TDR
Editing Organization

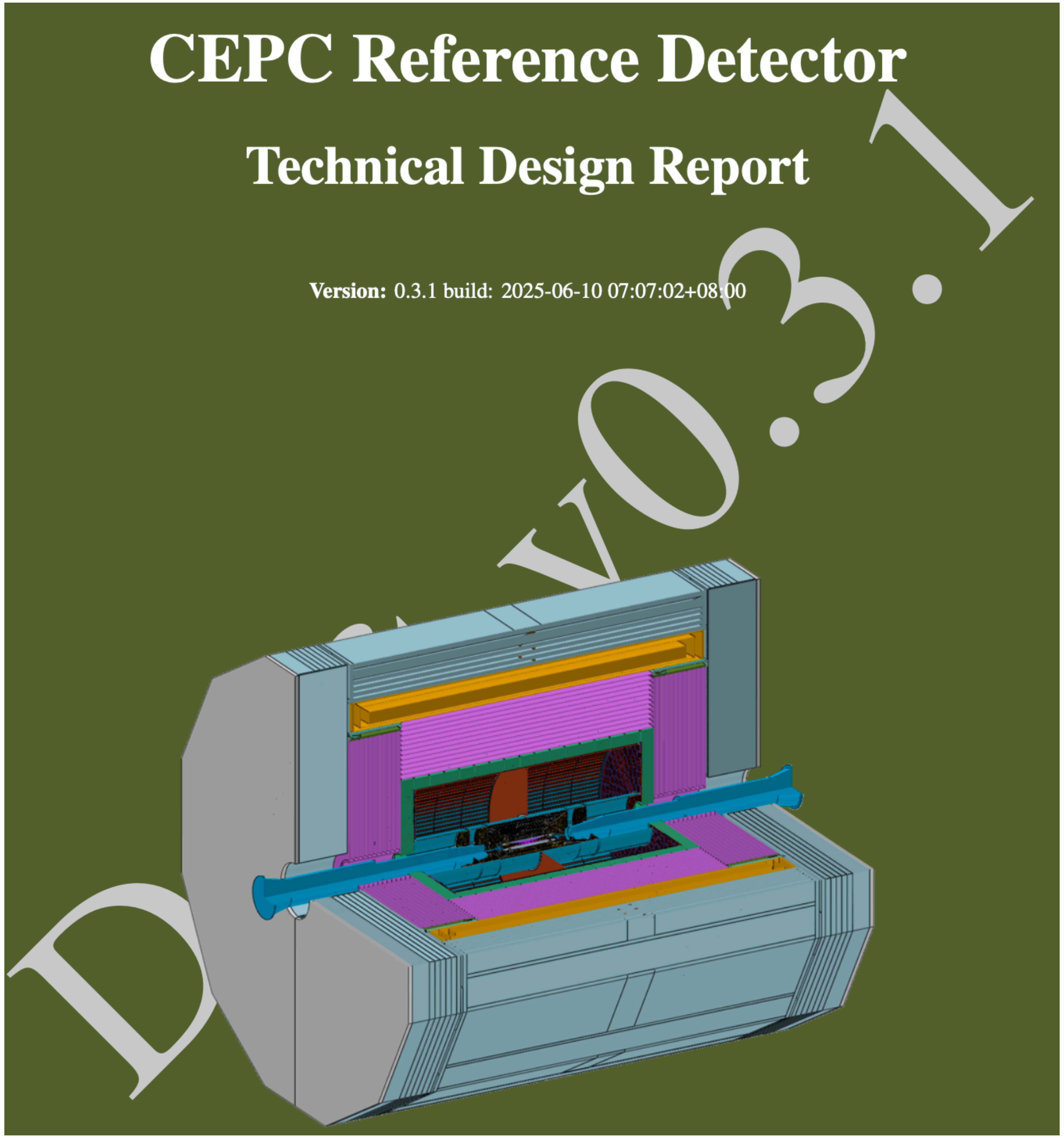
Tuesday CEPC TDR Meeting

June 10, 2025

Joao Guimaraes

Outline

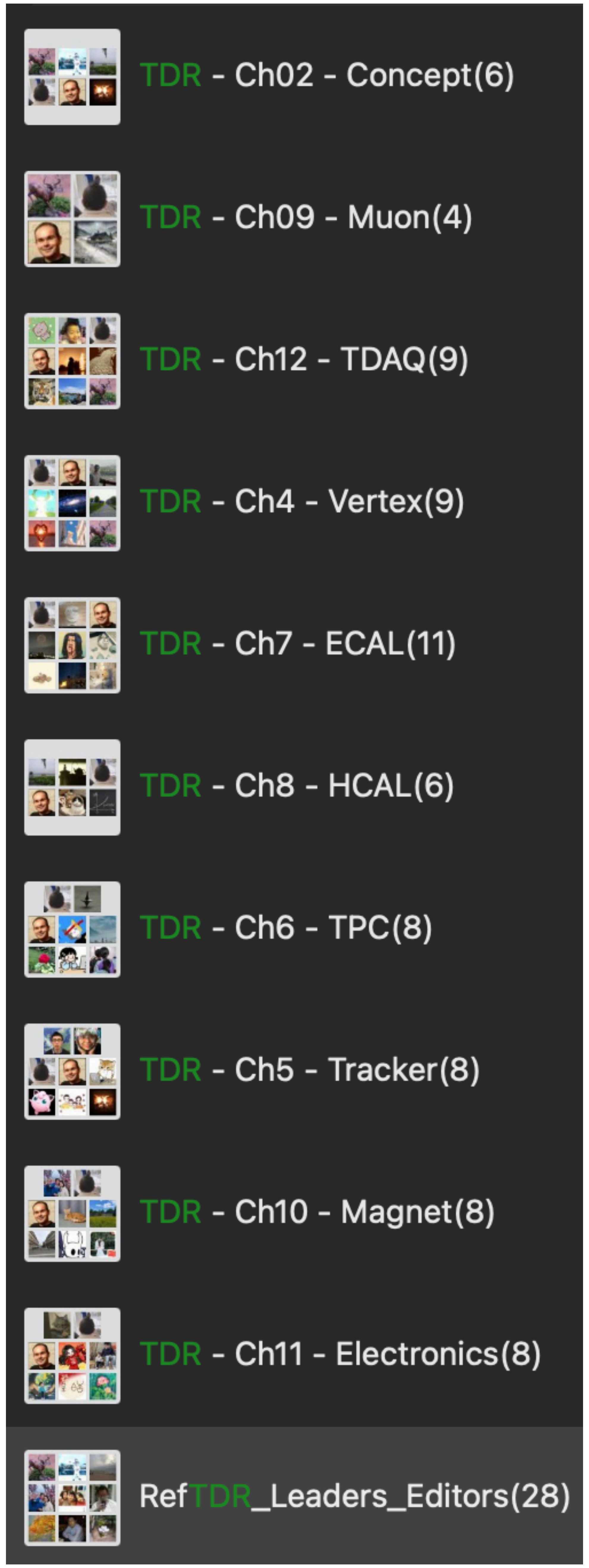
- Keeping track of modifications — overall situation
  - Today using version 0.3.1 available at 07:07 am
- Length of chapters
- Introduction
- Symbol consistency and glossary
- My plan



Keeping track of modifications

- **Spreadsheet monitoring the status moved by Zhaoru to IHEP docs:**
  - https://docs.ihep.ac.cn/link/ARF4C648FCA57D4CF281A8E821A110229E
  - 文件名：Status of TDR.xlsx
  - 文件路径：AnyShare://ZHANG Zhaoru(zhangzr)/CEPC Det TDR/Status of TDR.xlsx

- Please fill in your input now, and **keep it updated** as we move along
  - Most people didn’t update it this week.... Please do!
  - You have one chapter, ... but we need to check 16 chapters
  - After last final cut-off time, several people were not ready (still working). It is helpful to enter such information on the spreadsheet



Keeping track of modifications

Blue section of the spreadsheet is for chapter leaders

Chapter	Overall Complete	Chapter structure	Updated date	Tables		Figures			Text	
			Ready for check	Unified format	Significant digits	Change to pdf	Unified Macro	Enlarge the font size	Symbols	Glossary
Executive summary	100%	100%		100%	100%		100%	100%	100%	
1 Introduction	100%	100%		100%	100%		100%	100%	100%	
2 Concept of CEPC Reference Detector	90%	100%		90%	90%	90%		90%		
3 MDI and Luminosity Measurement	90%	90%		100%	100%	100%	80%	70%	70%	
4 Vertex Detector	90%	100%		90%	95%	50%		70%	80%	
5 Silicon Trackers	100%	100%		100%		80%			90%	
6 Pixelated Time Projection Chamber	95%	100%		100%	100%	100%		80%	95%	95%
7 Electromagnetic calorimeter	90%	90%		90%	90%	50%		80%		
8 Hadronic calorimeter	90%	100%		90%	90%	70%		80%	90%	
9 Muon Detector	95%	100%		100%		75%		80%		
10 Detector magnet system	95%	100%		95%	100%	100%	100%	100%	95%	95%
11 Readout Electronics	90%	100%		100%	100%	60%		80%	100%	
12 Trigger and Data Acquisition	95%	100%	Jun. 5th	100%	100%	100%	100%	100%	100%	90%
13 Offline software and computing	97%	100%	Jun. 5th	100%	100%	100%	100%	100%	95%	95%
14 Mechanics and integration	80%	80%		100%	80%	100%		70%	90%	
15 Detector and physics performance	80%	80%		100%		70%			100%	

I will check today, chapter by chapter according to this table input

Keeping track of modifications

Yellow section of the spreadsheet is for chapter review editors (english) appointed by Jianchun

Chapter	Chapter Review Editors	
	Name	Status
Executive summary		
1 Introduction		
2 Concept of CEPC Reference Detector	Mingshui	80%
3 MDI and Luminosity Measurement	Manqi	60%
4 Vertex Detector	Mingyi	90%
5 Silicon Trackers		
6 Pixelated Time Projection Chamber	Mingyi	70%
7 Electromagnetic calorimeter	Manqi	50%
8 Hadronic calorimeter	Jianbei	
9 Muon Detector	Weidong	
10 Detector magnet system	Haijun	
11 Readout Electronics	Zheng	80%
12 Trigger and Data Acquisition	Zheng	85%
13 Offline software and computing	Gang	
14 Mechanics and integration	Jingbo	80%
15 Detector and physics performance	Weidong	85%
16 Timeline and Future Plans	Jianbei	
17 Reference detector costing		
18 Summary		

Chapter Review Editors	
Name	Status
Mingshui	80%
Manqi	60%
Mingyi	90%
Jingbo	100%
Mingyi	70%
Manqi	50%
Miao He/Jianbei	
Jianchun/Miao He	
Haijun	
Zheng	80%
Zheng	85%
Gang	100%
Jingbo	100%
Weidong	100%

	Chapter	Chapter Leader(s)	Responsible Editors	
1	Introduction	Joao Costa / Gang Li	-	
2	Concept of Ref-Detector	Haijun Yang / Mingyi Dong	Mingshui	
3	MDI and Luminosity Measurements	Haoyu Shi	Manqi	
4	Vertex Detector	Zhijun Liang / Jerome ?	Mingyi	
5	Silicon Trackers	Qi Yan	Jingbo	
6	Gaseous Tracker	Huirong Qi / Nicola De Filippis	Mingyi	
7	Electromagnetic Calorimeter	Yong Liu / Hwidong Yoo	Manqi	TCZ
8	Hadron Calorimeter	Sen Qian	HeMiao	jianbei
9	Muon Detector	Xiaolong Wang / Pavel Pakhlov	Jianchun	JCW JGC
10	Superconducting Solenoid Magnet	Feipeng Ning	Haijun	
11	Readout Electronics	Wei Wei	Zheng	
12	Trigger and Data Acquisition	Fei Li	Zheng	
13	Software and Computing	Weidong Li	Gang	
14	Mechanics and Integration	Quan Ji	Jingbo	
15	Detector and Physics Performance	Mingshui Chen	Weidong	
16	Construction Cost	Miao He	-	
17	Future Plans	Gang Li / Miao He / JCW	-	

(new assignments done during last meeting)

Please indicate how far have you read and when you will be finished

Length of Chapters

- Total length now: 646 pages
  - 30 pages longer than the goal
- Chapters that didn't reach goal indicated in red
  - Will check chapter in red in more gains can be made
  - Major outliers:
    - TPC: 14 pages more than goal
    - Muon: 11 pages more than goal
    - Mechanics: 6 pages more

	Page	Length	Goal length	Length v0.3.1
Executive summary	1		1	2
1 Introduction	17	16	16	17
2 Concept of CEPC Reference Detector	30	13	15	17
3 MDI and Luminosity Measurement	70	40	35	34
4 Vertex Detector	120	50	40	41
5 Silicon Trackers	200	80	60	69
6 Pixelated Time Projection Chamber	264	64	40	54
7 Electromagnetic calorimeter	334	70	50	50
8 Hadronic calorimeter	389	55	50	47
9 Muon Detector	434	45	30	41
10 Detector magnet system	491	57	40	41
11 Readout Electronics	551	60	50	46
12 Trigger and Data Acquisition	604	53	45	45
13 Offline software and computing	660	56	45	45
14 Mechanics and integration	717	57	35	41
15 Detector and physics performance	779	62	50	55
16 Timeline and Future Plans	785	1	8	1
17 Reference detector costing	786	2	5	
18 Summary	788		615	646

Introduction(s) — bad examples — Need changes

Chapter	Introduction
Executive summary	
1 Introduction	Yes
2 Concept of CEPC Reference Detector	Yes
3 MDI and Luminosity Measurement	Yes
4 Vertex Detector	No
5 Silicon Trackers	Yes
6 Pixelated Time Projection Chamber	Too long
7 Electromagnetic calorimeter	Yes
8 Hadronic calorimeter	No
9 Muon Detector	Yes
10 Detector magnet system	Yes
11 Readout Electronics	Yes
12 Trigger and Data Acquisition	Yes
13 Offline software and computing	Yes
14 Mechanics and integration	Incomplete
15 Detector and physics performance	Yes

Chapter 4 Vertex Detector

4.1 Introduction

The CEPC vertex detector is a crucial component of the tracking system, designed to provide excellent spatial resolution and ultra-low material budget for precision vertexing and flavor tagging.

A high-granularity low-mass design based on Monolithic Active Pixel Sensors (MAPS) has been proposed and selected as the CEPC vertex detector baseline, in or-

Not final version?

Chapter 6 Pixelated Time Projection Chamber

The development of the pixelated readout Time Projection Chamber (TPC) detection technology is based on several fundamental R&D efforts within the High Energy Physics (HEP) community, notably the TPC concept in International Linear Detector (ILD) and TPC detector in Electron Ion Collider (EIC) project. The main goal of the tracking detectors is to measure the trajectory and momentum of charged particles[1]. The CEPC tracker consists of a number of silicon trackers and a TPC[2, 3]. The most central detectors including of the silicon trackers described in Chapter 4 and Chapter 5, which

Too long, needs to be shorten

Chapter 8 Hadronic calorimeter

8.1 Overview

Not final version?

Hadronic calorimeter (HCAL) is employed in the CEPC detector system to provide an energy measurement of hadronic jets with excellent resolution and hermetic coverage. To fully exploit the potential of physics program for Higgs and electroweak physics, all possible final states from decays of intermediate vector bosons, Z, W and the Higgs boson need to be reconstructed and well identified with high sensitivity. In particular, to clearly identify hadronic final states of $H \to ZZ^* \to 4j$ and $H \to WW^* \to 4j$, the energy resolution of the calorimetry for hadronic jets needs to be pushed beyond today's limit. In order to distinguish the hadronic decays of W and Z bosons, a 3-4% invariant mass resolution for two-jet system is required. Such a performance needs a jet energy resolution of $30\%/\sqrt{E}$ at energies below 100 GeV as shown in Figure 8.1. This would be about a factor of two better than that of the LEP detectors and the currently operating LHC detectors, which is a very challenging performance to achieve.

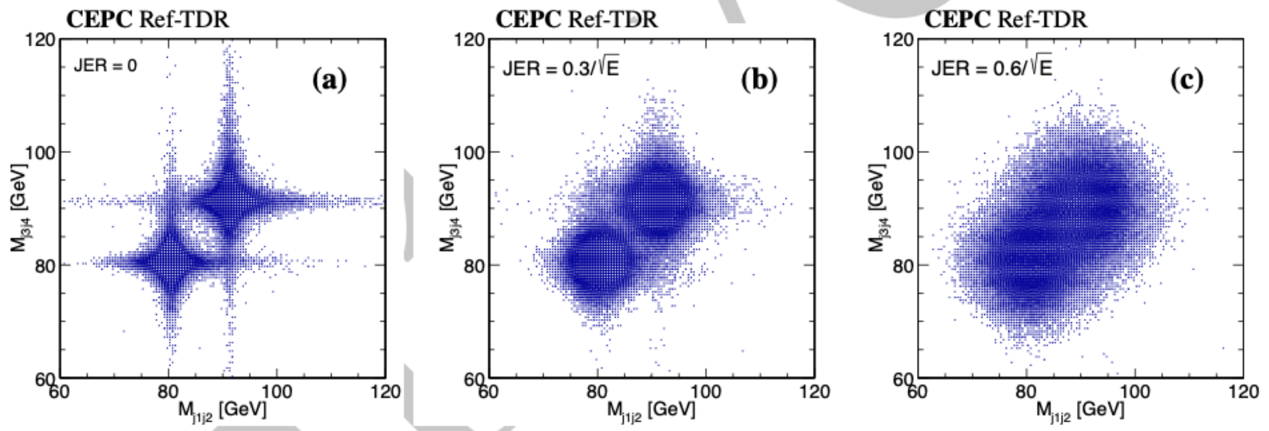


Figure 8.1: Separation of W and Z bosons in their hadronic decays with different jet energy resolutions: $0\%/\sqrt{E}$ (left plot), $30\%/\sqrt{E}$ (middle plot), $60\%/\sqrt{E}$ (right plot). A jet energy resolution of $30\%/\sqrt{E}$ is required to well separate the hadronic decays of W and Z bosons.

Chapter 14 Mechanics and integration

This chapter introduces the mechanical layout of the CEPC reference detector, details the boundaries and connections of each sub-detector. In consideration of future maintenance and upgrades of each sub-detector, the interface design requirements, installation scheme of each sub-detector and the uniform installation tooling are given. The design of the installation layout of the underground experimental hall for the whole detector and the layout of the auxiliary hall for the ancillary facilities are given.

No mention of sections

Glossary

- Being led by Zhaoru and Tao Lin
- First version of glossary added at end of TDR, albeit without page numbers yet
- Tao Lin working to add it to all chapters via a script
- Excel spreadsheet to be provided for people to add more names

News?

Glossary

AAI Authentication and Authorization Infrastructure
AC Alternating Current
AC-LGAD AC-coupled Low Gain Avalanche Detector
ADC Analog-to-Digital Convert
AFE Analog Front-End
AHCAL Analog HCAL
AI Artificial Intelligence
ALDD Array Laser Diode Driver ASIC
ALP Axion-Like Particle
ALPs Axion-Like Particles
APD Avalanche Photodiodes
APDs Avalanche Photodiodes
APEP Associated Proton Beam Experiment Platform
AR Augmented Reality
ASIC Application Specific Integrated Circuits
ASICs Application-Specific Integrated Circuits
ASTC Aluminum stabilized Stacked REBCO Tape Cable
ASU Active Sensor Unit
ATCA Advanced Telecommunications Computing Architecture
ATIA Array Transimpedance Amplifier ASIC

BAU Baryon Asymmetry of the Universe
BE Back-end Electronics
BEE Backend Electronics
BEPCII Beijing Electron-Positron Collider
BESIII Beijing Spectrometer
BGB Beam Gas Brems
BGC Beam Gas Coulomb
BGO Bismuth Germanate
BMR Boson Mass Resolution
BOSS BES III Offline Software System
BPMs Beam Position Monitors
BR Branching Ratio
BSC Beam Stay Clear
BSM Beyond the Standard Model
BSO Bismuth Silicate
BTH Beam Thermal Photon

My plan

- Check chapter by chapter
  - Quick overview of the lengthy ones:
    - TPC
    - Muon
    - Mechanics
  - Check chapter 2: concept
  - Go chapter by chapter, following the status table on the spreadsheet (see page 4)
    - Focus on the ones that still need to reduce pages

The end

Chapter Structure

Chapter X:				
X.	**1**	**Overview**		What are we going to build? **Design**, expected performance ("requirements")
X.	**2**	**Detailed Design**		
X.	**2.**	**1**	**Detailed design**	
X.	**2.**	**2**	**Challenges and critical R&D**	
X.	**3**	**Key Technologies to address challenges**		
X.	**4**	**R&D and prototypes**		
X.	**5**	**Simulation and Performance**		
X.	**6**	**Alternative Solutions**		Can be either backup or more advanced solution (demonstrate backup solutions are in hand and that their possible selection still meet the requirements)
X.	**7**	**Summary and Future Plan**		
X.	**8**	**(Cost table and justification)**		Eventually to be moved to a common chapter

- Sections should not have more than 4 numbered subsection levels x.y.z.w
- If using AI, editors need to read the AI output and finalize the text themselves. Cannot blindly use AI output. Also, AI usage should be minimized to correct english, NOT write sections from scratch
- Captions should be long and describe plot, not just a title

Introduction(s)

Chapter 13 Offline software and computing

The development of the CEPC software (CEPCSW) [1] is based on several foundational HEP software packages, including the Gaudi [2] software framework for event processing, EDM4hep [3] for the event data model, DD4hep [4] for detector description, Geant4 [5] for simulation, and ROOT [6] for data analysis. A key aspect of this endeavor is the development of CEPC-specific software, designed to meet the experiment's unique requirements. The core software will be introduced in Section 13.1, while the applications for simulation, reconstruction, analysis, and visualization will be described in Sections 13.2, 13.3, and 13.4, respectively.

To tackle the growing complexity of data processing tasks, emerging technologies are being actively explored. Research and development efforts focus on areas such as concurrent computing, machine learning, and quantum computing, which will be discussed in Section 13.5.

Grid computing technology, successfully implemented in the LHC experiments, connects computing and storage resources distributed across laboratories worldwide, facilitating the processing and analysis of EB-level data. Leveraging this technology, we have established a distributed computing infrastructure (DCI) to support detector R&D activities. On this prototype, the latest Grid computing technologies are being investigated and evaluated to ensure robust support for the experiment's future operations. These aspects will be discussed in Sections 13.7 and 13.10.

In the current project, the software and computing team is responsible for providing the core software, including the framework, various services, data management, and computing systems. The development of detector-specific algorithmic code for simulation, calibration, and reconstruction is a shared responsibility between the software and computing team and the sub-detector teams. Close collaboration with the physics group ensures the smooth development of global event-reconstruction code and software tools for physics analysis.

Chapter 12 Trigger and Data Acquisition

While collision rates reach tens of megahertz, the actual Higgs production rate remains vanishingly small—a fundamental discrepancy that demands a trigger and data acquisition (TDAQ) system capable of identifying rare physics events within an overwhelming background of non-interesting processes. This system must achieve real-time event selection while preserving the integrity of critical physics signals.

This chapter presents the technical design of the CEPC reference detector's TDAQ system. Subsequent sections address critical topics including system requirements and overall architectural design as Section 1, hardware trigger implementations as Section 2, software-based high-level triggers as Section 3, trigger simulations and algorithms as Section 4, data acquisition infrastructure as Section 5, and integrated run control with online monitoring systems as Sections 6 and 7.

Chapter 7 Electromagnetic calorimeter

The CEPC electromagnetic calorimeter (ECAL) plays a critical role in precision measurements of Higgs and flavour physics. It is a high-granularity homogeneous calorimeter with dense scintillating crystals. Based on the Particle Flow Algorithms (PFA), it aims to achieve an unprecedented jet energy resolution and excellent electromagnetic (EM) performance, which will enable the accurate reconstruction of Higgs decaying into photons and jets as well as EM showers of meson decays involving with photons.

The primary objective of the ECAL is to identify and reconstruct EM showers, even in the presence of near-by particles, while also serving as the first section for hadronic showers. To ensure superior separation of near-by particle showers, the ECAL is highly segmented both longitudinally and transversely. Based on detailed simulation optimisations, the granularity of the longitudinal and transverse segmentations is at the level of X_0 (radiation length) and R_M (Moliere Radius), respectively. The ECAL design emphasises maximum possible hermeticity, modularity and scalability.

This chapter is organised as follows: Section 7.1 first introduces the ECAL, followed by the ECAL design in Section 7.2 and key technologies in Section 7.3. Dedicated R&D activities and performance studies will be discussed in Section 7.4 and Section 7.5. ECAL backup options will be listed in Section 7.6 and summary and prospects will be presented in Section 7.7.

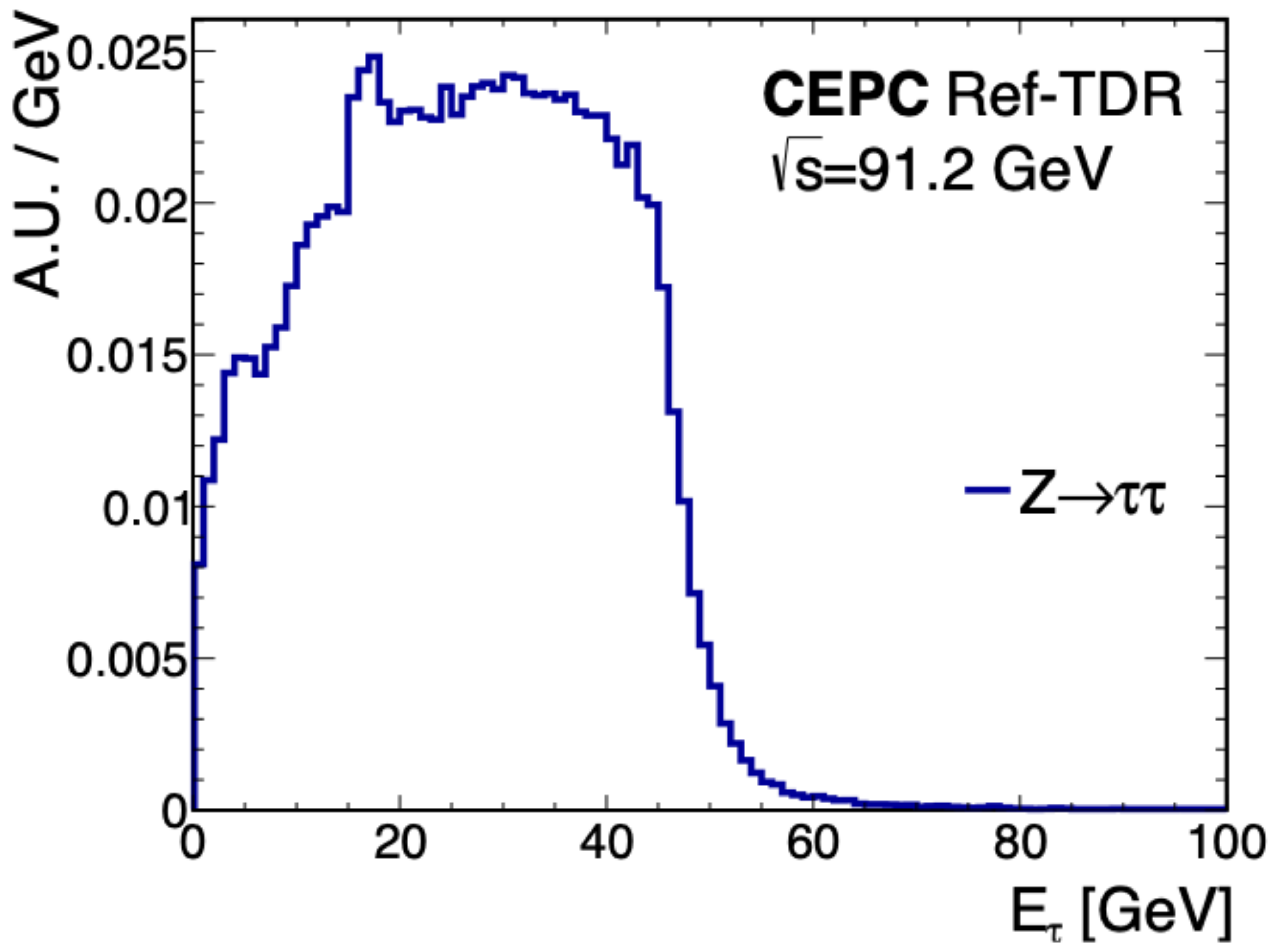
Most people seem to have misunderstood the request

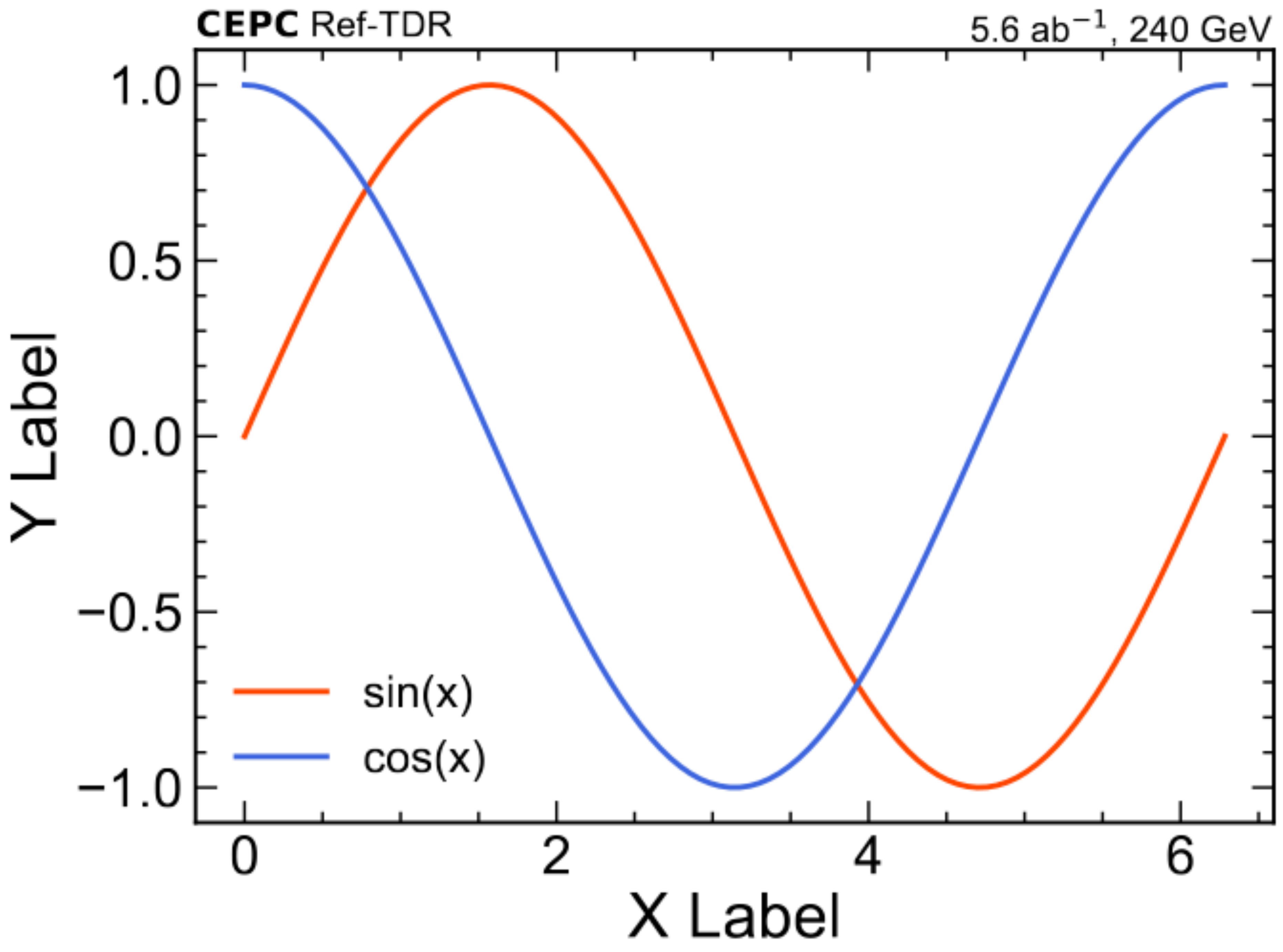
Check the CDR and these chapters for good examples

Plot formats → sample plots

by Zhang Yang and Kaili

- Templates with instructions at: https://latex.ihep.ac.cn/project/68347a429cc3e0db27dacfc4
- Python code: Gitlab: https://code.ihep.ac.cn/zhangyang98/cepc-style
- ROOT style file for CEPC: ~zhangkl/cefs/plot/CEPCStyle.h



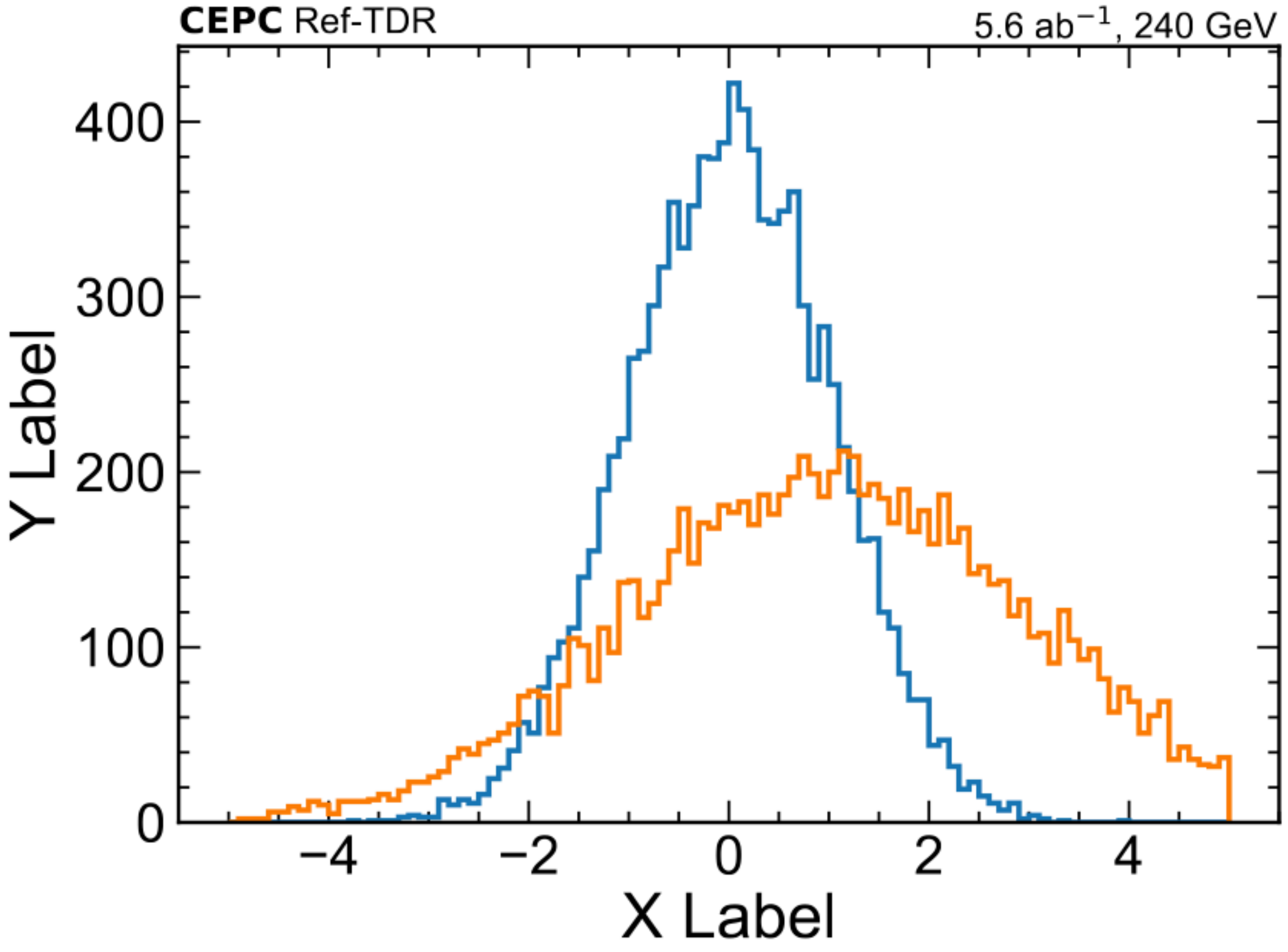


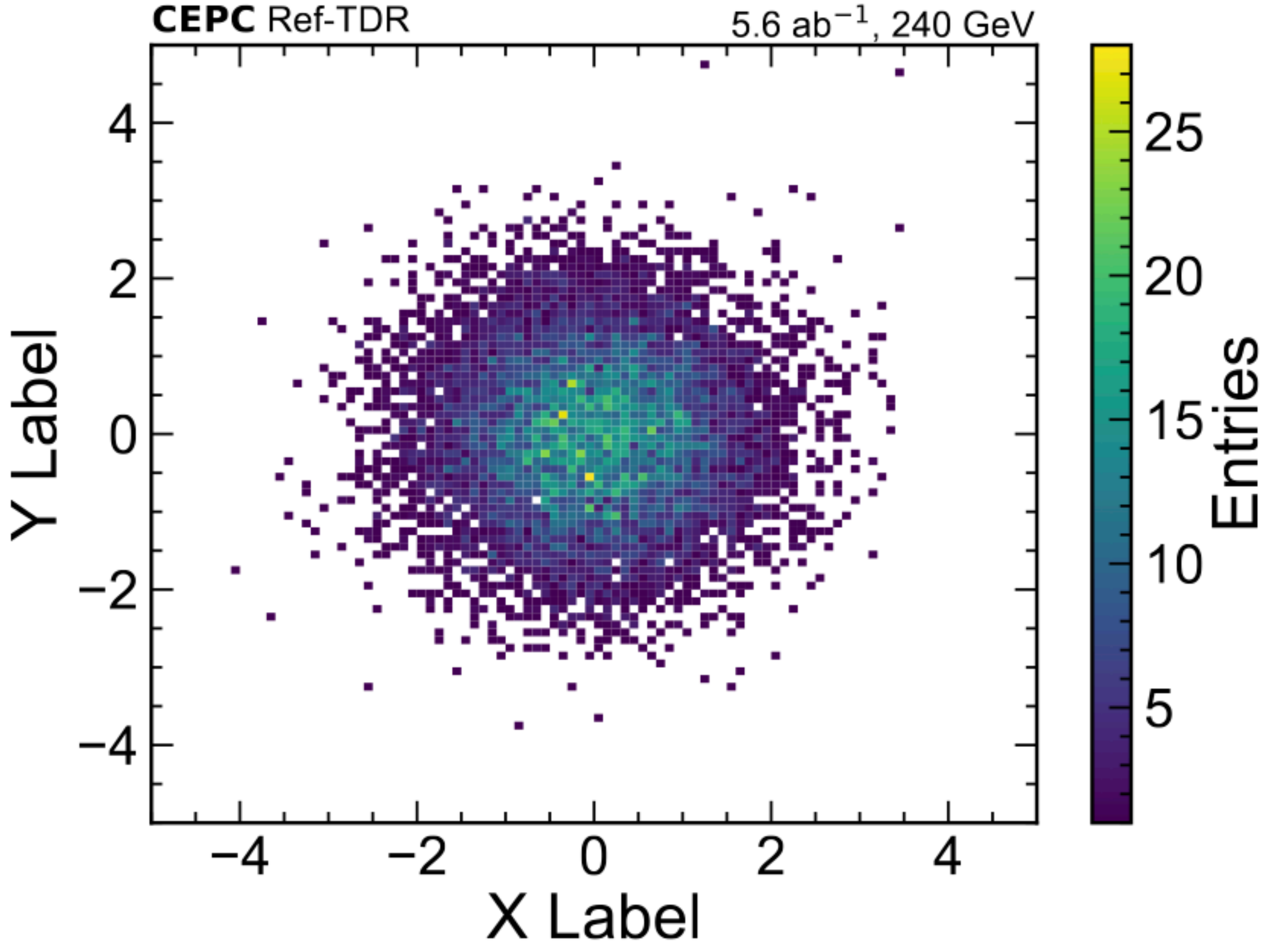
Most important: keep proportions of the text large compared to the plot

Plot formats → sample plots

by Zhang Yang and Kaili Zhang

- More sample plots from python
  - Fonts and styling a little different between root and python





Label for plots: **CEPC** Ref-TDR

Symbols unification

- Being led by Zhaoru and Tao Lin

- File with physics/math symbols to be used by all: **cepcphysics.sty**

- **Unit Symbols**:
  - Unit symbols should be written in **non-italic** font, especially when they appear in equations. Use `\mathrm{}` for units in equations.
  - Add a space between numbers and units, e.g., `1~mm`.
  - Use unit symbols exclusively, e.g., do not use "meters" or "microns".
- **Energy Units**:
  - Replace **GeV**, **TeV**, **MeV**, etc., with `\GeV`, `\TeV`, `\MeV`.
  - The `cepcphysics.sty` file defines these terms; reference them using `\` + the term.
- **Particle Names**:
  - **H**, **Z**, **W** should be written in **uppercase italics**. Use `\Hboson`, `\Zboson`, etc., to replace them (refer to the definitions in `cepcphysics.sty`).
  - Check other particles, such as **pi**, **K**, etc., and use the `.sty` file definitions, `\` + the term.
- **Variable Names**:
  - Replace **p_T**, **E_T**, **Missing E_T**, etc., with the definitions from the `.sty` file.

- Add your own symbols to the file and let Zhaoru and others know

Keeping track of modifications

Green section is for Joao's feedback

Chapter	Joao									
	Overall structure									
	Introduction	Introduction Quality	Overall complete	Chapter Structure	Page	Length	Tables to fix	Figures to fix	References	Comments
Executive summary					14	2				
1 Introduction	Yes	Needs references to sections		NA	16	13				
2 Concept of CEPC Reference Detector	No	0	70%	NA	29	12	2.1,		Need mor r	All collider in
3 MDI and Luminosity Measurement	No	0	80%	80%	41	42	left justify fi	Some lumical figures are too small		
4 Vertex Detector	No	0	80%	80%	83	52	some tables	some Figures are not qu	Need to rear	
5 Silicon Trackers	Yes	OK, but needs expansion to cover sections	90%	95%	135	41	The positior	The positions of some fi	Too long. Th	
6 Pixelated Time Projection Chamber	Yes	Need to reorganize			176	119				
7 Electromagnetic calorimeter	Yes	Needs expansion of references to sections	80%	80%	295	70				Checked
8 Hadronic calorimeter	No	0		90%	365	54				
9 Muon Detector	No	0	70%	50%	419	43				
10 Detector magnet system	Yes	Needs to expand to cover sections			462	57				
11 Readout Electronics	No	Use the introduction and remove the title, then it needs reference to sections	80%		519	60		fig11.4, 11.5, 11.9, 11.1	It is too muc	
12 Trigger and Data Acquisition	Yes	Perhaps too long, needs to expand to cover sections	90%		579	52				
13 Offline software and computing	Yes	Very good → Excellent :-)			631	61				
14 Mechanics and integration	Yes	Needs to expand to cover sections			692	50				
15 Detector and physics performance	Yes	Use the introduction and remove the title, then it needs reference to sections	85%	90%	742	55		Figure 13, Figure 14, Figure 15, Figu		
16 Timeline and Future Plans					797	1				
17 Reference detector costing					798	2				
18 Summary					800					

Check this section and get back to me if you need clarifications on something