Proposal for the prompt inclusive J/ψ production measurement at future Super c-tau factories

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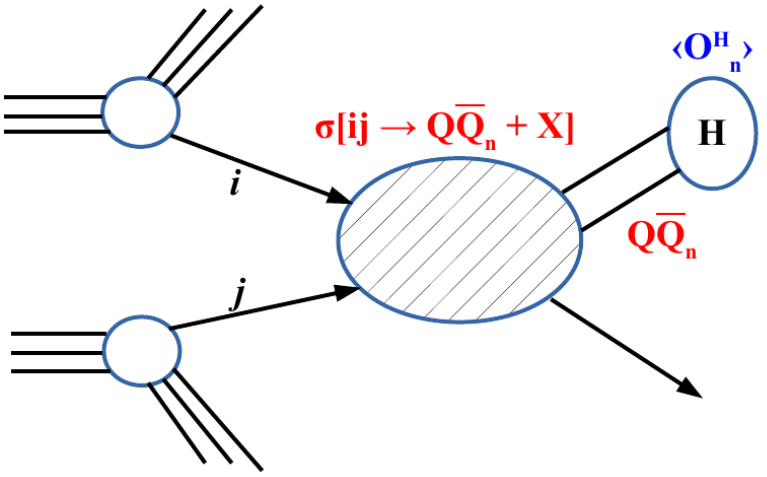
Motivation

- **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 $c\bar{c}$ channel in the range of $\sqrt{s}$ below the J/ψ threshold (~6 GeV): the color-octet LDMEs are non-zero if **σ>10 pb** at **$\sqrt{s}$ = 4.6 ~ 5.6 GeV** (Eur. Phys. J. C (2017) 77: 597)

For a heavy quarkonium process, factorization was proved in inclusive decay and conjectured in production:

$$\sigma[ij \to H + X] = \sigma[ij \to Q\bar{Q}_n + X] \times \langle O^H_n \rangle$$



Nonperturbative NRQCD long distance matrix elements (LDMEs) $\langle O^H_n \rangle$ are determined from experimental data.

- **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)

Prompt inclusive J/ψ production ($e^+e^- \to J/\psi_{prompt} X$)

- Prompt = Total – $\{\psi' \to J/\psi\}$ – $\{\chi_{c1,2} \to J/\psi\}$ – $\{e^+e^- \to \gamma_{ISR} J/\psi(\psi')\}$
  - J/ψ produced in the decay of classical charmonia ψ' and $\chi_{c1,2}$ are excluded
  - J/ψ produced via the ISR return to the J/ψ and to the ψ' resonances are excluded
  - **Other classical charmonia** like ψ(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 Y(4260), Z_c(4200), etc. **are treated as a signal** in the present analysis
- The region of main interest is $\sqrt{s} > 4.5$ GeV (far from resonances)

Event reconstruction

- $J/\psi \rightarrow \mu^+\mu^-$
- $\psi' \rightarrow J/\psi\pi^+\pi^- \rightarrow (\mu^+\mu^-)\pi+\pi-$
- $\chi_{c1,2} \rightarrow \gamma J/\psi \rightarrow \gamma(\mu^+\mu^-)$

Detector requirements:

- Reconstruction of charged tracks & photons
- Identification of muons & pions
- Acceptance is close to 4π

Expected measurement accuracy

- **Statistical error @4.65 GeV, 100 fb^{-1}:** ~4%
- **Main sources of systematic error:**
  - Reconstruction of charged tracks & photons
  - Uncertainty of values Br($\psi' \rightarrow J/\psi X$) and Br($\psi' \rightarrow J/\psi \pi^+ \pi^-$)

Thank you for your attention!