Noise analysis of the 1m^3 DHCal test beam

Qingmin Zhang

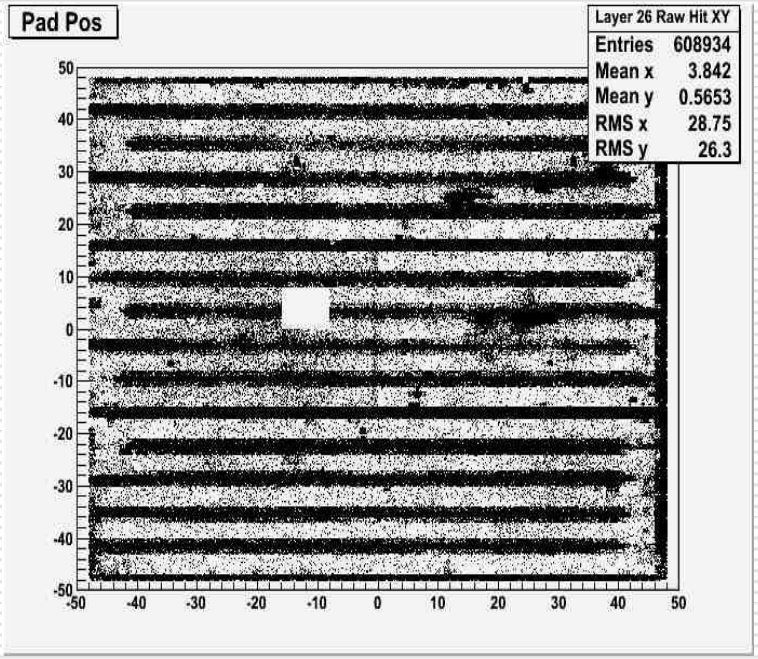
Lei Xia

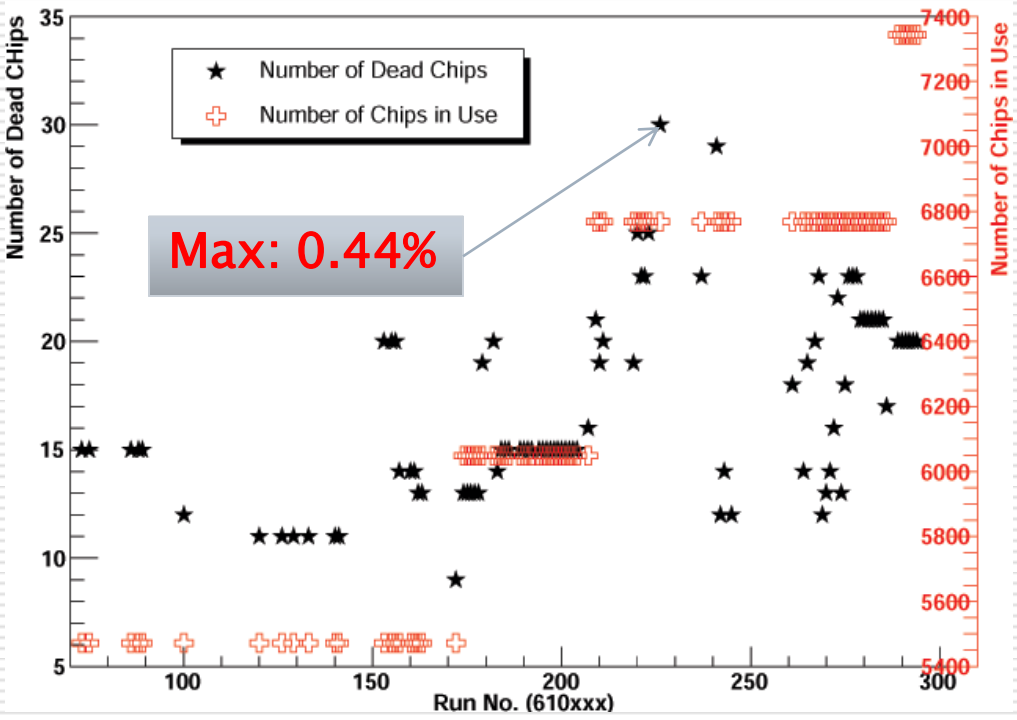
Outline

- ‘Dead’ ASIC’s
- Noise rate monitoring from self-triggered runs
- Noise comparison between self-triggered and randomly triggered runs
- Noise ‘hot’ spot study

‘Dead’ ASIC’s

- A tiny fraction of the FE asic’s will not give any data in any run type: appear to be ‘dead’
  - Reason is not clear at the moment
  - Average fraction is only 0.27%
  - They are not ‘really’ dead (most of them)
  - Their status can change with time and power cycle
- Blank areas due to FE board, LV and HV problems are not included (very rare)

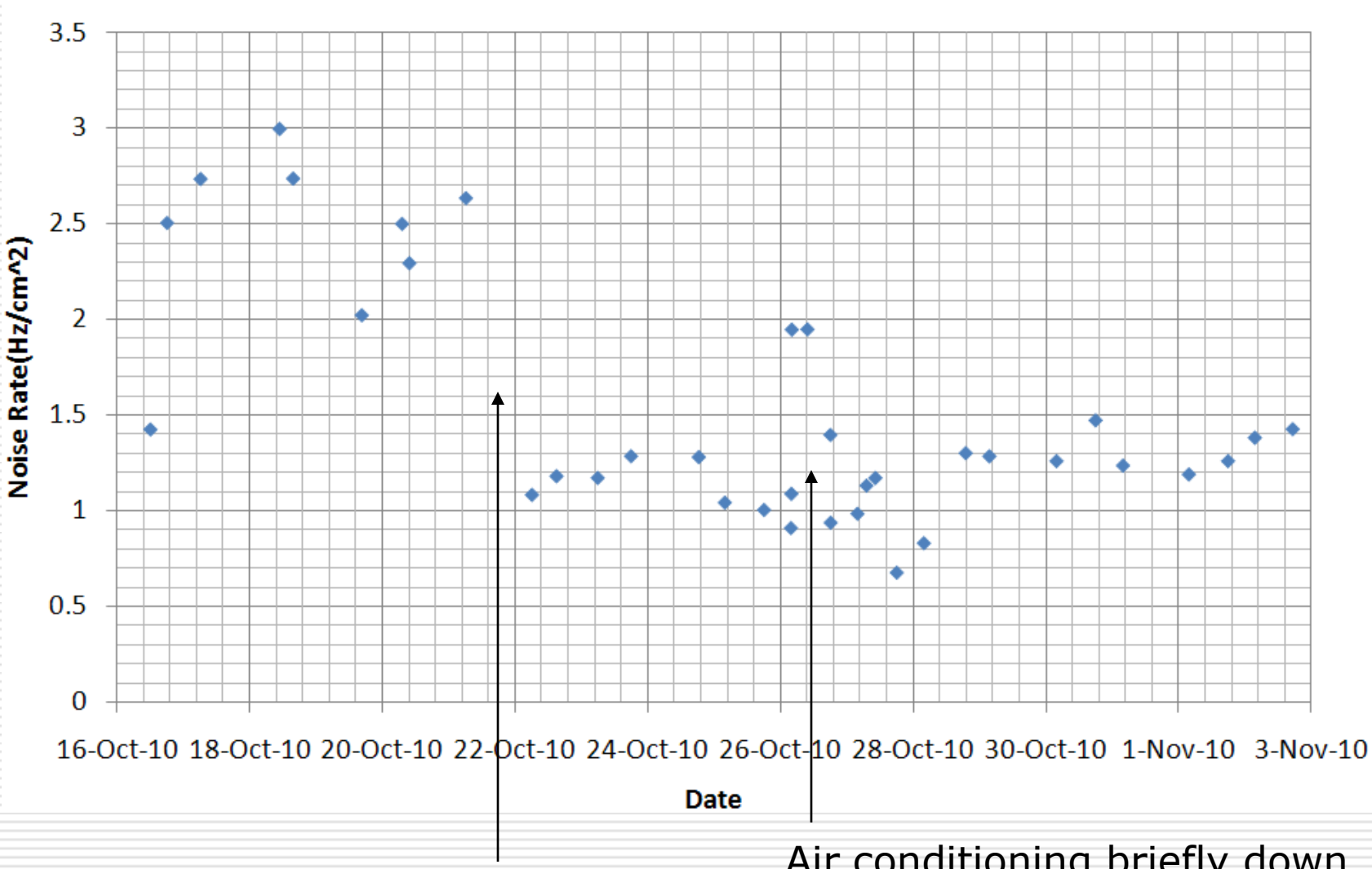




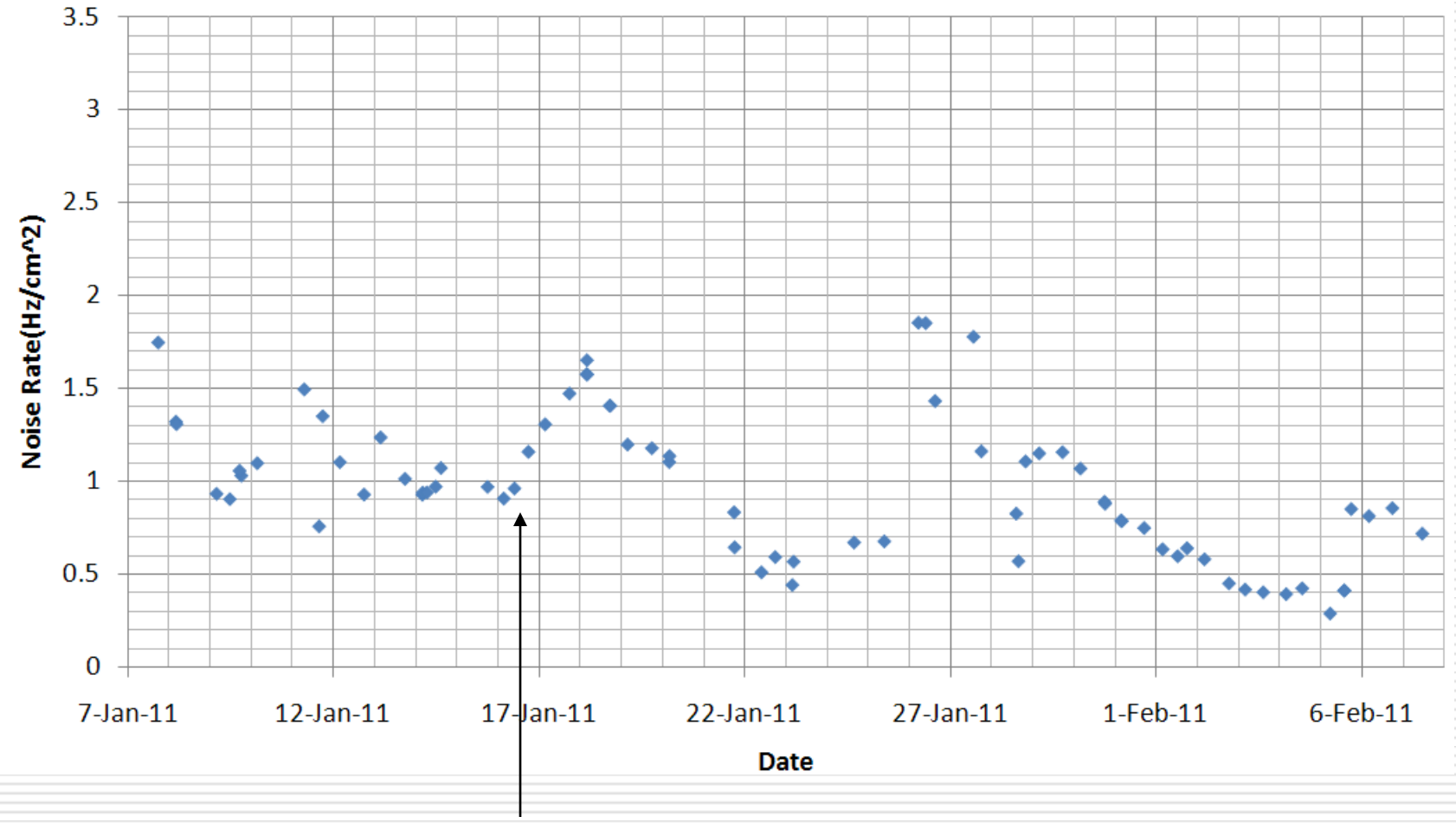
Noise monitoring

- The $1m^3$ DHCal prototype is capable of setting the FE freely running (self-trigger)
  - All FE signals are recorded, up to a certain rate limit (not likely to reach without beam)
  - Perfect running mode to record RPC noise
- We use this running mode to monitor RPC noise during test beam
  - 2+ noise runs per day
  - It indicates 'healthiness' of the RPC's

1st run period: 10/2010

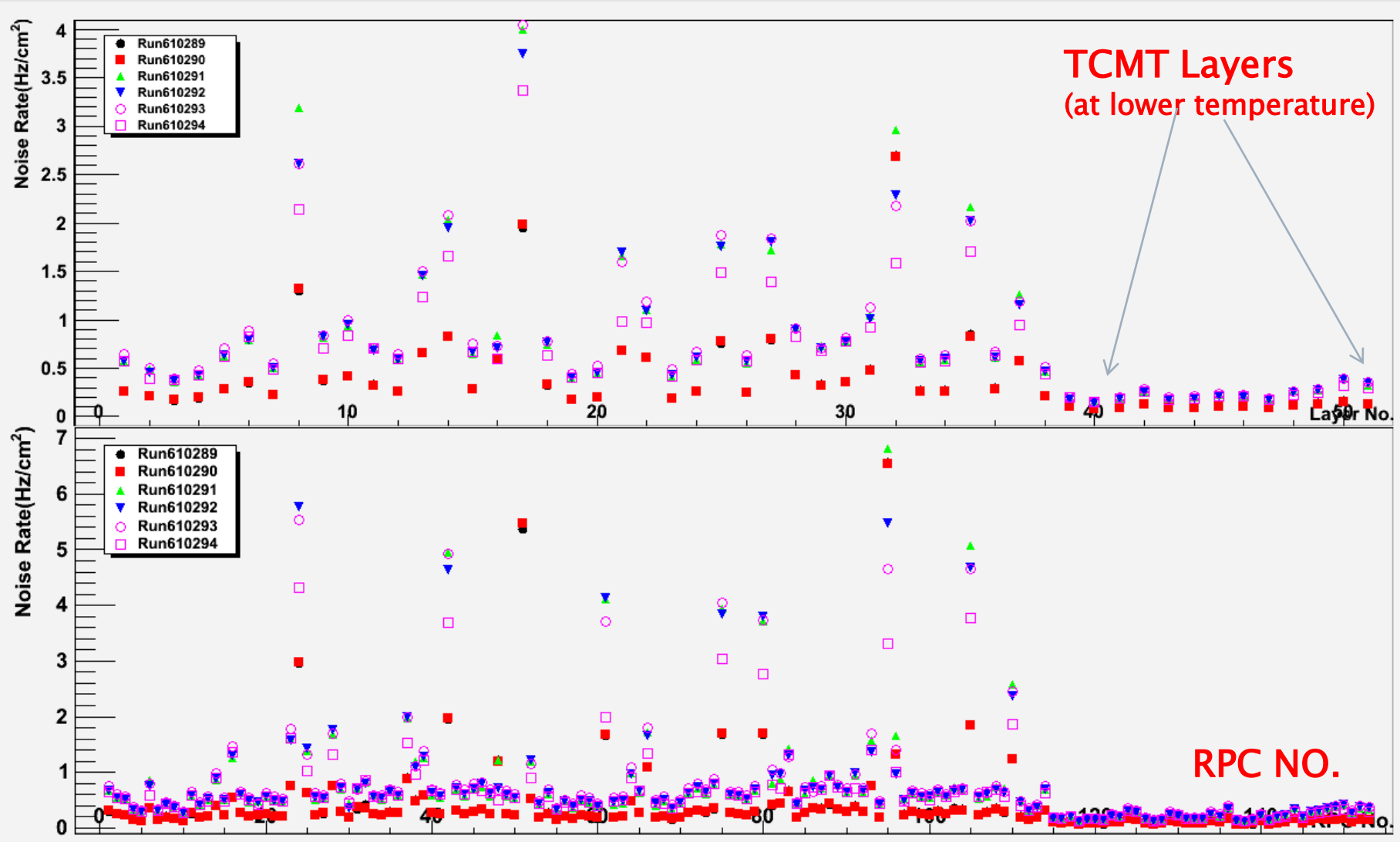


2nd run period: 1/2011



Gas flow reduced to 150cc/min, from 300cc/min

Noise rate vs. layers/RPCs



Noise hit estimate

- Using the measured noise rate, we can estimate the expected noise level in triggered beam data
  - Assume all measured noise in self-triggered runs is from RPC itself (not exactly true)
  - Total number of channels in 1m3 + TCMT (51 layers) is 96x96x51 = 470K
  - Not including any possible correlated noise

RPC Noise rate (Hz/cm^2)	0.1	0.5	1.0	2.0	4.0
N_{noise}/evt 200ns gate	0.0094	0.047	0.094	0.19	0.38
N_{noise}/evt 700ns gate	0.033	0.165	0.33	0.66	1.32

Expected noise level for current test beam analysis

Expected for a 'cool' DHCal stack

Noise analysis: consistency check

- To study possible correlated noise, we compare self-triggered noise run with randomly triggered noise run
  - Uncorrelated (RPC) noise should behave in the same way in the two run types
  - Noise related to trigger/readout may show up differently in these run types
- Use (time wise) close by runs to avoid effects from temperature change, etc.

	Triggerless Noise run	Random Trigger Run
1st (Monday, 10/25)	610085 (10/25 04:00am) 610086 (10/25 18:10pm)	600047 (started at 10/25 7:31am, ended at 10/25 9:49am)
2nd (Thursday, 1/13)	610179 (1/13 18:06pm) 610183 (1/14 4:26pm)	610180 (started at 01/13 18:20,overnight)

Self-triggered noise run

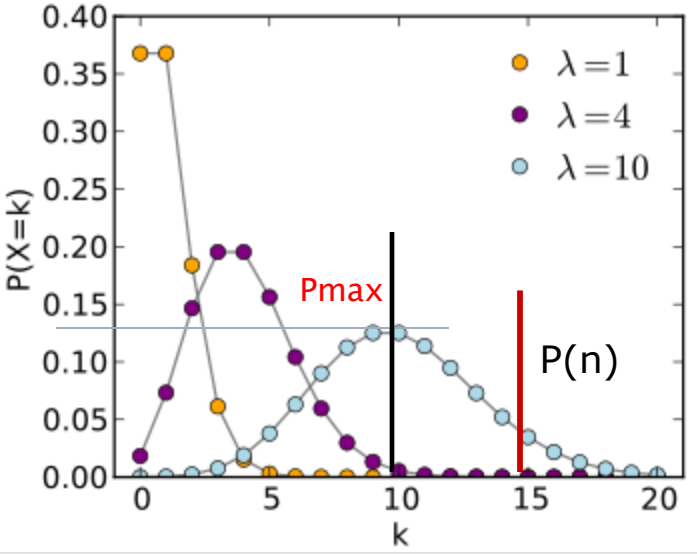
Randomly triggered noise run

Noise rate on each pad: $\boldsymbol{\lambda_i}$ compare $\mathbf{N_i}$: observed number of hits

Consistency check

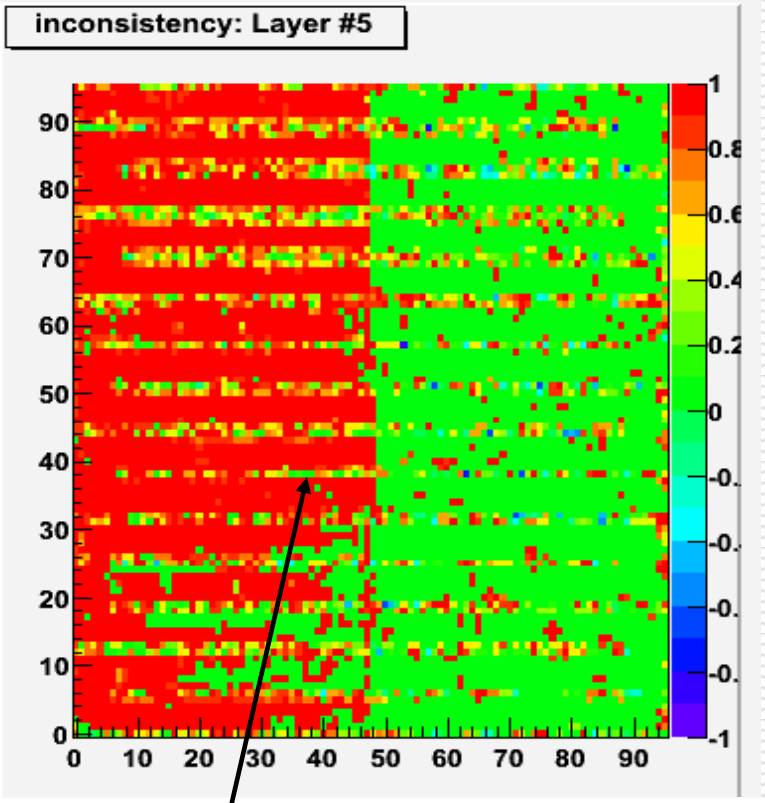
- P(n, λ) is the probability of observing n hits when expect λ in a poisson distribution
- Pmax(λ) is the peak value of the same poisson distribution with a mean of λ
- Define R
  - If $n < \lambda$, $R = -(1 - P(n, \lambda)/P_{max}(\lambda))$
  - If $n \geq \lambda$, $R = +(1 - P(n, \lambda)/P_{max}(\lambda))$

To see the inconsistency explicitly
1)If R is close to 0.0, it means n is consistentλ
2)If R is approaching 1.0, n is too large compare to λ
3)If R is approaching -1.0, n is too small compare to λ



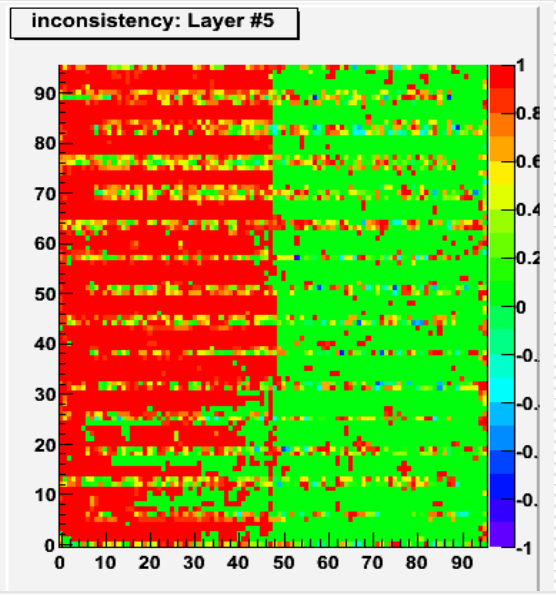
Run 600047 vs. 610085+610086

- For most of the layers, the noise levels are consistent
- Several layers show higher noise level in randomly triggered run
  - Noise is grounding related
  - Often contain hits at the ground connector, edge pads on FE board
  - Often fire a lot of pads
  - Exact mechanism not well understood yet
- Try to eliminate these hits in the randomly triggered runs
  - Filter out events with hits on the boundary between two FE boards
  - Filter out events with hits on the HV ground connector



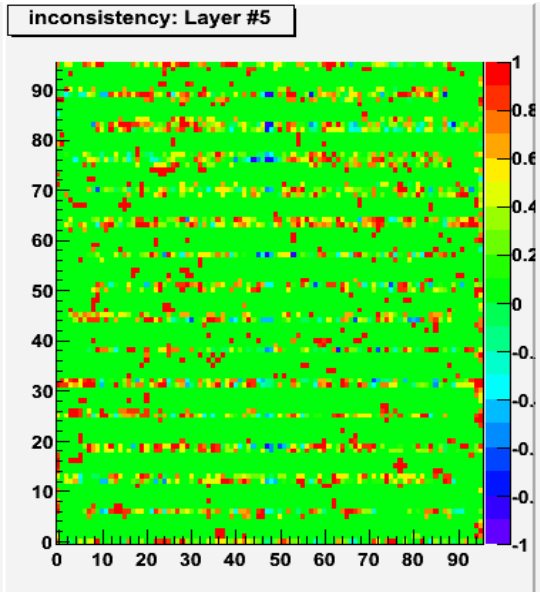
Noise hits in random-triggered run far exceeded expectation from self-triggered noise run

Run 600047 vs. 610085+610086: after filtering

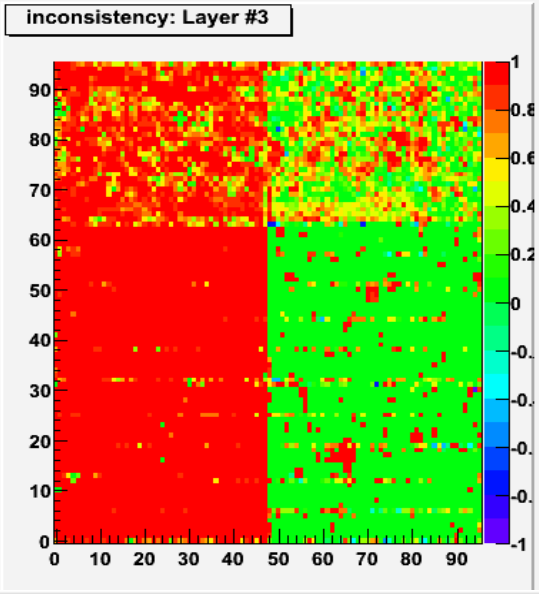


After Filtering

For Layer#4,5,6

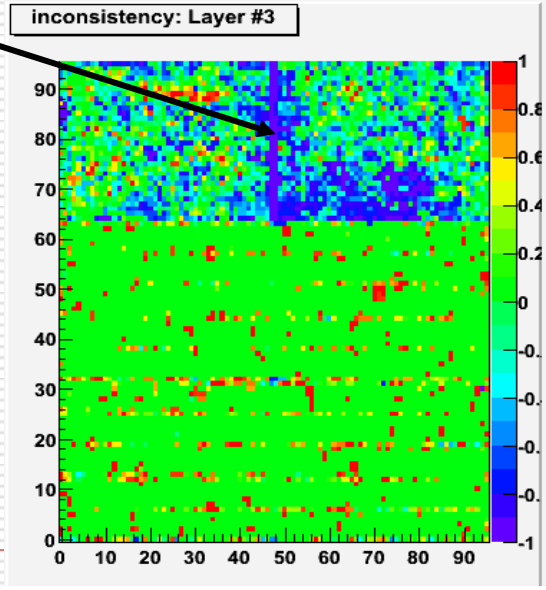


Suggest correlated noise in self-triggered run as well

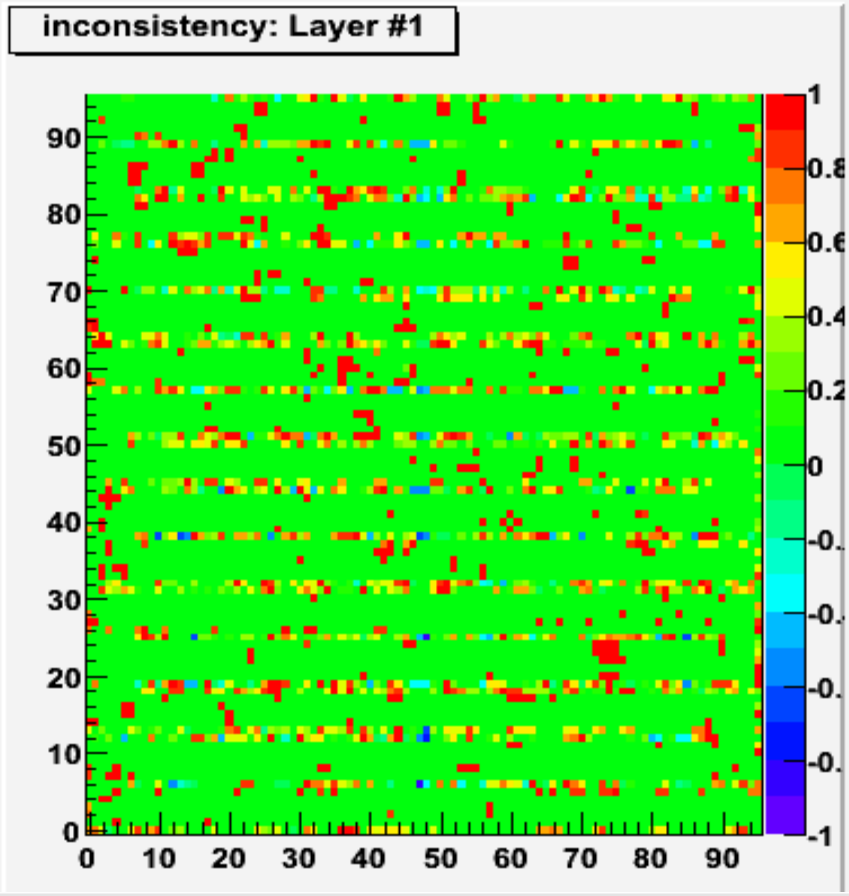


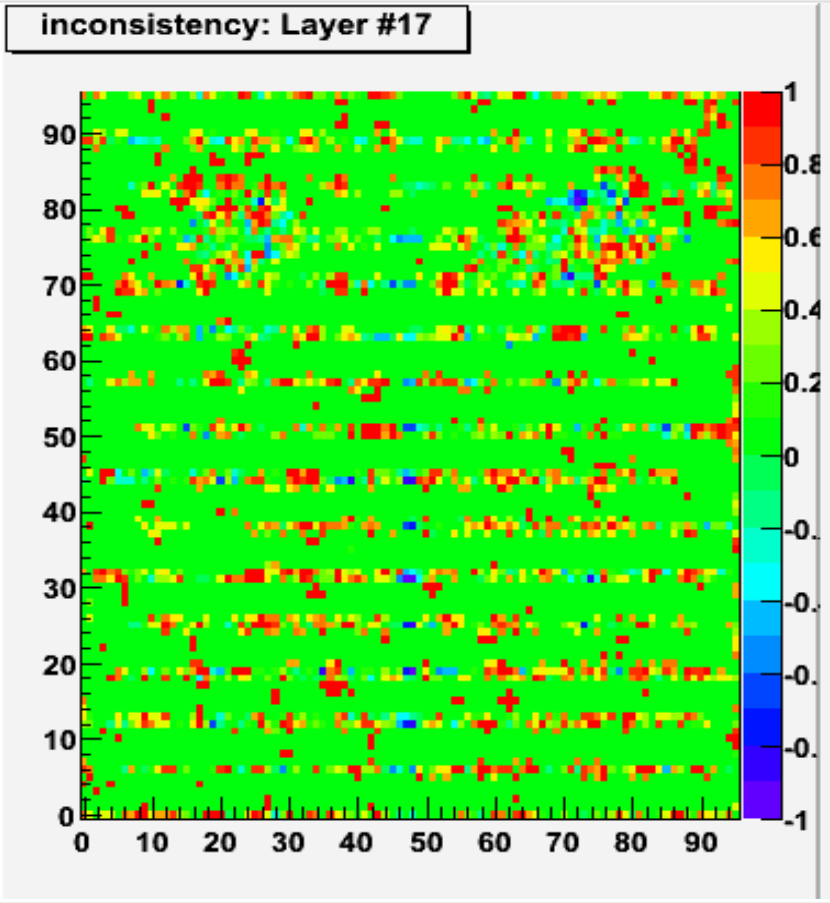
After Filtering

For Layer#3

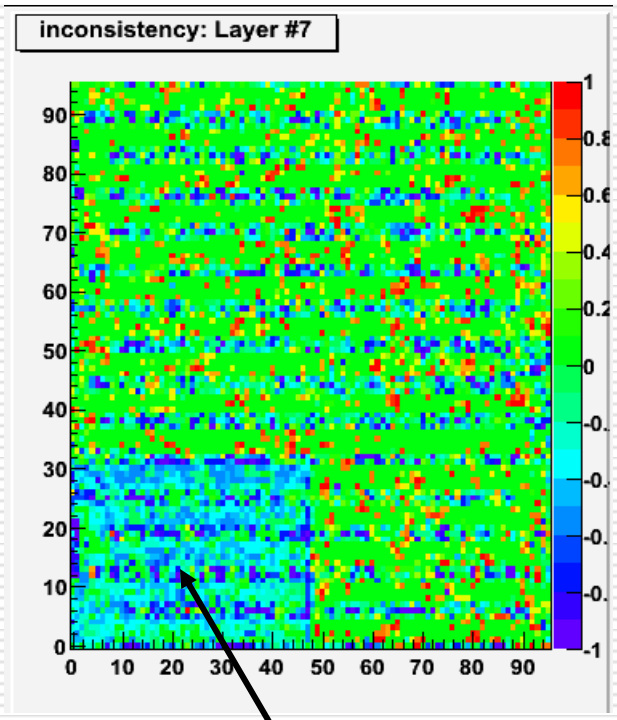


Other layers: looks OK

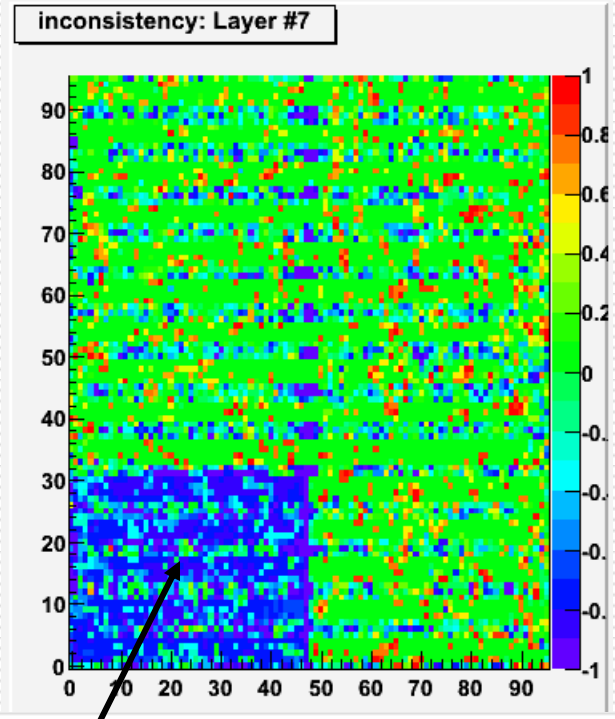




Run 610180 vs 610179+610181: after filtering



After Filtering



Layer#7,11,13,25, 27,28,29,30,31,34, 35,36,37

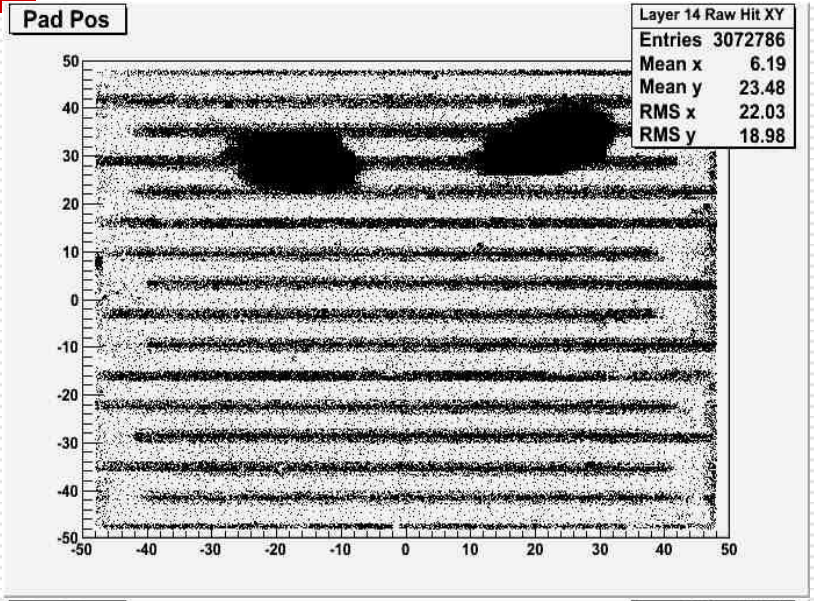
Suggest significant correlated noise in self-triggered run

Conclusion

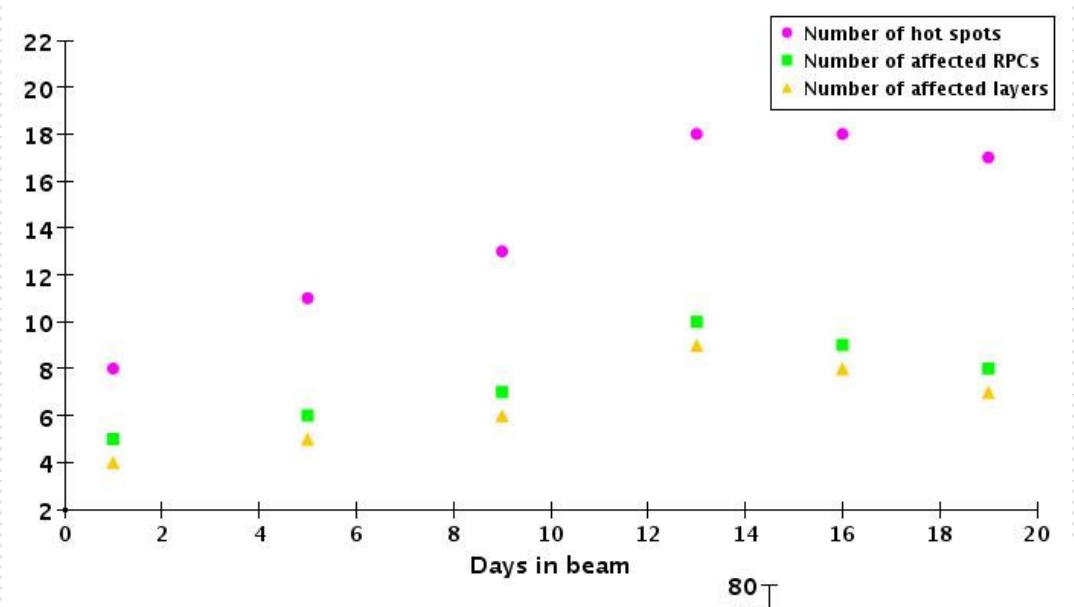
- More careful study of different noise categories is needed
- Need to measure the impact of correlated noise in beam data

Noise 'hot' spot

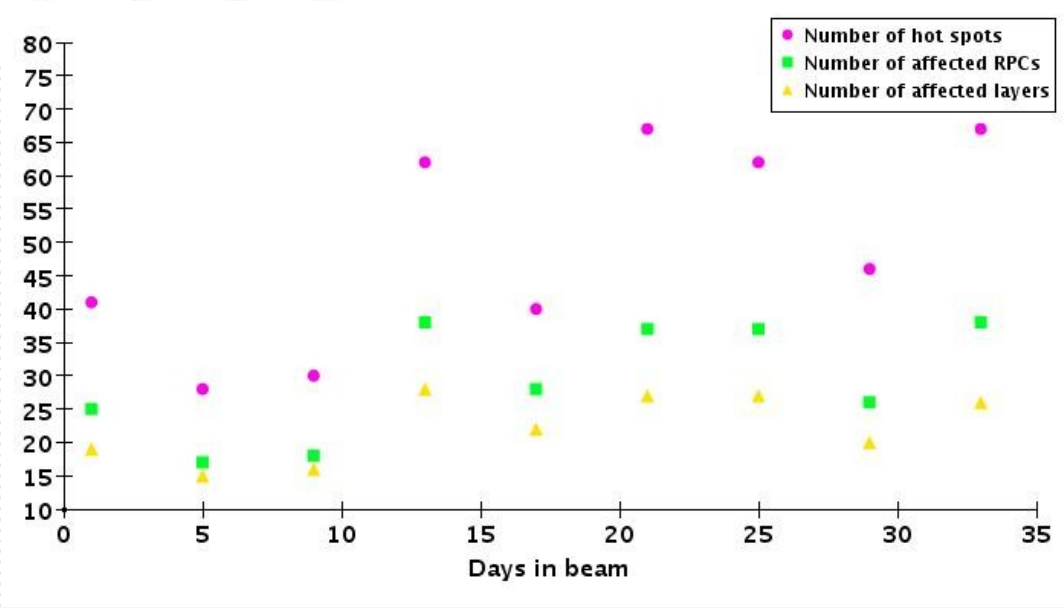
- Noise 'hot' spots are seen in both test beam period
  - Nearly no visible effect on beam data (a little bit on multiplicity)
  - Significantly worse in 2nd test beam period
  - Varies with time, temperature, gas flow rate, etc.
  - NOT seen in the 'cooler' tail catcher
  - (mostly) not seen in cosmic ray test at ANL
- In the worse case, affected 33% of RPC's during a noise run in $1m^3$



Run history plot



1st run period



2nd run period

Digging into the log books…

- Use one noise run close to the end of 2nd run period
  - Layer affected: 19/38
  - RPCs affected: 27/114
  - RPC positions: top (14), middle (4), bottom (9)
- Track down the producers of the RPCs

	Producer A	Producer B	Producer C	unknown
Affected RPC	14	2	7	4
Total produced	53	39	40	
Fraction	0.26	0.05	0.18	

Conclusion

- This is due to inadequate surface cleaning
- It only shows up with elevated temperature

Summary

- Number of ‘dead’ asics is very small
- RPC’s are in good shape after two beam tests
  - Average noise level is stable
  - Absolute noise level is high due to high temperature
- Overall noise contribute very few noise hits
  - RPC contribute negligible noise hits to beam data
  - Correlated noise level needs more study
- Noise ‘hot spots’ were due to unclean surface
  - Not a problem if temperature is low

Consistency check (alternative)

n < λ, P(x<=n) --> R = -P(x<=n)

n > λ, P(x>=n) --> R = P(x>=n)=1-P(x<n)

1)If |R| close to 0.0, it means n is far from λ

2)If |R| close to 0.5-1.0, it means n is close to λ