Binomial Test for Oscillations

SCT Barrel Modules

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LBL

Motivation

- A quantitative measure of the presence of oscillations
- Test at high thresholds where the occupancy is less than 5%

Strategy

- Ideal module – strips are independent
- If there is no correlation between strips then the probability of n hits on one side when the probability of a hit on a single strip is f is a binomial distribution

$$P(n) = \frac{N!}{n!(N-n)!} f^n g^{N-n}$$

where g = 1-f and N = 768 strips

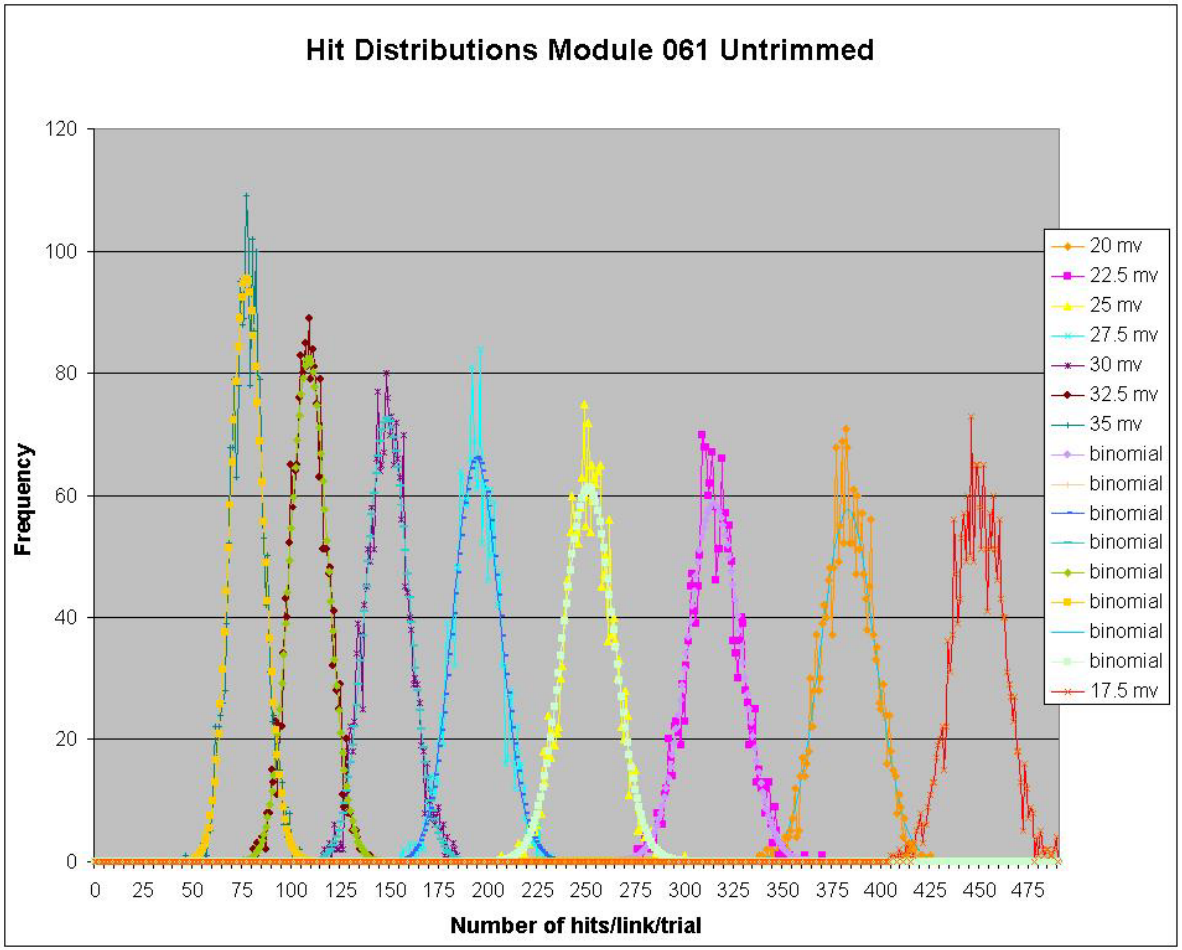
Strategy II

- If oscillations are feedback from the output of the comparator coupled into adjacent strips then we do not expect a binomial distribution.
- Let Q(n) be the observed distribution of hits
- Define Residual as

$$R = \sum_{n} \frac{\left(Q(n) - P(n)\right)^2}{P(n) + 1}$$

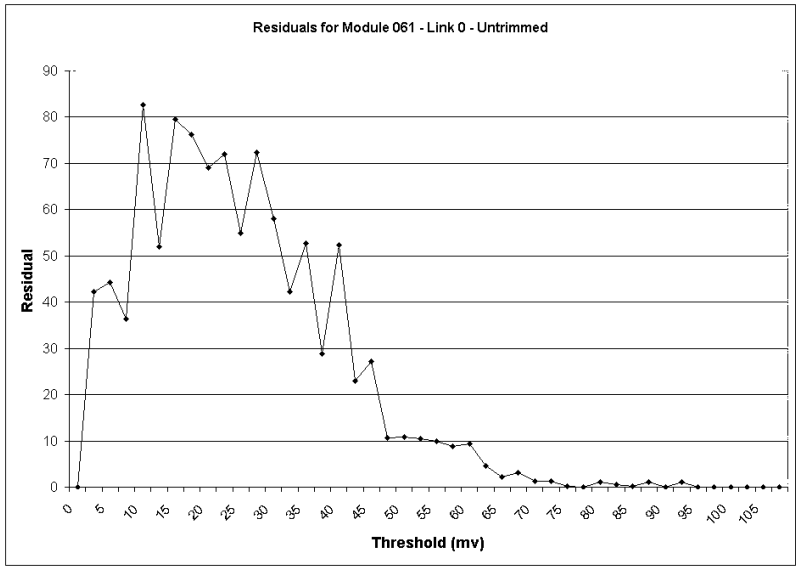
Calibrate Test

- Module 61 – untrimmed
  - No oscillation observed in untrimmed module
- The fit is superb



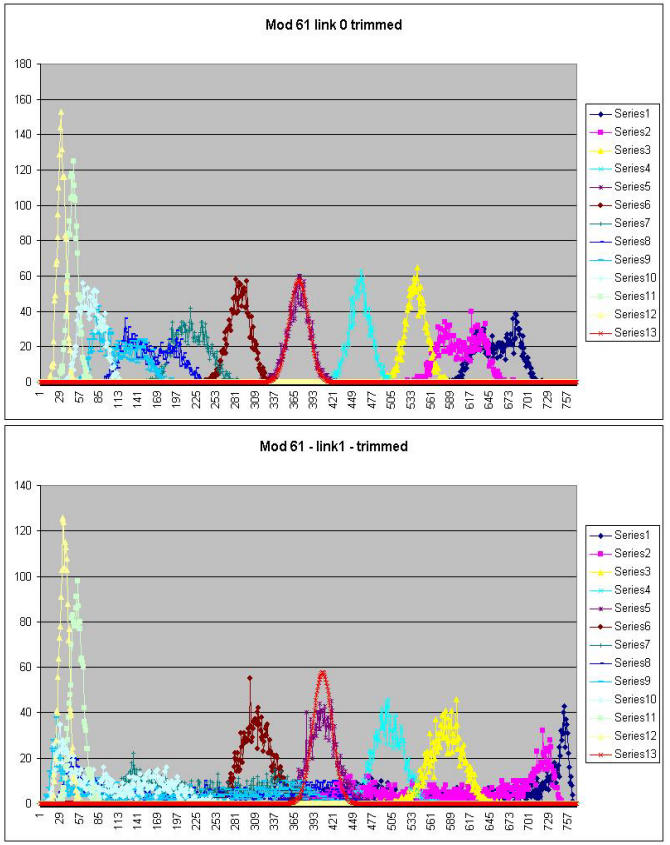
Residuals for Module 61 - untrimmed

- The residuals are nearly a chi square and the number of degrees of freedom is close to the number of non zero bins in the hit distributions.
- The residuals for module 61 are about equal to the number of non zero bins.



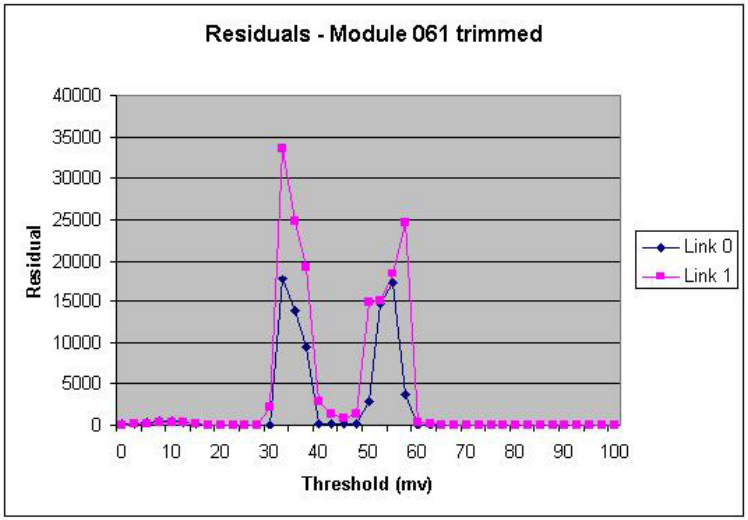
Hit Plots for Module 61 - trimmed

- Link 1 -The distributions for high and low occupancy are very smeared.
- Link 0 – No oscillations are visible in the S curves but the distributions are clearly distorted.
- The ‘oscillation’ problem can exist even when it is not visible in the S curves.



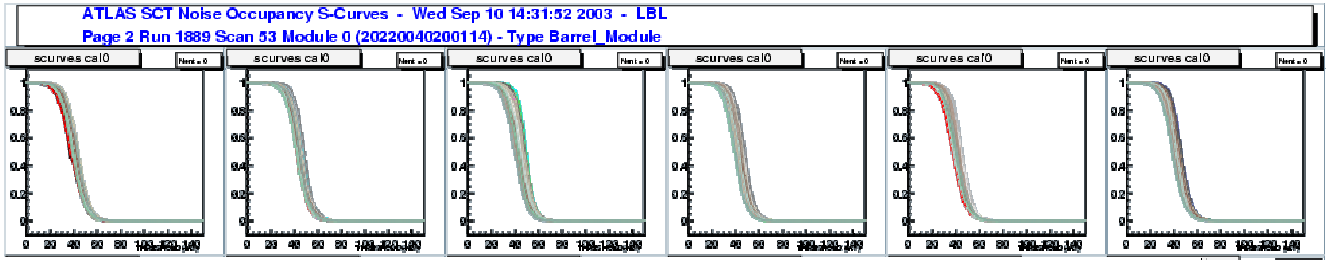
Residuals for Module 61 - trimmed

- Visible distortions of the S curves cause residuals greater than 20000.
- We define the highest threshold at which ‘oscillations’ are observed as the highest threshold where R > 5000.

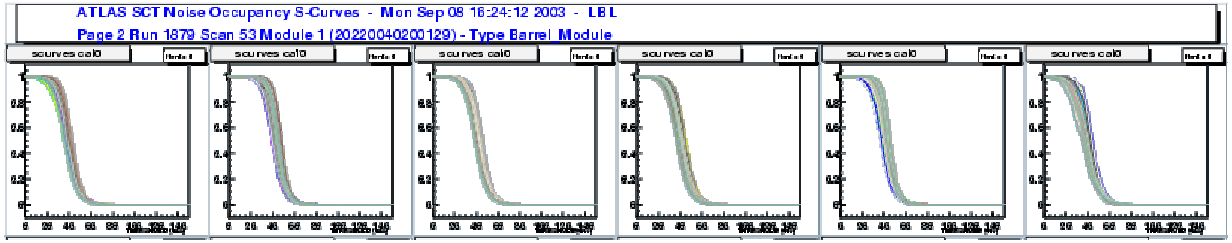


Visual figure of merit

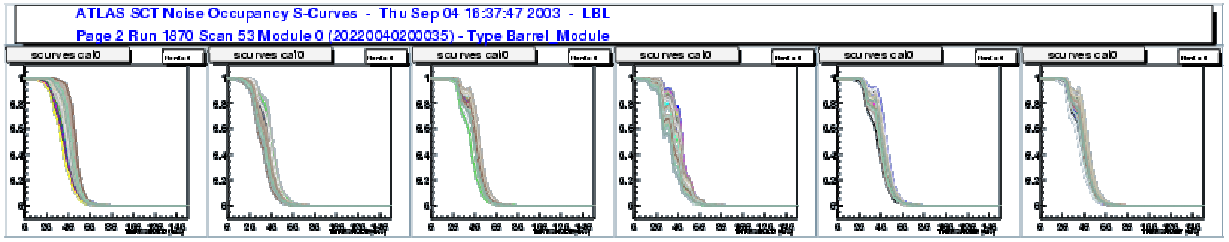
None - 0



Weak - 1

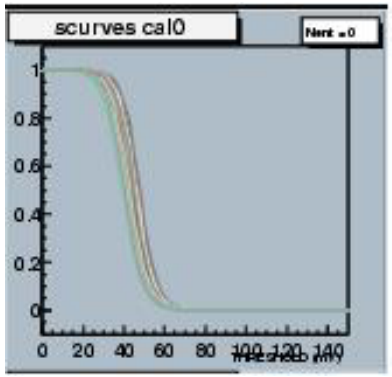


Strong - 2

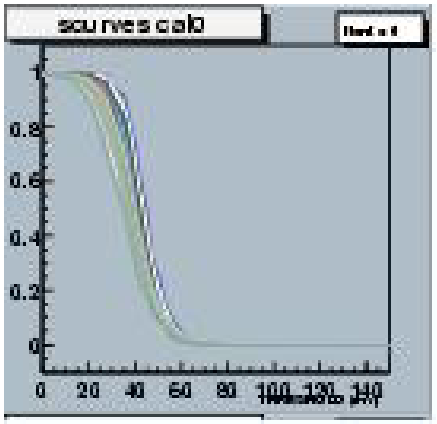


Visual Rating of Oscillation

0 - None

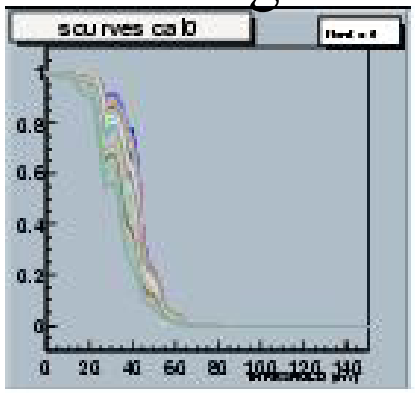


1 - weak



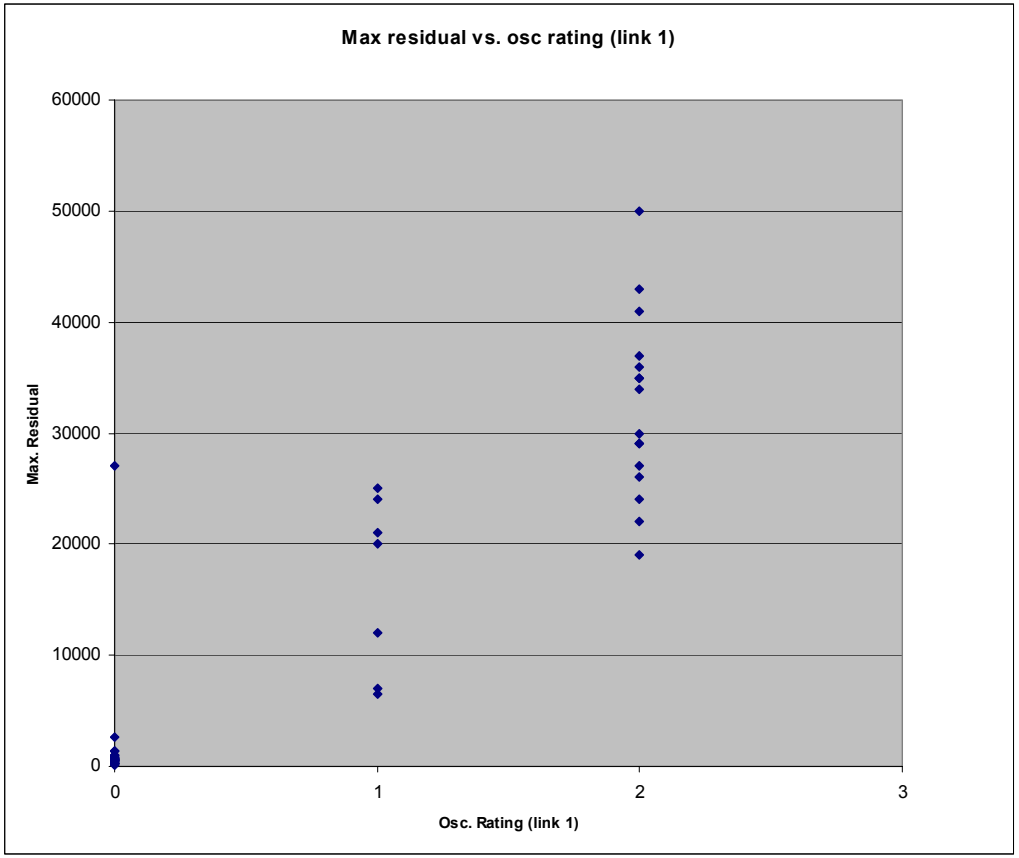
Barely visible

2 - Strong



Residual vs Visual Rating

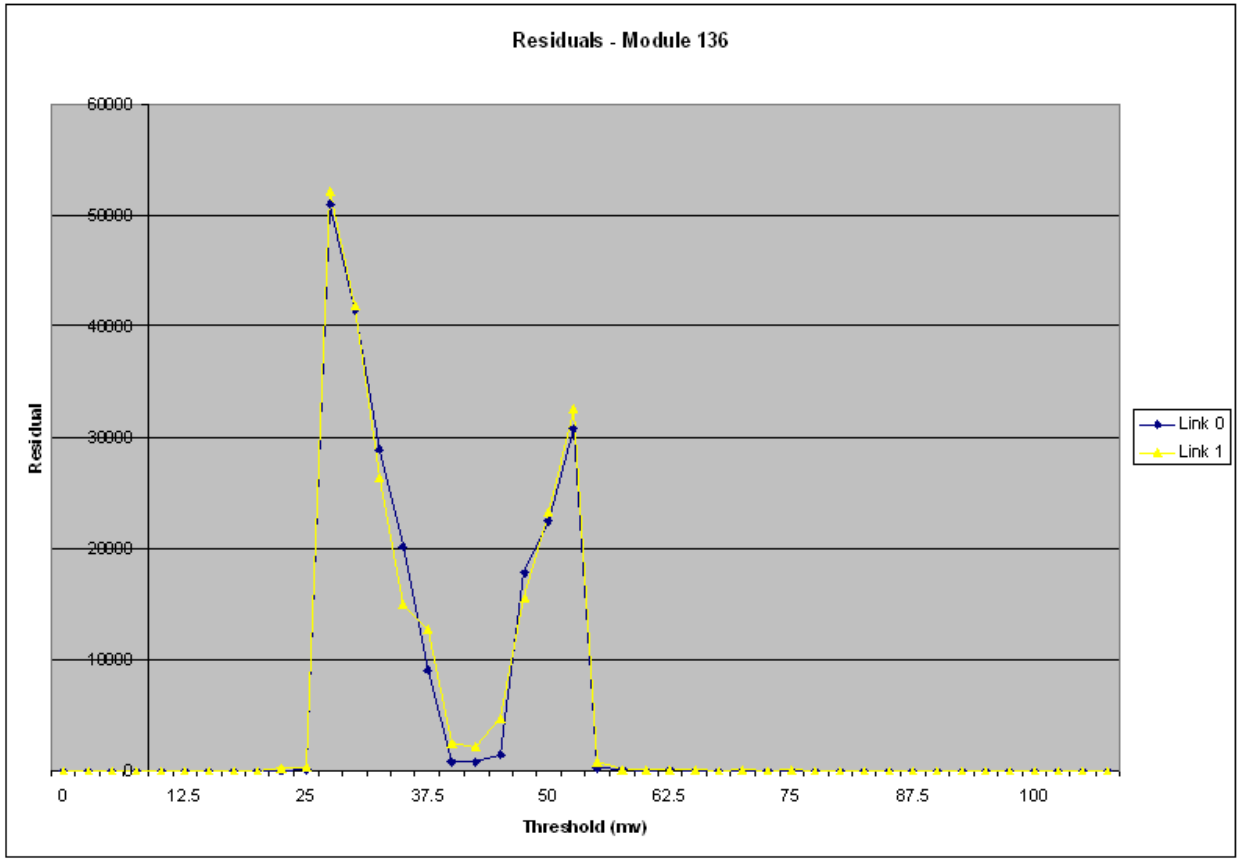
Strong correlation between R and S curve distortions



Oscillations on Link 0

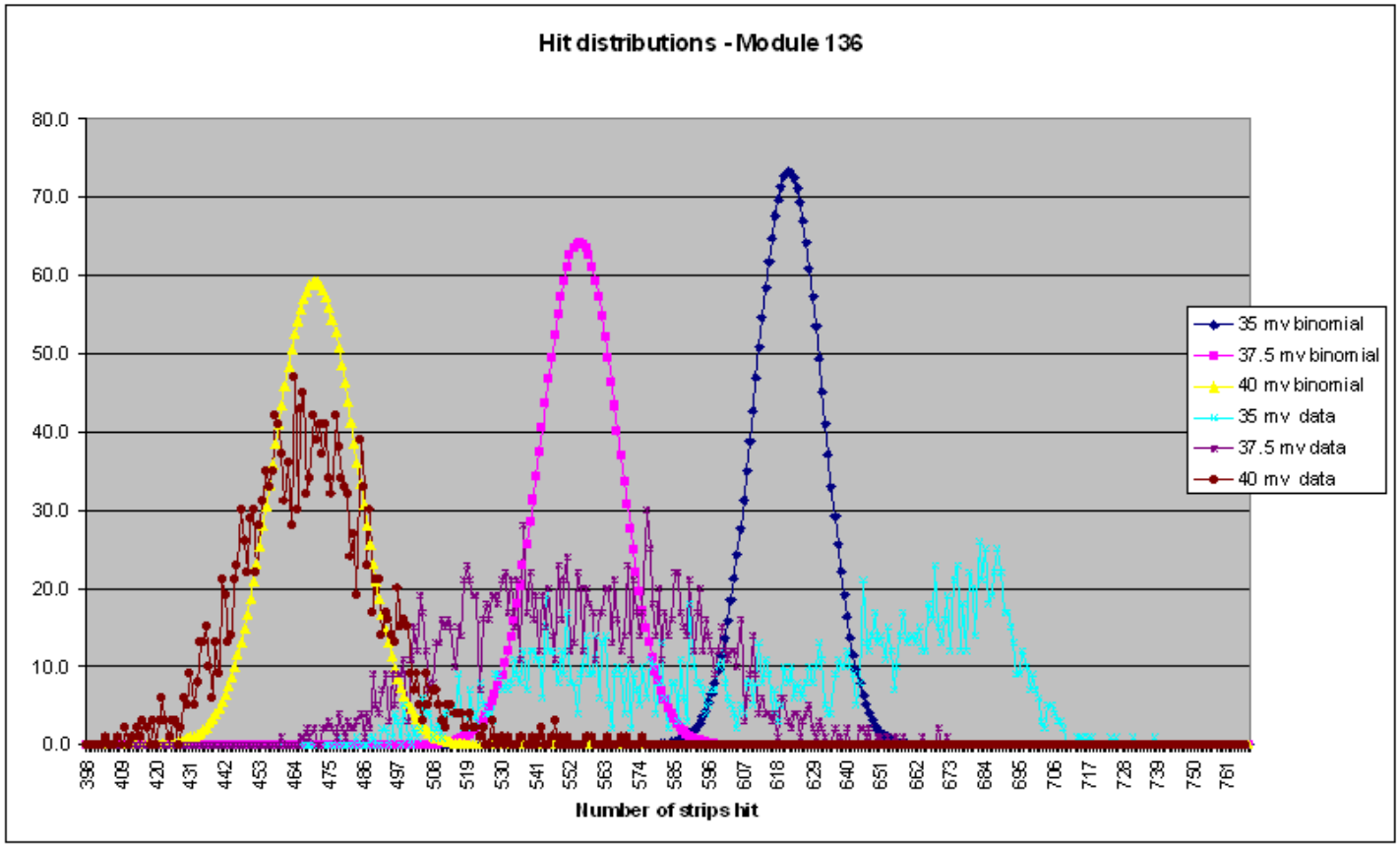
- Module LBL 136
- Large residuals and nice S curves
- The hit distributions appear to have the same disease as Link 1

Residuals for Mod 136



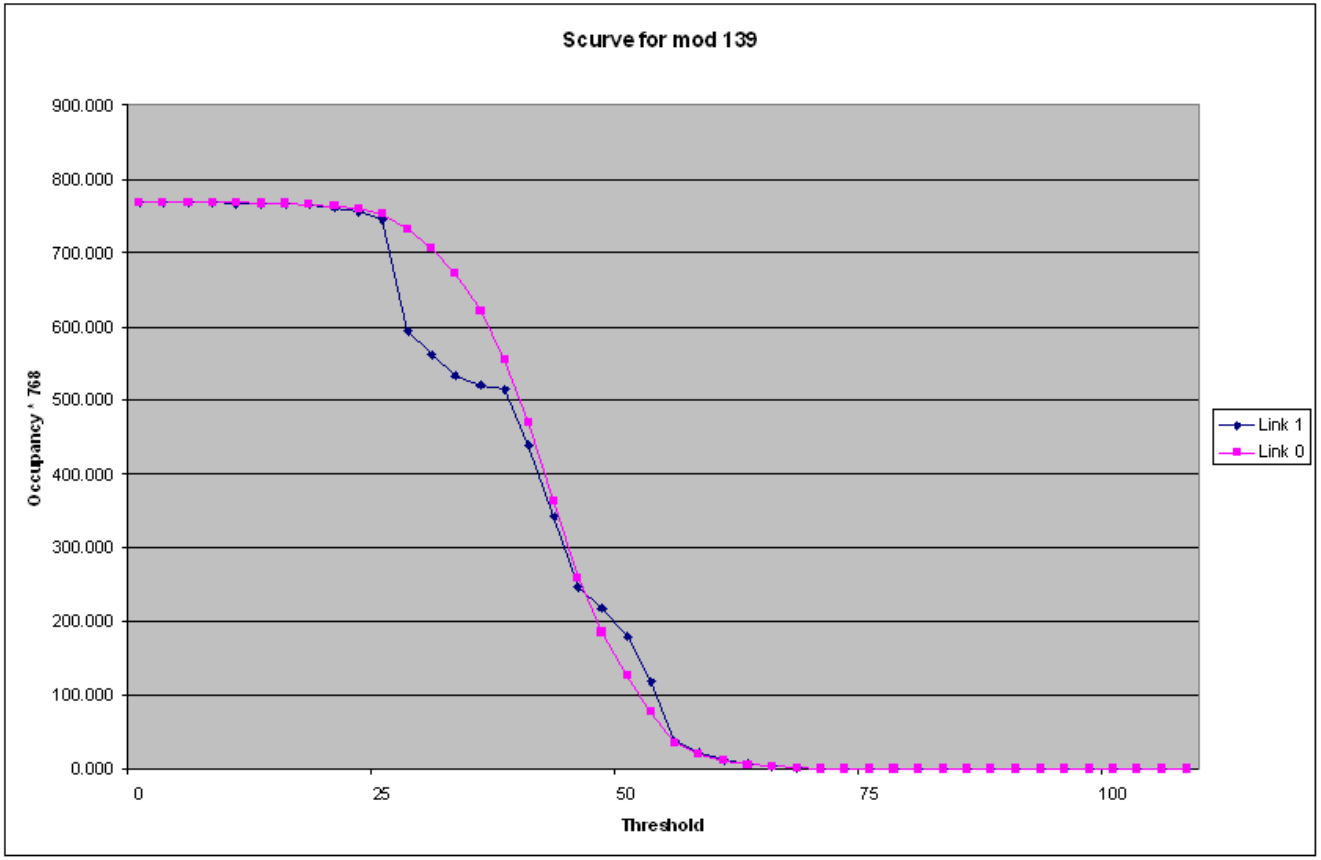
Hit distributions – Module 136

Link 0



S curves for Module 139

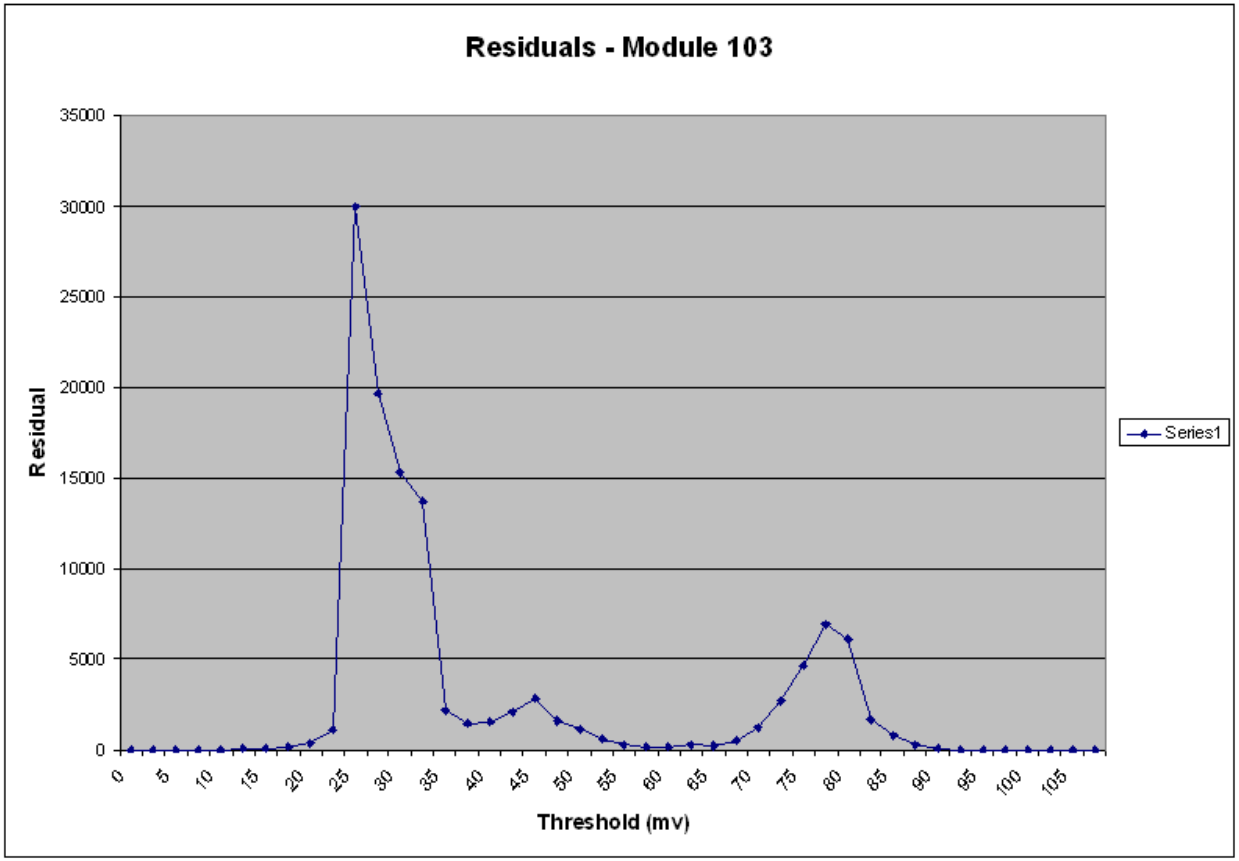
Average over entire link



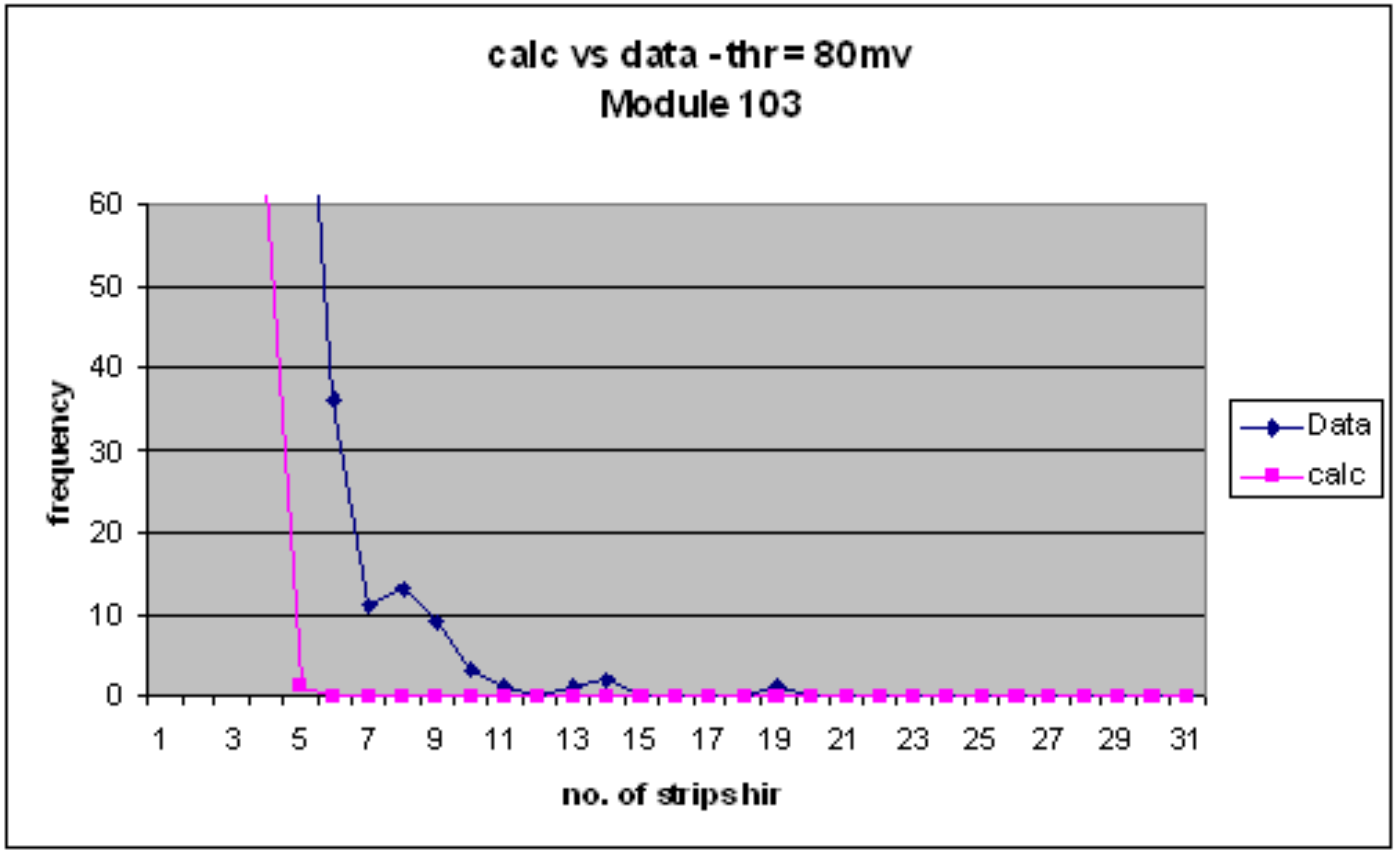
Oscillation at High Thresholds

- Can we detect oscillations at low occupancy?
- We record the highest threshold with residuals greater than 5000
- Module 103 is the only example over .4 fc
  - Highest thr = 80mv (R = 6600, 10^6 events)
  - Occupancy = .074 strips (768 possible)
  - Data-calc (P(n)<5) = 166 ev, ~ 1/6000
  - Are the strips contiguous?
  - Does this effect hit efficiency?

Residual Distribution of Module 103



Hit distribution



Conclusions

- Binomial test is a sensitive test for ‘oscillations’
- The numerical measure will be useful to establish correlations with temperature and Ish etc.
- More experience is necessary to find the most useful parameters.
- Care must be used to avoid false signals
- Necessary to upgrade the Mustard firmware.