Summary

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Outline

- Top quark mass measurements with CEPC at the $t\bar{t}$ threshold
- HZa Analysis
- Sensor Irradiation

Top quark mass measurements with CEPC at the $t\bar{t}$ threshold

- EPJC accepted the paper and it was published on April 1st.
- From Jan to Mar, we have gone through 2 rounds (the 2nd and 3rd times) of reviewer comments.

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Regular Article - Experimental Physics

Top quark mass measurements at the $t\bar{t}$ threshold with CEPC

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Abstract We present a study of top quark mass measurements at the $t\bar{t}$ threshold based on CEPC. A centre-of-mass energy scan near two times of the top quark mass is performed and the measurement precision of top quark mass, width and α_S are evaluated using the $t\bar{t}$ production rates. Realistic scan strategies at the threshold are discussed to maximise the sensitivity to the measurements individually and simultaneously in the CEPC scenarios assuming a total luminosity limited to 100 fb^{-1}. With the optimal scan for individual property measurements, the top quark mass precision is expected to be 9 MeV, the top quark width precision is expected to be 26 MeV, and α_S can be measured at a precision of 0.00039, considering only the statistical uncertainty. Taking into account the systematic uncertainties from theory, width, α_S, experimental efficiency, background subtraction, beam energy and luminosity spectrum, the top quark mass can be measured at a precision of 25 MeV optimistically and 59 MeV conservatively at CEPC.

1 Introduction

Top quark, the heaviest fundamental particle observed so far, plays an important role in the Standard Model (SM). It provides the strongest coupling to the SM Higgs boson and opens doors to new physics beyond the SM (BSM). Till now, the top quark mass have only been measured at hadron collisions, e.g. the Tevatron and the Large Hadron Collider (LHC), using the direct reconstruction of the invariant mass of the top quark decay products. In future electron–positron colliders the top quark mass can be measured not only by the direct reconstruction but also by a scan on the centre-of-mass energy at the $t\bar{t}$ threshold. The cross-section of $t\bar{t}$ increases sharply as the centre-of-mass energy goes through the $t\bar{t}$ threshold and depends strongly on the top quark mass, width and α_S, which provides a sensitive probe to these measurements. This is the so-called threshold-scan method that was discussed for top quark mass measurements at an electron–positron collider [1–4].

In experiments, the top quark mass has been measured by using the direct reconstruction of the top quark decay products as 174.30 ± 0.35 (stat.) ± 0.54 (syst.) GeV from the combined results of CDF and D0 at Tevatron [5], 172.69 ± 0.25 (stat.) ± 0.41 (syst.) GeV with ATLAS [6] and 172.44 ± 0.13 (stat.) ± 0.47 (syst.) GeV with CMS [7] at the LHC. The precision till now is about half a GeV and it is mainly limited by the systematic uncertainties that are not easily reduced in the future. On the contrary, the threshold-scan method has been widely used [8,9] and shown good performance with a statistical uncertainty of top quark mass measurement at $\mathcal{O}(10)$ MeV that was studied previously with ILC, CLIC and FCC-ee [10–14].

The threshold-scan method also provides a theoretically well defined mass that can be calculated with a high degree of precision and can be easily converted to various theoretical schemes. This is difficult to be realised in the reconstructed top quark mass peak method in which the generated mass peak is usually used as a template to fit to the observed data. The recent progresses in the interpretation of the reconstructed top quark mass measurements are reviewed in Ref. [15].

In this article, we discuss the threshold-scan method and propose realistic scan strategies for the top quark mass measurements with electron–positron collisions based on the Circular Electron Positron Collider (CEPC). The experimental

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2nd reply to reviewers

- In our study, we use ‘quick-scan’ method to roughly locate the best Ecm point to measure the properties.
  - They doubt if we have no assumption on top mass, this method will work or not.
  - We scan the points far away from default assumption (171.5 GeV), and show that in these points the values of NLL are not accepted.
- We updated cross-section stats error as 1.07%.
- We updated the uncertainty of width variation (0.19GeV->0.14GeV), but little improve because of their similar cross-section.

3rd reply to reviewers

- We updated how the top mass uncertainty would change as a function of the uncertainty on the efficiency:
  - 0.5%: 4.5MeV
  - 1%: 9MeV
  - 3%: 27MeV
  - 5%: 45MeV
- We updated the uncertainty by varying the beam energy with the minimal step that the CEPC beam energy can move with, which is 3 MeV.
- We updated the uncertainty of efficiency with the 6-point scheme, which shows no obvious improvement compared with 1-point scheme.

HZa

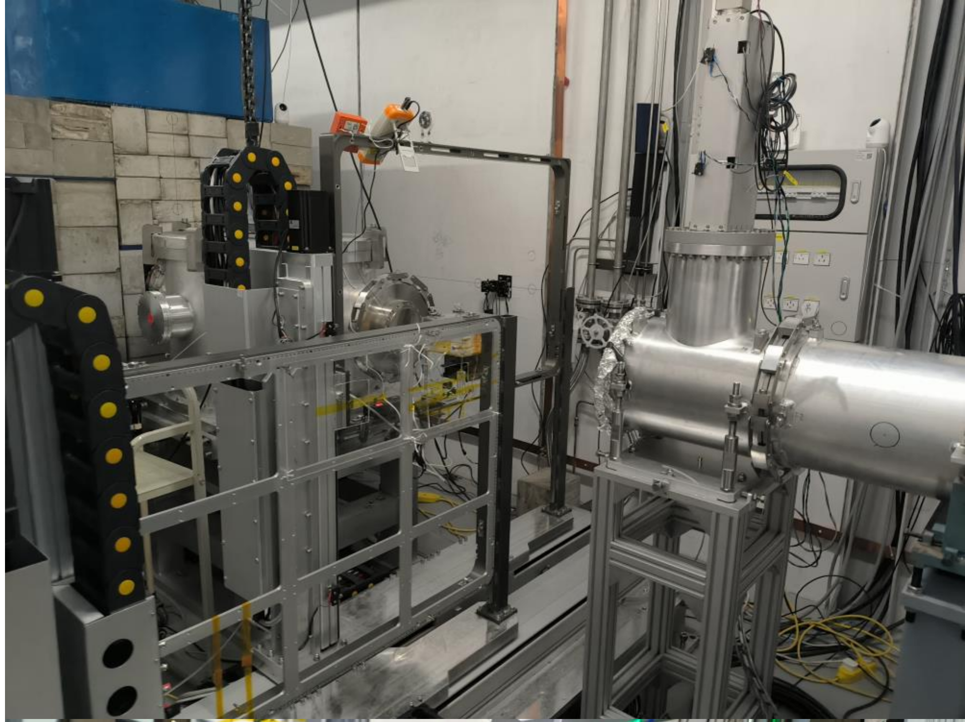
- The HZZAnalCode Framework were tested and adjusted for Hza process.
- Background and signal samples are generated with the framework, but still need to adjust something.

Sensor Irradiation

- Use Mini-sensor to do irradiation test.
  - Mini-sensor is the offcut of the sensor. By irradiating the mini-sensor we can get the performance of the sensor.
  - The irradiation use the associated proton beam of CSNS.
  - If a reliable procedure can be built, we can have our own sensor irradiation test site in CSNS.

Sensor Irradiation

- We went to Dongguan CSNS.
- The test is on China Spallation Neutron Source (CSNS) Associated Proton Experiment Platform (APEP, 伴生质子束实验平台).
- 80MeV proton beam will be shot on the sensor, and after the irradiation the sensor will be taken back and do some test.
- Work going on: Use Geant4 to simulate the irradiation.
  - Done: Simulate the deposit energy, compare with theoretical value to check the problem.
  - Going on: Simulate the IV of the sensor, to understand the process.



Thank you!