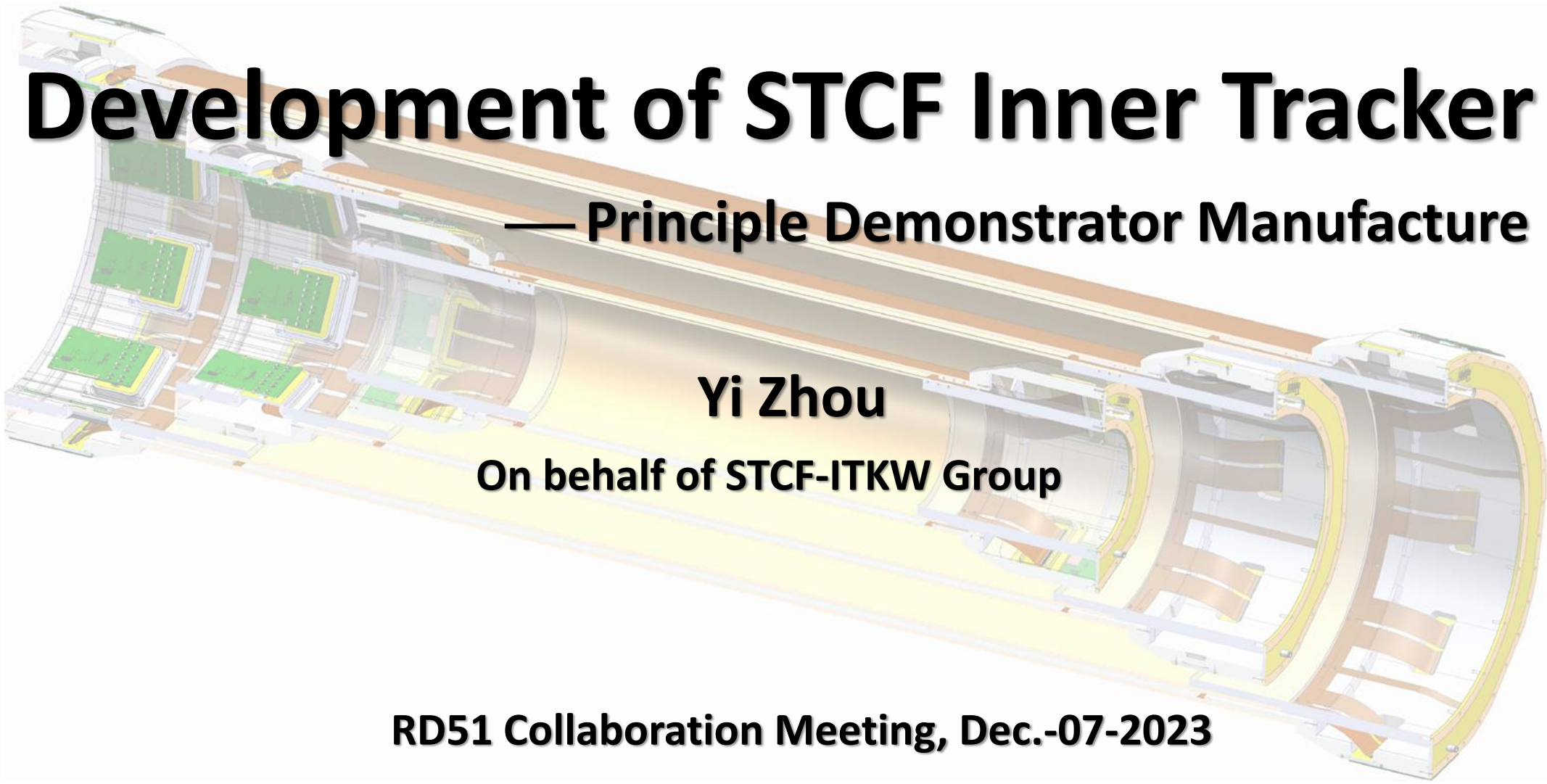
Development of STCF Inner Tracker

—Principle Demonstrator Manufacture



Yi Zhou

On behalf of STCF-ITKW Group

RD51 Collaboration Meeting, Dec.-07-2023

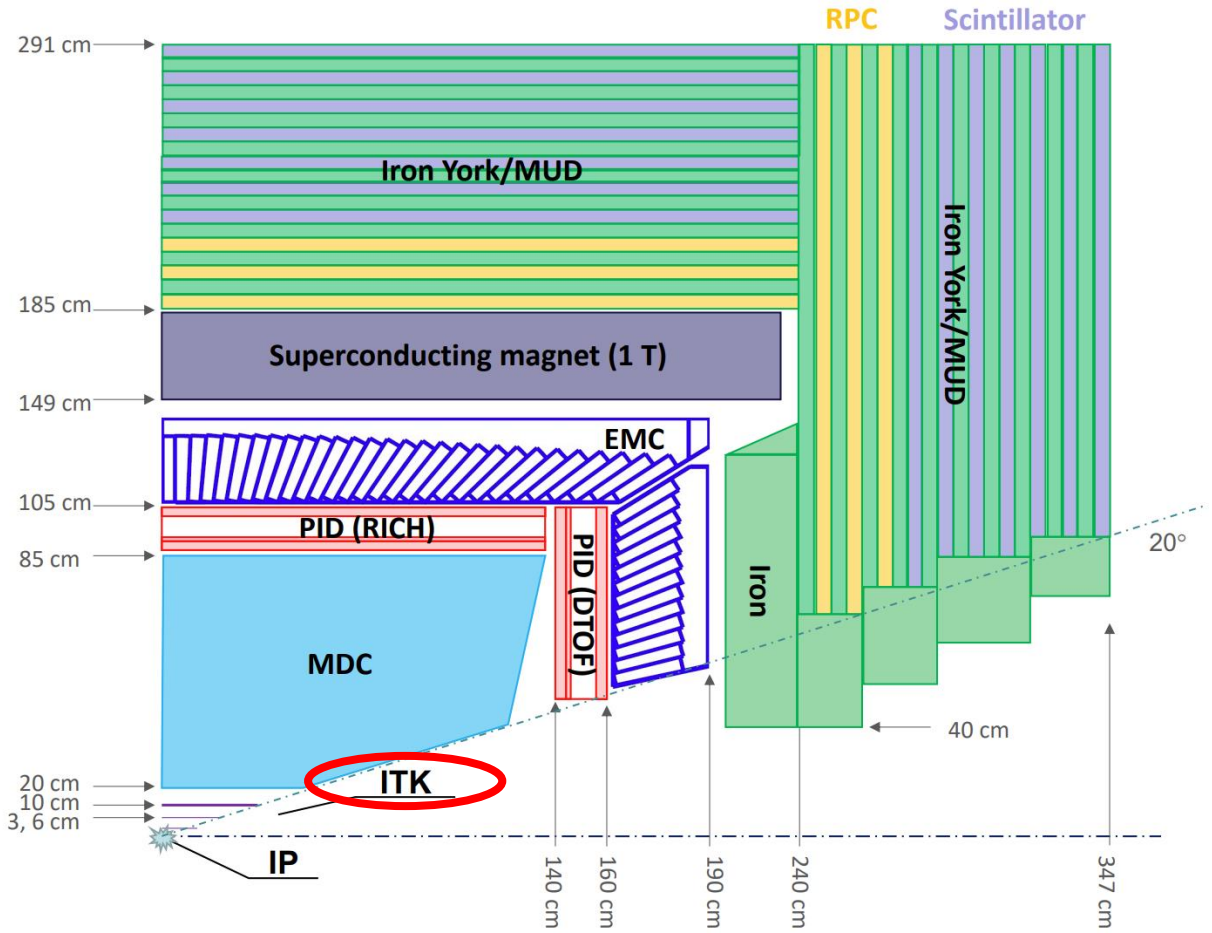
- **Introduction**
- Electrode Design
- Mechanical Design
- Mechanical Model Assembling
- Material Budget
- Future Plans

Motivation

STCF is an e + e- collider operating at $\sqrt{s}$=2～7 GeV with a peak luminosity of 0.5×10^{35}cm^{-2}s^{-1}.

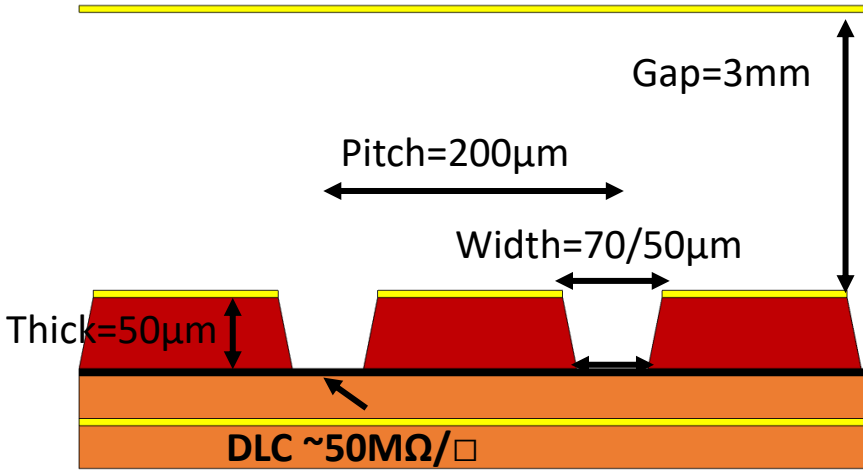
The required performance of ITKW used in STCF includes:

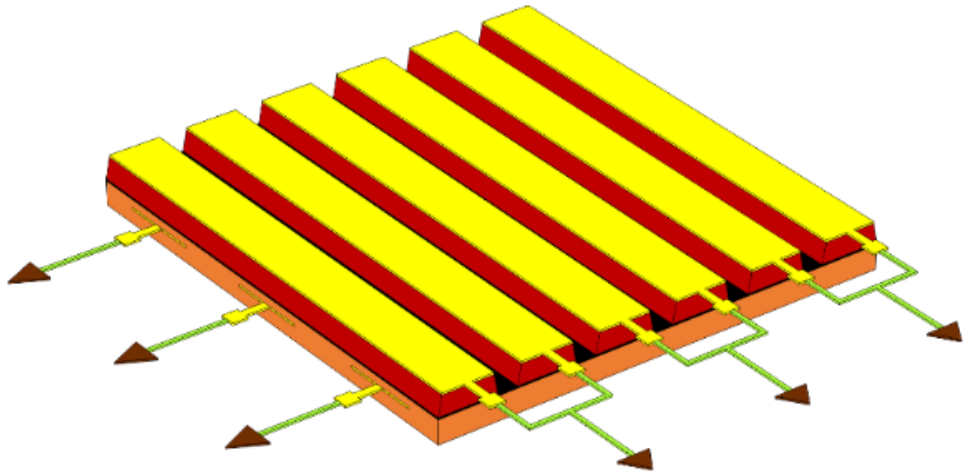
- **Good Spatial resolution**
- Measurement for Low-momentum charged particles
- **Ultra-Low material budget**
- High occupancy operated in µTPC mode (10 signals per hit)
- …



Detector Candidates: µRWELL/µRGroove

Advantages of µRGroove

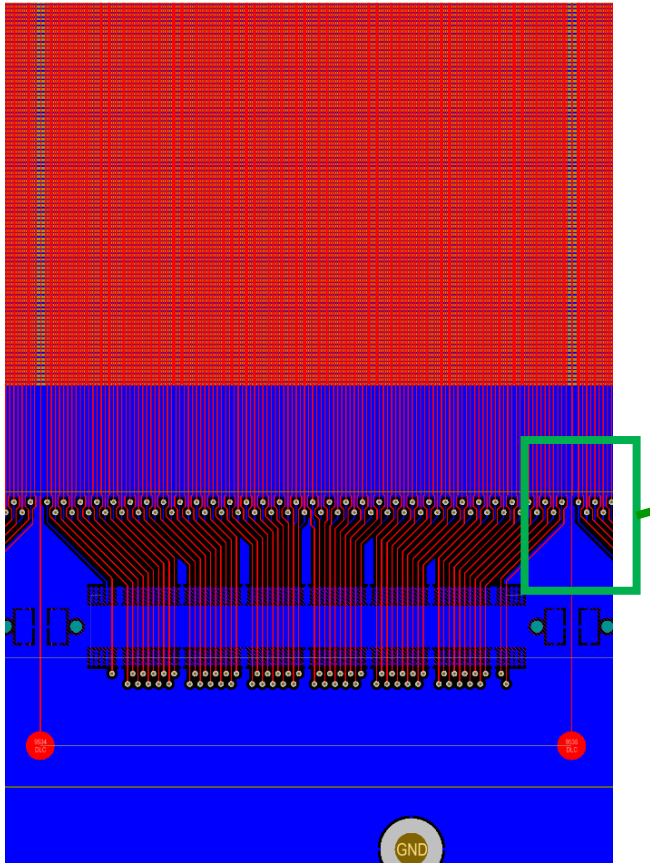


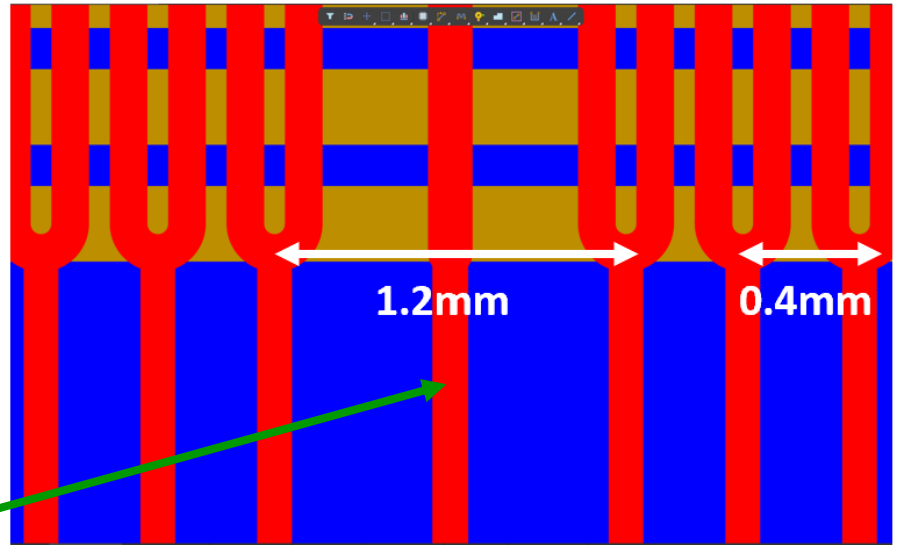


- Decoupled X&Y readout strips, no charge sharing problem, lower gas gain required;
- Signal amplitude is almost the same if the top & bottom readout strips have the same width;
- Manufacture process is almost the same as the Compass read/out, easy to produce with low cost;
- Groove structure is very easy for clean;
- Compatible with all the techniques developed for the µRWELL manufacture

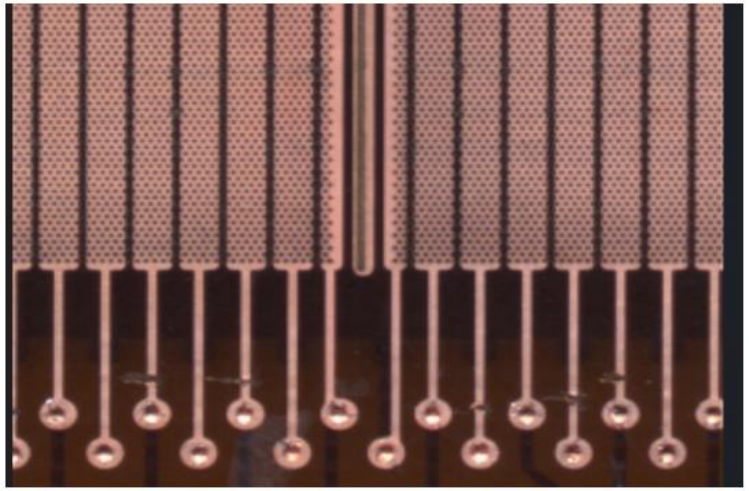
Siqi He, RD51 Mini-Week, 02/27/2023
Xiangqi Tian, RD51 Collaboration Meeting, 12/07/2023

Dead Area in PEP Model





2 readout strips are replaced by a PEP GND line in each 128 readout strips; A 50cm×50cm PEP µRGroove is in production.



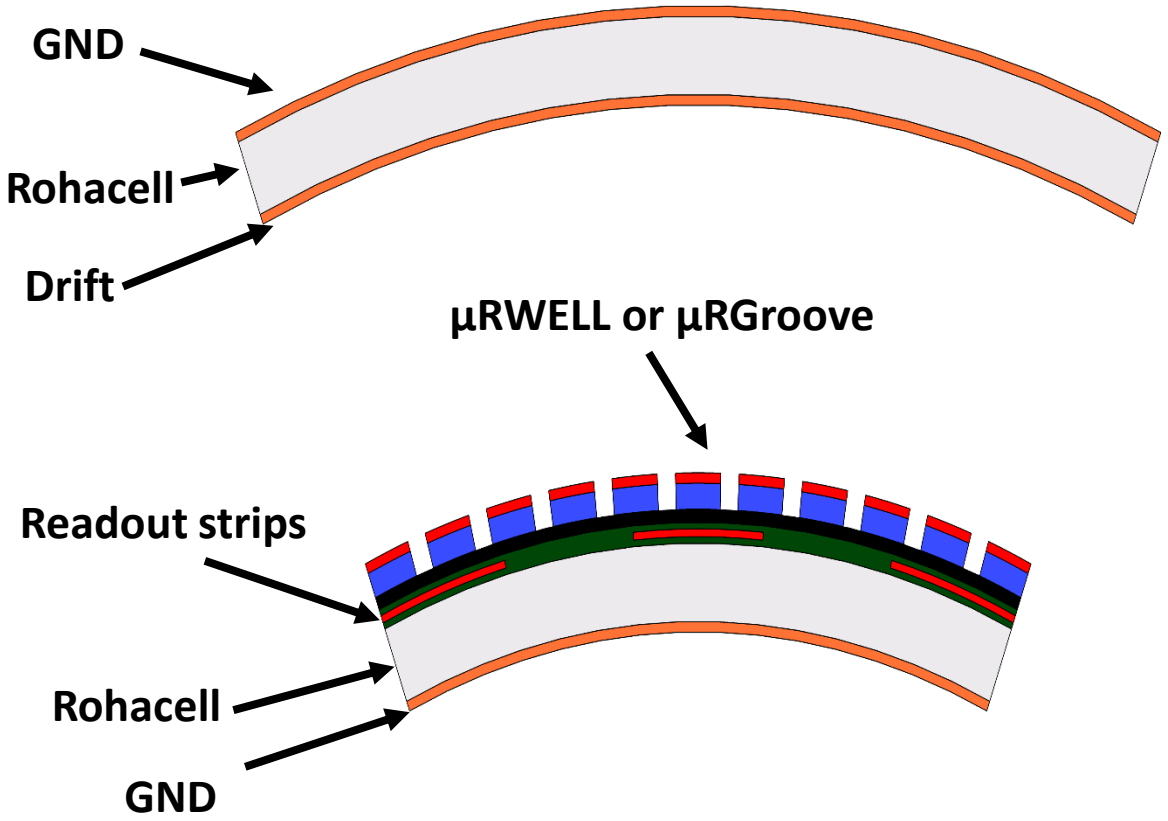
Active area= 100x100 mm2
Resistivity= 50 MΩ/
Strip pitch= 0.8 mm
Strip width = 0.7 mm
Dead zone (TOP) ~ 15%
Pre-preg thickness= 70 um

Dead Area (TOP): 2/128=1.5625%

Marco Poli Lener, RD51 Collaboration Meeting, 12/06/2023

Geometry & Performance of STCF-ITKW

STCF-ITKW



Layer0 is the principle demonstrator

Size of active area:

- Layer0: D=131.0mm, L=100.0mm;
- Layer1: D=131.0mm, L=380.0mm;
- Layer2: D=229.4mm, L=650.0mm;
- Layer3: D=327.9mm, L=920.0mm;

Performance:

- Spatial resolution in r−φ @1T Magnetic field :
  - 100μm perpendicular incident track;
  - 130μm for oblique incidence track;
- Material budget : ≤0.3% X0;
- Rate Capability: ≥30kHz/cm^2;

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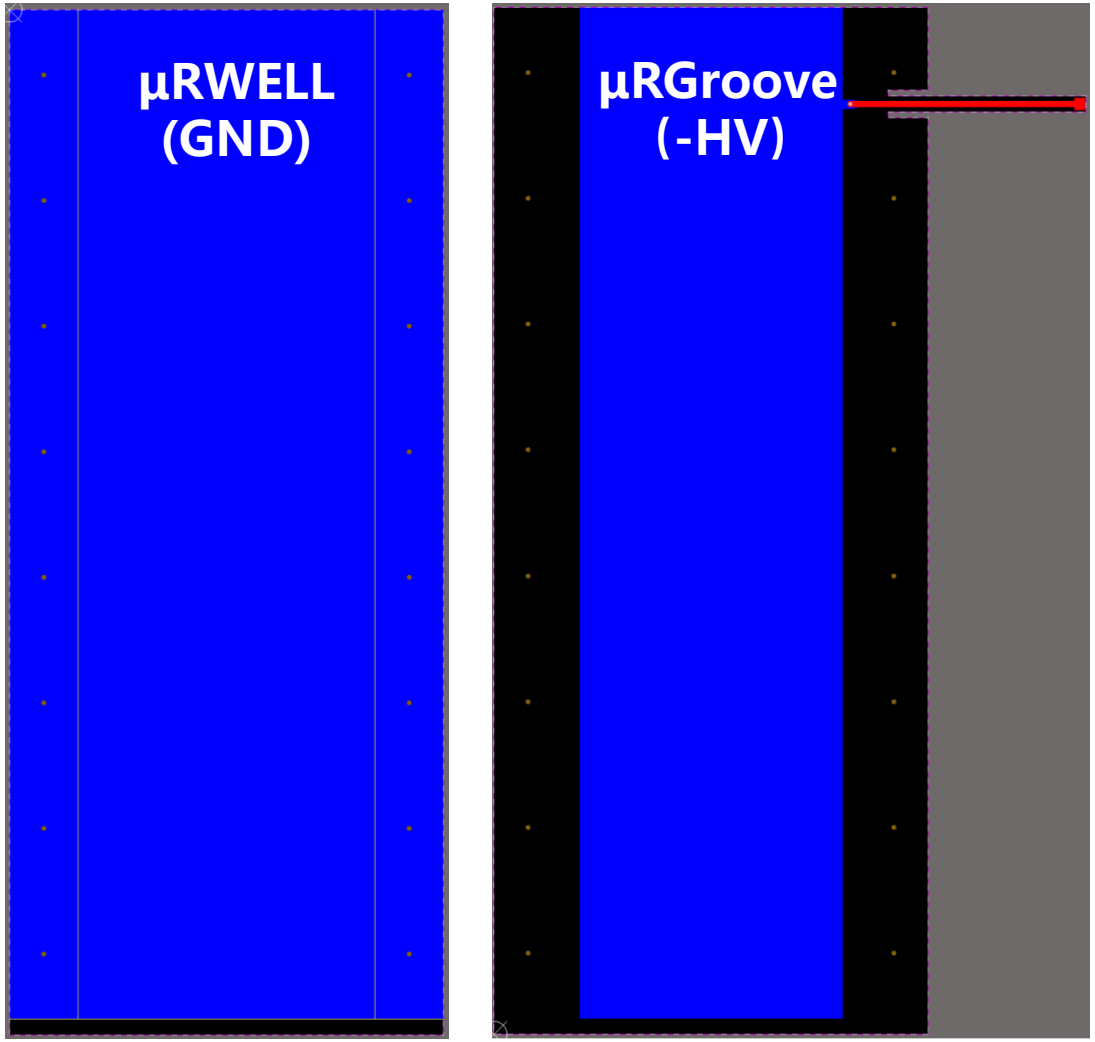
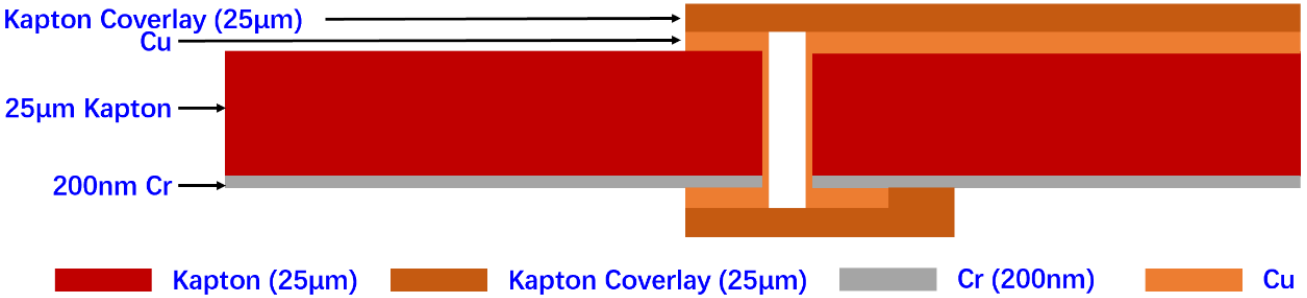
Drift Electrode

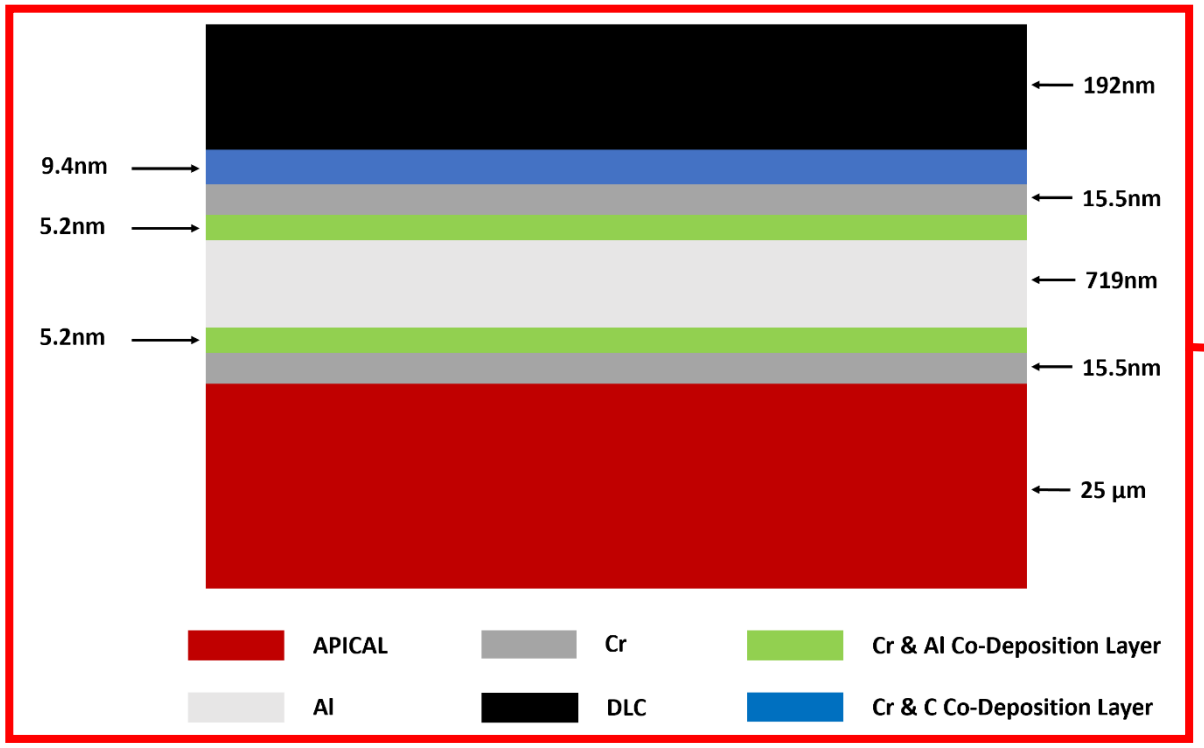


Layer stack of μRWELL drift

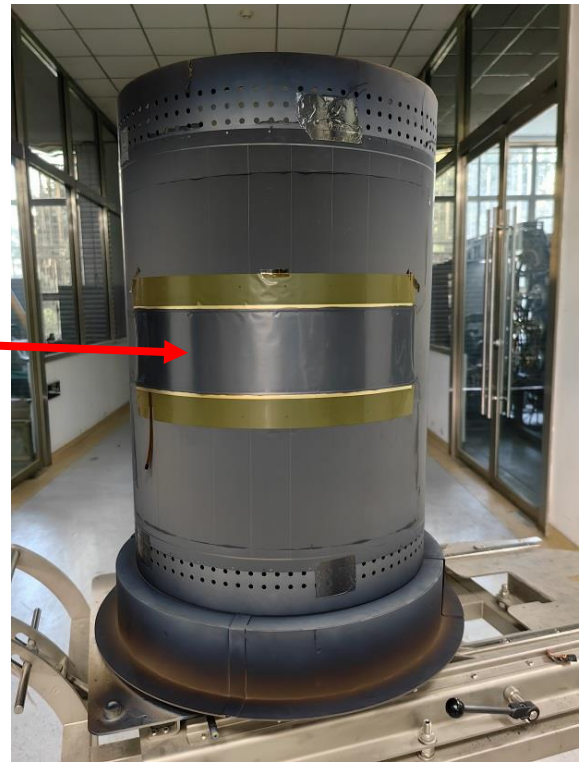
Layer stack of μRGroove drift

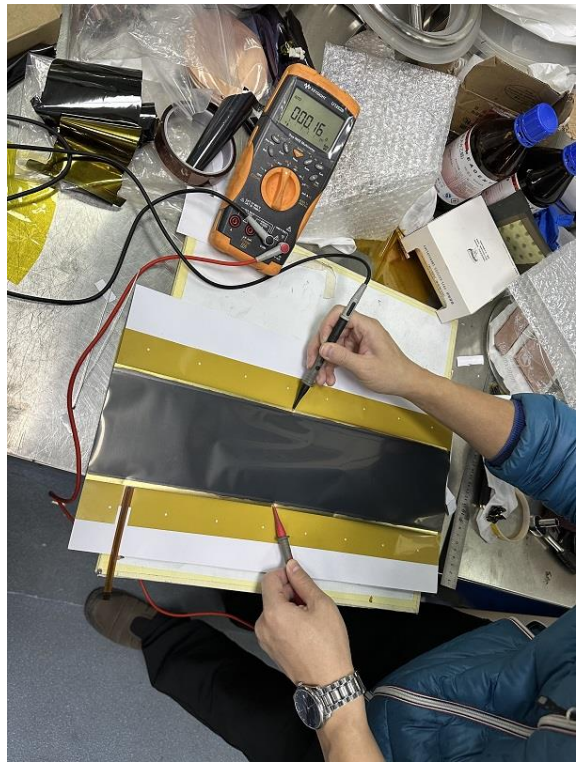


Low Material Budget Electrode



	X0 (mm)	Thickness (nm)	Material Budget (%X0)
C	188.4	193.6	0.0001028
Al	88.97	721.6	0.0008110
Cr	20.7	46.5	0.0002246
Total:			0.0011384





LMB Drift & GND are both made

Zhou Lin, RD51 Collaboration Meeting, 21/06/2023

Many thanks to Fabien for his suggestion on using the aluminum instead of copper!!!

PCB for Readout Strips

Requirement of readout strips:

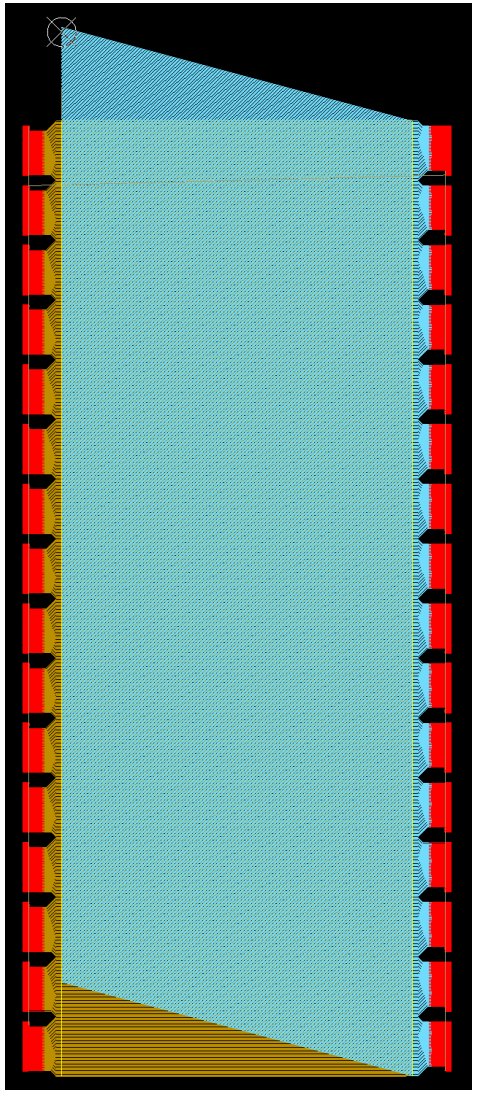
U/V 2D strip-readout, pitch of U strips is 0.4mm, Pitch of V strips is 0.8mm, angel between UV is 15°;

Design of readout strips:

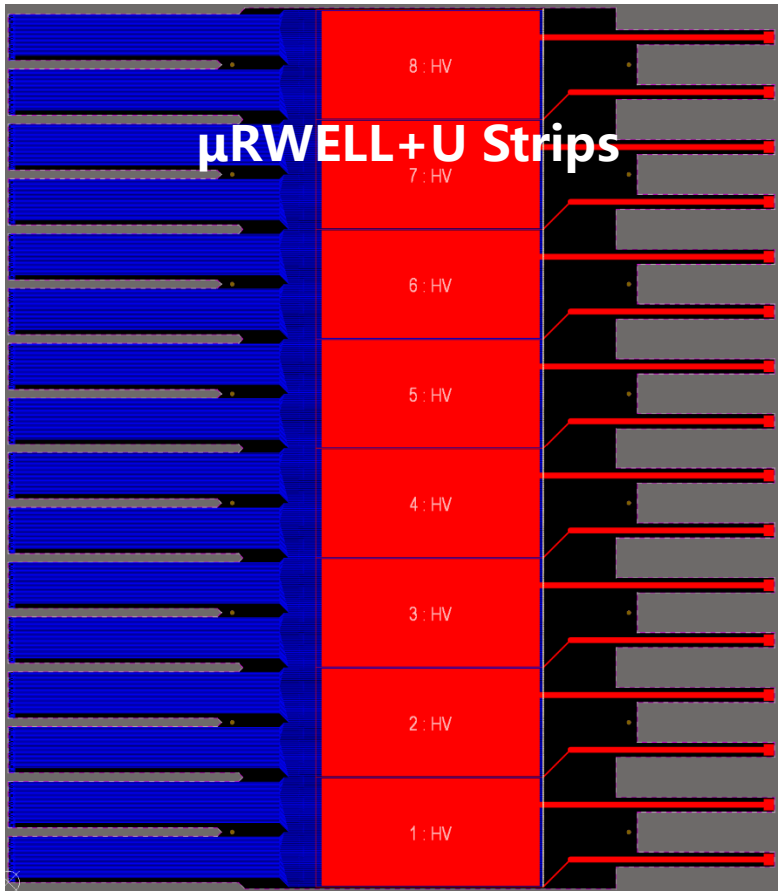
1. 2 PCBs (rectangle on top and parallelogram on bottom) each containing 1d strips are used, instead of 1 multilayer PCB, to avoid strip cut off on the edge of PCB, extra material budget or extra channels of electronics;

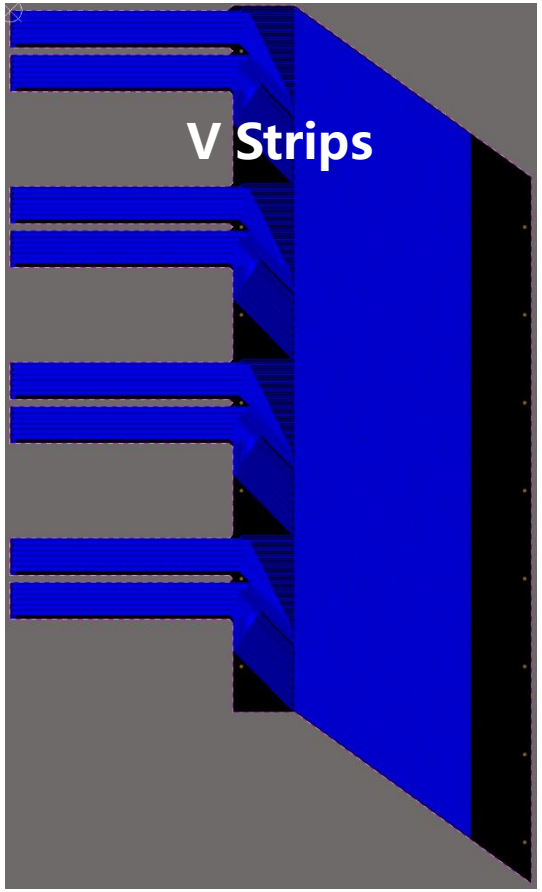
2. No electronic component soldered on the PCB, to avoid damage of the flexible PCB during the vacuum pump gluing process;

3. Use Goldfinger for the electrical connections.

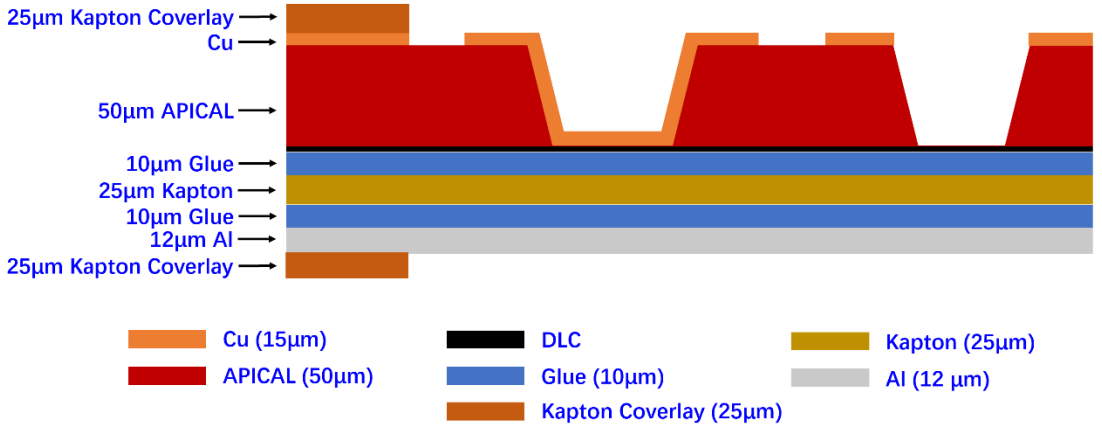


μRWELL and Readout Strips

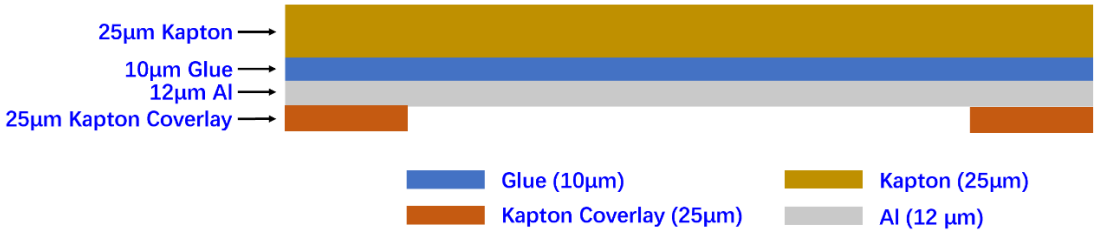




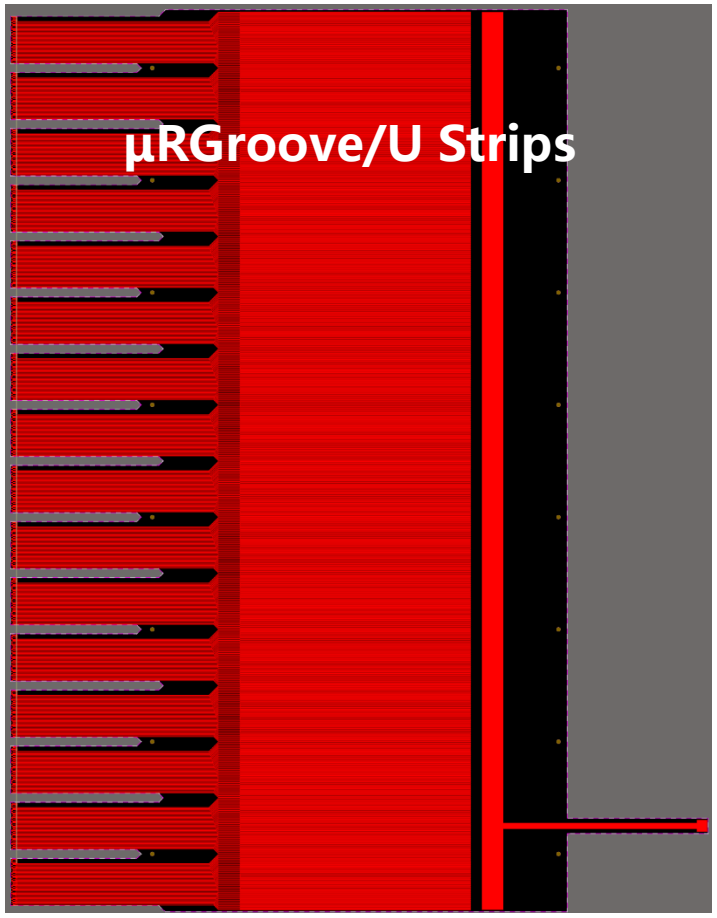
Layer stack of μRWELL

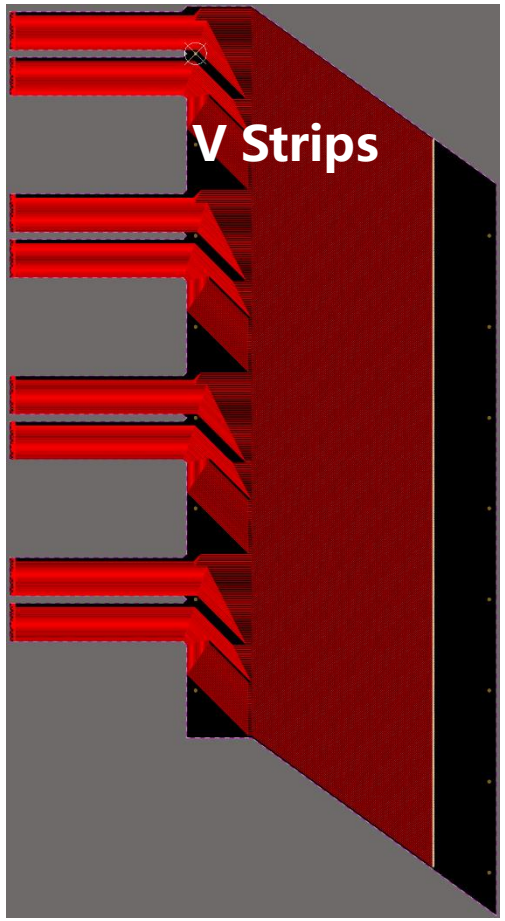


Layer stack of V readout

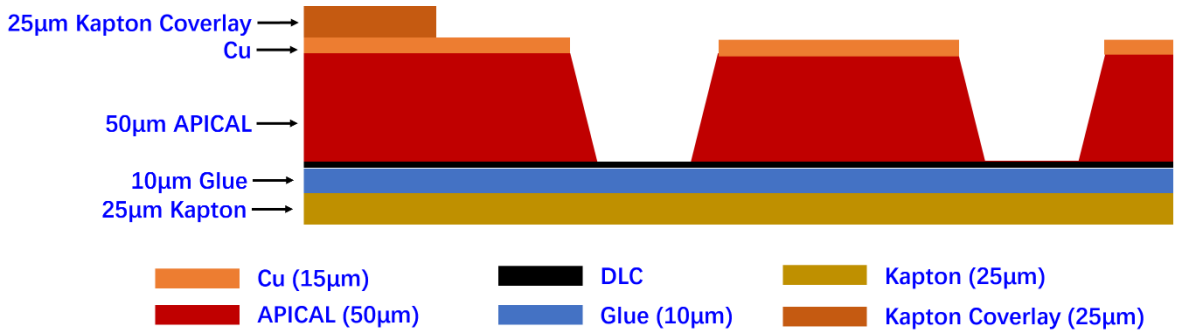


μRGroove and Readout Strips

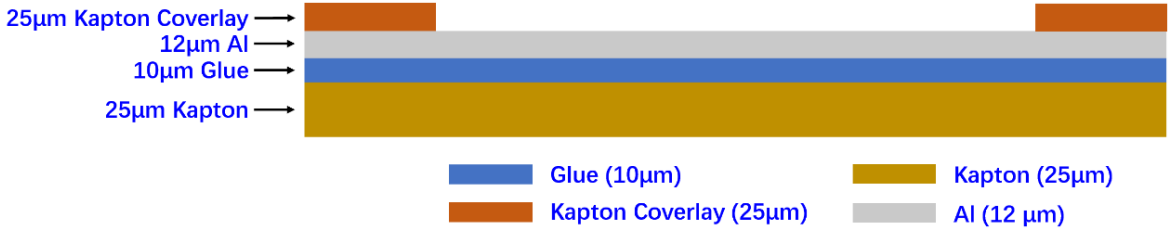




Layer stack of μRGroove

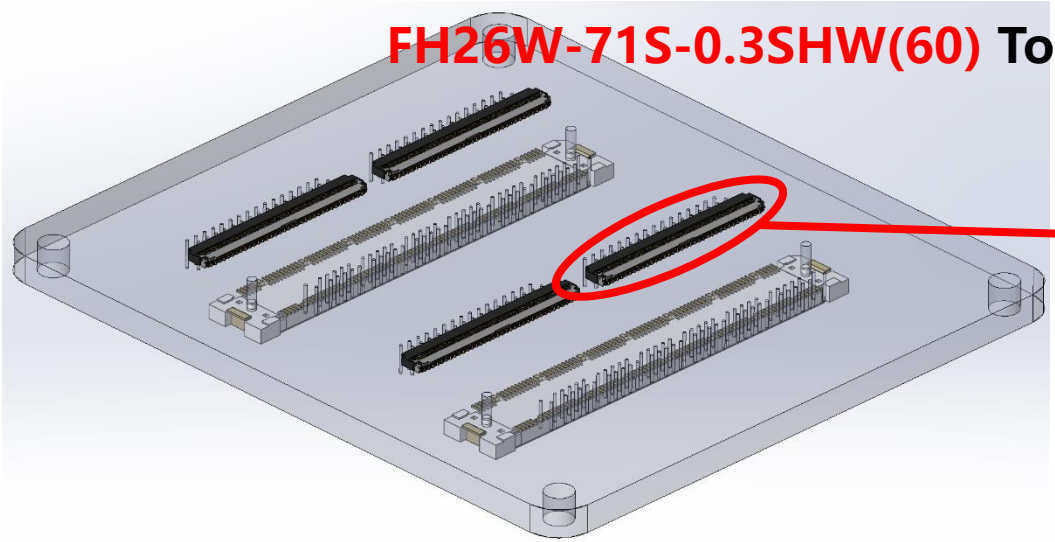


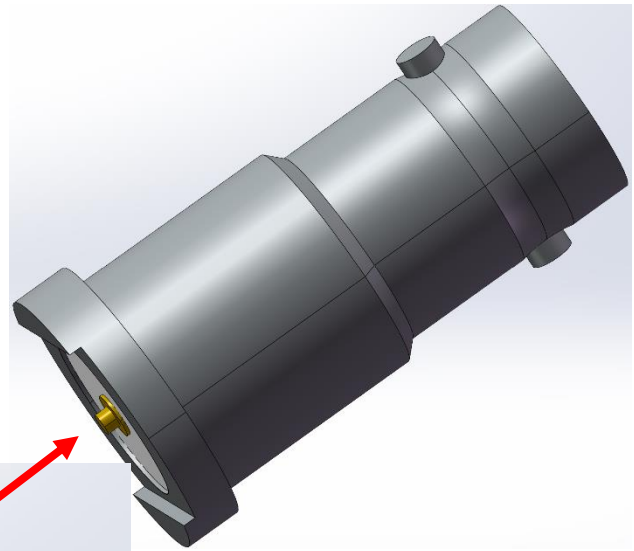
Layer stack of V readout



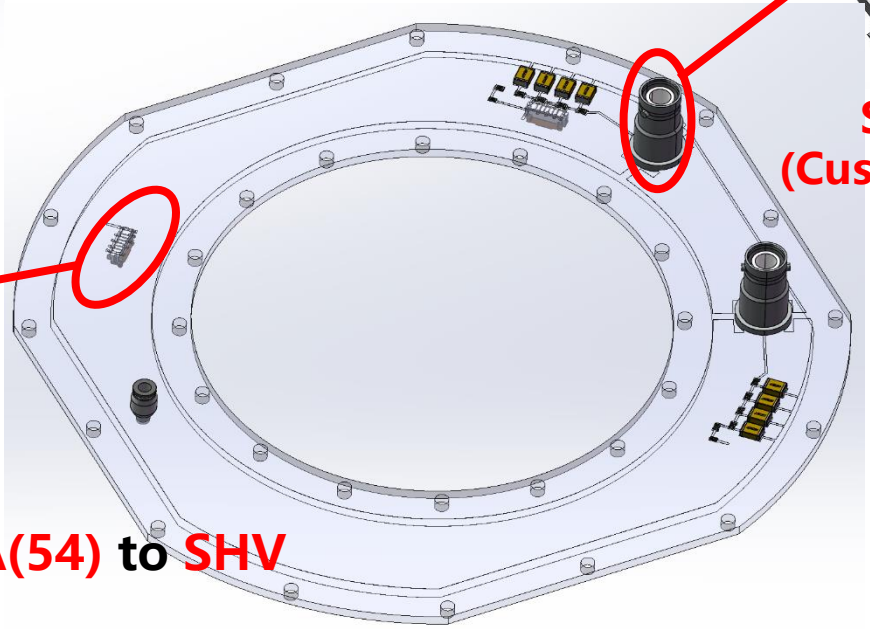
FPC for Signal and HV Connections：

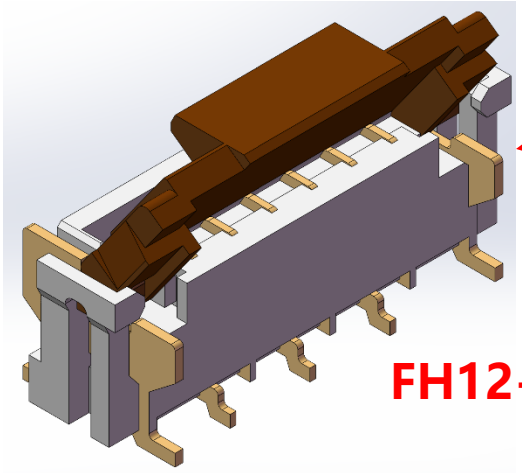
FH26W-71S-0.3SHW(60) To FX10A-140S14-SV





Surface mount SHV
(Custom made by FIN TEST)
Max. HV: 3kV





FH12-6S-1SVA(54) to SHV

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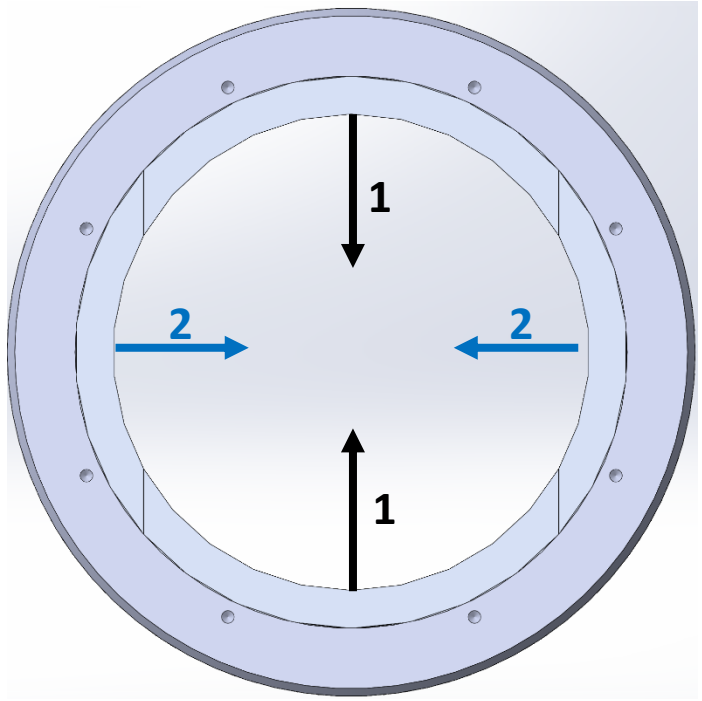
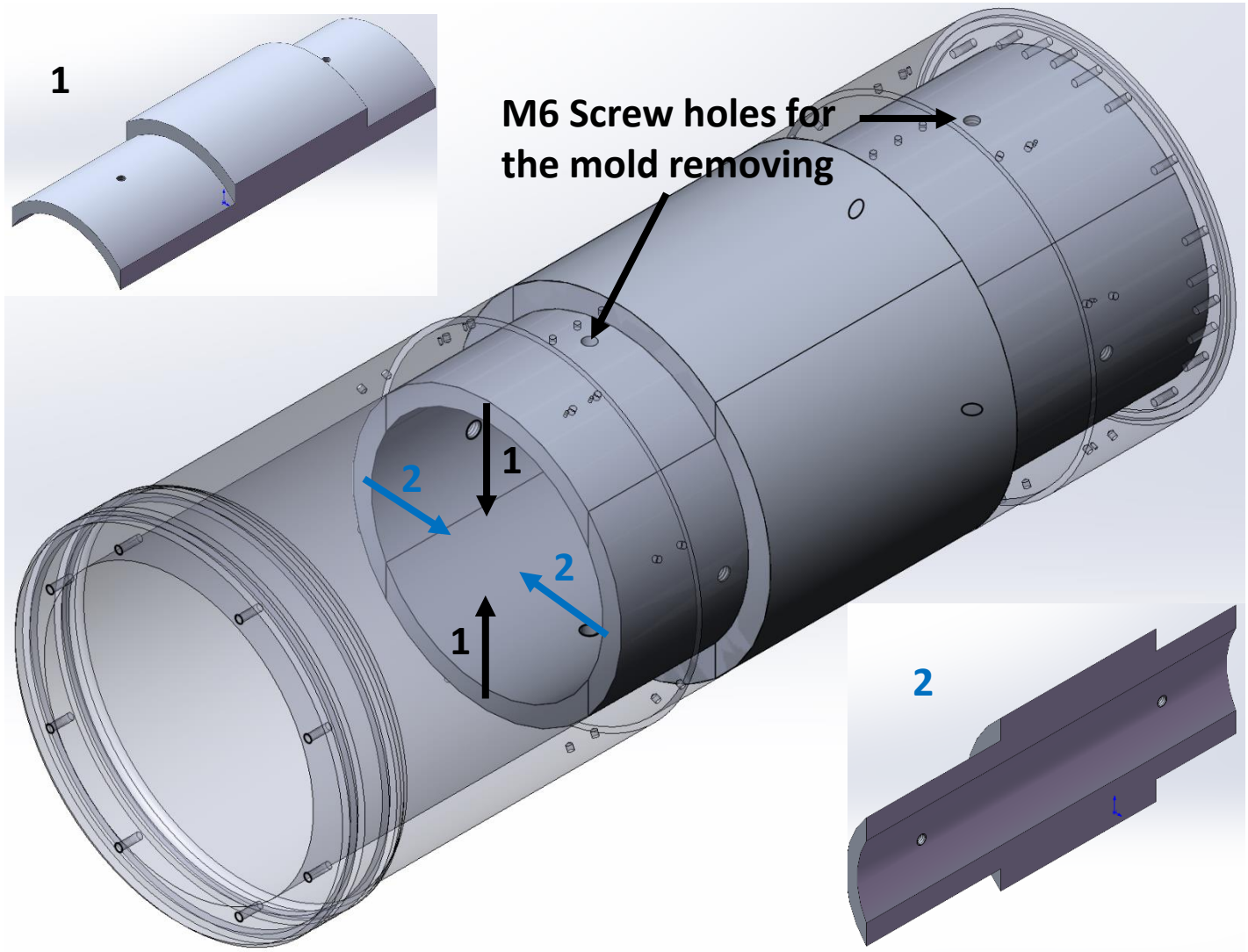
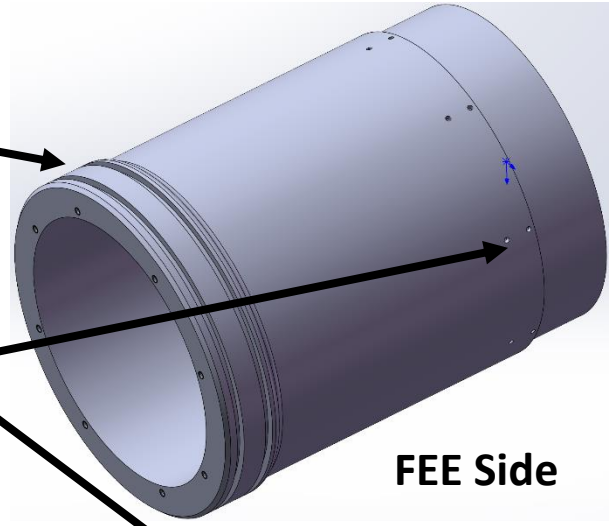
The Cylindrical Molds of µRWELL/µRGroove

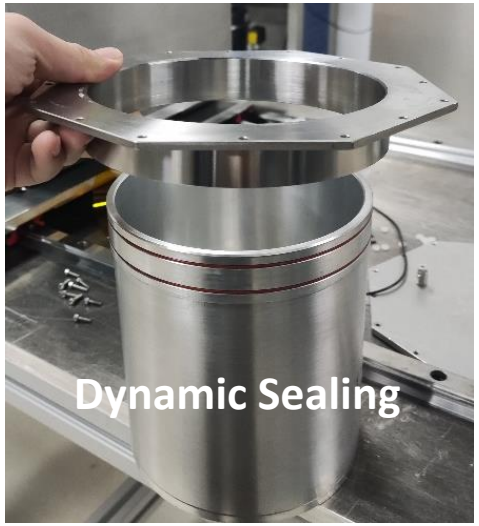


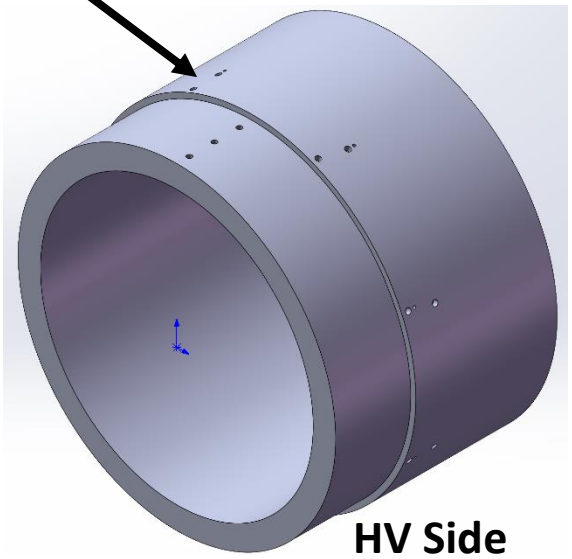


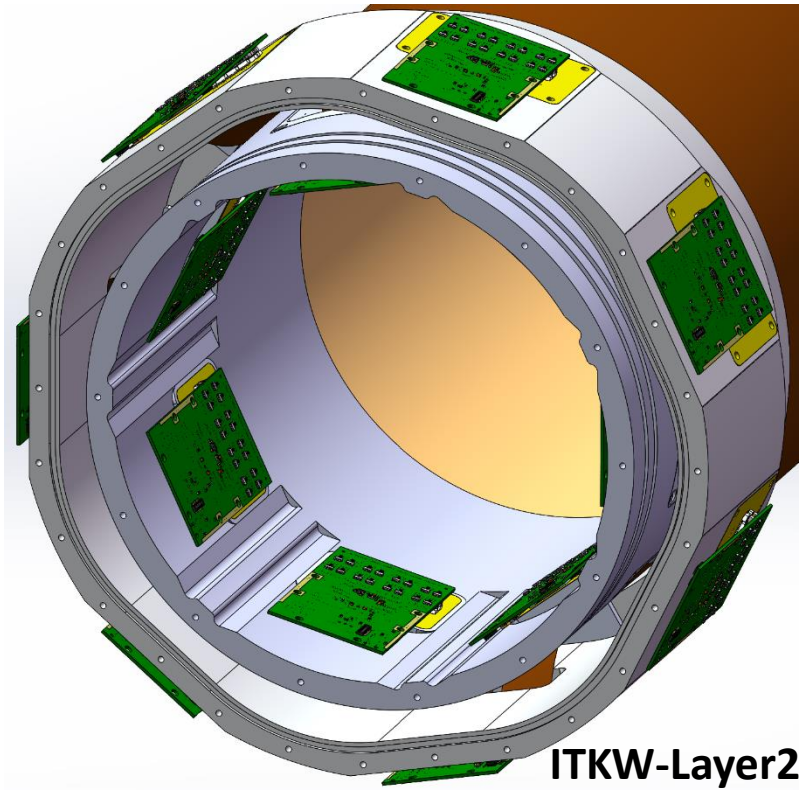
- The mold consists of 4 pieces;
- After gluing, mold1 can be removed vertically, then mold2 can be removed horizontally
- M6 screw holes on both end of each piece are used for the mold removing

The Sleeves of µRWELL/µRGroove



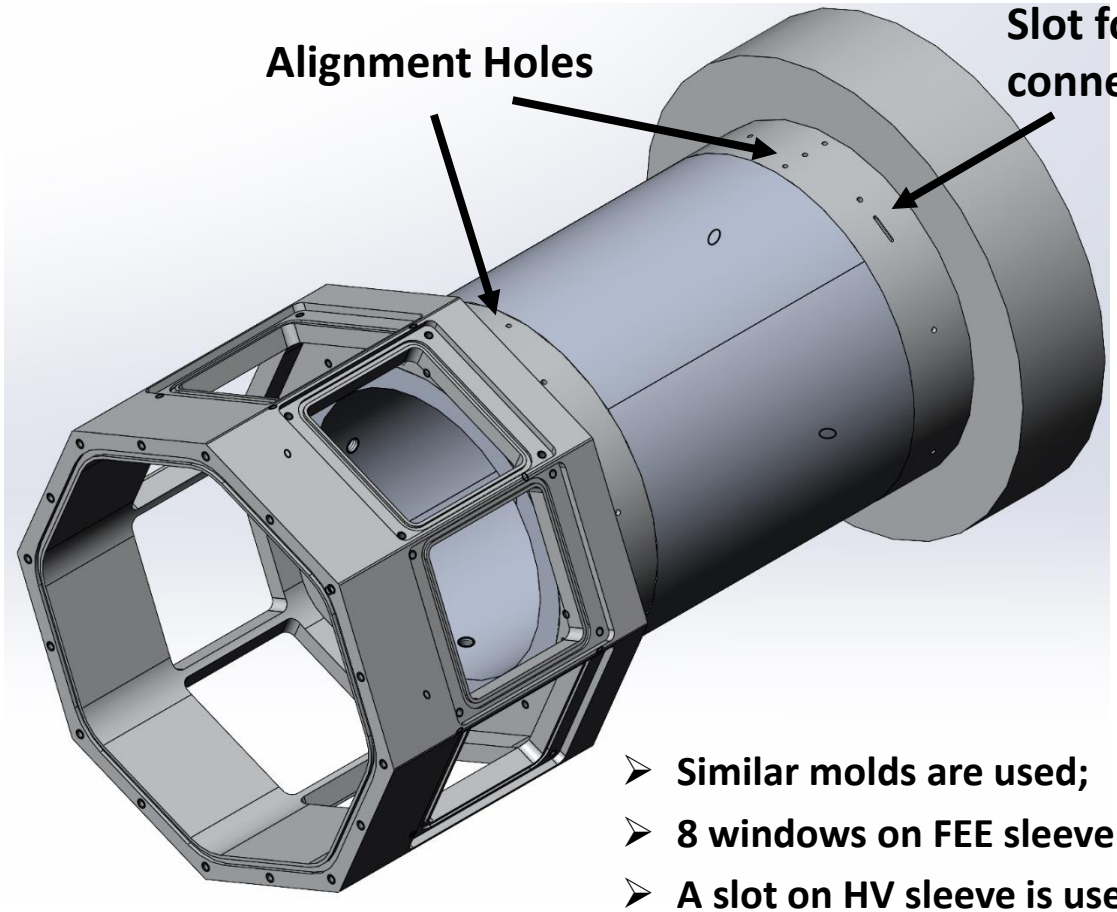


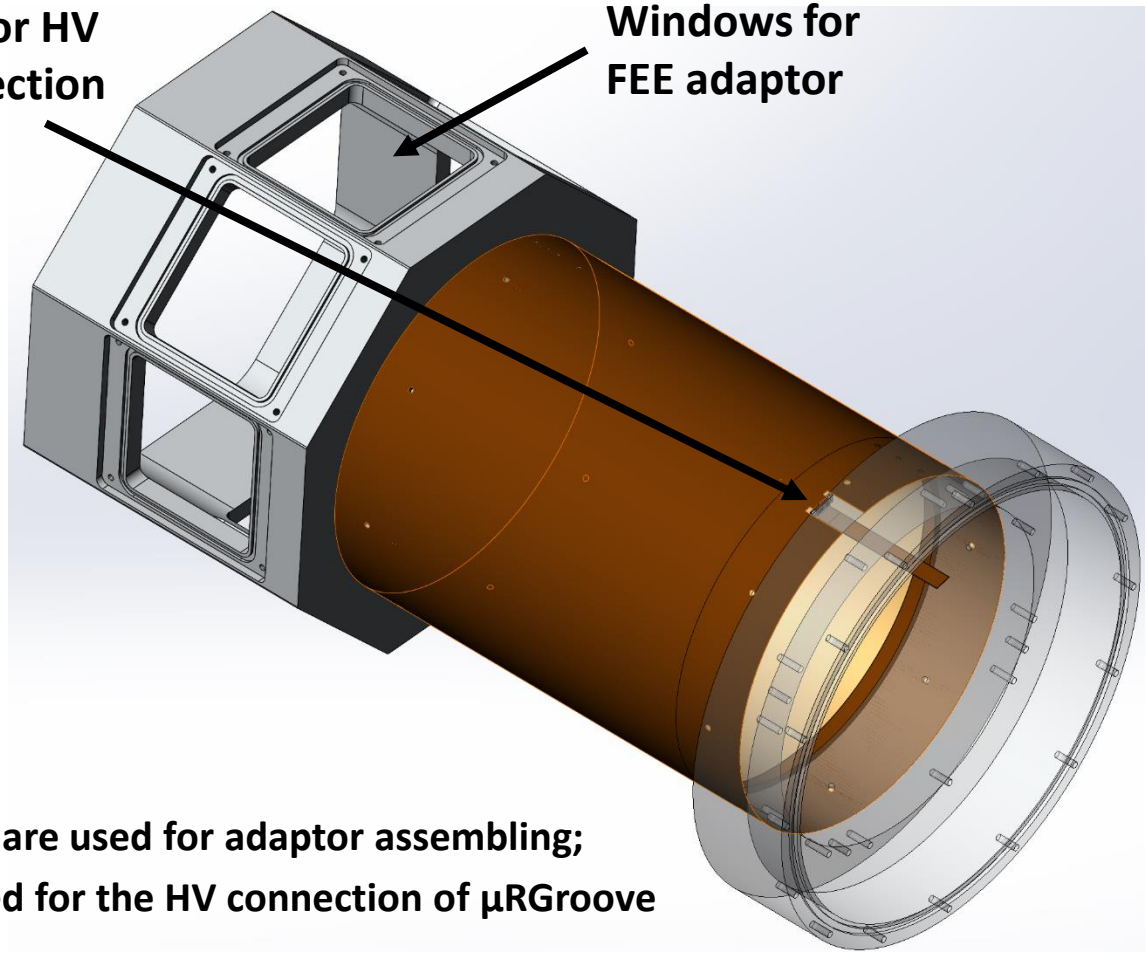




There are FEEs fixed onto the inner sleeves start from layer2, we have no space for the sealing slot on the end face, that why we use dynamic sealing

The Molds & Sleeves of Drift Electrode

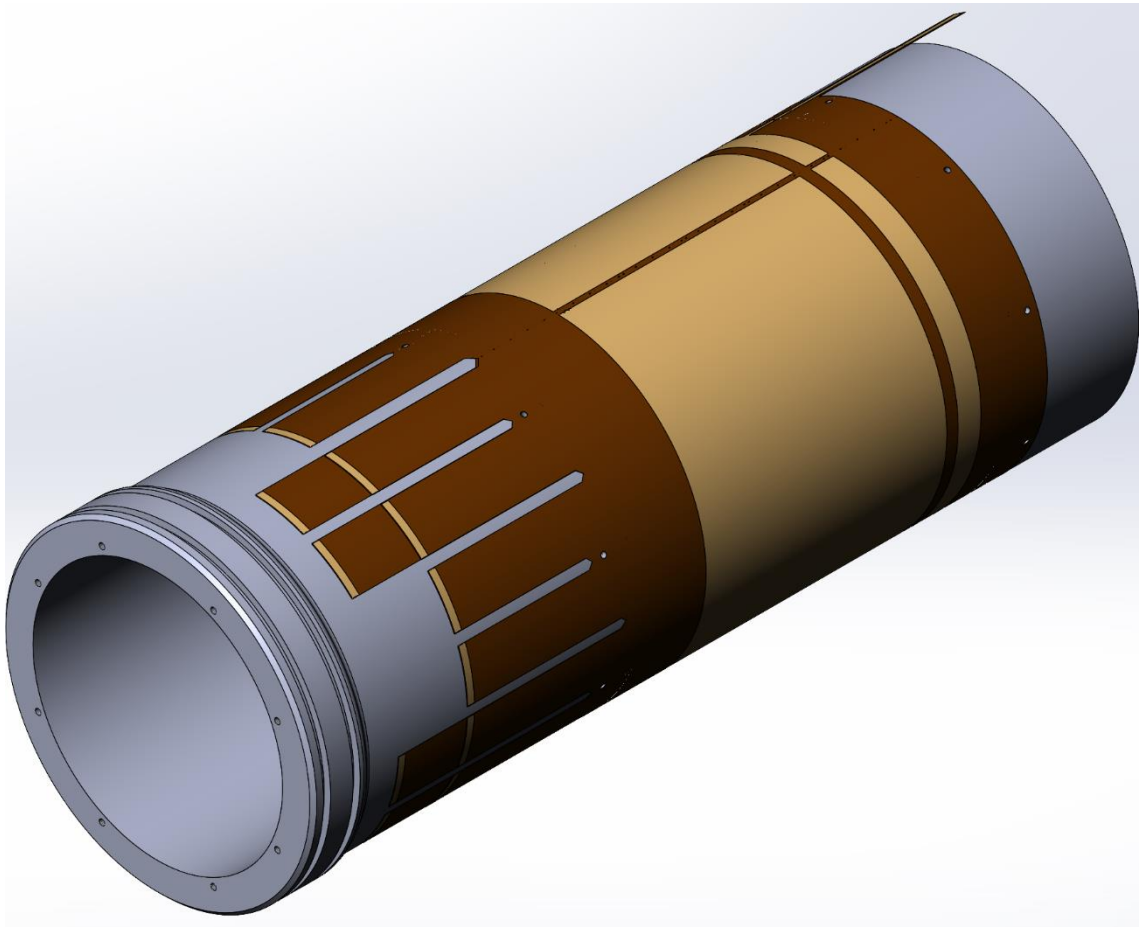




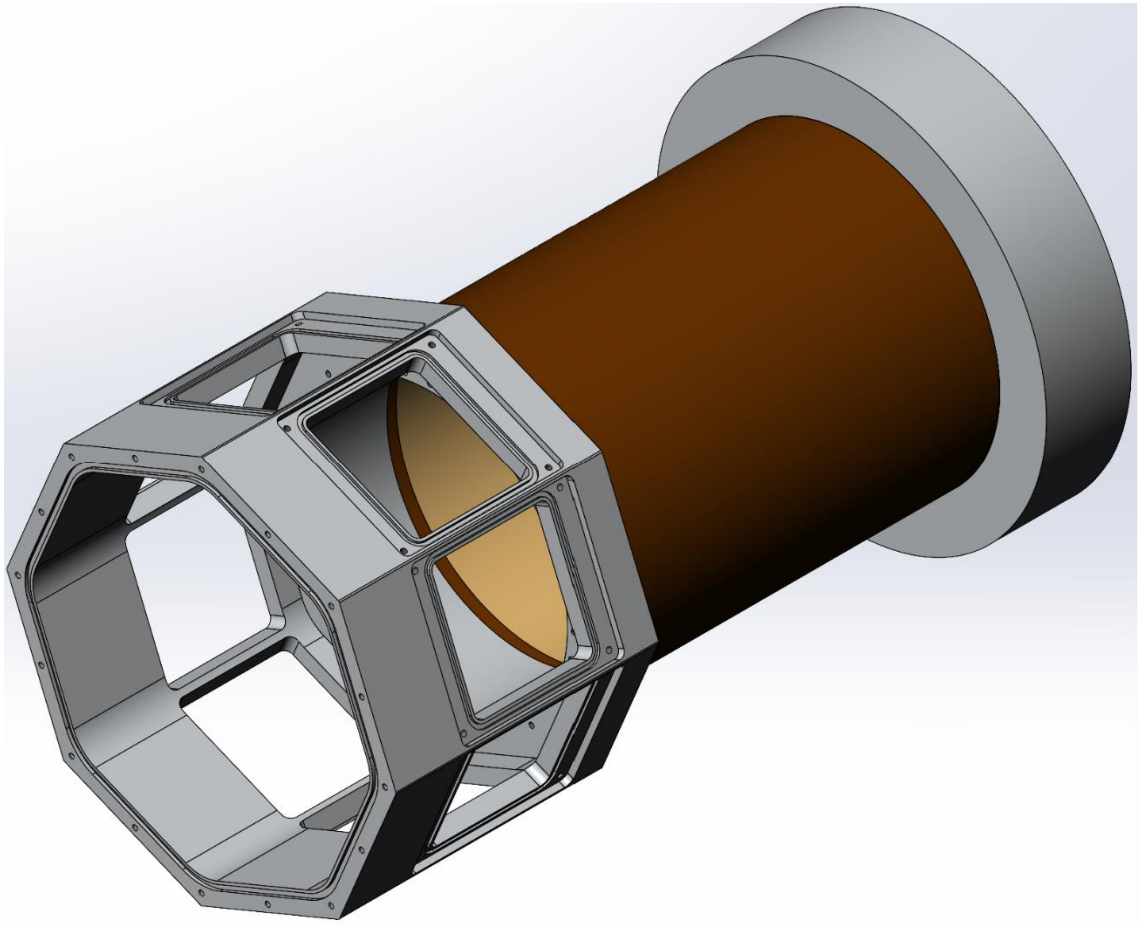
- Similar molds are used;
- 8 windows on FEE sleeve are used for adaptor assembling;
- A slot on HV sleeve is used for the HV connection of µRGroove

The Electrode After Gluing

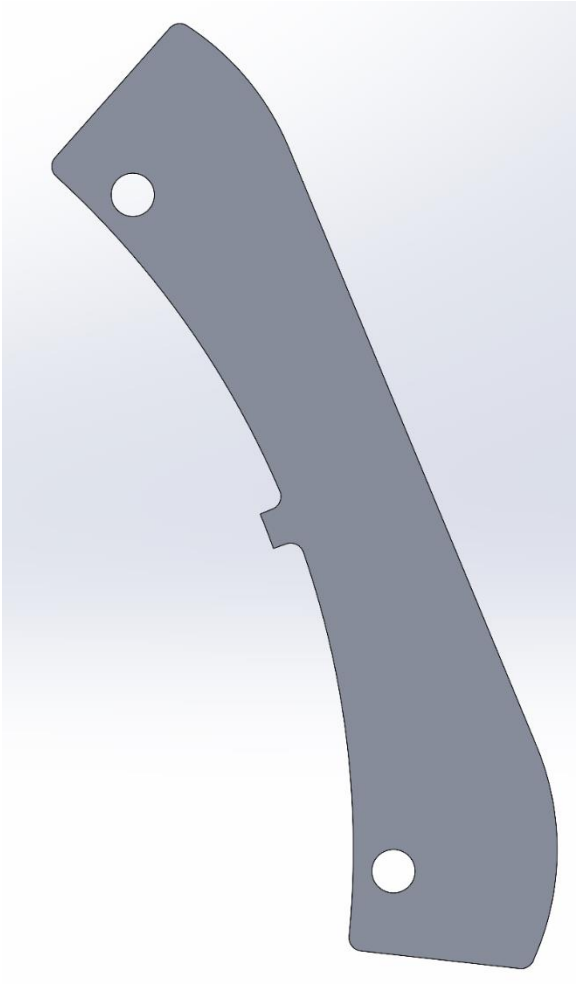
µRGroove

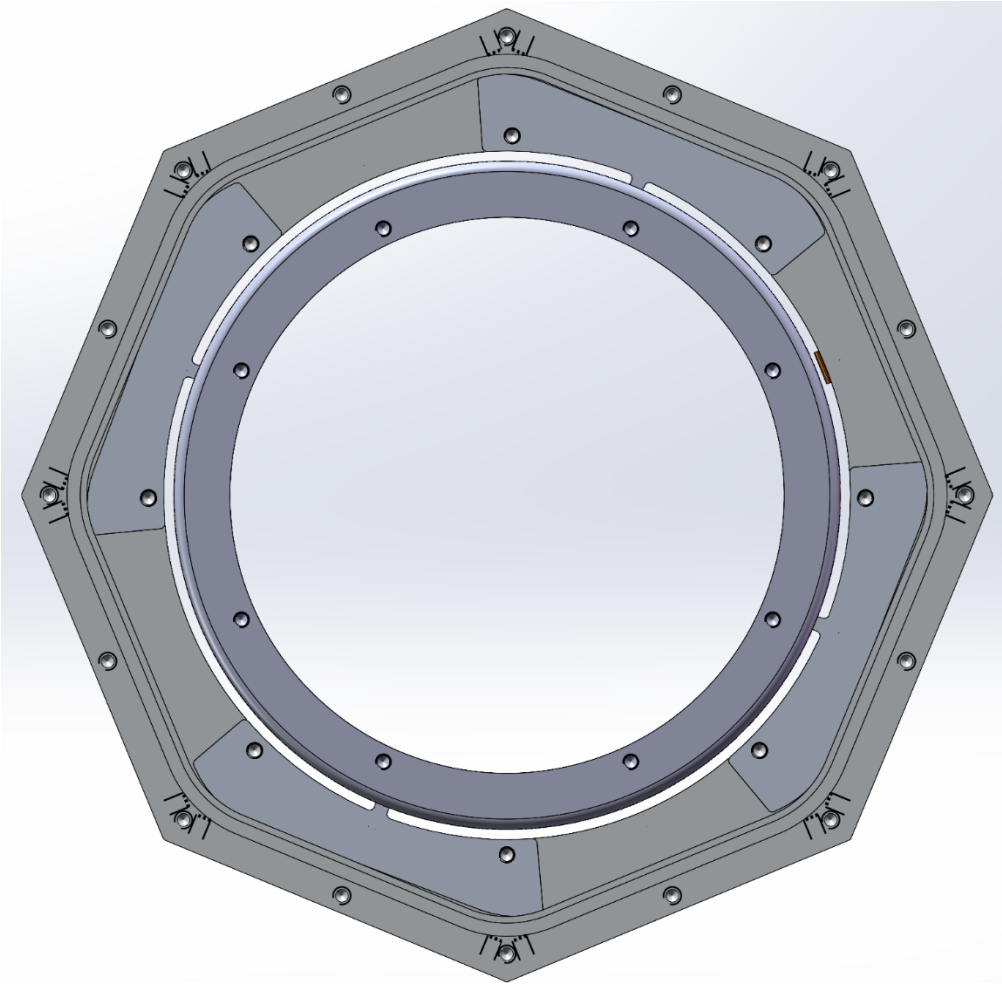


Drift



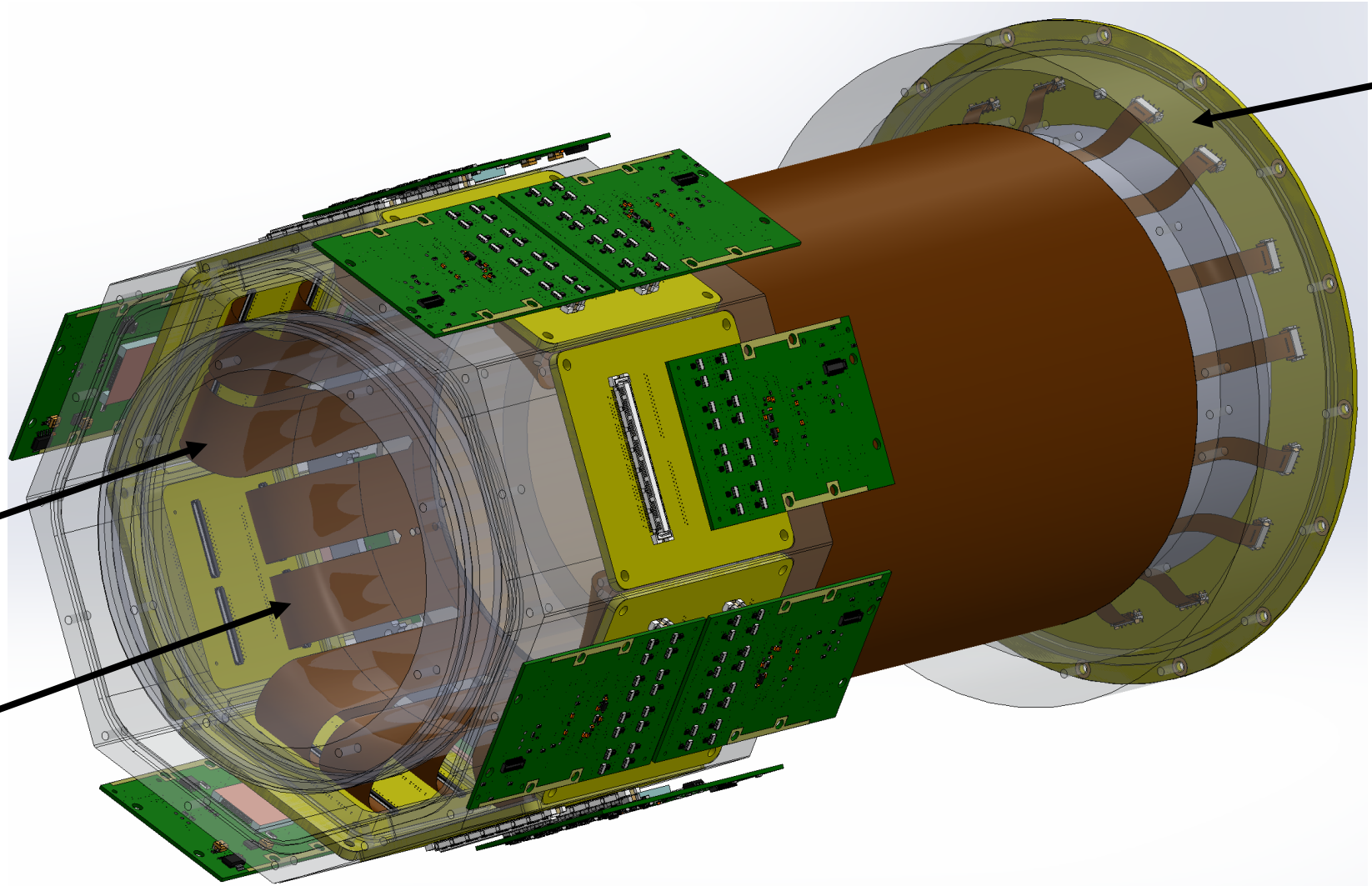
Spacer For The Inner & Outer Sleeves



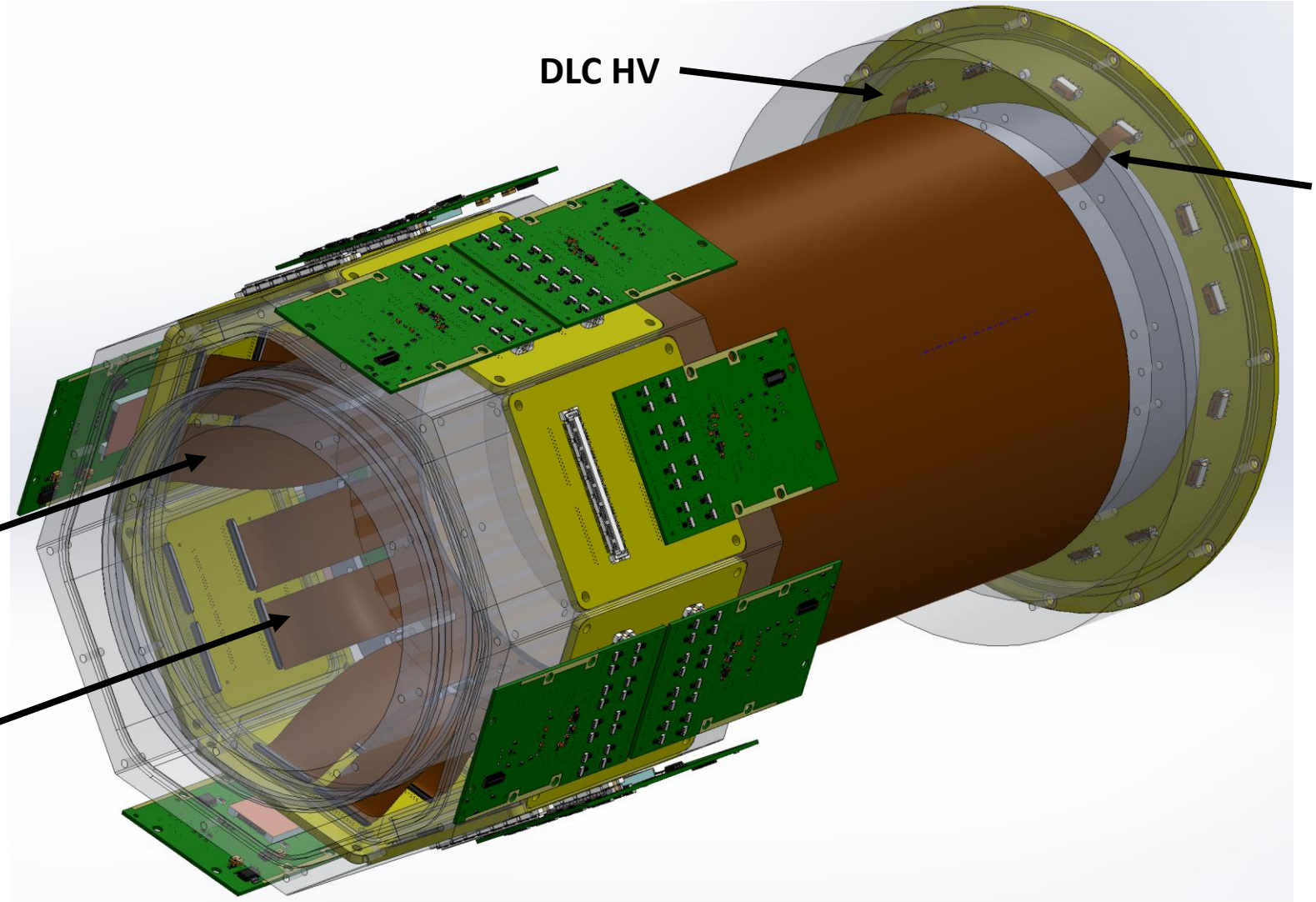


The spacers provide an uniform 5mm drift gap

c-μRWELL



c-μRGroove



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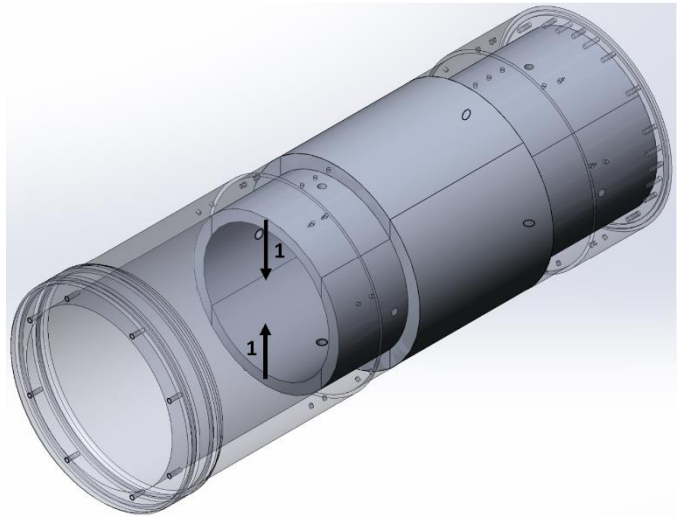
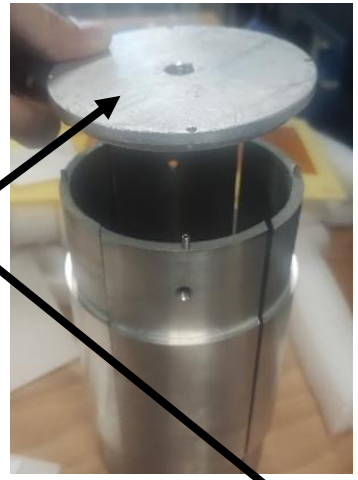
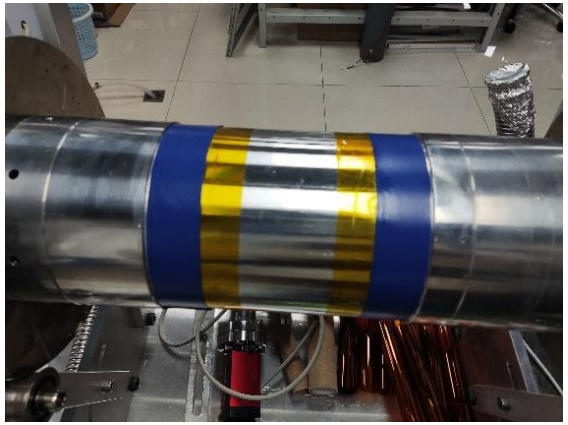
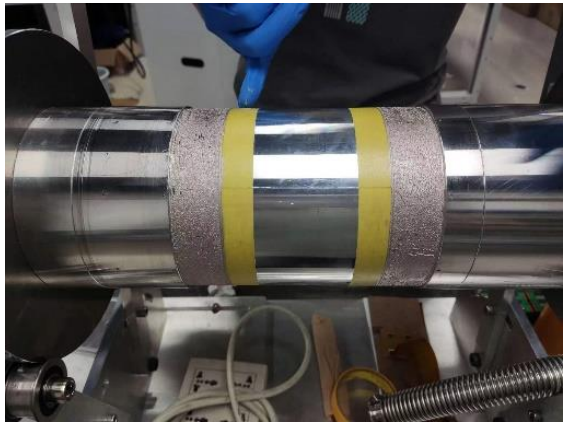
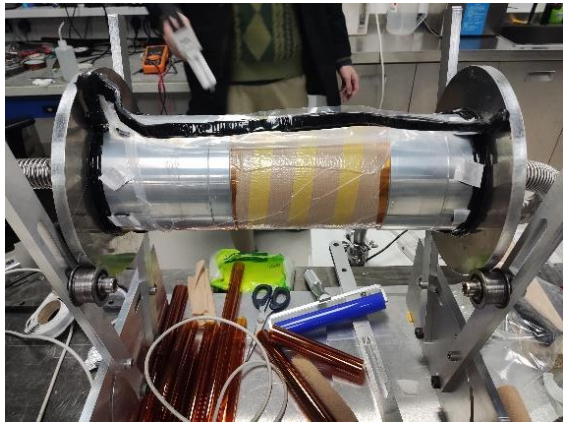
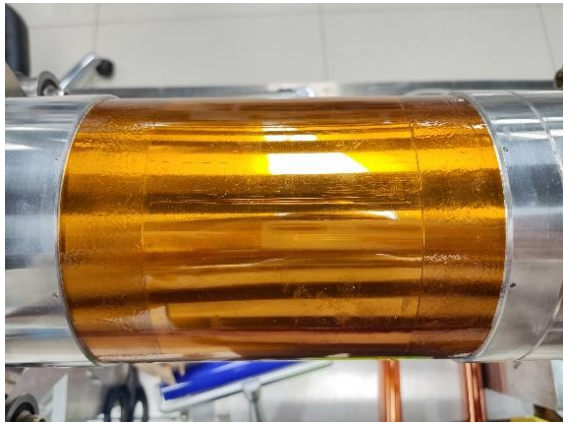
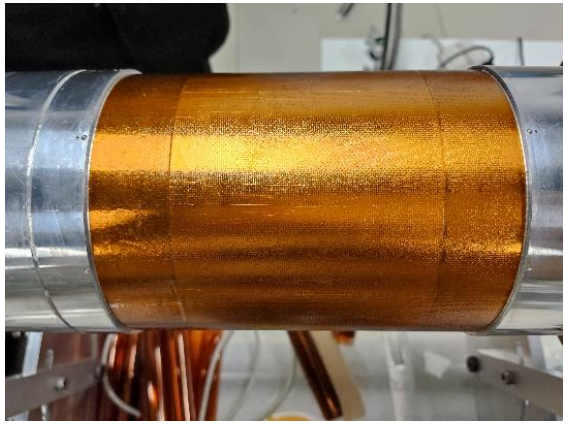
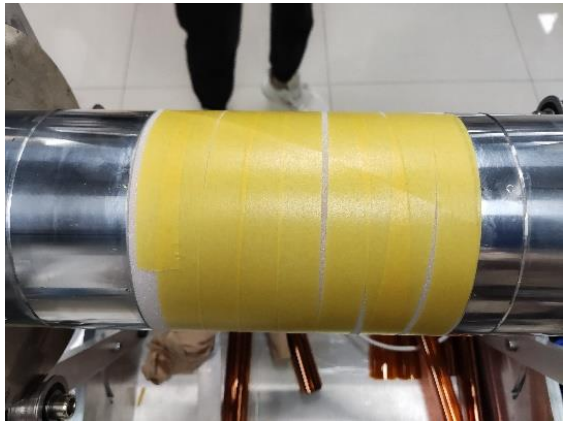
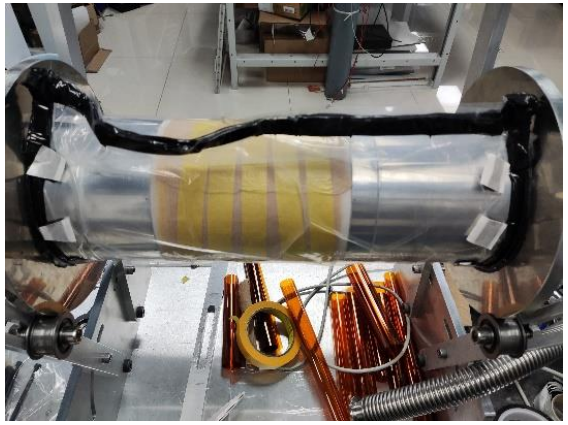
Assembling of Molds and Sleeves

2 conical caps are used for supporting the 4 pieces of molds, to avoid the invagination of the 2 type1 molds during the vacuum pumping





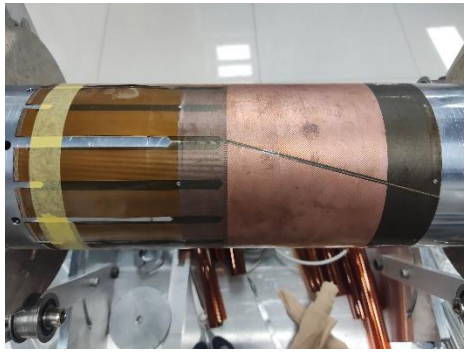
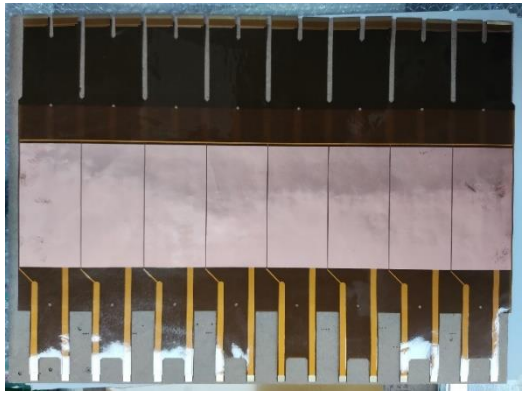
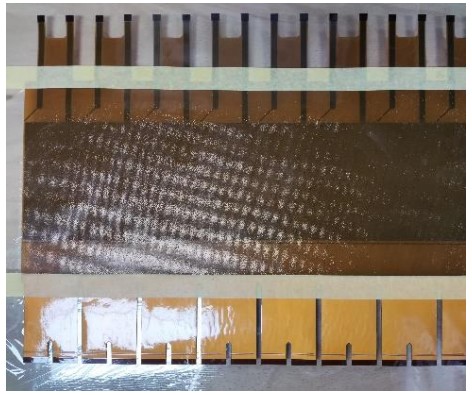
Inner Cylinder Gluing: GND & Rohacell

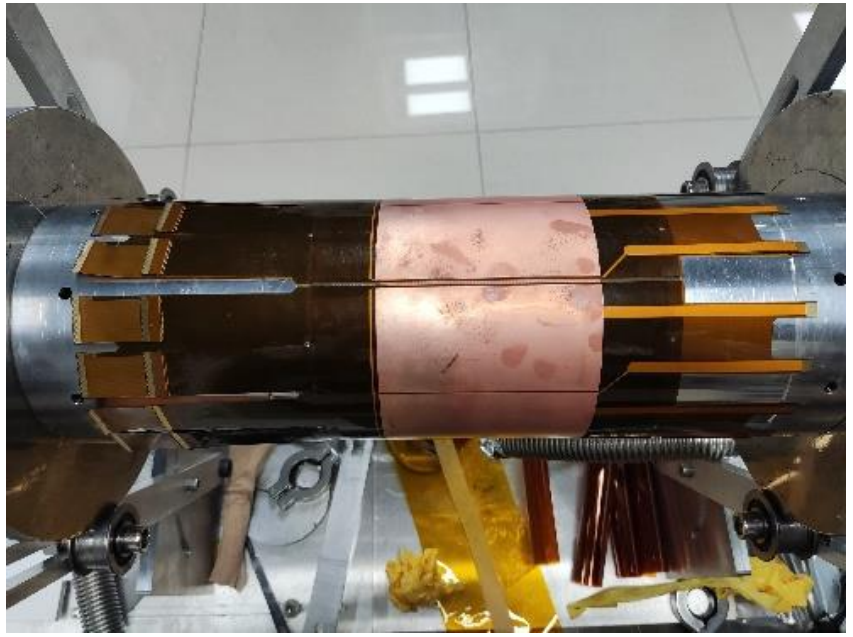









Inner Cylinder Gluing: Readout & µRWELL(Model)

Bottom Readout

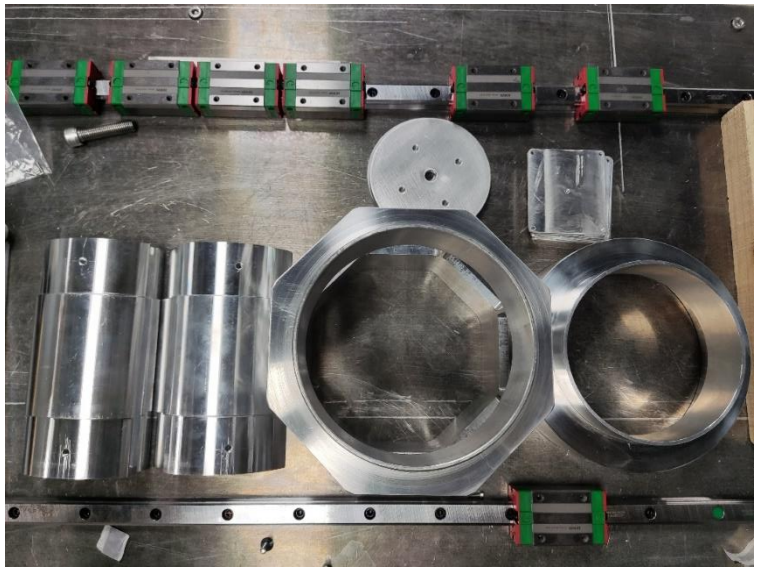


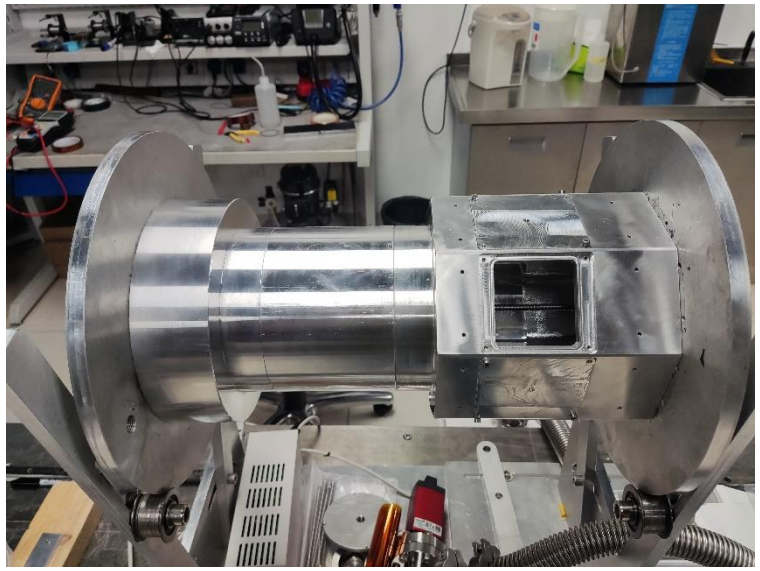





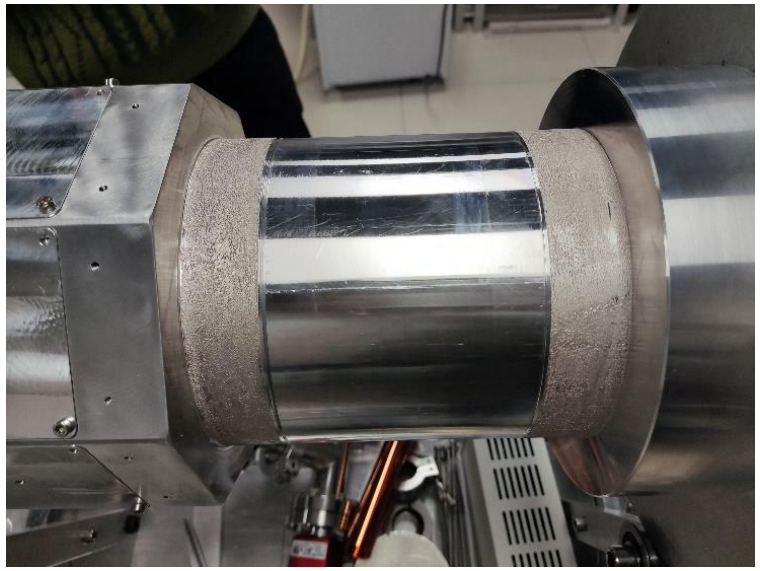


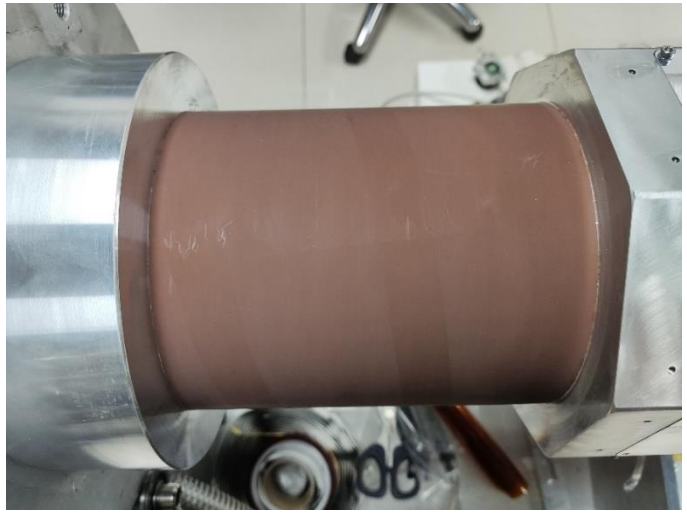
µRWELL(model) & Top Readout

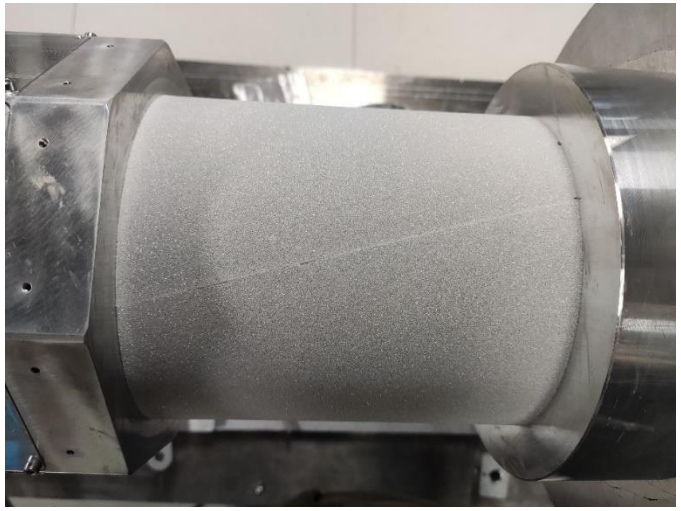
Outer Cylinder Gluing



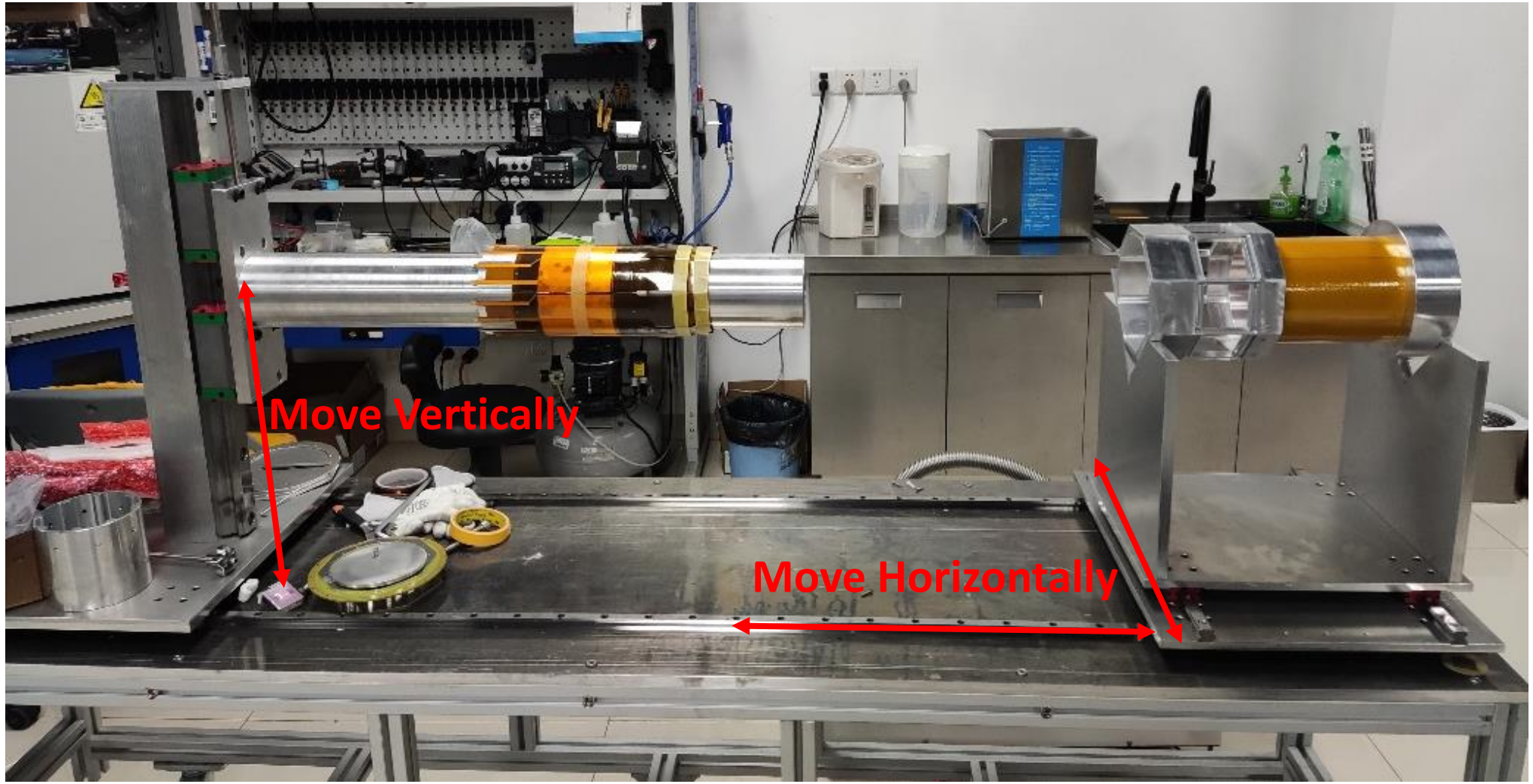




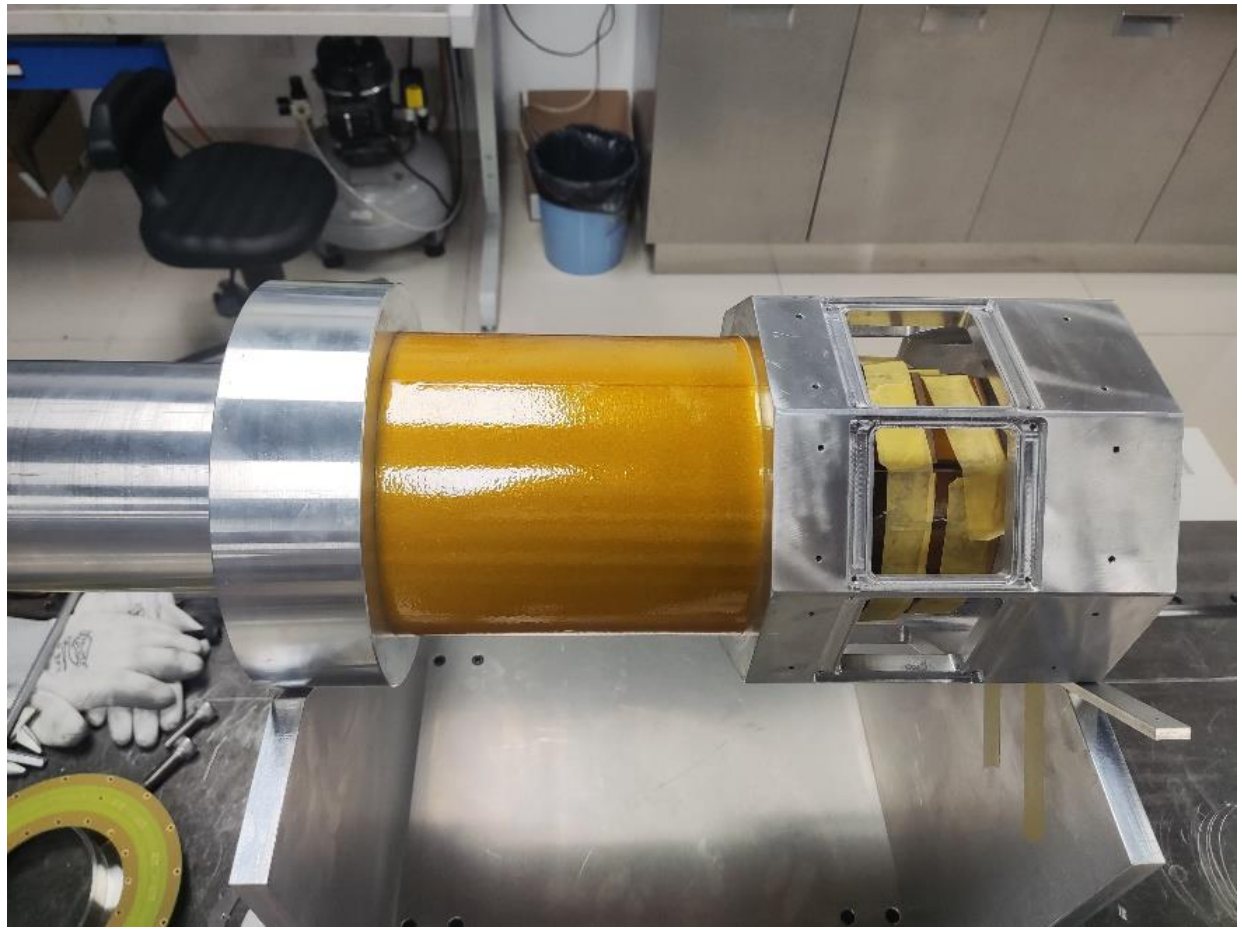


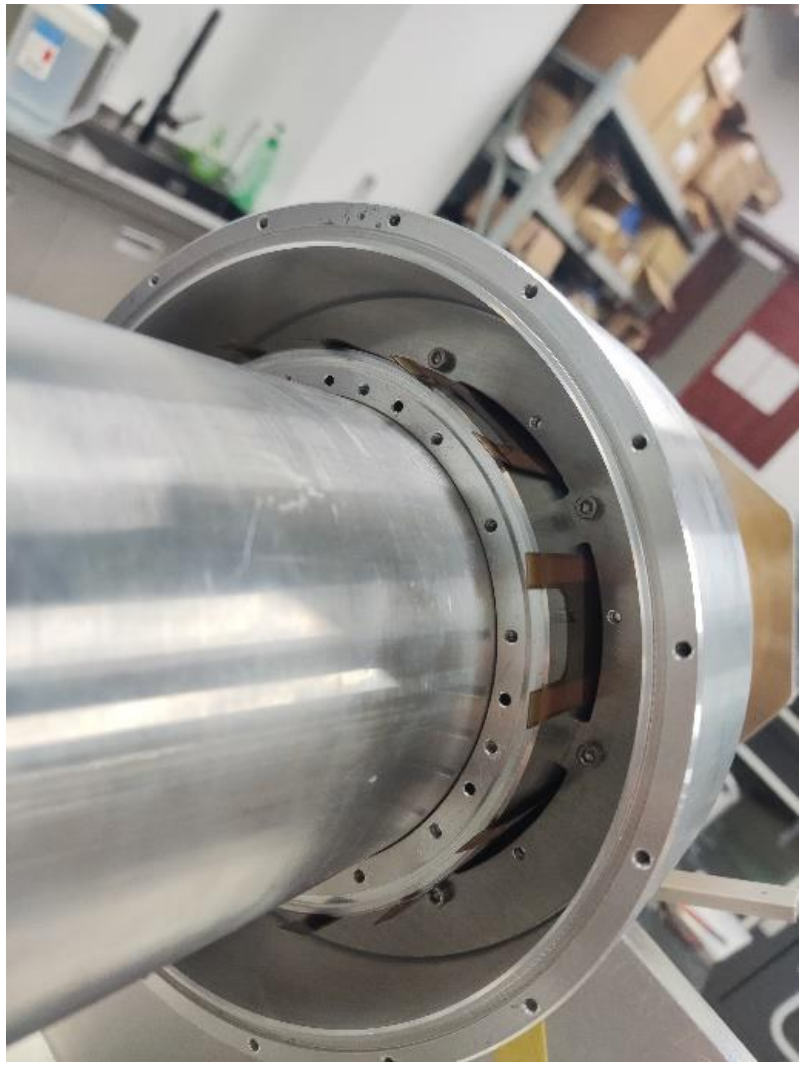


Model Assembling 1



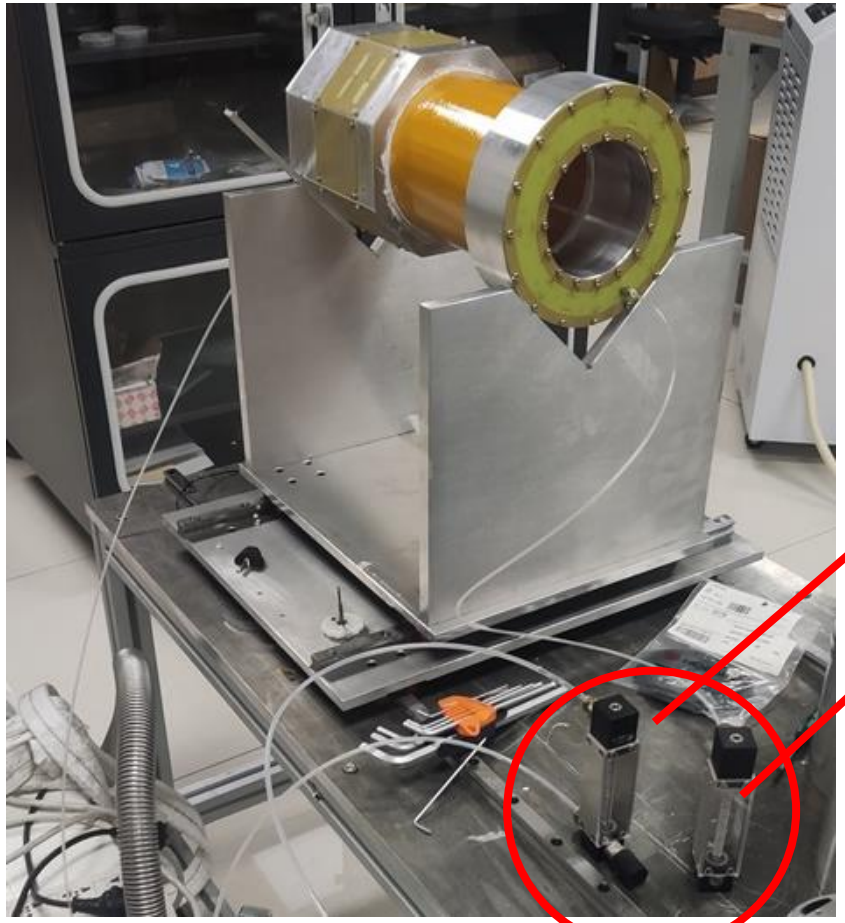
Model Assembling 2

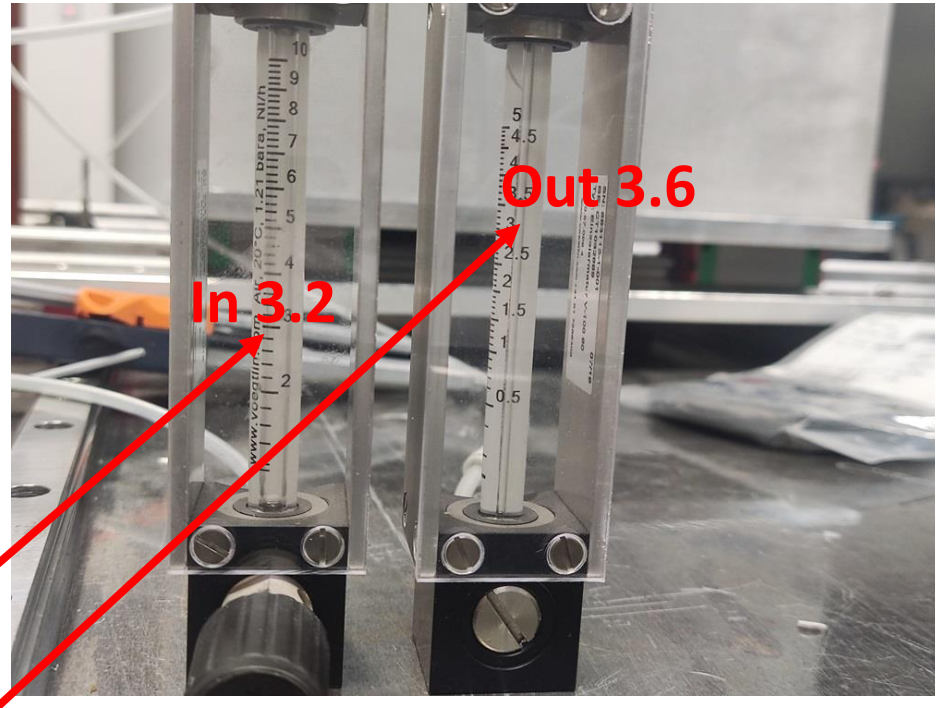




Installation of Cylinders & Spacers

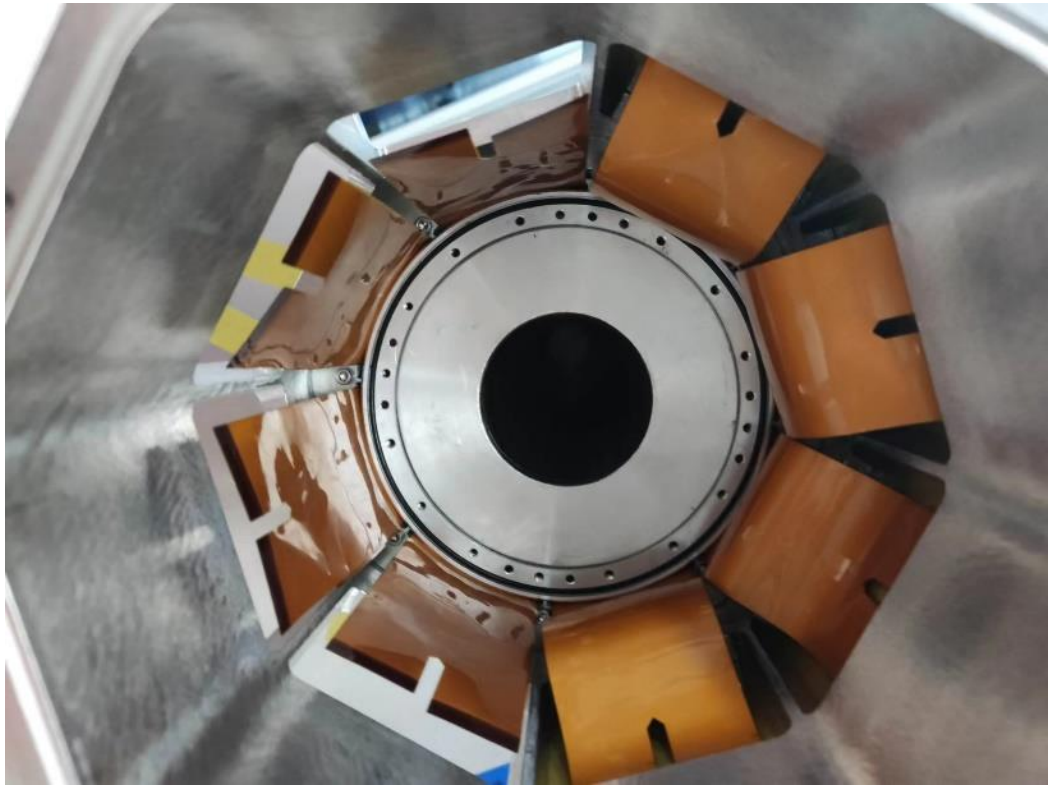
Gas Leakage Check

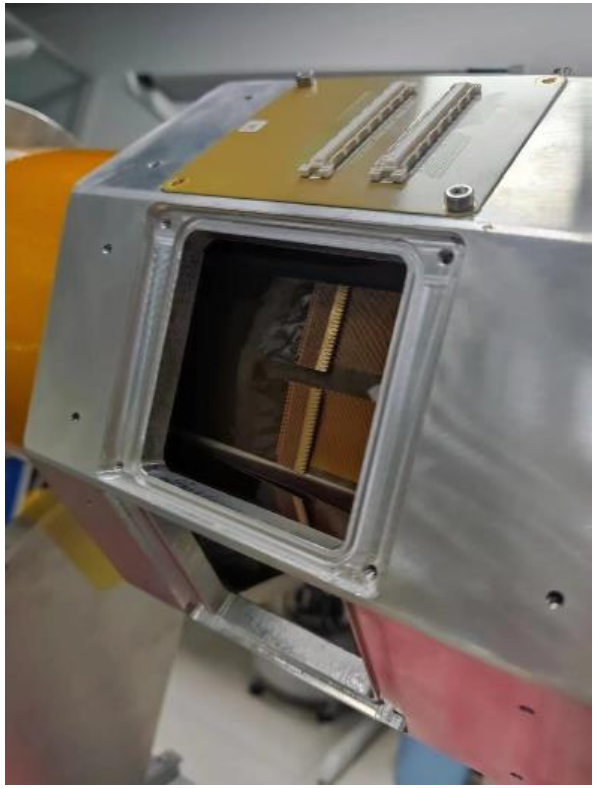




When we directly connect the two flowmeters, they shows almost the same: In 3.2, Out 3.6

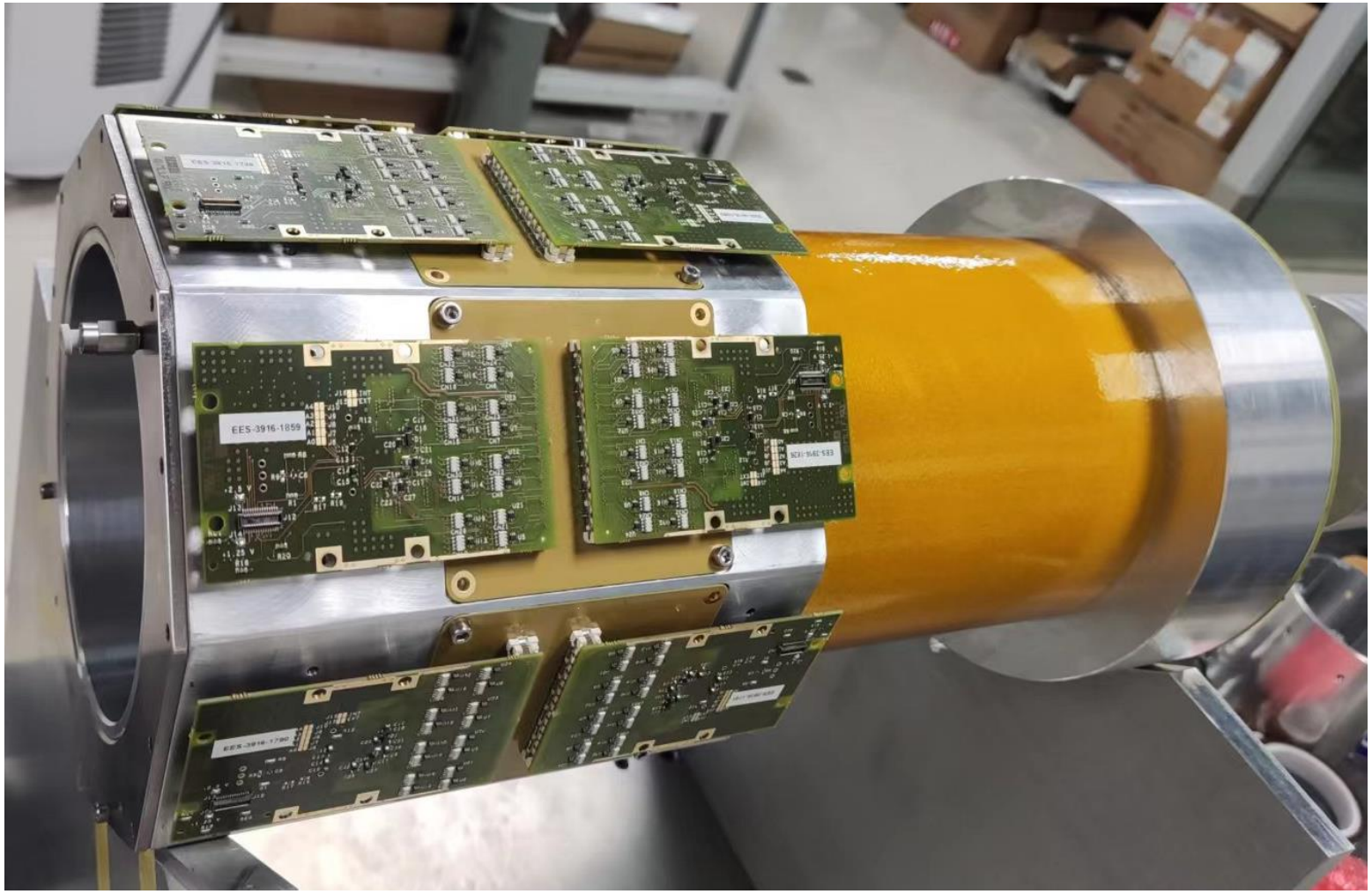
Model Assembling 3





FEEs & HV Connection

Final Detector Model



- Introduction
- Electrode Design
- Mechanical Design
- Mechanical Model Assembling
- **Material Budget**
- Future Plans

Estimation of Material Budget

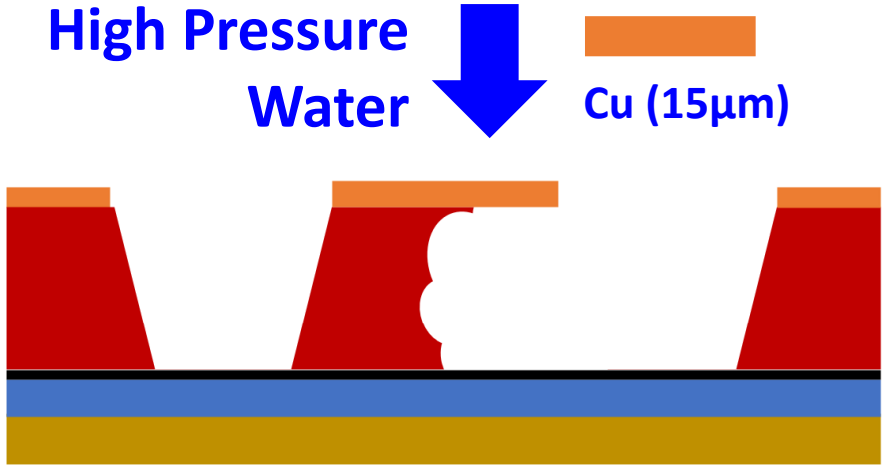
µRWELL

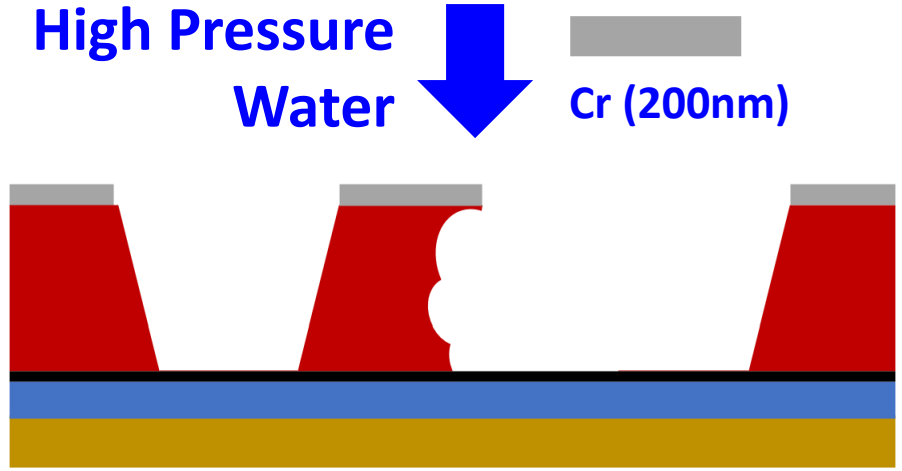
Structure	Material	Thickness (cm)	Material budget (X0)
Drift electrode	LMB-GND	---	0.001138%
	Polyimide (X0=28.57cm)	0.0025*2	0.0175%
	Glue (X=20cm)	0.001*2	0.01%
	Rohacell (X0≈ 689cm)	0.2	0.029%
	Cr (X0=2.077cm)	0.00002*77.33%	0.0007432%
Gas volume	Argon-based gas mixture (X0=11760cm)	0.5	0.00425%
Inner cylinder (µRWELL foil)	Cu (X0=1.43cm)	0.0015*77.33%	0.08112%
	Cr (X0=2.077cm)	0.000001*77.33%	0.0000372%
	Apical (X0=28.57cm)	0.005*83.19%	0.0147%
	Glue (X0=20cm)	0.001*6	0.03%
	Kapton (X0=28.57cm)	0.0025*2	0.0175%
	Al (X0=8.892cm)	12um*(1*20%+1*75%)	0.013%
	DLC (X0=12.13cm)	0.0001	0.00082%
	Polyimide (X0=28.57cm)	0.0025	0.00875%
	Rohacell (X0≈ 689cm)	0.2	0.029%
	LMB-ground	---	0.001164%
Total			0.2587%

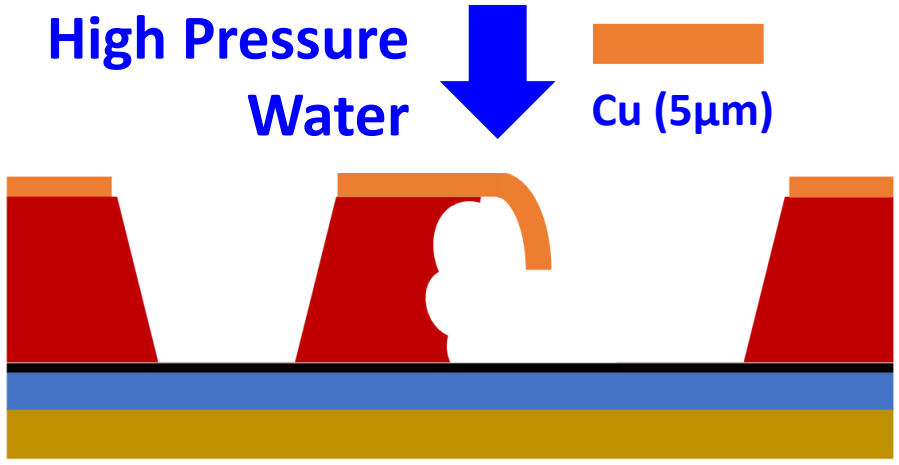
µRGroove

Structure	Material	Thickness (cm)	Material budget (X0)
Drift electrode	LMB-GND	---	0.001138%
	Polyimide (X0=28.57cm)	0.0025*2	0.0175%
	Glue (X=20cm)	0.001*2	0.01%
	Rohacell (X0≈ 689cm)	0.2	0.029%
	Cr (X0=2.077cm)	0.00002*77.33%	0.0007432%
Gas volume	Argon-based gas mixture (X0=11760cm)	0.5	0.00425%
Inner cylinder (µRGroove foil)	Cu (X0=1.43cm)	0.0015*65%	0.0682%
	Cr (X0=2.077cm)	0.000001*65%	0.0000313%
	Apical (X0=28.57cm)	0.005*70%	0.01225%
	Glue (X0=20cm)	0.001*5	0.025%
	Kapton (X0=28.57cm)	0.0025*2	0.0175%
	Al (X0=8.899cm)	0.0012*(32.5%)	0.00438%
	DLC (X0=12.13cm)	0.0001	0.00082%
	Polyimide (X0=28.57cm)	0.0025	0.00875%
	Rohacell (X0≈ 689cm)	0.2	0.029%
	LMB-ground	---	0.001164%
Total			0.2297%

Top Metal of µRWELL





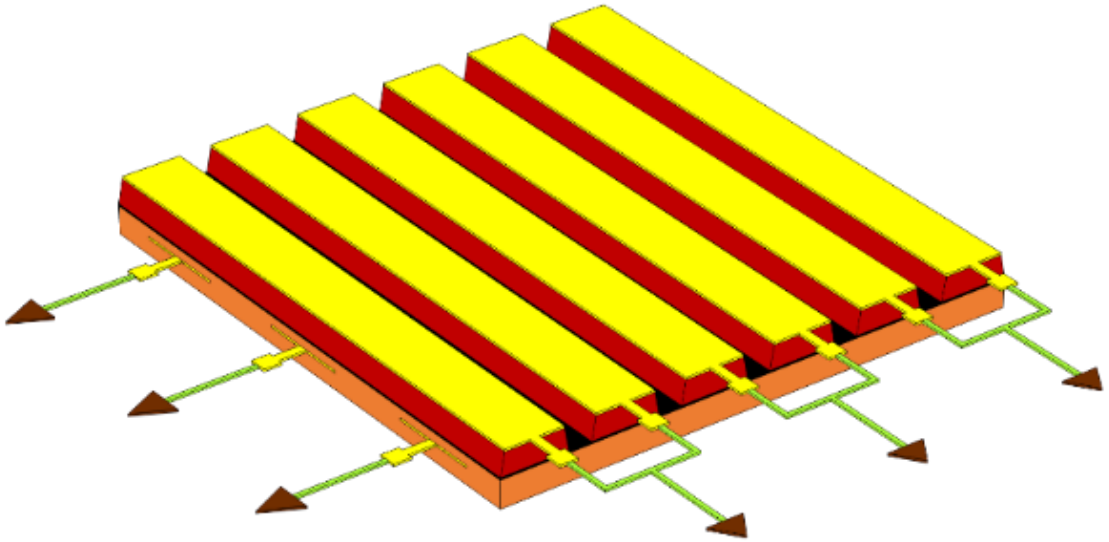


Material budget decreasing of µRWELL

Cu (15µm) → **Cr (200nm)**

0.2587%X0 → **0.1783%X0**

Top Metal of µRGroove



We still use 15µm Cu this time,
to make sure there is no any delay of the production !!!

- The top metal is the U-readout strips, we can't use 200nm Cr here;
- Ultrasonic bath is OK for the clean, 5µm Cu is enough ;

Material budget decreasing of µRGroove

Cu (15µm) → Cu (5µm)

0.2297%X0 → 0.1843%X0

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Future Plans

The electrodes should be ready at the beginning of 2024, we will assemble the real detectors at the end of January and then test them.

Special thanks to Rui and his team, for their help on electrode design and manufacture！ ！ ！

I REALLY HOPE THESE DETECTORS CAN WORK !!!