Background Numbers and Background Levels

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A lot of input here from the rest of the group

BCM1F Review Workshop

Basically several studies which are partially finished

CMS Background Numbers

EDMS document number: 1051267
Version: 4.0, 19 July 2010.
Validity: From 18 July 2010 until superceded
Authors: N. Bacchetta, R. Hall-Wilton, D. Stickland

Introduction

LHC operations have requested that each LHC experiment provide several background numbers which act as figures of merit for the state of background conditions in the experiments (1). These are intended to be the primary source of information for LHC operations to evaluate whether background conditions are acceptable for the experiments. They are presented on the LHC operations Vistar (2). The interpretation of these numbers is intended initially to be by visual impression. Eventually it is foreseen that they may be used for automatic machine tuning, so a high degree of reliability is required.

LHC Operations Request

As detailed in (1), the LHC wishes to receive 3 background numbers, which broadly reflect:

1. BKGD1: Flux in the inner detector region.
2. BKGD2: Rate of background halo.
3. BKGD3: Fraction of ABORT as reported by the Beam Conditions Monitors.

These numbers are to be broadcast in the LHC Technical Network over DIP (3), under the publication location: dip/EXPT/LHC/BKGD. In the long term, these numbers should converge to be normalised between the experiments. The scale is 0-100, 0 being good, >20 being warning meaning the background is detrimental for data taking, >50 being an alarm level and >100 meaning that conditions are so bad that LHC Operations should consider ABORTing the beam. A problem or no reading should be flagged with a value of -1. In the short term, the numbers will probably not represent this desired scale, and will almost definitely not be immediately comparable between experiments. The normalisation scale chosen has changed between the 2009 and 2010 run.

Practically, the trend plots for background 1 and background 2 (should) have a lin y axis with a range 0 and 100. The history of the plot is approximately 30 minutes.

CMS Background Numbers

For the 2010 run, as the best estimators of the quantities requested, the BCM1F detector(4) is taken as the best estimator of inner detector flux, the BSC technical trigger(5,6) for the background halo and the Beam Conditions Monitors(7) for the ABORT inputs. The requested target normalisation implies that a log-scale better fulfills this long-term aim. The following choice of algorithms are made:

1. BKGD1: 0.002*(sum(Hit rate of all 8 BCM1F detectors)) (Hz)
2. BKGD2: 0.0002*(sum(BSC-splash trigger beam {1,2})-1.8*BSCMinBiasAllThreshold1) (Hz)
3. BKGD3: Maximum(Percentage Fraction of 40us, 5s, 83s ABORT threshold(All 8 inner BCM2 diamonds))

If any of the numbers are below 0.002, the value 0.002 is sent. If BKGD{1,2} exceed 99, a value of 99 is sent.
All of these quantities are independent of CMS data taking, and of machine mode. Technically, these numbers are processed and produced from raw data within the BRM architecture.

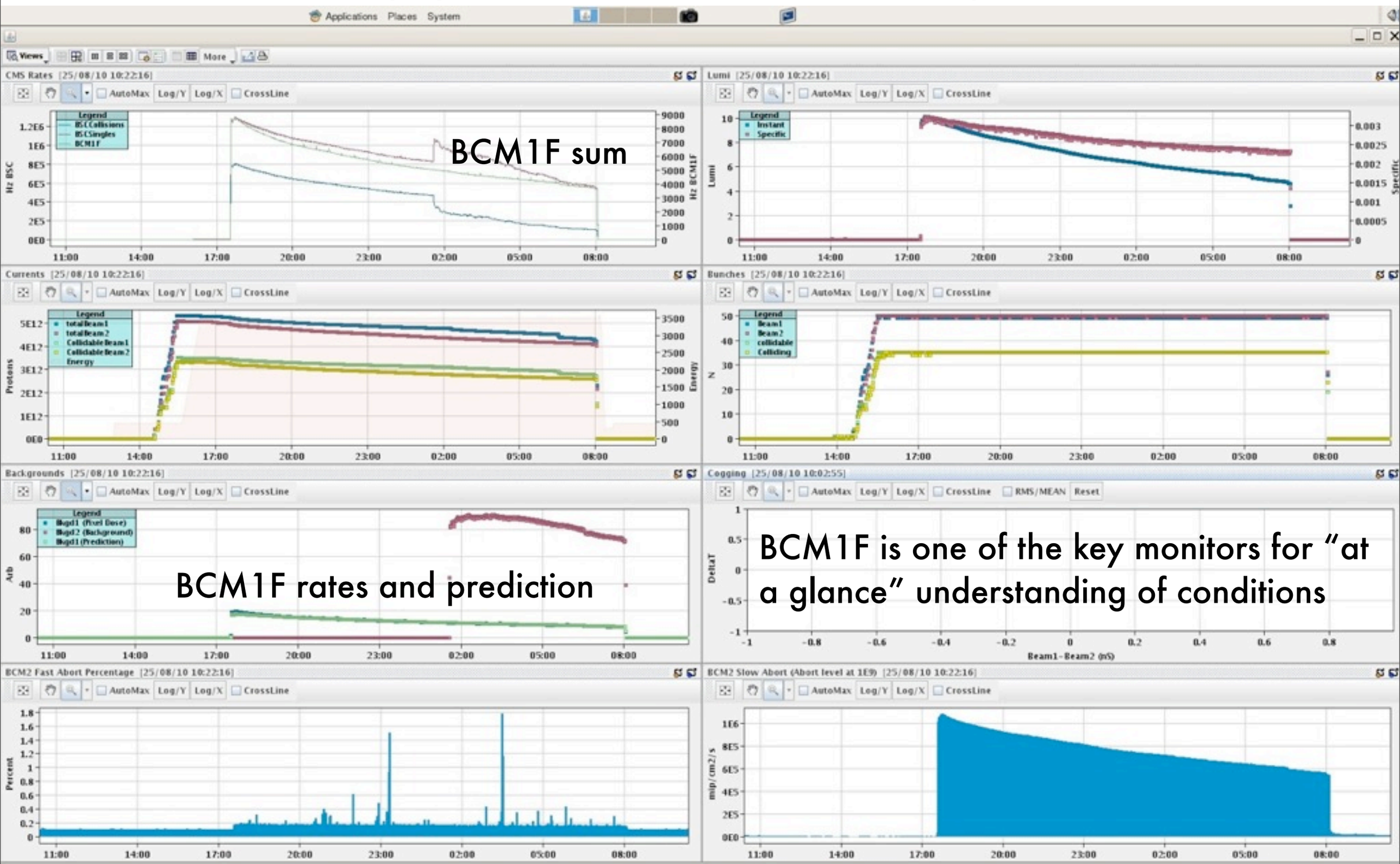
Background Numbers

- Background document is EDMS 1051267
- BKGD1 is defined to be the flux in the inner detector region
- Therefore rate of hits at BCM1F is chosen
- Normalisation is given so that 20 indicates warning
- Set scale so that expected lumi is around 20

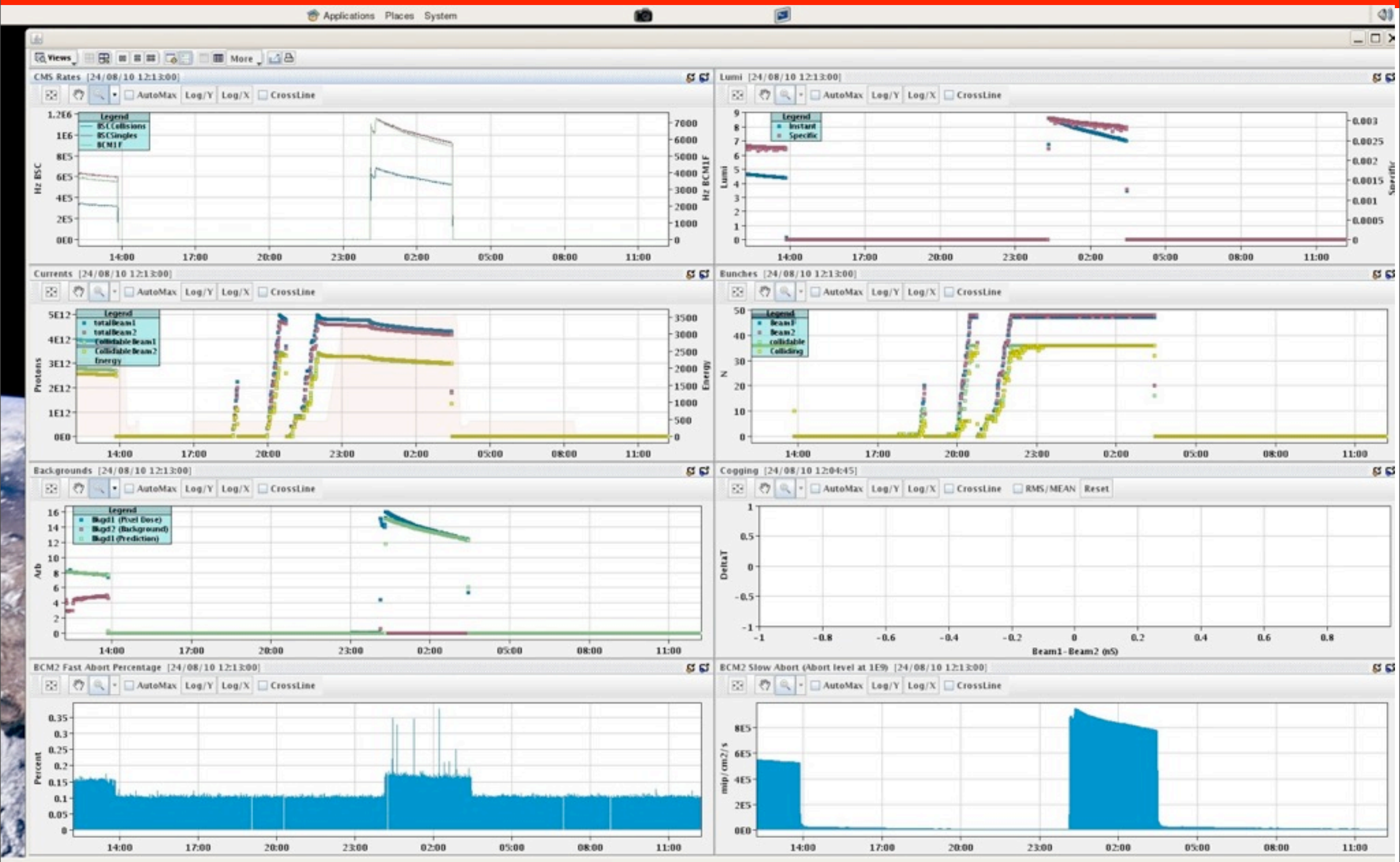
- This number is a useful number as it tells us about the rates in the pixel region
- Therefore it is related to the dose in the pixels and to the absolute rate for the electronics
- It is primarily (in good conditions) luminosity dominated
- It also does not tell us about short timescale losses
- Need to add measurements of background to this

Shift leader display/prediction

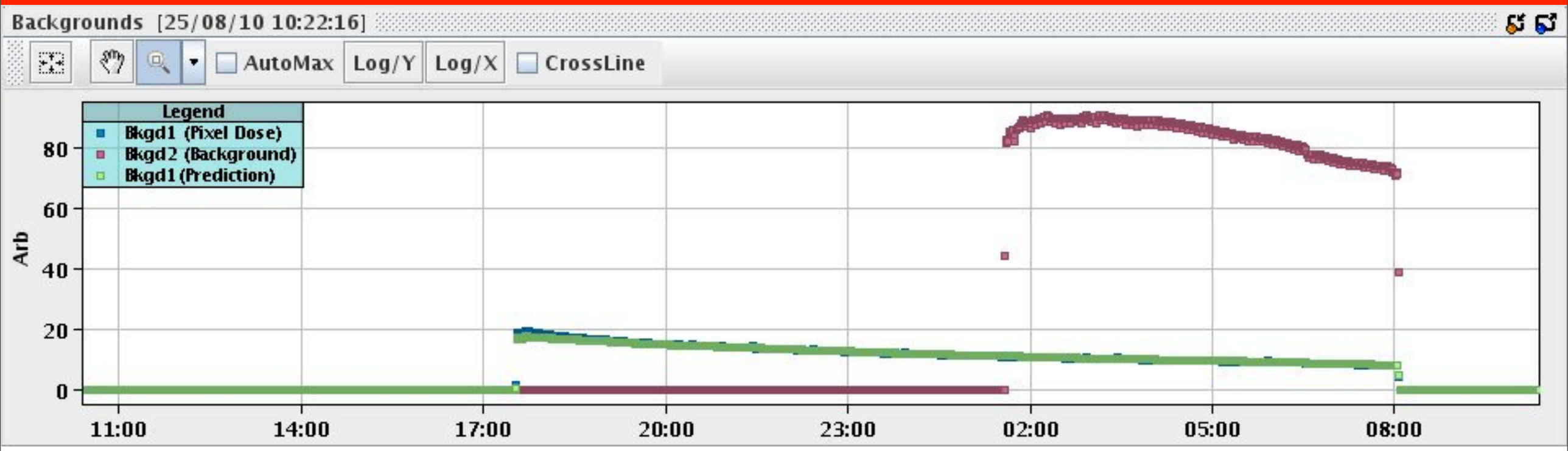
The new shift leader display (available on CMS WBM and snapshots saved in CASTOR)



Shift leader display/prediction



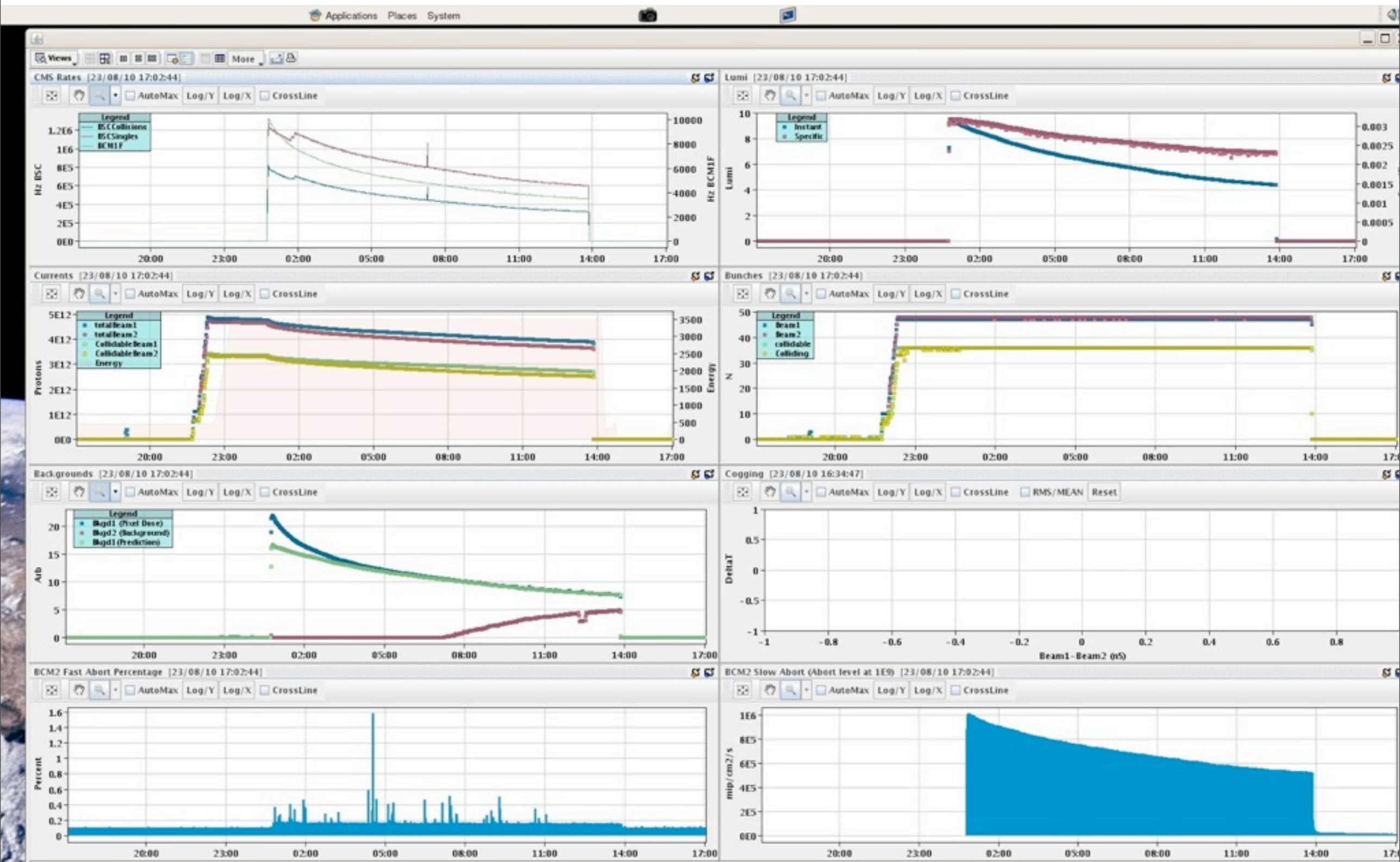
Shift leader display/prediction



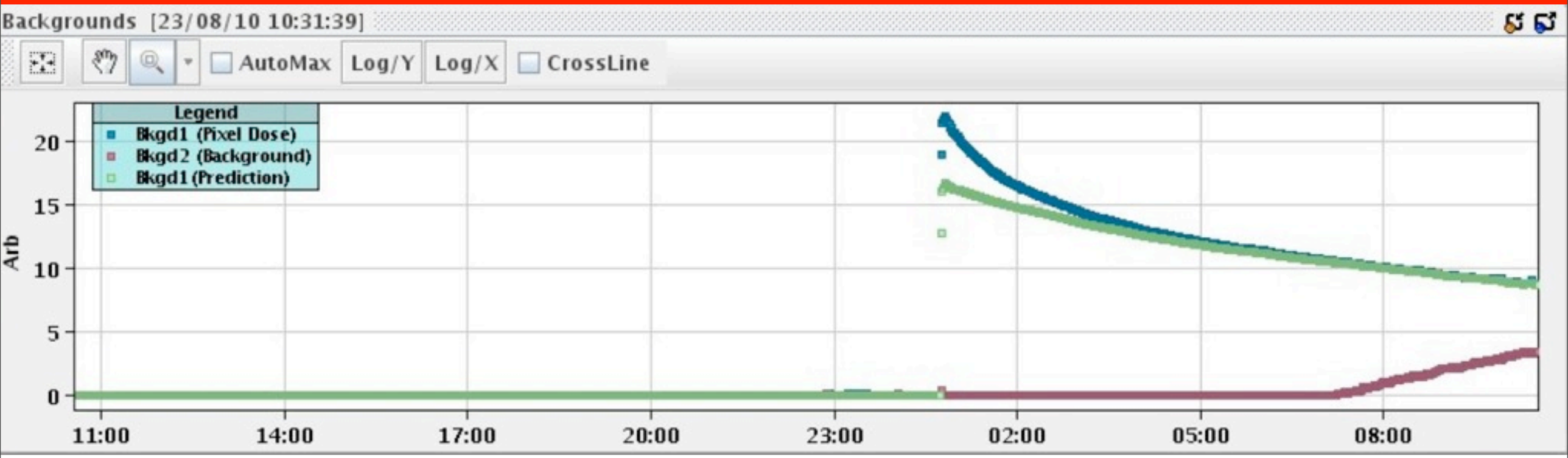
- Basic idea is to get a predicted value for the BCM1F rate, to measure the "excess" above the luminosity expected flux
- Looking at the data, got a value of:
  - `BCM1F_RATE_PREDICTION = 875 * Lumi_inst (units 10^30).`
- Seems to work quite well
  - Open item: should really extract a prediction from simulation - no reason why this should not be accurate
  - Approximate numbers in simulation were looked at in April, and "hand-wavingly" ok
  - However …

Shift leader display/prediction

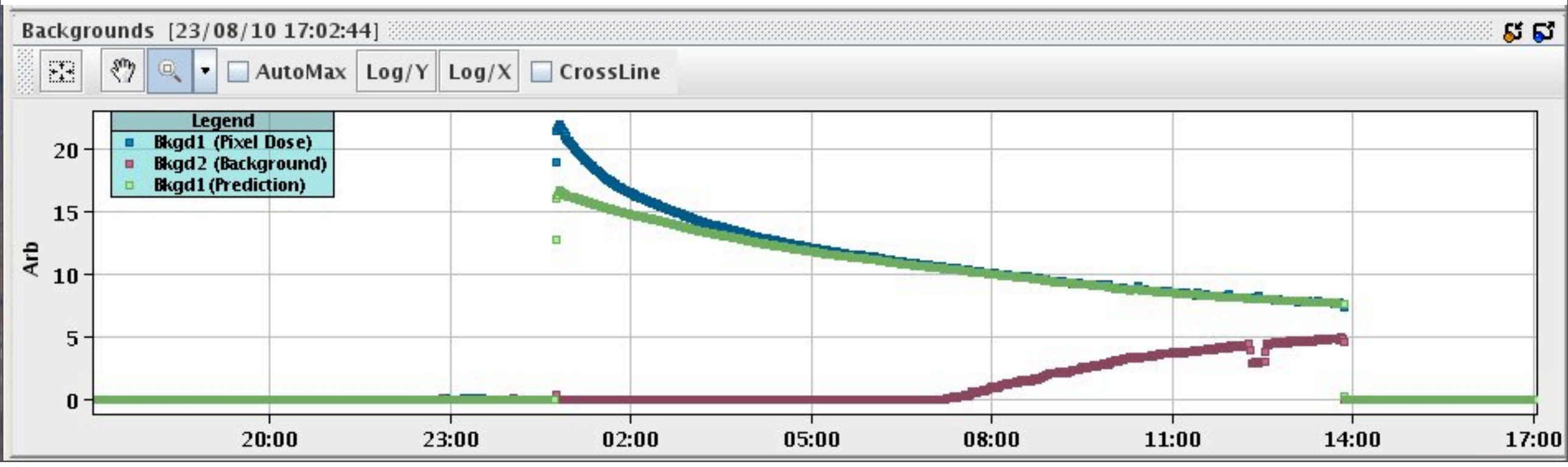
... there is another class of fill ...



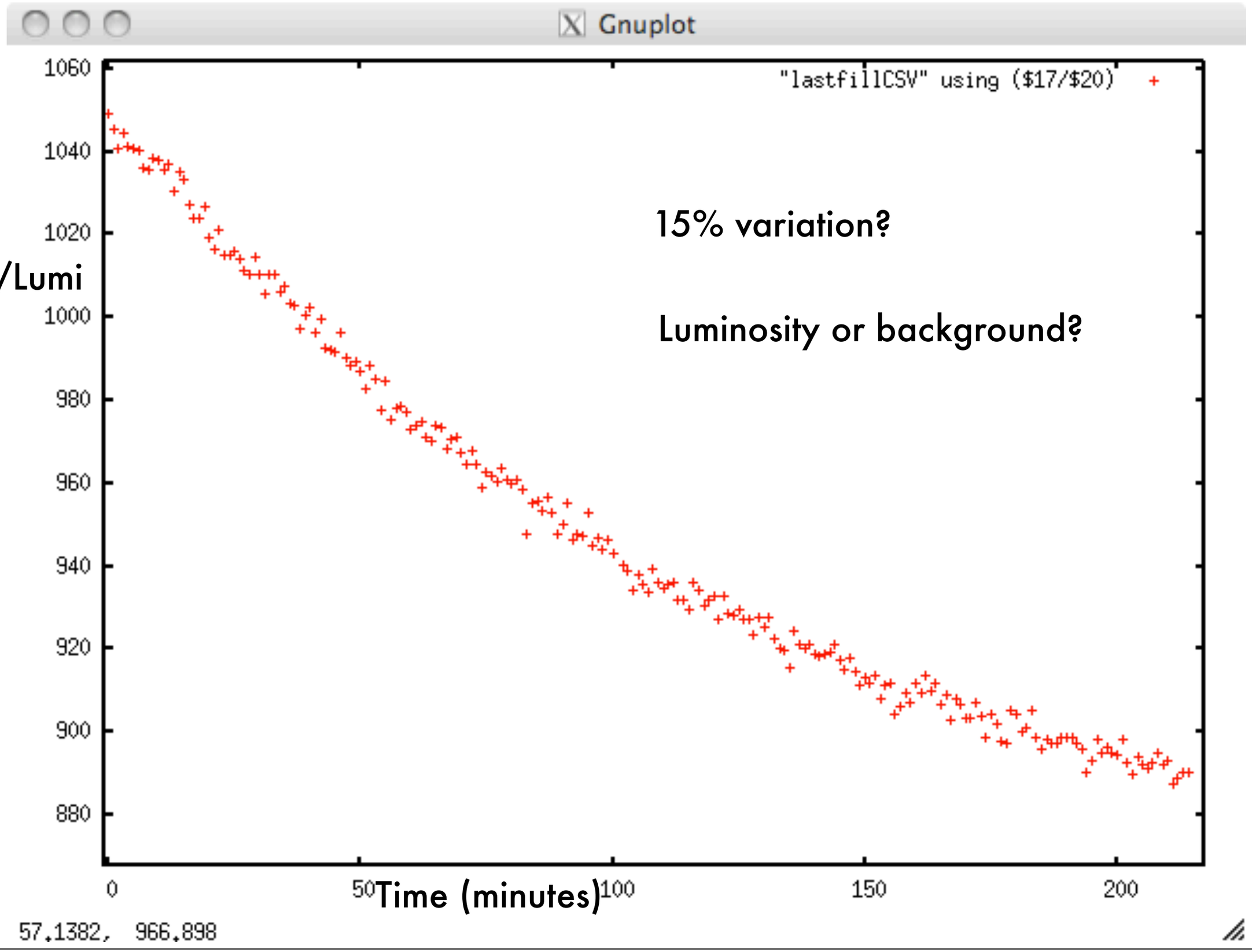
Shift leader display/prediction



2 examples



Shift leader display/prediction

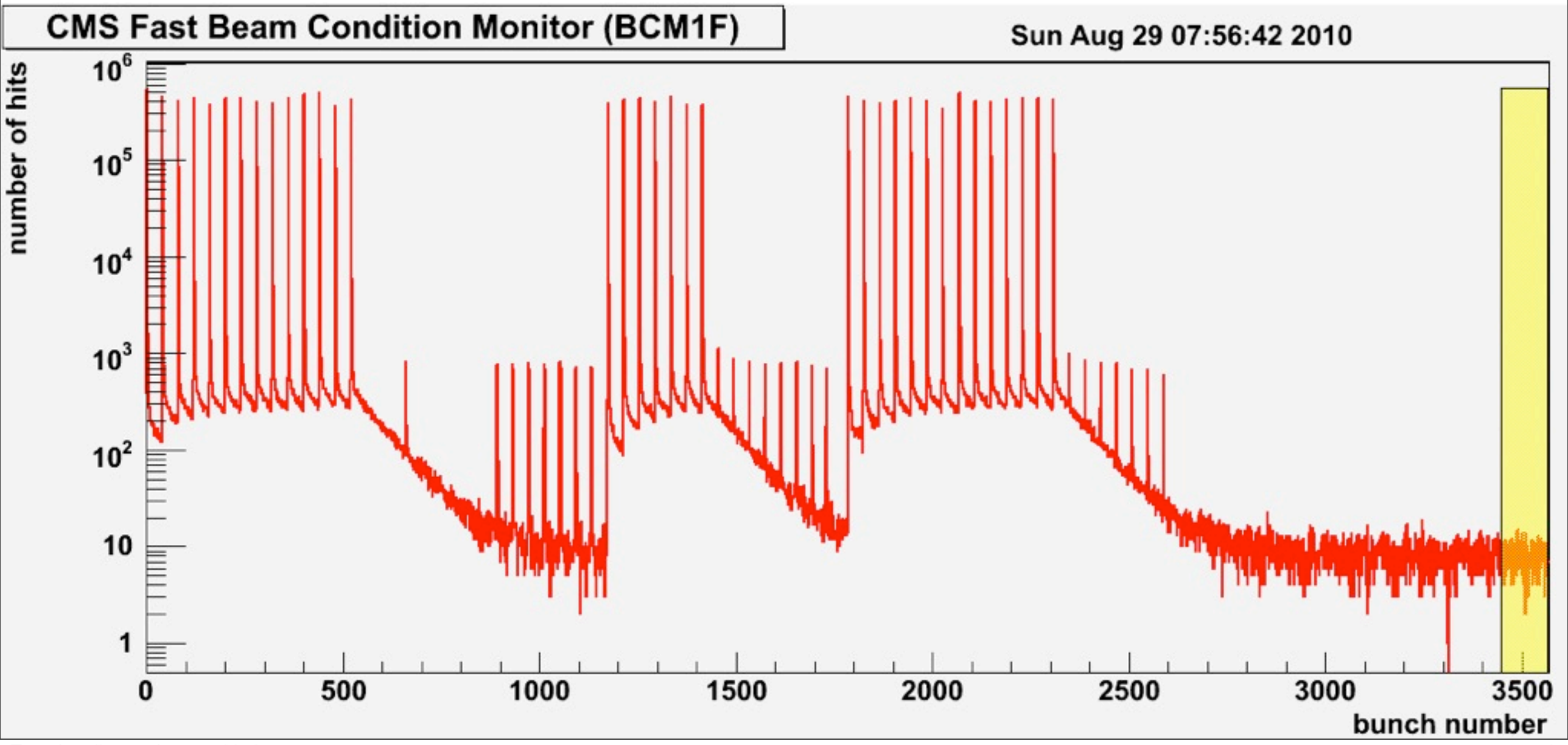


15% variation?

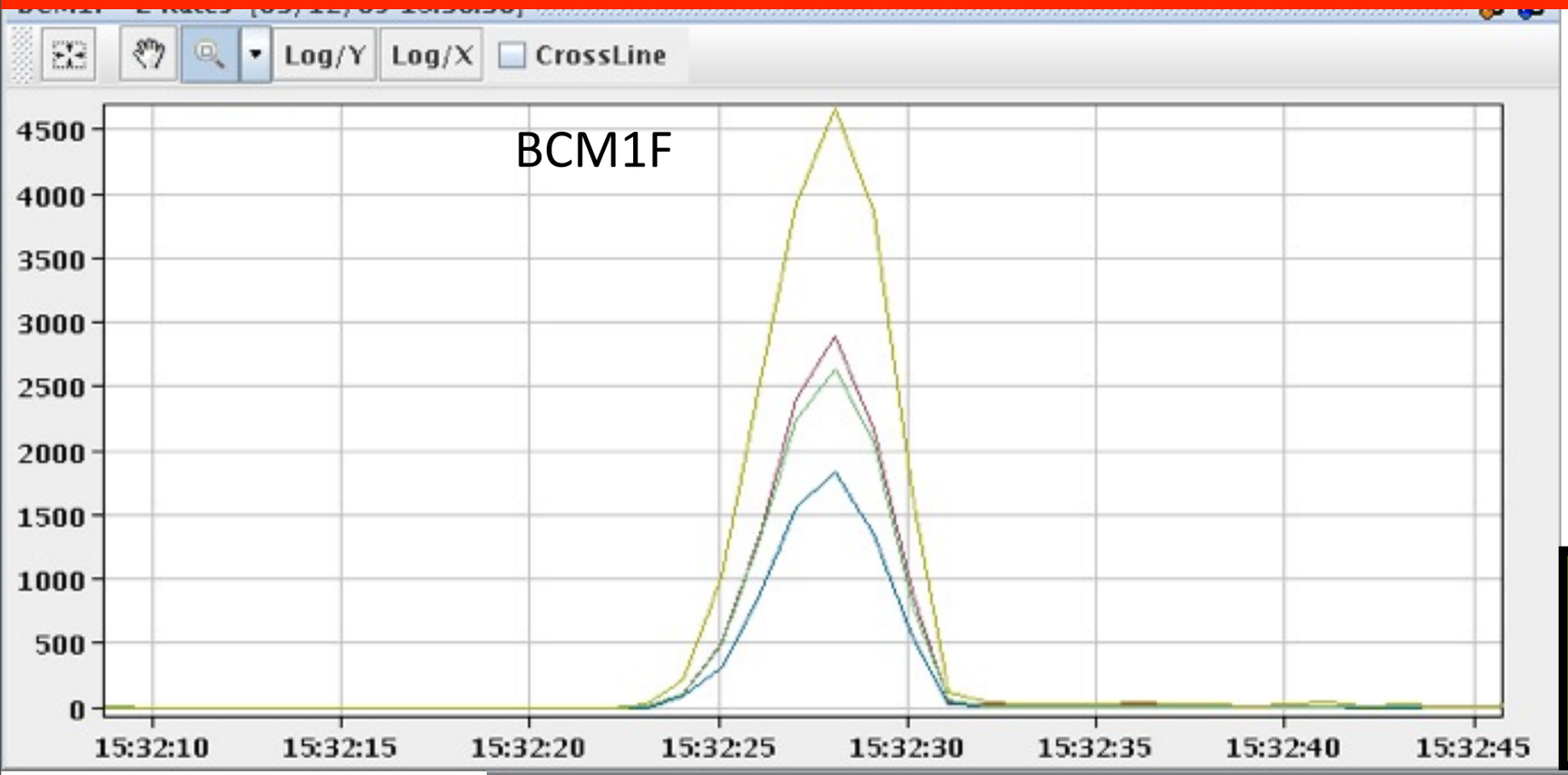
Luminosity or background?

Shift leader display/prediction

- Luminosity or background related effect?
- For both sorts of fill, but the TDC plot always shows the non-colliding bunches highly suppressed - Certainly not 15% !
- Implies that this effect comes from colliding bunches
  - Luminosity-induced background? Enhanced luminosity???
  - Also seen in luminosity coincidences - see Maria's talk.



Spikes

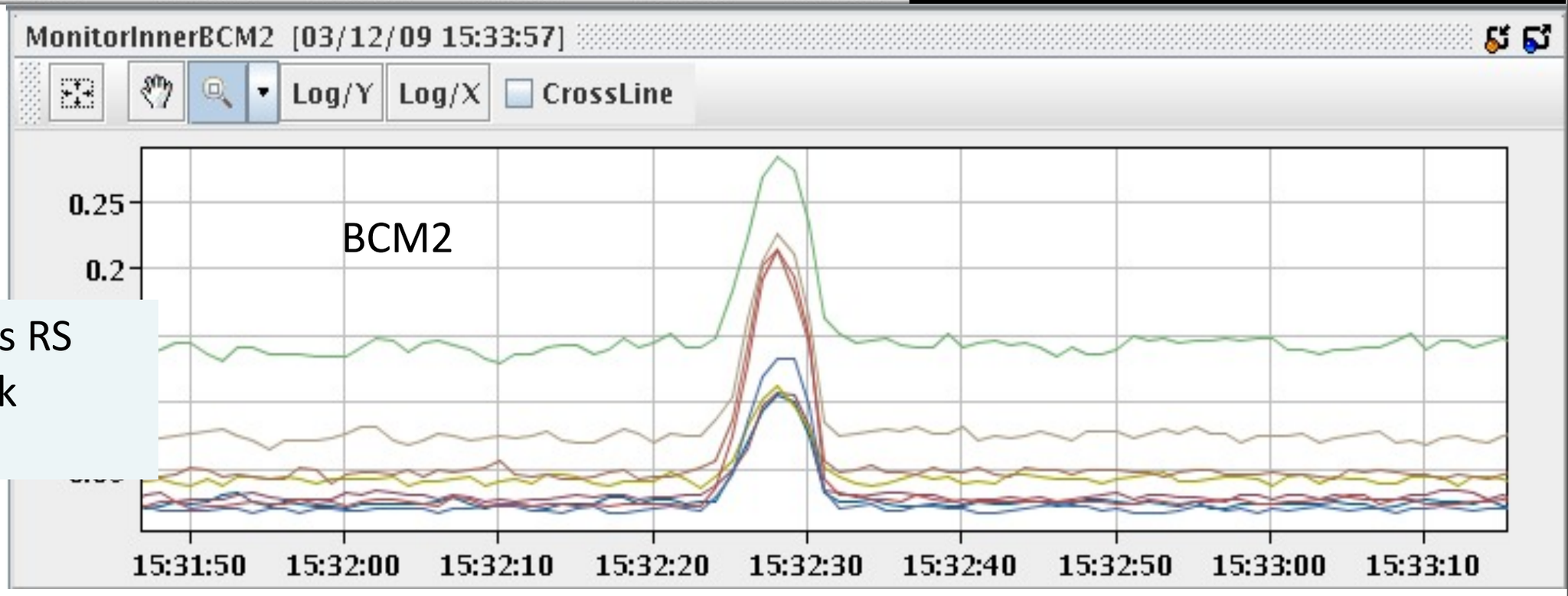


Spikes can be clearly seen ....

Obviously the timescale of losses here is slow ... (seconds)

Excellent correlations between detectors

There are a significant number of studies using BCM1F rates for understanding BCM2 data



8 inner diamonds 1.3s RS (different, stable dark currents)

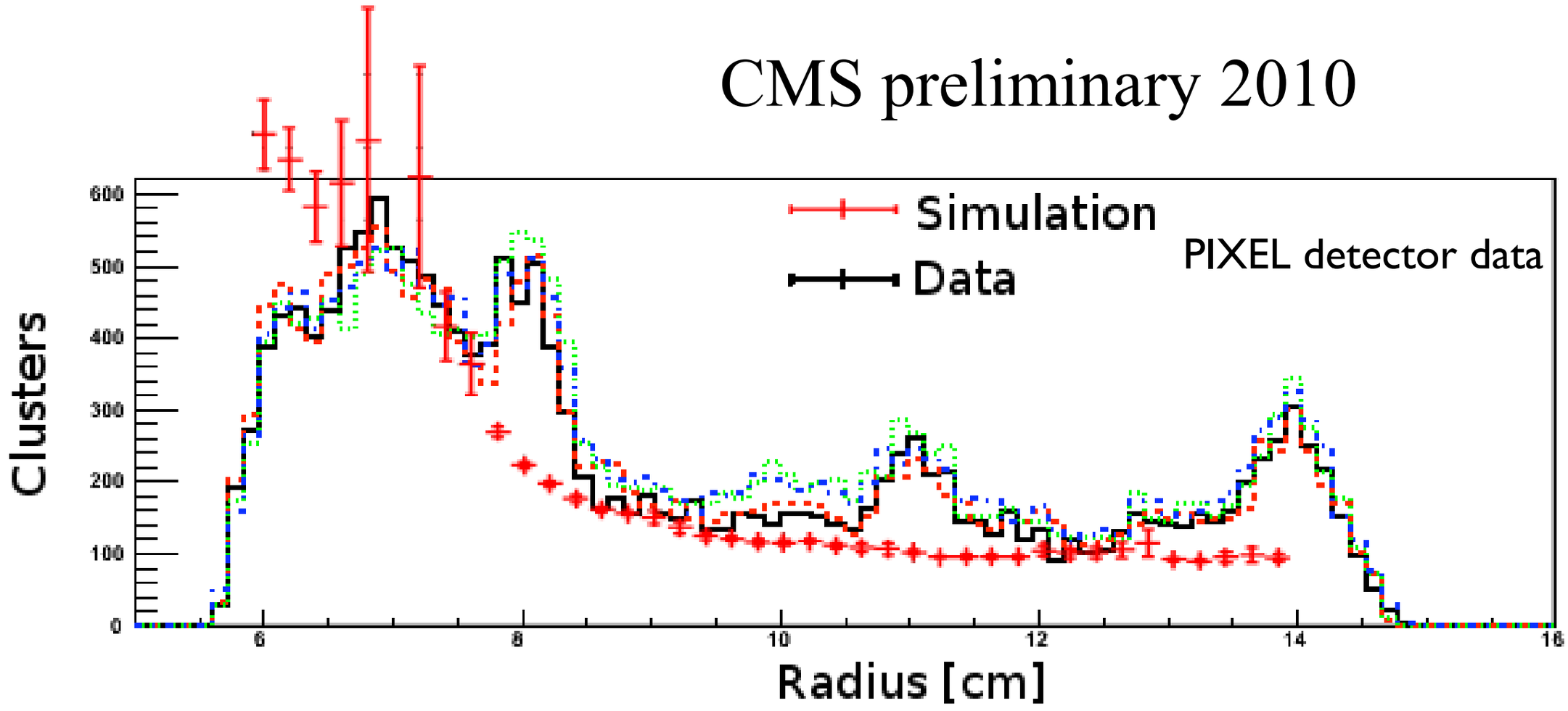
Shift leader display/prediction

- Clearly highly useful in understanding conditions
- Peaks and spikes can be seen - large losses visible
- Predicted value represents a first attempt to be able to look at excess of losses over expectation
- Clearly the difference between the fills needs to be understood to be able to put limits on background contribution
- To put it in perspective - typical rates of 10 kHz at the moment
  - Means >1% statistical uncertainty
  - Background at the per-mil level
  - Need alternative discriminants to measure expected beam background during luminosity
- However ideally would like to end with a predicted value which is dependent only on beam currents and luminosity to describe the observed rates

A reminder about the background

Charged particles from machine induced background.
Scaled to 10^10 protons in the machine.

PP-c
edge



Da

Steffen Mueller

A reminder about the background

PX background: Rate comparison

All numbers scaled to 10^10 protons in the machine.

During data taking background tracks in the forward pixel disks (average cluster density):

$$50 \times 0.5 \frac{1}{\mathrm{s}} = 25 \text{ tracks per second}$$

Area of the pixel disk:

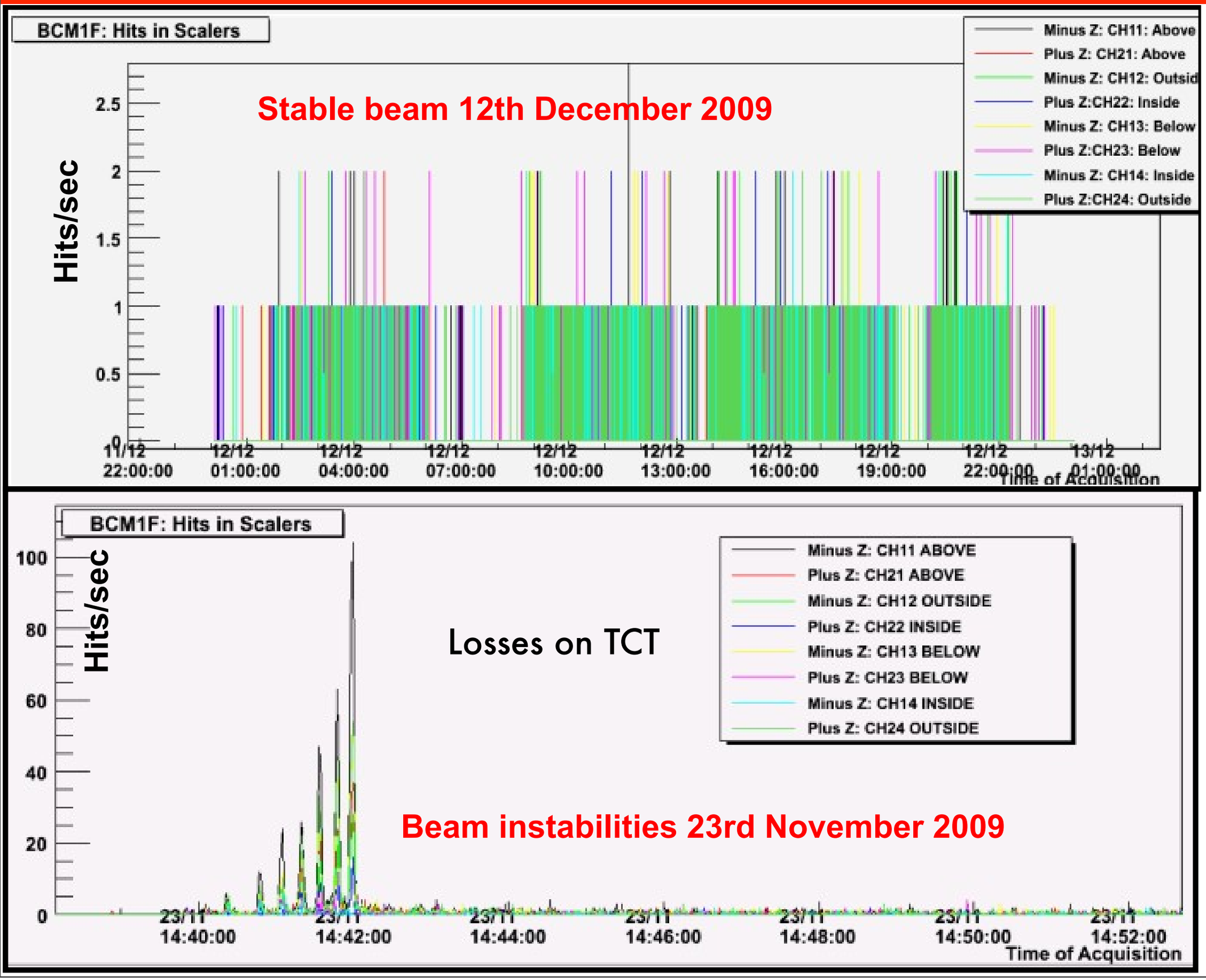
$$\pi \times (r_o^2 - r_i^2) = \pi \times (14^2 - 6^2) = 503 \text{ cm}^2$$

Leading to 0.049 tracks per second per cm^2, the average of the full disk obtained from simulation is 0.023 tracks per second per cm^2.

Background seen in pixel detector is compatible with expected machine-induced background

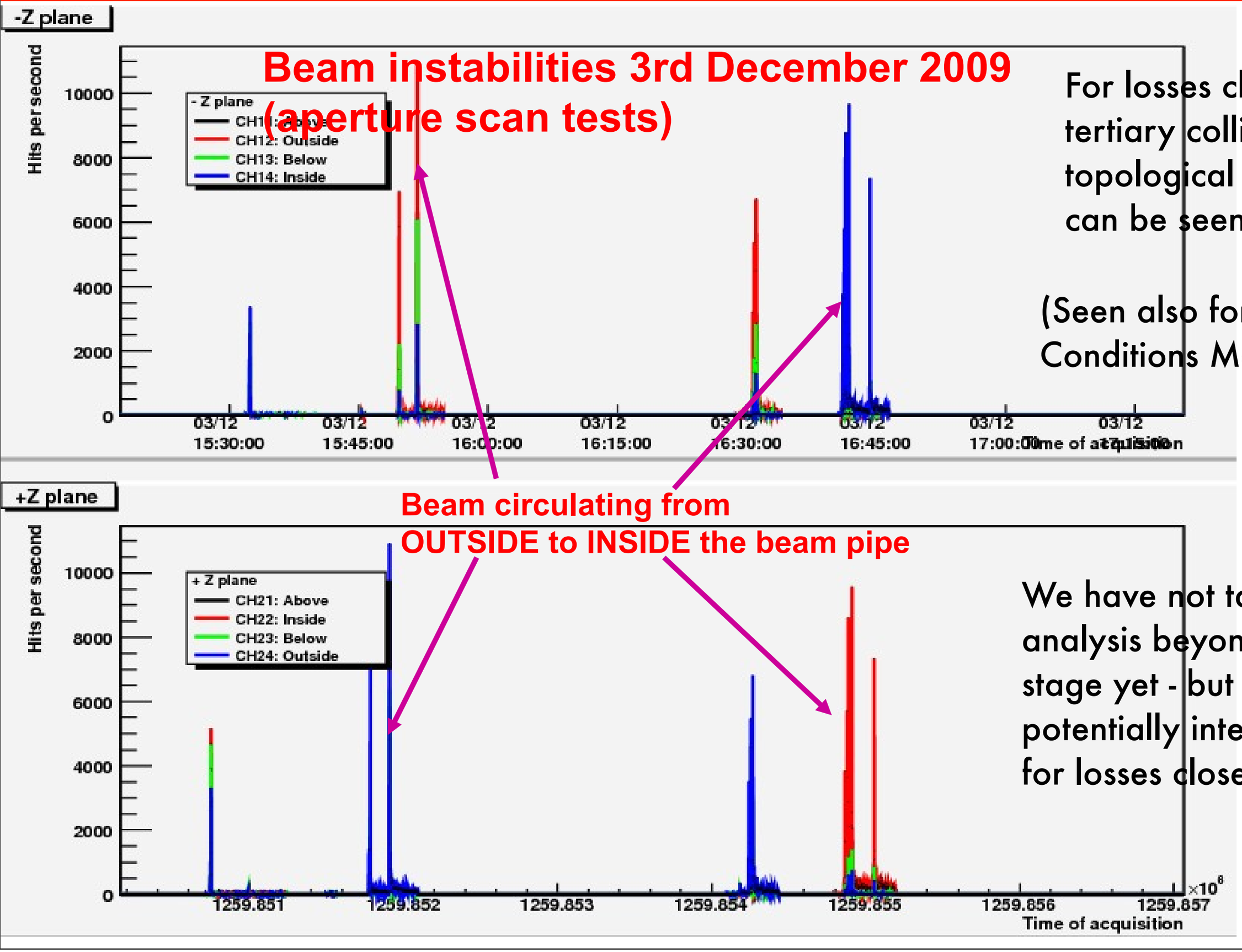
... would be very nice to add BCM1F into the understanding that we have ...

Beam Losses seen in BCM1F rates



What follows is a look at losses at the beginning of operation as an example of what can be done

Topological Patterns



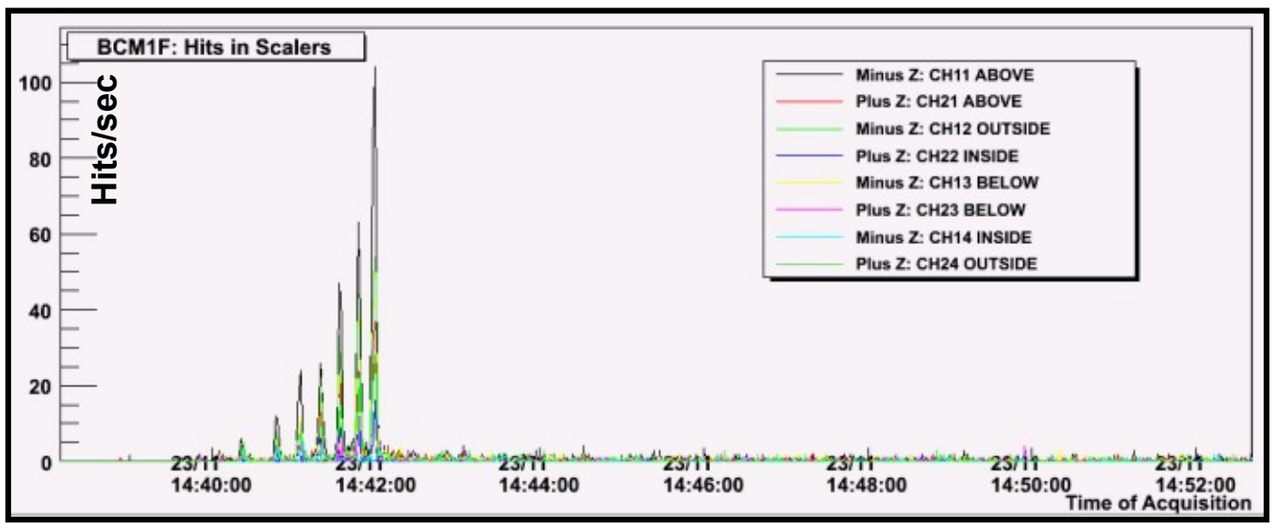
For losses closer than tertiary collimators, topological patterns can be seen

(Seen also for Beam Conditions Monitor 2)

We have not taken the analysis beyond this stage yet - but potentially interesting for losses close to IP

Possible Discriminants

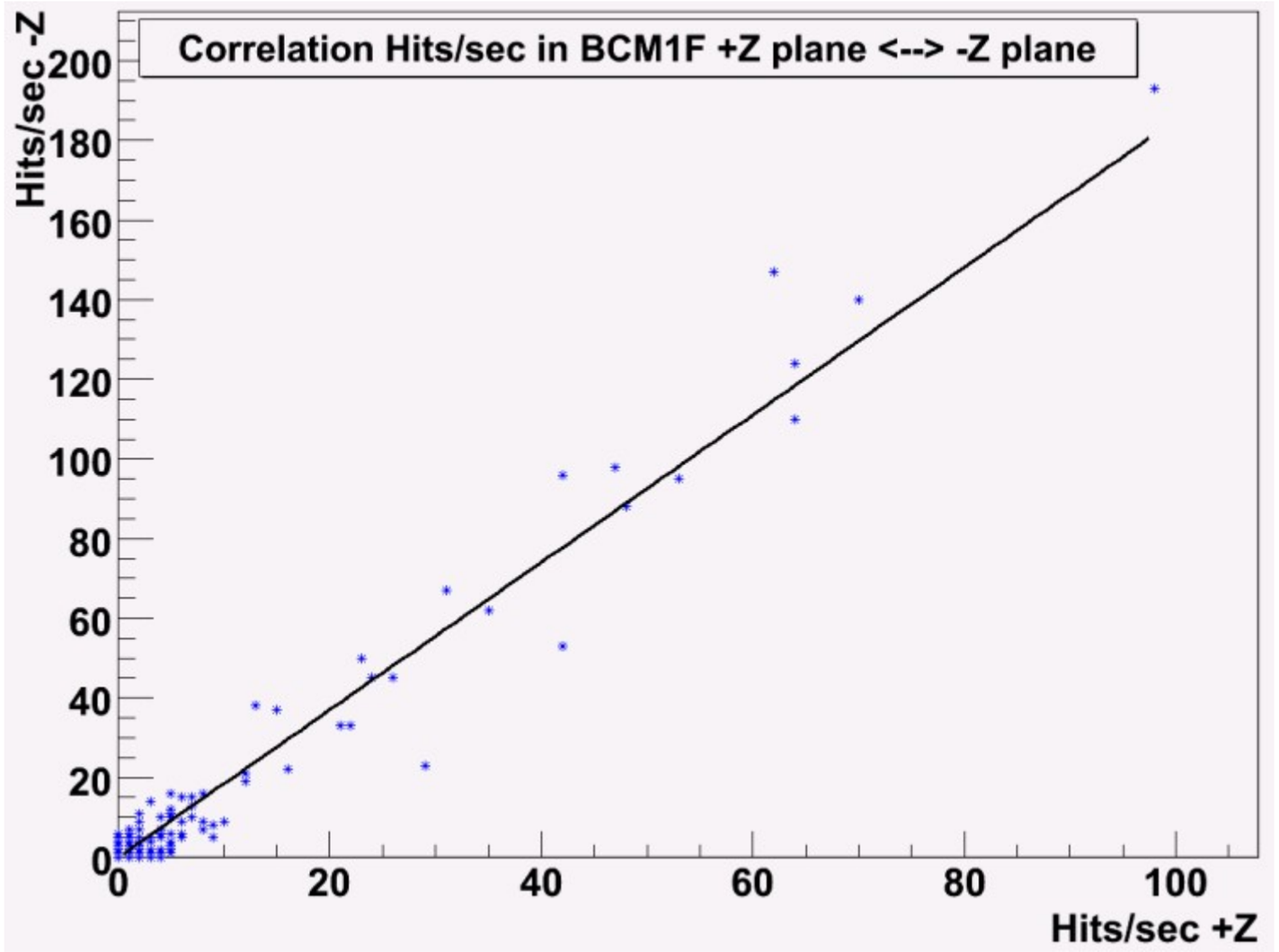
BCM1F 23 Nov 2009 Beam instabilities



- This was the 1st attempt to achieve collisions at 450 GeV
- Beam steering hit TCTs on beam 2

BCM1F 23 Nov 2009 Beam instabilities

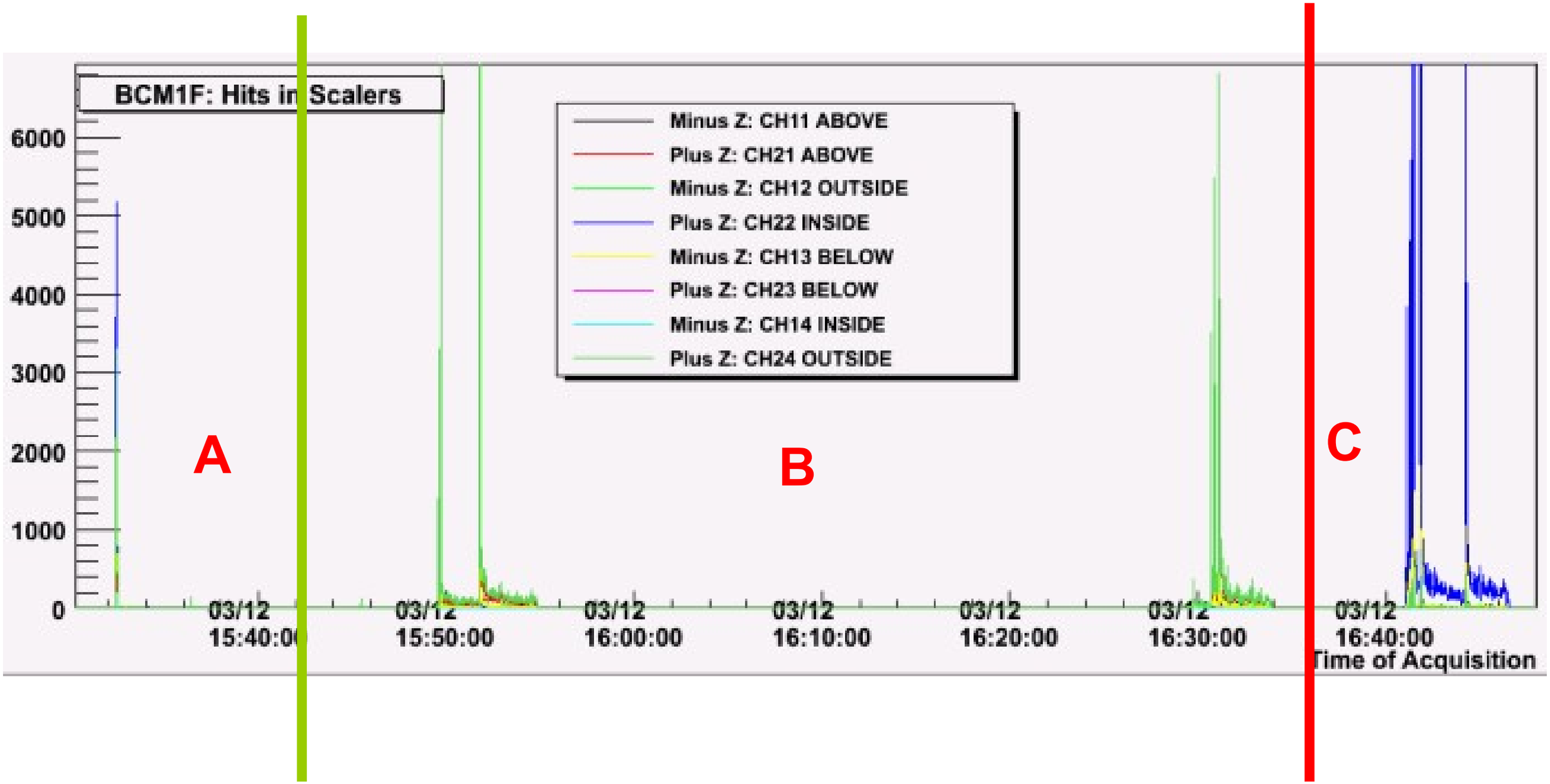
- Take a look at the correlation between hits at +z/-z



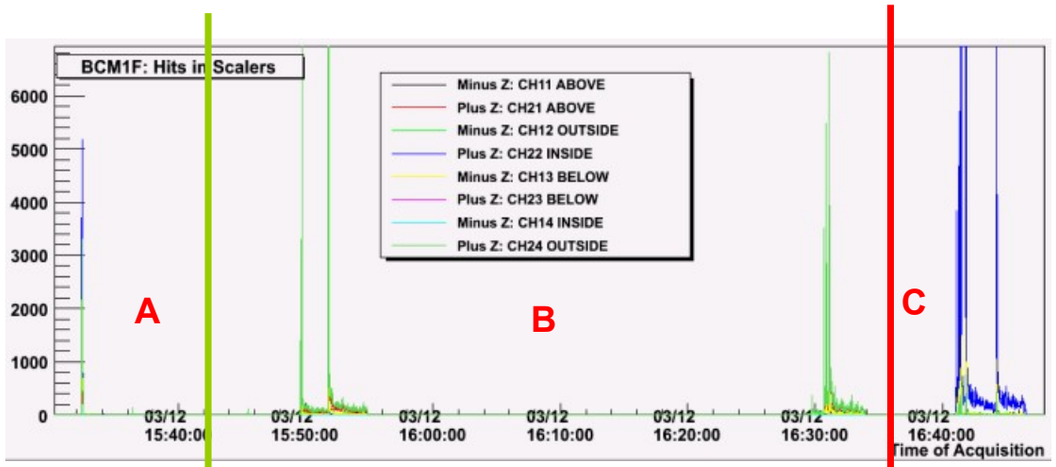
Possible Discriminants

BCM1F 3 Dec 2009 Beam instabilities

- Aperture scans close to IP (i.e. at triplet)



Possible Discriminants



Q2/D1 downstream

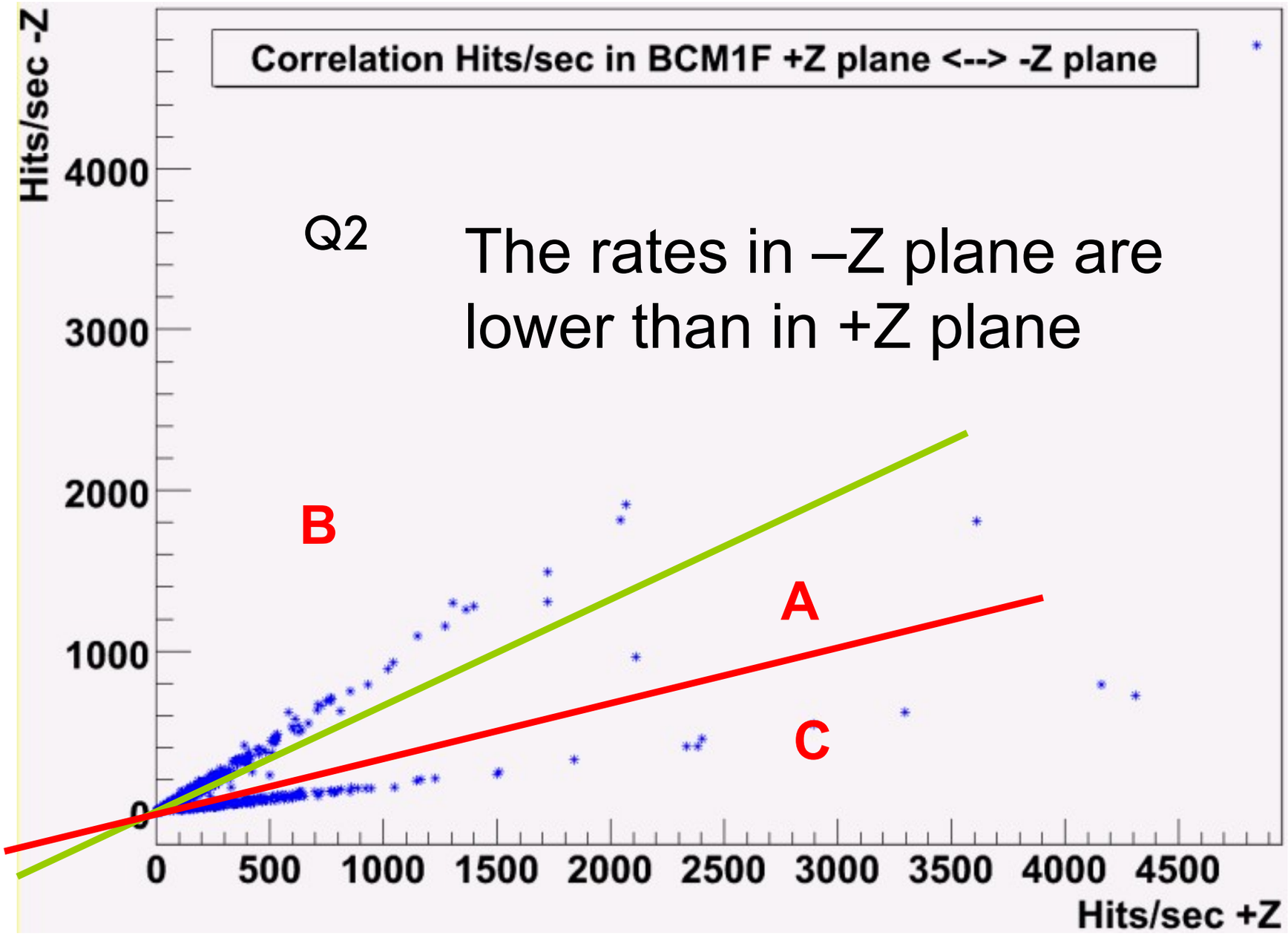
TCT

Q2 upstream

BCM1F 3 Dec 2009 Beam instabilities

- Aperture scans for triplet near IP
- There is good discrimination between the 3 periods
- 3 periods correspond different scraping locations

- This has potential
- We have not really followed up on this - but should give higher sensitivity than pure rates

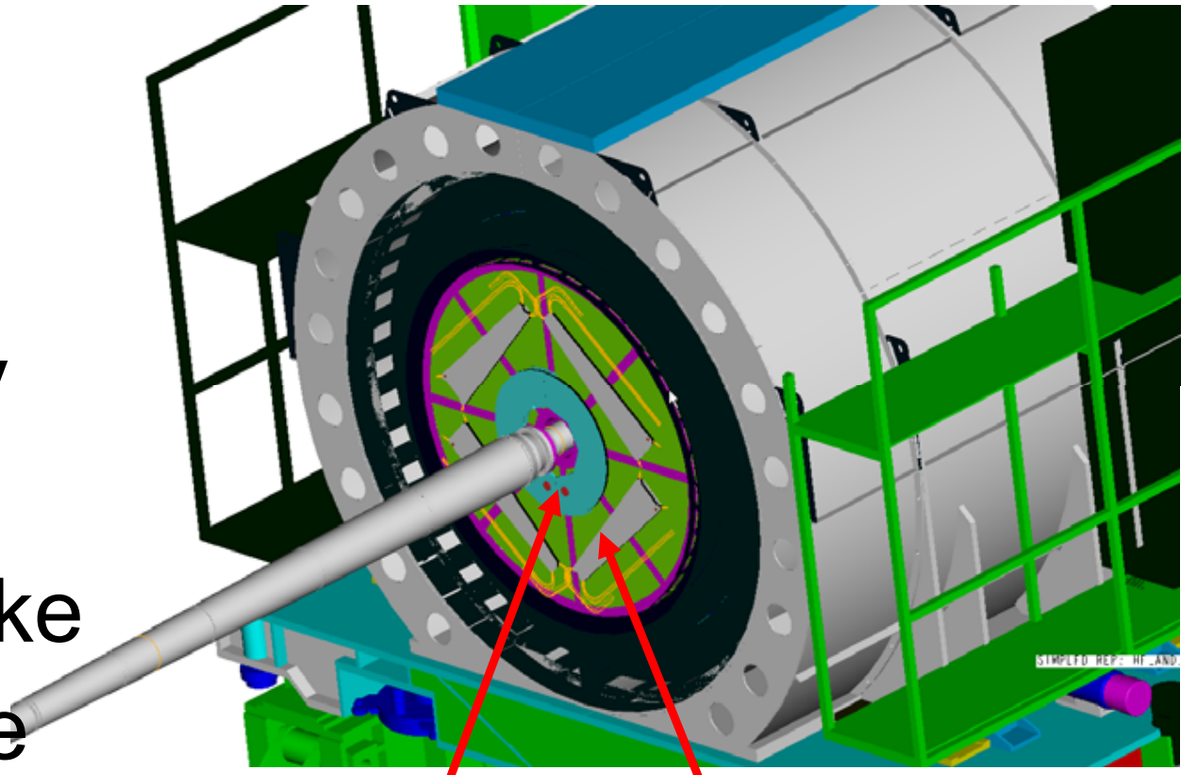


Possible Discriminants (BCM1F/BSC)

CORRELATION OF BCM1F WITH BSC

We tried to find correlations of data registered with our scalers with the information provided by other BRM subsystems.

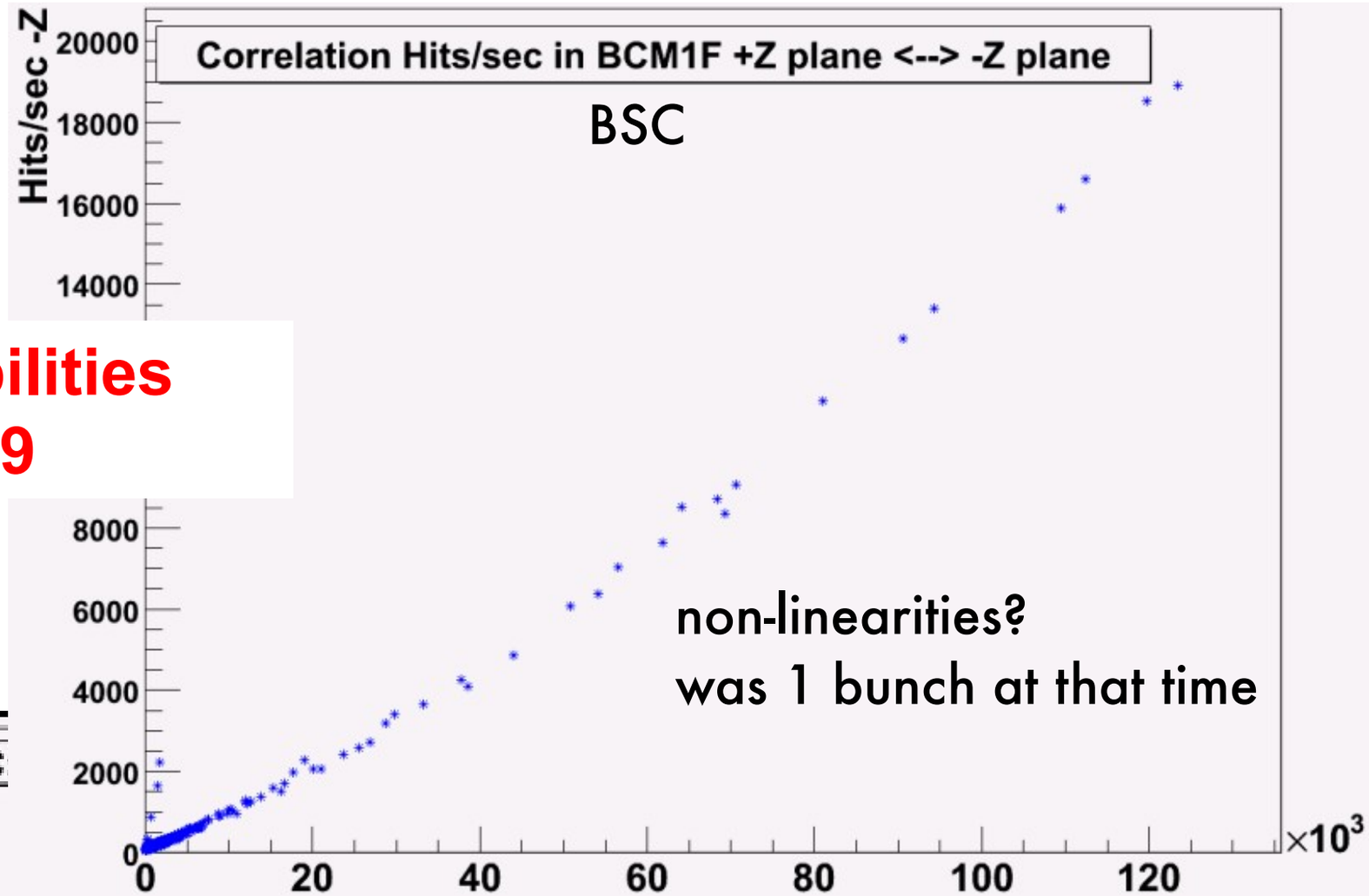
Since BSC DAQ scheme is like ours but with more channels, we used the information of its 16 scalers.

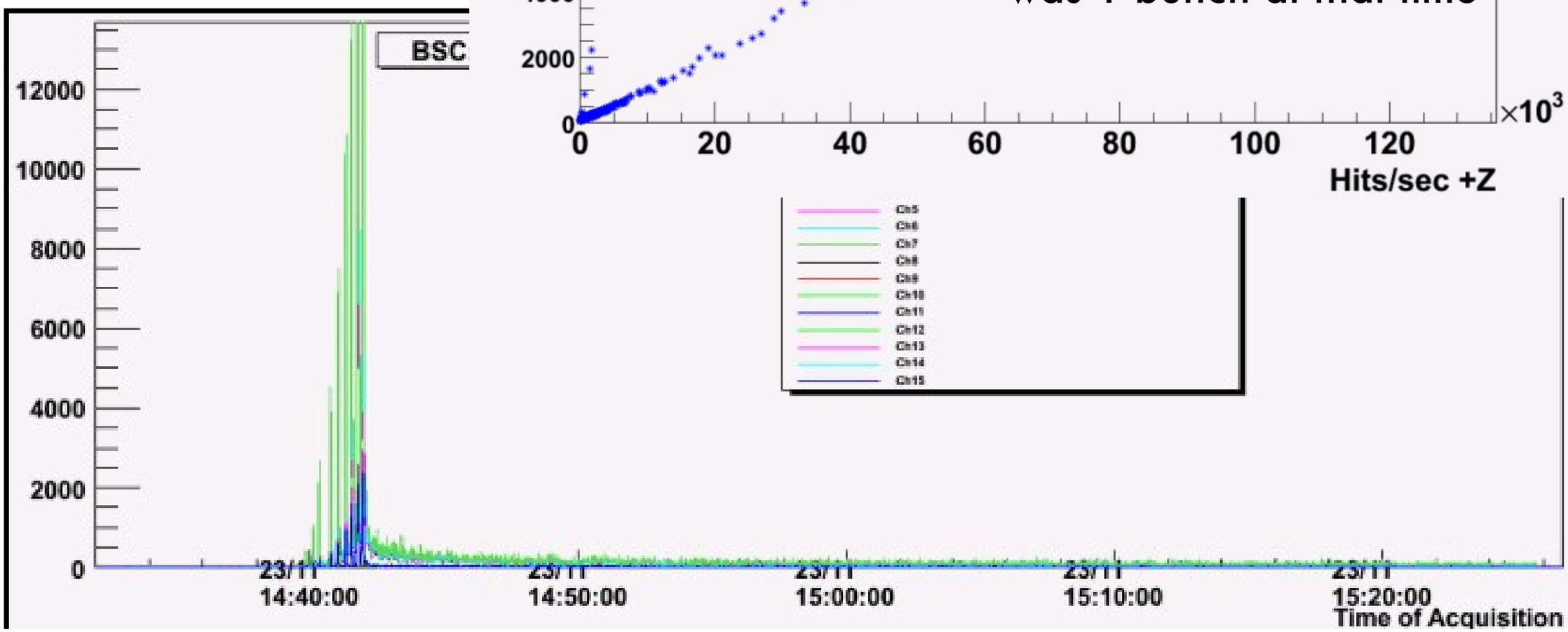


... again a topic that has only been touched on ...

Possible Discriminants (BCM1F/BSC)

BSC Beam instabilities
23 November 2009

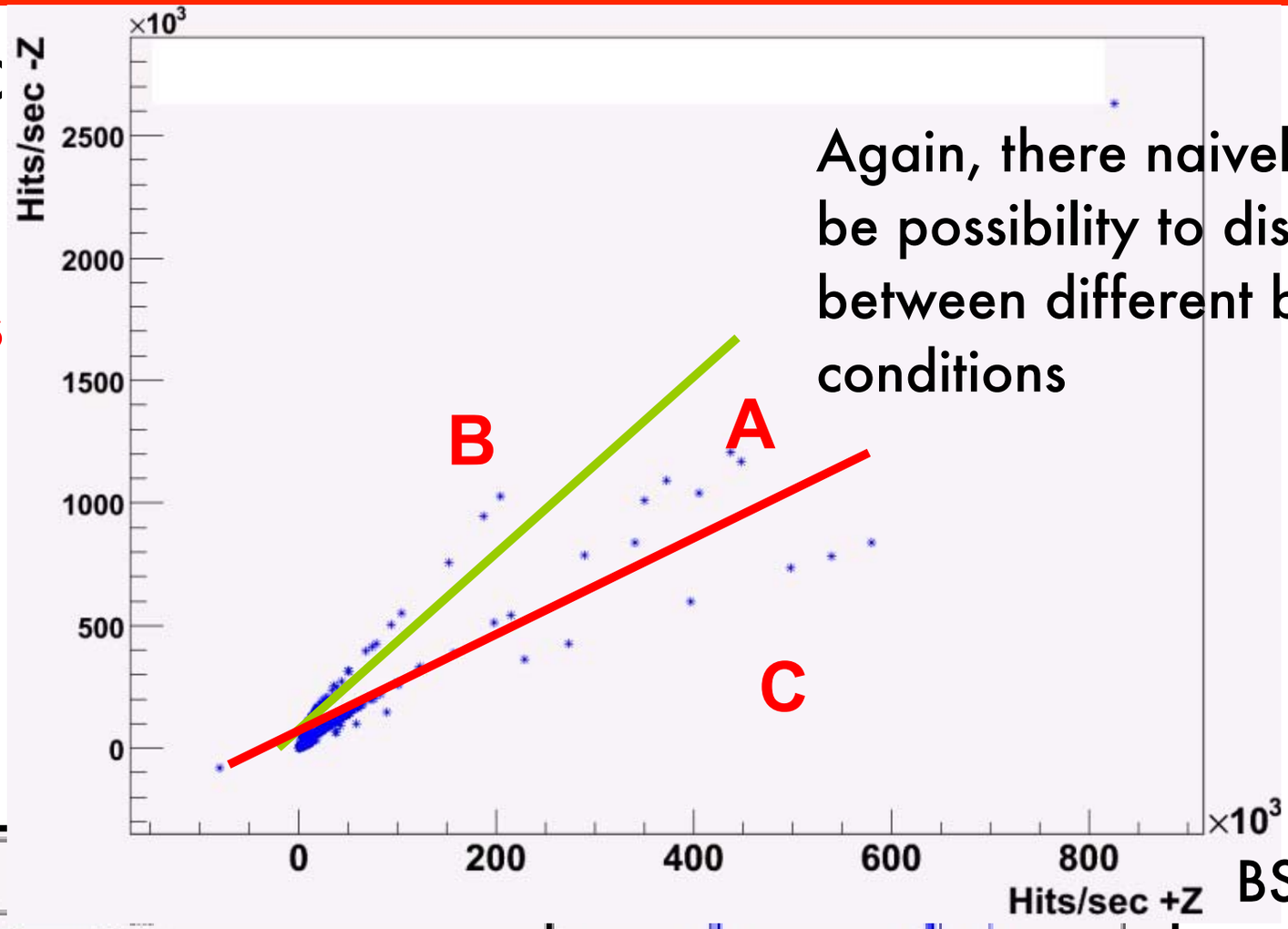




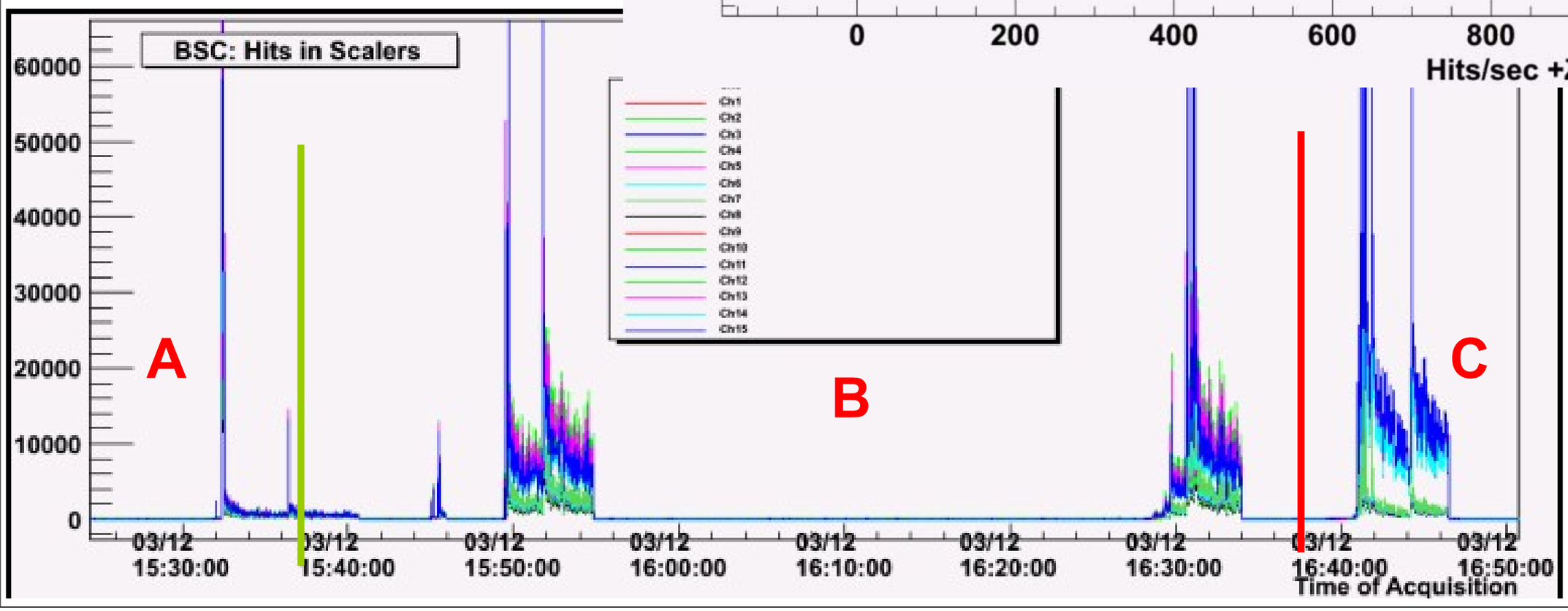
Possible Discriminants (BCM1F/BSC)

BSC Beam instabilities
3rd December 2009

BSC

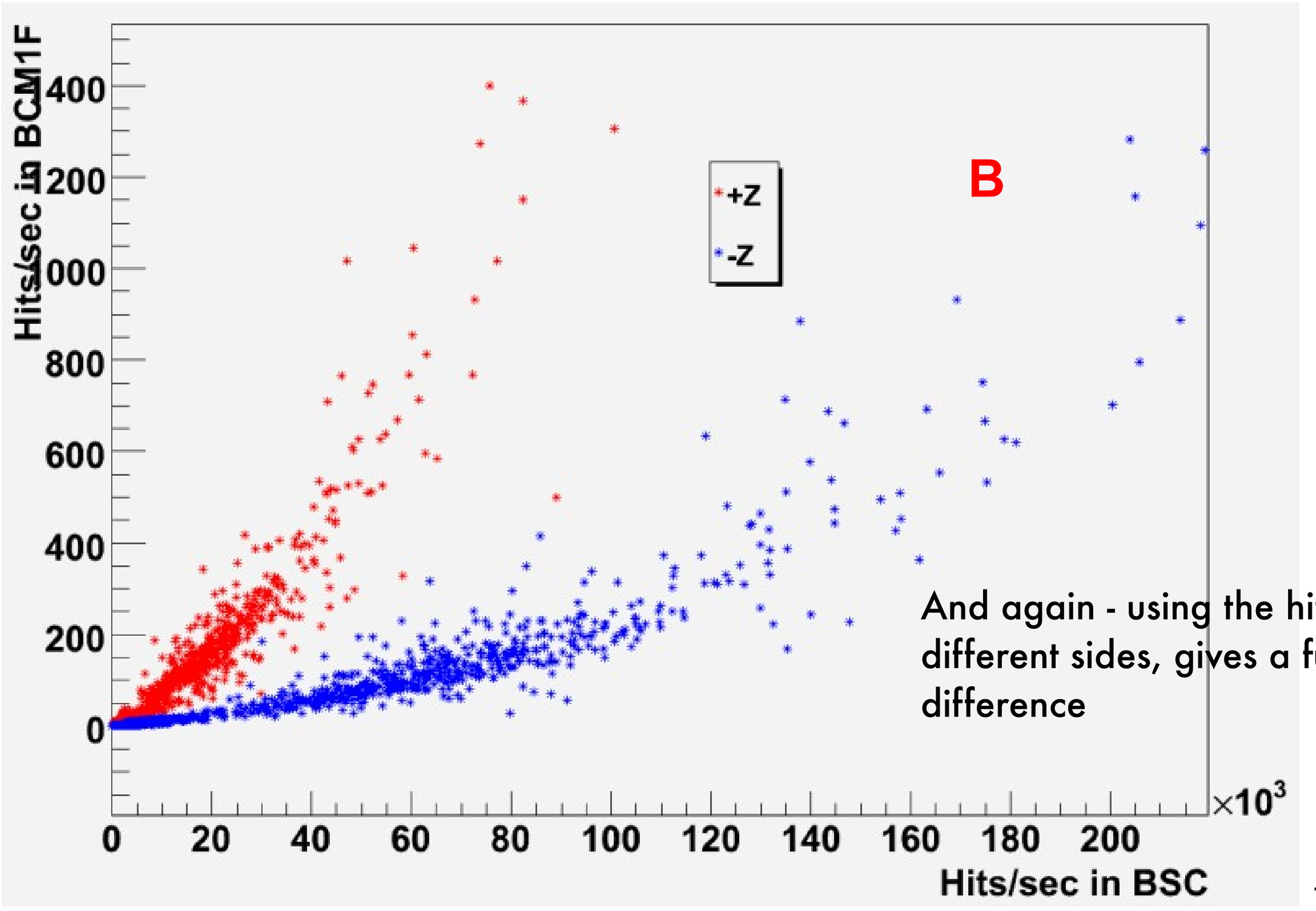


Again, there naively seems to be possibility to discriminate between different beam conditions



Possible Discriminants (BCM1F/BSC)

3 Dec 2009: Analysis of 1st part of data file



And again - using the hits from different sides, gives a further difference

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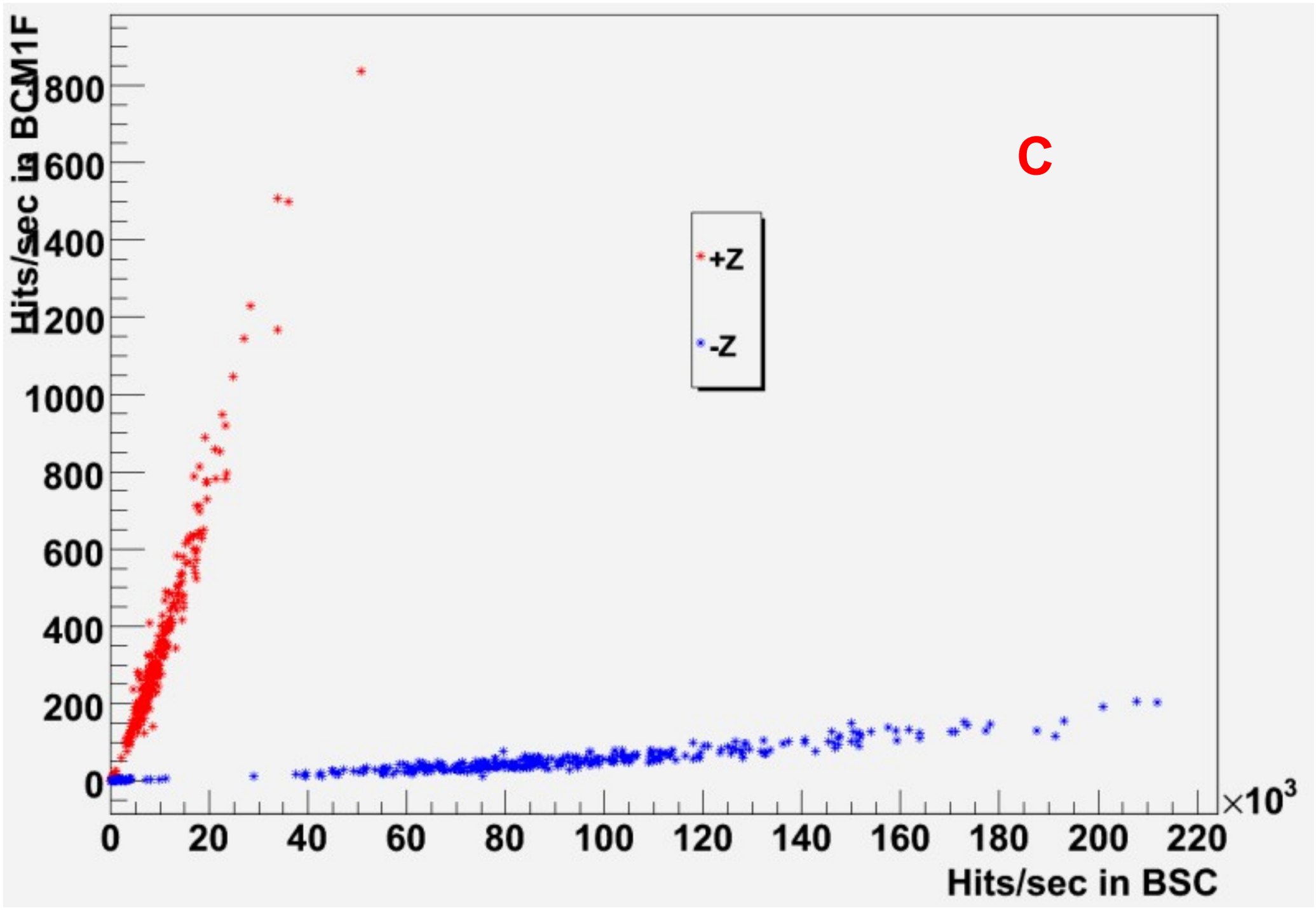
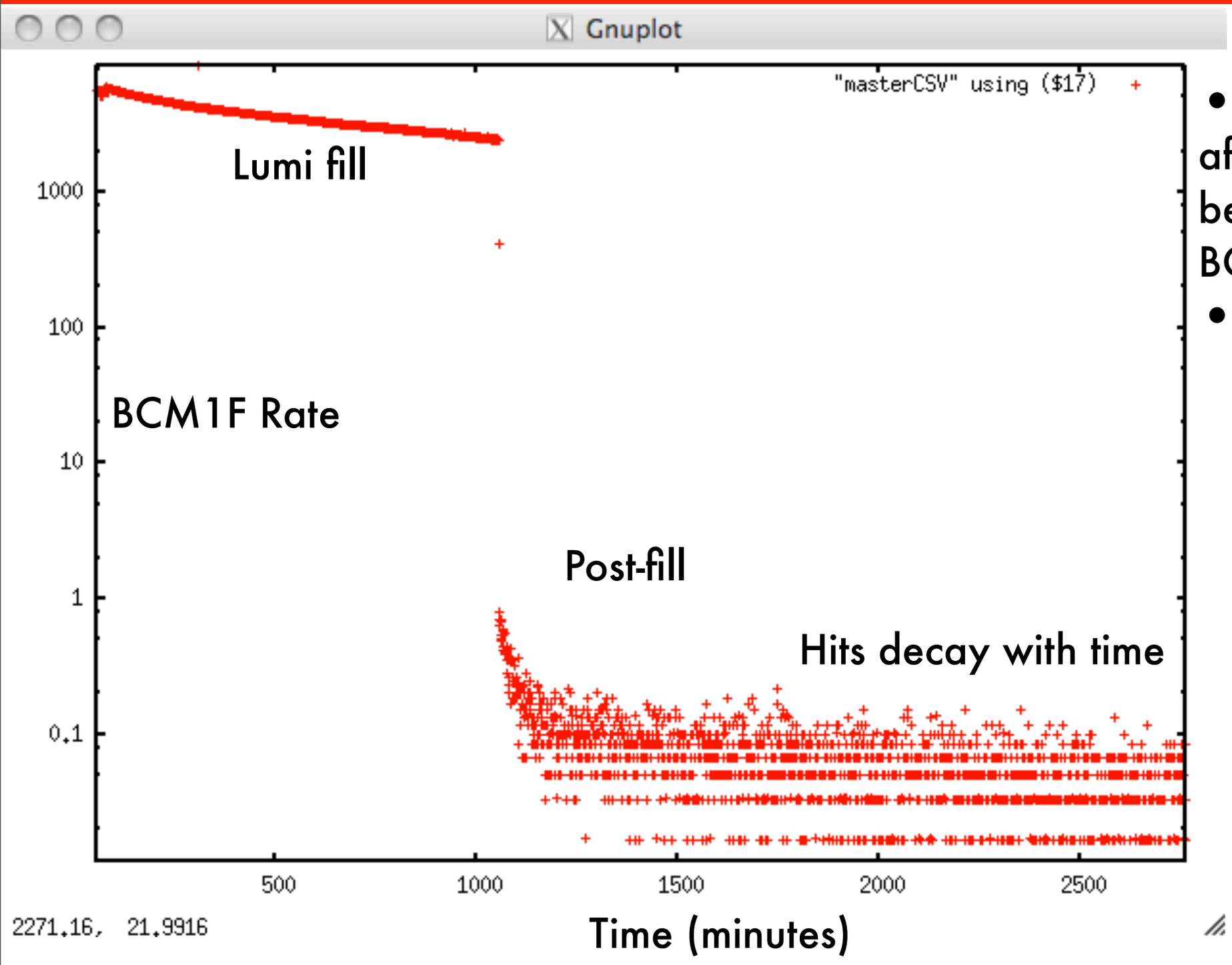
Possible Discriminants (BCM1F/BSC)

3 Dec 2009: Analysis of 2nd part of data file



Post-Fill Behaviour of Rates



- Elsewhere, decay of rate after a fill has ended has been seen in BSC and BCM2
- Also present in BCM1F

- A possible explanation is activated material
- When this effect is looked at, should look at effects in all detectors

Conclusion

- Rates are essential and useful everyday operation
- Need to understand what is happening with the rates and chacterise regular operation in terms fo luminosity and beam currents
  - i.e. `prediction = A . Lumi + B . I_1 + C. I_2`
  - Deviations from this can characterise “abnormal” background
  - This is really our key method to access “constant” background (as opposed to quick losses)

- To proceed further, need to investigate all “golden events” (i.e. incidents), and characterise them systematically
  - Investigate the correlations during these events
  - There seems to be a fair amount of information contained in the rates

- In terms of what might go into the paper:
  - Rates during a fill, expectation, parameterisation
  - Discriminant(s) between conditions and between beams
  - Correlations between ends, and between topologies of losses
  - Correlations with other detectors
- No-one explicitly working on this at the moment, though several people looking at these effects “from time to time”