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# New ideas about production and detection of cc-tetraquarks ⋆

Mitja Rosina[a,b] and Damijan Janc[a]

[b] J. Stefan Institute, 1000 Ljubljana, Slovenia
[a] Faculty of Mathematics and Physics, University of Ljubljana, 1000 Ljubljana, Slovenia

**Abstract.** We estimate the rate of double charm production in B-factories Belle and BaBar, in hadronic machines with fixed targets RHIC and SELEX, and in high energy colliders Tevatron and LHC. For detection we propose the branching ratio between pionic and gamma decay.

## 1 Introduction

We have shown that the molecule-like configuration of the $DD^*$ dimeson (also called tetraquark) enables weak binding even in the case of the Bhaduri or Grenoble AL1 interaction (-0.7 or -2.6 MeV, respectively) [1,2]. The surprise that the cc-tetraquark is likely to be bound against the $D + D^*$ decay strongly motivates experimental exploration. To encourage future experimental analyses, we estimate the production rate on several present and future machines, and propose an experimental signature for detection.

## 2 Production

Regarding the **production of** $T_{cc}$, we consider a three-step process:
(i) production of two $c\bar{c}$ pairs,
(ii) formation of a diquark $c + c \to cc$,
(iii) dressing of the diquark $cc \to ccq,\ q = u, d, s$ (90 %), or $cc \to cc\bar{u}\bar{d}$ (10 %).

Here are some provocative guesses: [3]

- SELEX [4] has seen 50 candidates for ccq $\Longrightarrow$ the corresponding hypothetical 5 $T_{cc}$ are to few to be recognized at present.
- Belle reported prompt $J/\psi$ production in $e^+e^-$ annihilation at $\sqrt{s}$ = 10.6 GeV and found that the most of the observed $J/\psi$ production is due to the double $c\bar{c}$ production $\sigma(e^+e^- \to J/\psi c\bar{c})/\sigma(e^+e^- \to J/\psi X) = 0.59$ which correspond to 2000 events from their 46.2 fb$^{-1}$ data sample $\Longrightarrow$ promising for the $T_{cc}$ production! Similar rate is also expected for BaBar.

⋆ Talk delivered by M. Rosina.

- High energy colliders (RHIC (p-p), RHIC (p-Au); Tevatron, LHCb, LHC--ALICE) might produce sufficient double charm by double two-gluon fusion [5–8,3]
$(g+g)+(g+g) \to (c+\bar{c})+(c+\bar{c})$. Our estimate for the $T_{cc}$ cross section are $4,750$; $21, 27, 58$ nb, respectively.

In most machines, the rate seems promising to start the hunt!

## 3 Detection

The main problem with detection of the weakly bound $T_{cc}$ tetraquark is how to distinguish the pion or photon emitted by the decay of the free $D^*$ meson from the one emitted by the $D^*$ meson bound inside the tetraquark. We can exploit the fact that the phase space for $D^* \to D + \pi$ decay is very small. Therefore we propose as a signature the branching ratio between radiative and pionic decay. In addition, the analysis using the Dalitz plot can help to distinguish whether the pion was emitted from a bound state, resonance state of $D + D^*$ or from free $D^*$ meson.

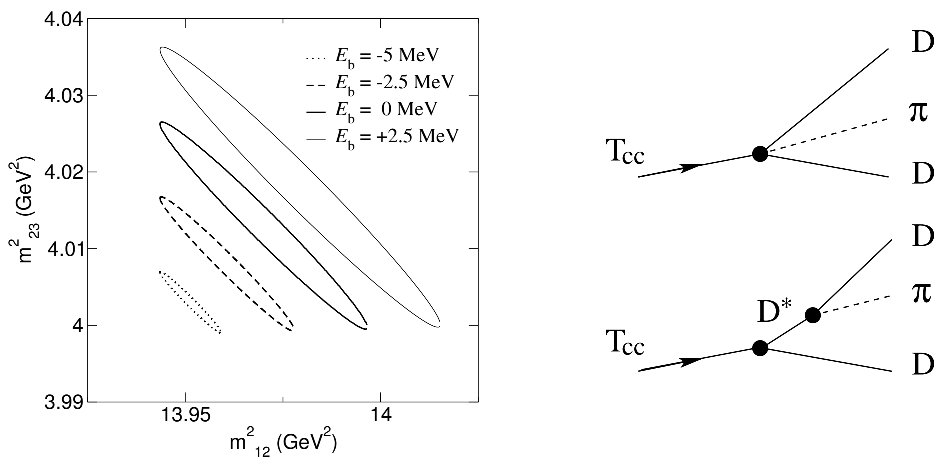


**Fig. 1.** Left: Dalitz plot for the $T_{cc} \to DD\pi$ decay, $E$ is binding energy of $T_{cc}$, 3 is pion; Right: The two graphs contributing in the case of resonance $E > 0$

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