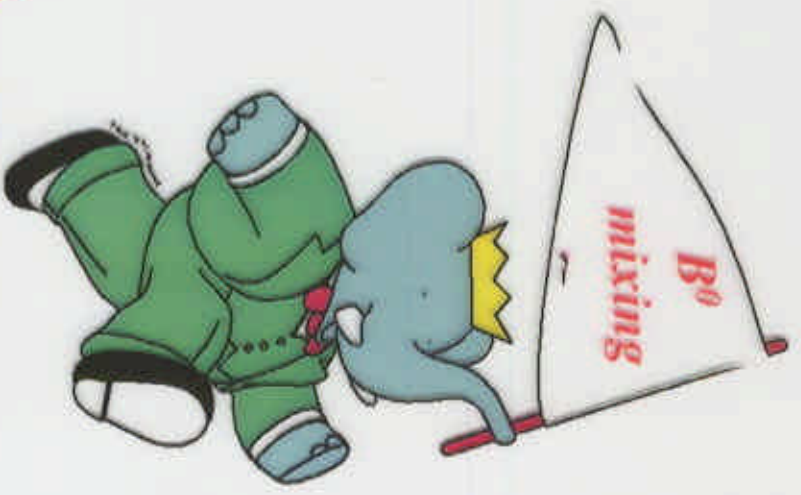


**Christophe Yèche**

**(CEA-Saclay, DAPNIA/SPP)**



**BABAR**

**Preliminary BABAR results  
on  $B^0$  mixing with dileptons  
and  
lifetime with partially-reconstructed  
 $B^0$  decays ( $D^{*l}V$  and  $D^{*l}\pi$ )**

*XXX<sup>th</sup> International Conference on High Energy Physics,  
July 27<sup>th</sup>, 2000, Osaka, Japan*

# BABAR Detector

Superconducting Coil (1.5T)

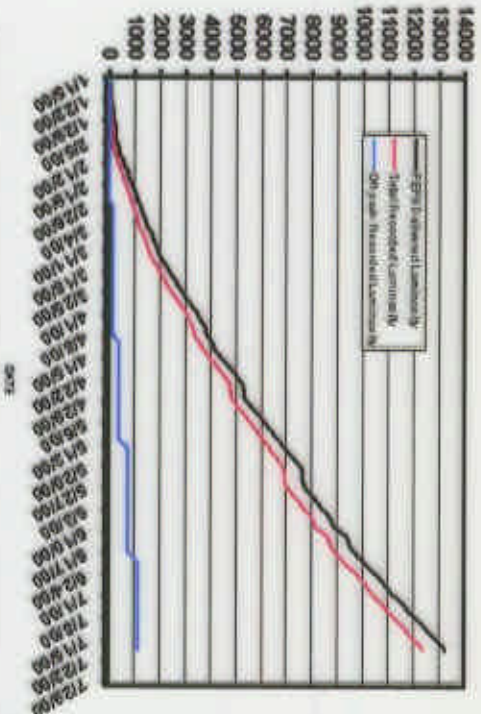
Silicon Vertex Tracker (SVT)

$e^+$  (3 GeV)

Drift Chamber (DCH)

CsI Calorimeter (EMC)

Instrumented Flux Return (IFR)



Recorded luminosity 14.2 fb<sup>-1</sup>

$e^-$  (9 GeV)

**Data Set**  
 Jan. 2000 ↔ June 2000  
 7.7 fb<sup>-1</sup> on-resonance  
 1.1 fb<sup>-1</sup> off-resonance

Cherenkov Detector (DIRC)

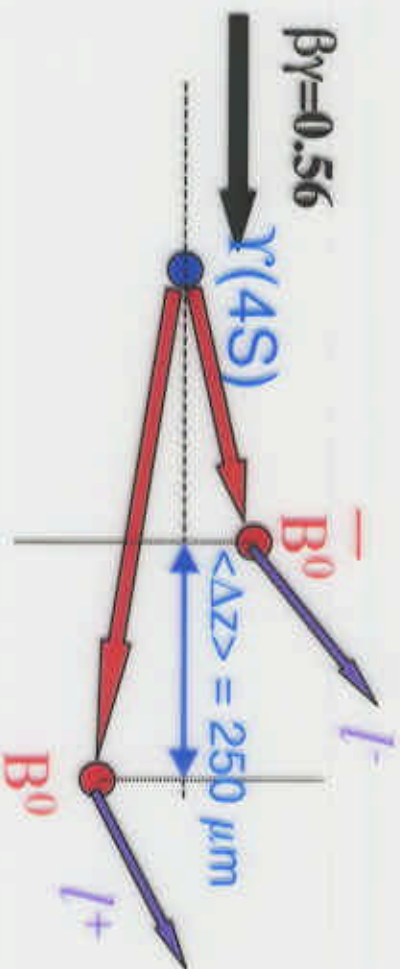
Ch. Yeché

ICHEP 2000

Osaka, 27 July, 2000



# Dilepton: an inclusive approach for $B^0$ mixing



- **B flavor**
- => sign of the direct lepton
- **Inclusive approach**
- => large BR (~4%)
- **Mixture of  $B^0$  and  $B^\pm$**
- => Fraction R fitted

$$A(\Delta t) = \frac{N(\ell^+\ell^-)(\Delta t) - N(\ell^\pm\ell^\pm)(\Delta t)}{N(\ell^+\ell^-)(\Delta t) + N(\ell^\pm\ell^\pm)(\Delta t)}$$

Fit of  $\Delta m$  and  
the fraction R

$$A(\Delta t) = \frac{e^{-\Gamma^0|\Delta t|} \cos(\Delta m_B \Delta t) + R \cdot e^{-\Gamma^+|\Delta t|}}{e^{-\Gamma^0|\Delta t|} + R \cdot e^{-\Gamma^+|\Delta t|}}$$

2 additional parameters  
in the fit to take into account  
the fraction of mistagged  
events (cascade leptons)

# Dilepton: Identification - Background Rejection

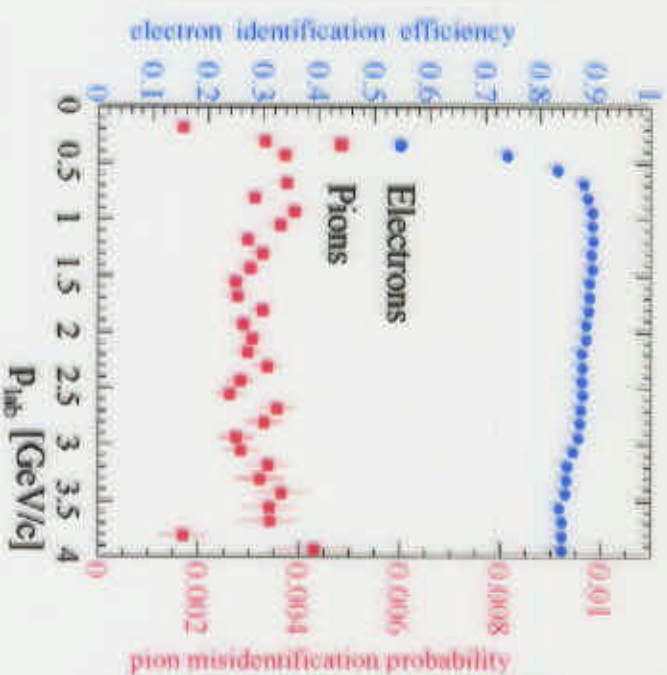
## Electron

$0.88 < E/p < 1.3$

Lateral shape in EMC  
 $dE/dx$  in drift chambers

Efficiency:  $\sim 88\%$

Mis-identification:  $\sim 0.3\%$



## Muon

Energy in EMC

Interaction length in IFR  
Track continuity in IFR  
Kaon rejection with DIRC

Efficiency:  $\sim 75\%$

Mis-identification:  $\sim 3\%$

## Rejection of the continuum, radiative bhabhas, $\gamma$ - $\gamma$ events:

Simple cuts on the Fox-Wolfram ratio, the squared invariant mass of the event and the number of charged tracks

## Gamma conversions :

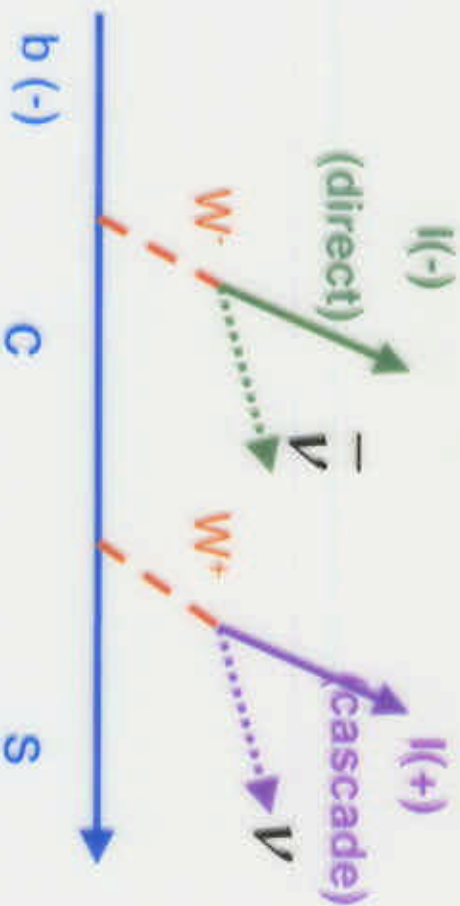
$(|m_{\text{conv}}| > 0.030 \text{ GeV}/c$

$J/\psi$  rejection:  $|m_{\mu\mu} - 3.097| > 0.040$

Time dependence and absolute amount of continuum background (2.9%) are measured with **off-resonance data**.



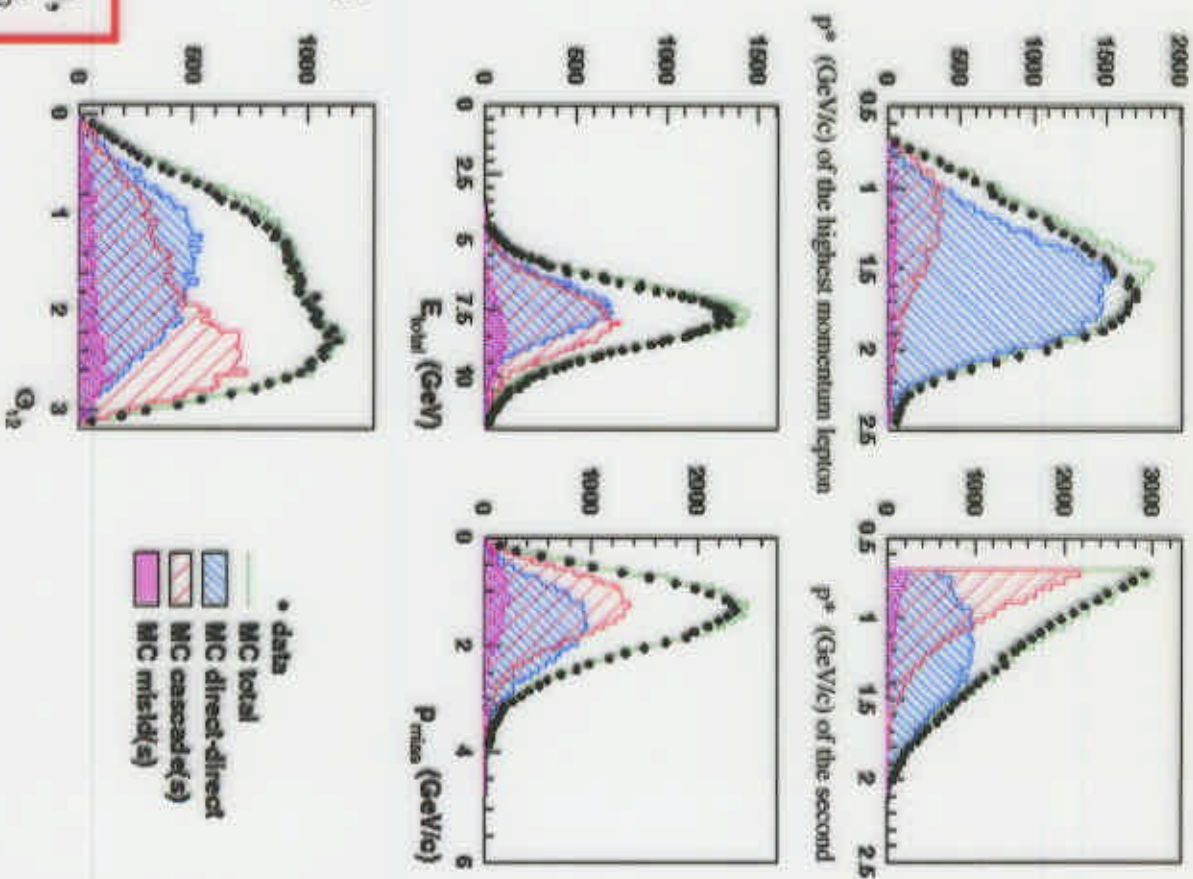
# Dilepton: Selection of direct leptons



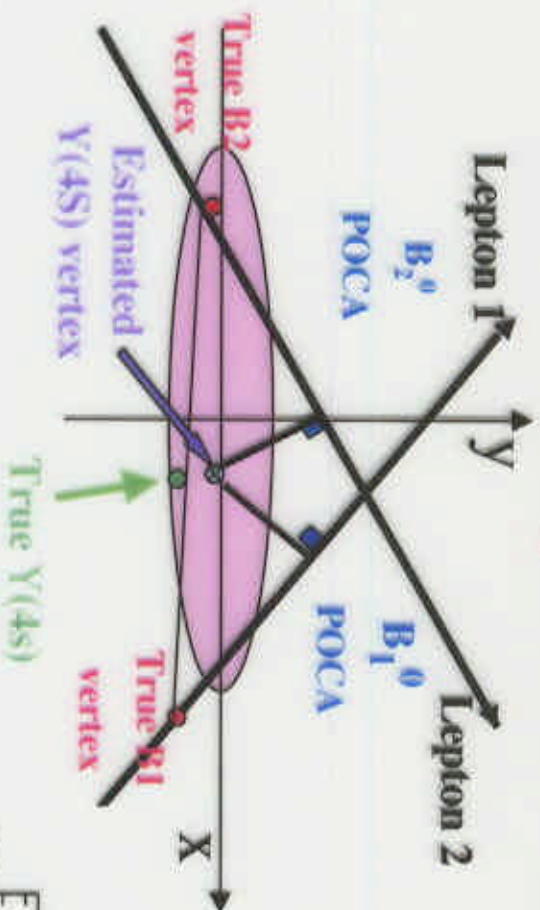
## 5 discriminating variables:

- The **momentum of 1<sup>st</sup> lepton** in the CMS
  - The **momentum of 2<sup>nd</sup> lepton** in the CMS
  - The **total energy** of the event
  - The **missing momentum** of the event
  - The **angle** between the 2 leptons in the CMS
- Combined with a NN(5:5:2) with 5 inputs and 2 outputs

Direct-Dir. 78%, Direct-Cas. 12 % (wrong tag 8%), Mis-Identified lepton 5% and continuum+other 5%



# Dilepton: $\Delta z$ measurement



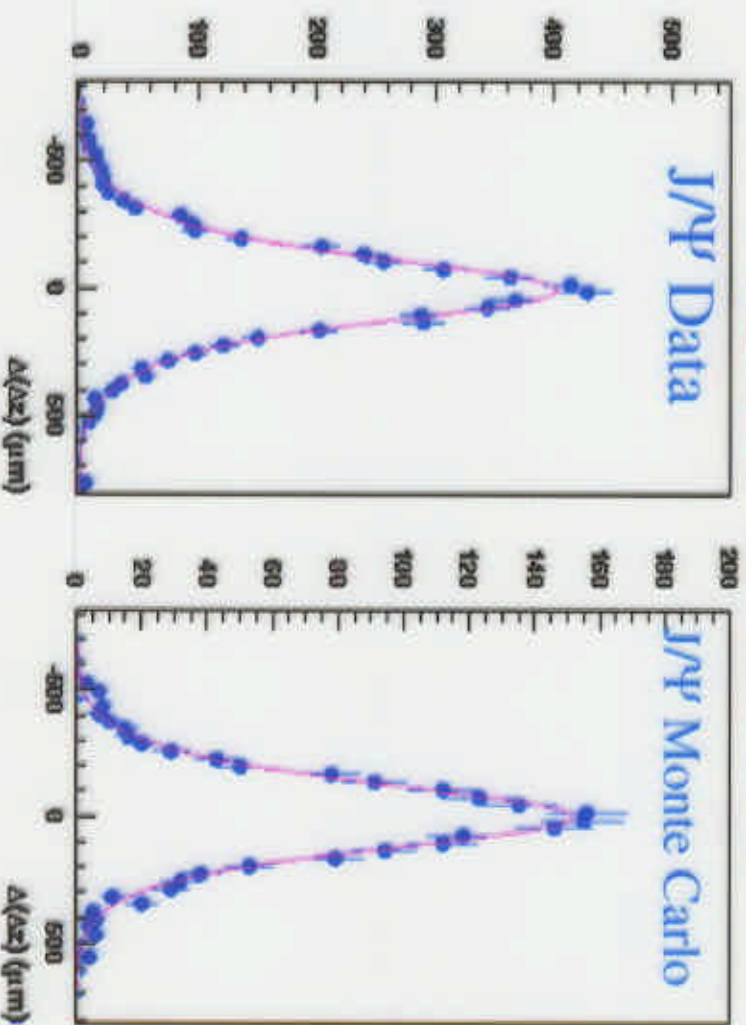
z of the point of closest approach (POCA) of the tracks to this estimated  $Y(4S)$  vertex .

Agreement within 10%

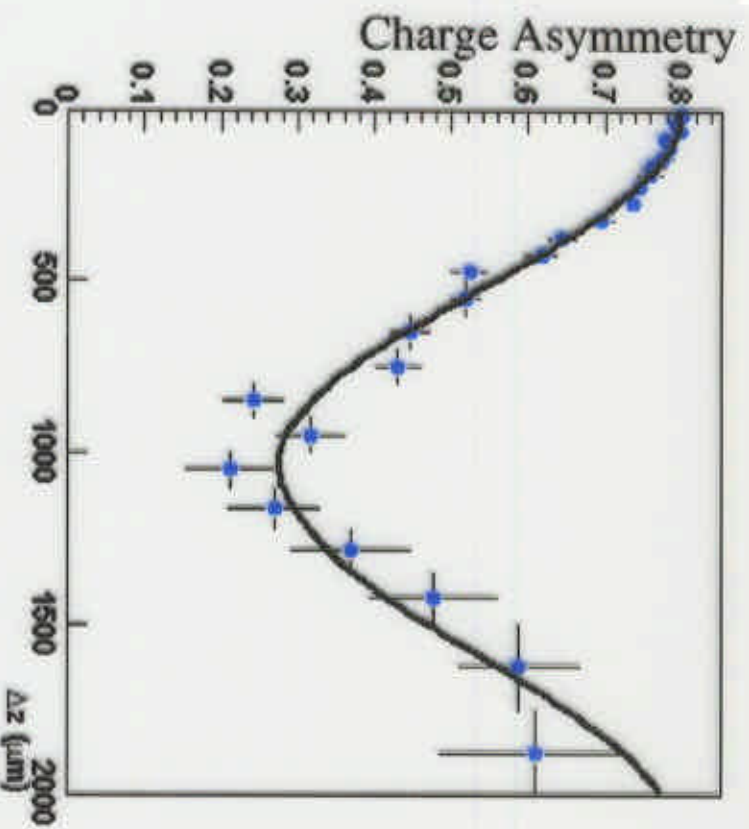
- $\Delta z$  resolution function determined with MC and cross-checked with  $J/\Psi$ .
- Narrow Gaussian :  $87\mu\text{m}$  (76%)
- Wide Gaussian :  $195\mu\text{m}$  (24%)

- Boost approximation:

$$\Delta t = \Delta z / (c < \beta \gamma >)$$







⇒ The continuum background is measured

with off-resonance data and cascade from the same B with the MC.

⇒ **Fit with 4 free parameters**

Mistag:  $\eta = 0.109 \pm 0.004$

Charged B fraction:  $R = 1.34 \pm 0.11$

$\eta$  time-dependence  $\alpha = (-1.7 \pm 3.3) \cdot 10^{-5}$

$\chi^2/\text{ndf} = 20.7/21$

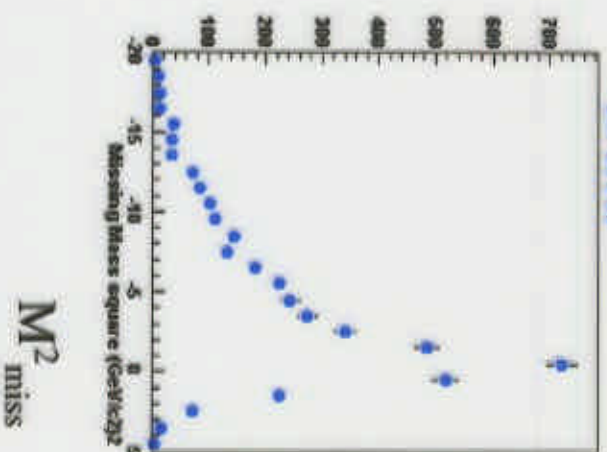
## Dilepton: Results

$$\Delta m_D = (0.507 \pm 0.015(\text{stat}) \pm 0.022(\text{syst})) \hbar \text{ ps}^{-1}$$

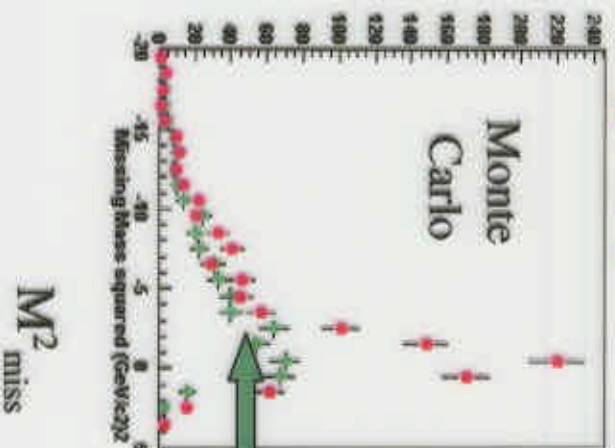
Systematic source	$\sigma(\Delta m)$ ( $\hbar\text{bar}/\text{ps}$ )
Non BB background	0.005
Lepton mis-identification	0.011
Time-dependence of cascade	0.009
Boost approximation	0.001
Beam spot position	0.001
$\Delta z$ resolution function	0.009
Tails of $\Delta z$ resolution function	0.004
Time-dependence of resolution	0.006
B lifetimes (PDG98 $\pm 1\sigma$ )	0.010
<b>Total</b>	<b>0.022</b>

# $B^0$ Mixing with inclusive $D^*l\nu$

• Data



•  $B^0$   $B^\pm$

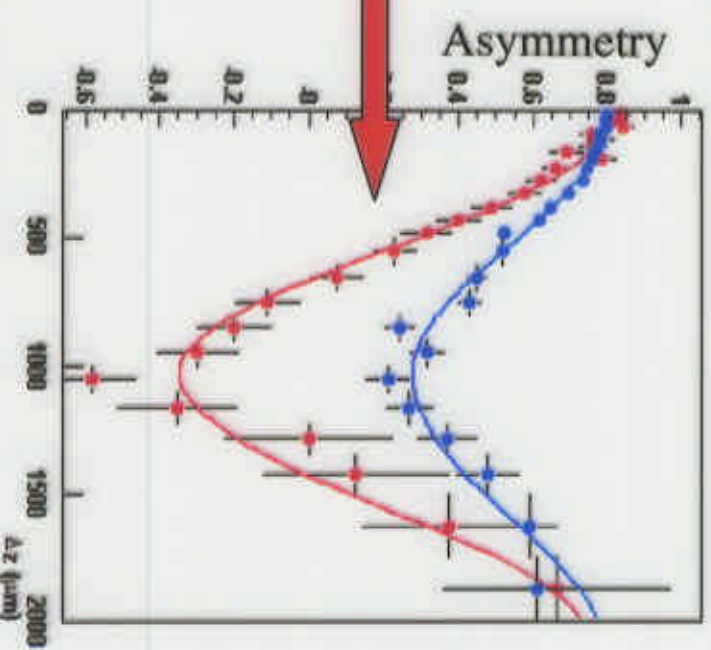


- Tagging of the  $D^*$  with soft pion  $\pi_s$ .
- $\pi_s$  is produced almost at rest.
- The direction of the  $D^*$  is the same as  $\pi_s$   
 $\Rightarrow$  Cut on the missing mass squared  $M_{\text{miss}}^2$  of the neutrino

Remaining  $B^+ \rightarrow D^{*+} \pi^+ l^+ \nu$  ( $D^{**}$ )

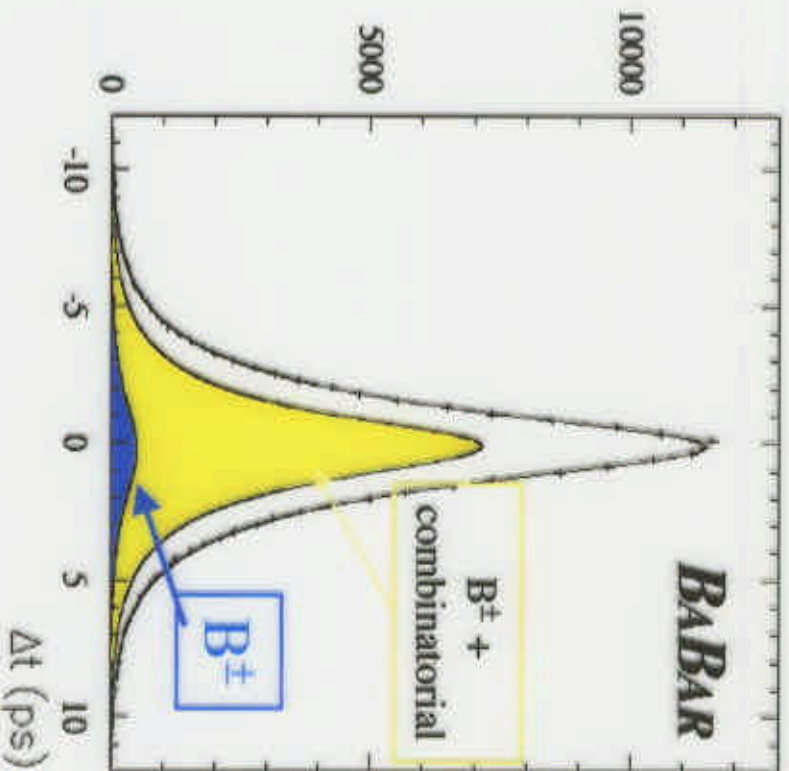
Dilepton sub-sample enriched in  $B^0$   
 with  $|M_{\text{miss}}^2| < 1 \text{ (GeV}/c^2)^2$

Promising approach with a comparable statistical error;  
 the studies of systematics are still underway.





# $B^0$ Lifetime with inclusive $D^*lV$

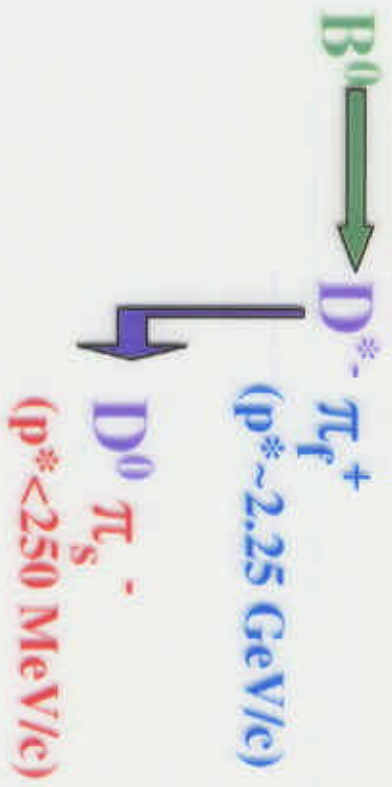


$$\tau_{B^0} = 1.63 \pm 0.01 (\text{stat}) \pm 0.09 (\text{syst}) \text{ ps}$$

- For the lifetime measurement only one lepton is considered.
- Time dependence and resolution of the background are determined from data with the same sign events ( $l^+\pi_s^+$  or  $l^-\pi_s^-$ ).
- $Z_1$  from the vertex between ( $l, \pi_s$ ).
- $Z_2$  from the other tracks outside  $60^\circ$  cone around  $D^0$  direction.
- Scale factor of the  $\Delta z$  errors fitted.

Systematic source	Variation	$\sigma(\tau)$ (ps)
Fractions of Background	-	+ 0.072 - 0.025
Charged B lifetime	$\pm 0.04$ ps	0.005
Z resolution function	$\pm 5\%$	0.040
Scale factor (z resolution)	1.00 $\rightarrow$ 1.06	-0.060
Bias (tracks from $D^0$ )	$0.04 \pm 0.020$	0.039
<b>Total</b>	-	<b>0.09</b>

# B<sup>0</sup> Lifetime with inclusive D\*<sup>\*</sup>π



- Partial reconstruction with  $\pi_f$  and  $\pi_s$

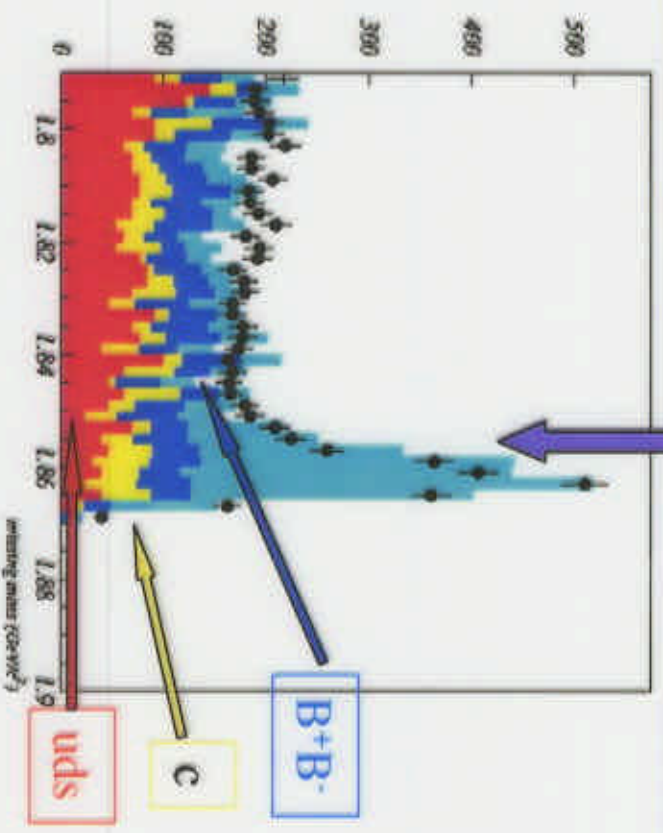
- Studies based on the missing mass of the  $D^0$  (averaged on the angle  $\Phi$  between the  $B^0$  and the  $\pi_f$  directions).

$$M_{miss}^{D^0} = \sqrt{(E_{beam} - E_{\pi_f} - E_{\pi_s})^2 - (\vec{p}_B - \vec{p}_{\pi_f} - \vec{p}_{\pi_s})^2} > \Phi$$

## Selection

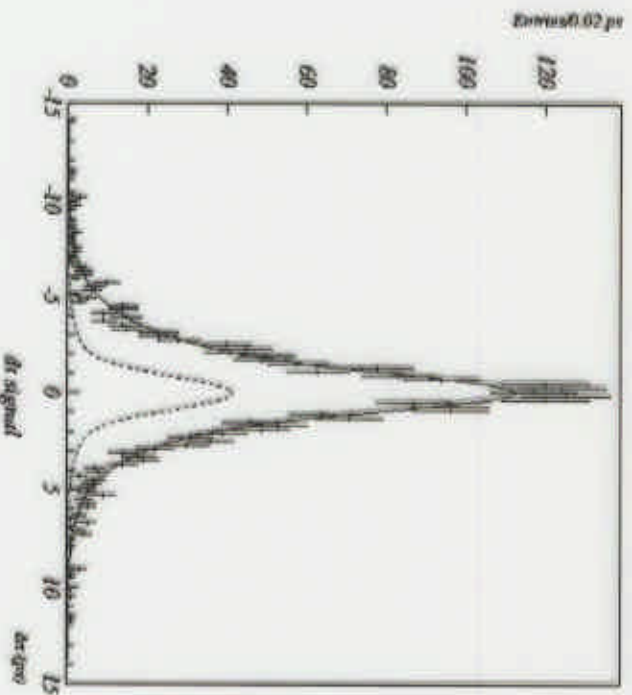
- ⇒ Kinematics  $2.114 < p_{\pi_f} < 2.404 \text{ GeV}/c$   
 $M_{miss} > 1.854 \text{ GeV}$
- ⇒ Event shape  $R_2 < 0.35$   
 $\pi_f$  isolation (0.4 rad)
- Variables combined with a Fisher
- ⇒ Helicity Angle  $|\cos \Psi| > 0.4$

- ⇒ Total efficiency = 10 %
- ⇒ (Bckg/(Sig+Bckg)) ~ 27 %





# $B^0$ Lifetime with inclusive $D^*\pi$



- Bias on the vertex: cut on a 2 rad cone around  $D^0$  direction.
- Time dependence of the background determined with Monte-Carlo.
- Background fractions fitted with the same sign events ( $\pi_r^+\pi_s^+$  or  $\pi_r^-\pi_s^-$ ).
- Scale factor of the  $\Delta z$  errors fitted.

$$\tau_{B^0} = 1.55 \pm 0.05(\text{stat}) \pm 0.07(\text{syst}) \text{ ps}$$

Systematic source	Variation	$\sigma(\tau)$ (ps)
Fraction of backgrounds	-	0.041
Background lifetime	$1.55 \pm 0.05$ ps	0.010
Scale factor ( z resolution)	$1.00 \pm 0.13$	0.051
Bias (tracks from $D^0$ )	$0.04 \pm 0.020$	0.020
<b>Total</b>	-	<b>0.07</b>

# Conclusions

## Mixing (Conference paper #601):

- With 7.7 fb<sup>-1</sup> on-resonance and 1.1 fb<sup>-1</sup> off-resonance data we presents a **preliminary study** of B<sup>0</sup> mixing.

$$\Delta m_d = (0.507 \pm 0.015(\text{stat}) \pm 0.022(\text{syst})) \hbar \text{ ps}^{-1}.$$

This is **one of the most precise**  $\Delta m_d$  measurements to date.

- The additional tagging of the dilepton sample with a soft pion is very promising and it should provide an alternative method with smaller systematic effects.
- Results consistent with the  $\Delta m_d$  measurements with fully reconstructed B<sup>0</sup> (see next talk).

## Lifetime (Conference paper #600):

- The partially reconstructed decay process B<sup>0</sup> → D\*lv provides a new measurement of B<sup>0</sup> lifetime

$$\tau_{B^0} = 1.63 \pm 0.01(\text{stat}) \pm 0.09(\text{syst}) \text{ ps}.$$

- By using the missing mass recoiling against two pions, we have shown a clear signal of D<sup>0</sup> and we measured for the lifetime of the B<sup>0</sup>

$$\tau_{B^0} = 1.55 \pm 0.05(\text{stat}) \pm 0.07(\text{syst}) \text{ ps}.$$