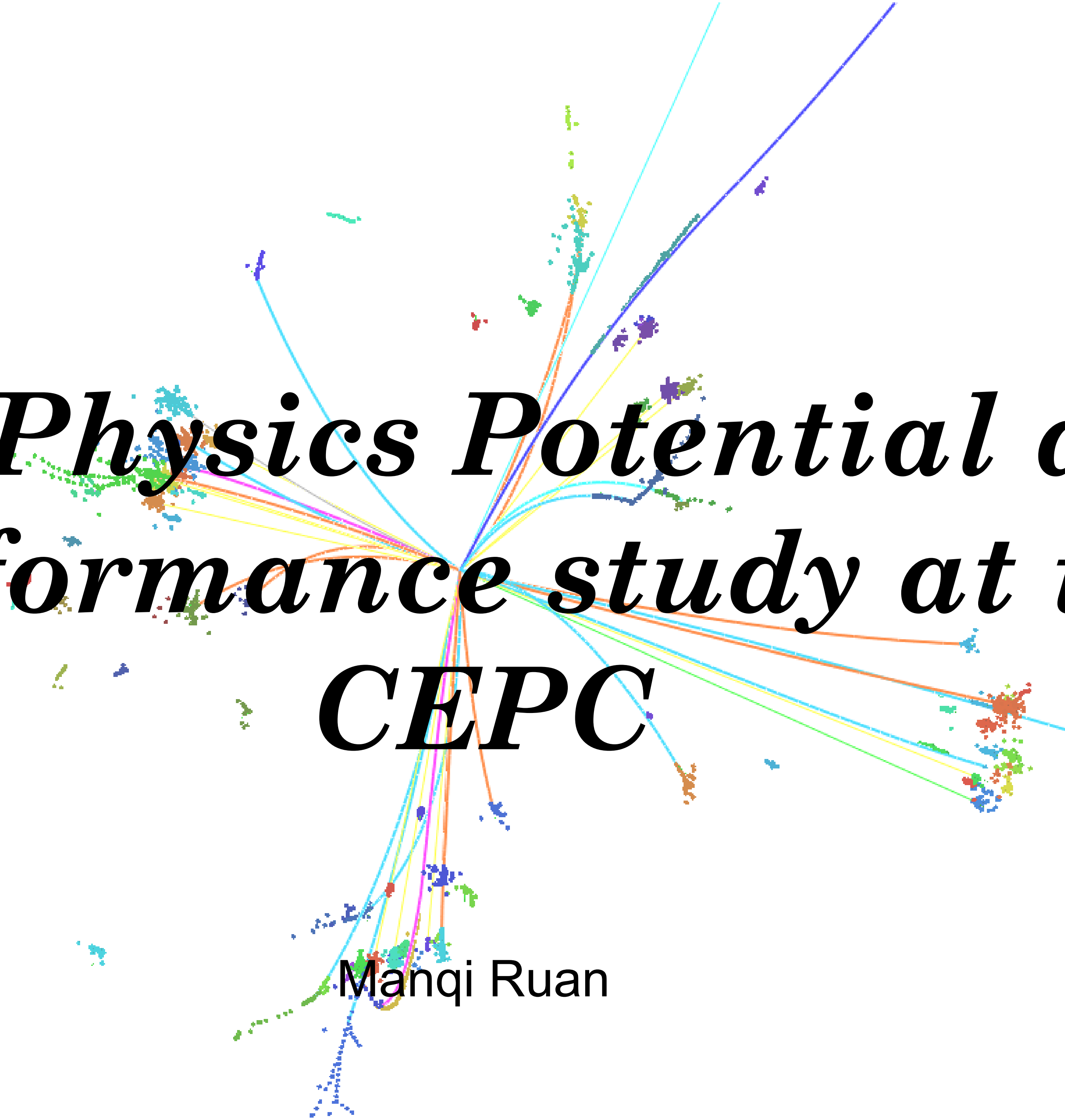
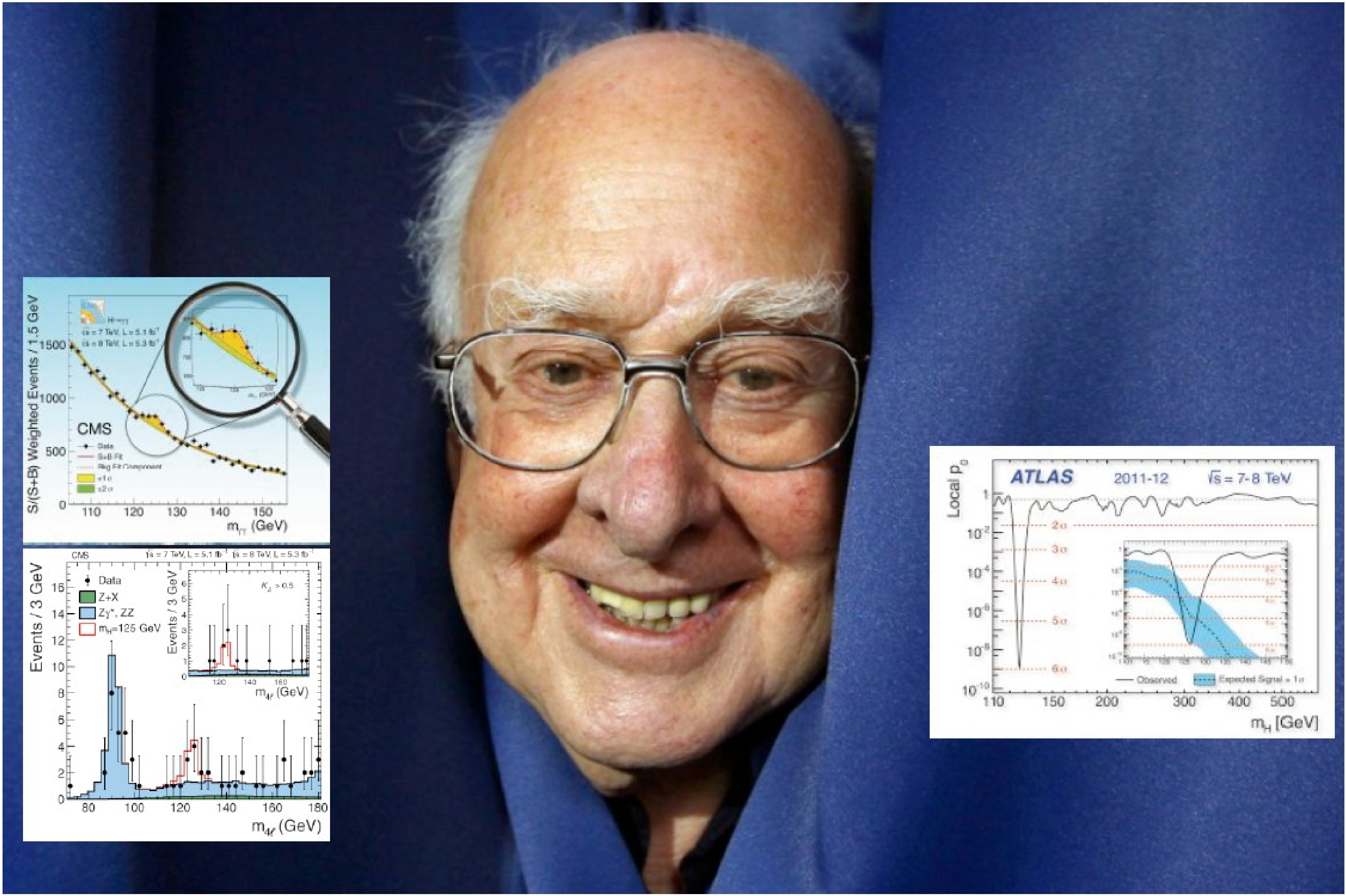


The Physics Potential and Performance study at the CEPC

Manqi Ruan

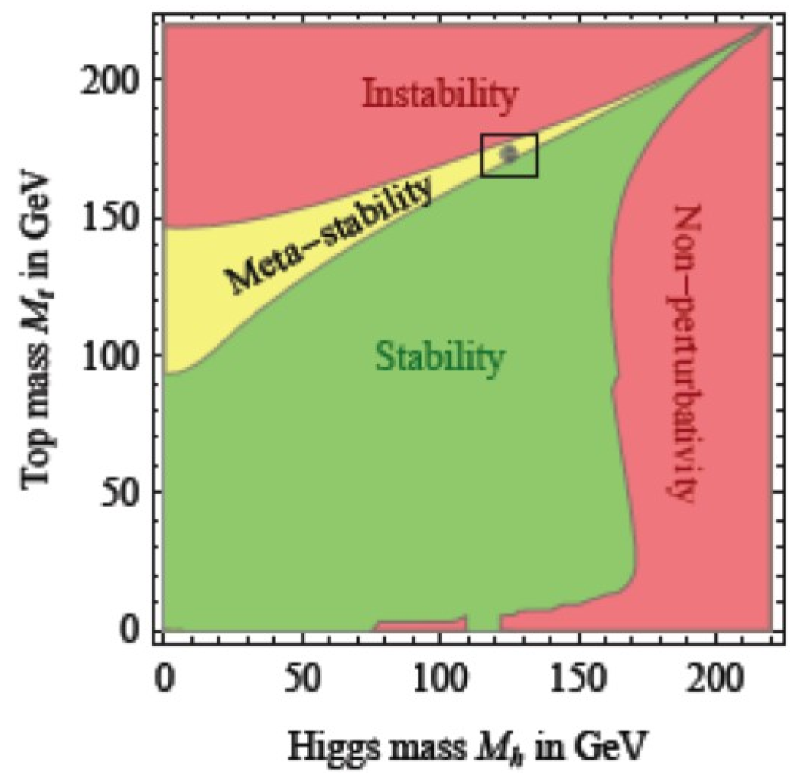

S/(S+B) Weighted Events / 1.5 GeV
CMS
Data
S+B Fit
m_γγ (GeV)
Events / 3 GeV
Data
Z+X
Zγ*, ZZ
m_H=125 GeV
m_4ℓ (GeV)
ATLAS
2011-12
√s = 7-8 TeV
Local p_0
2σ
3σ
4σ
5σ
6σ
Observed
m_H [GeV]

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

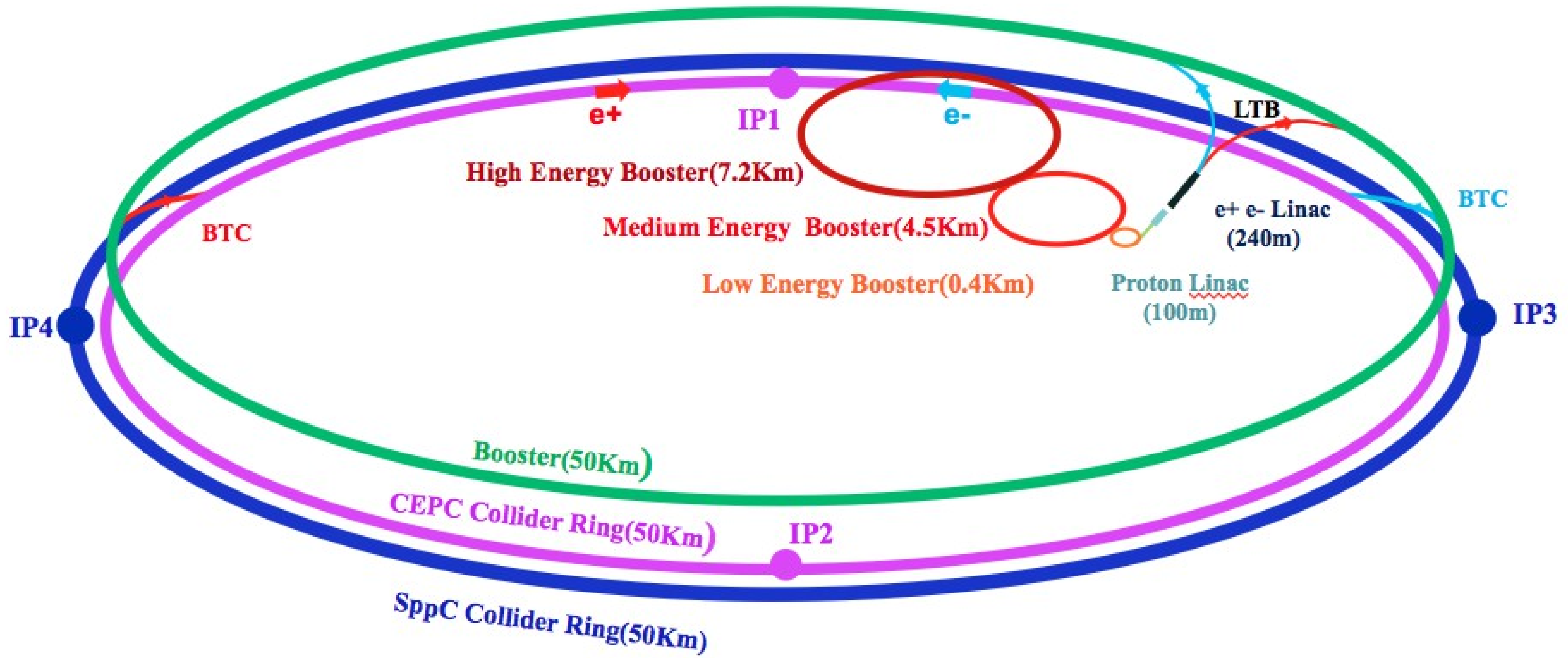
- **Most issues related to Higgs**

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



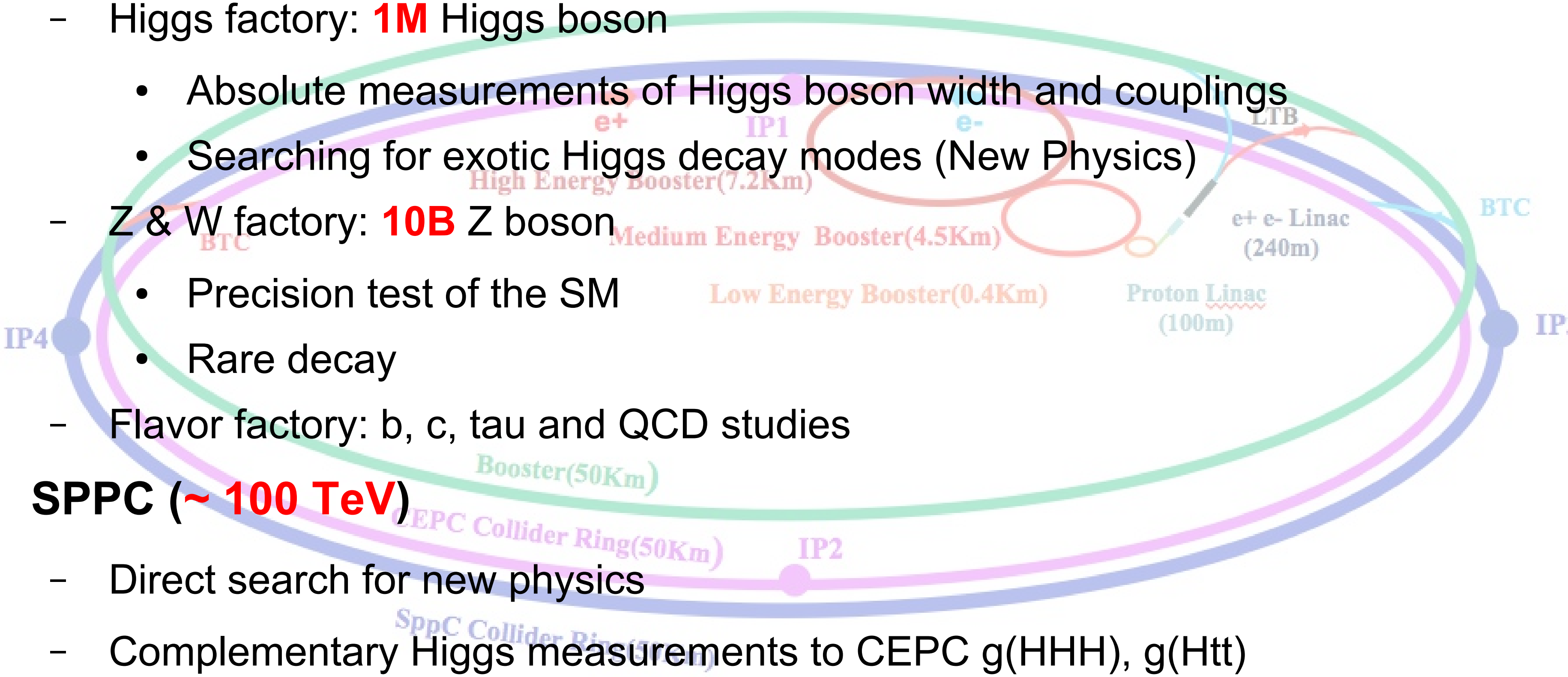
Key: a precise Higgs factory

- Higgs mass ~ 125 GeV, it is possible to build a Circular e+e- Higgs factory (CEPC), followed by a proton collider (SPPC) in the same tunnel
- Looking for Hints (from Higgs) at CEPC → direct search at SPPC



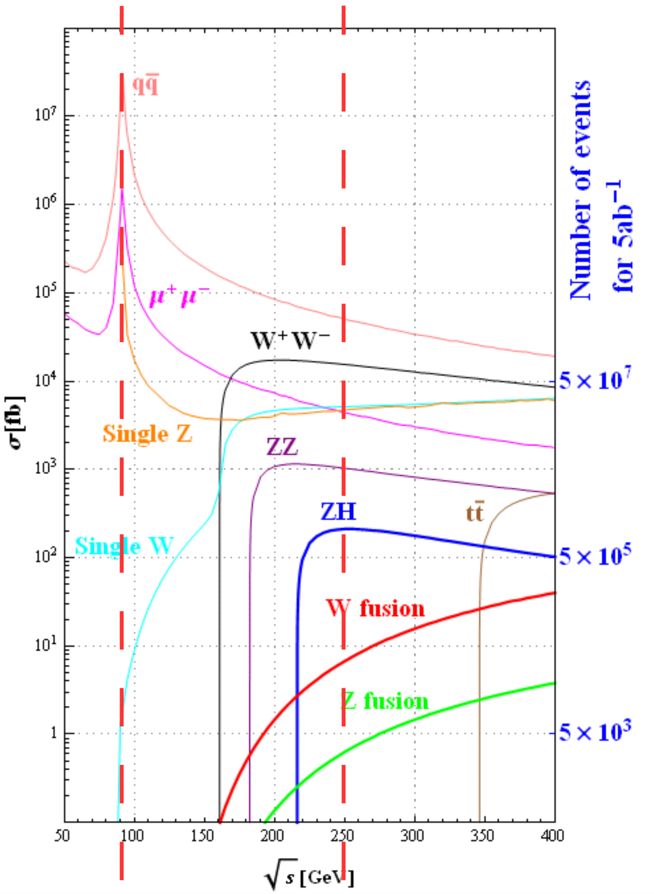
Science at CEPC-SPPC

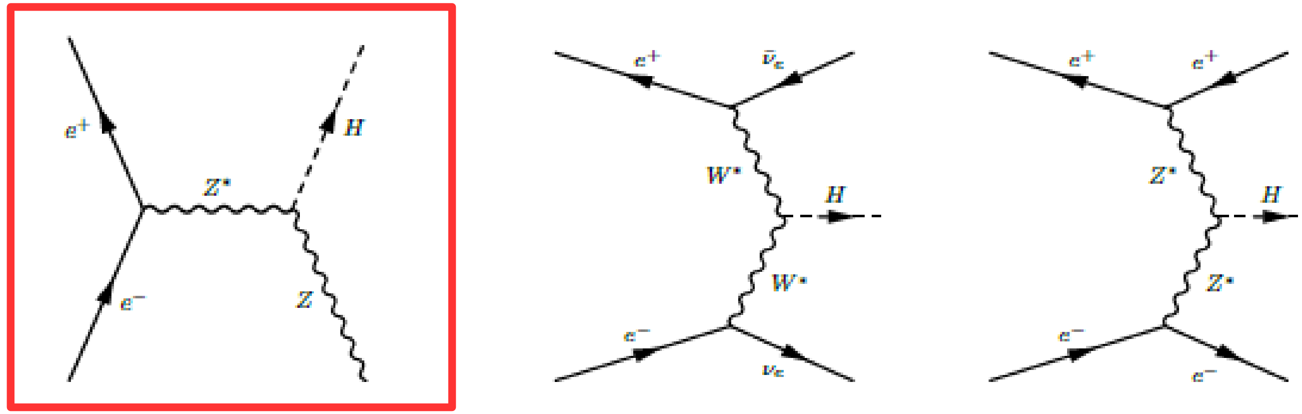
- **Tunnel ~ 100 km**
- **CEPC (90 – 250 GeV)**
  - Higgs factory: **1M** Higgs boson
    - Absolute measurements of Higgs boson width and couplings
    - Searching for exotic Higgs decay modes (New Physics)
  - Z & W factory: **10B** Z boson
    - Precision test of the SM
    - Rare decay
  - Flavor factory: b, c, tau and QCD studies
- **SPPC (~ 100 TeV)**
  - Direct search for new physics
  - Complementary Higgs measurements to CEPC g(HHH), g(Htt)
  - ...
- **Heavy ion, e-p collision...**



Complementary

Higgs @ CEPC





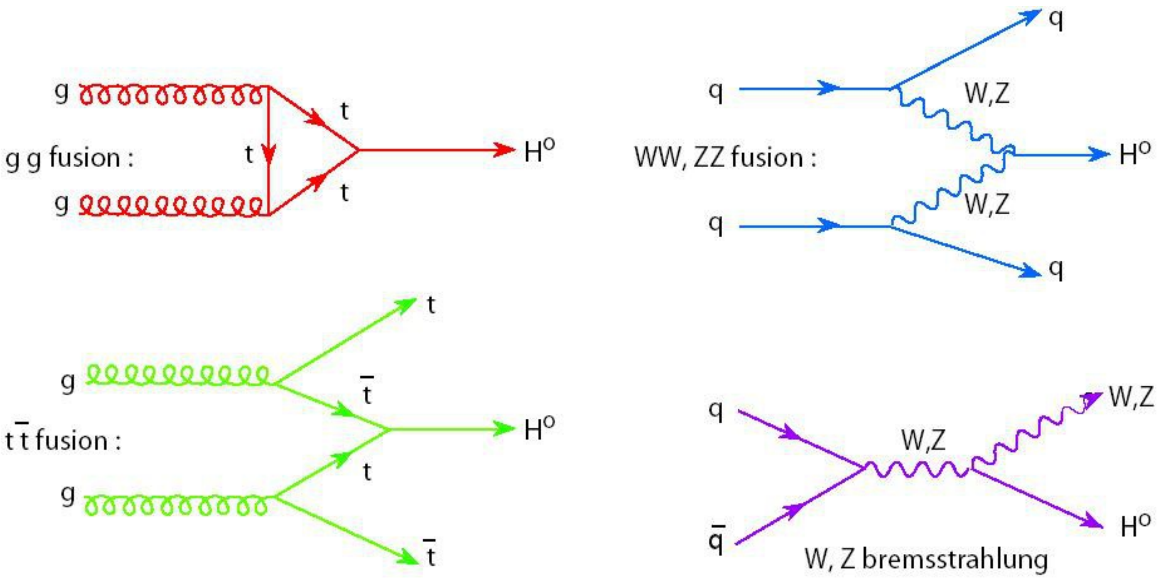
Process	Cross section	Events in 5 ab^{-1}
Higgs boson production, cross section in fb		
$e^+e^- \to ZH$	212	1.06×10^6
$e^+e^- \to \nu\bar{\nu}H$	6.72	3.36×10^4
$e^+e^- \to e^+e^-H$	0.63	3.15×10^3
Total	219	1.10×10^6

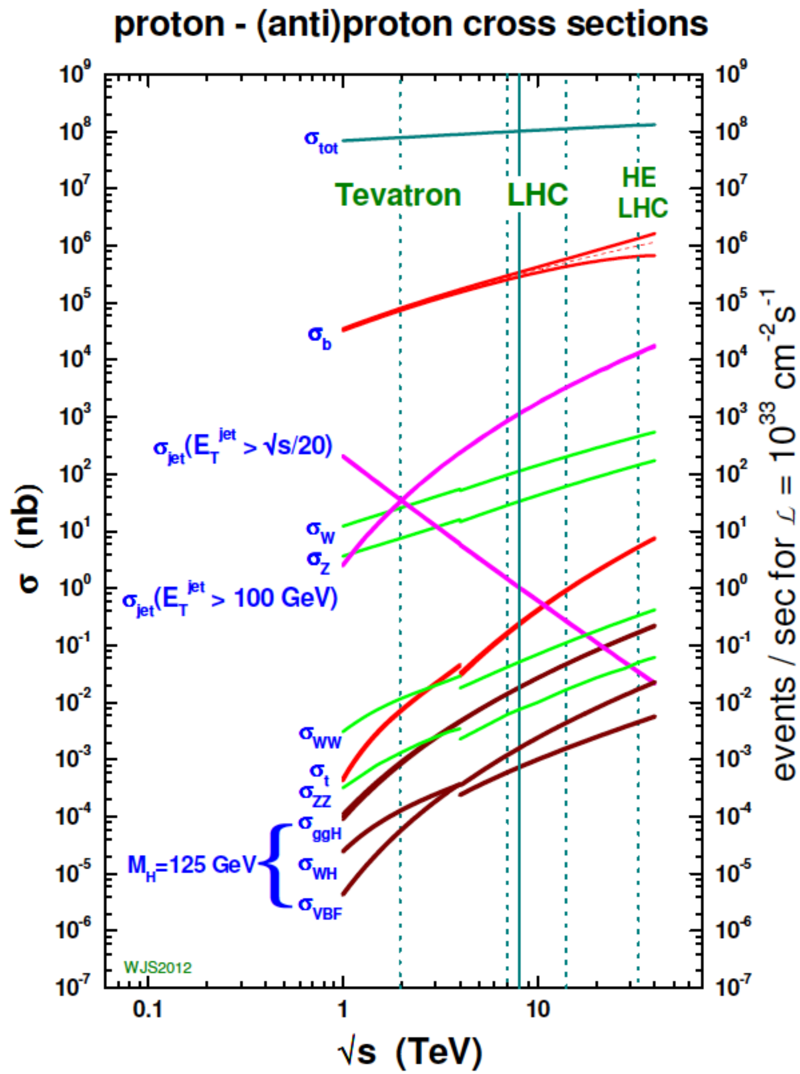
S/B ~ 1:100 - 1000

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

Derive: Absolute Higgs width, branching ratios, couplings

Higgs @ LHC

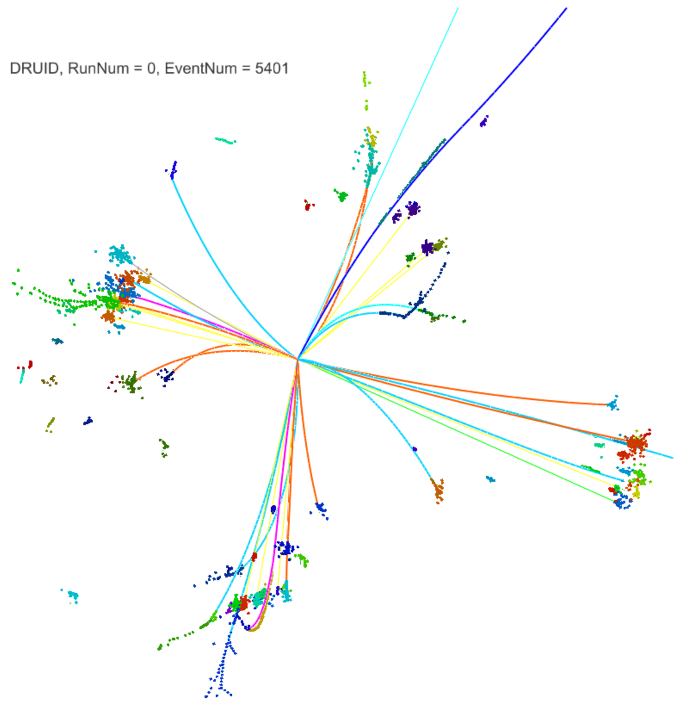


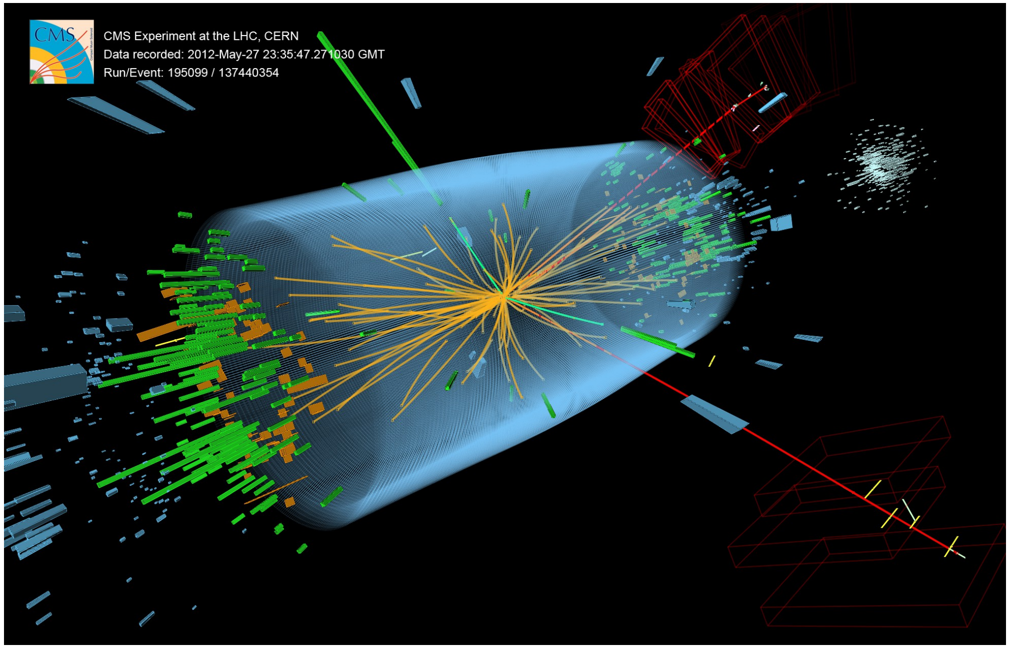


S/B ~ 1:1E10 !!!

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

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

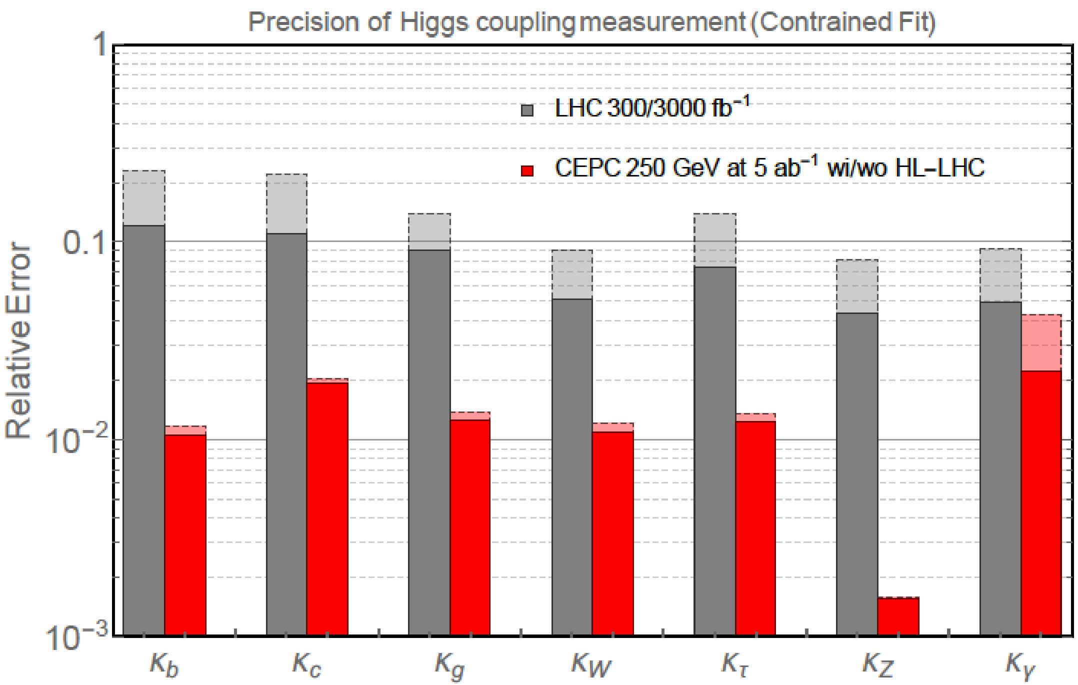
Complementary

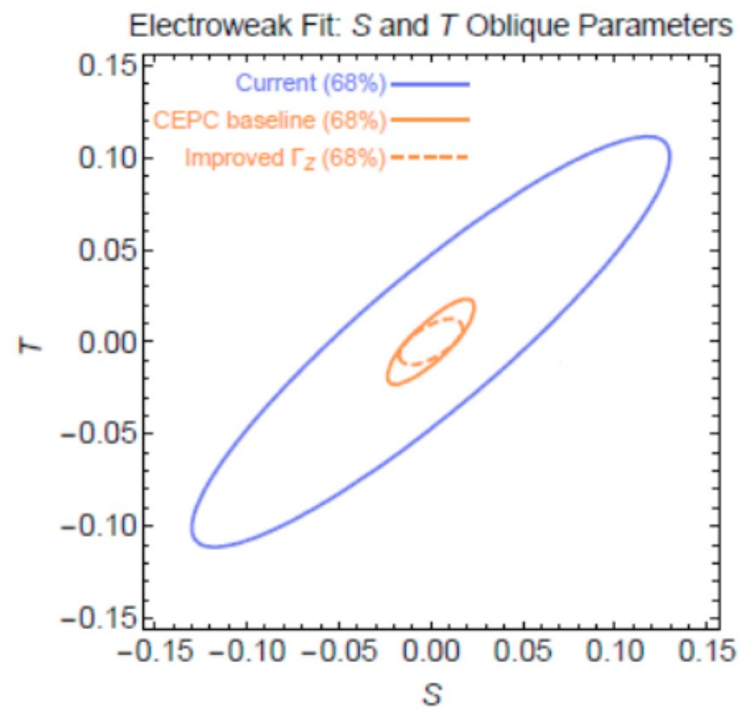
Status of W/Z physics study in CEPC

- The prospect of W/Z physics study in CEPC are under study
- Mainly based on projection from LEP

Observable	LEP precision	CEPC precision	CEPC runs	$\int \mathcal{L}$ needed in CEPC
m_Z	2 MeV	0.5 MeV	Z threshold scan	3.2ab^{-1}
$A_{FB}^{0,b}$	1.7%	0.1%	Z threshold scan	3.2ab^{-1}
$A_{FB}^{0,\mu}$	7.7%	0.3%	Z threshold scan	3.2ab^{-1}
$A_{FB}^{0,e}$	17%	0.5%	Z threshold scan	3.2ab^{-1}
R_b	0.3%	0.02%	Z pole	3.2ab^{-1}
R_μ	0.2%	0.01%	Z pole	3.2ab^{-1}
N_ν	1.7%	0.05%	ZH runs	5ab^{-1}
m_W	33 MeV	2-3 MeV	ZH runs	5ab^{-1}
m_W	33 MeV	1 MeV	WW threshold	2.5ab^{-1}

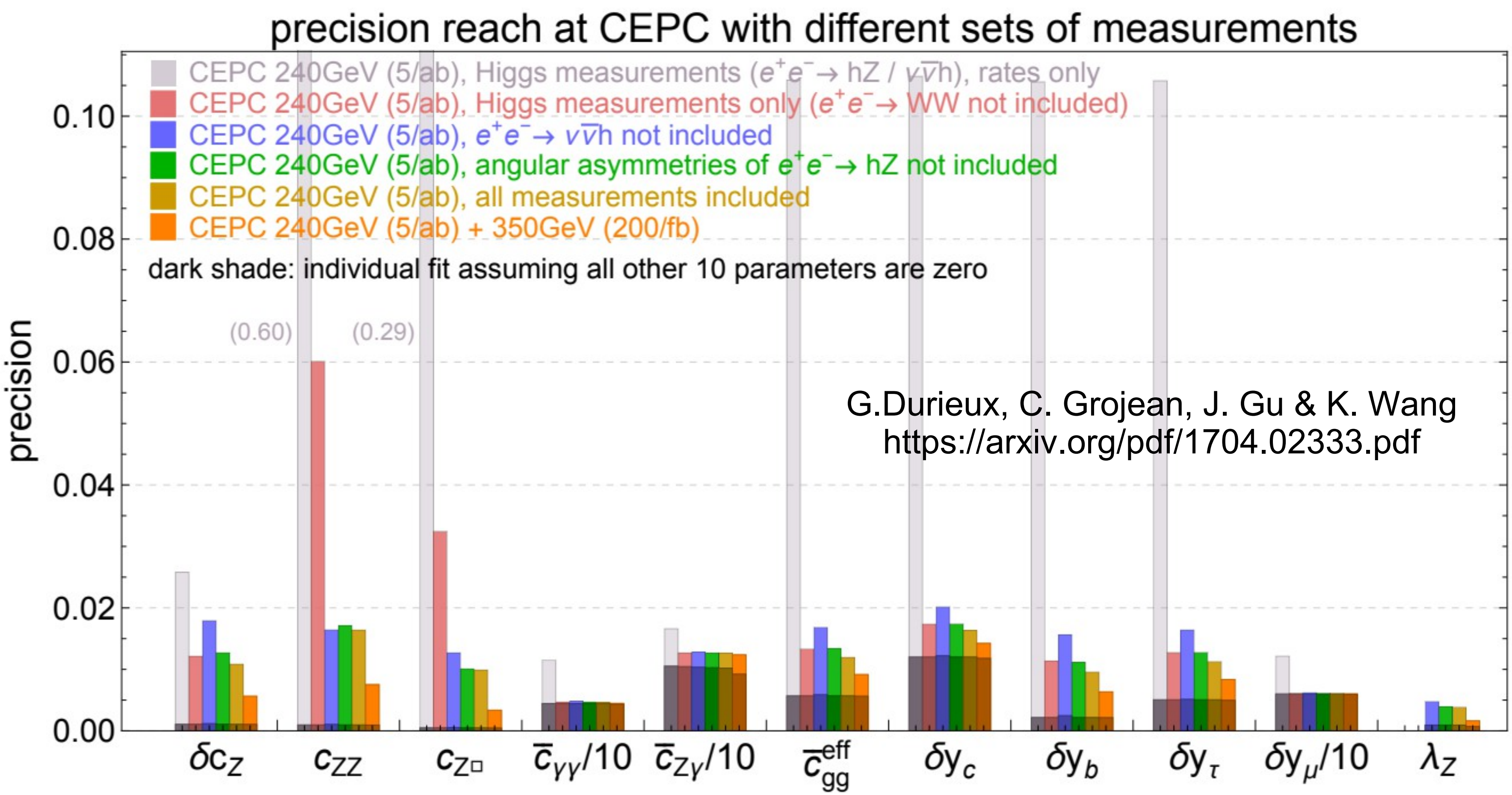
Physics Potential





- 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)
  - Improve EW measurement precision by at least 1 order of magnitude

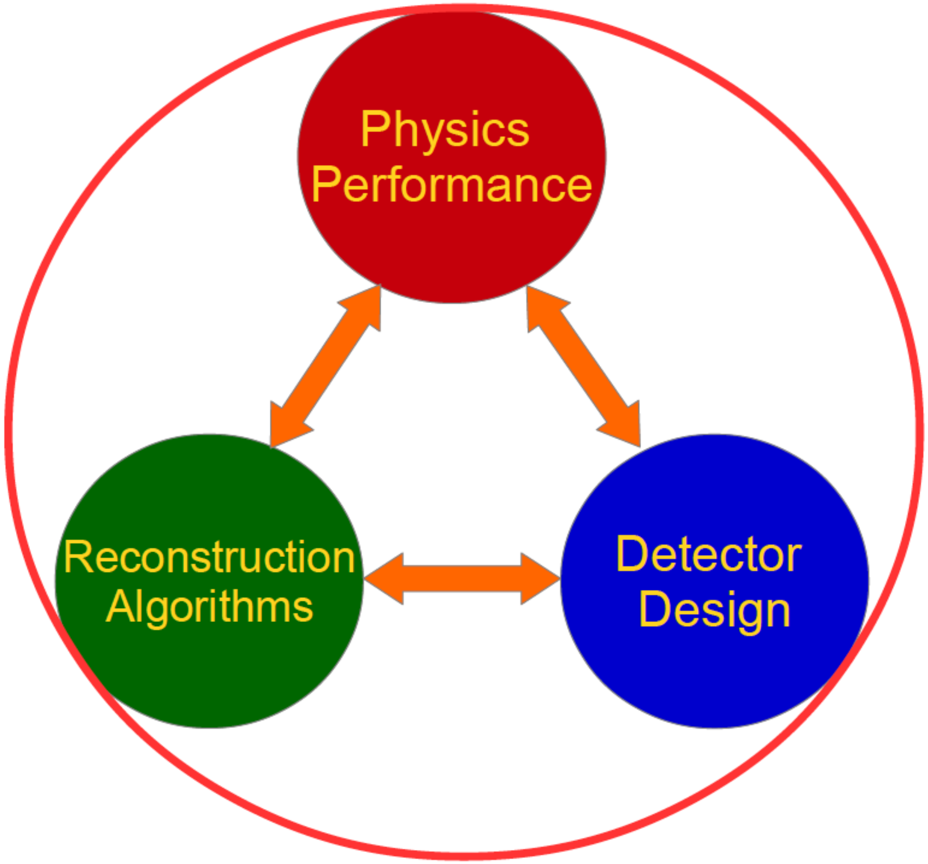
Pheno-studies: EFT & Physics reach



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

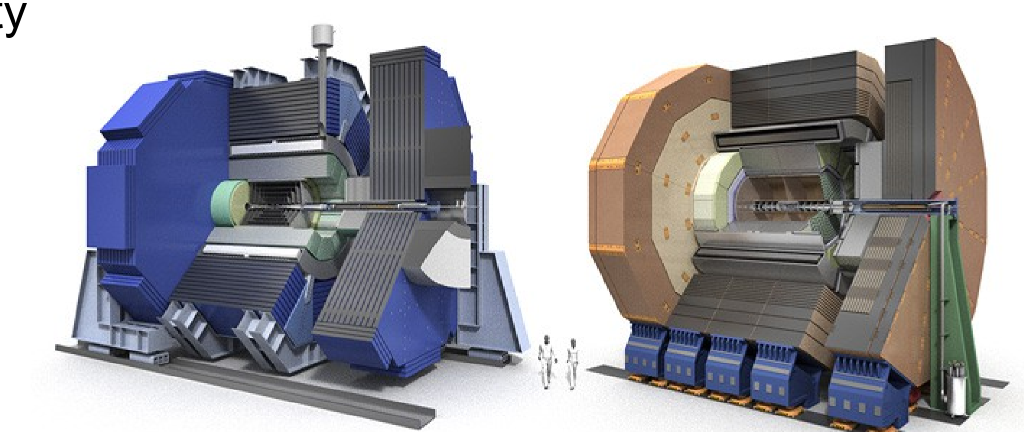
Performance

- Determined by
  - Detector geometry
  - Reconstruction algorithm
- Characterized at
  - **Physics Objects**
  - **Higgs Signal**
  - Benchmark Physics Analyses

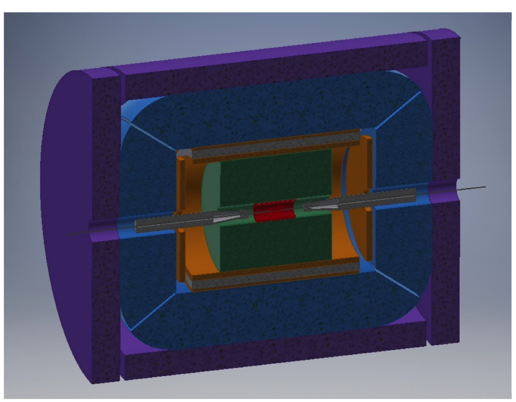


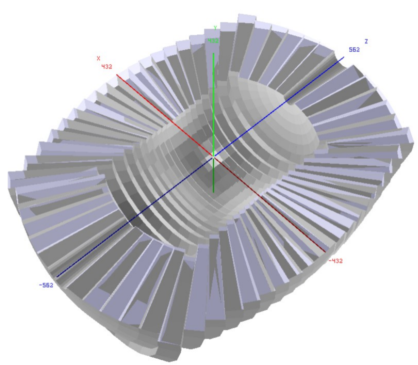
Two classes of Concepts

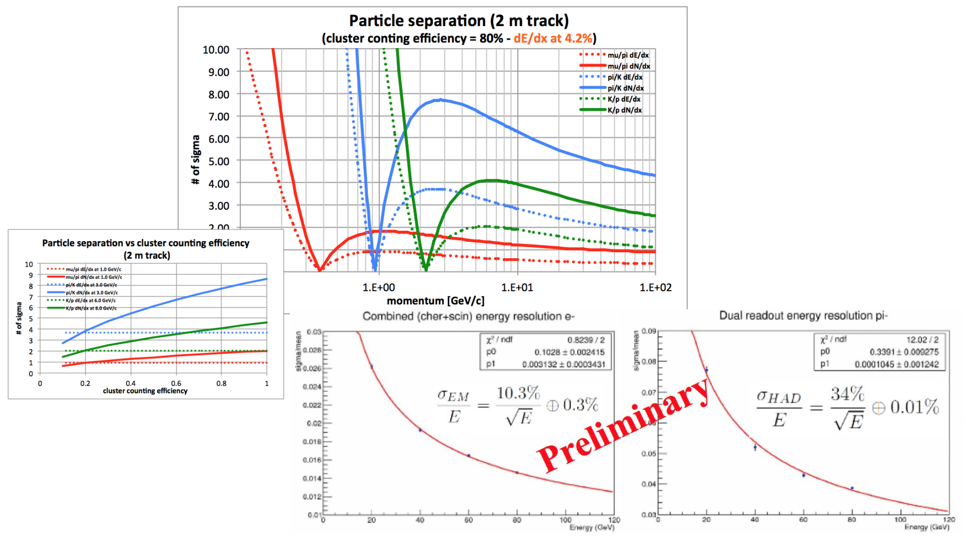
- PFA Oriented concept using High Granularity Calorimeter
  - \+ TPC (ILD-like, **Baseline**)
  - \+ Silicon tracking (SiD-like)



- Low Magnet Field Detector Concept (IDEA)
  - Wire Chamber + Dual Readout Calorimeter



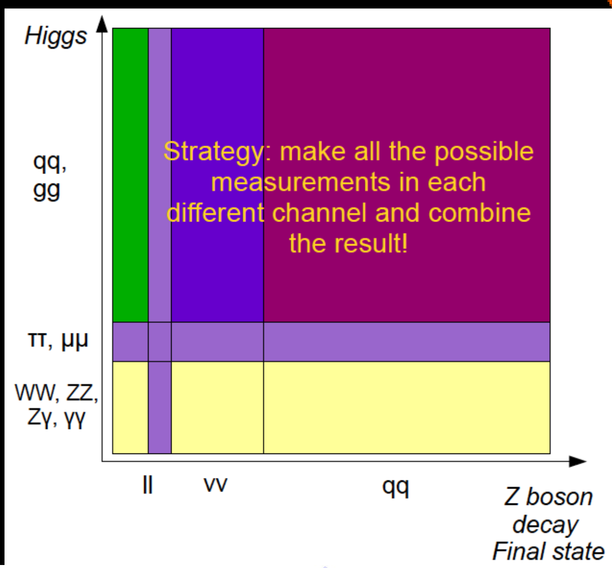


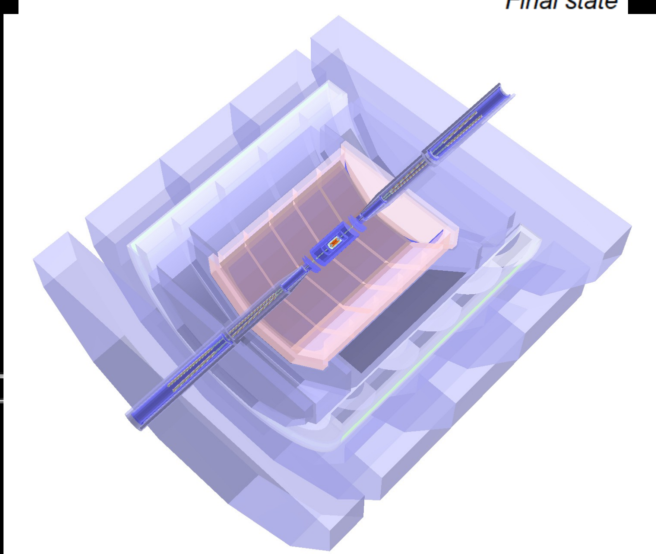


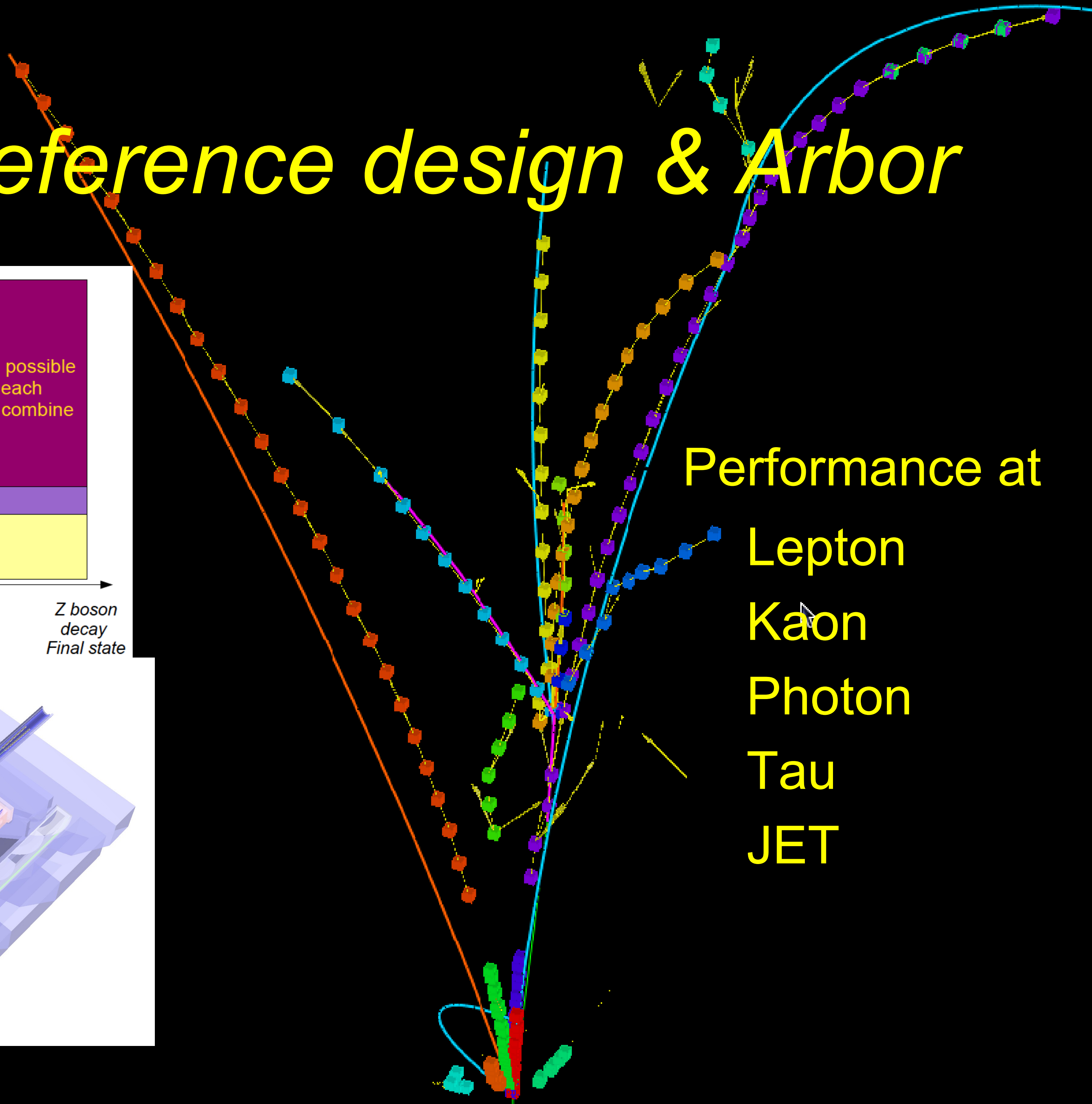
https://indico.ihep.ac.cn/event/6618/

https://agenda.infn.it/conferenceOtherViews.py?view=standard&confId=14816

Reference design & Arbor



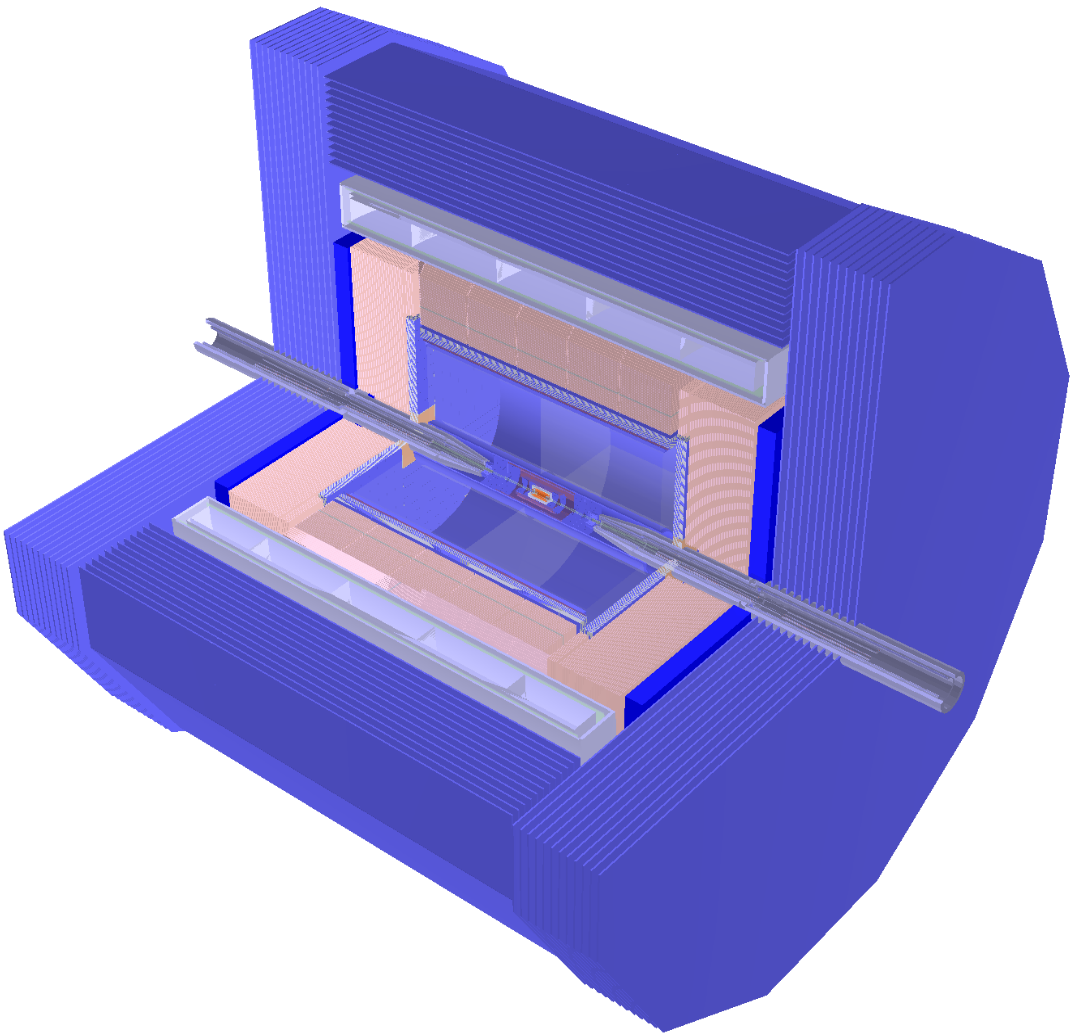


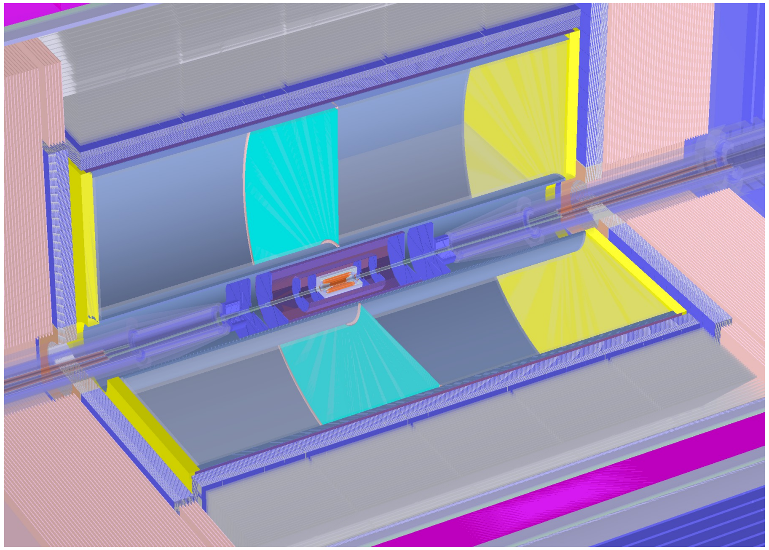


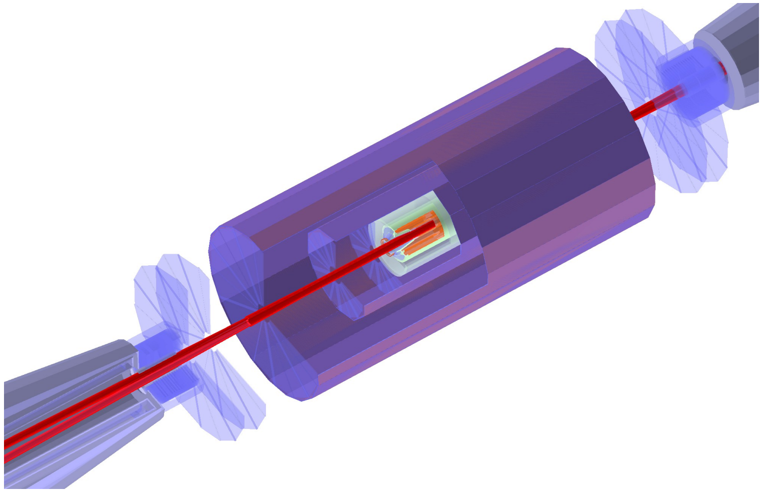
Performance at

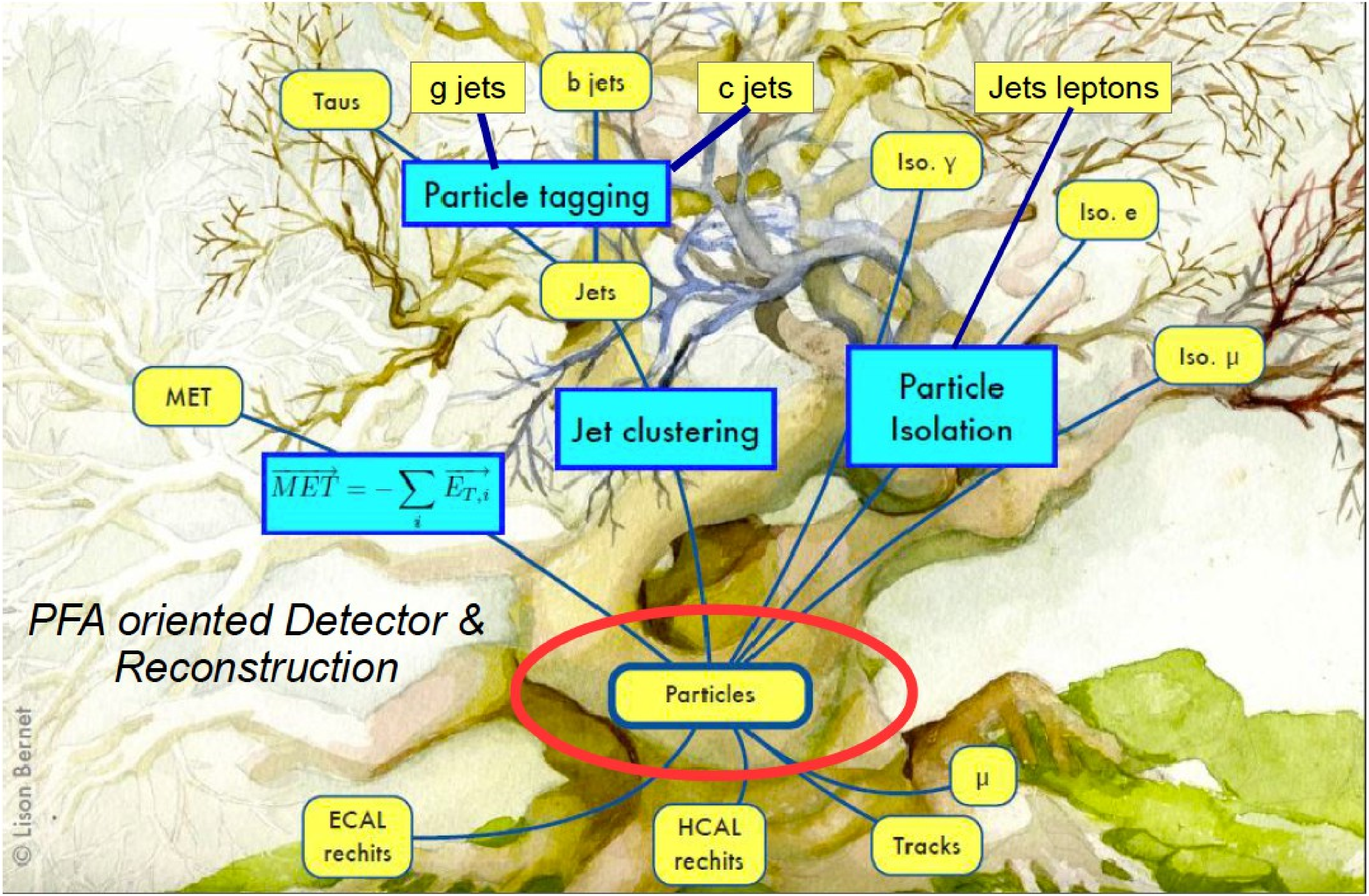
- Lepton
- Kaon
- Photon
- Tau
- JET

APODIS Geometry

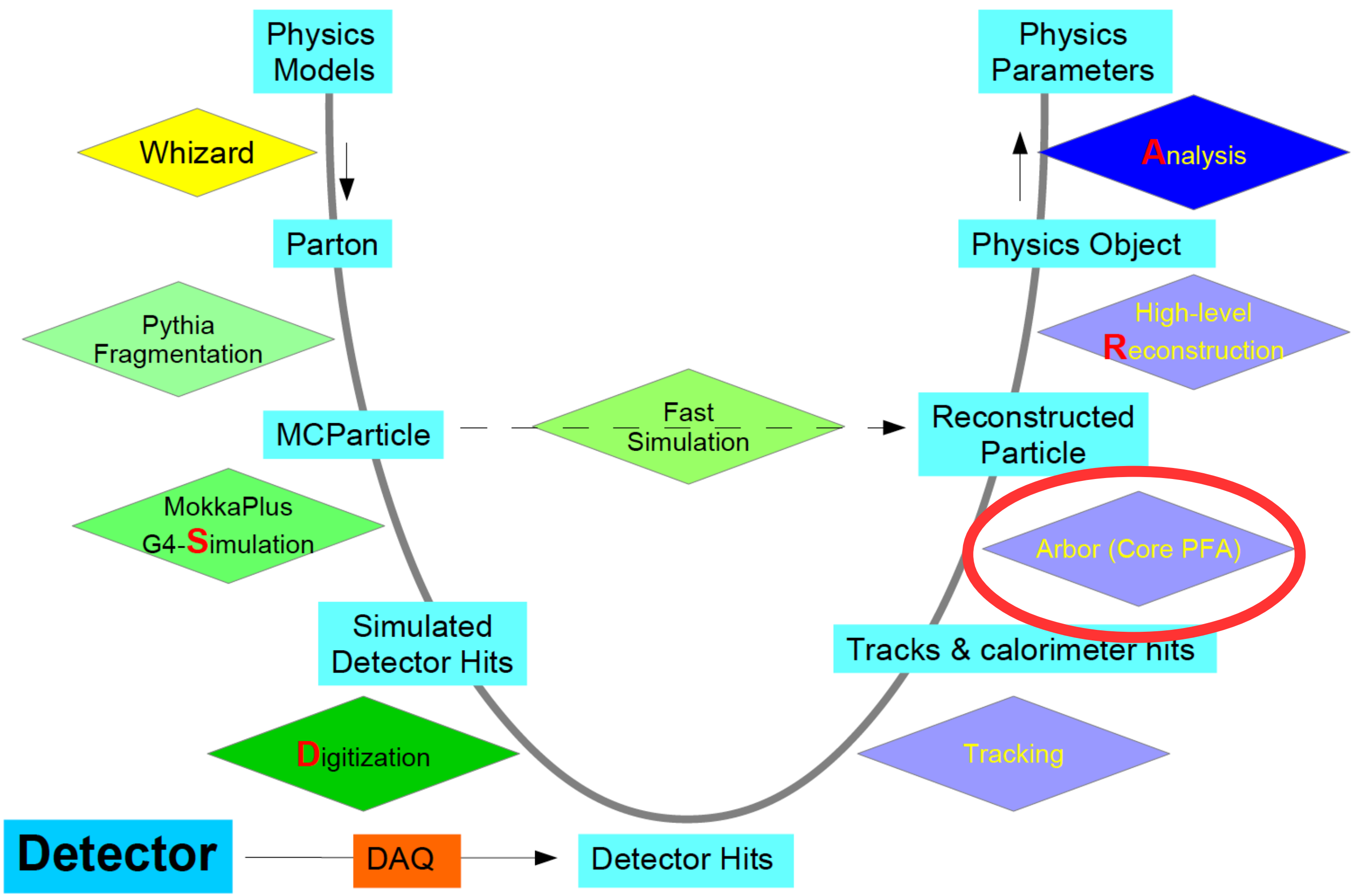







Taus
g jets
b jets
c jets
Jets leptons
Particle tagging
Iso. γ
Iso. e
Jets
Iso. μ
MET
Jet clustering
Particle Isolation
$\overrightarrow{MET} = -\sum_i \overrightarrow{E_{T,i}}$
PFA oriented Detector & Reconstruction
Particles
μ
ECAL rechits
HCAL rechits
Tracks
© Lison Bernet

The Simu-Reco Chain at CEPC

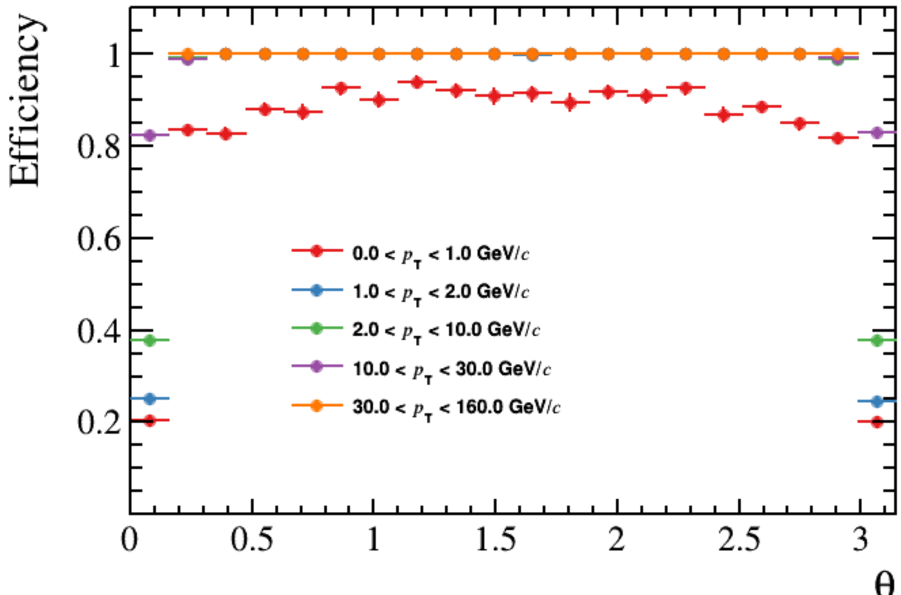


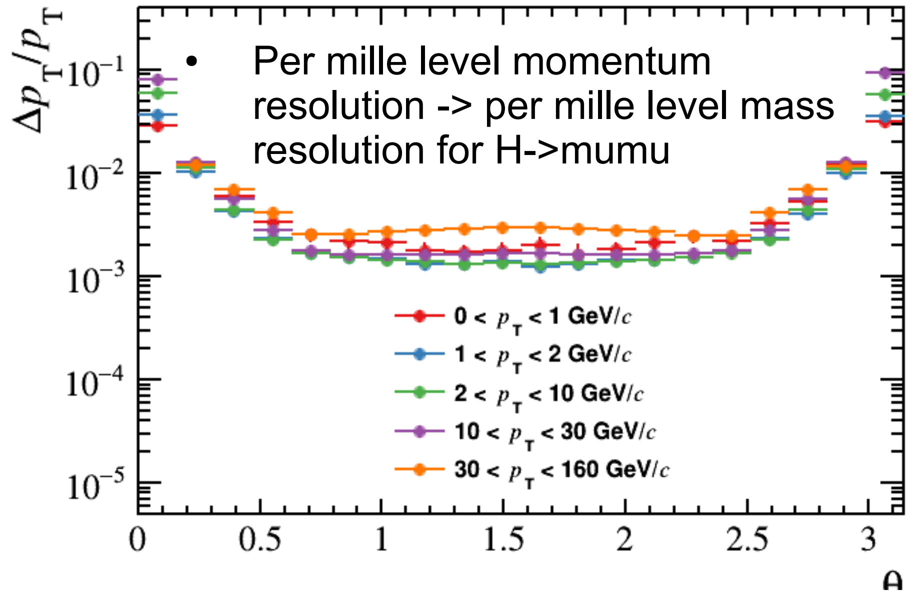
- Generators (Whizard & Pythia)
- Data format & management (LCIO & Marlin)
- Simulation (MokkaC)
- Digitizations
- Tracking
- PFA (Arbor)
- Single Particle Physics Objects Finder (LICH)
- Composed object finder (Coral)
- Tau finder
- Jet Clustering (FastJet)
- Jet Flavor Tagging (LCFIPLus)
- Event Display (Druid)
- General Analysis Framework (FSClasser)
- Fast Simulation (Delphes + FSClasser)

CEPC-SIMU-2017-001,
CEPC-SIMU-2017-002,
(DocDB id-167, 168, 173)

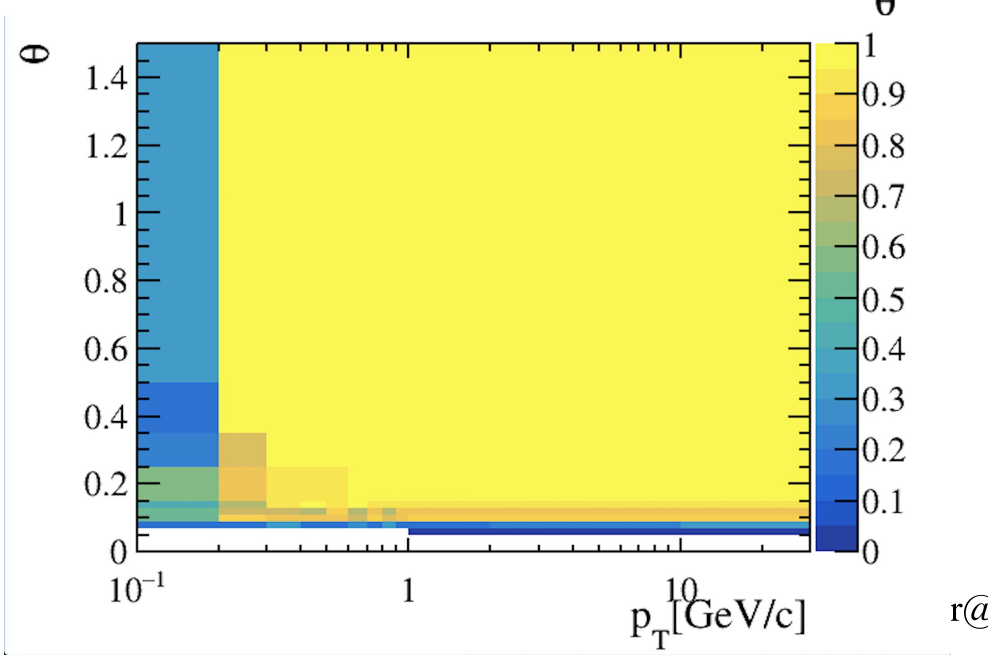
General Software | ILCSoft | ILCSoft + Development | Developments

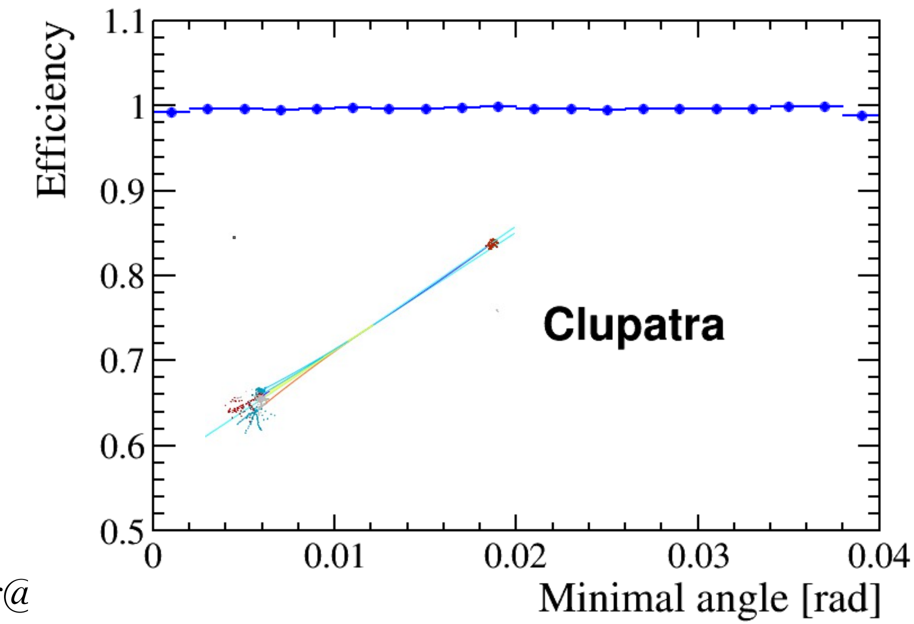
Tracking



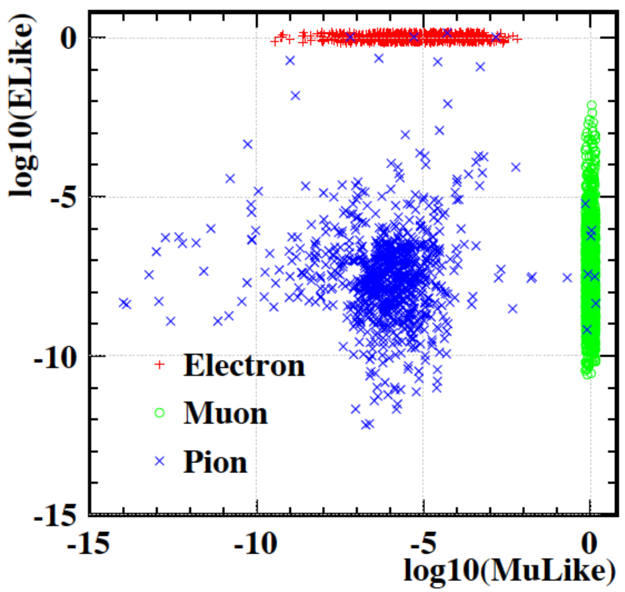


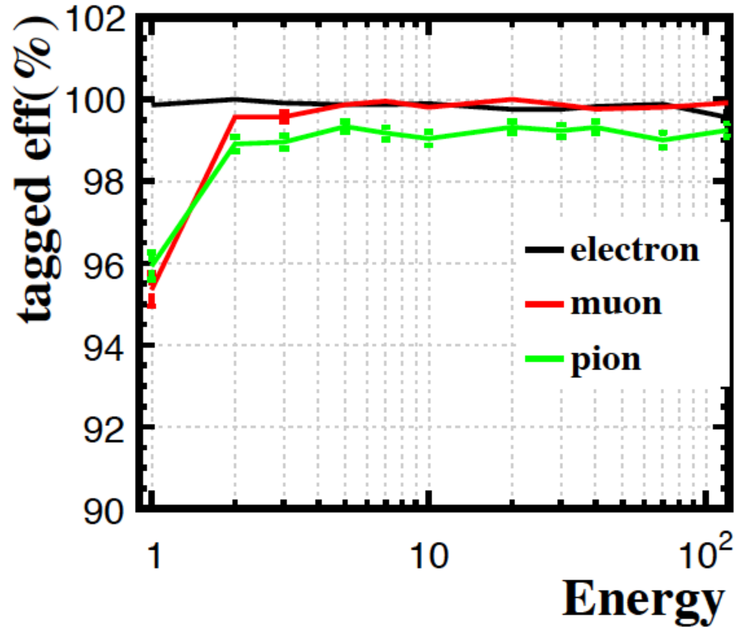
- Per mille level momentum resolution -> per mille level mass resolution for H->mumu

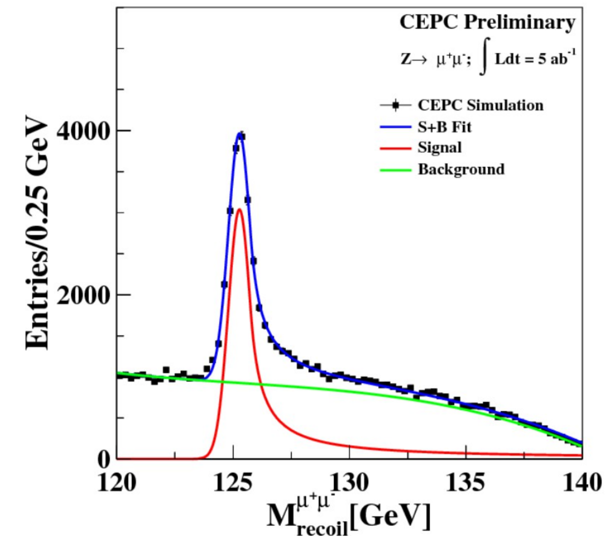


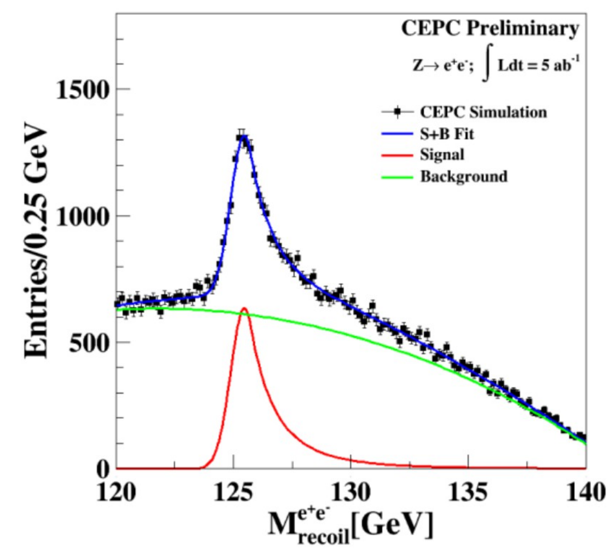


Lepton







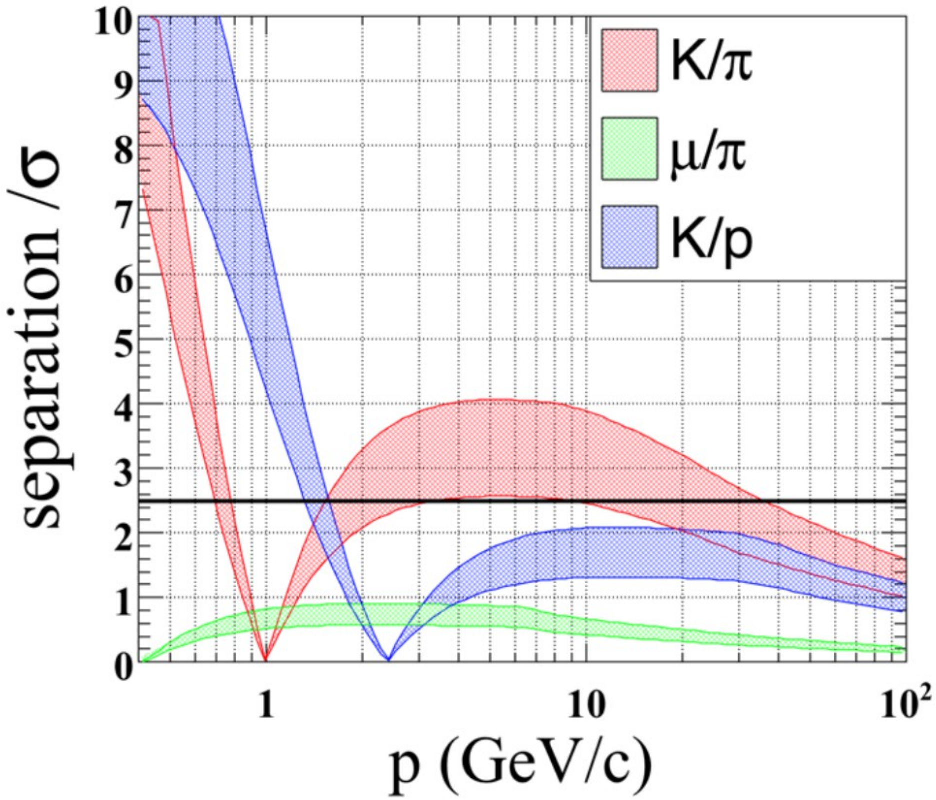


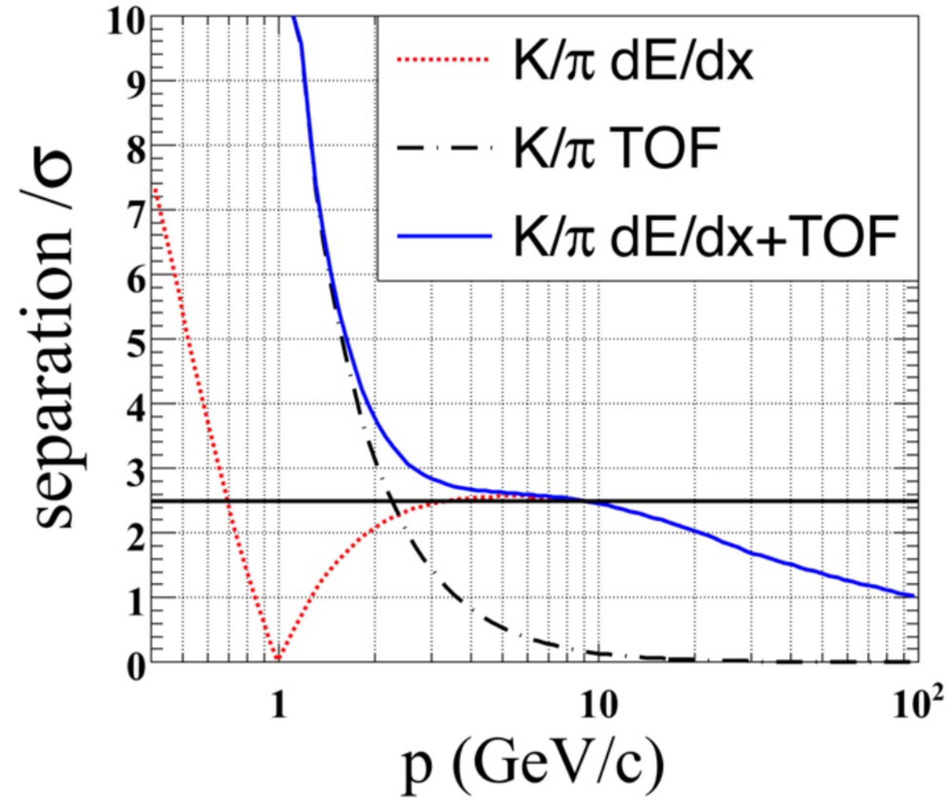
BDT method using 4 classes of 24 input discrimination variables.

Test performance at: Electron = E_likeness > 0.5 ;
Muon = Mu_likeness > 0.5
Single charged reconstructed particle, for E > 2 GeV:
lepton efficiency > 99.5% && Pion mis id rate ~ 1%

https://link.springer.com/article/10.1140/epjc/s10052-017-5146-5
CEPC-DocDB-id:148, Eur. Phys. J. C (2017) 77: 591

Kaon





Highly appreciated in flavor physics @ CEPC Z pole

TPC dEdx + ToF of 50 ps

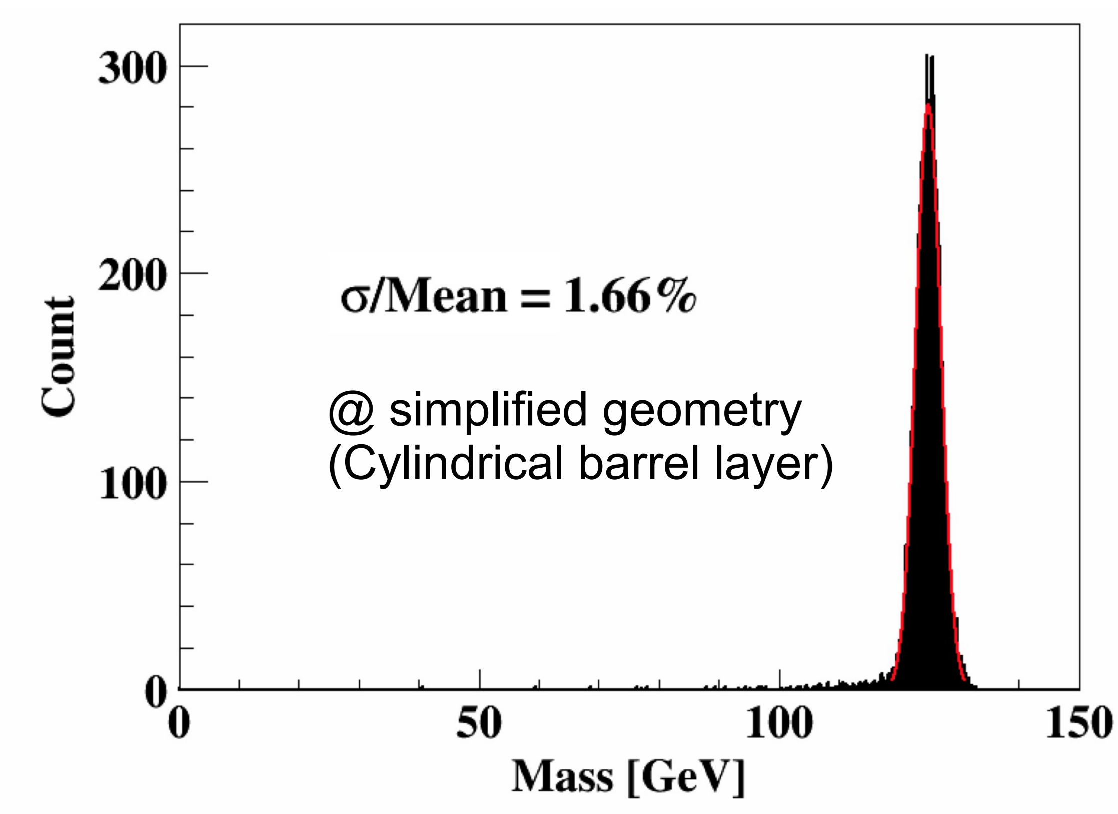
At inclusive Z pole sample:

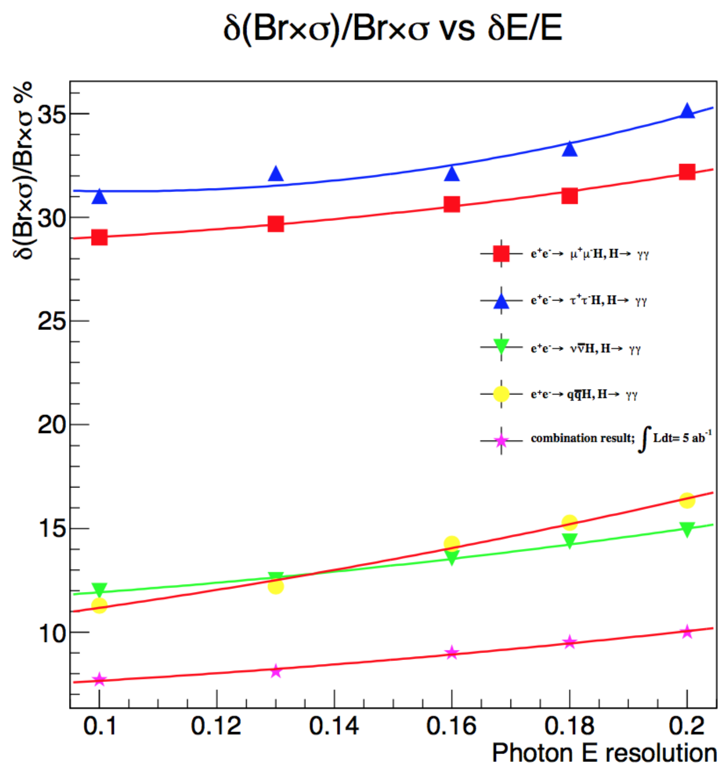
Conservative estimation gives efficiency/purity of 91%/94% (2-20 GeV, 50% degrading +50 ps ToF)

Could be improved to 96%/96% by better detector/DAQ performance (20% degrading + 50 ps ToF)

CEPC-DocDB-id: 172
https://arxiv.org/abs/1803.05134
Eur. Phys. J. C (2018) 78:464

Photon



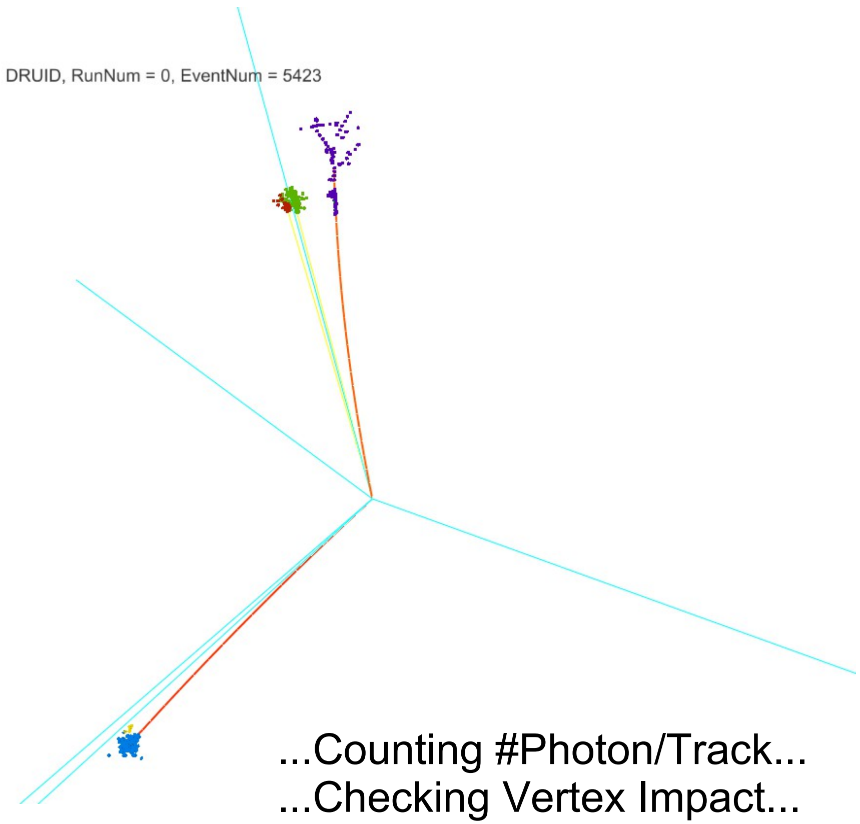


Relative Accuracy: ~ 8.5%

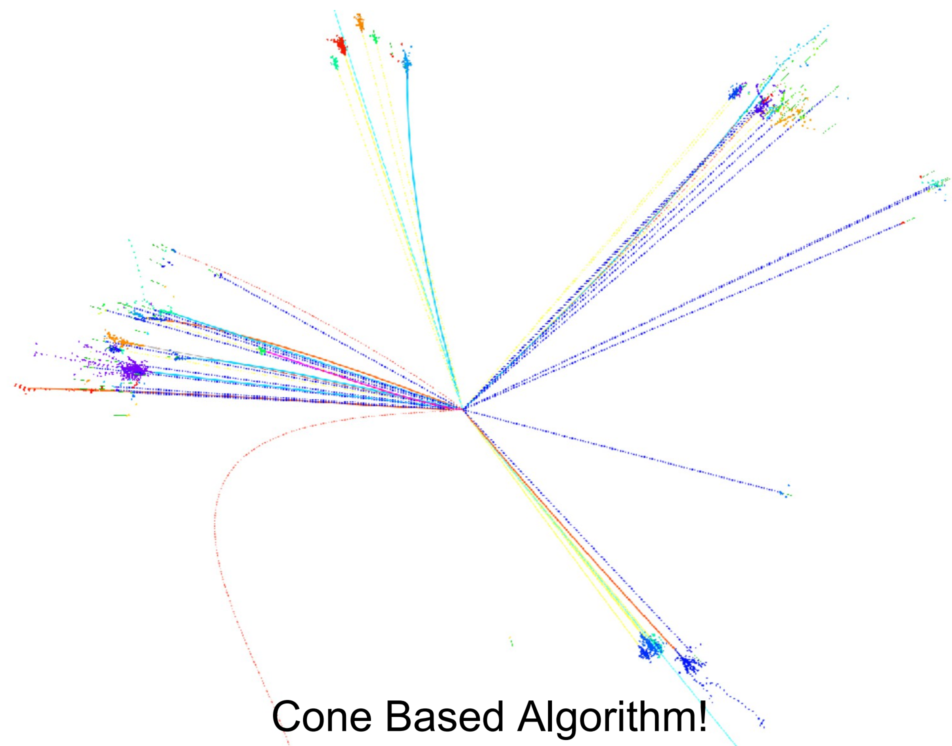
Inhomogeneity degrades the resolution significantly.
Physics requirement: constant term < 1%
Detector geometry defects degrades the mass resolution to **2.2%/2.6%** (CEPC-v1/APODIS);

http://iopscience.iop.org/article/10.1088/1748-0221/13/03/P03010
CEPC-DocDB-id (149, 169)
https://arxiv.org/pdf/1712.09625.pdf

Tau



...Counting #Photon/Track...
...Checking Vertex Impact...

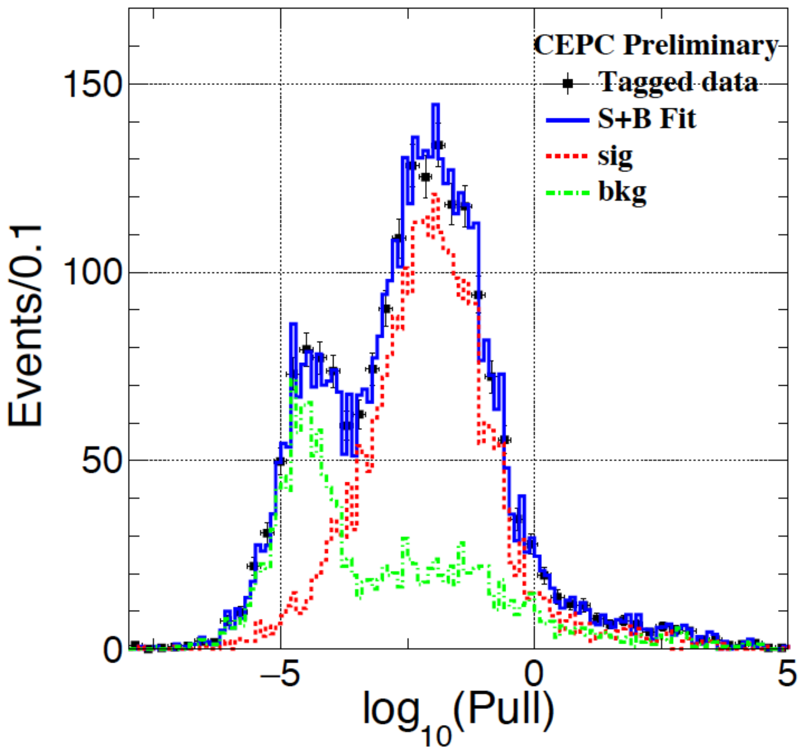


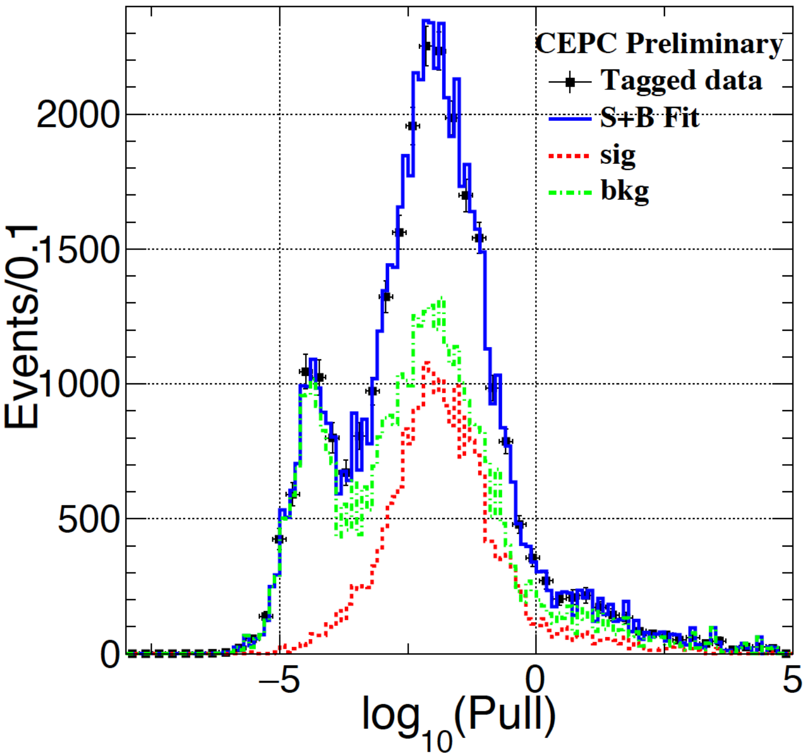
Cone Based Algorithm!
Para. Optimization

- Two catalogues:
  - Leptonic environments: i.e, llττ(ZZ/ZH), ννττ(ZZ/ZH/WW), Z→ττ;
  - Jet environments: i.e, ZZ/ZH→qqττ, WW→qqντ;

Ph.D thesis: D. Yu, reconstruction of leptonic objects at e+e- Higgs factory

g(Hττ) measurement





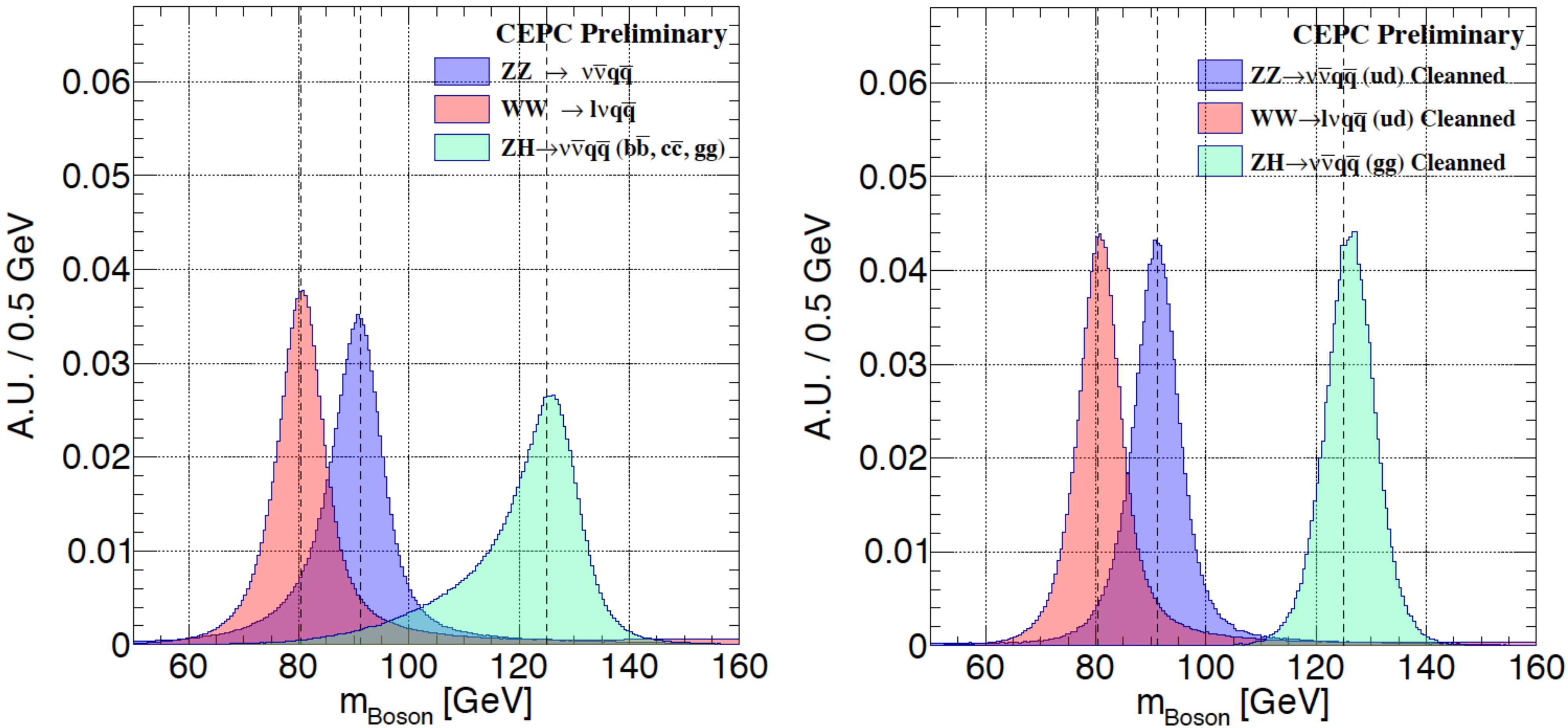
- ZH→μμττ
- Extremely Efficient Event Selection
- Signal efficiency of 93% - entire SM background reduced by 5 orders of magnitude

- ZH→qqττ
- Cone based tau finding algorithm, Compromise the efficiency & purity
- Signal efficiency of 51%

Jets

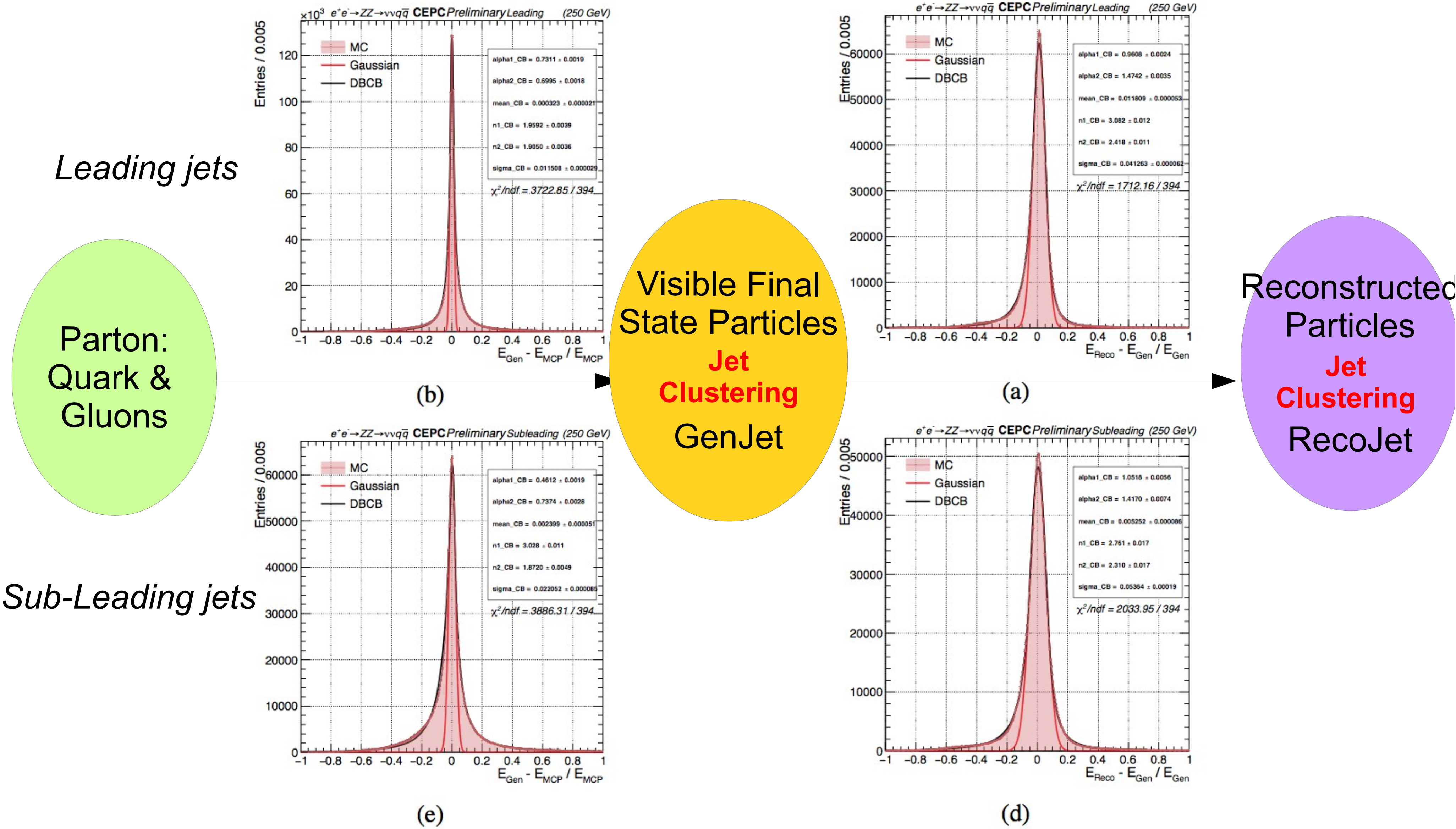
- Boson Mass Resolution: Separate W, Z and Higgs in hadronic decay mode
  - Essential for Higgs measurement
    - Separate Higgs from Z/W (relatively easy)
    - Separate H→ZZ/WW events (challenging)
  - Appreciated in Triplet Gauge Boson Coupling measurements
    - Separate WW (Signal) from ZZ, ISR return Z, etc.
  - ...
- Jet Clustering & Single jet response
  - To understand the Degrading induced by Jet Clustering, Matching, etc
  - Search for the most suited jet clustering algorithm (Presumably channel dependent) – Understand the Corresponding Systematic
  - ...

Massive Boson Separation



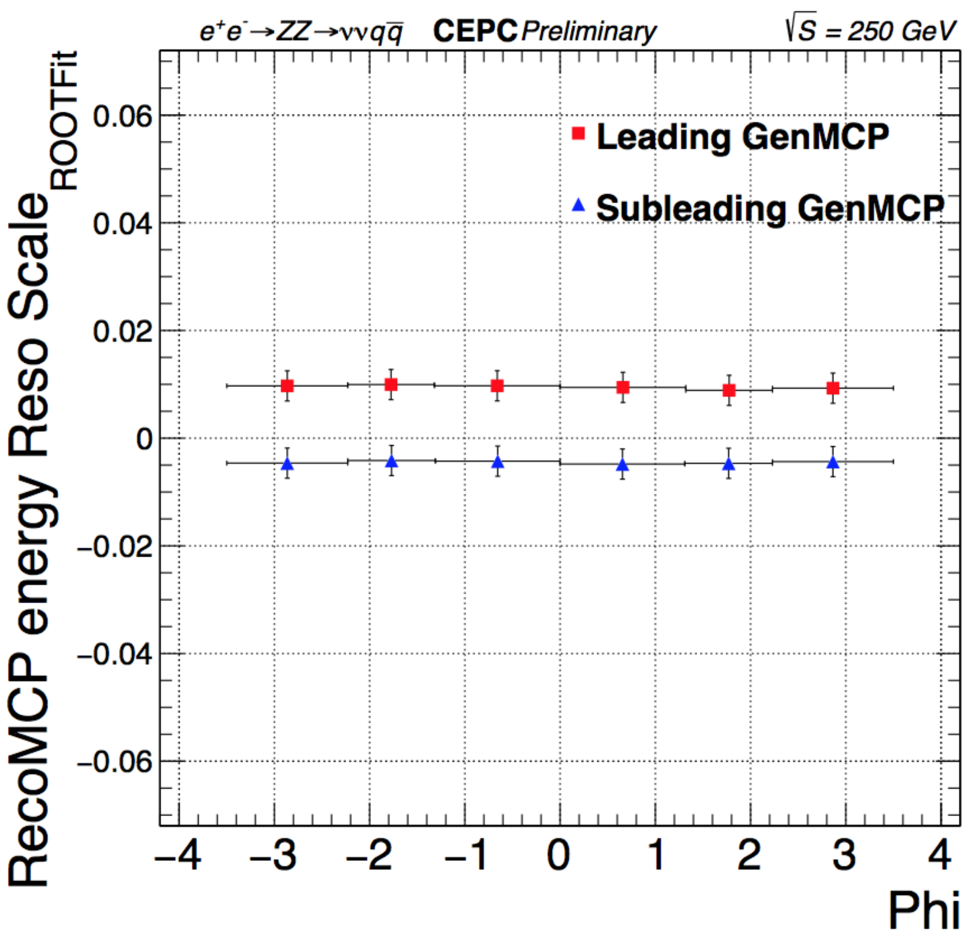
CEPC-RECO-2017-002 (DocDB id-164),
CEPC-RECO-2018-002 (DocDB id-171),
Eur.Phys.J. C78 (2018) no.5, 426

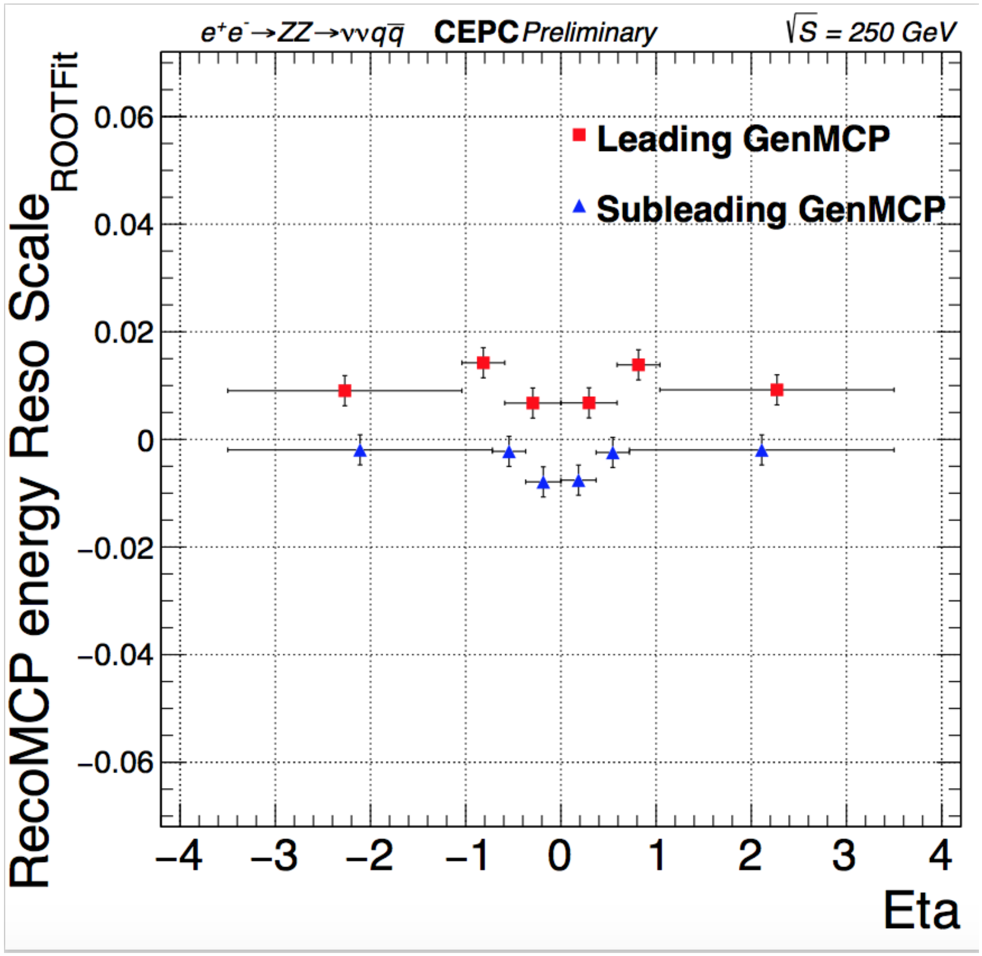
Impact of Jet Clustering: Significant



Jet Clustering is Mainly responsible for the tails

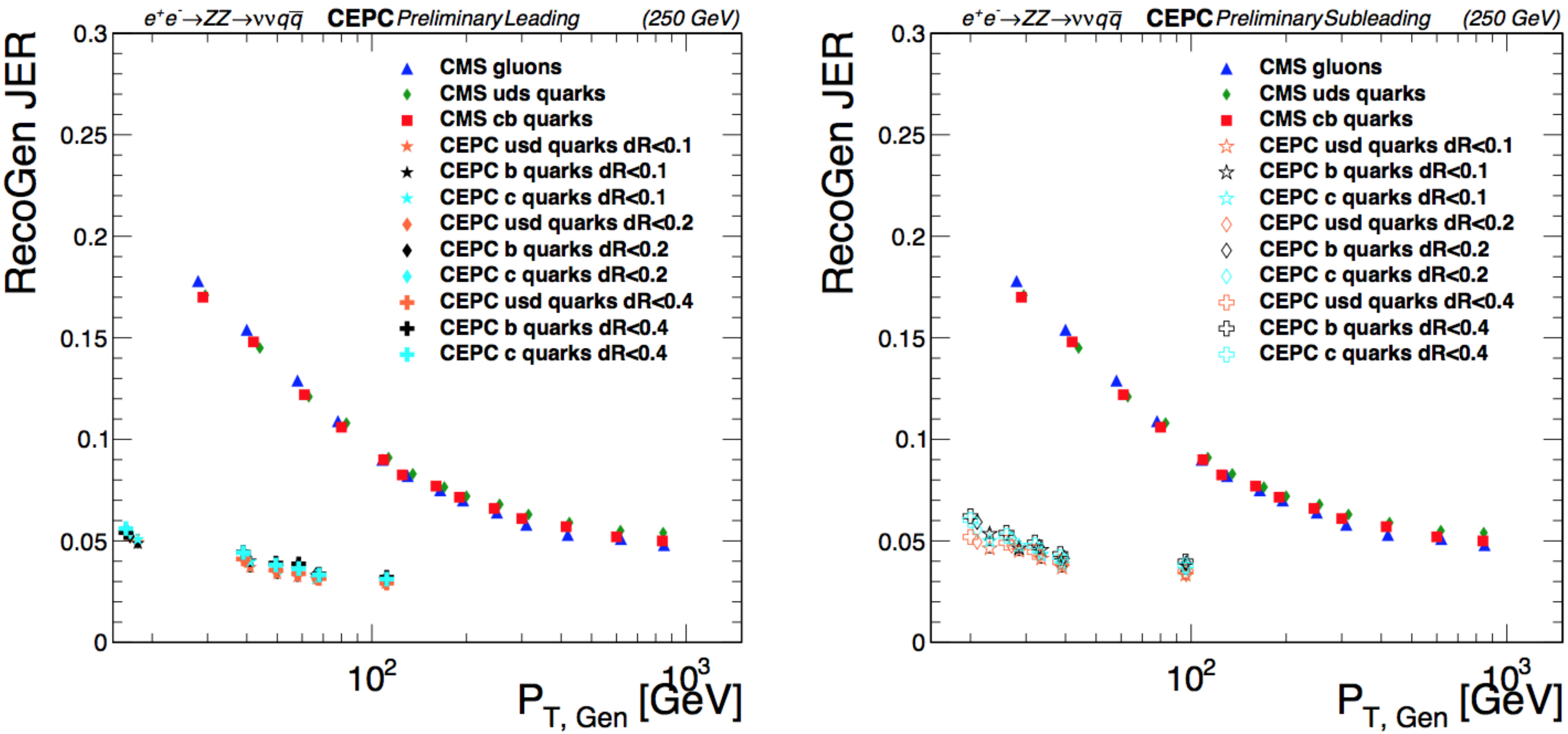
Jet energy Scale





Amplitude ~ 1%
Large JES observed at Leading Jet (Correlated), and at overlap region (Increasing of Splitting)

Jet Energy Resolution

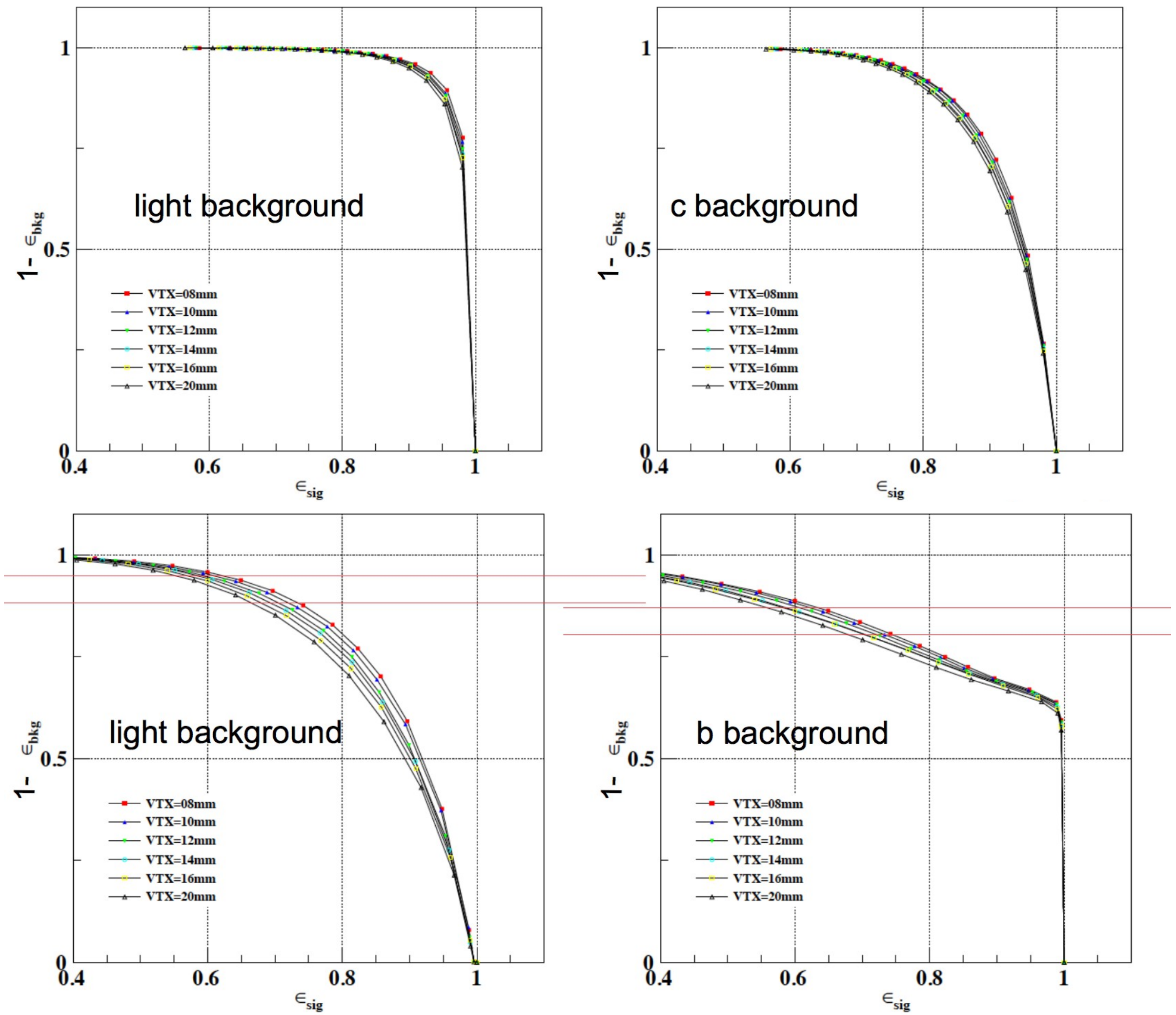


CMS Reference: CMS-JME-13-004,

Jet energy scale and resolution in the CMS experiment in pp collisions at 8 TeV

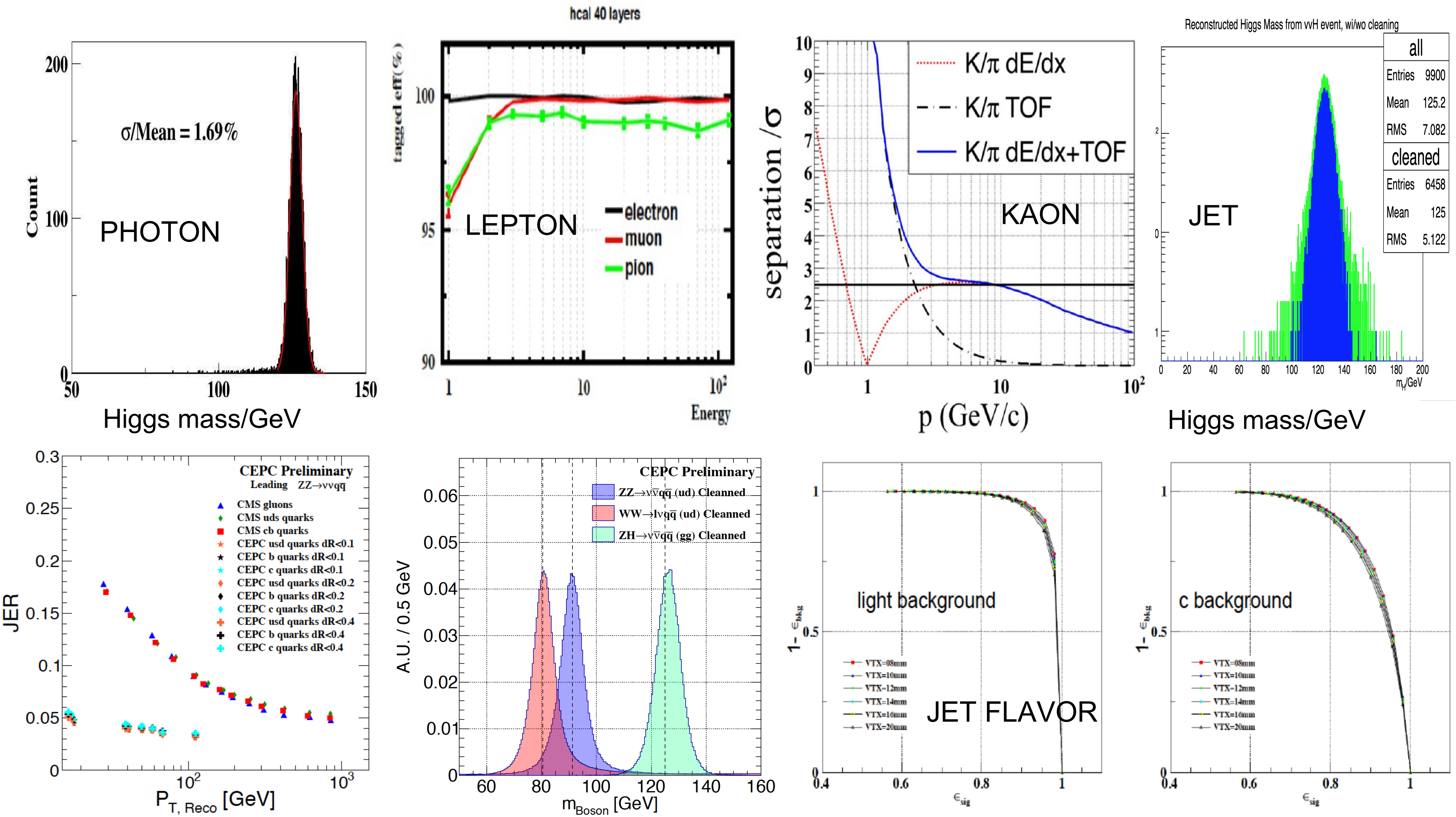
Flavor Tagging

- LCFIPlus Package
- Typical Performance at Z pole sample:
  - *B-tagging: eff/purity = 80%/90%*
  - *C-tagging: eff/purity = 60%/60%*
- Geometry Dependence of the Performance evaluated



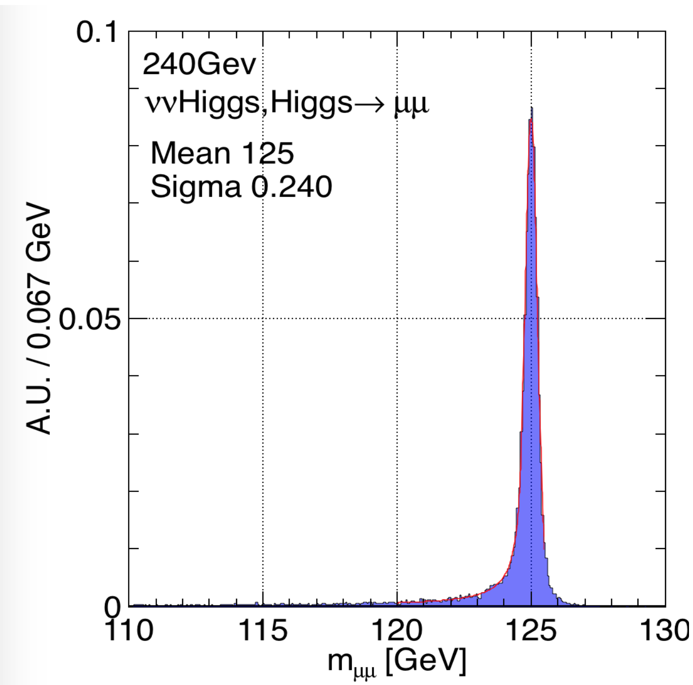
https://agenda.linearcollider.org/event/7645/contributions/40124/

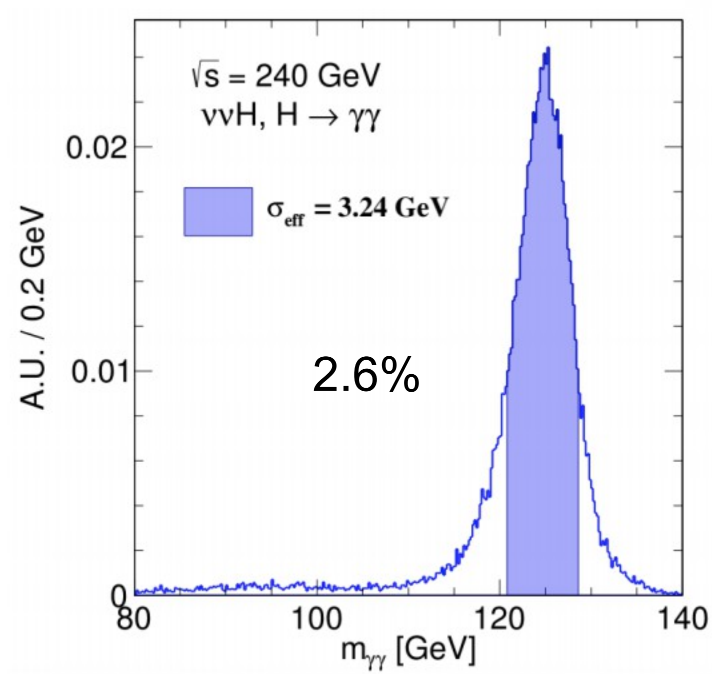
Physics Objects: Tamed

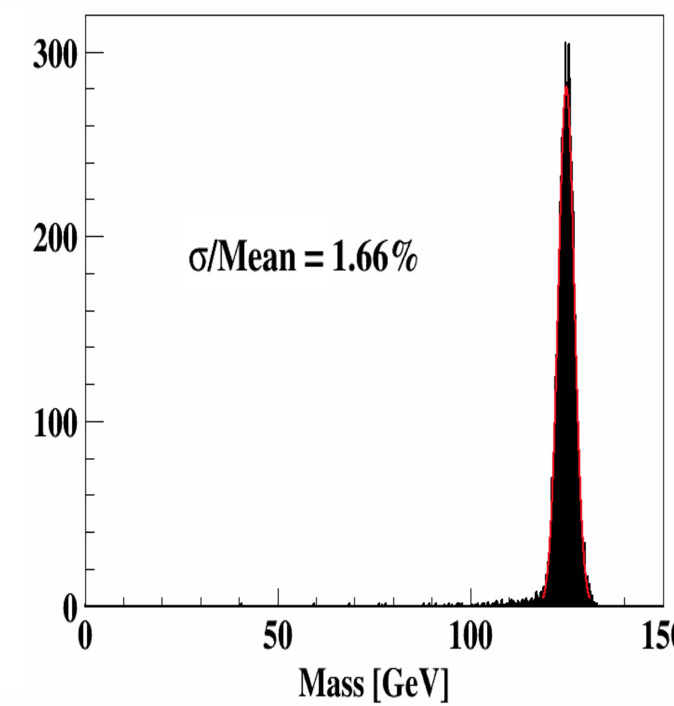


Higgs Signal at APODIS

- Tracks - Leptons & Photons





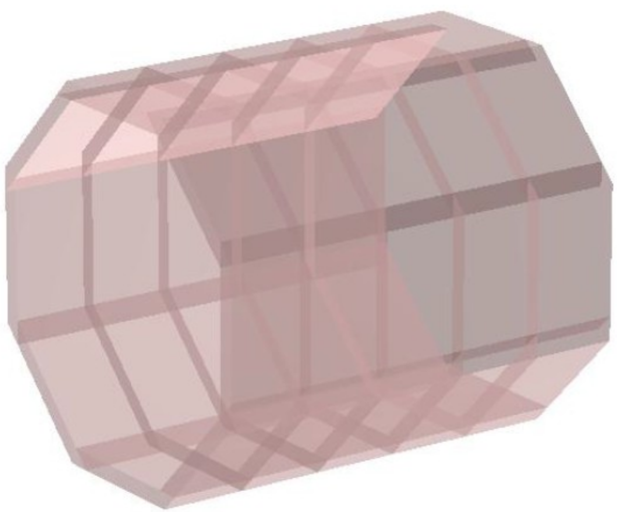


H→γγ at CEPC-v4/Simplified geometry

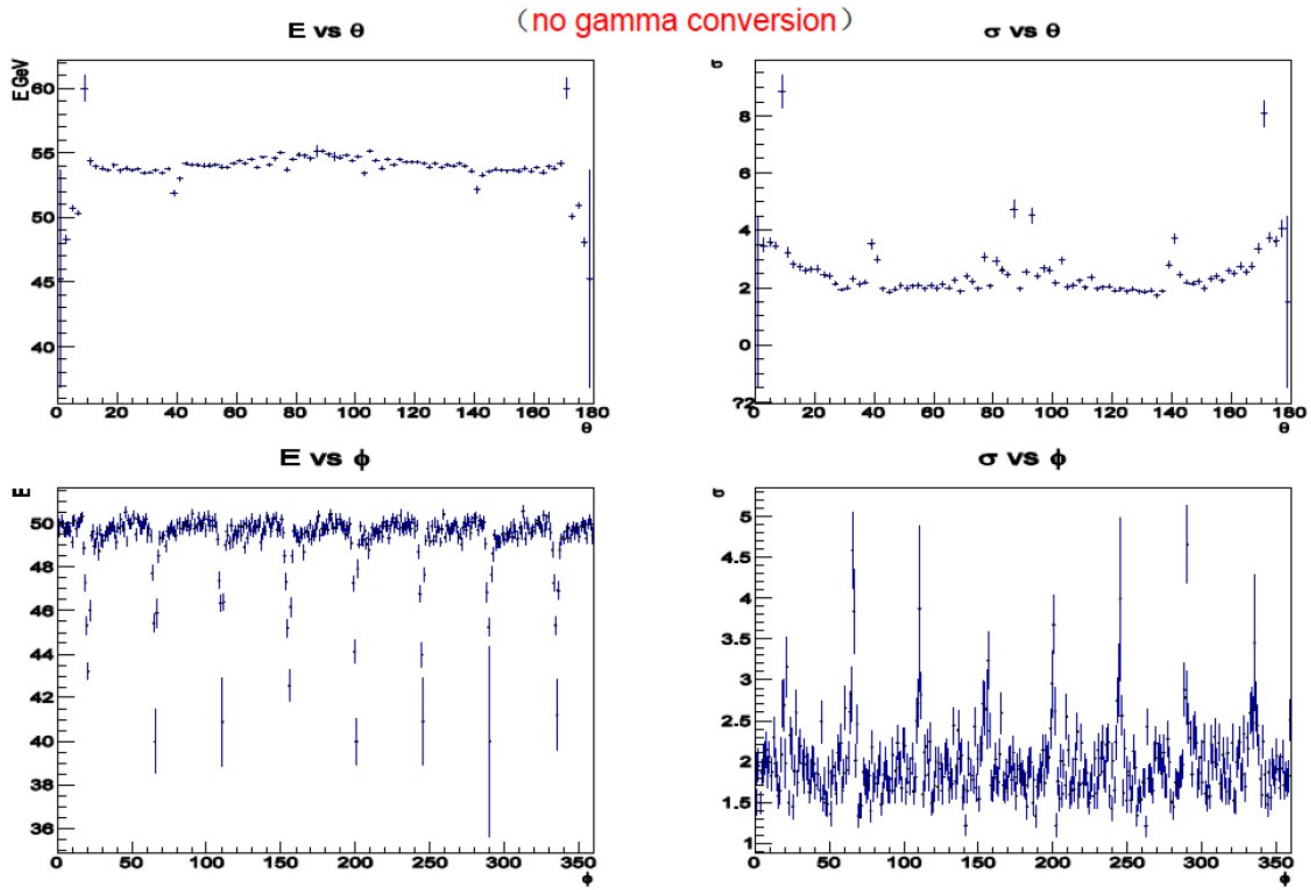
CEPC-RECO-2018-002
CEPC-Doc id 174, 175

Asymmetric tails in CEPC-v4 induced by geometry defects need careful geometry corrections

Arbor: photon reconstruction

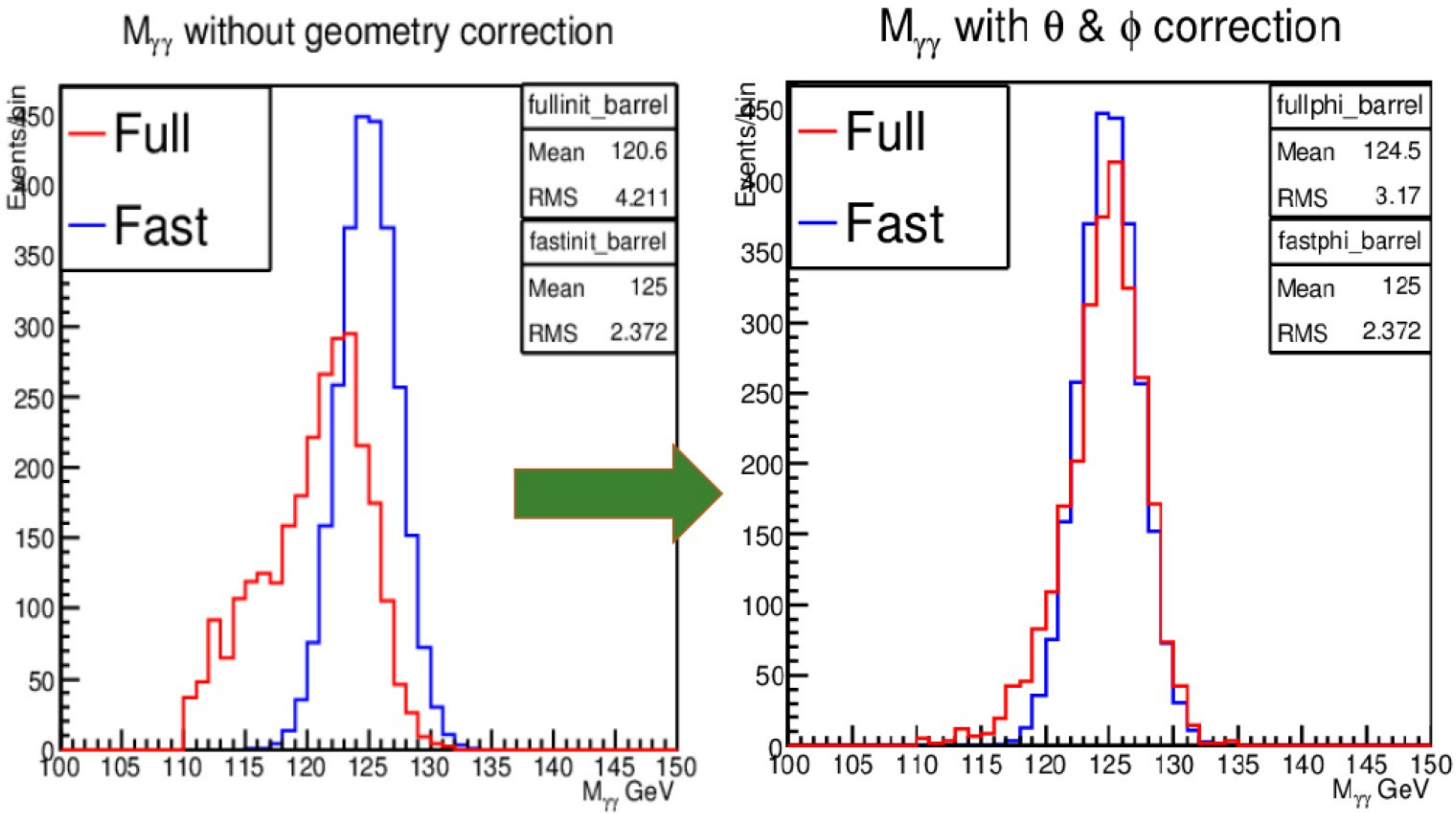


ECAL Barrel of ILD/CEPC_v1

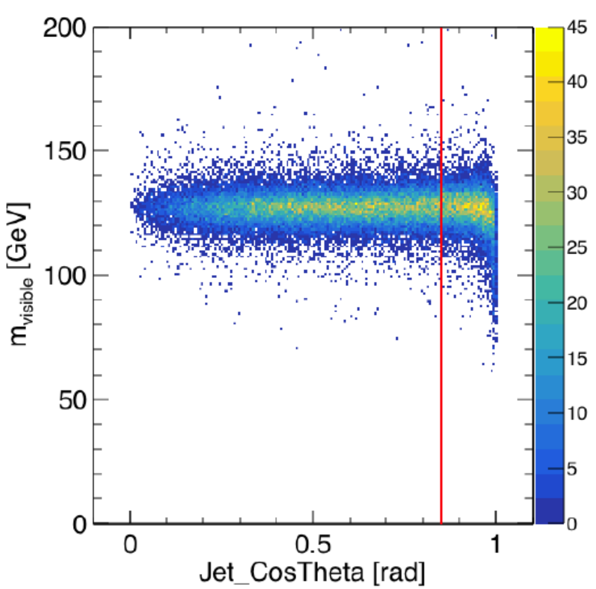


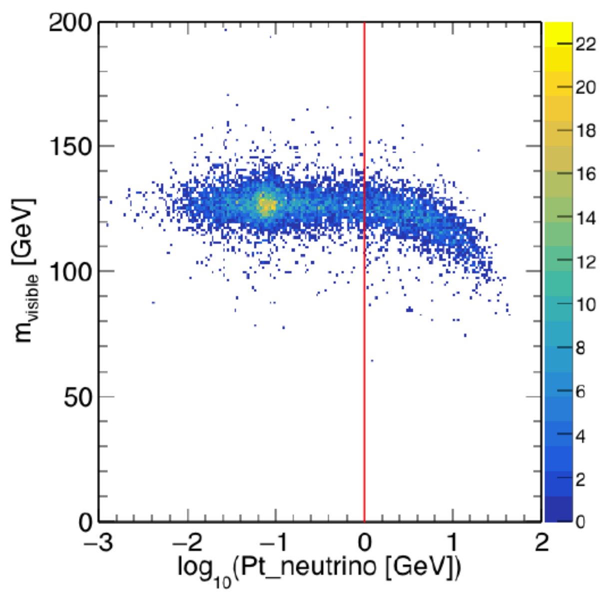
Angular Correlation of EM Shower energy response

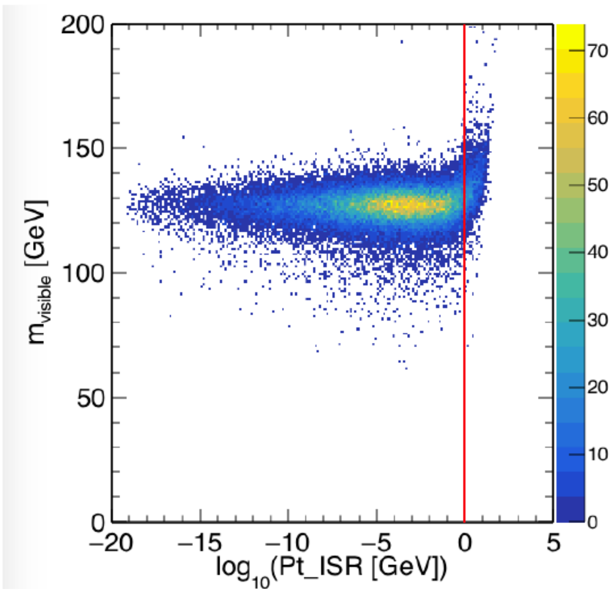
Arbor: photon reconstruction



H to gluons: total visible mass







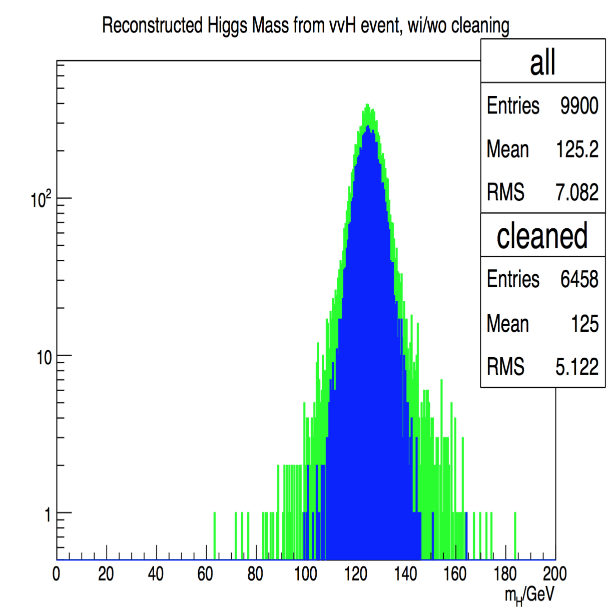
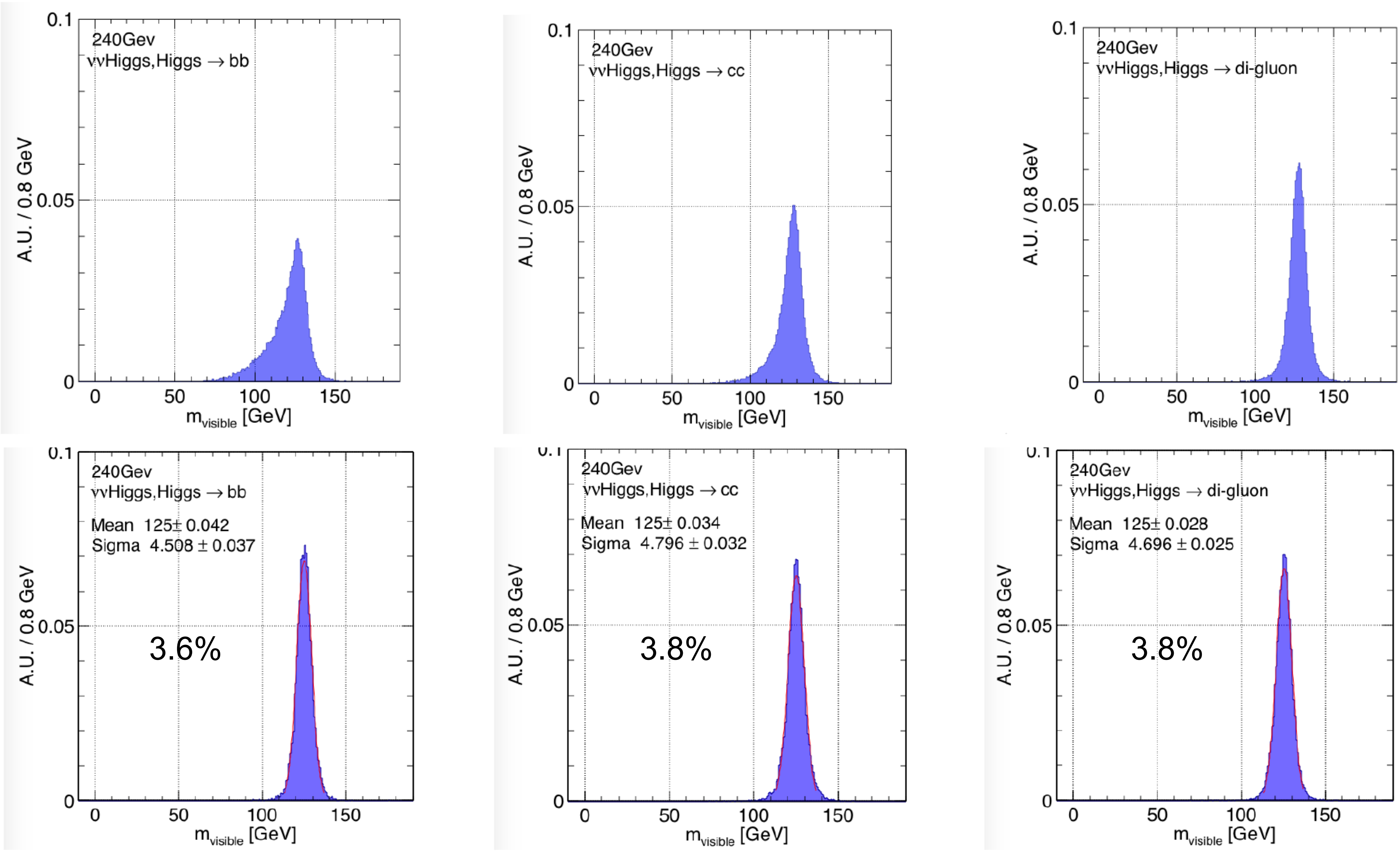


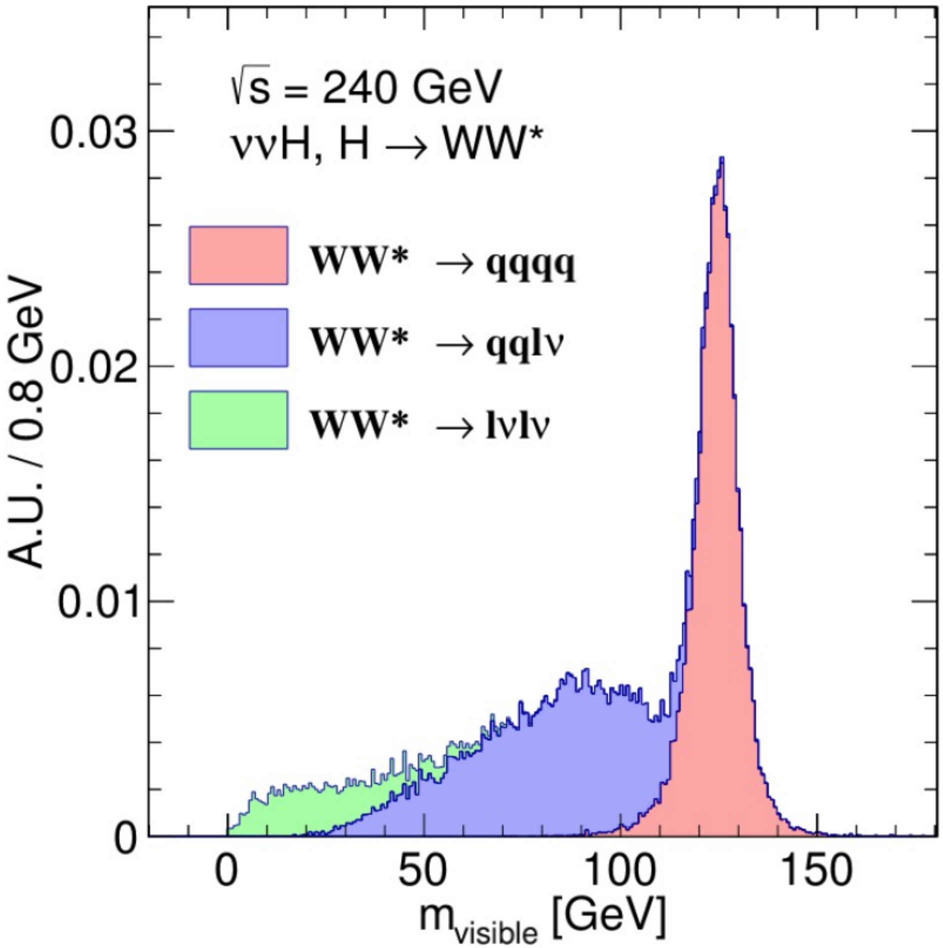
Table 1. Event selection efficiency for Higgs boson exclusive decay at CEPC with $\sqrt{s} = 240$ GeV.

	$\mu\mu$	$\gamma\gamma$	*di_gluon*	bb	cc	WW^*	ZZ^*
Total	45000	48000	48000	45000	46000	47000.	45000
$Pt\_ISR < 1GeV$	-	95.52%	95.14%	95.37%	95.27%	95.19%	95.22%
$Pt\_neutrino < 1GeV$	-	-	89.35%	39.00%	66.30%	37.41%	41.42%
$\lvert costheta \rvert < 0.85$	-	-	67.27%	28.58%	49.23%	37.03%	40.91%

Higgs to bb, cc, gg



Higgs to WW, ZZ



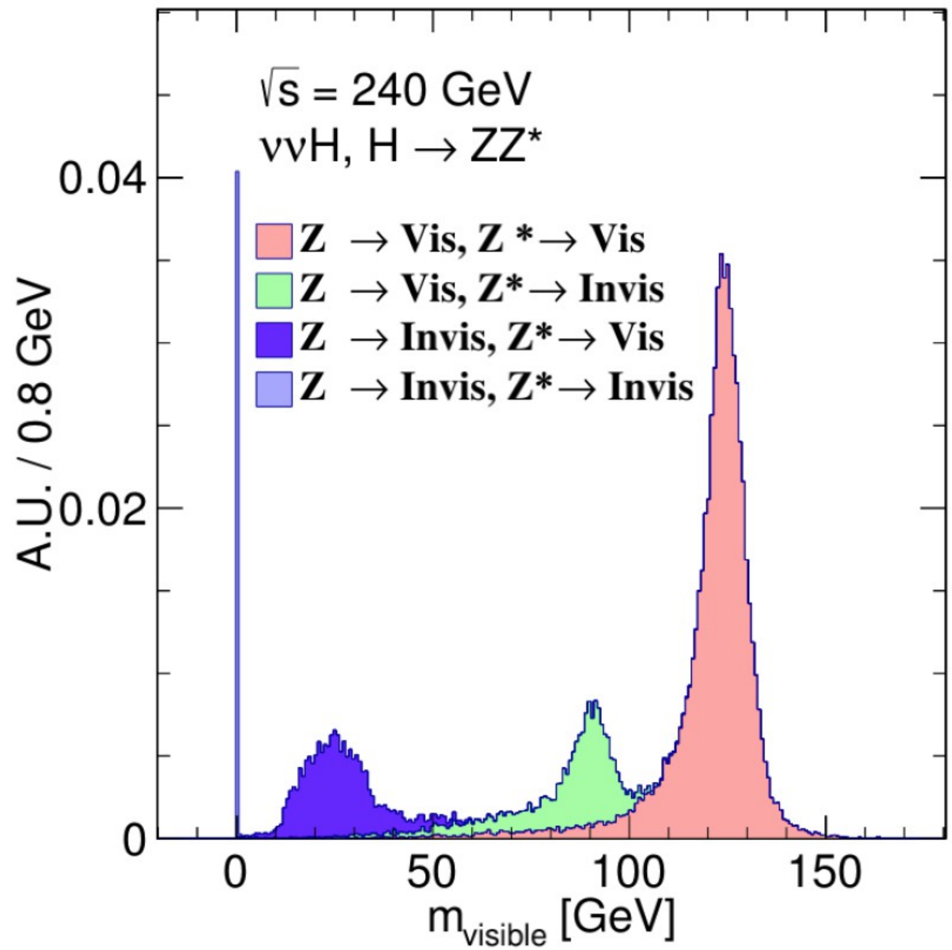


Table 2. Benchmark resolutions ($\sigma/Mean$) of reconstructed Higgs boson mass, comparing to LHC results.

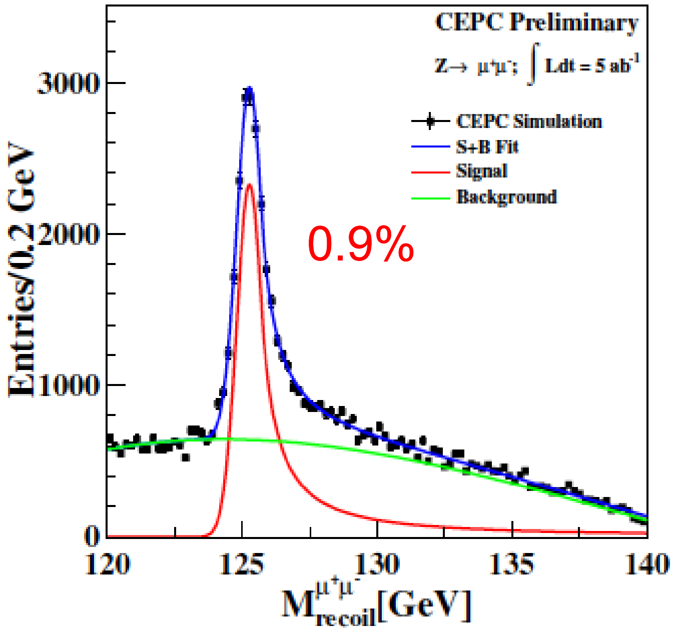
	Higgs→ $\mu\mu$	Higgs→ $\gamma\gamma$.	Higgs→bb
CEPC (APODIS)	0.20%	2.59%[1]	3.63%
LHC (CMS, ATLAS)	~2% [19, 20]	~1.5% [21, 22]	~10% [23, 24]

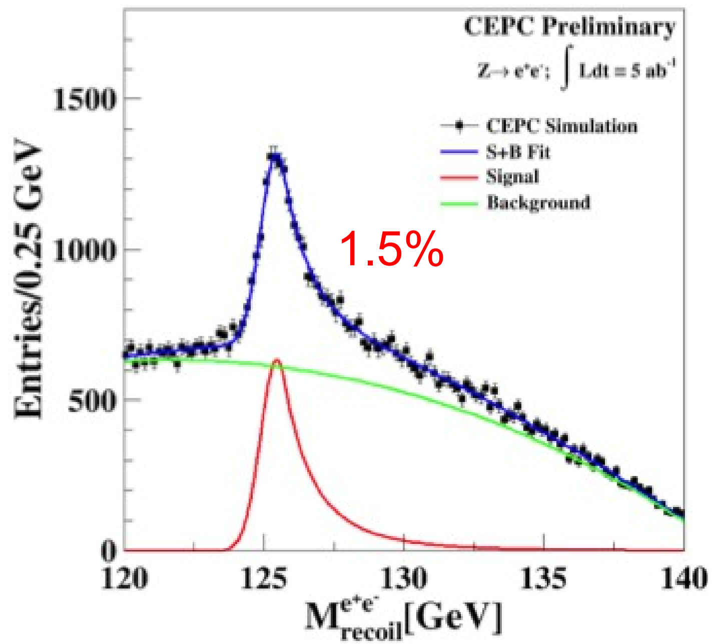
[1] primary result without geometry based correction and fine-tuned calibration.

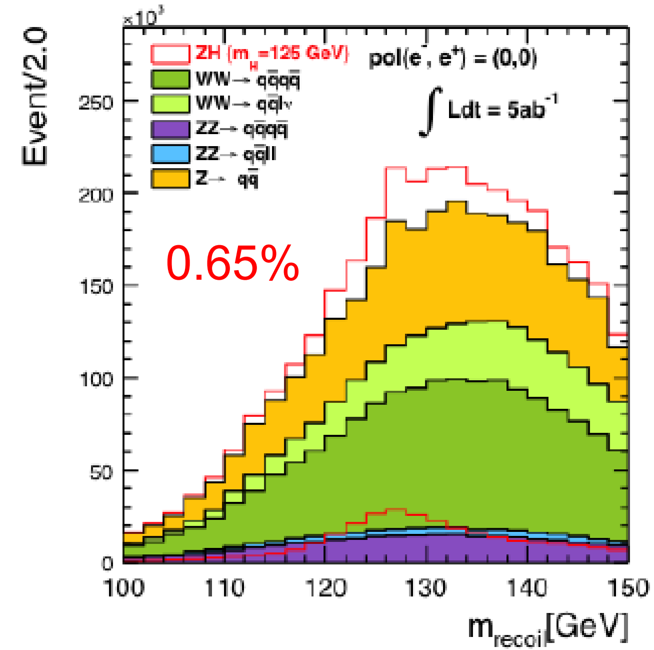
https://arxiv.org/abs/1806.04992

Model-independent measurement of σ(ZH)

Zhenxing Chen & Yacine Haddad

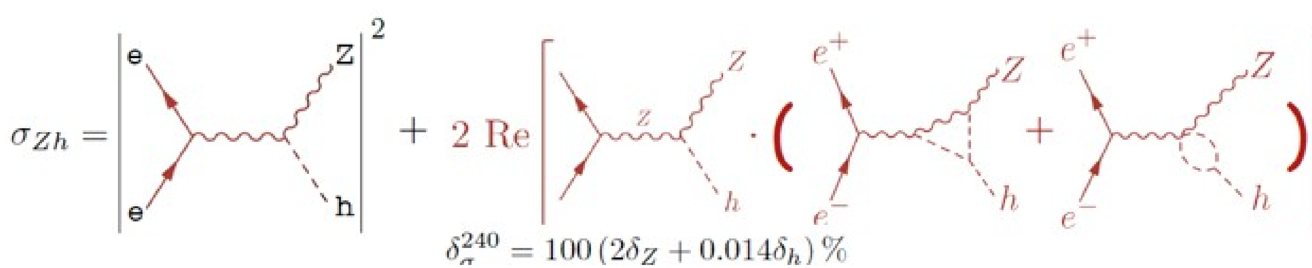






- Recoil mass method. Combined precision:
  $\delta\sigma(ZH)/\sigma(ZH) = 0.5\%$ -
  $\delta g(HZZ)/g(HZZ) = 0.25\%$

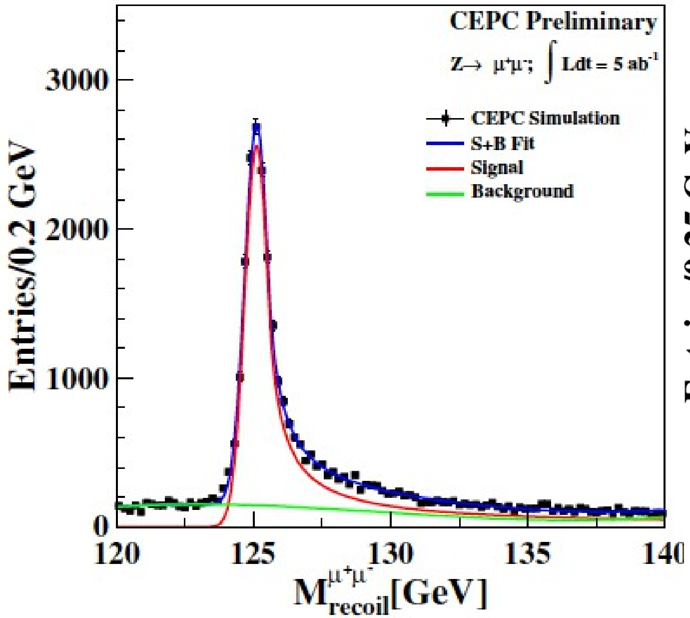
- Indirect Access to g(HHH)

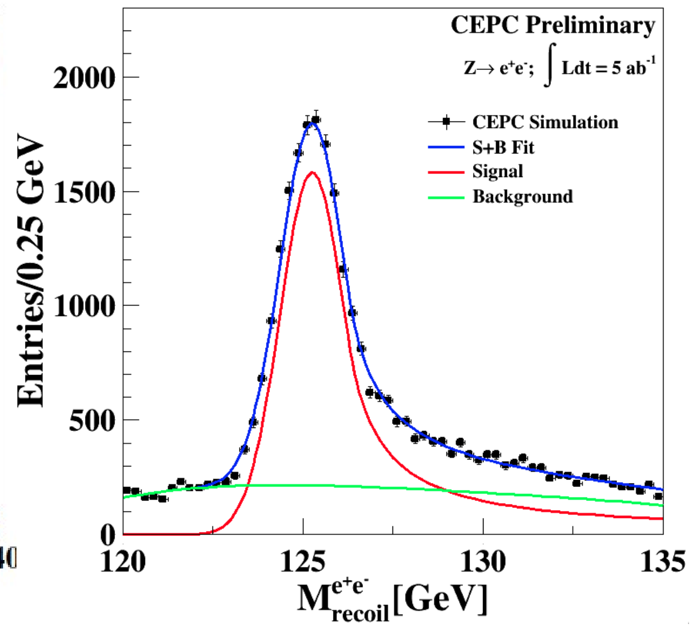


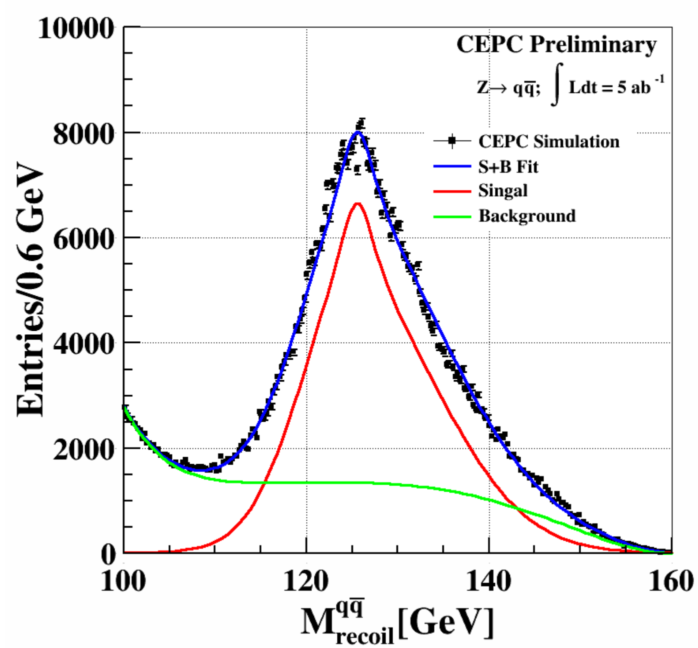
- *M. McCullough, 1312.3322*

Exotic: Higgs invisible decays

*Assuming sigma(ZH)*Br(H->inv) = 200 fb*

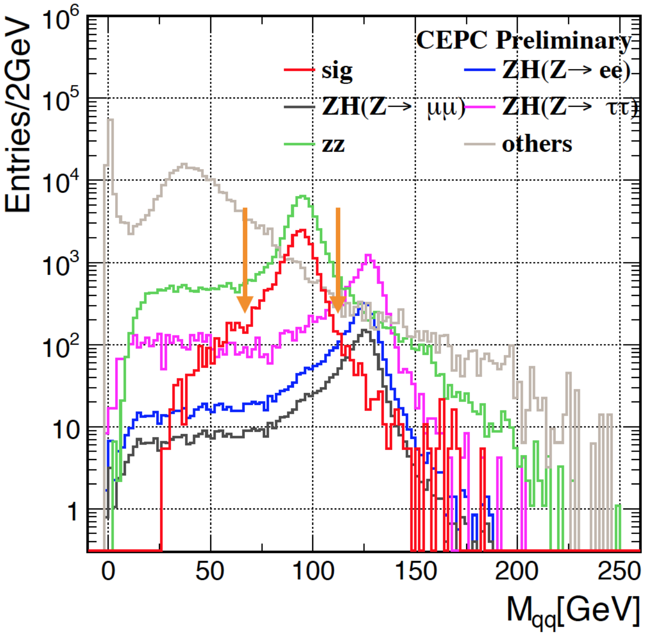


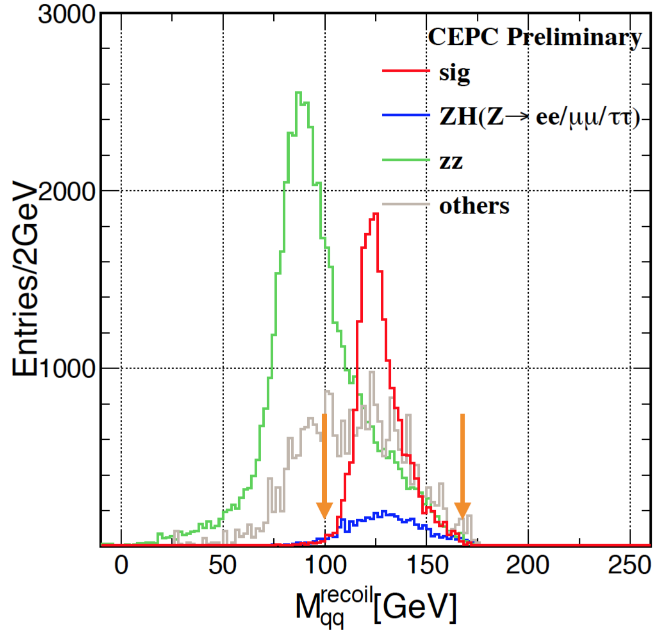


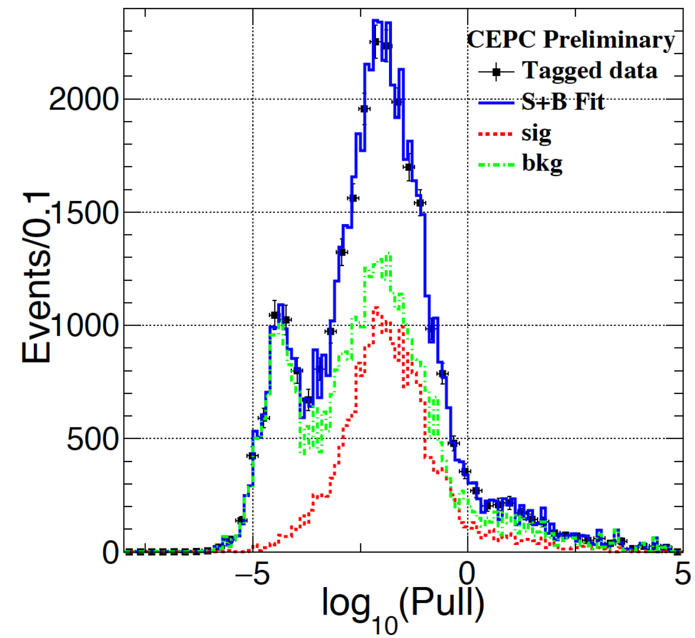


Invisible up limit at CEPC: ~0.3% at 95% C.L

An Analysis Example (Dan): *g(Hττ)* at qqH







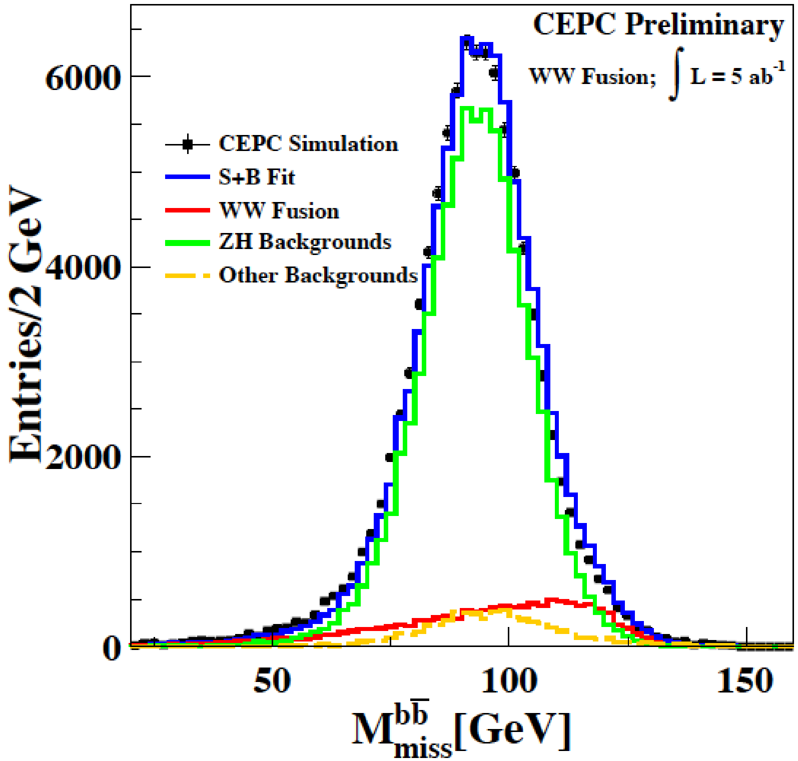
- Cone based tau finding: di-tau system
- The other particles are define as the di-jet system: to distinguish the qqττ background
- Isolated tracks are intensionally defined as tau candidate: be distinguished by the VTX

	m_{jj}	$m_{jj\text{-recoil}}$
Signal: Z(qq)H(ττ)	91.2	125
Z(ττ)H(qq)	125	91.2
ZZ	91.2	91.2

Ph.D thesis of D. Yu

Higgs width measurement

- $g^2(HXX) \sim \Gamma_{H\to XX} = \Gamma_{total} * Br(H\to XX)$
- Branching ratios: determined simply by
  - σ(ZH) and σ(ZH)*Br(H→XX)
- Γ_{total}: determined from:
  - σ(ZH) (~g^2(HZZ))
    σ(ZH)*Br(H→ZZ) (~$g^4(HZZ)/\Gamma_{total}$)
  - σ(ZH)*Br(H→bb),
    σ(νH)*Br(H→bb),
    σ(ZH)*Br(H→WW),
    σ(ZH)



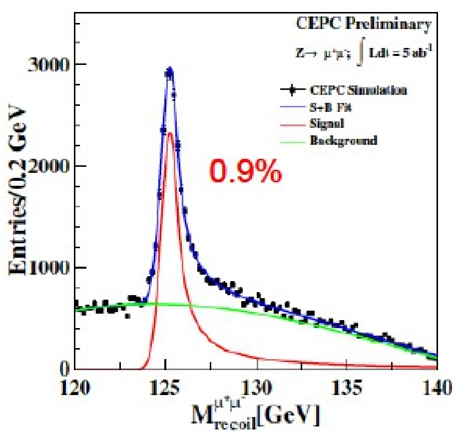
Br(H->ZZ): relative error of 6.9% achieved with ZH->ZZZ*->vv(Z)llqq(H) final states. Extrapolation of TLEP result leads to 4.3% relative error

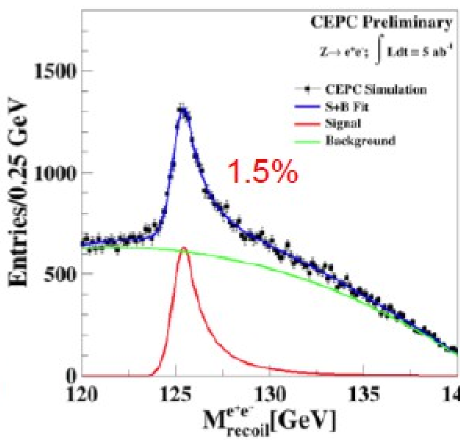
σ(vvH)*Br(H->bb): relative error of 2.8%

A combined accuracy of 2.8% for the Higgs total width measurements

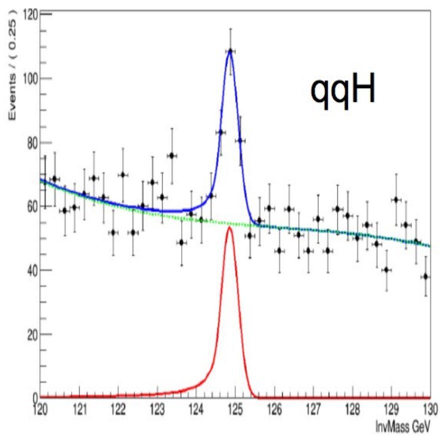
Higgs benchmark analyses

Mostly done with CEPC-v1 geometry @ 250 GeV c.m.s...

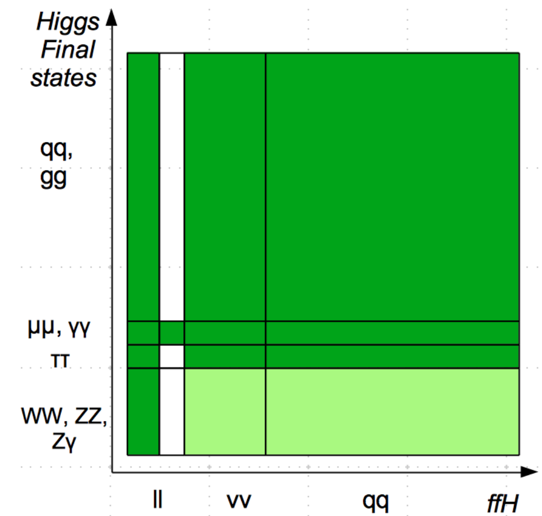


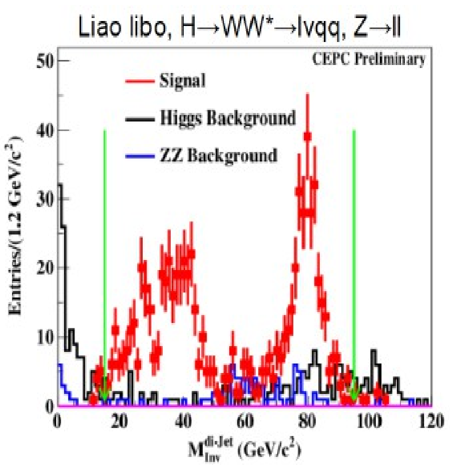


σ(ZH) measurements

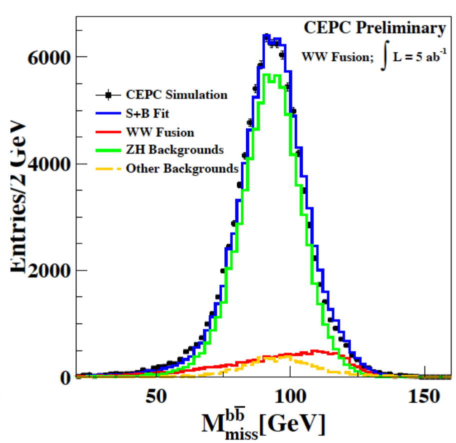


Br(H→μμ)

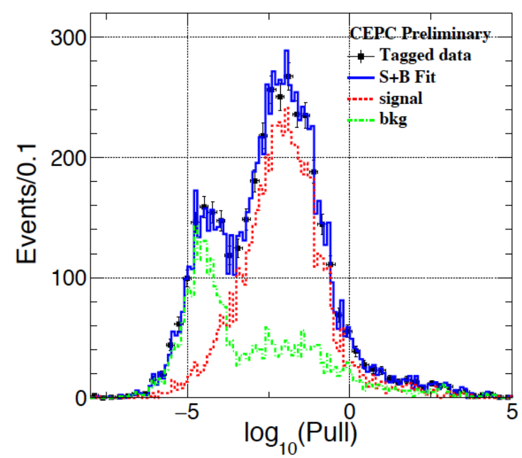




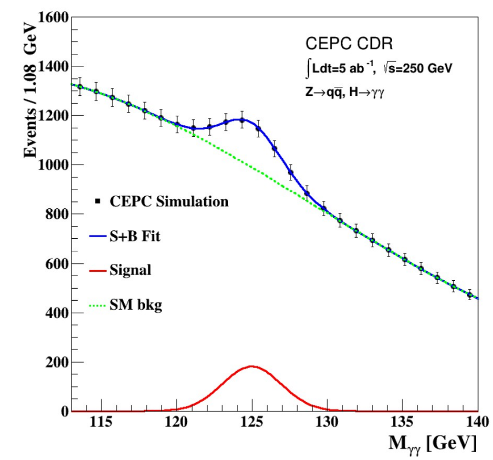
Br(H→WW)



σ(ννH)*Br(H→bb)



Br(H→ττ)



Br(H→γγ) (Asimov)

CEPC Higgs White Paper – be available soon

Issues to be addressed

- Tracking
  - Dedx/material effect correction (induces o(100) MeV bias in Higgs mass at in H->mumu) (20, 30, 20)
  - Development, Performance analysis & Integration of CEPC tracking (Arbor & Conformal & ...) (50, 90, 90)
- PFA
  - Cluster energy estimator development
    - Photon (EM Shower) Geometry dependent energy correction (50, 90, 20)
    - HAD? (40, 50, 50)
  - Usage of Timing information... (60, 90, 80)
  - Optimization of HCAL geometry (50, 60, 70)
- Lepton ID & P ID:
  - Integration & Usage of Timing information (60, 80, 20)

Urgency, Importance, Difficulties

Issues to be addressed

- Composited object finder: **CORAL** (finding Pi0, Kshort, Lambda, J/Psi, ...)
  - Framework is ready... and lots of performance study and optimization awaits (40, 90, 50)

Urgency, Importance, Difficulties

- Jets
  - Jet Clustering: finding the color singlet? (40, 90, 90)
  - Distinguish between 2 jet, 3 jet, 4jet, 5jet, 6jet events.... (80, 80, 60)
    - Mila's analysis (ZH->6 jets) gives a very good example
- **Jet Flavor Tagging** (**90**, **99**, **80**)
  - The efficiency of reconstruct 2nd Vertex in Z->cc events is ONLY 20%!!!
- Separation of gluon to quark jets? (**50**, **50**, 50)
- Usage of Deep learning at reconstruction... (**30**, **90**, 50)
- ...Lots Lots of Detector Optimization & Integration....

Summary

- CEPC, a super Higgs/W/Z factory
- Physics Potential
  - Higgs:
    - Absolute determination of Higgs couplings, width...
    - 1 order of magnitude improvement w.r.t HL-LHC (Signal Strength)
    - Exotic decay: 2-3 orders of magnitude better than HL-LHC
  - EW: boost by at least 1 order of magnitude
  - Rich program on Flavor physics
- Performance at the baseline design (APODIS + Arbor)
  - High efficiency/accuracy reconstruction of all key physics objects
  - Clear Higgs signature in all SM Higgs decay modes
  - Clear distinguish between the Signal and SM backgrounds
  - Fulfills the physics requirements of the CEPC Higgs operation

Summary

- CDR in finalization: long to do list towards the TDR
  - Software & Reconstruction
  - Analysis:
    - Anything beyond the Higgs Rates measurements
  - Detector design & optimization...

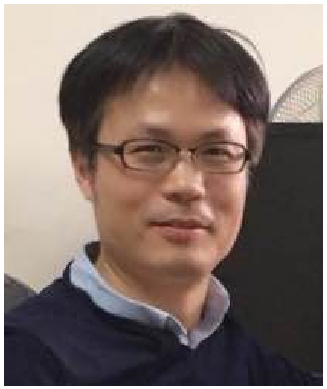
- You ideas & Participations are essential & more than welcome!

backup

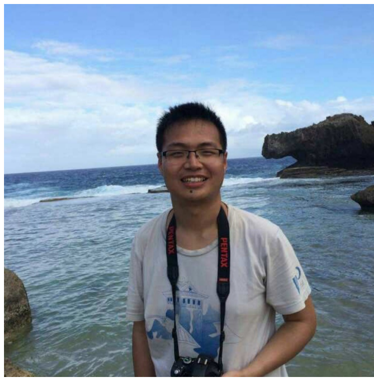
Summary

- The Particle Flow oriented detector is well established and serves as the baseline detector for the CEPC CDR studies
  - High efficiency/accuracy reconstruction of all key physics objects;
  - Clear Higgs signature in all SM Higgs decay mode
  - **Mature software/reconstruction tool/team**
- APODIS, Optimized for the CEPC collision environments
  - Significantly reduced B-Field (15%), #readout channels (75% in ECAL) & HCAL layer-thickness (20%) & cost (15%/30% w.r.t CEPC-v1/ILD)
  - Same Higgs performance & enhanced Pid Performance
  - Iterate with hardware studies
- Todo:
  - Physics study, especially flavor tagging & EW measurements (τ leptons)
  - Towards the TDR, Integration, Sub detector modeling, Systematic Studies

软件队伍



成栋：几何及寻迹



新人：赵祥虎
软件-计算

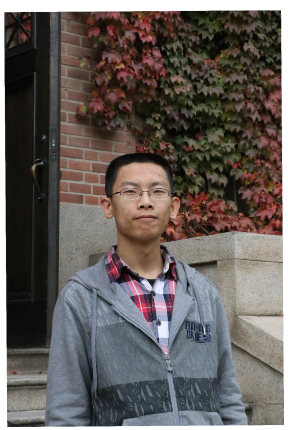
于丹：轻子甄别
PFA，tau

新人：赖培筑
喷注

安芬芬：
Pid，软件

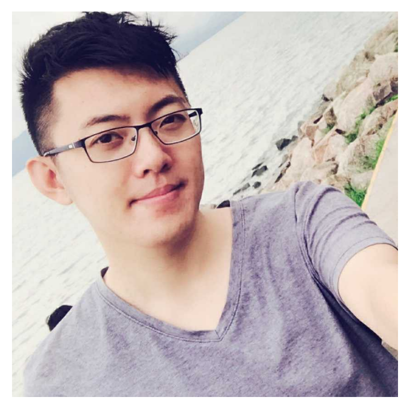
吴志刚
顶点优化

徐音：几何



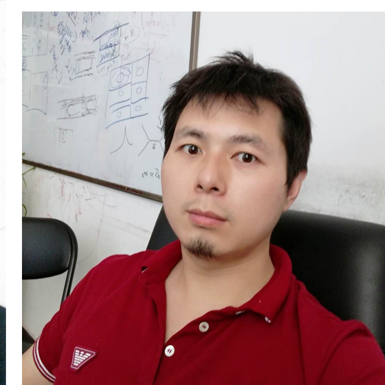
赵明锐：寻迹，
软件

李刚：产生子，
喷注味道甄别



赵航： PFA，
量能器优化

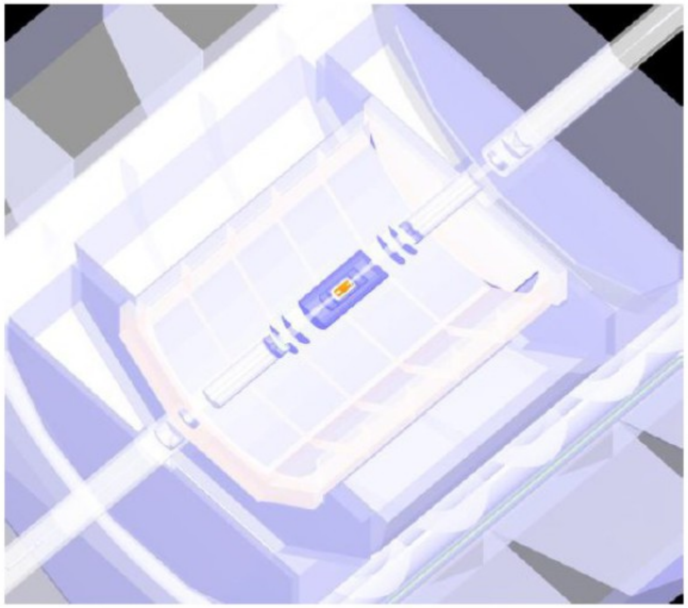
李亮：轻子

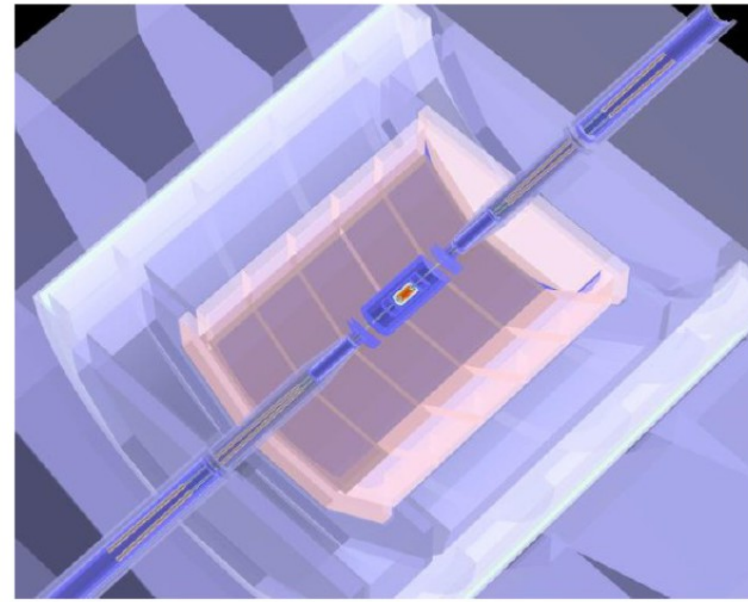


曼奇：探测器设计
软件，分析

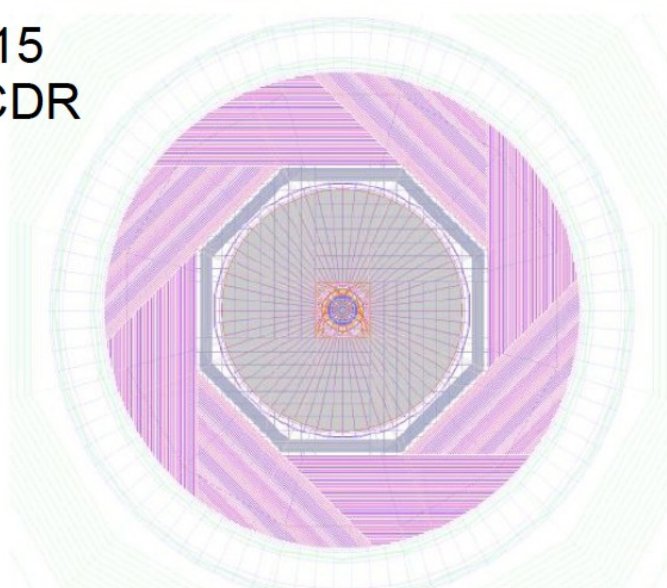
Benchmark detector for CDR: **APODIS**

(A PFA Oriented Detector for HIggS factory. a.k.a CEPC_v4)





2015
PreCDR



2017
CDR

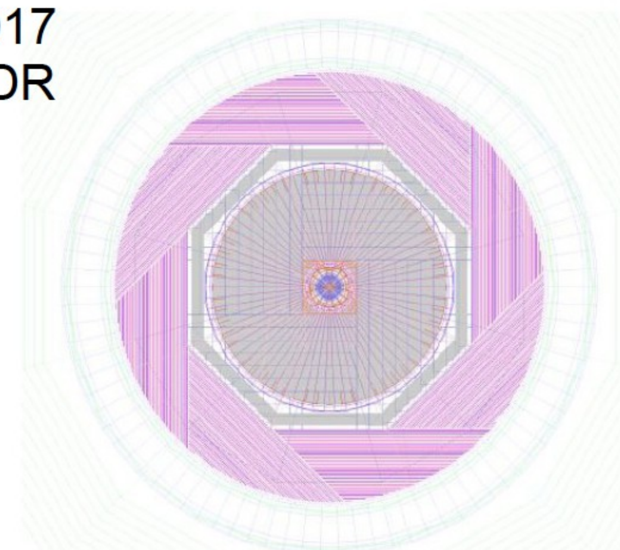
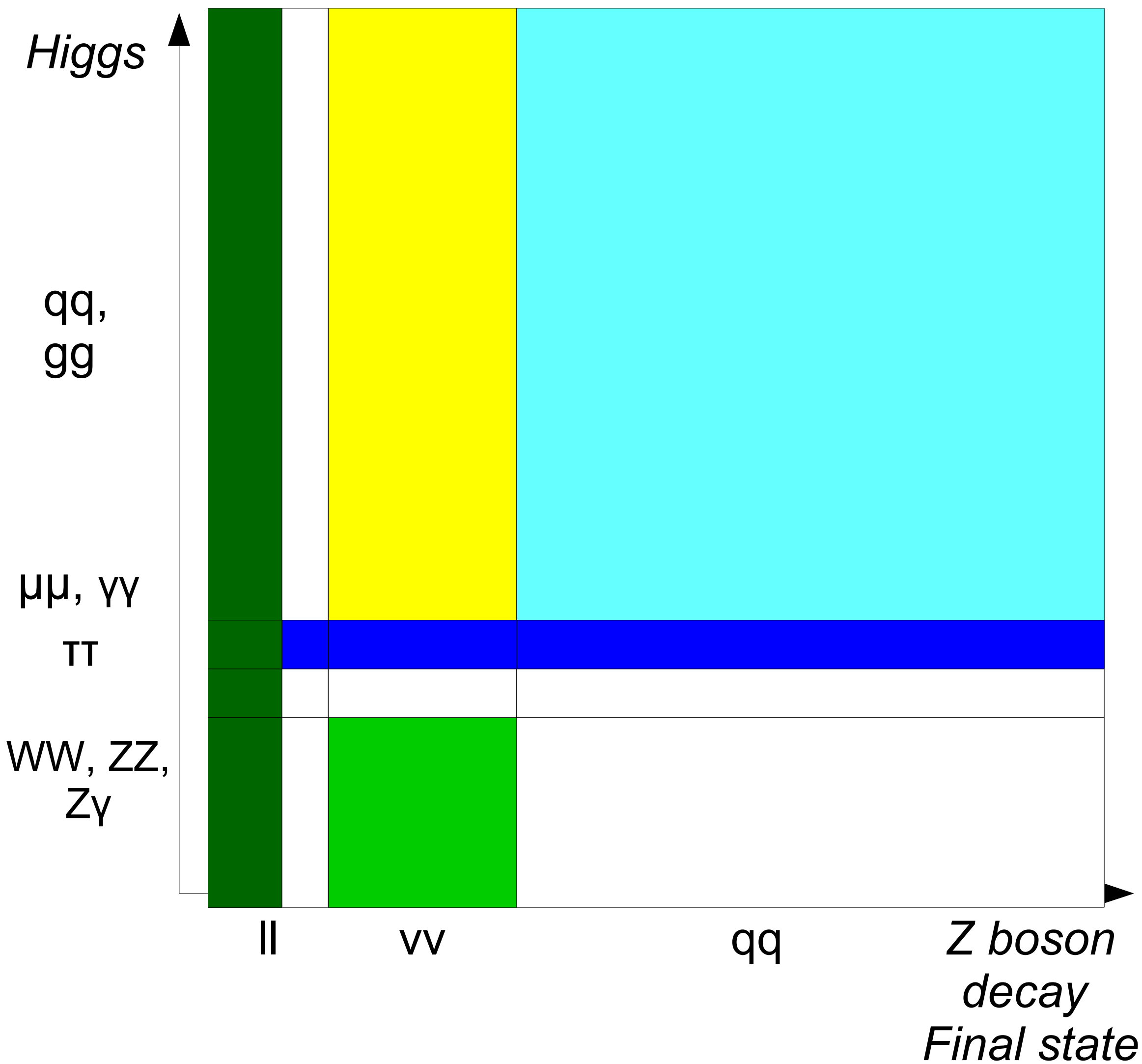


Table 9 Cut Flow of MC sample for $qqH \to \tau\tau$ selection on signal and inclusive SM backgrounds

	$qqH\tau\tau$	qqH inclusive bkg	ZH inclusive bkg	ZZ	WW	single$W$	single$Z$	$2f$
total generated (scaled to 5 ab^{-1})	45597	678158	357249	5711445	44180832	17361538	7809747	418595861
1st preselection	45465	677854	310245	5039286	42425195	1267564	1398362	148401031
2nd preselection	45145	174650	226059	293306	12452091	125735	117306	547402
$N_{\tau^+} > 0, N_{\tau^-} > 0$	24674	7342	33721	93955	723989	33887	54386	103642
$20GeV < M_{\tau^+\tau^-}$ < 120GeV	24284	6290	32344	88245	597480	24927	36039	56615
$70GeV < M_{qq}$ <110GeV	22937	2103	4887	65625	21718	738	1893	556
$100GeV < M_{qq}^{Rec}$ <170GeV	22703	2045	4524	23789	13154	315	306	193
efficiency	49.97%	0.31%	1.26%	0.41%	0.04%	<0.01%	<0.01%	$<$ 0.01%

Benchmark measurements



Lepton & Momentum resolution: Br = 6.7%

Flavor Tagging & JER: Br = 14%

Composition of Jet/MET, lepton: Br = 4%

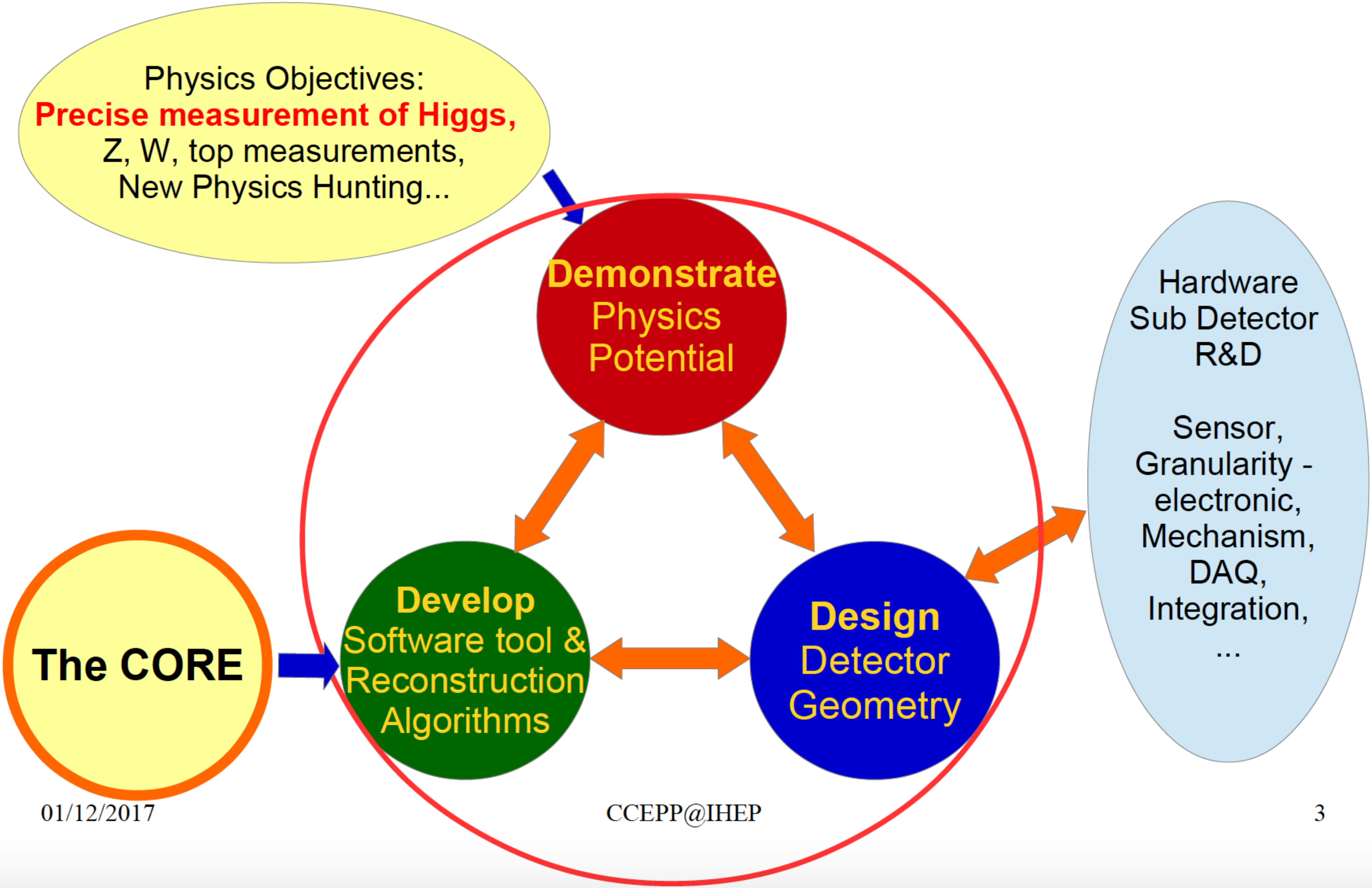
Jet Clustering: Br = 50%

Photon/ECAL: Br = 0.2%

qqH, H->inv. MET & NP: SM Br = 0.1%

EW, Br(tau->X) @ Z pole: Separation

Key SOFT ingredients



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175-v2	Higgs Signal Reconstruction at CEPC-v4 Baseline Detector when CEPC Operate at 240GeV	YongFeng Zhu	Software Higgs Physics	13 May 2018
174-v1	Higgs Signal Reconstruction at CEPC-v4 Baseline Detector for the CEPC CDR	Hang Zhao	Simulation: Full/Fast Simulation Higgs Physics	10 Apr 2018
173-v1	Detector Geometry in Model CEPC IDEA	Yin Xu	Implementation into Full Simulation Software Framework General of CEPC	27 Mar 2018
172-v1	Performance study of particle identification at the CEPC using TPC dE/dx information	fenfen An	TPC Physics at CEPC	15 Mar 2018
171-v1	Reconstruction of physics objects at the Circular Electron Positron Collider with Arbor	Manqi RUAN	Physics at CEPC General	06 Mar 2018
170-v1	Optimization for CEPC vertex	Zhigang Wu	VTX	10 Jan 2018
169-v1	PFA Oriented ECAL Optimization for the CEPC	Hang Zhao	Simulation: Full/Fast Simulation Calo	27 Dec 2017
166-v3	Jet Energy Deposition Studies with CEPC Electromagnetic Calorimeter, Hadronic Calorimeter and Muon Detector	Jifeng Hu *et al.*	Calo Muon Reconstruction Higgs Physics General of CEPC	14 Nov 2017
168-v1	Mannual of the CEPC software	Gang LI	Software	02 Nov 2017
167-v1	Full Simulation Software at CEPC	Chengdong Fu	Software	23 Oct 2017
165-v1	Physics Impact of the Solid Angle Coverage at CEPC	Peizhu Lai	Detector Design Physic Analysis	17 Oct 2017
164-v1	Jet Reconstruction at CEPC	Peizhu Lai	Detector Design Physic Analysis	17 Oct 2017

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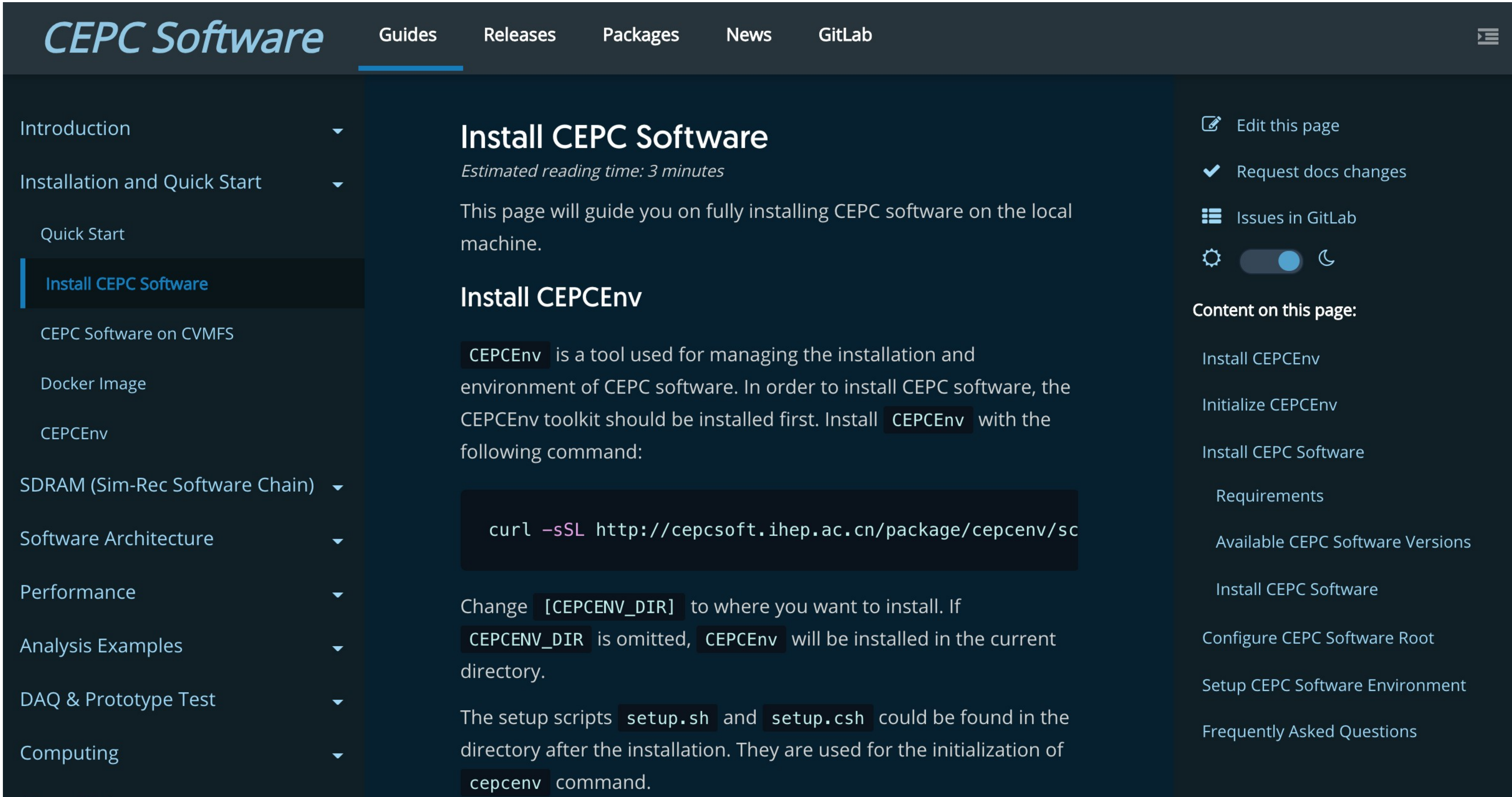
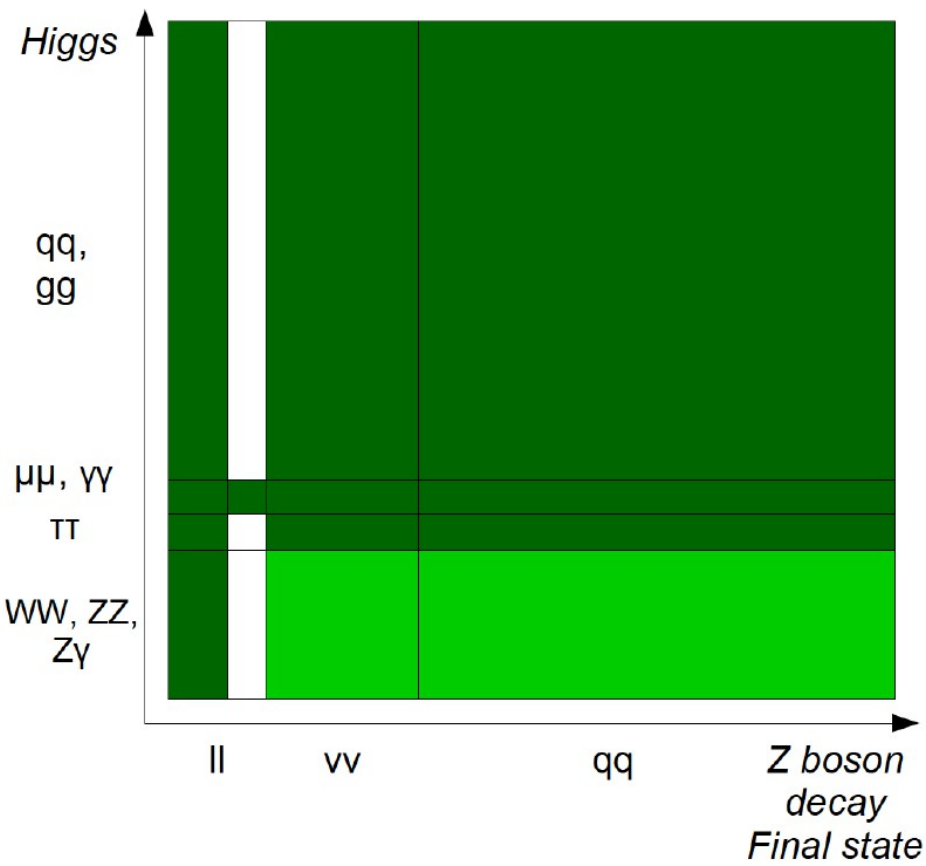


5 commands & you got the cepcsoft installed on an SL6 machine

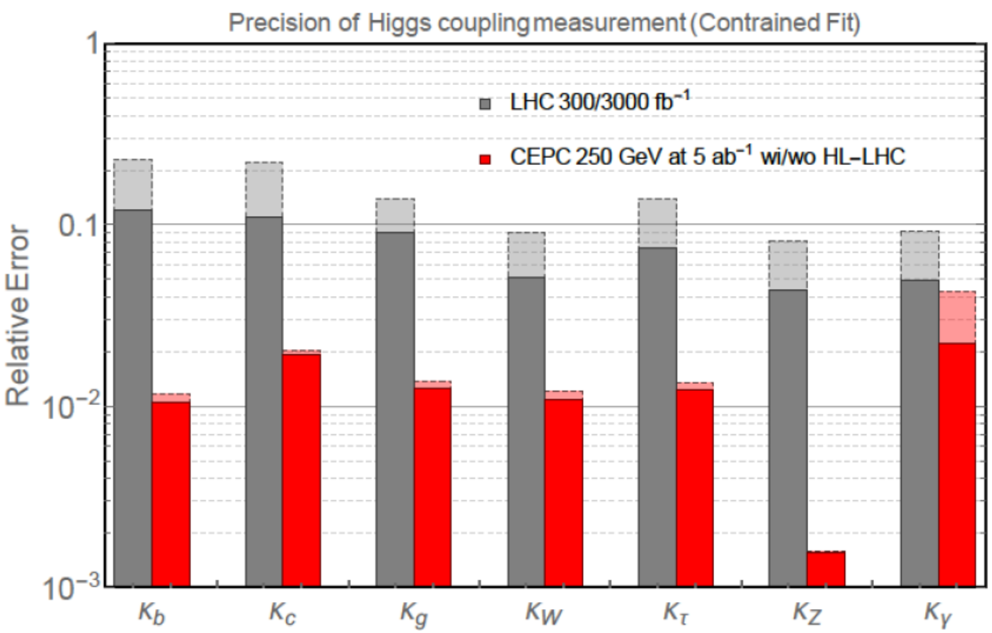
CEPC Higgs Analyses

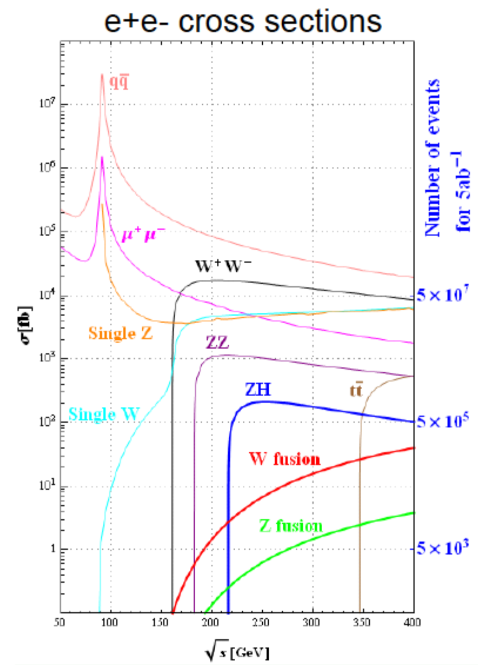


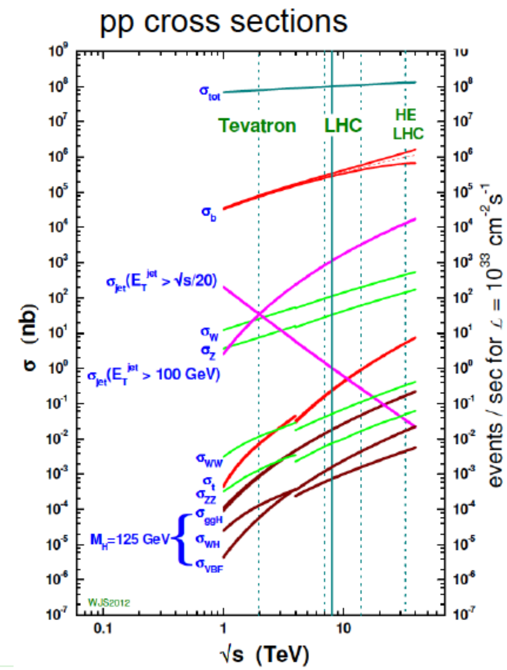
	PreCDR (Jan 2015)	Now (Aug 2016)
σ(ZH)	0.51%	0.50%
σ(ZH)*Br(H→bb)	0.28%	0.21%
σ(ZH)*Br(H→cc)	2.1%	2.5%
σ(ZH)*Br(H→gg)	1.6%	1.3%
σ(ZH)*Br(H→WW)	1.5%	1.0%
σ(ZH)*Br(H→ZZ)	4.3%	4.3%
σ(ZH)*Br(H→ττ)	1.2%	1.0%
σ(ZH)*Br(H→γγ)	9.0%	9.0%
σ(ZH)*Br(H→Zγ)	-	~4 σ
σ(ZH)*Br(H→μμ)	17%	17%
σ(ννH)*Br(H→bb)	2.8%	2.8%
Higgs 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

Higgs Physics @ CEPC-v1: event rate measurements almost fully covered
(*mostly with **old** reconstruction...*)

Higgs measurement at e+e- & pp



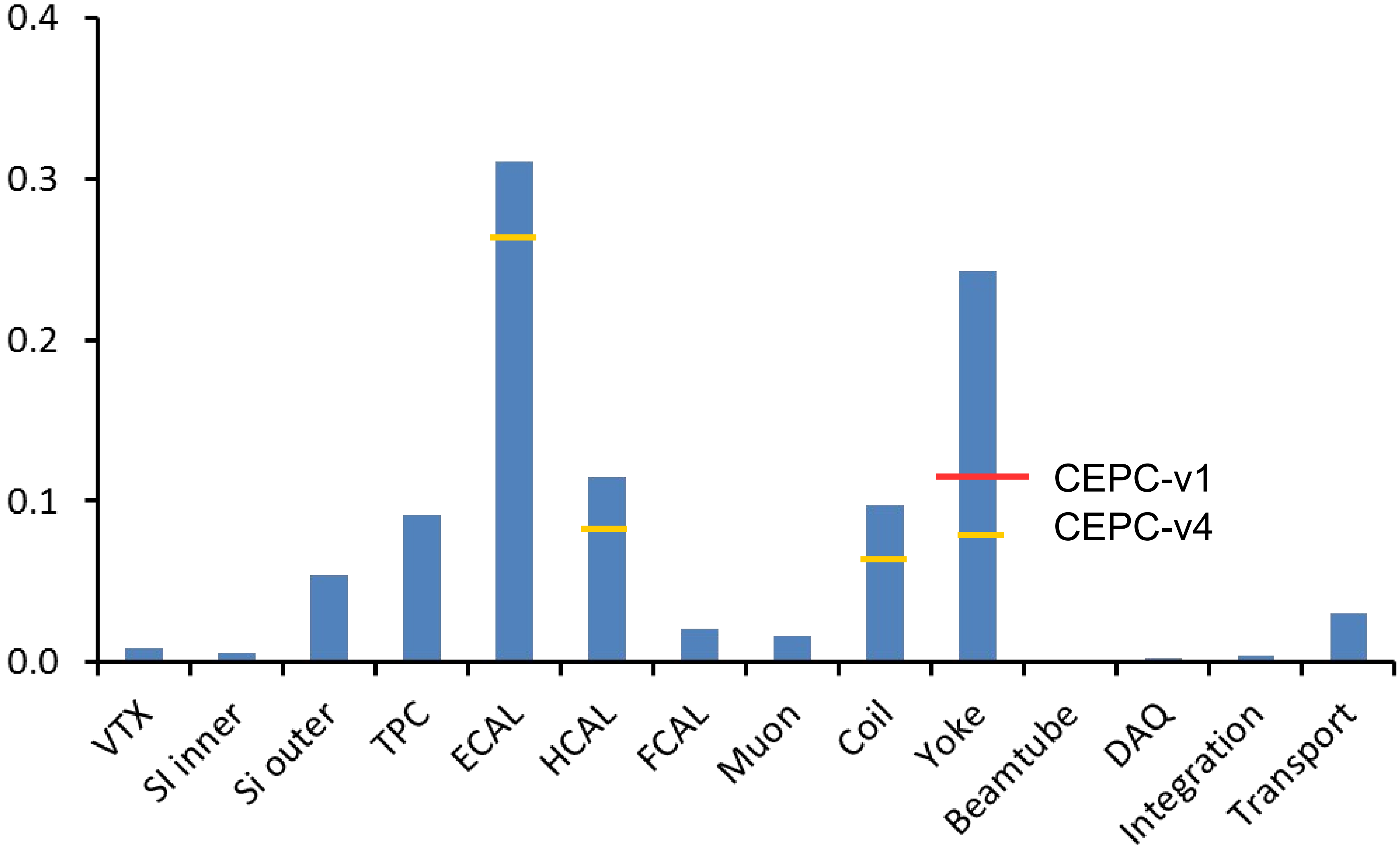




	Yield	efficiency	Comments
LHC	Run 1: 10^6 Run 2/HL: $10^{7\text{-}8}$	~o(10^{-3})	High Productivity & High background, Relative Measurements, Limited access to width, exotic ratio, etc, Direct access to g(ttH), and even g(HHH)
CEPC	10^6	**~o(1)**	Clean environment & Absolute measurement, Percentage level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

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 $(Z \rightarrow qq)$	$P(\text{uds} \rightarrow \text{b}) = 1\%$ $P(\text{c} \rightarrow \text{b}) = 10\%$
c-jets	60%	60% at Z pole runs	$P(\text{uds} \rightarrow \text{c}) = 5\%$ $P(\text{b} \rightarrow \text{c}) = 15\%$


0.4
0.3
0.2
0.1
0.0
VTX
SI inner
Si outer
TPC
ECAL
HCAL
FCAL
Muon
Coil
Yoke
Beamtube
DAQ
Integration
Transport
CEPC-v1
CEPC-v4