Measurement of $J/\psi \rightarrow p\bar{p}$, $n\bar{n}$

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Outline

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- DATA sample
- $J/\psi \rightarrow p\bar{p}$
- $J/\psi \rightarrow n\bar{n}$
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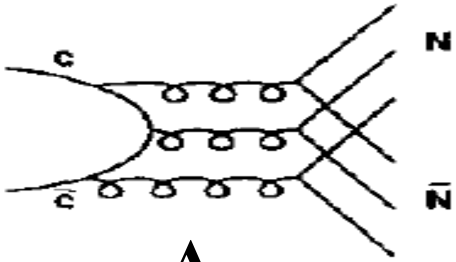
Introduction

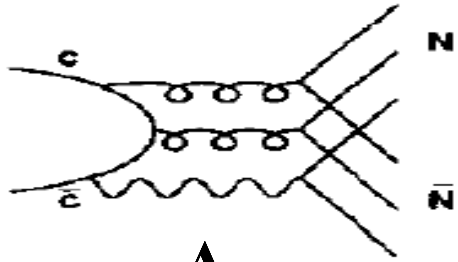
- $J/\psi \rightarrow n\bar{n}$ has been measured with poor precision.
- The difference between $B(J/\psi \rightarrow p\bar{p})$ and $B(J/\psi \rightarrow n\bar{n})$ is a good test for the pQCD prediction.
- The final states involving baryons may take a large proportion of the missing part of J/ψ decay modes

Introduction

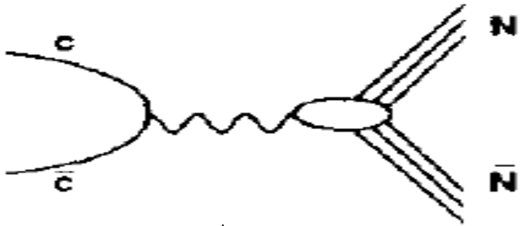
Comparable B(J/ψ→nn) and B(J/ψ→pp) indicate a **large phase angle** **between the strong (A_g) and electromagnetic (A_{em}) decay amplitudes of J/ψ.**



A_g



A_{mix}



A_{em}

Although previous measurements have provide high precision Br(J/ψ→pp),
the Br(J/ψ→nn) is still suffering from a large error.

$$R = \frac{BR(J/\psi \to n\bar{n})}{BR(J/\psi \to p\bar{p})} = \frac{|A_g + A^n_{em}|^2}{|A_g - 0.03A_g + A^p_{em}|^2}.$$

- **BESII@BEPC : Br(J/ψ→pp) = (2.26±0.01±0.14) ×10^{-3} (PLB591,42)**
- **FENICE@Adone : Br(J/ψ→nn) = (2.31±0.49) ×10^{-3} (PLB444,111)**

Data samples

Based on boss 6.5.1 at BESIII

Data samples:~226M J/ψ data

MC $J/\psi \rightarrow p\bar{p}$: 1 M PHSP

Control sample of $n\bar{n}$: $J/\psi \rightarrow p\bar{n}\pi^-$+cc.

Inclusive MC samples: 200 M J/ψ inclusive MC

MC $e^+e^- \rightarrow \gamma\gamma$ MC ($|\cos\theta|<0.8$)

$N_{\gamma\gamma} = L \times \sigma = 80981.43\text{nb} \times 19.2984\text{nb}^{-1} = 1.56$ M

$J/\psi \rightarrow p\bar{p}$

Event Selection

Good charged tracks

- **IP region: $|R_{xy}| \leq 1cm$, $|Rz| \leq 10cm$**
- **Momentum: $p<2.0GeV$**
- **Polar angle: $|\cos\theta|<0.93$**

Particle Identificatioin

- **TOF+dE/dX**
- **p Prob(p) > Prob(π)**
- **p Prob(p) > Prob(K)**

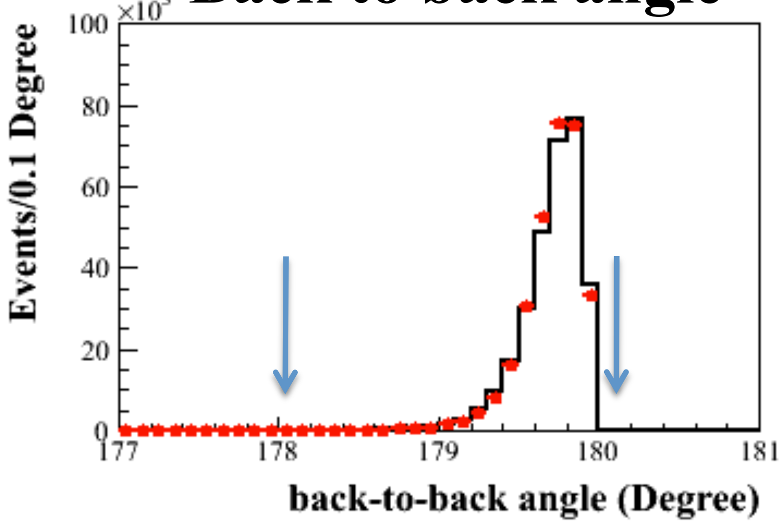
Event level

- **Two tracks opening angle > 178^o**
- **$|P(p) - 1.232|<0.05GeV$**
- **$|P(p) - 1.232|<0.05GeV$**
- **$|\cos\theta| < 0.8$, polar angle of p**

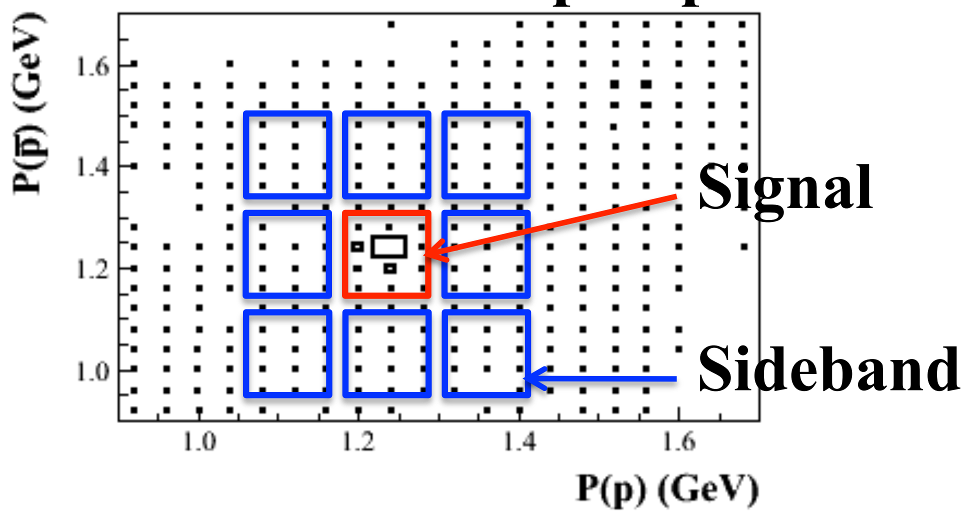
The selection of $J/\psi \rightarrow p\bar{p}$ does not depend on information of the calorimeter, and the energy deposit in EMC of $J/\psi \rightarrow p\bar{p}$ is also used to verify efficiency of $J/\psi \rightarrow n\bar{n}$

Data/MC

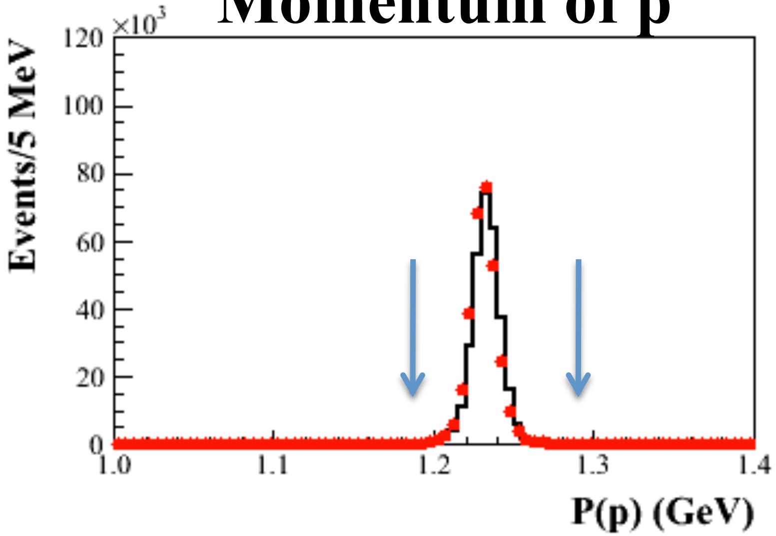
Back to back angle



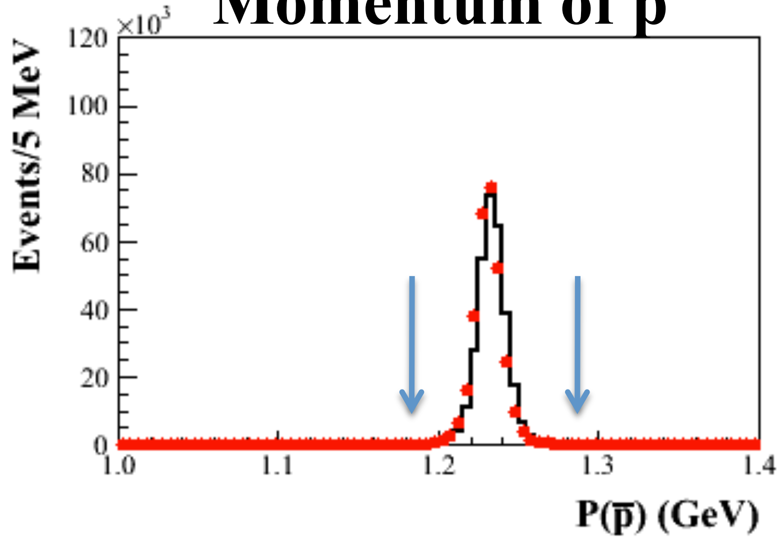
Momentum of p vs $\bar{p}$



Momentum of p

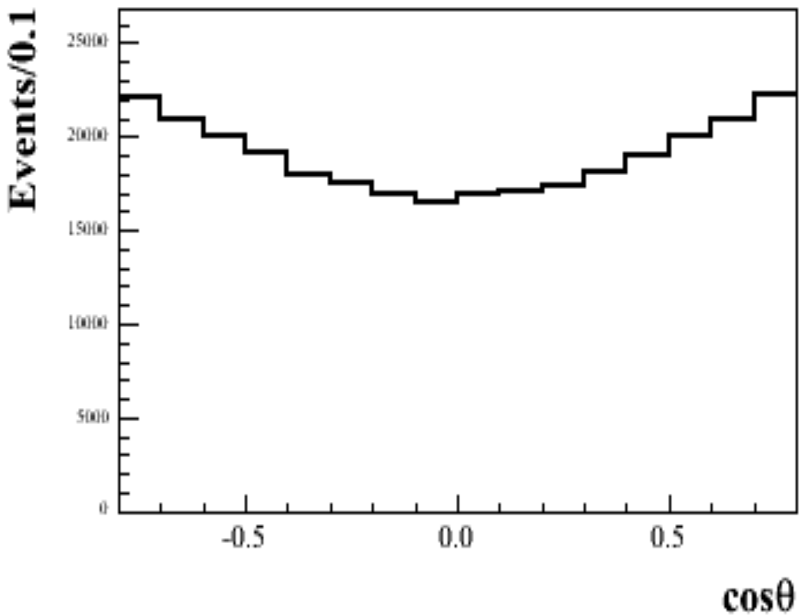


Momentum of $\bar{p}$

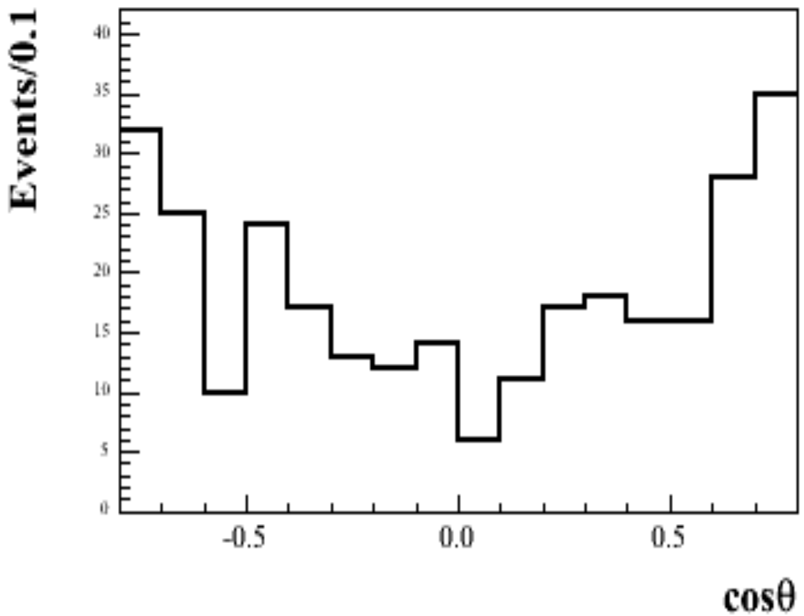


Angular distribution

polar angle of p



polar angle of p in $p\bar{p}$
momentum sideband



N=303190
N_{side}=294
N_{side}/N = 0.1%

Normalized with signal area

Inclusive MC background

No.	decay chain	final states	iTopo	nEvt	nTot
0	$J/\psi \to \gamma\eta_c, \eta_c \to p\bar{p}$	$\bar{p}\gamma p$	0	13	13
1	$J/\psi \to \mu^+\mu^-$	$\mu^-\mu^+$	8	7	20
2	$J/\psi \to e^+e^-$	e^-e^+	4	5	25
3	$J/\psi \to \Sigma^0\bar{\Lambda}, \Sigma^0 \to \gamma\Lambda, \bar{\Lambda} \to \bar{p}\pi^+, \Lambda \to \pi^-p$	$\pi^-\bar{p}\pi^+\gamma p$	14	3	28
4	$J/\psi \to \gamma_{FSR}e^+e^-$	e^-e^+	17	2	30
5	$J/\psi \to \pi^0\pi^+\pi^-$	$\pi^-\pi^0\pi^+$	19	2	32
6	$J/\psi \to \bar{K}^0\pi^-K^+, K_S \to \pi^0\pi^0$	$\pi^-\pi^0\pi^0K^+$	6	1	33
7	$J/\psi \to \rho^+\pi^-b_1^0\rho^0, \rho^+ \to \pi^+\pi^0, b_1^0 \to \omega\pi^0, \rho^0 \to \pi^+\pi^-, \omega \to \pi^-\pi^0\pi^+$	$\pi^-\pi^-\pi^-\pi^0\pi^0\pi^0\pi^+\pi^+\pi^+$	7	1	34
8	$J/\psi \to K^{*+}\bar{K}^*\rho^-, K^{*+} \to \pi^+K^0, \bar{K}^* \to \pi^+K^-, \rho^- \to \pi^-\pi^0, K_S \to \pi^+\pi^-$	$\pi^-\pi^-K^-\pi^0\pi^+\pi^+\pi^+$	2	1	35
9	$J/\psi \to a_2^+\rho^-, a_2^+ \to \pi^+\rho^0, \rho^- \to \pi^0\pi^-, \rho^0 \to \pi^-\pi^+$	$\pi^-\pi^-\pi^0\pi^+\pi^+$	9	1	36
10	$J/\psi \to \gamma\bar{K}^*K_1^0, \bar{K}^* \to K^-\pi^+, K_1^0 \to \pi^0K^0\pi^0, K_S \to \pi^0\pi^0$	$K^-\pi^0\pi^0\pi^0\pi^0\pi^+\gamma$	10	1	37
11	$J/\psi \to \pi^0\gamma\pi^0\pi^+\pi^-$	$\pi^-\pi^0\pi^0\pi^+\gamma$	11	1	38
12	$J/\psi \to \pi^+f_1(1285)\rho^-, f_1(1285) \to K^0\pi^0\bar{K}^0, \rho^- \to \pi^0\pi^-, K_S \to \pi^-\pi^+$	$\pi^-\pi^-\pi^0\pi^0K_L\pi^+\pi^+$	12	1	39
13	$J/\psi \to K_2^{*+}K^{*-}\omega, K_2^{*+} \to \pi^+K^0, K^{*-} \to \pi^0K^-, \omega \to \pi^+\pi^0\pi^-$	$\pi^-K^-\pi^0\pi^0K_L\pi^+\pi^+$	13	1	40
14	$J/\psi \to \pi^-\gamma\rho^0\rho^+, \rho^0 \to \gamma_{FSR}\pi^-\pi^+, \rho^+ \to \pi^0\pi^+$	$\pi^-\pi^-\pi^0\pi^+\pi^+\gamma$	3	1	41
15	$J/\psi \to \bar{\Sigma}^0\Lambda, \bar{\Sigma}^0 \to \bar{\Lambda}\gamma, \Lambda \to \pi^-p, \bar{\Lambda} \to \bar{p}\pi^+$	$\pi^-\bar{p}\pi^+\gamma p$	15	1	42
16	$J/\psi \to \bar{p}\pi^0p$	$\bar{p}\pi^0p$	16	1	43
17	$J/\psi \to h_1(1170)\rho^-\rho^+, h_1(1170) \to \rho^+\pi^-, \rho^- \to \pi^-\pi^0, \rho^+ \to \pi^+\pi^0, \rho^+ \to \pi^+\pi^0$	$\pi^-\pi^-\pi^0\pi^0\pi^0\pi^+\pi^+$	1	1	44
18	$J/\psi \to \Sigma^+\bar{\Sigma}^-, \Sigma^+ \to \pi^0p, \bar{\Sigma}^- \to \pi^0\bar{p}$	$\bar{p}\pi^0\pi^0p$	18	1	45
19	$J/\psi \to \pi^-\phi\pi^+\pi^+\pi^-, \phi \to K_LK_S, K_S \to \pi^+\pi^-$	$\pi^-\pi^-\pi^-K_L\pi^+\pi^+\pi^+$	5	1	46
20	$J/\psi \to \gamma\eta_c, \eta_c \to f_1(1285)b_1^0, f_1(1285) \to K^+\pi^-\bar{K}^0, b_1^0 \to \pi^0\omega, K_S \to \pi^-\pi^+, \omega \to \pi^+\pi^-\pi^0$	$\pi^-\pi^-\pi^-\pi^0\pi^0\pi^+\pi^+\gamma K^+$	20	1	47
21	$J/\psi \to a_2^0\rho^0, a_2^0 \to \pi^+\rho^-, \rho^0 \to \pi^+\pi^-, \rho^- \to \pi^0\pi^-$	$\pi^-\pi^-\pi^0\pi^+\pi^+$	21	1	48
22	$J/\psi \to K^-K^0\pi^+$	$K^-K_L\pi^+$	22	1	49
23	$J/\psi \to a_2^-\pi^+\pi^0, a_2^- \to \rho^-\pi^0, \rho^- \to \pi^0\pi^-$	$\pi^-\pi^0\pi^0\pi^0\pi^+$	23	1	50
24	$J/\psi \to \eta\pi^0\rho^0, \eta \to \pi^-\pi^+\pi^0, \rho^0 \to \pi^+\pi^-$	$\pi^-\pi^-\pi^0\pi^0\pi^+\pi^+$	24	1	51
25	$J/\psi \to \rho^-\pi^+, \rho^- \to \pi^0\pi^-$	$\pi^-\pi^0\pi^+$	25	1	52
26	$J/\psi \to \pi^-K_0^{*+}K_0^{*-}\pi^+, K_0^{*+} \to \pi^+\gamma_{FSR}K^0, K_0^{*-} \to \pi^0K^-$	$\pi^-K^-\pi^0K_L\pi^+\pi^+$	26	1	53
27	$J/\psi \to \omega\rho^-\rho^+, \omega \to \pi^-\pi^+\pi^0, \rho^- \to \pi^-\pi^0, \rho^+ \to \pi^0\pi^+$	$\pi^-\pi^-\pi^0\pi^0\pi^0\pi^+\pi^+$	27	1	54
28	$J/\psi \to a_0^-\pi^+\omega, a_0^- \to \eta\pi^-, \omega \to \pi^0\pi^-\pi^+, \eta \to \pi^0\pi^0\pi^0$	$\pi^-\pi^-\pi^0\pi^0\pi^0\pi^0\pi^+\pi^+$	28	1	55
29	$J/\psi \to K^+K^-\eta, \eta \to \gamma\gamma$	$K^-\gamma\gamma K^+$	29	1	56

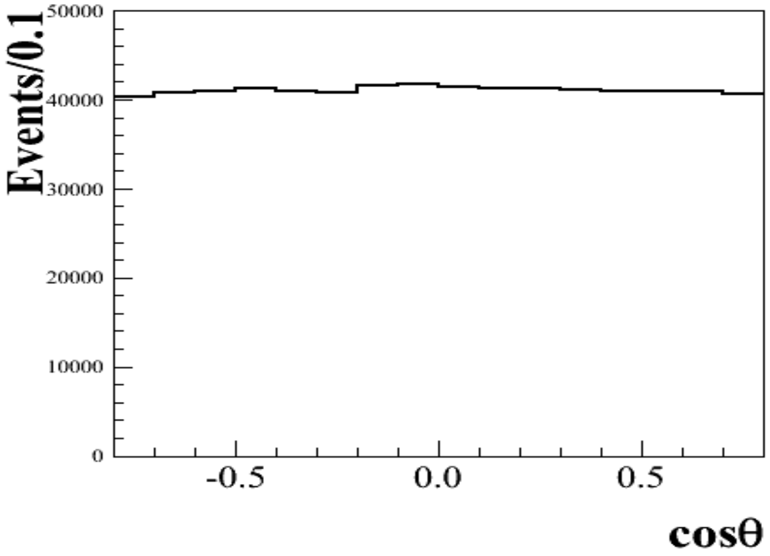
N=303190

N_{incbkg}=104

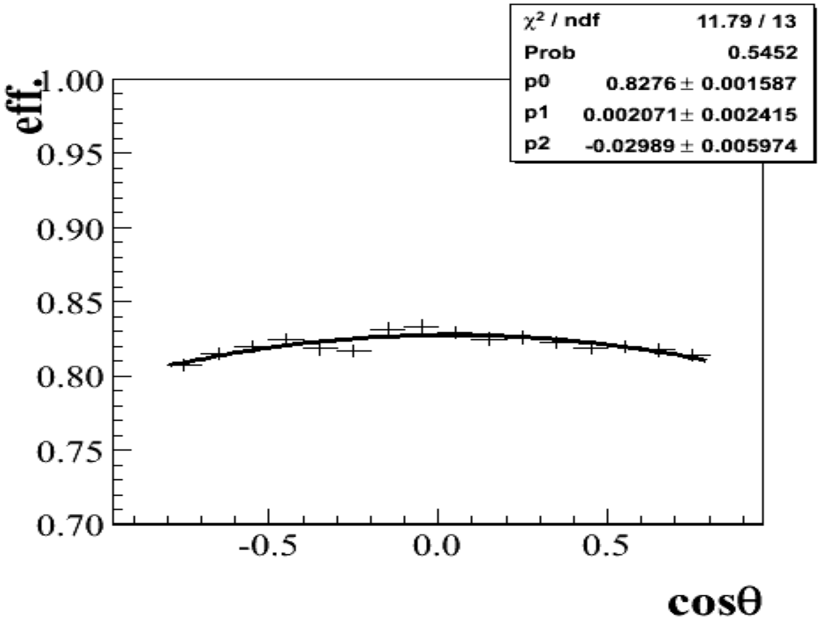
N_{incbkg}/N = 0.03%

Efficiency correction

Polar angle of p of PHSP MC

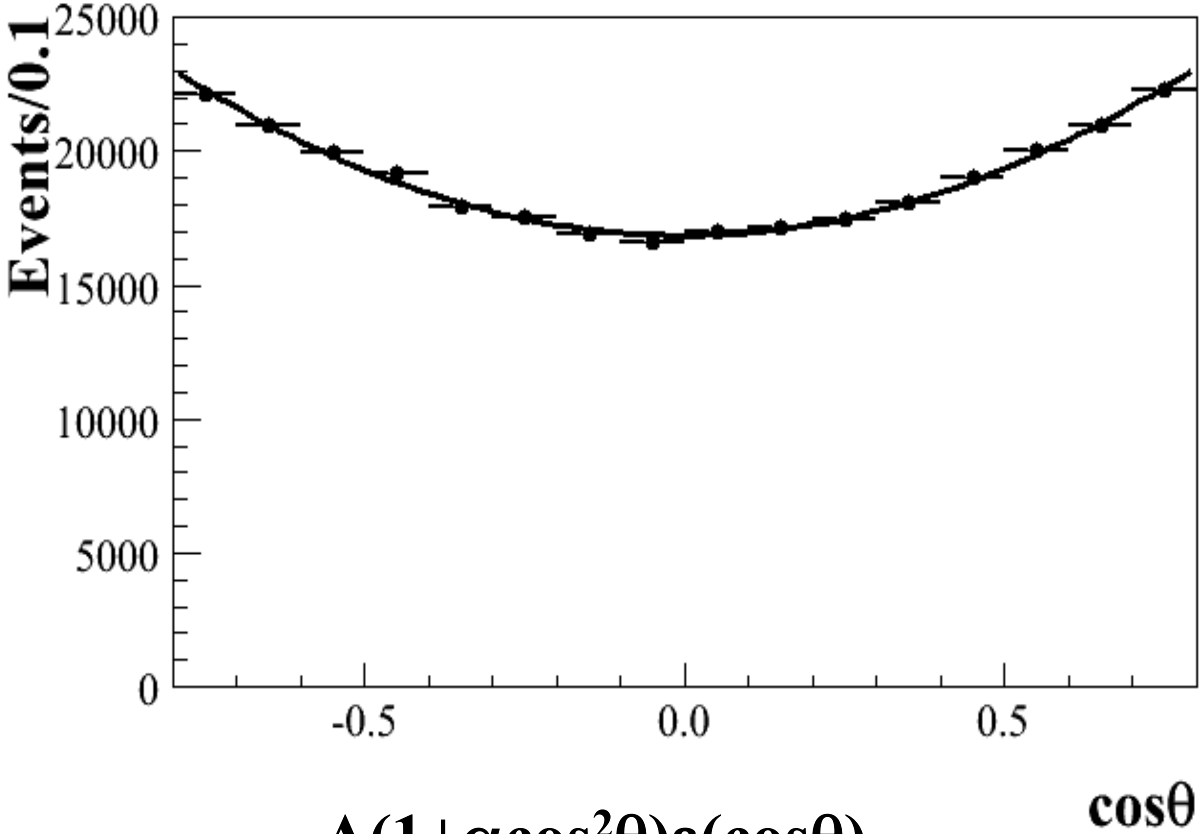


Efficiency correction function



$$\varepsilon(\cos\theta) = C_0 + C_1 \cos q + C_2 \cos^2\theta$$

Fit to angular distribution



$A(1+\alpha\cos^2\theta)\varepsilon(\cos\theta)$

$\alpha = 0.628 \pm 0.013$

Branching ratio

Correction for angular acceptance

$$N_{cor} = N_i(\cos\theta)/\varepsilon_i(\cos q) \bullet [\int_{-1}^{1}(1+\alpha\cos^2\theta)d\theta / \int_{-0.8}^{0.8}(1+\alpha\cos^2\theta)d\theta)]$$

N	**303190±551**
α	**0.628±0.013**
N_{cor}	**492191±894**
Eff.	**61.6%**
$N(J/\psi)$	**2.26×10^8**
Br	**$(2.179\pm0.004)\times10^{-3}$**

Systematic errors and results

	α=0.628±0.013	Br = (2.179±0.004) $\times 10^{-3}$
Tracking (1%)	0.021	0.022
PID (1%)	0.021	0.022
Background	0.004	0.002
Eff. Correction	0.010	0.008
Error of α (tot 0.035)	-	0.007
N(J/ψ) (1.2%)	-	0.026
Total	0.032	0.042

Br(J/ψ→pp) = (2.179±0.004±0.042)$\times 10^{-3}$
α=0.628±0.013±0.032
PDG: Br(J/ψ→pp) = (2.17±0.07)$\times 10^{-3}$
BESII: α=0.676±0.036±0.042

$J/\psi \rightarrow n\bar{n}$

Event selection for $J/\psi \rightarrow n\bar{n}$

Good Shower

- **Barrel(|cosθ|<0.8):E_γ > 25MeV**
- **Endcap(0.86<|cosθ|<0.92):E_γ>50MeV**
- **EMC time: $|t-t_{emax}| \leq 10*50$ns**

nbar identification

- **Most energetic shower**
- **E>0.6 GeV, E<2.0 GeV**
- **SecondMoment>20**
- **Total hits nearby 50^o the most energetic shower : Nhit50>40**

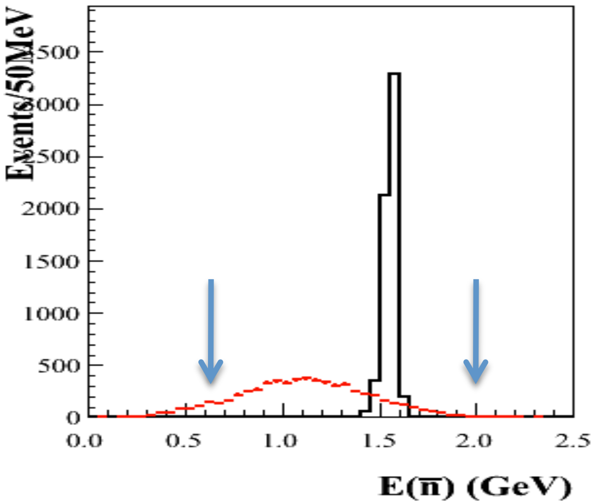
n identification

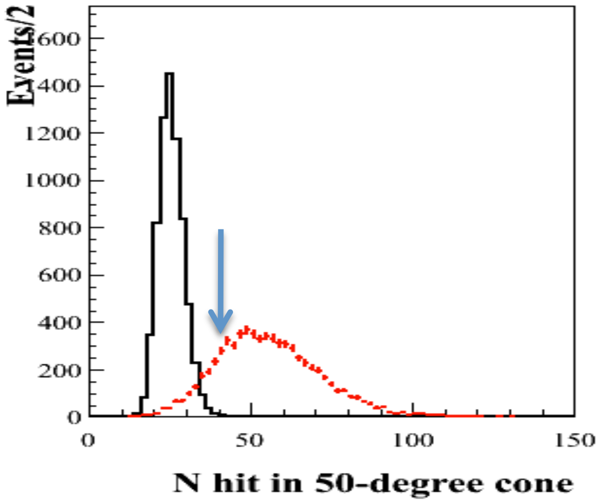
- **0.6GeV>E>0.06GeV**

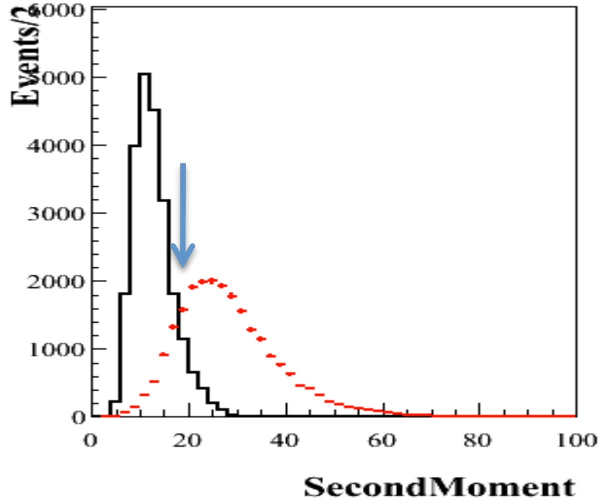
Event level

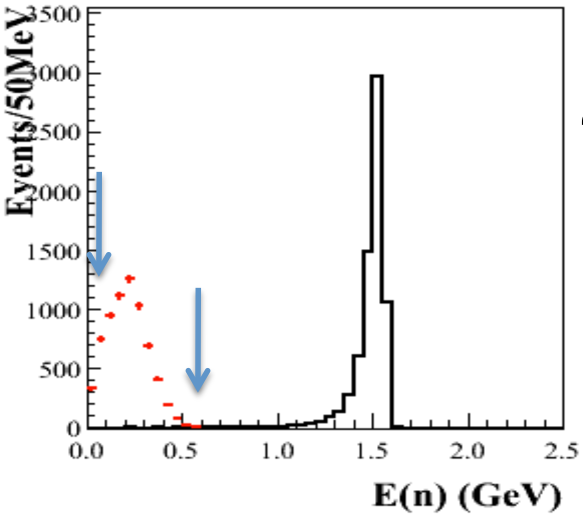
- **No good charged tracks**
- **The most energetic shower which pass nbar ID criteria is taken as the nbar candidate**
- **The shower which is most near the recoil direction of nbar and passes n ID criteria is taken as n**
- **$E_{miss}=E_{tot}$ – E(nbarsum50) – E(n)=0, E_{tot} is the total deposit energy in the calorimeter, E(nbarsum50) is the energy deposit in a 50^o cone nearby the nbar candidate**
- **|cosθ| < 0.8 (the polar angle of the nbar candidate)**
- **The signal will be an enhancement nearby zero in the distribution of the the angle between n and recoil direction of nbar.**

$n\bar{n}$(red cross) vs γ (histogram)





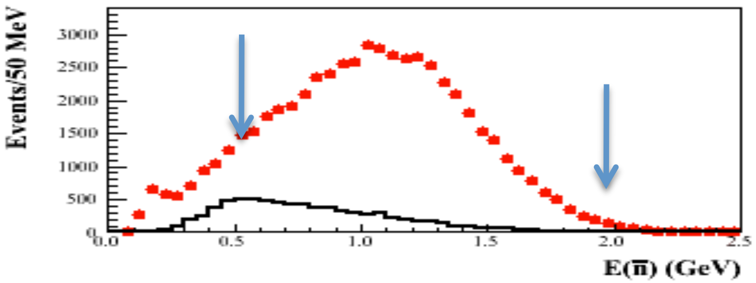


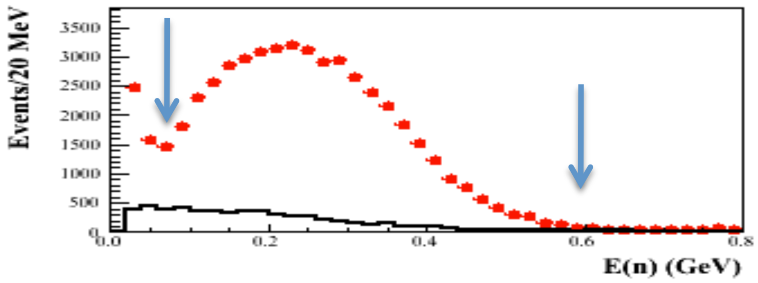


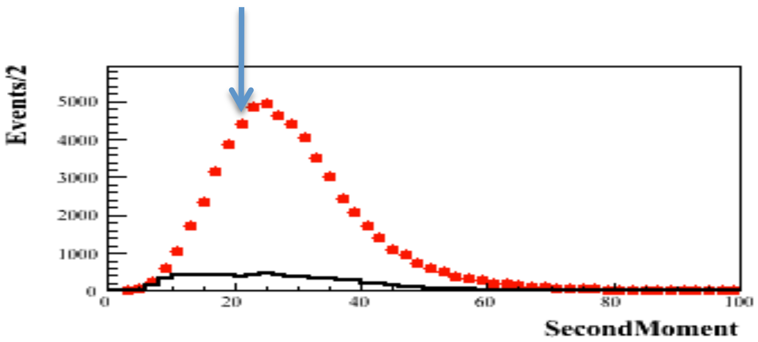
$n\bar{n}$(red cross) sample: $J/\psi \rightarrow p\bar{n}\pi^-$ + cc.
in the data (Selected by the missing mass of $p\pi$)
γ (red cross) sample: $e^+e^- \rightarrow \gamma\gamma$

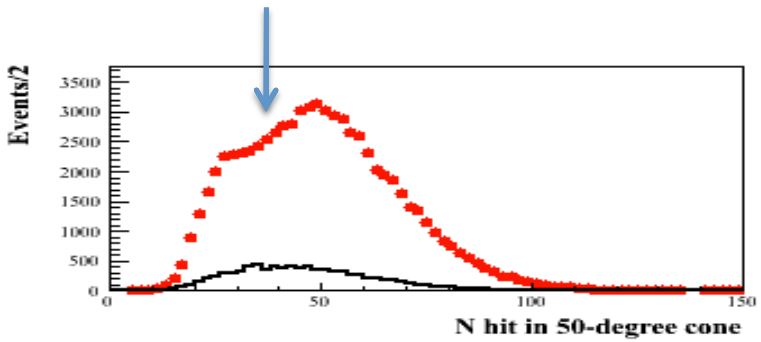
The deposit energy, secondmoment and N nits in a 50^o cone near the $\bar{n}$ candidate can well discriminate $n\bar{n}$ and $\gamma\gamma$ events. Only 8 $\gamma\gamma$ events in a 1.56M sample pass our selection criteria.

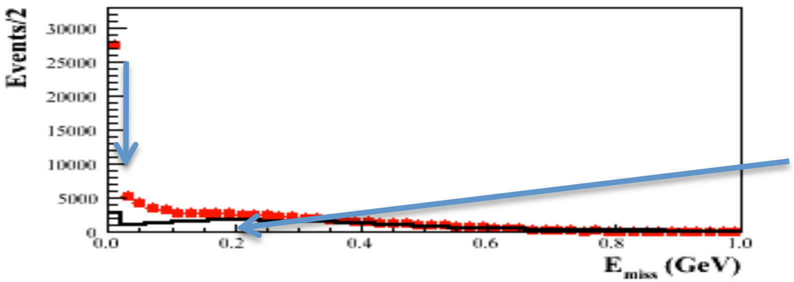
Distributions in the data(dot) and inclusive MC(hist)





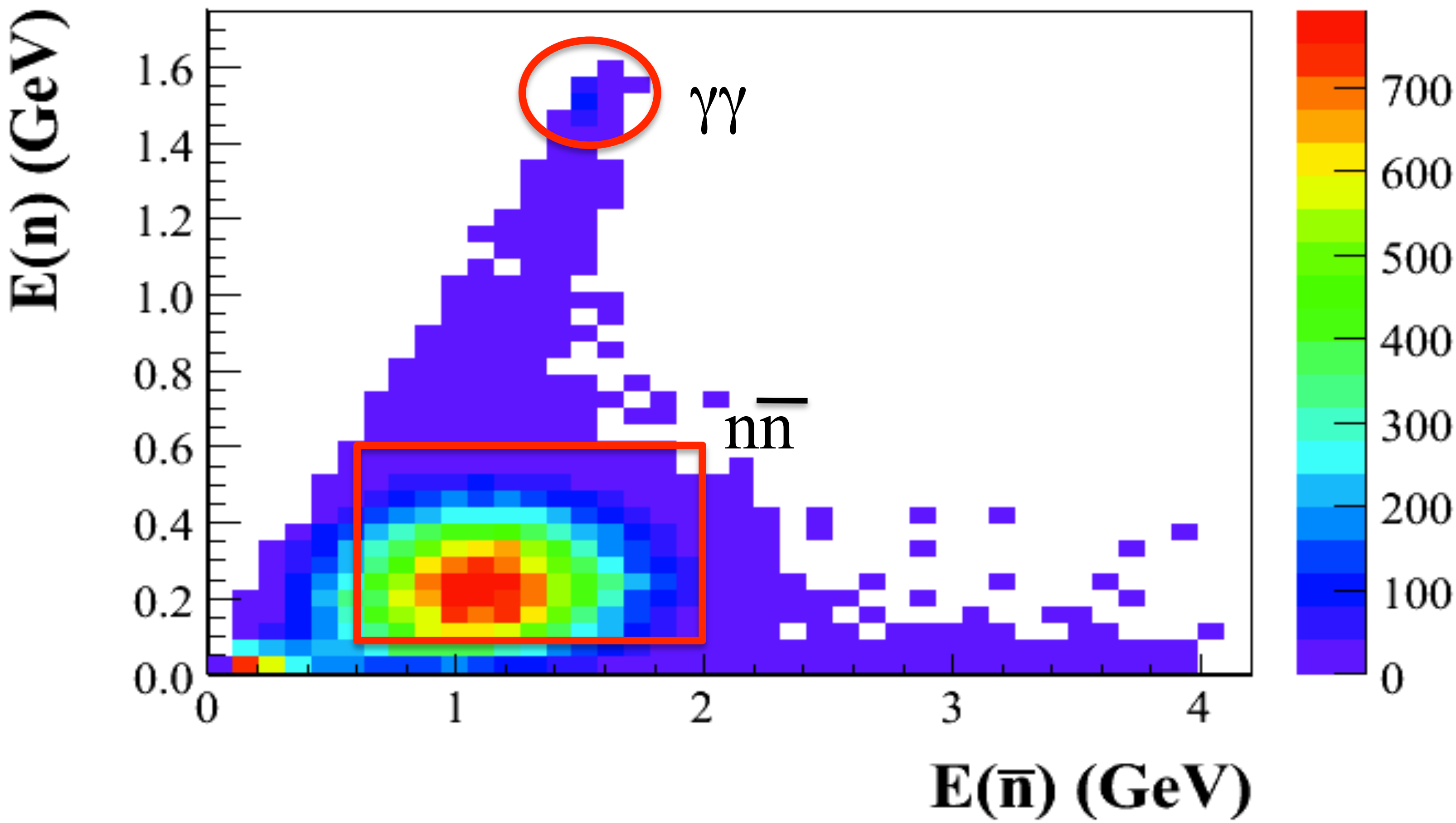




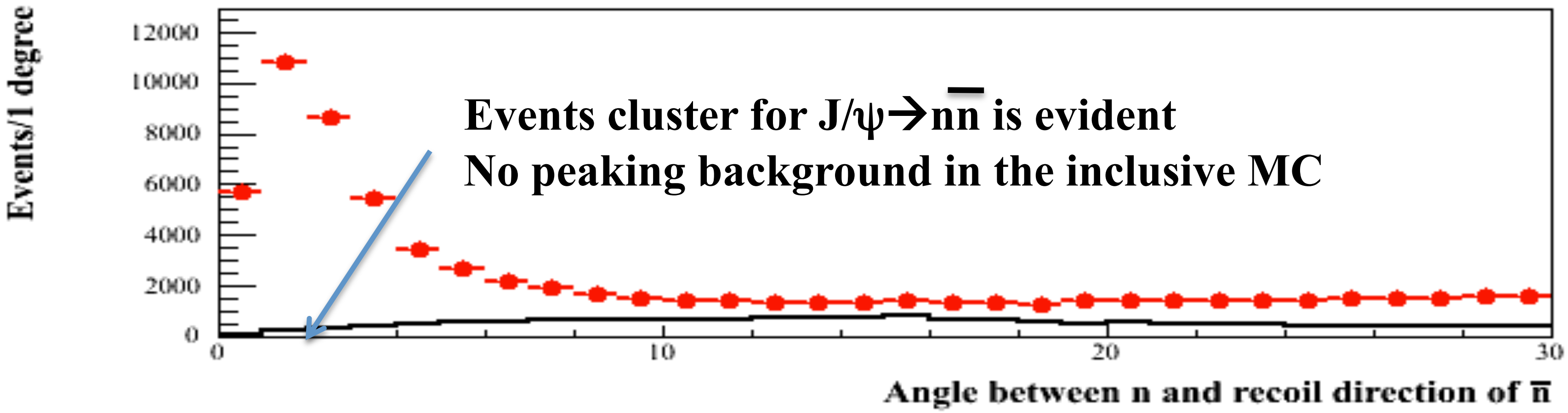


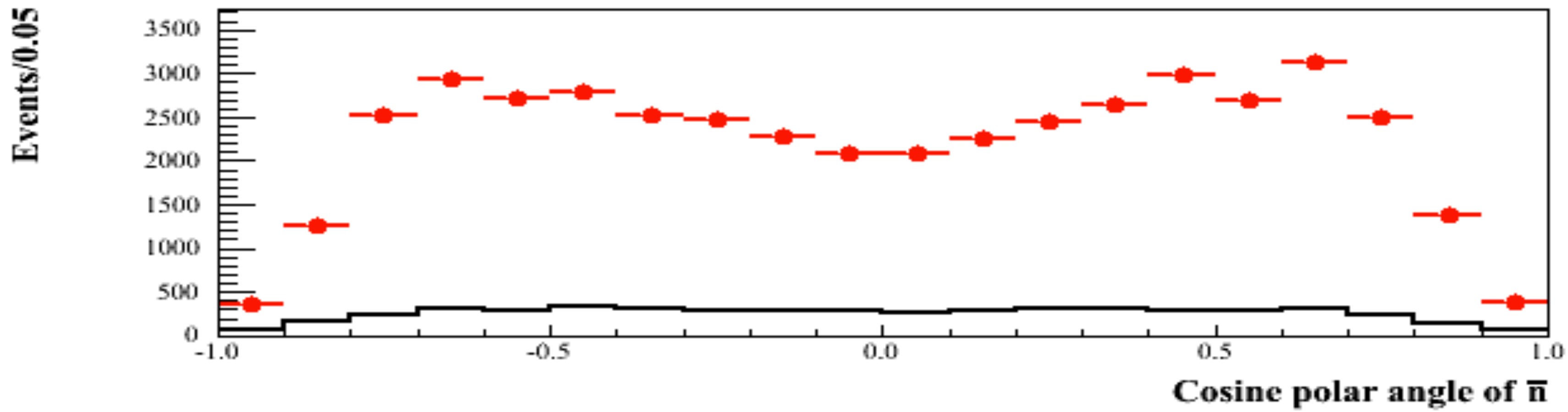
E_{miss} cut can well eliminate backgrounds as it appears in the inclusive MC

Deposit energy of n vs $\bar{n}$ candidate in the data



Inclusive MC background





Topology in inclusive MC

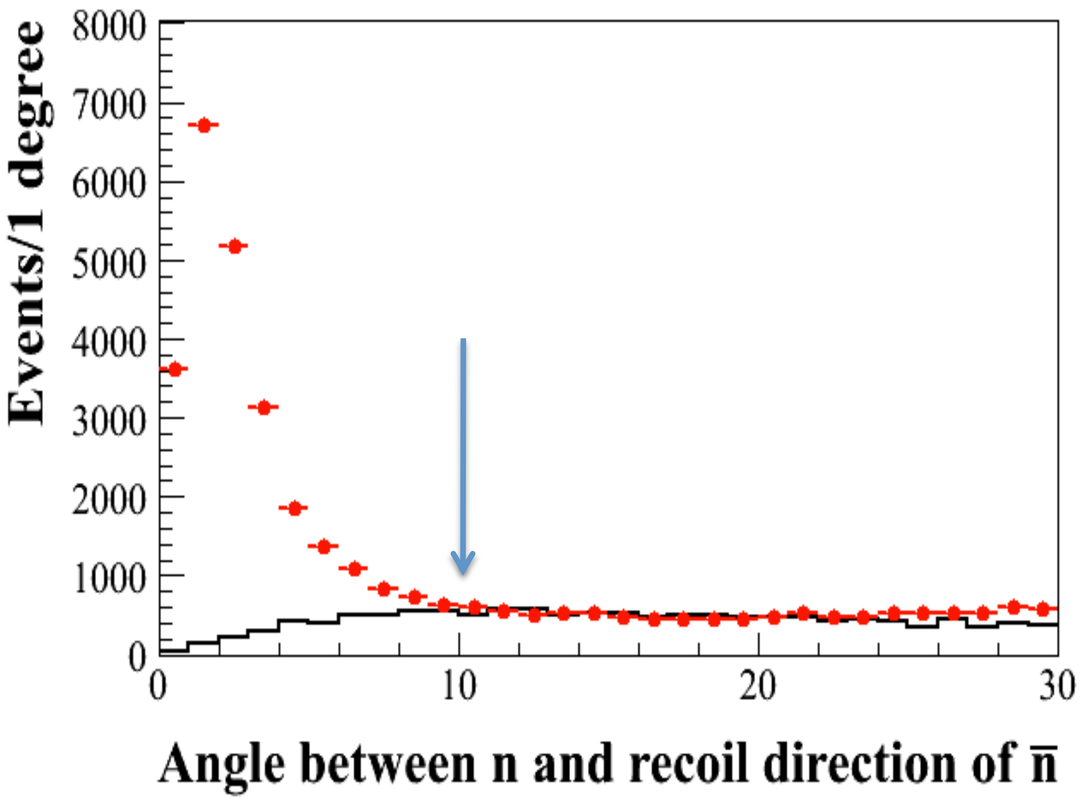
No.	decay chain	final states	iTopo	nEvt	nTot
0	$J/\psi \to \pi^0 \bar{n} n$	$\bar{n}\pi^0 n$	2	1024	1024
1	$J/\psi \to p\bar{p}$	$\bar{p}p$	3	445	1469
2	$J/\psi \to \bar{K}^0 K^0$	$K_L K_L$	5	176	1645
3	$J/\psi \to K^* \bar{K}^0, K^* \to \pi^0 K^0$	$\pi^0 K_L K_L$	1	130	1775
4	$J/\psi \to K^0 \bar{K}^*, \bar{K}^* \to \pi^0 \bar{K}^0$	$\pi^0 K_L K_L$	46	106	1881
5	$J/\psi \to K^0 \pi^0 \bar{K}^0$	$\pi^0 K_L K_L$	4	82	1963
6	$J/\psi \to \bar{\Delta}^- \Delta^- \pi^0, \bar{\Delta}^- \to \pi^+ \bar{n}, \Delta^- \to n\pi^-$	$\pi^- \bar{n} \pi^0 \pi^+ n$	23	81	2044
7	$J/\psi \to \pi^- \pi^0 \pi^+$	$\pi^- \pi^0 \pi^+$	0	62	2106
8	$J/\psi \to \bar{p}\pi^+ p\pi^-$	$\pi^- \bar{p}\pi^+ p$	15	55	2161
9	$J/\psi \to K^0 \bar{K}^0 \gamma$	$K_L K_L \gamma$	11	54	2215
10	$J/\psi \to \bar{\Lambda}\Lambda, \bar{\Lambda} \to \pi^+ \bar{p}, \Lambda \to \pi^- p$	$\pi^- \bar{p}\pi^+ p$	8	49	2264
11	$J/\psi \to K_L K_S, K_S \to \pi^0 \pi^0$	$\pi^0 \pi^0 K_L$	12	44	2308
12	$J/\psi \to \pi^+ n\bar{p}$	$\bar{p}\pi^+ n$	42	25	2333
13	$J/\psi \to K^+ K^-$	$K^- K^+$	137	25	2358
14	$J/\psi \to \Lambda\bar{\Lambda}\gamma, \Lambda \to p\pi^-, \bar{\Lambda} \to \bar{p}\pi^+$	$\pi^- \bar{p}\pi^+ \gamma p$	25	24	2382
15	$J/\psi \to \gamma f_4(2050), f_4(2050) \to \pi^0 \pi^0$	$\pi^0 \pi^0 \gamma$	26	23	2405
16	$J/\psi \to \pi^0 \bar{p}p$	$\bar{p}\pi^0 p$	21	23	2428
17	$J/\psi \to f_0(1710)\gamma, f_0(1710) \to K^0 \bar{K}^0$	$K_L K_L \gamma$	40	22	2450
18	$J/\psi \to \Lambda\bar{\Sigma}^0, \Lambda \to p\pi^-, \bar{\Sigma}^0 \to \bar{\Lambda}\gamma, \bar{\Lambda} \to \pi^+ \bar{p}$	$\pi^- \bar{p}\pi^+ \gamma p$	59	22	2472
19	$J/\psi \to K^0 \bar{K}^0, K_S \to \pi^0 \pi^0$	$\pi^0 \pi^0 K_L$	32	22	2494
20	$J/\psi \to \Lambda\bar{\Lambda}, \Lambda \to \pi^0 n, \bar{\Lambda} \to \pi^+ \bar{p}$	$\bar{p}\pi^0 \pi^+ n$	48	21	2515
21	$J/\psi \to K^* \bar{K}^0, K^* \to K^+ \pi^-$	$\pi^- K_L K^+$	65	20	2535
22	$J/\psi \to \bar{\Lambda}\Sigma^0, \bar{\Lambda} \to \pi^+ \bar{p}, \Sigma^0 \to \gamma\Lambda, \Lambda \to \pi^- p$	$\pi^- \bar{p}\pi^+ \gamma p$	16	18	2553
23	$J/\psi \to K^+ K^{*-}, K^{*-} \to \pi^- \bar{K}^0$	$\pi^- K_L K^+$	30	18	2571
24	$J/\psi \to K^0 K^- \pi^+$	$K^- K_L \pi^+$	9	17	2588
25	$J/\psi \to \rho^- \pi^+, \rho^- \to \pi^0 \pi^-$	$\pi^- \pi^0 \pi^+$	52	17	2605
26	$J/\psi \to K^- K^{*+}, K^{*+} \to K^0 \pi^+$	$K^- K_L \pi^+$	128	17	2622
27	$J/\psi \to \pi^- \rho^+, \rho^+ \to \pi^0 \pi^+$	$\pi^- \pi^0 \pi^+$	58	17	2639
28	$J/\psi \to \bar{p}\Delta^{++}\pi^-, \Delta^{++} \to p\pi^+$	$\pi^- \bar{p}\pi^+ p$	109	16	2655
29	$J/\psi \to \pi^0 \bar{n}\pi^0 n$	$\bar{n}\pi^0 \pi^0 n$	13	14	2669

Main bkg.

Will be taken into account as systematic error.

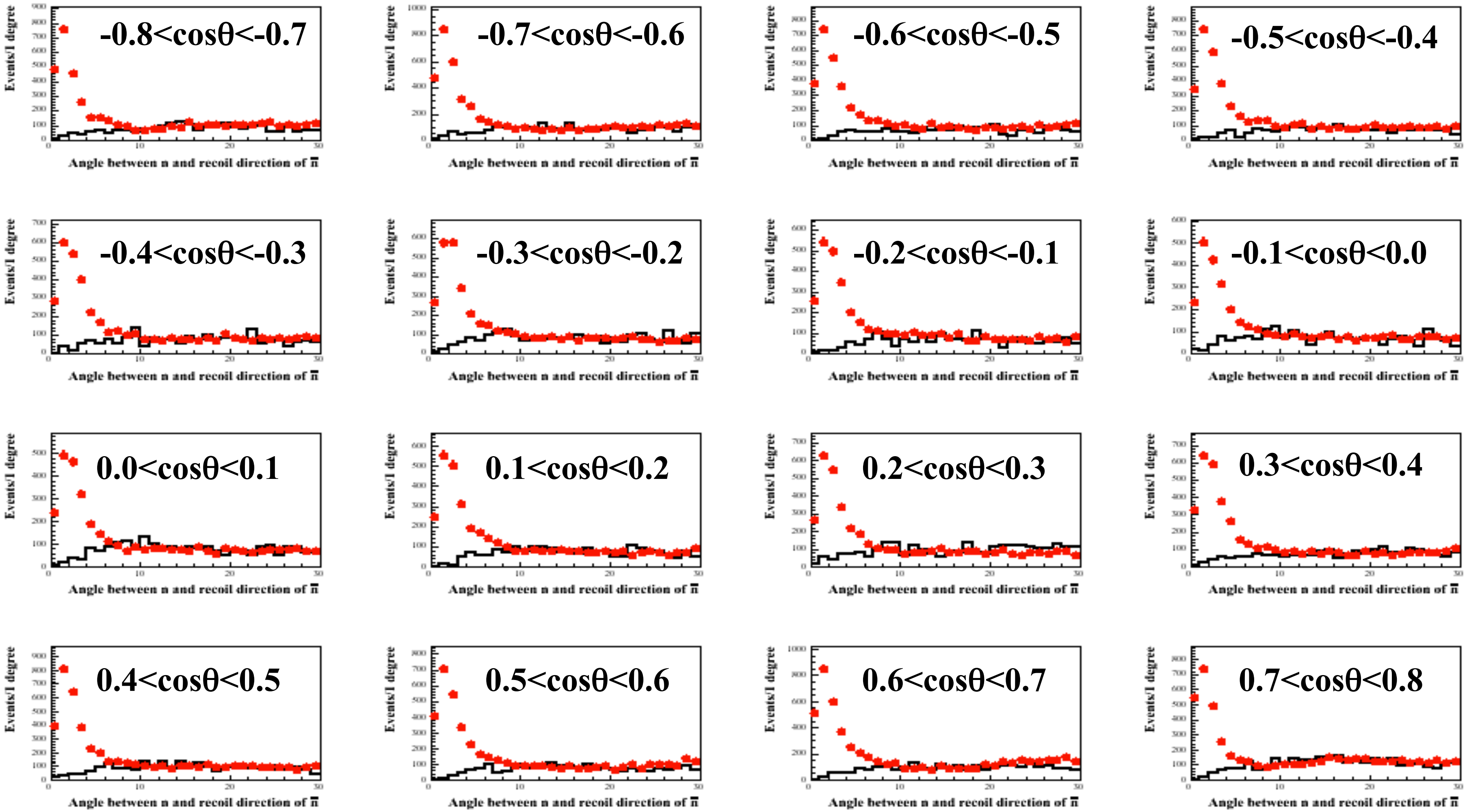
Forbidden

Use bkg shape of Monte Carlo $J/\psi \rightarrow \pi^0$nnbar to estimate number of bkg events in signal region



Bkg shape obtained from $J/psi \rightarrow \pi^0$nnbar in MC.
Normalize data and Bkg in sideband $10 \sim 20^o$.
signal region: angle$<10^o$

Number of signal extraction in every polar angle region



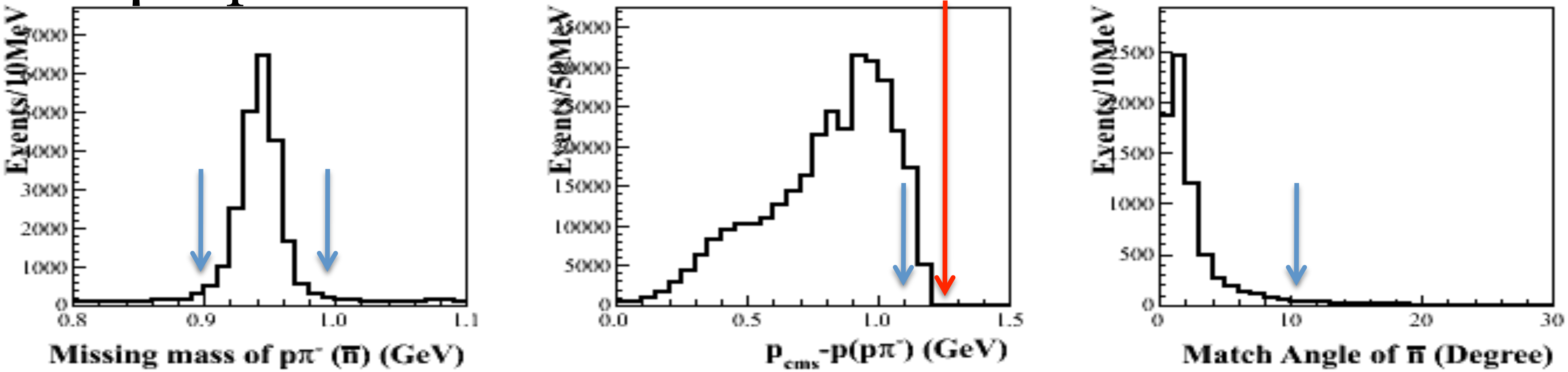
Event selection for $J/\psi \rightarrow p\bar{n}\pi^- + cc.$ (calibration channel)

- Identify P: Prob(p)>Prob(π),Prob(p)>Prob(K),Prob(p)>0.001
- Identify π: Prob(π)>Prob(p),Prob(π)>Prob(K),Prob(π)>0.001
- Recoil mass of pπ ~ $|M-M_n|<0.05$GeV
- Recoil momentum of pπ ~(1.1~1.2) GeV (near by momentum of $n\bar{n}$ in $J/\psi \rightarrow n\bar{n}$)
- Angle between recoil direction and N(Nbar) candidate shower ~ 10^o

Distributions of J/ψ→pn̄π⁻ + cc.

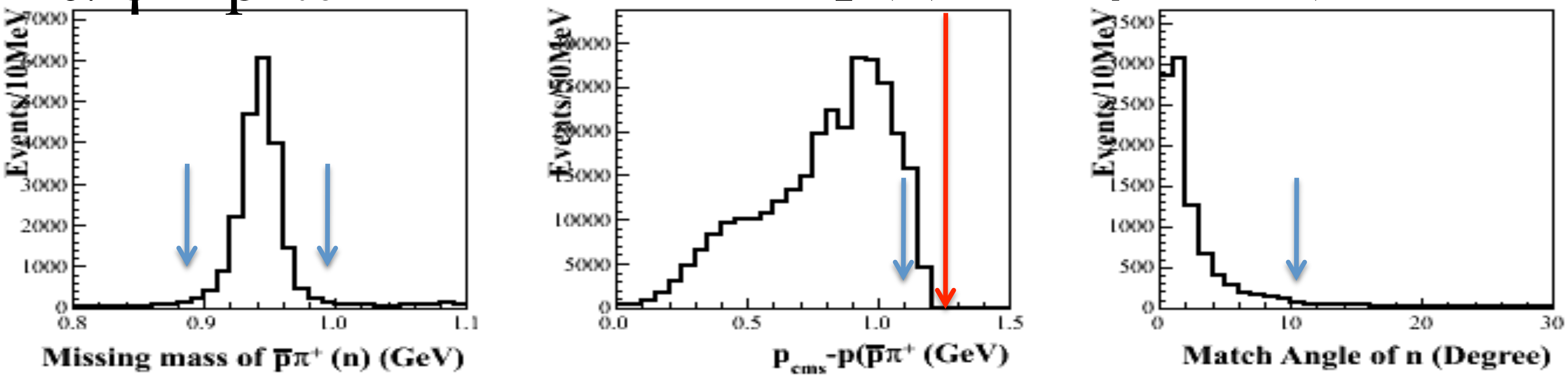
J/ψ→pn̄π⁻

p(n̄) in J/ψ→nn̄ (1.23GeV)

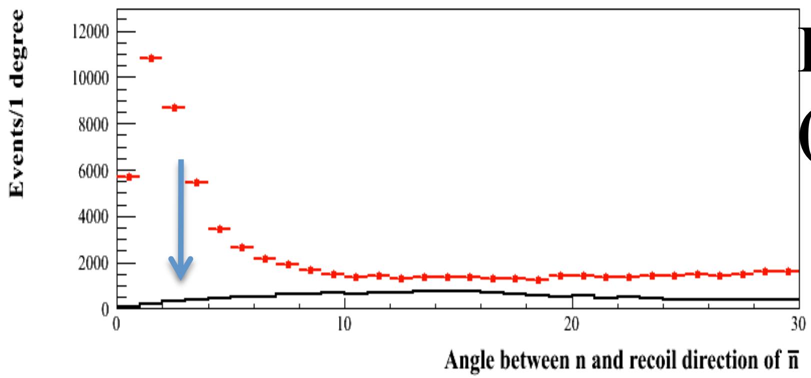


J/ψ→p̄nπ⁺

p(n) in J/ψ→nn̄ (1.23GeV)

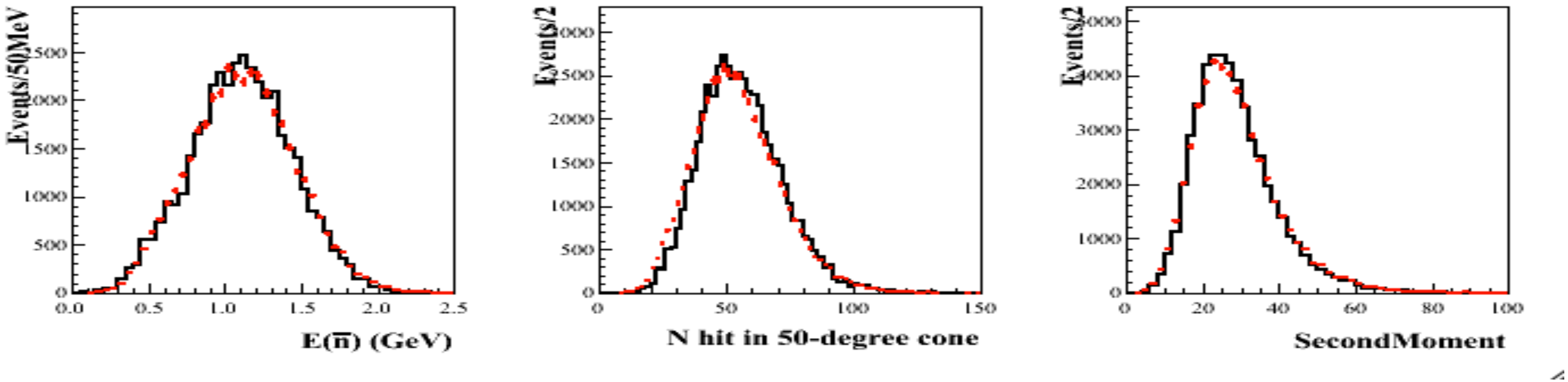


Comparisons of $\bar{n}$ samples in $J/\psi \rightarrow \bar{n}n$ (red cross) and $J/\psi \rightarrow p\bar{n}\pi^-$(hist)



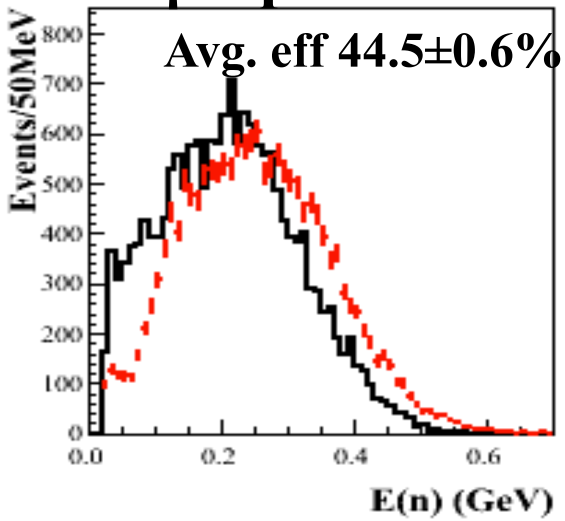
Events having small back-to-back angle (2^o) are taken as $n\bar{n}$ sample in $J/\psi \rightarrow n\bar{n}$

$J/\psi \rightarrow p\bar{n}\pi^-$ is used to calibrate efficiency of $\bar{n}$ selection



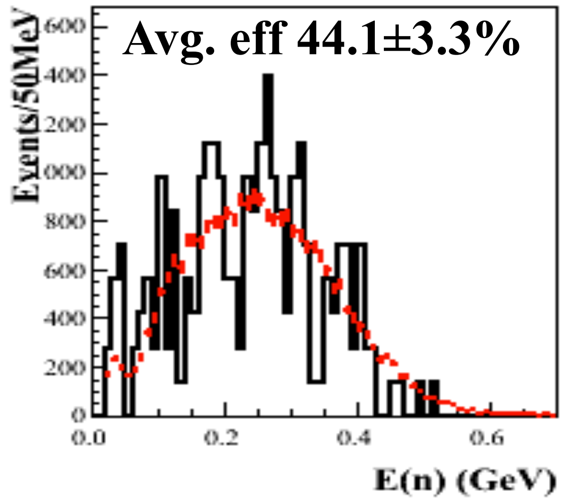
Comparisons of n samples in $J/\psi \to n\bar{n}$ (red cross) , $J/\psi \to \bar{p}n\pi^+$ and $\psi' \to \pi^+\pi^- J/\psi, J/\psi \to \bar{p}n\pi^+$

$J/\psi \to \bar{p}n\pi^+$



Momentum of n (1.1-1.2)GeV

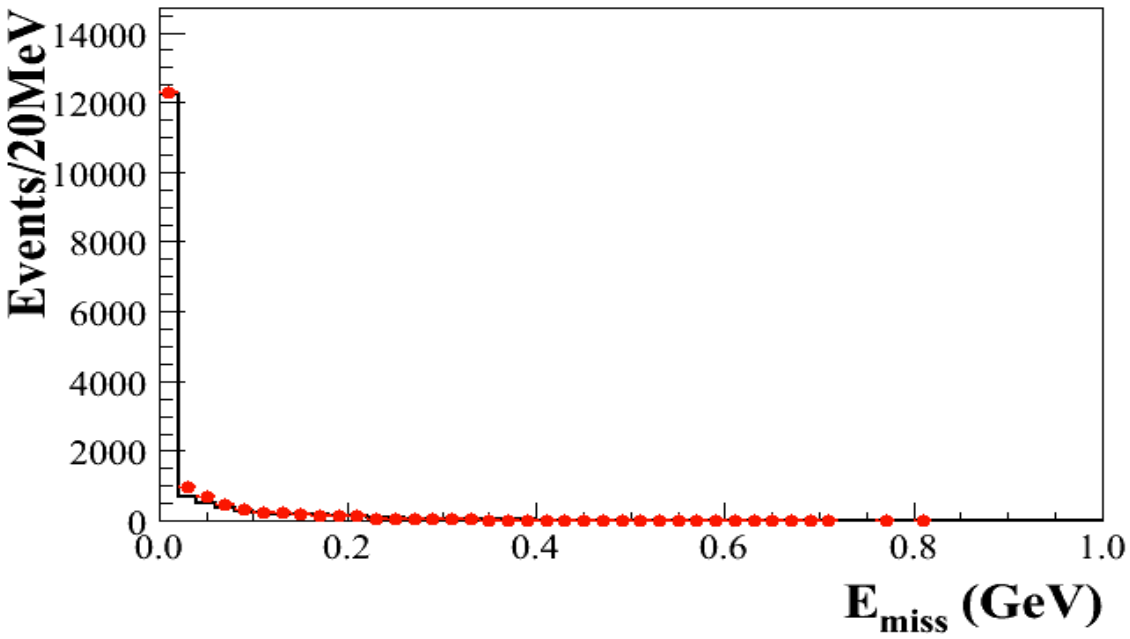
$\psi' \to \pi^+\pi^- J/\psi, J/\psi \to \bar{p}n\pi^+$



Momentum of n (1.2-1.3)GeV

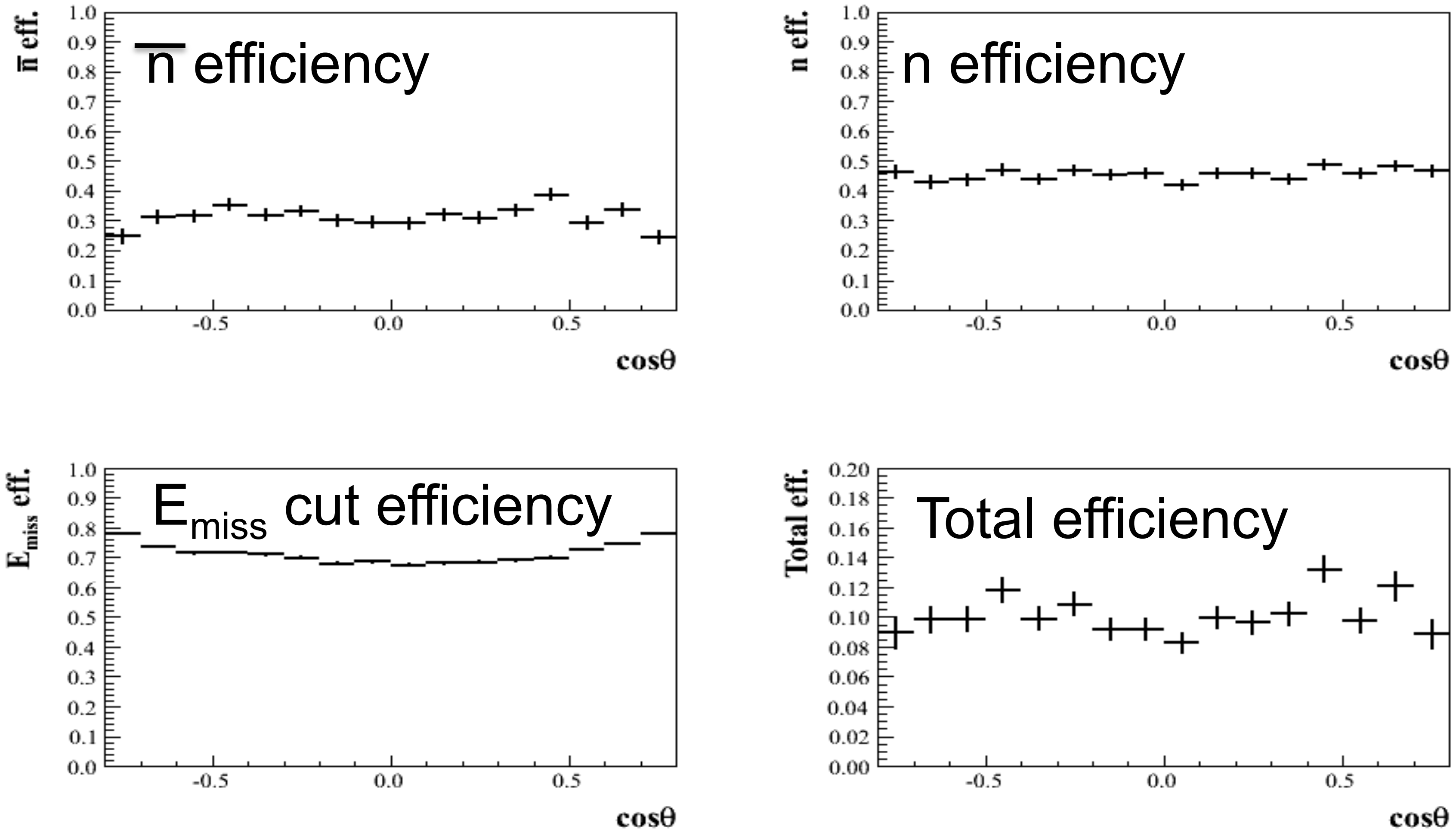
$J/\psi \to \bar{p}n\pi^+$ is used to calibrate efficiency of n selection,
$\psi' \to \pi^+\pi^- J/\psi, J/\psi \to \bar{p}n\pi^+$ is used to estimate systematic error.

E_{miss} in $J/\psi \rightarrow n\bar{n}$ and $J/\psi \rightarrow p\bar{p}$

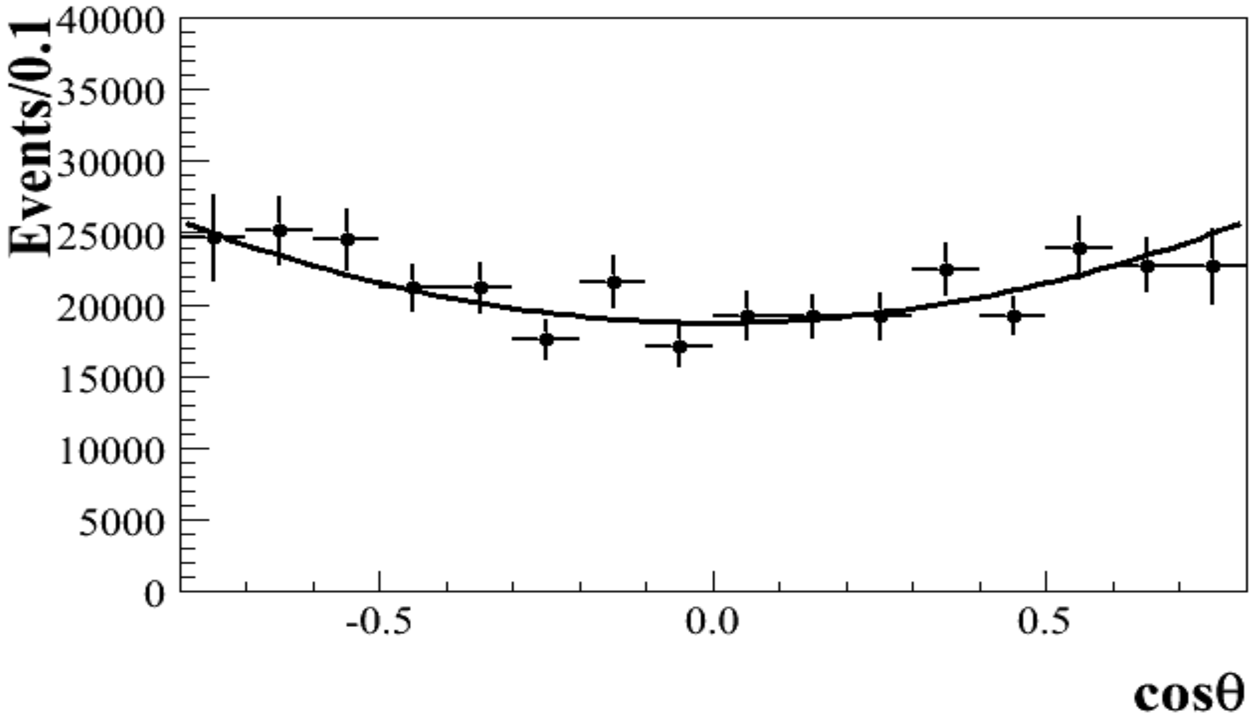


The $J/\psi \rightarrow p\bar{p}$ sample is selected by means of MDC information only.
It is used to calibrate the efficiency of E_{miss} cut.
We select showers in EMC in $J/\psi \rightarrow p\bar{p}$ sample
with the same method as $J/\psi \rightarrow n\bar{n}$.

Efficiency corrections



Corrected number of events vs. polar angle and the fitting



$A(1+\alpha\cos^2\theta)\varepsilon(\cos\theta)$

$\alpha = 0.59 \pm 0.16$ ($\alpha(pp) = 0.628 \pm 0.013 \pm 0.032$)

Branching ratio

Correction for angular acceptance

$$N_{cor} = N_i(\cos\theta)/\varepsilon_i(\cos q) \bullet [\int_{-1}^{1}(1+\alpha\cos^2\theta)d\theta/\int_{-0.8}^{0.8}(1+\alpha\cos^2\theta)d\theta)]$$

α	0.59 ± 0.16
N_{cor}	471795 ± 11721
$N(J/\psi)$	2.26×10^8
Br	$(2.01 \pm 0.05) \times 10^{-3}$

Systematic errors and results

	α= 0.59±0.16	Br = (2.01±0.005)×10^{-3}
Trigger(2%)	**0.03**	**0.04**
Eff (nbar)	**0.02**	**0.02**
Eff (n)	**0.05**	**0.06**
Error of α	**-**	**0.03**
Background	**0.08**	**0.04**
N(J/ψ) (1.2%)	**-**	**0.02**
Total	**0.10**	**0.09 (Preliminary)**

Br(J/ψ→nn) = (2.01±0.05±0.09)×10^{-3}
α=0.59±0.16±0.10

Summary

We have measured

$Br(J/\psi \rightarrow p\bar{p}) = (2.179 \pm 0.004 \pm 0.042) \times 10^{-3}$
$\alpha = 0.628 \pm 0.013 \pm 0.032$
PDG: $Br(J/\psi \rightarrow p\bar{p}) = (2.17 \pm 0.07) \times 10^{-3}$
BESII: $\alpha = 0.676 \pm 0.036 \pm 0.042$

$Br(J/\psi \rightarrow n\bar{n}) = (2.01 \pm 0.05 \pm 0.09) \times 10^{-3}$
$\alpha = 0.59 \pm 0.16 \pm 10$
PDG: $Br(J/\psi \rightarrow n\bar{n}) = (2.2 \pm 0.4) \times 10^{-3}$

Our $Br(J/\psi \rightarrow n\bar{n})$ is much larger than $\sim 1.5 \times 10^{-3}$ which is expected with 0 phase angle assumption.
The consistency between $Br(J/\psi \rightarrow p\bar{p})$ and $Br(J/\psi \rightarrow n\bar{n})$ suggests a large phase angle ($\sim 90^{o}$) between the strong and the em amplitude.

Thanks!

Backup

Estimation for real A_g, A_{em} (0 phase)

- $|A_{em}|^2 = B(J/\psi \rightarrow \mu\mu) * R(3.1\text{GeV}) * \sigma(pp)/\sigma(tot)$

  $= B(J/\psi \rightarrow \mu\mu) * R(3.1\text{GeV}) * \sigma(pp)/$

  $(\sigma(\mu\mu) * R(3.1\text{GeV})/3.1^2)$

  $= B(J/\psi \rightarrow \mu\mu) * \sigma(pp)/\sigma(\mu\mu) * 1/9.61$

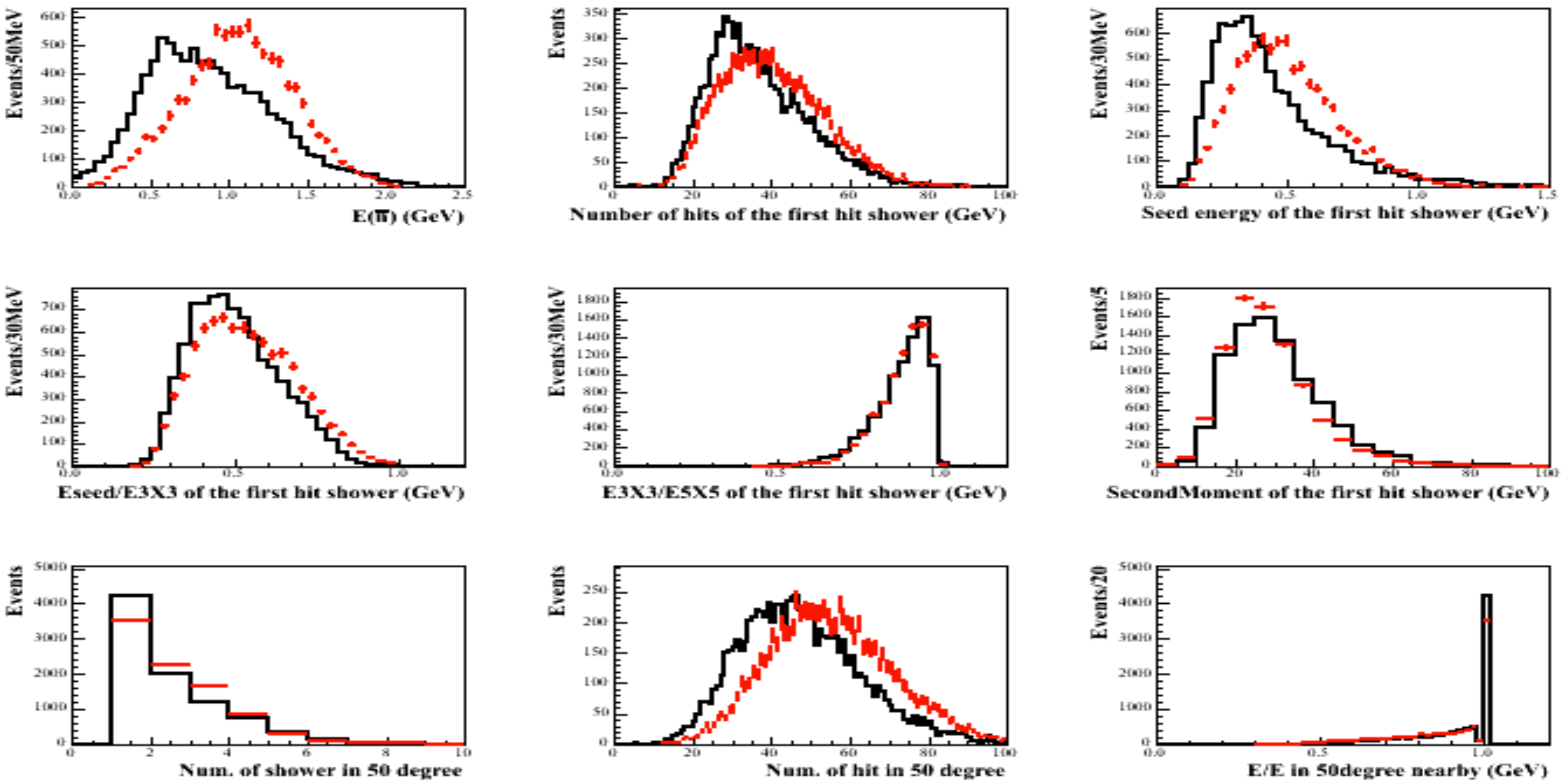
  $= (5.9 \times 10^{-2}) * (4\text{nb}/86.8\text{nb}) * 1/9.61$

  $= 0.28 \times 10^{-4}$ $(|A_{em}| = 0.53 \times 10^{-2})$

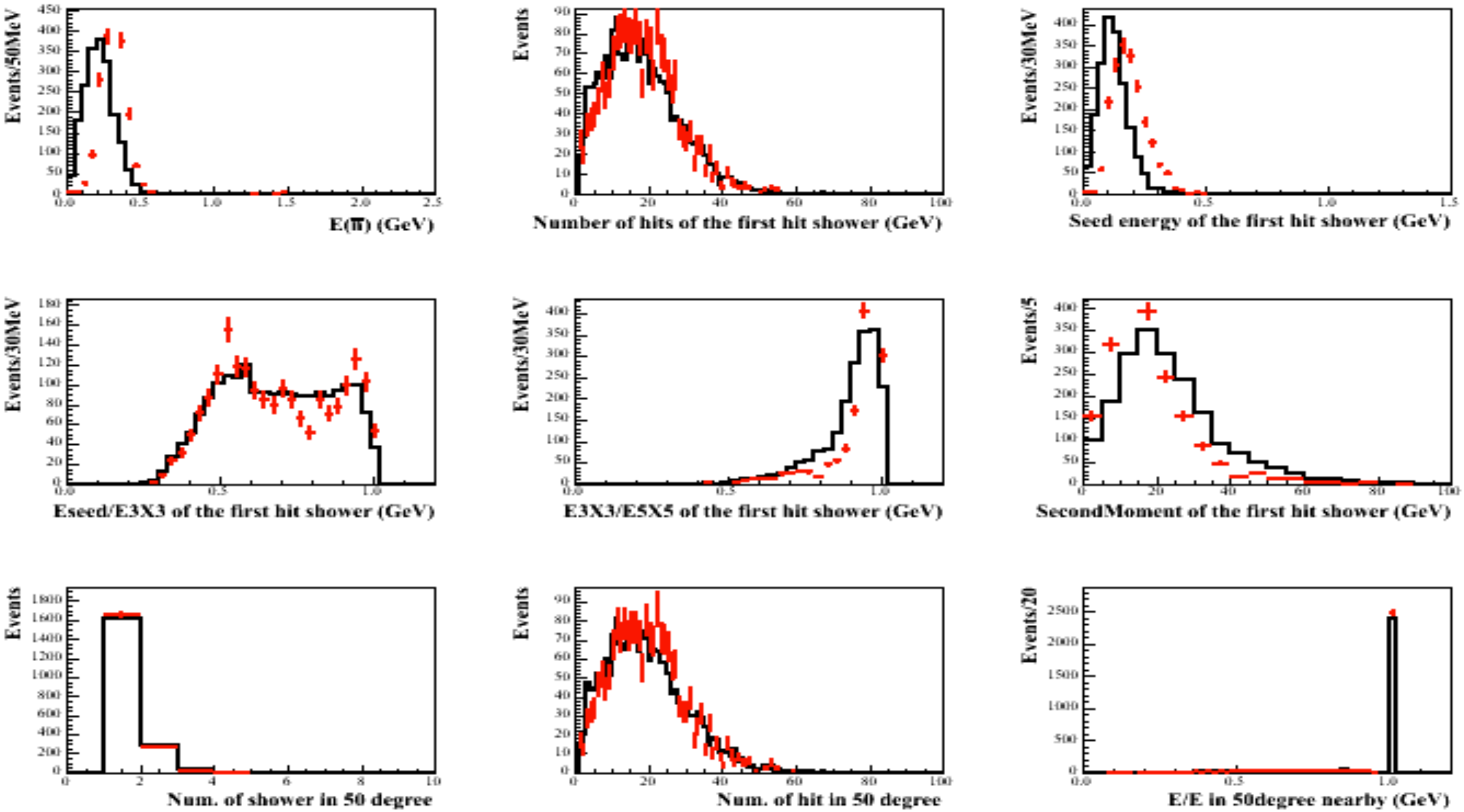
$|A_g + A_{em}|^2 = B(J/\psi \rightarrow pp)$, if real, $A_g = 4.2 \times 10^{-2}$

$B(J/\psi \rightarrow nn) = |A_g - (1/2)A_{em}|^2 = 1.5 \times 10^{-3}$

DATA/MC for Nbar



DATA/MC for N



Events/50MeV
Events
Number of hits of the first hit shower (GeV)
Events/30MeV
Seed energy of the first hit shower (GeV)
Events/30MeV
Eseed/E3X3 of the first hit shower (GeV)
Events/30MeV
E3X3/E5X5 of the first hit shower (GeV)
Events/5
SecondMoment of the first hit shower (GeV)
Events
Num. of shower in 50 degree
Events
Num. of hit in 50 degree
Events/20
E/E in 50degree nearby (GeV)