I saac
N ewton
G roup
R ed
I maging
D etector

Summary of Detector Stage 1 Testing - First Cool Down

(29th October - 9th November 1999.)

Peter Moore 11h November 1999.

1. PRE-COOL DOWN

1.1 Galvanic isolation was proved between the SDSU controller and the cryostat. A direct short to cryostat ground is provided for through the temperature cable (SK8) and this is intact. With only the detector cables (PL6, PL7) plugged in, an impedance of between 1.2 and 4.7 Meg ohm is seen between SDSU ground and the cryostat. This is not explainable. After replacing the MUX with the ENG array, this high impedance path is not apparent as measured from the cryostat connectors to inside the cryostat. Must be re-tested after shield and cryostat jacket is assembled.

NOTE. Procedures for instrument set-up to incorporate the following: - "ALWAYS connect cables in the following order. Power cable to the SDSU power supply, Power supply to SDSU controller, Temperature cable between the cryostat and SDSU controller, Disconnect shorting plugs from cryostat detector connectors, Clock cable between cryostat and SDSU controller, Pre-amp to SDSU controller cable, Pre-amp mount to cryostat, Motor amplifiers to cryostat. (Assuming motor controller and motor amplifiers are pre-wired)."

This will minimise danger from static discharge to the instrument.
1.2. MUX was functional and consistent at room temperatures before cool down. Temperature sensor for detector was connected reverse polarity. Problem corrected during MUX change over. Bias levels adjusted to 30,0000 adu warm with the following offset constants: -

Quadrant 1 3.125v
Quadrant 2 3.208v
Quadrant 3 3.360v
Quadrant 4 3.630v (Note this quadrant is almost unusable)

Slope of correction calculated as approx. +0.1v per +5000 ADU. All quadrant channels equivalent which checks consistent gain (x5) across pre-amp subsystem.

1.3. Terminal pressure after 3 day pump down on the cryostat was 2.9E-4 mbar on 110 litre / sec pump.

2. COOL DOWN

2.1 Cool down began at 11:05 2nd November. Temperatures and pressures were logged each ten minutes. A dedicated LN2 fill tube needs to be constructed to prevent excess LN2 from freezing neck 'O' ring and endangering vacuum integrity.

2.2 The attached graphs show the temperature and pressure profiles during cool down. Terminal temperatures for the casting and detector were reached in 15 hours. The calculated values where 86 K and 76 K respectively. These values are most probably offset by the fixed error in the calculation algorithm that adjusts the value by a common 2nd order polynomial with fixed offset. The algorithm has since been revised to spread the error over the high-end temperature range.

2.3 The SDSU temperature calculation algorithm failed as a result of limited dynamic range in the math processing. This has since been corrected. The SDSU temperature now reads the sensor value and computes a value in milli-Kelvin between the ranges of 60 to 333 Kelvin. Temperature reading resolution is 0.377 K with the actual electronic gain configuration.

2.4 A significant amount of noise was seen on the temperature (and other telemetry data) as a result of wide bandwidth noise on the signal inside the SDSU controller. An attempt was made to electrically damp the signal but a more successful approach was implemented in the SDSU software that now calculates a running average over 16 samples.

2.4 The pressure increase remained within reasonable limits during this phase and the rate logged to facilitate a Getter design. The pressure increase rate dropped with temperature as expected. Final pressure reached cold and after two 'top ups' from the pump was 1.2E-5 mbar. This pressure increased to 5.2E-5 mbar after 11 hours.

2.5 A total of 150 litres of LN2 was used to affect cool down and maintain the cryostat cold until the closed cycle cooler could be brought on line at 10:50 on the 5th November. The total for cool down stage was approx. 100 litres.

2.6 The detector image bias was logged during cool down and demonstrated a near 1:1 correspondence to temperature. The three operational quadrants maintained track to within 1400 ADU across the 225 degrees temperature range. The mean slope of this correspondence is 123.5 ADU per degree Kelvin. THIS IMPLIES THAT THE DETECTOR TEMPERATURE NEEDS TO BE STABILISED TO BETTER THAN 4 MILLI KELVIN FOR THE DURATION OF ANY INTEGRATION TO ELIMINATE TEMPERATURE INDUCED SIGNAL ERROR DUE TO BIAS SHIFT!! (Note that this target is 100 times less than the actual resolution of the temperature sensor resolution!). This correspondence needs to be checked with the science detector to determine the validity of these readings.

2.7 Noise figures for the MUX were recorded each 10 minutes. The noise values for the warm mux are very high (Because the drain of the analog mux switches is left unterminated at the indium bonds?). This noise signature increased generally with decrease in temperature (or increase in time). In addition the spread of the noise value increased consistent to the increase of noise value. No explanation for this at present. Apply test to engineering array.

3. <u>COLD TESTING</u>

3.1 Temperature servo testing was attempted but failed. Firstly the maximum temp rise observed for full heater power was 3 degrees Kelvin (measured within the noise of the telemetry circuit which produced 5 degrees rms of signal error!). Upon disassembly of the cryostat after warm up it was found that the thermal shield box of the detector was thermally shorted to the copper heater block, thus producing a massive thermal load to the heater. In addition the thermal time constant was very, very long. This situation is also a consequence of the thermal short. The thermal shield has since been relieved to remove this short. In addition the two heater elements (2 x 50 ohms) which were wired in series have now been wired in parallel to provide a potential 4 times increase in available power (1.9 watts).

3.2 The closed cycle cooler was 'inaugurated' at 10:20 the 5th November and mechanically functioned without flaw. Vibration levels are very low and effectively isolated by the suspension system. An estimated 5 time's reduction of vibration (on the ccc head) is observed compared to the WHIRCAM ccc. However, the ccc did not support the thermal load of the instrument and warm up began to occur. In contrast, after 2 hours running the internal cryostat pressure had dropped and remained at 2.5E-5. This suggests that the internal cold finger had reached a very low temperature and was acting as a cryo-pump. Supporting this was the observed temperature differential of the inlet and exhaust helium lines. This suggested that the problem was in the thermal link between the cold finger and the instrument casting. After warm up it was found that the braid used for this link was woven and therefore the thermal length was very much longer than the physical length. In addition the clamping system used to connect this braid was inadequate in strength. A sold copper leaf design is currently being implemented to overcome this problem. Temperature increase using the ccc was 107 degrees over 60 hours.

3.3 The LN2 can was evacuated 2 hours after the ccc was brought on line; however, due to the temperature increase it is impossible to determine the thermal load change achieved. The vacuum state of the LN2 can was adequate when warm up commenced (i.e. very low out gassing).

4. WARM UP

4.1 Warm up began at 09:00 8th November and took less than 24 hours for the casting (at 190 K). However, the detector, without additional heating) took 26 hours to reach 285 degrees Kelvin. No measurements were performed during warm up.

4.2 A series of electrical tests were performed to confirm that the high noise seen on the MUX detector originated at the MUX itself. Essentially, having shut down the analog switches from the mux, the rms noise as measured was between 1.6 ADU (quadrant 1) and 3.2 ADU (quadrant 3). Programming the quadrant 'HIGH' supplies and 'BIAS GATE' to zero volts effected the shutdown. No effect on noise was seen when adjusting 'BIAS GATE' between different values. RMS noise for quadrant 1 with 'normal' bias voltages was 270 ADU (!). With inputs to the pre-amp shorted, the rms noise for all quadrants was on average 1.2 ADU. These values were recorded WITHOUT the cryostat ground connected to the SDSU star point. With the cryostat ground connected, noise values rose by 3.0 ADU rms. After strip down and work carried out to remove the thermal short on the detector shield, it was found that the detector thermal shield was electrically isolated from the cryostat ground. The wiring scheme provides for a ground connection to the fan out board thermal plane so this result is puzzling. However, an extra ground bond wire was installed to ground the thermal shield box.

5. POST WARM UP

5.1 Normal operation of the MUX was observed.

6. SUMMARY OF ANALYSIS.

1. Yes. Electronics of the detector look reasonable and reliable
2. Offset voltage to temperature relationship is coherent, within available dynamic range. The scale of the dependence suggests that either a system to maintain very tight temperature tolerances or an automatic adjustment must be implemented. The resolution of the offset voltage DAC is not currently sufficient for this.
3. Cool down time is roughly 24 hours. The detector cool down rate is considered safe.
4. Thermal time constant is too long and insufficient heater power exists. However, the problem could well have been the thermal short.

5. No observed thermal induced bifurcation of noise. Noise does not correlate with temperature, basic electronics seem to provide reasonable noise figures for first attempt. Further noise tests required on engineering detector.
6. No servo optimisation attempted. No data.
7. No data available.