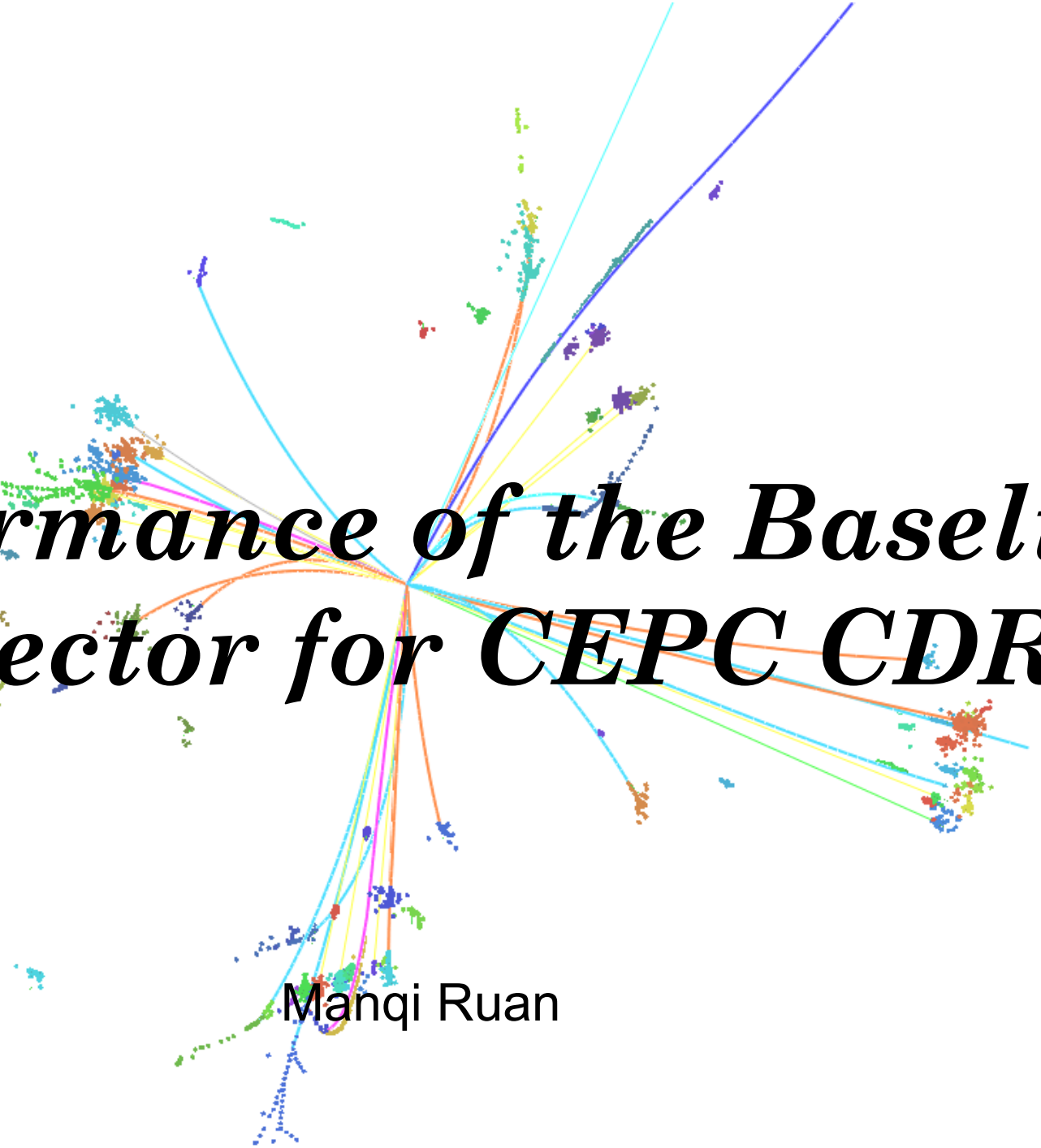
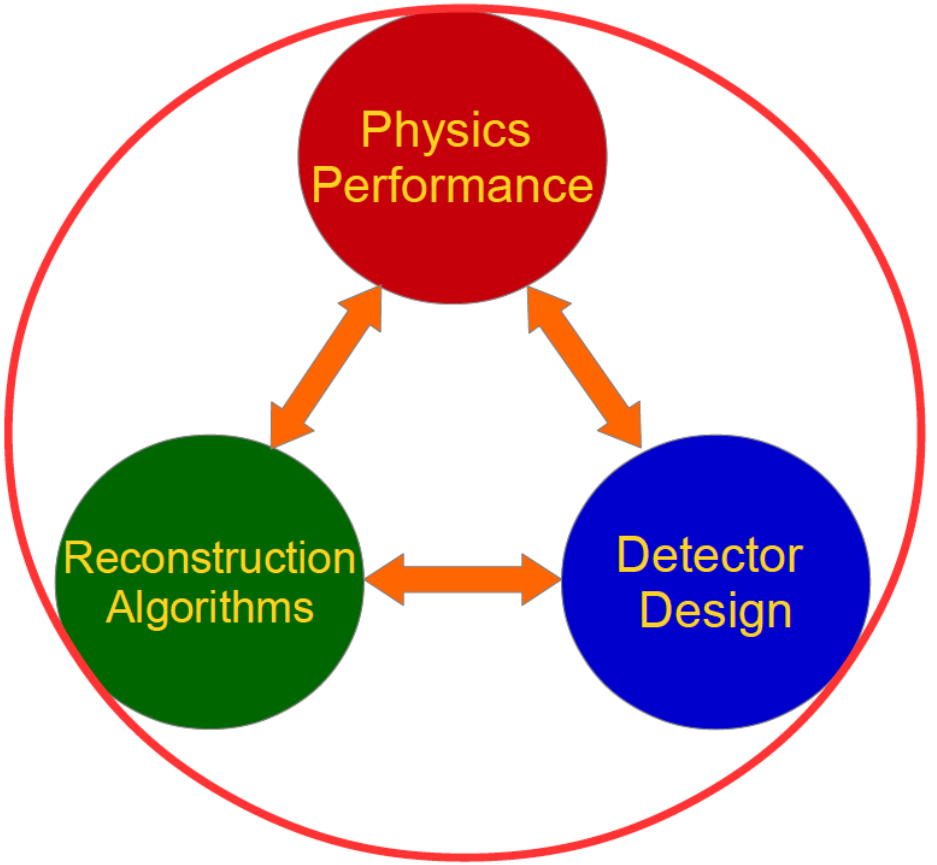


Performance of the Baseline detector for CEPC CDR

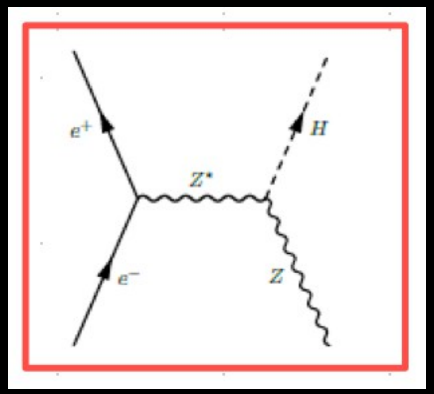
Manqi Ruan

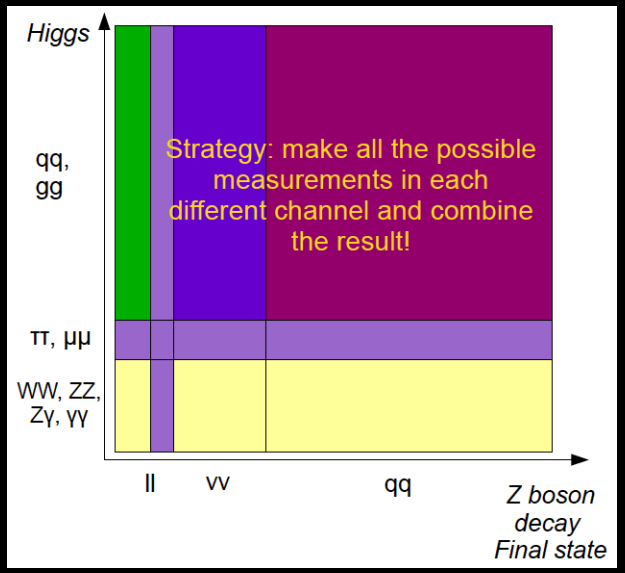
Three pillars

- Performance
  - Determined by the detector geometry & Reconstruction algorithm
  - Be characterized at
    - **Physics Objects**
    - **Higgs Signal**
    - Benchmark Physics Analyses



Reference design & Arbor

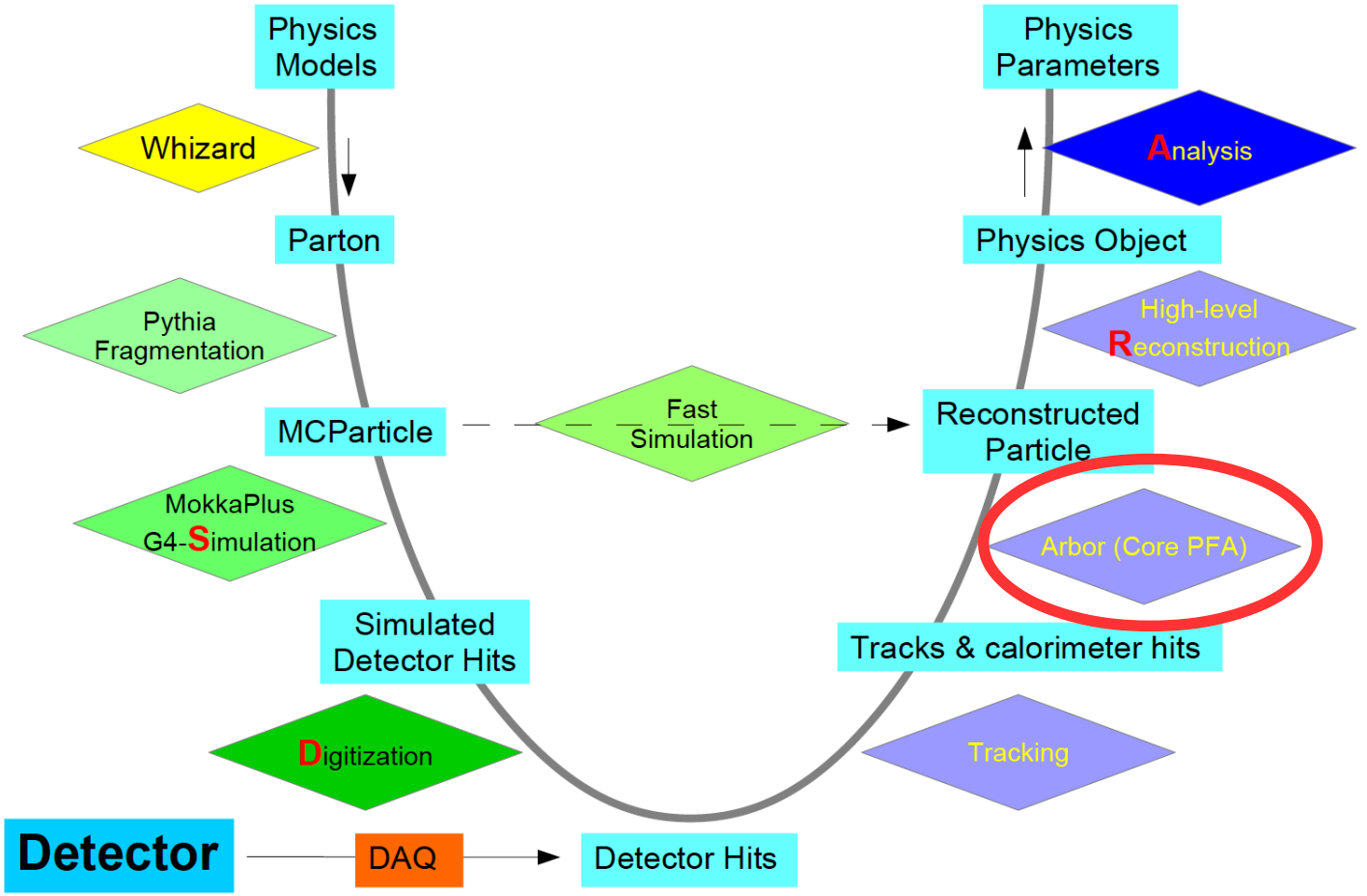




Performance at

- Lepton
- Kaon
- Photon
- Tau
- JET

Simulation-Reconstruction Chain with Arbor



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 tool | ILC soft | ILC Soft + New developments | New developments

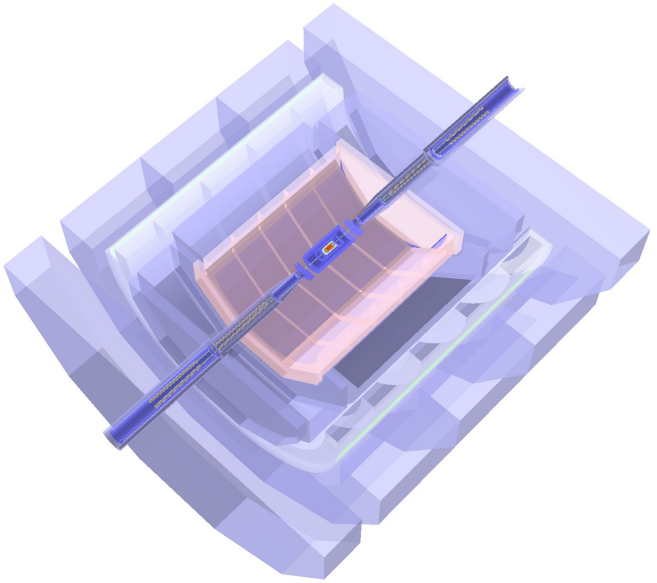
Geometry: APODIS (A PFA Oriented Detector for HIggS factory)

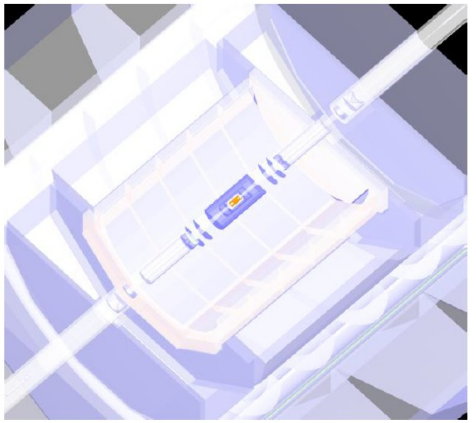
Feasibility analysis: TPC is OK for CEPC (2017 JINST 12 P07005)

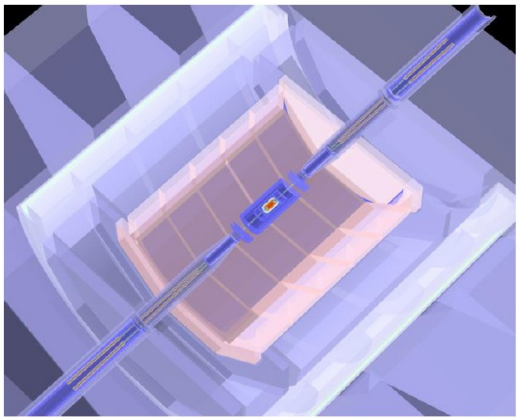
	CEPC_v1 (~ ILD)	APODIS (Optimized)	Comments
Track Radius	1.8 m	>= 1.8 m	Requested by Br(H->di muon) measurement
B Field	**3.5 T**	**3 T**	**Requested by MDI**
ToF	**-**	**50 ps**	**Requested by pi-Kaon separation at Z pole**
ECAL Thickness	84 mm	84(90) mm	Optimized on Br(H->di photon) at 250 GeV
ECAL Cell Size	5 mm	10 mm	Passive cooling request ~ 20 mm. 10 mm is required for EW measurements
ECAL NLayer	30	30	Depends on the Silicon Sensor thickness
HCAL Thickness	**1.3 m**	**1 m**	-
HCAL NLayer	**48**	**40**	Optimized on Higgs mass resolution at vvH, H->gg events at 250 GeV

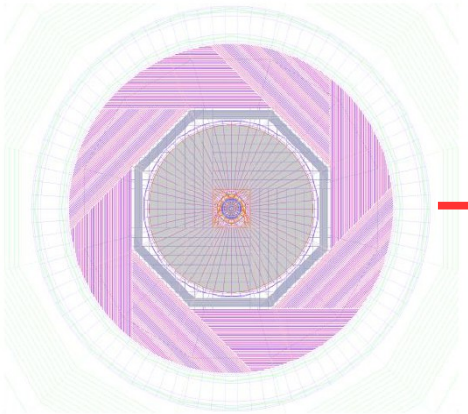
APODIS

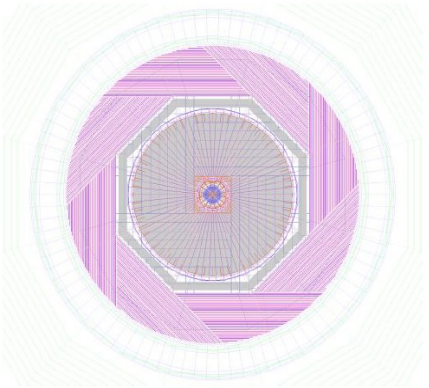
- Operational at CEPC Collision environment & Geometry parameter Optimized
- Significantly reduced Cost/Energy Consumption
  - ECAL power: 75 - 80%
  - Yoke weight: 60 -70%
  - Construction cost: 30%







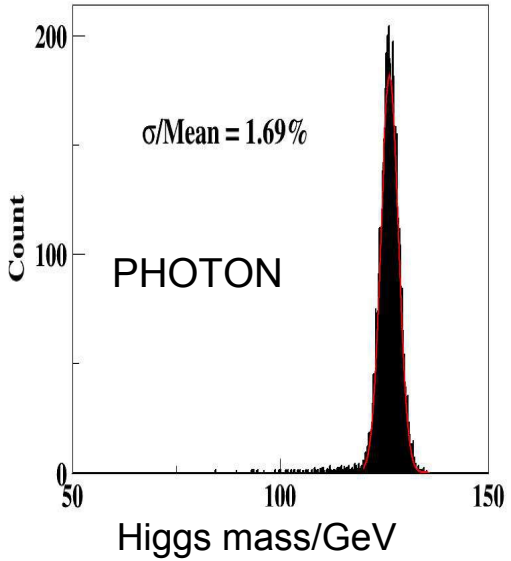


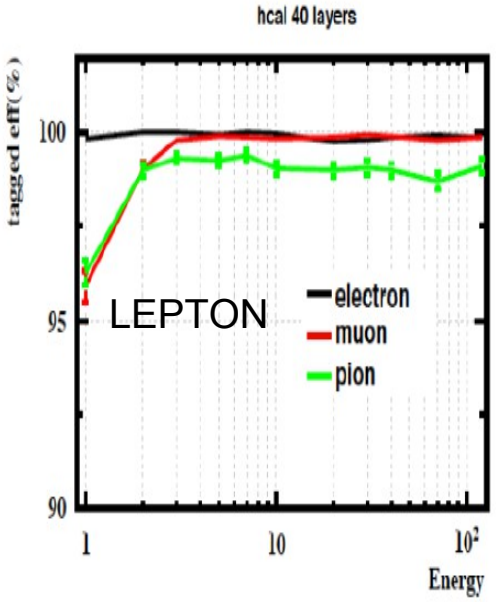


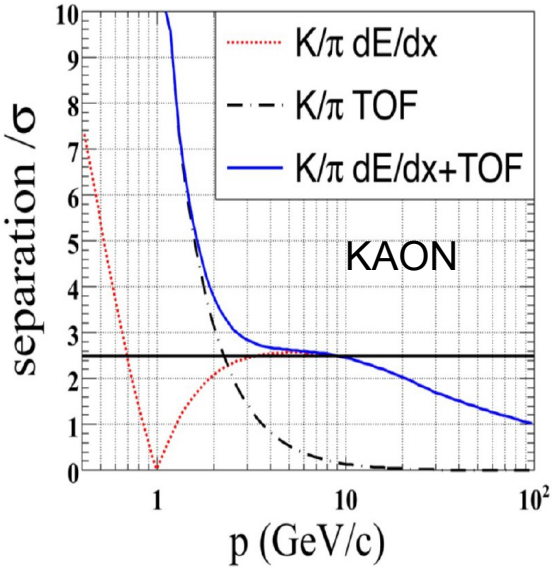
2015 PreCDR

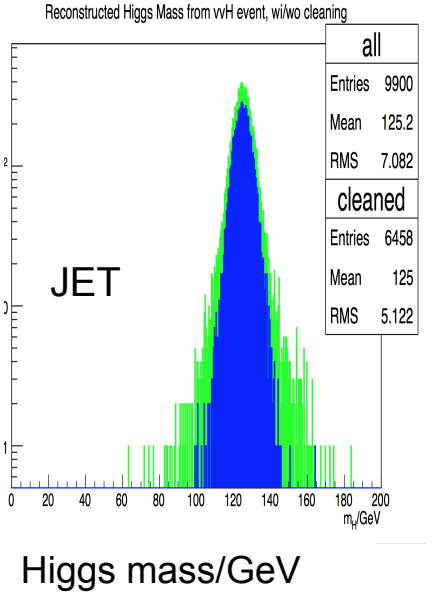
2017 CDR

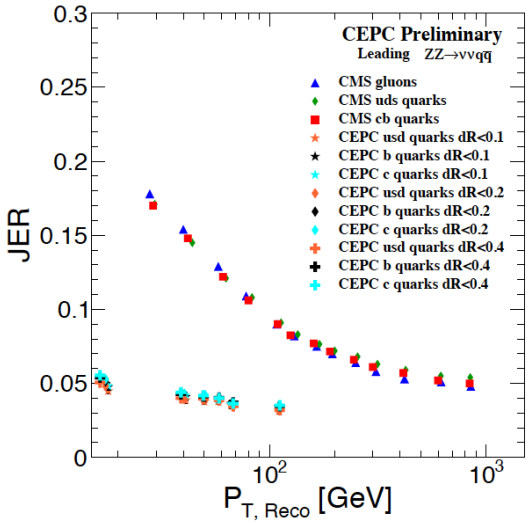
Performance at Physics Objects

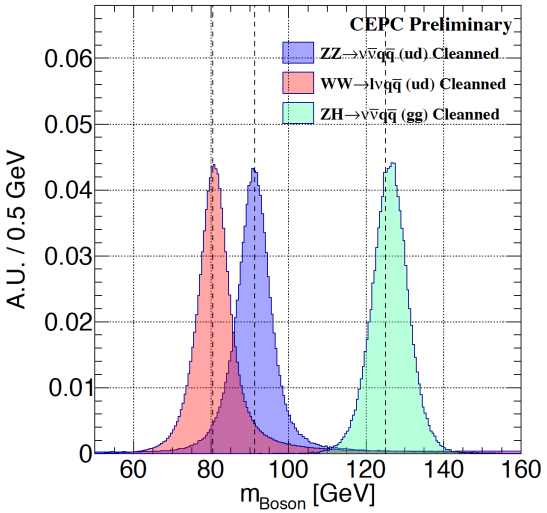


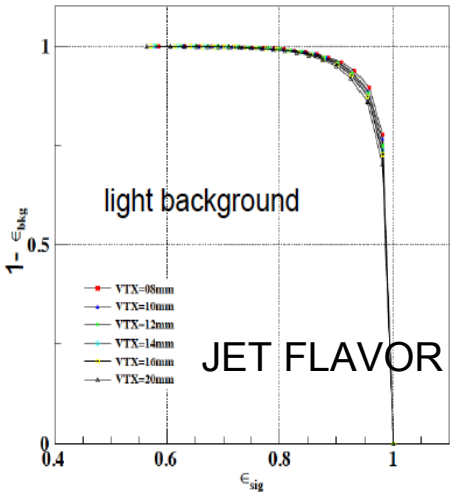


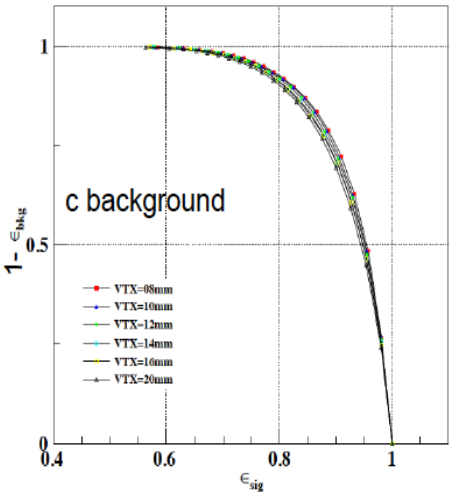




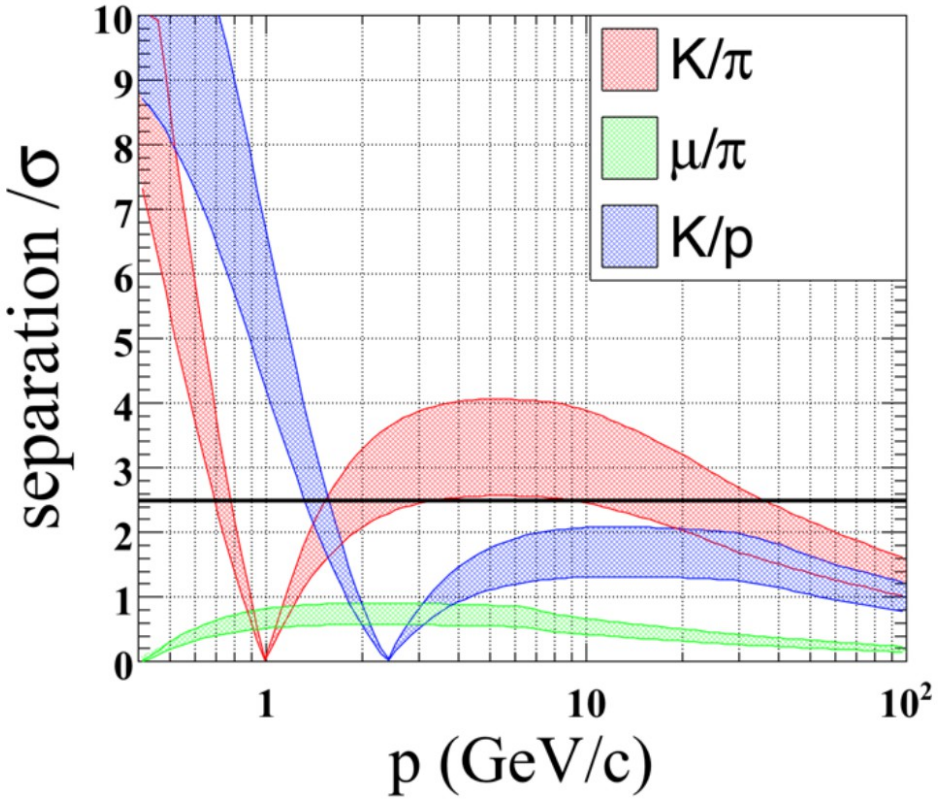


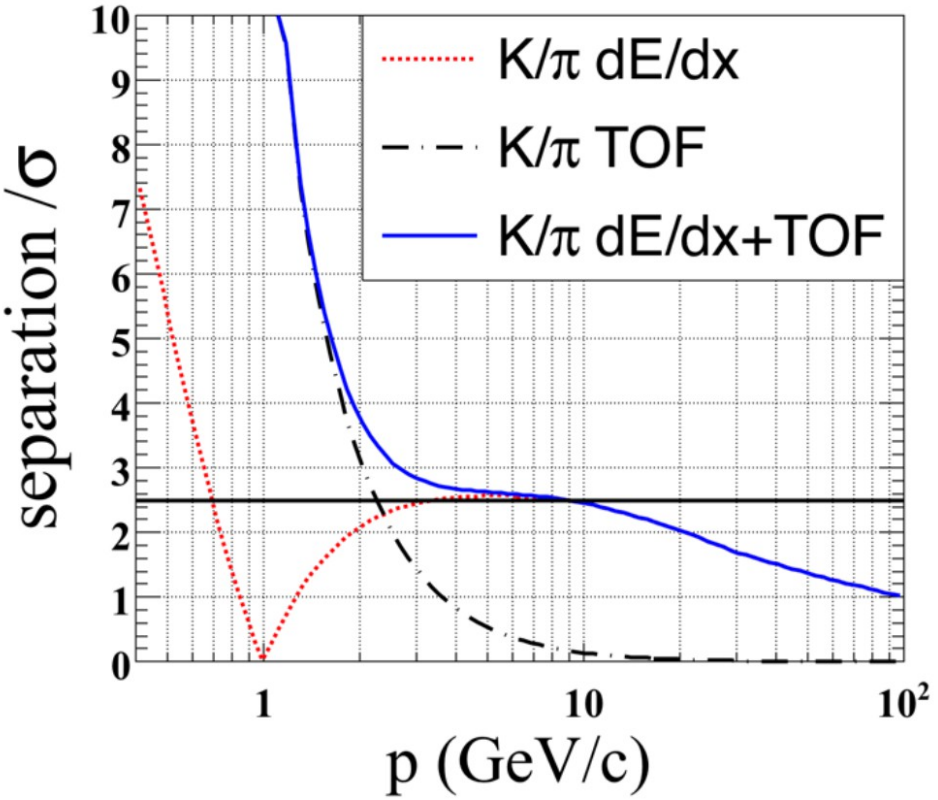






Kaon





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)

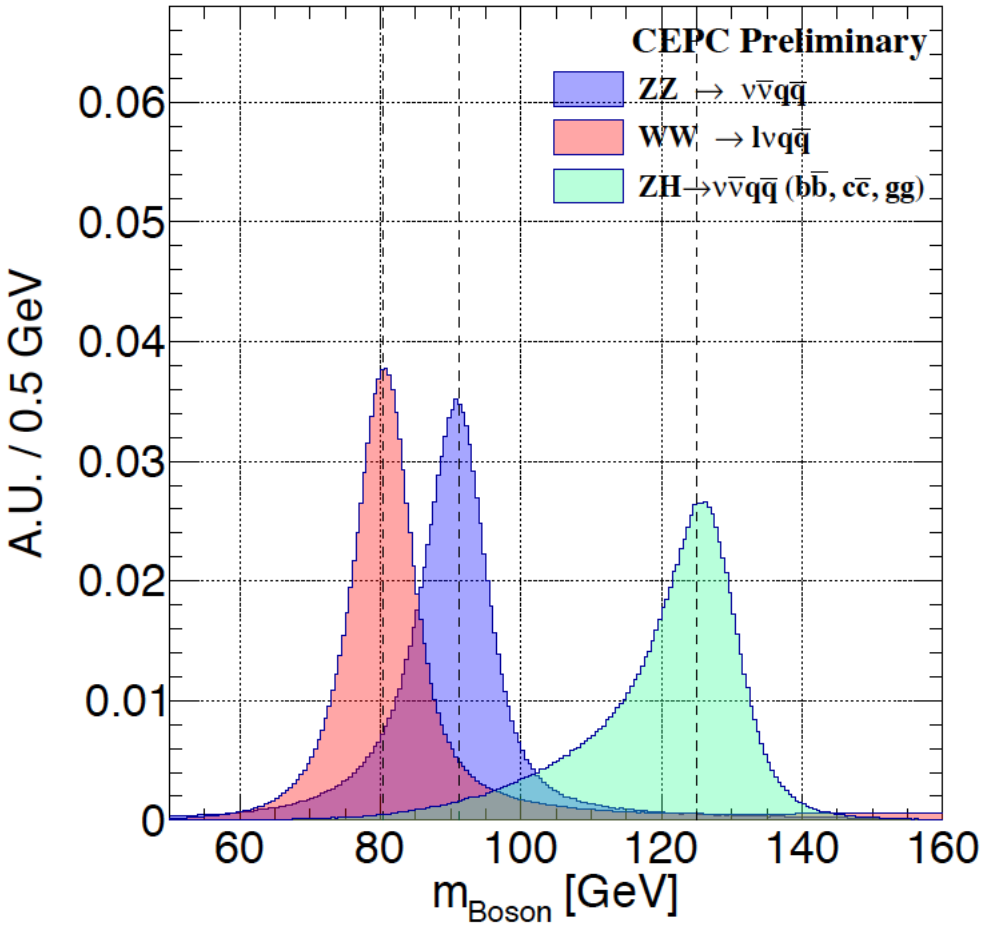
Could be improved to 96%/96% by better detector/DAQ performance (20% degrading + 50 ps ToF)

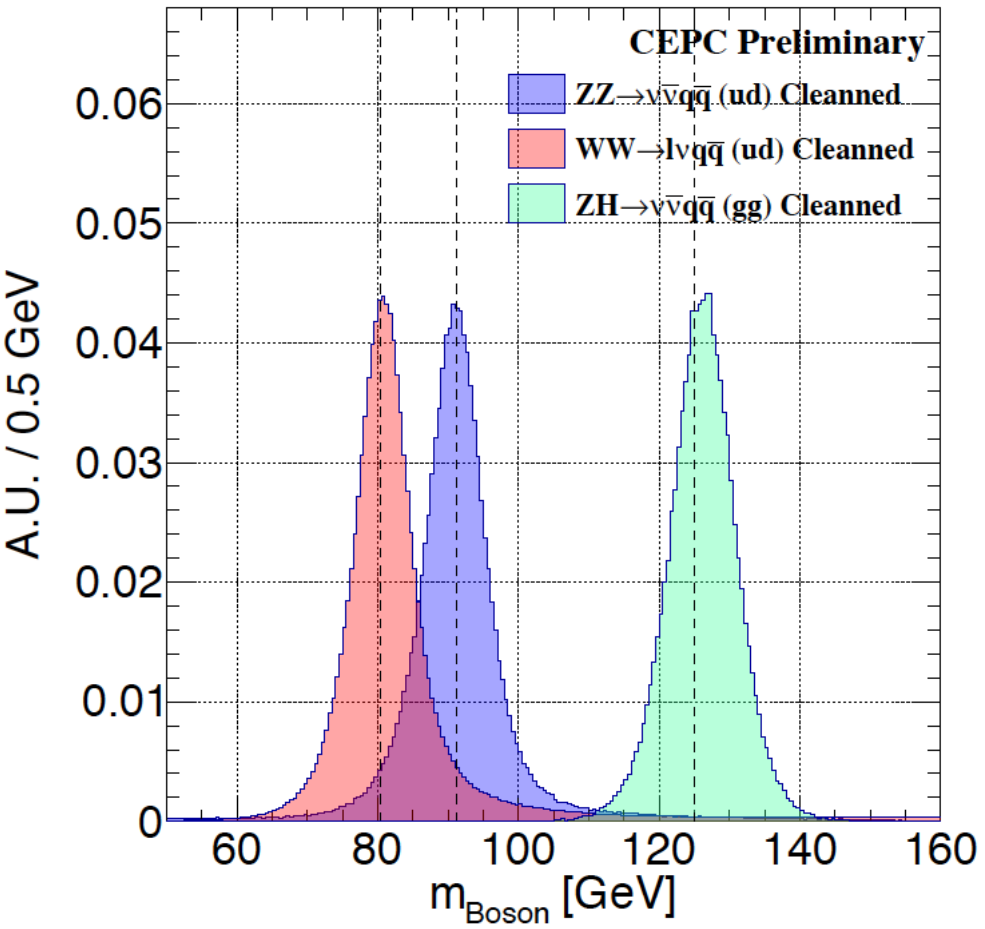
CEPC-DocDB-id: 172

https://arxiv.org/abs/1803.05134

Eur. Phys. J. C (2018) 78:464

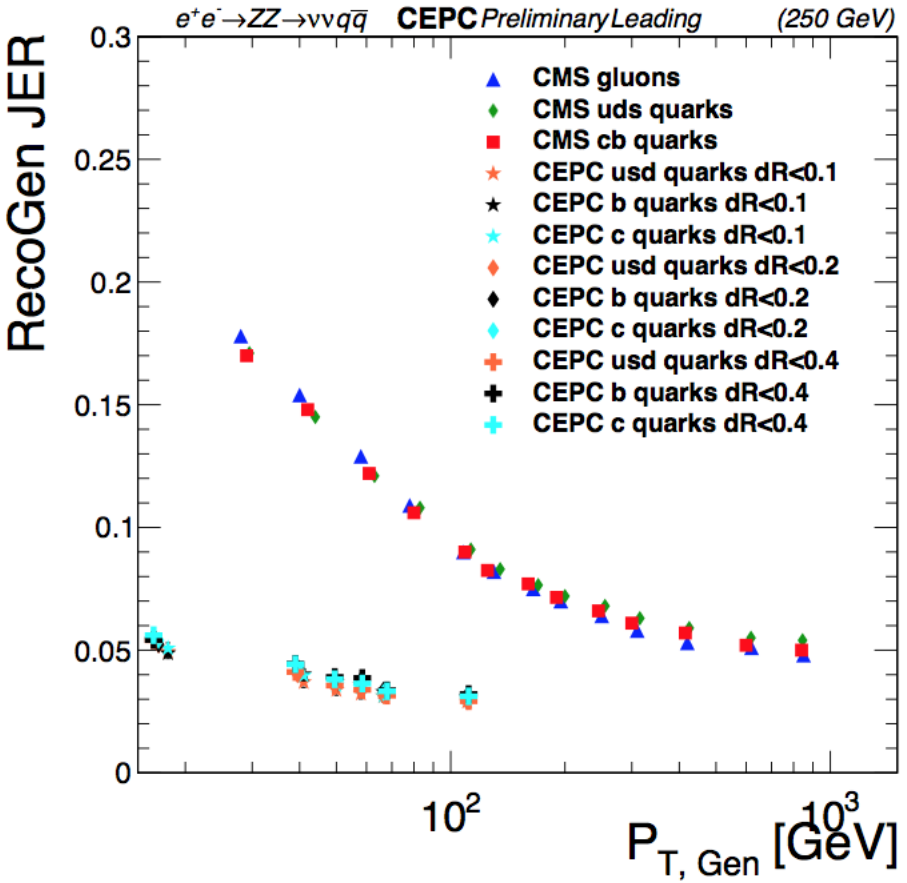
Massive Boson Separation

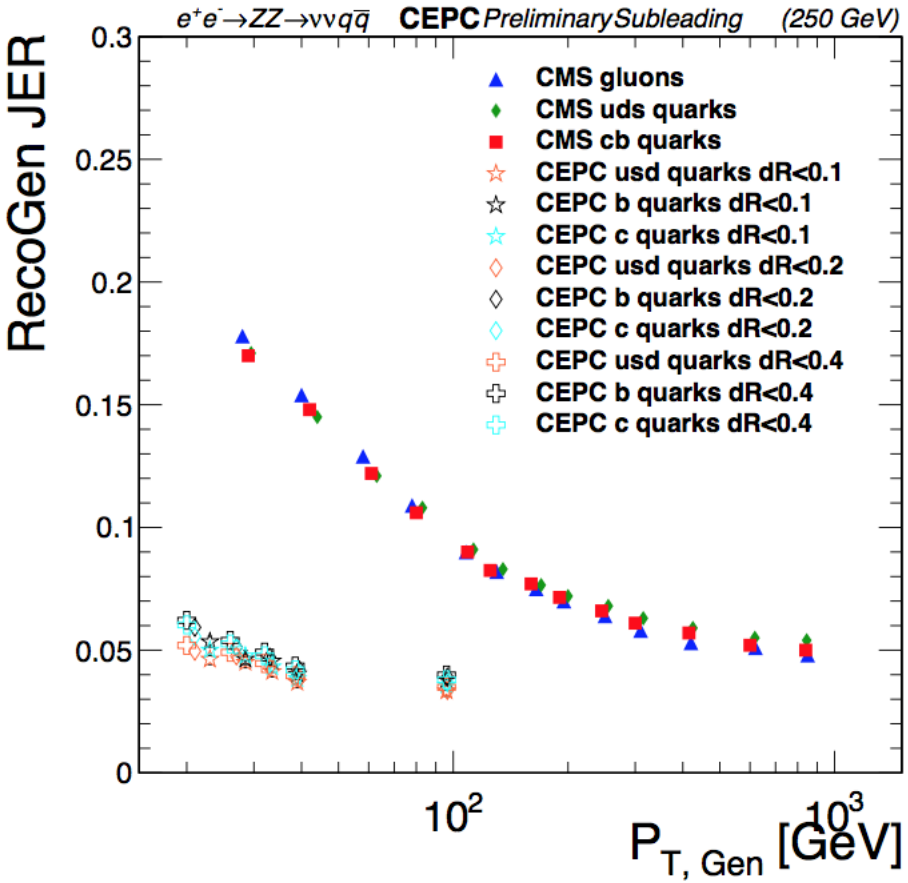




CEPC-RECO-2017-002 (DocDB id-164),
CEPC-RECO-2018-002 (DocDB id-171),
Eur.Phys.J. C78 (2018) no.5, 426

Jet Energy Resolution

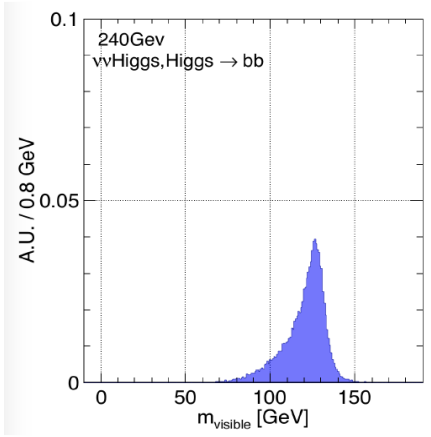


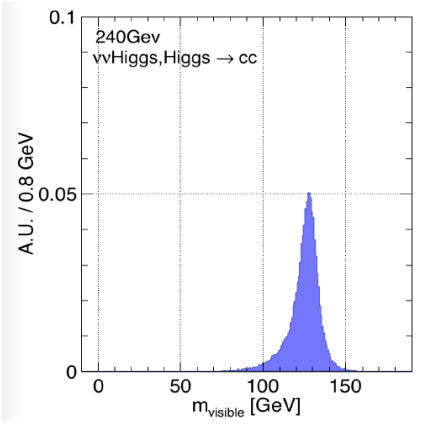


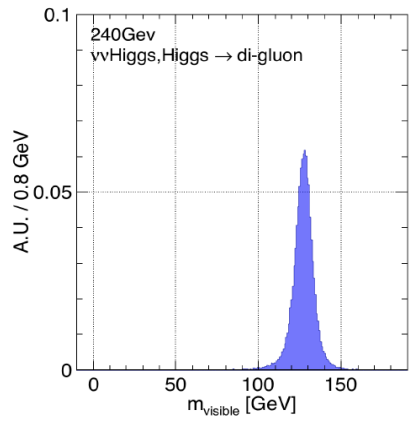
CMS Reference: CMS-JME-13-004,

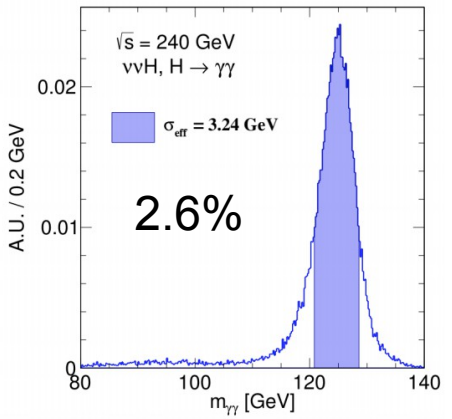
Jet energy scale and resolution in the CMS experiment in pp collisions at 8 TeV

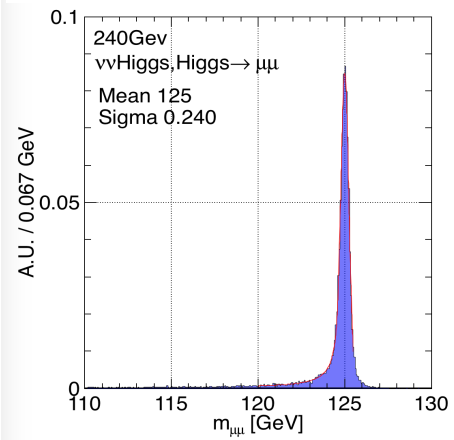
Performance at Higgs Signal: total visible mass at vvH events

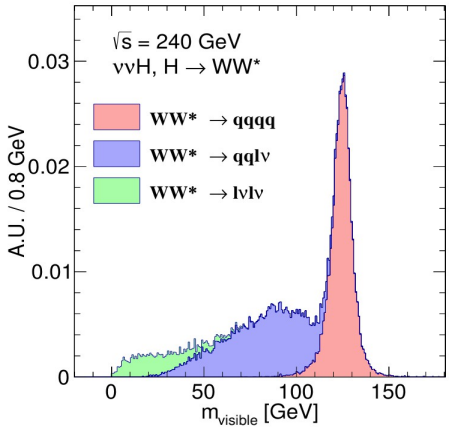


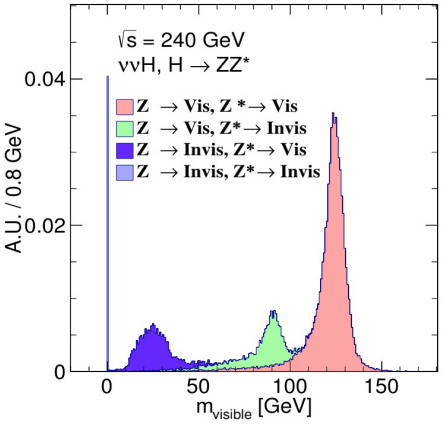












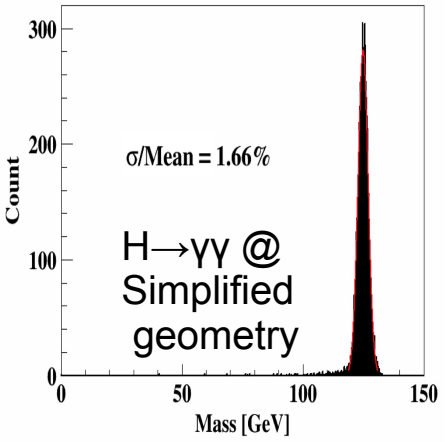


Table 2. Benchmark resolutions ($\sigma/Mean$) of reconstructed Higgs boson mass, comparing to LHC results.

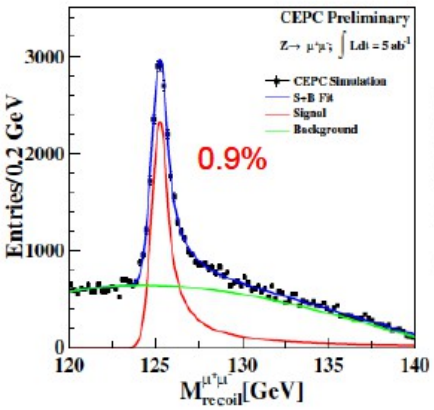
	Higgs→ $\mu\mu$	Higgs→ $\gamma\gamma$.	Higgs→bb
CEPC (APODIS)	0.20%	2.59%[1]	3.63%
LHC (CMS, ATLAS)	∼2% [19, 20]	∼1.5% [21, 22]	∼10% [23, 24]

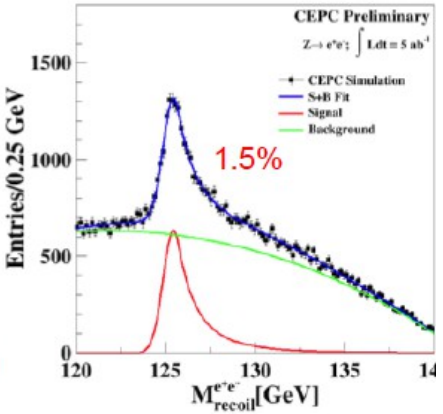
[1] primary result without geometry based correction and fine-tuned calibration.

https://arxiv.org/abs/1806.04992

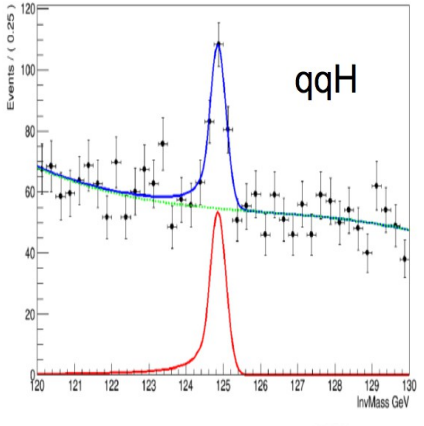
Higgs benchmark analyses...

Mostly done with CEPC-v1 geometry

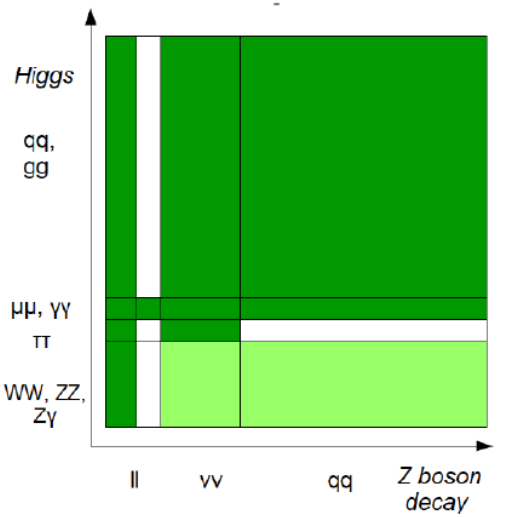


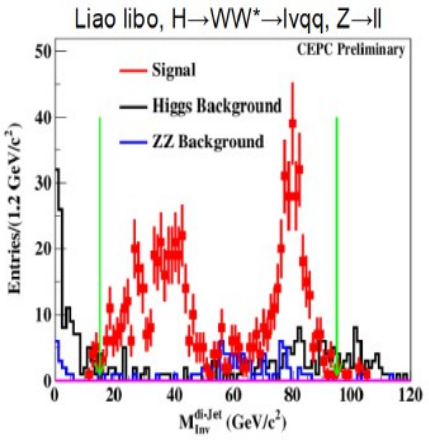


σ(ZH) measurements

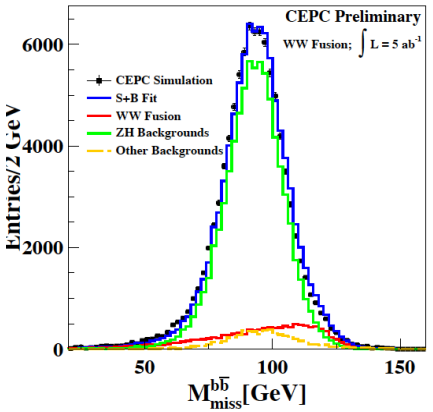


Br(H→μμ)

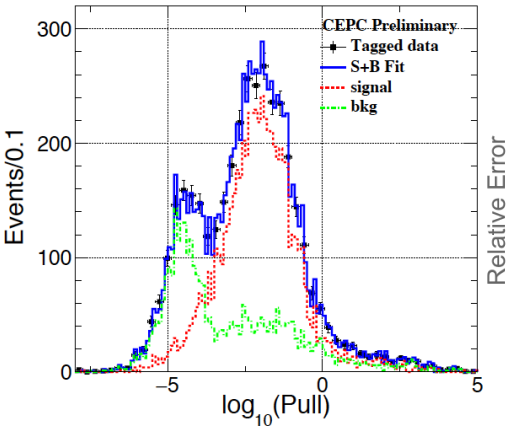




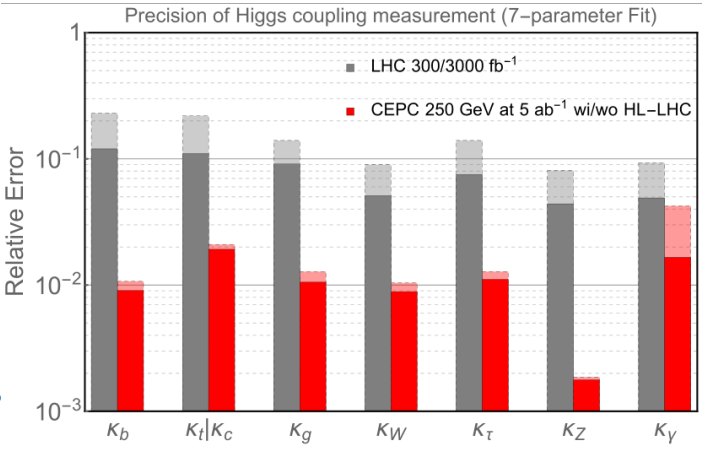
Br(H→WW)



σ(νvH)*Br(H→bb)



Br(H→ττ)

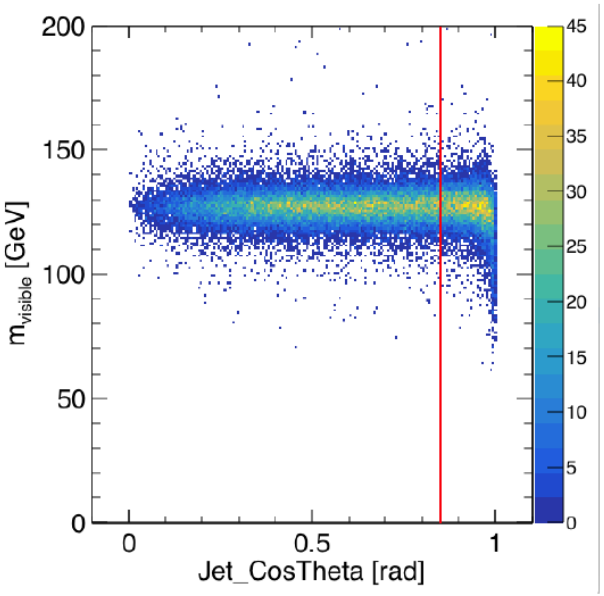


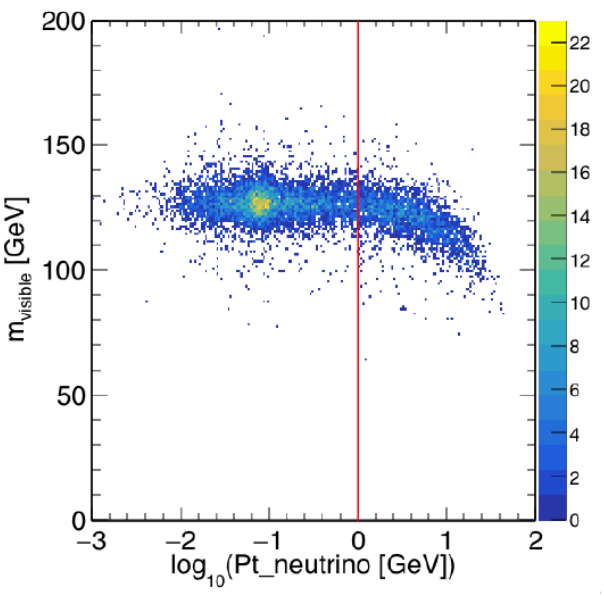
Summary

- 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

Thank you!

H to gluons: total visible mass





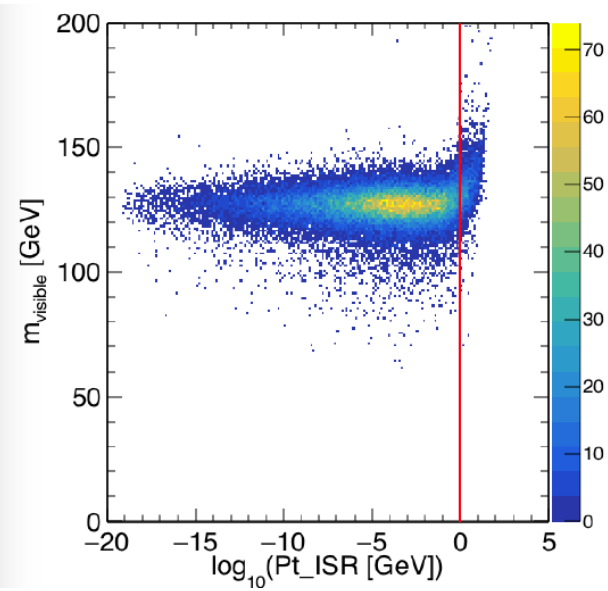
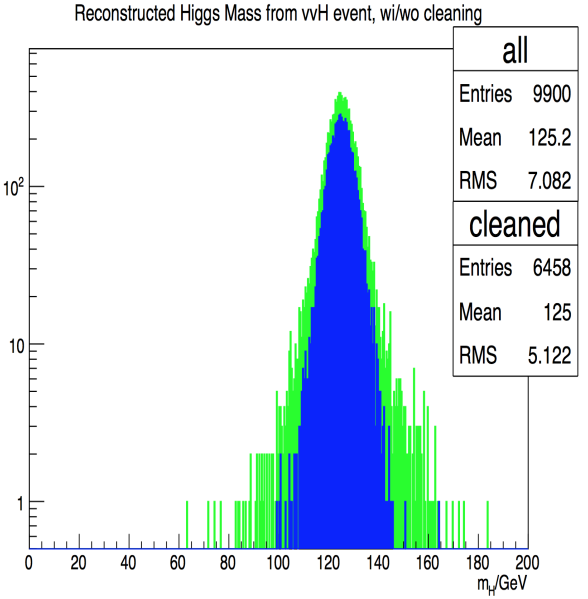


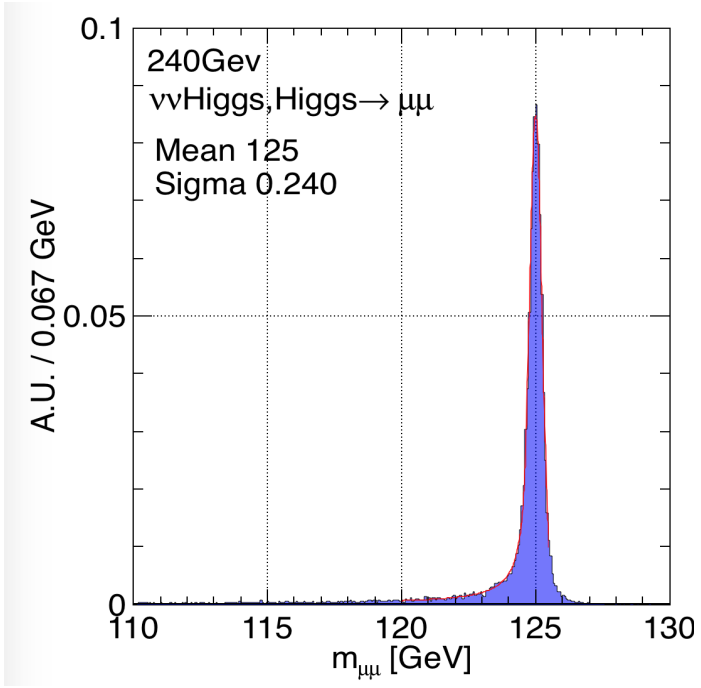
Table 1. Event selection efficiency for Higgs boson exclusive decay at CEPC with $\sqrt{s} = 240$ GeV.

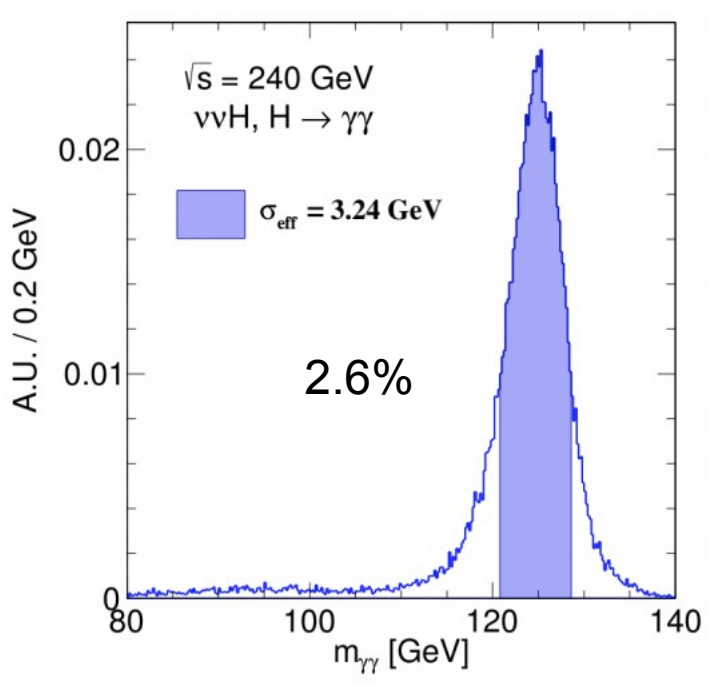
	$\mu\mu$	$\gamma\gamma$	*di_gluon*	bb	cc	*WW**	*ZZ**
Total	45000	48000	48000	45000	46000	47000.	45000
$Pt\_ISR < 1GeV$	-	95.52%	95.14%	95.37%	95.27%	95.19%	95.22%
$Pt\_neutrino < 1GeV$	-	-	89.35%	39.00%	66.30%	37.41%	41.42%
$\lvert costheta \rvert < 0.85$	-	-	67.27%	28.58%	49.23%	37.03%	40.91%

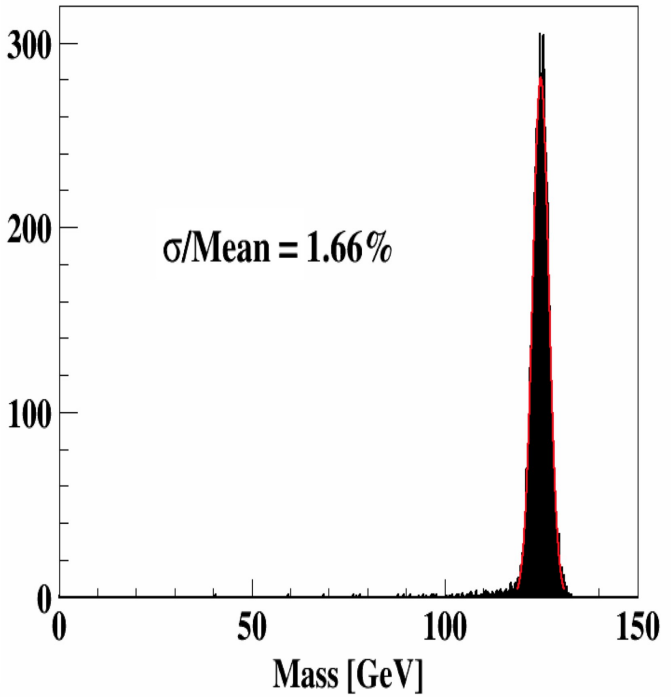


Higgs Signal at APODIS

- Tracks - Leptons & Photons





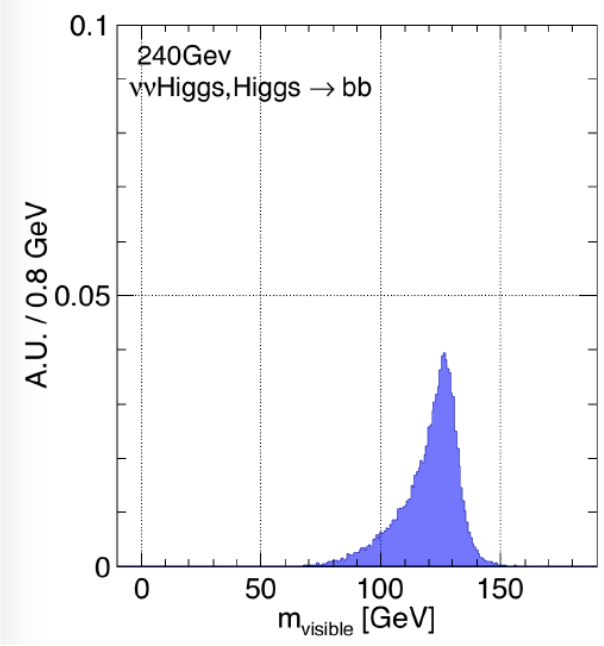


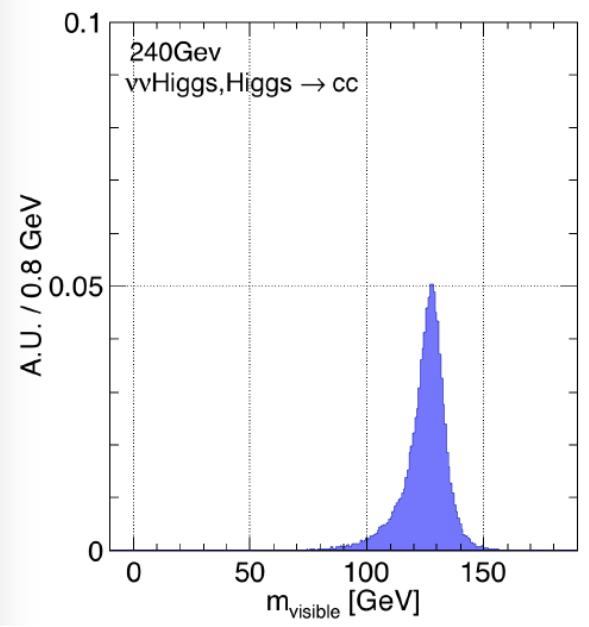
H→γγ at CEPC-v4/Simplified geometry

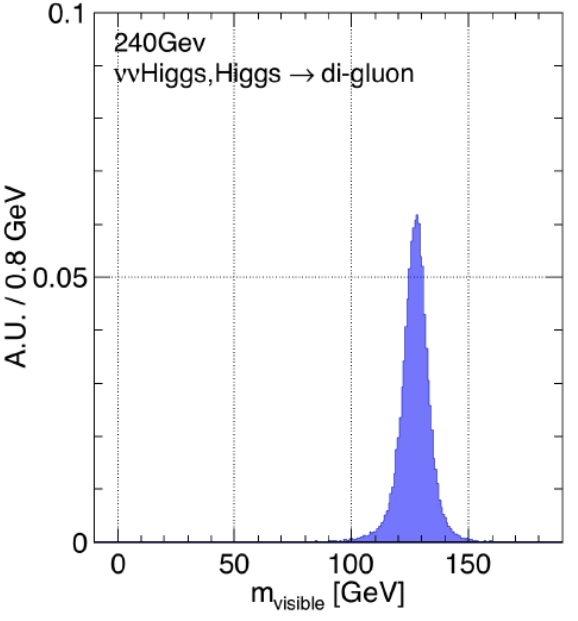
CEPC-RECO-2018-002
CEPC-Doc id 174, 175

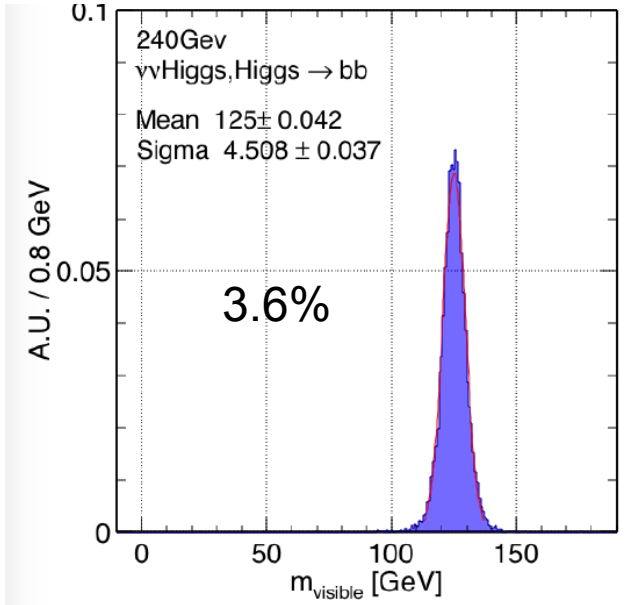
Asymmetric tails in CEPC-v4 induced by geometry defects need careful geometry corrections

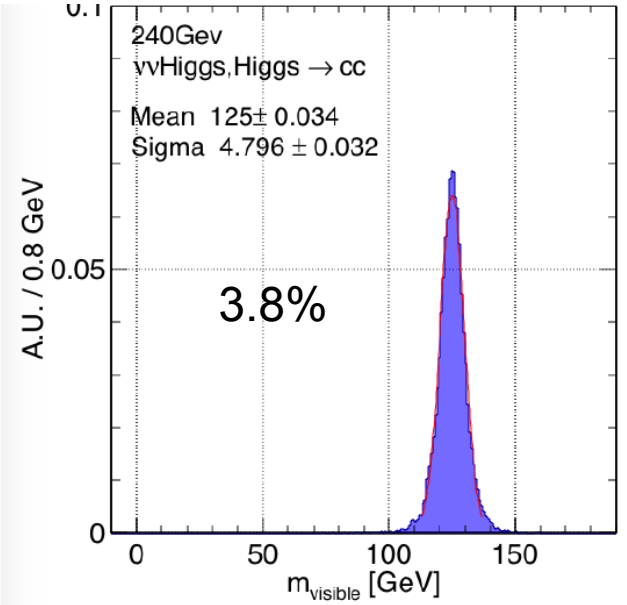
Higgs to bb, cc, gg

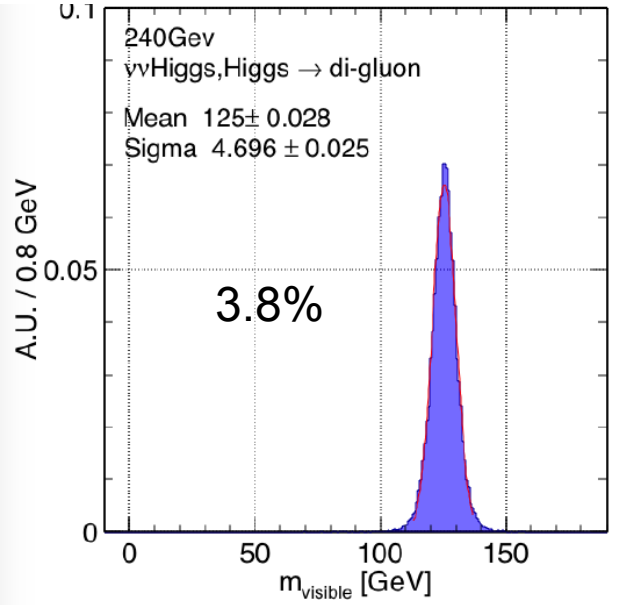




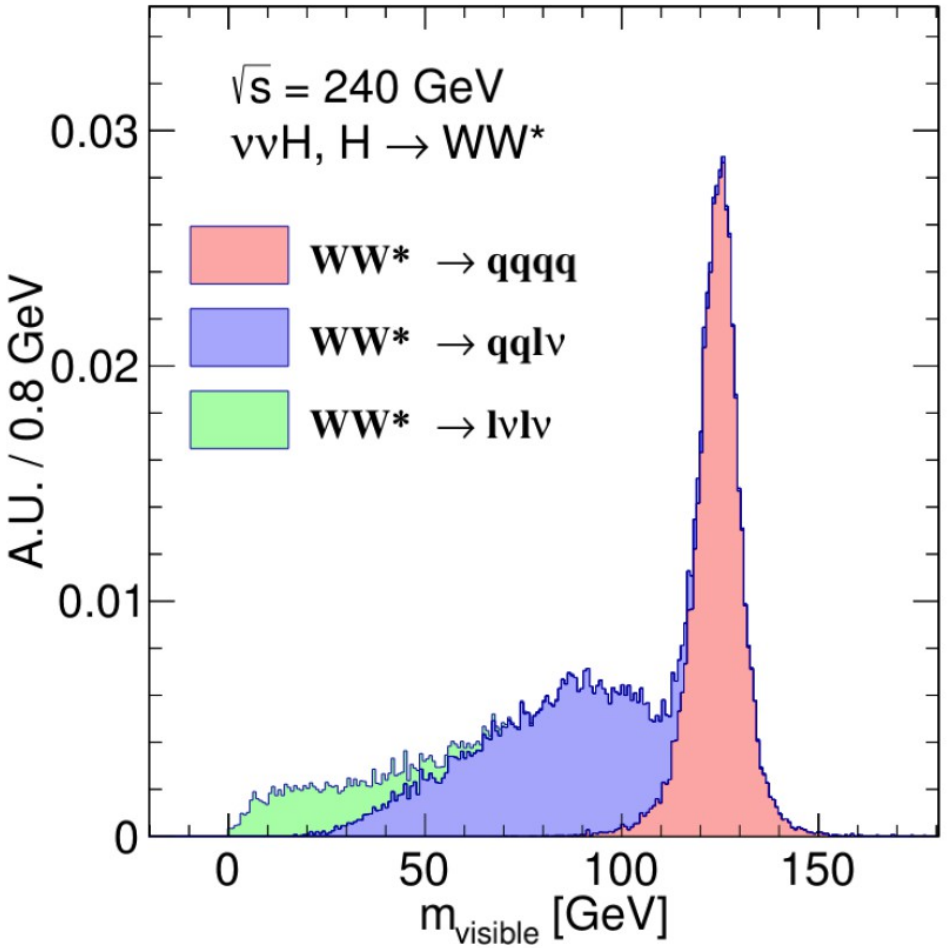








Higgs to WW, ZZ



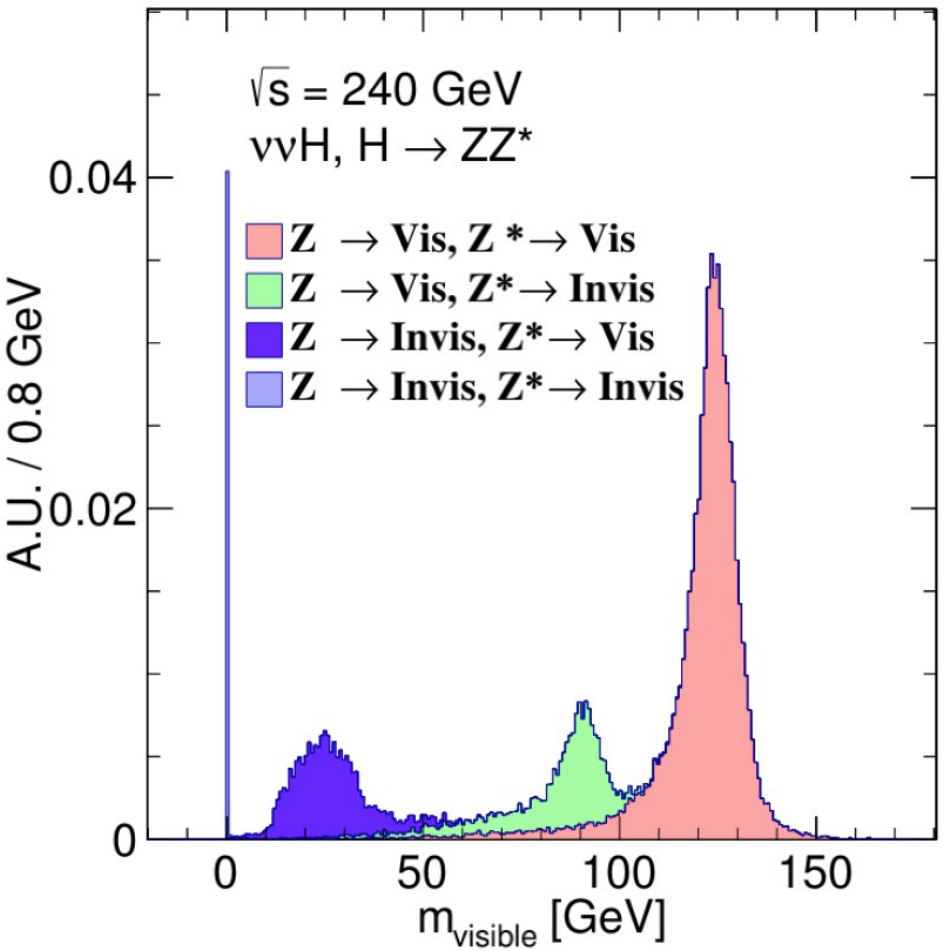


Table 2. Benchmark resolutions ($\sigma/Mean$) of reconstructed Higgs boson mass, comparing to LHC results.

	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