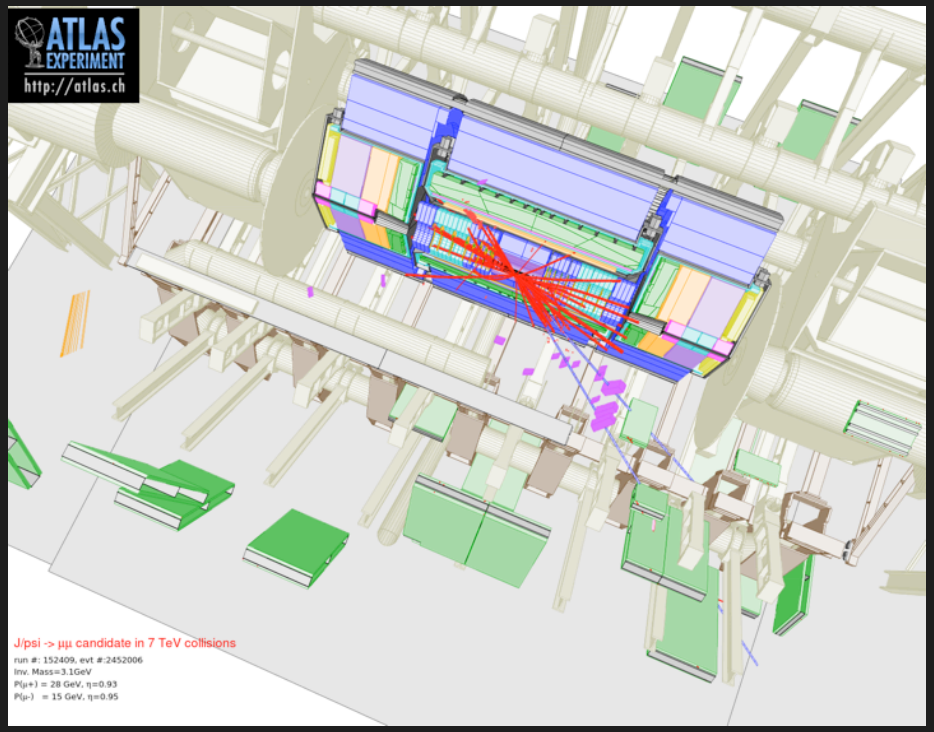

The charmonium and beauty physics programme in ATLAS

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Layout of the talk

- ATLAS J/ψ selection strategy for early beam conditions
- Mass determination, method, results
- Kinematic properties of J/ψ with early selections
- First performance results with J/ψ
- B-physics program
  - two examples of early measurements under preparation
  - two examples future high sensitivity B-measurements

Early J/ψ: event selections

- p-p collision data at 7 TeV, taken between March 30th and May 17th 2010
- Integrated luminosity of data used for this study: $6.4 \pm 1.3 nb^{-1}$
- Strategy:

  collect largest possible statistics; determine mass, resolution and J/ψ properties, understand backgrounds
- Trigger requirements:
  - Minimum Bias Trigger Scintillators (MBTS) mounted at each end of the detector in front of the Liquid Argon Endcap-Calorimeter cryostats at z= ± 3.56m. The MBTS trigger - requires at least two hits from either sides of the detector.
  - L1 minimum bias trigger was not prescaled for runs with luminosity $< 10^{28}$ $cm^{-2}\,s^{-1}$.
  - A dedicated muon software trigger commissioning chain at the Event Filter level initiated by the MBTS L1 trigger searches for muon track in the entire Muon Spectrometer
    - Analysing data in MBTS stream we requested at least one muon must pass the EF muon-commissioning chain with a muon of any *p*T reconstructed in the Muon System
- To ensure collision events are selected, at least 3 tracks form a primary vertex.

μμ and J/ψ selections

Types of muons used:

- Combined muon:
  - statistical combination of track parameters and the covariance matrices of Muon System(MS) track and Inner detector (ID) track;
  - the tracks with tight matching criteria selected to create a combined muon track traversing the ID and MS
- Tagged muon:
  - muon segments matched to ID tracks extrapolated to MS. Reconstructed muon adopts parameters of ID track.
- Pairs of muons with at least one Combined muon were retained

Cosmic ray background:

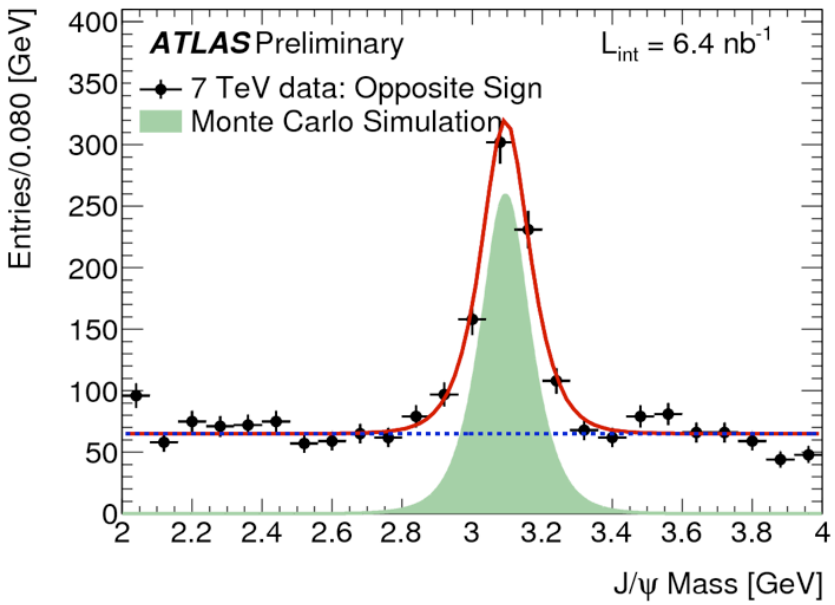
- may come from a pair formed by a cosmic muon and a muon from the collision. The probability is very small ($< 10^{-4}$) from the 900 GeV data analysis
- A cosmic muon mimicking a J/ψ decaying back-to-back is excluded - muons detected in the MS can only have momentum higher than 3 GeV.

μμ and J/ψ selections, cont

- **ID selections, Vertexing:**
  - >= 1 hit in the pixels and 6 hits in silicon strip layers
  - pT > 0.5 GeV on each track
  - Tracks fitted to a common vertex using vertexing tools based on Kalman filter.
  - No constraints on mass or pointing to the primary vertex, and a very high vertex fit χ^2 upper limit is applied ($\chi^2 < 200$).

- Only ID track parameters of muons used for this J/psi study
- **Same sign pairs retained for cross-checking.**
- **Cuts not optimized to reject backgrounds, since the aim of this study is to understand the shape of the low pT combinatorial background**

Early J/ψ signal in ATLAS



$$L = \prod_{i=1}^{N} \left[f_{signal}(m^i_{\mu\mu}) + f_{bkg}(m^i_{\mu\mu}) \right]$$

$$f_{signal}(m_{\mu\mu}, \delta m_{\mu\mu}) \equiv a_0 \frac{1}{\sqrt{2\pi}\, S\, \delta m_{\mu\mu}} e^{\frac{-(m_{\mu\mu} - m_{J/\psi})^2}{2(S\,\delta m_{\mu\mu})^2}}$$

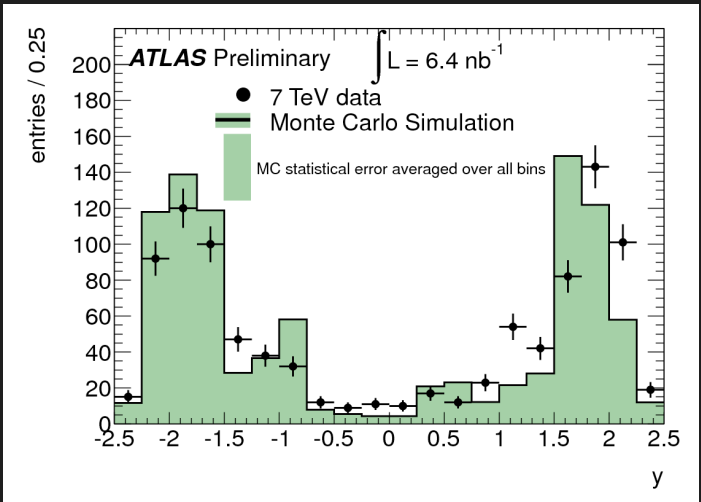
$$f_{bkg}(m_{\mu\mu}) \equiv (1 - a_0)$$

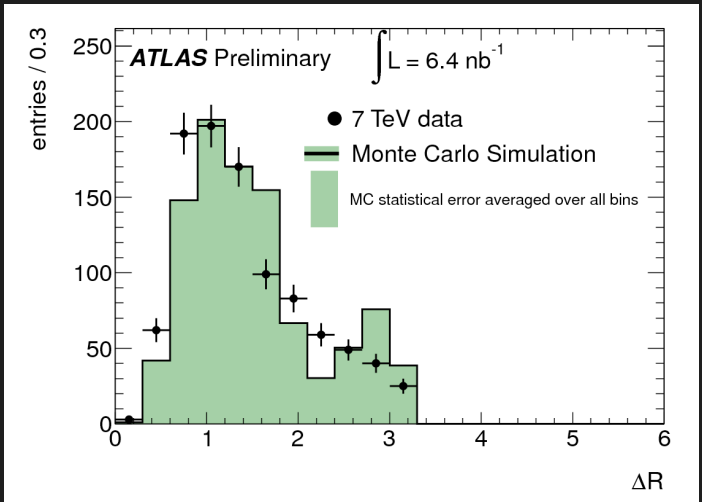
- $\delta m_{\mu\mu}$ - measured mass uncertainty of each pair of muon tracks
- S - scale factor to cover for unaccounted uncertainties on track parameters (e.g. non-gaussian tails)

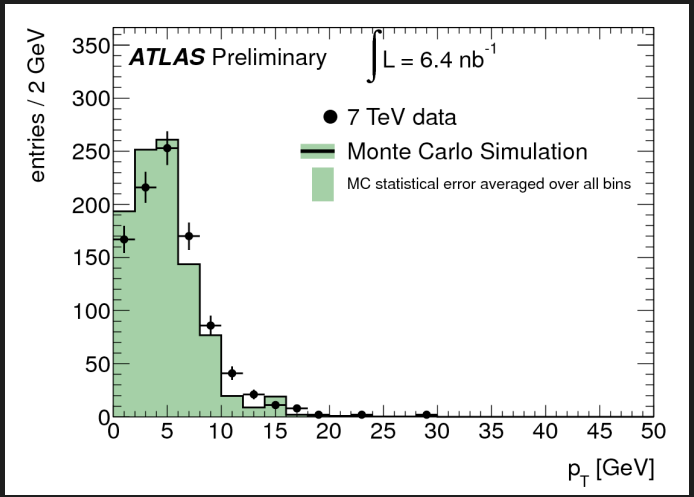
		$m_{J/\psi}$, GeV	σ_m, MeV	N_{sig}	N_{bck}
all	data	3.095 ± 0.004	82 ± 7	612 ± 34	332 ± 9
	MC	3.098 ± 0.001	74 ± 0.4		

- The measured mass agrees with PDG within statistical precision of first data
- mass resolution agrees with that expected from MC

Properties of early J/ψ in ATLAS

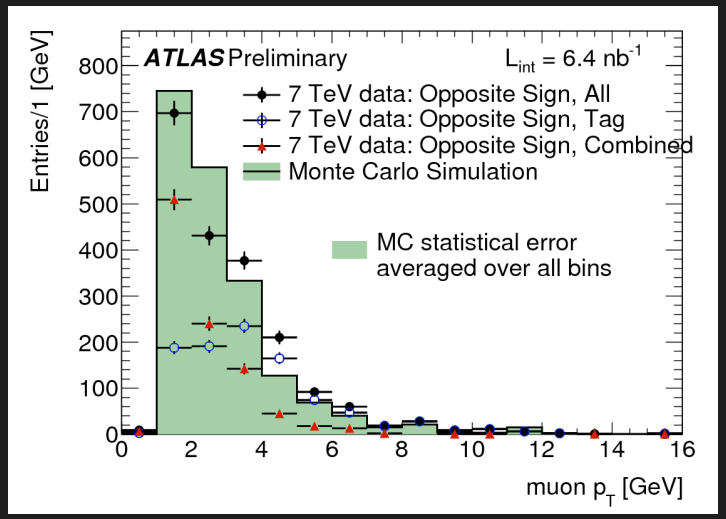


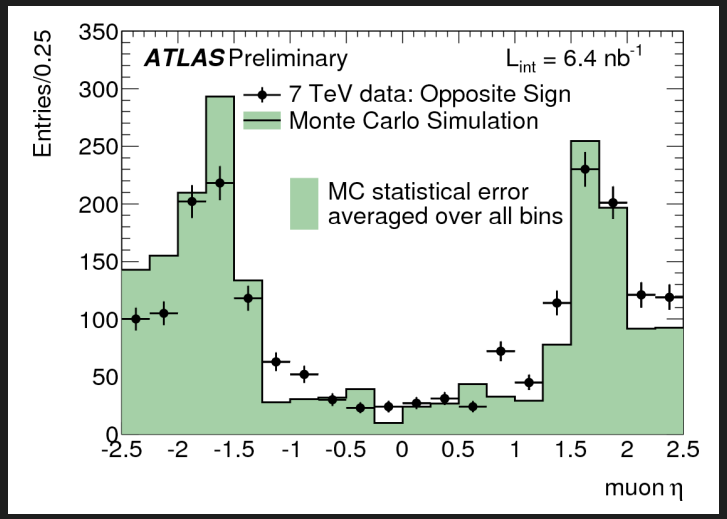


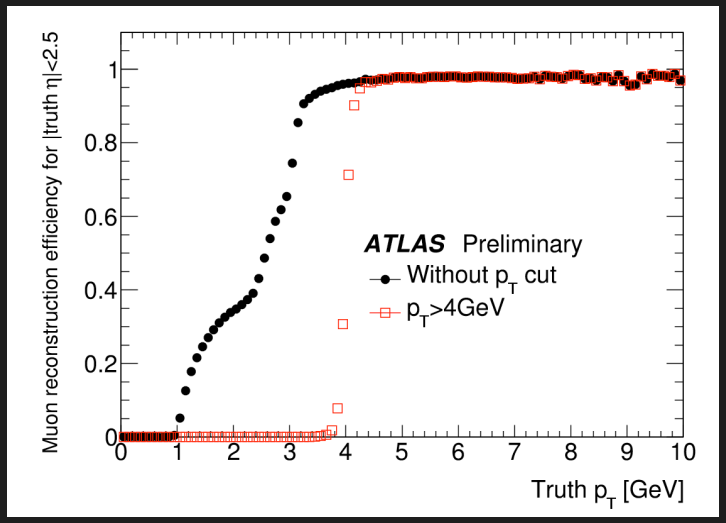


- Data agree with MC predictions of resolution and PDG mass
- Also good agreement between data and MC on kinematic properties of J/psi
  - Essential conclusions derived from these first *J*/ψ signal studies.

Properties of muons from early J/ψ

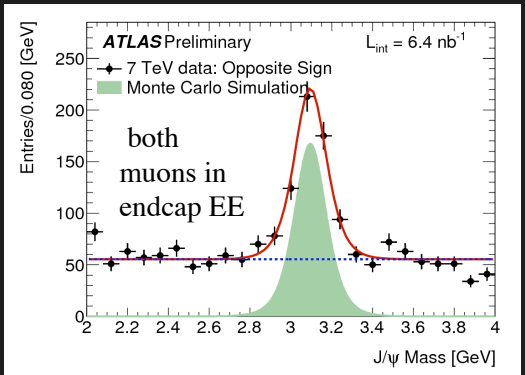


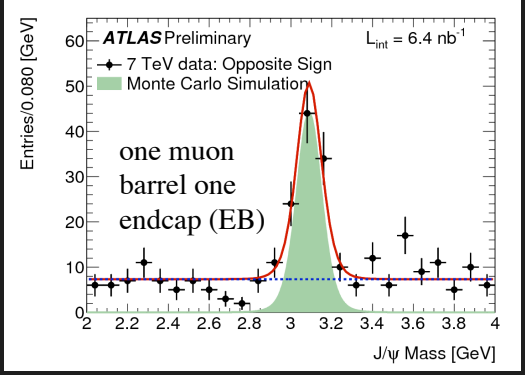


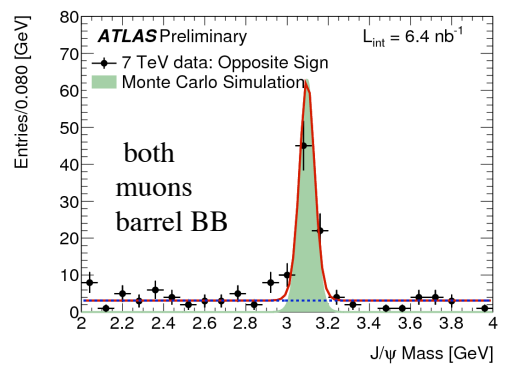


- Our early analysis can access very low *p*T *J*/ψ producing soft *p*T muons, see left top
- Muons with enough energy to cross the calorimeters reach the MS mainly in the forward region
- This is a consequence of the muon acceptance of the ATLAS detector without any threshold requirement on the muon trigger, see the muon efficiency (left bottom, black) determined from MC

Performance of early J/ψ in ATLAS



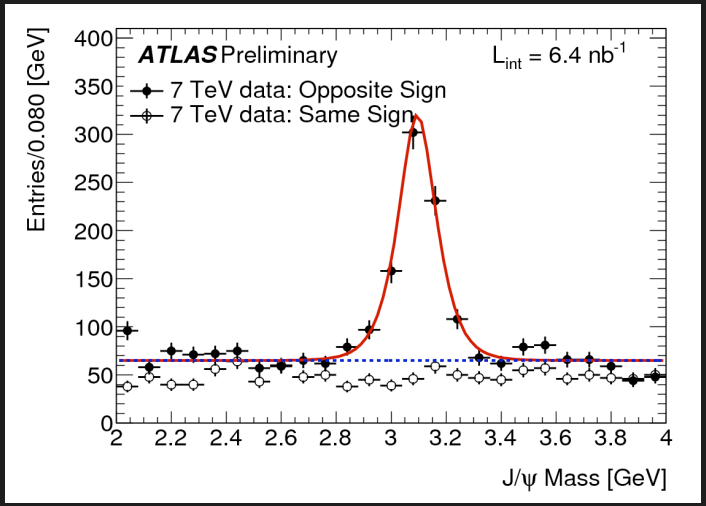




- J/ψ mass resolution varies with the pseudorapidity of muons accordingly to MC expectations
  - endcap $2.5 > |\eta| > 1.05$, barrel $|\eta| < 1.05$
- no statistically significant mass shifts from the PDG value observed in any of the pseudorapidity regions

		$m_{J/\psi}$, GeV	σ_m, MeV	N_{sig}	N_{bck}
all	data	3.095 ± 0.004	82 ± 7	612 ± 34	332 ± 9
	MC	3.098 ± 0.001	74 ± 0.4		
	data n/v	3.096 ± 0.004	82 ± 7	612 ± 34	351 ± 10
BB	data	3.097 ± 0.005	36 ± 6	69 ± 9	8 ± 1
	MC	3.098 ± 0.001	37 ± 0.7		
	data n/v	3.099 ± 0.005	38 ± 7	69 ± 9	8 ± 1
EB	data	3.089 ± 0.008	66 ± 12	88 ± 11	34 ± 3
	MC	3.097 ± 0.001	53 ± 0.8		
	data n/v	3.089 ± 0.009	66 ± 12	87 ± 11	36 ± 3
EE	data	3.095 ± 0.006	88 ± 9	437 ± 31	324 ± 10
	MC	3.098 ± 0.001	82 ± 0.5		
	data n/v	3.096 ± 0.006	88 ± 9	437 ± 31	344 ± 10

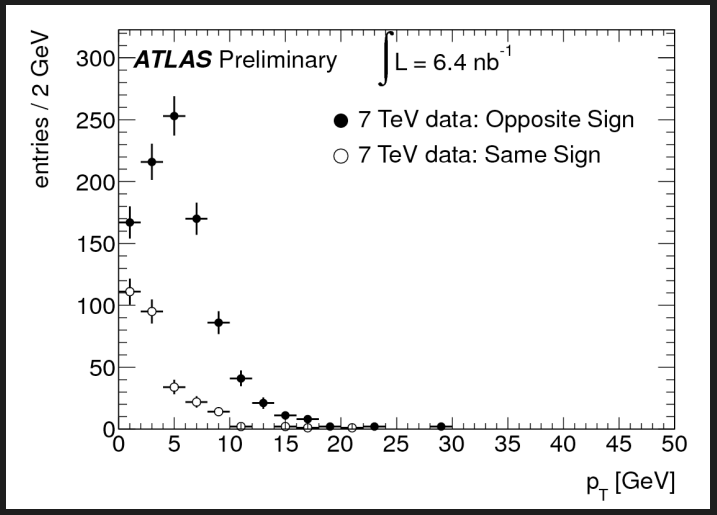
Comparison with like sign pairs

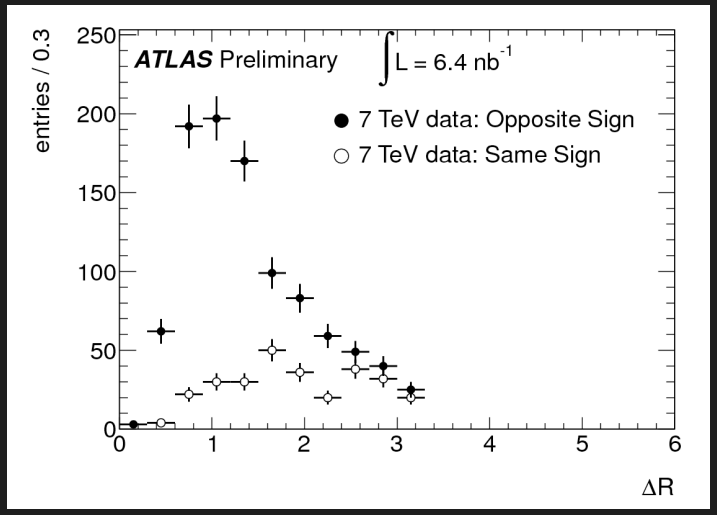


Early di-muon pairs selected at lowest pT have specific features visible when comparing like sign pairs with J/ψ candidates

- like sign pairs almost match the level of the *J*/ψ background (unlike pairs) in the side bands
  - source of both dominated by muons from K/pi decays
  - very little b/c content in tails

Di-muon pairs of opposite sign in the J/ψ region have evidently different kinematic properties from the like sign pairs

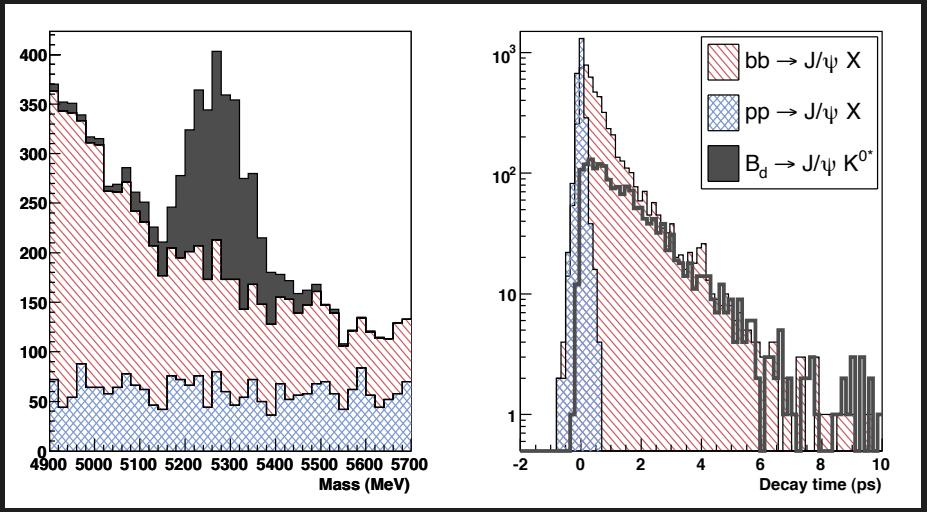


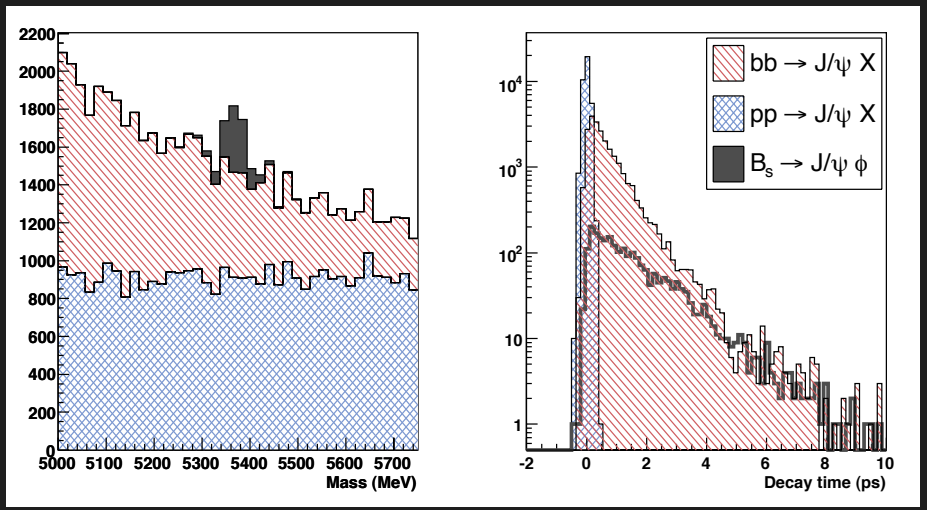


ATLAS B-physics program

- ATLAS B-physics program is realised in following sub-projects
  - HF quarkonia measurements
  - B → J/ψ (inclusive, exclusive) channels
  - Rare B-decays B_{sd} →μμ, b →s μμ, b →d μμ
  - Production properties of B and D-mesons decaying into hadrons
- Each sub-project has tasks/measurements for early, medium and advanced periods
  - First measurements, in addition to physics results, serve to improveunderstanding of detector performance to allow later high precision measurements
- Selected examples of MC based studies are given further for the early and for advanced periods
  - Complete B-physics program arXiv:0901.0512 ; CERN-OPEN-2008-020, Chapter 11.

Early measurements with exclusive B → J/ψ





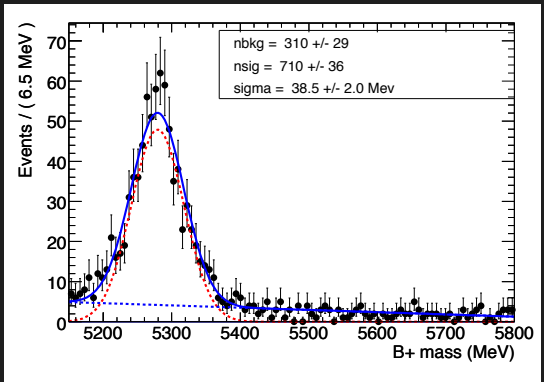
Parameter	Simulated value	Fit result with statitical error
Γ, ps^{-1}	0.651	0.73 ± 0.07
m(B), GeV	5.279	5.284 ± 0.006
Γ_s, ps^{-1}	0.683	0.743 ± 0.051
m(B), GeV	5.343	5.359 ± 0.006

Applying simultaneous mass - lifetime likelihood fit to events

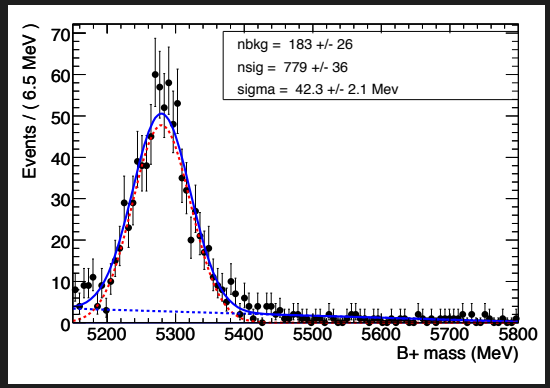
- $B \rightarrow J/\psi\, K^{0*}$ (10 pb^{-1})
- $B_s \rightarrow J/\psi\, \phi$ (150 pb^{-1})

Lifetimes measured with sensitivity better than 10%. Early lifetime measurements test the calibrations and alignments necessary for precise CPV studies

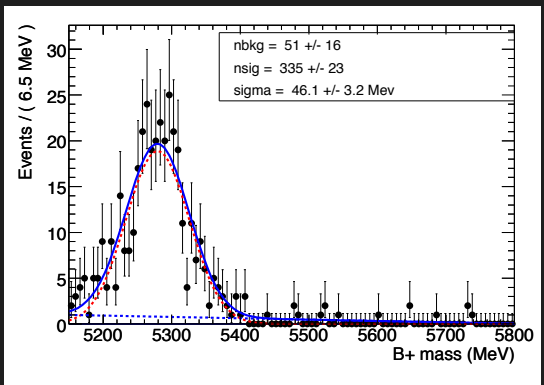
Differential cross section $B^+ \rightarrow J/\psi K^+$



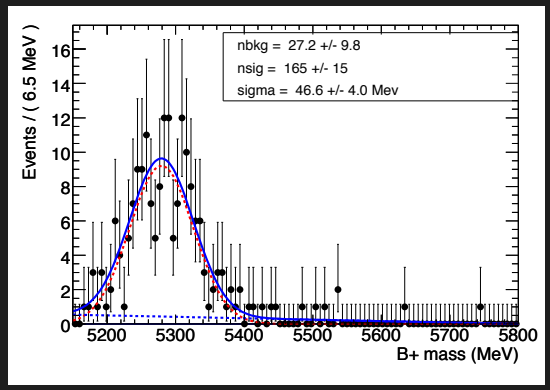
(a) $10 \leq p_T < 18$ GeV



(b) $18 \leq p_T < 26$ GeV



(c) $26 \leq p_T < 34$ GeV



(d) $34 \leq p_T < 42$ GeV

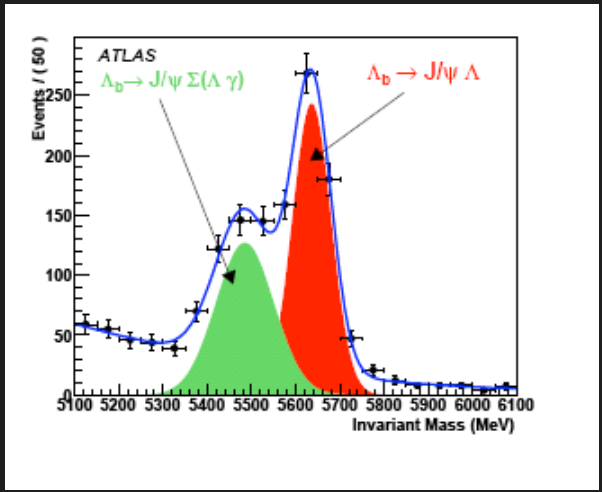
Fit of the *B*+ mass in four *pT* ranges

The $B^+ \rightarrow J/\psi K^+$ total and differential production cross-sections

- With 10 pb^{-1} the total cross-section can be measured with a statistical precision better than 5%
- The differential cross-section with precision of the order of 10%.

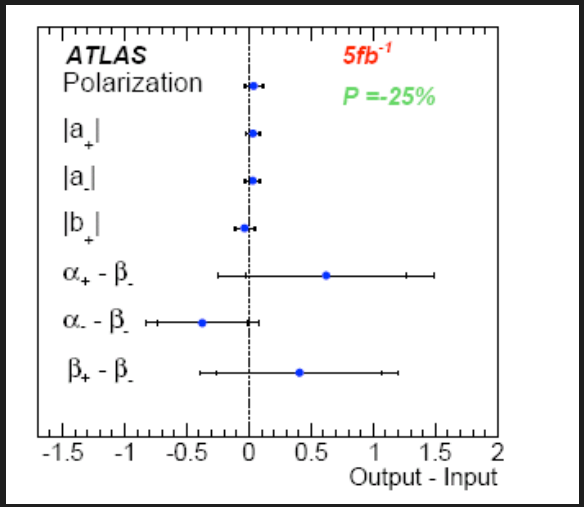
p_T range [GeV]	$p_T \in [10,18]$	$p_T \in [18,26]$	$p_T \in [26,34]$	$p_T \in [34,42]$	$p_T \in [10,\text{inf})$
stat. $+ \mathscr{A}$ [%]	7.7	6.9	10.5	13.9	4.3
total [%]	16.1	15.8	17.6	19.8	14.8

Production polarization of Λ_b with 5 fb^{-1}



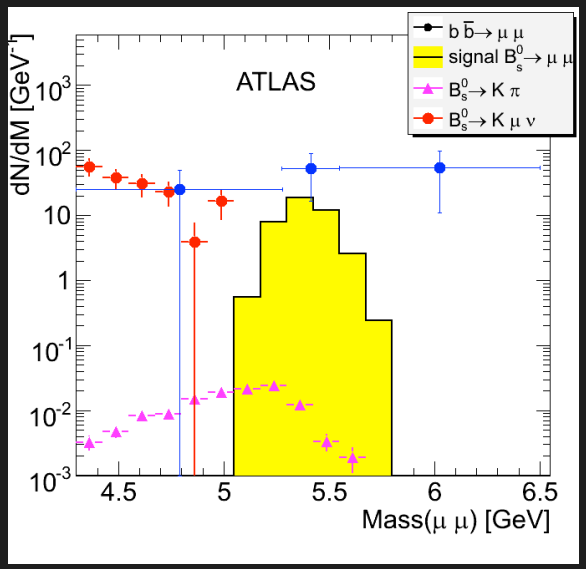
Polarization varies with pseudorapidity thus ATLAS/CMS and LHCb can perform complemetary measurements to map full range.

With 5 fb^{-1} the Λ_b polarization in ATLAS can be measured with precision of 0.07



Parameter	Value ± Uncertainty (Polarization = -25%)
Polarization	-0.213 ± 0.069
$\lvert a_+ \rvert$	0.461 ± 0.051
$\lvert a_- \rvert$	0.289 ± 0.058
$\lvert b_+ \rvert$	0.259 ± 0.071
$\alpha_+ - \beta_-$	-0.991 ± 0.640
$\alpha_- - \beta_-$	0.856 ± 0.364
$\beta_+ - \beta_-$	-1.442 ± 0.666

ATLAS potential for B → μμ



$B_s \rightarrow \mu\mu$ signal and backgrounds after applying all selection cuts - relevant at > 10^{33} cm $^{-2}$ s $^{-1}$

Selection cut	$B_s^0 \rightarrow \mu^+\mu^-$ efficiency	$b\bar{b} \rightarrow \mu^+\mu^- X$ efficiency	
$I_{\mu\mu} > 0.9$	0.24	$(2.6 \pm 0.3) \cdot 10^{-2}$	
$L_{xy} > 0.5$mm	0.26	$(1.4 \pm 0.1) \cdot 10^{-2}$	$(1.0 \pm 0.7) \cdot 10^{-3}$
$\alpha < 0.017$ rad	0.23	$(8.5 \pm 0.2) \cdot 10^{-3}$	
Mass in $[-\sigma, 2\sigma]$	0.76	0.079	
TOTAL	0.04	$0.24 \cdot 10^{-6}$	$(2.0 \pm 1.4) \cdot 10^{-6}$
Events yield	5.7		14^{+13}_{-10}

- The ATLAS performance was analysed for first $J/\psi \rightarrow \mu\mu$ Shown that di-muon performance with real data consistent with MC predictions
- The MC simulation of $B_s \rightarrow \mu\mu$ potential (left) to test potential with 10 fb^{-1} was done with trigger menus for > 10^{33}
  - both muons required pT> 6 GeV.
- Low pT B-physics di-muon triggers will be applied at low instantaneous luminosities of early LHC period to maximize reach for first sensitivity
- At ~ 10^{34} dedicated triggers prepared to use full ATLAS potential for $B_s \rightarrow \mu\mu$
- $B_s \rightarrow \mu\mu$ $B_d \rightarrow \mu\mu$ in physics program for ATLAS upgrade

Summary

- Early **J/ψ** data taken with minimum bias trigger show excellent agreement with expected performance
- Reproducing **J/ψ** PDG mass in all pseudorapidity regions – confirms that pT scale understood at low pT range
- **J/ψ** mass resolution over entire pseudorapidity regions of detector – consistent with MC.
- B-physics program prepared for both early and advanced periods.
- ATLAS will significantly contribute to B →μμ potential as an instantaneous LHC luminosity will be increased to several times 10^{33} and to a nominal value 10^{34} Rare B decays for detector upgrade being prepared.