Gaseous detector chapter towards CEPC TDR

Huirong Qi and Linghui Wu

Weekly meeting of CEPC TDR Group, August 20, 2024

Content

- **Updated gaseous detector part in TDR**
- **Updated design of TPC for TDR**
- **Planning presentations for CEPC2024**

Updated gaseous detector part in TDR

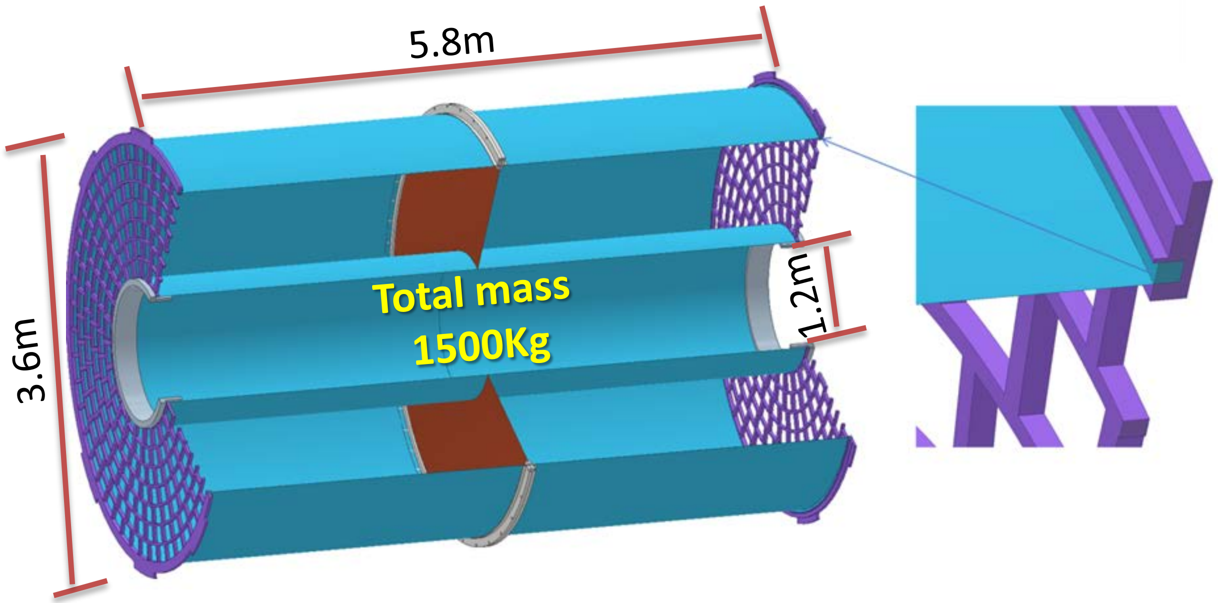
- **Core of the research team** (10 staffs + TPC group)
  - IHEP: Huirong Qi, Linghui Wu, Guang Zhao, Mingyi Dong, Yue Chang, Xin She, Jinxian Zhang, Junsong Zhang
  - Tsinghua: Zhi Deng, Canwen Liu, Guanghua Gong, Feng He, Jianmeng Dong, Yanxiao Yang
- **Collaboration of the research team** (6 staffs +10 students + 5 LCTPC members)
  - TPC: CIAE, Shandong University, Nankai University, Zhengzhou University and Liaoning University / DC: Wuhan University, Jilin University
  - TPC and DC: DRD1 collaboration and LCTPC collaboration

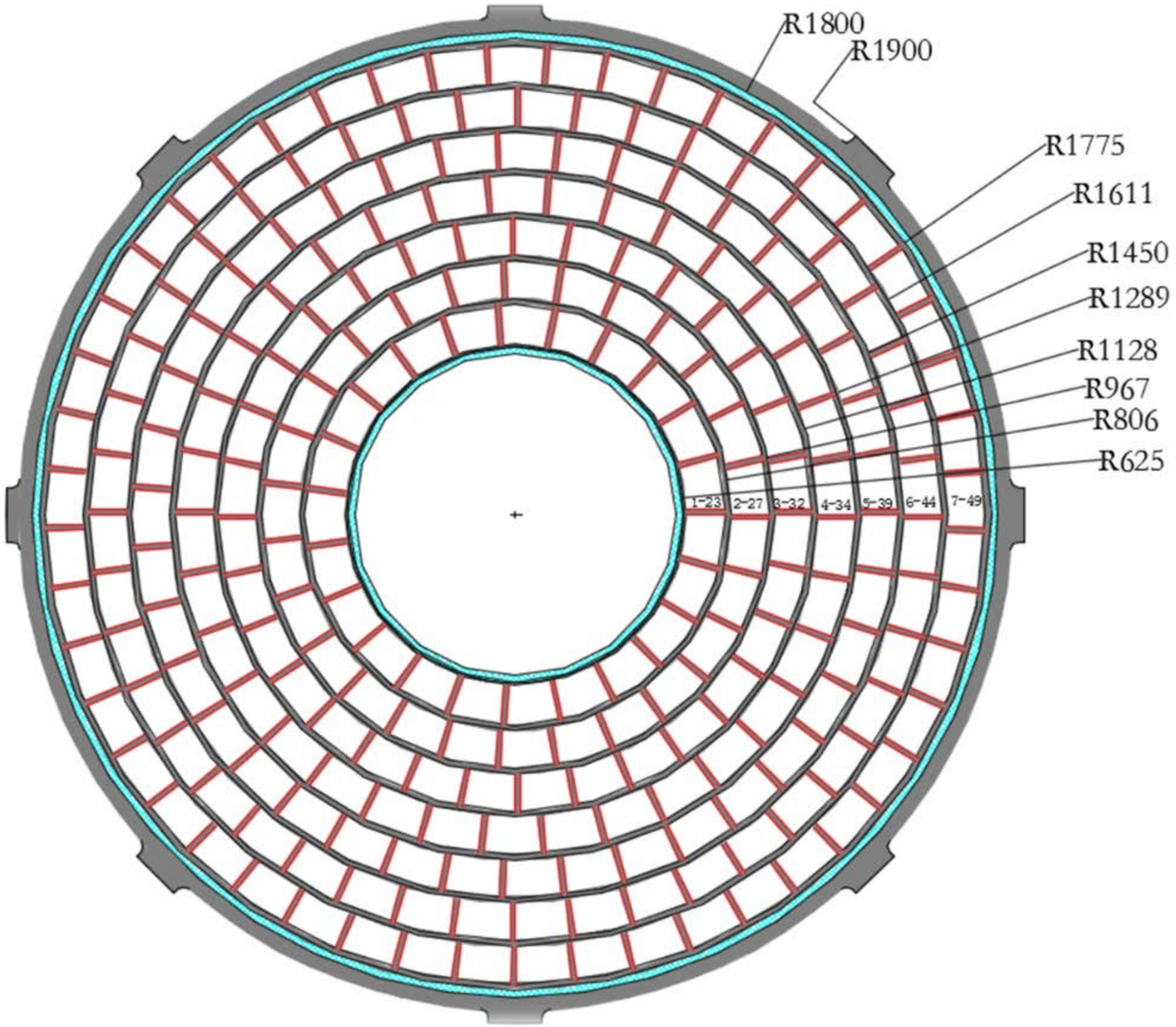
Chapter 5 Gaseous trackers

Shared editing chapter from overleaf

Updated design of TPC mechanics for TDR

TPC detector	Key Parameters
Modules per endcap	248 modules /endcap
Module size	206mm×224mm×161mm
Geometry of layout	Inner: 1.2m Outer: 3.6m Length: 5.9m
Voltage of Cathode	- 62,000 V
Operation gases	T2K: Ar/CF4/iC4H10=95/3/2
Total drift time	34μs @ 2.75m
Pixelated detector	Pixelated Micromegas

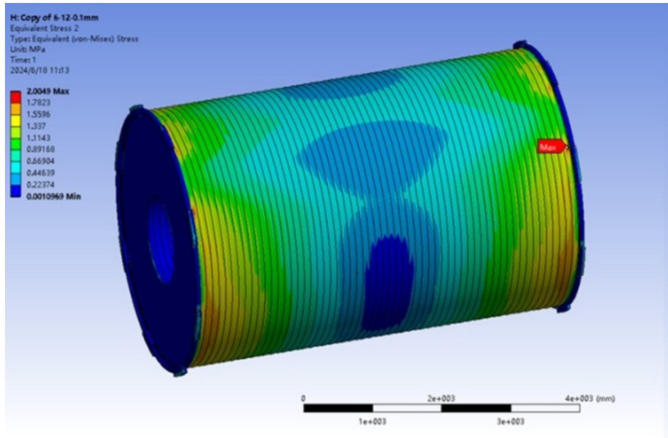


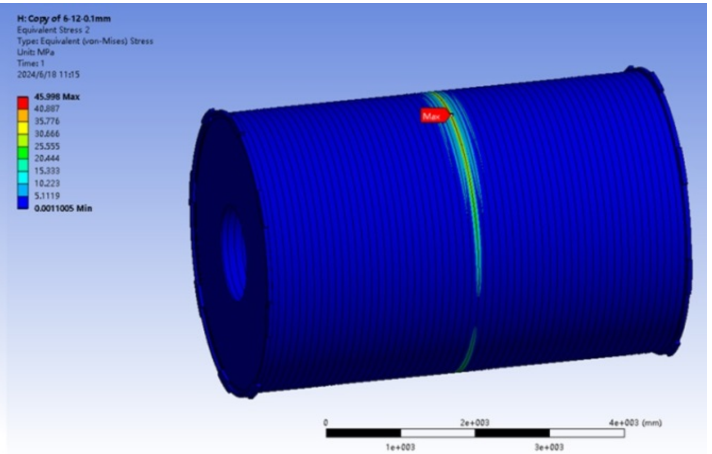


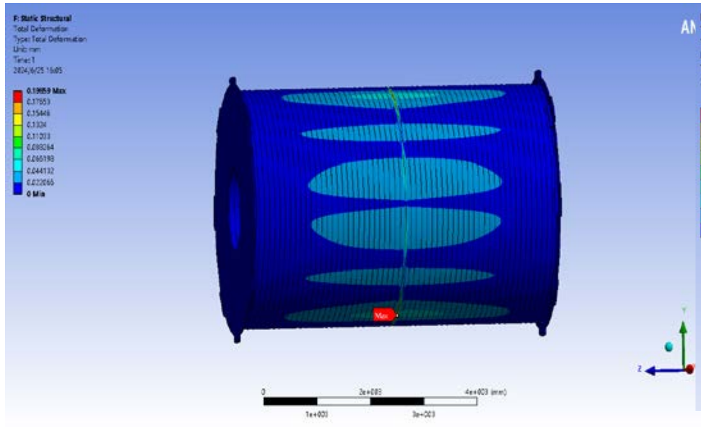
Detailed design of TPC detector in ref-TDR

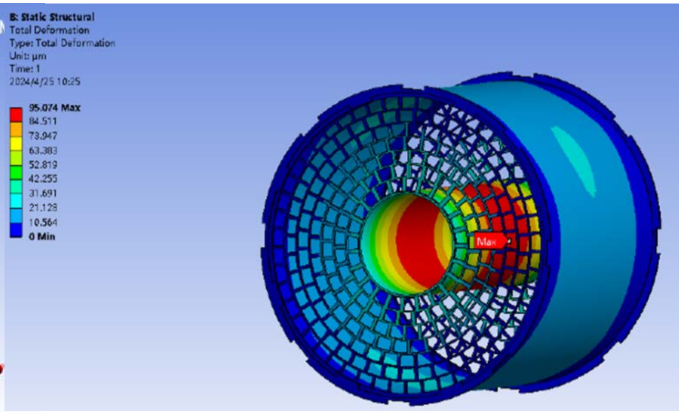
Updated ultra-light barrel and FEA analysis

- Consideration of new Carbon Fiber barrel instead of the honeycomb barrel (**~2% X_0**)
- **Ultra-light material** of the TPC barrel (QM55 CF) : **0.59% X_0 in total, including**
  - FEA preliminary calculation: 0.2mm carbon fibber barrel can tolerant of LGAD OTK (**100Kg**)
- Optimization of the connection back frame of the endcap (on going, MDI meeting this week)









Material budget of TPC barrel

Layer of the barrels	D[cm]	X_0[cm]	d/X_0[%]
Copper shielding	0.001	1.45	0.07
CF outer barrel	0.020	25.28	0.08
Mirror strips	0.003	1.35	0.19
Polyimide substrate	0.005	32.65	0.02
Field strips	0.003	1.35	0.19
CF inner barrel	0.010	25.28	0.04
Sum of the material budget			**0.59**

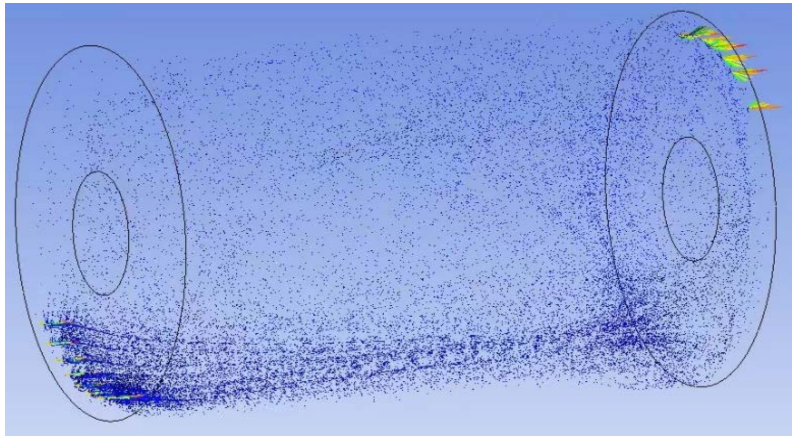
- **Low material of the TPC endcap**

15%X_0 in total, including

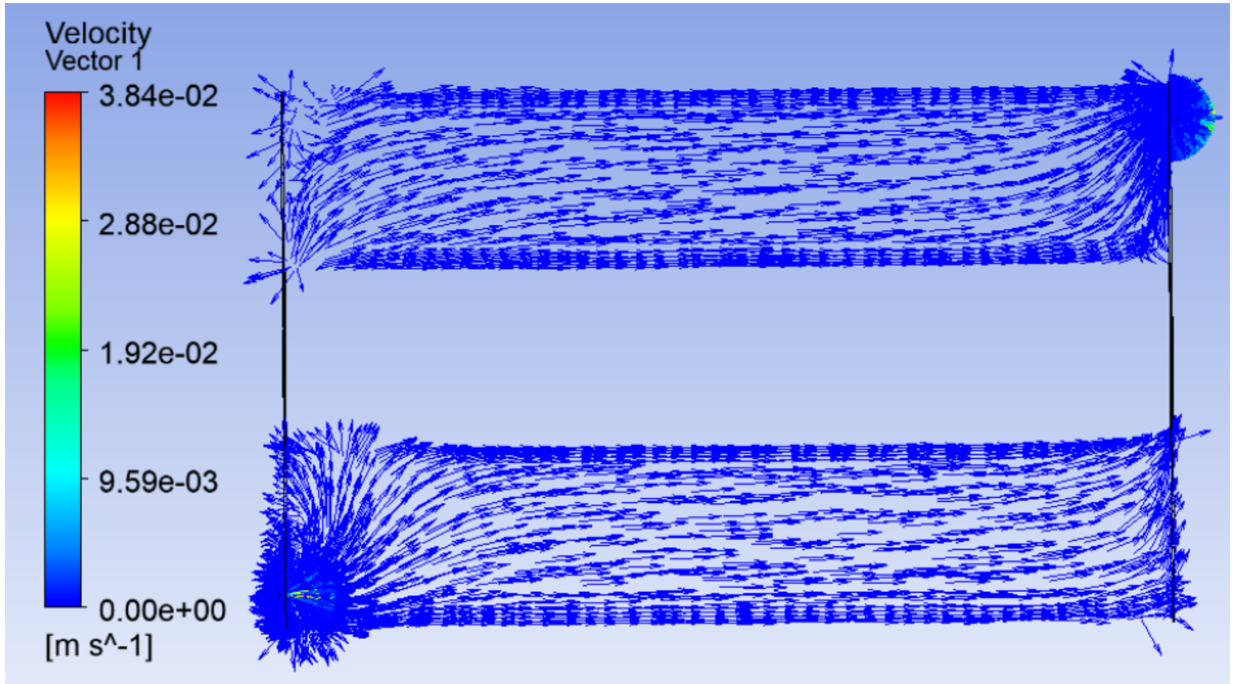
Readout plane, front-end-electronics	4%
Cooling	2%
Power cables	9%

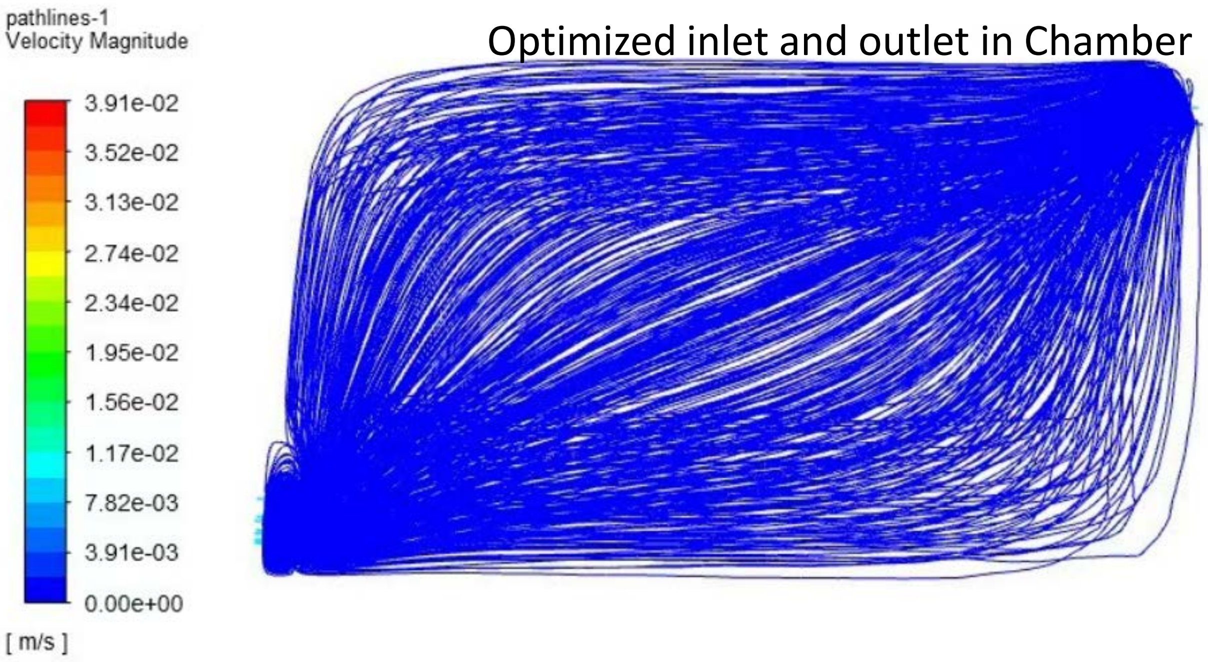
Optimization of Gas flow in Chamber

- Optimized design gas uniformity of **99% or more** in large TPC chamber
  - **8 Ø10mm** gas inlets + **8 Ø10mm** gas outlets (opposite, 90°/endcap)
  - Working gas flow: 300 – 500 mL/min
  - **Online monitoring system**: O_2 (ppm) and water H_2O (ppm)
  - Friendly the gases recycle system and mesh cathode considered



Optimized inlet and outlet in Chamber

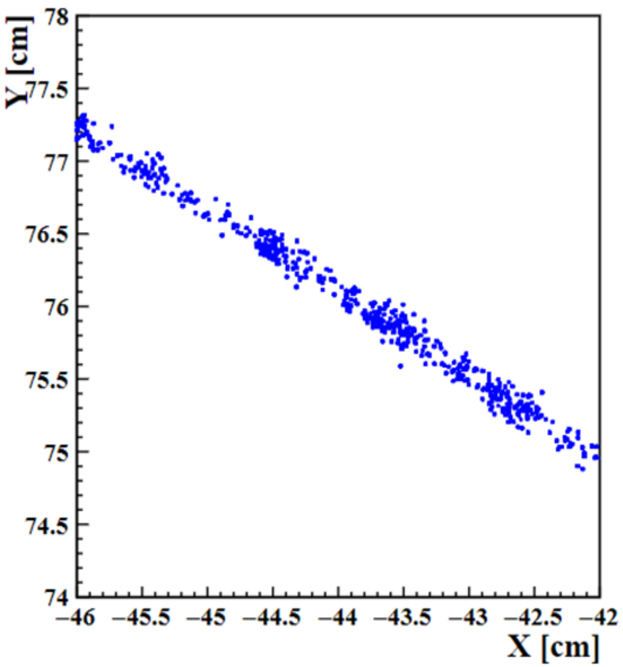




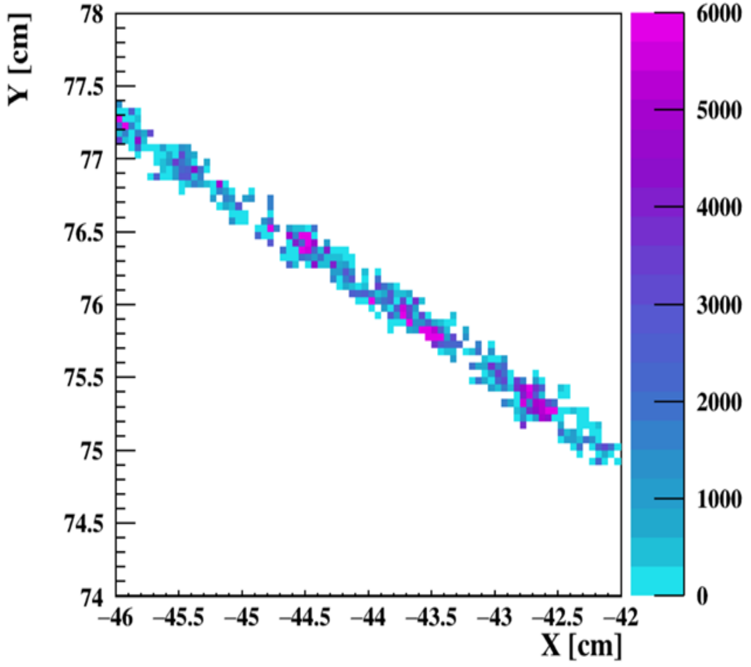
Simulation of gas flow and uniformity distribution in TPC Chamber

Updated high granularity readout TPC

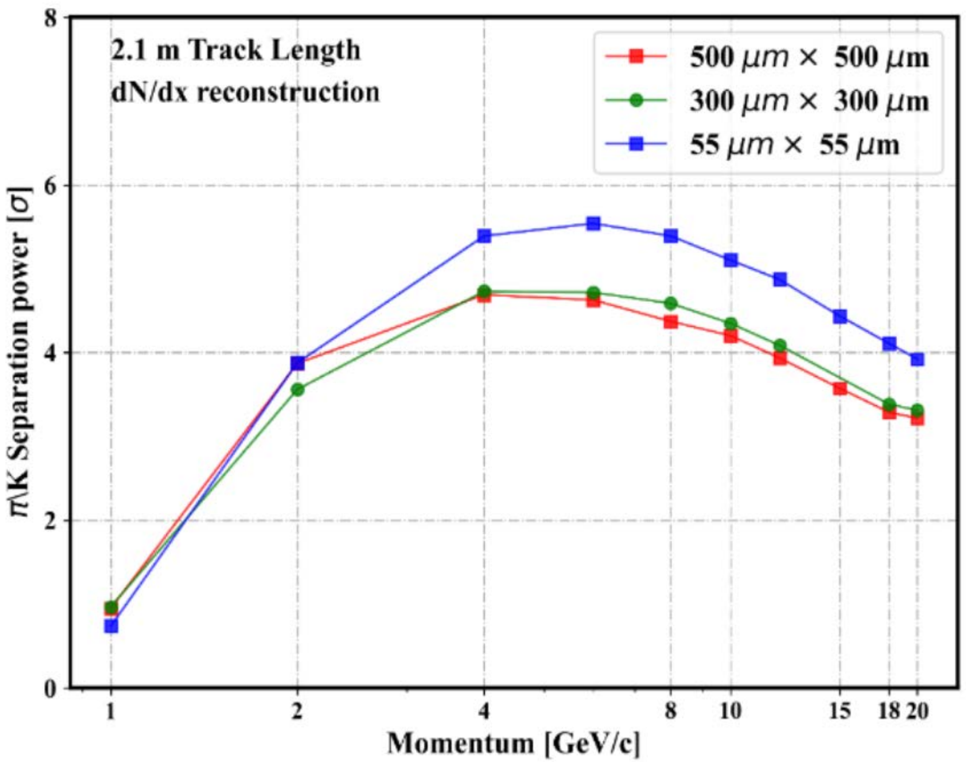
- Timepix (55μm×55μm) readout TPC prototype has been validation four times on DESY beams
  - Power consumption: 2W/cm^2 ; Low power mode: 1W/cm^2 (**Too high power for pixelated readout**)
- Simulation results showed that readout size can be optimized at 300μm-500μm
  - Reasonable readout channels and power consumption need to be studied
  - Focused on **100mW/cm^2 and 500μm readout** for CEPC refTDR (2-phase CO_2 cooling **OK!**)



pixel response (55 μm× 55 μm)

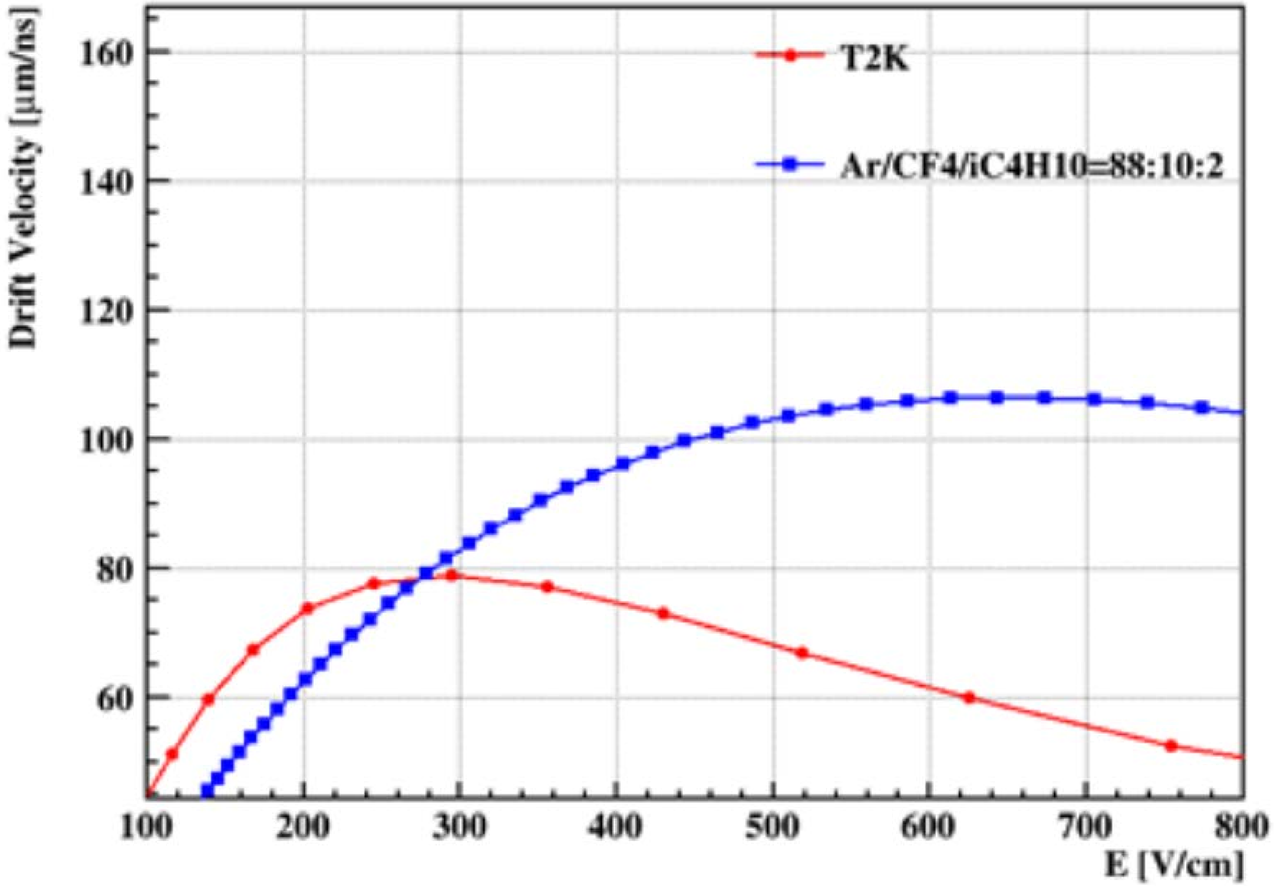


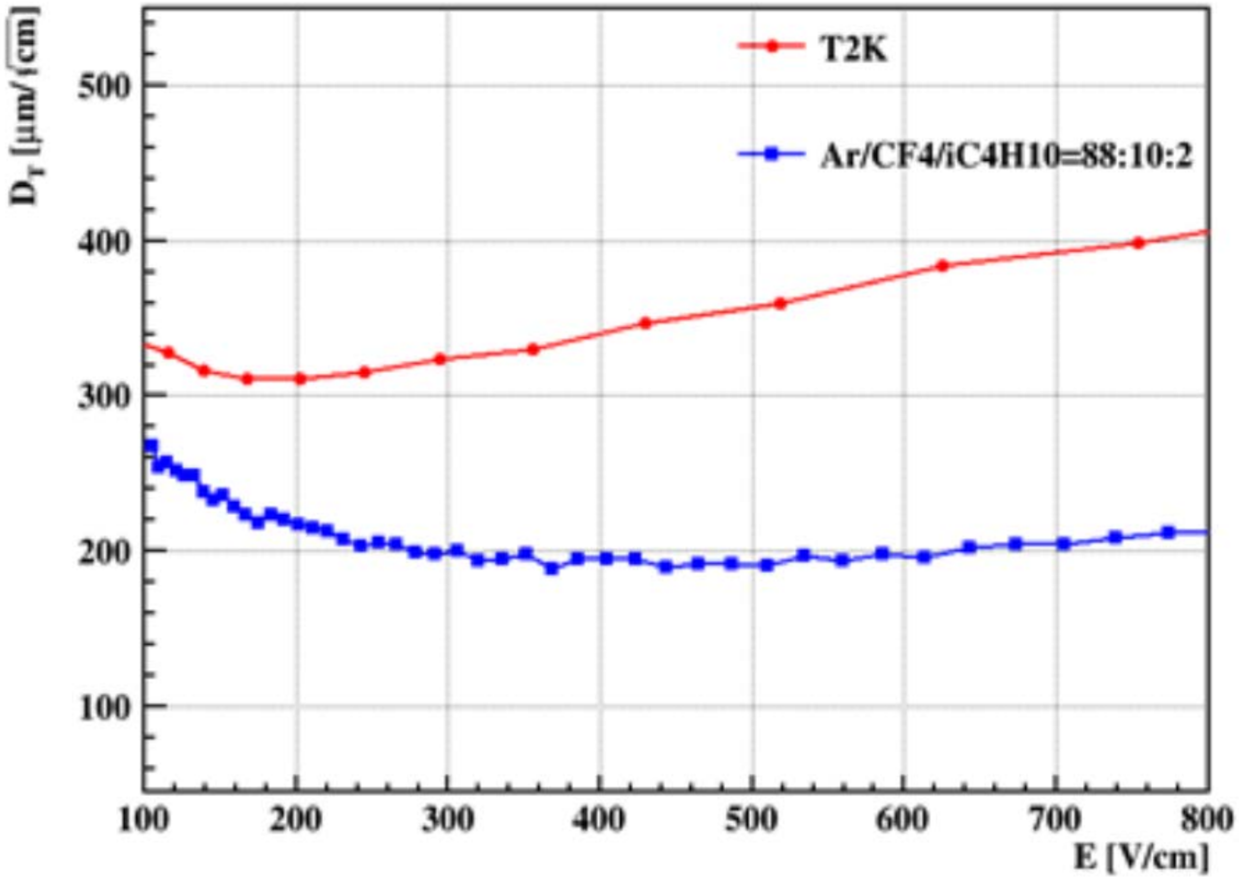
pixel response (500 μm× 500 μm)



Fast simulation of the mixture working gases

- Fast drift velocity **at >450V/cm**
- Lower D_T diffusion





Passive ions gating using GridPIX at CPAD

- High granularity GridPix R&D

GridPix with Pasive Bipolar Grid in high Magnetic Field

Evgeny Shulga[1] Babak Azmoun[2] Prakhar Garg[3] Thomas Hemmick[1] Jochen Kaminski[4] Alexander Milov[5] Nikolai Smirnov[4]

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[2]Physics Department, Brookhaven National Laboratory, USA [5]

[3]Department of Physics, Yale University, USA [6]

[4]Institute of Physics, University of Bonn, Germany [7]

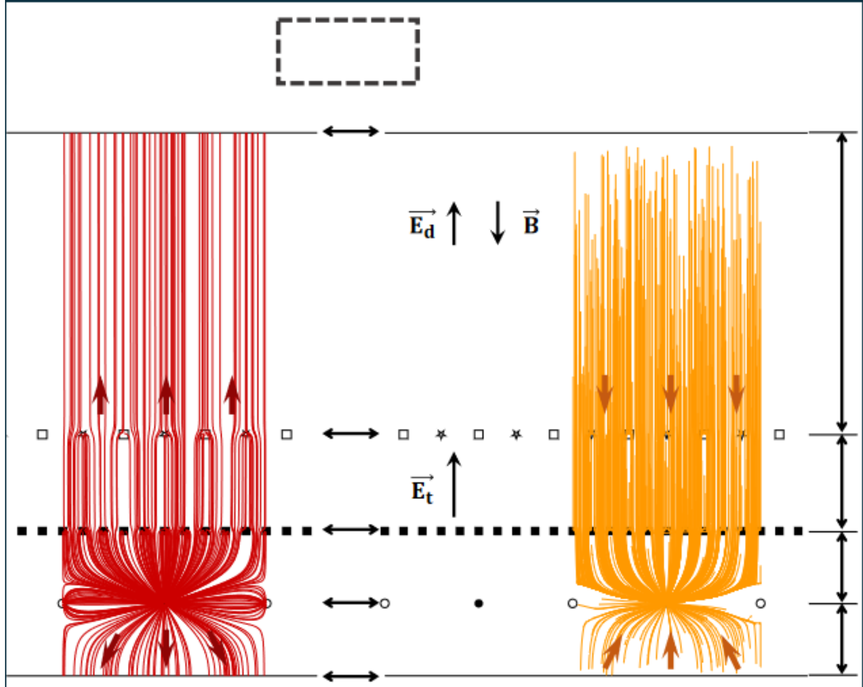
[5]Department of Particle Physics and Astrophysics, Weizmann Institute of Science, Israel [8]

https://indico.fnal.gov/event/65448/

Passive ions gating using GridPIX at CPAD

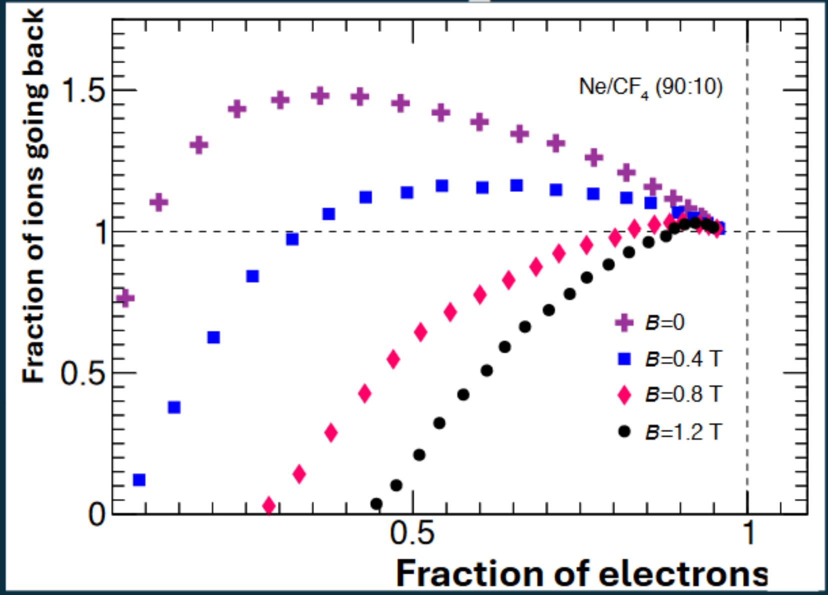
- High granularity GridPix R&D

Ion Blocking by the Passive Bipolar Grid



arXiv:2007.13616

IEEE:9279256



- Results show that IBF can be suppressed down to 0 with a cost of 45% of primary electrons @ B≥1.2 T
- Comparison to simulations have been performed, better measured gases provide better results, improvement could be obtained in the future
- Beam test was performed @ the Argon National Laboratory to increase magnetic field
- Garfield++ simulations have shown good results for Ar/CH4

Presentations and Posters for CEPC2024 in Hangzhou (planning)

- **Just only from CEPC gaseous track study group at IHEP and internal University**
  - **Based on previous CEPC meeting programme**

	Presenter	Type	Draft title	Planning session
1	Huirong Qi	Oral	Status of CEPC TPC towards TDR	Gaseous track detector
2	Mingyi Dong	Oral	Status of CEPC DC	Gaseous track detector
3	Guang Zhao	Oral	Machine leaning for dN/dx reconstruction	Machine learning session
4	Zhi Deng	Oral	Low power readout ASIC R&D	Electronics session
5	Xin She	Oral	BK analysis at Tera-Z	MDI session
6	Yue Chang	Oral	Pixelated readout gas detector for PID	PID session
7	Canwen Liu	Poster	Status of FEE ASIC for TPC	Gaseous track detector
8	Jinxian Zhang	Poster	High granularity readout TPC at Tera-Z	MDI session
9	USTC (TBD)	Oral	MPGD R&D	
10	SDU (TBD)	Oral	IBF R&D	
11	CEIA (TBD)	Oral	Micromegas R&D	\
12	Student	Poster	\	\

TPC机柜需求初步考虑（DAQ部分未考虑）

	主要分项	机柜	需求描述	机箱
1	高压需求	一个机柜	每个module一路高压，共需要500路	3个9U的SHV机箱
2	阴极高压	合用机柜	一路，10万伏以内，电流5mA以内,	一个6U机箱
3	电子学低压 LV	一个机柜	+-24V、+-12V等 由于功率的需求，需定制	需要较多,定制
4	气体成分在线监测及回收	一个机柜	气体成分在线监测及气体回收	研制、定制
5	温湿度在线监测、流量监测	一个机柜	温湿度在线监测、流量监测	研制、定制

Many thanks!

- High granularity small-pad resistive Micromegas R&D

High granularity small-pad resistive Micromegas for high-rate environment

Roberto Di Nardo

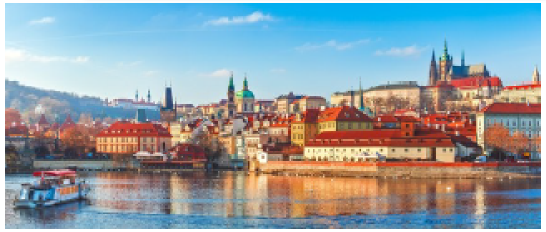
on behalf of the RHUM collaboration:

M. Alviggi [1,2], M. Biglietti [3], M.T. Camerlingo [8], K. Chmiel [3,4], M. Della Pietra [1,2], C. Di Donato [1,6], R. Di Nardo [3,4], P. Iengo [1], M. Iodice [3], R. Orlandini [3,4], S. Perna[1,2], F. Petrucci [3,4], G. Sekhniaidze [1], M. Sessa [7]

(1) INFN Napoli (2) University Napoli Federico II, (3) INFN Roma Tre
(4) University Roma Tre, (5) CERN, (6)University Napoli Parthenope, (7) INFN ROMA 2, (8) INFN Bari

ROMA TRE UNIVERSITÀ DEGLI STUDI

INFN Istituto Nazionale di Fisica Nucleare



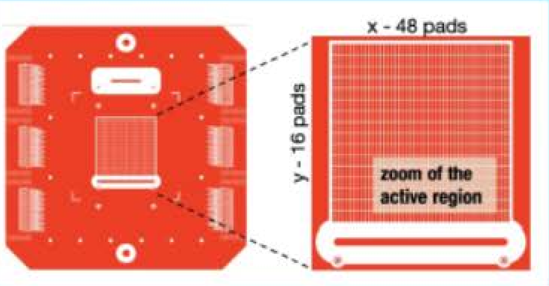
XLII International Conference on High Energy Physics
July 18th - 24th 2024 Prague (Czech Republic)

Some pixelated readout TPC R&D at ICHEP2024

- Smaller pad size and short drift length（5mm）

The prototypes size evolution

Small size prototypes

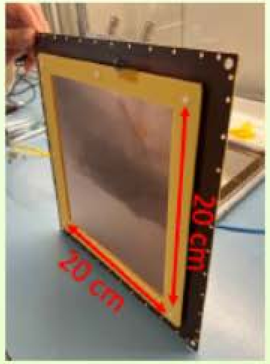


Several resistive layout tested

Active area: 4.8 x 4.8 cm^2 active region
Anode plane pad size: 0.8 x 2.8 mm^2 → 768 pads

48 pads – 1 mm pitch ("x")
16 pads – 3 mm pitch ("y")

Medium size prototypes

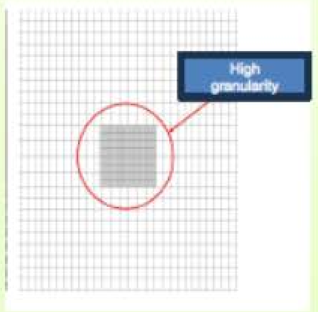


Two detectors:
Paddy400-1 & Paddy400-2

Active area : 20 cm x 20 cm (partial readout in central part, ~40%)
Anode plane pad size: 1x8mm^2 → 4800 pads

- Tests performed also in "common cathode" configuration

Large size prototypes



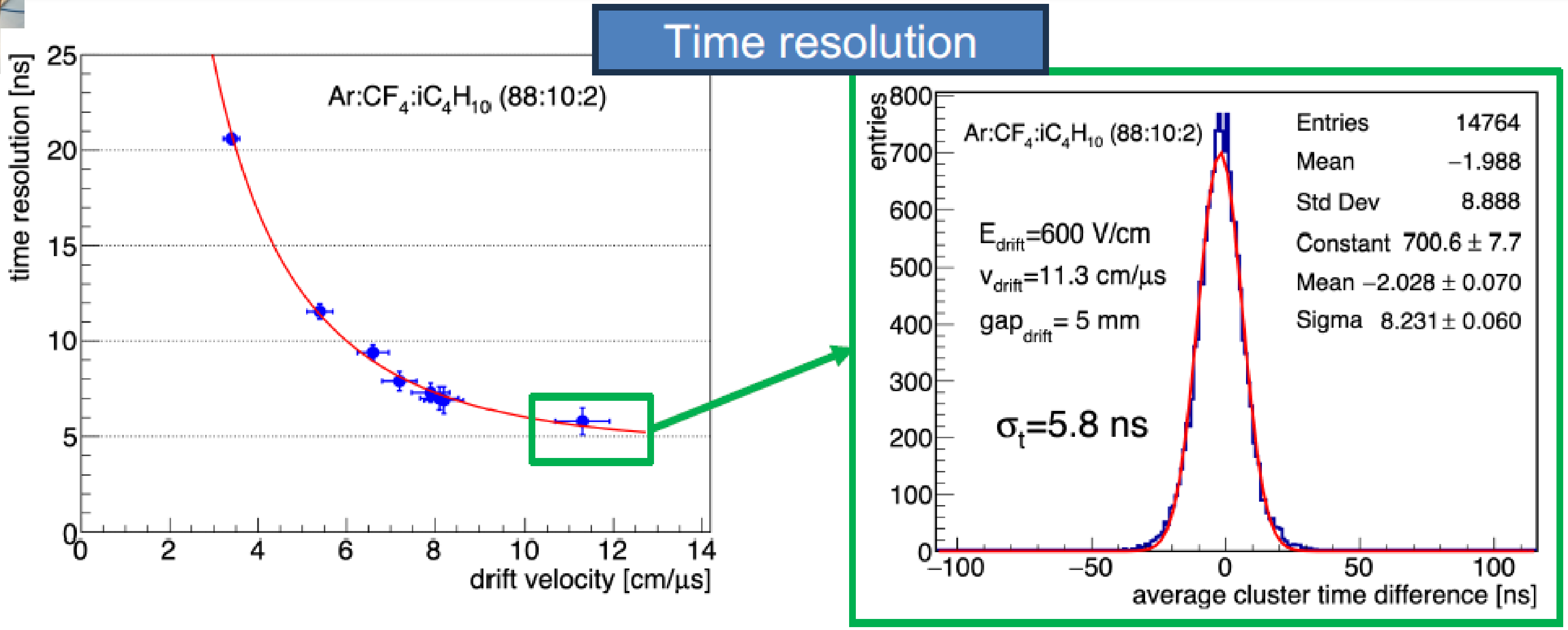
Paddy-2000 - "The Big one"

Active area : 50 cm x 40 cm
Anode plane pad size:
Central part
1x8mm^2 → 512 pads
Surrounding area
10x10mm^2 → 2048 pads

Some pixelated readout TPC R&D at ICHEP2024

- High granularity small-pad resistive Micromegas R&D

Performances of the mid-size prototypes



- Evaluated by computing the time difference between on-track clusters in two different chambers
  - Common cathode configuration
- Fast gas mixture **Ar:CF4:iC4H10 (88:10:2)** exploited
- Drift velocities at various E_{drift} measured using the hit time distributions
  - In agreement with simulation
- Measured resolution for the medium size prototype ~6ns at v_{drift} ~11 cm/µs