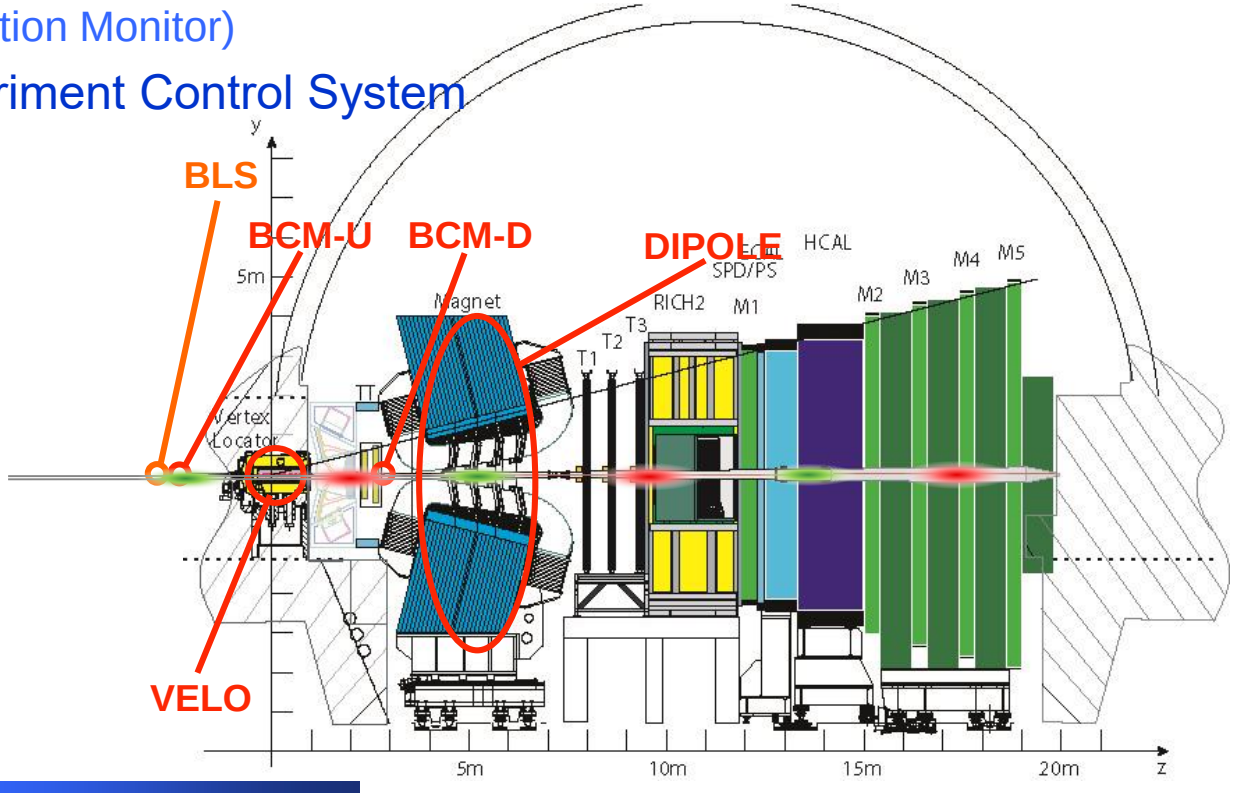
LHCb Beam Interlocks

- Beam Permits
- Injection Permits

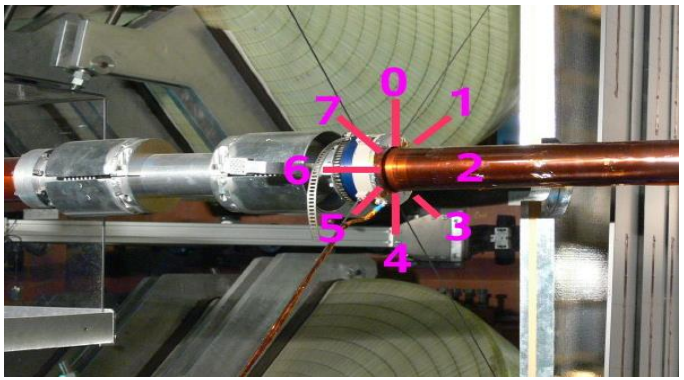
Beam and Injection Permits

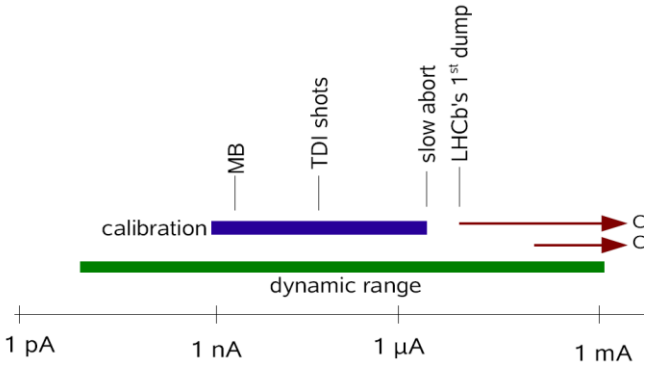
- Three ‘hard’ sources of Beam Permit interlocks
  - Beam Condition Monitor
  - Vertex Locator
  - LHCb Dipole
- One ‘hard’ source of Injection Permit interlock
  - Beam Loss Scintillator
  - (Beam Condition Monitor)
- + ‘soft’ by Experiment Control System



Beam Permits

- Beam Condition Monitor (BCM) – Main LHCb Life Guard
  - 2 stations (Upstream/Downstream) of 8 diamonds each 5/4cm from beam axis
  - 40μs integration – 36 pA/mips
  - Running sums 2x40μs and 32x40μs
    - Sum based on diamond 2-6 to account for possibly dead and noisy diamonds
    - Available in CCC divided by dump threshold as BKG1 (BKG2)
  - Directly connected to non-maskable BIS – always operational
    - Dump criteria based on three adjacent diamonds for the 2x40us running sum





  - System has no dependence on control/software
    - Immediately operational on power-up
    - Reset after dump normally by software but may be done with hardware
  - Dump thresholds 'hardcoded' in VHDL code
    - Easy compilation and loading by expert
  - Whole system powered by same power as LHC in sector 78
  - Entire spare system stored at P8 (except diamonds!)

Beam Permits – cont'd

- Beam Condition Monitor – cont'd
  - PostMortem processing upon PM signal via GMT
  - Beam Permit (Injection Permit) = false during PM processing O(2-3 min)
    - Rearming automatic if dump was not triggered by BCM
    - Rearming requires manual rearm if triggered by BCM

- LHCb Vertex Locator
  - Movable device : garage position at 30mm, DAQ position 5mm
  - Moving in/out O(2.5min)
  - Interlock logic combination of GMT safe flags and VELO position
    - Permit True:
      - ((VELO_out) and (any Beam_Mode))
        or ((VELO_in) and (Movable_Devices_Allowed))

      - Where Movable_Devices_Allowed ~ Stable Beams or Unstable Beams
      - And VELO_out is defined as >28mm

Beam Permits – cont'd

- LHCb Vertex Locator – cont'd
  - GMT flag Safe Stable Beam=false is used to decide withdrawing VELO
    - Might become automatic
  - Consequence:
    - VELO must be retracted before switching to ADJUST or DUMP
      - Handshakes!
      - Retracting before DUMP logic should change….
  - VELO interlock system relies on a BCM_OK
  - Position system and interlock on LHCb UPS
    - Withdraws automatically on power cut
    - Also possible to retract VELO manually…
  - PostMortem processing triggered by GMT PM telegram

Beam Permits – cont'd

- LHCb Dipole Magnet
  - Controlled by LHC
  - Magnet Safety System under responsibility of PH/DT1
  - Interlock logic based on SC parameters:
    - Temperature
    - Cooling
    - Power converter etc
    - Polarity?
  - LHCb Magnet failure
    - Slow influence on orbit, typically $\mathcal{O}(\sigma)$ in several 100 ms
    - Power converter: Reaction time to dump beam ~100 ms
    - Cooling failure: Transmit beam interlock 10ms before power converter switches off
  - Magnet Safety System on UPS

Injection Permit

1. Prevent injection while experiment is in incompatible mode
2. Prevent further injection after 'dirty transfers'
   - Without dumping existing beam
3. Prevent further transfers during physics

- Incompatible mode
  - Any interfill activity which involves switching on detectors or VELO_in
    - Normally switch to false (if not already done) after dumping each physics fill (calibrations)
  - Some interventions on 'life supporting' systems
  - Injection Permit controlled manually and automatically by ECS
  - Rely on Handshakes to issue Injection Permit
  - Obviously will not be needed in repeated LHC tests during MDs etc

Injection Permit – cont'd

- 'Dirty transfers' measured by Beam Loss Scintillators
  - Prevent repeated splashes not seen by CCC immediately
  - 25ns integration and readout of fast losses
  - Using injection prepulse via BST to integrate 3-10 turns after each transfer
  - Experiment off during injection so 'high threshold'
  - Will only be activated in automatic mode once experience has been gained
- Injection Permit interface same as BCM
  - Safe power, operational without software etc
- Beam Loss Scintillator system on LHCb UPS