SCUBA-2 Data Processing

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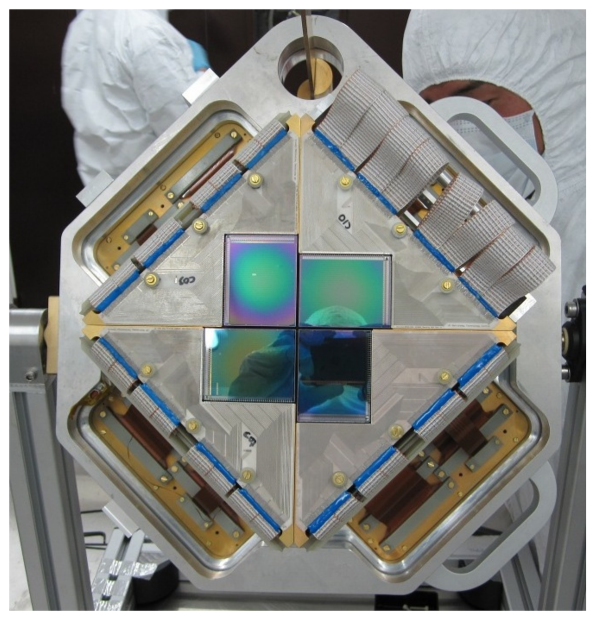
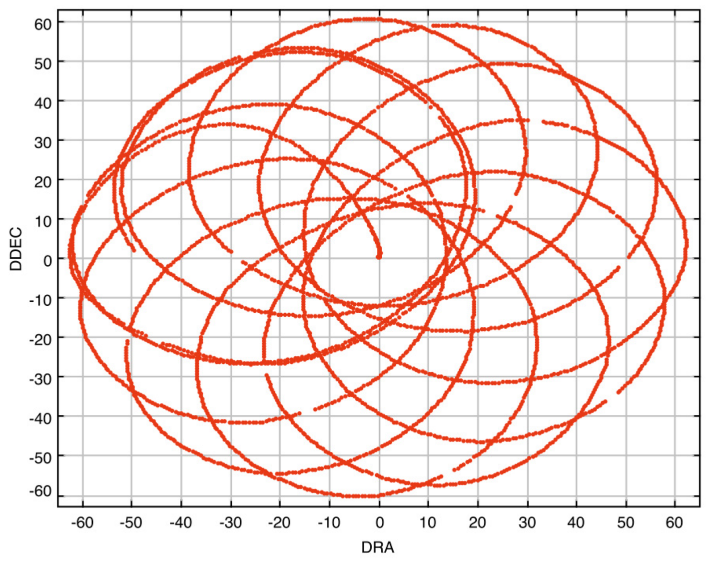
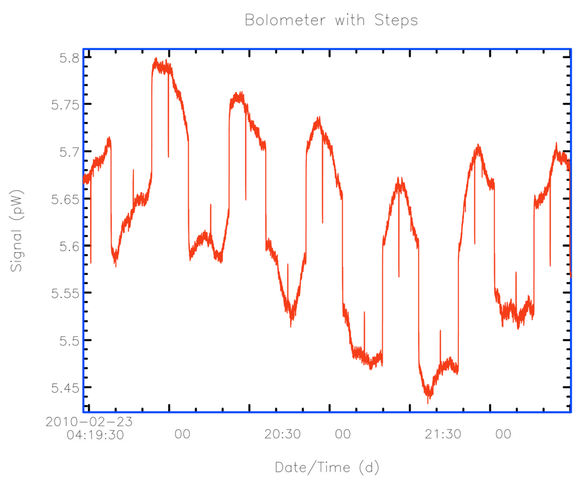


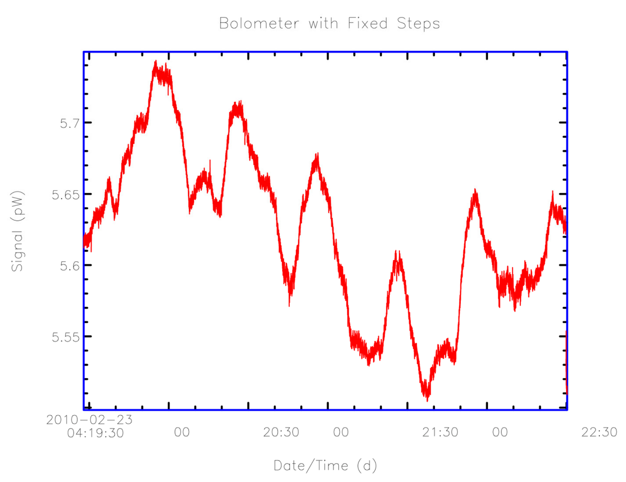
SCUBA-2 is the largest submillimetre array camera in the world and was commissioned on the James Clerk Maxwell Telescope (JCMT) with two arrays towards the end of 2009. A period of shared risks observing was then completed, and the full planned complement of 8 arrays are now installed and ready to be commissioned. SCUBA-2 has 10,000 bolometers which are sampled at 200Hz corresponding to a data rate of 8MB/s. The pipeline has a goal of producing useful maps in near real time at the telescope and near publication quality maps in the JCMT Science Archive. This poster describes the SCUBA-2 data and the processing infrastructure. The software is available under the GPL as part of the Starlink Software Collection (http://www.starlink.ac.uk). The image above is the assembled 450 micron focal plane unit consisting of four sub-arrays, and there are also four 850 micron arrays. The beamsize at 450 microns is about 7.5 arcseconds and at 850 microns it is about 14 arcseconds.



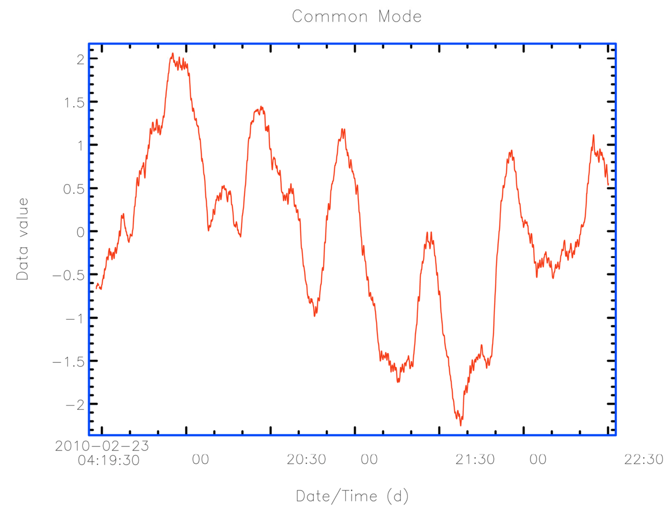
SMURF Iterative Map-Maker

SCUBA-2 is a direct detection bolometer array and so measures the temperature variation of the sky as well as the astronomical signal. Data are taken by scanning the telescope over the source using a pattern designed such that the time taken to return to the same place on the sky is not a fixed interval. An example pattern, called a "daisy", used for point source observations is shown above. This allows the map-maker to separate time varying signals from those that are fixed in a particular location on the sky. The map-maker works by iteratively fitting a collection of models to the time stream in turn and subtracting them leaving the astronomical signal. We iterate so we can improve the models as we know more about them. Before we can do this though we need to fix up any problems with the time series. The SQUID readout electronics can introduce steps which need to be fixed. We have developed a robust algorithm for correcting these problems. The plot on the left is from a bolometer that is particularly sensitive to steps. The plot on the right is the fixed time series with both steps and spikes removed.





Data Models

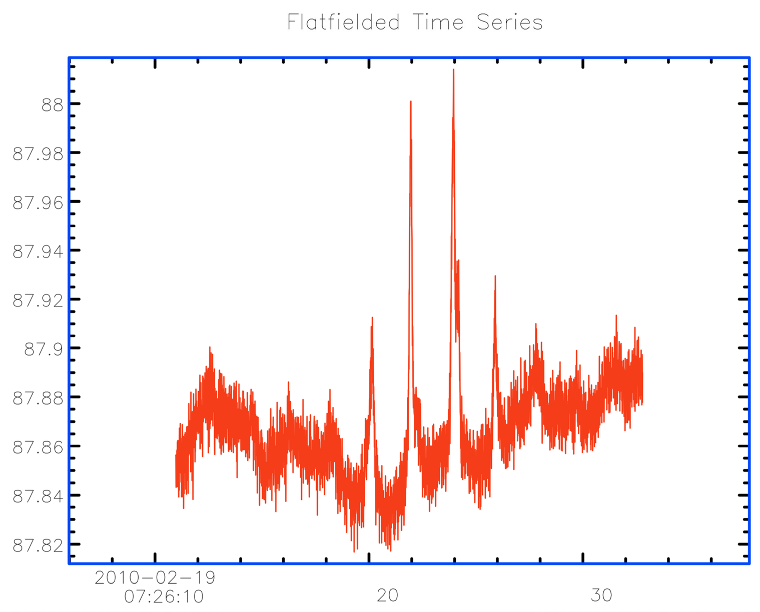


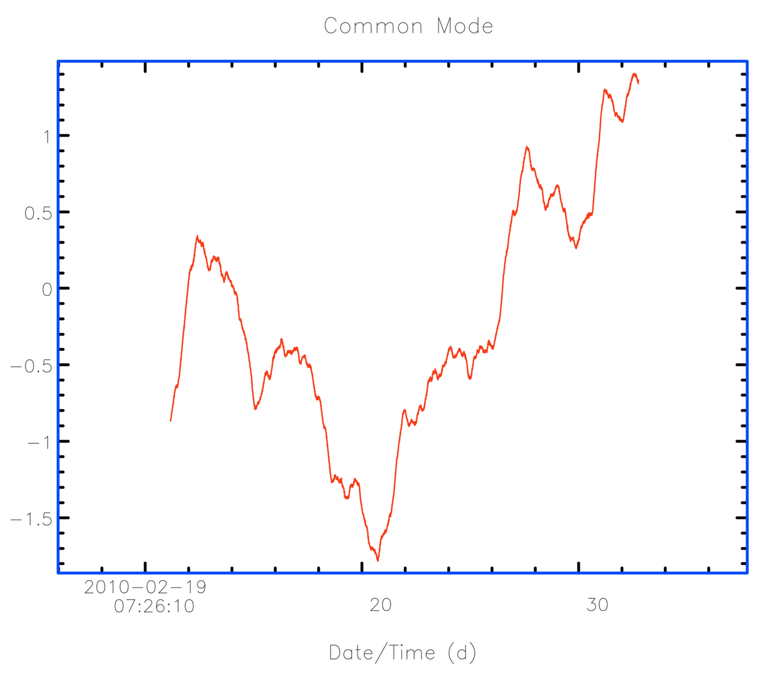
The plot on the left is the signal that is common to all the bolometers in the observation that contained the steps. It contains the atmospheric signal and any changes in the base temperature of the fridge (25 second timescale), as well as low-frequency instrument drifts. We throw out any bolometers that do not seem to be measuring the common-mode signal. We can also use the common-mode signal to correct for any errors in the flatfield by comparing the size of the common-mode of each bolometer.

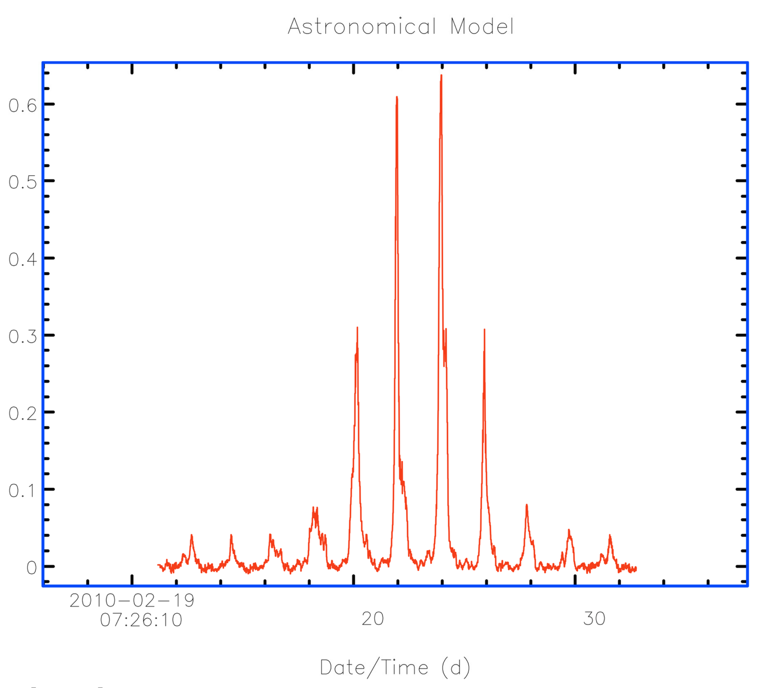
Other models include:

▪ A Fourier filter to remove low and high frequencies from the data based on the scan speed of the telescope and the wavelength.
▪ Correction for atmospheric extinction.
▪ An alternative to the FFT filter that removes a median value from a rolling box.

At the end of each iteration we look for spikes in the residual time series or in the map data and optionally look again for steps, now that the large scale models have been removed. This is repeated until the models converge.

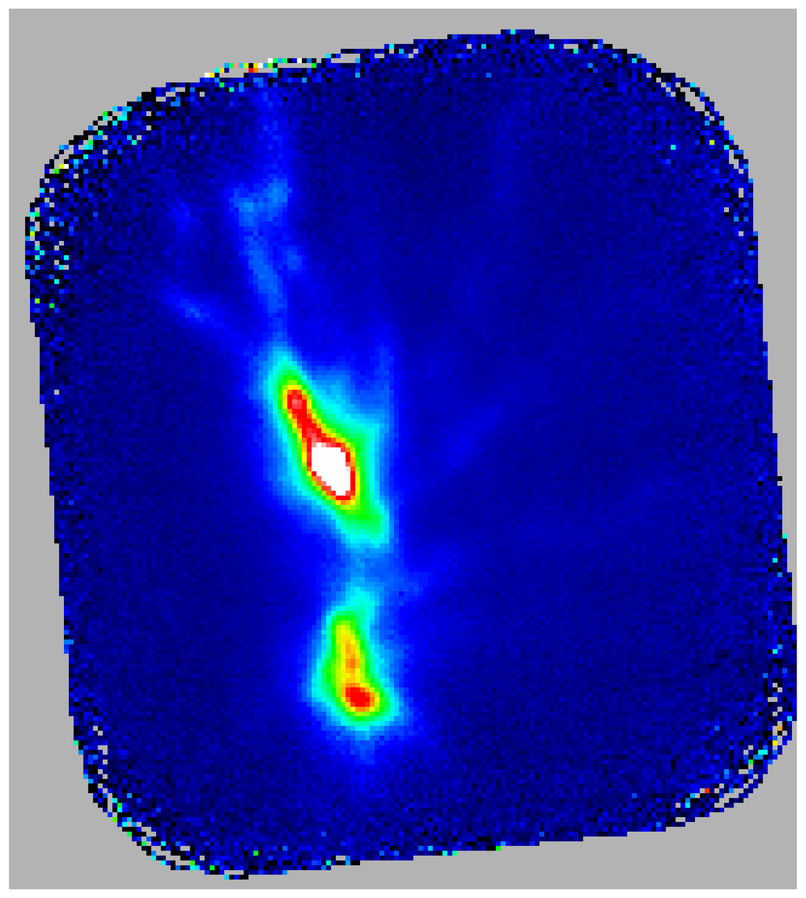






The next three plots show a bolometer from a 20 second 450 micron observation of OMC-1 in Orion. The top plot is the flatfielded time series. The middle plot is the common mode signal, and the lower plot is the astronomical model showing the astronomical signal with the instrument and atmosphere signals removed.

The final image is shown below covering an area of about 4x4 arcminutes.

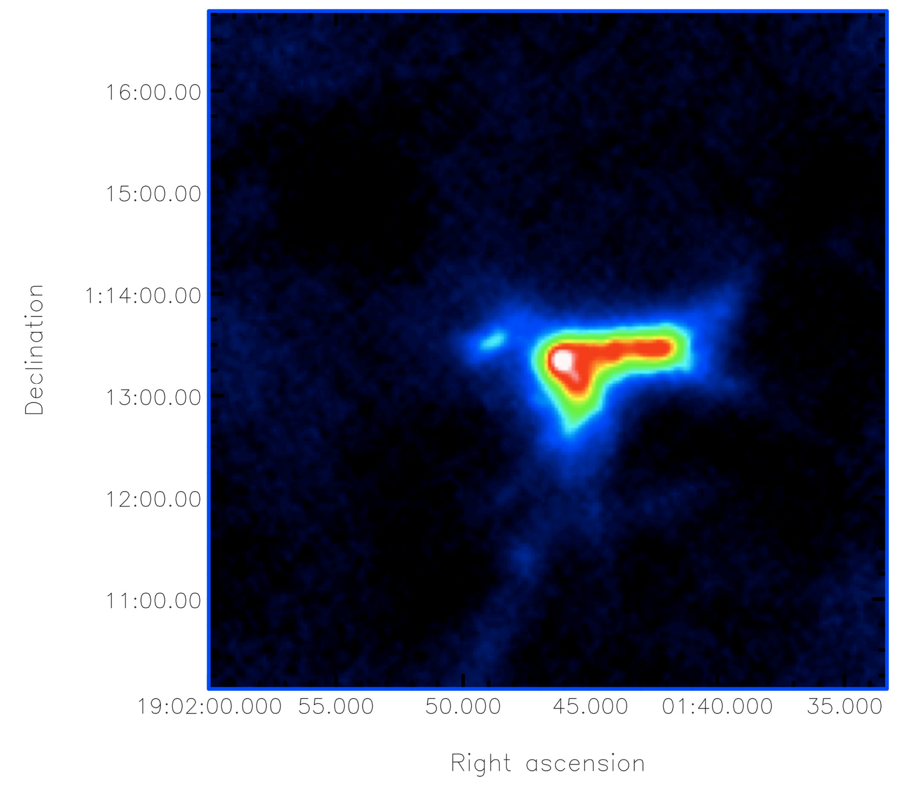


Pipeline and the JCMT Science Archive

At the telescope and at the JCMT Science Archive (hosted at CADC) we use the ORAC-DR data reduction pipeline to run the SMURF map-maker and to do mosaicking, pointing corrections and data analysis. PiCARD is used for off-line data analysis.

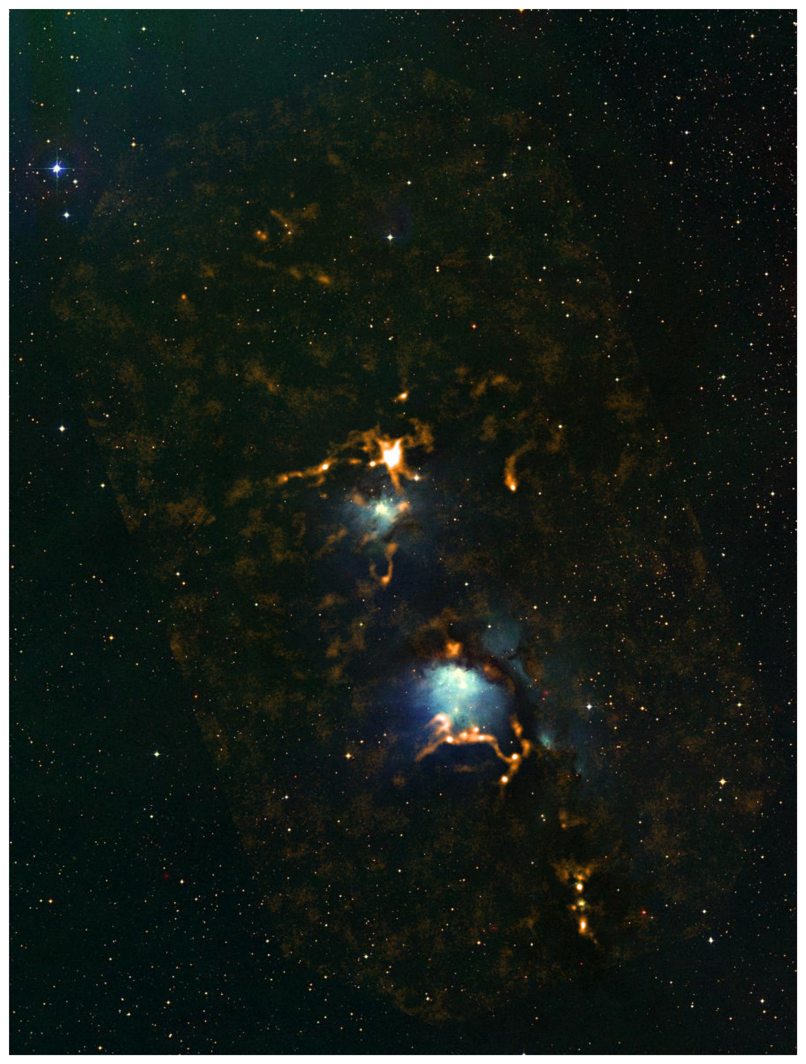
At the summit there are four pipelines running on dedicated machines. For each of the two wavelengths there is a Quick Look pipeline which processes single observations as quickly as possible to provide instant feedback to the observer, and also to reduce pointing and focus observations. The other pipelines can take a little longer to process the observations, and try to do a reasonable job at showing observation progress by waiting for more data to accumulate and mosaicking separate observations.

In the science archive time is not an issue, so the pipeline can run on the CADC grid processing cloud (see the talk on Wednesday afternoon by Frossie Economou). It is also possible to run the pipeline in the new CANFAR cloud computing infrastructure (see poster P077 by Séverin Gaudet).



Above: The high-mass star forming region IRAS 18592+0108 in 450 microns.

Below: An 850 micron map of Orion B North (orange) overlaid on a multi-colour DSS optical image. The image is about 45 x 75 arcminutes. Image courtesy Dave Nutter.



Starlink: http://www.starlink.ac.uk
ORAC-DR: http://www.oracdr.org
SCUBA-2 DR blog: http://pipelinesandarchives.blogspot.com
JCMT Science Archive: http://cadcwww.dao.nrc.ca/jcmt/search/product

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