

E570 extension : SDD self trigger calibration

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I analyzed self trigger events to see the gain stability. After selection of the calibration events by some conditions (SDDT2, KSTOP, SDDT4...), the events were parted 37 parts. Then the parts were fitted by 8 Gaussians and a quadratic background.

The gain of all SDD shifted. We need the shift correction if we want to sum up all events.

1 Event selection

The self triggered event means the self TDC hit event which corresponds to SDDT2 in the CMS table. In principle the self TDC spectrum must be δ function, but there are other continuous structure due to some cross talk events caused by the next SDD reset pulse. The typical self TDC spectrum is shown in the Figure 1. We can see that the cross talk events are about 10^{-2} - 10^{-4} of total events.

Now the self trigger was defined by the self TDC hits in 0 to 1000 ch loosely. The conditions to select "calibration" events are shown on Table 1.

Table 1: The conditions to select "calibration" events.

condition	region	trigger
self TDC	$0 < \text{ch} < 1000$	SDDT2
multiplicity	1	
K stop	$\text{not}(0 < \text{ch} < 4096)$	KSTOP
veto	$\text{not}(0 < \text{ch} < 4096)$	SDDT4

The trigger SDDT4 which is added from this extension experiment to clean the self trigger

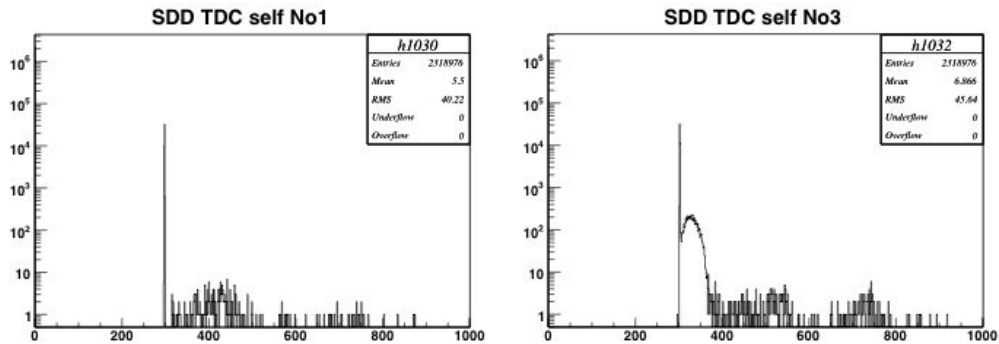


Figure 1: Typical self TDC spectrum. The left is sdd1 (best) and the right is sdd3 (worst). This is only run 419 and 1 bin = 1ch.

means veto through event. The veto are reset veto (RSTV), upper threshold veto (UPPERV) and bipolar cross talk veto (BPLV).

We think the veto through event is caused by the reset pulse induced by pion direct hits. When about 10 pion hit a SDD directly, a reset pulse is induced to discharge. If the discharge coincides with a pion hit, the reset timing comes about 600 ns faster than ordinary. This is shown in Figure 2.

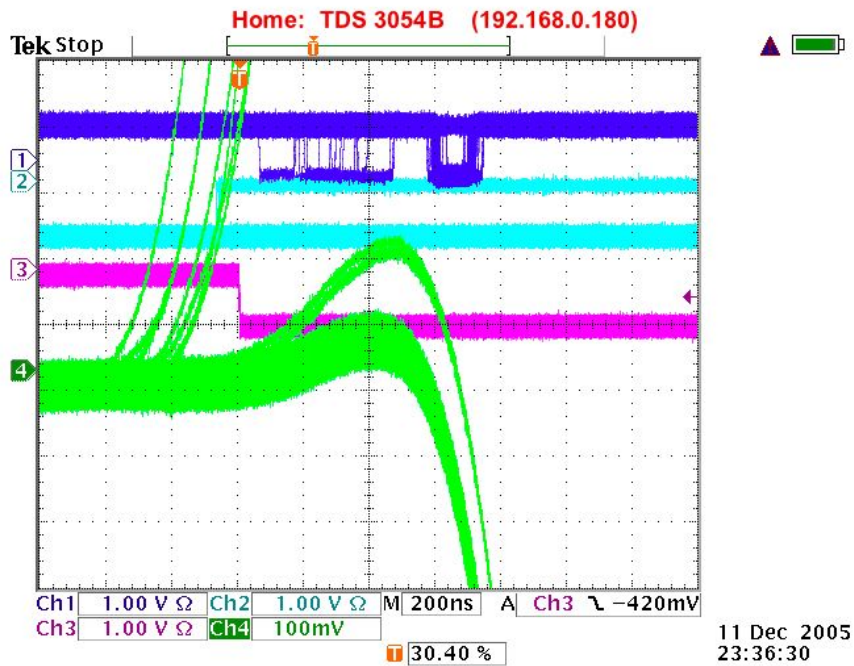


Figure 2: Faster reset timing caused by direct pion hits. Blue is self trigger, light blue is BPLV, red is RSTV and green is shaping amp out. The reset timing comes about 600 ns faster than ordinary.

2 Event partition

The calibration events are parted 37 parts to scan the gain stability. The calibration events includes all production runs from 419 to 583. One part has about 100,000 events in the interesting region, but it has some distribution depends on the noise level.

3 Fitting

The calibration part is fitted by 8 Gaussians and a quadratic background. 8 Gaussians are TiK α 1, TiK α 2, TiK β , NiK α 1, NiK α 2, NiK β , CuK α 1, and CuK α 2. A typical fitting result is below,

```

FCN=98.9897 FROM MIGRAD      STATUS=CONVERGED      639 CALLS      640 TOTAL
                        EDM=9.60678e-07  STRATEGY= 1      ERROR MATRIX ACCURATE
EXT PARAMETER
NO.  NAME      VALUE      ERROR      STEP      FIRST
      NAME      VALUE      ERROR      SIZE      DERIVATIVE
 1  e2c [eV/ch]  2.99711e+00  2.87557e-03  1.11405e-05  5.73805e-01
 2  intercept [eV] -1.48068e+02  5.88551e+00  2.28427e-02  2.35621e-04
 3  BGa          3.14667e+02  3.64933e+01  3.58543e-02  -1.43008e-04
 4  BGb          2.36216e-01  3.30041e-02  1.53280e-05  -3.34063e-01
 5  BGc         -5.72013e-05  7.16248e-06  5.94165e-09  -7.47454e+02
 6  Ka1Kb_ratio  1.76559e+00  9.73858e-02  1.43732e-03  3.02163e-03
 7  Fano         2.23268e-01  4.30223e-02  4.21420e-04  -7.01067e-03
 8  SigmaTi     2.60980e+01  6.11799e-01  5.99003e-03  7.04309e-04
 9  TiKa1Height  7.61235e+02  1.85597e+01  2.31351e-01  8.18762e-06
10  NiKa1Height  6.95132e+02  1.63709e+01  2.04440e-01  3.10959e-05
11  CuKa1Height  6.86158e+00  9.17189e+00  5.17645e-04  -2.06315e-02

```

The parameters e2c [eV/ch] and intercept [eV] are fitted to satisfy the Gaussian's mean distance corresponds to the theoretical X-ray energy interval. So all information of peaks mean is included these two parameters.

BGa, BGb and BGc are quadratic background parameters. The function is $y = a + bx + cx^2$.

Ka1Kb_ratio is a common parameter which is multiplied to a referential intensity ratio. The referential relative intensities used this fitting are shown on Table 2. K α 2 and K β height are calculated from these values, fitted K α 1 height value and Ka1Kb_ratio.

Table 2: The referential relative intensities.

symbol	K α 1	K α 2	K β
Ti	100.0	50.0	15.0
Ni	100.0	51.0	17.0
Cu	100.0	51.0	17.0

Fano is Fano factor to calculate a Gaussian's sigma from TiK α 1 sigma. The equation is

$$\text{sigma} = w \sqrt{W_N^2 + \frac{FE}{w}} \quad (1)$$

where W_N is white noise, F is Fano factor of Si, $w = 3.81$ eV is average energy for an electron-hole pair creation in Si (77K) and E is X-ray energy. In this calculation white noise W_N is constant. In this fitting I referenced X-ray Data Booklet (Table 3).

Table 3: The referential X-ray energy [eV].

symbol	K α 1	K α 2	K β
Ti	4510.84	4504.86	4931.81
Ni	7478.15	7460.89	8264.66
Cu	8047.78	8027.83	8905.29

A typical fitted figure is Figure 3.

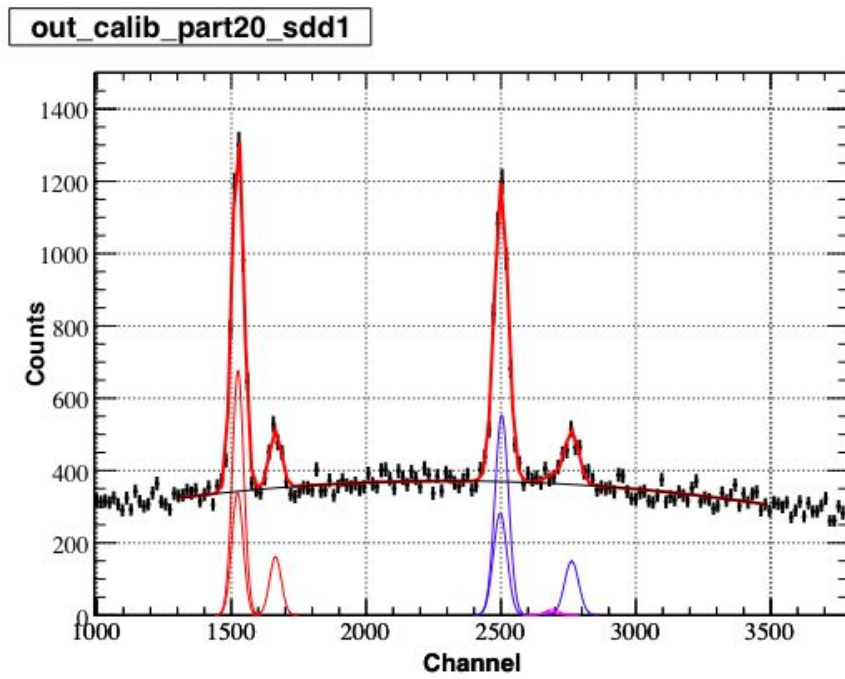


Figure 3: Typical fitted figure. Fit function is 8 Gaussian and a quadratic background. (1 bin = 16 ch)

4 Results

There are too many figures, so I will show them by OHP. (And I will upload them as pdf files).

The contents are ...

1. e2c
2. intercept
3. sigma and FWHM
4. Ka1Kb_ratio
5. Fano factor
6. correlation of e2c and intercept
7. typical and not converged histograms

"not converged histogram" means failed to fit histograms. So the error is the default value 1.0 or some strange value. Almost "not converged" is caused by not Gaussian like shape peak. Especially $K\beta$ shape is dirty.

4.1 SDD1

1. e2c : quadratic, need correction?
2. intercept : flat? some times moves 20 eV
3. sigma and FWHM : about 155 eV
4. Ka1Kb_ratio : not stable 0.15 ?
5. Fano factor : about 0.10-0.16
6. correlation of e2c and intercept : no correlation
7. typical and not converged histograms : not Gaussian shape

4.2 SDD2

There are many not converged parts, this is because sdd2 has a strange background near Ti $K\alpha$ peak.

1. e2c : flat? jumping max 0.01 eV/ch
2. intercept : flat?
3. sigma and FWHM : about 180 eV
4. Ka1Kb_ratio : about 0.16
5. Fano factor : about 0.15 ?
6. correlation of e2c and intercept : negative correlation
7. typical and not converged histograms : strange background and not Gaussian shape

4.3 SDD3

1. e2c : stepping about 0.03 eV/ch
2. intercept : flat?
3. sigma and FWHM : about 175 eV
4. Ka1Kb_ratio : about 1.6
5. Fano factor : about 0.18
6. correlation of e2c and intercept : no correlation
7. typical and not converged histograms : not Gaussian shape

4.4 SDD4

1. e2c : oscillating
2. intercept : also oscillating
3. sigma and FWHM : also oscillating about 155 eV
4. Ka1Kb_ratio : not stable about 1.5

5. Fano factor : about 0.15
6. correlation of e2c and intercept : negative correlation
7. typical and not converged histograms : not Gaussian shape

4.5 SDD5

1. e2c : stepping about 0.03 eV/ch
2. intercept : oscillating
3. sigma and FWHM : about 188 eV
4. Ka1Kb_ratio : about 1.6
5. Fano factor : about 0.15
6. correlation of e2c and intercept : no correlation
7. typical and not converged histograms : not Gaussian shape

4.6 SDD6

Not used.

4.7 SDD7

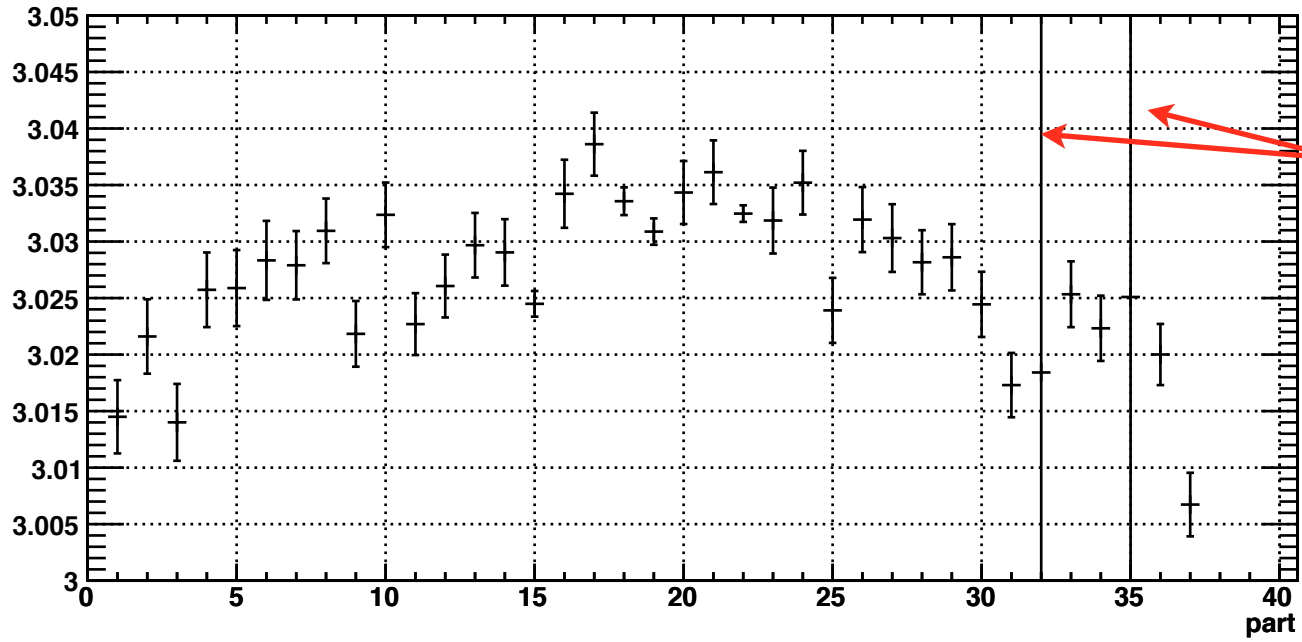
1. e2c : oscillating
2. intercept : also oscillating
3. sigma and FWHM : about 205 eV
4. Ka1Kb_ratio : not stable about 1.65
5. Fano factor : about 0.18
6. correlation of e2c and intercept : negative correlation
7. typical and not converged histograms : not Gaussian shape

4.8 SDD8

SDD8 has strange excess between the $\text{TiK}\alpha$ and $\text{TiK}\beta$. I don't know where from this excess comes. Because of this the fit is not reliable.

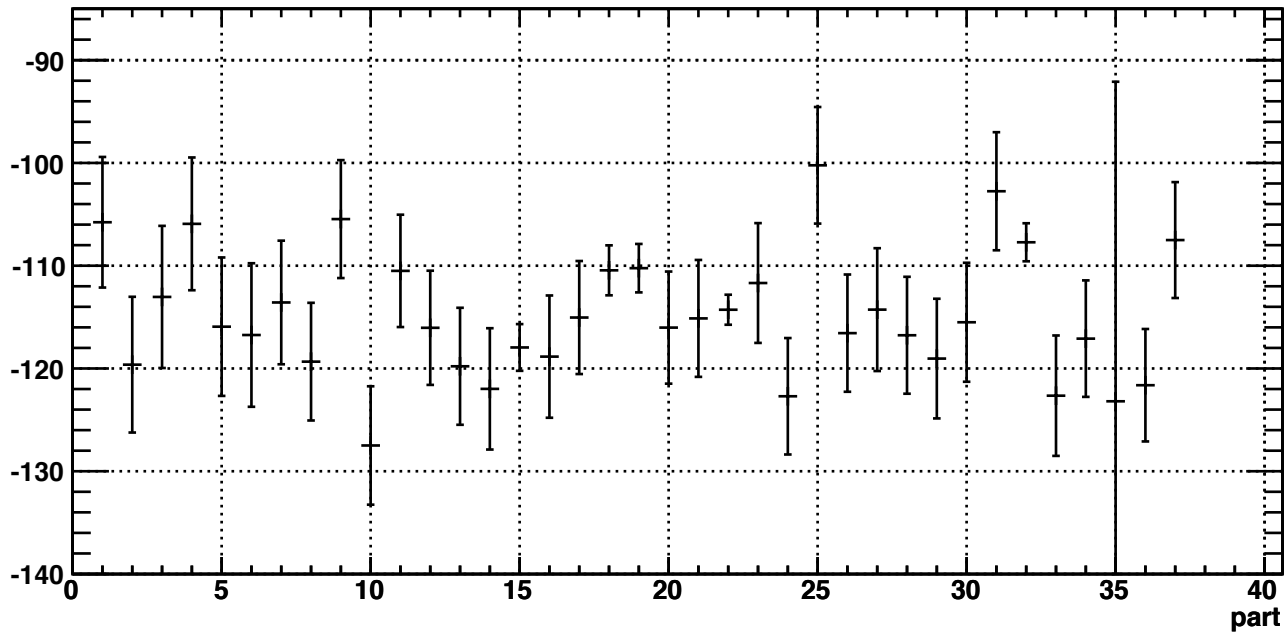
1. e2c : oscillating
2. intercept : also oscillating
3. sigma and FWHM : also oscillating
4. Ka1Kb_ratio : not stable
5. Fano factor : not stable
6. correlation of e2c and intercept : negative correlation
7. typical and not converged histograms : strange excess and not Gaussian shape

E570ex sdd1 Calibration ev2ch

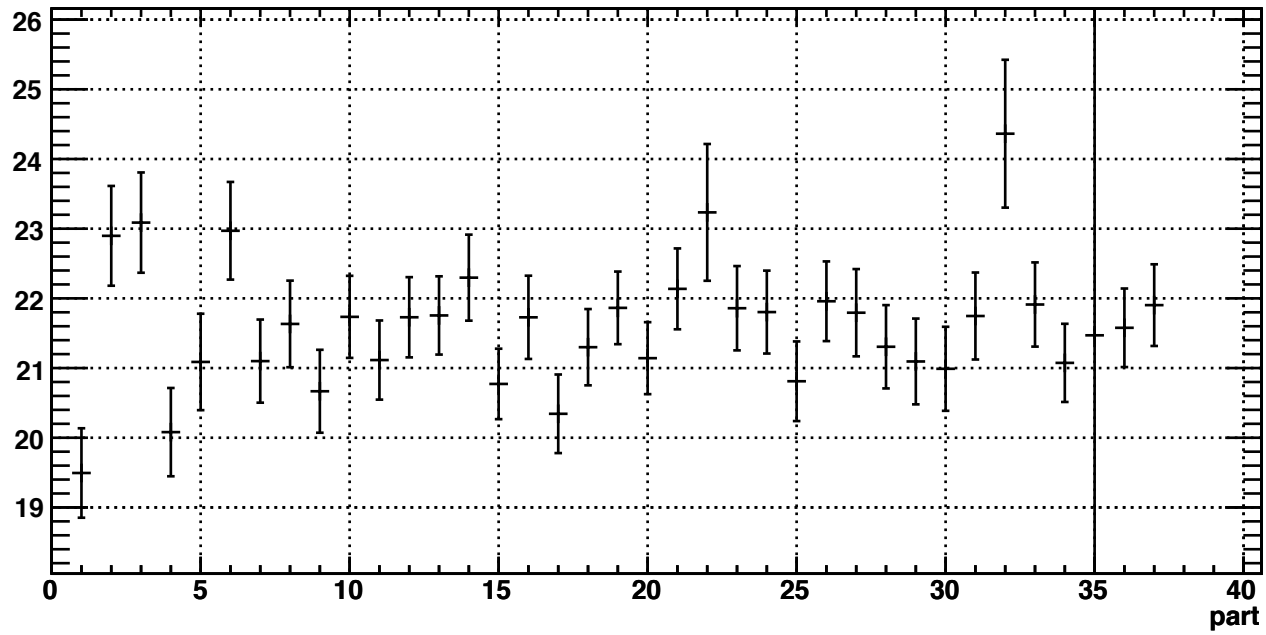


fitting doesn't converged at part32 and 35

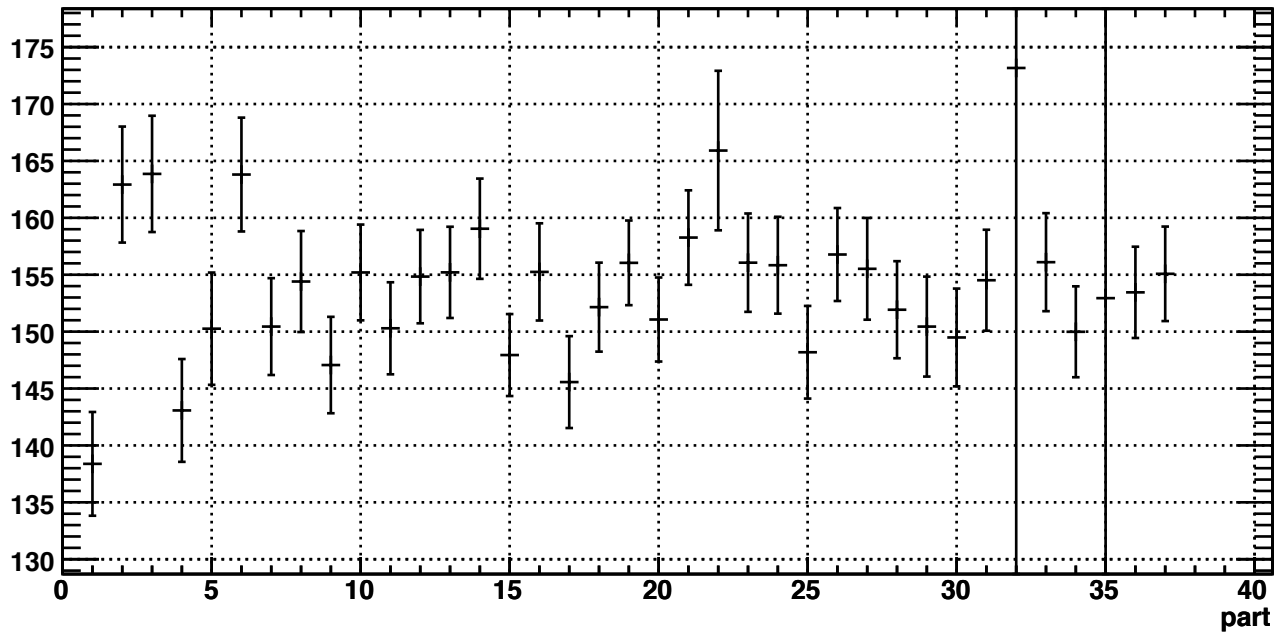
E570ex sdd1 Calibration intercept



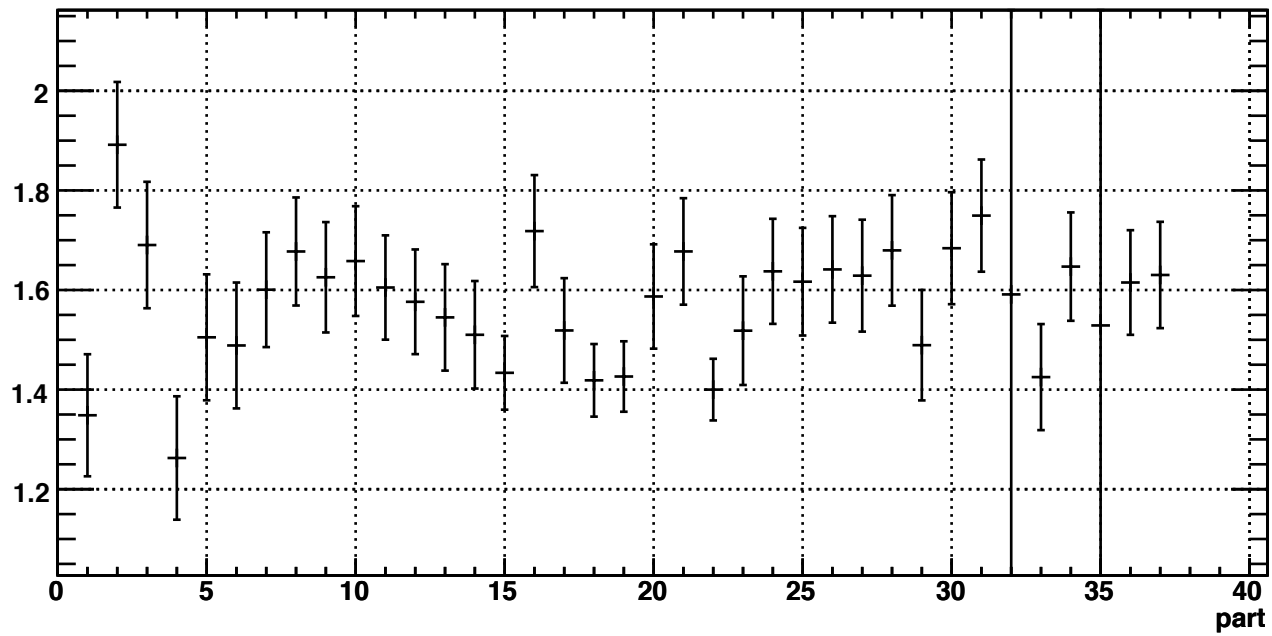
E570ex sdd1 Calibration TiKa1Sigma



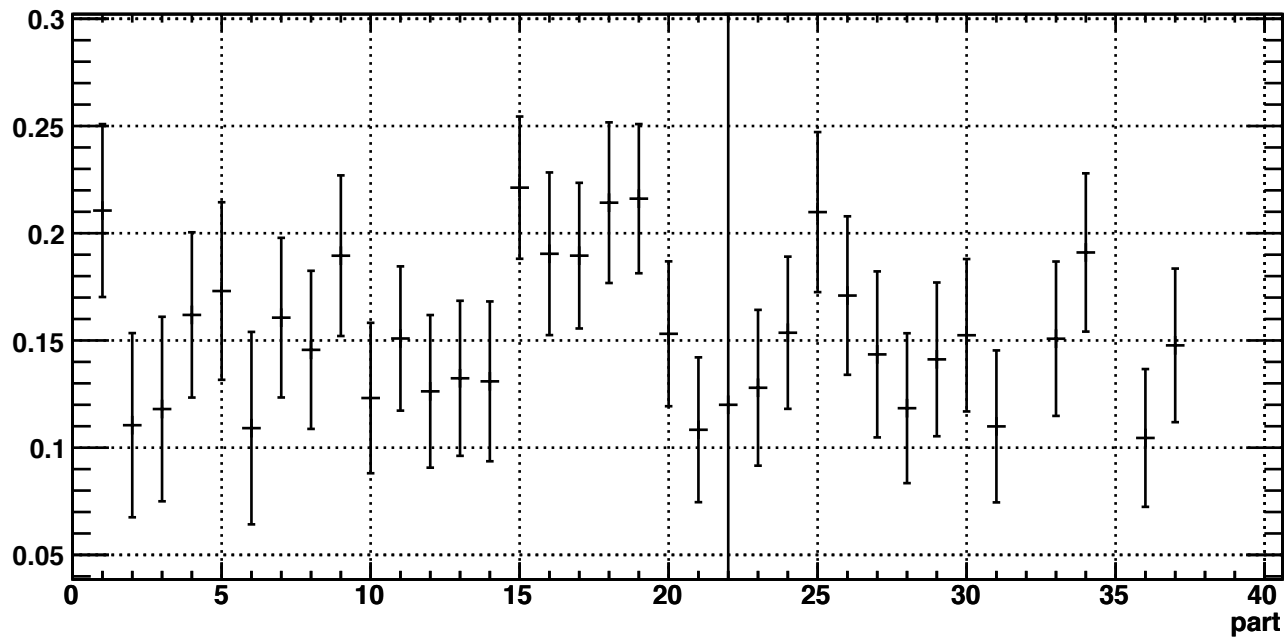
E570ex sdd1 Calibration TiKa1FWHM



E570ex sdd1 Calibration Ka1Kb_ratio

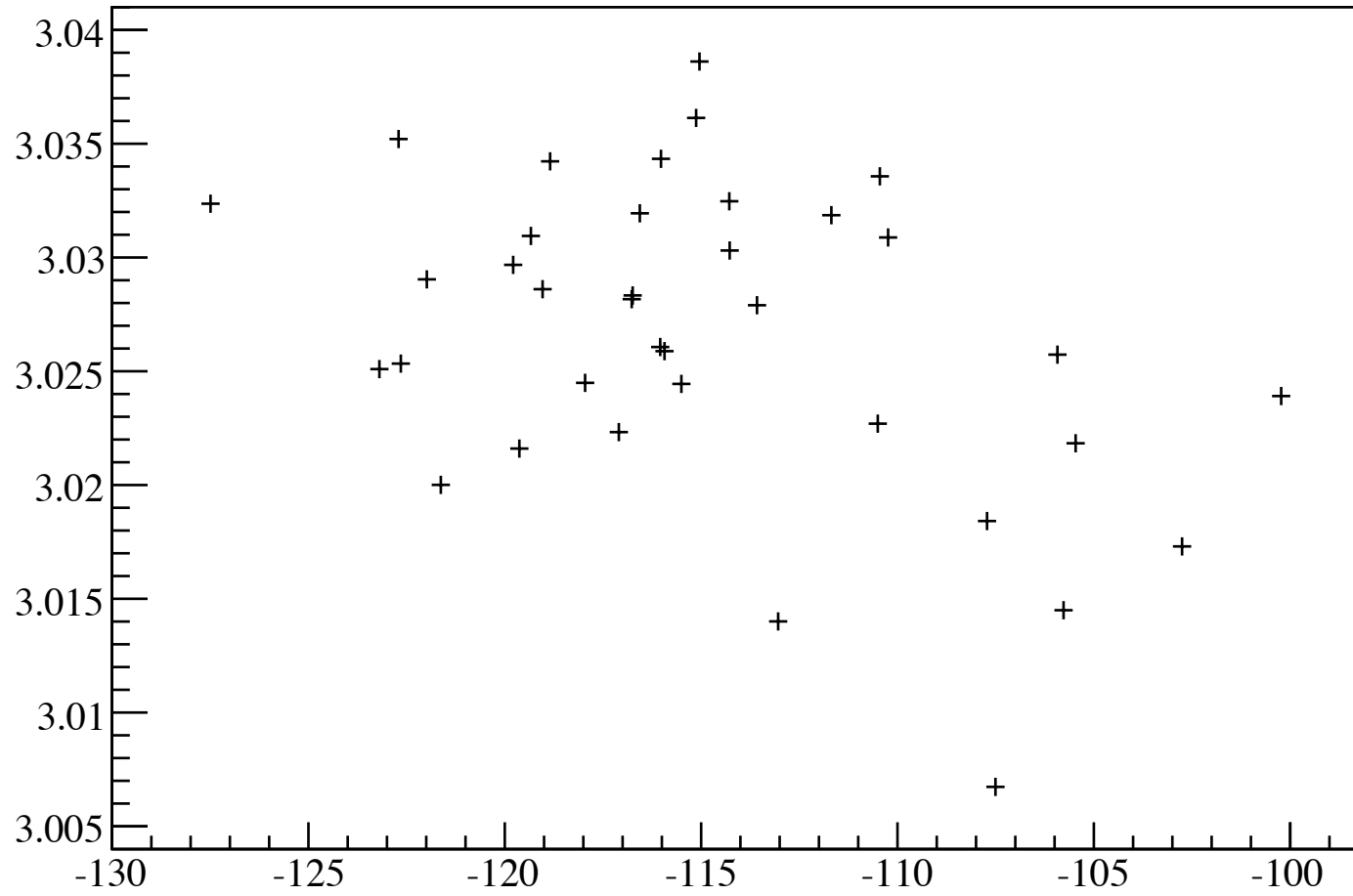


E570ex sdd1 Calibration Fano



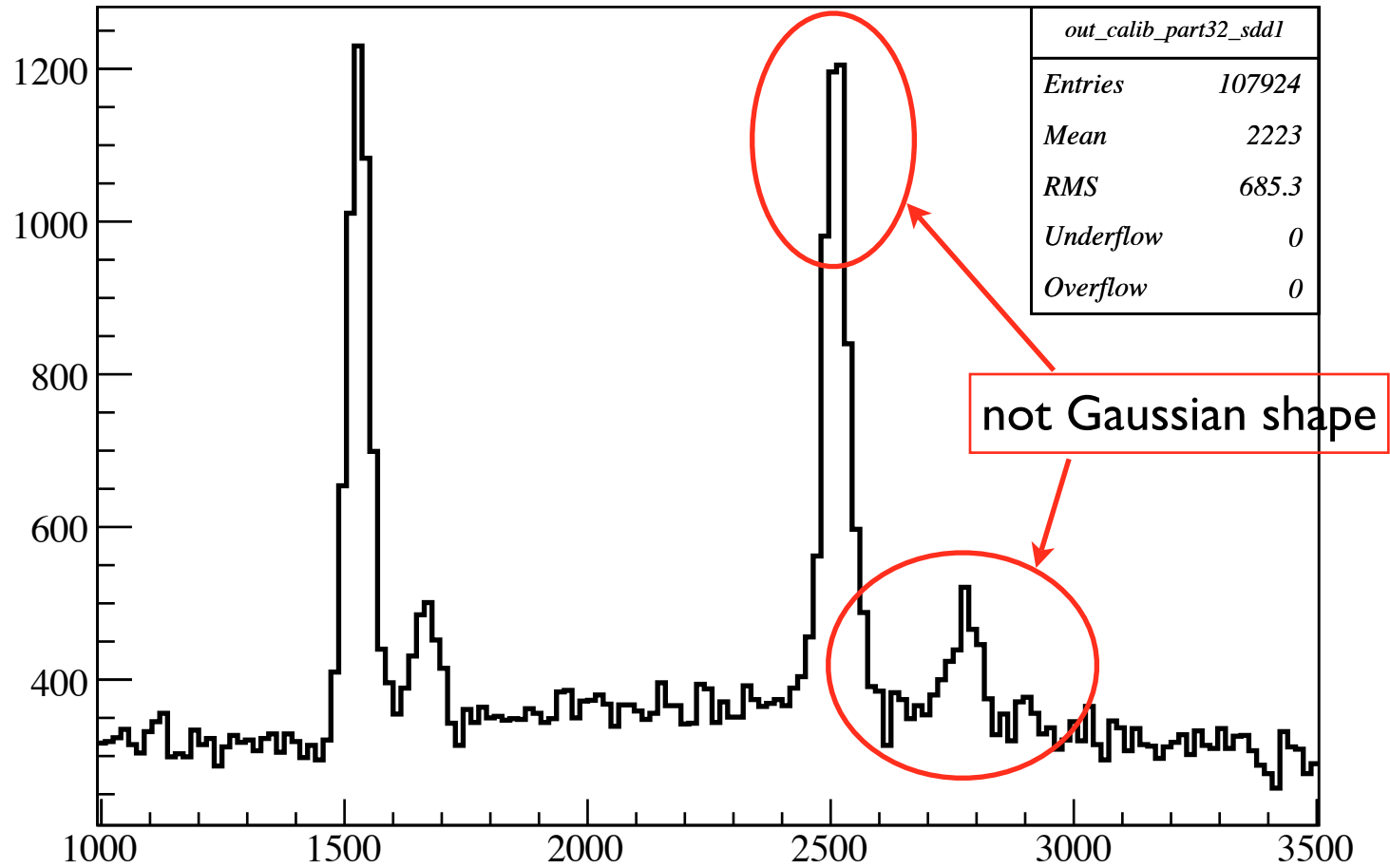
No correlation ...

ev2ch:intercept

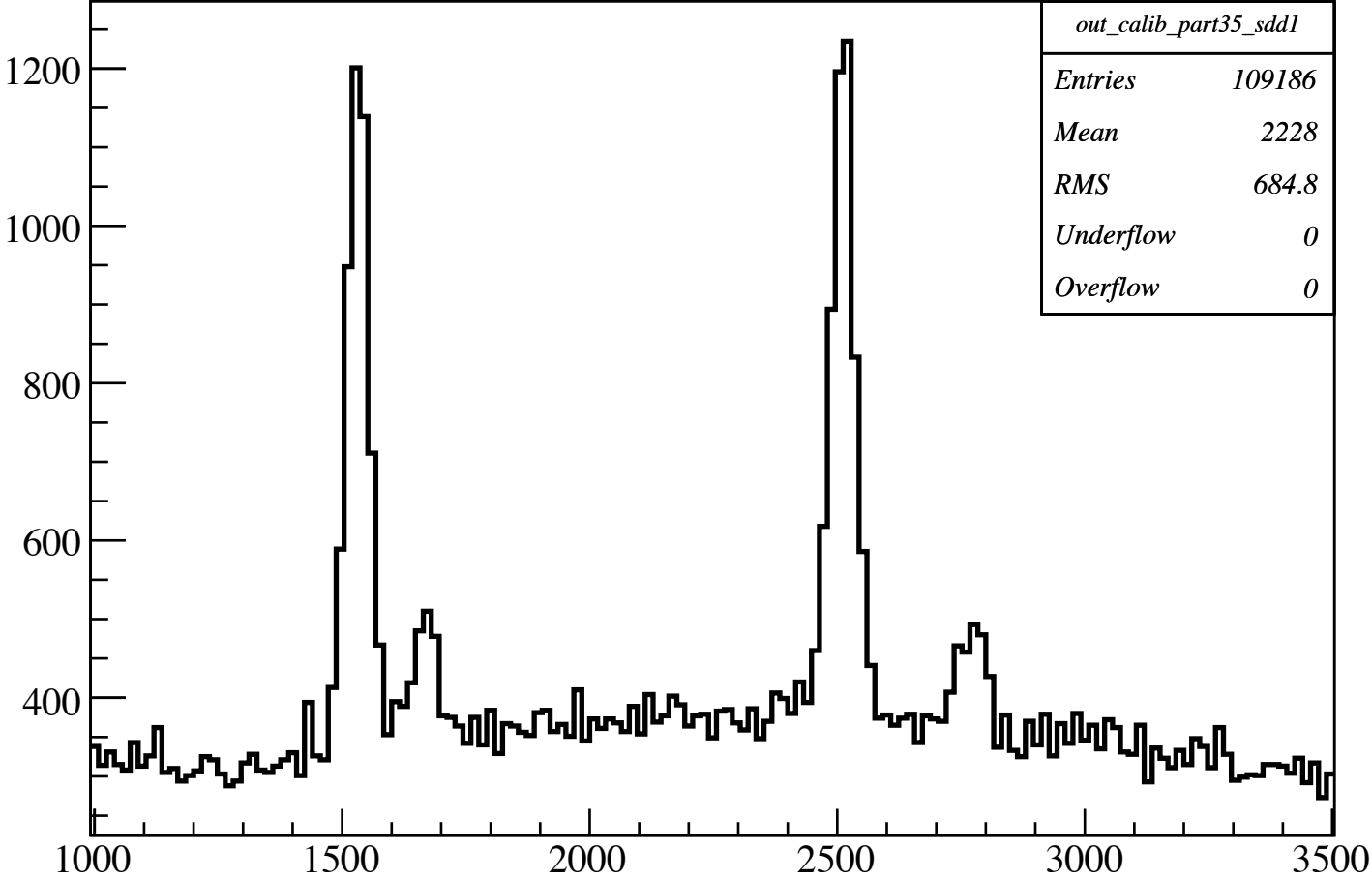


Not converged histogram

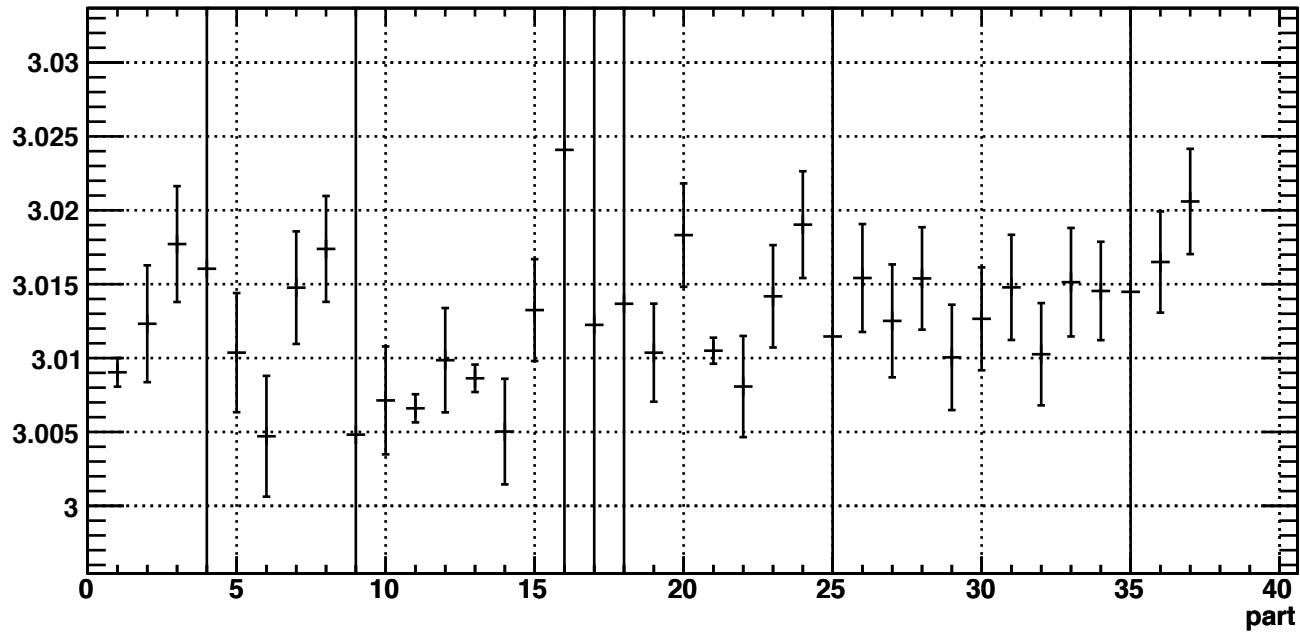
out_calib_part32_sdd1



out_calib_part35_sdd1

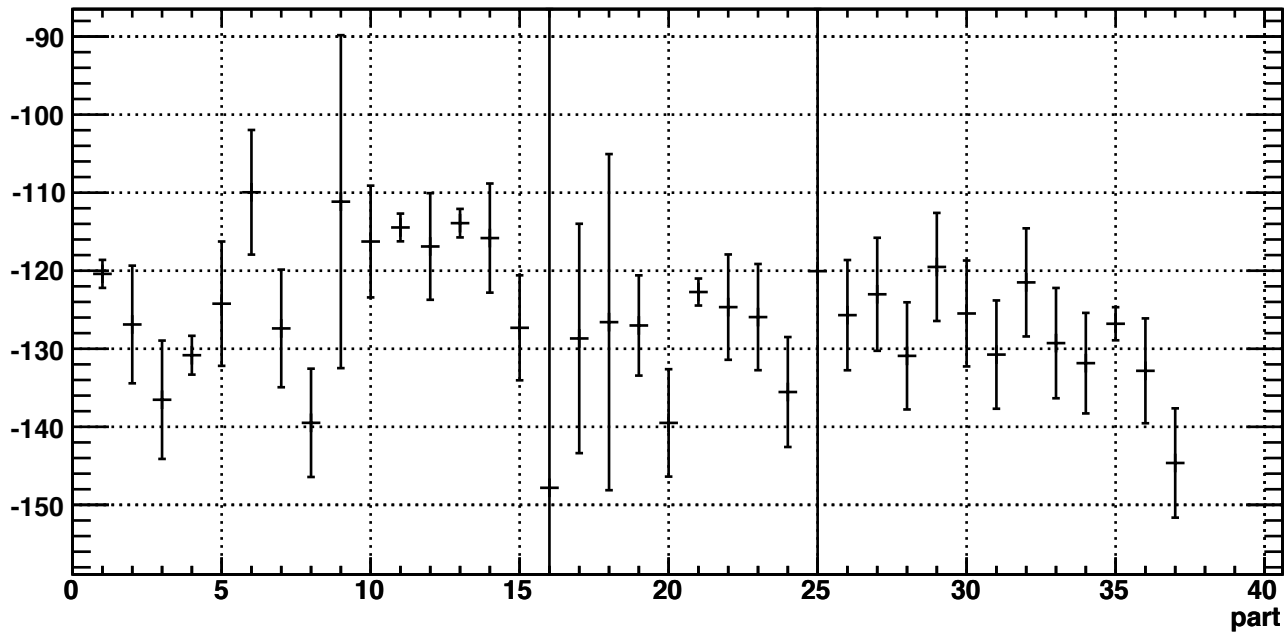


E570ex sdd2 Calibration ev2ch

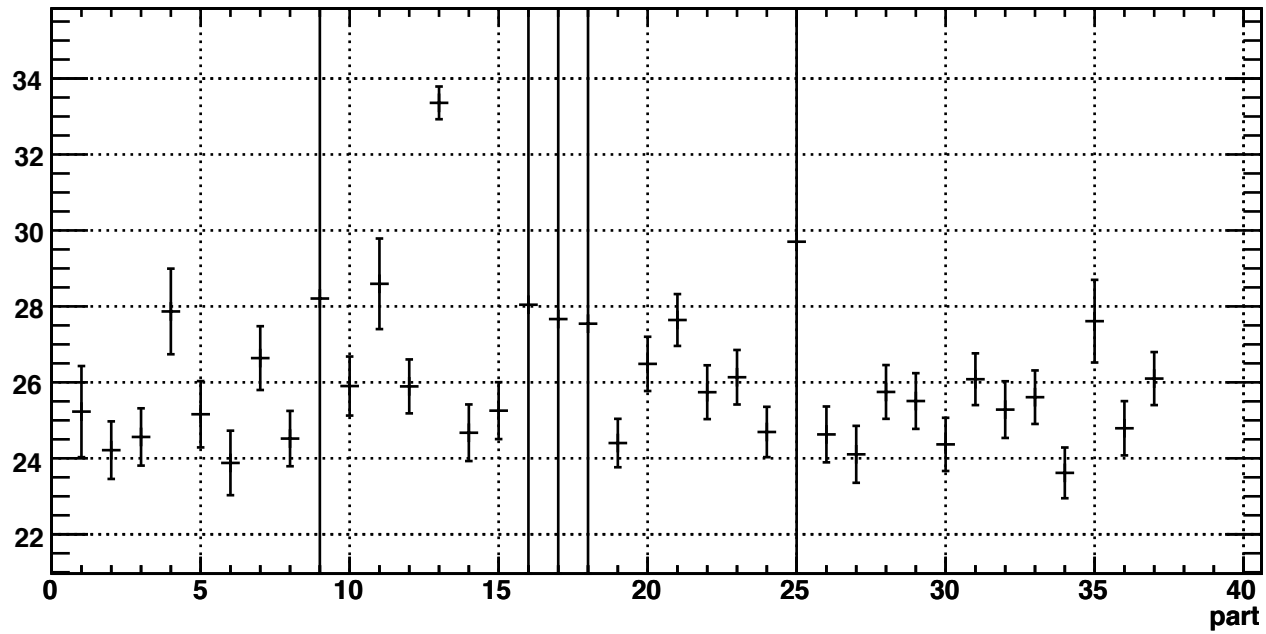


there are many not converged parts, this is because sdd2 has a strange background near Ti Ka peak

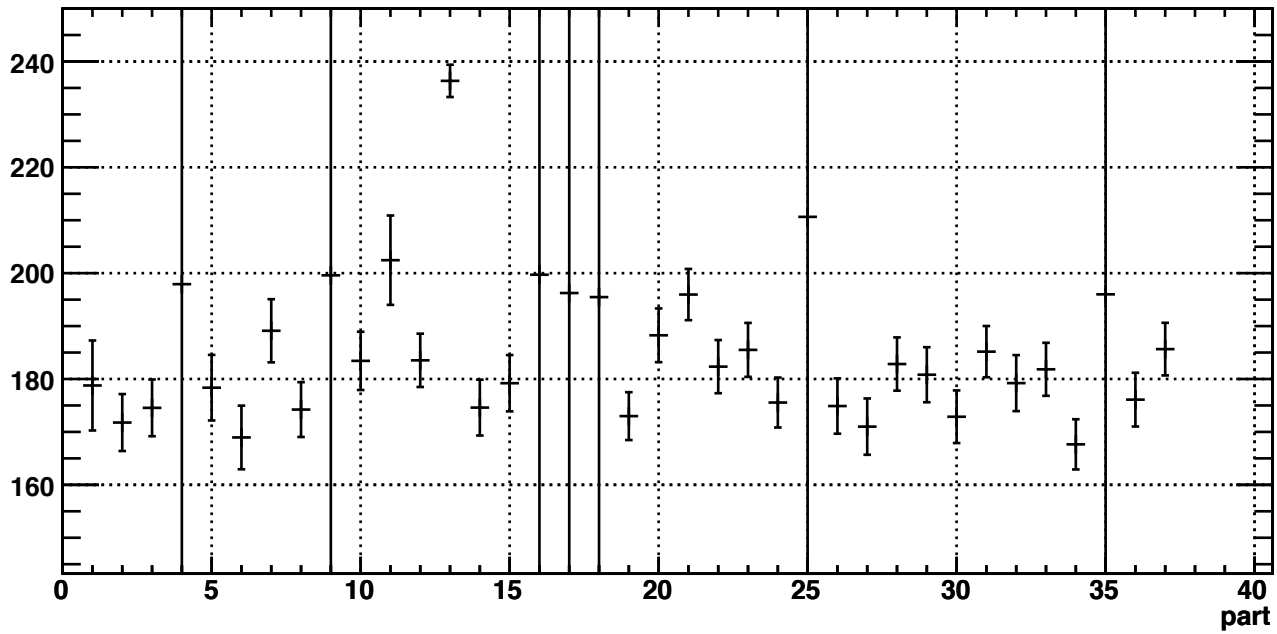
E570ex sdd2 Calibration intercept



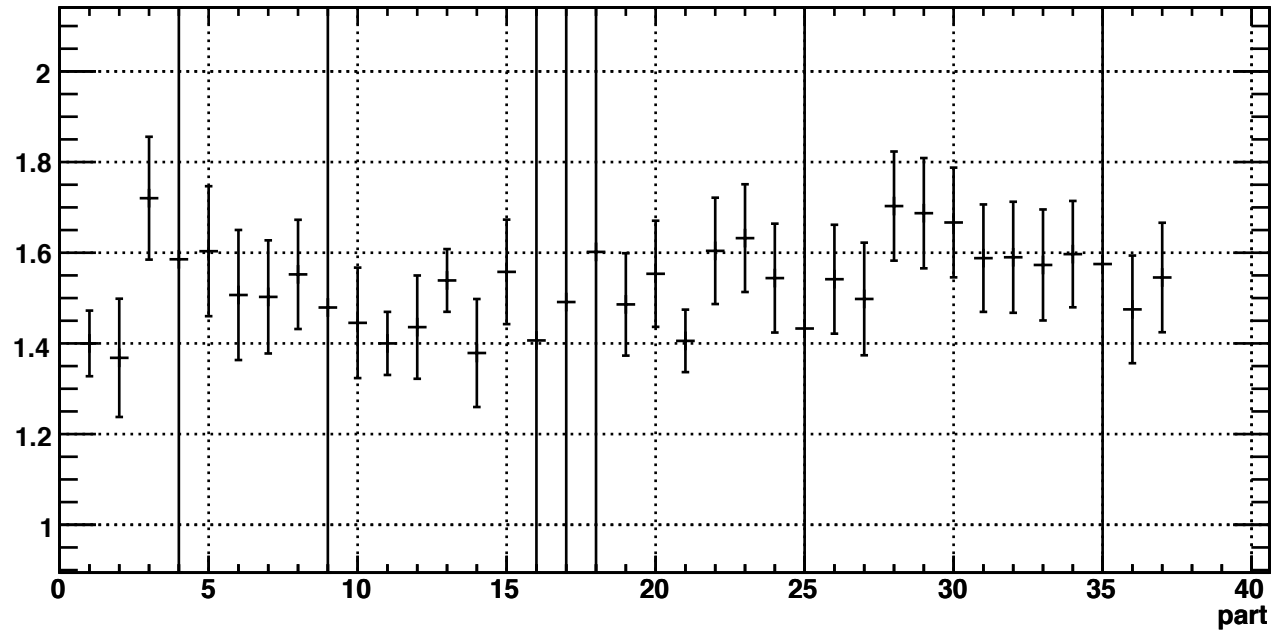
E570ex sdd2 Calibration TiKa1Sigma



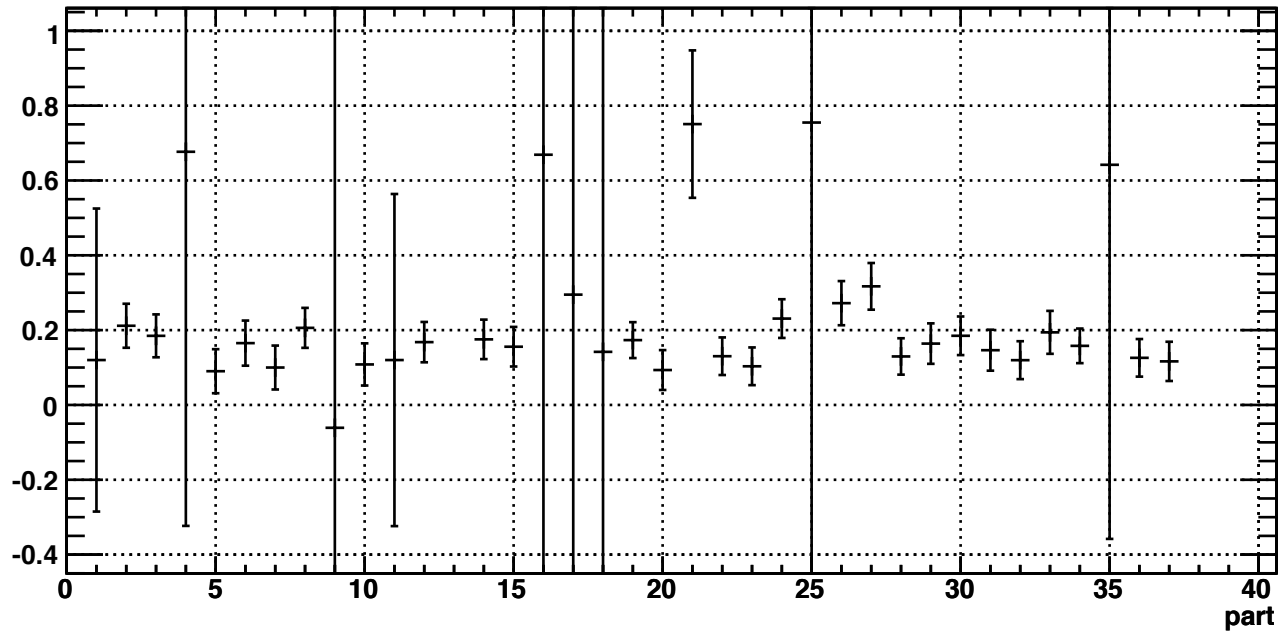
E570ex sdd2 Calibration TiKa1FWHM



E570ex sdd2 Calibration Ka1Kb_ratio

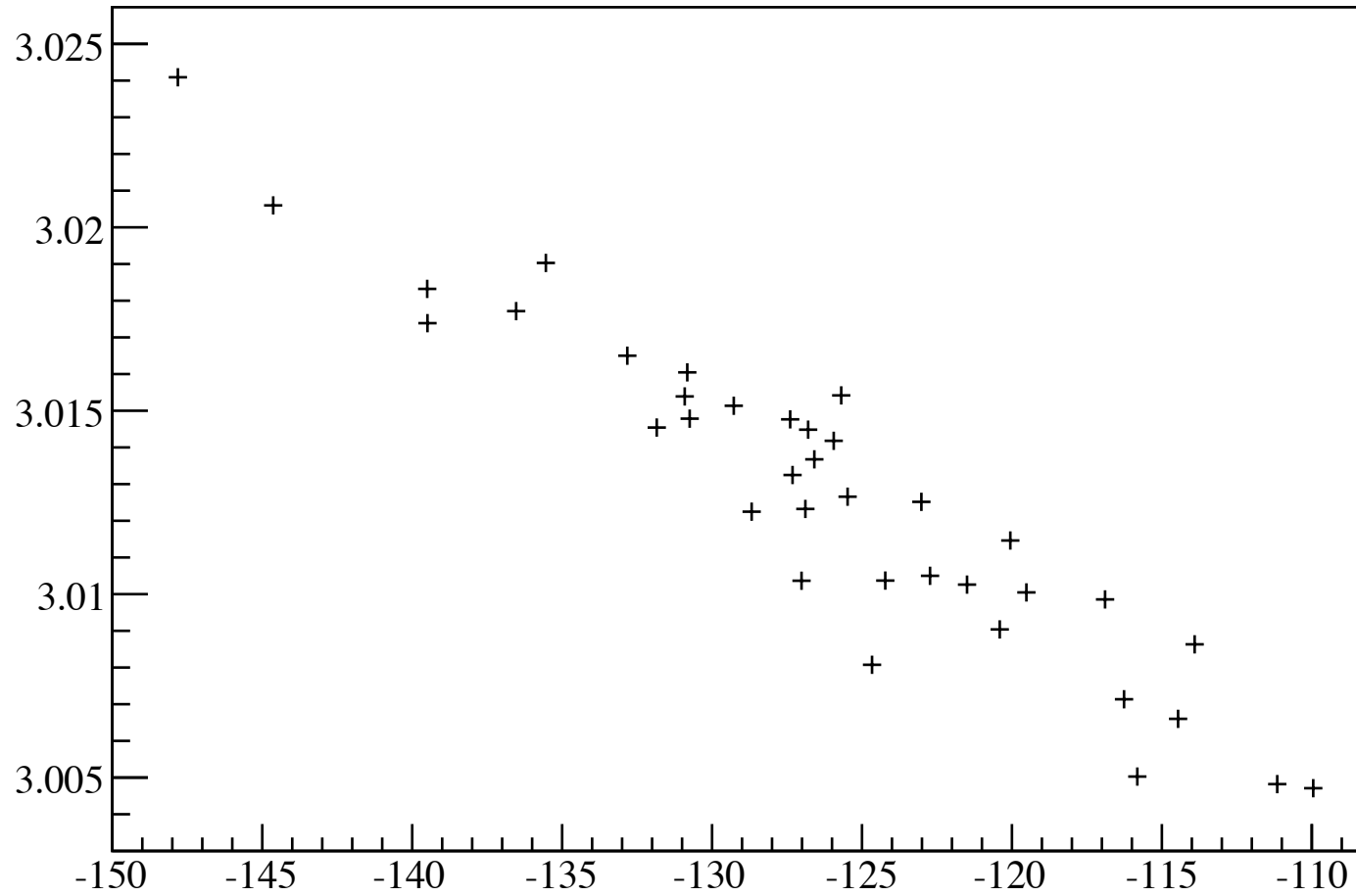


E570ex sdd2 Calibration Fano

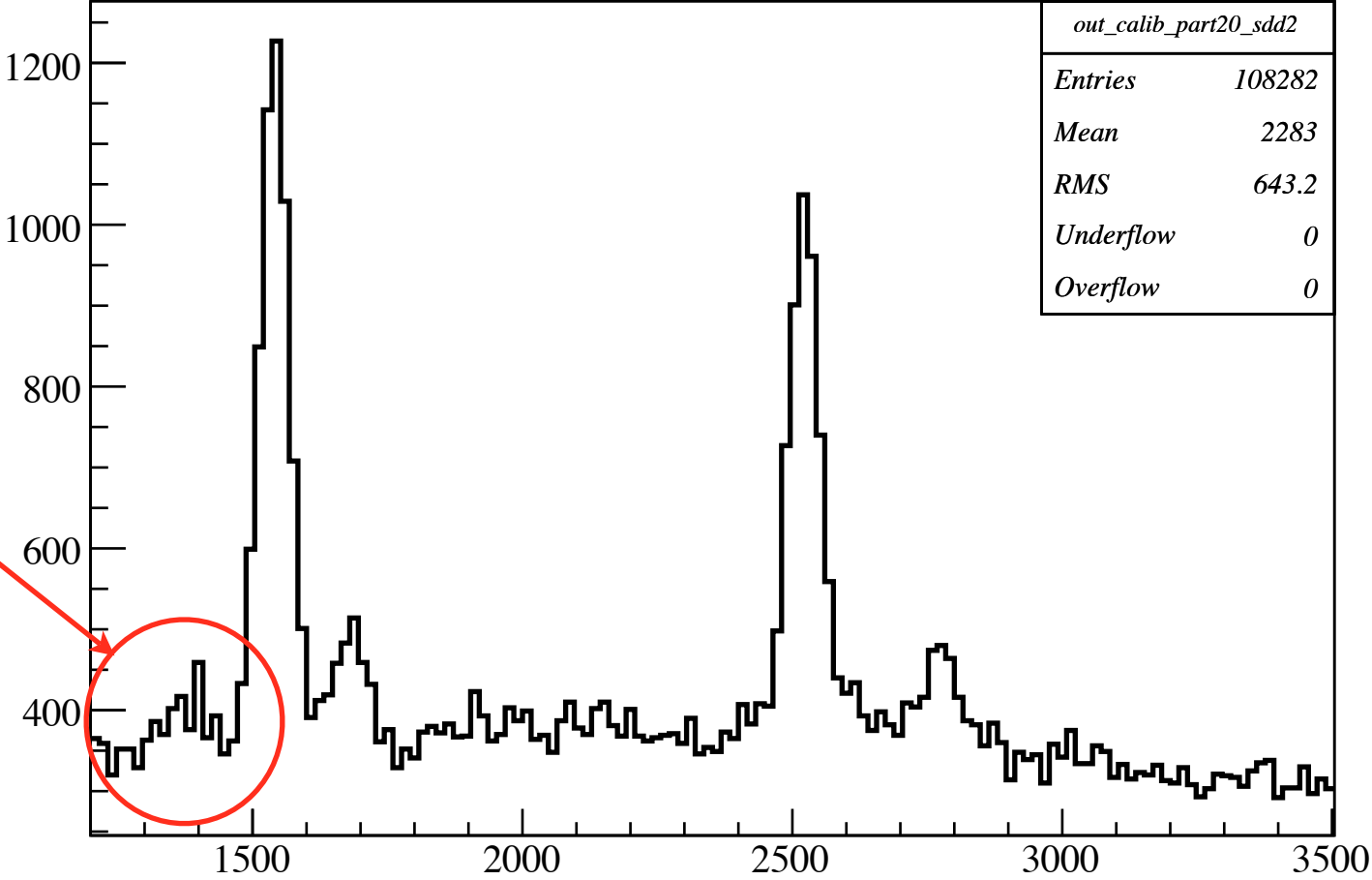


there is a negative correlation

ev2ch:intercept

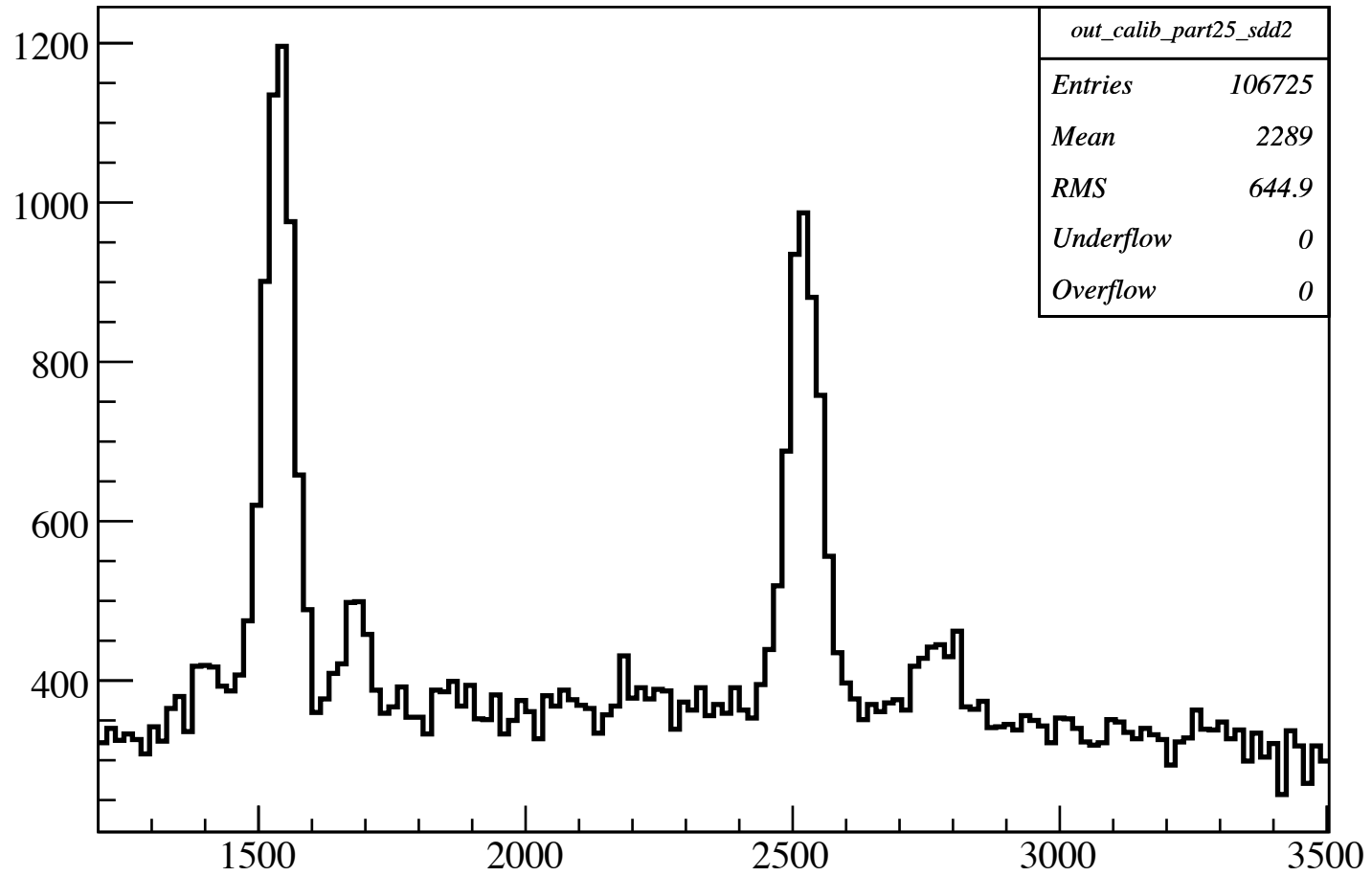


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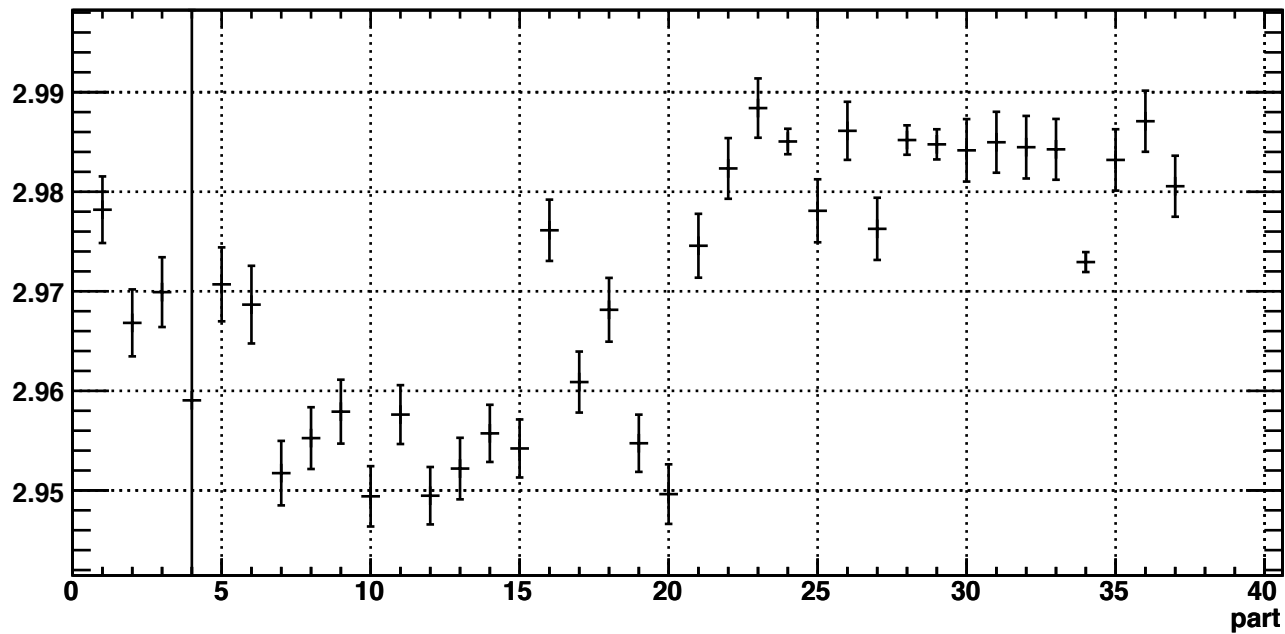


strange
background

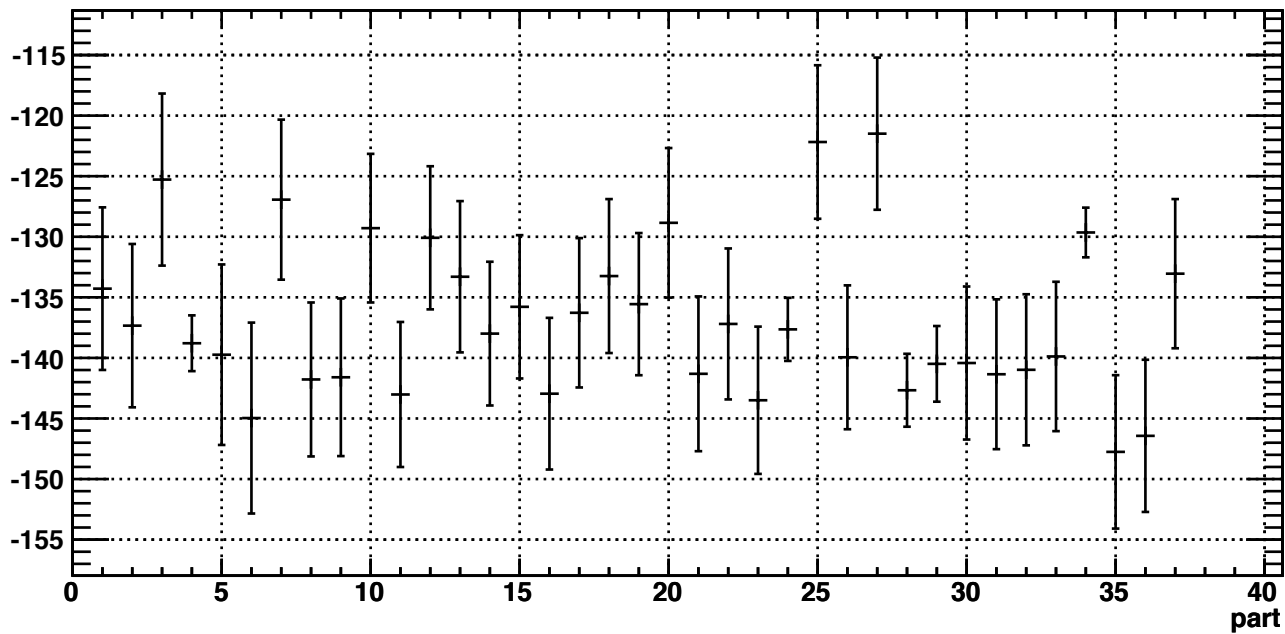
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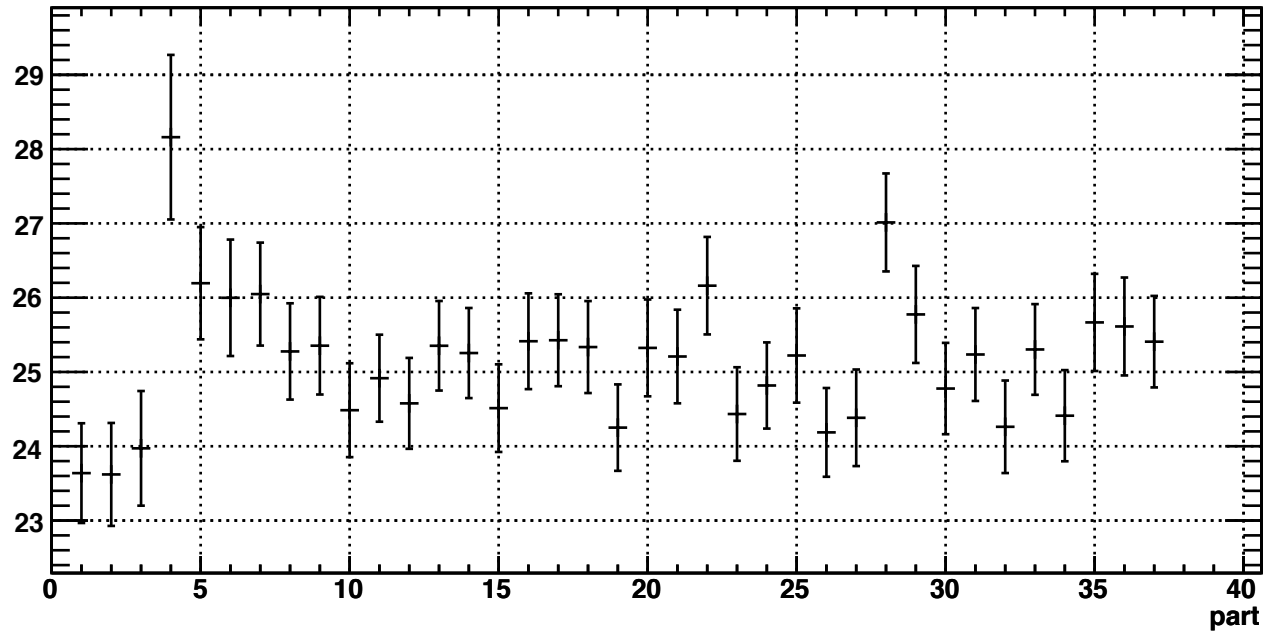
E570ex sdd3 Calibration ev2ch



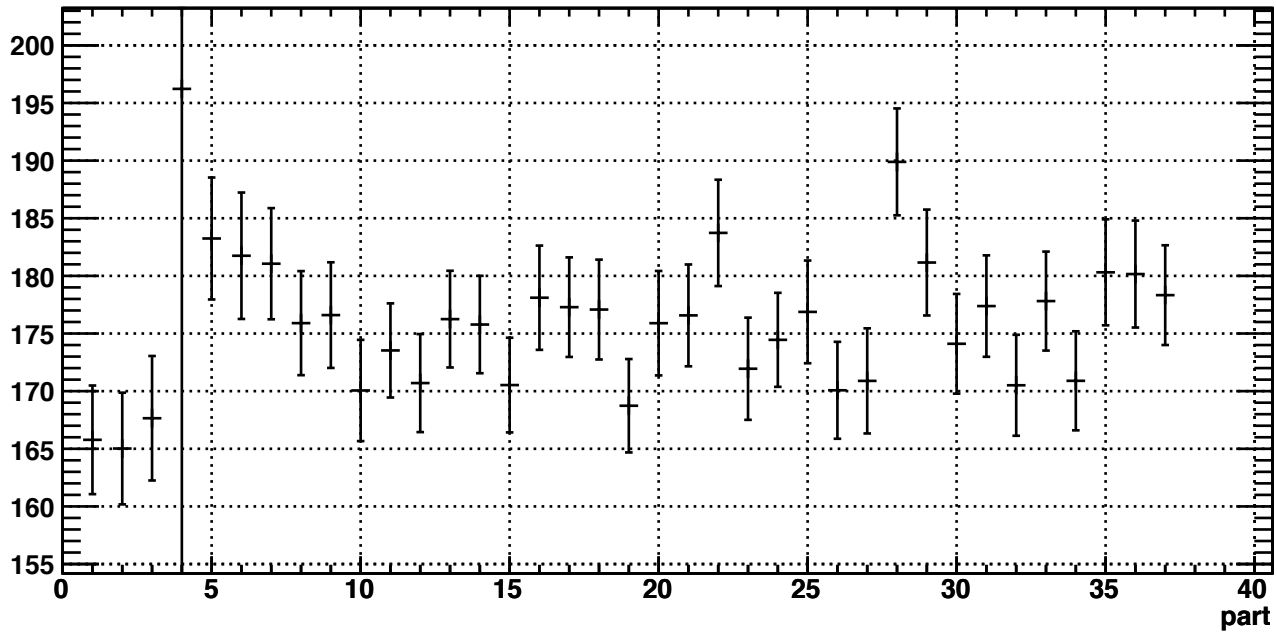
E570ex sdd3 Calibration intercept



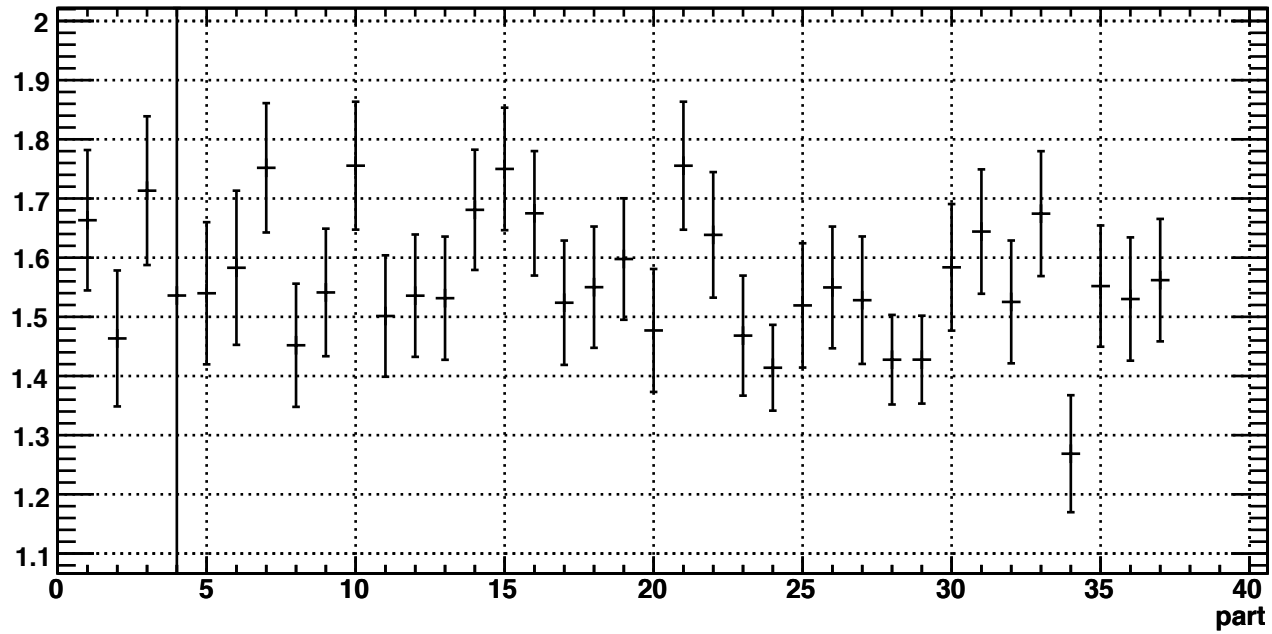
E570ex sdd3 Calibration TiKa1Sigma



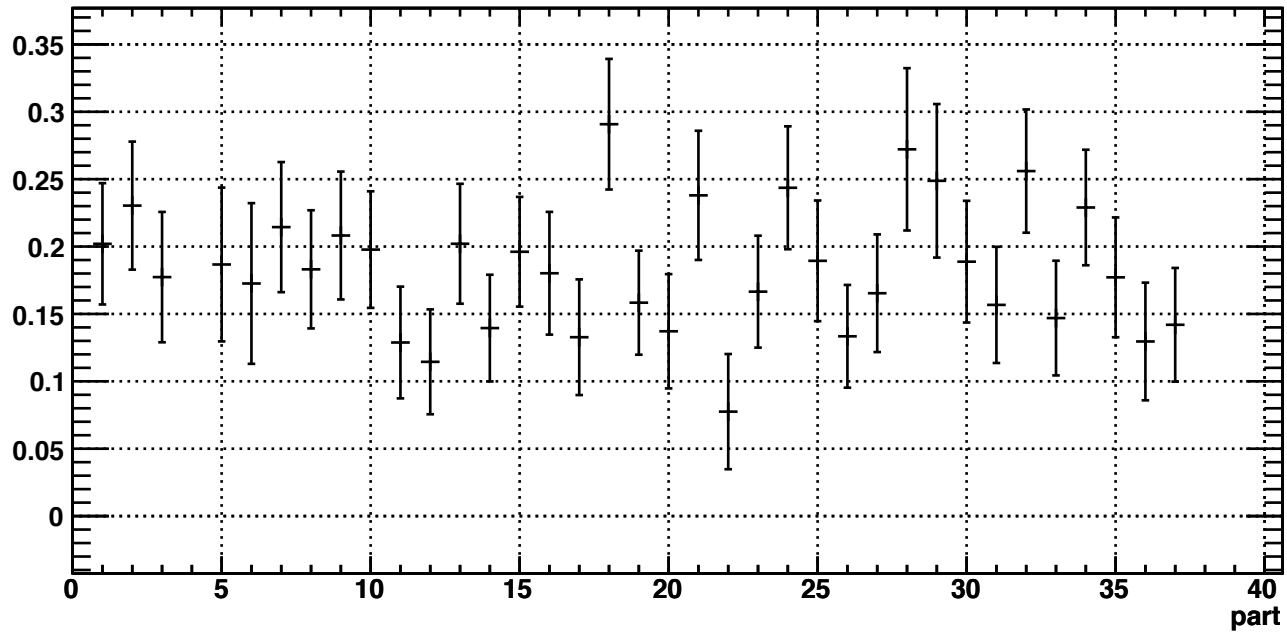
E570ex sdd3 Calibration TiKa1FWHM



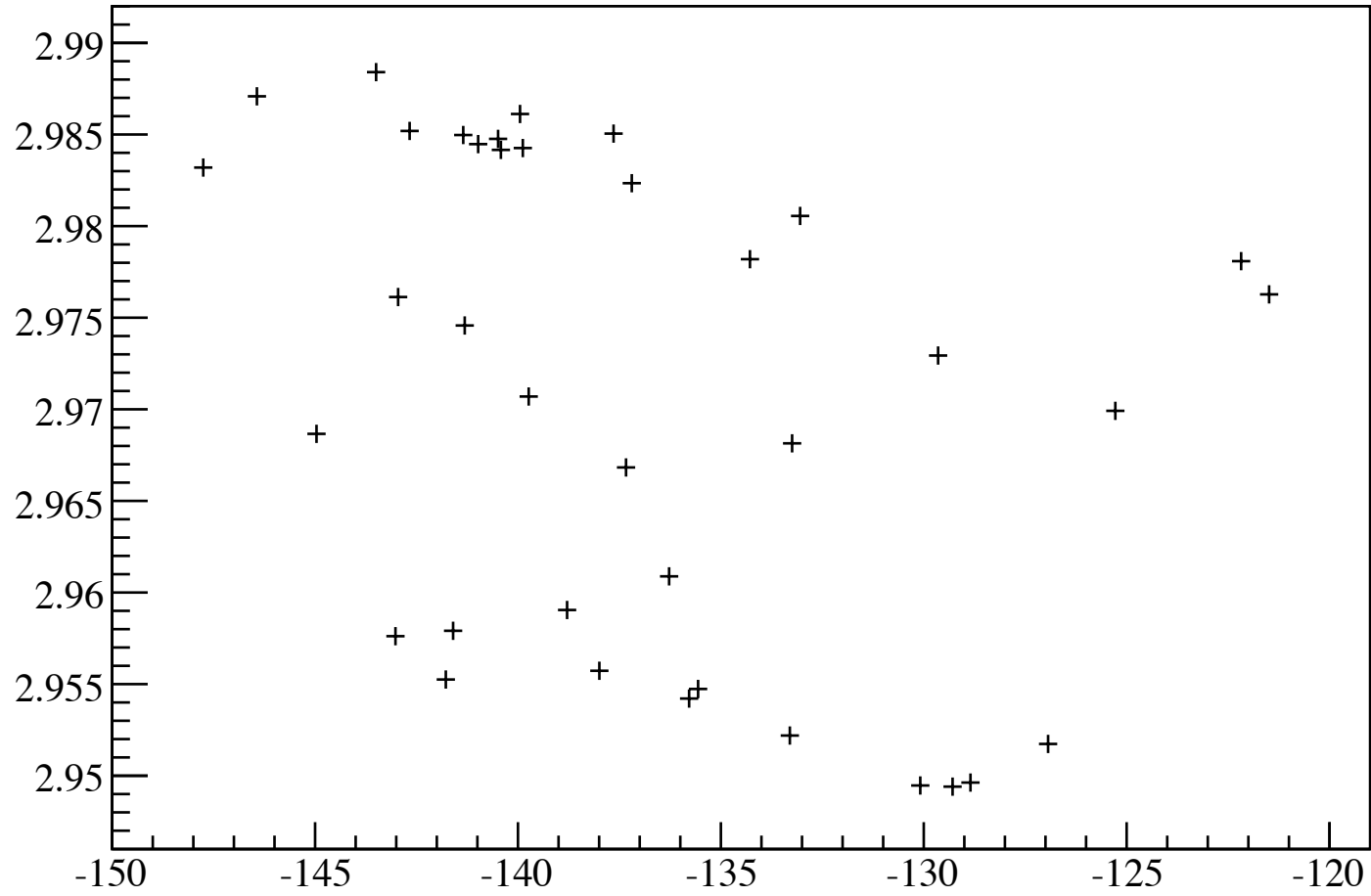
E570ex sdd3 Calibration Ka1Kb_ratio



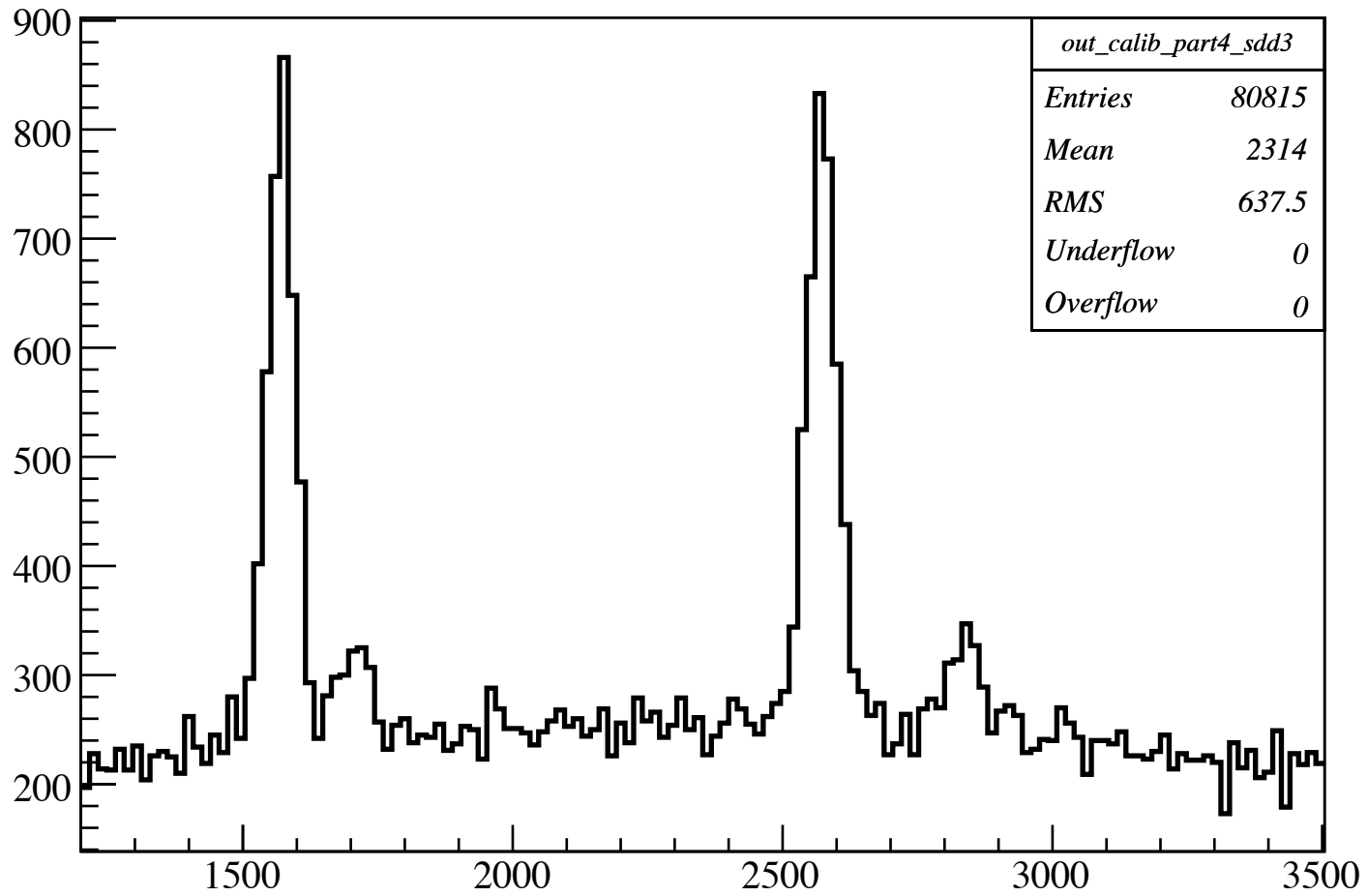
E570ex sdd3 Calibration Fano



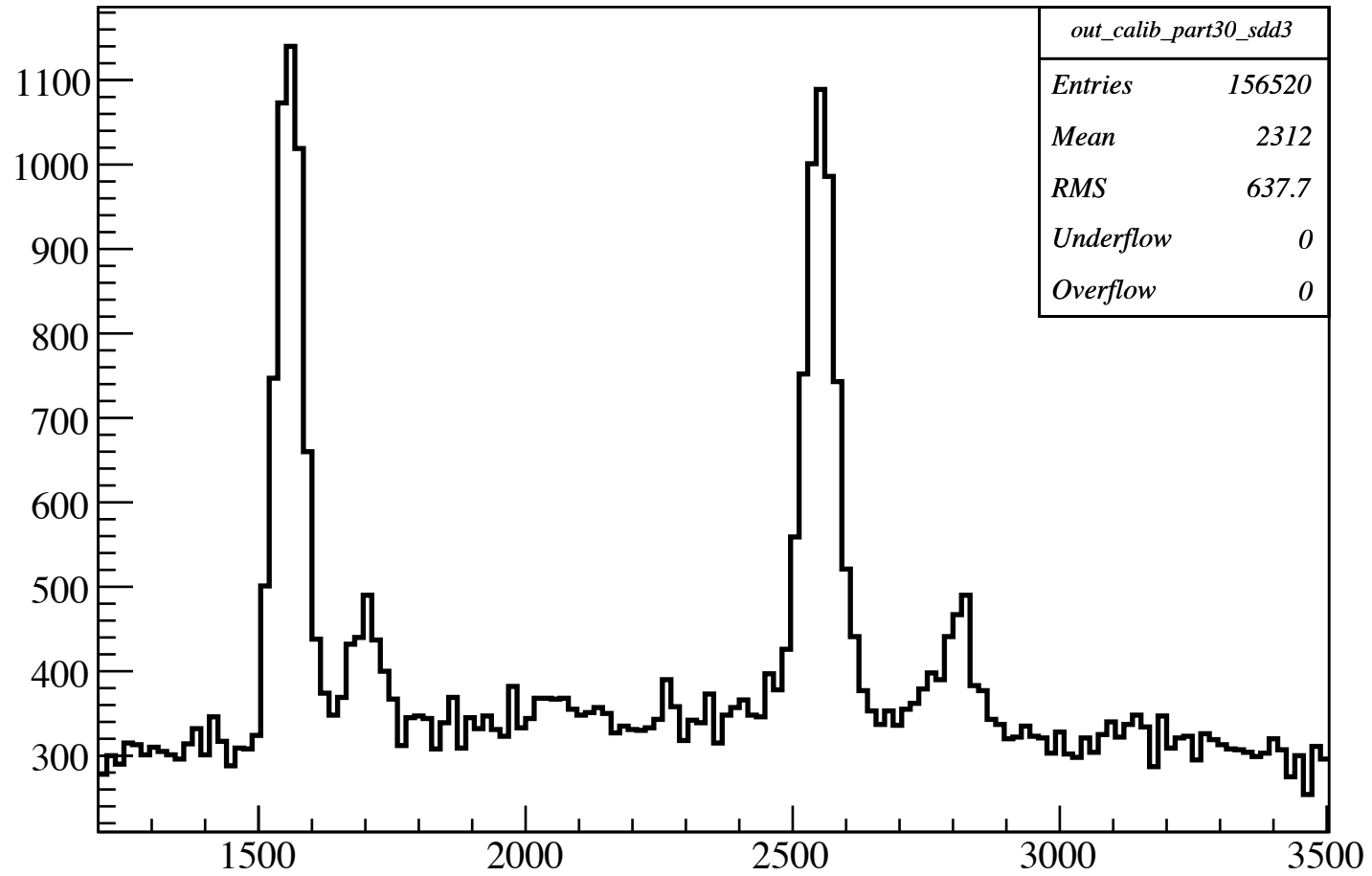
ev2ch:intercept



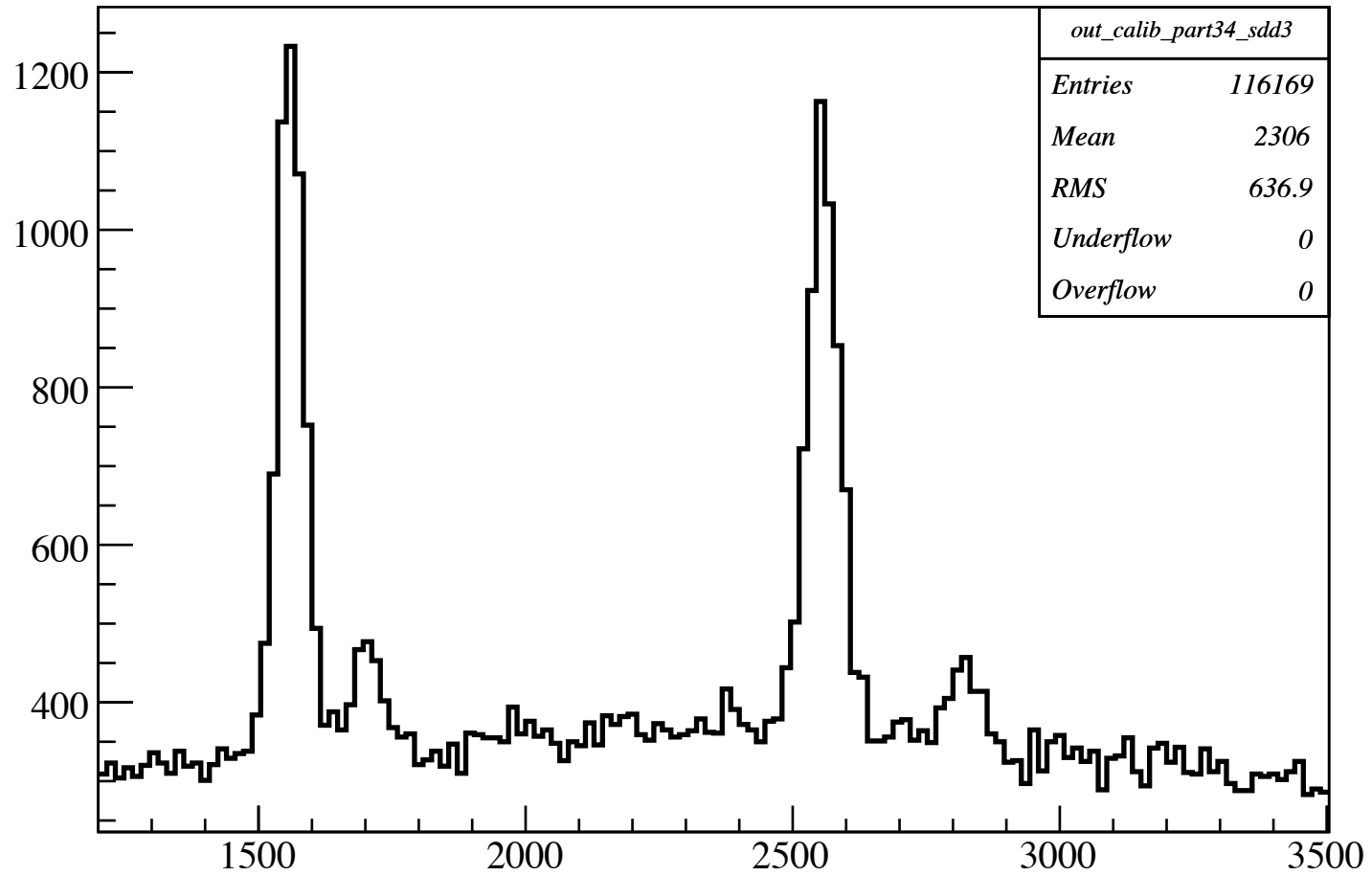
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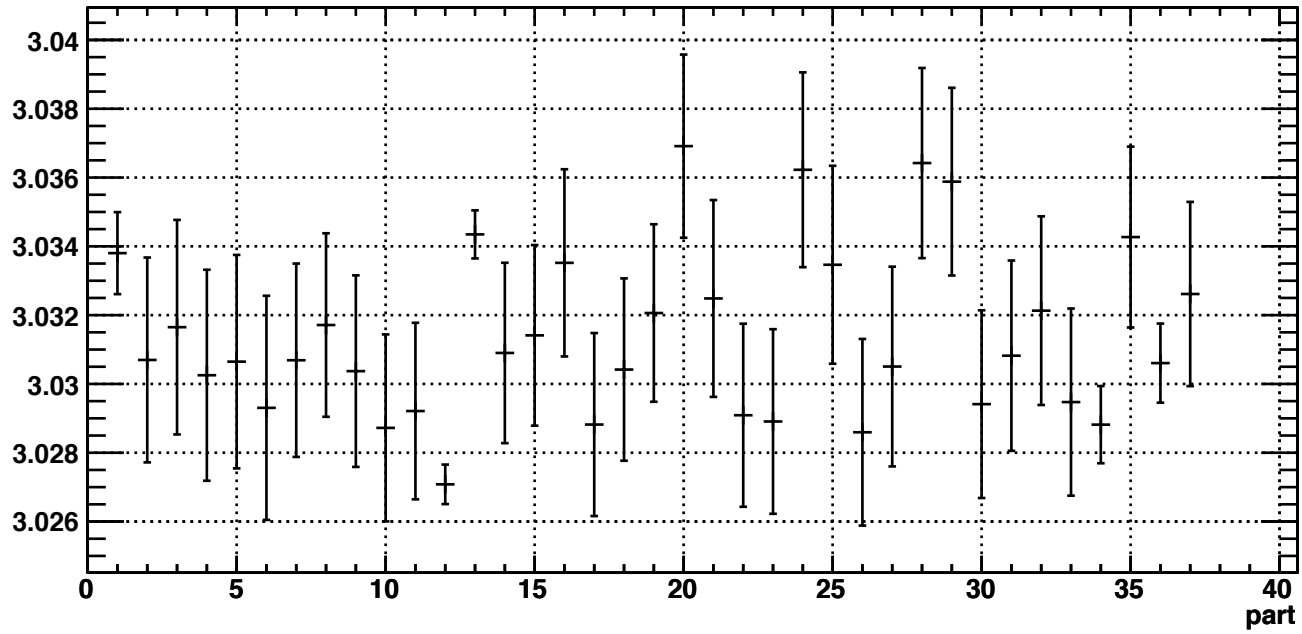
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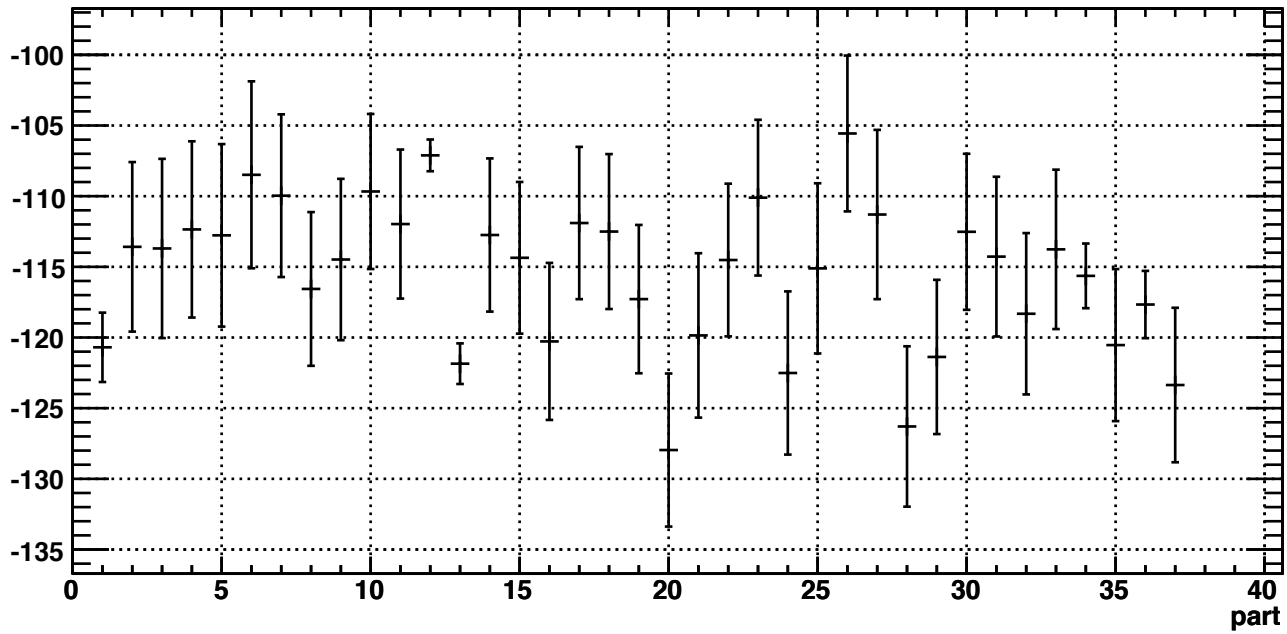
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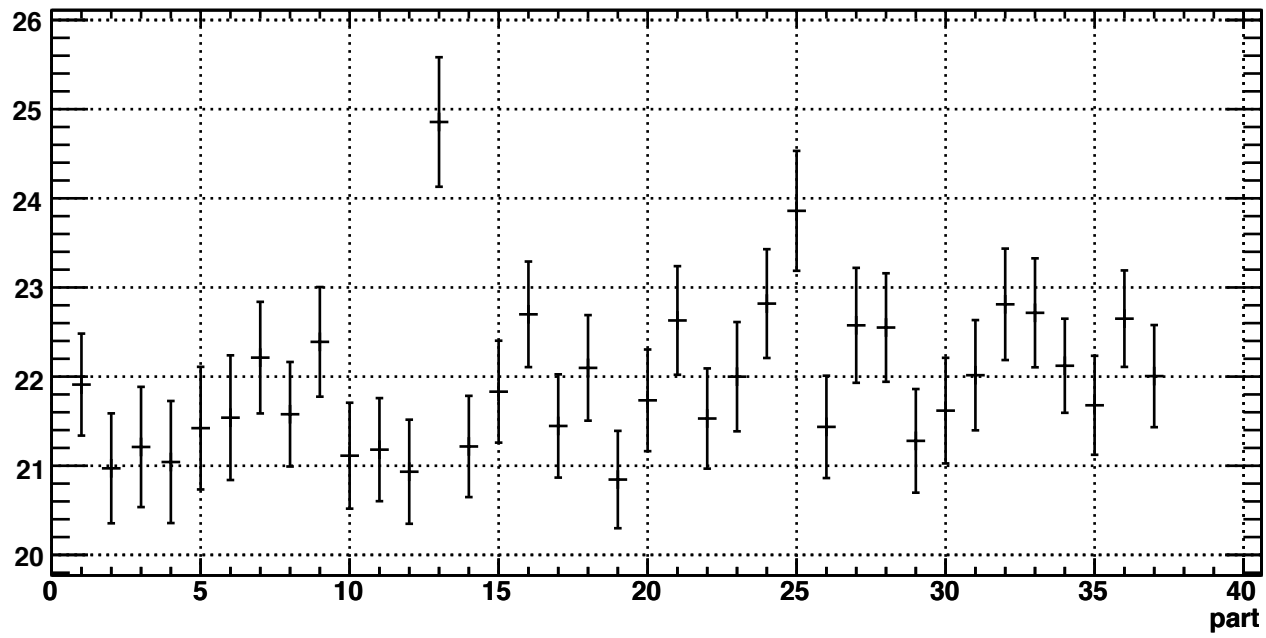
E570ex sdd4 Calibration ev2ch



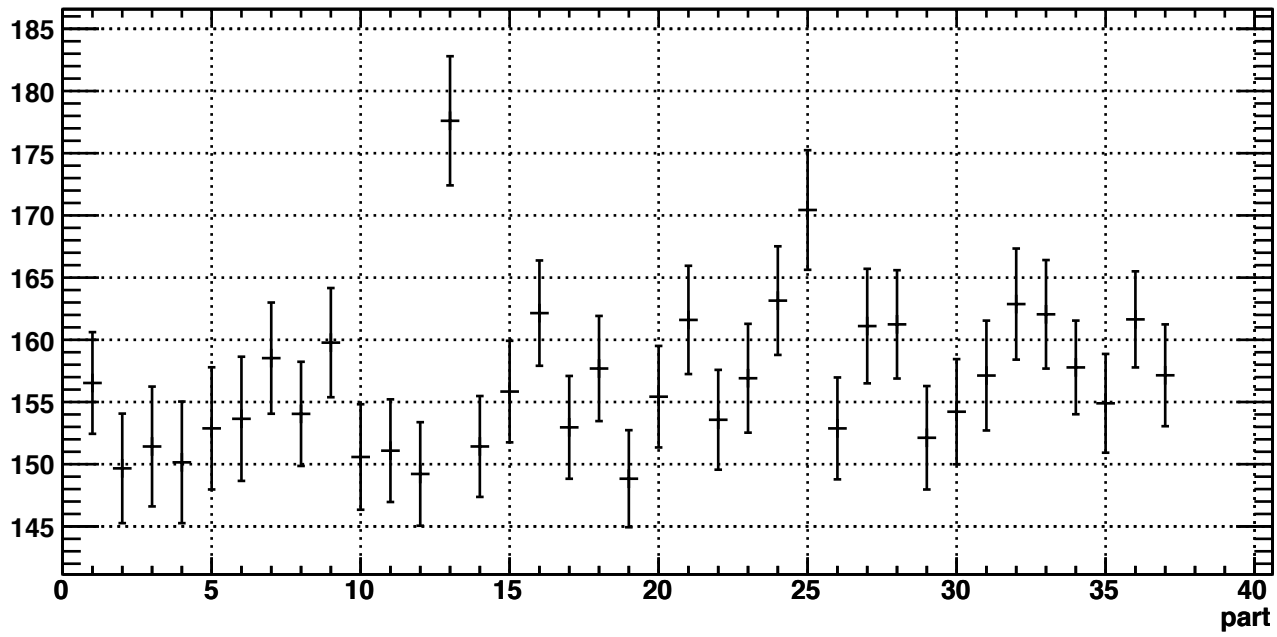
E570ex sdd4 Calibration intercept



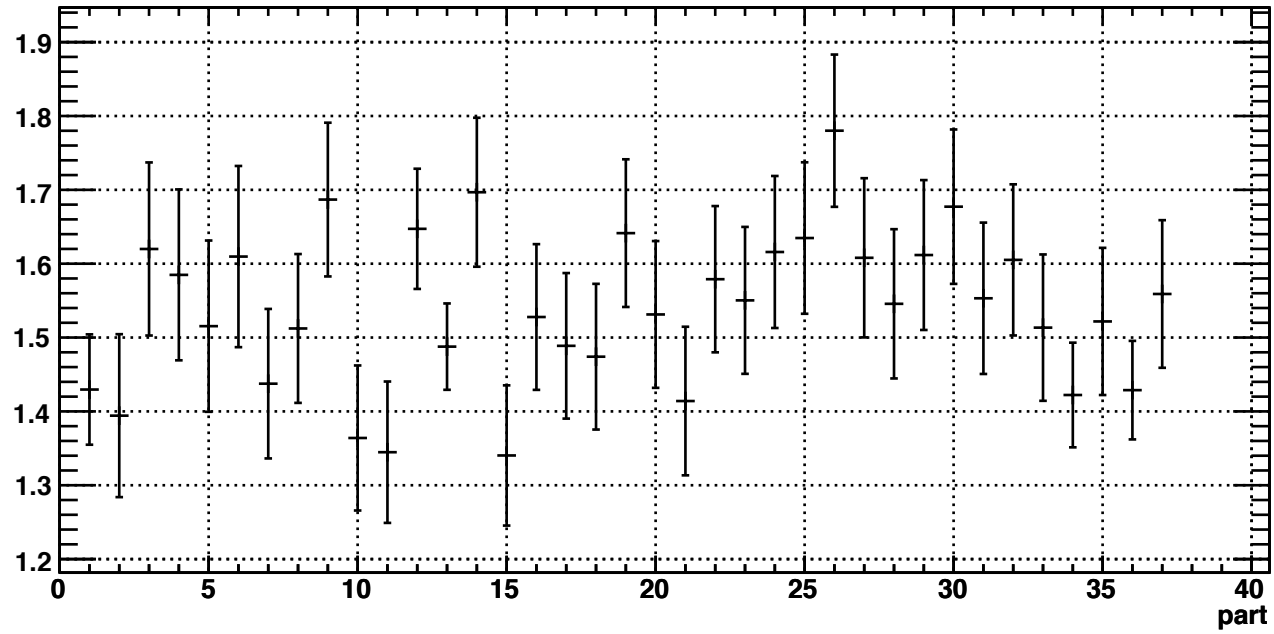
E570ex sdd4 Calibration TiKa1Sigma



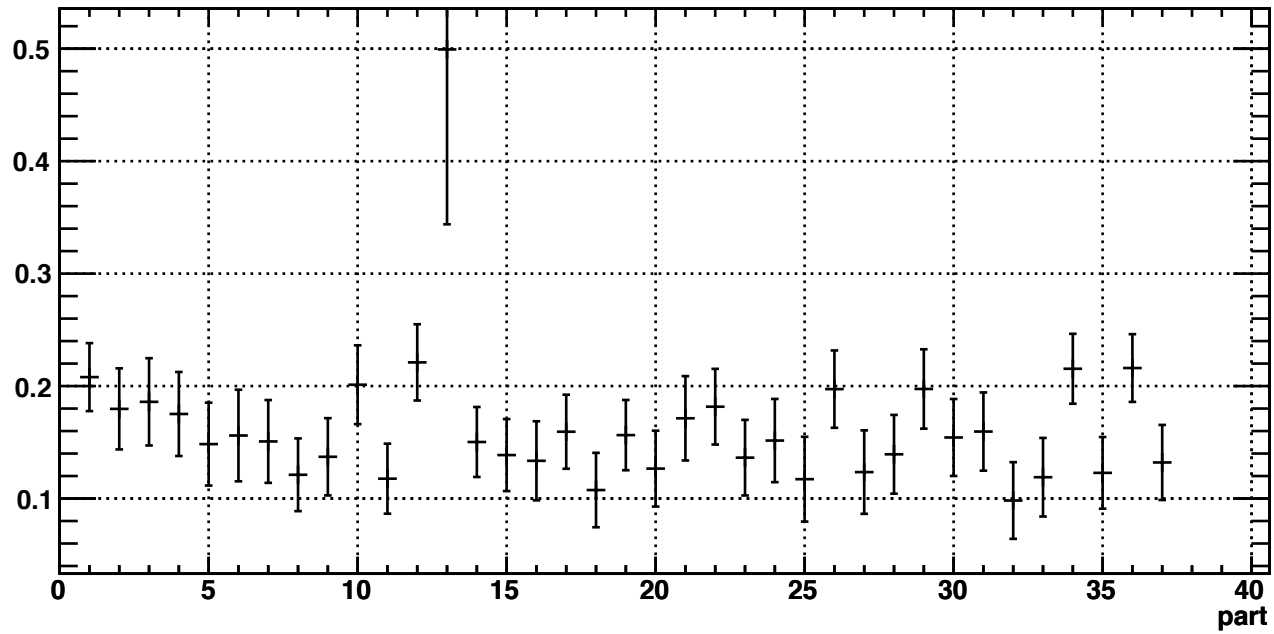
E570ex sdd4 Calibration TiKa1FWHM



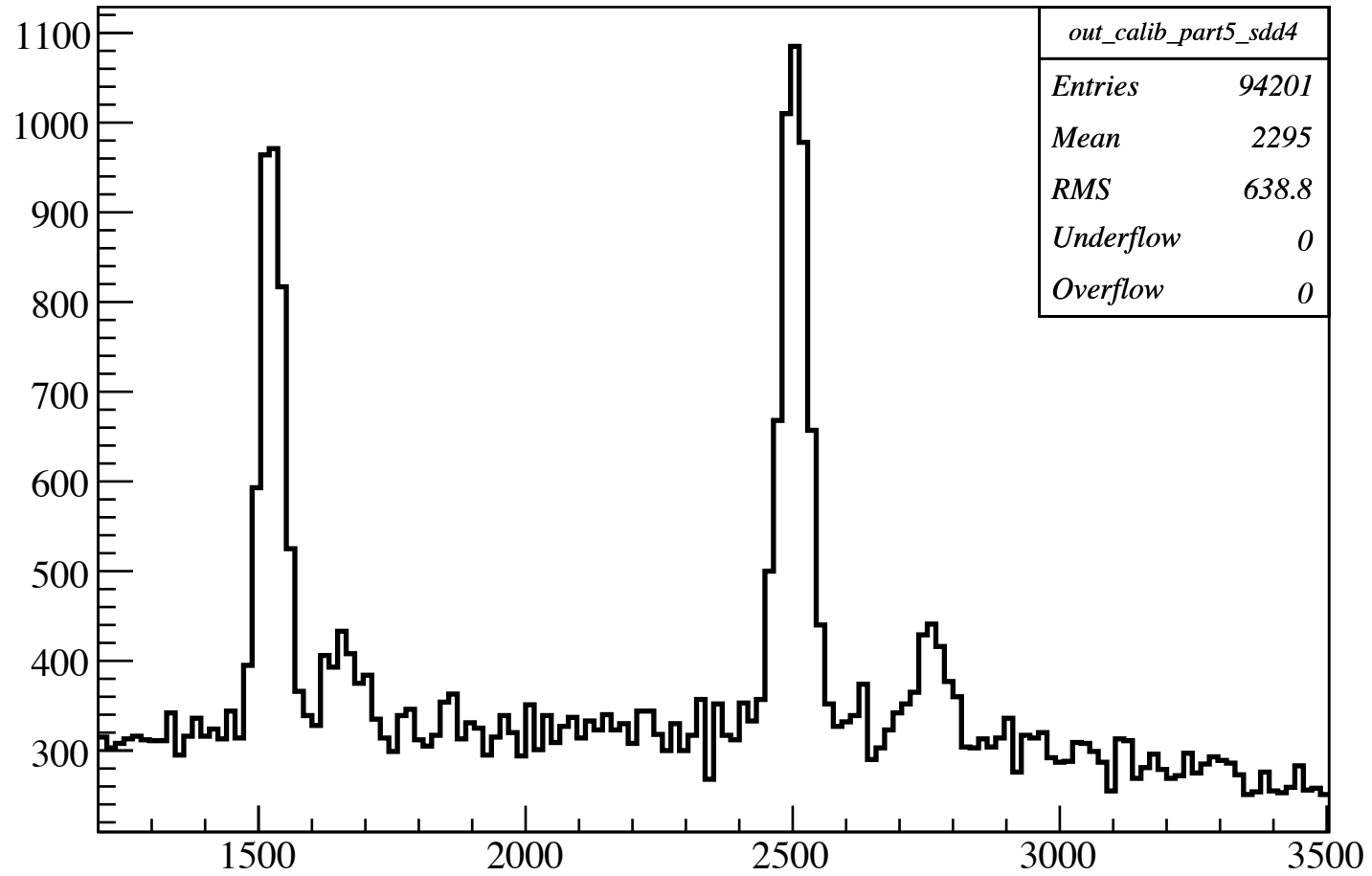
E570ex sdd4 Calibration Ka1Kb_ratio



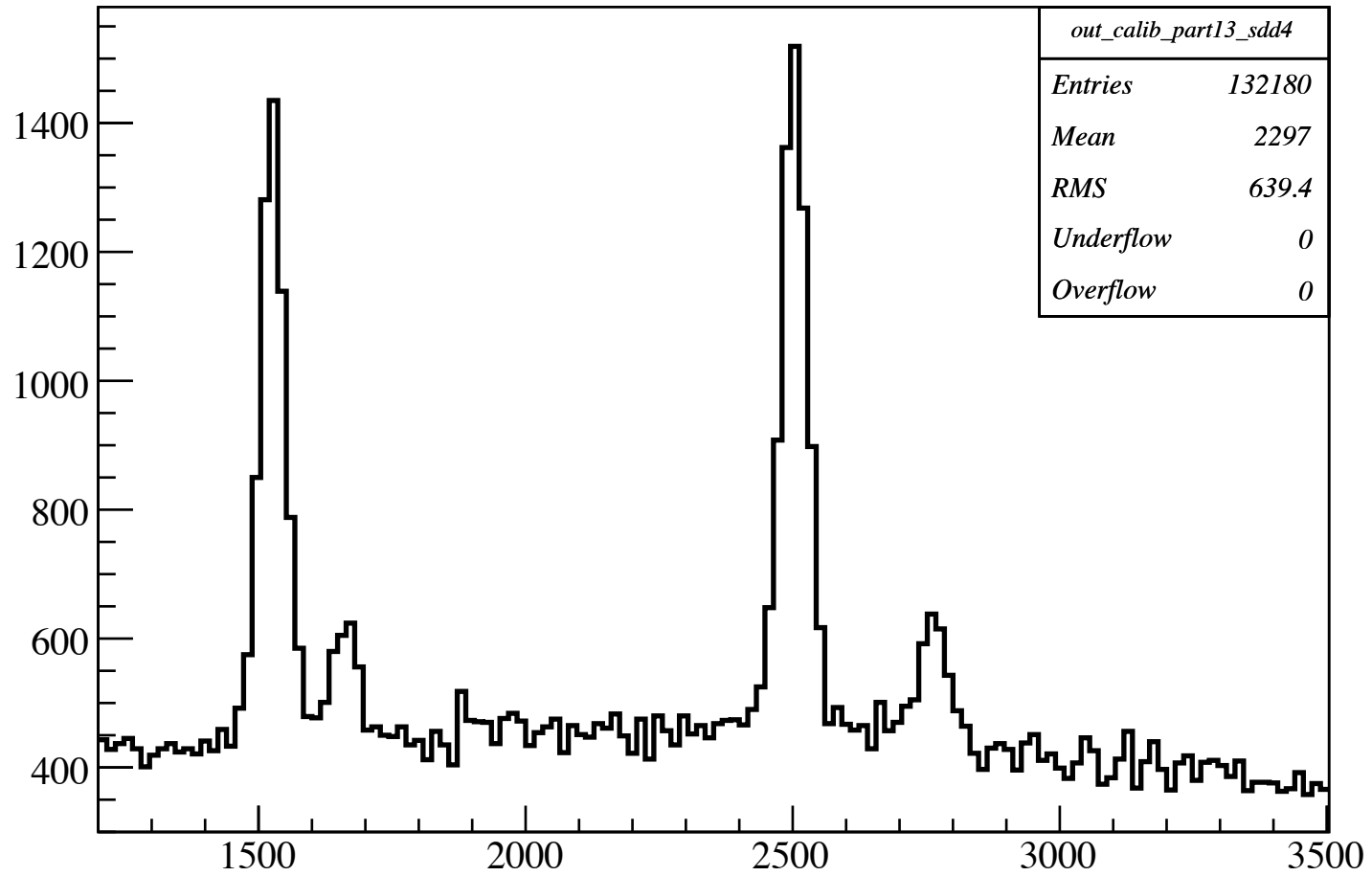
E570ex sdd4 Calibration Fano



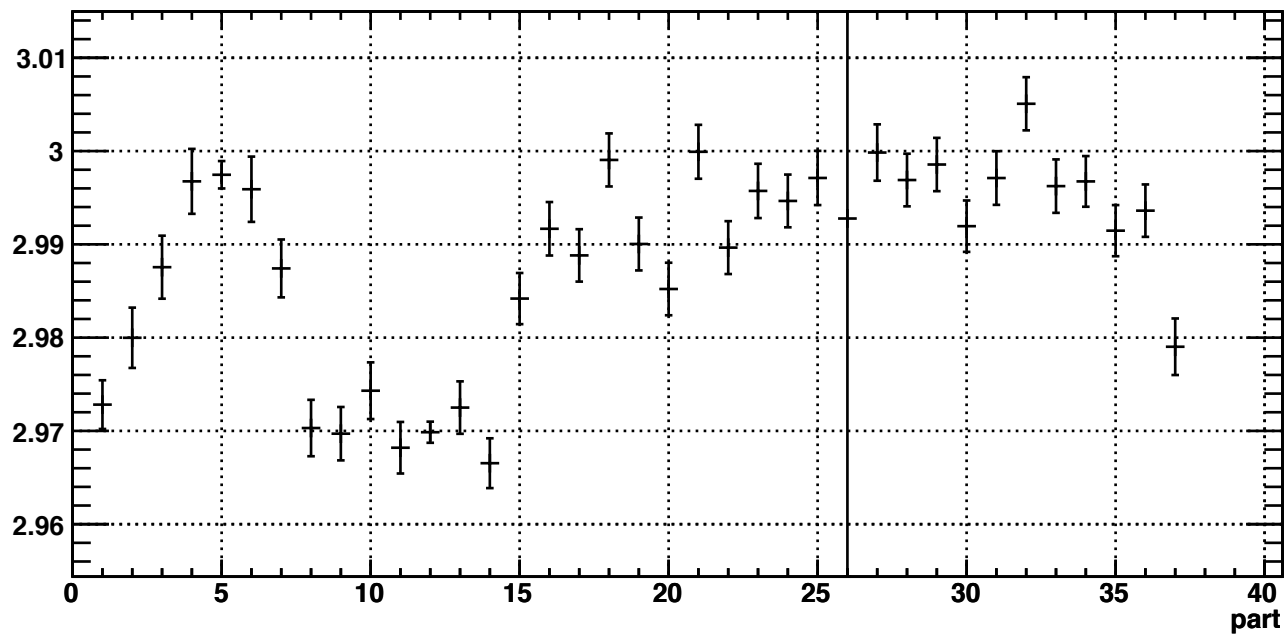
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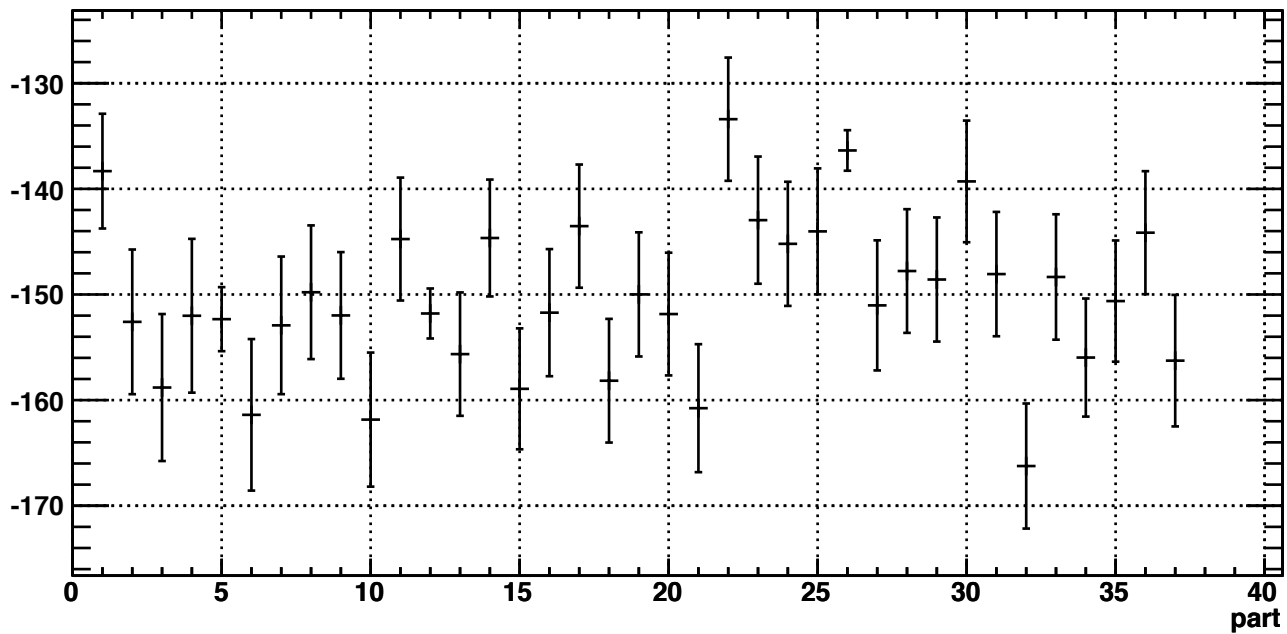
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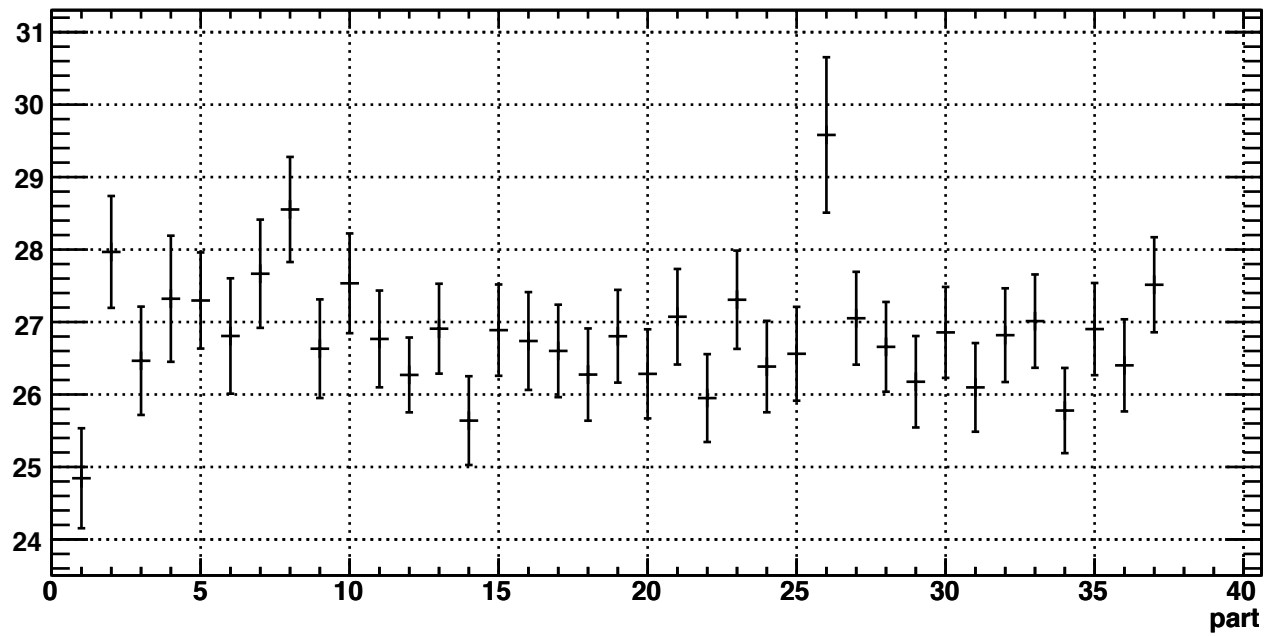
E570ex sdd5 Calibration ev2ch



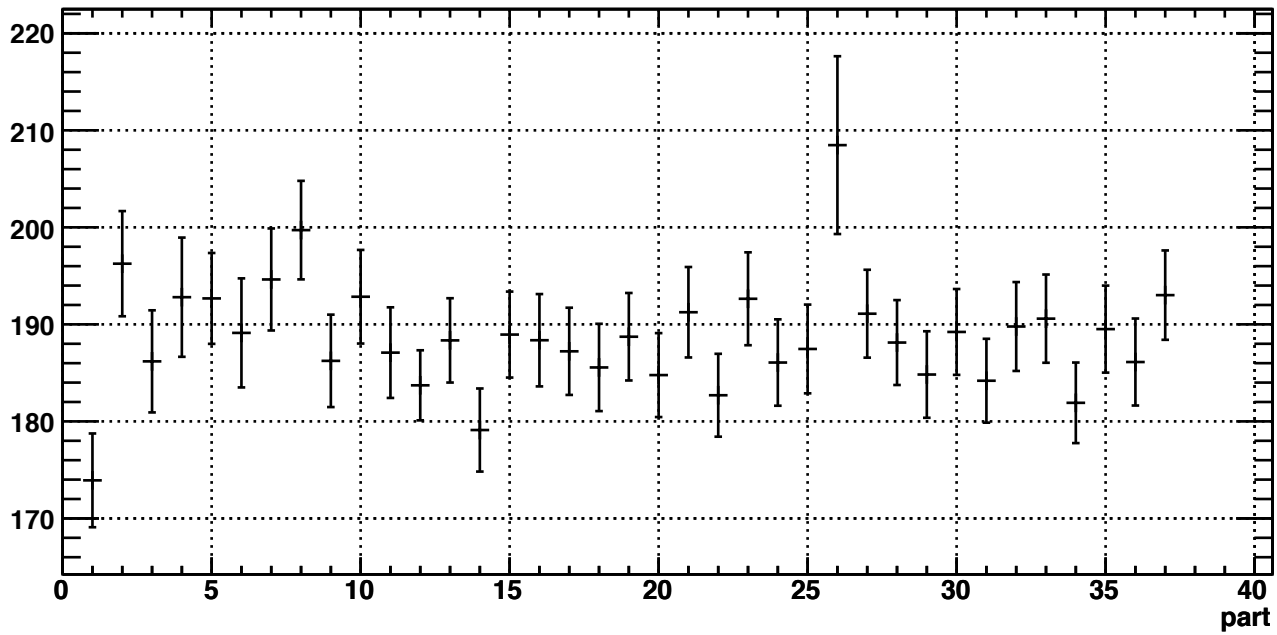
E570ex sdd5 Calibration intercept



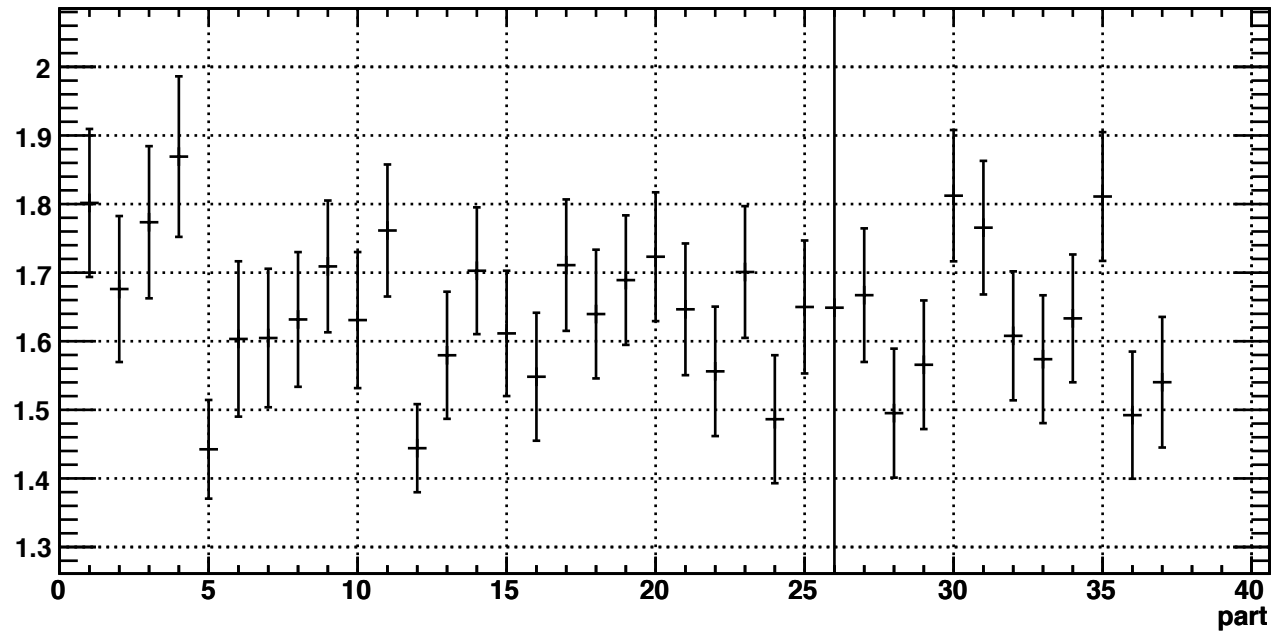
E570ex sdd5 Calibration TiKa1Sigma



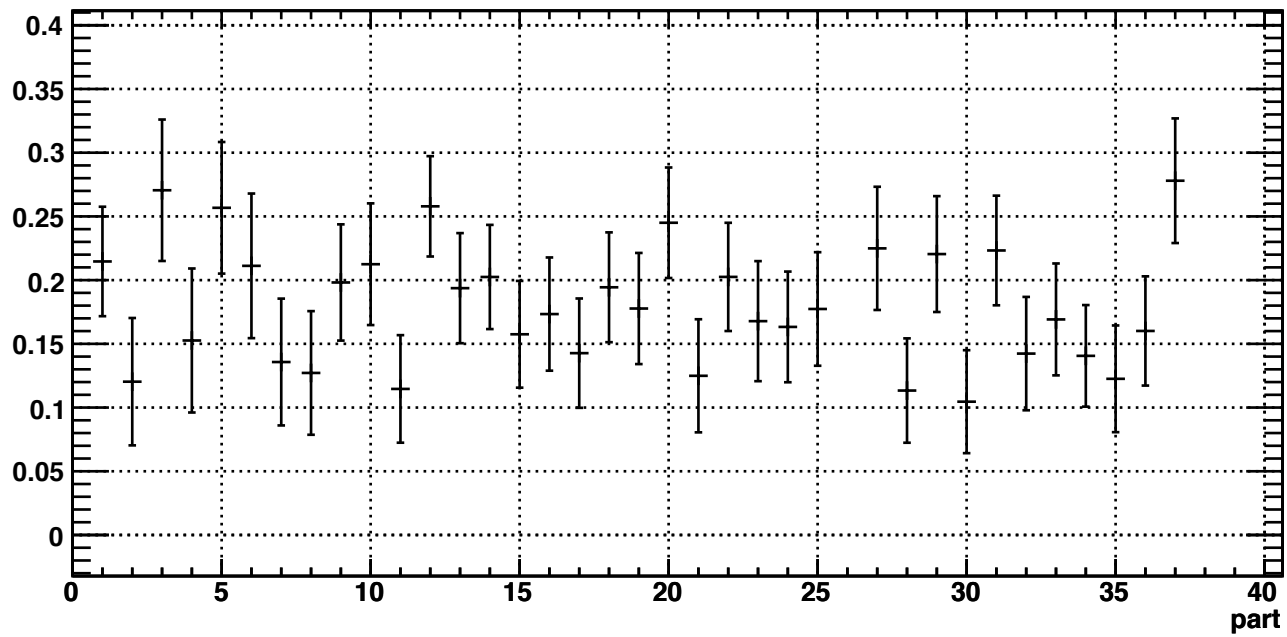
E570ex sdd5 Calibration TiKa1FWHM



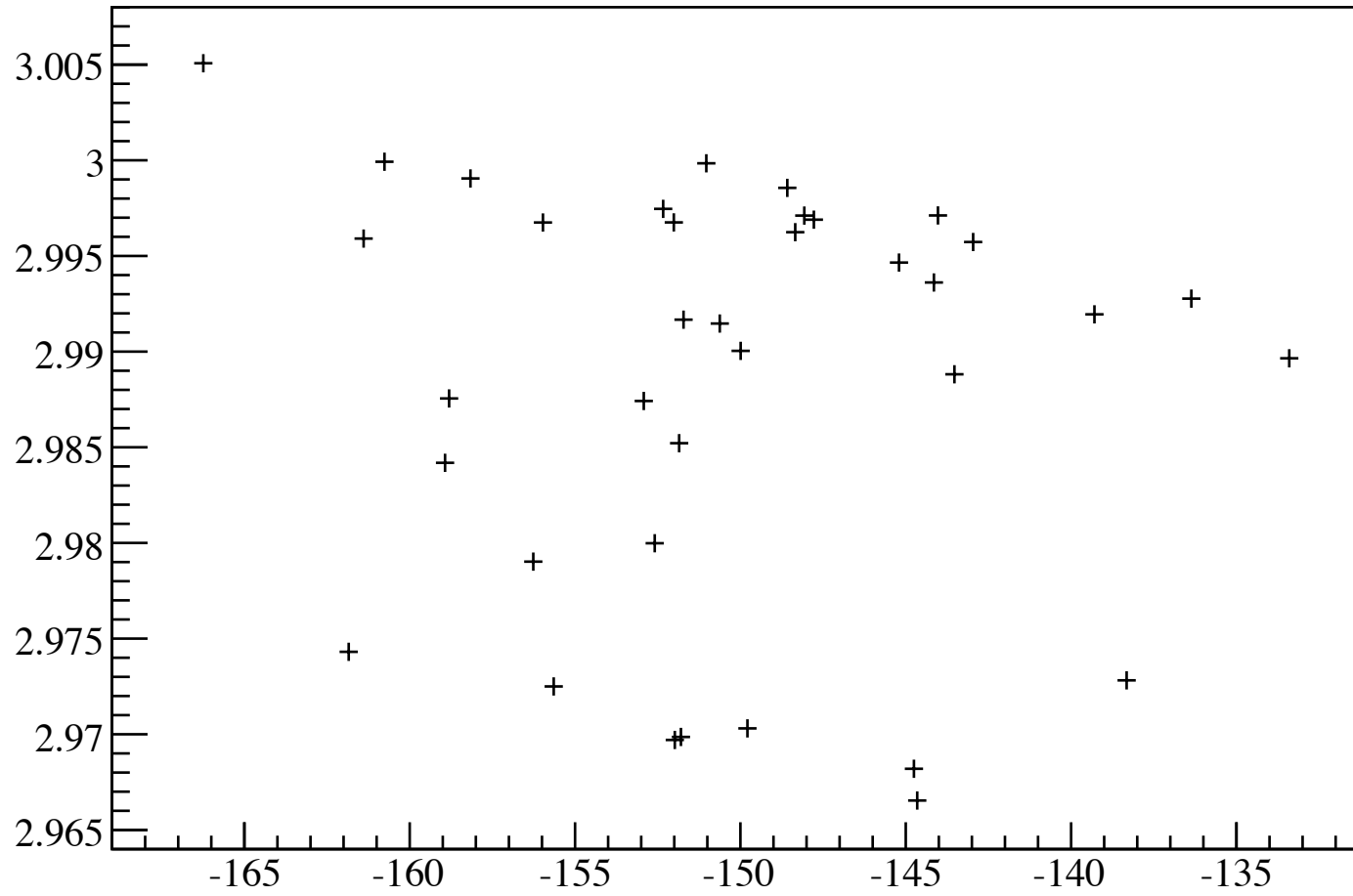
E570ex sdd5 Calibration Ka1Kb_ratio



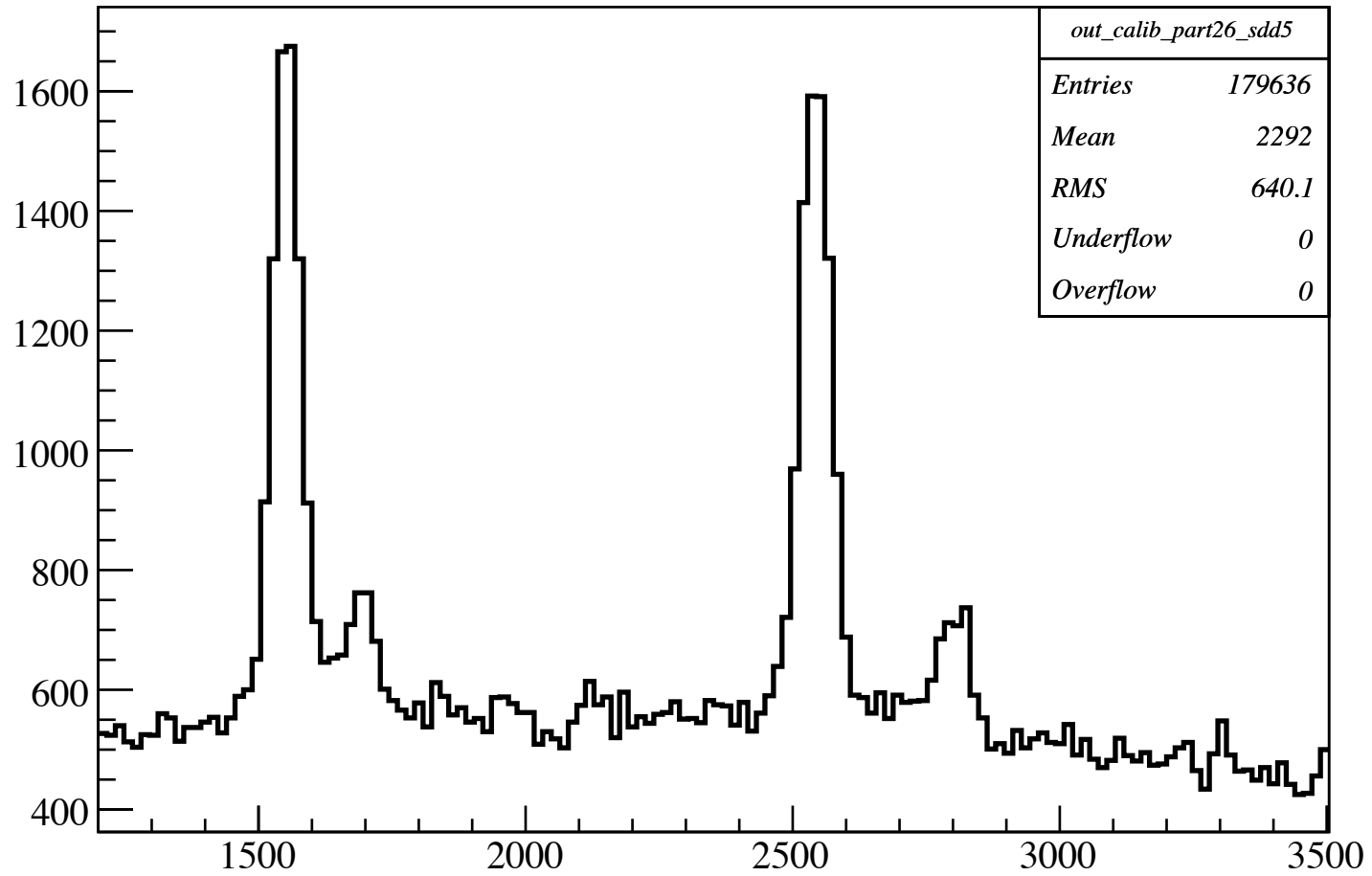
E570ex sdd5 Calibration Fano



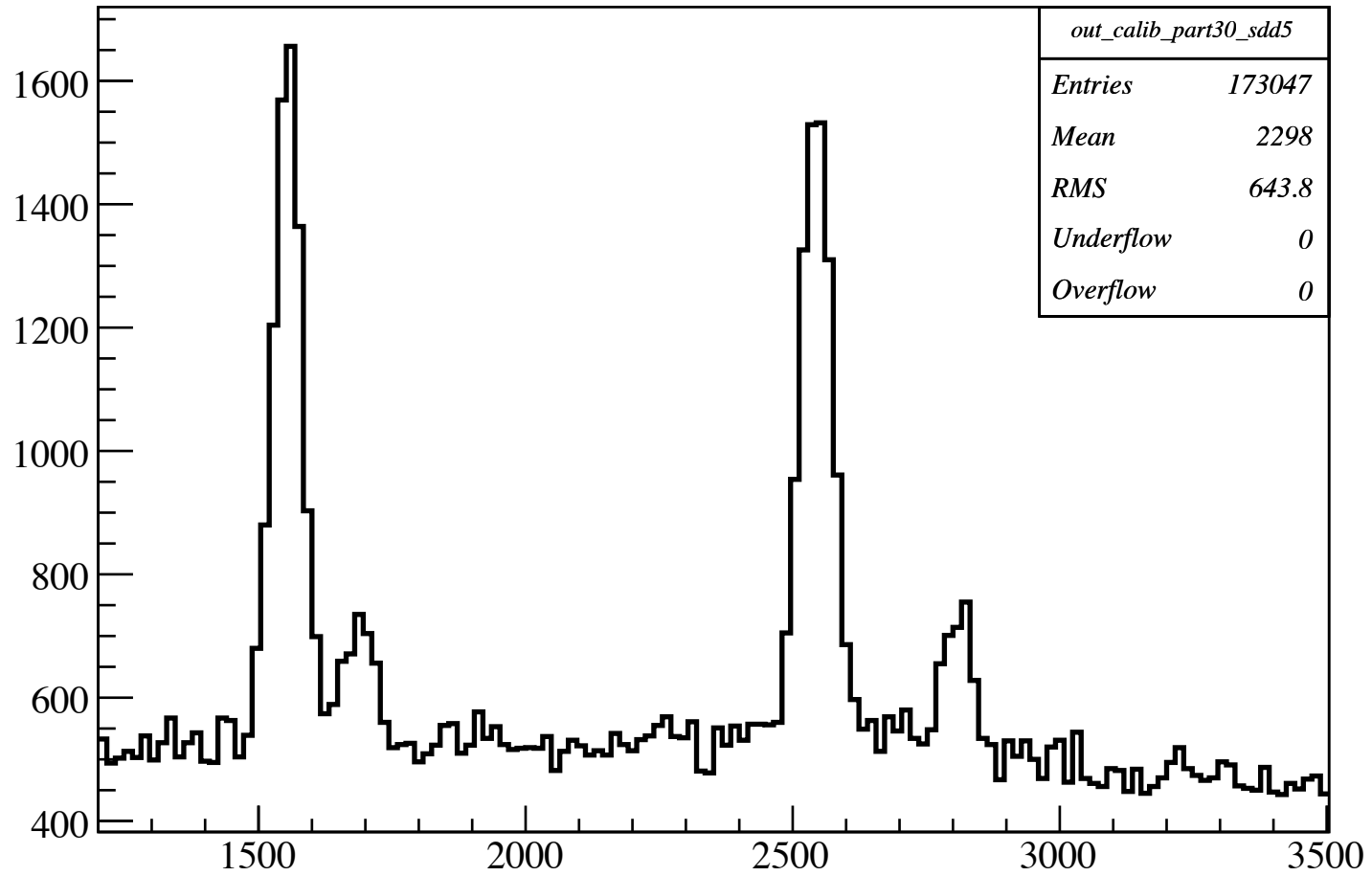
ev2ch:intercept



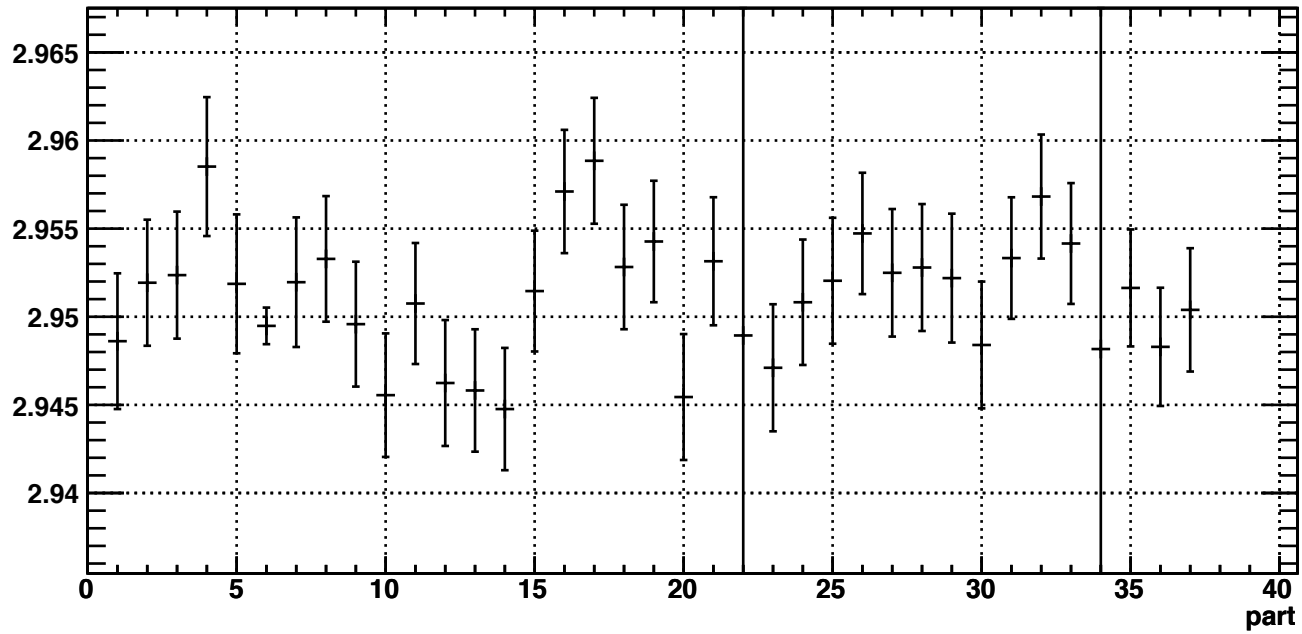
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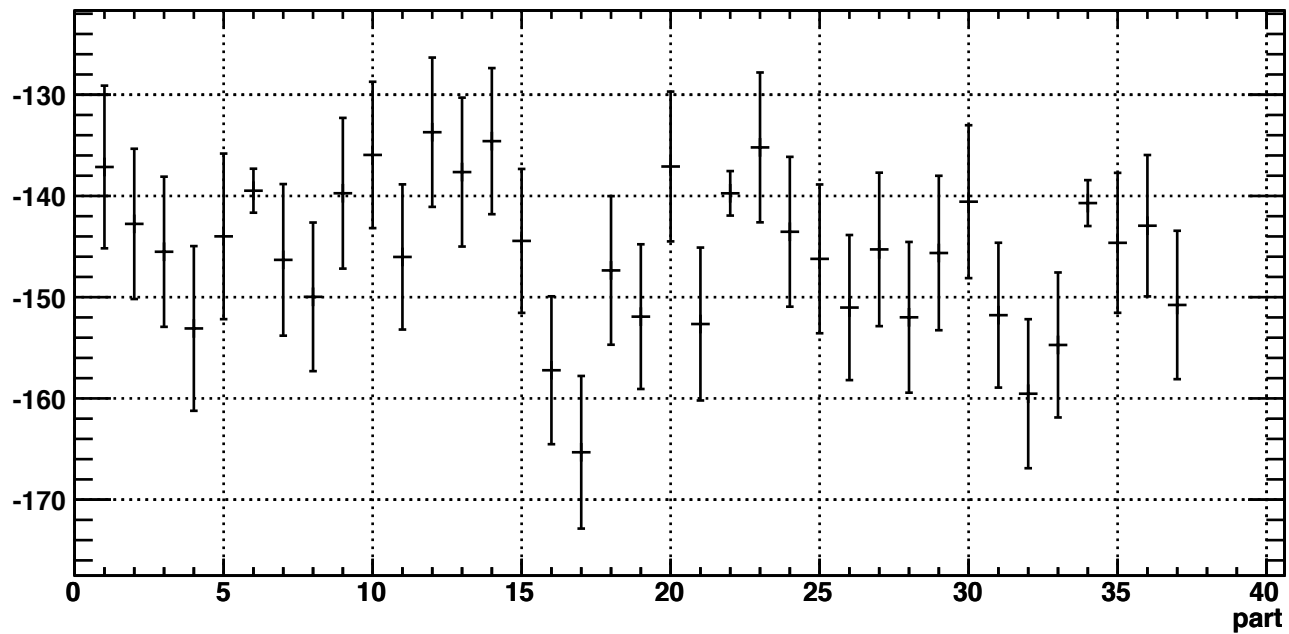
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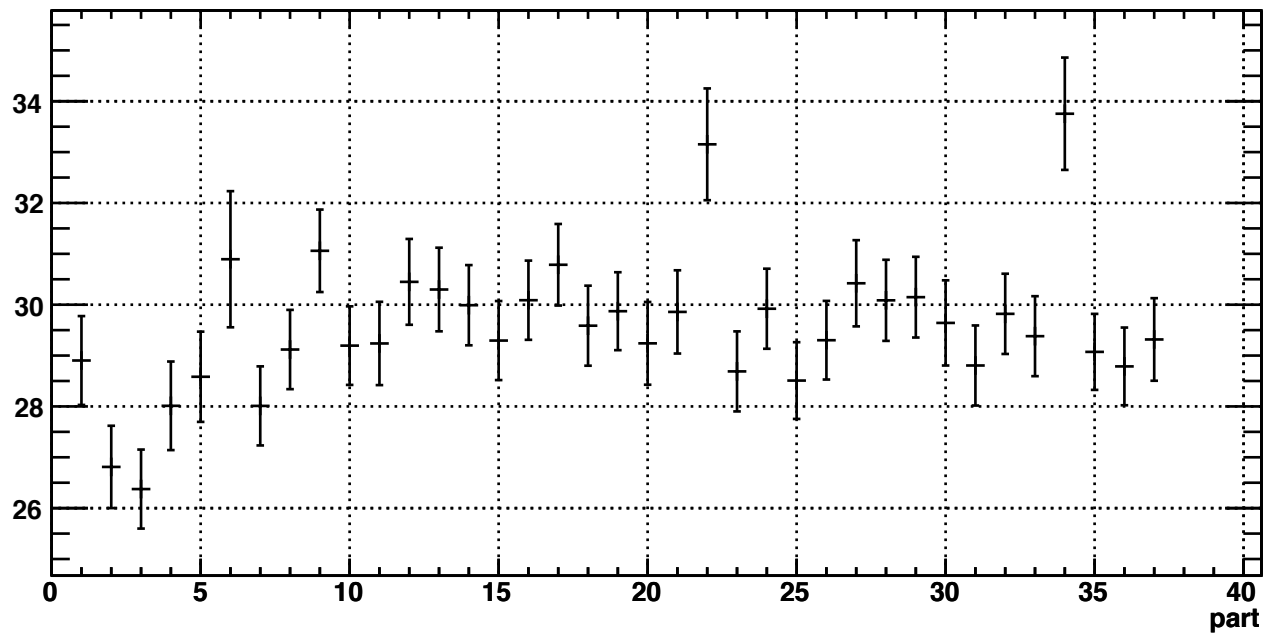
E570ex sdd7 Calibration ev2ch



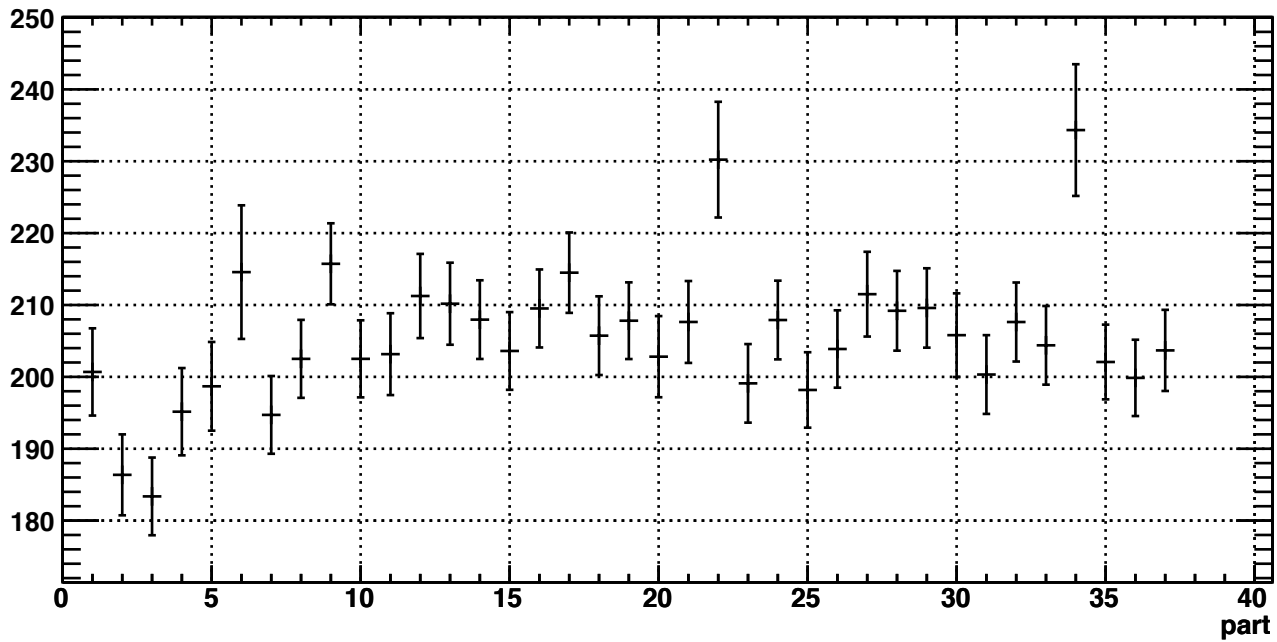
E570ex sdd7 Calibration intercept



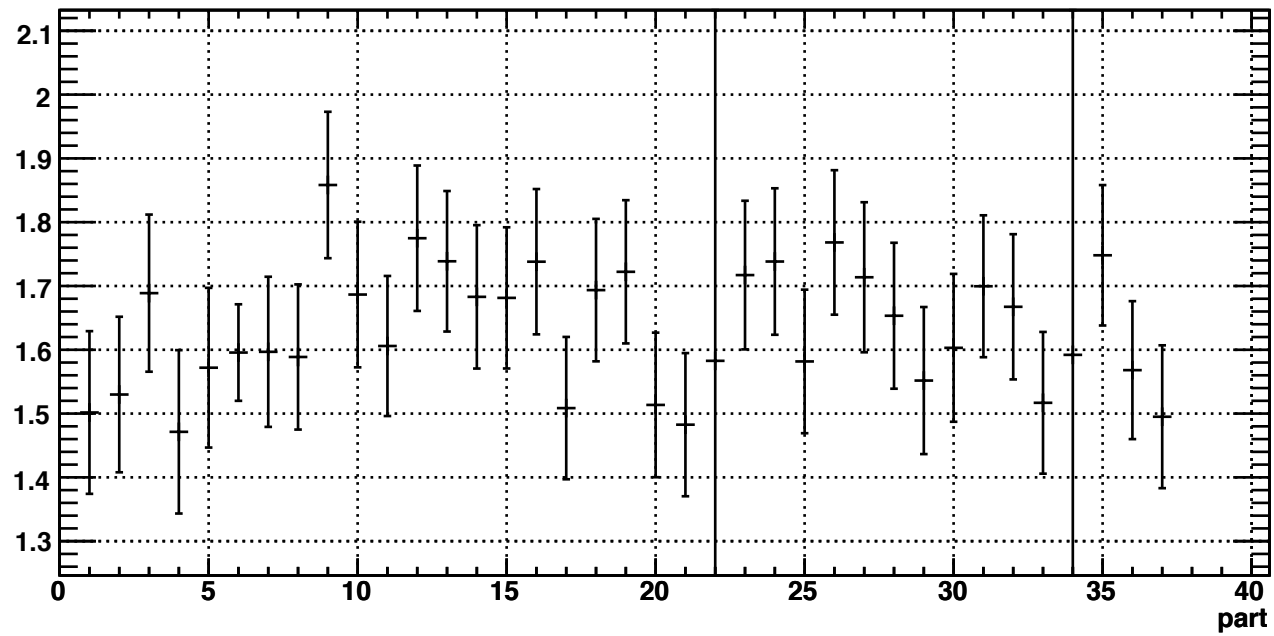
E570ex sdd7 Calibration TiKa1Sigma



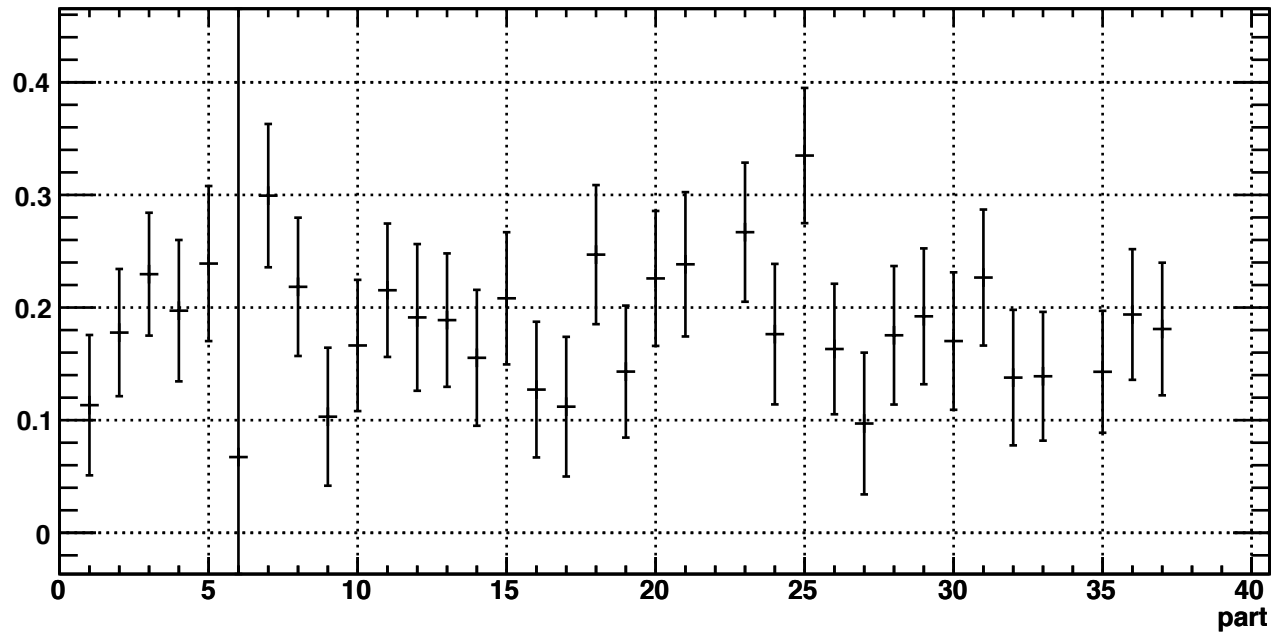
E570ex sdd7 Calibration TiKa1FWHM



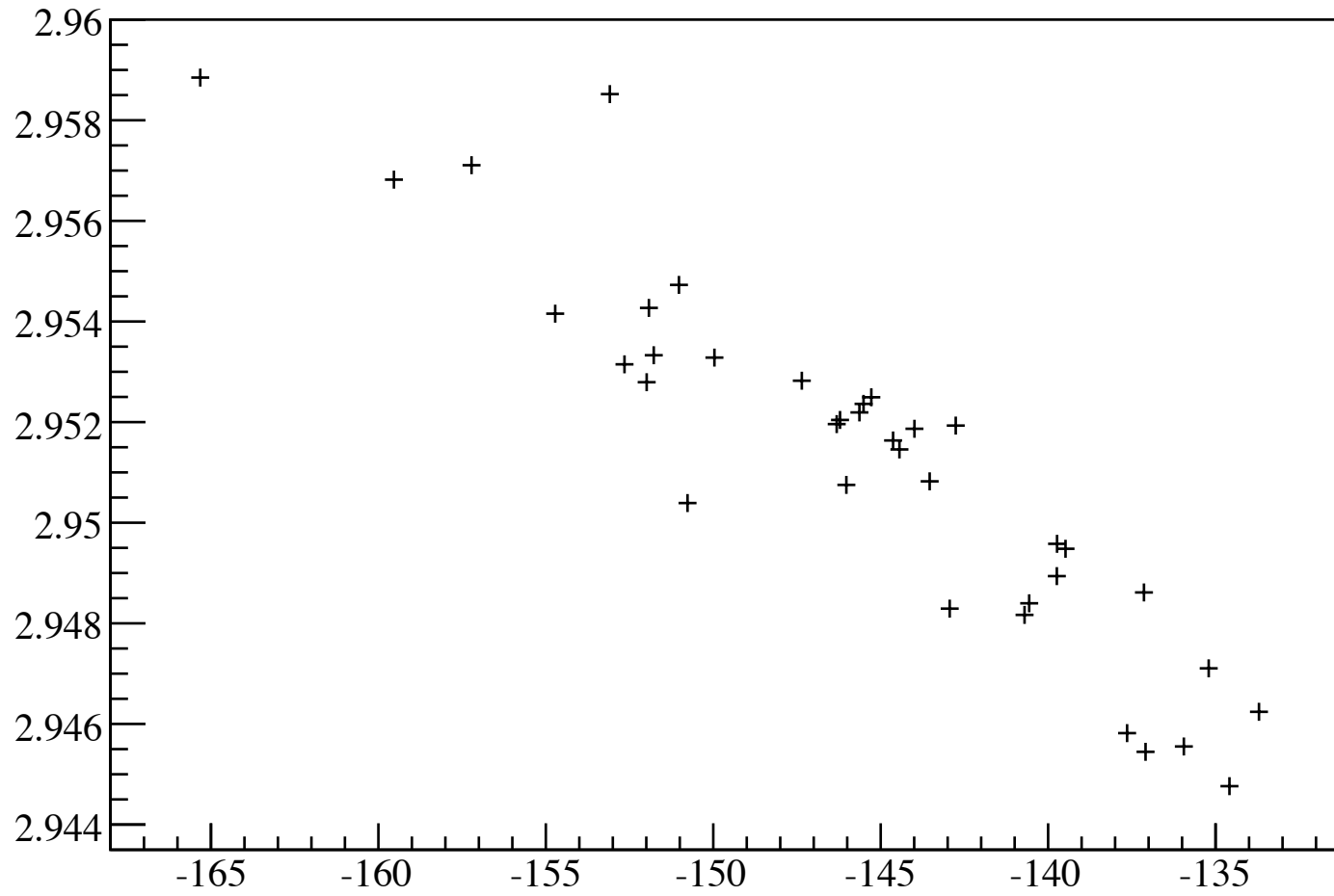
E570ex sdd7 Calibration Ka1Kb_ratio



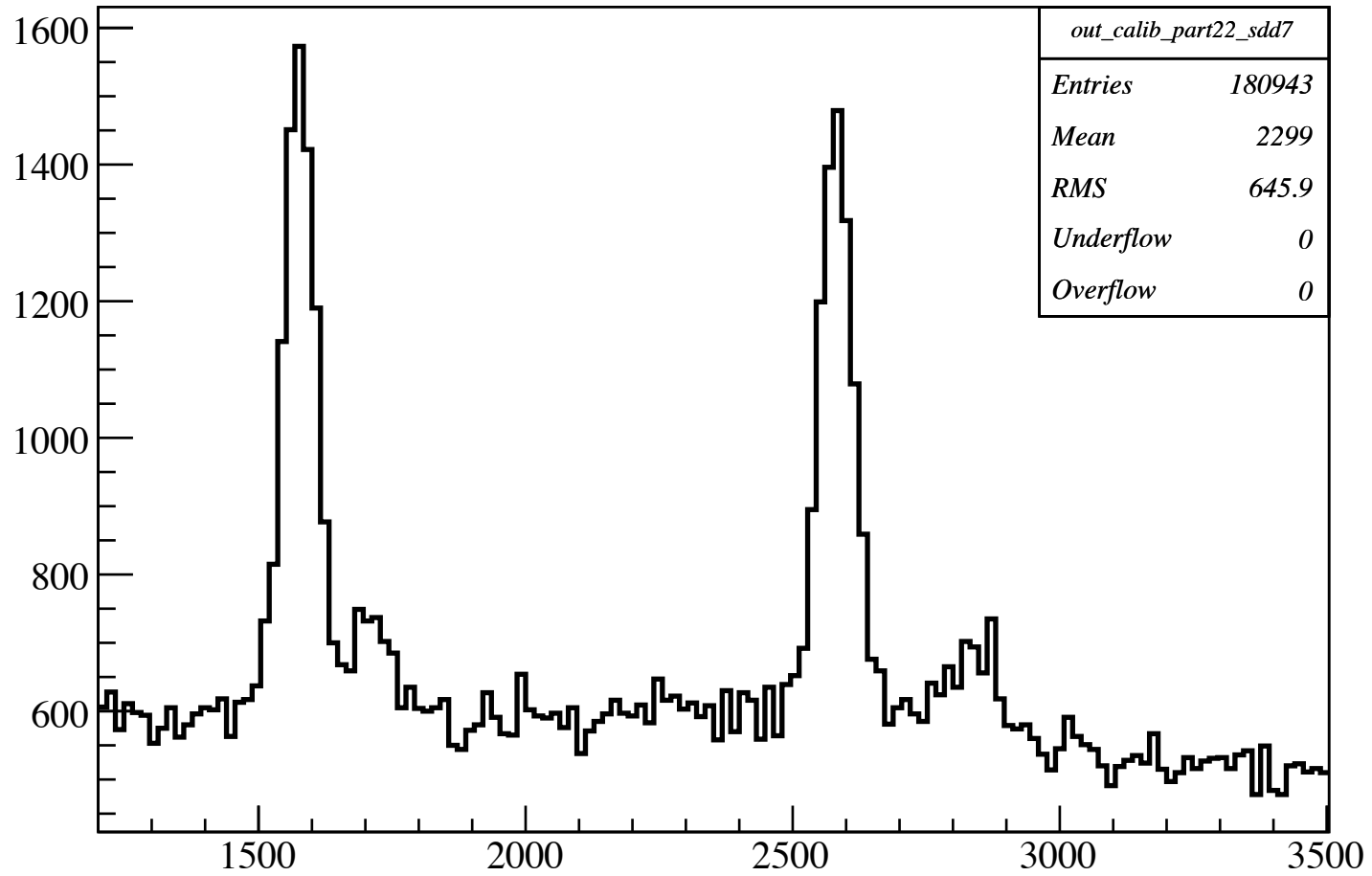
E570ex sdd7 Calibration Fano



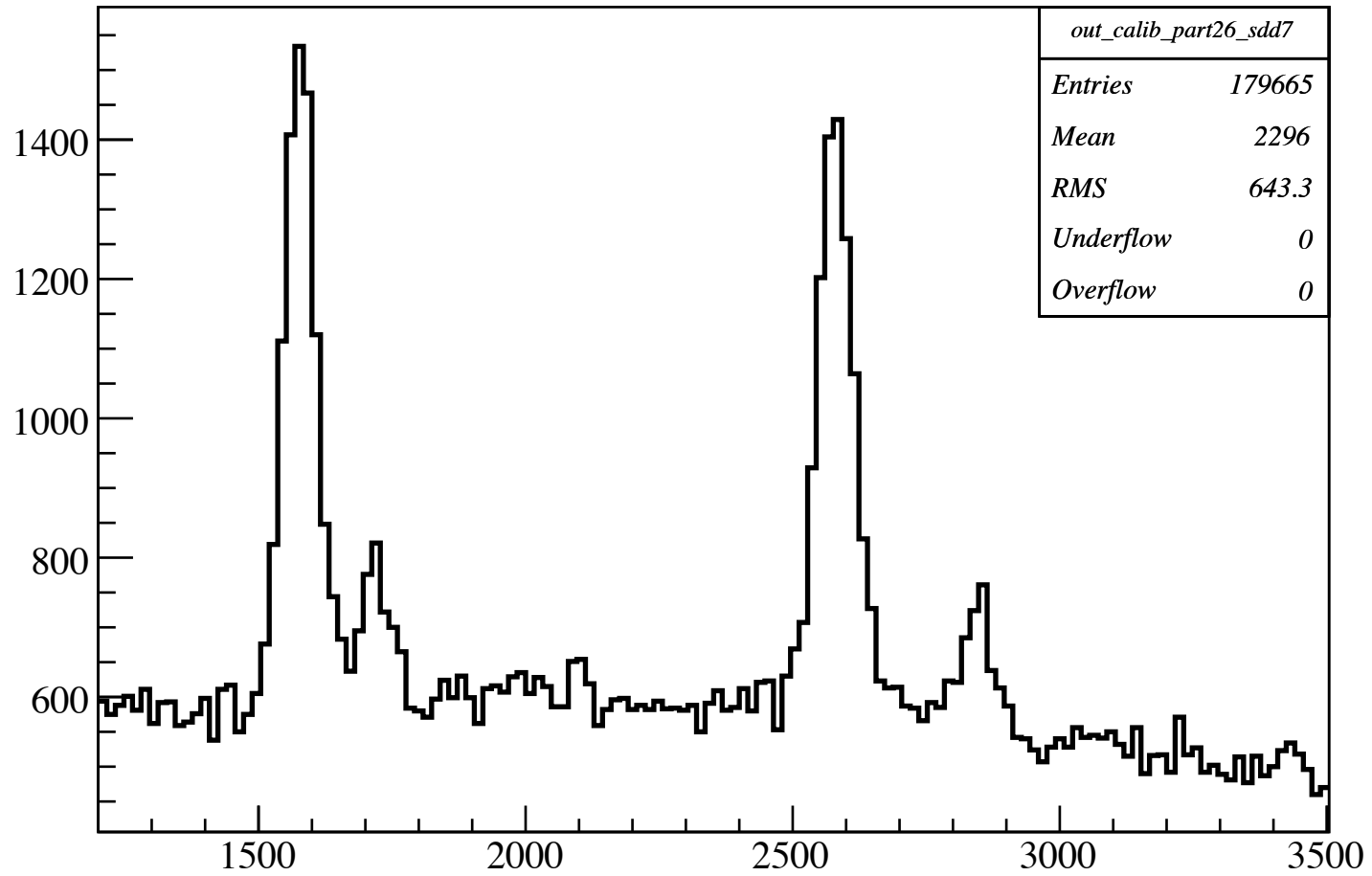
ev2ch:intercept



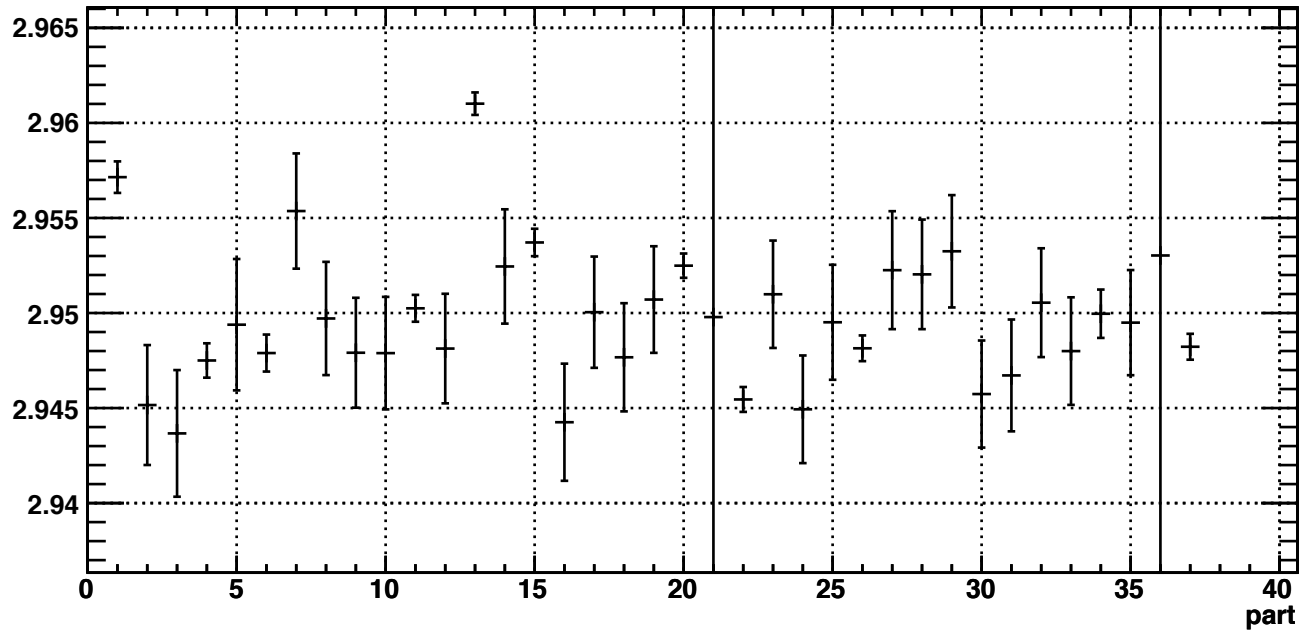
out_calib_part22_sdd7



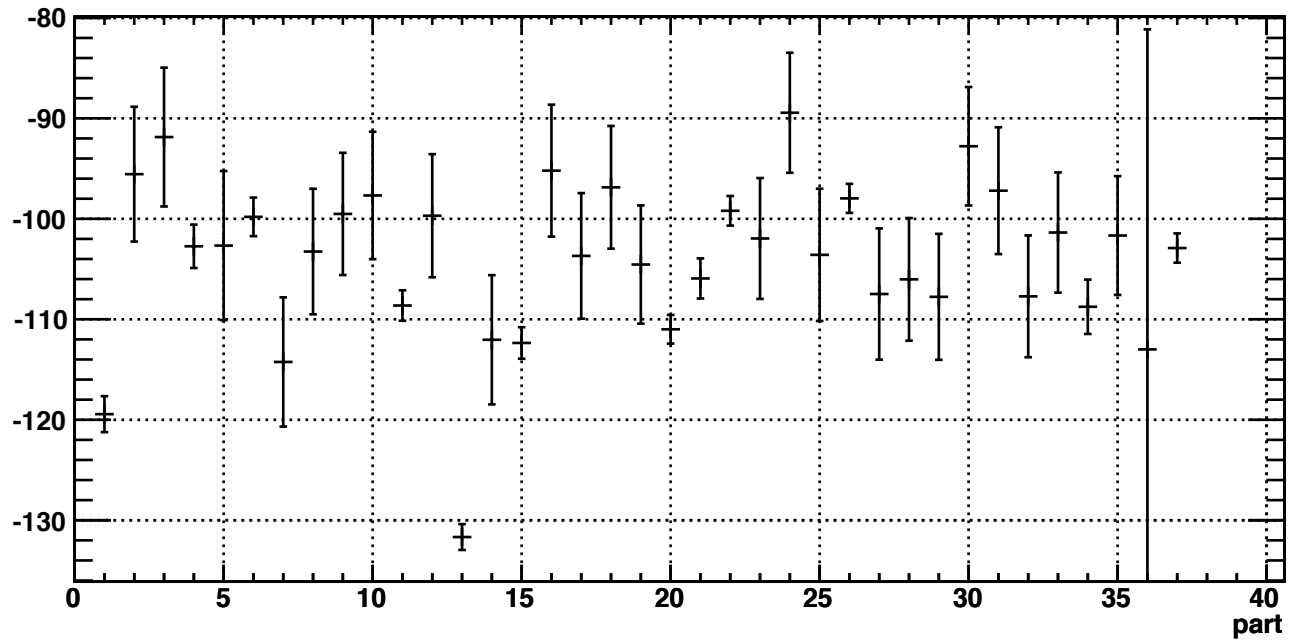
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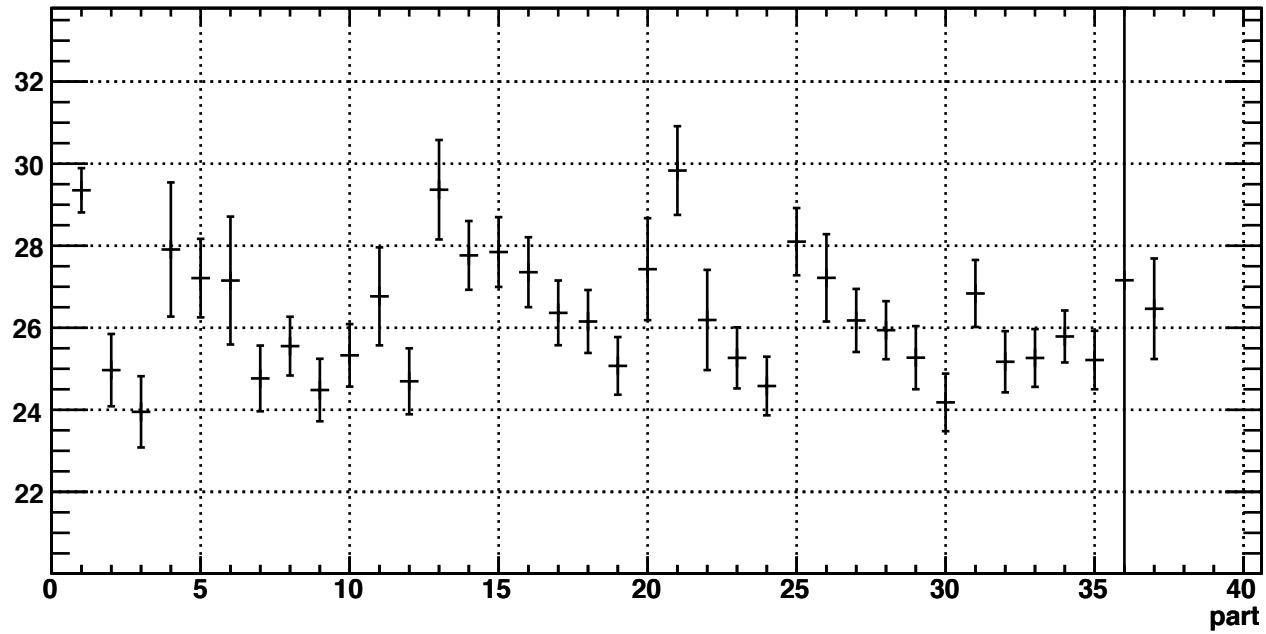
E570ex sdd8 Calibration ev2ch



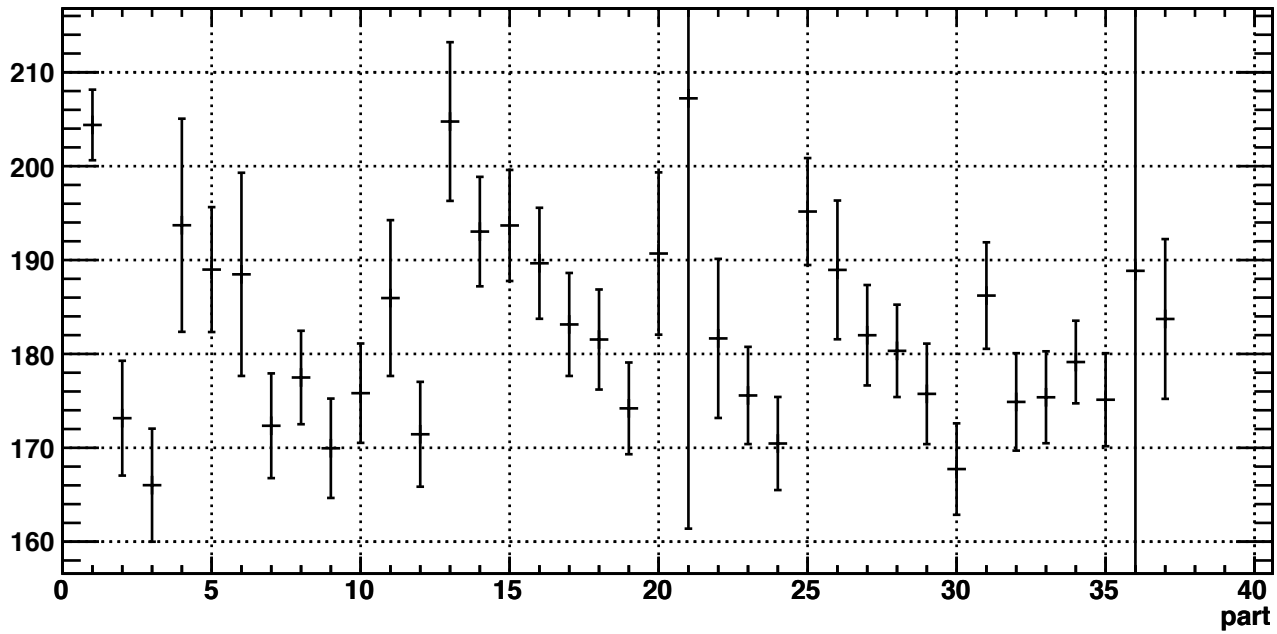
E570ex sdd8 Calibration intercept



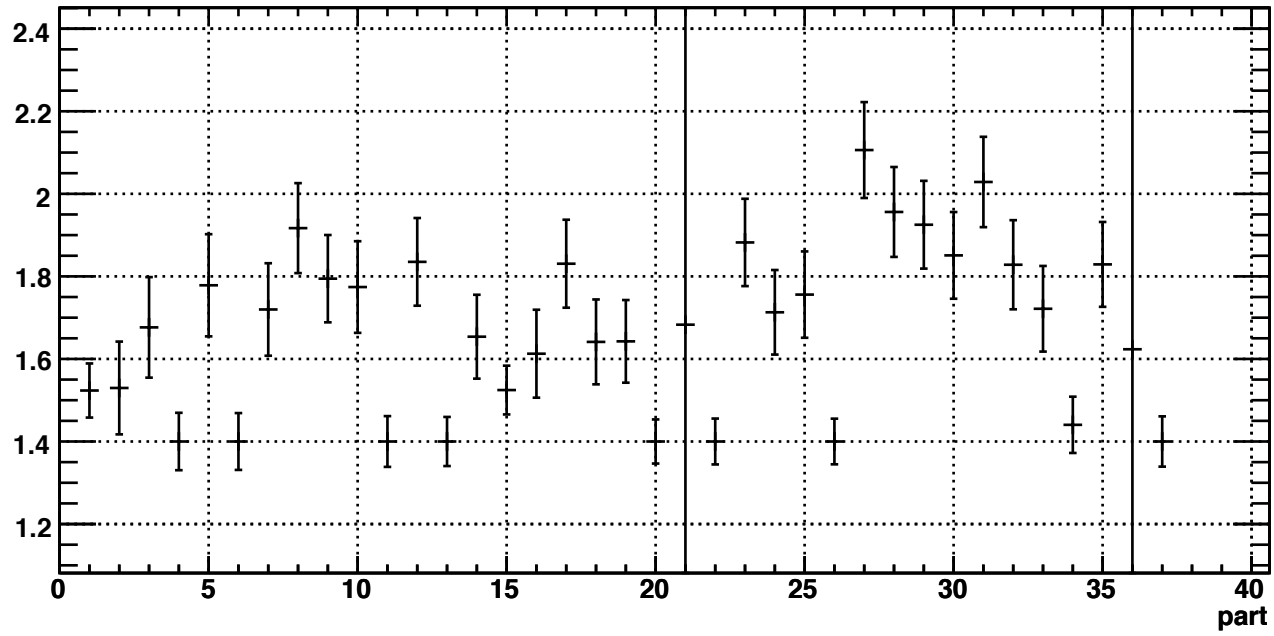
E570ex sdd8 Calibration TiKa1Sigma



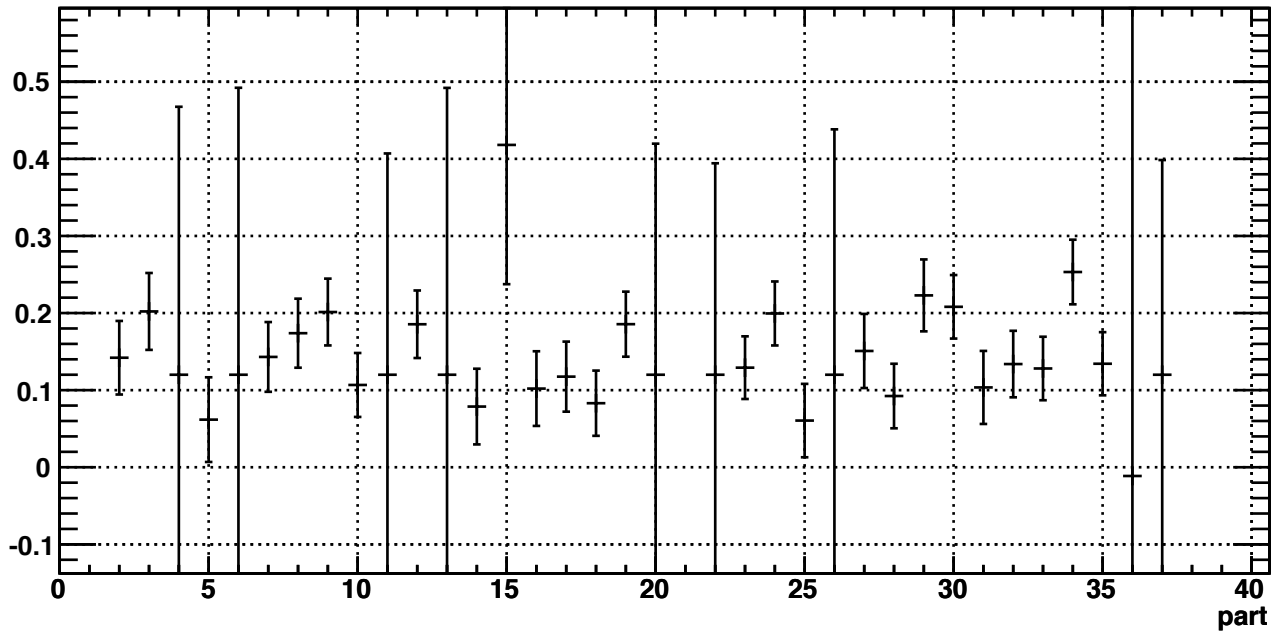
E570ex sdd8 Calibration TiKa1FWHM



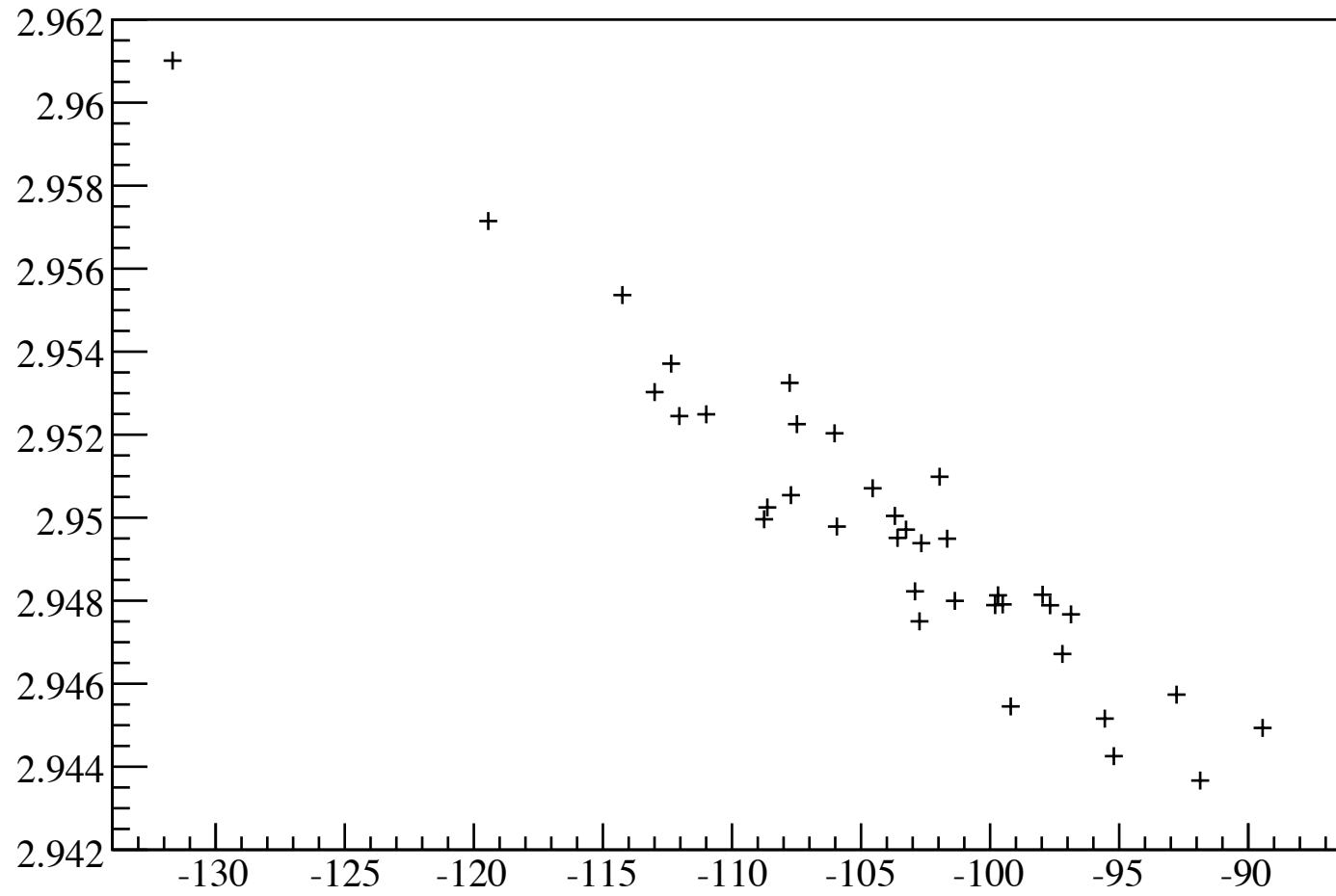
E570ex sdd8 Calibration Ka1Kb_ratio



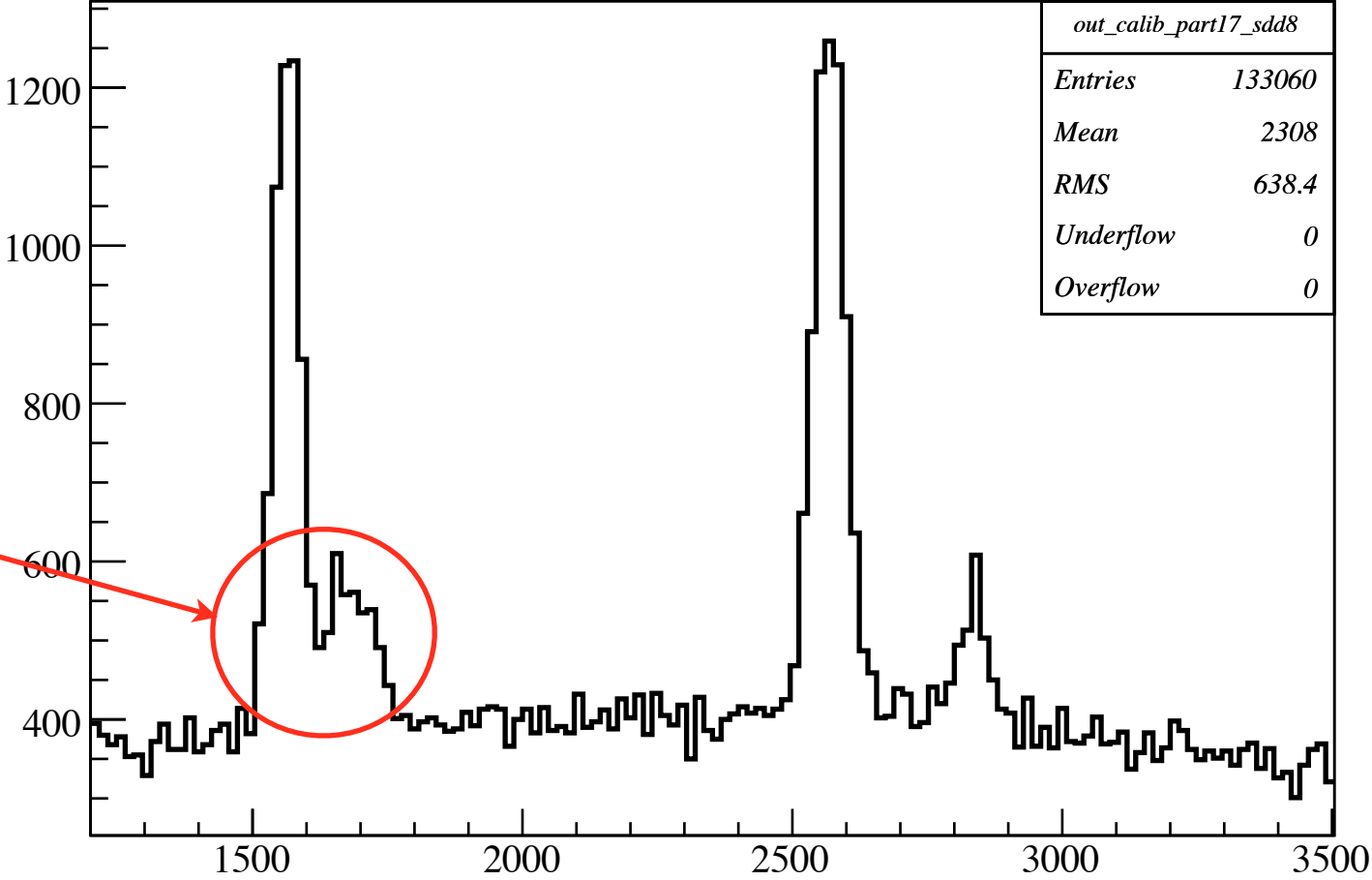
E570ex sdd8 Calibration Fano



ev2ch:intercept



out_calib_part17_sdd8



strange
excess

out_calib_part21_sdd8

