Inclusive Tag-Side Vertex Reconstruction in Partially Reconstructed B decays

-A Progress Report -

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Franco Simonetto
INFN & Universita'di Padova'

Outline

- Brief Reminder
- Status
- Next Steps

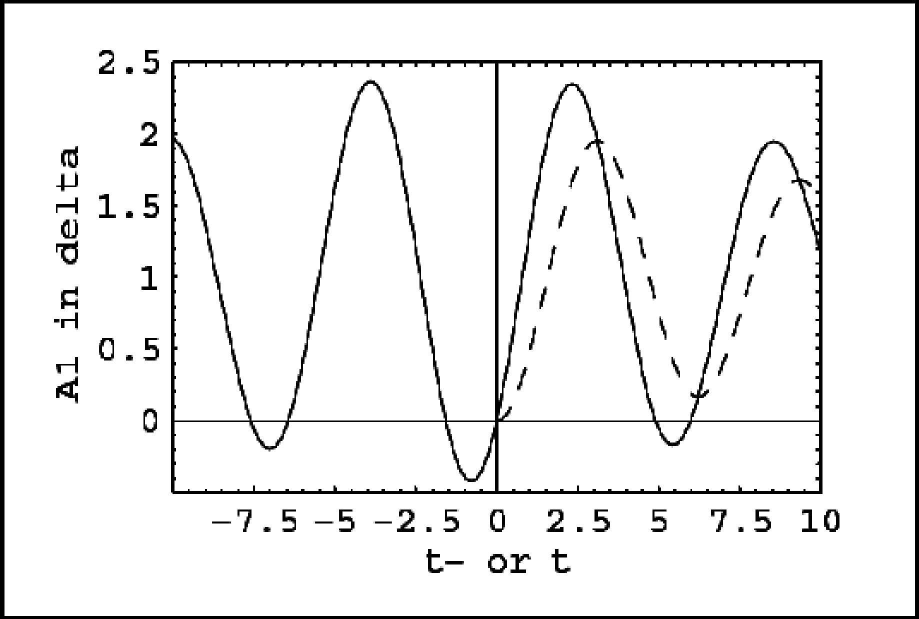
Single Tag – CP asymmetry

$$\mathcal{A}_l(\Delta t) = \frac{\mathcal{N}(\bar{B}_d)(\Delta t) - \mathcal{N}(B_d)(\Delta t)}{\mathcal{N}(\bar{B}_d)(\Delta t) + \mathcal{N}(B_d)(\Delta t)}$$

$$\delta = \frac{1}{2}\mathcal{A}_{ll} = 1 - \left|\frac{q}{p}\right|$$

$$\sim \delta\left(1 - \cos(\Delta m \Delta t) + \frac{\Delta m}{\Gamma}\sin(\Delta m \Delta t)\right)$$

- δ can be measured as the amplitude of the time-dependent asymmetry
- detector asymmetries can be simultaneously measured as a time independent overall bias
- Different w.r.t. double tag approach, where $\mathcal{A}_{ll}$ is time-independent



Inclusive CP Asymmetries in Semileptonic Decays of B Mesons
Hitoshi Yamamoto
hep-ph/9707427v2

Inclusive Vertex Recosntruction

- Event with $\mathcal{N}_{good}$ tracks selected, consider all permutations of $\mathcal{N}_D$ "decay" tracks and $\mathcal{N}_O = \mathcal{N}_{good} - \mathcal{N}_D$ other side tracks, compute a likelihood as:

$$\begin{aligned}\log \mathcal{L} = & \log \mathcal{L}(\mathcal{N}_D / \mathcal{N}_{good}) + \\ & + \log \mathcal{L}(E_D|\mathcal{N}_D) + \log \mathcal{L}(\cos(\theta_{D,\ell})|\mathcal{N}_D) + \log \mathcal{L}(\mathcal{M}^2_{\nu,D}|\mathcal{N}_D) + \\ & + \log \mathcal{L}(E_O|\mathcal{N}_O) + \log \mathcal{L}(\cos(\theta_{O,\ell})|\mathcal{N}_O) + \log \mathcal{L}(\Pi(Vertex)|\mathcal{N}_O) + \\ & + \log \mathcal{L}(\Delta E) + \log \mathcal{L}(\cos(B_1, B_2)) + \log \mathcal{L}(\cos(B, beam))\end{aligned}$$

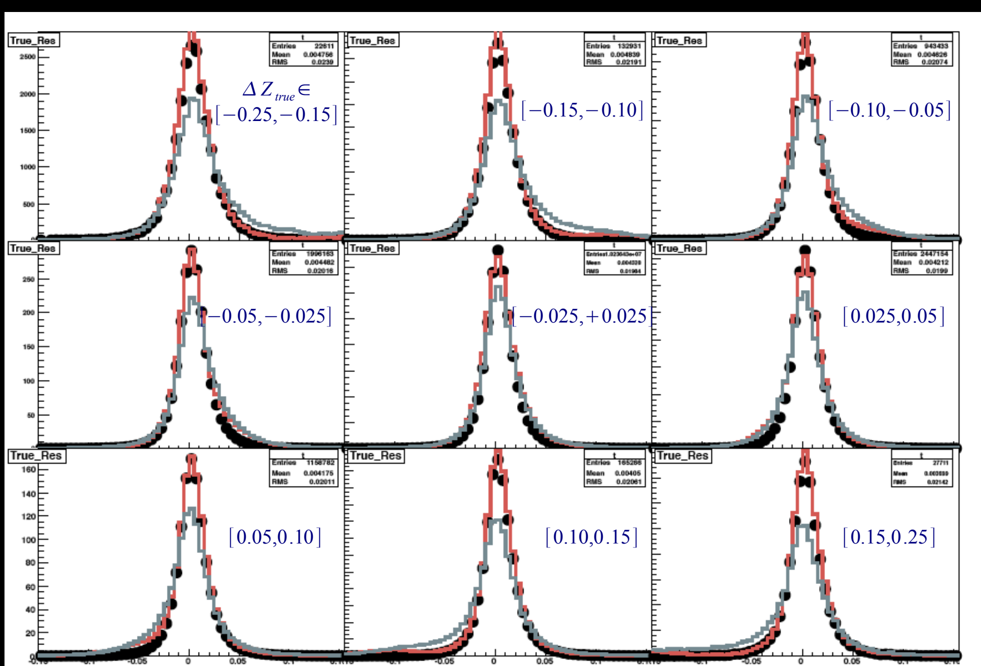
- Choose the combination providing the largest value of $\mathcal{L}$
- Compute the 2[nd] B vertex from the "other side" tracks selected this way

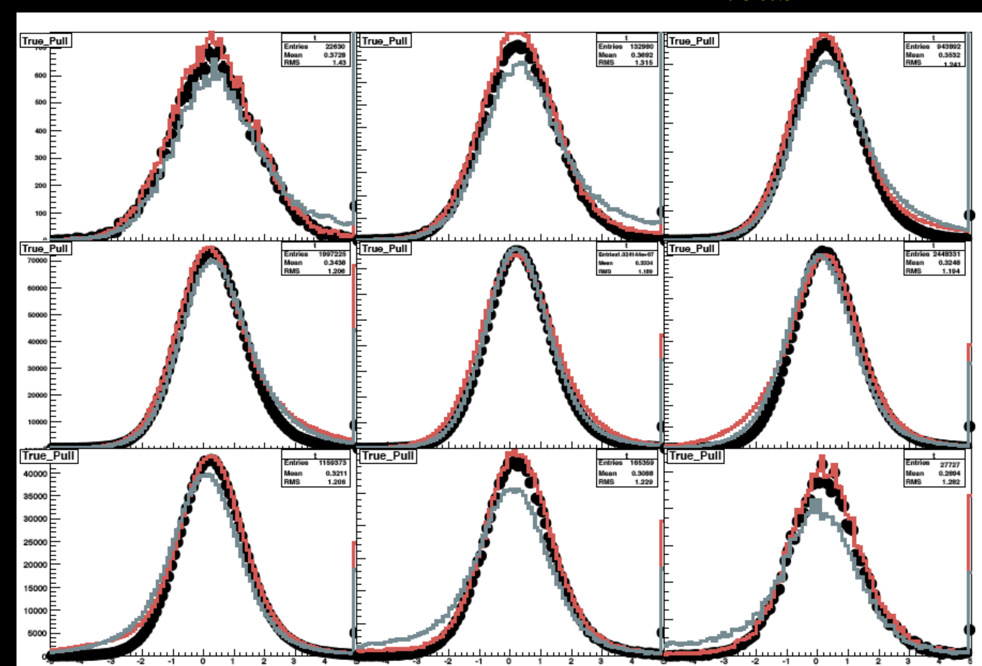
Resolution vs true ΔZ

- Resolution and pull much improved wrt cone cut approach
- Also a sizable efficiency gain (~30% for 90° cone)

$$\Delta Z_{reco} - \Delta Z_{true}$$

$$Pull : \frac{\Delta Z_{reco} - \Delta Z_{true}}{\sigma(\Delta Z_{meas})}$$





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Validation

- PDFs shapes taken from simulation
- Many variables are involved, individual tuning is time expensive
- Difficult to control correlations
- A posteriori validation :
  - Compare ΔZ, $\sigma(\Delta Z)$ signal distributions in Data and MC
  - Smear – if necessary – the MC to the data

Method

- Fit data Squared-Missing-Mass (M_ν^2) distributions in several bins of the selected variable (e.g. DZ), with the sum of :

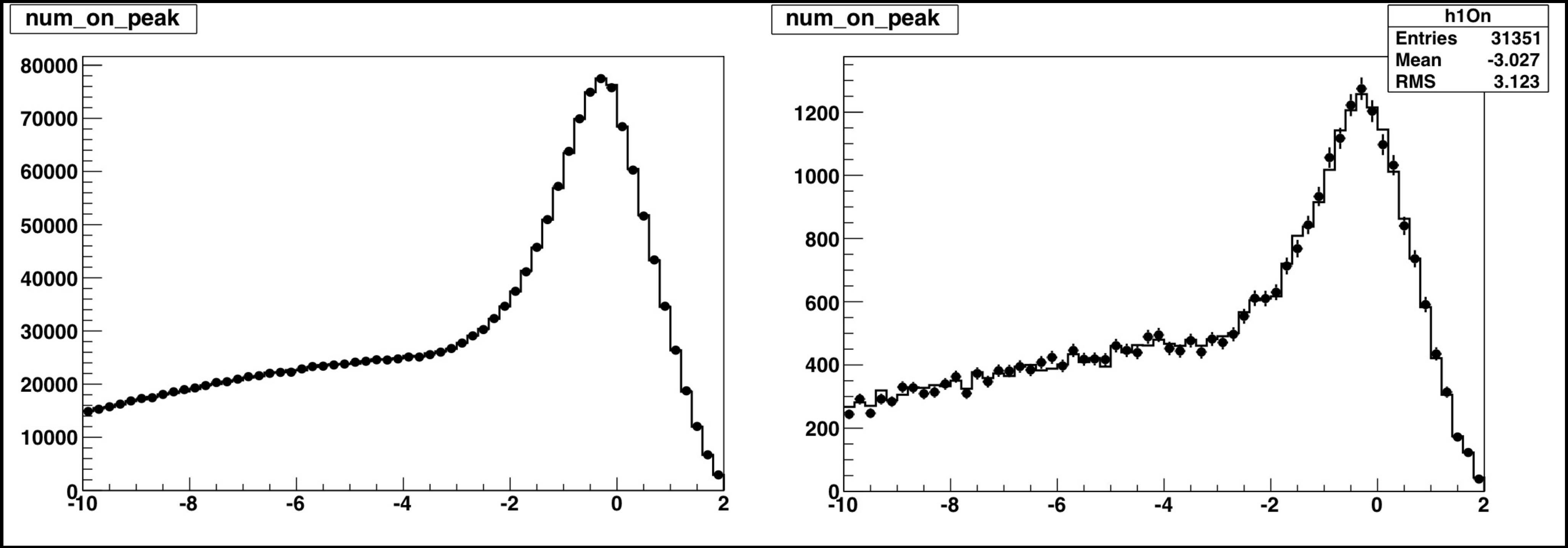
$$(1)\ \ B_d \to D^{*-} l^+ \nu_l$$
$$(2)\ \ B_q \to D^{**-} l^+ \nu_l$$
$$(3)\ \ B_d \to D^{*-} l^+ \nu_l X \quad \text{other peaking, including CP eigenstates}$$
$$(4)\ \ \text{Combinatoric } B_d + B_u$$
$$(5)\ \ \text{Continuum}$$

- Float (1),(2),(4) . Fix (5) to off-peak events
- Compare amount of peaking events (1+2+3) to truth-matched MC in each bin

Examples

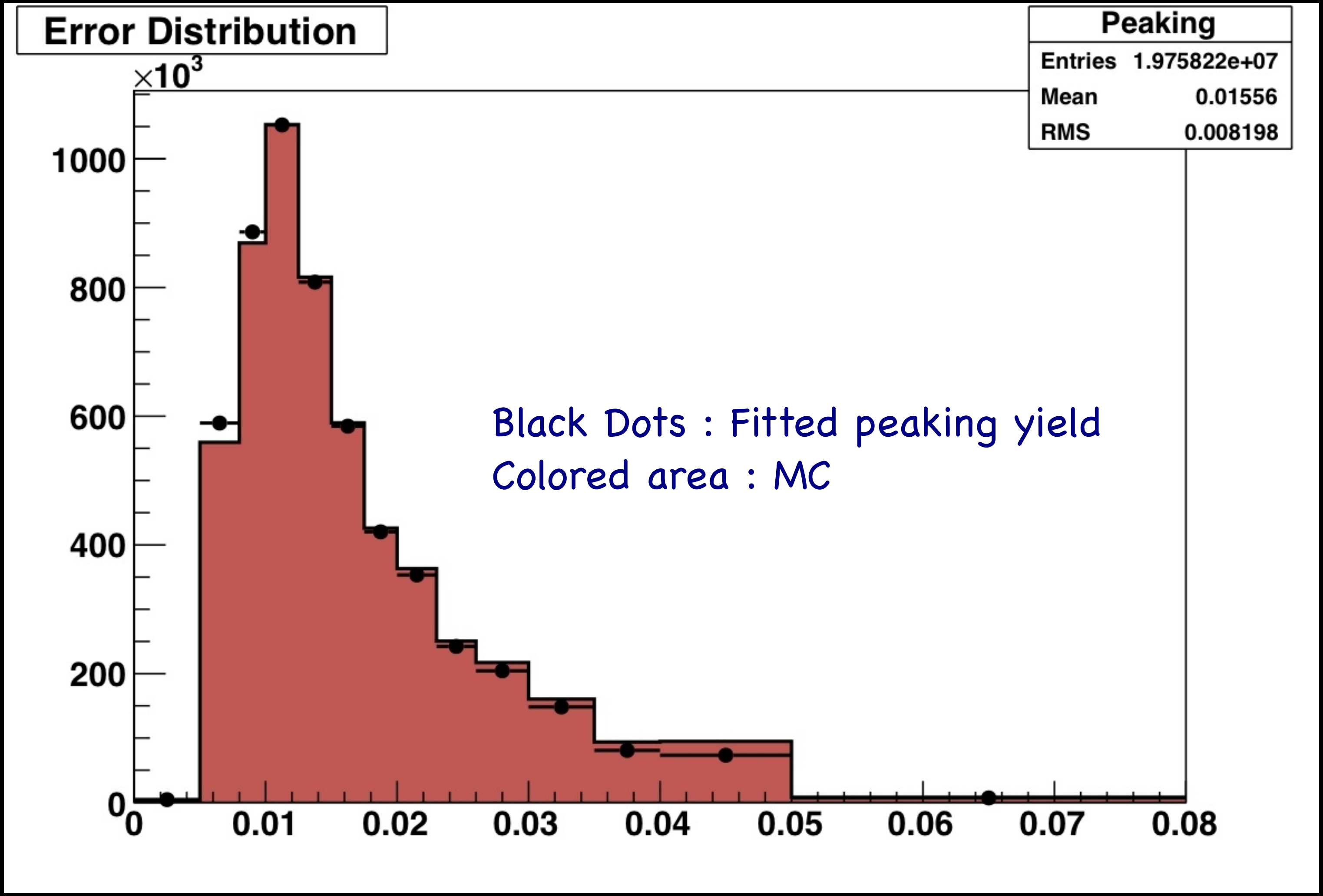
Fit Result for Events with $-0.004 < \Delta Z < 0.004$

Fit Result for Events with $0.20 < \Delta Z < 0.25$



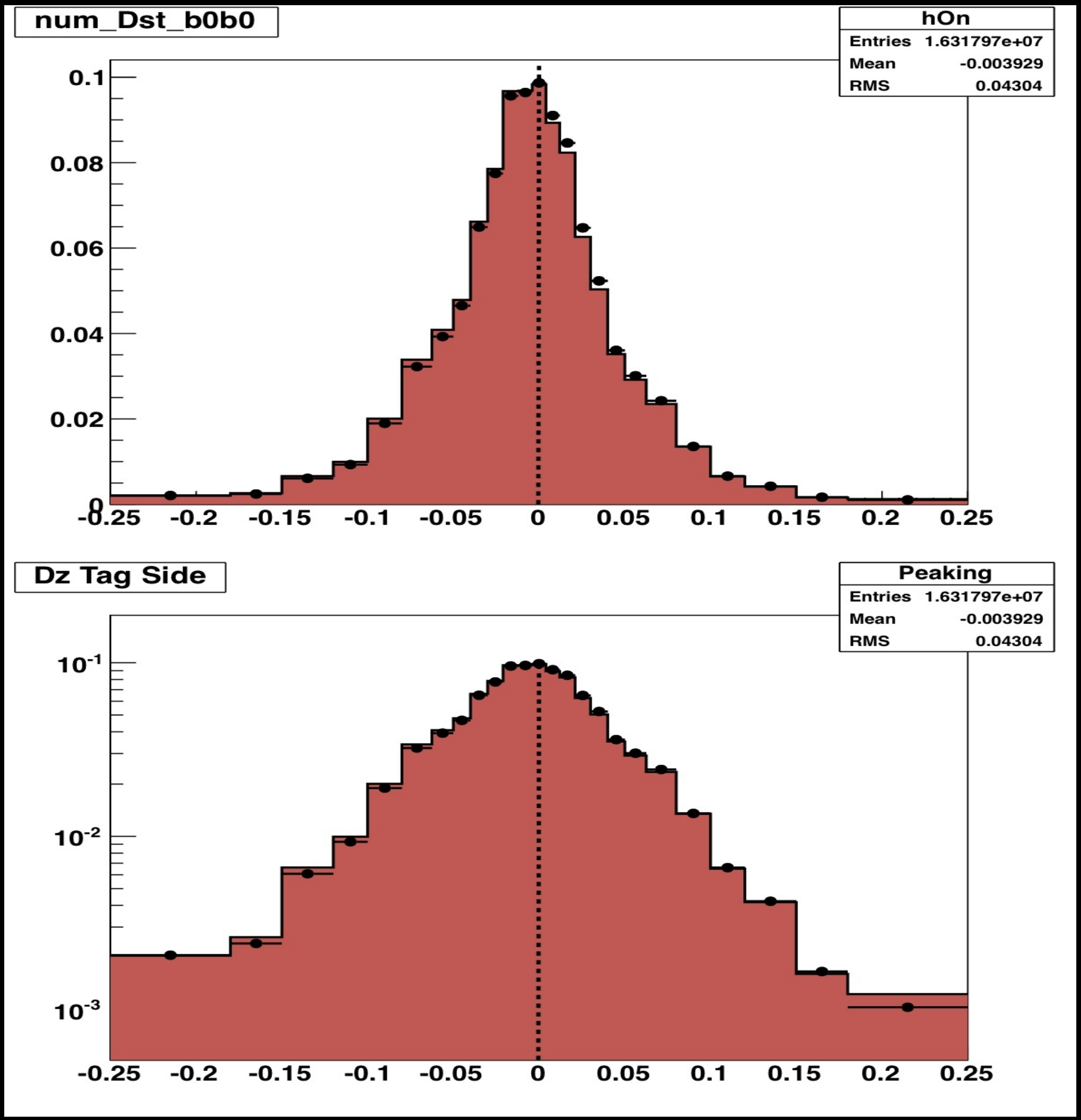
Squared Missing Mass (GeV^2)

Results : $\sigma(\Delta Z)$



Results : $Z_{lepton}-Z_{DecaySide}$

- ΔZ computed wrt the tracks assigned to the "other side", corresponding to the other B meson
- Input for the $\mathcal{A}_{ll}$ measurement
- Good overall agreement



Recent Developments

- Fit true Δt distributions for MC events selected as data
- Simultaneous fit to τ, Δm_d, and n(events) to true signal data splitted by lepton kind, lepton charge, mixing status (8 samples, 10 param.)

τ	1.53790+-0.00066
Δm_d	0.48803+-0.00020

e+	2674125+-1635	UNMIXED
e-	2626602+-1621	
m+	2355011+-1535	
m-	2314104+-1521	
e+	556471+-746	MIXED
e-	547725+-740	
m+	485497+-697	
m-	477249+-691	

Recent Developments (1)

- Fit true Δt distributions for MC events selected as data
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Reconstruction asymmetries (%):

e unmixed	0.896533	0.0436342
e mixed	0.792013	0.0955594
e all	0.878514	0.039692
mu unmixed	0.87612	0.0464871
mu mixed	0.856674	0.102372
mu all	0.872795	0.0423274
lep all	0.875838	0.0289534

Recent Developments (2)

- Fit true Δt distributions for MC events selected as data
- Simultaneous fit to τ, δ, and n(events) to true signal data splitted by lepton kind and lepton charge (4 samples, 6 param.)

τ	1.51756+-0.00062	
Δm_d	0.48800+-0.00000	fixed
δ	0.00028+-0.00062	
$\Delta\Gamma$	0.00000+-0.00000	fixed

e+	3230778+- 1798
e-	3174548+- 1782
μ+	2840733+- 1686
μ-	2791503+- 1671

Reconstruction asymmetries (%):

e all	0.877761	0.037217
mu all	0.874077	0.0423274
lep all	0.876091	0.0190036

Status

- Detector effects induce ~ 0.8% asymmetry in $\ell^+\pi^-_s$ vs $\ell^-\pi^+_s$ tagging
- Same asymmetry for μ and e , probably due to π_s reconstruction
- At truth level, it is possible to fit both the CP asymmetry and the individual event rates – i.d. the detector asymmetry (at least for $\delta = 0$)

Next Steps

- Prepare MC events with $\delta \neq 0$ (+-0.005, +-0.002, +-0.001)
- Check linearity at truth level
- Fit reconstructed simulated events, including resolution effects
- Add background:
  - peaking B+
  - combinatorial
  - continuum
- Toy studies
- Data

Conclusion

- Developed a new algorithm to build the "other" vertex in inclusive event
- The method improves sizably wrt the usual cone cut approach:
  - removes the bias
  - improves the overall resolution
- A precision similar to fully reconstructed events can be reached
- The method can be in principle implemented with each partially reconstructed sample (even single leptons)
- CP analysis at start – do not expect fast progresses ...