Large Synoptic Survey Telescope

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BROOKHAVEN NATIONAL LABORATORY

Pocket Pumped Image Analysis

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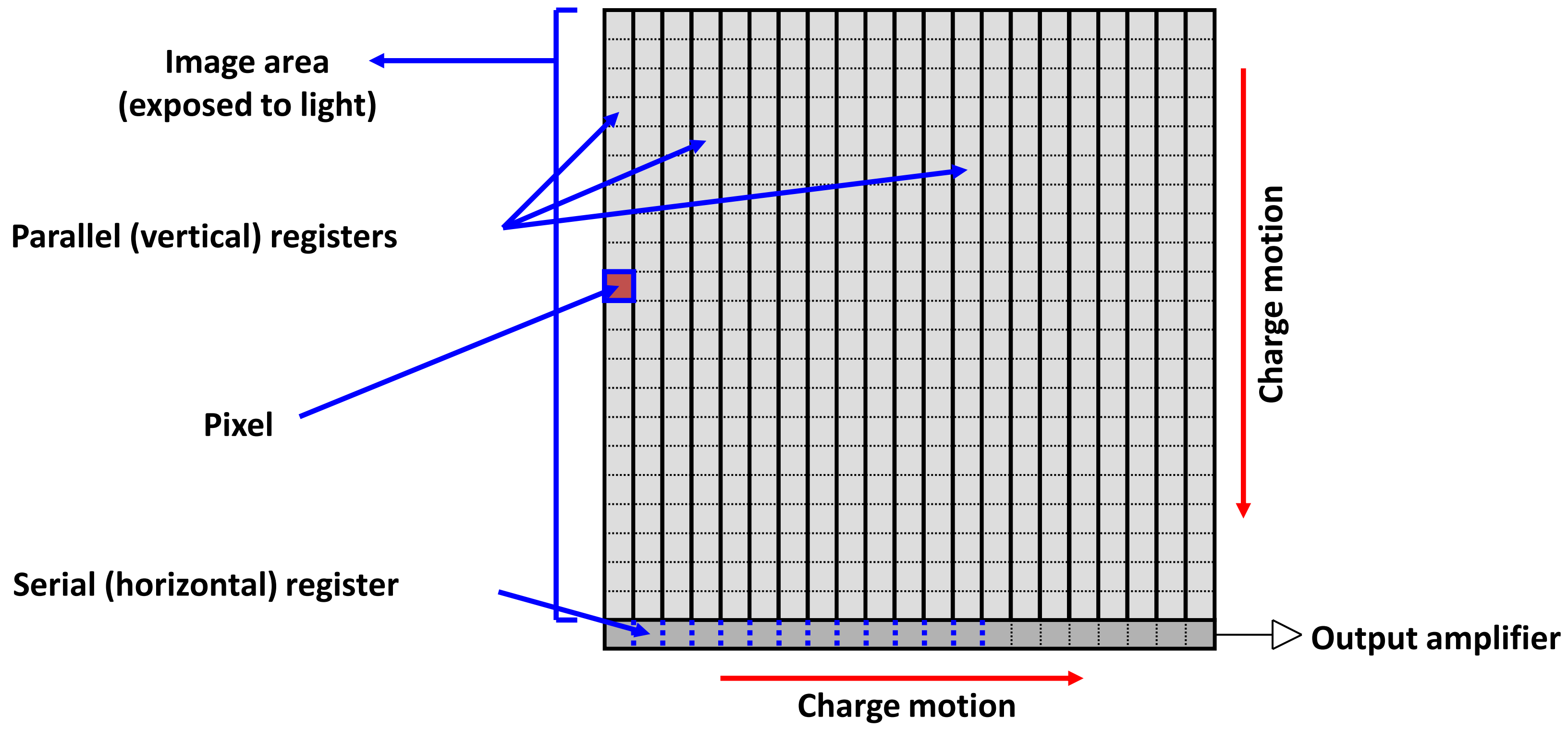
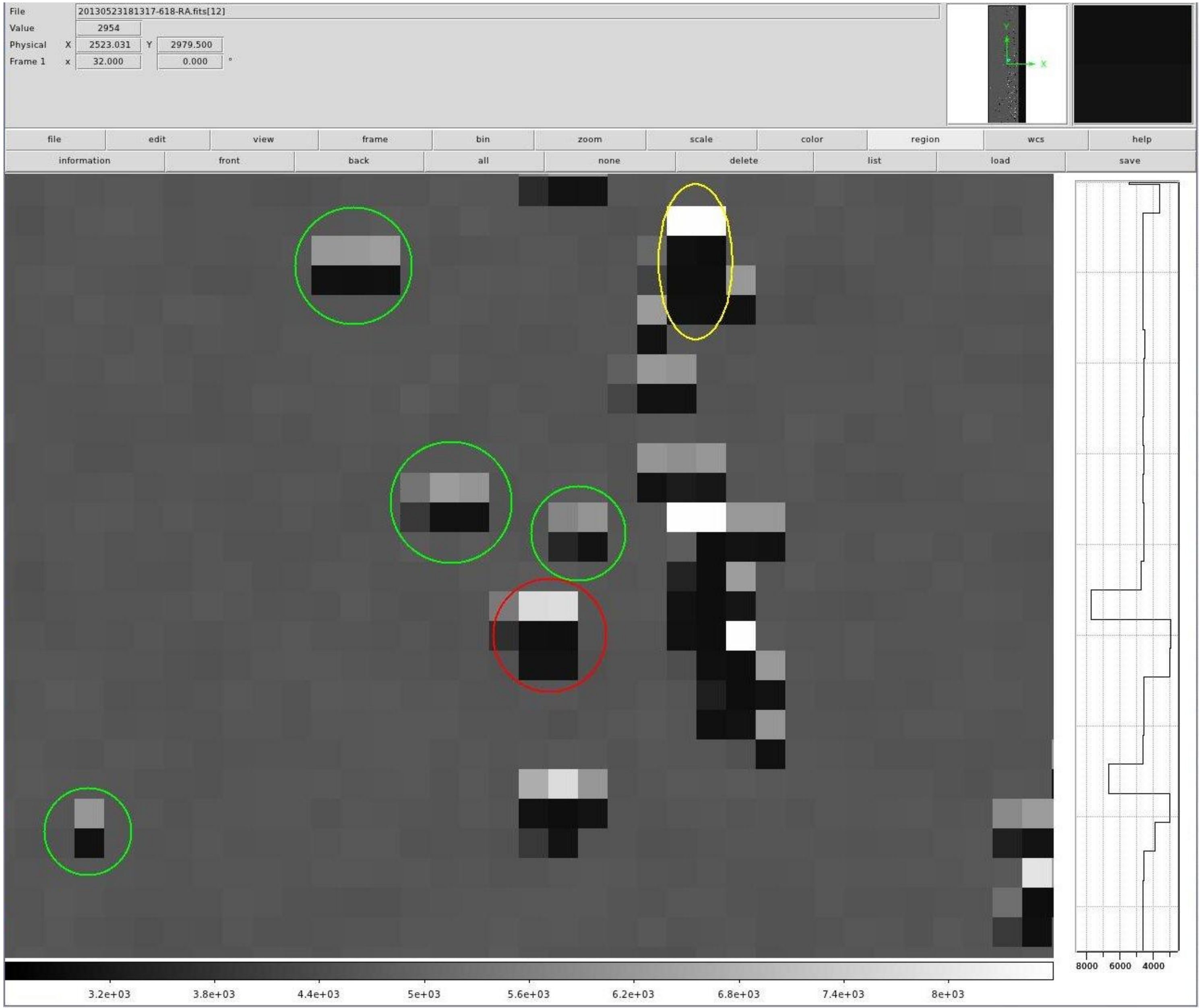
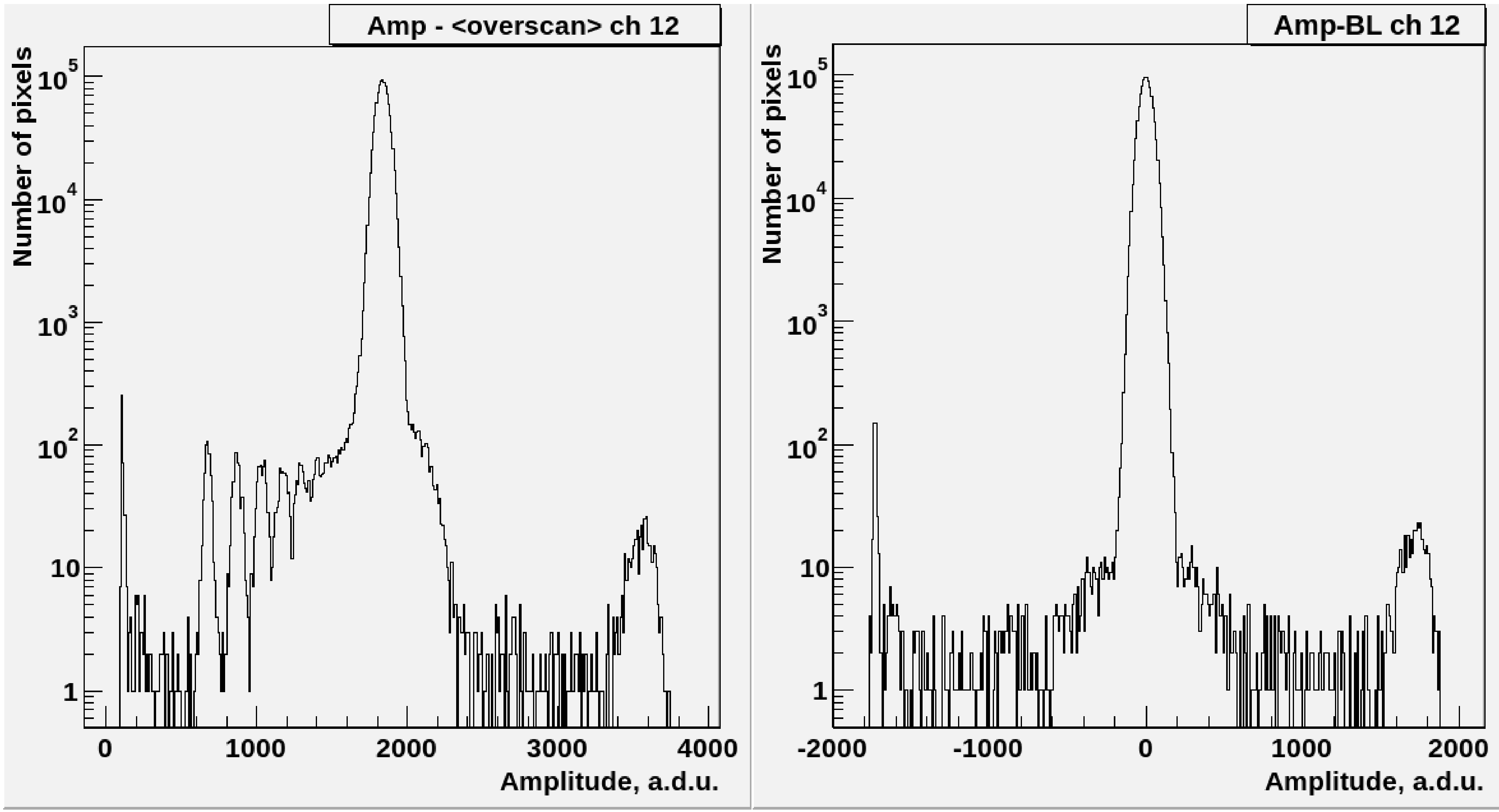
CCD Readout Architecture Terms



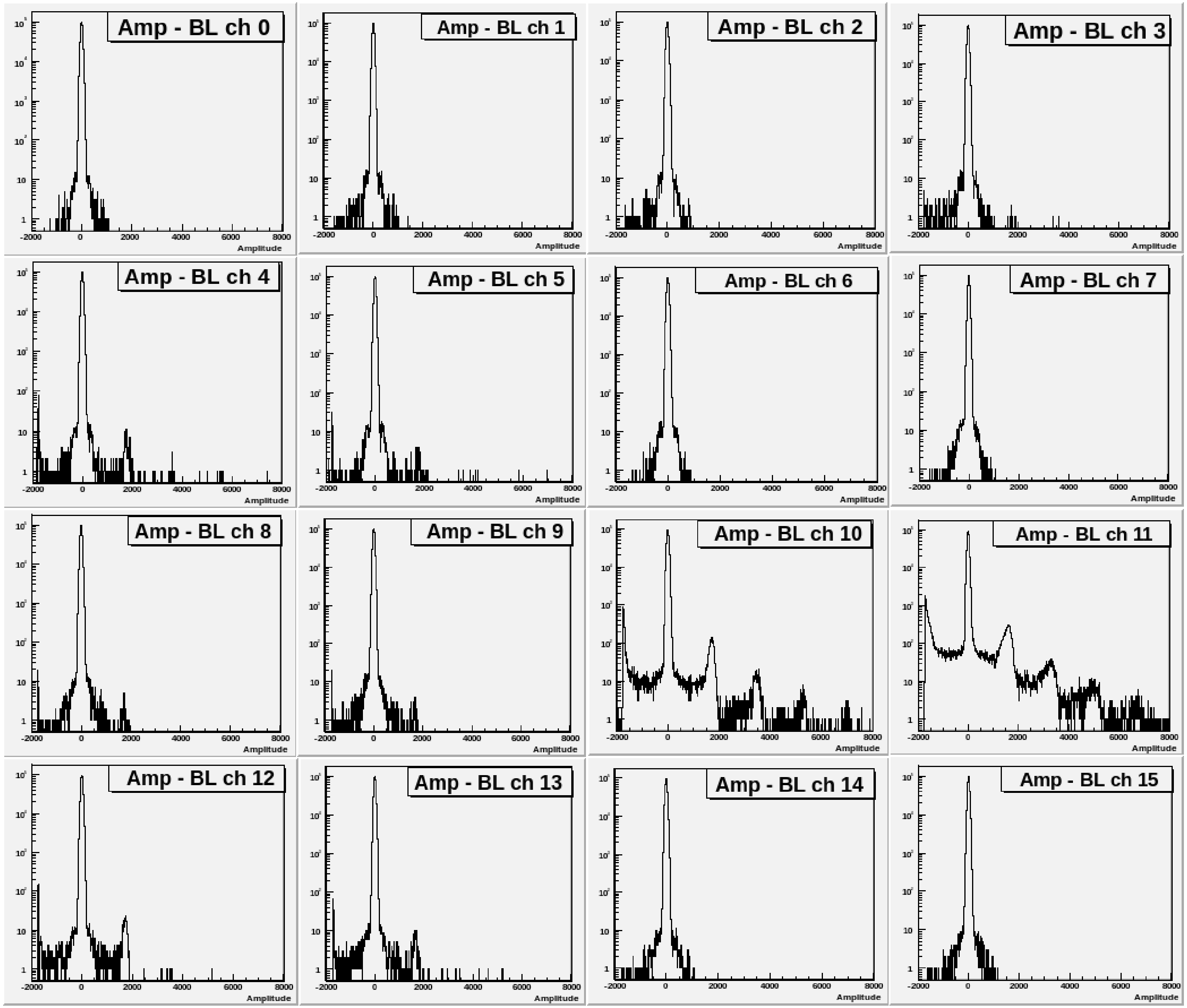
POCKET PUMPED IMAGE, ds9 viewer



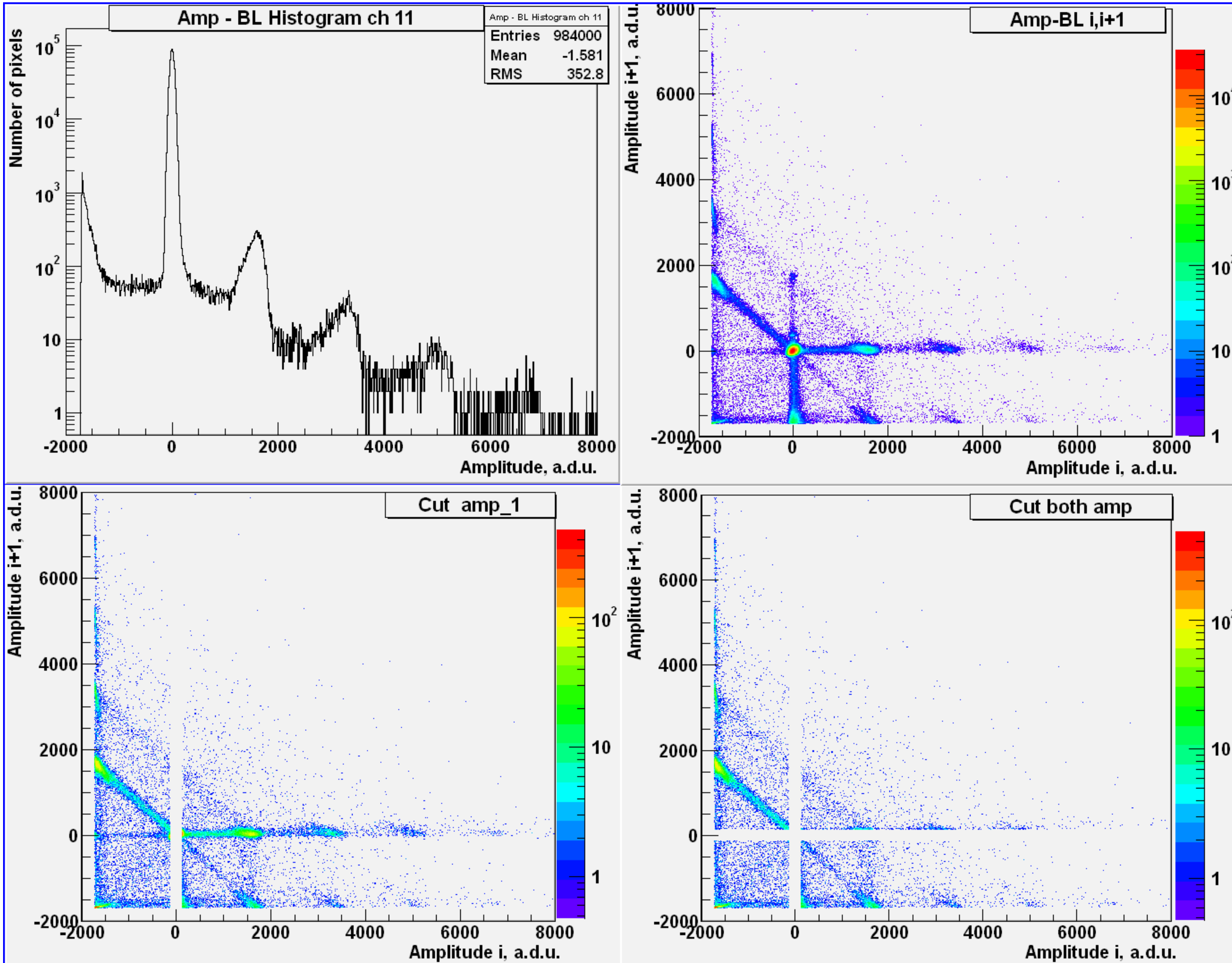
Trap identification. Amplitude distribution. Leveling the field (Base Line subtraction)



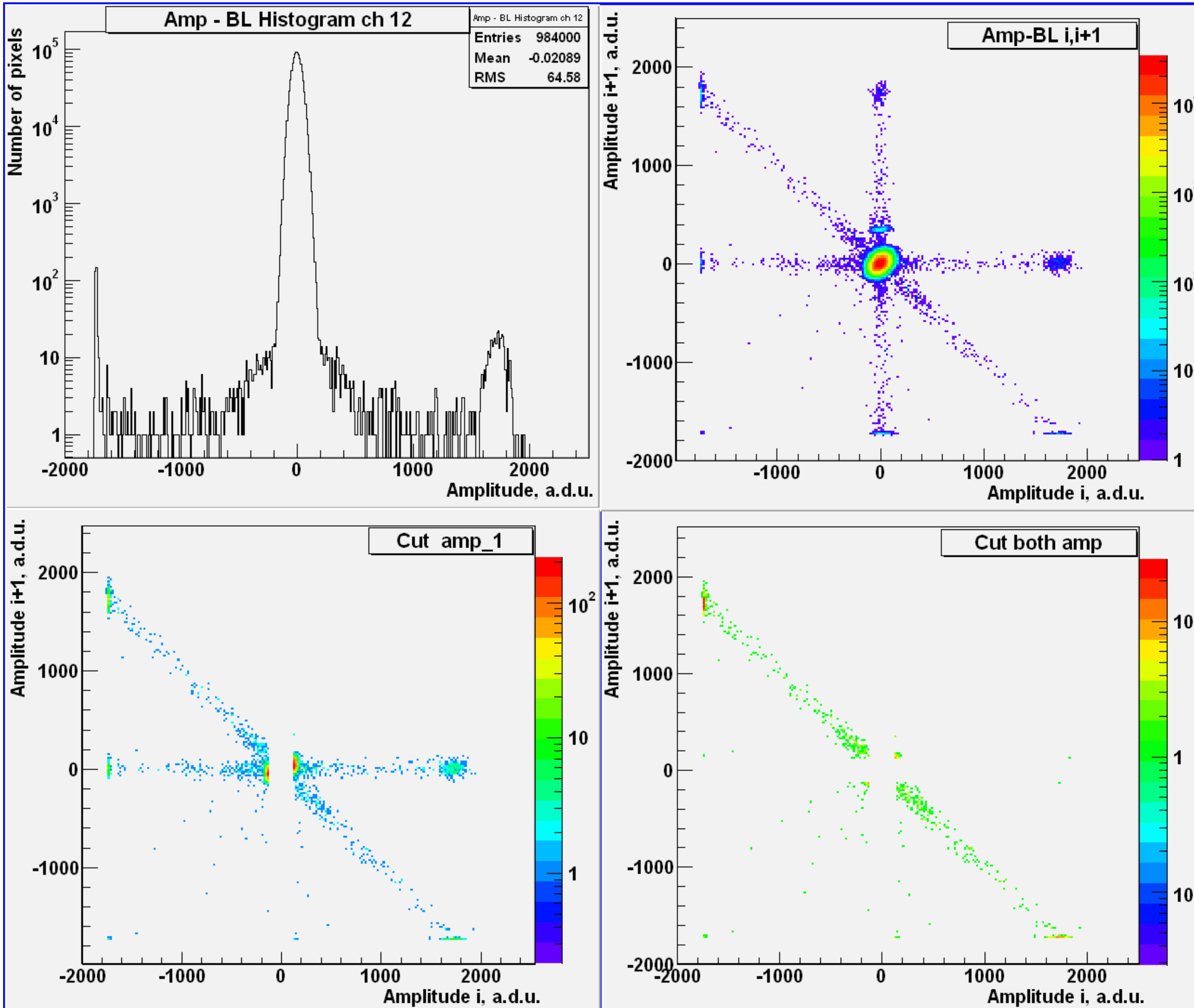
Trap identification. Amplitude distribution



Trap identification. Amplitude-Amplitude plot



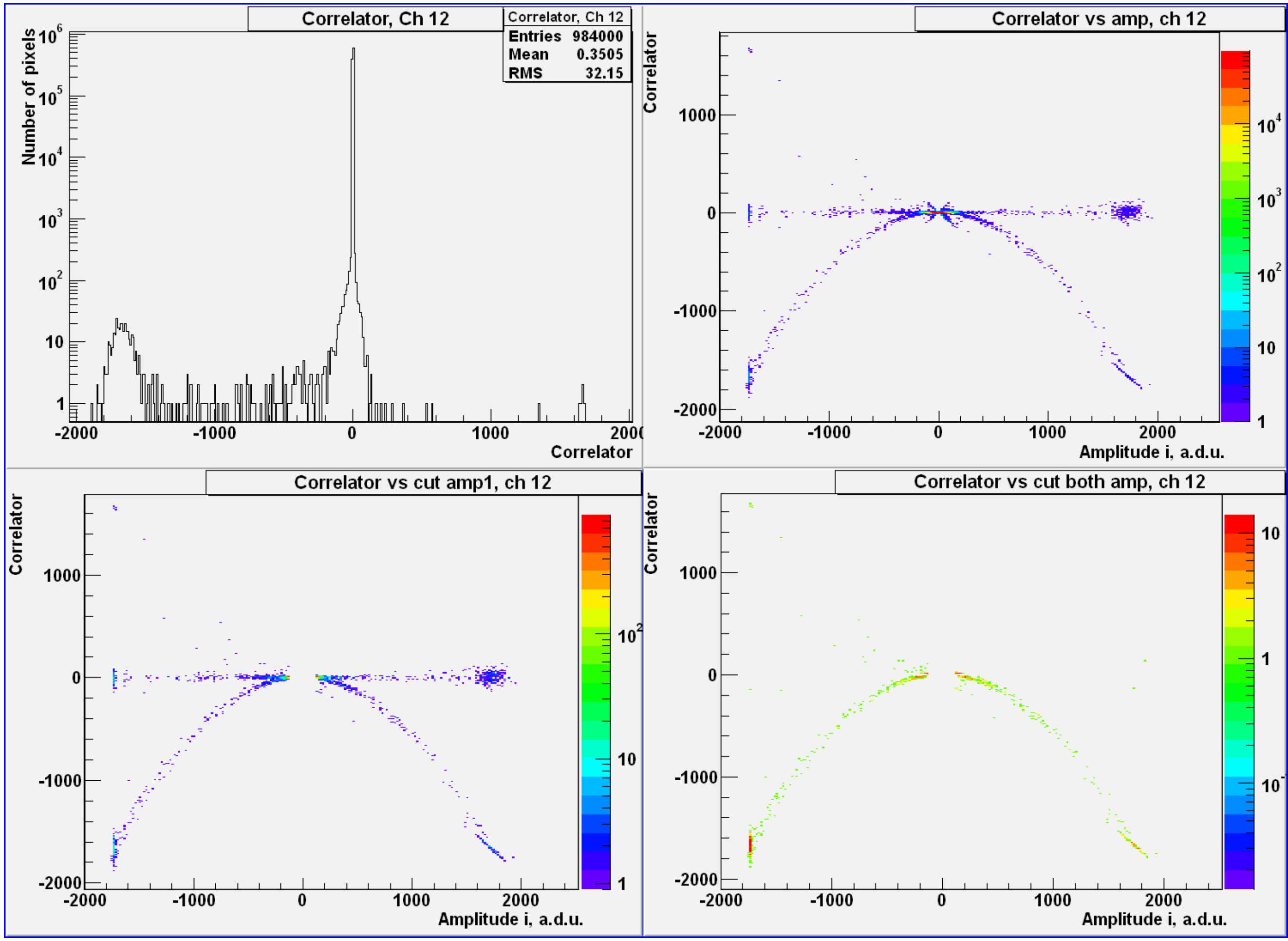
Trap identification. Amplitude-Amplitude plot



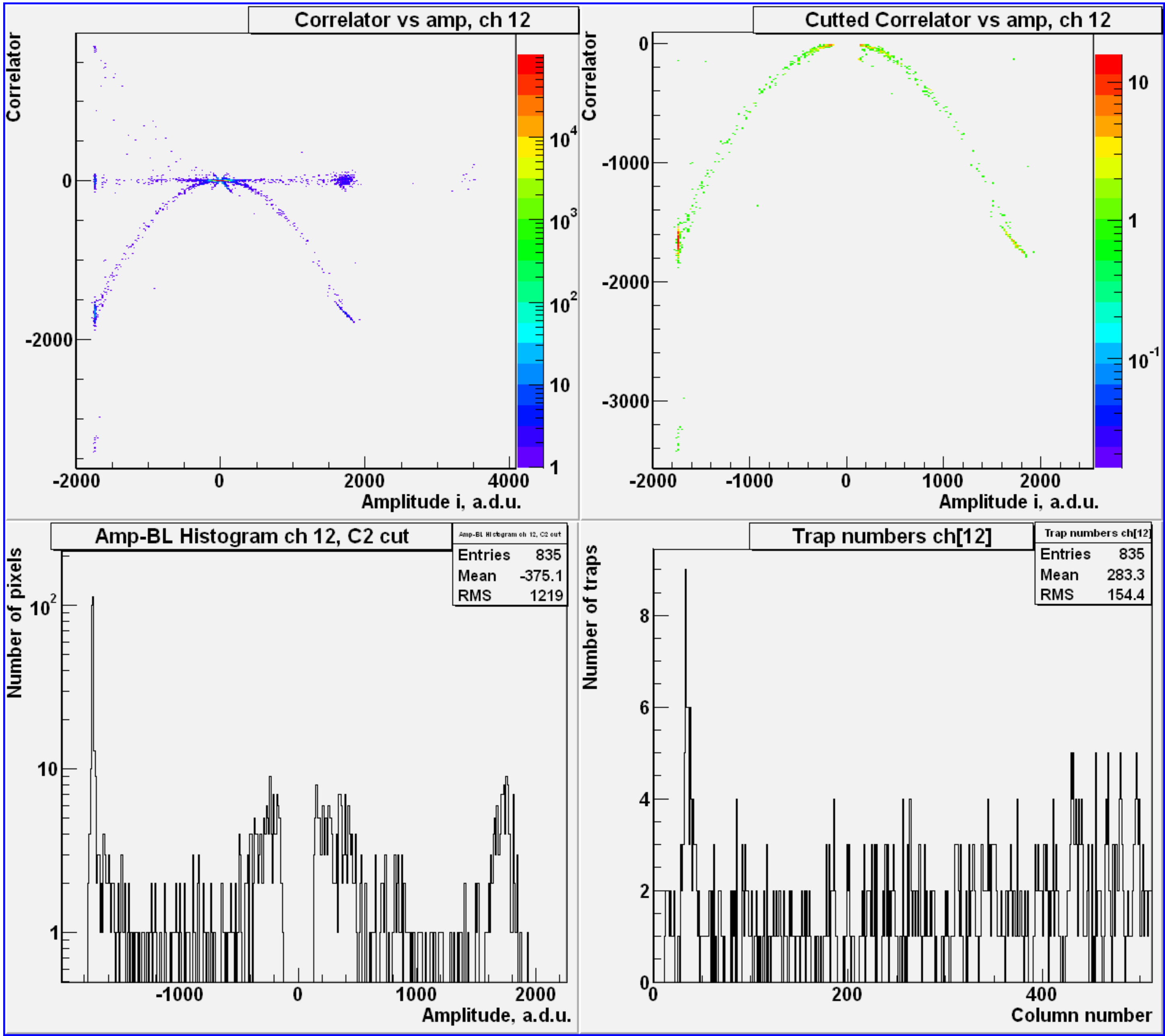
Trap identification. Correlator

$$C_2 = \frac{amp_i}{\sigma} * \frac{amp_{i+1}}{\sigma}$$

the parabolic shape is expected for amplitude dependence since amount of charge lost in one pixel is equal to amount of charge gained by another pixel and $C_2 \sim -amp^2$

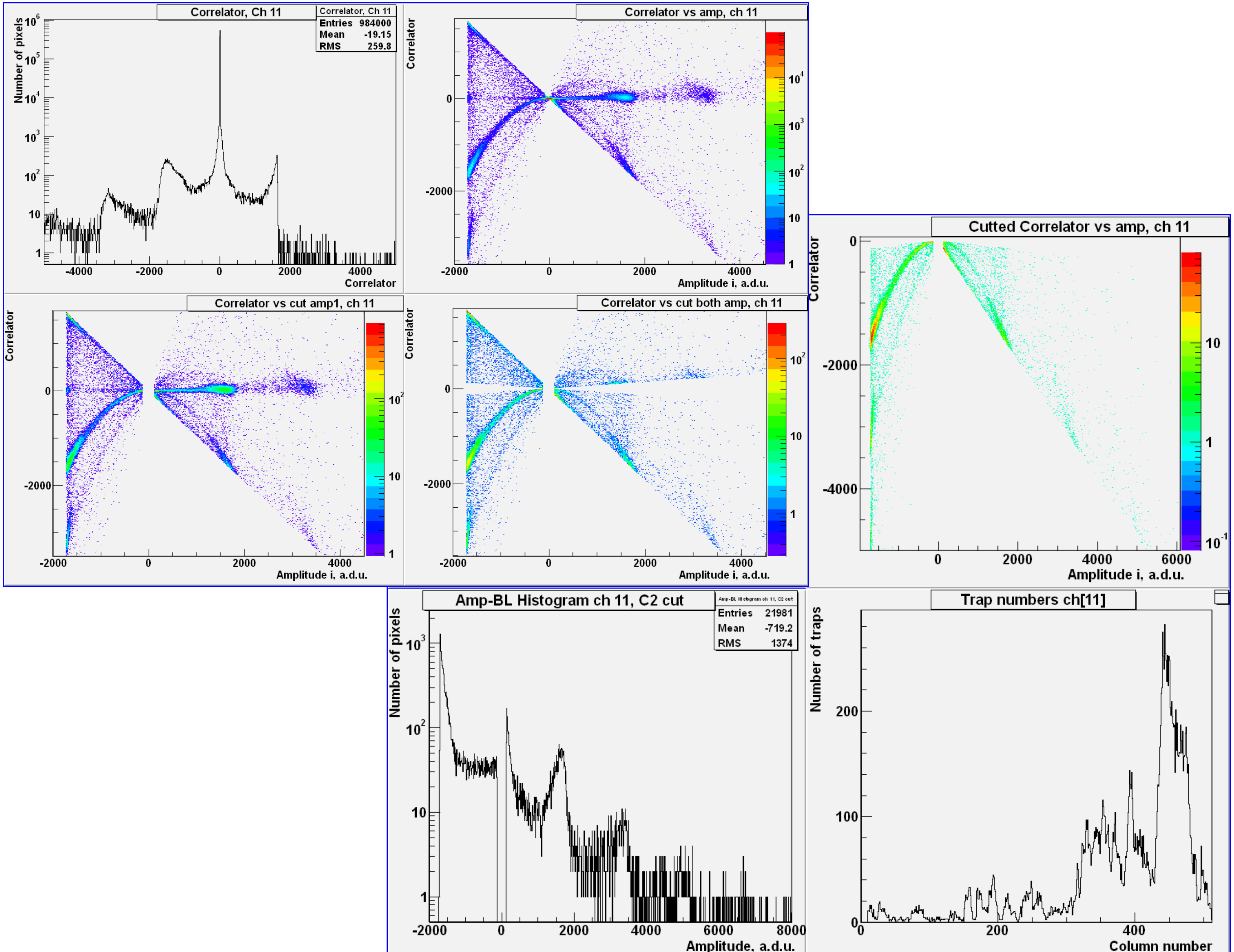


Trap count

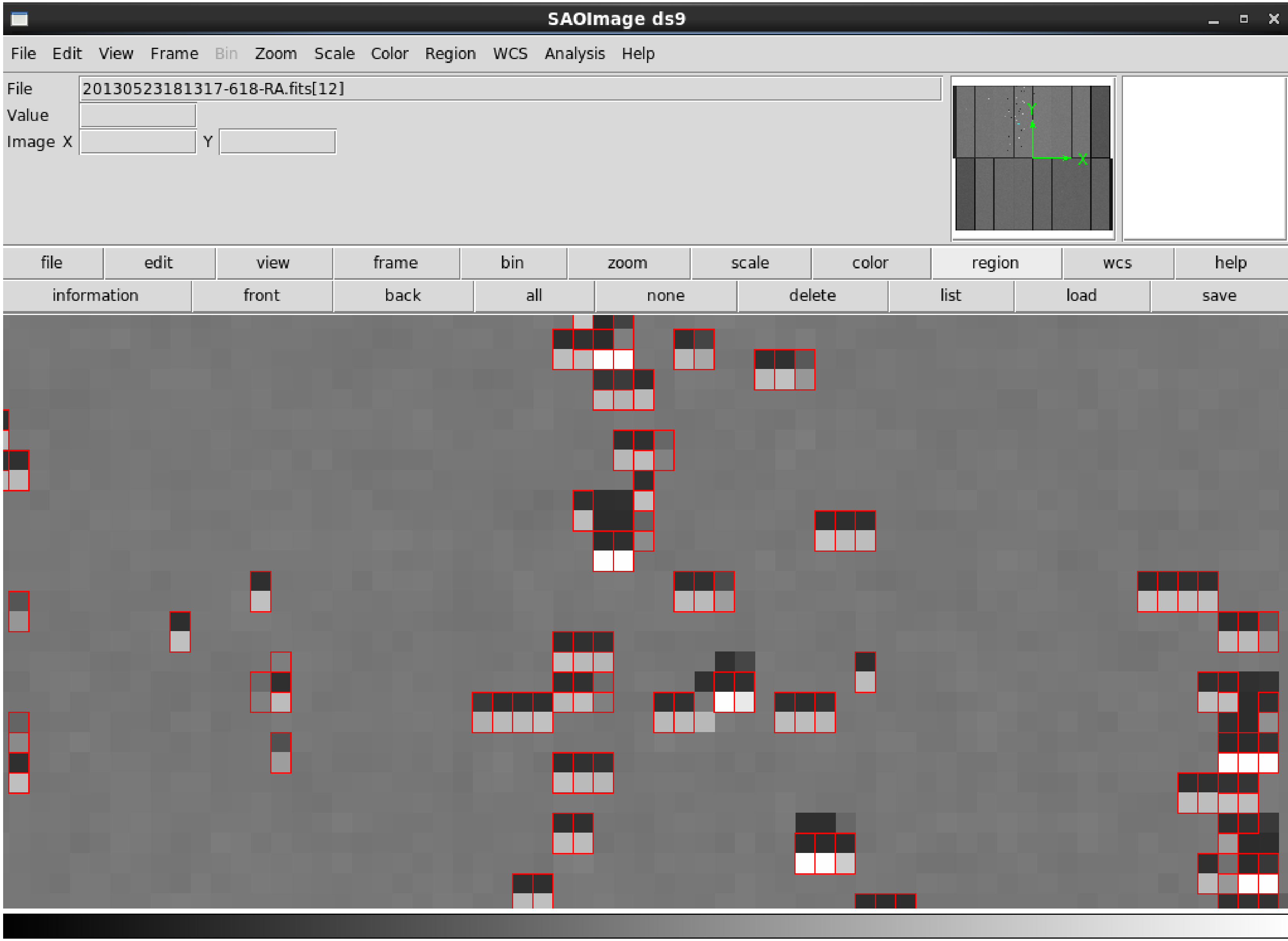


Correlator vs amp, ch 12
Correlator
Amplitude i, a.d.u.
Cutted Correlator vs amp, ch 12
Correlator
Amplitude i, a.d.u.
Amp-BL Histogram ch 12, C2 cut
Entries 835
Mean -375.1
RMS 1219
Number of pixels
Amplitude, a.d.u.
Trap numbers ch[12]
Trap numbers ch[12]
Entries 835
Mean 283.3
RMS 154.4
Number of traps
Column number

Trap count


Correlator, Ch 11
Correlator, Ch 11
Entries 984000
Mean -19.15
RMS 259.8
Number of pixels
Correlator
Correlator vs amp, ch 11
Correlator
Amplitude i, a.d.u.
Cutted Correlator vs amp, ch 11
Correlator
Amplitude i, a.d.u.
Correlator vs cut amp1, ch 11
Correlator
Amplitude i, a.d.u.
Correlator vs cut both amp, ch 11
Correlator
Amplitude i, a.d.u.
Amp-BL Histogram ch 11, C2 cut
Entries 21981
Mean -719.2
RMS 1374
Number of pixels
Amplitude, a.d.u.
Trap numbers ch[11]
Number of traps
Column number

Trap catalog



POCKET PUMPED IMAGE. CONCLUSION

Trap identification technique has been developed.

This technique works on pocket pumped images.

- traps can be counted in individual columns, rows etc
- trap location can be reported as well, for example, trap catalog can be generated

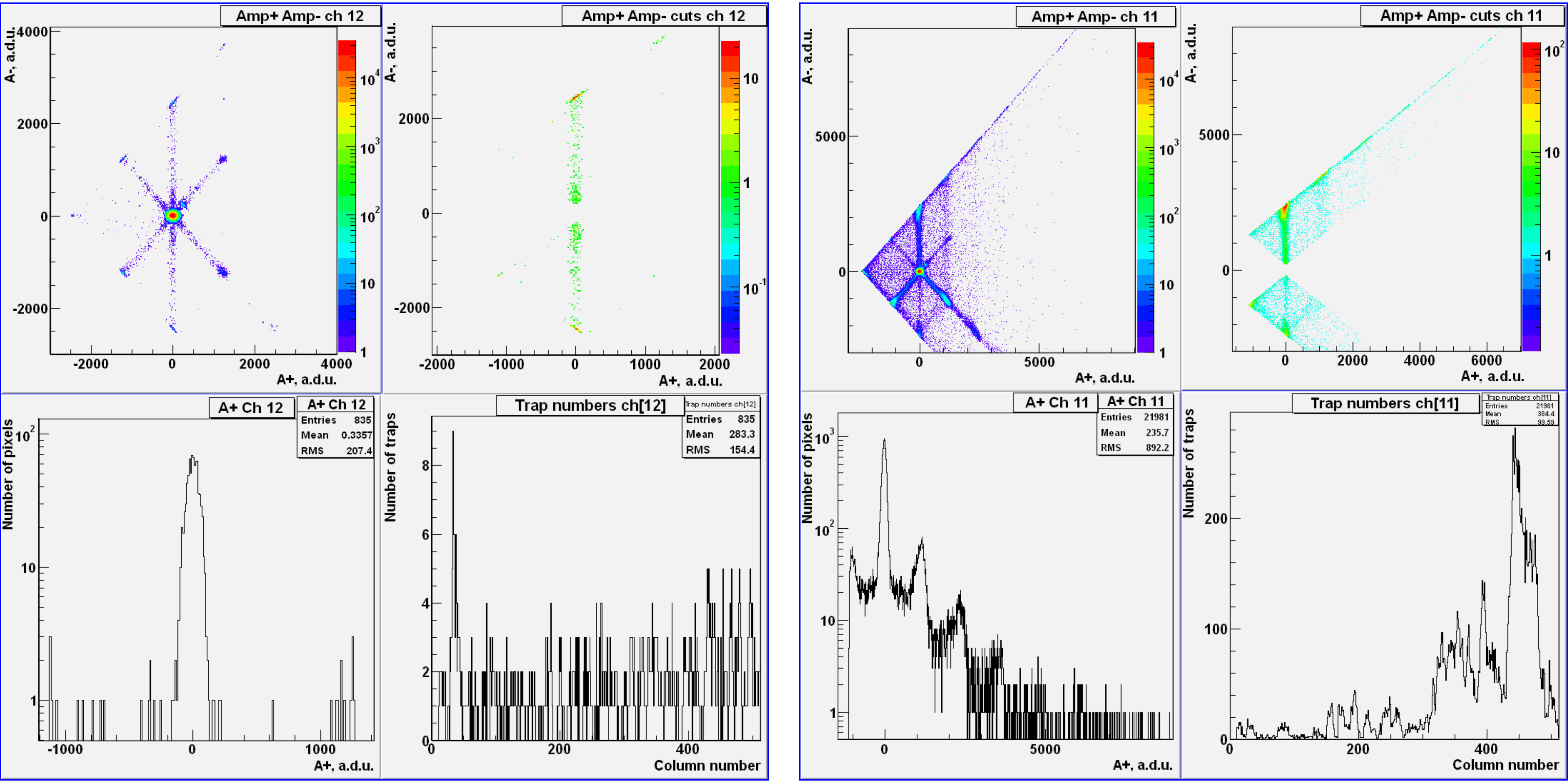
Back up slides

Transformations

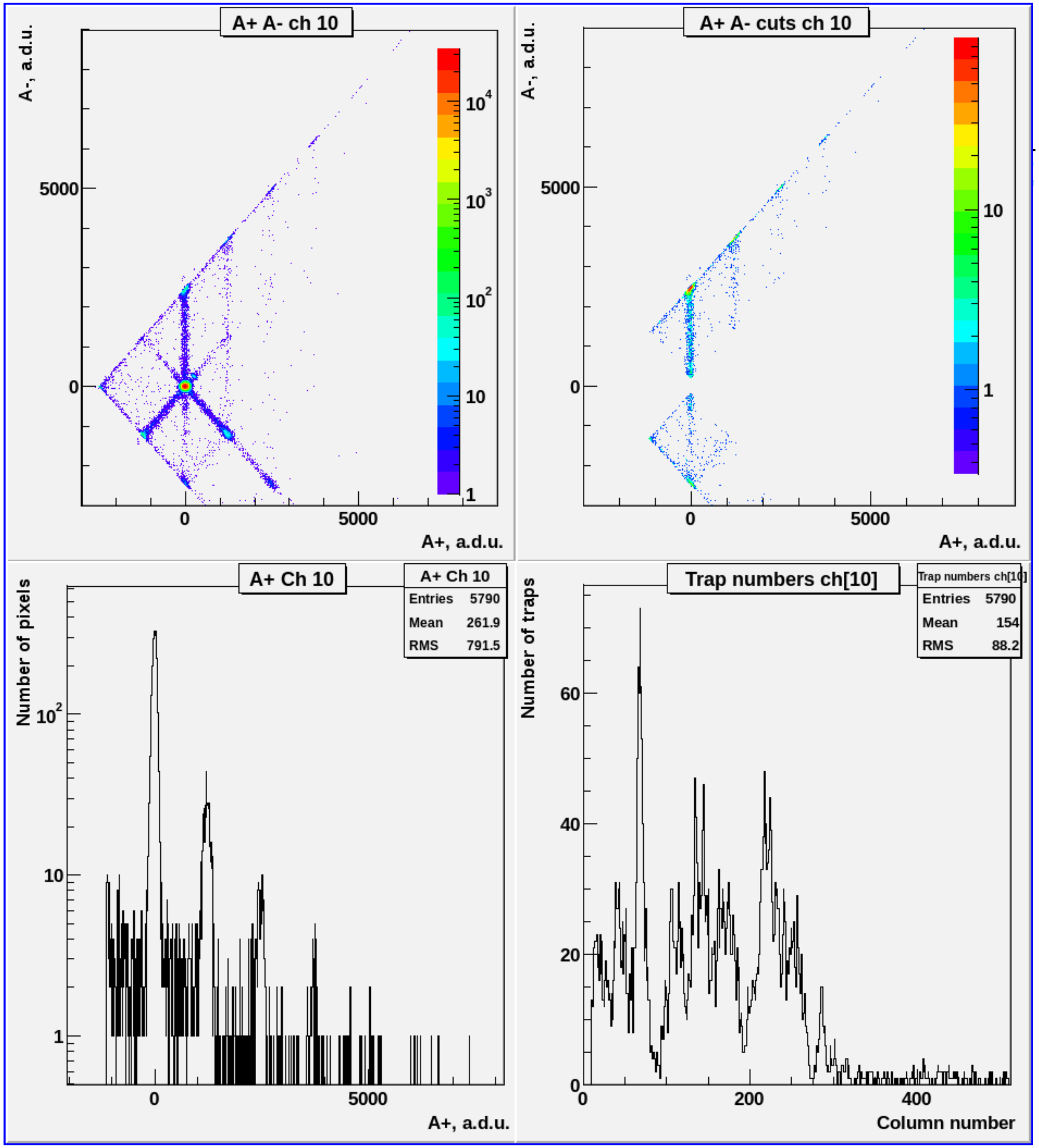
The selection of trap bands in the amplitude scatter plot can be simplified using coordinate system transformation.
The useful transformation is rotation by 45 degree

$$A+ = (amp_i + amp_{i+1})/\sqrt{2}$$

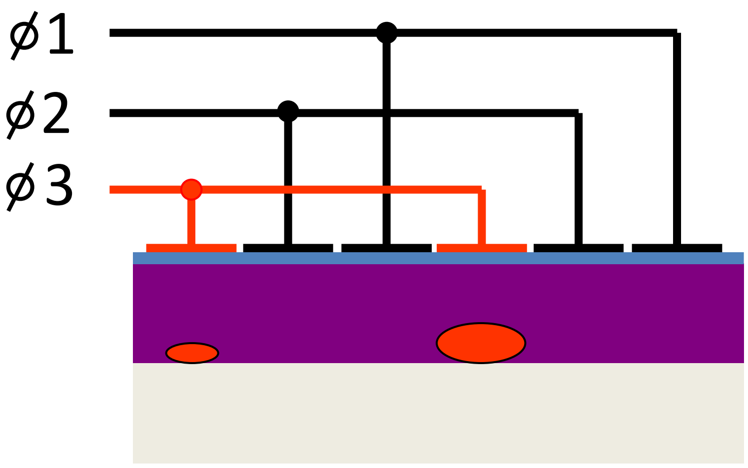
$$A- = (amp_{i+1} - amp_i)/\sqrt{2}$$

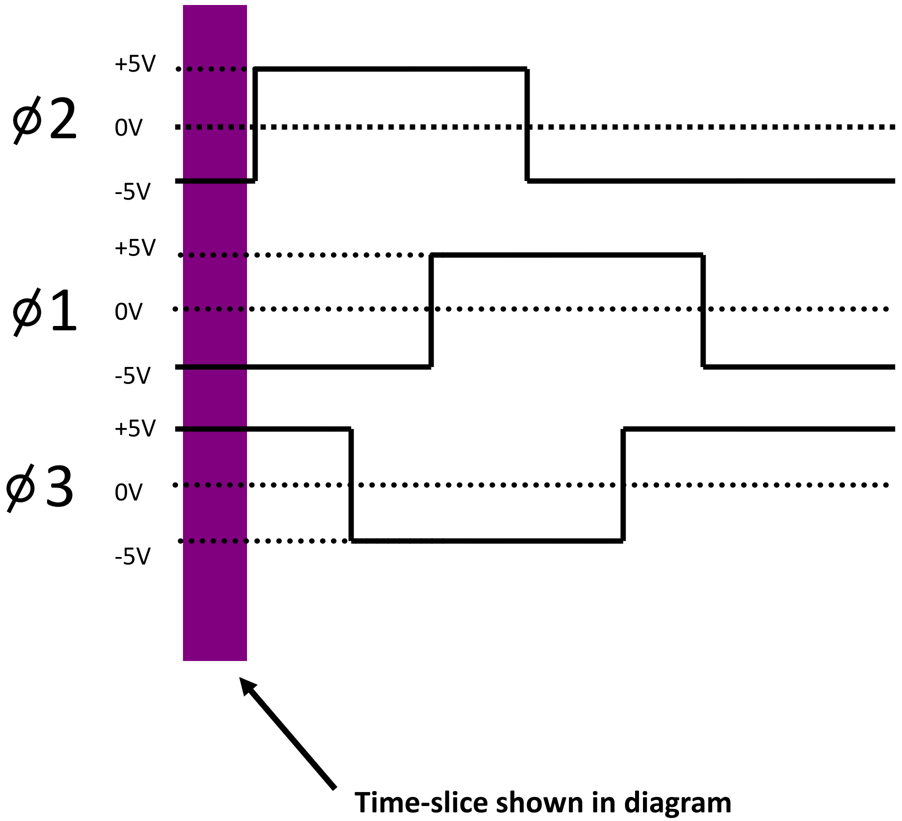


Transformations

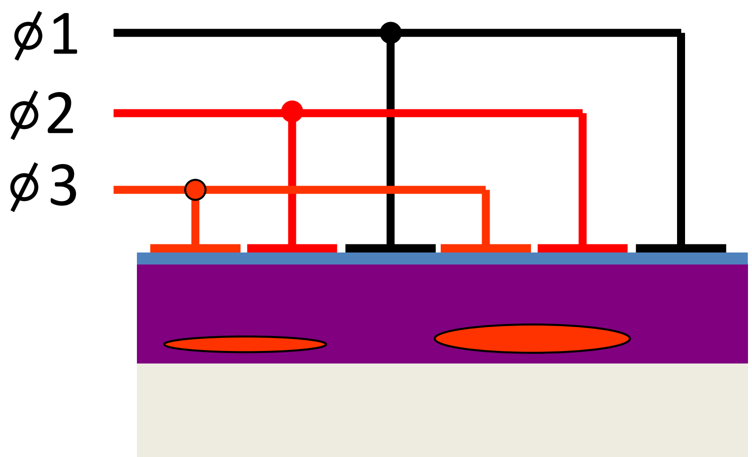


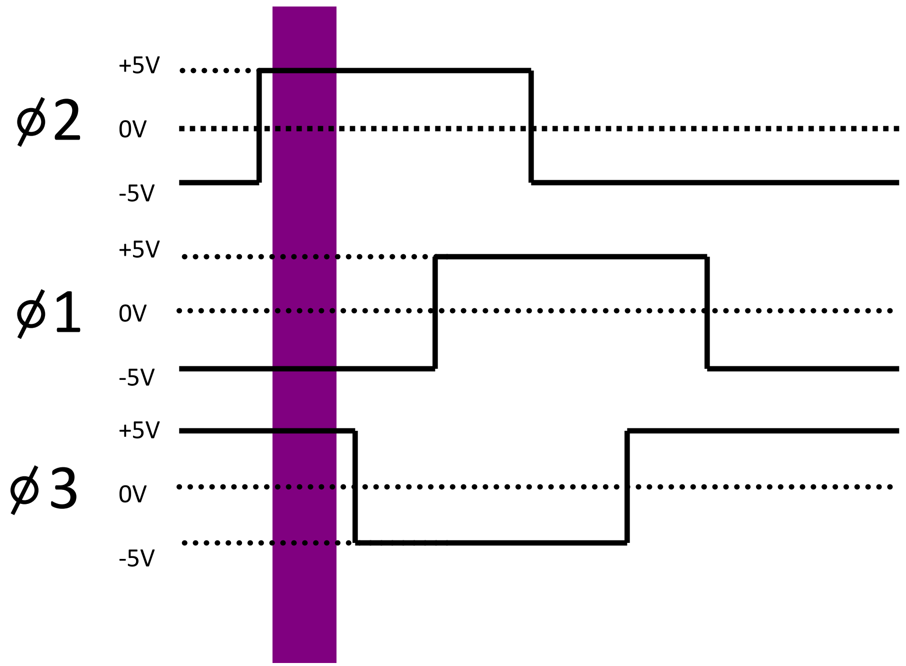
CCD Phased Clocking: Step 1



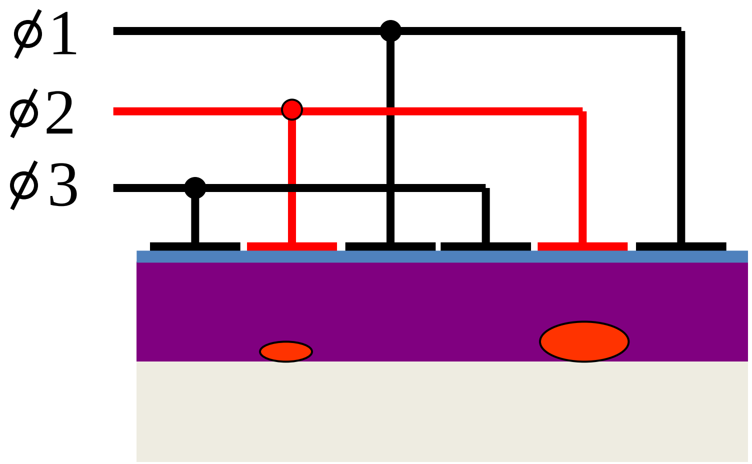


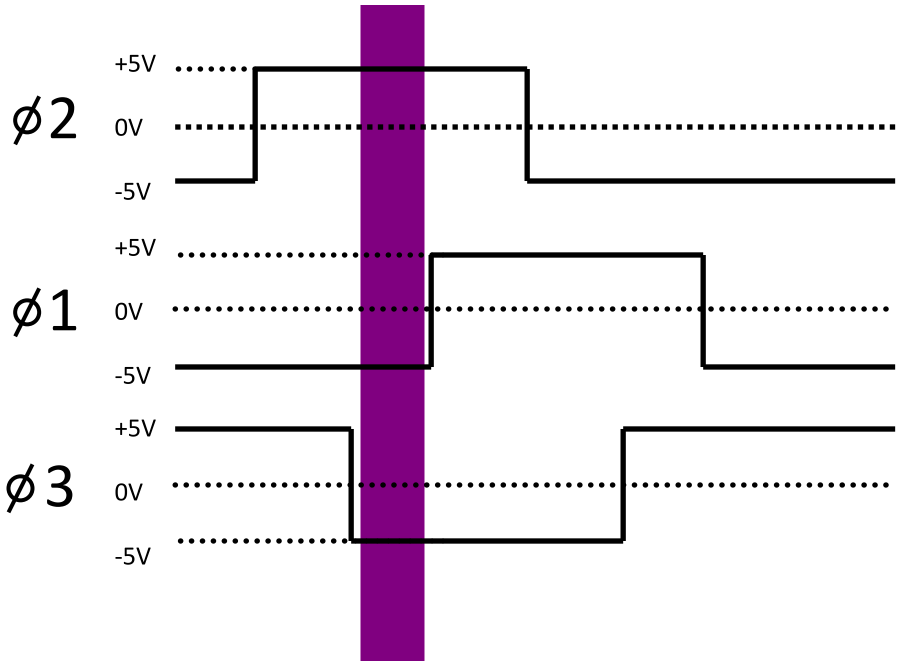
CCD Phased Clocking: Step 2





CCD Phased Clocking: Step 3





Charge Transfer Efficiency

CTE = Charge Transfer Efficiency (typically 0.9999 to 0.999999)
= fraction of electrons transferred from one pixel to the next

CTI = Charge Transfer Inefficiency = 1 – CTE (typically 10^{-6} to 10^{-4})
= fraction of electrons deferred by one pixel or more

Cause of CTI:
charges are trapped (and later released) by defects in the silicon crystal lattice

CTE of 0.99999 used to be thought of as pretty good but ….

Think of a 2K x 0.5K CCD segment

The Wallet Card

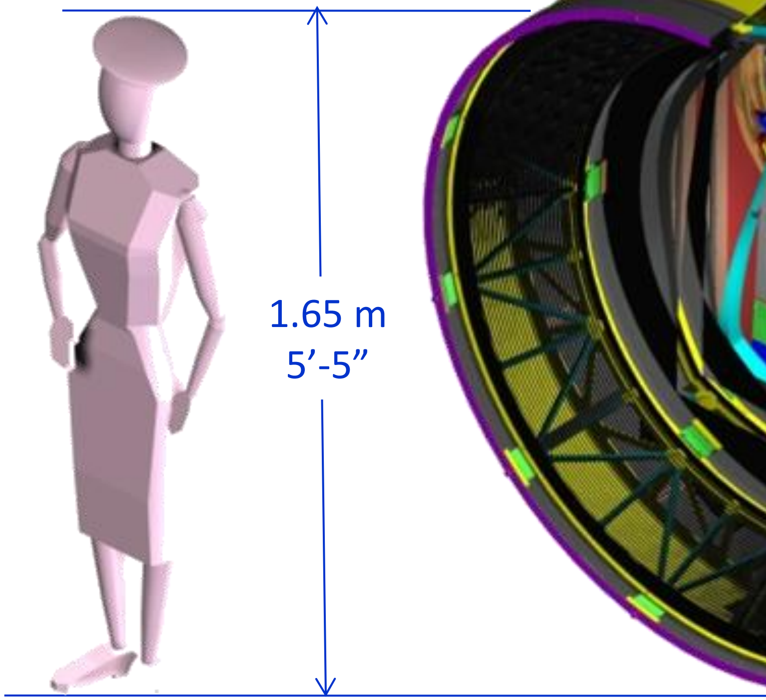
- Three Mirror Anastigmat (TMA) optical design.
  - 8.4 meter primary, 6.5 meter effective aperture
  - 3.4 meter diameter secondary
  - 5 m tertiary is being fabricated in same substrate as primary mirror
  - three-element refractive corrector
  - f/1.2 beam delivered to camera
  - 9.6 square degree field (on science imaging pixels)
  - optics deliver < 0.2 arcsec FWHM spot diagram,
  - 6 filters: ugrizy: 320 nm to 1050 nm (UV atmospheric cutoff to Si bandgap)

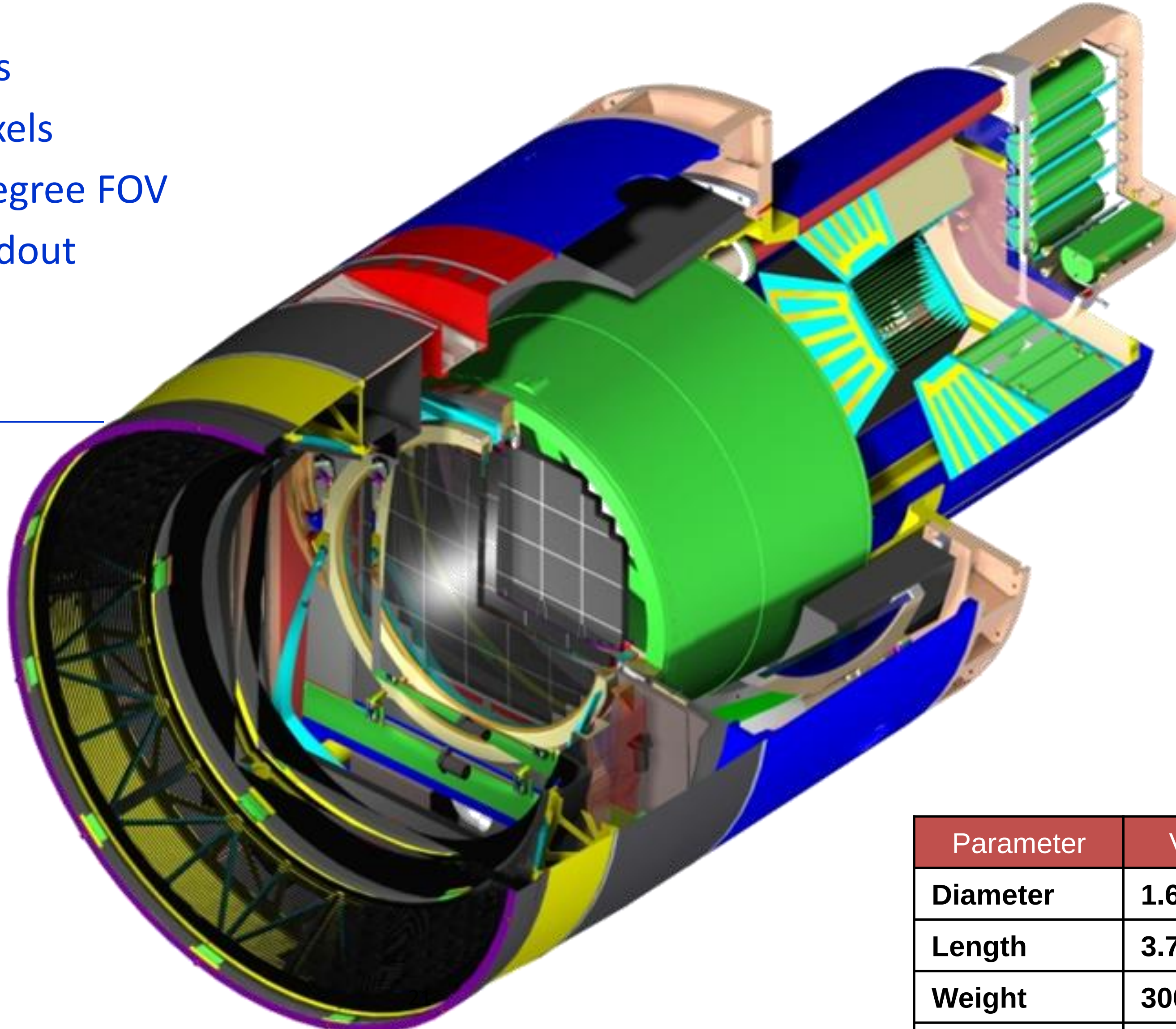
- 3.0 Gpixel camera
  - 10 micron pixels, 0.2 arcsec/pixel
  - Deep depletion (100 μm), high-resistivity CCDs for NIR response
  - Dual 15 second exposures (to avoid trailing of solar system objects)
    - 2 second readout (trade between noise and imaging efficiency)
    - 550 kpix/sec through 16 amps/CCD x 189 CCDs = 3024 channels
    - 12 GBytes per image (as floating point numbers), 20 TBytes/night.

- Real-time frame subtraction for time domain alerts, ~850 visits for each patch of sky, allows co-adds to r ~ 27 (AB), over 18,000 square degrees.

Camera

- 3.2 Gigapixels
- 0.2 arcsec pixels
- 9.6 square degree FOV
- 2 second readout
- 6 filters





Parameter	Value
Diameter	**1.65 m**
Length	**3.7 m**
Weight	**3000 kg**
F.P. Diam	**634 mm**

Primary/Tertiary in Fabrication, completion in 2014

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