Apsel3D_TC chip characterization

Alejandro Pérez
Giuliana Rizzo, Giulia Casarosa,
Fabio Morsani
INFN – Sezione di Pisa

LNF SuperB Collaboration Meeting

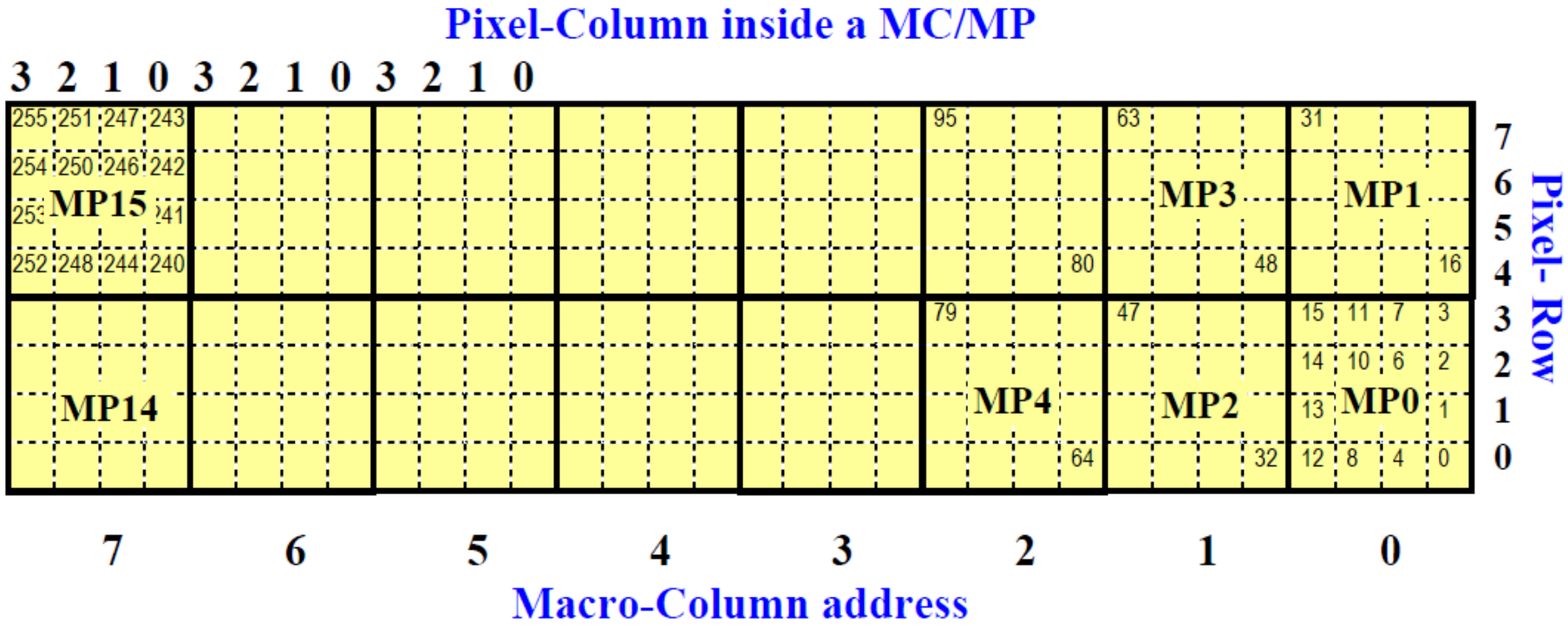
Outline

- **Noise scans**
  - Chip5
  - Chip6

- **Differential spectrum with the Fe55 source**
  - Chip5
  - Chip6

Apsel3D_TC matrix layout

- Matrix with 8 (rows) x32 (columns) = 256 pixels
- Matrix is divided in macro-pixels (MP) 4x4 pixels => 16 MP
- Can enable some MP and mask others



Noise scans: the fit function

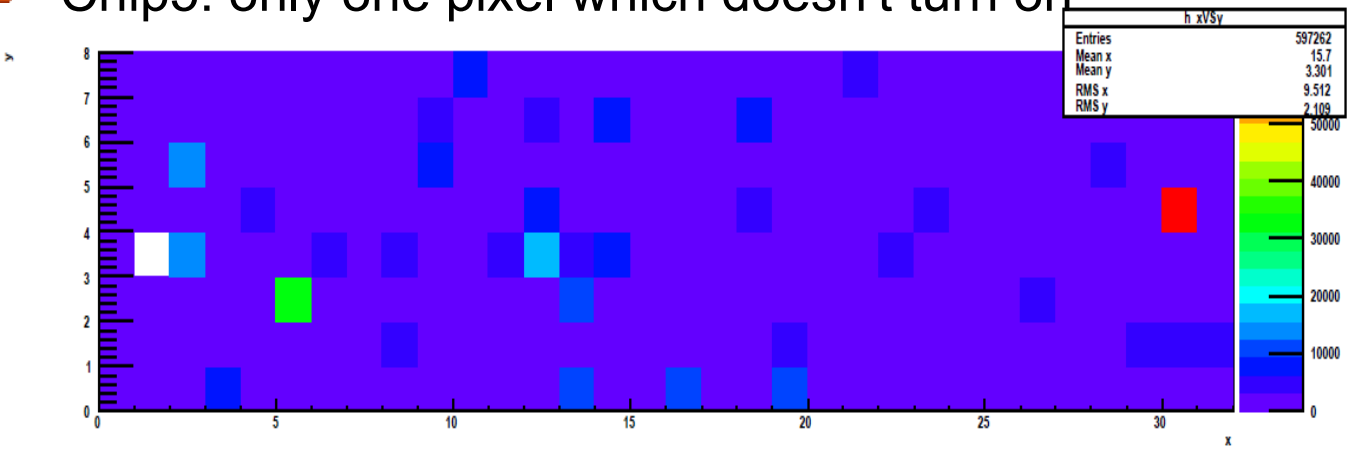
- Previously used a physics motivated function to describe the occupancies of the noise scans

$$\textbf{Occupancy} = 1.0 - \exp\{-\nu_0 t_{obs} \exp(-(thr - \mu)^2/2\sigma^2)\}$$

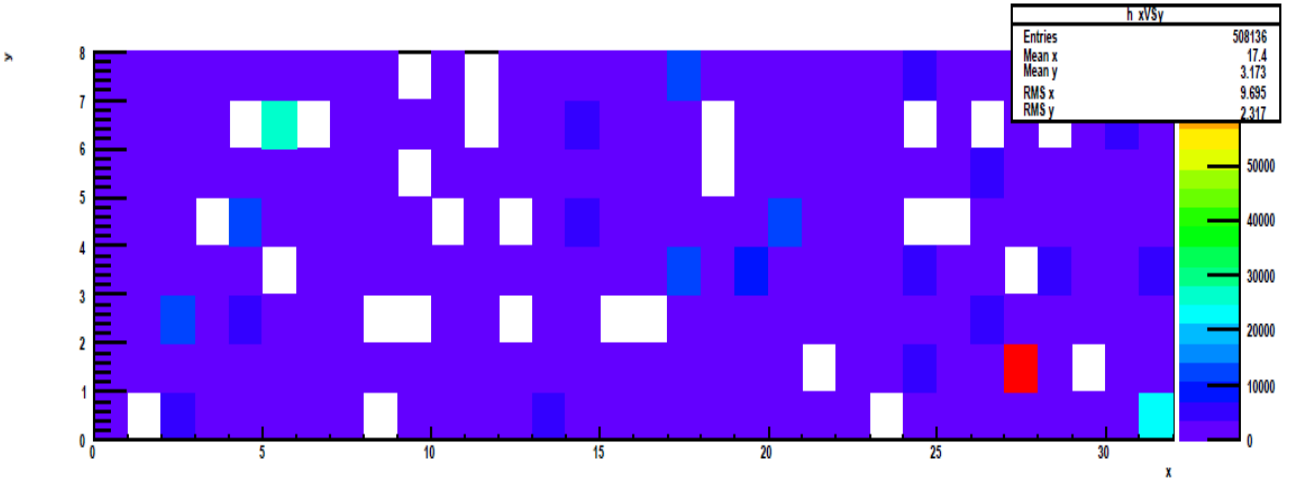
- Where, σ is the noise, the μ baseline, ν_0 the fire rate at zero threshold, t_{obs} the observation time. This expression is only valid if t_{obs} >> worst death-time. We used t_{obs} = 2ms (worst death time ~ 4*50ns*16 = 3.2μs).
- Using this function a significant fraction of the fits didn't converge (~28% for chip-5)
- Decided to used an asymmetric function with a different $\sigma(\mu)$ to the left/right of μ. $\sigma(\mu) = \sigma_L$ (σ_R) for thr – μ < 0 (thr – μ > 0)
- With this function the failed fit reduces significantly (~12.8% for chip-5)
- The noise scan fits are used to extract the pixel base-line, which will be used to estimate the gain from Fe55 spectra

Noise scans: Chip5 and Chip6

- Performed noise scans from 1250 up to 1500 DAC (100 steps of 4 DAC) with t_{obs} = 2ms
- Chip5: only one pixel which doesn't turn on

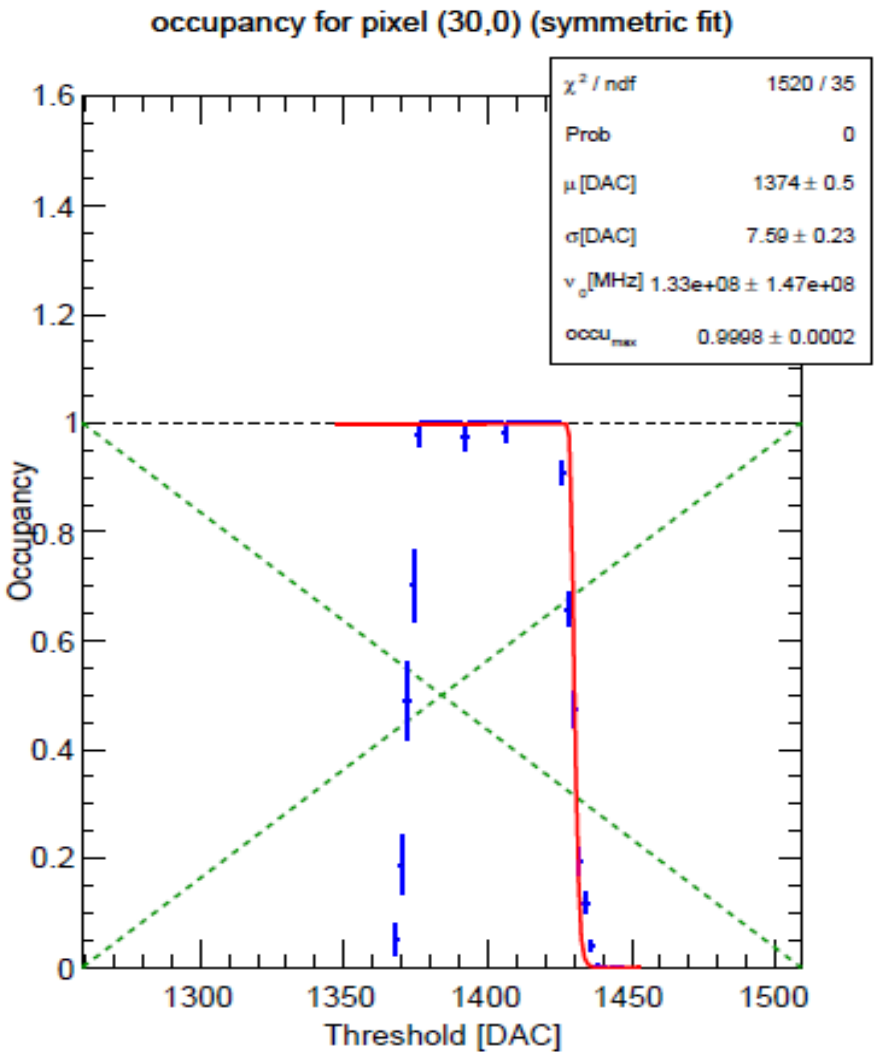


- Chip6: a significant amount of dead pixels (28 ⇒ 11%)

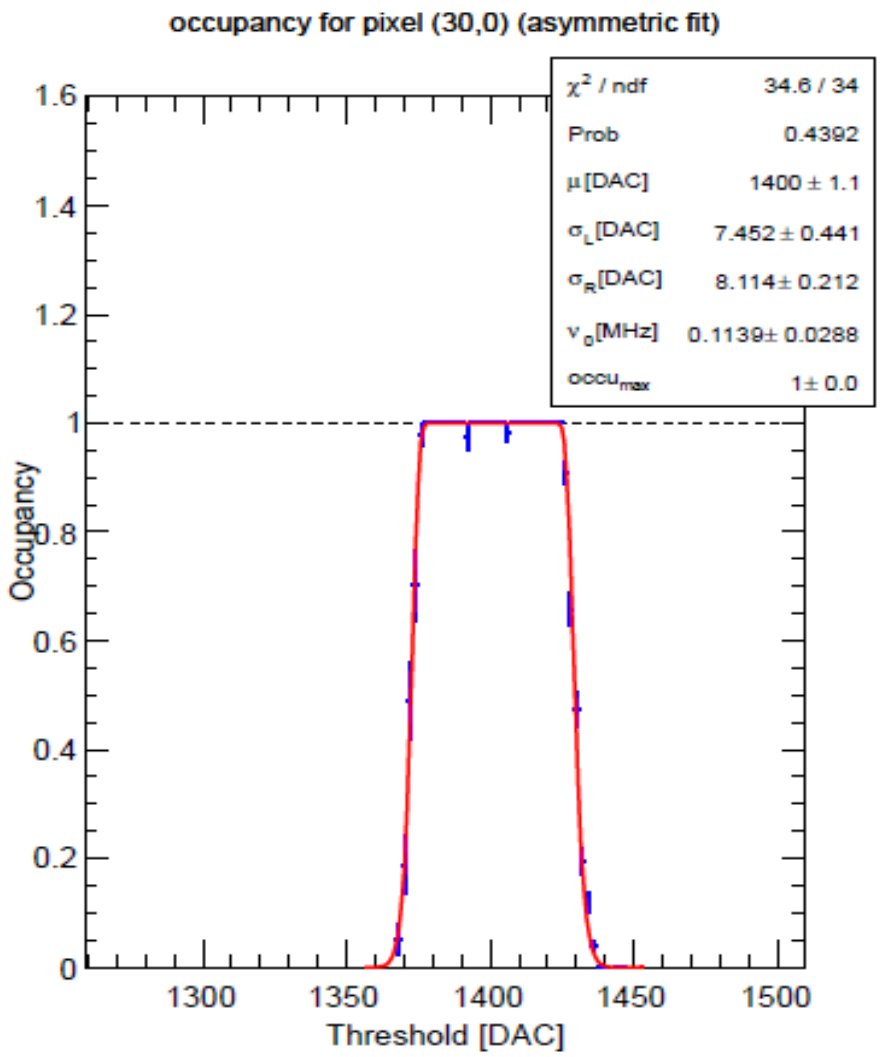


Noise fit: Chip5

Symmetric fit

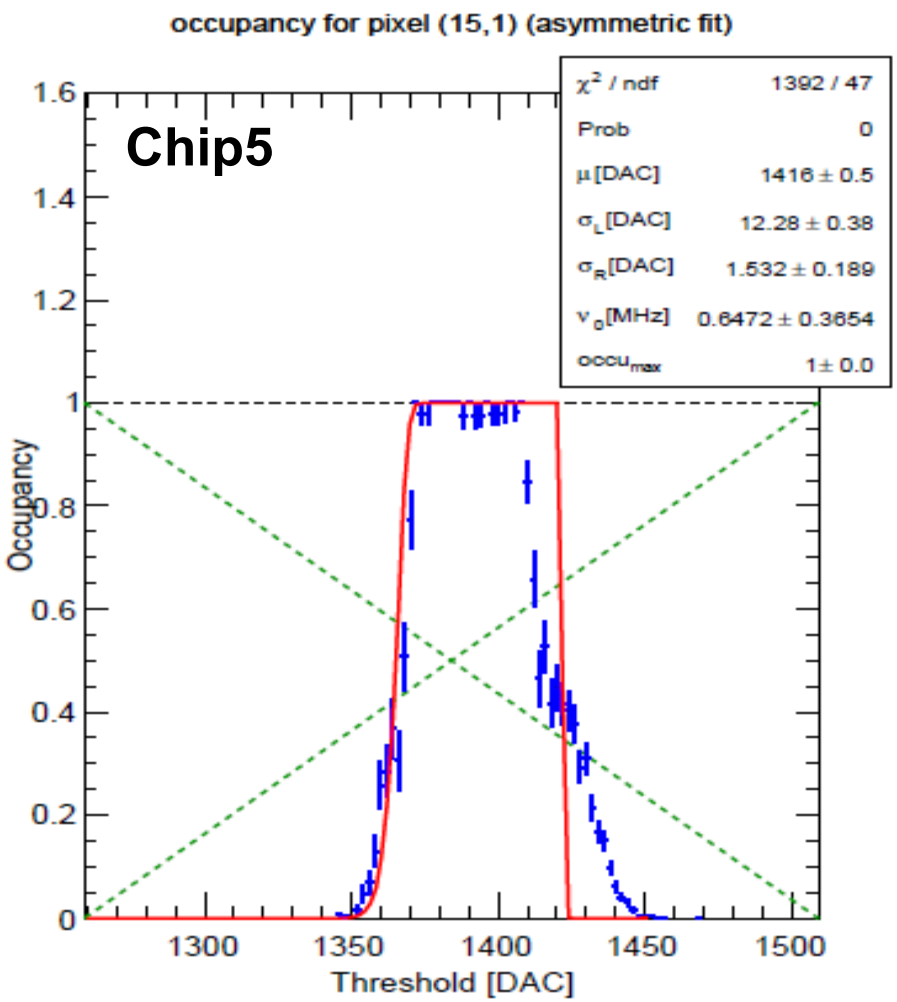


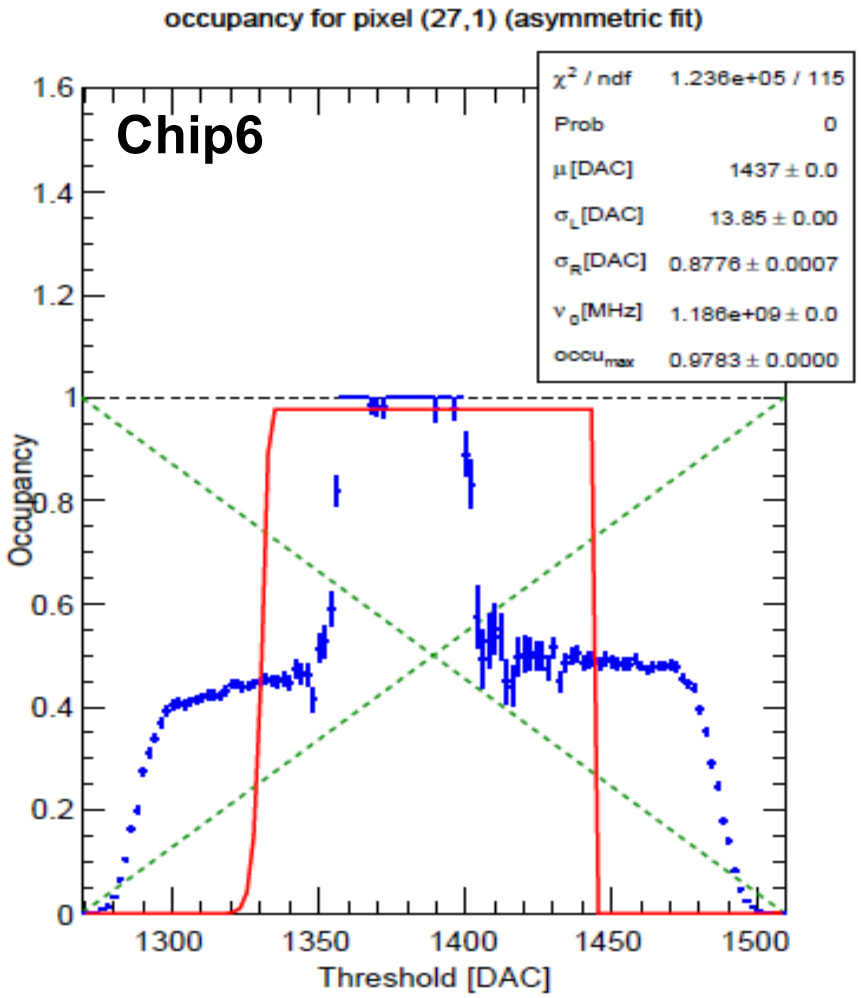
Asymmetric fit



Noise scans: Chip5 and Chip6

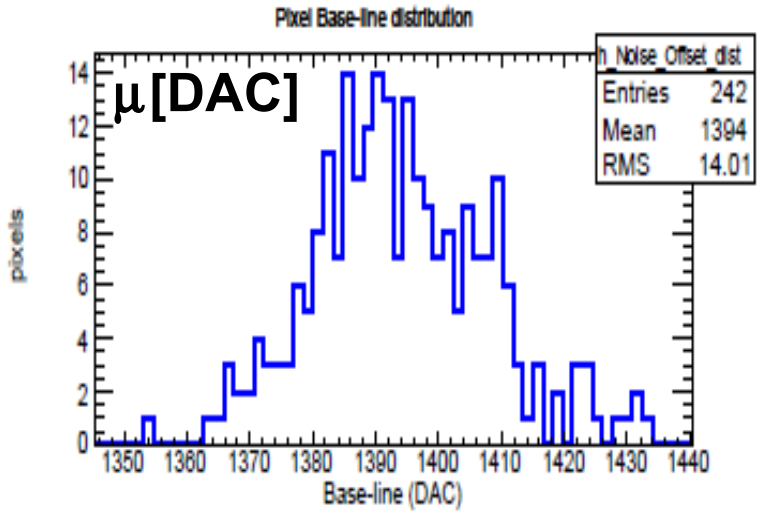
- Some pixels for both chips show strange features
- The fit poorly converges in those cases

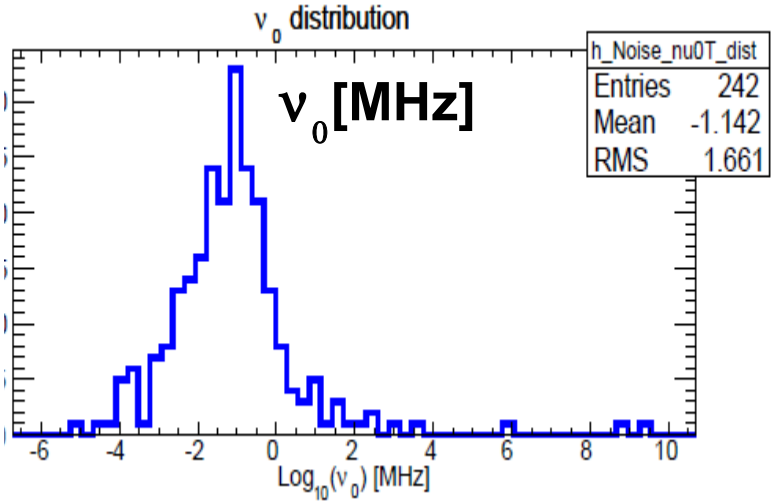


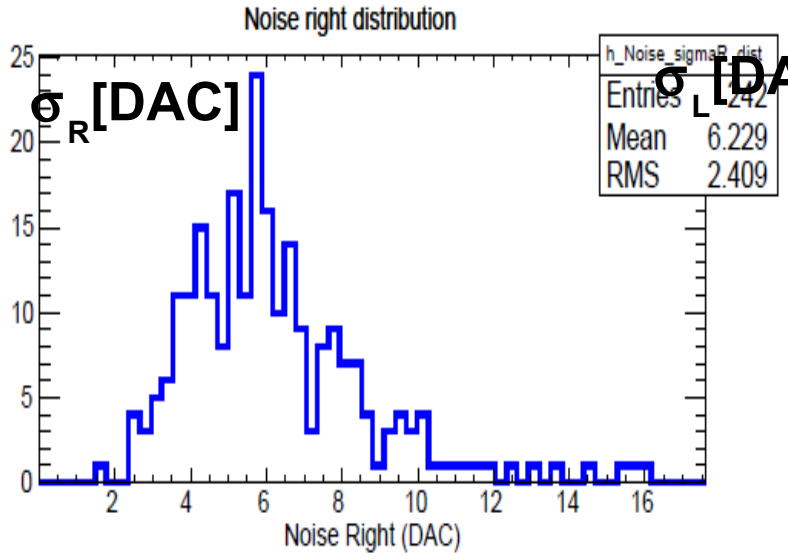


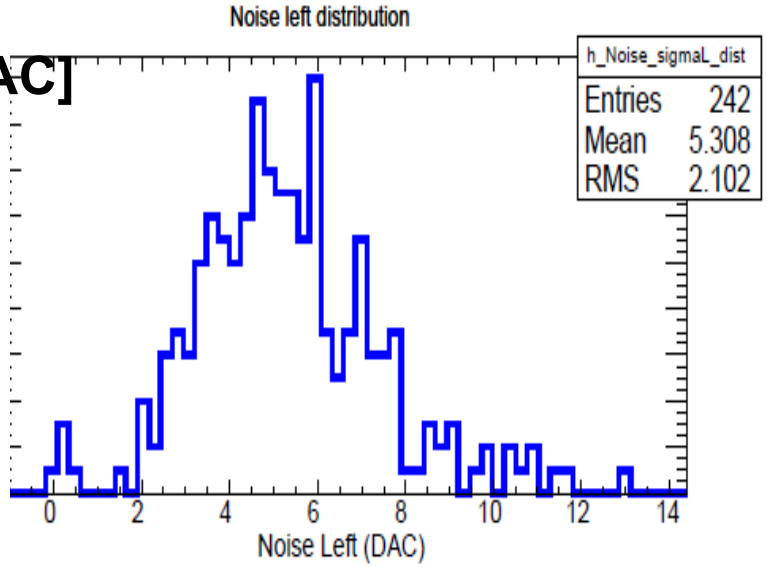
Noise scans: Chip5

- In some cases the fit doesn't converge properly. Those pixels are not used for the plots below. 221 fits converged (there is 1 dead pixel).



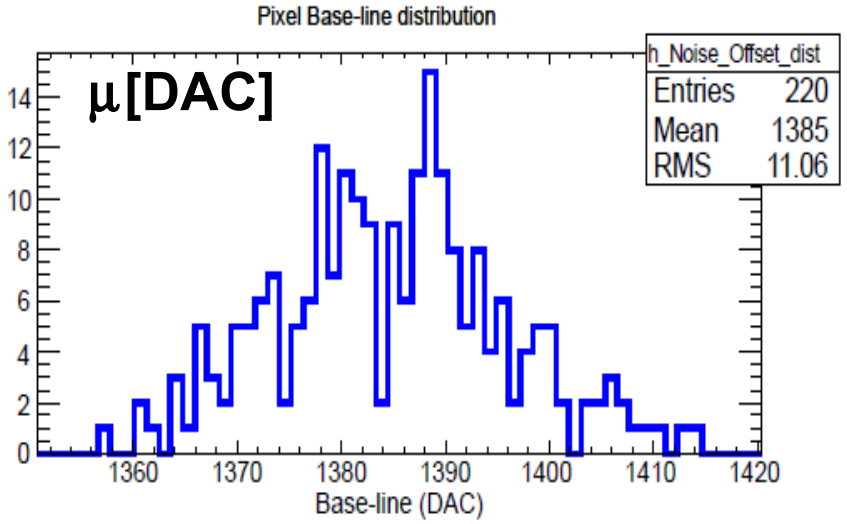


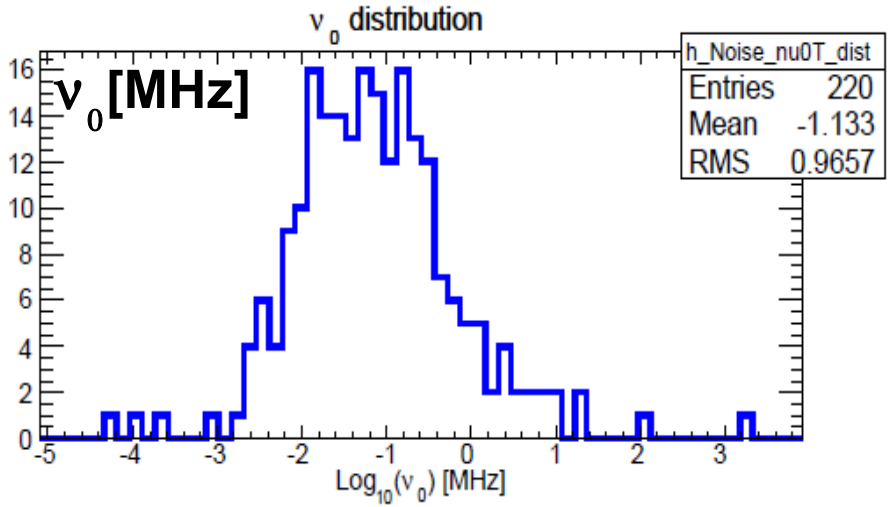


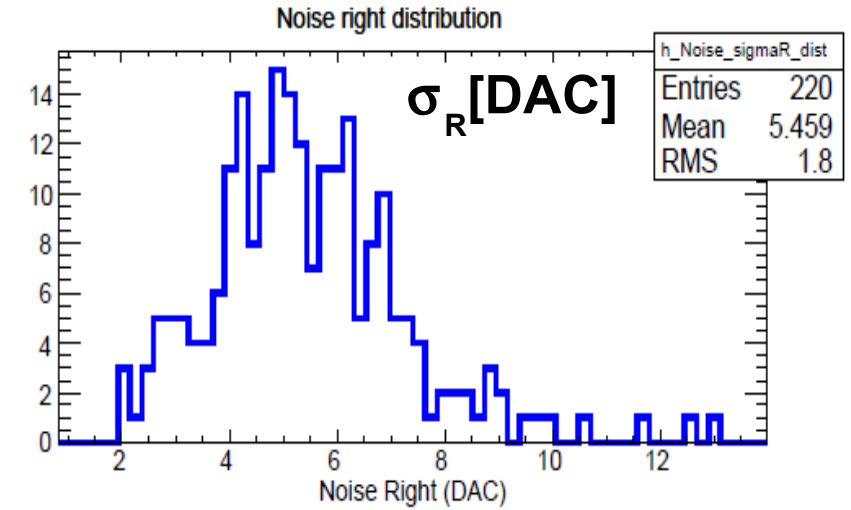


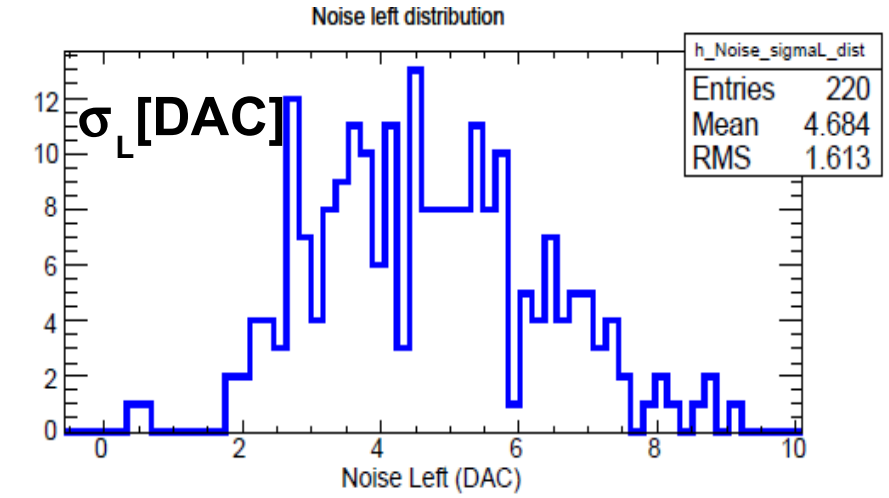
Noise scans: Chip6

- In some cases the fit doesn't converge properly. Those pixels are not used for the plots below. 204 fits converged (there is 28 dead pixel).





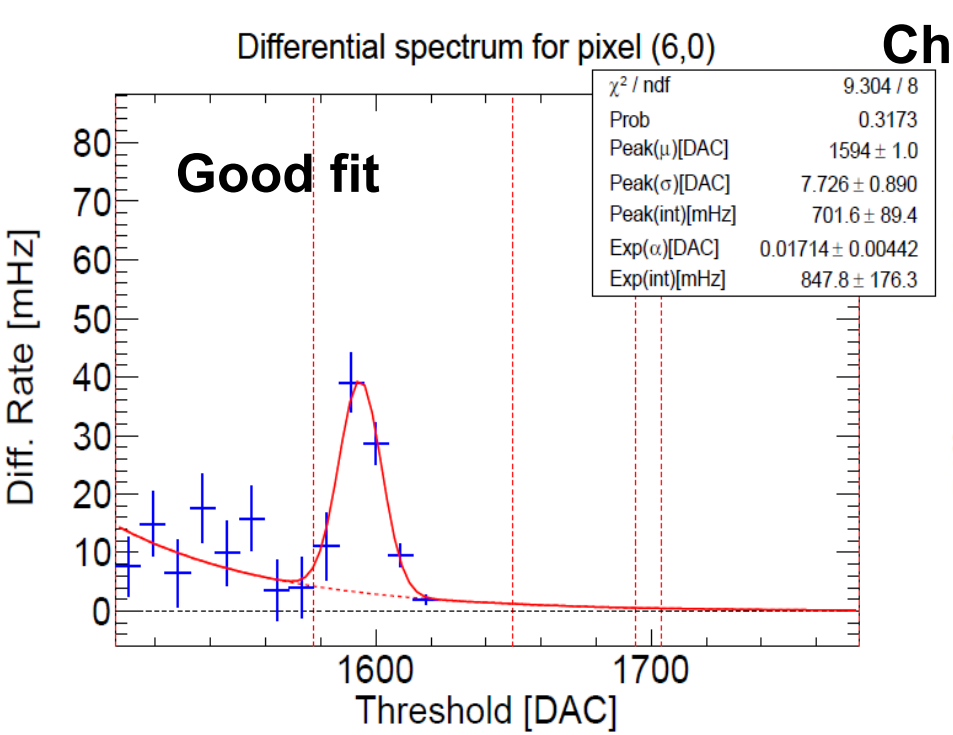


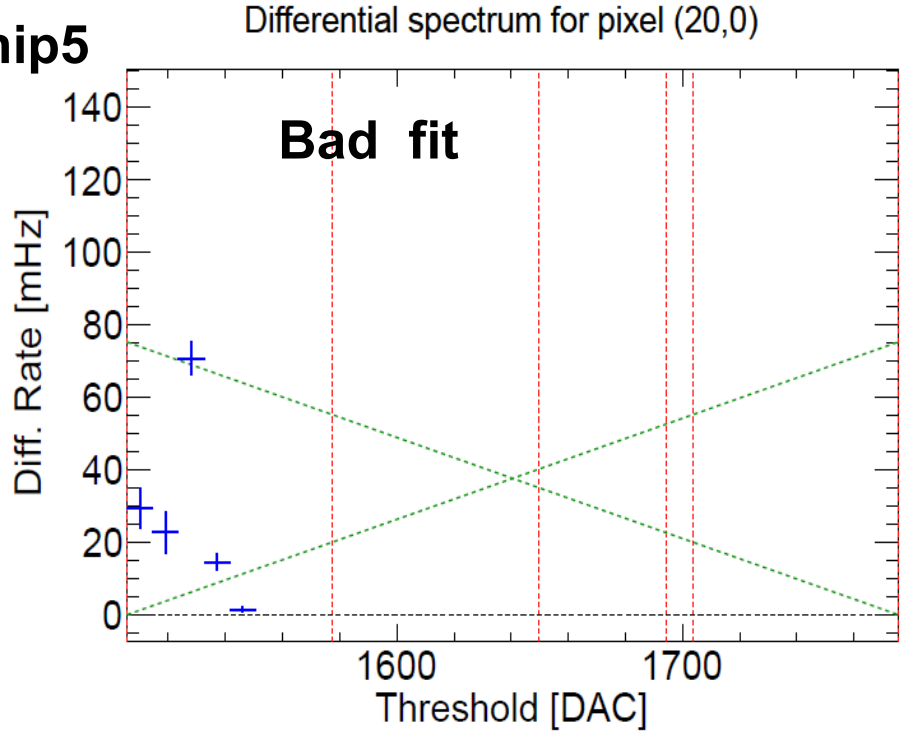


Data-taking with Fe55 source

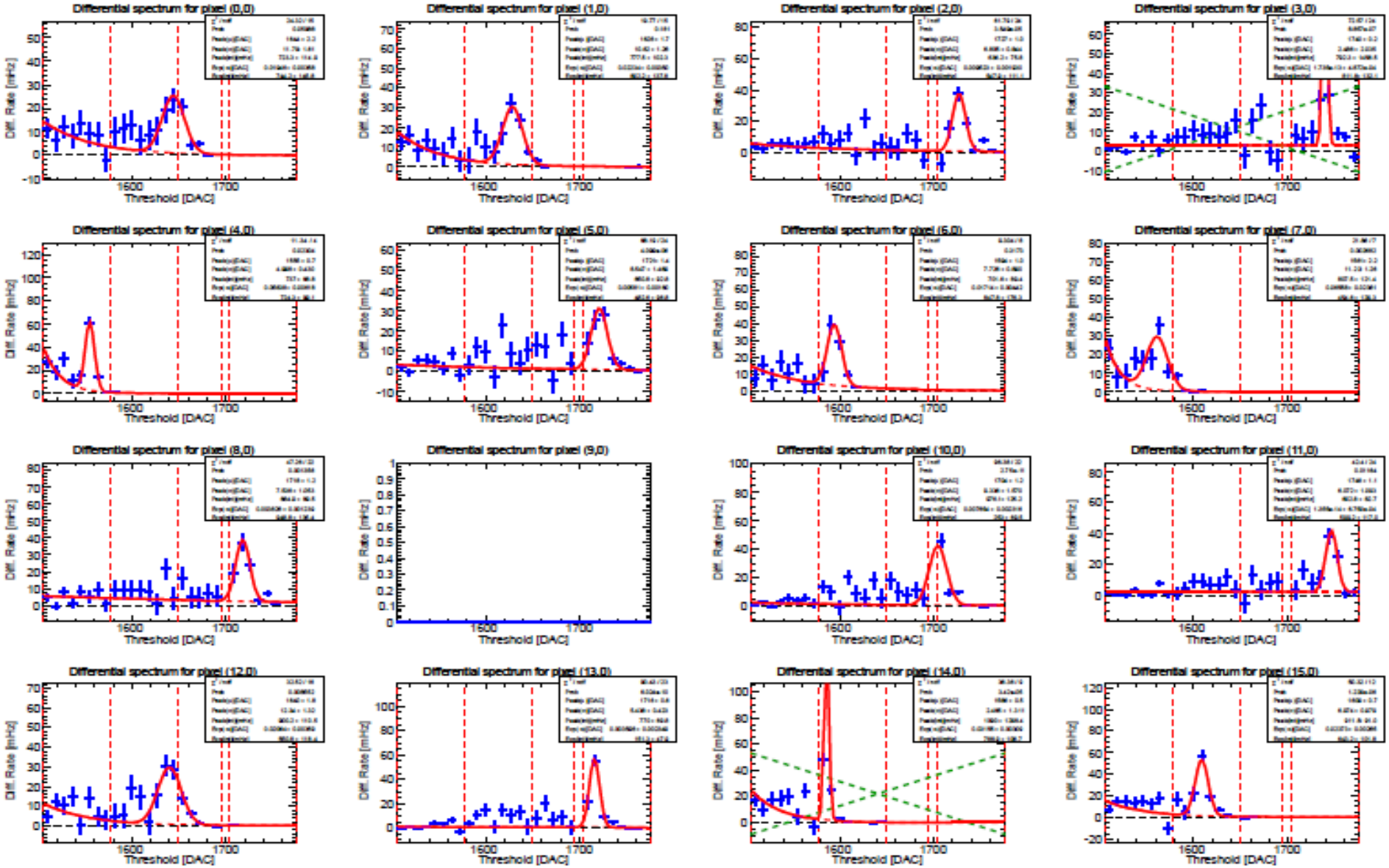
Data with Fe55 source

- With the Fe55 source took data varying the threshold,
  - Chip5: 1510 to 1780 in steps of 9 (units in DAC)
  - Chip6: 1591 to 1789 in steps of 9
- Out of the integral spectrum calculated the differential spectrum (bin_i+1 – bin_i on the integral spectrum)
- Put together the differential spectrum of all the runs
- Tried to look for the Fe55 peak and fit it ⇒ Guassian+exponential

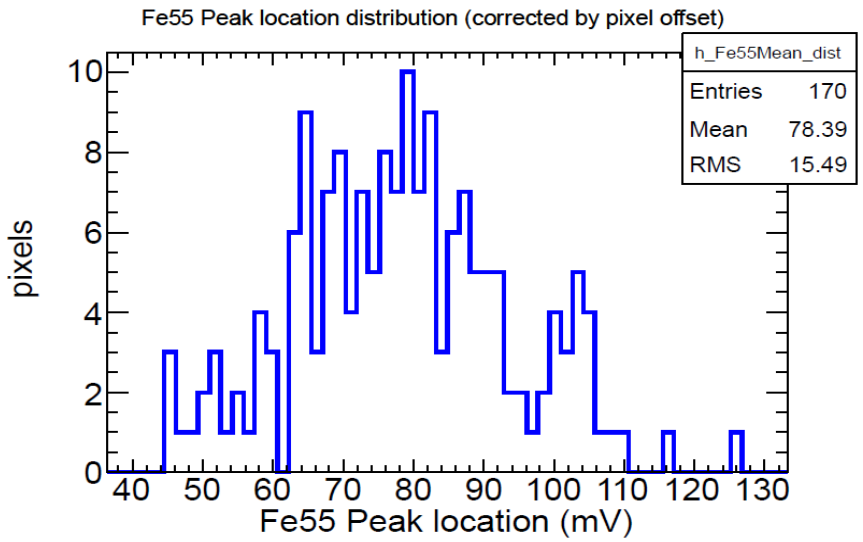


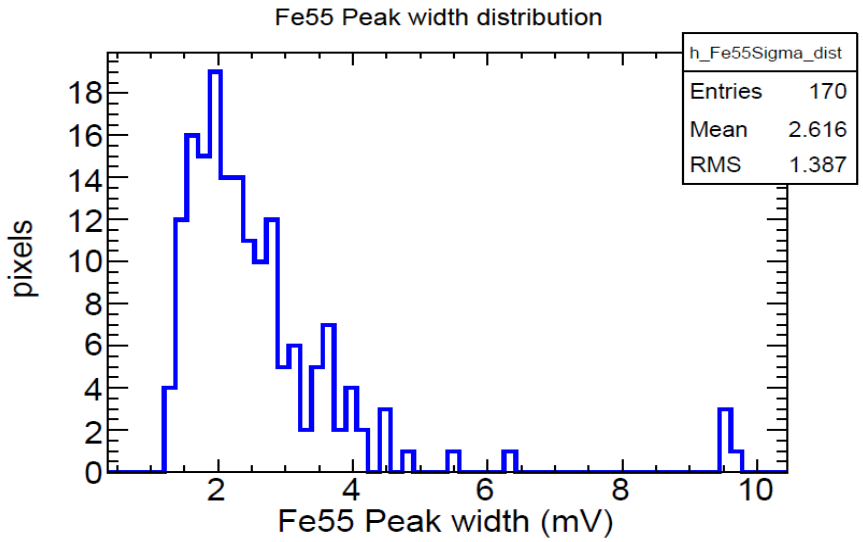


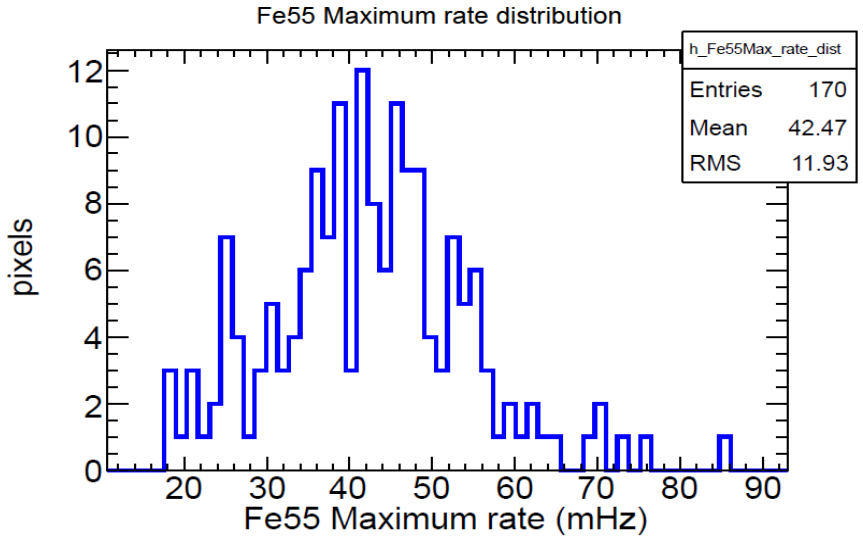
Fe55 source: Chip5 fit example



Fe55 source: Chip5 fit results





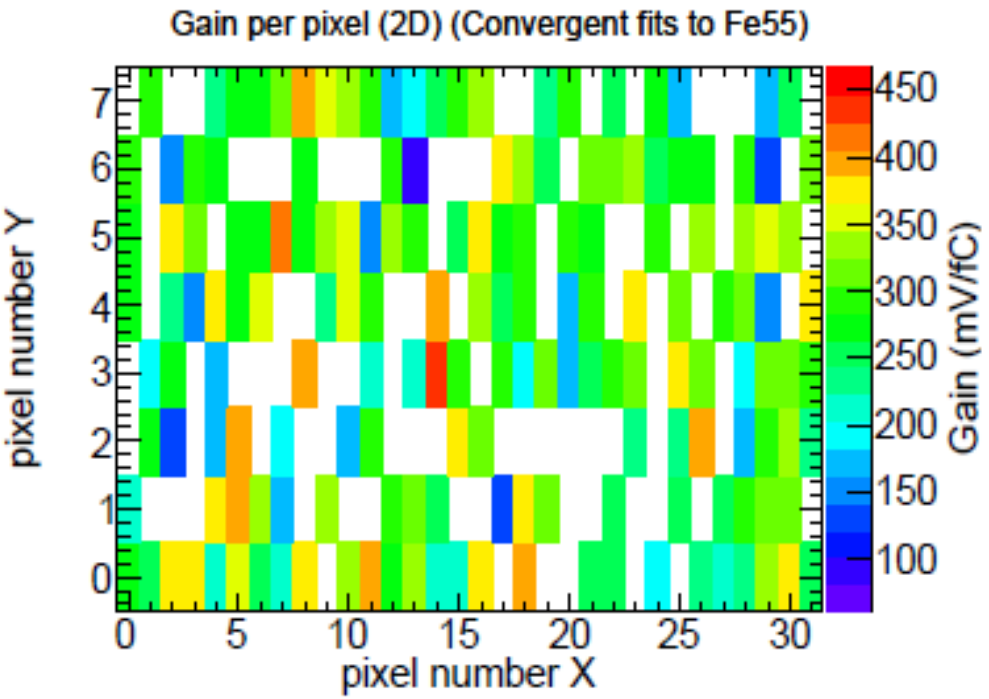


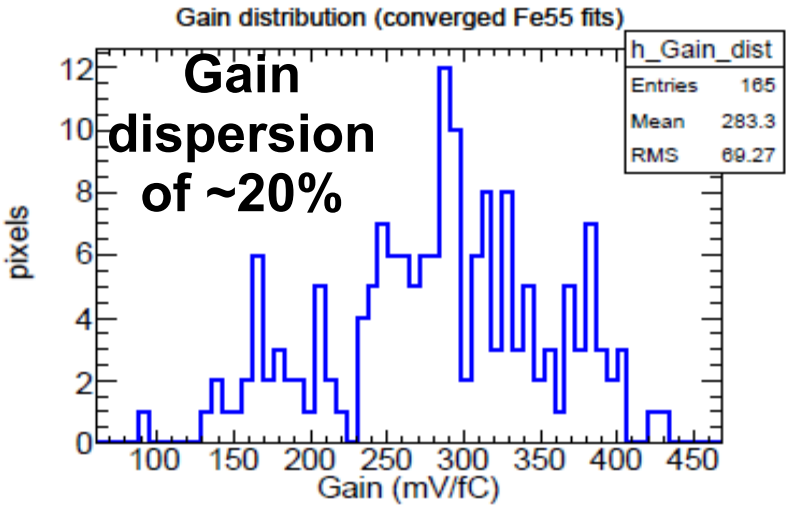
- Subtracted pixel base-line from peak mean
- Mean and width of the peak has been converted from DAC to mV

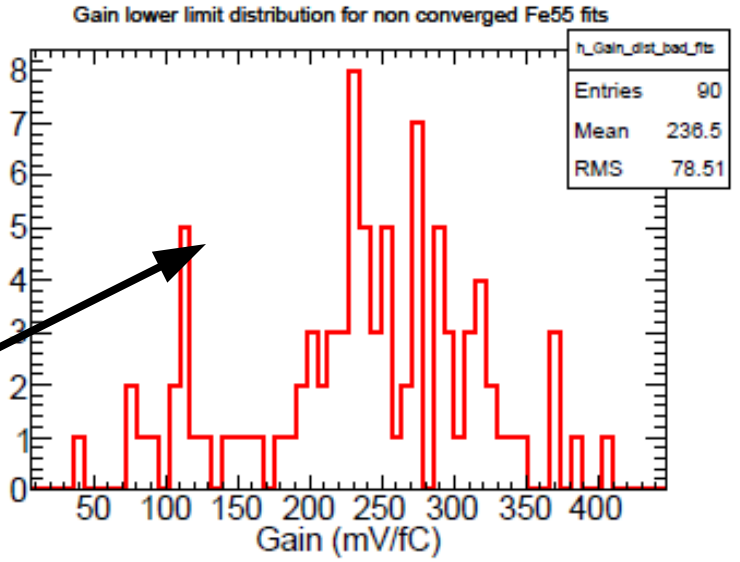
Fe55 source: Chip5 the gain

- Use the peak base-line subtracted mean to estimate the gain

  gain = mean/charge (charge = 1640 e^-)





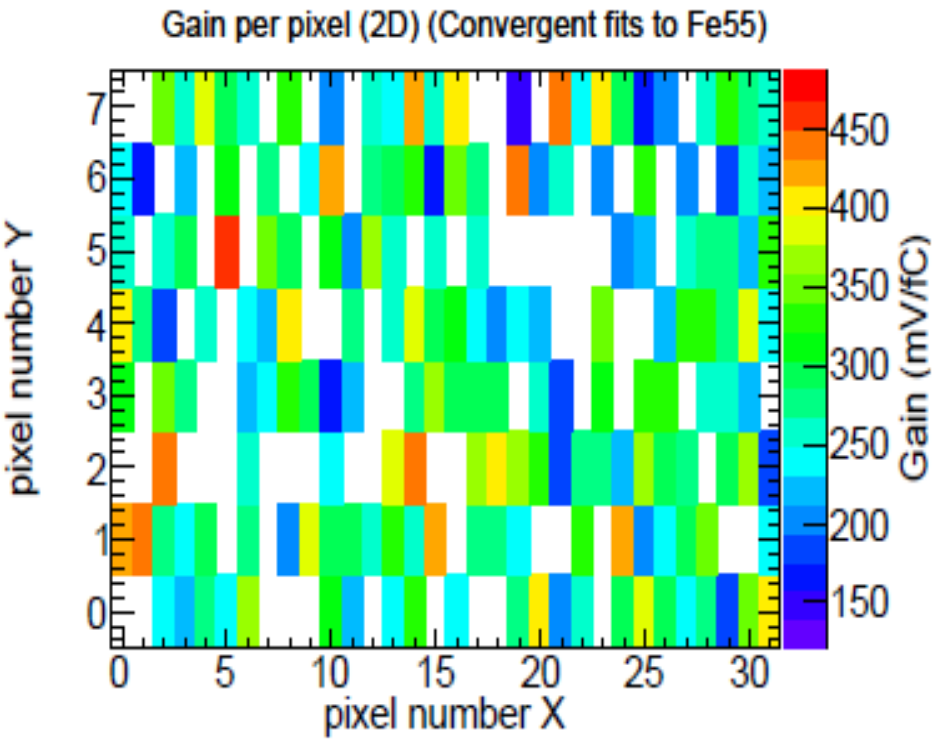


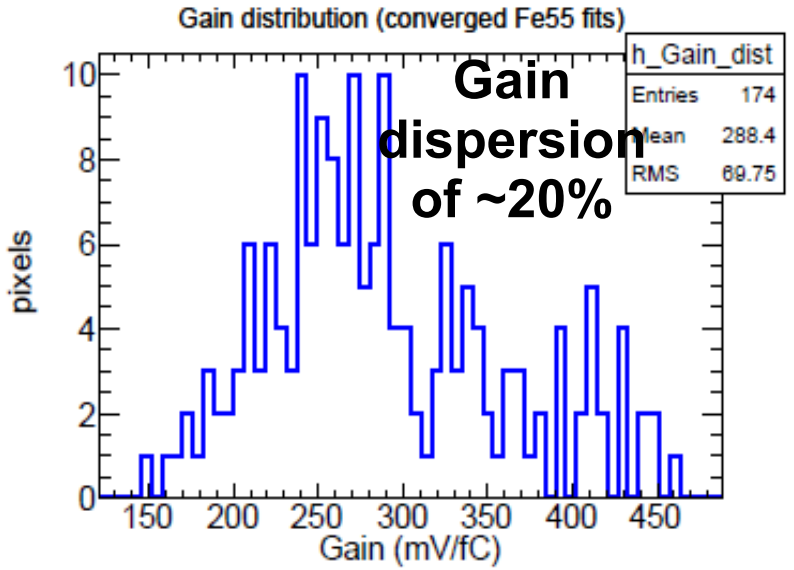
- For pixels for which the the fit doesn't converge estimate a lower-limit of the gain

Fe55 source: Chip6 the gain

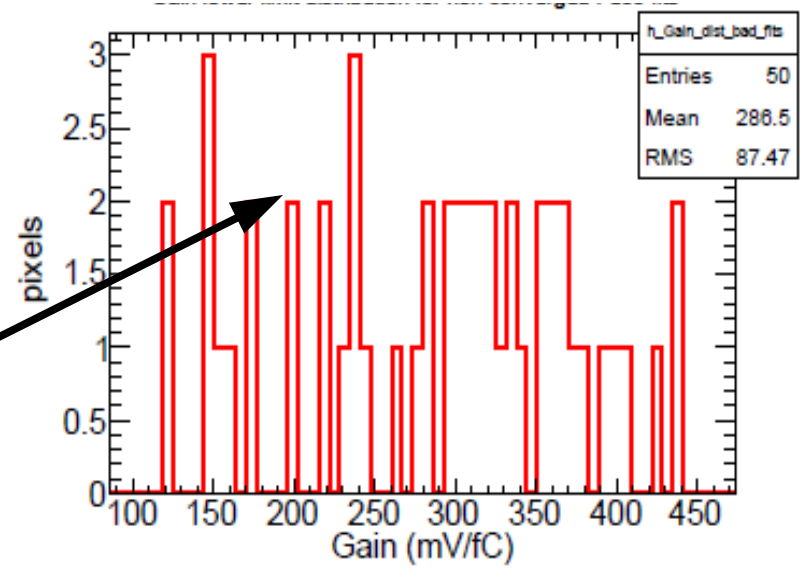
- Use the peak base-line subtracted mean to estimate the gain

  gain = mean/charge (charge = 1640 e^-)

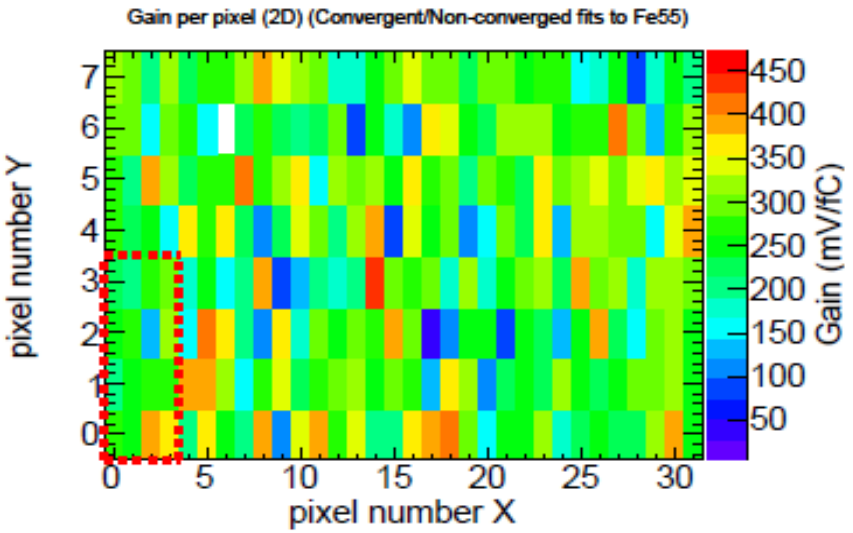




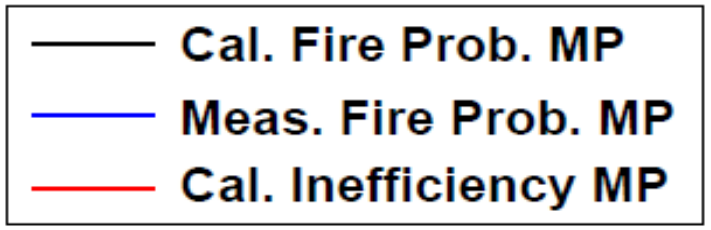
- For pixels for which the the fit doesn't converge estimate a lower-limit of the gain

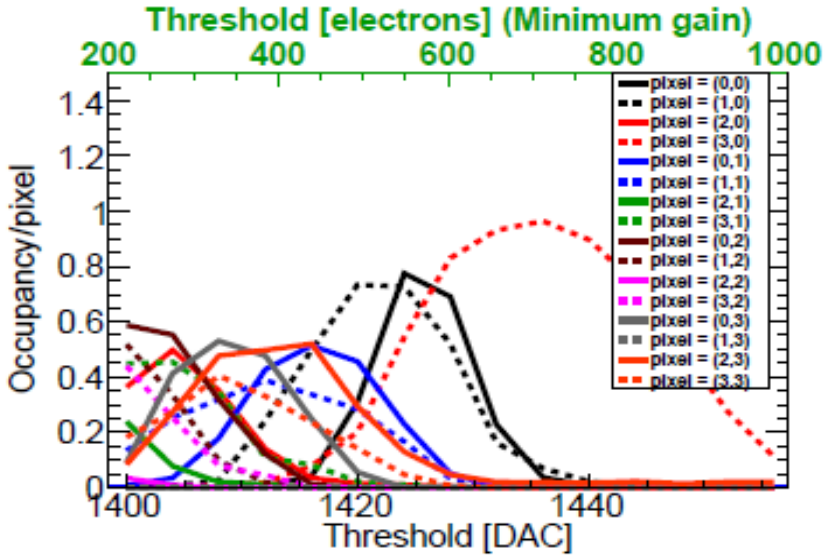


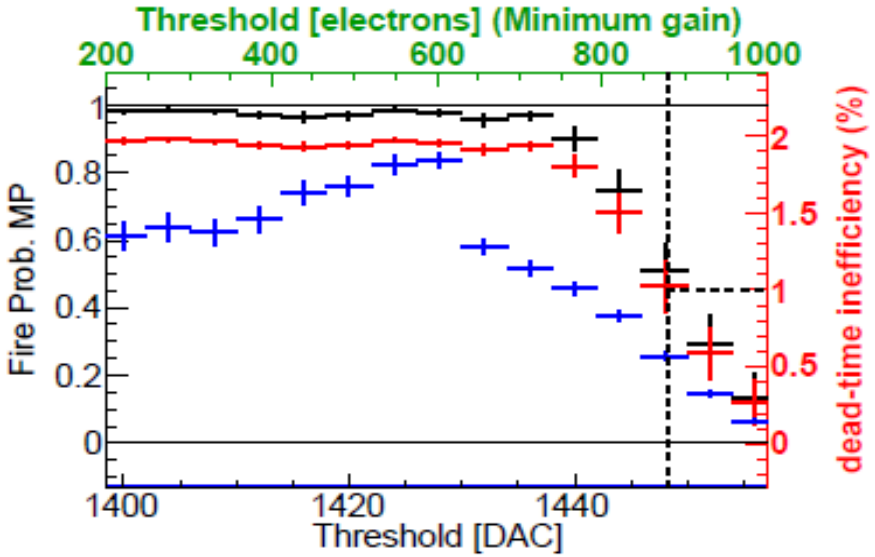
Trying to pilot the Apsel3D_TC chips (Chip5)



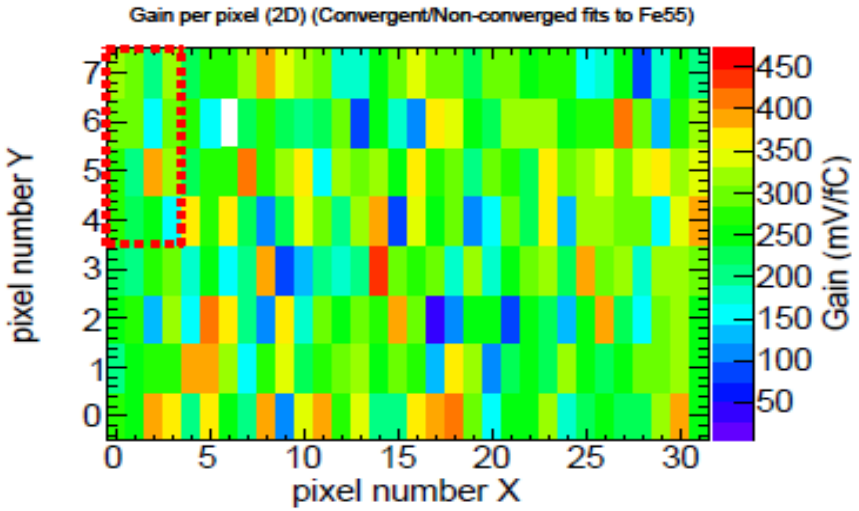
Macro Pixel (MP) 0
N. unused pixels = 0
$Gain_{min}$ = 139.75 mV/fC
$Gain_{max}$ = 381.98 mV/fC





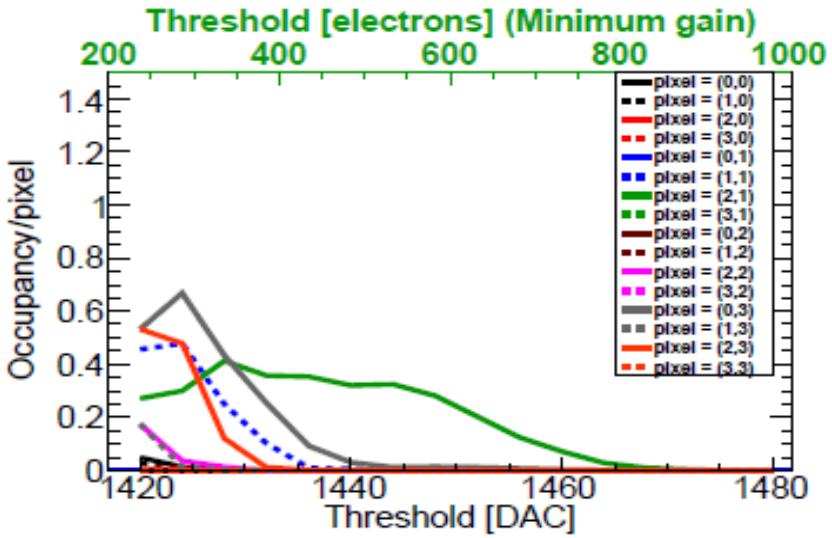


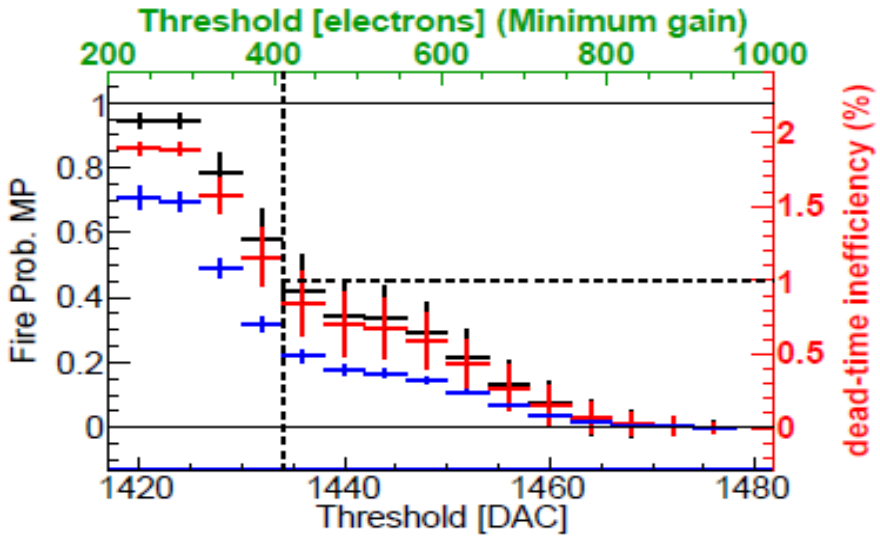
Trying to pilot the Apsel3D_TC chips (Chip5)



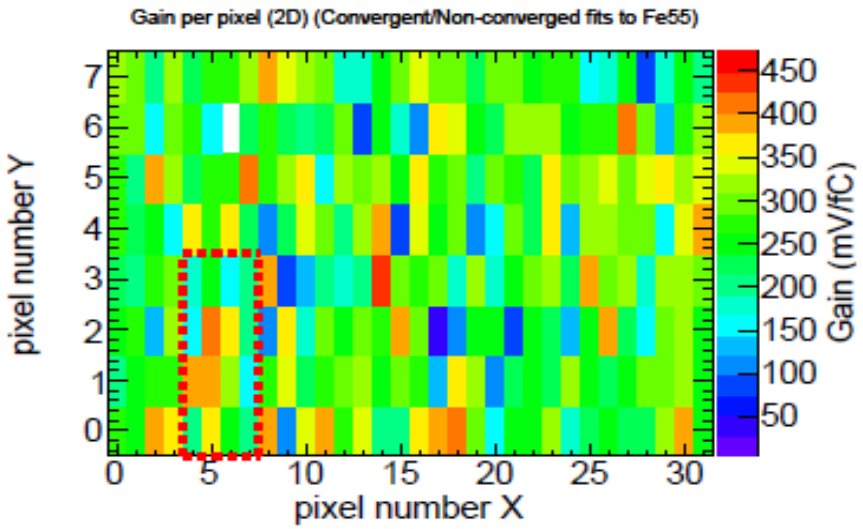
Macro Pixel (MP) 1
N. unused pixels = 0
$Gain_{min}$ = 154.38 mV/fC
$Gain_{max}$ = 385.42 mV/fC

Cal. Fire Prob. MP
Meas. Fire Prob. MP
Cal. Inefficiency MP



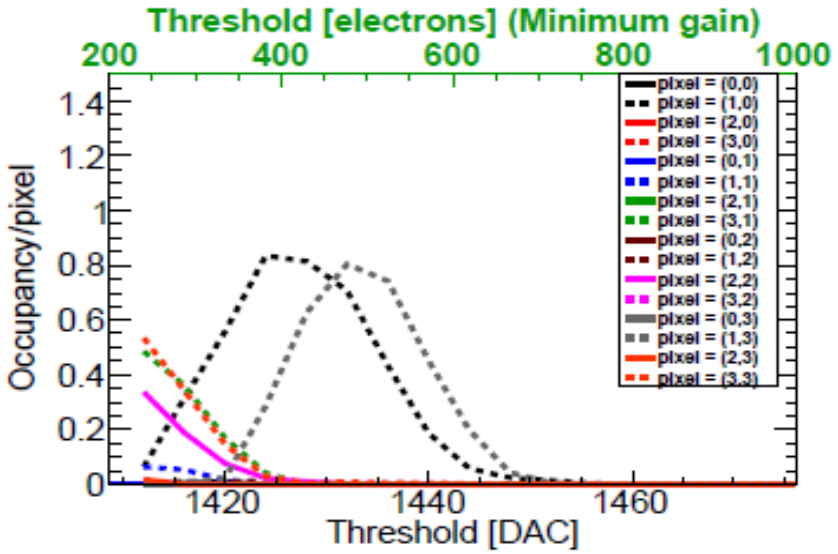


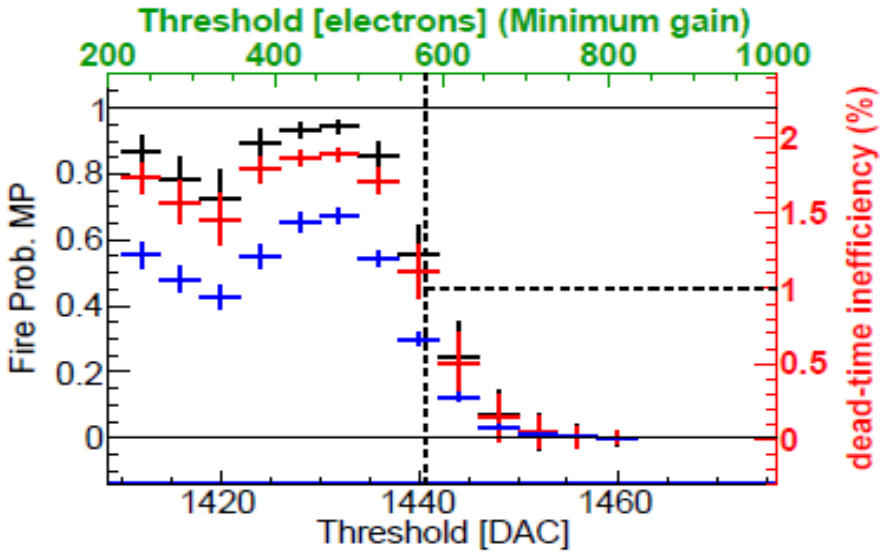
Trying to pilot the Apsel3D_TC chips (Chip5)



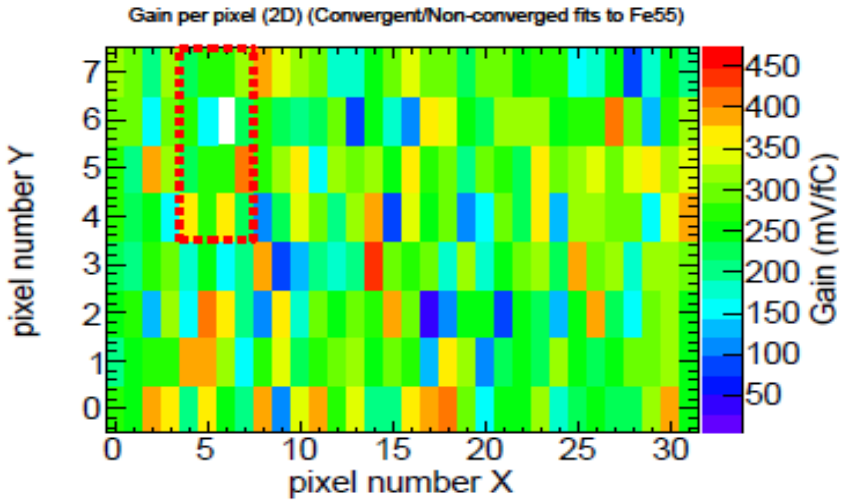
Macro Pixel (MP) 2
N. unused pixels = 0
$Gain_{min}$ = 160.69 mV/fC
$Gain_{max}$ = 404.20 mV/fC

Cal. Fire Prob. MP
Meas. Fire Prob. MP
Cal. Inefficiency MP



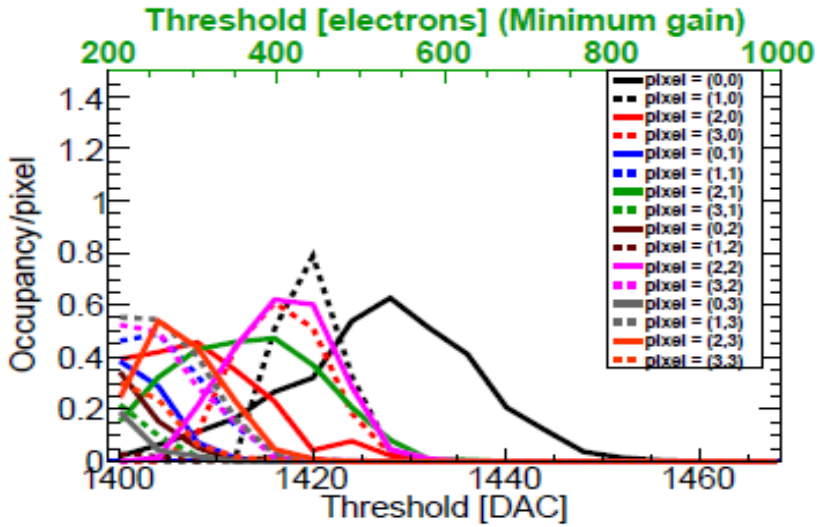


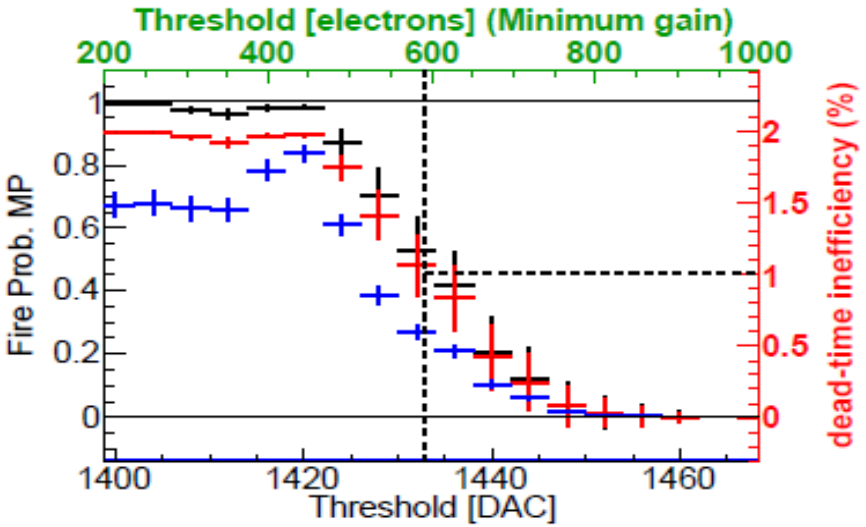
Trying to pilot the Apsel3D_TC chips (Chip5)



Macro Pixel (MP) 3
N. unused pixels = 1
$Gain_{min}$ = 165.78 mV/fC
$Gain_{max}$ = 420.32 mV/fC

Cal. Fire Prob. MP
Meas. Fire Prob. MP
Cal. Inefficiency MP





Summary on Apsel3D_TC

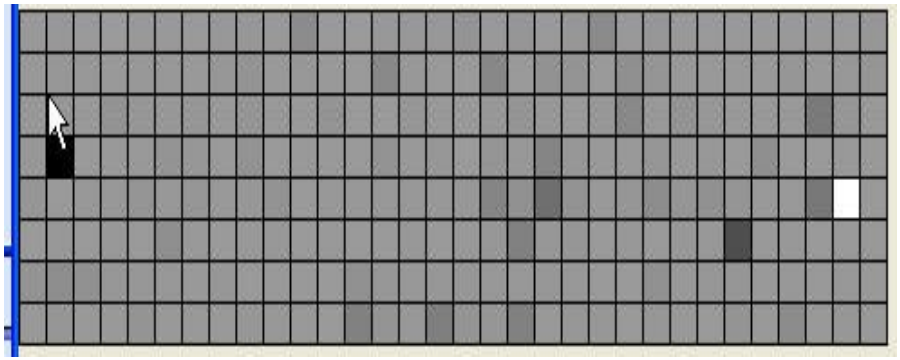
- Measurements with ^{55}Fe source show a significant variation of the gain inside the matrix
- Gain variation seems to be random: no evident structures inside the matrix
- Significant variation of the gain even within a MP
- All these features makes the Apsel3D_TC chips difficult to pilot in a configuration with a reasonable efficiency

- The strategy for test-beam on November:
  - Main priority INMPS32x32
  - Put the chip on beam if some time available
  - Unfortunately had no time to take data with these chips

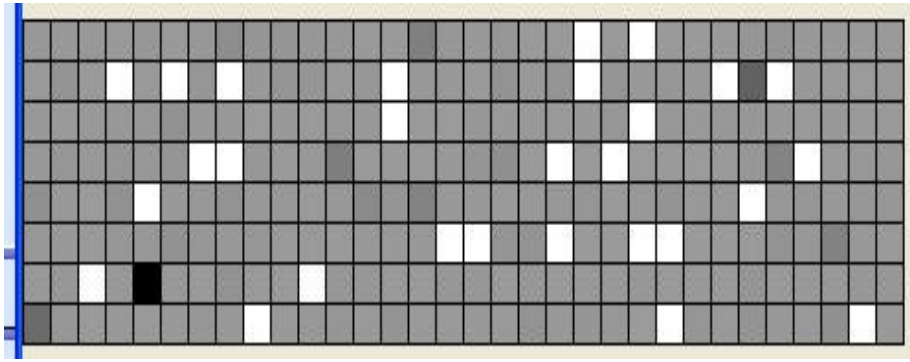

Backup

Fe55 source: Chip5

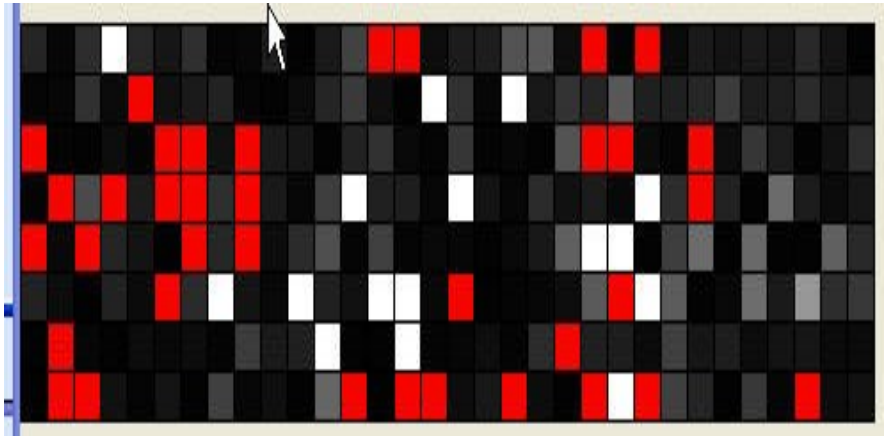
Noise scan Chip5



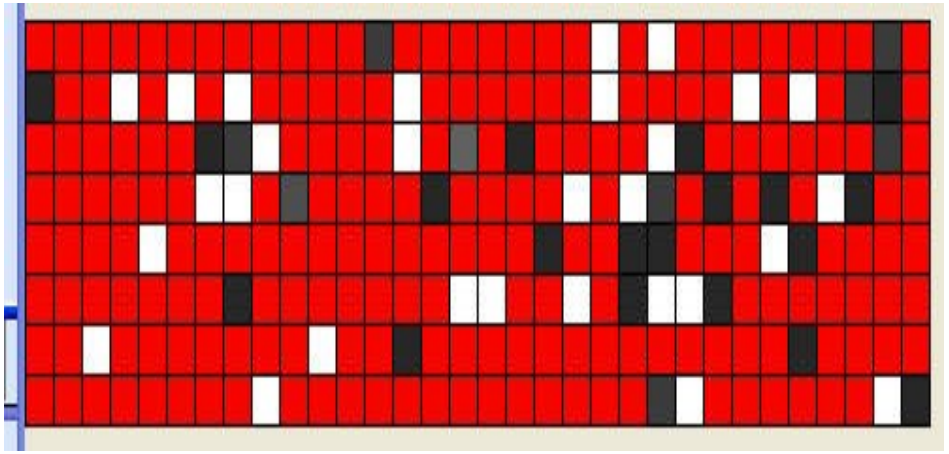
Noise scan Chip6



Fe55 at 1520
DAC Thr Chip5

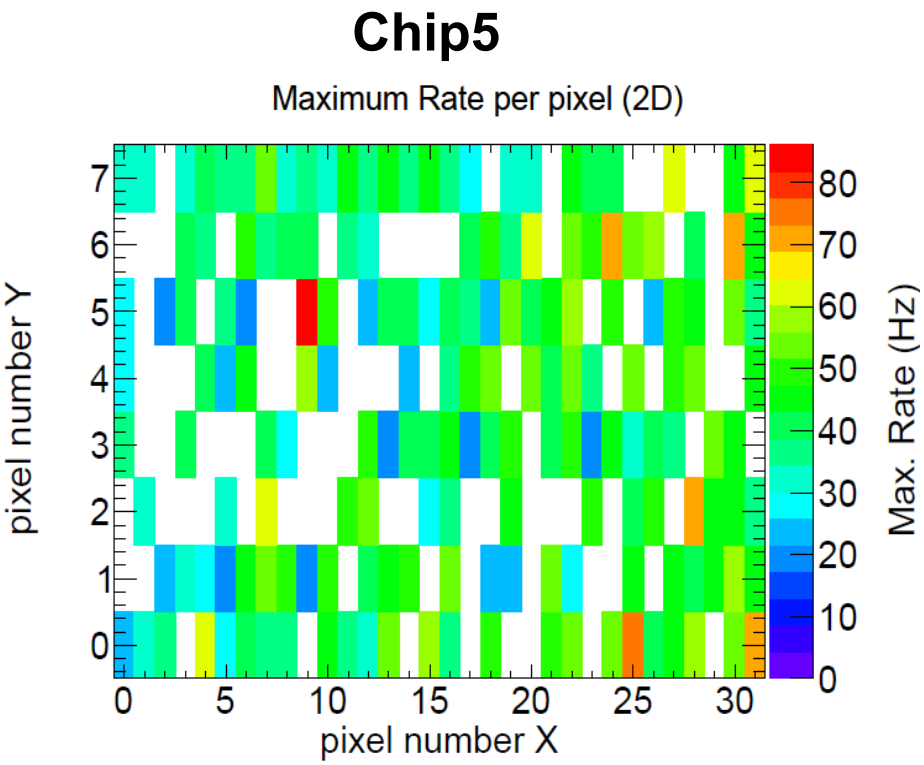


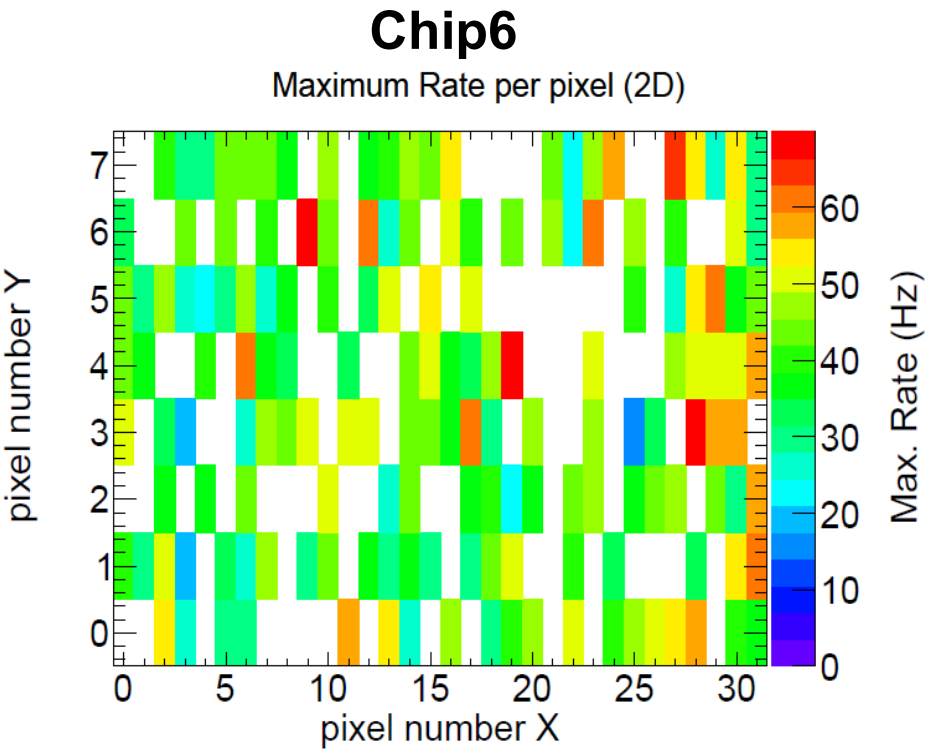
Fe55 at 1477
DAC Thr Chip6



Fe55 source: Chip5 and Chip6

- For every pixel plot the maximum rate. Wants to check if source irradiates uniformly the matrix





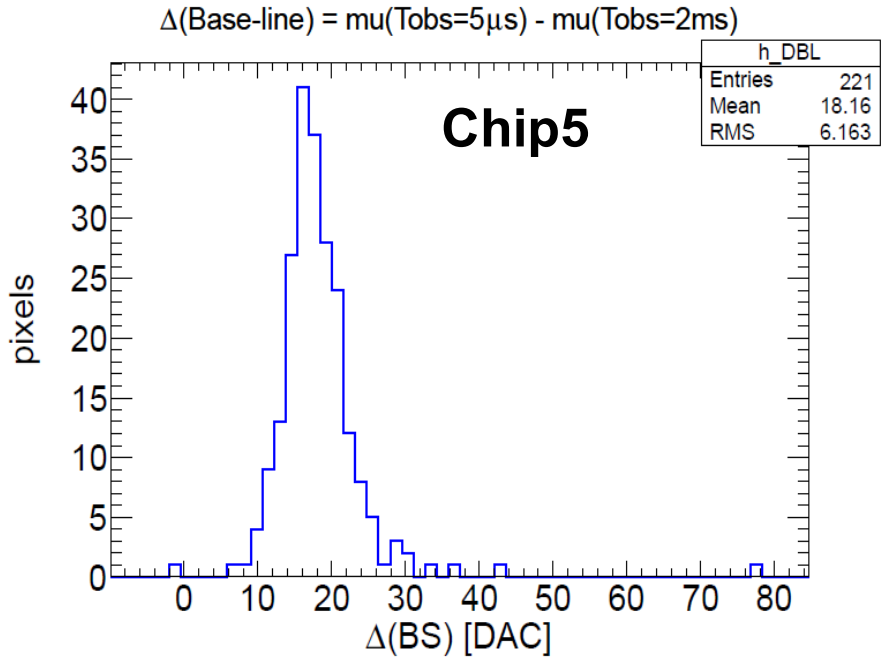
Noise occupancy with realistic t_{obs} (5μs)

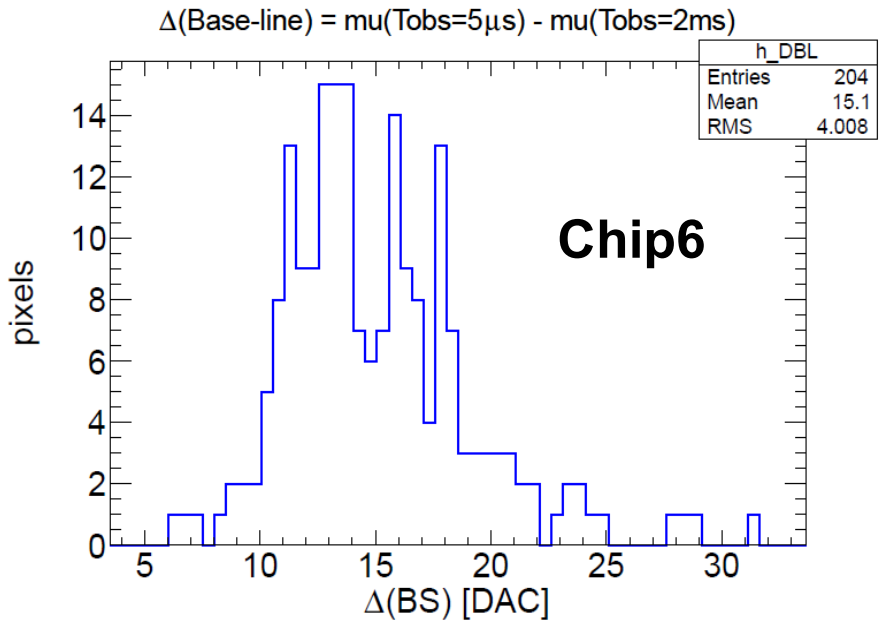
Realistic t_{obs} (5μs)

- Wants to evaluate what is the matrix occupancy due to noise for realistic observation times (5μs) and for different thresholds
- Also wants to have an idea of the death time as a function of the threshold
- Did noise scans from 1388 to 1504 in steps of 4 (units in DAC)
- Prediction function: use the results from the high t_{obs} (2ms) noise scans (μ,ν_0,σ_R and σ_L) and scale to the current t_{obs} $\Rightarrow$ use the same noise function with the current t_{obs}
- Use this function to try to predict the occupancies for the current t_{obs}. Don't expect good description as death-time is non negligible
- Also estimate the matrix occupancy (fraction of pixel of the matrix that fired due to noise)

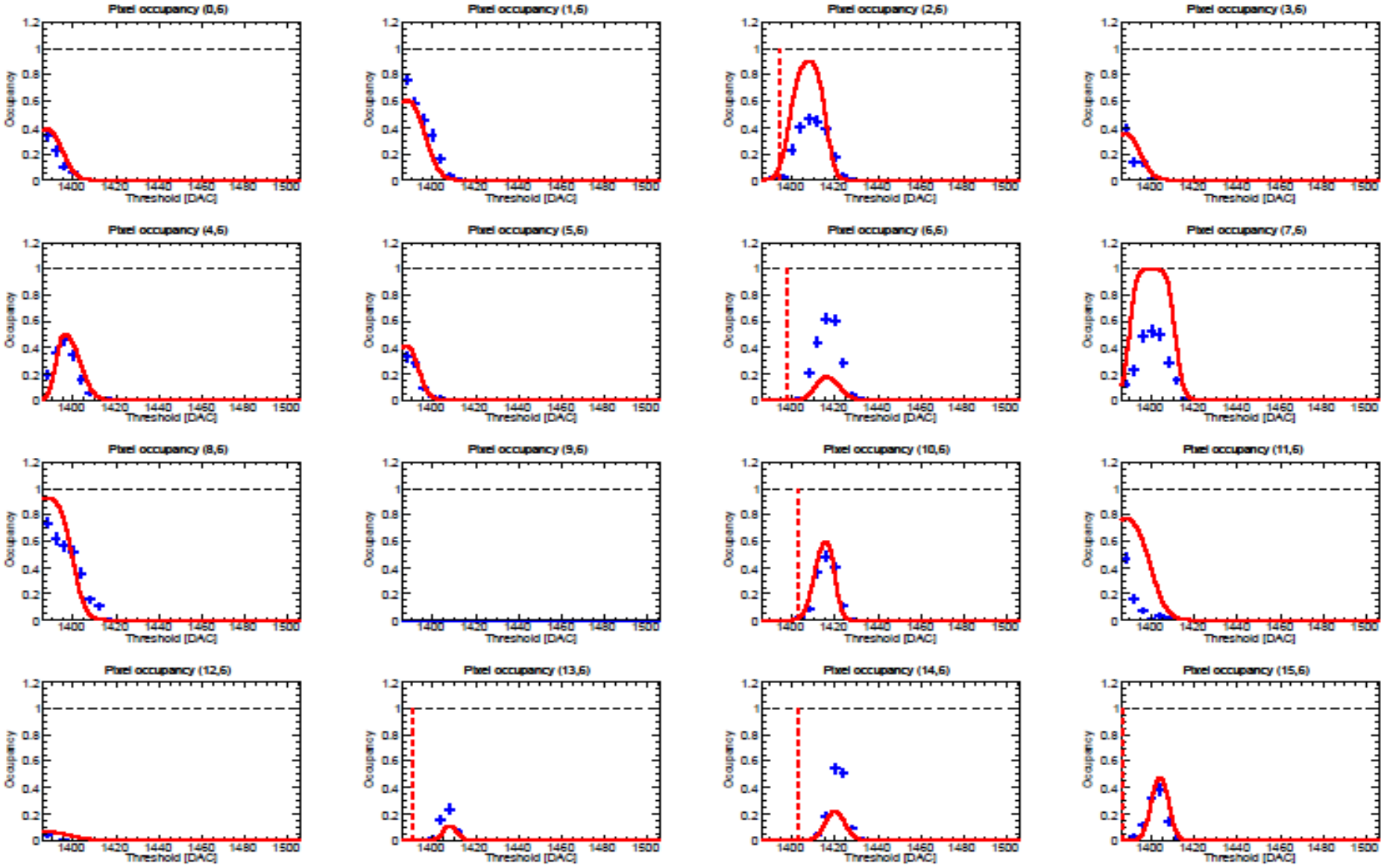
Realistic t_{obs} (5µs): variation of the base-line

- Base-line of noise scans for t_{obs} = 5µs is different than the one for t_{obs} = 2ms
- Is this an effect of the temperature?
- To predict the pixel and matrix occupancy used the base-line for t_{obs} = 5µs and the other parameters (ν_0,σ_R,σ_L) extracted for the noise scans with t_{obs} = 2ms





Realistic t_{obs} (5µs): occupancies per pixel (Chip5)



Realistic t_{obs} (5µs): matrix occupancy

- Wants to evaluate what is the matrix occupancy due to noise for realistic observation times (5µs) for different thresholds