Performance and readiness of TPC for CEPC

Huirong Qi

Yue Chang, Xin She, Jian Zhang, Zhi Deng, Liwen Yu, Lingwu Wu, Guang Zhao, Gang Li

CEPC Track meeting, 2024.02.29

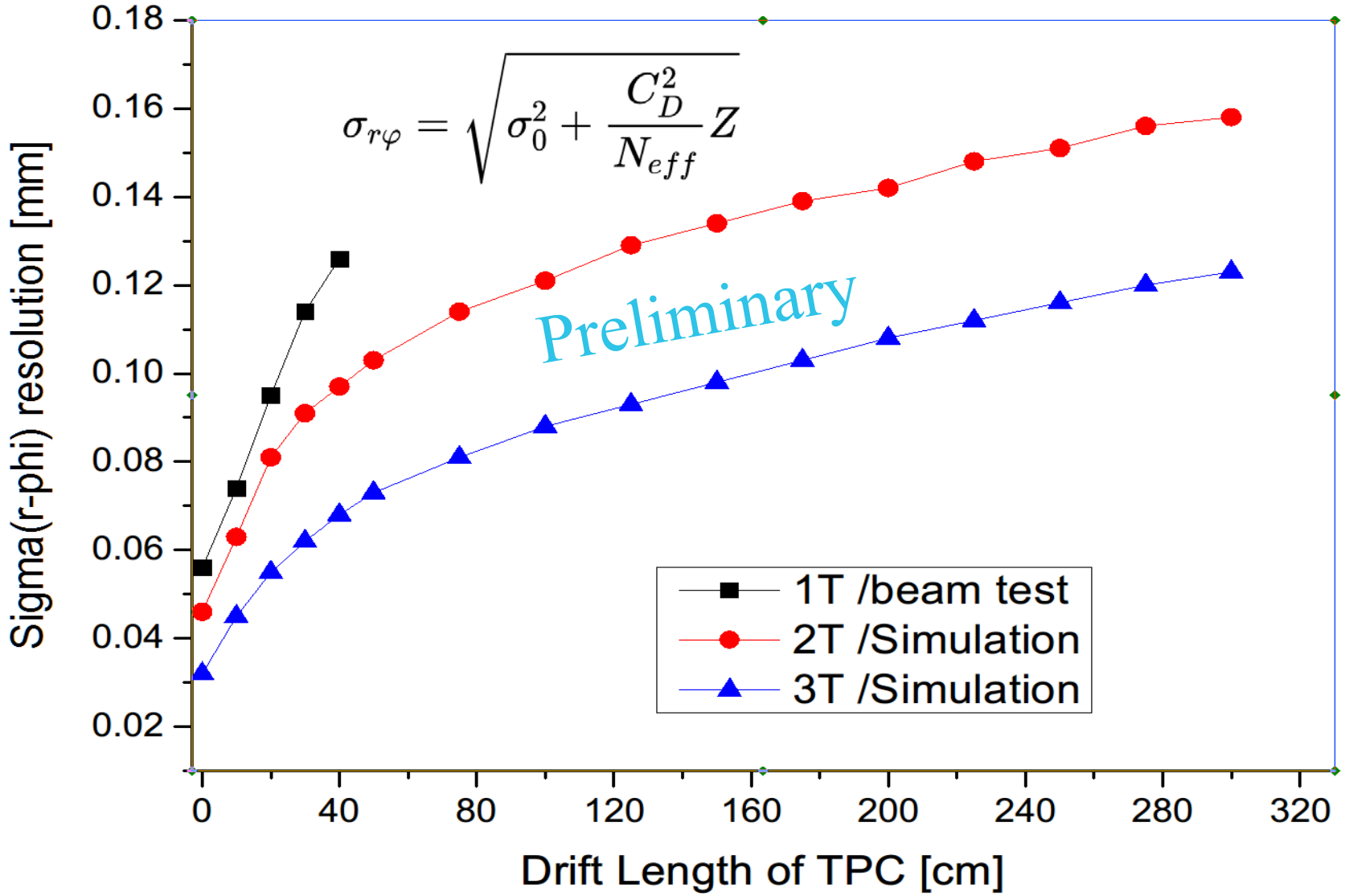
- **Performance of TPC for CEPC TDR**

Comparisons of the performance @cosθ≃0.85

Parameters	Higgs run		Z pole run	
B-field	3.0T		2.0T	
Detector	TPC	DC	TPC	DC
Material budget barrel	≃ 0.012 X_0		≃ 0.012 X_0	
Material budget endcap	< 0.17 X_0		< 0.20 X_0	
Points per track in rφ	200		320	
σ_{point} in rφ	≤ 100μm (full drift)		≤ 300μm (full drift)	
σ_{point} in rz	≃ 0.4 – 0.8 mm (for zero – full drift)		≃ 0.5 – 1.5 mm (for zero – full drift)	
2-hit separation in rφ	< 2mm		< 1mm	
K/π separation power @20GeV	≤ 3σ		≤ 3σ	
Momentum resolution normalised: $\sigma_{1/pT} = \sqrt{a^2 + (b/pT)^2}$	a = 1.82 e -5	a = 2.11 e -5	a = 3.32 e -5	a = 3.16 e -5
	b = 0.60 e -3	b = 0.77 e -3	b = 0.92 e -3	b = 1.16 e -3

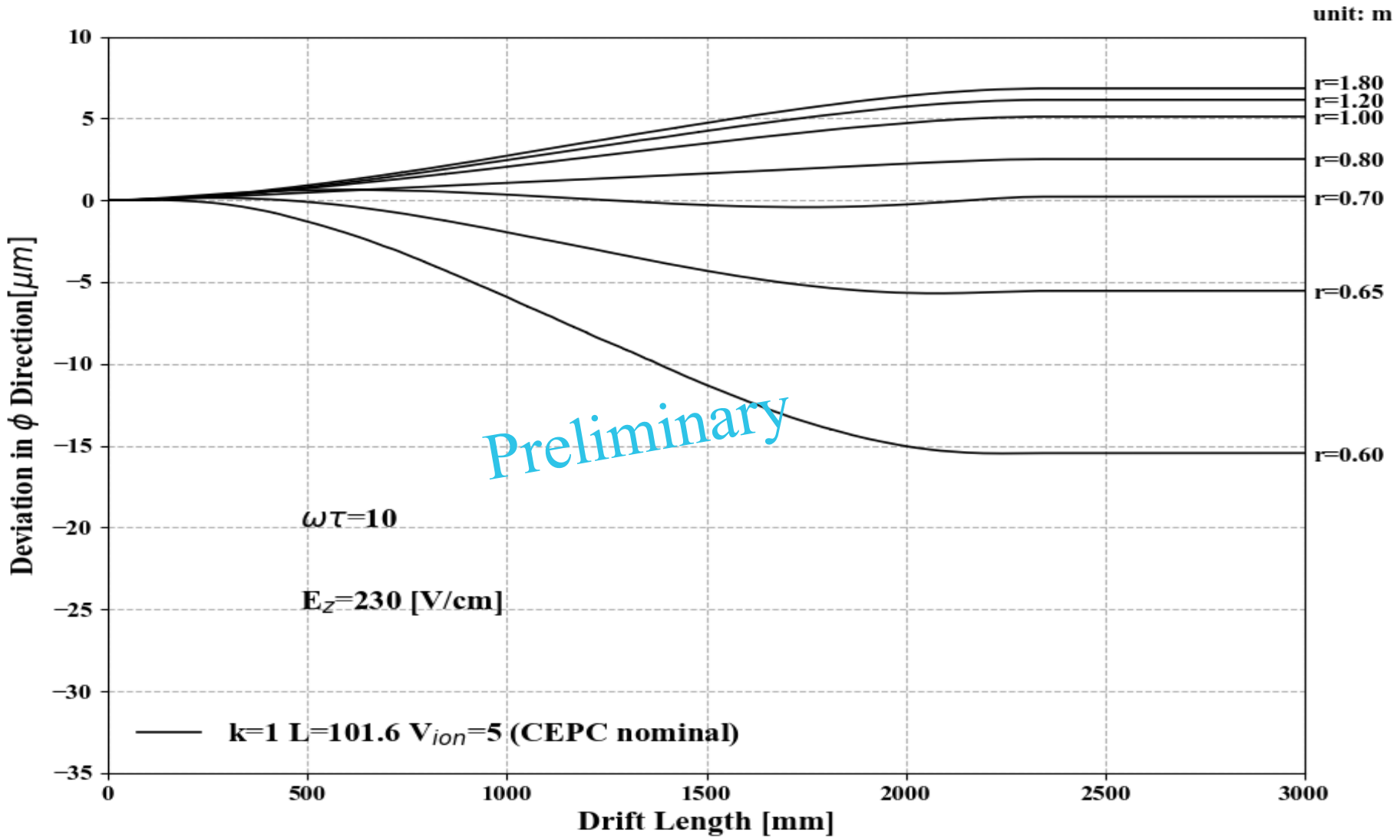
Spatial resolution of r-phi @New Geometry

- **Estimation of distortion of TPC at the new Geometry for CEPC TDR**



Ions distortion at Z pole run – physics events @New Geometry

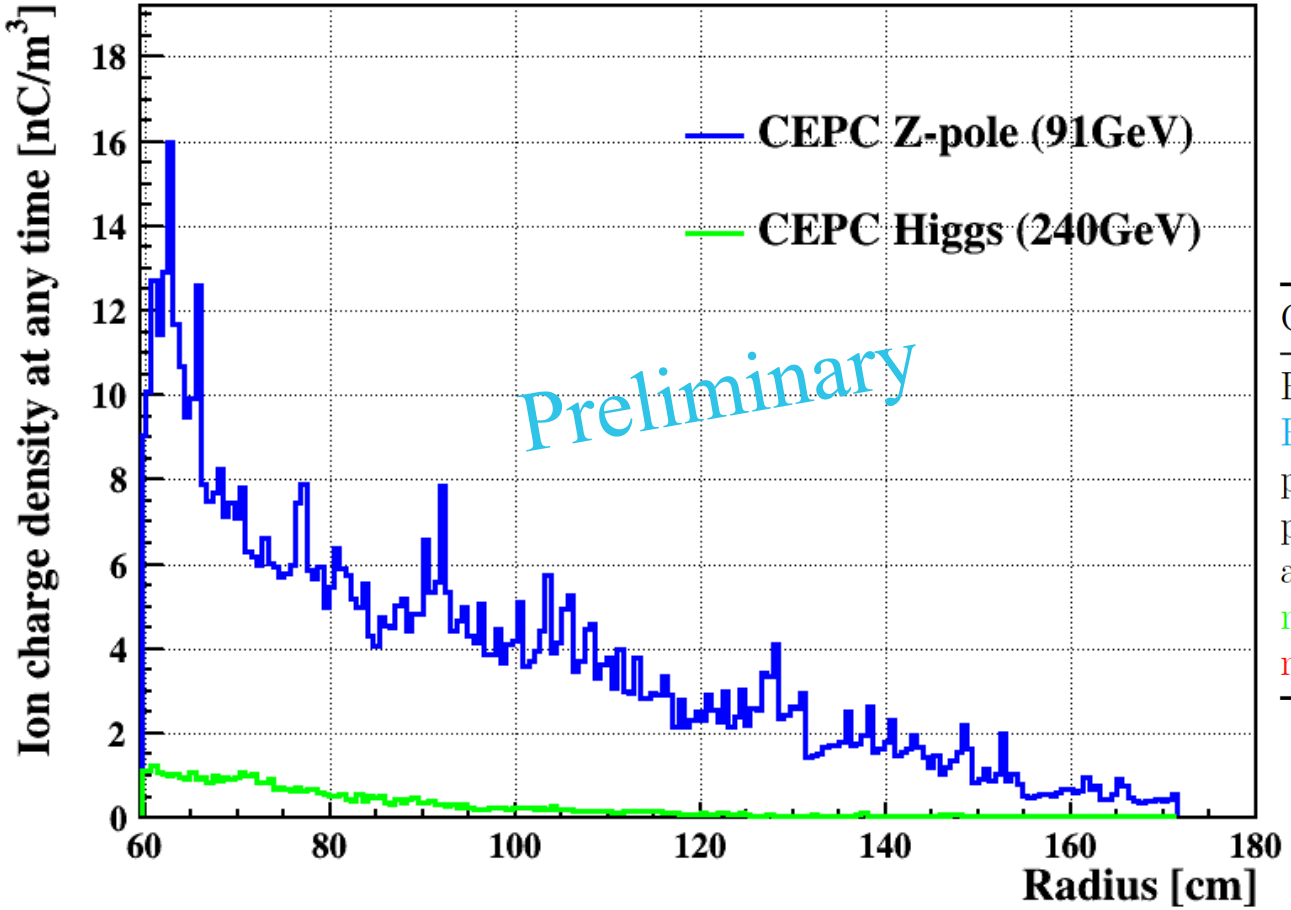
- **Estimation of distortion of TPC at the new Geometry for CEPC TDR**



Ions distortion at Z pole run – background @ New Geometry

- **For Higgs run, no problem detector factor for TPC**
- **For Z pole run**
  - **TPC with IBF×Gain=1 at CEPC-91**

    → at best, less or similar space-charge as at ALICE



Collider Detector Model	CEPC_v4	CEPC_v4
Beamstrahlung pairs	CEPC Z-pole(91GeV)	CEPC Higgs(240GeV)
BX freq.	1/23 ns	1/680 ns
primary ions/BX	27.37 k	72.36 k
primary ions at any time	5.95×10^{11}	5.32×10^{10}
average primary ρ_{ion} [nC/m^3]	2.43	0.22
max (single BX) [nC/m^3/BX]	1.05×10^{-6}	5.4×10^{-6}
max (steady state) [nC/m^3]	11.4	1.98

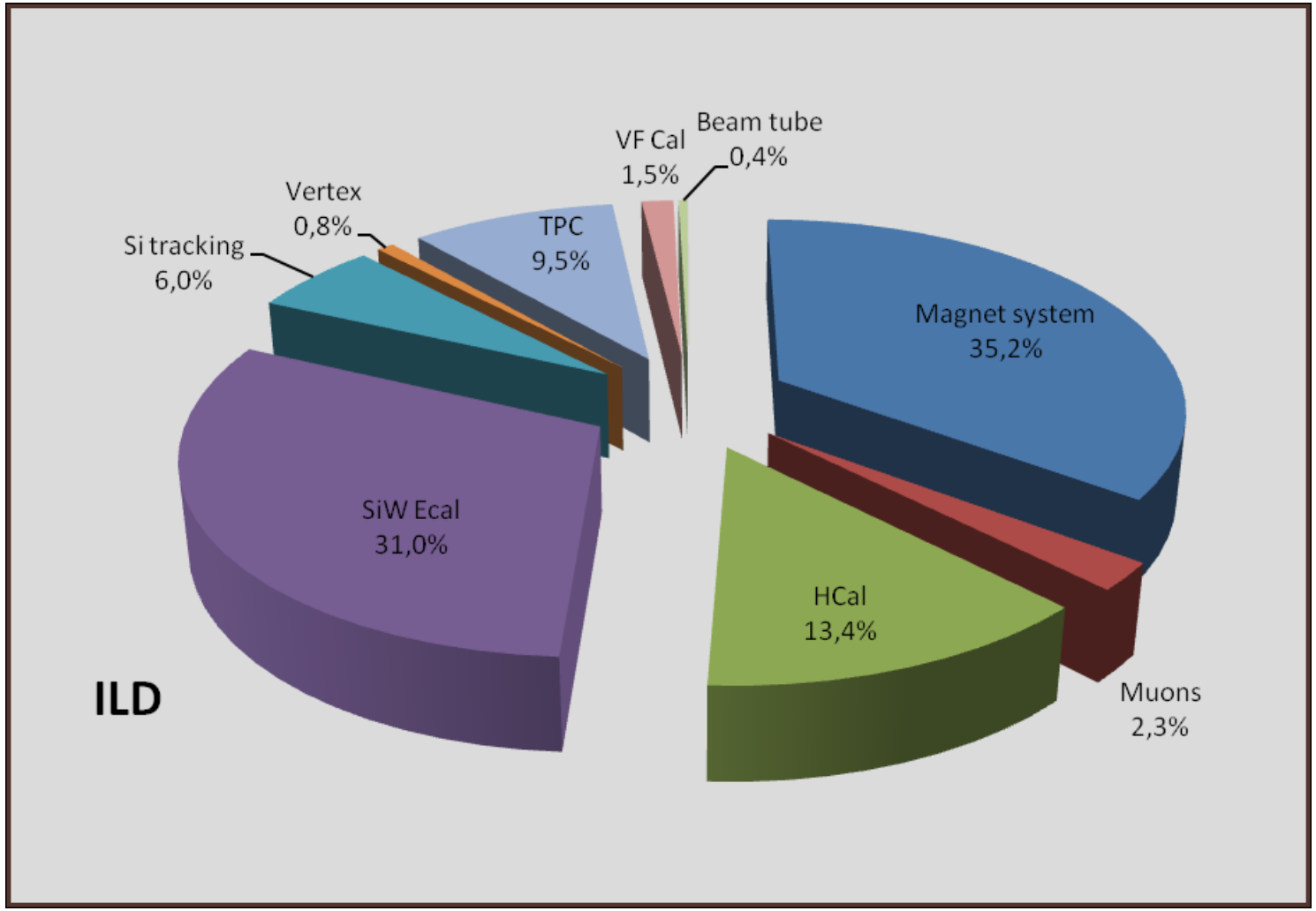
Cost – TPC

- **TPC cost estimation**
  - Chamber
  - Endplate
  - Electronics
  - Alignment
  - HV
  - Gas system

TPC COST ESTIMATION (Unit: *10K RMB)						
		Detector concept/ Detector items	Unit	Unit cost (RMB)	Quantity	total cost (RMB)
Number		CEPC				
3.2		**Time Projection Chamber**				18000.00
	3.2.1	**Chamber**				**3600.00**
	3.2.1.1	Fieldcage		1200.00	1	1200.00
	3.2.1.2	Connector		800.00	1	800.00
	3.2.1.3	Barrel		600.00	1	600.00
	3.2.1.4	HV test bef. Assembly		400.00	1	400.00
	3.2.1.5	Support board		600.00	1	600.00
	3.2.2	**Endplate**				**2500.00**
	3.2.2.1	MPGD detector		800.00	1	800.00
	3.2.2.2	Support board		600.00	2	1200.00
	3.2.2.3	Readout bef. Assembly		2.50	200	500.00
	3.2.3	**Electronics**				**10000.00**
	3.2.3.1	FEE ASIC readout		0.012	200000	2400.00
	3.2.3.2	Cables		0.03	50000	1500.00
	3.2.3.3	Optical driver		0.03	50000	1500.00
	3.2.3.4	Optical link, connectors		1.00	500	500.00
	3.2.3.5	DAQ system		0.30	5000	1500.00
	3.2.3.6	Crate and controller		20.00	50	1000.00
	3.2.3.7	Cooling system		1600.00	1	1600.00
	3.2.4	**Alignment and calibration**				**500.00**
	3.2.4.1	Calibration system		500.00	1	500.00
	3.2.5	**HV and Gas system**				**1400.00**
	3.2.5.1	HV and low power		600.000	1	600.00
	3.2.5.2	Gas system		300.00	1	300.00
	3.2.5.3	Slow control system		300.00	1	300.00
	3.2.5.4	Shipping bef. Assembly		200.00	1	200.00

Cost – TPC – Reference of ILD

- **Uncertain**
  - Evaluation of the materials cost not easy to anticipate in the 10 coming next years
  - Missing items
  - Uncertainty analysis should have been based on “multi-estimate” and analytical analysis of the probability distribution.
  - The rigthinflation rate ?
    - Currency exchange,uncertainty ?



Tasks of TPC R&D for CEPC TDR

主要的分工如下：

- **1. 常悦：Pad size优化和像素型研究。**
- **2. 佘信：TPC performance优化及像素型研究。**
- **3. 张建：TPC 径迹探测器尺寸确认和机械集成（与负责总体纪全老师合作）**
- **4. 邓智：像素型优化研究。**

Parameter of the references

- Cite#1 https://doi.org/10.1088/1748-0221/12/07/P07005
- Cite#2 Correcting for Distortions due to Ionization
- Cite#3 Occupancy in the CLIC
- Cite#4 https://doi.org/10.1088/1748-0221/12/07/P07005
- Cite#5 GridPix detectors
- Cite#6 Low power WASA chip
- Cite#7 Cost estimation of ILD concept
- Cite#8 https://agenda.linearcollider.org/event/5504/contributions/24543/attachments/20144/31818/PositiveIonEffects-kf.pdf
- Cite#9 https://indico.fnal.gov/event/46746/contributions/208077/attachments/141125/177798/LCTPC.pdf
- Cite#10 Di Meglio, Alberto, et al. CERN Quantum Technology Initiative Strategy and Roadmap. No. CERN-OPEN-2021-012. 2021
- Cite#11 arXiv:1902.01987 [physics.ins-det, 2019] Yuan, Zhiyang, et al. International Journal of Modern Physics A 36.22 (2021): 2142015.
- Cite#12 Chang, Y., et al. "Performance of the continuous ions suppression TPC prorotype for circular collider." Journal of Instrumentation 15.09 (2020): C09065.

Many thanks!