SPD Physics Weekly meeting
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Study track fitting problem

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Introduction

As you know the next 2 problems are discussed connecting with the track fitting procedure:

1) not 100% fitting efficiency (?);

2) 2 peaks in chi2/ndf distribution;

3) it was generated, simulated and reconstructed 10000 events with 1 GeV/c single muon, uniformly distributed inside $\cos\theta$, $5^0 < \theta < 175^0$ and $0^0 < \varphi < 360^0$;

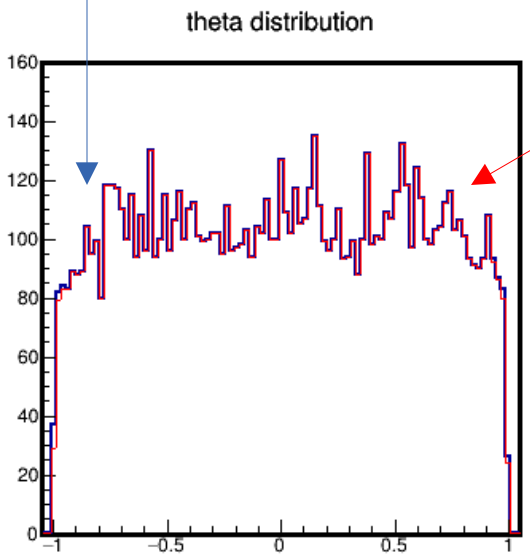
4) MAPS version of vertex detector is used;

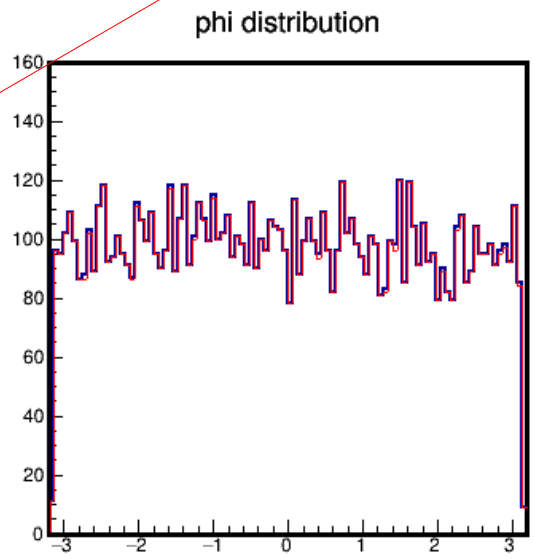
5) during reconstruction only select those tracks which have 3 or more Its+Ts hits.

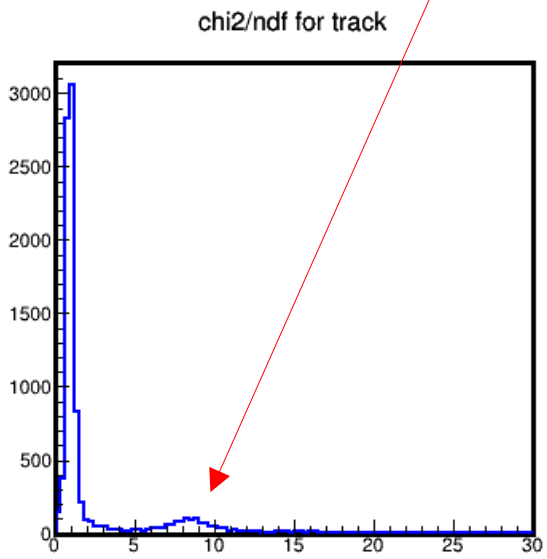
Track fit result

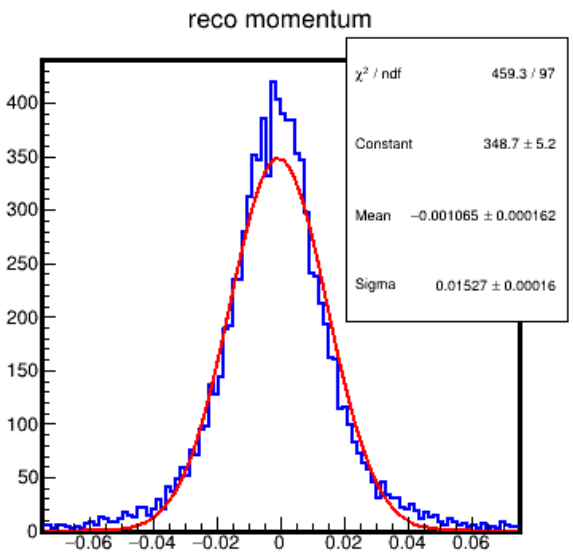
Second peak

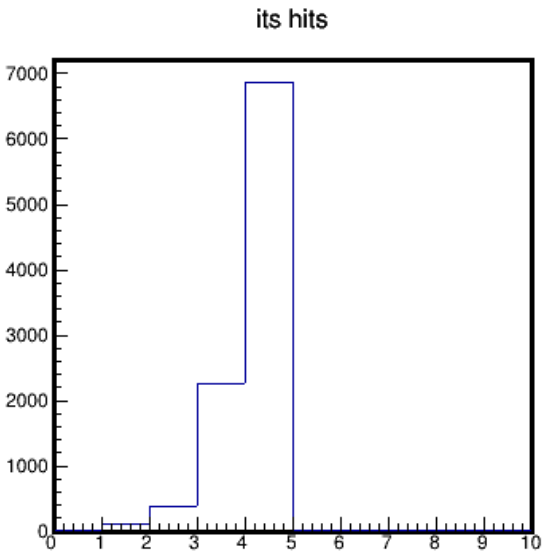
Blue line – gen. particle with >= 3 hits Red line – fitted track

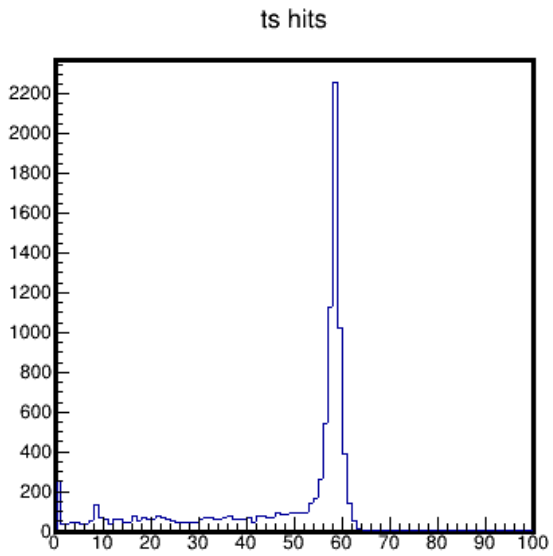












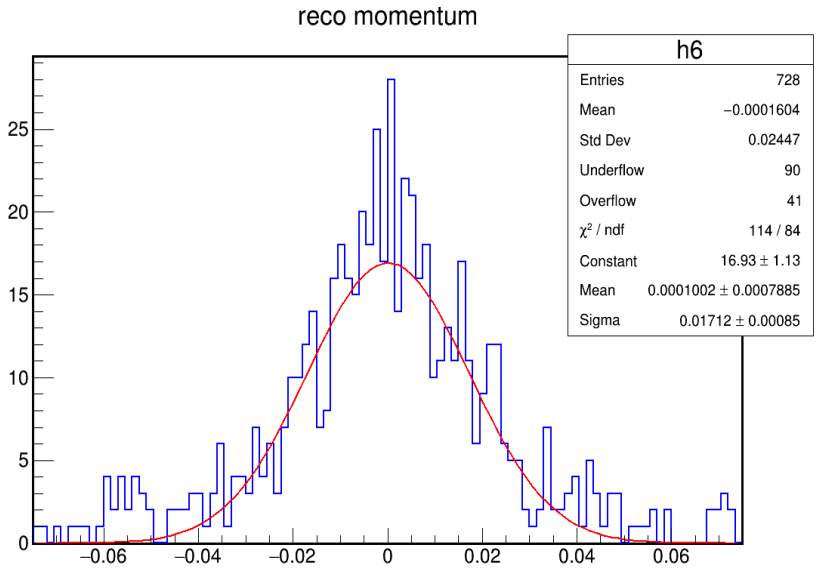
$\sigma = 0.015 \Rightarrow (p^{gen}p^{fit})/p^{gen}$

Track fit result

	All	$-0.5 < \cos\theta < 0.5$
Total	= 10000	4980
Track class (hit>=3)	= 9663 (96.63 %)	4933 (99.06 %)
Trk Id = p Id	= 9644 (99.80 %)	4933 (100.00 %)
Trk pars	= 9644 (99.80 %)	4933 (100.00 %)
Partly converged (-1)	= 0 (0)	0
No converged (0)	= 747 (7.73 %)	177 (3.59 %)
Converged (1)	= 8916 (92.27%)	4756 (96.41 %)

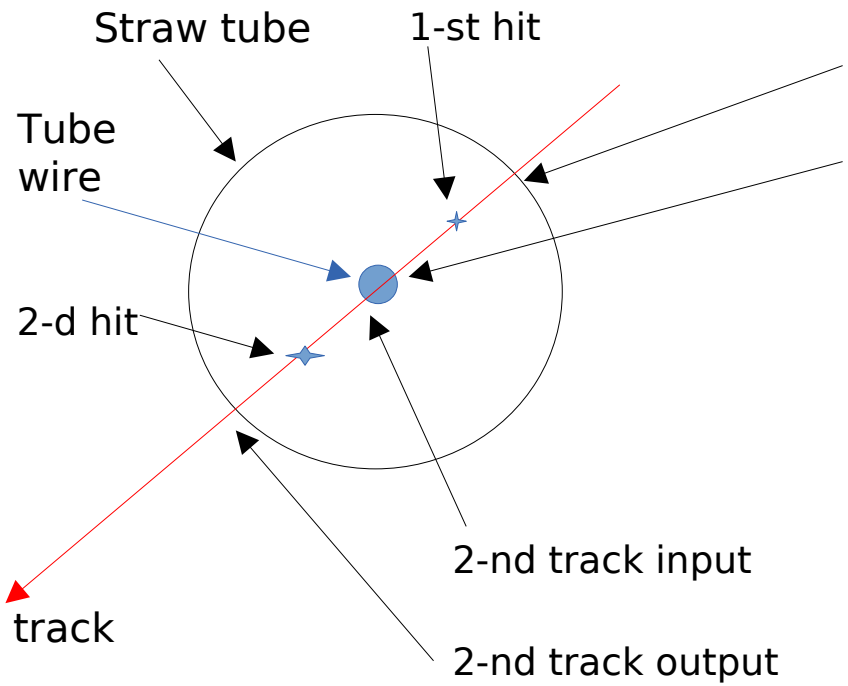
1. chi2/ndf condition is not considered in the tables

2. Difference 10000 - 9663 = 337 and 4980 – 4933 = 47 are events with Its+Ts hits < 3 in vertex and tracker.



$(p_{gen} - p_{fit}) / p_{gen}$ distribution for events with no converged flag (?)

Fit result (second peak in chi2/ndf)



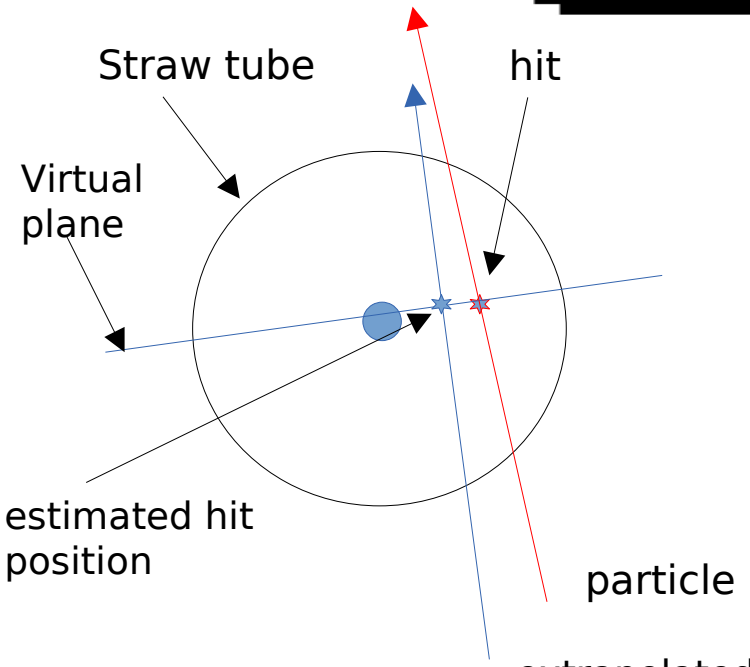
It was understand that second peak in chi2/ndf distribution is connected with the special case when in one straw tube 2 hits are observed.

Hit in straw tube is in the middle position between track input position (in sensitive volume) and track output position (from sensitive volume).

When both such type of hits were removed from the fitting procedure - fit was successful with chi2/ndf < 2

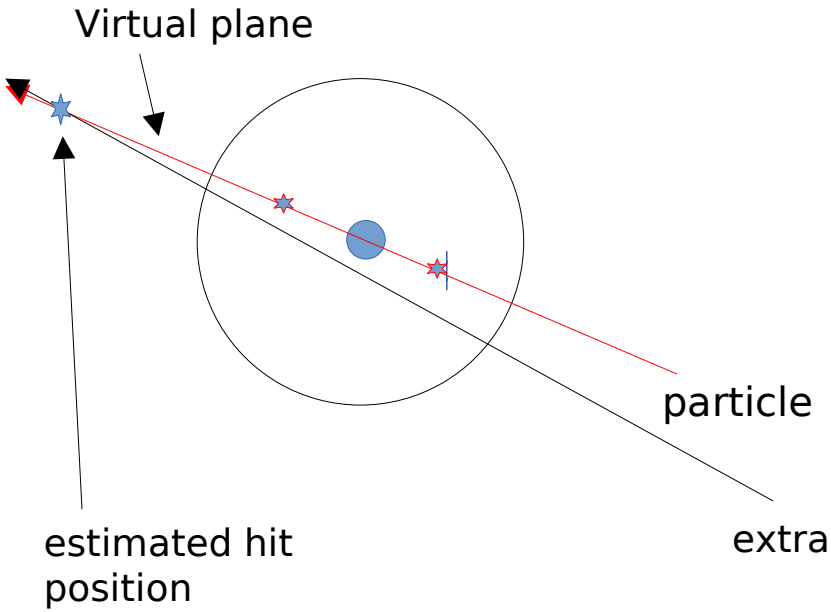
But when only the one hit was removed from the fitting procedure – fit again has large chi2/ndf ??

Fit result (second peak in chi2/ndf) (2)



Genfit2 fitting procedure for straw tube:

1) construct virtual plane with hit and wire of tube
2) extrapolate track candidate to this virtual plane
3) produce hit estimation
4) update track parameters taking into account real hit position



For the events when particle crosses straw wire and 2 hits are produced the virtual pane is coincident with direction of particle.

The extrapolated track candidate and virtual plane are almost parallel and the big difference between real hit position and estimated hit position will produced => big chi2

What can we do in this case ?

DAF track fitting procedure

The deterministic annealing filter (DAF) is a powerful tool for rejecting outliers. It is a Kalman filter which uses a weighting procedure between iterations, based on the measurement residuals, to determine the proper weights.

The Kalman fitter weighs all measurements according to their covariances. Measurements from noise signals or other particles that were added to the track by the track finder mistakenly can bias the fit. A DAF can lower the weight of these measurements by introducing an annealing scheme:

- the track is fitted with a Kalman fitter several times, beginning with a high temperature, i.e. a factor that the covariances of the measurements are increased by. The user can specify the annealing scheme, i.e. a series of decreasing temperatures;

- after one fitting pass, the weights of all measurements are updated. The weight depends on the distance to the track (in terms of the measurement's covariance) and has distribution shown on the next slide. For small distances, it has a value close to 1, and for large distances the value of weight goes to 0;

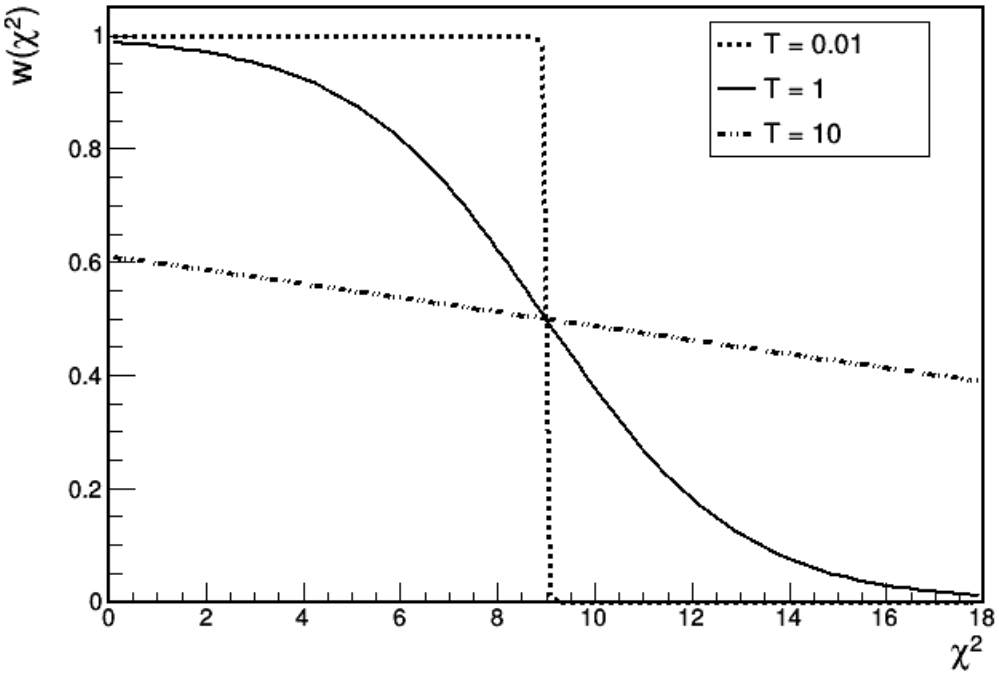
- for high temperatures, the transition from 1 to 0 is smooth, and becomes more step-like for lower temperatures;

- the temperature is lowered, and the track is fitted again. In the end, a low temperature of e.g. 0.1 is reached, and the weight function has almost become a step function;

- therefore, each measurement has now a weight either close to 1 or 0.

DAF track fitting (2)

After the iteration with the last temperature of the annealing scheme, convergence is checked: If the absolute change of all weights is less than 1×10^{-3} (user configurable), the fit is considered as converged. Otherwise more iterations with the last temperature are done, until the fit converges or a maximum number of iterations is reached.

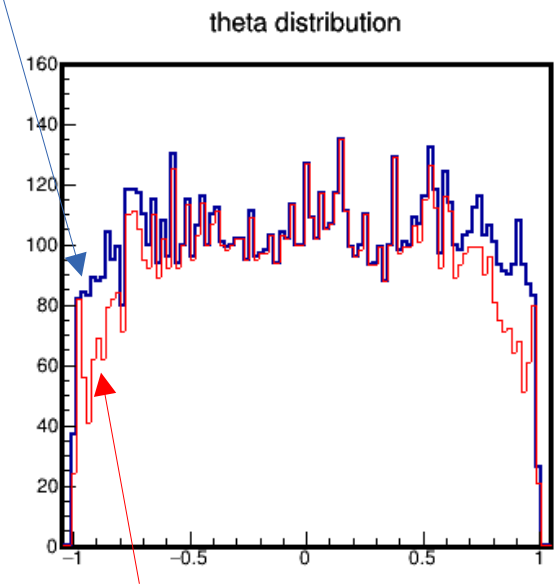


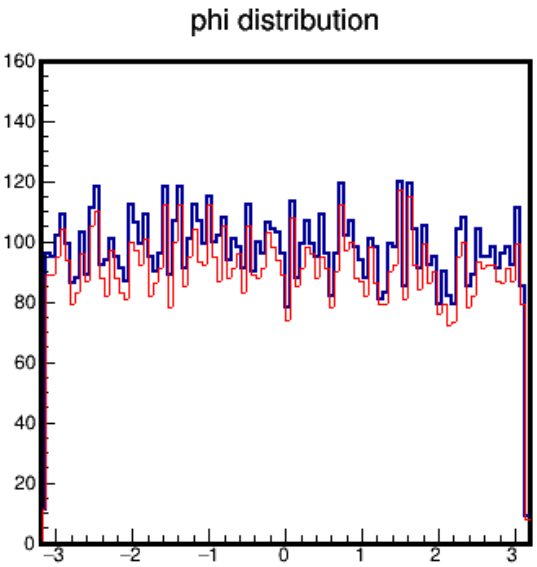
Example of the weight depends on the distance to the track (in terms of the measurement's covariance) and looks like a Fermi-Dirac distribution.

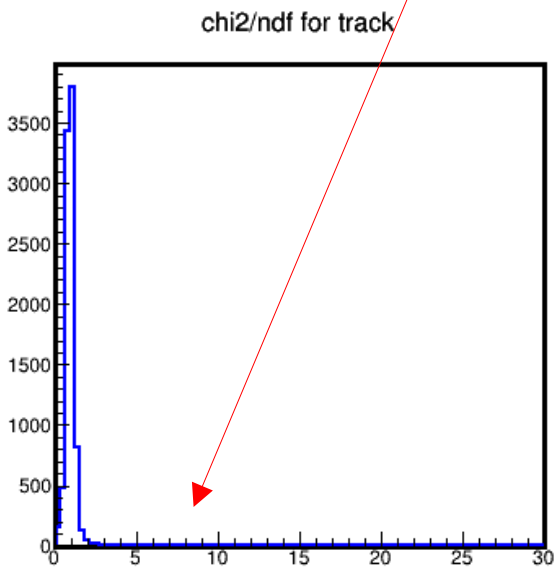
DAF track fit

All gen. particle (blue)

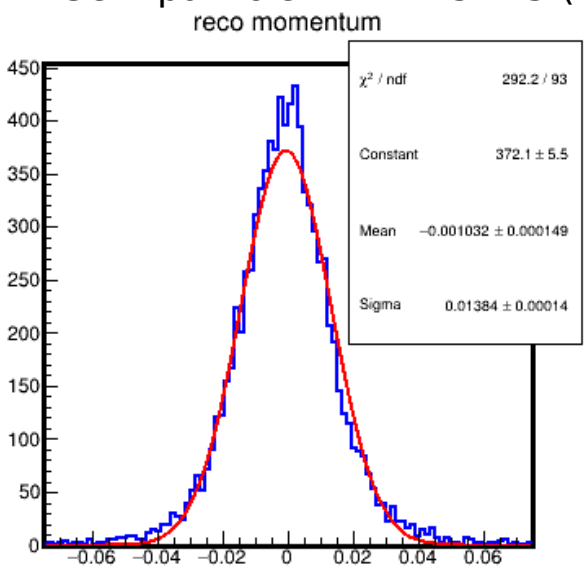
No second peak

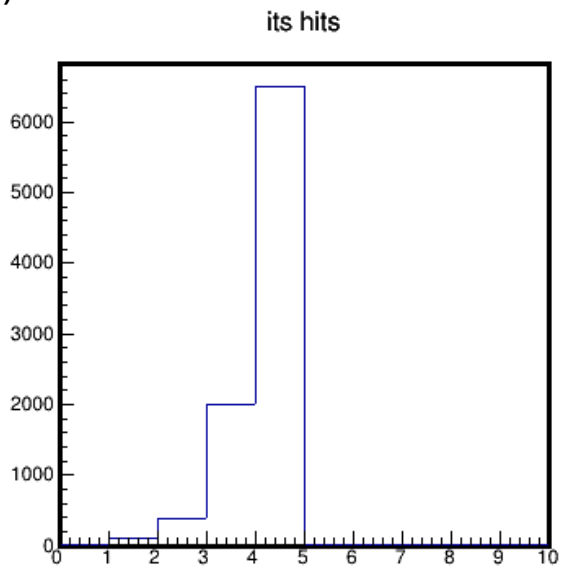


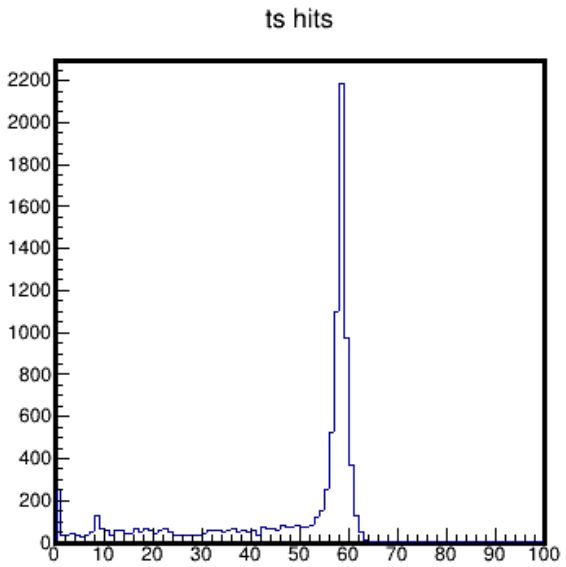




Gen. particle with hits > 3 (red)





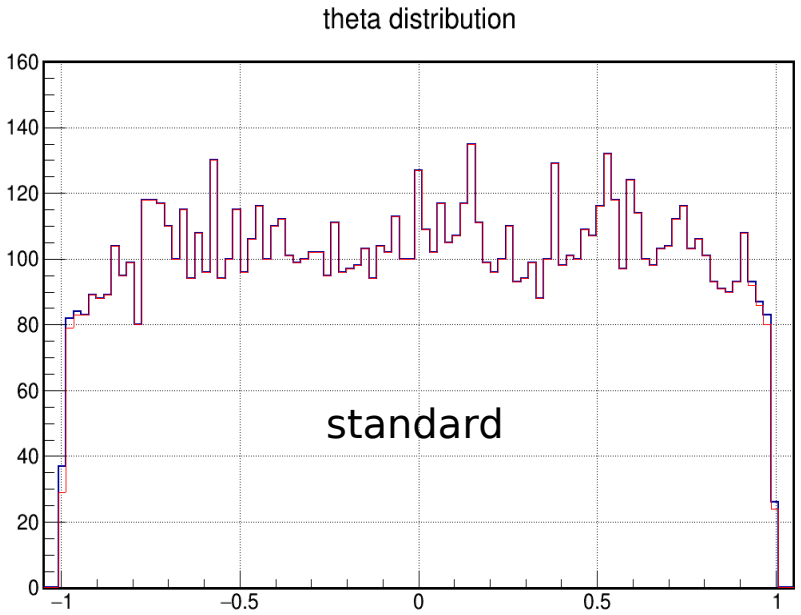


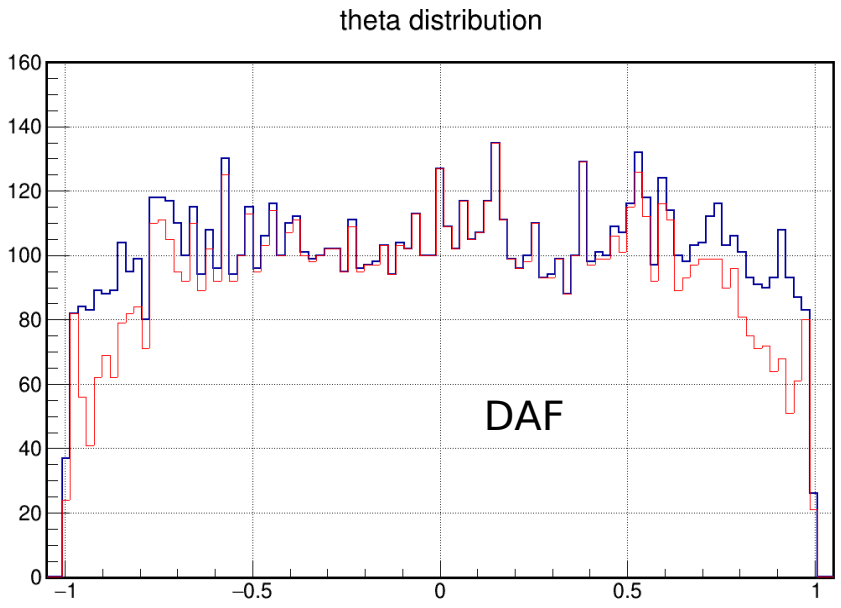
$\sigma = 0.013 \Rightarrow (p^{gen}p^{fit})/p^{gen}$

DAF fit result

	All	$-0.5 < \cos\theta < 0.5$
Total	= 10000	4980
Track class (hits >= 3)	= 9663 (96.63 %)	4933 (99.06 %)
Trk Id = p Id	= 9663 (100 %)	4933 (100 %)
Trk pars	= 9003 (93.17 %)	4900 (99.33 %)
Partly converged (-1)	= 0 (0)	0
No converged (0)	= 289 (3.0 %)	150 (3.0 %)
Converged (1)	= 8714 (90.18 %)	4750 (96.30 %)

Standard and DAF fit result comparison





All	DAF	Stand.	-0.5 < cos θ < 0.5	DAF	Stand.
Total	= 10000	10000		4980	4980
Track class (hits >= 3)	= 9663	9663		4933	4933
Trk Id = p Id	= 9663	9644		4933	4933
Trk pars	= 9003	9644		4900	4933
Partly converged (-1)	= 0	0		0	0
No converged (0)	= 289	747		150	177
Converged (1)	= 8714	8916		4750	4756

Summary

1. presence second peak in χ^2/ndf distribution is understood
2. temporary decision – do not apply strong cut χ^2/ndf < 2 (maybe χ^2/ndf < 10 ?)
3. is it possible to find decision inside standard fitting procedure ?
4. DAF fitting procedure removes second peak in χ^2/ndf distribution and works good for the central part
5. need to tune DAF procedure for forward and backward directions