

RPC limits in view of LHC upgrade (preliminary thoughts)

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For the RPC group*

Muon Strategy Group mandate

From Pino Iaselli minutes of the first Muon Strategy Group meeting

- The CMS upgrade office demands the muon community to study the performance detector perspective toward 2020 versus the foreseen trigger scheme and the background conditions. The physics case should be also clearly addressed and motivated.
- In such framework, possible detector upgrades and related technologies should be evaluated. In particular, the GEM option should be investigated in view of some important interest of part of the muon community for this new technology. However it is also recommended to look at other options.
- Preliminarily it is pointed out that barrel and forward region could have emphasis on different issues. It is therefore decided that each sub detect prepares a list of possible expected problems to be addressed for high luminosity operation. It is especially felt that the “barrel- forward” overlap region could requires some carefully understanding. Also certainly, high eta completion is an important milestone.

Outline

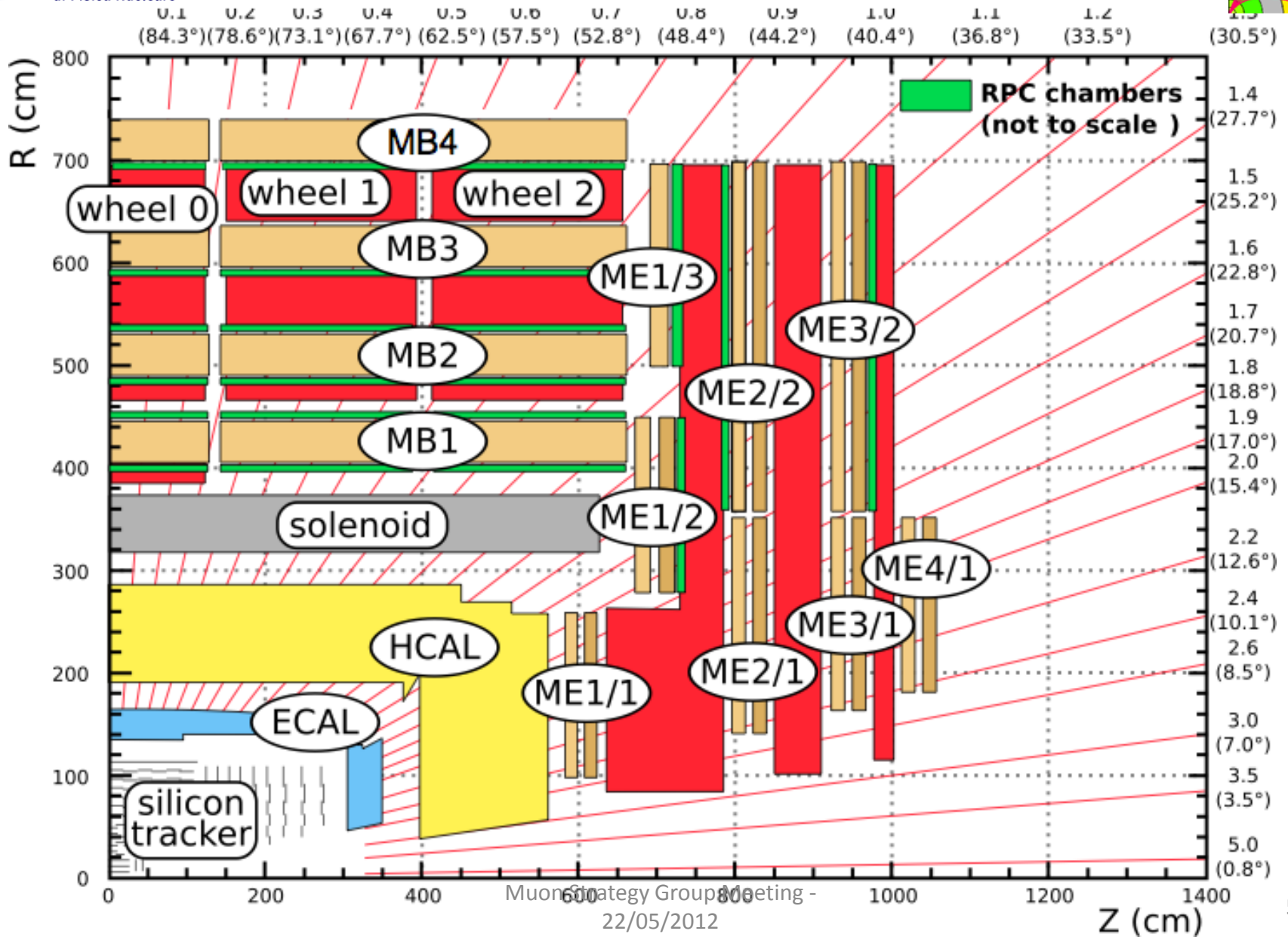


- Collection of informations to discuss about perspectives for RPC performance in the next years
- Layout of slides fitted for the plenary report of this afternoon
 - To be merged with trigger part (see next talk of Karol)

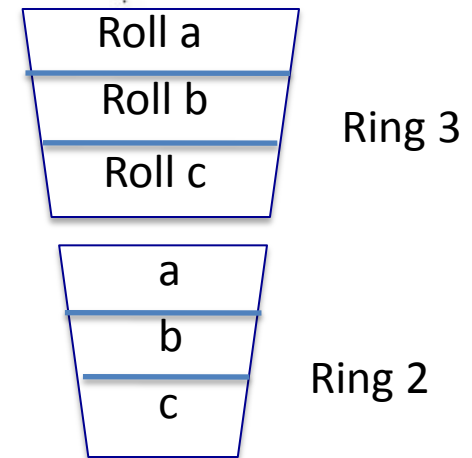
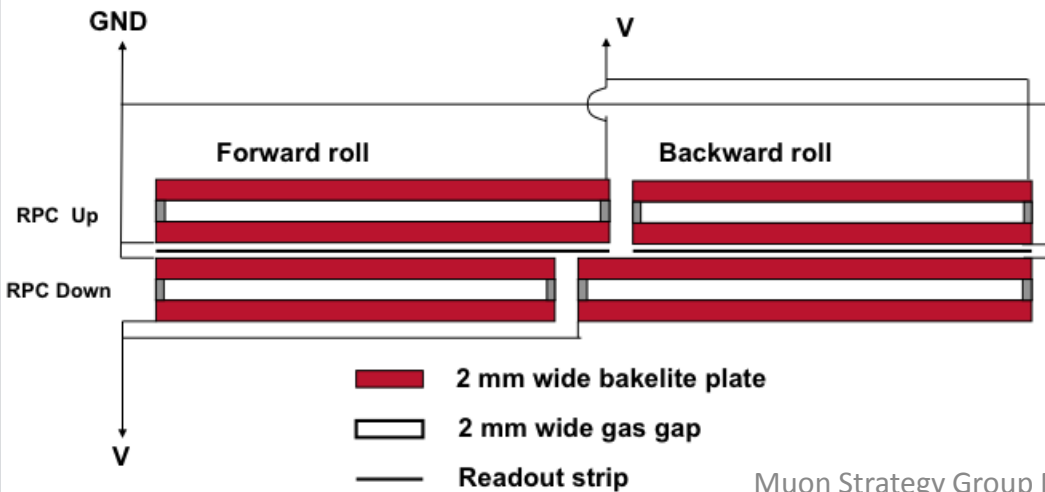
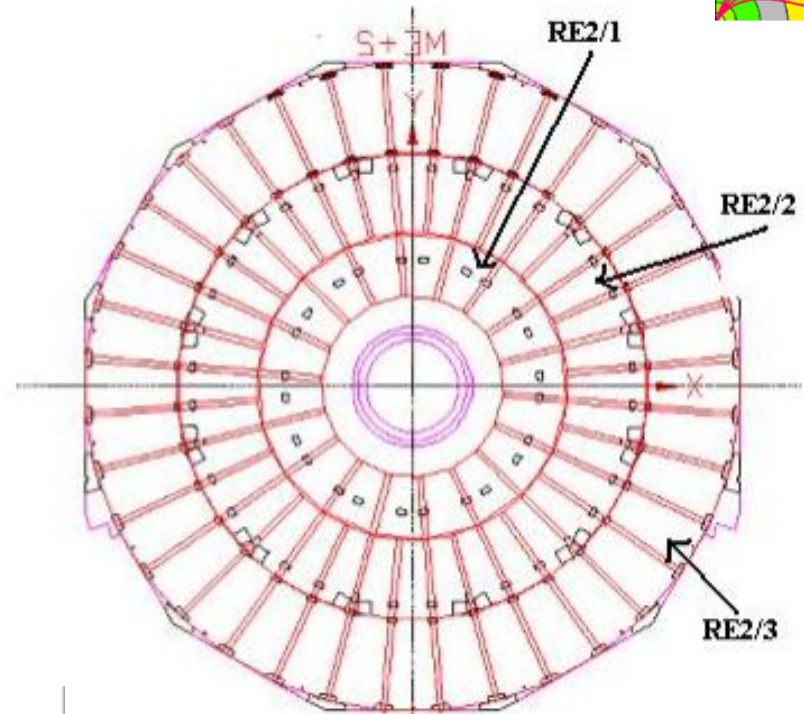
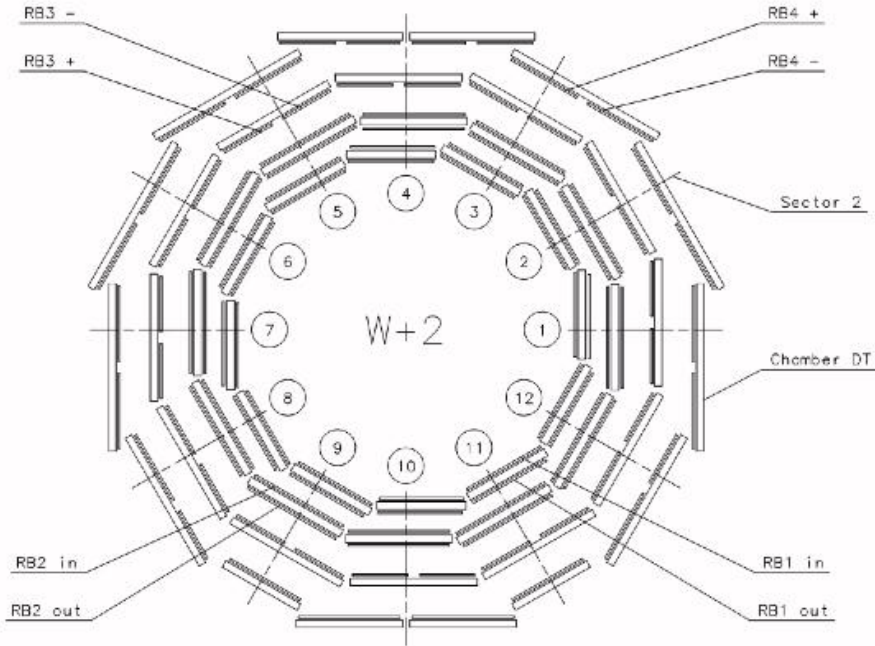
RPC Production

- RPC Barrel and massive construction between 2002-2007
 - Barrel: 480 chambers (1020 rolls)
 - Endcap: Cover just $|\eta| < 1.6$
 - Station 1, 2 and 3, rings 2 and 3
 - 432 chambers (1296 rolls)

RPC geometry



RPC geometry (2)

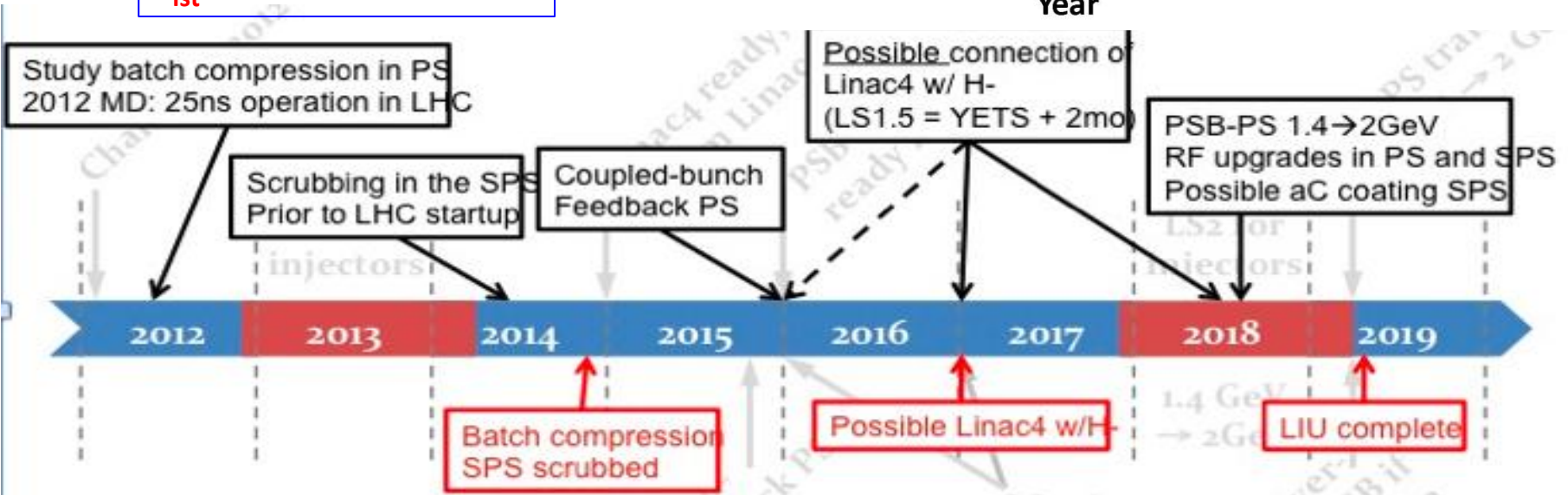
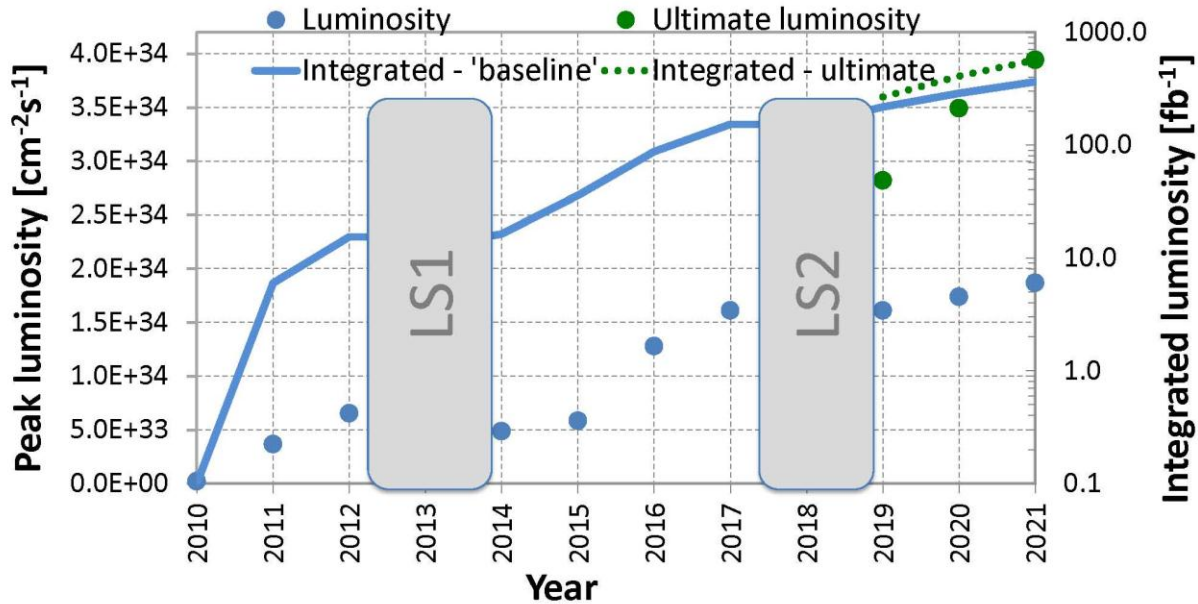


LHC projections



10-year projection from
 - Frank Zimmerman's talk CMS Upgrade Workshop, Fermilab, Nov 2011 and
 - H. Damerou's talk on LHC Injector Upgrade at Chamonix 2012

AS reference I will use
 $L_{int} = 1000 \text{ fb}^{-1}$
 $L_{ist} = 10^{35} \text{ cm}^{-2} \text{ s}^{-1}$



Electronics



- Main on-detector electronics has been tested up the doses of > 10 LHC years
 - Neutron fluence 10^{12} , corresponding to >10 LHC years for RE1/1 (RPCs at $|\eta| < 1.6$)
- Most of the Front End electronics is analogic
 - SEUs just increase the random noise rate
 - Only a small Digital Memory for FEB threshold
- SEU events have not been detected during test
- More discussion in progress
 - Front End (Flavio Loddo)
 - Trigger electronics (Poland group)

- Theoretical limits of the RPC system at TDR time (1997):
 - RPC performance: efficiency $\sim 95\%$ up to $1\text{kHz}/\text{cm}^2$
 - RPC trigger system stable up to $\sim 100\text{Hz}/\text{cm}^2$
- Test at GIF
 - Integrated charge: RPC tested at GIF up to $0.3\text{C}/\text{cm}^2$
 - $\langle Q \rangle \sim 30\text{pC}/\text{hit}$ (preliminary studies on data collected ongoing confirms the value see next slides)

Background rate (Barrel)



Higher rates in Barrel:

External wheels

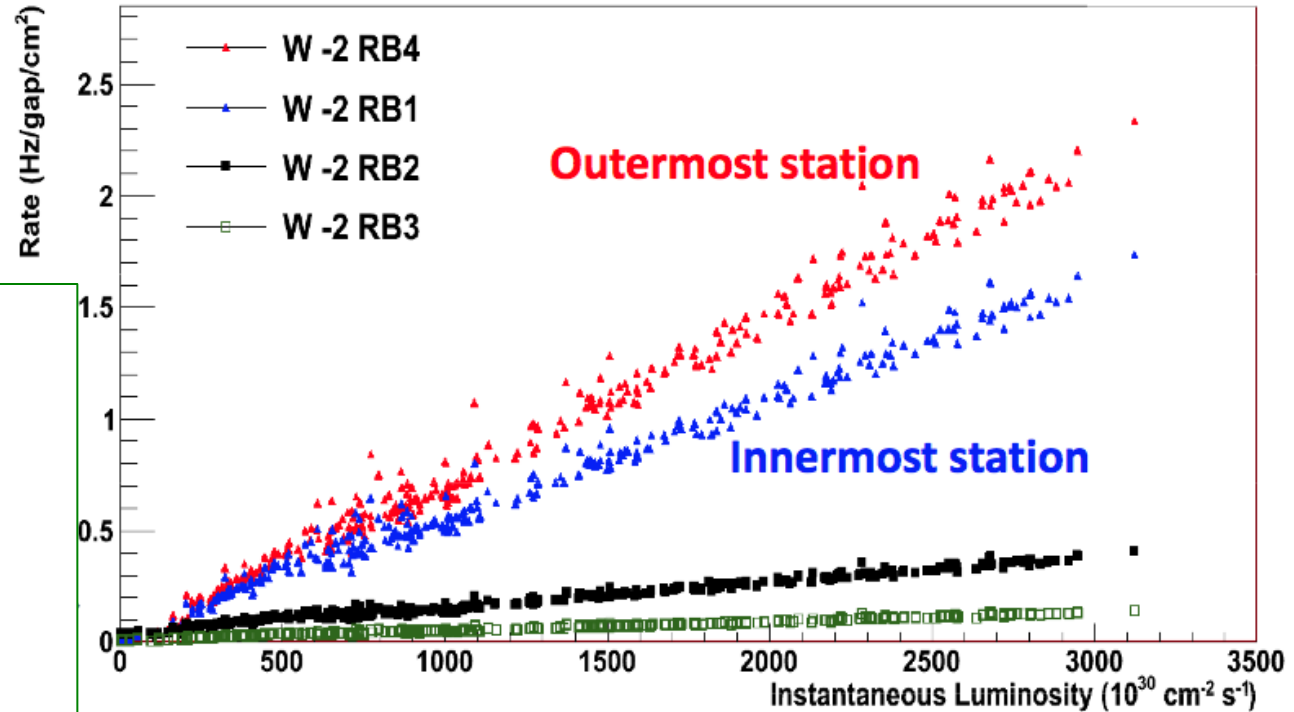
Innermost and
outermost stations

For RB4 W-2
Rate = 1.4 * L

[L] = $10^{33} \text{ cm}^{-2} \text{ s}^{-1}$
[Rate] = Hz/cm^2

Linear Extrapolation
at $L = 10^{35} \text{ cm}^{-2} \text{ s}^{-1}$
Rate = $140 \text{ Hz}/\text{cm}^2$

RB2 and RB3 at least a factor 5
less



Consequences:

RPC performance should not be affected up to $10^{35} \text{ cm}^{-2} \text{ s}^{-1}$

Trigger performance to be checked

Warning:

this is mean rate. Due to phi asymmetry in RB4 some chamber could get a factor 2 more

Background rate (Endcap)

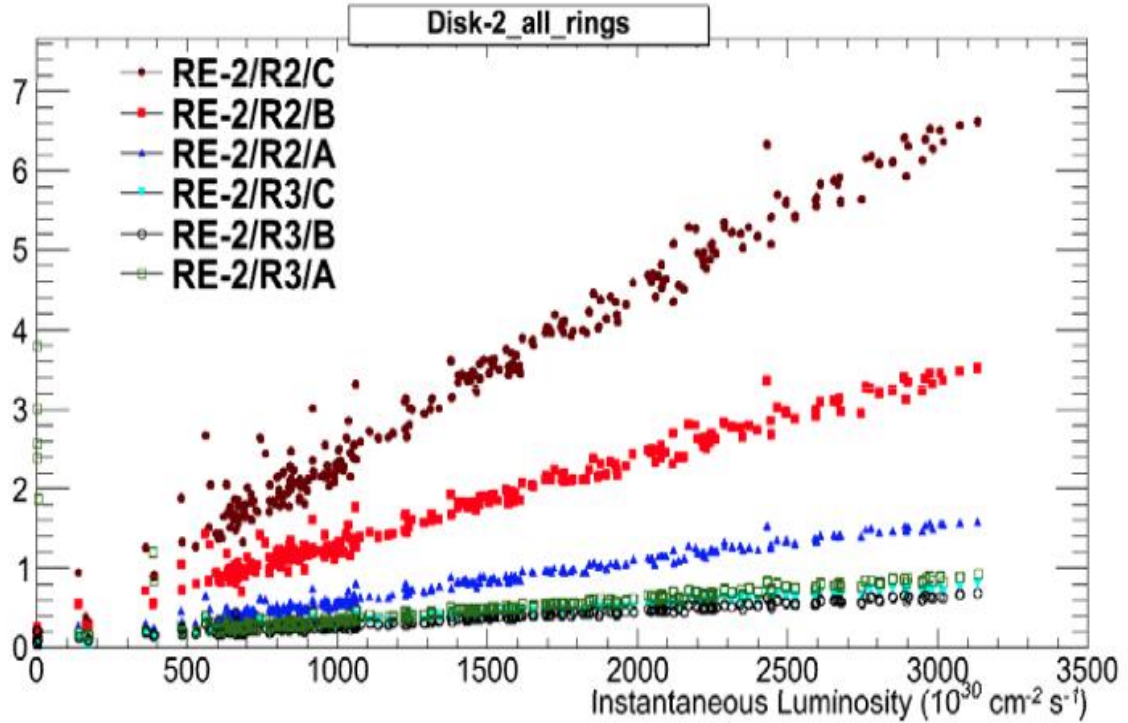


Higher rates in Endcap:

Innermost Rings

Station 2 and station 3

(Hz/gap/cm²)



For RE-2/R2/C

$$\text{Rate} = 4 * L$$

$$[L] = 10^{33} \text{ cm}^{-2} \text{ s}^{-1}$$

$$[\text{Rate}] = \text{Hz/cm}^2$$

Linear Extrapolation

$$\text{at } L = 10^{35} \text{ cm}^{-2} \text{ s}^{-1}$$

$$\text{Rate} = 400 \text{ Hz/cm}^2$$

Consequences:

RPC performance should not be affected up to $10^{35} \text{ cm}^{-2} \text{ s}^{-1}$

Trigger performance to be checked

What happen to RE4 ?

Integrated charge (Preliminary)



r = rate in hz/cm²
L = ist. Lumi in cm⁻² s⁻¹



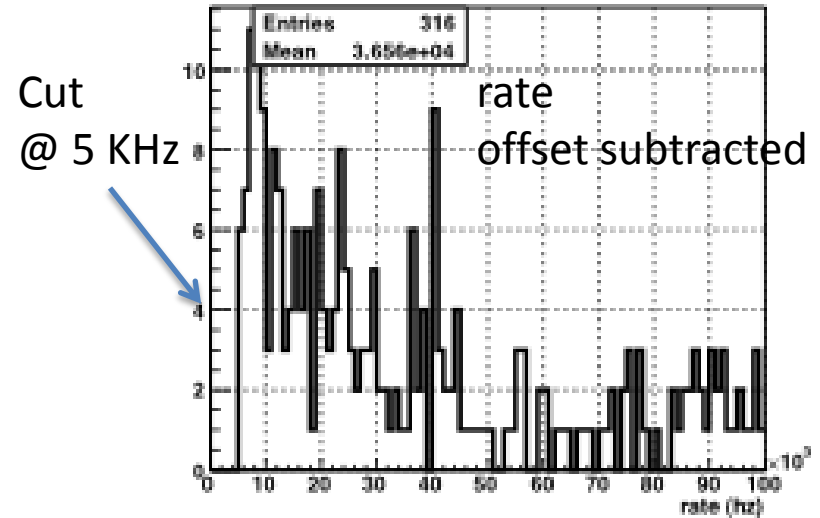
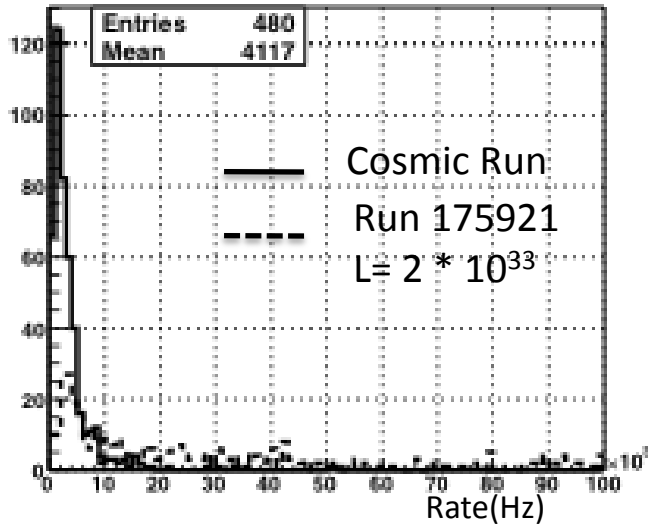
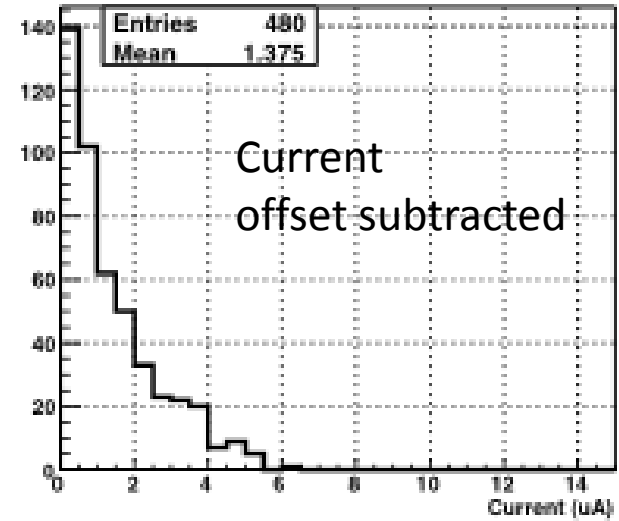
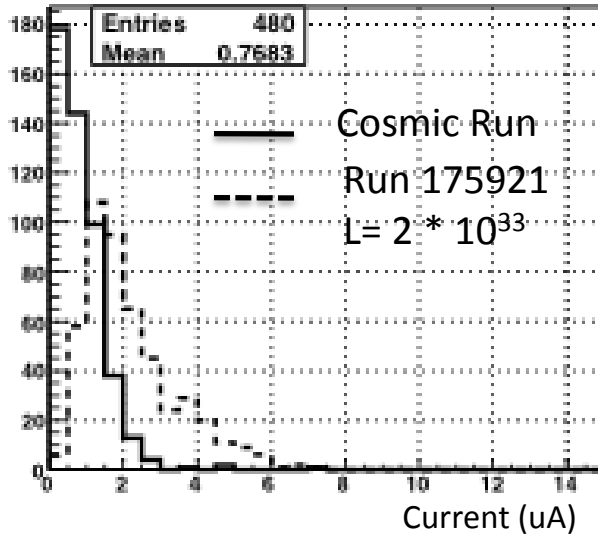
If the rate is linear as a function of L
the total integrated charge is a function of integrated Luminosity

Extrapolation to 1000 fb⁻¹ for RE-2/R2/C :

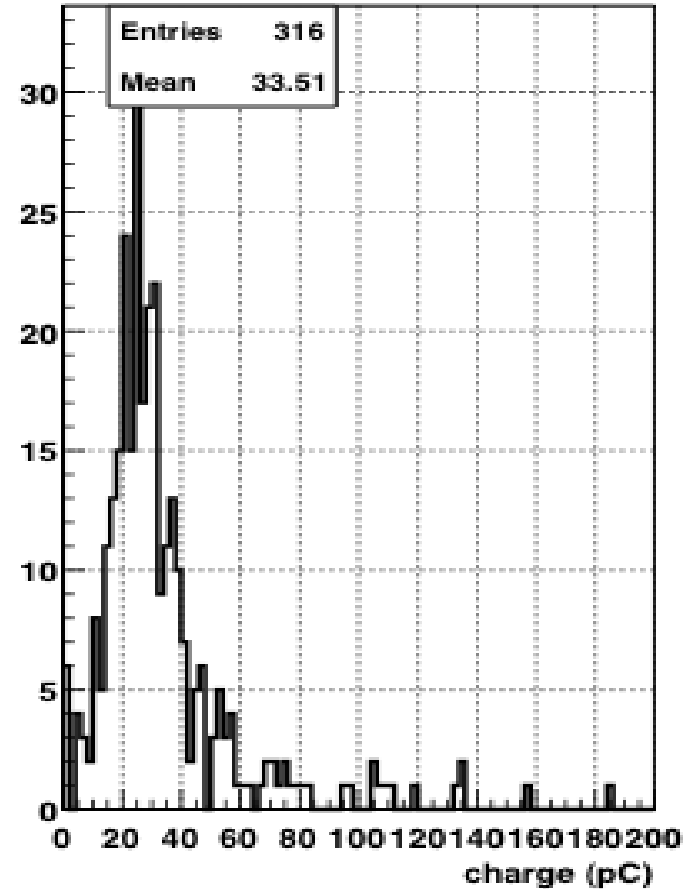
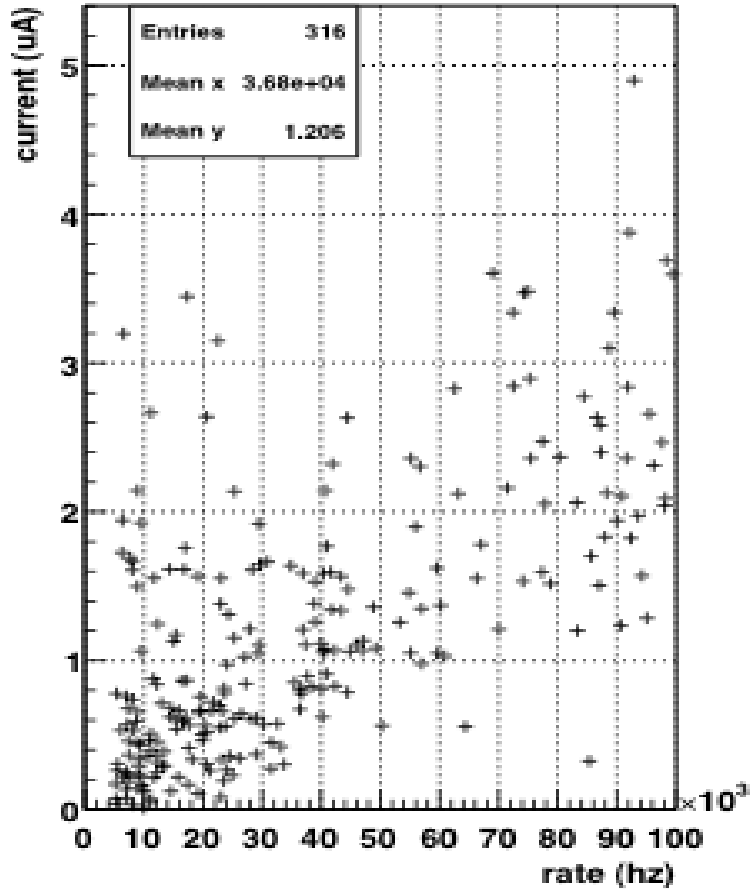
$$N = 0.4 \cdot 10^{10} \text{ hits/cm}^2$$

Q ~ 0.12 C/cm² innermost ring of endcap still under the limit of GIF test

RPC charge



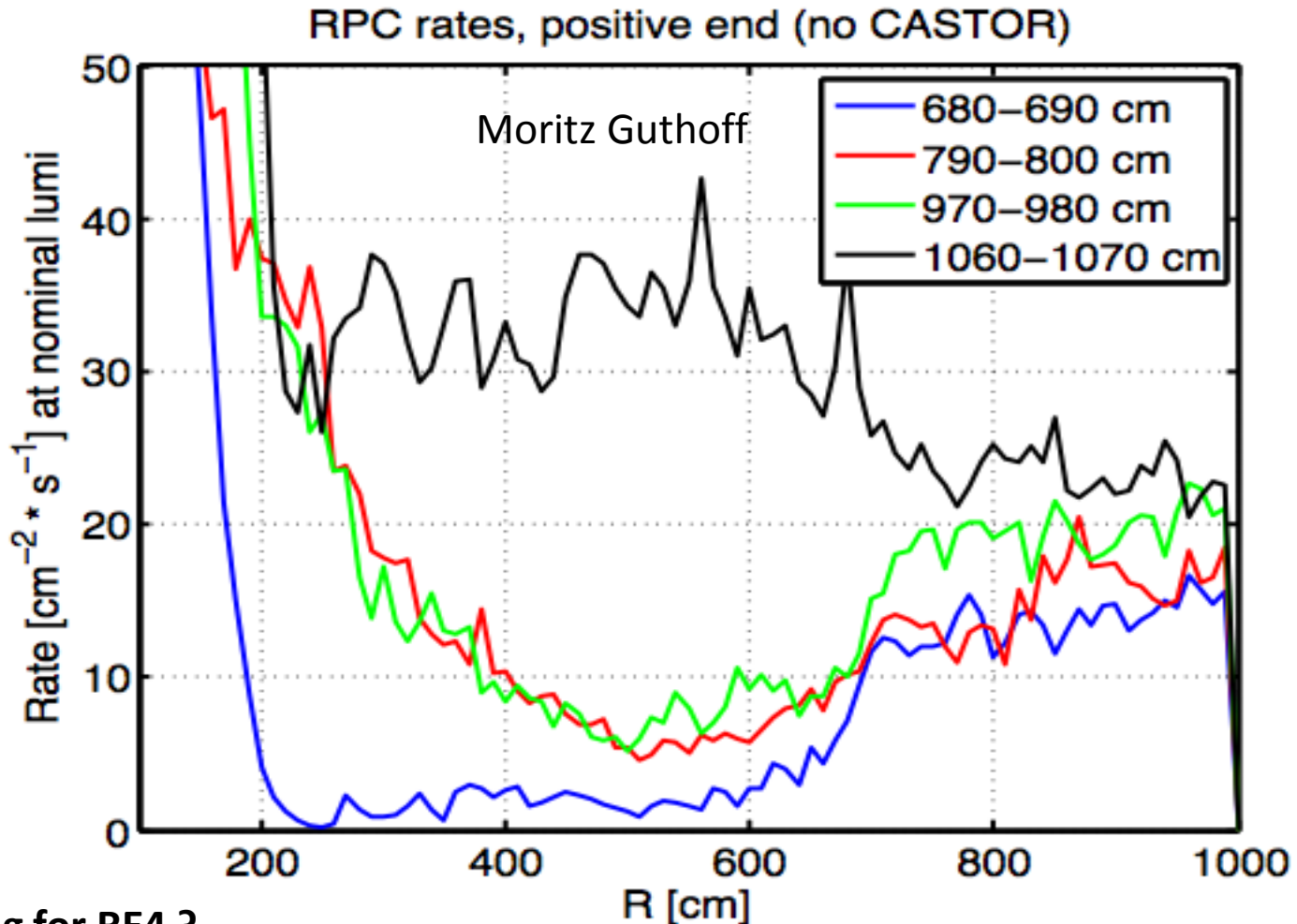
RPC charge



Background simulation



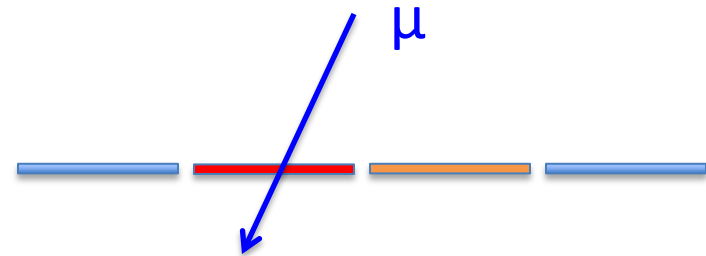
Expected RPC rates with neutrons (0.1% sensitivity) and photons (1% sensitivity), FLUKA,



No shielding for RE4 ?

Cluster size

- Higher cluster size affect trigger Pt assignment
- Probability to add spurious hits to a Physics cluster so to increase the cluster size:
 - Negligible: example for RB4 extrapolation at 10^{35} probability 0.15 %

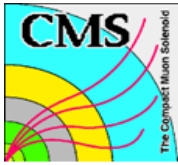


Plans

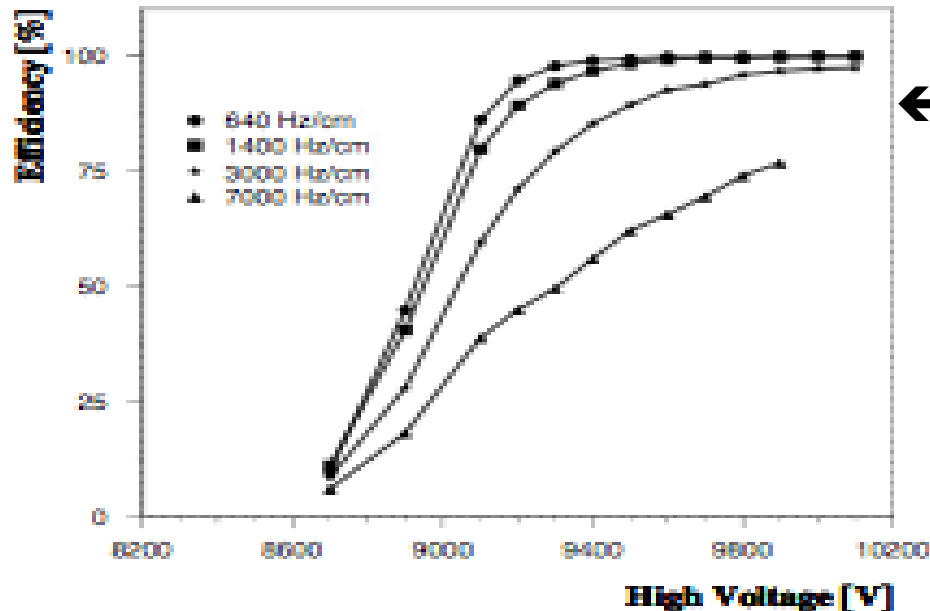


- Refine studies on background extrapolation
- Refine studies on charge estimation
 - Different regions, stability
- Background simulation with shielding on RE4
- Collection and organization of results at GIF
- Dedicated MC with rate distributions according to extrapolation
 - Study of impact on trigger performance
 - Study of impact on Muon Reco

Backup



- Theoretical limits of the RPC system at TDR time (1997):
 - RPC performance: efficiency $\sim 95\%$ up to $1\text{kHz}/\text{cm}^2$



← Test RPC with $10^{11} \Omega \text{ cm}$

Present RPC resistivity
 $1-5 * 10^{10} \Omega \text{ cm}$

- RPC trigger system stable up to $\sim 100 \text{Hz}/\text{cm}^2$