**SPIRE Data Rate**

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**Introduction:**

Up to now the baseline average data rate available for SPIRE has been a maximum of 50 kbs (see IID-A). Through the use of X-band transponders, it is likely that this will go up to around 200 kbs. This note summarises the assumptions we currently make about data sampling and the estimated telemetry rate requirements

**FTS**

- Baseline FTS operating parameters as in BMS note of 3 Mar 99 which updated the previous case for the selected Mach-Zehnder design
- Filled arrays (worst case for data rate)

Detectors assumed to have 20 Hz response and are sampled at 100 Hz to give 5x oversampling.

- Oversampling by a factor of 5 but on-board decimation of the oversampled data (i.e., we transmit critically-sampled data to the ground)
- 16-bit sampling (maybe overkill), no nulling of telescope offset; no lossless compression
- For the old 50 kbs data rate, we need to do on-board deglitching and averaging of 6 interferograms. This requires an instantaneous data rate of 39.2 kbs
- This doesn't assume any observing overhead (for telescope slewing, scan dead-time, etc.). Assume 90% observing efficiency - 35.3 kbs
- To dispense with on-board averaging and deglitching, we therefore need (6)(35.3) = 212 kbs
- Some compromises are possible: slow down mirror; observe at lower data rate for fraction of the orbit; assume some lossless compression.
- For the feedhorn option, the maximum data rate is 90 kbs (transmitting completely raw data)
- For the filled array options, a 1/5 duty cycle would allow us to transmit raw data as a special engineering mode
- If desired, we could also transmit raw data from a few detectors (e.g., the central pixels)

**Conclusion: With the new data-rate we can dispense with most of the on-board processing for the FTS**

**Photometer**

- Filled arrays
- 4 x 8 arcminute fov
- Baseline assumptions:
  1. Chopping:
     - Chop at 5 Hz (maximum)
     - Sample at 40 Hz (4 samples per chop half-cycle)
     - Average each half-cycle on board
     - For each full chop cycle, compute difference between half-cycles on board and transmit this to the ground
  2. Continuous scanning:
     - Move the SPIRE beam steering mirror (or the telescope) so as to sweep the beam continuously across the sky
     - Sample at 40 Hz and average over 4 samples ($\equiv$ 10 Hz)

- Scan rate should be such that beam crossing time gives us at least 3 such averaged samples per beam ⇒ beam crossing time < 0.3 sec.
- Smallest beam is 18 arcsec so scan rate must be < (18 arcsec)/0.3 = 1 arcmin/second. This is consistent with the maximum scan rate of the telescope which is also 1 arcmin/sec.(*FIRST Scientific Pointing Modes,* p8)

- Assume DC coupling, so we need enough dynamic range to digitise the noise on top of the telescope background power (which will always be greater than the power received by the detectors from even a strong source)

What about the voltage offset? The V-I curve thingy you talked about? Does AC Biasing get rid of this or not?

- Estimation of sampling requirements for digitisation of the total noise on top of the total power:

| | 250 mm | | 350 mm | | 500 mm | | |
|---|---|---|---|---|---|---|---|
| Number of detectors | 32 x 64 | + | 24 x 48 | + | 16 x 32 | = | 3712 |
| Telescope power for feedhorn option | 7.4 | | 5.3 | | 4.8 | | pW |
| Add 2 pW for strongest source signal | 9.4 | | 7.3 | | 6.8 | | pW |
| Total power on detector for filled array option (x above by 0.18/0.77) | 2.2 | | 1.7 | | 1.6 | | pW |
| Photon noise for feedhorns with above backgrounds | 13.9 E-17<br>9.4 | | 10.2 E-17<br>7.3 | | 8.3 E-17<br>6.8 | | W $Hz^{-1/2}$<br>pW |
| Photon noise levels for filled arrays (x above by $[0.18/0.77]^{0.5}$) | 6.7 E-17 | | 4.9E-17 | | 4.0E-17 | | W $Hz^{-1/2}$ |
| Total NEP (assuming $NEP_{det}$ = 3E-17) | 7.3E-17 | | 5.7 E-17 | | 5E-17 | | W $Hz^{-1/2}$ |
| Total noise levels (for 20 Hz BW) | 3.25E-16 | | 2.5E-16 | | 2.2E-16 | | W $Hz^{-1/2}$ |
| Divide total power by this: (e.g., 2.2E-12/3.3E-16) | 7300 | | 6800 | | 7300 | | |

- 13 bits = 8192 so assume we need 14 bits
- Raw data rate: 3712 dets x 14 bits x 40 Hz ⇒ 2.08 Mbs
- Average by factor of 4 (i.e., average each chopper half-cycle) ⇒ 520 kbps
- Subtract positive and negative chop half-cycles on board ⇒ 260 kbs
- Assume 90% overall observing efficiency factor ⇒ 234 kbs
- This assumes no lossless compression
- It uses a few% at most of the DPU/SPU processor

Note: For continuous scanning at maximum possible rate, data rate can be faster, but there are ways of reducing it (e.g., scan a bit more slowly and average more samples; average more samples in any case for the 350 and 500 um arrays; implement lossless compression which should be fairly easy as signals will be smoothly varying on the whole)

**Question:** Is our assumption of DC coupling appropriate? Do we also need to digitise the detector bias voltage? Presumably, if we do it will this require more bits.

**Conclusion:** A data rate of 200 kbs is close to allowing us to transmit individual " photometer frames" (a frame here is defined as the result of an ON-OFF subtraction of one 0.2-second chopper cycle) without deglitching or averaging on board. If lossless compression by a factor of two can be achieved, (which is no problem according to some experts . . ) then we can do this comfortably within the 200 kbs limit.