B^0 Lifetime and Mixing with partially reconstructed $D^*l\nu$ and Lepton Tag

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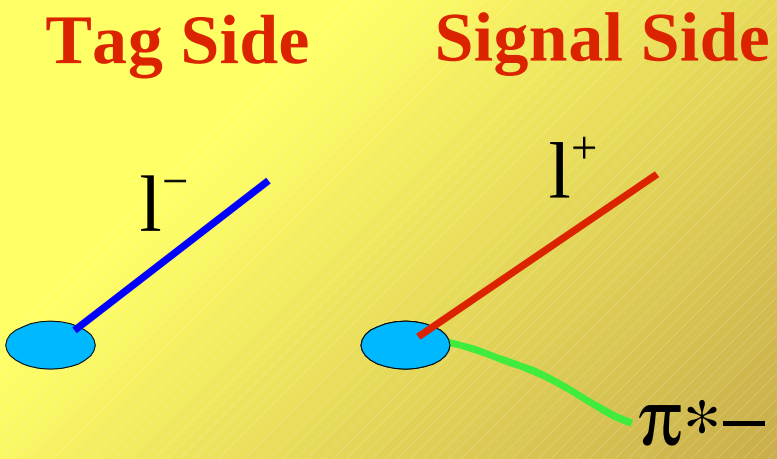
Analysis Strategy

Signal Vertex: $l\pi^*$ + beam spot (x,y)

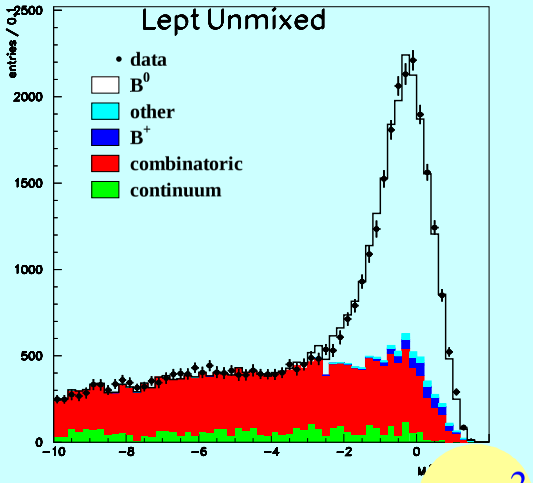
Tag Vertex: l (Elbatag) + beam spot (x,y)

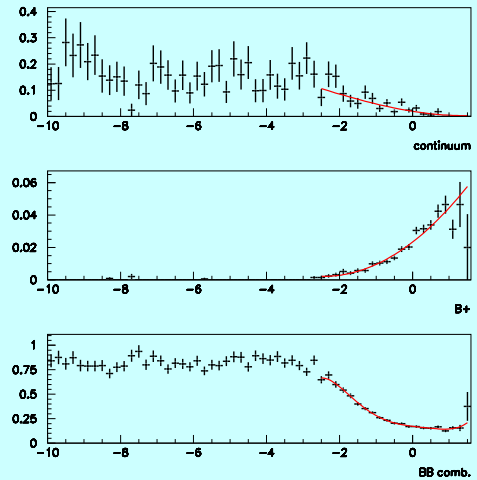


* Fit to Δz distribution to determine simultaneously Δm, τ and dilution constrained to the inclusive fraction of mixed events χ_d

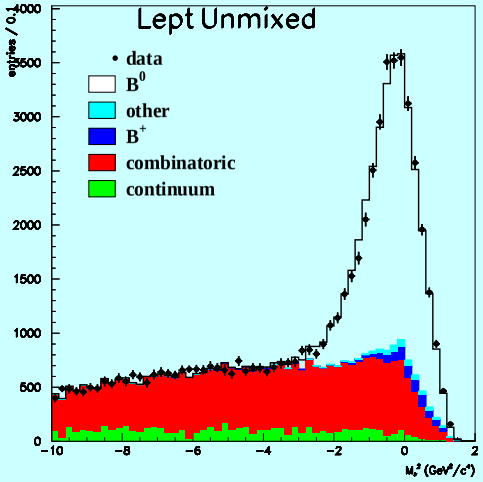
Lepton Tag Sample

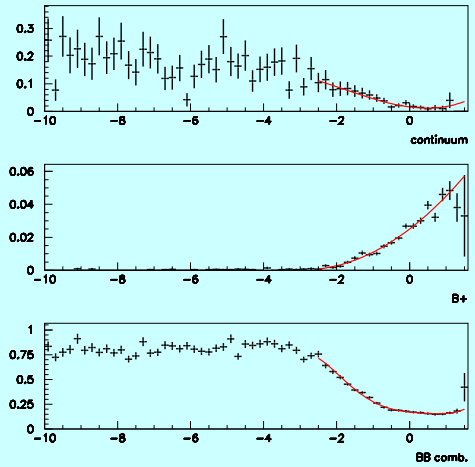
2000



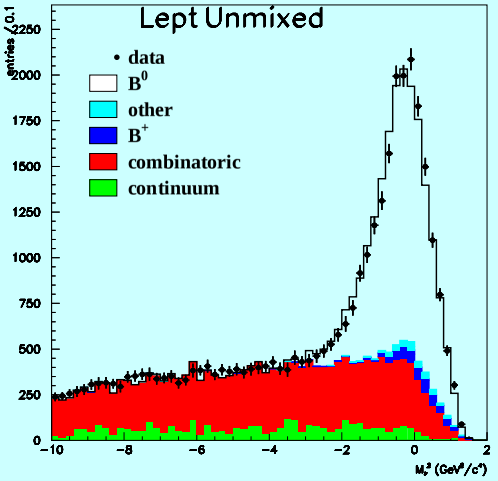


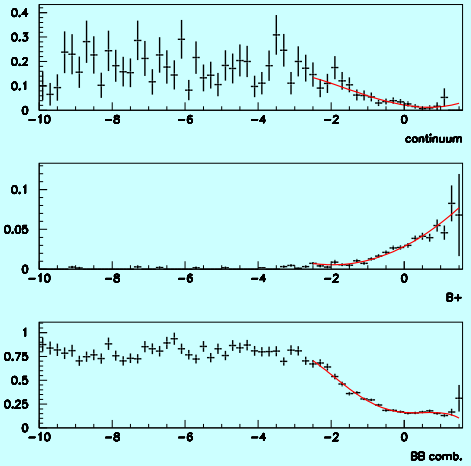
2001





2002





m_ν^2

The Signal PDF

Tagging Lepton Sample: { b−> l (From tag B) ; b−>c−>l ; D0 −> l (From decay B)

Resulting PDF:

$f\pm(\Delta t;\tau_B;\Delta m;...)=$

$\Gamma_B/2 \exp(-\Gamma_B|\Delta t|) * (1-\alpha)/2 *[F_{b->l}(1\pm D_{b->l} \cos(\Delta m \Delta t)) +$

$+ F_{b->c->l}(1\pm D_{b->c->l} \cos(\Delta m \Delta t))]$

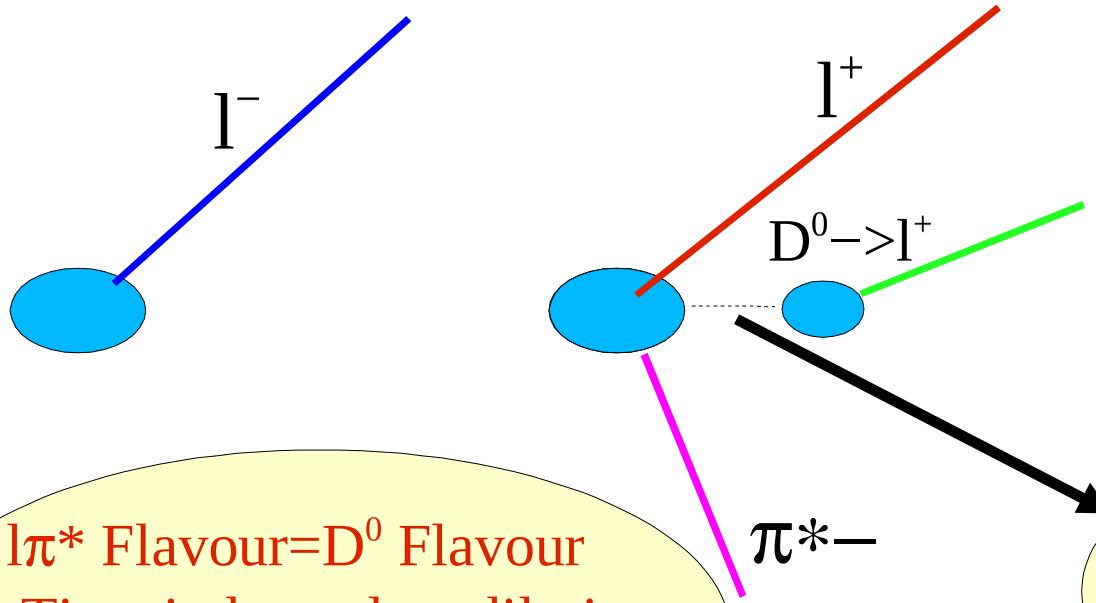
$+ \Gamma_D/2 \exp(-\Gamma_D|\Delta t|) * \begin{cases} \alpha(1-\rho) \\ \alpha\rho \end{cases}$

Tag Side Composition 1

Lepton from D^0 (Signal Vertex) affects the Tag−Side

Signal Side

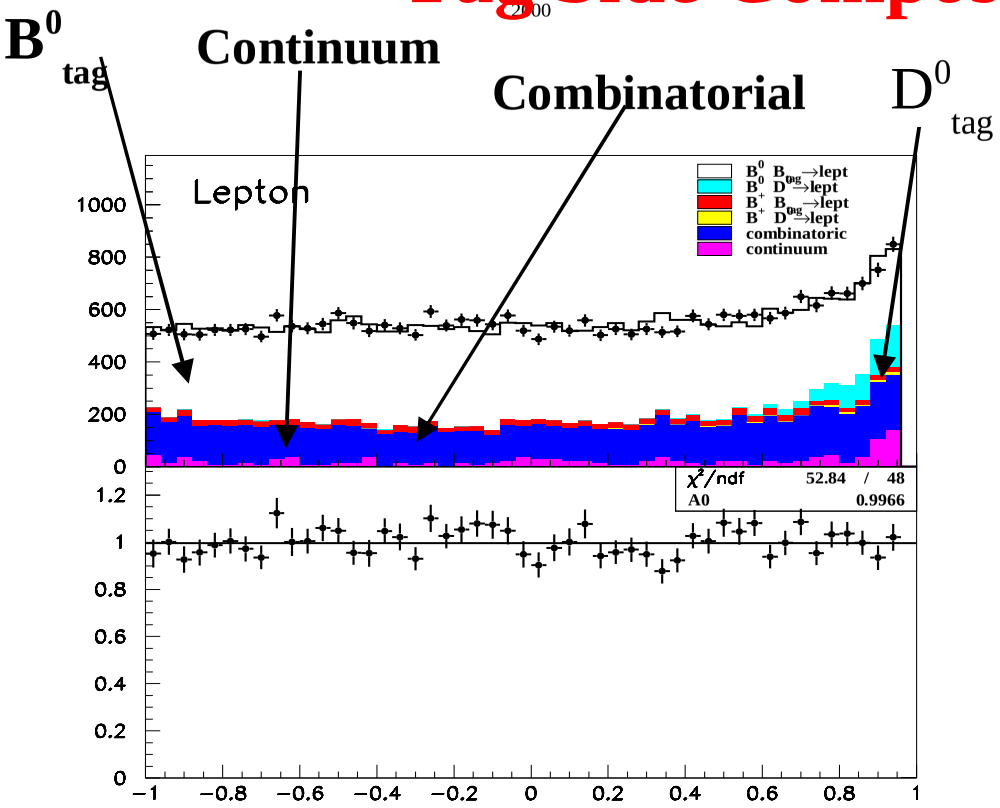
Tag Side

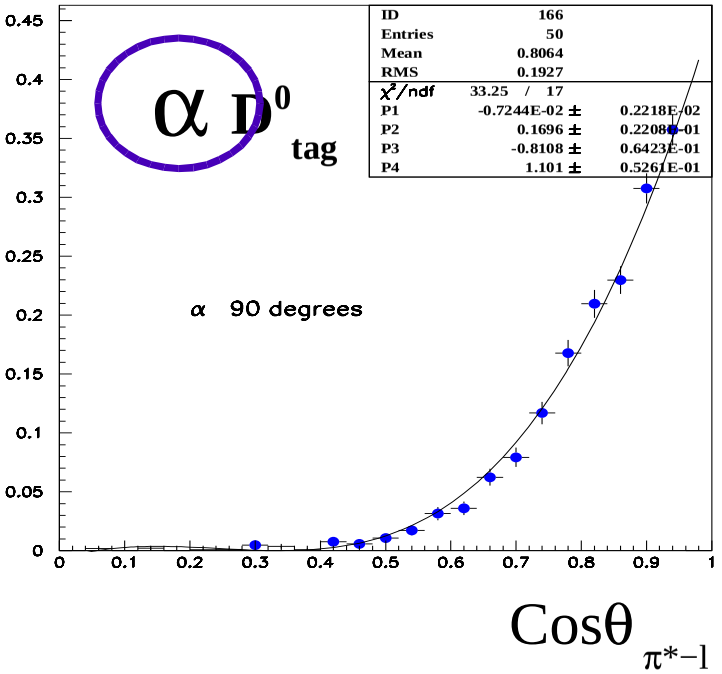


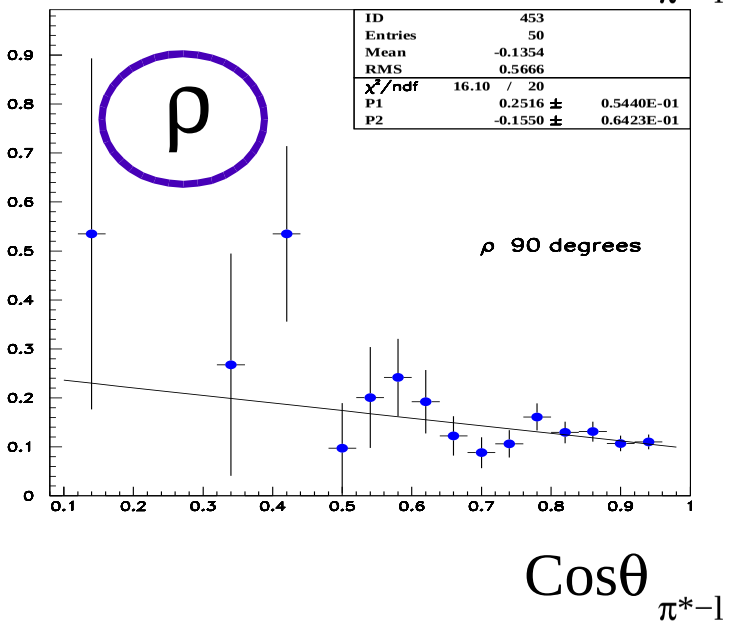
lπ* Flavour=D^0 Flavour
Time independent dilution
D0 leptons mostly populate unmixed sample

$\Delta z_{meas} < \Delta z_{true}$
$\tau^{D}_{effective}$ free parameter in the PDF

Tag Side Composition 2







$\alpha\ (Cos\theta_{\pi^*-l}) = NDtag/NTag$

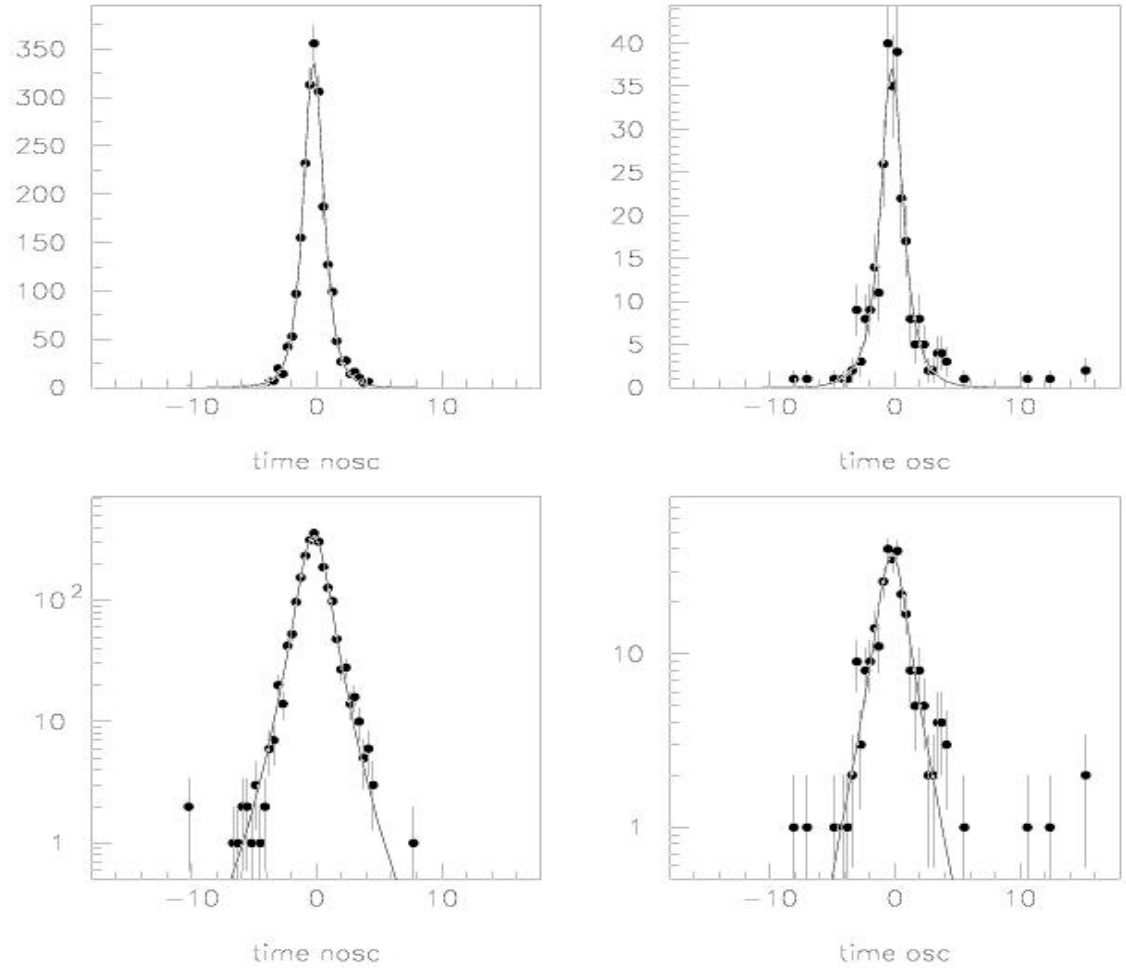
$\rho\ (Cos\theta_{\pi^*-l}) = (NMixed/Ntot)_{Dtag}$

Expressed in terms of $Cos\theta_{\pi^*-l}$ to disentagle Btag from Dtag components

Signal Vertex: $D^0 \rightarrow l$ Description

- Dtag PDF: $\tau \otimes 2G$
- Free parameters: effective τ_{D0}, bias

Unmixed **Mixed**



MC 2000

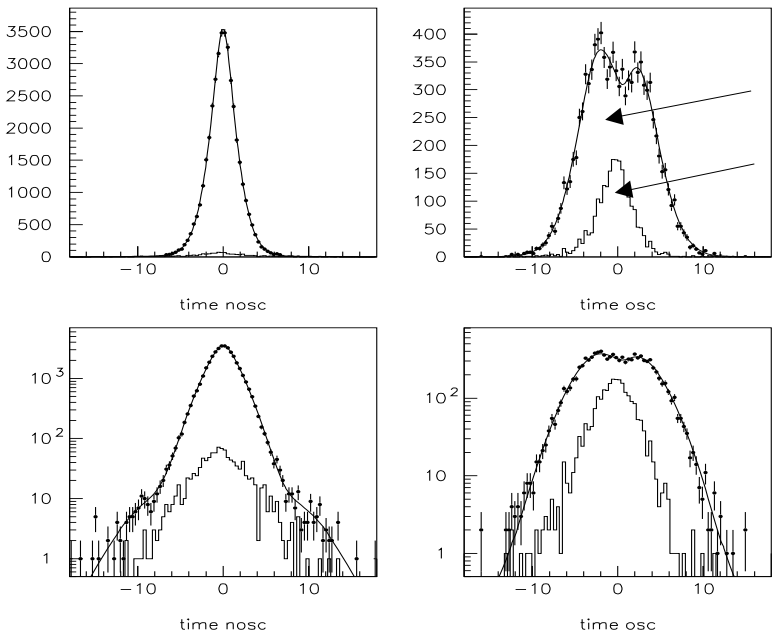
$\tau_{D0} = 0.316 \pm 0.022$ ps

bias $= -0.233 \pm 0.019$ ps

Tag Vertex: b→l / b→c→l Description

Unmixed **Mixed** MC 2000

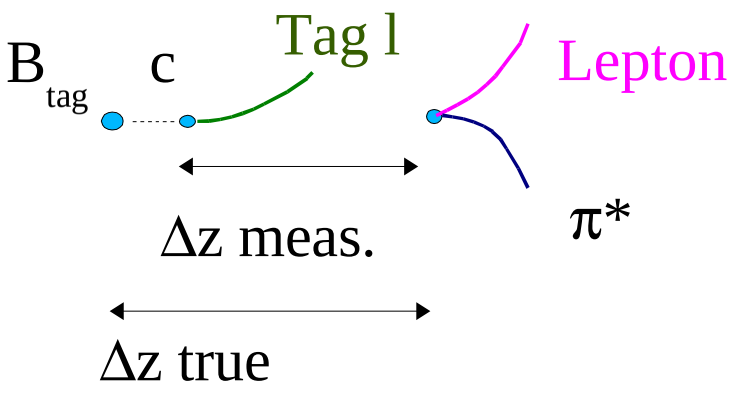
- Separate treatment of the prompt and cascade lepton samples: same pulls, different biases (~ 0 for b→l) and dilutions.
- Cascade fraction (~ 7%) from external fit to Lepton Momentum (up to now fixed from MC)

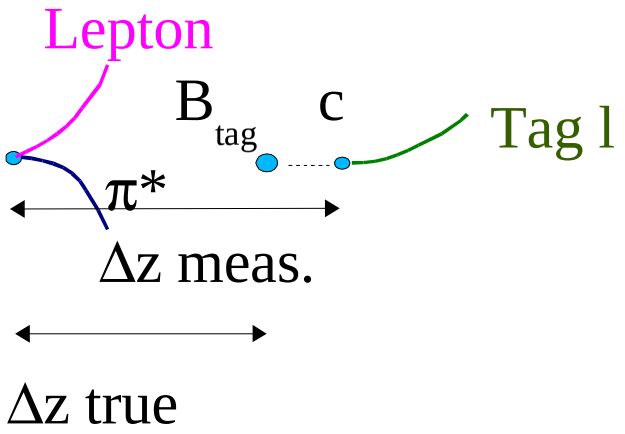


Prompt

Cascade

$\Delta z = Z_{reco} - Z_{tag}$



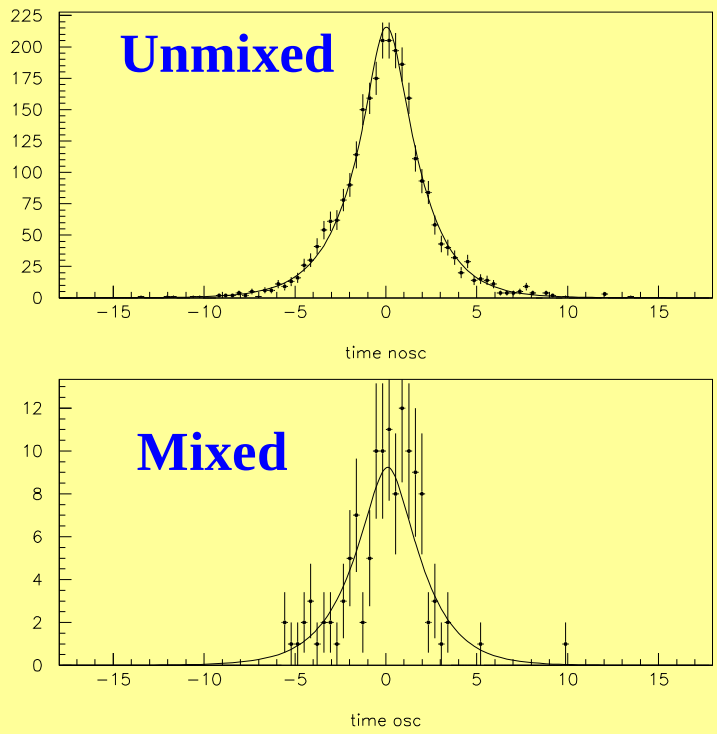


If $\Delta z > 0$: $\Delta z_{meas} < \Delta z_{true}$

If $\Delta z < 0$: $|\Delta z_{meas}| > |\Delta z_{true}|$

Fit to resonant B^+

2000 MC



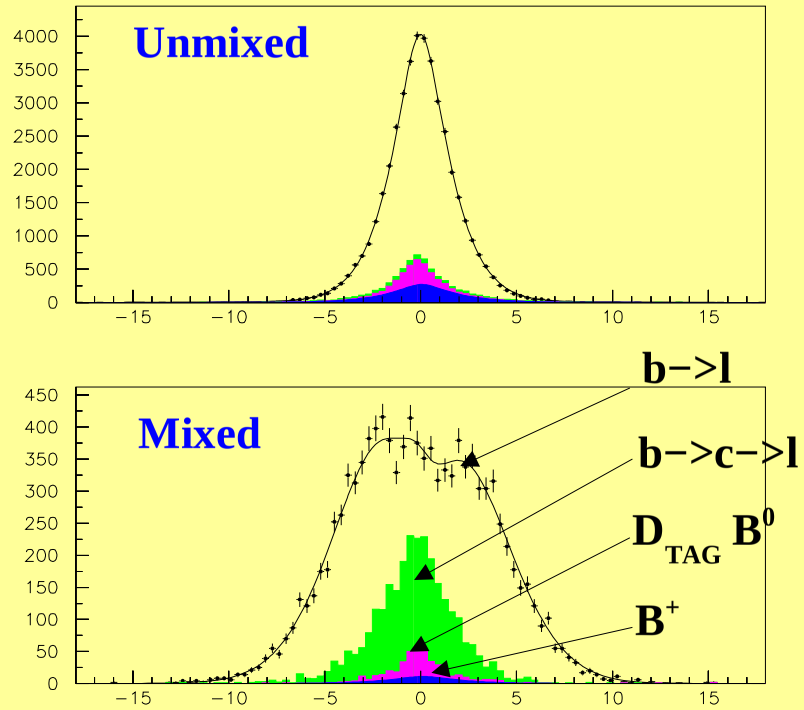
PDF
pure lifetime term ⊗ resolution
resolution: same as for signal B^0,
with separate biases for
narrow and wide gaussians

Free parameters:
– two biases

α^+,ρ^+ vs $\cos\theta$
taken from MC

Fit to signal B^0 + resonant B^+

2000 MC



- B^+ lifetime fixed to 1.65ps
- B^+ fraction constraied (σ=50%) to MC estimation
- $-\alpha^+$, ρ^+ vs cosθ calculated from MC

Free parameters:
- signal B^0 resolution function params
- two biases in B^+ resolution function, same pulls as for B^0 resolution

2000 MC

Results

$\tau_B = 1.5379 \pm 0.0069$ ps

$\Delta m_d = 0.4683 \pm 0.0050$ ps^{-1}

$D_{b->l} = 0.9823 \pm 0.0032$

$D_{b->c->l} = -0.663 \pm 0.087$

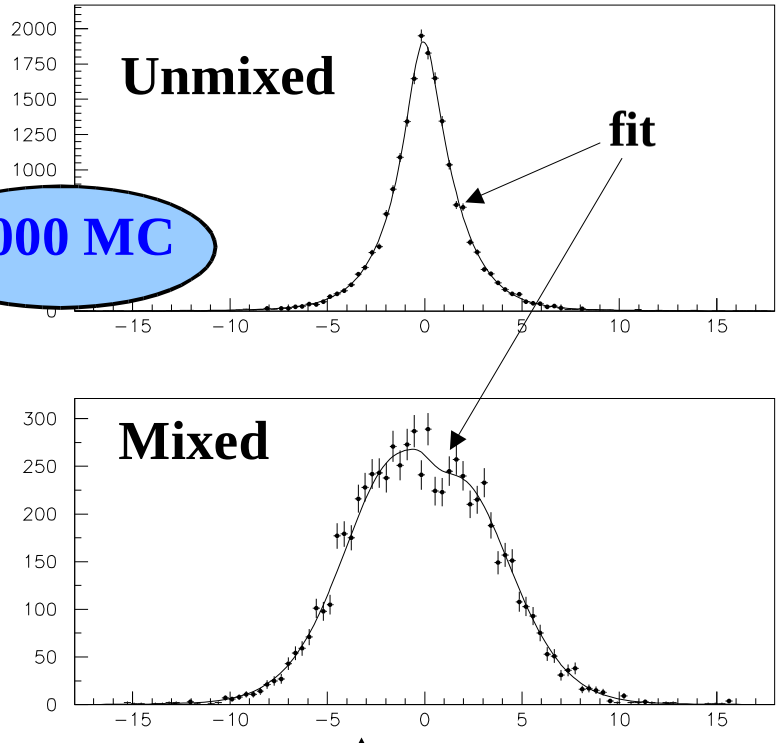
$\tau_D = 0.423 \pm 0.061$ ps

$f_{B+} = 0.74 \pm 0.32$

$\chi_d = 0.171 \pm 0.003$

Combinatorial background

$B^0 + B^+$ combinatorial (MC)
side band, right charge

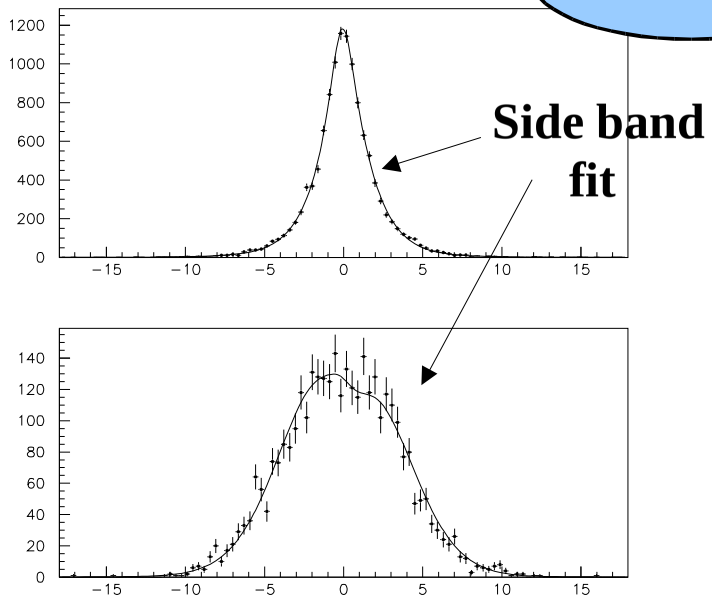


2000 MC

Compatible shapes

$B^0 + B^+$ combinatorial (MC)
mass band, right charge

2000 MC



Combinatorial PDF

Empirical parametrization:

- **combinatorial B^0**
- **combinatorial B^+**
- **B^0 and B^+ fractions are free parameters in the fit**

f_{BKG}^{B} : (oscill + lifetime) ⊗ 3G

f_{BKG}^{D} : lifetime ⊗ 2G (same bias)

2 lifetimes (τ_{unmix}, τ_{mix})

f_{BKG}^{+} : lifetime ⊗ 3G (same resolution params as in f_{BKG}^{B})

f_{D}^{+} : lifetime ⊗ 2G (same resolution params as in f_{BKG}^{D})

1 lifetime only

Unmixed:

Free parameters

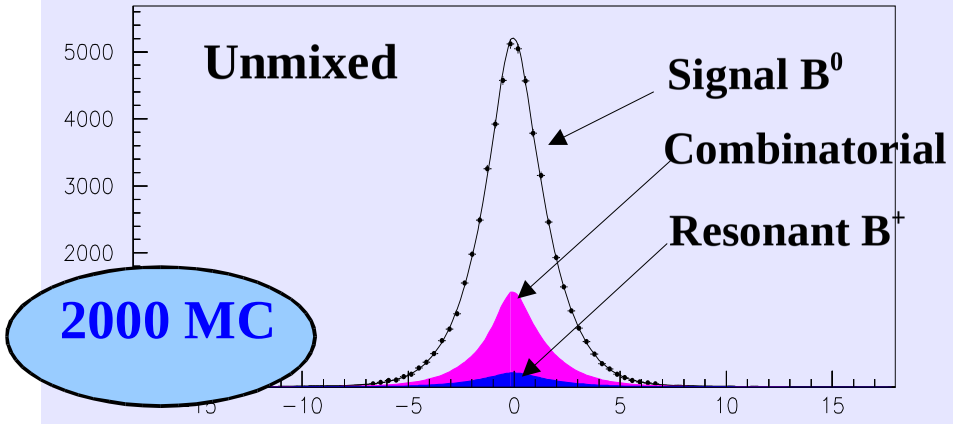
$$f_{BKG} = f_{BKG}^{B0}(1-\alpha_{BKG}^{B+}) + f_{BKG}^{B+}\alpha_{BKG}^{B+}(1-\rho_{BKG}^{B+})$$

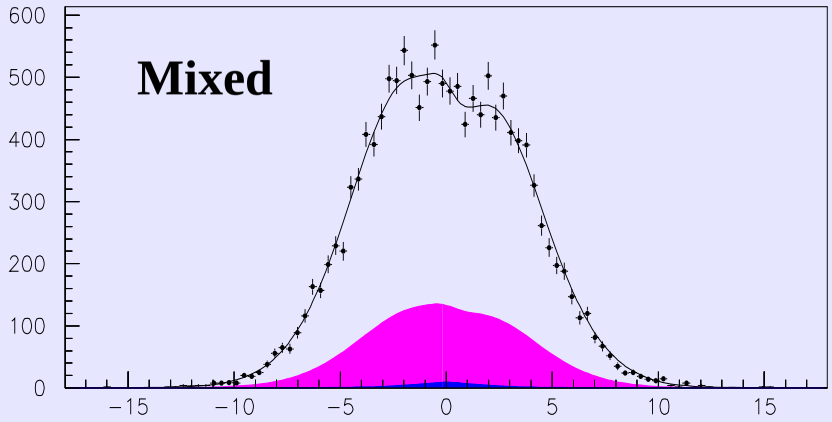
B^0: $$f_{BKG}^{B0} = f_{BKG}^{B}(1-\alpha_{BKG}) + \alpha_{BKG}\, f_{BKG}^{D}(1-\rho_{BKG})$$

B^+: $$f_{BKG}^{B+} = f_{BKG}^{+}(1-\alpha_{BKG}^{+}) + \alpha_{BKG}^{+} f_{D}^{+}(1-\rho_{BKG}^{+})$$

Signal + background MC fit

Combinatorial parameters fixed
from side−band fit





$\tau_B = 1.5447 \pm 0.0086$ ps

$\Delta m_d = 0.4661 \pm 0.0063$ ps^{-1}

to be compared with the
pure−signal fit result:

$\tau_B = 1.5379 \pm 0.0069$ ps

$\Delta m_d = 0.4683 \pm 0.0050$ ps^{-1}

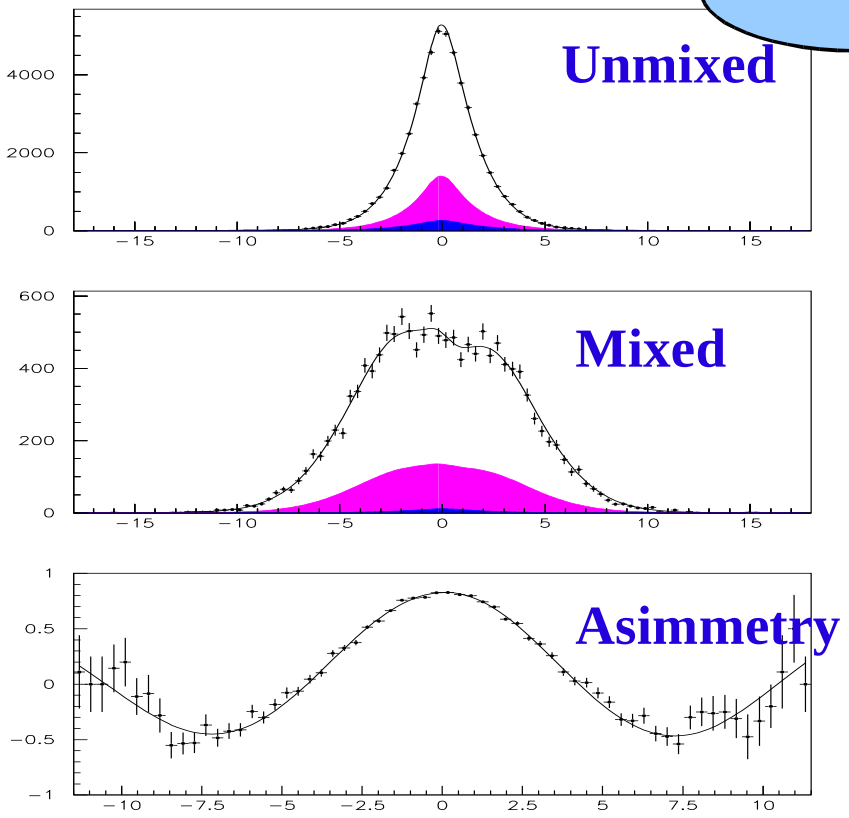
$\Delta(\tau_B) = 0.0068 \pm 0.0051$ ps

$\Delta(\Delta m_d) = -0.0022 \pm 0.0038$ ps^{-1}

New approach: Systematics from combinatorial BKG absorbed in the statistical error by means of a simultaneous side−band fit

Preliminary

2000 MC



$\tau_B = 1.5426 \pm 0.0058$ ps

$\Delta m_d = 0.4657 \pm 0.0042$ ps^{-1}

$\chi_d = 0.170 \pm 0.002$

to be compared with the old−approach result:

$\tau_B = 1.5447 \pm 0.0086$ ps

$\Delta m_d = 0.4661 \pm 0.0063$ ps^{-1}

$\chi_d = 0.171 \pm 0.004$

$(\rho_{ij}) =$

	Δm_{sig}	τ_{sig}
Δm_{BKG}	.03	−.23
τ_{BKG}	. 13	−.55

Statistical errors significantly lowered due to strong anticorrelations arising between signal/BKG parameters

Conclusions and Next Steps

*** MC fit finalized:**

- Separate description of prompt and cascade leptons
- Dtag fraction from $\cos\theta_{\pi^*-l}$ fit
- Dtag PDF described in terms of an effective τ_D
- B^+ PDF described by a pure lifetime term
- B^+ fraction constrained to $m^2\nu$ fit result
- Combinatorial PDF from simultaneous fit to the side−band right charge sample
- χ_d constraint from the fraction of mixed events

*** Given the available luminosity (Run1+Run2) we expect:**

$\sigma_{stat}(\tau_B)$~0.005 ps

$\sigma_{stat}(\Delta m)$~0.004 ps^{-1}

Δm: −0.005 ps^{-1} (Boost Approximation Bias)

***Next Steps:**

−Year by year stability

−Real Data Analysis