CEPCSW Analysis Tutorial

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Beginning

- We assume you are familiar with:
  - Linux, git, ssh
  - C++/Python
  - ROOT

Also, you should have one IHEP computing account.
If you belong to other experiments, request the sub-group “higgs” under:
http://ccsuser.ihep.ac.cn/

Get access to IHEP Cluster

Windows: WSL, vscode, putty, mingw, Mobaxterm……
Linux/Mac: your terminal

ssh –XY provides X11 forwarding.
(mobaxterm for windows)

- ssh youraccount@lxlogin.ac.cn
- export PATH=/cvmfs/container.ihep.ac.cn/bin:$PATH
- hep_container shell CentOS7 -g higgs
- You will see:

```
Singularity>
```

Alternatively, you can also use CEPCSW outside of the Centos7 container.

For hepjob, add this to your bashrc:
export PATH=/cvmfs/common.ihep.ac.cn/software/hepjob/bin:$PATH

Found CEPCSW

Currently 2025/01/15, latest release tdr25.1.1.

- If you do not need any changes for CEPCSW, use the official release:
  - source /cvmfs/cepcsw.ihep.ac.cn/prototype/releases/tdr25.1.1/CEPCSW/setup.sh

  To test:

  - cd /cvmfs/cepcsw.ihep.ac.cn/prototype/releases/tdr25.1.1/CEPCSW/
  - ./run.sh Examples/options/helloalg.py

```
Singularity> ./run.sh Examples/options/helloalg.py
# setting LC_ALL to "C"
# --> Including file '/cvmfs/cepcsw.ihep.ac.cn/prototype/releases/tdr24.10.0/CEPCSW/Examples/options/helloalg.py'
# <-- End of file '/cvmfs/cepcsw.ihep.ac.cn/prototype/releases/tdr24.10.0/CEPCSW/Examples/options/helloalg.py'
ApplicationMgr    SUCCESS
================================================================================================================================
=========
                                                  Welcome to ApplicationMgr (GaudiCoreSvc v36r16)
                                        running on lxlogin003.ihep.ac.cn on Sat Oct 26 14:52:13 2024
================================================================================================================================
=========
ApplicationMgr       INFO Application Manager Configured successfully
helloAlg             INFO MyInt: 42
EventLoopMgr      WARNING Unable to locate service "EventSelector"
EventLoopMgr      WARNING No events will be processed from external input.
ApplicationMgr       INFO Application Manager Initialized successfully
ApplicationMgr       INFO Application Manager Started successfully
ApplicationMgr       INFO Application Manager Stopped successfully
EventLoopMgr         INFO Histograms converted successfully according to request.
ApplicationMgr       INFO Application Manager Finalized successfully
ApplicationMgr       INFO Application Manager Terminated successfully
```

Your CEPCSW

you /afs only 500M. Maybe in /cefs/higgs/your directory.
If you build your CEPCSW in container, always in container.
If you build your CEPCSW without container, always without container.

- If you would like maintain your own fork:
  - Login https://code.ihep.ac.cn
  - Manage your own ssh key
  - Fork

    https://code.ihep.ac.cn/cepc/CEPCSW
  - git clone

    git@code.ihep.ac.cn:you/CEPCSW.git

- git clone https://code.ihep.ac.cn/cepc/CEPCSW.git
  - cd CEPCSW
  - git checkout tdr25.1.1
  - source setup.sh
  - ./build.sh
  - source setup.sh
  - ./run.sh Examples/options/helloalg.py

Your second process

- copy scripts in Reconstruction/RecPFACyber/script/ to your working dir.
  - Run them one by one
  - ./run.sh sim.py
  - ./run.sh digi.py
  - ./run.sh tracking.py
  - ./runsh rec.py

sim.py performs GEANT4 full simulation.
use stdhep file as input.

Calo Digitalization

Track reconstruction

Get CyberPFO containers
Extra: run ana.py for jet clustering

Scripts you may modify:

- Sim.py stdheprdr.Input =

  /cefs/higgs/zhangkl/stdhep/E240/higgs/E240.Pnnh_e2e2.e0.p0.whizard195/nnh_e2e2.e0.p0.0001.stdhep “

- rec.py out.filename = "Rec_TDR_o1_v01.root"

Found other samples in data dirs.

- rec.py EvtMax=10

Do not run too much events in front end.

Optional: Generator input

- Generator and CEPCSW are decoupled.
  - You can use either stdhep/HepMC/Hepevt/slcio/ParticleGun as input.
  - Existing stdheps in /cefs/higgs/zhangkl/stdhep
- Normal users are not suggested to generate your own sample
  - Limited computing source and disk quota.
  - Most SM sample will be officially provided for CEPC240/360 with Whizard1.9.5.
  - For generating stdhep files, https://code.ihep.ac.cn/zhangkl/whizardais
  - Whizard1.9.5 with ISR. If you use MadGraph or other processes, validate them.

Optional: job submitting

- git clone https://code.ihep.ac.cn/zhangkl/cepcsw_tutorial.git
- cd cepcsw_tutorial/scripts
- See script for submitting jobs
  - Please only submit when you know what you are doing.
- Template temp_*.py and CEPC*.sh

```
unset PYTHONHOME
```
You may need this if hep_sub not correctly set;
```
-os CentOS7
```
You can submit CEPCSW jobs either in containers or not.
But be consistent with your cepcsw build.
```
-g higgs
```
Can also be other groups like ATLAS.
```
-mem 8000
```
Memory setting. At least 6G needed.

Structure of outputs

- root –b Rec_TDR_o1_v01.root
- .ls
- events->Print()
- events->Show(0)
- PFO objects as ntuple
  - Information is lost in ntuple stage. To get all information, use packages in CEPCSW.

```
Warning in <TClass::Init>: no dictionary for class podio::ObjectID is available
Warning in <TClass::Init>: no dictionary for class edm4hep::Vector3f is available
Warning in <TClass::Init>: no dictionary for class edm4hep::Vector3d is available
Warning in <TClass::Init>: no dictionary for class edm4hep::MCParticleData is available
Warning in <TClass::Init>: no dictionary for class edm4hep::Vector2i is available
Warning in <TClass::Init>: no dictionary for class edm4hep::ReconstructedParticleData is available
Warning in <TClass::Init>: no dictionary for class podio::GenericParameters is available
Warning in <TClass::Init>: no dictionary for class podio::CollectionIDTable is available
Warning in <TClass::Init>: no dictionary for class podio::version::Version is available
(TFile *) 0x1cc8b30
```

This indicates that you are not in CEPCSW env. However, you don’t need it for ntuple reading.

Tree events are organized like normal ntuple. You can play with it with your good old tools.

Developing codes in CEPCSW

- Examples in
  - Analysis/GenMatch Jet Clustering and parameters to store
  - Analysis/AnalysisPID PID implement

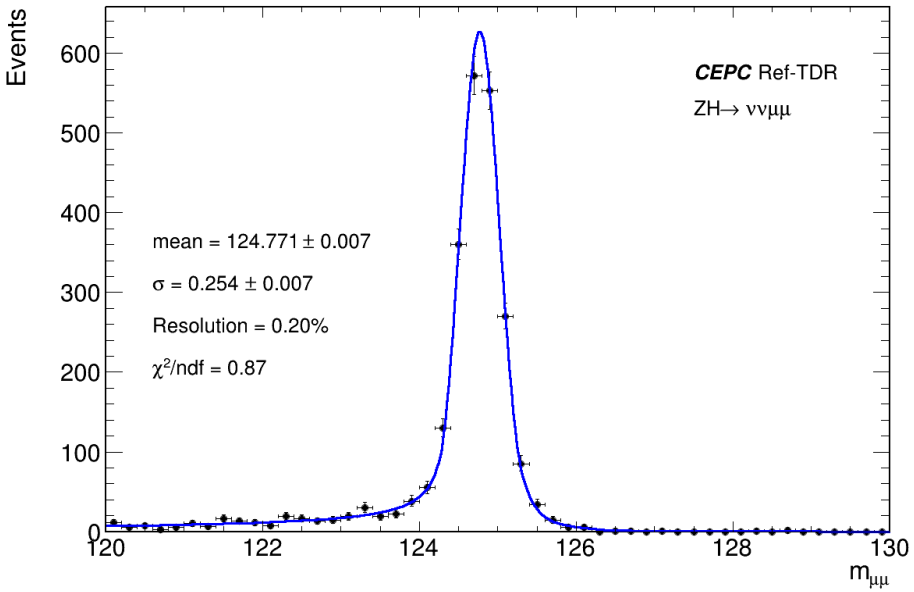
Analysis: Dimuon mass plot

- cd cepcsw_tutorial/analysis
- root –b Reader_CEPCSW_mmGenmatch.cxx

Analysis codes

- CEPCStyle.h: Recommended to use in CEPC.
- TChain + TTreeReader(Array);
- CyberPFO for reco and MCParticleGen for truth info.
- Gen-Reco Match by DeltaR
- RooFit: DSCB Fit
- 1D/2D plotting, formatting

Please explore more after the tutorial.



TDR physics

	Process @ c.m.e	Domain	Relevant Det. Performance
Z→μμ	Z@ 91.2 GeV	Z	lepton ID, tracking
H→γγ	qqH	Higgs	photon ID, EM resolution
Higgs recoil	$\ell\ell$H	Higgs	Lepton ID, track dP/P
H→ss	ννH @ 240 GeV	Higgs	PID, Vertexing, PFA + JOI
H→inv	qqH	Higgs/NP	PFA, MET
Vcs/Vcb	WW→ℓνqq @ 240/160 GeV	Flavor	PFA, JOI + PID (lepton, tau)
H→LLP	$\ell\ell$H	NP	TPC, TOF, calo, muon detectors
H→μμ	qqH	Higgs	lepton ID, tracking, OTK
Top mass & width	Threshold scan @ 360 GeV	EW	Beam energy
Weak mixing angle	Z→bb @ 91.2 GeV	EW	JOI