Bs Mixing Analysis with the Fourier Method

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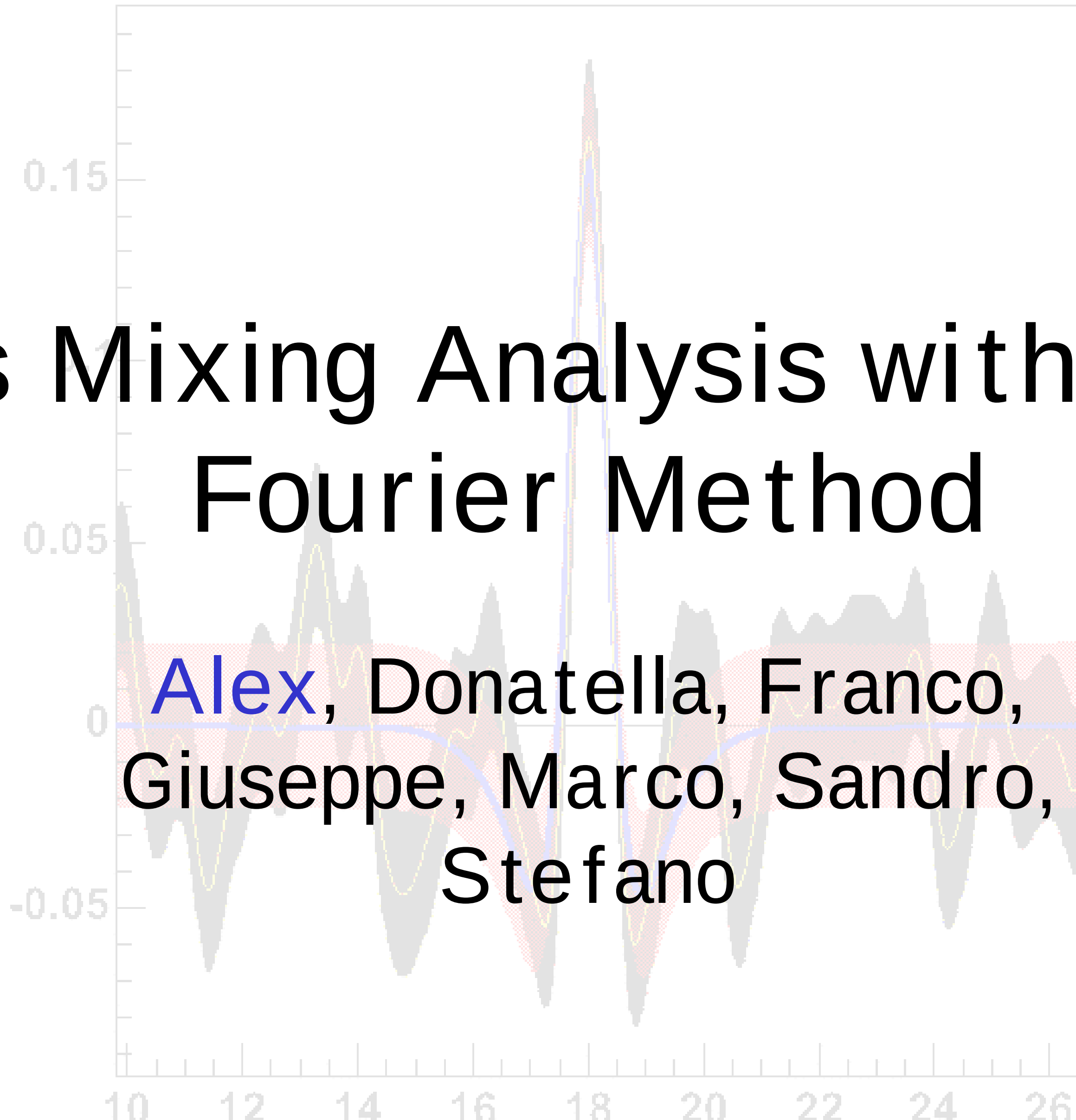


Contents

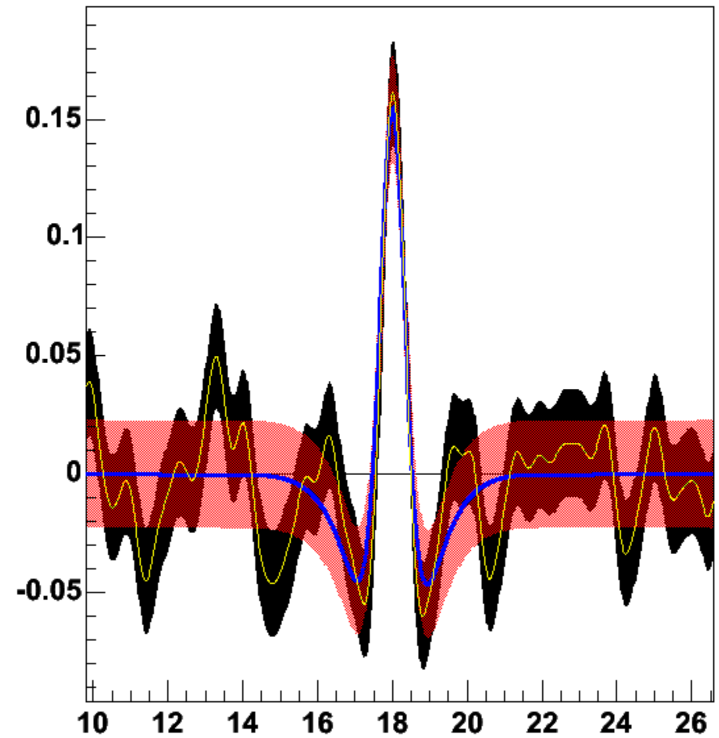
- Method
  - Quick basics
  - Improvements and clean-up
  - Connection with the amplitude scan
- (Few) toy examples
- Analysis plans
- Conclusions and outlook

The Method

- We are looking for a periodic signal: Fourier space is the natural tool
  - Even Moser and Roussarie mention this!
  - Amplitude approach is seen as an approximation of the Fourier transform
  - Amplitude from scan $\leftrightarrow$ Re[Fourier]
- Why not go for the real thing?
  - Computationally lighter
  - As powerful as A-scan
  - As is, no need *in principle* for measurements of D, ε etc. (however these ingredients add information and tighten the limit)

From the last episode...

- Re[fourier]
  - contains pretty much all the information
  - More convenient tool (linearity) than magnitude
- Re[F] and $\sigma_{Re[F]}$ can be computed directly from data!
- Sensitivity is qualitatively analogous to the amplitude scan (same dependencies)



News

- We are improving our toy simulation and "fitter" simultaneously and consistently:
  - Ct efficiency uses now same parameterization as A-scan analysis
  - Scale factor parameterized at our best (two components ~1 and ~1.7)
  - Homogeneously accommodate various samples with different properties (semileptonic vs hadronic, partially reconstructed vs fully reconstructed, etc.)
- Next logical step: compare with the amplitude fit!
- How? Aren't we looking at (slightly?) different quantities?

Amplitude from Fourier

- Most A-scan properties derived from this connection (Moser)

$$f(t) \xrightarrow{Fourier} F[w; \Delta m_{true}]$$

$$\boxed{\langle A(w) \rangle = \frac{\mathrm{Re}\left[F[w; \Delta m_{true}]\right]}{\mathrm{Re}\left[F_{theo}[w; \Delta m = w]\right]}}$$

☺ With the proper normalization Fourier gives A-scan plot!

😐 This additional step requires the same ingredients (D,ε etc.) of the traditional A-scan approach

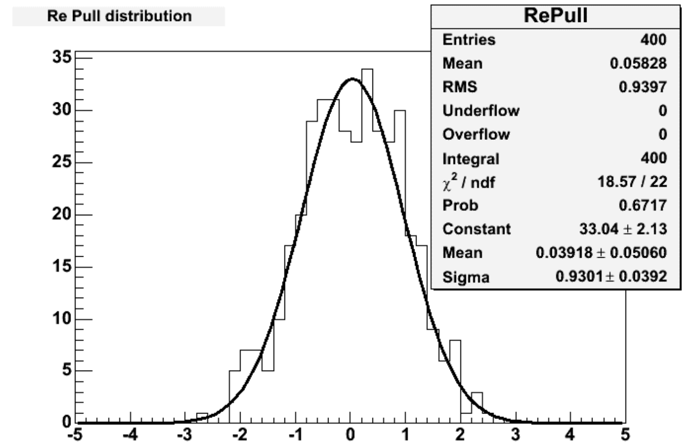
“Fitter” pulls

Same procedure as for a regular fit:

•Draw N events from toy model with known ε,D,S/B,Δm etc.

•“Measure” Re[F] and error

•Compute (Re[F]-exp.)/σ

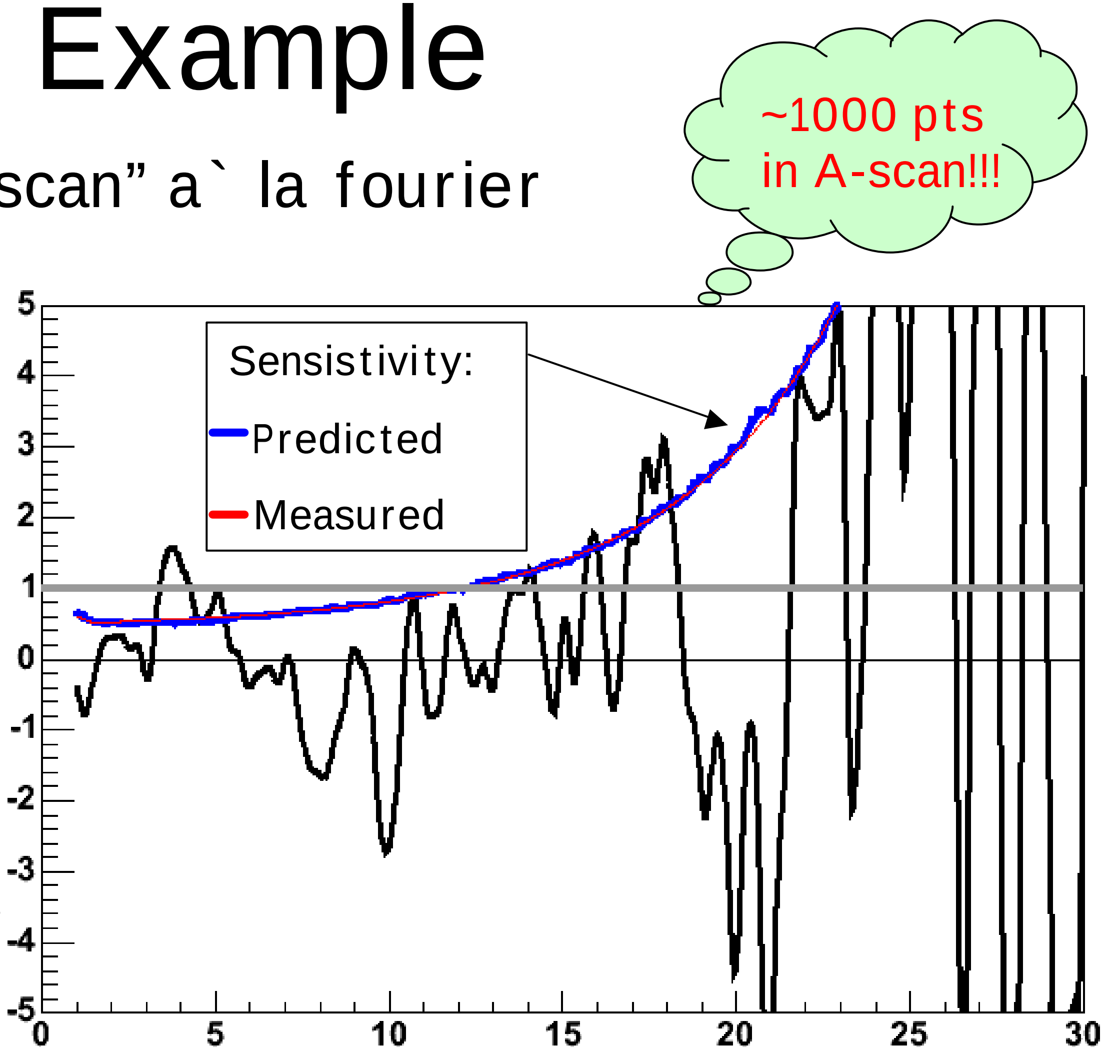


		BACKGROUND							SIGNAL				Pull(Re)		Pull(DRe)	
Ntoy	Omega	tot. Events	bias	Tag fb	fprompt	e	D	A	bias	Dms	e	D	mu	sigma	mu	sigma
400	1.	10000	off	1.	0.8	0.4	0.1	0.3	off	18.	0.4	0.2	0. +-0.05	1.04+-0.04	-0.03+-0.05	1.04+-0.04
400	18.	10000	off	1.	0.8	0.4	0.1	0.3	off	18.	0.4	0.2	-0.05+-0.05	0.96+-0.03	-0.04+-0.05	1.10+-0.04
400	25.	10000	off	1.	0.8	0.4	0.1	0.3	off	18.	0.4	0.2	-0.04+-0.05	0.96+-0.03	0.02+-0.05	1.02+-0.04
400	1.	10000	on	1.	0.8	0.4	0.1	0.3	off	18.	0.4	0.2	0.14+-0.05	0.99+-0.03	0.00+-0.05	1.05+-0.04
400	18.	10000	on	1.	0.8	0.4	0.1	0.3	off	18.	0.4	0.2	-0.03+-0.05	1.02+-0.04	0.09+-0.05	0.99+-0.03
400	25.	10000	on	1.	0.8	0.4	0.1	0.3	off	18.	0.4	0.2	-0.02+-0.05	0.95+-0.03	0.01+-0.05	0.96+-0.03
400	1.	10000	off	0.	0.8	0.4	0.1	0.3	off	18.	0.4	0.2	-0.06+-0.05	1.01+-0.03	-0.06+-0.05	1. +-0.03
400	18.	10000	off	0.	0.8	0.4	0.1	0.3	off	18.	0.4	0.2	0.11+-0.05	1.03+-0.04	0.05+-0.05	0.94+-0.03
400	25.	10000	off	0.	0.8	0.4	0.1	0.3	off	18.	0.4	0.2	-0.02+-0.05	1.1 +-0.04	-0.09+-0.05	0.99+-0.03
400	1.	10000	off	0.	0.8	0.4	0.1	0.3	on	18.	0.4	0.2	0. +-0.05	0.98+-0.03	-0.04+-0.05	1.05+-0.04
400	18.	10000	off	0.	0.8	0.4	0.1	0.3	on	18.	0.4	0.2	0.05+-0.05	1.03+-0.04	-0.03+-0.05	1.02+-0.04
400	25.	10000	off	0.	0.8	0.4	0.1	0.3	on	18.	0.4	0.2	0.15+-0.05	1.02+-0.05	0.10+-0.06	1.07+-0.05
400	1.	10000	on	1/3	0.8	0.4	0.1	0.3	on	18.	0.4	0.2	-0.03+-0.05	0.97+-0.03	-0.03+-0.05	1. +-0.03
400	18.	10000	on	1/3	0.8	0.4	0.1	0.3	on	18.	0.4	0.2	0.08+-0.05	0.99+-0.03	-0.09+-0.05	1.07+-0.04
400	25.	10000	on	1/3	0.8	0.4	0.1	0.3	on	18.	0.4	0.2	0.16+-0.05	1.08+-0.04	-0.01+-0.05	0.99+-0.03

Example

"A-scan" a` la fourier

- 1000 toy events
- Δm_s=18
- S/B=2.
- εD_{signal}^2=1.6%
- εD_{back}^2=0.4%
- Background and signal parameterized according to standard analyses
- σ_{ct}=0.0927 (fixed, including 1.44 S.F.)

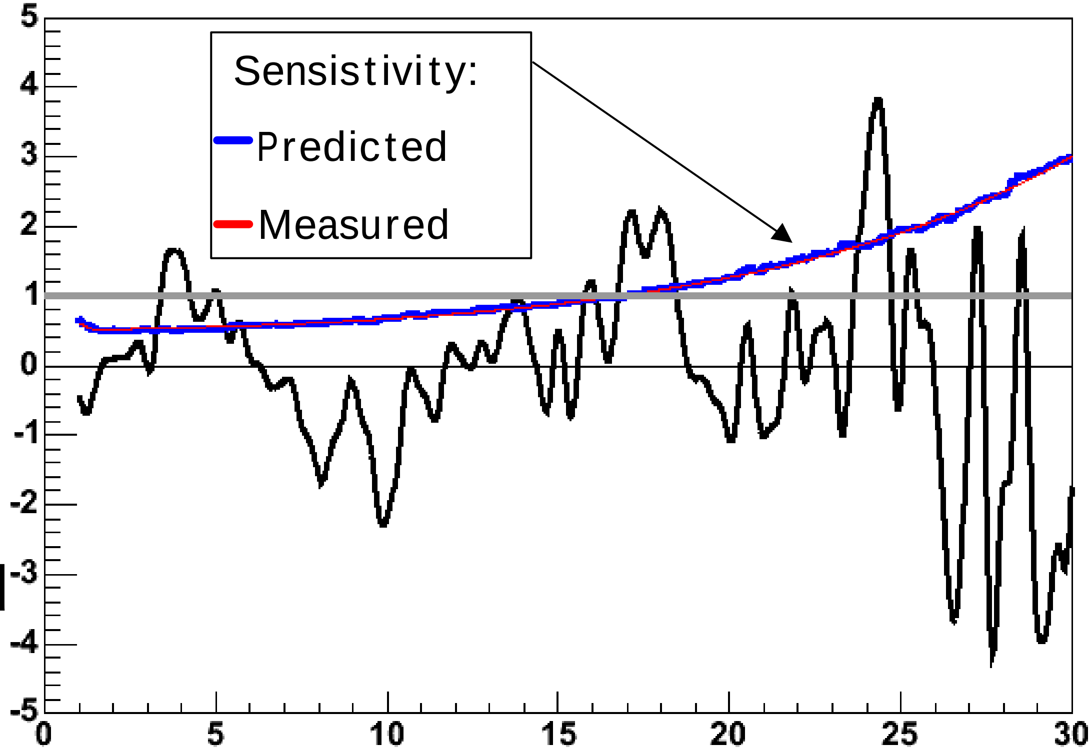


Impressively close to our standard toy A-scans!

Example

"A-scan" a` la fourier

- 1000 toy events
- Δm_s=18
- S/B=2.
- εD_{signal}^2=1.6%
- εD_{back}^2=0.4%
- Background and signal parameterized according to standard analyses
- Histogrammed σ_{ct}
- Best knowledge on SF parameterization



This method allows to flexibly study these possibilities (and systematics!) in a matter of minutes!

What's next?

- Obtain from the same toy A-scan histogram and compare point by point
- Further refine our toy model: EbE dilution etc.
- Final proof of principle:

Process data from last round of analyses and show consistent picture with standard A-scan

- Machinery for systematics (toy + ?)
- B_d Mixing!

Plans for our method

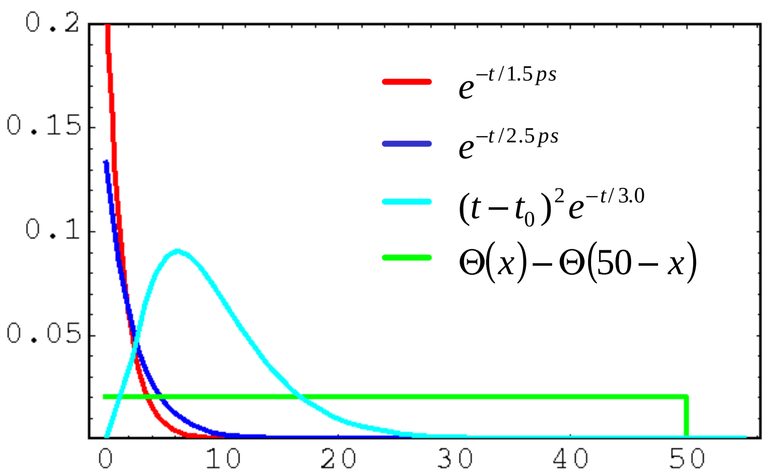
- Prove viability of our method:
  - Full semileptonic and hadronic samples
  - Same taggers and datasets as latest blessed A-scans
  - Compare results to our method
  - Will be ready on time for winter conferences
- Extend:
  - $1fb^{-1}$
  - All possible modes
  - State of the art taggers
  - We will have a full analysis by Summer conferences

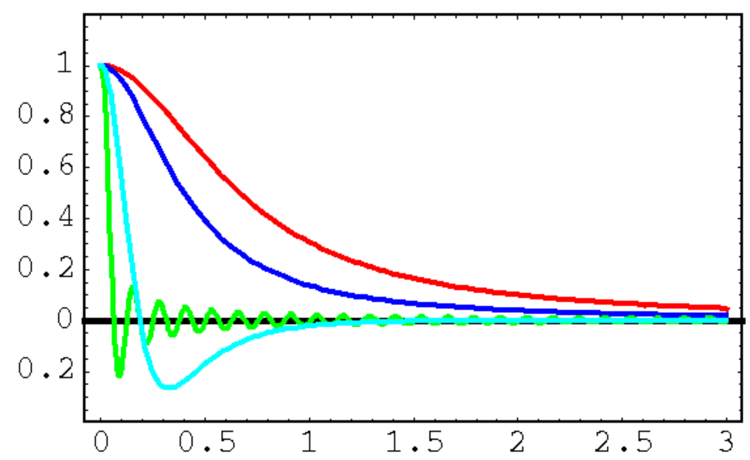
Backup

Asymptotic Behavior

$$\{t_1,\ldots,t_N\} \rightarrow G(w) \equiv \sum_{i=1}^{N} e^{-iwt_i} \qquad \langle G(w) \rangle = F[r]$$

$$F[f(t) \otimes g(t)] = F[f] \times F[g] \qquad F[f(t) \times g(t)] = F[f] \otimes F[g]$$





- Wider time distributions↔narrower in f-space
- Convolution with narrow distributions in F-space is “small correction” on top of wide ones