# Early B-physics and Onia measurements in ATLAS

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on behalf of the ATLAS B-Physics Group

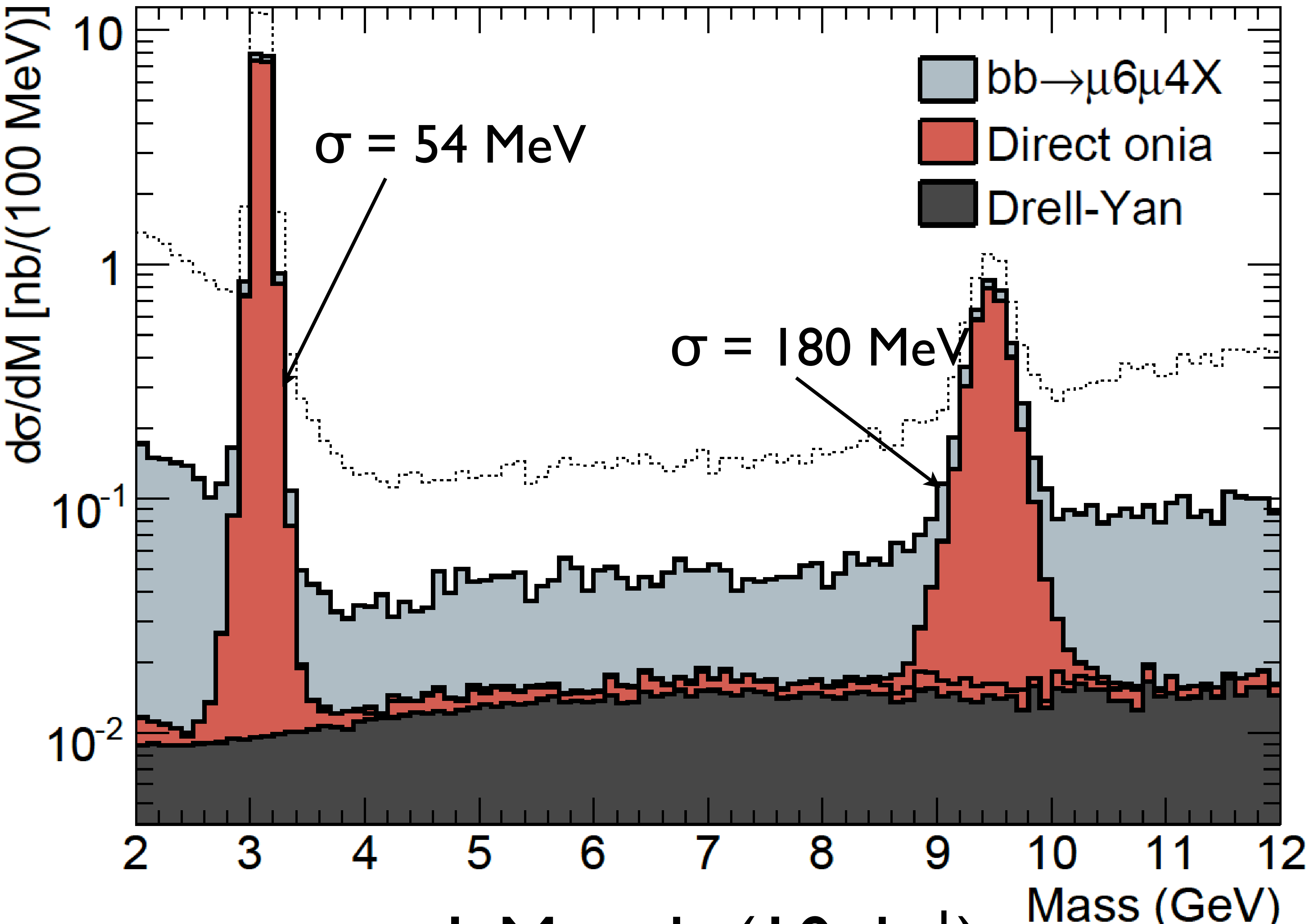
# Motivation



- When switched on, the LHC will produce charm and beauty quarks in abundance even in low luminosity runs during the first few years of running.
- The first task for all the experiments will be to understand their detectors.
- Early B-Physics measurements will be crucial in our understanding of the ATLAS detector.
- The reasonable branching fraction of both the J/ψ and the ϒ into charged lepton pairs allows for easy separation of these events from the huge hadronic background at the LHC.
- One of the first physics results to come out of ATLAS will be an analysis of the J/ψ and ϒ produced.
- New limit on $B_s \rightarrow \mu\mu$ will also be possible with early data. (~8 months)
- This talk will outline some of the B-Physics channels that will have sufficient statistics early on to make interesting measurements.

# Quarkonium Reconstruction



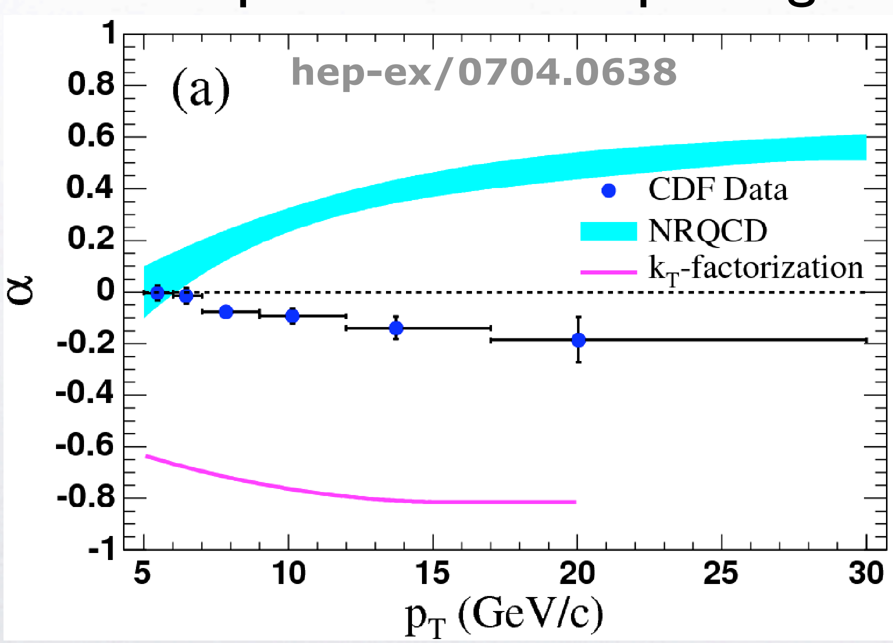


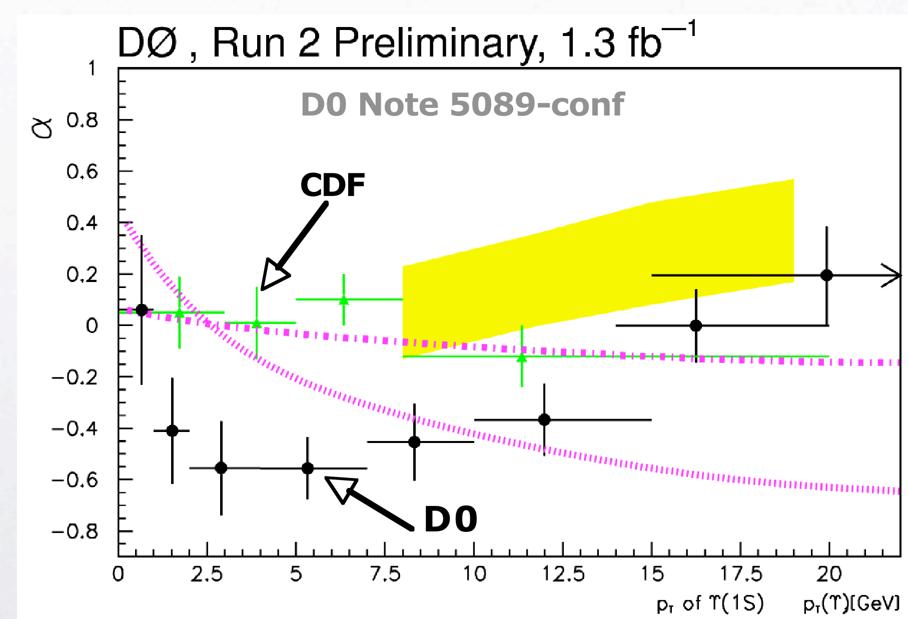

~ 1 Month ($10pb^{-1}$)

# Onia Production Studies



- Understanding the underlying production mechanism of quarkonium is a good test of our understanding of perturbative/non-perturbative QCD.
- Early Tevatron data showed the then current predictions underestimated production cross sections by orders of magnitude.
- A number of new theories incorporating new models and higher order corrections have been suggested.
- Measurement of spin alignment of quarkonium and its pT dependence can give us insight into the dominant production mechanisms.
- Theoretical predictions of spin alignment are on firmer ground at high (10GeV+) pT

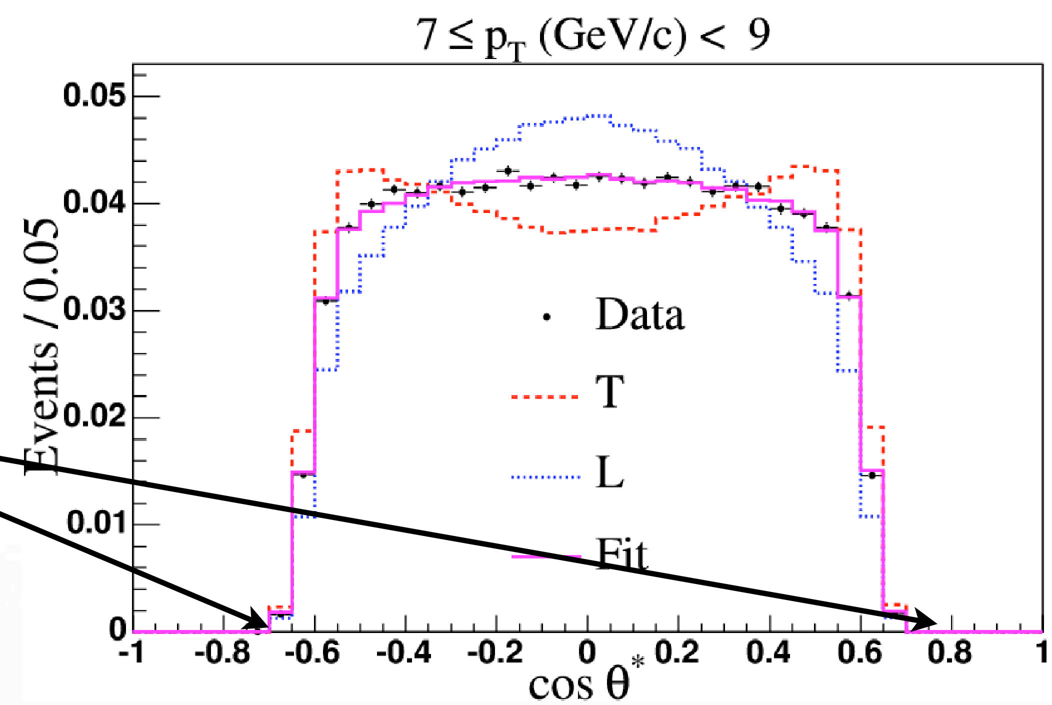


# Onia Reconstruction

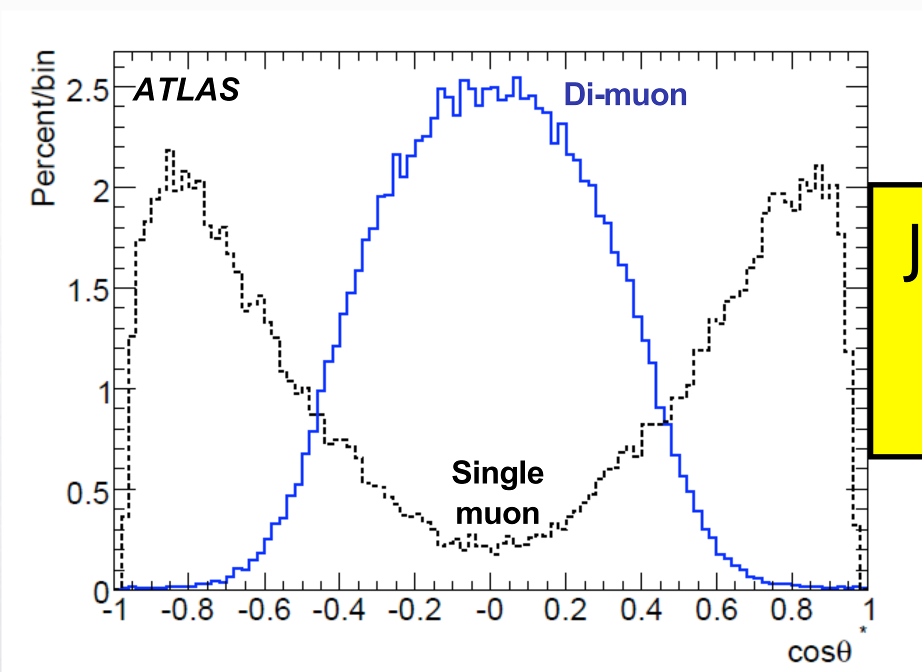


Spin alignment measurements from the Tevatron don't currently agree with theory or each other!

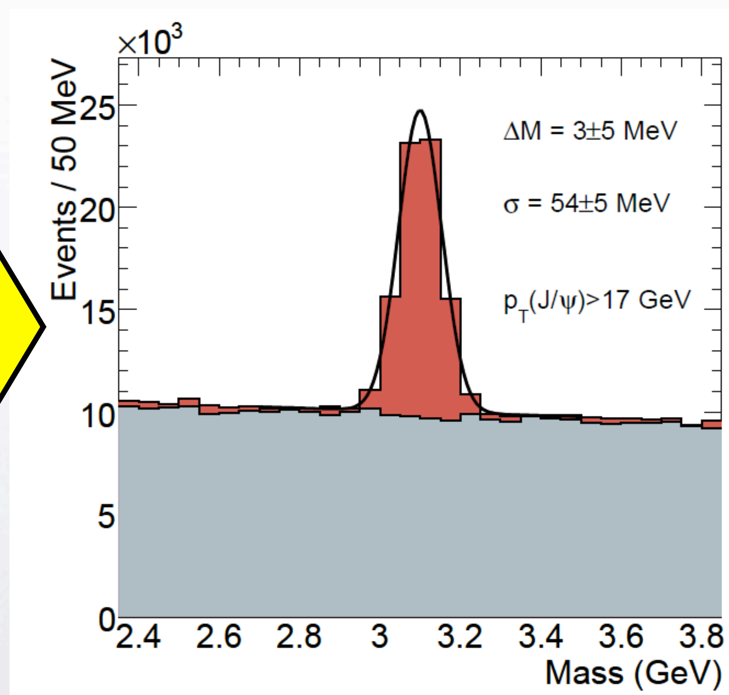



Tevatron experiments use a di-muon trigger that limits acceptance

ATLAS uses both a di-muon and a single muon trigger for greatly improved acceptance




J/ψ reconstruction with single muon trigger



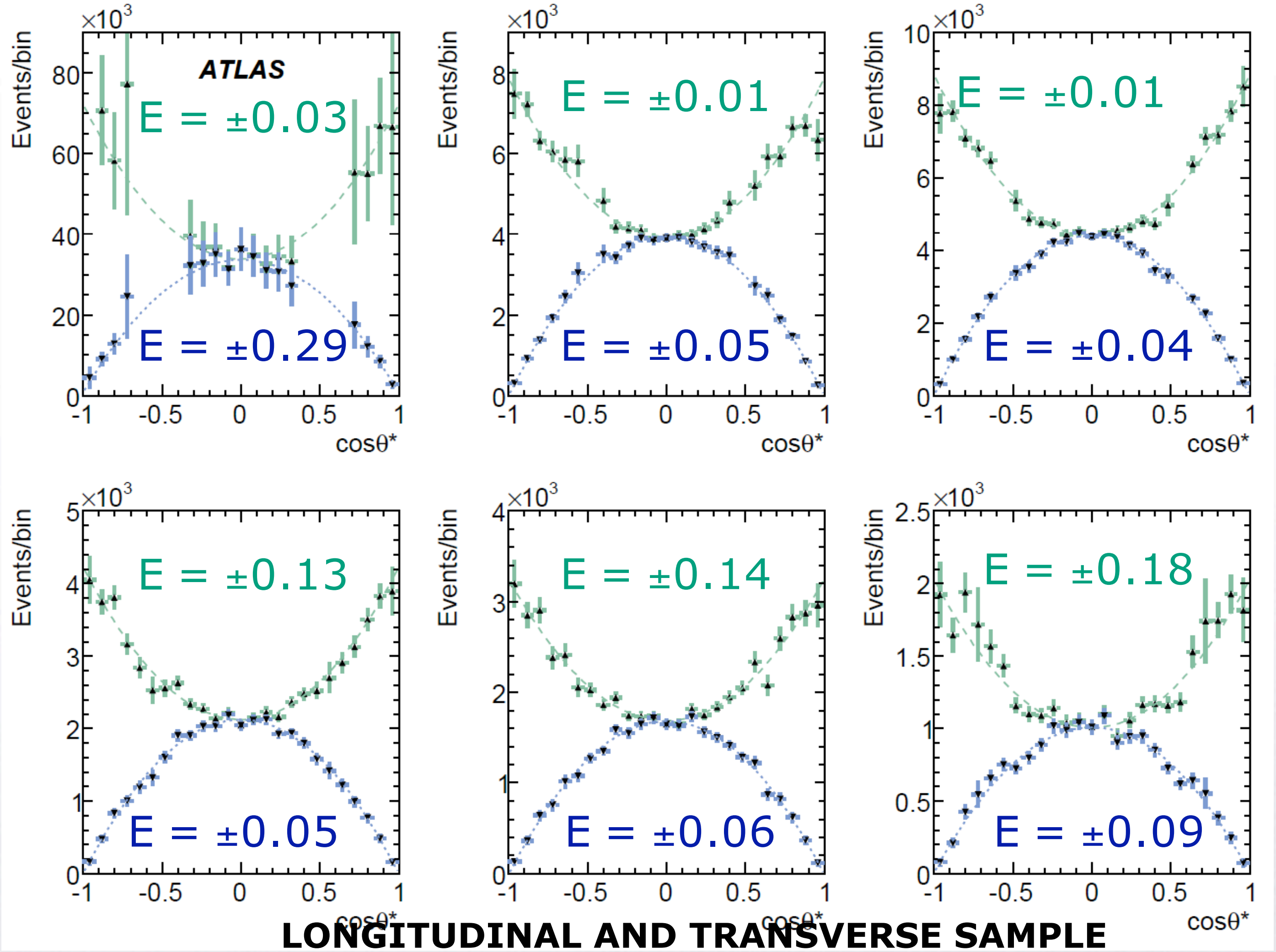
# Expected Precision



- With 1 month (10 $pb^{-1}$) data combined stat + systematic errors on polarization measurement ATLAS will have the same errors as Tevatron published measurements with 1.3 fb-1.
- With 10 $pb^{-1}$ data ATLAS will have sufficient statistics to measure upto a pT of 50 GeV (compared with 20 GeV at the Tevatron)

Histograms show polarization in different pT bins for 100% longitudinally and transversely polarised states.

Cross normalising and combining single and di-muon trigger samples provides significantly improved precision



# Early Measurements



- Onia and B-Physics measurements will provide a whole range of test and feedback for the ATLAS inner detector alignment which will be complementary to single particle track studies. These include:

1. The $J/\psi(\mu\mu)$ is ideal for magnetic field studies.
2. Onia is useful for validation of track fitters.
3. Onia is sensitive to unintended beam spot shifts.
4. B-Physics Masses and Lifetime are sensitive to B-field, material distortions and alignment.

- As seen in the Onia study ATLAS will also rapidly have the required statistics to improve on current world precisions.

- In some $B_s$ channels ATLAS expects to exceed current world precision with 1 $fb^{-1}$

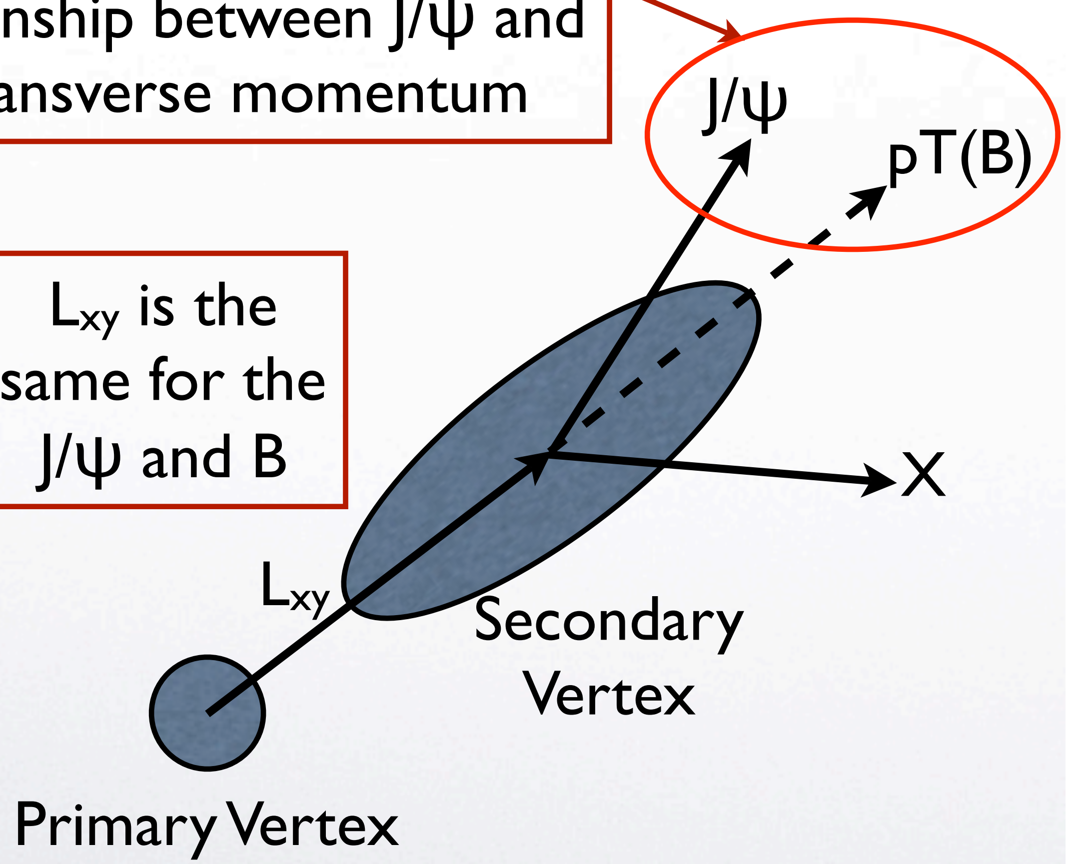
# Inclusive bb → J/ψ X Lifetime



With just 0.4 $pb^{-1}$ (10 hours) of data inclusive lifetime will be used for monitoring and calibration of inner detector.

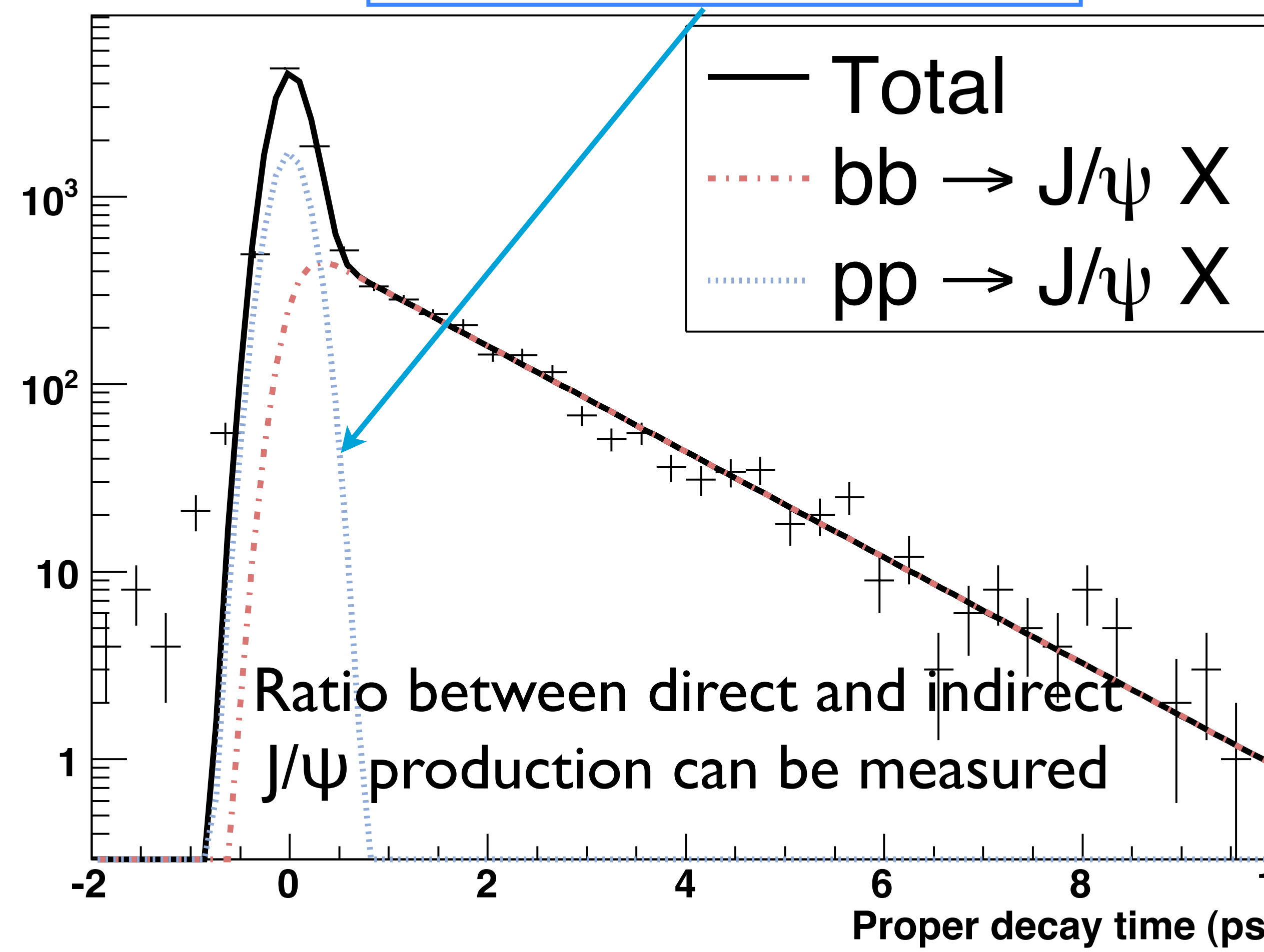
Use a correction factor to take into account the relationship between J/ψ and B transverse momentum

$L_{xy}$ is the same for the J/ψ and B




$$t = L_{xy}(B) \times \frac{M_B}{pT(B)}$$

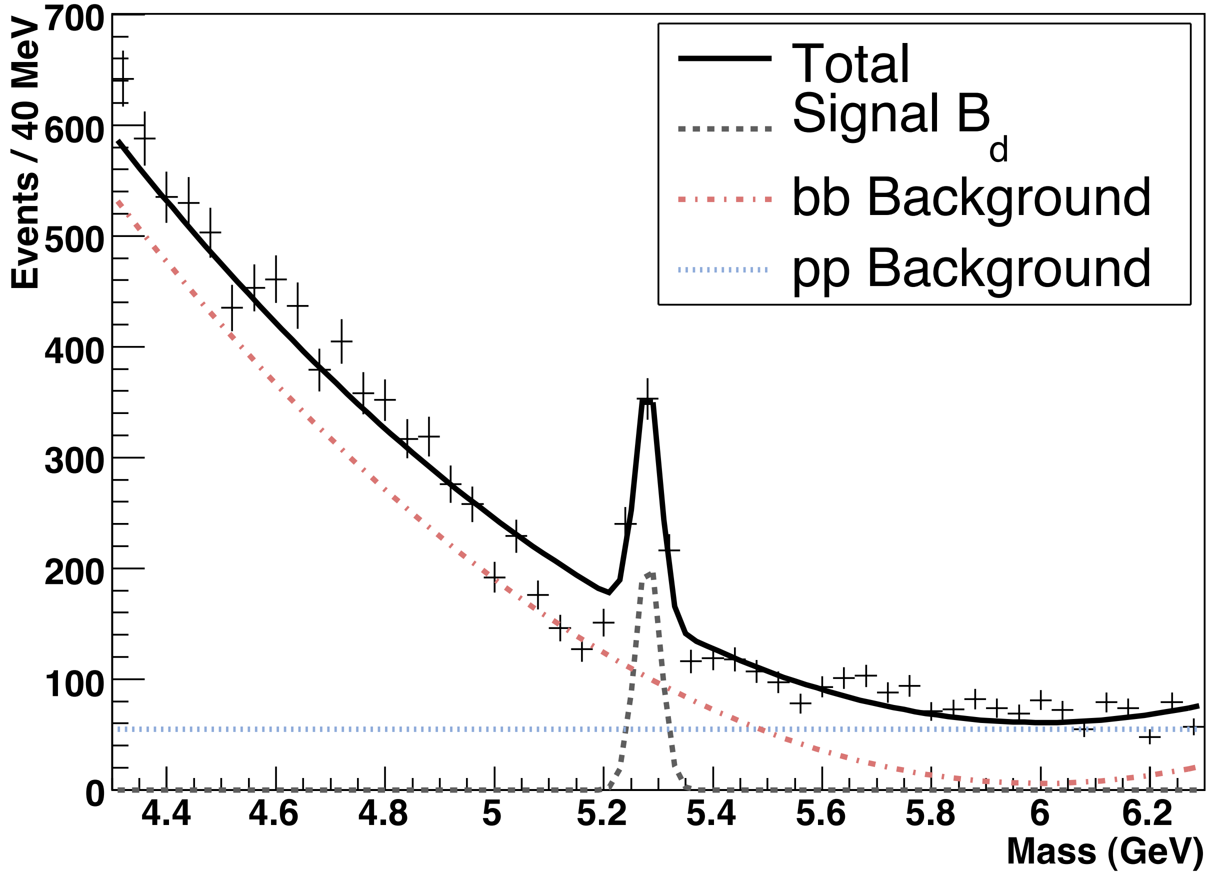
Primary background from direct J/ψ production

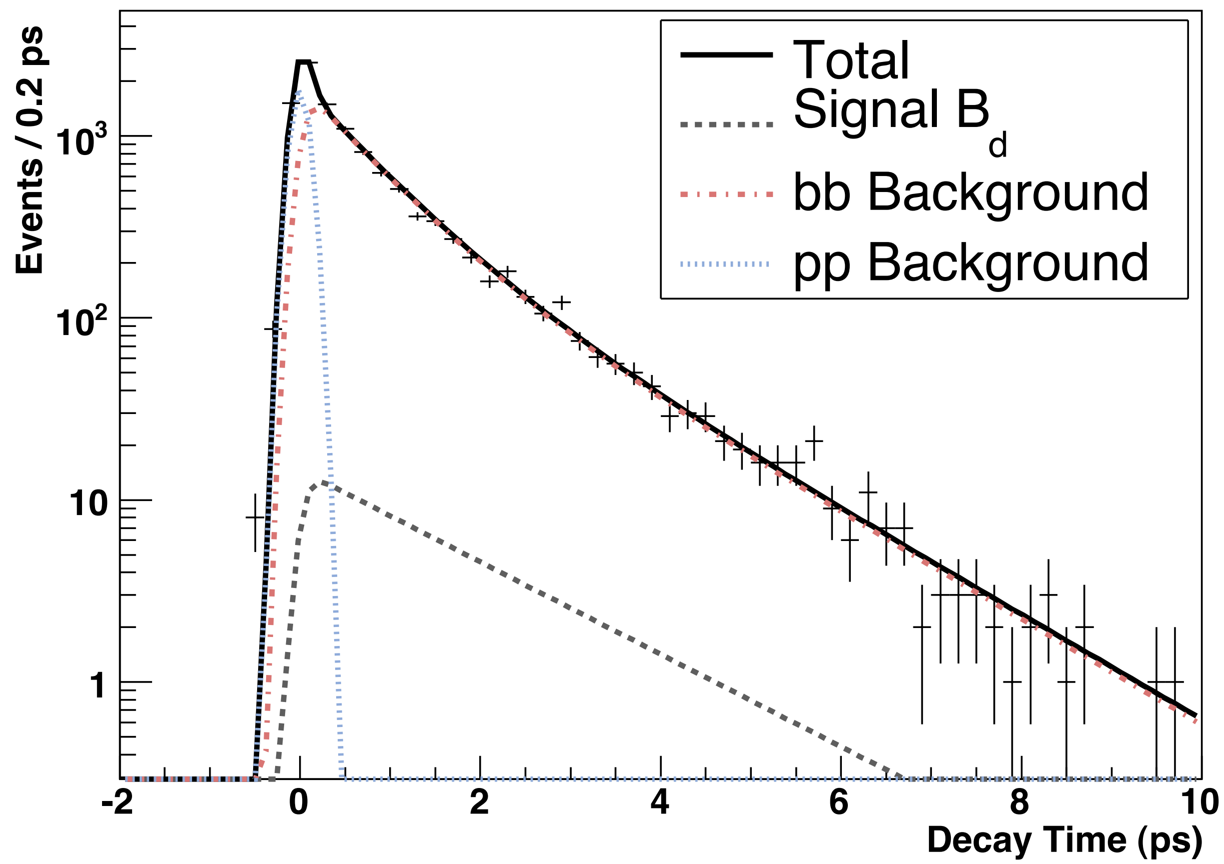


# $B_d \rightarrow J/\psi\ K^{0*}$ Lifetime



With 10 $pb^{-1}$ (~1 month) of data exclusive $B_d$ Lifetime measurement will serve as a high precision alignment test.

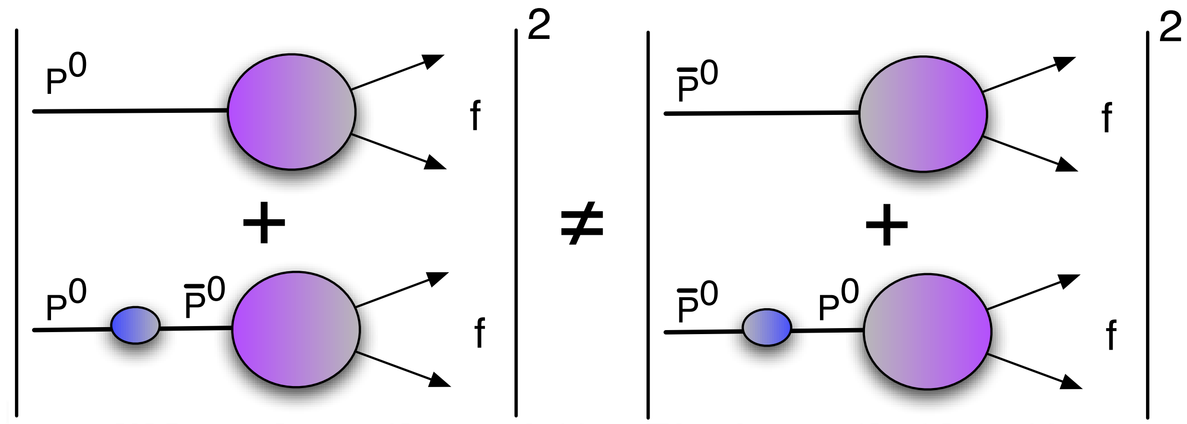



| Parameter | Fit Results |
|---|---|
| $\Gamma(ps)^{-1}$ | $0.585 \pm 0.057$ |
| S | $1.164 \pm 0.027$ |
| Mass (GeV) | $5.2808 \pm 0.0029$ |
| $\sigma_m$ (GeV) | $0.0230 \pm 0.0025$ |

# $B_s \rightarrow J/\psi\ \Phi$ Lifetime measurement

- In the $B_s \rightarrow J/\psi\ \Phi$ channel CP violation can be induced through interference between mixing and decay amplitudes.
- This occurs because both the particle and antiparticle can decay into the same final state.
- An angular analysis must be performed in order to extract the full physics behind the decay. This has 8 free parameters.




$$B_s^0 \rightarrow J/\psi\,(\mu\mu)\,\phi\,(KK) \leftarrow \bar{B}_s^0$$

Weak CP violating phase → $\phi_s$

Mass Difference → $\Delta M_s$

$$\Gamma_s,\, \Delta\Gamma,\, \phi_s,\, \Delta M_s,\, A_{||},\, A_{\perp},\, \delta_1,\, \delta_2$$

2 Lifetimes → $\Gamma_s$, $\Delta\Gamma$

2 independent Helicity Amplitudes → $A_{||}$, $A_{\perp}$

2 strong phases → $\delta_1$, $\delta_2$

# $B_s \rightarrow J/\psi\ \phi$ discovery potential

- Table shows the expected ATLAS precision with various luminosities in the $B_s \rightarrow J/\psi\ \phi$ channel. Results will be publishable.
- $\delta_1$ $\delta_2$ have been ignored here because they do not change the result significantly
- Results from $B_d \rightarrow J/\psi\ K^{0*}$ can be used to fix the helicity amplitudes
- $\Delta\Gamma$ and $\phi_s$ are fixed at 0 if they are not being fitted

| | $100pb^{-1}$ | $1fb^{-1}$ | $10fb^{-1}$ | $30fb^{-1}$ |
|---|---|---|---|---|
| Reco signal events | 800 | 8000 | 80 000 | 240 000 |
| $\Gamma_s$ | 10% | 2% | 2% | 1% |
| $\Delta\Gamma$ | Fixed | 40% | 25% | 13% |
| $\|A_{\|\|}\|^2$ | Fixed | Fixed | 7% | 3% |
| $\|A_{\perp}\|^2$ | Fixed | Fixed | 9% | 5% |
| $\phi_s$ | Fixed | Fixed | 0.1 | 0.07 |

# Conclusions



- With early data the B-Physics group is essential for understanding the ATLAS detector.
- Onia studies will provide world-leading results with around 10 $pb^{-1}$
- In the $B_s \rightarrow J/\psi\ \Phi$ channel can start improving on current measurements with 2 $fb^{-1}$