Mixing and Lifetime from Partially Reconstructed $B^0 \rightarrow D^* \, l \, \nu$

1)Analysis Strategy;

2)Tagging Lepton Sample description:
- Prompt Leptons;
- Cascade Decay Side;
- Cascade Tag Side

3)Preliminary BLIND Results; Comparison w.r.t. Similar Analyses

4)Study of the Analysis Bias

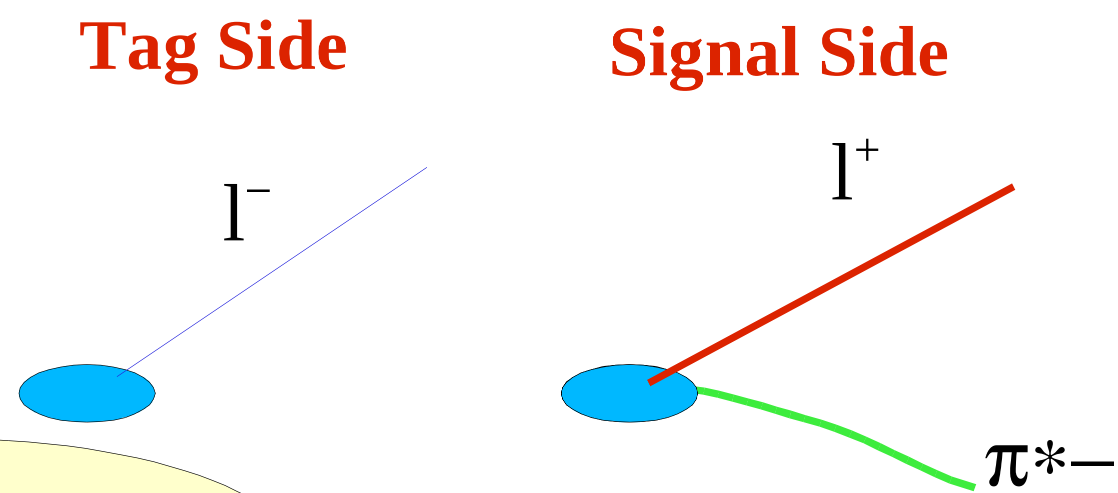
5)Conclusions

M. Margoni, Time Dependent Analysis Forum, 5/5/2004

Analysis Strategy

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

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



Tag Lepton alone:
No D^0 bias in tag Vertex

Fit to Δt to determine simultaneously τ, Δm and dilution D, constrained to the fraction of mixed events:

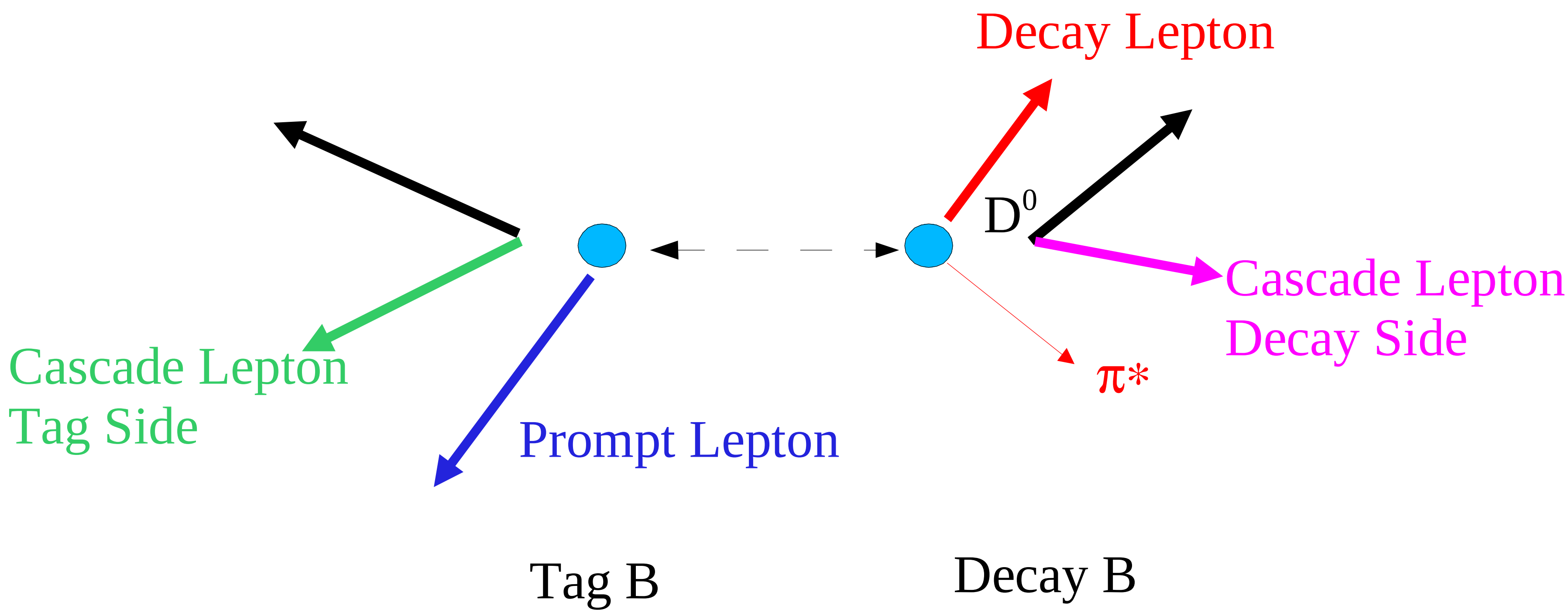
$$N_{mix}/N_{tot} = \chi_d D + (1-D)/2; \quad \chi_d = x^2/(1+x^2)2; \quad x = \Delta m\, \tau$$

The Signal PDF

Tagging Lepton Sample:
- b−> l
- b−>c−>l
- D^0 −> l

From tag B

From decay B

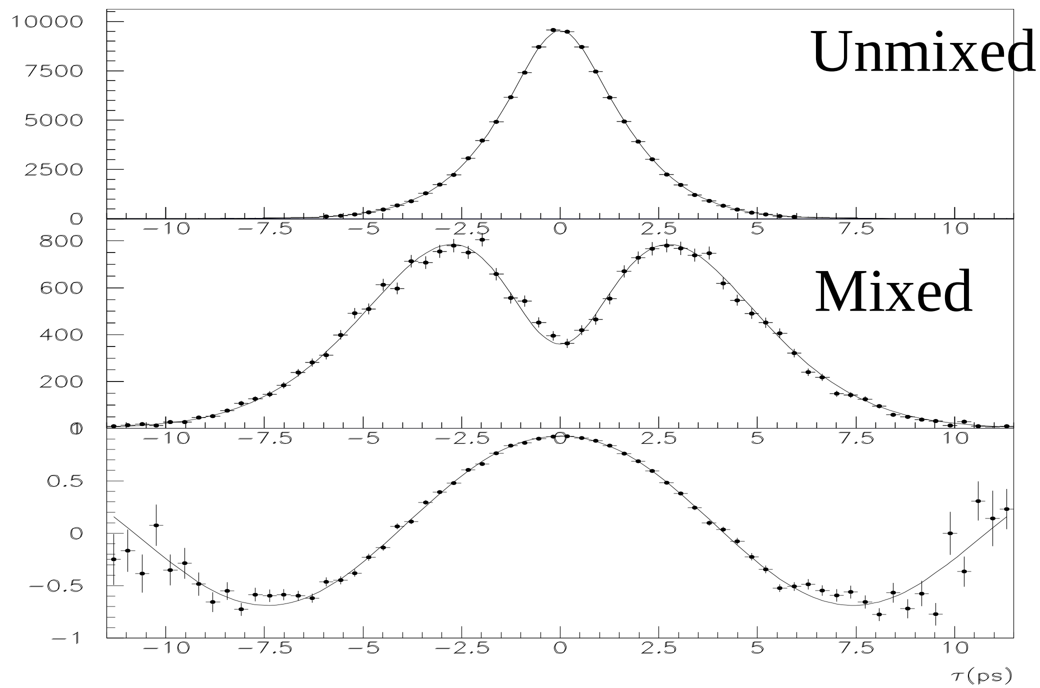


Prompt Leptons

- MC: $D_P \sim 0.98$

  Floated in the fit;
- DT: $D_P \sim 0.96$
- $b_{N,}$ b_W compatible with zero

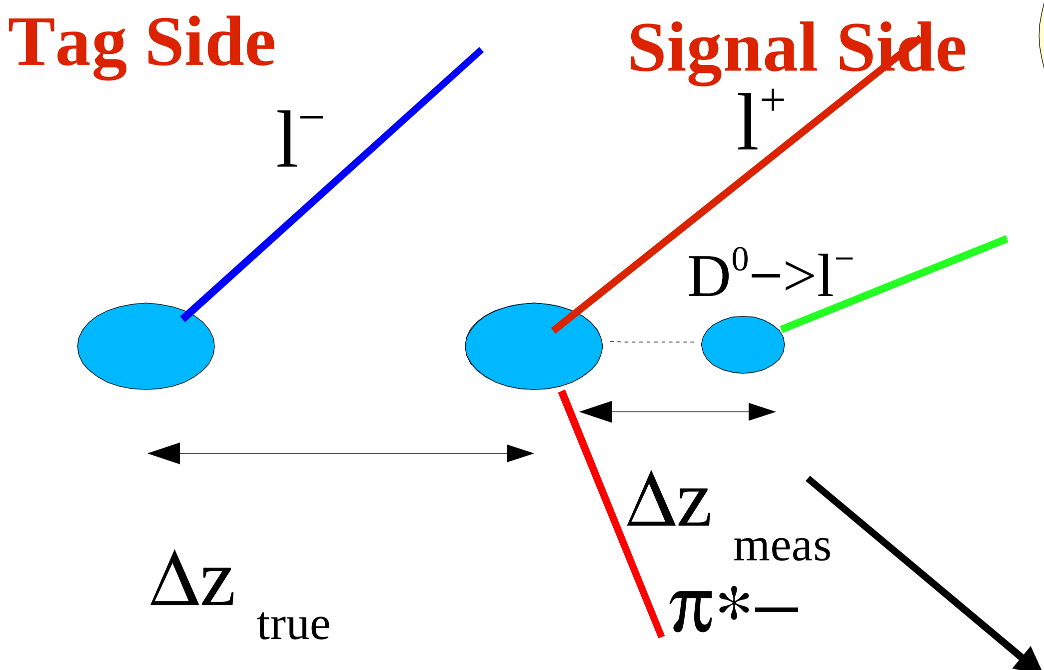
$$F^{U/M}_P = e^{-|\Delta t|/\tau}(1 \pm D_P \cos(\Delta m \Delta t))$$



$\tau_B = 1.539 \pm 0.003$ ps

$\Delta m = 0.465 \pm 0.001$ ps^{-1}

Cascade Decay Side



Time independent dilution
D^0 leptons mostly populate unmixed sample;
No information on mixing

$\Delta z_{meas} < \Delta z_{true}$

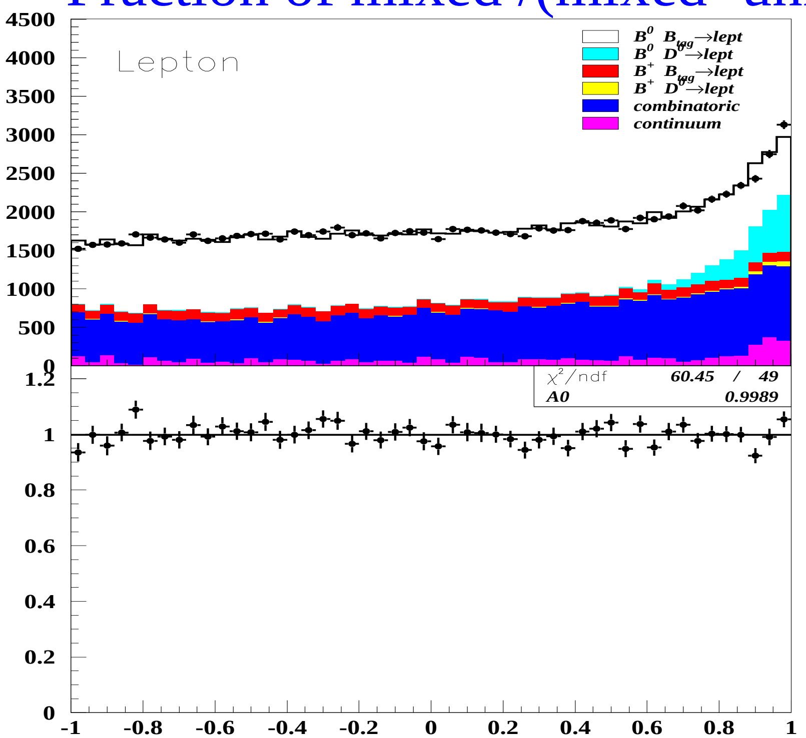
$\tau^D_{effective}$ **free parameter in the PDF**

Cascade Decay Side

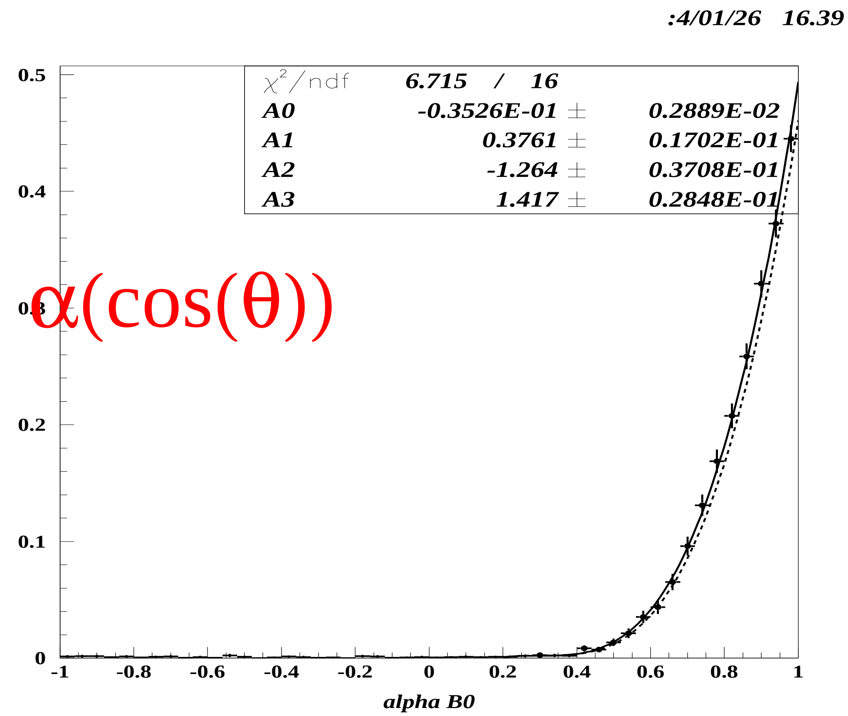
Cascade Fraction $\alpha(\theta)$ for B^0 and peaking B^+ determined in three steps as a function of the angle (tag lepton−$\pi*$) in the Y frame:

1) Float the relative amount of cascade/prompt for the B^0 sample with fixed B^+;
2) Rescale the B^+ cascade/prompt yields according to the corrections obtained for the B^0;
3) Fix the B^+ and float again the B^0

- ρ = Fraction of mixed /(mixed+unmixed) Cascade ~ 5%



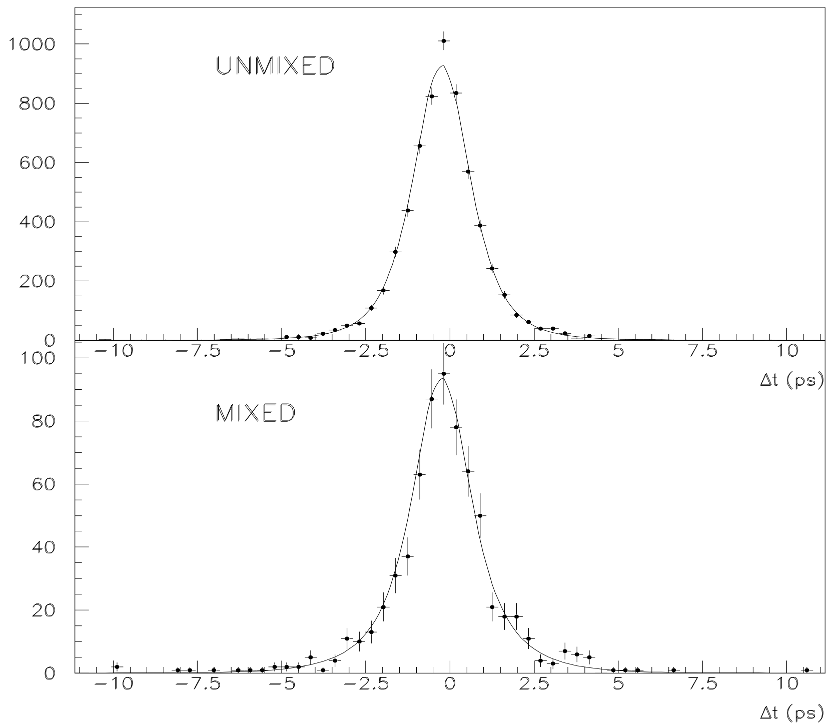
cos(θ)



cos(θ)

Cascade Decay Side

$$F^{U/M}_{D} = e^{-|\Delta t|/\tau_D}$$

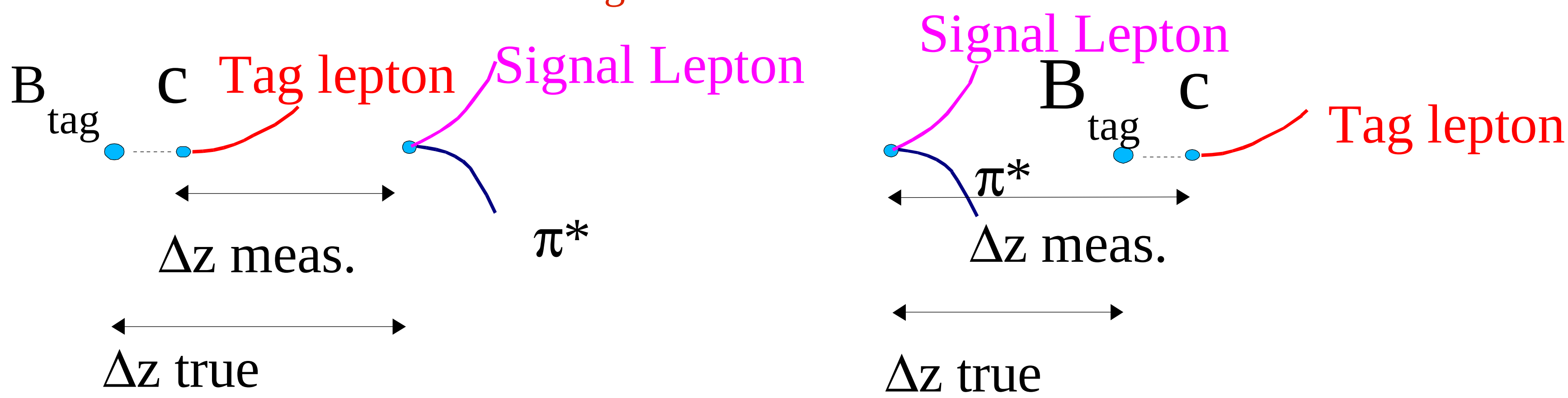


"τ_D" = 0.35± 0.01 ps

$b_N = b_W$ = −0.25± 0.01 ps

Cascade Tag Side

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



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

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

- b_N, b_W <0 due to D lifetime
- Float the Ratio f_{bcl}=Cascade/Prompt in the fit

Cascade Tag Side

$$F^{U/M}_{C} = e^{-|\Delta t|/\tau}\,(1 \mp D_{C} \cos(\Delta m \Delta t))$$

- D_C : due to wrong flavor charm from upper vertex + hadron misidentification
- PDG gives:

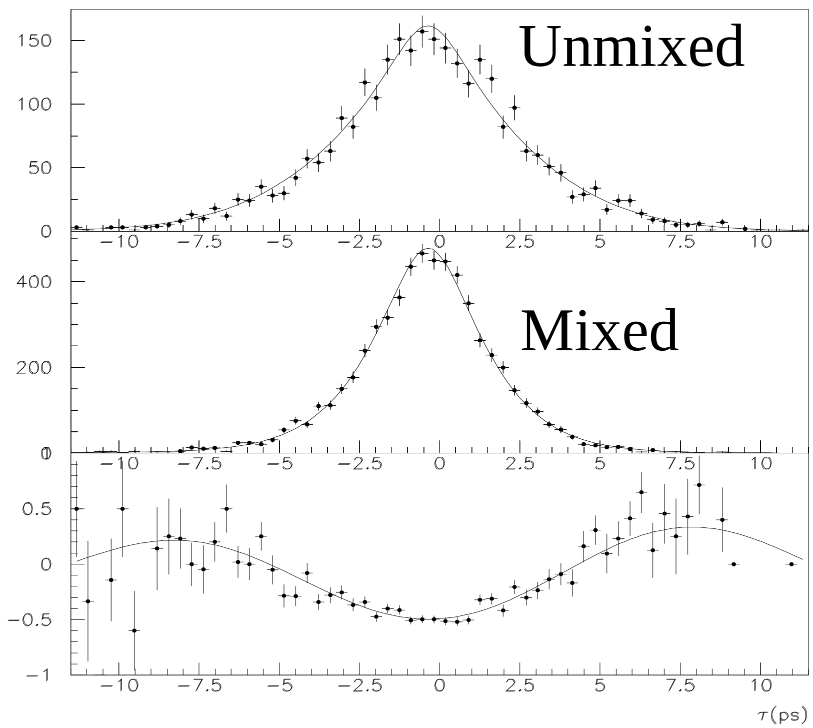
$$w_{ct} = \frac{\mathcal{B}(b \to \bar{c} \to \ell^-)}{\mathcal{B}(b \to \bar{c} \to \ell^-) + \mathcal{B}(b \to c \to \ell^+)} = 0.167 \pm 0.040$$

$$D_{ct} = 1 - 2w = 0.65 \pm 0.08$$

Fixed in the fit on Data

- MC truth : $D_C = 0.536$
- Correction added o(%) due to fake leptons (as for the prompt lepton component)

Cascade Tag Side

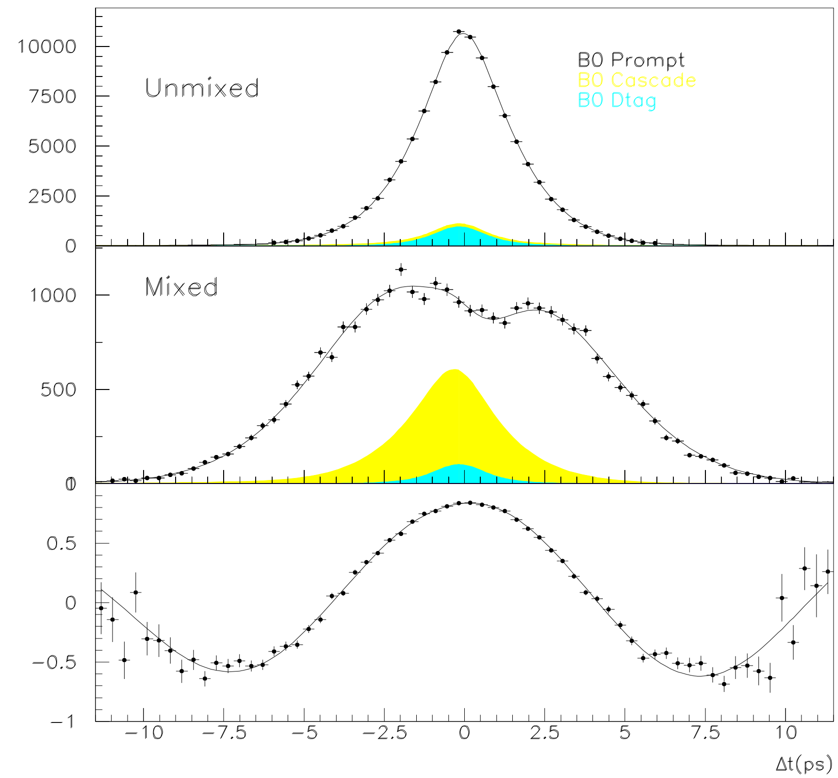


$\tau_B = 1.555 \pm 0.045$ ps
$\Delta m = 0.431 \pm 0.022$ ps^{-1}
$D_C = 0.522 \pm 0.016$
bN = -0.35 ± 0.15 ps
bW=-3 ± 4 ps

B^0 Signal: Prompt+Cascade (Tag+Decay)

$$F_{B0}^{U} = (1-\alpha(\Theta))\ \{\ (1-f_{bcl})\ F_P^{U}(\Delta t,\tau_{B0},\Delta m_d) + f_{bcl}\ F_C^{U}(\Delta t,\tau_{B0},\Delta m_d)\ \} + \alpha(\Theta)\ (1-\rho)\ F_D(\Delta t,\tau_D)$$

$$F_{B0}^{M} = (1-\alpha(\Theta))\ \{\ (1-f_{bcl})\ F_P^{M}(\Delta t,\tau_{B0},\Delta m_d) + f_{bcl}\ F_C^{M}(\Delta t,\tau_{B0},\Delta m_d)\ \} + \alpha(\Theta)\rho F_D(\Delta t,\tau_D)$$



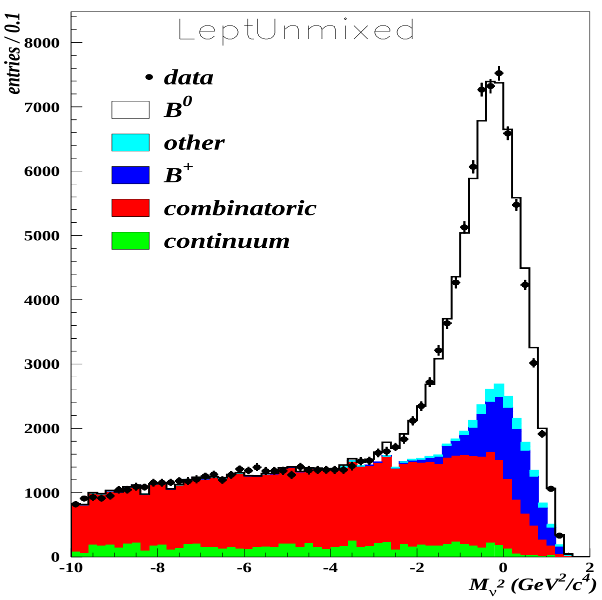
τ=1.548± 0.003 ps; Δm=0.466± 0.001 ps^{-1} ; ρ=−4%

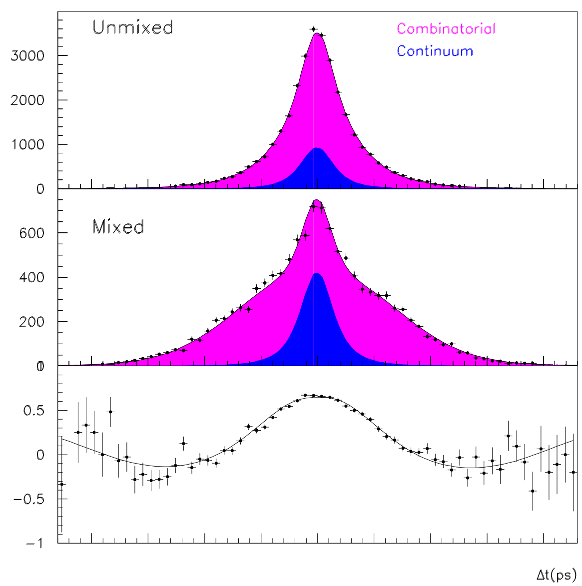
Preliminary Results

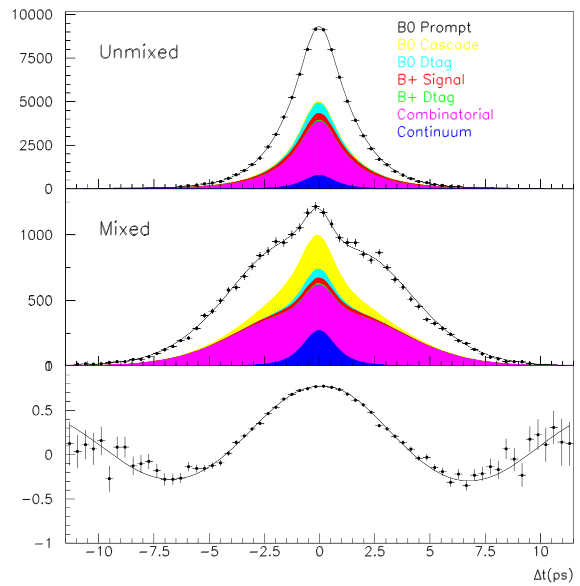
Adding in the PDF:

- Signal
- B^+: pure lifetime;
- BB Bkg: empirical function (oscillating+lifetime+cascade tag+decay tag)
- Continuum: pure lifetime;
- Sample Composition from $M\nu^2$ fit;
- Resolution: 2 Gaussians with floating offsets and pulls+outliers

:3/12/08 20.25







From ~65 K evts: τ=xxx $\pm$0.010$\pm$ 0.016 ps; Δm=xxx$\pm$ 0.005 $\pm$0.008 ps^{-1}

Comparison with other similar analyses

- "Old" τB^0 analysis (Run1, no tagging), use now only lepton−tagged events:
  - −Determination of fr(B^+) from the global fit (B^+ events do not mix);
  - −Improved signal/Bkg ratio;
  - −Tag−lepton alone in the Tag Vertex: no D^0 bias;
- Dilepton analysis:
  - −Lower Efficiency... but:
  - −Separation between Decay Side (no dilution) and Tag Side;
  - −Smaller Bkg Fraction;
  - −Δt distribution of Combinatorial using also side−bands in the fit;

  → Simultaneous meas. of τB^0 and Δm
- Exclusive $D^* l \nu$:
  - − Bigger amount of combinatorial Bkg;
  - − Higher Efficiency: 65K evts in 81 fb^{-1} vs 14K evts in ~20 fb^{-1} ;
  - − Not sensitive to K or NN tags;

	Δm	τB^0
Hadronic	0.516±0.016±0.010	1.546±0.032±0.022
dilepton	0.493±0.012±0.009	-
$D^*l\upsilon$ (P.R.)	-	1.529±0.012±0.029
$D^*\pi$(P.R.)	-	1.533±0.034±0.033
$D^*l\upsilon$	0.492±0.018±0.013	1.523±0.024±0.022
this (blind)	XXX ±0.005±0.006	yyy±0.010±0.013

Study of the Analysis Bias

"Old" Problem:
From the fit to the MC Pure Signal we observe a bias (BAD 287, v11):

$\delta\Delta m = -0.006 \pm 0.001\ \mathrm{ps}^{-1}$

➡ The mixed event fraction is underestimated:

$$\delta\chi_d = -0.003 \pm 0.001$$

But...

...The fraction of MC truly mixed events when just a single π^*l pair/event is reconstructed is correct!

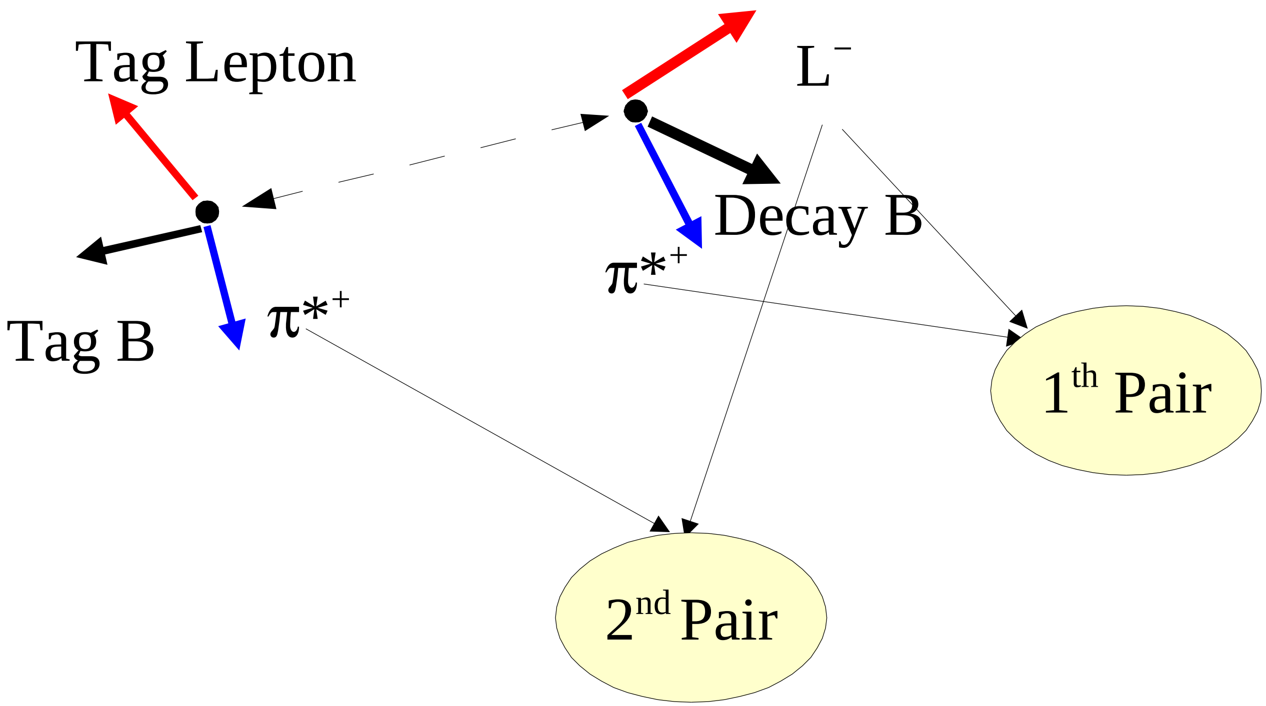
$$\chi_d = 0.1744 \pm 0.0005 \text{ (w.r.t. 0.174 MC truth)}$$

➡ Bias induced by the events with more than one π^*l pair...

...Why?

In the case of mixed events with two D* from different Bs, a second π^* l "true" pair can be reconstructed with the Right Charge Correlation.
If the 2nd pair is chosen by the selection algorithm, the event can fall in the Side Band region and it is classified as "Combinatorial Background"

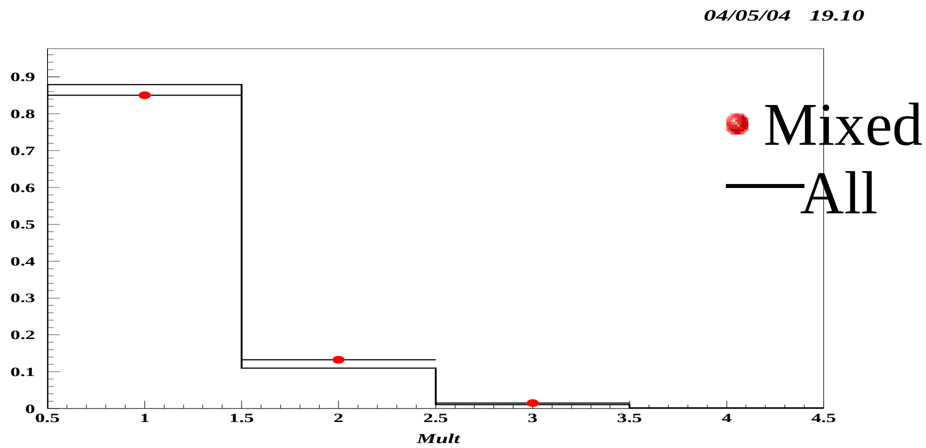
➡ Reduction of the measured mixed event fraction.

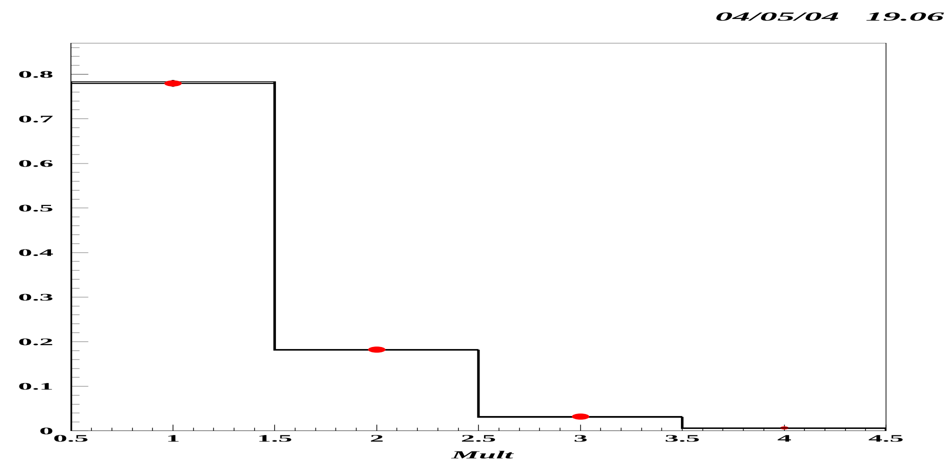


- Number of π^*l candidates / event (Signal MC)

Right Charge Correlation

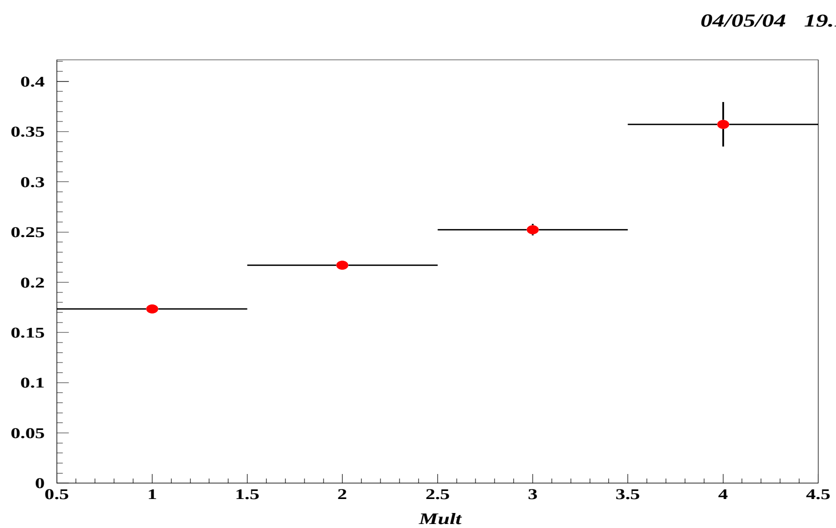
R.C + Wrong Charge Correlation

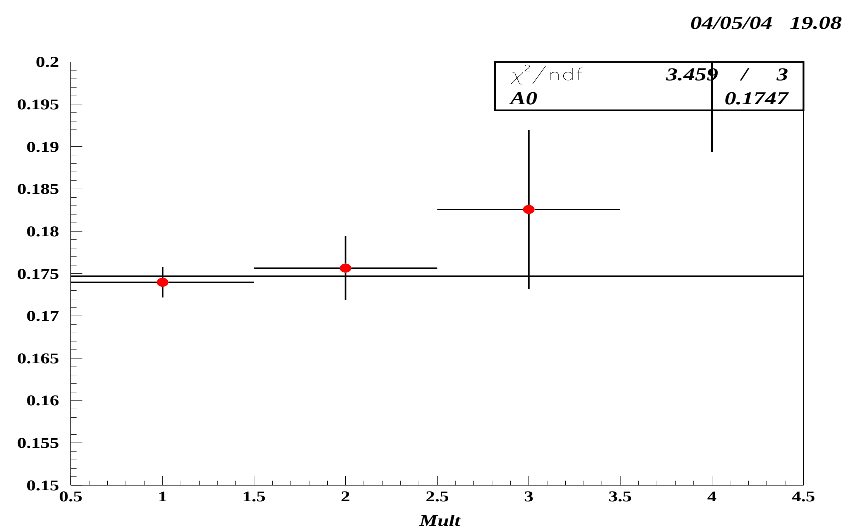




- R. C. Mixed event sample shows higher fraction of multiple candidates
- Fraction of Mixed Events:

Strong χ_d dependence vs number of reconstructed candidates for R.C. Correl.





Mixed Event Fraction χ_d vs Event Tag

Event Tag:

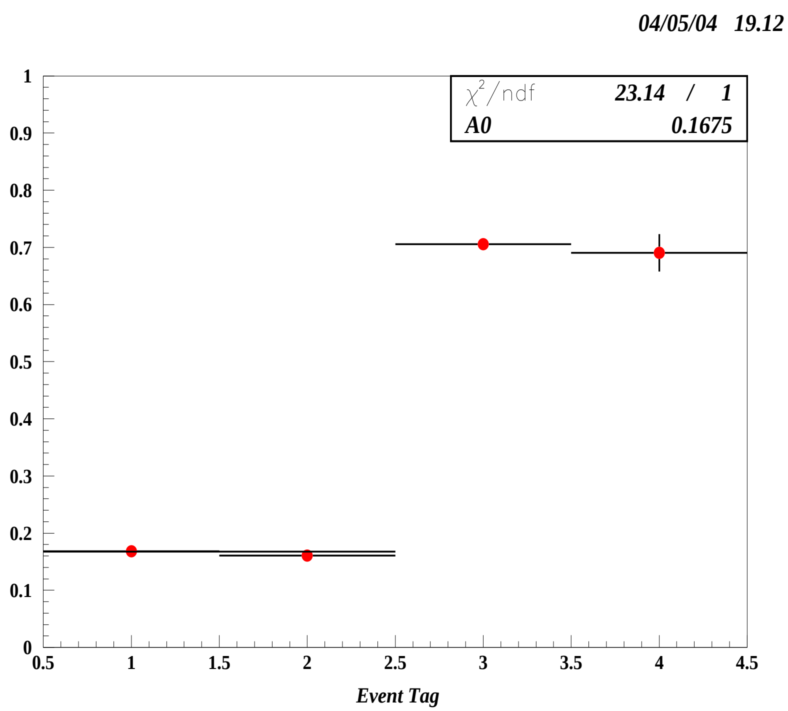
1: just one π^* l candidate;

2: one additional π^* l candidate (π^* not from D*);

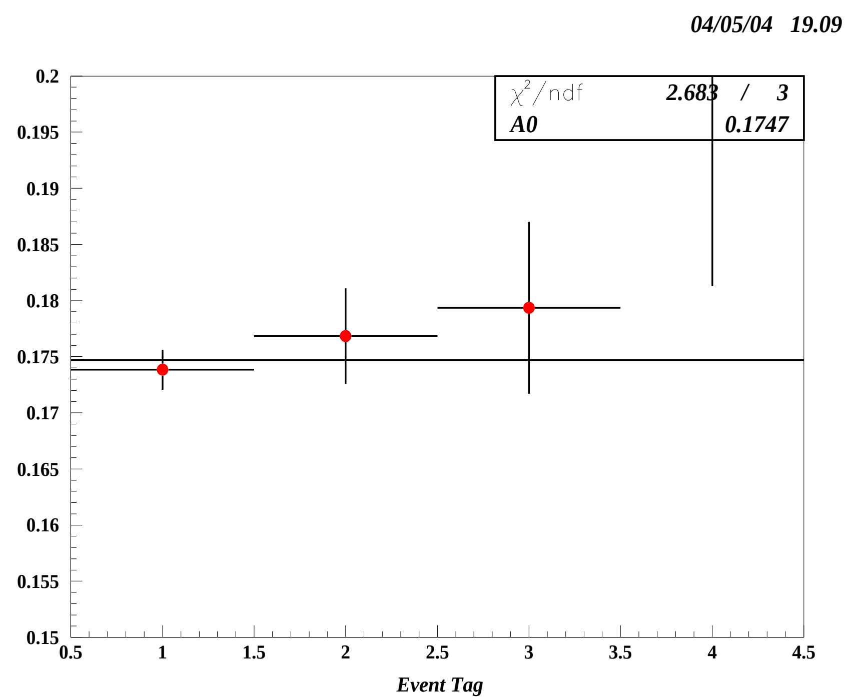
3: one additional π^*l candidate (π^* from D*);

4: two or more π^* l candidates (at least one from D*)

Right Charge Correlation



R.C + Wrong Charge Correlation



How to manage this effect on the data?
Three possible strategies:

1) Use only the event sample with just one π*l candidate,
(ε~80% for R.C+W.C);

2) Determine the fraction of events with more then one D* in Data and MC,
tune the simulation and compute the expected bias;

3) Use two separate analysis streams for the two subsamples:
−single candidate;
−two candidates from D* from different Bs :
"golden events" with two $B \rightarrow D^* l \nu$ and lowest dilution

... Approach to be chosen...

Strategy n. 2:
Determination of the Fraction of Events with more then one D* (Data vs MC)

1) Compute the ratio

$R = N(D^* \rightarrow (K\pi)\pi^*)_{\text{Side Band, Wrong Charge}} / N(D^* \rightarrow (K\pi)\pi^*)_{\text{Mass Band, Right Charge}}$

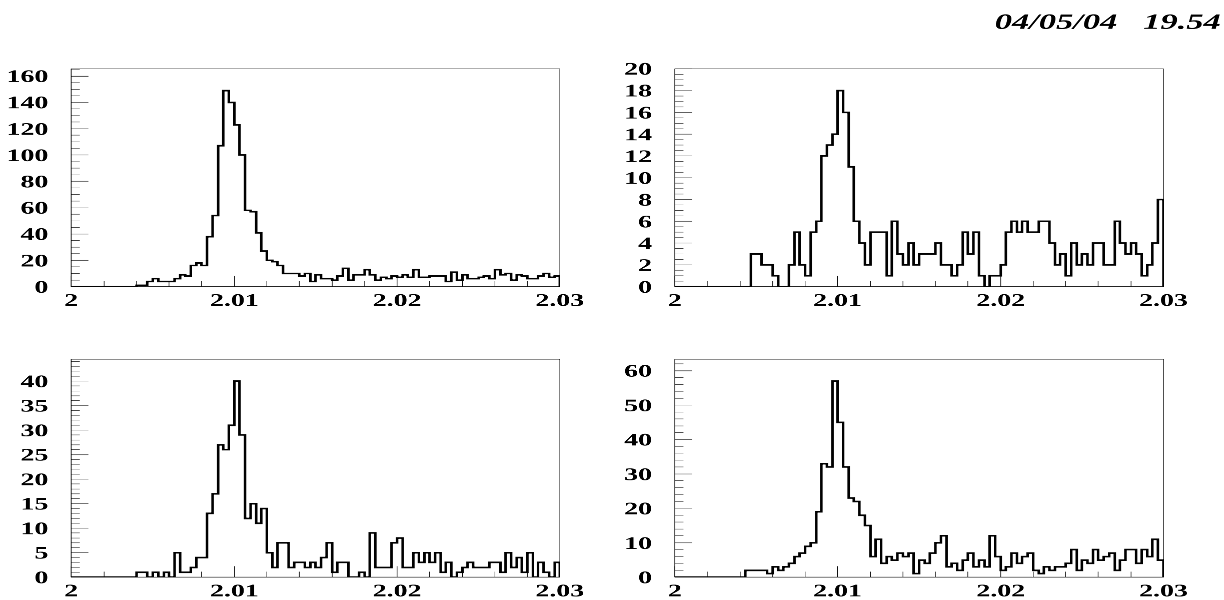
independent from efficiency/ mixing effects

2) Rescale the MC to the DATA result
3) Compute the expected bias.

$D^* \rightarrow (K\pi)\ \pi^*$

Mass Band
Right Charge

Side Band
Right Charge



Mass Band
Wrong Charge

Side Band
Wrong Charge

M

Work going on...

Conclusions

- Systematic errors still preliminary
- Statistical errors to be validated (Toy)

.... but a very promising measurement...