

BES III



Proposal for the prompt inclusive J/ψ and $\psi(3686)$ production measurement at STCF

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Prompt inclusive charmonium production

Goal:

- **Test the NRQCD factorization hypothesis:** the independence of Long Distance Matrix Elements (LDME) that describe the hadronization of the $c\bar{c}$ pair from the process (hadron-hadron collisions, electroproduction, or e^+e^- annihilation);
- **Clarify the contribution of the color octet channel** in the range of \sqrt{s} below the $J/\psi c\bar{c}$ threshold (~ 6 GeV): the color-octet LDMEs are non-zero if $\sigma > 10$ pb at $\sqrt{s} = 4.6 \sim 5.6$ GeV (Eur. Phys. J. C (2017) 77: 597);
- **Test if unknown channels/states exist.**

Data only available at $\sqrt{s} = 10.6$ GeV:

- ✓ 2.5 ± 0.3 pb (BaBar)
- ✓ 1.5 ± 0.2 pb (Belle)
- ✓ 1.9 ± 0.2 pb (CLEO)

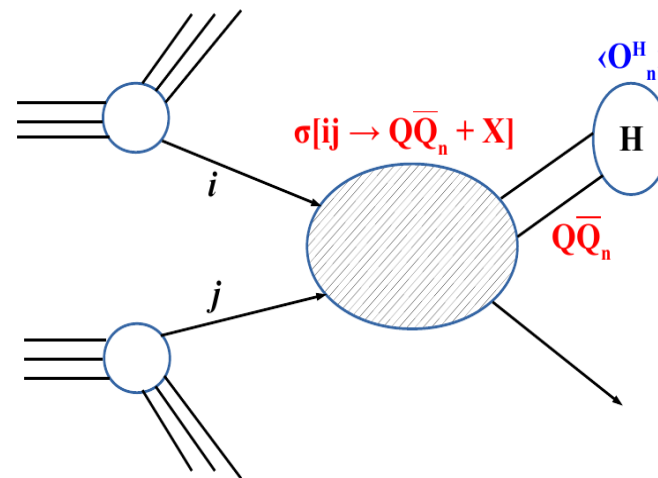


Figure: NRQCD factorization. The LDMEs $\langle O_n^H \rangle$ are determined from experimental data.

Prompt inclusive J/ψ production

$(e^+e^- \rightarrow J/\psi_{\text{prompt}} X)$

- **Prompt** = **Total** - $\{\psi(3686) \rightarrow J/\psi X\}$ - $\{\chi_{c1,2} \rightarrow J/\psi X\}$ - $\{e^+e^- \rightarrow \gamma_{\text{ISR}} J/\psi\}$ - $\{e^+e^- \rightarrow \gamma_{\text{ISR}} \psi(3686)\}$
 - J/ψ produced in the decay of classical charmonia $\psi(3686)$ and $\chi_{c1,2}$ are **excluded**
 - J/ψ produced via the ISR return to the J/ψ and $\psi(3686)$ resonances are **excluded**
 - **Other classical charmonia** like $\psi(3770)$, χ_{c0} , etc. are **ignored** as far as their possible contribution is **negligibly small**
 - J/ψ produced in the decay of **exotic XYZ states** like $\psi(4230)$, $Z_c(4200)$, etc. **are treated as a signal** in the present analysis
- The region of main interest is $\sqrt{s} > 4.5 \text{ GeV}$ (far from resonances)

Prompt inclusive $\psi(3686)$ production ($e^+e^- \rightarrow \psi(3686)_{\text{prompt}} X$)

- **Prompt** = **Total** - $\{e^+e^- \rightarrow \gamma_{\text{ISR}}\psi(3686)\}$
 - $\psi(3686)$ produced via the ISR return to the $\psi(3686)$ resonance are **excluded**
 - $\psi(3686)$ produced in the decay of **exotic XYZ states** like $\psi(4230)$, $\psi(4360)$, etc. **are treated as a signal** in the present analysis
- The region of main interest is $\sqrt{s} > 4.8 \text{ GeV}$ (far from resonances)

BESIII: Prompt inclusive J/ ψ and $\psi(3686)$ production (I)

Data: $\mathcal{L} = 22 \text{ fb}^{-1}$, $\sqrt{s} = 3.81 - 4.95 \text{ GeV}$

Channel: $J/\psi \rightarrow \mu^+\mu^-$, $\psi(3686) \rightarrow J/\psi \pi^+\pi^-$, $\chi_{cJ} \rightarrow \gamma J/\psi$, ($J = 1, 2$)

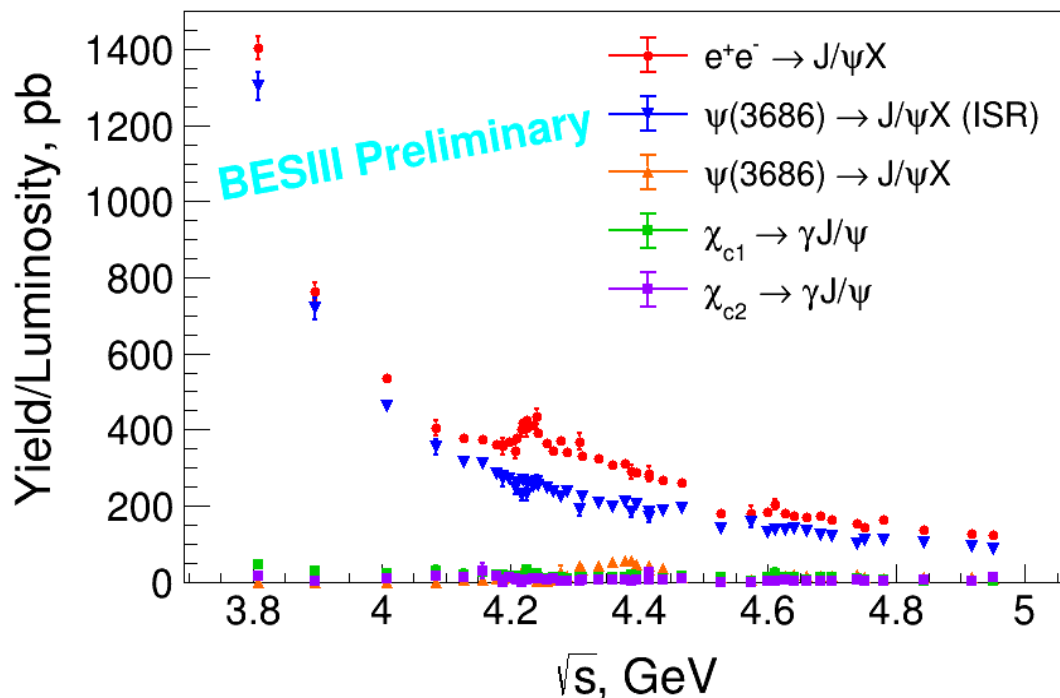


Figure: Yield of J/ψ from different sources normalized to corresponding luminosity.

BESIII: Prompt inclusive J/ψ and $\psi(3686)$ production (II)

The preliminary result for the prompt inclusive production of

the J/ψ meson in the range
 $4.53 \sim 4.95$ GeV is
 $\sigma = 14.0 \pm 1.7_{\text{stat}}$ pb

the $\psi(3686)$ meson in the range
 $4.84 \sim 4.95$ GeV is
 $\sigma = 16.9 \pm 2.8_{\text{stat}}$ pb

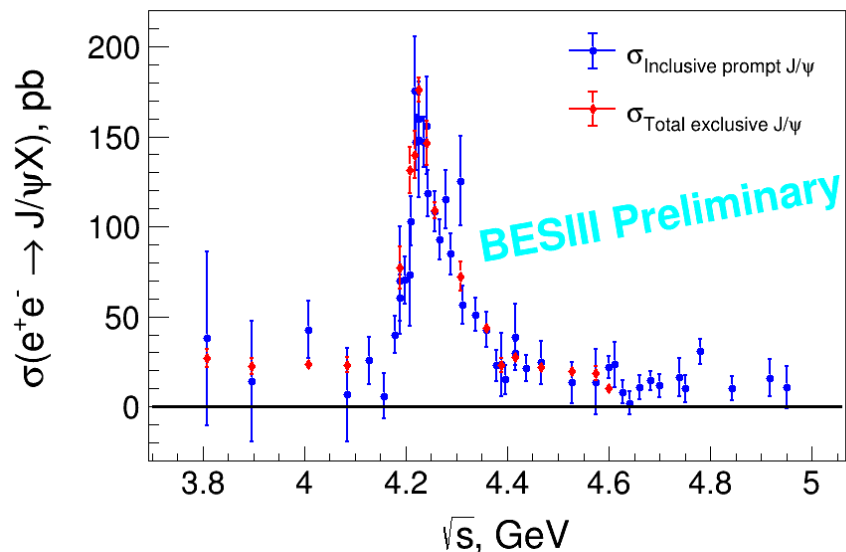


Figure: Prompt inclusive and total exclusive J/ψ cross sections.

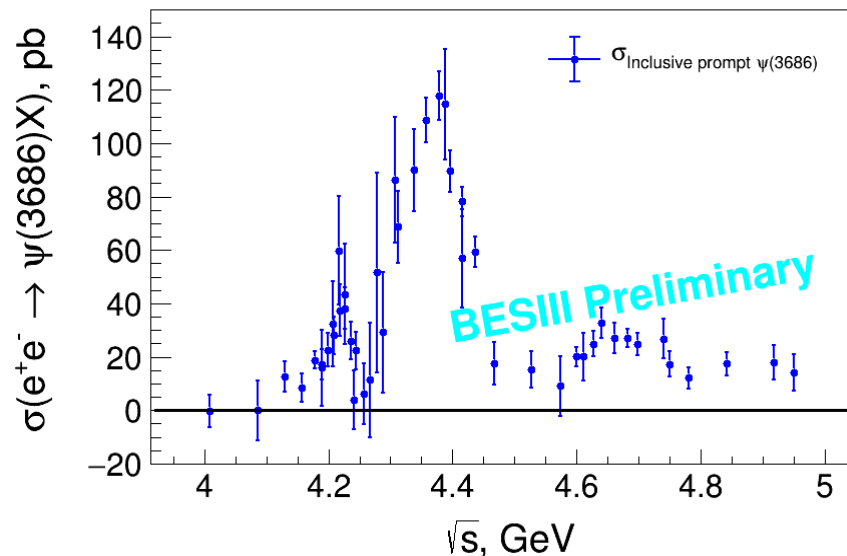


Figure: Prompt inclusive $\psi(3686)$ cross-sections.

Main sources of systematic uncertainty:

- Reconstruction of charged tracks & photons;
- Uncertainties of the branching fraction values for the $\psi(3686) \rightarrow J/\psi X$ and $\psi(3686) \rightarrow \pi^+\pi^-J/\psi$ decays.

Opportunities of STCF:

Measurements of the prompt inclusive charmonium production in the wide energy range $\sqrt{s} = 5 \sim 7$ GeV (below and above the $J/\psi c\bar{c}$ threshold) will allow to obtain the full set of the color-octet LDMEs.

Thank you for your attention!