Imperial laser system and analysis

Paul Dauncey, Matt Noy

Laser/stage set up

- Matt revived a set of x-y stages and laser/microscope system
  - Unused for several years
  - Interfaced to USB_DAQ board so easy to drive with DAQ
- Laser specs
  - Wavelength 1064nm
  - Power 50mW
- Timings
  - Laser fires ~2.5μs after start of bunch train (adjustable but fixed here)
  - Laser pulse length is 25ns
  - Number of bunch crossings set to 10 ~ 4.0μs
  - Laser hit seen in bunch crossing 8 (counting from 0), i.e. ~3.2μs
  - Note, single pixel cannot fill memory with only 10 bunch crossings
- Only got working last Tuesday
  - All results here are really commissioning-level

Alignment

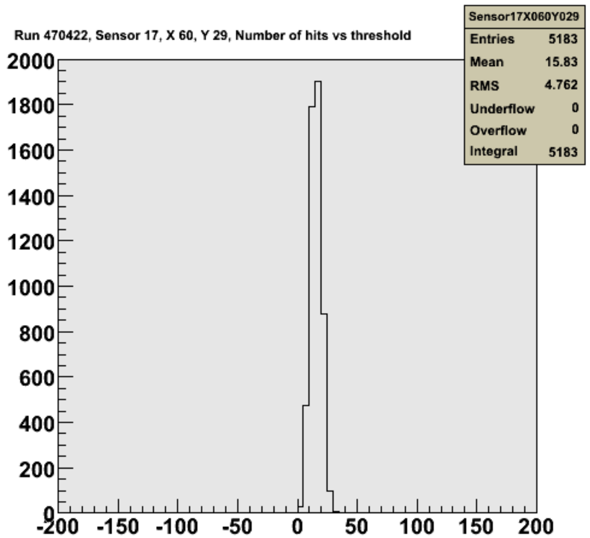
- Move to ~10 semi-random positions on sensor
  - Tried for corners and centre but not all gave a response
- Do position scan (like Anne-Marie's results)
  - Coarser; 12 steps of 10μm in each direction
  - 120μm should always fully include at least one pixel
- Find average stage position weighted by number of hits per position for each pixel
  - Try to identify "good", fully-contained pixels to use
- Fit points for each axis direction and scale separately
  - Axes scales: 0.9962±0.0014, 0.9977±0.0006; ~0.3% difference to sensor
  - Axes angles: 6.0±0.6mrad, 9.0±1.4mrad; ~3mrad non-orthogonality
  - Both cases: error ~0.001 means 10μm error over full sensor movement
- Position of overall coordinate system ±3.5μm
  - Relative motion over short distances much better; ~0.1μm

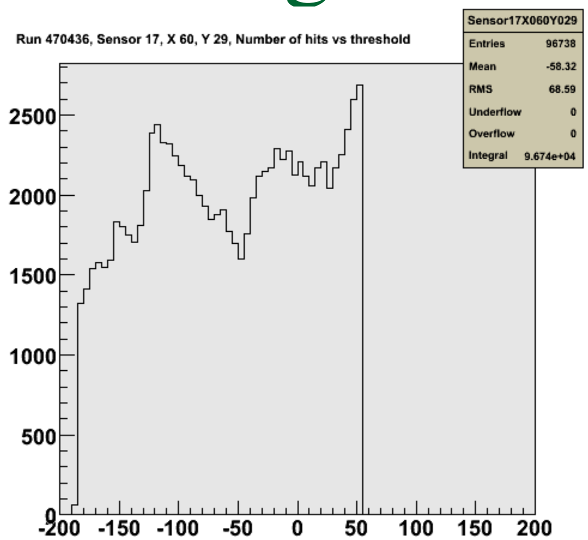
Threshold scans

- Move to centre of chosen pixel
  - Within errors of alignment
  - Anne-Marie's plots show not so sensitive at 5μm level
- Mask all pixels but the chosen one
  - See plots on next page
- Scan threshold, -500TU $\rightarrow$ 500TU in steps of 5TU
- Take 1000 bunch trains at each threshold value
- For next few plots, all chosen pixels were shapers
  - Looked at 3×3 pixels in Quad0 ($x<84$) and 5×5 pixels in Quad1 ($x\geq84$)
  - Statistics limited by time to do fits…

Effect of laser and masking

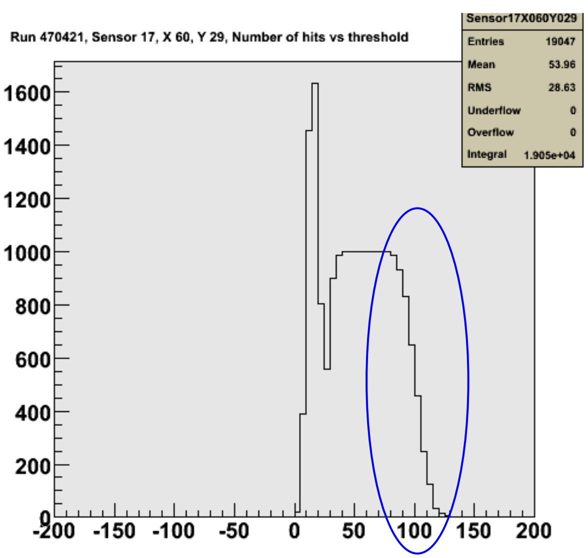
Laser disabled
Others masked

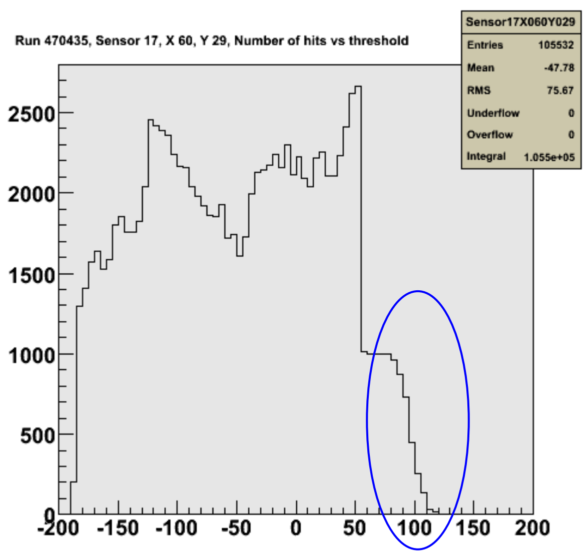




Laser disabled
Others unmasked

Laser enabled
Others masked



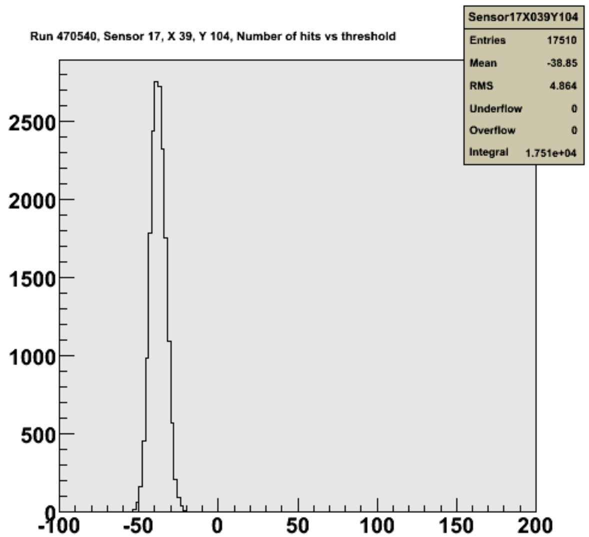


Laser enabled
Others unmasked

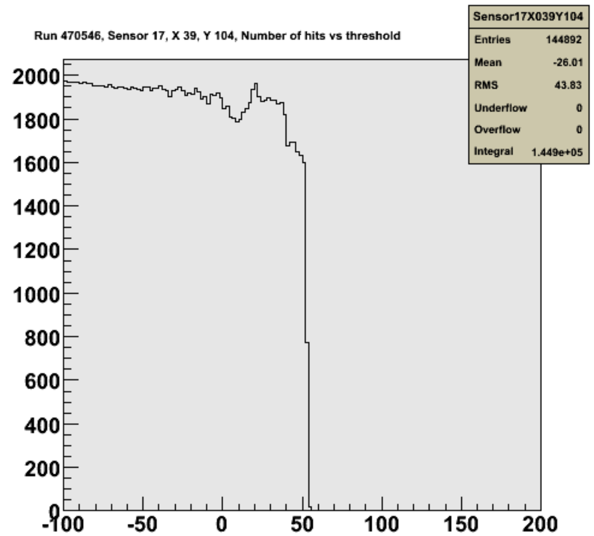
Laser signal falling edge same for both; masked runs much quicker!

Different masks

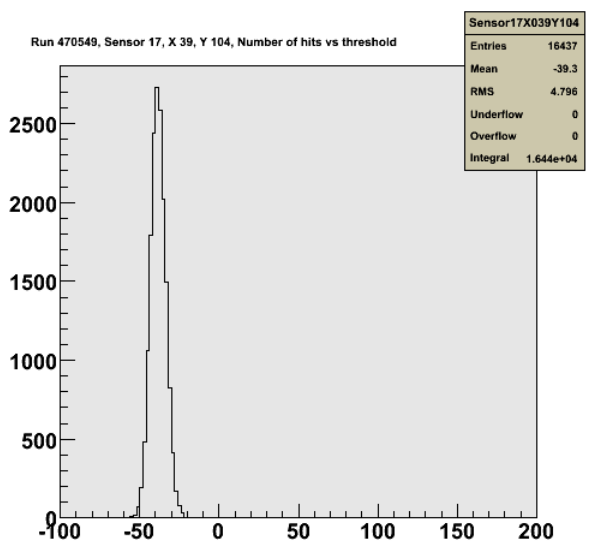
Single pixel



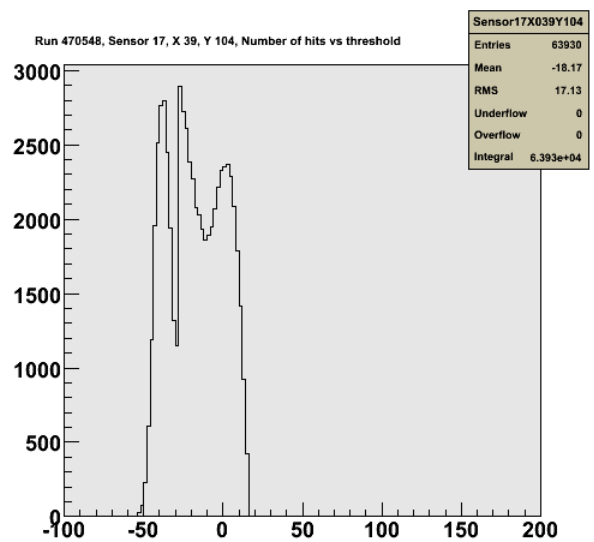
Whole sensor



Whole row

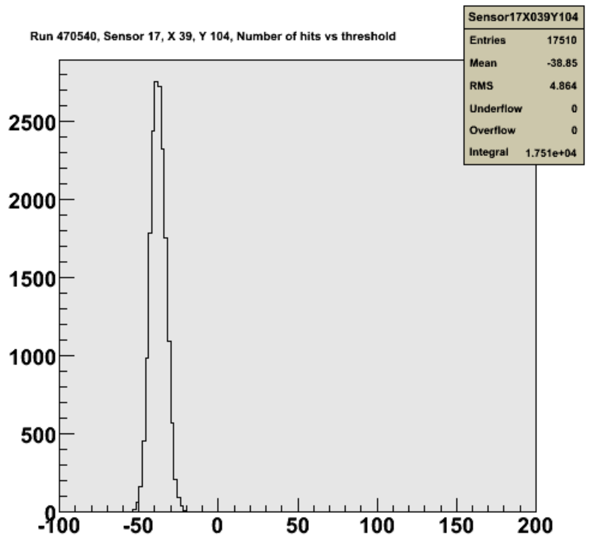


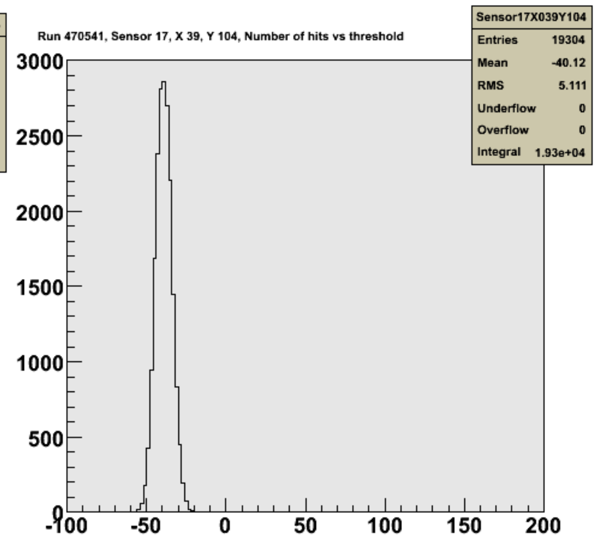
Whole column



Effect of common mode

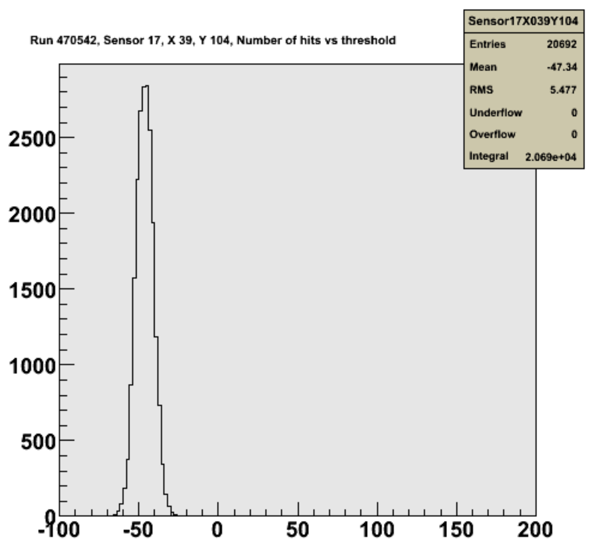
Common
mode = 3072

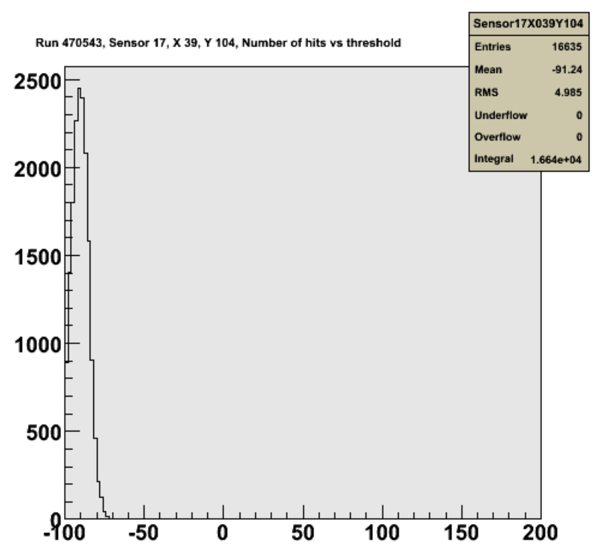




Common
mode = 3200

Common
mode = 3328

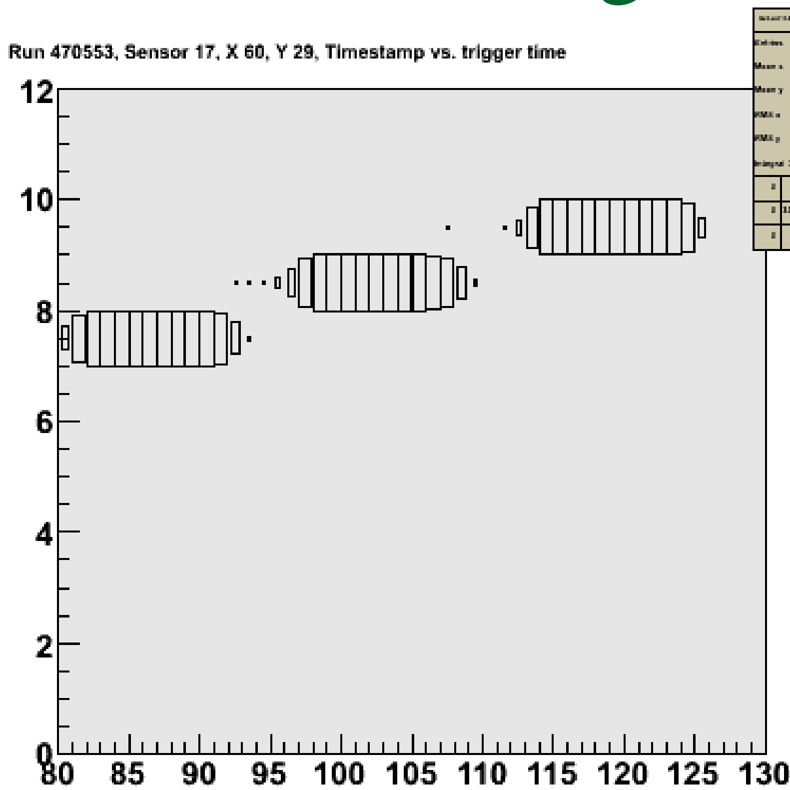


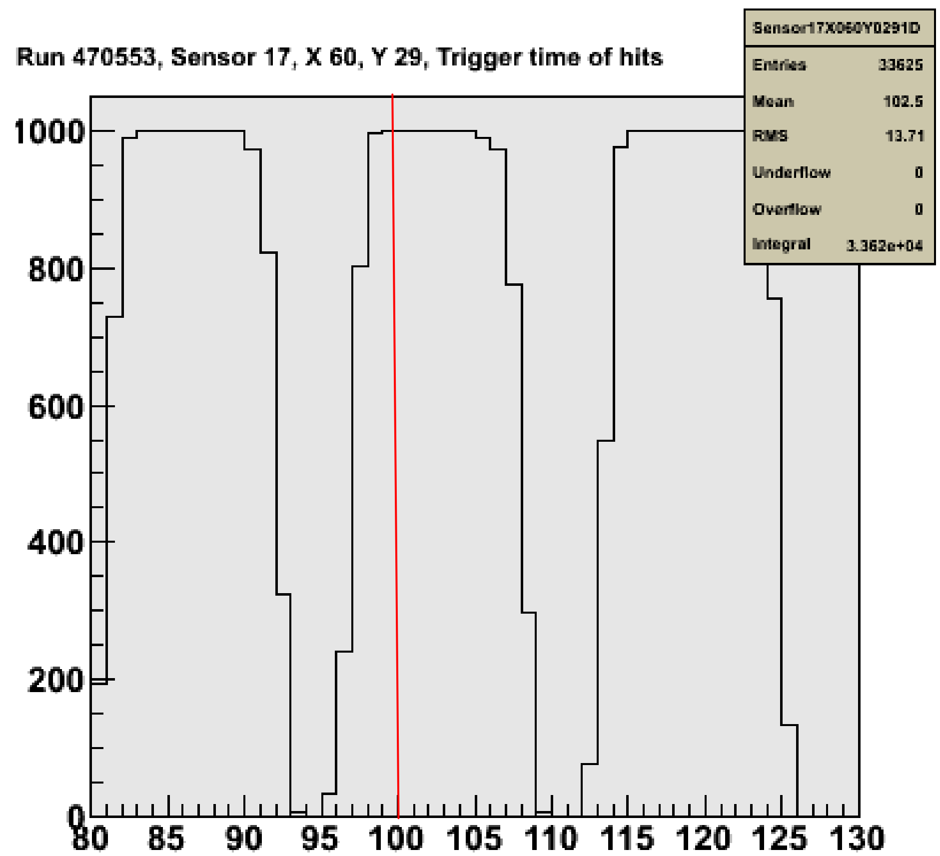


Common
mode = 3456

Common
mode = 3584
Off scale
completely!

Effect of timing

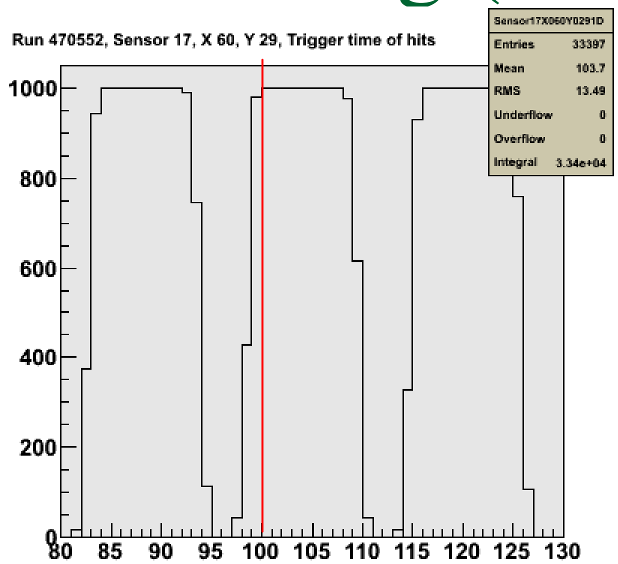




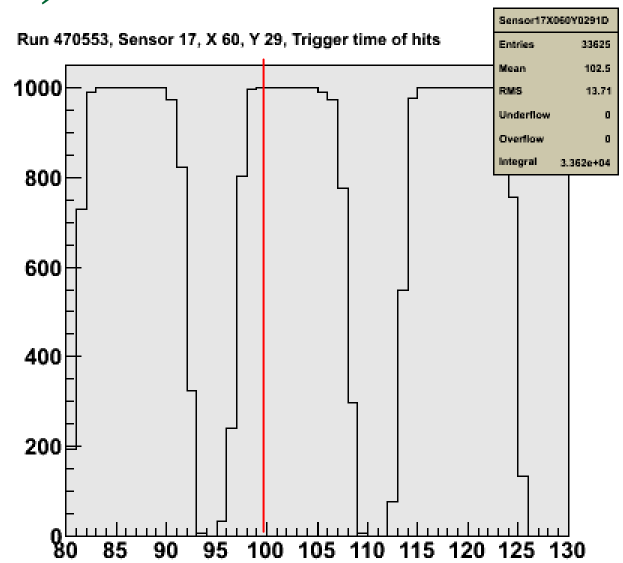
Threshold 60TU

Effect of timing (cont)

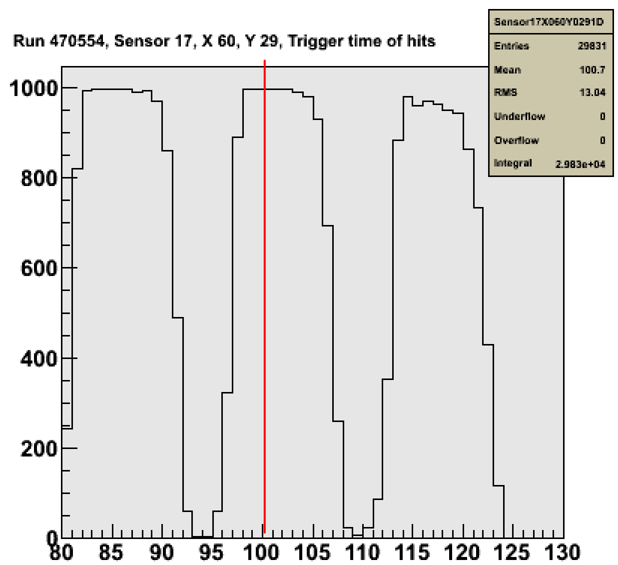
Threshold 40TU



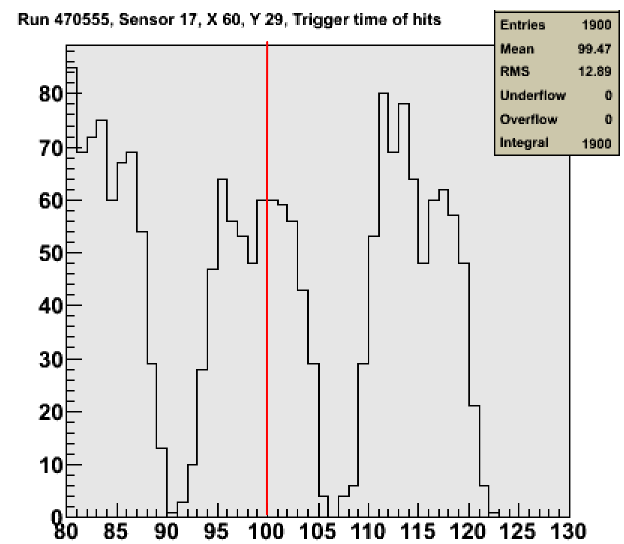
Threshold 60TU



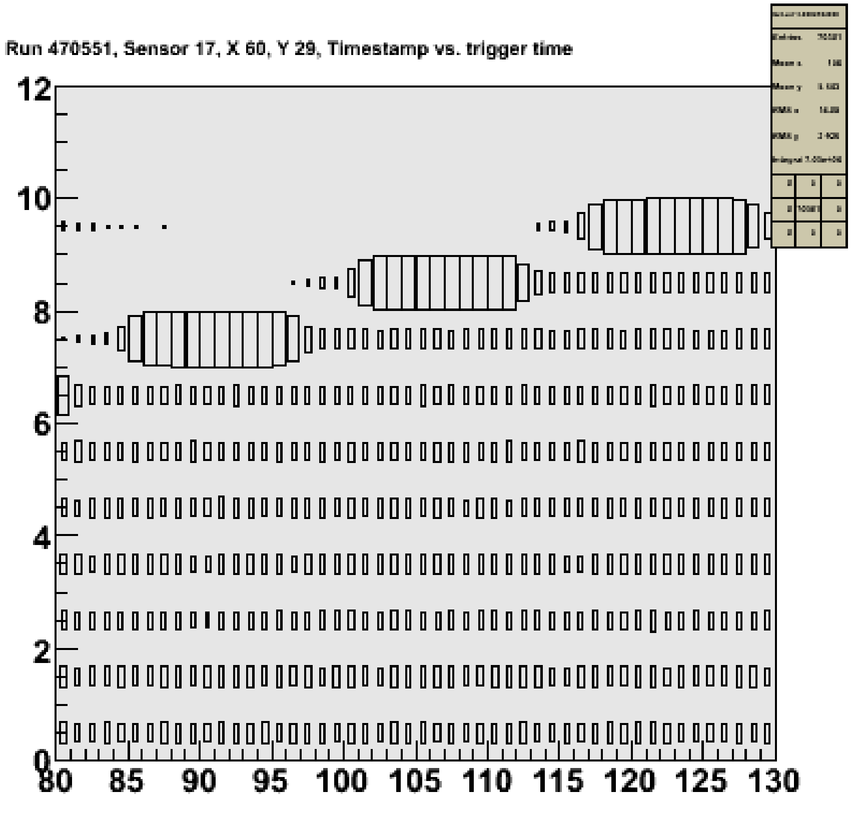
Threshold 80TU



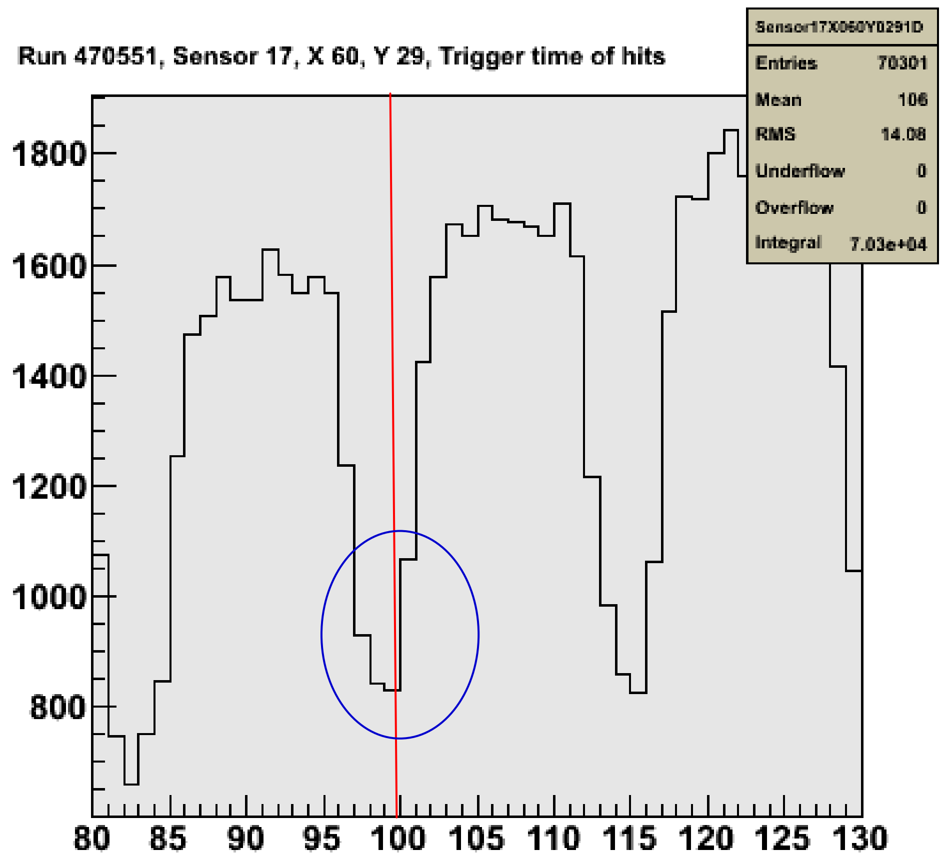
Threshold 100TU



Effect of timing (cont)



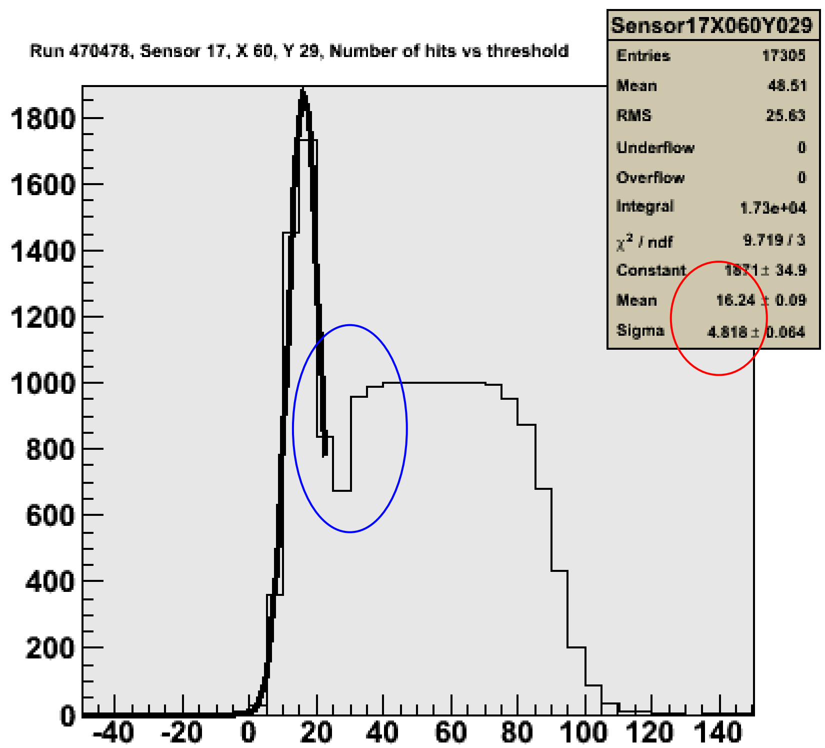
Threshold 20TU



Apparent drop of efficiency at low threshold;
gives rings shown by Anne-Marie

Pedestal values

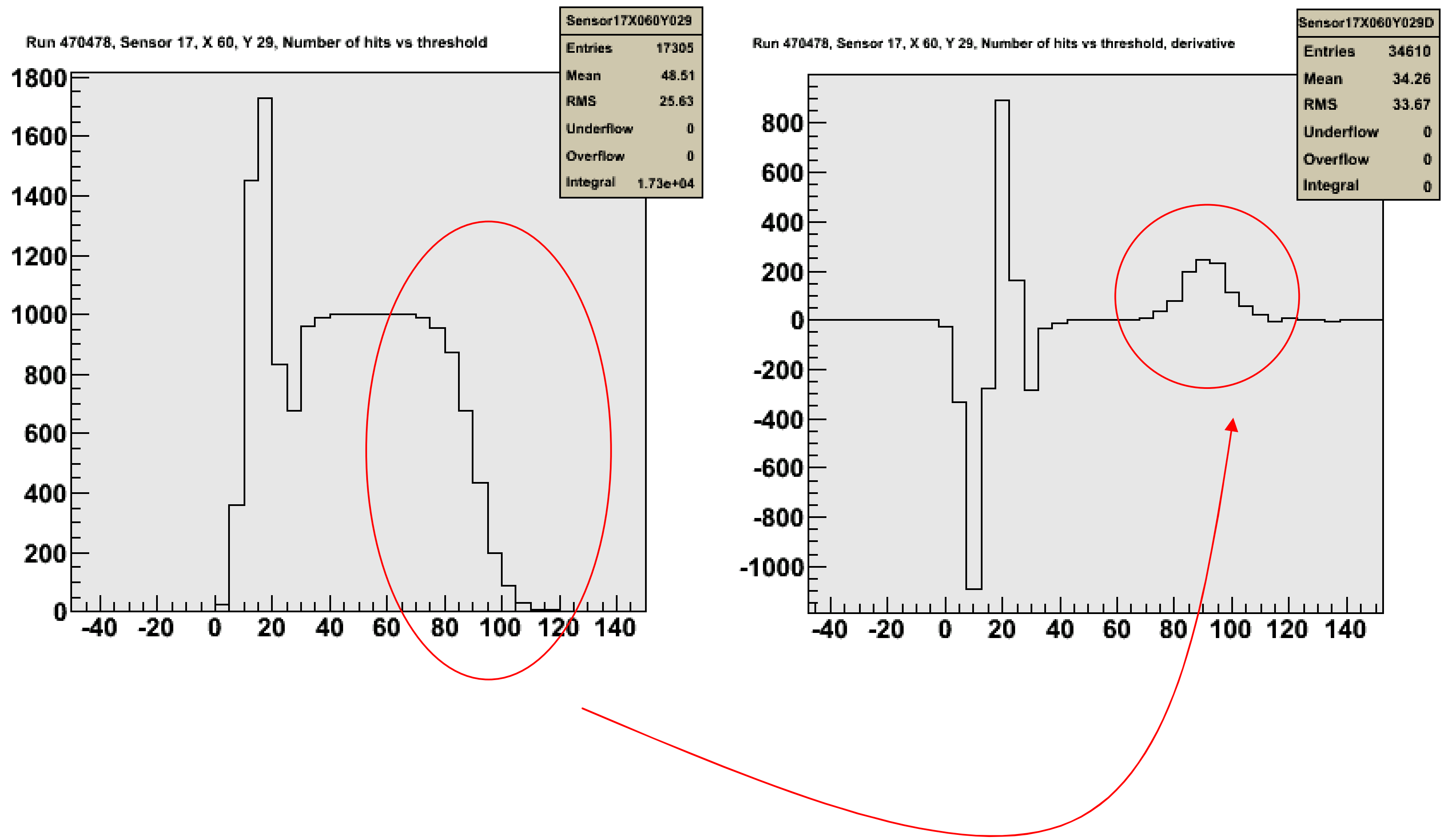
- Measured from peak around zero
  - Renato stated (29/02/08) the pedestal shape in the threshold scan plot should be ideally Gaussian with width = noise
- Ideally would do threshold scan without laser for every pixel used
  - Not yet done so fit lower side of Gaussian



- Pedestal ~16TU in this pixel
- RMS ~5TU, so 5TU steps too coarse for accurate fit
- From Jamie's measurements (also 29/02/08) we guesstimated 1TU ~ 30eV ~ 8e⁻ so this noise would be ~40e⁻, close to expected
- Dip at ~30TU related to ring shown by Anne-Marie

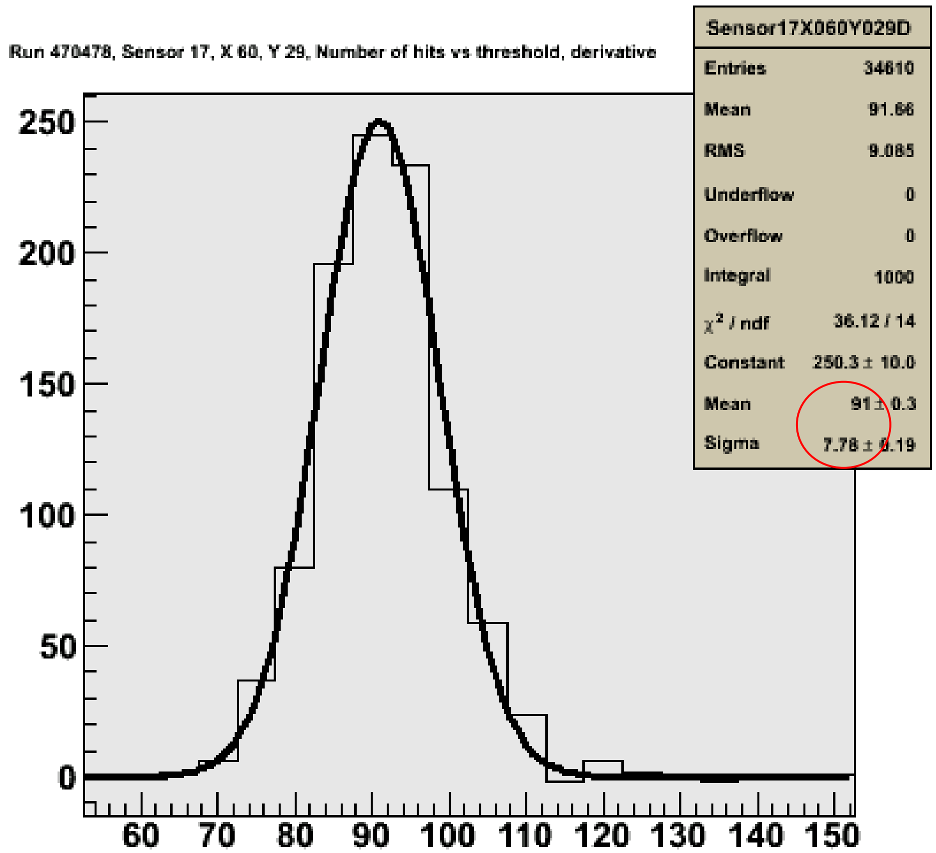
Signal extraction

- Take derivative of threshold plot (neighbour bin subtraction) to get laser signal



Signal values

- Fit to simple Gaussian
  - Note points are correlated (from derivative calculation) so errors uncertain
  - Not yet at that level of sophistication; fit to erf would be better but less robust



- Signal peak ~91TU in this pixel
  - With Jamie's scale, this would be 700e⁻
- RMS ~8TU; again 5TU steps are too coarse
- RMS is direct measure of spread
  - Contribution from laser pulse variation and sensor noise
- Gives an upper limit on sensor noise if laser assumed negligible
  - Noise < 8TU ~ 60e ⁻

Fit values entered into spreadsheet

Microsoft Excel - sensor

File Edit View Insert Format Tools Data Window Help

A1 Run

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Run	Pixel X	Pixel Y	Ped Norm	Ped Mean	Ped Rms	Sig Norm	Sig Mean	Sig Rms	Sig Area	Gain	Gain/Sig R	Gain/Ped Rn
2	470472	9	9	2257	-12.4	6.25							
3													
4	470474	59	28	1554	-8.3	4.13	262	67.7	7.41	4866	76.0	10.3	18.4
5	470475	60	28	1470	-11.3	4.61	269	66.5	7.20	4855	77.8	10.8	16.9
6	470476	61	28	2734	-2.2	5.07	250	76.0	7.62	4775	78.2	10.3	15.4
7	470477	59	29	1800	13.2	4.27	260	98.2	7.48	4875	85.0	11.4	19.9
8	470478	60	29	1871	16.2	4.82	250	91.0	7.78	4875	74.8	9.6	15.5
9	470479	61	29	1914	-52.7	4.69	257	23.2	7.62	4909	75.9	10.0	16.2
10	470480	59	30	2694	12.3	10.05	166	89.9	11.38	4735	77.6	6.8	7.7
11	470481	60	30	2438	9.4	4.67	252	91.2	7.67	4845	81.8	10.7	17.5
12	470482	61	30	1683	47.1	6.21	203	139.2	9.57	4870	92.1	9.6	14.8
13													
14	470506	37	102	2640	11.5	5.95	201	116.5	9.76	4917	105.0	10.8	17.6
15	470507	38	102	2773	-17.6	5.30	191	92.6	10.28	4922	110.2	10.7	20.8
16	470508	39	102	2202	2.8	5.39	202	95.2	9.63	4876	92.4	9.6	17.1
17	470509	40	102	2041	-11.7	5.72	210	78.4	8.92	4695	90.1	10.1	15.8
18	470510	41	102	2931	6.4	6.22	226	93.8	8.53	4832	87.4	10.2	14.1
19	470511	37	103	2987	48.5	8.82	158	160.1	11.57	4582	111.6	9.6	12.7
20	470512	38	103	3350	6.1	8.03	176	115.3	10.96	4835	109.2	10.0	13.6
21	470513	39	103	2336	-23.8	6.69	220	83.2	8.71	4803	107.0	12.3	16.0
22	470514	40	103	1948	-18.0	5.94	213	90.1	9.20	4912	108.1	11.8	18.2
23	470515	41	103	3288	52.4	6.16	215	154.0	8.64	4656	101.6	11.8	16.5
24	470516	37	104	2313	12.3	6.78	163	123.0	11.91	4866	110.7	9.3	16.3
25	470517	38	104	2027	-10.9	4.61	234	75.8	8.37	4909	86.7	10.4	18.8
26	470518	39	104	2420	-35.9	4.87	232	49.7	8.41	4891	85.6	10.2	17.6
27	470519	40	104	2258	-2.4	5.69	180	97.3	10.68	4819	99.7	9.3	17.5
28	470520	41	104	2394	-31.4	5.42	255	49.8	7.68	4909	81.2	10.6	15.0
29	470521	37	105	2503	-37.9	5.15	240	52.9	8.16	4909	90.8	11.1	17.6
30	470522	38	105	2208	-44.1	7.78	168	70.3	11.41	4805	114.4	10.0	14.7
31	470523	39	105	2739	-15.8	4.60	221	85.7	8.81	4880	101.5	11.5	22.1
32	470524	40	105	2474	51.0	7.32	131	173.5	14.12	4637	122.5	8.7	16.7
33	470525	41	105	2589	-4.5	4.61	272	87.6	7.27	4957	92.1	12.7	20.0
34	470526	37	106	2098	-16.6	5.73	202	91.5	9.67	4896	108.1	11.2	18.9
35	470527	38	106	2296	-3.7	5.09	171	109.5	11.23	4814	113.2	10.1	22.2
36	470528	39	106	1623	-21.4	6.13	175	79.4	10.69	4689	100.8	9.4	16.4
37	470529	40	106	2116	-23.7	4.27	235	62.7	8.29	4883	86.4	10.4	20.2
38	470530	41	106	2345	24.2	5.60	213	101.7	8.99	4800	77.5	8.6	13.8
39													

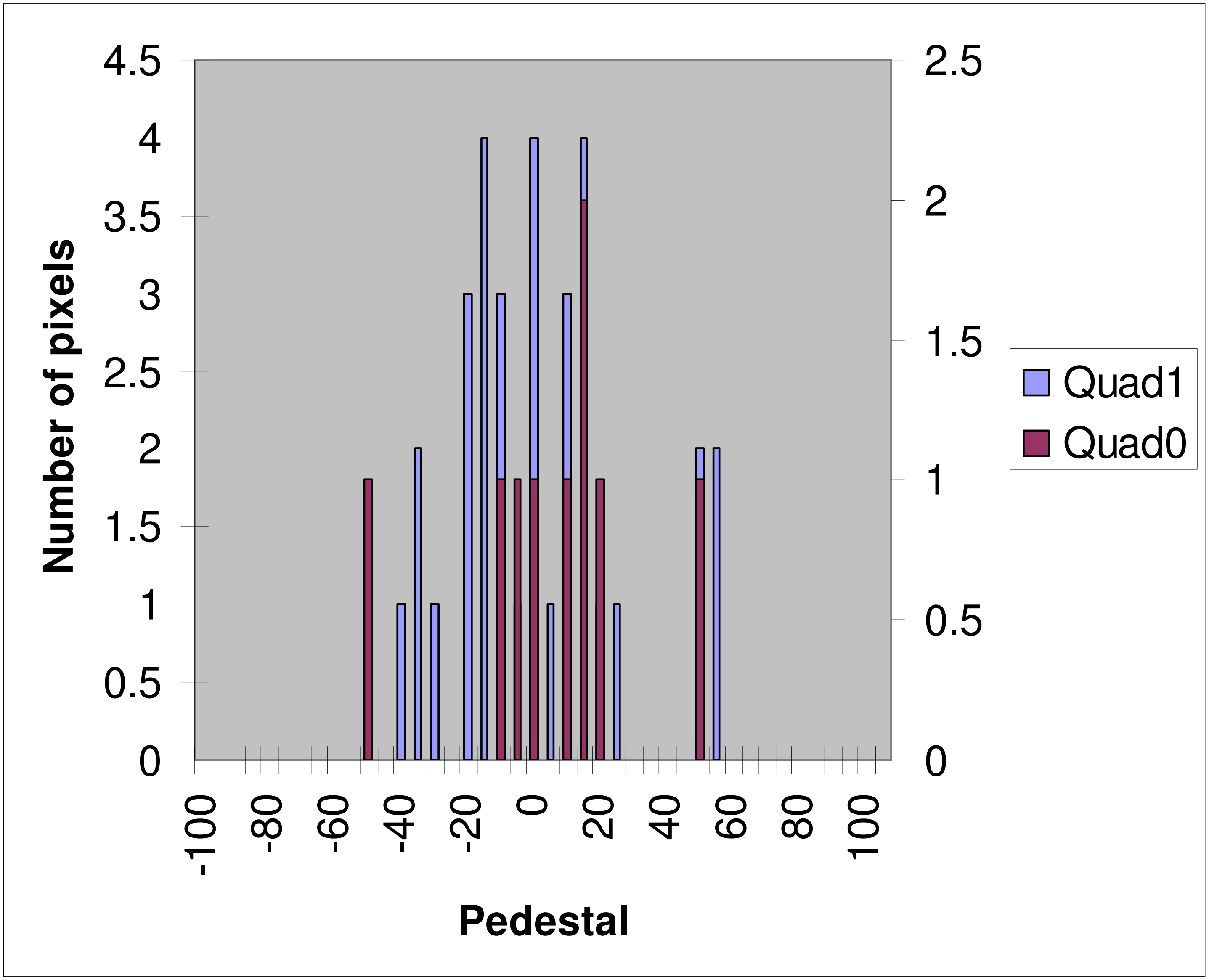
Shapers Plots Hist1 Hist2 Hist3 Hist4 Hist5 Hist6 Samplers Sh

Ready

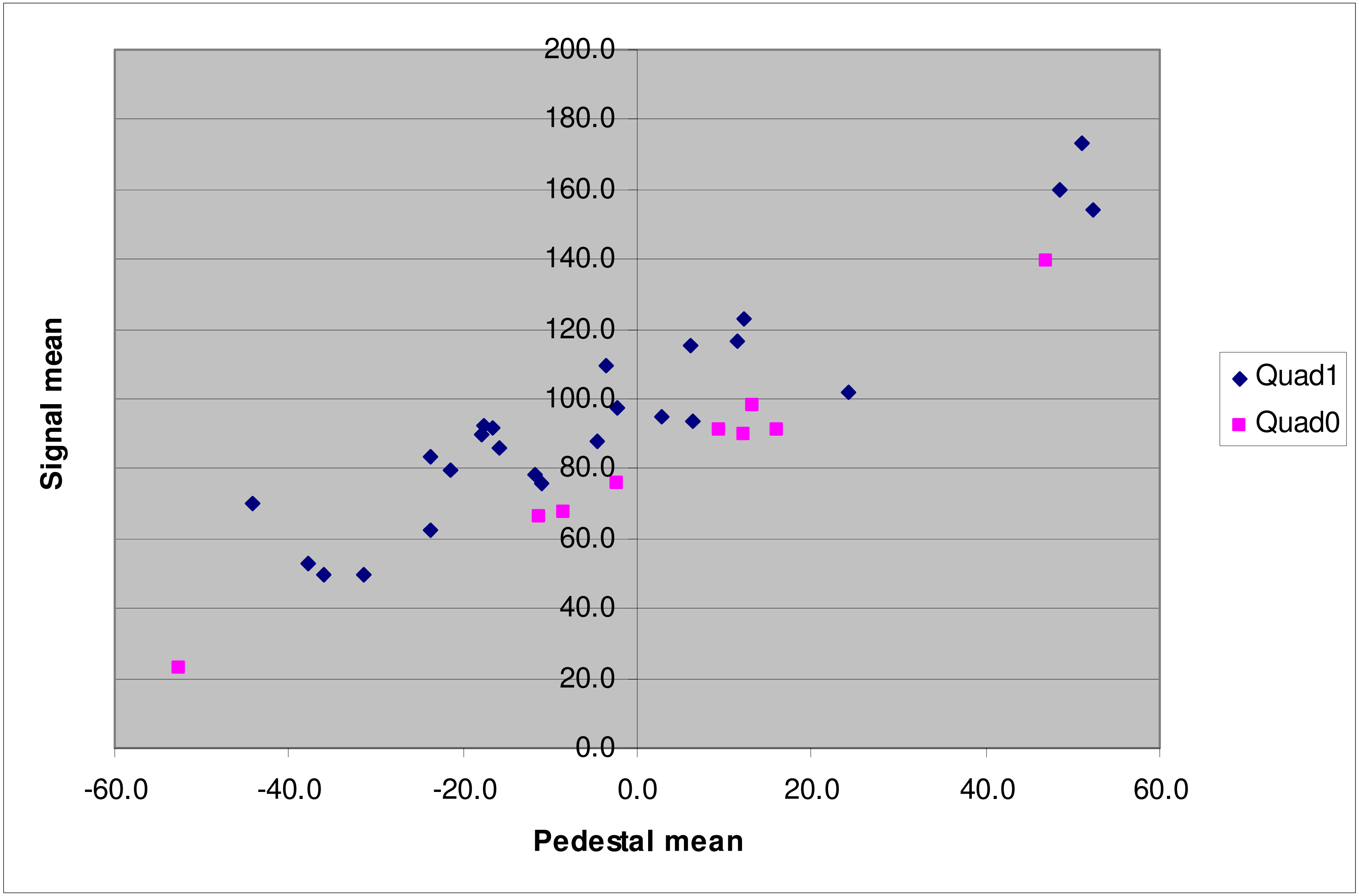
Quad0

Quad1

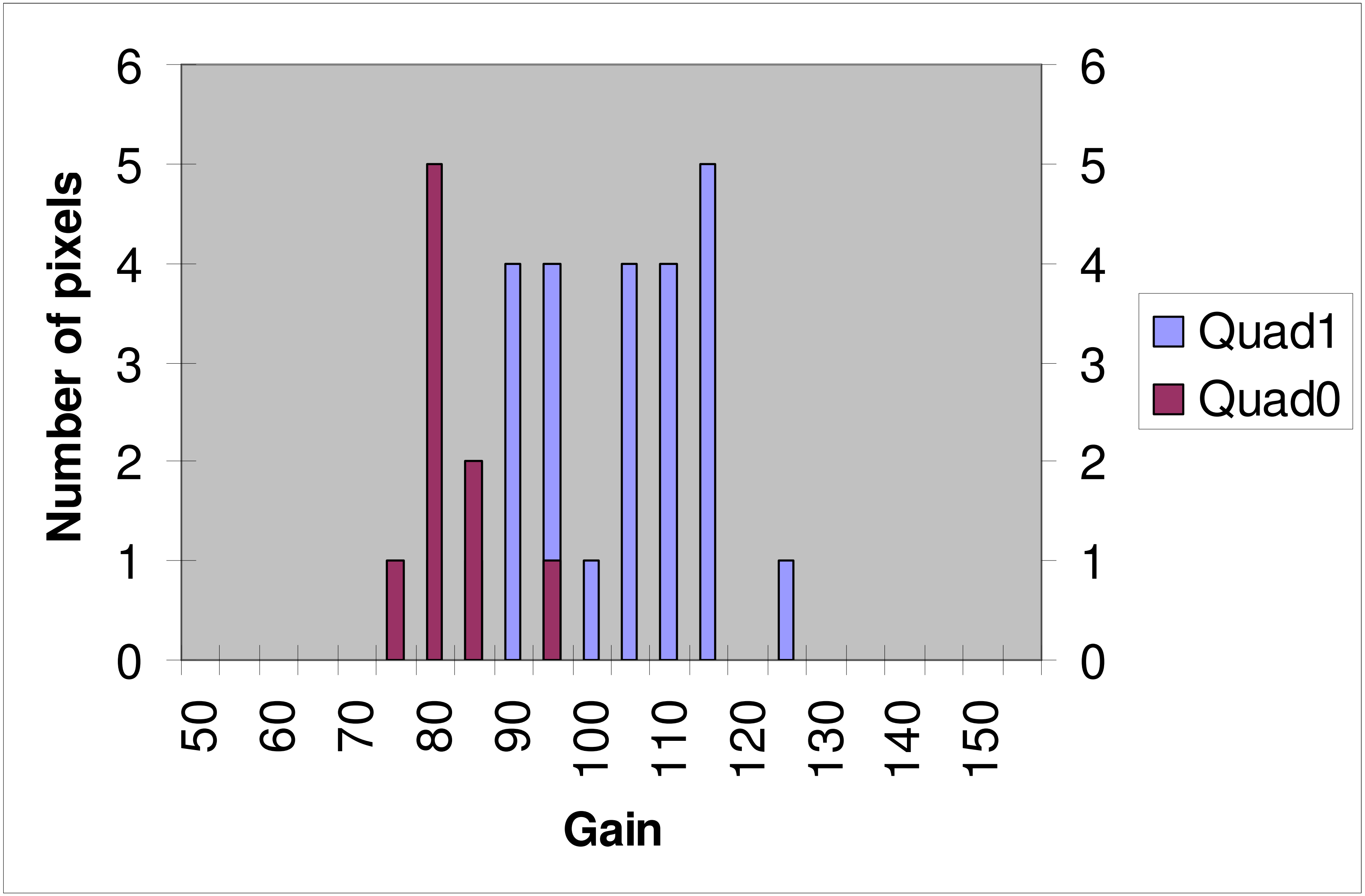
Pedestal distribution



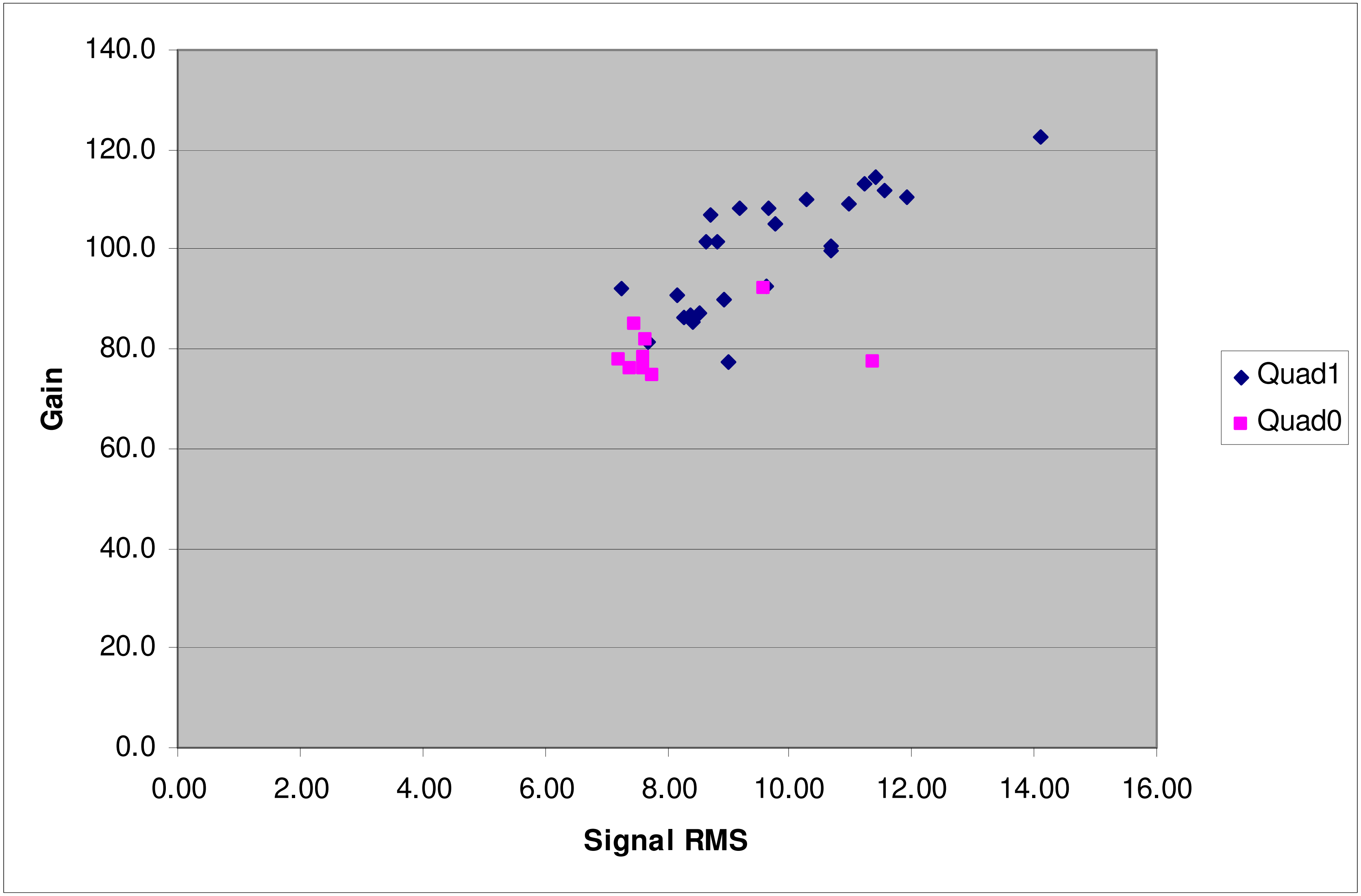
Correlation of signal vs pedestal means



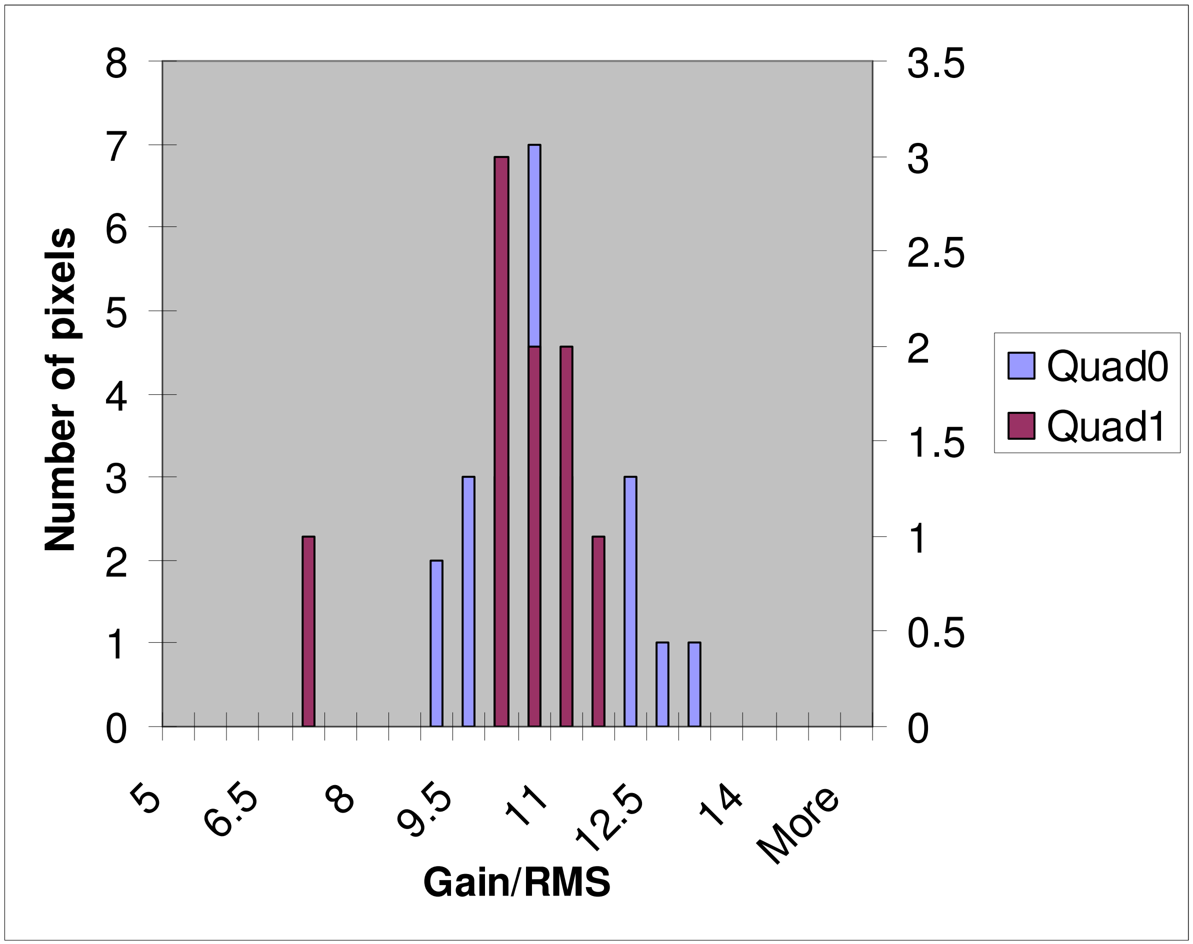
Gain distribution



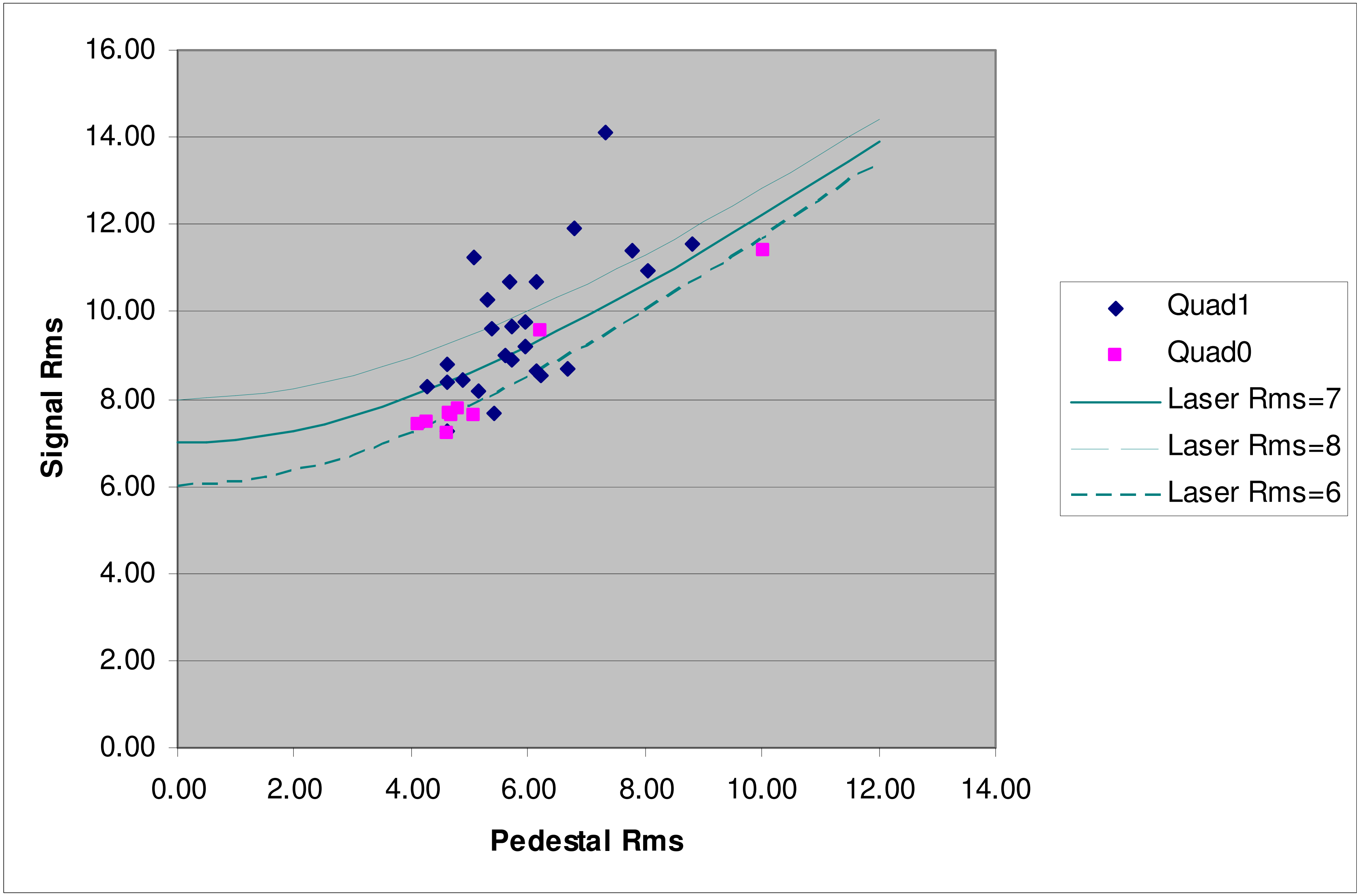
Correlation of gain vs signal RMS



Gain/Signal RMS distribution

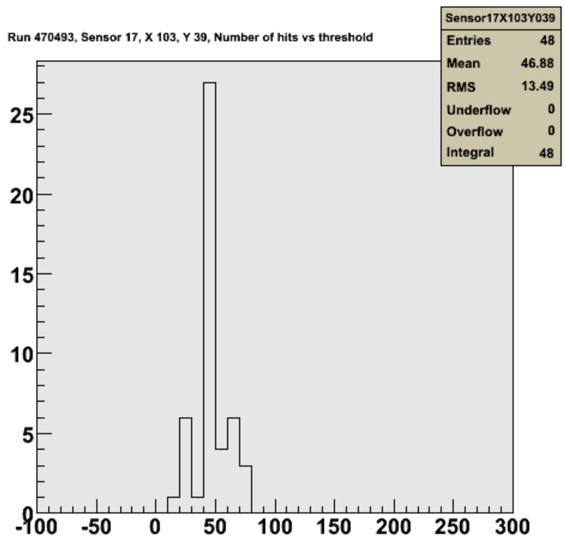


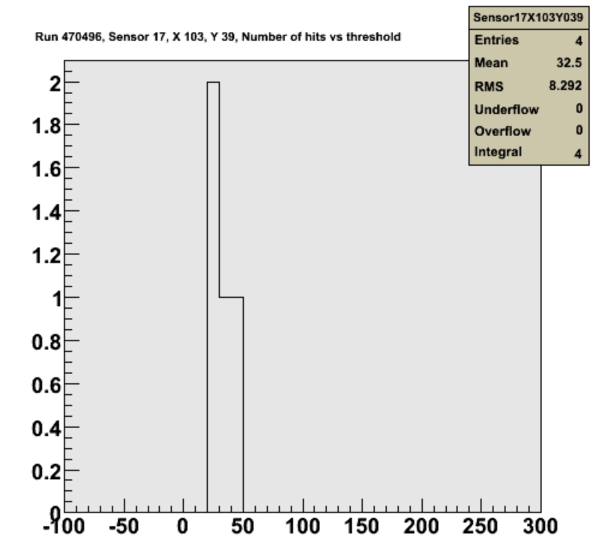
Correlation of signal vs pedestal RMSs



Samplers; effect of laser and masking

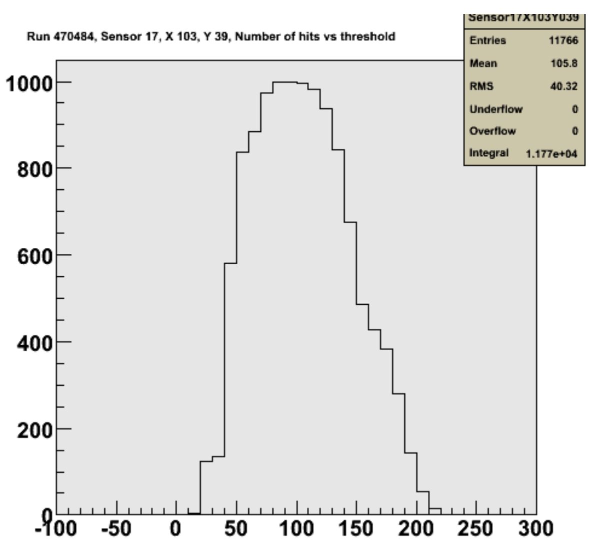
Laser disabled
Others masked

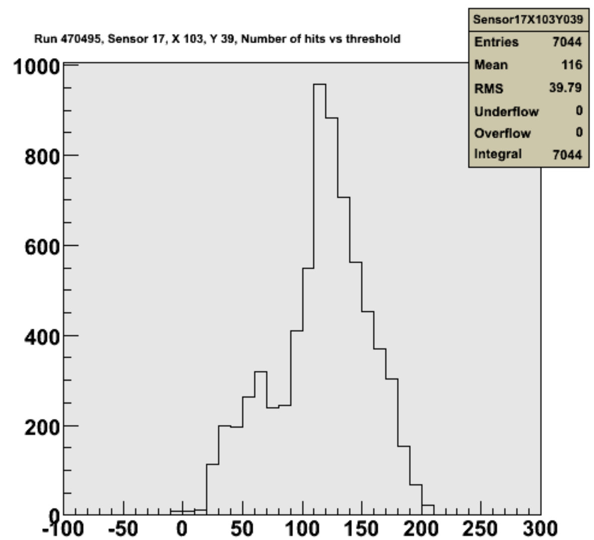




Laser disabled
Others unmasked

Laser enabled
Others masked

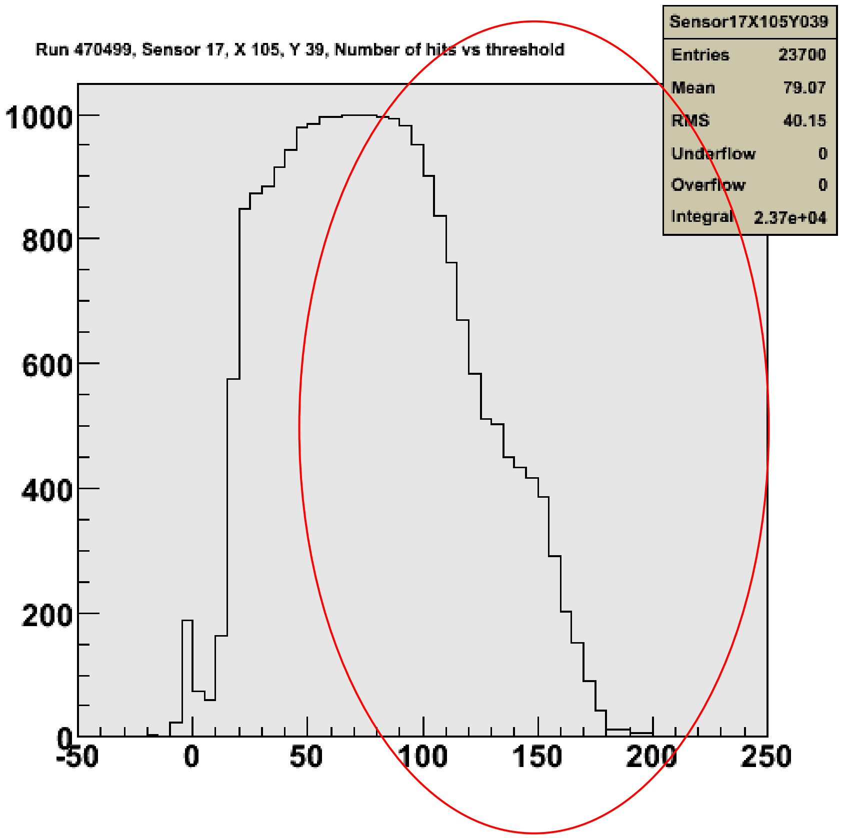


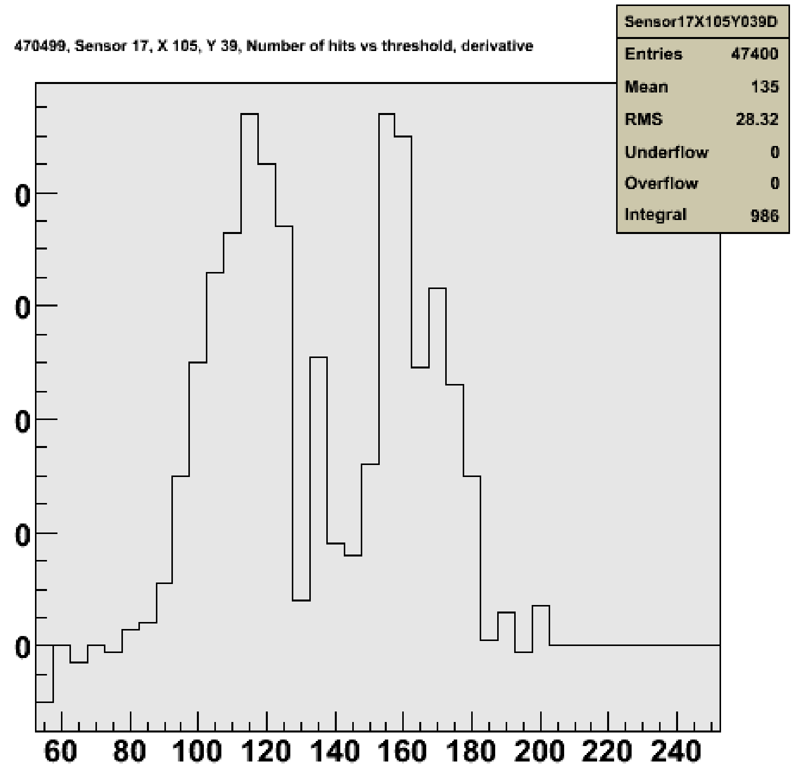


Laser enabled
Others unmasked

Samplers; signal shape

- Try same trick with derivative of threshold plot to get laser signal





- Double peak structure; common to most sampler pixels
- Not understood by me…

Conclusions

- Variation of pedestal as observed previously
- Much smaller variation of gain
- Small difference in gain of Quad0 and Quad1 shapers but S/N is roughly the same
- Masking makes a big difference to observed pedestal
- Noise is < 8TU and may be ~6TU
- Samplers not understood…
- Many things to do:
  - More statistics
  - Set overall calibration scale
  - Gain independent of trim?
  - Noise with finer threshold scan, without laser
  - Cause of masking and noise rate coupling?