Combining Flavor Taggers

How Best to Combine the Taggers?

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Where We Stand

- At present we have three taggers
  - SLT $\equiv$ Single Lepton Tag
  - STT $\equiv$ Same Side Tag
  - JETQ $\equiv$ Jet Charge
- The questions we wish to answer is how best to combine the taggers to minimize the error on Δm

How to Combine Tagger Significance

- Reminder, we want to maximize is ϵD^2 or minimize the error on Δm.

$$\sigma \propto \frac{1}{\sqrt{N\epsilon D^2}} \quad \text{or} \quad S \equiv \text{Significance} \propto \sqrt{N\epsilon D^2}$$

$$\epsilon = \frac{\text{tagged}}{\text{total sample}} \qquad D = \frac{\text{Correct tags} - \text{Wrong tags}}{\text{Total tagged}}$$

- Recall, error for n independent measurements is given by

$$\frac{1}{\sigma^2} = \sum_i^n \frac{1}{\sigma_i^2} \propto S^2$$

- Therefore, if n taggers are independently used, then $S^2 \propto \sum_i^n \epsilon_i D_i^2$

Approach to study

- Use toy Monte Carlo to generate a sample of events
- Start with ϵ & D given by Christos

Tag	ϵ	D
SLT	5.2%	42.0%
SST	83.3%	14.4%
JETQ	51.1%	13.7%

Taggers

- Considered 3 tagging methods
  - 1 measurement use tag with largest dilution

ϵ	D	ϵD^2
92.2%	15.9%	2.3%

  - 3 independent measurements
    - tag1 = SLT
    - tag2 = SST if not tagged by SLT
    - tag3 = JETQ if not tagged by either SLT or SST

Tag	ϵ	D	ϵD^2
tag1	5.2%	42%	0.91%
tag2	79.0%	14.4%	1.65%
tag3	8.1%	13.6%	0.15%
Sum			2.71%

Taggers—*cont.*

◇ Make five independent measurements

1. tag1 = SLT; Exclude these from remaining tags
2. if SST = JETQ then tag2 = SST
3. if SST ≠ JETQ then tag3 = SST
4. if only SST tag4 = SST
5. if only JETQ tag5 = JETQ

Tag	ϵ	D	ϵD^2
tag1	5.2%	42%	0.91%
tag2	20.6%	27.8%	1.59%
tag3	19.7%	-0.6%	0.00%
tag4	38.7%	14.4%	0.80%
tag5	8.1%	13.6%	0.15%
Sum			3.45%

A Sanity Check

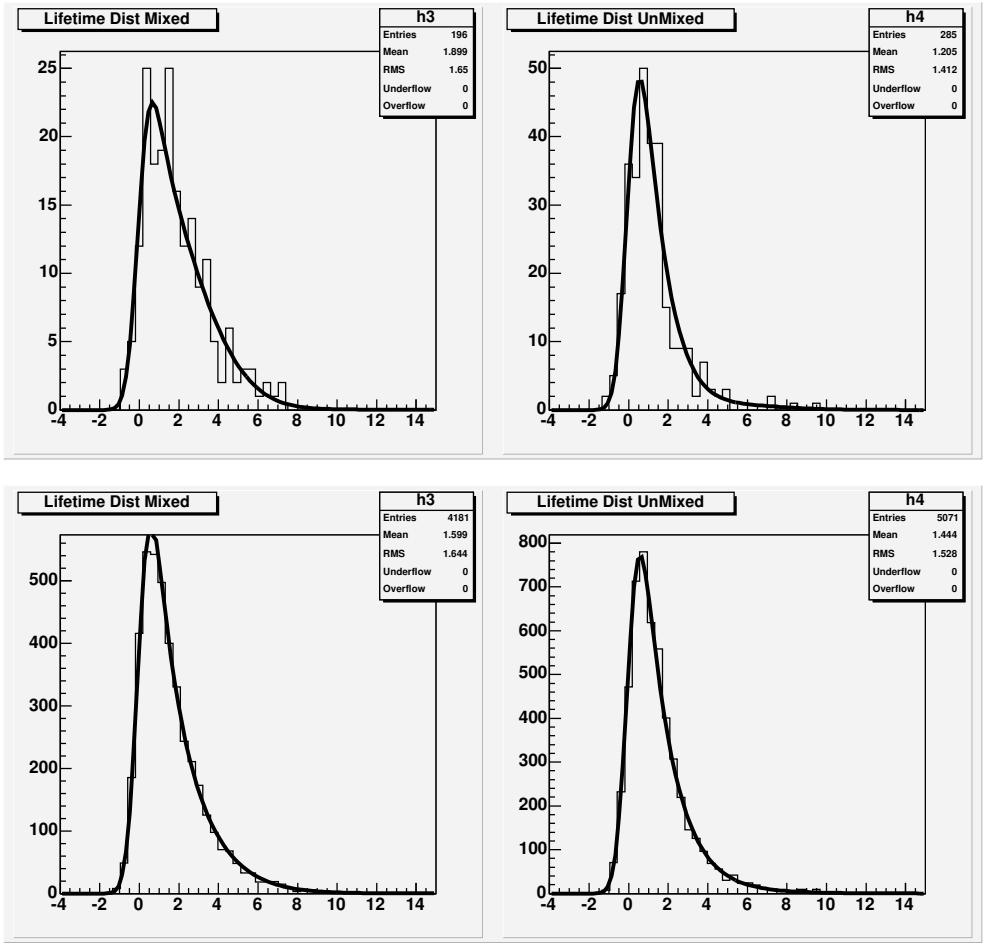
- Generated 10K events with previously given ϵ and D
- Fit lifetime distributions using an unbinned Likelihood function
  - Fit for Lifetime, Resolution, Δm, and Mistag Rate

$$L^{\mathrm{U/M}} = (1-\alpha)\int e^{-(t-t')/2\sigma^2} e^{-t/\tau}[1 \pm \cos(\Delta m)]\, dt' + \alpha \int e^{-(t-t')/2\sigma^2} e^{-t/\tau}[1 \mp \cos(\Delta m)]\, dt'$$

- Initial parameters
  - $\tau = 1.5$ ps
  - $\sigma = .5$ ps
  - $\Delta m = 0.51$ ps^{-1}
  - Dilutions as given earlier

Examples of Fits

- Lifetime distribution of mixed and unmixed sample for SLT and (SLT*SST*JETQ) Combined tags



Comparison of errors and ϵD^2

- Compare errors of Δm for single measurement $\epsilon D^2 = 2.3\%$ and combine 5 measurments $\epsilon D^2 = 3.45\%$

Errors

Tag	Error (ps^{-1})	ϵD^2
Single Tag	0.051	0.023
1	0.0665	0.91%
2	0.0623	1.59%
4	0.0945	0.80%
5	0.1857	0.15%
Total	0.0400	3.45%

Ratios

- $\sigma_1/\sigma_5 = 0.784$
- $\sqrt{\epsilon_5 D_5^2/\epsilon_1 D_1^2} = 0.824$
- Recalculate ϵ & D for 10K sample $\sqrt{\epsilon_5 D_5^2/\epsilon_1 D_1^2} = 0.786$

Summary and Conclusions

- Quantity to maximize is ϵD^2
  - The significance is $\propto \sqrt{N\epsilon D^2}$
  - ϵD^2 add for combined measurements
- The effect of any new tagger can be easily calculated once ϵ and D are known
- Current study shows combining 5(4) taggers yields improvement over a single tagger