

LHCb VELO: Performance and Radiation Damage in LHC Run I and Preparation for Run II Tomasz Szumlak, Agnieszka Obłąkowska-Mucha, AGH UST Kraków on behalf of the LHCb Collaboration 13th Pisa Meeting on Advanced Detectors, 24-30 May 2015





 $\pi \rightarrow K misID \sim 5\%$





The LHCb detector at LHC (JINST 3 2008 S08005)

Performance during Run I



- □ Using the ADC distribution fit Landau ⊗ Gauss function in order to retrieve MPV for signal and noise value
- □ Typical noise across the VELO ~ 1.6 2 ADC counts (depending on sensor position and type)
- □ Average signal to noise ratios measured for the VELO:



Performance of the LHCb VELO (JINST 9 2014 P09007)



Resolutions



- Single hit resolution linear dependence on strip pitch for a given projected angle range
 - the best resolution @LHC: ~ $4 \ \mu m$
- **Primary Vertex resolution ~ 69 (13)** μm for z (x,y) respectively for 25 tracks
- Impact Parameter resolution critical for trigger performance – amounts to ~ 12 μm for high momentum tracks



[mu]

resolution

2

Radiation damage



- LHCb VELO preliminary 70 60 40 50 40 40 20 10^{10} 10^{11} 10^{12} 10^{10} 10^{13} 10^{13} 10^{13} 10^{13} 10^{13} 10^{13} 10^{13} 10^{13} 10^{13} 10^{13} 10^{13} 10^{13} 10^{13} 10^{12}
- Bulk current increases with delivered luminosity
- **Typical increase amounts to** roughly $\sim 1.9 \ \mu A/pb^{-1}$
- All silicon sensors operating at the same bias voltage of 150 V
 Good agreement with theory
- □ Effective depletion voltage V_{ED} decrease with fluence
- $\Box \text{ Minimum of } V_{ED} \sim 18 \text{ V observed}$ $@ ~ 1.5 \times 10^{13} n_{eq} cm^{-2}$
- Overall good agreement with the Hamburg Model – the apparent departure related to small electric field

Preparation for Run II



 172 ± 12

 164 ± 11

Sensor V_{ED} at 4.4 fb⁻¹ [V] V_{ED} at 10 fb⁻¹ [V]

 432 ± 30

 404 ± 26

- Fully operational VELO replacement has been built
- in case of accident or some unexpected radiation damage related problem
- □ Need to define new procedures for CCE
- More aggressive approach to calibration scans done on daily basis
- $\Box V_{ED} \text{ is not going to be uniform across} \\ \text{sensors careful monitoring needed}$
- Operation with different bias voltage for different sensors envisaged

 V_{ED} well below 500 V!

We can operate the VELO successfully till the end of the Run II

fluence Radiation damage in LHCb VELO (JINST 8 2013 P08002)