First high rate x-ray results

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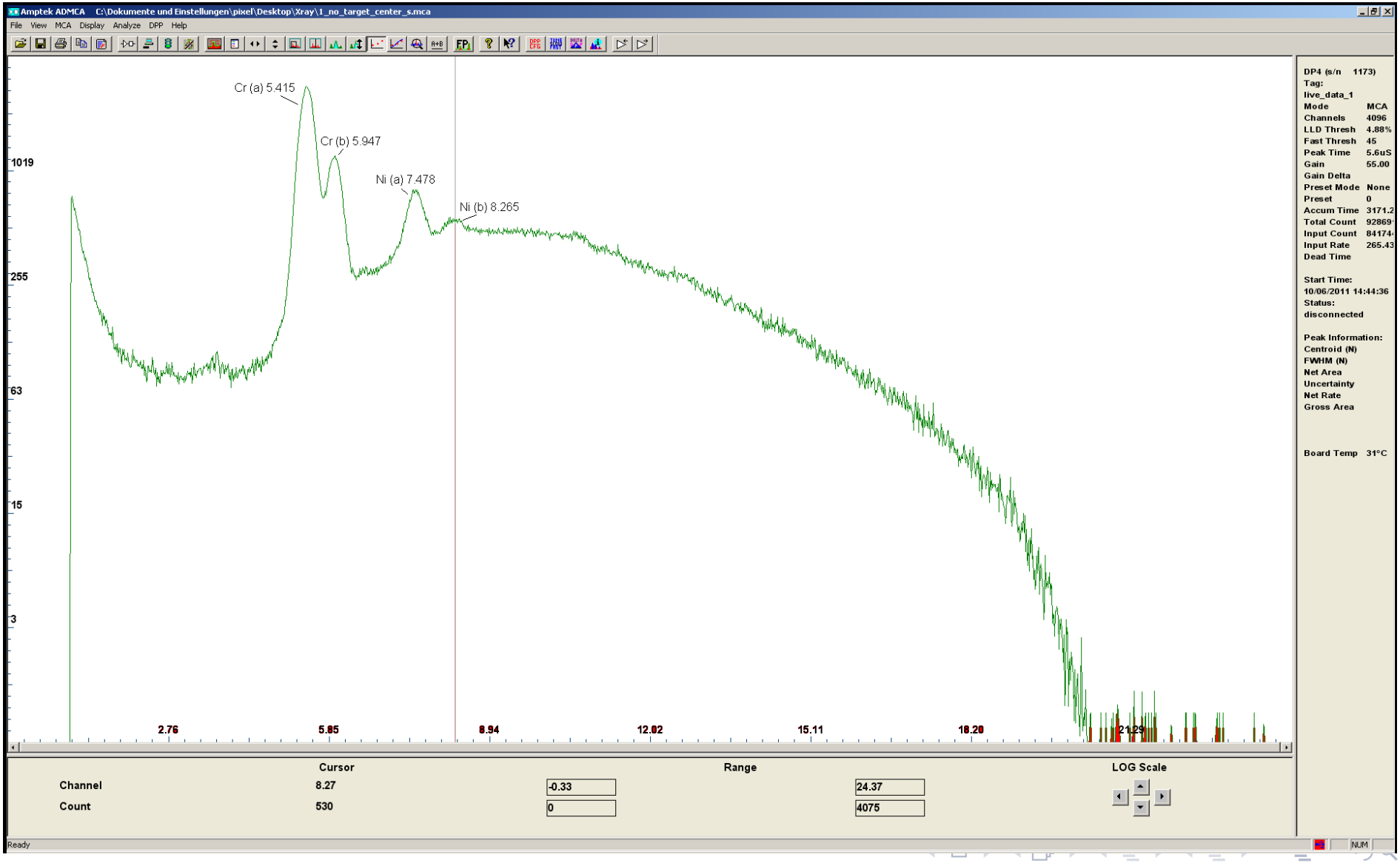
X-ray source

- 0-60 keV photon energy
- 2-80 mA current
- chromium anode tube, max power 1800 W

- Works very nicely
- Computer controllable
- Tube warmup required for $E > 20$ keV [$O(30')$]
- Using full range of machine capabilities.

X-ray spectrum

Non-direct spectrum (elastically scattered, mostly), 20 keV



Test implementations

Implemented tests in psi46expert which

- program the ROC
- make the testboard trigger periodically
- use the testboard RAM as data buffer
- analyse the readout data

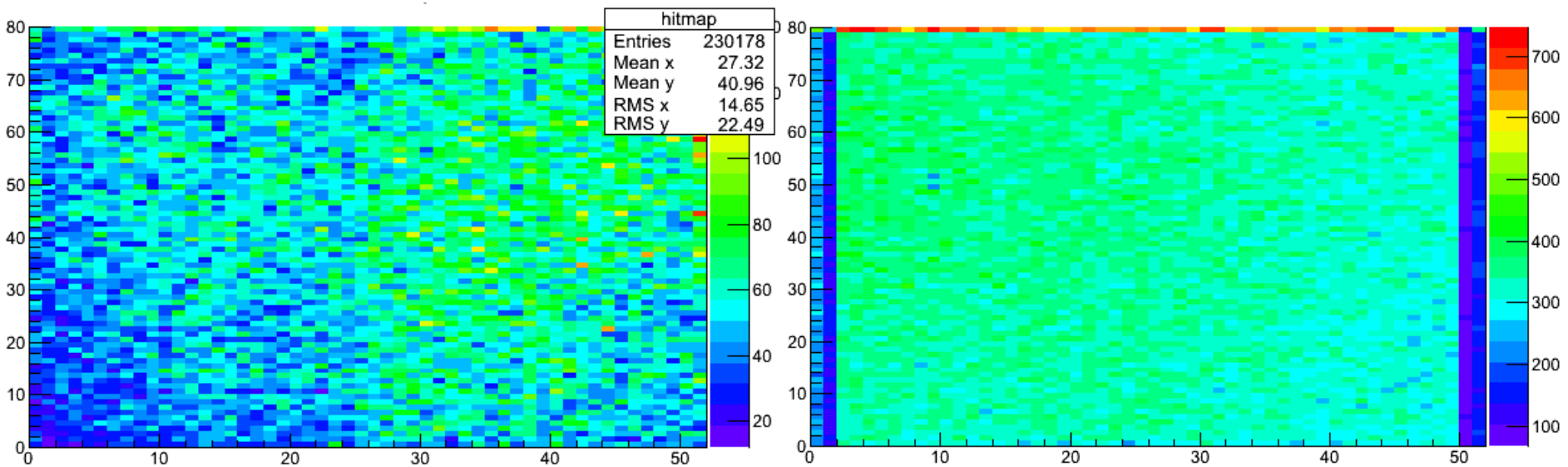
Limitations:

- Testboard RAM size (64 MB)
- Connection speed to PC (300 kB/s)
- Triggering capabilities of testboard
- No possibility to analyse data on testboard with current firmware

Hit Map

Used as

- Bump-bonding test
- Double column (in-)efficiency test
- VCal calibration

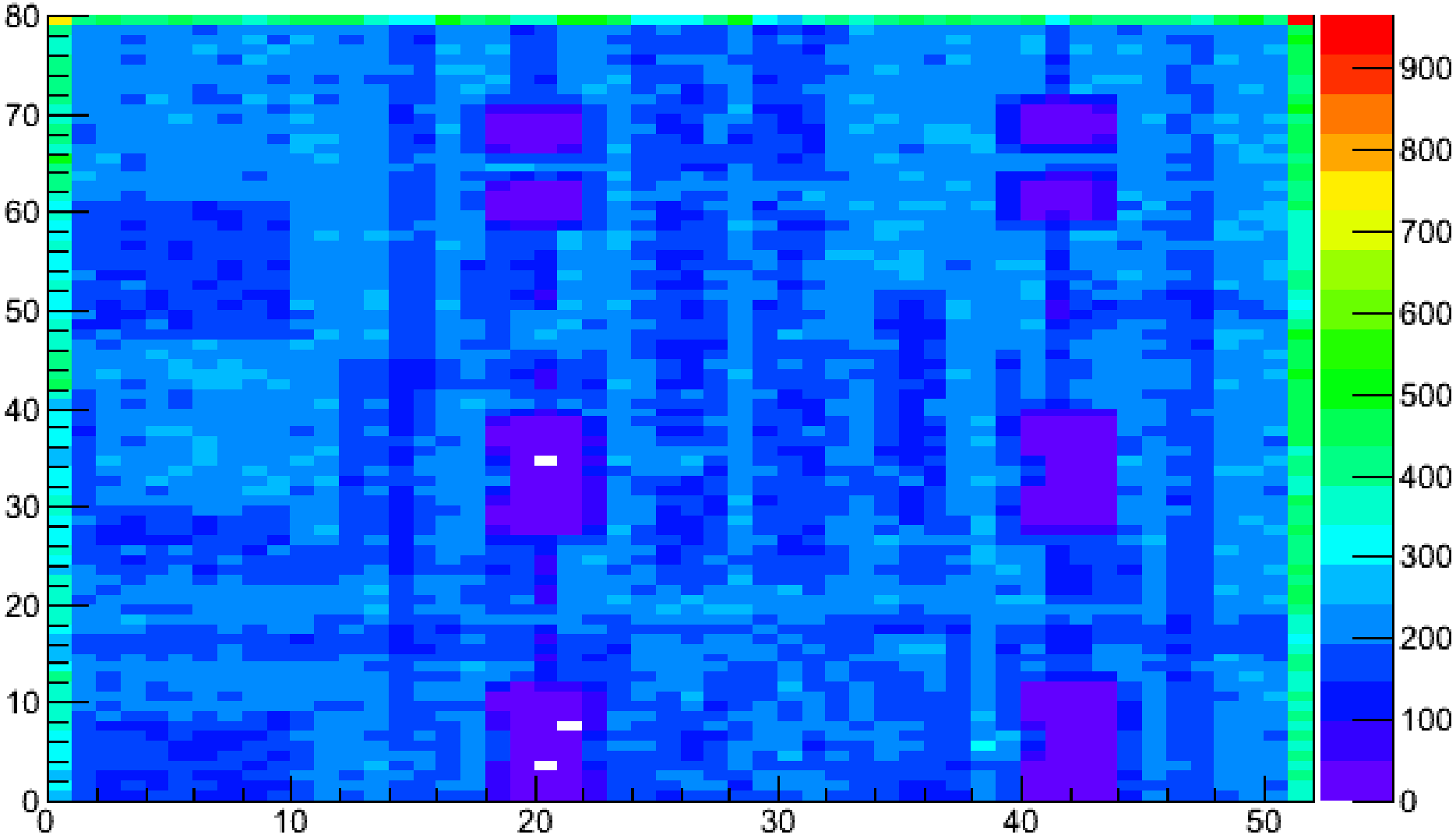


Here: 30 kV, 60 mA; untrimmed, trimmed

I used it also to determine the hit rate.

Hit Map (HDI)

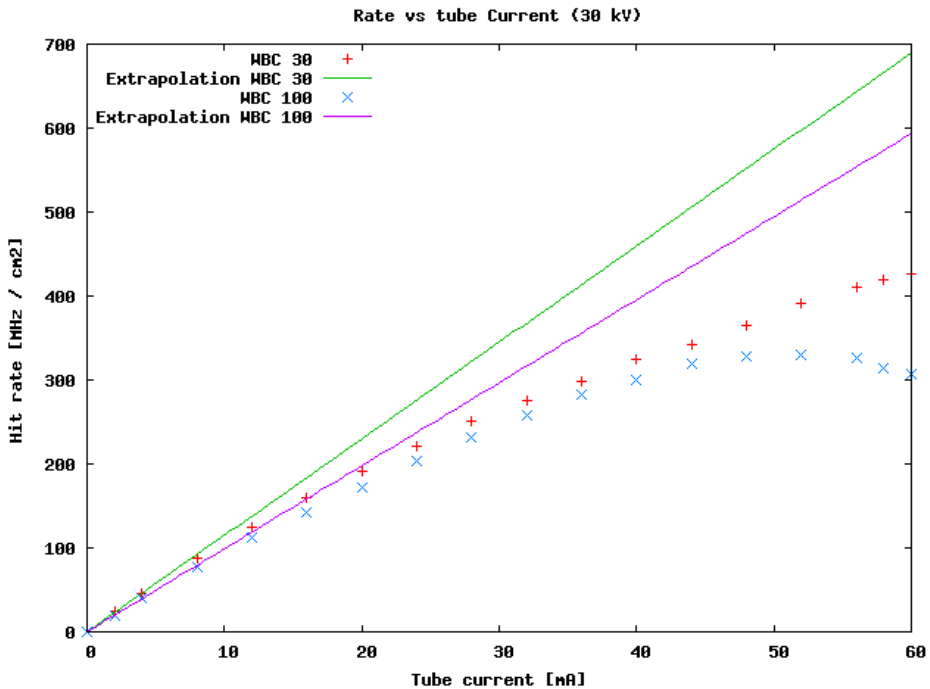
I put an HDI on top of the ROC (9 mm distance, 30 kV, 30 mA):

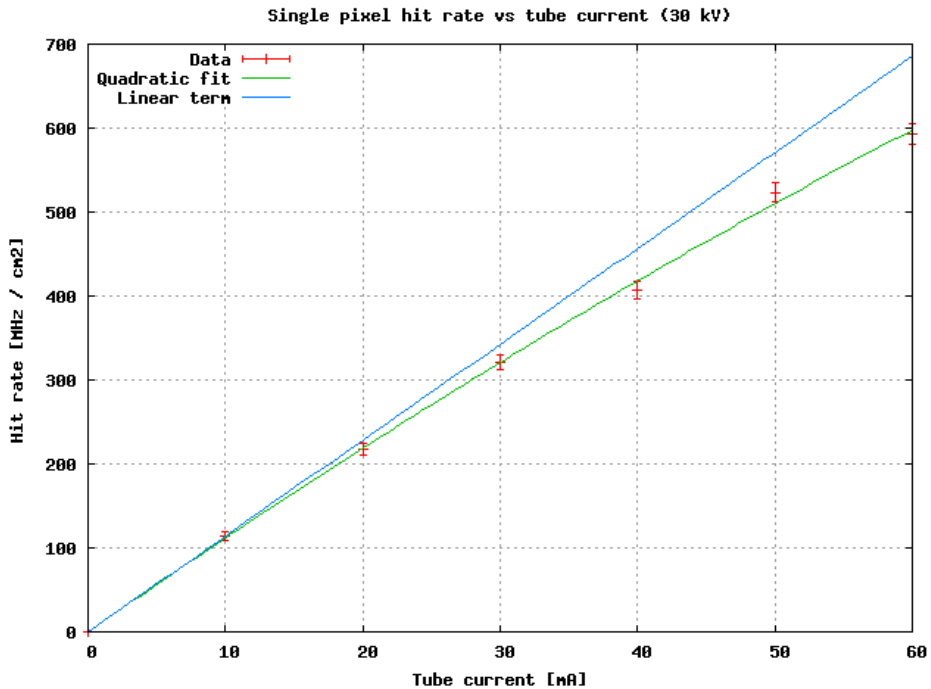


Hit rate

I used the hit map to measure the 'readout' rate vs x-ray intensity:

- with WBC 100
- with WBC 30
- with only one pixel unmasked (WBC 100)

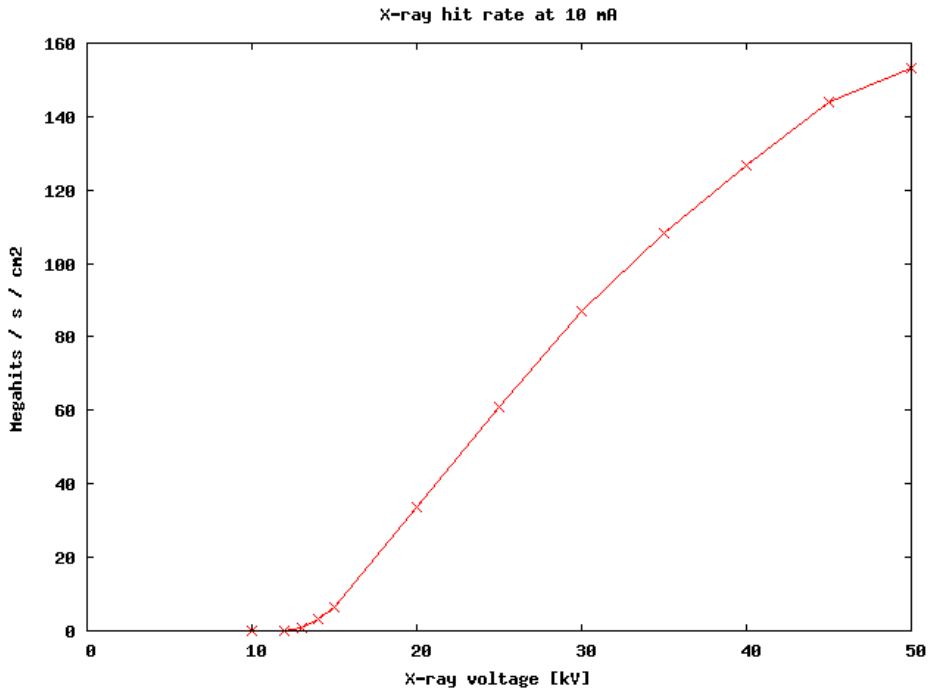


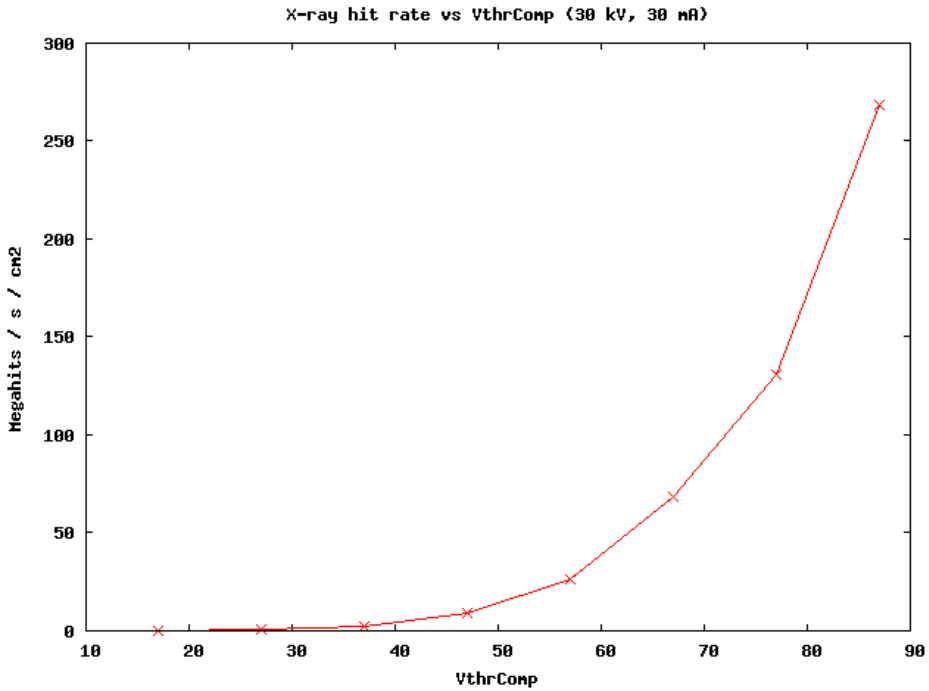


We see the inefficiency of the chip at high rates.

Hit rate vs spectrum, threshold

Changing the spectrum or threshold, the hit rate changes also:

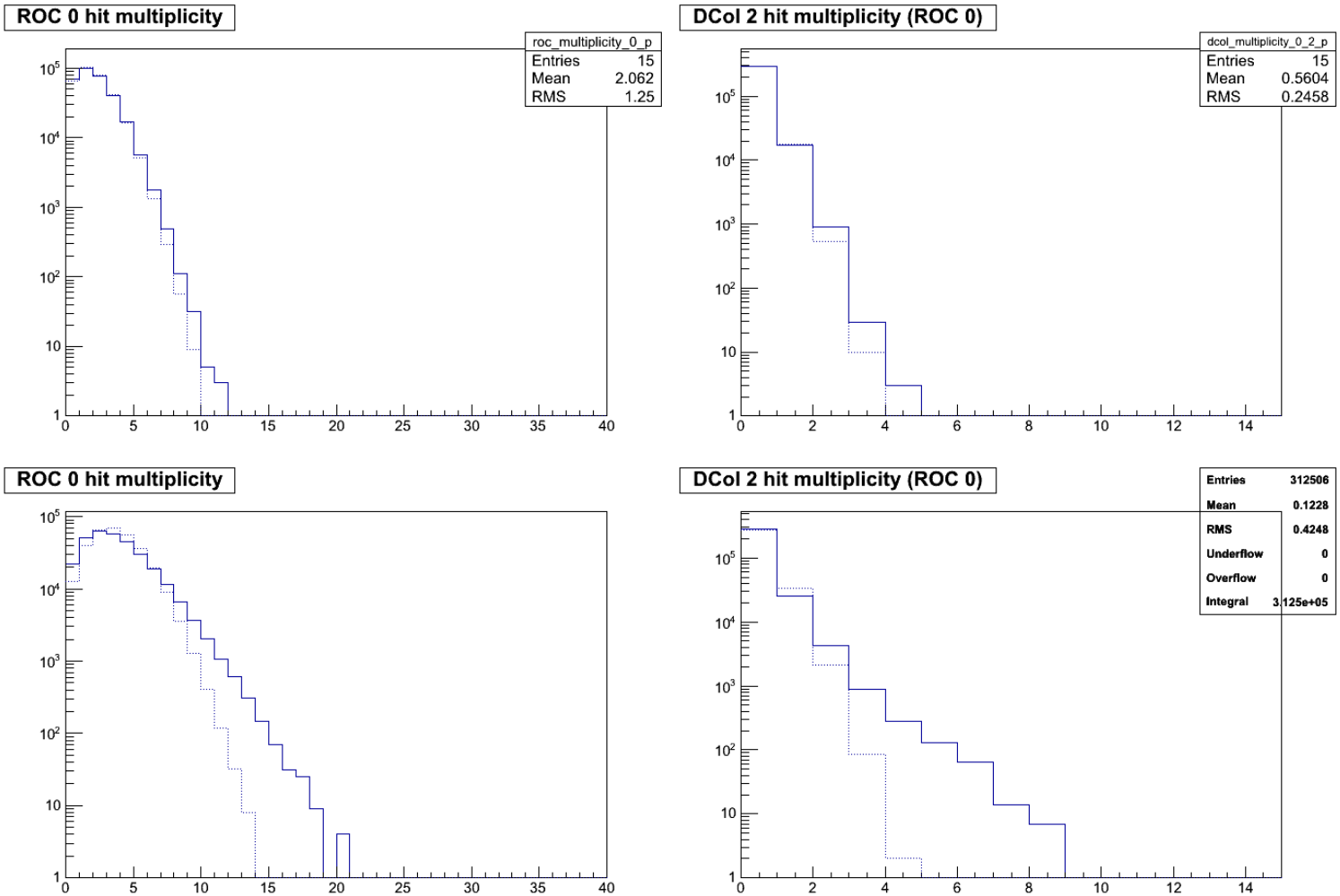




Question: In what range can the threshold be changed in electrons?

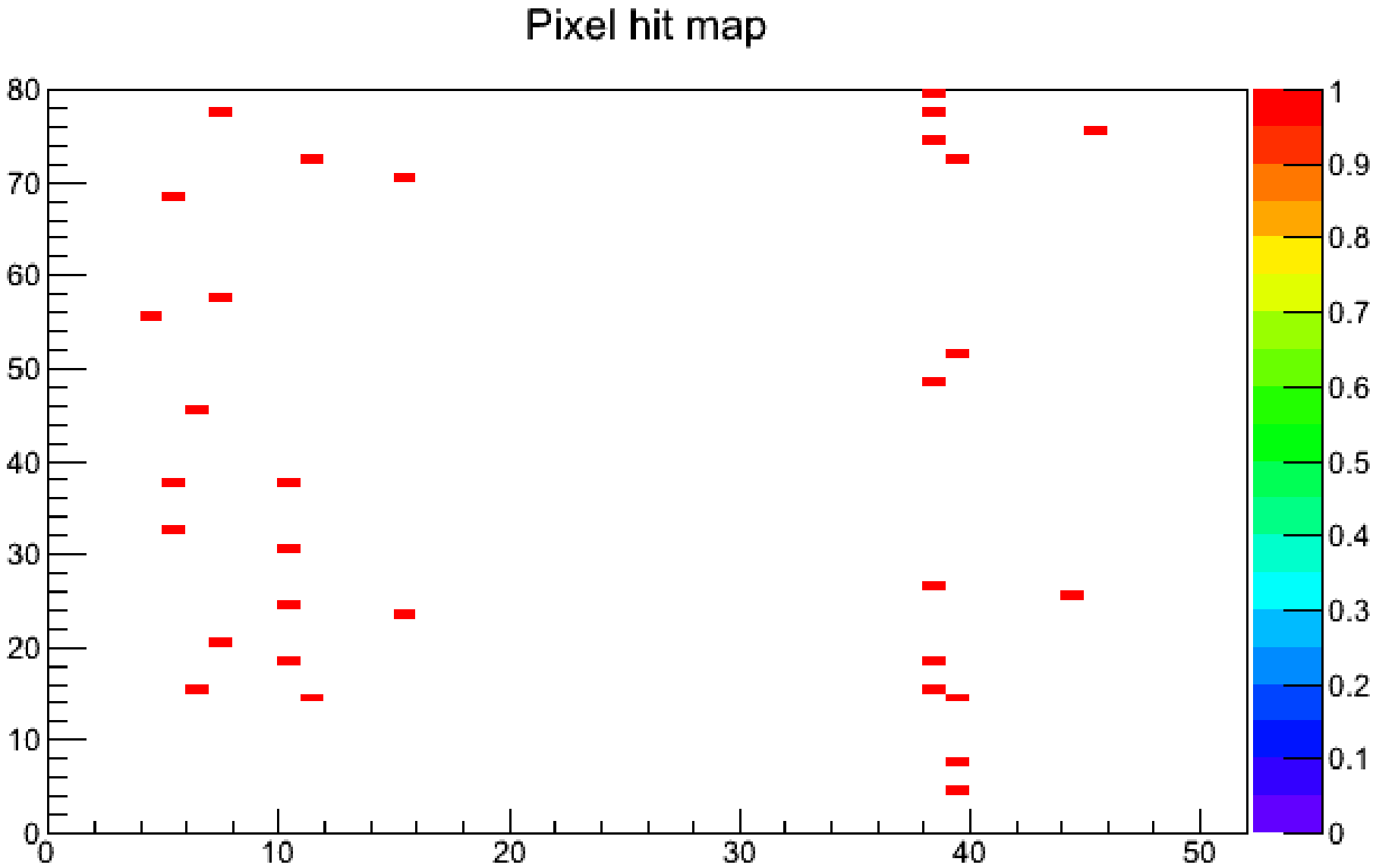
Multiplicities (hits per BX)

When measuring the hit map, one can also histogram the multiplicity easily. Top 100 MHz / cm^2, bottom 230 MHz / cm^2:



Comparison with Poisson distribution (dotted).

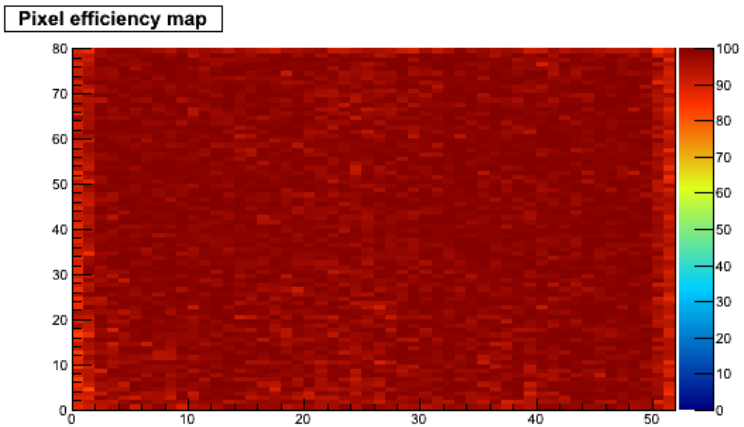
High multiplicity event display

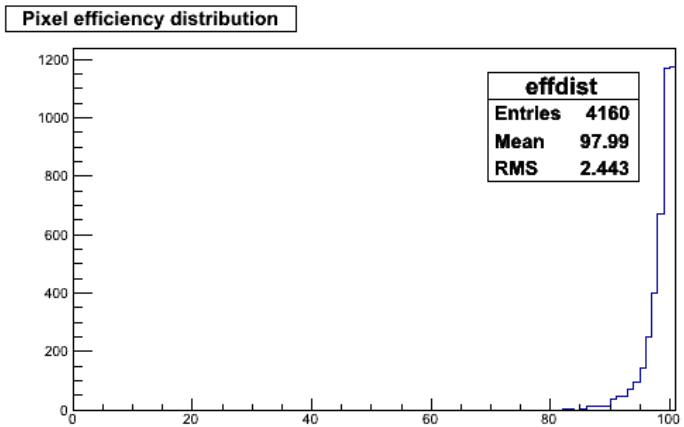


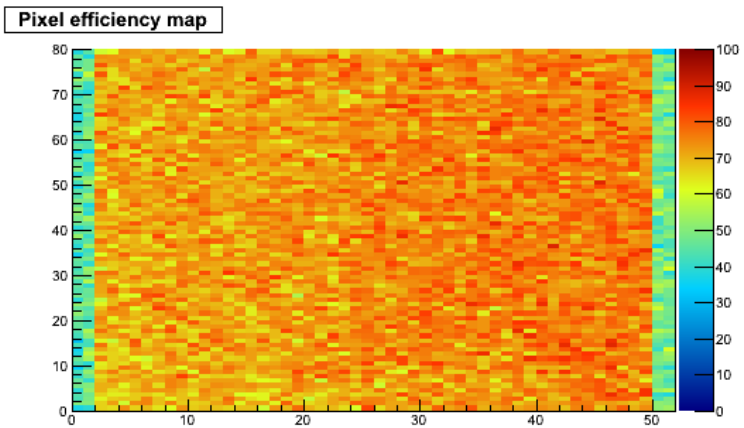
Pixel efficiency

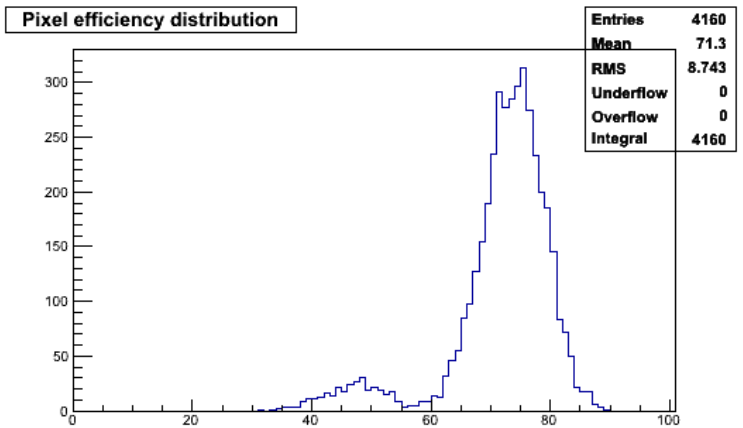
Send calibrates with triggers while illuminating a ROC/module at high rate. Count number of calibrates read out.

Top 100 MHz / cm^2, bottom 230 MHz / cm^2, trigger rate < 2 kHz:



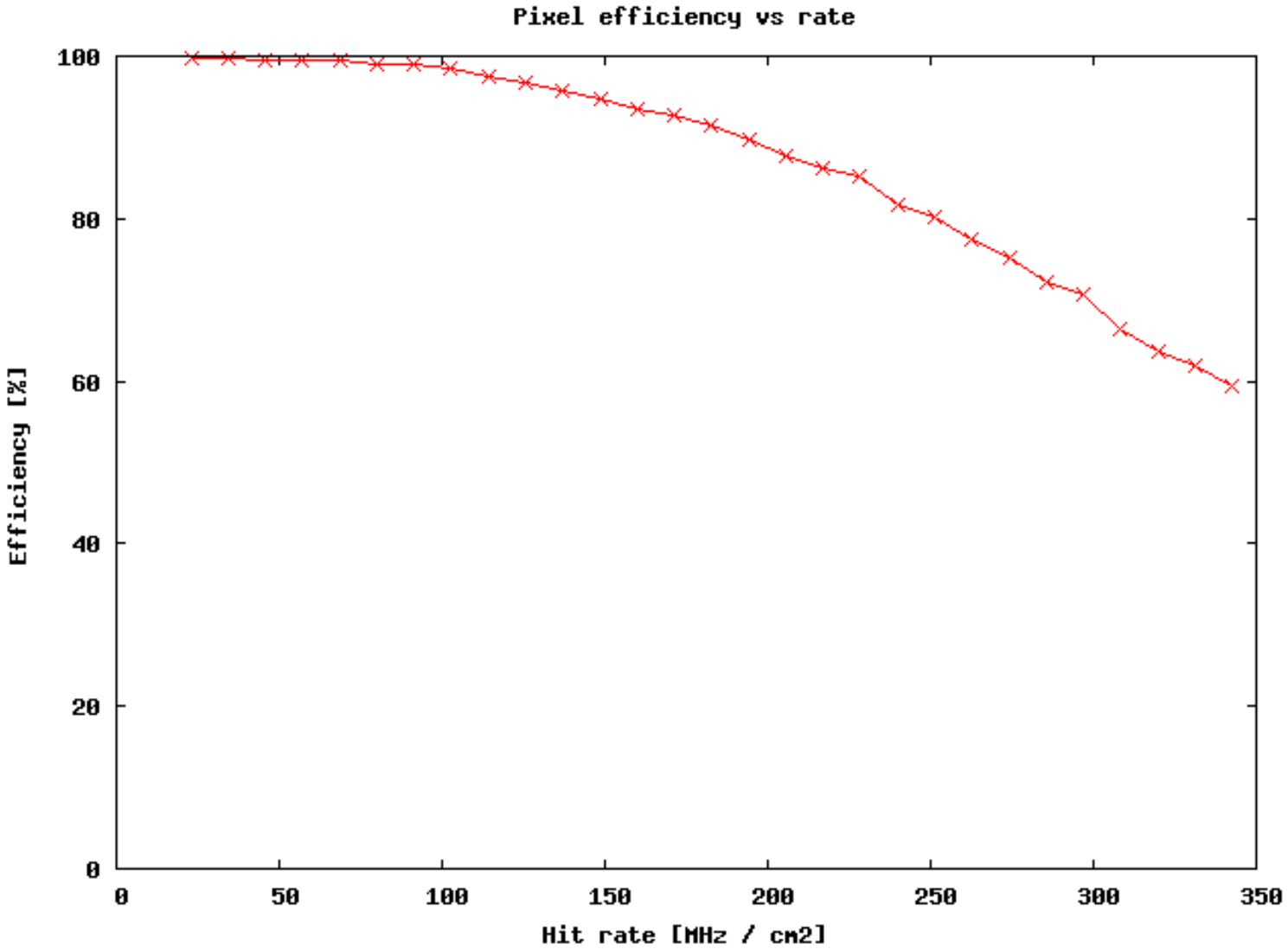






Pixel efficiency vs rate

Average pixel efficiency vs hit rate



Fluorescence test (preliminary)

I tested the rate when using a molybdenum target, at a distance of 70 cm to the chip. As expected, the rate is highly dependent on the tube voltage.

Tube voltage	Tube current	Tube power	Hit rate
30 kV	60 mA	1800 W	122 kHz / cm^2
40 kV	45 mA	1800 W	257 kHz / cm^2
50 kV	36 mA	1800 W	360 kHz / cm^2
60 kV	30 mA	1800 W	426 kHz / cm^2

Conclusions

Until now:

- Experience with x-ray machine
- X-ray capabilities adequate for high rate tests
- Tests were implemented
- ROC inefficiencies seen, but not yet fully understood

Future plans:

- Implement test to measure noise/cross-talk of new chip, lowest possible threshold.
- Implement more other tests.
- Write some useful functions in firmware that reduce the problem with the limited RAM size and connection speed.