Brief Report on the high Luminosity Fill 2110 and a first attempt to estimate of the expected limit of RPC currents

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1. Introduction

The following report contains information about the high luminosity fill 2110 and some very personal predictions about the expected maximum RPC currents we have to cope with in the future when LHC will hopefully run at higher luminosity. This latter contribution got benefit from the very nice presentation sent by Plamen and Nicolas and Min-Suk. Though the quantitative data come only for the Barrel, I assume they will apply also to the Endcap (which sustain a higher particle flux).

2. Over current and Trip of chambers

At the beginning of the fill 2010 (Run 176463) we had the following:

- <u>Over current (OVC) oscillations of channel EN3_R2_R3_CH36 (see Fig 1)</u>

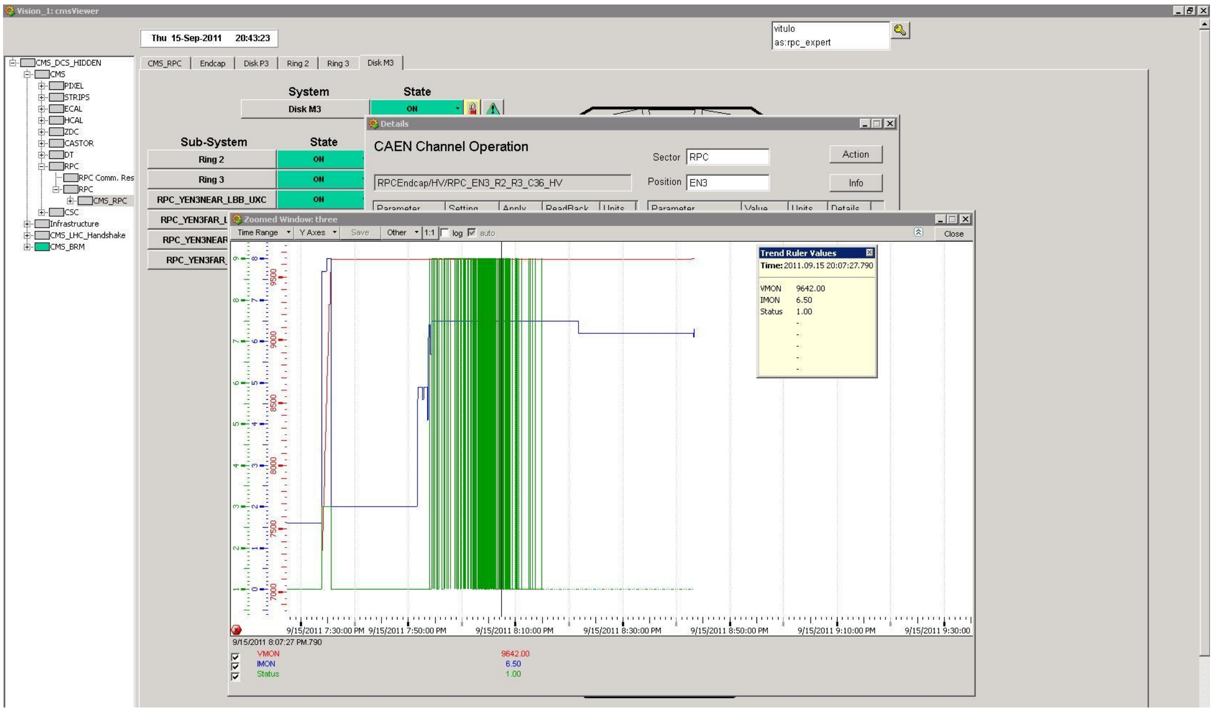

Fig. 1 OVC oscillations of the endcap chamber EN3_R2_R3_CH36 as a function of the time after the beginning of Fill 2110. Current-Imon (blu curve), Voltage-Vmon (red curve) and Status (green curve) are superimposed. In the small square their values at a particular time (indicated by the black line) are also shown.

- <u>Over current (OVC) oscillations of channel EP3_R2_R3_CH21 (see Fig 2)</u>

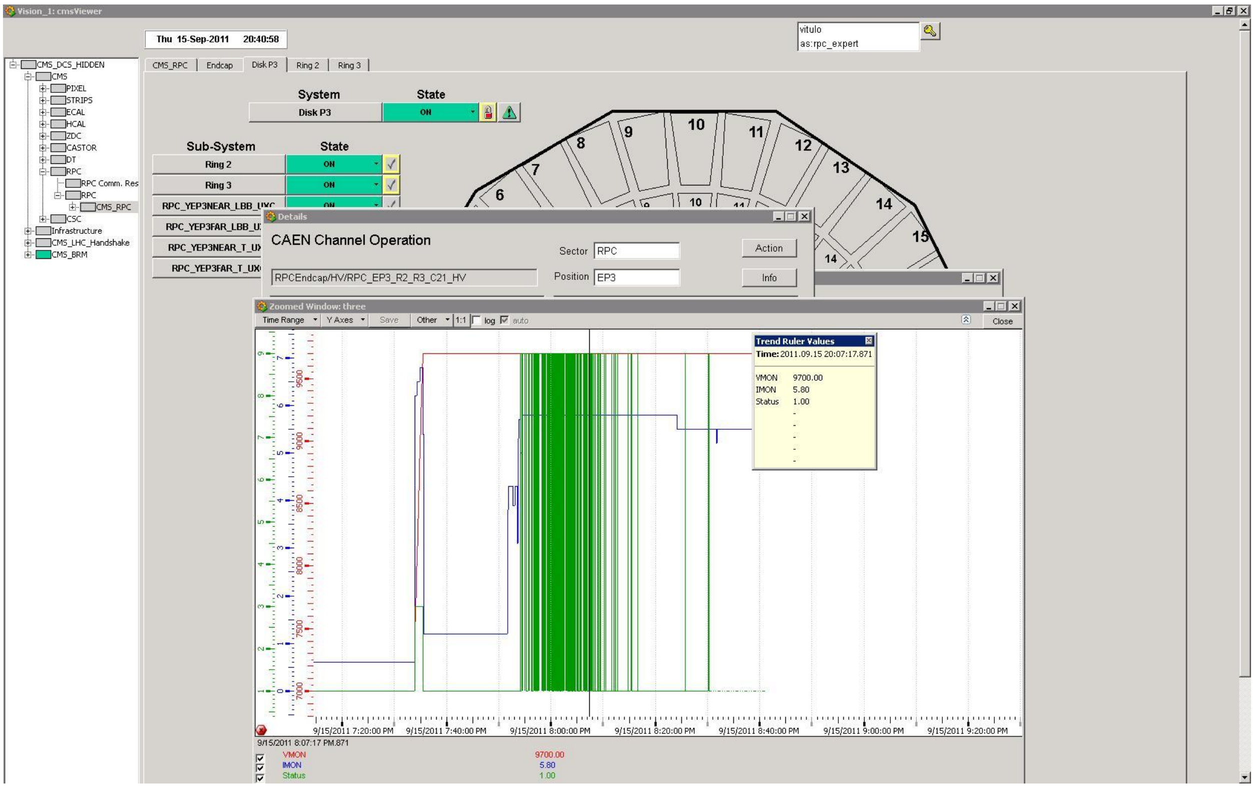

Fig. 2 OVC oscillations of the endcap chamber EP3_R2_R3_CH21 as a function of the time after the beginning of Fill 2110. Current-Imon (blu curve), Voltage-Vmon (red curve) and Status (green curve) are superimposed. In the small square their values at a particular time (indicated by the black line) are also shown

It is interesting to note that these OVC oscillations start at the same time and last both for about 20 minutes ; moreover the shape of their current (blue curve) is very similar and in some kind "strange" (see later on this) .

The plot in Fig. 3 is taken from the Condition Browser DB and shows the fill 2110 Instantaneous Luminosity in the time interval during which EN3_R23_CH36 and EP3_R23_CH21 were giving the pulsed OVC warnings. As can be seen from the figure the time window corresponds to the very beginning of the fill. After 20 minutes the OVC oscillations finished and the chambers worked properly up to the end of the fill.

Since the maximum allowed current for the chambers was i0= 10 uA one can guess that this value can be safe up to a luminosity of about 3.1 x 10^{33} cm^{-2} s^{-1} . Above this luminosity value these two chambers start to draw higher current.

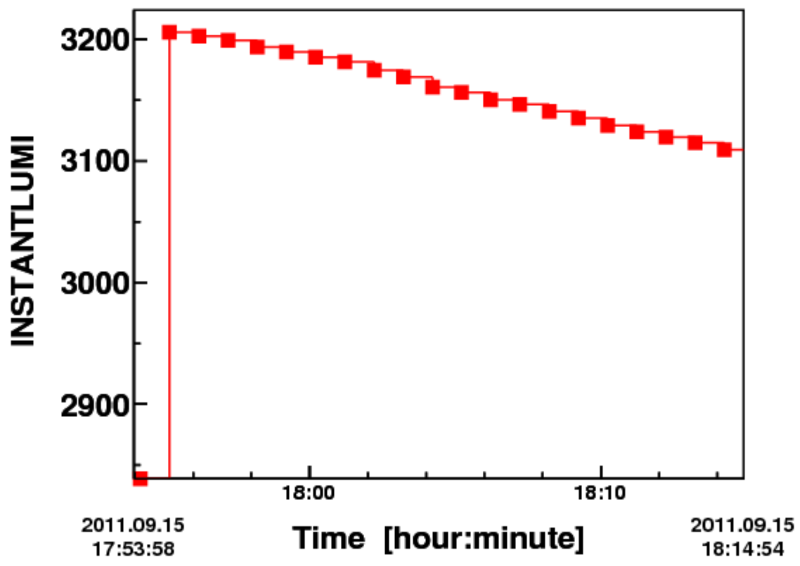

Fig. 3 Condition Browser DB: Instantaneous Luminosity (x 10^{30} cm^{-2} s^{-1}) for fill 2010 during the time in which EP3_R2_R3_CH21 and EN3_R2_R3_CH36 were giving OVC oscillations

Fig4 shows the same variable as Fig.3 but here we have expanded the time window to include also the adjust phase of the beams. The time is now in arbitrary units. The red circle defines the zone (corresponding to the "adjust beams" phase) in which the luminosity stops rising for a while before increasing again. Also a fluctuation appears at higher times.

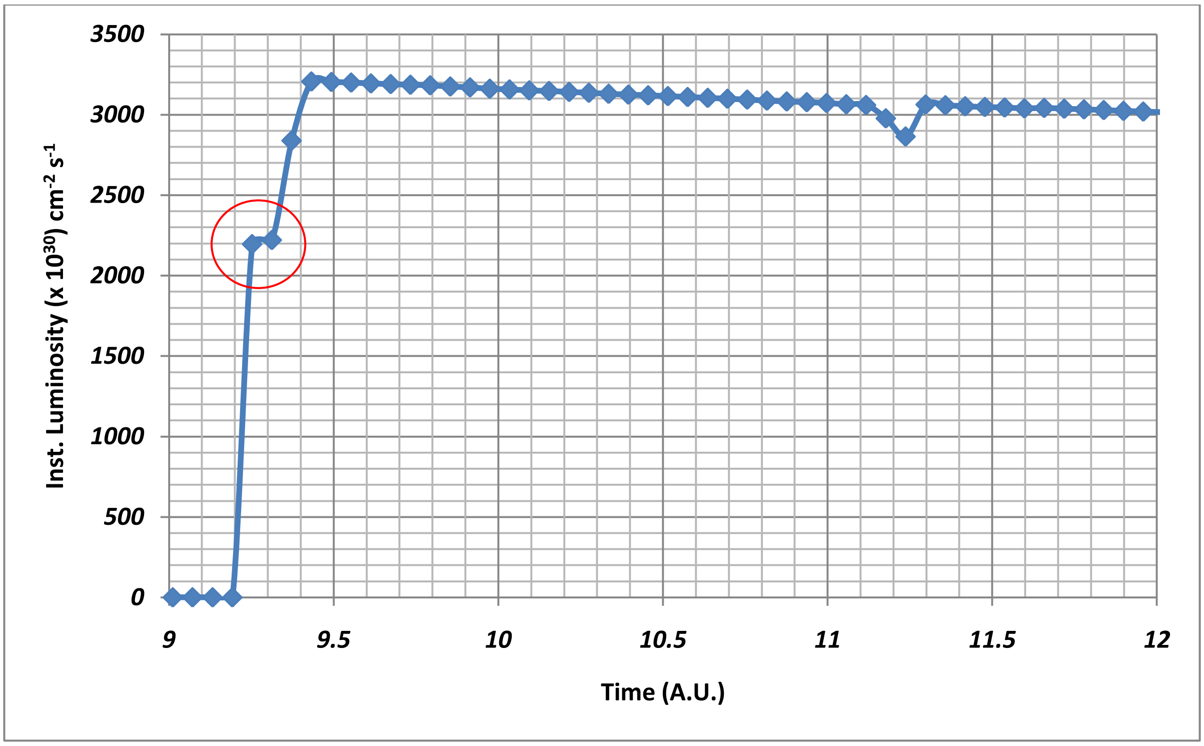

Fig. 4 Instantaneous Luminosity (x 10^{30} cm^{-2} s^{-1}) for fill 2110 as a function of time (in arbitrary units). The red circle defines the zone (corresponding to the "adjust beams" phase) in which the luminosity stops rising for a while before increasing again but less steeply.

As already observed by Plamen, during "adjust" of the beams the detectors start to increase their current. The shape of the currents follows the shape of the adjust region as shown in Fig. 5 where the luminosity plot in the adjust region has been expanded and superimposed to the currents of the two chambers. The correlation is evident.

Actually for chamber EP3_R23_CH21 (red curve) and EN3_R23_CH36 (purple curve) we plot the increase of the currents due to the beam (current during the fill minus current before the fill).

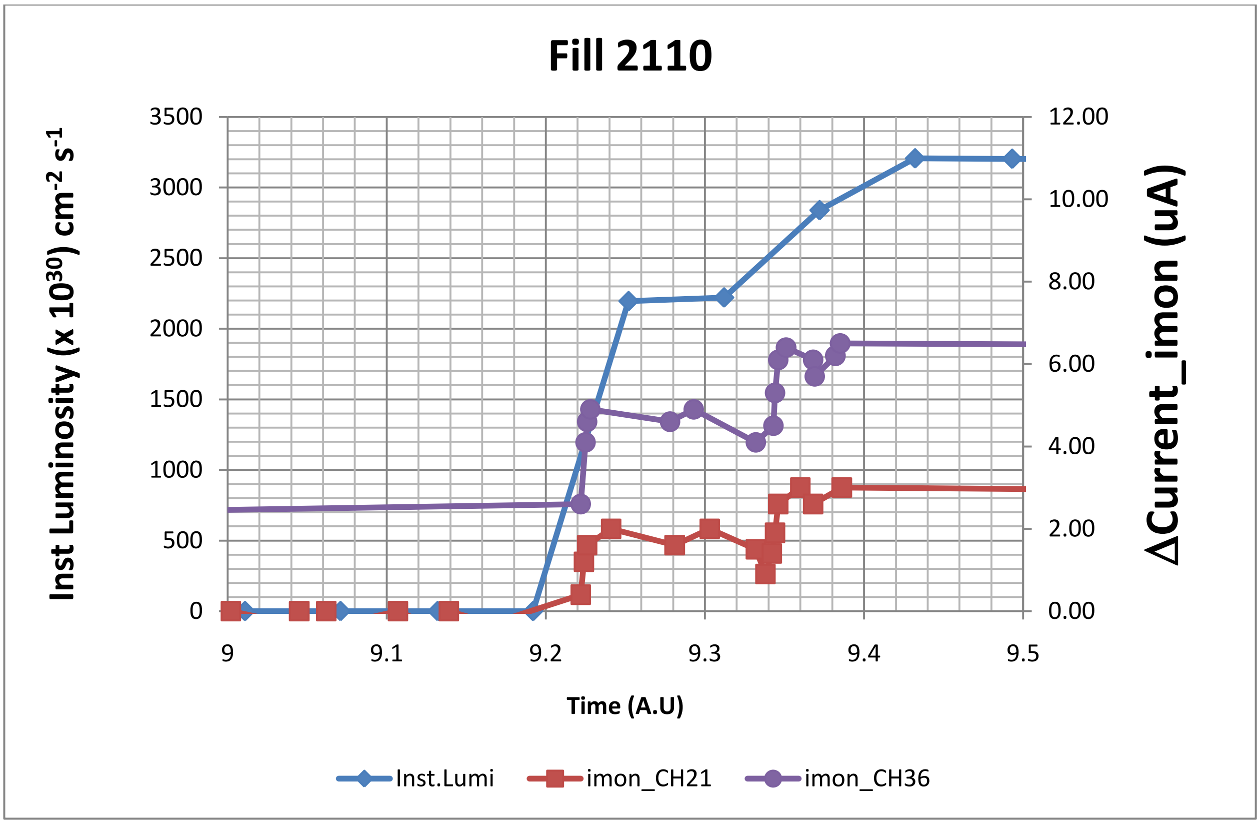

Fig. 5 Instantaneous Luminosity (x 10^{30} cm^{-2} s^{-1}) for fill 2011 as a function of time (in arbitrary units). The increase of the current during the fill has been superimposed for EP3_R23_CH21 (red curve) and for EN3_R23_CH36 (purple curve) .

The currents of the RPCs show two steps correlated to the "adjust beam" (up to 2.2 x 10^{33} cm^{-2} s^{-1}) and to the next increase of the luminosity (up to a maximum of 3.2 x 10^{33} cm^{-2} s^{-1}). More precisely chamber 21 increased its current by 1.6 uA per 2.2 luminosity-units (1 lumi-unit=10^{33} cm^{-2} s^{-1}) and afterwards by 1.3 uA per 1 more lumi-unit.

The numbers for chamber CH36 are, correspondingly, 1.9 uA and 1.6 uA. From this numbers we can roughly says that the current increase, at least for these two chambers, is more than linear with the luminosity (0.7 uA/lumi-unit and 1.3 uA/lumi-unit for CH21 and 0.9 uA/lumi-unit and 1.6 uA/lumi-unit for CH36). These numbers will be checked against those obtained for the barrel later on.

Another thing to be noticed from Fig.s 1 2 and 5 is that the returned value for i-mon during oscillations is lower than the maximum allowed (10 uA).

- <u>Trip of the chamber EP3_R2_R3_CH09 (see Fig. 6)</u>

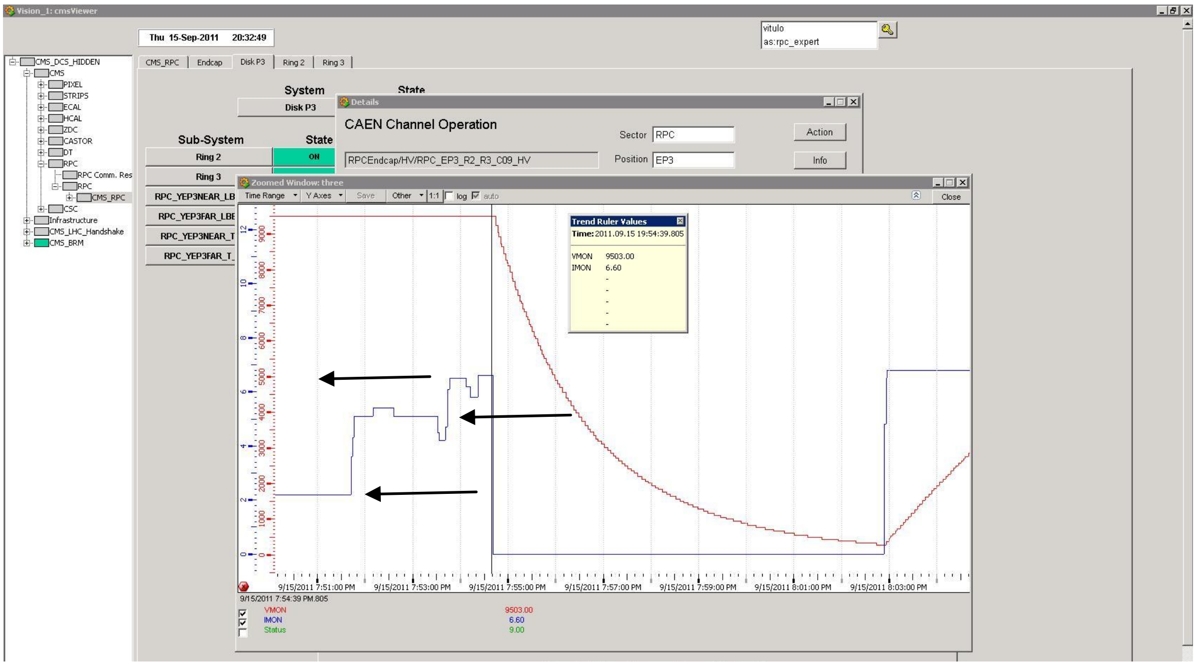

Fig. 6 TRIP of the endcap chamber EP3_R2_R3_CH09. As usual, the current imon (blue curve) and the HV value vmon (red curve) have been shown as a function of the time. Also in this case the chamber follows the "adjust beams" shape before tripping at the maximum of the luminosity. The black arrows correspond to the luminosity steps of Fig. 5

Also in this case the detector follows the "adjust beams" shape before tripping at the maximum of the luminosity. The black arrows correspond to the luminosity steps of Fig. 5 and for this chamber correspond to 1.3 uA/lumi-unit and 1.4 uA/lumi-unit respectively. In this case the current growth seems to be linear with the luminosity. However it should be pointed out that this and the previous statement about the current per lumi-unit is based only on two points and more data have to be taken into account. This will be done in the next section with the Barrel data taken from Nicolas and Min-Suk's report.

3. *Estimate of the expected maximum current limit.*

In the cited report current distributions are reported separately for collisions and for cosmic periods and only for the barrel. Fig. 7 shows the mean values of these distributions for the entire barrel and for the collisions only. A linear fit, which is superimposed, seems to well describe the behavior as a function of the luminosity.
However we would like to study not at the average values but the tail of the current distributions since their population is at risk of over currents or trips. Unfortunately the RMS values of the current distributions do not follow the same linear behavior as shown in Fig. 8. Furthermore we have to take into account also the "no beam" contribution. This has been done in Fig. 9 where the

mean values of the no-bean distributions have been added to the collision ones. This apparently changes the liner behavior of Fig. 7.

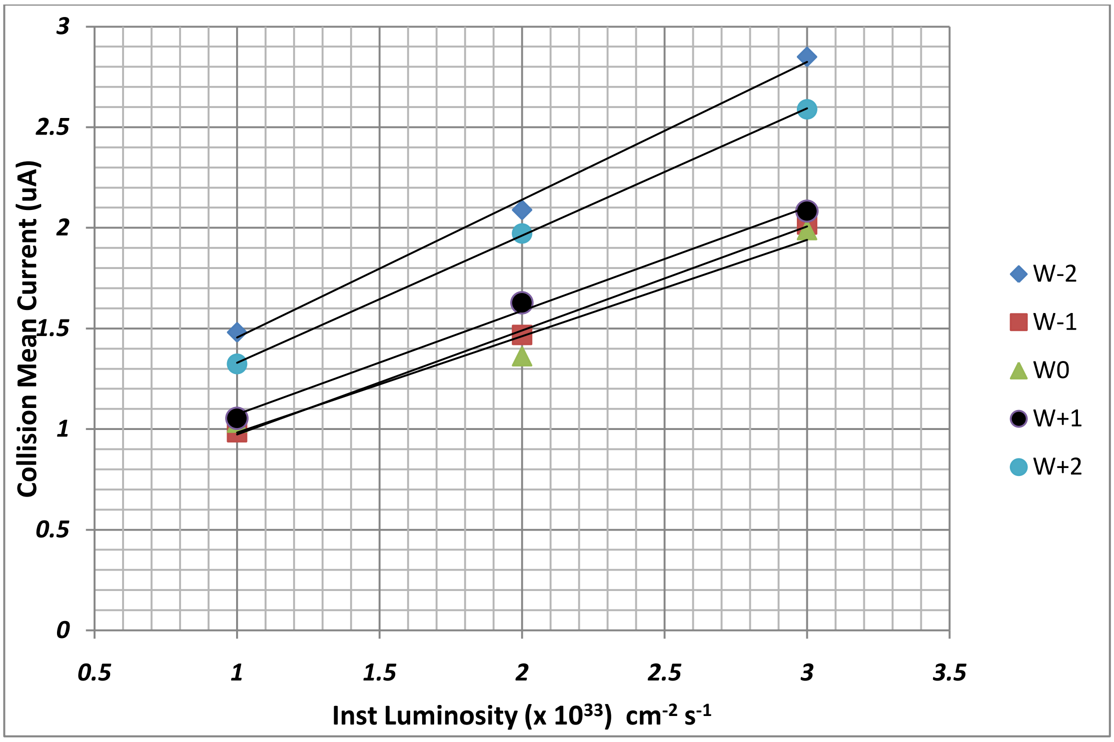

Fig. 7 Wheels Collision mean current as a function of the Instantaneous luminosity. Data are taken from Nicolas and Min-Suk's report. Linear fits are superimposed.

A thing to be note is that the no-beam current should be always the same and should not change the linear trend. Unfortunately, from these data, this is not the fact and it may suggest a drift of the baseline current of the detectors or a presence of radioactivity in the cavern.

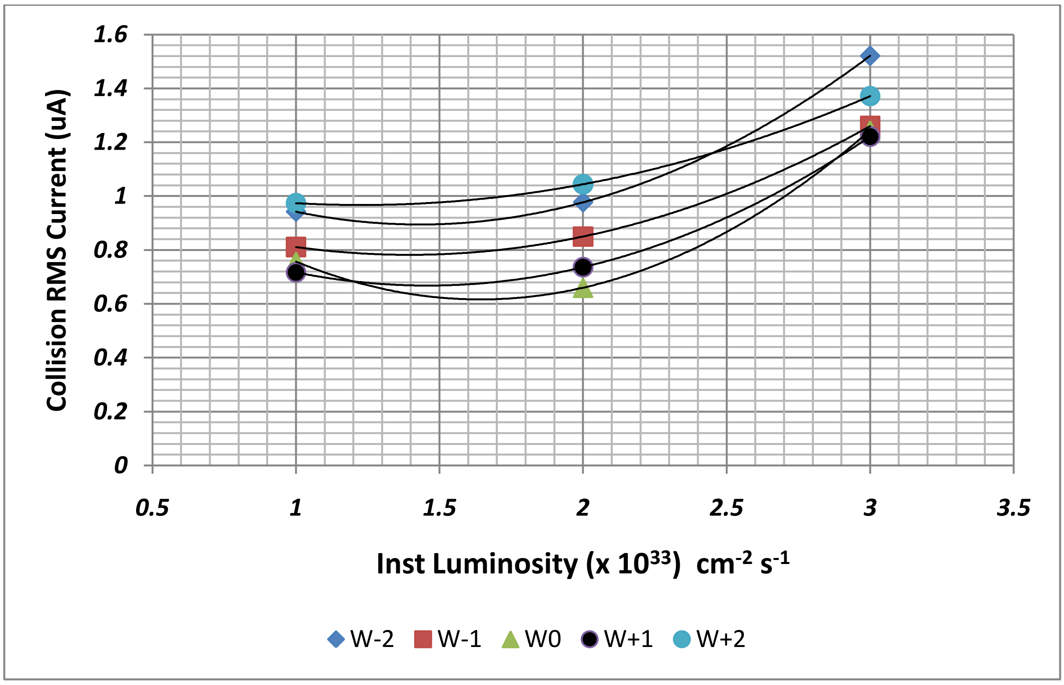

Fig.8 Barrel RMS currents as a function of the Instantaneous luminosity. Data are taken from Nicolas and Min-Suk's report.

A second order polynomial fit has been superimposed to the data of Fig.9 and its prediction extended to higher value of the luminosity.

This may be assumed as a prediction for the average current limit of most of the chambers. However, as already said, it is important to study those chambers whose current values lie close to the tail of the distribution.

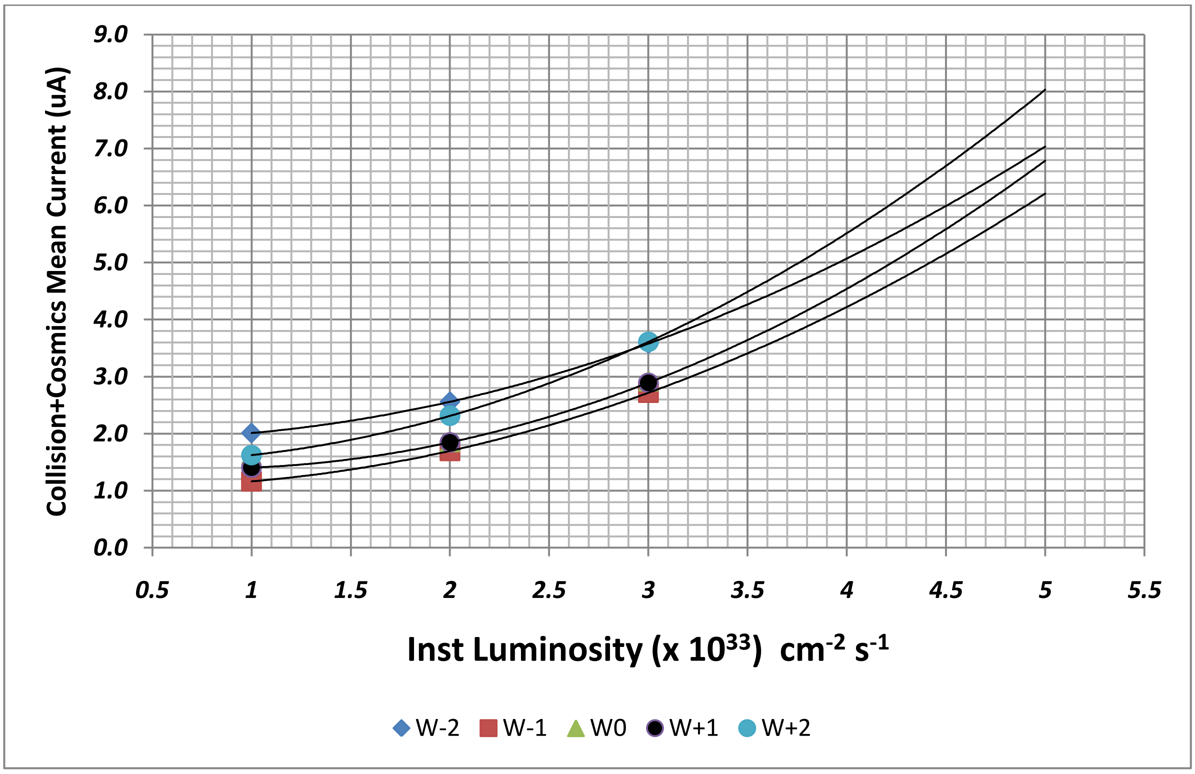

Fig.9 Collision and no-beam mean currents are added for the different periods as a function of the instant luminosity. A second order polynomial fit has been superimposed and extended to higher values of luminosity.

To do that we made some hypothesis: we consider the current distributions as Gaussian (which is not quite the case) and that within 4 RMSs from the mean value all the chambers are included into the distributions.

To the sum of the mean currents distributions of Collision and Cosmic data we added 4 times the sum in quadrature of their RMSs and obtained the plot shown in Fig. 10 which correctly foresees a maximum of 10 uA at 3 lumi-unit for some wheels. A second order polynomial fit has been superimposed and its prediction extended to higher values of luminosity. The curves have to be considered as maximum value that few chambers can reach as a function of the luminosity.

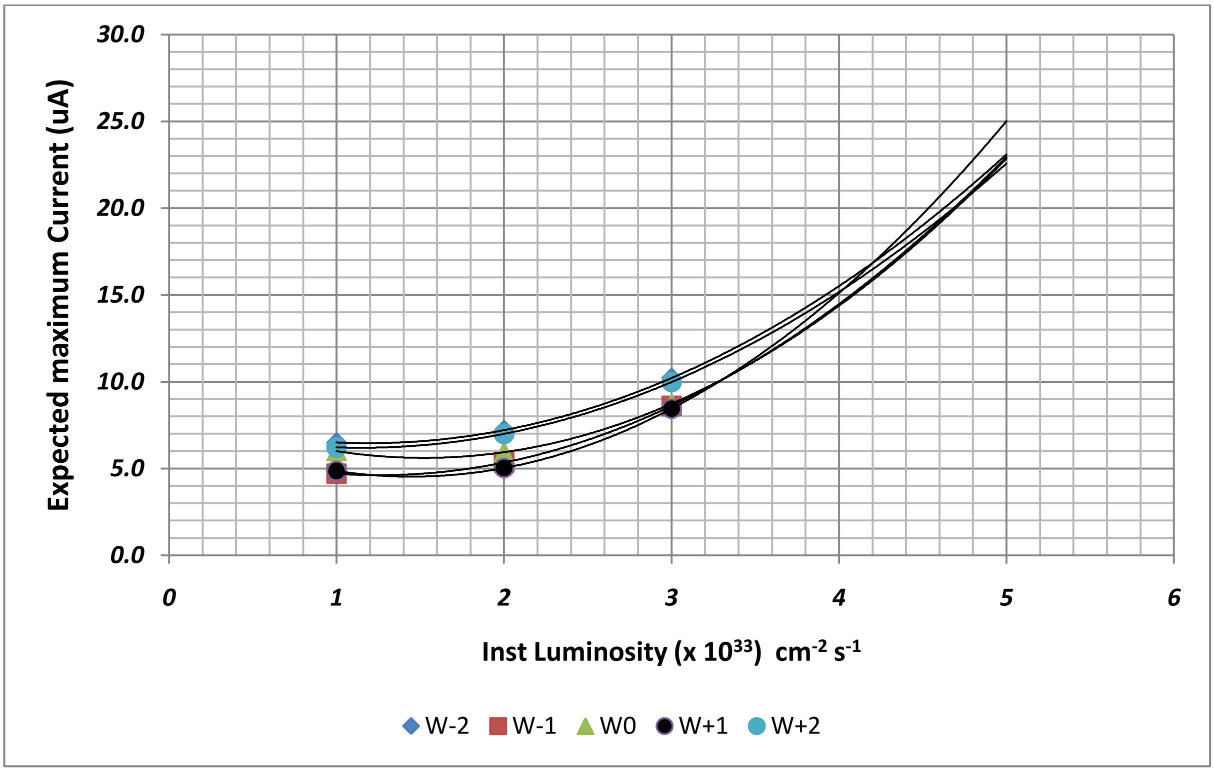

Fig.10 Expected maximum current as a function of the instantaneous luminosity for the Barrel system. A second order polynomial fit has been superimposed and extended to higher values of luminosity. Data are obtained by summing cosmic and collision data values and assuming a 4 RMS spread.

4. Conclusion

Some results can be inferred from the preceding points:

1) The actual maximum value for the current, i0= 10 uA, seem to be well adequate for most of the chambers in the Barrel. However for few of these the choice to change i0 to a higher value seems to be correct.
2) The new value of i0=12 uA set for some of the Barrel and Endcap chambers can be as well adequate. However if the prediction of Fig. 10 is valid at 3.4 lumi-units we can have new trips or over currents warning.
3) There is a hint that the mean values of the currents without beam are maybe drifting .
4) Since the endcap system is subjected to a higher particle flux the value of i0=12 uA may be not completely adequate. A similar report as that of the barrel would be very interesting.