay mode	N_{sig}	ϵ (%)	B ($\times 10^{-4}$)
$\chi_{c0} \to p\bar{p}K^+K^-$	785 ± 31	10.1	1.77 ± 0.07
$\chi_{c1} \to p\bar{p}K^+K^-$	960 ± 33	14.2	1.55 ± 0.05
$\chi_{c2} \to p\bar{p}K^+K^-$	1251 ± 37	14.8	1.98 ± 0.06

TABLE I. The branching fractions for $\chi_{cJ} \to p\bar{p}K^+K^-$, where errors are statistical only.

Quantity	χ_{c0}	χ_{c1}	χ_{c2}
$N_{\rm obs}$	48.2 ± 7.7	81.5 ± 9.2	131 ± 12
ε(%)	3.8 ± 0.1	6.2 ± 0.1	6.8 ± 0.1
$\mathcal{B}(\chi_{cJ} \to p\bar{p}K^+K^-)$ (10^{-4})	1.24 ± 0.20	1.35 ± 0.15	2.08 ± 0.19

Table 3: The results of fitting and branching fractions of χ_{cJ}.

Decay mode	N_{sig}	ϵ (%)	B ($\times 10^{-5}$)
$\chi_{c0} \to p\bar{p}\phi$	167 ± 20	11.5	6.72 ± 0.80
$\chi_{c1} \to p\bar{p}\phi$	39 ± 11	16.2	1.11 ± 0.30
$\chi_{c2} \to p\bar{p}\phi$	59 ± 12	16.5	1.69 ± 0.35

TABLE IV. The branching fractions for $\chi_{cJ} \to p\bar{p}\phi$. The errors are statistical only, and the upper limit is at the 90% C.L.

Quantity	χ_{c0}	χ_{c1}	χ_{c2}
$N_{\rm obs}$	42.4 ± 8.2	<13.3	24.4 ± 6.8
ε(%)	13.9 ± 0.1	17.7 ± 0.1	17.7 ± 0.1
$\mathcal{B}(\phi \to K^+K^-)$(%)	48.9	48.9	48.9
$\mathcal{B}(\chi_{cJ} \to p\bar{p}\phi)$ (10^{-5})	6.12 ± 1.18	<1.58	3.04 ± 0.85

Table 6: The results of fitting and branching fractions of χ_{cJ}.

Decay mode	N_{sig}	ϵ (%)	B ($\times 10^{-4}$)
$\chi_{c0} \to \Lambda(1520)\bar{\Lambda}(1520)$	273 ± 21	16.8	7.33 ± 0.56
$\chi_{c2} \to \Lambda(1520)\bar{\Lambda}(1520)$	131 ± 16	22.7	2.68 ± 0.33

TABLE III. The branching fractions for $\chi_{cJ} \to \Lambda(1520)\bar{\Lambda}(1520)$. The errors are statistical only, and the upper limit is at the 90% C.L.

Quantity	χ_{c0}	χ_{c1}	χ_{c2}
$N_{\rm obs}$	28.1 ± 9.8	<6.9	28.9 ± 7.4
ε(%)	17.1 ± 0.1	16.3 ± 0.1	12.2 ± 0.1
$\mathcal{B}(\Lambda(1520) \to pK)$(%)	22.5	22.5	22.5
$\mathcal{B}(\chi_{cJ} \to \Lambda(1520)\bar{\Lambda}(1520))$ (10^{-4})	3.18 ± 1.11	<0.86	5.05 ± 1.29

Table 4: The results of fitting and branching fractions of χ_{cJ}.

Decay mode	N_{sig}	ϵ (%)	B ($\times 10^{-4}$)
$\chi_{c0} \to pK^- \bar{\Lambda}(1520)$	210 ± 20	12.4	1.71 ± 0.16
$\chi_{c1} \to pK^- \bar{\Lambda}(1520)$	268 ± 22	16.8	1.63 ± 0.14
$\chi_{c2} \to pK^- \bar{\Lambda}(1520)$	290 ± 24	16.8	1.80 ± 0.15

Table 5: The results of fitting and branching fractions of χ_{cJ}.

Decay mode	N_{sig}	ϵ (%)	B ($\times 10^{-4}$)
$\chi_{c0} \to \Lambda(1520)\bar{p}K^+$	228 ± 21	12.6	1.83 ± 0.17
$\chi_{c1} \to \Lambda(1520)\bar{p}K^+$	207 ± 21	16.9	1.24 ± 0.13
$\chi_{c2} \to \Lambda(1520)\bar{p}K^+$	291 ± 23	16.9	1.79 ± 0.14

TABLE II. The branching fractions for $\chi_{cJ} \to \bar{p}K^+\Lambda(1520)$ + c.c., where errors are statistical only.

Quantity	χ_{c0}	χ_{c1}	χ_{c2}
N_{obs}	62 ± 12	48 ± 10	79 ± 13
ε(%)	9.0 ± 0.1	12.1 ± 0.1	12.4 ± 0.1
$\mathcal{B}(\Lambda(1520) \to pK^-)$(%)	22.5	22.5	22.5
$\mathcal{B}(\chi_{cJ} \to \bar{p}K^+\Lambda(1520)$ + c.c.) (10^{-4})	3.00 ± 0.58	1.81 ± 0.38	3.06 ± 0.50

conclusion

TABLE VII. Summary of branching fractions for 12 χ_{cJ} decay modes to $p\bar{p}K^+K^-$. The first errors are statistical, and the second ones are systematic. The upper limits are at the 90% C.L. including the systematic errors.

	χ_{c0}	χ_{c1}	χ_{c2}
$\mathcal{B}(\chi_{cJ} \to p\bar{p}K^+K^-)$ (10^{-4})	1.24 ± 0.20 ± 0.18	1.35 ± 0.15 ± 0.19	2.08 ± 0.19 ± 0.30
$\mathcal{B}(\chi_{cJ} \to \bar{p}K^+\Lambda(1520)$ + c.c.) (10^{-4})	3.00 ± 0.58 ± 0.50	1.81 ± 0.38 ± 0.28	3.06 ± 0.50 ± 0.54
$\mathcal{B}(\chi_{cJ} \to \Lambda(1520)\bar{\Lambda}(1520))$ (10^{-4})	3.18 ± 1.11 ± 0.53	<1.00	5.05 ± 1.29 ± 0.93
$\mathcal{B}(\chi_{cJ} \to p\bar{p}\phi)$ (10^{-5})	6.12 ± 1.18 ± 0.86	<1.82	3.04 ± 0.85 ± 0.43

4.2 AngSam

Author: Rong-Gang Ping
Usage:
BrFr D1 D2 AngSam Parameter;

Explanation:

This model is constructed for the two body decay $A \to B + C$ with the daughter particle A taking the angular distribution $\frac{d\Gamma}{d\cos\theta} \propto (1 + \alpha\cos^2\theta)$ with a parameter α in the laboratory frame. The α could be negative or positive real numbers.

Example:

$\psi' \to p\bar{p}$ with the angular parameter $\alpha = 0.5$:
Decay psi(2S)
1.000 p+ anti-p- AngSam 0.5;
Enddecay

Notes:

Since this model is only based on angular distribution information in the laboratory fra it is not suitable to the sequential decays. It is only for the decay $e^+e^- \to A \to B + C$.

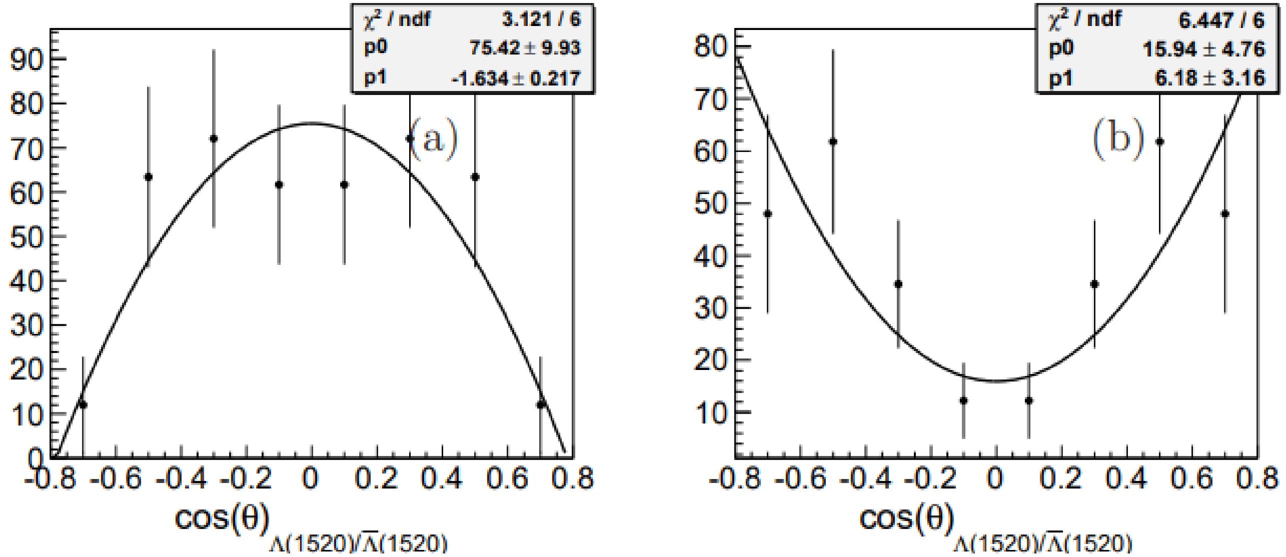


Figure 22: The $cos(\theta)$ distribution of $\Lambda(1520)/\bar{\Lambda}(1520)$ (Dots), which has been scaled with detection efficiency, is fitted by formula "$1 + \alpha \bullet cos^2(\theta)$"(line). (a) is $\chi_{c0} \to \Lambda(1520)\bar{\Lambda}(1520)$ and (b) for $\chi_{c2} \to \Lambda(1520)\bar{\Lambda}(1520)$. "p1" in the top right corner denotes the fit value of "α".

$\chi_{cJ} \to p\bar{p}\phi$

去掉veto of $\Lambda(1520)$和$\bar{\Lambda}(1520)$后（此时cut与Gengc一致）

三个衰变道去掉cut后效率整体上浮，但分支比与自己结果保持一致

χ_{c0}

	Nsig	Effiency	Br
With （memo）	167	11.5%	$(6.72 \pm 0.80) \times 10^{-5}$
without	230	15.94%	6.69×10^{-5}
GengC	42.4	13.9%	$(6.12 \pm 1.18) \times 10^{-5}$

χ_{c1}

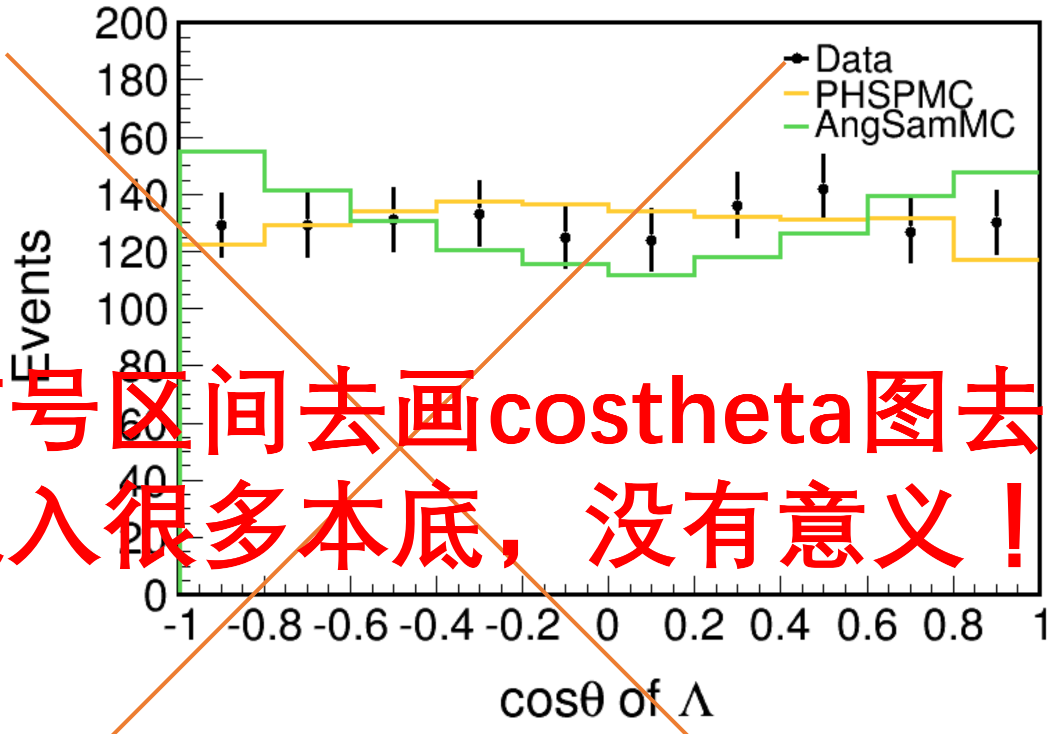
	Nsig	Effiency	Br
With （memo）		16.2%	
without		20.63	
GengC	<13.3	17.7%	

χ_{c2}

	Nsig	Effiency	Br
With （memo）	59 ± 12	16.5%	1.69 ± 0.35
without	72	20.58	1.67
GengC	24.4 ± 6.8	17.7%	3.04 ± 0.85

$\chi_{c0} \to \Lambda(1520)\bar{\Lambda}(1520)$

Boost 后的data、PHSP与AngSam的对比图



PHSP比AngSam更符合data分布

没在信号区间去画costheta图去比较，混入很多本底，没有意义！！！

目前只检查了chic0，效率和分支比变化都不大。用不同的拟合方法和产生子给出的结果差别不大。data也检查过，事例数和cut没什么问题。但是分支比就是和文章里的不一致。这个目前搞不清楚。chic2到ppphi也是这样，效率和数据都检查过了，但是分支比和文章相比就是不一致

Nsig		Npsi(2S)	Eff					
249		4.48E+08	15.09%	9.79%	22.50%	22.50%	7.43E-04	sideband信号数，PHSP产生子效率
249		4.48E+08	14.90%	9.79%	22.50%	22.50%	7.52E-04	sideband信号数，AngSam产生子效率（0912年）
57		1.07E+08	15.52%	9.79%	22.50%	22.50%	6.92E-04	sideband信号数，AngSam产生子效率（09年）
28.1		1.07E+08	17.10%	9.62%	22.50%	22.50%	3.15E-04	耿聪09年结果
273	21	4.48E+08	16.78%	9.79%	22.50%	22.50%	7.33E-04	fit结果，PHSP产生子效率（memo上写的）

Gary and Yong,

In the new version, the measurements of chi_cJ-> ppbar k+k- has excluded the contribution of intermediates, such as pk lambda(1520) and phi ppbar. We think both of two methods, the old one in 2nd version and the new one in 3rd version, are OK.

I need your comments on it --- excluding or including intermediate states? This will determine how I draft the paper. What's your point?

Chic2->lamlamb的第一级衰变也用的AngSam，说是因为boss版本的问题！！

****

The updating includes:

0) The analysis is based on BOSS6.5.1-p02

1) All of measurements has excluded the intermediate states, such as measurement of chi_cJ->pk Lambda(1520) exclude chi_cJ-> Lambda(1520) Lambda(1520)bar and meansurements of chi_cJ-> ppbar k+k- exclude pk lambda(1520) and phi ppbar

2) The comments about cut chi^2 of kinematic fitting on 50 has been added.

3) According to Ronggang's suggestion, values of branching fractions of chi_cJ and phi->KK has been updated to 2010, which come from PDG website.

4) According to Ronggang's suggestions, model "AngSam" is used to produce MC for psi(2S)->gamma chi_c2 instead of model "P2GC2".

5) Model "AngSam3" is adopted to estimate uncertainty of generator for 3-body decay in chi_cJ, which generate MC with angular distribution.

6) Uncertainties of mass window of chi_cJ , phi and Lambda(1520) are added.

7) 2% is quoted as uncertainty of Tracking efficiency and 4% quoted as uncertainty of total number of psi(2S), as suggested.

8) Input-Output check and Cross check are added in the Appendix E.

9) Simultaneous fitting is adopted in the measurement of chi_cJ->Lambda(1520) Lambda(1520)bar.

Attachment:
http://hnbes3.ihep.ac.cn/HyperNews/get/AUX/2010/09/28/23.04-55110-ree_answer_2_memo_3rd.pdf

Inline Depth: 1 All Outline Depth: 1 2 All Add message:

$\chi_{c2} \to \Lambda(1520)\bar{\Lambda}(1520)$

```
Decay psi(2S)
1.0000   gamma chi_c2                  AngSam 1.0 0.0769;
Enddecay

Decay chi_c2
1.0000   Lambda(1520)0 anti-Lambda(1520)0    AngSam 1.0 0.388;
Enddecay

Decay anti-Lambda(1520)0
1.0000   anti-p-    K+                    PHSP;
Enddecay

Decay Lambda(1520)0
1.0000   p+     K-                        PHSP;
Enddecay

End
~
~
```

$\chi_{c0} \to \Lambda(1520)\bar{\Lambda}(1520)$

```
Decay psi(2S)
1.0000   gamma chi_c0                     P2GC0;
Enddecay

Decay chi_c0
1.0000   Lambda(1520)0 anti-Lambda(1520)0   AngSam 1.0 -0.0217;
Enddecay

Decay anti-Lambda(1520)0
1.0000   anti-p-    K+                    PHSP;
Enddecay

Decay Lambda(1520)0
1.0000   p+     K-                        PHSP;
Enddecay

End
~
```

$\chi_{c2} \to p\bar{p}\phi$

```
Decay psi(2S)
1.0000   gamma chi_c2                  AngSam 1.0 0.0769;
Enddecay

Decay chi_c2
1.0000   p+ anti-p- phi                PHSP;
Enddecay

Decay phi
1.0000   K+   K-                       VSS;
Enddecay
```

$\chi_{c0} \to \Lambda(1520)\bar{\Lambda}(1520)$			
09AngSam/092dfit/Mycut	68	18.13%	7.07×10^{-4}
09AngSam/09sideband/Mycut	57	16.47%	6.53×10^{-4}
0912PHSP/0912sideband/cut与Gengc相同	260	15.38%	7.61×10^{-4}
09AngSam/09sideband/cut与Gengc相同	68	16.8%	7.63×10^{-4}
09PHSP/09sideband/Mycut	57	16.4%	6.55×10^{-4}
09PHSP/09sideband/cut与Gengc相同	68	16.7%	7.68×10^{-4}
0912PHSP/09122dfit/Mycut	273 ± 21	16.8%	7.33 ± 0.56
09PHSP/092dfit/Mycut	68	18.3%	7.00×10^{-4}
Gengc	28.1 ± 9.8	17.1 ± 0.1	$(3.18 \pm 1.11) \times 10^{-4}$

1. 比较09年AngSam和Gengc的结果发现，chic0->lamlamb是效率相同，但信号事例数09年的AngSam是Gengc的两倍多，chic2->lamlamb的09年的AngSam是他的两倍多，但信号事例数是Gengc的1.5倍，没到两倍。
2. 年份和产生子没有影响。

效率

	0912PHSP	09PHSP	09AngSam
Sideband (1.47,1.57)(Mycut)	15.1%	16.41%	16.47%
Sideband(1.47,1.57)(Gengc)	15.38%	16.75%	16.80%

	0912PHSP	09PHSP	09AngSam
Fit range cut(1.47,1.77)(Mycut)	16.78%	18.32	18.13

信号事例数

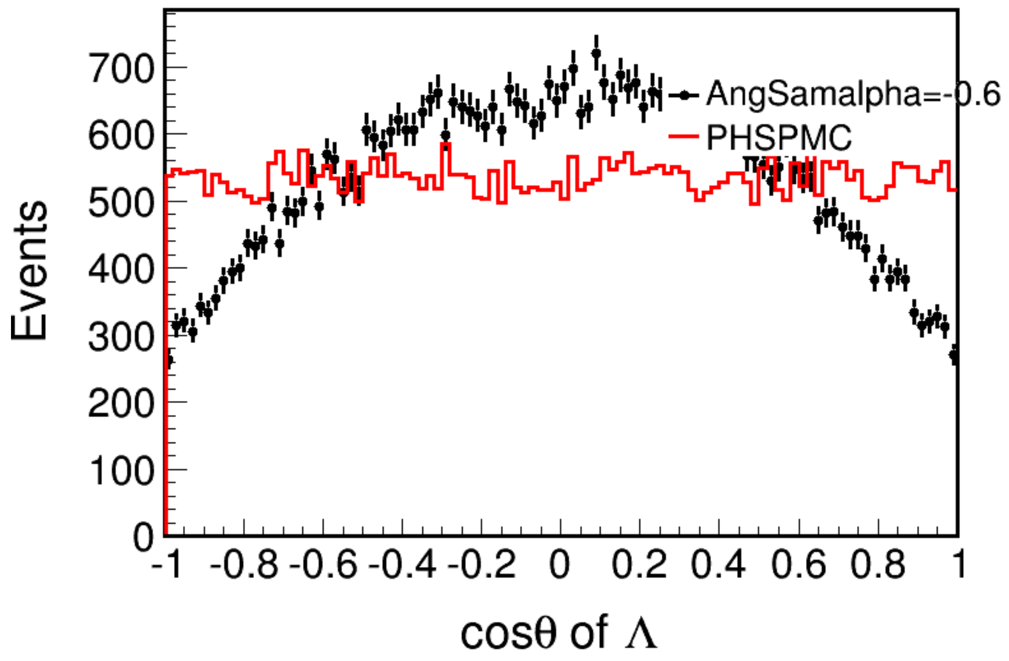
效率和信号事例数分别用sideband和2dfit方法得到的时候，由于使用的cut条件不同会有差别！

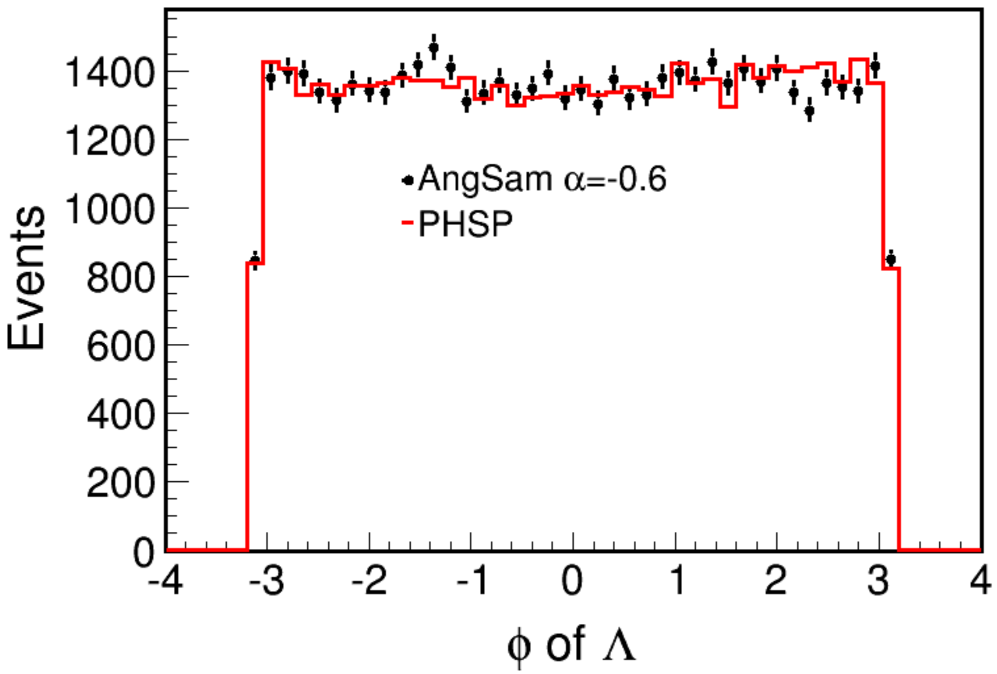
	0912data	09data
Sideband(1.47,1.57)(Mycut)	249	57
Sideband(1.47,1.57)(Gengc)	260	68

	0912data	09data
2dfit	273 ± 21	68

Mctruth级别下AngSam和PHSP在boost和rotate后的$cos\theta$和ϕ of $\Lambda(1520)$

对Mctruth的操作画costheta和phi不需要指定要在信号区间内，data和MC是必须需要的！





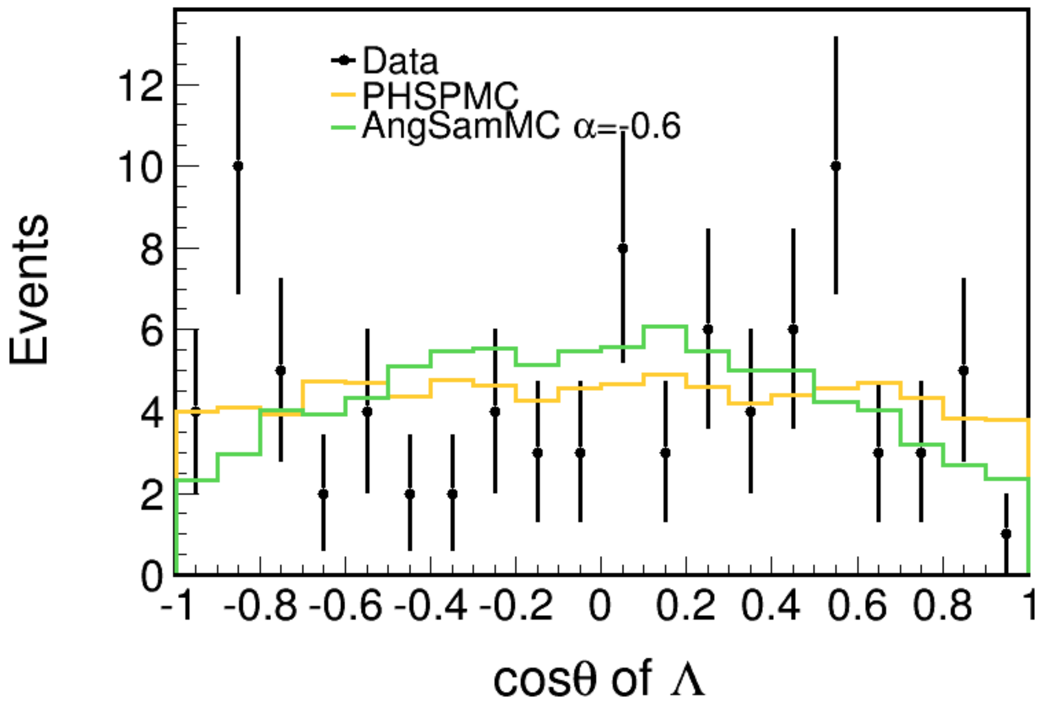
AngSam效率=18.314%

PHSP效率=18.3%

用的fit的cut

重建后的（h4）boost和rotate后的data、PHSP和AngSam在Λ(1520)的信号区内的cosθ（09年10700*5sample）

if(mPkm>1.57||mPkm<1.47) continue;
if(mPbarkp>1.57||mPbarkp<1.47) continue;

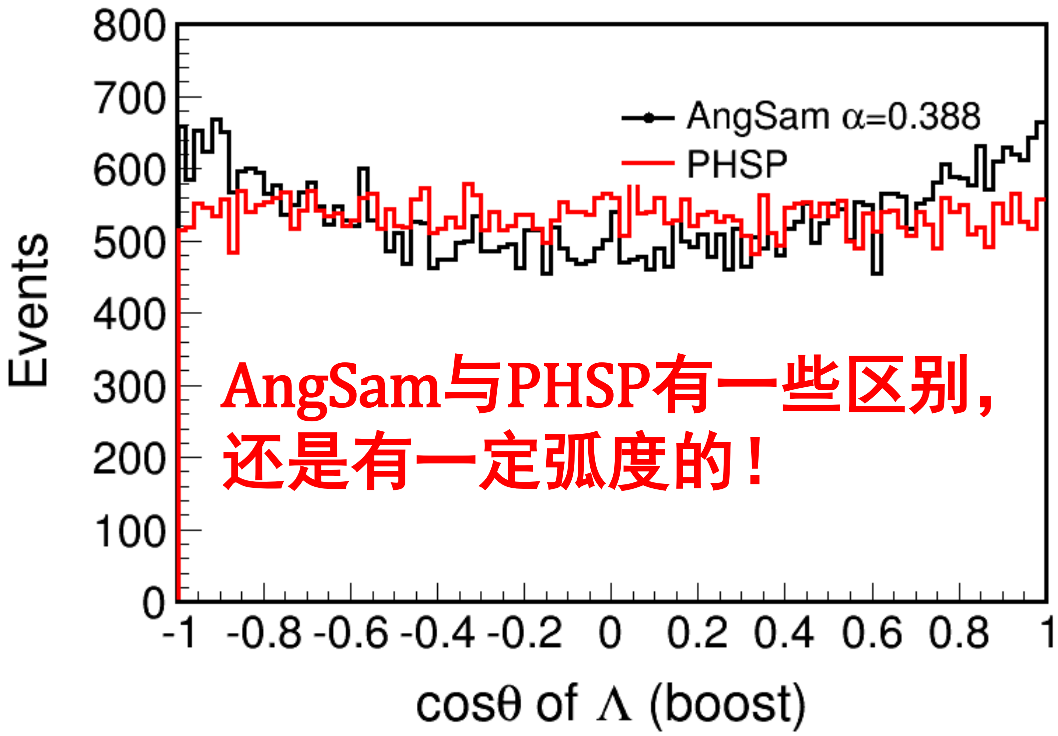


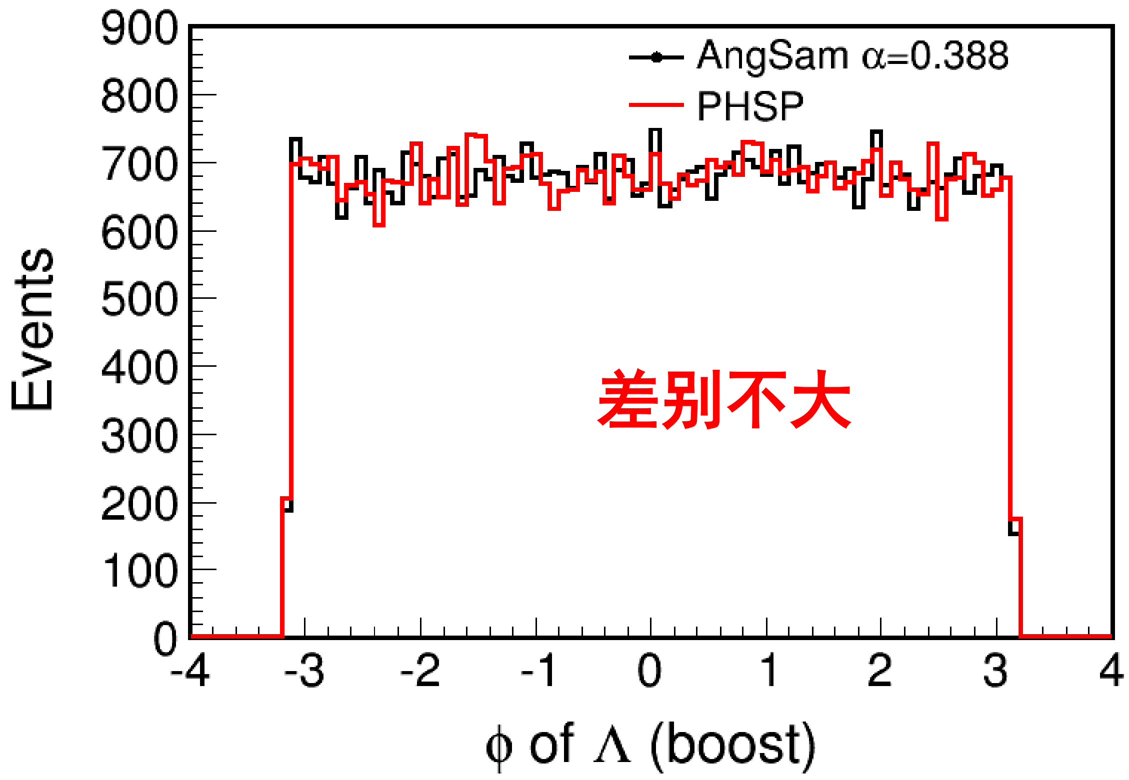
$\chi_{c2} \to \Lambda(1520)\overline{\Lambda}(1520)$	Nsig	effi	Br
09AngSam0.388（2dfit）	44	24.0%	3.55×10^{-4}
09AngSam0.388（Sideband）	57	21.64%	5.11×10^{-4}
09AngSam0.388(精确的sideband)	39	21.64%	3.49×10^{-4}
09PHSP(2dfit)	44	23.83%	3.58×10^{-4}
09PHSP(sideband)	57	21.42%	5.16×10^{-4}
PHSP(0912)(2dfitmemo)	131 ± 16	22.7	2.68 ± 0.33
Gengc	28.9 ± 7.4	12.2 ± 0.1	5.05 ± 1.29

	0912PHSP	09PHSP	09AngSam
Sideband (1.47,1.57)(Mycut)		21.42%	21.64%
Sideband(1.47,1.57)(Gengc)			

	0912PHSP	09PHSP	09AngSam
Fit range cut(1.47,1.77)(Mycut)		23.83%	24.0%

Mctruth级别下AngSam和PHSP在boost和rotate后的$cos\theta$和ϕ of $\Lambda(1520)$（09年10700*5sample）

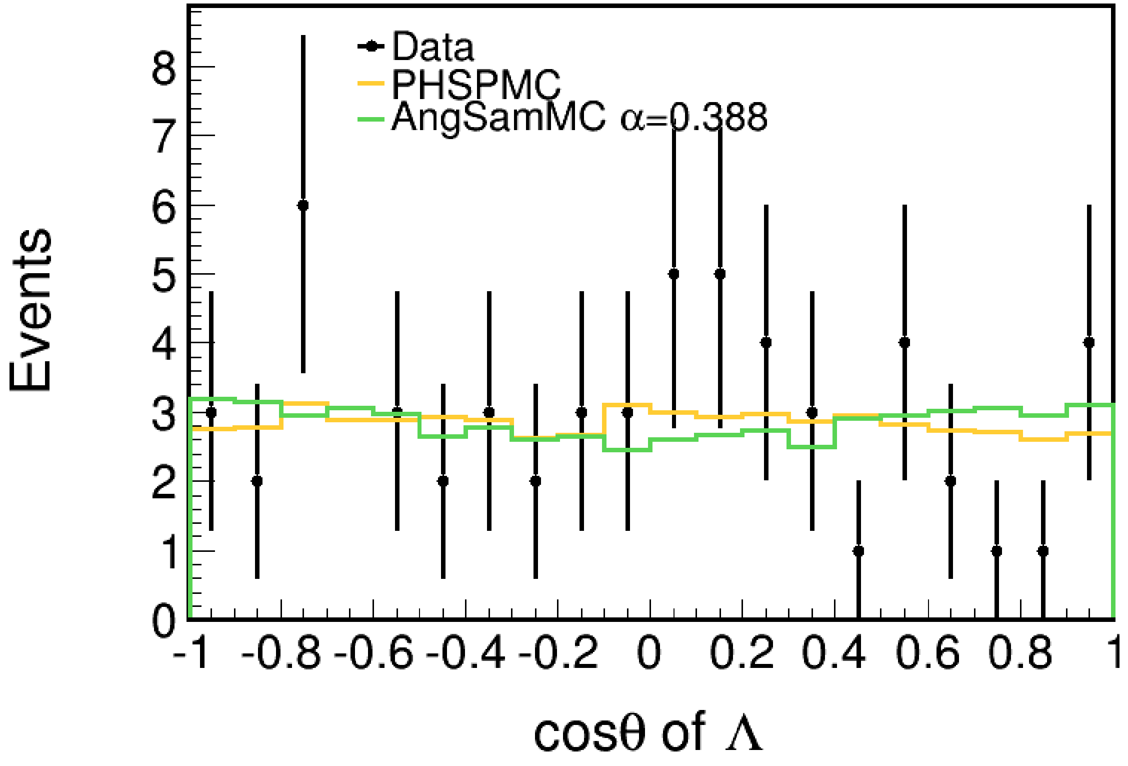




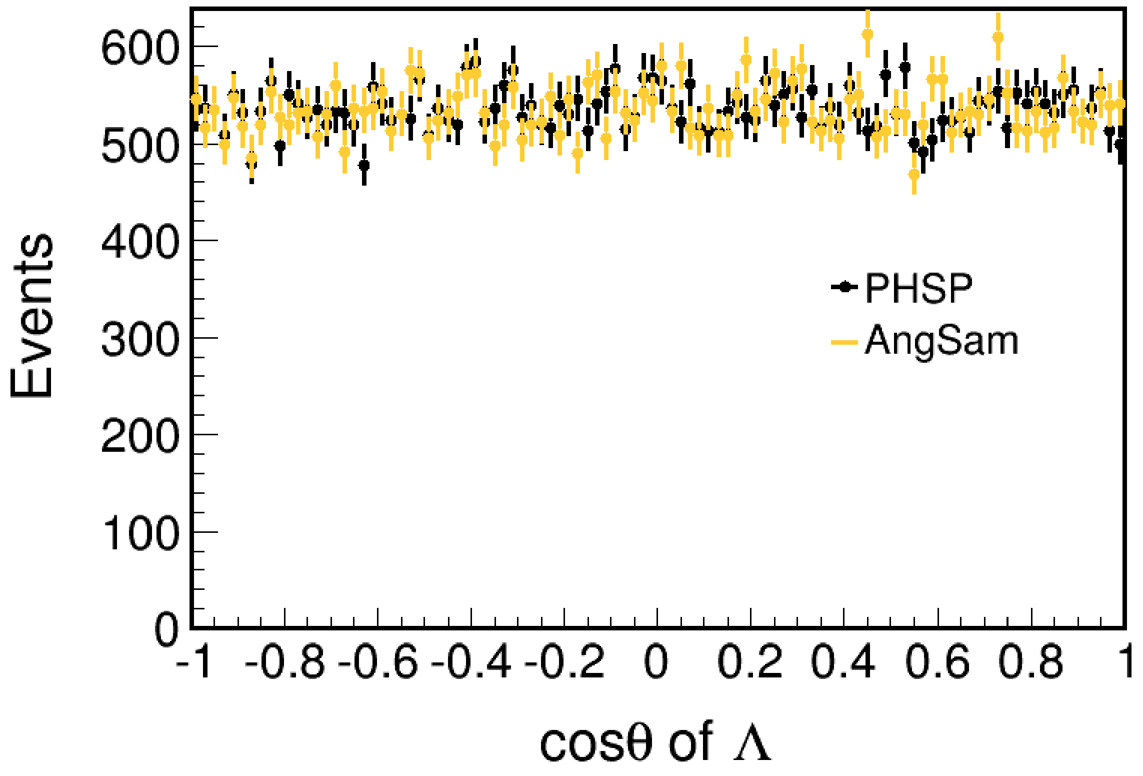
AngSam效率=24.0%
PHSP效率=23.83%
用的fit的范围

重建后的（h4）boost和rotate后的data、PHSP和AngSam在Λ(1520)的信号区内的cosθ（09年10700*5sample）

if(mPkm>1.57||mPkm<1.47) continue;
if(mPbarkp>1.57||mPbarkp<1.47) continue;



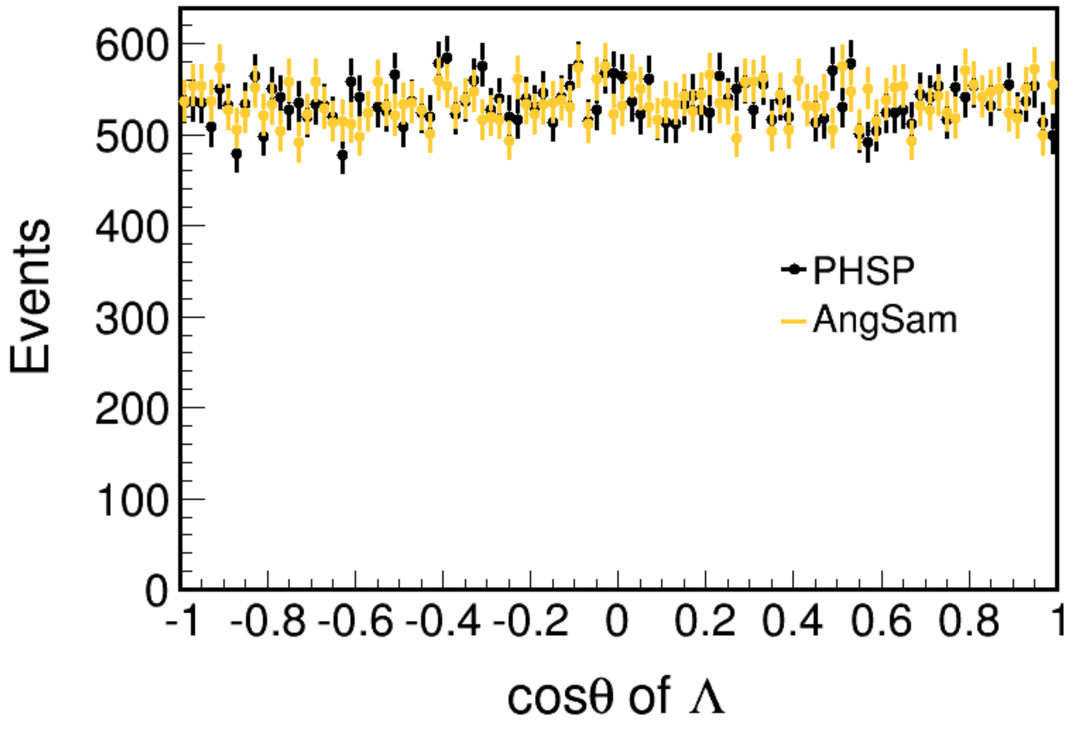
AngSam $\alpha = -0.388$ Mctruth角分布对比（no boost）



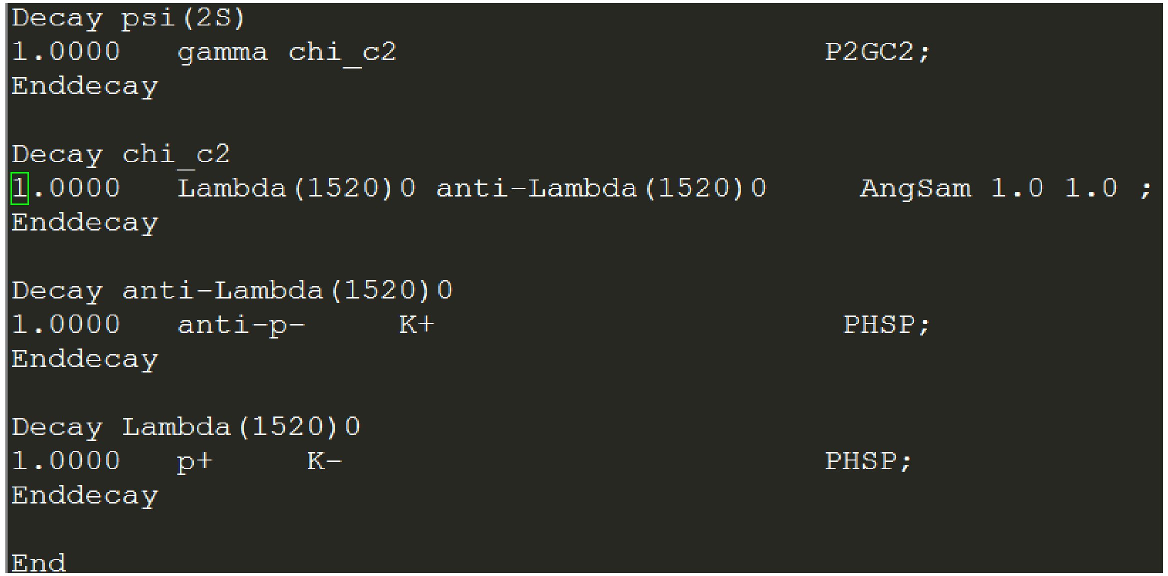
$\alpha = -0.388$

```
Decay psi(2S)
1.0000    gamma chi_c2                         P2GC2;
Enddecay

Decay chi_c2
1.0000    Lambda(1520)0 anti-Lambda(1520)0      AngSam 1.0 -0.388 ;
Enddecay

Decay anti-Lambda(1520)0
1.0000    anti-p-     K+                        PHSP;
Enddecay

Decay Lambda(1520)0
1.0000    p+      K-                           PHSP;
Enddecay

End
```

AngSam $\alpha = 1.0$ Mctruth角分布对比（no boost）

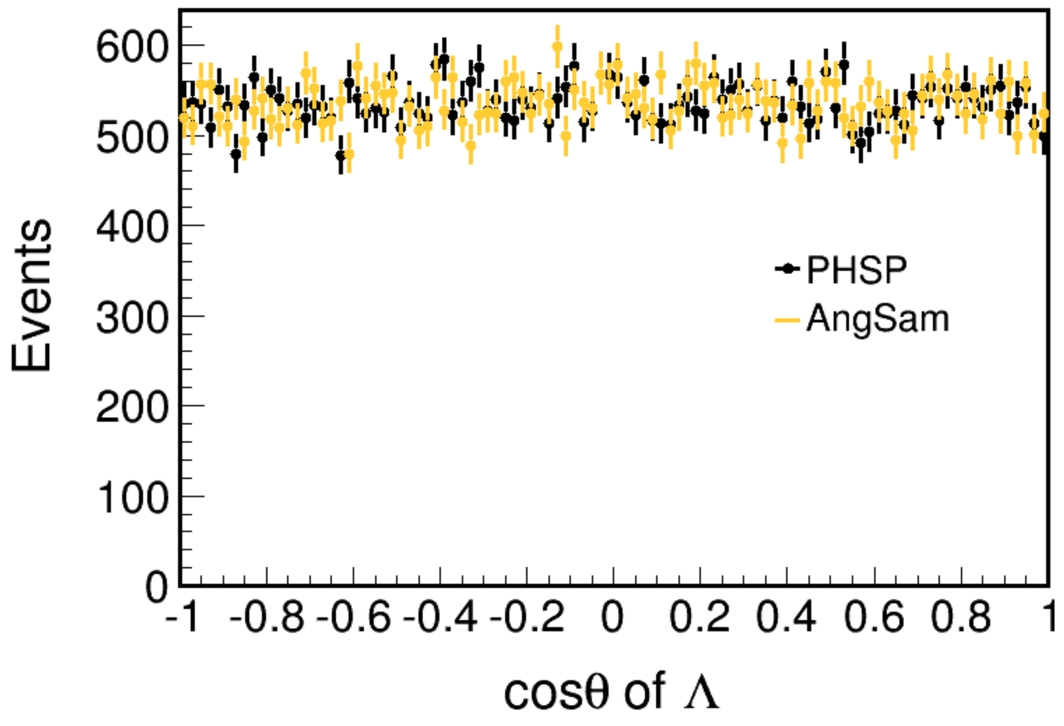


$\alpha = 1.0$



```
Decay psi(2S)
1.0000    gamma chi_c2                          P2GC2;
Enddecay

Decay chi_c2
1.0000    Lambda(1520)0 anti-Lambda(1520)0     AngSam 1.0 1.0 ;
Enddecay

Decay anti-Lambda(1520)0
1.0000    anti-p-     K+                        PHSP;
Enddecay

Decay Lambda(1520)0
1.0000    p+      K-                            PHSP;
Enddecay

End
```

AngSam $\alpha = -1.0$ Mctruth角分布对比（no boost）

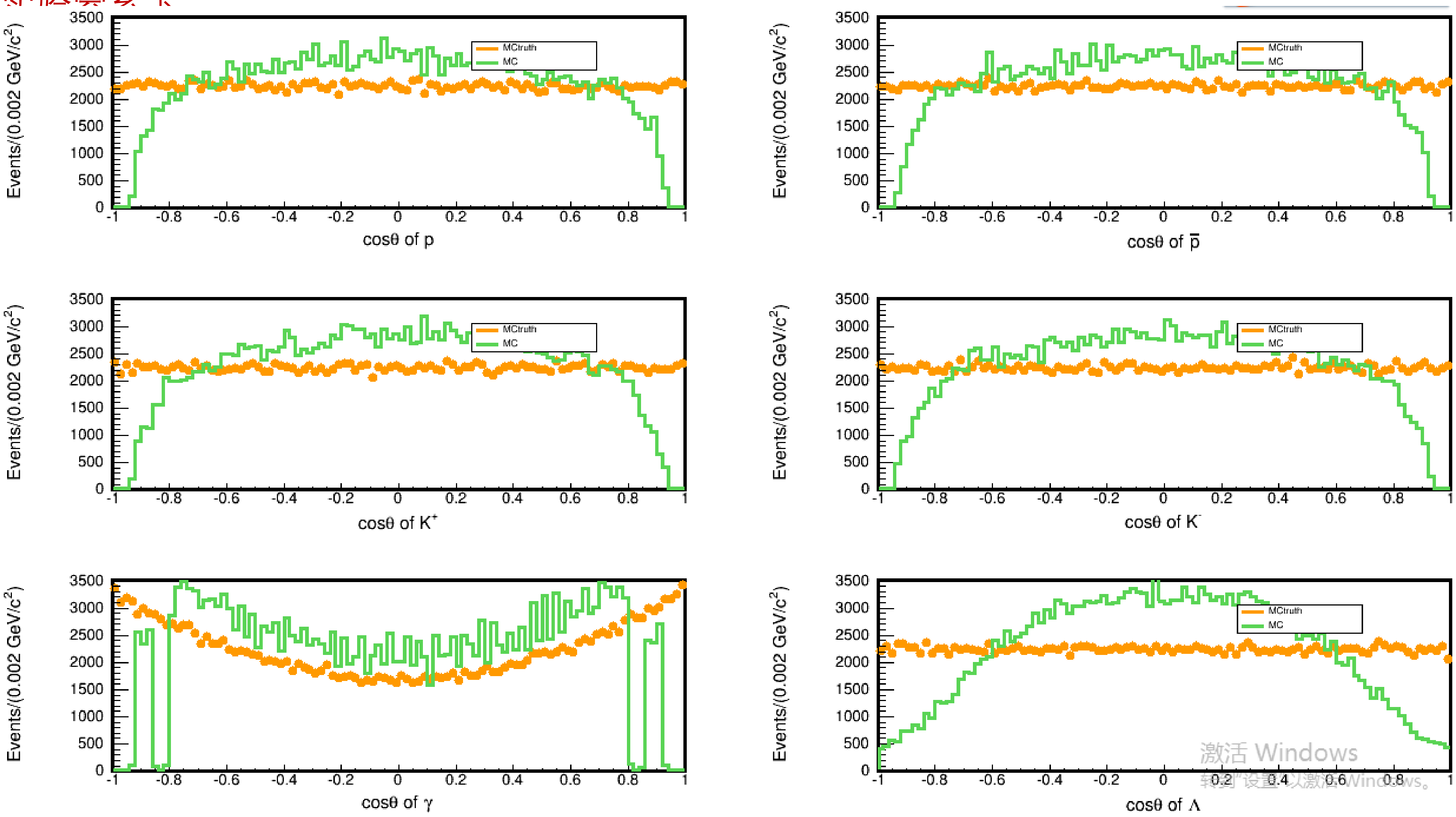


$\alpha = -1.0$

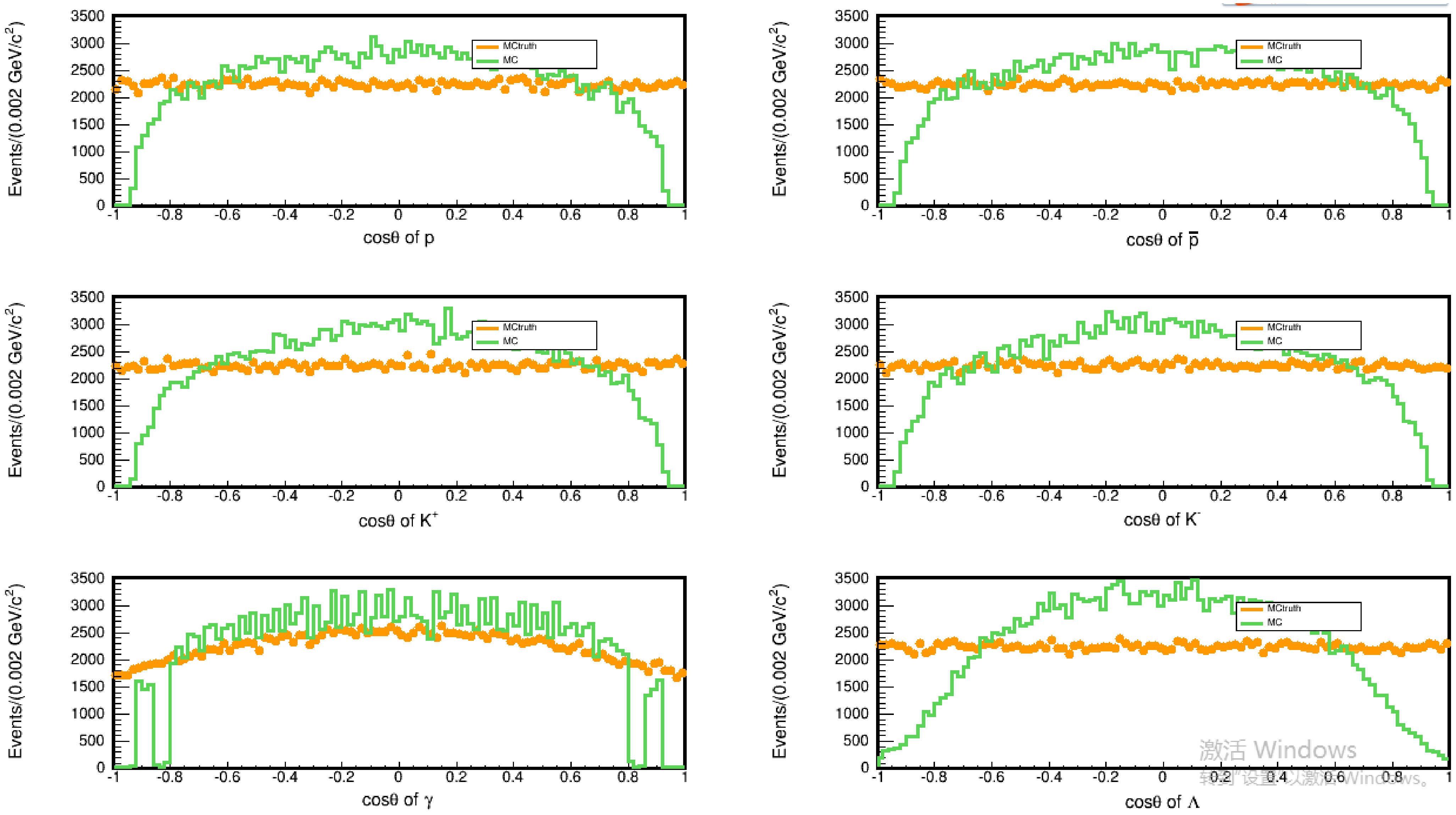
```
Decay psi(2S)
1.0000    gamma chi_c2                              P2GC2;
Enddecay

Decay chi_c2
1.0000    Lambda(1520)0 anti-Lambda(1520)0     AngSam 1.0 -1.0 ;
Enddecay

Decay anti-Lambda(1520)0
1.0000    anti-p-     K+                            PHSP;
Enddecay

Decay Lambda(1520)0
1.0000    p+      K-                                PHSP;
Enddecay

End
```

关于cosθ的Mctruth和MC的对比图（PHSP）

χ_{c0} no boost 实验室系下



χ_{c1} no boost 实验室系下



χ_{c2} no boost 实验室系下