Recent results of light hadron spectroscopy from BESIII

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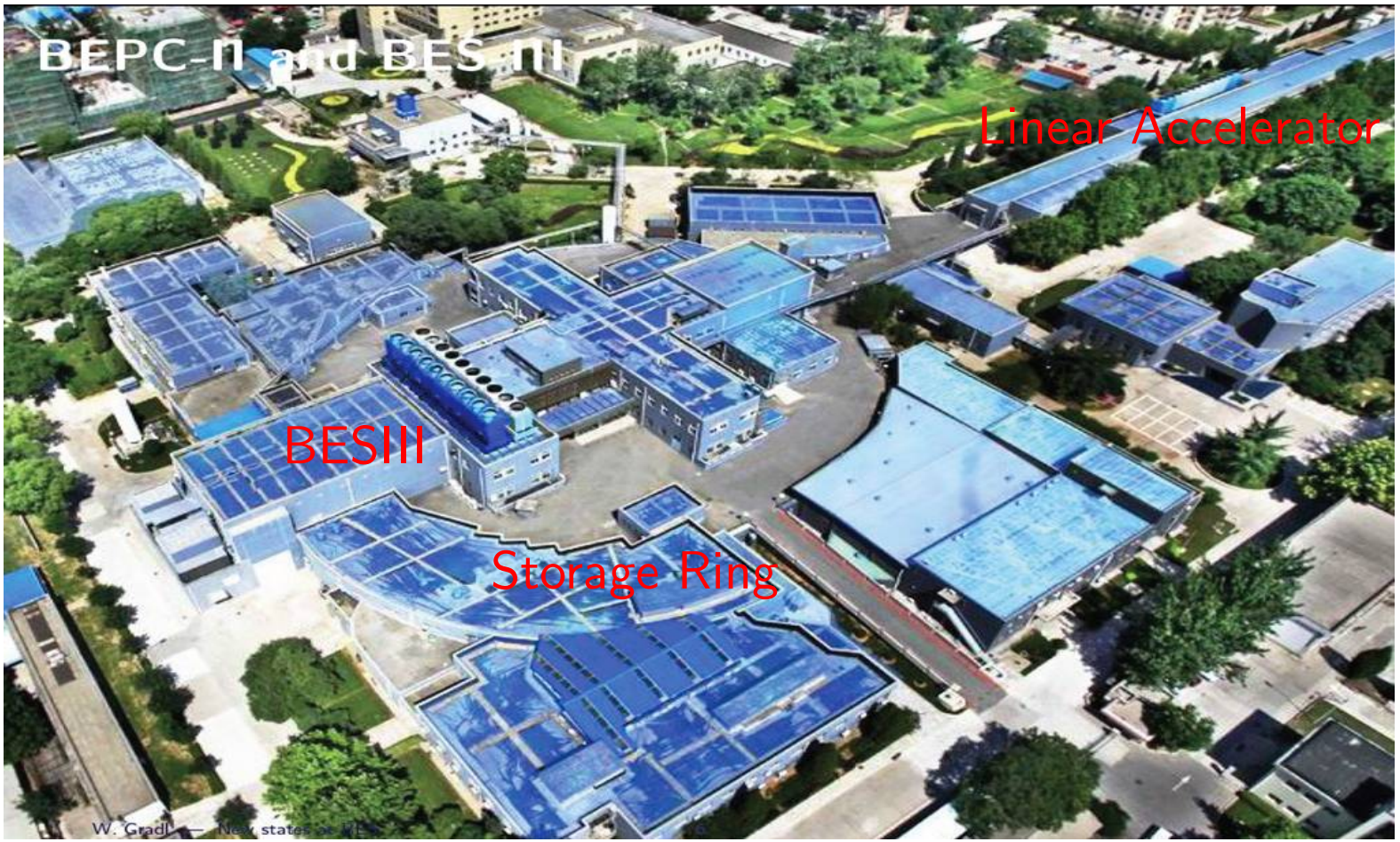
Outline

Overview of BEPCII and BESIII



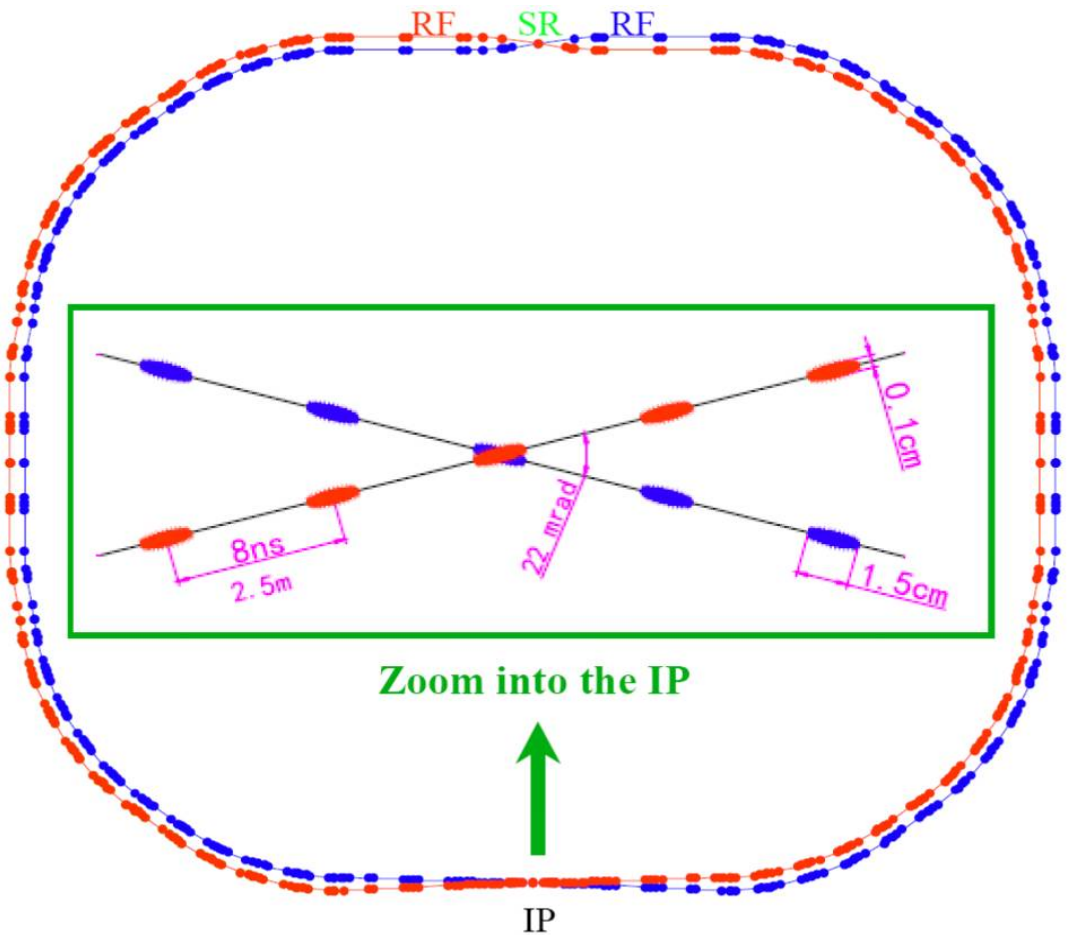
2004: start BEPCII construction

2008: test run of BEPCII

2009-now: BEPCII/BESIII data taking

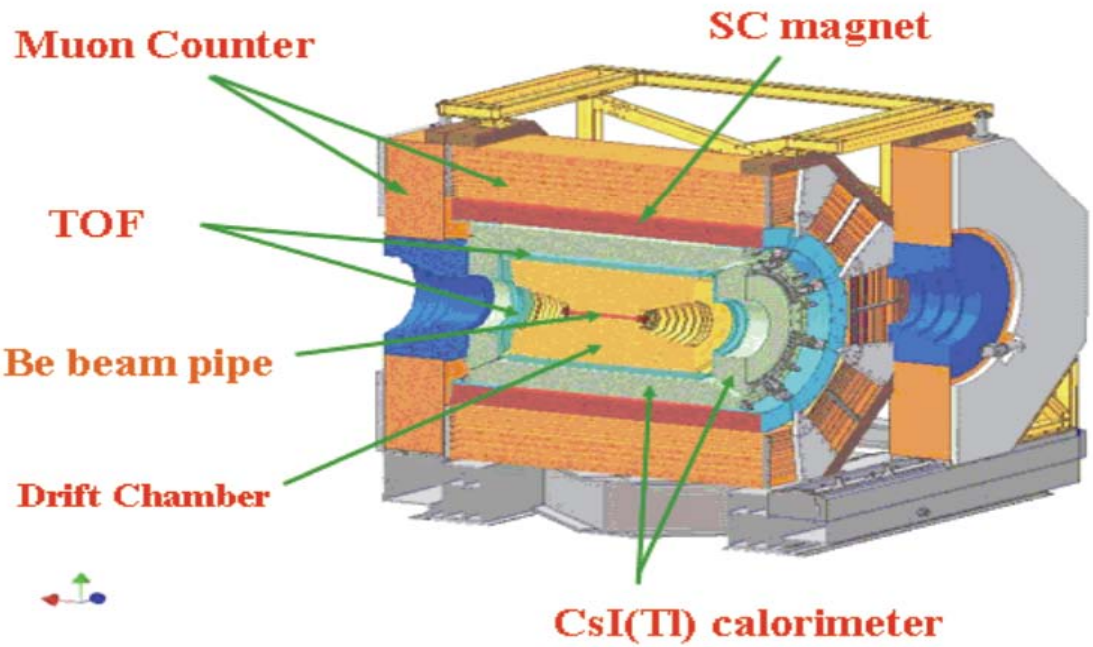
BEPCII storage rings

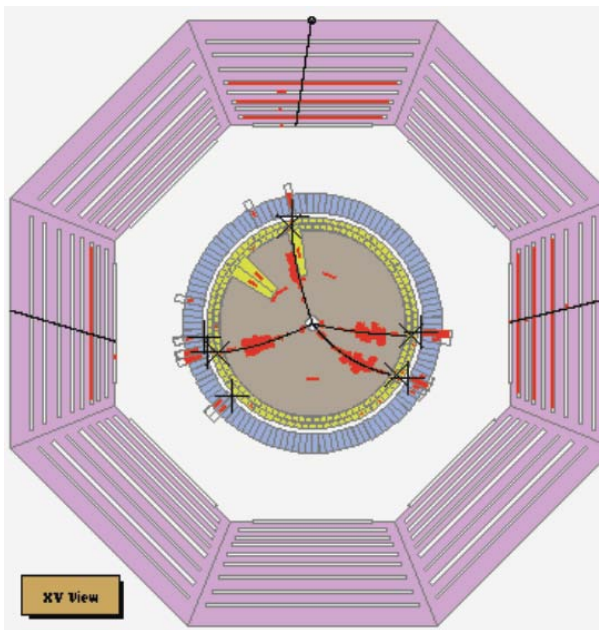
BEPCII(the Beijing Electron Positron Collider)



Beam energy:
1.0-2.3GeV
Design Luminosity:
$1 \times 10^{33} cm^{-2} s^{-1}$
Record Luminosity:
$6.492 \times 10^{32} cm^{-2} s^{-1}$
Energy spread:
5.16×10^{-4}
Optimum energy:
$1.89 GeV$
No.of bunches:
93
Bunch length:
$1.5 cm$
Total current:
$0.91 A$
Circumference:
$237 m$

The BESIII Detector





BESIII(the Beijing Spectrometer)

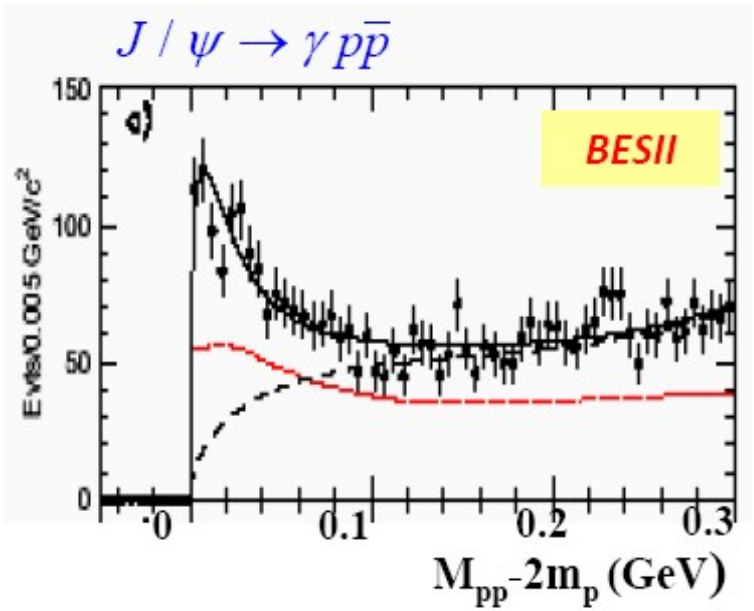
- MDC:43 layers; $\sigma(p)/p = 0.5\%@1GeV$; $\sigma(dE/dx) < 6\%$; $\sigma_{xy} = 130um$
- TOF:100ps for Barrel;110ps for Endcap
- EMC:$\sigma(E)/E = 2.5\%@1GeV$
- MUC:9 layers of RPC for barrel, 8 for endcap

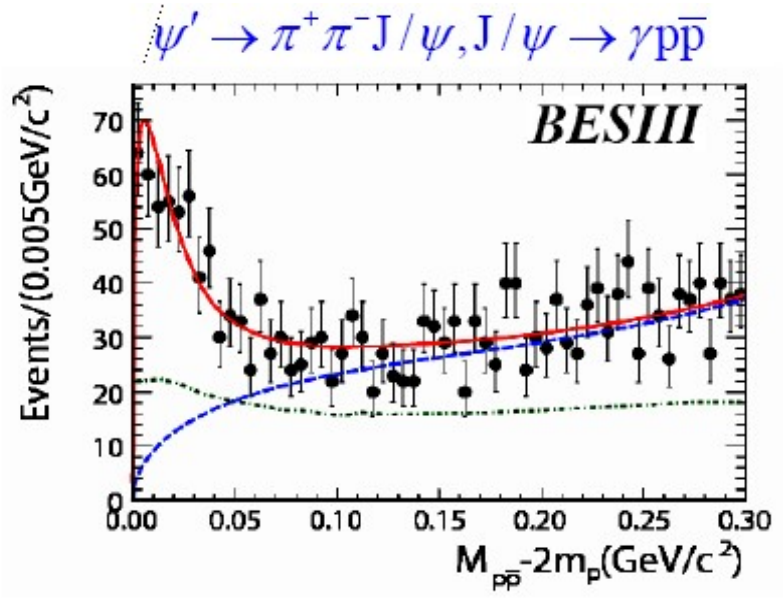
BESIII Commissioning

- July 19, 2008: first e^+e^- collision event in BESIII
- Nov. 2008: ~14M ψ(2S) events for detector calibration
- 2009: 106M ψ(2S) (four times of CLEOc)
  225M J/ψ (four times of BESII)
- 2010: ~900 pb^{-1} ψ(3770)
- 2011: ~2000 pb^{-1} ψ(3770)
  470 pb^{-1} at 4.01 GeV
- 2012: tau mass measurement
  ψ(2S): 0.4 billion; J/ψ: 1 billion (May 25)

World's largest sample of J/ψ, ψ(2S) and ψ(3770).
The numbers are still growing.

$X(p\bar{p})$ was observed at BESII and confirmed by BESIII





BESII:
$M=1859^{+3+5}_{-10-25}$ MeV/c^2
Γ <30MeV/c^2 at the 90% C.L.
PRL 91(2003)022001

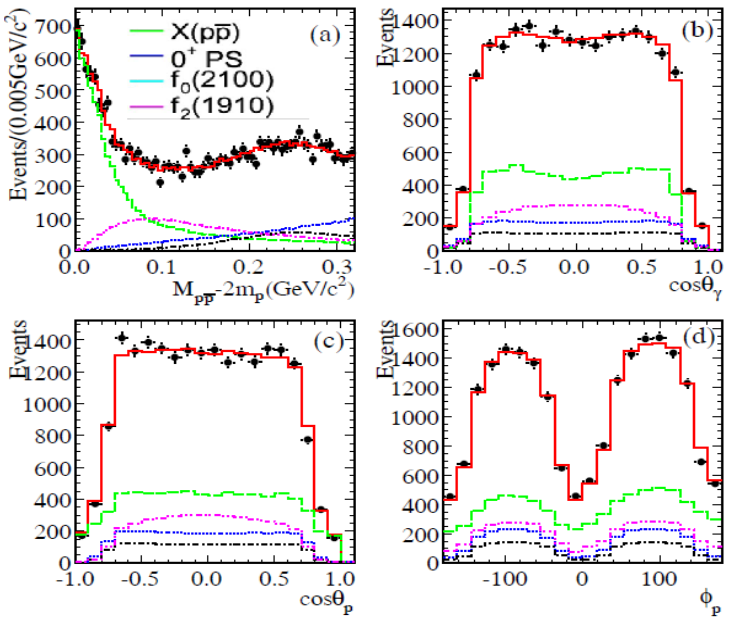
BESIII:
$M=1861^{+6+7}_{-13-26}$ MeV/c^2
Γ <38MeV/c^2 at the 90% C.L.
Chinese Physics C 34, 421(2010)

Confirmed the enhancement! Results are consistent with BESII.

What could it be? $p\bar{p}$ bound state or Final state interaction effect(FSI) or some of both?

Partial Wave Analysis (PWA) of $J/\psi \to \gamma p\bar{p}$

Phys. Rev. Lett. 108, 112003(2012)



- The fit with a BW and S-wave FSI (I=0) factor can well describe ppbar mass threshold structure.
- It is much better than that without FSI effect, and $\Delta 2\ln L = 51 \Rightarrow 7.1\sigma$.

$f_0(2100)/f_2(1910)$ fixed to PDG. Signif. of $X(p\bar{p}) \gg 30\sigma$

J^{pc} is determined to be 0^{-+}

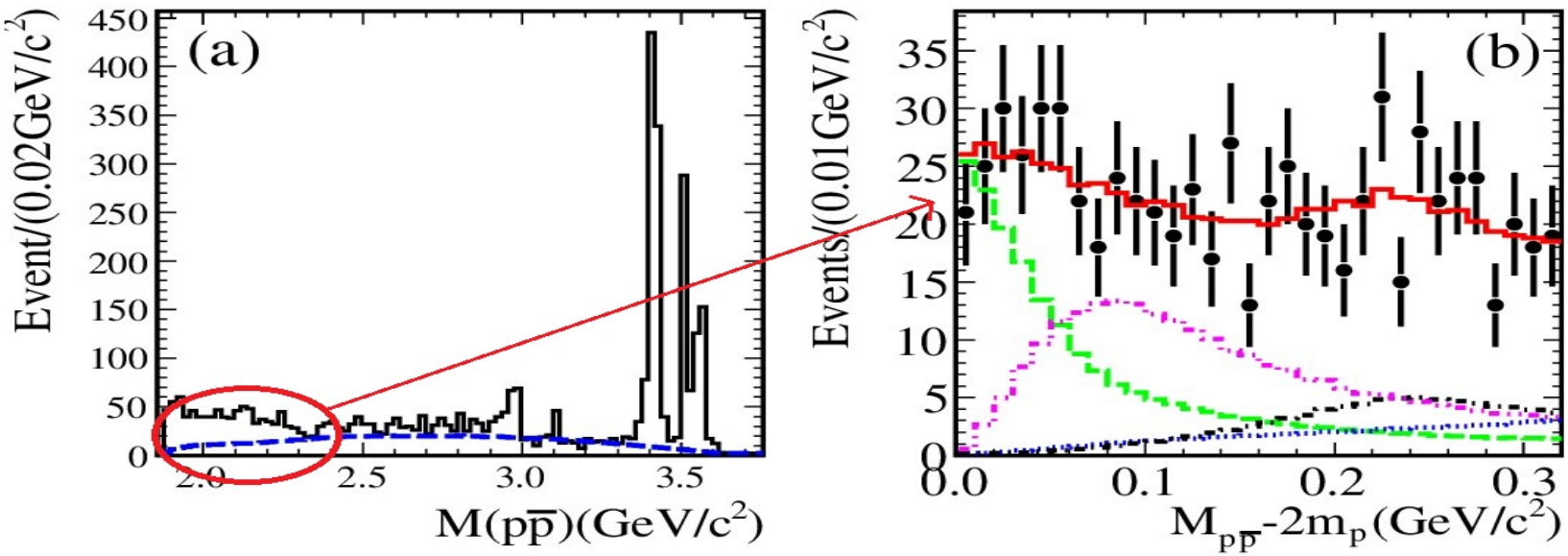
$M = 1832^{+19}_{-5}(stat.)^{+18}_{-17}(syst.) \pm 19(model)\mathrm{MeV}/c^2$

$\Gamma = 13 \pm 39(stat.)^{+10}_{-13}(syst.) \pm 4(model)\mathrm{MeV}/c^2$ (Γ <76MeV/c^2, 90% C.L.)

$Br(J/\psi \to \gamma X(p\bar{p}))Br(X(p\bar{p}) \to p\bar{p}) =$

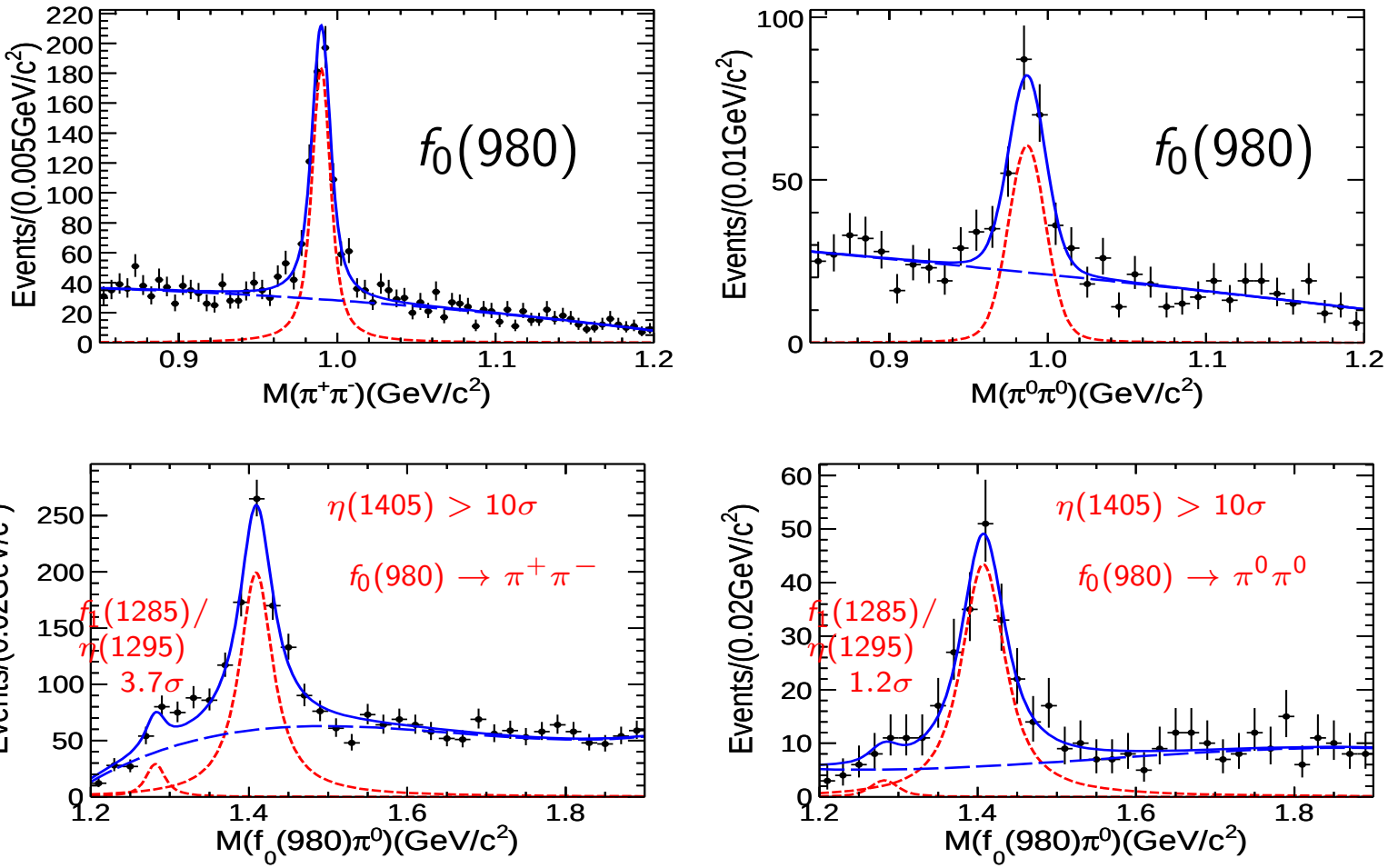
$(9.0^{+0.4}_{-1.1}(stat.)^{+1.5}_{-5.0}(syst.) \pm 2.3(model)) \times 10^{-5}$

PWA of $\psi(2S) \to \gamma p\bar{p}$



$Br(\psi(2S) \to \gamma X(p\bar{p}))Br(X(p\bar{p}) \to p\bar{p}) =$
$(4.57 \pm 0.36(stat.)^{+1.23}_{-4.07} \pm 1.28(model)) \times 10^{-6}$
The production ratio R:
$R = \frac{Br(\psi(2S) \to \gamma X(p\bar{p}))}{Br(J/\psi \to \gamma X(p\bar{p}))} = (5.08^{+0.71}_{-0.45}(stat.)^{+0.67}_{-3.58}(syst.) \pm 0.12(model))\%$
It is suppressed compared with 12%rule.

$M(\pi^+\pi^-)/M(\pi^0\pi^0)$, $M(f_0(980)\pi^0)$



Helicity analysis indicates that peak at $1400MeV$ is from $\eta(1405) \to f_0(980)\pi^0$(isospin violated decays), not from $f_1(1420)$

First observation of $\eta(1405) \to f_0(980)\pi^0$ in $J/\psi \to \gamma f_0(980)\pi^0$

Phys. Rev. Lett. 108, 182001 (2012)

Anomalous lineshape of $f_0(980)$:

$f_0(980) \to \pi^+\pi^-$:

M=$989.9 \pm 0.4 \mathrm{MeV}/c^2$, $\Gamma = 9.5 \pm 1.1 \mathrm{MeV}/c^2$

$f_0(980) \to \pi^0\pi^0$:

M=$987.0 \pm 1.4 \mathrm{MeV}/c^2$, $\Gamma = 4.6 \pm 5.1 \mathrm{MeV}/c^2$

The measured width of the $f_0(980)$ is much narrower than the world average(PDG2010,Γ: 40-100MeV/c^2).

$Br(J/\psi \to \gamma\eta(1405) \to \gamma\pi^0 f_0(980) \to \gamma\pi^0\pi^+\pi^-) =$
$(1.50 \pm 0.11(stat) \pm 0.11(sys)) \times 10^{-5}$

$Br(J/\psi \to \gamma\eta(1405) \to \gamma\pi^0 f_0(980) \to \gamma\pi^0\pi^0\pi^0) =$
$(7.10 \pm 0.82(stat) \pm 0.72(sys)) \times 10^{-6}$

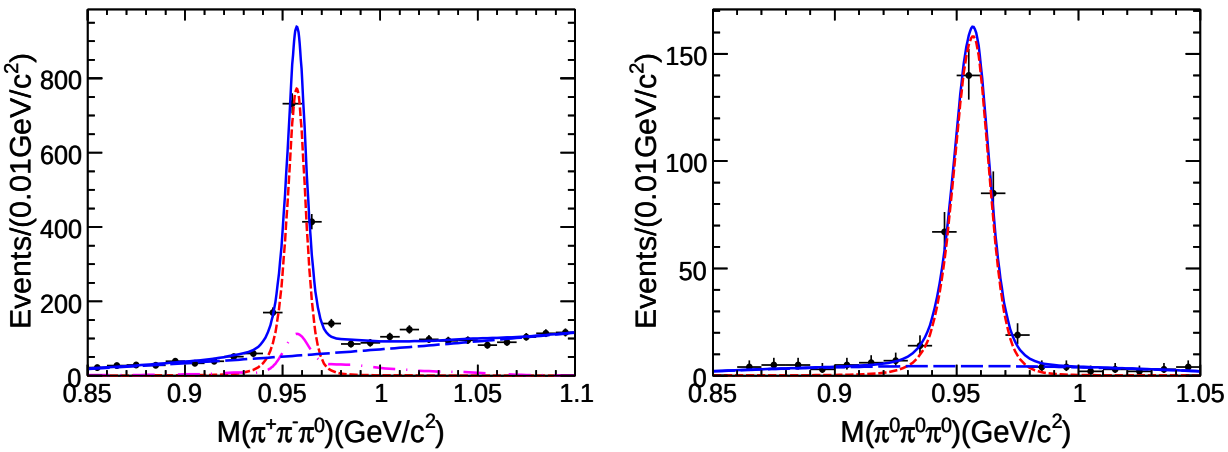
Large Isospin-violating decay rate(in general,$< 1\%$ at 0.1% level):

$Br(\eta(1405) \to f_0(\pi^+\pi^-)\pi^0)/Br(\eta(1405) \to \pi^+\pi^-\eta) \sim 7.5\%$,

$Br(\eta(1405) \to f_0(980)\pi^0)/Br(\eta(1405) \to a_0(980)\pi) \sim 25\%$

A possible explanation is KK^* loop(J.J.Wu et al, PRL 108, 081803 (2012))

$J/\psi \to \gamma\eta', \eta' \to 3\pi$



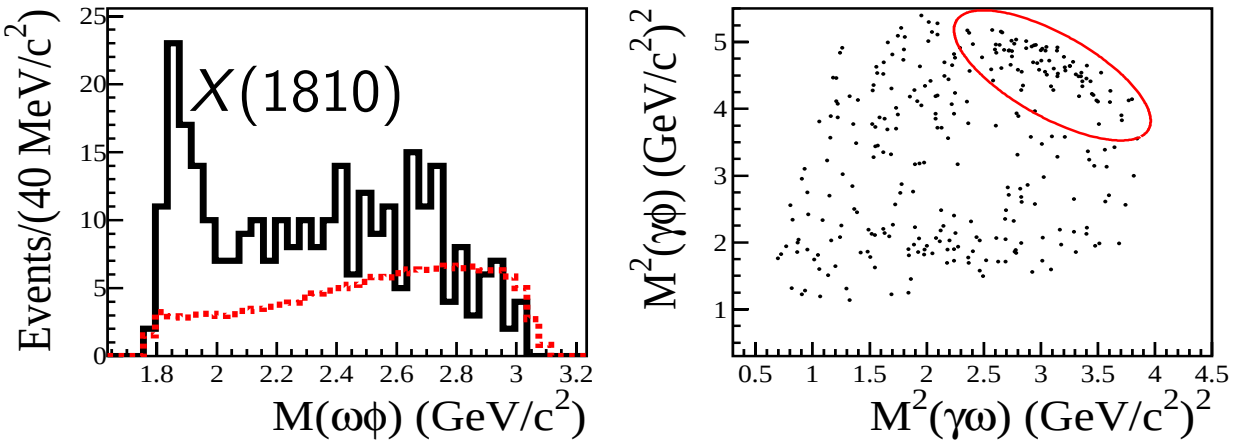
New results:

$Br(\eta' \to \pi^+\pi^-\pi^0) = (3.83 \pm 0.15 \pm 0.39) \times 10^{-3}$(PDG2010,$(3.6^{+1.1}_{-0.9}) \times 10^{-3}$)

$Br(\eta' \to 3\pi^0) = (3.56 \pm 0.22 \pm 0.34) \times 10^{-3}$(PDG2010,$(1.68 \pm 0.22) \times 10^{-3}$)

For the decay $\eta' \to 3\pi^0$, it is two times larger than the world average value.

$\omega\phi$ threshold enhancement in $J/\psi \to \gamma\omega\phi$(BESII)



Phys. Rev. Lett. 96(2006)162002

- Doubly OZI suppressed decay.
- First observed by BESII collaboration
- $J^{PC} = 0^{++}$
- M $= 1812^{+19}_{-26} \pm 18\text{MeV}/c^2$, $\Gamma = 105 \pm 20 \pm 28\text{MeV}/c^2$
- B($J/\psi \to \gamma$ X(1810))*B(X(1810)$\to \omega\phi$)
  $=(2.61 \pm 0.27(stat) \pm 0.65(syst)) \times 10^{-4}$

What could it be? A tetraquark state, a hybrid, a glueball state, an effect due to intermediate meson rescatterings, etc.?

Preliminary PWA Results of $J/\psi \to \gamma\omega\phi$

Resonance	J^{PC}	M(MeV/c^2)	Γ(MeV/c^2)	Significance
$X(1810)$	0^{++}	1795 ± 7	95 ± 10	$> 30\sigma$
$f_2(1950)$	2^{++}	1944	472	$> 10\sigma$
$f_0(2020)$	0^{++}	1992	442	$> 10\sigma$
$\eta(2225)$	0^{-+}	2240	1903	6.4σ
phase space	0^{-+}	2400	5000	$> 8\sigma$

Spin-parity, mass, width and B.R. of $X(1810)$:

J^{pc}=0^{++}

M=$1795 \pm 7(stat)^{+23}_{-5}(syst)$MeV/$c^2$

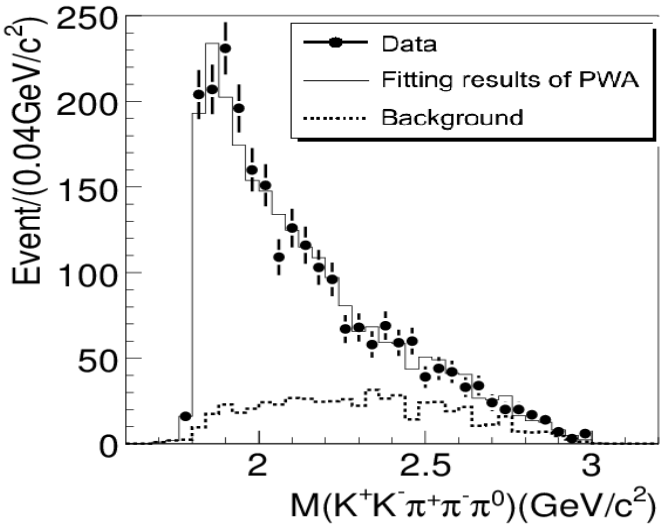
Γ=$95 \pm 10(stat)^{+78}_{-34}(syst)$MeV/$c^2$

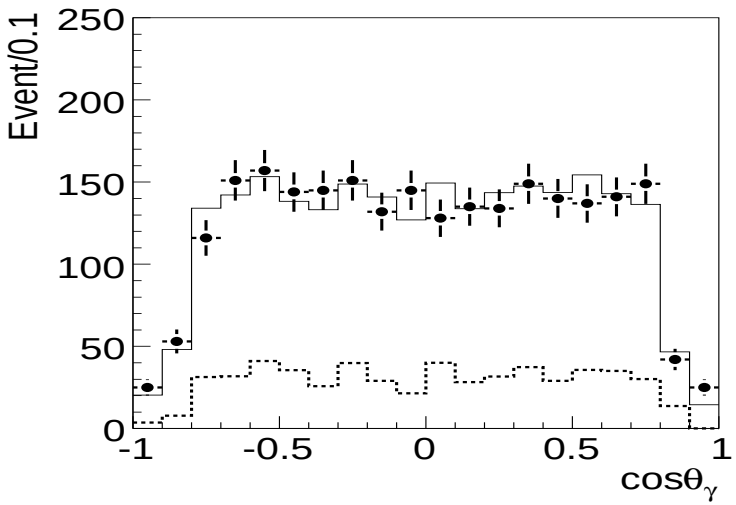
B($J/\psi \to \gamma\ X(1810)$)*B($X(1810) \to \omega\phi$)

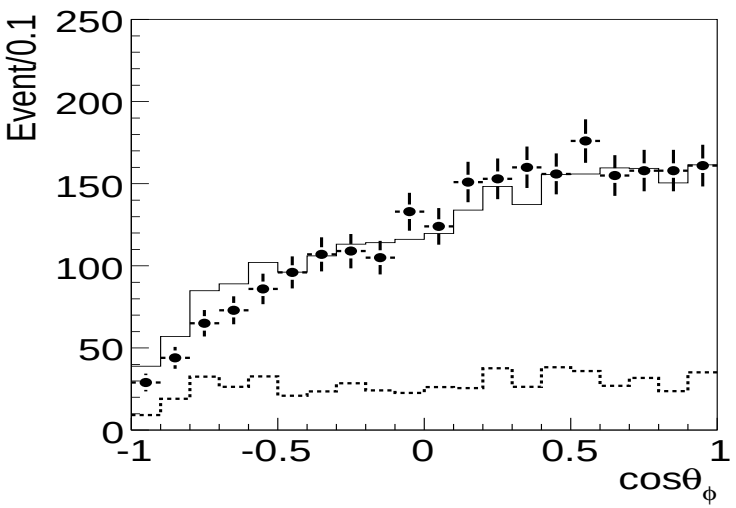
$=(1.99 \pm 0.08(stat)^{+1.37}_{-0.99}(syst)) \times 10^{-4}$

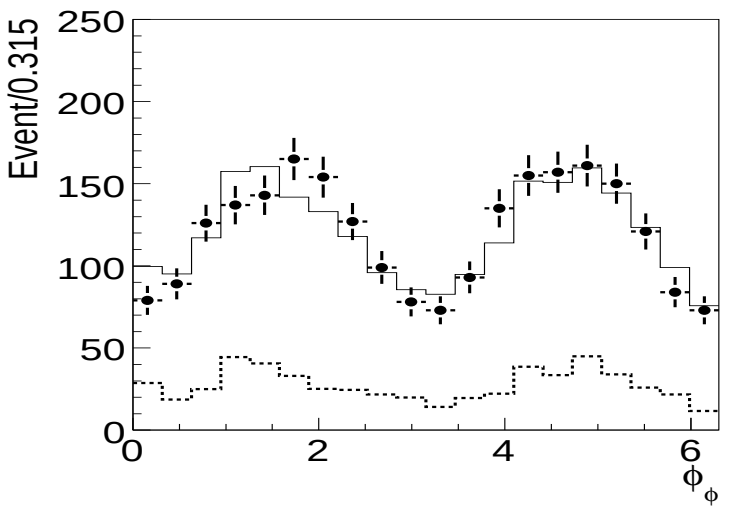
Results are consistent with those of BESII.

Preliminary PWA Results of $J/\psi \to \gamma\omega\phi$





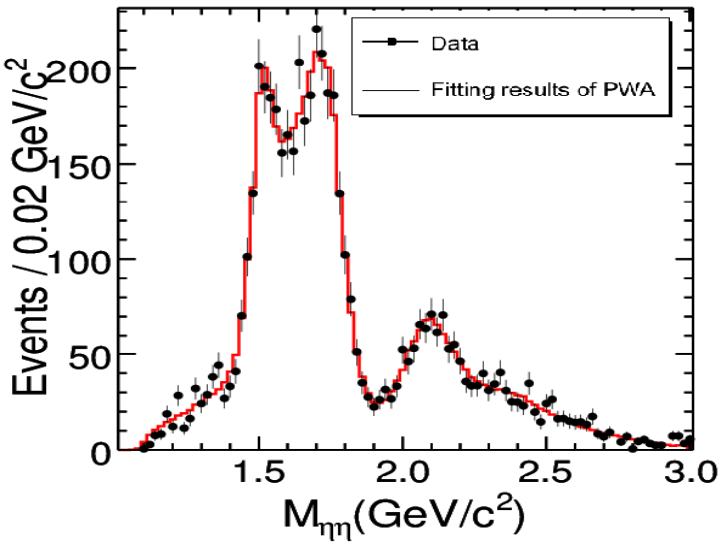


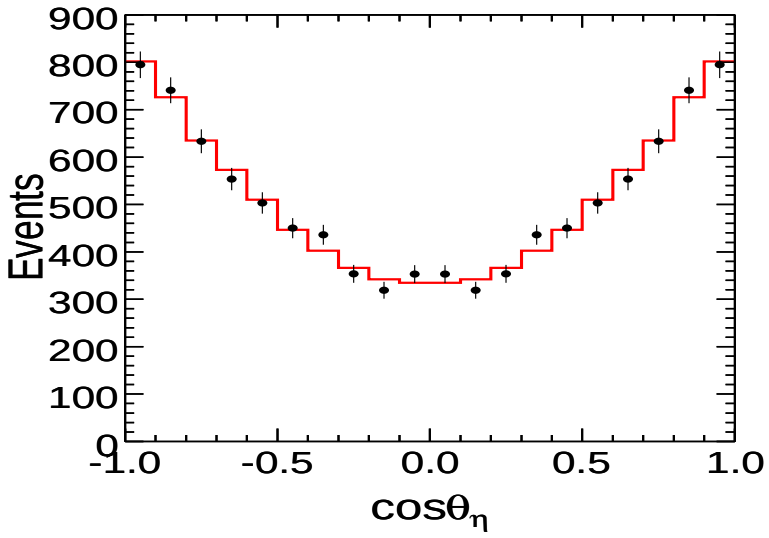


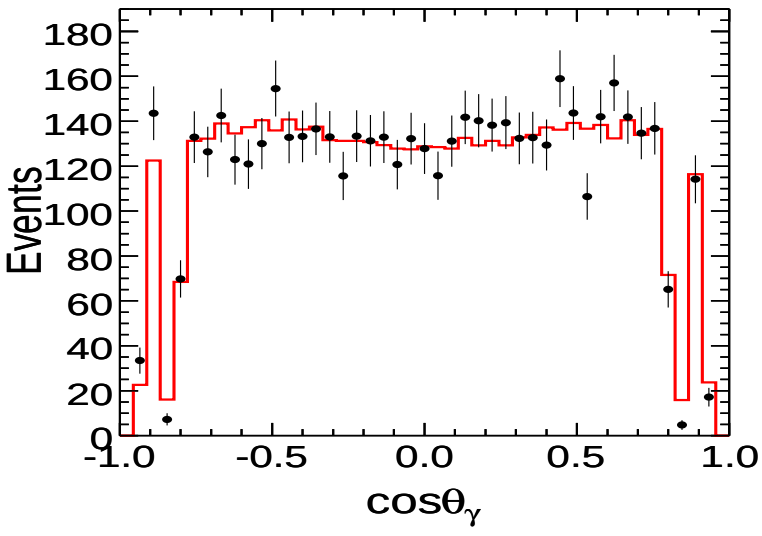
Some results from other experiments

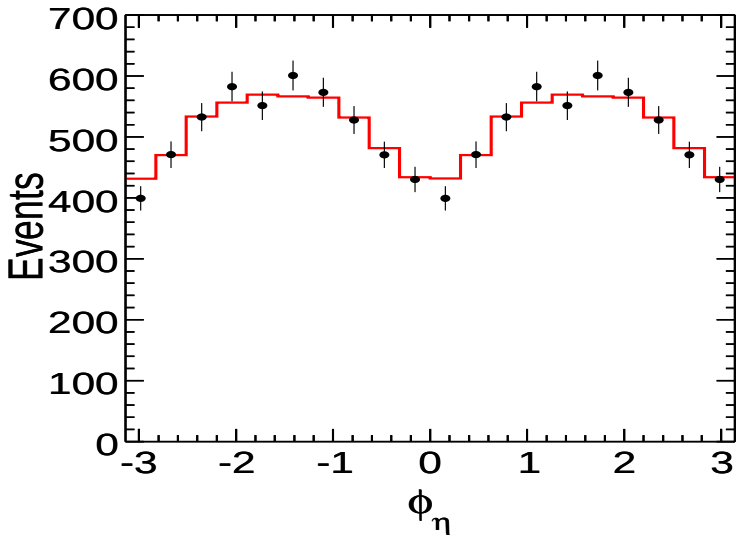
- First observed $f_0(1710)$ from J/ψ radiative decays to $\eta\eta$ by Crystal Ball in 1982.
- Crystal Ball Collaboration(2002) analyzed the three final states $\pi^0\pi^0\pi^0$, $\eta\pi^0\pi^0$ and $\pi^0\eta\eta$ with K matrix formalism. Found a 2^{++} ($\sim$1870), but no $f_0(1710)$.
- E835(2006): $p\bar{p} \to \pi^0\eta\eta$, found $f_0(1500)$ and $f_0(1710)$.
- WA102 and GAMS all identified $f_0(1710)$ in $\eta\eta$.

Preliminary PWA Results of $J/\psi \to \gamma\eta\eta$









Preliminary PWA Results of $J/\psi \to \gamma\eta\eta$

Resonance	Mass(MeV/c^2)	Width(MeV/c^2)	$\mathcal{B}(J/\psi \to \gamma X \to \gamma\eta\eta)$	Significance
$f_0(1500)$	1468^{+14+20}_{-15-74}	$136^{+41+8}_{-26-100}$	$(1.61^{+0.29+0.41}_{-0.32-1.28}) \times 10^{-5}$	8.2 σ
$f_0(1710)$	1759^{+6+14}_{-6-25}	172^{+10+31}_{-10-15}	$(2.35^{+0.07+1.23}_{-0.07-0.72}) \times 10^{-4}$	25.0 σ
$f_0(2100)$	2081^{+13+23}_{-13-34}	273^{+27+65}_{-24-18}	$(9.0^{+0.57+5.52}_{-0.52-2.21}) \times 10^{-5}$	13.9 σ
$f_2'(1525)$	1513^{+5+3}_{-5-10}	75^{+12+15}_{-10-7}	$(5.41^{+0.43+1.22}_{-0.50-1.23}) \times 10^{-5}$	11.0 σ
$f_2(1810)$	1822^{+29+61}_{-24-54}	229^{+52+64}_{-42-}	$(5.38^{+0.60+3.31}_{-0.67-2.24}) \times 10^{-5}$	6.4 σ
$f_2(2340)$	$2362^{+31+139}_{-30-59}$	334^{+6}_{-}	$(5.58^{+0.61+1.93}_{-0.65-1.81}) \times 10^{-5}$	7.6 σ

- $f_0(1710)$ and $f_0(2100)$ are dominant scalars
- $f_0(1500)$ exists (8.2σ)
- $f_2'(1525)$ is the dominant tensor

Summary

- Confirmation of $p\bar{p}$ threshold structure.
  J^{PC} of $X(p\bar{p})$ is firstly determined to be 0^{-+} by PWA.
  First measurement of branching ratio for $\psi(2S) \to \gamma X(p\bar{p})$.
- First observation of $\eta(1405) \to f_0(980)\pi^0$ in $J/\psi \to \gamma 3\pi$.
- Confirmation of $\omega\phi$ threshold structure.
- Observation of $f_0(1500)$ and $f_0(1710)$ in $J/\psi \to \gamma\eta\eta$.

Thanks for your attention! 谢谢！