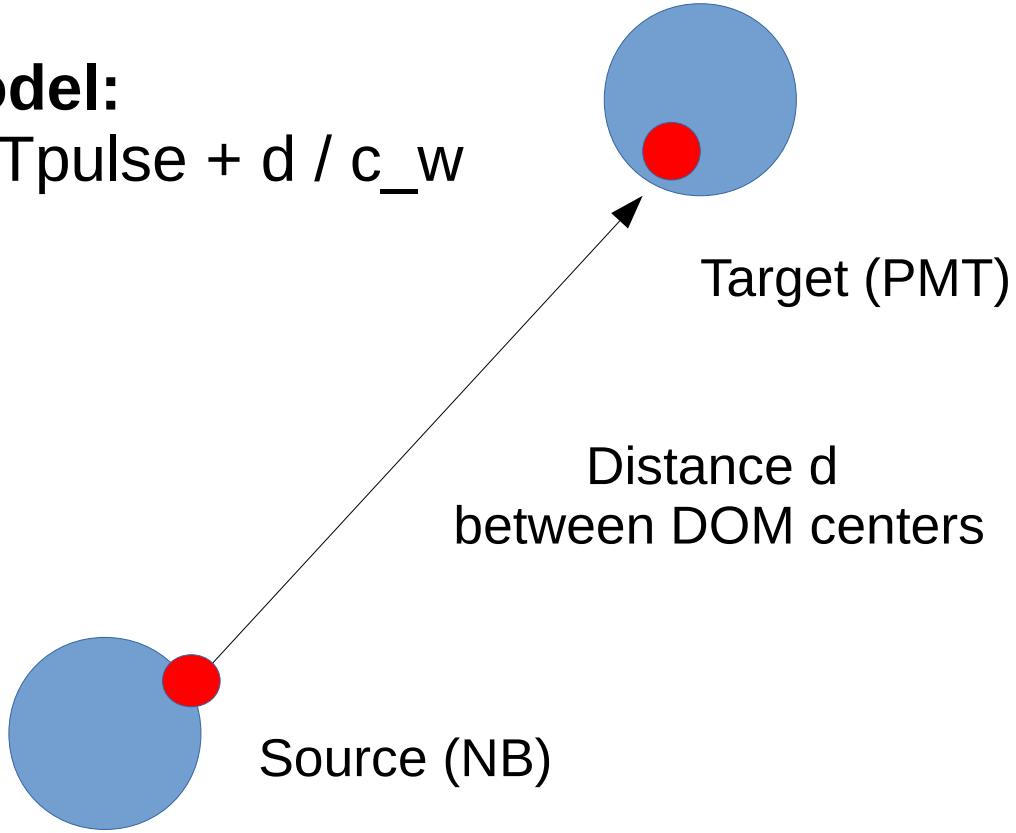
NB calibration

ANTARES/KM3NeT group meeting
Nikhef
9 Febrary 2017

How it works

Super simple model:
Raw arrival time + PMT T0 = Tpulse + d / c_w



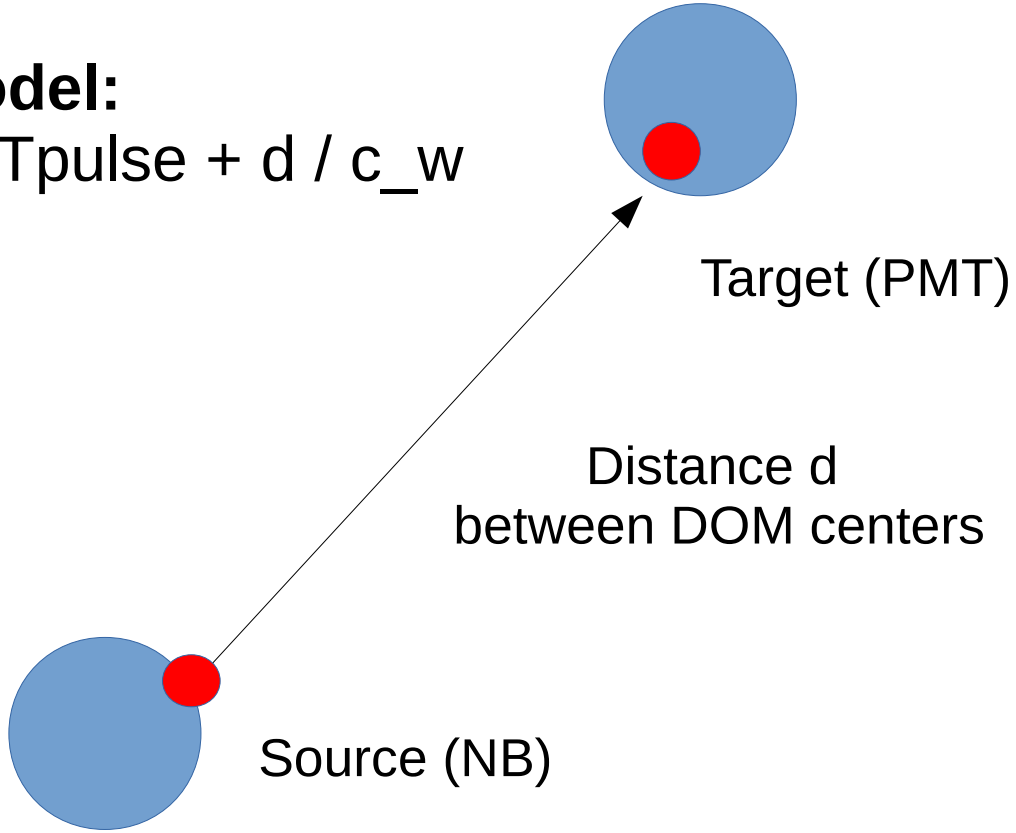
Degrees of freedom

- X, Y, Z of each DOM
- 31 T0's for each DOM
- NB pulse emission times
- c_w

How it works

Super simple model:

Raw arrival time + PMT T0 = Tpulse + d / c_w

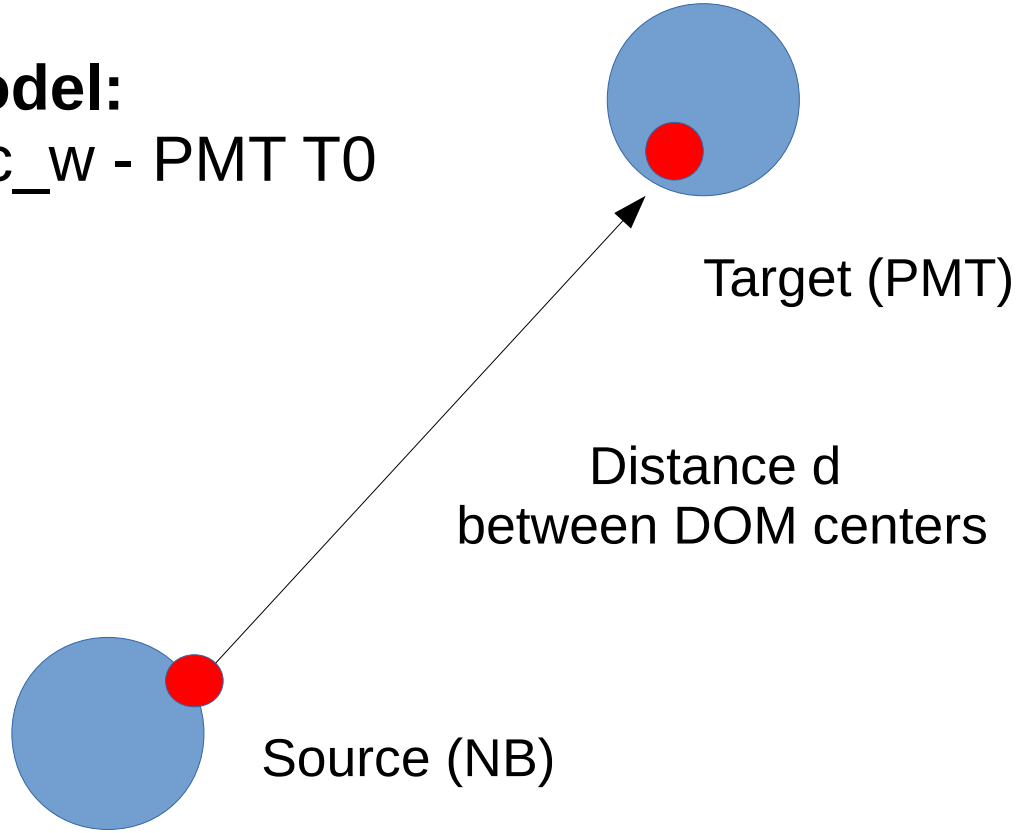


Constraints

- Each pulse that we see gives one constraint
- Note that each NB is seen by multiple PMTs on different DOMs

How it works

Super simple model:
t_expected = Tpulse + d / c_w - PMT T0

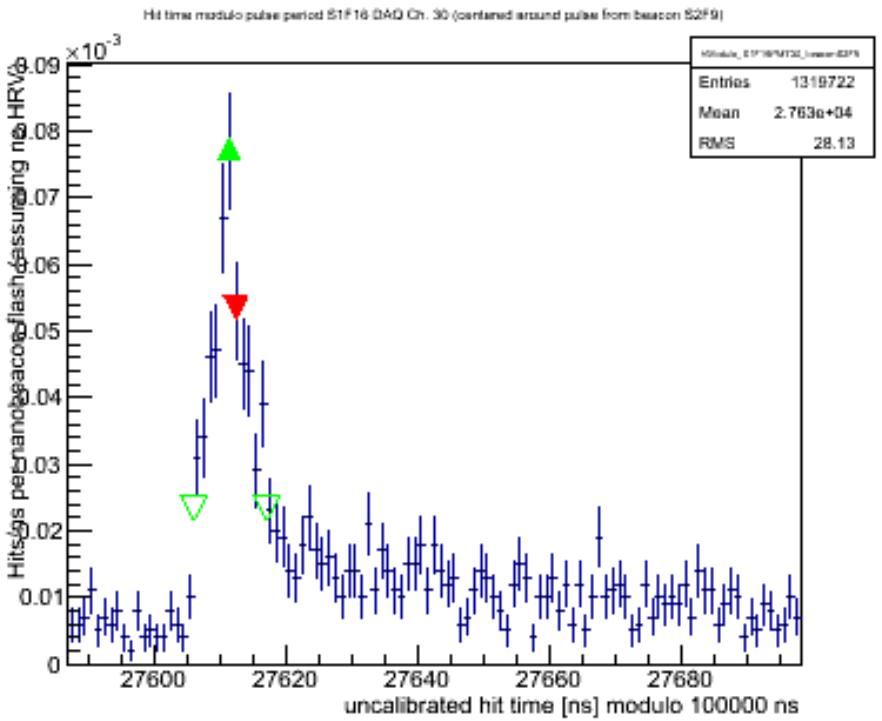


Chi-squared

- Sum over constraints of (t_meas–t_exp)^2 / sigma^2
- Simply minimize parameters for the given constraints!

Pulse selection and fit

- Select only true pulses
  - range of bins over 0.3 x max is smaller than 6 ns
  - TSpectrum finds exactly one “significant” peak
- Fit arrival time
  - currently center of maximum bin +- distance to furthest bin with val > 0.3 x max
- Primitive, but it works
  - ugly peaks are rejected
  - enough left to get a good fit

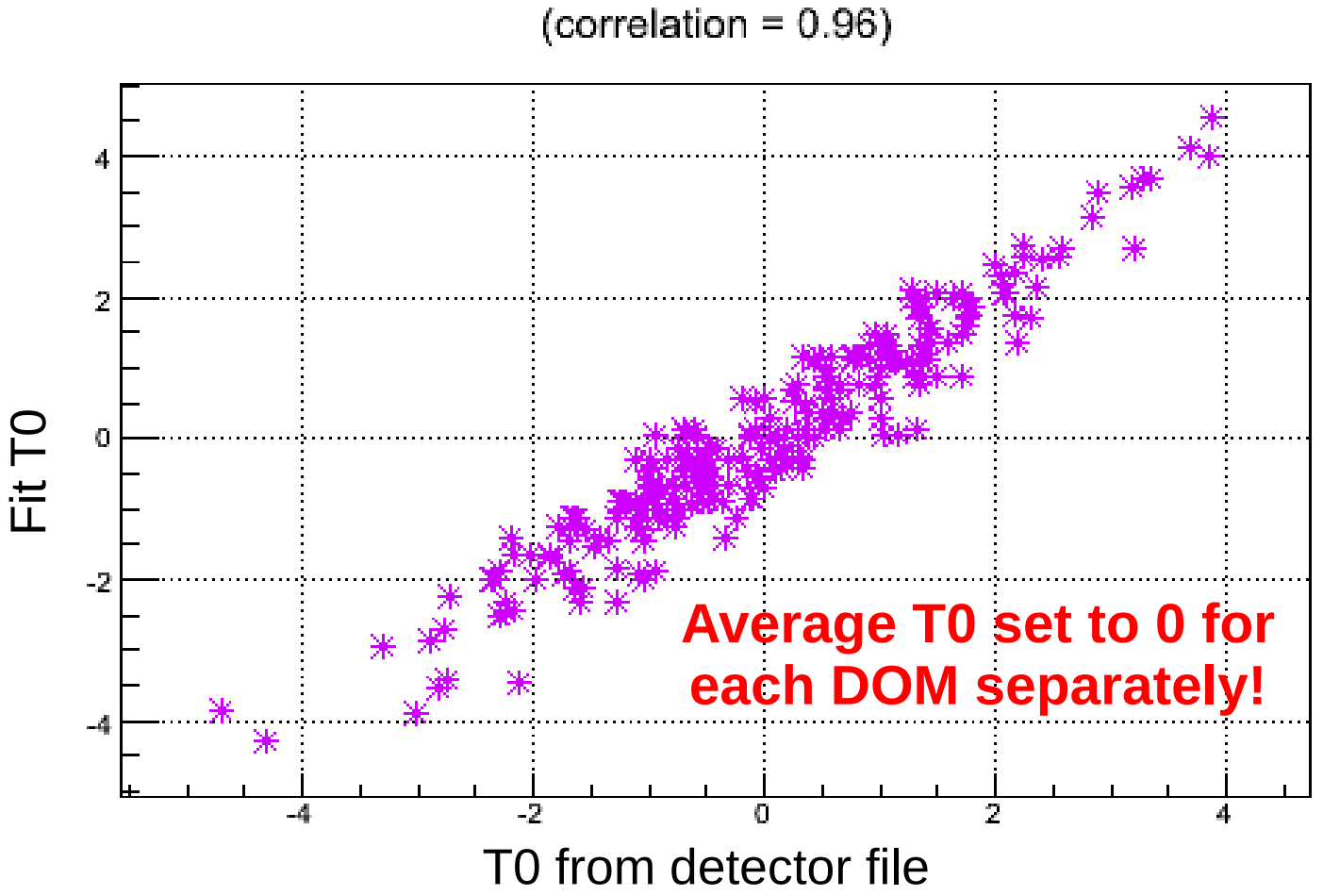


Example: pulse seen on PMT30 of S1F16 due to the nanobeacon on S2F9
(run #5113)

First results

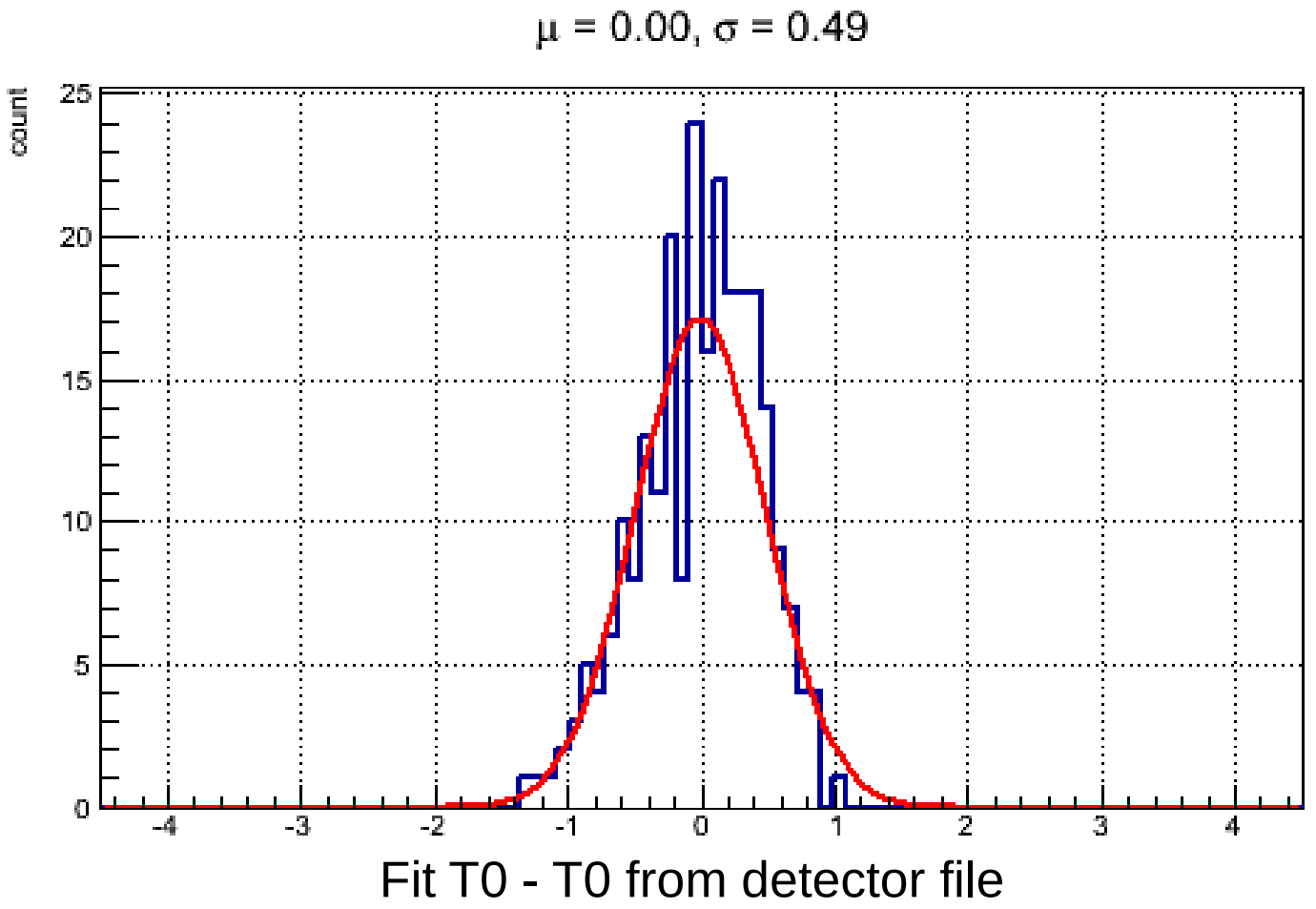
- Using one set of NB runs (5111-5114)
  - low-luminosity string 1
  - low-luminosity string 2
  - high-luminosity string 1
  - high-luminosity string 2
- Several of these are available
  - will be able to check stability in time (over a few weeks)
- Detector file: **using recent K-40 calibration from Karel**

Using only lower-half PMTs looking at the beacon one floor down



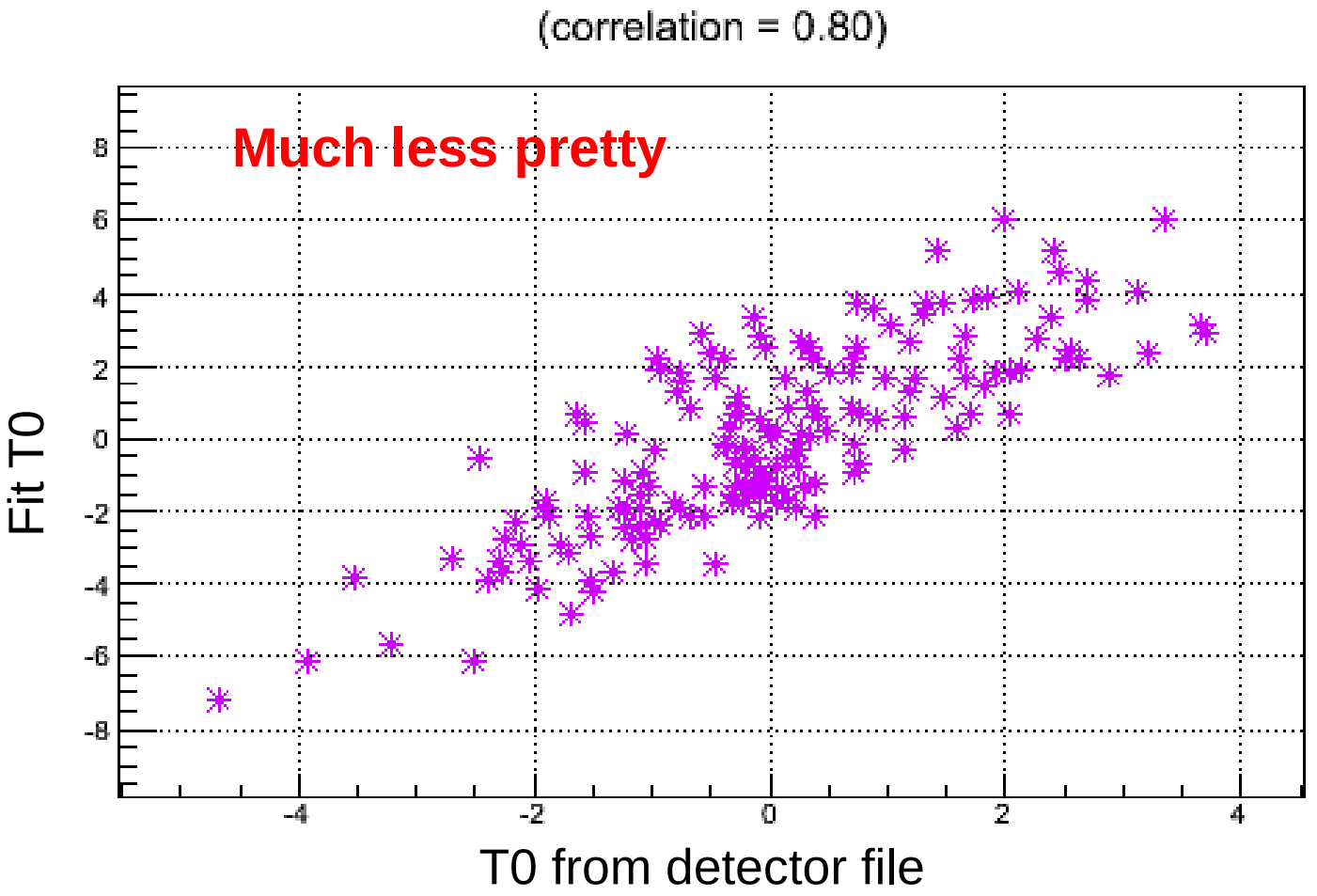
Run #5111 (low luminosity, string 1)

Using only lower-half PMTs looking at the beacon one floor down



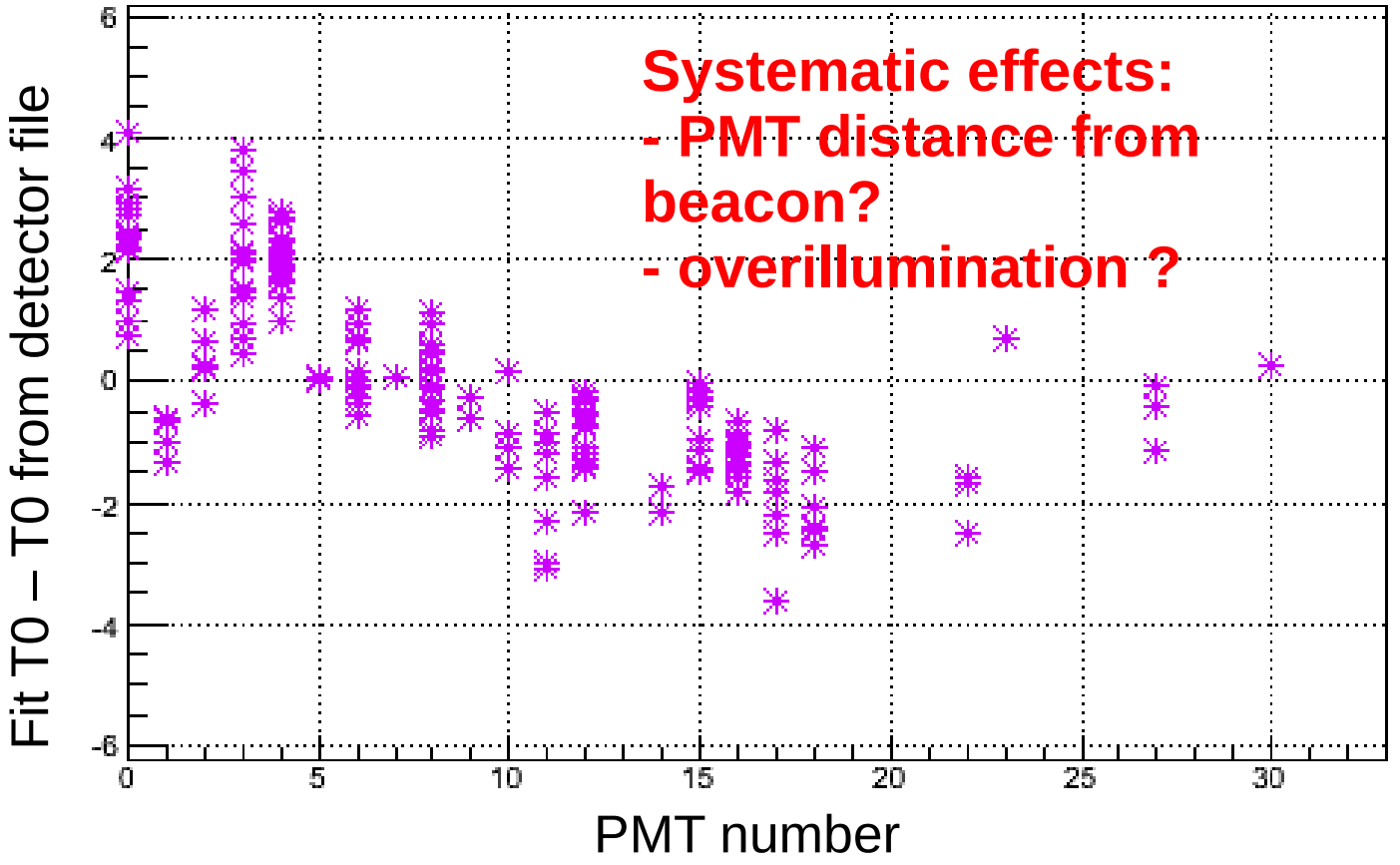
Run #5111 (low luminosity, string 1)

Using all PMTs on the beacon DOM



Run #5111 (low luminosity, string 1)

Using all PMTs on the beacon DOM

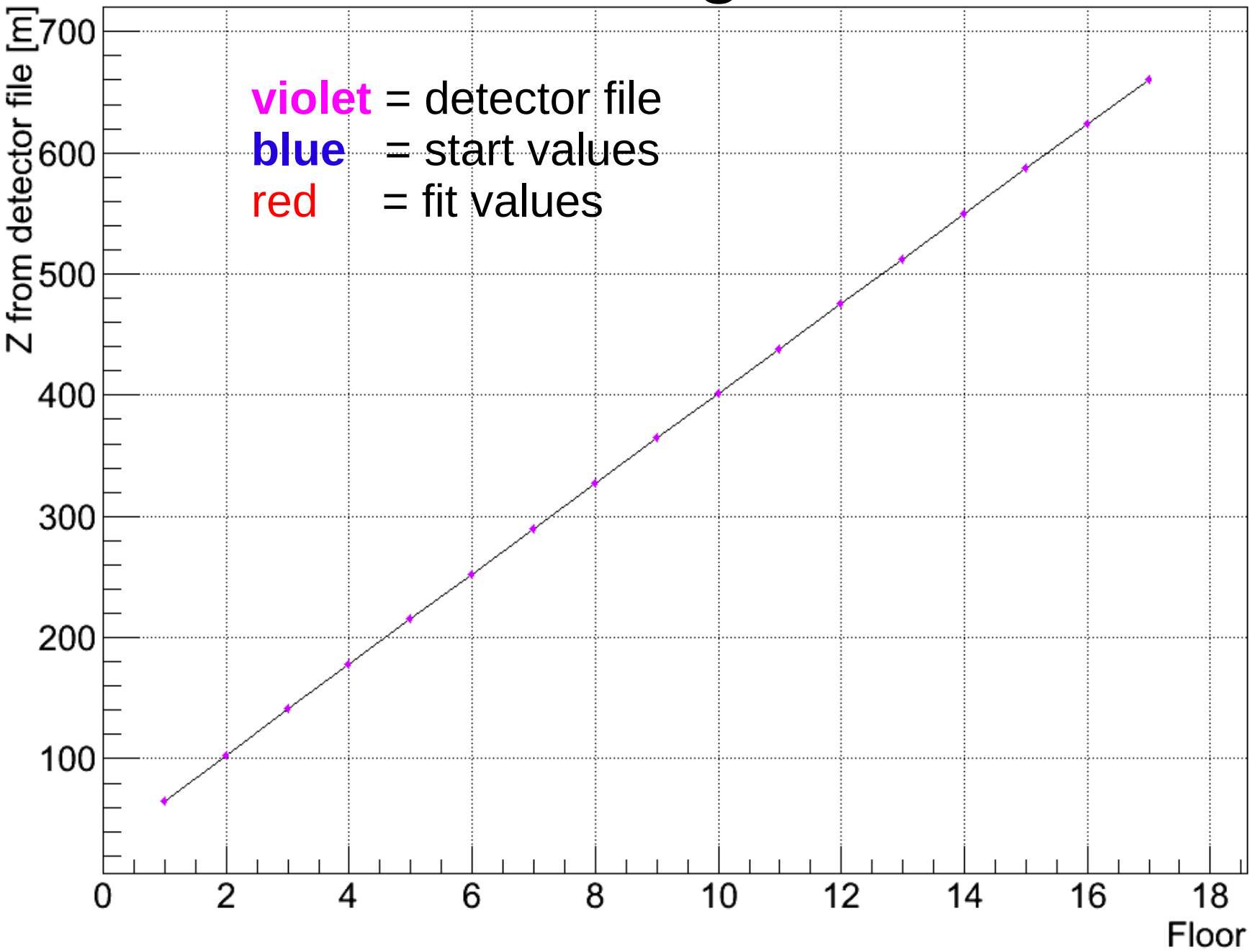


Run #5111 (low luminosity, string 1)

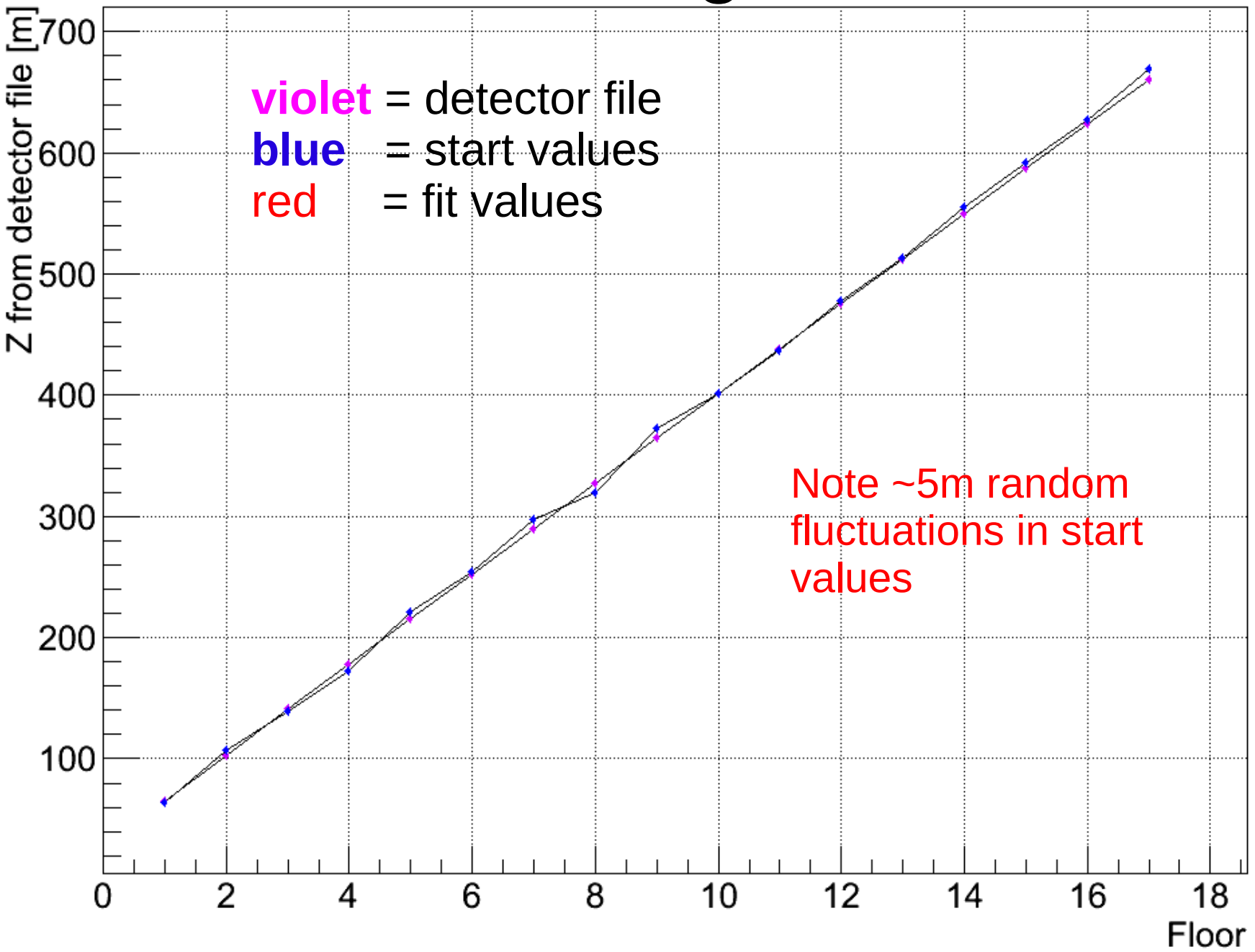
Fit of DOM heights

- Combining all 4 runs
  - 1213 “good” pulse profiles
- fit
  - T0s, pulse emission times and DOM heights
  - **fixed** x and y position (= inter-string spacing)
  - **fixed** speed of light in sea water 0.217449 [m/ns]
- Random Gaussian fluctuations added to DOM heights (sigma = 5 m)

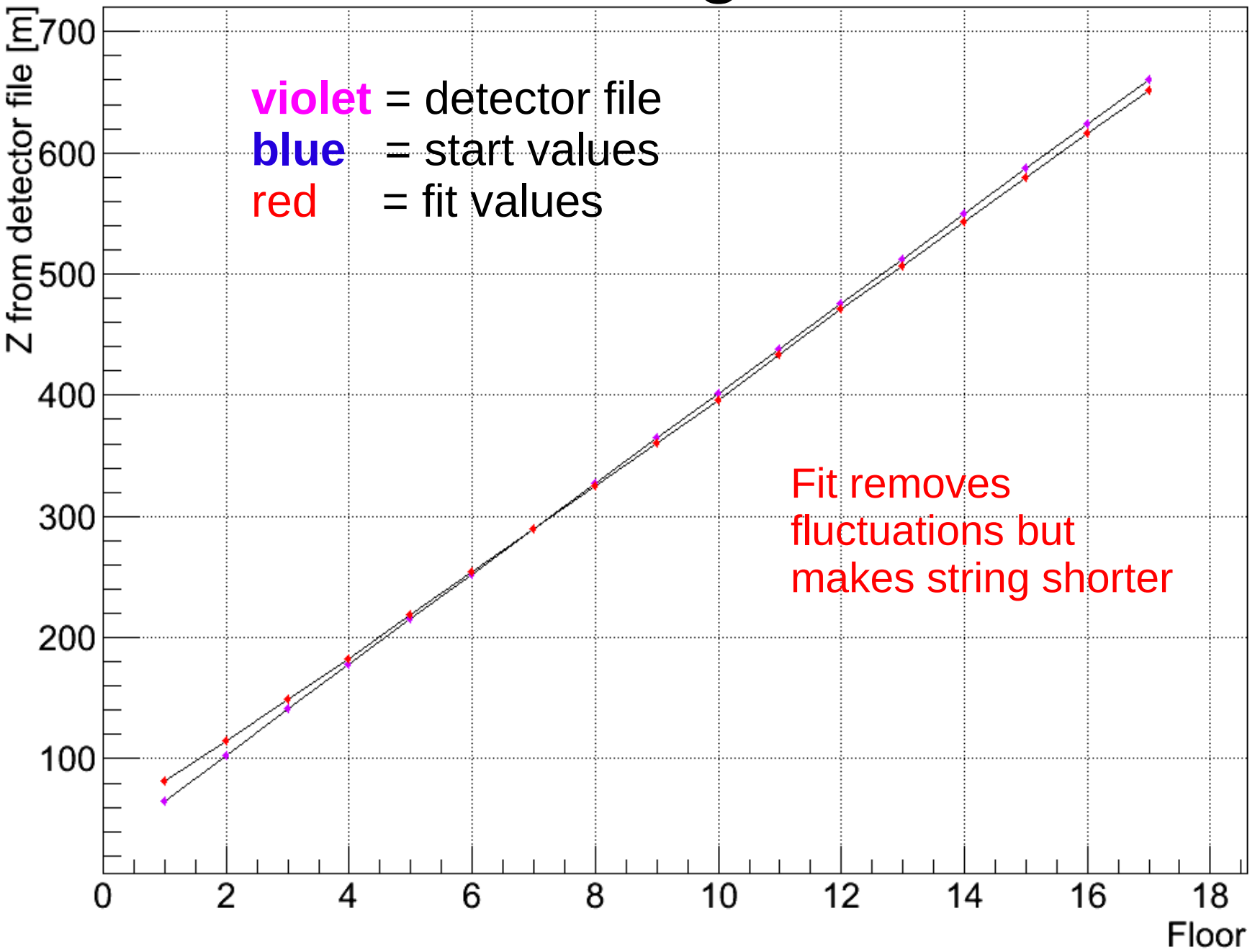
String 1


violet = detector file
blue = start values
red = fit values
Z from detector file [m]
700
600
500
400
300
200
100
0
2
4
6
8
10
12
14
16
18
Floor

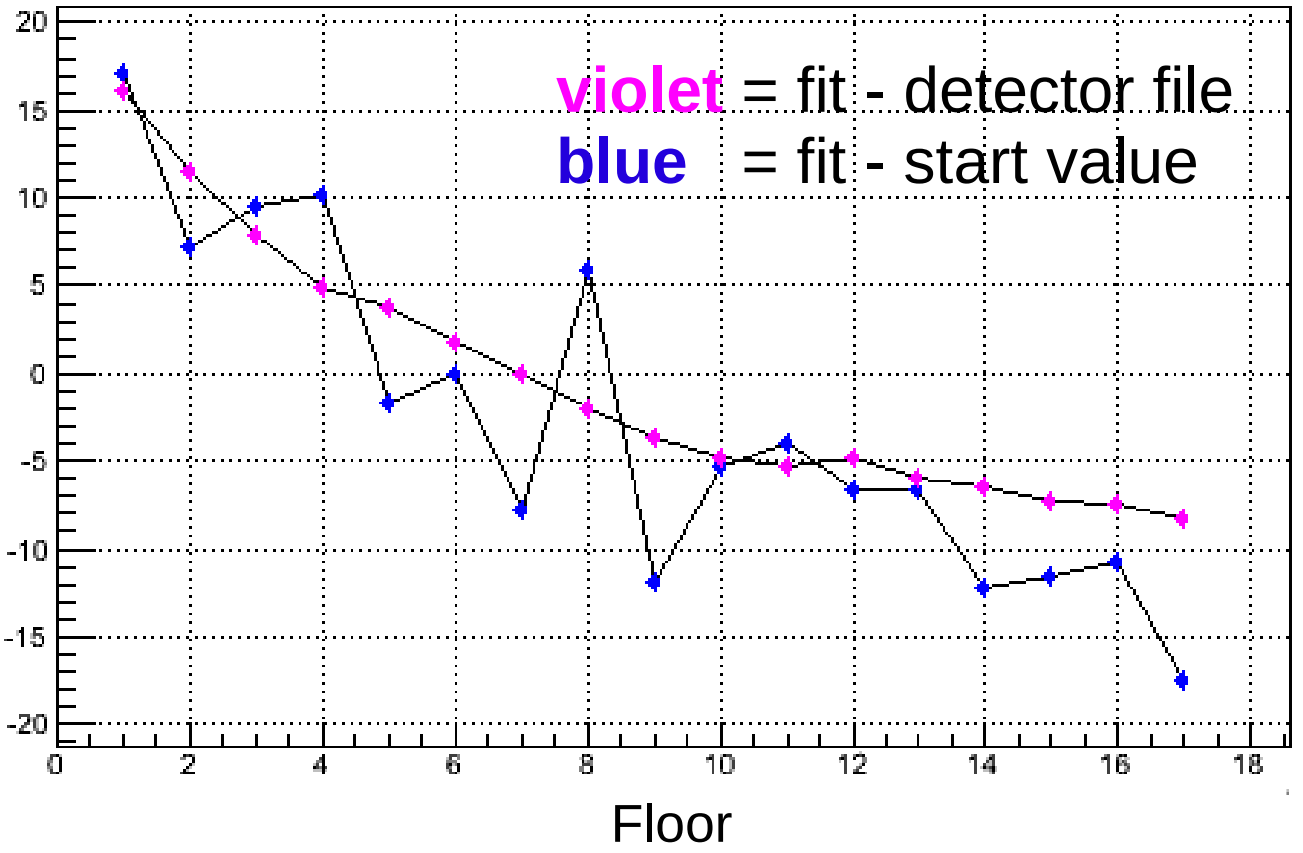
String 1


violet = detector file
blue = start values
red = fit values
Note ~5m random fluctuations in start values
Z from detector file [m]
100
200
300
400
500
600
700
0
2
4
6
8
10
12
14
16
18
Floor

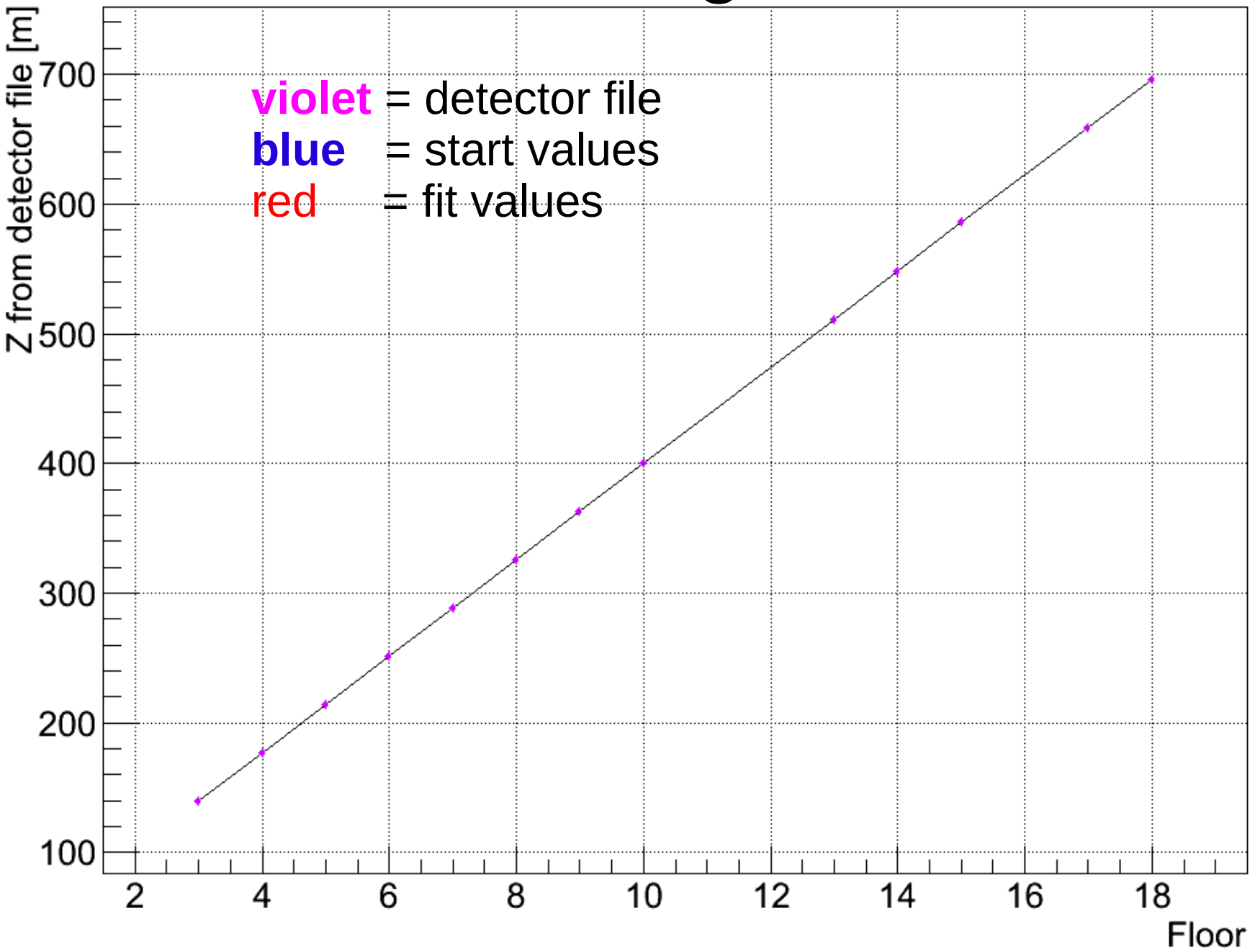
String 1


violet = detector file
blue = start values
red = fit values
Fit removes fluctuations but makes string shorter
Z from detector file [m]
700
600
500
400
300
200
100
0
2
4
6
8
10
12
14
16
18
Floor

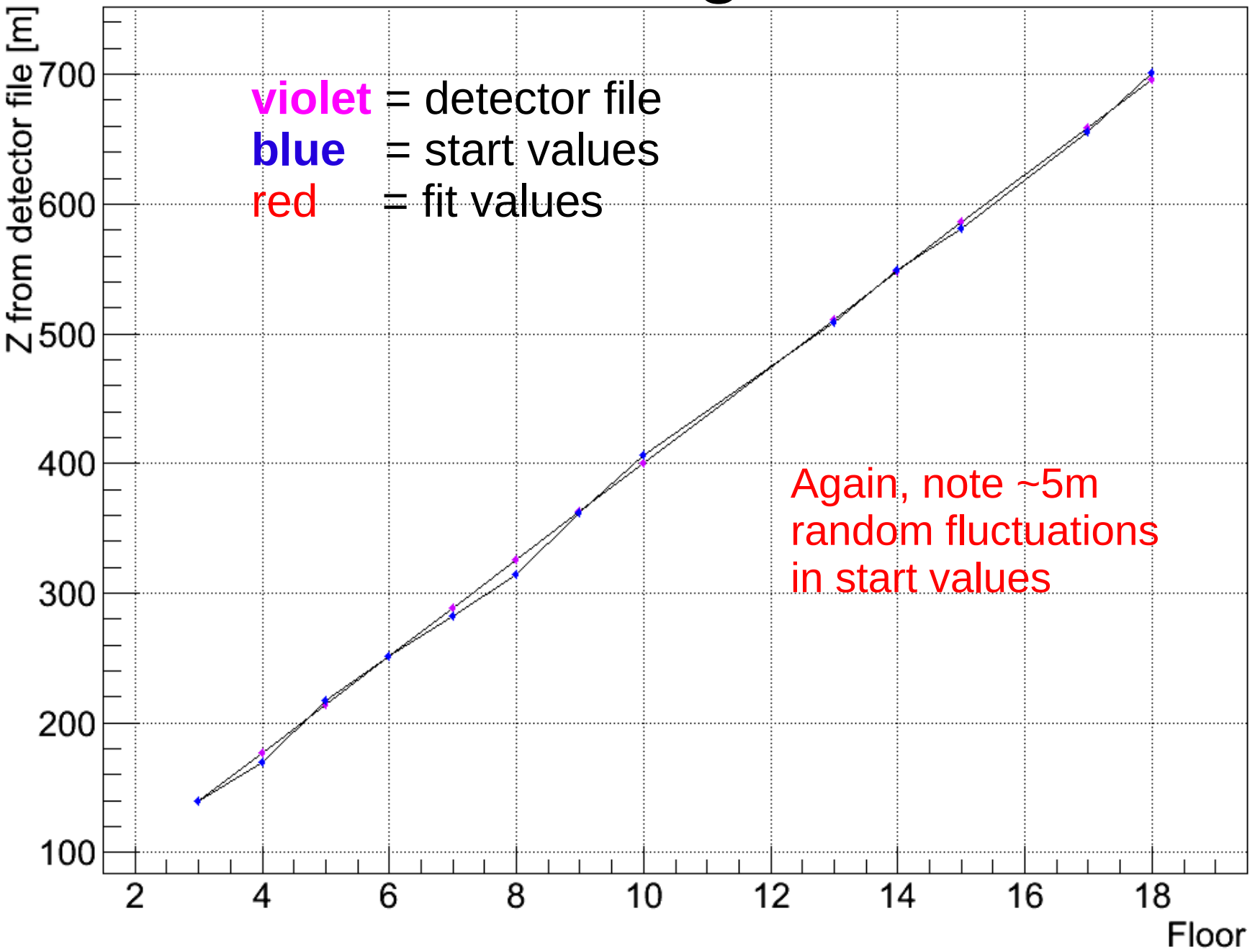
String 1


violet = fit - detector file
blue = fit - start value
20
15
10
5
0
-5
-10
-15
-20
0
2
4
6
8
10
12
14
16
18
Floor

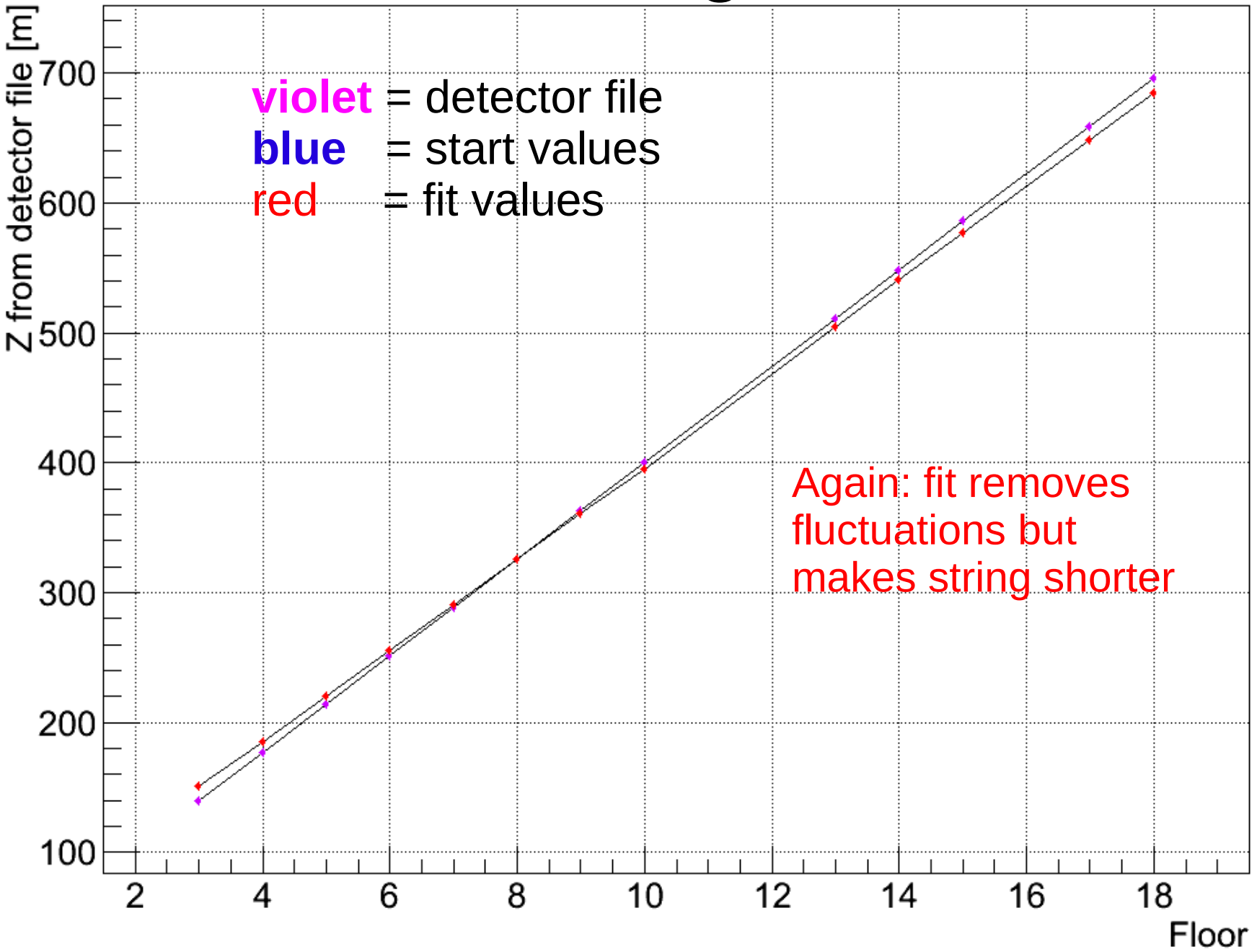
String 2


violet = detector file
blue = start values
red = fit values
Z from detector file [m]
100
200
300
400
500
600
700
2
4
6
8
10
12
14
16
18
Floor

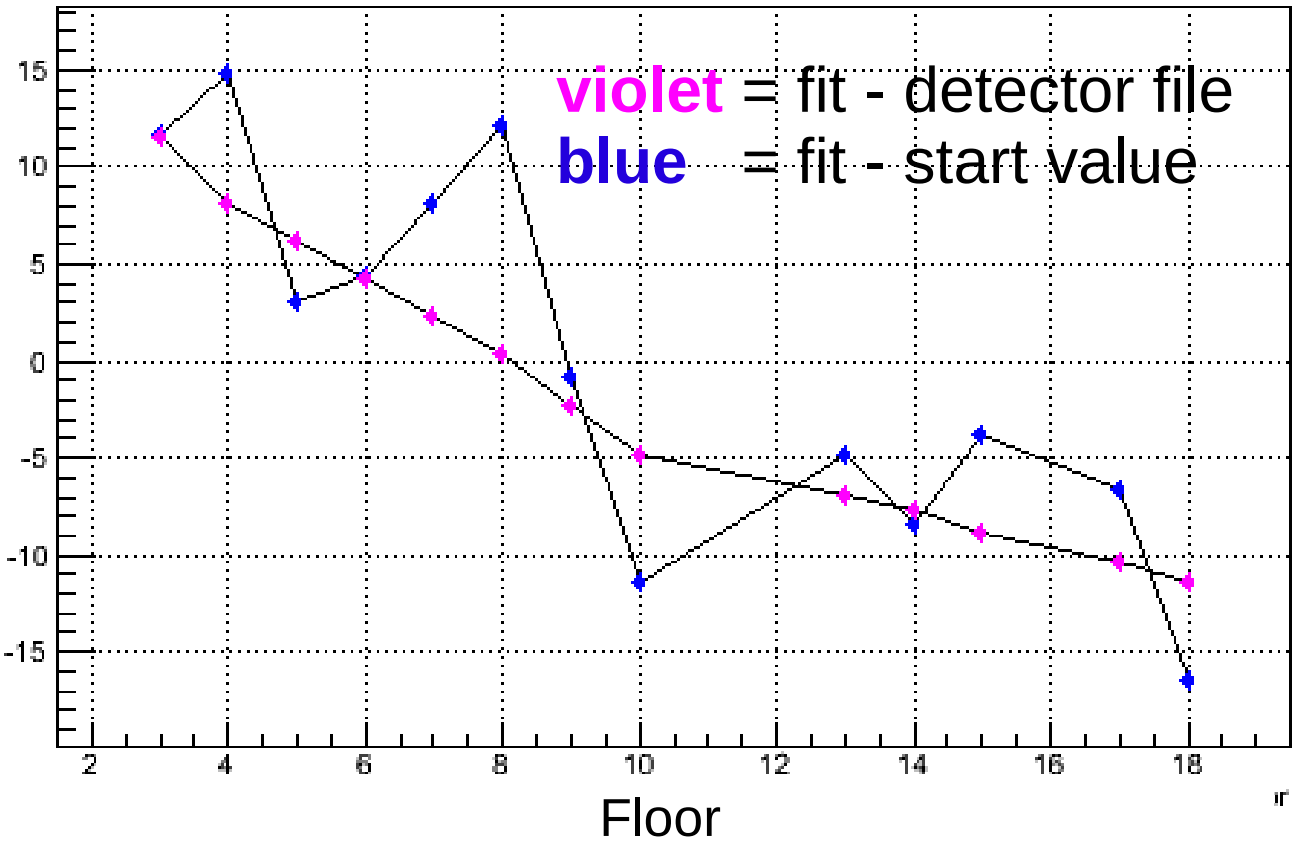
String 2


violet = detector file
blue = start values
red = fit values
Again, note ~5m
random fluctuations
in start values
Z from detector file [m]
100
200
300
400
500
600
700
2
4
6
8
10
12
14
16
18
Floor

String 2

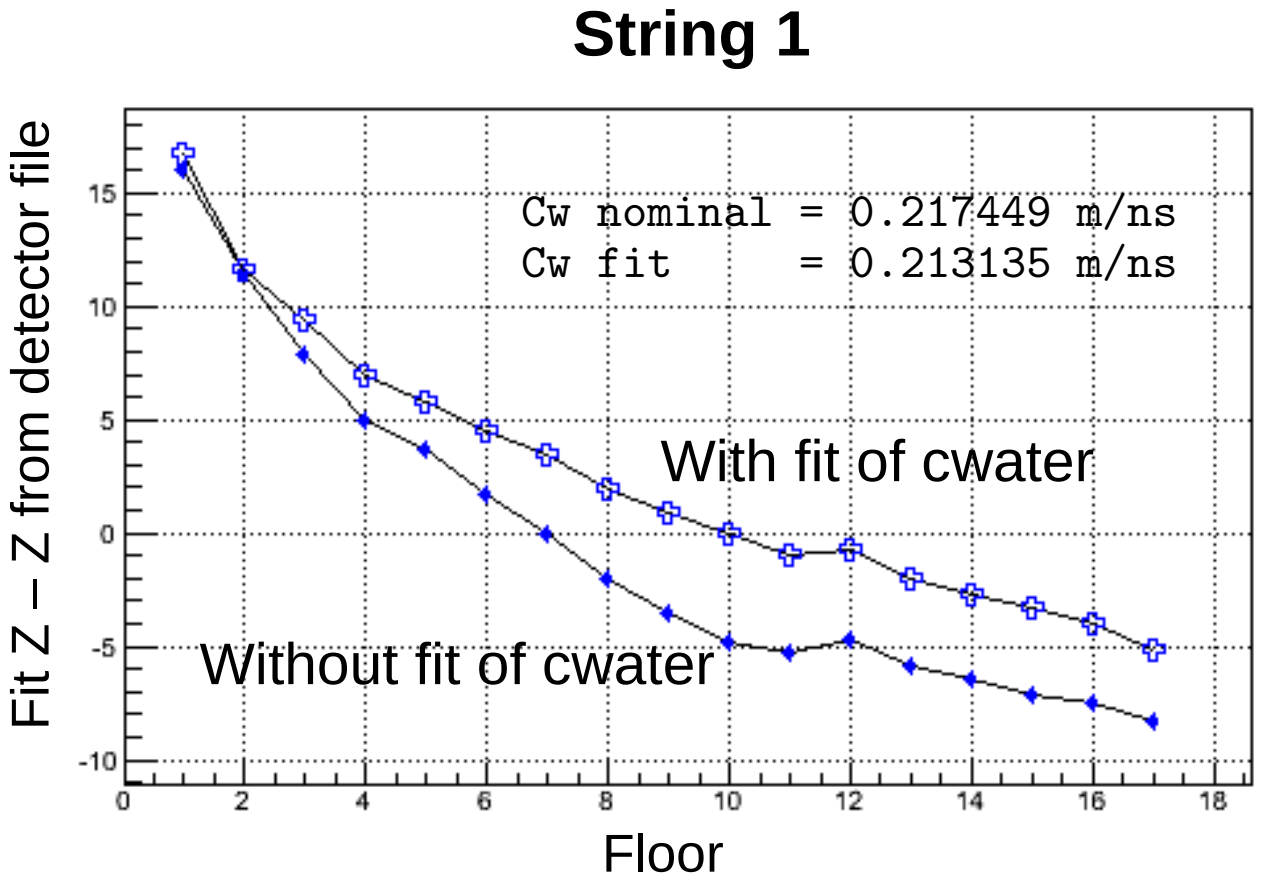

violet = detector file
blue = start values
red = fit values
Again: fit removes fluctuations but makes string shorter
Z from detector file [m]
100
200
300
400
500
600
700
2
4
6
8
10
12
14
16
18
Floor

String 2


violet = fit - detector file
blue = fit - start value
15
10
5
0
-5
-10
-15
2
4
6
8
10
12
14
16
18
Floor

Including cwater

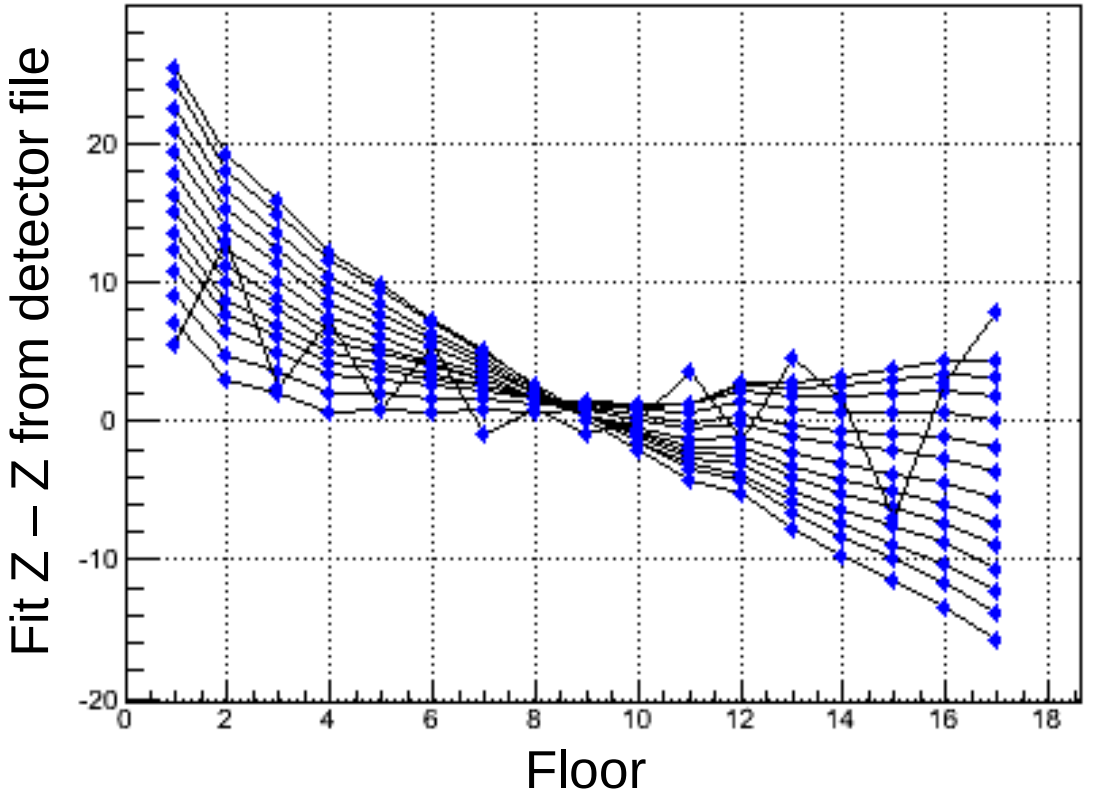
- Now I also free cwater in the fit
  - still the strings come out of the fit shorter



Inter-string distance

- Try different inter-string distances
- For each value, fit cwater, T0's, pulse times and DOM heights

Quick first result

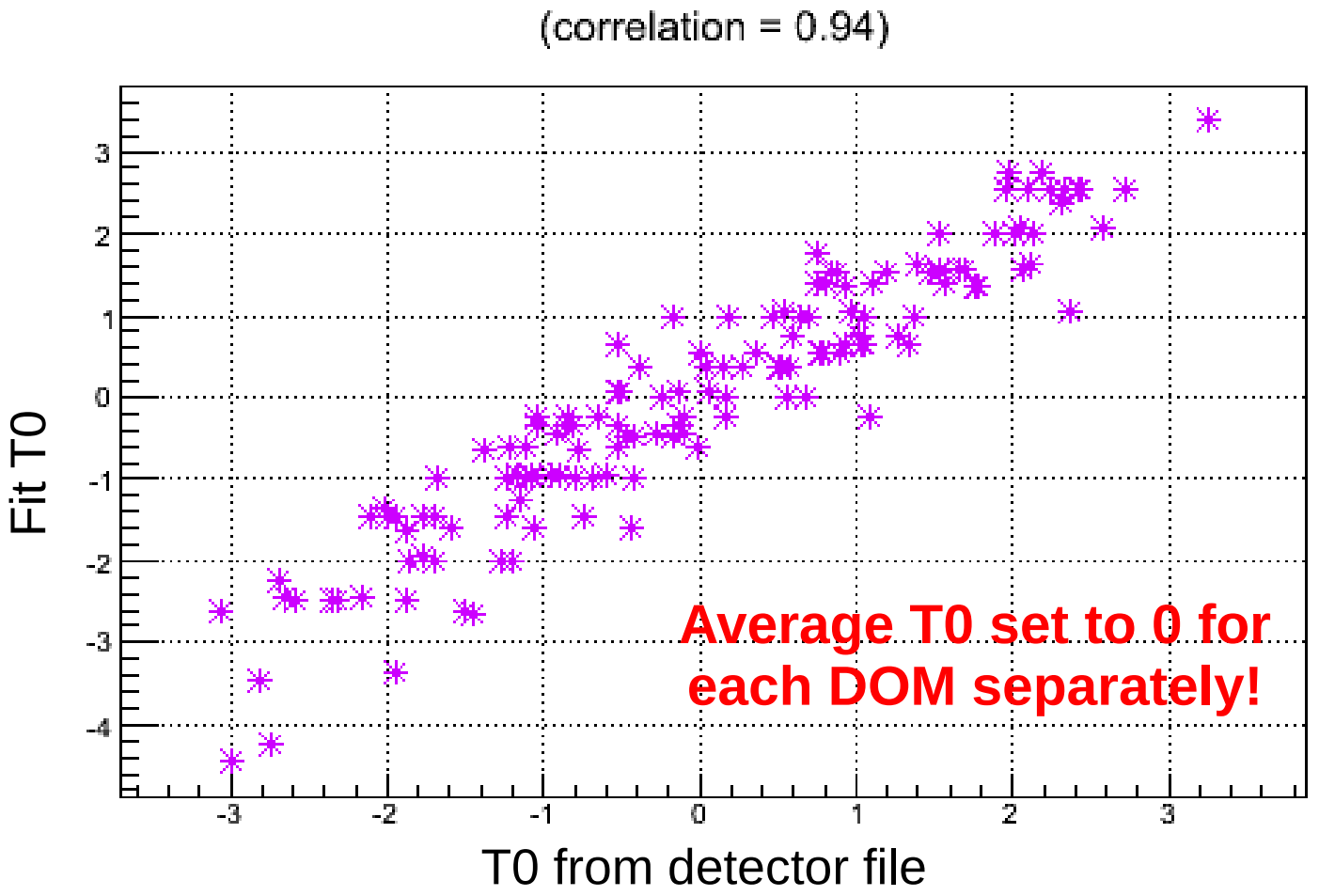


Backup slides

Home-brewed minimizer

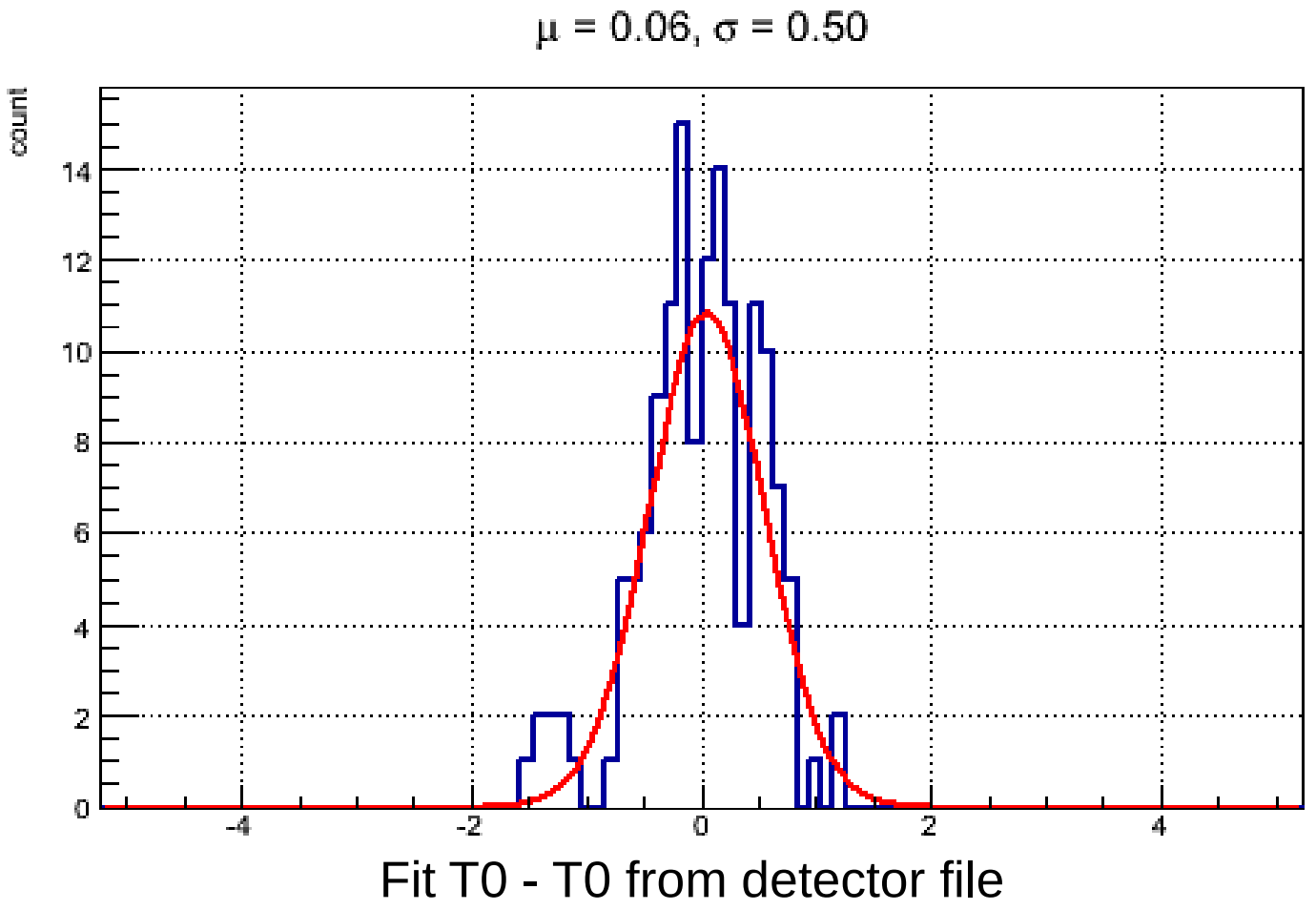
- Yes, I should have just used TMinuit or matrix inversion
- Taking advantage of analytical formula
- Use linear approximation of t_expected
  - chi-squared becomes quadratic for each parameter (for fixed values of the other parameters)
- Algorithm
  - for each parameter, calculate minimum analytically
  - move to the minimum
  - keep looping over parameters until they are all at their minimum

Using only lower-half PMTs looking at the beacon one floor down



Run #5112 (low luminosity, string 2)

Using only lower-half PMTs looking at the beacon one floor down



Run #5112 (low luminosity, string 2)