**Cross section measurement and search for exotic states at BESIII**

### $e^+e^- \rightarrow p\bar{p}\eta$ and $e^+e^- \rightarrow p\bar{p}\omega$ $^1$

**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 $V \rightarrow p\bar{p}$, where $V$ is a (exotic) vector charmonia and $h$ is a light, unflavored meson, can be related to the production cross section $\sigma \rightarrow Vh$ (PANDA) $^2$.

**Analysis:**

![Diagram showing cross sections](image)

Born cross sections successfully determined.

**Upper limits $\sigma_{ul}$:**

- $\psi(4230) \rightarrow p\bar{p}\eta$: 7.5 pb
- $\psi(4230) \rightarrow p\bar{p}\omega$: 10.4 pb

### $e^+e^- \rightarrow \gamma X_{c0,c1,c2}$ $^{12}$

**Motivation:** Exotic vector charmonia $\psi$ 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 $X_{cJ}$ states in the range of $0 \text{ keV}, 35 \text{ keV}$. These values can be compared with those belonging to the exotic $\psi$ states and thus help to understand their nature.

**Analysis:**

![Diagram showing data and analysis](image)

$e^+e^- \rightarrow \gamma X_{c0,c1,c2}$ successfully observed.

$e^+e^- \rightarrow \psi(3686) \rightarrow \gamma X_{c2}$ observed with 5.8σ.

Supports the radiative transition.

$e^+e^- \rightarrow \gamma X_{c0}$ not found.

### $e^+e^- \rightarrow D_s^+D_s^- + c.c.$ $^{15}$

**Motivation:** Three excited $P$-wave states above the $D^{(*)}K$ threshold have been observed and are listed in the PDG, namely the $D_{s2}^*(2317)^-$, $D_{s1}(2460)^+$ and $D_{s2}(2536)^+$. 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 $e^+e^- \rightarrow D_s^+D_s^-$ 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.

$D_{s2}^*(2317)^-$: dots; $D_{s1}(2460)^+$: rectangles; $D_{s2}(2536)^+$: triangles

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**BESIII Detector/Charmonia**

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