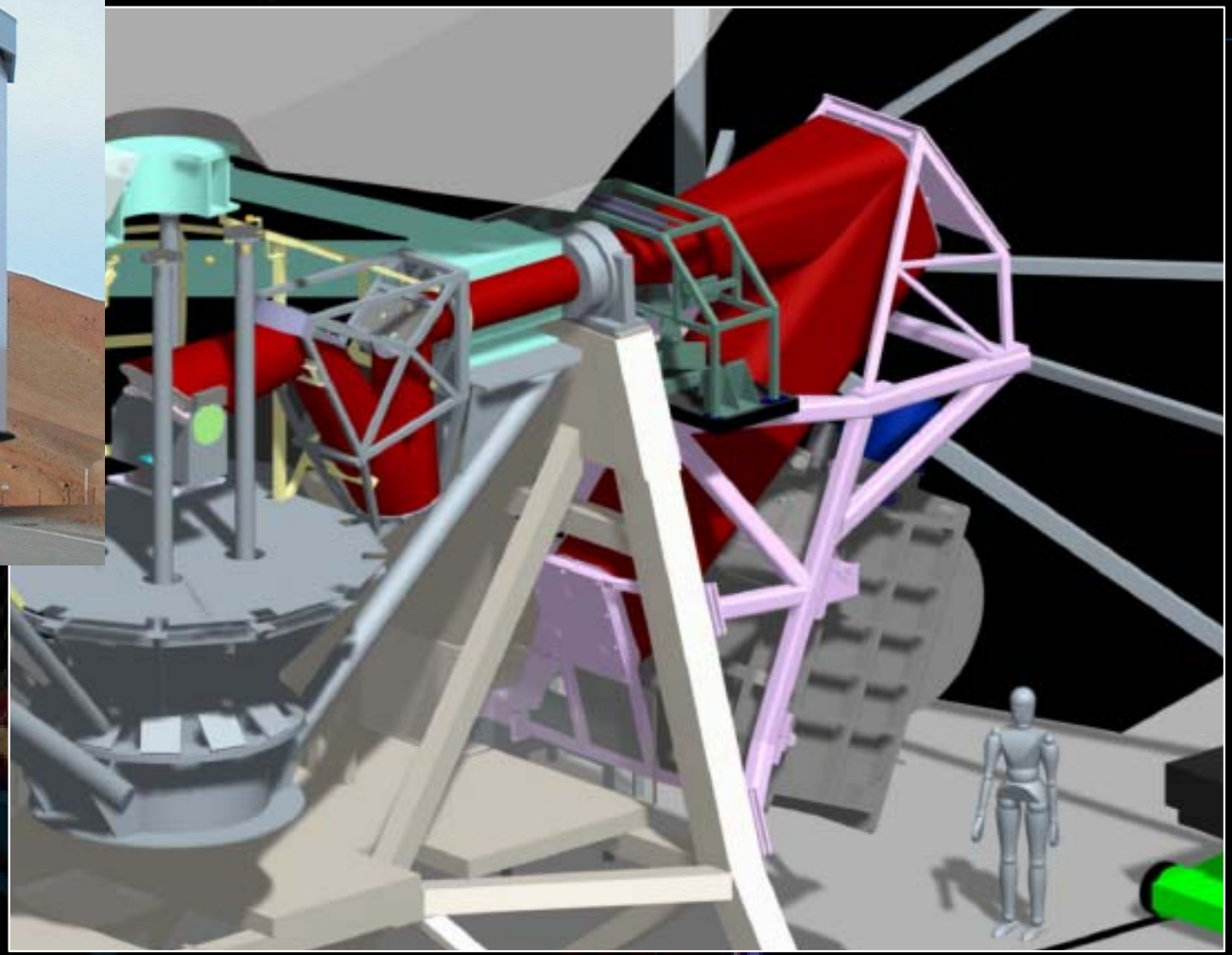
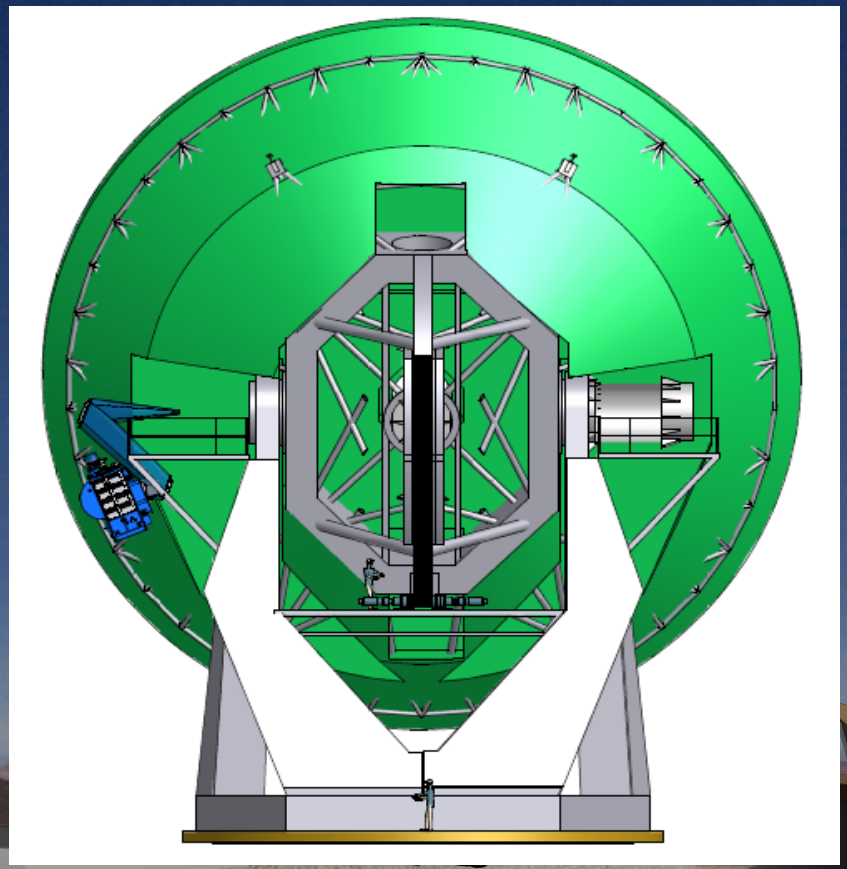
SCUBA-2 on JCMT
(late 2007)



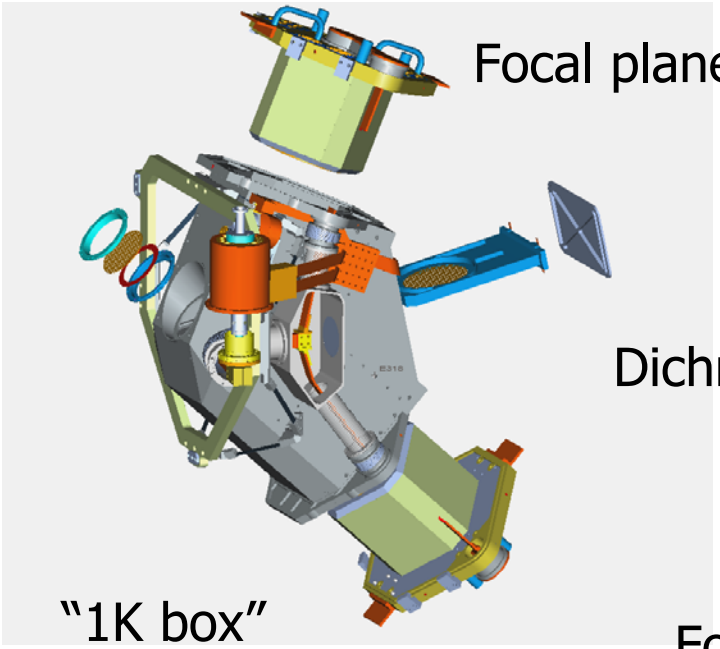
SCUBA-2 on CCAT
(circa 2013)



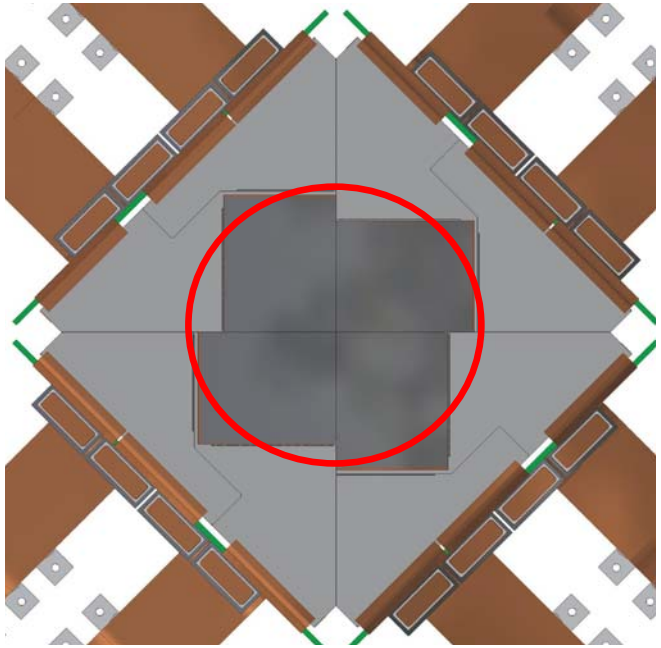
Wayne Holland
UK ATC, Royal Observatory Edinburgh

SCUBA-2 in a Nutshell

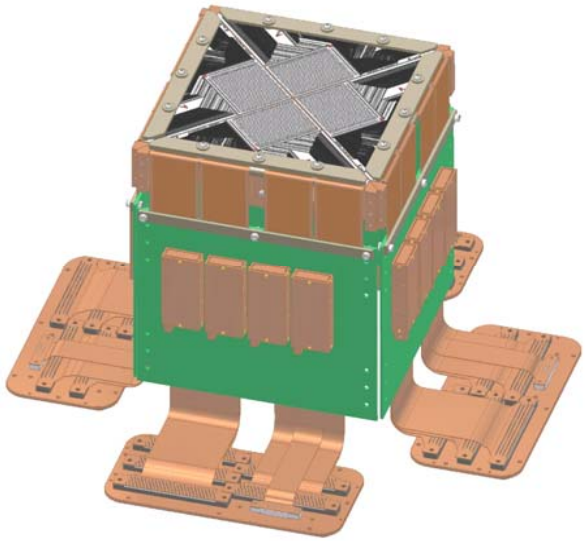
- Two focal planes, working simultaneously at 450 and 850μm
- Each focal plane has ~5000 pixels in 4 sub-arrays (TES with in-focal plane MUX)
- 850 fully-samples the sky; 450 under-samples by a factor of 2
- Field-of-view on sky is ~50 sq-arcmin at both wavebands
- Mapping speeds some 1000 times faster than SCUBA…
- Facility class instrument (DR pipeline, OT, SDT etc.)

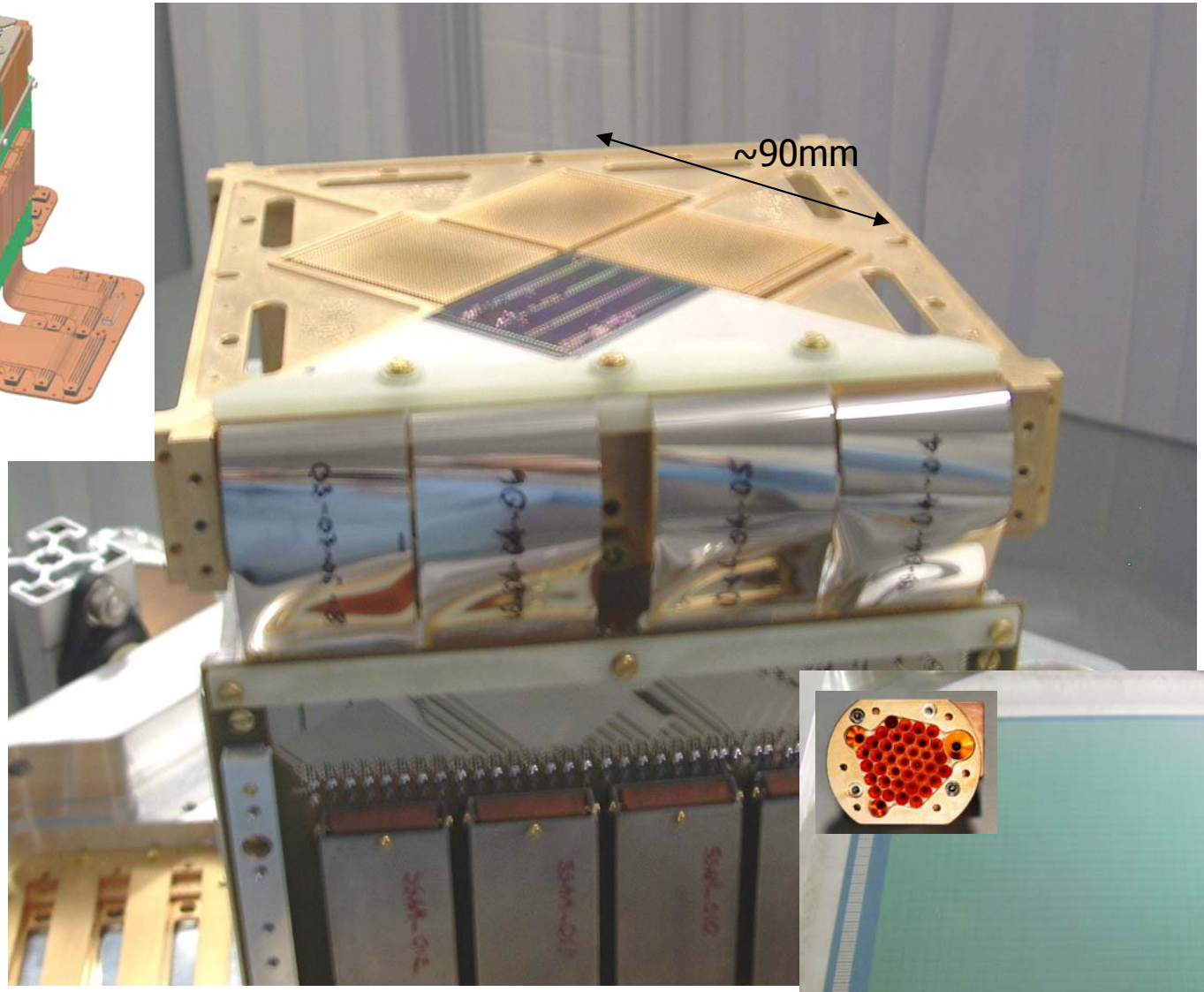


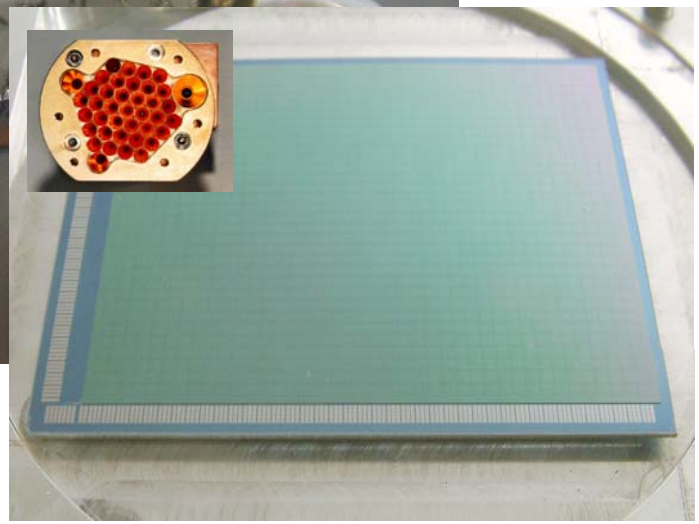
Focal plane



Large Format Arrays







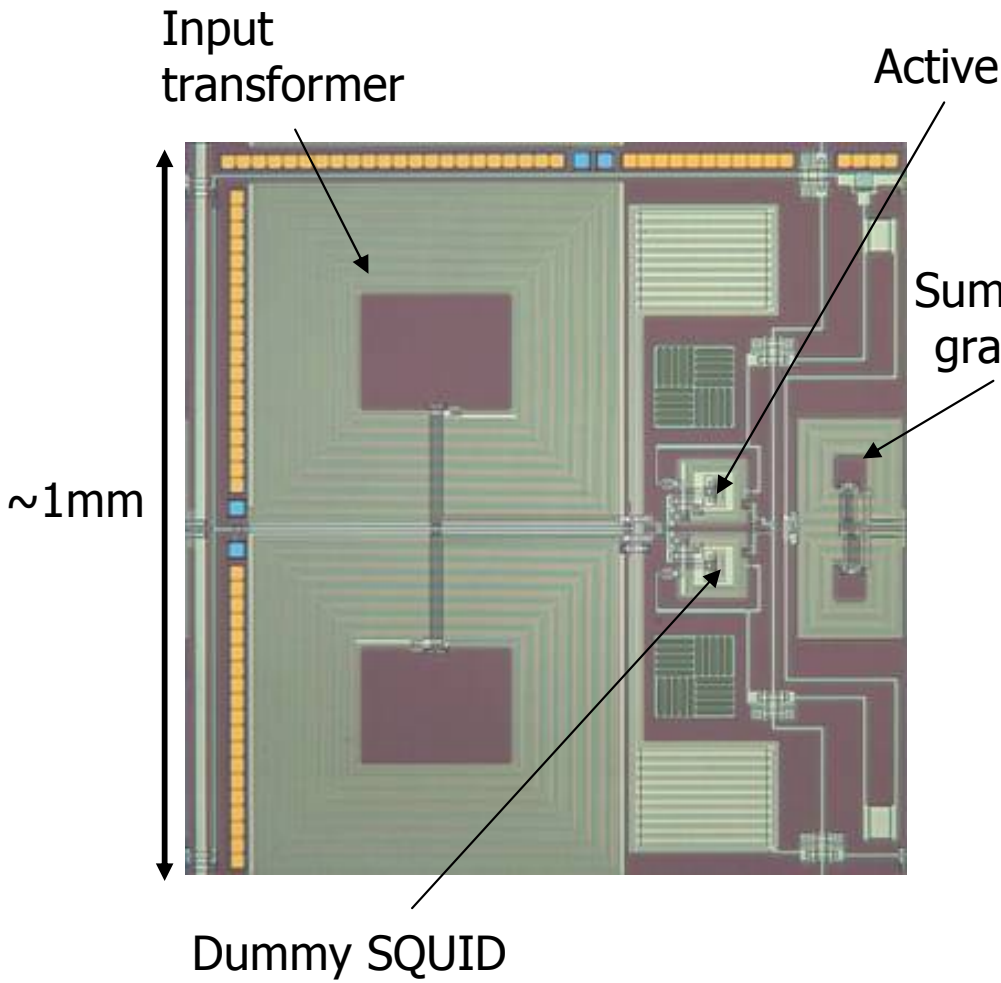
SCUBA-2 450μm prototype array mounted in focal plane unit

NIST National Institute of Standards and Technology

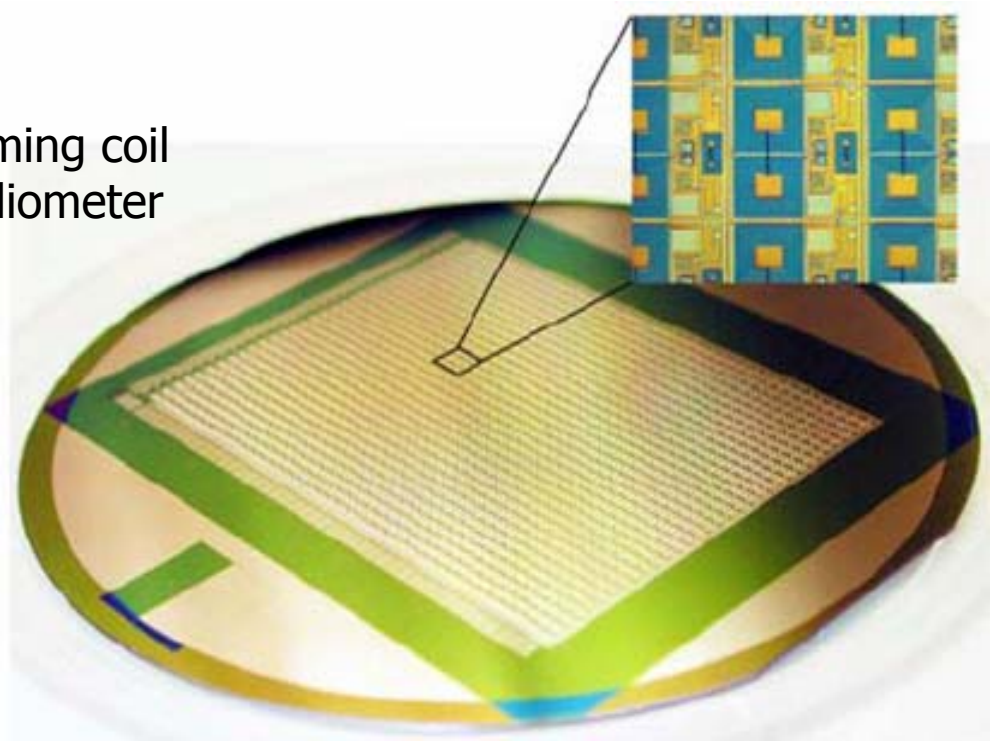
SMC SCOTTISH MICROELECTRONICS CENTRE

Raytheon

In-Focal-Plane Multiplexing



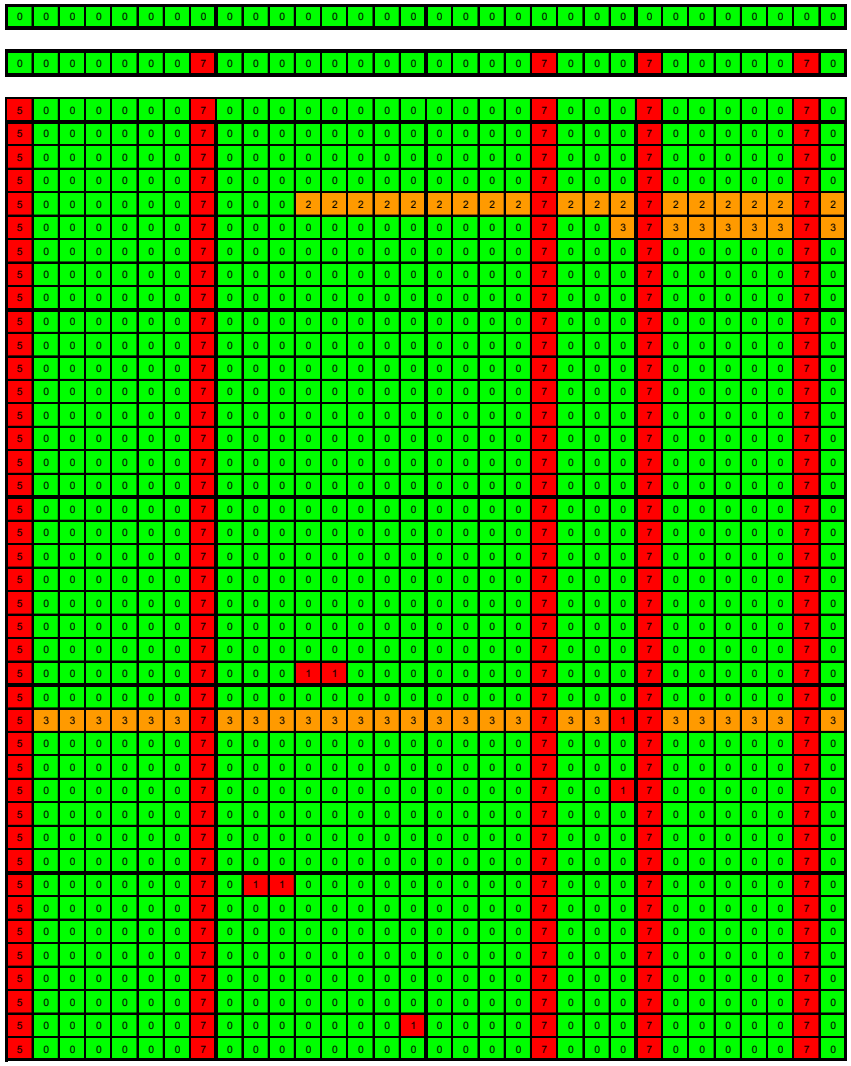
Pixel scale



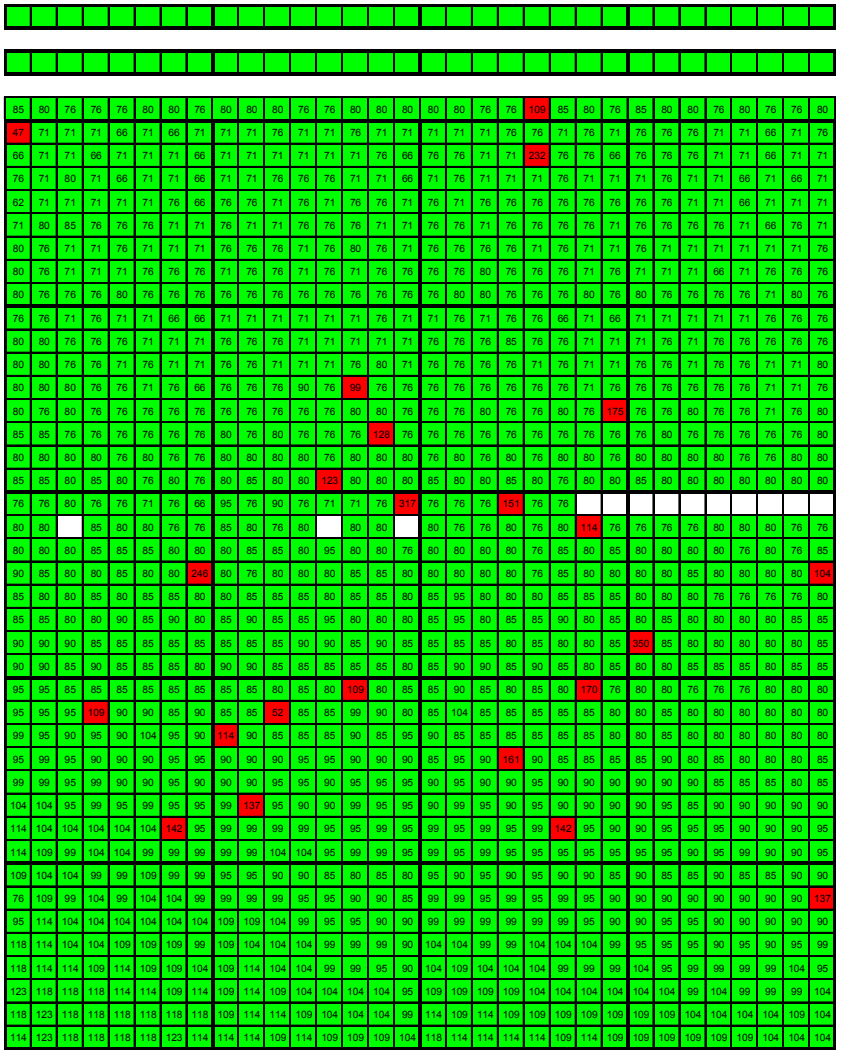
Array scale

NIST National Institute of Standards and Technology

MUX Fab and Screening



850 current array: Yield ~ 85%

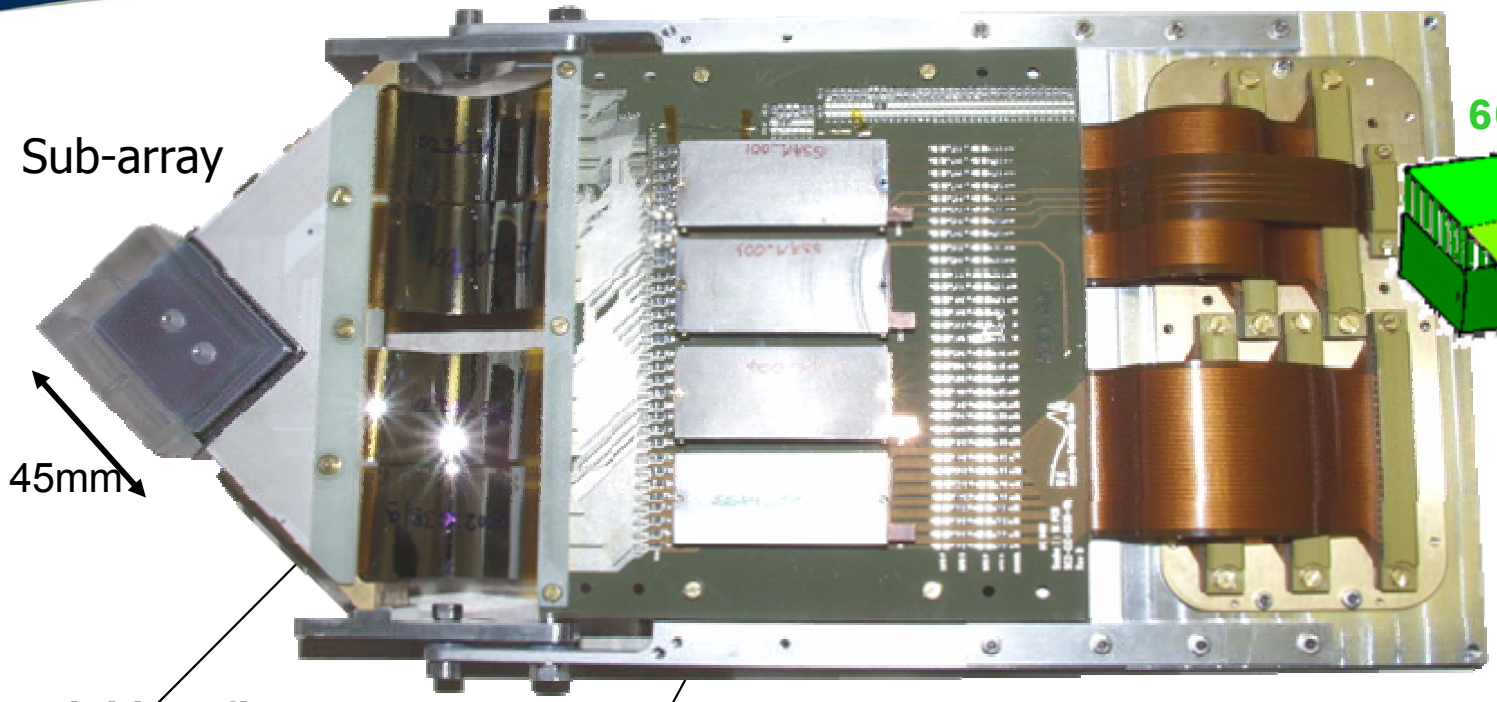


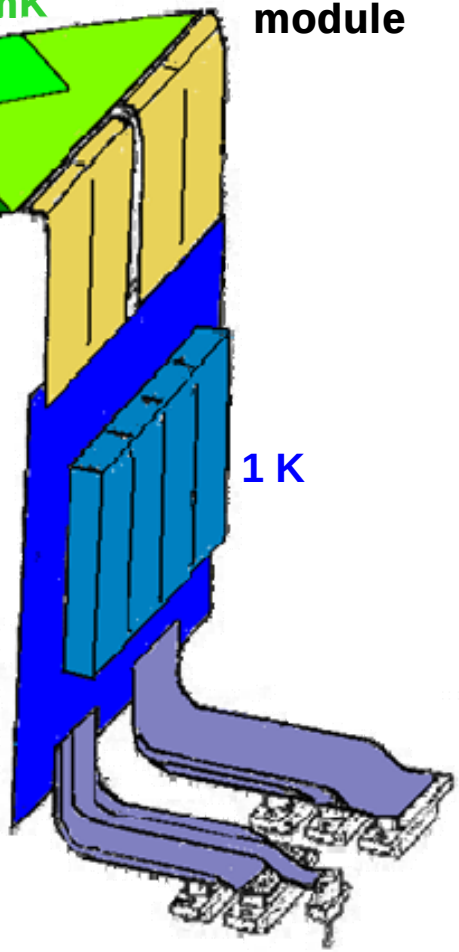
New MUX wafer: Yield > 95%

NIST National Institute of Standards and Technology

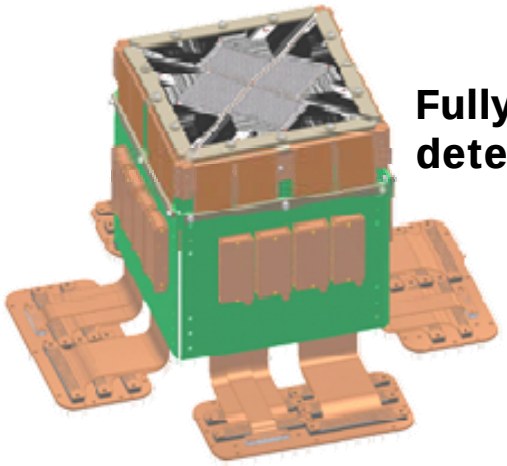
University of Waterloo

Sub-Array Module

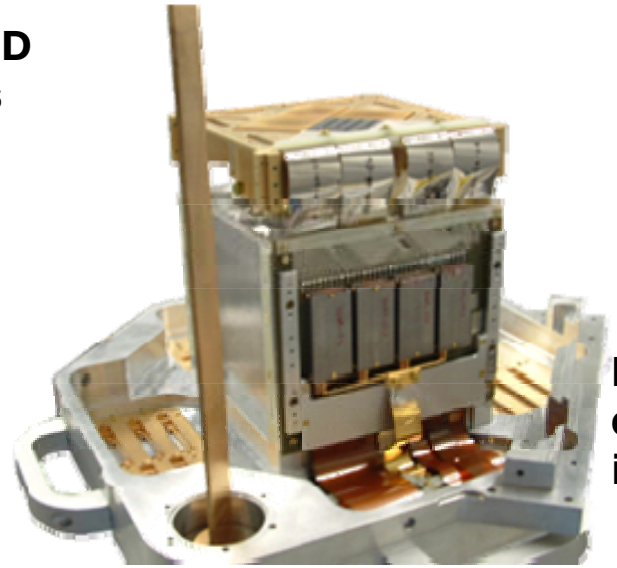




Folded sub-array module

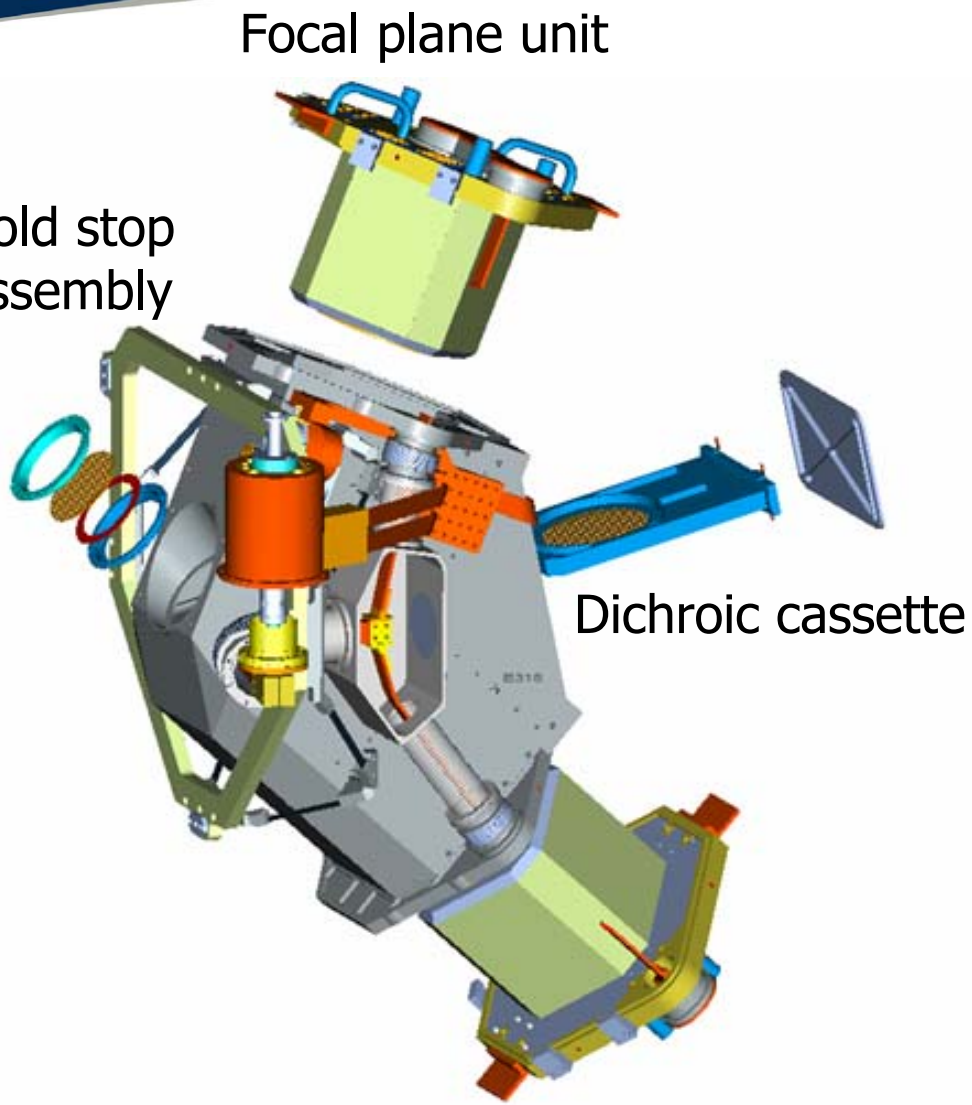


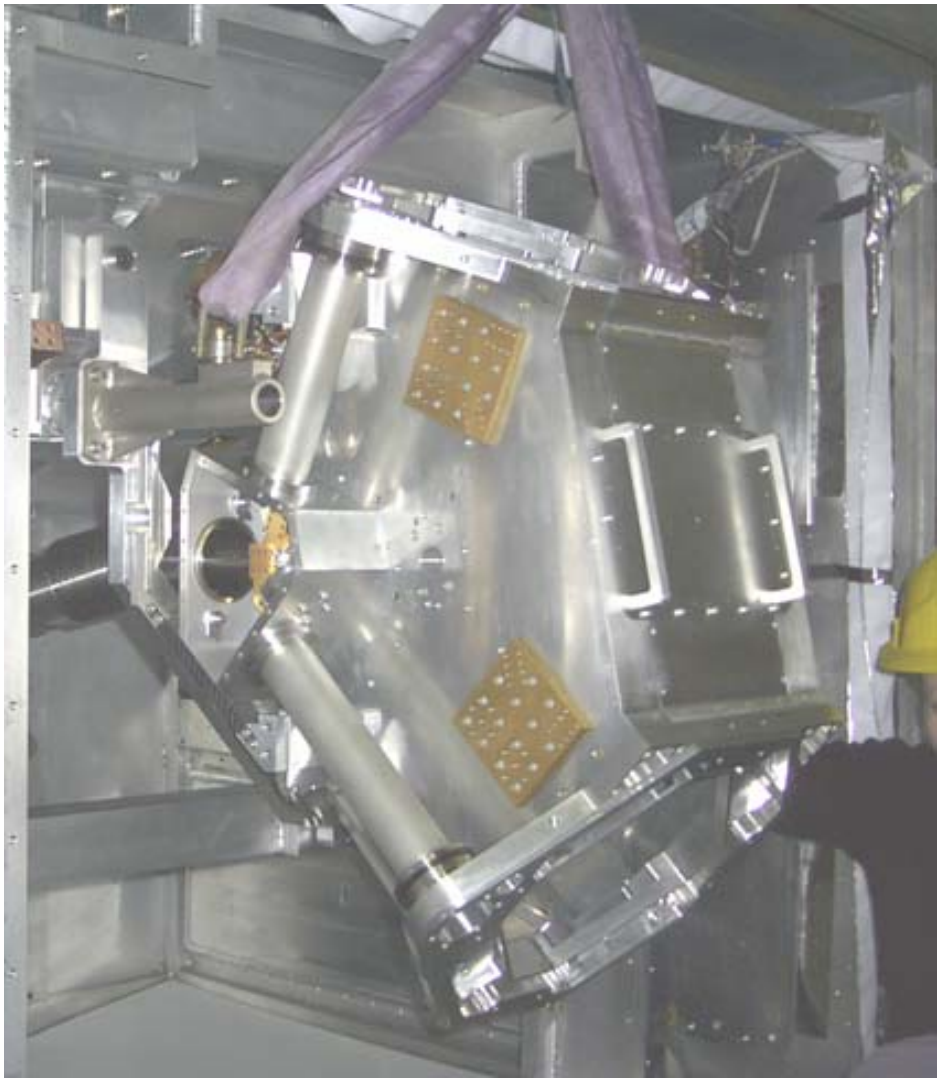
Fully populated detector unit



Detector unit with one prototype array installed

1K Enclosure ("1K Box")



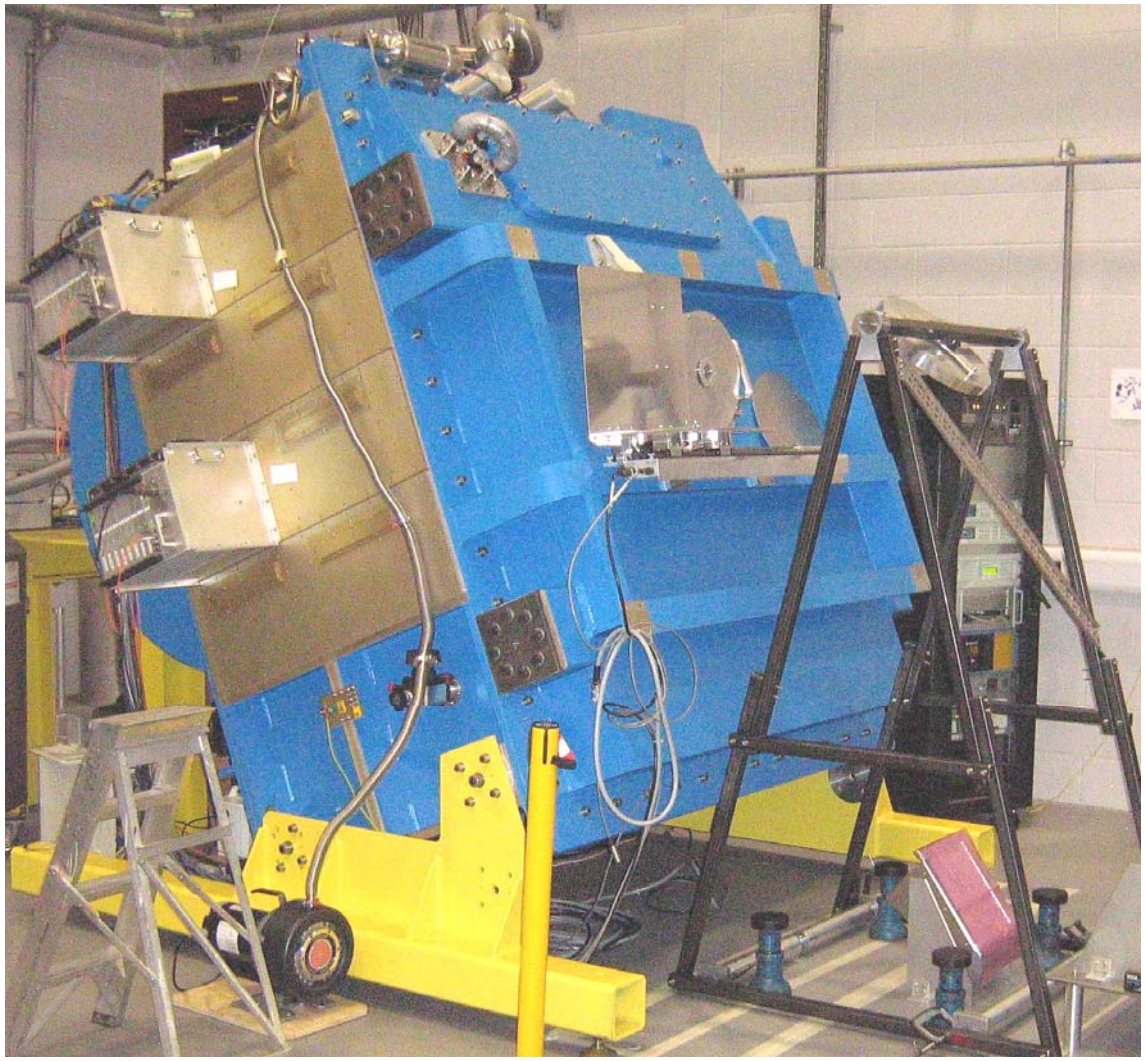


CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

1K Box Installed

Current Status

- Instrument is now complete – at delivery standard
- Final cooldown in progress followed by acceptance test
- Delivery expected to JCMT in Sept 2007
- Survey programme approved and due to start in ~mid-2008



SCUBA-2 Legacy Surveys

Debris Disk Legacy Survey
(Greaves, Holland and Matthews)

JCMT Galactic Plane Survey
(Moore, Shipman and Plume)

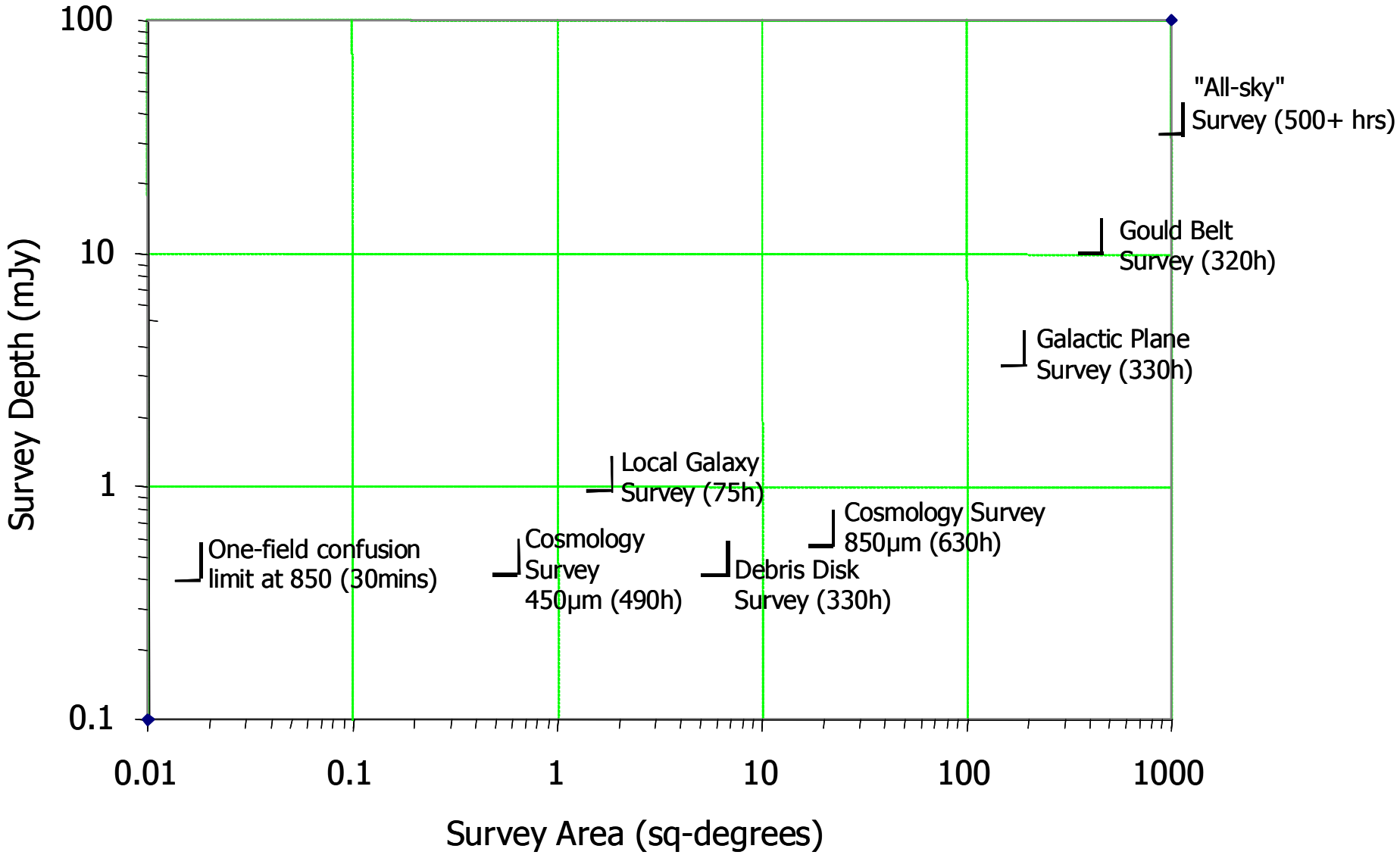
JCMT Gould Belt Legacy Survey
(Ward-Thompson, Johnstone, Di Francesco, Hatchell and Hogerheijde)

Physical Processes in Galaxies in the Local Universe
(Wilson, Israel and Serjeant)

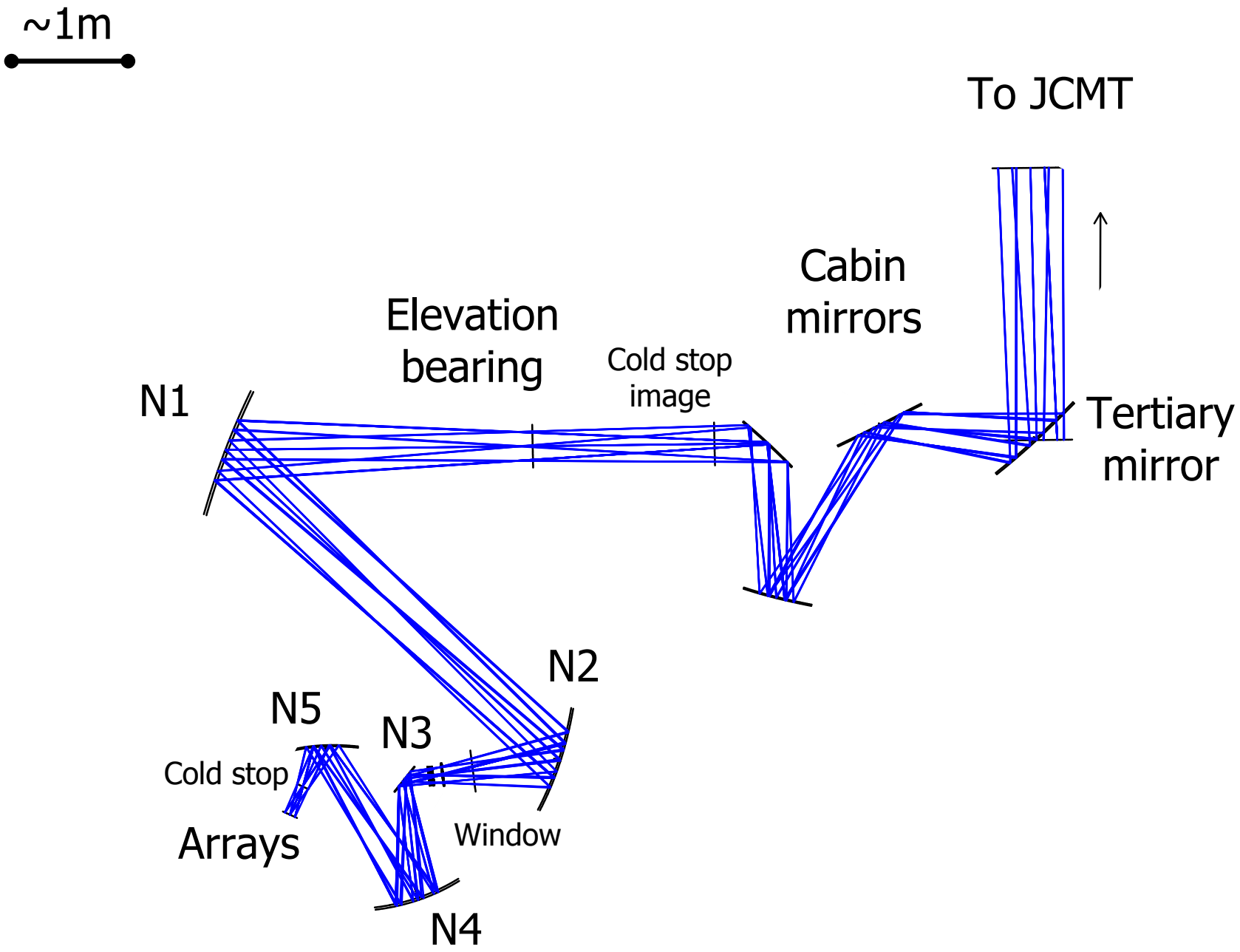
SCUBA-2 Cosmology Legacy Survey
(Smail, Dunlop, Halpern and van der Werf)

SCUBA-2 "all-sky" Survey
(Thompson, Serjeant, Jenness and Scott)

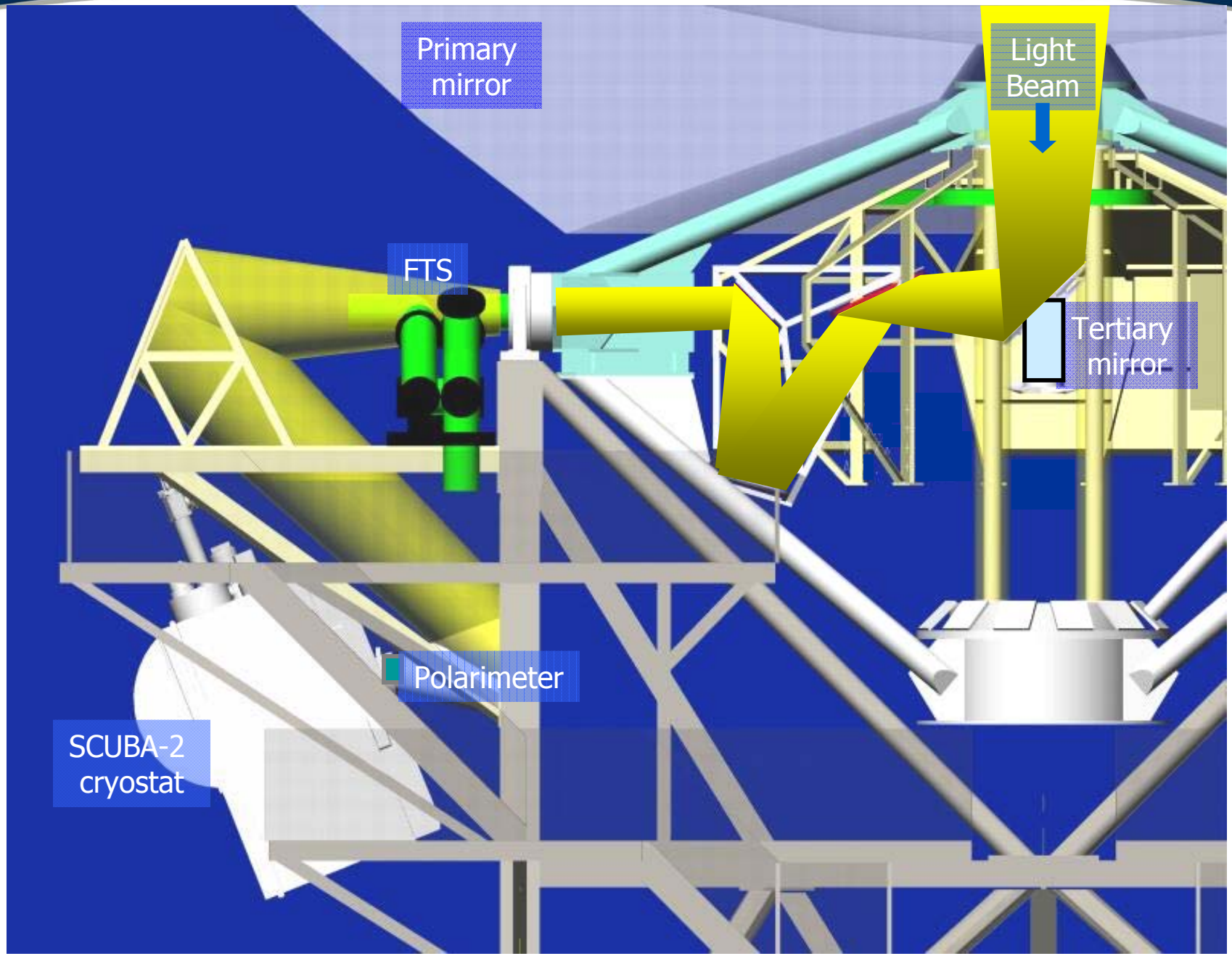
SCUBA-2 Surveys



Optical Layout of SCUBA-2 on JCMT

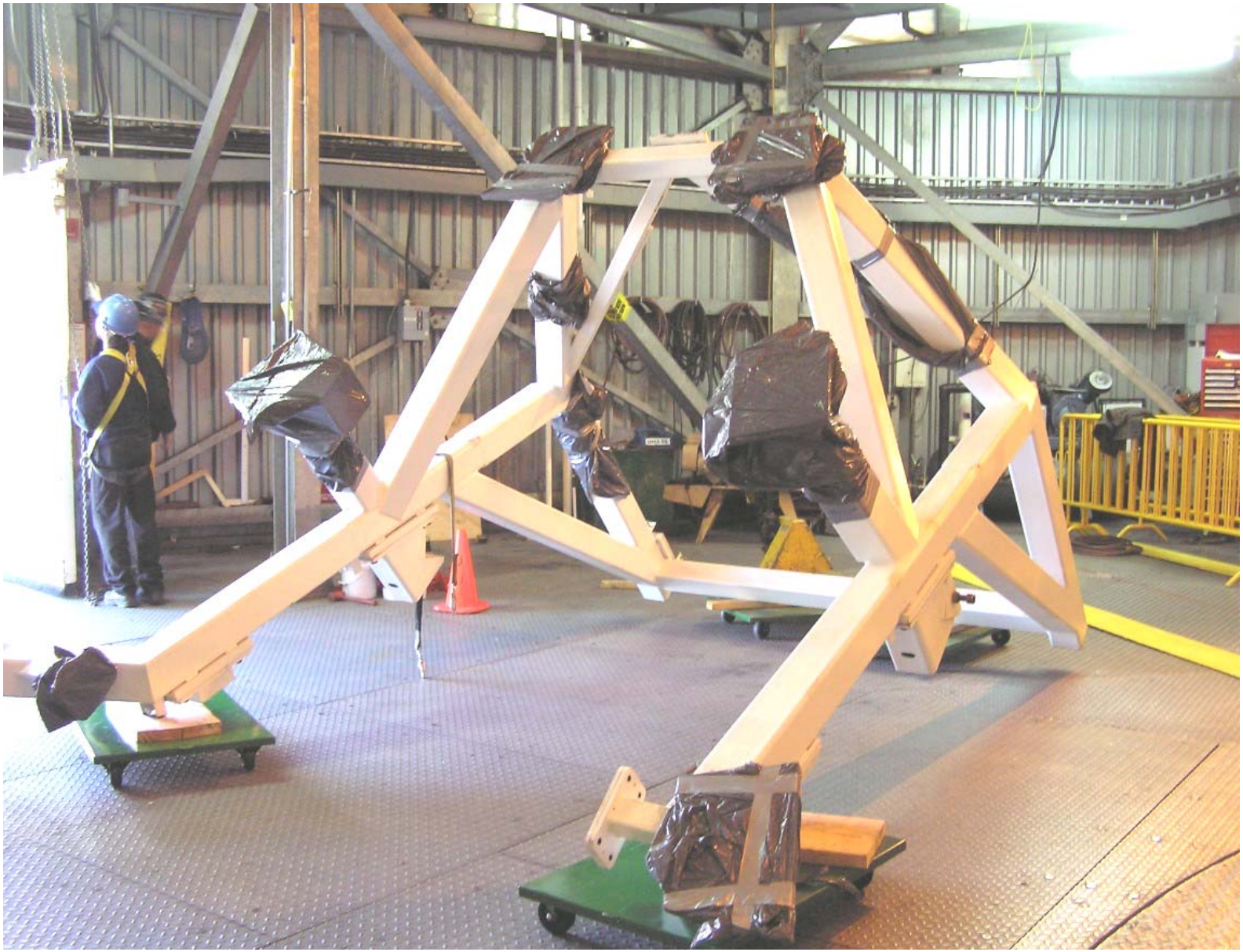


SCUBA-2 on JCMT

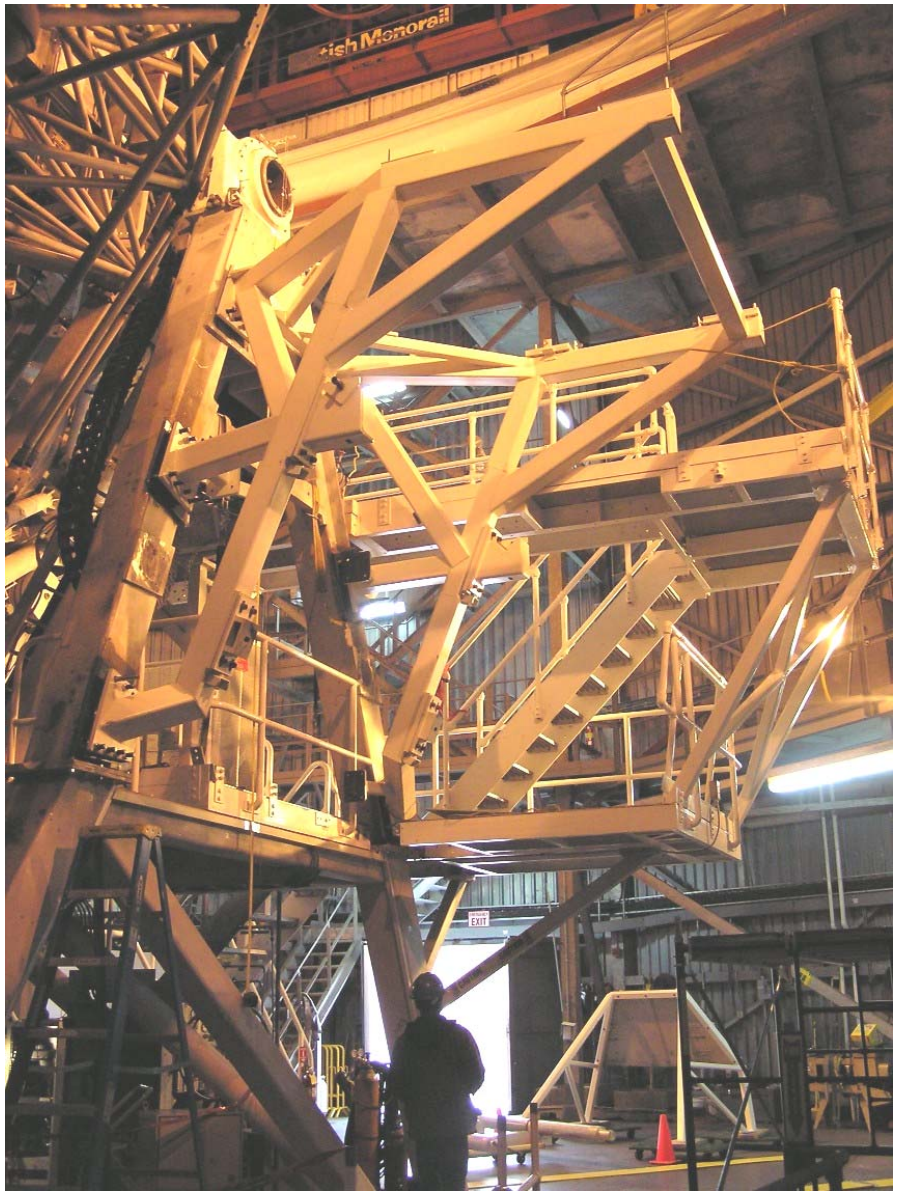


Left Nasymth – Era of SCUBA

Cryostat Frame



Cryostat Frame Mounted



Getting SCUBA-2 Into Position…

SCUBA-2 on CCAT: Design Criteria

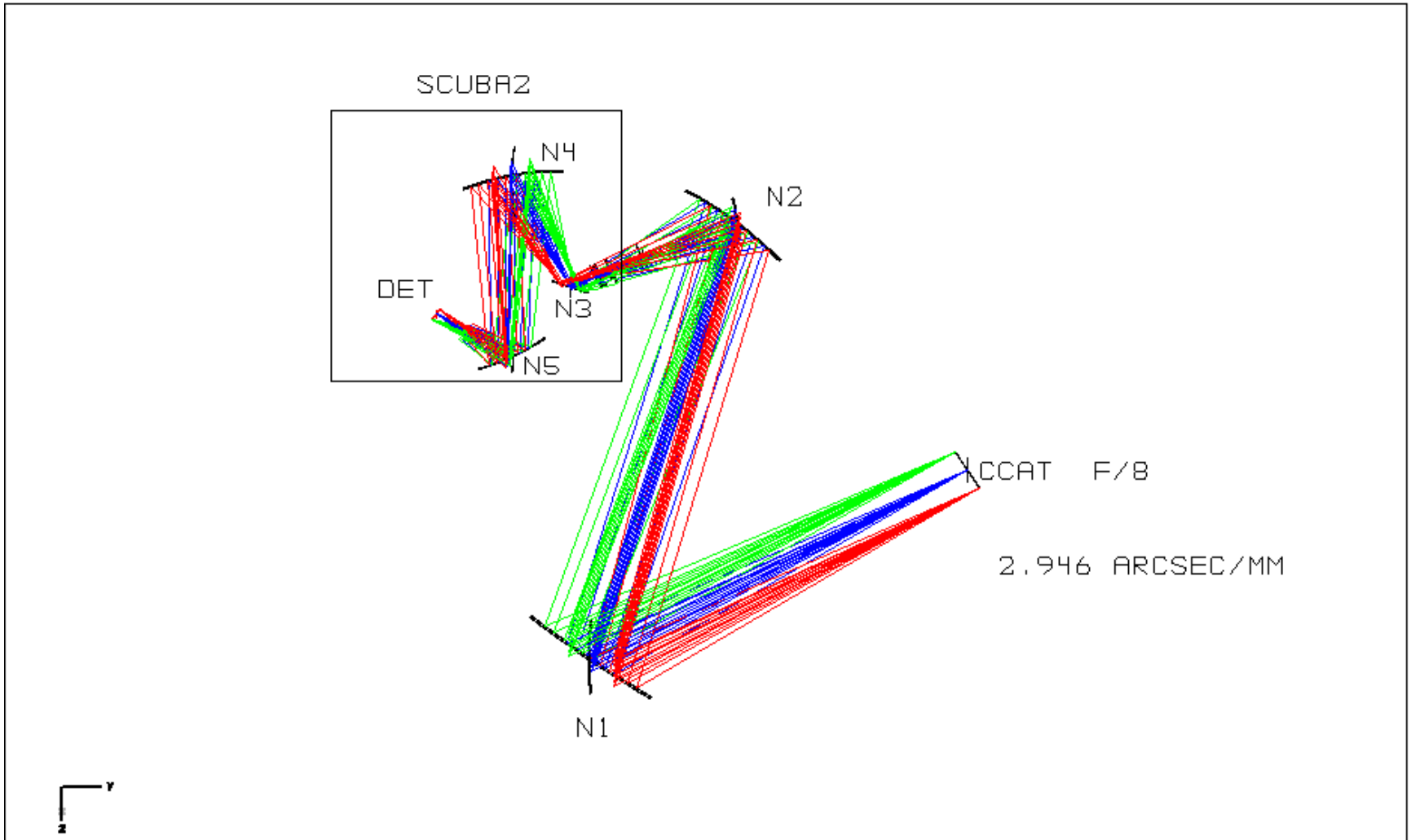
- Has to match to CCAT optics, specifically to the f/8 Nasmyth focus

- Assume no changes to the SCUBA-2 cryostat: window and filters are same, cold mirrors and cold stop not altered

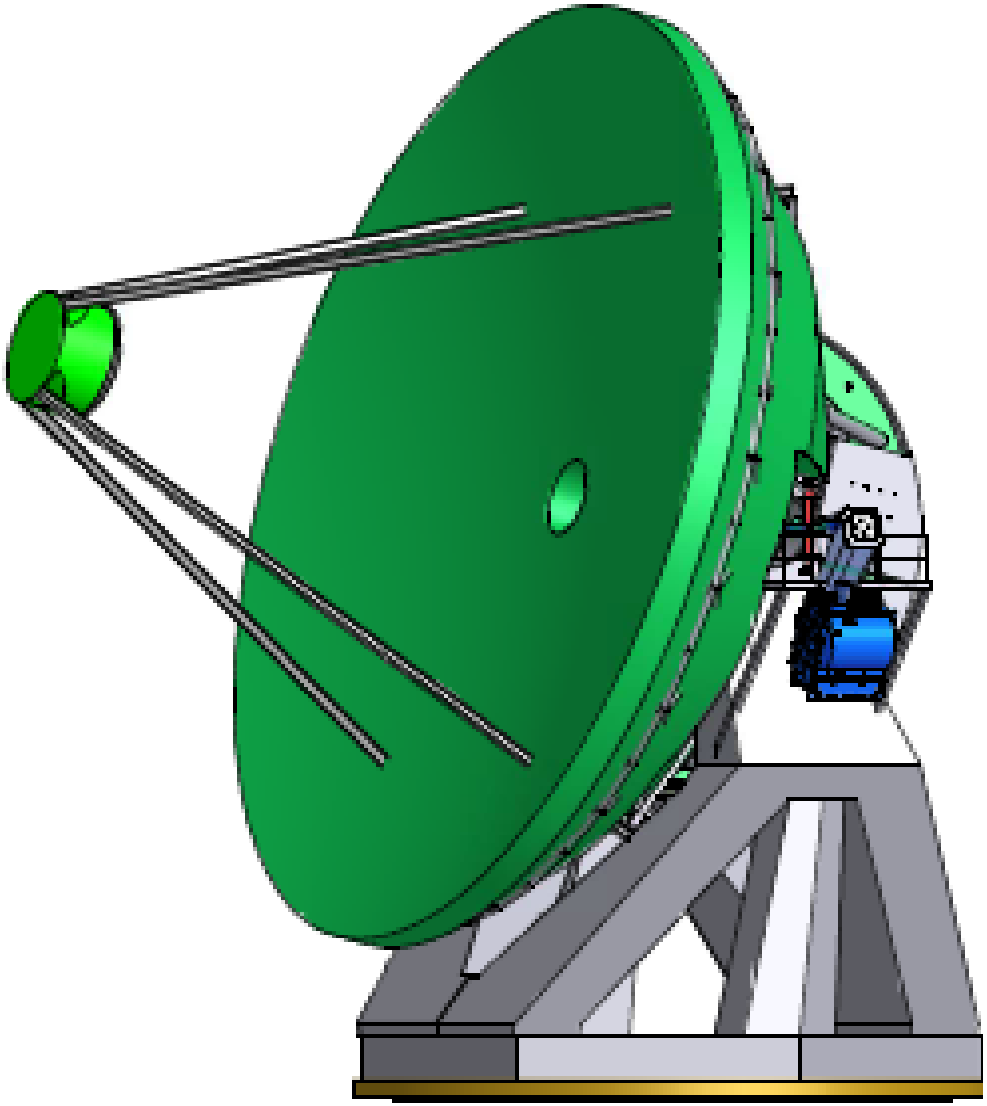
- Can change (warm) re-imaging optics but keep mirrors of order 1m class or smaller

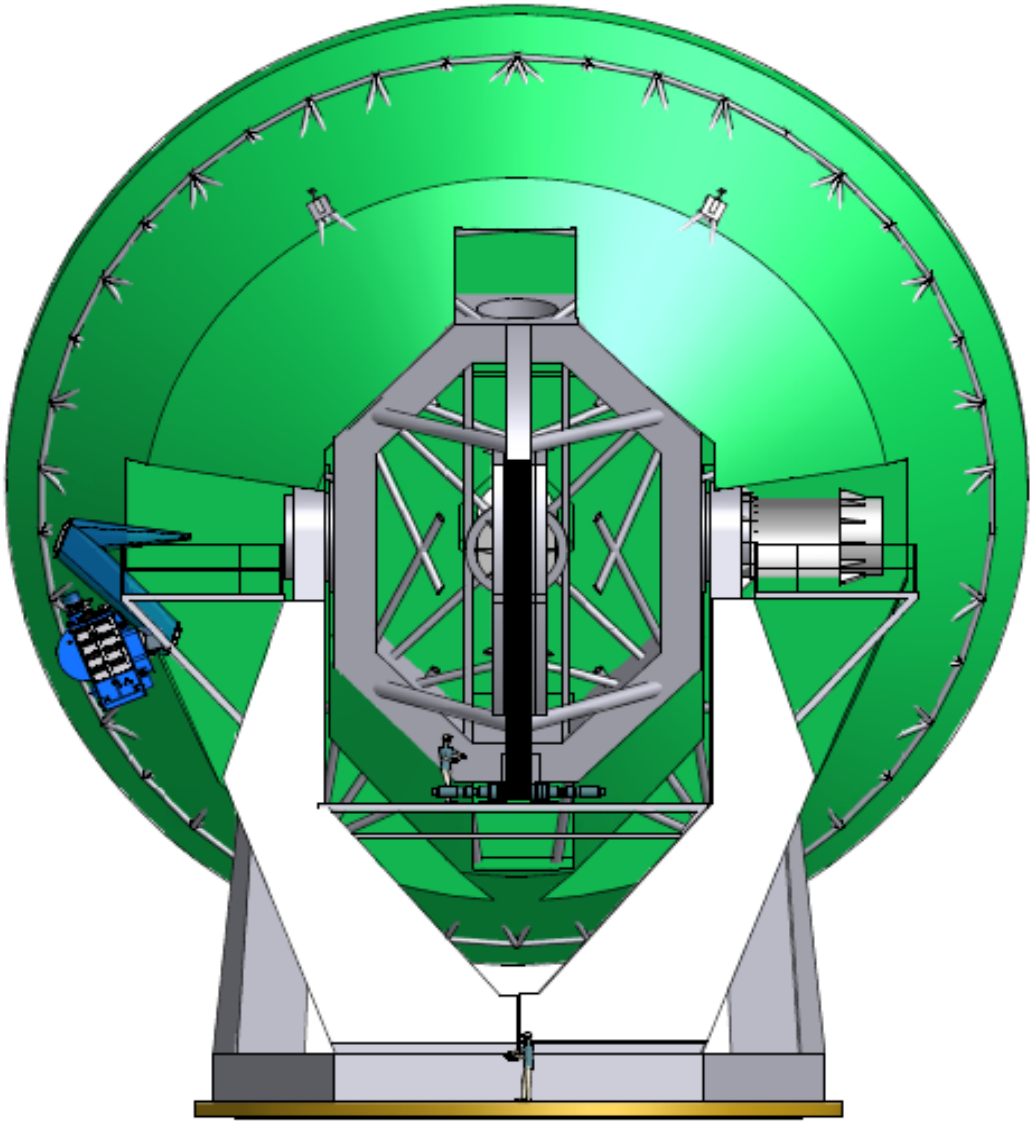
- What field-of-view is possible?

SCUBA-2 on CCAT

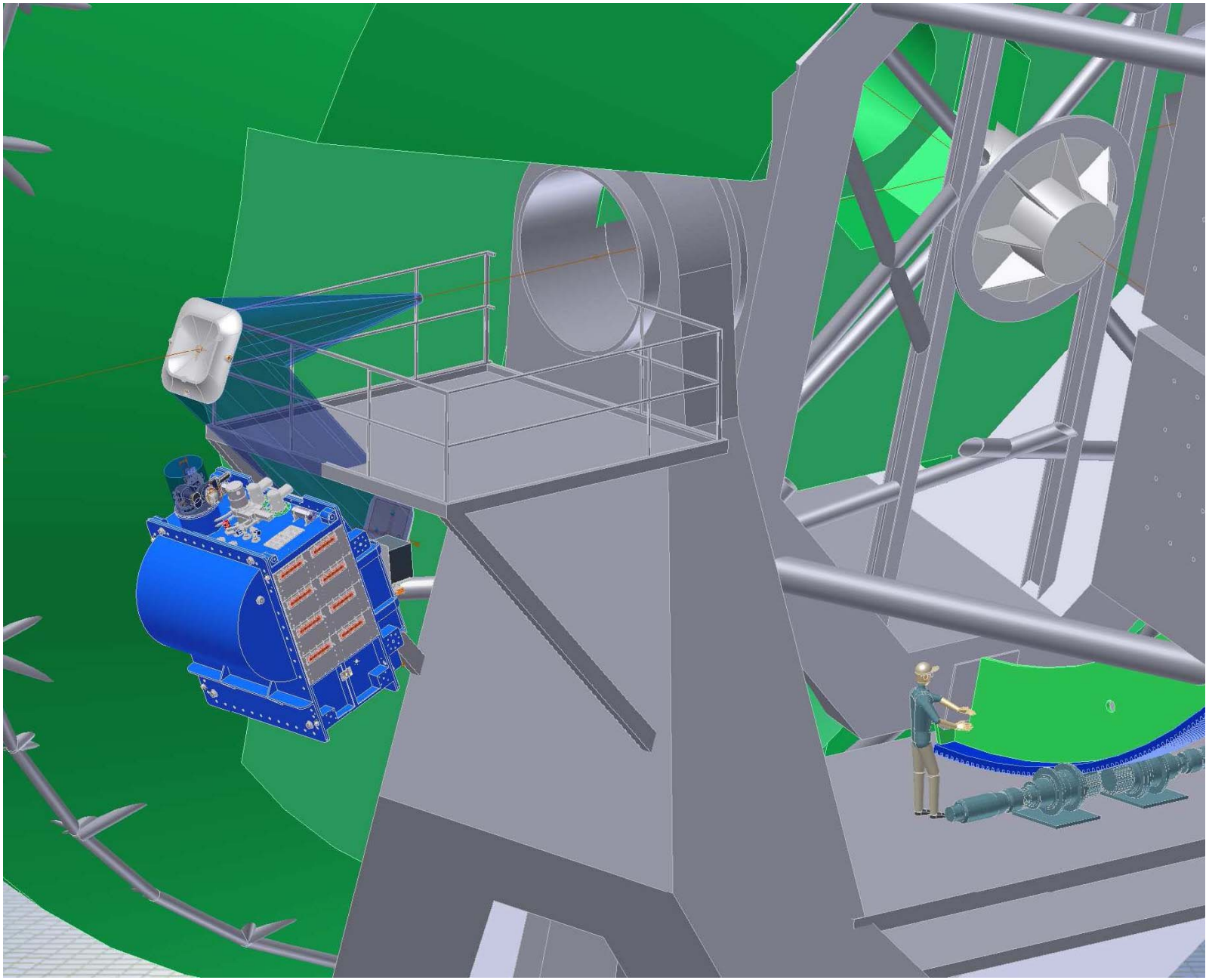


SCUBA-2 on CCAT

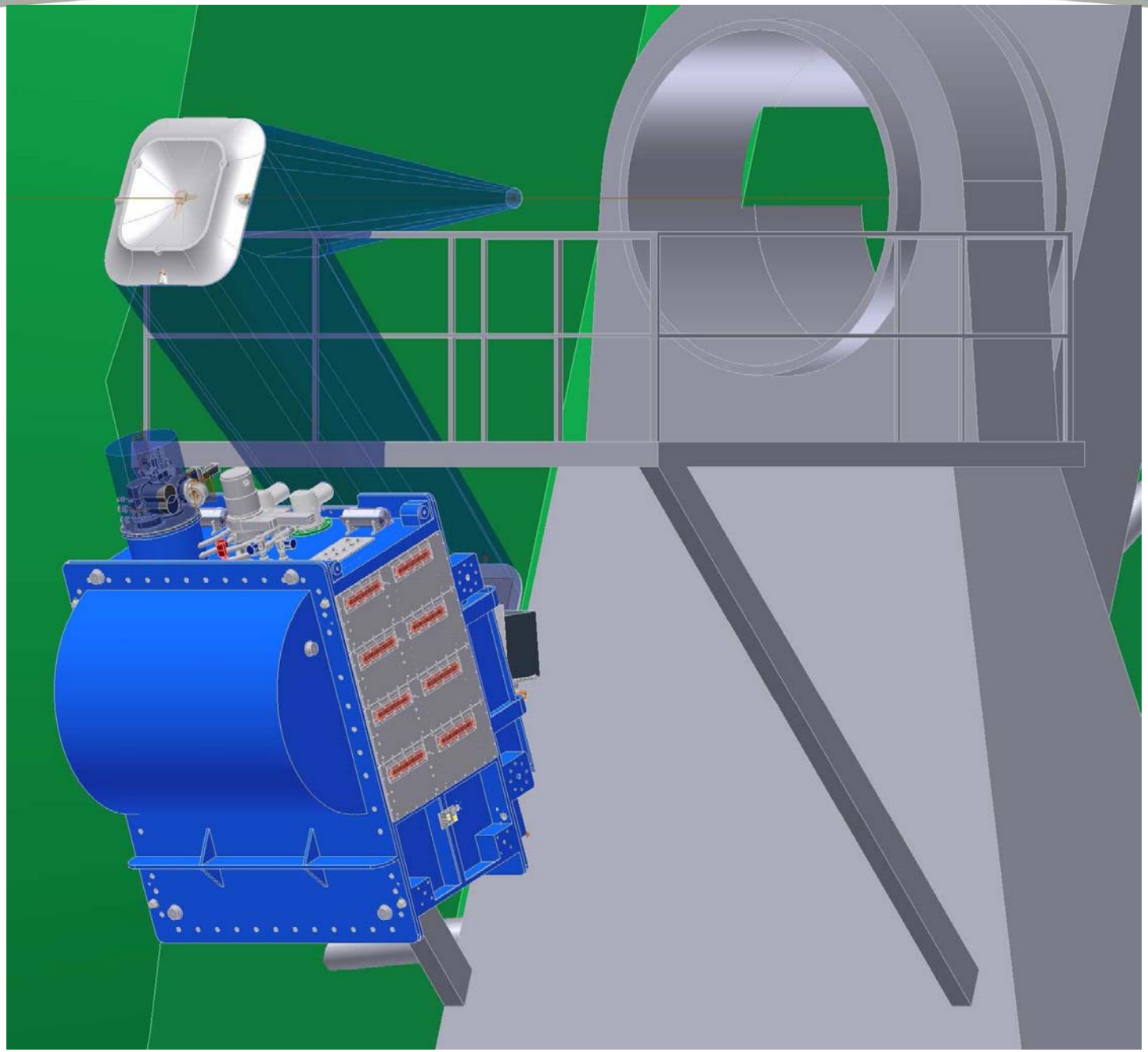




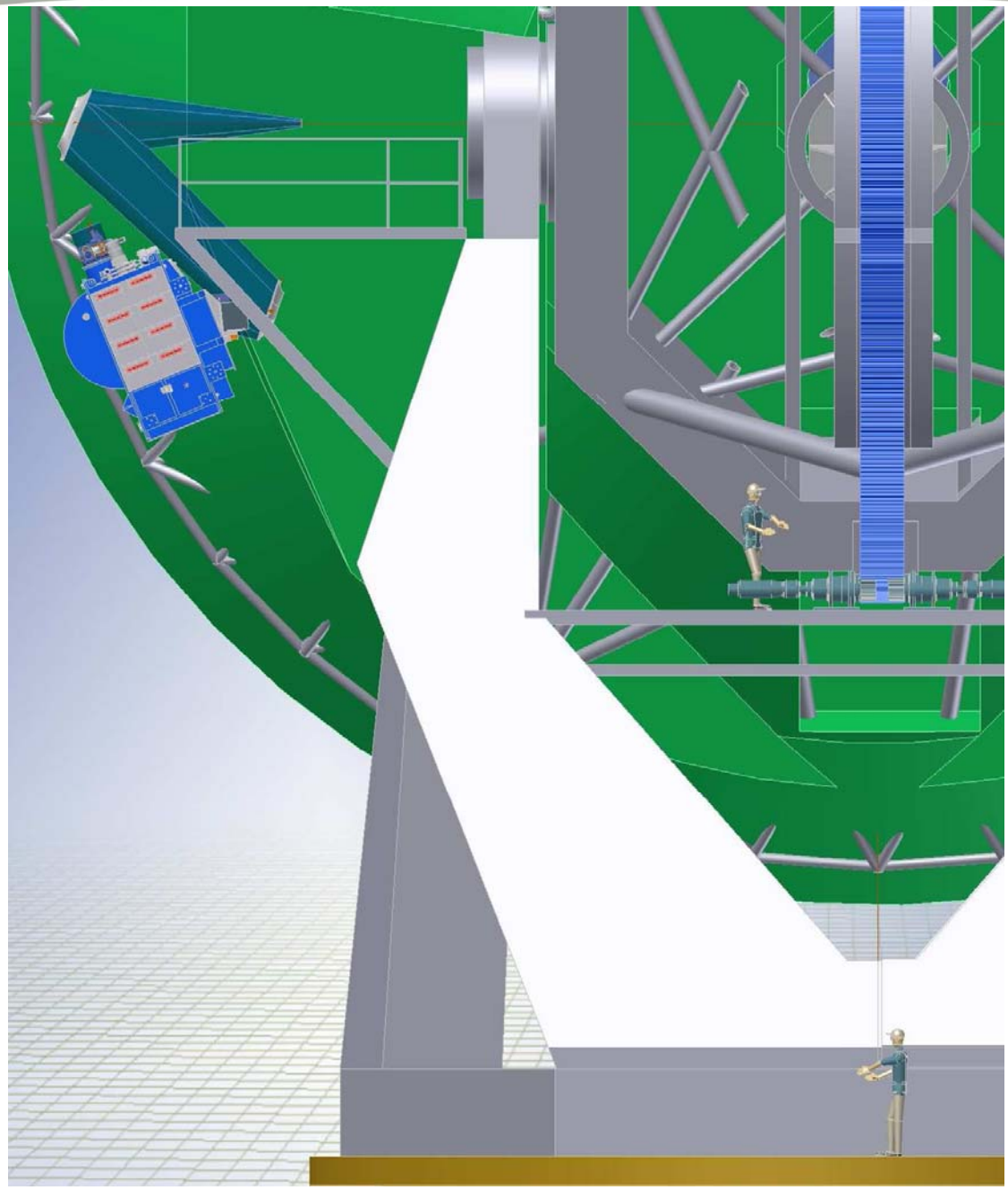
SCUBA-2 on CCAT



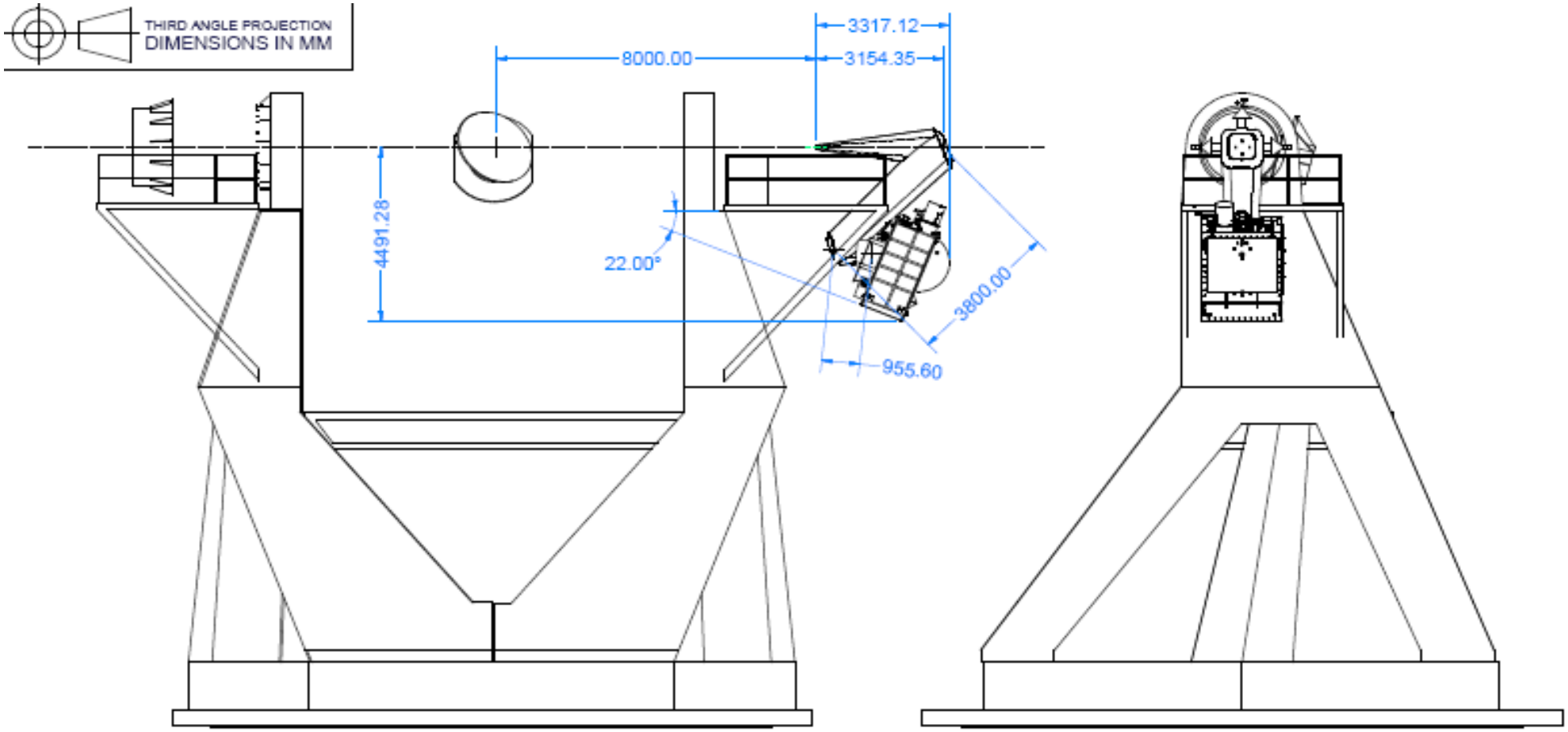
SCUBA-2 on CCAT



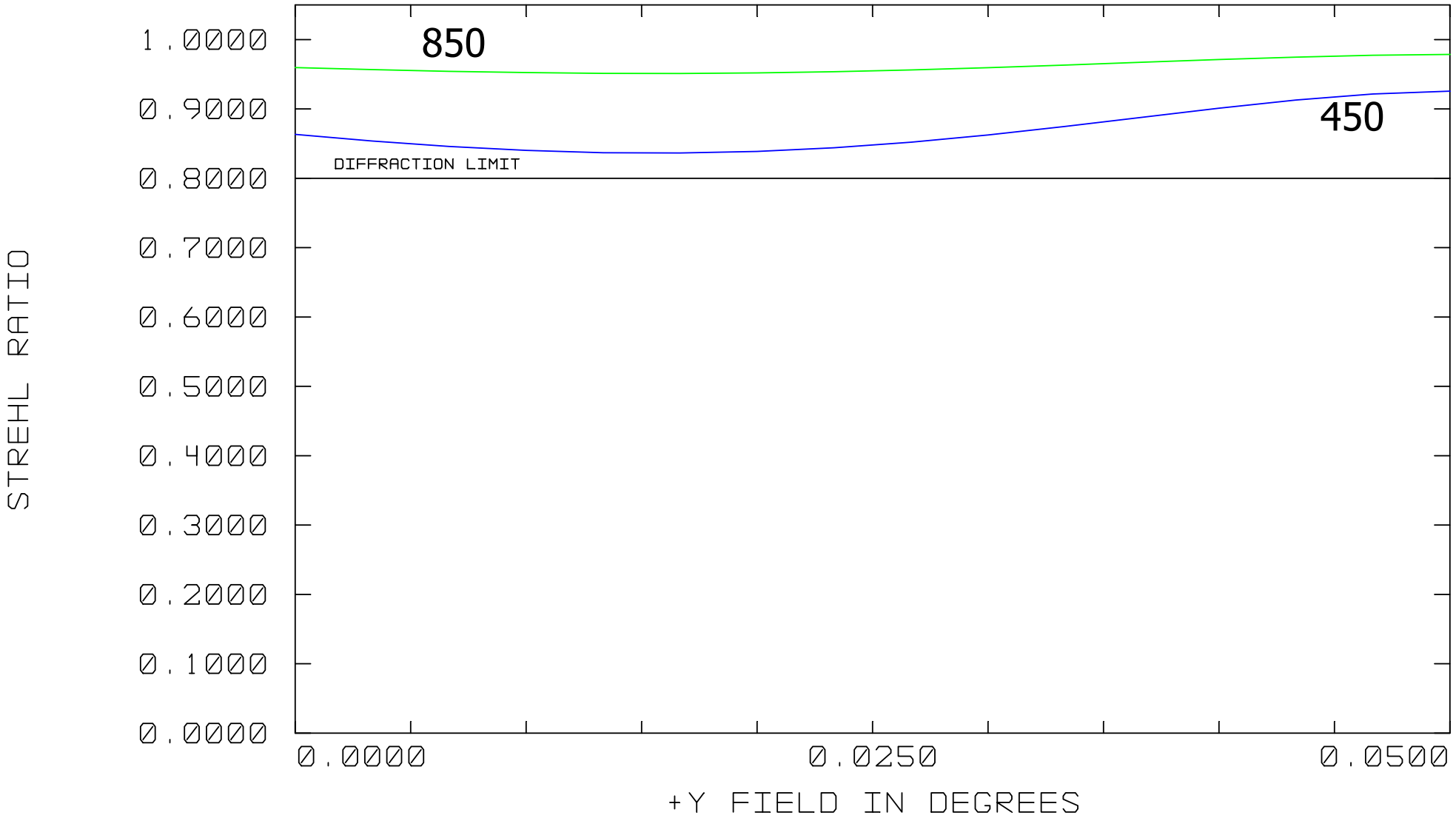
SCUBA-2 on CCAT



SCUBA-2 on CCAT



Strehl Ratios



SCUBA-2 Properties/Services

Dimensions: Cryostat 2.3 × 1.7 × 2.1m (pumped volume of 5m^3)

Weight: Cryostat (including electronics) 3400kg

Power consumption: ~45kW in total

Communications: Fibre optics from electronics to RT Linux PCs; RS232 control of mechanisms

Cryogens: 600 litres of LN for pre-cool; ~5 litres of LN per day during operation

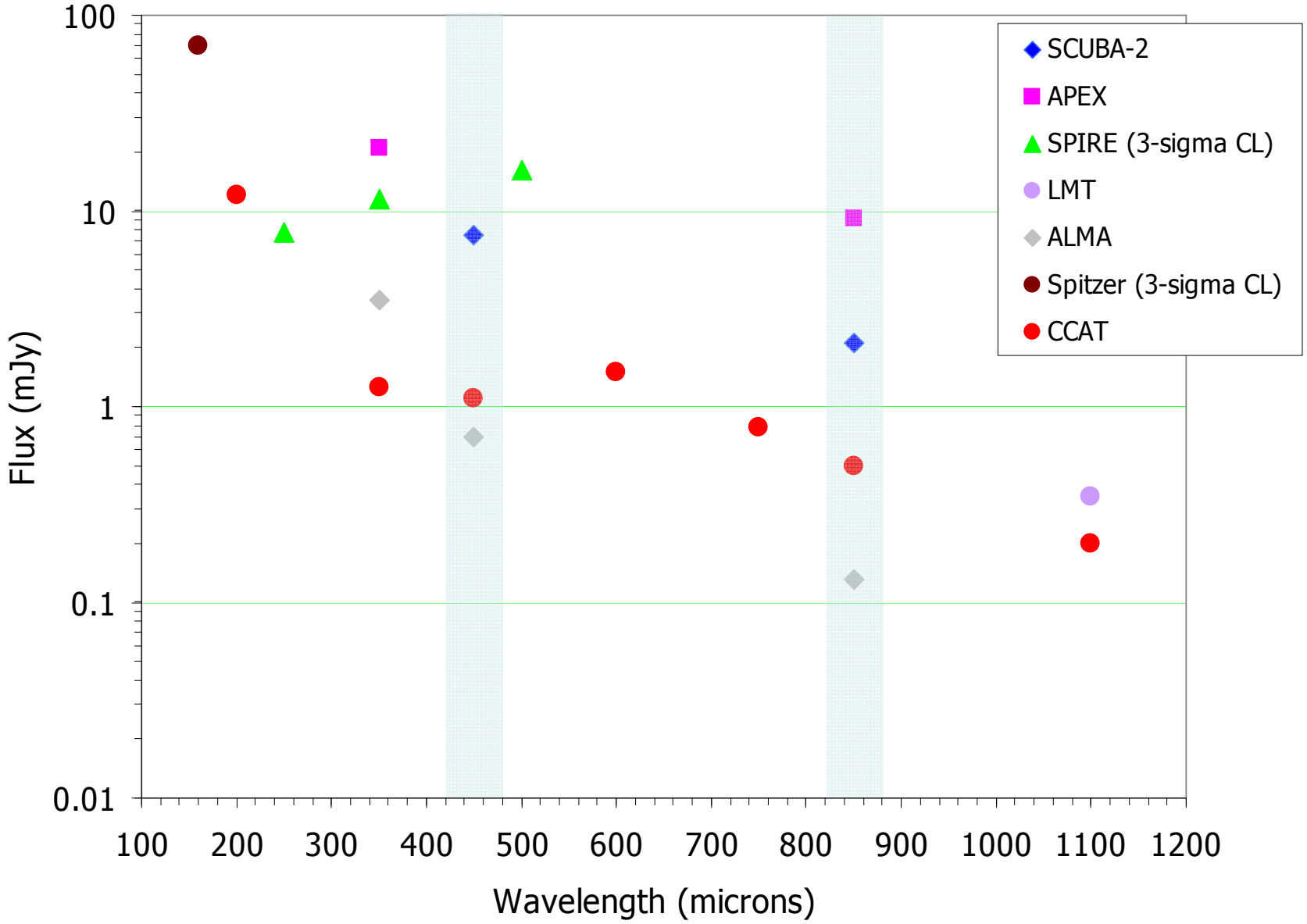
Services: Two electronics service racks; DR control unit; 3 (water cooled) compressors for PTCs; backing pump for turbo; compressed air for gate-valves

Dilution Fridge Control

SCUBA-2 Pixel Scales on CCAT

	Number of pixels	Arcsecs/ pixel	Pixel size (Fλ)	Field-of-view (sq-arcmin)
450μm (JCMT)	5120	6.0	0.9	51.3
850μm (JCMT)	5120	6.0	0.5	51.3
450μm	5120	4.5	1.2	30
850μm	5120	4.5	0.6	30

Sensitivities

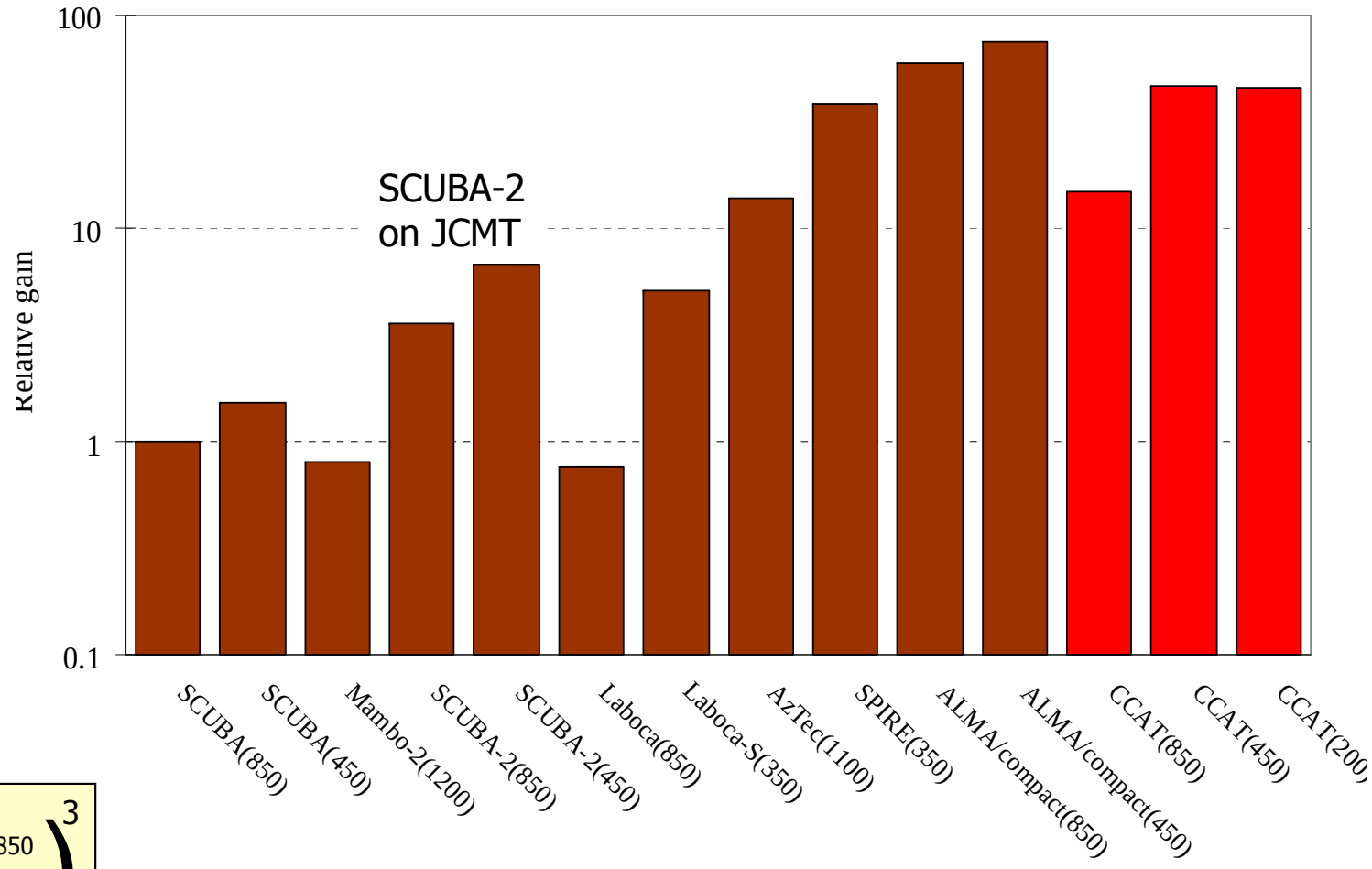


Dust Mass Sensitivity (per pixel)

For dust at >30K and objects z<2 emission has a spectral index slope of ~2+β

β=0 for a pure black-body, whilst β=2 for small ISM grains

Taking β=1 compute the relative gain of CCAT for a given mass of dust compared with other instruments



Relative to SCUBA at 850μm

$$\text{Relative Gain} = \frac{\text{NEFD}_{S/850}}{\text{NEFD}} \left(\frac{\lambda_{S/850}}{\lambda} \right)^3$$

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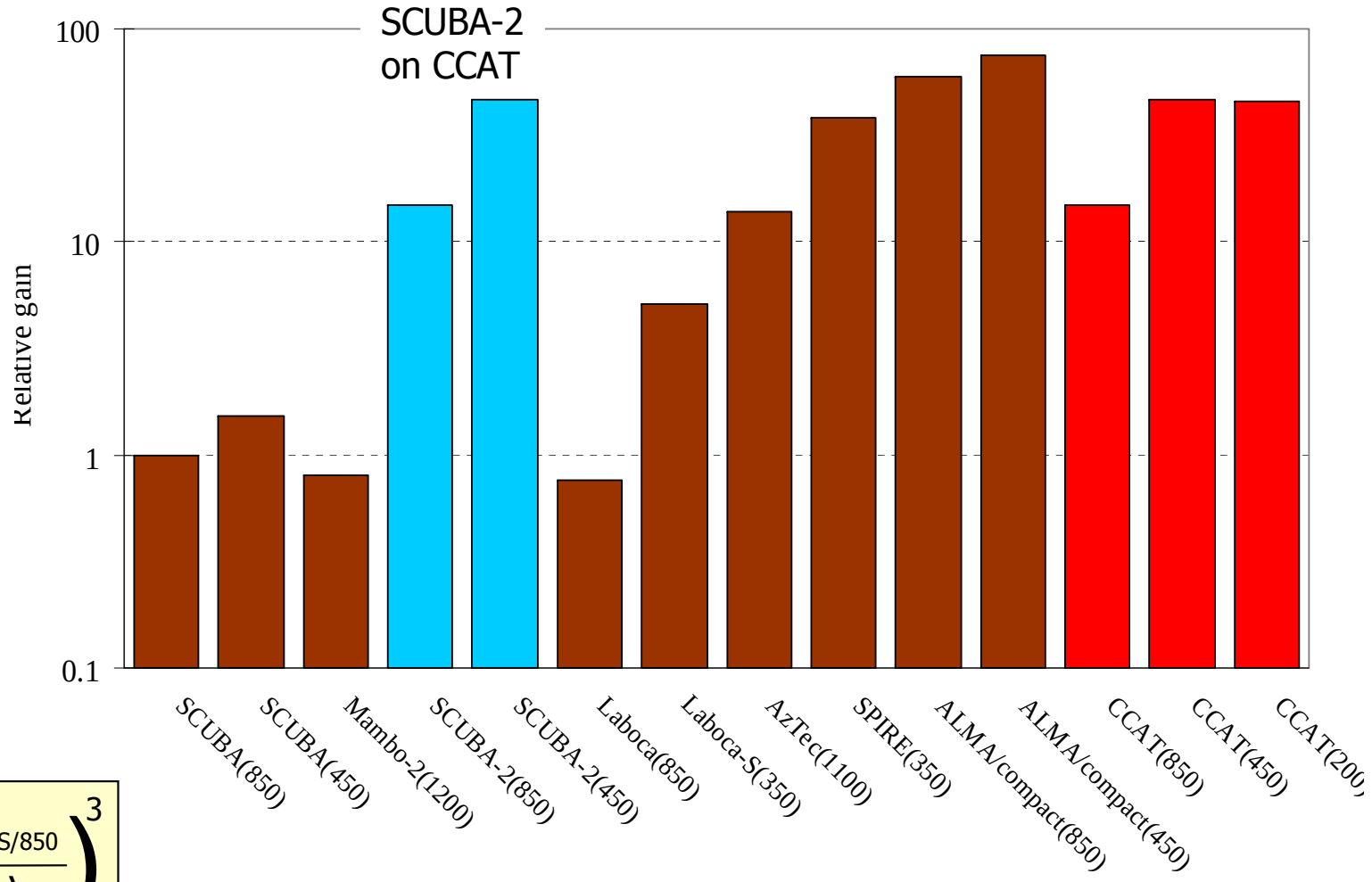
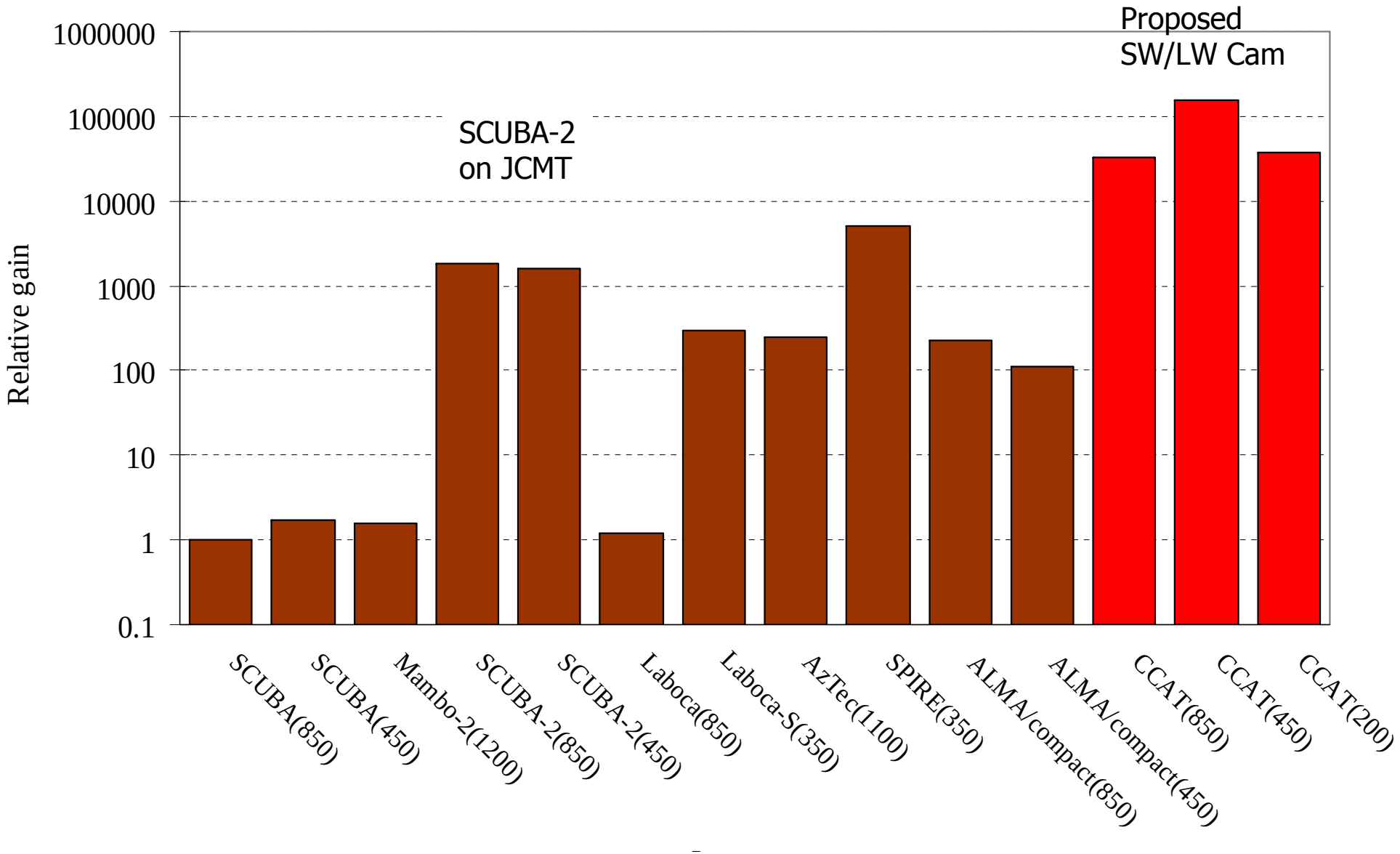


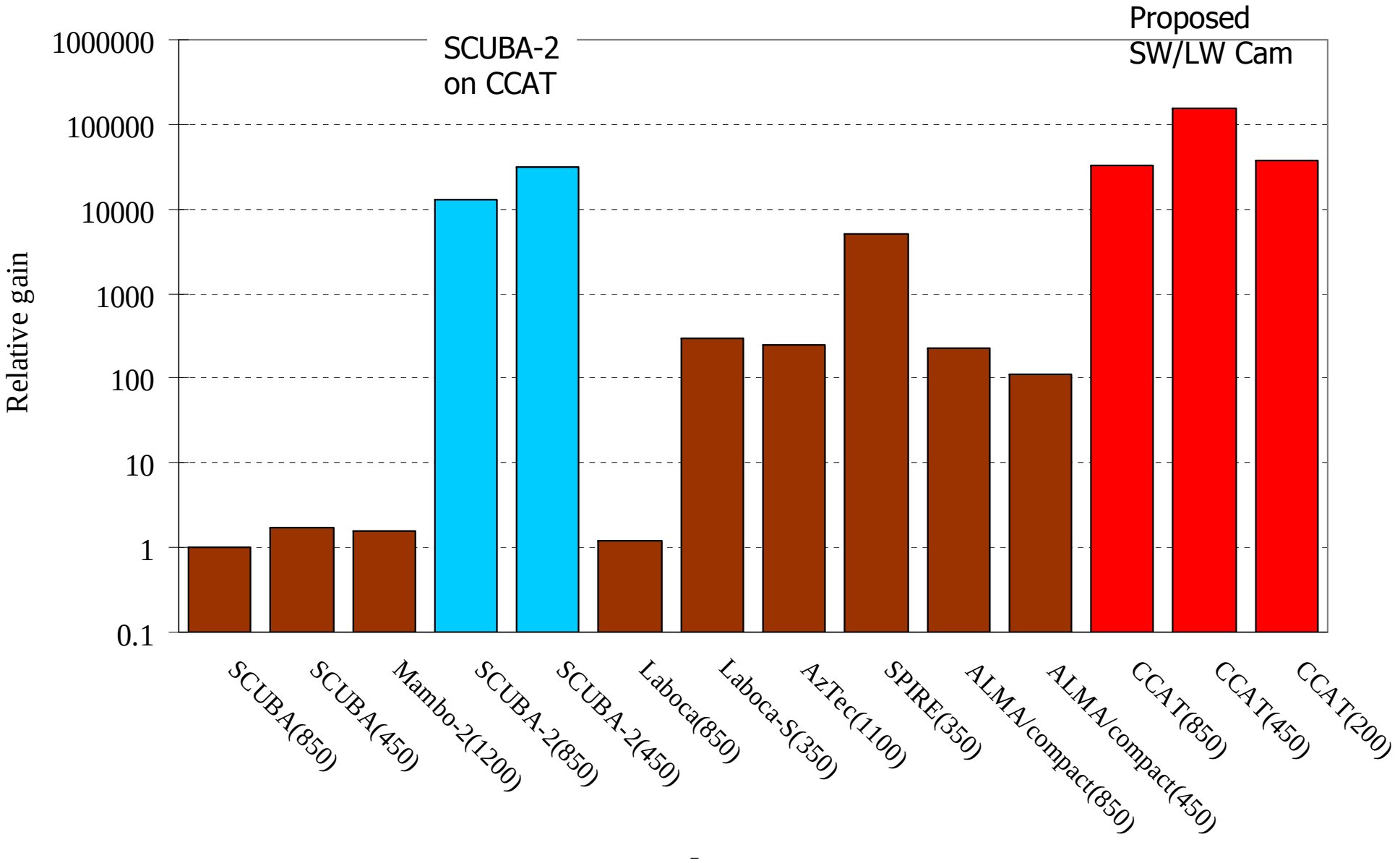
$$\text{Relative Gain} = \frac{\text{NEFD}_{S/850}}{\text{NEFD}}\left(\frac{\lambda_{S/850}}{\lambda}\right)^3$$

Relative to SCUBA at 850μm

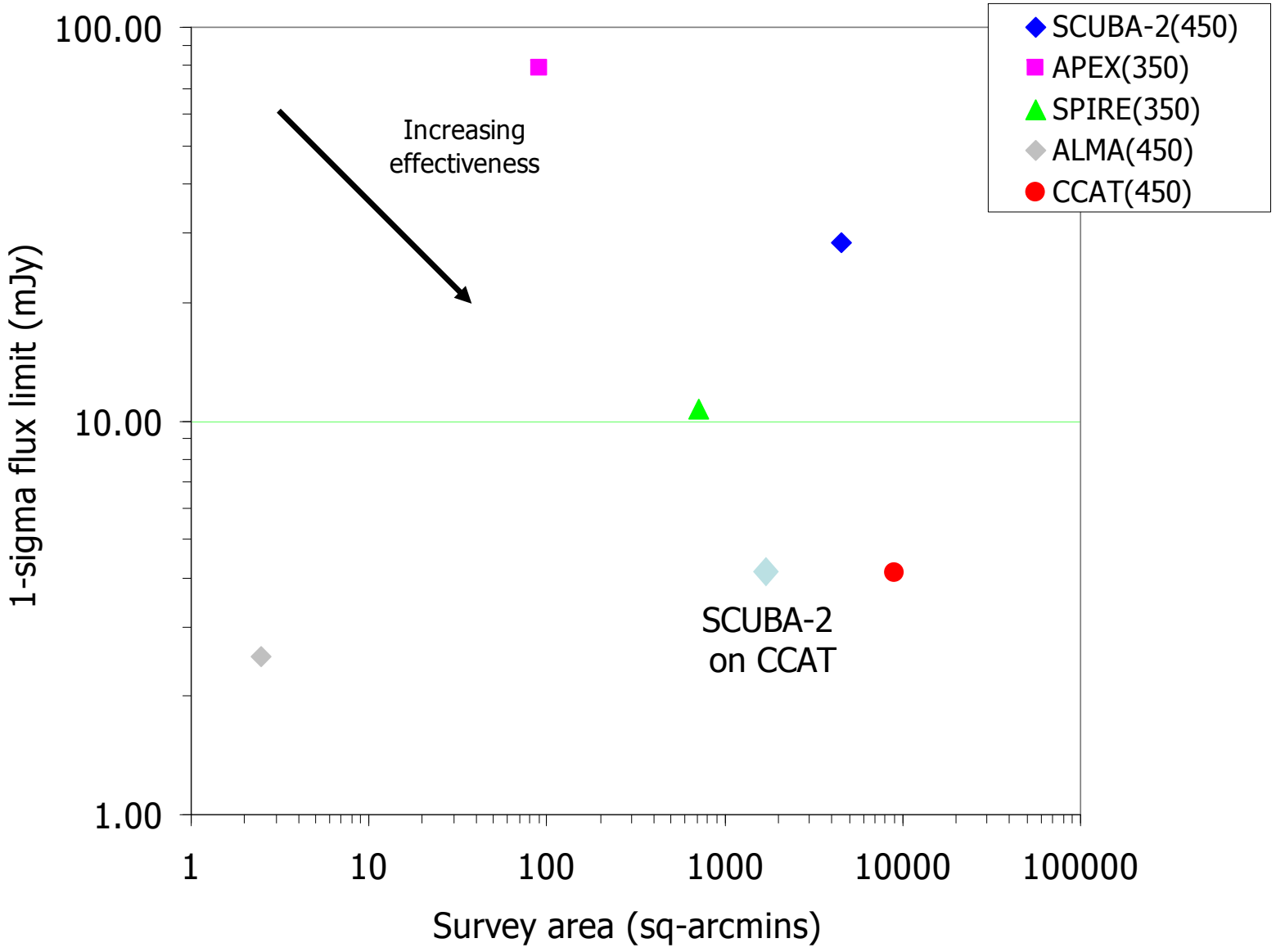
Mapping Speed



Mapping Speed



Field Mapping



10 seconds per field – no overheads

New Arrays for Shorter Wavelengths

SCUBA-2 like option:

→ Less risk, but less flexibility in terms of sampling etc.

- 1280 pixels/sub-array
- 1.135mm pitch
- ~100mK operating temperature

- Less setup cost

- Earlier initial production

New Arrays for Shorter Wavelengths

Less SCUBA-2 like option:

→ More flexibility, but more risk…

- ~5k pixels/sub-array – more pixels per output channel
- 0.5mm pitch
- ~100 – 300mK (?) operating temperature
- Simpler magnetic shielding

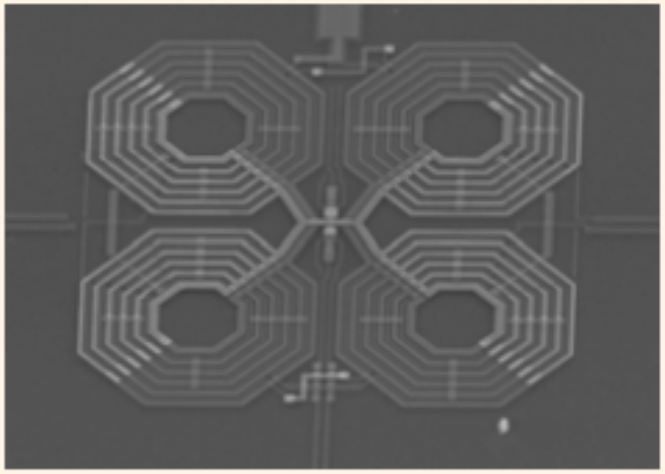
- Less production costs (…at least per pixel)

- Is this practical?

Multiplexer Improvement

Second-order gradiometric SQUIDS

- Much less magnetic shielding required (~100× reduction in effective area)
- Improved SQUID noise (2× - helps muxing or reduces unit cell)
- Improved dynamic range (4×)

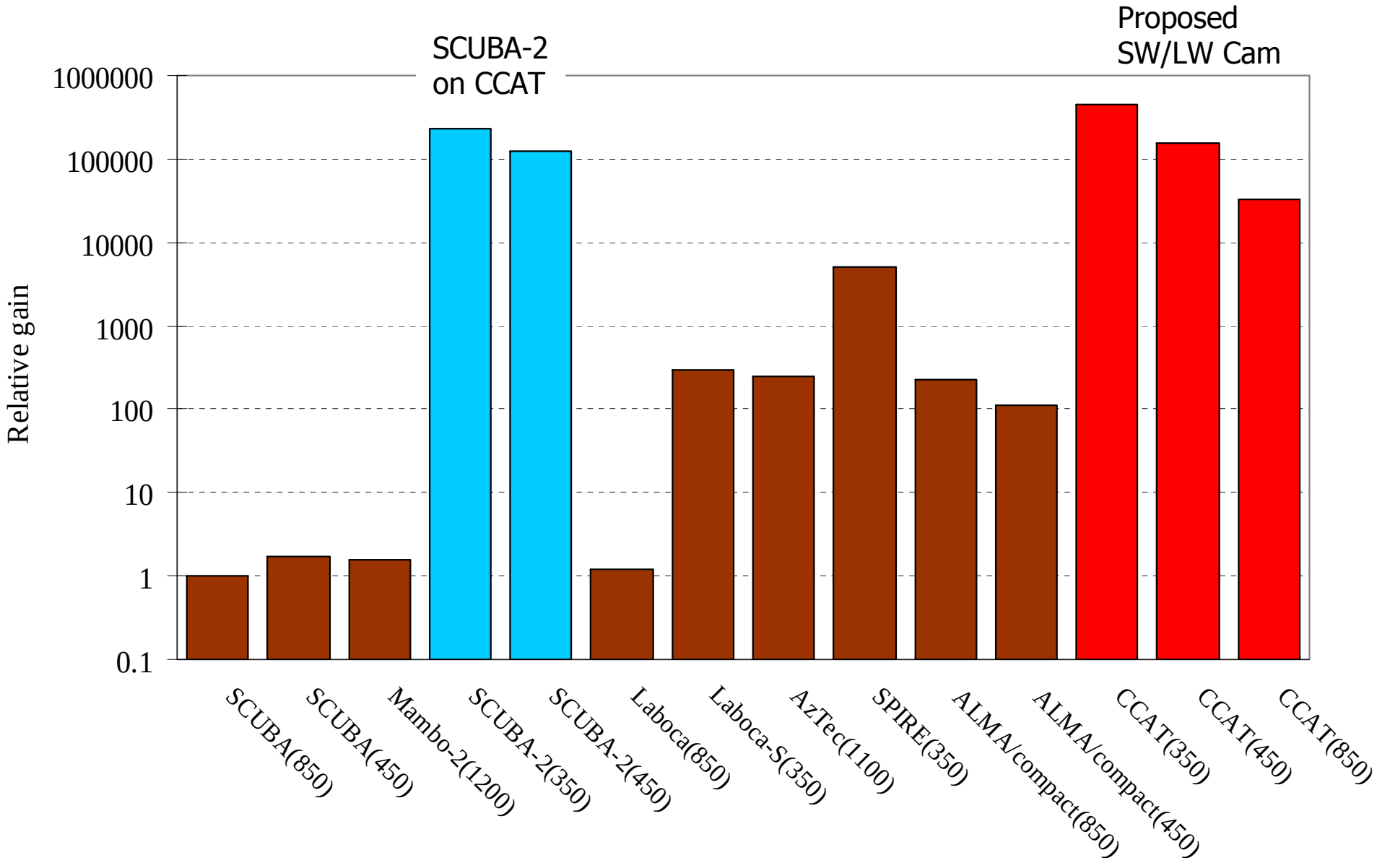


New designs could allow MUX unit cell to be shrunk to ~0.5mm and allow a 4x pixel count increase per sub-array

SCUBA-2 on CCAT with New Arrays

- SCUBA-2 on CCAT with 350/450μm arrays with 0.5mm pixel pitch
- Assume 4 times as many pixels per focal plane as for current SCUBA-2 (i.e. ~20,000 pixels at each band)
- Field-of-view of ~25 sq-arcmin is achievable
- What performance is possible?

Mapping Speed



Summary

- It is possible to interface SCUBA-2 to CCAT giving an ~30 sq-arcmin field-of-view
- This is possible by just changing two of the re-imaging mirrors in the current JCMT/SCUBA-2 optical layout
- Infrastructure needs could be minimised by using the existing JCMT mounting frames, lines/compressors etc
- SCUBA-2 would provide CCAT with a well-tested imaging instrument at 450 and 850μm from Day One
- There exists the possibility to develop and fit new arrays (e.g. for 350μm) in the future