Preliminary

Pre-Production of Resistive Plate Chambers for RE4

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for the CMS-RPC-Upscope collaboration

CERN, Geneva

08th April 2011

Index

1. The Upscope :

The RPC upscope project, descoped earlier for lack of funds, envisages the fourth end-cap for the Compact Muon Solenoid experiment at the Large Hadron Collider facility at CERN, Geneva. As LHC moves to higher luminosity, the fourth end-cap is important to provide a better trigger efficiency.

RE4 stands for **R**PC **E**nd-cap – **4**th station on both sides (±) of the collision point. The two end-caps will have RPCs covering the pseudorapidity range $1.6 < \eta < 2.1$. Each end-cap has two rings designated as RE4/3 (outermost) and RE4/2 (innermost). In each ring, there are 10^{o} chambers, amounting to 36 chambers in each ring. Thus each end cap will have 72 chambers. It is also proposed to build some extra chambers which would be backward compatible with the existing end caps in CMS. Table 1, shows the total number of RPCs to be built for the upscope :

Table 1

Station	RPC type	Numbers
RE4 (+)	RE4/2	36
RE4 (+)	RE4/3	36
RE4 (-)	RE4/2	36
RE4 (-)	RE4/3	36
Spare	RE4/2	28
Spare	RE4/3	28
Total		**200**

The production of various components for assembly (gas gaps, mechanics, electronics), the assembly sites and the jobs to be accomplished at the assembly sites are detailed in Table 2.

Table 2

SN	Component	From	Details
1	Gas gaps	Korea / Italy	a. Bottom b. Narrow c. Wide
2	Mechanics	China	a. Honey Comb Panels with screws b. Cu Faraday Cage with Mylar glued on it c. Cu Read Out strips with lamination & soldering point d. Screen Box
3	FEBs	Pakistan	a. FEBs b. Distribution Board c. Coaxial signal cables (3 mm, 50 Ω) soldered on to the adaptor board with ferrules
4	Assembly sites	a. India b. Belgium c. CERN	a. Pre-Assembly b. Final assembly c. Characterization d. Cosmic tests e. Transportation
5	Accessories	to be arranged by the assembly sites	a. Mylar b. patch panel supports c. Cu Cooling d. Gas unions (Legris, 6 mm ϕ) e. Gas pipes f. Flat cables and connectors g. Plexiglass spacers h. Screws, washers, nuts, insulation tapes,

6	Components from CERN	To be provided by CERN for each assembly site	a. H V connector b. Potting compound c. Conducting Gel d. Sagana connectors (8 mm ϕ) e. Temperature sensor/cable/connector f. HV / LV cables g. Instrumentation for spacer test h. Hardware for threshold control on FEBs i. Frequency meter for noise measurement

2. Objectives of March 2011 visit :

The teams from India, Pakistan, China and Belgium were in ISR for about a month during March/April 2011, to achieve the following objectives :

1. Assembly of RPCs for the Pre-Production run to establish the QCs and validate the assembly procedures.
2. Fine tune the drawings, mechanics, cooling and electronics in terms of missing links.
3. To come out with a plan for the upscope by fixing the milestones and deliverables to be achieved.

The gas gaps and mechanics for the pre-production had arrived in ISR in October 2010 with an objective to assemble six sets of RPCs, three each for the Type 4/2 and Type 4/3. The status of 18 gas gaps for two types of chambers is mentioned in Table 3. In Oct. 2010, one of the Type 4/3 chambers (NPD-BARC-SN11) with Indian mechanics and accessories was assembled to evaluate if the gas gaps behaved as an RPC. During Oct. 2010 to March 2011, the gas gaps underwent spacer test, polymerization tests, etc. and some of the gaps were destroyed during such an evaluation.

Table 3

SN	Type	SN	Status
1	4/2	RE4-2-TW01	DESTROYED by pressure test
2		RE4-2-TW02	Assembled in RE4/2-CERN-PP02 in Mar. 2011
3		RE4-2-TW03	Assembled in RE4/2-CERN-PP01 in Mar. 2011, Cosmic QC done
4		RE4-2-TN01	broken nozzle, on table in ISR
5		RE4-2-TN02	Assembled in RE4/2-CERN-PP02 in Mar. 2011
6		RE4-2-TN03	Assembled in RE4/2-CERN-PP01 in Mar. 2011, Cosmic QC done
7		RE4-2-B01	Assembled in RE4/2-CERN-PP02 in Mar. 2011
8		RE4-2-B02	DESTROYED by pressure test
9		RE4-2-B03	Assembled in RE4/2-CERN-PP01 in Mar. 2011, Cosmic QC done
10	4/3	RE4-3-TW01	Assembled in RE4/3-CERN-PP01 in Mar. 2011 (2 spacers popped)
11		RE4-3-TW02	DESTROYED by pressure and polymerisation test
12		RE4-3-TW03	Assembled in NPD-BARC-SN11 in Oct. 2010
13		RE4-3-TN01	On the table for Spacer test in ISR
14		RE4-3-TN02	Assembled in NPD-BARC-SN11 in Oct. 2010
15		RE4-3-TN03	Assembled in RE4/3-CERN-PP01 in Mar. 2011
16		RE4-3-B01	Assembled in RE4/3-CERN-PP01 in Mar. 2011
17		RE4-3-B02	Assembled in NPD-BARC-SN11 in Oct. 2010
18		RE4-3-B03	In Cosmic Rack, towards spacer test facility, in ISR (gas inlet broken)

As, is clear from Table 3, one had only 9 (shown in green rows) out of 11 gas gaps that could be used to assemble only the following :

a. Two chambers of Type 4/2 and
b. One chamber of Type 4/3

One set of accessories for RE4/2 type chamber was dispatched from Mumbai which included the Cu cooling assembly as per the new proposed design, six connectorised flat cables, mylar sheets cut as per the drawings, aluminum angles for gas gap support and the patch panels. The box with above mentioned accessories arrived in ISR on 22nd Mar., 2011 and all the components were found to be compatible with the mechanics.

All the necessary drawings were scrutinized once again with the mechanics for Pre-Production and all required corrections as regards to various pitches, thickness of aluminum supports and positioning of gas unions and Cu cooling unions were incorporated. The Cu cooling assembly with its Cu plates was re-iterated in order that it provides maximum cooling without having the need to extend the length of the flat cables. The drawings were also redesigned from tooling point of view.

The following convention as shown in Fig. 1, is being followed as per the drawings as regards to the geometry of HCP, gas gaps, which would be helpful in mounting the associated accessories.

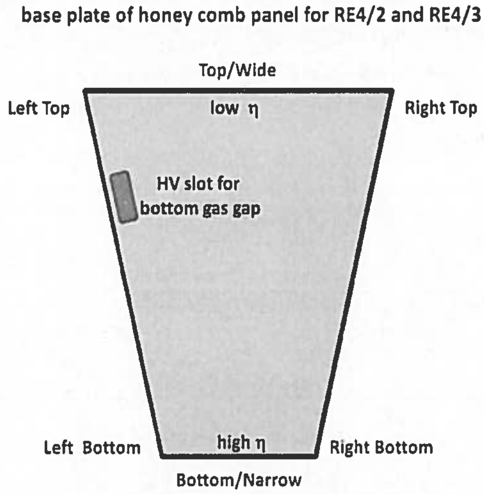


Fig. 1, Nomenclature for different positions of HCP/gas gaps etc.

3. Assembly Procedure :

To start with, as the Cu cooling assembly from Mumbai was available for Type 4/2, the first chamber for Pre-Production was selected to be of the Type 4/2 and named as "RE4/2-CERN-PP01" (PP meaning Pre-Production). The following steps were followed during the assembly :

A. Mechanical testing of the gas gaps :

1. The spacer and leak test for the gas gaps was done at 20 mbar of over pressure and the leak rate was monitored at two different over pressures, viz. 20 mbar and 3 mbar. For the spacer test, the relevant template is to be placed over the gas gap and fixed properly. The spacer test is performed with a pressure transducer and the variations in pressure (~ 0.1 - 0.5 mbar) above the mean value, in terms of spikes for each spacer position are digitally recorded. In Fig. 2, below 39 peaks are recorded corresponding to each of the 39 spacers in the Top Wide gas gap (RE4/2-TW03). One has to take care to apply same force while the data is being recorded. The higher peaks on the right end (much above 0.5 mbar over the mean value) correspond to non-spacer regions where the same force applied amounts to larger pressure variations because of more compression in the gas volume. This is just for the sake of demonstration and non – spacer regions should not be subjected to any force while the measurements are being undertaken. One can also see the fall in pressure with respect to time. After the spacer test is over, the leak rate is monitored for 5 minutes, both at 20 mbar and later on at 3 mbar of overpressure. The fall in pressure with time is then fitted to get the slope for dP/dt. The leak rate is then mentioned in units of [(mbar x litre) / s] by taking the product of fall in pressure with time (dP/dt) and the volume of gas gap in litres. (volumes of gas gaps and permissible leak rates to be mentioned). Each gas gap has a different volume and care should be taken while obtaining the leak rate for each gas gap.

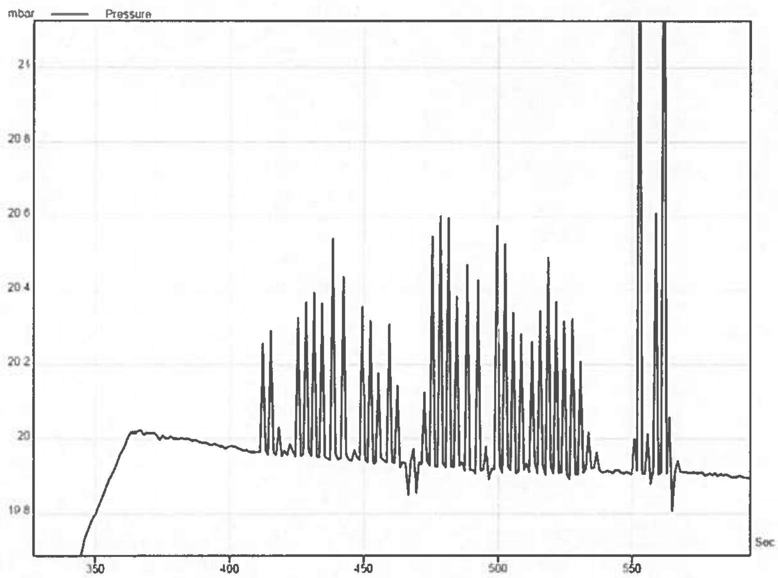


Fig. 2, The above figure shows variations in pressure (mbar – Y axis) as a function of time (seconds – X axis) for pressure applied at the spacer's position

2. After the gas gaps have passed the spacer and leak test, the HV cables for each gas gap are to be connected with Jupiter connectors, cable sheath and heat shrink tubes and subsequently subjected to the HV scan for dark current. At this stage, these cables should be individually tagged as Bottom, Top Narrow and Top Wide. This is important, so as to known at a later stage, as to which HV cable belongs to which layer, once when the top plate of HCP is closed.

B. Electrical testing of the gas gaps :

1. For the HV scan, firstly, the dark current is measured RPC gas mix, which has 40 % RH at a gas flow rate of 5 lph (Fig. 3)

Dark current plots to be inserted
08th April 2011

Fig. 3, Dark current versus HV for RPC gas mix

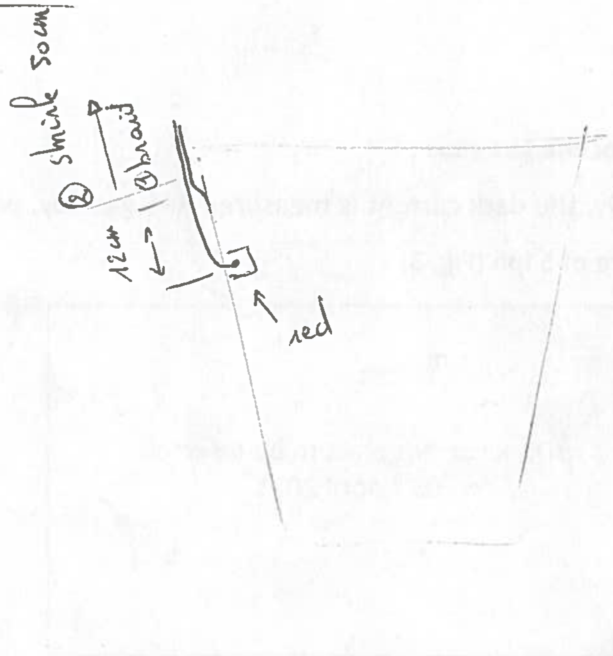
2. Next, the same HV scan is repeated with Argon gas for measuring the resistivity of bakelite (Fig.4)

Resistivity plot to be inserted
08th April 2011

Fig. 4, Dark current versus HV with Argon for resistivity measurements

~~Kabellengte = shrink + 9cm~~

top narrow



cable lengths

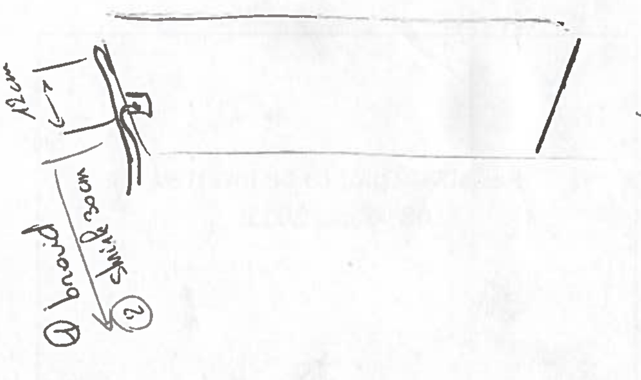
		NEW
TN	150 cm	150 cm
TW	90 cm (+35)	125 cm
B	110 cm (+20)	130 cm

~~braid~~ shrink length		
TN	60 cm	60 cm
TW	30 cm (+5)	35 cm
B	30 cm (+5)	35 cm

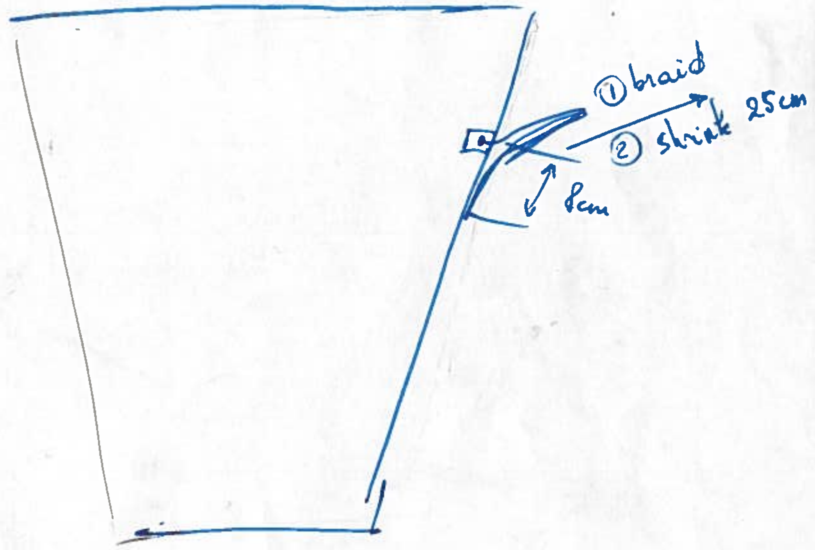
length metal braid
= cable length − 10 %

length polyamid braid
= cable length + 15 %

top wide



bottom



C. **Pre-Assembly jobs for the final assembly :**

There are several pre-assembly jobs to be configured which are required during the final assembly of Resistive Plate Chambers, which are briefly outlined below :

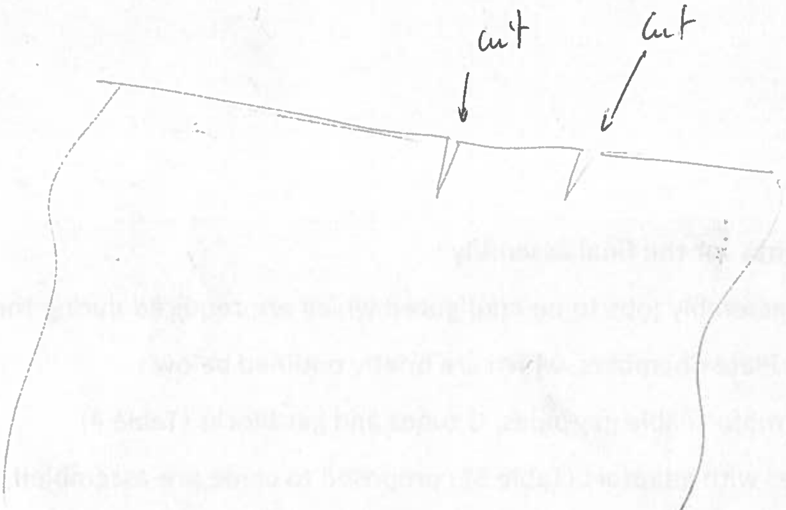
1. Configuring of thermoformable gas pipes, U tubes and gas blocks (Table 4)
2. Coaxial signal cables with adaptors (Table 5) : proposed to come pre-assembled
3. Fixing of Mylar on the top plate of Honey Comb Panel with slots for gas pipes, HV cables and coaxial signal cables
4. Preparation of 40 pin flat cables with suitable connectors & orientation (Table 6)
5. Preparation of 26 pin flat cables with suitable connectors & orientation (Table 6)
6. Cu cooling assembly
7. Mounting of FEB on the Cu cooling assembly

Dingen die we tekort hebben

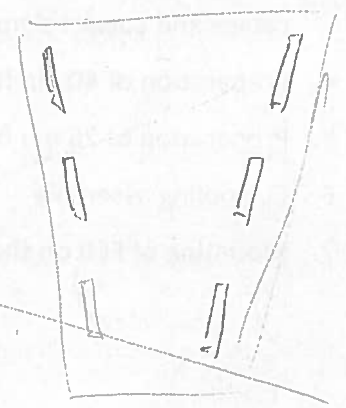
(1) braid voor over de HV kabels v/d gaps

(2) soldeer flux → zie CERN EDH store "flux water"

(1)



(2) strips of doublesided tape (12mm)
1st on the box, then roll the mylar on



Drop it

3.1 fold the copper over the ends up until the mylar
3.2 cut the HV cutout a bit smaller then the one for the previous mylar
3.3

4.1 Don't screw on the left ~~ones~~ L-profiles just yet.
! Right L-profiles bigger ∅ holes (6.5mm at least)

testgap · B013

0. clean table

D. Final assembly of the Resistive Plate Chamber :

1. The base plate of the Honey Comb Panel (hereafter called as HCP) was cleaned with iso-propyl alcohol to remove the metallic dust, muck and oil etc. sitting on the HCP.

1.1 clean mylar w. Acrylnet.

2. The 200 μm thick mylar is punched with 8 mm ϕ clear holes at necessary places for mounting the screws for the "L profiles" for gas-gap support on the base plate, inside the HCP. Then it is laid over the base plate of HCP ~~with double sided tape~~. (2) Necessary cuts are made in the mylar over the HV point for the bottom gas gap and the surface cleaned once again. ↳ only cut the short sides so the mylar can remain as a protection

3. The Cu Faraday Cage foil with mylar glued on to it is then laid on top of the mylar on the base plate. Before laying it, the copper side is thoroughly cleaned. The vertical flap on the Cu is cut at the places where one expects the HV point for the bottom and top gaps and the U tube for the top layer. The wide and narrow ends of the Cu were wrapped with insulation tape to avoid contact between the Cu and the HCP. The mylar which is glued to the copper is then wiped clean.

composition: mylar / copper / mylar

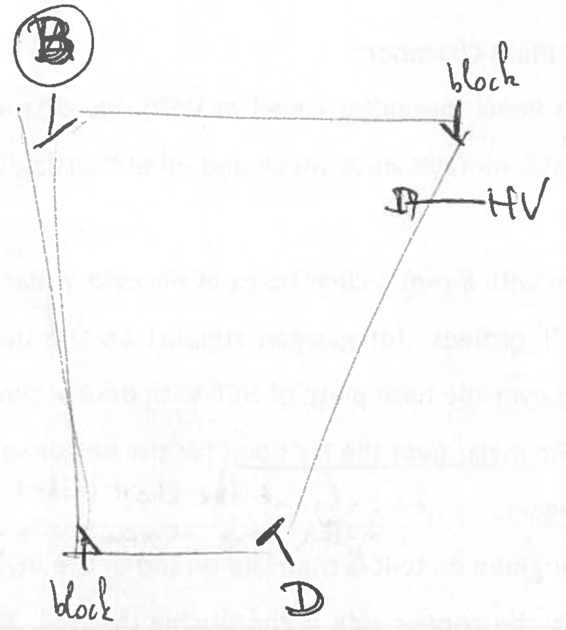
4. The vertical portion of the aluminum "L profiles" for gas gap supports (3mm thick) are fixed with insulation tape (0.5 mm Bakelite strips ~~or 200 μm mylar could also be used instead~~, extending 1 cm on either side of the aluminum face) in order to insulate the Cu Faraday cage with the aluminum support. The top right and bottom right supports were then screwed on to the HCP. These are the fixed supports. 4-1 ↳ M5 x 6

5. At this stage, note down the details of the bottom gas gap (e.g. SN – RE4/2-B01-KODEL, etc.) and all relevant information on any additional stickers (about the bakelite). Do not peel out the stickers and let them remain as it is on the gas gaps. The protective layer from the bottom gas gap is then removed and laid over the mylar of Cu Faraday Cage.

put a label on the table!

6. The gas blocks are then put on the left top and right bottom nozzles and gas pipes were mounted on the right top and left bottom nozzles of the bottom gaps. The lengths of the gas blocks and gas pipes to be fixed on the nozzles is cut

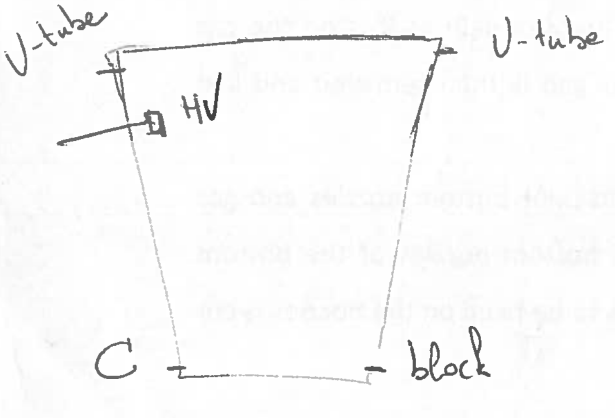
6- bottom gap "block" orientation. & gas tube orientation



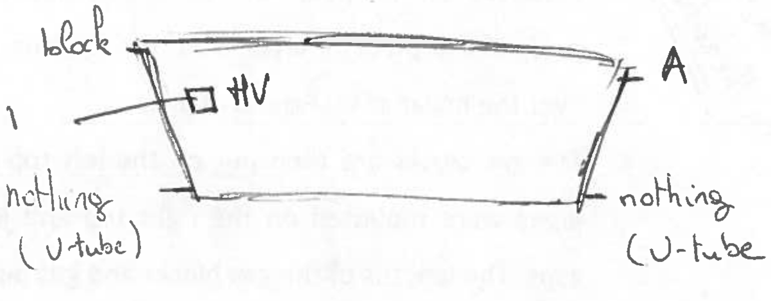
8-1 attach the gas tubes before getting the top gaps in

6b

top narrow



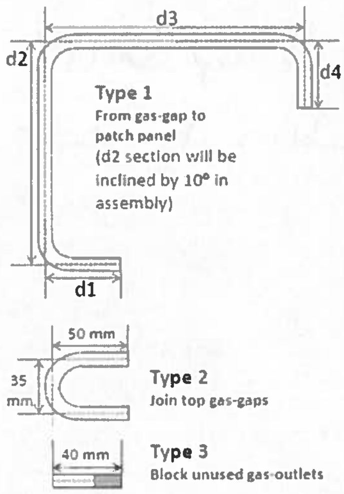
top wide



and adjusted as required. They are slightly warmed and pushed gently over the nozzles. The gas pipes and gas blocks should have been configured separately as part of pre-assembly jobs (C-1). Table 4 shows the dimensions for configuring the relevant gas pipes for the two types of chambers :

Table 4

Designs and Dimensions of gas pipes in RE4 assembly (modified in March 2011)



Dimensions of Type 1 gas pipes for each gas-gap

Ring	Side	Gas-gaps	d1 (mm)	d2 (mm)	d3 (mm)	d4 (mm)
RE4/2	wide	top	55	205	180	140
		bottom	55	225	210	145
	narrow	top	45	130	200	60
		bottom	55	150	230	65
RE4/3	wide	top	55	205	355	110
		bottom	55	230	385	120
	narrow	top	50	135	235	80
		bottom	50	163	270	95

Gas-pipes needed for each chamber:

- 4 "Type 1" pipes with different dimensions
- 2 "Type 2" pipes with same dimension
- 4 "type 3" blocker pipes

7. The bottom surface of the "Cu read out plane segmented in η" is then wiped clean and placed on top of the bottom gas gap. The read out plane with 96 strips is to be checked for lamination over the Cu strips and the soldering points.
8. The Top Narrow and Top Wide gas gaps are then placed over the read out plane, as detailed for bottom gas gap in SN 5. Care is to be taken to remove the protective covering on the gas gaps before placing them over the read out plane and noting down the information provided on the stickers.
9. Insert the aluminum "L profiles " for gas-gap support on the left side with adjustable slots, after having put the necessary insulation on their vertical sides, as is detailed in SN 4. Check for the discontinuity between the copper and the HCP.
10. Similarly, as detailed in SN 6, the gas blocks are then put on the left top and right bottom nozzles and gas pipes were mounted on the right top and left bottom

11.1 position gaps w.  spacers

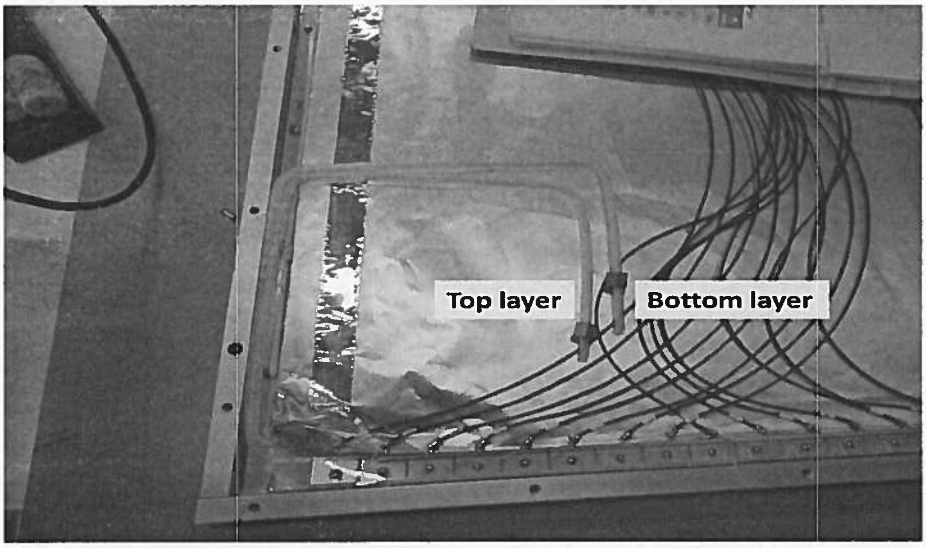
11.2 position the Cu + Milar top foil w. tape on the correct spot.

12.1 solder bottom cables to strips and shield

12.2 solder bottom shield to top shield.

12.3 solder middle cables to strips and shield nozzles of the top gaps (Narrow and Wide). Additionally, two "U tubes" are also mounted between the Top Narrow and Top Wide gas gaps.

11. The gas pipes from the top and bottom layer should not cross each other or get entangled at any place. They should be configured as shown in Fig. 5 below. The Top layer gas pipe should be always be nearer to the nearest side bar of the HCP. At this stage, the gas pipes should be tagged as Bottom and Top, both at the top left and bottom right sides. This is important, so as to know at a later stage, as to which gas pipe belongs to which layer, once when the top plate of HCP is closed.



Orientation of gas pipes for the Top and Bottom layers
Top Right : Wider side : low η

Fig. 5, The Top layer gas pipe should be always be nearer to the nearest side bar (top right/bottom left) of the HCP as shown in the above figure

12. The coaxial signal cables (~ 3 mm diameter, 50 Ω) are soldered separately with their ground ferrules on the Cu of the cut sized, Cu Faraday Cage foils glued with mylar in their inside for the top gas gaps (Top Narrow and Top Wide). It is important to insert a Cu strip with mylar fixed underneath, while soldering so as to avoid damage to the mylar glued to the Cu. After soldering is over this strip should be taken out. The orientation of the cables is important for their further

routing towards the FEBs (Fig. 6). The mylar on the inside of the cut sized, Cu Faraday Cage foils is wiped clean and then placed over the respective gas gaps (Top Narrow and Top Wide). Relevant cuts are made over the respective HV points for the top gas gaps.

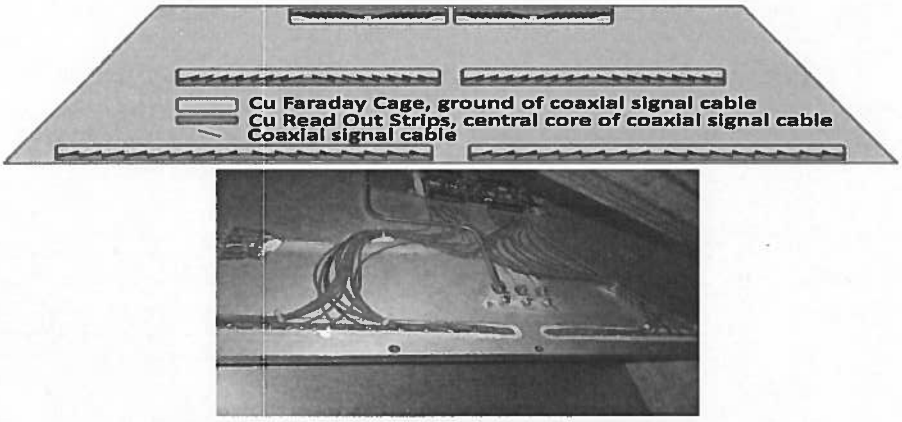


Fig. 6, The coaxial signal cables should be oriented in the right direction for proper routing to FEBs

13. The lengths of the coaxial signal cables are similar to as they were kept in earlier production and detailed in Table 5, below. Configuring the coaxial cables is part of the pre assembly jobs (C-2).

Table 5

RPC type	A1, A2	B1, B2	C1, C2
RE4/3	680 cm	670 cm	550 cm
RE4/2	550 cm	500 cm	450 cm

14. Next, the central core of the coaxial cable is soldered with the Cu read out and the plexiglass spacers are placed in between the Top gas gaps and the HCP. While, soldering always insert the Cu strip to avoid any damage due to transfer of any excess heat to any components of RPC.
15. The flap of the Cu foil of Faraday Cage coming from beneath the bottom gas gap should be soldered at several points with the Cu foil of Faraday cage kept over

the gas gaps in the top layer. Take care to insert the Cu strip while soldering and to remove it after the soldering is over. Finally, Cu tape with conducting glue, is fixed to cover the entire soldering points on the Faraday Cage.

16. The top HCP mounted with mylar cut for slots for signal cables, gas pipes and HV cables is then laid over the gas gaps. This should be configured separately as a pre assembly job (C-3). While laying the top HCP, the following things have to be taken out through the slots in the HCP :
    a. The three HV cables
    b. Two gas pipes, each at the Top and Bottom end
    c. 6 sets, each consisting of 16 coaxial signal cables, soldered to the Faraday Cage and read out strips.
17. After mounting the top HCP, the discontinuity between the HCP and the Faraday Cage is verified with a multimeter. If found Ok then, the screws are tightened with a torque of 15 Nm.
18. Next, the aluminum "L profiles" for the connectors is mounted on the outside of the top plate of the HCP at the Top and Bottom sides.
19. The following connectors and unions are to be mounted on the 3 mm thick aluminum "L profiles – long, short, small" :
    a. On the "L profile - long" to be mounted on the Top side (Wider side - low η), two screws are fixed from beneath for holding the distribution board. This has to be done before fixing the "L profile - long" on the top plate of HCP. The screws used for fixing the "L profile - long" on the Top side (Wider side) are to be counter shrunk. The other "L profile - small" to be mounted on the Bottom side (Narrow side – high η) has adjustable slots and is to be fixed with normal screws, which are not counter shrunk. Same procedure is to be followed for both RE4/2 and RE4/3 type chambers, except that in case of RE4/3 type chamber, one additional "L profile – short" is also to be mounted on the top plate of the HCP with counter shrunk screws.

b. Cu cooling unions, (Sagana, 8 mm ϕ outer diameter) – 4 nos., 2 each on the L profiles (long and small). The Sagana unions have double ferrules on either side.

c. Gas pipe unions, (Legris, 6 mm ϕ, outer diameter) – 4 nos., 2 each on the L profiles (long and short). The gas pipes should have brass inserts in them, before fixing the ferrules, towards the L profile side.

d. The lengths of flat cables with connectors is shown in Table 6,

Table 6

Flat Cable Type	RE4/2 and RE4/3
A1, A2 (40 pin)	50 cm
B1, B2 (40 pin)	100 cm
C1, C2 (40 pin)	150 cm
DB to FEBs (26 pin)	300 cm

These lengths are same for both the type of chambers (RE4/2 and RE4/3). These cables with respective connector's orientation are to be configured separately and tested for their continuity as part of the pre assembly jobs (C-4,5). They are then laid on to the top plate of HCP with the female connectors fixed on the "L profile – long" on the Top side and laid as shown schematically in Fig. 7.

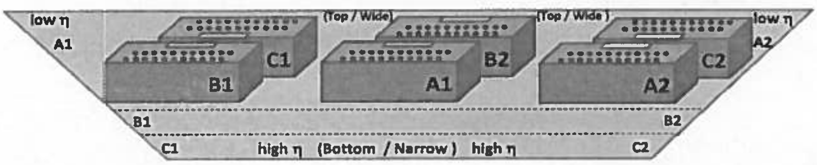


Fig. 7, Orientation of flat cable connectors on the "L profile – long"

e. Cu cooling pipes (8 mm ϕ, outer diameter, 1 mm thick) soldered on 1 mm thick Cu plates is configured separately as part of pre assembly jobs (C-6). The Cu cooling assembly with Cu pipes and Cu plates is different for R4/2 amd RE4/3 type chambers (Fig. 8 and Fig. 9).

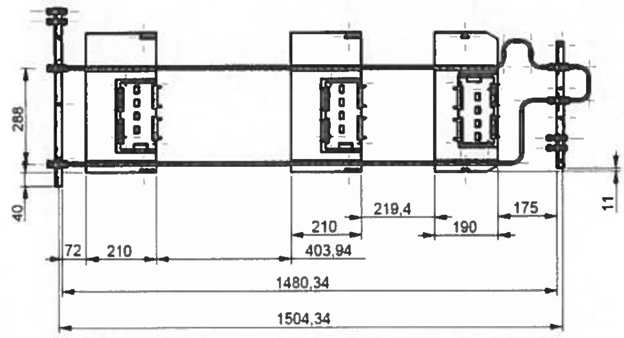


Fig. 8, The Cu cooling assembly for RE4/2 with position of FEBs

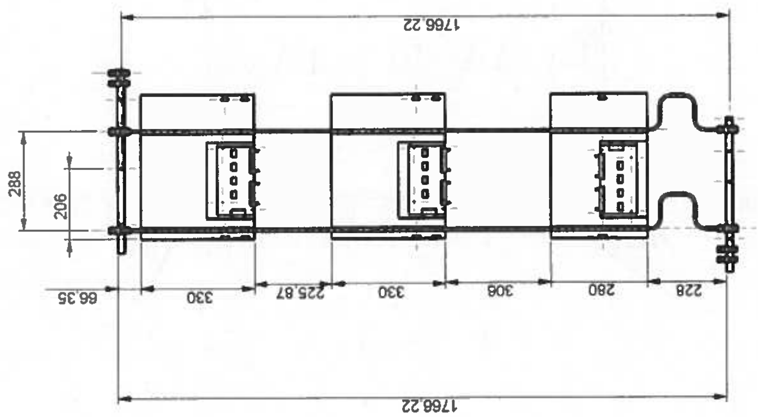
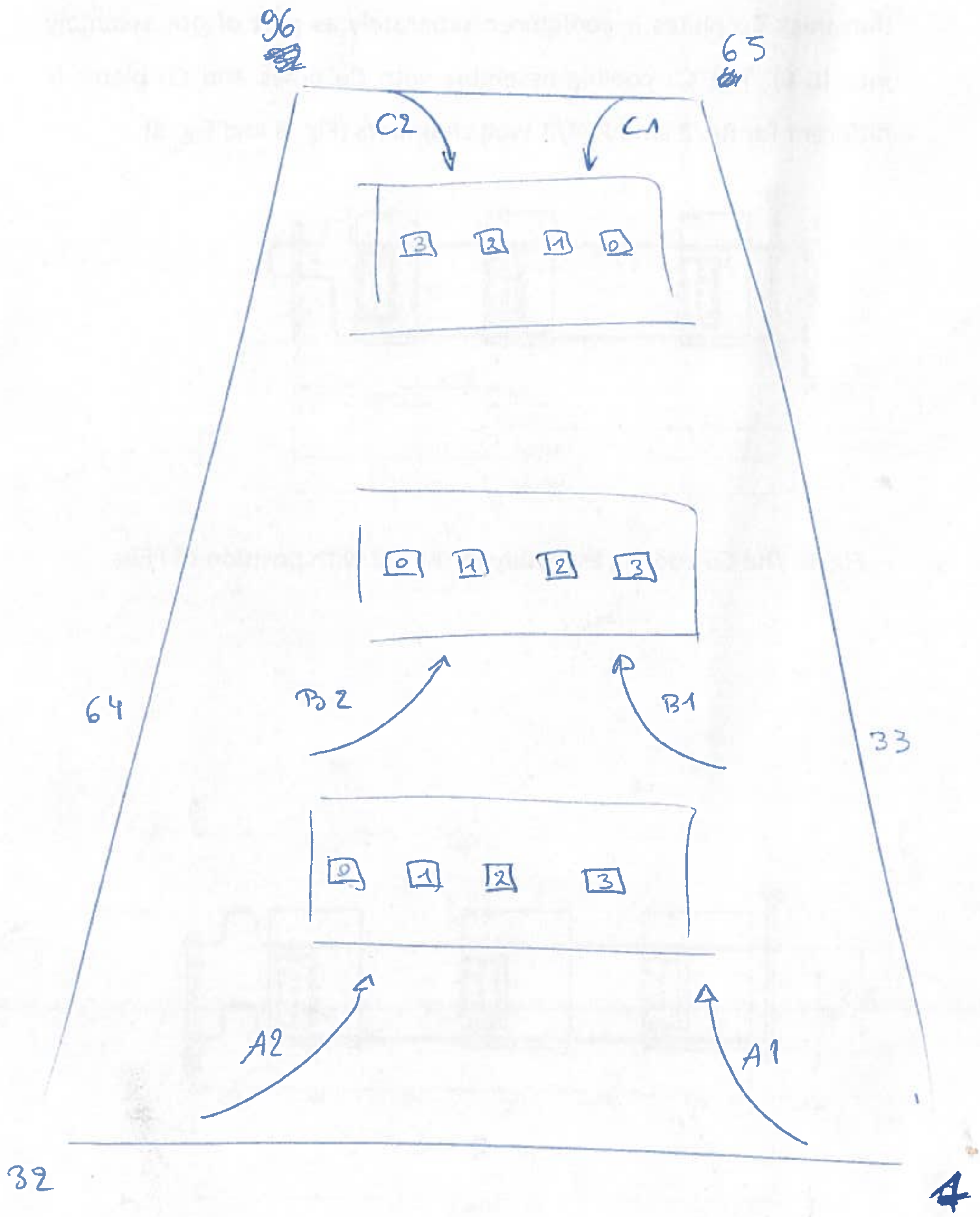


Fig. 9, The Cu cooling assembly for RE4/3 with position of FEBs


96
65
C2
C1
3
2
1
0
0
1
2
3
64
B2
B1
33
0
1
2
3
A2
A1
32
4

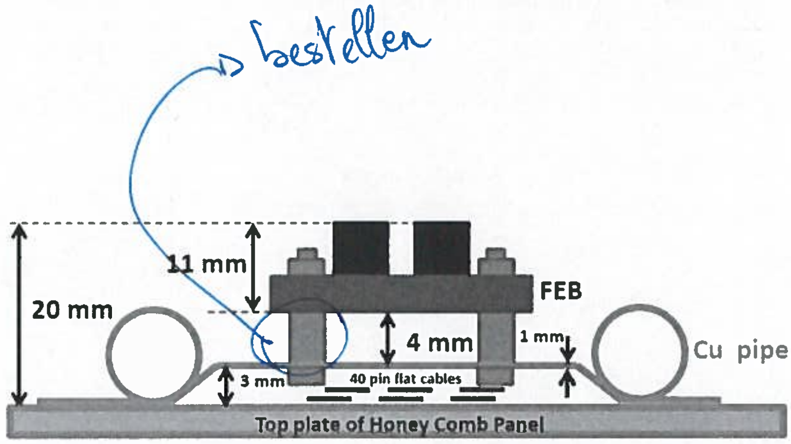


Fig. 11, Orientation of FEBs on the Cu plate raised 3 mm above and passage of flat cables beneath the Cu plate

g. The hardware threshold on the FEBs is then set at 200 mV, with the helh of potentiometers mounted on the FEBs. They are then mounted on the Cu plates with 4 mm spacers between them.

h. The Cu cooling assembly with FEBs mounted is to be placed carefully on the top HCP with the flat cables going beneath the 3 mm raised height of the Cu plates.

i. The flat cables (40 pin) are connected to the FEBs.

j. The Cu pipes are tightened to the Sagana unions on the L profiles.

k. The gas pipes are tightened to the Legris unions on the L profiles.

l. Lastly,the distribution board is mounted and connected to the three FEBs through the 26 pin flat cable.

m. The continuity of the flat cables can be checked by a frequency meter or a pulsar. The distribution board can then be powered and checked for its functionality by observing the currents drawn by the three FEBs. (currents drawn to be listed)

n. The following four grounds are screwed at a common place on the "L profile – long". The colour code followed is the same as in the previous production.

(i) From Faraday Cage : Blue colour

(ii) From Distribution Board : Green colour

(iii) From HV Tripolar connector : Black colour &

(iv) From the HV shielding sheath : White colour

20. If everything is found OK, then the screen box is mounted and secured properly with screws and aluminum tapes.
21. At this point, the three HV cables are still connected to the Jupiter connectors and are drawn out separately for monitoring the HV behavior of the gas gaps after full assembly. These three connectors are then mounted on a separate panel.
22. The RPC is then loaded on to the cosmic hodoscope and flushed with RPC gas mixture (with 40 % humidity in the gas mixture) at 5 lph for a day, before ramping the HV. The HV is ramped slowly and the efficiency, cluster size, noise etc. monitored carefully from 8.6 kV to 9.6 kV in steps of 100 V.
23. If the efficiency is better than 95%, cluster size less than 3.0 at 9.4 kV, the strip profile and dark currents as expected and the chamber is not too noisy, then the RPC is said to have qualified the cosmic QC. While measuring the efficiency, the top and bottom layers are monitored separately for their efficiencies with a quick cosmic scan to ensure that both the layers are functioning independently.
24. For the chamber that has qualified the cosmic test, the three Jupiter connectors are then replaced with the tripolar HV connector and fixed with the potting compound (Stycast), which needs 24 hours for curing. The tripolar HV connector is then mounted on the "L profile – long" at the wider end as shown schematically in Fig. 12. (HV connector figure to be provided)
25. Then the chamber is monitored again for its dark current for a week and if the performance is found satisfactory (currents not increasing appreciably), the chamber can then be shifted for transportation.

4. Efficiency measurements :

The RE4/2-CERN-PP01, after full assembly was subjected to cosmic tests with two scintillator paddles mounted above and beneath the RPC and scanning the region A1, B1 and C1. The present configuration for evaluating the efficiency was borrowed from RD51, as the cosmic hodoscope was not functional in ISR. The single rates from the scintillators, S1 (bottom) and S2 (top) were of the order of ~3 Hand ~ 5 Hz at a threshold of -120 mV and -180 mV respectively (Fig. 13).

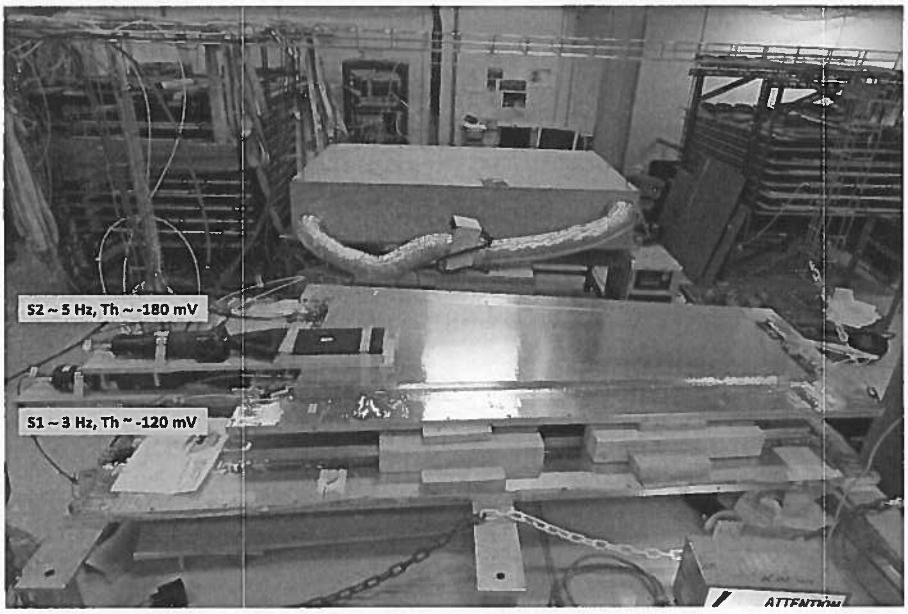
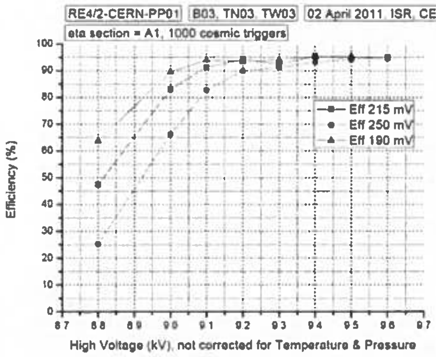


Fig. 13, Efficiency measurement for RPC

The coincidence trigger was of the order of ~ 0.3 Hz. For the efficiency scan 1000 cosmic triggers were taken. The plots below (Fig. 14 to 16) show the efficiency scan and cluster size as a function of high voltage for segment A1 for different thresholds on FEBs (190 mV, 215 mV and 250 mV). The HV is not corrected for the pressure and temperature. As is seen from the plot (Fig. 14 - left), the RPC had more than 95 % efficiency at the operating voltage of 9.4 kV from all the three segments. While taking the efficiency scan, the top and bottom layers were also scanned separately for their efficiencies, as such to ascertain the functioning of the two layers independently. For such a measurement, the HV for the layer which was not to be scanned was reduced to 7 kV (Fig. 15 - right). Plots in Fig. 16, shows the cluster size and strip profile (1 cluster) for segment B1 at 9.4 kV.



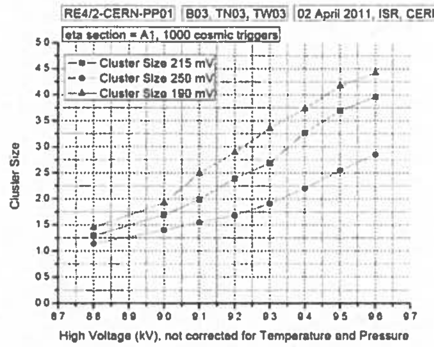
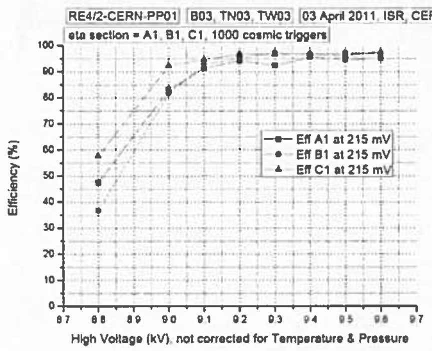


Fig. 14, Efficiency (left) and cluster size (right) from A1 for different thresholds



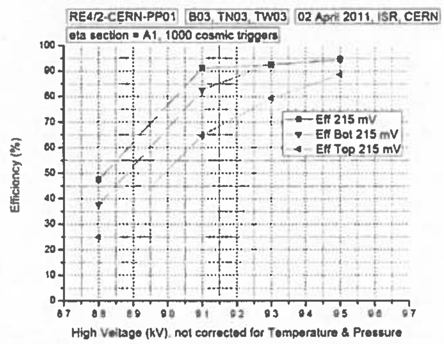
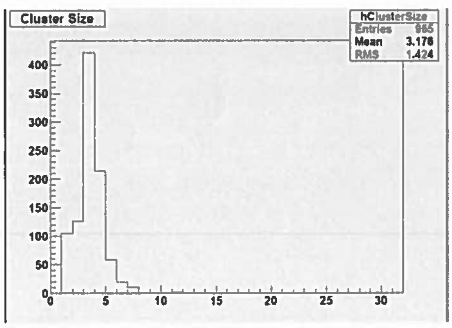


Fig. 15, Efficiencies from the three segments A1, B1 and C1 at 215 mV (left) and efficiencies of Top and Bottom layers from A1 segment



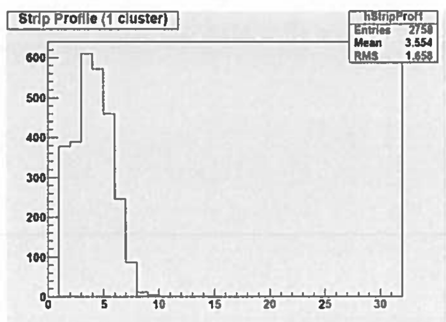


Fig. 16, Cluster size (left) and Strip profile-1 cluster (right) from B1 segment at 9.4 kV

In parallel, after the arrival of the team from Ghent, the assembly of RE4/3-CERN-PP01 and RE4/2-CERN-PP02 was also started. The team members from Ghent were explained about all the steps involved in the assembly from spacer tests to final assembly. However, as the Cu cooling drawings were still being iterated, the Cu cooling assembly was not ready at the time of writing this report.

To summarise, the following was achieved during the March visit at ISR :

a. Full assembly of RE4/2-CERN-PP01 with cosmic QC

b. Partial assembly of RE4/3-CERN-PP01 – held up for arrival of Cu cooling assembly

c. Partial assembly of Re4/2-PP02 – held up for arrival of Cu cooling assembly

The two partially assembled RPCs are lying on the tables for further patch panel mounting with Cu cooling system in ISR.

5. Time schedules and deliverables :

As per the RPC Upgrade meeting on 15th March 2011 and the time scale as shown in the chart in Fig. 17 below, it is proposed that the production of first ten chambers at the assembly sites in Ghent (Belgium) and Mumbai (India) should commence from August 2011.

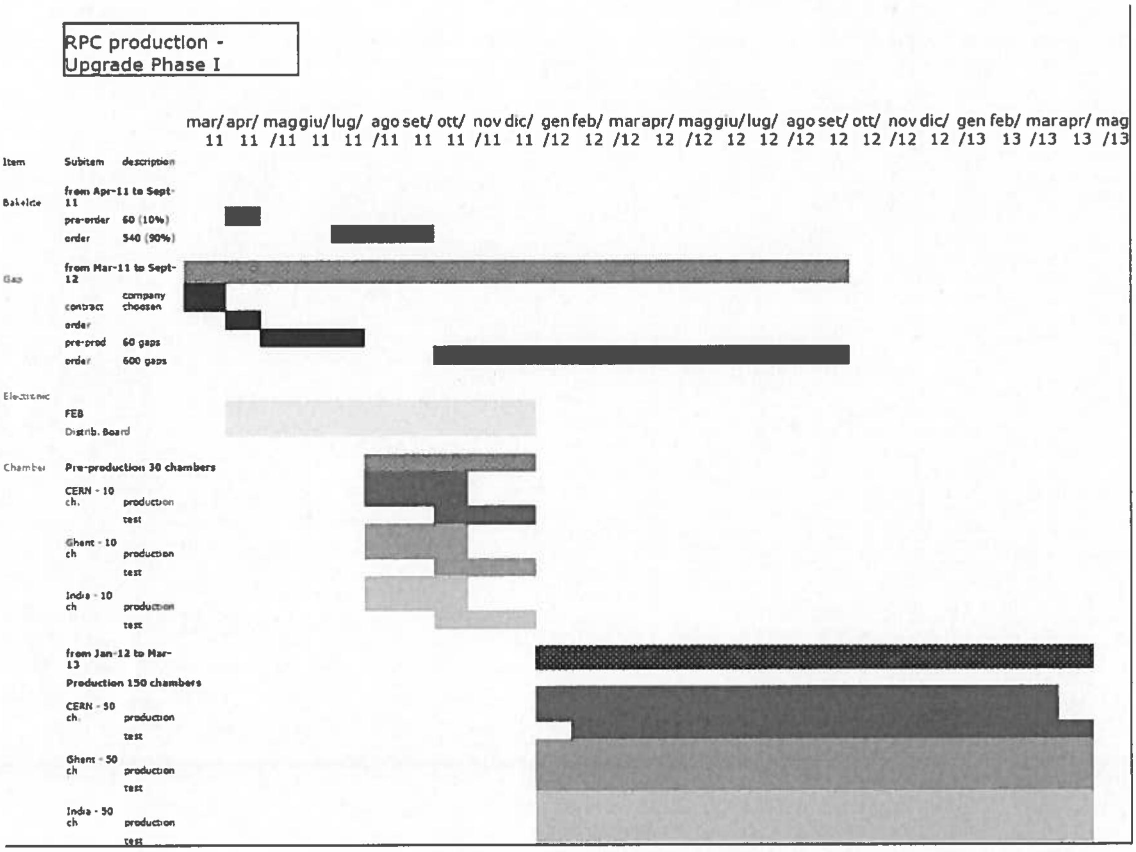


Fig. 17, The proposed time schedule for Pre Production

In order to follow the time schedule it is necessary that the following components arrive at the assembly sites by **31st July 2011**, as shown below in Table 8 for Pre-Production of first ten chambers at each of the three assembly sites, totaling to thirty chambers in all.

Table 8

SN	Equipment	Location	Responsible	Arrival at assembly sites
1	Gas gaps	Korea/Italy	?	**31st July 2011**
2	Mechanics	China	Yong Bang	**31st July 2011**
3	Electronics	Pakistan	Waqar Ahmed	**31st July 2011**
4	Accessories	Mumbai Ghent	L. M. Pant M. Tytgat	**31st July 2011**
5	Components from CERN	CERN	Ian Crotty	**31st July 2011**
6	Delivery of RPCs from assembly sites	Mumbai Ghent CERN	L. M. Pant M. Tytgat A. Sharma	**31st Dec., 2011**

As, the components would first arrive at CERN and then dispatched to the assembly sites, one has to take into account the necessary delays involved in procurement, fabrication, pre-tests, transport, custom clearances, etc. so that the pre-production could commence at the assembly sites from 01st August 2011. For the fabrication of the Distribution Board, the delay in testing the chip should be discussed in subsequent RPC Upgrade meetings.

The most important among the above is the procurement of components by CERN for the three assembly sites, for a total of 30 chambers with 10 chambers for each assembly site, which should be :

1. **ordered by CERN by — end of April 2011,**
2. **procured by CERN by — end of May 2011,**
3. **dispatched by CERN by — end of June 2011,**
4. **delivery at Assembly sites by — end of July 2011**

The detailed list has been discussed in RPC Upgrade meetings for which the ordering / procurement should start immediately.

6. Open queries :

The following queries need to be addressed and resolved in subsequent meetings :

1. At the assembly sites, after the full assembly, whether, the tripolar HV connector is to be installed on the patch panel or the chamber is to be sent with three Jupiter connectors for the three gaps.
2. Thirty days of monitoring dark current after full assembly and before shipment looks like an overexercise. Dark current monitoring could be reduced to week to see the long term performance of the chambers.
3. Whether, temperature sensors are to be mounted at the assembly sites. If so their positions are to be defined, the connector is to be established which may need to be fixed on the patch panel.
4. Decision on use of conducting gel beneath the Cu plates.

7. Acknowledgements :

I would like to thank Waqar, Cai, Andrey, Nicolas, Yong, Luc, Walter, Ian and Archana for many useful discussions, assembly, testing and characterizing of the chambers in ISR and valuable inputs for preparing this report.

End of report

PS :

1. Drawings based from the following source – were last modified in March 2011
   http://w3.iihe.ac.be/~vanlanck/RE4-Ring3/
   http://w3.iihe.ac.be/~vanlanck/RE4-Ring2/

2. Please find all the final drawings for RE4/2 and RE4/3 on the RE4 web site, uploaded in April 2011 :

   https://rpc-cms-re4-upscope.web.cern.ch/rpc-cms-re4-upscope/RPC/Chamber%20production/Components/Mechanics/LucDrawings/REtype3/29April2011/

   and

   https://rpc-cms-re4-upscope.web.cern.ch/rpc-cms-re4-upscope/RPC/Chamber%20production/Components/Mechanics/LucDrawings/REtype2/29April2011/