



Status and First Results from the LHCb Experiment



Franz Muheim University of Edinburgh

LHCb UK is 10 institutes: Bristol, Cambridge, Edinburgh, Glasgow, Imperial College London, Liverpool, Manchester, Oxford, Warwick and RAL/ STFC

UK HEP Forum LHC first results and outlook

20 -21 Sept. 2010

Outline



- LHCb Experiment
- Detector Performance
- First Results with LHC Beam Data

For prospects of LHCb measurements with 1 fb-1 in CP violation and Rare Decays

See talk by Mitesh Patel

Outlook and Conclusions











First LHCb Events at 7 TeV



LHCb Operation



- LHCb operation efficiency > 90%
- Luminosity
 - ~ 3.2 pb⁻¹ recorded
 - Currently L~10³¹ cm⁻² s⁻¹
 at start of fill
- Goal for 2010
 - Lumi ~ 10³² cm⁻² s⁻¹ looks realistic
 - t 20-50 pb⁻¹ this year
- Goal for 2011
 - Expect ~1 fb⁻¹



- LHCb should reach its design luminosity in 2011

LHCb statistics



LHCb Integrated Luminosity

LHCb Cumulative Efficiency





LHCb operates very reliably with high efficiency



LHCb Detector Performance

20 -21 Sept. 2010

VErtex LOcator (VELO)



Major UK involvement

- Sensors, Hybrids, ...

• 21 VELO stations

- R & phi sensor halves
- Open during LHC beam injection and ramp-up
- Fully closed a 7 TeV stable running

• VELO Status

- VELO sensors all powered
- Cluster finding efficiency 99.8%





VELO Performance



- Cluster finding efficiency 99.7%
- Module and sensor alignment known to better than 5 mm
- VELO is opened during injection !
- Fill-to-fill variation of two halves
- relative alignment < 5mm







Best VELO hit resolution is 4 μm Great achievement !!!

VELO Performance



 ~20µm Impact Parameter resolution @ high p_T
 Further improvement expected with better alignment and material description



20 -21 Sept. 2010



Primary Vertex resolution:

Silicon Tracker (IT & TT)

ГНСК

IT 98.6% of channels working



TT 99.6% of channels working

20 - 21 Sept. 2010

hit resolution [µm] IT TT

- old MC, inspired by test beam:	40	40
- data:	55	65
 hit resolution: 	54	55
- misalignment:	10	35

 \rightarrow retuned hit resolution in MC (not yet in standard production)



Outer Tracker (OT)



OT 99.3 % of channels working

outer tracker resolution \pm 250 μ m, close to expectation from test beam data

C frames of OT are moved in and out for maintenance





Invariant Mass Resolution

Already very good mass resolution, will be improved with better alignment, huge data samples



Ring Imaging Cherenkov Counters Hick



RICH Particle Identification



PID Performance

- Alignment and Calibration ongoing

LHCh

- Angular resolutions close to expectations
- Calibration of efficiencies and Mis-id rates with data $(K_S, \Lambda, \phi \text{ and } D^{*+})$









LHCb Trigger Strategy



For bulk of running foreseen this year, with luminosities up to a few 10³¹ cm⁻² s⁻¹, we can relax many of our trigger cuts



Trigger Efficiencies



Take D*, D⁰ \rightarrow K π signal collected in minimum bias events & evaluate preliminary L0*HLT1 performance with 2010 low luminosity trigger settings

Eff-trig_{L0*HLT1}(data) = $60 \pm 4 \%$ MC expectation = 66 %

Performance curves of single-hadron HLT1 line on data





Data agree well with MC

LHCb trigger concept has been proven with data !!!

LHCb is currently running with the pile-up higher than expected at nominal conditions



First Results



- Particle production
 - K_s cross section
 - Λ/Λ , p/p, Λ/K_s production ratios
- J/ψ cross section
- $\sigma(pp \rightarrow bbX)$ cross sections
 - extrapolation from inclusive J/ψ
 - extrapolation from $b \rightarrow D^0 \mu \nu X$
- Open-charm cross sections
 - $D^+/D^{\circ}/D^*/D_s$ production
- First Exclusive B Decays
 - Leptonic (J/ ψ X) and modes

Most Results Preliminary



exploit unique coverage of phase space

Data Sets:

20 -21 Sept. 2010

Ks⁰ Production





20 -21 Sept. 2010



LHCb

.....

First Published LHCb Result

arXiv:1008.3105

Physics Letters B 693 (2010) pp. 69-80

2009 Data Sample

- √s = 900 GeV
- 6.8±1.0 μb⁻¹
- Method
 - K_{s} reconstruction in $\pi\pi$ mode
 - Vertex detector (open) not used
- Luminosity measurement
 - from beam-beam and beam-gas profile
- Results
 - Transverse Momentum p_{T} in 3 bins of rapidity y
 - Data slightly harder than Pythia6 diffraction and PerugiaO tuning

Inelastic pp Collisions



First *pp* results at this energy Extended the kinematic range towards higher rapidity and very low p_T



20 -21 Sept. 2010







20 - 21 Sept. 2010

Nanti-A Production Ratio



At 0.9 TeV

- Perugia tunes do not include diffraction
- LHCb tunes include diffraction
- Tends to be lower than PYTHIA
 PerugiaO tune and LHCb tune,
 lower with large y

At 7 TeV

ratio larger, ~ flat in y
prediction in fair agreement



N/K_s and anti-p/p Ratios



Baryon vs meson production ratio with pp collisions at √s = 0.9 & 7 TeV

- Baryon suppression in hadronisation significantly lower than predicted
- Anti-p/p production ratio with pp collisions at √s = 0.9 & 7 TeV
 - Results at both beam energies compared in ∆y show consistency, also with other experiments



$J/\psi \rightarrow \mu^{+}\mu^{-}$ at $\int s = 7 \text{ TeV}$

Three main sources of J/ψ

- direct production in pp collisions
- feed down from heavier charmonium states $(\psi(2S), \chi_{c},...)$
- J/ψ from b hadrons decays

J/ψ measurements of interest because

- Prompt production mechanism not well understood
- Secondary J/ψ provide convenient b-tag
- Di-muons central to many of core LHCb flavour studies



32



$J/\psi \rightarrow \mu^{+}\mu^{-}$ at $\int s = 7 \text{ TeV}$



bb Cross Section at $\sqrt{s} = 7$ TeV $\frac{LHCD}{HCD}$

Events / (2 MeV/c²) 00 00 000 00 0000 000 0000 0000 000 0000 000 000 000 000 000 0 Measured with $B \rightarrow D^{0}\mu X$ events $N_{signal} = 12284 \pm 135$ LHCb $m_{o} = 1862.559 \pm 0.094 \text{ MeV}$ Preliminary $\sigma_{1} = 7.14 \pm 0.56 \text{ MeV}$ √s = 7 TeV Data $\sigma_{2}/\sigma_{1} = 1.662 \pm 0.094$ $K^{-}\pi^{+}$ mass spectrum used $t_2 = 0.40 \pm 0.16$ to define signal shape $L \sim 3 \ nb^{-1}$ 400 200 LHCb 1000 Prompt Preliminary 1850 1900 1800 1950 √s = 7 TeV Data $m(K\pi^+)$ (MeV/c²) Events/ (0.1) 800 600 DfB Impact Parameter (IP) D 400 distribution used to separate 200 prompt D and D produced in B decays (DfB)

-2

Log (Impact Parameter/mm)

O

-6

20 - 21 Sept. 2010

-4



bb Cross Section at √s = 7 TeV

For the cross section measurement use sub-sample of $L \sim 14 \text{ nb}^{-1}$

η	LHCb
2-6	75.3±5.4±13.0 μb
all	284±20±49 μb

First LHCb B-Physics paper arXiv:1009.2731 Submitted to PLB



Averaging between b $\rightarrow J/\psi X$ and b \rightarrow D⁰Xµv gives

σ(pp → bbX) = 292 ± 15 ± 43 μb (assuming LEP frag. fractions)

Theory: MCFM 332 μb, NFMR 254 μb

Open Charm Production



Open charm production cross-sections measured in forward region 2 < y < 5 for D^{*}, D⁰, D⁺ and D_s.



20 -21 Sept. 2010

Excellent S/BParticle ID (RICH)Expect several million tagged $D^0 \rightarrow KK$ in 100 pb⁻¹

D^o Production











D⁺ **Production**











Exclusive B mesons



$B \rightarrow D(K\pi)n\pi$ with ~ 0.3 pb⁻¹



 $B \rightarrow D(K\pi)\pi$: B and D mass peaks



20 -21 Sept. 2010



Quarkonia with ~0.6 pb-1



46

$B_s \rightarrow \mu \mu$ Background ~0.2 pb⁻¹



- Super rare decay in SM BR ~ $O(10^{-9})$
- Very sensitive to new physics

See talk by Mitesh Patel

Fully reconstructed $B \rightarrow J/\psi K^{(+*0)} \frac{LHCb}{HHCp}$

~600 nb⁻¹



- Lifetime unbiased selection
- Yields as expectations
- Very good B mass resolution (J/psi mass constraint)



W Physics at LHCb



Unique η coverage of LHCb allows for very interesting W,Z production studies





Switch-over in W^+ / W^- ratio in acceptance

Observation of W boson











Outlook



~20 - 50 pb⁻¹

- Lots of new results
- Several more papers in preparation

~1 fb⁻¹ 2011

- Start to Compete with and Tevatron and B-factories
- Bs \rightarrow J/ $\psi\phi$, Bs \rightarrow µµ, , Bd \rightarrow K*µµ, Bs mixing, CKM angle γ ,
- Start of full LHCb physics programme
- Probe new physics in CP Violation and rare heavy flavour decays

See talk by Mitesh Patel

• LHC Physics in ~2015

- New Physics (NP) will hopefully be discovered by ATLAS/CMS and LHCb
- New Physics will very likely show up in Flavour observables
- Better Flavour Physics will be required to elucidate NP flavour structure or probe NP at higher mass scale

• LHCb Upgrade

- LHC is a Super Flavour factory, O(1MHz) rate of b-quarks
- Operate experiment at ~10 times design luminosity

Conclusions



LHCb experiment is fully commissioned

- All detectors are fully operational
- Data taking with LHC beams at 7 TeV

Excellent LHCb Detector Performance

- Detector performance close to expectations
- Trigger Concept validated with data
- Vertex detector and Particle ID close to expectations

• First LHCb Results

- Observed most SM particles, including Charm Resonances and B mesons and W bosons with yields as expected
- First cross section measurements for light, strange, charm and Beauty
- Looking forward to analyse full 2010/11 LHC data set
 - Exciting prospects with 1 fb⁻¹
 - Will compete with or improve upon Tevatron and B-factories
 - Could observe New Physics with this run
- R&D for LHCb upgrade has started





20 -21 Sept. 2010



Tracking Efficiency





ECAL performance x_c Signal KHCb

 σ fixed to 27 MeV (MC value)



58

Compilation of preliminary LHC results for J/y from B fractions



Plot by H.Woehri & C.Lourenco 59

lhcb

20 -21 Sept. 2010



$B \rightarrow K\pi\pi$ with ~0.55 pb⁻¹





20 -21 Sept. 2010

UK HEP Forum

61

Essential information for determination of b - fragmentation fractions



LHCh

W bosons in LHCb – first results





Luminosity



LHC is ramping up Expect O(200 pb-1) in 2010





MC simulation

- At E_{cm} = 14 TeV
- Event yields for 2fb-1
- LHCb design luminosity of 2x 1032 cm-2s-1
- Cross section (bbbar) = 500 µb
- Outlook/Comparison
 - For 2011 expect design luminosity
 - Lower energy, but conservative cross section
 - Small reduction in statistical precision for
 - LHCb should reach nominal physics performance in 2011
 - In 2010 lower luminosity allows to lower thresholds (charm)





