

LHCb and Introduction to Tuning and QCD Measurements at LHCb

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LHCb workshop on quantum interference effects, QCD measurements and generator tuning

20th October 2014



Outline

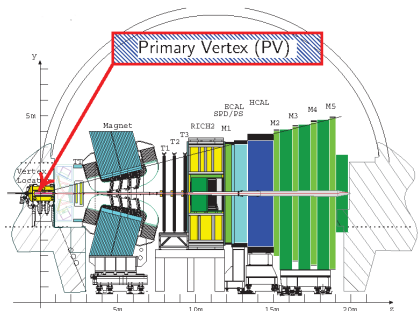
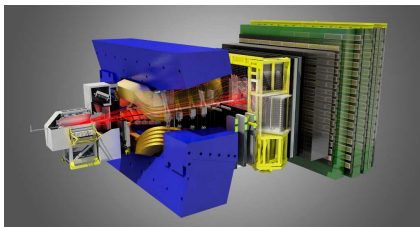
- 1 LHCb Detector - Forward spectrometer
- 2 LHCb Detector, LHC Run 1 data
- 3 LHCb Physics Program and Objectives
- 4 LHCb results - CPV
- 5 LHCb results - $B_{s,d} \rightarrow \mu^+ \mu^-$
- 6 LHCb results - list
- 7 QCD measurements, overview for Workshop
- 8 Tuning of a dedicated generator to HEP data
- 9 EW Measurements : Parton
- 10 Conclusions



813 members
16 countries
59 institutes
(July 1, 2012)



LHCb Detector - Forward spectrometer

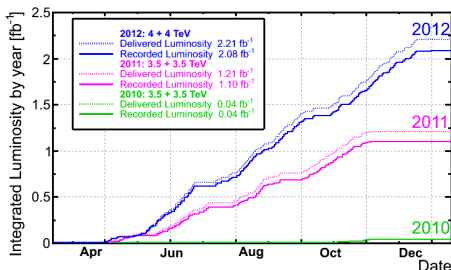
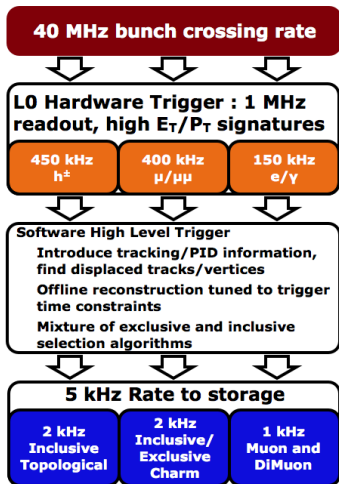


- 1 Single arm spectrometer, $\eta \in [2, 5]$.
- 2 Stations:
 - VERtice LOcator (VELO);
 - 4 tracker stations;
 - 4 Tm integrated field;
 - Calorimeters;
 - RICH detectors;
 - Muon system.
- 3 Precise measurements:
 - Impact parameter resolution $\approx 20 \mu\text{m}$ for high- p_T .
- 4 Excellent Particle IDentification (PID) and tracking in a unique pseudorapidity range.

JINST 3 (2008) S08005

LHCb Detector, LHC Run 1 data

- 2010: 37 pb^{-1} ; 2011: 1.0 fb^{-1} ; 2012: 2 fb^{-1} .
- Excellent reconstruction allowed a higher level of pile-up.



- Trigger operates with 5 KHz (physics trigger lines).
- 3 types : Topological, charm inclusive/exclusive; muon lines.

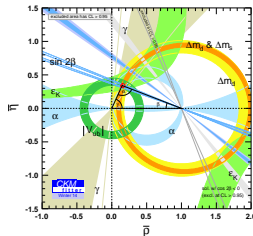
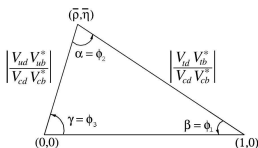
LHCb Program and Objective

- 1 Search for new physics - indirect searches *complementary to ATLAS and CMS:*
 - CP violation measurements;
 - Rare b and c decays;
- 2 Tests of QCD in non-perturbative case;
 - Excited states and new particles;
 - Measurements of decay parameters and mass of known particles;
- 3 Tests of QCD to NNLO:
 - Electroweak production (W,Z);
 - Differences in proton PDFs important at this scale.
- 4 heavy quarks production, fragmentation and hadronization parameters:
 - polarization and production of heavy hadrons;
 - associated jets;
 - pA and Ap results, e.g. on Z and Quarkonia;

LHCb results - CPV

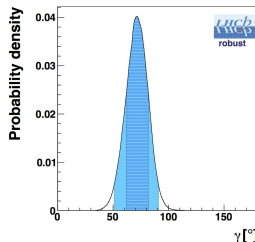
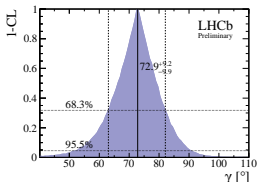
- Measurement of the CKM angle γ , note LHCb-CONF-2014-004:

$$V = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}.$$



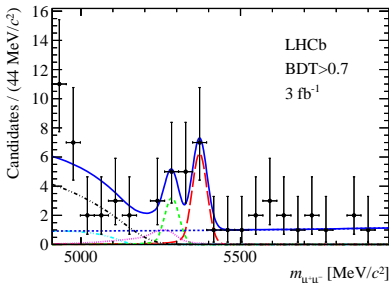
- $\gamma = (73_{-10}^{+9})^0$ best precision measurement for a single detector.

Frequentist: 72.9^0 , Bayesian: 71.9^0 .



LHCb results - $B_{s,d} \rightarrow \mu^+ \mu^-$

- 1 $B_{s,d} \rightarrow \mu^+ \mu^-$ (PRL,111,(2013),101805).
- 2 Rare decays in the standard model; no tree-level diagrams, helicity and GIM suppression, sensitive to NP.
- 3 measured branching fraction $B(B_s \rightarrow \mu^+ \mu^-) = 2.9_{-1.0}^{+1.1} \times 10^{-9}$ with (4σ significance).
 - No clear $B \rightarrow \mu^+ \mu^-$.
 - Combined measurement with CMS, to be published.



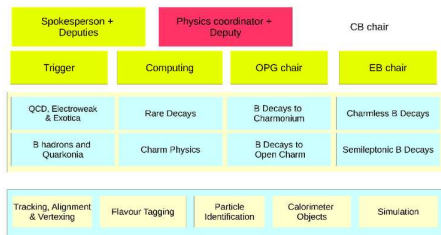
LHCb results - list

1 A partial list of measurements on Run 1 data:

- The loop and FCNC transition $B \rightarrow K^{(*)} \mu\mu$ BJHEP 06 (2014) 133. - agree with SM.
- Rare radiative decays of type $b \rightarrow s\gamma$ penguin/loop transition, very sensitive to NP. Photon polarization measured in an angular analysis.. PRL 112 (2014) 161801.

- $Z(4430)^-$, PRL 112,222002(2014). Other spectroscopic measurement
- B hadron life times.
- B_C lifetime, mass,
- Many more;

The PPG



2

QCD measurements, overview for Workshop

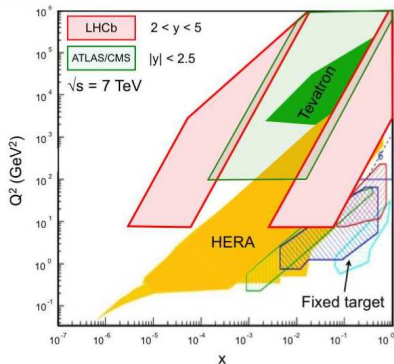
- Jet production in LHCb with correlated Jet and Z, jet b- and c- tag.
- Talk on EW Z/W production. Shall restrict myself on some general notions and p-Lead data in LHCb.
- Tuning procedure in LHCb. PYTHIA8 LHCb, standard analyses of LHCb implemented in RIVET.
- General talk on tuning.
- p-Lead results form LHCb.
- Open charm and beauty at LHCb
- Quarkonia and double charm
- Soft QCD measurements in LHCb

Tuning of the dedicated generator

- 1 Tuning in LHCb refers generally to PHYTIA8, though COSMIC ray generators are being considered especially in description of proton-Lead interactions. Other generators are tested, too.
 - For Z and W production ResBos, FEWZ, PAWHEG are used.
 - The RIVET platform and package stands for an umbrella of many published results which are made available to
 - The last talk in the agenda describes the tools used in doing the tuning of a generator.
 - Find the set of model parameters that describe best the set of measurements chosen from RIVET.
- 2 What LHCb measurements might be used in generator tuning?
 - Soft-QCD: p_T/y particle spectra in LHCb, N_{ch} charge multiplicity, EF - energy flow, strangeness, light baryon to meson ratios. All in forward phase-space of the initial collision.
 - Open charm measurements, jets, and EW production,

EW Measurements: Parton Distribution in LHCb

- LHCb geometrical acceptance about:
 $\eta \in [2, 5]$.
- Compared with CMS and ATLAS, LHCb explores low and high x regions.
- For Z, W bosons $Q \approx 100$ GeV,
 $x \in [10^{-4}, 10^{-3}]$.
- Low mass Drell-Yan γ^* at $Q = 5$ GeV spans down to $x = 0.8 \times 10^{-5}$.
- Lower Q^2 limit given by LHCb muon trigger efficiency.



Conclusions

- 1 LHCb has the chance contribute to the tuning of the next generation of generators.
- 2 In Forward region we are very competitive in measuring Baryon transport number, strangeness production, fragmentation, the effects of Color Reconnections, collective flow, MPI, UE, see <http://skands.web.cern.ch/skands/slides/14/14-Aug-LHCb.pdf>
- 3 Thank you for you attention.