BEAM LOSS SCINTILLATOR SYSTEM FOR BACKGROUND MONITORING AT THE LHCb EXPERIMENT

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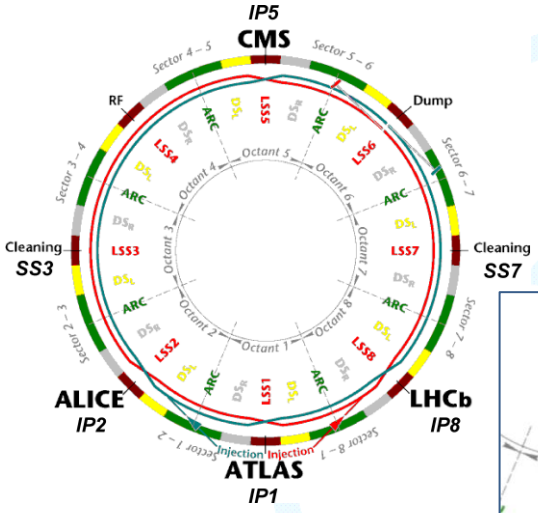
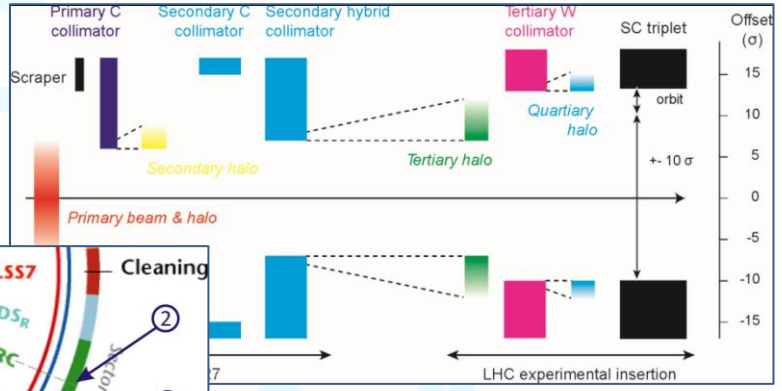
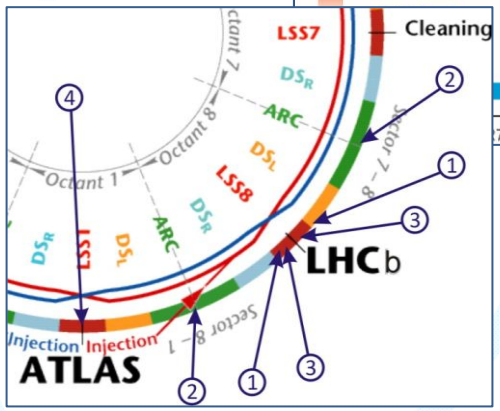
LHCb EXPERIMENT AT LHC





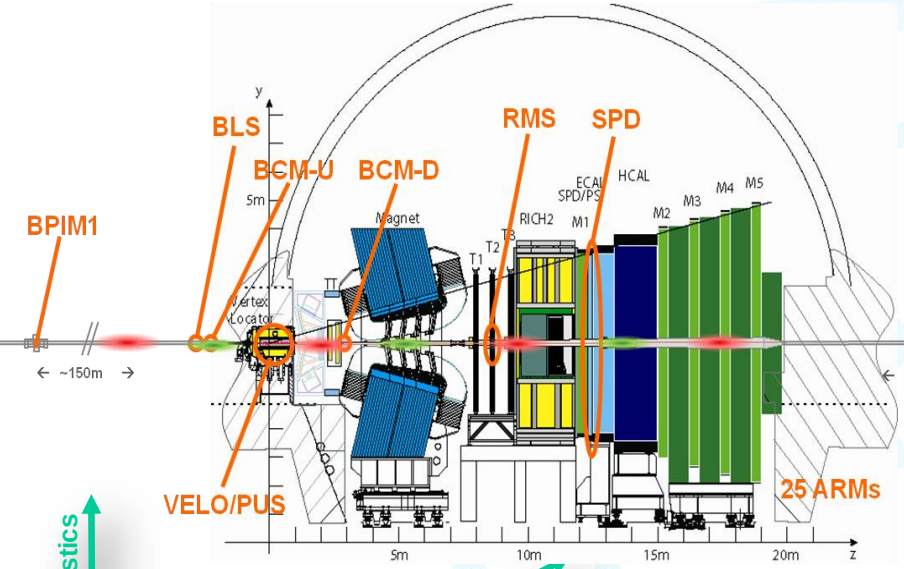


Losses around IP8:

1. Beam-gas interactions in the LSS
2. Elastic scattering in the cold sectors
3. Tertiary halo ("tails from collimation")
4. Collisions in the neighboring IPs

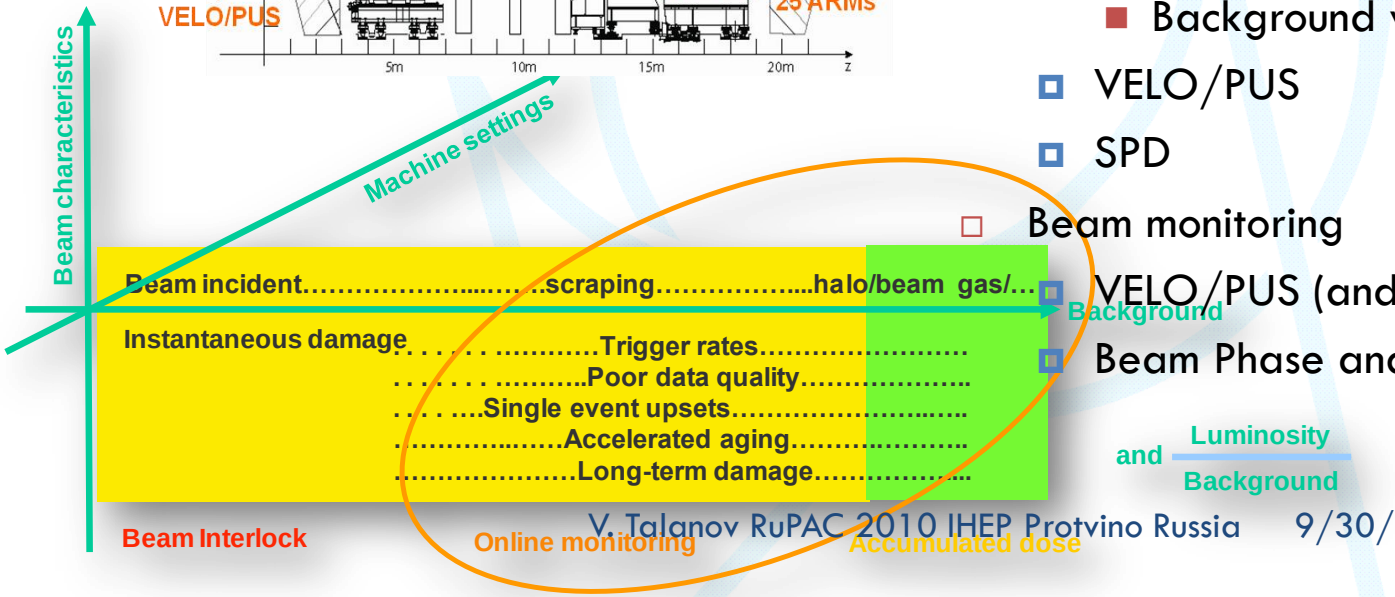
- Designed to investigate CP-violation and rare decays
- Located at IP8 between ATLAS (IP1) and betatron cleaning (IP7)
- Single arm spectrometer in the direction of LHC Beam 1 (clockwise)
- Nominal operation at $L = 2\times10^{32}$ cm^{-2} s^{-1} with mostly single p-p interaction per BX

B&B MONITORING IN LHCb



Complete study framework which involves:

- Background monitoring
  - Beam Condition Monitor
  - Radiation Monitoring System
  - Active Radiation Monitors
  - **Beam Loss Scintillator**
    - Detect fast losses at crossing rate
    - Background vs. beam settings
  - VELO/PUS
  - SPD
- Beam monitoring
  - VELO/PUS (and indirectly all the above)
  - Beam Phase and Intensity Monitor



BLS INSTALLATION

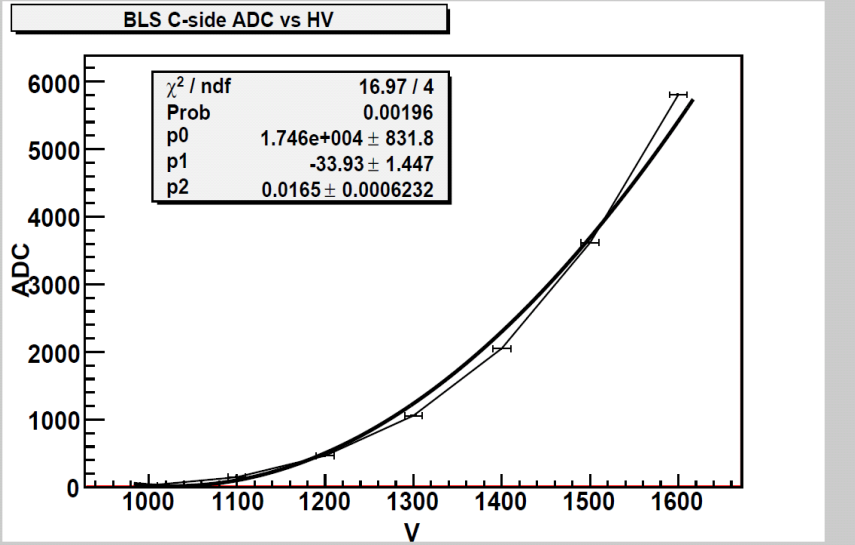
- BLS design
  - Scintillator: 4x4x3 cm^3 wrapped in TYVEK
  - PMT1: HM R2490-05, 2”diam, multi-mesh
  - PMT2:EMI 9839A, 2”diam, pan-type
  - LED: red-light, fast
  - Shielded against stray magnetic field
- Installation
  - Close to shielding wall upstream of VELO
  - On the horizontal plane
  - 12 cm from beam pipe
  - 2.1 m from the IP

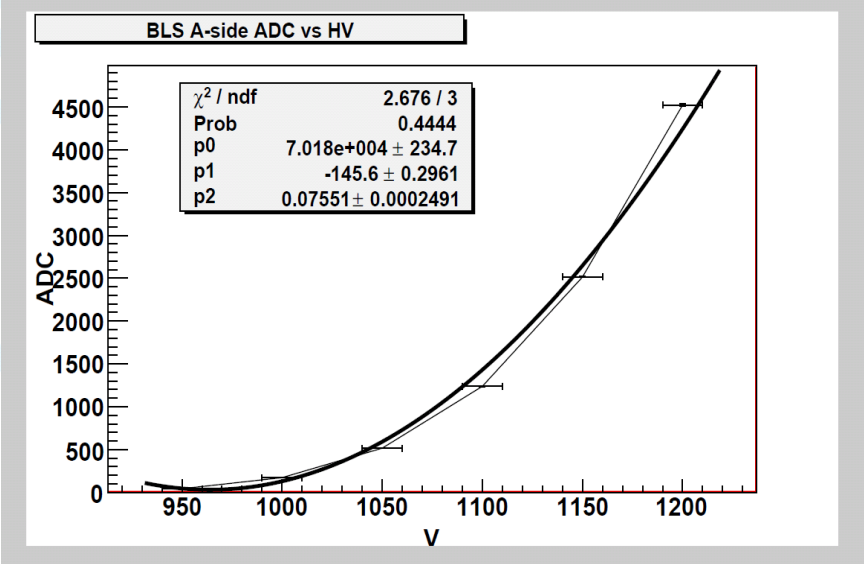
COMMON READOUT BOARD

Initially developed for beam monitoring (timing and intensity measurement) custom-made acquisition board with very high performances:

- 6U VME, one per scintillator
- Online analysis of a input pulse
  - Can handle FWHM 1 ns at 40 MHz, ±5Vmax processing amplitude
  - Onboard attenuator for higher pulses, external up to -200V)
- **Can locate the loss in a particular BXID**
- **Can integrate the full area of pulse in successive 25ns slots**
  - 12-bit resolution by integrating pulse per bunch
  - **Resolve the fine time structure of a loss**
  - Output intensity on front-panel at 40 MHz (8/4-bit resolution)
  - Triggered via controls interface, fill in FIFO with more than10000 measurement every 5 seconds
  - **Worst loss within the 5 seconds interval used as BCKG2**
- Readout and control via Experiment Control System, CCPC based interface and VME alternatively
- Interfaced directly to LHCb Timing and Fast Control system
- **Data processing on FPGA, two main working modes:**
  - INJECTION: synchronized with beam extraction from SPS
  - CIRCULATING: continuously measure worst beam loss and measure luminosity delivered in LHCb.

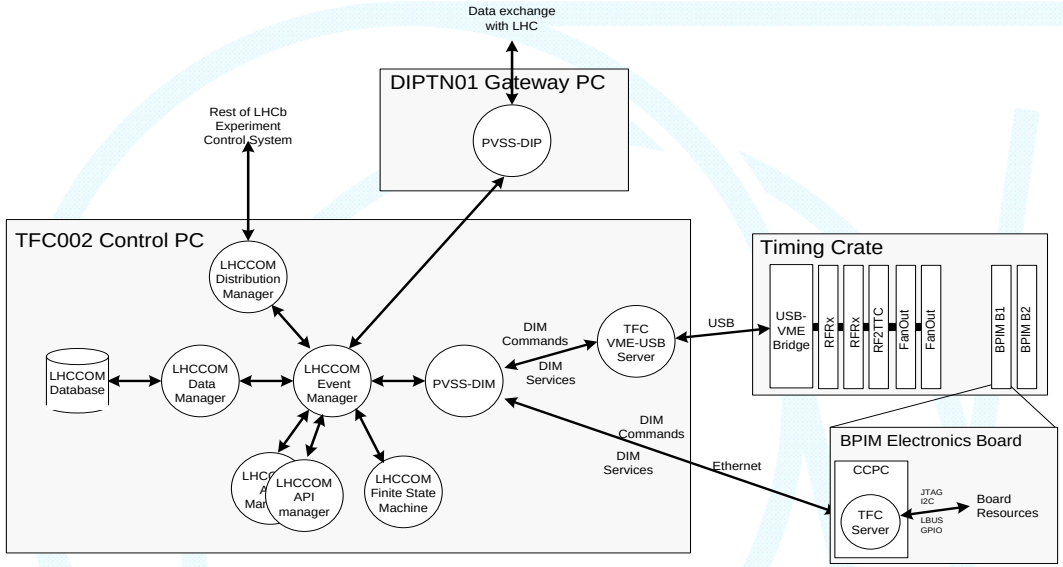
CALIBRATION IN SITU





- Same input LED pulse
- Varying the HV applied to the PMT
- Find a common ADC point in order to choose the same response for each scintillator
- Important for monitoring the PMT gain and ageing

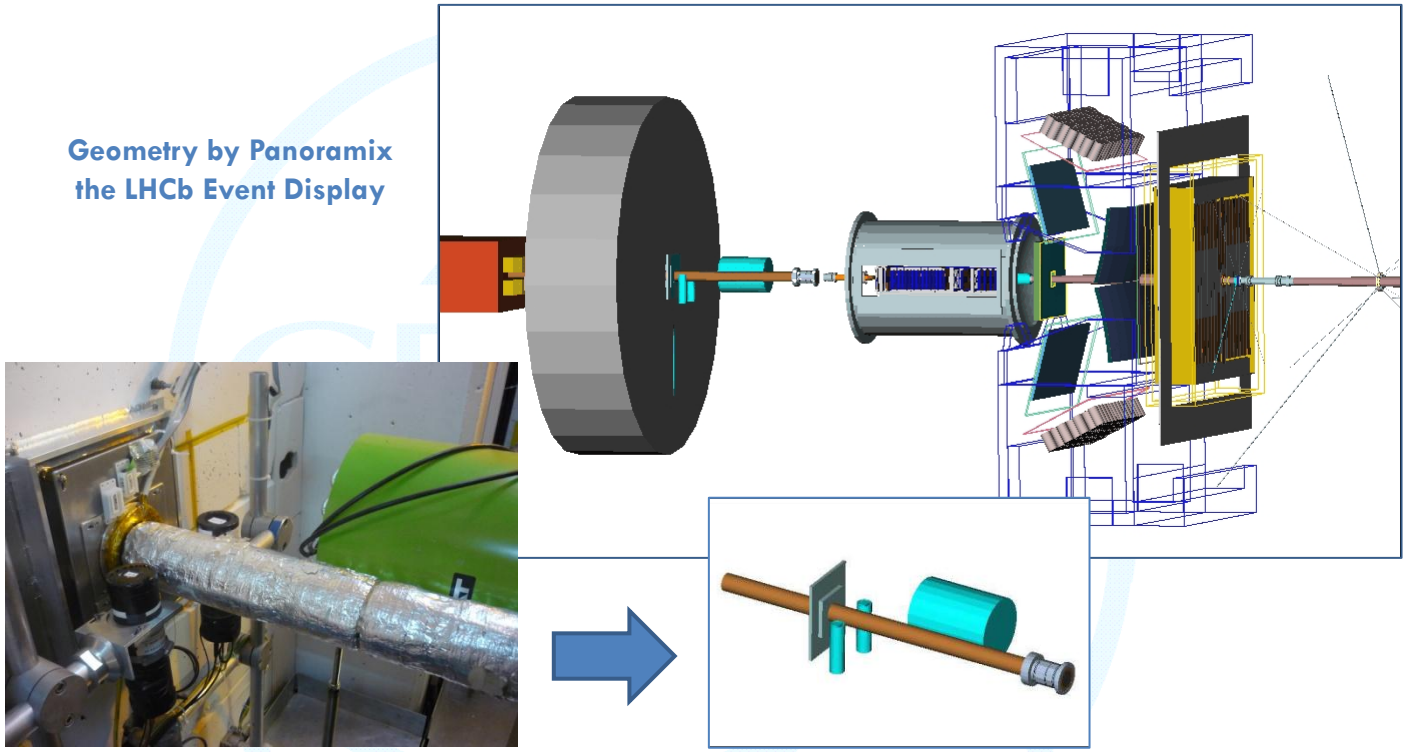
CONTROL AND MONITORING



- BLS are part of the LHCb common Online system
- Based on Credit Card-sized PC with Ethernet running a strip-down version of Linux
  - Access board resource via PCI bus converted to native hardware busses by glue logic
  - Server based on the same generic protocol on top of DIM allows the PVSS-based control system to configure and monitor the electronics
- Continuous archiving and permanent display in the LHCb control room

BLS SIMULATION

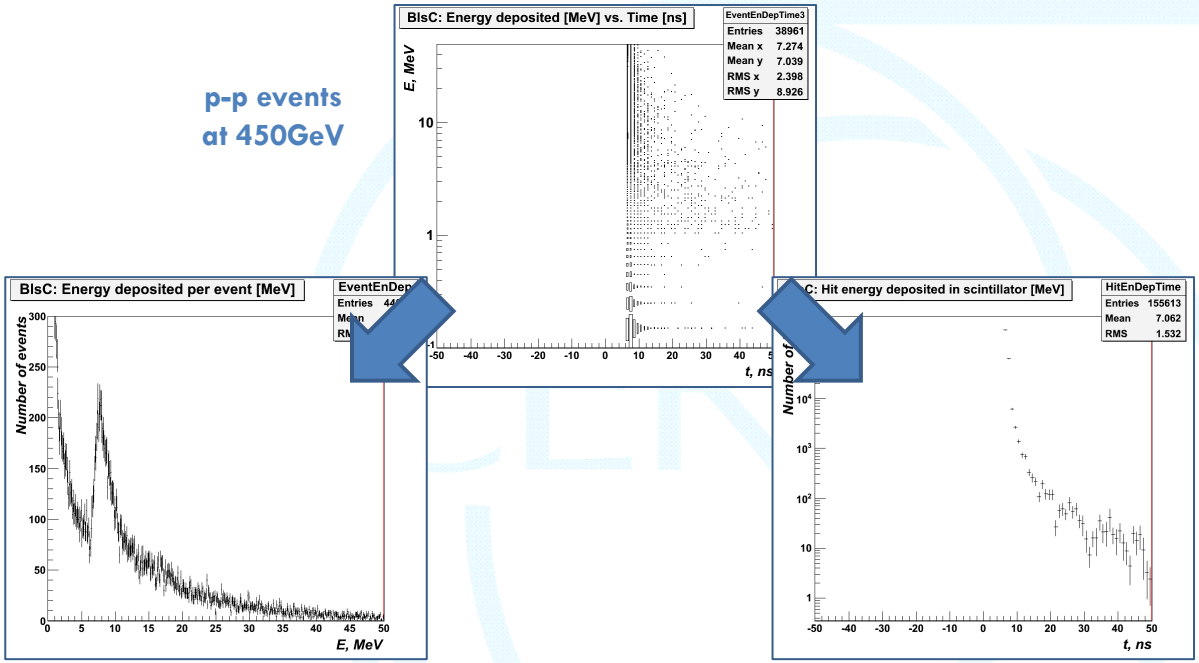
Geometry by Panoramix
the LHCb Event Display

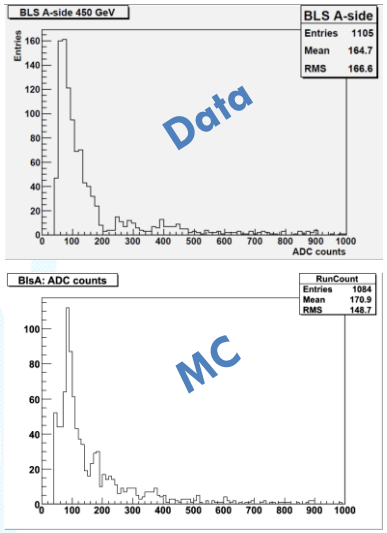


- Simulations were performed for various modes of the LHC operation
- Essential to estimate rates in squeeze and collision to adjust the BLS sensitivity
- BLS description is available from the common LHCb detector description database

BLS SIMULATION (2)

p-p events
at 450GeV

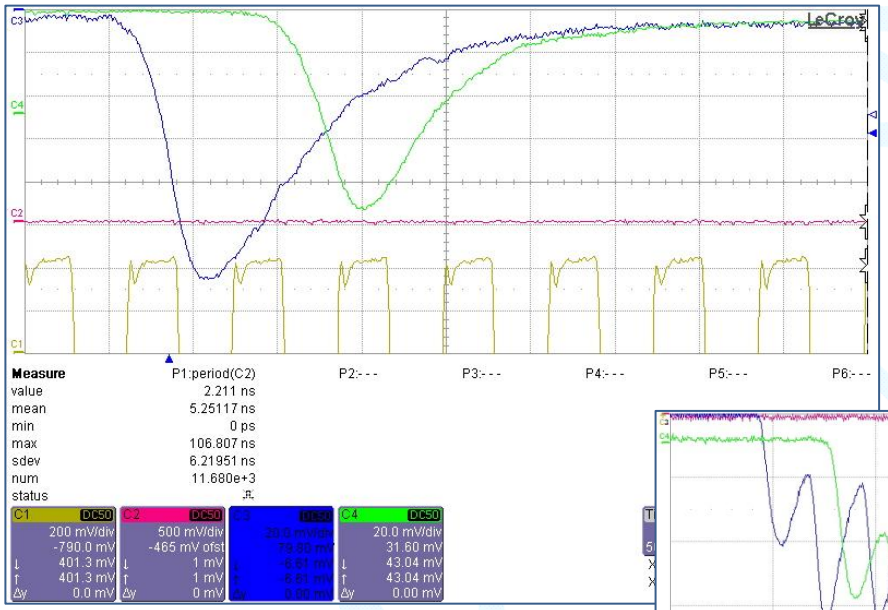




TED shot at 450GeV

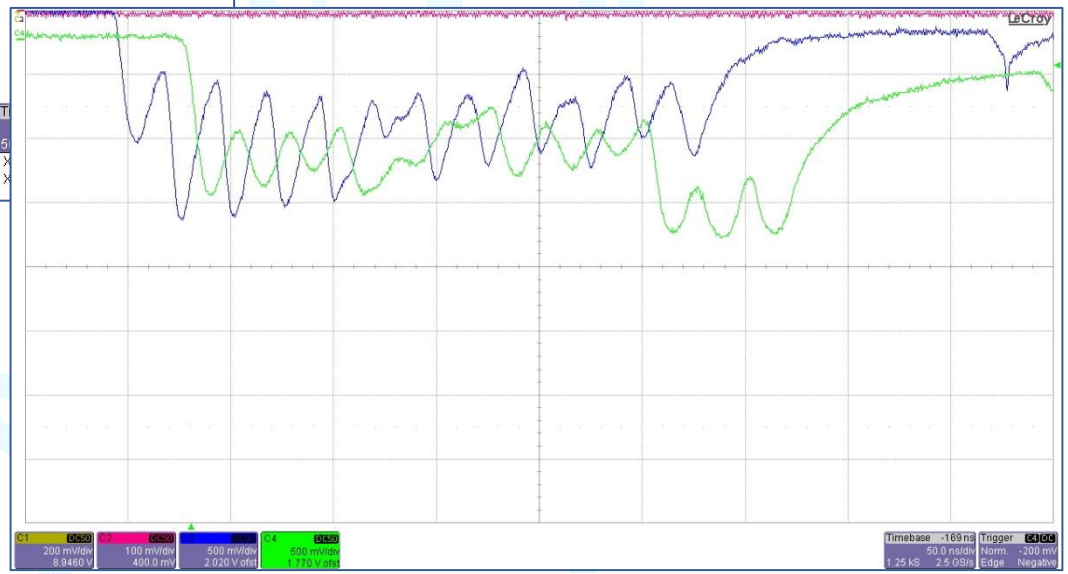
- Dedicated algorithm and monitoring package within the LHCb simulation framework
- Analyze position of hits, time profile of energy deposition, track vertices etc.
- In preparation the digitization algorithm to give same signal as DAQ

FIRST PULSES WITH BEAM

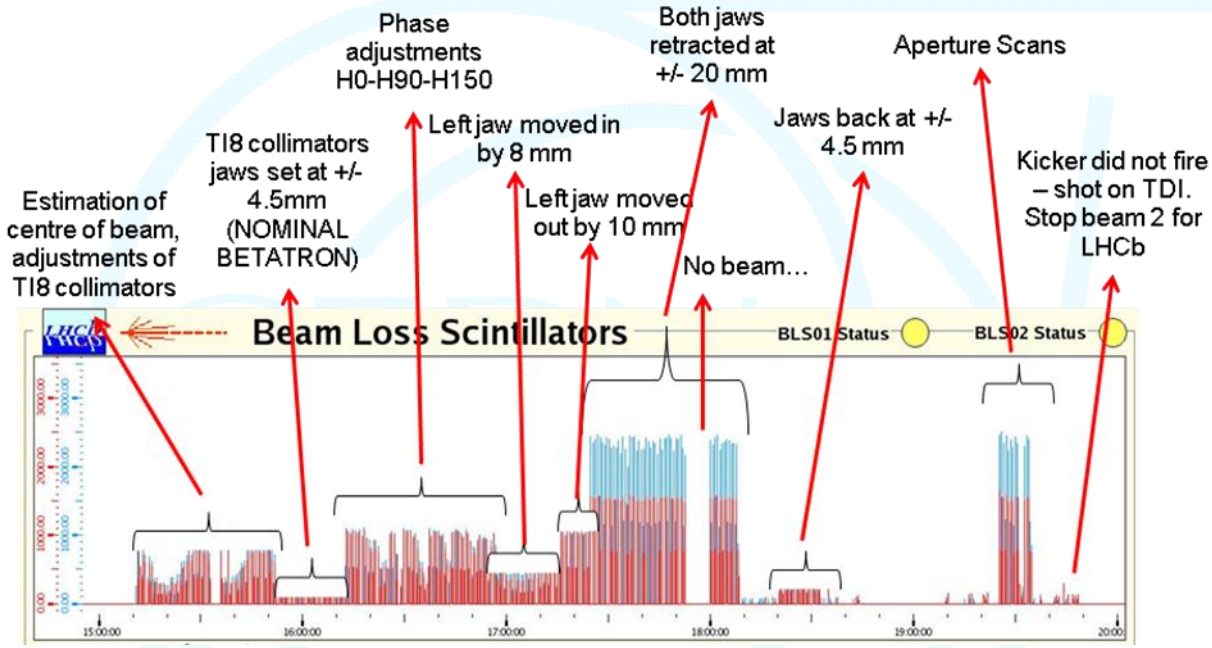


Pulses from both scintillators with real pilot beam injected through LHCb, width of ~2 clock cycles

Train of bunches injected at a spacing of 25 ns (test on June 2009)

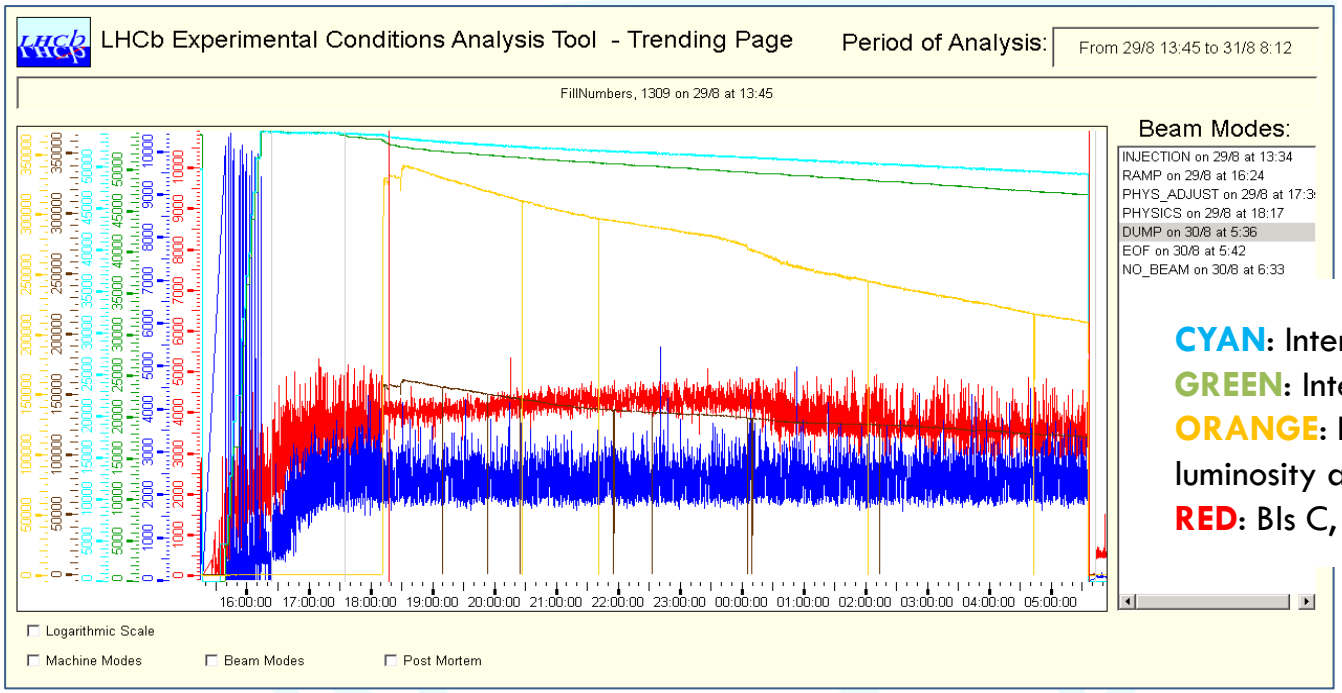


INJECTION COMMISSIONING



- Possible to "calibrate" the position of the collimators with "desired" losses
- Whole range of losses is covered by BLS and BCM
  - BLS are more sensitive than BCM
  - BLS saturate at 10% of threshold BCM

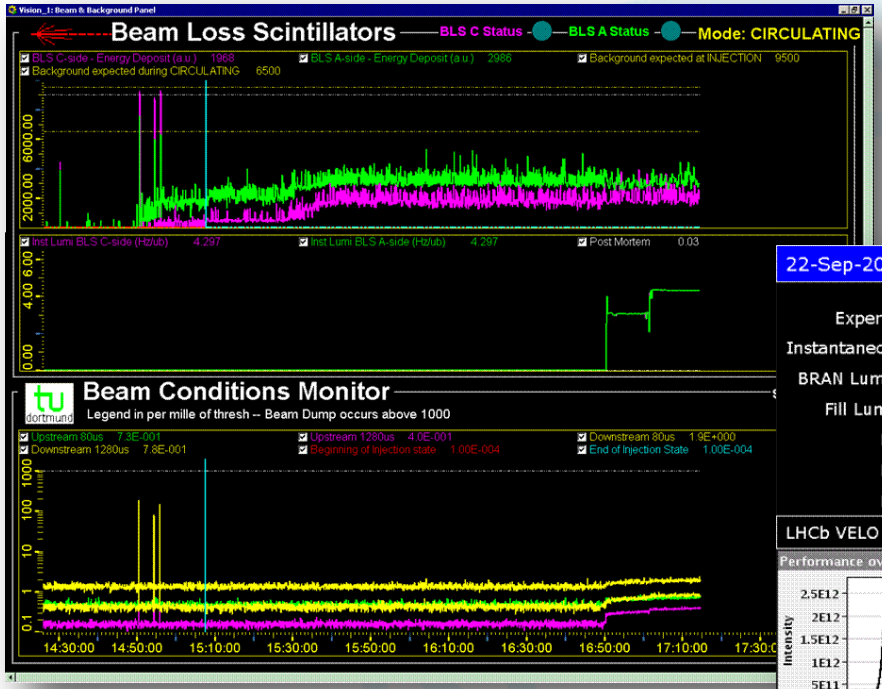
PERFORMANCE WITH BEAM



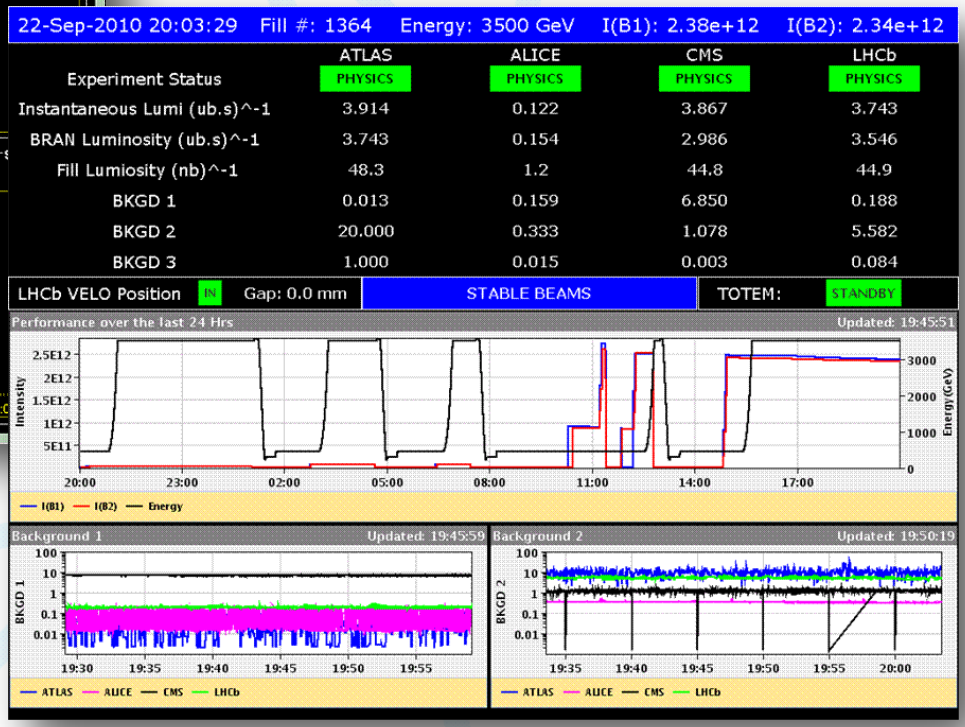
CYAN: Intensity, Beam 2
GREEN: Intensity, Beam 1
ORANGE: Instantaneous luminosity as measured by BLS
RED: Bls C, **BLUE**: BLS A

- INJECTION: high peaks at low rate are observed
- RAMP: as the energy of the beam approaches 3.5TeV occasional losses are getting higher in intensity, but still at a lower rate
- COLLISIONS: the rate of signal is dominated by the p-p collisions in the IP

DATA PRESENTATION



As seen by the LHCb operators in the LHCb control room



As seen at CERN and worldwide

http://op-webtools.web.cern.ch/op-webtools/vistar/vistars.php?usr=LHC3

CONCLUSIONS

- Complete sub-system for beam and background monitoring in LHCb has been developed
- Core of sub-system consists of two scintillating counters
- It uses high performance, fast and precise readout electronics
- Sub-system has been successfully installed, calibrated and tested with the first pulses of the real beam in the LHC
- It has been used already in 2009 in commissioning of the LHC injection lines
- Sub-system delivers data at various mode of the LHC operation
- It is used as a part of control and monitoring of the experiment
- Description of counters implemented in the LHCb detector database
- Dedicated algorithm created to simulate and analyze BLS response to adjust the sensitivity according to available dynamic range and set thresholds
- Digitization package should enable to include the BLS response into standard reconstruction in the LHCb experiment

THANKS FOR ATTENTION!