中国科学院高能物理研究所

Institute of High Energy Physics Chinese Academy of Sciences

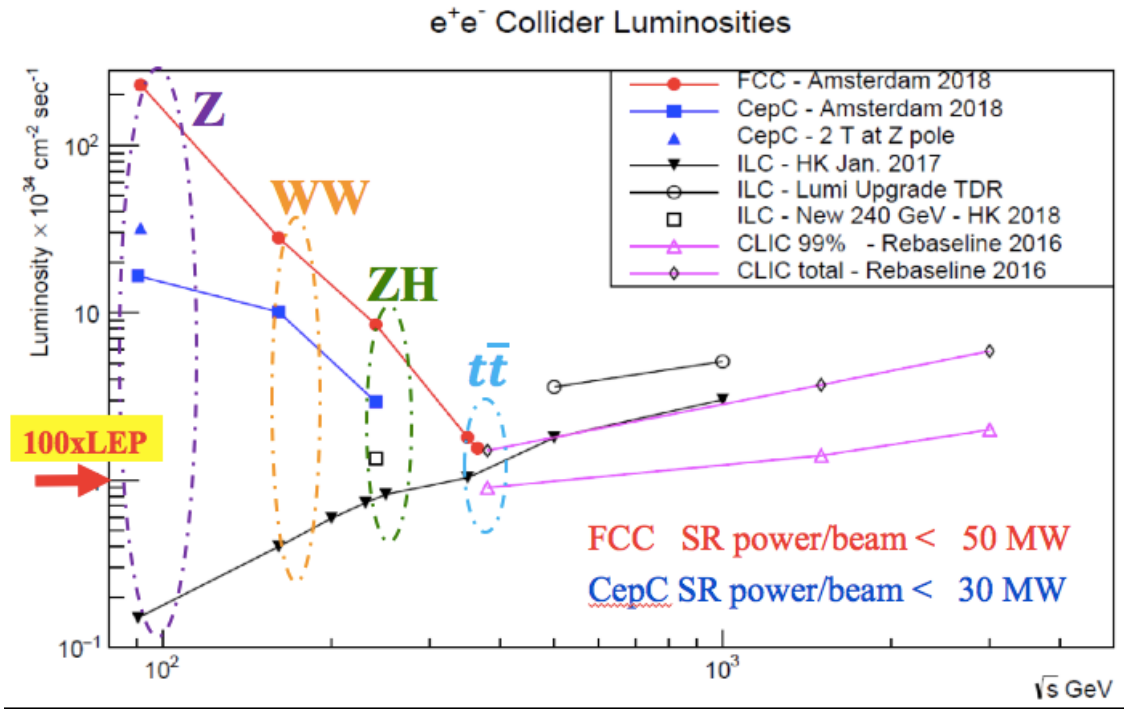
Top threshold physics

Zhijun Liang

Institute of High Energy Physics ,
Chinese Academy of Science

Introduction

- CEPC is Higgs Factory (E_{cms}=240GeV , 10^6 Higgs)
- CEPC is Z factory(E_{cms}~91GeV) ,electroweak precision physics at Z pole.
  - baseline **L=1.6 X 10^{35} $cm^{-2}s^{-1}$, Solenoid =3T, 3X10^{11} Z boson, two years**
  - **L= 3.2 X 10^{35} $cm^{-2}s^{-1}$, Solenoid =2T , 6X10^{11} Z boson**
- WW threshold scan runs (~160GeV) are also expected.
  - One year, Total luminosity 2.6 ab^{-1} **14M WW events**



From F. Bedeschi

Top threshold scan

- Review of the key electroweak constant

Fundamental constant	δx/x	measurements
$\alpha = 1/137.035999139\ (31)$	1×10^{-10}	$e^{\pm}\ g_2$
$G_F = 1.1663787\ (6) \times 10^{-5}\ \mathrm{GeV}^{-2}$	1×10^{-6}	$\mu^{\pm}$ lifetime
$M_Z = 91.1876 \pm 0.0021\ \mathrm{GeV}$	1×10^{-5}	LEP
$M_W = 80.379 \pm 0.012\ \mathrm{GeV}$	1×10^{-4}	LEP/Tevatron/LHC
$\sin^2\theta_W = 0.23152 \pm 0.00014$	6×10^{-4}	LEP/SLD
$m_{top} = 172.74 \pm 0.46\ \mathrm{GeV}$	3×10^{-3}	Tevatron/LHC
$M_H = 125.14 \pm 0.15\ \mathrm{GeV}$	1×10^{-3}	LHC

Top scan Runs

From PDG2018

Input from CEPC accelerator design

- Instant luminosity for CEPC at ttbar threshold is low for now.
  - 5~10 times lower than Fcc-ee design ,
  - Need ~2 years to get 200fb^{-1}

CEPC parameters
(Tentative at tt)

30MW
0.38*10^{34}cm^{-2}s^{-1}@ 350GeV
0.32*10^{34}cm^{-2}s^{-1}@ 365GeV

If 50MW
0.63*10^{34}cm^{-2}s^{-1}@ 350GeV
0.53*10^{34}cm^{-2}s^{-1}@ 365GeV

tt based on lattice fcp=0.3% and εx =1.2nm, if fcp=0.2% and εx =0.89nm or even lower, the luminosity at tt will be higher.

	Higgs (high)	*Higgs (CDR)*	*tt*	tt
Number of IPs	2	2	2	2
Beam energy (GeV)	120	120	175	182.5
Circumference (km)	100	100	100	100
Synchrotron radiation loss/turn (GeV)	1.68	1.73	7.61	9.0
Crossing angle at IP (mrad)	16.5×2	16.5×2	16.5	16.5
Piwinski angle	3.78	3.48	0.91	0.89
Number of particles/bunch N_e (10^{10})	17.0	15.0	24.15	26.7
Bunch number (bunch spacing)	218 (0.76μs)	242 (0.68μs)	34	26
Beam current (mA)	17.8	17.4	3.95	3.3
Synchrotron radiation power /beam (MW)	30	30	30	30
Bending radius (km)	10.7	10.7	10.9	10.9
Momentum compact (10^{-5})	0.91	1.11	1.14	1.14
β function at IP β_x^* / β_y^* (m)	0.33/0.001	0.36/0.0015	1.2/0.0037	1.2/0.0037
Emittance $\varepsilon_x/\varepsilon_y$ (nm)	0.89/0.0018	1.21/0.0024	2.24/0.0068	2.46/0.0074
Beam size at IP σ_x/σ_y (μm)	17.1/0.042	20.9/0.06	51.8/0.16	54.4/0.17
Beam-beam parameters ξ_x/ξ_y	0.024/0.113	0.018/0.109	0.077/0.105	0.076/0.103
RF voltage V_{RF} (GV)	2.4	2.17	8.93	10.3
RF frequency f_{RF} (MHz) (harmonic)	650 (216816)	650 (216816)	650 (217500)	650 (217500)
Natural bunch length σ_z (mm)	2.2	2.72	2.54	2.62
Bunch length σ_z (mm)	3.93	4.4	2.87	2.93
HOM power/cavity (2 cell) (kw)	0.58	0.46	0.53 (5cell)	0.49
Energy spread (%)	0.19	0.134	0.14	0.15
Energy acceptance requirement (%)	1.7	1.35	1.57	1.7
Energy acceptance by RF (%)	3.0	2.06	2.67	2.48
Photon number due to beamstrahlung	0.104	0.082	0.19	0.15
Beamstruhlung lifetime /quantum lifetime* (min)	30/50	80/80	60	1.0
Lifetime (hour)	0.22	0.43		0.7
F (hour glass)	0.85	0.89	0.89	0.88
Luminosity/IP *L* (10^{34}cm^{-2}s^{-1})	5.2	2.93	0.38	0.32

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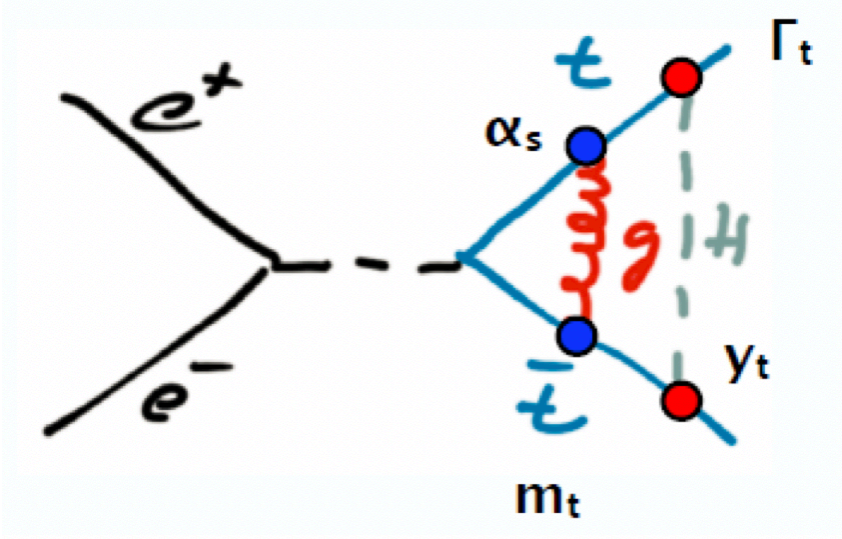
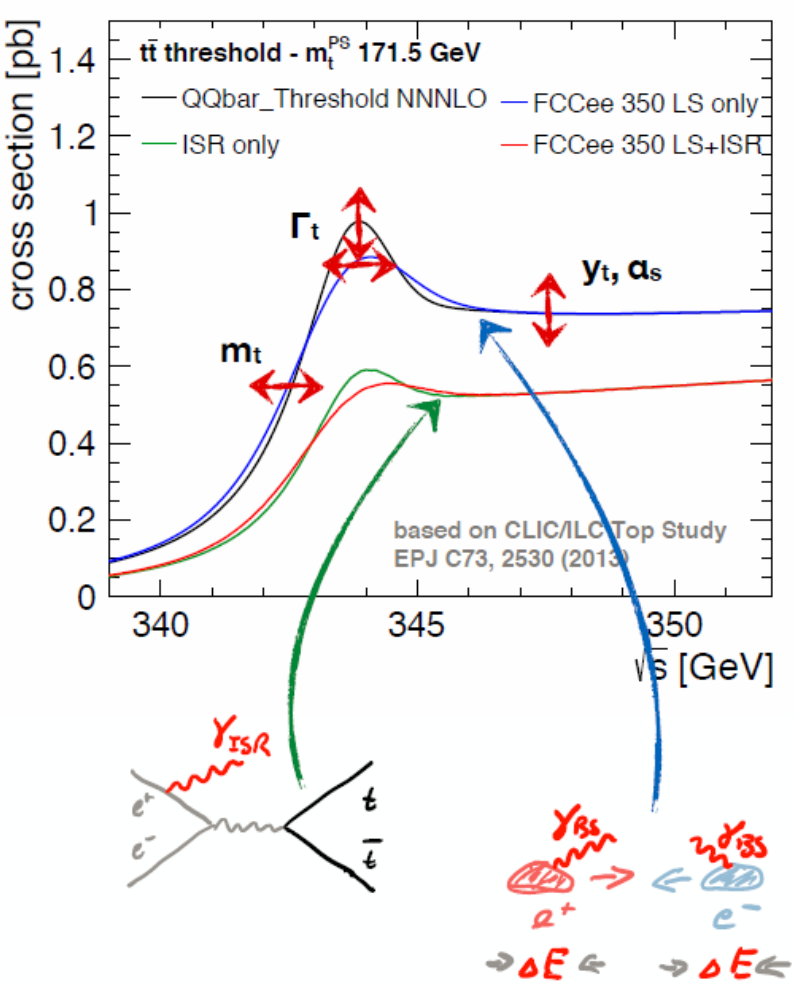
https://indico.ihep.ac.cn/event/11069/contribution/3/material/slides/0.pdf

top threshold scan

- Top threshold cross-section depends on:
  - top mass
  - top width (lifetime)
  - top-Higgs coupling
  - αQCD

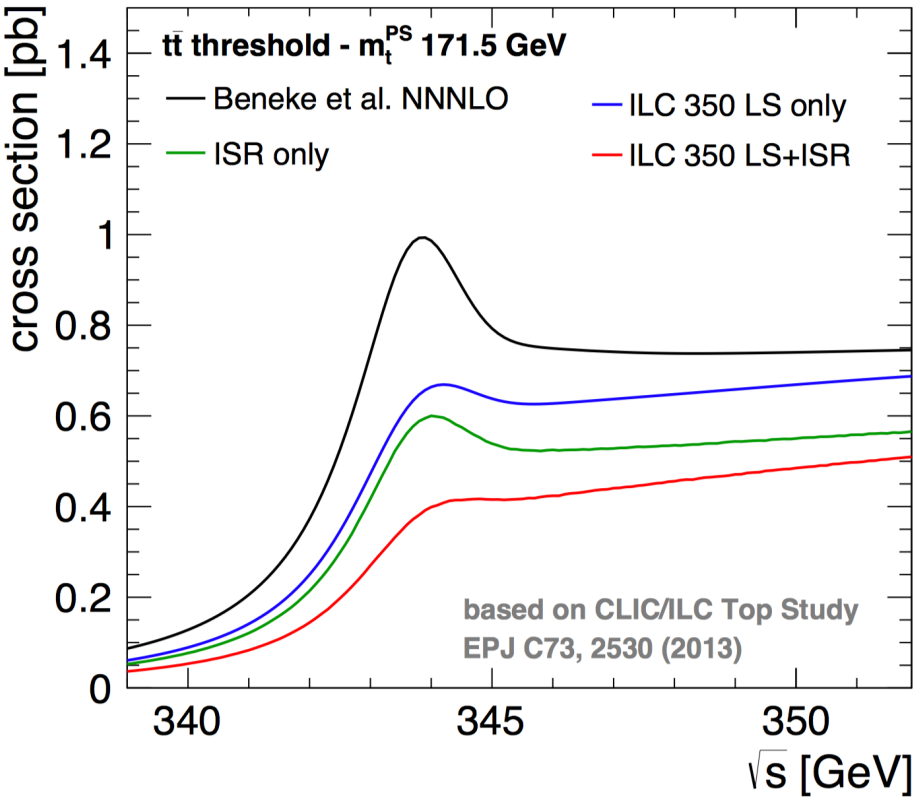




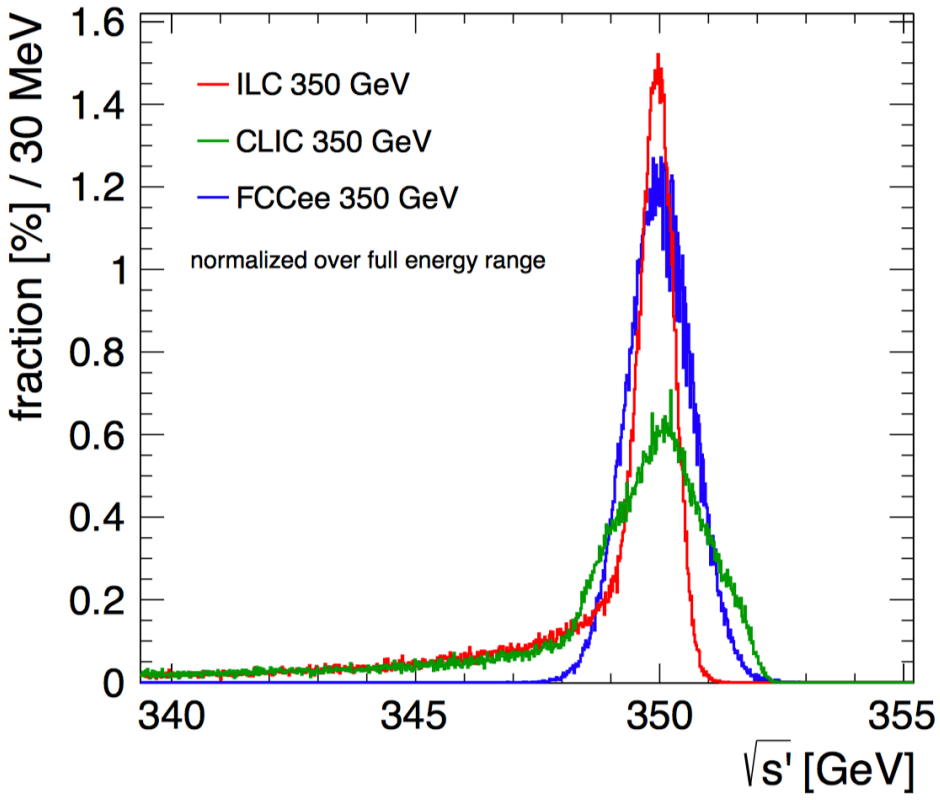
Thanks to discussion and slides from Alain Blondel
Study by Frank Simon (CLIC/ILC study, EPJC 73,(2013)2530)

Theory prediction

- Impact due to luminosity spectrum and ISR is large
- Cross section to be re-calculated with CEPC luminosity spectrum

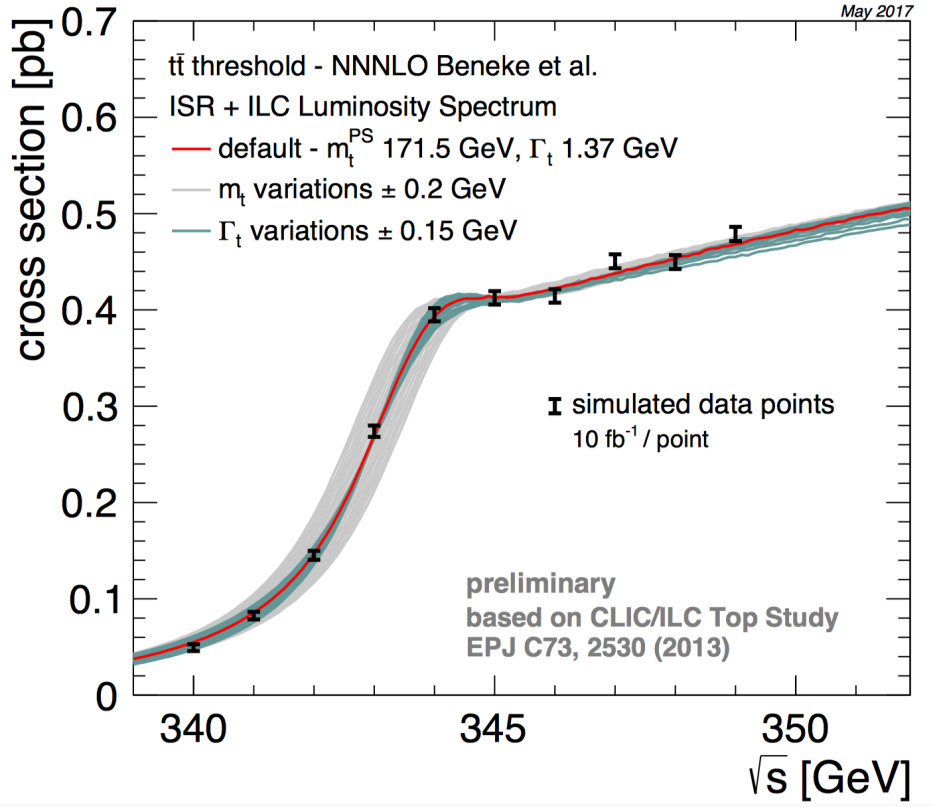


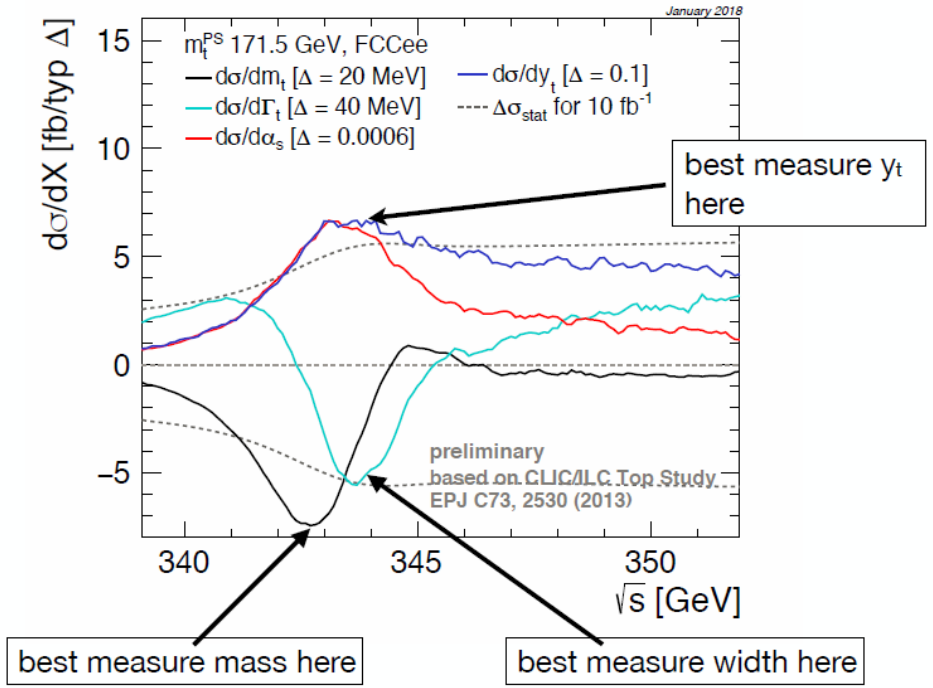
luminosity spectrum for ILC/CLIC/FCCee



Top threshold scan

- Strategy:
  - Need a rough scan in step of 1GeV to measure the top mass (5 fb^{-1})
  - Fix the final scan points
  - since there are four parameters to fix, need at least 4 scan points
    - Scanning range 342GeV ~350GeV
    - Focusing 342GeV ~345GeV

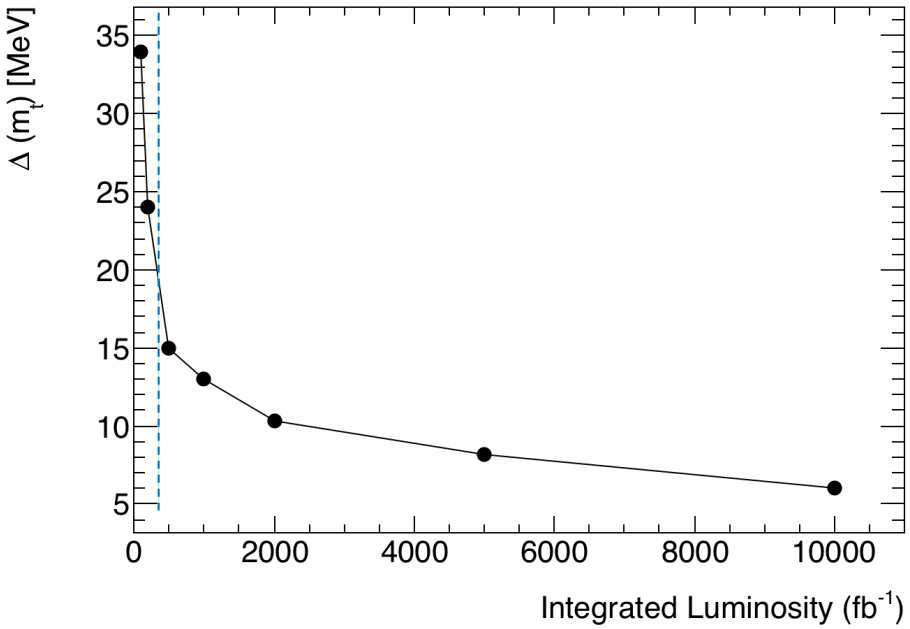




BUT: You have to find that point!

Top threshold scan

- If CEPC decided to have top threshold scan
  - Better to have integrated Lumosity larger than 200~400fb^{-1}
  - Need to re-calculated with CEPC lumiosity spectrum
  - Aim for 15MeV precision



ILC/CLIC estimation with 100 fb^{-1}

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

Summary

- Potential of electroweak measurement at CEPC
  - Possible target for top mass precision (15MeV) for CEPC
    - Propose 200~400 fb^{-1} integrated Luminosity scanning
    - According to current CEPC design at ttbar threshold,
      - Need about two years to accurate 200~400 fb^{-1}
      - The instant luminosity is 5~10 times lower than Fcc-ee
      - Need to add more RF cavity if we need higher instant luminosity.
    - Scan range : 342GeV~345GeV
  - Energy points above 345GeV is not very useful for top mass measurement

Backup