B_d Mixing with Kaon Tag Update

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- Introduction and Motivation
- Likelihood Parameterization
- Perfect MC Scans
- "Everything but Proper time Resolution"
- Conclusions and Plans

Why study B_d mixing?

A. B_d mixing can determine the V_{td} element of the CKM matrix:

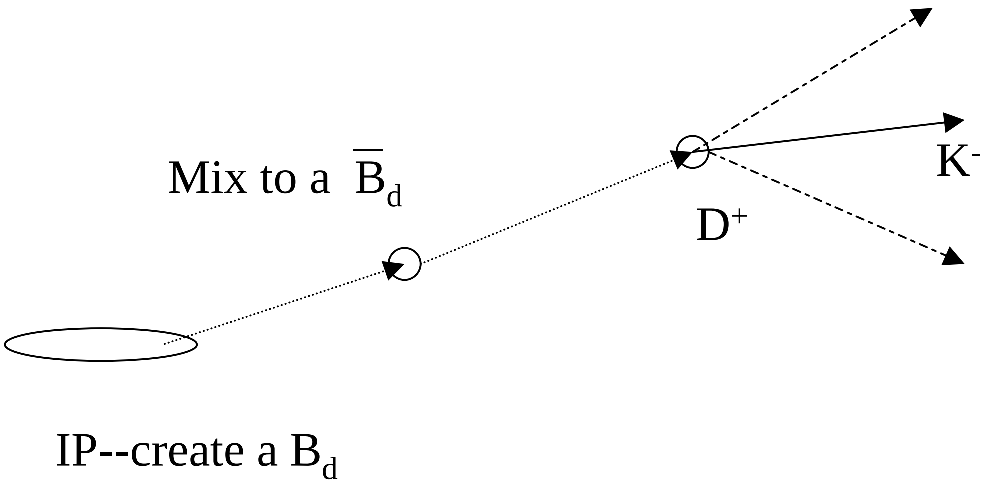
$$\Delta m_d = \frac{G_F^2}{6\pi^2}\eta_B m_{Bd} m_t^2 f_{Bd}^2 B_{Bd} S_0 \left|V_{td} V_{tb}^*\right|^2$$

However, the theory is not that good (error on magnitude of $f_{Bd}\sqrt{B_{Bd}} \cong 20\%$). Thus, we need B_s mixing:

$$\frac{\Delta m_s}{\Delta m_d} = \frac{m_{Bs} f_{Bs}^2 B_{Bs}}{m_{Bd} f_{Bd}^2 B_{Bd}} \cdot \frac{\left|V_{ts}\right|^2}{\left|V_{td}\right|^2} = (1.15 \pm 0.05)^2 \cdot \frac{\left|V_{ts}\right|^2}{\left|V_{td}\right|^2}$$

B. Once a likelihood fit for the Kaon right sign fraction is developed, one could “swap in” other tags and measure the right sign fractions for those tags from the data, giving a cross check for other analyses.

B_d Mixing with a Kaon tag



Final State Tag:

$B_d \rightarrow D^- \rightarrow K^+$

$\overline{B}_d \rightarrow D^+ \rightarrow K^-$

- We tag the initial state using jet charge + polarization
- We tag the final state using the kaon. Kaons make very good final state tags for B_d events (right sign fraction is currently measured to be $(82\pm5)\%$ (Argus)). However, this is also the largest systematic error in the previous version of this analysis…a goal is to fit to this value instead of inputting it.

Unbinned Log-Likelihood Fit to Δm_d

For a single event, the probability to mix is:

$$\boxed{P_{mix} = f_{Bd} P_{mix,Bd} + f_{Bs} P_{mix,Bs} + f_{Bu} P_{mix,Bu} + f_{Baryon} P_{mix,Baryons}}$$

Where the individual terms are as follows:

$$\boxed{P_{mix,Bd} = \frac{\Gamma_{Bd}}{2} e^{-\Gamma_{bd} t} (1 - (1 - 2R_{Bd} - 2i + 4R_{Bd} i) \cos(\Delta m_d t))}$$

$$\boxed{P_{mix,Bu} = \Gamma_{Bu} e^{-\Gamma_{bu} t} (R_{Bu} + i - 2 R_{Bu} i)}$$

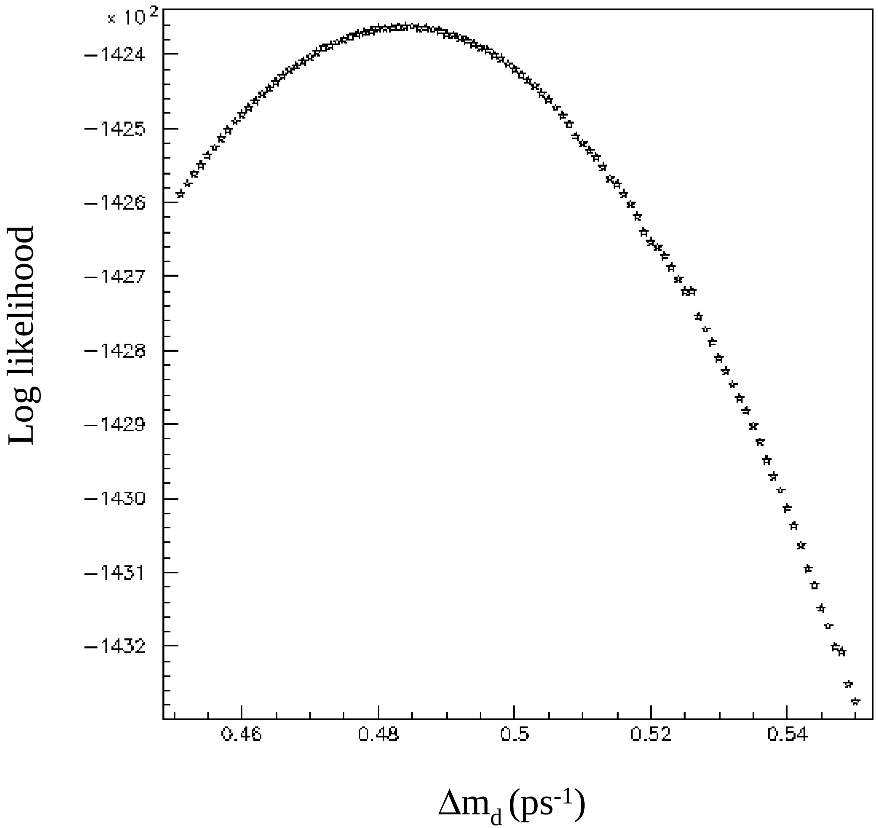
- B_s is analogous to B_d, and the Baryons to B_u.
- $f_{(b)}$ is the fraction of that B type (parameterized in MC); i is the initial state right sign probability; t is the proper time and will be replaced by a resolution integral.
- $R_{(b)}$ is the Kaon right sign fraction for that B type, parameterized from MC.

Parameterizations from MC

Species	R	f
B_u	0.817	0.443
B_d	0.771	0.399
B_s	0.479	0.109
Baryons	0.616	0.049

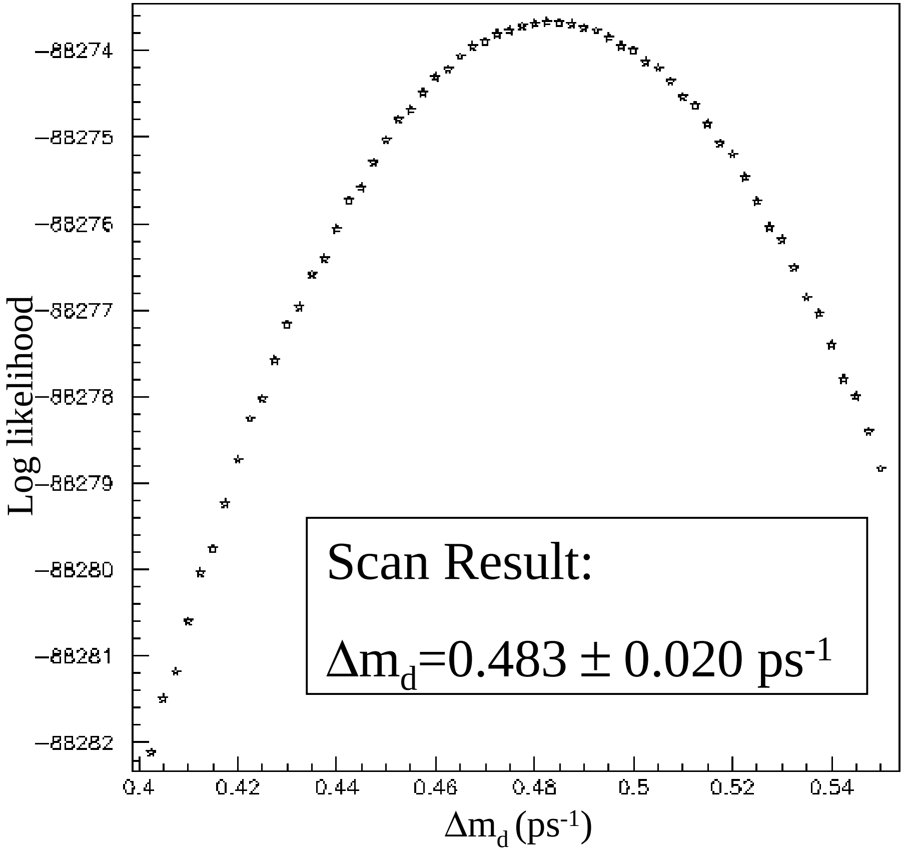
- *The eventual goal is to fit to the B_d RSF as well as Δm_d. This concept has been tested in Minuit on the Monte Carlo.*
- *To be included in the analysis, we require a hemisphere have at least one vertex with a kaon(s) attached and where the sum of the charges of those kaons is non-zero.*

Likelihood Scan Fit on Perfect MC



- $\Delta m_d = 0.484\ ps^{-1}$ in MC.
- Scan 100 Δm_d values evenly spaced from 0.40-0.55 ps^{-1}.
- $\Delta m_d = 0.485 \pm 0.002$ (33K B_d, no other types).

"Everything but Proper Time Resolution": MC

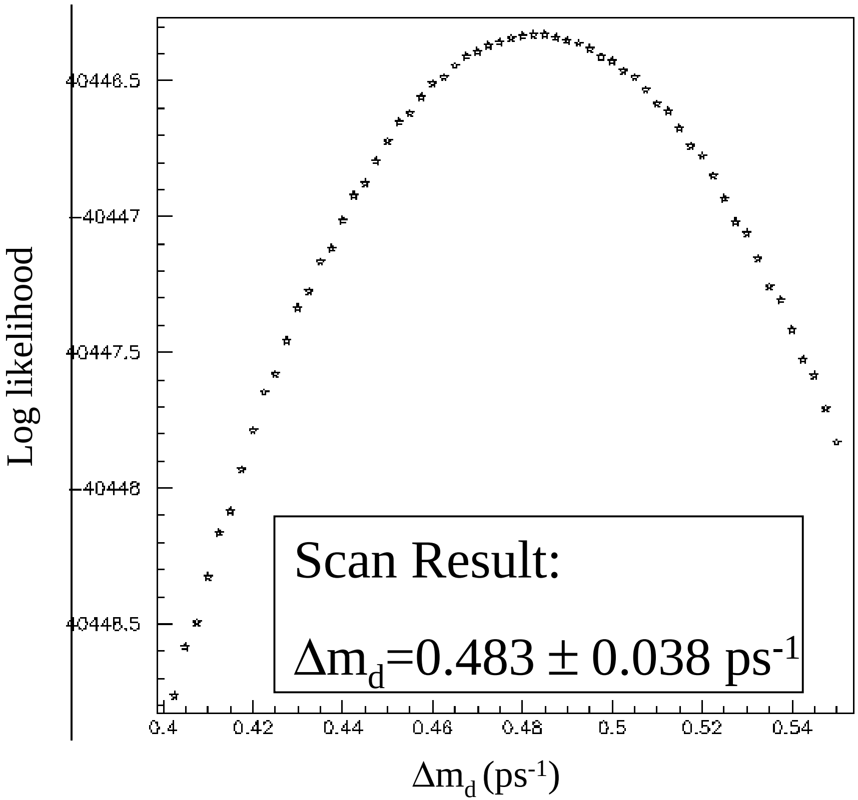


- Everything reconstructed, including proper time. BUT, the proper time is not parameterized for resolution effects.
- Scan uses 60 steps from 0.40-0.55 ps^{-1}.
- 42k usable vertices in sample.
- 1-D Minuit fit:

  $\boxed{\Delta m_d = 0.482 \pm 0.023\ ps^{-1}}$
- 2-D Minuit fit results:

  $\Delta m_d = 0.463 \pm 0.024\ ps^{-1}$
  RSF (B_d)=0.720 ±0.011

"Everything but Proper Time Resolution": Data



- Using 1997-98 R16: 20437 usable vertices.
- 1-D Minuit result:
  $\boxed{\Delta m_d = 0.483 \pm 0.036\ ps^{-1}}$
- 2-D Minuit result:
  (this work is in progess)

Plans and Conclusions

Plans:

- Get proper time parameterization (resolution function) working!!!
- Run 2-d fit for Data.
- Perform systematics studies.
- Be ready for DPF release.

Conclusions:

- The likelihood parameterization method works and does well for B_d mixing.
- It is feasible, using Minuit, to do a 2-D (or more) fit to eliminate the large systematic error from the kaon RSF in the previous version of this analysis.

With a lot of work and a little luck, we will be ready for DPF!!