

Nikhef NMO analysis and RooFit

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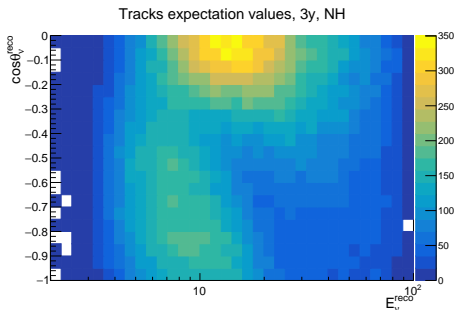
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Fit model in the context of NMO analysis

A fit model $f = f(E, \cos\theta, By, \sin^2\theta_{ij}, \delta_{cp}, \Delta m_{ij}^2)$:

- 1 Provides N_{expected} for each bin for given observables ($E, \cos\theta, By$) and parameters ($\sin^2\theta_{ij}, \delta_{cp}, \Delta m_{ij}^2$).
- 2 Technically, is wrapped in TF3 in ROOT and a custom pdf in RooFit.



ROOT vs RooFit principle

Why bother with RooFit?

- A lot of stuff for free.
- Particularly, very easy to setup and extend the simultaneous fitting of several histograms (tracks, showers, ...).

In ROOT, fit function returns:

$$\text{return} = N_{\text{expected}} \quad (1)$$

In RooFit, fit function is converted to PDF, i.e:

$$I = \int dE d(\cos \theta) d(By) f(E, \cos \theta, By, \sin^2 \theta_{ij}, \delta_{cp}, \Delta m_{ij}^2) \quad (2)$$

is required for normalisation each time the parameters change.

RooFit default

By default, RooFit tries to perform numerically:

$$I = \int dE d(\cos \theta) d(B_y) f(E, \cos \theta, B_y, \sin^2 \theta_{ij}, \delta_{CP}, \Delta m_{ij}^2) \quad (3)$$



Figure: RooFit choking on numeric integration.

Escape: tell RooFit how to integrate analytically =
`hExpectation->Integral()`.

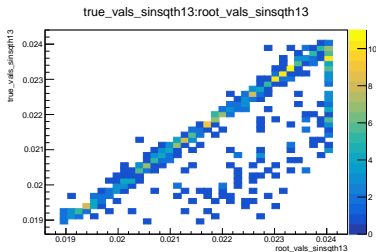
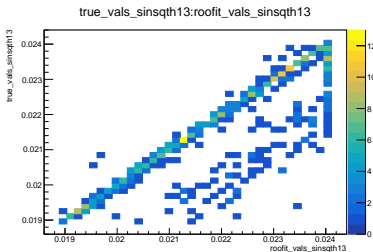
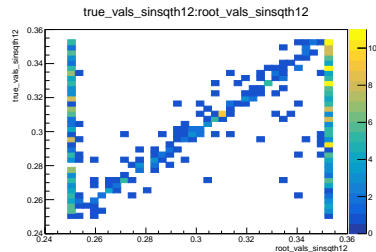
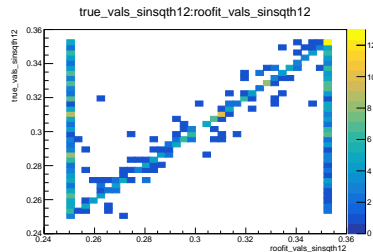
Root vs RooFit performance

Procedure:

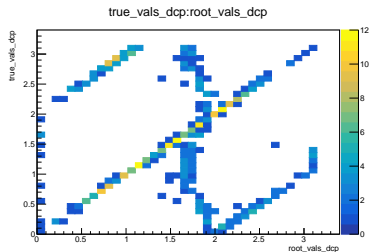
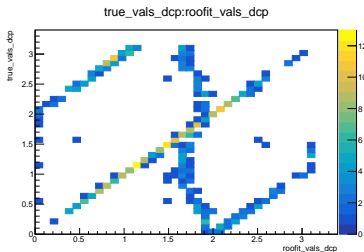
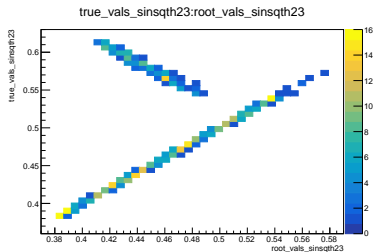
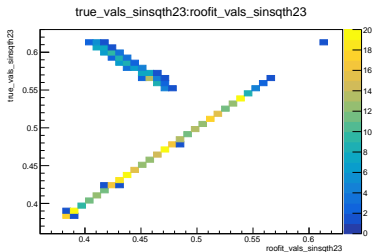
- 1 Randomize oscillation parameters.
- 2 Create expectation value plot. NB: No Poisson-smearing!
- 3 Set parameters to central values, fit with RooFit and ROOT.
NB: Tracks only!

Purpose: check that I have understood the role of integration correctly in RooFit and results are “reasonable”.

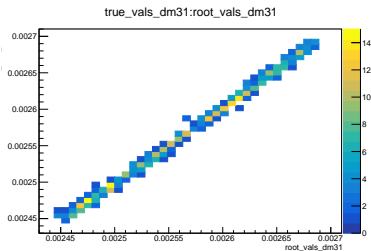
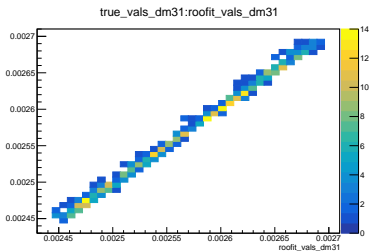
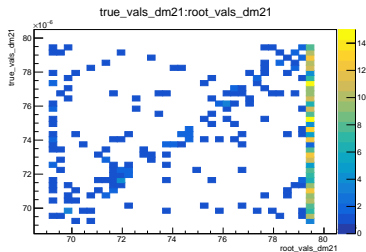
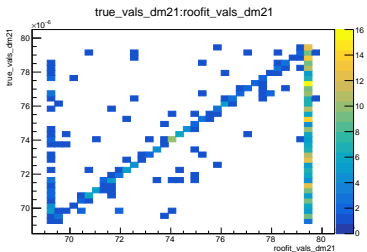
Root vs RooFit performance



Root vs RooFit performance



Root vs RooFit performance



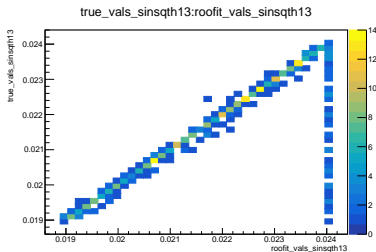
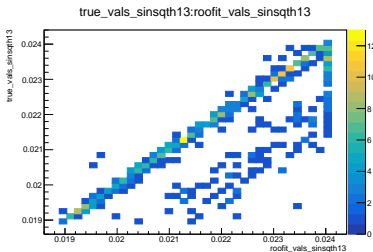
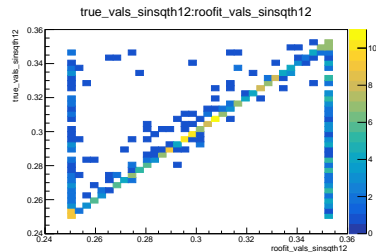
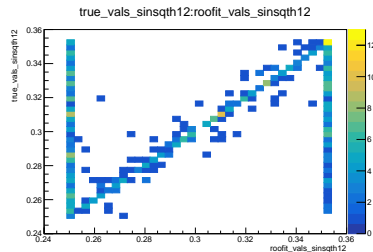
Root vs RooFit performance

Conclusions:

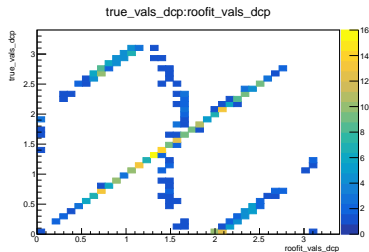
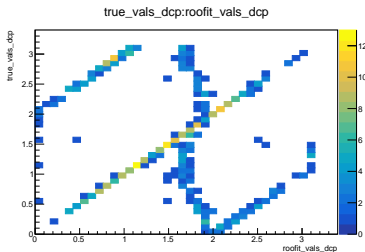
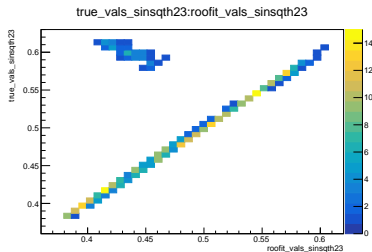
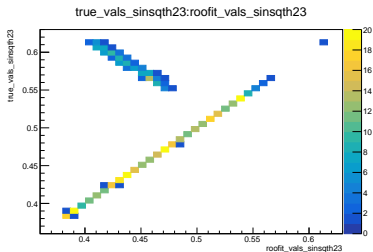
- 1 Results quite similar - some parameters slightly better in ROOT, some slightly better with RooFit.
- 2 Phenomenological computing - kind-of works, but I would still like to understand a few details better.

Now compare simultaneous fit of tracks and showers with a fit only to tracks.

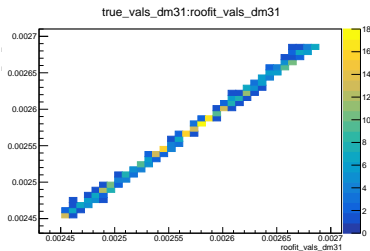
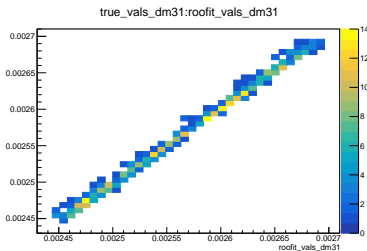
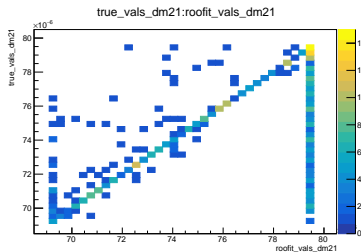
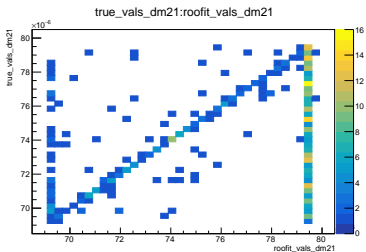
Tracks vs Tracks&Showers



Tracks vs Tracks&Showers



Tracks vs Tracks&Showers



Tracks vs Tracks&Showers

Conclusions and remarks¹:

- 1 Fitting both tracks and showers instead of tracks only improves the accuracy.
- 2 Reasonably sensitive to $\sin^2 \theta_{23}$, $\sin^2 \theta_{13}$, Δm_{31}^2 .
- 3 Relatively insensitive to $\sin^2 \theta_{12}$, Δm_{21}^2 , δ_{cp} .
- 4 Performance will degrade once Poisson statistics is accounted for.

¹already well known or trivial