WWU MÜNSTER

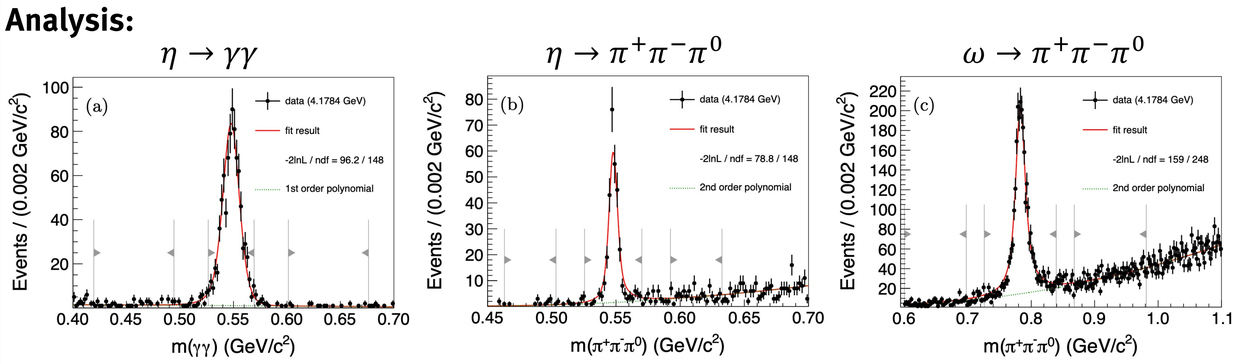
Graduiertenkolleg 2149
Research Training Group

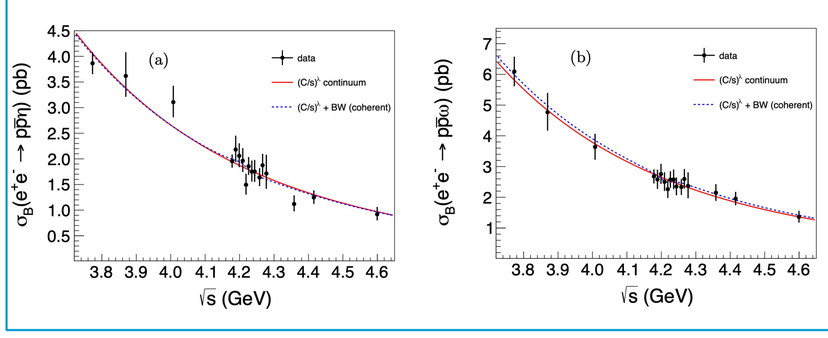
Cross section measurement and search for exotic states at BESIII

$e^+e^- \to p\bar{p}\eta$ and $e^+e^- \to p\bar{p}\omega$ [1]

Motivation: So far no observations have been made of decays into light mesons or baryons for the $\psi(4230)$. Channels that include a proton anti-proton pair are of special interest, since the partial width of decays of the type $V \to p\bar{p}h$, where V is a (exotic) vector charmonia and h is a light, unflavored meson, can be related to the production cross section $p\bar{p} \to Vh$ (PANDA) [2].

Analysis:





Born cross sections successfully determined.

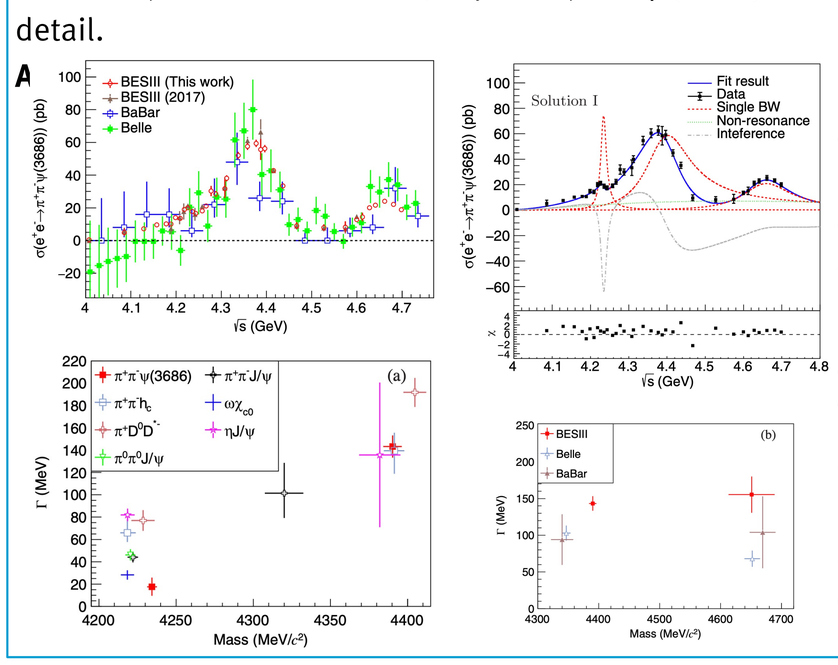
Upper limits σ_{UL}:

$\psi(4230) \to p\bar{p}\eta$: 7.5pb

$\psi(4230) \to p\bar{p}\omega$: 10.4pb

$e^+e^- \to \pi^+\pi^-\psi(3686)$ [3]

Motivation: Exotic vector charmonia, e.g. $\psi(4220), \psi(4360)$ and $\psi(4660)$ have been observed by various experiments in decays containing charm such as charmonium transitions $\psi \to A + c\bar{c}$, with A being $\pi\pi$ [4,5,6,7,8], η [9] or ω [10] and $c\bar{c}$ being $J/\psi, \psi(3686), h_c$ or χ_{cJ}, or open charm decays $\psi \to \pi^+D^0D^{*-}$ [11]. However, the masses and widths of the observed resonances differ significantly. Using the high luminosity data sets at BESIII, especially the $\psi(4660)$ can be investigated here in more detail.



First observation of $\psi(4660)$ at BESIII with equal mass but higher width.

Confirmation of $\psi(4220)$ and $\psi(4390)$.

Parameters of the $\psi(4390)$ are consistent within BESIII.

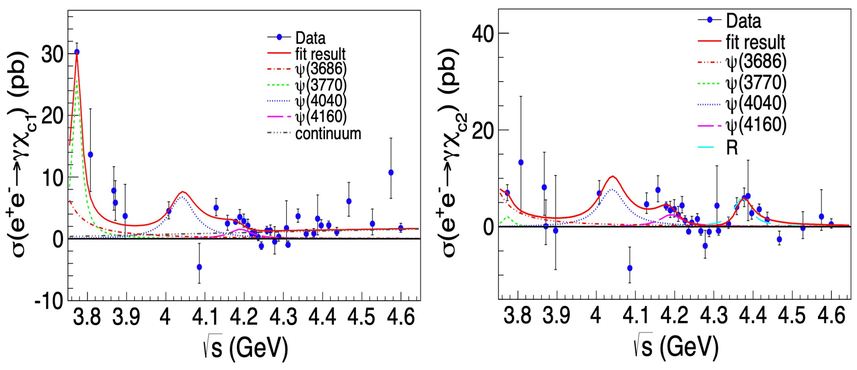
Width of the $\psi(4220)$ is slightly lower.

Mass of the $\psi(4390)$ is slightly larger compared to other experiments.

$e^+e^- \to \gamma\chi_{c0,c1,c2}$ [12]

Motivation: Exotic vector charmonia ψ have shown strong couplings to hidden-charm final states, which indicates that they might be non-conventional quarkonium states. Radiative transition rates between conventional charmonium states have been predicted from potential models [12], e.g. for E1 transitions between $\psi(4040)/\psi(4160)/\psi(4415)$ and χ_{cJ} states in the range of $[0\,\text{keV}, 35\,\text{keV}]$. These values can be compared with those belonging to the exotic ψ states and thus help to understand their nature.

Analysis:



$e^+e^- \to \gamma\chi_{c1,c2}$ successfully observed.

$e^+e^- \to \psi(4360) \to \gamma\chi_{c2}$ observed with 5.8σ.

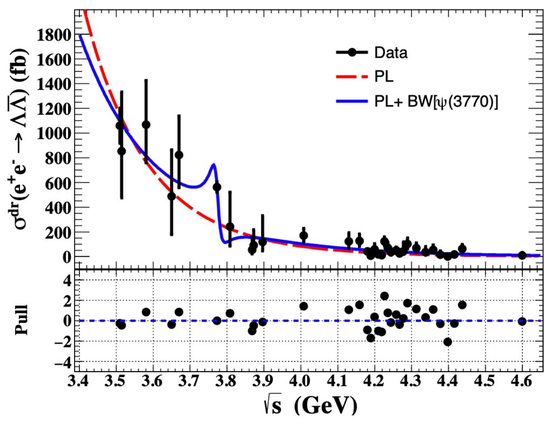
→ Supports the radiative transition.

$e^+e^- \to \gamma\chi_{c0}$ not found.

$\psi(3770) \to \Lambda\bar{\Lambda}$ [13]

Motivation: The $\psi(3770)$ is believed to be a pure $c\bar{c}$ state above the $D\bar{D}$ threshold and therefore is expected to decay into a $D\bar{D}$ pair with $Br(\psi(3770) \to D\bar{D}) > 99\%$ [14]. However, non-$D\bar{D}$ decays have been observed both by BES and CLEO (see [13]), indicating gluonic or light $q\bar{q}$ content of the $\psi(3770)$. Also, the production of light quark baryon-antibaryon ($B\bar{B}$) final states can be used to study such charmless decays of (exotic) vector charmonia. Additionally, measuring the coupling of these states to $B\bar{B}$ final states is crucial for the understanding of the el.mag. structure of the baryons.

Analysis:



First evidence for $\psi(3770) \to \Lambda\bar{\Lambda}$ with 4.9σ.

90% C.L.: $2.4 \cdot 10^{-6} < Br < 1.8 \cdot 10^{-4}$.

No coupling of a higher mass (exotic) vector charmonia to $\Lambda\bar{\Lambda}$.

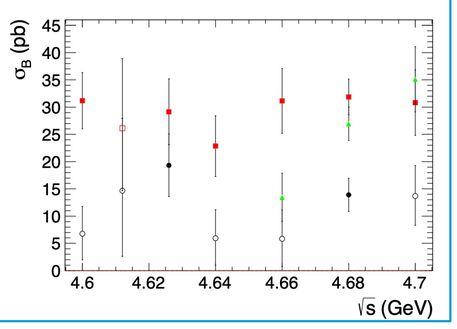
Important analysis concerning the puzzle of large non-$D\bar{D}$ components of the $\psi(3770)$.

$e^+e^- \to D_s^{*+}D_{sJ}^- + c.c.$ [15]

Motivation: Three excited P-wave states above the $D^{(*)}K$ threshold have been observed and are listed in the PDG, namely the $D_{s0}^*(2317)^+, D_{s1}(2460)^+$ and $D_{s1}(2536)^+$. However, the masses of the former two are significantly lower than the theoretical predictions for the charmed-strange mesons in the P-wave doublet [16]. This has inspired various exotic explanations, such as tetraquark states or $D^{(*)}K$ molecule states (see [15]). Moreover, the study of $e^+e^- \to D_s^{*+}D_{sJ}^-$ at BESIII may provide insights into the nature of exotic vector charmonia.

Analysis: First measurement of these processes.

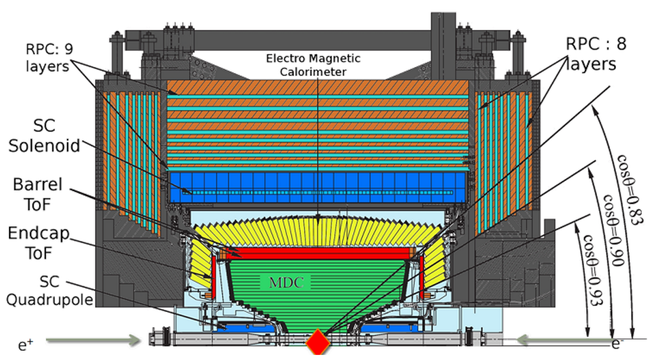
No significant coupling of (exotic) vector charmonia to the investigated final states was found.

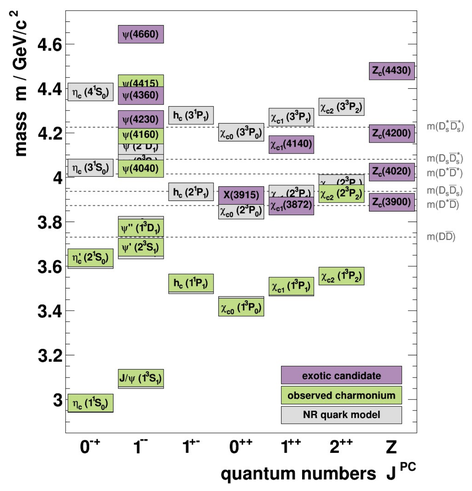


$D_{s0}^*(2317)^+$: dots; $D_{s1}(2460)^+$: rectangles;

$D_{s1}(2536)^+$: triangles

BESIII Detector/Charmonia





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[2] Phys. Rev. D 73, 096003 (2006)
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[5] Phys. Rev. D 102, 012009 (2020)
[6] Phys. Rev. D 96, 032004 (2017)
[7] Phys. Rev. D 89, 111103(R) (2014)
[8] Phys. Rev. Lett. 118, 092002 (2017)
[9] Phys. Rev. D 102, 031101(R) (2020)
[10] Phys. Rev. D 99, 091103(R) (2019)
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[12] Phys. Rev. D 72, 054026 (2005)
[13] Phys. Rev. D 104, L091104 (2021)
[14] Phys. Rev. D 17, 3090 (1978)
[15] Phys. Rev. D 104, 032012 (2021)
[16] Rep. Prog. Phys. 80, 076201 (2017)

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