A first look at CPV in mixing using P.R. D*lν and K−tag

Martino, 6/06/06

- Motivations & Method:
  - Determination of detector asymmetry from D−tagged events;

- Preliminary Signal fit on MC RUN1:
  - Δt fit of D−tagged events;
  - Δt fit of B−tagged events (perfect vs real tag & resolution);
  - Fraction of D−tagged events;
  - Combined fit to D−tagged+B−tagged events;

- Conclusions

Motivations

- Improve the |q/p| determination obtained by means of the $B^0 \rightarrow D^* l \nu$ Partial Reconstruction, by combining the result with the Perugia−Padova analysis using the Lepton−Tag
(expected statistical error on 200 fb^{-1}: ~$3.1 * 10^{-3}$ from the latter)

➡ Average of the two P.R. Measurements competitive with the dilepton one:
$(|q/p| -1 = (-0.8 \pm 2.7 \pm 1.9) * 10^{-3})$

- Measurement of $\Delta\Gamma$;

- Improved Measurement of Δm & τB^0 (?)

Method

- Partial $B^0 \to D^* l \nu$ reconstruction on one side already exploited in several measurements (CPV in mixing with Lepton Tag, CP violation on Tag−side, B^0 Lifetime & Mixing (published), B^0 Lifetime (published),...)

- New Tag−vertex determination using only the Tag−Kaon tracks +B.S. Constraint (as for the Lepton −Tag analysis):

  ➡ No bias from tracks from the un−reconstructed D^0 in the Tag−vertex.

- Used all the Tag−Kaons in the event;
- |q/p| obtained from the charge asymmetry in mixed events:

$$|q/p| = 1+K_{PHYS};\ K_{PHYS} = -A/2;\ A = N(l^+K^+)/(N(l^+K^+)+N(l^-K^-))$$

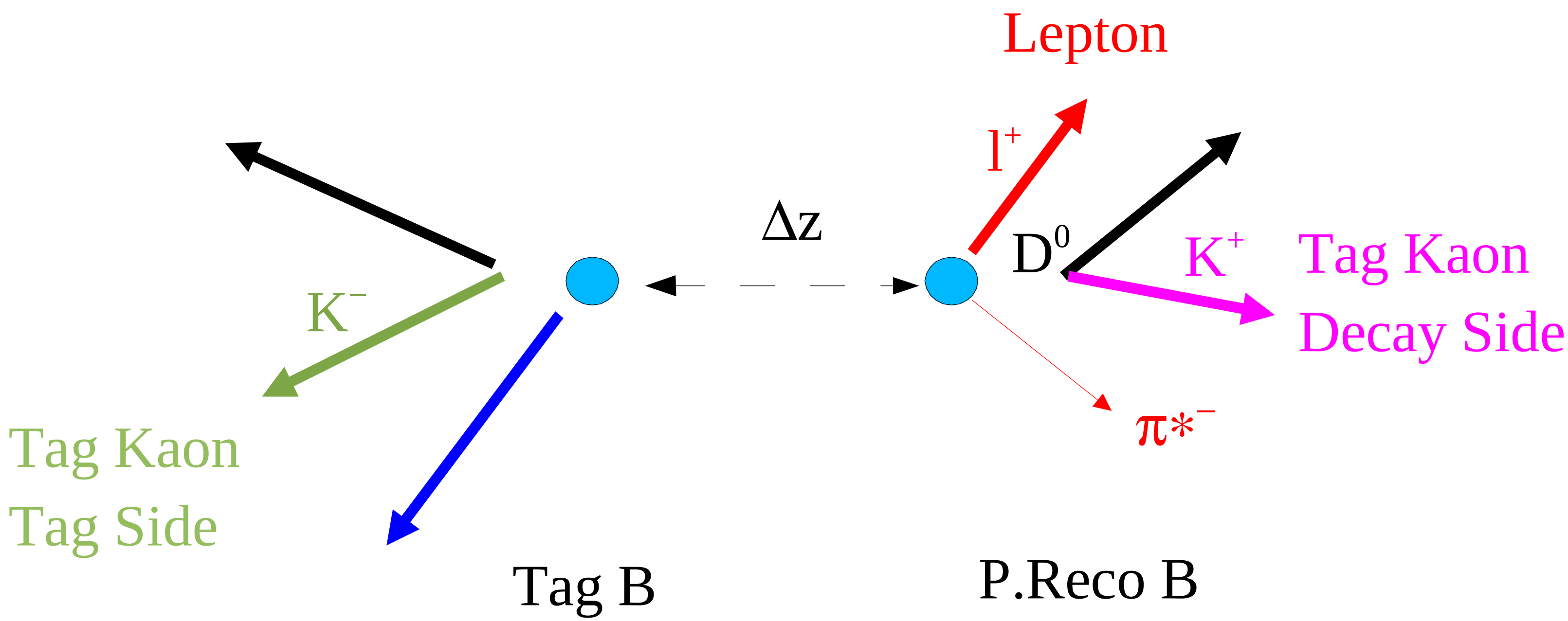
- Simultaneous Δt fit to the 4 different subsamples:

unmixed +, unmixed −, mixed +, mixed −

defined according to the Tag−K charge and the lepton charge on the Partial Reco Side;

K−Tagging categories

Tagging Kaon Sample: { b−> K + b−>c−>K — **From tag B**
D^0 −> K — **From decay B**



Determination of detector asymmetry

- Crucial point: discriminate between physical and detector charge asymmetry without relying on control samples results to contain systematic errors;

- Idea: determine the experimental charge asymmetry directly from the real data using the D−tagged event sample wich does not carry mixing & CPV information (mostly D−tag events populate the mixed sample due to l−K charge correlation);

- Separation between B−tag and D−tag events exploiting:
  - Different shape of the Δt distributions (Effective D lifetime τ_D floated);
  - D−tag fraction $\alpha(\theta)$ from angle $K-\pi*$ in the e^+e^- reference frame (D−tagged events mostly populate the low angle region);

- Compatibility between B−tag & D−tag detector asymmetry checked on MC.

- B−tag vs D−tag detector charge asymmetry: MC RUN1 (realistic tagging)
- Some definitions:
  - $r_{ek} = r_e * r_k = N(e^+K^+)/N(e^-K^-)$
  - $A_{ek} = (N(e^+K^+)-N(e^-K^-))/(N(e^+K^+)+N(e^-K^-))=(r_{ek}-1)/(r_{ek}+1)$
  - $f=N(e^+K^+)/(N(e^+K^+)+N(e^-K^-))=(A_{ek}+1)/2$
  - $K=-A_{ek}/2$; $(|q/p|=1+K)$

	B−tag	D−tag
$N(e^+K^+)$	28598	69607
$N(e^-K^-)$	27589	66892
$N(\mu^+K^+)$	20551	49275
$N(\mu^-K^-)$	19609	47194

- Electron on Reco−Side

	B−tag	D−tag
r_{ek}	1.0366± 0.0087	1.0406 ± 0.0056
A_{ek}	0.0180± 0.0042	0.0199± 0.0027
f_{ek}	0.5090± 0.0021	0.5099± 0.0013
K_{ek}	−0.0090± 0.0021	−0.0099± 0.0013

- Muon on Reco−Side

	B−tag	D−tag
$r_{\mu k}$	1.0480± 0.0105	1.0441± 0.0067
$A_{\mu k}$	0.0234±0.0050	0.0216± 0.0032
$f_{\mu k}$	0.5117± 0.0025	0.5108± 0.0016
$K_{\mu k}$	−0.0117± 0.0025	−0.0108± 0.0016

- Good agreement found between B−tag and D−tag event sample;
- Results obtained using just true Kaons: a few percent A_{lk} is induced by misidentified positive protons; Alessandro Gaz is currently working on optimisation of proton rejection.

Signal PDF Description

$$\mathcal{F}^{st,sm}(\Delta t, \sigma\Delta t, M^2_\nu \mid \tau, \Delta m, k) =$$

$$(1-\alpha(\theta)^{sm}) * \mathcal{F}^{st,sm}_{Btag}(\Delta t, \sigma\Delta t \mid \tau, \Delta m, k) \otimes \mathcal{R}_{Btag}(\delta\Delta t, \sigma\Delta t) +$$

$$\alpha(\theta)^{sm} * \mathcal{F}_{Dtag}(\Delta t, \sigma\Delta t \mid \tau_D) \otimes \mathcal{R}_{Dtag}(\delta\Delta t, \sigma\Delta t)$$

- $\mathcal{F}^{st,sm}_X(\Delta t, \sigma\Delta t)$: PDF, $\alpha(\theta)$: D−tag fraction, st=1(K^+), −1(K^-), sm=1(unmixed), −1(mixed)

- Resolution Function:

$$\mathcal{R}(\delta\Delta t, \sigma\Delta t) \sim (1-f_w-f_o)\ \exp(-(\delta\Delta t-o_n)^2/2(S_n\sigma\Delta t)^2) \quad \text{Narrow}$$
$$+\ f_w\ \exp(-(\delta\Delta t-o_w)^2/2(S_w\sigma\Delta t)^2) \quad \text{Wide}$$
$$+\ f_o\ \exp(-\delta\Delta t/2S^2_o) \quad \text{Outlier}$$

$\delta\Delta t = \Delta t(\text{measured}) - \Delta t\ (\text{true})$

- Offset o_n, o_w adjusted for each sample (Btag vs Dtag)

- Fit to Δt to determine simultaneously:

τ, Δm and dilution $\mathcal{D}$, constrained to the fraction of mixed events:

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

- K_{DET} constrained to the fraction of positive mixed events in the D−tag sample:

$$N^{Dtag}(e(\mu)^+K^+)/(N^{Dtag}(e(\mu)^+K^+)+N^{Dtag}(e(\mu)^-K^-))= (1-2*K^{e(\mu)}{}_{DET})/2$$

- K_{PHYS} constrained to the fraction of positive mixed events in the B−tag sample:

$$N^{Btag}(e(\mu)^+K^+)/(N^{Btag}(e(\mu)^+K^+)+N^{Btag}(e(\mu)^-K^-))=$$

$$(1-2*K^{e(\mu)}{}_{DET}-2*K_{PHYS}+4*K^{e(\mu)}{}_{DET}*K_{PHYS})/(2+8*K^{e(\mu)}{}_{DET}*K_{PHYS})$$

- Binned (100/250 Δt X 25/50 $\sigma\Delta t$) Maximum−likelihood fit to the mixed/unmixed/K+/K− 4 subsamples
- Likelihood value computed at the bin center

MC Validation

- Fit the D−tag sample alone with realistic resolution & tagging to check the fit strategy for K^{Dtag}_{DET}

- Validate the resolution model and the realistic tagging comparing the generated τ, Δm, K_{PHYS} values with the results of the fits on B−tag events using:

− true Δt and tagging (Selection Bias)

− true Δz and tagging (Boost Approximation check)

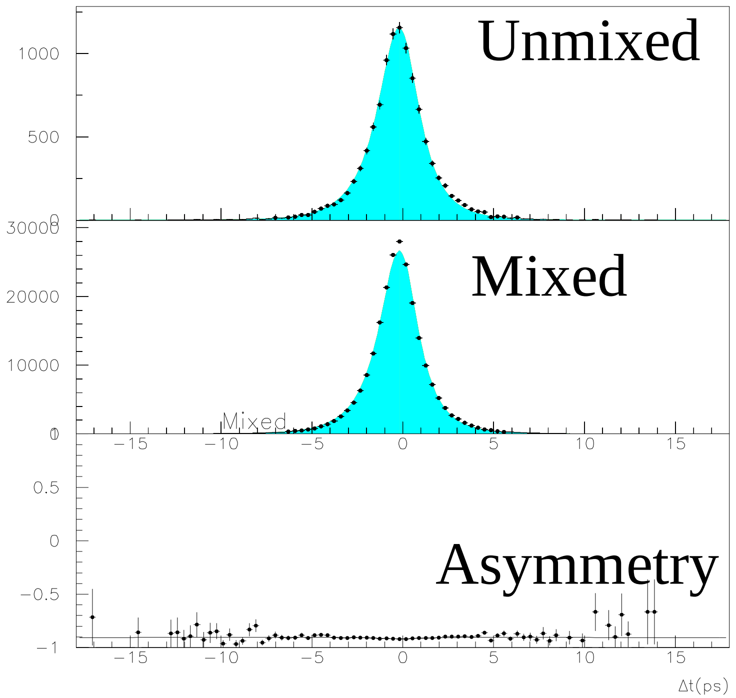
− true Δz and experimental tagging (realistic tag & Check of $K^{Btag}_{DET}=K^{Dtag}_{DET}$)

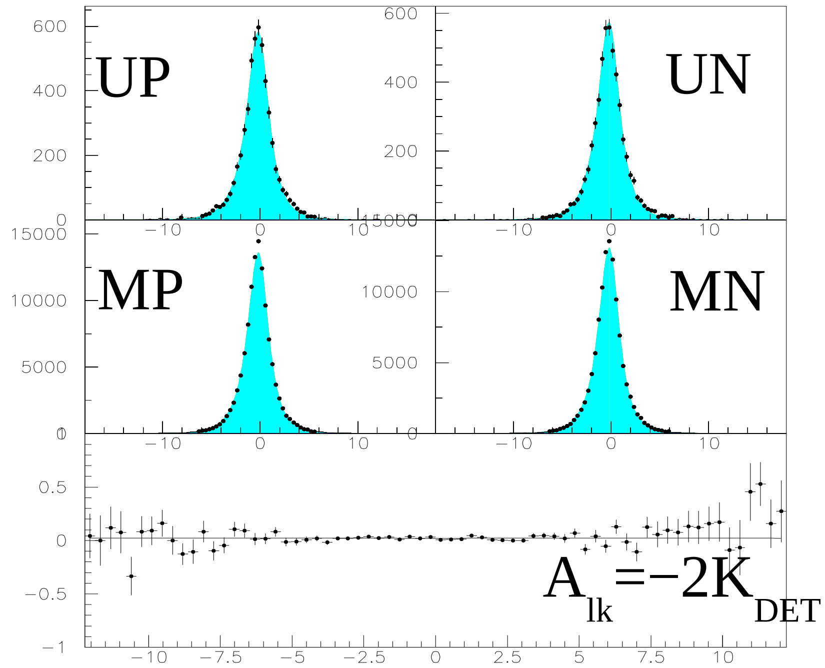
− experimental Δz and true tagging (resolution function)

− experimental Δz and tagging (realistic fit)

- Determine the fraction $\subseteq(\measuredangle)$ of D−tag events in terms of the K−f* angle
- Add B−tag & D−tag samples together and repeat the fit

D−tag fit: realistic resolution & tagging





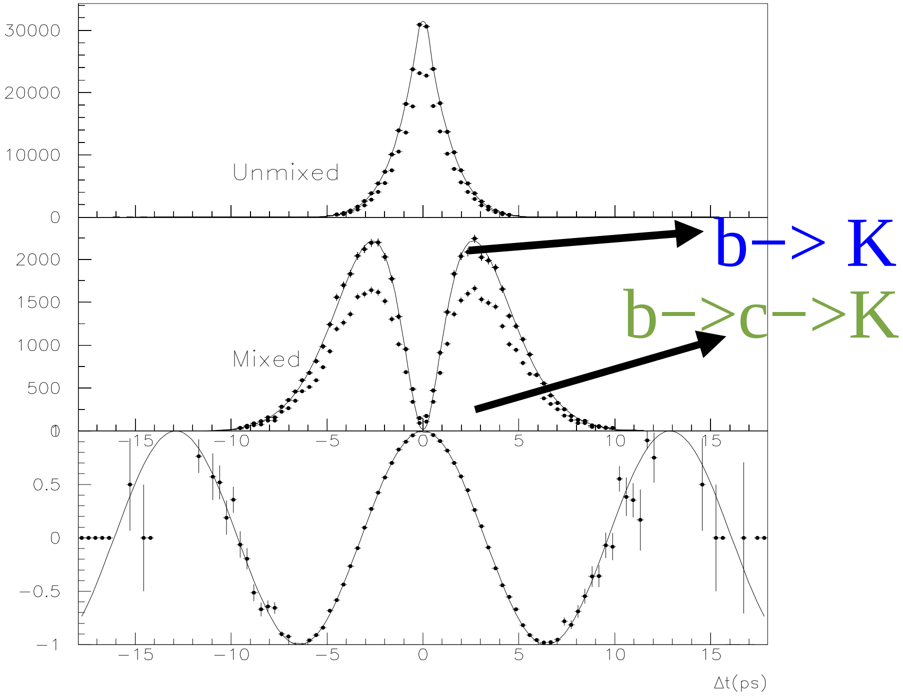
τD= 0.10±0.06 ps

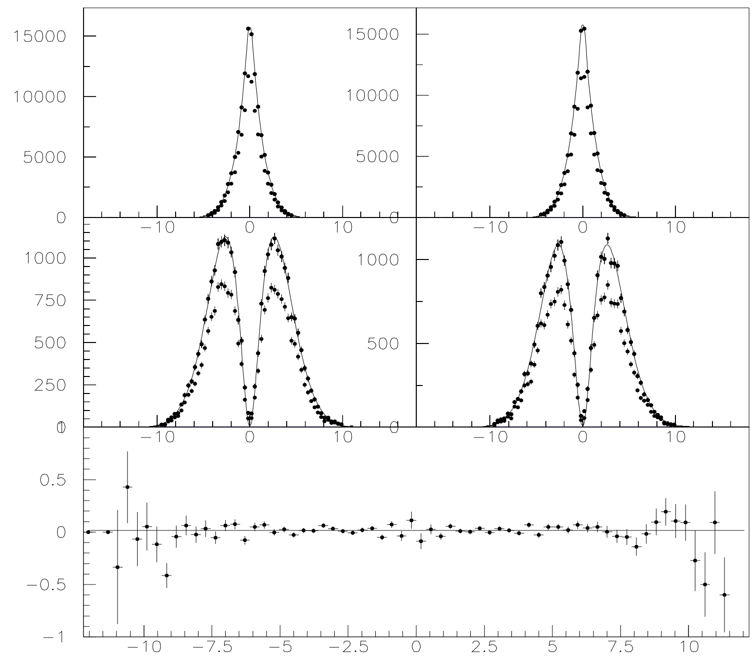
K_{DET}^{e} = −0.0100±0.0013 (−0.0099±0.0013 from counting)

K_{DET}^{μ}= −0.0108±0.0015 (−0.0108±0.0015 from counting)

Fit to K_{DEC} OK!

B−tag fit: true Δt & tagging





MC TRUTH:

τB= 1.540 ps

Δm=0.489

χ =0.1809

Selection Bias:

$\delta\tau$ = −0.0121±0.0027ps

$\delta\Delta m$= −0.0011±0.0004ps^{-1}

$\delta\chi$=−0.0023±0.0004

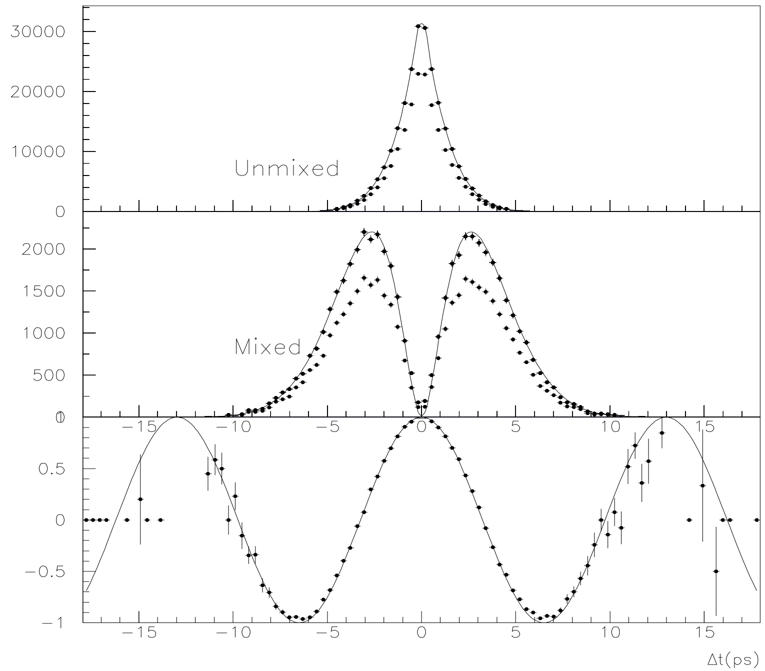
τB= 1.5279±0.0027ps

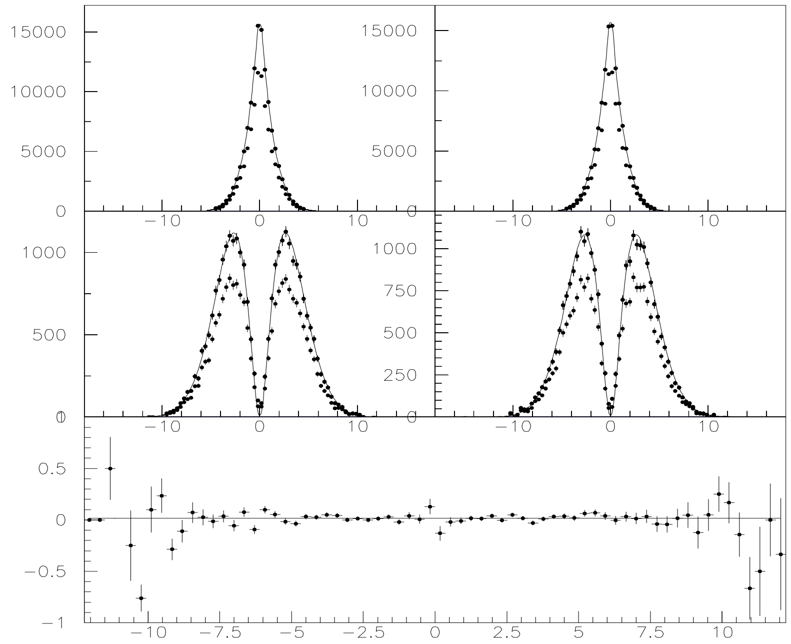
Δm=0.4879±0.0004 ps^{-1}

χ_{fit} =0.1786±0.0007

χ = 0.1787±0.0004

B−tag fit: true Δz & tagging





τ_B= 1.5343±0.0028ps

Δm=0.4842±0.0007 ps^{-1}

χ_{fit} =0.1778±0.0007

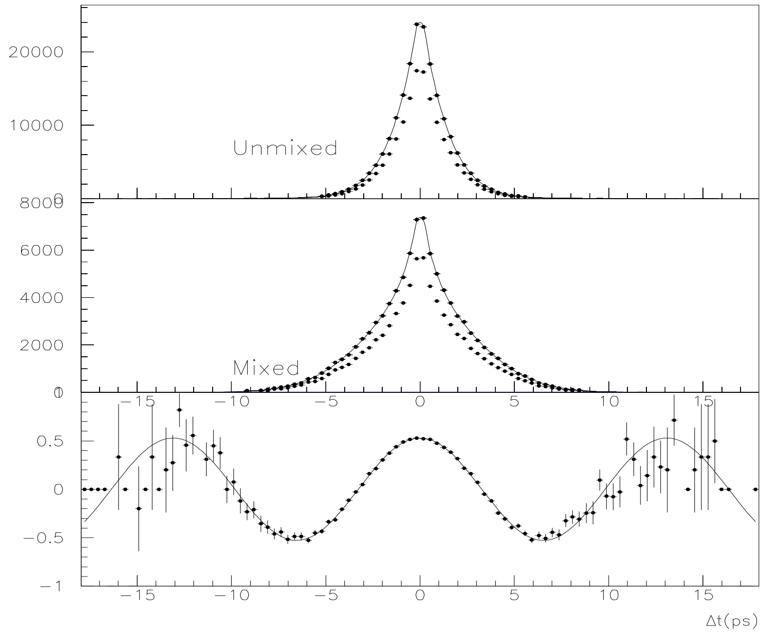
Boost Approx. Bias:

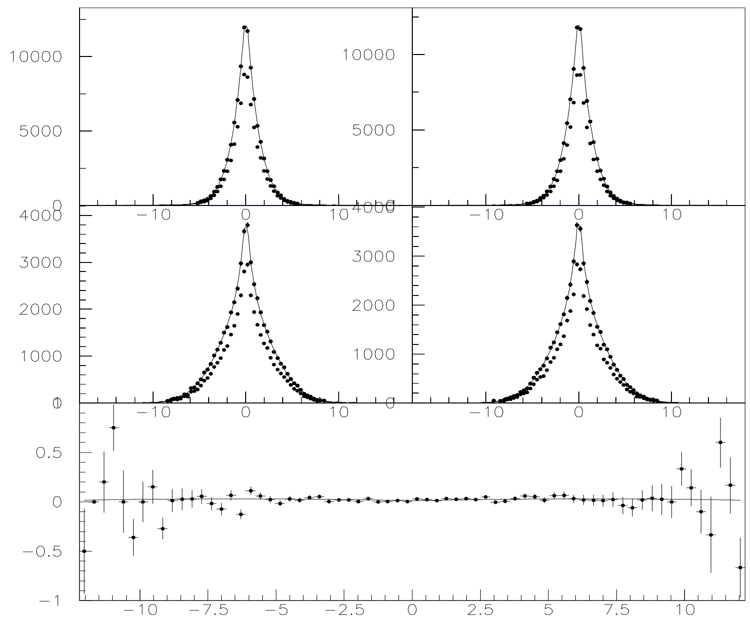
$\delta\tau$ = +0.0064±0.0007ps

$\delta\Delta m$= −0.0037±0.0006ps^{-1}

$\delta\chi$=−0.0008±0.0003

B−tag fit: true Δz & realistic tagging





τB= 1.5334±0.0028ps

Δm=0.4800±0.0020 ps^{-1}

χ_{fit} =0.1757±0.0011

K_{DET}^{e} = −0.0090±0.0021(identical from counting)

K_{DET}^{μ} = −0.0117±0.0025(identical from counting)

w=0.2357±0.0010 (0.2322 from counting)

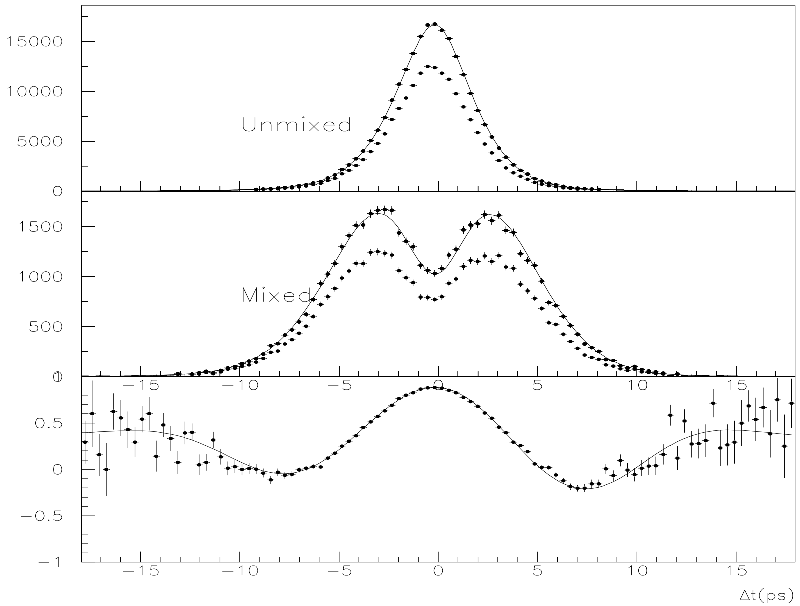
Mistag Bias:

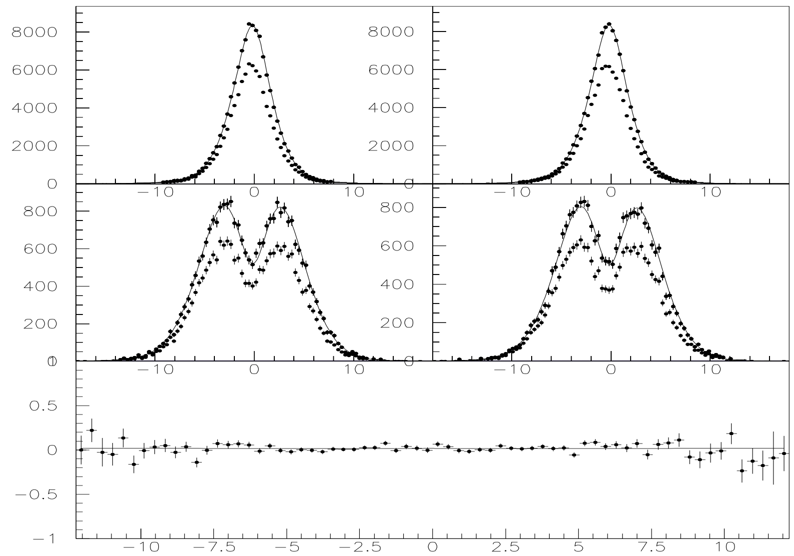
$\delta\tau$ = −0.0009ps

$\delta\Delta m$= −0.0042±0.0019ps^{-1}

$\delta\chi$=−0.0021±0.0010

B−tag fit: realistic Δz & perfect tagging



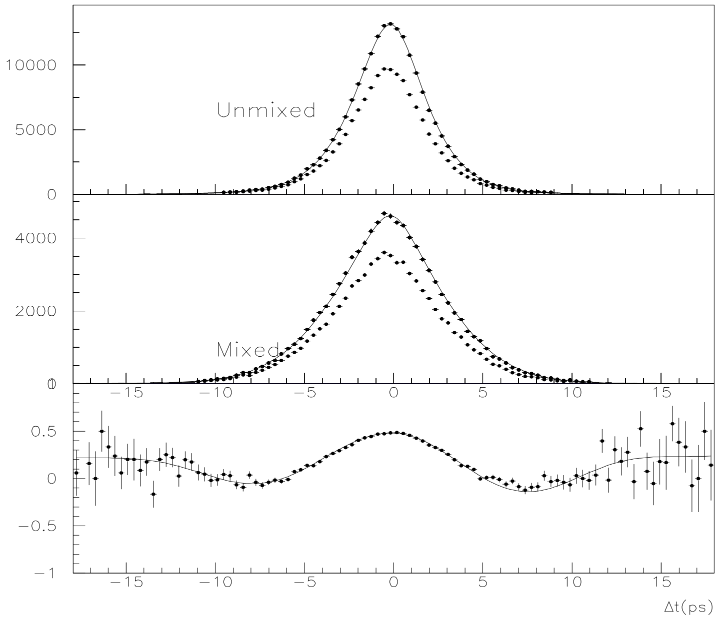


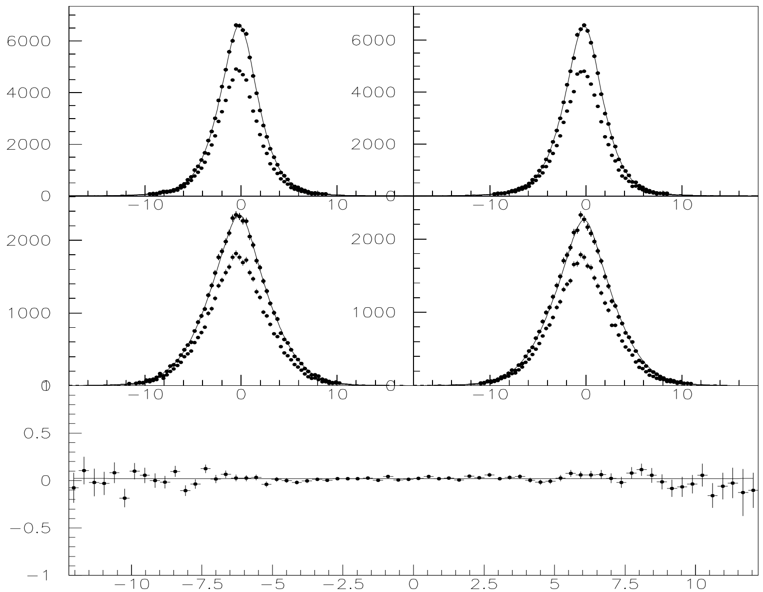
$\tau B = 1.5242 \pm 0.0046 ps$

$\Delta m = 0.4872 \pm 0.0015\ ps^{-1}$

$\chi_{fit} = 0.1777 \pm 0.0007$

B−tag fit: realistic Δz & tagging





τB= 1.5432±0.0060ps

Δm=0.4862±0.0038 ps^{-1}

χ_{fit} =0.1801±0.0017

K_{DET}^{e} = −0.0090±0.0021

K_{DET}^{μ} = −0.0117±0.0025

w=0.2314±0.0014

Resolution Bias:

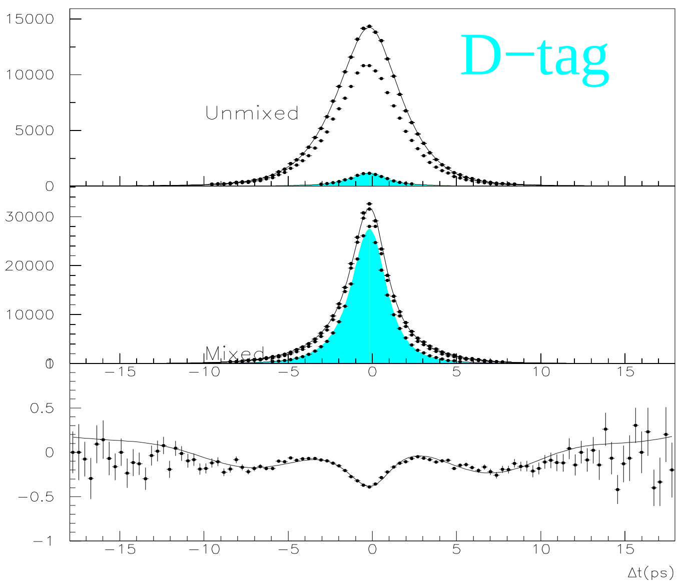
δτ = +0.0098±0.0053ps

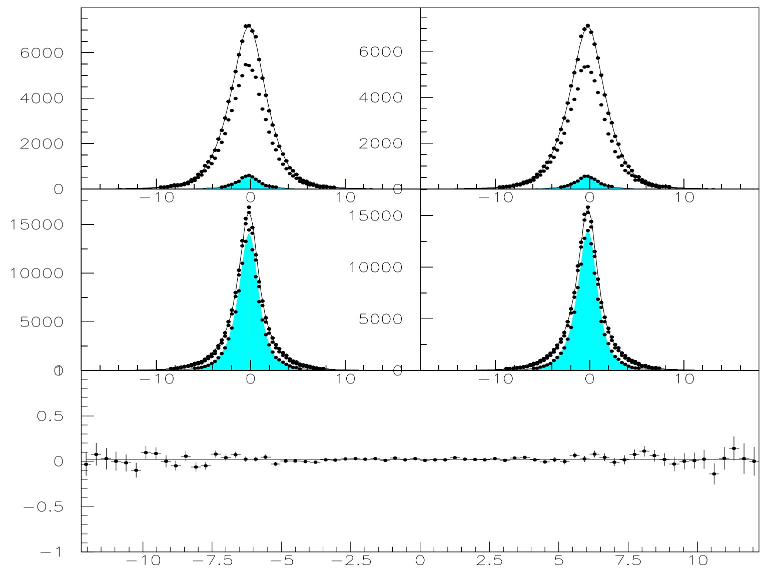
δΔm= +0.0062±0.0032ps^{-1}

δχ=−0.0044±0.0013

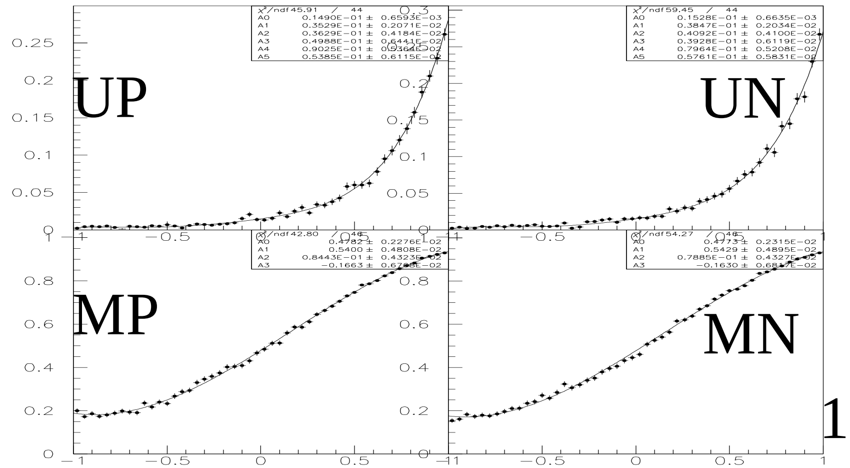
δw= −0.0016±0.0010

B−tag +D−tag fit: true Δz & tagging





D−tag fraction



$K_{DET}^{e} = -0.0098 \pm 0.0013$

$K_{DET}^{\mu} = -0.0110 \pm 0.0015$

$K_{PHYS} = 0.0002 \pm 0.0027$

Fit to be improved:

$\tau B = 1.563 \pm 0.005$

$\Delta m = 0.523 \pm 0.003$

Conclusions

- Very preliminary results show that the strategy to constrain detector effects in the B−tag sample charge asymmetry by exploiting the D−tag one seems to be reasonable.
- From the results of the fit to the B−tag vs D−tag signal samples in MC run1 (56.4fb−1) one would expect δK_{PHYS}(stat)=0.0019;
- From the combined B−tag+D−tag fit one gets δK_{PHYS}(stat)=0.0027, with a dilution, due to the not perfect separation of the two samples, which reflects in a 0.0019 additional effect.
- From a simple rescaling to the global Run1−Run4 real data statistics one gets: δK_{PHYS}(stat)=0.0014;
- No systematics computed at the moment, but they should be not so big due to the analysis strategy;
- Fit to be improved in order to obtaine a mesurement of τB and Δm