RE4-1 & RE3-1 a proposal for the Phase II

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Muon Upgrade

RPC community is working on the RE4-1 & RE3-1 phase II upgrade

- A preliminary version of the proposal has been included in present version of the muon TP.
- A preliminary cost book has been prepared for the April RRB meeting.
- An RPC R&D proposal document will be circulated in May 2014.

- An R&D activity on the next generation of Bakelite RPC is starting this year with the following main goals:
    - Test the present detector up to the 3000 fb-1 needed for HL-LHC
    - Improve the present design thanks to the lesson learned during LS1
    - Design a iRPC (thin gap, new front-end electronic, eco-gas, multi-gap….) to be able to run in the inner ring of the two outermost disks at a maximum rate of about 1 KHz/cm^2 and an Integrated charge of about 1 C/cm^2.

Basic upgrade info

The two main requirements, described before, can be fulfilled optimizing the bulk resistivity of the Bakelite electrodes and the average charge generated by the avalanche.

- The role of these parameters can be explained looking at the three following equations, obtained using simple electrostatic model:
  - The time constant of an elementary cell involved in the avalanche process:

  $t = e_0 (e_r + 2) r$
  - The area of the “cell” concerned in the discharge: $S = 2\langle q\rangle/e_0E = 2\langle q\rangle d/e_0V_d$
  - The rate capability of the single cell: $r = 1/St$

Where <q> is the average charge per avalanche (C), r is the rate (Hz/cm^2), r is bulk resistivity (Ωcm), s_e is the electrode thickness (cm), ε_ρ is the relative dielectric constant of the electrode, E is the electric field inside the gas, V_d is the voltage drop that stop the avalanche in the cell and d is the gas gap width.

- To increase the rate capability and reach the kHz/cm^2 foreseen in the high eta region we can <u>decrease the resistivity of the Bakelite electrode and reduce the average charge <q> associated to the avalanche</u>. A resistivity around 10^{10} Ωcm can be produced taking into account that for the RE4 region we were already able to reach the 2-3$\times 10^{10}$ Ωcm.
- A thinner gas gap (from 2 mm to 1.5-1.0 mm) and a more performing front-end chip are two possible aspects to be investigated to reduce the average charge produce in an avalanche and at same time the power consumption of the detector.

Some useful numbers

- RE4 system consists of 144 chambers and cover a region of about 230 m^2.
  - Average chamber area is about 1.6 m^2.
- Chamber cost was about 2.20 MCHF (half of the total)
- Total cost is 4.2 MCHF
- RE4-1 and RE3-1 cover a region of 115 m^2
  - 72 chambers (20^o) needed
  - Average chamber area is about 1.6 m^2.
- We can apply a factor 2 to the cost of the chamber construction and to some services (HV, LV and Gas)

Estimated cost

- Chambers cost is about 1.43 MCHF
- Electronics has been scaled with number of channels.
- Services and installation costs are the same of RE4.
- A contingency of about 10% has been included in the total cost.
- Most of the numbers have been easily extrapolated from RE4 project and are very close to the today cost.

Summary

Chamber	**1430**
Electronics	**415**
Services	**601**
Installation	**290**
Contingency	**273,6**
TOTAL	**3010**

Note:

20º chamber mode:		# component	# incl. Spare
# chambers		72	100
# strip per chamber		96	
# FEBs		288	300
# HV channels		36	40
# HV boards		7,2	8

Detailed costs

item	quantity	cost
Detector 20º size		**1000**
Bakelite	300	200
Chamber mechanics/strips	100	150
Gap	600	400
Chamber cooling circuit	100	100
Varie		100
R&D		50
FE Electronics		**200**
FE boards/ distribution board	400	160
Strip connect. To FE		40
Off detector electronics		**215**
Link Boards	100	100
Control Boards	25	35
LB integration	manpower	80
Link Box	10	10
Trigger		
Services		**450**
HV & LV systems	40 channels	200
HV&LV integration	manpower	30
Cooling System		100
Gas system		100
Miscellanea		20

Cables		**151**
Signal		30
HV&LV DCS		20
LB Fiber		10
HV connector		50
LV connector		1
Connectorisation (Manpower)		40
Chamber assem&test		**430**
Infrastruture at site		100
Assembly consumable at sites		100
Ass&test manpower at 904		100
Shipment to CERN		80
Chamber test at 904		50
Logistic & Installation		**290**
Consumable installation		60
Mechanics installation		100
Manpower installation		80
Manpoower commissioning		50
Contingency		**273,6**
Total cost		**3010**

Conclusion

- Present RPCs have been certified up to 400 Hz/cm^2 and will be test up to 1 kHz/cm^2 at GIF++.
- A lower resistivity Bakelite foils and a more performing electronics will be studied.
- At same time a thin gap (eventually multi-gap) detector will be designed and tested at GIF++ in the next 2 years.
- A preliminary table cost have been produced (uncertainty of 10%) in details.
- TP and R&D document will be ready in few months.
- More simulation studies are going on.
- RPC institutions are thinking about the next upgrades and in June 2014 we will have the full list of interested people.