기초과학연구원
Institute for Basic Science

Design and Fabrication of LAMPS TPC

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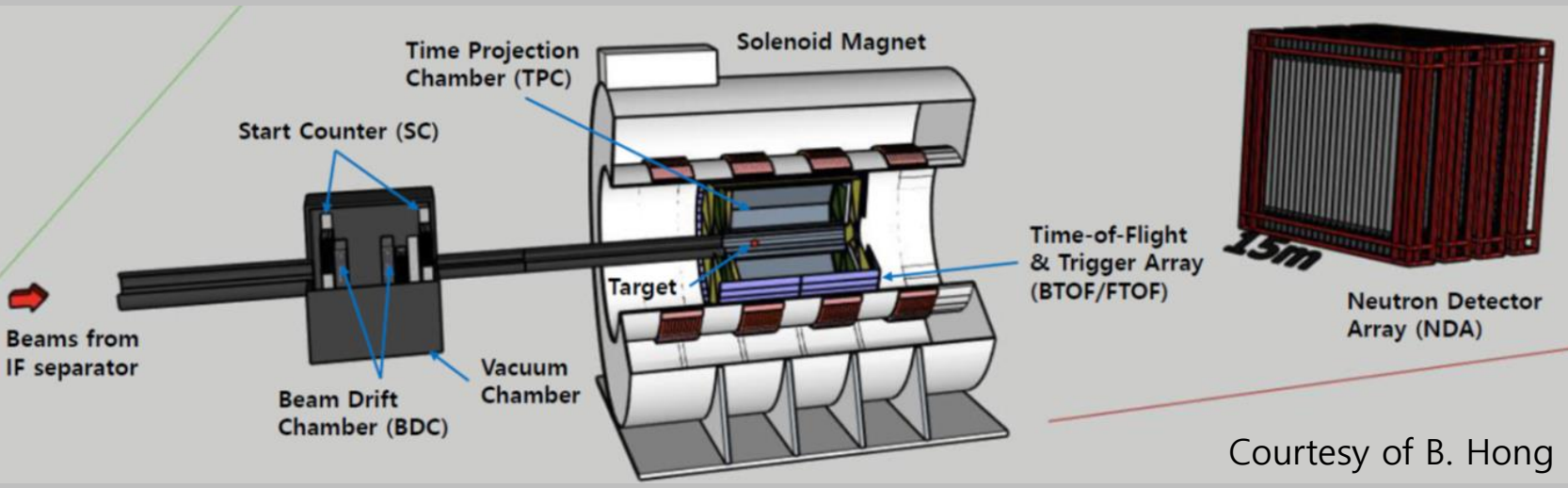
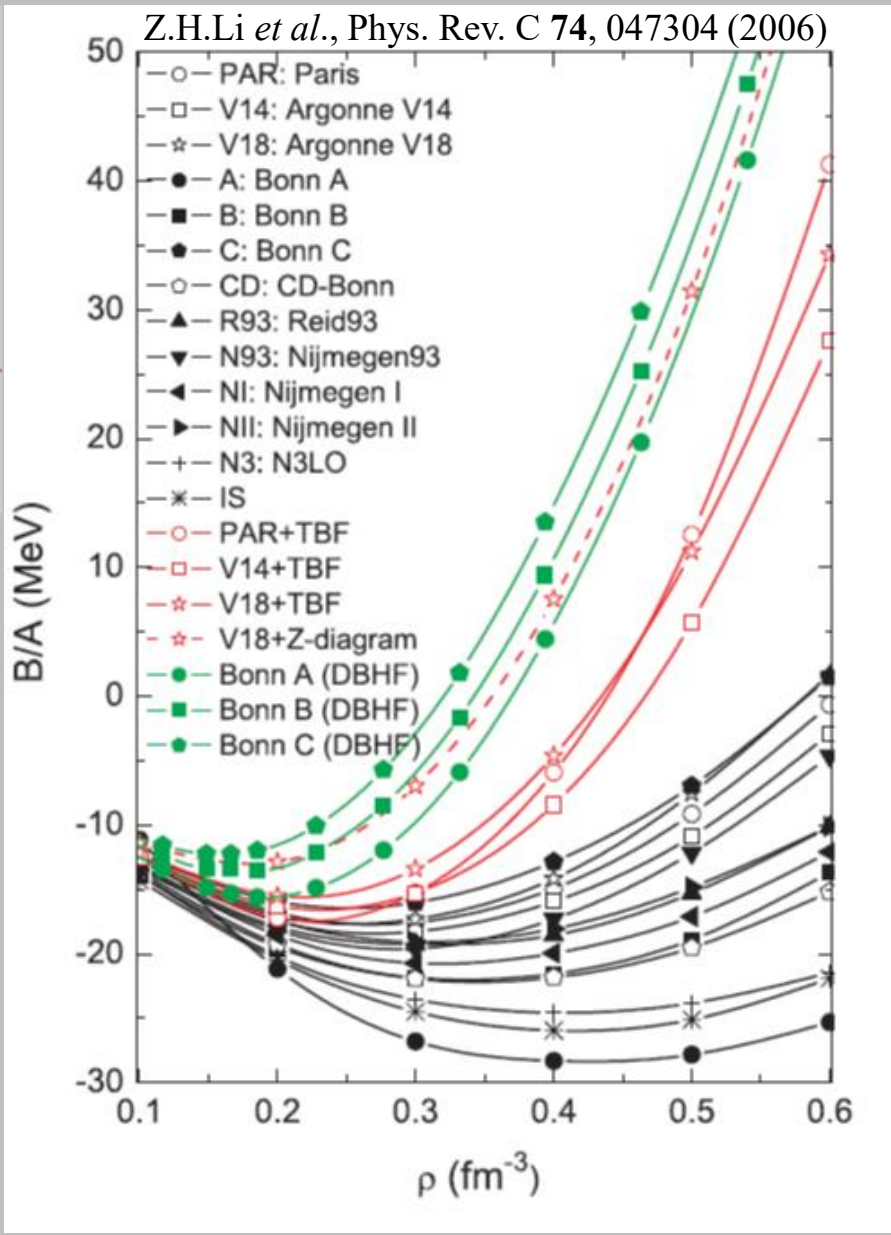
LAMPS TPC for EoS



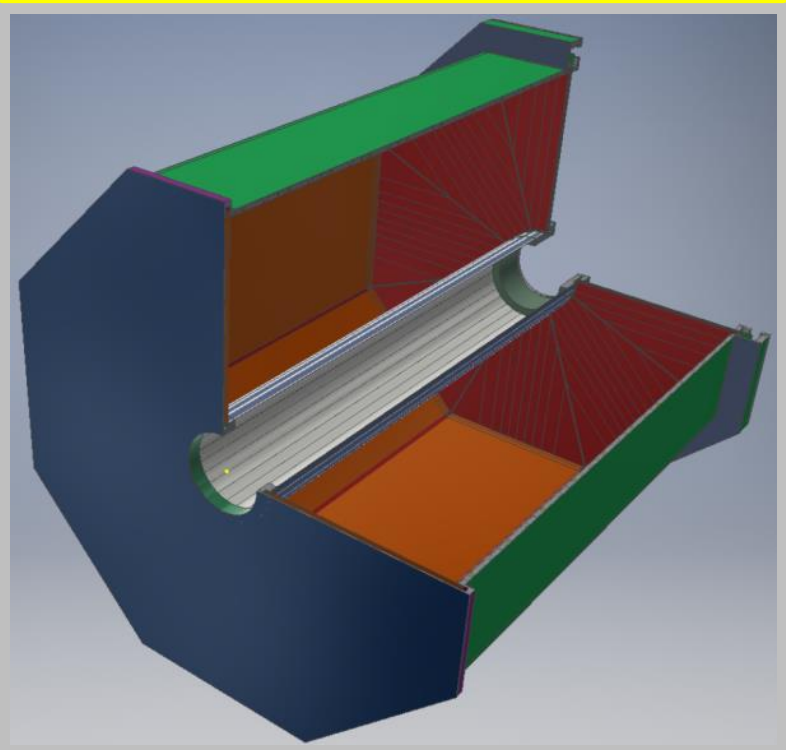
Courtesy of B. Hong

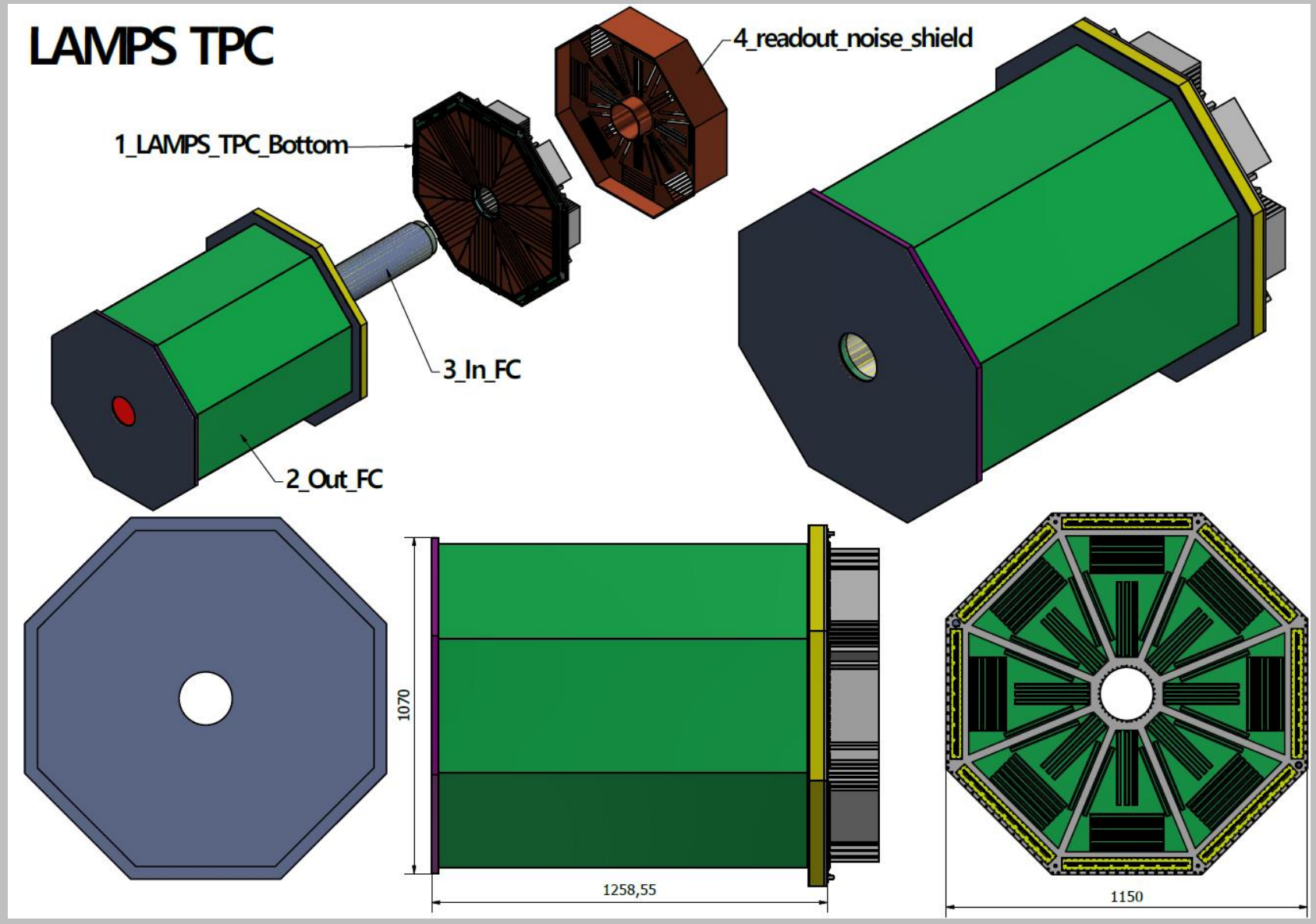
- Large Acceptance Multi-Purpose Spectrometer(LAMPS)
- (Planned) Beam Energy : up to 250 MeV/u for ^{132}Sn
- (Planned) Beam Intensity : up to 10^8 pps
- Detection system including :
  - SC to make trigger time
  - BDC to determine beam position on the target
  - **TPC to track charged particles originated from reactions**
  - ToF/Trigger Array to measure time-of-flight of charged particles
  - NDA for neutron detection



LAMPS TPC – Overview

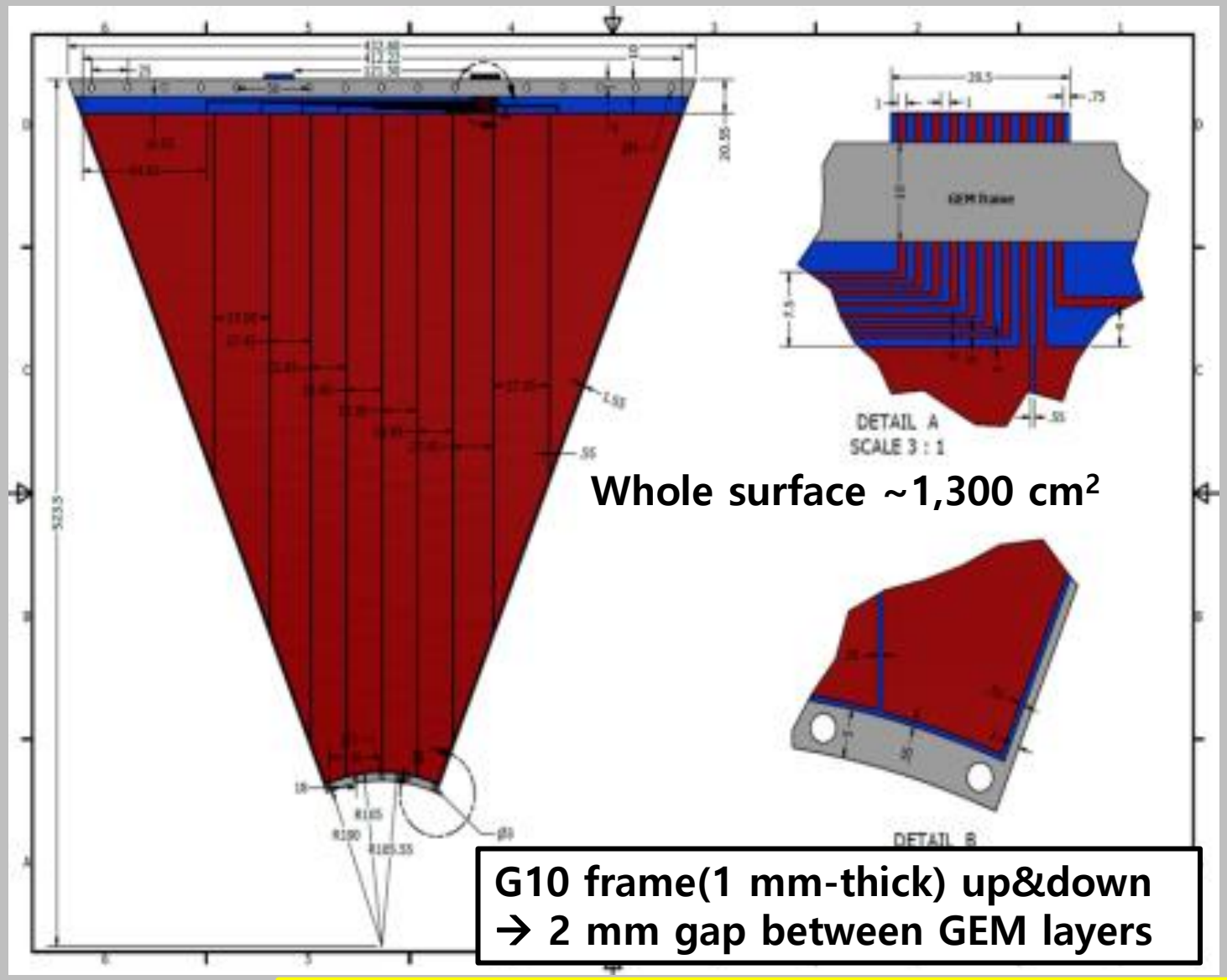
- 21,584 channels in total
- Max. drift length 120 cm
- Active volume ~1,200 L
- Non-magnetic materials
- Effective gas gain ≥ 10^4
- Drift velocity ≥ 6 cm/μs
- solid angle coverage ≥ 3π





Design of LAMPS TPC

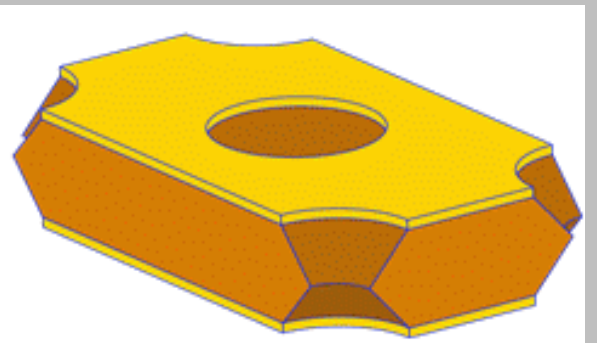
LAMPS TPC Design – GEM



Whole surface ~1,300 cm²

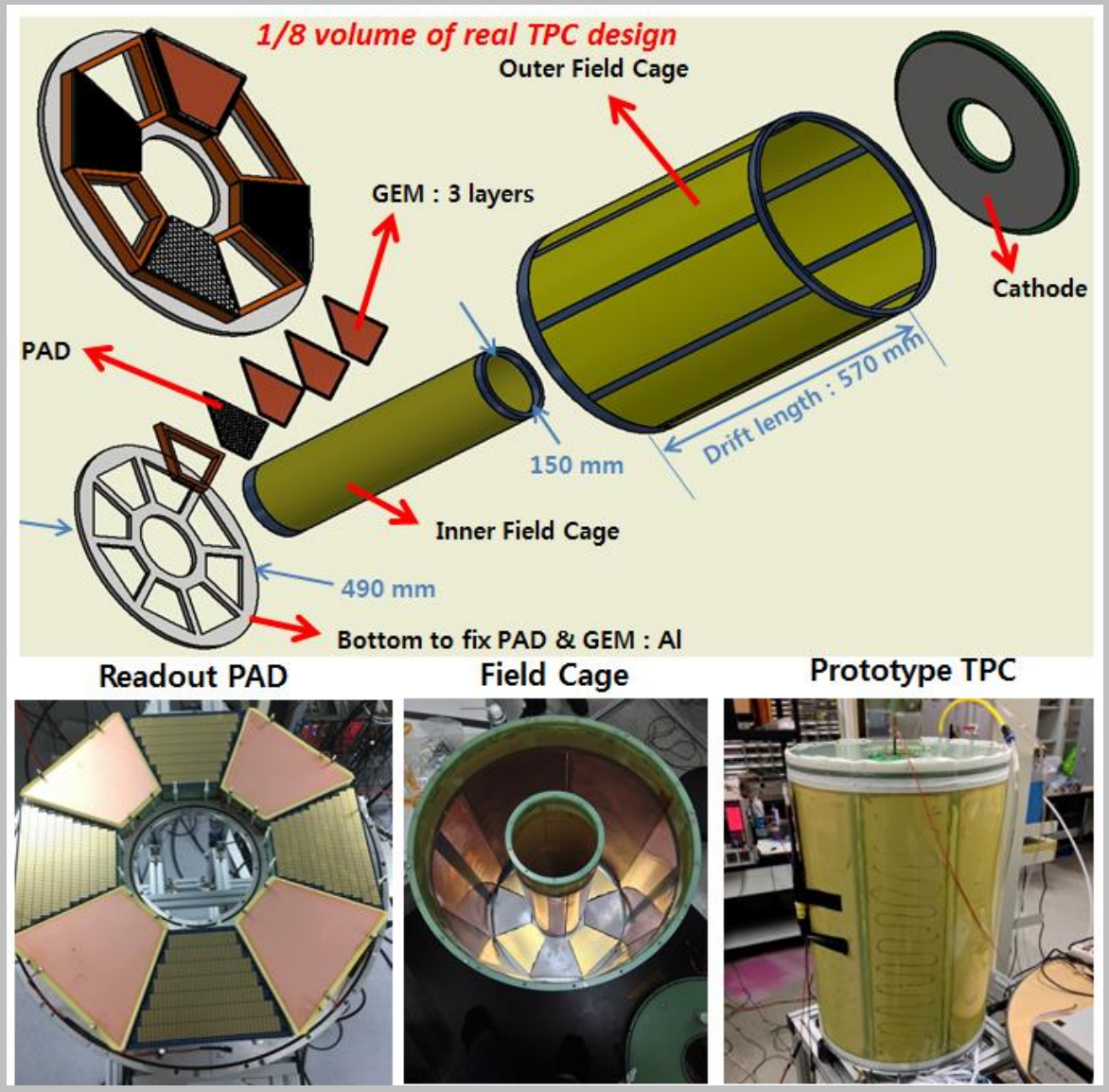
G10 frame(1 mm-thick) up&down
→ 2 mm gap between GEM layers

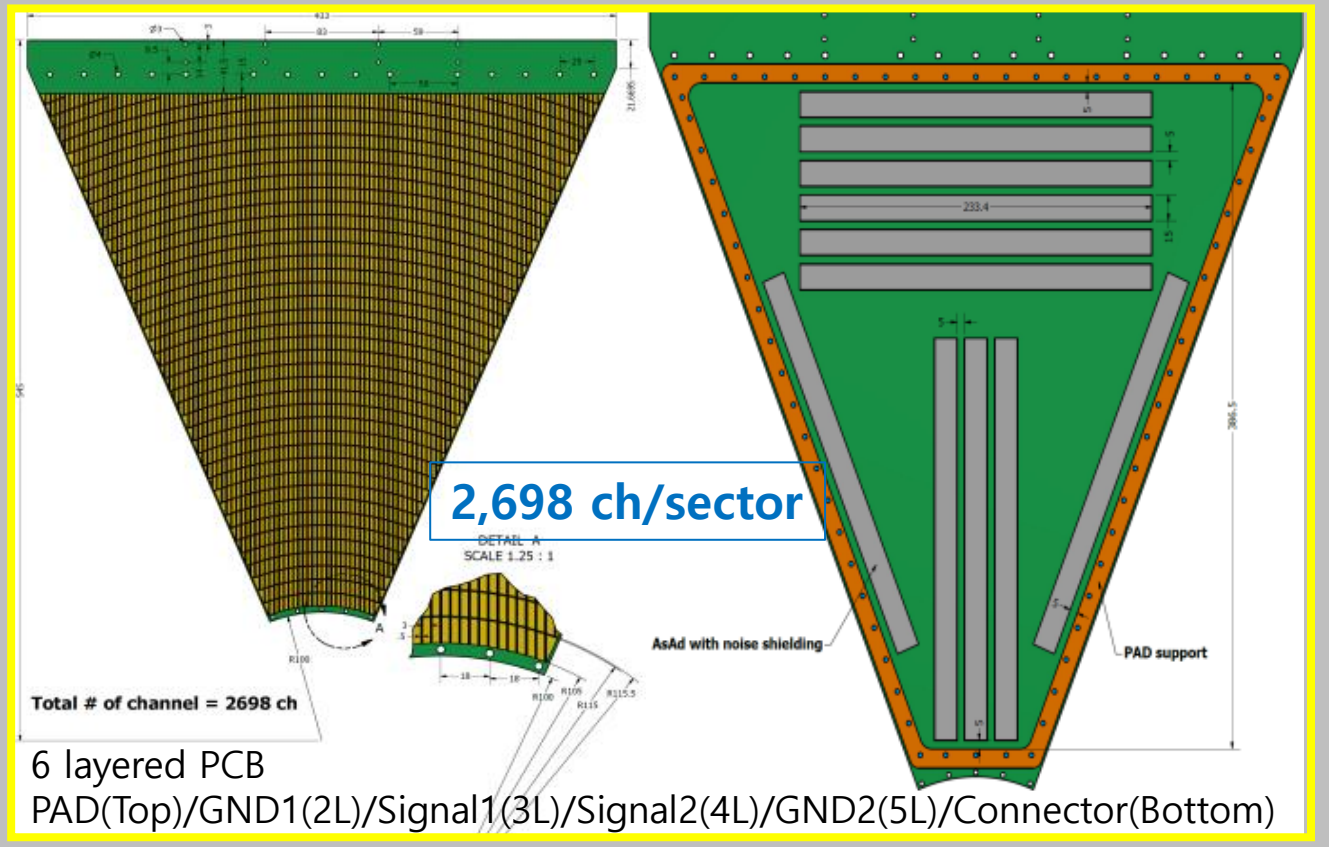
Gas Electron Multiplier for LAMPS TPC	
Thickness of PI	50 μm
Thickness of Cu	5 μm each
Hole size	70(2) μm
Shape of hole	Bi-conical
Pitch	140 μm
# of Segment	10
Capacity	≤ 6 nF/100 cm²
Leakage current (@500V bias)	≤ 5 nA/100 cm² ~ ≤ 5 nA/section

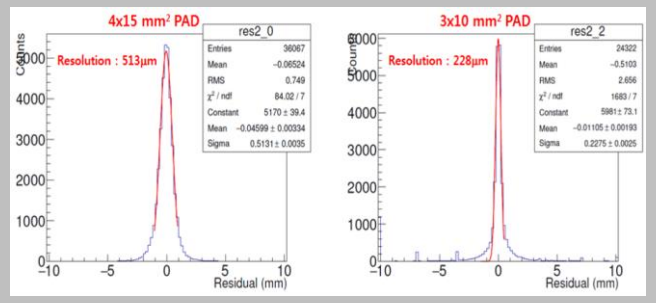


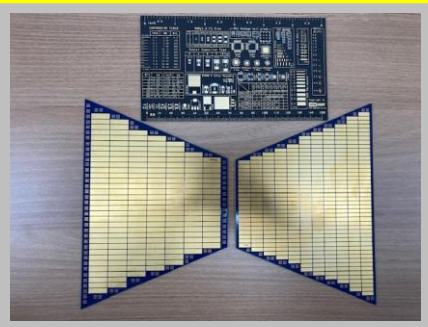
Quadrupole GEM configuration to obtain sufficient gas gain over 10^4

LAMPS TPC Design – Readout Pad

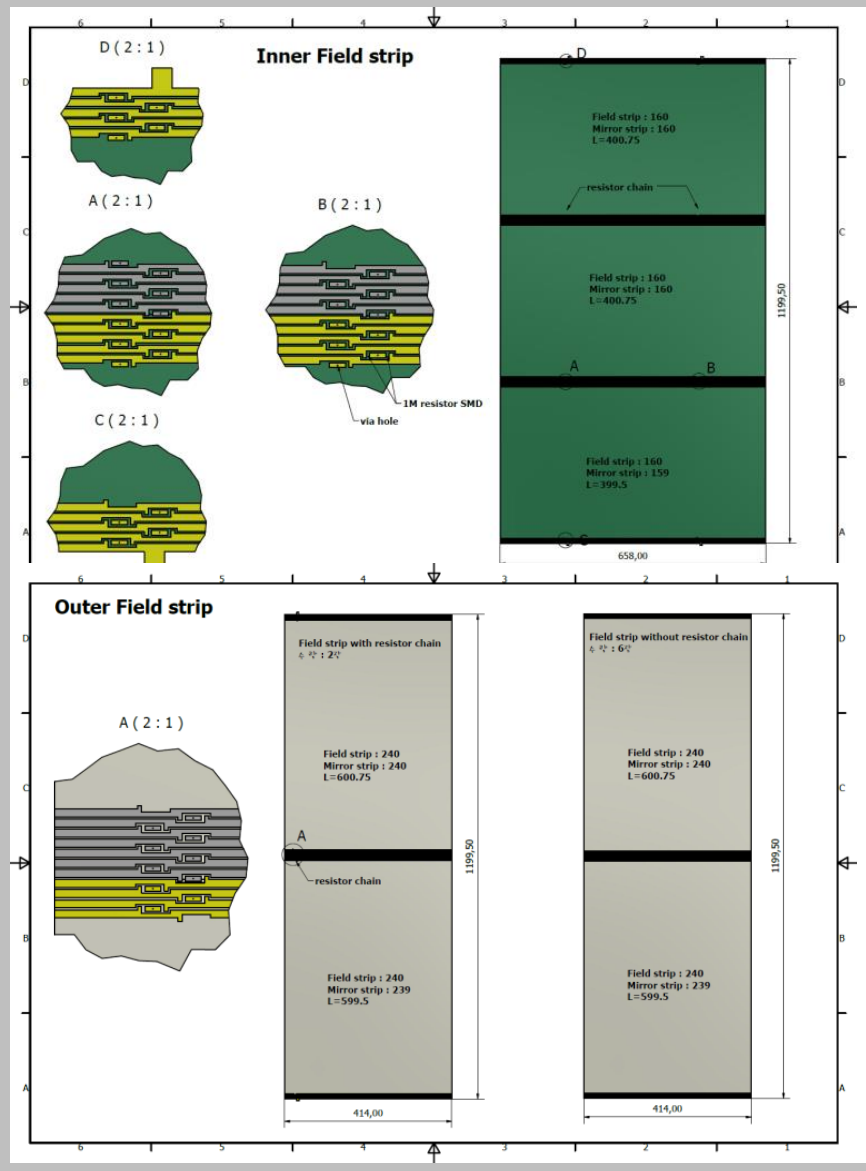


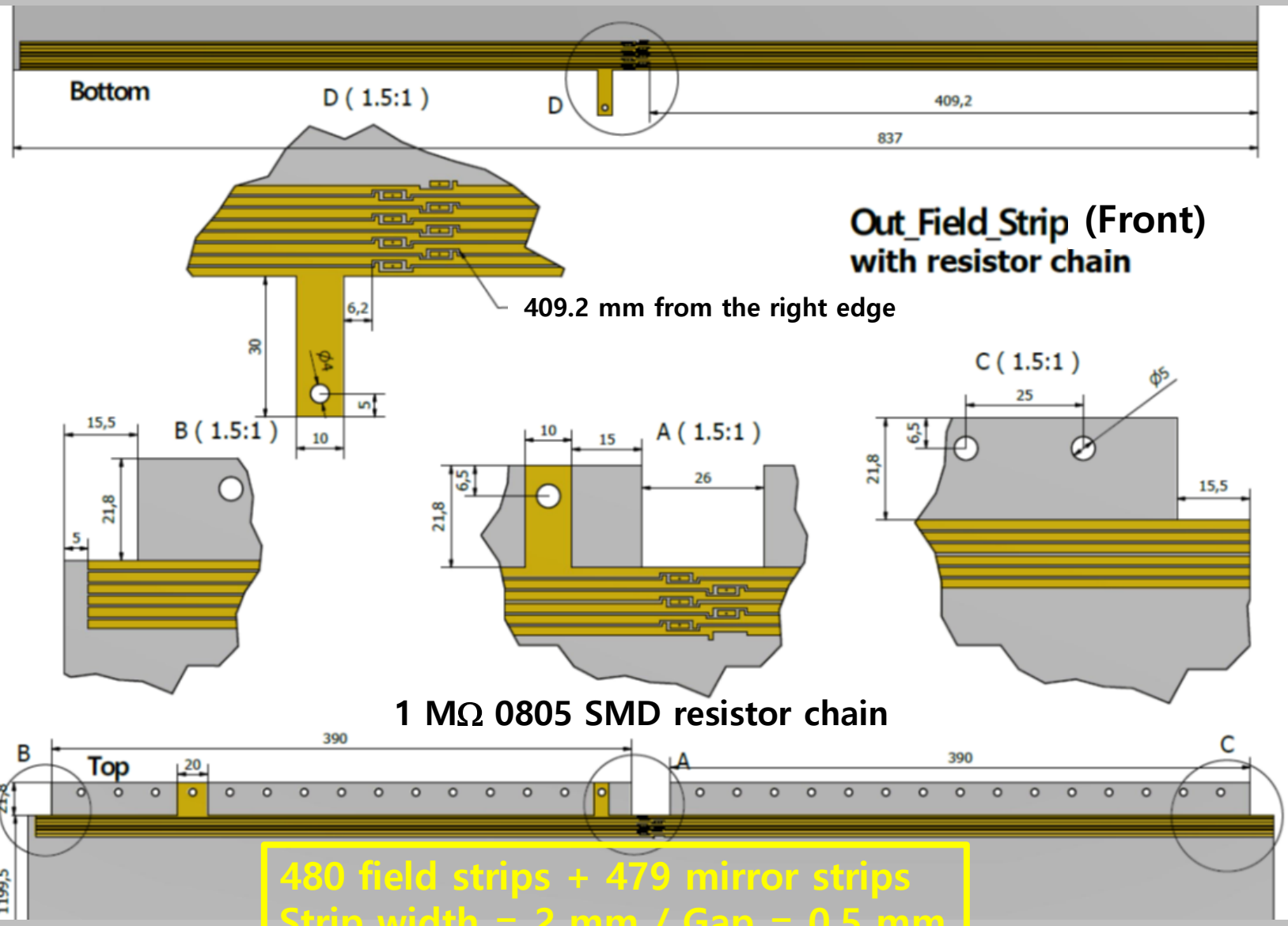




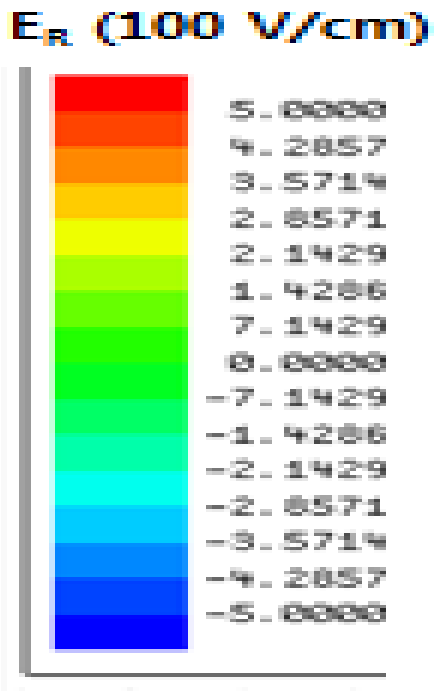


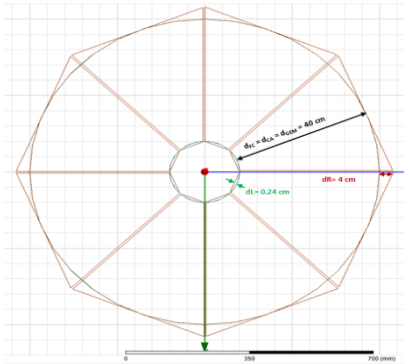
LAMPS TPC Design – Field Strips for Fieldcage

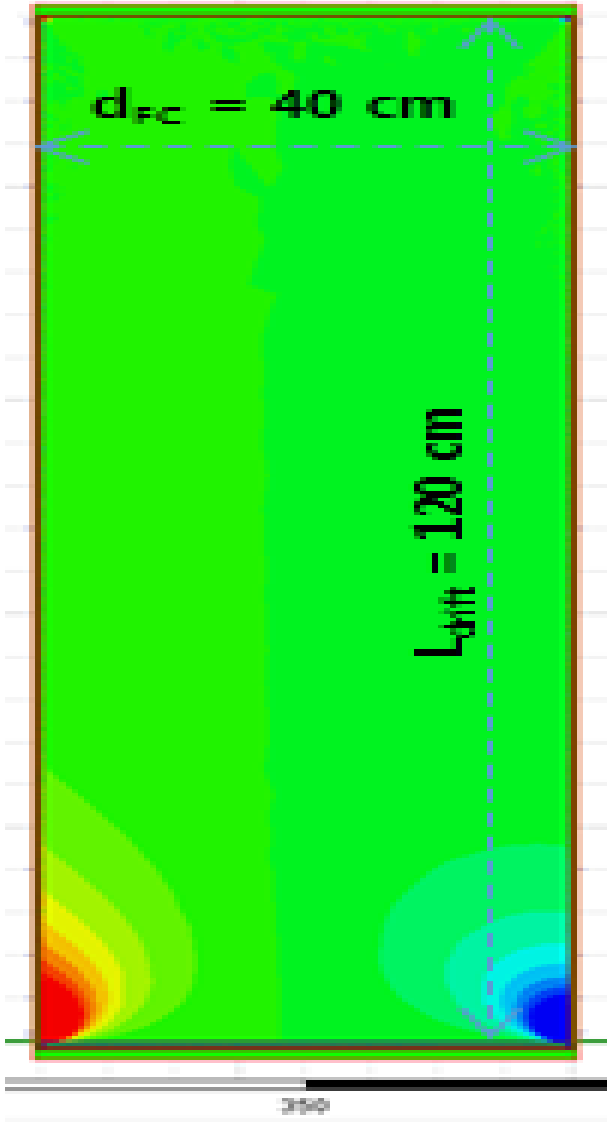


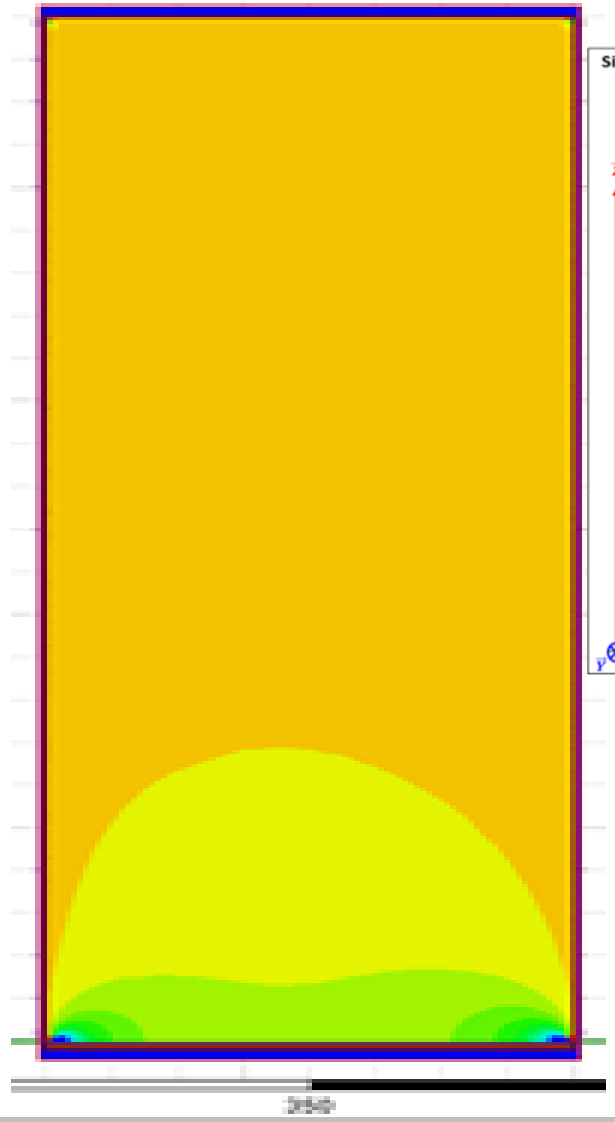


LAMPS TPC Design – Drift Field Uniformity

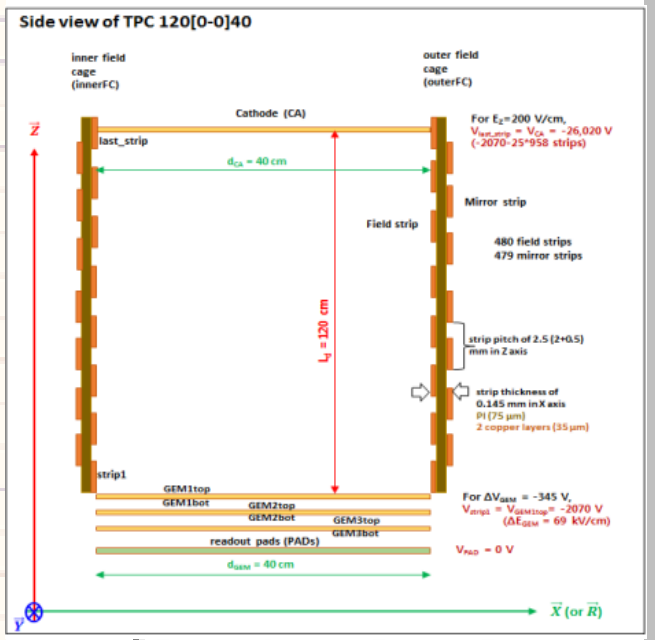








E_Z (100 V/cm)



480 field strips
+ 479 mirror strips
Strip width = 2 mm
Strip gap = 0.5 mm

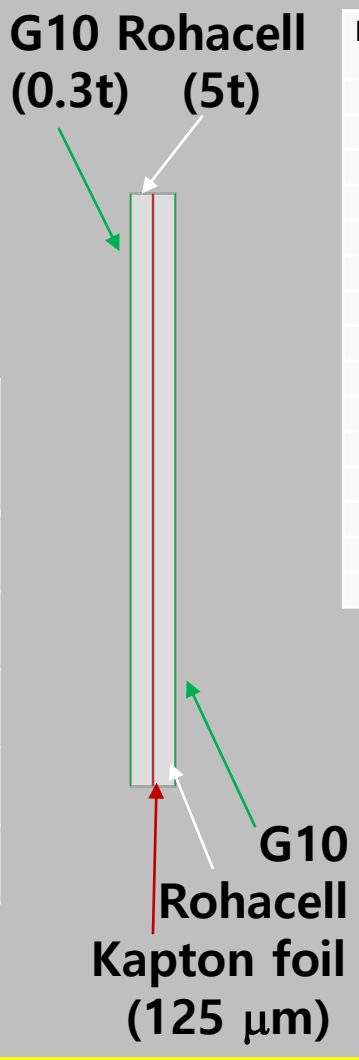
Calculated by M.S. Ryu

LAMPS TPC Design – Material Budget

- Materials consisting gas vessel : G10, Rohacell(IGF-71), Kapton, Epoxy

Material (Inner FC)	Thickness [mm]
G10	0.3
Al-Kapton	0.05

Material (Outer FC)	Thickness [mm]
G10	0.3
Rohacell	5
Kapton foil	0.125
Rohacell	5
G10	0.3



Layer #	Material	Thickness t [mm]	X_0 [mm]	t/X_0 [%]
1	Cu	0.012	14.3	0.08391608
2	PCB(FR4)	1	159.3	0.62774639
3	Epoxy	0.007	352	0.00198864
4	PI(Kapton)	0.125	286	0.04370629
5	Epoxy	0.007	352	0.00198864
6	Rohacell	5	5440	0.09191176
7	Epoxy	0.007	352	0.00198864
8	PI(Kapton)	0.125	286	0.04370629
9	Epoxy	0.007	352	0.00198864
10	Rohacell	5	5440	0.09191176
11	Epoxy	0.007	352	0.00198864
12	G10	0.3	167.608	0.17898907
13	Epoxy	0.007	352	0.00198864
14	PI(Kapton)	0.0254	286	0.00888112
15	Al	0.0002	89	0.00022472

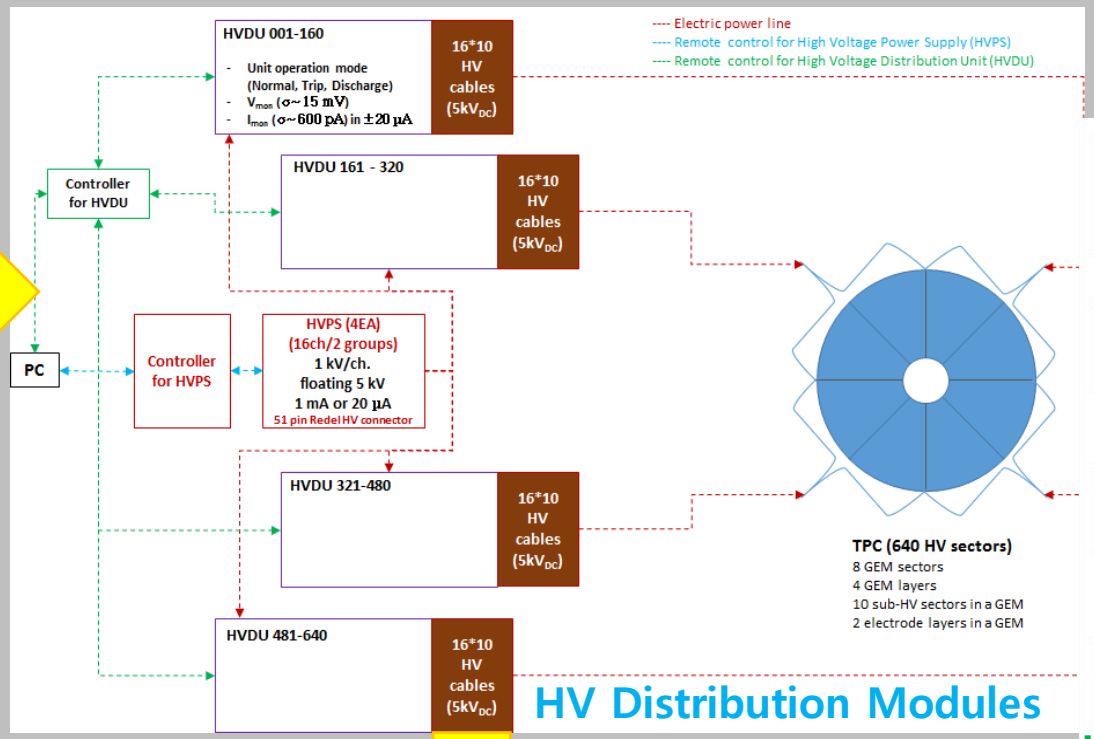
Outer FC ~1.3% X_0
Endcap ~ 1.2% X_0
Inner FC ~ 0.45% X_0

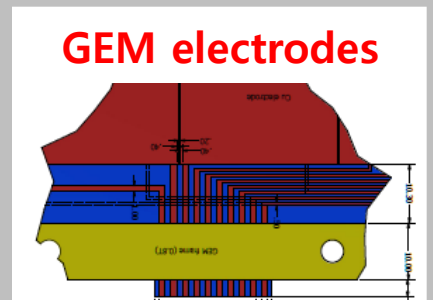
Layer #	Material	Thickness t [mm]	X_0 [mm]	t/X_0 [%]
1	air	85	304200	0.02794214
2	Al	0.0002	89	0.00022472
3	PI(Kapton)	0.0254	286	0.00888112
4	Epoxy	0.007	352	0.00198864
5	G10	0.3	167.608	0.17898907
6	Epoxy	0.007	352	0.00198864
7	PI(Kapton)	0.115	286	0.04020979
8	Epoxy	0.007	352	0.00198864
9	Cu	0.0125	14.3	0.08741259
10	PI(Kapton)	0.125	286	0.04370629
11	Cu	0.0125	14.3	0.08741259
12	P20(gas)	460	223240	0.20605626
13	Cu	0.0125	14.3	0.08741259
14	PI(Kapton)	0.125	286	0.04370629
15	Cu	0.0125	14.3	0.08741259
16	Epoxy	0.007	352	0.00198864
17	PI(Kapton)	0.115	286	0.04020979
18	Epoxy	0.007	352	0.00198864
19	G10	0.3	167.608	0.17898907
20	Epoxy	0.007	352	0.00198864
21	Rohacell	5	5440	0.09191176
23	Epoxy	0.007	352	0.00198864
24	PI(Kapton)	0.125	286	0.04370629
25	Epoxy	0.007	352	0.00198864
26	Rohacell	5	5440	0.09191176
28	Epoxy	0.007	352	0.00198864
29	G10	0.3	167.608	0.17898907
30	Epoxy	0.007	352	0.00198864
31	PI(Kapton)	0.0254	286	0.00888112
32	Al	0.0002	89	0.00022472

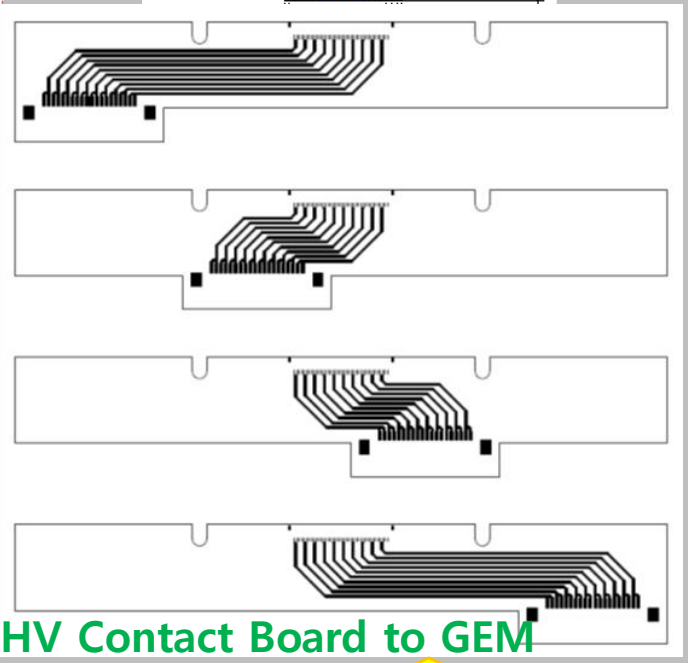
Sandwich structure using epoxy glue for outer FC wall to reinforce rigidity.

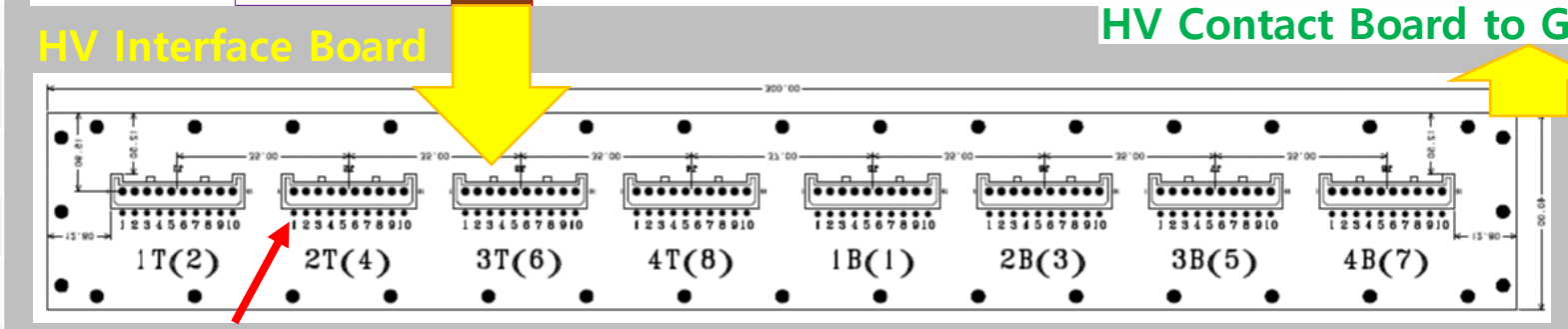
LAMPS TPC Design – HV for GEMs

EMS F8 002n_R51
16 ch High Precision Mix HV-PS
Single channel floating-GND
Negative polarity
I_{nom}/ch : max 1 mA
V_{nom}/ch : max 1 kV
Configuration : 2 groups, 1group/sector
HV output : 51pin REDEL





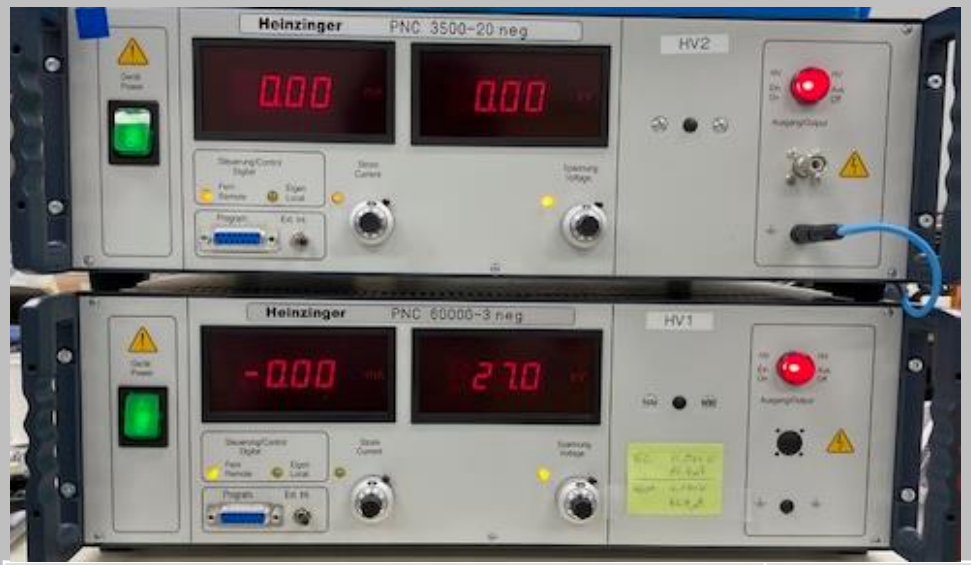




Direct contact points to GEM segments were added for recovery cares.

LAMPS TPC Design – HV for Fieldcage

- Heinzinger PNC Universal High-Voltage Power Supplies

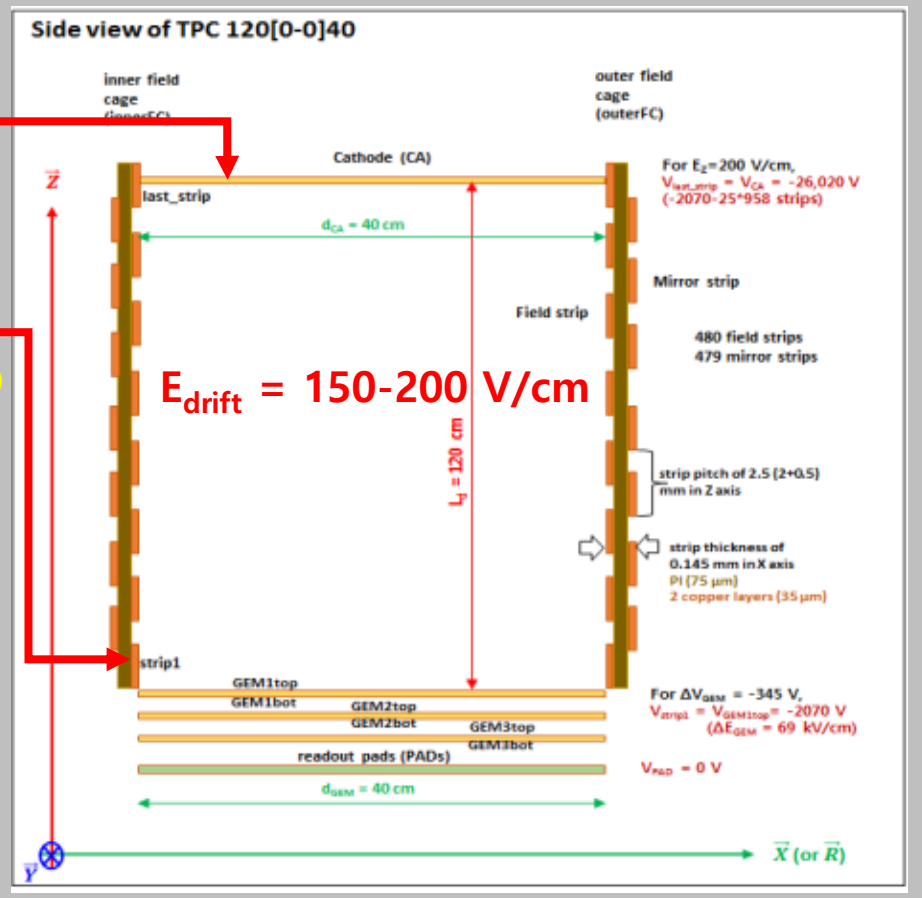


PNC 60000-3

to the cathode plate

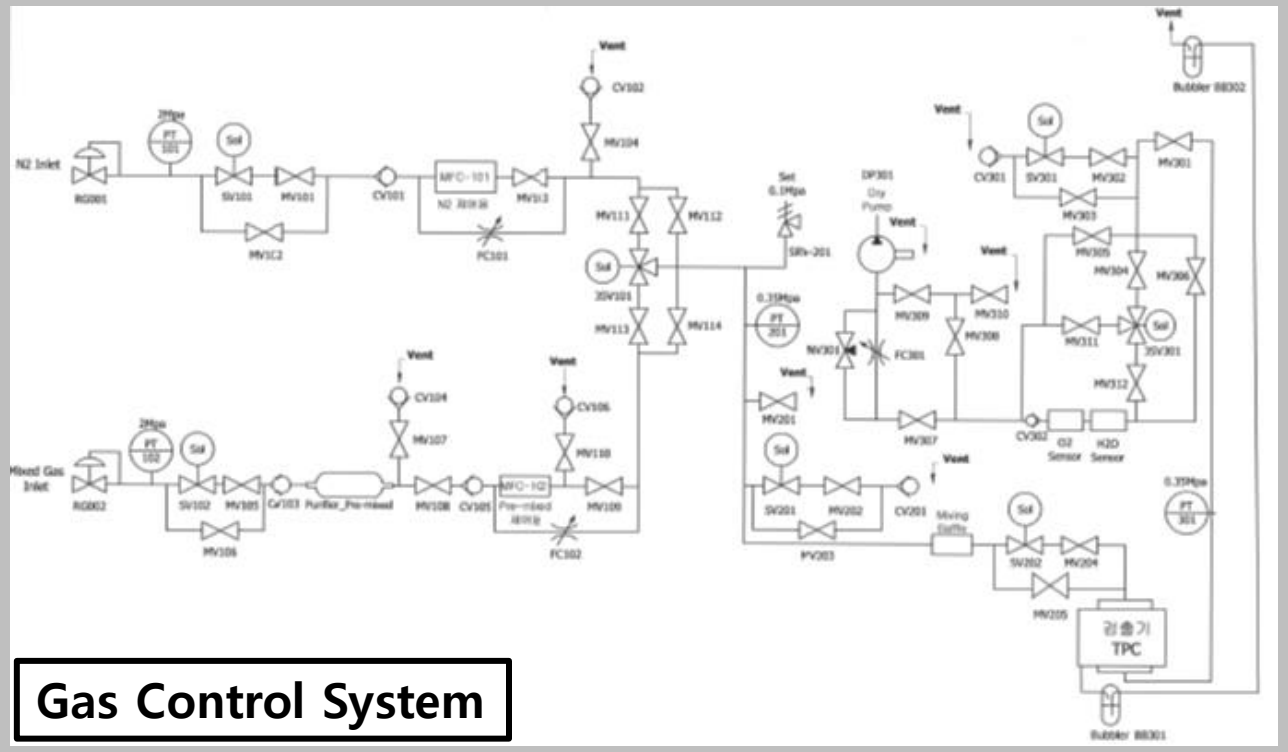
PNC 3500-20

to the last strip



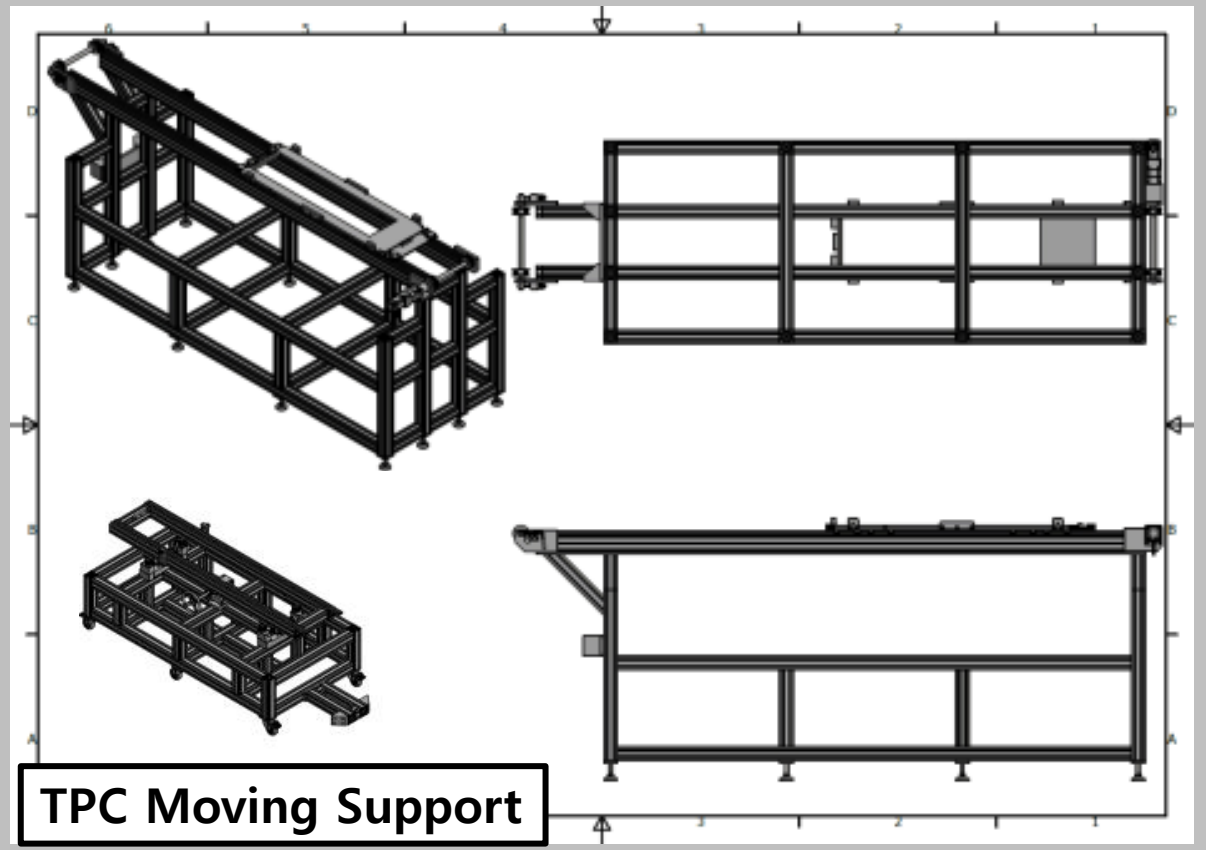
PNC 60000 - 3 neg	PNC 3500 – 20 neg
High voltage up to 60 kV	High voltage up to 3.5 kV
Current Limit 3 mA	Current Limit 20 mA
Negative polarity	Negative polarity
Power 160 W	Power 70 W
Voltage stability ≤ 0.01% V_{nom}	Voltage stability ≤ 0.01% V_{nom}
Voltage Precision ≤ 0.02% V_{nom}	Voltage Precision ≤ 0.02% V_{nom}

LAMPS TPC Design – Gas System & etc.



Gas Control System

- Gas pipeline length ~ 70 m for each inlet/outlet
- Local & Remote control available
- Amount of gas : 4,320 L/day for 3 L/min flow rate
- Use P20 and N_2

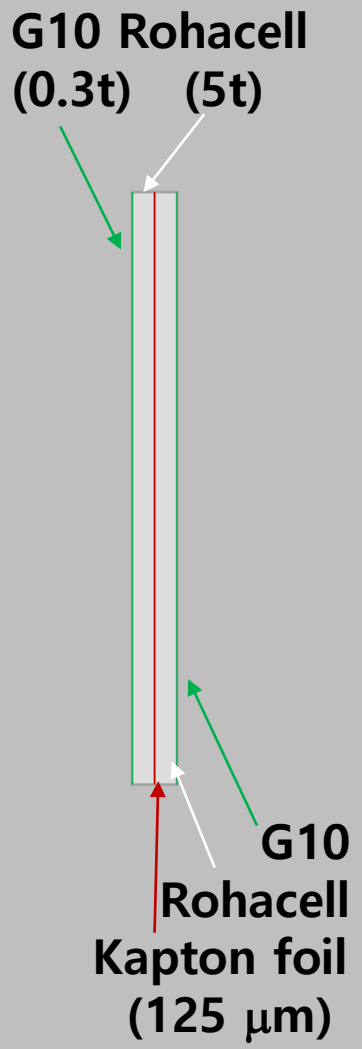


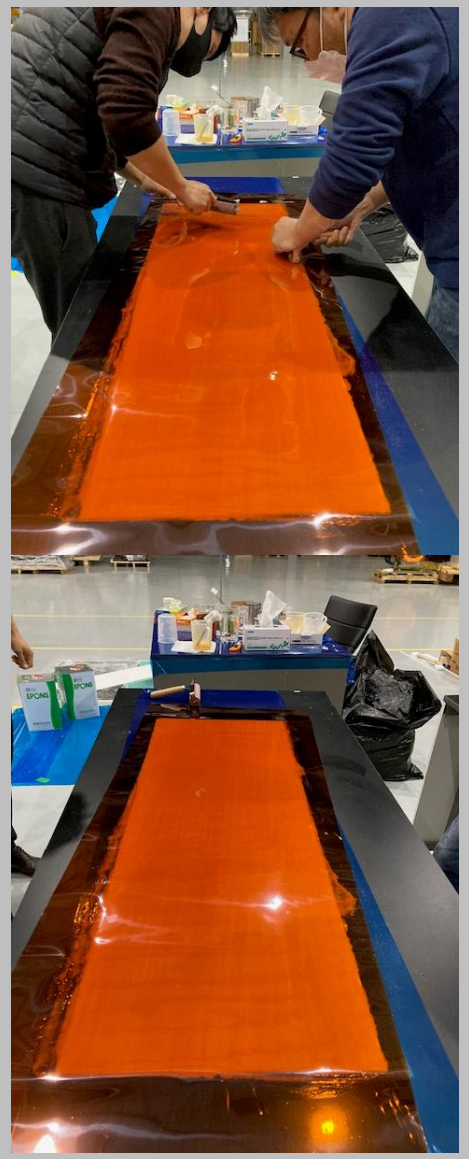
TPC Moving Support

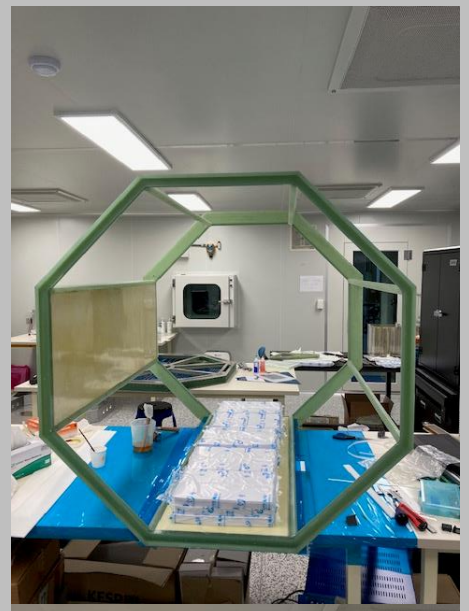
- Load durability over 400 kg
- Bending tolerance up to 2 mm
- Non-magnetic materials
- Torque over 200 Nm

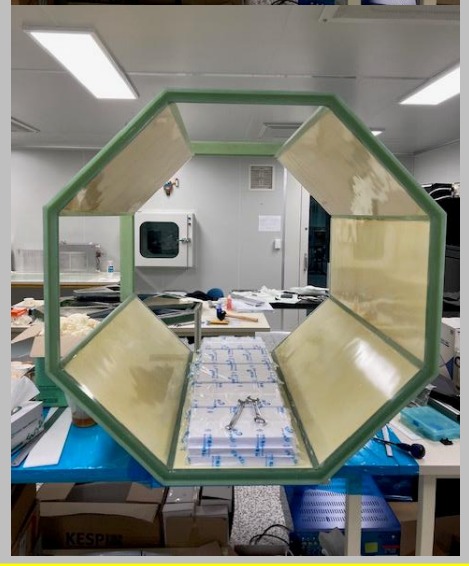
Fabrication of LAMPS TPC

LAMPS TPC Fabrication – Gas Vessel; Outer FC









And more epoxy..

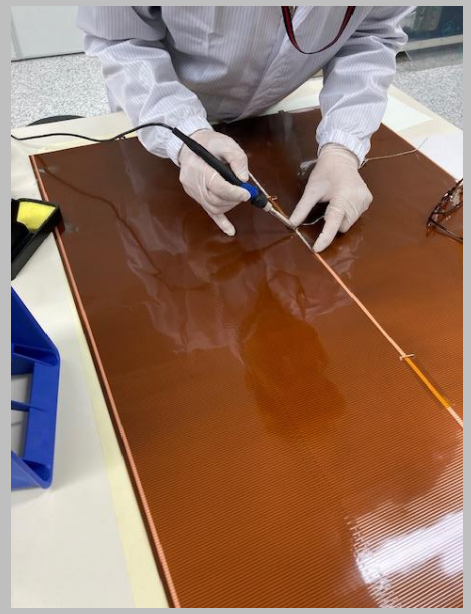
Cut Rohacell and Kapton → Epoxy → Epoxy → Epoxy !!

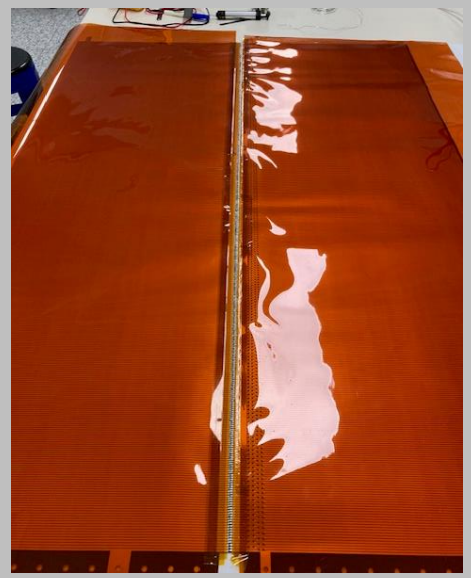
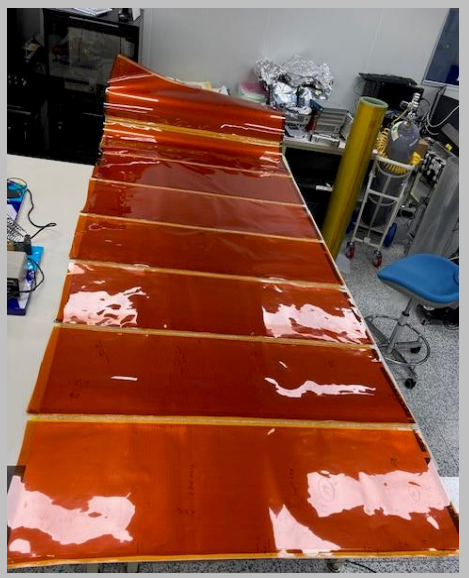
LAMPS TPC Fabrication – Gas Vessel; Inner FC

Inner FC : G10 sheet (0.3 mm-thick) + Al-Kapton (50 μm-thick)

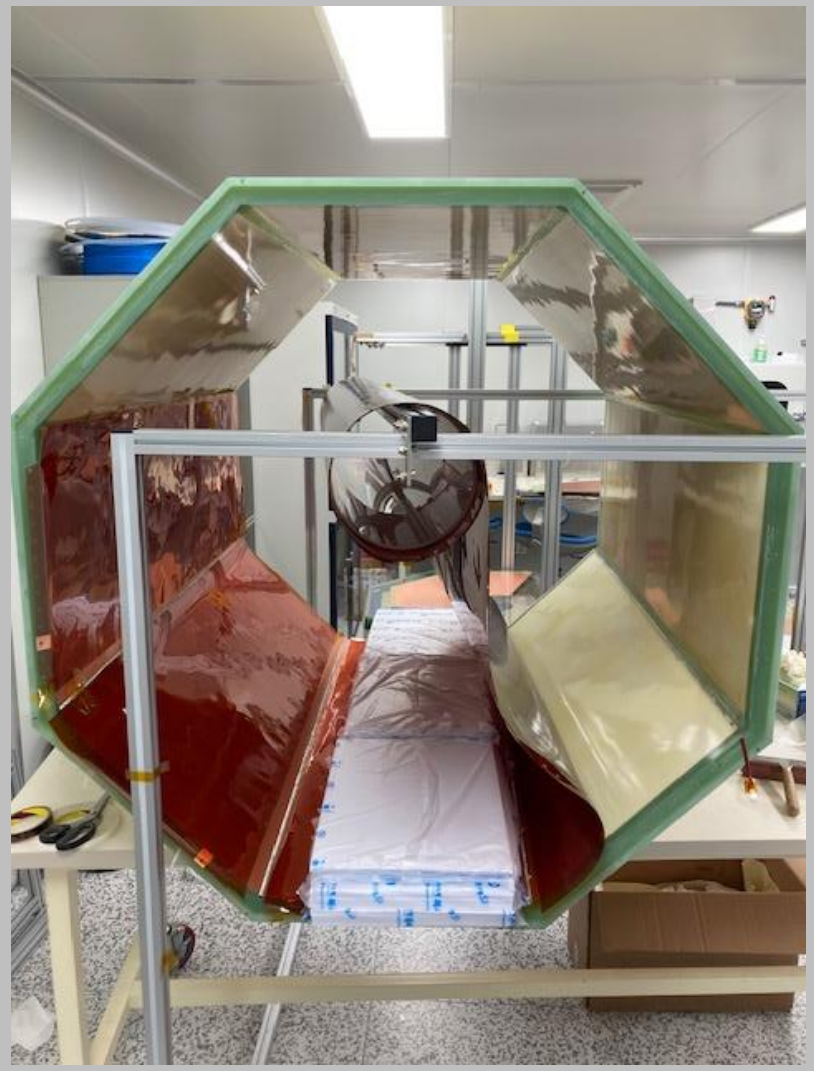
LAMPS TPC Fabrication – Field Strip

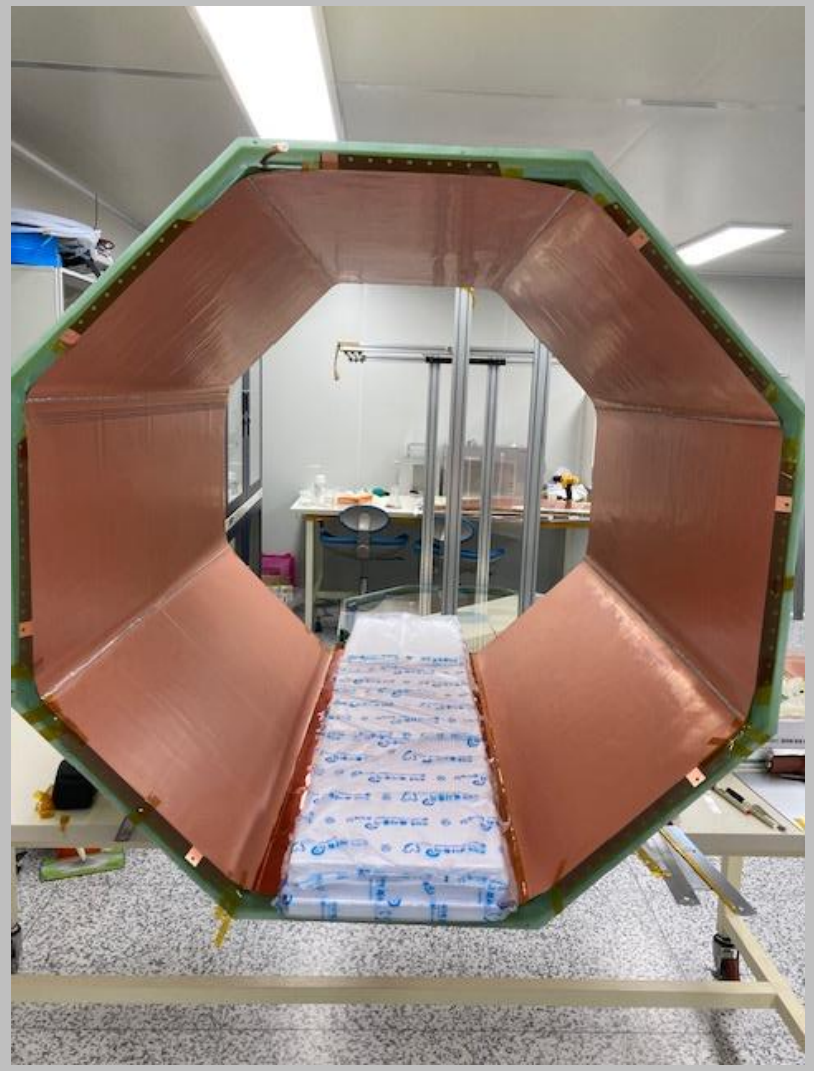




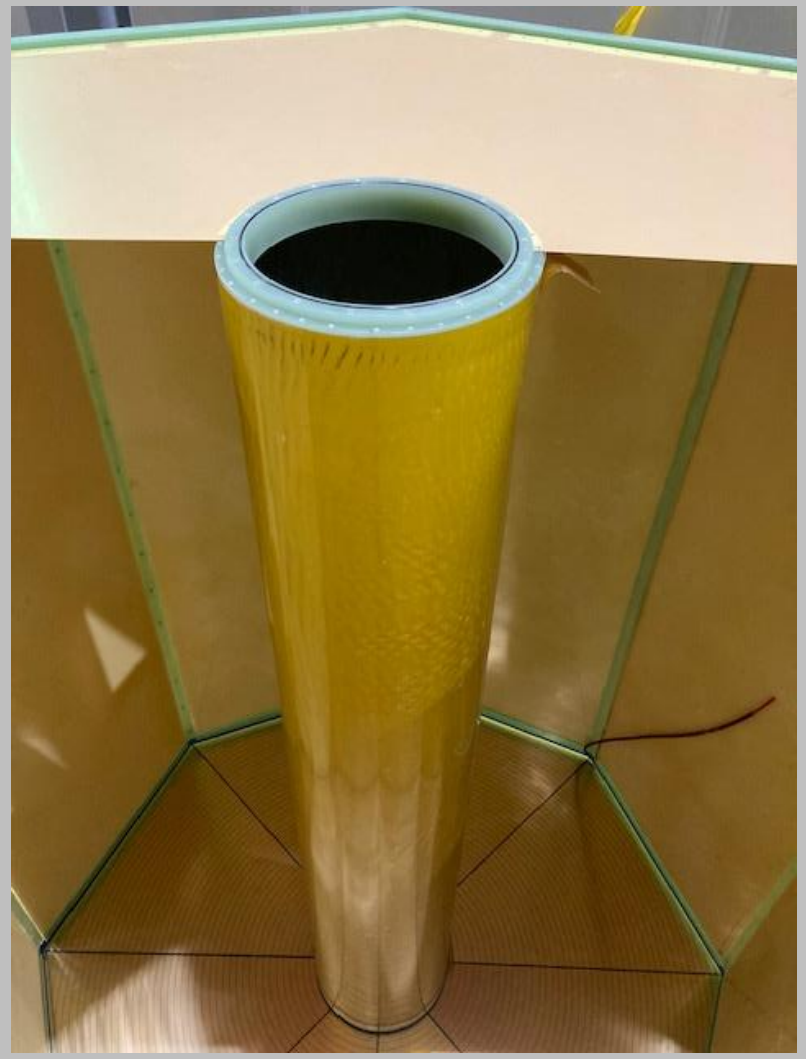




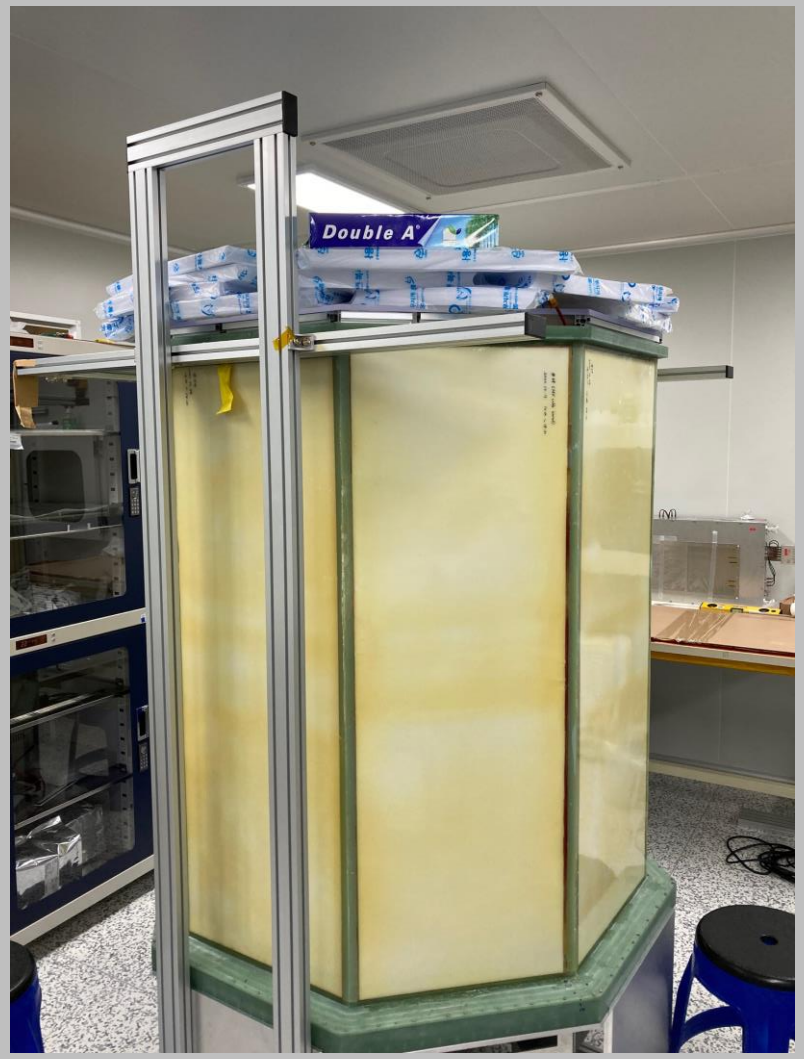
LAMPS TPC Fabrication – Field Strip





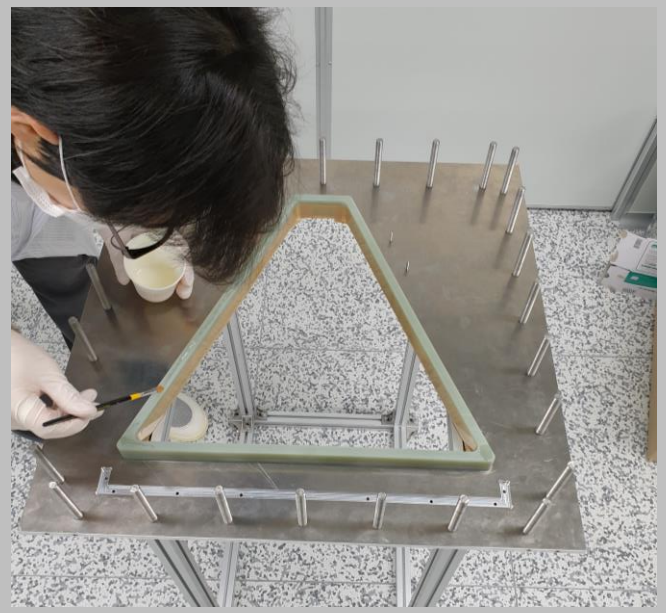
LAMPS TPC Fabrication – Fieldcage

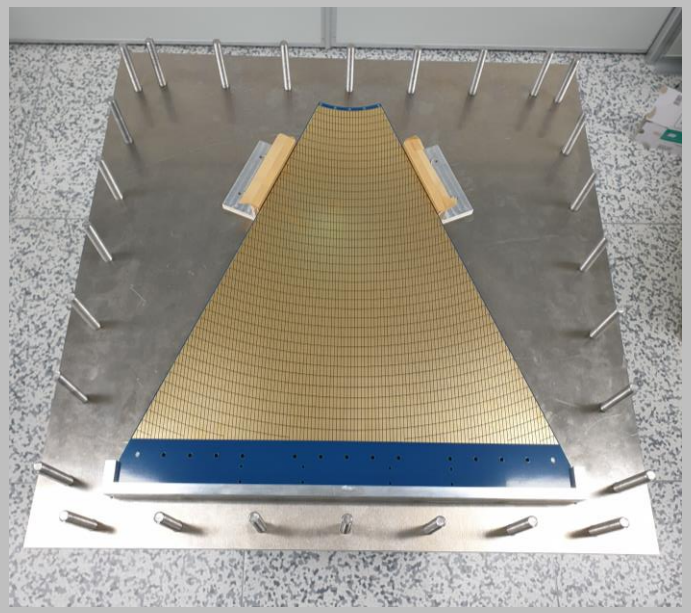


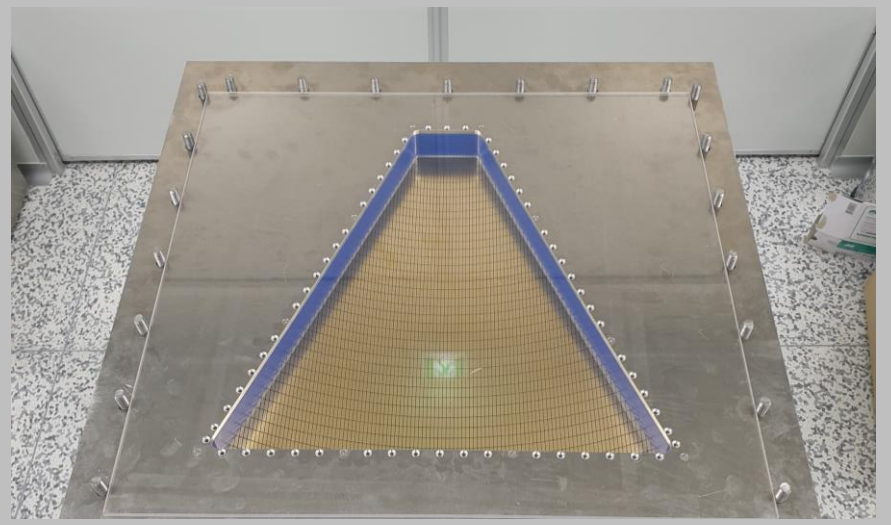


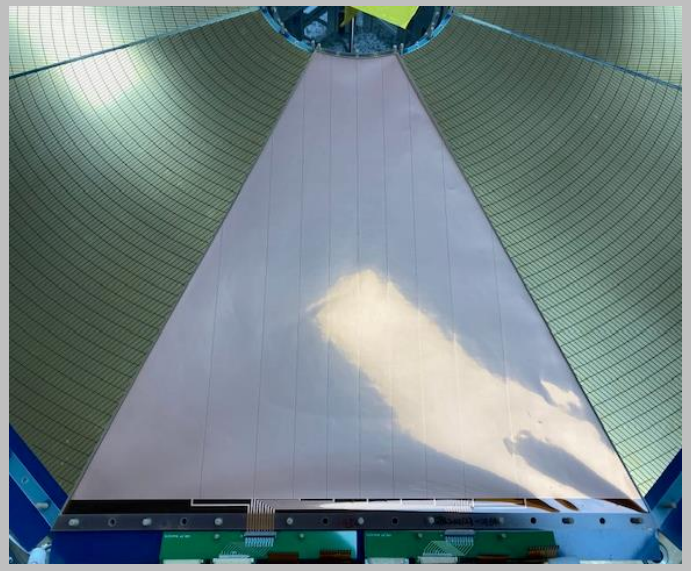
Connection test was done by measuring total resistance from the cathode plate to the last strip.

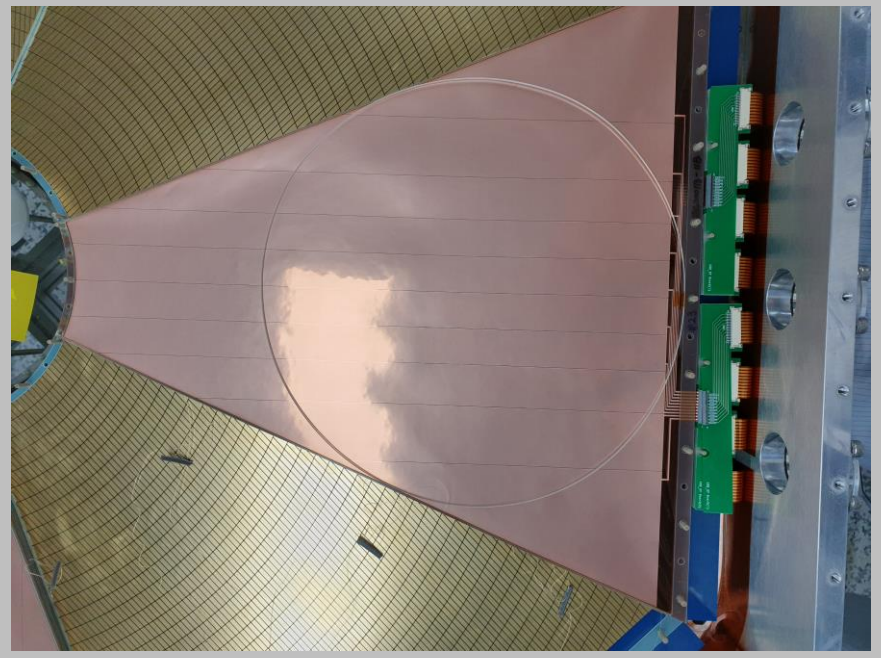
LAMPS TPC Fabrication – Readout











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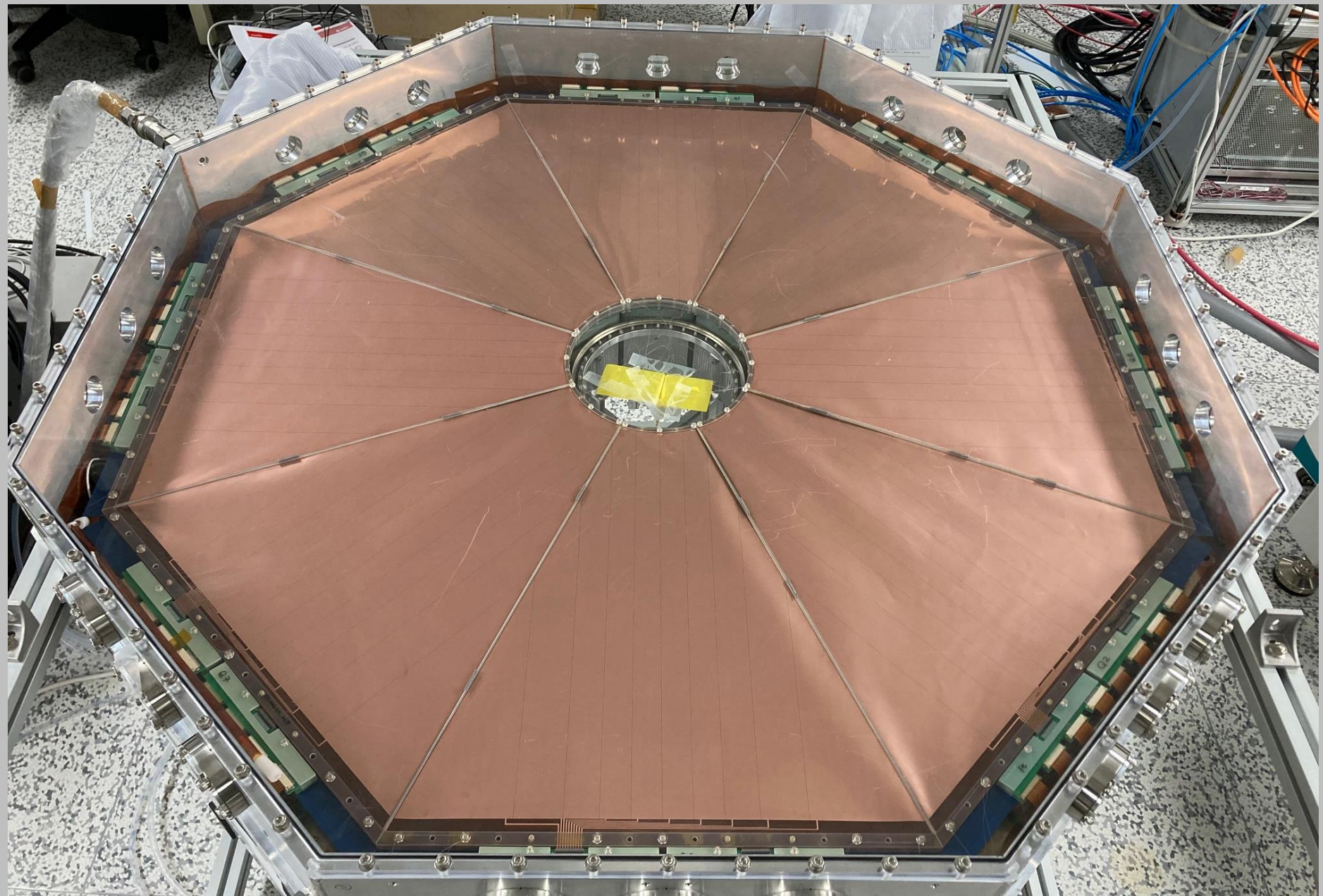
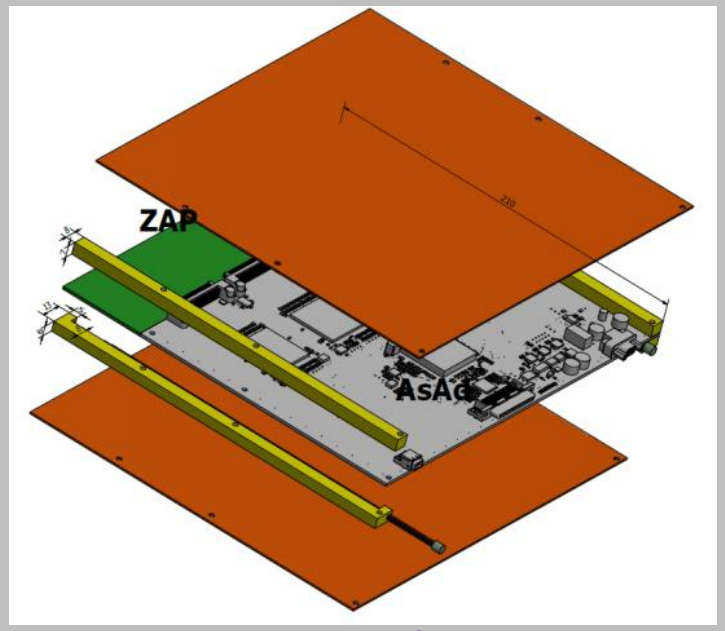
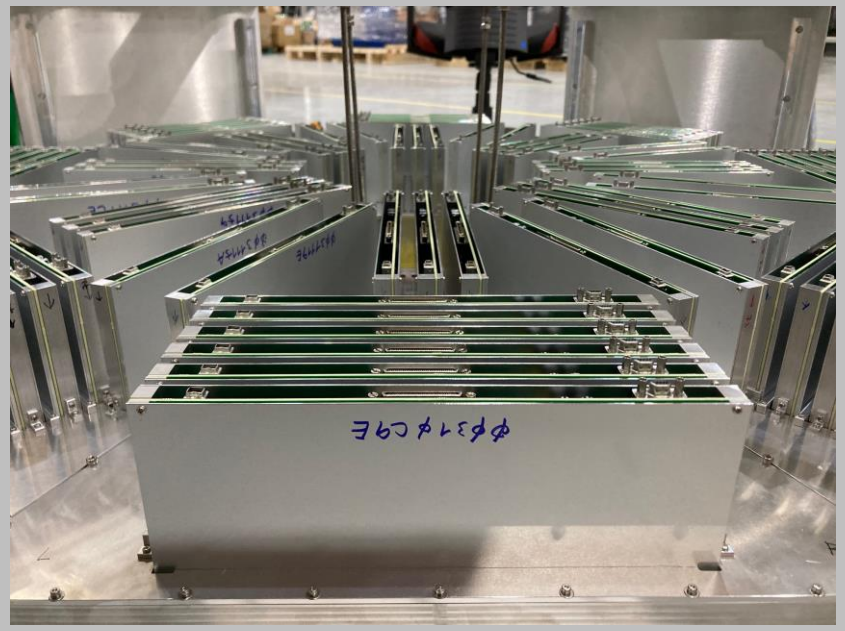
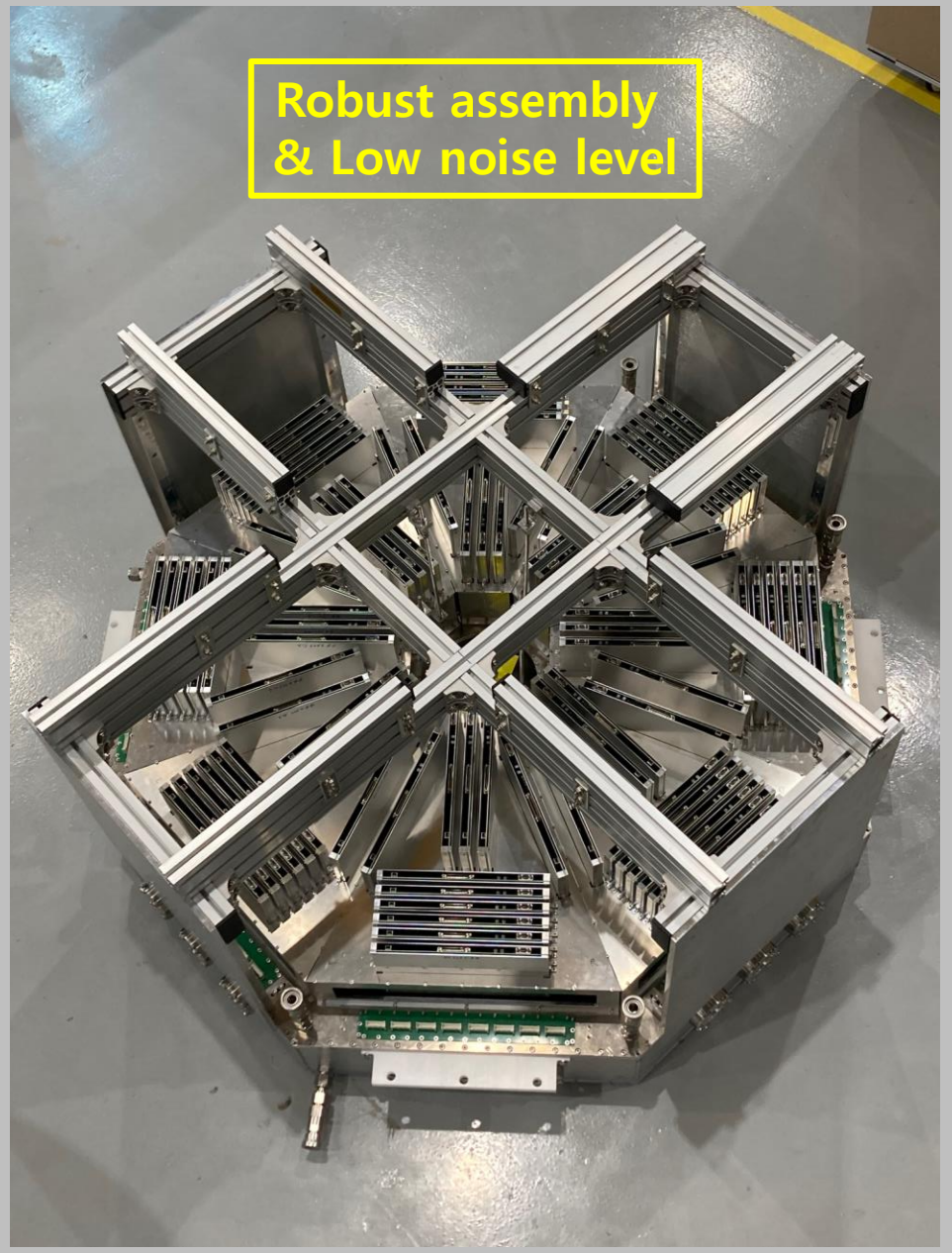


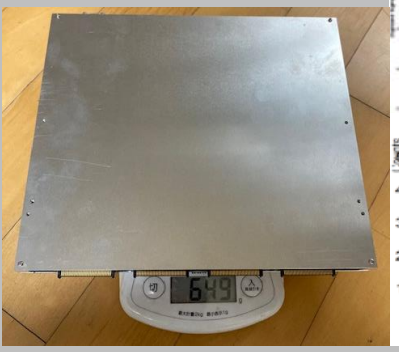
LAMPS TPC Fabrication – Readout

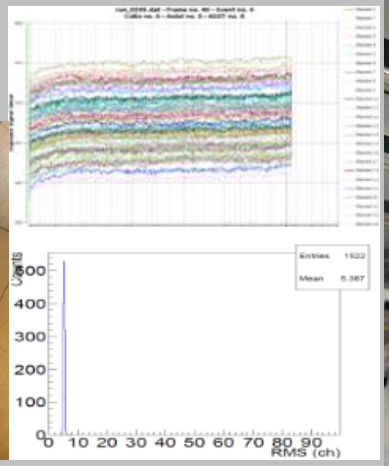




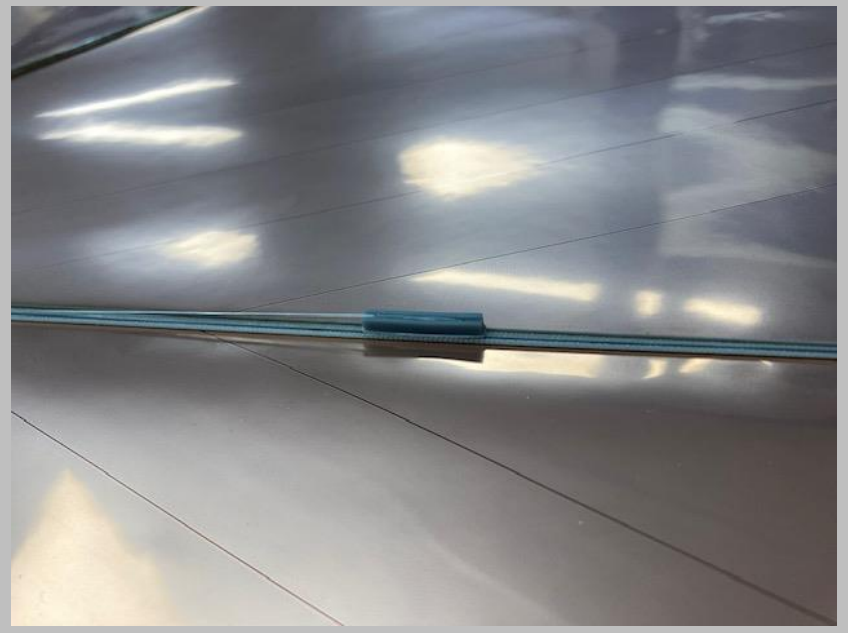


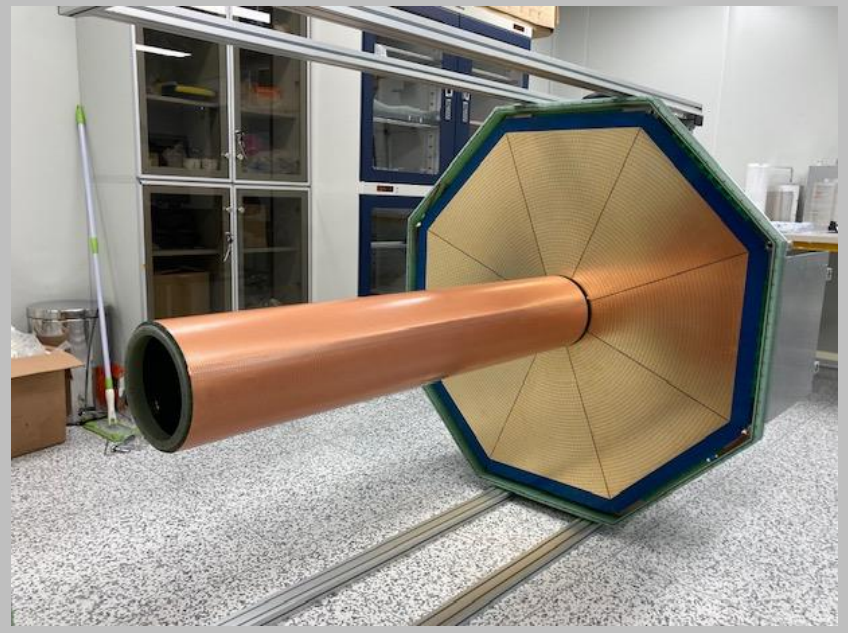
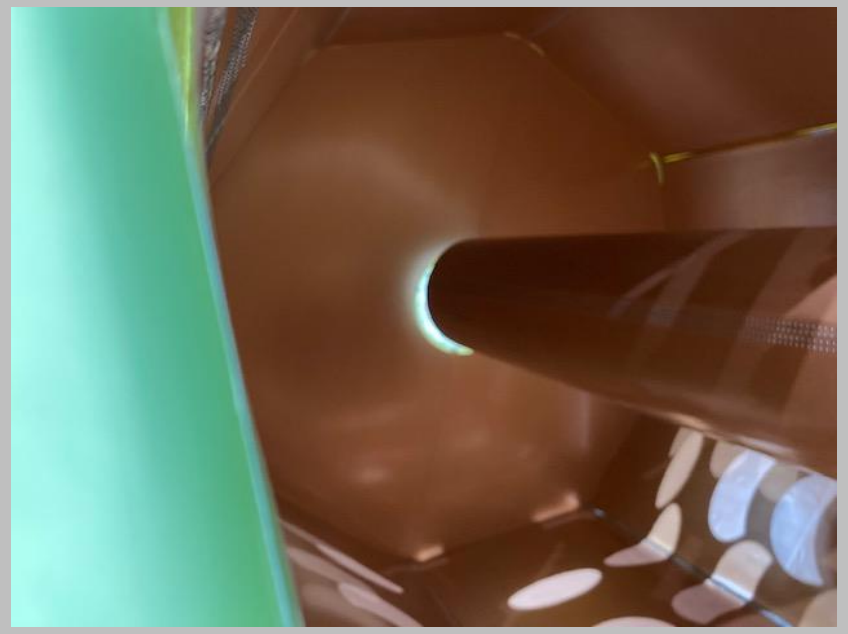
Aluminum shield for each AsAd
→ 88 AsAds were installed.

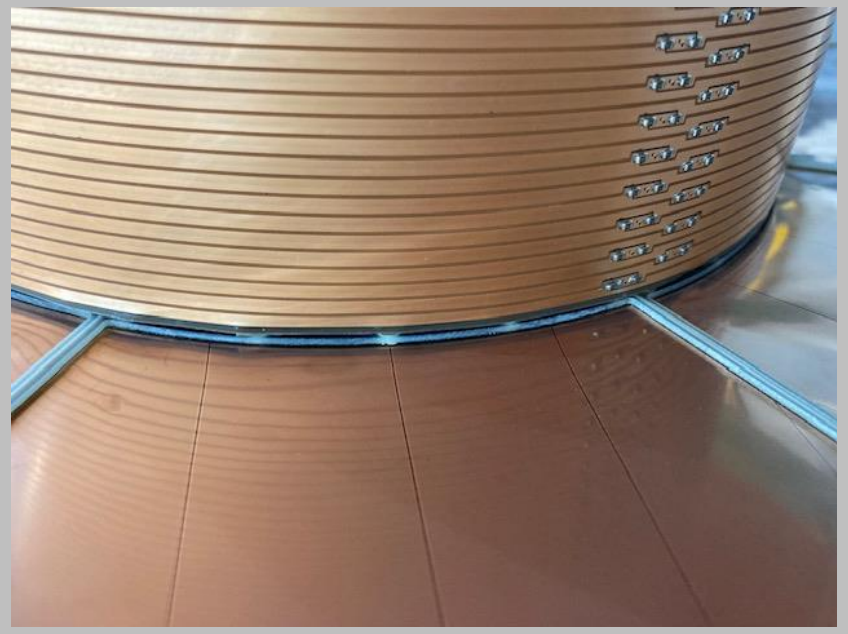




LAMPS TPC Fabrication – Whole Assembly

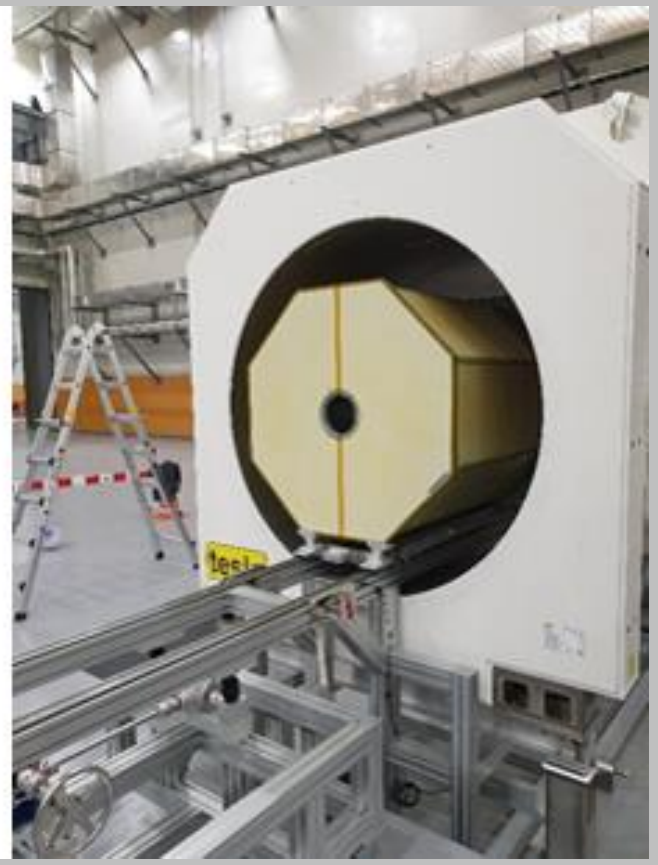




LAMPS TPC – Mounting

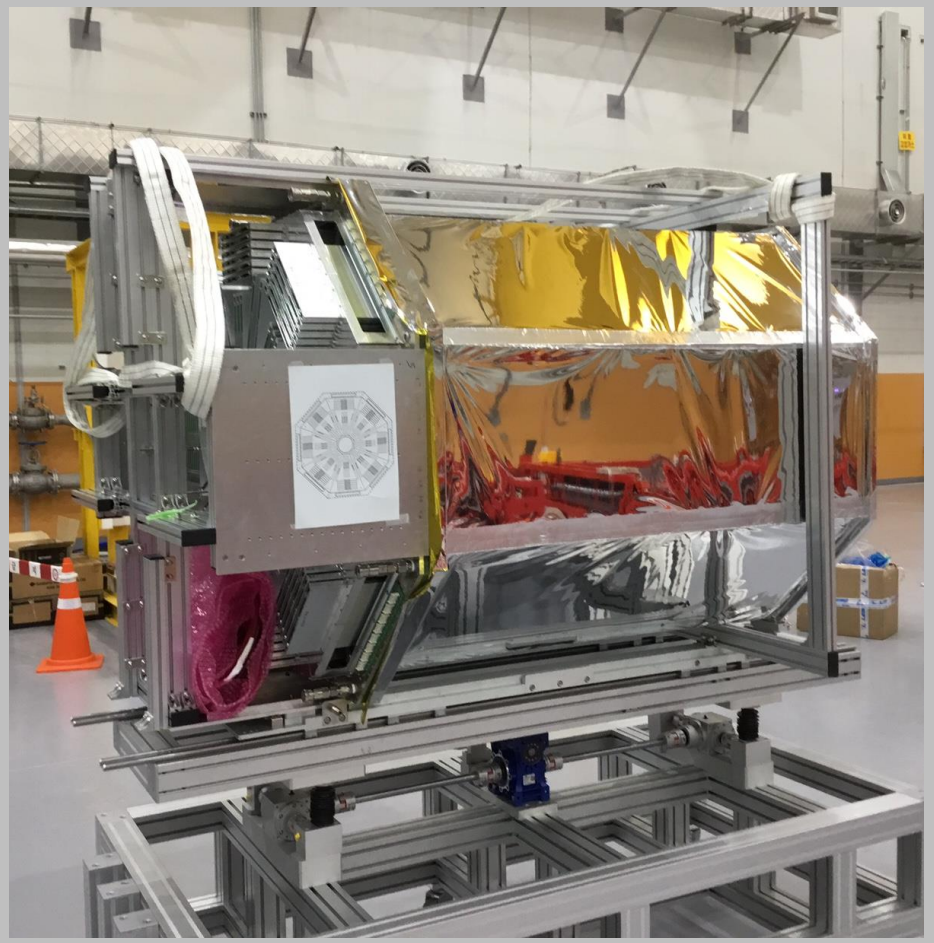
- TPC moving stage demonstration

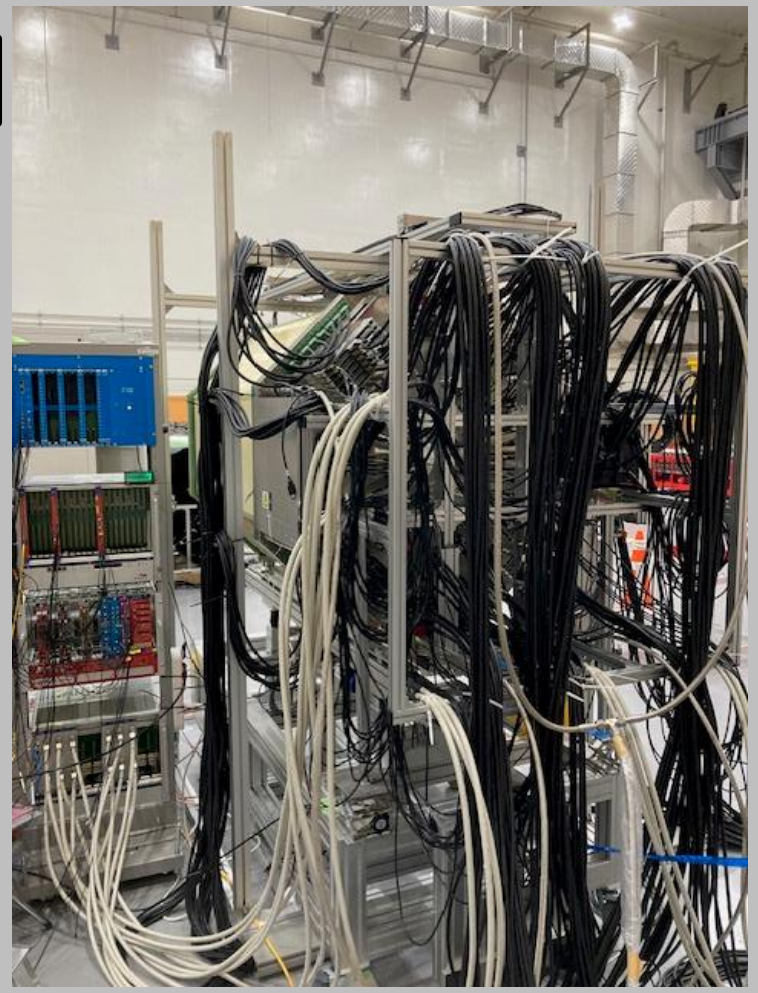


Carried by high torque(over 200 Nm) servo motor with accuracy 0.1 mm by using laser sensors

LAMPS TPC Fabrication – Current State

Covered by Al-Kapton noise shield





Fully assembled with cables
→ Measuring Cosmic-rays

GEM HV Distribution
(cable length = 20 m)

Gas Control System

Summary

- LAMPS TPC has been built last year.
  - GEM-based TPC working at atmospheric pressure P-20 gas
  - Entirely non-magnetic materials and light-weight
  - 21,584 channels in total, using GET electronics
  - Active volume ~ 1,200 L with a gas-tight barrel
  - Effective gas gain $\geq 10^4$, drift velocity ≥ 6 cm/μs
- Performance test with cosmic-ray is ongoing.
- Full setup combination with ToF/Trigger array will be prepared.

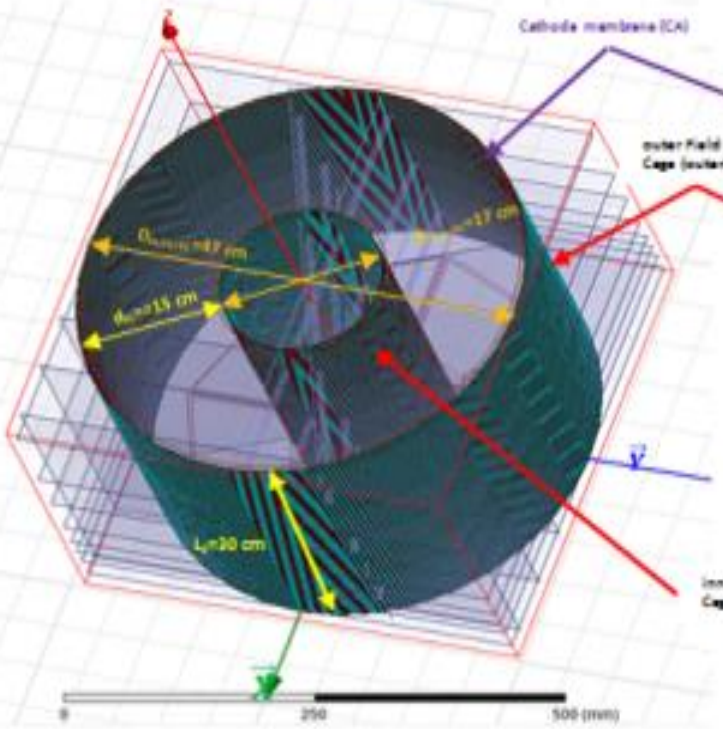
Back-ups

LAMPS TPC Design – Electric Field Uniformity

<Basic design concept>

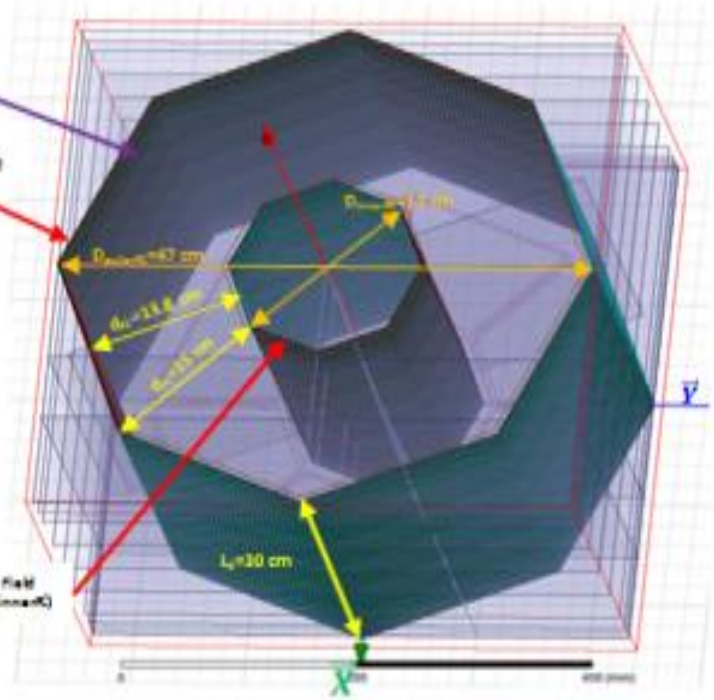
1. The drift length(L_d) is 30 cm.
2. The inner and outer diameters of field cage are 17 and 47 cm, respectively.

TPC 30[cylindrical]15



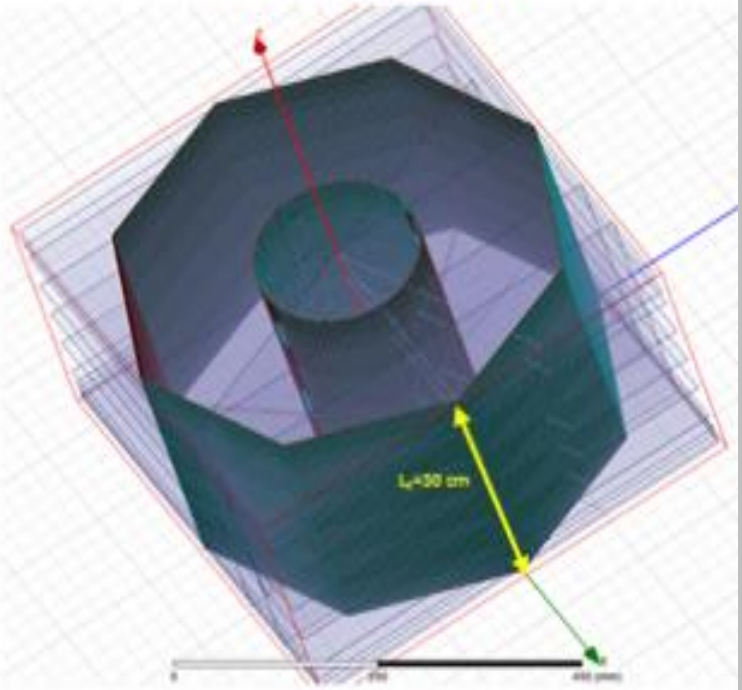
Each strip has 36 segments in Φ direction (10°/segment).

TPC 30[octagon]15



Each strip has 8 segments in Φ direction (45°/segment).

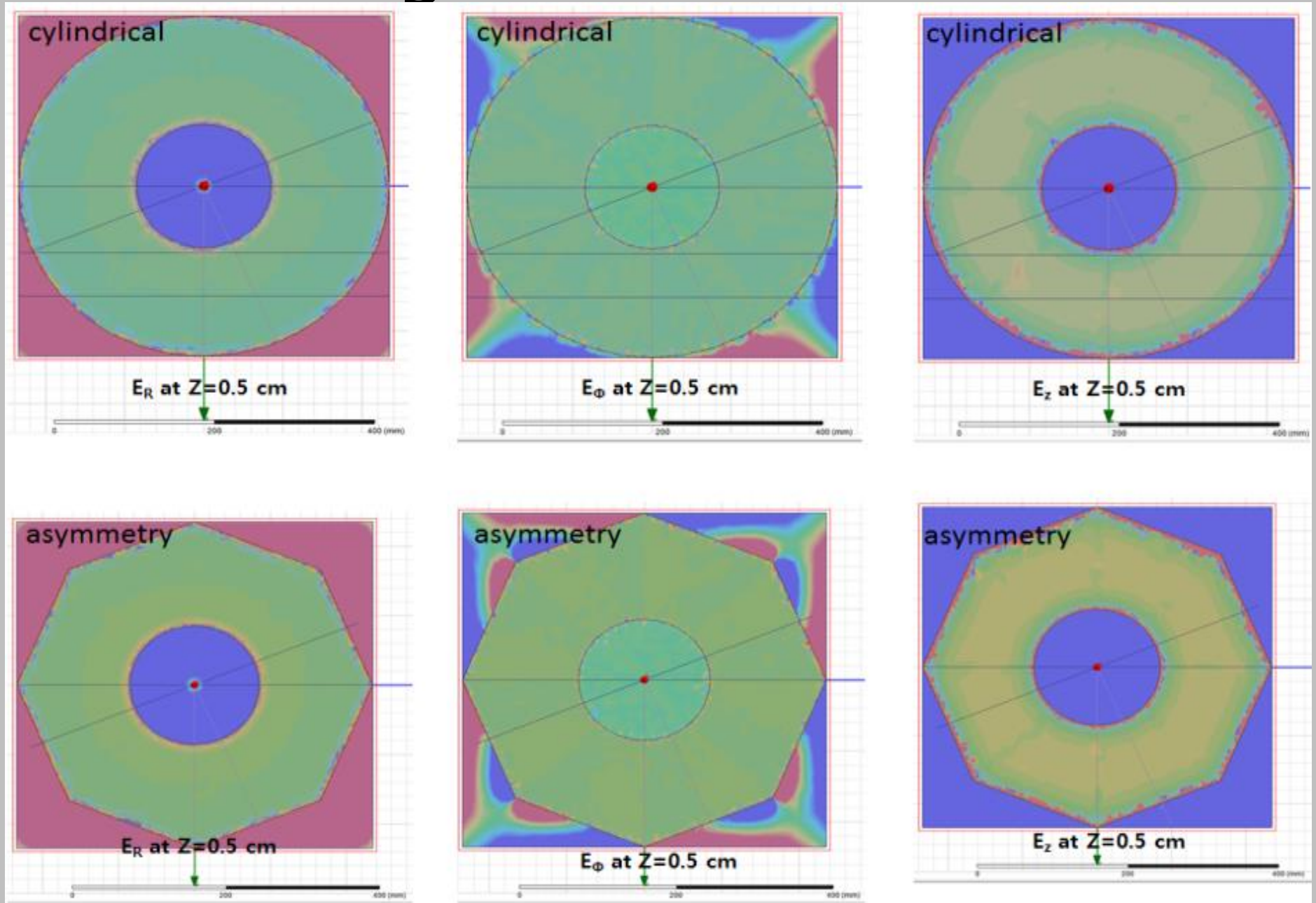
TPC 30[asymmetry]15



Each strip has 36 segments in Φ direction (10°/segment) for inner field cage.

Each strip has 8 segments in Φ direction (45°/segment) for outer field cage.

LAMPS TPC Design – Electric Field Uniformity



LAMPS TPC Fabrication – Cooling System

Air Flow Rate
: up to 4,500 m³/h

제 품 표 시 사 항

모델명	HSB-F29S		
제 품 명	시로코팬 송풍기	MSIP-REM-whs-HSB-F29S	
정격전압	단상 220V 60Hz		
소비전력	1,580W	극 수	4극
최대풍량	4,500㎥/h	사용환경	옥외용
최대정압	700Pa	IP 등급	IPX4
날개크기	Ø260	제품중량	23kg
제조년월	2019.09	제 조 국	대한민국
제조번호	190900003	제조업체	한일전기주식회사

사용상 주의사항
1. 사용시 안전을 위하여 반드시 접지를 하십시오.
2. 설치 위치상 필요할 경우 별도의 안전장치를 하십시오.
3. 사용중 문제가 발생할 때에는 즉시 전원을 차단 후 가까운 고객서비스센터로 문의하여 주십시오.

▷고객서비스센터 1588-1183
▷온라인 A/S접수 http://www.hanilelec.co.kr
▷온라인소모품구매 http://myhanil.co.kr