Study of the Excited Baryon States at BES

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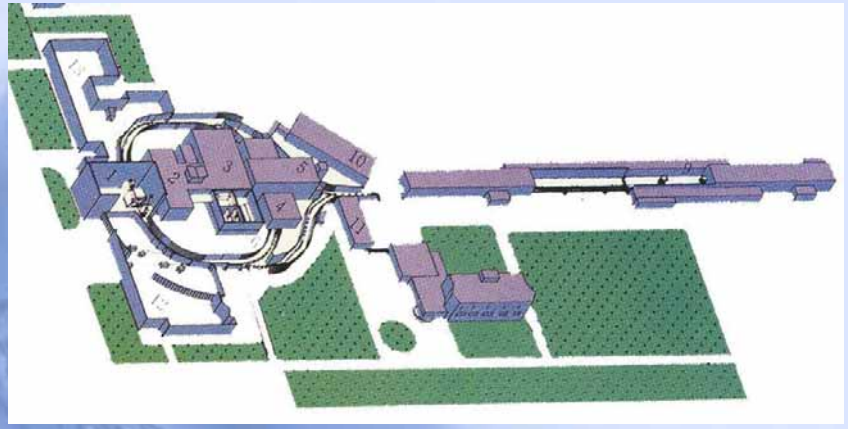
Outline

- Introduction
- PWA results of $J/\psi \to p\bar{p}\eta$ (BESI)
- Preliminary studies of $J/\psi \to p\bar{n}\pi^-$ and $p\bar{p}K\pi$ (BESII)
- Mass plots of $J/\psi \to p\bar{p}\pi^0$ and $p\bar{p}\omega$ (BESII)
- Summary

The Beijing Electron Positron Collider

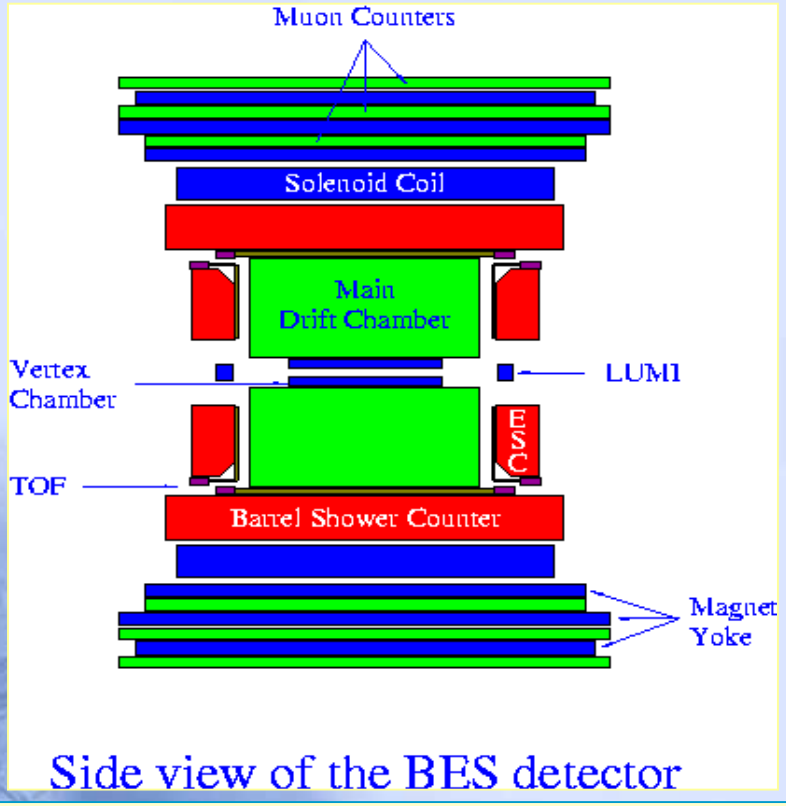
L ~ ~5 $\times 10^{30}$ /cm^2·s at J/ψ peak

E_{cm}~2-5 GeV

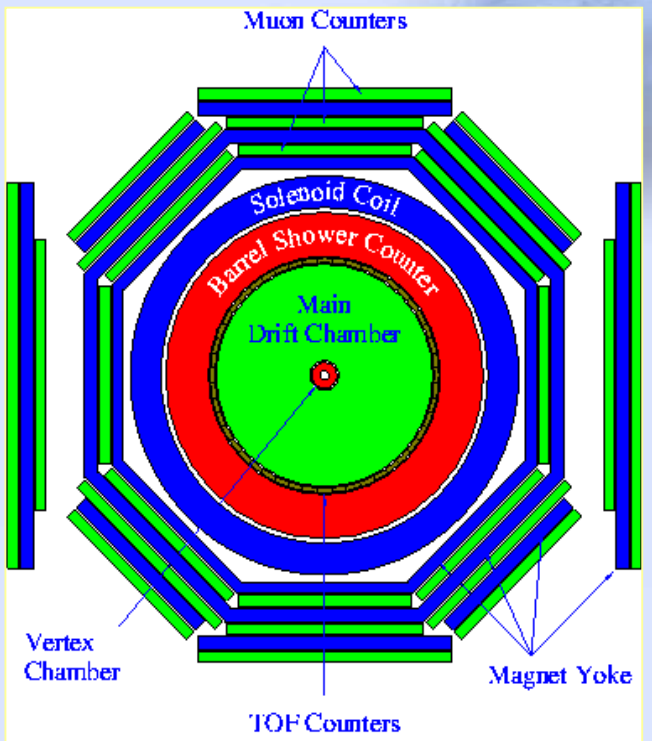


An unique e^+e^- machine in the world in the τ-charm energy region since 1989

BESII Detector



Side view of the BES detector



End view of the BES detector

VC: σ_{xy} = 100 μm
MDC: σ_{xy} = 220 μm
$\sigma_{dE/dx}$ = 8.5 %
$\Delta p/p = 1.7\sqrt{(1+p^2)}$

TOF: σ_T = 180 ps
BSC: $\Delta E/\sqrt{E}$ = 22 %
σ_ϕ = 7.9 mr
σ_z = 2.3 cm

μ counter: $\sigma_{r\phi}$ = 3 cm
σ_z = 5.5 cm
B field: 0.4 T

Data Collected with BESI and BESII

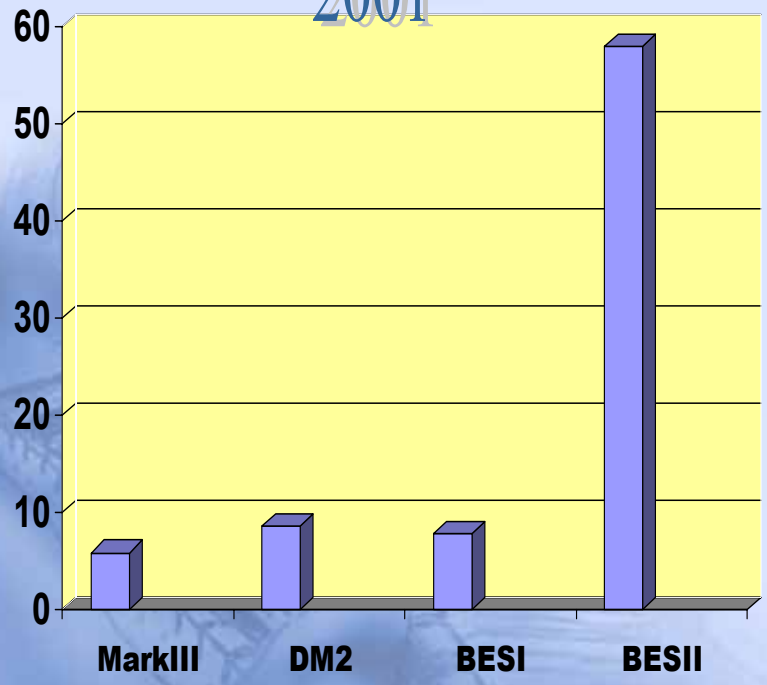
Detector	E_{CM}(GeV)	Physics	Data Sample
BES I	3.097	J/ψ	7.8×10^6
	3.686	$\psi(2S)$	3.96×10^6
	4.03	D_S, D	$22.3pb^{-1}$
	3.55, m_τ scan	m_τ	$5pb^{-1}$
BES II	2-5 GeV R scan	R, α_{QED}, g-2	6+85 points
	$\psi(2S)$ scan	res. para.	24 points
	3.097	J/ψ	58×10^6
	ψ'' scan	res. para.	$\sim 2.2pb^{-1}$
	3.686	$\psi(2S)$	$\sim 14 \times 10^6$

World J/ψ and ψ(2S) Samples (10^6)

Largest from BES

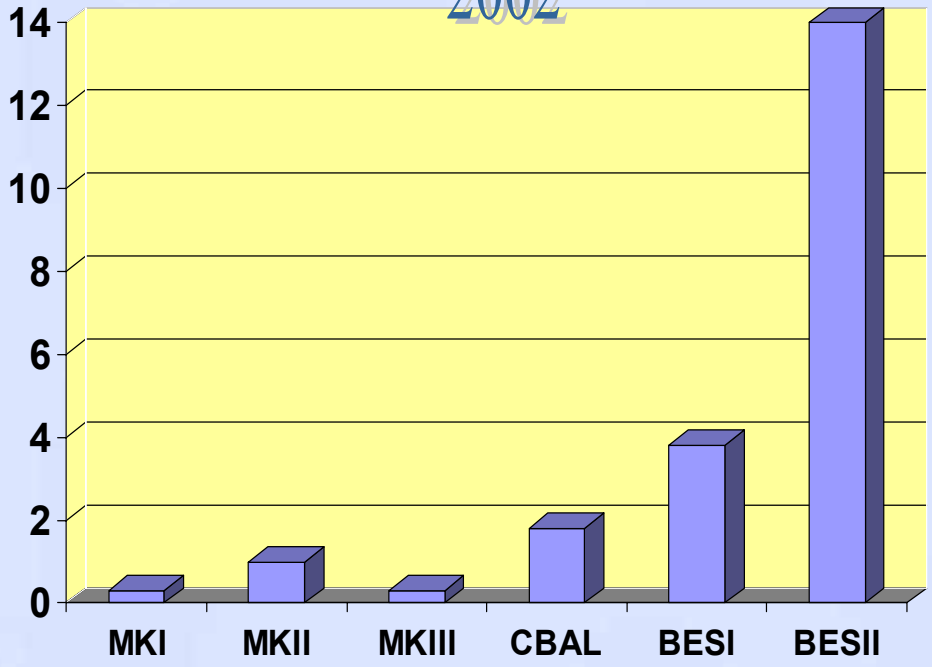
J/ψ

2001

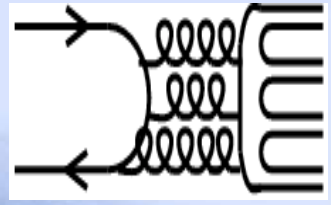


ψ(2S)

2002

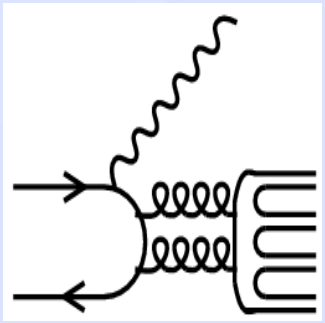


Introduction to J/ψ Physics

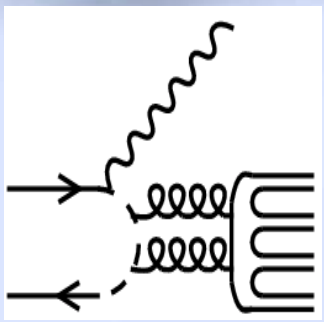


3-gluon

Electromagnetic



Radiative



Via η_c

- a good lab in studying hadron spectroscopy
- a good lab for excited baryon states
- hunting for glueballs in J/ψ radiative decays

Study of Excited Baryon States

Motivation

- Probe the internal structure of light quark baryons
- Search for missing baryons predicted by quark model
- Obtain a better understanding of the strong interaction force in the non-perturbative regime

Experimental status

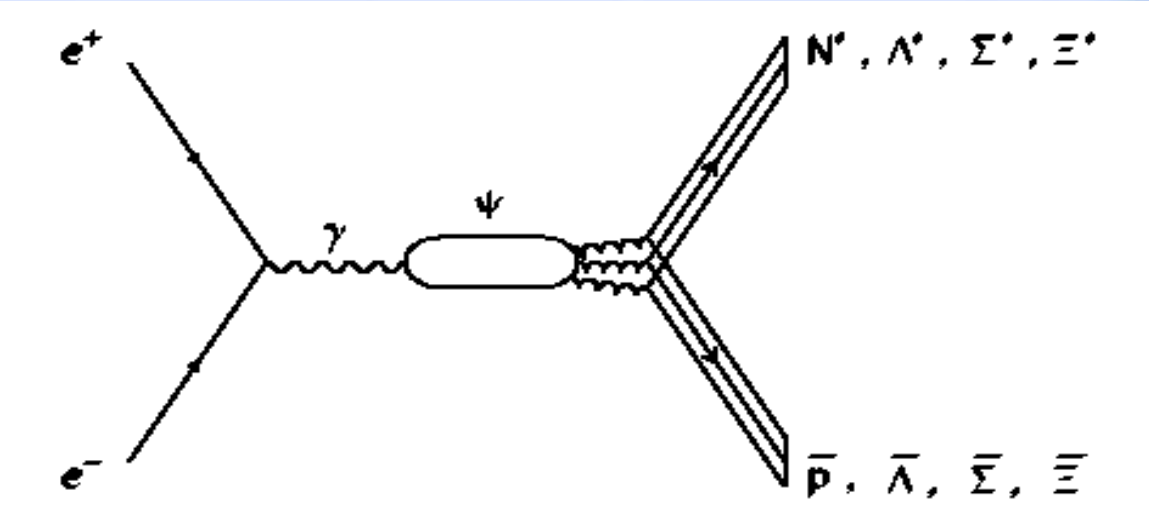
- the present knowledge came almost entirely from the old generation of πN experiments more than 20 years ago
- Jefferson Lab. electro&photo-production exps. started some years ago
- CB-ELSA facility at Bonn University
- SPRING8 in Japan
- GRAAL at Grenoble of France started exps

J/ψ decays

- relatively large branching ratios

processes	branching ratios(10^{-3})	N* decays
$J/\psi \to p\bar{p}\pi^0$	2.0±0.1	$N^* \to \pi N$
$J/\psi \to p\bar{p}\pi^+\pi^-$	6.0±0.5	$N^* \to \pi^+\pi^- N$
$J/\psi \to \bar{p}\pi^+ n$	2.0±0.1	$N^* \to \pi N$
$J/\psi \to p\bar{p}\eta$	2.1±0.2	$N^* \to \eta N$
$J/\psi \to p\bar{p}\eta'$	0.9±0.4	$N^* \to \eta' N$
$J/\psi \to p\bar{p}\omega$	1.3±0.3	$N^* \to \omega N$

- Pure isospin 1/2



Feynman diagram of the production of $\bar{p}N^*, \bar{\Lambda}\Lambda^*, \bar{\Sigma}\Sigma^*, \bar{\Xi}\Xi^*$

For $J/\psi \to N\bar{N}\pi$ and $J/\psi \to N\bar{N}\pi\pi$, $N\pi\pi$ and $N\pi$ systems are limited to be pure isospin 1/2.

Introduction to PWA

- construct amplitude A_i for i-th possible partial wave

$$A_i = A^i_{prod} \cdot A^i_X \cdot BW^i_X \cdot A^i_{decay}$$

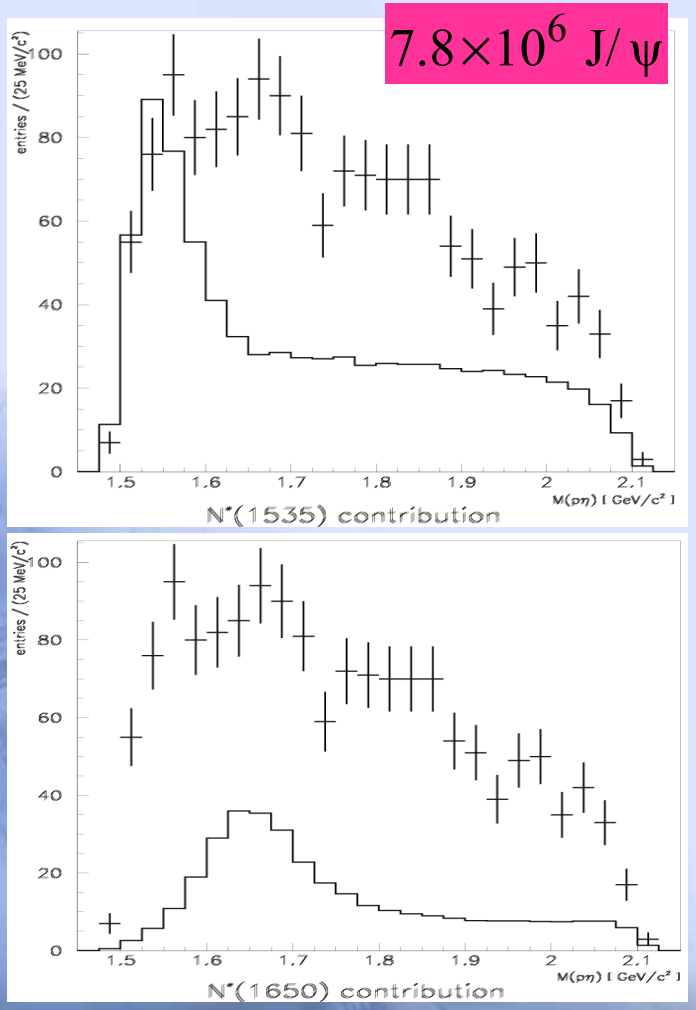
- differential cross section is:

$$\frac{d\sigma}{d\Phi} = |\sum_i A_i|^2 + A_{bg}$$

- likelihood function $\ln L = \sum_{i=1}^{N} \ln\left(\frac{d\sigma}{d\Phi} / \sigma \right)$

- maximum likelihood method

$J/\psi \to p\bar{p}\eta$ from BESI data



- two well known N* states found
- $N(1535)S_{11}$:
  $M = 1530 \pm 10$ MeV/c²
  $\Gamma = 95 \pm 25$ MeV/c²
  PDG2002:
  M=1520~1555MeV/c²
  Γ = 100~200 MeV/c²

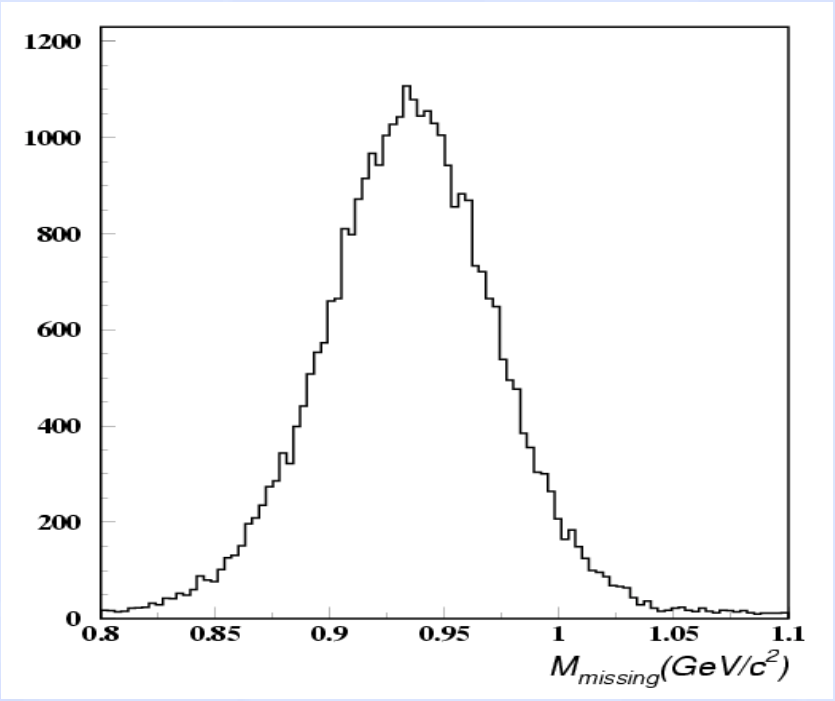
- $N(1650)S_{11}$:
  $M = 1647 \pm 20$ MeV/c²
  $\Gamma = 145^{+80}_{-45}$ MeV/c²
  PDG2002:
  M=1640~1680MeV/c²
  Γ = 145~190 MeV/c²

$J/\psi \to p\bar{n}\pi^-$ from BESII data

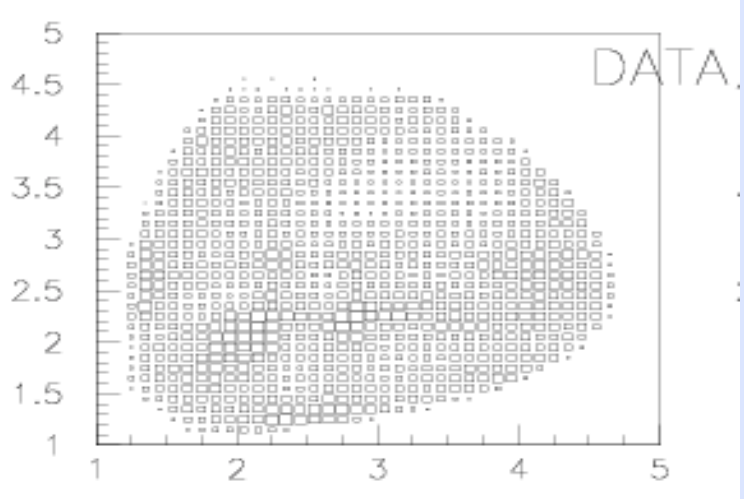
- Events selection

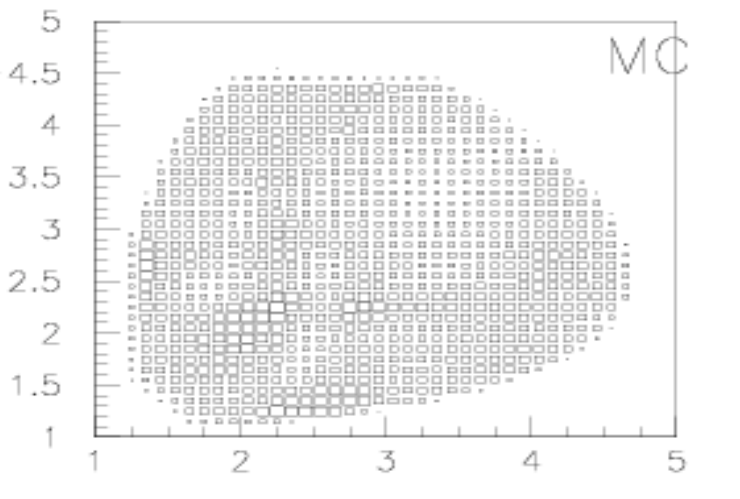
- 2 good charged tracks
- Q1+Q2 = 0
- $|\cos\theta| < 0.85$
- PID: TOF and dE/dx
- *Prob*(χ^2, 1C) > 0.055
- 0.78 GeV < $M_{missing}$ < 1.13 GeV
- $M_{p\pi}$ > 1.13 GeV

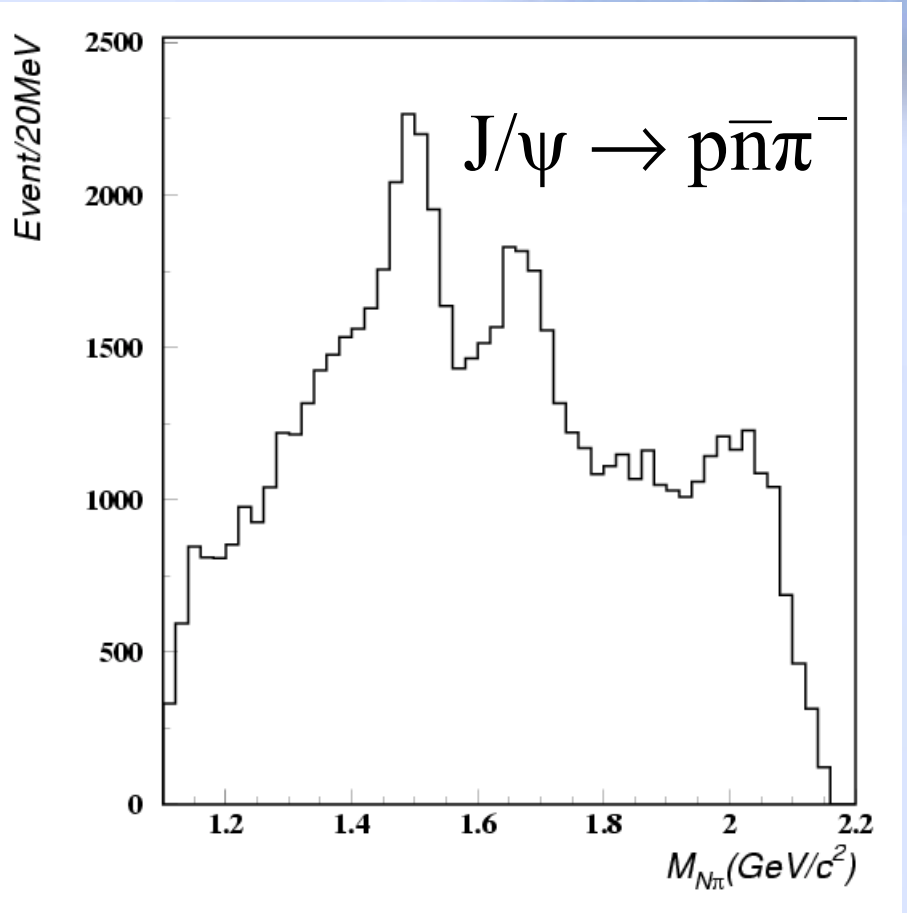
BESII 27M (preliminary)



BESII 27M (preliminary)





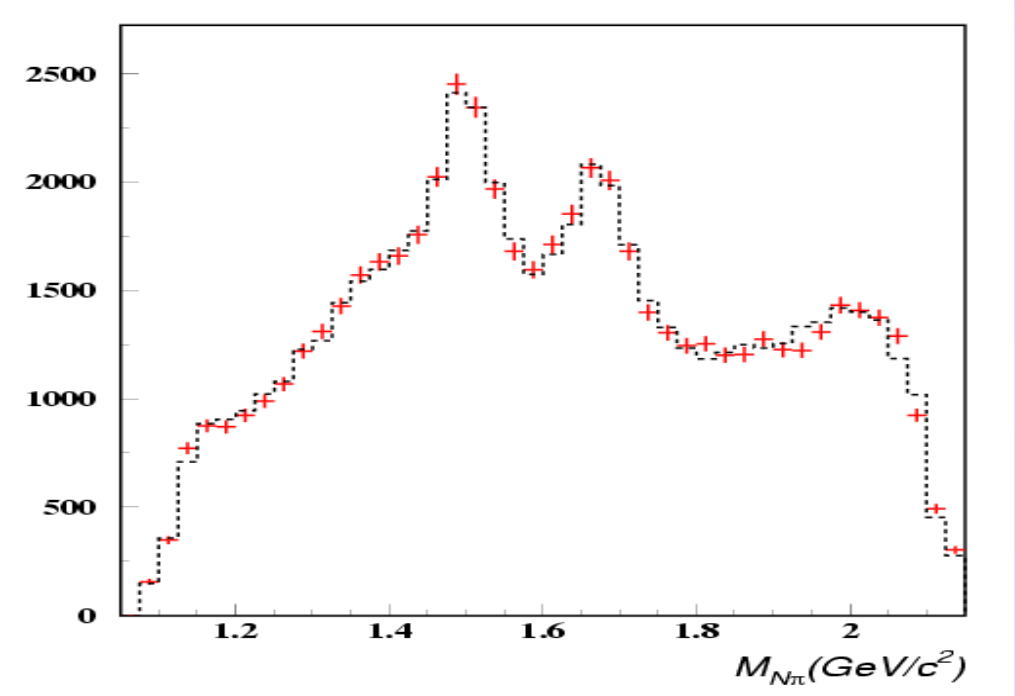


- partial wave analysis is performed
- partial waves used in the fit:

N*(1440) (1/2+)
N*(1520) (3/2-)
N*(1535) (1/2-)
N*(1650) (1/2-)
N*(1675) (5/2-)
N*(1680) (5/2+)
N*(2020) (3/2+)
……

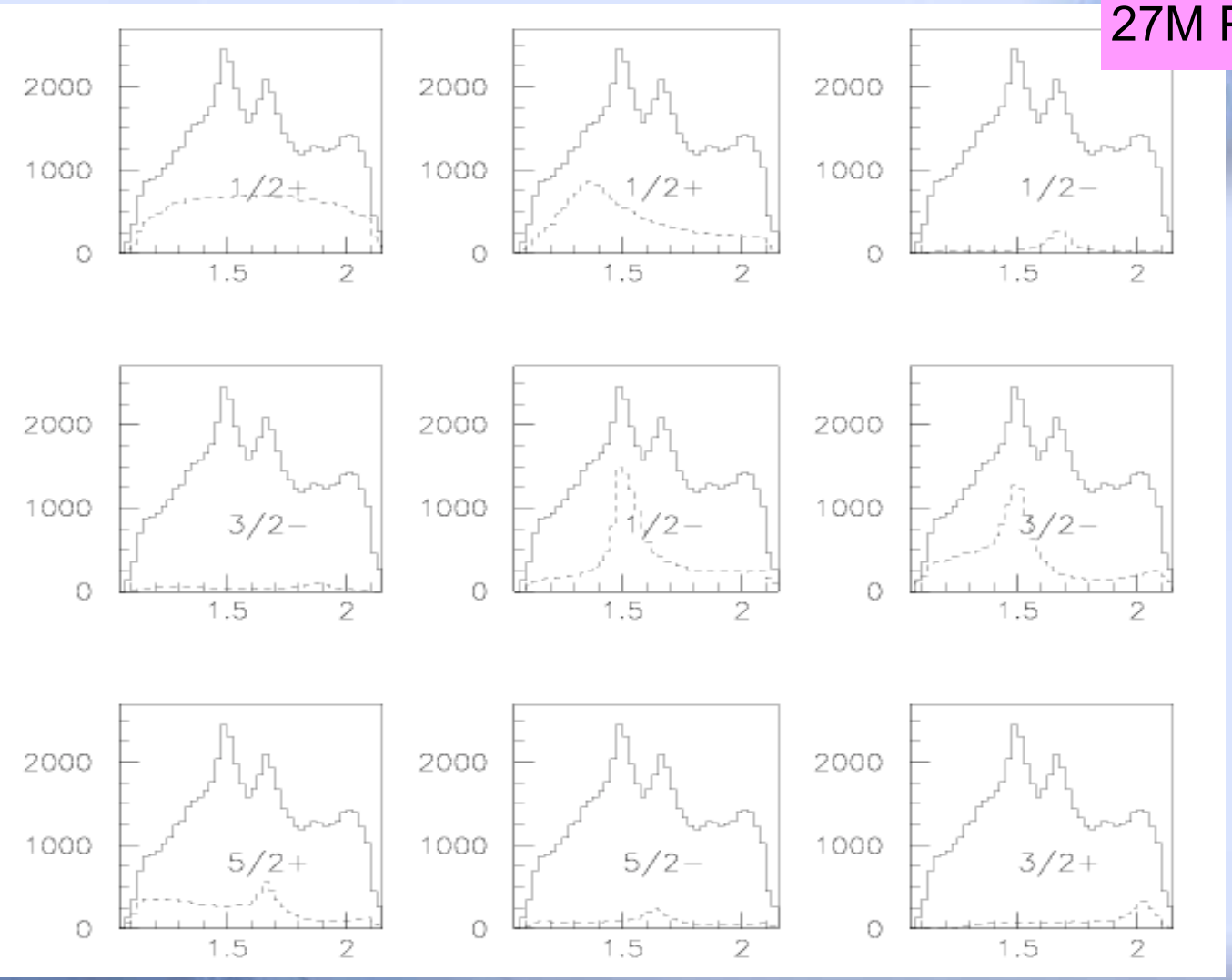
Where, N*(1440), N*(1520), N*(1535) and N*(1680) are significant.

BESII 27M (preliminary)

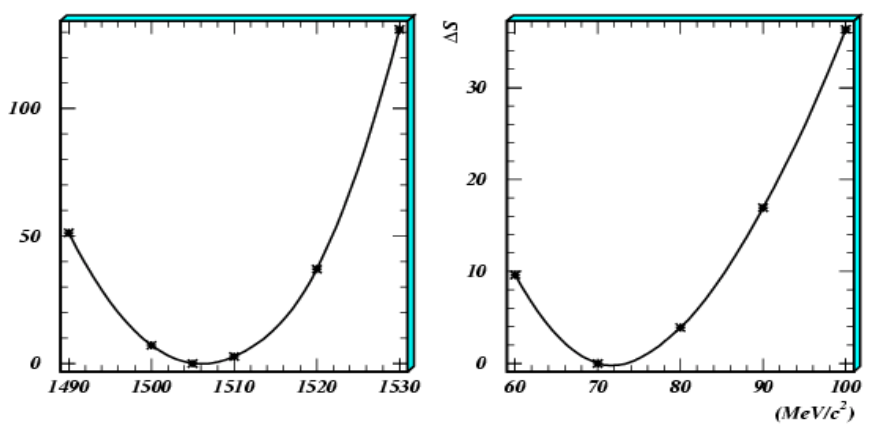


Contribution of each component

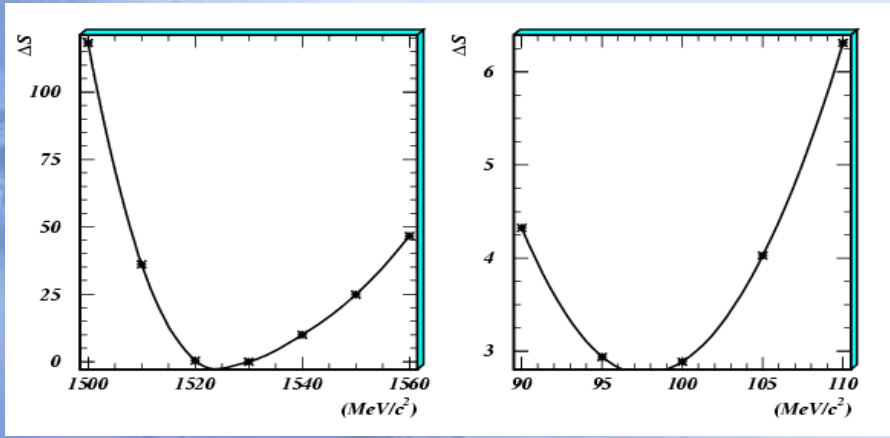
27M Preliminary



scan of N*(1520) mass and width



scan of N*(1535) mass and width



BESII 27M (preliminary)

- N*(1520)(3/2-)
  M = 1510 ±5 MeV/c^2
  Γ = 110 ± 5 MeV/c^2
  PDG2002:
  M=1515~1530MeV/c^2
  Γ = 110~135 MeV/c^2

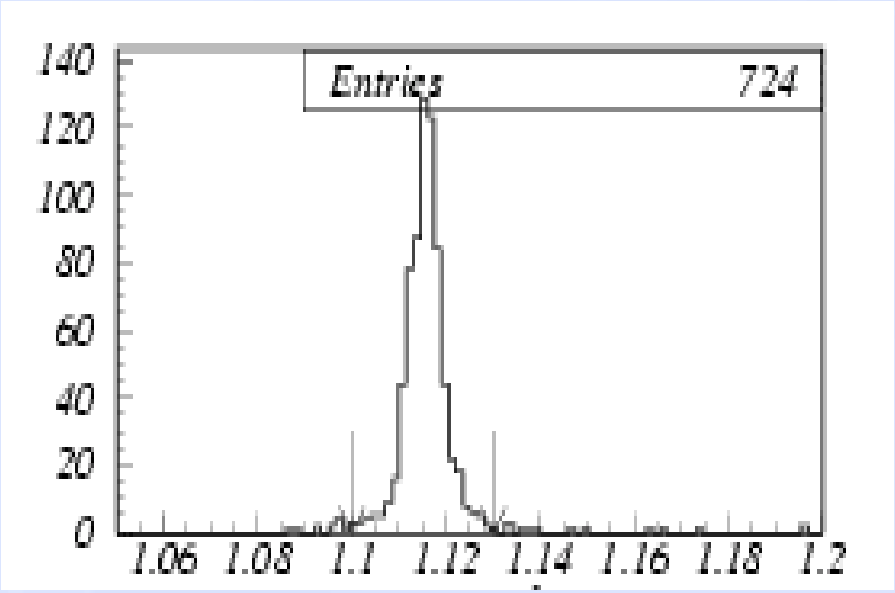
- N*(1535)(1/2-)
  M = 1535 ±15 MeV/c^2
  Γ = 170 ± 20 MeV/c^2
  PDG2002:
  M=1520~1555MeV/c^2
  Γ = 100~200 MeV/c^2

$J/\psi \to p\bar{p}K\pi$ from BESII data

BESII 58M (preliminary)

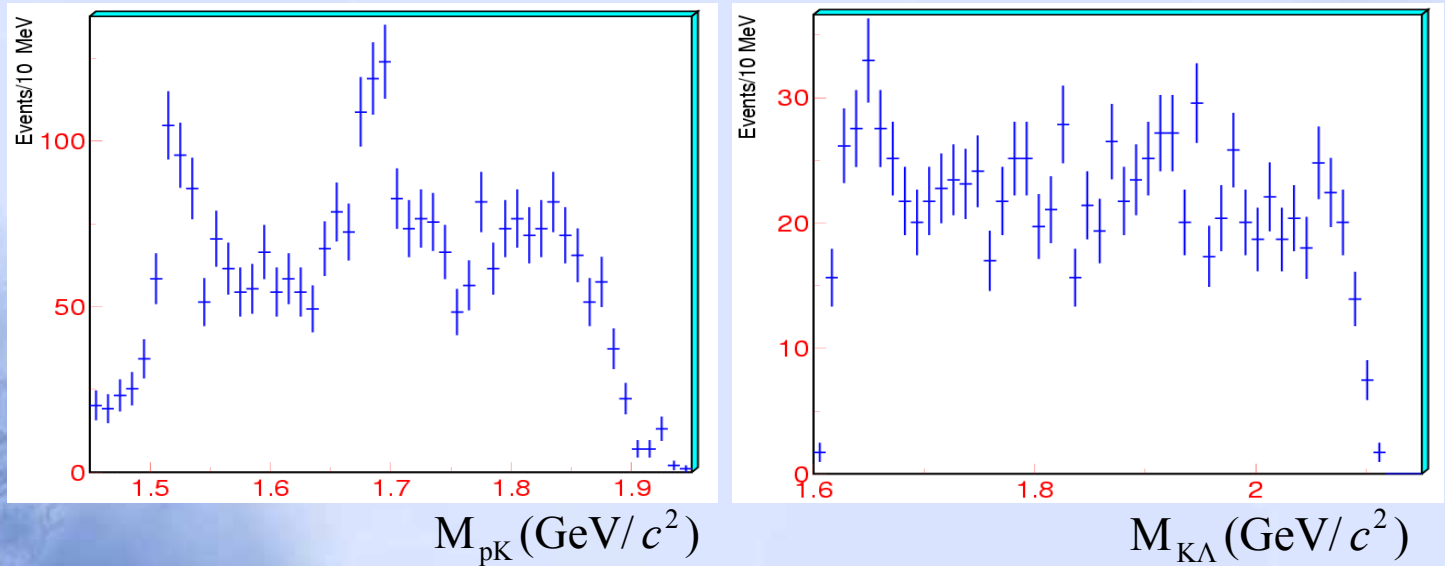
Events selection

- 4 good charged tracks
- At least one $p(\bar{p})$
- χ^2<20
- 0.35 GeV<M_K<0.65 GeV



$J/\psi \to p\bar{p}K\pi$ from BESII data

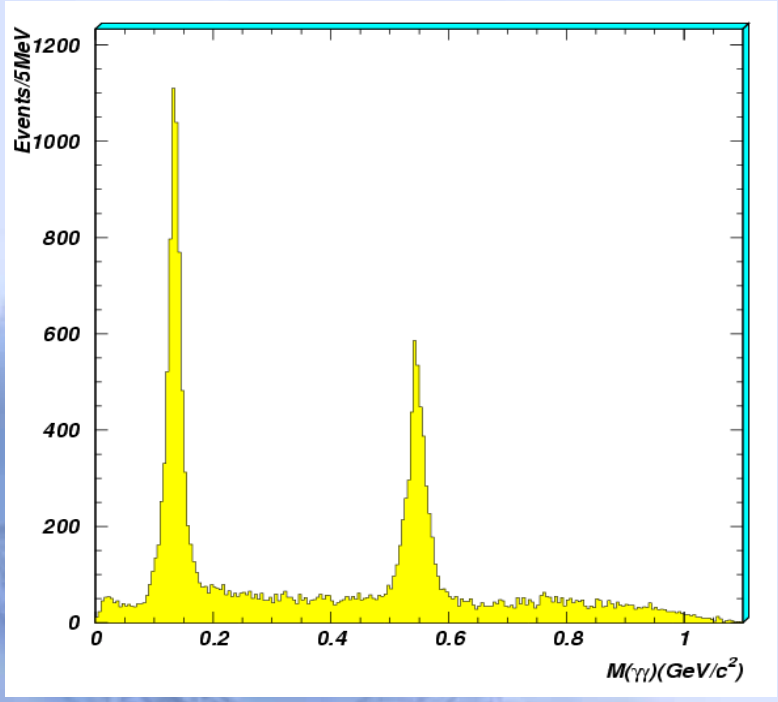
BESII 58M (preliminary)

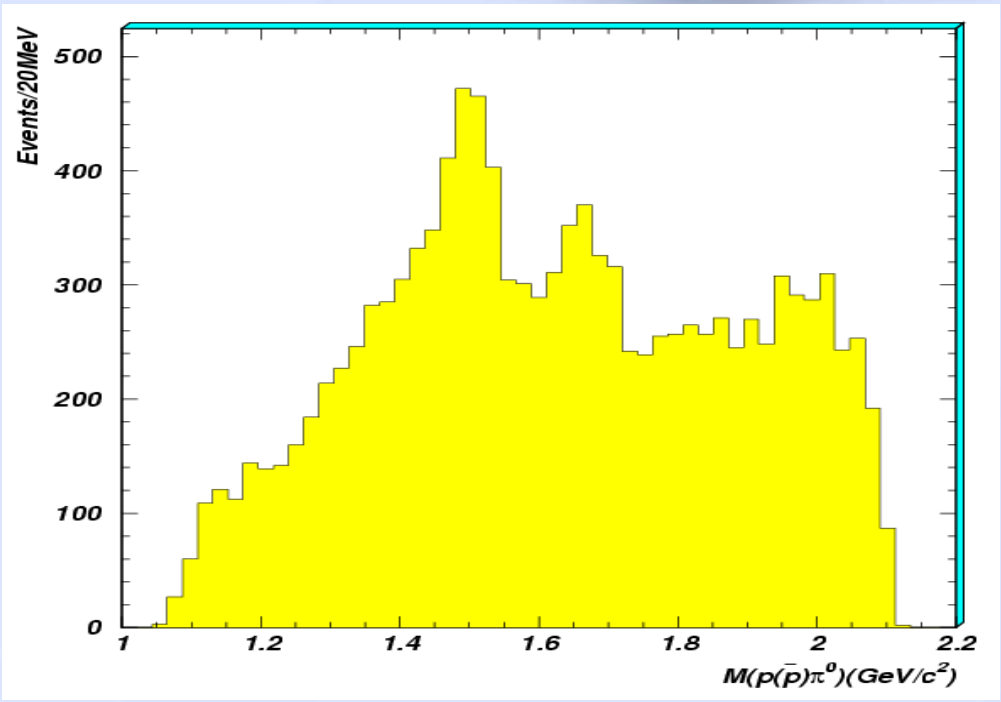


- preliminary PWA show $\Lambda(1520)$, $\Lambda(1690)$ and $\Lambda(1810)$ in pK mass
- N* in $K\Lambda$ mass

$J/\psi \to p\bar{p}\pi^0$ from BESII data

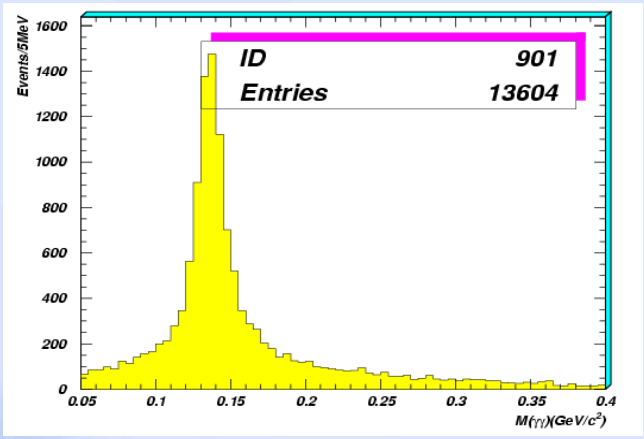
BESII 58M (preliminary)

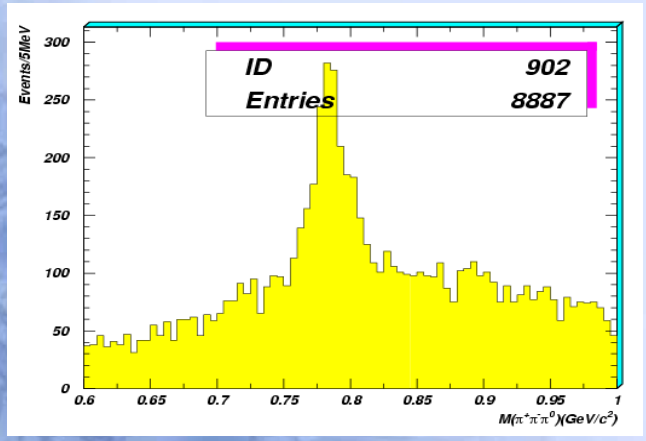




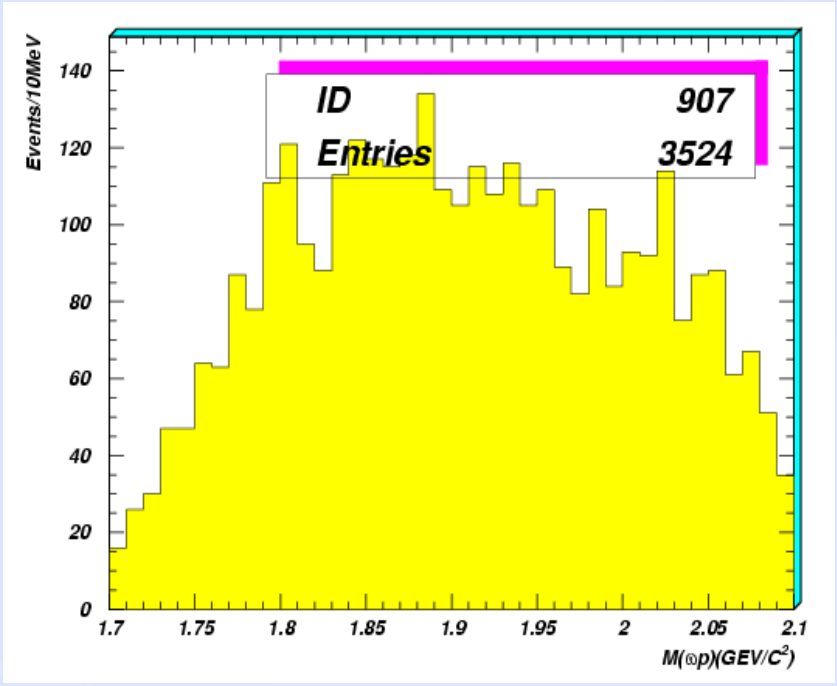
PWA will be performed

$J/\psi \to \omega p\bar{p}$ from BESII data





BESII 58M (preliminary)



PWA will be performed

Summary

$J/\psi \to p\bar{p}\eta$ (BESI 7.8 M)

- two well known N* states found
- $N(1535)S_{11}$:

  $M = 1530 \pm 10$ MeV/c^2 , $\Gamma = 95 \pm 25$ MeV/c^2

  $N(1650)S_{11}$:

  $M = 1647 \pm 20$ MeV/c^2 , $\Gamma = 145^{+80}_{-45}$ MeV/c^2

Summary

$J/\psi \to p\bar{n}\pi^-$ (BESII preliminary)

- Preliminary PWA to BESII 27M data show significant N*(1440), N*(1520), N*(1535) and N*(1680)
- PWA to BESII 58M data is in progress

$J/\psi \to p\bar{p}K\pi$ (BESII preliminary)

- preliminary PWA show $\Lambda(1520)$, $\Lambda(1690)$ and $\Lambda(1810)$ in pK mass
- N* in KΛ mass

Summary

PWA to BESII $J/\psi \to p\bar{p}\pi^0$ *and* $J/\psi \to p\bar{p}\omega$

will be performed soon.