Recent BES results on hadron spectroscopy

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International Conference on Quarks and Nuclear Physics
Sept 21-26, 2009 Beijing

Outline

- Introduction
- Preliminary BESII results of charged κ
- Preliminary BESIII results of $\psi(2S)\to\pi^+\pi^- J/\psi$, $J/\psi\to\gamma p\bar{p}$ and $\psi(2S)\to\gamma p\bar{p}$
- Preliminary BESIII results of $\chi_{cJ}\to\pi^0\pi^0/\eta\eta$
- Summary

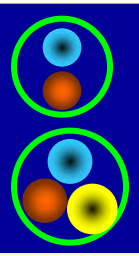
Multi-quark State, Glueball and Hybrid

- **Hadrons consist of 2 or 3 quarks:**

  Naive Quark Model:

  Meson（ q $\bar{q}$ ）

  Baryon（q q q）



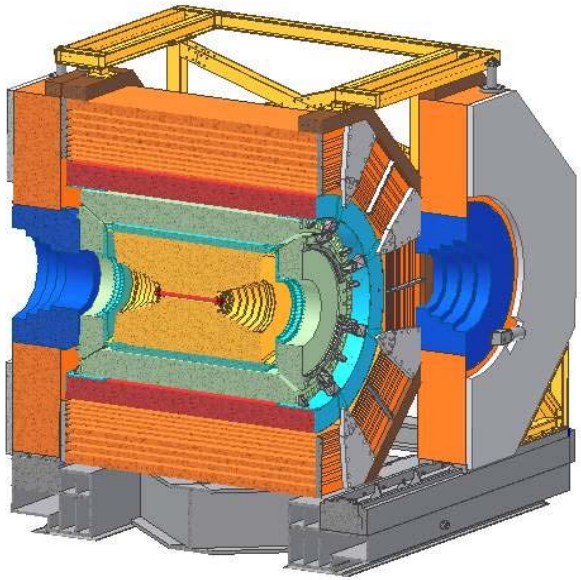
- **New forms of hadrons:**
  - **Multi-quark states： Number of quarks >= 4**
  - **Hybrids： q$\bar{q}$g，qqqg …**
  - **Glueballs： gg， ggg …**

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

However, the effort has never been stopped, especially, during the past couple of 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 provides ideal Lab for searches for new forms of hadrons and study of the light hadron spectroscopy.

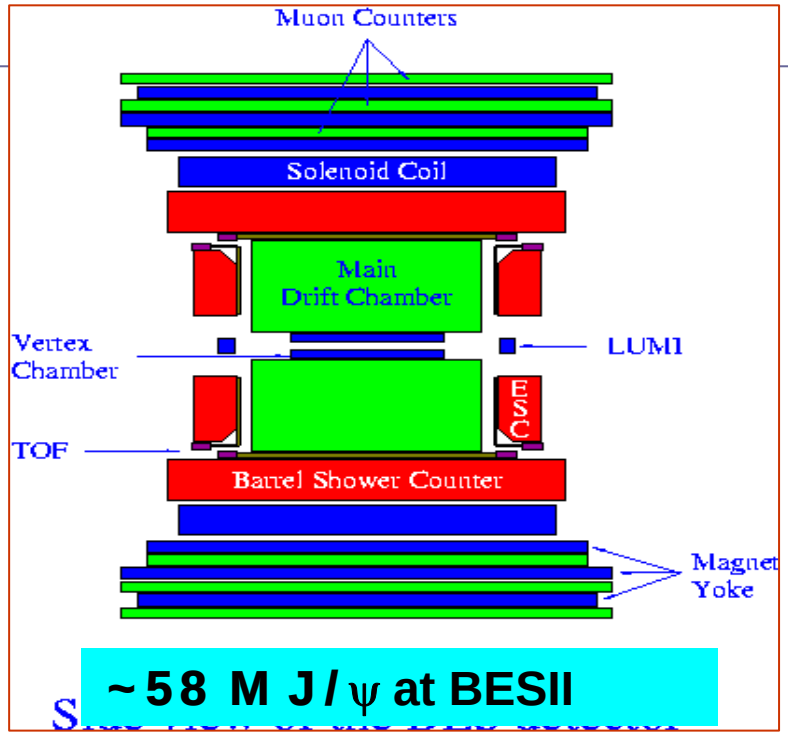
BESIII @ BEPCII



~110M ψ(2S) collected (4x CLEOc)

~230M J/ψ collected (4x BESII)

BESII @ BEPC



~58 M J/ψ at BESII

	BESIII	BESII
MDC	$\sigma_{p_t}/p_t = 0.32\% p_t, dE/dx < 6\%$	$\sigma_p/p = 1.78\%\sqrt{1+p^2}, dE/dx = 8\%$
TOF	90 ps (for bhabha)	180 ps (for bhabha)
EMC	$\sigma_E/E = 2.3\%/\sqrt{E}$	$\sigma_E/E = 22\%/\sqrt{E}$
MUC	9 for barrel, 8 for end-cap	3 layers for barrel
Magnet	1.0 T	**0.4 T**

Observation of charged κ at BESII

- κ was first found in Kπ scattering data

- However, its phase shift is much less than 180° and it cannot be filled into any nonets of ordinary $q\bar{q}$ mesons. There have been hot debates on the existence of κ.

In recent years:

- FNAL E791 found evidence of neutral κ in $D^+ \to K^-\pi^+\pi^+$.

$$M = 797 \pm 19 \pm 43\ \mathrm{MeV/c^2}, \Gamma = 410 \pm 43 \pm 87\ \mathrm{MeV/c^2}$$

- CLEO $D^0 \to K^-\pi^+\pi^0$ data find no evidence of κ.

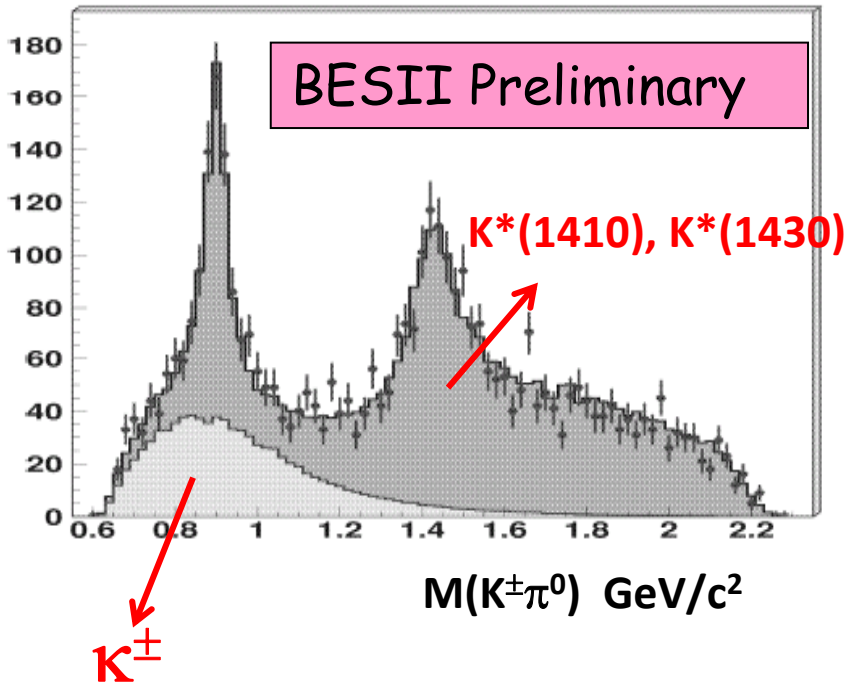
- FOCUS data on $K^+ \to K^-\pi^+\mu^+\nu$ require K^{*0} interfere with either a constant amplitude or a broad 0^+ resonance in Kπ.

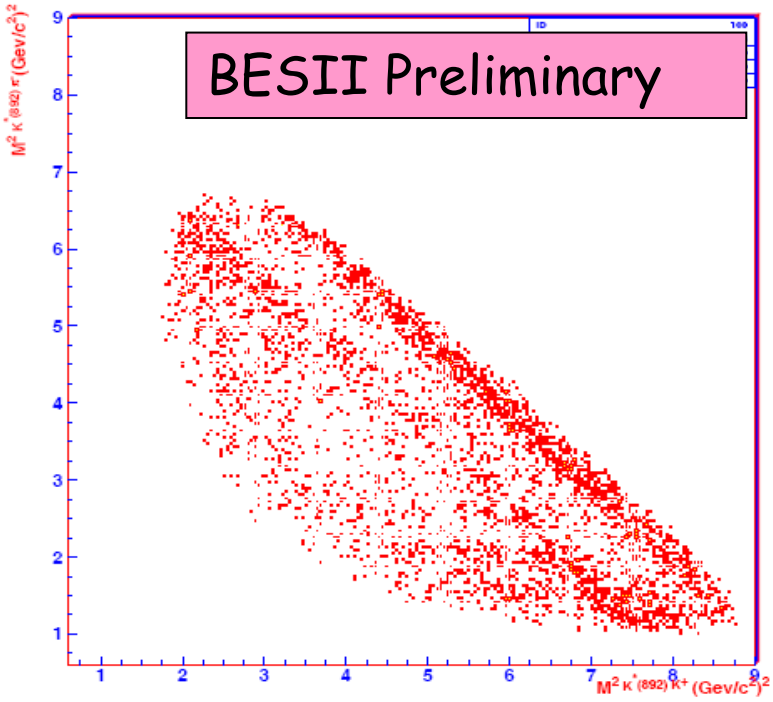
- BESII observed neutral κ in $J/\psi \to K^{*0}K\pi \to K\pi K\pi$ in 2006.

neutral κ pole: $(841 \pm 30^{+81}_{-73}) - i(309 \pm 45^{+48}_{-72})\ \mathrm{MeV/c^2}$

The existence of charged κ is expected !

- **CLEO reported the necessity of $\kappa^{\pm} \to K^{\pm}\pi^{0}$ in $D^{0} \to K^{+}K^{-}\pi^{0}$.**
- **However, no charged κ is needed in BABAR data.**
- **BESII studied charged κ in $J/\psi \to K^{*\pm}\kappa^{\mp} \to K_{s}\pi^{\pm}K^{\mp}\pi^{0}$**





Resonance parameters of charged κ

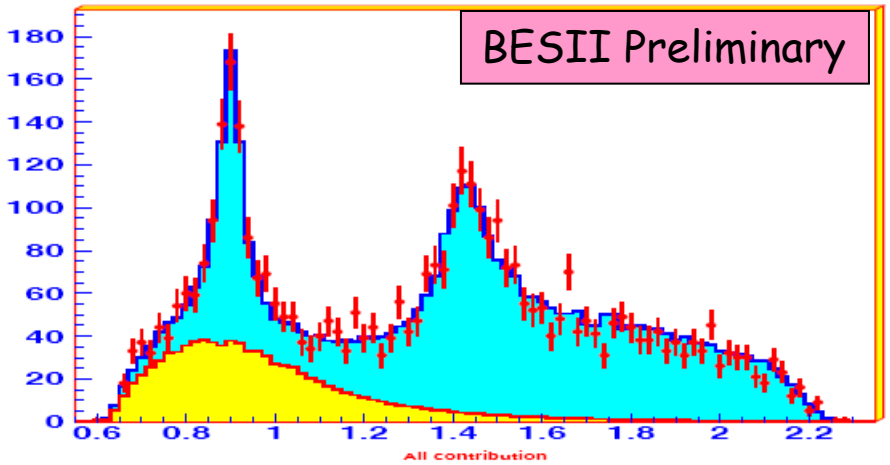
	Constant BW	BW with ρ	Zheng
Mass (MeV)	$810 \pm 68^{+15}_{-24}$	$884 \pm 40^{+11}_{-22}$	$1165 \pm 58^{+120}_{-41}$
Width (MeV)	$536 \pm 87^{+106}_{-47}$	$478 \pm 77^{+71}_{-41}$	$1349 \pm 500^{+472}_{-176}$
pole (MeV)	$(849 \pm 77^{+18}_{-14})$ $-i(256 \pm 40^{+46}_{-22})$	$(849 \pm 51^{+14}_{-28})$ $-i(288 \pm 101^{+64}_{-30})$	$(839 \pm 145^{+24}_{-7})$ $-i(297 \pm 51^{+50}_{-18})$

For reference, resonance parameters of neutral κ

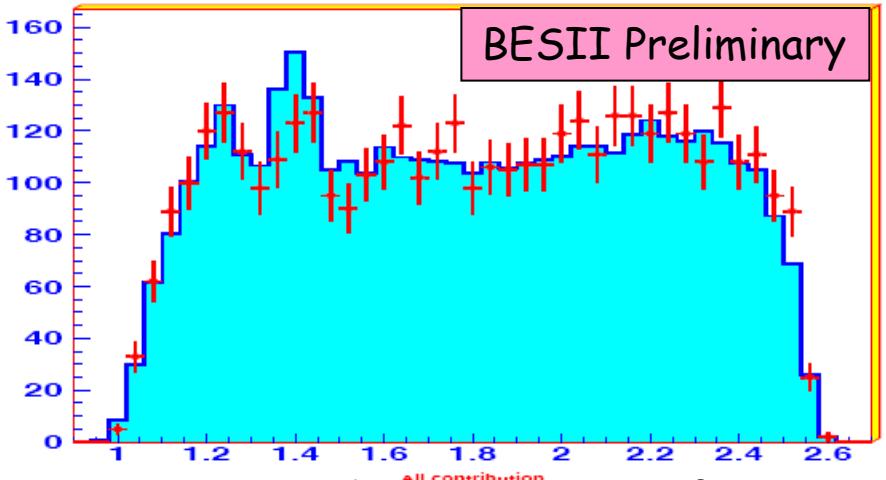
	Constant BW	BW with ρ	Zheng
Mass (MeV)	$745 \pm 26^{+14}_{-91}$	$874 \pm 25^{+12}_{-55}$	$1140 \pm 39^{+47}_{-80}$
Width (MeV)	$622 \pm 77^{+61}_{-78}$	$518 \pm 65^{+27}_{-87}$	$1370 \pm 156^{+406}_{-148}$
pole (MeV)	$(799 \pm 37^{+16}_{-90})$ $-i(290 \pm 33^{+25}_{-38})$	$(836 \pm 38^{+18}_{-87})$ $-i(329 \pm 66^{+28}_{-46})$	$(811 \pm 74^{+17}_{-83})$ $-i(285 \pm 20^{+18}_{-42})$

- Different parameterizations of κ give consistent results on the pole of charged κ .
- The pole position for charged κ is consistent with that for neutral κ within the error.

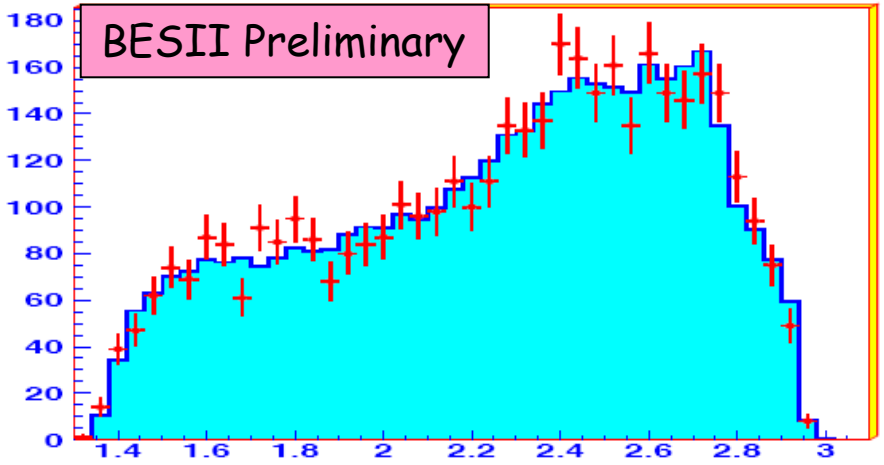
Partial wave analysis results



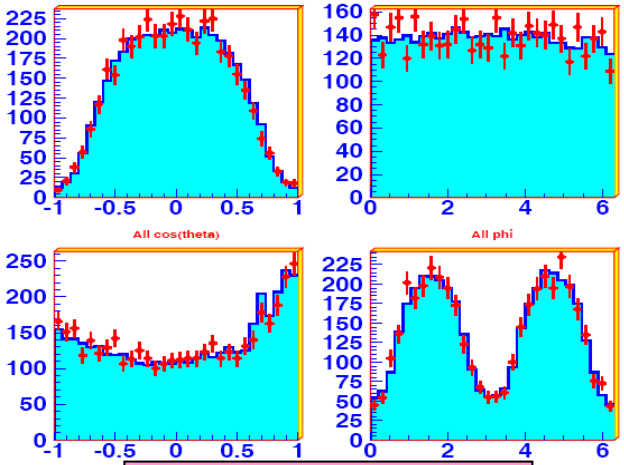
$M(K\pi)$ (GeV/c^2)



$M(K^*(892)\pi)$ (GeV/c^2)

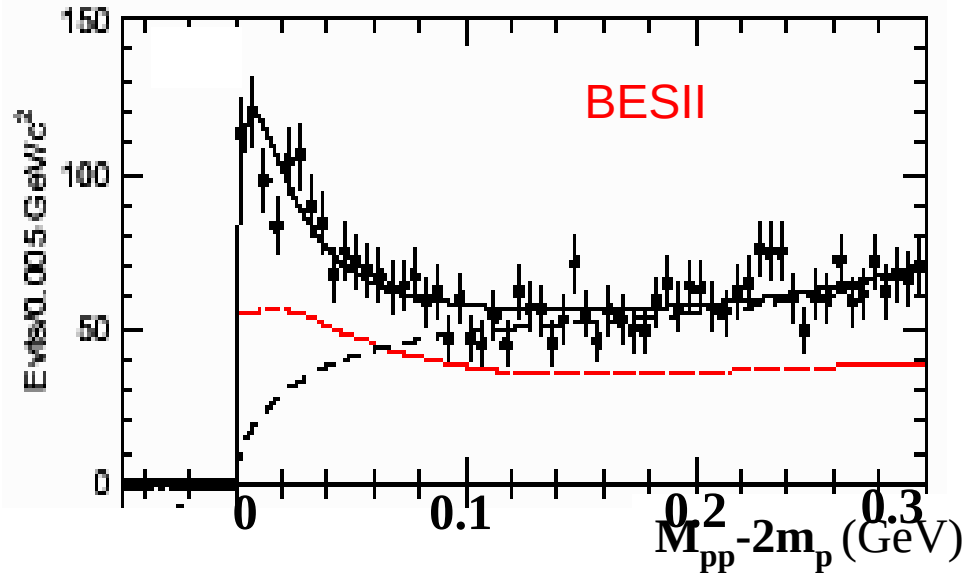


$M(K^*(892)K)$ (GeV/c^2)



Observation of an anomalous enhancement X(1860) near the threshold of $p\bar{p}$ mass spectrum

$J/\psi \to \gamma p\bar{p}$ PRL 91, 02201 (2003)

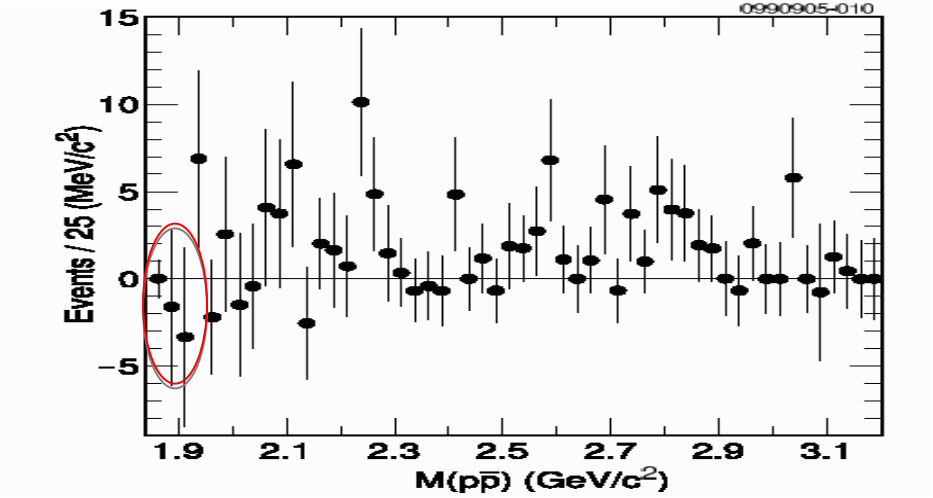


theoretical speculation:

- $p\bar{p}$ **bound state (baryonium)**
- **FSI effects**
- **……**

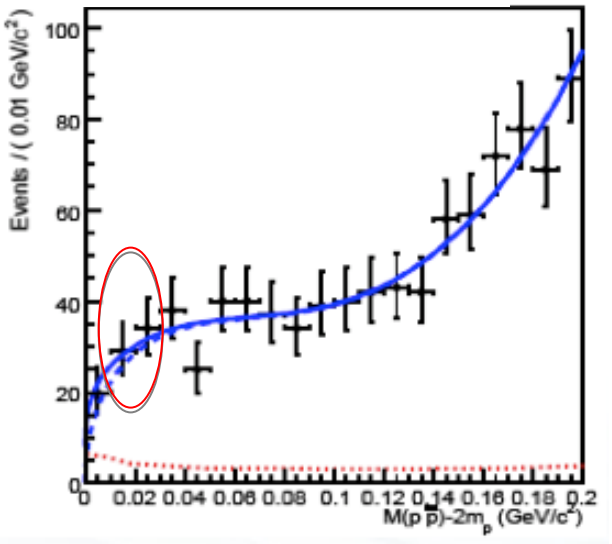
The narrow threshold enhancement is NOT observed in those channels

$\Upsilon(1S) \to \gamma\ p\bar{p}$@CLEO PR D73, 032001 (2006)

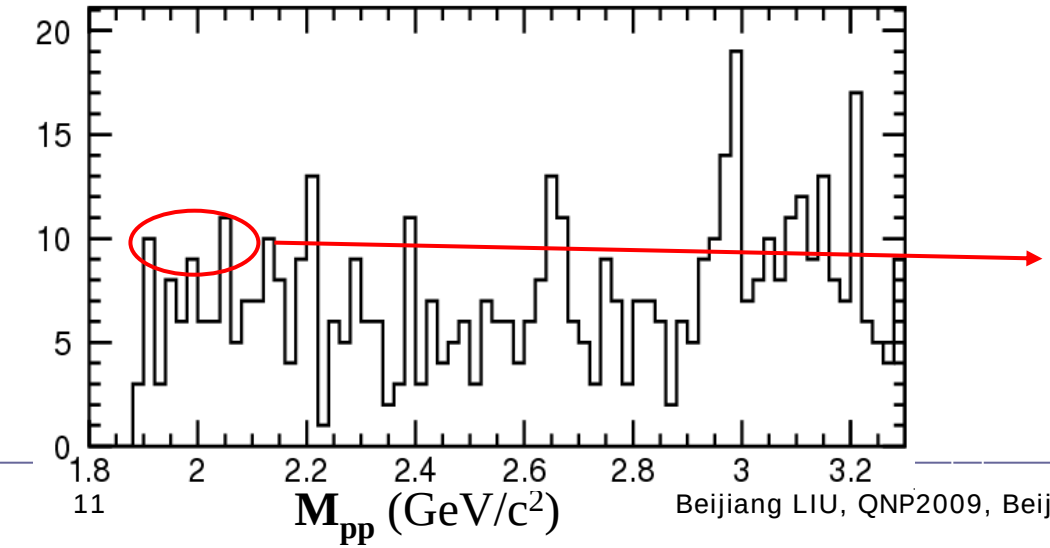


$J/\psi \to \omega\ p\bar{p}$@BESII

EPJ C53 ,15 (2008)



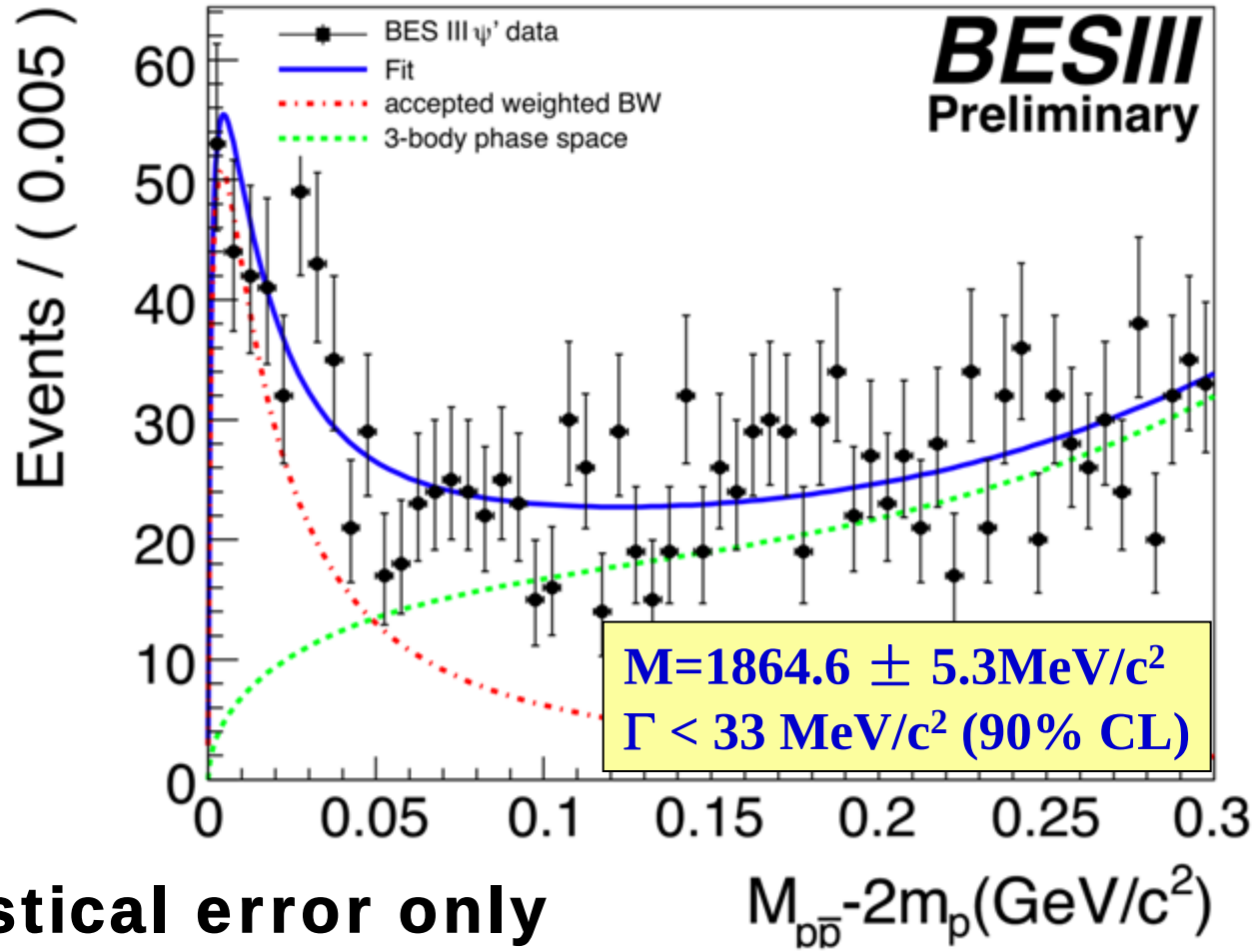
$\psi(2S) \to \gamma p\bar{p}$ @ BESII PRL 99, 011802 (2007)



No significant narrow strong enhancement near threshold (~2σ if fitted with X(1860))

Observation of an anomalous enhancement near the threshold of $p\bar{p}$ mass spectrum at BES III

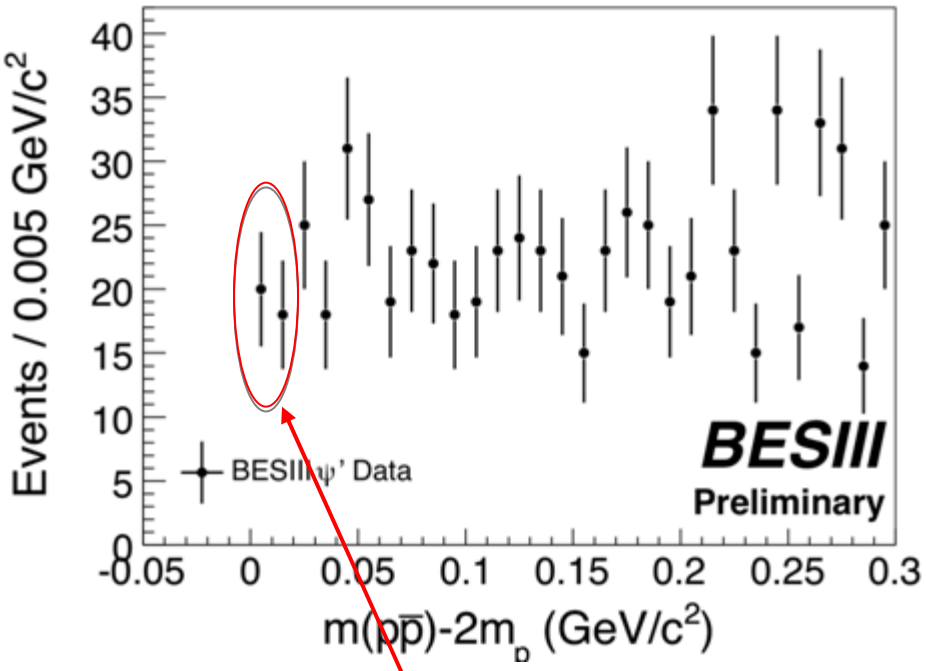
$\psi' \to \pi\pi J/\psi, J/\psi \to \gamma p\bar{p}$ @ BESIII



Statistical error only

This narrow threshold enhancement is "NOT" observed in $\psi' \to \gamma p\bar{p}$ at BESIII

$\psi' \to \gamma\ p\bar{p}$ @BESIII



No significant narrow strong enhancement near threshold

Study of $\psi(2S) \rightarrow \gamma\pi^0\pi^0$, $\gamma\eta\eta$ ($\eta \rightarrow \gamma\gamma$, $\pi^0 \rightarrow \gamma\gamma$)

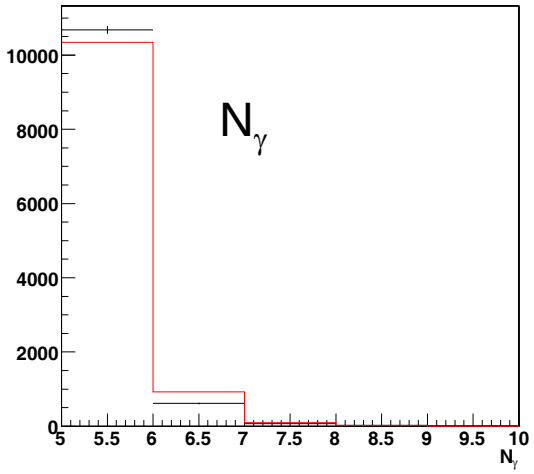
- Radiative decay of charmonium to $\eta\eta$, $\eta\eta'$, $\eta'\eta'$ is still a 'missing' part of hadron spectroscopy.
- χ_c decay into light meson pairs has its implication on light hadron spectroscopy.

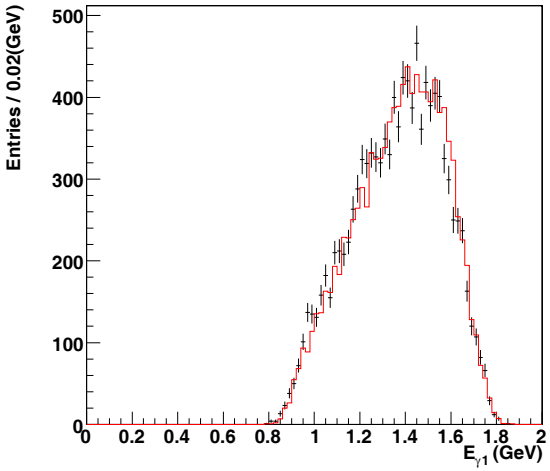
In the starting phase of BESIII

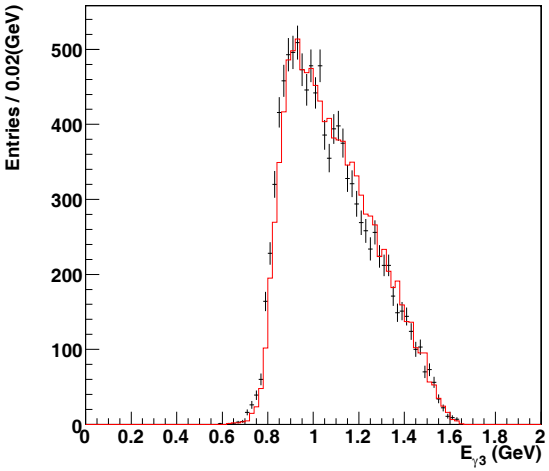
- Pure neutral channels: 5γ final state, only count on EMC

Data / MC comparisons

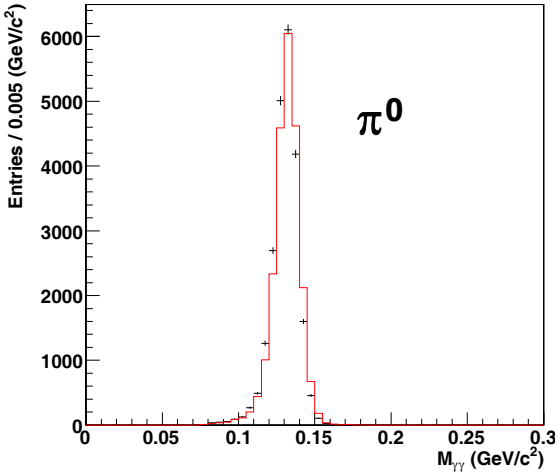
$\psi(2S) \rightarrow \gamma \chi_{c0}$, $\chi_{c0} \rightarrow \pi^0\pi^0$

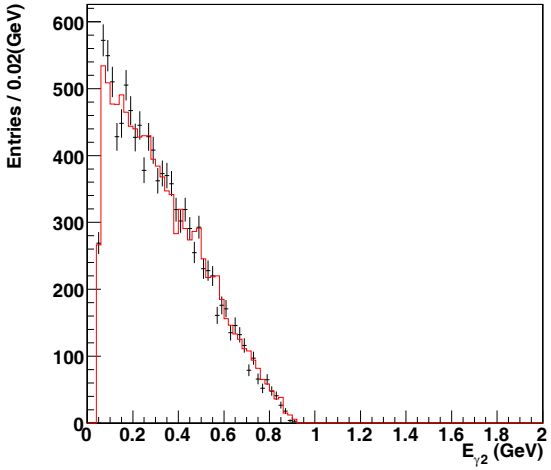


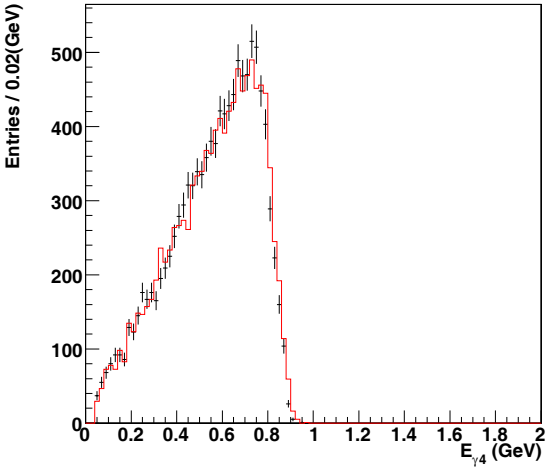


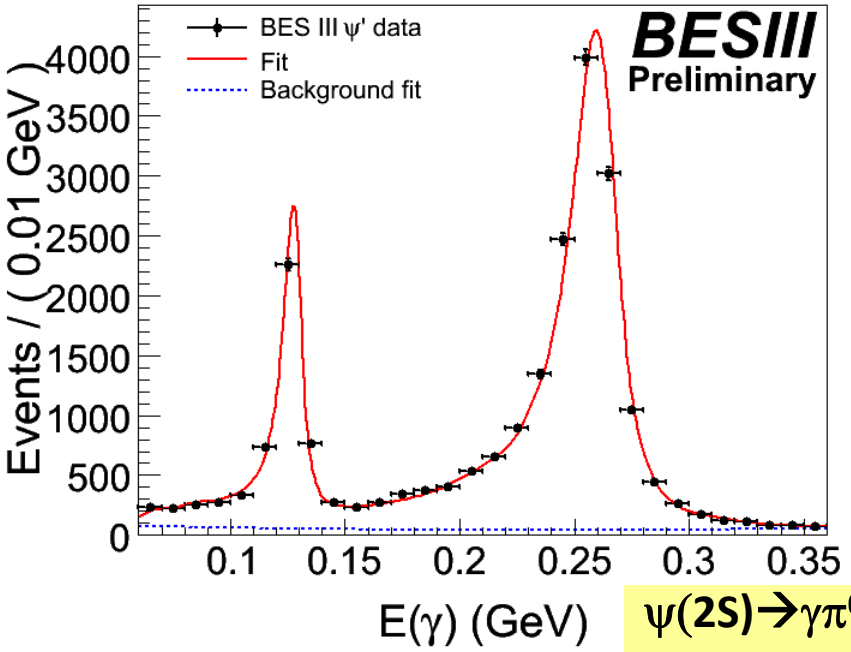


Energy of photons decayed from π^0



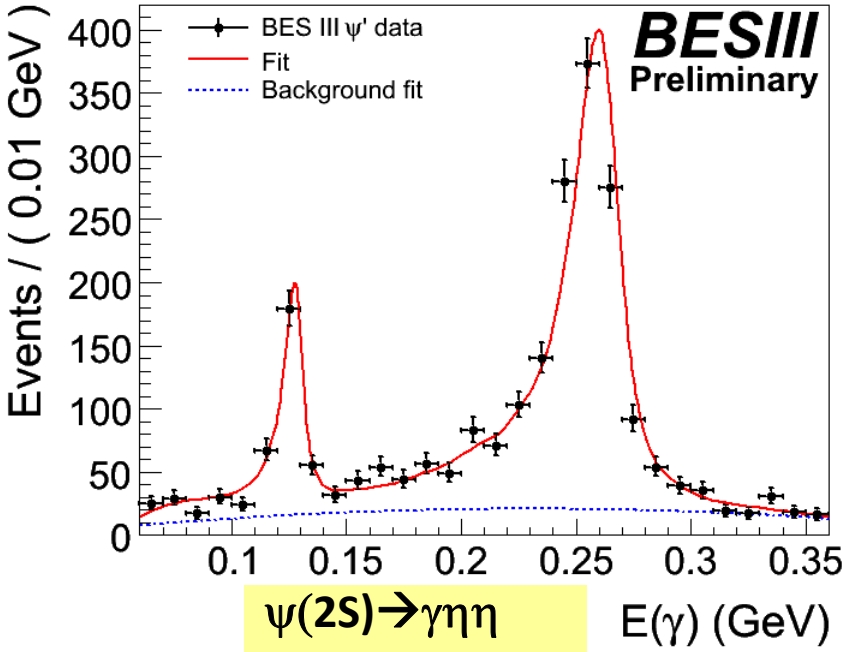






$\psi(2S)\rightarrow\gamma\pi^0\pi^0$

$N_{\chi c0}$ 16645±175
$N_{\chi c2}$ 4149±82



$\psi(2S)\rightarrow\gamma\eta\eta$

$N_{\chi c0}$ 1541±56
$N_{\chi c2}$ 291±23

BR (10^{-3})		χ_{c0}	χ_{c2}
$\pi^0\pi^0$	BESIII	3.25±0.03(stat)	0.86±0.02(stat)
	PDG08	2. 43±0.20	0.71±0.08
	CLEO-c	2.94±0.07±0.35	0.68±0.03±0.08
$\eta\eta$	BESIII	3.1±0.1(stat)	0.59±0.05(stat)
	PDG08	2.4±0.4	<0.5
	CLEO-c	3.18±0.13±0.35	0.51±0.05±0.06

Summary

- **Recent hadron spectroscopy results at BES are presented:**
  - **Partial wave analysis results of charged κ**
  - **X(1860) has been confirmed in $\psi(2S)\rightarrow\pi^+\pi^- J/\psi$, $J/\psi\rightarrow\gamma$ ppbar; no significant narrow enhancement is observed in $\psi(2S)\rightarrow\gamma$ ppbar.**
  - **$\chi_{cJ}\rightarrow\pi^0\pi^0$ and $\eta\eta$**

- **BESIII started running**

  ~110M $\psi(2S)$ collected

  ~230M J/psi collected

- **Expecting new and exciting results from new data.**

Thank you