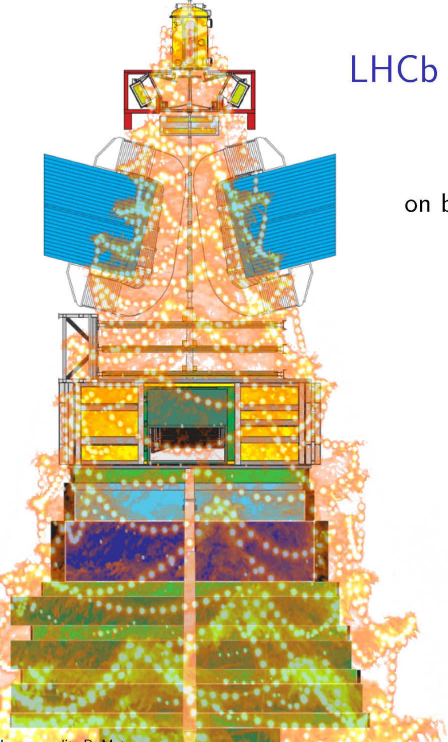


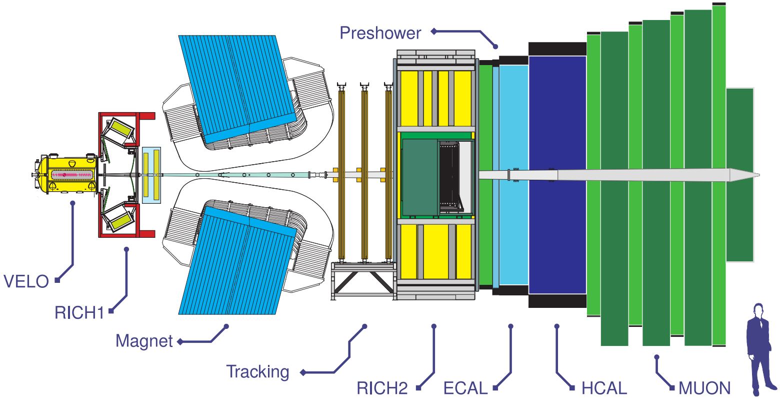
Image credit: R. Matev

LHCb 2015 highlights and status

Conor Fitzpatrick
on behalf of the LHCb collaboration

LHC Physics colloquium

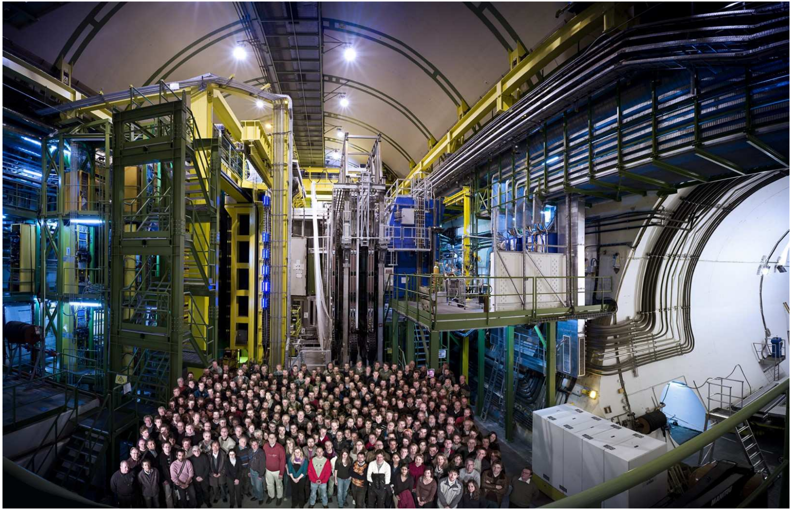
LHCb is...



- 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

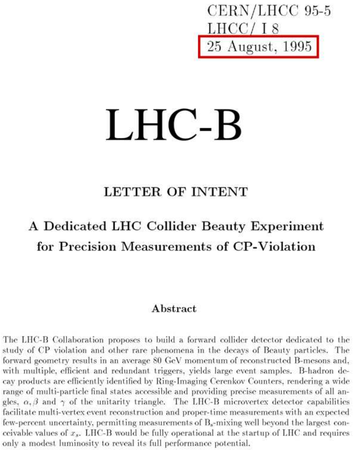
LHCb is...

- 1169 Members, from 69 Institutes in 16 Countries



LHCb is...

- 20 this year!


CERN/LHCC 95-5
LHCC/ I 8
25 August, 1995

LHC-B

LETTER OF INTENT

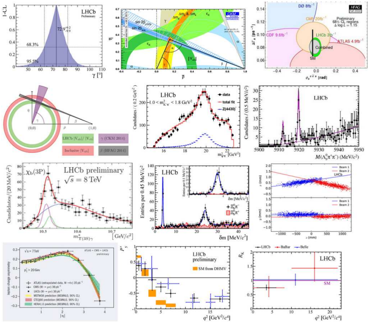
A Dedicated LHC Collider Beauty Experiment
for Precision Measurements of CP-Violation

Abstract

The LHC-B Collaboration proposes to build a forward collider detector dedicated to the study of CP violation and other rare phenomena in the decays of Beauty particles. The forward geometry results in an average 80 GeV momentum of reconstructed B-mesons and, with multiple, efficient and redundant triggers, yields large event samples. B-hadron decay products are efficiently identified by Ring-Imaging Cerenkov Counters, rendering a wide range of multi-particle final states accessible and providing precise measurements of all angles, α, β and γ of the unitarity triangle. The LHC-B microvertex detector capabilities facilitate multi-vertex event reconstruction and proper-time measurements with an expected few-percent uncertainty, permitting measurements of B_s-mixing well beyond the largest conceivable values of x_s. LHC-B would be fully operational at the startup of LHC and requires only a modest luminosity to reveal its full performance potential.

- 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

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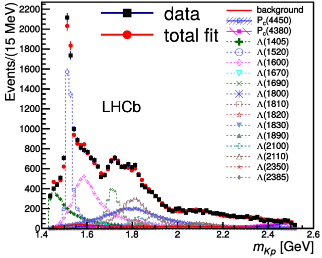
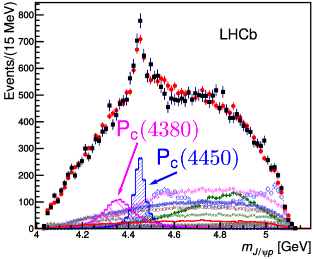
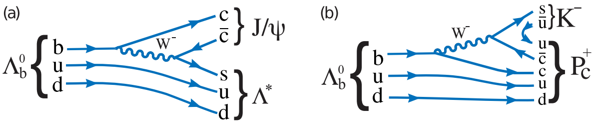
Plenty of surprises left in Run1 data

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







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

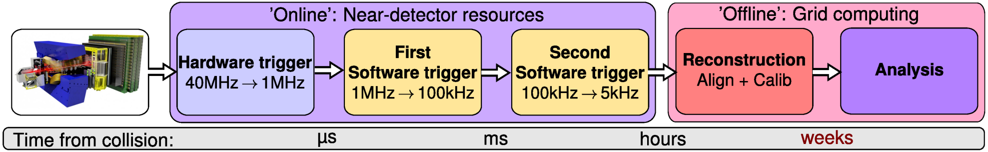
PRL 115 (2015) 072001

C. Fitzpatrick

December 18, 2015

Precision at 13 TeV

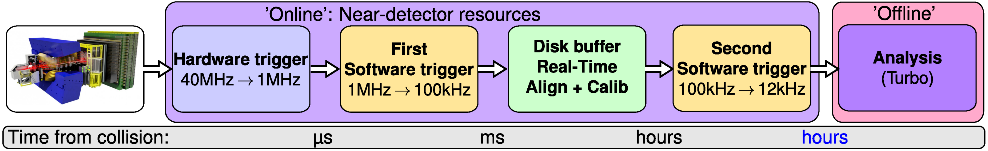
- For the main physics goals of LHCb, more data is more important than higher energies:
  - Direct searches: new energy $\rightarrow$ new particles could appear immediately
  - Precision measurements: only gain in increased production rates
- But digesting more data is a challenge
- Run 1: LHCb collected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



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

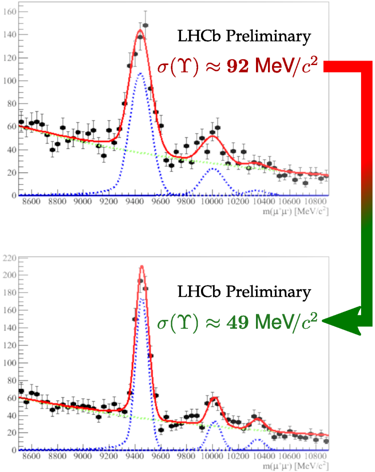
Increasing precision while saving resources

- 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!



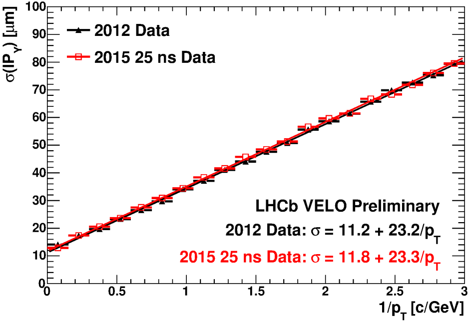
- Real-time calibration and alignment in the trigger: No need to recalibrate offline
  - Calibration in the trigger means cleaner signals: Purer, larger data samples
- Real-time analysis (turbo stream):
  - In many cases, results found in trigger can be analysed directly
  - Factor of 10 saving in storage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

Real-time alignment & Calibration



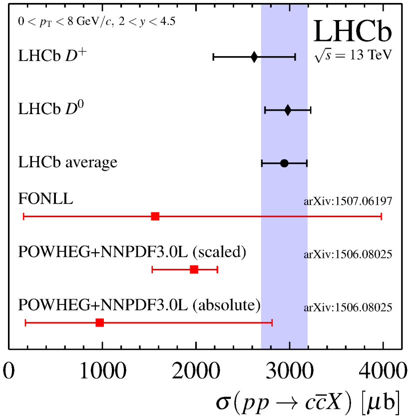
- Benefits of alignment + calibration

- 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:

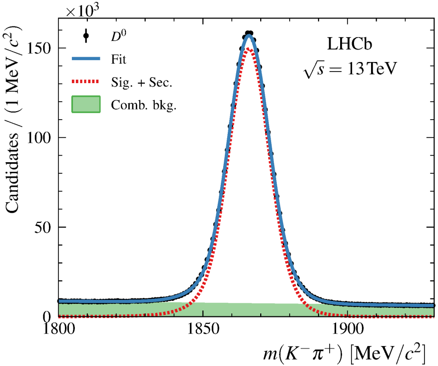


Charm production at 13 TeV

- 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

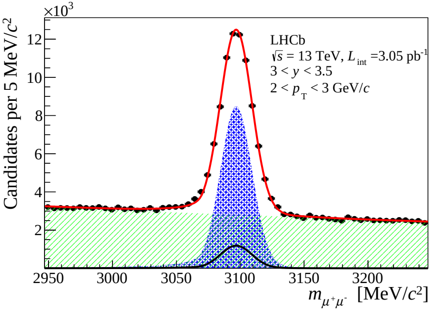


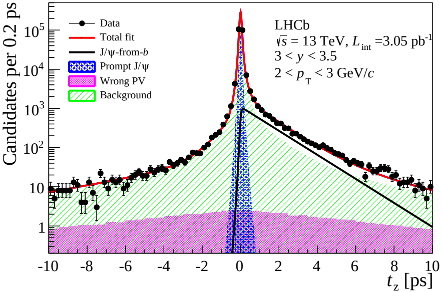
- Extremely pure signals in real time!
- Rate consistent with, but slightly higher than theory predicts: Good news for the LHCb charm programme in 2016!

J/ψ production at 13 TeV

JHEP 10 (2015) 172

- 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: $\sigma(\mathrm{pp} \to \mathrm{b\bar{b}X}) = 512 \pm 2 \pm 53\mu\mathrm{b}$

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 μbarn 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!

C. Fitzpatrick

December 18, 2015

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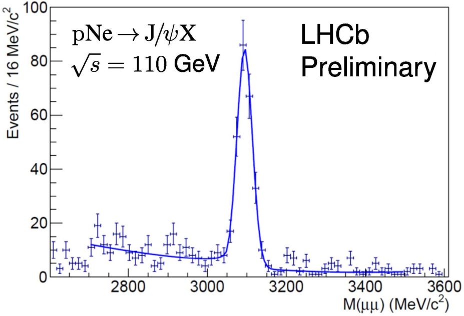
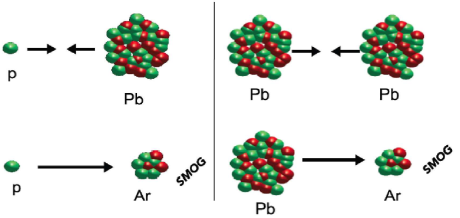
J/ψ signals in SMOG

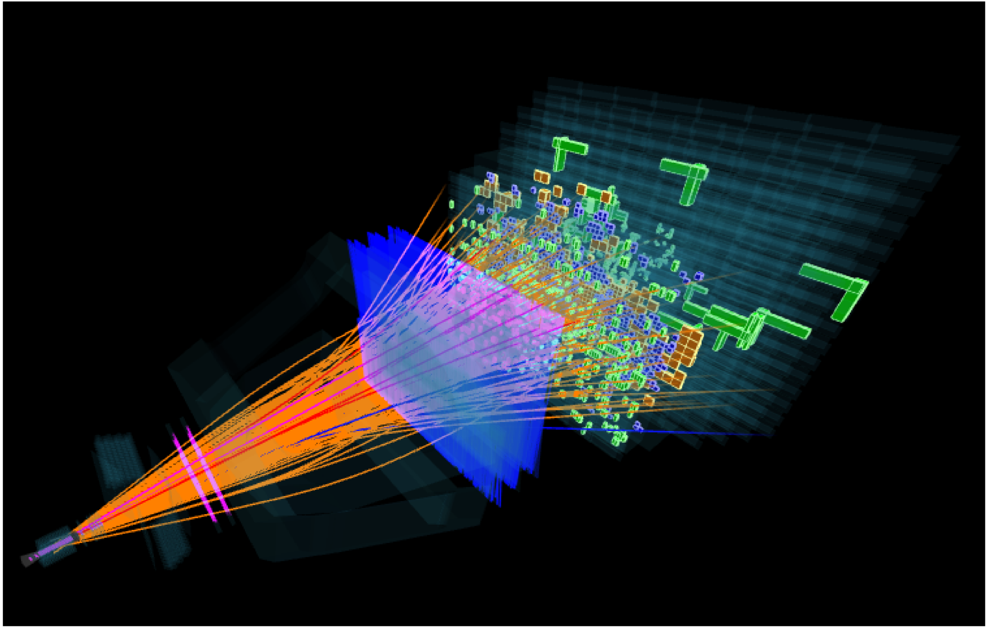
- SMOG: gas injection into the path of the beam
- LHCb becomes a fixed target experiment at the LHC
- Used for precision luminosity measurements in Run 1 & 2

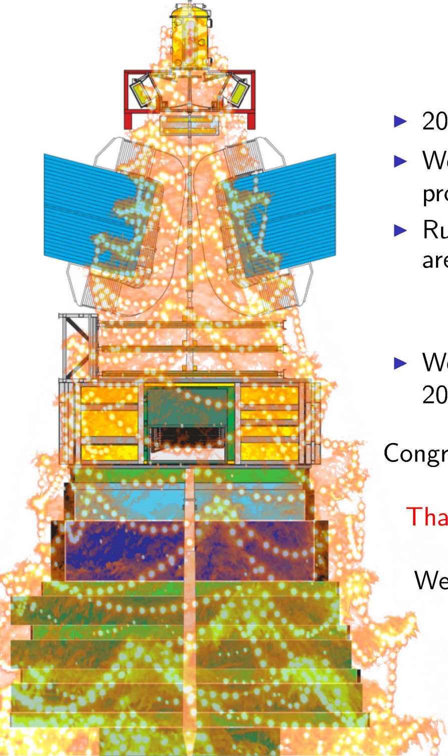




- Run 2: proton-argon,-neon and -helium as well as lead-argon studies
- Proton-helium results are important inputs for understanding the AMS/PAMELA antiproton spectrum
- J/ψ particles already observed in proton-neon collisions

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