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Barrel System Test, 31.07 – 11.08.2000

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We report measurements done on the barrel sector of the system test with KEK modules K3111 and K3112. For comparison we also present results obtained at the electrical test stand in building 186, as well as the numbers provided on module data sheets, as measured on a similar test stand at KEK. Two noise measurement methods were used.

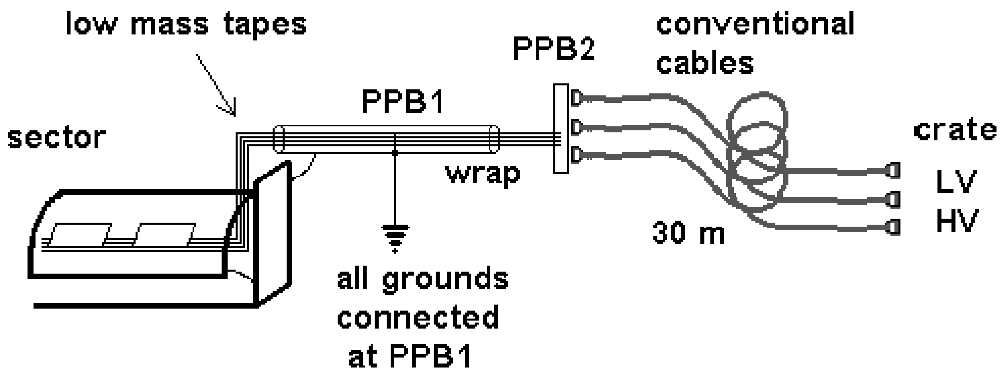
The electrical readout

By the "electrical readout" we mean the test stand in the system test lab that is separate from the proper system test prototypes. The electrical readout is similar to what is being used in various laboratories for testing individual modules. Modules can be tested while inside their metal boxes. Connection to the MuSTARD+SLOG+CLOAC readout set is done electrically, using a PCB called a support card (see http://www.ph.unimelb.edu.au/epp/epp_atlas.html).

The modules were powered by SCTLV2, with additional chokes. Detectors were biased using a bench supply.

The barrel sector

The barrel sector is meant to be a prototype of a part of an SCT barrel. The aim is to reproduce the mechanics as well as cabling and grounding. The setup used for the measurements reported here is identical to what has been presented during the last June SCT week (see the talks at the system test page http://atlas.web.cern.ch/Atlas/GROUPS/INNER_DETECTOR/SCT/systemtest/). The following diagram represents the cabling of the barrel sector:



The setup consisted of:

- a sector of an SCT barrel with cooling pipes and brackets for mounting modules
- 3 working “doglegs” (units of optical readout)
- 10 “low low mass” tapes, ~1.5 m long
- ZIF connectors (representing PPB1),
- 10 low mass tapes, ~10 m long
- a patch panel (equivalent to PPB2)
- 30 m SCT prototype cables
- SCTLV2 low voltage power supplies, Cracow high voltage power supply in Canbus

The cabling was done for 5 modules placed along one half of a cooling pipe. The bunch of 10 power tapes was wrapped in aluminum foil in order to try the planned screening. Near the ZIF connector, which represents barrel patch pannel 1 (PPB1), all 3 grounds (Vcc return, Vdd return, detector bias return) were connected together for all the tapes. This assembly of grounds was also connected to the screening foil. The screen was connected to the base plate of the sector at the end where the cables entered. The base plate was connected to the carbon shell of the sctor itself, which in turn was connected to the cooling pipes. There was no DC connection to the building ground.

Doglegs provide the optical readout of barrel modules. Each dogleg connects to one module, two power tapes and three optical fibres. One fibre is used for sending clock and control to a module, the other two are for sending the data from the FE chips to the readout system.

The modules were mounted on the sector in positions 1 and 3 (counting from the patch panel end). The modules were isolated, i.e. the redundancy arms of the doglegs were not connected and there was no DC connection between the modules and the cooling pipe to which they were attached.

The sector was covered by an aluminium lid which enclosed it on top and the two long sides. Together with the frame holding the sector, this lid forms a light-tight and fairly gas-tight box around the sector. A continuous flow of dry nitrogen was maintained. Coolant at +18 degrees was pumped through the cooling pipe. The temperature of the hybrids was monitored, and maxima of around 35 degrees C noted. Humidity was constantly monitored and stayed below 20%, giving a large safety margin between the dew point and the temperature of the cooling pipe.

The noise measurement methods

In order to provide a correct comparison of the reported results covering the module data sheets, the measurements at the electrical stand in 186 and the measurements at the sector we need to report results of two noise measurement methods:

1. “kwikgain” by Peter Phillips. Two threshold scans are done, injected charges are 2 and 3 fC (20 and 30 mV on calibration pulse, respectively). Gain is determined as a difference of vt50 points for the two scans. Noise in ENC is calculated using an average of noises in mV measured at both points. This noise measurement method is the standard used in the barrel system test. It was used both on the electrical stand and on the sector.

2. Three point measurement with injected charges of 0, 2 and 3 fC, linear fit to determine gain. Output noise (in mV), measured at the 2 fC point, is used to calculate the input noise (in ENC). This method was implemented in the system test in order to follow exactly what was done at KEK. It was later compared with the original KEK version of the code, giving consistent results. As the electrical stand work was done before the code was put together, this method was not used at the electrical stand.

The module settings

Vcc= 3.5 V, Vdd=4.0 V, FEbias = 267 μA, FEshaper = 30 μA, edge detect OFF, data compression X1X, strobe delay = 28 (chosen using a method recommended by N.Unno and used previously at KEK to produce data for module sheets)

The results

K3111, using kwikgain on 2 and 3 fC				
	Side 0		Side 1	
	electrical stand	sector	electrical stand	sector
Gain [mV/fC]	59.8	59.5	60.4	59.9
Output noise [mV]	13.9	13.9	13.9	13.9
ENC [e]	1440	1450	1420	1440

K3112, using kwikgain on 2 and 3 fC				
	Side 0		Side 1	
	electrical stand	sector	electrical stand	sector
Gain [mV/fC]	60.9	60.7	61.3	60.9
Output noise [mV]	13.1	13.2	13.2	13.0
ENC [e]	1350	1310	1360	1340

K3111, using linear fit to 0,2,3 fC				
	Side 0		Side 1	
	data sheet	sector	data sheet	sector
Gain [mV/fC]	53.1	55.3	54.0	57.4
Output noise [mV]	12.2	14.3	12.2	14.3
ENC [e]	1440	1620	1410	1560

K3112, using linear fit to 0,2,3 fC				
	Side 0		Side 1	
	data sheet	sector	data sheet	Sector
Gain [mV/fC]	54.8	55.7	56.1	57.9
Output noise [mV]	12.6	13.1	12.9	13.4
ENC [e]	1440	1470	1440	1450

The noise measured on the barrel sector is reproducible to within 50 ENC (about 3%). It is not understood what uncontrolled environmental factors cause the small variations we observe.

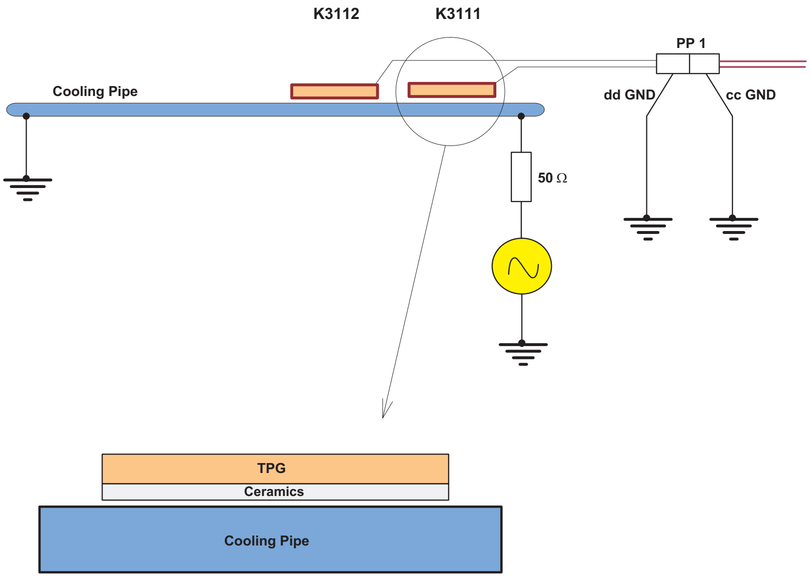
Other things tried

One known difference between the electrical setup in 186 and the KEK setup is the low voltage power supply. An attempt was made to investigate the potential effect. A module named SCAND1, equipped with a hybrid that is similar to those of the KEK modules, was used. No significant difference in either noise or gain was observed when the SCTLV2 was replaced by a bench-top supply without sensing.

Measurements with pulse generator connected to the cooling pipe

This measurement is a continuation of earlier studies on the noise coupled to a module from the cooling pipe documented in
http://atlas.web.cern.ch/Atlas/GROUPS/INNER_DETECTOR/SCT/systemtest/notes/cp_main.ps
and in
http://atlas.web.cern.ch/Atlas/GROUPS/INNER_DETECTOR/SCT/systemtest/notes/cp_study.ps

The measurement was performed on the barrel sector operating both K3111 and K3112 modules with the standard settings as described earlier in this note. The basic setup was enriched with sine-wave generator connected through a 50 Ω resistor to one end of the cooling pipe.



Noise was measured from threshold scans with injected calibration charge of 2.5 fC (25 mV calibration pulse). Noise in ENC was calculated using gain determined as a difference of 50% points for scans at 2.0 and 3.0 fC. It should be noted that gain values were determined only once (with no signal input on the cooling pipe) and used as universal numbers for all individual noise measurements. This method is very similar to the standard “kwikgain” one and gives compatible results.
The individual channel noise together with their average values over one side of a module (6 chips) measured under standard conditions (no input on the cooling pipe) are given on page 9. The following two pages summarize noise measured on the modules when the parasitic sinusoidal signals were input on the cooling pipe. The frequencies correspond to the region of the highest sensitivity of the front-end circuitry as was widely discussed in the earlier reports.
Plots on page 10 give module response when there is no direct (close) connection between grounds on the hybrid and the cooling pipe. In such a case one expects a maximal coupling of noise from the cooling pipe to the module TPG baseboard (detector backplane). Amplitude of the signal output by the generator was 100 mV (0-peak). Effective amplitude on the cooling pipe at the point of generator connection was measured to be about half that. The modules show maximal sensitivity to frequencies around 10 MHz in agreement with previous reports. However the magnitude of the observed excess noise is much lower than observed previously Moreover, there is a clear non-uniformity over the chip number. The sensitivity grows significantly at the end of the bottom side of a module i.e. for the highest chip numbers.
Page 11 gives results of identical series of noise measurements but with module digital GND connected (closely) to the cooling pipe (Note: the amplitude of the signal from the generator was increased to 400 mV.). For practical reasons it was impossible to avoid a short (1-2 cm) section of a thin wire to realize the connection. This could deteriorate the de-coupling effect due to a finite

inductance of the conductor. This should, however affect mostly the highest frequencies. The sensitivity to signals on the cooling pipe got largely reduced. However, an interesting chip position pattern remained.
Finally, page 12 shows the corresponding attenuation of the noise coupled from the cooling pipe due to the close DC connection of the hybrid GND to the cooling pipe.

Conclusions

- The results from the electrical stand agree well with those from the sector.

- The measured ENC for K3111 is around 120 e more than the data sheet values (using the same method). For K3112 we measure ENC consistent with the data sheet

- The gains measured using only 2 and 3 fC points are consistently higher than those measured using 0, 2 and 3 fC. This results in lower input noise figures calculated when using only 2 and 3 fC points. The three point method gives larger ENC values.

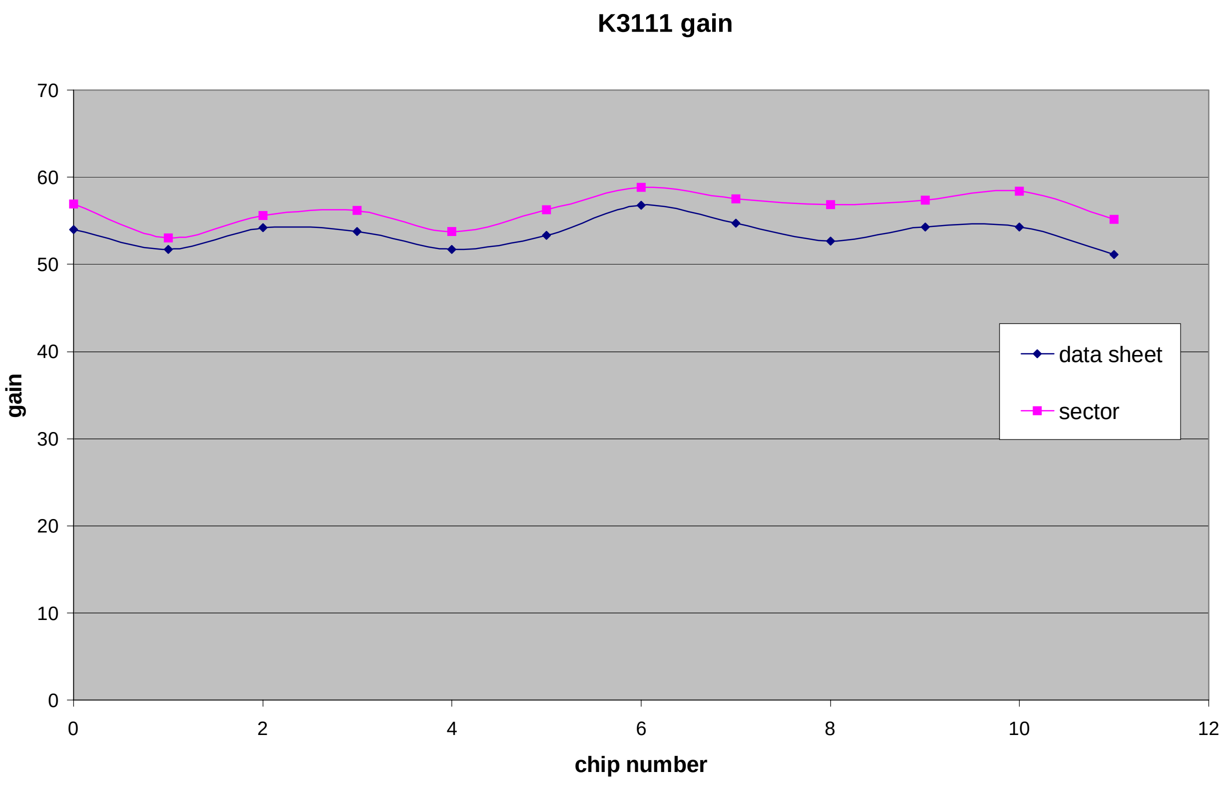
- Reducing Vcc by 50 mV produces no significant change. Replacing the power supply at the electrical stand by a bench-top unit without sensing does not produce a significant change either.

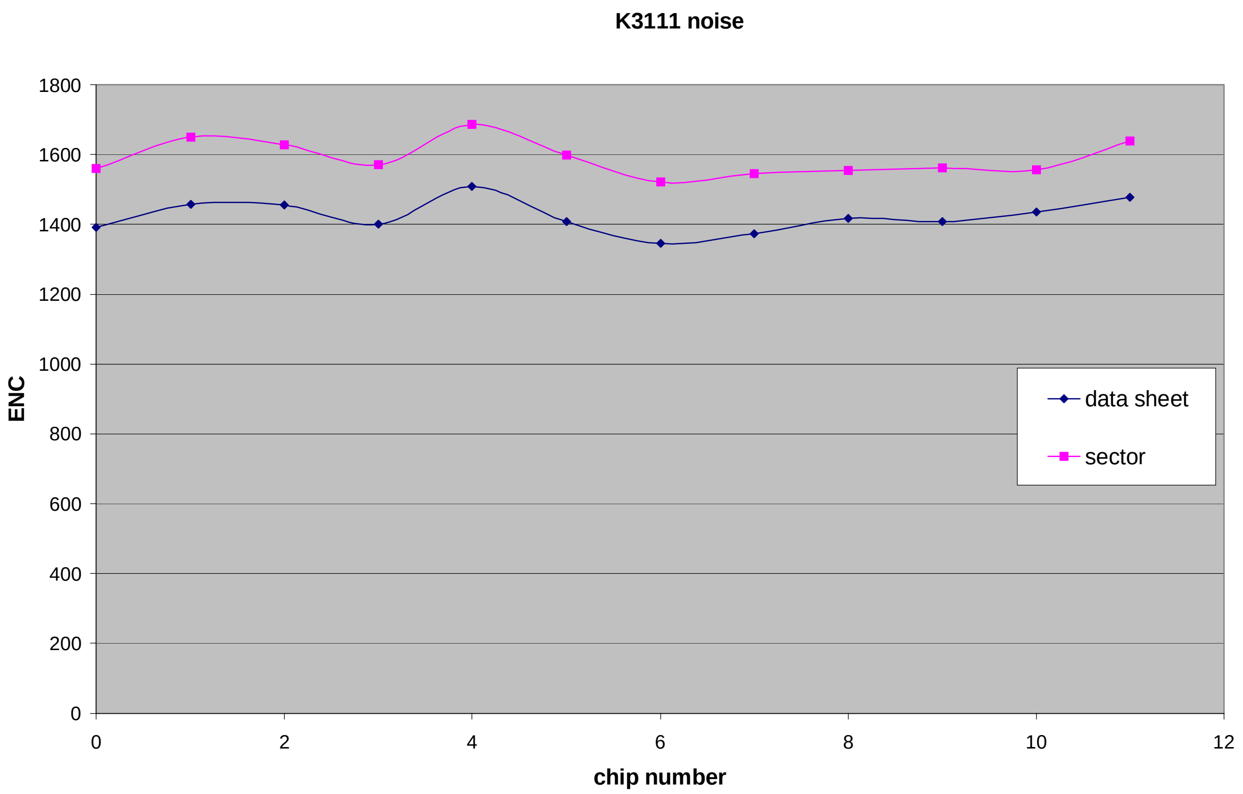
- Both K3111 and K3112 show a very low overall sensitivity to signals on the cooling pipe (as compared e.g. to RLT1 module) although the frequency dependence agrees with earlier measurements. Nontrivial chip position dependence was observed.

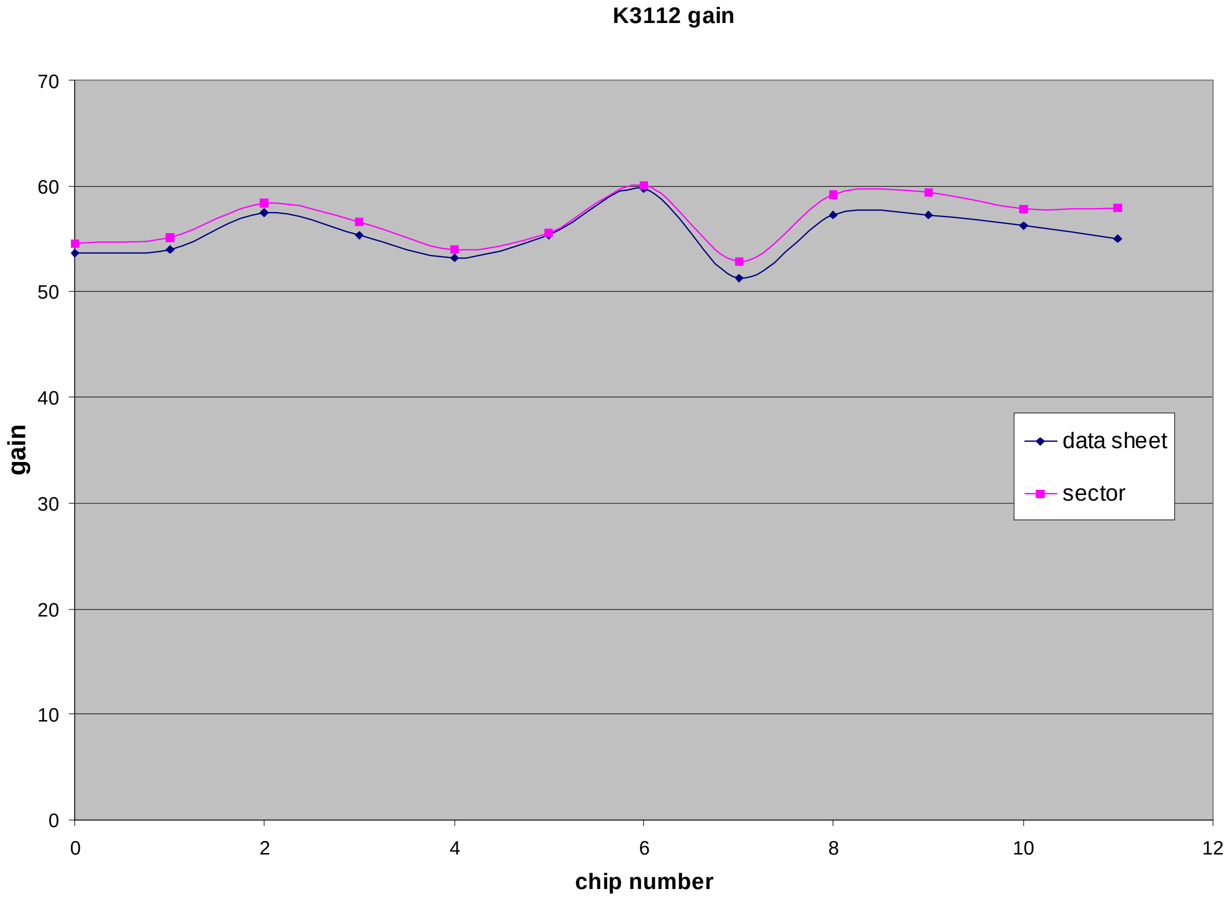
Objectives of future measurements

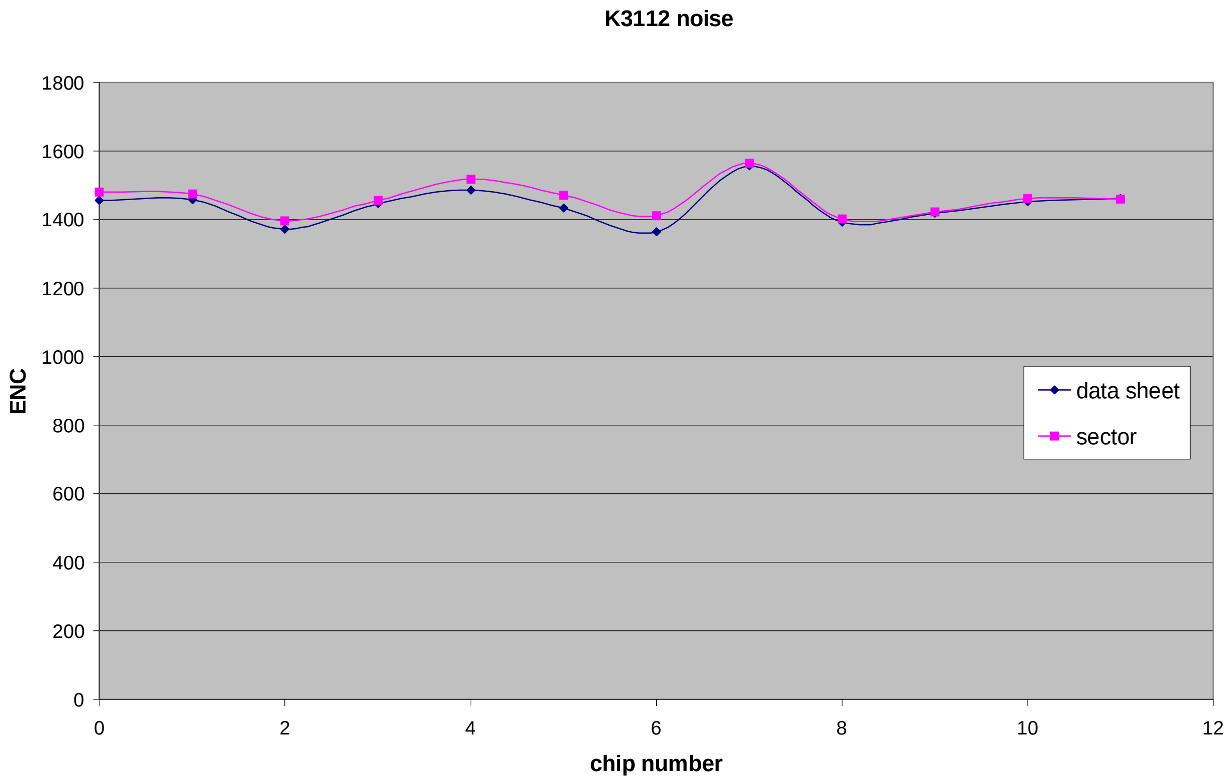
The August run was the first opportunity to test the barrel system aspects with complete baseline modules. The results are encouraging, but several improvements are necessary to make the tests more stringent. Modules will need to be operated while mounted next to each other, overlapping in Z as well as in Rφ. The overlap in Z seems particularly important because of the small distance between the detectors of neighboring modules overlapping in this direction.

It is also necessary to test the system using several modules. The tests should also be done with a realistic trigger rate, if possible using random triggers. Pairs of triggers separated by a variable delay that can be made comparable to the latency are an alternative. Studies with signals injected onto the cooling pipe need to be continued in order to explain the observed differences between various prototypes.

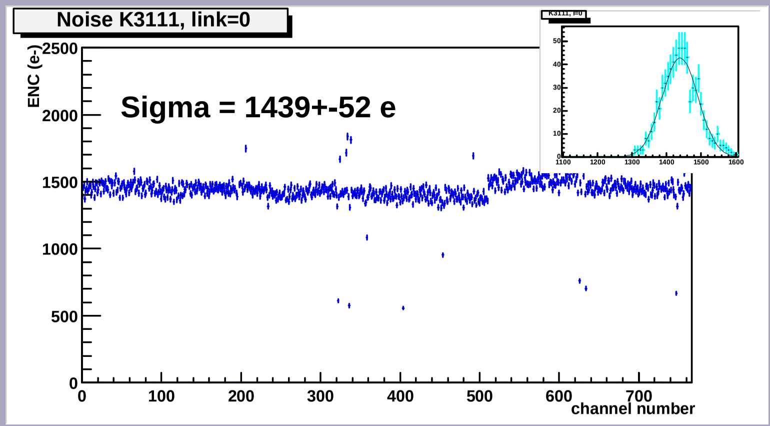

K3111 gain
70
60
50
40
30
20
10
0
gain
0
2
4
6
8
10
12
chip number
data sheet
sector

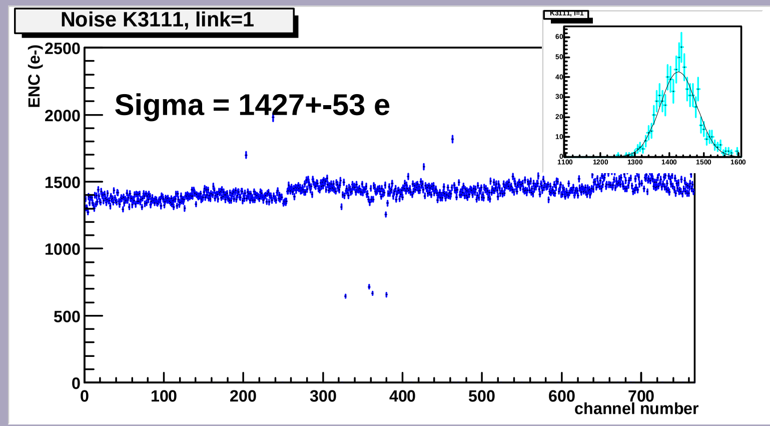

K3111 noise
1800
1600
1400
1200
1000
800
600
400
200
0
ENC
0
2
4
6
8
10
12
chip number
data sheet
sector

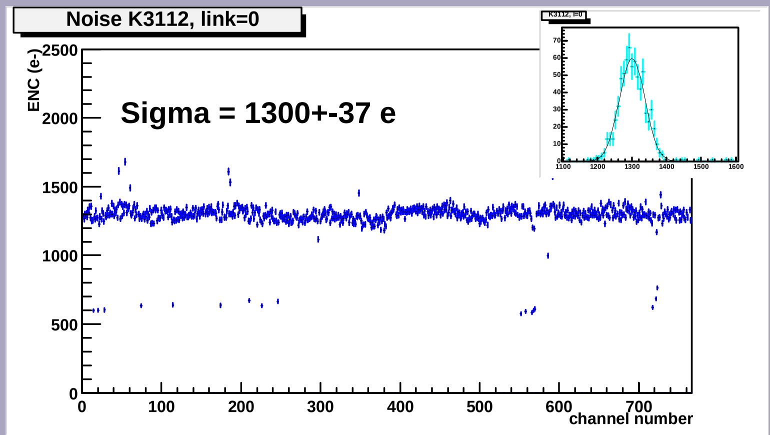

K3112 gain
70
60
50
40
30
20
10
0
gain
0
2
4
6
8
10
12
chip number
data sheet
sector

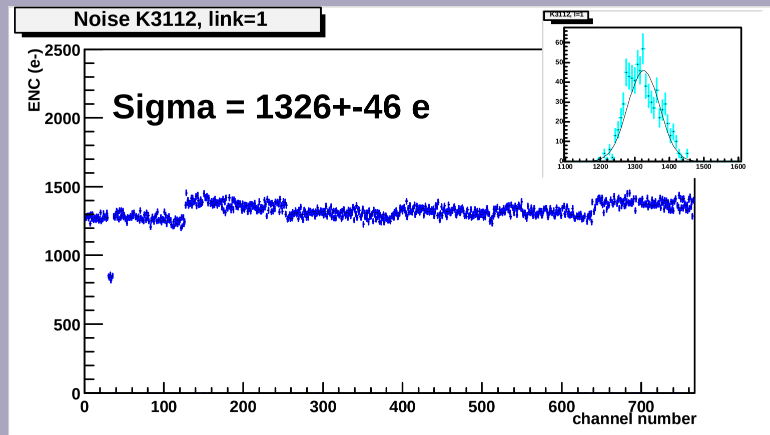

K3112 noise
1800
1600
1400
1200
1000
800
600
400
200
0
ENC
0
2
4
6
8
10
12
chip number
data sheet
sector

K3111 + K3112 reference characteristics

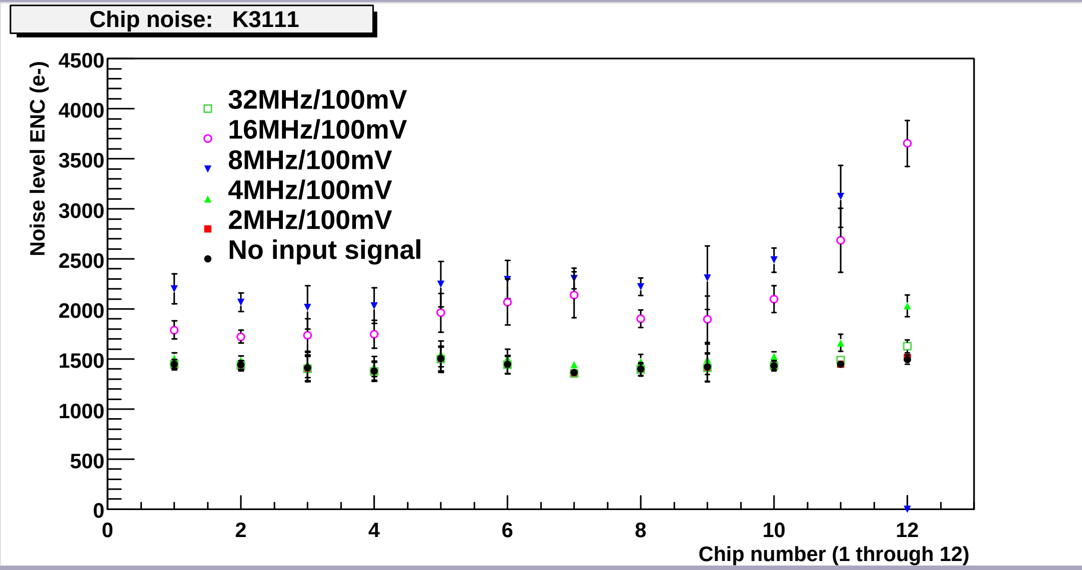


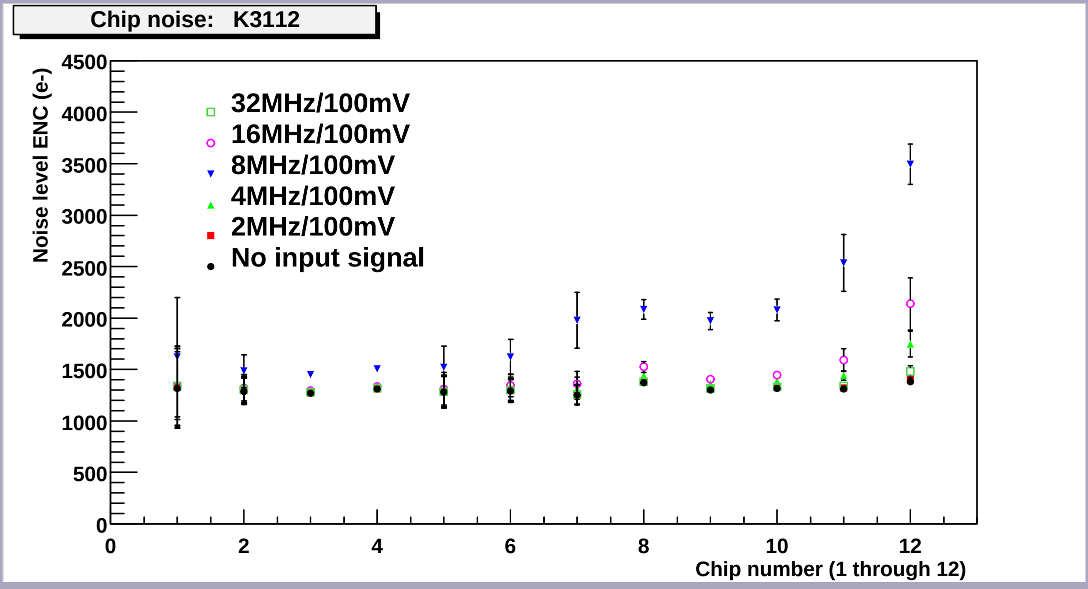


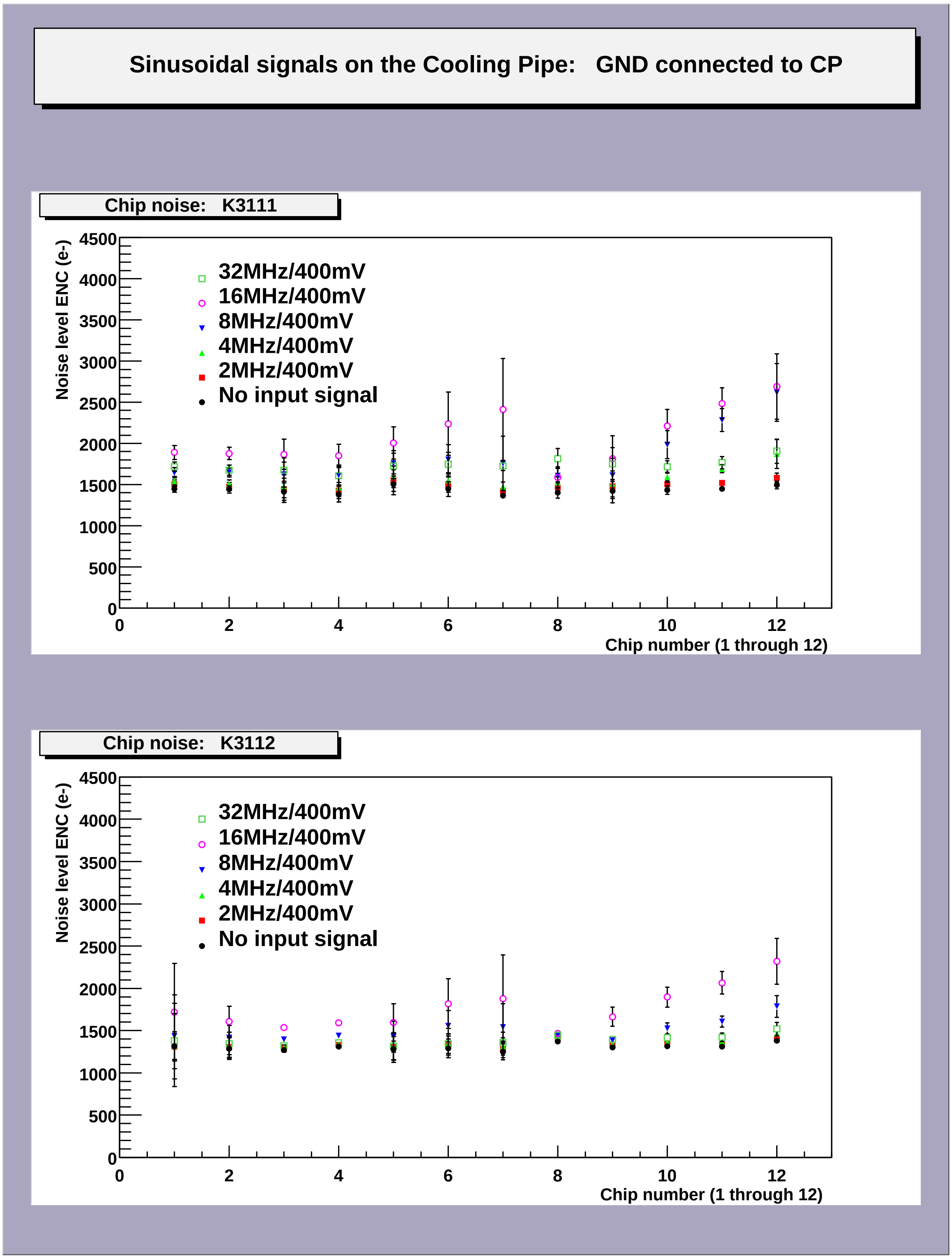




Sinusoidal signals on the Cooling Pipe: GND not connected







Sinusoidal signals on the Cooling Pipe: GND connected to CP
Chip noise: K3111
Noise level ENC (e-)
Chip number (1 through 12)
32MHz/400mV
16MHz/400mV
8MHz/400mV
4MHz/400mV
2MHz/400mV
No input signal
Chip noise: K3112
Noise level ENC (e-)
Chip number (1 through 12)
32MHz/400mV
16MHz/400mV
8MHz/400mV
4MHz/400mV
2MHz/400mV
No input signal

Attenuation due to GND connection