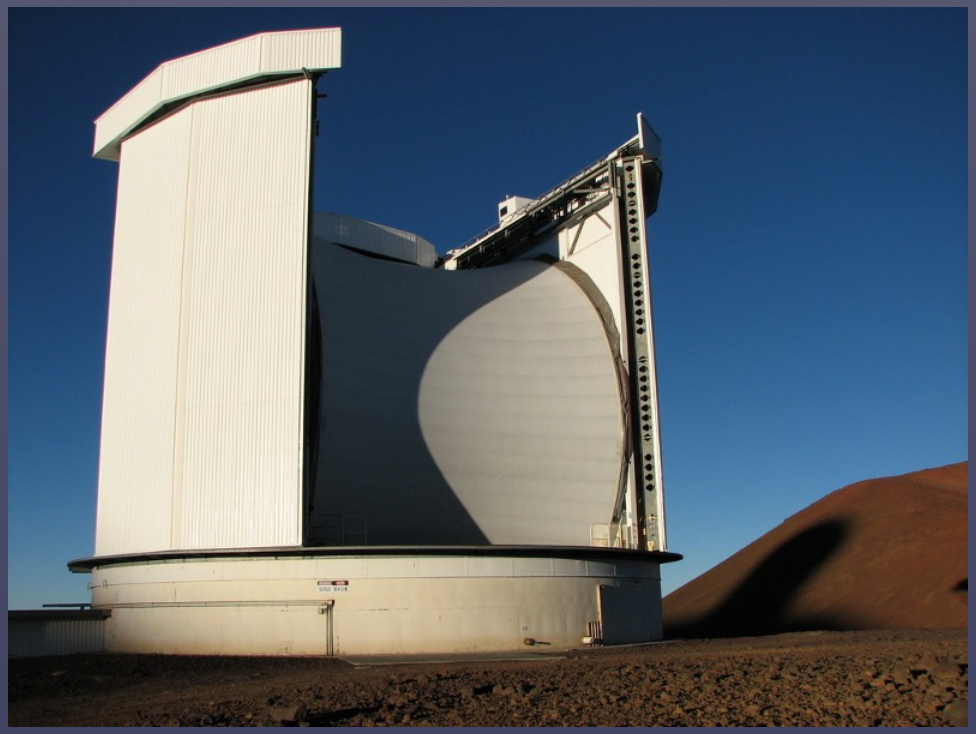
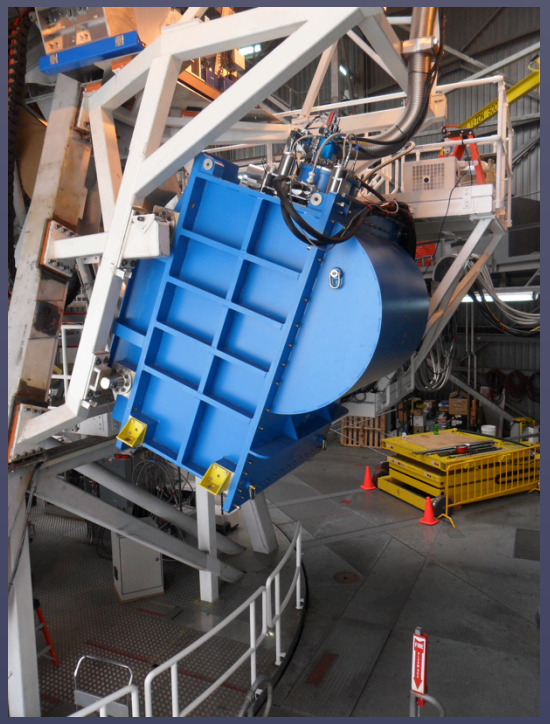
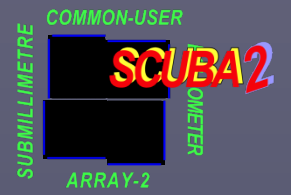
Upgrade or Replacement Options for SCUBA-2





Upgrade or Replace SCUBA-2



- Upgrades to the instrument that increase the mapping speed by 5 to 10 times, while significantly improving the ability to map faint extended structure would realise the full potential of SCUBA-2.
- On the other hand, a replacement instrument might be similar cost and a less risky way to achieve the same results as an upgraded SCUBA-2, while SCUBA-2 itself continues uninterrupted on the telescope.
- Or we could design and build a new instrument that pushes the boundaries again.
- **The key: is to understand the needs of our uses and to develop an updated science case.**

The Factors for the Science Case

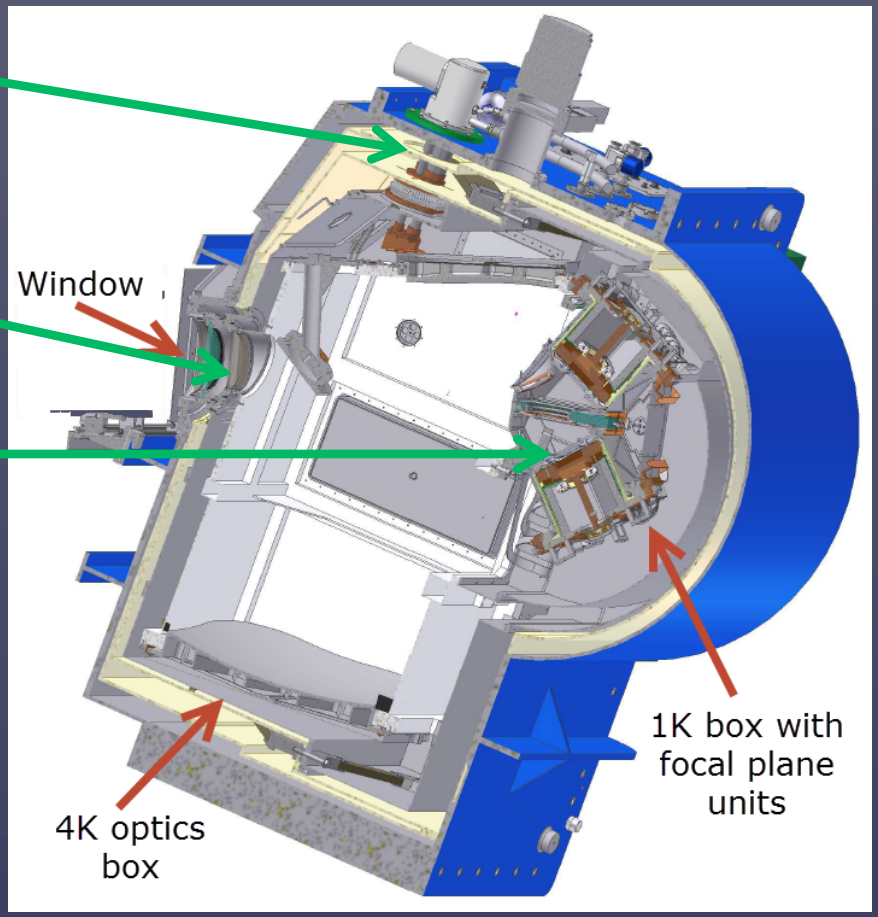
- Mapping speed
- Improved / faster polarization maps
- Better functional scanning FTS
- Enhanced map making of extended emission

- Or are there other capabilities and features that users of JCMT would want in a continuum instrument such as
  - Multi-chroic detectors or on-wafer spectrometers

Upgrade SCUBA-2

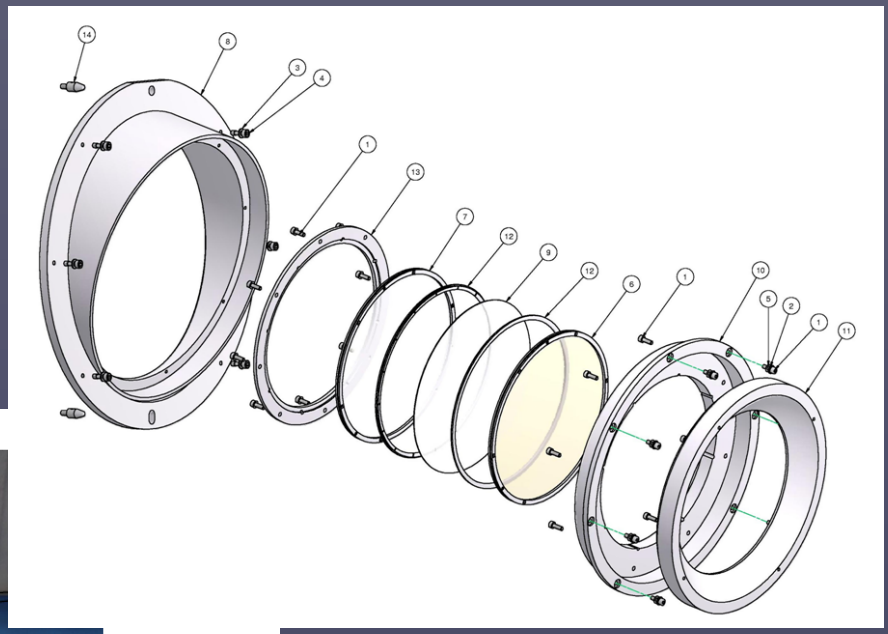
- Reuse the SCUBA-2 cryostat, cold optics and cryogenics
- Reduce stay light / excess optical power on the arrays
- Replace the detector arrays or possibly the focal plane units or 1K box

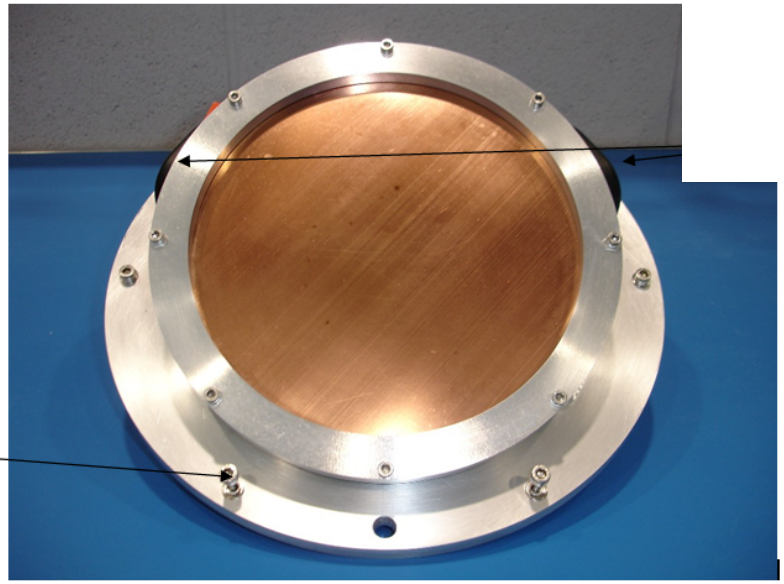
The available field of view (at the Naysmyth) 8 x 8 arcmin, is used optimally – To get a larger field of view, requires moving to the cabin or a radical solution using new relay mirrors from the cabin



Reduce stay light/excess power

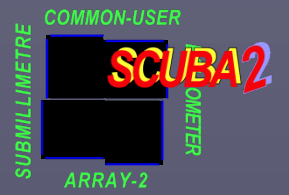
There have been significant improvements in the Cardiff filter design and manufacture, since the SCUBA-2 filters were designed and made





Proposing to remodel and then re-design and install new filters from the window to the 4K

Detector arrays



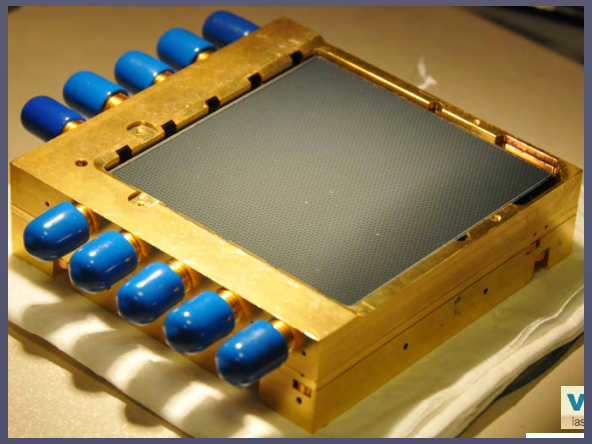
TES vs KID

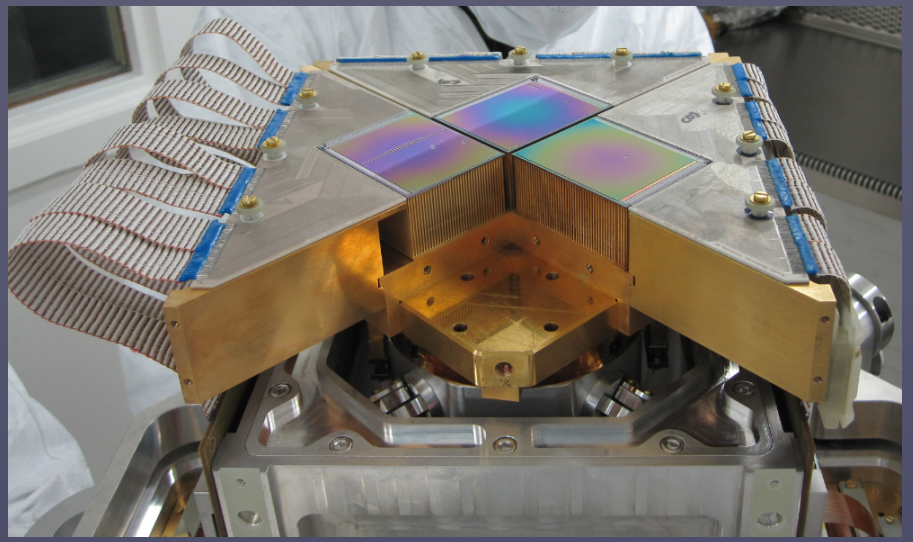
- Both can achieve the required specs to upgrade SCUBA-2
- Neither are off the shelf solutions
- TES are more mature and have advanced since SCUBA-2
- SQUID MUX has improved
    - lower power
    - more uniformity
    - less magnetic pickup
    - higher muxing factors
- Know how to make good absorber and/or couple to TES

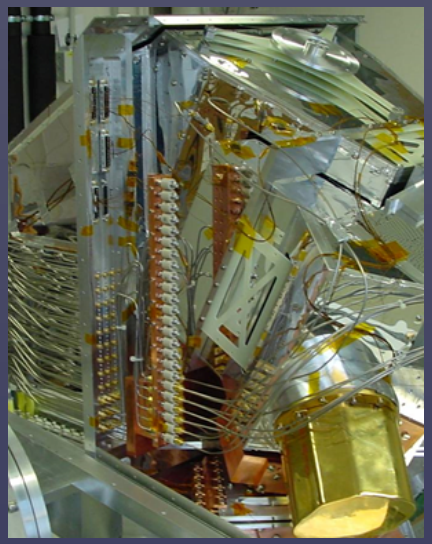
- KID arrays are potentially simpler to fabricate
- KID arrays don't require a SQUID MUX
- The cold electronics for KIDs is an amplifier per 1000/2000 pixels
- For TES arrays, the cold electronics is a SSA per 40 pixels

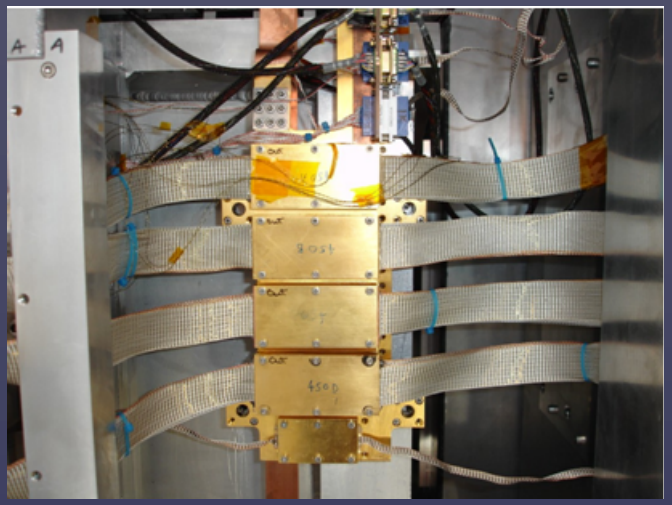
- KID arrays are far less sensitive to thermal fluctuations

Engineering requirements For KID arrays



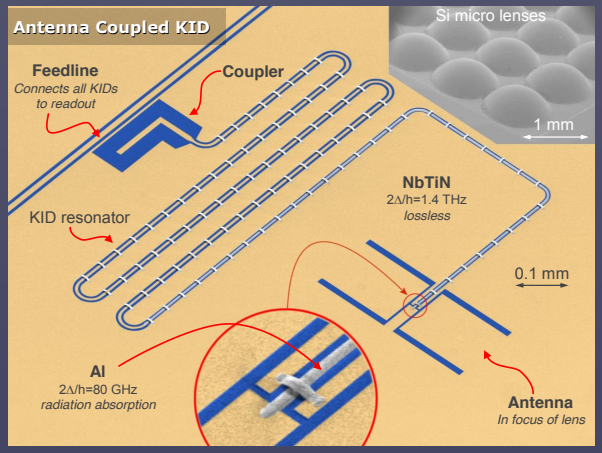




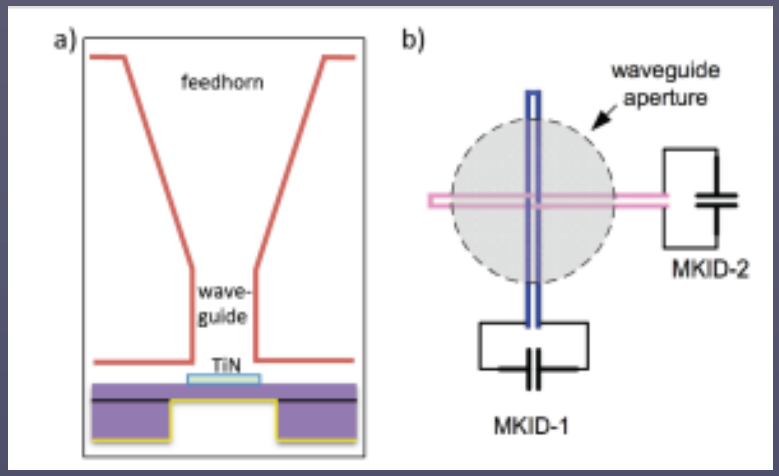


KID array development work for SCUBA-2

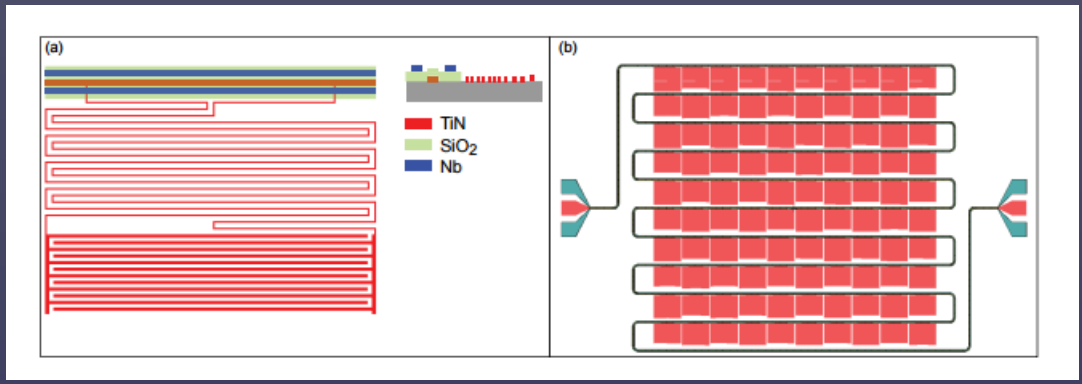
- Pixel design
- Choice of materials [Al, TiN]
- Choice of frequency of operation
- Coupling to radiation
- Testing and optimisation



AMKID



Next gen BLASTpol



MAKO

Exploratory work

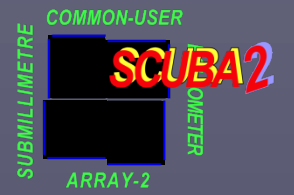
Meeting in Cardiff:

Agreed to remodel/redesign the fillers.

Plan to swap in the summer (4-5 weeks down time)

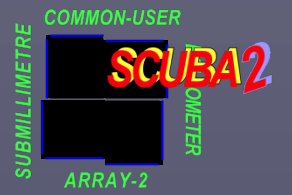
- Simon Doyle (Cardiff) – offered to investigate designs and possibly make test pixels (already has funding).
- In contact with groups at NIST Boulder and Stanford that are developing BLASTpol KID arrays.
- Cardiff also have rectangular feed horn arrays developed for KIDCAM

Options for new arrays



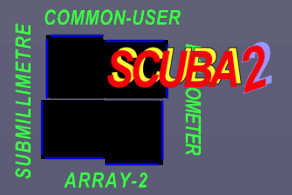
- TES new 32 x 40 sub-arrays (most likely based on GSFC BUG architecture)
- Larger TES arrays 40 x 40 (increase pixel count by factor of ~2) using larger 6 inch wafer. So far only NIST has this process worked out (making Advanced ACTPol detectors)
- KID arrays at least 40 x 40 sub-arrays
  - [could move 450 to Fλ/2 spacing - 80 x 80 sub-arrays]
- Horn coupled KID arrays with 2Fλ spacing
  - (See Griffin,Bock, Gear 2002)
- Dual-Polarisation sensitive KID array (BLASTpol pixel)
  - 2 KIDs per pixel

New arrays



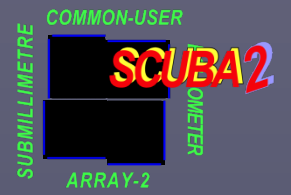
- Any new TES array will not be a copy of the existing SCUBA-2 array
  - Therefore cold electronics, wiring and heater (likely no heaters) will need to be redesigned.
  - This is particularly the case for larger TES arrays
- We have not done a full costing but we are sure that we could put KID arrays in SCUBA-2 for $1-$2 million.
- Success of new arrays contingent in improving sensitivity AND reducing the excess optical power.
- KID arrays will be relatively immune to the temperature oscillations from the existing dilution fridge.

Potential gains in mapping speeds



- Mapping speed scales with number of pixels and sensitivity^2
- 40 x 40 sub-arrays (with dark NEP 3×10^{-17} W/Hz$^{0.5}$)
  - Gains in mapping speed ~ 9x
  - (assuming 90% yield and successful reduction of excess optical power)

Replacement Instrument



- To do better than an upgraded SCUBA-2 (in mapping speeds) – need bigger field of view.
- "Small" instrument in cabin with 15arcmin field of view, using KID arrays 100,000 pixels – 20,000 at 850um could have 30x mapping speeds.
- Baseline: Compact instrument, 3He or mini DR with Pulse tube cooler. Good control of stay light.
- Would require significant work to the telescope/cabin structure.