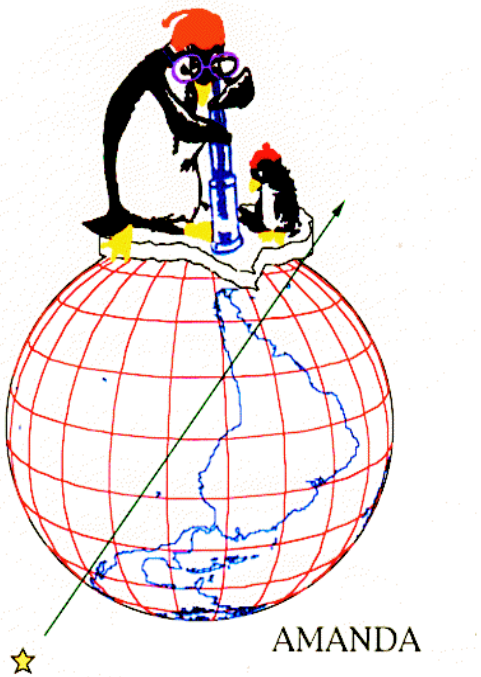
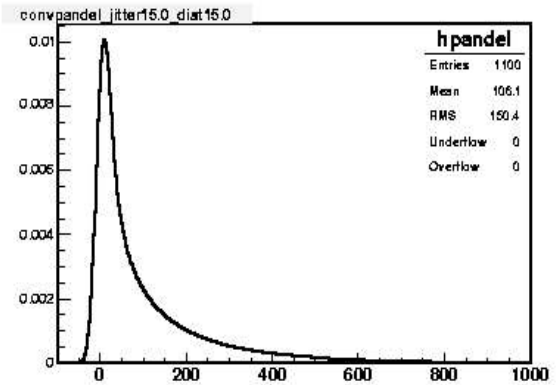
Towards inclusion of inhomogeneous ice in reconstruction of UHE events with TWR

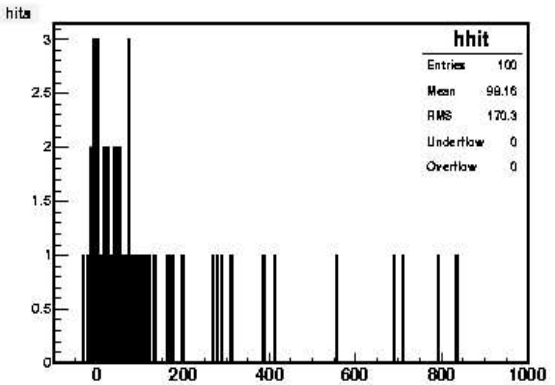


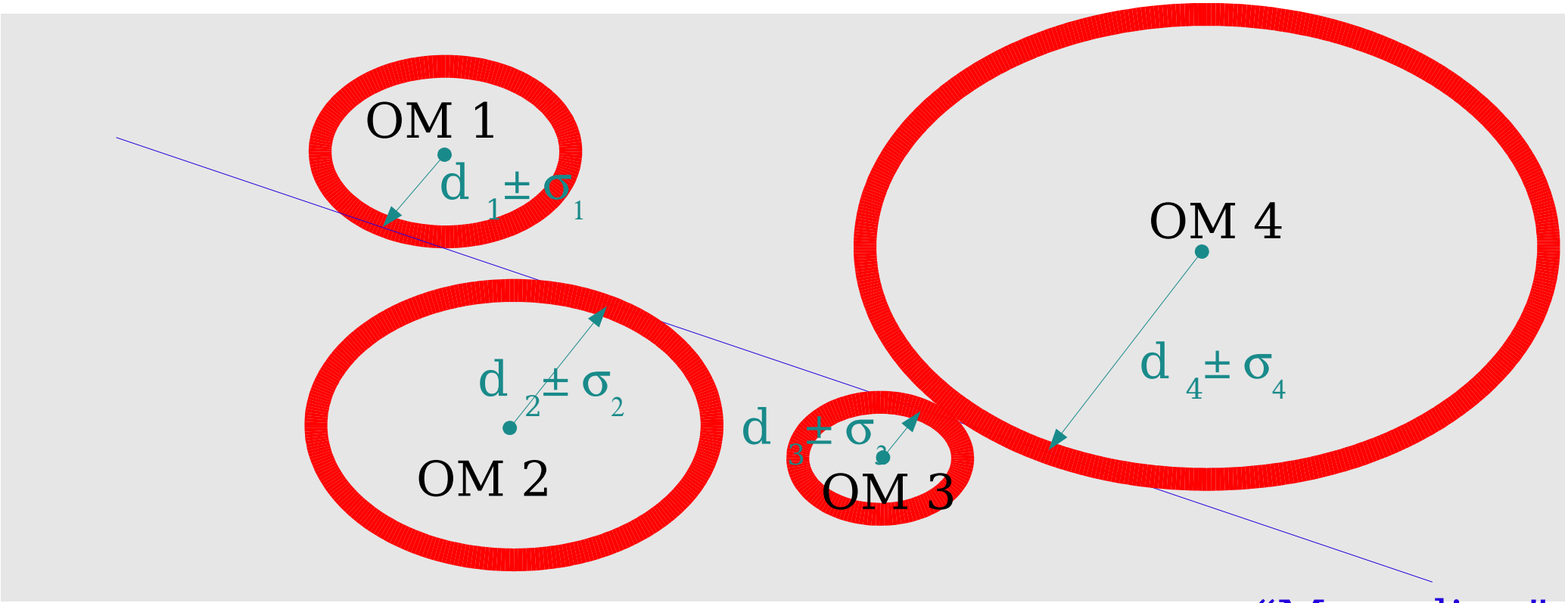
Thierry Castermans, Mathieu Ribordy
University of Mons-Hainaut
Belgium

This reconstruction = fit of time distributions of hits with PDF to get distances $d \pm \sigma_d$ between each OM and the track;

Then 3D linear regression to get the track.







Toy MC (Mons collaboration meeting):

Promising results:

5 hits ==> σ_{15m} ~ 8 m ==> 0.5°/sqrt(nch)/L[km] on a lever arm of L

* Toy fit is an ideal view of the problem, based on 2 assumptions:

1) All the hits are resolved, and are physical (no fake; no afterpulse, ...)

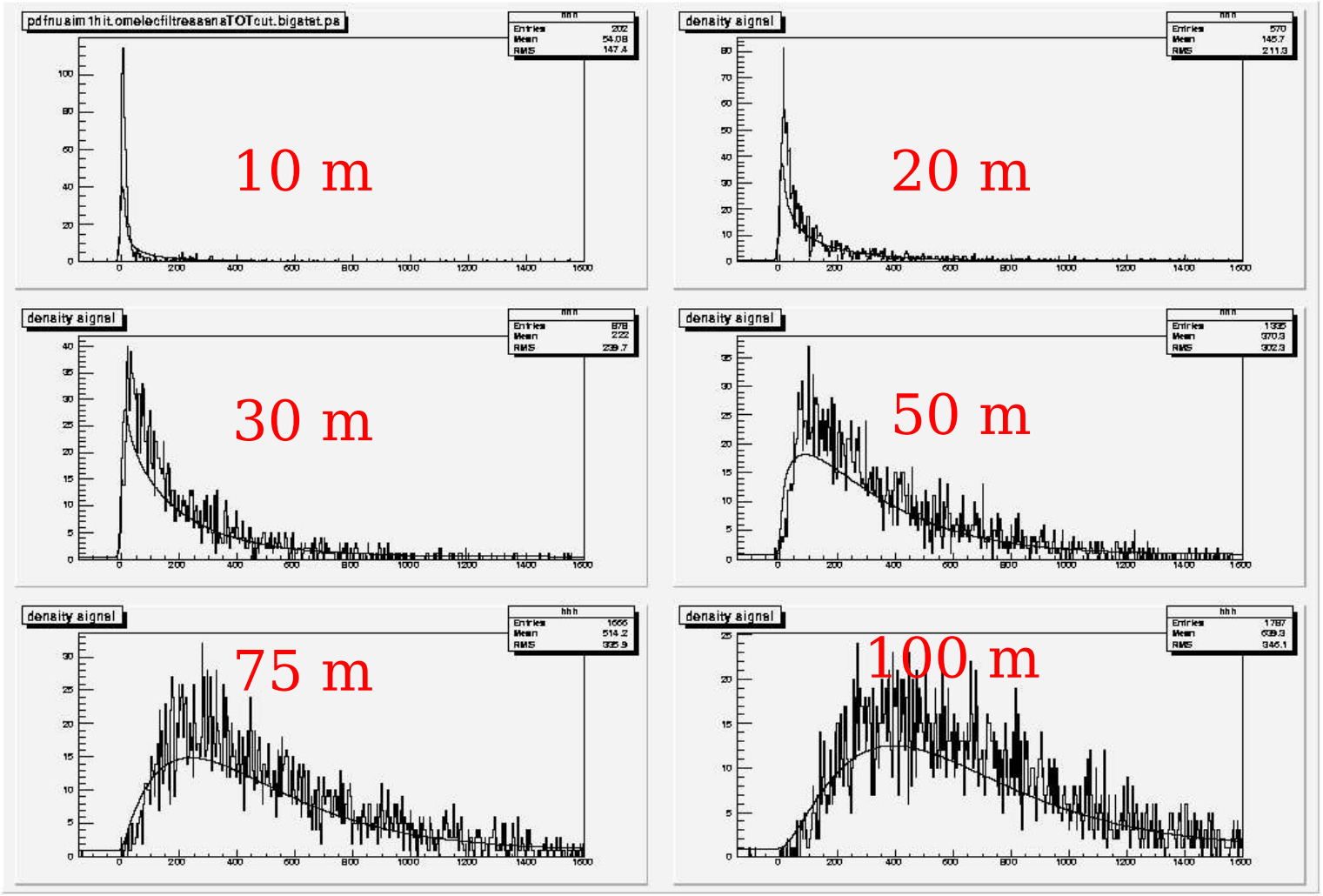
2) Pandel PDF describes correctly the distribution of residual times

Tests with NUSIM μ-DAQ MC events

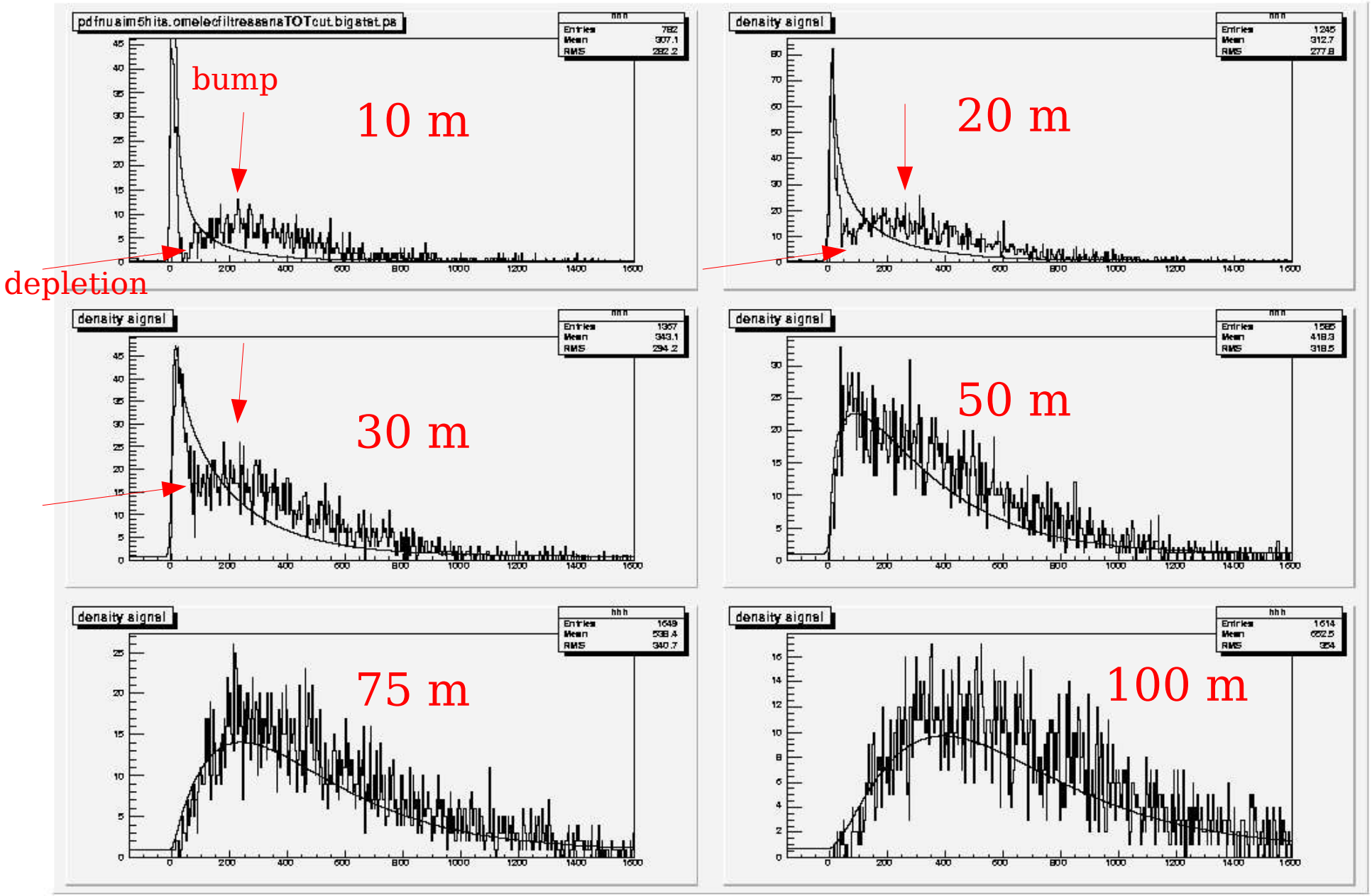
IT DOESN'T WORK !

WHY? ==> Let's compare residual times distributions and Pandel fct

a) OM's with exactly 1 hit ; electrical channels filtered



b) OM's with exactly 5 hits ; electrical channels filtered



Conclusions for nusim and muon-DAQ

- Residual times distributions based on OM's with only 1 hit are compatible with the analytical Pandel function (no bias or saturation)

- When OM's are hit several times, information is lost (1st hit detected, then depletion -detector blind- followed by bump) Response of the detector doesn't correspond to Pandel function anymore (up to ~ 40 – 50 m) (convolution of TOT distribution with n photons)

- At large distances, hits are more easily and completely recorded and resolved (Pandel function much less steep)

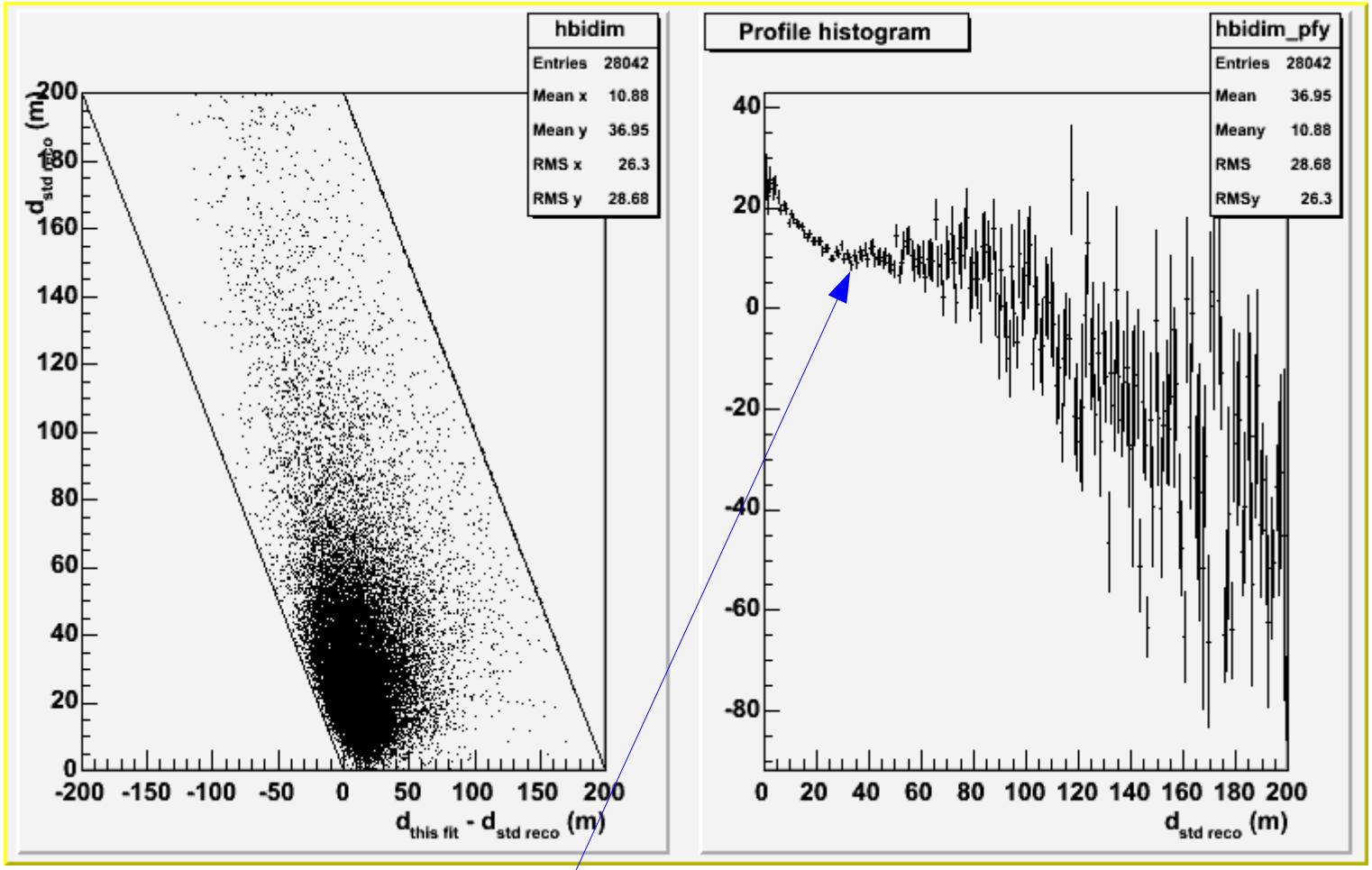
--> explains why the method didn't work in this case...

TWR experimental data

Assumption: std lkhd 16-iterative reco gives correct tracks !

Comparison ($d_{this\ fit}$ - $d_{std\ reco}$) vs $d_{std\ reco}$

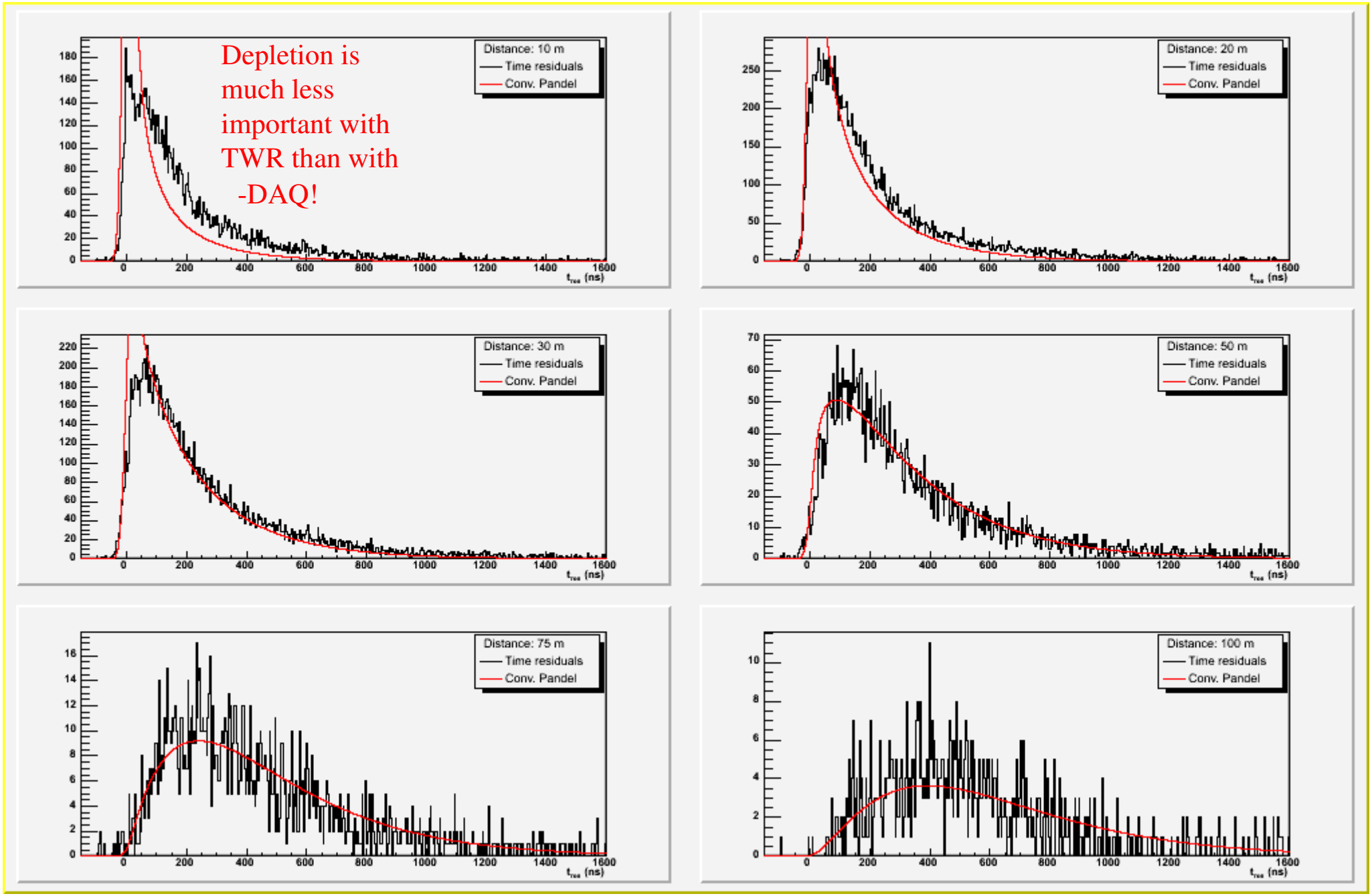
5 hits; TOT < 100 ns; only optical channels (sharp signals)



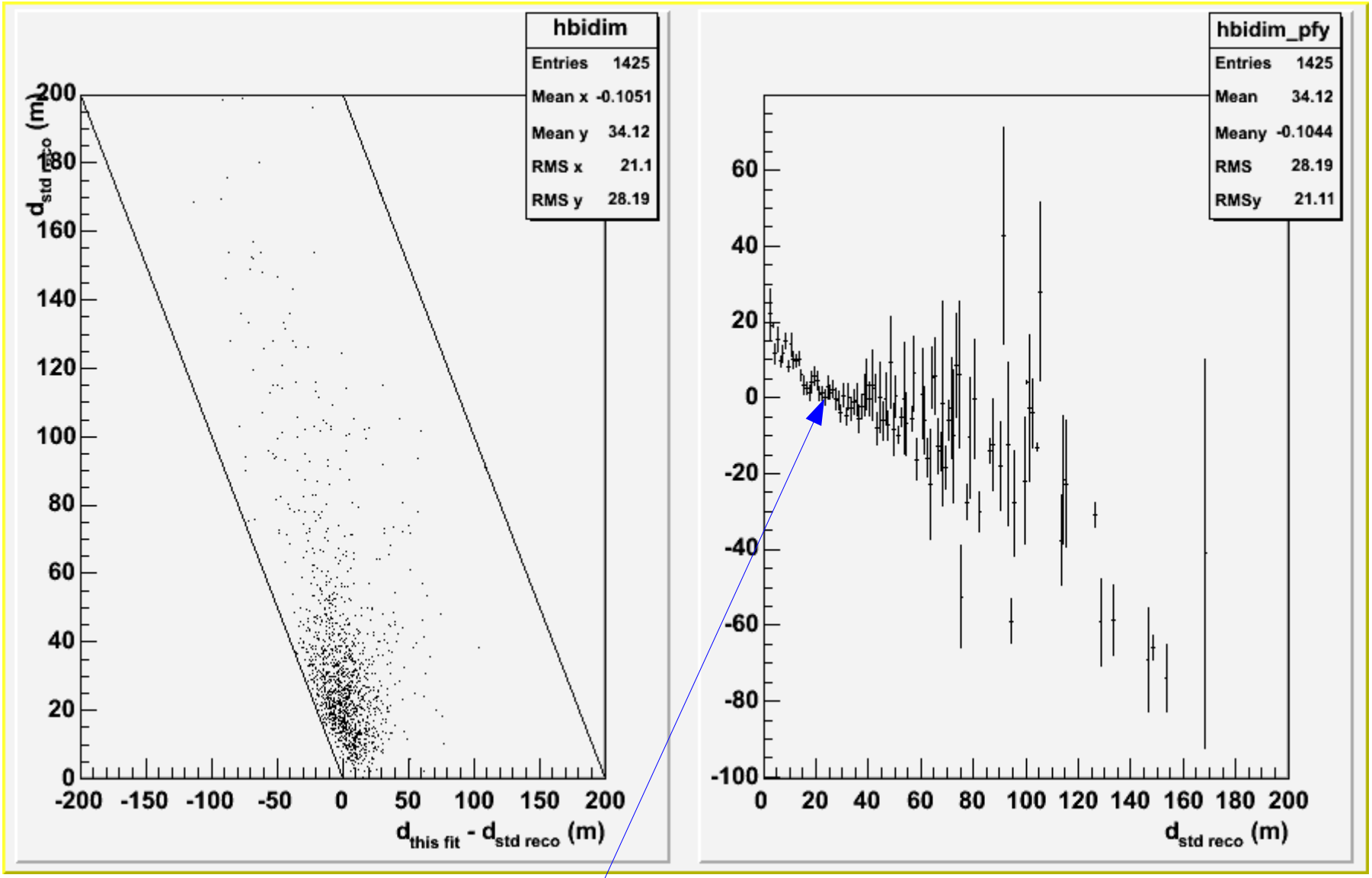
There is information, but shift!

Std lkhd 16-iterative reco

5 hits – TOT < 100 ns; only optical channels (sharp signals)



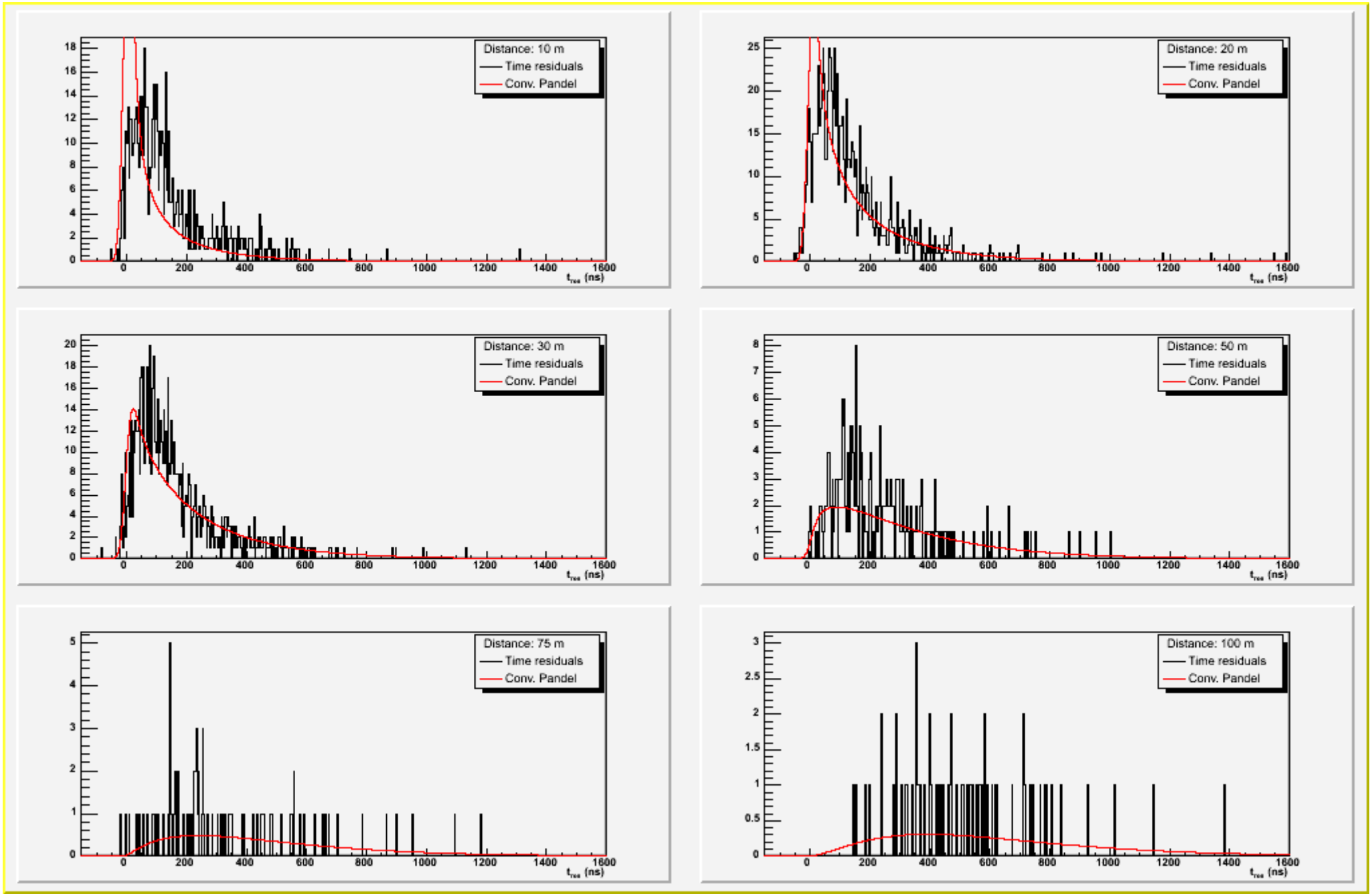
5 hits – TOT < 50 ns; only optical channels (sharp signals)



Shift has disappeared

Std lkhd 16-iterative reco

5 hits – TOT < 50 ns; only optical channels (sharp signals)



Discussion

* Mismatch between time residuals and Pandel fct due to hit extraction algo weaknesses (no hardware limitation anymore)

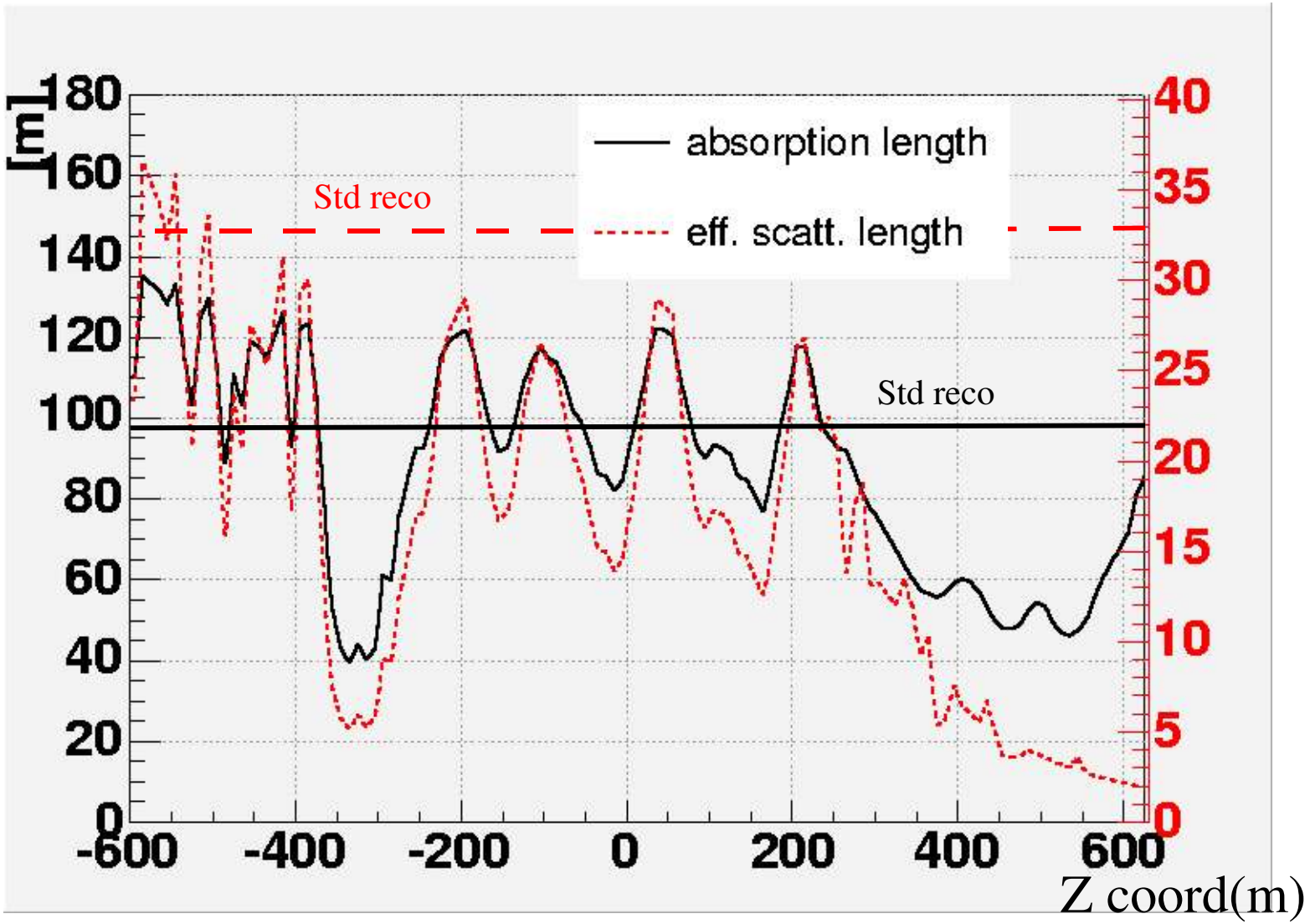
pathological cases :

a) high intensity, 'piling up' --> 1 hit with 'high amplitude' is not 1 p.e.
b) hit extraction algorithm based on threshold: bad if 2 peaks partly overlapping ==> 1 hit with large TOT is not 1 p.e.

==> Hit extraction to be improved !
(main difficulty: 1pe response not constant)

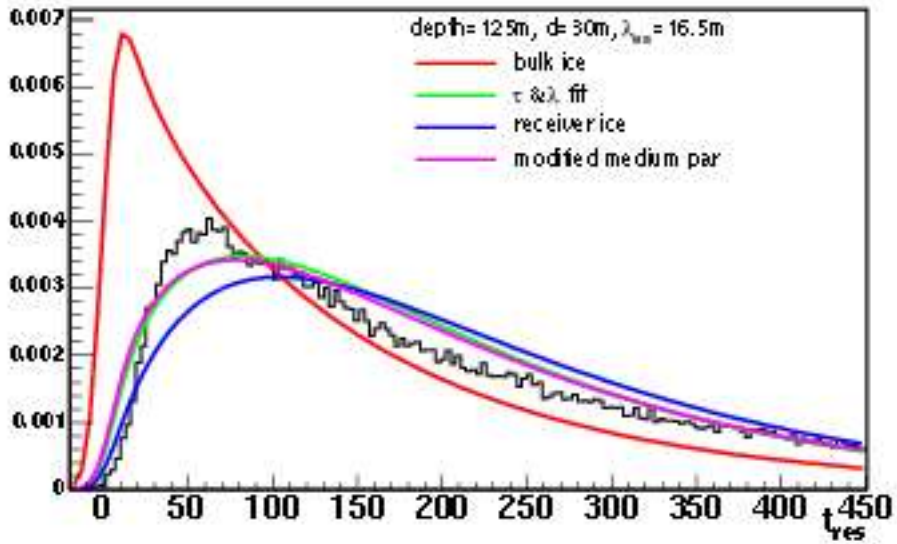
==> deconvolution of WF with 1p.e. pulse shape (diploma student)

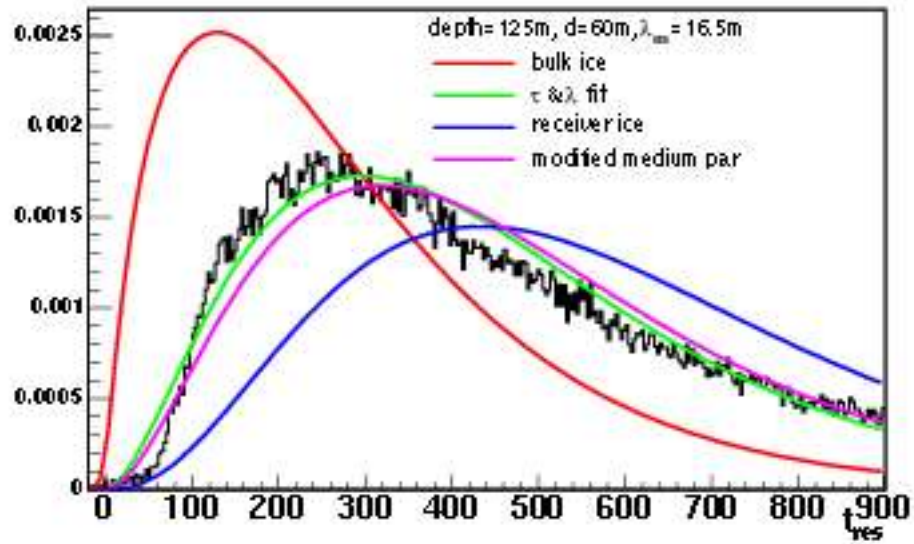
Optical parameters of the ice vs z coordinate in AMANDA

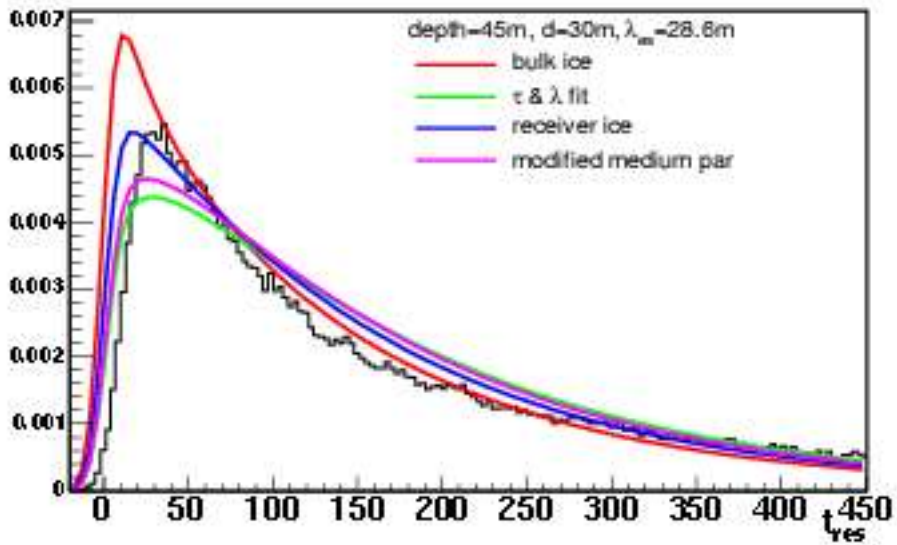


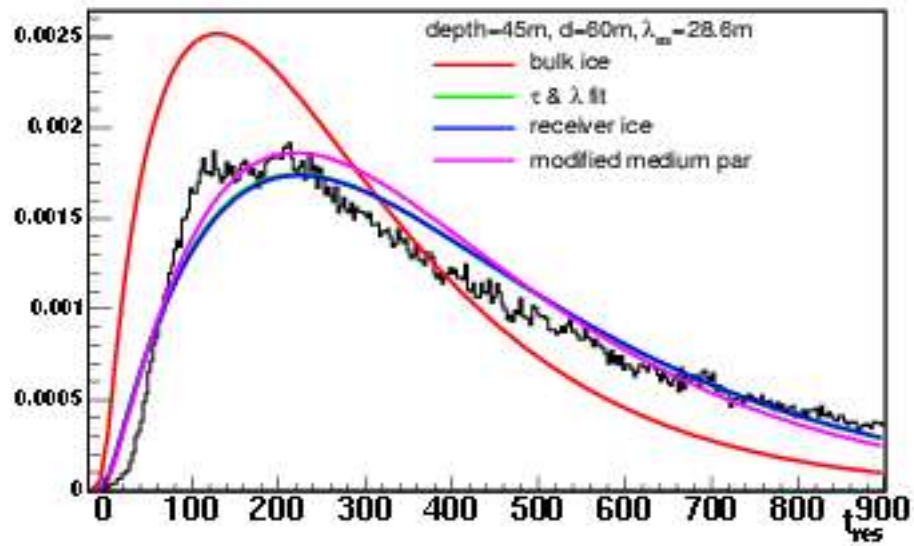
Min bias PTD corsika MC (Amanda IR/20050301)

"Dusty" ice...



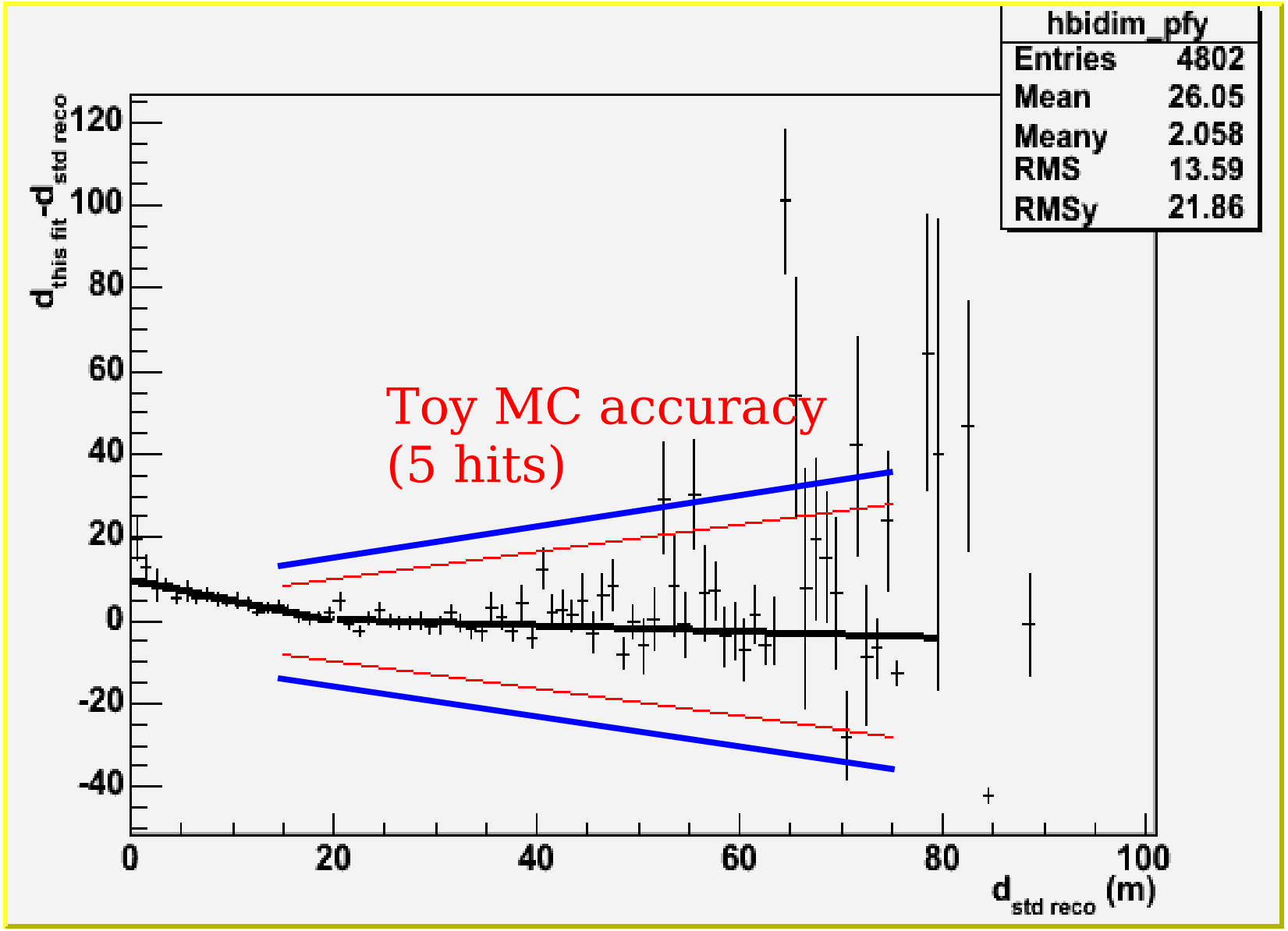


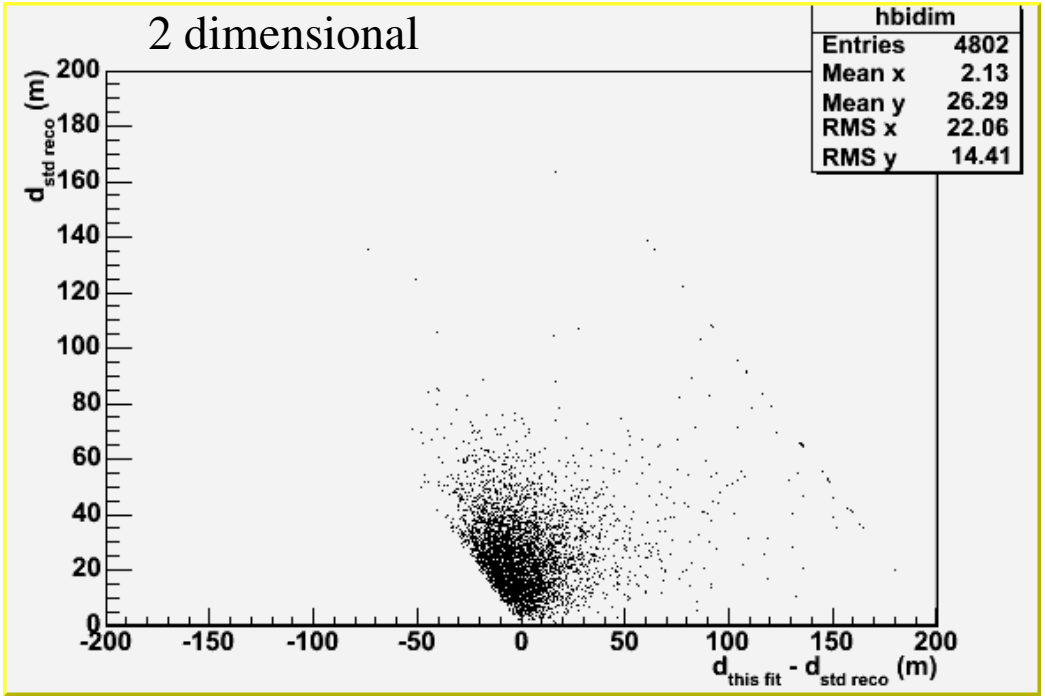


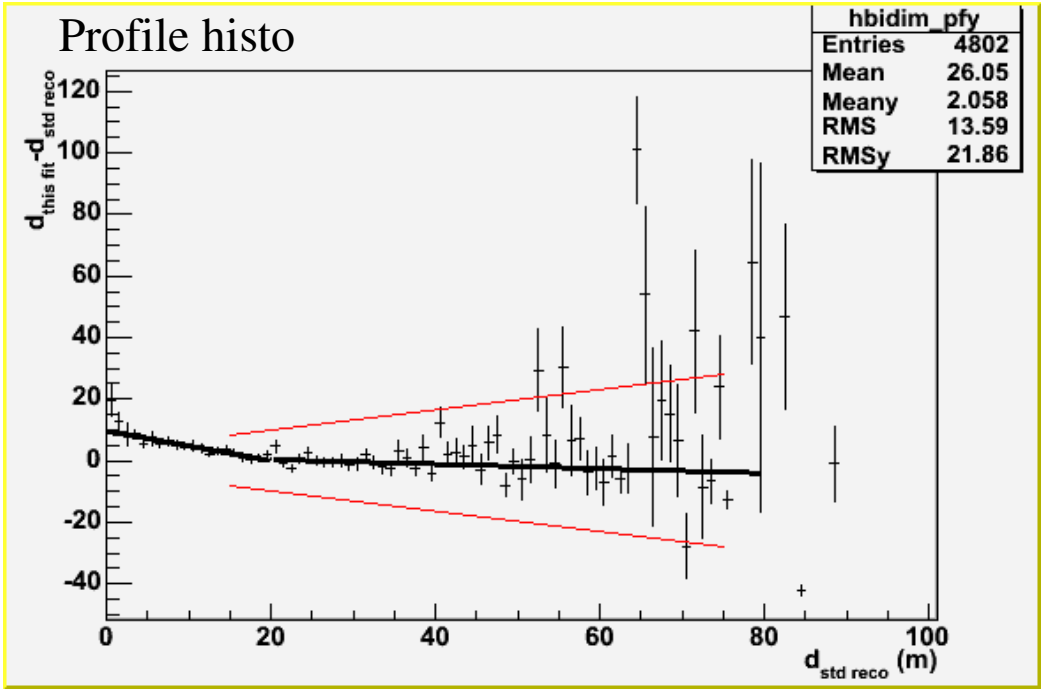


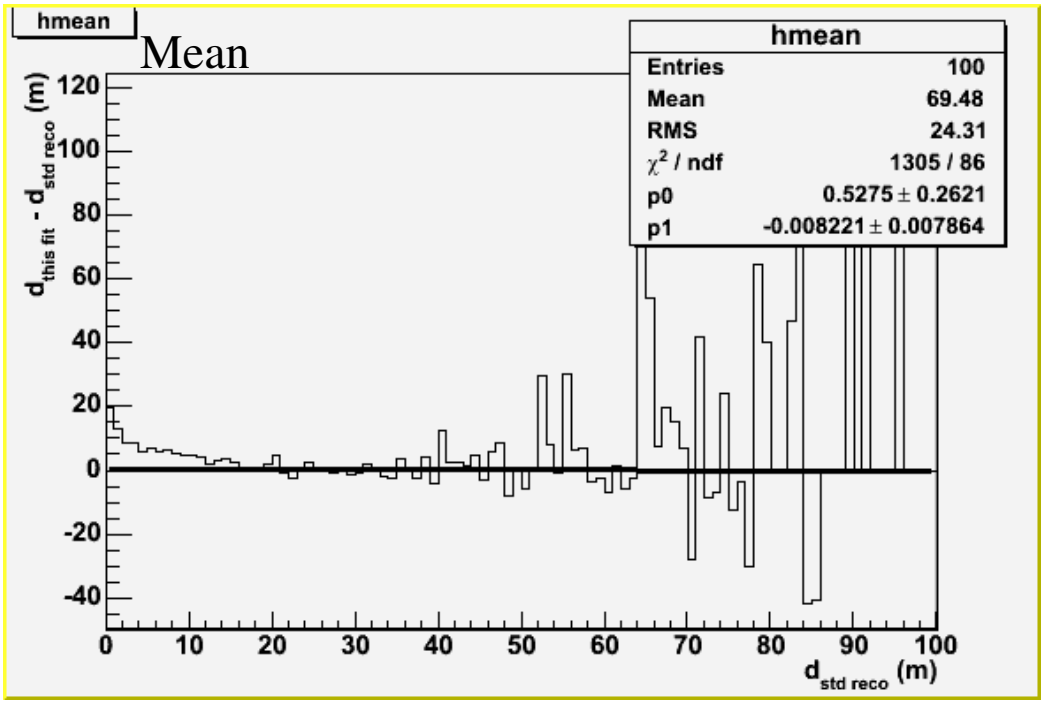
... vs "clear" ice

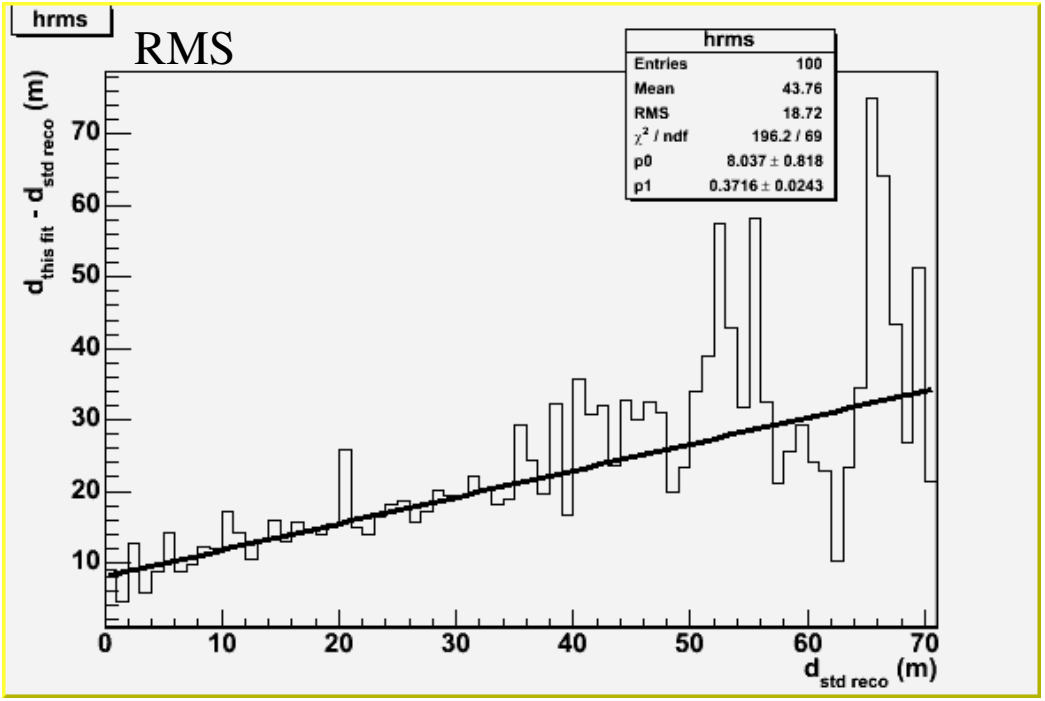
Including inhomogeneous ice




2 dimensional
hbidim
Entries 4802
Mean x 2.13
Mean y 26.29
RMS x 22.06
RMS y 14.41
d_std reco (m)
d_this fit - d_std reco (m)


Profile histo
hbidim_pfy
Entries 4802
Mean 26.05
Meany 2.058
RMS 13.59
RMSy 21.86
d_this fit -d_std reco
d_std reco (m)


hmean
Mean
hmean
Entries 100
Mean 69.48
RMS 24.31
χ² / ndf 1305 / 86
p0 0.5275 ± 0.2621
p1 -0.008221 ± 0.007864
d_this fit - d_std reco (m)
d_std reco (m)


hrms
RMS
hrms
Entries 100
Mean 43.76
RMS 18.72
χ² / ndf 196.2 / 69
p0 8.037 ± 0.818
p1 0.3716 ± 0.0243
d_this fit - d_std reco (m)
d_std reco (m)

Conclusions

* Accounting for ice properties leads to great improvements w.r.t previous results

* A lot of progress made, many problems understood

* TWR-DAQ superiority in hit resolution w.r.t. -DAQ

* Could still improve hit extraction algo

* Determination of distances between OM's and track with TWR and variable ice makes excellent angular resolution achievable. Scales with track length, number of OM's and number of hits

==> ICECUBE!

* Detailed report is in preparation

* UHE analysis