Progress with SCUBA-2

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On behalf of the SCUBA-2 Project Team

SCUBA-2

A Submillimetre Camera for the JCMT

SCUBA-2 (Submillimetre Common-User Bolometer Array-2)

University of Waterloo

University of Lethbridge

UBC

Université de Montréal

UK Astronomy Technology Centre

Canada Foundation for Innovation / Fondation canadienne pour l'innovation

PPARC

University of Calgary

Royal Observatory Edinburgh

The University of Edinburgh

University of Victoria

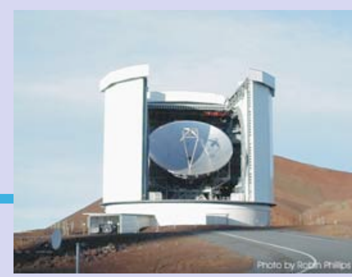
Université Laval — Aujourd'hui Québec, demain le monde

Cardiff University / Prifysgol Caerdydd

Saint Mary's University — Halifax, Nova Scotia, Canada

NIST — National Institute of Standards and Technology

Joint Astronomy Centre — UKIRT — JCMT

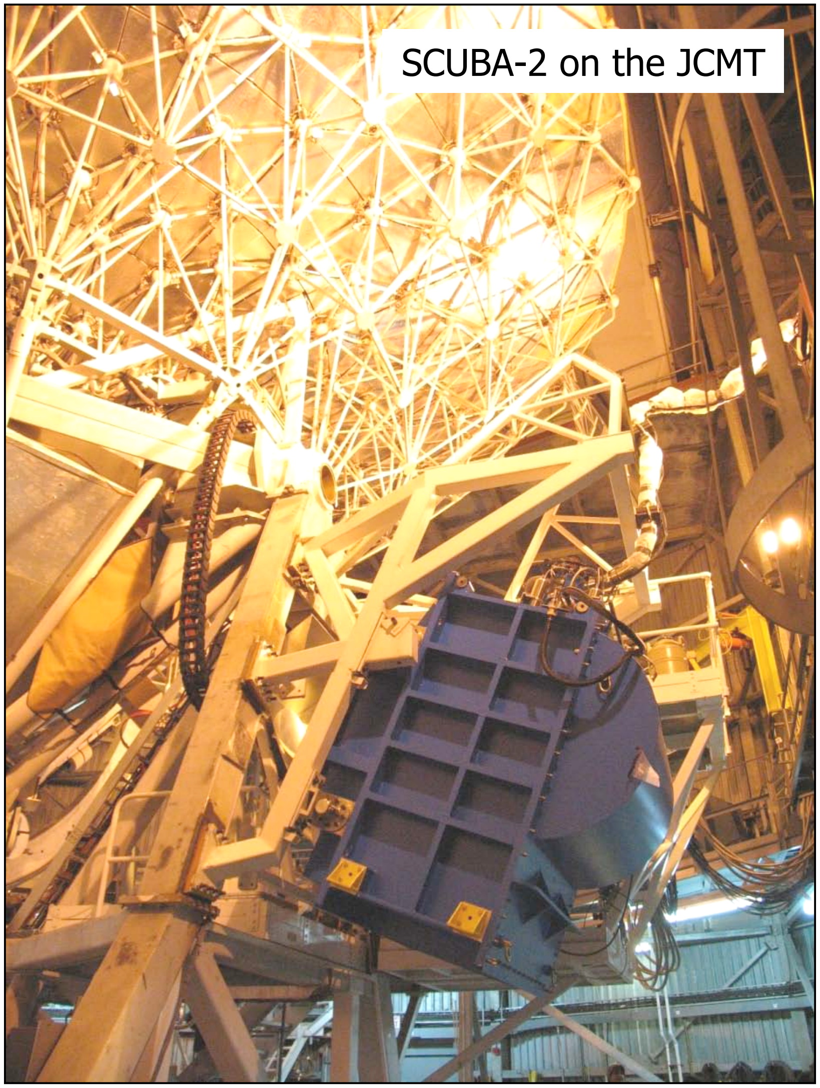


University of Durham

SCUBA-2 in a nutshell

- Large-scale survey instrument with 45 sq-arcmin field-of-view
- Simultaneous imaging at both 450 and 850μm with sky-background-limited sensitivity

- Involves many new technologies from advanced detector arrays to ultra-low temperature cryogenic systems
- First observing run for the JCMT community in Feb-Apr 2010 (with one-quarter focal planes)

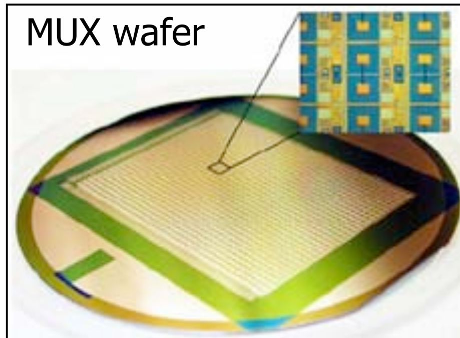


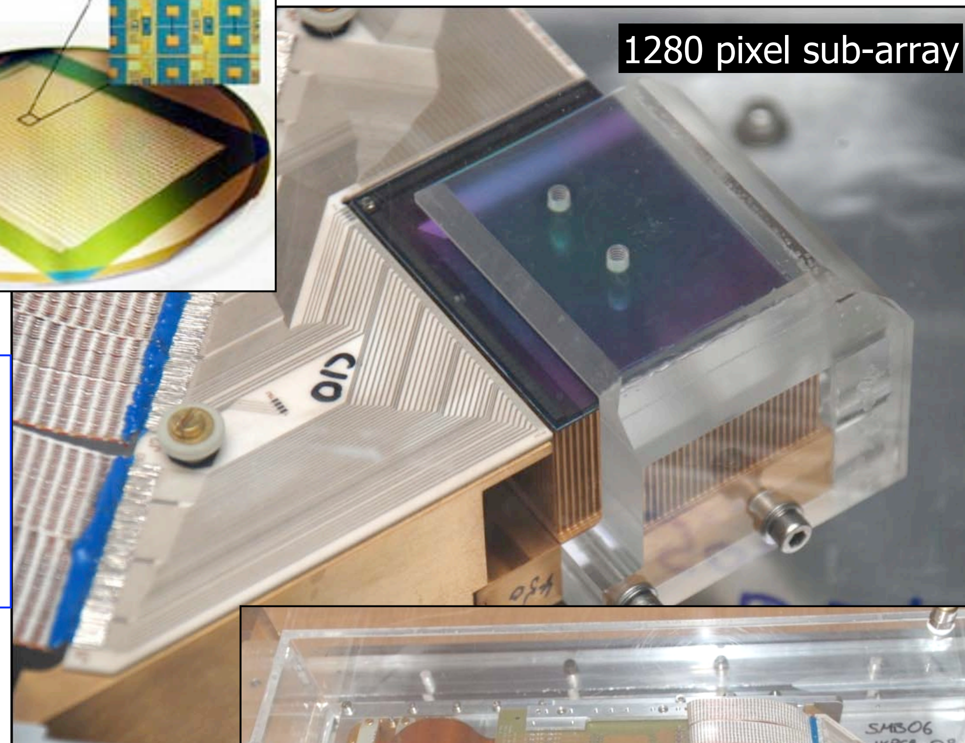
SCUBA-2 on the JCMT

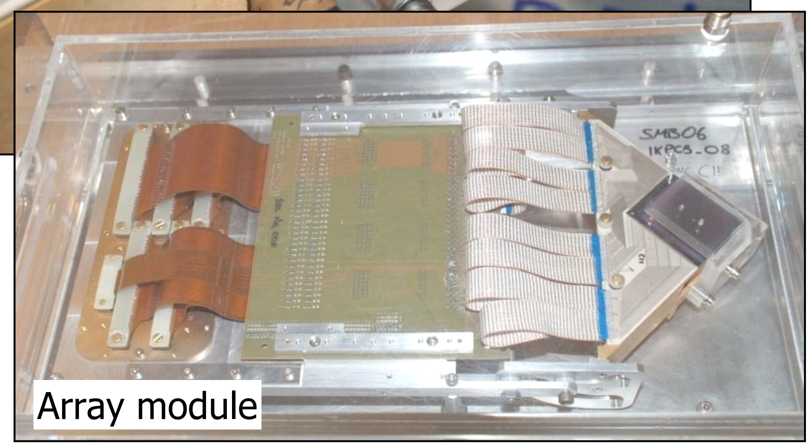
Detector arrays

- Large-format superconducting TES detector arrays – ~5000 pixels in each focal plane
- SQUID-based multiplexer to read out the signals
- Detectors cooled to ~100mK for best performance

Questions? See Kent Irwin (here today)

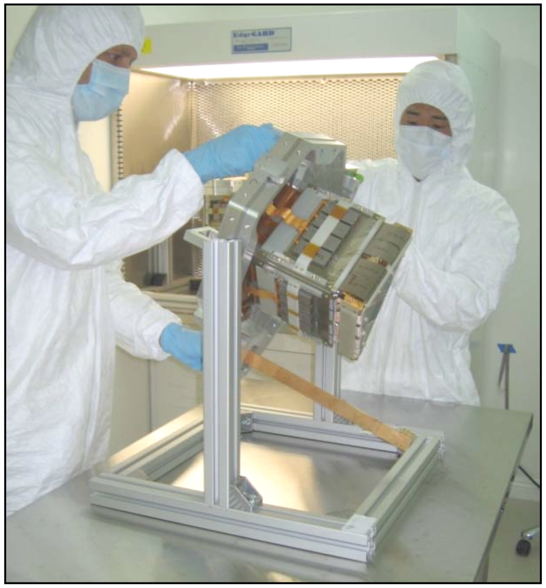






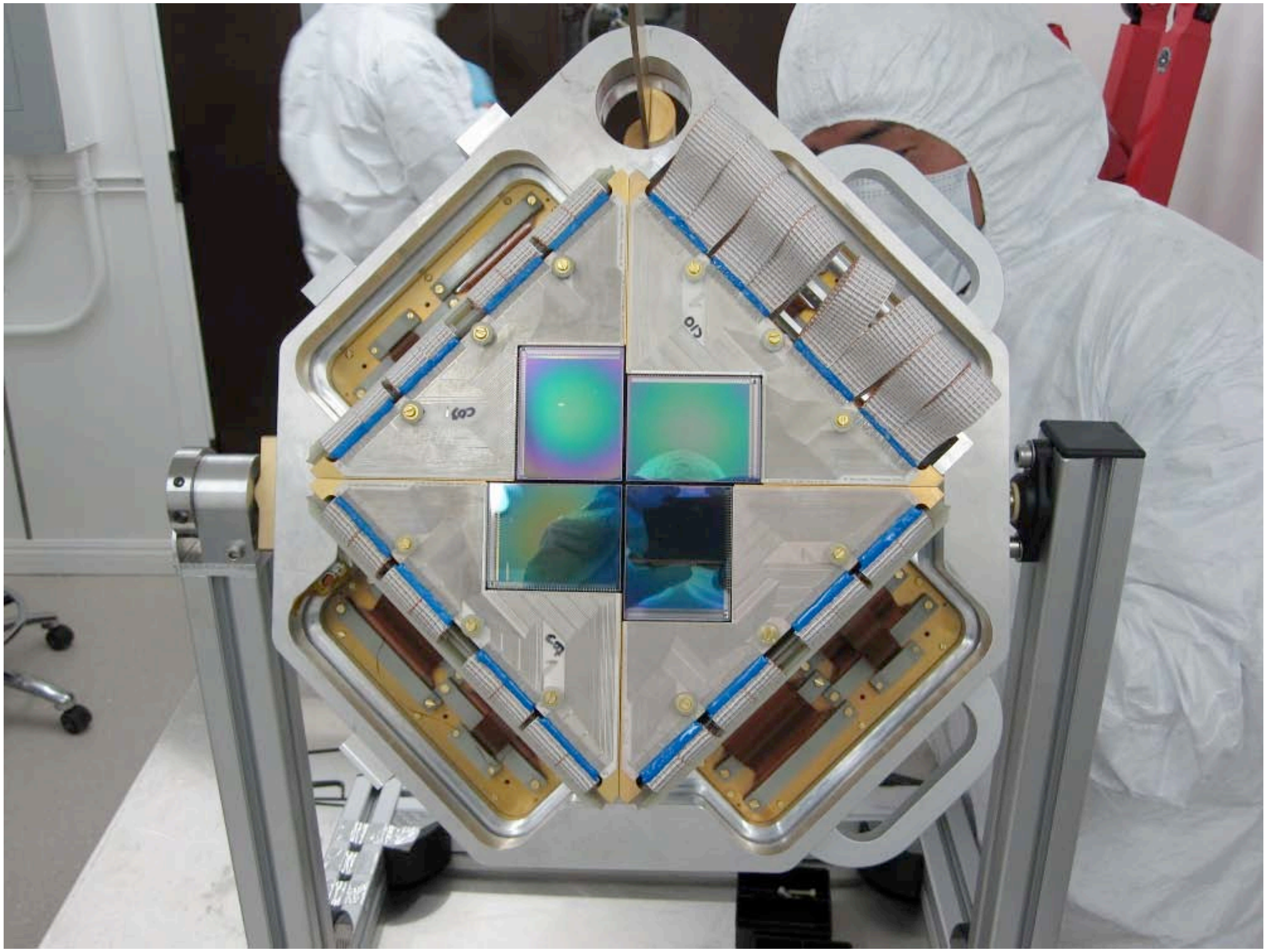
SCUBA-2 at JCMT

- First two science-grade arrays were installed in July/Aug 09 – one quarter of each focal plane populated



- The remaining 6 science-grade arrays were installed over the summer 2010

Fully-populated focal planes

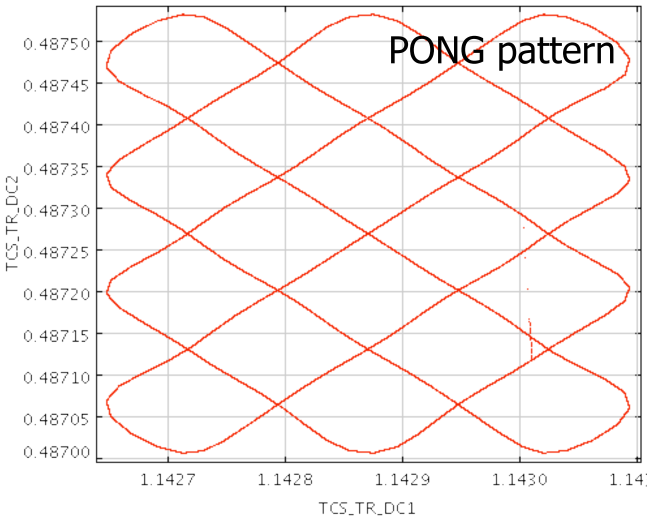


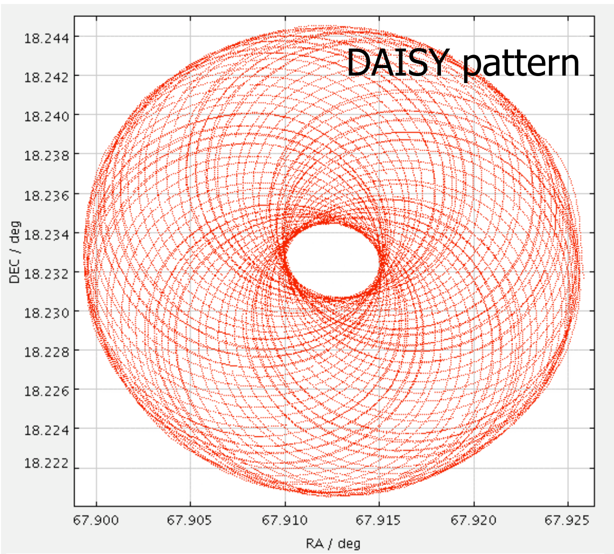
Fully-populated 450um focal plane – over 5000 bolometers!

Observing with SCUBA-2

- Exclusively concentrated on scanning methods so far ("imaging" mode options are still available to try)

- Rotating PONG patterns work well – good for large areas

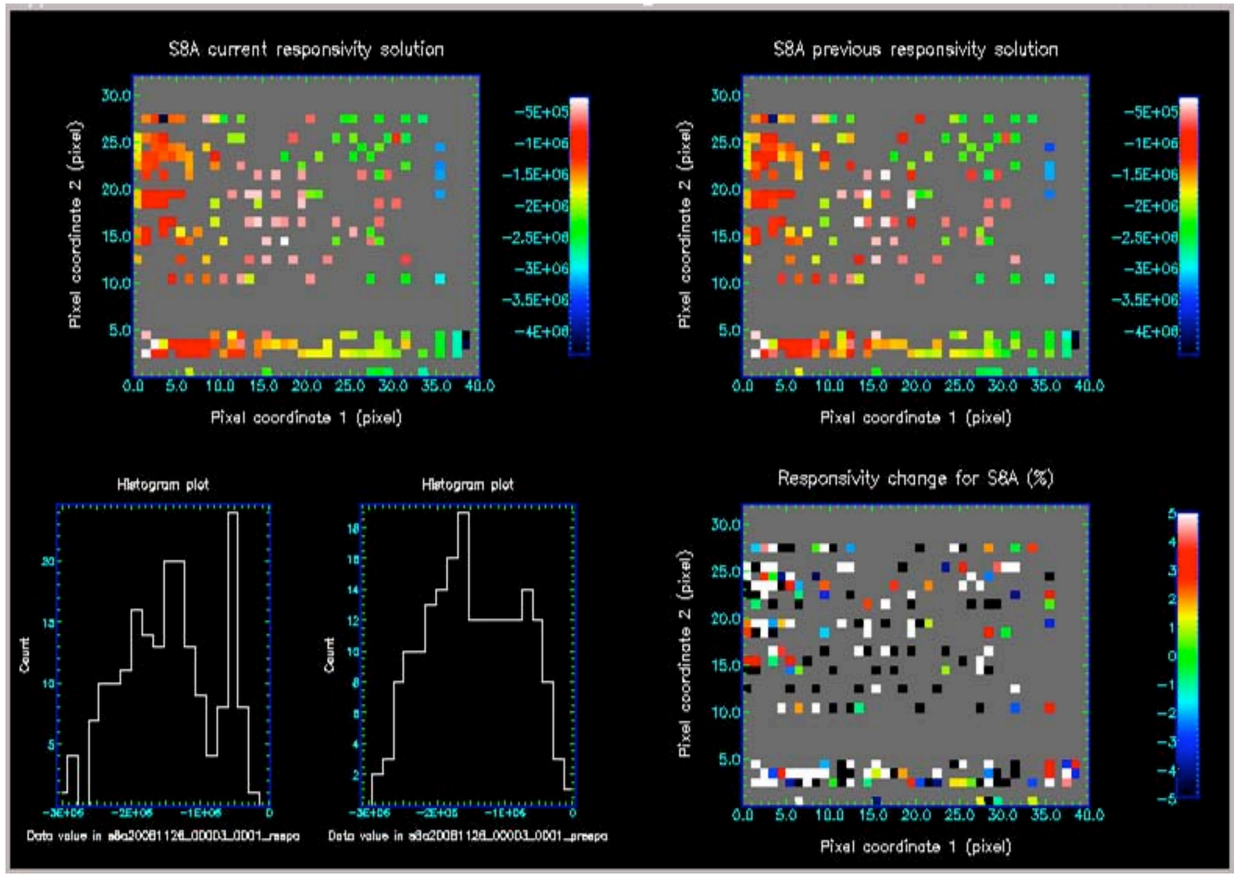




- DAISY scan patterns have also been used for more compact fields

Observing with SCUBA-2

- Data is automatically reduced in real-time at the telescope by a "Quick-Look" pipeline
- A "science" pipeline using an iterative "map-maker" is used off-line



Example Q-L pipeline output for a flatfield measurement

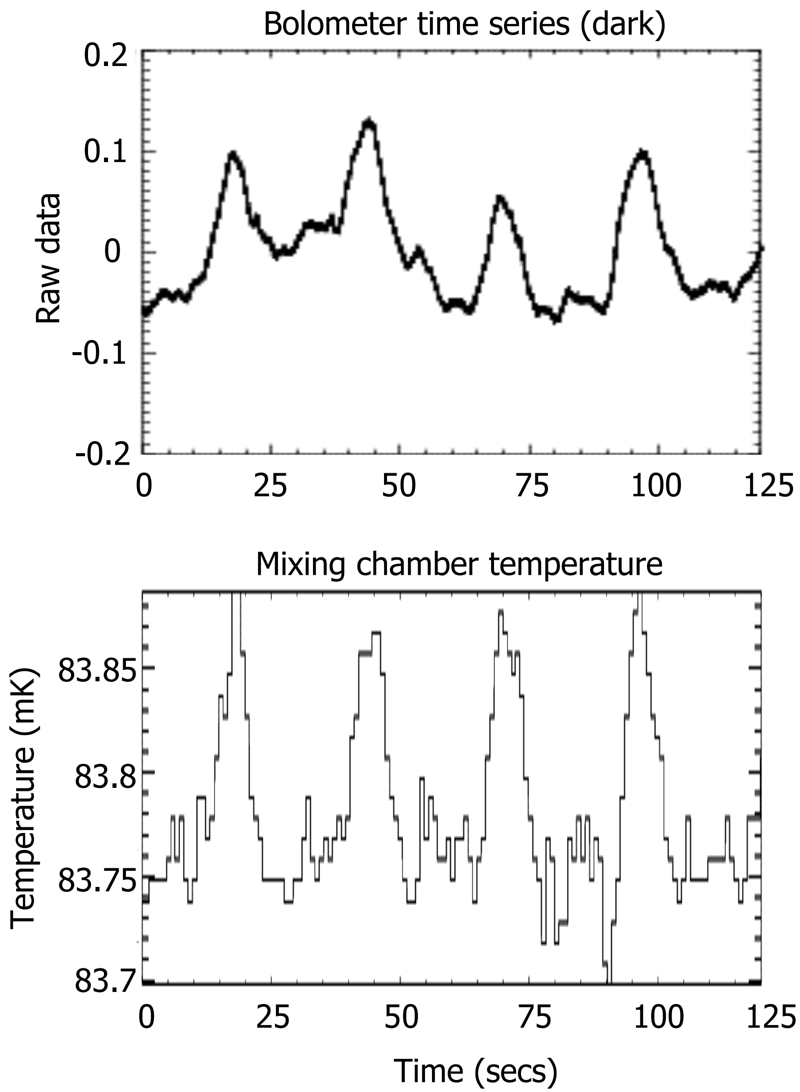
Map-making limitations

- A number of limitations to data quality have been found:

- Temperature oscillations (~25 secs period) from the dilution refrigerator

- General high "1/f noise" component from the detectors (worse for 850 array)

- Synchronous pick-up for larger area scans (magnetic in origin)



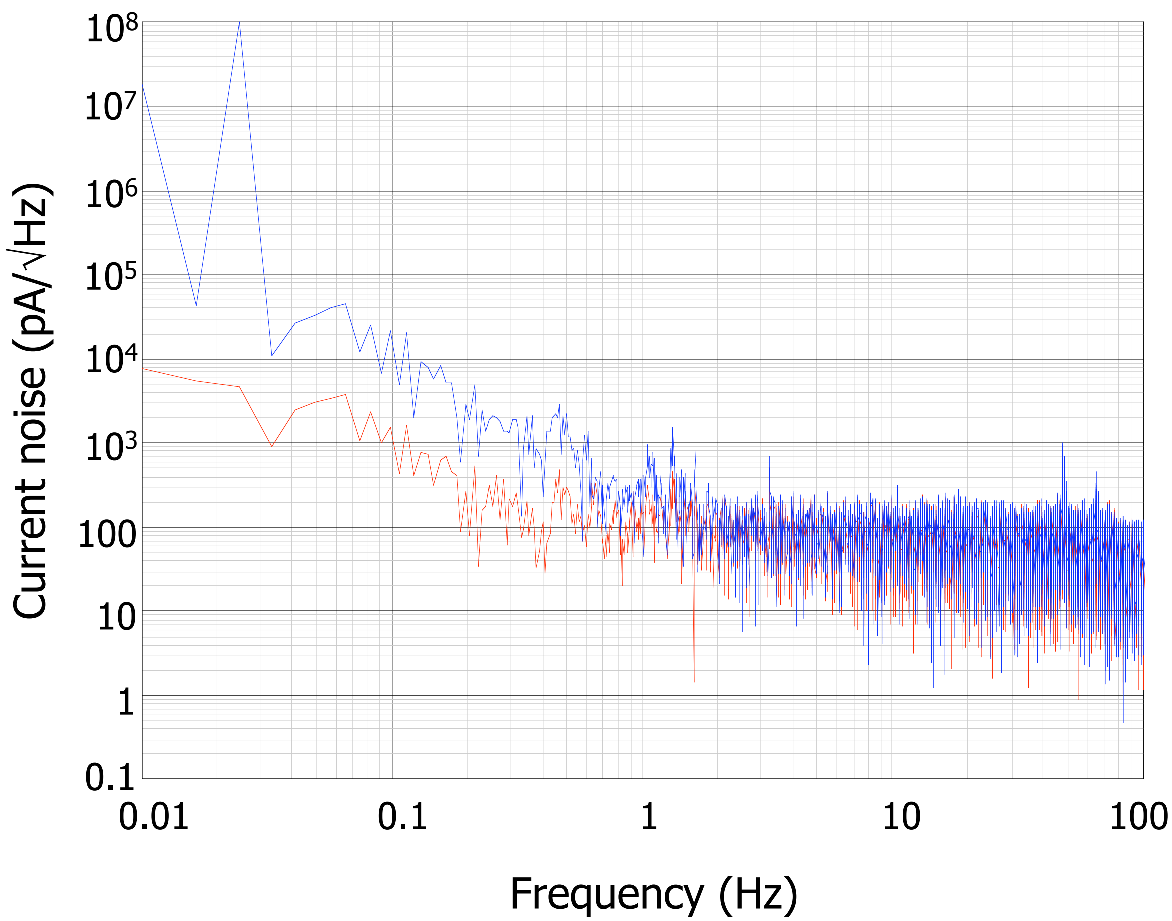
Low-frequency noise

- Various techniques have been adopted to minimise these effects

- Subtraction of a common-mode signal for temperature instabilities

- “Dark” SQUID subtraction to remove magnetic pick-up from the summing coil

- High pass filtering of the data (0.3 – 1Hz+)

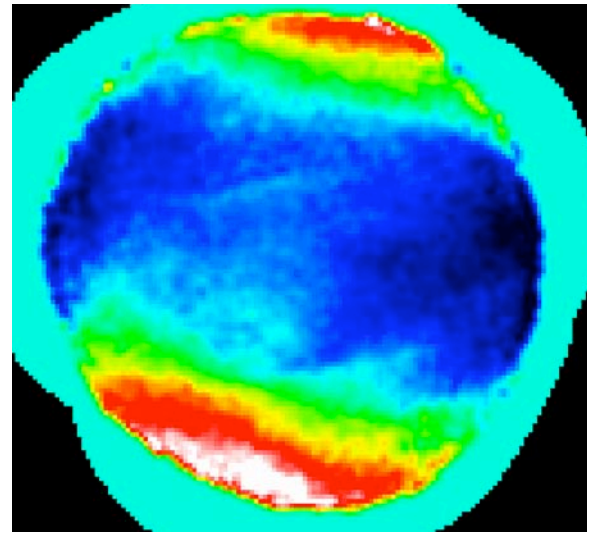


Blue: “raw” power spectrum; Red: column C-M subtraction

Image reconstruction

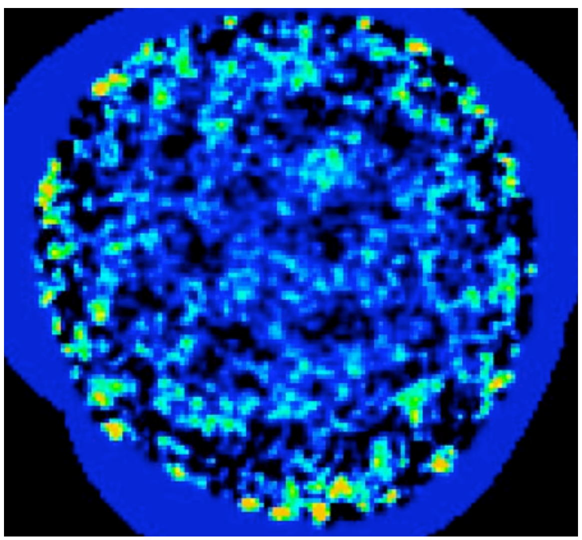
- Residual images tend to have saddles and gradients

- Can recover the data by high-pass filtering (but removes source flux and large-scale structure)



“Raw” image from map-maker

- Other techniques include using matched filters to extract point-sources, and background fitting/removal algorithms



High-pass filtered (1Hz) image

Further enhancements

Several other ways to make improvements:

- Identify the source of the low-frequency noise/pick-up and minimise
  - Very difficult to do without major fridge re-work (or more shielding)

- Modify the observing mode and/or scan faster to move the source signal away from the excess low-frequency noise
  - Looking into alternative scan/imaging strategies and will scan faster with larger field-of-view

- Create a better model of the noise components and remove in map-maker
  - Better measurement of the temperature fluctuations would help (underway)

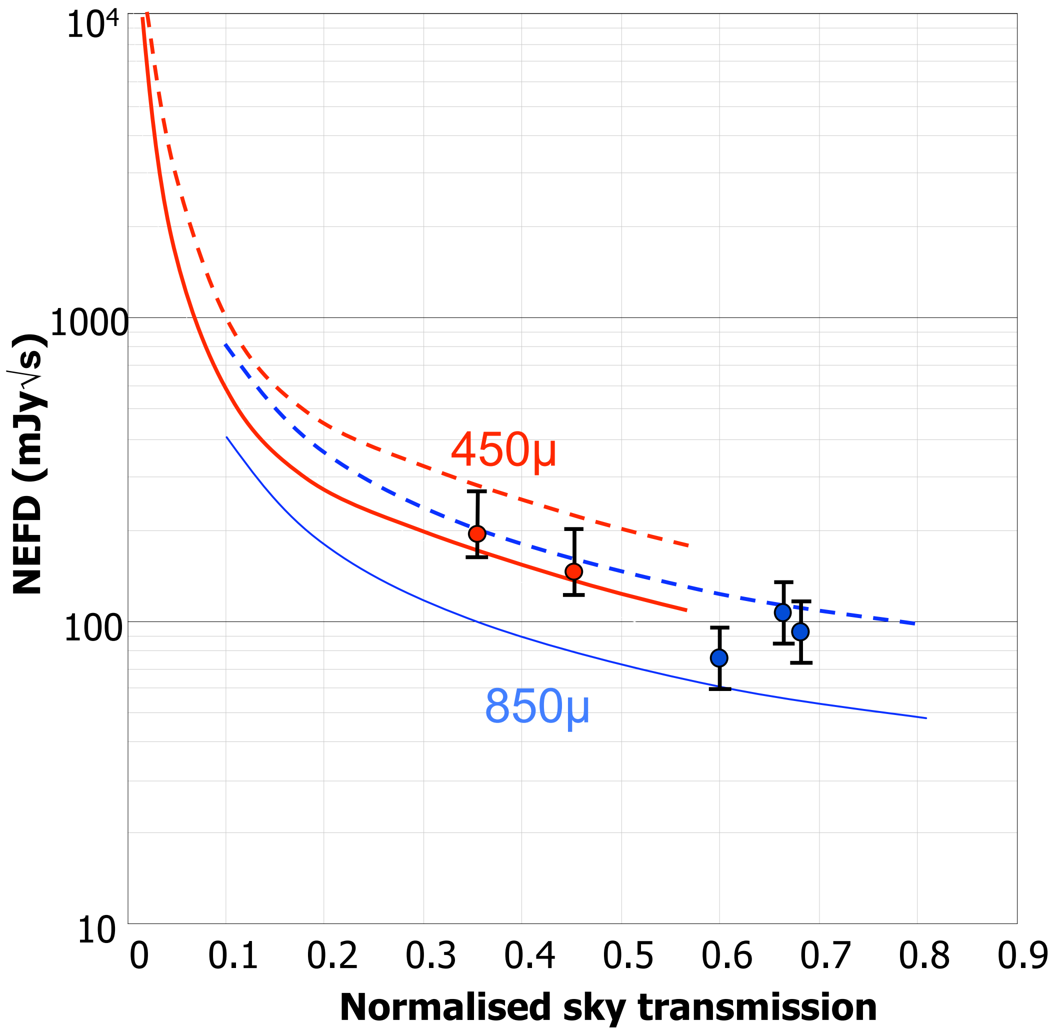
Even Further enhancements

- POL-2 – polarimeter for SCUBA-2
  - Built at U. Montreal by Pierre Bastien
  - Installed at JCMT in July 2010

- FTS-2 – imaging FTS
  - Built at U. Lethbridge by David Naylor
  - Installed at JCMT in July 2010

Questions:
ask Martin Houde
(here at meeting)

Performance on the sky

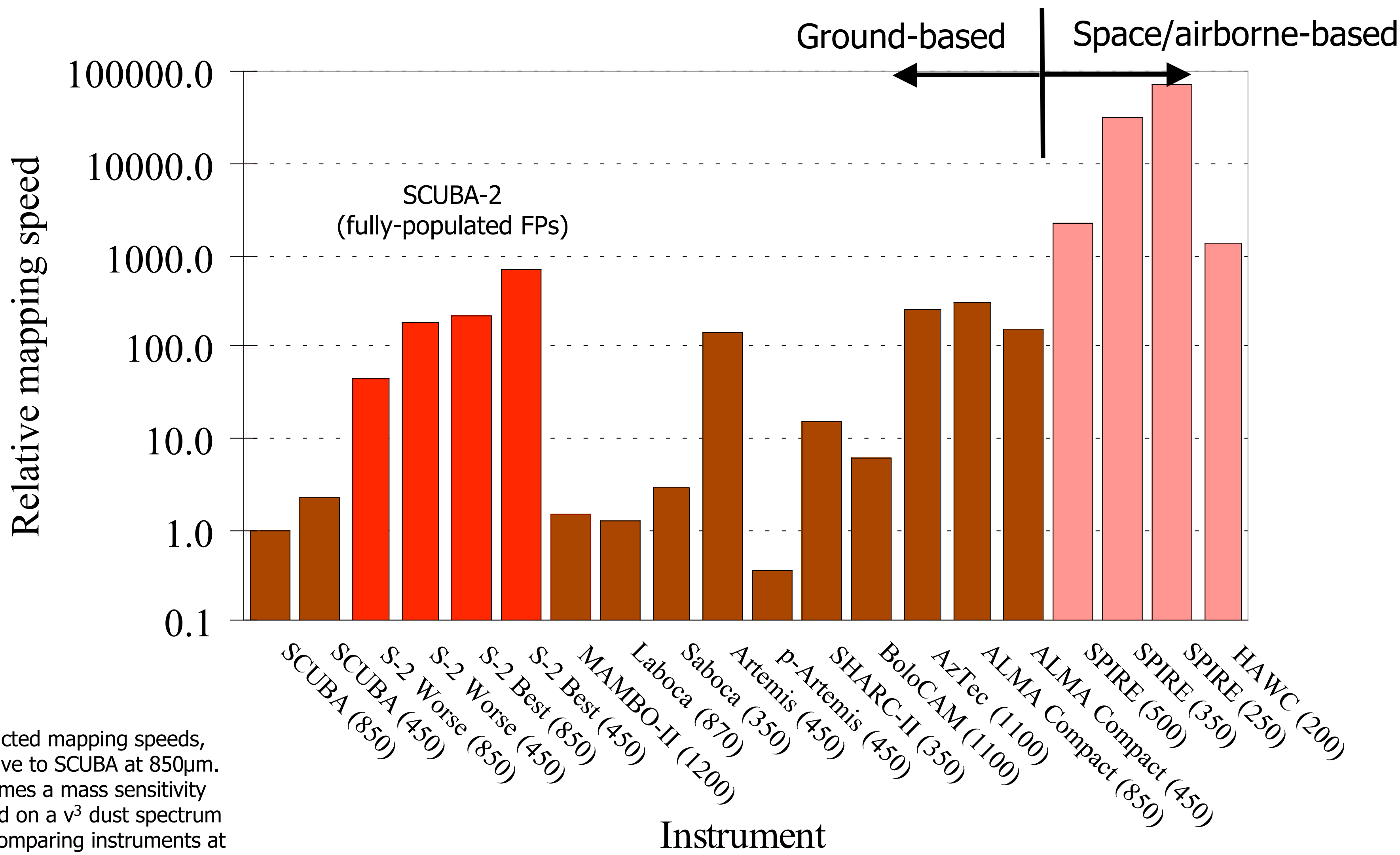


RED CURVE: (solid) "Best" achievable (no excess noise); (dashed) from background corrected maps

BLUE CURVE: (solid) "Best" achievable (no excess noise); (dashed) from background corrected maps

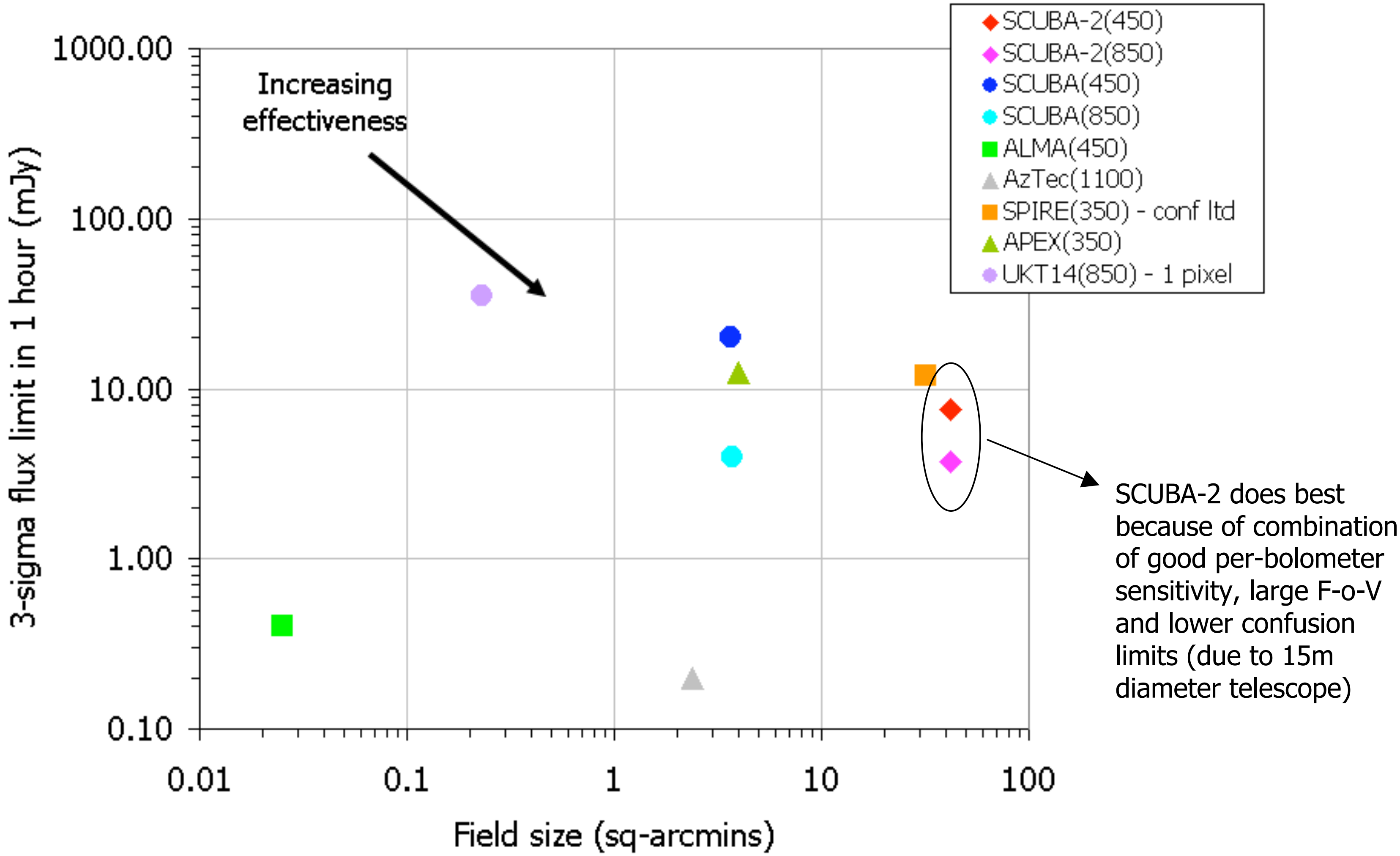
Circles: measured values from deep maps analysed with the matched filter

Predicted mapping speeds



Predicted mapping speeds, relative to SCUBA at 850µm. Assumes a mass sensitivity based on a ν^3 dust spectrum for comparing instruments at different wavelengths

Deep imaging per field



In summary

- SCUBA-2 has undertaken the first science for the JCMT community – data being analysed, lots of papers soon (some already in press. One already published - data from Nov 2009)

- Considerable work ongoing to optimise both the observing modes and data reduction recipes

- The instrument has now been upgraded to full array complement - conservative mapping speed some 200× better than SCUBA to the same S/N

- Re-commissioning has started, to be followed by the start of the Legacy Survey Programme in the New Year