Augular distribution of $\Psi(2S) \to \Omega^+\Omega^-$

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Outline

- Formalism for $\Omega^+ \Omega^-$ production
- Introduction
- Data sets
- Event selection
- Tracking and pid efficiency correction
- Fitting result
- systematic uncertainty
- Summary and next to do

Spin density matrix for e+e- -> Ω-Ω+

$$\rho^{\lambda_1\lambda_2,\lambda_{1'}\lambda_{2'}}_{3/2,\overline{3/2}} = \sum_{\kappa=\pm1} D^{1*}_{\kappa,\lambda_1-\lambda_2}(0,\theta_\Omega,0) D^{1}_{\kappa,\lambda_{1'}-\lambda_{2'}}(0,\theta_\Omega,0) A_{\lambda_1\lambda_2} A^{*}_{\lambda_{1'}\lambda_{2'}}$$

(Complex) Form Factors

$$\mathbf{h}_k \to h_k \exp(i\phi_k)$$

$$A = \begin{pmatrix} \mathbf{h}_4 & \mathbf{h}_3 & 0 & 0 \\ \mathbf{h}_3 & \mathbf{h}_1 & \mathbf{h}_2 & 0 \\ 0 & \mathbf{h}_2 & \mathbf{h}_1 & \mathbf{h}_3 \\ 0 & 0 & \mathbf{h}_3 & \mathbf{h}_4 \end{pmatrix}$$

h4=$A_{\frac{-3}{2},\frac{-3}{2}}=A_{\frac{3}{2},\frac{3}{2}}$

h3=$A_{\frac{-1}{2},\frac{-3}{2}}=A_{\frac{1}{2},\frac{3}{2}}=A_{\frac{-3}{2},\frac{-1}{2}}=A_{\frac{3}{2},\frac{1}{2}}$

h2=$A_{\frac{1}{2},\frac{-1}{2}}=A_{\frac{-1}{2},\frac{1}{2}}$

h1=$A_{\frac{1}{2},\frac{1}{2}}=A_{\frac{-1}{2},\frac{-1}{2}}$

Using base 3/2 spin matrices it could be written as

$$\rho_{3/2,\overline{3/2}} = \sum_{\mu=0}^{15}\sum_{\bar{\nu}=0}^{15} C_{\mu,\bar{\nu}}\, Q_\mu \otimes Q_{\bar{\nu}}$$

Single 3/2 spin baryon density matrix is: $\rho_{3/2} = \sum_{\mu=0}^{15} r_\mu Q_\mu = \sum_{\mu=0}^{15} C_{\mu,0} Q_\mu$

Uppsala: G.Fäldt, AK, S. Leupold, E. Perotti

Single tag angular distribution

Single 3/2-spin baryon density matrix is

$$\rho_{3/2} = \sum_{\mu=0}^{15} r_\mu Q_\mu = \sum_{\mu=0}^{15} C_{\mu,0} Q_\mu$$

Angular distribution (using decay matrices in helicity frames):

$$W = \sum_{\mu=0}^{15}\sum_{\kappa=0}^{3} C_{\mu,0}\, b^{\Omega}_{\mu,\kappa}\, a^{\Lambda}_{\kappa,0}$$

decay 3/2->1/2 0 (Ω->ΛK)

decay 1/2->1/2 0 (Λ->pπ)

$$r_0 = (1+\cos^2\theta_\Omega)(h_2^2 + 2h_3^2) + 2\sin^2\theta_\Omega(h_1^2 + h_4^2)$$

$$r_1 = 2\sin 2\theta_\Omega \frac{2\Im(\mathbf{h}_1\mathbf{h}_2^*) + \sqrt{3}\Im(\mathbf{h}_3^*(\mathbf{h}_1 + \mathbf{h}_4))}{\sqrt{30}}$$

$$r_6 = -\frac{2\sin^2\theta_\Omega(h_1^2 - h_4^2) + h_2^2(\cos^2\theta + 1)}{\sqrt{3}}$$

$$r_7 = \sqrt{2}\sin 2\theta_\Omega \frac{\Re(\mathbf{h}_3^*(\mathbf{h}_4 - \mathbf{h}_1))}{\sqrt{3}}$$

$$r_8 = 2\sin^2\theta_\Omega \frac{\Re(\mathbf{h}_3\mathbf{h}_2^*)}{\sqrt{3}}$$

$$r_{10} = 2\sin^2\theta_\Omega \frac{\Im(\mathbf{h}_3\mathbf{h}_2^*)}{\sqrt{3}}$$

$$r_{11} = 2\sin 2\theta_\Omega \frac{\Im(\sqrt{3}\mathbf{h}_2\mathbf{h}_1^* + \mathbf{h}_3^*(\mathbf{h}_1 + \mathbf{h}_4))}{\sqrt{15}}$$

$$\frac{d\Gamma}{d\cos\theta_\Omega} = 1 + \alpha_\psi \cos^2\theta_\Omega$$

$$\alpha_\psi = \frac{h_2^2 - 2(h_1^2 - h_3^2 + h_4^2)}{h_2^2 + 2(h_1^2 + h_3^2 + h_4^2)}$$

We set h_2=1 and phi_2=0

Inclusive of e+e- -> Ω-Ω+

$$\rho_{3/2} = \sum_{\mu=0}^{15} r_\mu Q_\mu \qquad \rho_\Omega = \sum_{\mu=0}^{15} r_\mu(\theta_\Omega; h_1, h_2, h_3, h_4) Q_\mu$$

$$\frac{3}{2}^+ \to \frac{1}{2}^+ + 0^- \qquad \Omega^- \to \Lambda + K^-$$

$$Q_\mu \to \sum_{\nu=0}^{3} b_{\mu,\nu} \sigma_\nu^d$$

$$\rho_\Lambda = \sum_{\mu=0}^{15} \sum_{\kappa=0}^{3} r_\mu \cdot b_{\mu,\kappa}^{\Omega}(\theta_\Lambda, \phi_\Lambda; \alpha_\Omega, \beta_\Omega, \gamma_\Omega) \sigma_\kappa^\Lambda$$

$\Upsilon_\Omega = \cos(\phi_\Omega)\sqrt{(1-\alpha_\Omega)^2}$

$\beta_\Omega = \sin(\phi_\Omega)\sqrt{(1-\alpha_\Omega)^2}$

$\alpha_{\Omega^2} + \beta_{\Omega^2} + \Upsilon_{\Omega^2} = 1$

$$\frac{1}{2}^+ \to \frac{1}{2}^+ + 0^- \qquad \Lambda \to p + \pi^-$$

$$\sigma_\mu \to \sum_{\nu=0}^{3} a_{\mu,\nu} \sigma_\nu^d$$

$$\rho_p = \sum_{\mu=0}^{15} \sum_{\kappa,\nu=0}^{3} r_\mu \cdot b_{\mu,\kappa}^{\Omega} \cdot a_{\kappa,\nu}^{\Lambda}(\theta_p, \phi_p; \alpha_\Lambda, \beta_\Lambda, \gamma_\Lambda) \sigma_\nu^p$$

$$Tr\rho_p \rightarrow \frac{d\Gamma}{d\xi} = \sum_{\mu=0}^{15} \sum_{\kappa=0}^{3} r_\mu b_{\mu,\kappa}^{\Omega} a_{\kappa,0}^{\Lambda}$$

Polarization of a spin 3/2 partice

Vector polarization:

$$r^1_{-1} \to P_y \quad r^1_0 \to P_x \quad r^1_1 \to P_z$$

$$\rho_{3/2} = r_0 \left(Q_0 + \frac{3}{4} \sum_{M=-1}^{1} r^1_M Q^1_M + \frac{3}{4} \sum_{M=-2}^{2} r^2_M Q^2_M + \frac{3}{4} \sum_{M=-3}^{3} r^3_M Q^3_M \right)$$

$$0 \le L \le 3, -L \le \mathrm{M} \le \mathrm{L}$$

$$Q^L{}_{\mathrm{M}}$$

$$\mathrm{L} = 0, \mathrm{M} = 0, \mathrm{Q}^0_0;$$

$$\mathrm{L} = 1, \mathrm{M} = -1, 0, 1, \mathrm{Q}^0_{-1}, \mathrm{Q}^0_0, \mathrm{Q}^0_1;$$

$$\mathrm{L} = 2, \mathrm{M} = -2, -1, 0, 1, 2, \mathrm{Q}^2_{-2}\mathrm{Q}^2_{-1}, \mathrm{Q}^2_0, \mathrm{Q}^2_1, \mathrm{Q}^2_2;$$

$$\mathrm{L} = 3, \mathrm{M} = -3, -2, -1, 0, 1, 2, 3, \mathrm{Q}^3_{-3}\mathrm{Q}^3_{-2}, \mathrm{Q}^3_{-1}, \mathrm{Q}^3_0\mathrm{Q}^3_1, \mathrm{Q}^3_2, \mathrm{Q}^3_3;$$

Degree of polarization

$$d(\rho_{3/2}) = \sqrt{\sum_{L=1}^{3} \sum_{M=-L}^{L} \left(r^L_M\right)^2}$$

Introduction

Considering the chain decay process, we use the helicity amplitude information to:

- Study the angular distribution of $\Omega^+\Omega^-$ in $\Psi(2S)\to\Omega^+\Omega^-$ decay process,

- Measure the branching ratio of $\Psi(2S)\to\Omega^+\Omega^-$ with a better precision,

- Search for Ω polarization

- Use new generator to measure the cross section of $e^+e^-\to\Omega^+\Omega^-$.

Introduction

Decay chains : $\psi(2S) \rightarrow \Omega^- \bar{\Omega}^+$

$\Omega^- \to K^- \Lambda \quad \bar{\Omega}^+ \to K^+ \bar{\Lambda} \qquad \Lambda(\bar{\Lambda}) \to \pi^- p (\pi^+ \bar{p})$

Analysis method:

signal tag analysis: reconstruct only one Ω via $\Omega \rightarrow K\Lambda$, and the number of signal events is obtained by fitting the invariant mass of $K\Lambda$ requiring the recoiling mass of $K\Lambda$ to be in the Ω signal region.

Data sets:

Experimental data: 106.8M(2009) + 341.1M(2012) $\psi(2S)$ data

MC Signal: 0.2M(2012) + 0.06M(2009) generated with KKMC and all the samples are generated in PHSP

Boss version: 6.6.4.p03

Event selection

- $|\cos\theta| < 0.93$;

 Charged particles are identified using only dE/dx information

- Proton and anti-proton: Prob(p) > Prob(π) && Prob(p) > Prob(K) ,
- Kaons: Prob(K) > Prob(π) && Prob(K) > Prob(p) ,
- The remaining charged particles are assumed to be pions

● Λ Reconstruction via $\Lambda \to p\pi$: loop over the pπ combination to reconstruct Λ, a pπ pair should pass the first vertex fit ,and we keep the one with pπ invariant mass closest to Λ mass,

● Ω Reconstruction via $\Omega \to K\Lambda$: loop over the KΛ combinations to reconstruct Ω, a KΛ pair should pass the first and secondary vertex fit , and wee keep the one with least secondary vertex fit chi square.

Requirements of single tag analysis

- At least three good charged tracks are identified as K- p π-(K- p π-), and ngood < 8 .

- p_t (k) >0.1GeV, p_t (p) >0.2GeV, p_t (π) >0.05GeV.

- 1.122GeV> Λ_{mass} >1.110GeV.

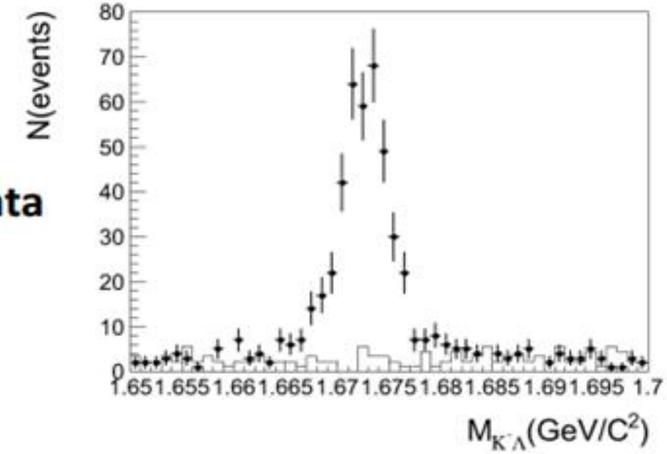
- 1.640GeV> $\Omega_{recoilmass}$ >1.692GeV.

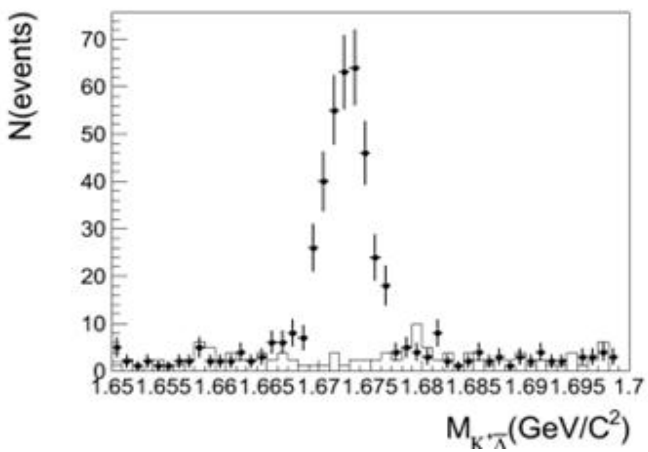
- 1.681GeV> Ω_{mass} >1.663GeV,sideband regions(1.644 1.653)GeV and(1.692 1.701)GeV

Background estimation

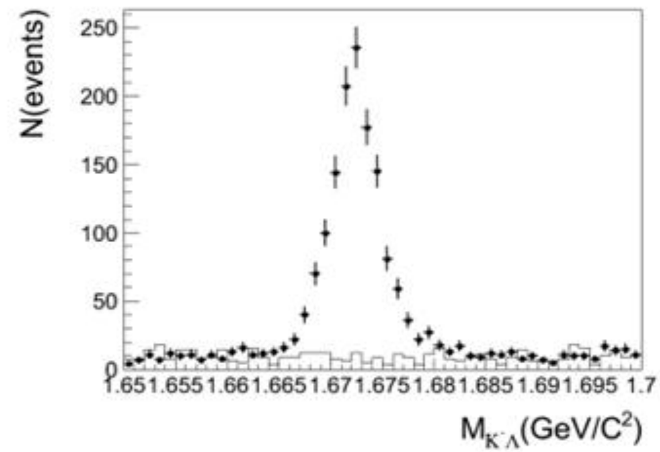
The invariant mass of KΛ (dots with error bars) in data after all the cuts and the invariant mass of KΛ(histogram) in Ω_{recoil} sideband region

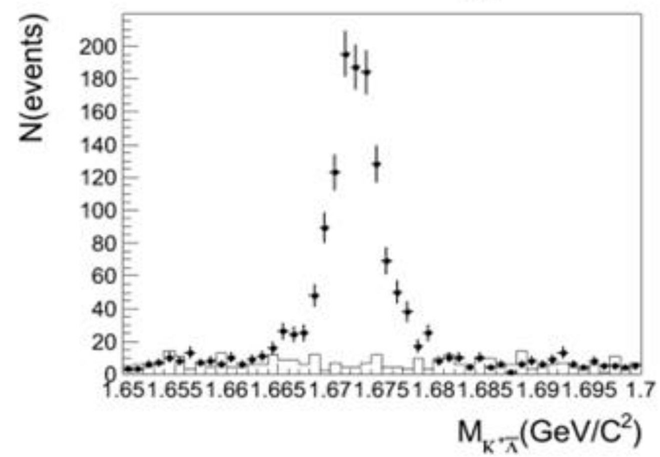
09 data





12 data





No peaking background

efficiency correction

- We use 0.2M ('12) and 0.06M ('09) MC samples after event selection, the samples are generated by KKMC and PHSP.

- The control samples are : J/ψ -> p p π π (p π), J/ψ -> p K Λ (slow k),J/ψ-> Ks K π(higer K)

Define :$r\varepsilon = \frac{\varepsilon_{pdata}}{\varepsilon_{pmc}} * \frac{\varepsilon_{\pi data}}{\varepsilon\pi_{pmc}} * \frac{\varepsilon_{Kdata}}{\varepsilon K_{pmc}}$ and a random variable： ζ(0 1);

- We consider three cases:

a: if rε<1:

rε< ζ， throw away；

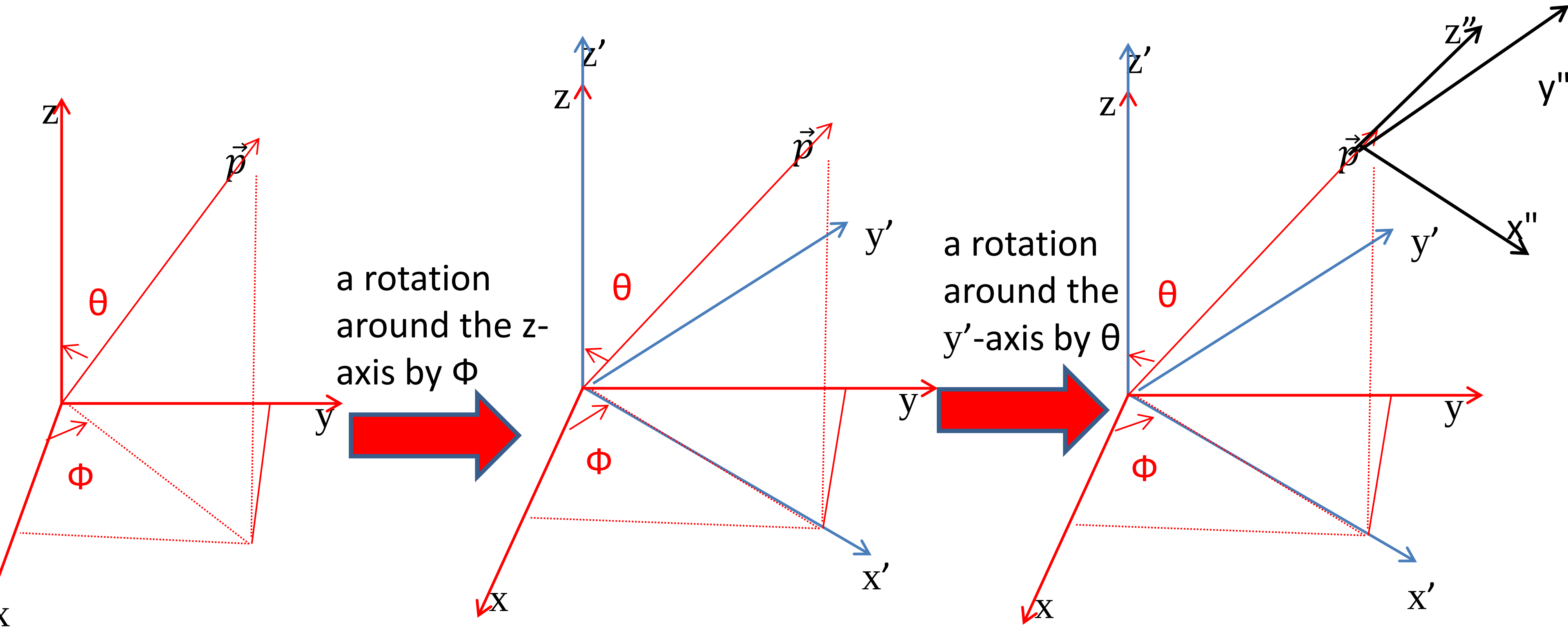
rε> ζ， keep；

b: if: rε>1: keep；

rε-1> ζ， add another one

c: rε=1: keep

Helicity Coordinate System



The rotation matrix:

$$
\begin{matrix}
cos\theta cos\phi & cos\theta sin\phi & -sin\theta \\
-sin\phi & cos\phi & 0 \\
cos\theta sin\phi & sin\theta sin\phi & cos\theta
\end{matrix}
$$

Fitting method

- The joint angular distribution can be written as :
  $W(\theta_\Omega,\theta_\Lambda,\varphi_\Lambda, \theta_p,\varphi_p; \mathbf{h_1}, \mathbf{h_2}, \mathbf{h_3},\mathbf{h_4},\alpha_\Omega, \Phi_\Omega)$
- To determine ten parameters: $\mathbf{A}=(\mathbf{h_i}=h_i \exp(i\Phi_i),\alpha_\Omega,\Phi_\Omega)$, we use the Maximum likelihood method to fit.
- Get the normalization factor using reconstructed phsp MC:

$$\bar{w}(A) = \sum_{j=1}^{j=N_{MC}} \frac{W(\theta_\Omega^j,\theta_\Lambda^j,\varphi_\Lambda^j, \theta_p^j,\varphi_p^j; \mathbf{A})}{N}$$

N_{MC} is the number of the MC events

- The normalized pdf is:

$$f(\theta_\Omega^j,\theta_\Lambda^j,\varphi_\Lambda^j, \theta_p^j,\varphi_p^j; \mathbf{A}) = \frac{W(\theta_\Omega^j,\theta_\Lambda^j,\varphi_\Lambda^j, \theta_p^j,\varphi_p^j; \mathbf{A})}{\bar{w}(A)}$$

- The logarithm of the likelihood is :lnLS=lnL-lnLb, where:

$L=\prod_{j=1}^{N} f(\theta_\Omega^j,\theta_\Lambda^j,\varphi_\Lambda^j, \theta_p^j,\varphi_p^j; \mathbf{A})$, N is the number of data events

$Lb=\prod_{j=1}^{nb} f(\theta_\Omega^j,\theta_\Lambda^j,\varphi_\Lambda^j, \theta_p^j,\varphi_p^j; \mathbf{A})$,nb is the background from sideband

- By minimizing the –lnLS, the parameters are obtained.

Preliminary fitting results ('12+ '09 data)

- The fit includes h1,φ1, h2,φ2, h3,φ3, h4=0,φ4=0 , and put h2=1, φ2=0
- Use the α_Λ α_Ω value from the PDG(Physics Letters B 617 (2005) 11–17 , PHYSICAL REVIEW D **71,** 051102(R) (2005), PRL **96,** 242001 (2006)) and the preliminary BES3 α_Λ value(BAM-00116) from to fit Φ_Ω:

αΩ=0.01538+/-0.00172 αΩbar=-0.01538+/-0.00172
α_Λ=0.753+/-0.00729 $\alpha_{\Lambda bar}$=-0.753+/-0.00729

Likelihood	h1	φ1	h3	φ3	Φ_Ω	α
-47.10(Ω+)	1.591+/-0.361	1.649+/-0.672	1.730+/-0.372	2.568+/-0.332	-4.456+/-0.592	0.159+/-0.094
-50.99(Ω-)	1.340+/-0.242	0.742+/-0.363	1.399+/-0.243	2.574+/-0.193	4.572+/-0.359	0.155+/-0.093

There are other three group results, because the φ have the 2π period.
When we add the h4 φ4 parameters, the likelihood value is negligible.

Simultaneous fit ('12 + '09 data)

- The fit includes h1,φ1, h2,φ2, h3,φ3, h4=0,φ4=0 , and put h2=1, φ2=0

- Use the α_Λ α_Ω value from the PDG(Physics Letters B 617 (2005) 11–17 , PHYSICAL REVIEW D **71,** 051102(R) (2005)) and the preliminary BES3 α_Λ value(BAM-00116) from to fit Φ_Ω:

  αΩ=0.01538+/-0.00172 αΩbar=-0.01538+/-0.00172
  α_Λ=0.753+/-0.00729 $\alpha_{\Lambda bar}$=-0.753+/-0.00729

Likelihood	h1	φ1	h3	φ3	Φ_Ω-(-Φ_Ω+)	α
-96.43	1.413+/-0.214	1.064+/-0.472	1.525+/-0.226	2.512+/-0.176	4.507+/-0.294	0.172+/-0.066

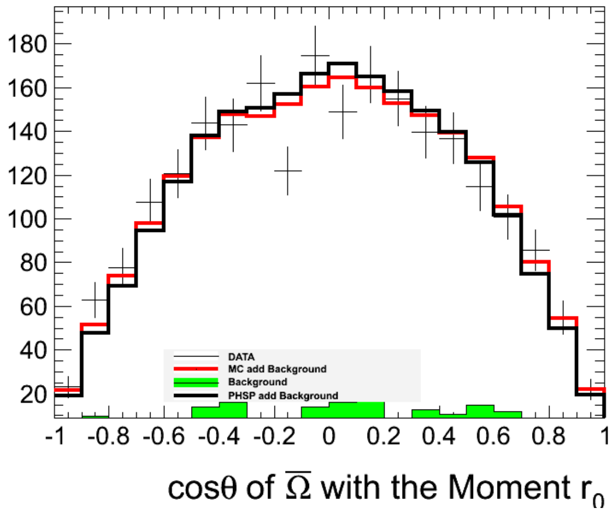
Moments

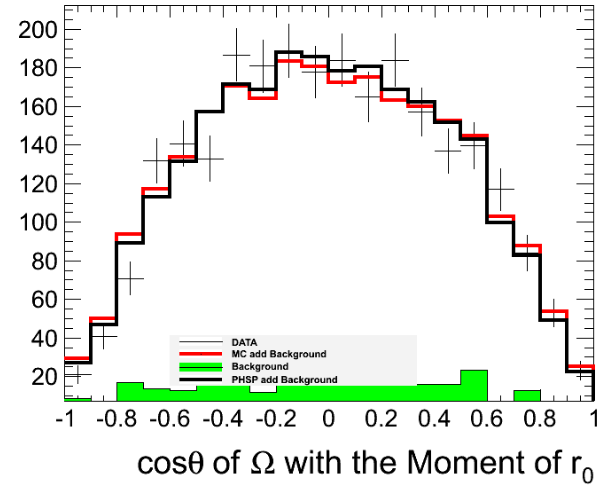
Compare data and the MC: (PHSP and the fitted amplitude) using moments for data before acceptance correction:

$$M_\mu = \frac{1}{N}\sum_{j=0}^{N}\sum_{\kappa=0}^{3} b_{\mu,\kappa}a_{\kappa,0}$$

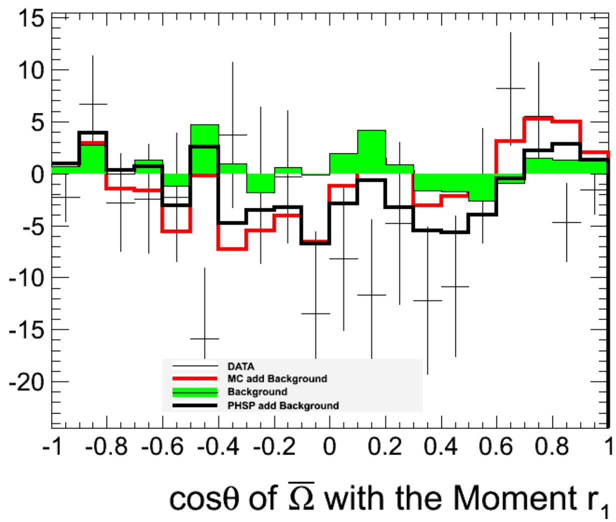
The moments are plotted as function of θ_Ω
(for data after the acceptance correction the plots would give the r_μ functions)

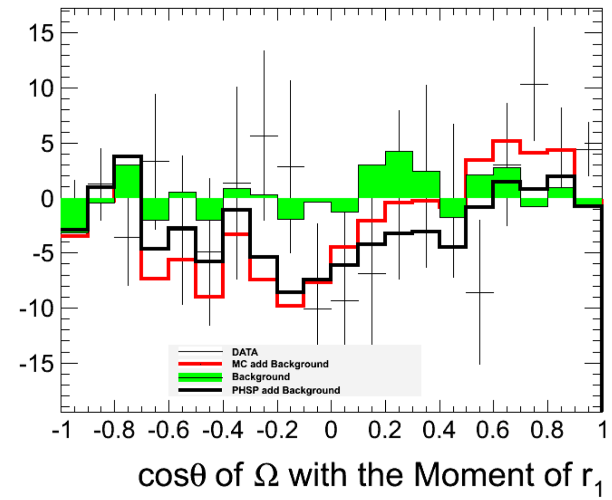
Moments





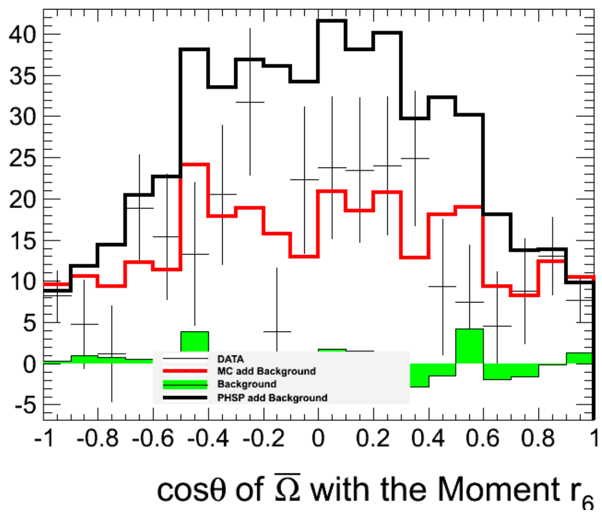
r0

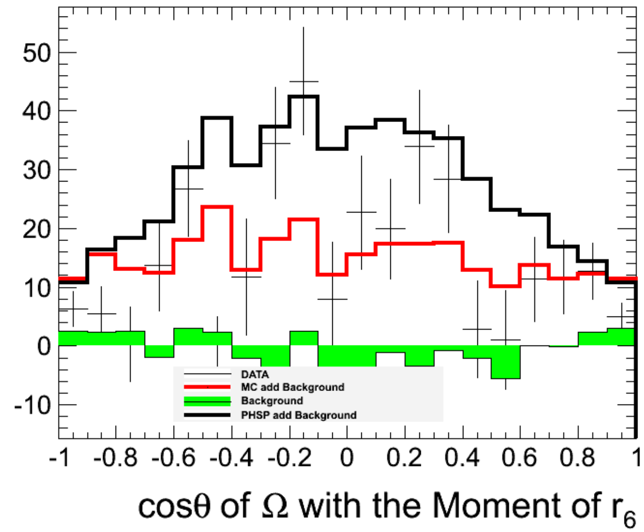




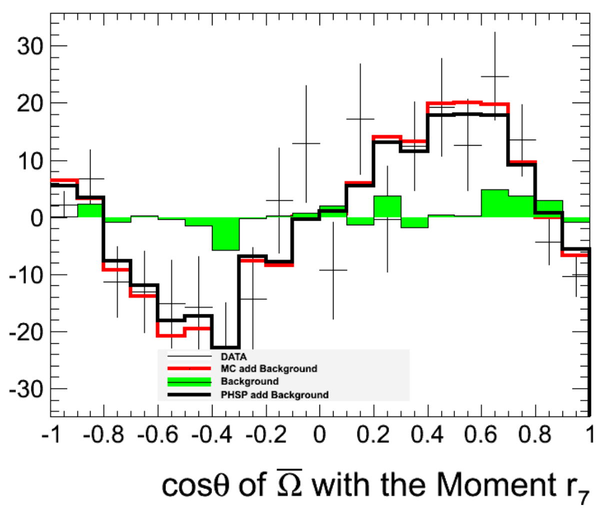
r1

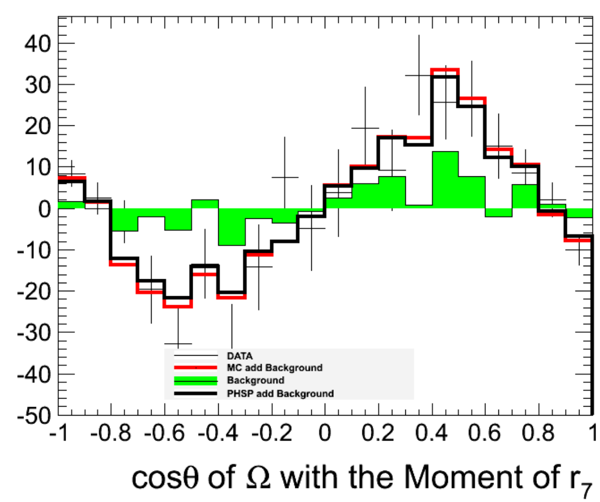
Moments





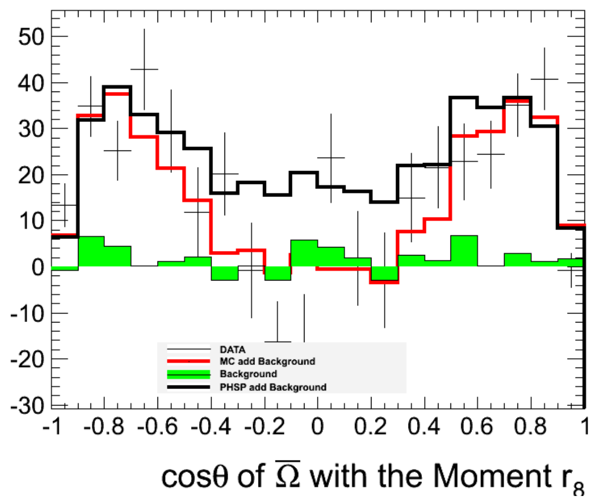
r6

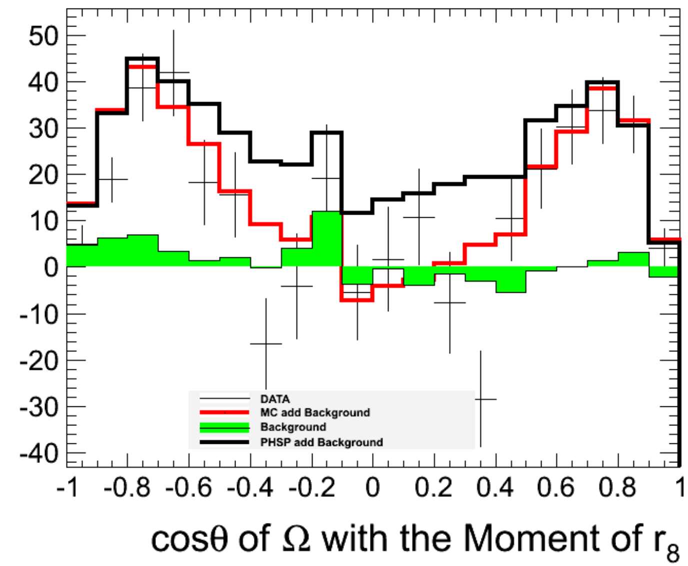




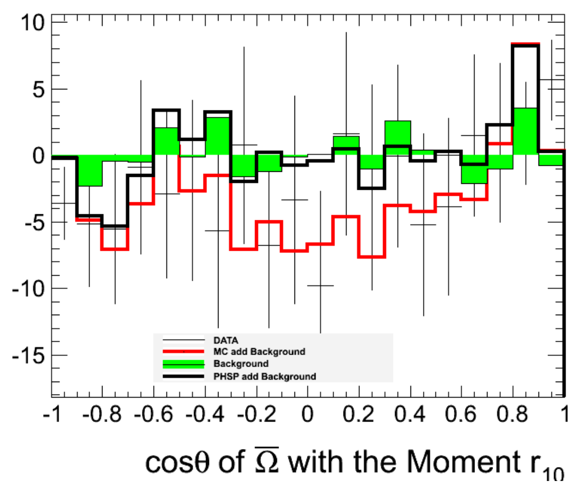
r7

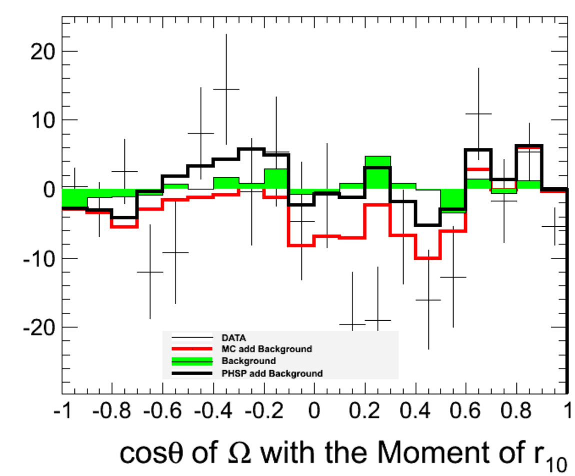
Moments





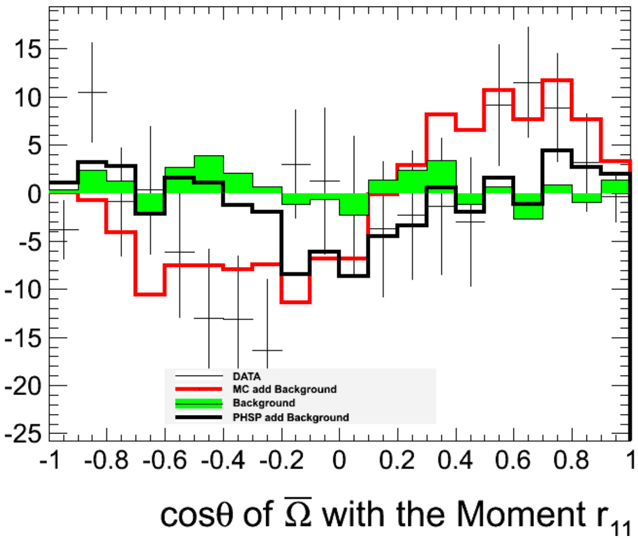
r8



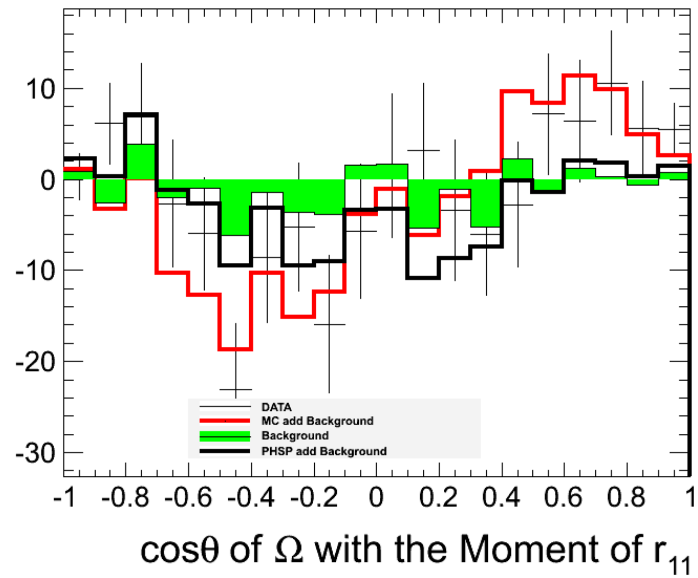


r10

Moments



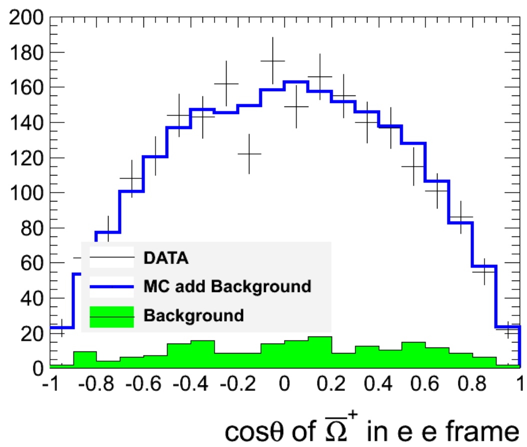
15
10
5
0
-5
-10
-15
-20
-25
-1 -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8 1
DATA
MC add Background
Background
PHSP add Background
cosθ of $\overline{\Omega}$ with the Moment r_{11}

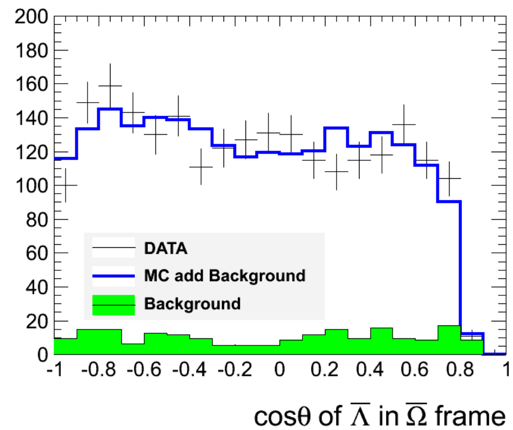


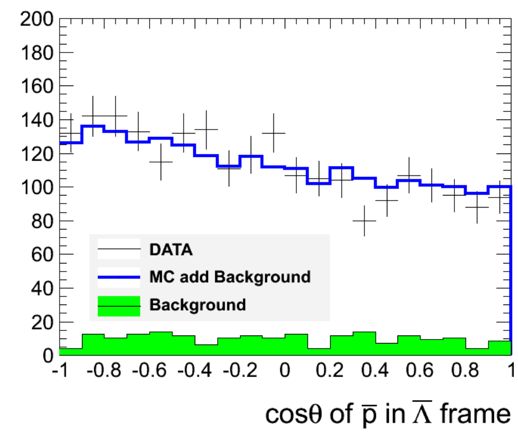
10
0
-10
-20
-30
-1 -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8 1
DATA
MC add Background
Background
PHSP add Background
cosθ of Ω with the Moment of r_{11}

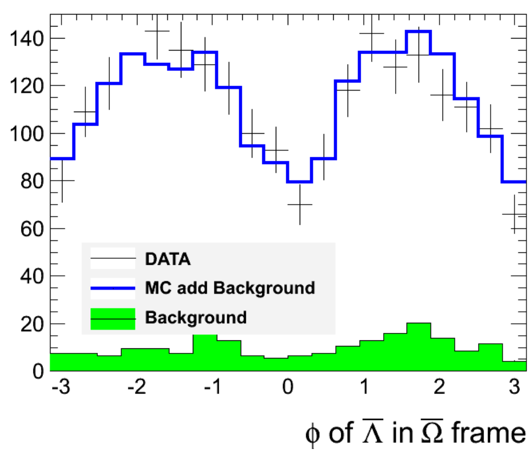
r11

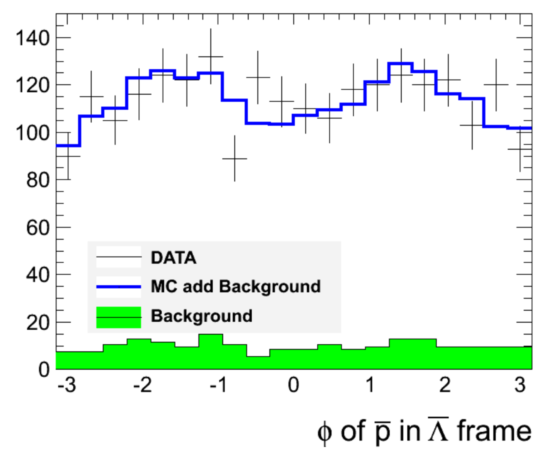
Compare the angular distribution



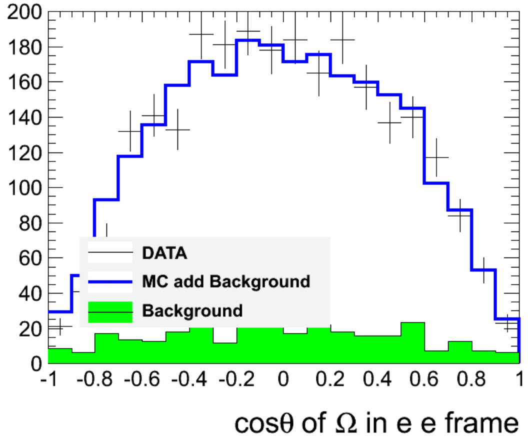


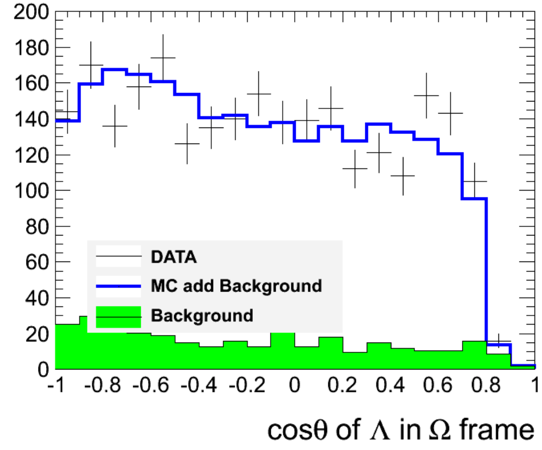


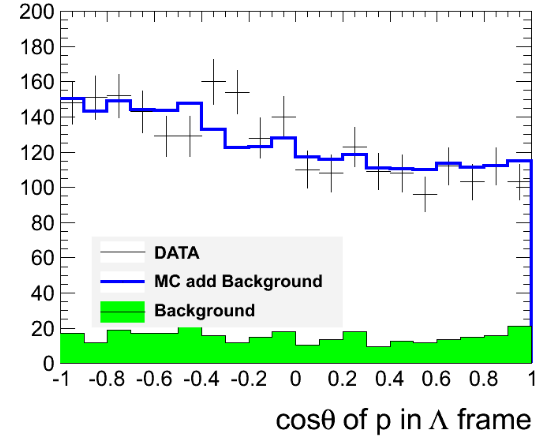


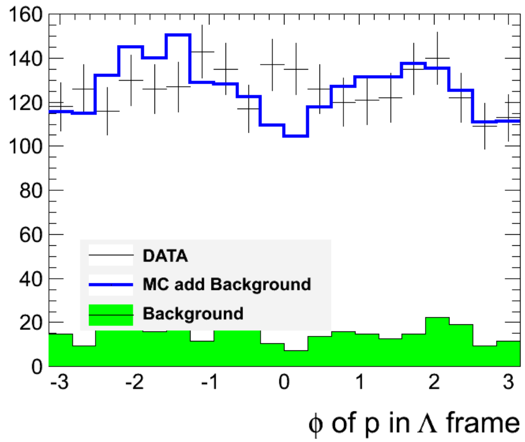


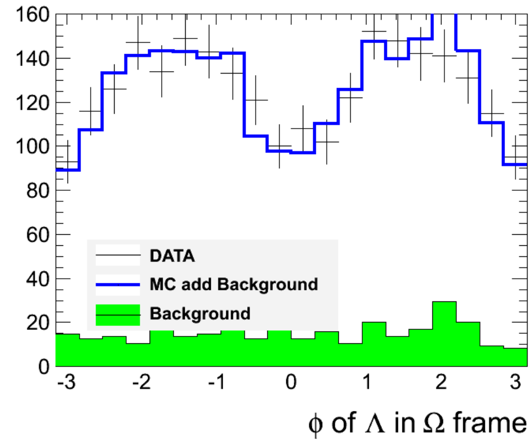
Compare the angular distribution











Tracking and pid systematic uncertainty

- Omegam:

For proton:

Cos(θ):-1 -1, Pt:0.2 – 0.6, Bin by bin correction(40 bins)

Pt:0.6 – 0.8 have no dependence of cos(θ) (1 bin)

For pim:

Cos(θ):-1 -1, Pt:0.05 – 0.2, Bin by bin correction(30 bins)

Pt:0.2 – 0.4 have no dependence of cos(θ) (1 bin)

For kim:

Pt:0.1 – 0.5 have no dependence of cos(θ) (1 bin)

- Omegap

α_sys=

$$\sqrt{(\alpha 1-\alpha 0)^2+(\alpha 2-\alpha 0)^2+\cdots+(\alpha 156-\alpha 0)^2}$$

For antiproton:

Cos(θ):-1 -1, Pt:0.2 – 0.6, Bin by bin correction(40 bins)

Pt:0.6 – 0.8 have no dependence of cos(θ) (1 bin)

For pip:

Cos(θ):-1 -1, Pt:0.05 – 0.2, Bin by bin correction(30 bins)

Pt:0.2 – 0.4 have no dependence of cos(θ)(1 bin)

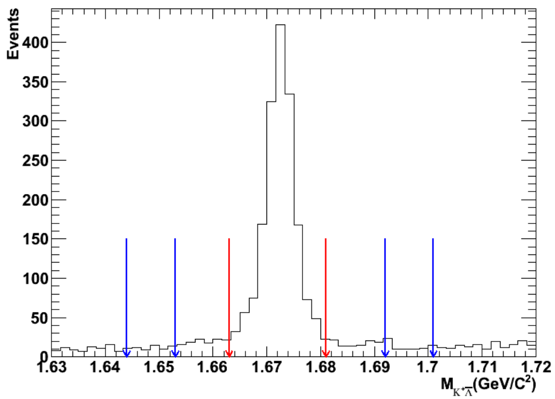
For kip:

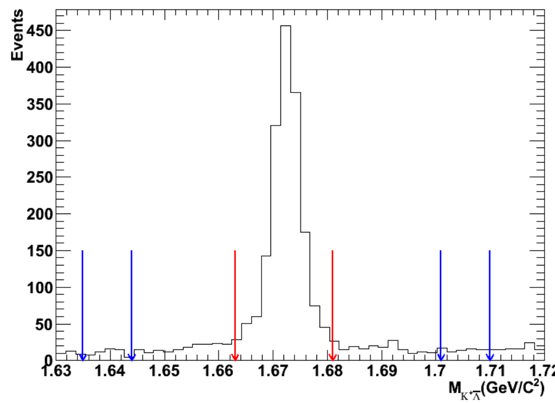
Cos(θ):-1 -1 ,Pt:0.1 – 0.2 Bin by bin correction (10 bins)

Pt:0.2 – 0.5 have no dependence of cos(θ) (1 bin)

Background systematic uncertainty

- By changing the sideband area of Ω to estimate the systematic





Before : sideband regions (1.644 1.653) GeV and (1.692 1.701) GeV
After : Change sideband regions (1.635 1.644) GeV and (1.701 1.710) GeV

Fixed parameters(αΩ αΛ) systematic uncertainty

- By changing the αΩ and αΛ 1σ to estimate these two systematic uncertainty

α_Ω=0.01538+/-0.00172 $\alpha_{\Omega bar}$=-0.01538+/-0.00172
α_Λ=0.753+/-0.00729 $\alpha_{\Lambda bar}$=-0.753+/-0.00729

Fitting results

	h1	Δh1	φ1	Δφ1	h3	Δh3	φ3	Δφ3	Φ_Ω-(-Φ_Ω+)	ΔφΩ	α	Δα
centr	1.413	0.214 (sta_er)	1.064	0.472 (sta_er)	1.525	0.226 (sta_er)	2.512	0.176 (sta_er)	4.507	0.294 (sta_er)	0.172	0.066 (sta_er)
Tra_pid		0.116		0.550		0.133		0.115		0.181		0.031
bakg	1.579	0.166	1.050	0.014	1.728	0.203	2.637	0.125	4.380	0.127	0.166	0.006
αΩ	1.413	0.000	1.067	0.003	1.526	0.001	2.513	0.001	4.507	0.000	0.172	0.000
αΛ	1.418	0.005	1.067	0.003	1.534	0.009	2.516	0.004	4.511	0.004	0.173	0.001
Total		0.295		0.725		0.332		0.245		0.368		0.073

Summary and next to do

- Have finished the measurement of the angular distribution of Ψ(2S)-> $\Omega^{+}\Omega^{-}$;
- Have fund the obvious polarization of Ω^{+} and Ω^{-} ;
- next will use the fitting results to measure the branch ratio of Ψ(2S)-> $\Omega^{+}\Omega^{-}$.

THANK YOU

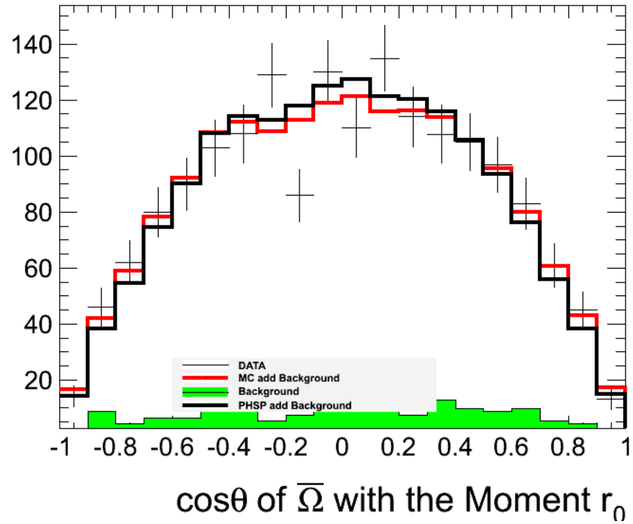
Check

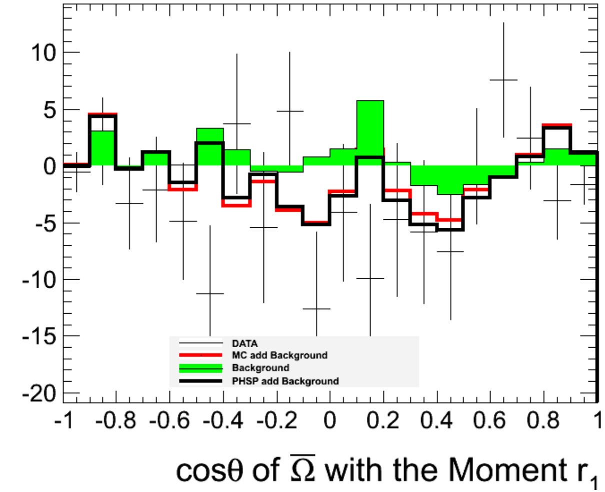
Back up

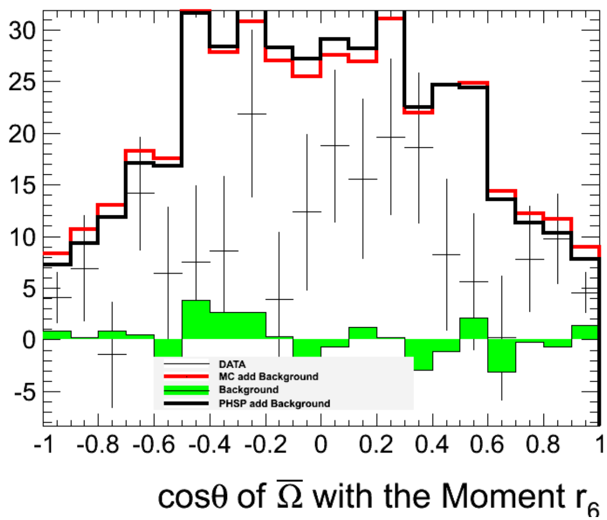
Fitting result of Omegap

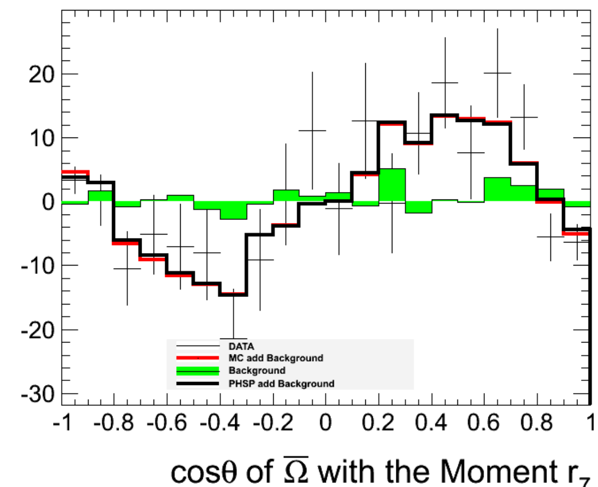
```
Minimum Found
FVAL   = -3.98456184669027413
Edm    = 4.8736558331548067le-07
Nfcn   = 93
ap          = 0.276528       +/-   0.135962
pp          = 2.80357        +/-   0.195517
aXi         = 0      +/-   0.001
pXi         = -1.8519        +/-   0.66396
aL          = -0.75          +/-   0.001

# of function calls: 93
function Value: -3.98456184669
expected distance to the Minimum (edm): 4.873655833155e-07
external parameters:
# ext. ||    Name     ||    type   ||      Value      ||  Error +/-

   0    ||         ap ||  free     ||     0.2765283449243 ||0.1359616887492
   1    ||         pp || limited ||      2.803572467119 ||0.1955172337966
   2    ||        aXi ||  fixed   ||                   0 ||
   3    ||        pXi || limited ||     -1.851901553539 ||0.6639596780977
   4    ||         aL ||  fixed   ||               -0.75 ||
```

Moments

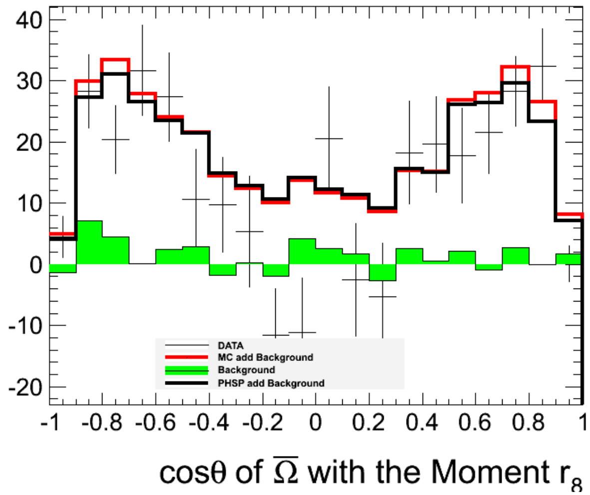

140
120
100
80
60
40
20
-1 -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8 1
DATA
MC add Background
Background
PHSP add Background
cosθ of $\overline{\Omega}$ with the Moment r_0

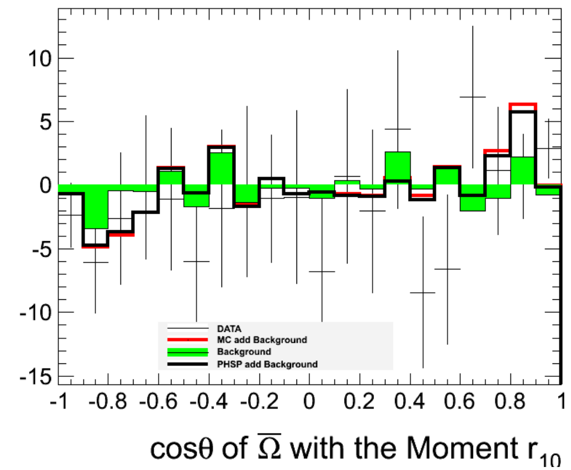

10
5
0
-5
-10
-15
-20
-1 -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8 1
DATA
MC add Background
Background
PHSP add Background
cosθ of $\overline{\Omega}$ with the Moment r_1

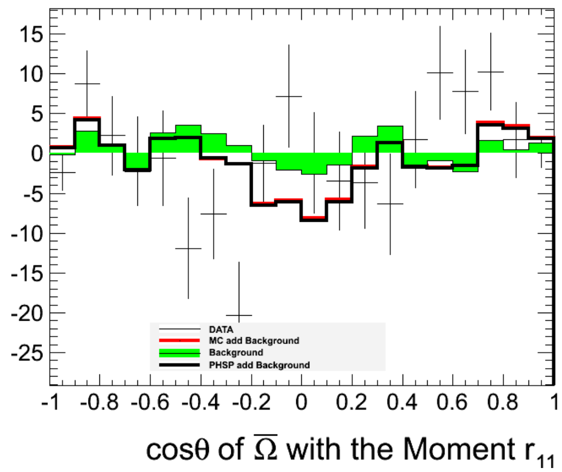

30
25
20
15
10
5
0
-5
-1 -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8 1
DATA
MC add Background
Background
PHSP add Background
cosθ of $\overline{\Omega}$ with the Moment r_6


20
10
0
-10
-20
-30
-1 -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8 1
DATA
MC add Background
Background
PHSP add Background
cosθ of $\overline{\Omega}$ with the Moment r_7

Moments


DATA
MC add Background
Background
PHSP add Background
cosθ of $\overline{\Omega}$ with the Moment r_8


DATA
MC add Background
Background
PHSP add Background
cosθ of $\overline{\Omega}$ with the Moment r_{10}


DATA
MC add Background
Background
PHSP add Background
cosθ of $\overline{\Omega}$ with the Moment r_{11}

Put the spin of Omega is 3/2 and let alpha_psip=0,r0=1,r1=r6=r7=r8=r10=r11=0,

h1=h4=1/2,h2=0;h3=sqrt(2)/2,phi1=phi2=phi3=phi4=0

Make the pdf is a constant:1

The likelihood value is large