

# Timing Calibration & Signal Selection

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Si

# Fitting of Timing

	mean	m_error	sigma	s_erro r
Si0_0	201.2	0.6	4.4	0.7
wall 0	200.52	0.03	4.48	0.04
Si1_0	202.6	0.4	4.6	0.4
wall 1	202.24	0.04	5.03	0.04
Si2_0	203.0	0.6	3.6	0.5
wall 2	203.22	0.09	5.95	0.08
Si3_0	202.8	0.7	5.3	0.9
wall 3	202.67	0.07	5.38	0.07

## Conclusion:

1. Different calibration constants for each wall
2. The fitting result of a wall is consistent with the strips that belong to it

## Calibration in the code

**Wall0: 200.52**

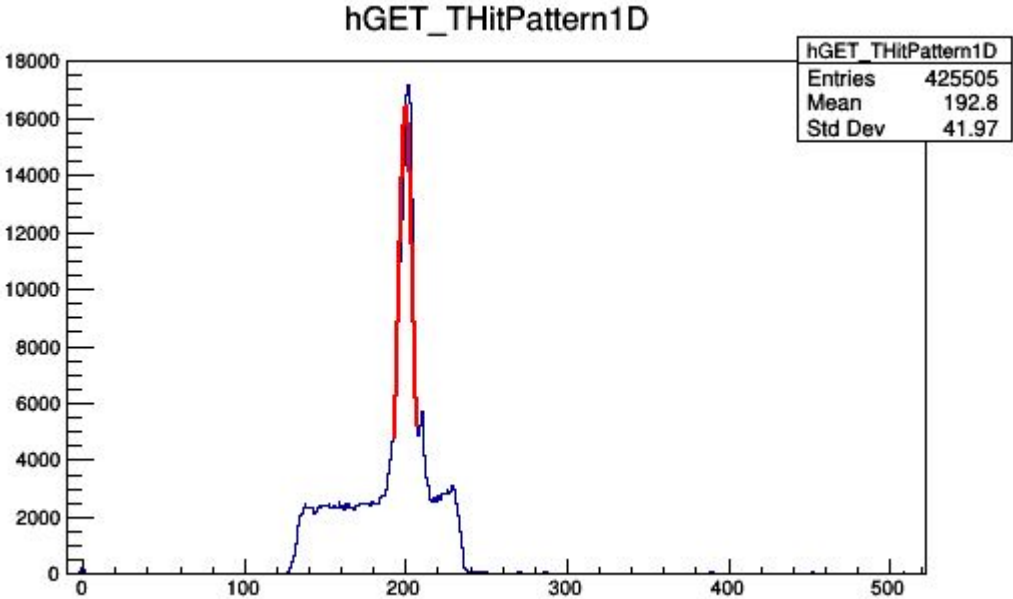
**Wall1: 202.24**

**Wall2: 203.22**

**Wall3: 202.67**

Wall 0	200.52	4.48
Wall 1	202.23	5.03
Wall 2	203.22	5.95
Wall 3	202.67	5.38

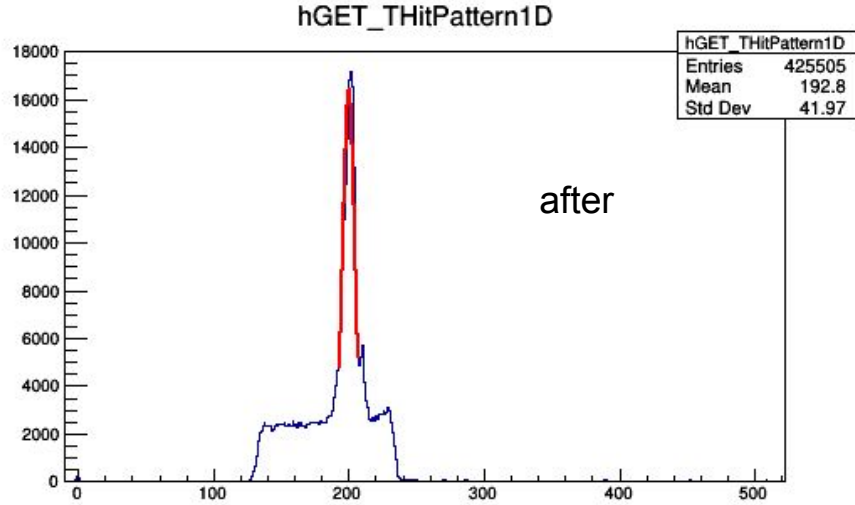
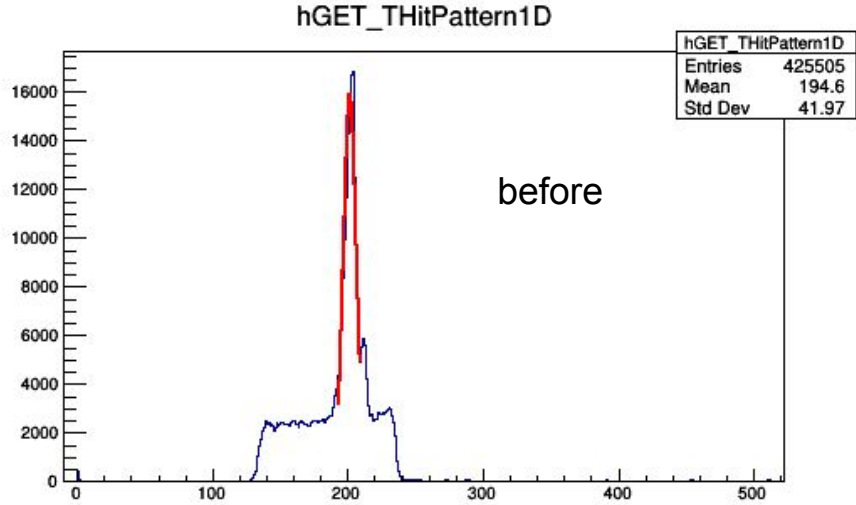
# Fitting of Timing with 4 walls combined(after calib.)



Wall 0	200.5180	4.4752
Wall 1	202.2390	5.0264
Wall 2	203.2190	5.9487
Wall 3	202.6740	5.3839
4Walls	200.1300	4.4762

NO.	NAME	VALUE	ERROR	SIZE	DERIVATIVE
1	Constant	1.64354e+04	5.66243e+01	6.02904e-02	-3.76815e-07
2	Mean	2.00130e+02	1.46267e-02	1.65763e-06	1.90229e-04
3	Sigma	4.47618e+00	1.83204e-02	-1.53052e-06	1.19530e-02

# Before and After Correction



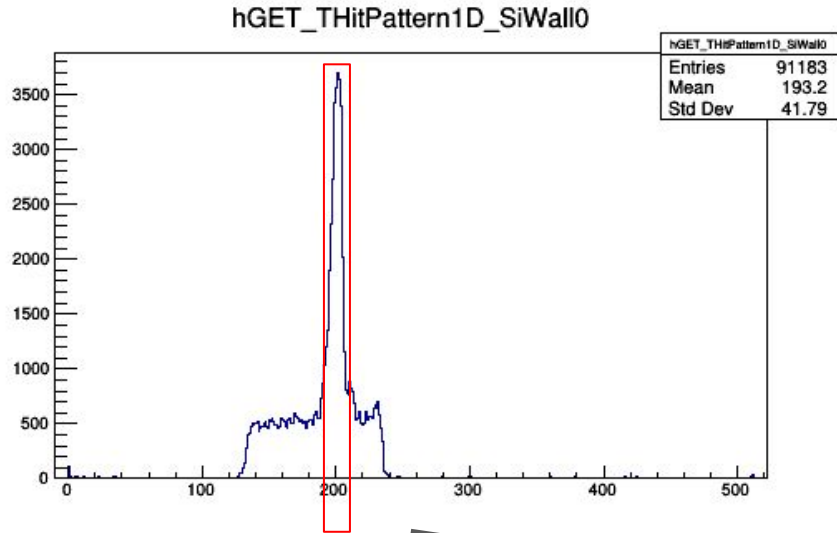
NO.	NAME	VALUE	ERROR	SIZE	DERIVATIVE
1	Constant	1.58810e+04	5.28177e+01	8.43930e-01	-2.49785e-05
2	Mean	2.01664e+02	1.43879e-02	3.15821e-04	5.28465e-02
3	Sigma	4.75511e+00	1.69268e-02	2.15108e-05	-6.71029e-01

201.66+-4.76

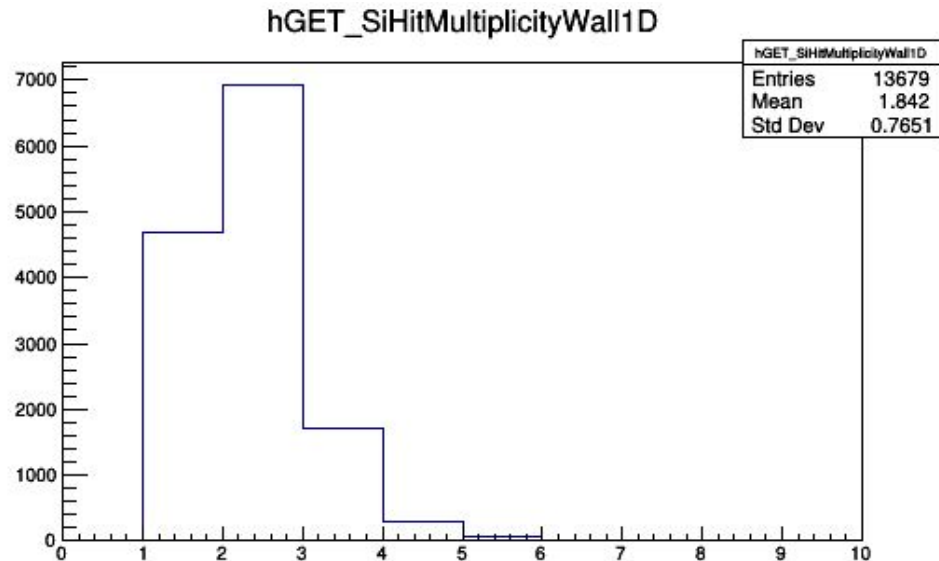
NO.	NAME	VALUE	ERROR	SIZE	DERIVATIVE
1	Constant	1.64354e+04	5.66243e+01	6.02904e-02	-3.76815e-07
2	Mean	2.00130e+02	1.46267e-02	1.65763e-06	1.90229e-04
3	Sigma	4.47618e+00	1.83204e-02	-1.53052e-06	1.19530e-02

200.13+-4.48

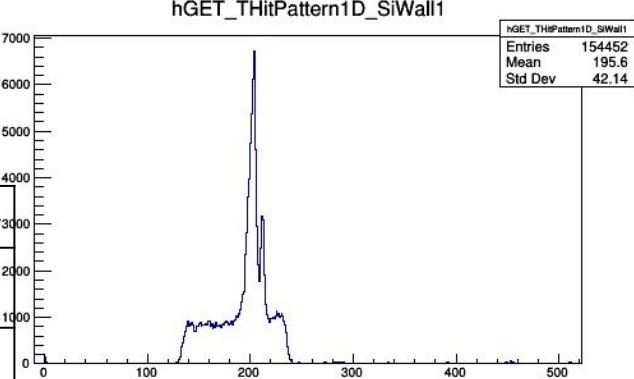
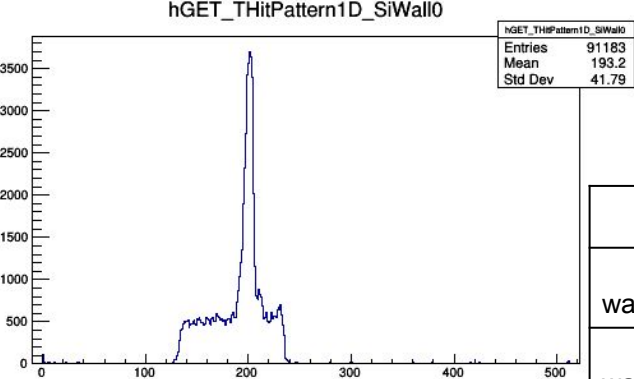
# Hit Multiplicity of Si\_Wall0\_Front



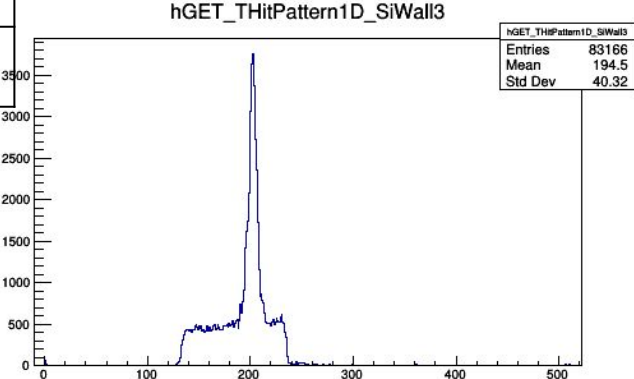
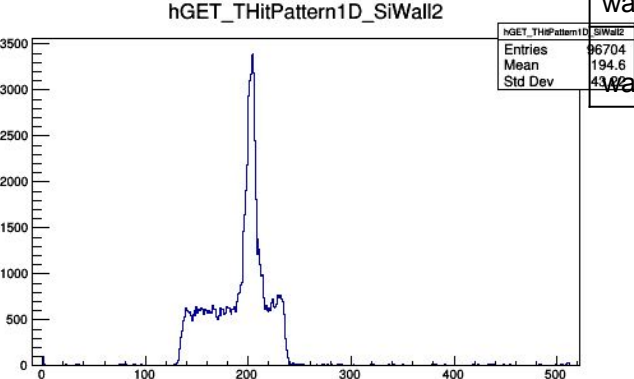
190-210



# Before Correction

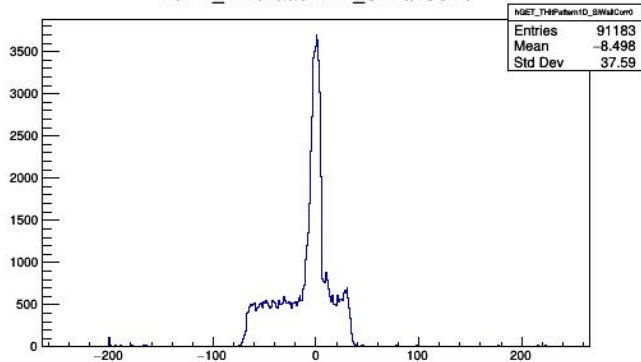


	mean	m_error	sigma	s_error	
wall 0	200.5	2	0.03	4.48	0.04
wall 1	202.2	4	0.04	5.03	0.04
wall 2	203.2	2	0.09	5.95	0.08
wall 3	202.6	7	0.07	5.38	0.07

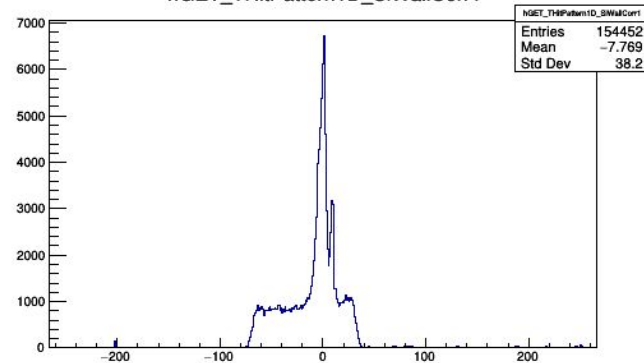


# After Correction

hGET\_THitPattern1D\_SiWallCorr0

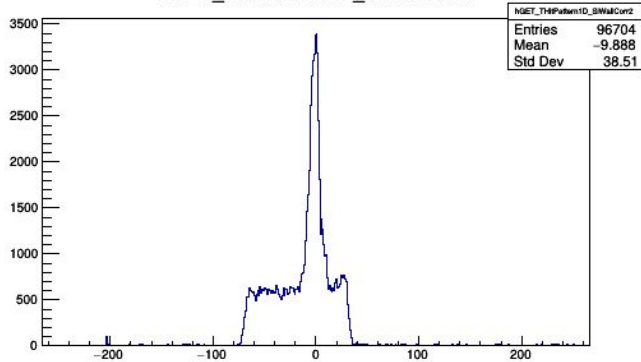


hGET\_THitPattern1D\_SiWallCorr1

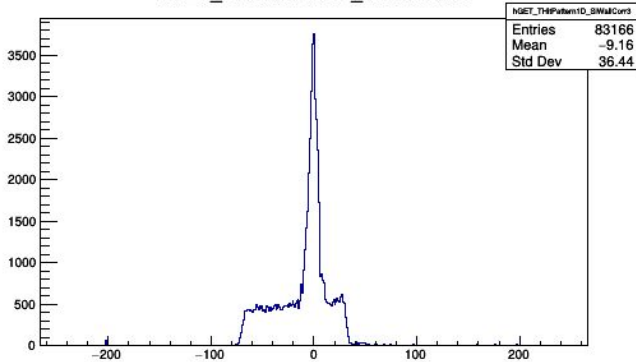


	mean	m_error	sigma	s_err r
wall 0	-0.55	0.03	4.37	0.03
wall 1	-0.87	0.02	4.71	0.03
wall 2	-1.30	0.04	5.20	0.05
wall 3	-0.67	0.03	4.53	0.03

hGET\_THitPattern1D\_SiWallCorr2



hGET\_THitPattern1D\_SiWallCorr3





before correction

	mean	m_error	sigma	s_error
wall 0	200.5 2	0.03	4.48	0.04
wall 1	202.2 4	0.04	5.03	0.04
wall 2	203.2 2	0.09	5.95	0.08
wall 3	202.6 7	0.07	5.38	0.07

after correction

	mean	m_error	sigma	s_error
wall 0	-0.55	0.03	4.37	0.03
wall 1	-0.87	0.02	4.71	0.03
wall 2	-1.30	0.04	5.20	0.05
wall 3	-0.67	0.03	4.53	0.03

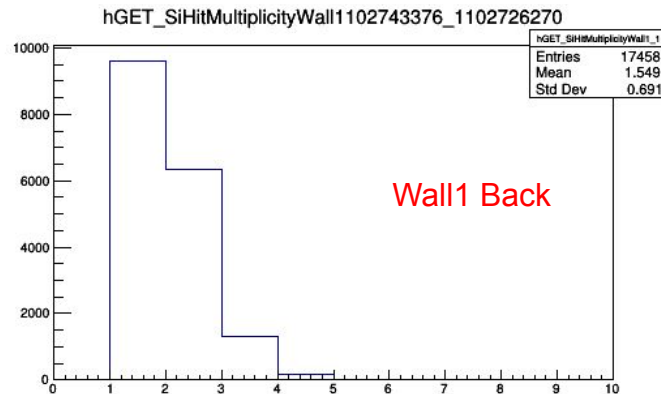
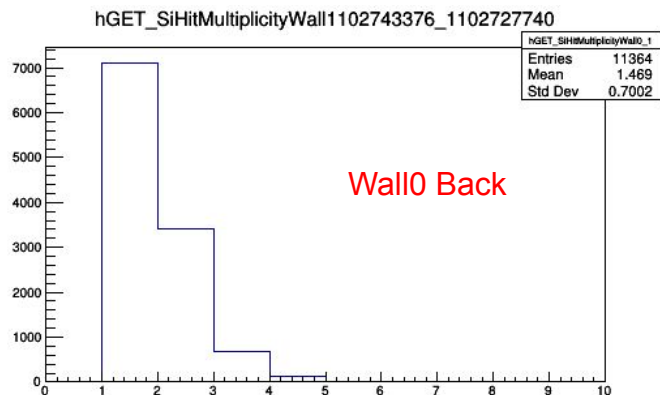
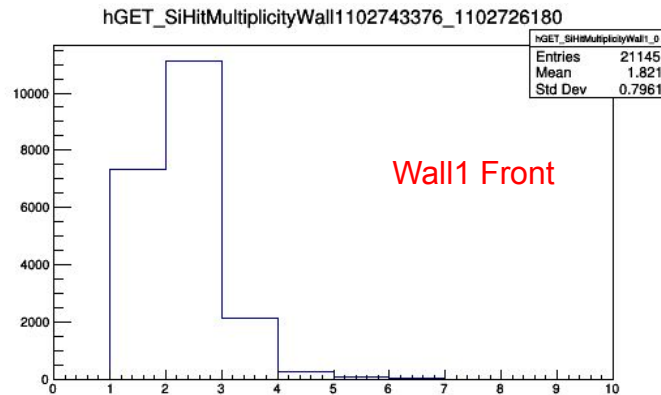
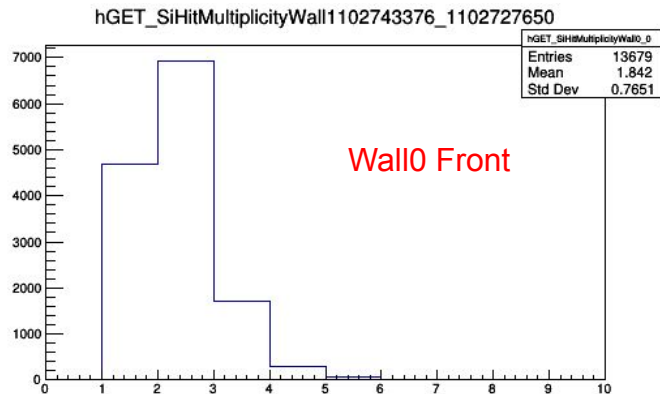
before correction

	mean	m_error	sigma	s_error
wall 0	199.94	0.03	4.34	0.03
wall 1	201.40	0.02	4.44	0.03
wall 2	201.84	0.04	4.97	0.05
wall 3	201.73	0.03	4.68	0.04

after correction

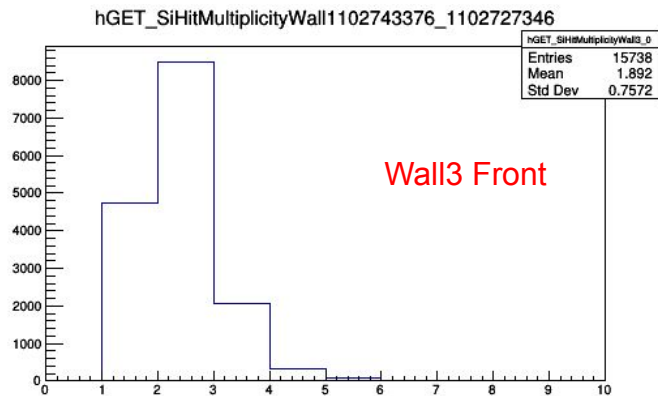
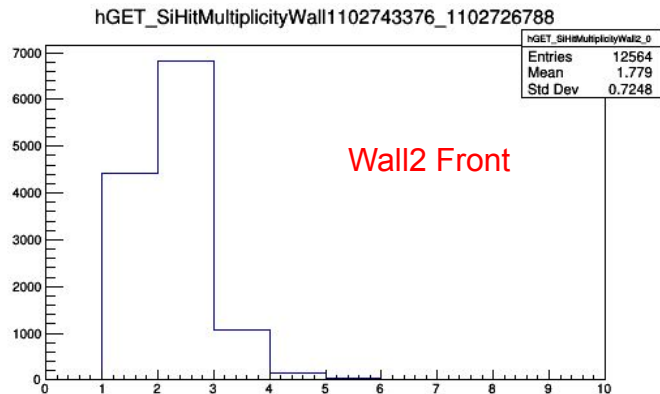
	mean	m_error	sigma	s_error
wall 0	-0.06	0.03	4.34	0.03
wall 1	0.40	0.02	4.44	0.03
wall 2	-0.03	0.04	4.92	0.05
wall 3	-0.21	0.03	4.42	0.04

# Hit Multiplicity of Si Wall, both sides

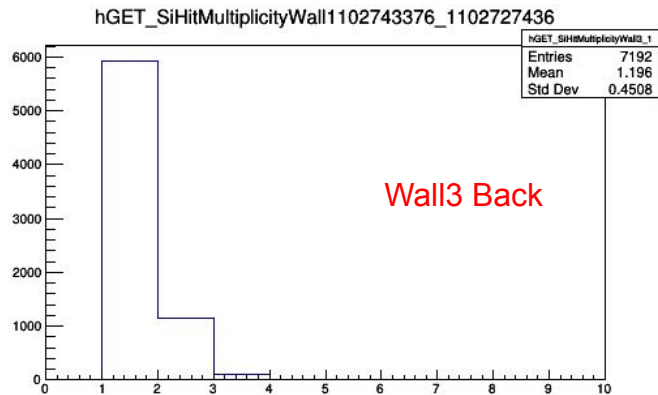
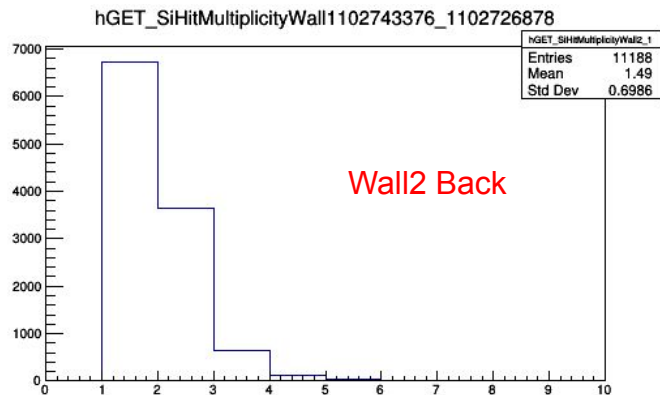


Two Sides  
Different Multi.

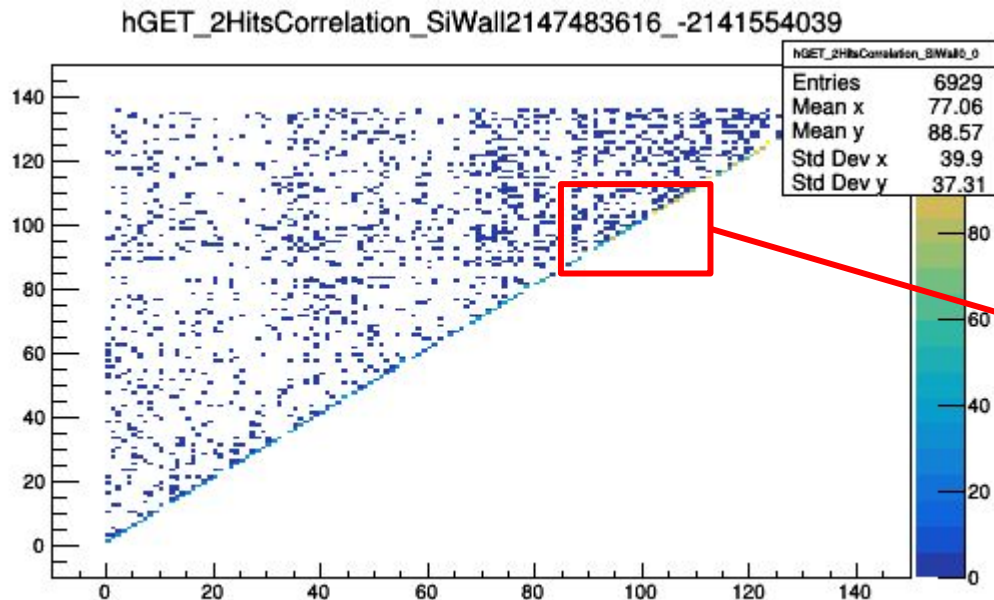
# Hit Multiplicity of Si Wall, both sides



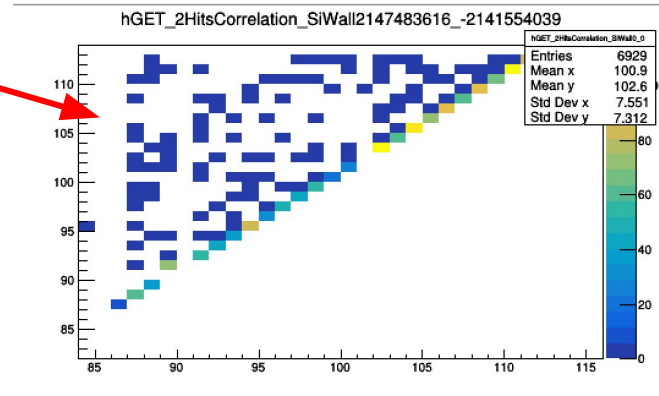
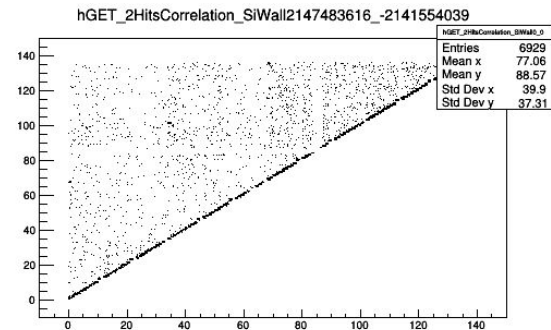
Two Sides  
Different Multi.



# Two Hits Correlation

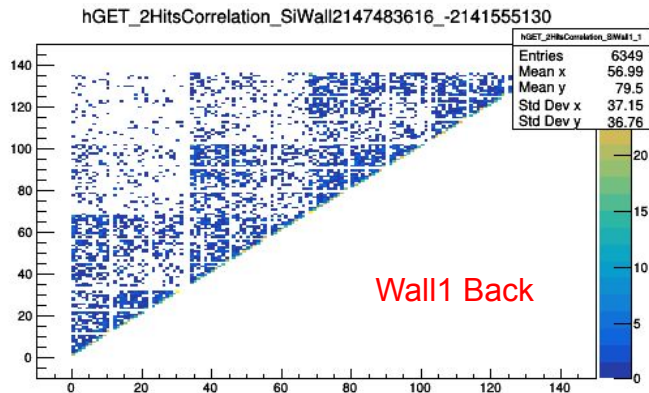
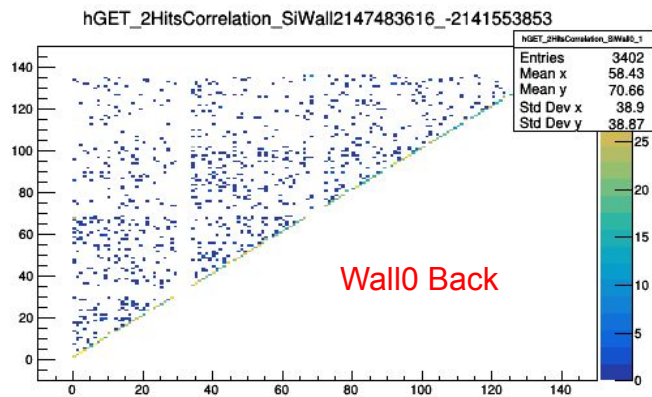
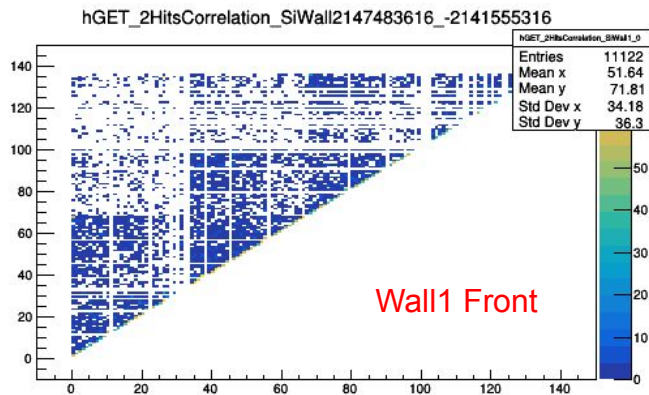
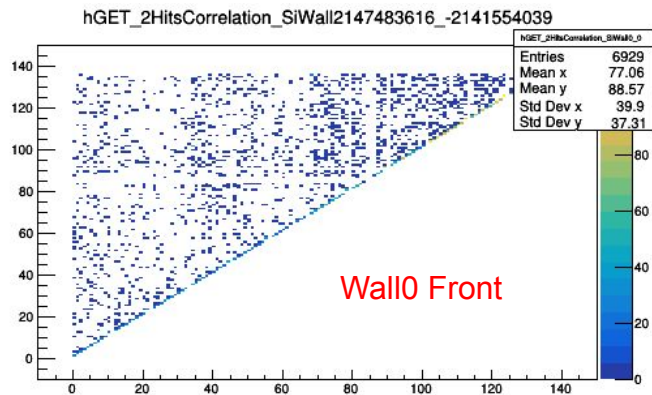


X: Strip No. of 1st Hit  
Y: Strip No. of 2nd Hit

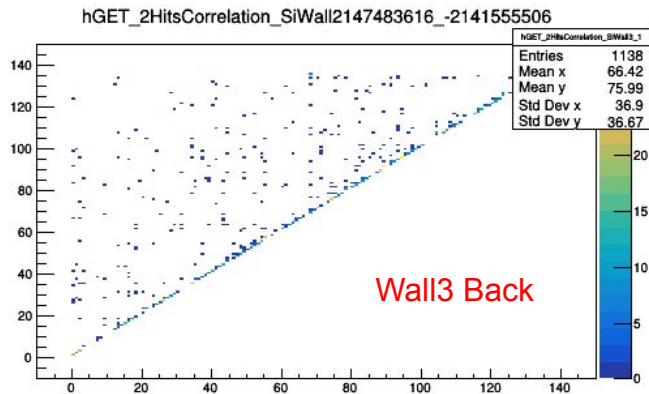
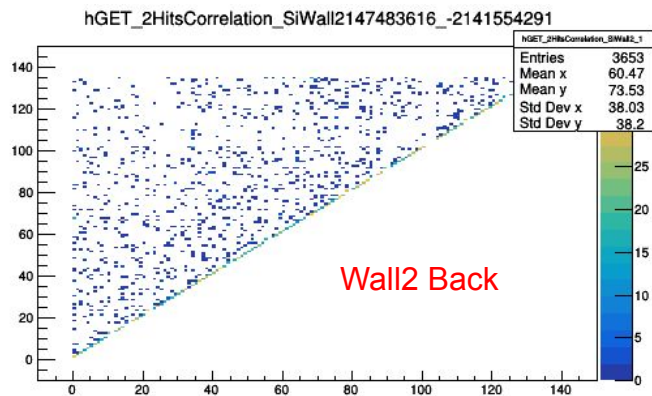
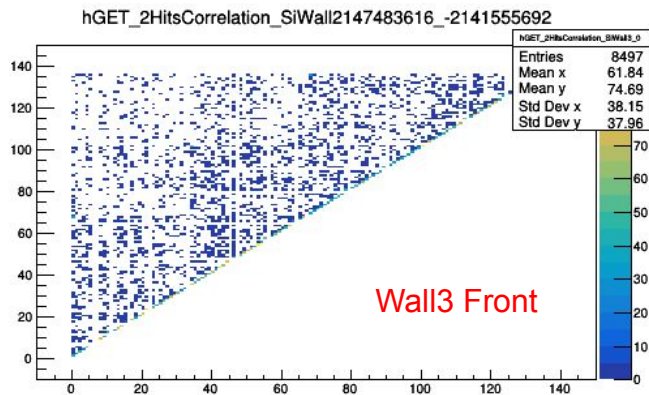
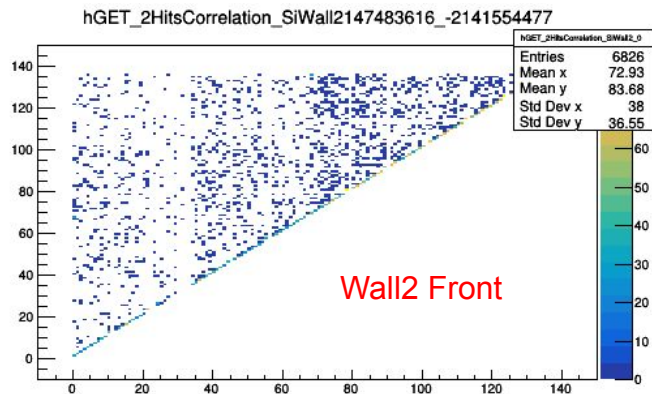


TWO Contributions: 1. Random; 2. Two neighbor strips

# Two Hits Correlation



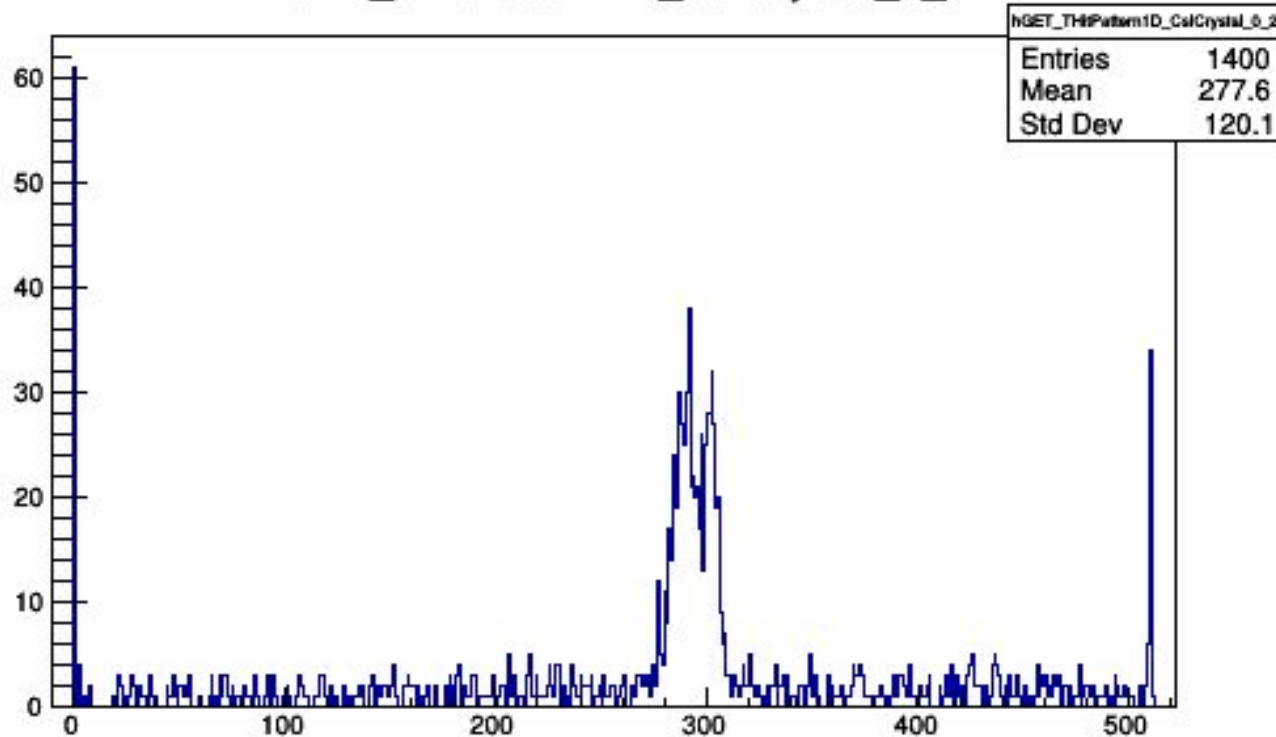
# Two Hits Correlation



Csl

# Timing of Single CsI Crystals

hGET\_THitPattern1D\_CsICrystal\_0\_2

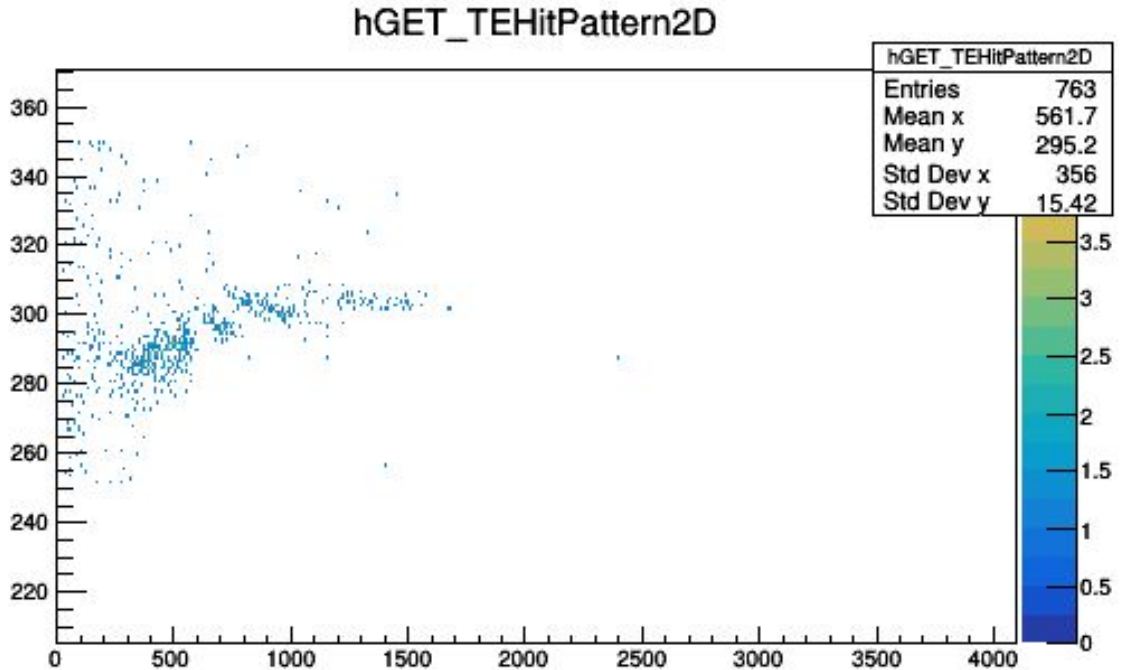




# TvsE for CsI\_0\_1

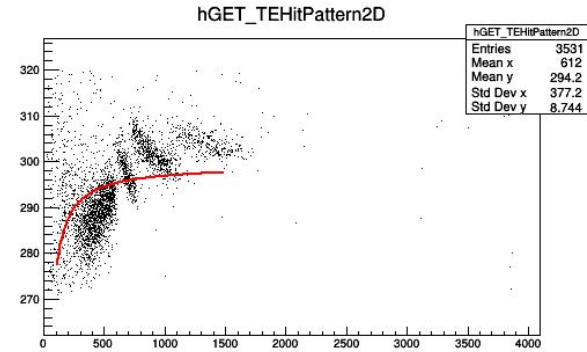
X: Energy

Y: Timing

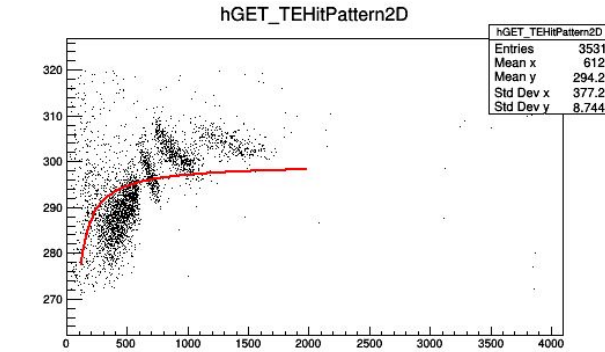


# Fitting with different range

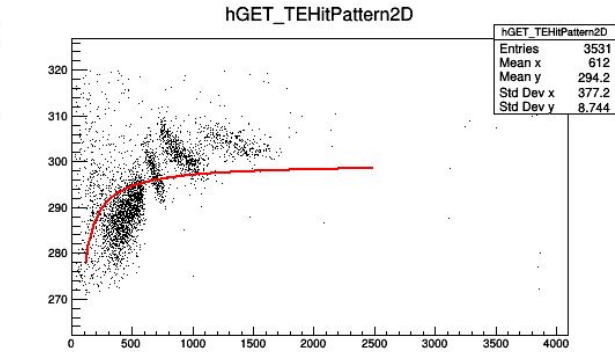
Fitting Function:  $p_0 - p_1/x$



100-1500



100-2000



100-2500

```
root [8] hGET_TEHitPattern2D->Fit("f1", "R")
*****
Minimizer is Minuit / Migrad
Chi2          =          207800
Ndf           =           1700
Edm           =          4.1125e-14
NCalls        =           32
p0            =          299.201 +/- 0.351671
p1            =          2316.45 +/- 131.461
(TFitResultPtr) <nullptr TFitResult>
```

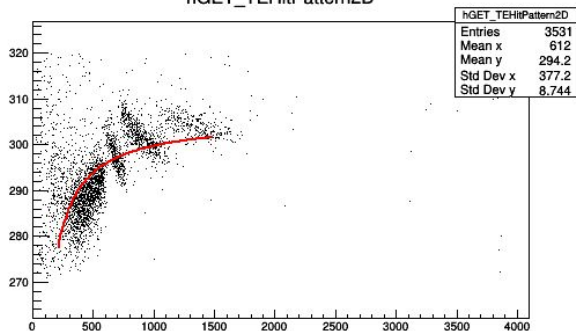
```
root [9] hGET_TEHitPattern2D->Fit("f2", "R")
*****
Minimizer is Minuit / Migrad
Chi2          =          211183
Ndf           =           1751
Edm           =          2.00108e-14
NCalls        =           32
p0            =          299.506 +/- 0.342141
p1            =          2402.85 +/- 129.054
(TFitResultPtr) <nullptr TFitResult>
```

```
root [10] hGET_TEHitPattern2D->Fit("f3", "R")
*****
Minimizer is Minuit / Migrad
Chi2          =          211561
Ndf           =           1755
Edm           =          3.21969e-16
NCalls        =           32
p0            =          299.518 +/- 0.341576
p1            =          2406.14 +/- 128.913
(TFitResultPtr) <nullptr TFitResult>
```

# Fitting with different range

Fitting Function:  $p_0 - p_1/x$

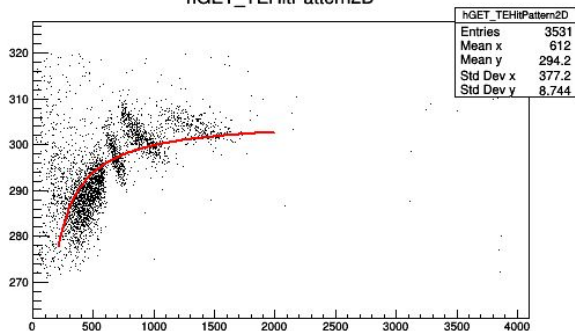
hGET\_TEHitPattern2D



200-1500

```
root [11] hGET_TEHitPattern2D->Fit("f4","R")
*****
Minimizer is Minuit / Migrad
Chi2          =      137074
Ndf           =      1537
Edm           =  4.67958e-16
NCalls       =      32
p0           =  305.526 +/- 0.413165
p1           =  5779.01 +/- 191.843
(TFitResultPtr) <nullptr TFitResult>
```

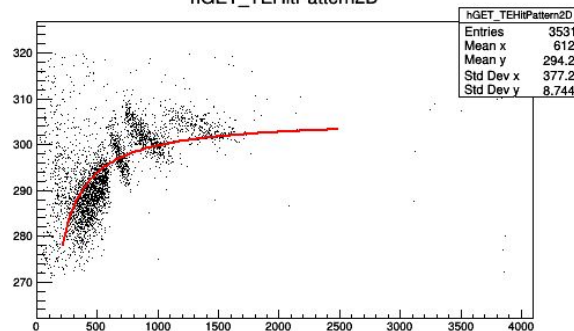
hGET\_TEHitPattern2D



200-2000

```
root [12] hGET_TEHitPattern2D->Fit("f5","R")
*****
Minimizer is Minuit / Migrad
Chi2          =      138397
Ndf           =      1588
Edm           =  4.97452e-15
NCalls       =      34
p0           =  305.686 +/- 0.395392
p1           =  5842.37 +/- 185.295
(TFitResultPtr) <nullptr TFitResult>
```

hGET\_TEHitPattern2D



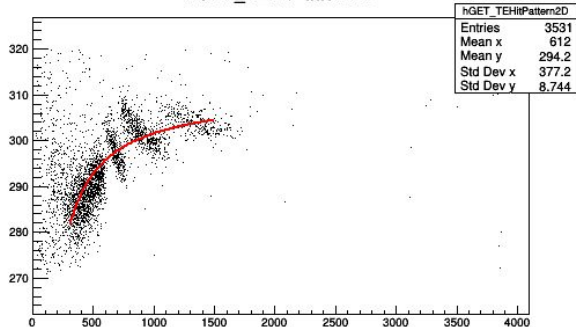
200-2500

```
root [13] hGET_TEHitPattern2D->Fit("f6","R")
*****
Minimizer is Minuit / Migrad
Chi2          =      138734
Ndf           =      1592
Edm           =  2.03224e-14
NCalls       =      32
p0           =  305.68 +/- 0.39447
p1           =  5839.72 +/- 184.972
(TFitResultPtr) <nullptr TFitResult>
```

# Fitting with different range

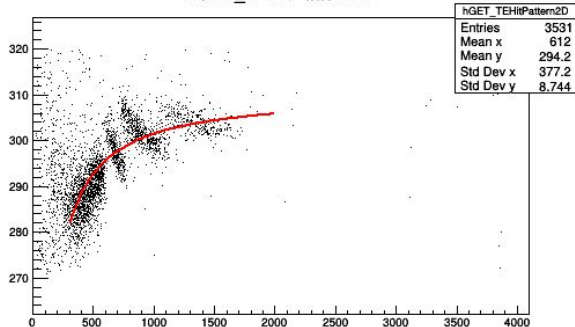
Fitting Function:  $p_0 - p_1/x$

hGET\_TEHitPattern2D



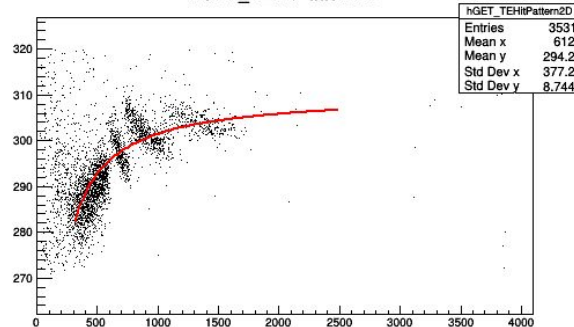
300-1500

hGET\_TEHitPattern2D



300-2000

hGET\_TEHitPattern2D



300-2500

```
root [17] hGET_TEHitPattern2D->Fit("f7", "R")
```

```
*****  
Minimizer is Minuit / Migrad  
Chi2 = 90245.7  
Ndf = 1370  
Edm = 1.54881e-14  
NCalls = 33  
p0 = 310.318 +/- 0.427351  
p1 = 8718.6 +/- 220.743  
(TFitResultPtr) <nullptr TFitResult>
```

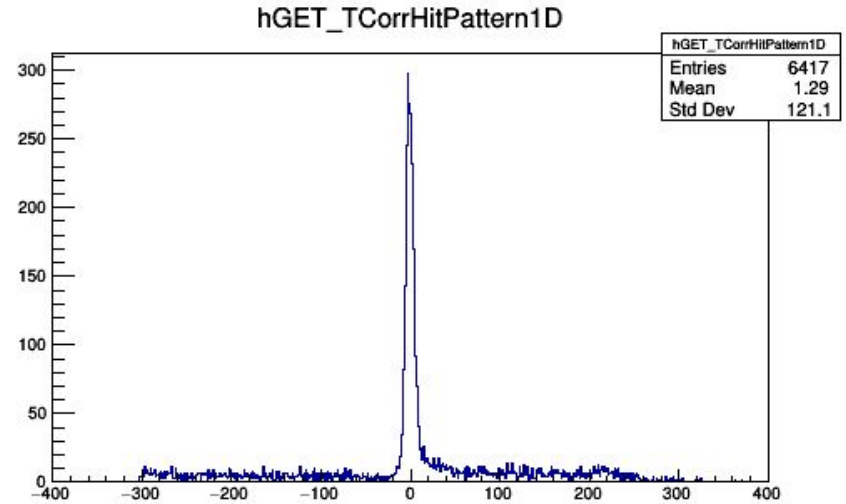
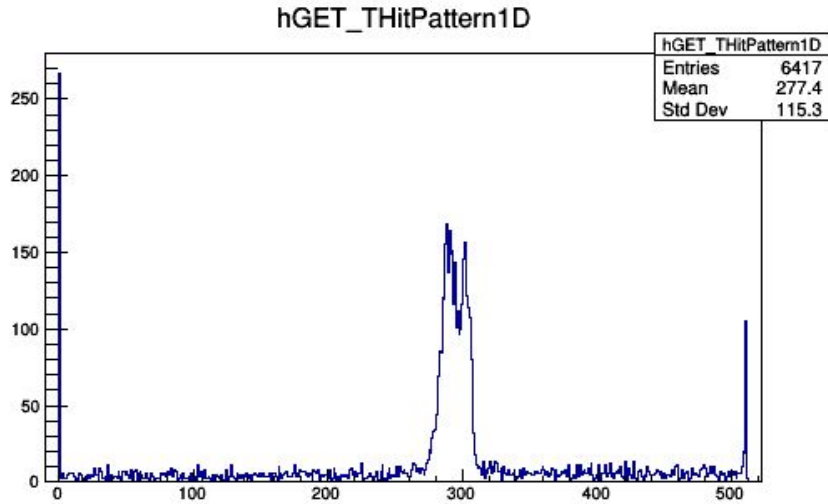
```
root [18] hGET_TEHitPattern2D->Fit("f8", "R")
```

```
*****  
Minimizer is Minuit / Migrad  
Chi2 = 91419.4  
Ndf = 1421  
Edm = 2.22134e-15  
NCalls = 32  
p0 = 310.193 +/- 0.404987  
p1 = 8662.28 +/- 211.232  
(TFitResultPtr) <nullptr TFitResult>
```

```
root [19] hGET_TEHitPattern2D->Fit("f9", "R")
```

```
*****  
Minimizer is Minuit / Migrad  
Chi2 = 91825.5  
Ndf = 1425  
Edm = 8.16168e-15  
NCalls = 32  
p0 = 310.159 +/- 0.404089  
p1 = 8646.51 +/- 210.894  
(TFitResultPtr) <nullptr TFitResult>
```

# Timing of Csl\_0\_1, before and after calibration

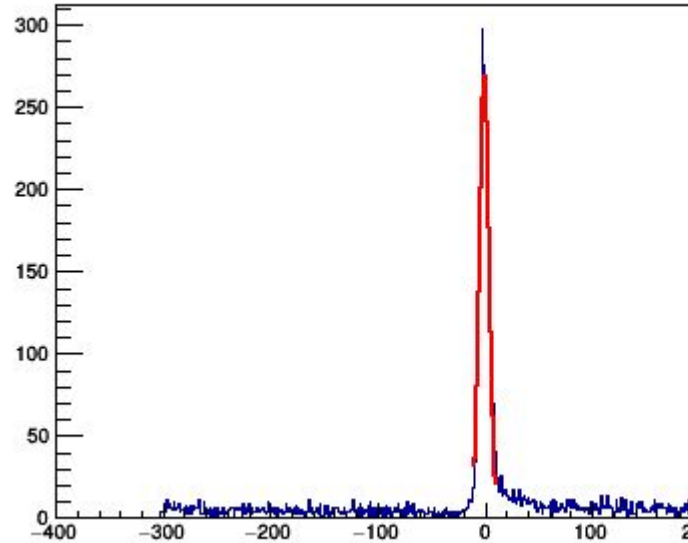


$$t_{\text{corr}} = t_{\text{obs}} - C_{0\text{wall}} - C_{1\text{wall}}/E$$

$$t_{\text{corr}} = t_{\text{obs}} - 310 - 8700/E$$

# Timing of Csl\_0\_1 after calibration with fitting results

hGET\_TCorrHitPattern1D

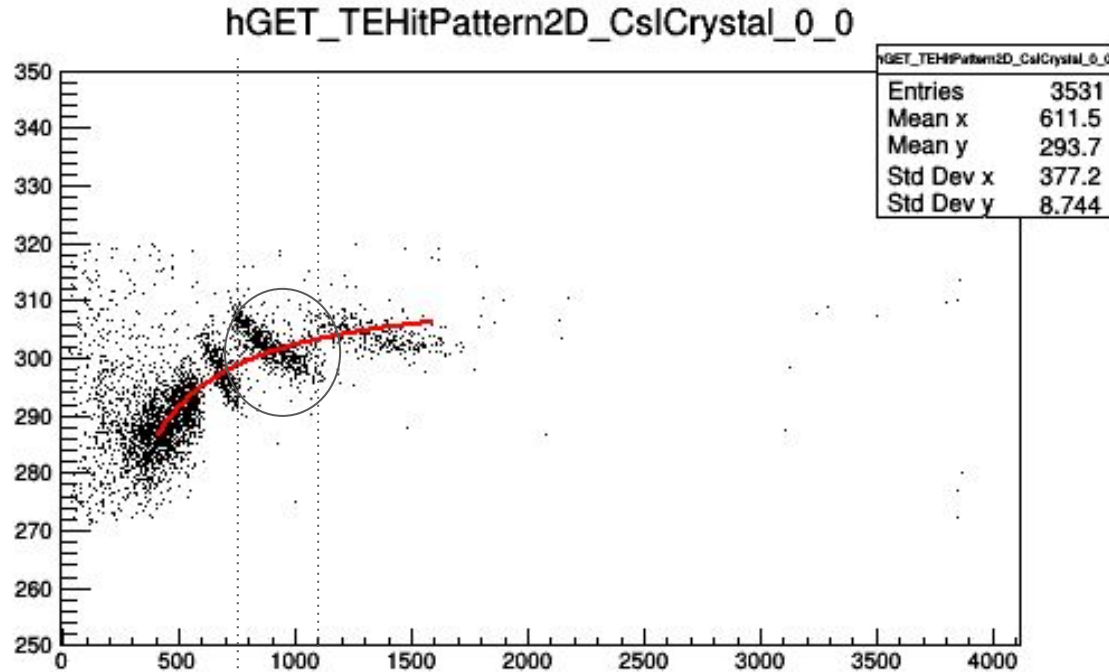


hGET_TCorrHitPattern1D	
Entries	6417
Mean	1.29
Std Dev	121.1

	mean	m_error	sigma	s_error
Csl0_0	-0.45	0.09	4.53	0.09

```
root [2] TF1 *f1= new TF1("f1","gaus", -10, 10)
(TF1 *) 0x4a875e0
root [3] hGET_TCorrHitPattern1D->Fit("f1","R")
FCN=40.9571 FROM MIGRAD STATUS=CONVERGED 67 CALLS 68 TOTAL
EDM=3.38688e-09 STRATEGY= 1 ERROR MATRIX ACCURATE
EXT PARAMETER STEP FIRST
NO. NAME VALUE ERROR SIZE DERIVATIVE
1 Constant 2.70032e+02 6.67363e+00 1.56452e-02 7.39373e-06
2 Mean -4.48231e-01 9.10916e-02 2.86063e-04 8.21714e-04
3 Sigma 4.52786e+00 8.90898e-02 1.60180e-05 3.26426e-03
(TFitResultPtr) <nullptr TFitResult>
```

# TvsE for CsI\_0\_0



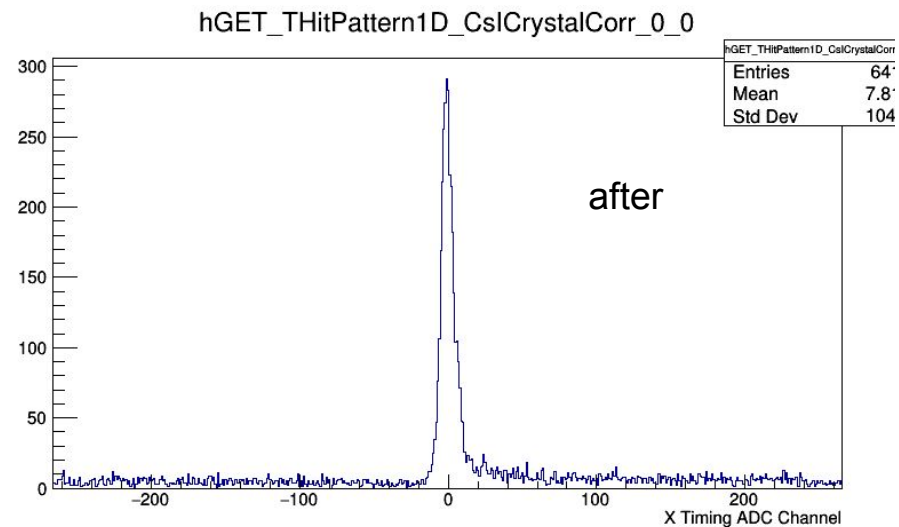
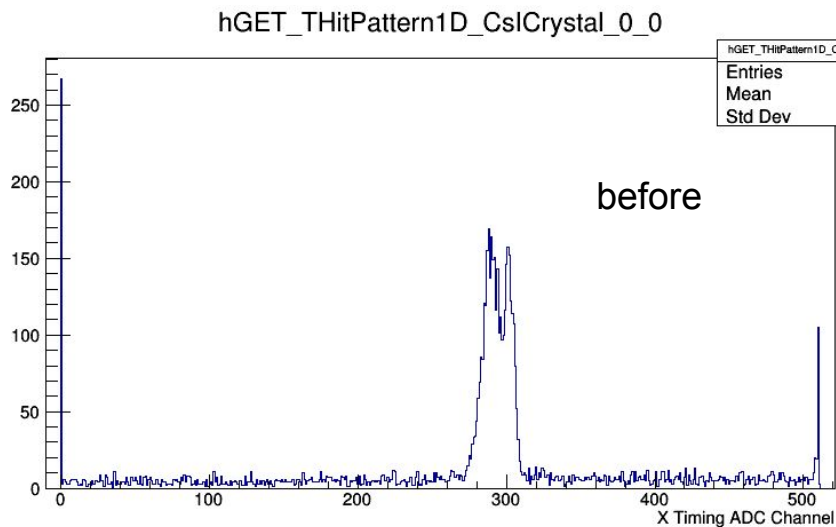
X: Energy ADC Channel

Y: Timing ADC Channel (270~320)

$$T_{\text{corr}} = T_{\text{obs}} - C_{0\text{wall}} - C_{1\text{wall}}/E$$

$$T_{\text{corr}} = T_{\text{obs}} - 313 - 10619.3/E$$

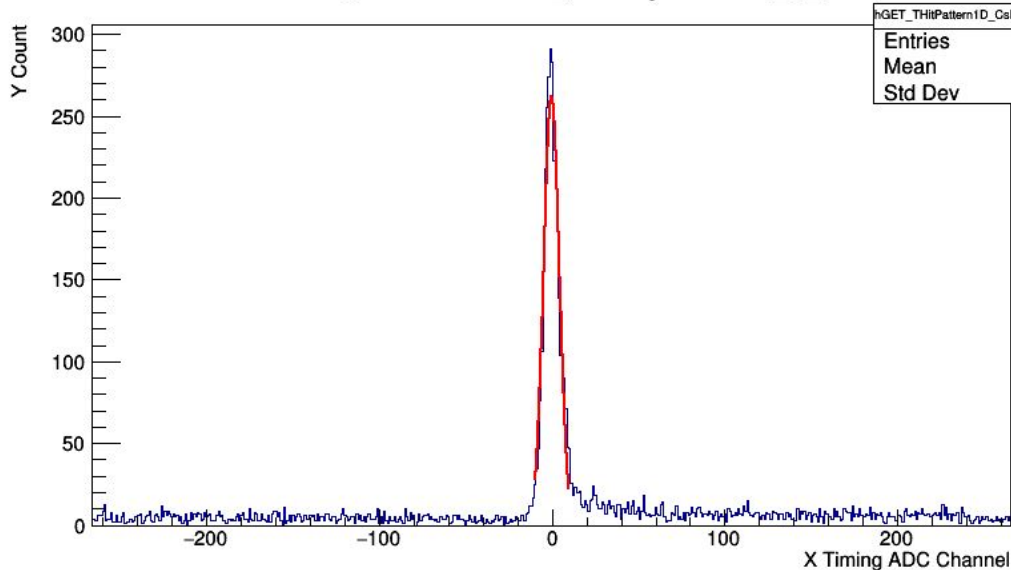
# Timing of Csl\_0\_1, before and after calibration





# Timing of Csl\_0\_0 after calibration with fitting results

hGET\_THitPattern1D\_CsICrystalCorr\_0\_0



hGET_THitPattern1D_CsICrystalCorr_0_0	
Entries	6417
Mean	7.813
Std Dev	104.5

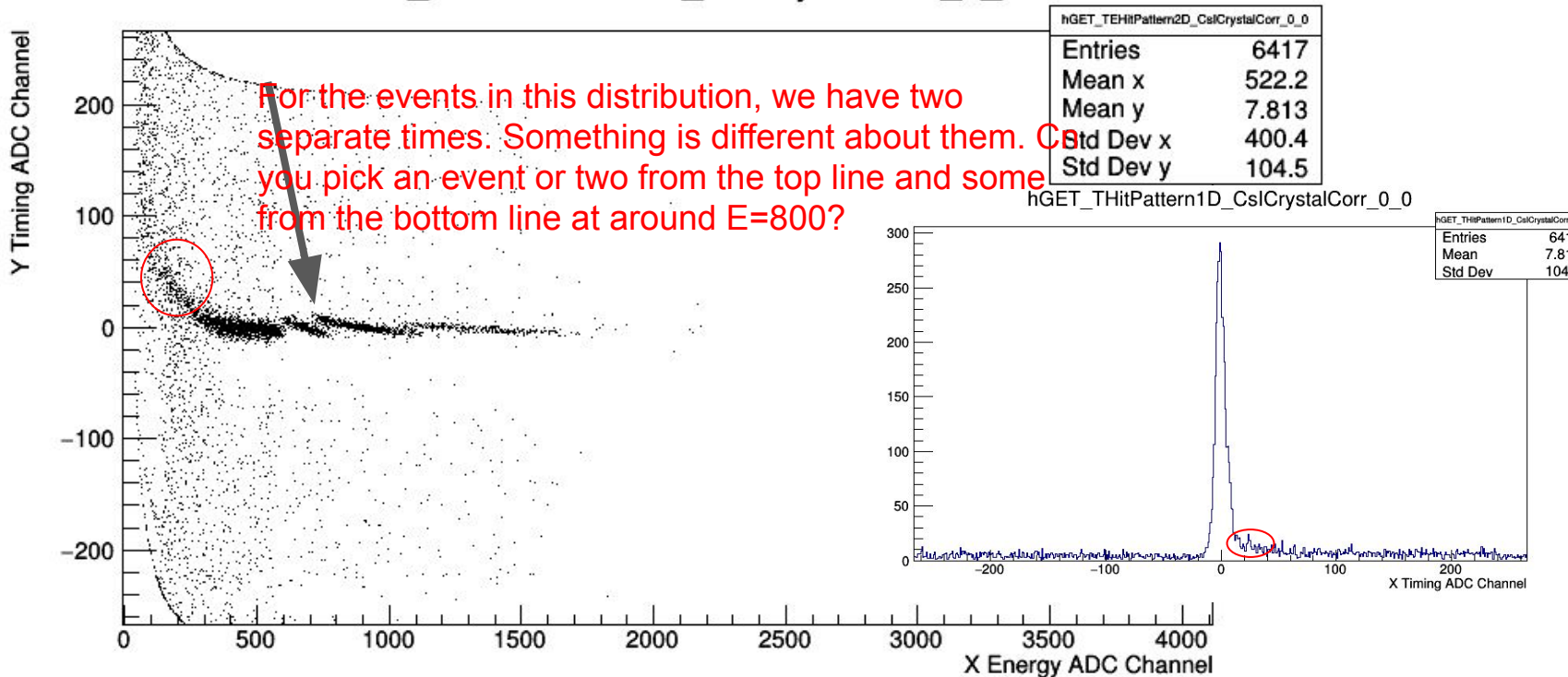
	mean	m_error	sigma	s_error
Csl0_0	-0.25	0.09	4.55	0.09

```

root [2] TF1 *f1 = new TF1("f1", "gaus", -10, 10)
(TF1 *) 0x475f840
root [3] hGET_THitPattern1D_CsICrystalCorr_0_0->Fit("f1", "R")
FCN=80.2786 FROM MIGRAD STATUS=CONVERGED 64 CALLS
EDM=8.31869e-10 STRATEGY= 1 ERR
EXT PARAMETER STEP
NO. NAME VALUE ERROR SIZE
1 Constant 2.61795e+02 6.62031e+00 2.13169e-02
2 Mean -2.55338e-01 9.47894e-02 3.97344e-04
3 Sigma 4.54909e+00 8.99940e-02 2.12984e-05
(TFitResultPtr) <nullptr TFitResult>
    
```

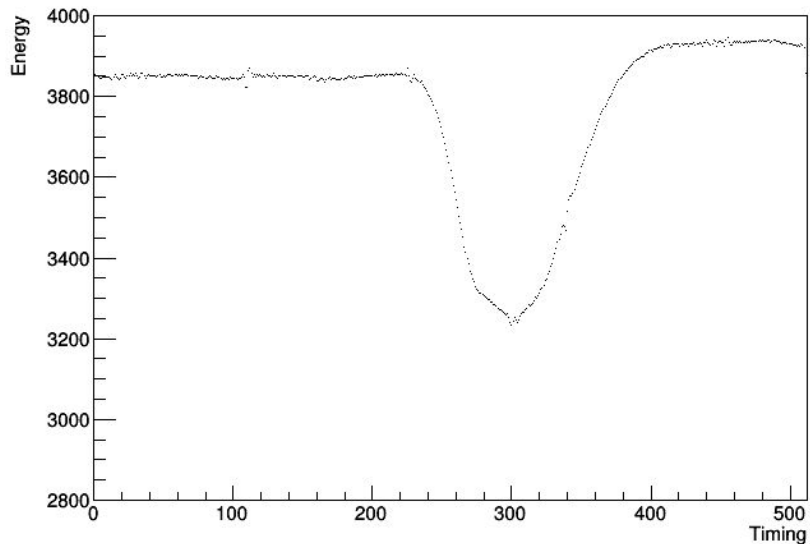
# TvsE of Csl\_0\_0 after correction

hGET\_TEHitPattern2D\_CslCrystalCorr\_0\_0

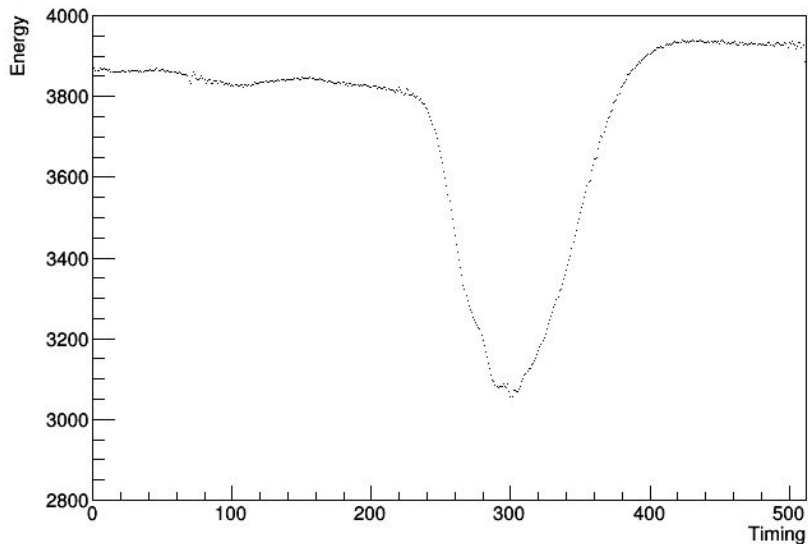


# Same Timing: 300; Energies: 612, 806

mmWaveformY:mmWaveformX (mmEventIdx==45569&&mmCobo==1&&mmAsad==0&&mmAget==0&&mmChan==2)  
Waveform: Timing300, Energy612

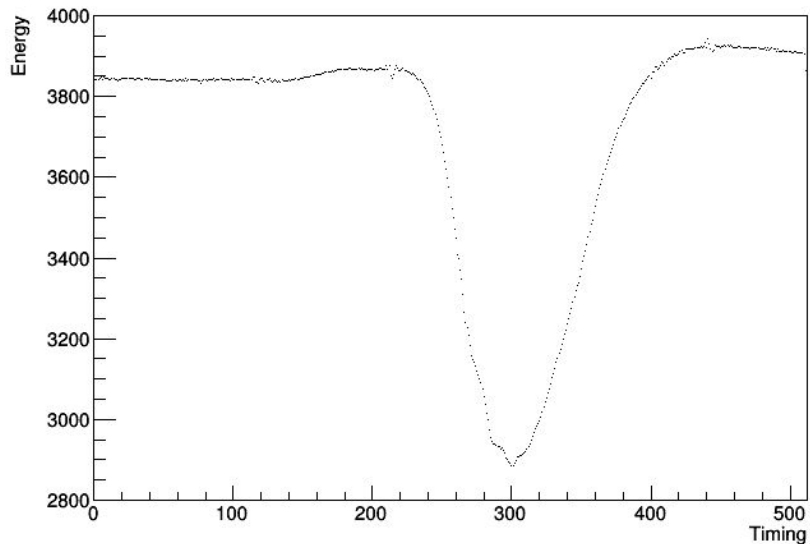


mmWaveformY:mmWaveformX (mmEventIdx==33010&&mmCobo==1&&mmAsad==0&&mmAget==0&&mmChan==2)  
Waveform: Timing300, Energy806

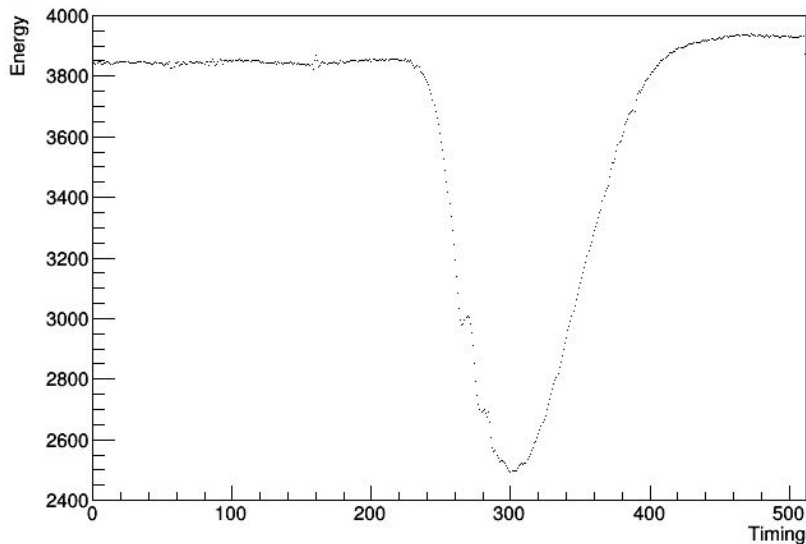


# Same Timing: 300; Energies: 961, 1351

mmWaveformY:mmWaveformX (mmEventIdx==29863&&mmCobo==1&&mmAsad==0&&mmAget==0&&mmChan==2)  
Waveform: Timing300, Energy961



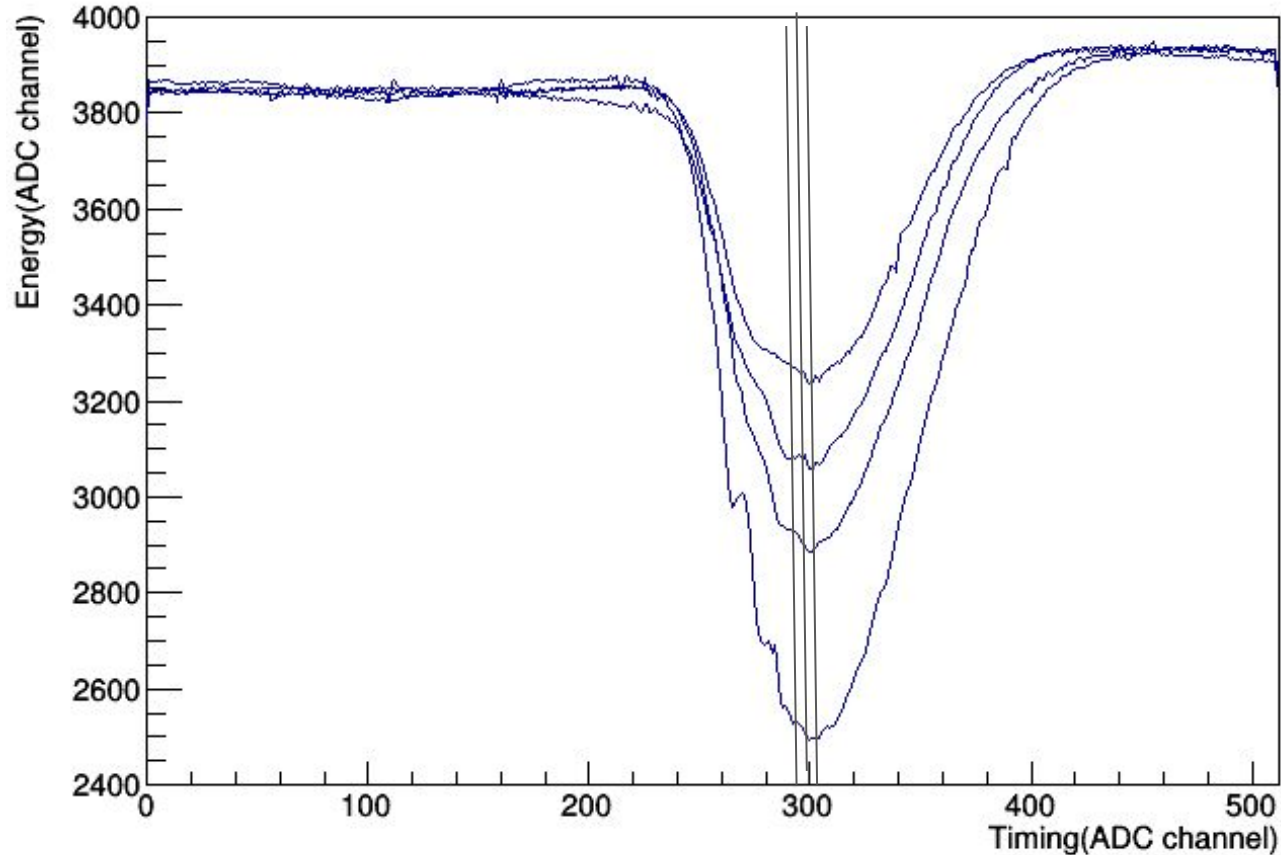
mmWaveformY:mmWaveformX (mmEventIdx==30021&&mmCobo==1&&mmAsad==0&&mmAget==0&&mmChan==2)  
Waveform: Timing300, Energy1351



# Timing: 300; Energies: 612, 806, 961, 1351

mmWaveformY:mmWaveformX {mmEventIdx==29863&&mmCobo==1&&mmAsad==0&&mmAget==0&&mmChan==2}

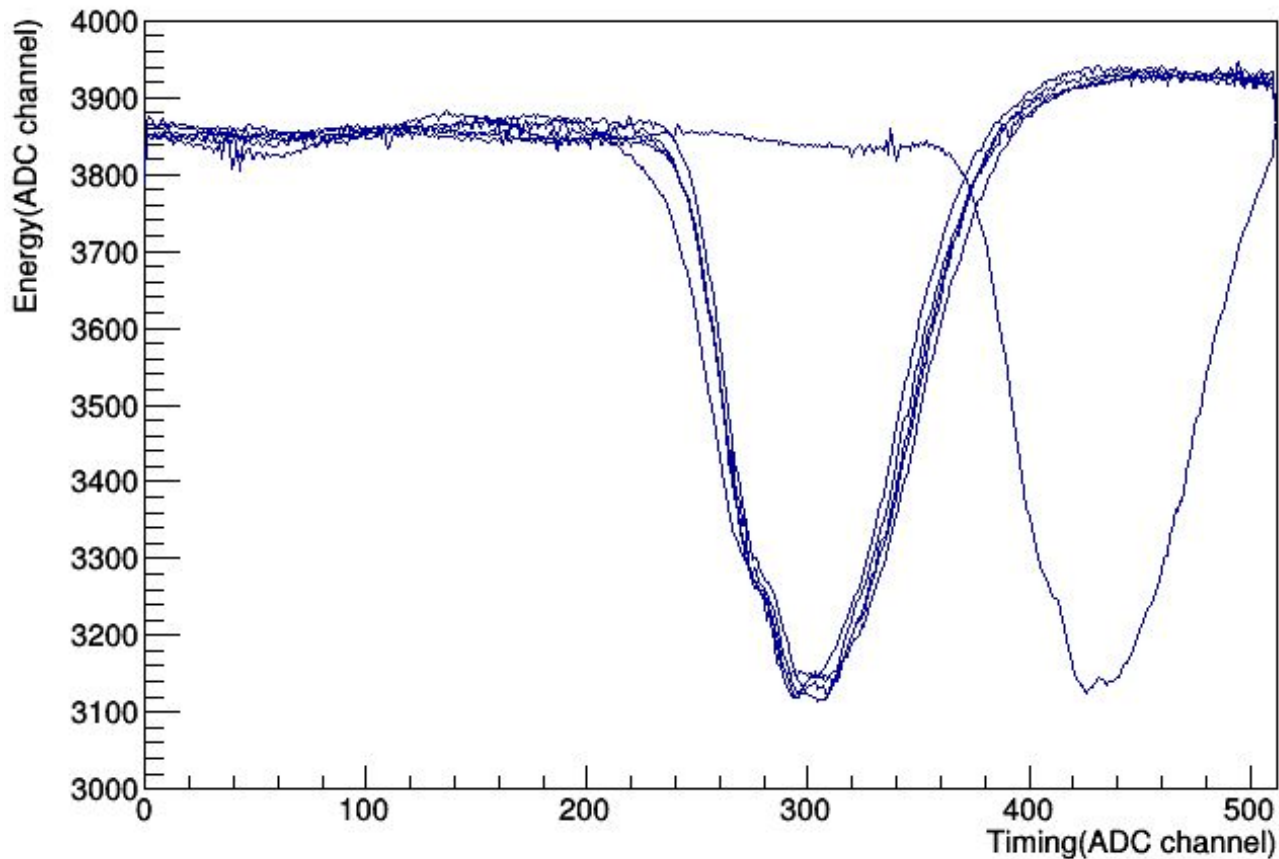
Timing: 300, Energies: 612, 806, 961, 1351



# Energy: 729; Times: 291, 296, 298, 304, 309, 426

mmWaveformY:mmWaveformX (mmEventIdx==37903&&mmCobo==1&&mmAsad==0&&mmAget==0&&mmChan==2)

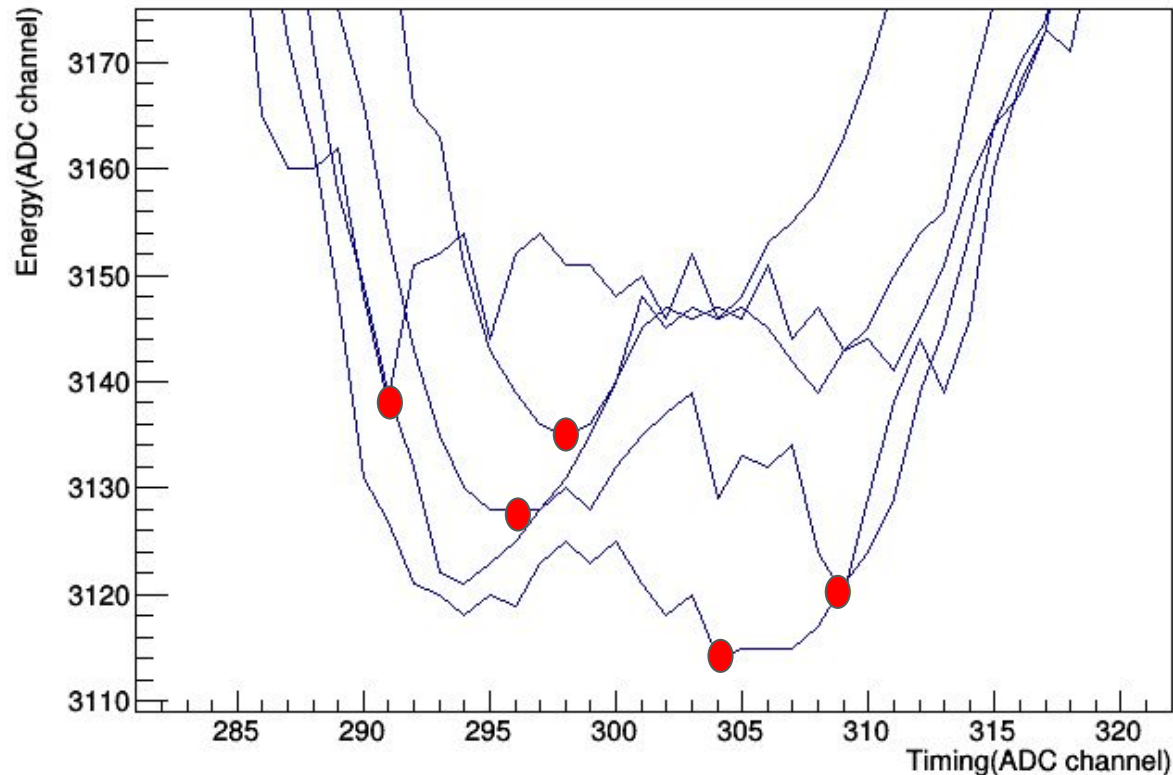
Energy: 729; Timings: 291, 296, 298, 304, 309, 426



# Energy: 729; Times: 291, 296, 298, 304, 309, 426

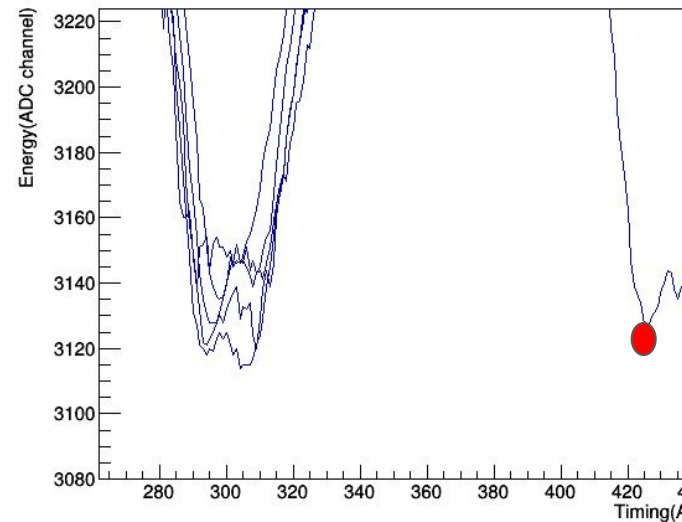
mmWaveformY:mmWaveformX (mmEventIdx==37903&&mmCobo==1&&mmAsad==0&&mmAget==0&&mmChan==2)

Energy: 729; Timings: 291, 296, 298, 304, 309, 426

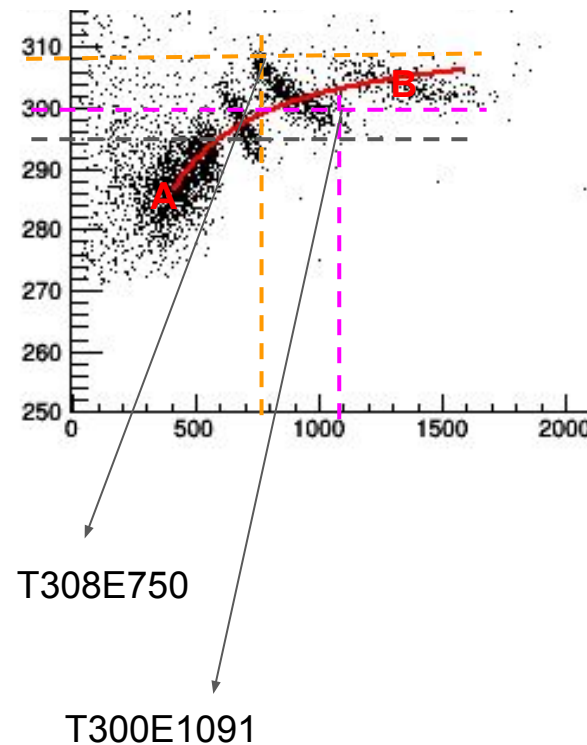
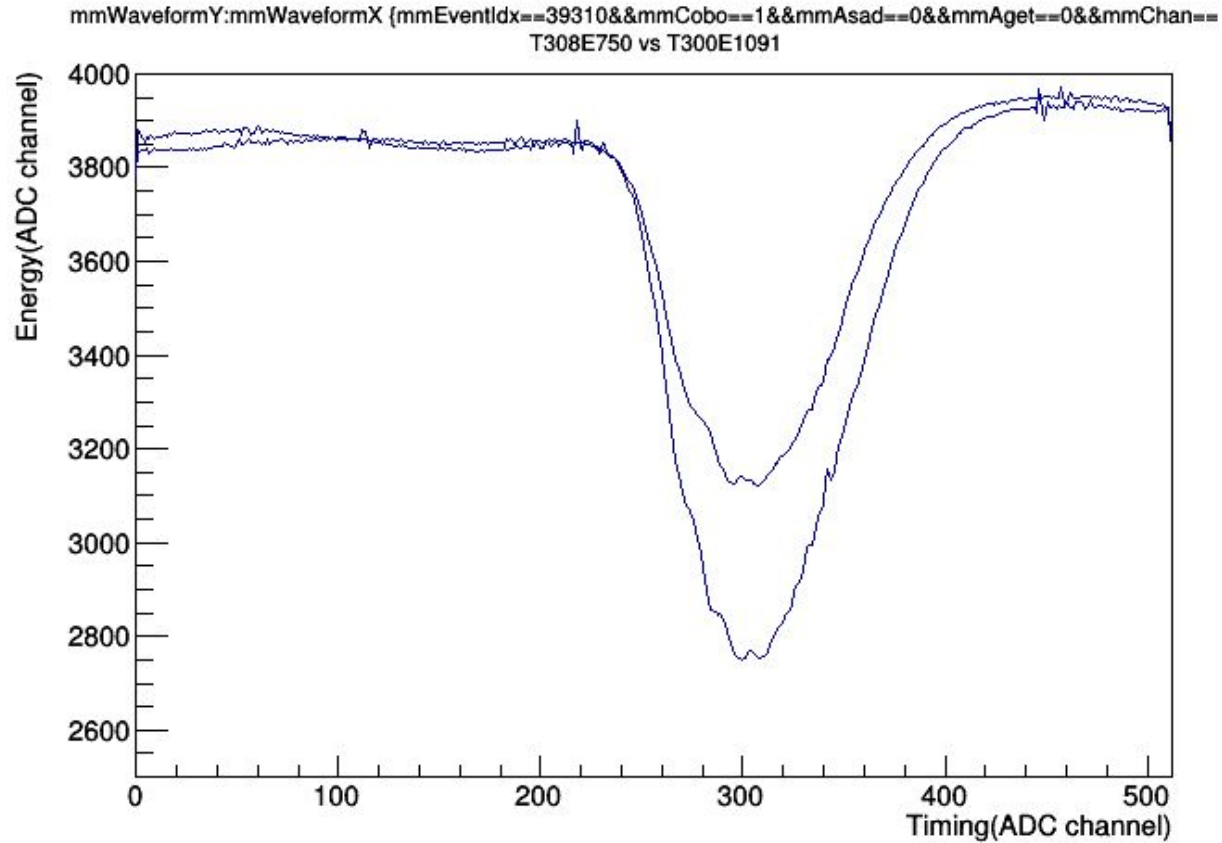


mmWaveformY:mmWaveformX (mmEventIdx==37903&&mmCobo==1&&mmAsad==0&&mmAget==0&&mmChan==2)

Energy: 729; Timings: 291, 296, 298, 304, 309, 426



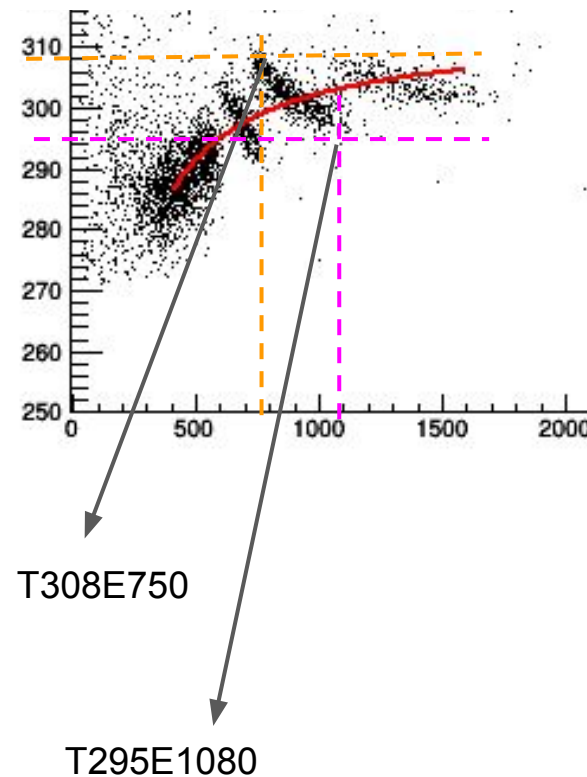
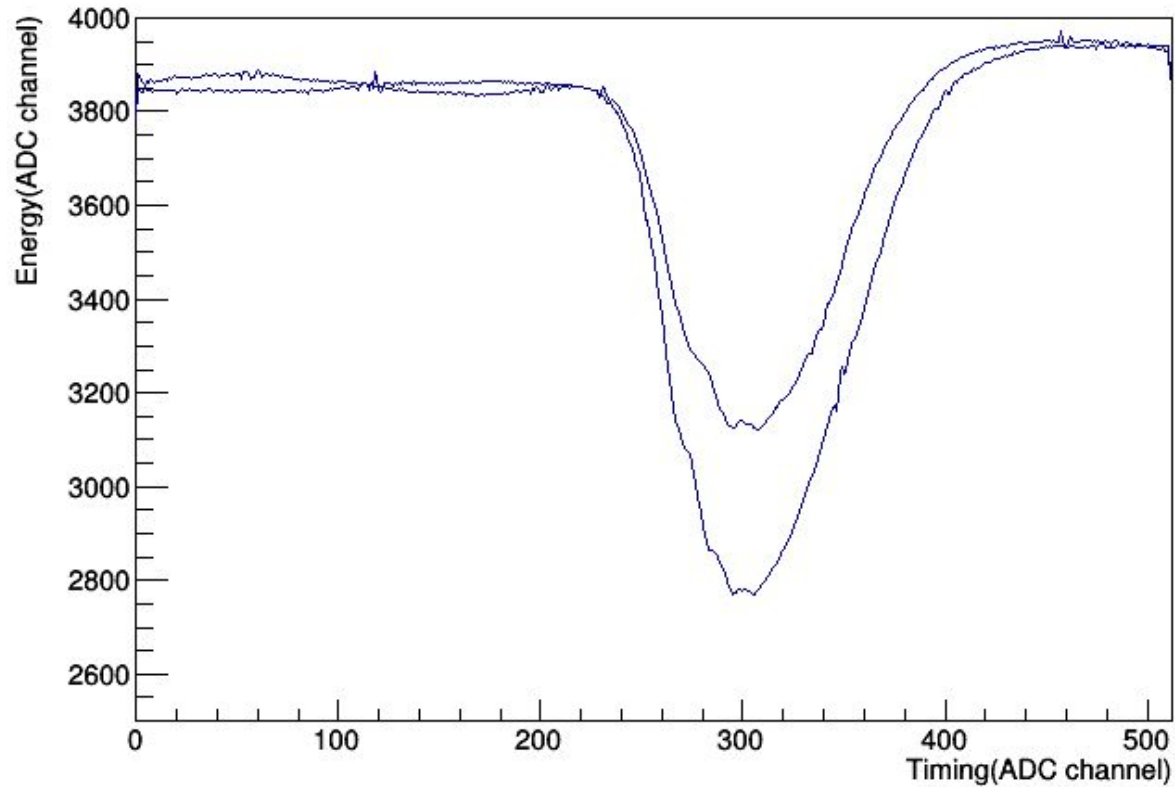
# T308E750 vs T300E1091





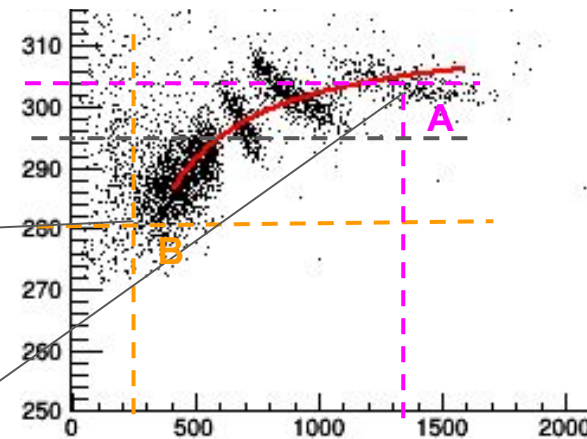
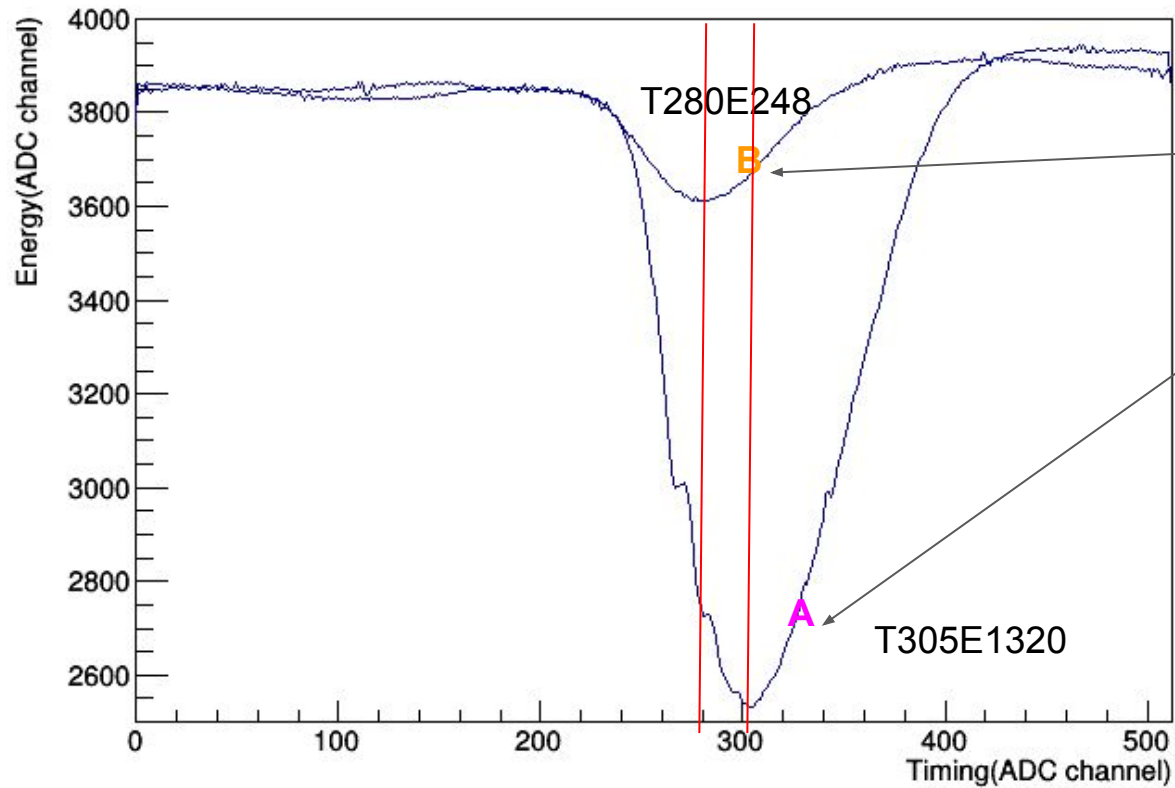
# T308E750 vs T295E1080

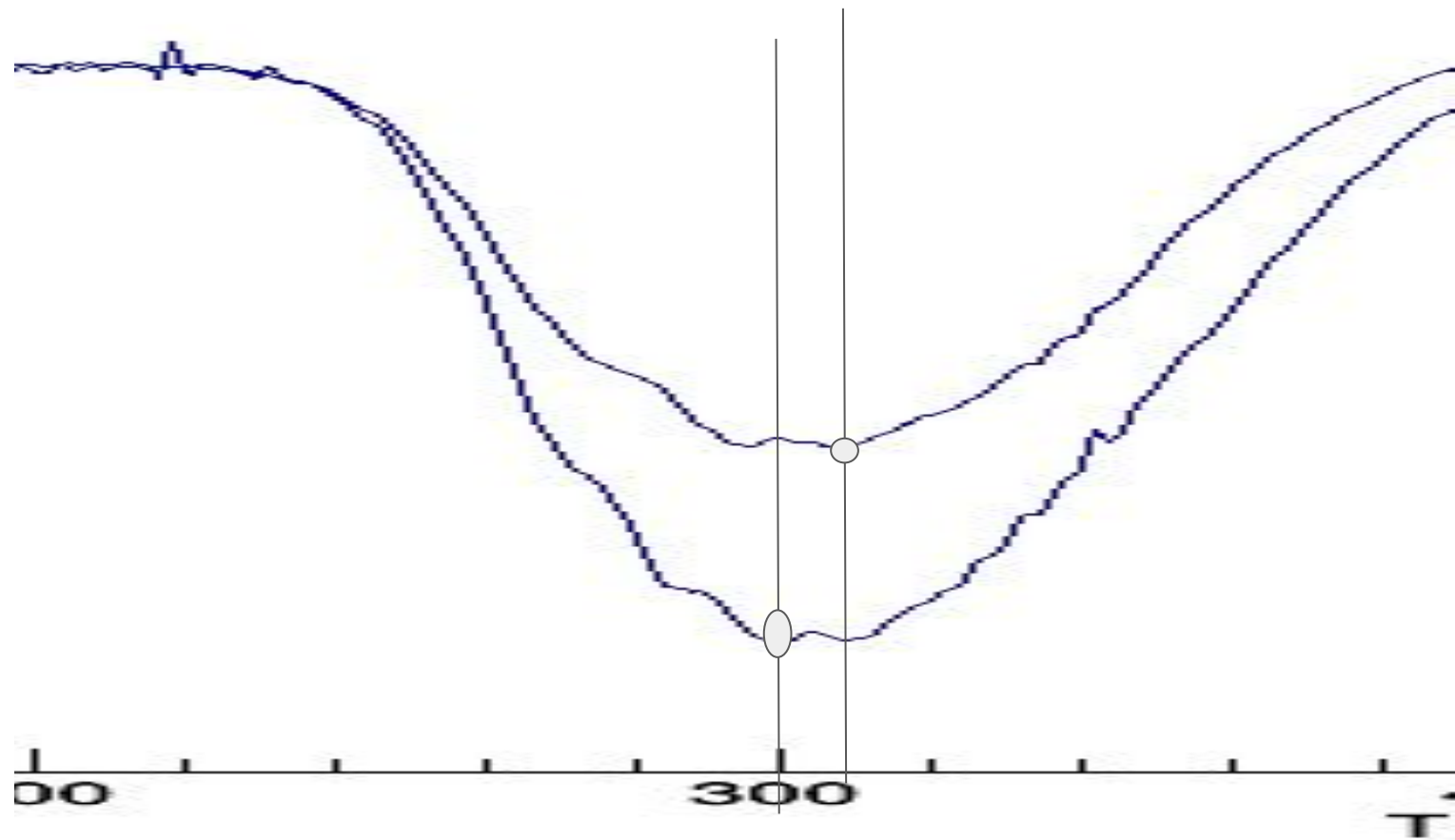
mmWaveformY:mmWaveformX (mmEventIdx==36503&&mmCobo==1&&mmAsad==0&&mmAget==0&&mmChan==  
T308E750 vs T295E1080



# T305E1320 vs T280E248

mmWaveformY:mmWaveformX (mmEventIdx==29735&&mmCobo==1&&mmAsad==0&&mmAget==0&&mmChan==  
T305E1320 vs T280E248





# T\_Corr Fitting Results of ALL Csl Crystals

Crystal	Peak	P_Err	Mean	M_Err	Sigma	S_Err
W0C0	261.80	6.62	-0.255	0.095	4.549	0.090
W0C1	259.44	6.58	-0.590	0.088	4.337	0.081
W0C2	240.02	6.40	-0.572	0.094	4.483	0.093
W0C3	186.41	5.67	-0.886	0.105	4.352	0.101
W0C4	323.84	7.39	-0.596	0.082	4.439	0.077
W0C5	282.26	6.24	1.588	0.114	5.164	0.099
W0C6	305.10	7.23	-0.186	0.086	4.469	0.082
W0C7	299.09	6.69	0.704	0.100	4.891	0.089
W0C8	248.99	6.67	-0.505	0.089	4.154	0.082

W2C0	0.00	0.00	0.000	0.000	0.000	0.000
W2C1	239.31	6.51	-0.924	0.091	4.216	0.085
W2C2	327.28	6.95	0.151	0.091	4.904	0.083
W2C3	200.88	5.86	-1.021	0.100	4.279	0.093
W2C4	295.36	6.78	-0.406	0.092	4.903	0.093
W2C5	161.32	4.92	-0.893	0.135	5.288	0.145
W2C6	279.02	6.76	-0.592	0.087	4.408	0.080
W2C7	193.13	5.25	0.386	0.117	4.963	0.107
W2C8	0.00	0.00	0.000	0.000	0.000	0.000

W1C0	291.09	6.39	0.032	0.107	5.605	0.115
W1C1	0.00	0.00	0.000	0.000	0.000	0.000
W1C2	362.17	7.23	-0.229	0.095	5.569	0.105
W1C3	216.61	5.59	-0.151	0.119	5.406	0.125
W1C4	391.87	7.46	-0.370	0.089	5.485	0.095
W1C5	306.95	6.41	0.416	0.116	6.062	0.131
W1C6	279.81	6.34	-0.598	0.102	5.295	0.105
W1C7	288.81	6.29	0.693	0.113	5.682	0.118
W1C8	125.60	4.35	-0.831	0.159	5.505	0.181

W3C0	165.69	4.82	-0.412	0.135	5.386	0.138
W3C1	363.39	7.51	-0.149	0.081	4.707	0.076
W3C2	252.54	5.86	0.454	0.113	5.265	0.103
W3C3	356.48	7.49	-0.397	0.082	4.647	0.076
W3C4	478.83	8.57	-0.351	0.072	4.899	0.071
W3C5	391.07	7.65	0.074	0.080	4.802	0.074
W3C6	0.00	0.00	0.000	0.000	0.000	0.000
W3C7	258.43	6.37	-0.335	0.096	4.694	0.091
W3C8	271.23	6.19	0.176	0.100	5.045	0.093