Study of the B^+ ->J/Psi K decay at LHCb

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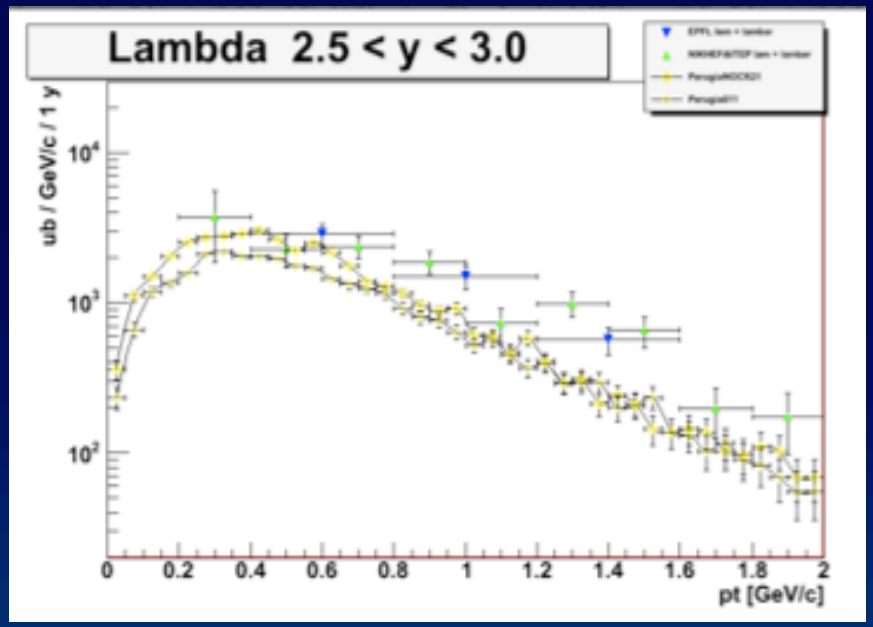
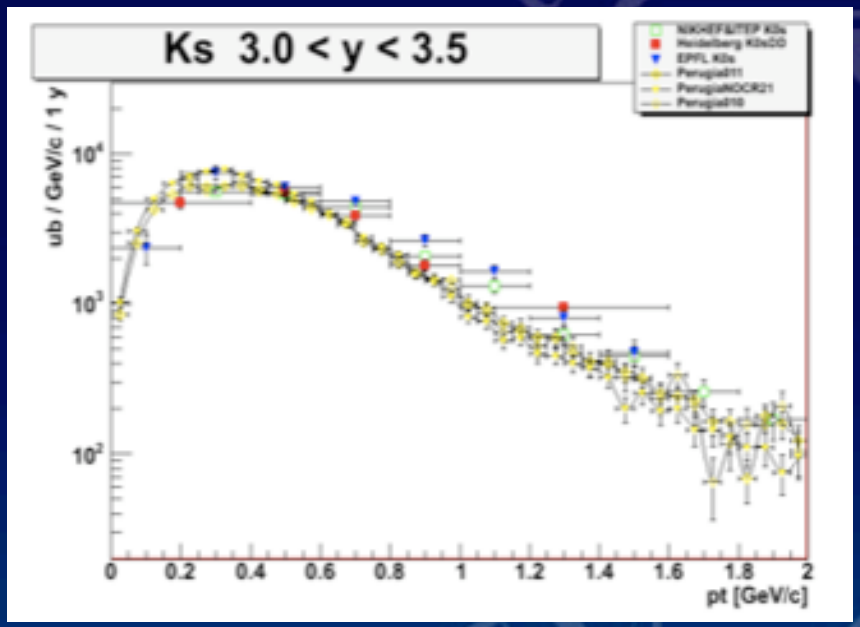
Introduction

- With the start-up of collisions at the LHC the priority is for early physics and calibration of our detector.
- Measuring the cross-sections for particles is vital in understanding the processes involved in pp interactions, and how we can use this understanding to simulate our data better.
- This talk covers the first steps involved in making a measurement of B^+ production cross-sections (in regions of transverse momentum p_T and rapidity y) at LHCb. It includes:
  - Plan of action
  - Preliminary results

Cross-section studies at LHCb





Λ_0 production cross section measured in 2009 data at E_{cm}=900GeV/c^2 (Vanya Belyaev)

K_S production cross section measured in 2009 data at E_{cm}=900GeV/c^2 (Manuel Shiller)

Analysis Outline

- This study uses the flavour-specific $B^+ \to J/\Psi K^+$, due to its high production rate and clean signal.
- Measure cross-section σ in bins of p_T and y,
  - $L_{INT} \cdot \sigma_{B+} = BR(B^+ \to J/\Psi K^+)^{-1} \cdot \varepsilon^{-1}_{sel}(p_T,y) \cdot \varepsilon^{-1}_{trig}(p_T,y)^{-1} \cdot N(p_T,y)$
- $\varepsilon_{sel}(p_T,y)$, $\varepsilon_{trig}(p_T,y)$ from Monte Carlo
- $N(p_T,y)$ from data.

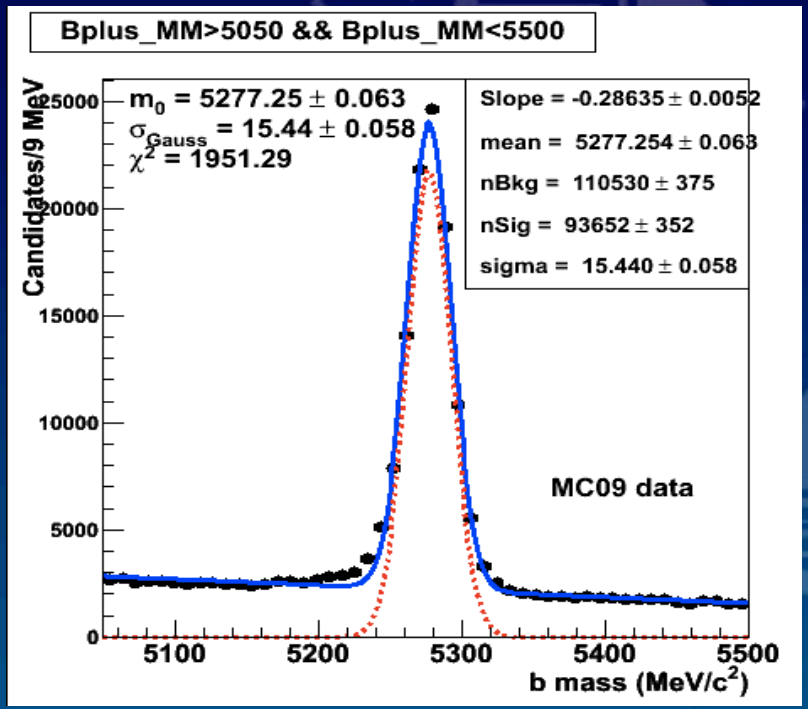
B^+->J/Psi K^+ selection

- We analysed 277k MC signal events (at E_{cm} = 10TeV).
- Loose cuts were applied to the dataset to discern true candidates from mis-reconstructed candidates.
- ε_{sel} = 33.8%

Signal data was fitted with a single Gaussian; background with a Chebychev.

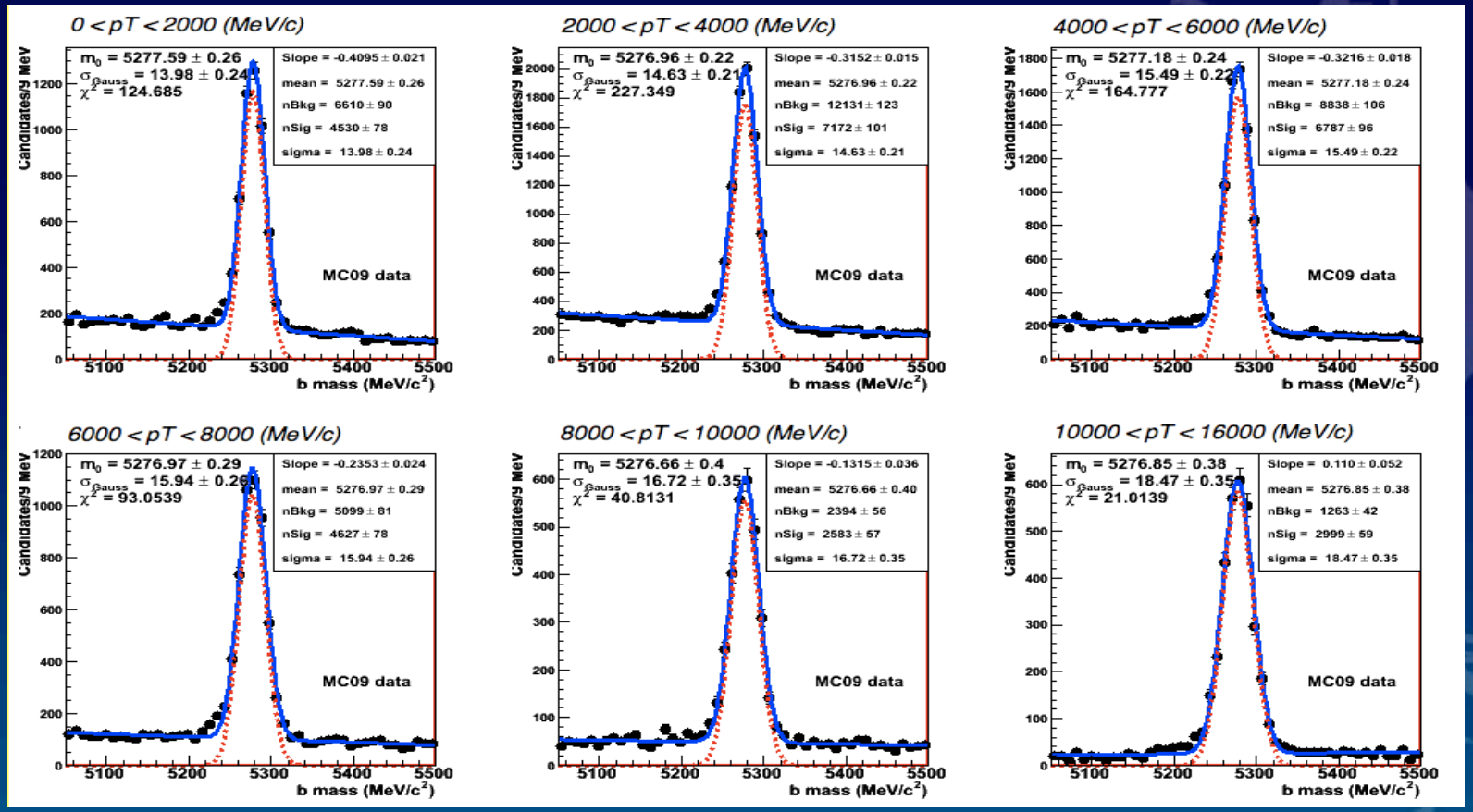
Particle	Cut	value
μ^+	*loose muon* track χ^2/nDOF p_T	 <10 >250MeV/c
μ^-	*loose muon* track χ^2/nDOF p_T	 <10 >250MeV/c
$\mu^+\mu^-$	p_T $\lvert M(\mu^+\mu^-) - M(J/\Psi) \rvert$	>500MeV/c <80MeV/c^2
J/Ψ	vertex χ^2/nDOF	20

Particle	Cut	Value
K^+	p_T	>250MeV/c
$J/\Psi K^+$	$\lvert M(J/\Psi K^+) - M(B^+) \rvert$	<300MeV/c^2
B^+	vertex χ^2/nDOF	<20



Yields in bins of p_T and y (1)

We split the data further into bins of transverse momentum p_T and rapidity y of the B^+ candidate and refit (below – $3<y<3.5$; $0<p_T<16$GeV/c).



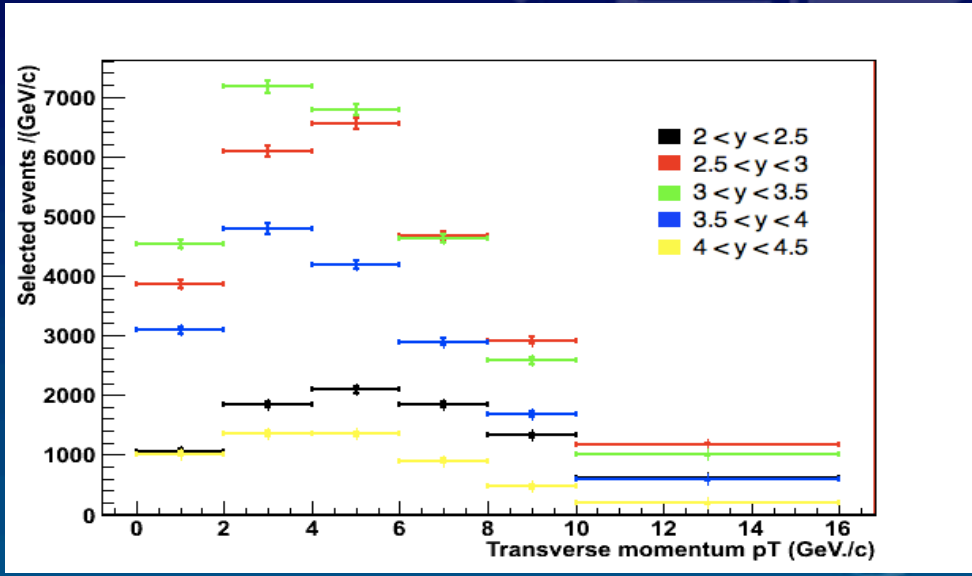
…and extend similarly to $2<\Upsilon<4.5$

Yields in bins of p_T and y (2)

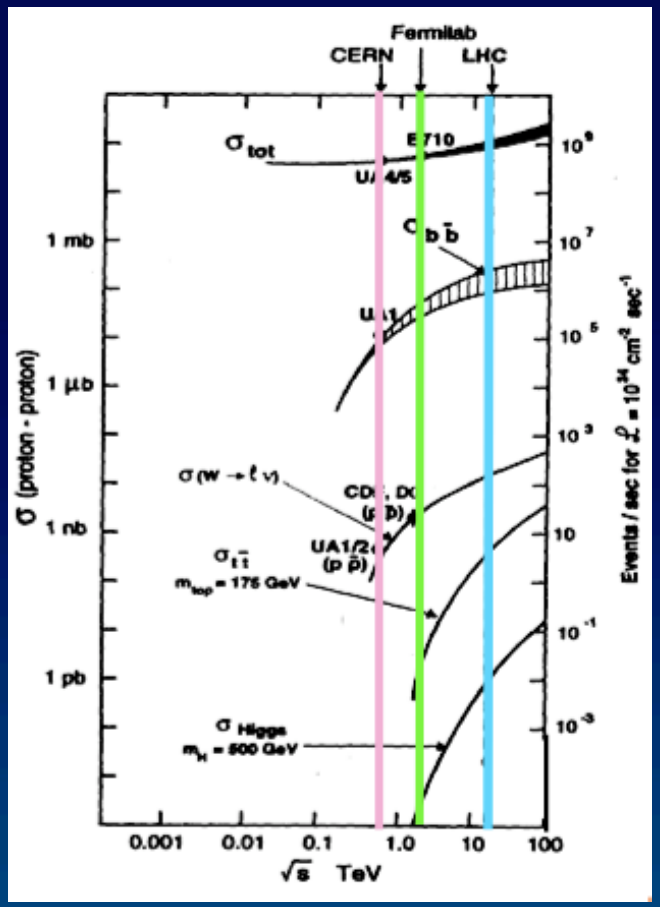
The table below gives the total number of selected events per region of y and pT…

	0->2	2->4	4->6	6->8	8->10	10->16	p_T GeV/c
2->2.5	1066±35	1837±48	2089±53	1846±49	1327±40	1819±46	
2.5->3	3856±70	6087±93	6550±94	4669±79	2918±60	3545±64	
3->3.5	4530±78	7172±101	6787±96	4627±78	2583±57	2999±59	
3.5->4	3085±64	4787±82	4186±76	2891±61	1681±46	1750±45	
4->4.5	1019±36	1354±44	1345±42	897±35	464±24	573±26	
Y							

…or histogrammed per unit p_T – one can see a clear peak in the regions $2<p_T<4$ and $3<y<3.5$



bb-production at LHCb



Cross-section as a function of beam energy

- The MC data used for this analysis is based on beam collisions of E_{cm} = 10TeV. The corresponding bb cross-section is approximately 300μb.
- There is an error on this, as bb cross sections at the LHC is not yet fully understood.
- In 0.1fb^{-1}, we expect:
  - 3e+10 bb events
  - 1.2e+10 B^+

Integrated luminosity and annual yield

- Let us make a quick calculation of the B^+ cross section.
- For the process B_u->J/Psi K:
  - Visible branching fraction BR = 6×10^{-5}
  - Generator-level efficiency $\varepsilon_{gen} = 0.1630$
  - Average selection efficiency $\varepsilon_{sel} = 0.330$
- The MC dataset (277k generated events) corresponds an integrated luminosity of $L_{int} = 0.12\ fb^{-1}$.
- Taking bin 3<y<3.5 and 0<pT<2 (=4530 events), we can extrapolate to a rough estimate of the cross section $\sigma_{b+} = 12 \mu b$.
- This is what we expect in the first few months of data-taking.

B^+/B^- production ratios

- The ratio of selected B^+ to B^- candidates was also investigated on the MC signal data.
- An asymmetry here may indicate differences in the production rates at the generator level, or in the reconstruction efficiencies.
- No significant deviation from an equal ratio is observed.

	0->2	2->4	4->6	6->8	8->10	10->16	p_T (GeV/c)
2->2.5	1.06±0.03	1.04±0.01	1.02±0.07	1.03±0.04	1.01±0.06	1±0.01	
2.5->3	1.03±0.04	1.03±0.03	1.07±0.05	1.06±0.04	1.02±0.01	1.02±0.02	
3->3.5	1.01±0.02	1.03±0.04	1.04±0.04	1.02±0.05	0.98±0.04	0.99±0.01	
3.5->4	1.03±0.03	1.04±0.05	1.03±0.03	1.02±0.03	1±0.02	0.93±0.02	
4->4.5	0.86±0.04	1.05±0.06	0.84±0.05	1.02±0.06	0.87±0.05	1.05±0.04	
Y							

Future Work

- This is a work in progress.
- A background study is being run on various samples to attain a full selection of the channel
- At first glance, prompt modes and ghost tracks look to be the main contributions – tighter cuts on the track χ^2 and a cut on the Kaon ID may need to be imposed.

Summary

- A Monte Carlo study on the B^+ production cross-section has been carried out using a selection of the decay B_u->J/Ψ K.
- The cross-section peaks in the 3<ϒ<3.5 and 2<pt<6 GeV/c.
- We expect a B^+ cross section of a few μb in the first few months of data-taking.
- There is no significant asymmetry in the ratio of produced B^+'s to produced B^-'s.