Summary

Students 李瞻
Supervisor 方亚泉

2023.01.05

Outline

- Top quark mass measurements with CEPC at the $t\bar{t}$ threshold
- Di-Higgs Multilepton
- ITk production
- Sensor Irradiation

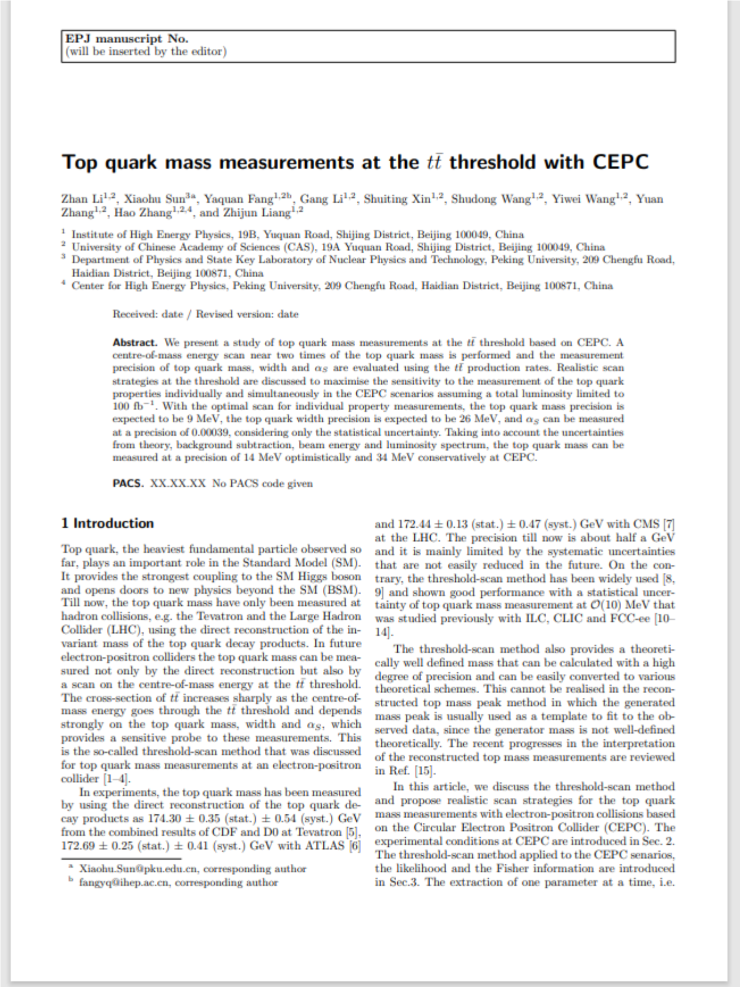
Top quark mass measurements with CEPC at the $t\bar{t}$ threshold

- Paper v1 finished and submitted to EPJC, which gives the expected uncertainties shown below.

Source	m_{top} precision (MeV)	
	Optimistic	Conservative
Statistics	9	9
Theory	9	26
Background	4	18
Beam energy	2	2
Luminosity spectrum	3	5
Total	14	34

Table 7: The expected statistical and systematical uncertainties of the top quark mass measurement in optimistic and conservative scenarios at CEPC.

- EPJC replied to us if we can give 2d uncertainties.



EPJ manuscript No.
(will be inserted by the editor)

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

Zhan Li[1,2], Xiaohu Sun[3a], Yaquan Fang[1,2b], Gang Li[1,2], Shuiting Xin[1,2], Shudong Wang[1,2], Yiwei Wang[1,2], Yuan Zhang[1,2], Hao Zhang[1,2,4], and Zhijun Liang[1,2]

[1] Institute of High Energy Physics, 19B, Yuquan Road, Shijing District, Beijing 100049, China
[2] University of Chinese Academy of Sciences (CAS), 19A Yuquan Road, Shijing District, Beijing 100049, China
[3] Department of Physics and State Key Laboratory of Nuclear Physics and Technology, Peking University, 209 Chengfu Road, Haidian District, Beijing 100871, China
[4] Center for High Energy Physics, Peking University, 209 Chengfu Road, Haidian District, Beijing 100871, China

Received: date / Revised version: date

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 measurement of the top quark properties 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 uncertainties from theory, background subtraction, beam energy and luminosity spectrum, the top quark mass can be measured at a precision of 14 MeV optimistically and 34 MeV conservatively at CEPC.

PACS. XX.XX.XX No PACS code given

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 cannot be realised in the reconstructed top mass peak method in which the generated mass peak is usually used as a template to fit to the observed data, since the generator mass is not well-defined theoretically. The recent progresses in the interpretation of the reconstructed top 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 conditions at CEPC are introduced in Sec. 2. The threshold-scan method applied to the CEPC senarios, the likelihood and the Fisher information are introduced in Sec.3. The extraction of one parameter at a time, i.e.

[a] Xiaohu.Sun@pku.edu.cn, corresponding author
[b] fangyq@ihep.ac.cn, corresponding author

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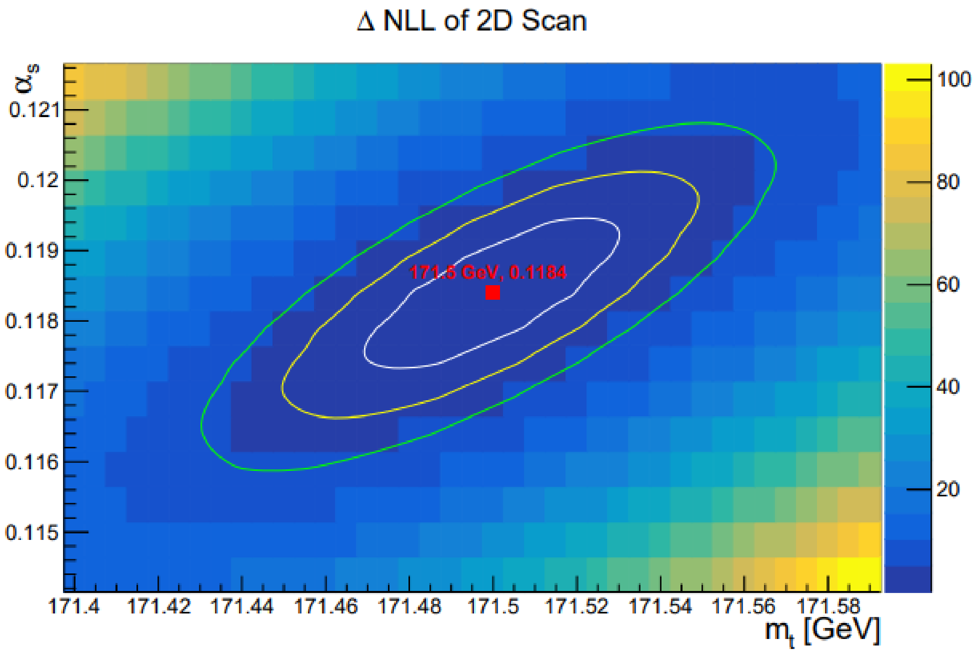

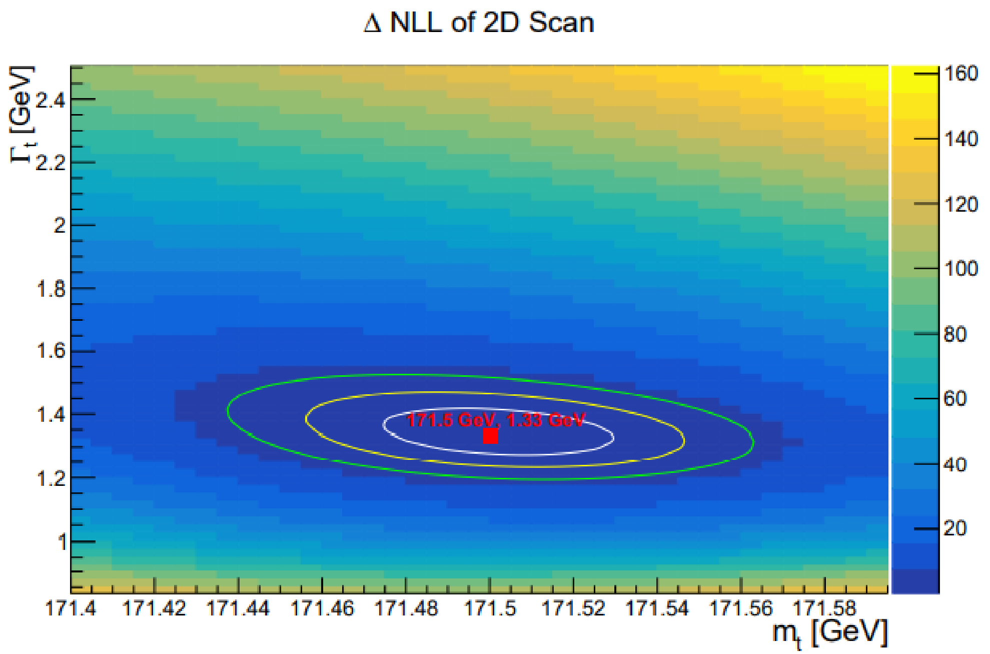

- The uncertainty is 28 MeV on top mass and 0.00106 on αS in the simultaneous fits of the two parameters using the energy points of 342.75 and 344.50 GeV.

The uncertainty is 27 MeV on top mass and 72 MeV on width in the simultaneous fits of the two parameters using the energy points of 342.75 and 344.00 GeV.

Table 3 Summary of the 2D simultaneous top mass and α_s determination with a threshold scan at CLIC for 10 points with a total integrated luminosity of 100 fb^{-1}

1S top mass and α_s combined 2D fit	
m_t stat. error	34 MeV
m_t theory syst. (1 %/3 %)	5 MeV/8 MeV
α_s stat. error	0.0009
α_s theory syst. (1 %/3 %)	0.0008/0.0022

Di-Higgs Multilepton

- The Run2 analysis searches the Standard Model di-Higgs production via two decay modes:
  - gluon-gluon Fusion (ggF) production mode is mainly studied in the analysis
  - Vector Boson Fusion (VBF) production mode is currently used as additional yields to the ggF signal
- Background composition:
  - Prompt background
    - Diboson (WZ , VVjj), ttW/Z, tV, Higgs, VVV, …
  - Non-prompt background: Fake lepton
    - Dedicated control regions and estimation methods
- Work going on: Calculating the theoretical uncertainty of the VV background.

ITk Production

- Prepare PPB SQ:
  - The SQ required clear and readable data in ITk Production Database.
    - Check the hybrid and make sure they agree with the data in Database.
    - Make all things meet requirement of the reviewer
- Produce hybrid and module:
  - Prepare the SOP (Standard Operating Procedure) document for hybrid assembly procedure.
  - Ensure the correct procedure.

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.
- Work going on: Use Geant4 to simulate the irradiation, check if any defect exists in the system.

Thank you!