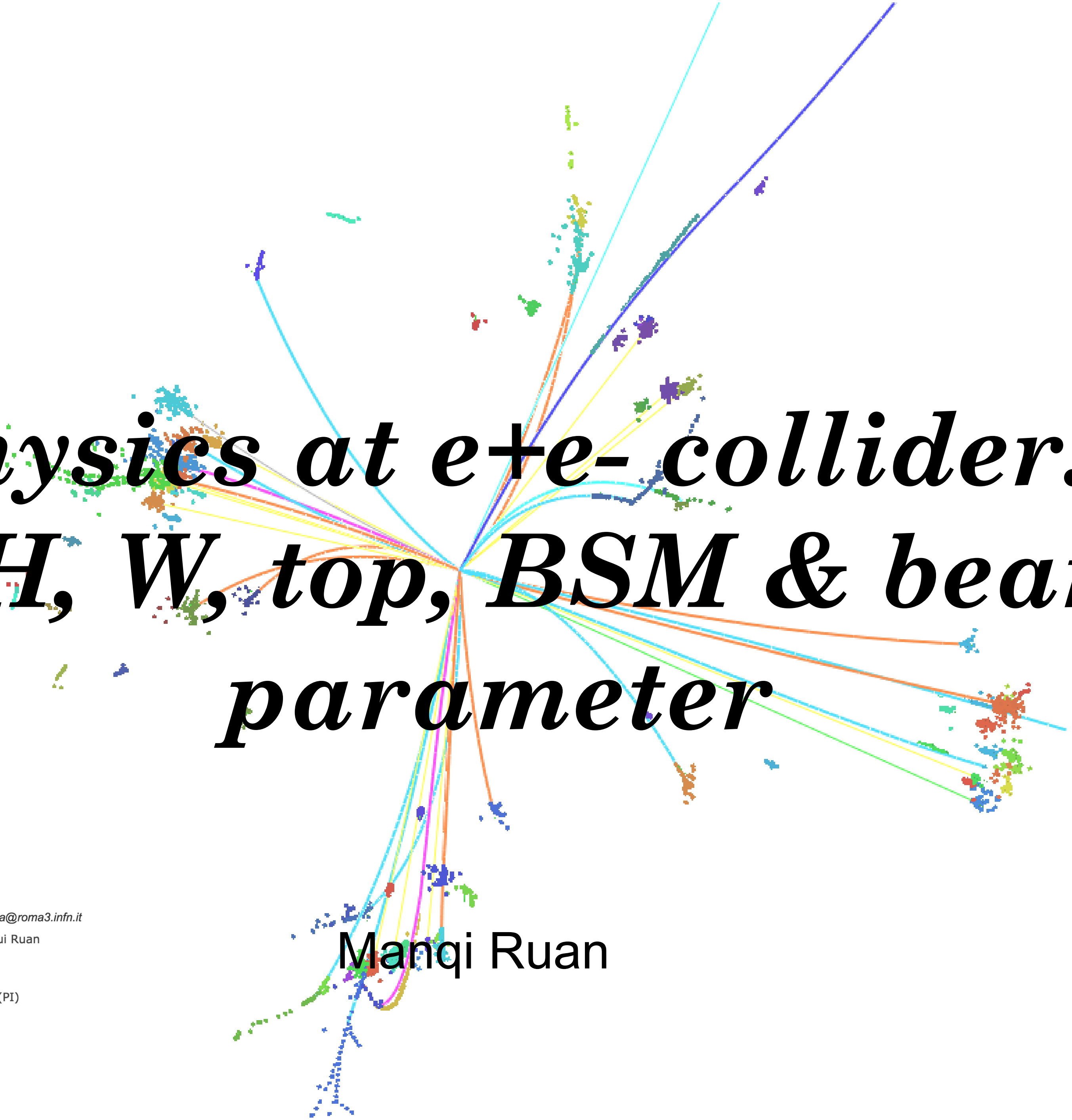
Physics at e+e- collider: Z, H, W, top, BSM & beam parameter



Manqi Ruan

14:30 - 17:00 Parallel session 2: Physics

Physics/Simulation
Session Manager Ada Farilla ada.farilla@roma3.infn.it

Convener: Fulvio Piccinini, Manqui Ruan

Location: Aula A3 - DAMS

14:30 **Z pole+WW** *40'*
Speaker: Paolo Azzurri (PI)

15:10 **Z+Higgs** *30'*
Speaker: Yaquan Fang

15:40 **Top** *20'*
Speaker: Marcel Vos

16:00 **BSM** *30'*
Speaker: Barbara Mele

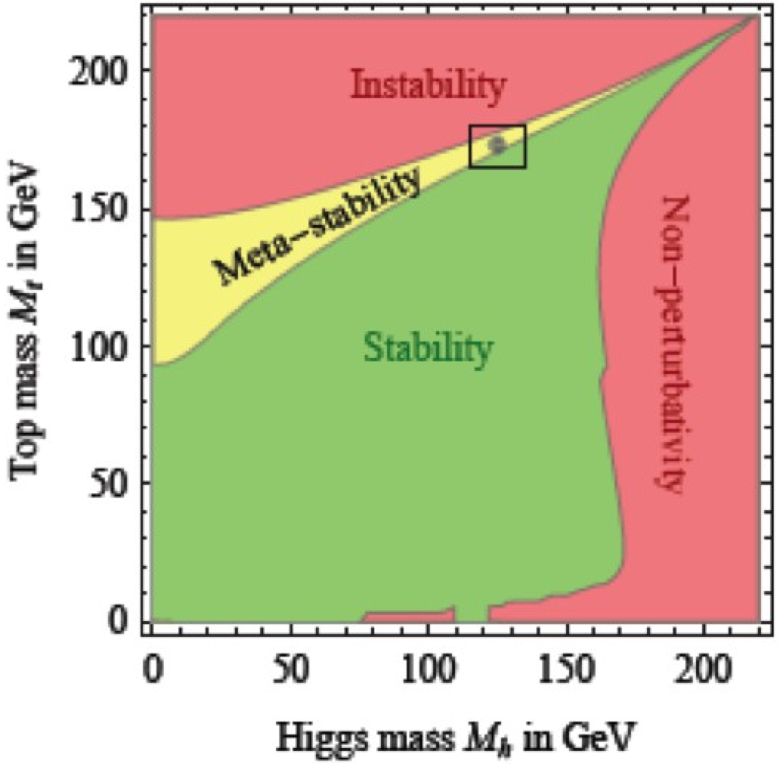
16:30 **Beam parameters** *30'*
Speaker: Alain Blondel (University of Geneva)

SM is **NOT** the end of story...

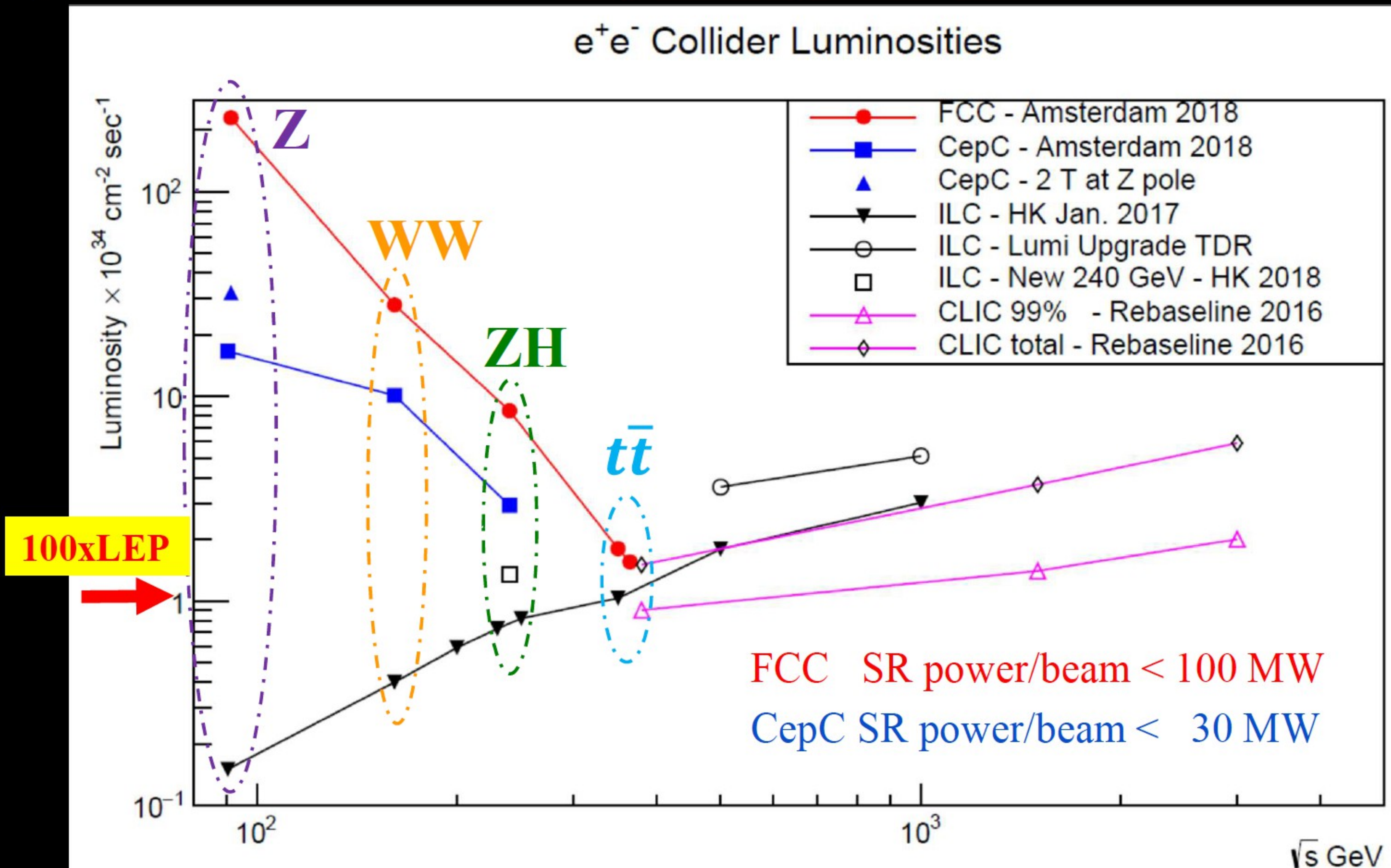
- Hierarchy: From neutrinos to the top mass, masses differs by 13 orders of magnitude
- Naturalness: Fine tuning of the Higgs mass
- Masses of Higgs and top quark: meta-stable of the vacuum
- Unification?
- Dark matter candidate?
- Not sufficient CP Violation for Matter & Antimatter asymmetry

- **Most issues related to Higgs**

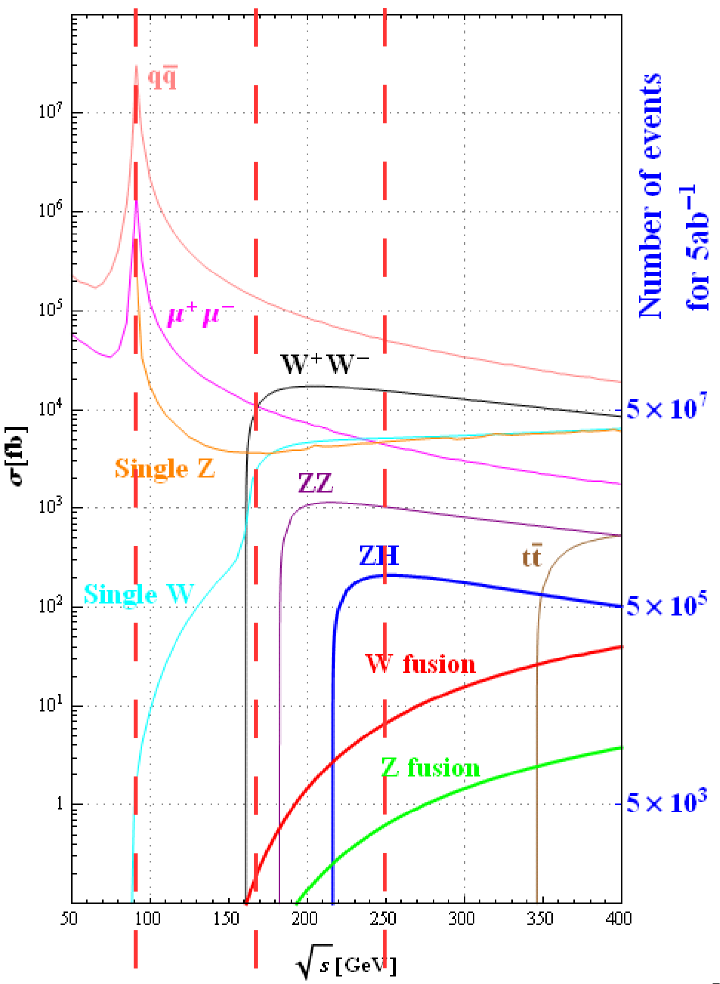
$$m_H^2 = 36{,}127{,}890{,}984{,}789{,}307{,}394{,}520{,}932{,}878{,}928{,}933{,}023$$
$$-36{,}127{,}890{,}984{,}789{,}307{,}394{,}520{,}932{,}878{,}928{,}917{,}398$$
$$= (125\ \mathrm{GeV})^2 \,!\, ?$$



CepC, FCC, ILC, CLIC luminosity comparison



Boson yields @ CEPC



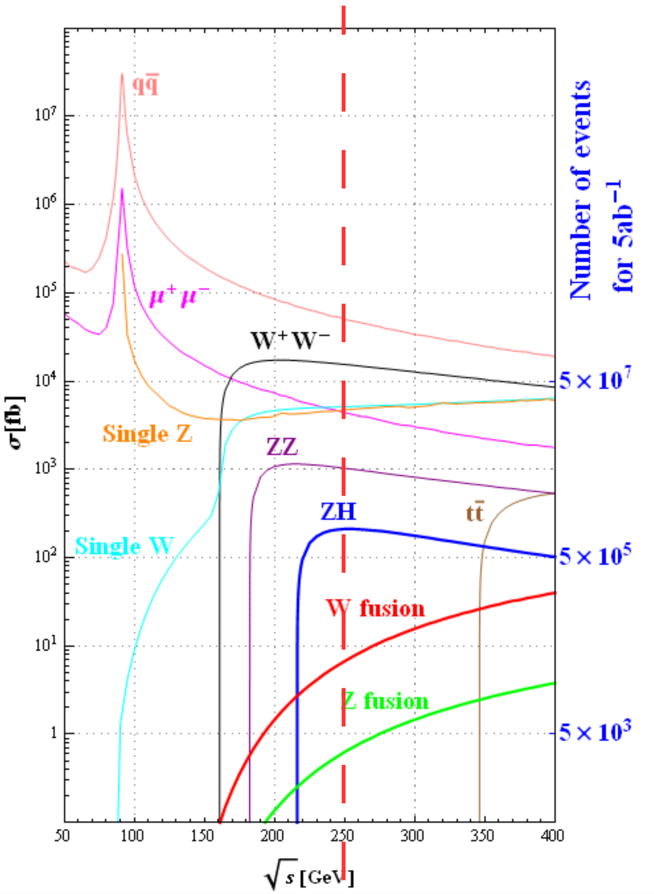
Operation mode	Z factory	W threshold scan	Higgs factory
$\sqrt{s}/GeV$	91.2	161	240
$L/10^{34}cm^{-2}s^{-1}$	16-32	10	3
Running time/year	1-2	1-2	8-10
Higgs yield	-	-	10^6
W yield	-	10^8	10^8
Z yield	10^{10-11}	10^9	10^9

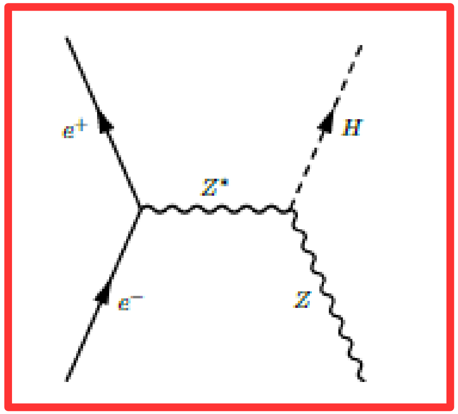
CEPC Baseline Accelerator design:

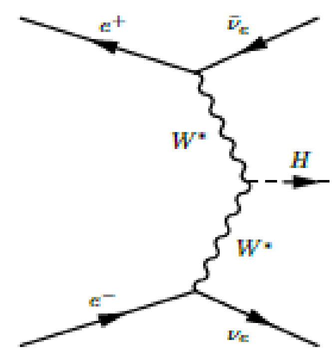
High productivity for all massive SM bosons.

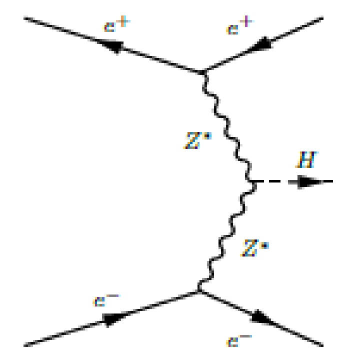
At FCC: even larger productivities for Z, W, H & top

Higgs @ CEPC









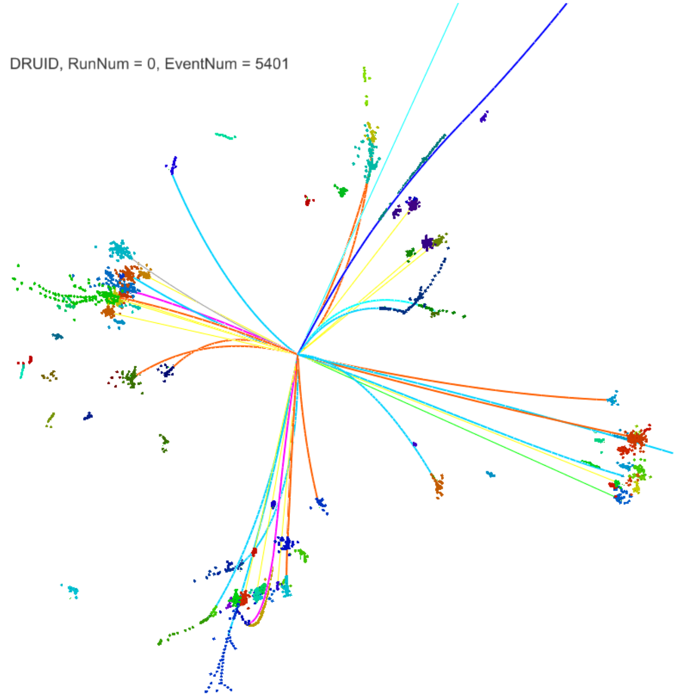
Process	Cross section	Events in 5 ab^{-1}
Higgs boson production, cross section in fb		
$e^+e^- \to ZH$	212	1.06×10^6
$e^+e^- \to \nu\bar{\nu}H$	6.72	3.36×10^4
$e^+e^- \to e^+e^-H$	0.63	3.15×10^3
Total	219	1.10×10^6

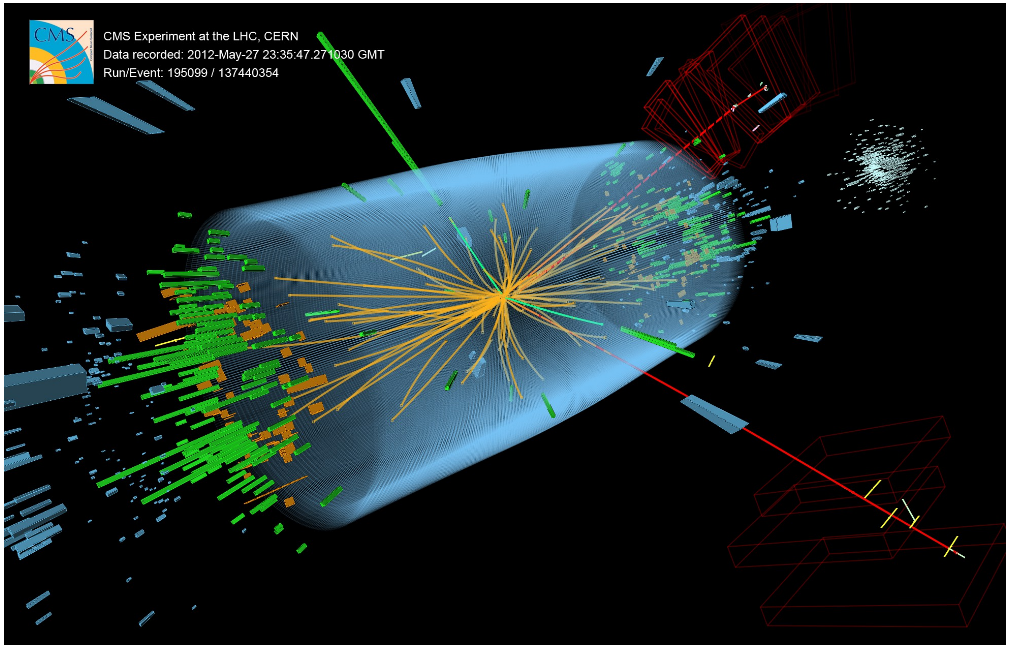
S/B ~ 1:100 - 1000

Observables: Higgs mass, CP, σ(ZH), event rates (σ(ZH, vvH)*Br(H→X)), Diff. distributions

Derive: Absolute Higgs width, branching ratios, couplings

Higgs measurement at e+e- & pp



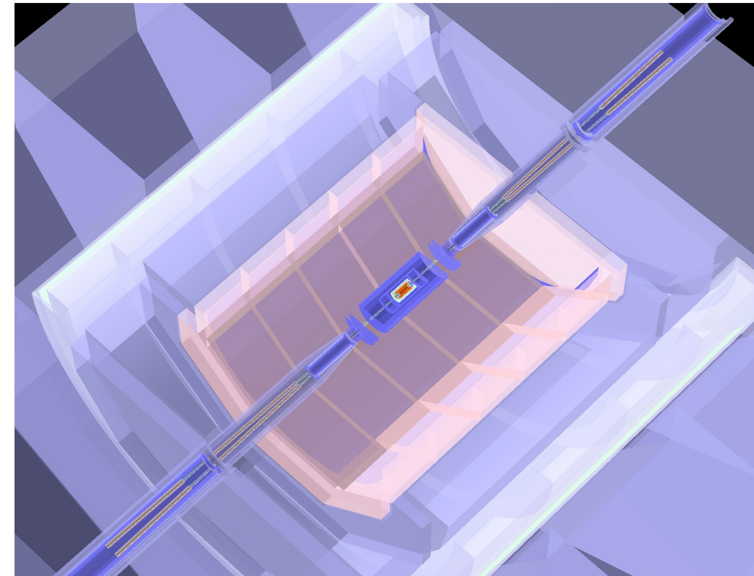


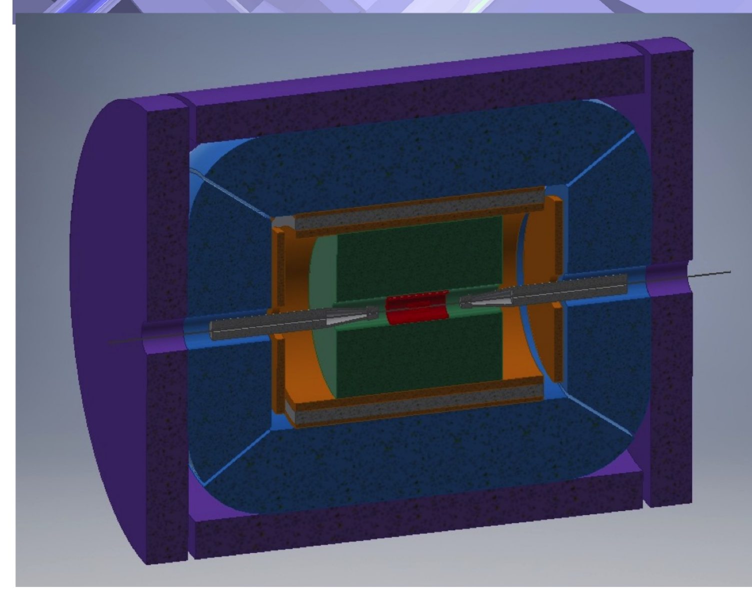
	Yield	efficiency	Comments
LHC	Run 1: 10^6 Run 2/HL: 10^{7-8}	~o(10^{-3})	High Productivity & High background, Relative Measurements, Limited access to width, exotic ratio, etc, Direct access to g(ttH), and even g(HHH)
CEPC	10^6	~o(1)	Clean environment & Absolute measurement, Percentage level accuracy of Higgs width & Couplings

Complementary

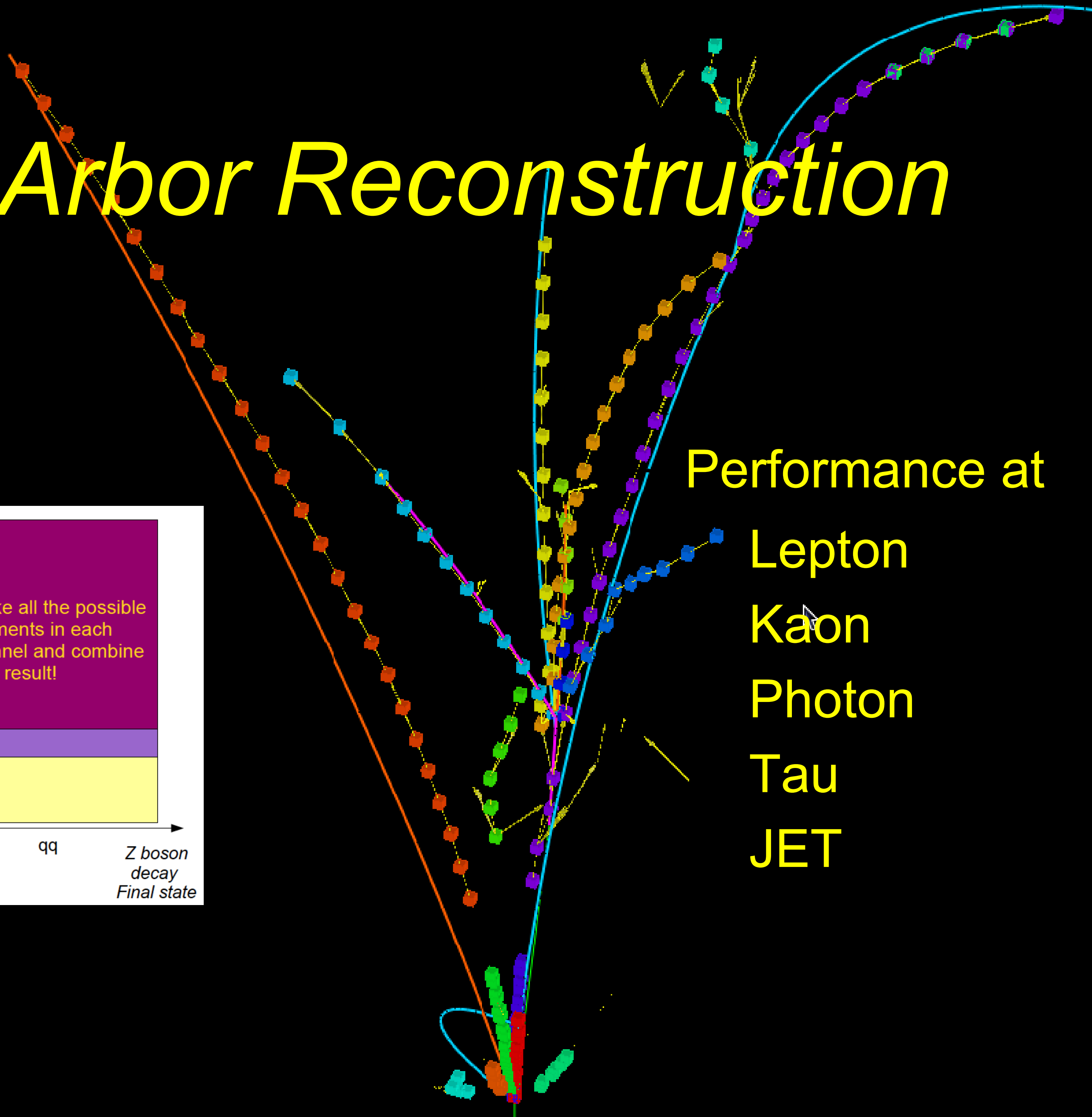
Detectors

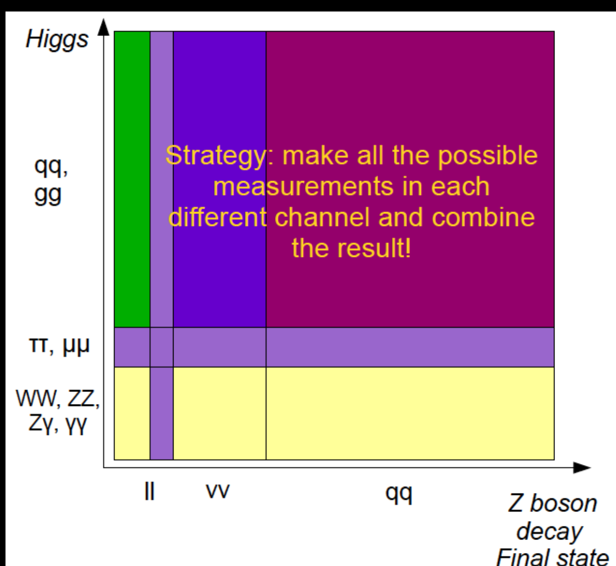
- CEPC:
  - APODIS (Baseline)
    - A PFA Oriented Detector for HIggS factory (Reference: ALEPH, SiD and **ILD**)
    - Low material tracker + ultrahigh granularity calorimeter (serve also as ToF) + large Solenoid
    - Dedicated MDI
    - Fully implemented into Geant 4 simulation and full reconstruction
    - Optimized versus Physics Benchmarks
  - IDEA (Alternative)
    - Wire Chamber + Dual Readout based: implementing into full simulation
- FCCee:
  - CLD & IDEA





Arbor Reconstruction

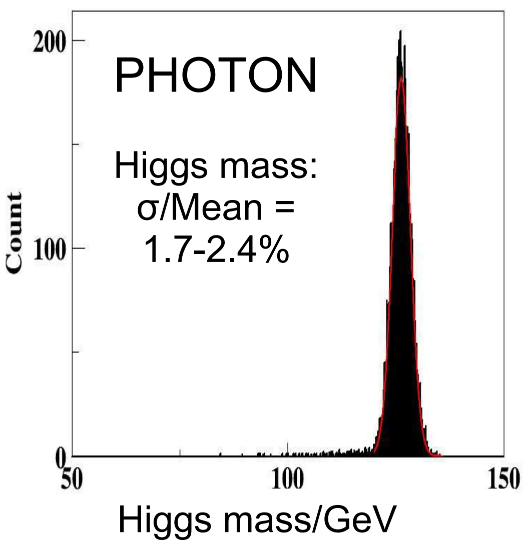


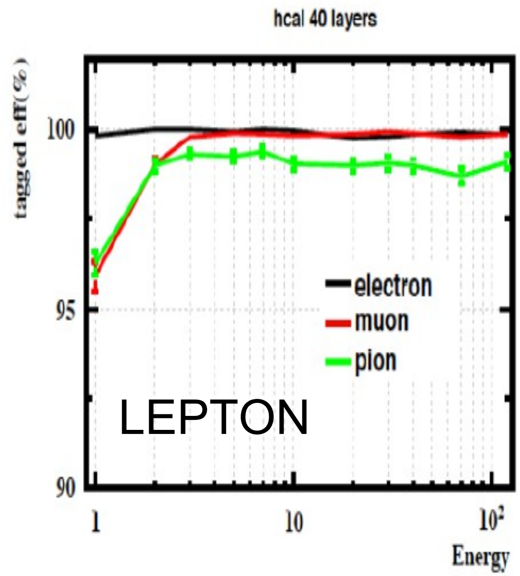


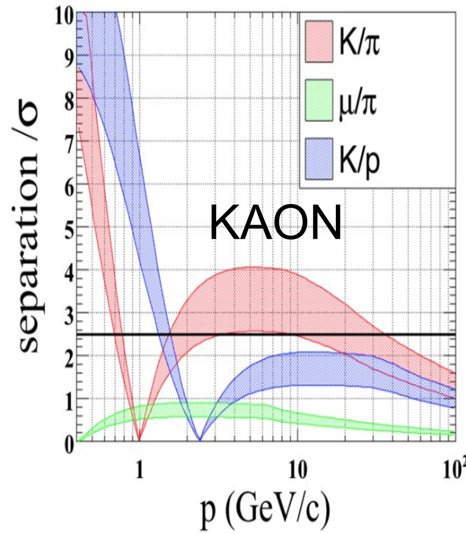
Performance at

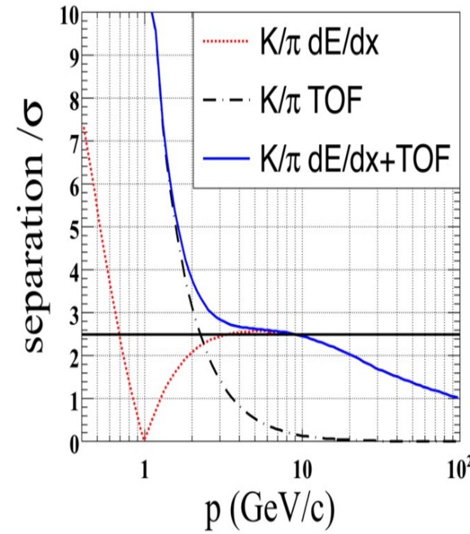
- Lepton
- Kaon
- Photon
- Tau
- JET

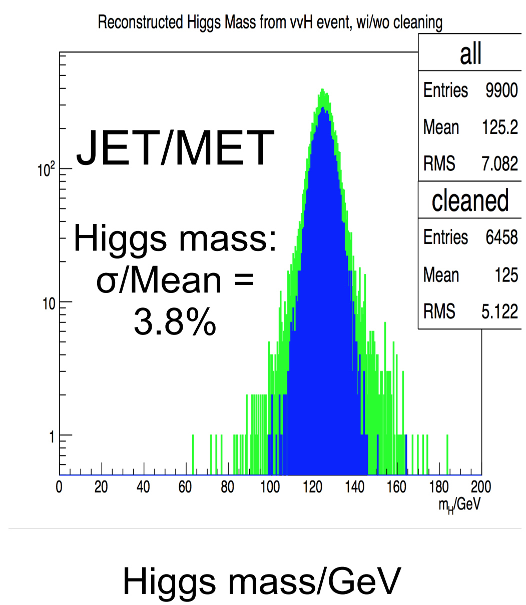
PFA Oriented Reconstruction

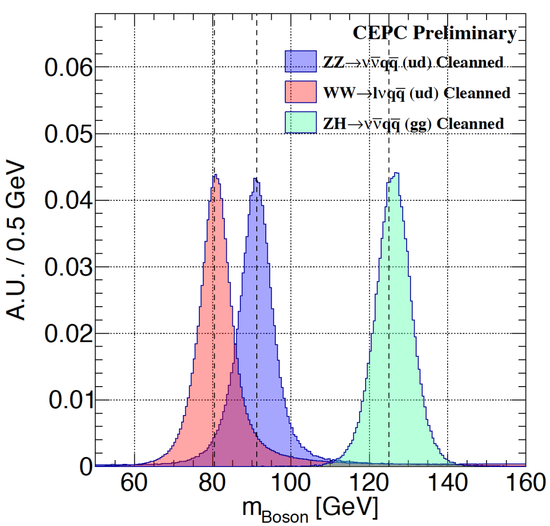


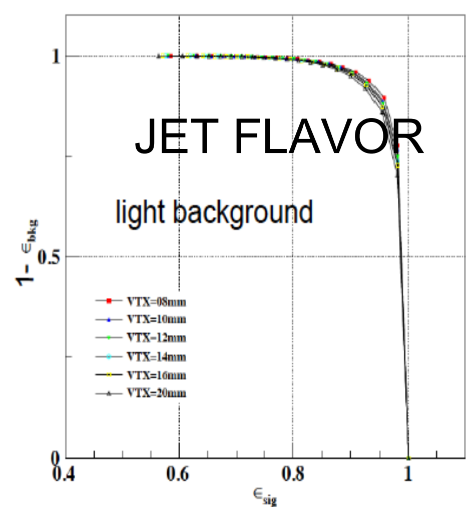


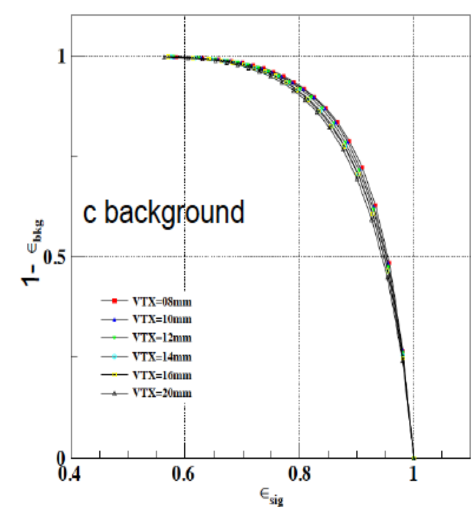




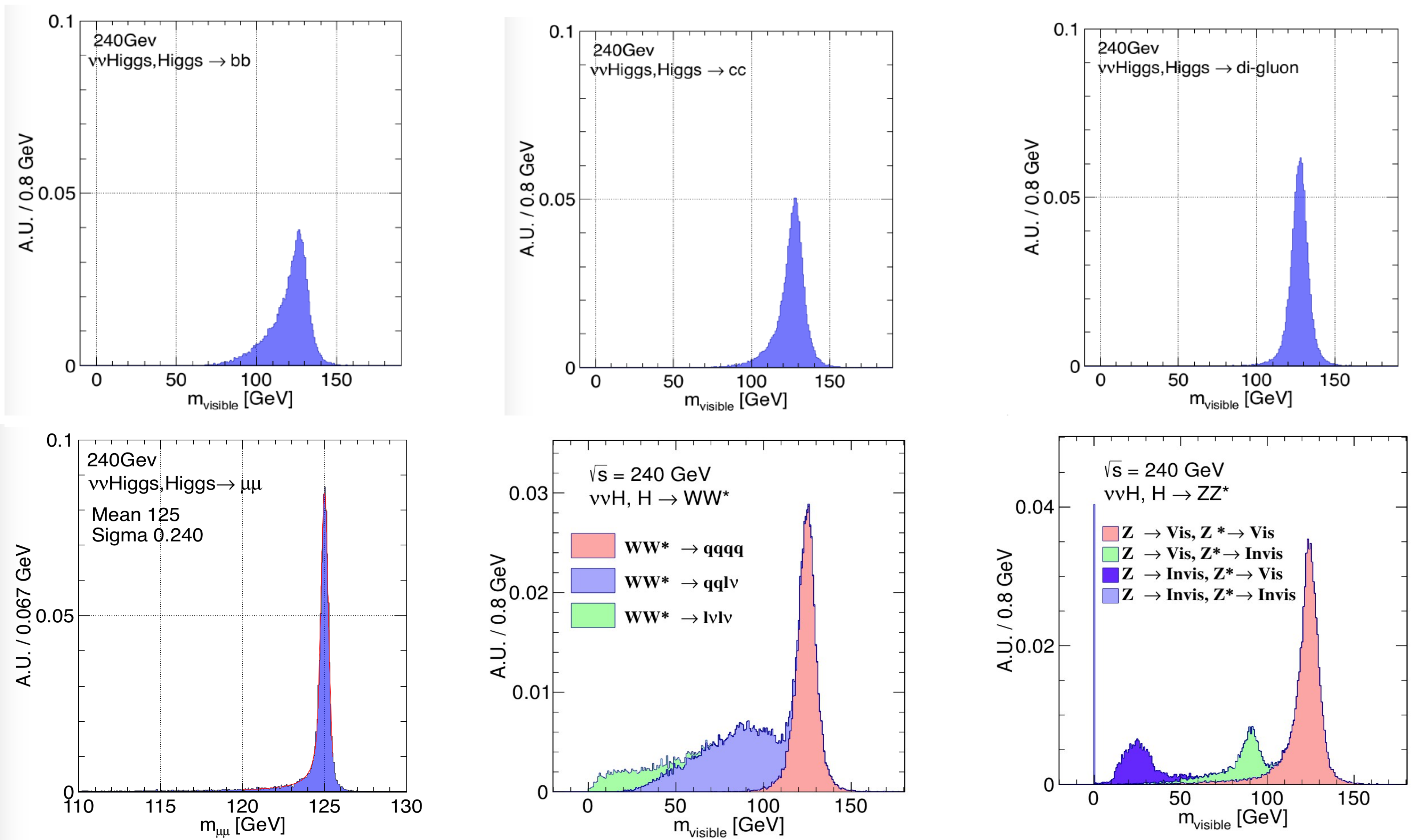






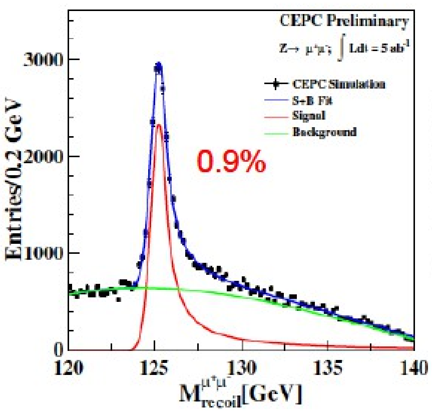


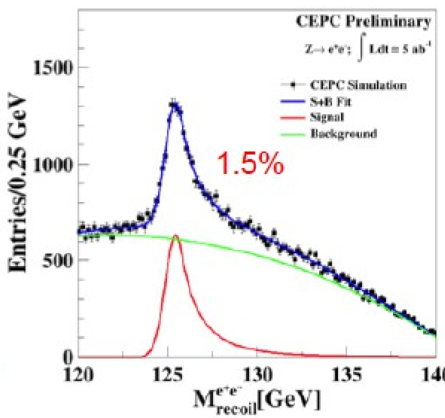
Higgs Signals at APODIS



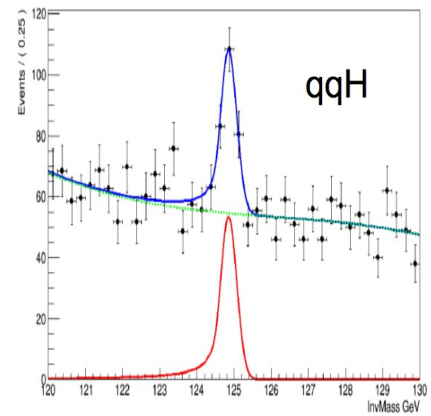
CEPC: absolute Higgs measurements

Zhenxing Chen & Yacine Haddad

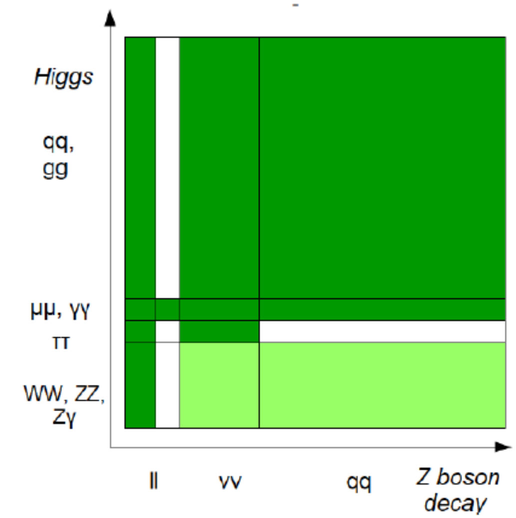




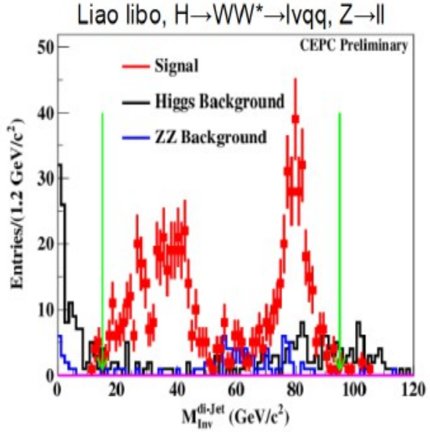
σ(ZH) measurements



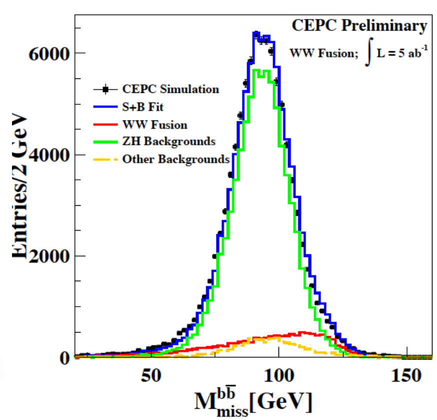
Br(H→μμ)



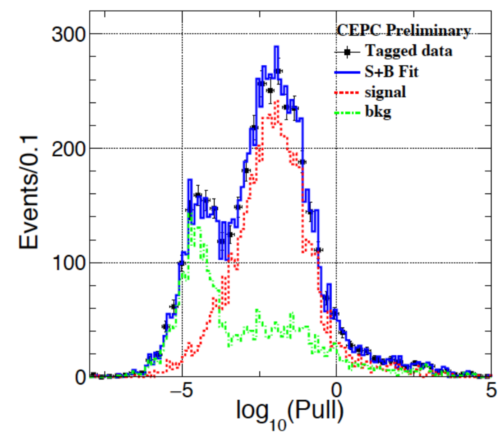
Liao libo, H→WW*→lνqq, Z→ll



Br(H→WW)



σ(ννH)*Br(H→bb)



Br(H→ττ)

	PreCDR (Jan 2015)	Now (Aug 2016)
σ(ZH)	0.51%	0.50%
σ(ZH)*Br(H→bb)	0.28%	0.21%
σ(ZH)*Br(H→cc)	2.1%	2.5%
σ(ZH)*Br(H→gg)	1.6%	1.2%
σ(ZH)*Br(H→WW)	1.5%	1.0%
σ(ZH)*Br(H→ZZ)	4.3%	4.3%
σ(ZH)*Br(H→ττ)	1.2%	1.0%
σ(ZH)*Br(H→γγ)	9.0%	9.0%
σ(ZH)*Br(H→Zγ)	-	~4 σ
σ(ZH)*Br(H→μμ)	17%	12%
σ(ννH)*Br(H→bb)	2.8%	2.8%
Higgs Mass/MeV	5.9	5.0
σ(ZH)*Br(H→inv)	95%. CL = 1.4e-3	1.4e-3
Br(H→ee/emu)	-	1.7e-4/1.2e-4
Br(H→bbχχ)	$<10^{-3}$	3.0e-4

See Dan's talk for more detail

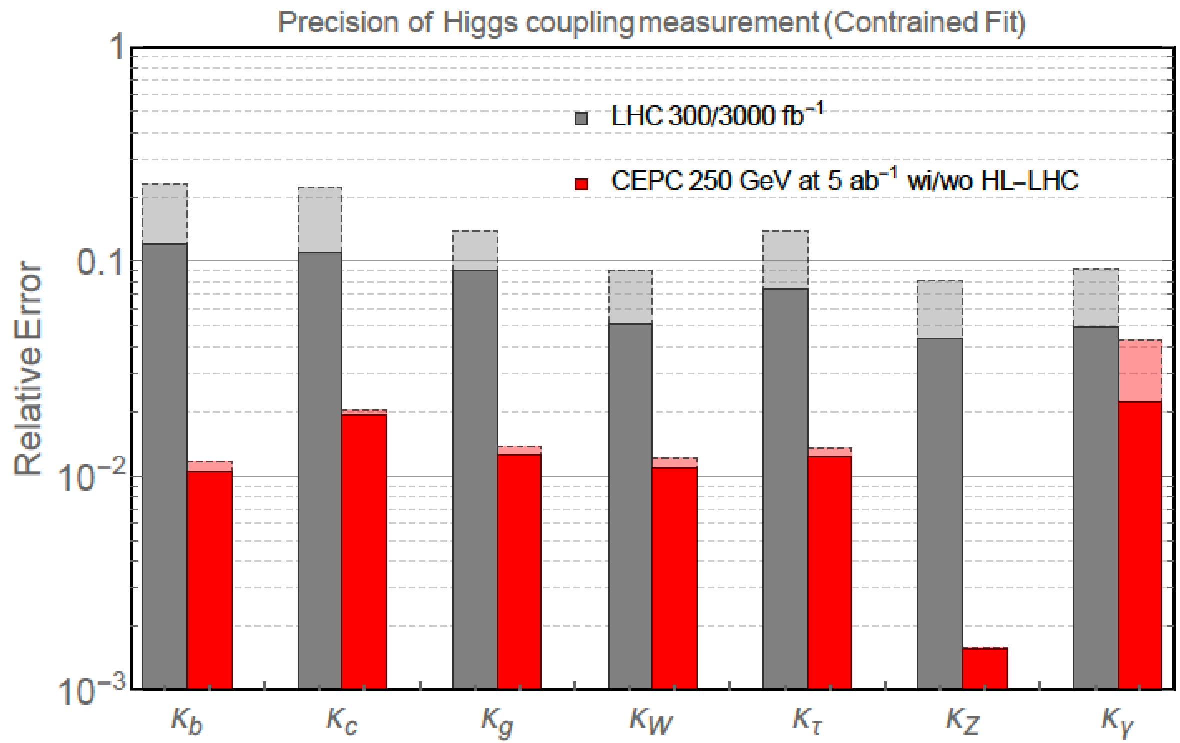
Physics Potential on Higgs

Accelerator

&

Detector

Well established
At conceptual level



- The nature of Higgs boson & EWSB, + flavor physics...
  - Higgs signal strengths (In kappa framework): expected accuracy roughly 1 order of magnitude better than HL-LHC
  - Absolute measurement to the Higgs boson: 2-3% level accuracy of Higgs boson width, 10^{-3} - 10^{-5} up limit to Higgs invisible/exotic decay modes (improved by at least 2 orders of magnitude comparing to HL-LHC)

Status of the Higgs white paper

Precision Higgs Physics at the CEPC

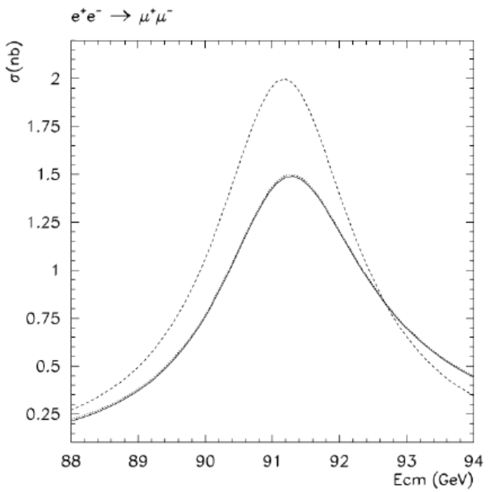
ABSTRACT: Version 0.3, Date: April 18, 2018
The discovery of a Higgs boson with its mass around 125 GeV by the ATLAS and CMS Collaborations has provided the first insight into the scalar sector of the Standard Model and beyond. The particle will be the subject of extensive studies of the ongoing LHC program. A lepton collider Higgs factory has been proposed as a logical next step beyond the LHC to measure the properties and study potential new physics associated with the Higgs boson. The Circular Electron Positron Collider (CEPC) is one of such proposed Higgs factories. The CEPC is an e^+e^- circular collider with a center-of-mass energy of $\sim 240-250$ GeV in a tunnel of approximately 100 km in circumference proposed by China. It will be followed by a Super Proton-Proton Collider (SPPC) in the same tunnel with an energy $70-100$ TeV. In this paper, we present the first estimates on the precision of Higgs property measurements achievable at the CEPC.

Contents

Z+Higgs physics at Circular e+e- collider (Y. Fang, IHEP) 22

the Giga/Tera Z pole precision

CEPC : 10^9-10^{11} Z decays : **LEP1 x 10^{2-4}**
FCCee: 4 10^{12} Z decays : **LEP1 x 10^5**



Radiation function calculated up to $O(\alpha^3)$: 10^{-5} precision → $\Delta m_Z \approx 100$ KeV

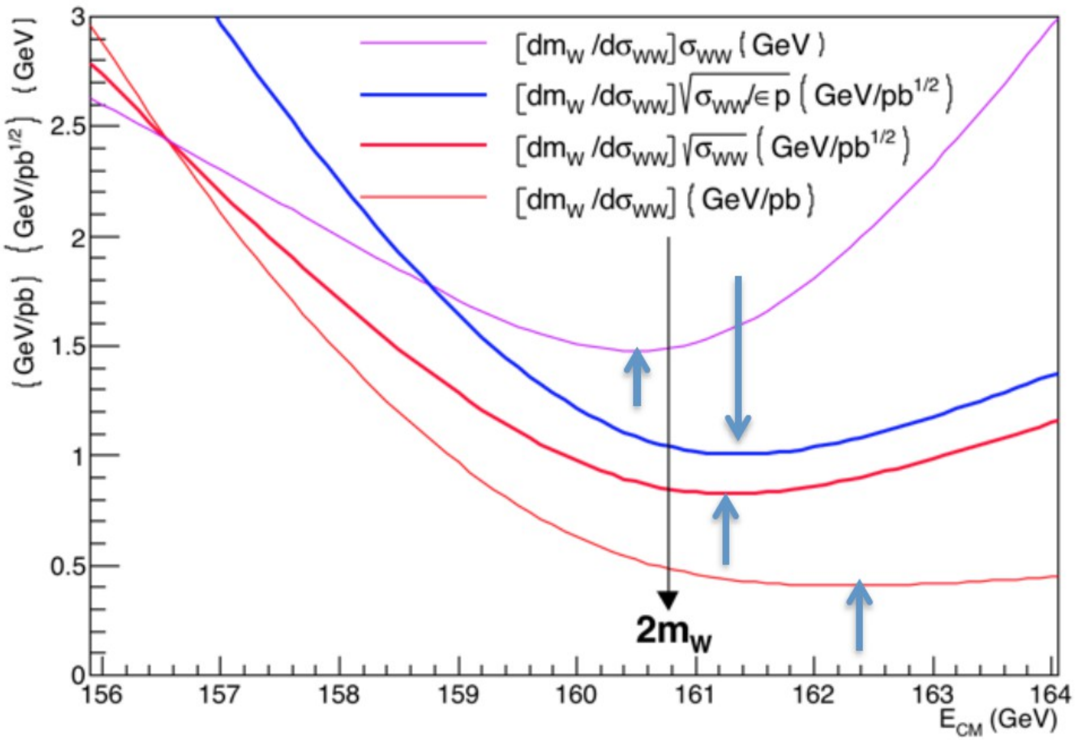
continuous E_{CM} calibration (resonant depolarization)
→ Z **mass** and **width** : 100-500 KeV (syst)

model (in) dependent (S-matrix) approach for γZ interference effects
off shell data needed for precise independent approach (reduced th assumptions)

beam spread (~60 MeV) and beams crossing angle (~30mrad) monitored with μ+μ-

m_W from σ_{WW}: sensitivity vs E_{CM}

m_W=80.385 GeV



σ_{WW} with YFSWW3 1.18

√εp with fixed : ε=0.75 and σ_B=0.3pb

statistical precision

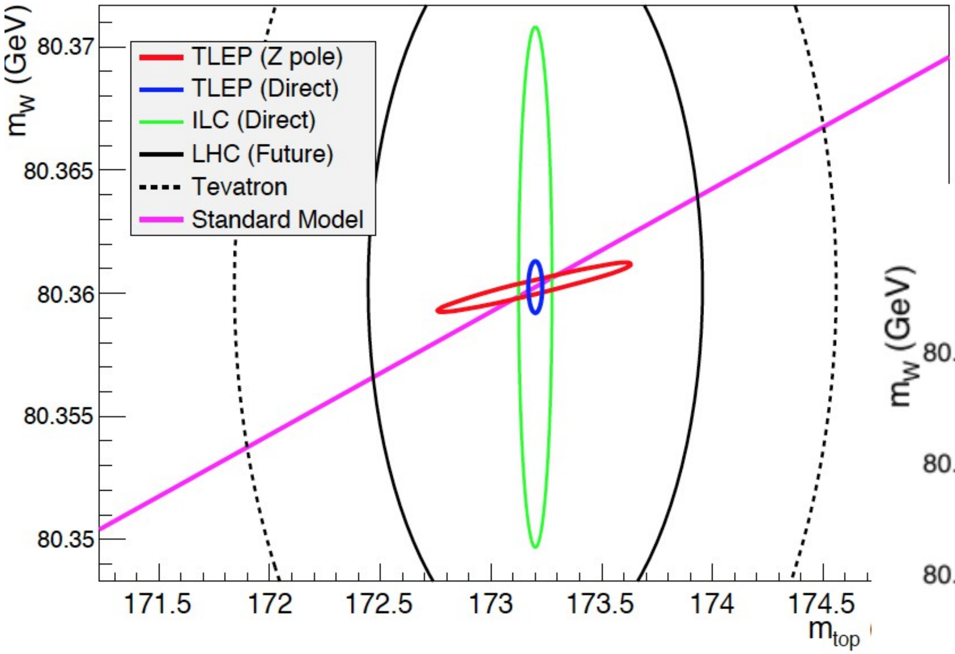
with L= 8/ab ➔ $\Delta m_w \approx 0.35$ MeV

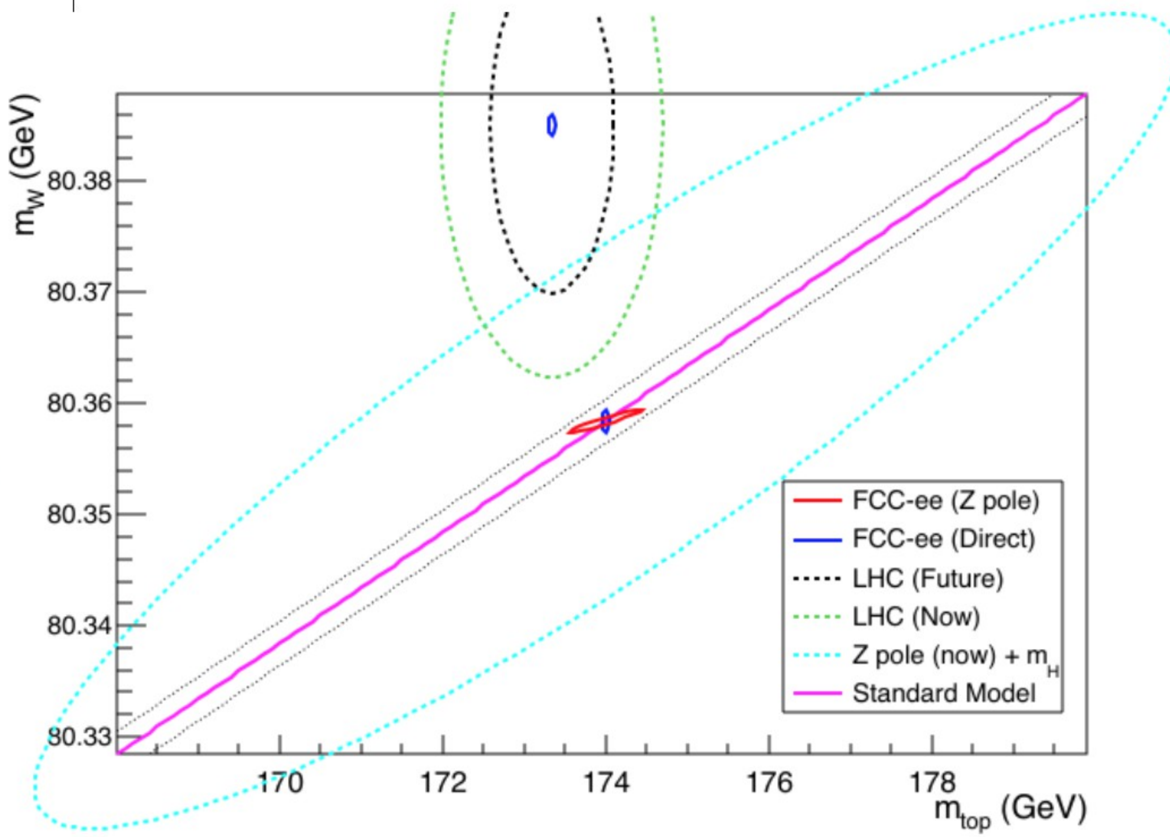
Max stat sensitivity at √s=2m_W+600 MeV
= 161.4 GeV

need syst control on :

- ΔE(beam)<0.35 MeV (**4x10^{-6}**)
- Δε/ε, ΔL/L < **2 10^{-4}**
- $\Delta\sigma_B$<0.7 fb (2 **10^{-3}**)

Z pole : effects on EW fit

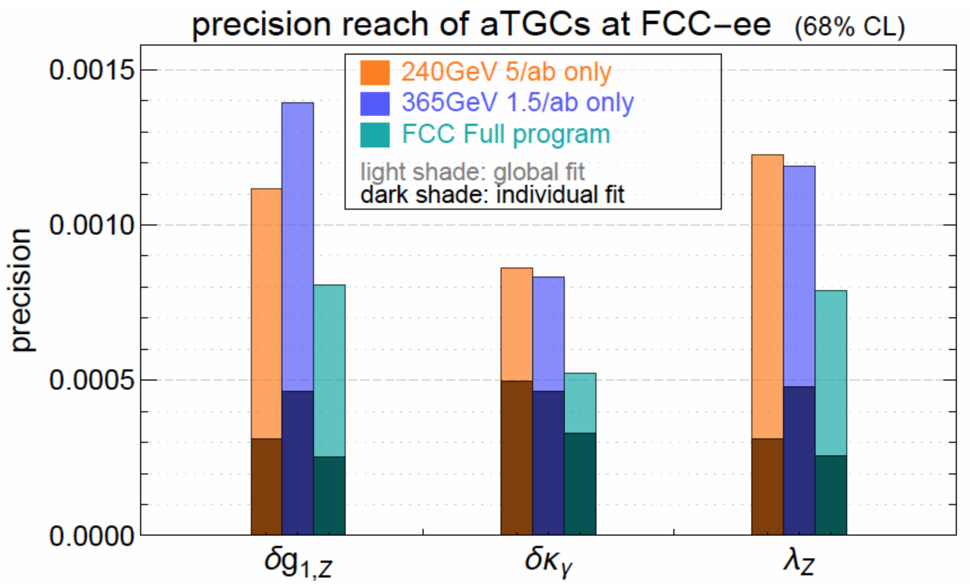


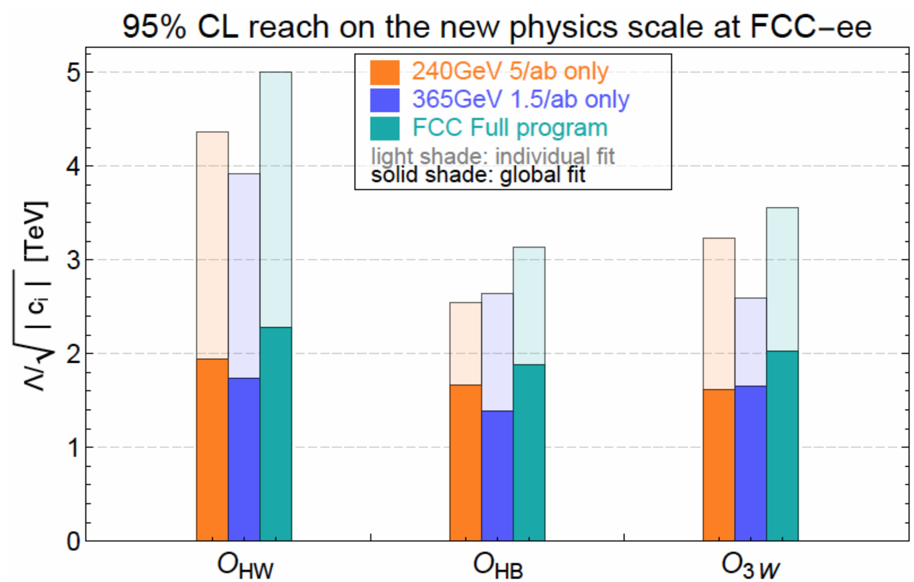


Triple gauge couplings

A binned chi-square fit is performed to estimate the precision reach of the three aTGCs at the FCCee.

Only the semileptonic channel, with one W decaying to e or μ is used.
The chi-square is summed over all bins of the five angles, considering only statistical uncertainties of signal events. The ambiguities in the reconstructions of the hadronic W decay angles (which are "folded") are taken into account.





LEP2 precision : 2-4 10^{-2}

current LHC limits $\Lambda/\sqrt{c}<$100-400 GeV

EW measurements at FCC/CEPC

- No "a priori wall" identified
- Key observables can be measured to an accuracy 1-2 orders of magnitude better than LEP
- Systematic analysis: part of the requirement on Detector & beam qualified.

Parameter	Dominating source	expected uncertainty	improvement w.r.t. LEP
m_Z	beam energy	100 keV	20
Γ_Z	beam energy	100 keV	20
σ^0_{had}	luminosity	5×10^{-3} nb	20
R_ℓ	exp. acceptance	5×10^{-5}	8

	Statistical uncertainty	Systematic uncertainty	improvement w.r.t. LEP
R_μ (R_ℓ)	10^{-6}	5×10^{-5}	20
R_τ	1.5×10^{-6}	10^{-4}	20
R_e	1.5×10^{-6}	3×10^{-4}	20
R_b	5×10^{-5}	3×10^{-4}	10
R_c	1.5×10^{-4}	15×10^{-4}	10

	Statistical uncertainty	Systematic uncertainty	improvement w.r.t. LEP
$\mathcal{A}_e$	$5. \times 10^{-5}$	$1. \times 10^{-4}$	50
$\mathcal{A}_\mu$	2.5×10^{-5}	1.5×10^{-4}	30
$\mathcal{A}_\tau$	$4. \times 10^{-5}$	$3. \times 10^{-4}$	15
$\mathcal{A}_b$	2×10^{-4}	30×10^{-4}	5
$\mathcal{A}_c$	3×10^{-4}	80×10^{-4}	4
$\sin^2\theta_{W,eff}$ (from muon FB)	10^{-7}	$5. \times 10^{-6}$	100
$\sin^2\theta_{W,eff}$ (from tau pol)	10^{-7}	6.6×10^{-6}	75

FCCee

“on the importance of beams parameters for e+e- colliders
Luminosity
Luminosity measurement
longitudinal beam polarization
transverse beam energy calibration, beam energy profile/spread”

At FCC-ee

10⁻ 10⁻ √s [GeV]

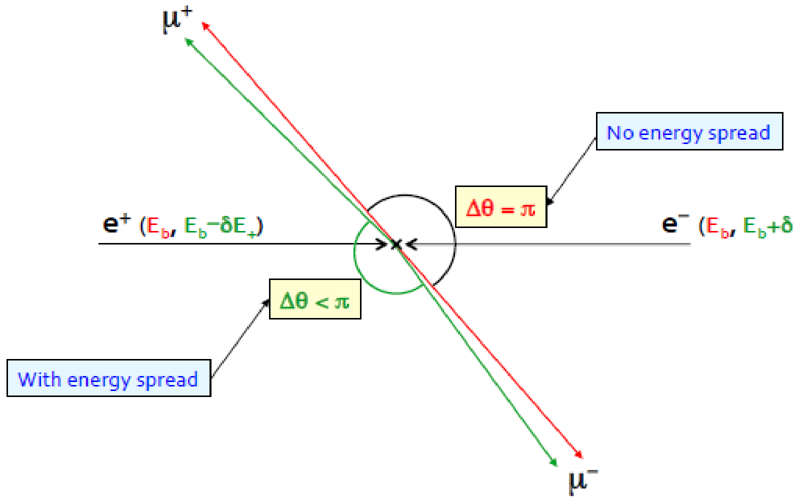
Event statistics :					E_{CM} errors:
Z peak	E_{cm} : 91 GeV	5 10^{12}	e+e- → Z	LEP x 10^5	100 keV
WW threshold	E_{cm} : 161 GeV	10^8	e+e- → WW	LEP x 2.10^3	300 keV
ZH threshold	E_{cm} : 240 GeV	10^6	e+e- → ZH	Never done	1 MeV
tt threshold	E_{cm} : 350 GeV	10^6	e+e- →tt	Never done	2 MeV

observable	Physics	Present precision		FCC-ee stat Syst Precision	FCC-ee key	Challenge
M_Z MeV/c2	Input	91187.5 ±2.1	Z Line shape scan	0.005 MeV <±0.1 MeV	E_cal	QED corrections
Γ_Z MeV/c2	$\Delta\rho$ (T) (no $\Delta\alpha$!)	2495.2 ±2.3	Z Line shape scan	0.008 MeV <±0.1 MeV	E_cal	QED corrections
$R_l = \frac{\Gamma_h}{\Gamma_l}$	α_s, δ_b	20.767 (25)	Z Peak	0.0001 (2-20)	Statistics	QED corrections
N_ν	Unitarity of PMNS, sterile ν's	2.984 ±0.008	Z Peak Z+γ(161 GeV)	0.00008 (40) 0.001	->lumi meast Statistics	QED corrections to Bhabha scat.
R_b	δ_b	0.21629 (66)	Z Peak	0.000003 (20-60)	Statistics, small IP	Hem. correlations
A_{LR}	$\Delta\rho$, ε_3, $\Delta\alpha$ (T, S)	$\sin^2\theta_W^{eff}$ 0.23098(26)	Z peak, Long. polarized	$\sin^2\theta_W^{eff}$ ±0.000006	4 bunch scheme	Design experiment
A_{FB}^{lept}	$\Delta\rho$, ε_3, $\Delta\alpha$ (T, S)	$\sin^2\theta_W^{eff}$ 0.23099(53)		$\sin^2\theta_W^{eff}$ ±0.000006	E_cal & Statistics	
M_W MeV/c2	$\Delta\rho$, ε_3, ε_2, $\Delta\alpha$ (T, S, U)	80385 ± 15	Threshold (161 GeV)	0.3 MeV <0.5 MeV	E_cal & Statistics	QED corections
m_{top} MeV/c2	Input	173200 ± 900	Threshold scan	~10 MeV	E_cal & Statistics	Theory limit at 50 MeV?

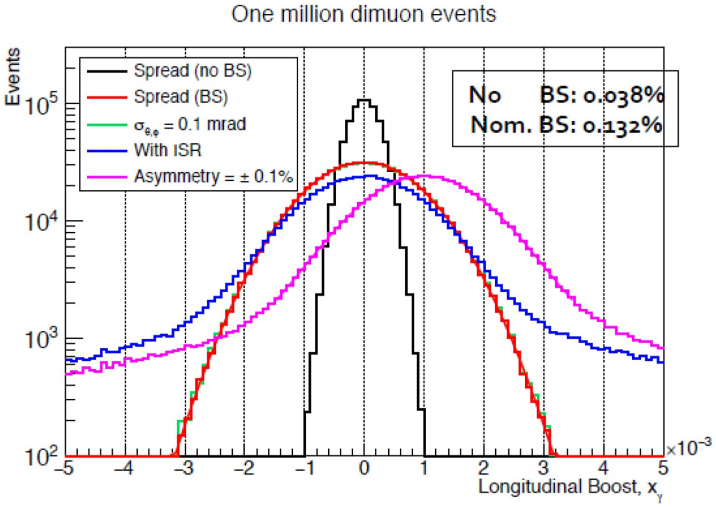
24/05/2018 8

Make use of $e^+e^- \to \mu^+\mu^-$ events

- How are the events modified with energy spread ?



With 10^6 dimuon events (every 5 minutes at the Z pole)



30 keV/5 min

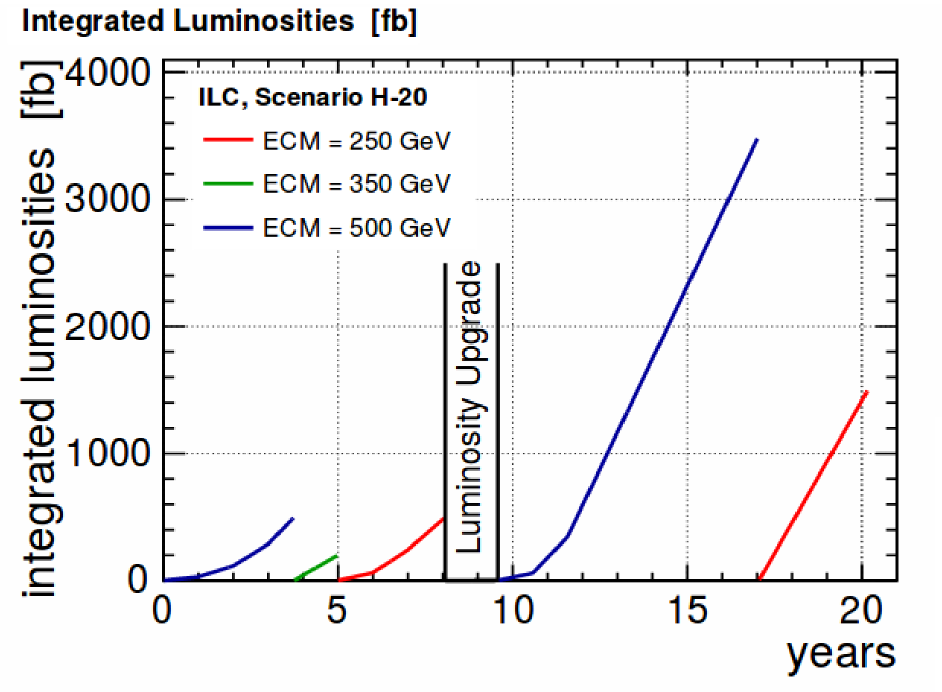
FCC-ee design study is placing a high emphasis on the fundamentals of systematic errors
- -- Maximize total luminosity
- -- luminosity measurement
- -- beam energy calibration with transverse beam polarization
- -- the need for longitudinal polarization is not very compelling, and it is difficult to obtain it without losing 1-2 orders of magnitude in luminosity

We can conclude that the energy calibration for Z and W will match the goals.

It could be better with more work

We can conlcude that luminosity will be measured at 2 10^{-4} relative level with low angle Bhabha scattering. Cross-calibration with ee→ $\gamma\gamma$ might improve the absolute normalization

Top physics@LC

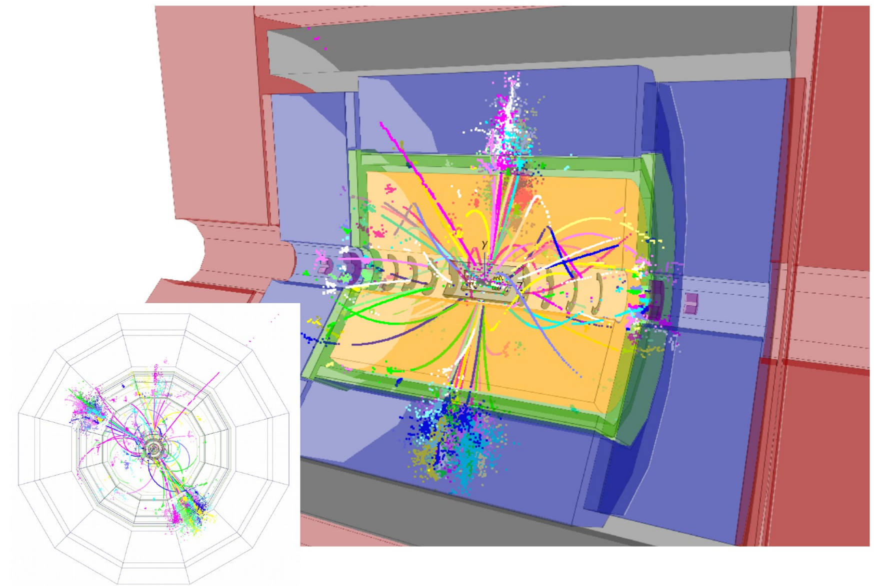


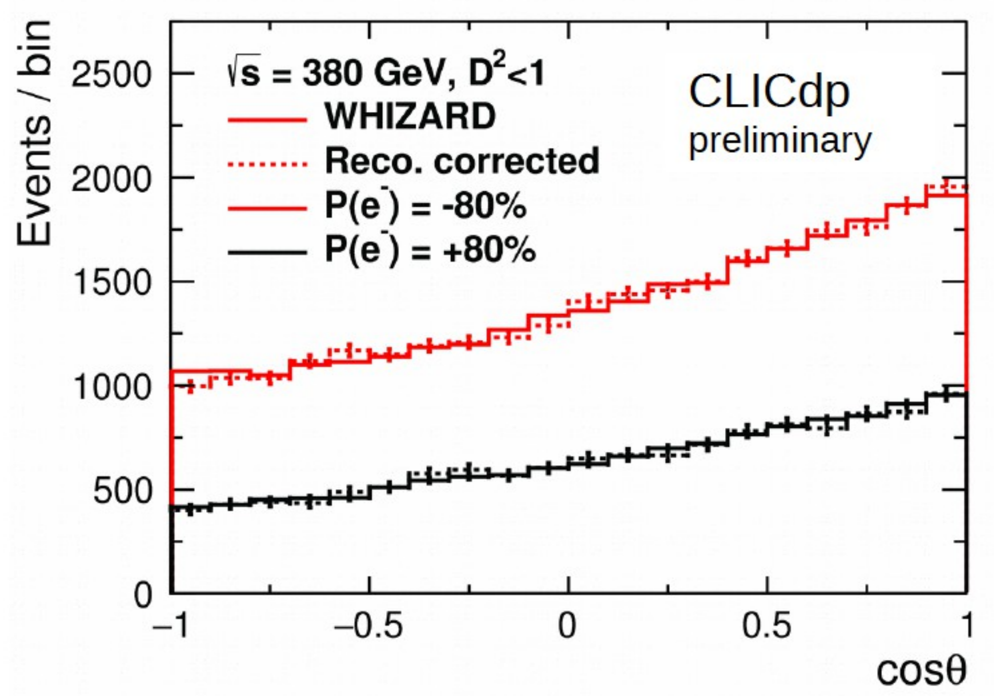
Full Sim/Reco analysis

Observables:

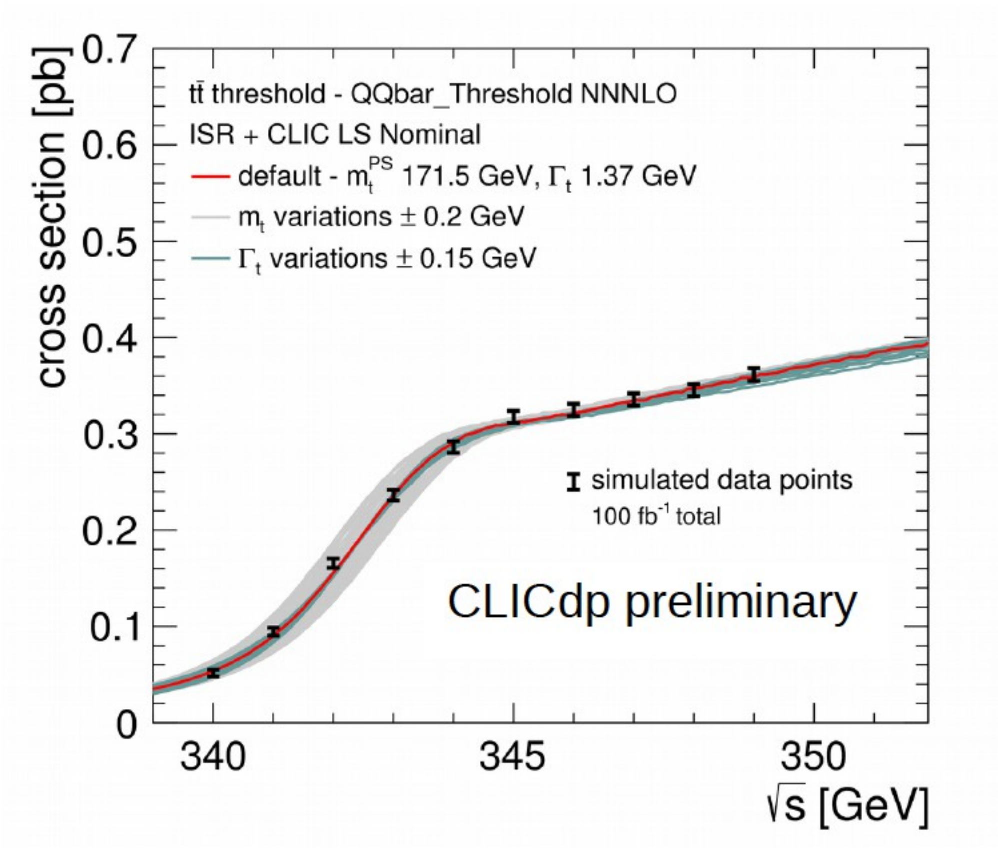
- Top: mass, width, FCNC, ...
- Top quark EW couplings
- Top + Higgs: Yukawa coupling

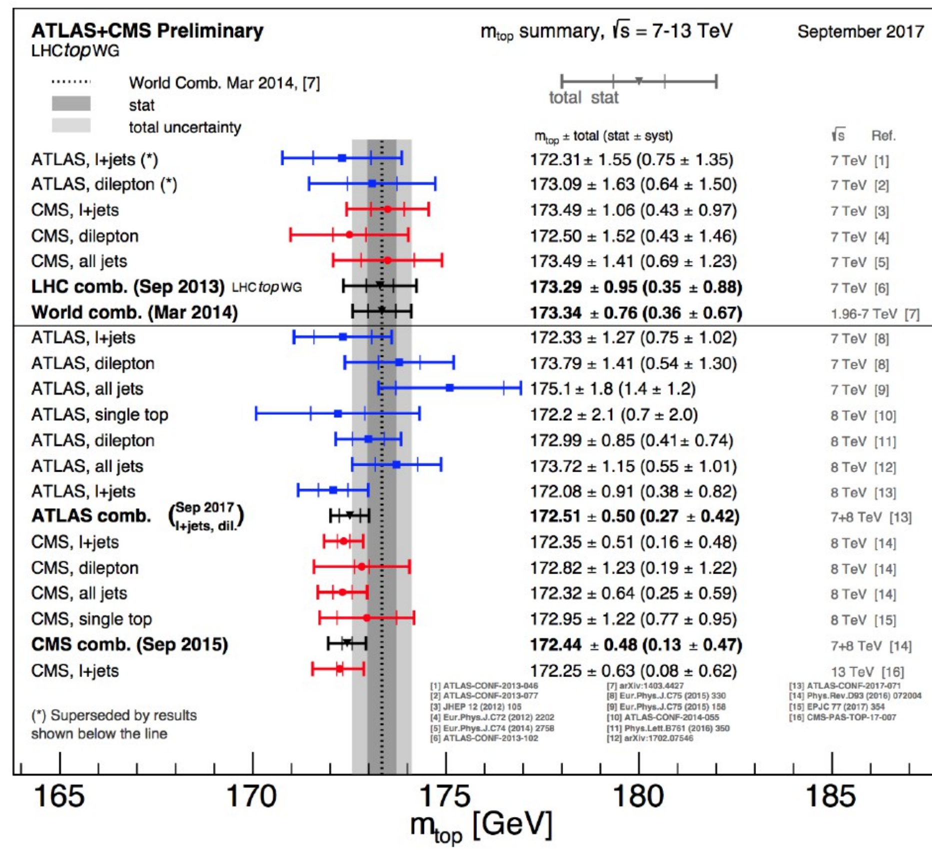
Boosted top quark production: √s > 1 TeV





Top mass threshold scan





Pole mass accuracy significantly improved...

From the theoretical side: ppl still need to understand what we really measured

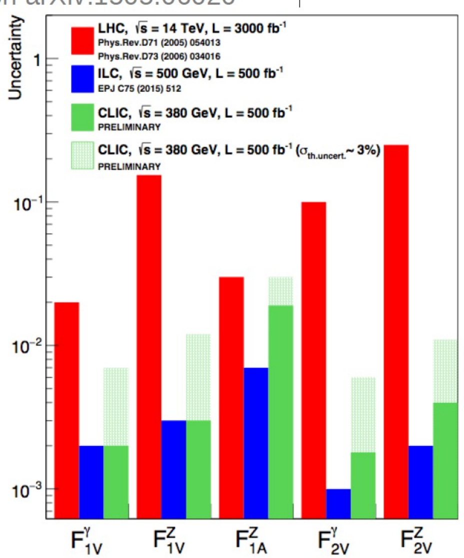
A very competitive top quark mass measurement:

$\Delta m_t \sim 50$ MeV *(= 3 x 10^{-4}, cf. Δm_b ~1%)*

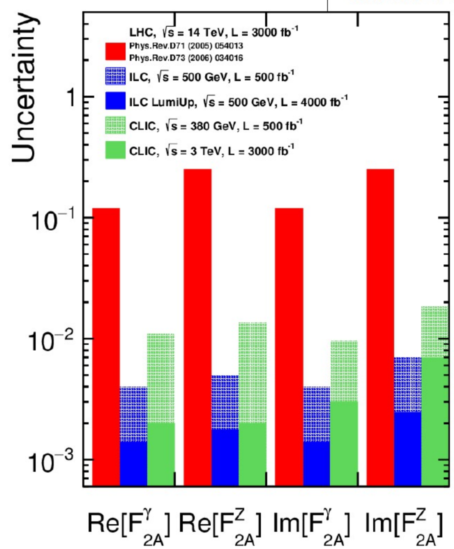
Top anomalous couplings

$$\Gamma_\mu^{t\bar{t}X}(k^2,q,\bar{q}) = ie\left\{\gamma_\mu\left(F_{1V}^X(k^2)+\gamma_5 F_{1A}^X(k^2)\right) - \frac{\sigma_{\mu\nu}}{2m_t}(q+\bar{q})^\nu\left(iF_{2V}^X(k^2)+\gamma_5 F_{2A}^X(k^2)\right)\right\}$$

CLIC staging, CERN-2016-004
based on arXiv:1505.06020

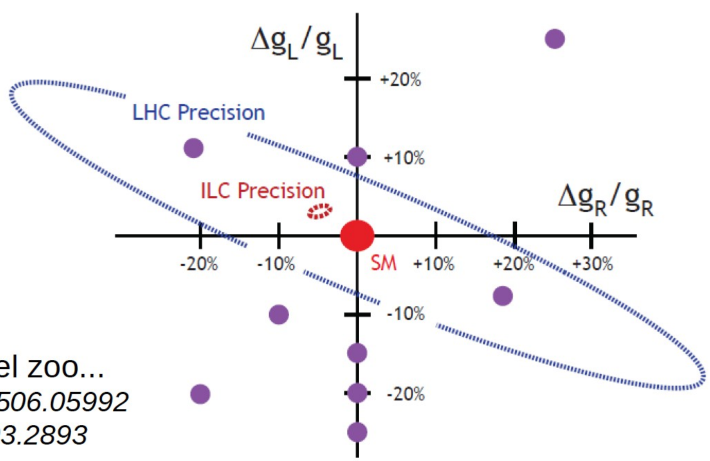


arXiv:1710.06737



Measurements in pair production in early stage have excellent BSM sensitivity

For FCCee perspective, see
P. Janot, arXiv:1503.01325



Scatter plot of the model zoo...
ILC Physics case, arXiv:1506.05992
Richard/Wulzer, arXiv:1403.2893

Top measurement at LC

The LC top physics program complements hadron colliders in important ways.

The precision of several key measurements exceeds the HL-LHC significantly:

- top mass measurement: **$\Delta m_t \sim 50$ MeV**
- FCNC interactions: **competitive for $t \rightarrow c\gamma$, $t \rightarrow ch$**
- top quark EW couplings: **improved by order of magnitude**
- the determination of the **top Yukawa coupling to 3-4%**

With this precision, these measurements have the potential answer important questions,

hopefully offering guidance towards a more complete theory

24 May 2018 CEPC workshop, Marcel Vos 45

Workshop on the Circular Electron-Positron Collider - EU edition

Università degli Studi Roma Tre, 24-26 May 2018

Beyond-SM Physics at CepC

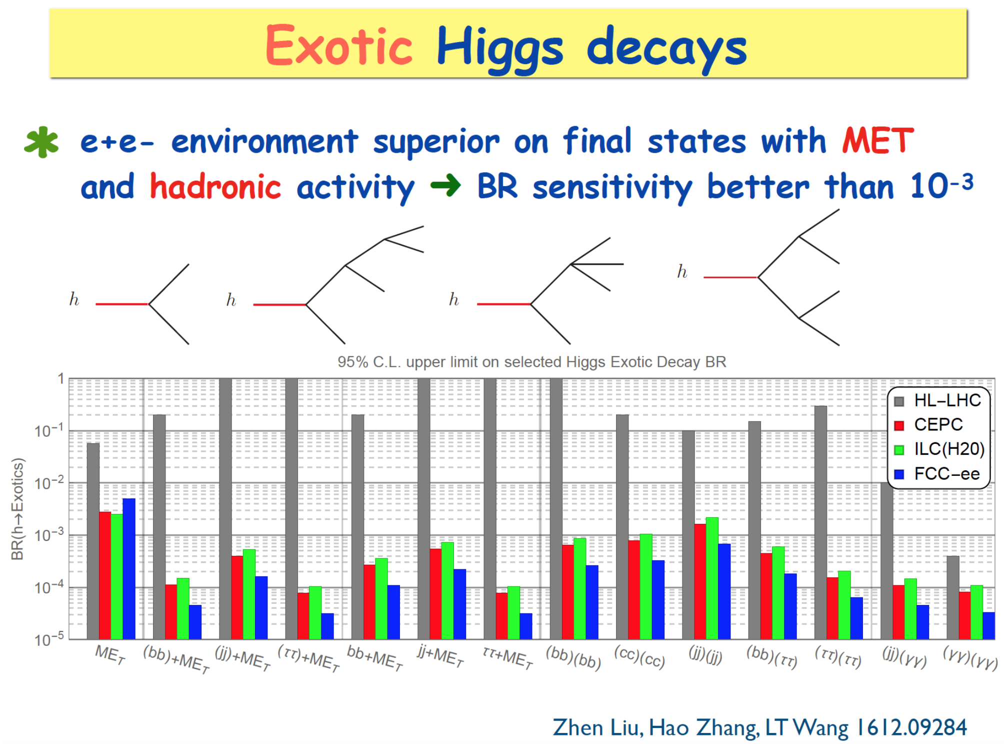
Higgs Factory (10^6 Higgs)

Z & W Factory (10^{10} Z)

Flavor Factory (b,c,tau)

INFN Roma Barbara Mele

Exotic Higgs & Z decay modes, Dark photon, WIMP, sterile neutrino...

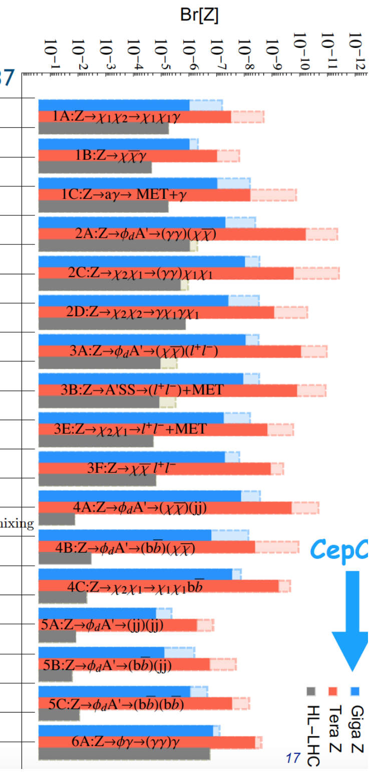


✱ long list of models/signatures

Liu, Wang ,Wang, Xue, 1712.07237

exotic decays	topologies	n_{res}	models
$Z \to \not{E} + \gamma$	$Z \to \chi_1\chi_2, \chi_2 \to \chi_1\gamma$	0	1A: $\frac{1}{\Lambda_{1A}}\bar{\chi}_2\sigma^{\mu\nu}\chi_1 B_{\mu\nu}$ (MIDM)
	$Z \to \chi\bar{\chi}\gamma$	0	1B: $\frac{1}{\Lambda_{1B}^3}\bar{\chi}\chi B_{\mu\nu}B^{\mu\nu}$ (RayDM)
	$Z \to a\gamma \to (\not{E})\gamma$	1	1C: $\frac{1}{4\Lambda_{1C}} a B_{\mu\nu}\tilde{B}^{\mu\nu}$ (long-lived ALP)
	$Z \to A'\gamma \to (\bar{\chi}\chi)\gamma$	1	1D: $\epsilon^{\mu\nu\rho\sigma}A'_\mu B_\nu \partial_\rho B_\sigma$ (WZ terms)
$Z \to \not{E} + \gamma\gamma$	$Z \to \phi_d A', \phi_d \to (\gamma\gamma), A' \to (\bar{\chi}\chi)$	2	2A: Vector portal
	$Z \to \phi_H\phi_A, \phi_H \to (\gamma\gamma), \phi_A \to (\bar{\chi}\chi)$	2	2B: 2HDM extension
	$Z \to \chi_2\chi_1, \chi_2 \to \chi_1\phi, \phi \to (\gamma\gamma)$	1	2C: Inelastic DM
	$Z \to \chi_2\chi_2, \chi_2 \to \gamma\chi_1$	0	2D: MIDM
$Z \to \not{E} + \ell^+\ell^-$	$Z \to \phi_d A', A' \to (\ell^+\ell^-), \phi_d \to (\bar{\chi}\chi)$	2	3A: Vector portal
	$Z \to A'SS \to (\ell\ell)SS$	1	3B: Vector portal
	$Z \to \phi(Z^*/\gamma^*) \to \phi\ell^+\ell^-$	1	3C: Long-lived ALP, Higgs portal
	$Z \to \chi_2\chi_1 \to \chi_1 A'\chi_1 \to (\ell^+\ell^-)\not{E}$	1	3D: Vector portal and Inelastic DM
	$Z \to \chi_2\chi_1, \chi_2 \to \chi_1\ell^+\ell^-$	0	3E: MIDM, SUSY
	$Z \to \bar{\chi}\chi\ell^+\ell^-$	0	3F: RayDM, slepton, heavy lepton mixing
$Z \to \not{E} + JJ$	$Z \to \phi_d A' \to (\bar{\chi}\chi)(jj)$	2	4A: Vector portal
	$Z \to \phi_d A' \to (bb)(\bar{\chi}\chi)$	2	4B: Vector portal + Higgs portal
	$Z \to \chi_2\chi_1 \to bb\chi_1 + \chi_1 \to bb\not{E}$	0	4C: MIDM
$Z \to (JJ)(JJ)$	$Z \to \phi_d A', \phi_d \to jj, A' \to jj$	2	5A: Vector portal + Higgs portal
	$Z \to \phi_d A', \phi_d \to b\bar{b}, A' \to jj$	2	5B: vector portal + Higgs portal
	$Z \to \phi_d A', \phi_d \to b\bar{b}, A' \to b\bar{b}$	2	5C: vector portal + Higgs portal
$Z \to \gamma\gamma\gamma$	$Z \to \phi\gamma \to (\gamma\gamma)\gamma$	1	6A: ALP, Higgs portal

Barbara Mele U. Roma Tre, 24 May 2018



✱ an ee circular collider running at ZH,WW, Z with L ~ $10^{(34-36)}$ cm^{-2}s^{-1} can go beyond LHC reach in many different BSM sectors

✱ ideal setup for discovering (very) new weakly interacting pls

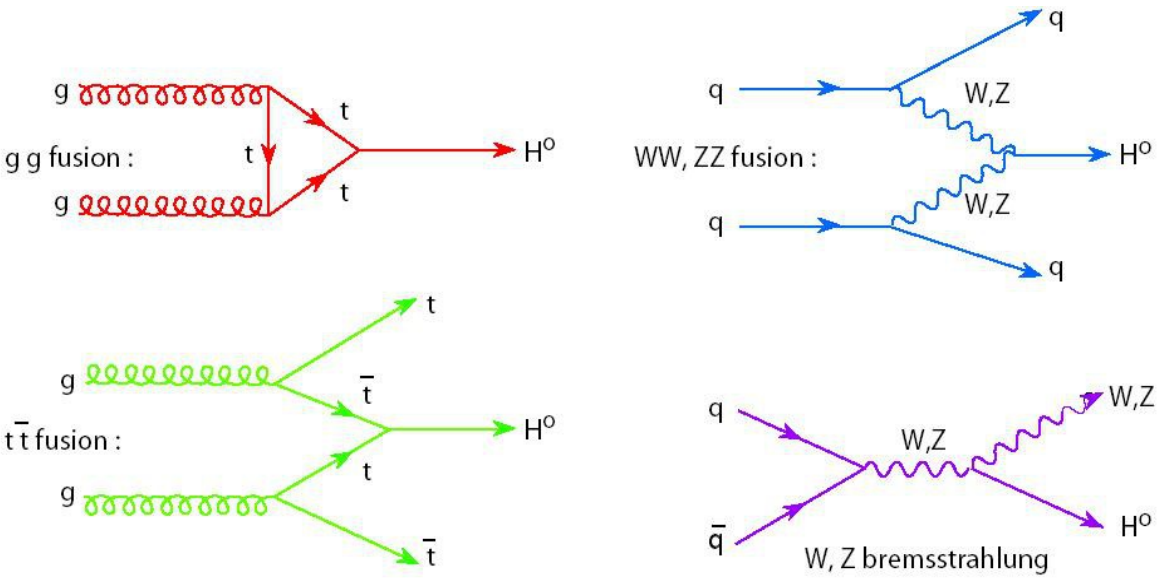
(additional light Higgses with reduced coupling not covered here...)

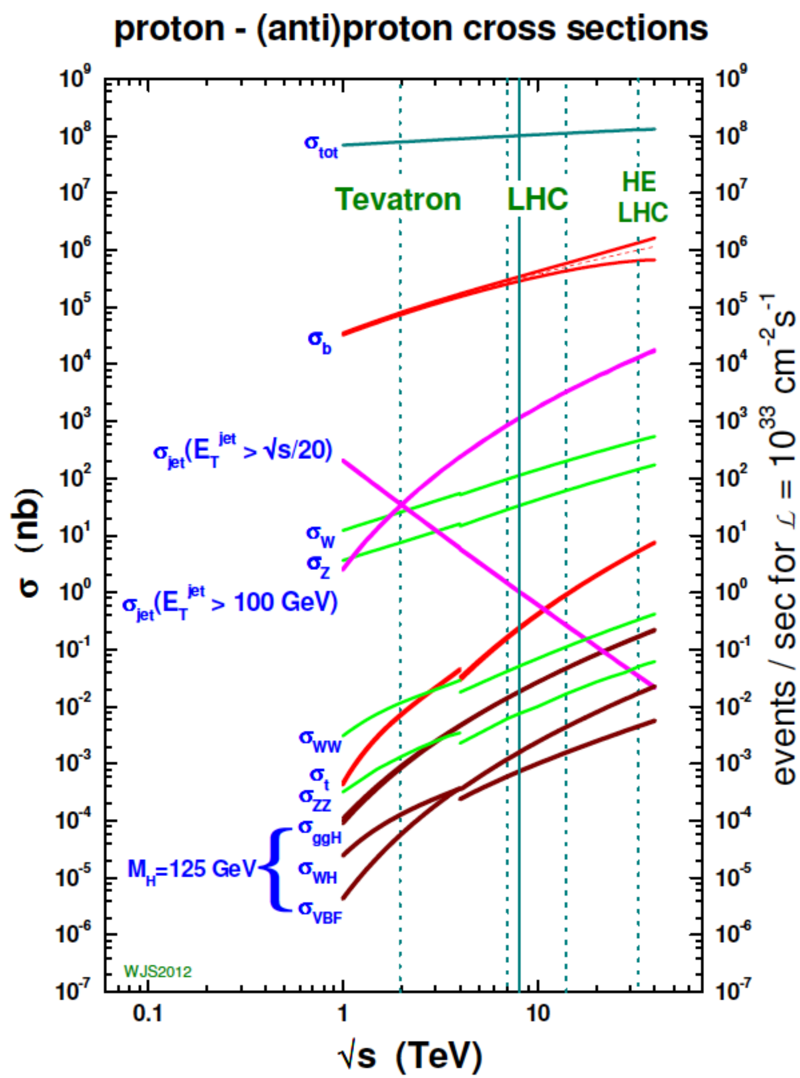
Summary: Great opportunity

- The precise measurement of the Higgs
  - Detector & Accelerator studies confirms 0.1 - 1/% precision
  - Precision mainly limited by statistic
- EW measurement: no “a priori” wall on the precision,
  - Promising results in systematic study
  - Still need huge efforts, especially on the theoretical uncertainty control
  - Requirement on detector & beam calibrations are partly quantified -> and the most important components is addressed (see Alain's talk)
- Top physics:
  - LC provides excellent coverage for the top associated measurements, which is highly complementary to the HL-LHC
  - Measurements also explored at FCC
- BSM: Promising
  - Exotic behaviors & New particle searching

Thank you!

Higgs @ LHC





S/B ~ 1:1E10 !!!

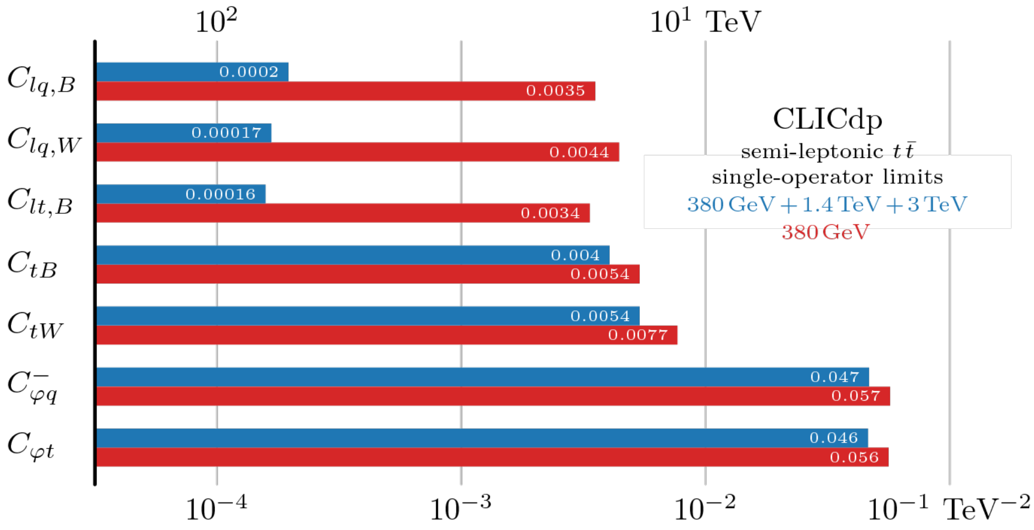
$$\sigma(AA \rightarrow H \rightarrow BB) \sim g^2(HAA)g^2(HBB)/\Gamma_{total}$$

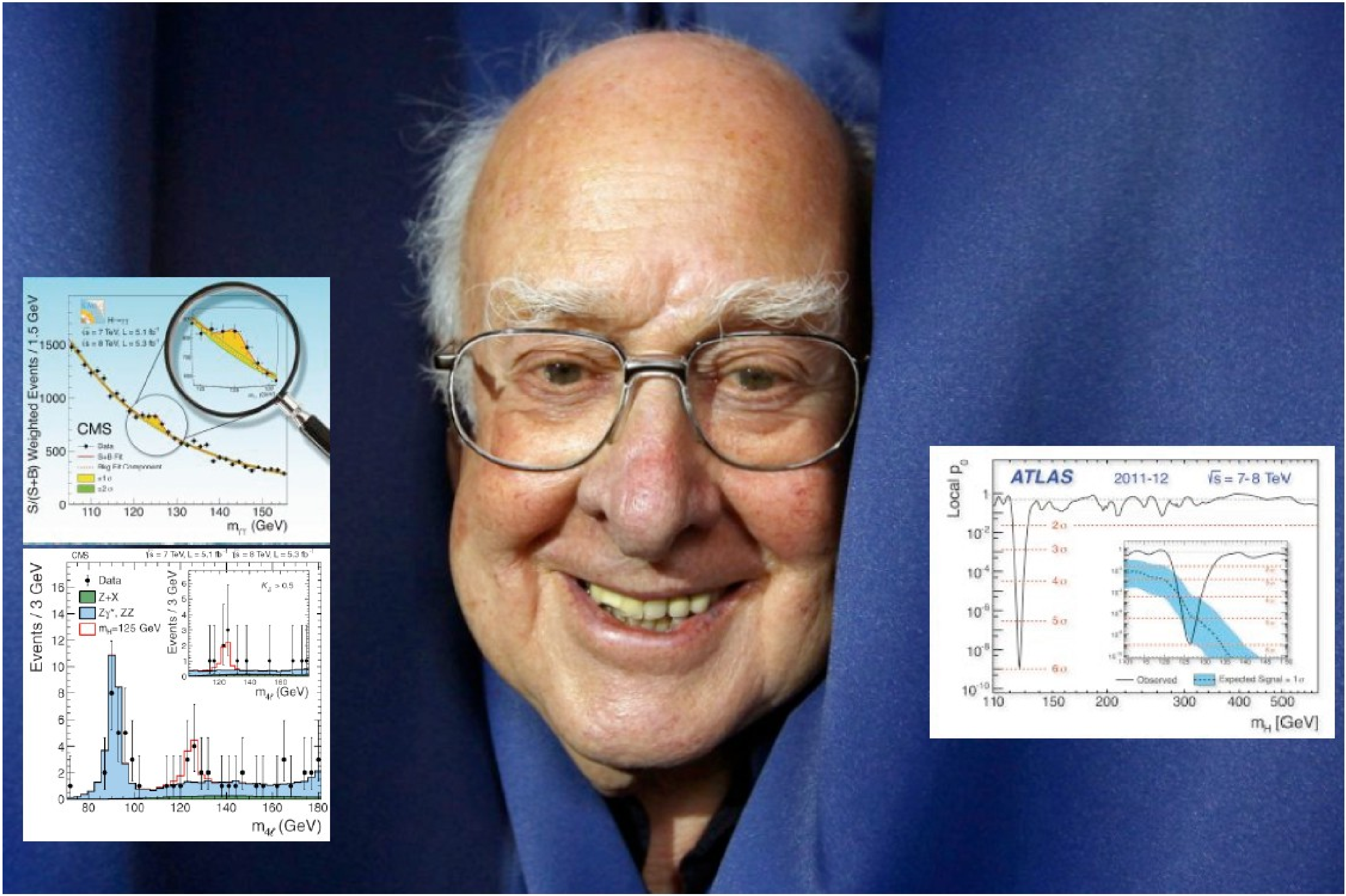
Outlook

- an ee circular collider running at ZH, WW, Z with $L \sim 10^{(34-36)}$ $cm^{-2}s^{-1}$ can go beyond LHC reach in many different BSM sectors
- it is "not just" a wonderful Higgs precision probe !
- EWPT : order of magnitudes improvements wrt LEP
- ideal setup for discovering (very) new weakly interacting pls

  (additional light Higgses with reduced coupling not covered here…)
- Hidden/Dark (SM-uncharged) Sectors can provide new signatures to scrutinise
- many different studies, just mentioned a few…

Complementarity: Low & High E
EM & Higgs & top

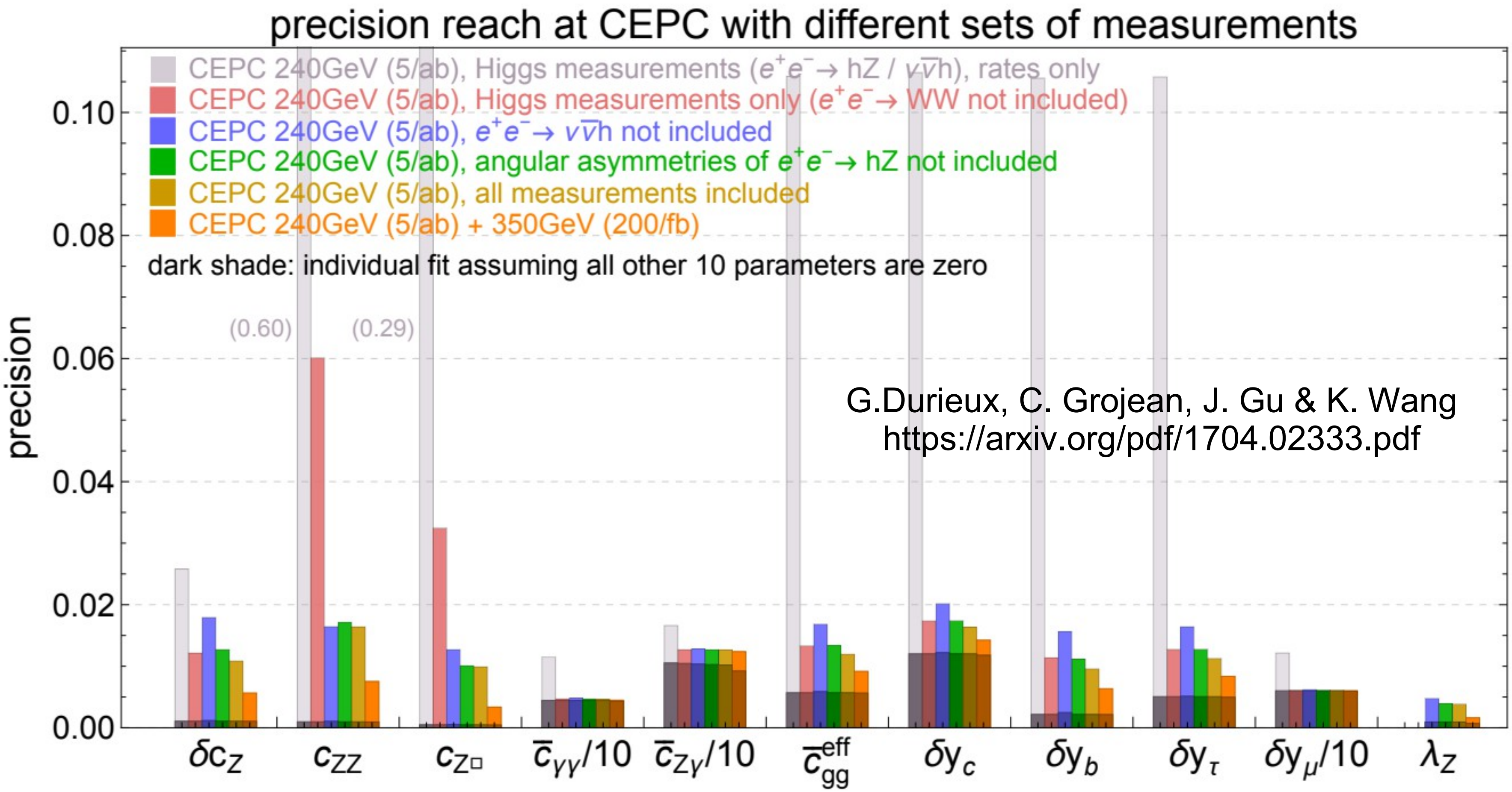



S/(S+B) Weighted Events / 1.5 GeV
CMS
Data
S+B Fit
m_γγ (GeV)
Events / 3 GeV
Data
Z+X
Zγ*, ZZ
m_H=125 GeV
m_4ℓ (GeV)
Local p_0
ATLAS
2011-12
√s = 7-8 TeV
Observed
m_H [GeV]

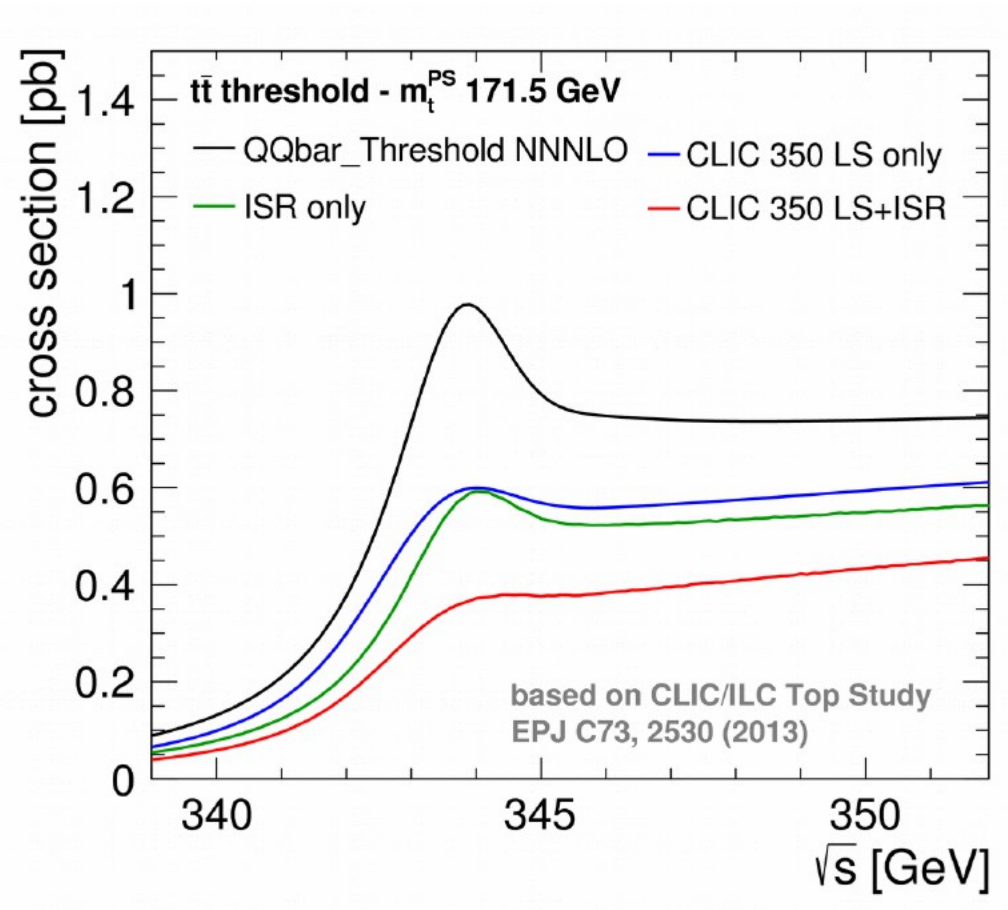
Conclusions

- CEPC/FCCee will be a total game-changer for EW W/Z physics measurements
- No "a priori" walls on the road map to achieve the FCC goals for EW precision measurements but a lot of work, firstly on the theoretical calculations side
- At the Z, off peak data will play an important role (more than at LEP times)
  - can deliver $a_{QED}(m_Z^2)$ to 3×10^{-5}
- The WW threshold lineshape is a great opportunity to measure both m_W and Γ_W:
  - optimal points to take data are $\sqrt{s}=2m_w+1.5$ GeV (**Γ-insensitive**) and $\sqrt{s}$=2mw-2-3 GeV (-Γ**off shell**)
- Huge potential for other W physics measurements including higher energy data :
  - direct m_W , W BRs, TGCs
- Work from experimentalist needed to evaluate with care limiting systematics, study ways to overcome them, and reflect on the detector design consequences: opportunities to contribute

Pheno-studies: EFT & Physics reach



The Physics reach could be largely enhanced if the EW measurements is combined
With the Higgs measurements (in the EFT)

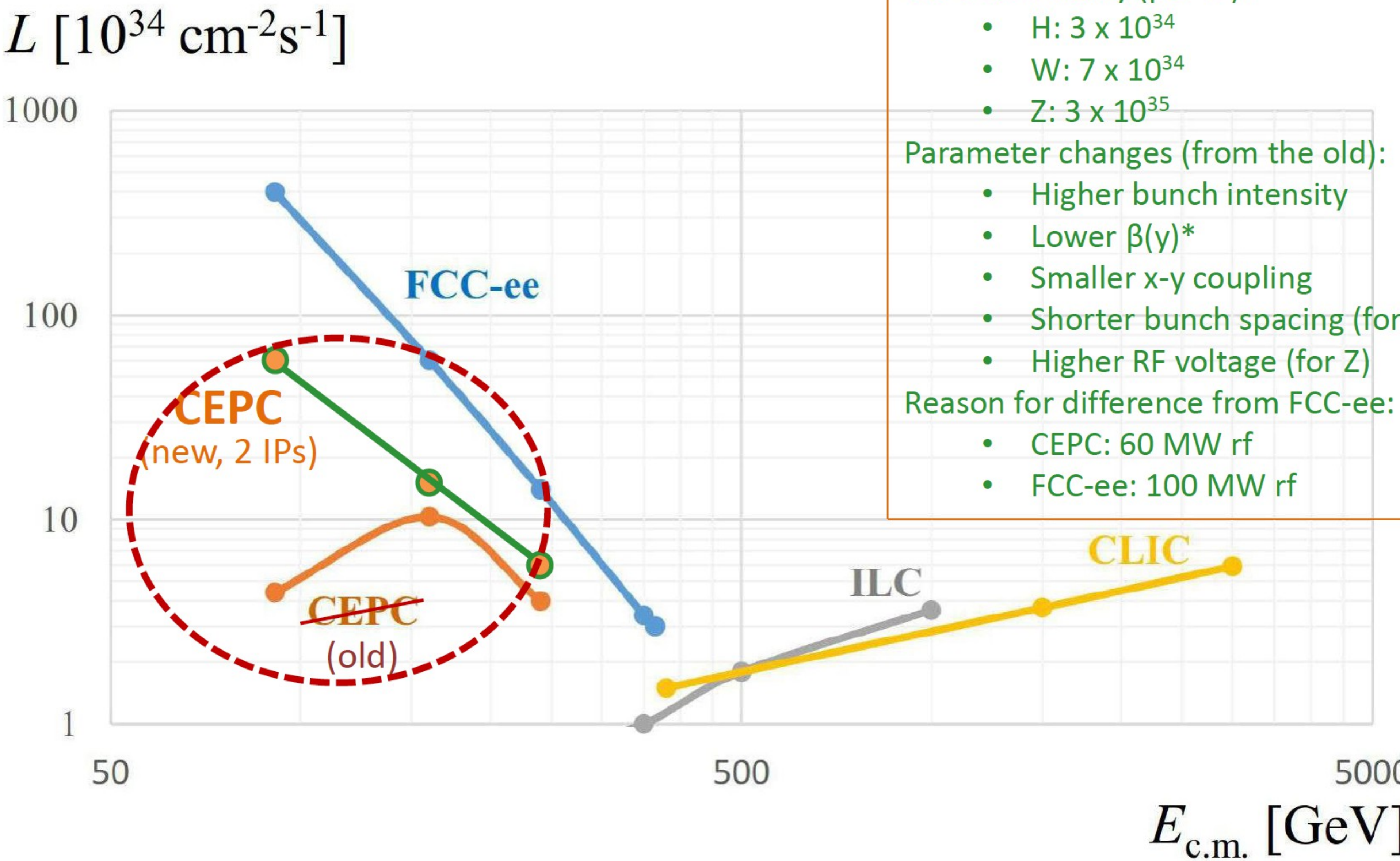

tt̄ threshold - m_t^PS 171.5 GeV
QQbar_Threshold NNNLO
CLIC 350 LS only
ISR only
CLIC 350 LS+ISR
based on CLIC/ILC Top Study
EPJ C73, 2530 (2013)
cross section [pb]
1.4
1.2
1
0.8
0.6
0.4
0.2
0
340
345
350
√s [GeV]

- Expertise, synergies, consensus

Example Working Points & Performance for Object identification (Preliminary)

	Efficiency	Purity	Mis-id Probability from Main Background
Leptons	99.5 – 99.9%	99.5 – 99.9% at Higgs Runs(c.m.s = 240 GeV), Energy dependent	$P(\pi^{\pm} \rightarrow leptons) < 1\%$
Photons*	99.3 – 99.9%	99.5 – 99.9% at Higgs Runs Energy Dependent	$P(\text{Neutron} \rightarrow \gamma) = 1\text{-}5\%$
Charged Kaons**	86 – 99%	90 – 99% at Z pole Runs (c.m.s = 91.2GeV, Track Momentum 2- 20 GeV)	$P(\pi^{\pm} \rightarrow K^{\pm}) = 0.3 - 1.1\%$
b-jets	80%	90% at Z pole runs $(Z \rightarrow qq)$	P(uds → b) = 1% P(c → b) = 10%
c-jets	60%	60% at Z pole runs	P(uds → c) = 5% P(b → c) = 15%

CEPC Luminosity



CEPC luminosity (per IP):

- H: 3×10^{34}
- W: 7×10^{34}
- Z: 3×10^{35}

Parameter changes (from the old):

- Higher bunch intensity
- Lower β(y)*
- Smaller x-y coupling
- Shorter bunch spacing (for Z)
- Higher RF voltage (for Z)

Reason for difference from FCC-ee:

- CEPC: 60 MW rf
- FCC-ee: 100 MW rf

CEPC CDR Baseline Parameters (Jan. 2018)

D. Wang

	Higgs	*W*	*Z*
Number of IPs		2	
Energy (GeV)	120	80	45.5
Circumference (km)		100	
SR loss/turn (GeV)	1.73	0.34	0.036
Half crossing angle (mrad)		16.5	
Piwinski angle	2.58	4.29	16.4
N_e/bunch (10^{10})	15	5.4	4.0
Bunch number (bunch spacing)	242 (0.68us)	3390 (98ns)	8332 (40ns)
Beam current (mA)	17.4	88.0	160
SR power /beam (MW)	30	30	5.73
Bending radius (km)		10.6	
Momentum compaction (10^{-5})		1.11	
β_{IP} x/y (m)	0.36/0.0015	0.36/0.0015	0.2/0.0015
Emittance x/y (nm)	1.21/0.0031	0.54/0.0016	0.17/0.004
Transverse σ_{IP} (um)	20.9/0.068	13.9/0.049	5.9/0.078
ξ_x/ξ_y/IP	0.031/0.109	0.0148/0.076	0.0043/0.04
V_{RF} (GV)	2.17	0.47	0.054
f_{RF} (MHz) (harmonic)		650 (216816)	
Nature bunch length σ_z (mm)	2.72	2.98	3.67
Bunch length σ_z (mm)	3.26	3.62	6.0
HOM power/cavity (kw)	0.54 (2cell)	0.47(2cell)	0.49(2cell)
Energy spread (%)	0.1	0.066	0.038
Energy acceptance requirement (%)	1.52		
Energy acceptance by RF (%)	2.06	1.47	0.76
Photon number due to beamstrahlung	0.29	0.16	0.28
Lifetime due to beamstrahlung (hour)	1.0		
Lifetime (hour)	0.67 (40 min)	2	4
F (hour glass)	0.89	0.94	0.99
L_{max}/IP (10^{34}cm^{-2}s^{-1})	**2.93**	**7.31**	**4.1**

J. Gao, IAS2018

without bootstrapping