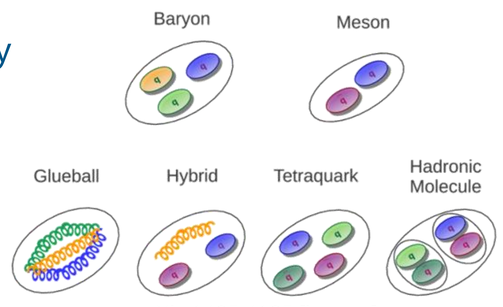
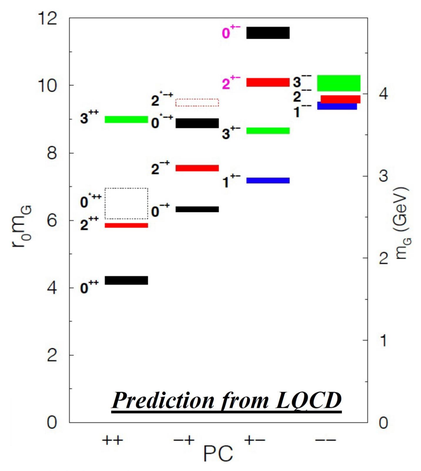
Light Meson Spectroscopy at BESIII

Light Meson Spectroscopy

Quark Model:
- Constraint from QCD: color neutrality
- Conventional hadrons: baryons and mesons
- Different combinations possible: glueball, hybrid, tetraquark, ...
- Conventional and exotic hadrons might mix



arXiv:1405.4195 [hep-ex]



https://doi.org/10.1142/S0218301309012124

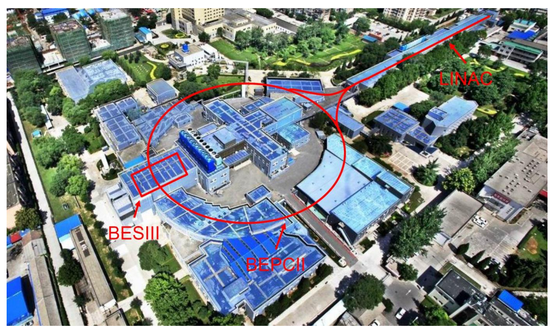
Glueballs:
- LQCD predicts glueball spectrum
- Lightest glueballs in the region from $1.5\ \mathrm{GeV}$ to $3\ \mathrm{GeV}$
- Gluon rich radiative decays of charmonia might give access, predicted BR:

$\mathrm{Br}(J/\psi \to \gamma G_{0^{++}}) = (3.8 \pm 0.9) \cdot 10^{-3}$

$\mathrm{Br}(J/\psi \to \gamma G_{2^{++}}) = (1.1 \pm 0.3) \cdot 10^{-2}$

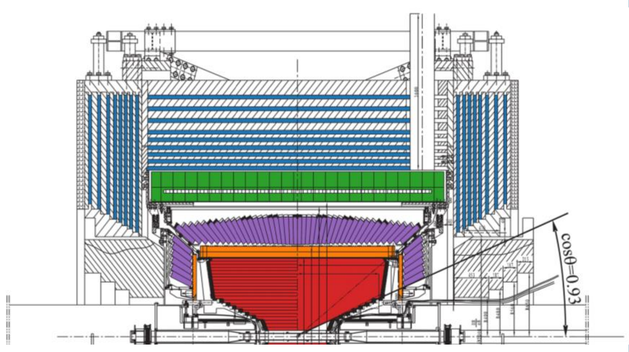
PRL 110, 021601 (2013), PRL 111, 091601 (2013)

The BESIII Experiment



BEPCII:
- e^+e^- collider with $C = 237.5\ \mathrm{m}$
- Located at the Institute of High Energy Physics, Beijing
- Energy range: $2.0\ \mathrm{GeV} \leq \sqrt{s} \leq 5.0\ \mathrm{GeV}$
- Design luminosity at $\sqrt{s} = 3.78\ GeV$: $L = 10^{33} cm^{-1} s^{-1}$

BESIII:
- MDC for momentum measurement and PID
- TOF for PID
- EMC for measurement of photons and electrons
- Solenoid prodividing a $1\ T$ magnetic field
- RPCs for muon identification

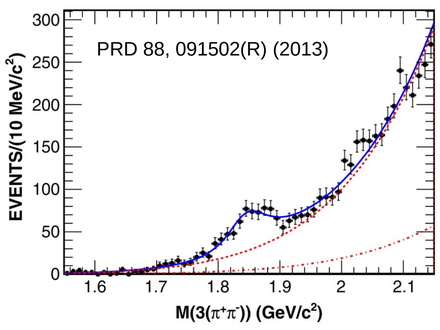


Nucl. Instrum. Meth., A614:345-399, 2010 [edited]

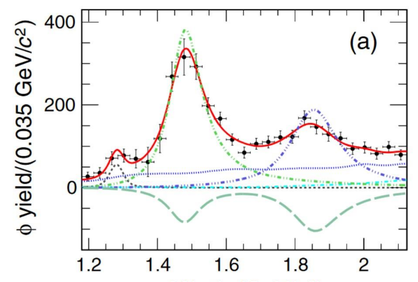
World's largest J/ψ data sample of 10 billion gives perfect environment to perform light meson spectroscopy!

The $X(1835)$

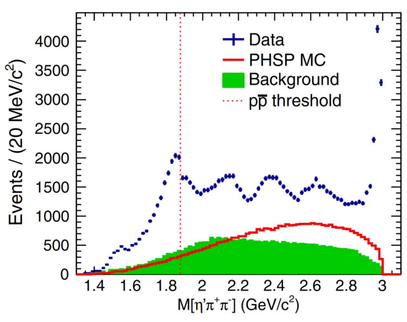
- Observed in $J/\psi \to \gamma\eta'\pi^+\pi^-$ by BESIII and confirmed in other decays
- Peak close to $p\bar{p}$ threshold
- Corresponding structure in $J/\psi \to \gamma p\bar{p}$
- Additional decays found: Masses consistent, widths differ significantly
- Nature unclear: glueball, $p\bar{p}$ bound state, ...



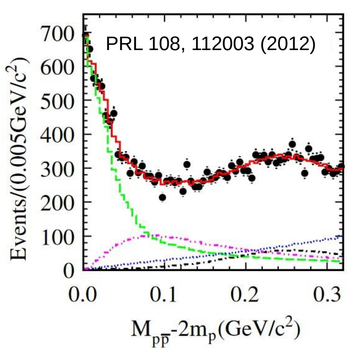
New results:
- Lineshape study in $J/\psi \to \gamma\eta'\pi^+\pi^-$ gives equally good fits for Flatté or Two-Breit-Wigner description
- Also seen in radiative decay $X(1835) \to \gamma\phi$
- Not seen in $J/\psi \to \omega\eta'\pi^+\pi^-$ →Sizeable $s\bar{s}$ component?

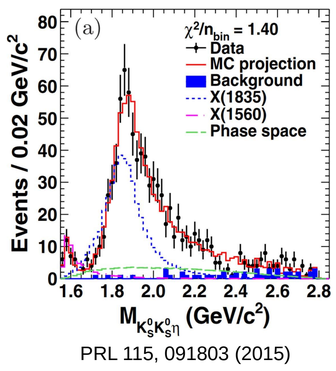


PRD 97, 051101(R) (2018)

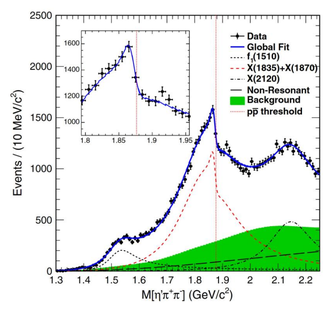


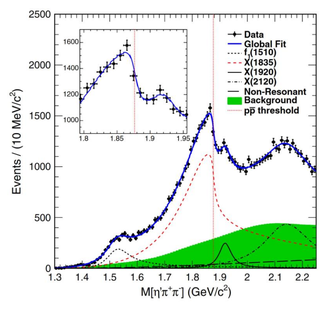
PRL 117, 042002 (2016)





PRL 115, 091803 (2015)





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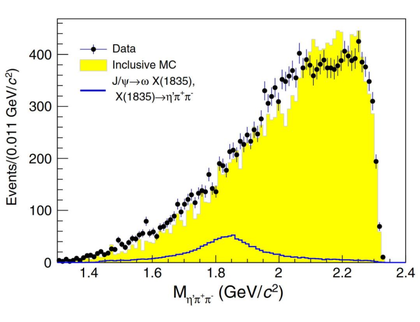
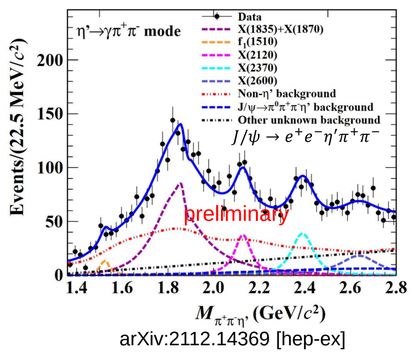


PRD 99, 071101(R) (2019)

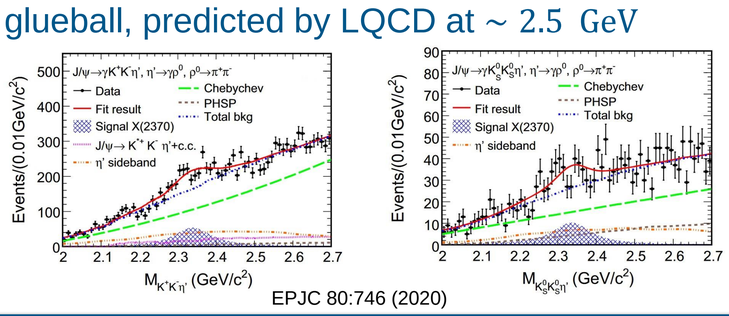
Additional X States

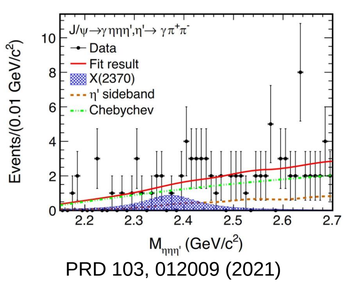
- $J/\psi \to \gamma\eta'\pi^+\pi^-$ shows enhancements at higher masses: $X(2120), X(2370), \ldots$
- Also seen in $J/\psi \to e^+e^-\eta'\pi^+\pi^-$
- $X(2370)$ also seen in $J/\psi \to \gamma\eta' K^+K^-$, but no $X(2120)$
- $X(2370)$ not seen in $J/\psi \to \gamma\eta'\eta\eta$ (but $\eta_c \to \eta'\eta\eta$ seen for the first time)

→ $X(2370)$ candidate for pseudoscalar glueball, predicted by LQCD at $\sim 2.5\ \mathrm{GeV}$



arXiv:2112.14369 [hep-ex]

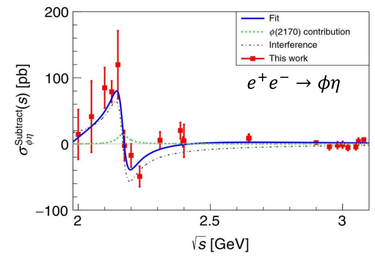




EPJC 80:746 (2020)
PRD 103, 012009 (2021)

Strangeonium

- Strangeonium spectrum less well studied than charmonium or bottomonium
- Possible exotic states found → cf. Y/ψ states in charmonium spectrum
- Possibly exotic meson $\phi(2170)$ seen in $e^+e^- \to \phi\eta^{(\prime)}$ and $e^+e^- \to \phi\pi^+\pi^-$
- $e^+e^- \to K^+K^-/K_SK_L/K^+K^-K^+K^-/\phi K^+K^-$ show peak at slightly higher mass

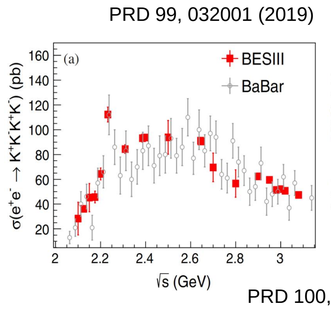


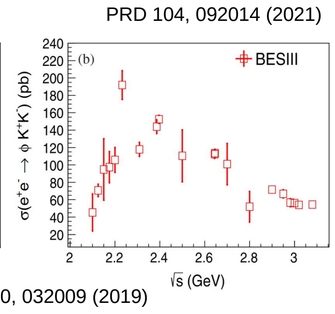
PRD 104, 032007 (2021)

PRD 99, 032001 (2019)

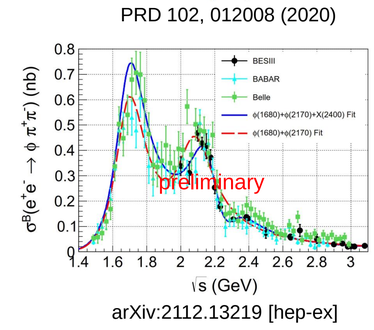
PRD 104, 092014 (2021)

PRD 102, 012008 (2020)





PRD 100, 032009 (2019)



arXiv:2112.13219 [hep-ex]

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PRD 103, 012009 (2021)

Conclusions & Outlook

- Possible exotic states found at BESIII in J/ψ radiative decays
- New results on the hybrid candidate $\phi(2170)$
- New analyses containing the full 10 billion J/ψ on the way
- New dataset at the ψ' resonance containing 2.5 billion events

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