BRIL

BRIL (*Beam Radiation Instrumentation and Luminosity*) is a new project within CMS. It comprises all sub-detectors for the measurement of the luminosity, monitoring of the beam conditions, and protection of CMS from serious radiation damage.

Luminosity measurement

The luminosity is a key parameter of any physics measurement the experiment does, since it directly relates the total number of events seen with the cross section of the process. More specifically, the higher the luminosity, the higher the sensitivity to interesting physics processes with small cross sections. Its precise measurement is of crucial importance, since the uncertainty in the luminosity translates directly to the uncertainty of the measured cross sections.

The BRIL detectors make two types of luminosity measurement: online and offline. The online luminosity is measured continuously "on the fly" while the LHC delivers beam and allows for the optimisation of the instantaneous luminosity before and during CMS data-taking. On the other hand, the offline luminosity is measured after data-taking is done and allows for a more precise measurement for physics analyses.

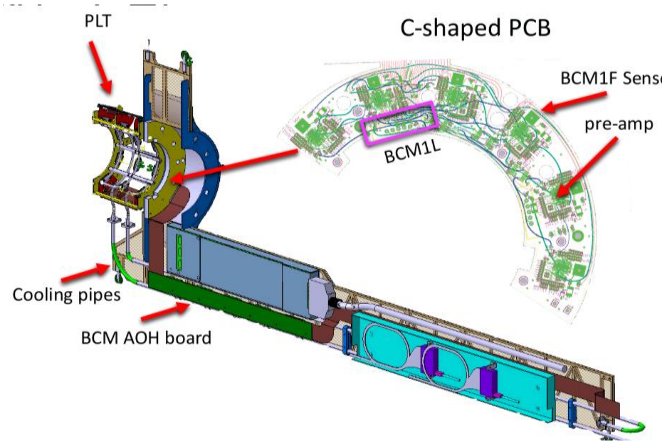

Figure 1 A sketch of the frame where PLT and the BCM1F sensors are placed

Several systems provide data for the online measurement. Two independent subdetectors, the Pixel Luminosity Telescope (PLT) and the Fast Beam Condition Monitor (BCM1F), deliver luminosity data independently from the status of CMS and are synchronized to the LHC clock. In addition, the forward hadron calorimeter also provides luminosity when CMS is taking data.

PLT is a set of 16 3-layer telescopes of small silicon pixel sensors positioned on both sides of the interaction point. The readout system is identical to that used for the pixel tracker. The luminosity will be derived from the number of pixels fired in a certain time interval.

BCM1F consists of 24 single crystal diamond sensors installed in two parallel rings just outside the beam pipe at a distance of 1.8 m on each side of the interaction point. A quarter of the full PLT and BCM1F detectors is shown in Figure 1.

Signals from charged particles crossing the sensors are amplified by dedicated fast front-end ASICs in 130 nm technology, then transferred via optical links to the backend electronics for processing. The backend consists of two parallel data-processing chains: a discriminator chain, to register the time of hits over a threshold, and an FPGA based fast sampling ADC for more complex analysis. This is illustrated in Figure 2.

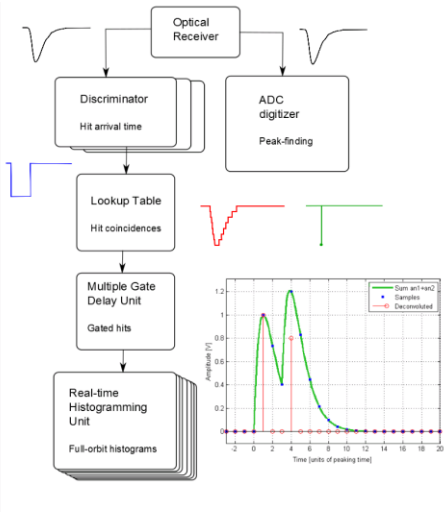

Figure 2 The two streams of the readout for BCM1F

The discriminator chain, which will be used as the initial standard backend system for Run II, is read out by fast histogramming units, which map the signal arrival time within a single LHC orbit. These devices, as shown in Figure 3, were developed in DESY, Zeuthen, and they will be a key component for the on-line luminosity measurement after 2015.The full-orbit histograms are integrated over a time interval of thousands of orbits. These histograms allow BCM1F to measure the luminosity separately for each bunch crossing, as shown in Figure 3 from a test-run in 2012. The fast ADC system will also provide full-orbit histograms of hits, but in addition it will be able to generate signal amplitude spectra due to the implementation of fast peak-finding algorithms. It will be commissioned during early Run II for later use.

Figure 3 The RHU histogramming unit

The finely granular forward hadron calorimeter is actually used to measure both online and offline luminosity, by counting the number of depositions in the calorimeter towers. The offline luminosity number is obtained after careful recalibration of the device, done over longer time intervals. In addition,

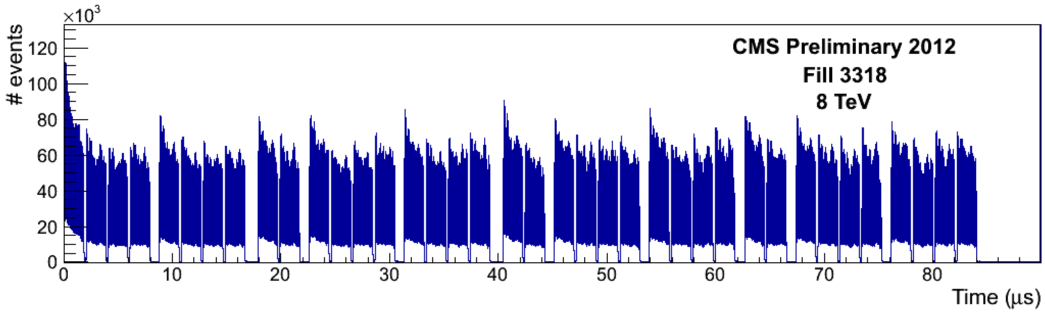

Figure 4 Counts as function of orbit-time for the determination of the bunch-by-bunch luminosity.

an off-line luminosity measurement is obtained from the pixel tracker by measuring the number of pixel clusters formed over a certain time interval. The redundancy in the luminosity measurement allows for a continuous comparison between the subsystems, important for the real-time detection of hardware malfunctions and reduction of systematic uncertainty.

Beam conditions and detector protection

Another important function of the BRIL subdetectors is to measure the machine induced background. This background consists mainly of relativistic particles originating from interactions of the beam with residual gas atoms in the beam-pipe or with the collimators. To obtain high quality data from the tracker and muon detectors, it is absolutely necessary to keep this background at a low level. This measurement will be done by BCM1F as well as the Beam Halo Monitor (BHM), which consists of several rings of direction-sensitive quartz Cherenkov counters at a larger radial position from the beam-pipe than BCM1F. Having measurements at two radial distances will provide a fuller picture of the beam condition.

When a beam abort is necessary due to adverse beam conditions, it will be induced by the Slow Beam Condition Monitor (BCML) system, using diamond sensors from which the signal current is measured over several microseconds. BCML is the ultimate protection of the CMS detector against depositions from catastrophic beam losses.

Both BCM1F and BCML are powered and read out independently from the CMS detector. LHC is not allowed to be filled if these systems are not fully operational.

For interested people

BRIL is the ideal place for students and young physicists to acquire experience in several promising forefront detector technologies and the interplay between detector and collider physicists to ensure optimal operation conditions for the whole detector. In addition, being involved in the luminosity measurement implies to determine a key parameter of the experiment, with high visibility assured.