(My) Summary of the BCM1F back-end workshop

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Current situation

The current BCM1F back-end architecture running at P5 is stably providing various important measurements to CMS and LHC, such as luminosity and beam backgrounds. The look-up table, whose flexibility to handle and combine various signals, has had a central role in the system. Also some issues concerning the front-end were discussed.

At the front-end two main problems are of concern: the saturation of the front-end from hits with very large amplitudes that overshoots the base line and gain loss. The overshoot hits have long recovery tails during which subsequent hits are missed which and therefore can be an important source of inefficiency. The loss in gain (5–10% for 10 fb^{-1} in 2012) should be mostly from radiation effects on the laser driver, but also some possible smaller contribution from the diamond sensor cannot be discarded.

The BCM1F readout systems is composed of an optical receiver that sends the analog signal to a fan out giving two identical signals. One signal goes into an ADC, while the other is input into a discriminator. From the discriminator the digital signal is sent to a look-up table (LUT) and sent to a TDC board and to scalers. At the LUT the signal is combined with various other signals coming from BPTX producing gated signals that counts the rates from beam-gas and from collisions (for luminosity).

After collisions we observe Albedo particles, whose rate after a few dozens of nanoseconds is negligible compared to collision rates, but it is typically larger than beam-gas rates. Therefore, to measure the beam-gas background the best would be to wait a few 100's ns. Nevertheless, inefficiency can be large due to dead-time produced by overshooting and to the fact, I would say at less extent, that we use a constant fraction discriminator with finite double-hit resolution and if two hits, one coming from Albedo and another from beam-gas, for example, are separate by less than ~14 ns, only one is counted.

Despite the Albedo rate being much less than the collision rate its contribution is estimated using intermediate gated signals between bunch crossings and subtracted for luminosity measurements. But the main problems come from the overshooting dead-time reflected in a loss of efficiency along every bunch train and gain loss credit to the radiation damage of the laser driver. Therefore the luminosity does not behave in a linear way, but quadratically. Because of this non-linear behaviour the BCM1F luminosity measurement is always re-calibrated to HF using the previous fill. Nevertheless the BCM1F and HF luminosities are almost indistinguishable, with variations ±1.5% along the fill.

Upgrade

Having in mind the current situation, most of the discussion concentrated in what can be done to solve or mitigate the problems we observe so far. In general lines, two main issues were raised: due to the size of the BRM group commercial solutions for the back-end should be more appropriate, and integration with other parts of CMS should be pursued, in the sense that after delivering signals to CMS other groups such as DAQ and/or LUMI are responsible for the equipment used to process those signals.

Just one remark on the front-end side for the upgrade. It was discussed the possibility to make two or four channels out of each sensor. The new ASIC being developed in Krakow should be able to handle up to four channels.

The possible commercial solutions essentially involves the use of fast ADCs with histogramming capabilities, some without dead-time. Two of the proposals looked more attractive. One, the M9703A AXIe digitiser, allows many functionalities, maybe more than needed, and has no dead-time. But it requires manpower with expertise to eventually change the functionalities pre-programmed on demand to the manufacturer. The cost per channel is not different from other possibilities in the market. The other solution, FMC ADC 250 MHz, is attractive not only for the price but also in the sense that is used by the other CMS groups, some infrastructure is existing and support can be provided by the physics electronics (ESE) group. But the main limitation is the low sampling rate taking into account the expected 6–7 ns peaking time. In this case, a high level of expertise is also a requisite for implementation of specific functionalities for BCM1F at CMS.

The main point of using fast ADCs with such characteristics is that one would replace the various existing oriented modules, LUT, discriminators, TDCs etc by a single unit that should also have the ability to combine various signals such as it is done at the LUT.

It was briefly raised the BCM1F4LHC situation. The point here is that the needs for CMS are getting more and more different from the ones from LHC, requiring solutions particularly for the high luminosity and high radiation environment. The current architecture seems to fulfil what the machine group requires and is proven to be robust and stable.

My view is that definitely the processing of the signals for the high luminosity runs after LS1 requires a more sophisticated readout architecture for CMS BCM1F. But I am still not sure the solutions presented so far, particularly in the sense of concentrating all the processing in a single commercial unit is the best. I also agree that more synergy and compliance with CMS standards should be pursued whenever possible, this would allow the members of the BRM group to concentrate on more important issues, instead of spending too much time with things like computer failures or VME firmware upgrades, and the data delivered from BCM1F should reach a larger number of consumers, particularly the luminosity measurements.