LHCb 2015 highlights and status

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on behalf of the LHCb collaboration

LHC Physics colloquium
LHCb is...

- A precision experiment flavor experiment at the LHC:
  - If collision energies are high enough, new particles can be directly observed
  - If precision is high enough, the effects of new particles on decays of known particles can be observed
- Complementary physics programme to that of the other experiments
- Core physics programme: Studies of matter/antimatter asymmetries in beauty and charm decays
LHCb is...

- 1169 Members, from 69 Institutes in 16 Countries
LHCb is...

- 20 this year!
- 290 run 1 physics publications so far
- 2 publications using run 2 data
- Lots more from Run 1 still to come
- Many more analyses ready for the winter conferences
- Some intriguing anomalies
- Looking forward to full exploitation of Run 1 + Run 2 datasets
Plenty of surprises left in Run1 data

- Quarks in nature are never observed in isolation: $q\bar{q}$ pairs (mesons) or 3-quark baryon states. LHCb analysed the structure of $\Lambda_b$ baryon decays:

- Data and model only agrees with the addition of two new 5-quark states
- First observation of pentaquarks!
Precision at 13 TeV

- For the main physics goals of LHCb, more data is more important than higher energies:
  - Direct searches: new energy $\rightarrow$ new particles could appear immediately
  - Precision measurements: only gain in increased production rates
- But digesting more data is a challenge
- Run 1: LHCb collected data in a similar manner to the other experiments:

  ![Diagram](image)

  - Hardware trigger: 40MHz $\rightarrow$ 1MHz
  - First Software trigger: 1MHz $\rightarrow$ 100kHz
  - Second Software trigger: 100kHz $\rightarrow$ 5kHz
  - Reconstruction Align + Calib
  - Analysis

  Time from collision: $\mu$s ms hours weeks

- Offline reconstruction takes time: alignment and calibration applied after data taking
- Offline processing costs money: Uses a lot of computing resources
Increasing precision while saving resources

- LHCb data collection strategy in run 2: a paradigm shift in HEP data collection!
- Harvest more data with better use of resources
- Streamlining the analysis procedure leads to quick results!

- **Real-time** calibration and alignment in the trigger: No need to recalibrate offline
  - Calibration in the trigger means cleaner signals: Purer, larger data samples
- **Real-time** analysis (turbo stream):
  - In many cases, results found in trigger can be analysed directly
  - Factor of 10 saving in storage requirements
Real-time alignment & Calibration

- Specific procedures applied for each subdetector
- Monitored in real-time at the control room
- Run 2 Impact parameter resolution in the trigger is now identical to Run 1 offline:

- Benefits of alignment + calibration
Charm production at 13 TeV

- Particles containing charm quarks: An LHCb specialty
- Increased collision energy $\rightarrow$ increased signal rates
- How often does LHC produce them at the new 13 TeV energy?

Submitted to JHEP

- Extremely pure signals in real time!
- Rate consistent with, but slightly higher than theory predicts: Good news for the LHCb charm programme in 2016!
J/ψ particles often produced by beauty-containing particles

beauty particles have long lifetimes: can be used to determine how many are produced at 13 TeV:

Extraction of J/ψ from beauty made possible due to excellent tracking resolution

Result presented 1 week after data taking

Total beauty production cross-section: \( \sigma(pp \rightarrow b\bar{b}X) = 512 \pm 2 \pm 53\mu b \)
Twenty years ago...

1 Introduction & Overview

The LHC offers a unique opportunity to study the physics of b-quarks. The expected $b\bar{b}$ production cross section of 500 $\mu$barn leads to a production rate of almost $10^{12}$ $b\bar{b}$ per $10^{7}$ second year already with a modest luminosity of $\mathcal{L} = 1.5 \cdot 10^{32}$ cm$^{-2}$ s$^{-1}$. With the present Letter-of-Intent, we propose an optimised open-geometry forward collider detector which we believe will be able to fully exploit the B-physics potential of the LHC.

- From the Letter of Intent:
- We got the beauty-cross section right...
- ...but we operate at over twice the collision rate!
J/ψ signals in SMOG

- SMOG: gas injection into the path of the beam
- LHCb becomes a fixed target experiment at the LHC
- Used for precision luminosity measurements in Run 1 & 2

Run 2: proton-argon,-neon and -helium as well as lead-argon studies

Proton-helium results are important inputs for understanding the AMS/PAMELA antiproton spectrum

J/ψ particles already observed in proton-neon collisions
First lead-lead collisions at LHCb
2015 has been a milestone year for LHCb

- We are expanding our SMOG and ion physics programmes
- Run 2 proton-proton physics analyses presented today are the first to use:
  - Real time detector calibration and alignment
  - Trigger-level particles without further processing
- We look forward to further exploiting these techniques in 2016 and beyond

Congratulations to the LHC machine and our colleagues on the other LHC experiments

Thank you in particular to the engineers, operators and technicians of the LHC for their hard work

We look forward to a productive (and exciting!) 2016