RUHR-UNIVERSITÄT BOCHUM

RUB

Light Meson Spectroscopy At BES III

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(on behalf of the BES III Collaboration)

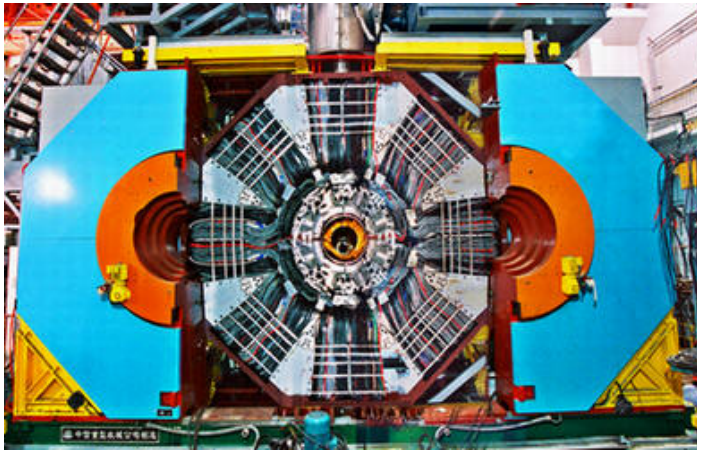
EuNPC 2015
Aug. 31- Sep. 4, 2015
Groningen, The Netherlands

DFG

BESIII

Physics Program

- Light Hadron Spectroscopy
  - Understand QCD in the non-perturbative regime
  - Understand origin of the hadron mass
  - Search for exotic hadrons, e.g. glueballs, hybrids, tetraquarks
- Charmonium Physics
  - X, Y, and Z states
  - Decays and transitions
- Open Charm Physics
  - D meson decays
  - $D\bar{D}$ mixing
  - CP violation in the charm sector
- And many further topics
  - e.g. tau and two-photon physics

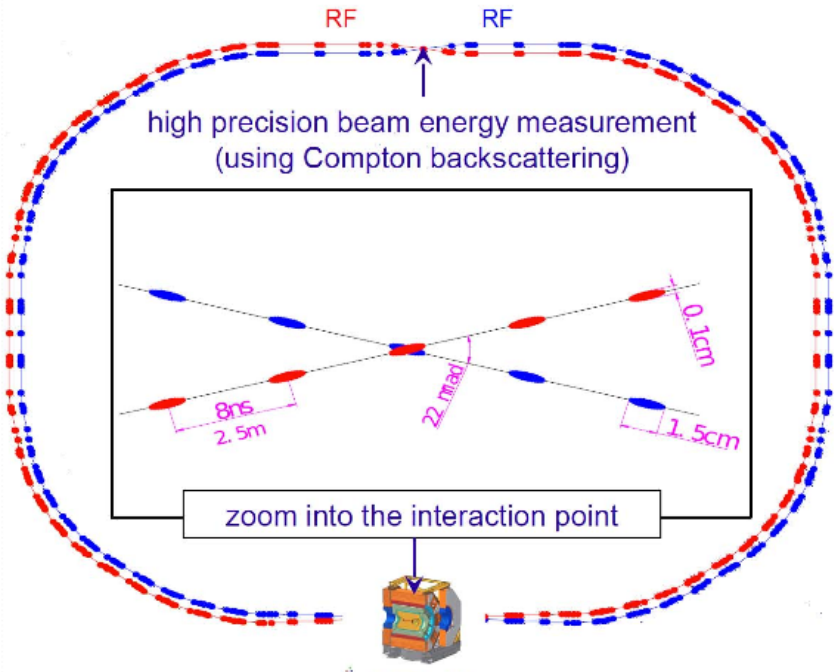


Further BESIII presentations at this conference

Hadron Structure II (Mon.)
X. Wang, Baryon spectroscopy at BESIII
L. Liu , XYZ spectroscopy at BESIII

Hadron Structure III (Tue.)
R. Ping, Studies of Charmonium at BESIII
Z. Haddadi, Radiative transition studies with BESIII

BES III at BEPC II



Symmetric electron-positron collider BEPC II

- Energy range: $\sqrt{s}$ = 2.0-4.6 GeV
- Design luminosity: 1×10^{33} cm^{-2}s^{-1} (at $\psi(3770)$)
- Energy spread: ~5×10^{-4}
- Operating since March 2008
- Achieved luminosity: 0.7×10^{33} cm^{-2}s^{-1}

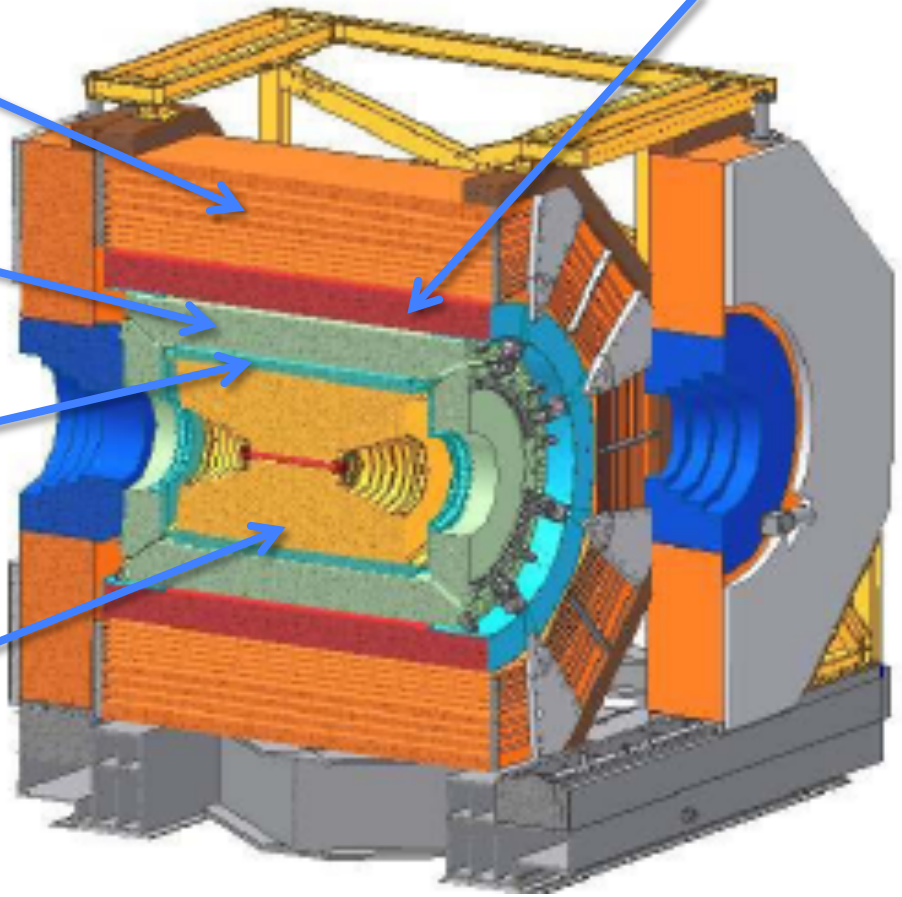
The BES III Detector

RPC Muon Detector

8 layers (end caps), 9 layers (barrel)

$\delta R_\phi = 1.4 - 1.7\,\mathrm{mm}$

Superconducting Solenoid (1 T)



Electromagnetic CsI(Tl) Calorimeter

$\sigma_E/E < 2.5\%/\sqrt{E}$

$\sigma_{z,\phi} = 0.5 - 0.7\,\mathrm{cm}/\sqrt{\mathrm{E}}$

Time of Flight System

$\sigma_t = 80\,\mathrm{ps}$ (barrel)

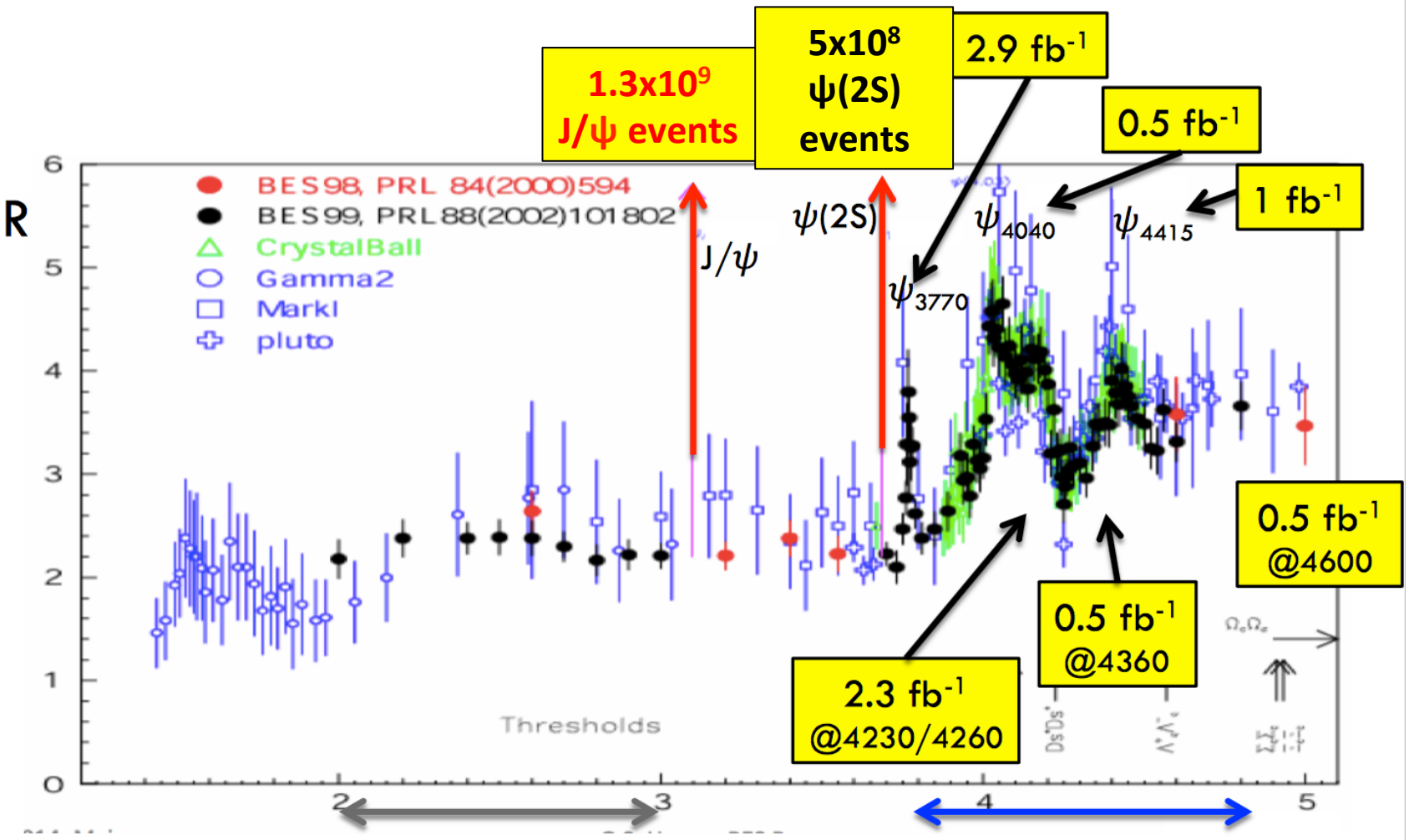
$\sigma_t = 110\,\mathrm{ps}$ (end caps)

Drift Chamber

$\sigma_{(dE/dx)} = 6\%$

$\sigma_{p_t}/p_t = 0.5\%$

Data Samples



R scan: 2-3 GeV, 19 points, ~0.5 fb^{-1}; 3.85-4.59 GeV, 104 points, ~0.8 fb^{-1}

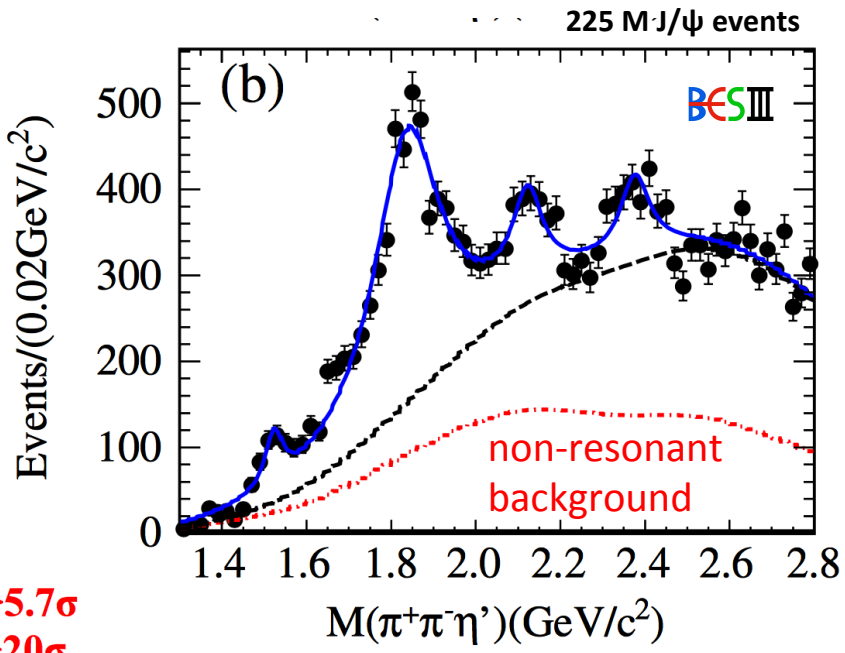
plus 24/pb at τ mass threshold and
0.5/fb in the region 4100-4400 MeV

X(1835) in $J/\psi \to \gamma\pi^+\pi^-\eta'$

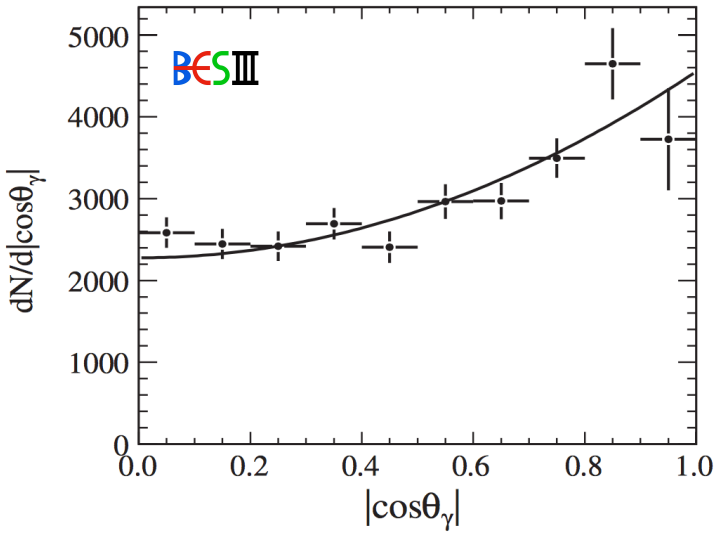
BESIII, Phys. Rev. Lett. 106, 072002 (2011)

- X(1835) previously observed at BES and BESII
- Nature unclear, interpretations include glueball, $\bar{p}p$ bound state, excited η meson
- Confirmed at BESIII with two additional structures above 2 GeV/c^2

Resonance	$M(\mathrm{MeV}/c^2)$	$\Gamma(\mathrm{MeV}/c^2)$	
$f_1(1510)$	1522.7 ± 5.0	48 ± 11	>5.7σ
$X(1835)$	1836.5 ± 3.0	190.1 ± 9.0	>20σ
$X(2120)$	2122.4 ± 6.7	83 ± 16	>7.2σ
$X(2370)$	2376.3 ± 8.7	83 ± 17	>6.4σ



- X(1835) angular distribution consistent with pseudoscalar, but other spin-parity assignments not excluded

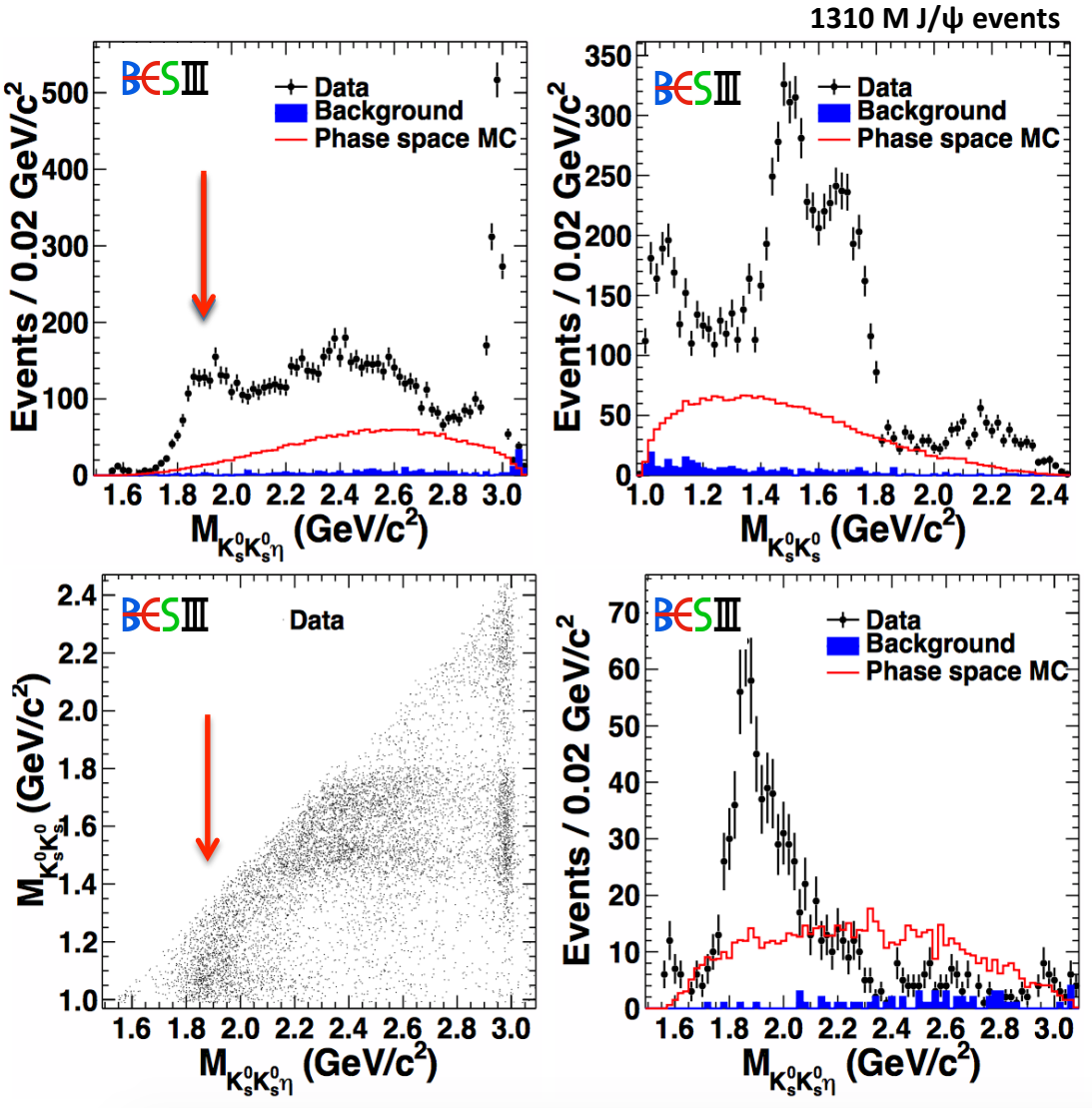


→ Systematic studies of X(1835) ongoing at BESIII (new decay modes, production mechanisms, PWA)

X(1835) in $J/\psi \to \gamma K_S^0 K_S^0 \eta$

BESIII, arXiv:1506.04807
accepted by Phys. Rev. Lett.

- Structure in invariant $K_SK_S\eta$ mass at ~1.85 GeV/c^2
- Strong correlation with enhancement at K_SK_S mass threshold (interpretated as $f_0(980)$)
- Structure in $K_SK_S\eta$ is enhanced for m(K_SK_S)<1.1 GeV/c^2



X(1835) in $J/\psi \to \gamma K_S^0 K_S^0 \eta$

BESIII, arXiv:1506.04807
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- Partial wave analysis for $m(K_SK_S)<1.1$ GeV/c² and $m(K_SK_S\eta)<2.8$ GeV/c²

- Two resonant pseudoscalar components (Breit-Wigner parameterization) required in best fit hypothesis

$X(1835) \to f_0(980)\eta$ (>12.9σ)

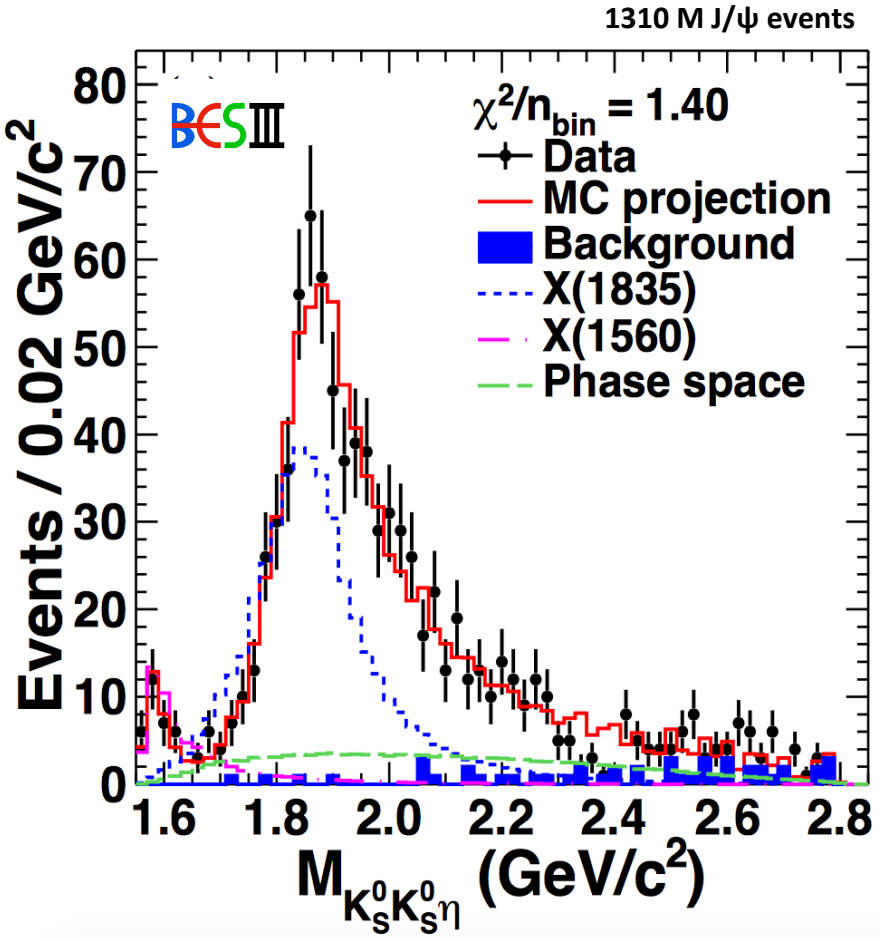
$$m = 1844 \pm 19^{+16}_{-25}\ \mathrm{MeV}/c^2$$

$$\Gamma = 192^{+20+62}_{-17-43}\ \mathrm{MeV}$$

$X(1560) \to f_0(980)\eta$ (>8.9σ)

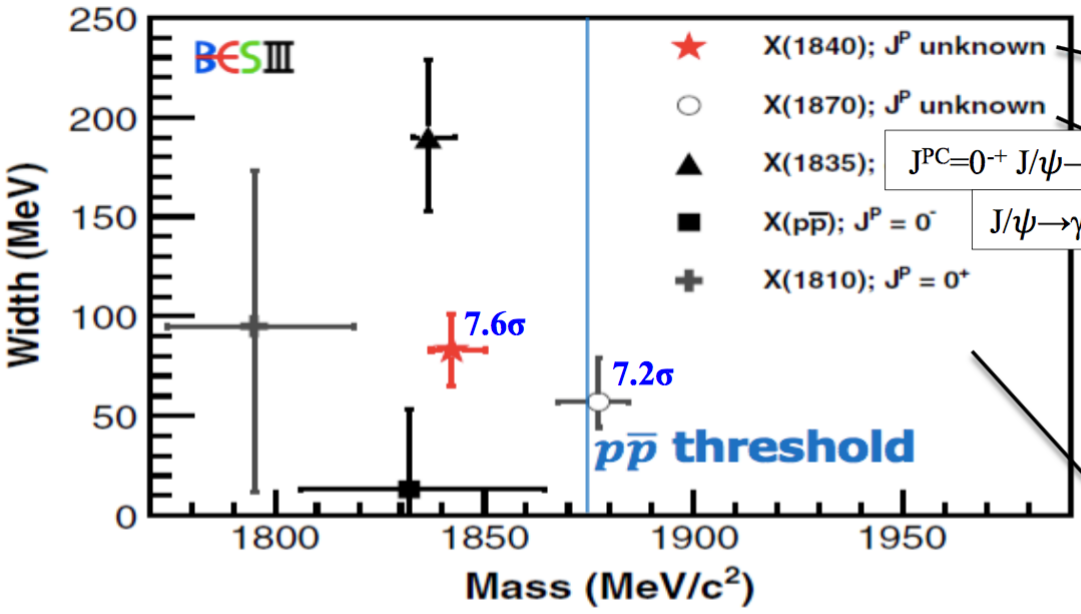
$$m = 1565 \pm 8^{+0}_{-63}\ \mathrm{MeV}/c^2$$

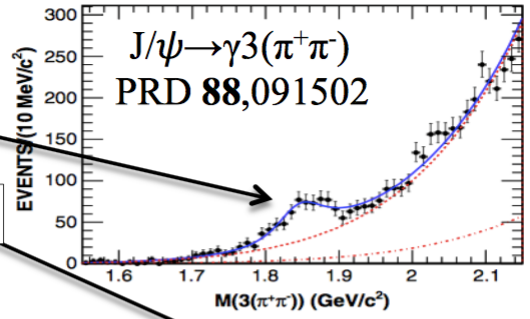
$$\Gamma = 45^{+14+21}_{-13-28}\ \mathrm{MeV}$$

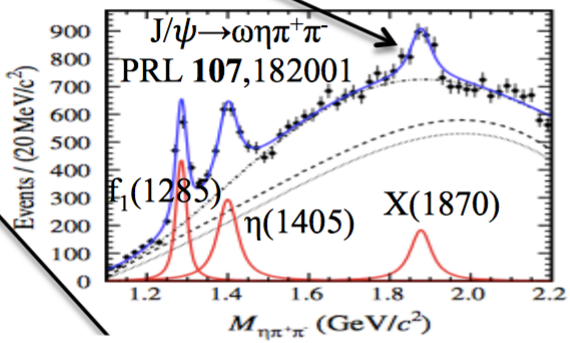


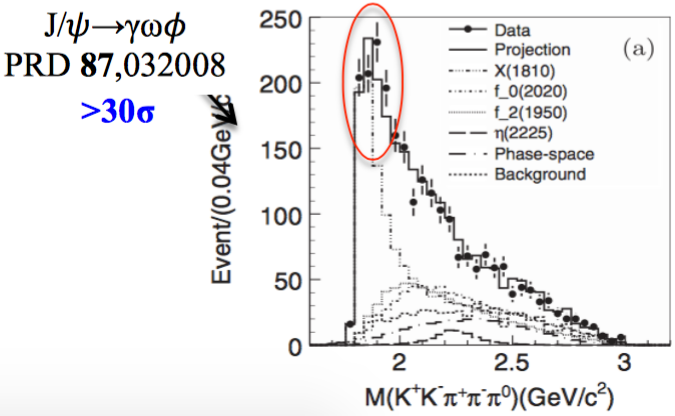
Values consistent with those of η(1405) / η(1475) at ~2σ
→ needs further investigation

Further Observations At $p\bar{p}$ Threshold









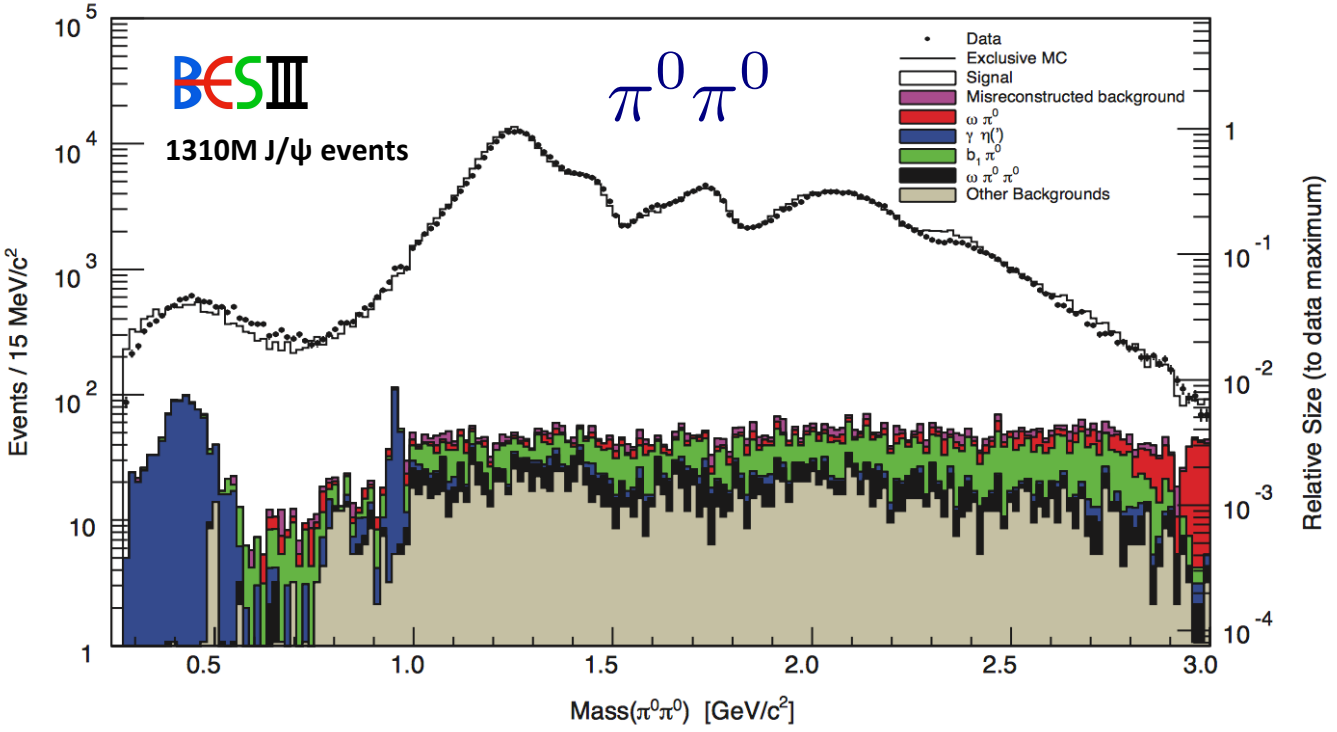
- Same origin?
- Further investigations required to clarify
  - J^{PC} not determined for all structures
  - Coupled channel analysis including various final states and production mechanisms

Model Independent PWA of $J/\psi \to \gamma\pi^0\pi^0$

- Radiative J/ψ decays into two pseudoscalar mesons: clean environment to search for scalar and tensor glueballs (predicted at ~1.5 to ~2 GeV/c^2)
- $\pi^0\pi^0$ system: only significant 0^{++} and 2^{++} contributions
  - Very complicated structure due to many broad and overlapping resonances with many open channels (parameterization challenging)
  - Model Independent Partial Wave Analysis

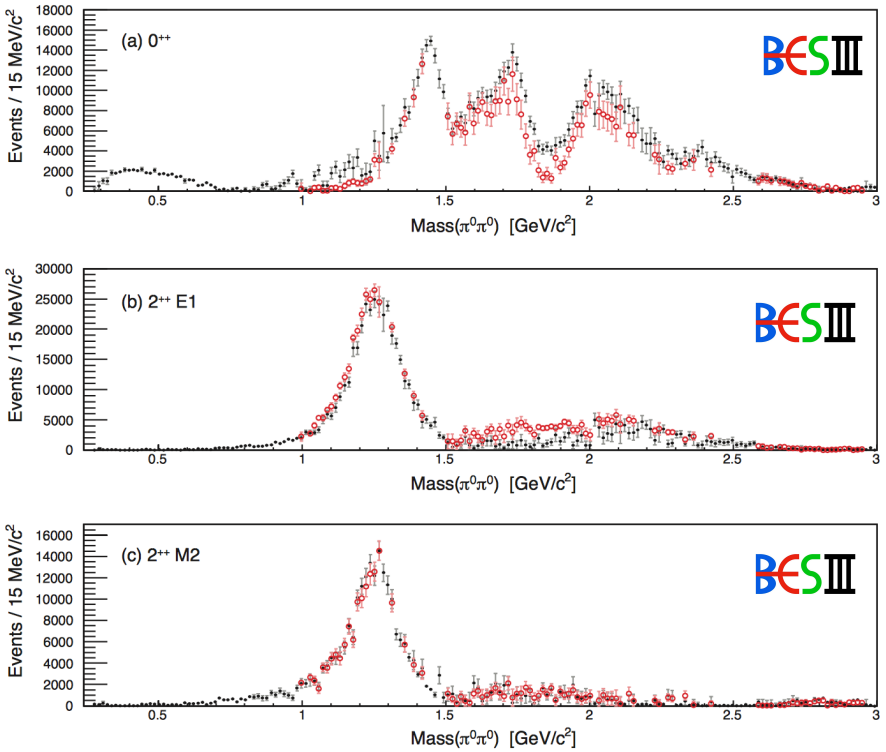
arXiv:1506.00546
accepted by Phys. Rev. D

>440k reconstructed events
at a background level of 1.8%

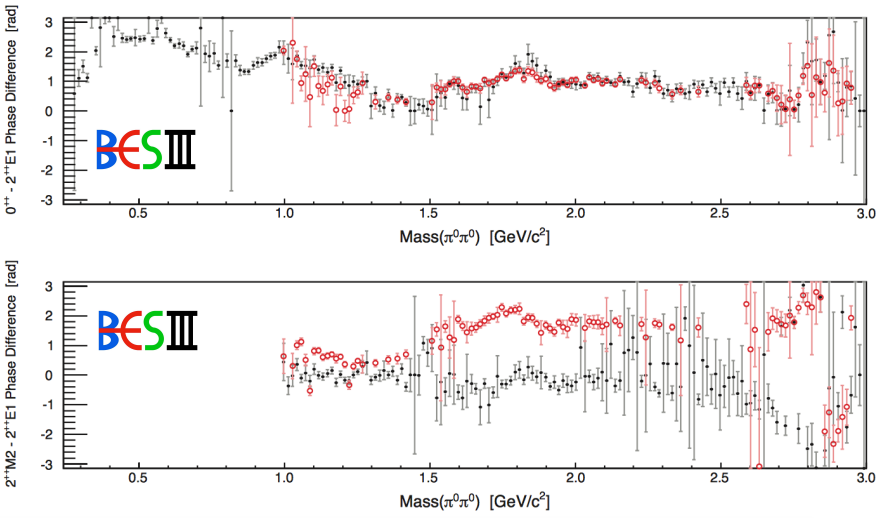


Model Independent PWA of $J/\psi \to \gamma\pi^0\pi^0$

Extracted Intensity



Relative Phase wrt/ 2^{++} E1 amplitude



nominal solution
ambigous solution

Ambiguities may be resolved in a model-dependent fit enforcing continuity between neighboring mass intervals

arXiv:1506.00546
accepted by Phys. Rev. D

Model independent approach is under investigation for other systems (e.g. ηη, KK)
→ improve our understanding of the nature of the observed resonances

Conclusions and Outlook

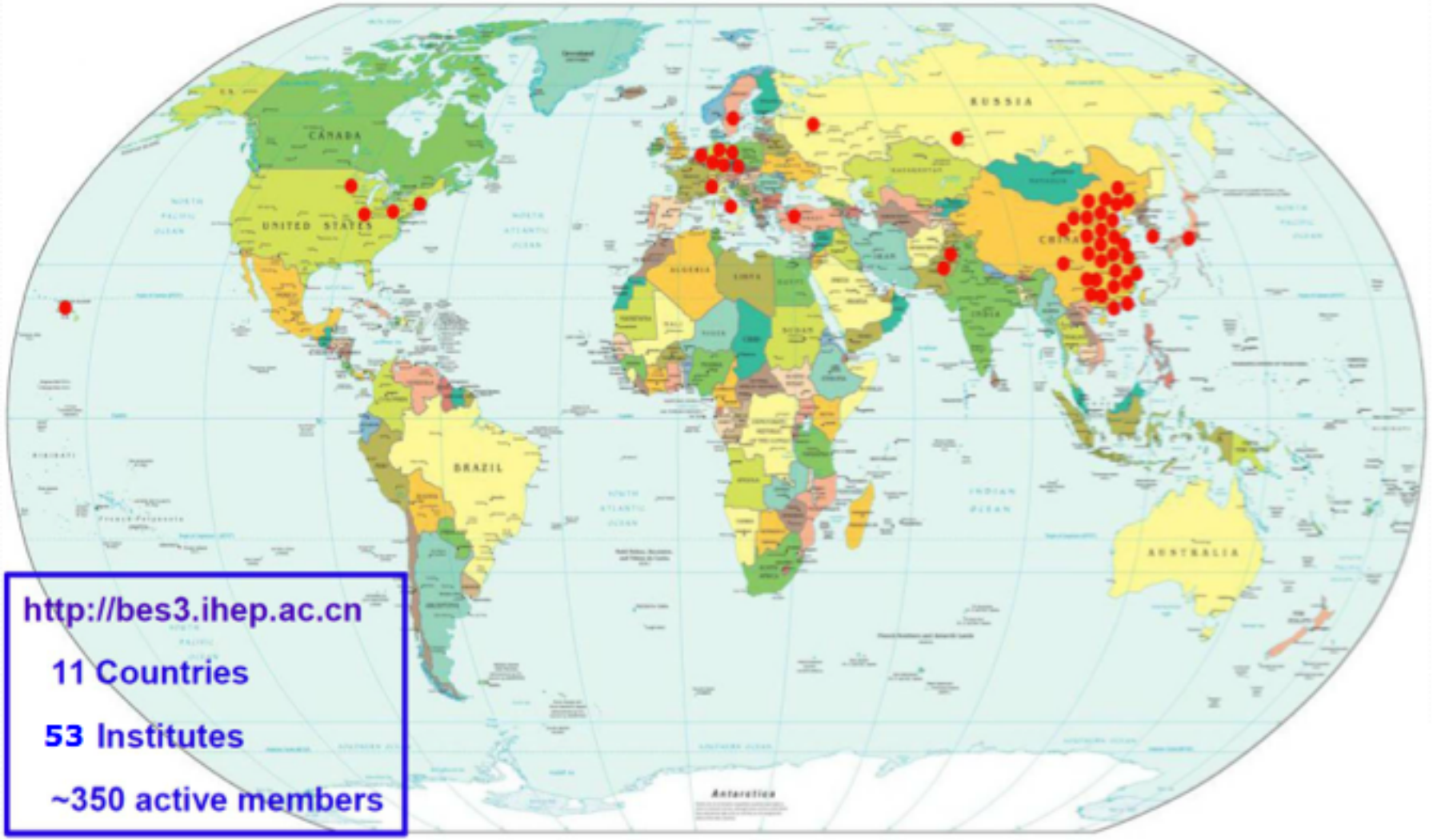
- BESIII is successfully operating since 2008
  - World's largest data sample at the J/ψ resonance recorded
  - Clean and rich source for light hadrons

- Systematic studies to understand X(1835) and other structures observed near $p\bar{p}$ threshold
  - Nature unclear: $p\bar{p}$ bound state, glueball, excited η meson?

- Sophisticated model-independent analysis of $J/\psi \to \gamma\pi^0\pi^0$
  - Improve our understanding of the rich structure in ππ
  - Future: Include information from other channels (e.g. KK and ηη) to understand nature of observed resonances (→ glueballs)

Exciting times in light hadron spectroscopy with many published results and still more to come!

The BES III Collaboration



http://bes3.ihep.ac.cn

11 Countries

53 Institutes

~350 active members