Data Rates for the *SCUBA2* Arrays

Mark Halpern 27 May 2003

The purpose of this note is to document our understanding of the data rates we anticipate supporting in the *SCUBA2* multichannel electronics. We will walk through the system calculating data bit rates, and then determine where bottlenecks might lie.

Read-out cards house 8 50 MHz 14-bit A/D converters which run without interruption. There are four such cards, allowing the simultaneous reading of 32 bolometers. All the cards are stepped from one to the next of 41 addresses at a frequency $f_{address} \approx 800\text{kHz}$. For each address value, a given readout card must add approximately 40 consecutive readings together from each converter. This requires performing $8 \times 50 \times 10^6 = 400$ million additions per second and storing $8 \times 8 \times 10^5 = 6.4$ million 20 bit numbers per second. A full array image is acquired at frequency $f_{array} = f_{address}/41 = 20$ kHz.

Full array images are reported out to the clock card, and from there to a data acquisition computer using one fibre optic link per sub-array. Although the actual data rate might be a bit slower, we are designing electronics to handle a 400 Hz sample rate for array images. There will be filtering of the 20 kHz data to bring the bandwidth this low, and it will be useful to transmit 32 bit numbers. This rate requires each readout card to send

$$BR_{card} = 8 \text{ channels} \times 41 \text{ addresses} \times 400 \text{ Hz} \times 32 \text{ bits} = 4.2 \text{ million bps}$$

to the clock card, and the clock card reports

$$BR_{sub-array} = 4 \text{ Cards} \times BR_{card} = 16.8 \text{ million bps}$$

over the fibre to the data acquisition computers. This is called *Science Mode*.

All of these rates are well below capacity of the bus and the fibre optics.

It is desireable to allow faster data reporting in a so-called *Engineerng Mode*. When reporting data at 20 kHz it is sufficient to report 20 bits (40 samples at 14 bits per sample). The full data rate per card is

$$BR_{EM-Card} = 8 \text{ channels} \times 41 \text{ addresses} \times 20 \text{ kHz} \times 20 \text{ bits} = 131. \text{ Mbps}$$

and the full array rate is

$$BR_{EM-sub-array} = 4 \text{ Cards} \times BR_{EM-card} = 525. \text{ Mbps}$$

The capacity of the fibre optic link is 200 Mbps, so the system will not be able to report out the full array at the raw image acquisition rate. There are a number of partial reporting options which we will support in oder to facilitate testing. It does not seem useful to cut the precision from 20 bits per number to 8 bits in order to fit within the fibre capacity.

We intend to provide a mode in which a fraction of the array is read out at 20 kHz indefinitely. For example, any one readout card. Equivalently, if there was a reason, any other grouping of 8 to 10 A/D outputs could be reported. This mode allows long data sets at full rate from any bolometer, making fourier analysis straightforward.

We also intend to store full frames on the clock card until memory is full and then report out this limited number of full array images collected at full rate. One full image reqires

$$\text{Memory} = 20\text{bits} \times 32 \text{ channels} \times 41 \text{ addresses}/over8 \text{ bits per byte} = 3.28 \text{ kbytes}$$

Storing several hundred images, or roughly 10 ms of data of the full array at the full sampling rate should be possible. the data are then transmitted to the data acquisition computers at a slower rate.

We do not anticipate a need for reporting out 50 MHz data once board level testing is complete.

Providing these modes palces requirements on both firmware and software. These modes are not likely to be useful in scientific operation of the camera, and they require less support than the scientific mode.