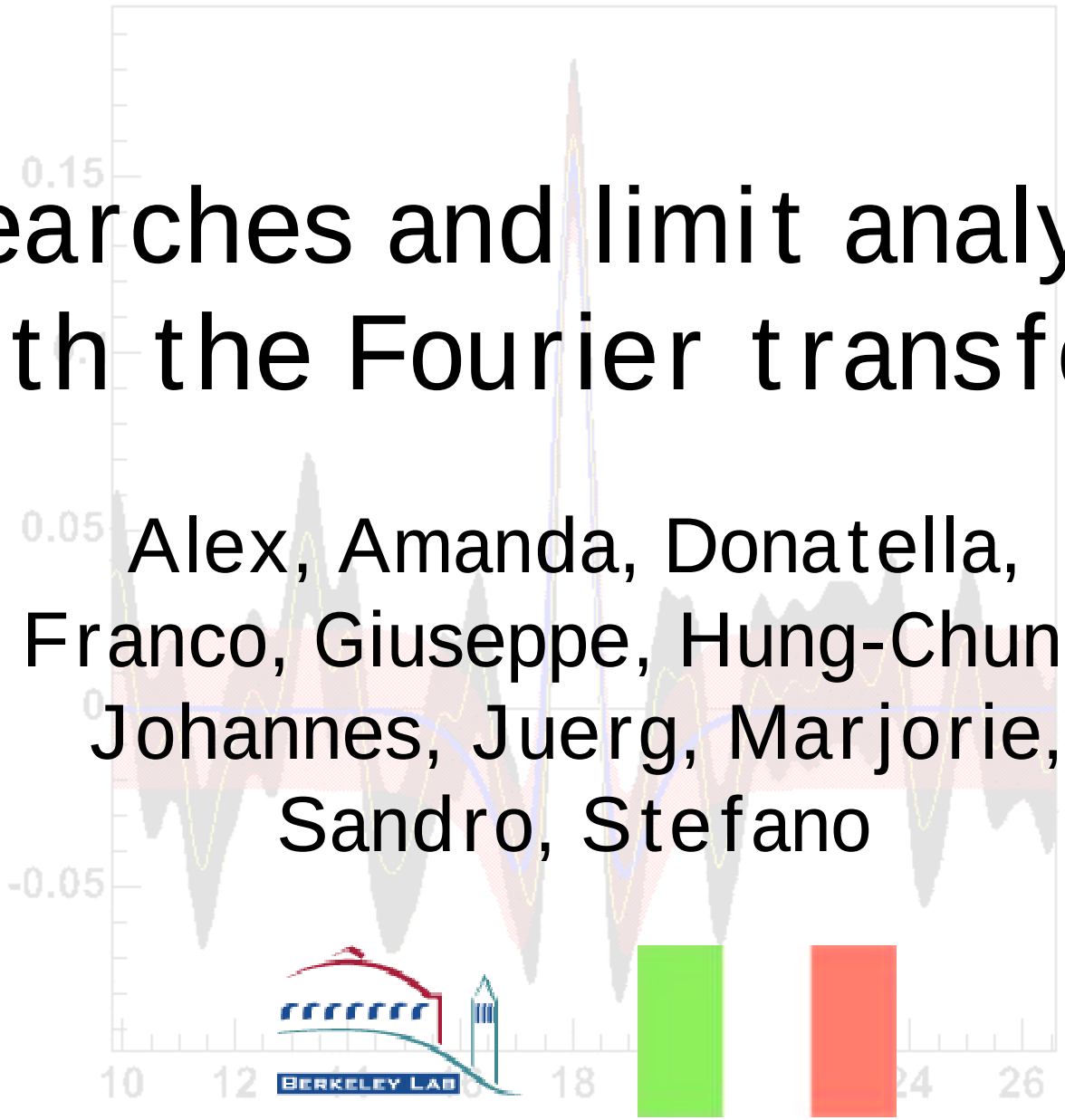
Searches and limit analyses with the Fourier transform

Alex, Amanda, Donatella,
Franco, Giuseppe, Hung-Chung,
Johannes, Juerg, Marjorie,
Sandro, Stefano



Outline

- Reminder of method
- Example
- Task list
- Status:
  - "Fitter"
  - More details on individual issues in other talks:
    - Mass fit (Hung-Chung)
    - Extraction of ct curves (Amanda)
    - σ_{ct} scale factor (Aart, Amanda)
    - Samples & Skimming (Marge)

The Method

- We are looking for a periodic signal: Fourier space is the natural tool
  - Moser and Roussarie already mentioned this!
  - They use it to derive the most useful properties of A-scan
  - Amplitude approach is approximately equivalent to the Fourier transform

    Amplitude from scan $\leftrightarrow$ Re[Fourier]
- Aim: move to Fourier transform based analysis
  - 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)
  - Will provide an alternate path to the A-scan result!

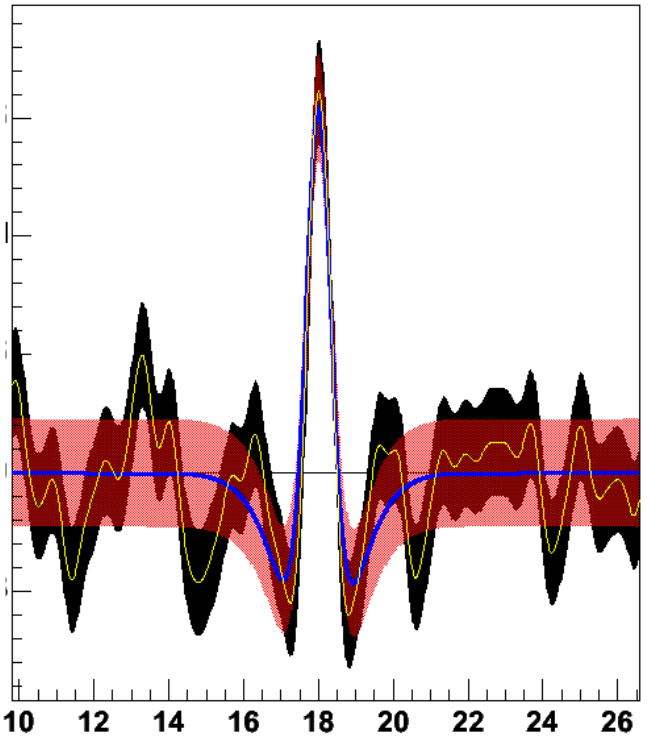
Dilution weighted transform

- Discrete Fourier transform definition
  - Given N measurements $\{t_j\}$ → $g(w)=\sum_{k=1}^{N} D_k e^{-iwt_k}$
- Properties:
  - A particular application of $g(w)=\sum_{k=1}^{N} w_k e^{-iwt_k}$ (CDF8054)
  - Average: $\langle g(w)\rangle = N\langle D\rangle \tilde{f}(w)$

    (f(t) is the parent distribution of $\{t_j\}$)
  - Corresponds to dilution-weighted Likelihood approach
  - Errors computed from data: $s^2(\mathrm{Re}\, g(w)) \approx N\left(\langle D^2\rangle + o\left(\frac{1}{N}\right)\right)$
    - NB: Errors can be calculated directly from the data!
    - $\Delta(w) \equiv g_{\mathrm{UnMix}}(w) - g_{Mix}(w)$ behaves "as you'd expect"
    - While Δ and its uncertainty are fully data-driven, predicted Δ requires exactly the same ingredients as the amplitude scan fit

Properties of Δ...

- Re[Δ]
  a) contains all the information of the standard amplitude scan
  b) Amplitude scan properties are mostly derived assuming: (Amplitude scan)≈Re[Δ]
- Re[F] and $\sigma_{Re[F]}$ can be computed directly from data!
- b) ⇒ Sensitivity is exactly:



$$\frac{\Delta(w=\Delta m_s)}{s_\Delta} = \sqrt{Ne\langle D\rangle^2}\sqrt{\frac{S}{S+B}}e^{-\Delta m^2 s_{ct}^2/2}\sqrt{1+\frac{s_D^2}{\langle D^2\rangle}}$$

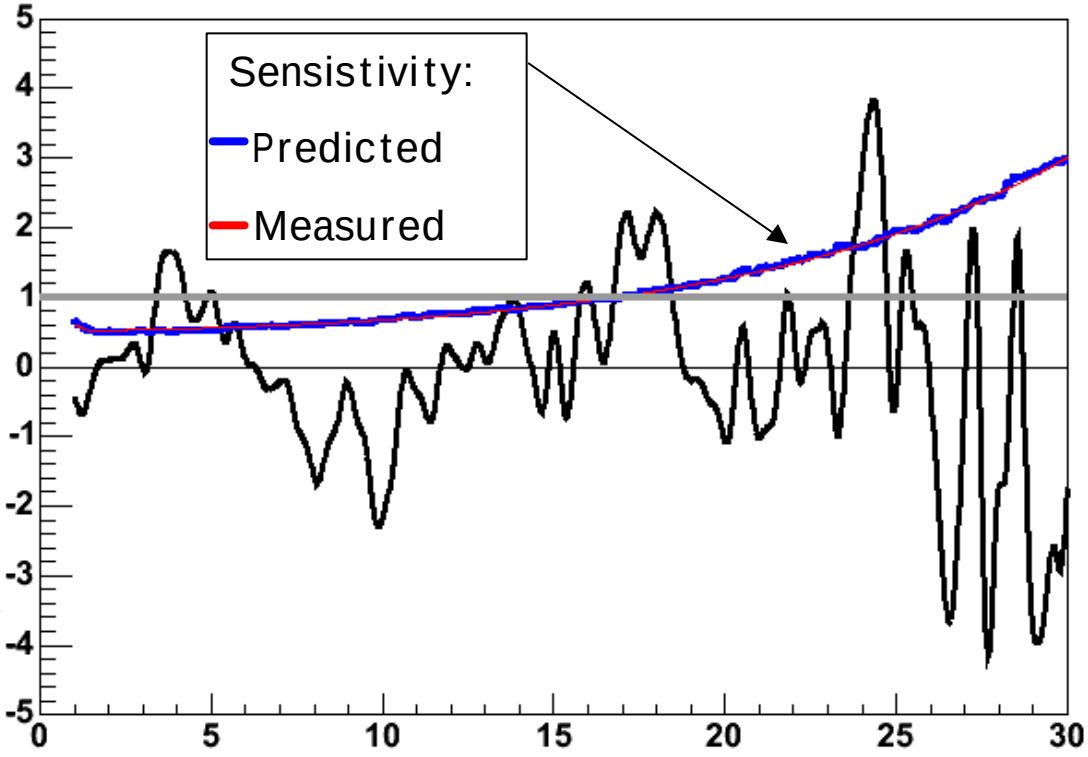
Can we reproduce the A-scan itself?

Toy Example

"A-scan" a` la fourier

$$\frac{\Delta(w)}{pred.\Delta(w;\ \Delta m_s = w)}$$

- 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



No actual fit involved: this method allows to flexibly study systematics!

Plans for our method

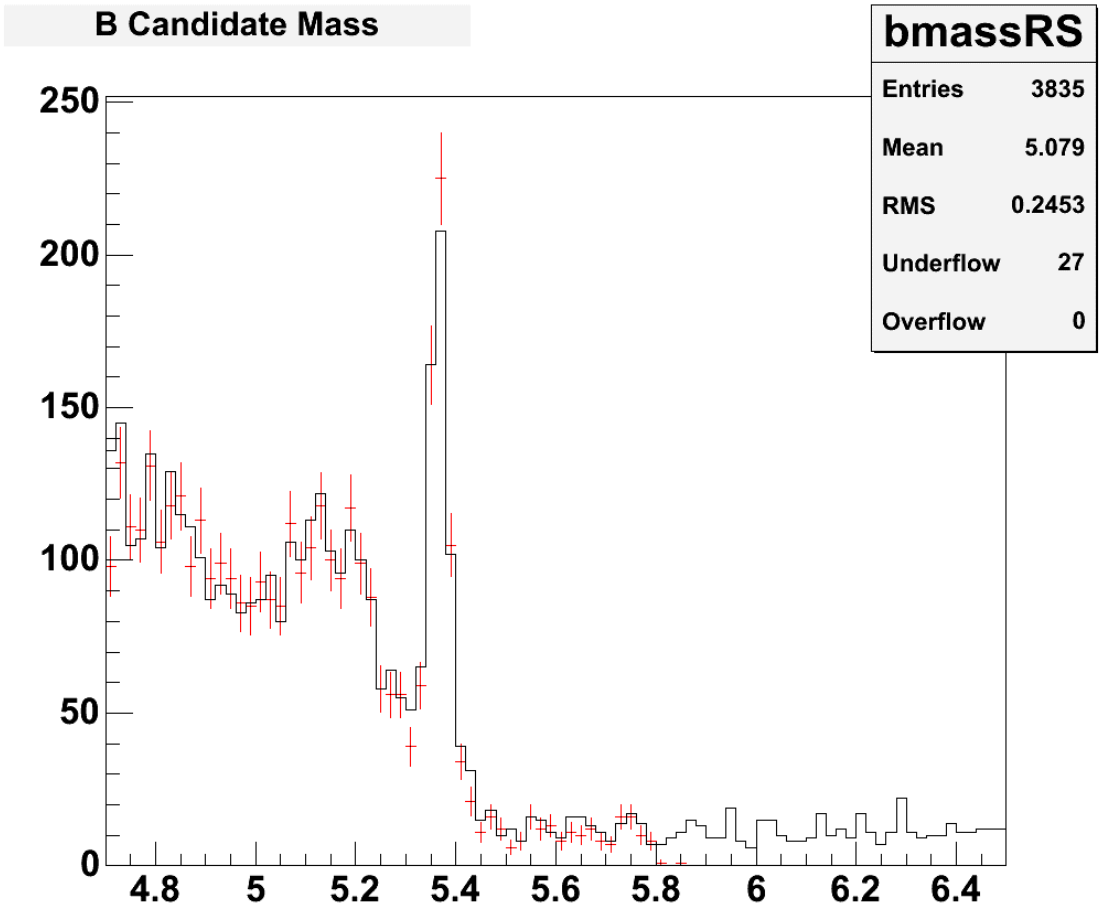
- Final proof of principle:

  Process all data from last round of analyses and show consistent picture with standard A-scan
- 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:
  - $1 fb^{-1}$
  - All possible modes
  - State of the art taggers
  - We will have a full analysis by Summer conferences

Ntuples & Skim

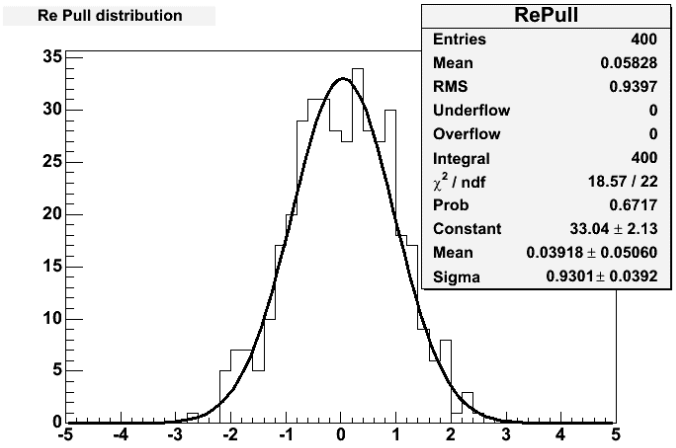
All modes being analyzed, started from the easiest for cross checks

- Old sample used as benchmark, based on last round of mixing results
- Satisfactory comparison so far (see histogram on right)
- Minor discrepancies:
  - Missing upper mass sideband: will fix
- Ready for prime time!
- (you'll see results on new data from Marge & Amanda)

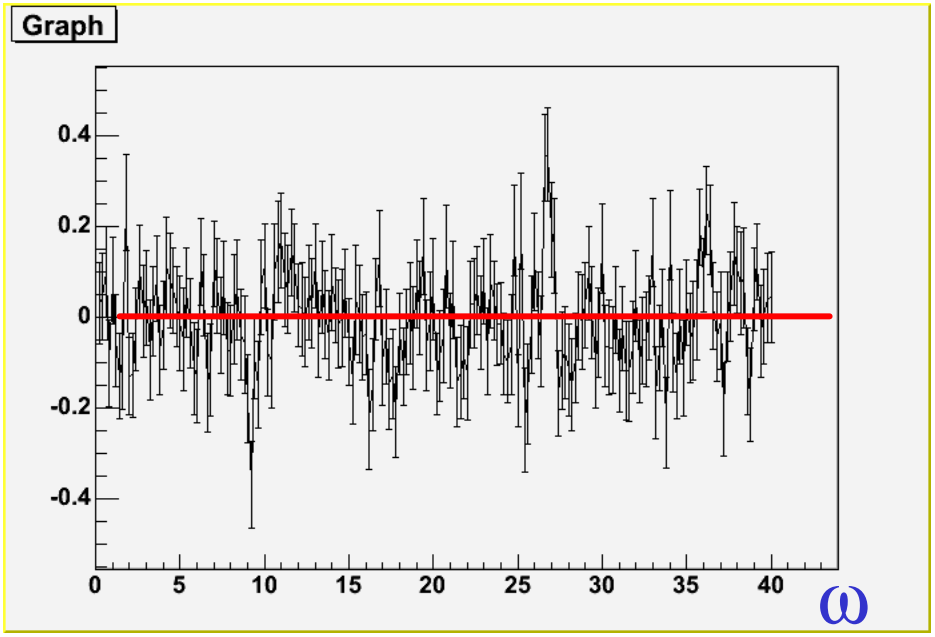


Fitter Status

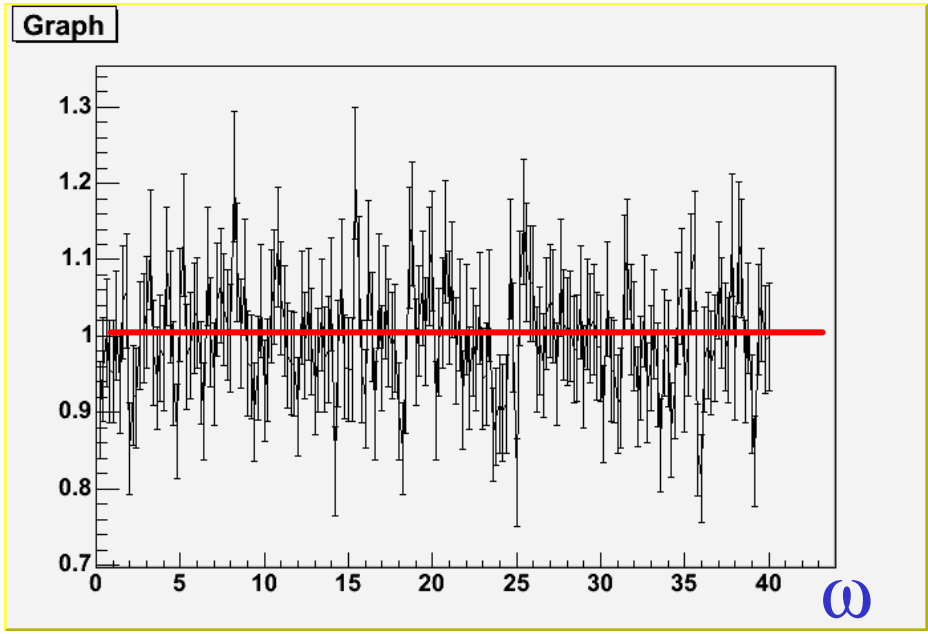
- "Fitter" fully implemented
- Provided in the same consistent framework:
  - Data processing
  - Toy MC generation
  - Bootstrap extraction
- Combination of several samples



Pulls Mean vs ω

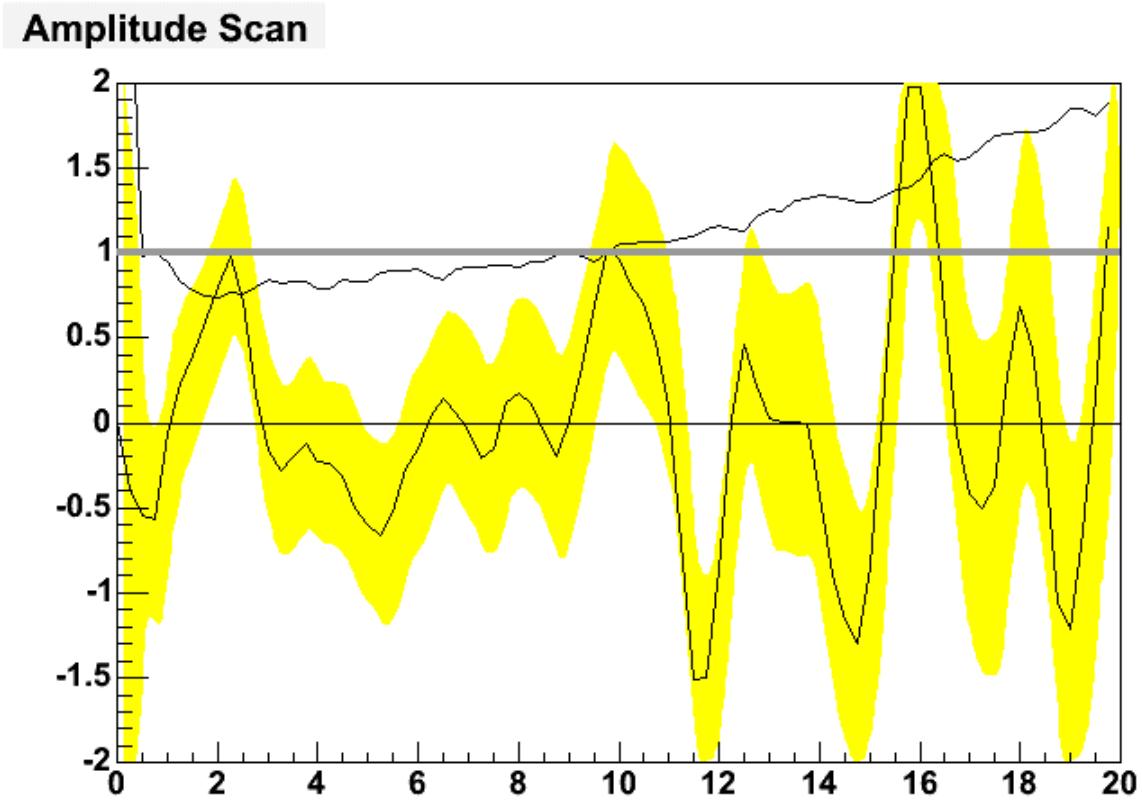


Pulls σ vs ω



Fitter performance: Amplitude scan on old data

- $D_s[\phi\pi]\pi$ alone
- All taggers included
- Already unblinded (355 pb^{-1})
- Model (D, σ_{ct} etc.) from the same sample



- Fitter works!
- Next steps:
  - Infrastructure to combine samples (almost ready)
  - Point-by-point comparison with a 'fitted' amplitude scan

Clean up and move to semileptonics!

Tasks

(my view, still being finalized not yet endorsed/discussed)

1) Data [Donatella, MDS, Stefano]
   - Skimming, event by event comparison with MIT sample [Donatella, Marjorie] **See Marge's talk**
   - MC [Hung-Chung+JHU] **See HC's talk on mass fits etc.**
   - Ntuples [Johannes, Giuseppe]
2) Reco: [Alex, MDS, Stefano]
   - Optimize selections [Alex, MDS]
   - New channels (new modes, partially reconstructed) [Alex, MDS]
3) Basic tools: [Stefano, Alex, MDS, Giuseppe, Johannes]
   - PID [Stefano]
   - Vertexing (understand resolutions etc.) [Alex, Amanda, MDS]
   - new taggers? (OSKT, SSKT...) [Giuseppe, Johannes]
   - Efficiency curves [Amanda]
   - Ct resolution & scale factors [Alex, Amanda, Marge] **See Amanda's talk**
4) Fourier "fitter" [Alex, Franco]
   - Toy MC [Alex, Franco] **This talk**
   - Tool for data Analysis (from ct, sigma, D, etc. to "the plot") [Alex, Franco]
5) Semileptonic Analysis [Alex, Sandro]
   - Spring Analysis: reproduce the MIT result
   - Summer Anal.: - full 1 fb^{-1} indipendent analysis
6) Hadronic Analysis (same as 5)

   [Alex, Amanda, Giuseppe, Hung-Chung, Stefano]
7) Combine Analyses [Alex]

Conclusions

- This is an AGGRESSIVE PLAN
- Good progress in the last 2 months
- We need to keep going, faster?
- We want to have
  - Reproduce blessed results by March (Moriond)
  - independent results by the summer!