Fine Time Measurements Calibration

4 TDCs for each pixel, 4 pixel for each column, 8 columns for each chip

128 calibrations * 6 chip

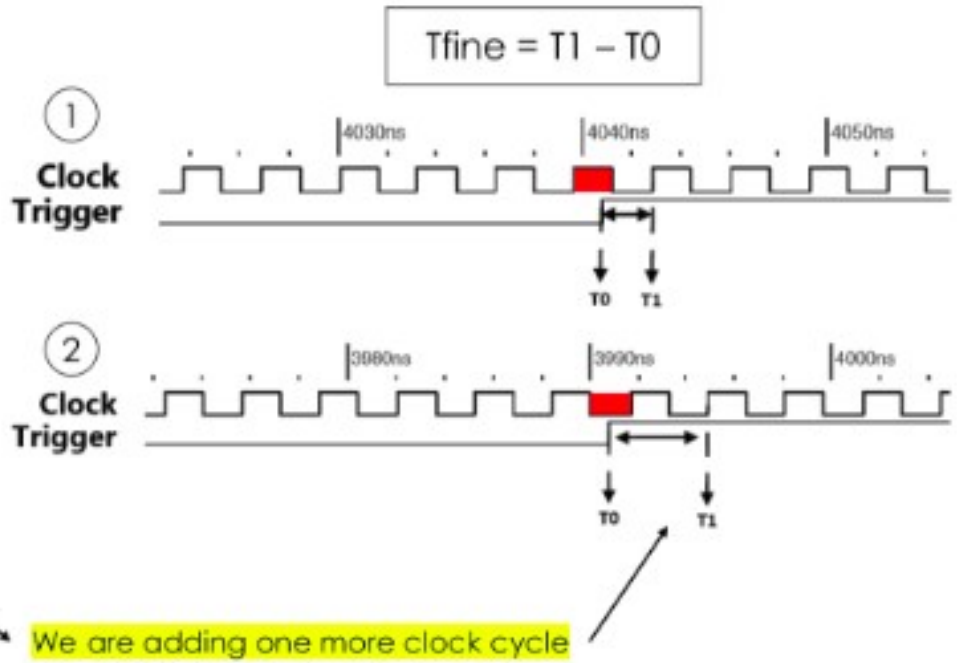
768 total calibrations

TDC principle of operation

[source: Fabio Cossio]

- Low-power TDC with analogue interpolation to measure **phase** between event **trigger** (T0) and **clock** (T1)

- To avoid metastability issues
  1. If trigger occurs BEFORE clock falling edge the signal is sampled w.r.t. NEXT clock rising edge
  2. If trigger occurs AFTER clock falling edge the signal is sampled w.r.t. SECOND NEXT rising edge



1

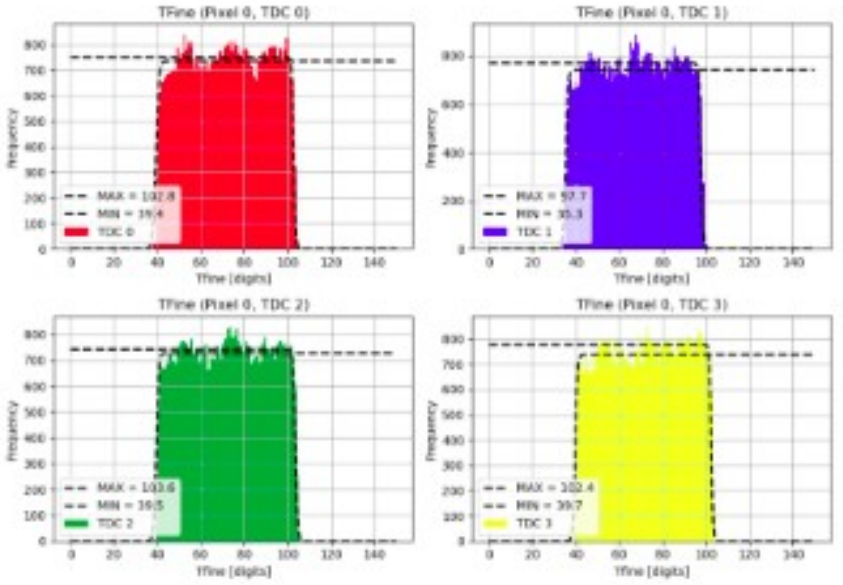
[source: Fabio Cossio]

Fine time measurement

- IF = MAX - MIN
- LSB = clk_period / IF
- CUT = (MAX + MIN) / 2
- 32 pixels, 4 TDCs → 128 entries LUT with MIN, MAX values
- Apply fine time correction for each hit data:

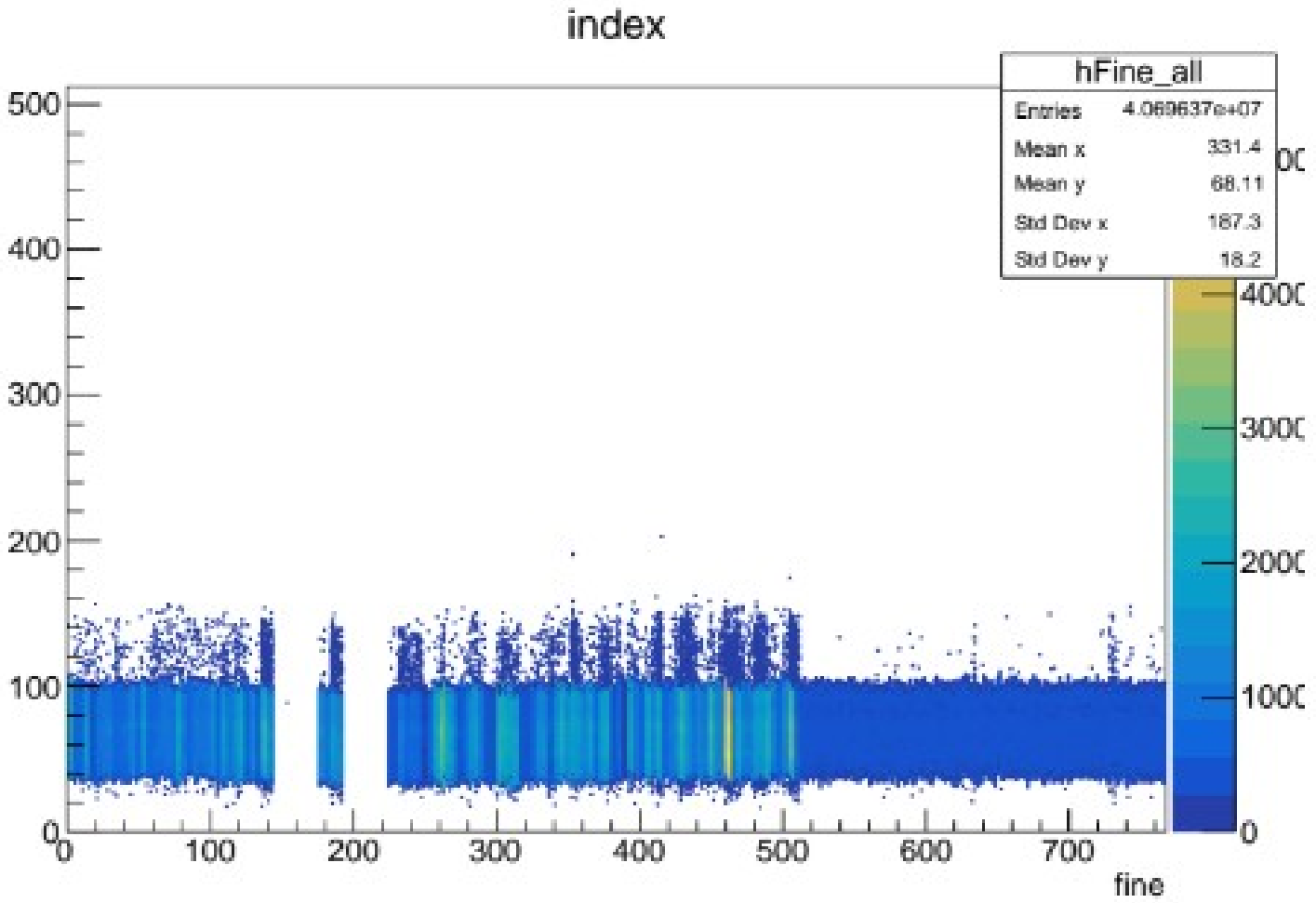
```
if Tfine < CUT:
    fine_time = ( Tfine - MIN ) / IF
if Tfine > CUT:
    fine_time = ( ( Tfine - MIN ) / IF ) - 1

Timestamp = Tcoarse - fine_time
```

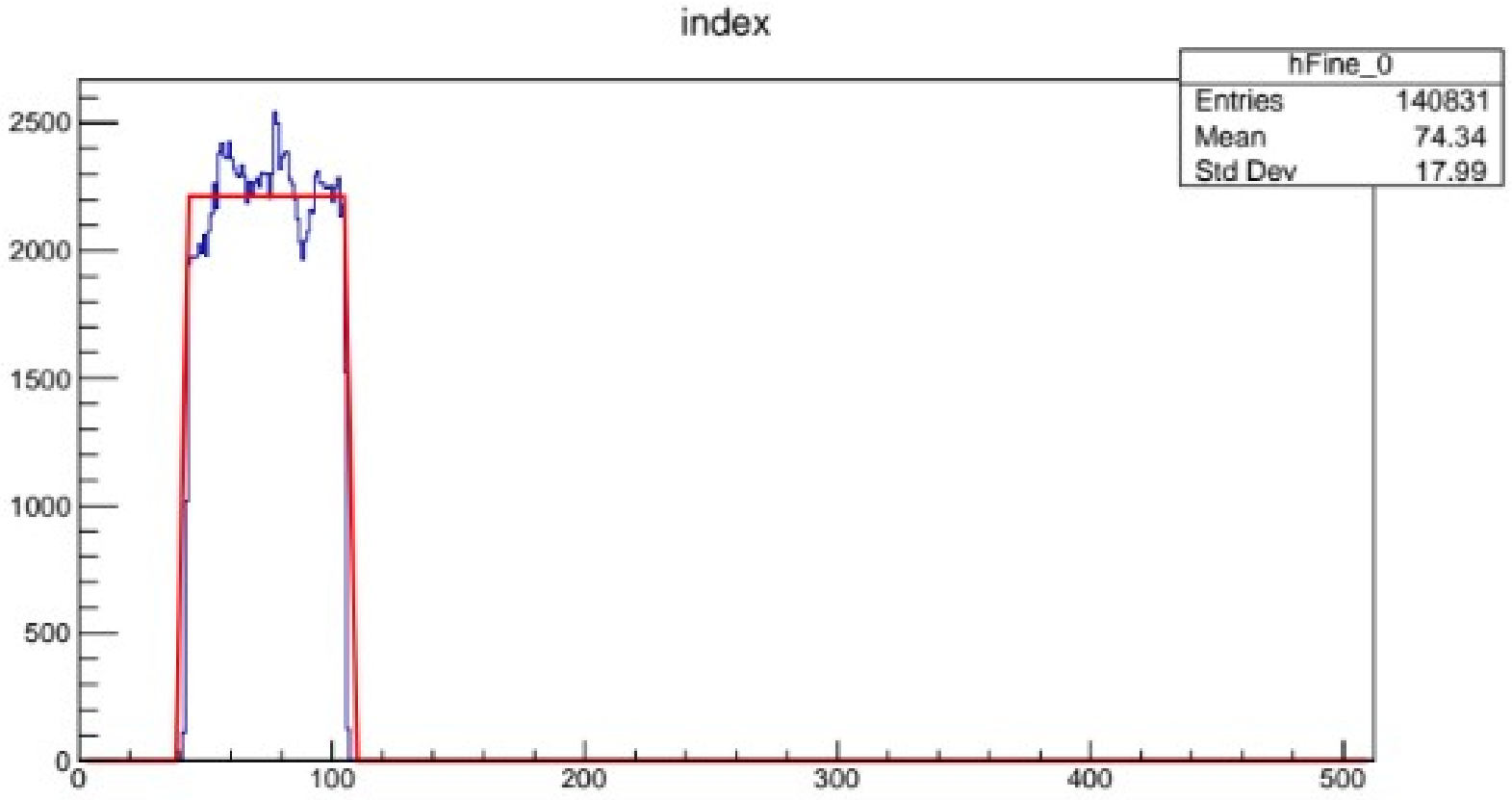


We remove the additional clock cycle

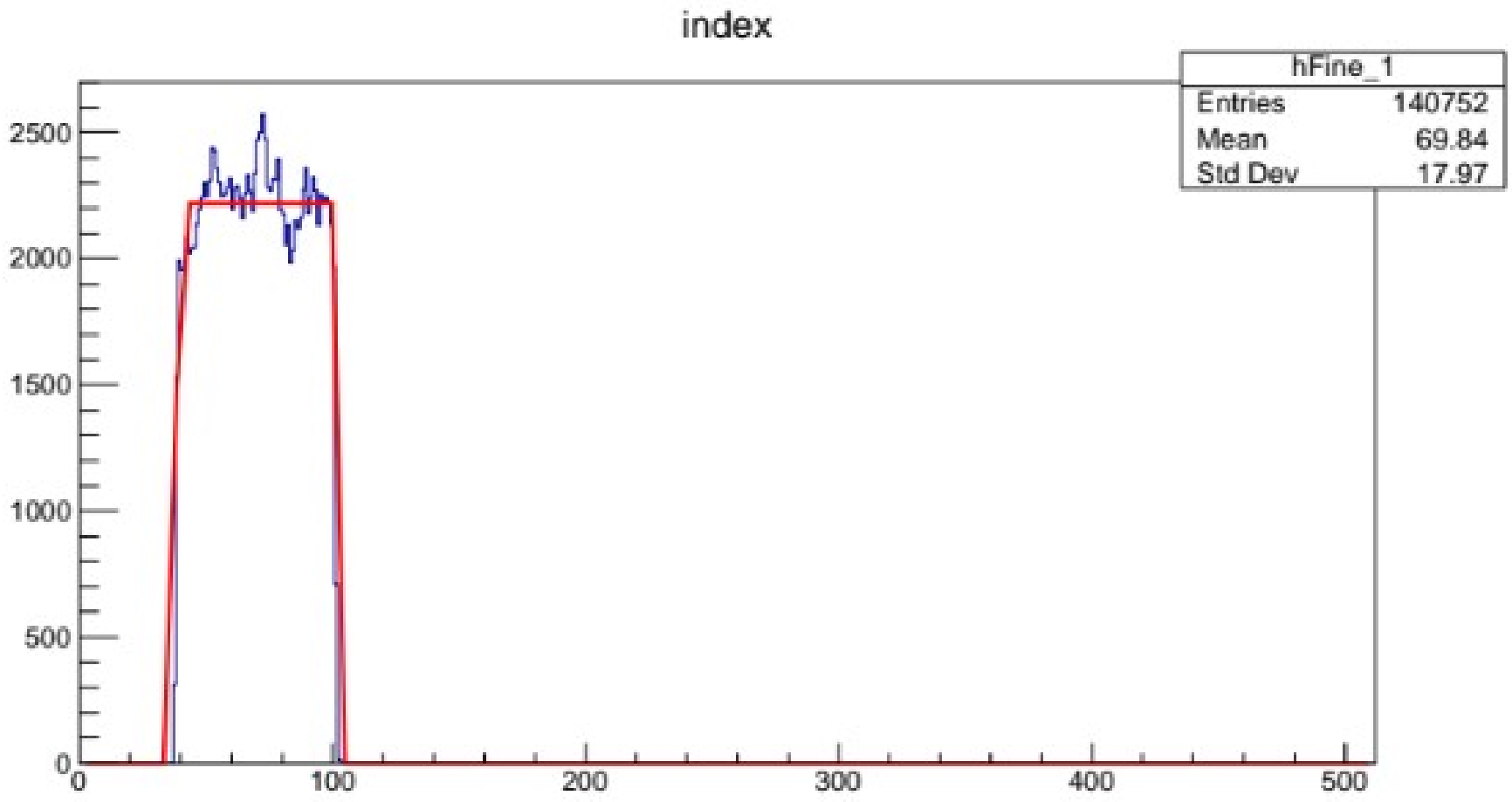
3


index
hFine_all
Entries 4.069637e+07
Mean x 331.4
Mean y 68.11
Std Dev x 187.3
Std Dev y 18.2
500
400
300
200
100
0
0
100
200
300
400
500
600
700
fine
4000
3000
2000
1000
0

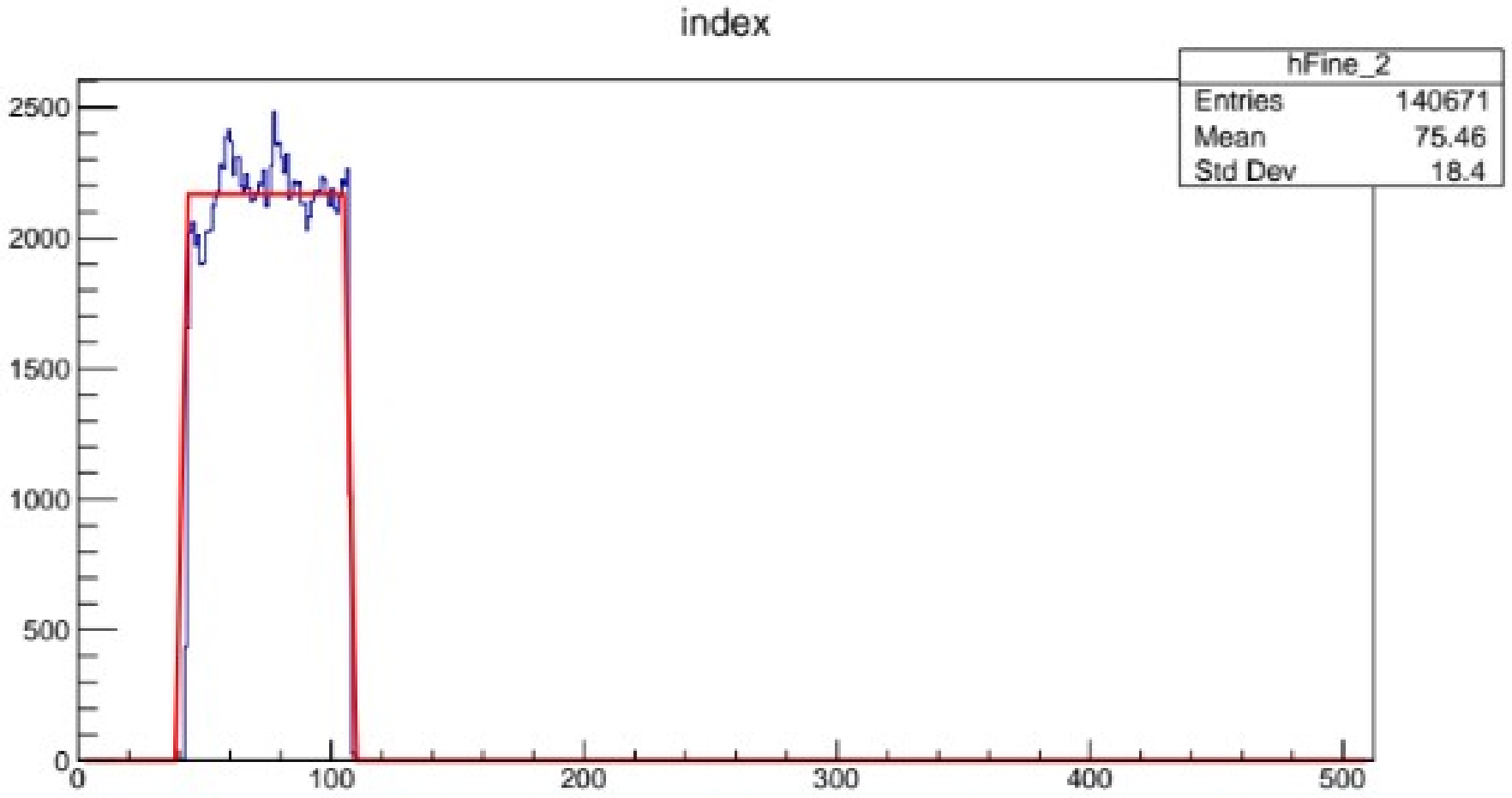
TDC 0, Channel 0, Chip 0 (HAMA1)



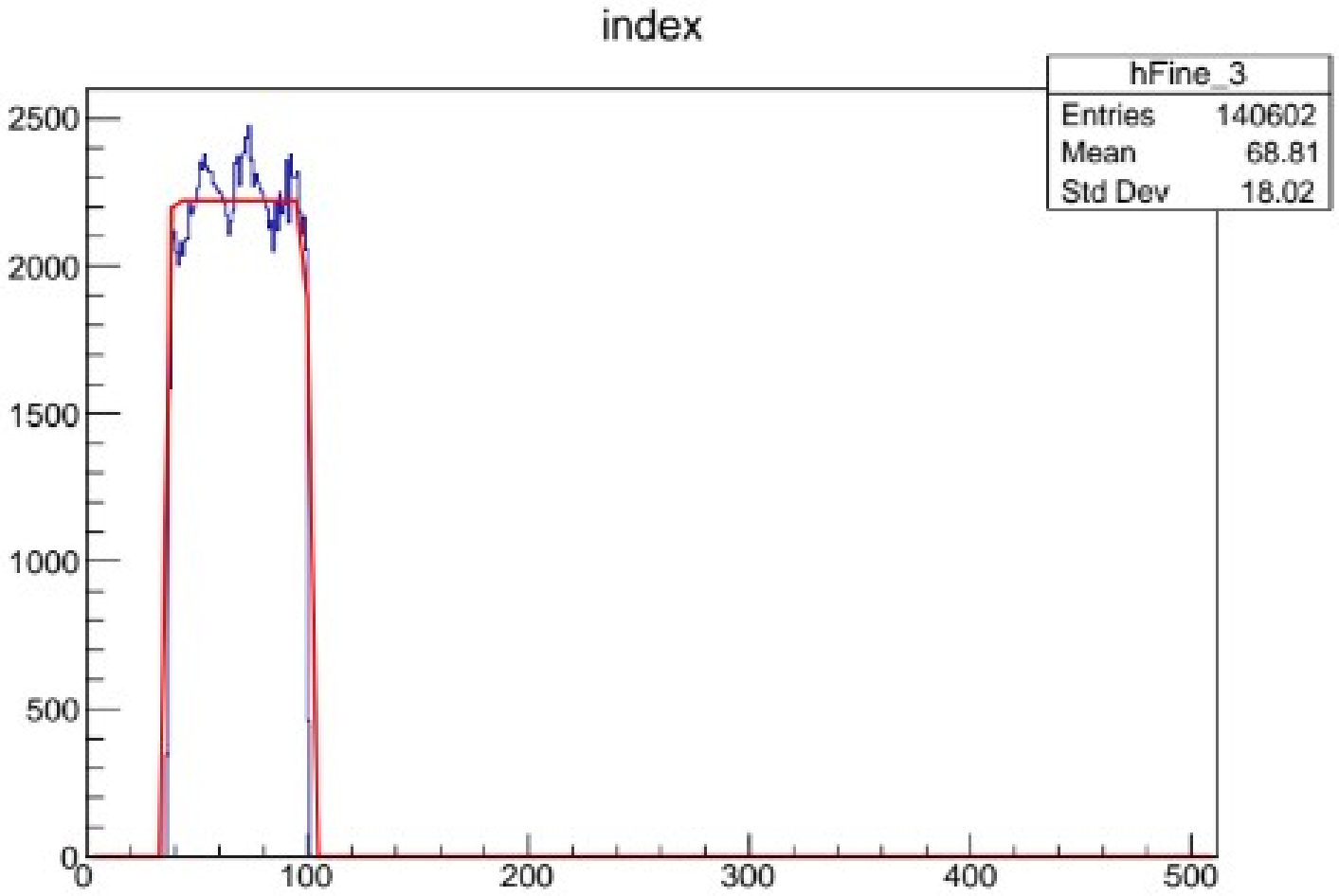
TDC 0, Channel 0, Chip 1 (FBK)



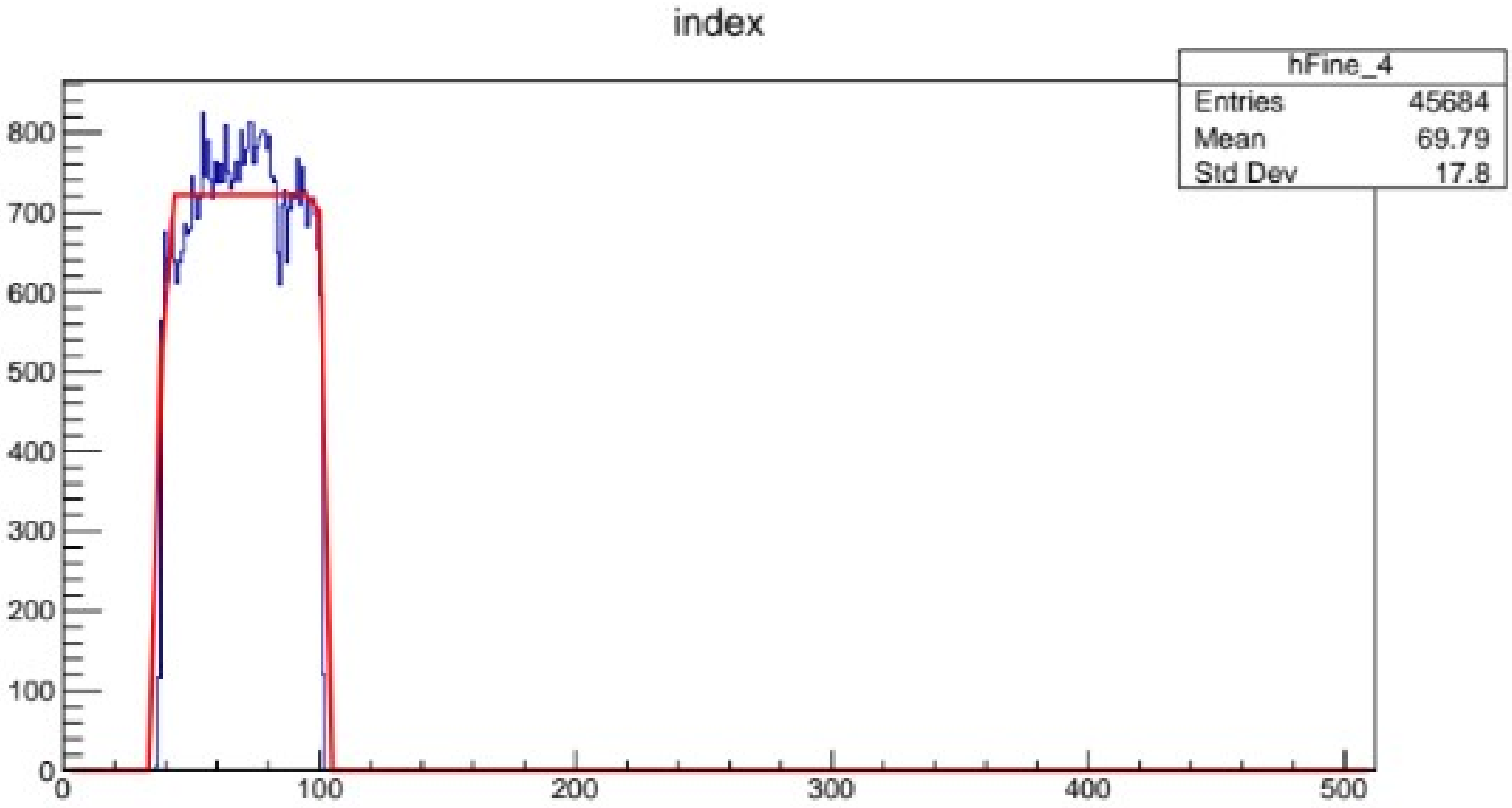
TDC 0, Channel 0, Chip 2 (HAMA2)



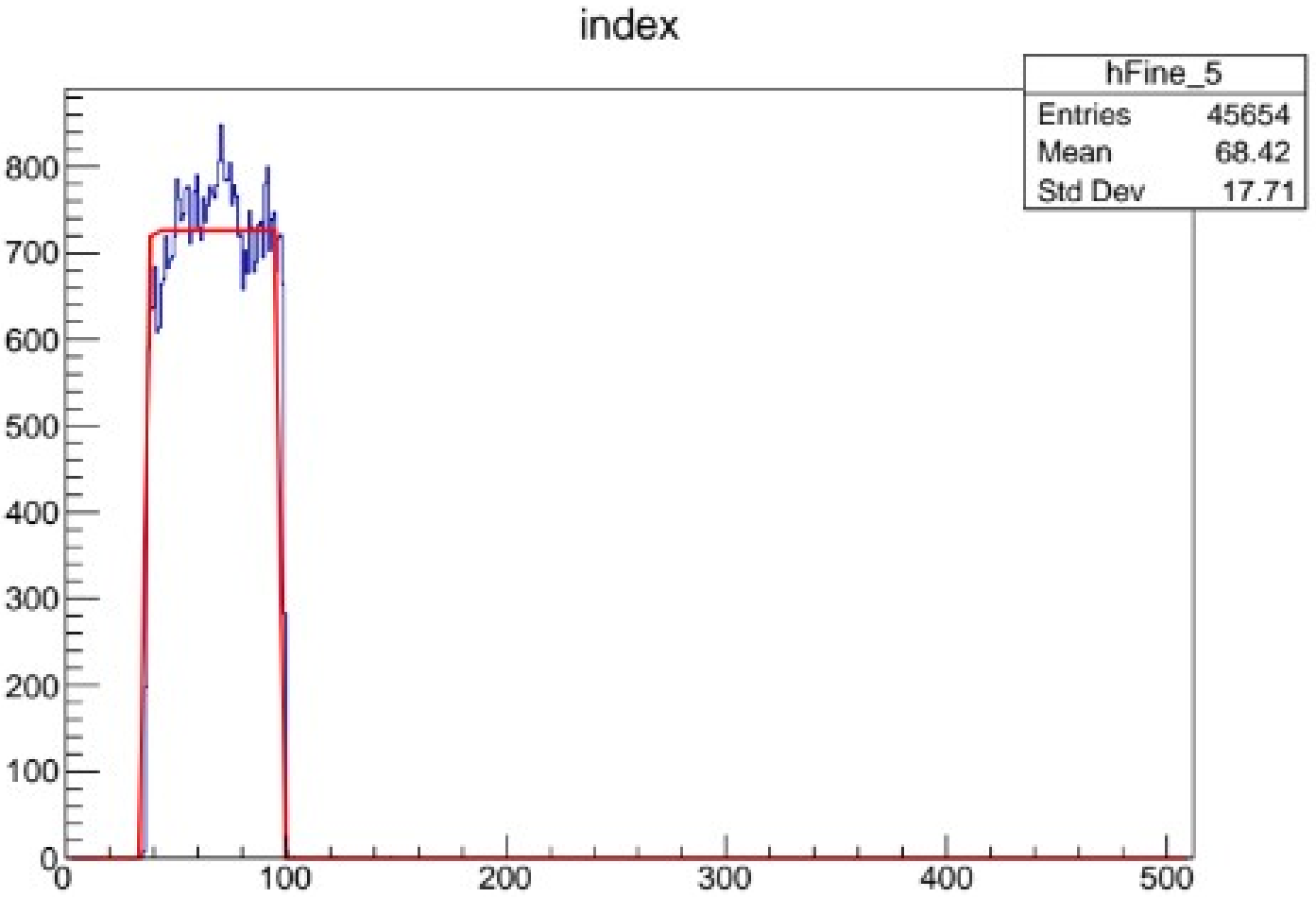
TDC 0, Channel 0, Chip 3 (SENSL)



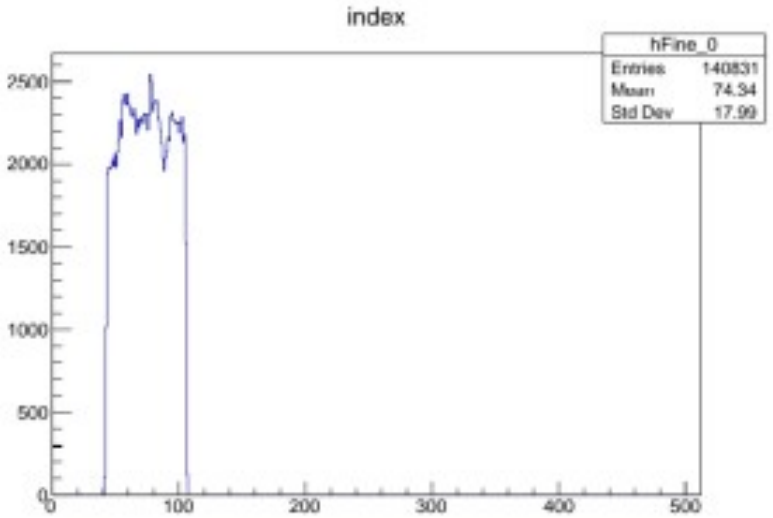
TDC 0, Channel 0, Chip 4

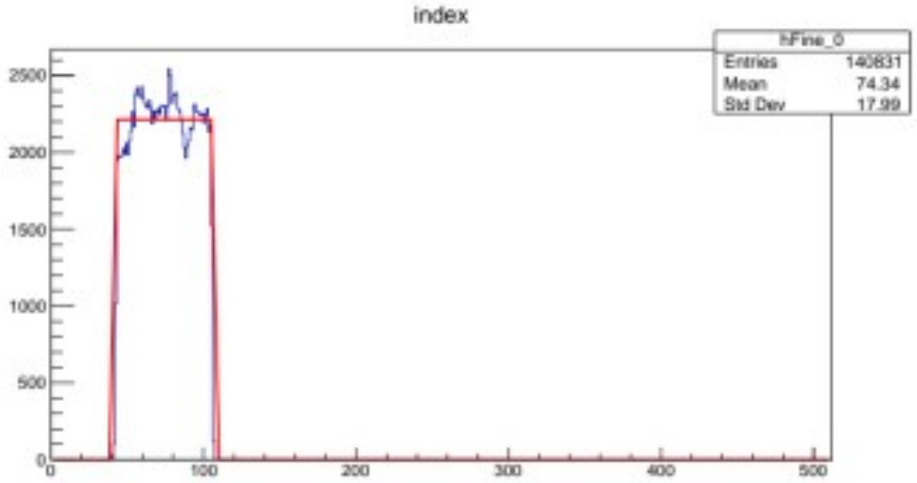


TDC 0, Channel 0, Chip 5



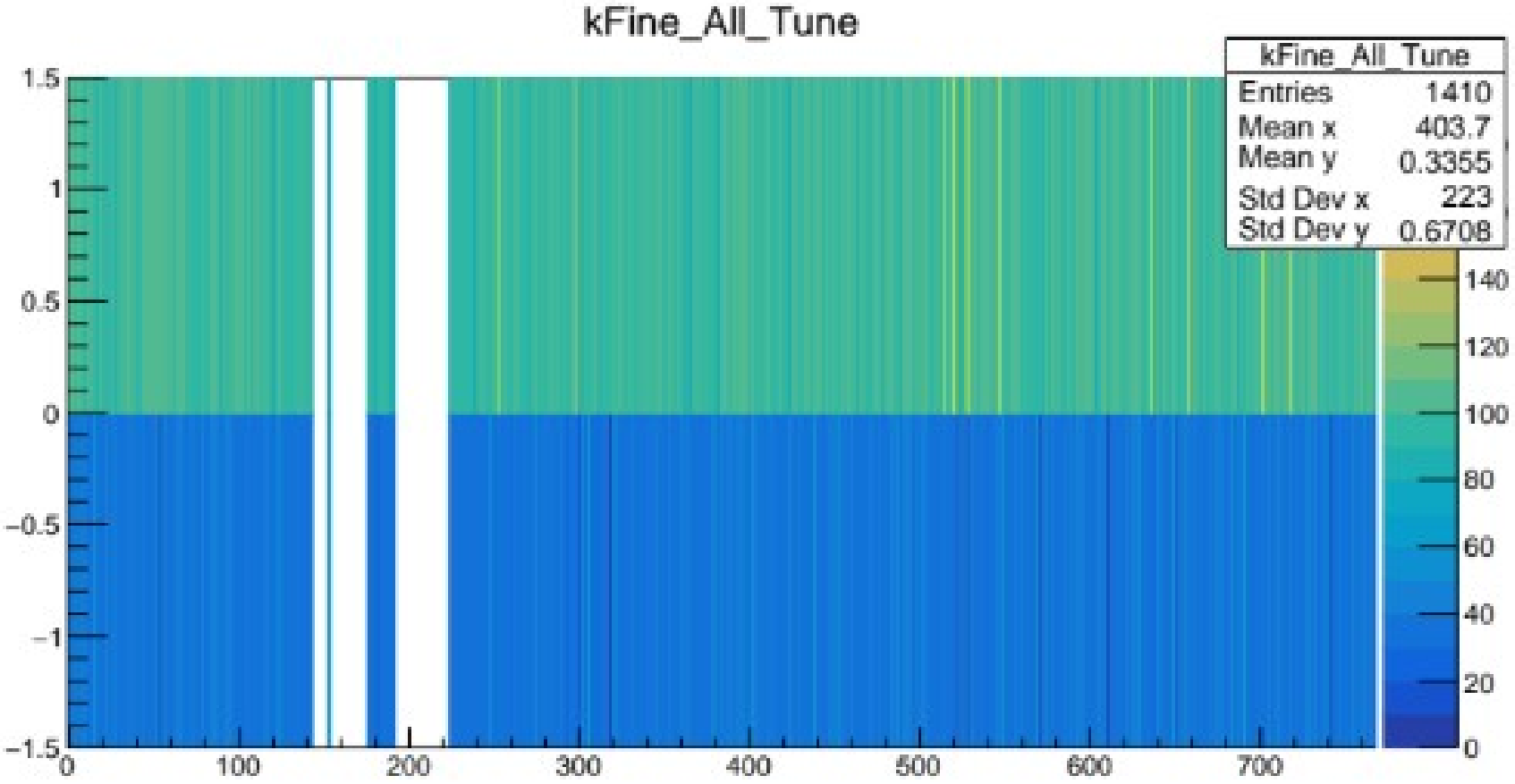
Fit & Fit Parameters



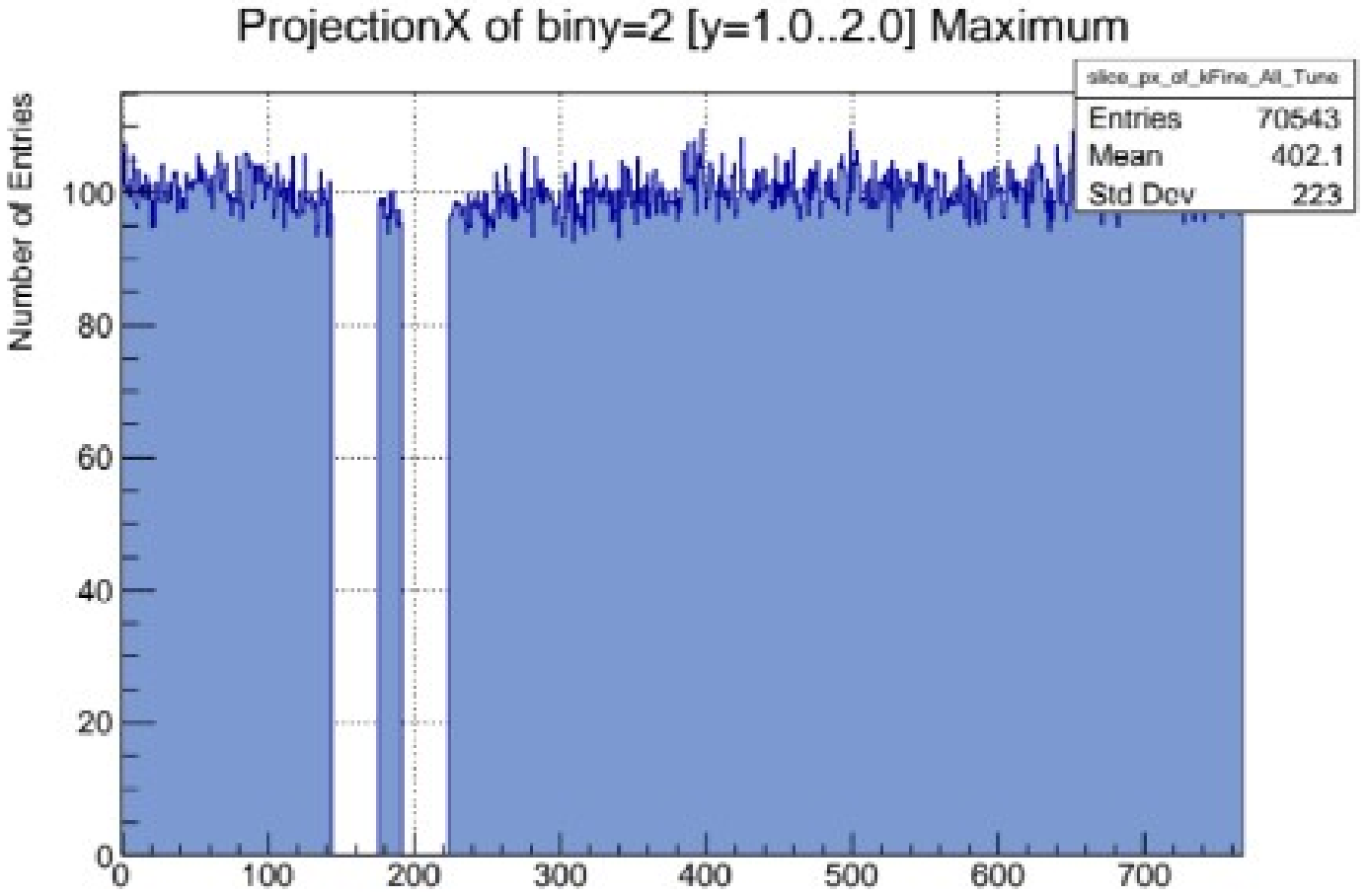



```
  EXT PARAMETER                   APPROXIMATE        STEP         FIRST
  NO.   NAME      VALUE            ERROR          SIZE      DERIVATIVE
   1  p0           2.21438e+03   5.67038e+00   0.00000e+00   7.01718e-01
   2  p1           1.06486e+02   1.00002e+00   0.00000e+00  -4.33218e+03
   3  p2           4.81133e-03   1.00000e+00   0.00000e+00  -1.26750e+04
   4  p3           4.27597e+01   1.00038e+00  -0.00000e+00   4.46111e-08
   5  p4           6.86736e-03   1.00000e+00   0.00000e+00  -9.14841e+06
root [6]
```

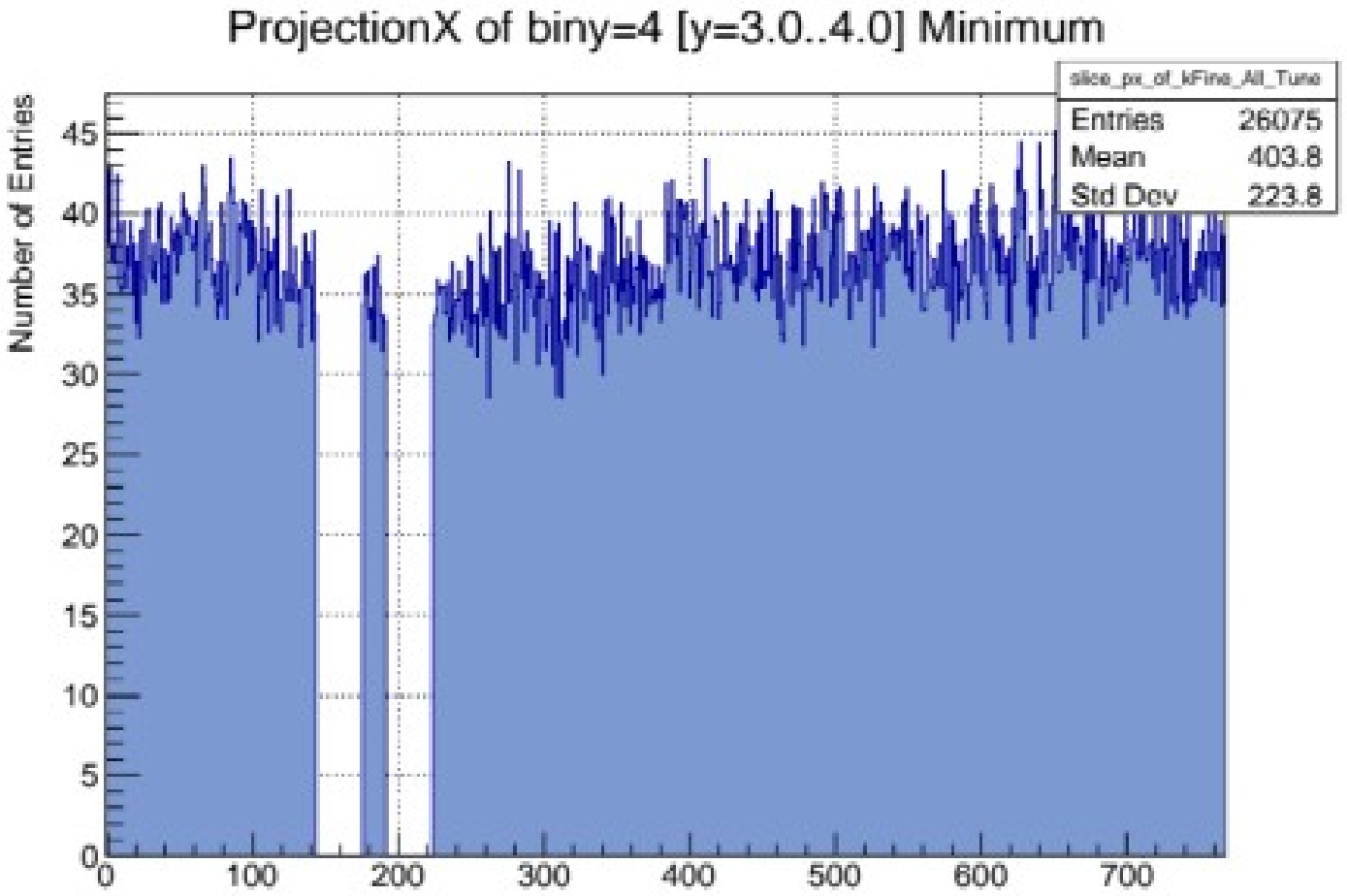
Max & Min Parameter Values



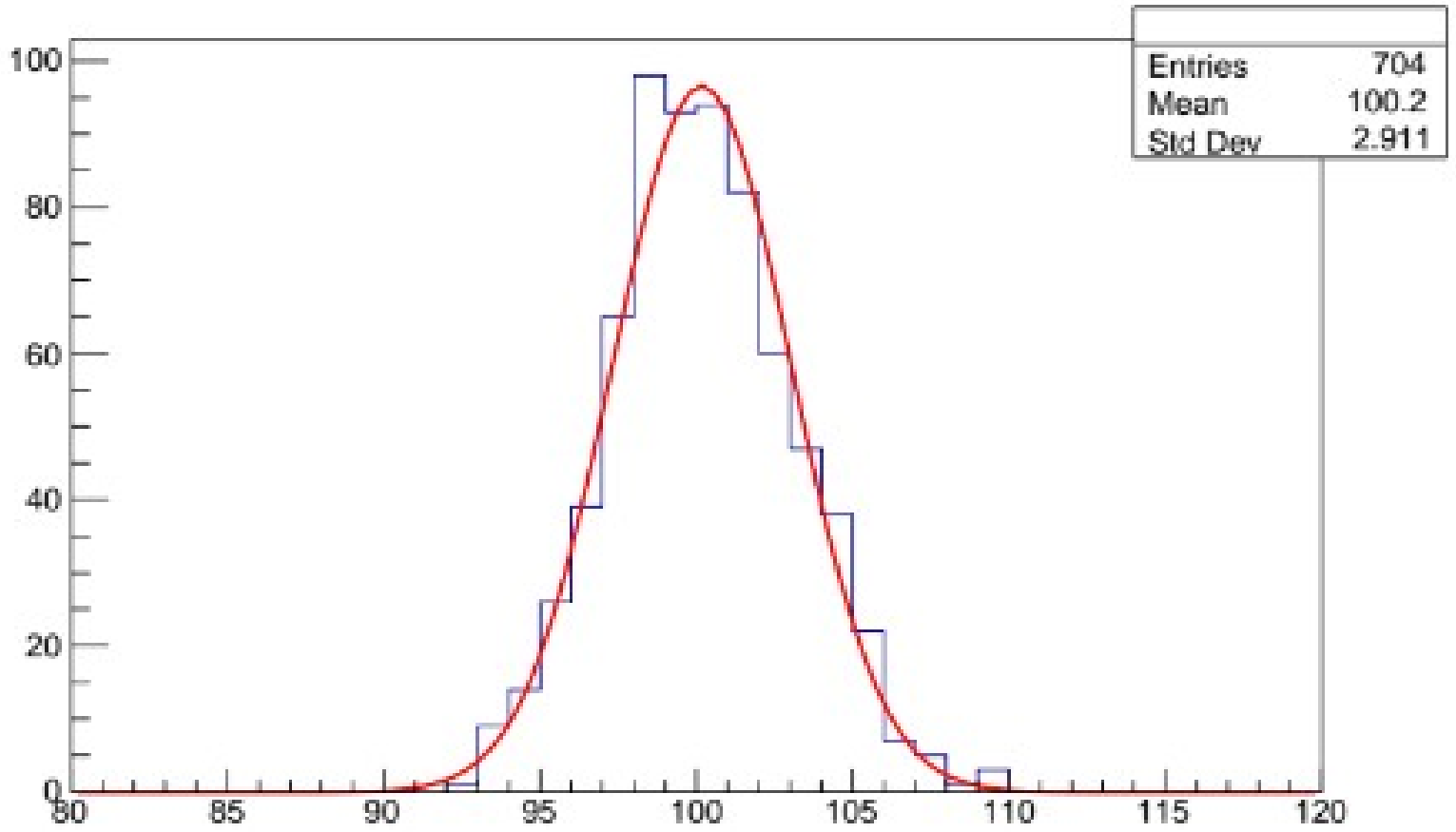
Max Values


ProjectionX of biny=2 [y=1.0..2.0] Maximum
Number of Entries
0
20
40
60
80
100
0
100
200
300
400
500
600
700
Entries 70543
Mean 402.1
Std Dev 223

Min Values


ProjectionX of biny=4 [y=3.0..4.0] Minimum
slice_px_of_kFine_All_Tune
Entries 26075
Mean 403.8
Std Dev 223.8
Number of Entries
0
5
10
15
20
25
30
35
40
45
0
100
200
300
400
500
600
700

Max Distribution



Min Distribution