Tag & Probe Method with J/ψ events

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B+ Study (CSC results)

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Introduction

- How to determine the efficiencies with data in order to not rely on the simulation ?

- The tracking efficiency for muon of low momentum (pT<20 GeV) can be measured using J/ψ events in principle.
  - This kinematic region is not covered by the Z decays but is important for the B physics

- The « Tag & Probe » method can be used to determine the muon stand-alone reconstruction efficiencies from data. This method can be used to measure the muon reconstruction efficiencies of the ID or the Trigger.

Introduction: Definition of the method

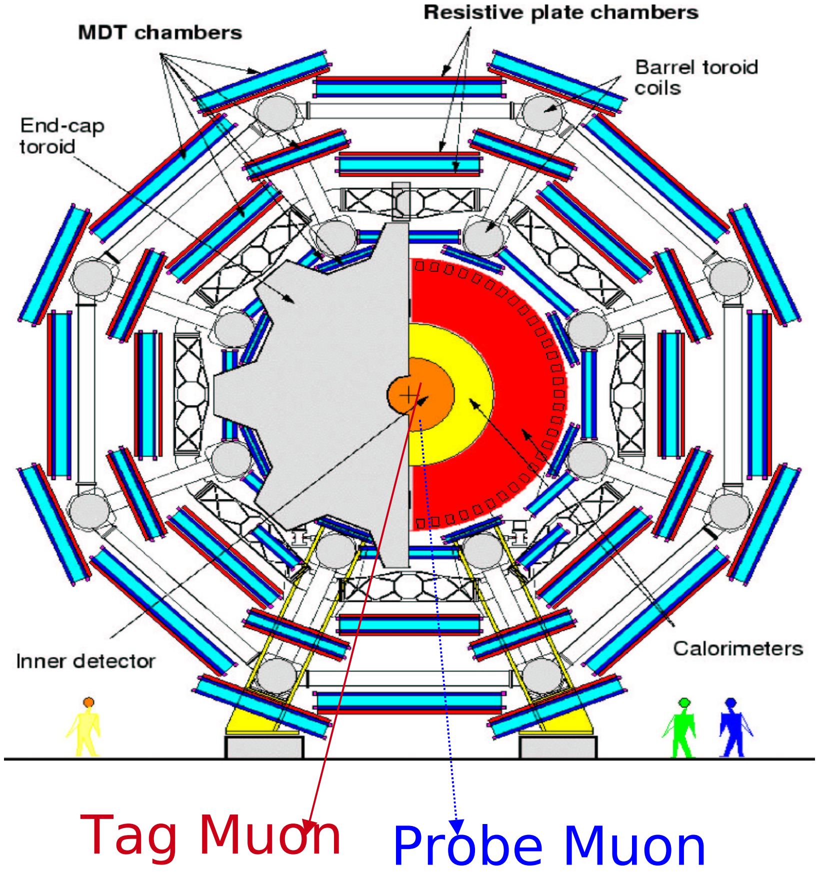
Tag and Probe Method to determine Efficiencies in J/ψ samples

• **Tag Muon**: Track in Inner Detector and Muon Spectrometer (pT-Cuts)

•**Probe Muon**: Track in Inner Detector (pT-Cuts)

•If this di-muon mass around J/ψ mass, then the probe muon is assumed to be a real muon:

- **•Muon efficiency is given by the fraction of probe muons with tracks in the Muon Spectrometer**



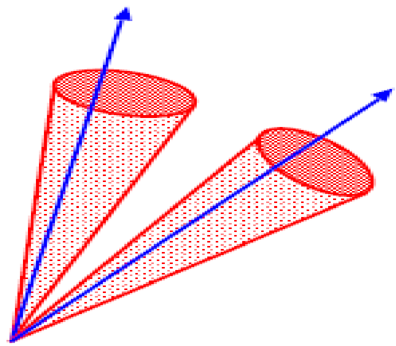
For the J/ψ , the feasibility of this measurement depends on the trigger requirements

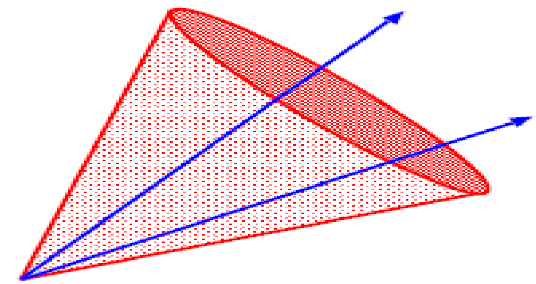
Systematics : Trigger

- An important systematic uncertainty comes from the assumption that the tag muon is independent of the measurement of the probe muon
- A correlation between tag and probe muon could be caused by the trigger
- **Single muon trigger**
  - Where one of the muon forming the J/ψ in the offline reconstruction, is trigged while the other one may be or not be triggeed.
  - This trigger provides an unbiased sample to study the MS efficiency
  - BUT, huge background contaminates the selected dimuon data sets so much that a reliable efficiency measurement becomes impossible (S/B~1.2)
- **Di-muon trigger**
  - J/ψ events collected by the topological di-muon trigger introduce correlations and cannot be used for the tag & probe method
    - The topological di-muon trigger starts from a di-muon trigger at level-1 which produces two muon regions of interest.
  - **Can we then use TrigDiMuon to select events for Tag & Probe ?**

Tag & Probe on Jpsi sample using TrigDimuon

Topological trigger, using two RoI's





TrigDiMuon seeded by a single muon RoI

- TrigDiMuon starts with a level-1single muon ROI and search for two muons in a wider eta and phi region. (*developed by Nathalia & Shlomit*)
- This algorithm starts from reconstructing tracks in the ID and extrapolating the track to the MS to tag muons tracks
- Since this method does not explicitly require the second muon at level-1, it has the advantage for reconstructing J/ at low-pT
- Events collected by TrigDimuon could provide a sample which is not completely unbiased
- It is not completely true that TrigDimuon does not introduce correlations between the two reconstructed muons, because they are, as an example, geometrically correlated by the RoI size; this kind of correlation is reduced as the RoI size is increased.

Systematics : Isolation

- The muons from J/ψ are on average separated by only DR ~ 0.5

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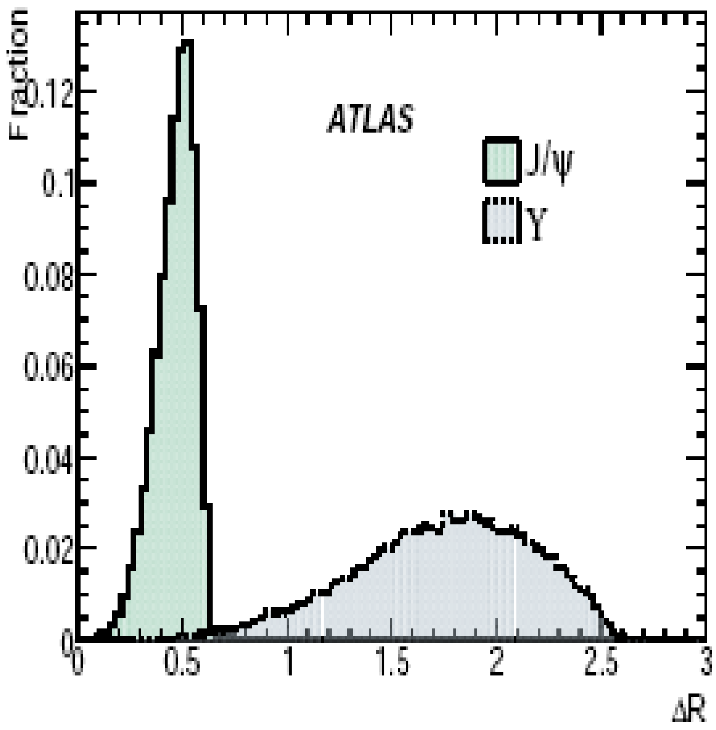

- They are subject to similar material and detector effects, and so these effects are carried over into the J/ψ reconstruction

- Difficult to apply isolation criteria or to use calorimeter information

Systematics : Background

- The expected sources of background for prompt J/ with a di-muon trigger are:
  - Indirect J/ψ production from beauty decays;
  - Continuum of muon pairs from beauty decays;
  - Continuum of muon pairs from charm decays;
  - Di-muon production via the Drell-Yan process;
  - Decays in flight of pi and K mesons;
- **One can apply the vertexing to suppress the background with the Tag & Probe method**
  - The measurement of the ID and the MS are independent
  - The vertexing involves the ID
- **The level of the backgrounds considered for Jpsi do not represent any serious problem for reconstruction and analysis of direct Jpsi with the di-muon trigger.** *(See Onia CSC note)*

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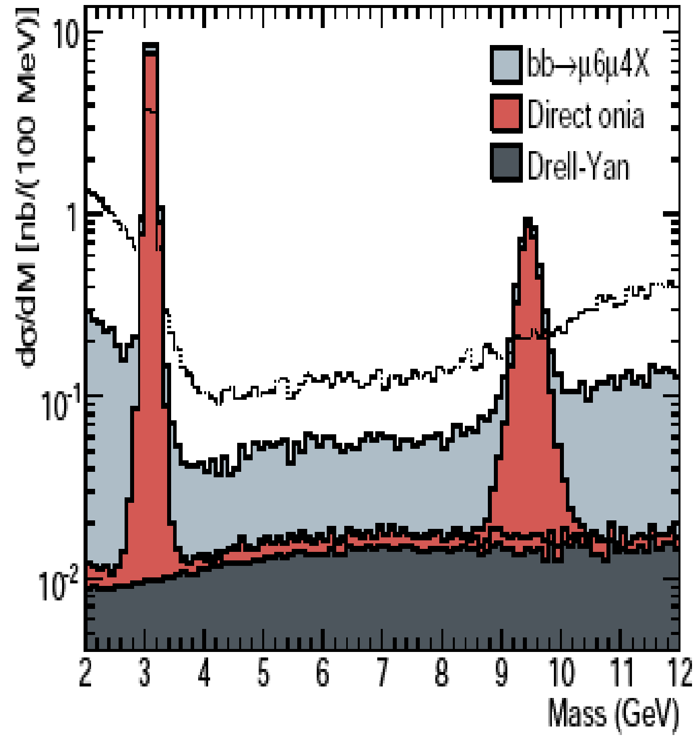
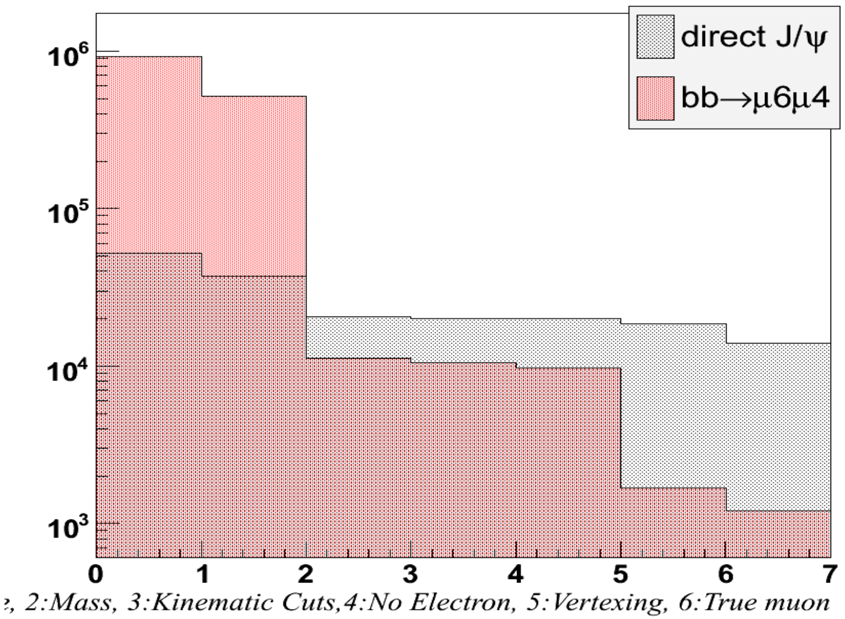
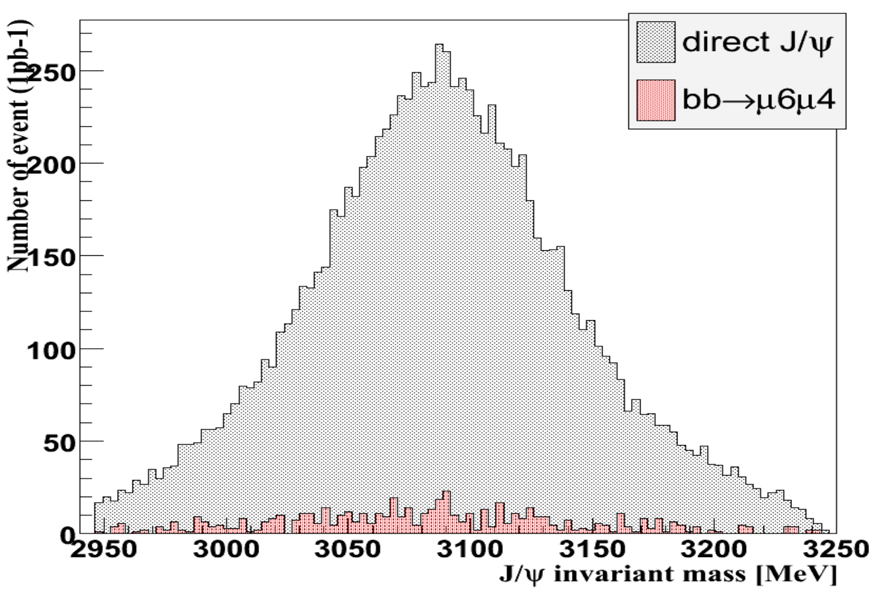


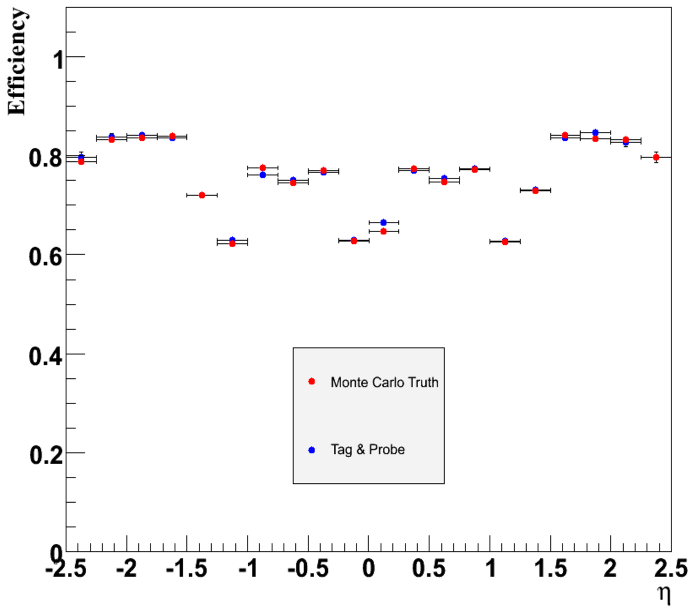
Selection cuts



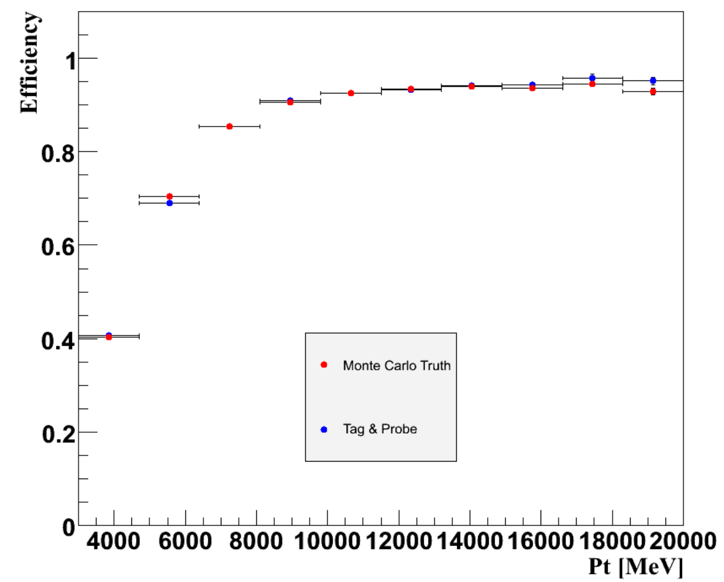


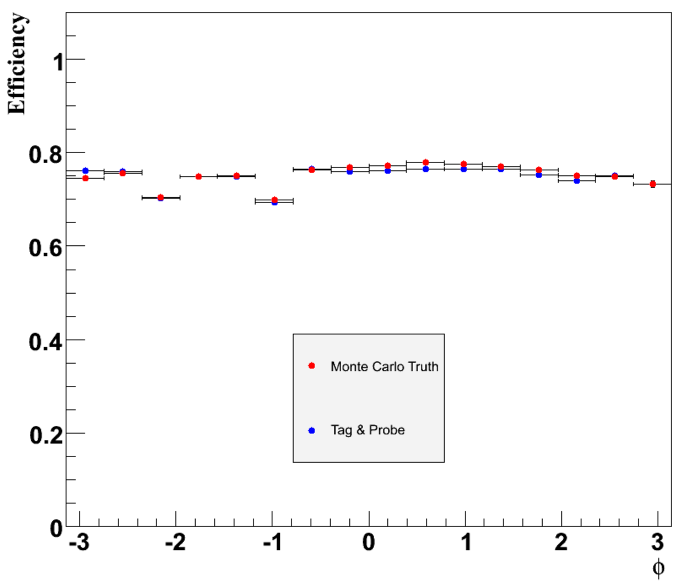
- **The tag muon should be the one corresponding to the LVL1 RoI**
- **Selection cuts:**
  - Mass (J/ -PDG)<150 MeV
  - Pt(muon)> 4 GeV
  - **Check if the track is not associated with an electron (~2% cases)**
  - **Tracks with secondary vertex are rejected**
- **Apply the vertexing to suppress the background with the Tag & Probe method**
  - **The vertexing involves the ID**
- **The level of the backgrounds is found to of the order of 8% (after cuts sigma(signal)=13.9 nb and sigma(bkg)=1.2 nb)**

Comparison of the MS efficiency using the Tag & Probe and the MC truth



1pb-1





- A good agreement is found between the muon reconstruction efficiency of the MS using the Tag & Probe and via the Monte Carlo truth information
- For 1pb-1, | Efficiency(Insitu) – Efficiency(true) ~0.6%

Summary-I

- Investigate the possibility to use TrigDiMuon trigger to select J/ψ events in order to determine the Muon Spectrometer efficiency for muon of low momentum (pT<20 GeV)

- A very good agreement is found between the muon reconstruction efficiency of the MS using the Tag & Probe and via the Monte Carlo truth information

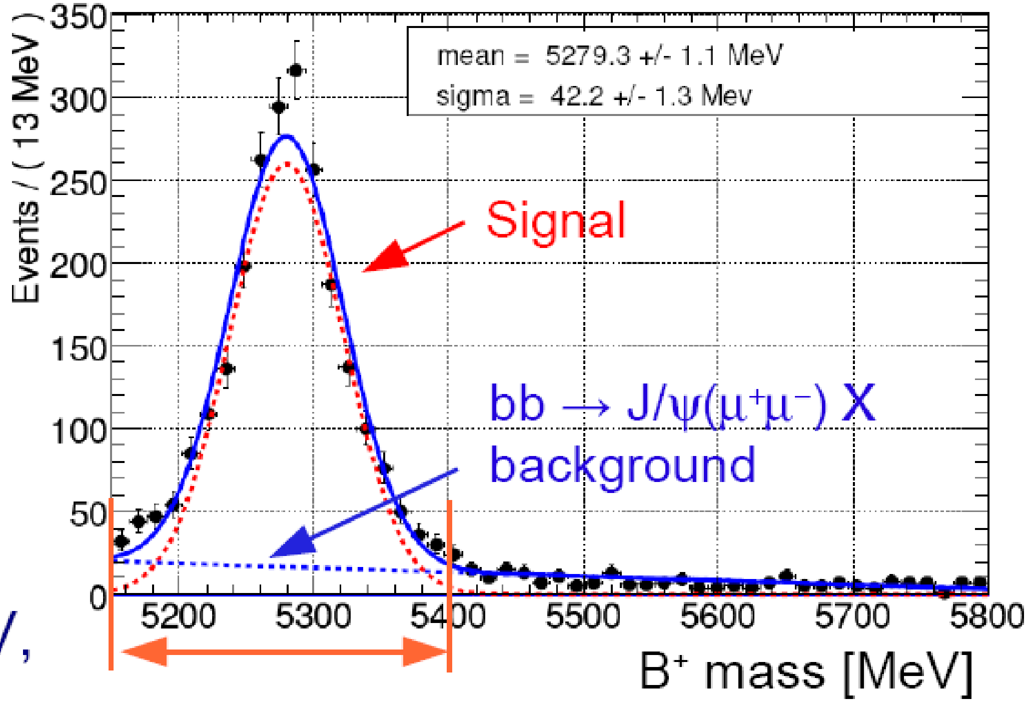
- Release the Tag & Probe code very soon

B+ -> J/ψ K+

- The exclusive B channel provides a clean reference signal due to
  - the clear event topology and its rather large branching ratio
- This channel can be measured during the initial luminosity phase of the LHC.
- The B+ -> J/ψ K+ decay can serve as a reference channel for the measurement of the decay probability of a very rare decay channel Bs->μ+μ-
- The total and differential cross-sections of the rare B decays can then be measured relative to the B+ -> J/ψ K+ cross-section since in a relative measurement, common systematic effects mostly cancel out.
- This channel can also act as a control channel for the CP violation measurement and can be used to estimate the systematic uncertainties and flavour tagging algorithm efficiencies.
- The relatively large statistics for this decay, expected already with the first 10 pb-1 provides a tool for initial detector studies calibration and alignment
- With first Atlas Data the we will measure
  - the B+ Mass , Differential and Total cross section, Lifetime

b Cross Section B+ -> J/ψ K+

- Reference channel
- Di-μ J/ψ trigger, $\varepsilon_{J/\psi}^{trig} \sim 82\%$
- J/ψ: $(p_T(\mu_{1,2}) > 6$ GeV, 3 GeV) displaced vertex $\lambda > 100\ \mu m$ $\varepsilon_{J/\psi}^{rec} = 55.8\%$
- B^+: J/ψ + 1 track ($p_T > 1.5$ GeV, large impact parameter) displaced vertex $\lambda > 100\ \mu m$ mass in ±120 GeV around m_{B^+}
- $\varepsilon^{total} = 29.8 \pm 0.84$ % $\sigma(m_{B^+}) = 42.2 \pm 1.3$ MeV



With 13.2 pb^{-1}:

- ~ 2100 signal events
- cross section to ~ 3 %
- mass resolution ~ 3 %
- signal lifetime to ~ 2 %

B+ Lifetime measurement

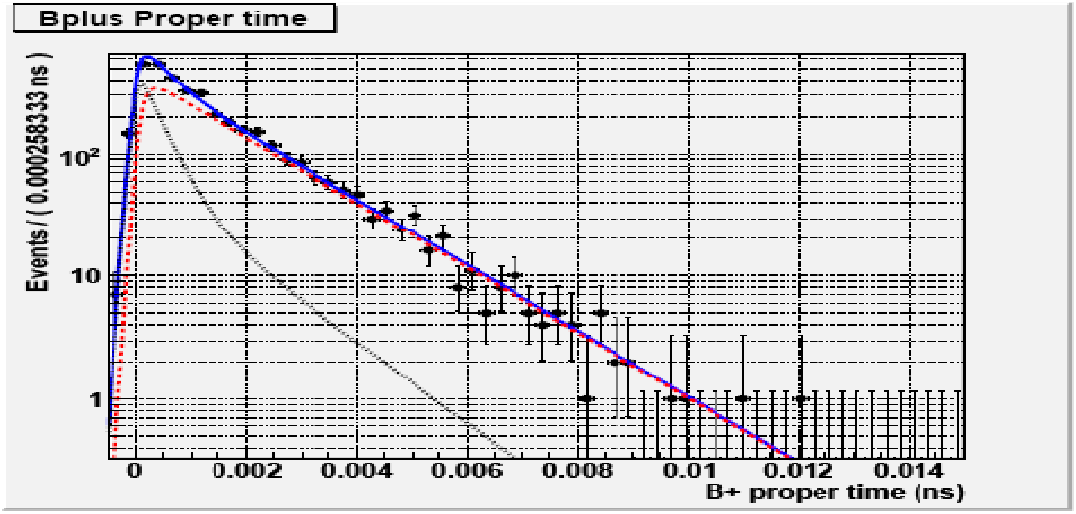


Figure 6: B^+ lifetime fit (STACO).Signal (dashed red), background (dashed black), overall (blue)

Lifetime Fit Results	
Signal lifetime τ ps	1.637 ± 0.036
Bkg1 lifetime τ_1 ps	1.320 ± 0.24
Bkg2 lifetime τ_2 ps	0.370 ± 0.067

Table 11: Lifetime fit results based on a luminosity of $13.2 pb^{-1}$

Accurate lifetime measurements are required for software validation such as the vertexing software

Summary-II

- The exclusive B+ -> J/ψ K+ channel provides a clean reference
- Lifetime measurements provide a sensitive test of detector alignment.
- Accurate lifetime measurements are required for software validation such as the vertexing software.