Study of TPC at the lower gain for Z run

Huirong Qi

23, December, 2020

Outline

Motivation
Study of IBF
dE/dx and V_{drift}

Motivation

TPC limitations for Z

- Ions back flow in chamber
- Calibration and alignmens^{FC} Low power consumption **FIDE**^{T1} ASIC chip

	Higgs		Z (2T)	
	CDR	Updated	CDR	Updated
Beam energy (GeV)	120		45.5	
Synchrotron radiation loss/turn (GeV)	1.73	1.68	0.036	
Piwinski angle	2.58	3.78	23.8	33
Number of particles/bunch N _e (10 ¹⁰)	15.0	17	8.0	15
Bunch number (bunch spacing)	242 (0.68µs)	218 (0.68µs)	12000	15000
Beam current (mA)	17.4	17.8	461.0	1081.4
Synchrotron radiation power /beam (MW)	30		16.5	38.6
Cell number/cavity	2		2	1
β function at IP β _x * / β _y * (m)	0.36/0.0015	0.33/0.001	0.2/0.001	
Emittance ε _x /ε _y (nm)	1.21/0.0031	0.89/0.0018	0.18/0.0016	
Beam size at IP σ _x /σ _y (μm)	20.9/0.068	17.1/0.042	6.0/0.04	
Bunch length σ_z (mm)	3.26	3.93	8.5	11.8
Lifetime (hour)	0.67	0.22	2.1	1.8
Luminosiiy/IP L (10 ³⁴ cm ⁻² s ⁻¹)	2.93	5.2	32.1	



IP

TPC detector concept

Study of IBF

Prospects for a TPC at Z

- Rough estimations at L = $35 \cdot 10^{35}$ cm⁻² s⁻¹ indicate primary ionisation at a ILC250 level $\Rightarrow < 5 \mu m$ distortions (This equals 8 μm with IBF = 1) See <u>Arai Daisuke</u>
- Simulation from CEPC TPC with Gain \times IBF = 1 and L = 32 \cdot 10³⁴ cm⁻² s⁻¹ \Rightarrow < 16 µm distortions (Gain \times IBF = 1 and L = 32 \times 10³⁴ cm⁻²s⁻¹) from <u>Huirong Qi</u> \Rightarrow < 46 µm distortions (Gain \times IBF=1 and L=101 \times 10³⁴ cm⁻²s⁻¹) from <u>Huirong Qi</u>
- FCCee/TLEP studies at Gain × IBF = 1 and 16.8 kHz hadronic Zs by <u>Philippe Schwemling</u>
 - \Rightarrow < 22 μ m distortions

Rough esitimation of primary ionisation

- 10 kHz Z event rate
- 500 ms will accumulate 5000 Z events
- 2₀ tracks / Z event and 10 000 e / track will make 10⁸ ions in volume
- Volume is ~4 10⁷ resulting in 25 e/cm³
- Similar to ILC250 accumulated charge

<u>国际会议: RD51 and TPC 2020</u>



TPC detector module R&D

- Study with GEM-MM module
 - New assembled module
 - Active area: 100mm × 100mm
 - X-tube ray and 55Fe source
 - **Bulk-Micromegas assembled from** Saclay
 - Standard GEM from CERN
 - Avalanche gap of MM:128µm
 - Transfer gap: 2mm
 - Drift length:2mm~200mm
 - pA current meter: Keithley 6517B
 - Current recording: Auto-record interface by LabView

 $100 \times 100 \text{mm}^2$

2017-2018

High mesh: 508 LPI

 $50 \times 50 \text{mm}^2$

2015-2016

K_{IBF} (=IBF*Gain) Standard Mesh: 400LPI

2019-

DOI: 10.1088/1748-0221/12/04/P0401 JINST, 2017.4 DOI: 10.1088/1674-1137/41/5/056003, CPC,2016.11 DOI: 10.7498/aps.66.072901Acta Phys. Sin. 2017,7



- 6 -

Different concepts with IBF suppression

Pixel TPC with double meshes	Triple or double GEMs	Resistive Micromegas	GEM+ Micromegas	Double meshes Micromegas
IHEP, Nikehf	KEK, DESY	Saclay	IHEP	USTC
Pad size: 55um-150um square	Pad size: 1mm×6mm	Pad size: 1mm×6mm	Pad size: 1mm×6mm	Pad size: 1mm×6mm (If resistive layer)
Advantage for TPC: Low gain: 2000 IBF×Gain: -1	Advantage for TPC: Gain: 5000-6000 IBF×Gain: <10	Advantage for TPC: Gain: 5000-6000 IBF×Gain: <10	Advantage for TPC: Gain:5000- 6000 IBF×Gain: <5	Advantage for TPC: High gain: 10^4 Gain: 5000-6000 IBF×Gain: 1-2
Electrons cluster size for FEE: About Ø200um	Electrons cluster size for FEE: About Ø5mm	Electrons cluster size for FEE: About Ø8mm	Electrons cluster size for FEE: About Ø6mm	Electrons cluster size for FEE: About Ø8mm
Integrated FEE in readout board Detector Gain: 2000	FEE gain: 20mV/fC Detector Gain: 5000-6000	FEE gain: 20mV/fC Detector Gain: 5000-6000	FEE gain: 20mV/fC Detector Gain: 5000-6000	FEE gain: 20mV/fC Detector Gain: 5000-6000

UV test of the new module

- □ UV lamp measurement
 - New designed and assembled UV test chamber
 - □ Active area: 100mm×100mm
 - **Deuterium lamp and aluminum film**
 - Principle of photoelectric effect
 - □ Wave length: 160nm~400nm
 - Fused silica: 99% light trans.@266nm
 - Improve the field cage in drift length





Deuterium lamp X2D2 lamp





Diagram of the UV test with new module

IBF suppression R&D

- **UV** lamp measurement
 - Added a new voltage controller
 - pA current meter from Keithley
 - First step test about the current in mesh
 - □ E_drift: 10~175V/cm
 - □ ~43pA@175V/cm
 - □ Stable current with UV light
 - □ ~200V/cm@T2K operation gas





实验装置图



Space charge effect test



Energy resolution@T2K



Next steps

Tests of the position resolution under different gains

- □ Confirmed: Gain@2000 VS Gain@5000
- □ Gain@2000 from LCTPC
- About 4days
- **Results will show in the next CEPC workday**

dE/dx and V_{drift} R&D

dE/dx by 266nm UV laser@IHEP



V_{drift} in one day



- 15 -

Summary

- Some motivations of TPC detector for collider at Z pole run listed.
- Some update results and performance of IBF, dE/dx, drift velocity listed.
- TPC can meet most requirements of PID and moment resolution, and others should be optimized and R&D.

Thanks!