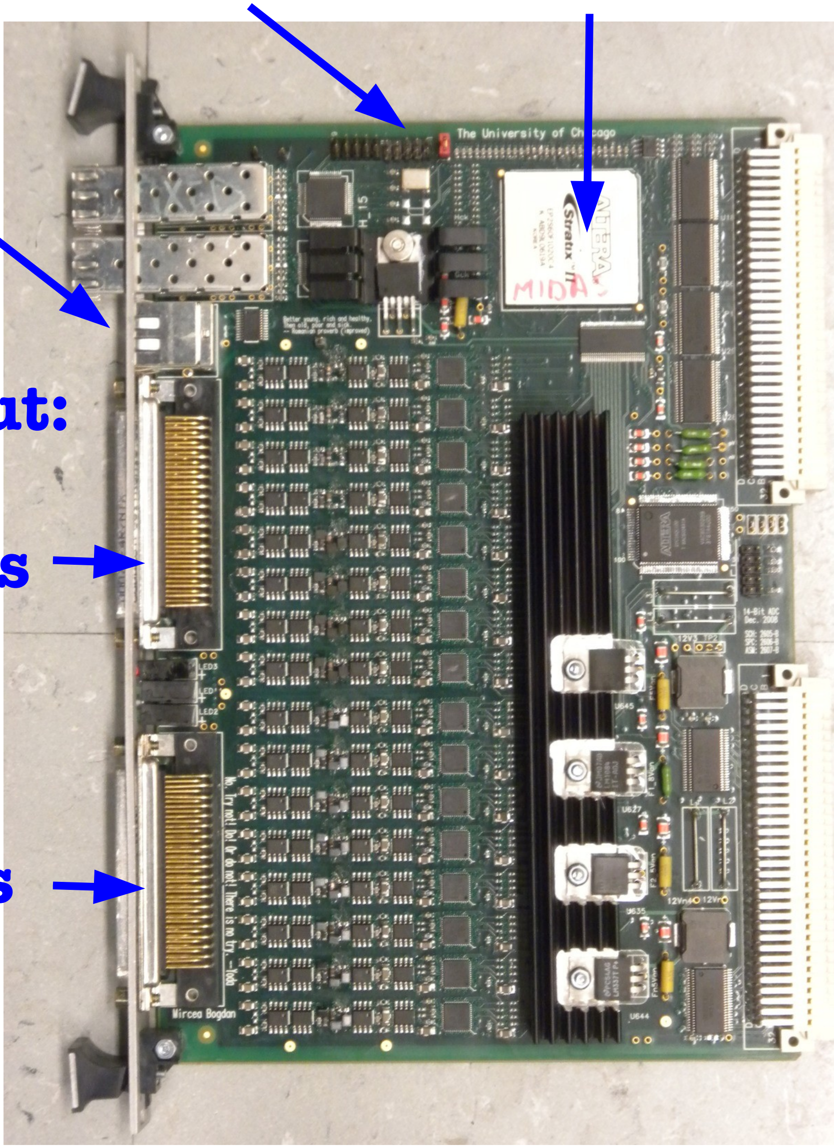
# **MIDAS**: Trigger system

**Microwave Workshop**
**Chicago, October 6th 2010**

# FADC boards



**Debug pins**

**FPGA**

**LVDS**

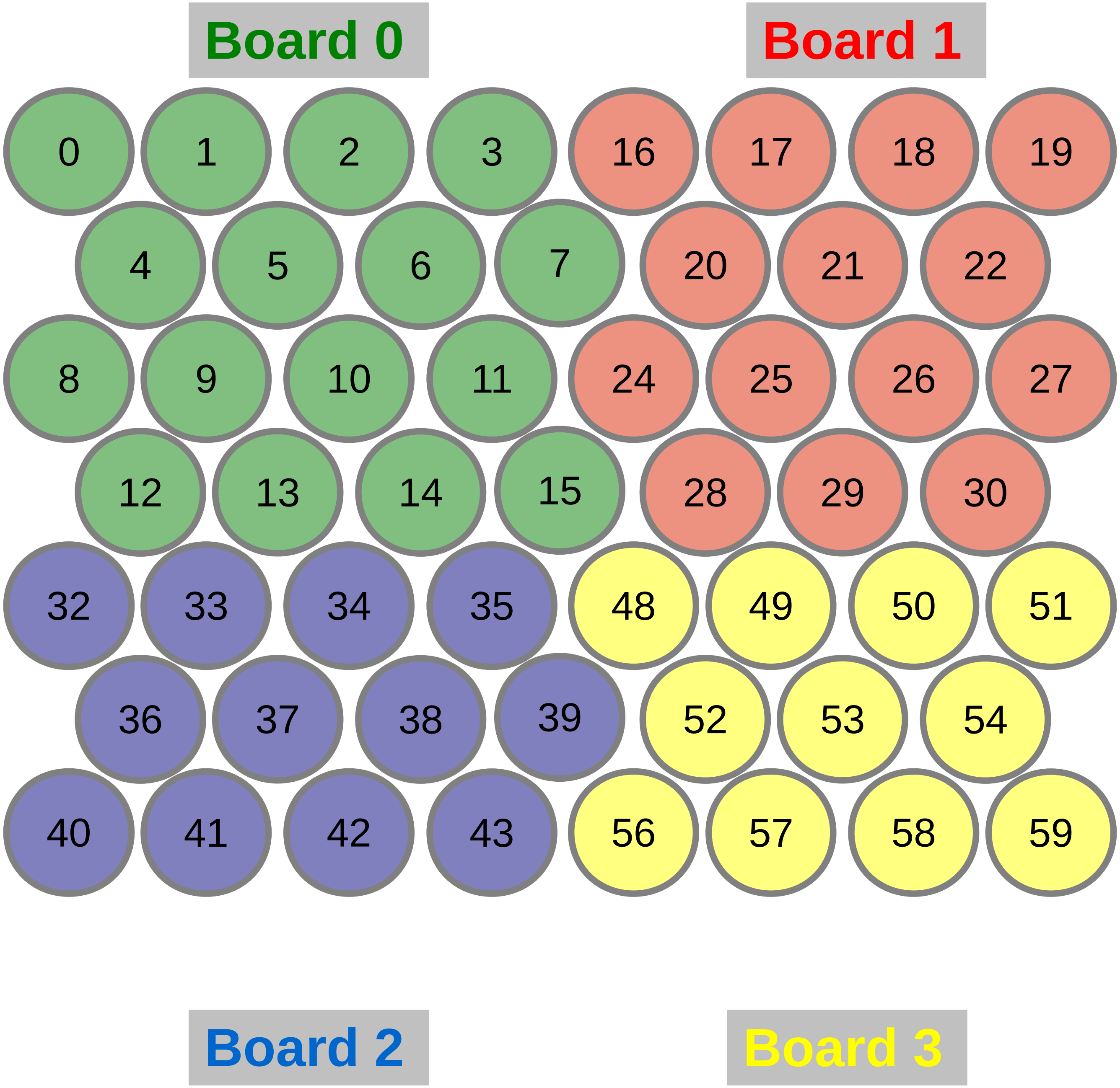
**Analog input:**

**8 channels**

**+**

**8 channels**

- FADC boards designed at UofC.
- 16 14-bit FADCs per board.
- Sampling frequency of 20 MHz => 50 ns.
- 4 independent boards to control the whole camera and 1 master board to coordinate the triggers from the 4 slave boards.



**Board 0**

**Board 1**

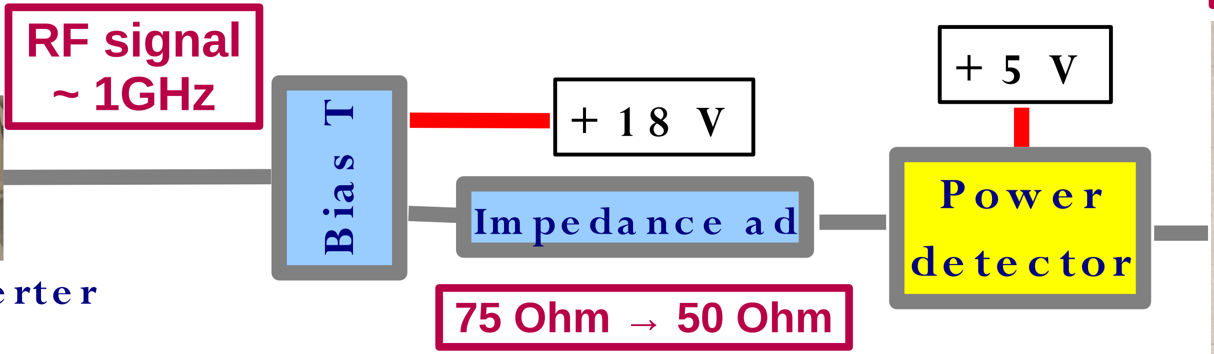
**Board 2**

**Board 3**

# Analog Electronics

RF signal
3.4-4.2 GHz

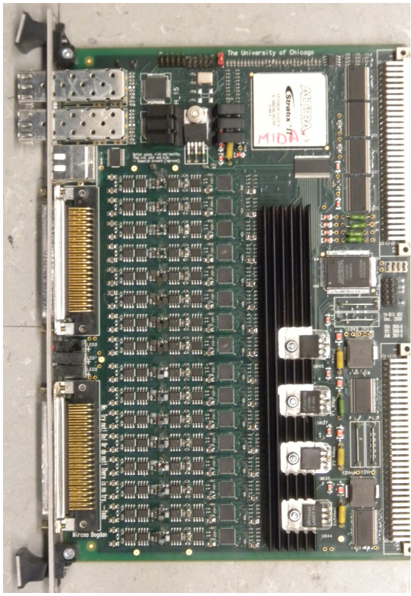
Feed & down-converter

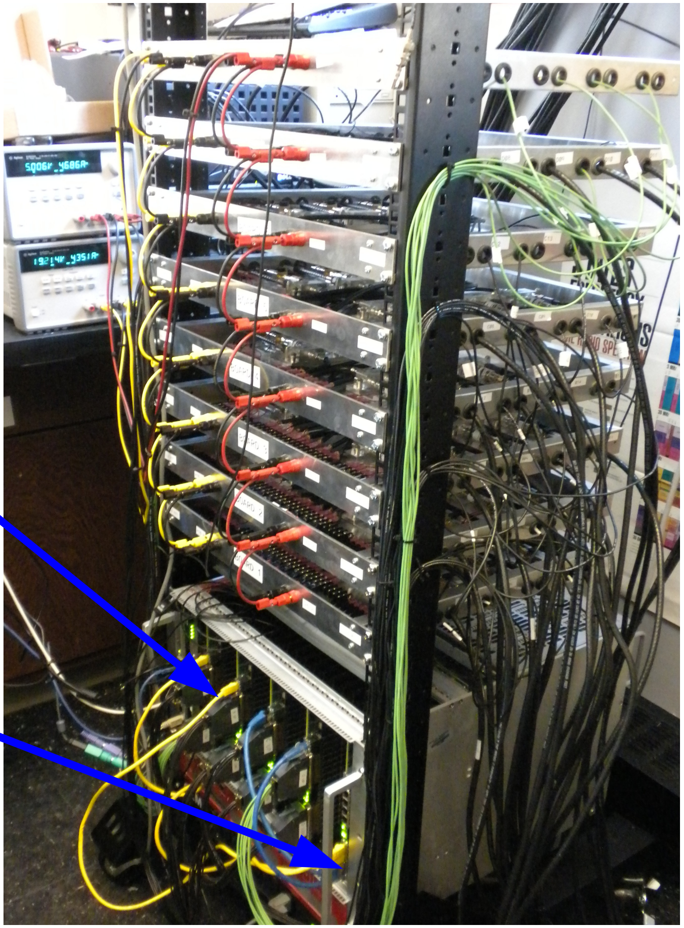


RF signal
~ 1GHz

75 Ohm → 50 Ohm

DC signal to
the ADC board





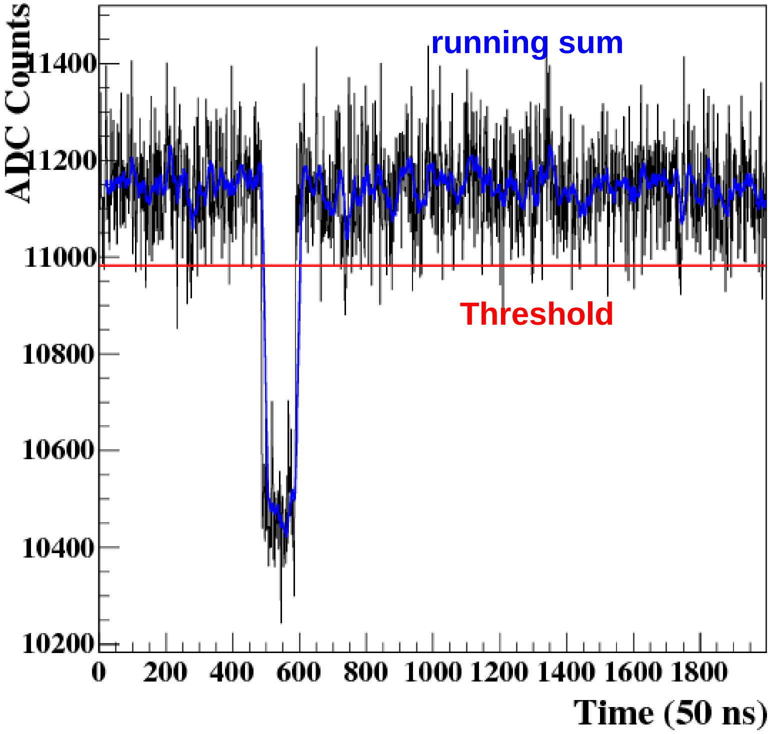
**ADC boards**

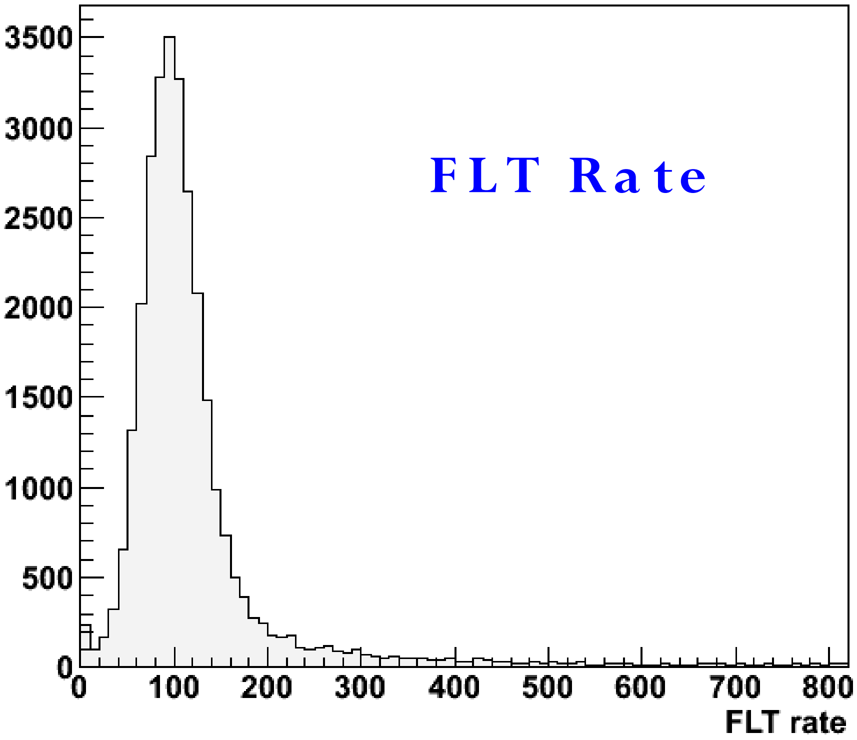
**Master board**

# First Level Trigger (FLT)

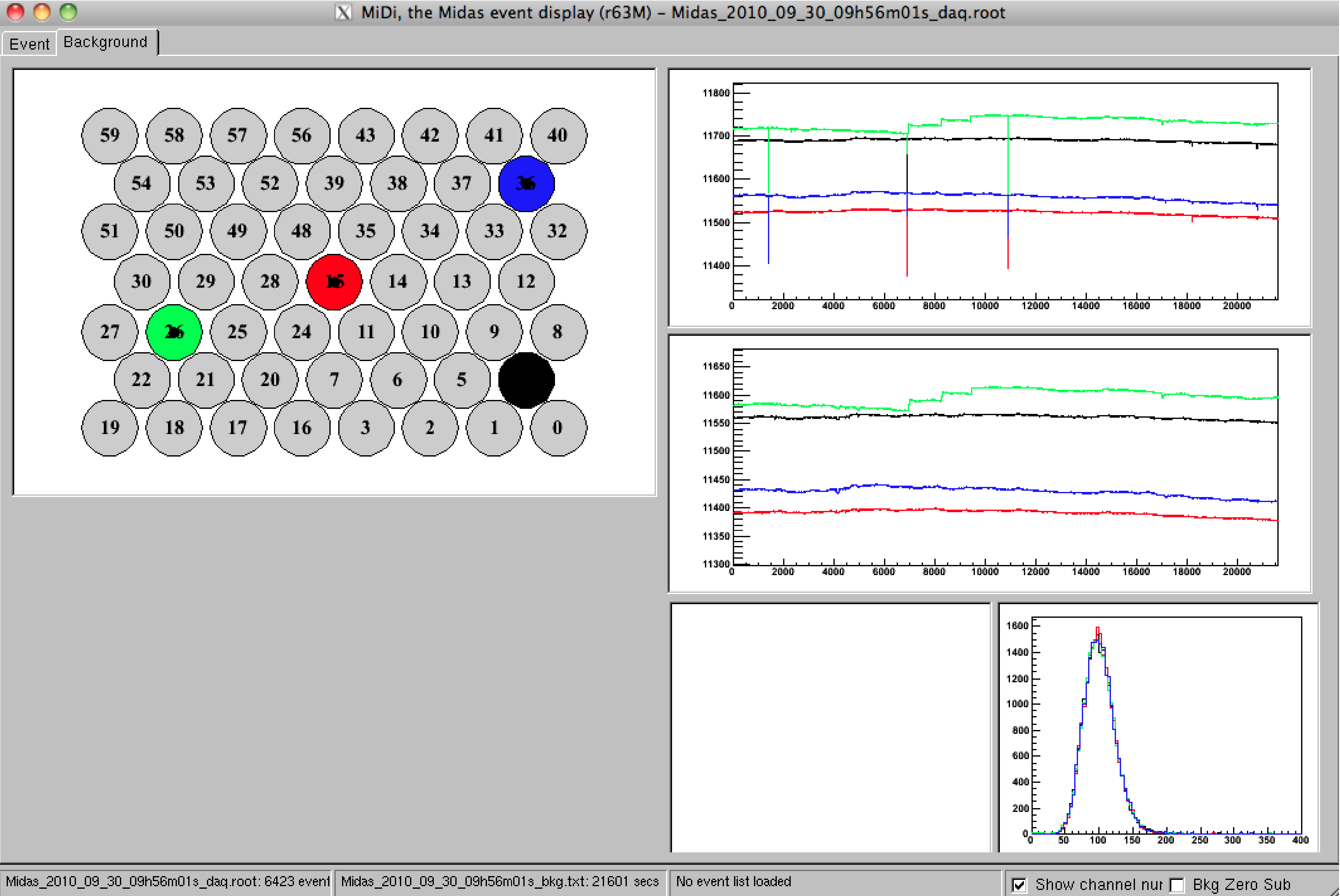
- Trigger at pixel level.
- The running sum of 20 bins (1 s) exceeding a certain threshold.
- This threshold is regulated to ensure a FLT rate per channel of 100 Hz.
- The FLT status is extended for 20 s to allow for coincidences.

**10 s (cross-checked with simulations)**





# MiDi (6 h run) with filters



MiDi, the Midas event display (r63M) – Midas_2010_09_30_09h56m01s_daq.root

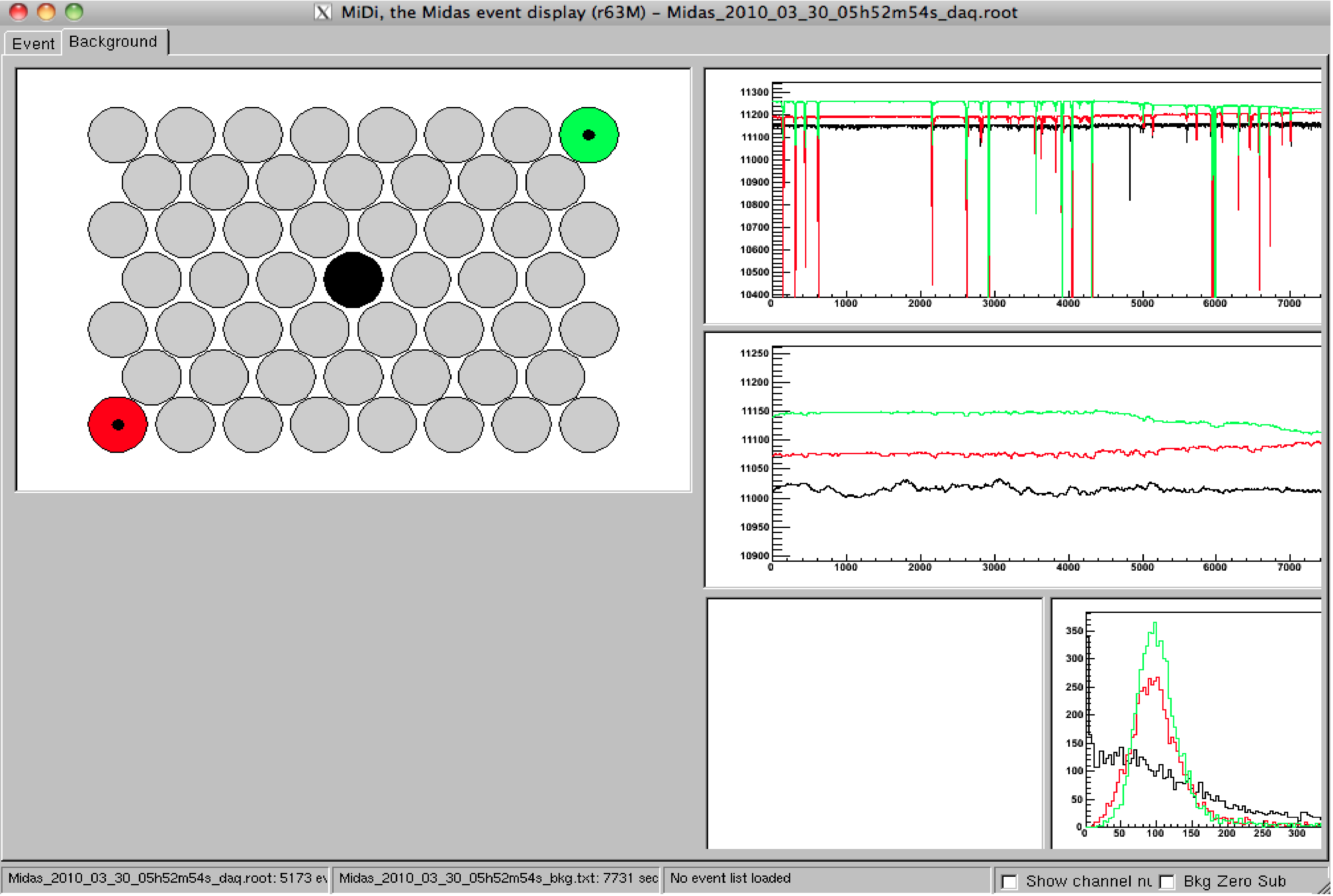
Midas_2010_09_30_09h56m01s_daq.root: 6423 event

Midas_2010_09_30_09h56m01s_bkg.txt: 21601 secs

No event list loaded

☑ Show channel nur ☐ Bkg Zero Sub

# MiDi (6 h run) no filters



MiDi, the Midas event display (r63M) – Midas_2010_03_30_05h52m54s_daq.root

Midas_2010_03_30_05h52m54s_daq.root: 5173 e

Midas_2010_03_30_05h52m54s_bkg.txt: 7731 sec

No event list loaded

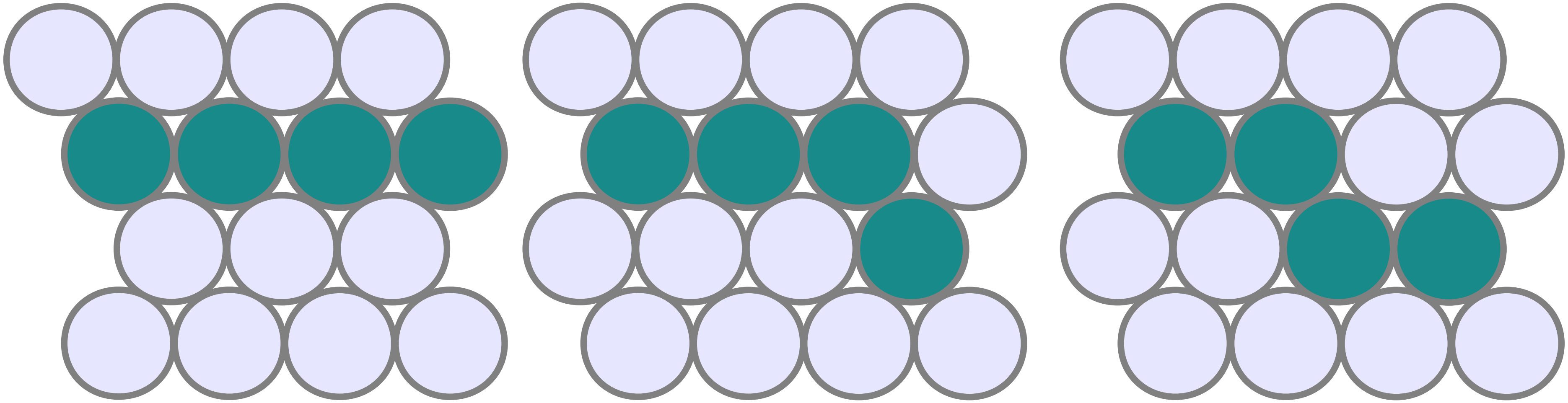
☐ Show channel nu ☐ Bkg Zero Sub

# Second Level Trigger (SLT)

- Channels with a FLT status are used to search for patterns compatible with a shower track.

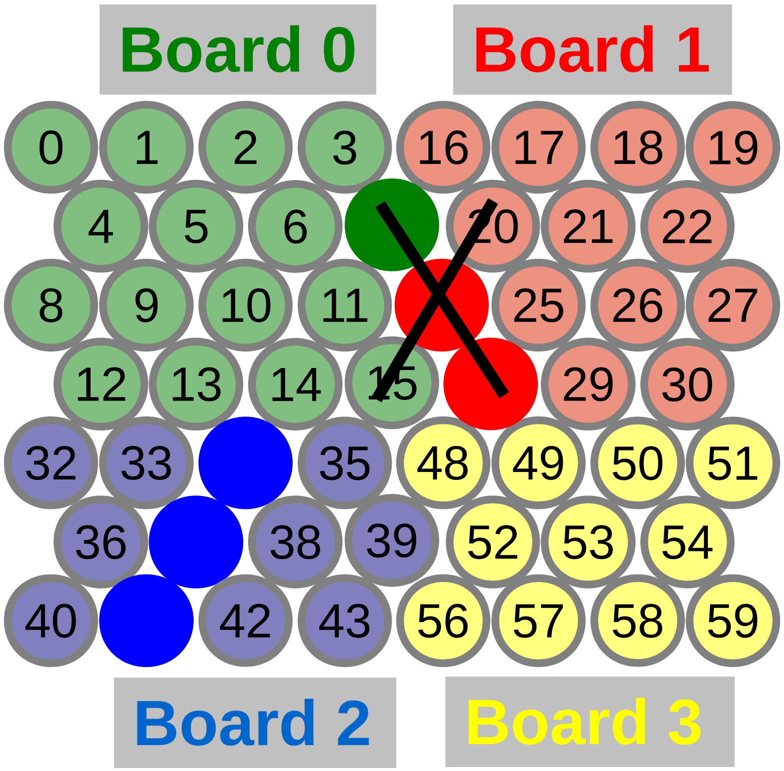
- The threshold regulation ensures a SLT rate due to accidentals of < 1 Hz.

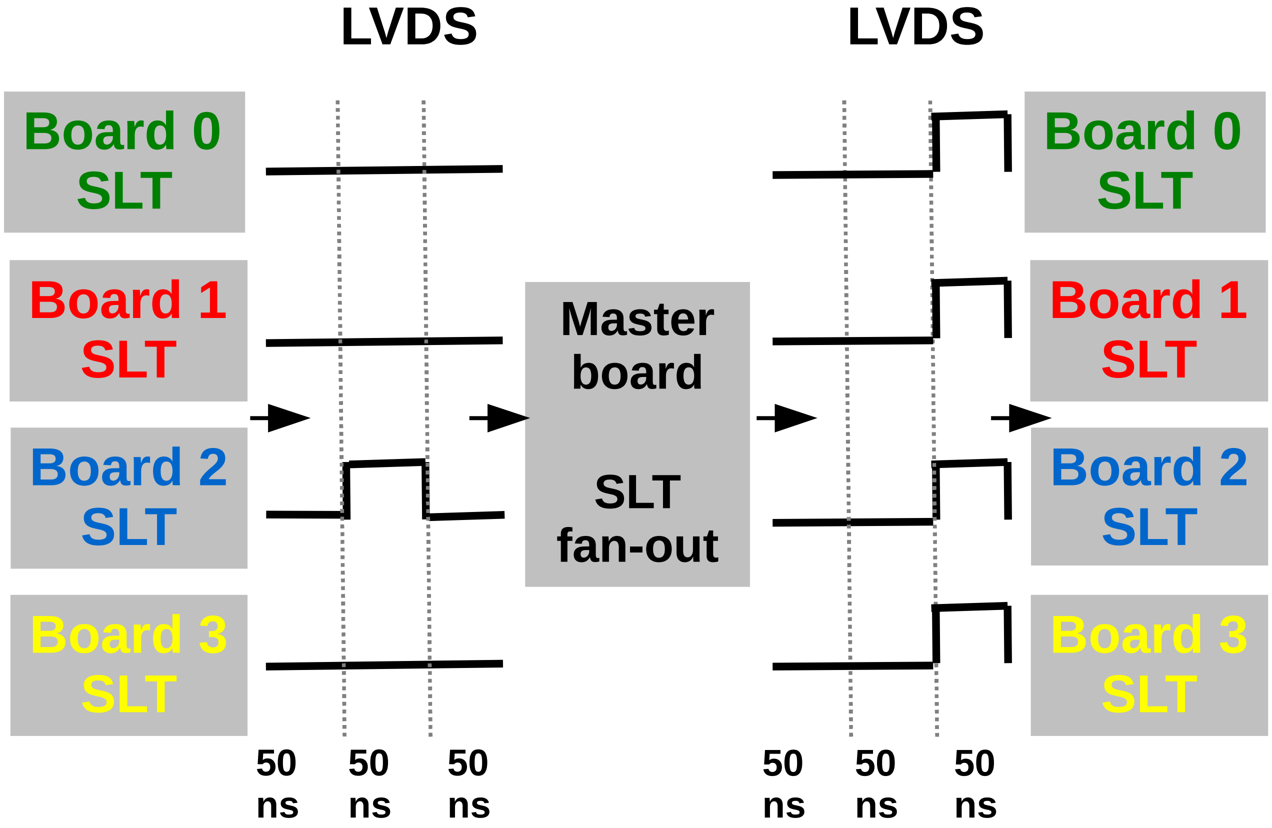
## Basic Patterns



In the old configuration we required 3-fold patterns basic in these basic ones.

# Second Level Trigger (SLT)
# Old configuration



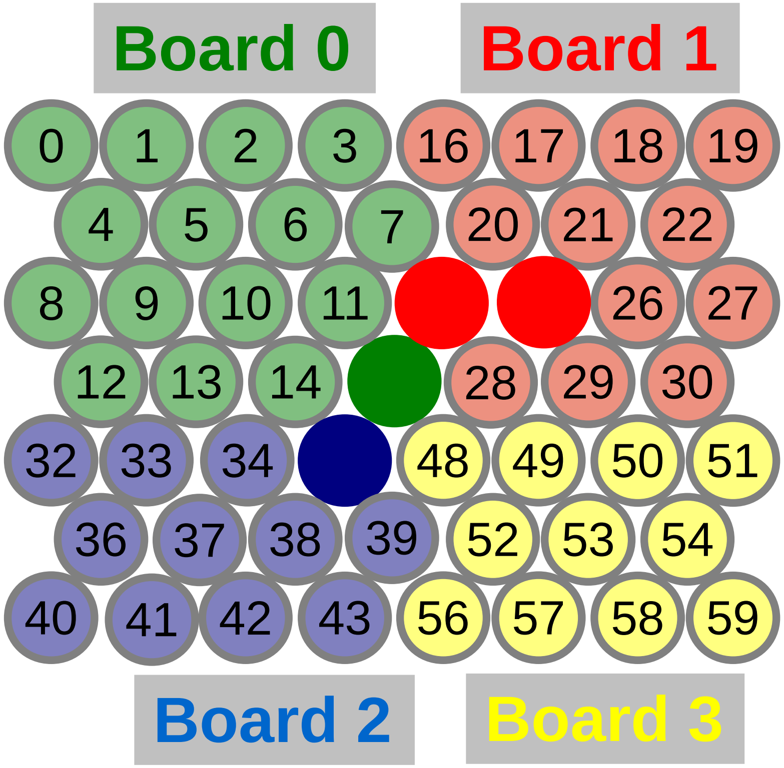


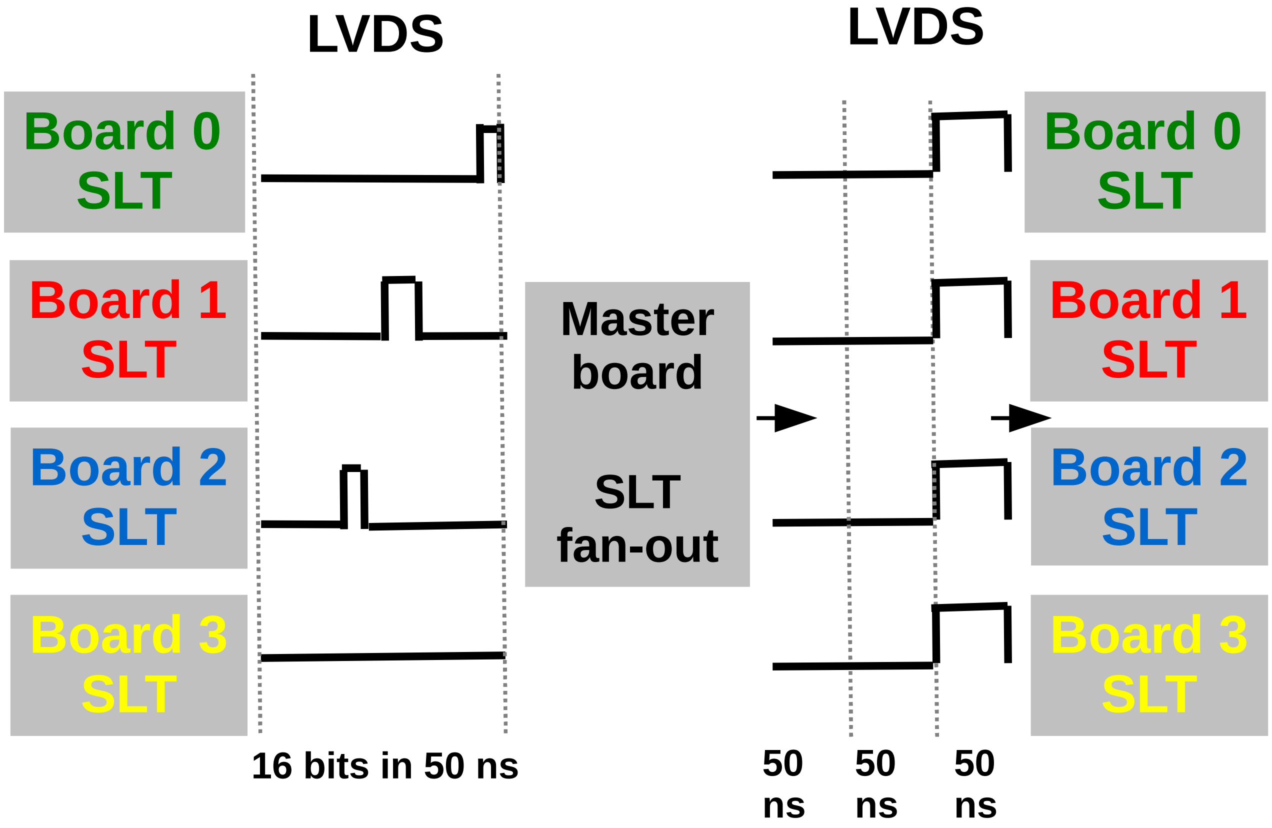
**3-fold patterns**

**Independent SLT per board**

# Second Level Trigger (SLT)

# New configuration





LVDS

LVDS

**Board 0 SLT**

**Board 1 SLT**

**Board 2 SLT**

**Board 3 SLT**

**Master board**

**SLT fan-out**

**Board 0 SLT**

**Board 1 SLT**

**Board 2 SLT**

**Board 3 SLT**

16 bits in 50 ns

50 ns 50 ns 50 ns

**4-fold patterns**

**Global SLT trigger**

**Synchronization and alignment is crucial**

# SLT rate

- The 4-fold trigger reduce the rate of random coincidences:
    - 3-fold patterns and 20 s: 0.4 Hz
    - 4-fold patterns and 20 s: 1.e-3 Hz
    - 4-fold patterns and 10 s: 3.e-4 Hz

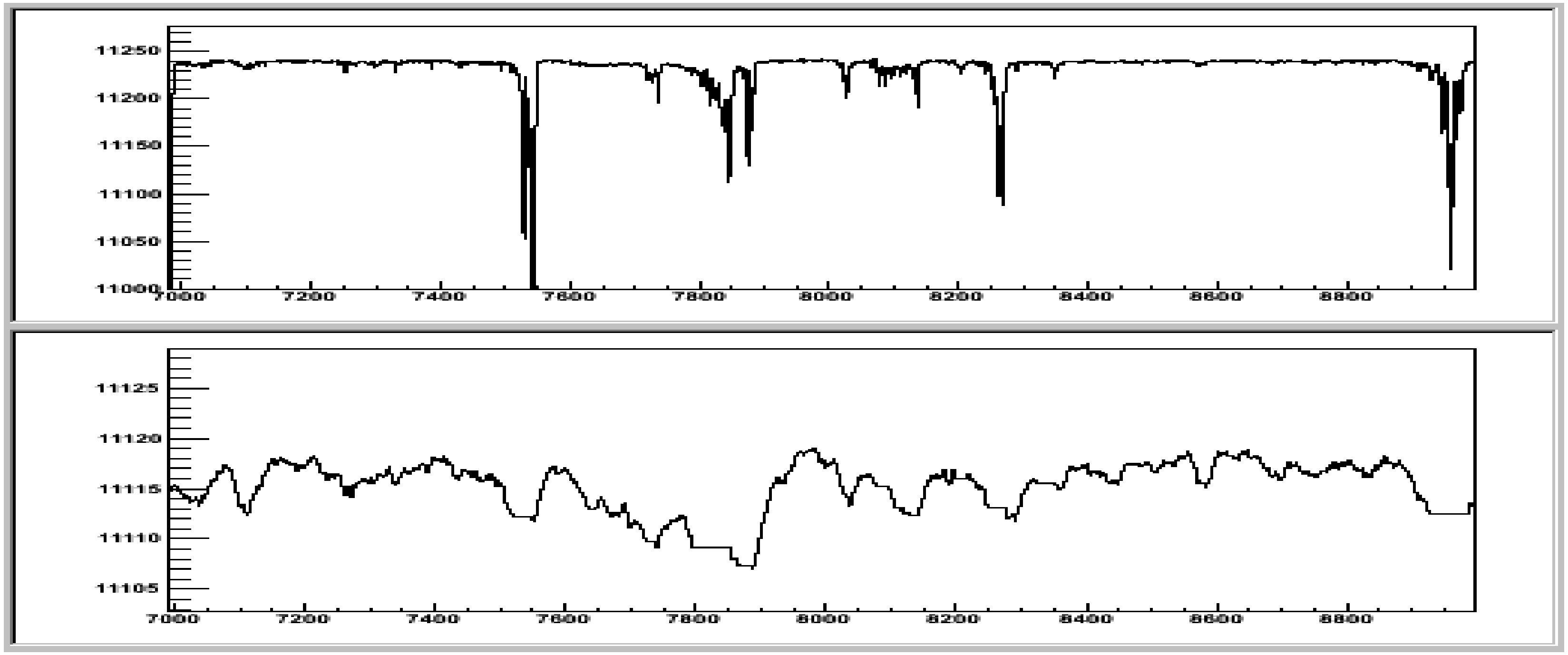
- With the new global implementation we increase the efficiency of the camera. On the other side, the 4-fold requirement we loss some sensitivity. Assuming a quadratic scaling:
    - 3 pixels: 1.1 events/day
    - 4 pixels: 0.8 events/day

28% loss assuming the 3-pixel events are distinguishable.

# Higher Levels

- The data acquisition and threshold regulation are inhibited when the SLT rate is higher than a pre-set value.

- The daq resets the threshold automatically after a certain time without SLT. The new input value is an average of the actual baseline. To deal with sudden changes that the regular threshold regulation is not able to follow.



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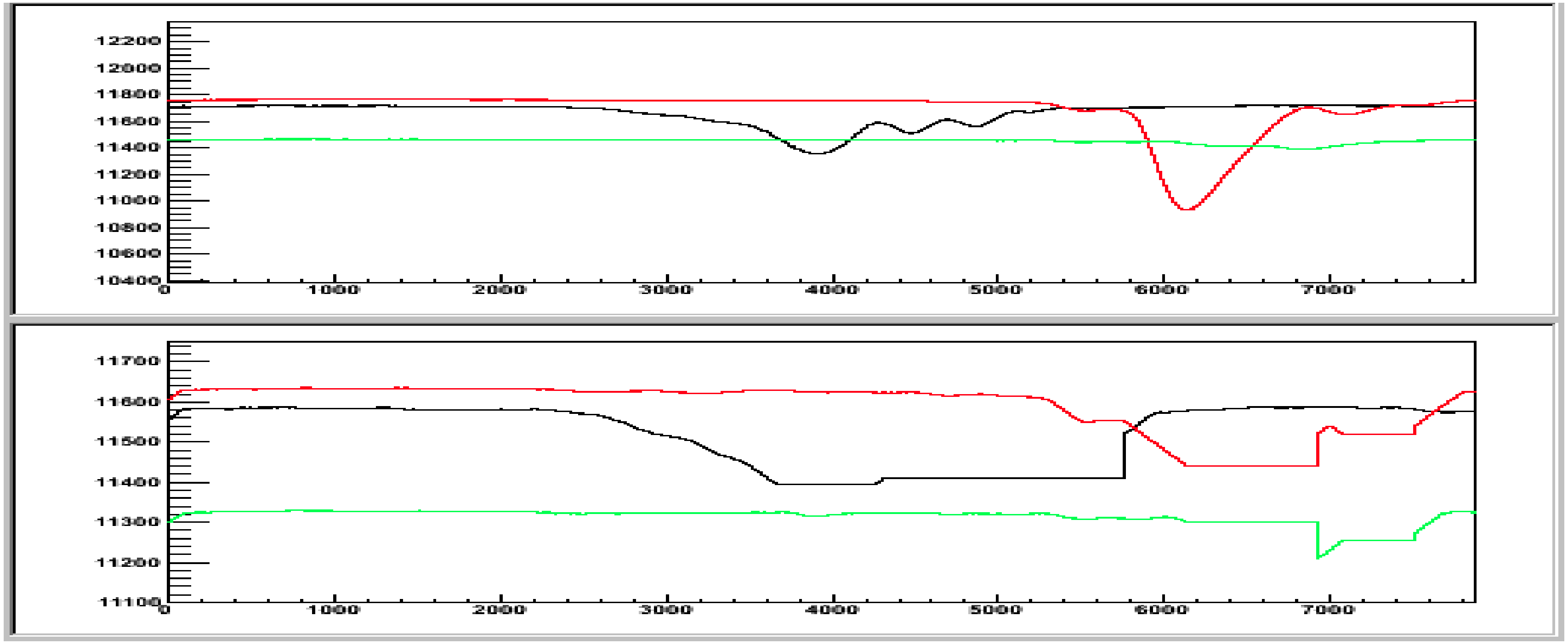
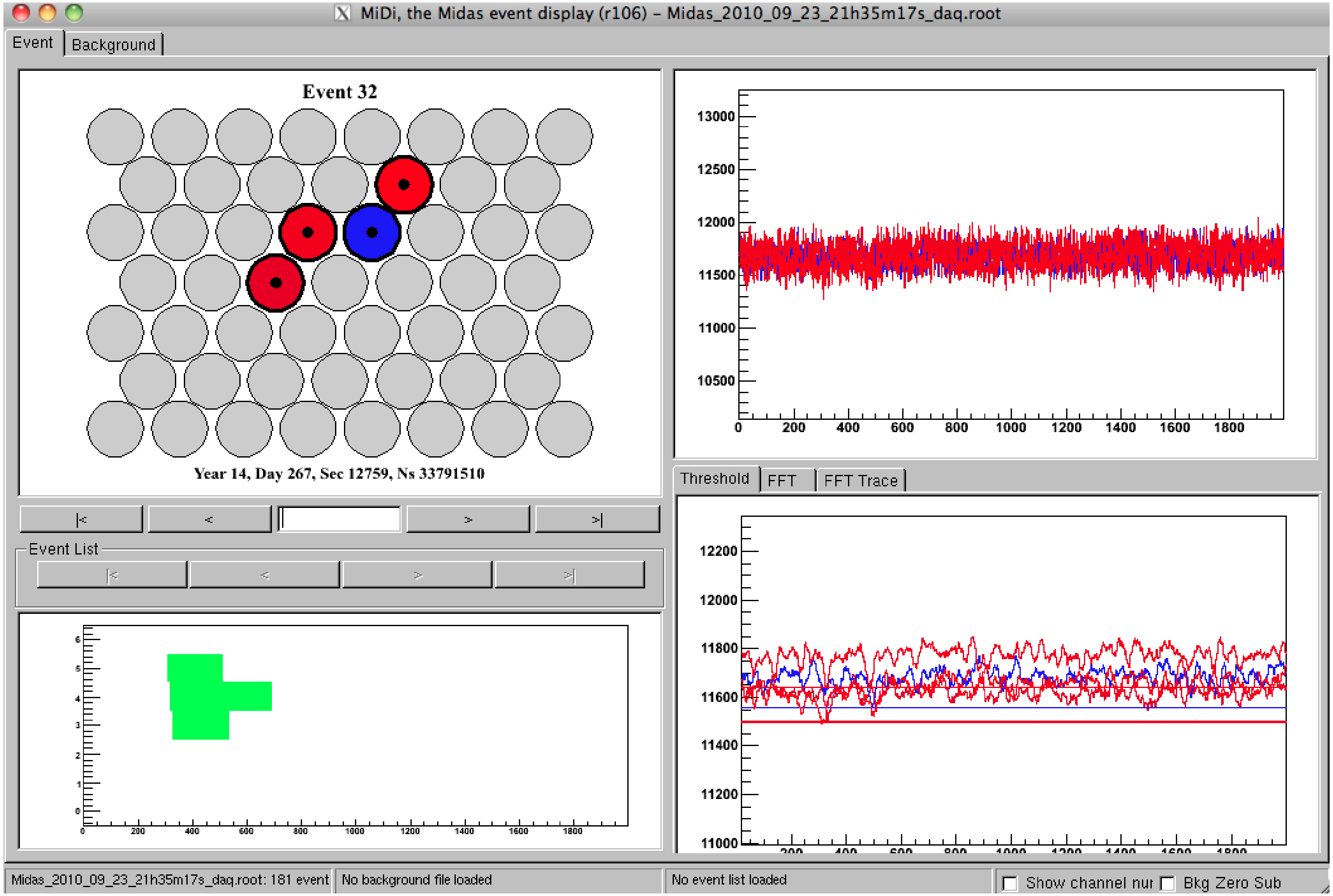


# Event data stream

After a SLT, a 100 μs stream of data (25 μs corresponding to data before the SLT trigger) is stored.


MiDi, the Midas event display (r106) – Midas_2010_09_23_21h35m17s_daq.root

Event 32

Year 14, Day 267, Sec 12759, Ns 33791510

Midas_2010_09_23_21h35m17s_daq.root: 181 event

No background file loaded

No event list loaded

☐ Show channel nur ☐ Bkg Zero Sub

All these trigger conditions are already implemented in the simulations.

# **MIDAS**: Absolute calibration

**Microwave Workshop**
**Chicago, October 6th 2010**

# Absolute calibration with the Sun

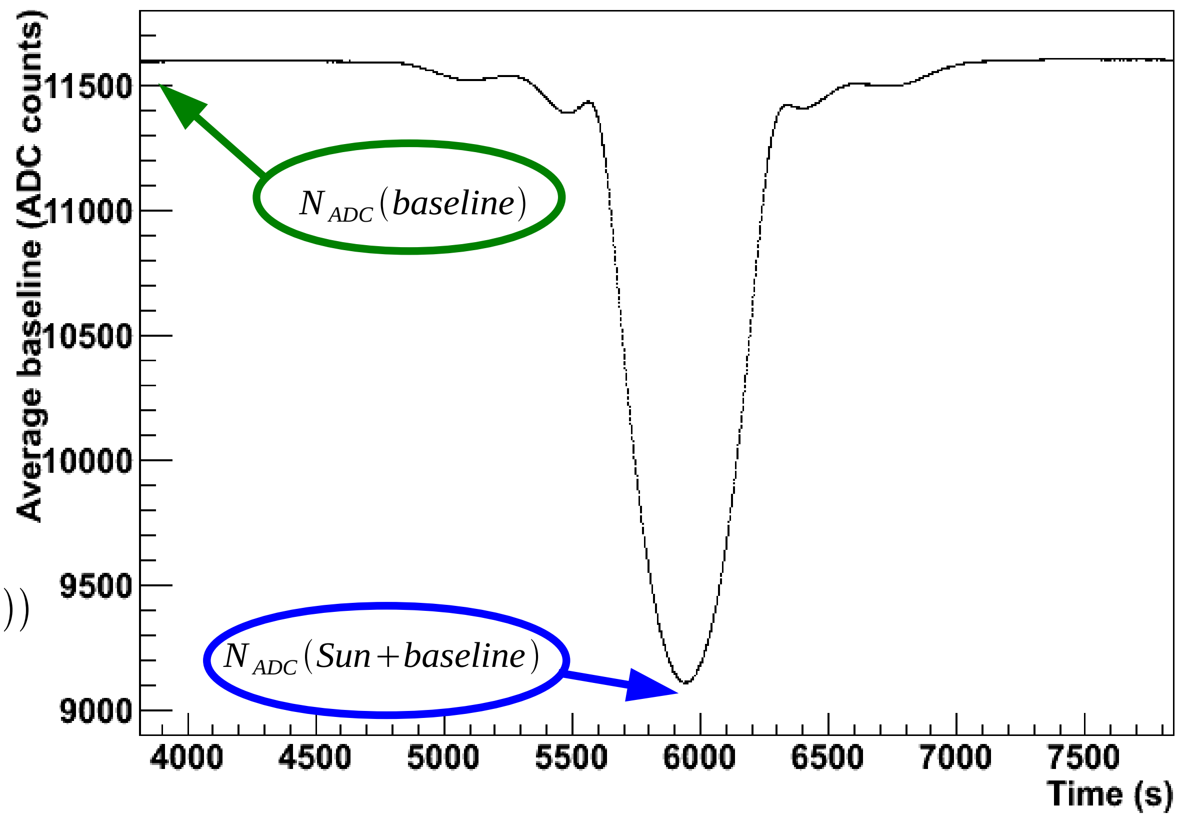
$$Y=\frac{S(baseline)+S(sun)}{S(baseline)}$$

$$P=10^{X(dBm)/10}=10^{\frac{A+BN_{ADC}}{10}}$$

$$Y=10^{\frac{-B}{10}(N_{ADC}(Sun+base)-N_{ADC}(baseline))}$$

**From our relative calibration (B=0.0054dBm/ADC)**

$$Y \sim 22$$



**From Nobeyama radio observatory (For this day: 81 sfu)**

$$S(baseline)=\frac{S(Sun)}{Y-1}=2.94\,W/m^2/Hz$$

$$T_{syst}=\frac{S(baseline)A_{eff}}{2k_B} \sim 106\,K$$

# System temperature at data taking position

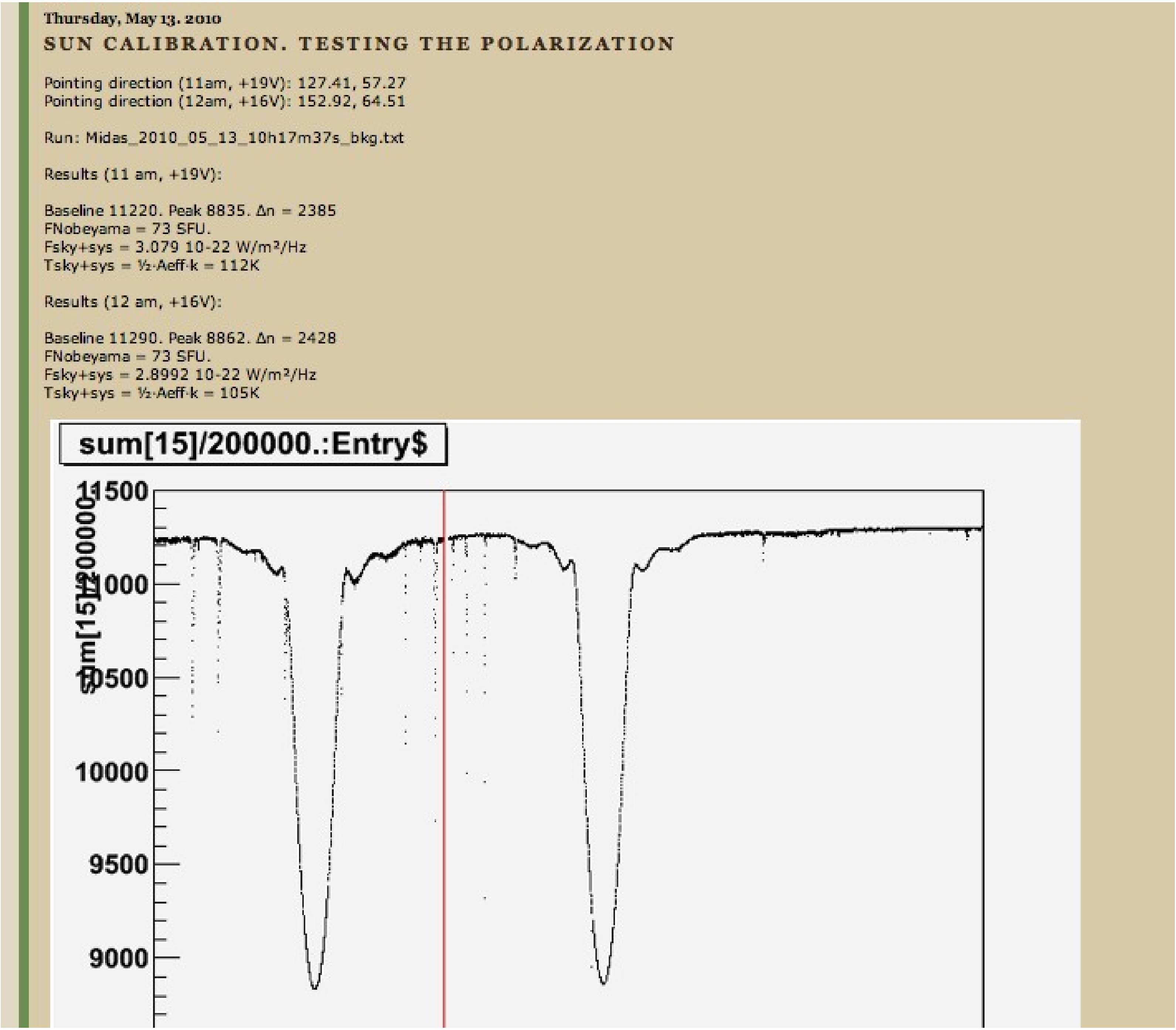
In daq position (phi=145, theta=15) $T_{syst}$ is a little bit larger. Comparing the number of ADC counts for the baseline in both daq and Sun pointing directions we can estimate $T_{syst}$ in daq position.

For the same day of the previous calibrations with the Sun the system temperature at daq position ~ 120K ($T_{syst}$(daq) = 1.12$T_{syst}$ (Sun)).

In general, for 2 different baselines:

$$\frac{P_{b1}}{P_{b2}}=\frac{T_{b1}}{T_{b2}}=10^{\frac{B}{10}(N_{ADC}(b1)-N_{ADC}(b2))}$$

# System temperature for both polarizations



Thursday, May 13. 2010

**SUN CALIBRATION. TESTING THE POLARIZATION**

Pointing direction (11am, +19V): 127.41, 57.27
Pointing direction (12am, +16V): 152.92, 64.51

Run: Midas_2010_05_13_10h17m37s_bkg.txt

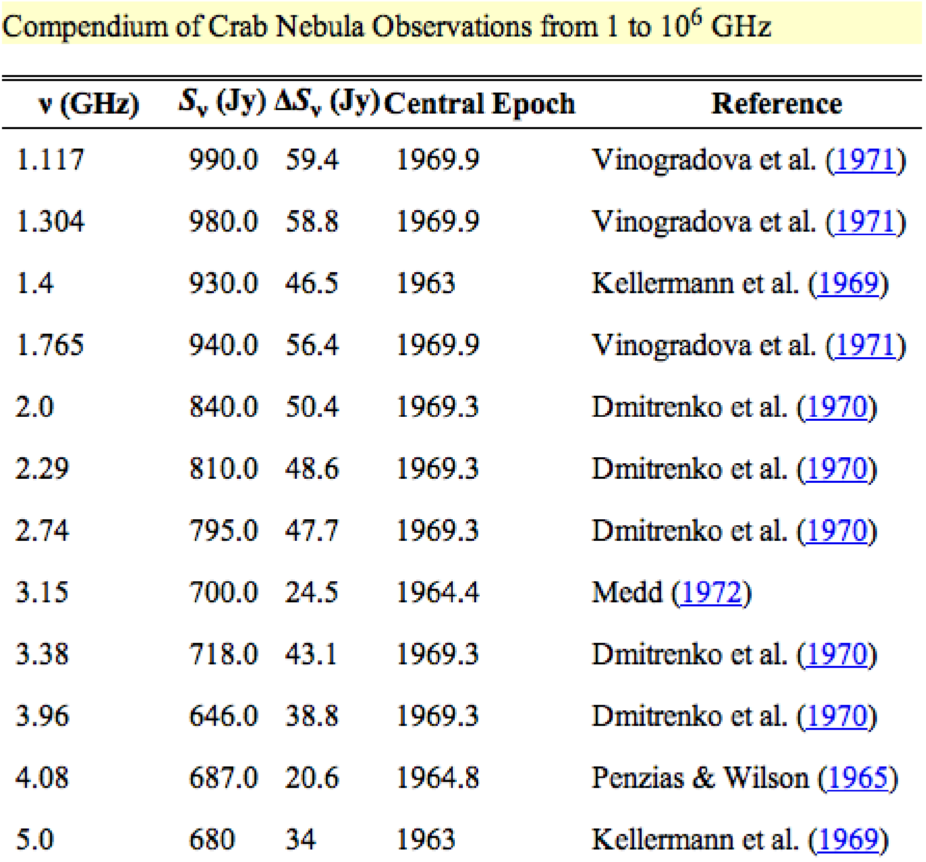
Results (11 am, +19V):

Baseline 11220. Peak 8835. Δn = 2385
FNobeyama = 73 SFU.
Fsky+sys = 3.079 10-22 $W/m^2/Hz$
Tsky+sys = ½·Aeff·k = 112K

Results (12 am, +16V):

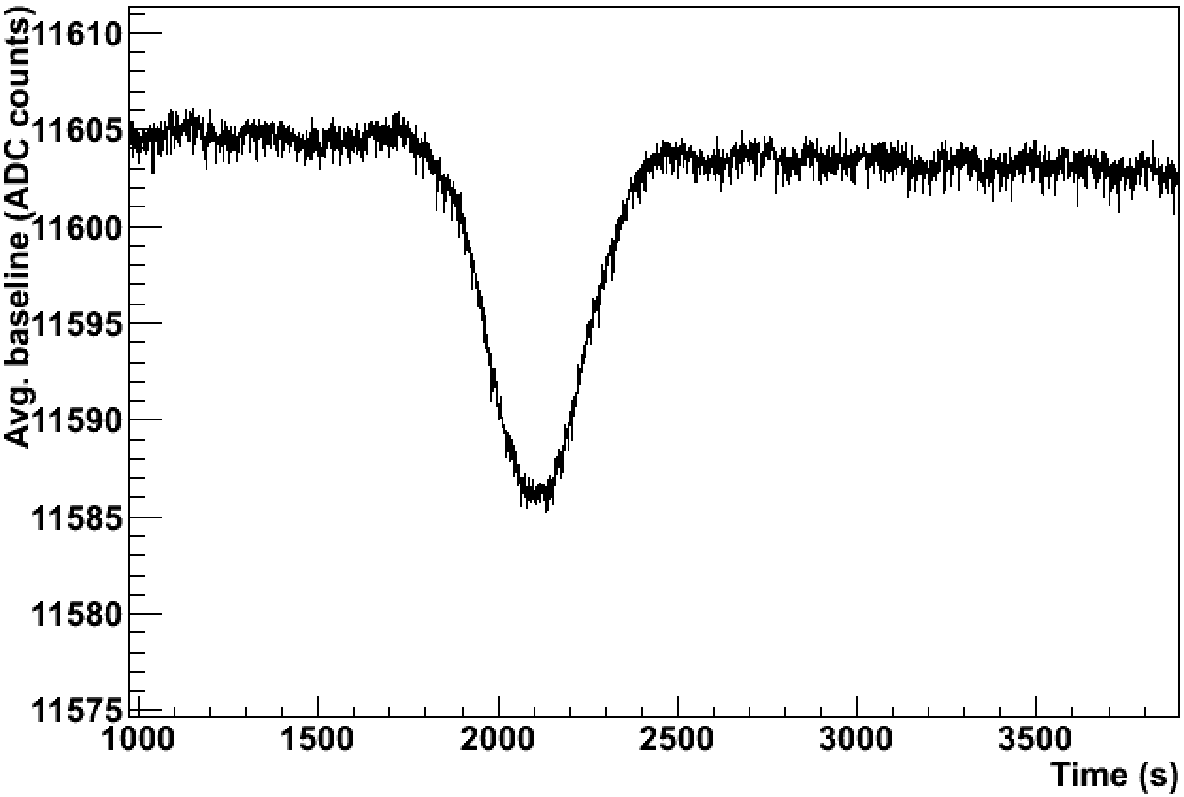
Baseline 11290. Peak 8862. Δn = 2428
FNobeyama = 73 SFU.
Fsky+sys = 2.8992 10-22 $W/m^2/Hz$
Tsky+sys = ½·Aeff·k = 105K

# Cross-checking with the Crab



Compendium of Crab Nebula Observations from 1 to $10^6$ GHz

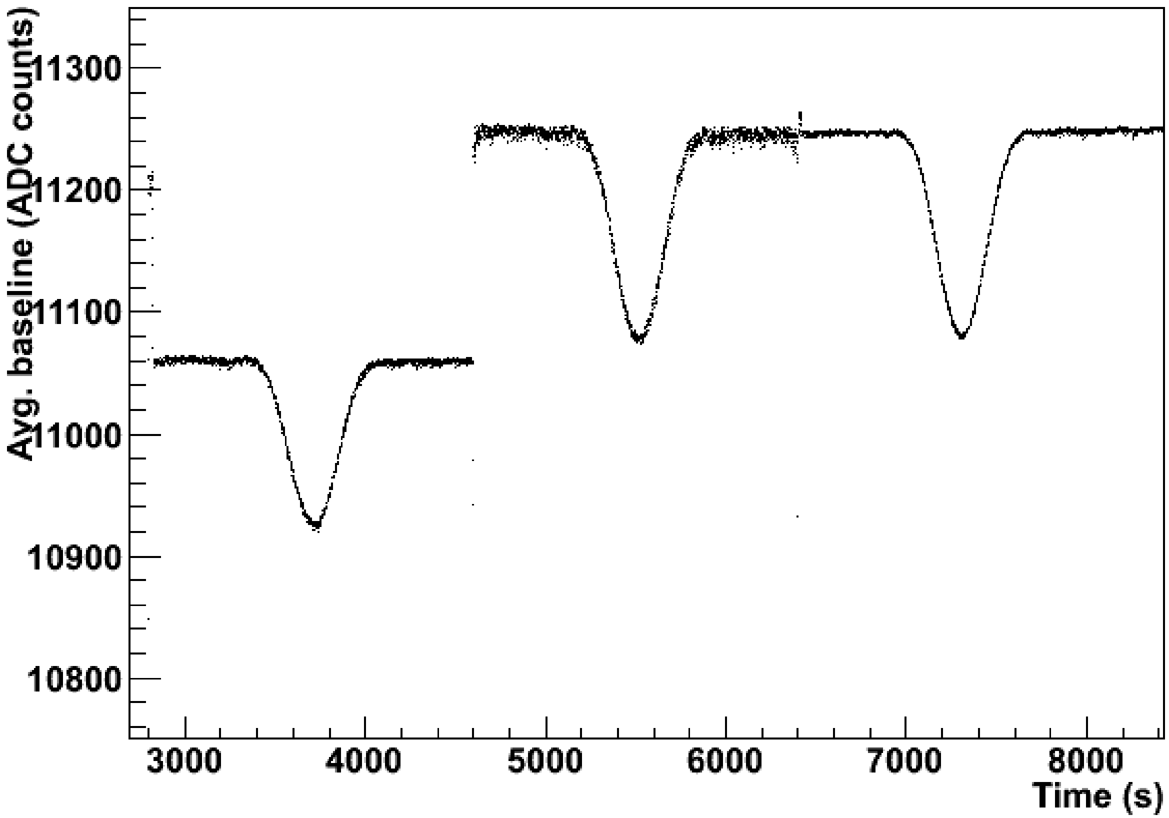
| ν (GHz) | $S_\nu$ (Jy) | $\Delta S_\nu$ (Jy) | Central Epoch | Reference |
|---|---|---|---|---|
| 1.117 | 990.0 | 59.4 | 1969.9 | Vinogradova et al. (1971) |
| 1.304 | 980.0 | 58.8 | 1969.9 | Vinogradova et al. (1971) |
| 1.4 | 930.0 | 46.5 | 1963 | Kellermann et al. (1969) |
| 1.765 | 940.0 | 56.4 | 1969.9 | Vinogradova et al. (1971) |
| 2.0 | 840.0 | 50.4 | 1969.3 | Dmitrenko et al. (1970) |
| 2.29 | 810.0 | 48.6 | 1969.3 | Dmitrenko et al. (1970) |
| 2.74 | 795.0 | 47.7 | 1969.3 | Dmitrenko et al. (1970) |
| 3.15 | 700.0 | 24.5 | 1964.4 | Medd (1972) |
| 3.38 | 718.0 | 43.1 | 1969.3 | Dmitrenko et al. (1970) |
| 3.96 | 646.0 | 38.8 | 1969.3 | Dmitrenko et al. (1970) |
| 4.08 | 687.0 | 20.6 | 1964.8 | Penzias & Wilson (1965) |
| 5.0 | 680 | 34 | 1963 | Kellermann et al. (1969) |



Once we have estimated $T_{syst}$ with the Sun:

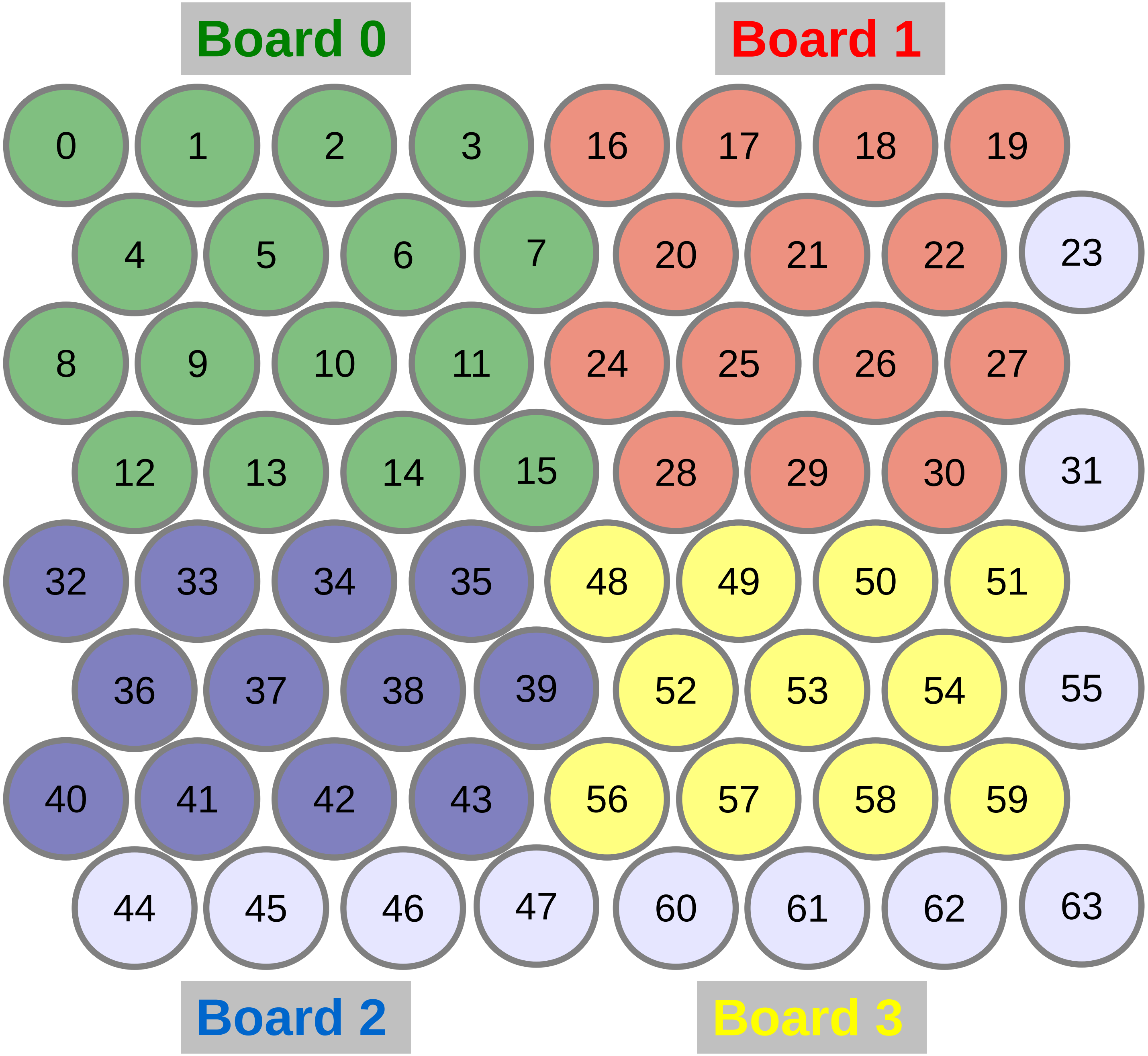
$$S_{crab} = 0.026 \cdot S_{baseline} = 7.6 \cdot 10^{-23}\, W/m^2/Hz = 760\, Jy$$

# Cross-checking with the Moon



$$\Delta T = T_{syst} \cdot 10^{(X_{moon}(dBm) - X_{syst}(dBm))/10} = 29\,K$$

$$T_{moon} = \frac{\Delta T \cdot \Omega_A}{\Omega_{Moon}} = \frac{29 \cdot 1.4^2}{\pi (0.56/4)^2} = 230\,K$$



**Board 0**

**Board 1**

**Board 2**

**Board 3**