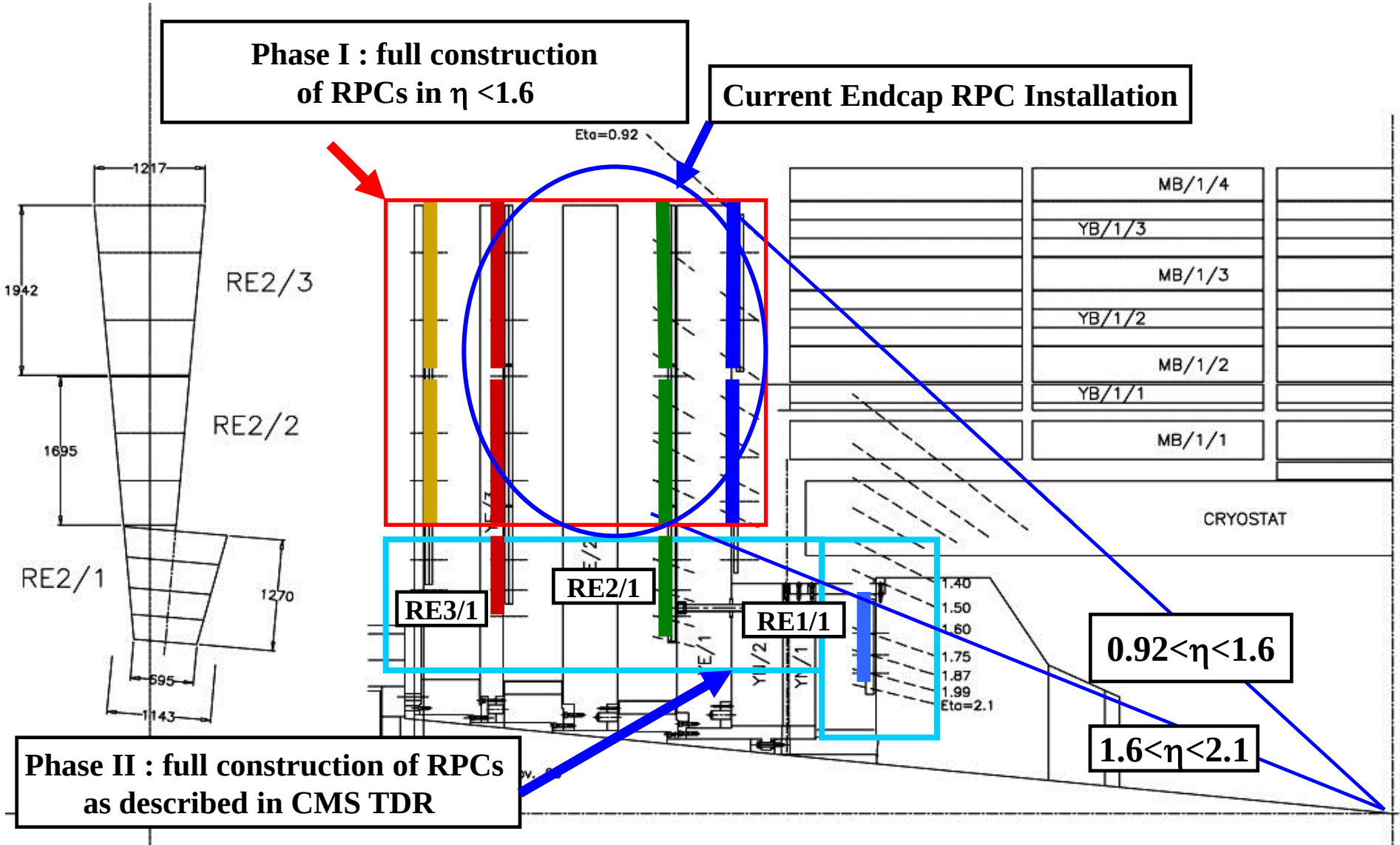
1. Introduction
2. Design of the RE1/1 RPCs
3. Link system
4. Services

CMS Forward RPC



Numbers of RPCs for the high η region

Region	# of RPCs for both sides	# of η div.
RE1/1	**36 x 2= 72**	**4**
RE2/1	**18 x 2 = 36**	**4**
RE3/1	**18 x 2 = 36**	**3**
Total	**144**	

RE1/1 : a “special” region of the CMS detector

Highest particle rate of muon system

Large possibility of aging to RPCs

Different install type with others

❖The installation of the Forward RPCs at YE1-1 (RE1/1) in
1.6 < eta < 2.1 effectively enhances the trigger efficiency :
in virtue of high magnetic field at the YE1-1 region, the strong bending force is expected to enhance the trigger performance of the CMS muon system despite of a large background.

❖backgrounds as much as 1.0 kHz/cm^2

❖In the initial design in the RE1/1 region 2 bakelite gap RPCs were the detectors to be placed closest to the beam bunch-crossing position.

❖6 RE1/1 Bakelite-RPC modules were constructed in KOREA, and were tested & qualified under the responsibility of our KOREAN colleagues for the quality certification

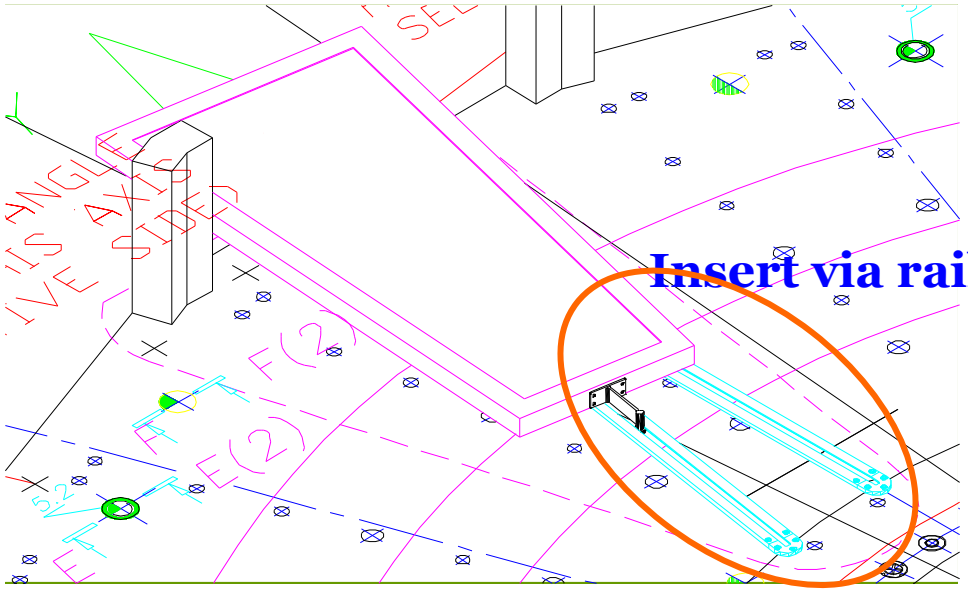
❖4 of them have been installed them at the YE1-1 region of CMS for testing with beam collisions

2. Design of the RE1/1 RPCs

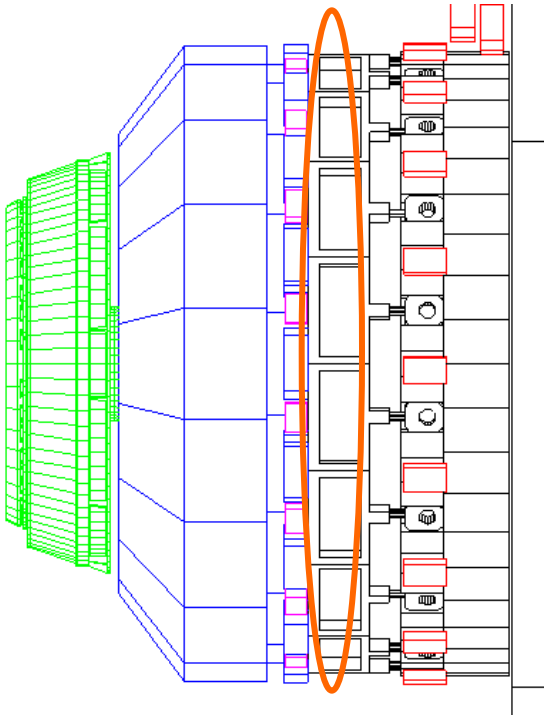
72 RE1/1 RPCs at YE1 :

- **Advantage of RE1/1 : RPCs closest to *pp* collision vertex with presence of strong magnetic fields.**

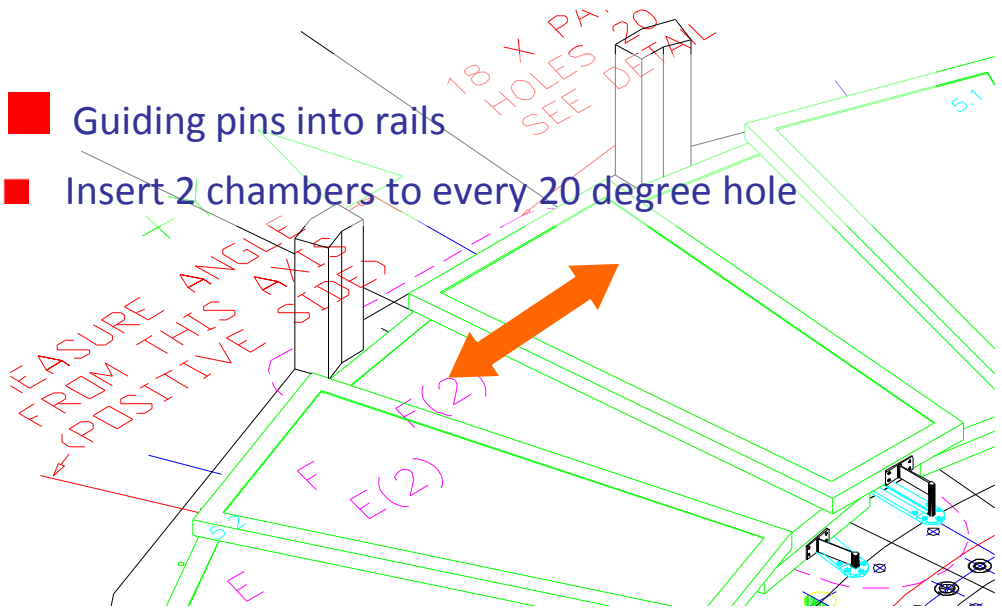
- **High beam backgrounds**
  Gammas, neutrons, charged pions …
  Systematic radiation hardness study has been strongly required.



Insert in End-cap nose



- Guiding pins into rails
- Insert 2 chambers to every 20 degree hole



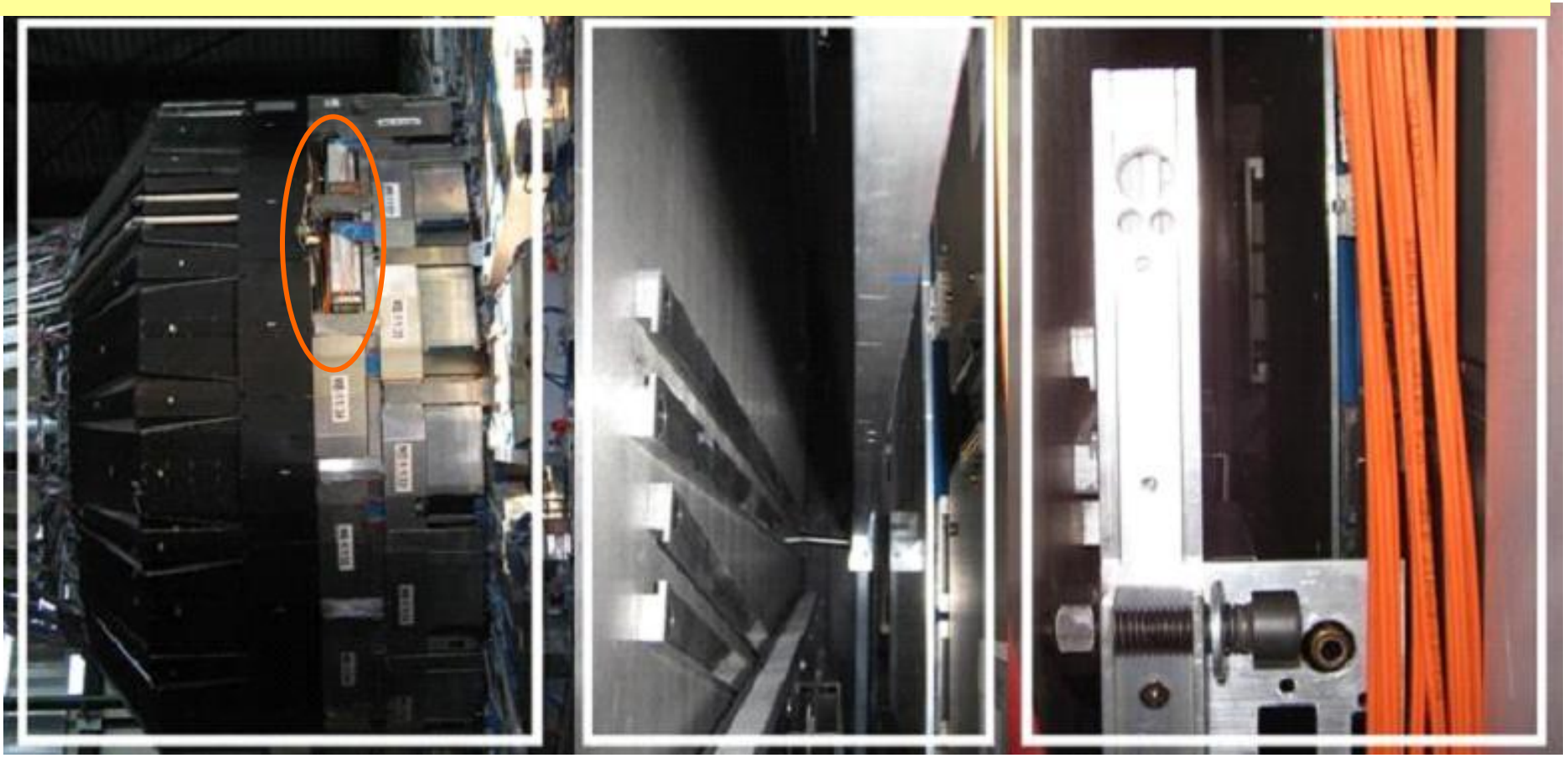
A LOT OF CONSTRAINTS …..

- Limited space for installation
  - Insert the chambers into nose
  - Narrow space for installation
  - Only one direction access
  - Affected by other detector
    - Same space with ME1/1(CSC)
    - Link board space with HCAL
- Overlapping chambers
  - Guiding pins into rails
  - Insert 2 chambers to every 20 degree hole
- installation after assembly of other detector
  - Near to the CSC ME1/1, a lot of cables, fibers,

3-D model design of RE1/1 Design is done and verified with :

−a mockup chamber was installed at YE-1 at 2007

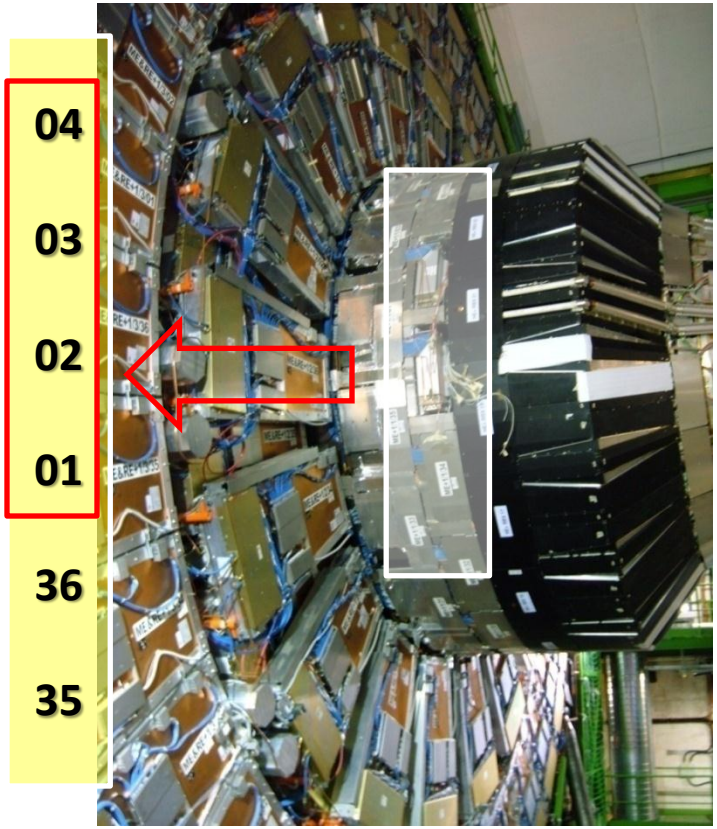
-four real chambers inserted in 2009-2010



- Total thickness of allowed installation for RE1/1 RPC is around 95mm.
- The 3-D model design for RE1/1 and integration for gas, cooling, cabling…

6 chambers (RE+1/1 35~36~01~04) were planned to install, but 4 chambers(RE+1/1 : 01→04) were installed.

2 chambers with bad gaps haven't been qualified and they are at cern



	RE 1/1	RE 1/2	RE 1/3	RE 2/1	RE 2/2	RE 2/3	RE 3/1	RE 3/2	RE 3/3	RE 4/1	RE 4/2	RE 4/3
No. of chambers (Plus & Minus Z)	36*2	36*2	36*2	18*2	36*2	36*2	18*2	36*2	36*2	18*2	36*2	36*2
η Segments	4	3	3	4	3	3	2	3	3	2	3	3
ϕ Coverage, deg.	10	10	10	20	10	10	20	10	10	20	10	10
Strips/η Segment	32	32	32	64	32	32	64	32	32	64	32	32
No. of channels/chamber	128	96	96	256	96	96	128	96	96	128	96	96

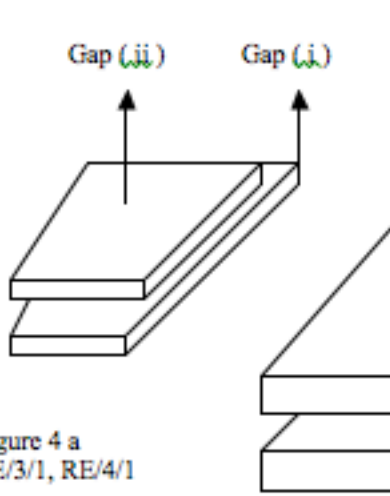


Figure 4 a
RE/3/1, RE/4/1

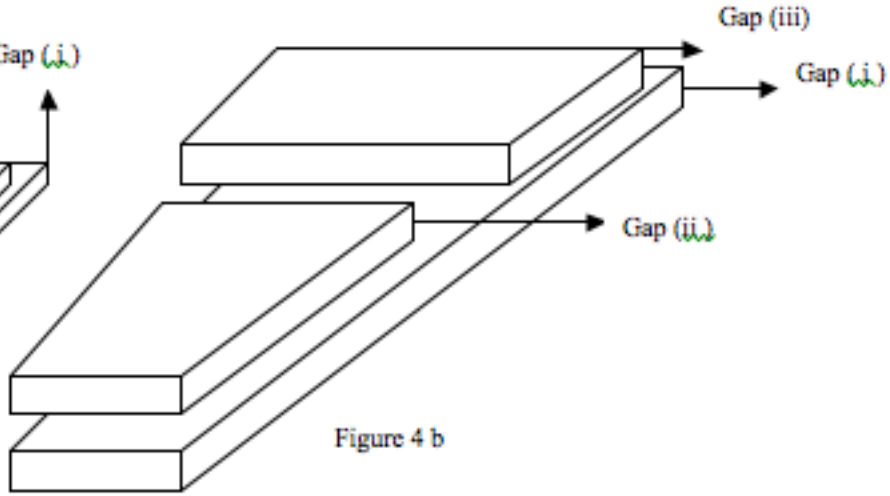


Figure 4 b

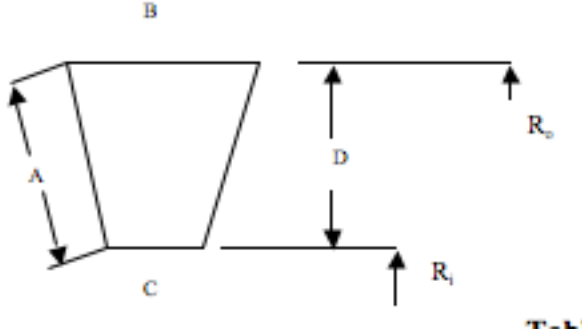
CMS document

C

Table: V

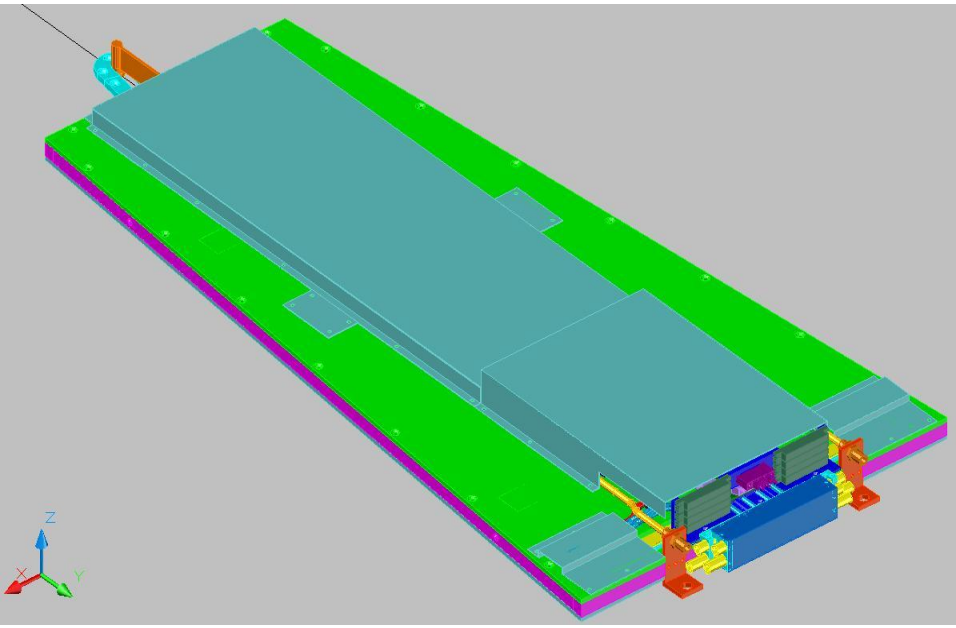
Active Area

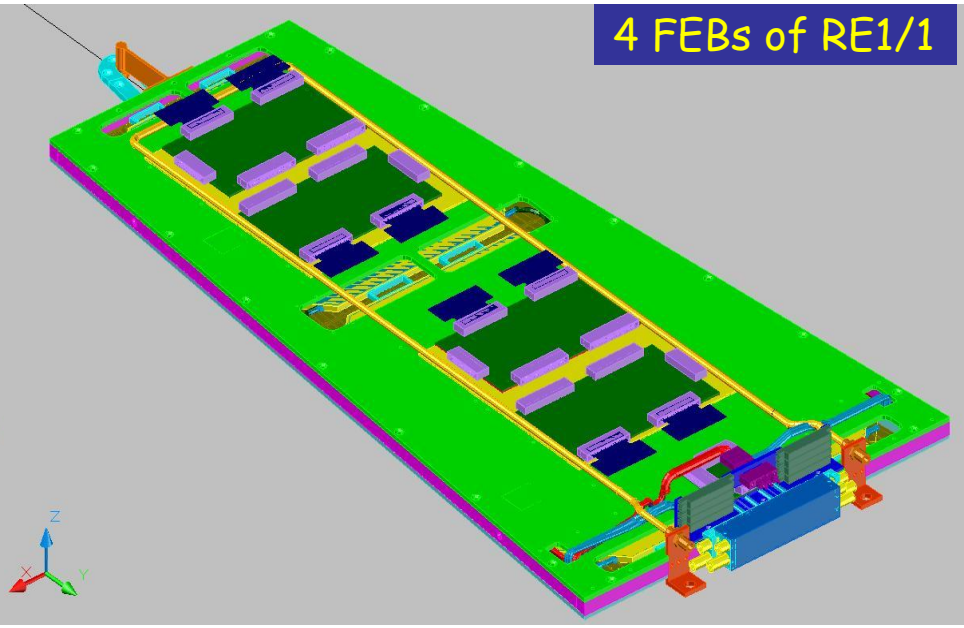
Station	Gap	Ri	Ro	A	B	C	D	Active Area M^2
	RE1/1(i)	1400	2359	963	413	245	959	0.315
RE1/1	RE1/1(ii)	1415	1772	358	310	248	357	0.099
	RE1/1(iii)	1842	2344	504	410	322	502	0.184
RE1/2	RE1/2(i)	2795	4599	1811	805	489	1804	1.170
	RE1/2(ii)	2807	4031	1229	705	491	1224	0.733
	RE1/2(iii)	4091	4587	498	803	716	496	0.378
RE1/3	RE1/3(i)	5110	6775	1671	1186	894	1665	1.736
	RE1/3(ii)	5125	6362	1242	1113	897	1237	1.245
	RE1/3(iii)	6422	6760	339	1183	1124	338	0.392
RE2/1	RE2/1(i)	1997	3204	1226	1130	704	1207	1.107
	RE2/1(ii)	2012	2500	495	881	710	488	0.388
	RE2/1(iii)	2570	3189	629	1125	906	620	0.629
RE2/2	RE2/2(i)	3336	4949	1619	866	584	1613	1.169
	RE2/2(ii)	3351	4311	964	754	586	960	0.644
	RE2/2(iii)	4371	4934	565	863	765	563	0.458
RE2/3	RE2/3(i)	5038	6918	1887	1211	882	1880	1.966
	RE2/3(ii)	5053	6367	1319	1114	884	1314	1.313
	RE2/3(iii)	6453	6903	478	1208	1125	476	0.555
RE3/1	RE3/1(i)	2472	3204	744	1130	872	732	0.733
	RE3/1(ii)	2487	3189	713	1125	877	702	0.703
RE3/2	RE3/2(i)	3336	4949	1619	868	584	1613	1.169
	RE3/2(ii)	3351	4311	964	754	586	960	0.644
	RE3/2(iii)	4371	4934	565	863	765	563	0.458
RE3/3	RE3/3(i)	5038	6918	1887	1211	882	1880	1.966
	RE3/3(ii)	5053	6367	1319	1114	884	1314	1.313
	RE3/3(iii)	6427	6903	478	1208	1125	476	0.555
RE4/1	RE4/1(i)	2692	3204	520	1130	949	512	0.533
	RE4/1(ii)	2707	3189	490	1125	955	482	0.502
RE4/2	RE4/2(i)						1613	1.169
	RE4/2(ii)						960	0.644
	RE4/2(iii)						563	0.458
RE4/3	RE4/3(i)						1880	1.966
	RE4/3(ii)						1314	1.313
	RE4/3(iii)						476	0.555

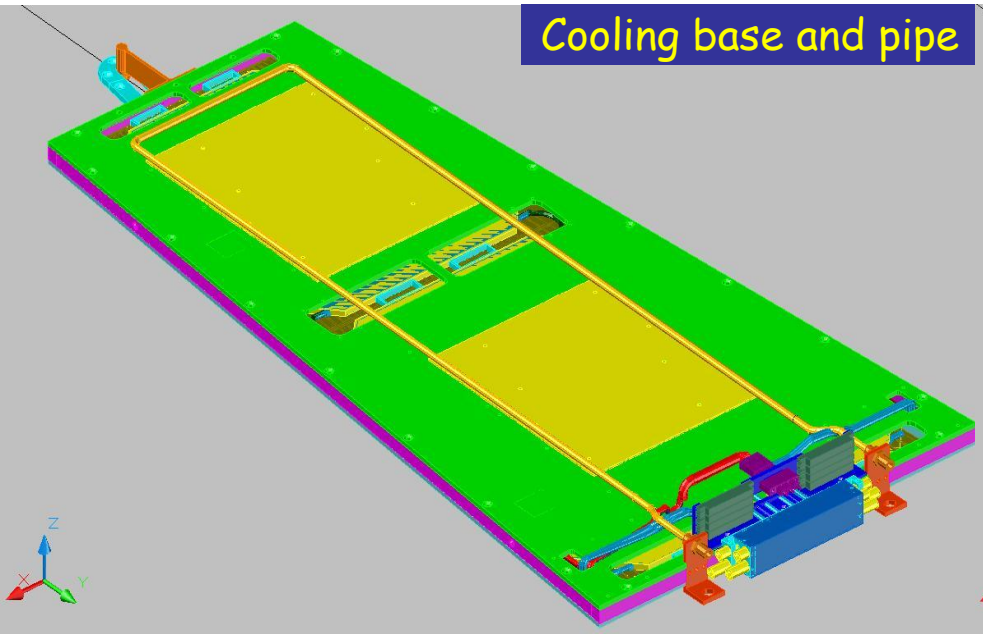


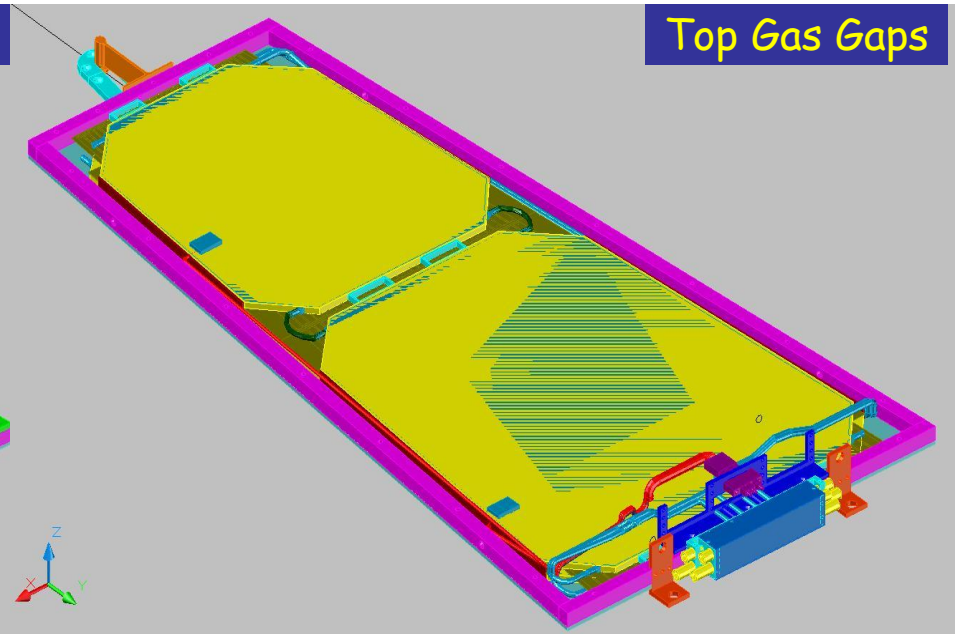
CMS document

Finally designed RE1/1 RPCs : 10 degree trapezoidal, 36 RPC modules on each wing

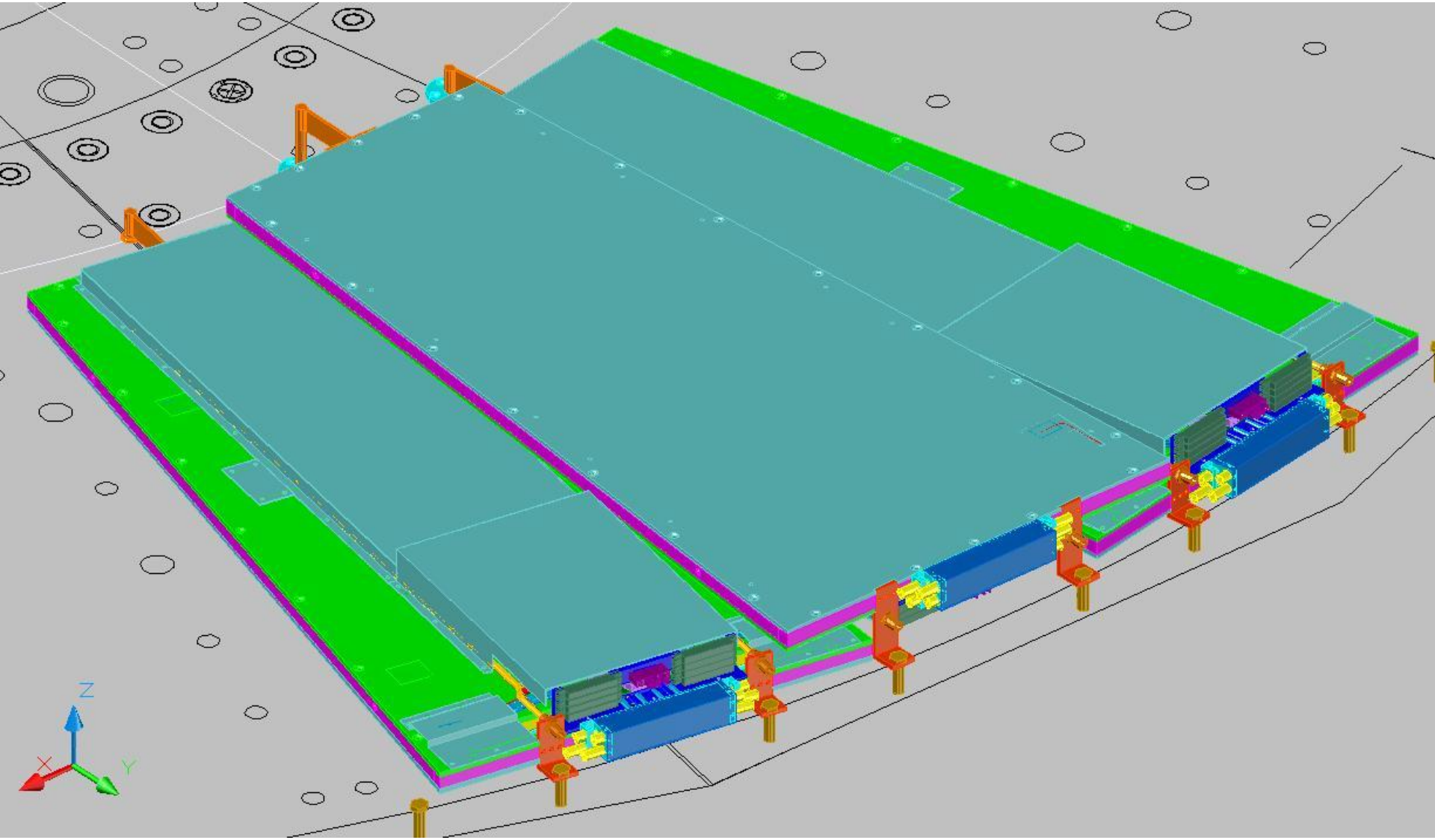




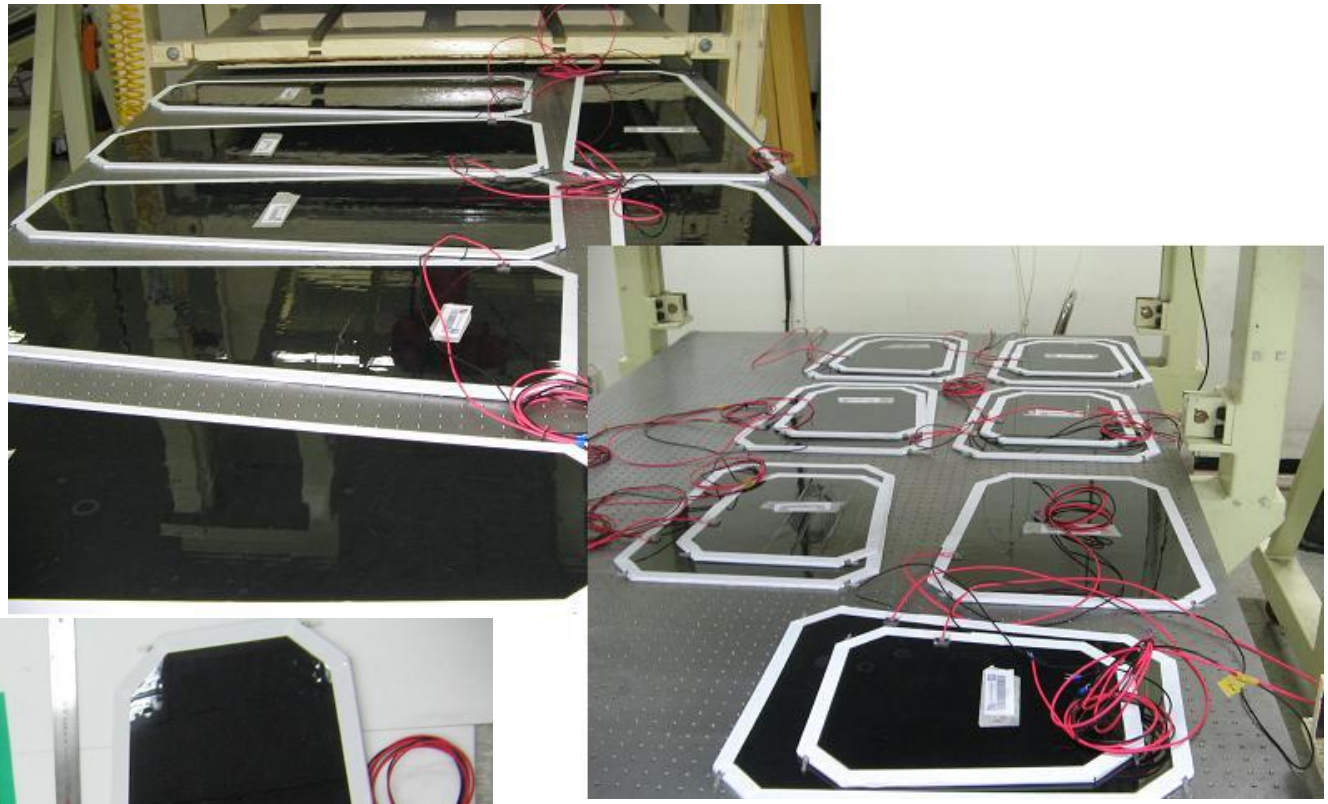


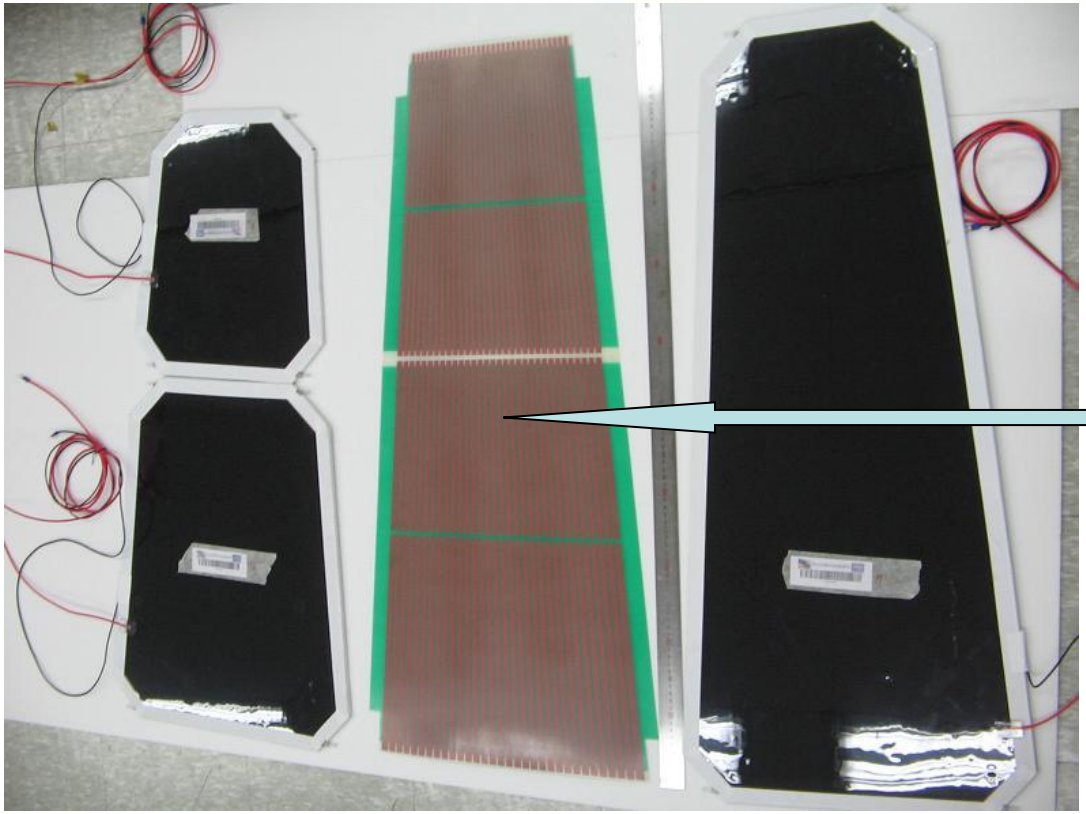


Overlap of RE1/1 Chambers : total 86 mm thick for two layers



10 sets of RE1/1 gas gaps constructed at KODEL (Dec. 2007).

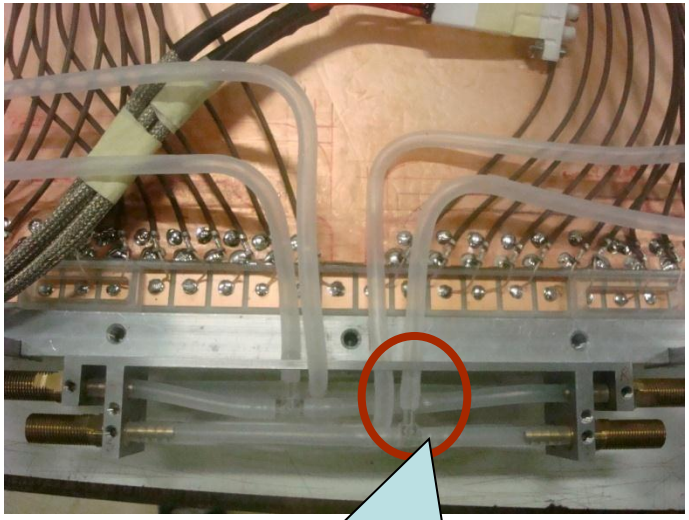


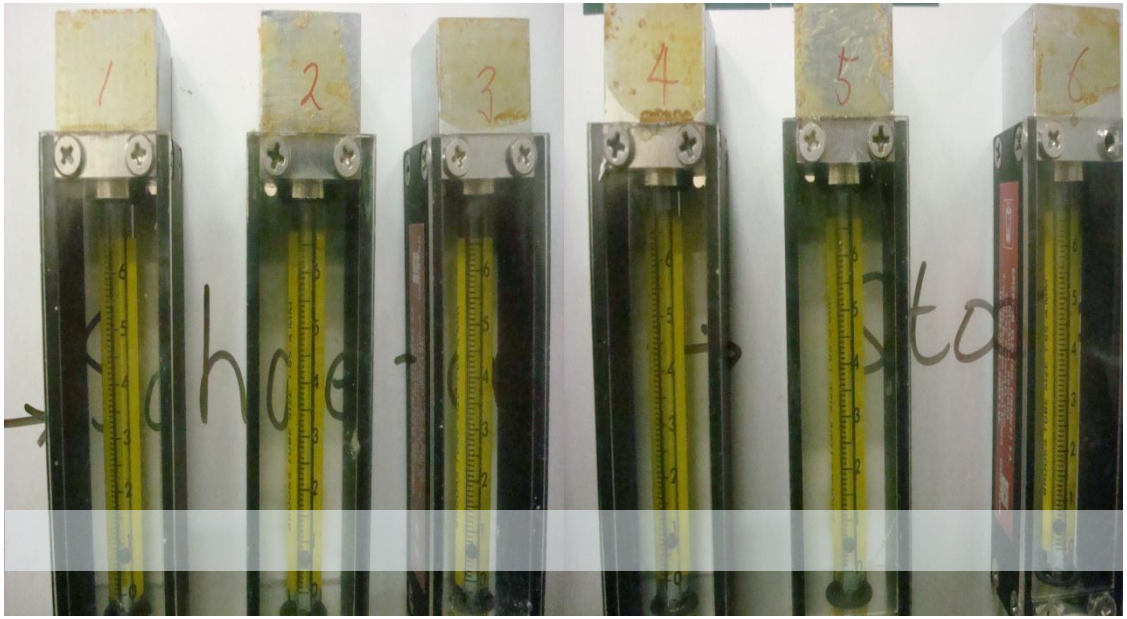


4 sectors of 32 strips covering 4 η's (from 1.5 to 2.1), produced by an etching method

Parallel gas connection

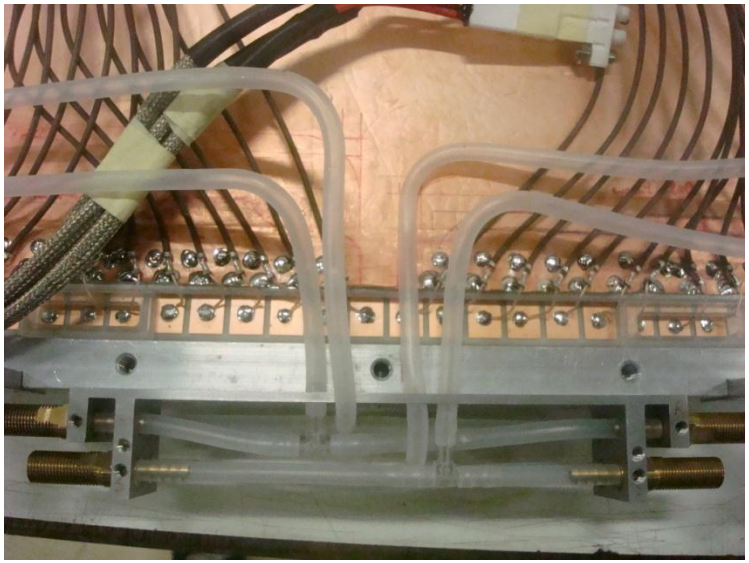
- RE1/1 gas connection : parallel connection (1 sector made of 6 chambers)
- Impedance mismatching → possibility of non-supply to the chamber
- For matching impedance → using impedance “T” connectors
- Parallel connection test (roughly)
    - Using 6 impedance connector and pipes (model of the 1 sector)
    - The difference between each line is not much & flow is not zero
        → Impedance is matched, so parallel connection no problem
    - Roughly result : The flow rate at each line is none zero.

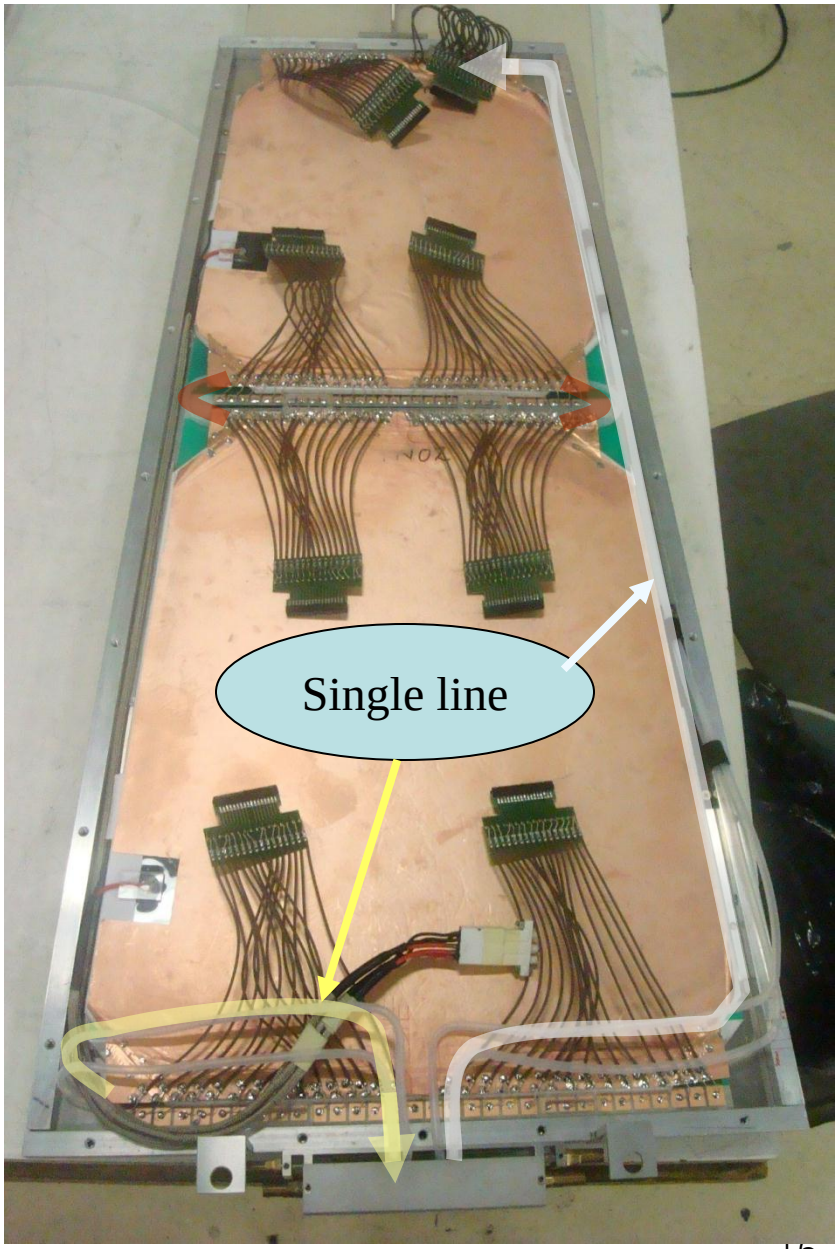




Simple gas connection line

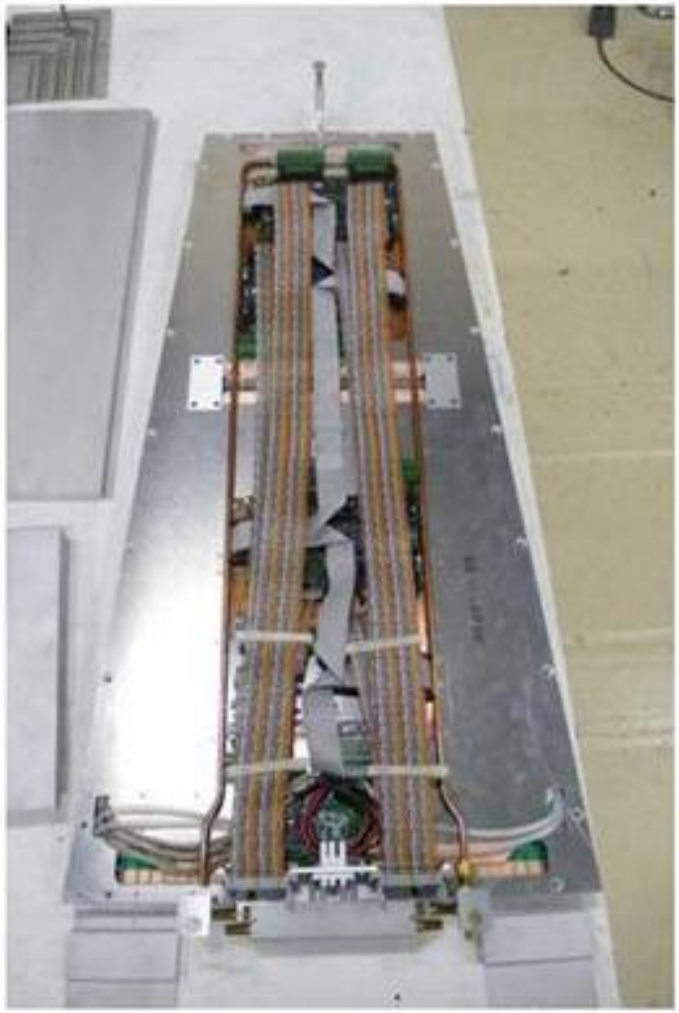
- From gap to T shape connector
  : Single line
  - Decreasing possibility of the gas leakage from connectors
- In the gas box : so much complicated





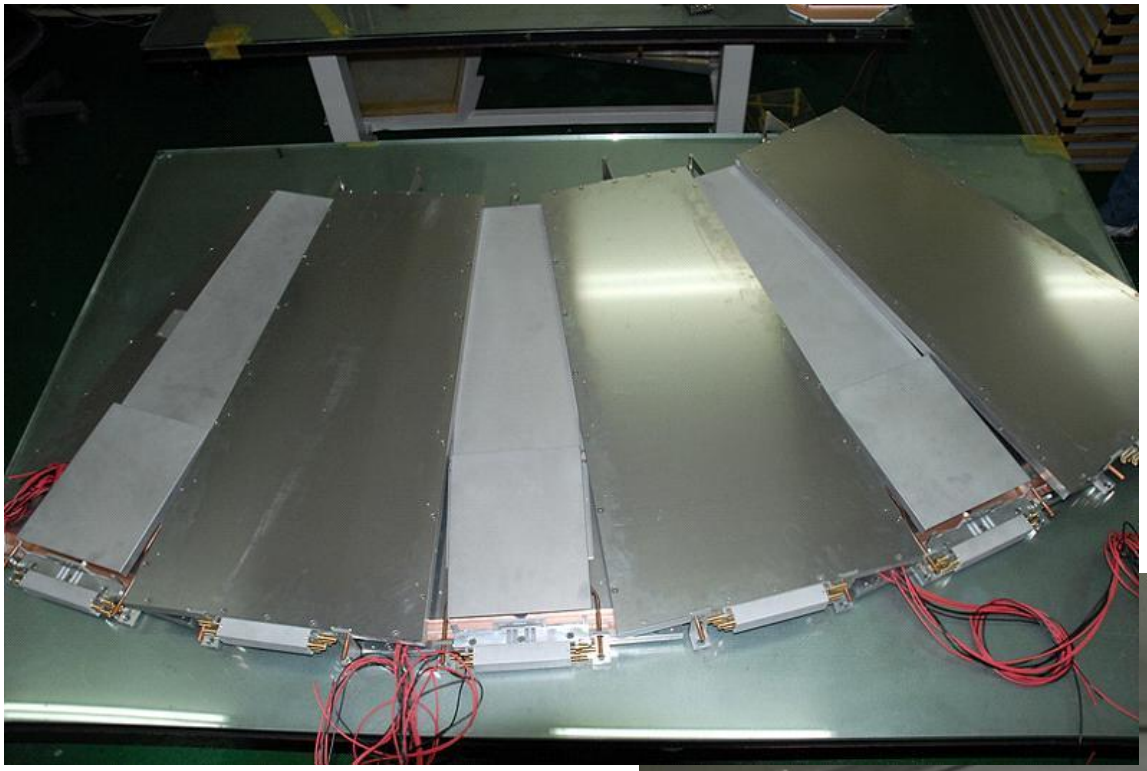
Assembled RE1/1 Chambers at ISR

Covered by FEB shielding box



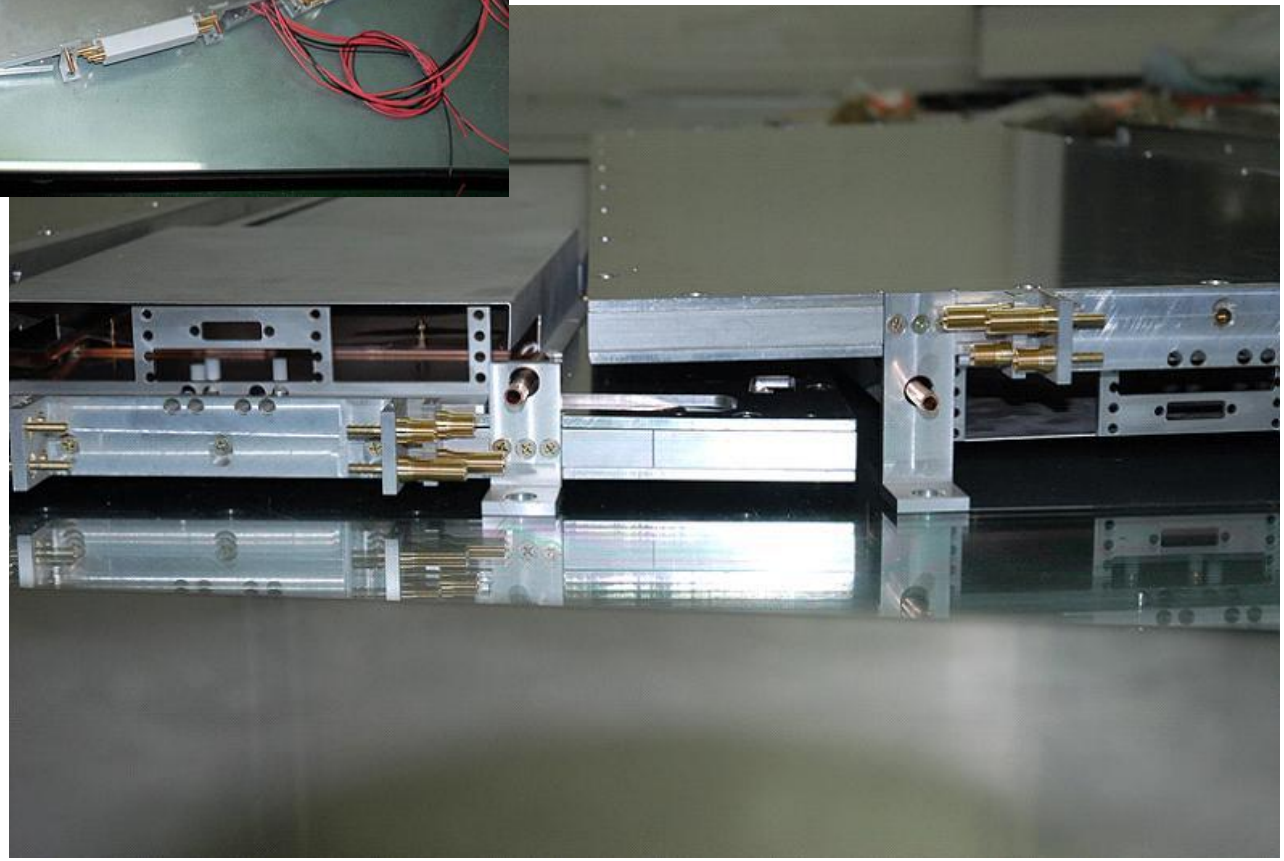
FEB flat cable layout

Signal cable layout

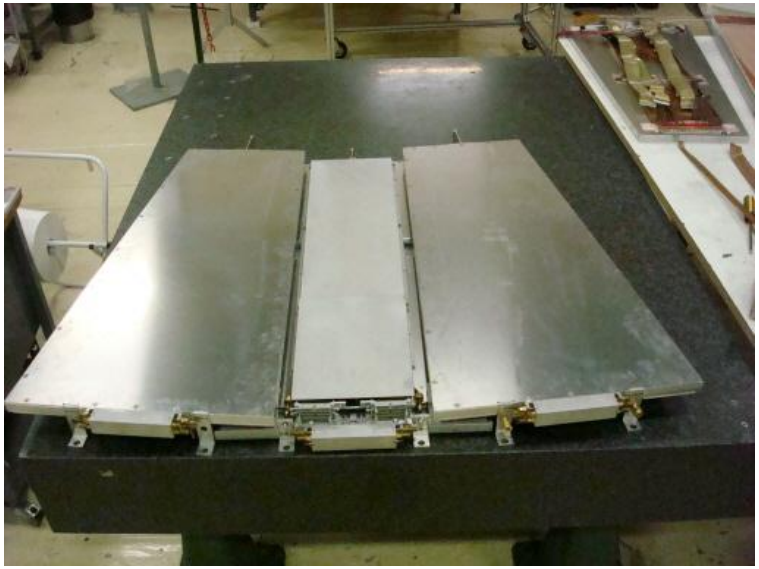


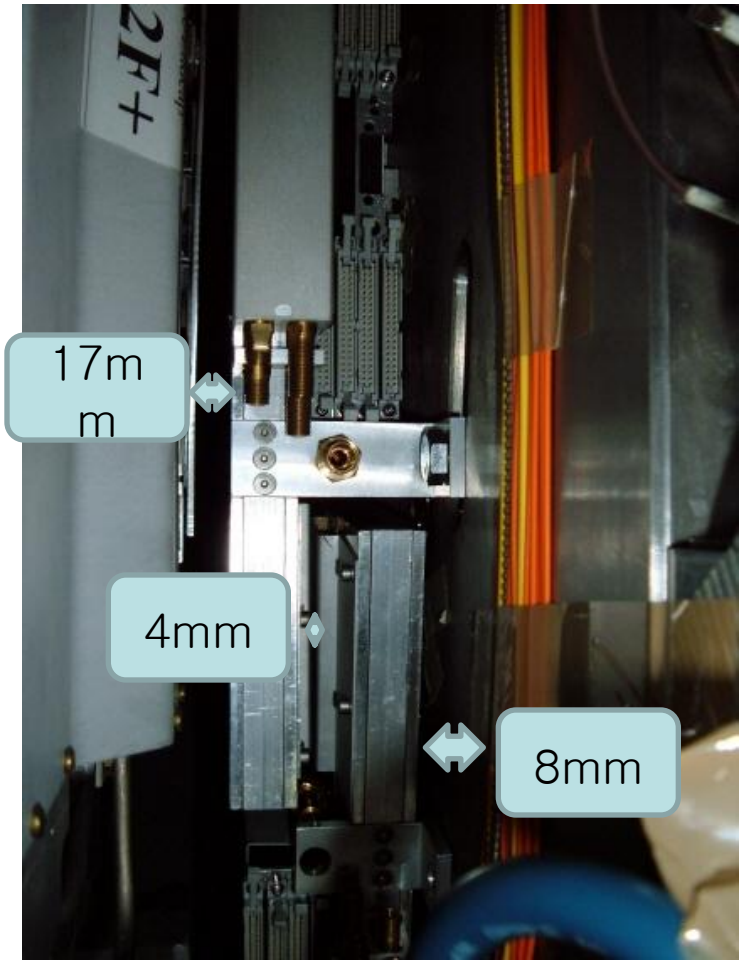
Check the configuration of 6 RE1/1 RPCs in a 60 degree sector

* Overlapped RE1/1 RPCs to check any interference among the cables, gas lines, and cooling lines



Mechanics： Clearance is OK





Difference between RE1/1 and other RE chambers

- More compact (thinner + smaller)
  - Thinner co-axial cable
  - Gluing thinner copper sheet with spray

- More complicated
  - Soldering method
  - Inside structure of the gas distribution box

- More particle rate
  - More FEBs : 3 boards (96 channels) → 4 boards (128 channels)
  - Change the gas connection method
    - serial connection → parallel connection with impedance “T” connector

RPC DAQ system in the RPC PAC muon trigger

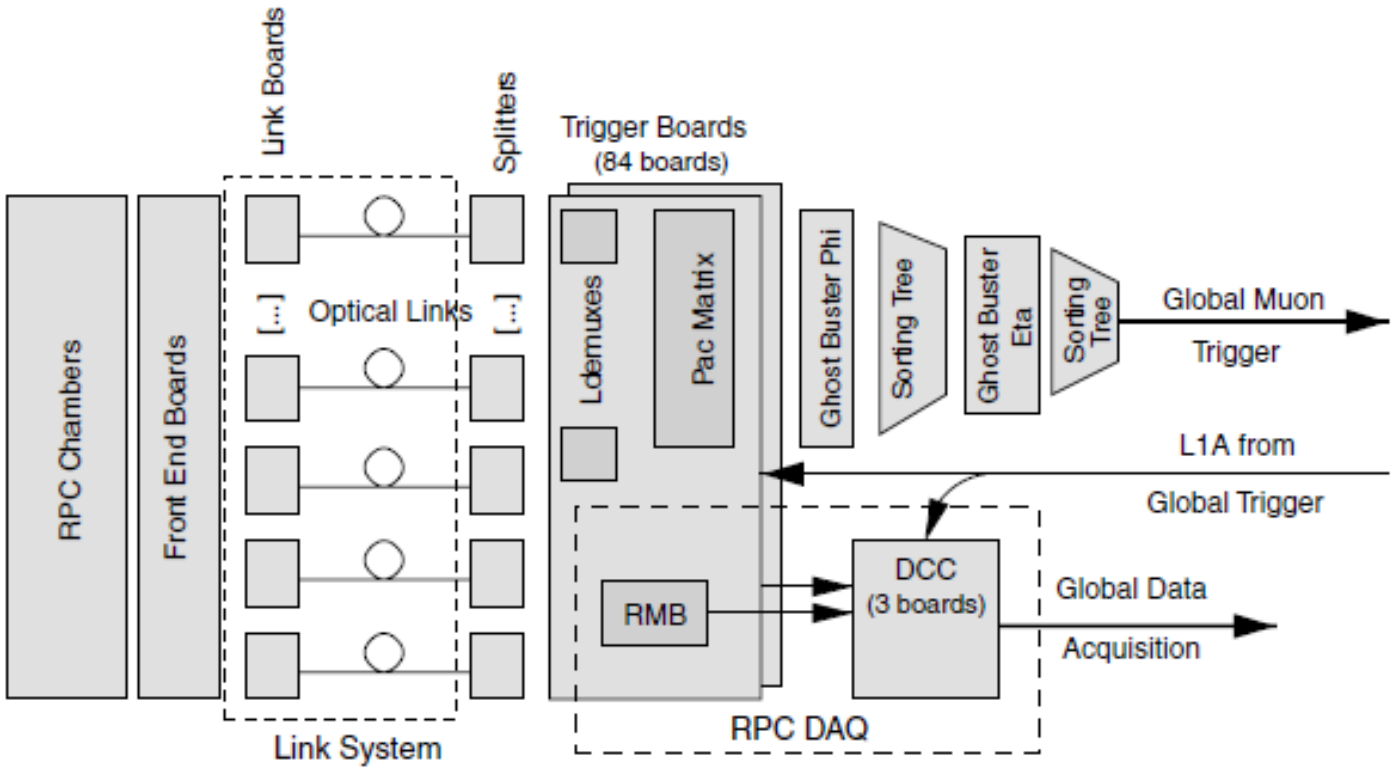
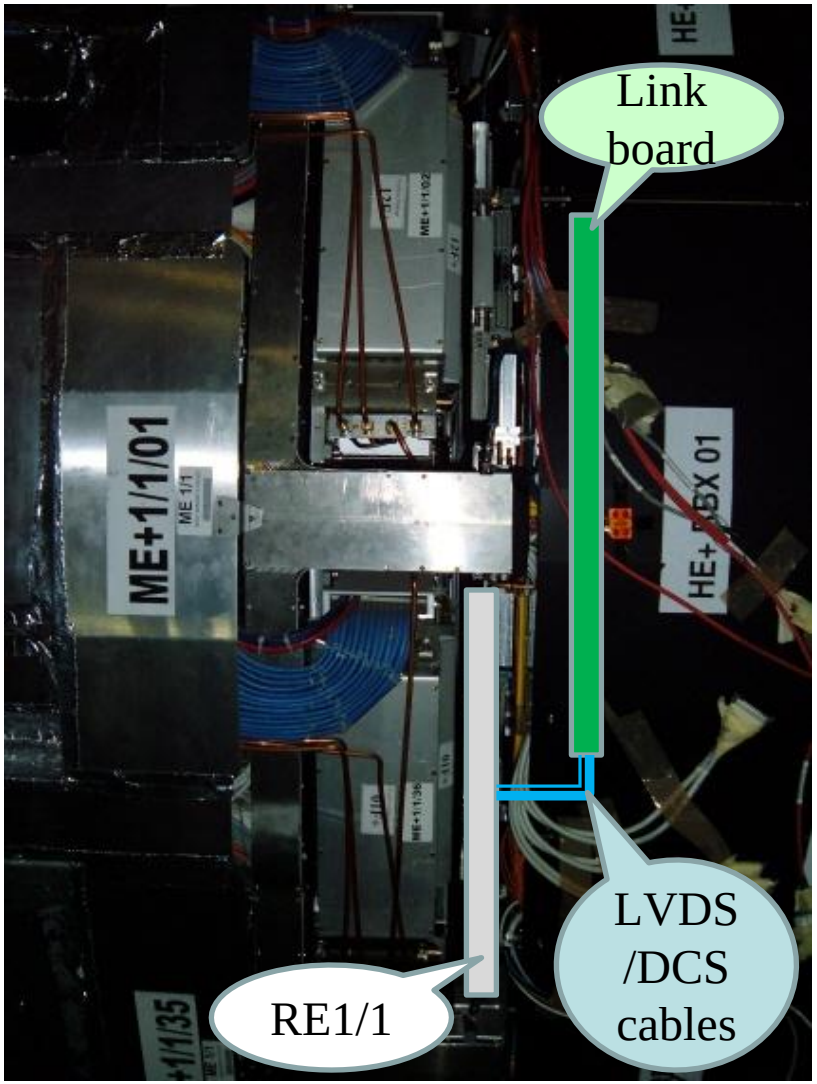


Figure 1. Location of the RPC DAQ system in the RPC PAC muon trigger electronics [2].

Signal & DCS cables



RE1/1 link board crate

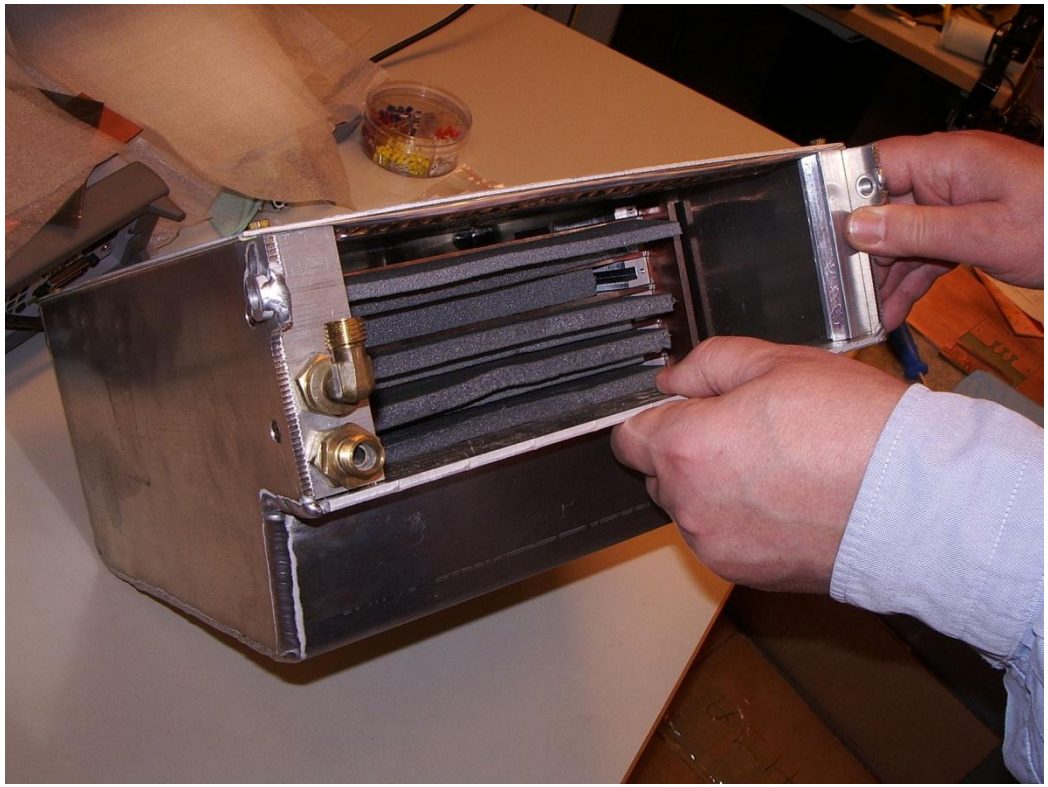
Installed in the CMS end caps

Liquid cooling

Need different layout for boards

No design exist

Prototypes 2007



Service systems

ALL services have been installed but

HV

6 channels have been tested / 4 channels are good

LV

6 channels tested are good

Gas

All the 6 channels are ready, need to check

Cooling

Already connect to HCAL, need to modify connection

Sensors

2 temperature sensors/chamber

Humidity and B-filed sensors are needed

- Another plan

  OPEN CMS

  – Directly connected to a LB rack in the balcony