中国科学院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences

Recent results from BESII J/ψ decay

Xiaoling Li

xlli@ihep.ac.cn

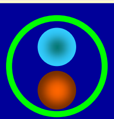
(Representing BES Collaboration)

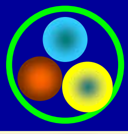
MESON 2008

June 7, 2008, Cracow, Poland

Multi-quark State, Glueball and Hybrid

- **Hadrons consist of 2 or 3 quarks：**
  - **Naive Quark Model：**

Meson（q $\bar{q}$）


Baryon（q q q）


- **New forms of hadrons:**
  - **Multi-quark states ：Number of quarks >＝ 4**
  - **Hybrids ： q$\bar{q}$g，qqqg …**
  - **Glueballs ： gg， ggg …**

- **How quarks/gluons form a hadron is far from being well understood.**

Multi-quark states, glueballs and hybrids have been searched experimentally for a very long time, but none of them is established.

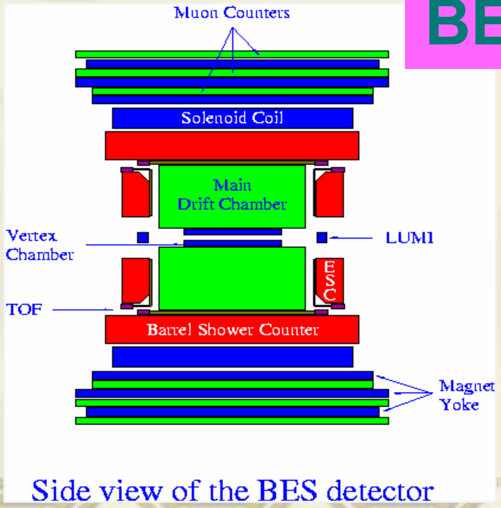
However, the effort has never been stopped, especially, during the past three years, a lot of surprising experimental evidences showed the existence of hadrons that cannot (easily) be explained in the conventional quark model.

J/ψ decays provide ideal Lab for searching the new forms of hadrons and studying the light hadron spectroscopy.

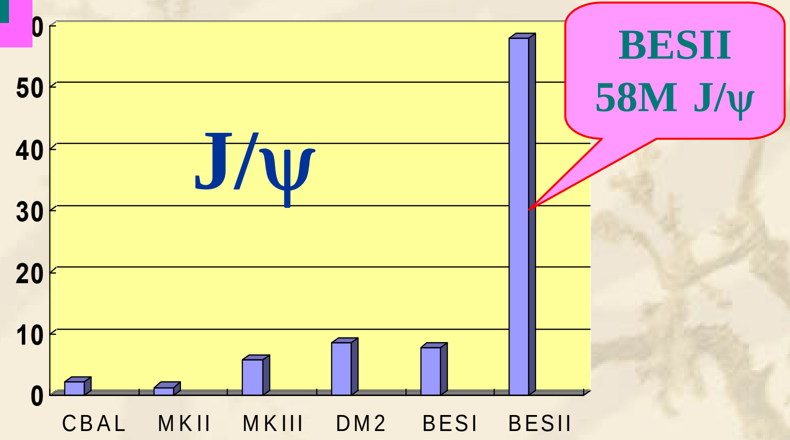
Outline

- New results in the following decay channels
  - The analysis of $J/\psi \rightarrow \omega$ p pbar
  - PWA of $J/\psi \rightarrow \pi^0$ p pbar
  - $K\Lambda$ mass threshold structure $N_X(1610)$ in $J/\psi \rightarrow pK^-\Lambda$
- Summary

BESII



Side view of the BES detector



Study of $J/\psi \rightarrow \omega\, p\, \bar{p}$ at BESII

Motivation

- A narrow enhancement is observed near ppbar threshold in J/$\psi \rightarrow \gamma$ppbar. An S-wave fit yields:

$$\text{Mass: } M = 1859^{+3}_{-10}{}^{+5}_{-25}\ \text{MeV}/c^2$$

$$\text{Width: } \Gamma < 30\ \text{MeV}/c^2\ \ (90\%\ \text{CL})$$

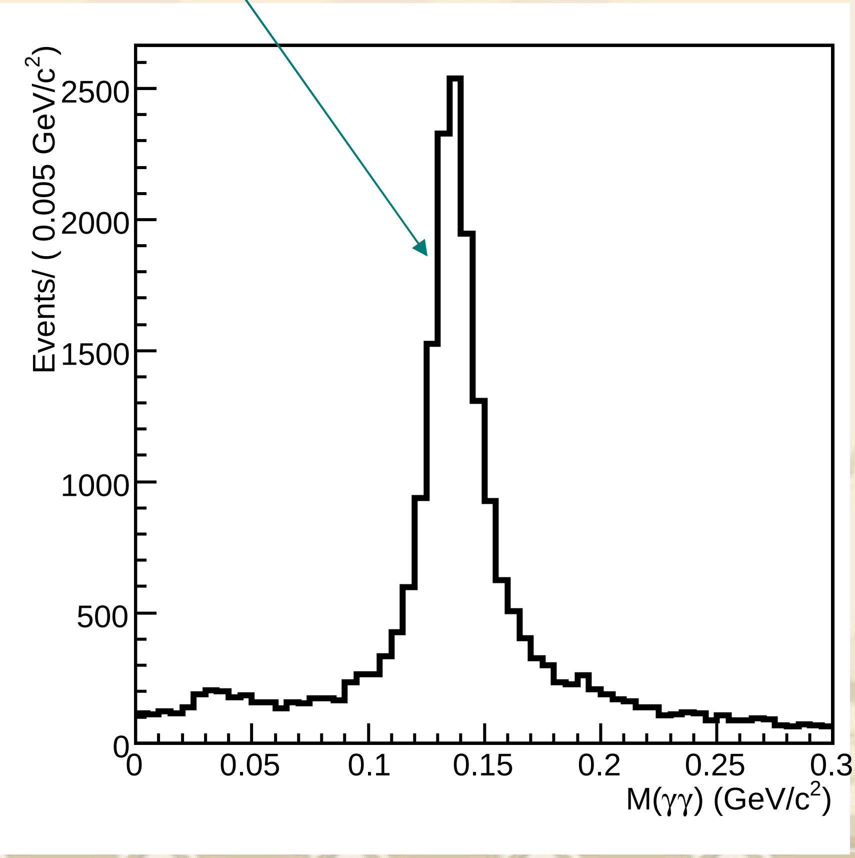
- Some people suggest that the enhancement is primarily due to the final state interaction (FSI) between the produced proton and antiproton.

- Investigate whether the enhancement exists near ppbar threshold in J/$\psi \rightarrow \omega$ppbar

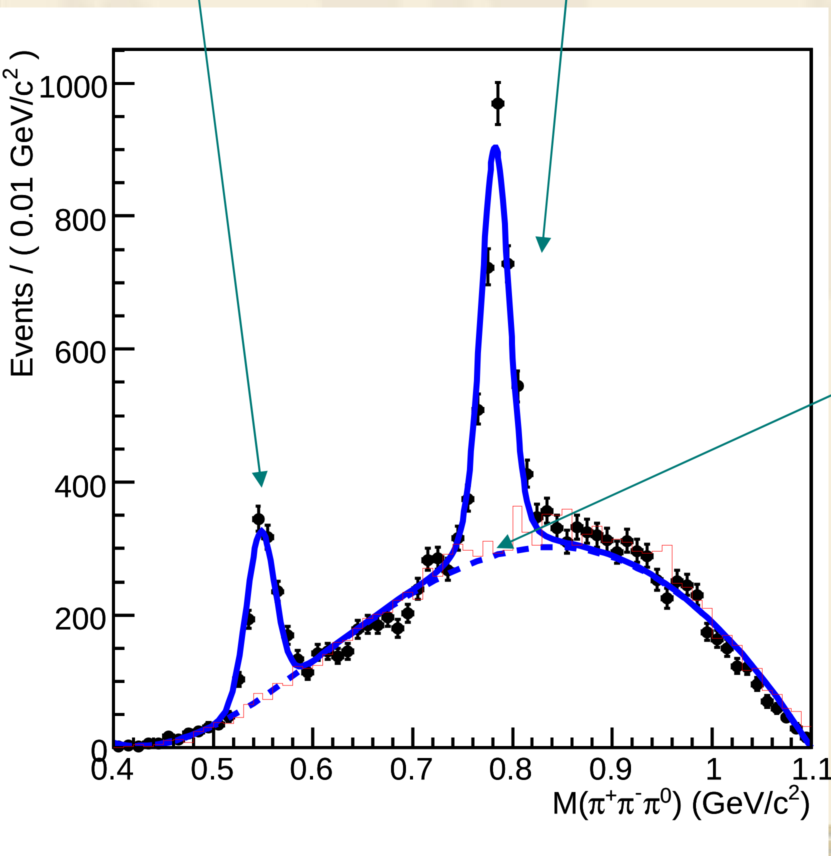
Event selection $J/\psi \to \omega p \bar{p}$

- **For final states $\gamma\gamma\pi^+\pi^- p\bar{p}$**
  - **4 good charged tracks**
  - **2 good gammas**
  - **PID, requiring 2 pions and 2 protons**
  - **For 4-constraint kinematic fit**
    - $\chi^2(\gamma\gamma\pi^+\pi^- p\bar{p}) < 20$
  - **Require good pi⁰ signal**
    - $|M(\gamma\gamma) - m_{\pi^0}| < 0.04\ \mathrm{GeV}/c^2$

π^0信号



ω signal



$J/\psi \to \eta' p\bar{p}(\eta' \to \pi^+\pi^-\eta)$;

$J/\psi \to \eta' p\bar{p}(\eta' \to \gamma\rho^0)$;

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

$J/\psi \to \Lambda\bar{\Lambda}\pi^0$;

$J/\psi \to \Sigma^0\bar{\Sigma}^0$;

$J/\psi \to \Sigma(1385)^-\bar{\Sigma}^+$;

$J/\psi \to \gamma\eta_c$;

$J/\psi \to \Delta^{++}\Delta^{--}$;

$J/\psi \to \gamma p\bar{p}\pi^+\pi^-$;

$J/\psi \to \Delta^{++}\bar{p}\pi^-$;

$J/\psi \to \Lambda\bar{\Sigma}^-\pi^+(+\text{c.c.})$;

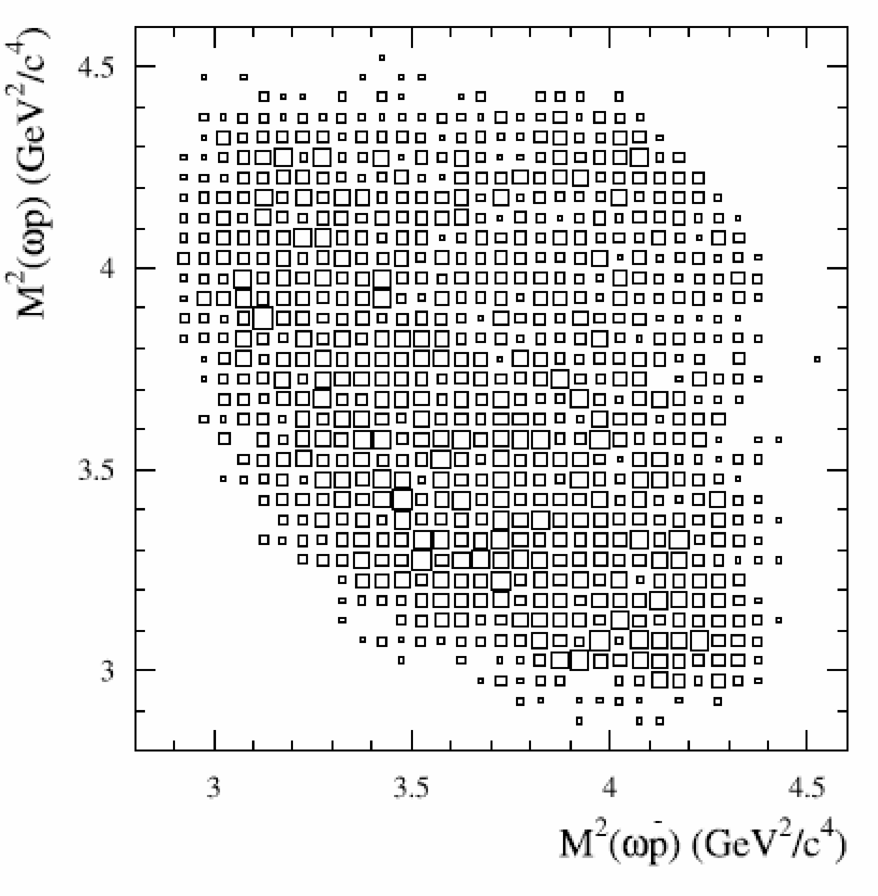
$J/\psi \to \bar{\Lambda}\Sigma^0\pi^0$;

$J/\psi \to \Sigma(1385)^0\bar{\Sigma}^0$;

$J/\psi \to \Delta^{++}\Delta^{--}\pi^0$;

$J/\psi \to \Xi^0\bar{\Xi}^0$

Study of J/ψ → ω p pbar at BESII



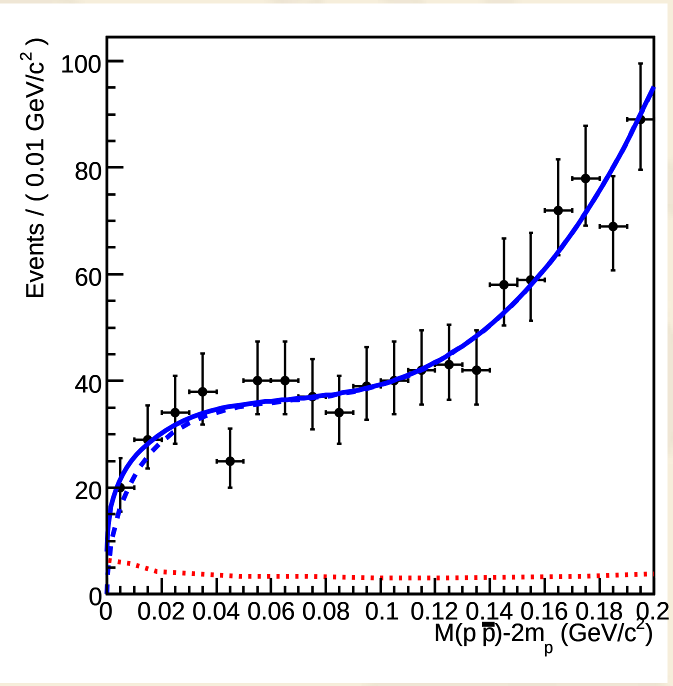
- No obvious N* in Dalitz plot.
- We measured:

$$\mathrm{BR}(J/\psi \to p\bar{p}\omega) =$$
$$(1.00 \pm 0.03 \pm 0.18) \times 10^{-3}$$
$$\text{PDG value}: (1.3 \pm 0.25) \times 10^{-3}$$

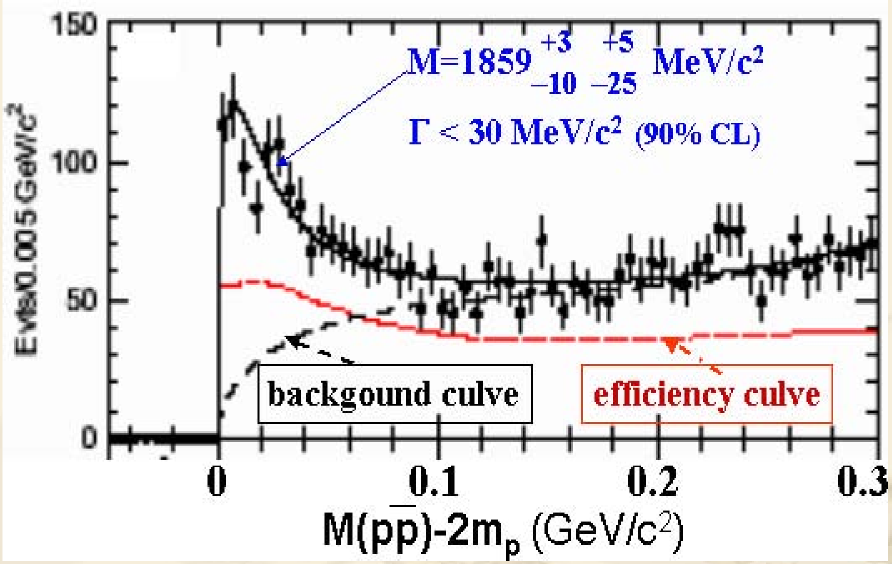
Study the M($p\bar{p}$) in J/ψ → ω p $\bar{p}$

$$f(\delta) = N(\delta^{1/2}+a_1\delta^{3/2}+a_2\delta^{5/2})\delta = M(p\bar{p}-2m_p)$$

it is used to discribe the contribution of background and non-resonance $\omega p\bar{p}$ events



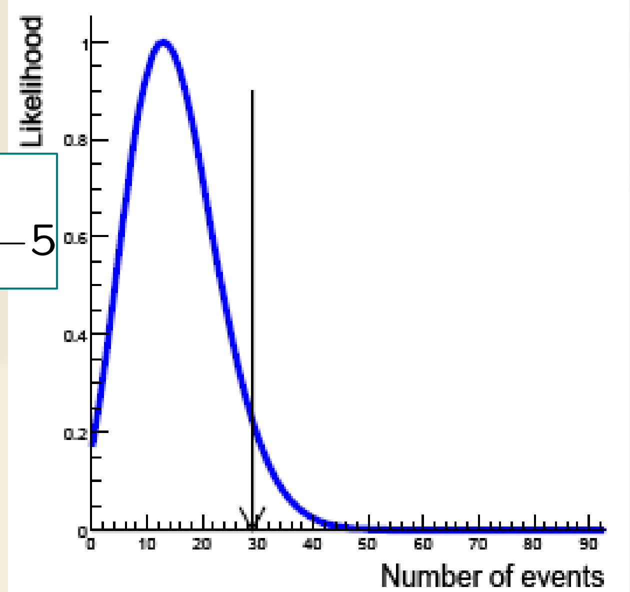
M($p\bar{p}$) near the $p\bar{p}$ threshold in $J/\psi \to \omega p\bar{p}$



J / ψ → γ p $\bar{p}$

There is no obvious enhancement in M(p $\bar{p}$) threshold

Upper limit of J/ψ → ωX(1860) → ω p $\bar{p}$



At 95% C.L.,
$Br(J/\psi \to \omega X(1680) \to \omega p\bar{p}) < 1.2 \times 10^{-5}$

$$p(\theta|x) = \frac{\mathcal{L}(x|\theta)\pi(\theta)}{\int \mathcal{L}(x|\theta')\pi(\theta')d\theta'}$$

$$\pi(s) = \begin{cases} 0 & s < 0 \\ 1 & s \geq 0 \end{cases}$$

$$1 - \alpha = \int_{-\infty}^{s_{up}} p(s|n)ds = \frac{\int_{-\infty}^{s_{up}} \mathcal{L}(n|s)\pi(}{\int_{-\infty}^{\infty} \mathcal{L}(n|s)\pi(}$$

Table 2: Systematic error sources and their contributions

	Br($J/\psi \to \omega p\bar{p}$)	Upper Limit
Tracking efficiency	8	8
Photon efficiency	4	4
Particle ID	6	6
Kinematic fit	5	5
Background uncertainty	5	7
Hadronic model	4.8	11.4
Monte Carlo generator	-	8.5
Intermediate decays	0.8	0.8
Total J/ψ events	4.7	4.7
Total systematic error	14.6	20.4

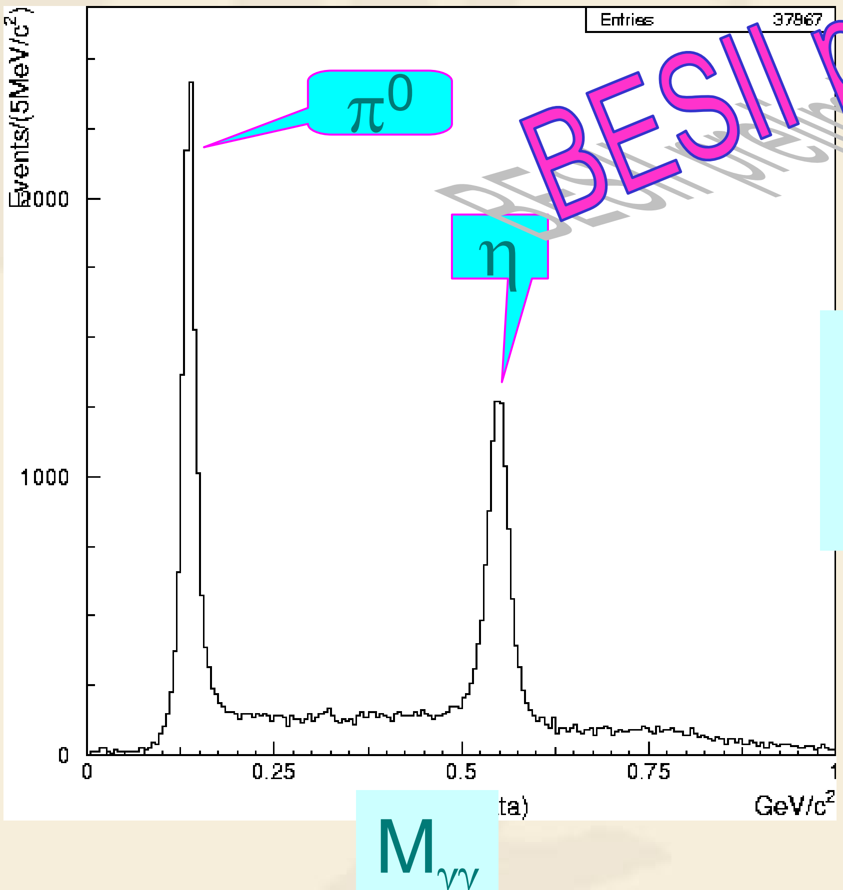
Summary for $J/\psi \rightarrow \omega p \bar{p}$

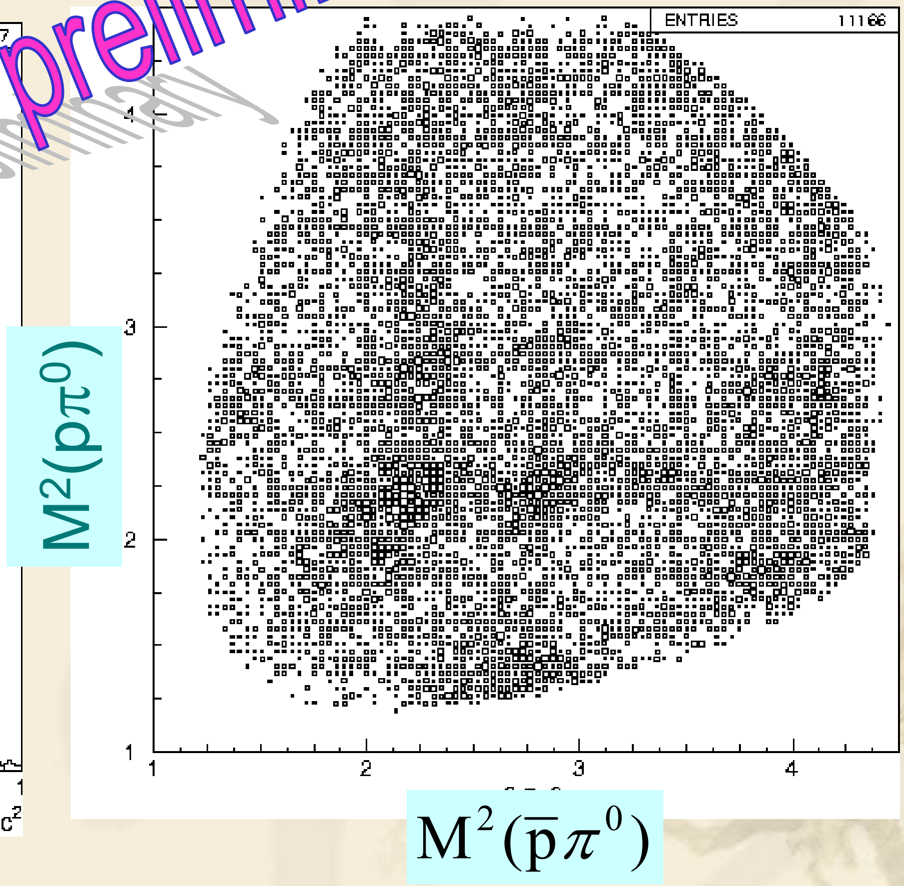
- There is no obvious N^* resonance in the Dalitz plot in $J/\psi \rightarrow \omega p \bar{p}$ chennal

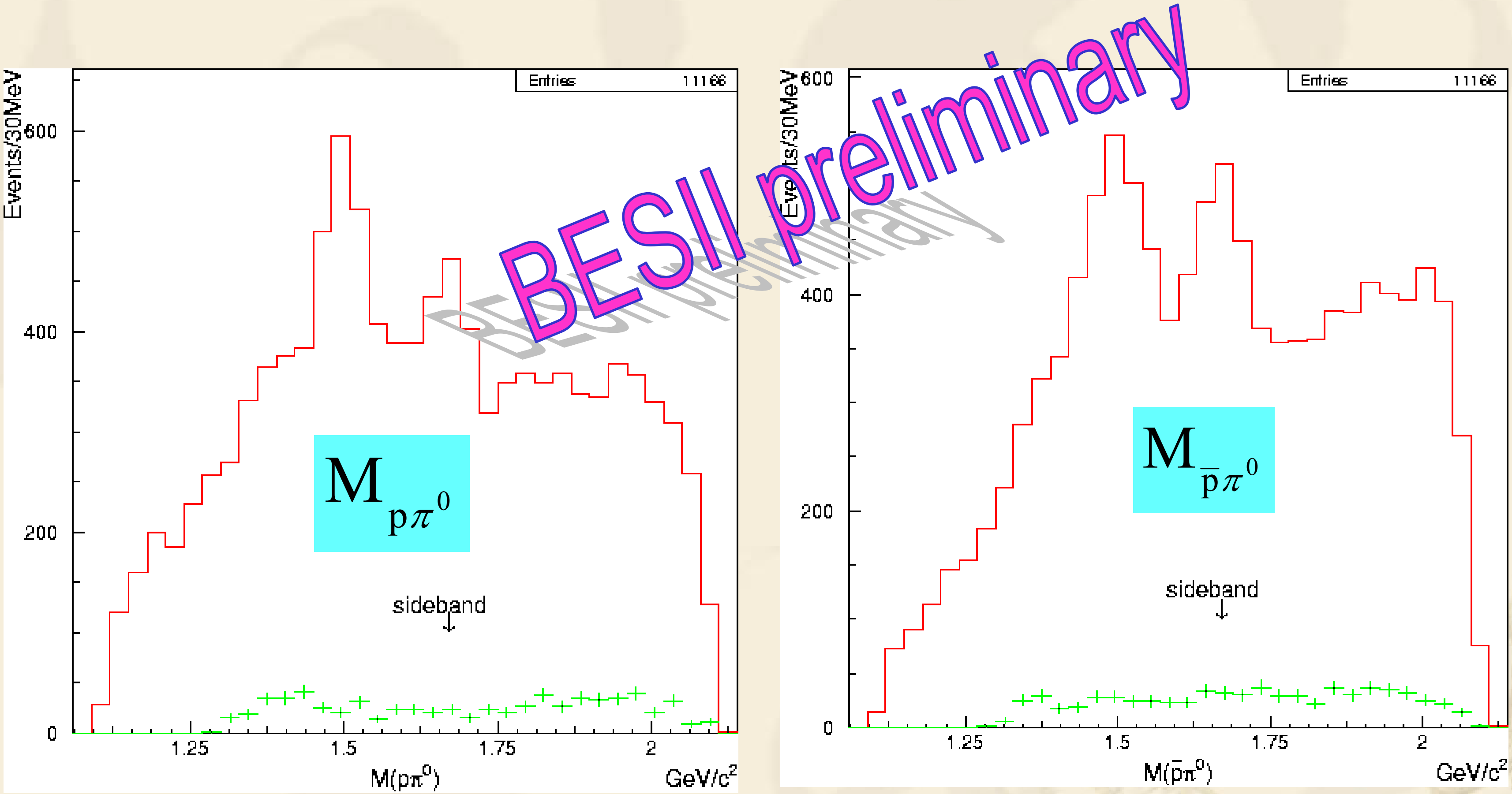
- The branching ratio of $J/\psi \rightarrow \omega p \bar{p}$ is measured
  - $Br(J/\psi \rightarrow \omega p \bar{p}) = (1.00 \pm 0.03 \pm 0.18) * 10^{-3}$

- There is no obvious enhancement in $M(p \bar{p})$ threshold, and that means X(1860) in $J/\psi \rightarrow \gamma p \bar{p}$ is not from pure FSI. At the same time, the upper limit is measured at 95% C.L.
  - $Br(J/\psi \rightarrow \omega X(1860)) * Br(X(1860) \rightarrow p \bar{p}) < 1.5 * 10^{-5}$

N* in $J/\psi \to p\bar{p}\pi^0$ at BESII

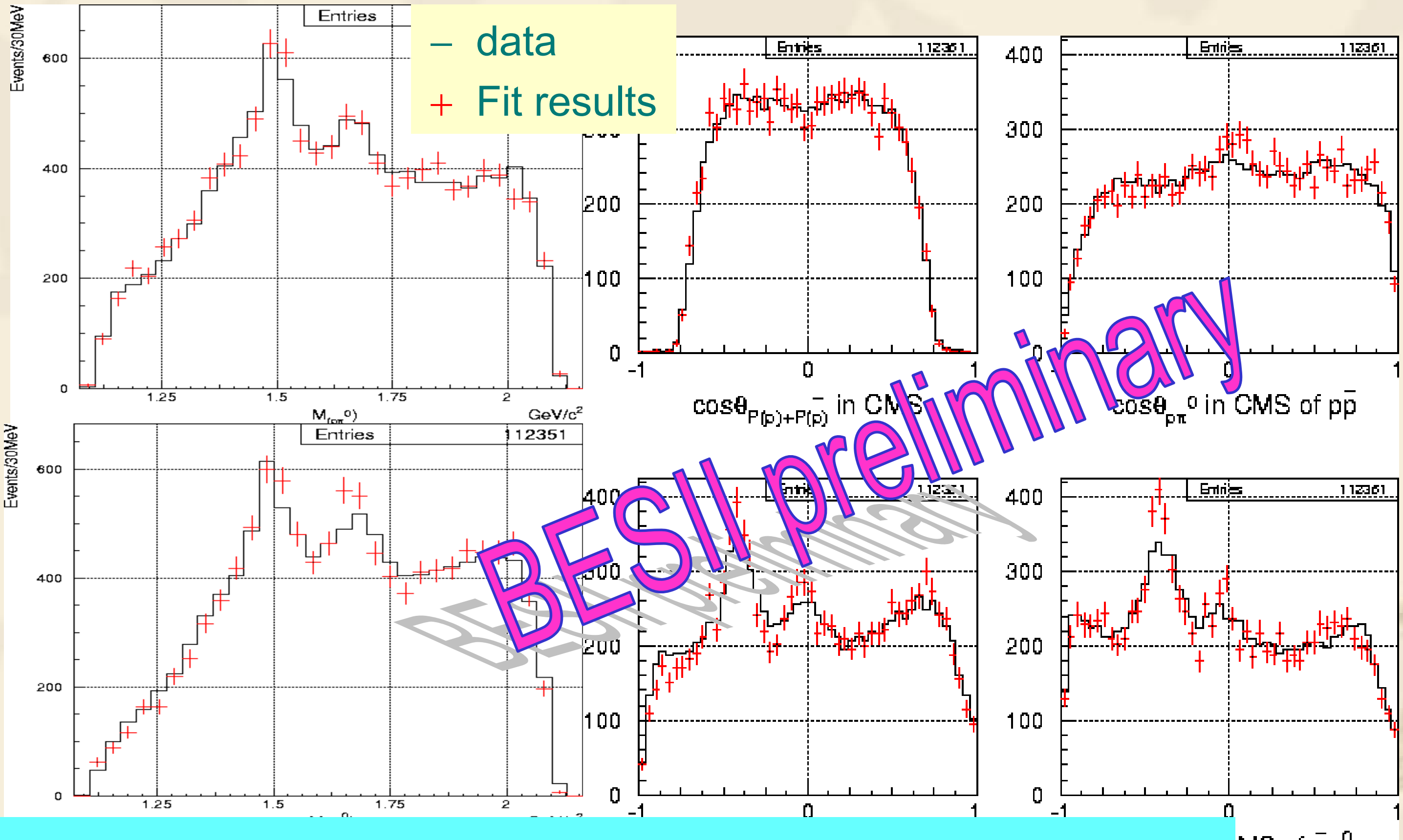






Entries 11166
Events/30MeV
600
400
200
0
1.25
1.5
1.75
2
$M(p\pi^0)$
GeV/c^2
$M_{p\pi^0}$
sideband
BESII preliminary
Entries 11166
Events/30MeV
600
400
200
0
1.25
1.5
1.75
2
$M(\bar{p}\pi^0)$
GeV/c^2
$M_{\bar{p}\pi^0}$
sideband

N* in $J/\psi \to p\bar{p}\pi^0$



The co… …sults.

Fit results agree with data reasonably, especially in the low mass region.

- N(1440), N(1520), N(1535), N(1650), N(1675), N(1680), N(1710) are needed.

- Nx(2065) exists in this channel (stat. sig. >>5σ)
  The spin-parity favors 3/2+

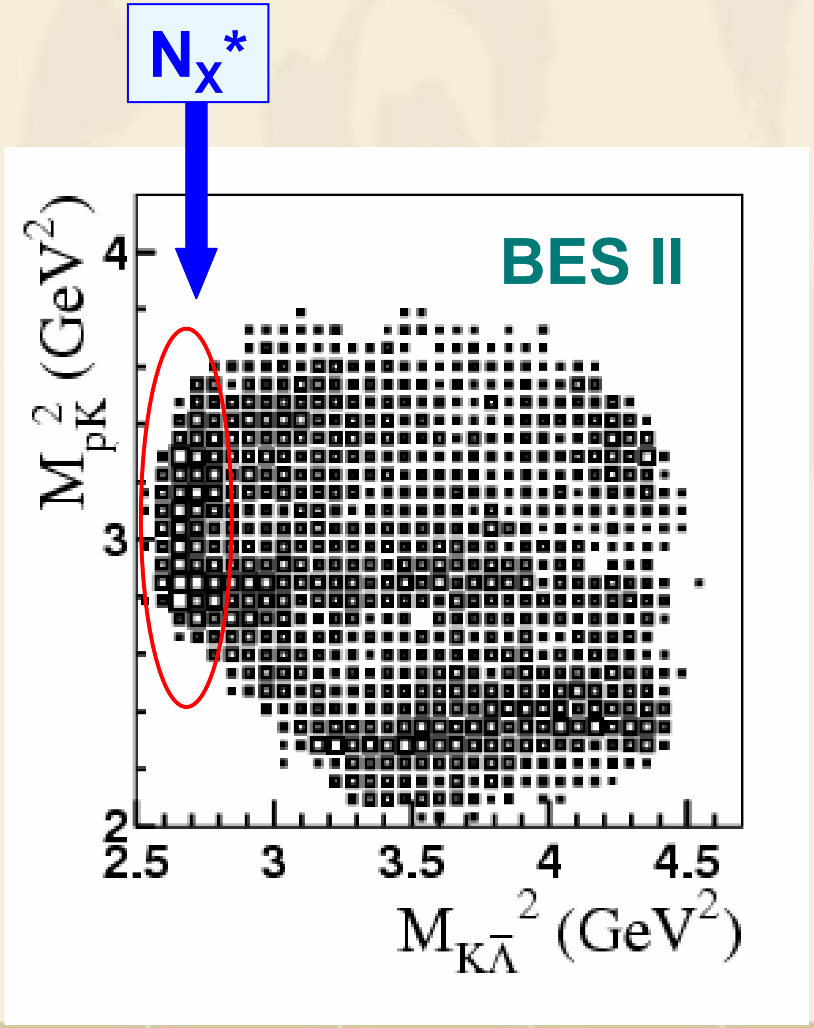
$$M = 2040^{+3}_{-4} \pm 25\ \mathrm{MeV},\ \ \Gamma = 230 \pm 8 \pm 52\ \mathrm{MeV}$$

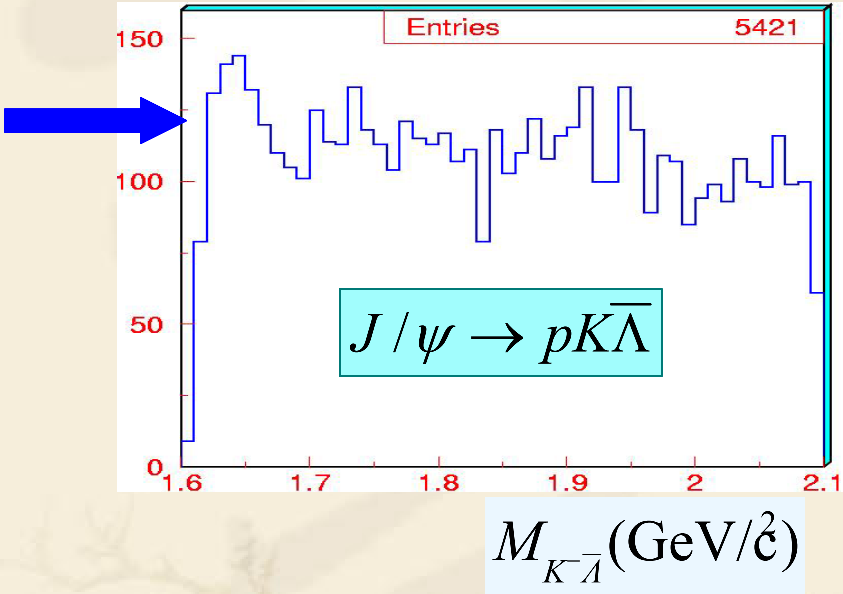
BESII preliminary

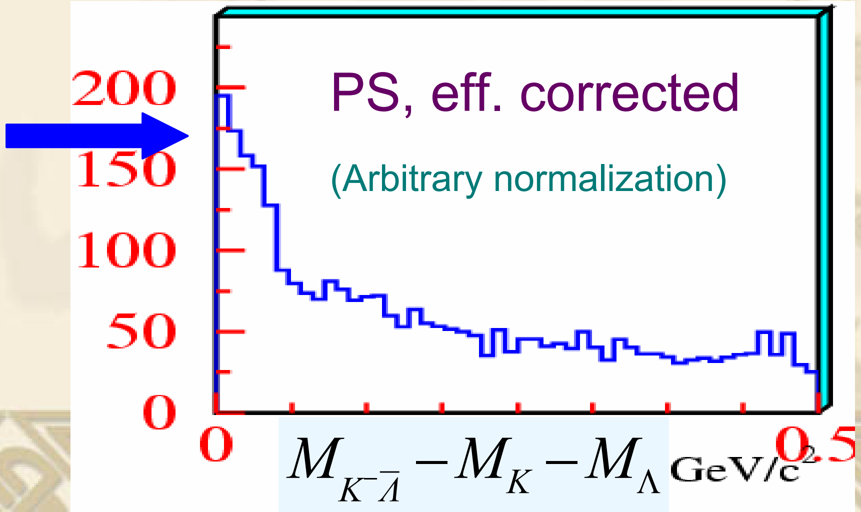
N*	M(MeV/c²)	Γ(MeV/c²)	J^P	fraction(%)	Br (×10⁻⁴)
N(1440)	$1455^{+2}_{-7} \pm 43$	$316^{+5}_{-6} \pm 67$	1/2+	9.74~25.93	1.33~3.54
N(1520)	$1513^{+3}_{-4} \pm 13$	$127^{+7}_{-8} \pm 37$	3/2-	2.38~10.92	0.34~1.54
N(1535)	$1537^{+2}_{-6} \pm 12$	$135^{+8}_{-8} \pm 39$	1/2-	6.83~15.58	0.92~2.10
N(1650)	$1650^{+3}_{-6} \pm 26$	$145^{+5}_{-10} \pm 31$	1/2-	6.89~27.94	0.91~3.71
N(1710)	$1715^{+2}_{-2} \pm 29$	$95^{+2}_{-1} \pm 44$	1/2+	4.17~30.10	0.54~3.86
N(2065)	$2040^{+3}_{-4} \pm 25$	$230^{+8}_{-8} \pm 52$	3/2+	23.0~41.8	0.91~3.11

$K\bar{\Lambda}$ mass threshold enhancement

Observation of a strong enhancement near the threshold of $K^-\bar{\Lambda}$ mass spectrum at BES II







- **Best PWA fit:** **(J^P=½$^-$ is favored)**

$$m = 1625^{+5+13}_{-7-23}\, MeV \qquad \Gamma = 43^{+10+28}_{-7-11}\, MeV$$

$$Br(J/\psi \to pNx) \times Br(Nx \to K\Lambda) = 9.14^{+1.30+4.25}_{-1.25-8.28} \times 10^{-5}$$

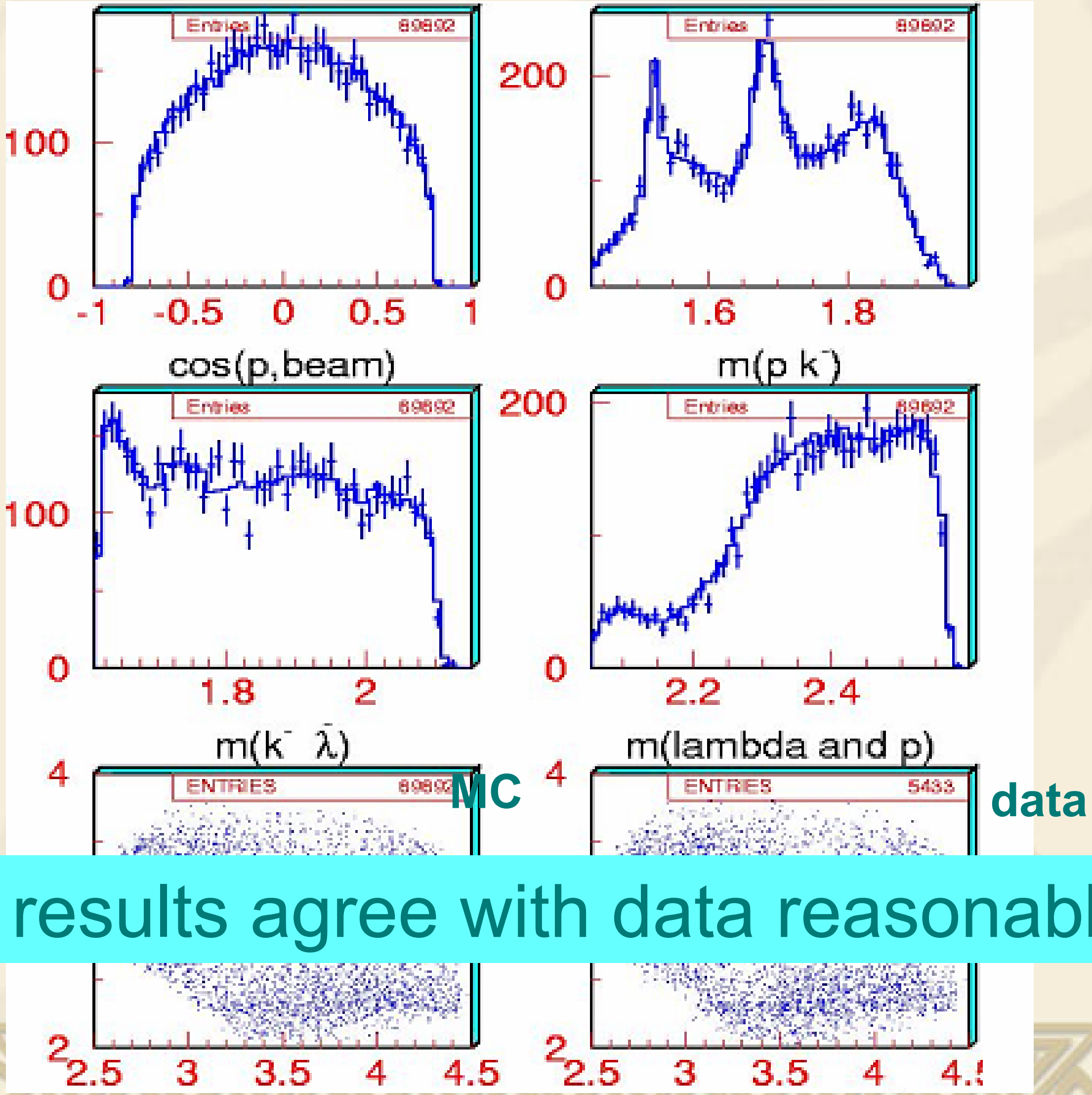
- **Fitted as N(1535)** (becomes worse by about 5 σ ($\Delta\chi^2$=28 with *d.o.f.*=2)).

$$Br(J/\psi \to pN(1535)) \times Br(N(1535) \to K\Lambda) = 4.26^{+0.15+4.22}_{-0.14-1.70} \times 10^{-4}$$

Big Br.

BESII preliminary

Comparison between data and PWA fit projections



Fit results agree with data reasonably.

N_x* is N(1535)?

- **From BESII measurements:**

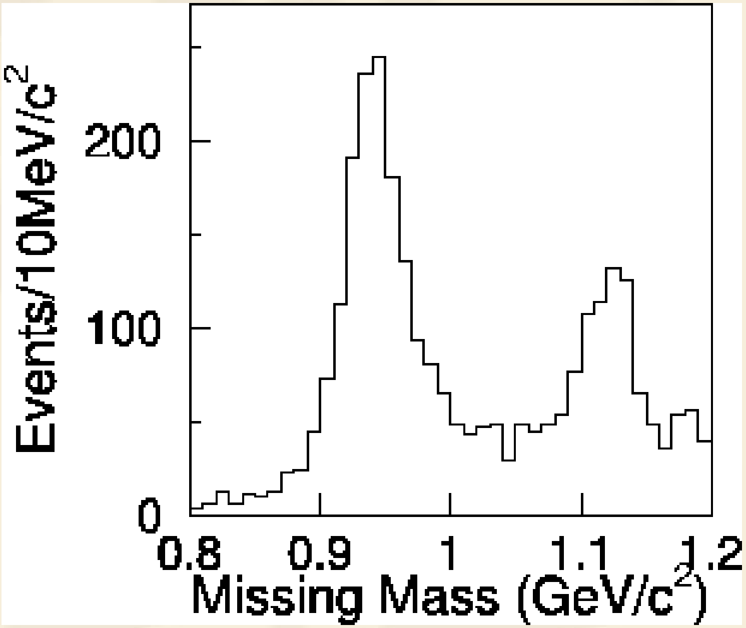
$$BR(J/\psi \to pN(1535)) \bullet BR(N(1535) \to p\pi) \sim (1 \sim 2) \times 10^{-4}$$

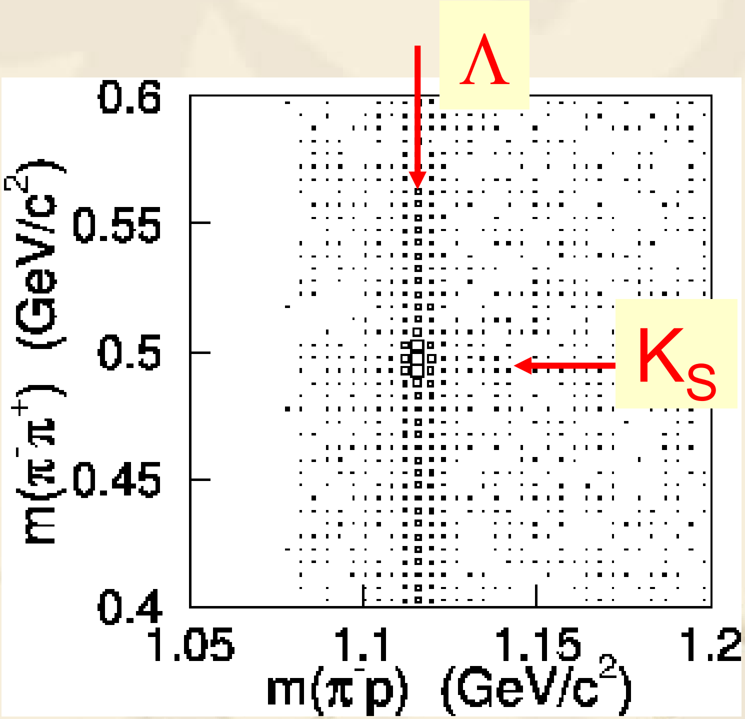
$$BR(J/\psi \to pN(1535)) \bullet BR(N(1535) \to K\Lambda) \sim 4 \times 10^{-4}$$

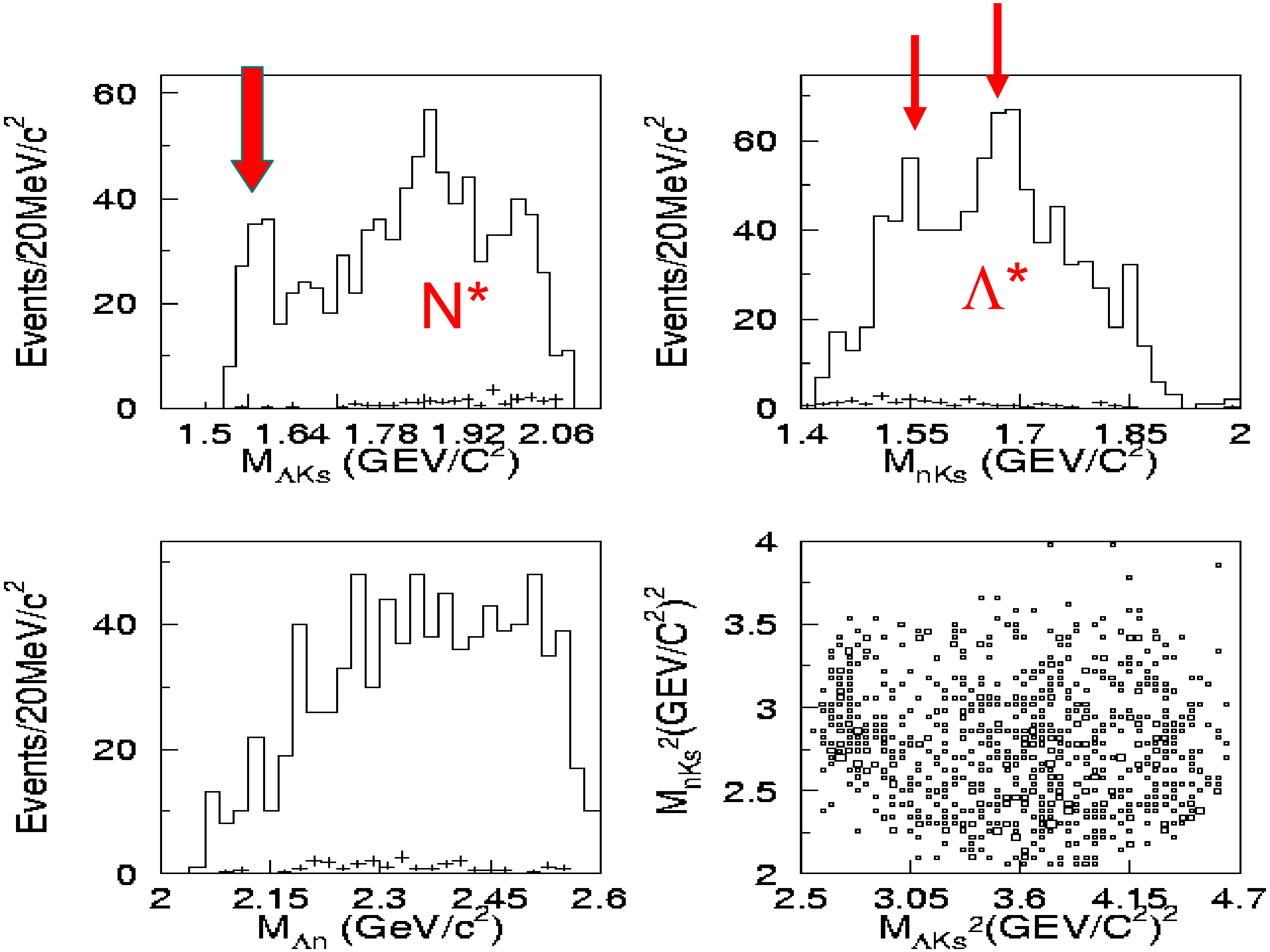
If N_x* is N(1535), its coupling to $K\Lambda$ is much stronger than to $p\pi$.

Then N(1535) would have very large ssbar component (a 5-quark system).

Observation of $J/\psi\,(\psi')\to nK_S^0\overline{\Lambda}$







- An enhancement near ΛK_S threshold is evident
- N* and Λ* found in the ΛK_S and nK_S spectrum

More statistics and PWA are needed for the detail information

Summary for $J/\psi \rightarrow p K^- \bar{\Lambda}$

- The $K\Lambda$ mass threshold enhancement $N_X(1610)$ could be a $K\Lambda$ bound/resonant state since it might contain a very large hidden ssbar component (no matter whether it can be interpreted as N(1535)).
- Whether $N_X(1610)$ is N(1535) needs further study. We hope to answer this at BESIII.

Summary of the report

- N* states are studied in $J/\psi \rightarrow p\,\bar{p}\,\pi^0$, and a new N*(2060) is observed and favors 3/2+.
- $K\Lambda$ threshold enhancement, $N_X(1610)$, is observed in $J/\psi \rightarrow pK\Lambda$, and PWA result shows its mass, width and J^P.
- In $J/\psi \rightarrow \omega\,p\,\bar{p}$, there is no obvious N^* band in Dalitz plot. In addition, the M(p pbar) information confirms the X(1680) in $J/\psi \rightarrow \gamma\,p\,\bar{p}$ is not from the pure FSI.
- We are expecting more new results on hadron spectroscopy at BESIII.

Thank You!　　　　　!