Computer Exercise: Toy-experiments of fits of a constant

Macro p0toyf.C, accessible at
http://www.desy.de/~obehnke/stat/school_apr14/p0toyf.C

generates toy experiments for the fit of a constant ("p0-fit") from several measurements of the same resolution. A physics example for this would be the determination of the (average) vertical position of a horizontal flying track in track-detectors. Additional Problem: the detectors are noisy, for each detector sometimes instead of a good signal hit a broadly distributed noise hit is observed.

- Steering parameters in the macro:
  - $Ntra =$ Number of repeated toy experiments (Default is 1000)
  - $Ndet =$ Number of measurements (Default is 10)
  - $frac\_noise$ Average fraction of noise hits (Default is 0.)
- Output
  - Histo $p0d$ - Distribution of residual: fitted constant - true value
  - Histo $chi2d$ - χ^2 distribution from the $p0$-fits
  - Histo $pchi2d$ - χ^2-probability distribution from the $p0$-fits
  - Histo a - shows the p0-fit for the last toy experiment

Tasks:

- Take a deep breath and have a few minutes look in the code and try to understand what's going on

a) Run the macro as it is with .x p0toyf.C and plot the histograms by p0d$\rightarrow$ Draw(); chi2d$\rightarrow$ Draw(); pchi2d$\rightarrow$ Draw(); a$\rightarrow$ Draw(); Fill the RMS value of the $p0d$ histogram in the table below (first row) and also the mean values of the $chi2d$ and $pchi2d$ distributions.

b) Now edit the macro and set $frac\_noise$=0.1;

- run the macro again and fill the obtained values in the table (second row).
- How much has the RMS of the residuals increased?
- Can you identify the bad track-fits in the $pchi2d$ distribution?

c) Rejection of tracks with bad χ^2-probability: Book another residual histogram $p0d\_rej$ in the macro:

- fill it only for the case that the χ^2-probability is not too small (see also hints in the code)
- fill in the third row of the table how many tracks survive this selection and the resulting RMS of the residuals.

d) Hit-outlier-rejection: Advanced method for super experts!

Book another three histograms $p0d\_iter$, $chi2d\_iter$ and $pchi2d\_iter$ in the macro and

- try hit outlier rejection and repeating the track-fit (see detailed instructions in the code);

- fill the resulting RMS of $p0d\_iter$ into the fourth row of the table.
- How does the RMS results of this method compare to the other cases a)-c)?

- Repeat the above exercises b)-d) for increased $frac\_noise$=0.5 and fill the results in the table. How much are the RMS results worse in this case?
- If time permits repeat the above exercises a)-d) for different number of detectors $ndet = 5$ and study how the results change qualitatively.

Task	$Ndet$	$frac\_noise$	Outlier rejection	Resid.-distr.	#tracks	Resid. RMS	chi2d mean	pchi2d mean
a)	10	0.0	No	p0d	1000	0.0032	8.8	0.51
b)	10	0.1	No	p0d	1000	0.0064	15.9	0.245
c)	10	0.1	Reject tracks with bad pchi2	p0d_rej	596	0.0036	–	–
d)	10	0.1	Outlier hit-rejection and repeated track-fit	p0d_iter	1000	0.00396	–	–
b)	10	0.5	No	p0d	1000	0.0133	34	0.0053
c)	10	0.5	Reject tracks with bad pchi2	p0d_rej	23	0.004	–	–
d)	10	0.5	Outlier hit-rejection and repeated track-fit	p0d_iter	1000	0.0099	–	–