GEM Modules Assembly for TPC Group Test Beam.

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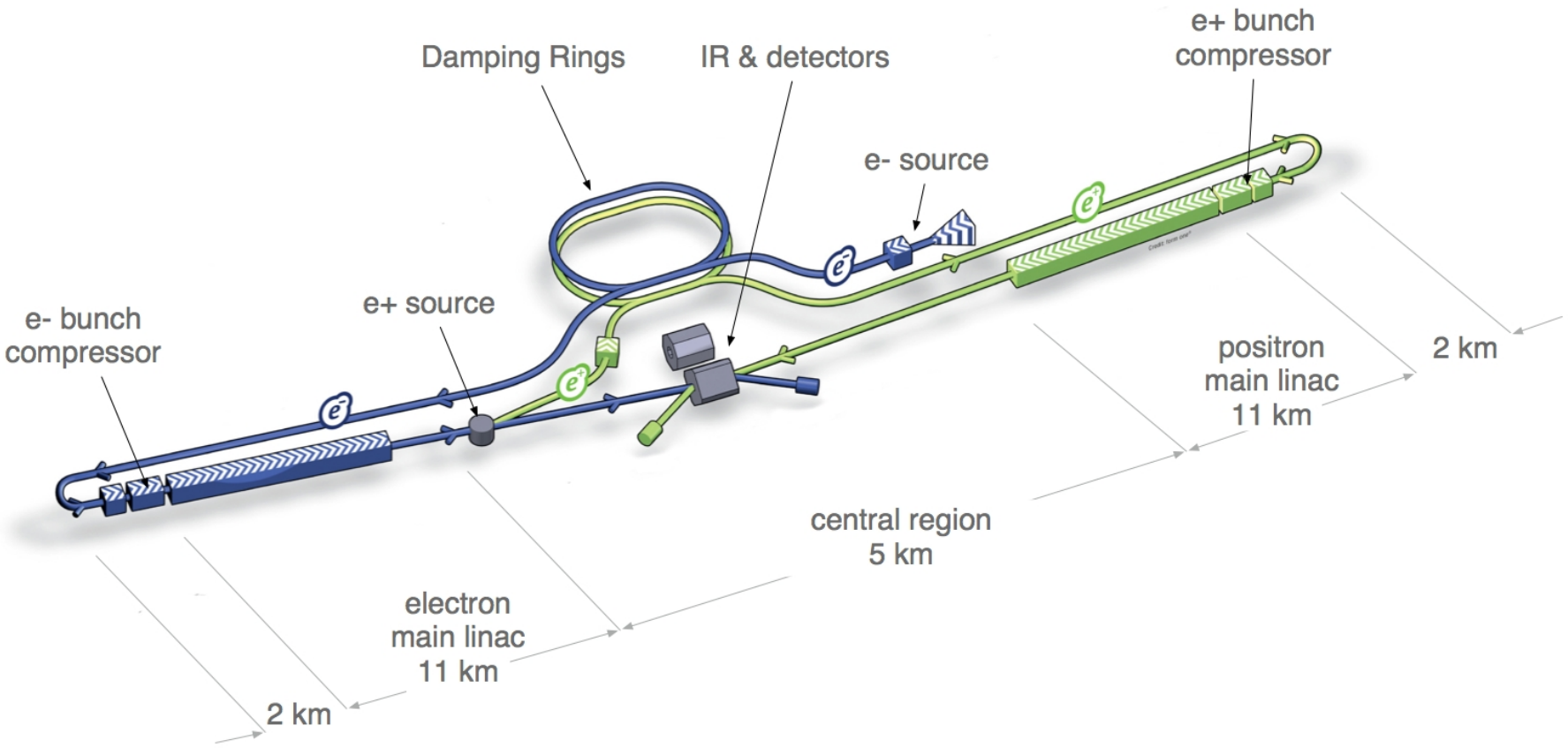
GEM Module Assembly,
TPC Test Beam Preparation, 29.08.2016

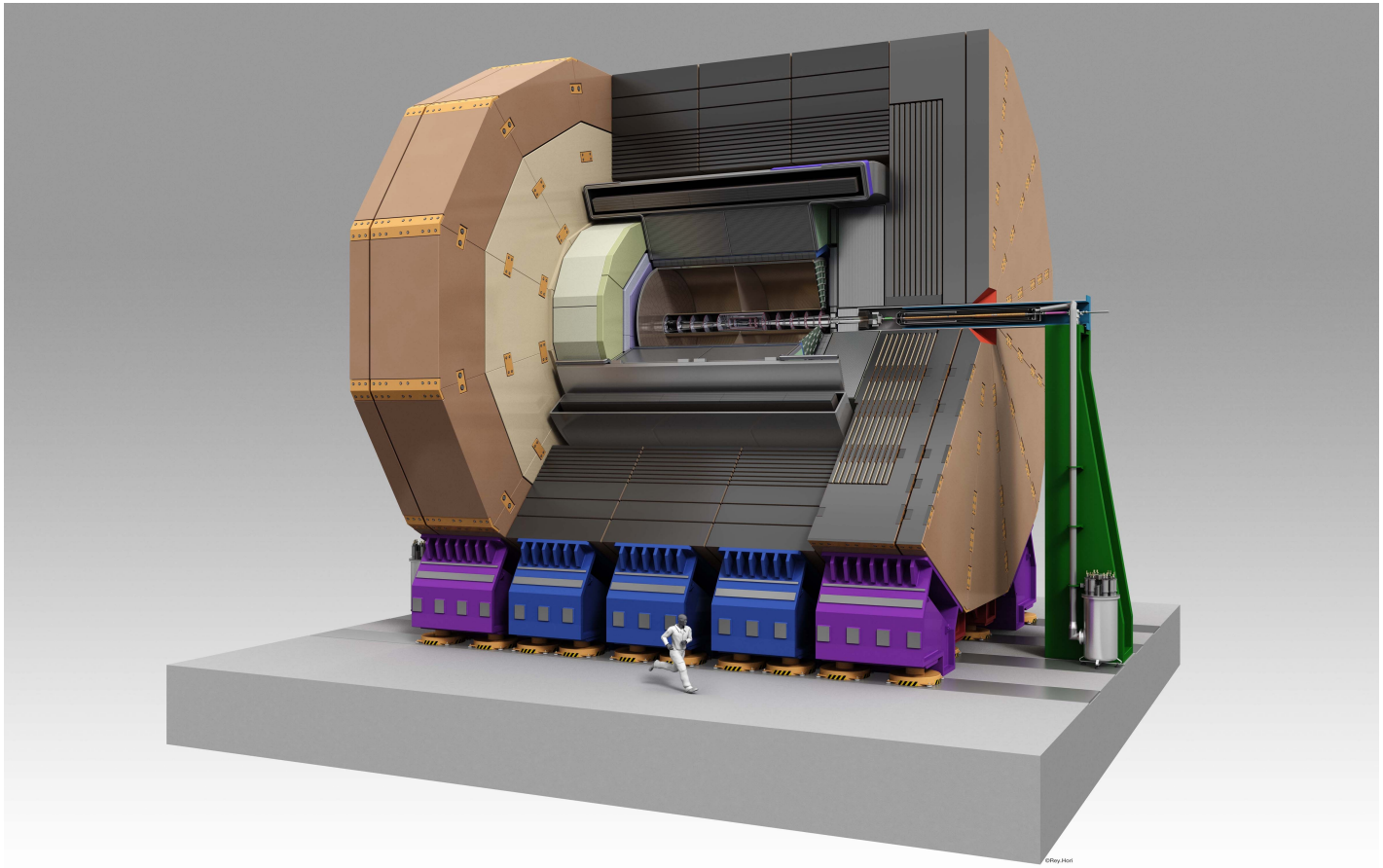
HELMHOLTZ ASSOCIATION

DESY

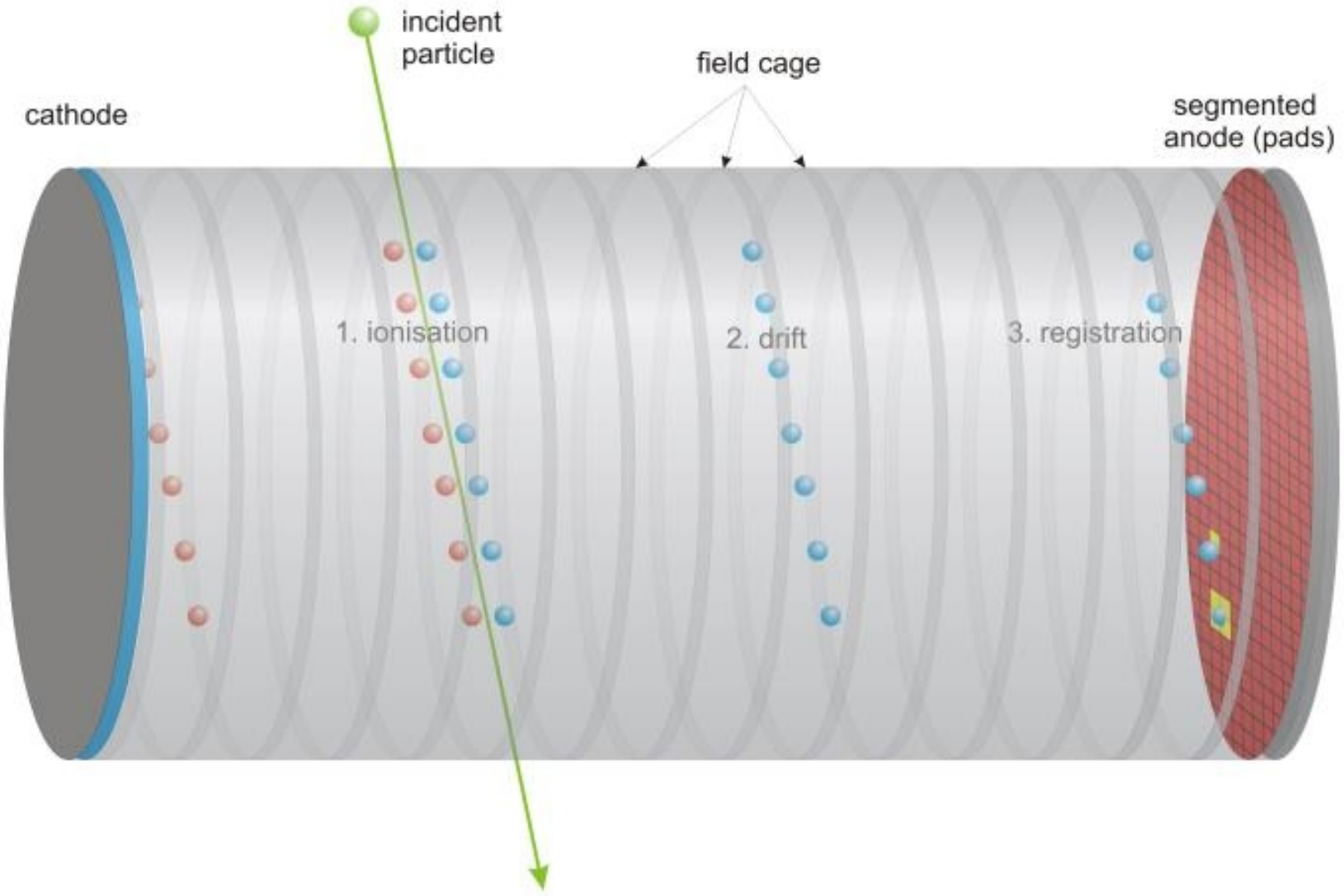
International Linear Collider



International Large Detector



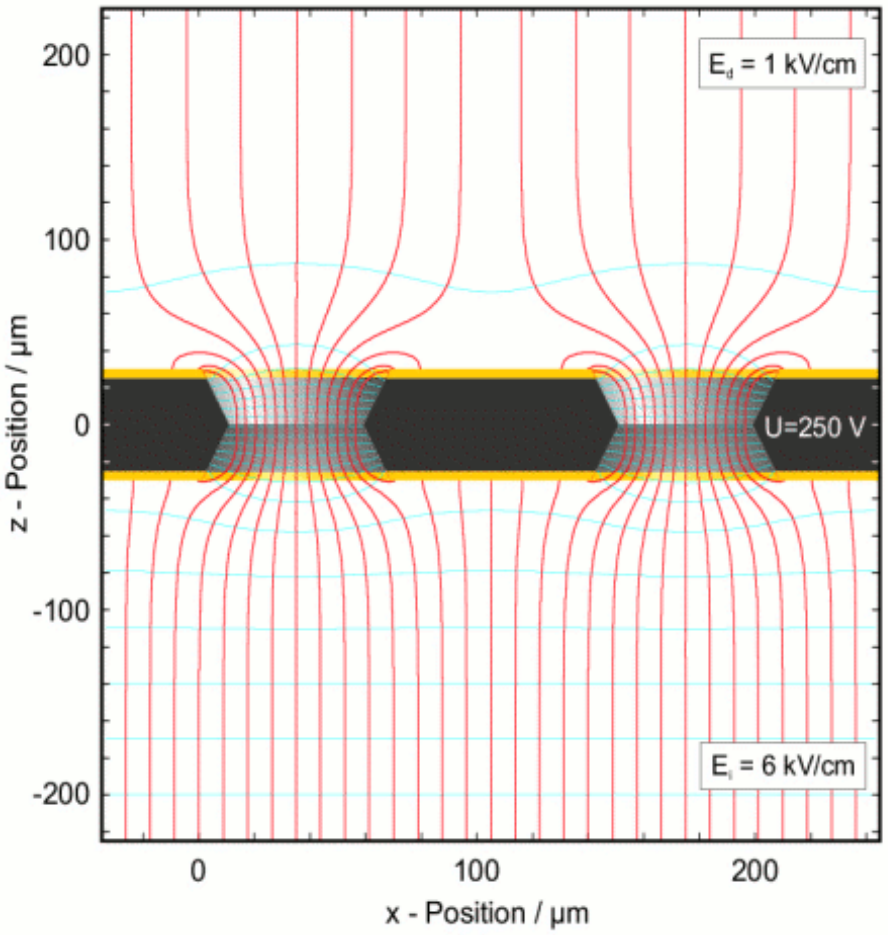
Time Projection Chamber

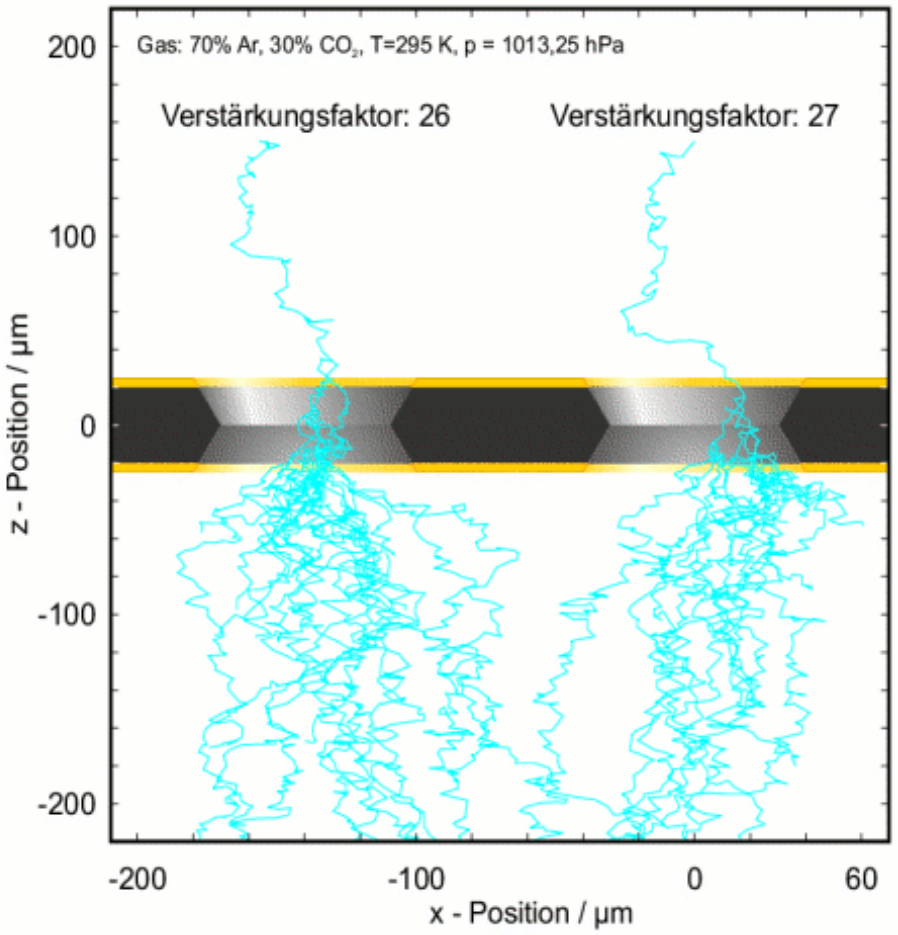


Gas Electron Multiplier

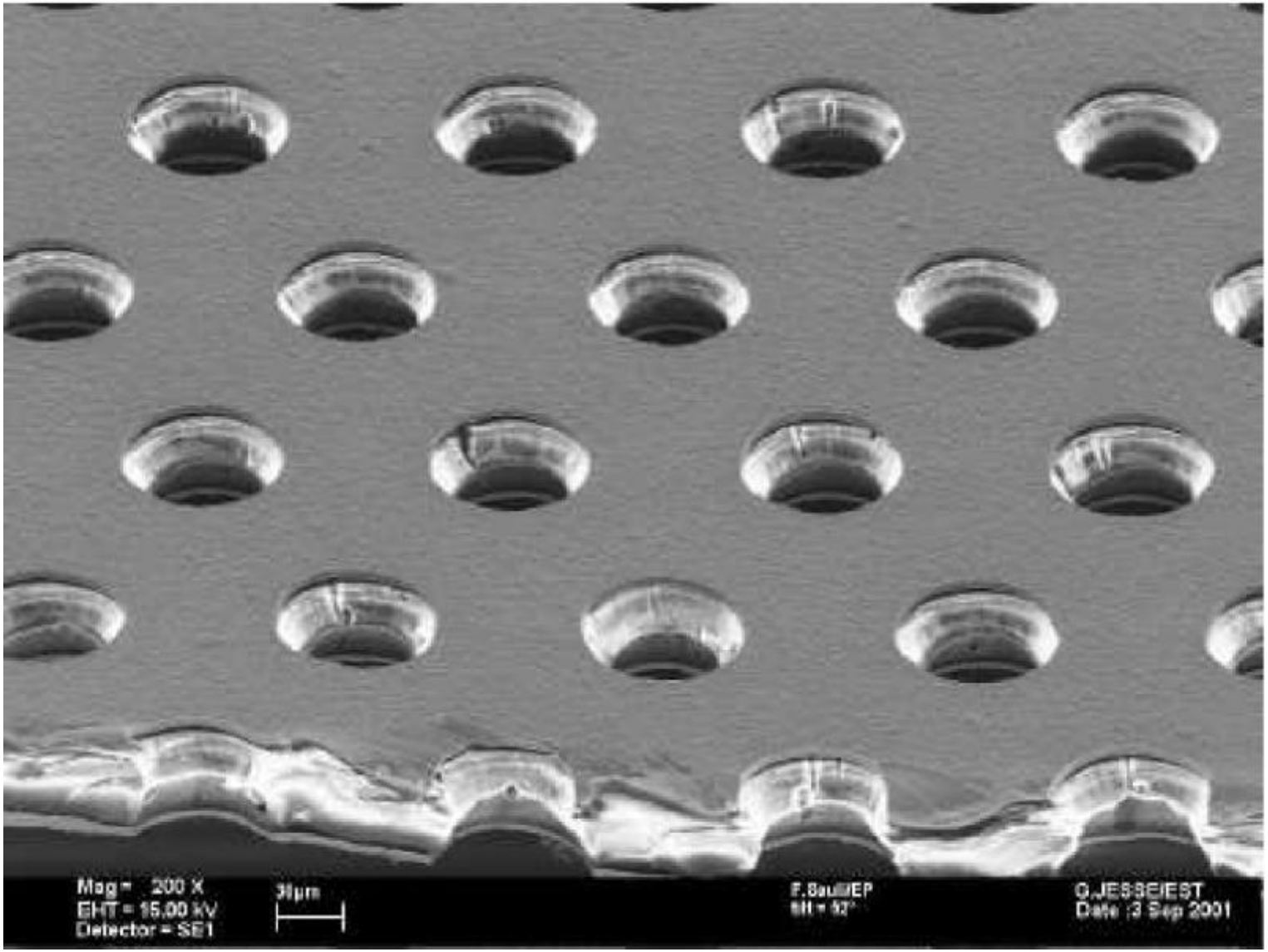
- GEMs are electron detection devices planned to be used in the ILC time projection chamber.
- Made of 2 thin sheets of copper spaced ~50 microns apart separated by Kapton foil.
- Each sheet has a series of holes etched in it.
- Holes 70μm in diameter and seperated by 140μm in a hexagonal grid.
- The GEMs are placed in an amplification gas (T2K).
- Potential difference across the GEM causes high electric fields in the holes.
- When an electron enters the hole it causes an avalanche (gas amplification).

GEMs


E_d = 1 kV/cm
U=250 V
E_i = 6 kV/cm
200
100
0
-100
-200
z - Position / µm
0
100
200
x - Position / µm

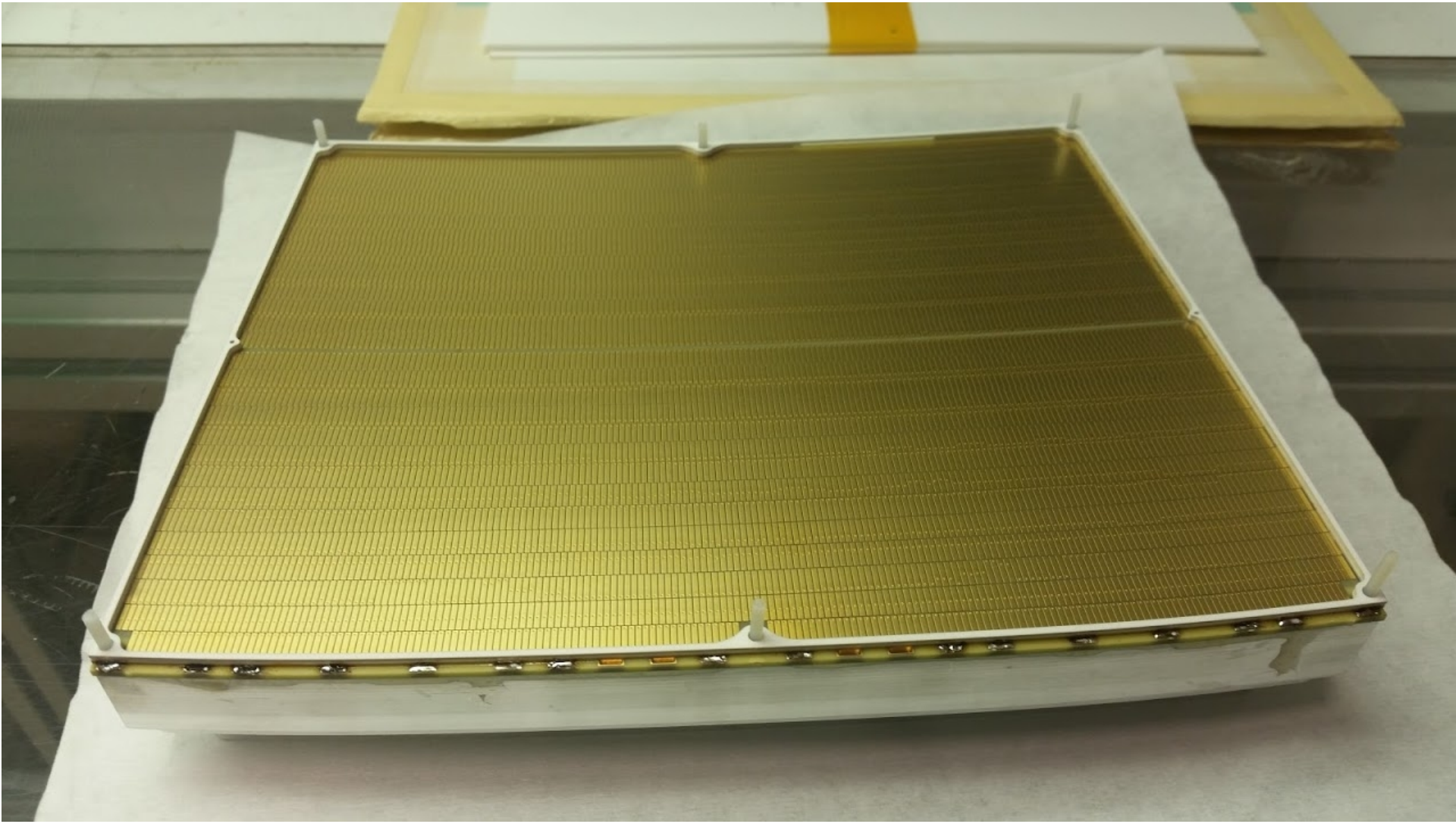

Gas: 70% Ar, 30% CO2, T=295 K, p = 1013,25 hPa
Verstärkungsfaktor: 26
Verstärkungsfaktor: 27
200
100
0
-100
-200
z - Position / µm
-200
-100
0
60
x - Position / µm

GEMs

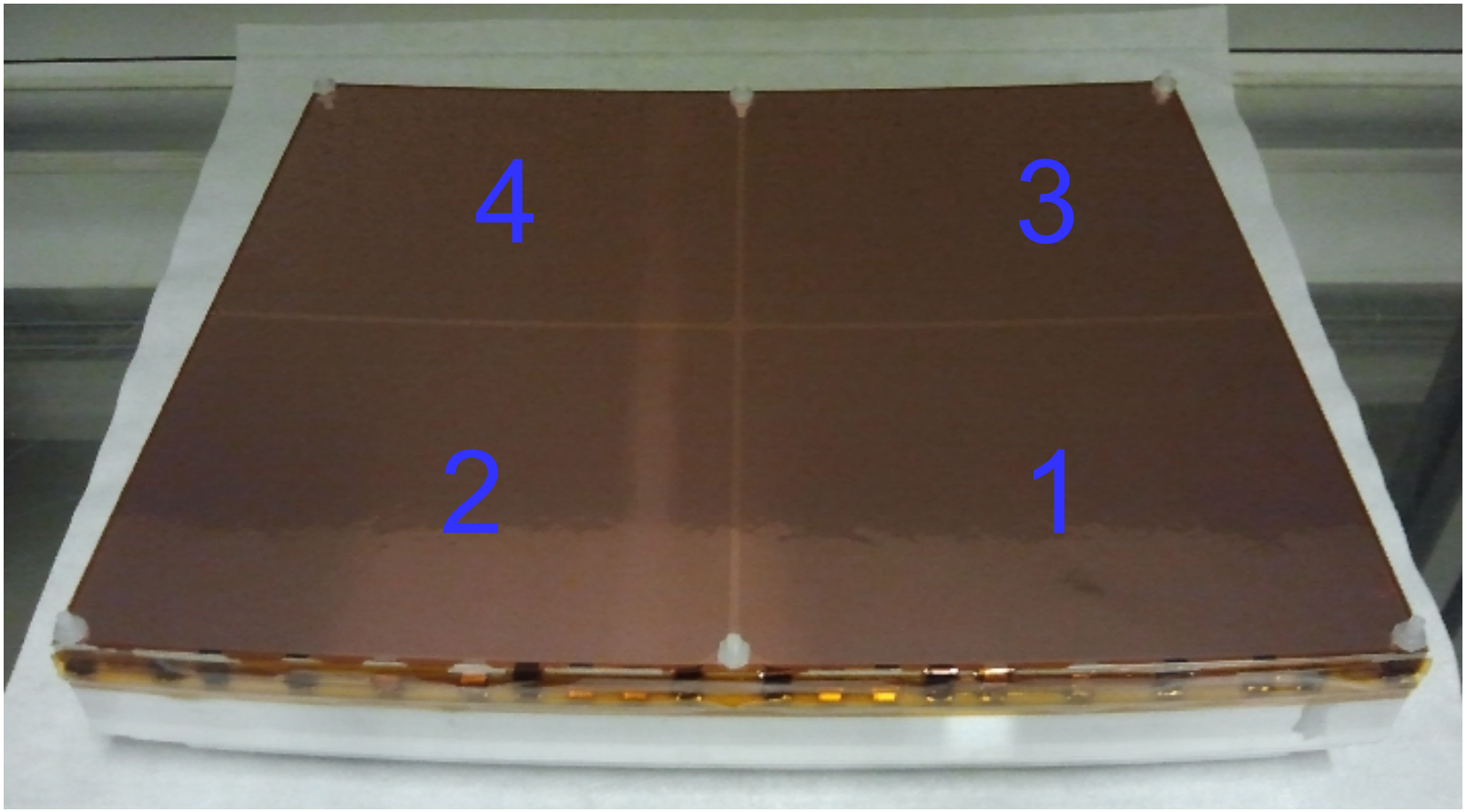

Mag = 200 X
EHT = 15.00 kV
Detector = SE1
30µm
F.Sauli/EP
G.JESSE/EST
Date :3 Sep 2001

GEM

GEM Back Frame



GEM Module



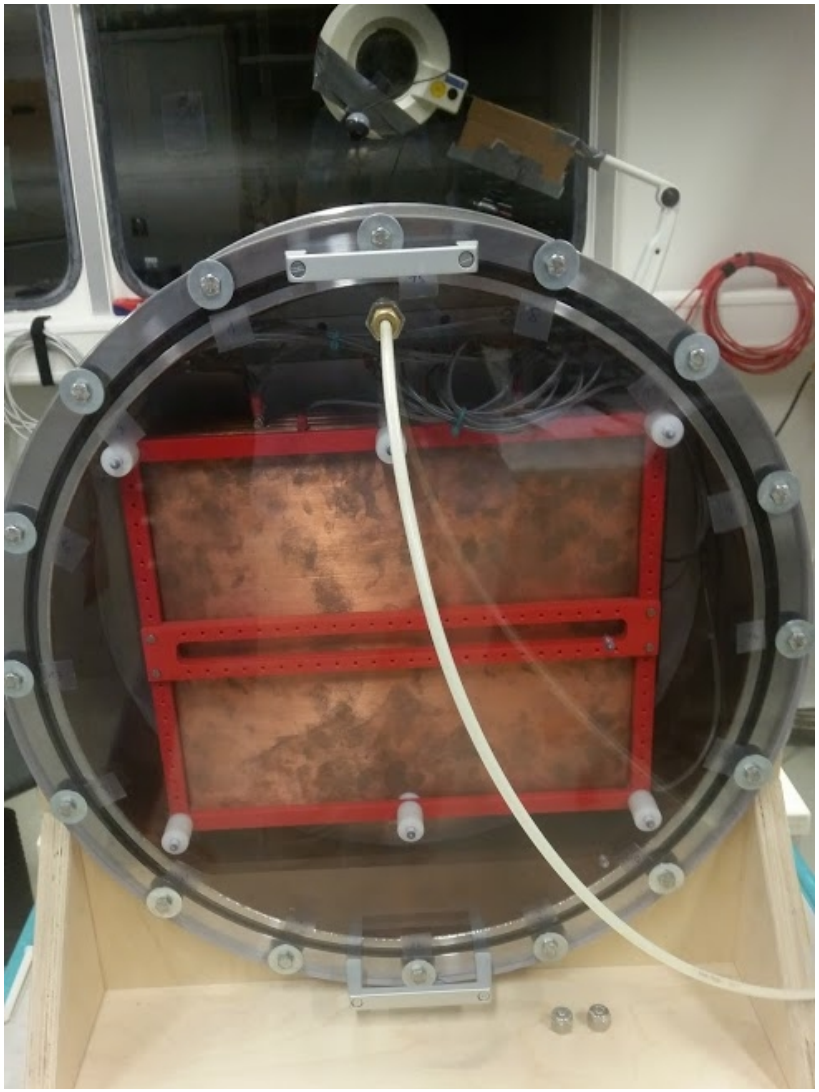
Aim/Motivation

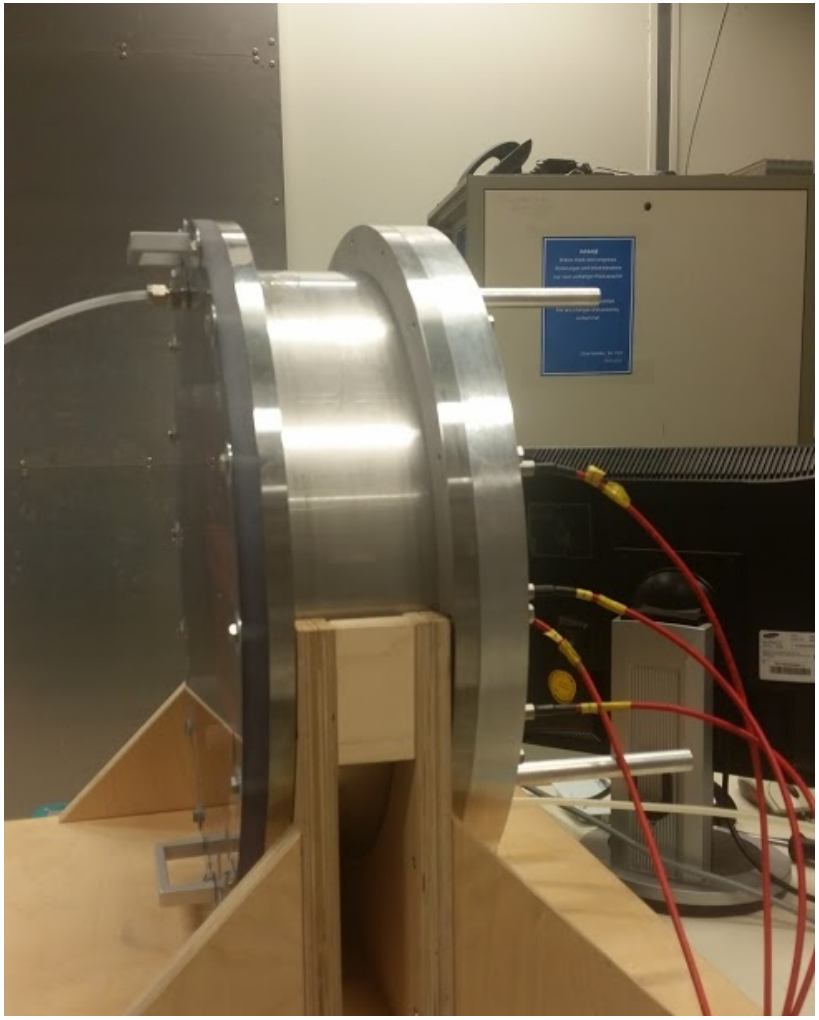
- Construct three completely working GEM stacks.
- New GEMs arrival delayed.
- Need three working GEM modules for test beam time in September.
- Recycling of old 'dirty' GEMs required.

Module Test Chamber Preparation

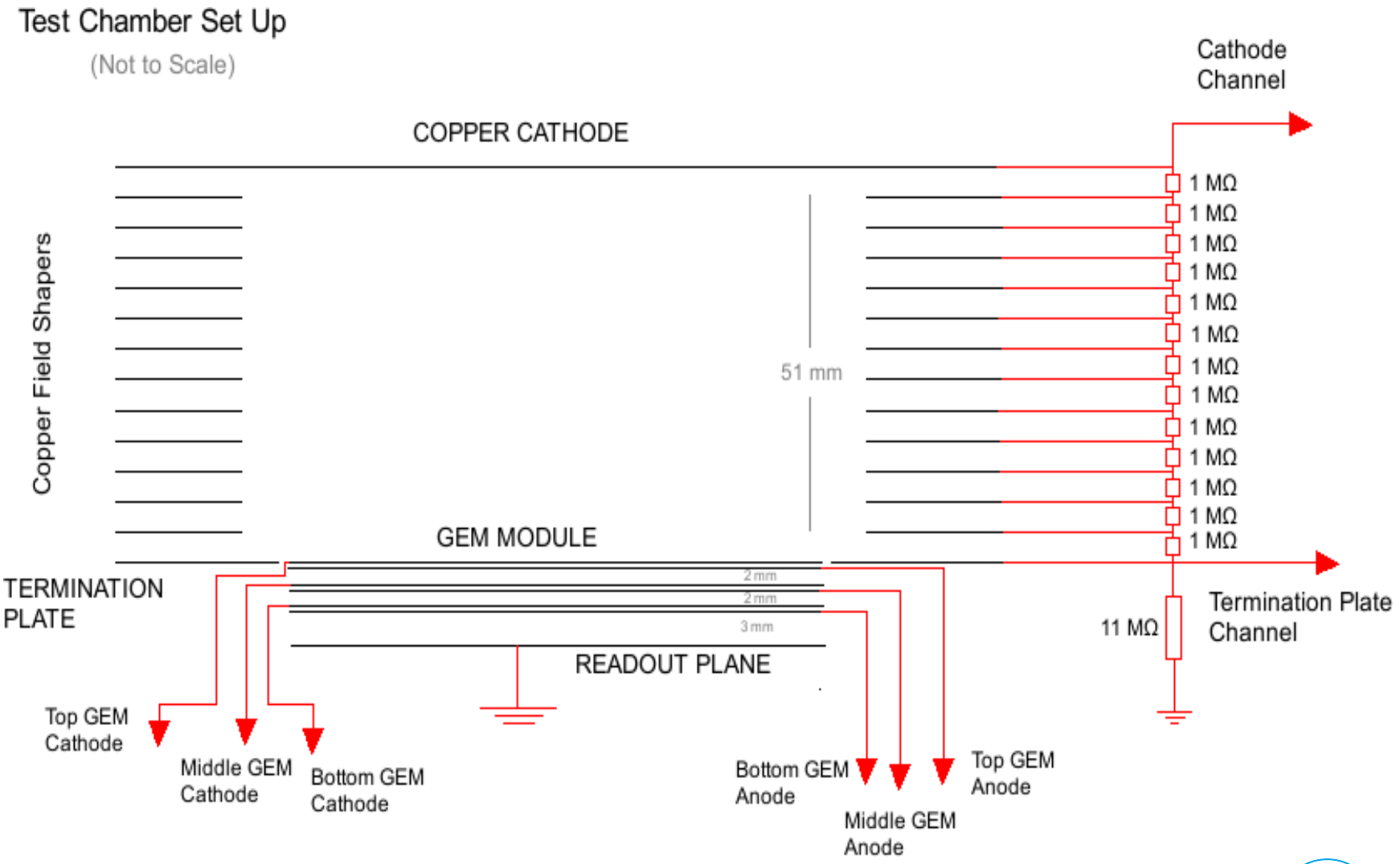
- Test chamber set up for tests.
- All connections checked inside chamber.
- Copper cathode had to be reconnected.
- High voltage testing of the chamber with dummy module was performed.
- Chamber thoroughly cleaned.

Module Test Chamber





Module Test Chamber Configuration

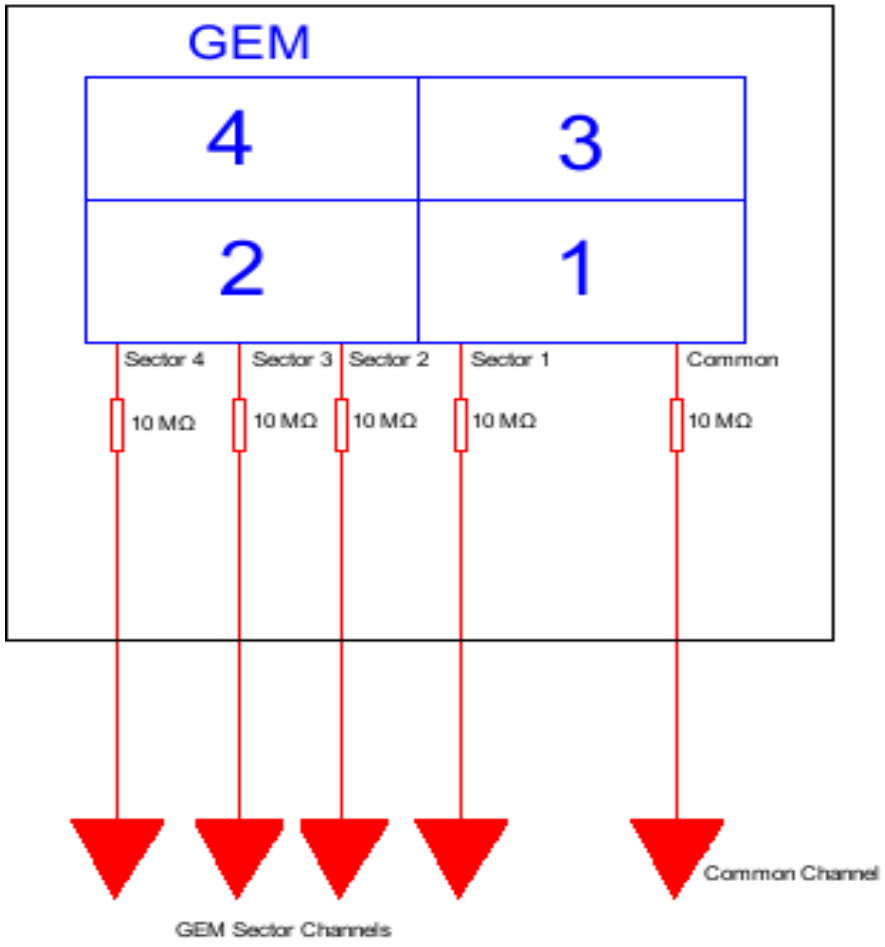


GEM test chamber preparation

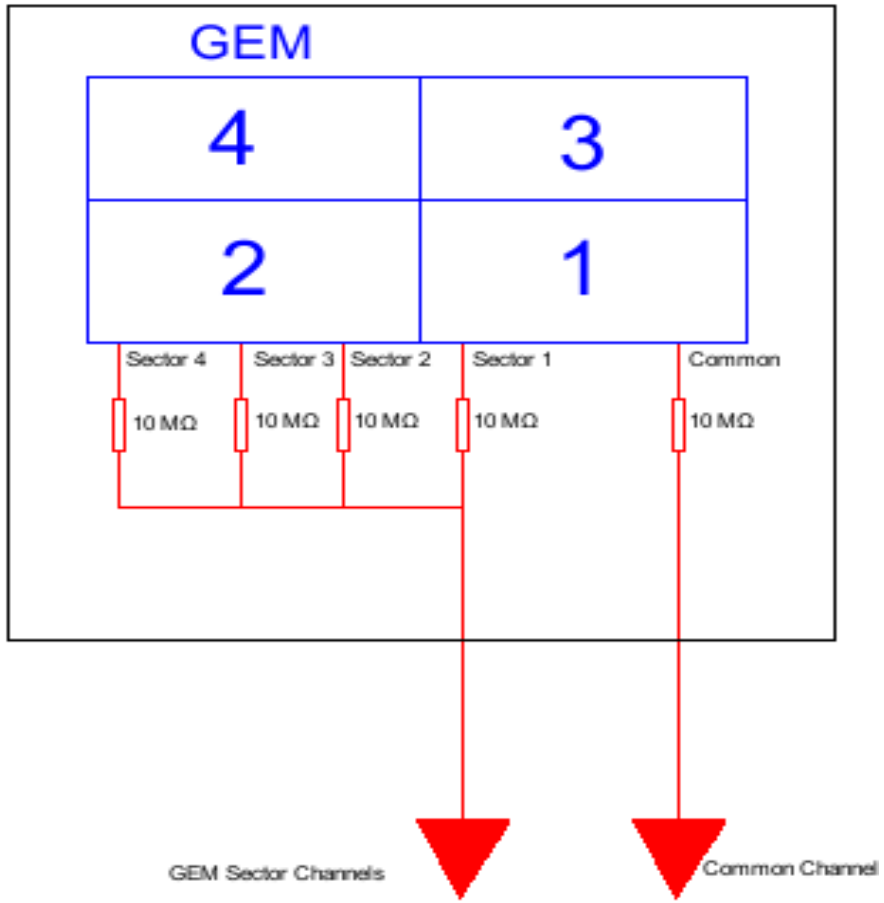
- Two test chambers set up for testing individual GEMs .
- One chamber was modified to apply voltages to each GEM sector separately.
- All connections checked inside chamber.
- Resistors added to simulated module conditions.
- Chambers thoroughly cleaned.

GEM Test Chamber Configuration

GEM Test Chamber 1



GEM Test Chamber 2



GEM Test Chamber

GEM Testing Procedure

- GEM connections tested directly with multimeter.
- Any GEM with a sector with a shortcut to common side << 1 MΩ of resistance was deemed 'unfixable'.
- Any GEM with resistance ~ 1 MΩ or greater we would try and fix.
- Any GEM with no connections would be tested under high voltage in nitrogen and 'trained' up to 560V .
- Any GEM surviving this would then be tested under high voltage in T2K to 250V.

Fixing GEMs

1) Apply high voltage across GEM for 1-3 days.
2) Blow on GEM with nitrogen gun.
3) Bathe GEM in isopropanol.
4) Apply low voltage high current directly to sector.
5) Pray/wait.

Results of Tests

Fully Working Gems

	Initial No.	Broken	Broke Under HV Nitrogen/T2K	Fixed	Operational after testing
Top GEMs	4	1	2	1	2
Middle GEMs	4	2	1	0	1
Bottom GEMs	4	1	2	1	1

Broken GEMs

	Total	Left Sectors Broken	Right Sectors Broken	Unusable	Usable
Top GEMs	2	1	2	1	1
Middle GEMs	3	3	2	1	2
Bottom Gems	3	0	3	1	2

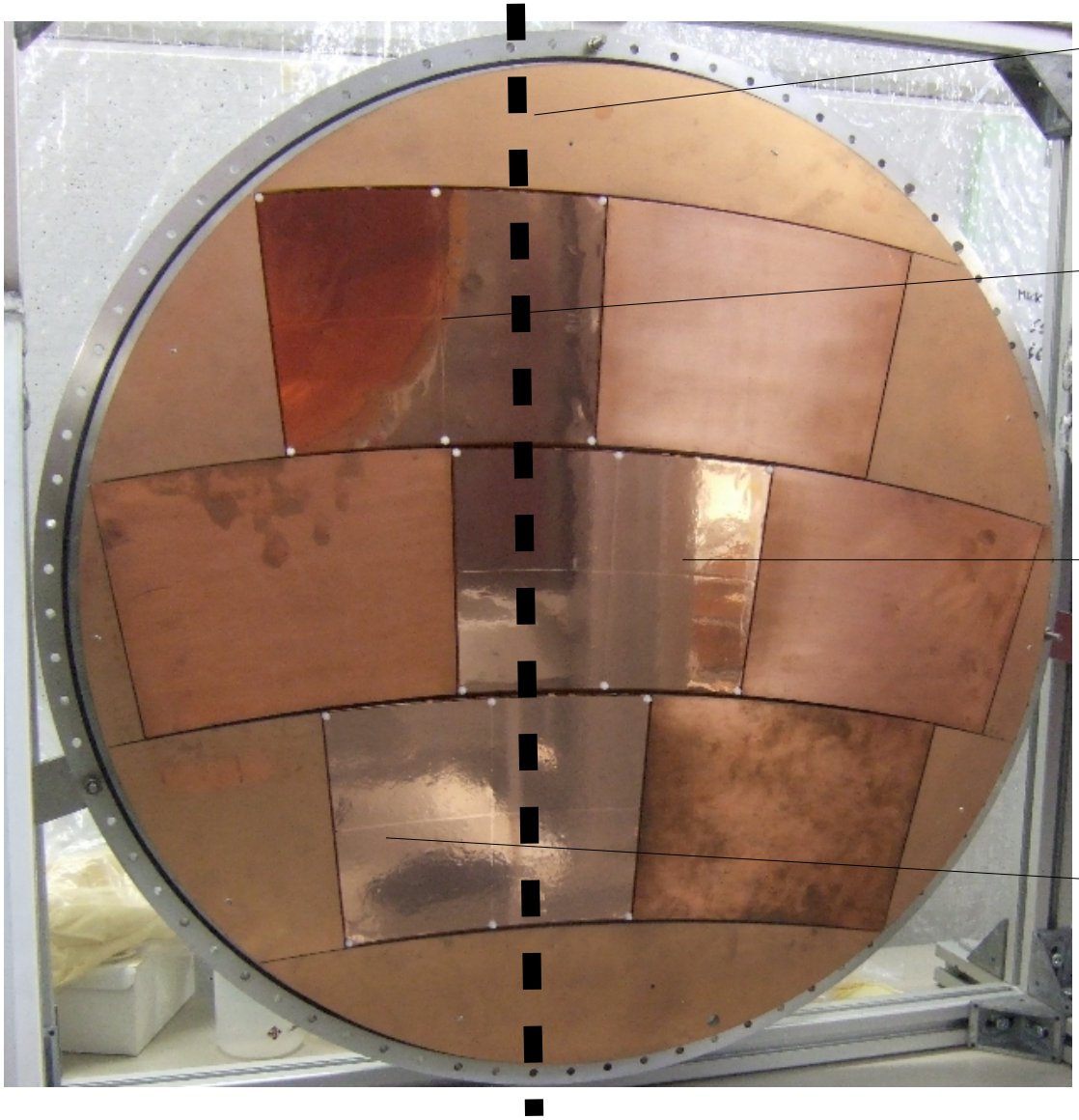
GEM Module Dismantling and Assembly

- 3 modules needed to be fully disassembled.
- 1 module just needed top GEM replaced.
- 1 GEM module assembled fully.
- 1 GEM module awaiting assembly.
- All assembly/disassembly took place in clean room conditions.

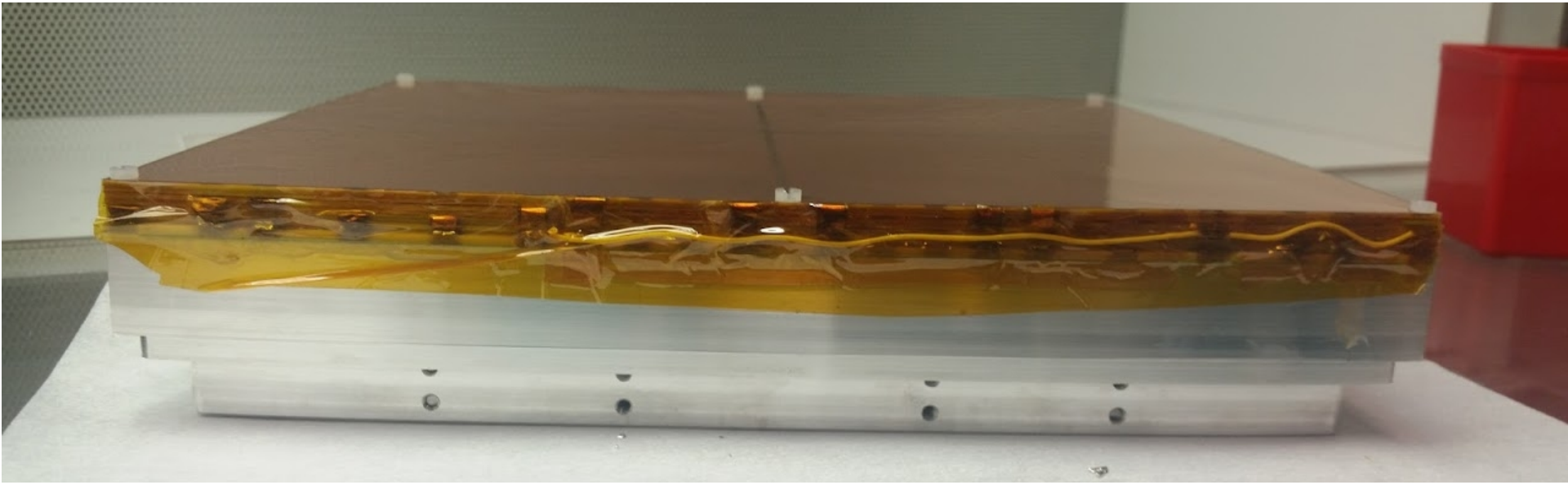
Test Beam final Modules

- 1 GEM module is fully working for the test beam time.
- 2 GEM modules will be placed such that their broken sectors are outside the test beam line.
- Broken sectors are shortcutted to common side to keep it at the correct voltage.
- In total we had 6 broken sectors. With 3 In one module on 'left side' and 3 On 'right side'.
- Still need to test one last GEM Module.

Final Configuration in test Beam

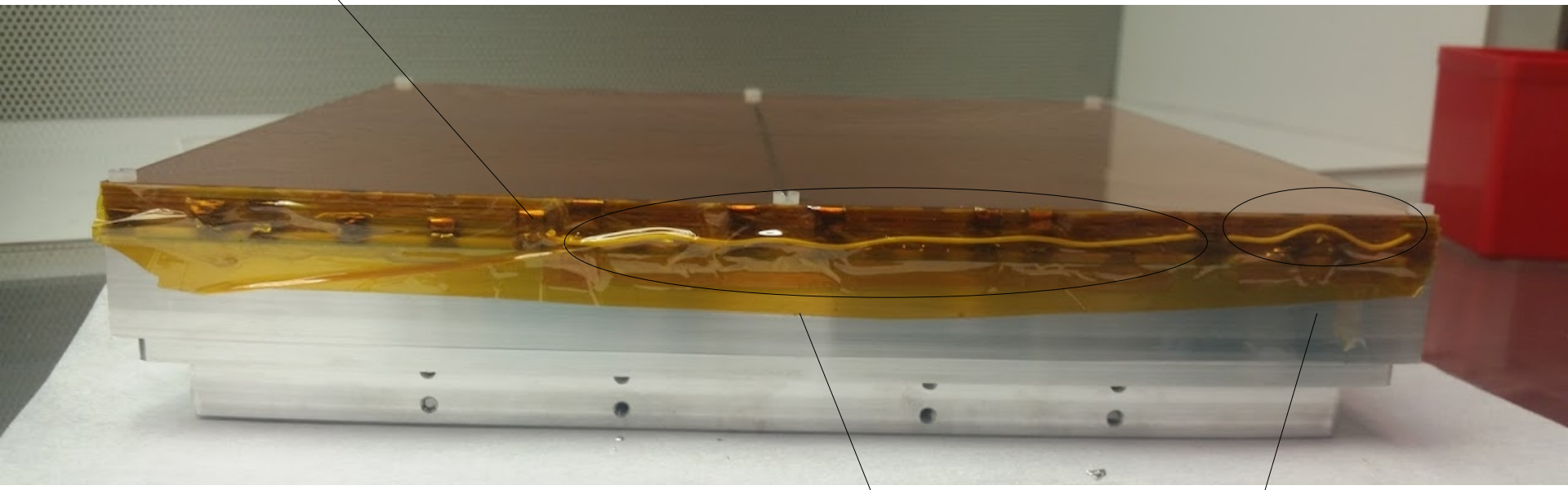


Shortcutting of a Sector



Shortcutting of a Sector

Connection to common side



Shortcutting Wires

Conclusion

- Test beam should have three working modules all tested at HV and in T2K gas.
- Two of the modules will have broken sectors but both lie outside beam line.
- Test beam will hopefully be able to run...