B meson studies - from commissioning to new physics effects.

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Talk Outline

- Early ATLAS measurements of lifetime and mass for
  - $B_s \rightarrow J/\psi(\mu^+\mu^-)\ \phi(K^+ K^-)$ and
  - $B_d \rightarrow J/\psi(\mu^+\mu^-)\ K^{0*}(K^+ \pi^-)$ decays

  - Stringent test of the alignment, magnetic field map and tracking
- Advanced studies of lifetime + lifetime difference in $B_s \rightarrow J/\psi(\mu^+\mu^-)\ \phi(K^+ K^-)$

  - Go beyond results from current experiments
- Full parameter fit including CP violating phase

  - probe for new physics with high statistics

Reconstruction method

Reconstruct $B_s \rightarrow J/\psi(\mu^+\mu^-)\ \phi(K^+ K^-)$, $B_d \rightarrow J/\psi(\mu^+\mu^-)\ K^{0*}(K^+ \pi^-)$ decays in several stages.

- Pairs of muons will be fitted to a vertex to make J/ψ candidates which will have to pass various cuts.
- Pairs of tracks fitted to make ϕ or K^{0*} candidates.
- B_s candidate vertices formed from J/ψ and K^{0*} candidates. Best candidate per event selected (based on χ^2 per degree of freedom)
- Note we use, vertex, direction and mass constrained fits

✓ Note, light cuts but *no* lifetime cuts at this stage

Available Statistics

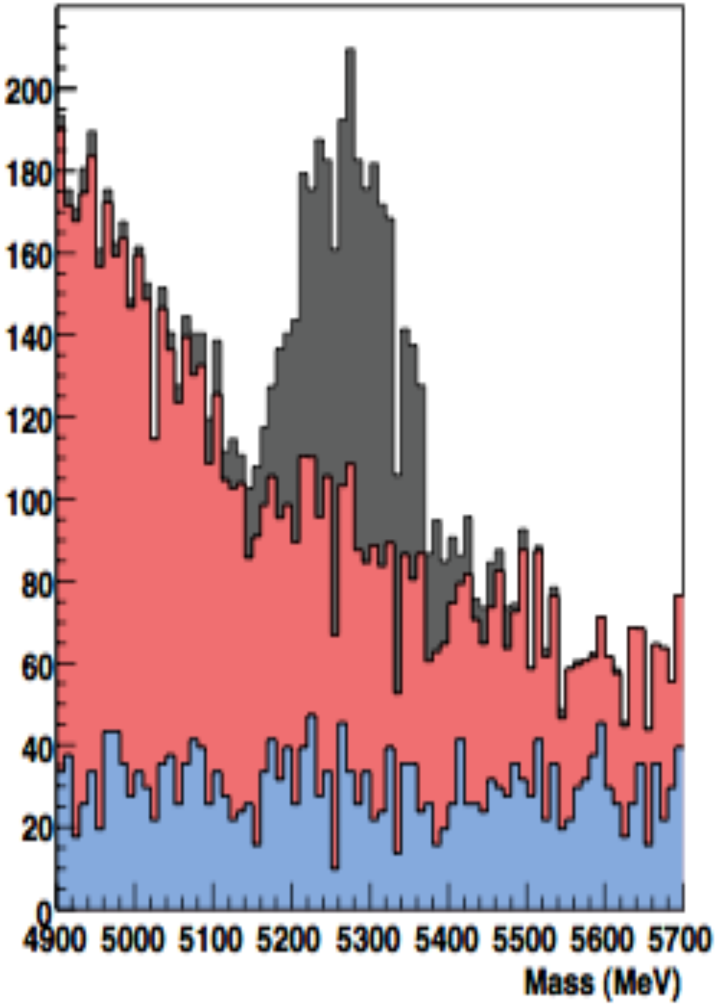
Because of the di-muon trigger and reconstruction method, the main types of background will come from events with $J/\psi \rightarrow \mu^+\mu^-$ in them. The table shows the number of candidates with a mass between 5 and 5.75 GeV for $100pb^{-1}$

Channel	Signal	Background 1 $pp \rightarrow J/\psi X$	Background 2 $bb \rightarrow J/\psi X$
$B_d \rightarrow J/\psi(\mu^+\mu^-)\ K^{0*}(K^+\ \pi^-)$	13 890	19 500	54 500
$B_s \rightarrow J/\psi(\mu^+\mu^-)\ \phi(K^+\ K^-)$	2 232	33 600	27 000

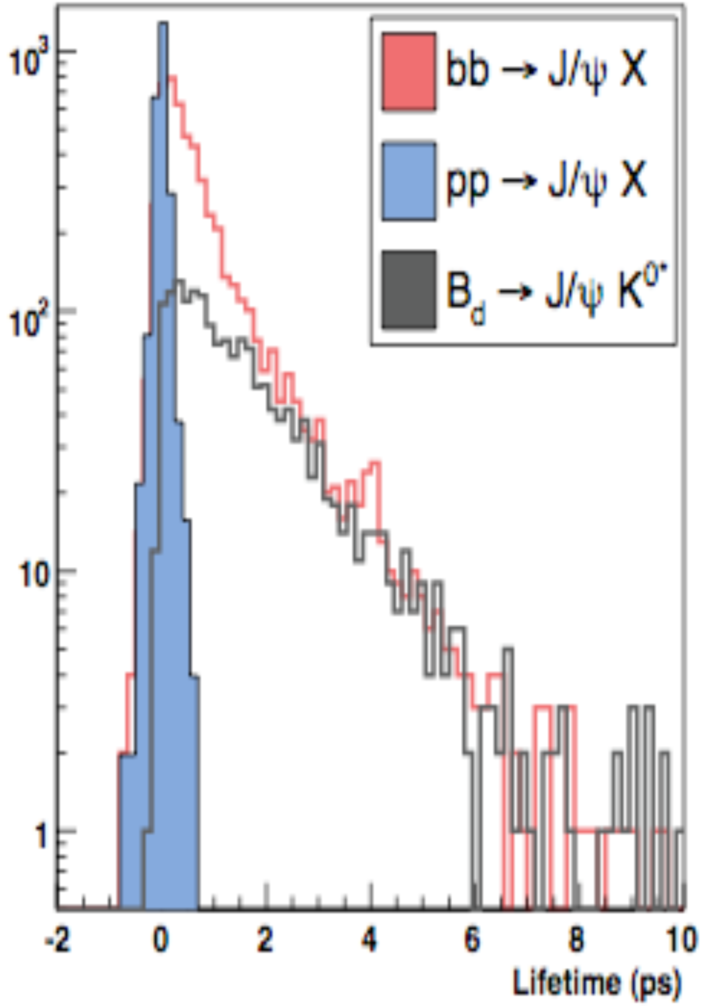
Simultaneous Mass & Lifetime fit

- At low luminosity it will be possible to use relatively loose cuts when selecting the B candidates.
  - This allows a sensitive test of detector unbiased by lifetime
  - Allow a relatively large number of background events → simultaneous fit to mass and lifetime to extract the physics
- For the B_d decay with $10pb^{-1}$ integrated luminosity:
  - Fraction of signal events in fit: 16%
  - Uncertainty in lifetime measurement: 5%
  - Mass uncertainty 4MeV
  - Good for alignment checks, improving the world knowledge beyond $100pb^{-1}$
- For the B_s decay with $100pb^{-1}$ integrated luminosity:
  - Fraction of signal events in fit: 1.8%
  - Uncertainty in lifetime measurement: 11%
  - Improving the world knowledge beyond $100pb^{-1}$ (but see later)

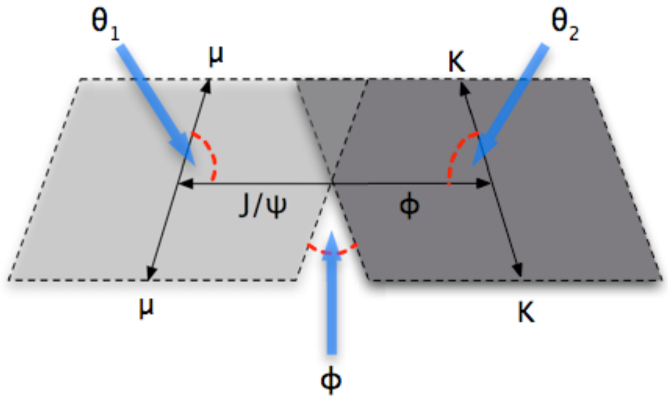
B_d invariant mass plot



B_d lifetime plot



Physics behind the B_s decay



Measured variables:

three decay angles
B_s proper decay time
Tag decision

8 Theory parameters to fit:

4 parameters of 3 complex helicity functions: $|A_\perp|$, $|A_{||}|$, $\delta_\perp$, $\delta_{||}$

4 parameters of B_s system: width difference $\Delta\Gamma_s$, mean width Γ_s, oscillation frequency Δm_s, weak mixing phase ϕ_s

Note, Δm_s is insensitive, effectively falls out

The number of physics parameters it is possible to extract with the simultaneous fit depends on the available statistics

B_s Lifetime and Lifetime Difference (or Γ & $\Delta\Gamma$)

- If we want both the lifetime and the lifetime difference we must fix the other parameters in the fit for low-ish statistics.
- $|A_\perp|$ and $|A_{||}|$ can be fixed by using the results from fits to B_d decays.
- Δm_s will be measured in other experiments and due to insensitivity/high correlations will always be fixed.
- $\delta_\perp$ and $\delta_{||}$, the strong phases have little correlation with the other parameters and can be fixed without significantly affecting the results.
- ϕ_S , the weak phase is predicted to be small in the standard model and can be fixed at 0.04 (SM) for early measurements.

Γ & $\Delta\Gamma$(2)

- It should be possible to perform the fit when there is at least 1fb^{-1} integrated luminosity available.
- Predicted statistical uncertainties for 1.8 fb^{-1}
  - $\mathbf{\Gamma_S}$ uncertainty: 1.8%
  - $\mathbf{\Delta\Gamma_S}$ uncertainty: 36%
  - Correlation between parameters: -0.63
- Results from DØ from Jan 2007 (1.1fb^{-1})
  - $\mathbf{\Gamma_S}$ uncertainty: 5.3%
  - $\mathbf{\Delta\Gamma_S}$ uncertainty: 67%

Measuring ϕ_s

- The standard model predicts ϕ_s to be 0.04.
- It is important to measure ϕ_s because if it is found to be much larger than 0.04 it will be a clear indication of new physics.
- In order to measure ϕ_s accurately it will be necessary to perform a fit to 5 parameters simultaneously.
- With $18 fb^{-1}$ integrated luminosity it should be possible to measure ϕ_s with an absolute uncertainty of 0.10.
- Note: we are working on improvements in statistics (via trigger) and tagging

Conclusions

- “Commissioning measurements” can remain as permanent sensitive tests alignment controls
- For $30fb^{-1}$ we can really test BSM effects in CP violating phase
- Note: in this phase, BSM in CPV & in rare decay modes become very competitive