



# SCelt: submm camera at Extreme Large Telescopes

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- ELT instrument status
- Astronomy with SCelt
- Design
- ELT site
- Performance, confusion limits
- Comparison with CCAT, ALMA

## ELT instrument+AO studies 2007-2009

INSTRUMENT STUDY	PROCUREMENT MODE	TIMEFRAME
<i>WF, Multi IFU NIR Spectrograph. +AO</i>	SSP with external consortium	Contract to be in place by July 2007
<i>CODEX</i>	ESO coordination of Consortium with external Institutes	Study Specs to be fully defined by 4Q 2007
<i>MCAO Module</i>	SSP with external consortium	Contract to be in place by July 2007
<i>MCAO Camera</i>	Open Call	Call to be launched in 3Q , replies in 4Q 2007
<i>EPICS + AO</i>	ESO coordination of Consortium with external Institutes	Study Specs to be fully defined by 4Q 2007
<i>Single Field, Wide Band Spectrograph</i>	Open Call	Call to be launched in 3Q , replies in 4Q 2007
<i>LTAO Module</i>	Open Call	Call to be launched in 3Q , replies in 4Q 2007
<i>MIR Instrument + AO</i>	SSP (tbc)	Contract to be in place by 4Q 2007
<i>New Instrument Concept- 1</i>	SSP or Open Call (tbd)	Contract to be in place by 1 <sup>st</sup> Q 2008
<i>New Instrument Concept-2</i>	SSP or Open Call (tbd)	Contract to be in place by 1 <sup>st</sup> Q 2008

SCelt ?

**ELT instruments concepts still to be investigated for 42m,  
or *not yet firmly associated to prominent science cases***



INSTRUMENT	OBS. MODES	FOCUS/ AO	WAV. RANGE (μm)	FIELD	PIXEL SIZE (mas)	$\Delta\lambda / \lambda$	SCIENCE CASE	REF. STUDY
Wide Field NIR Imager	Imaging	Nasmyth/ GLAO, LTAO	0.8 - 2.5	> 5' x 5'	50	Wide, narrow bands	C4, C10, S5, G4	ONIRICA @ OWL
High Time Res. Imager	Fast photometry	NASMYTH/ GLAO, SCAO	0.4 - 0.8	2 times (2" x 2")	tbd	Wide, narrow bands	Photon stat., rapidly varying phenomena	QUANTEYE @ OWL, HTRI
High Res. IR Spectrog.	HR spectroscopy	coude/ SCAO, LTAO	0.8 - 1.8 (5)	<1"	tbd	150000:	S9, G4, G9, C7	HISPEC
High Res. MIR Spectrog	HR spectroscopy	Nasmyth/SCAO, LTAO	3 - 20:	2" :	tbd	50000:	S9, G9, C7,	MIDIR
Polarimeter*	Imaging, spectroscopy	IF, Nasmyth? / GLAO, LTAO:	0.35- 0.8	tbd	tbd	W-n bands, LRS	S9, C7,	No study
MOS Visual	MR spectroscopy	Nasmyth/ GLAO	0.35 - 1	~ 6' x 6'	100:	1000-15000:	C10, C4, G4	No study
Wide Field Visual Imager	Imaging	Nasmyth/ GLAO	0.35- 1	~7' x7'	50-100:	Wide bands	C10, C4, G4	No study
→ Sub-mm Imager	Imaging	Nasmyth/ tbd	350-450-850	5'	1- 2.5"	Wide Bands	C10	<b>SCelt</b>

# Astronomy with SCILT



**Solar system:** - distant KBOs

## **Galaxy:**

- protostars: the lowest and highest masses
- debris discs
- planet-forming discs: how do planets form?
- origin of dust: supernovae & evolved stars

## **Extragalactic:**

- cold dark matter in galaxies
- galaxy & star formation in the early Universe
- galactic cluster formation
- resolving the submm background

# Kuiper Belt Objects



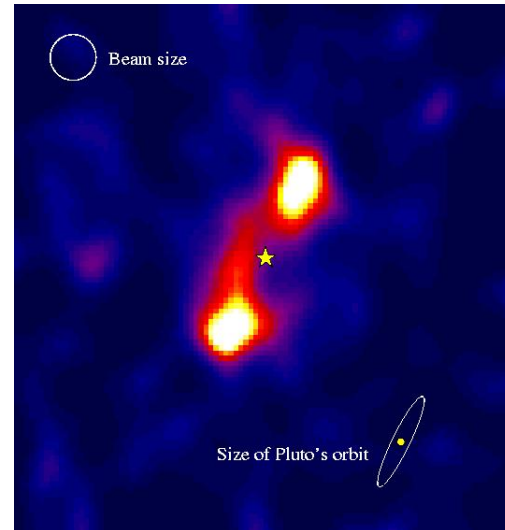
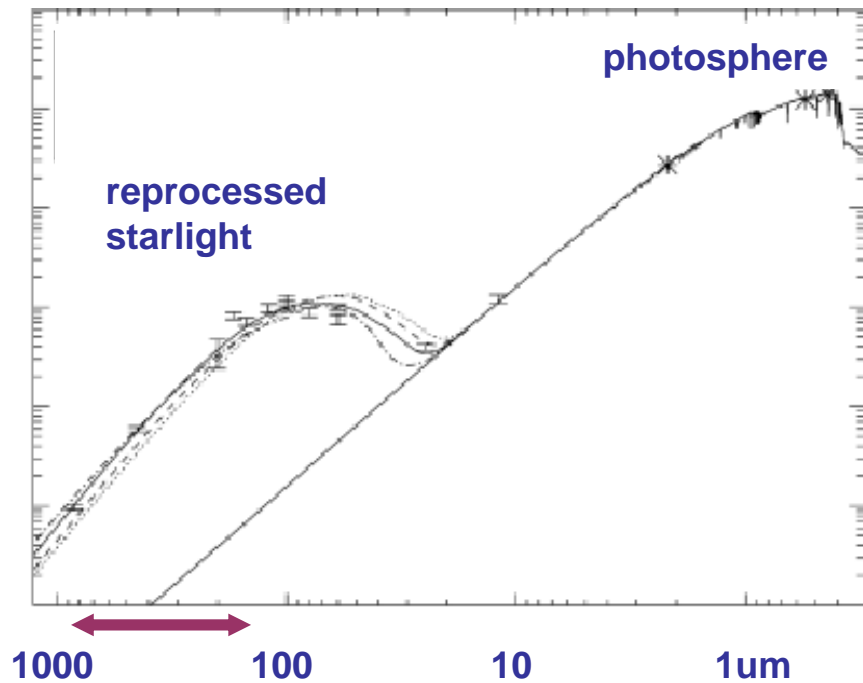
- What is the distant KBO population?  
Size distribution?
- How many cool "Xenas" are there beyond 30au?
- How far does the Solar System extend?
- How did distant KBOs form?



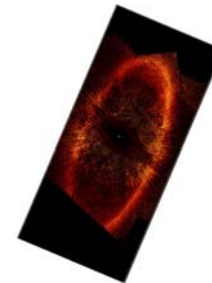
# Debris discs



## Fomalhaut



SCUBA

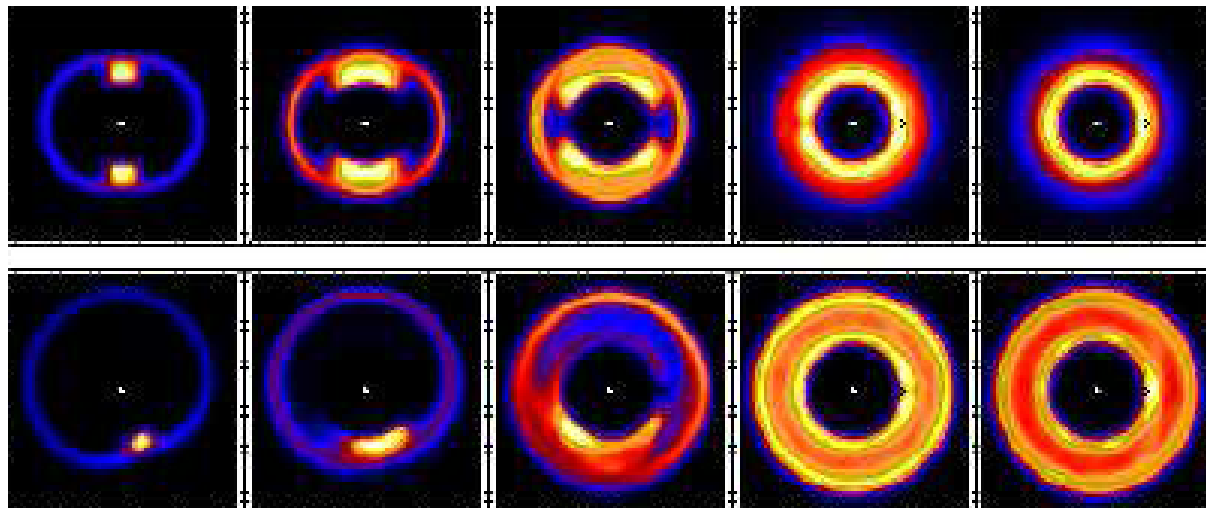


HST

# Debris discs



- Cool dust caused by asteroid collisions
- Submm clumps in discs:  
resonances with unseen planets
- Disc sizes  $\sim 100\text{au}$   $\rightarrow$  extended planetary systems



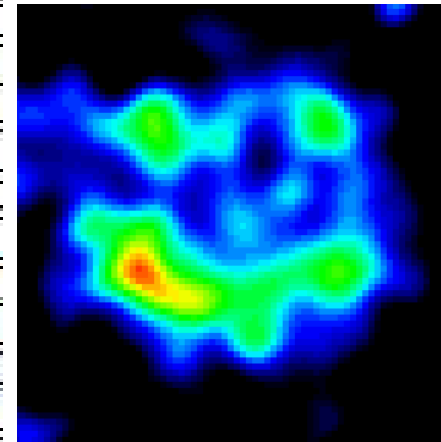
Models:  
Wyatt  
(2006)

mm

FIR

optical

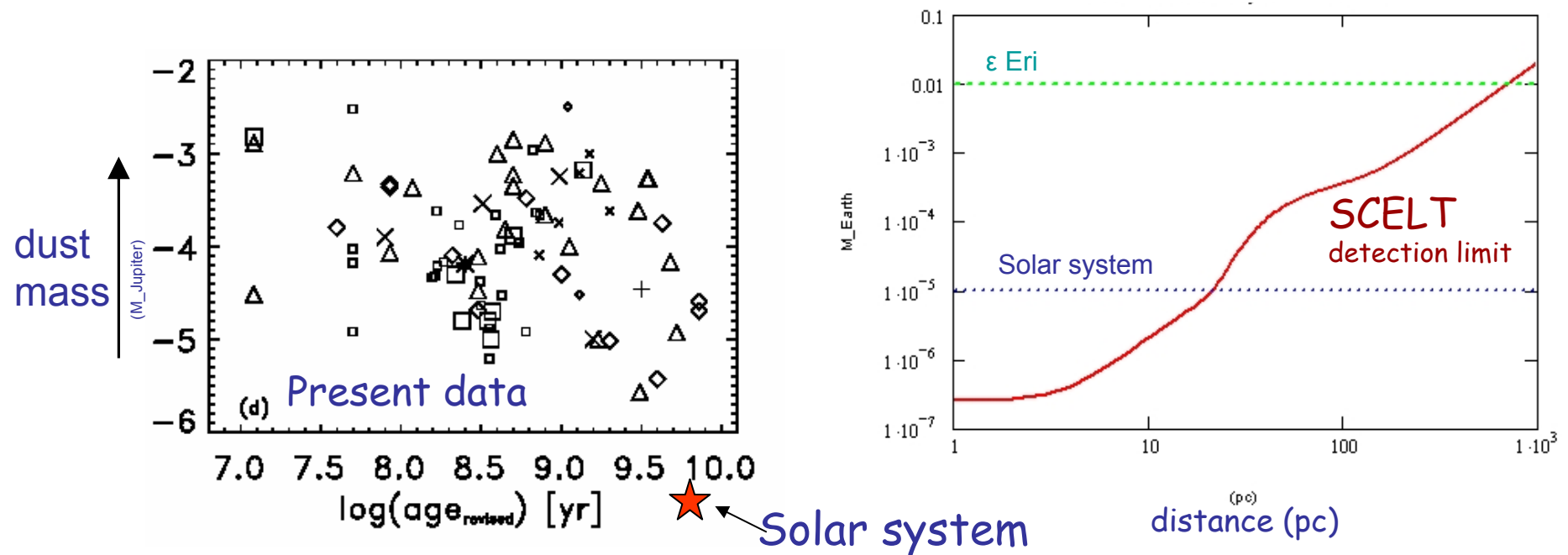
$\epsilon$ Eri - SCUBA



# Debris discs



➤ SCEL T could detect Solar System to ~16pc





# Debris discs

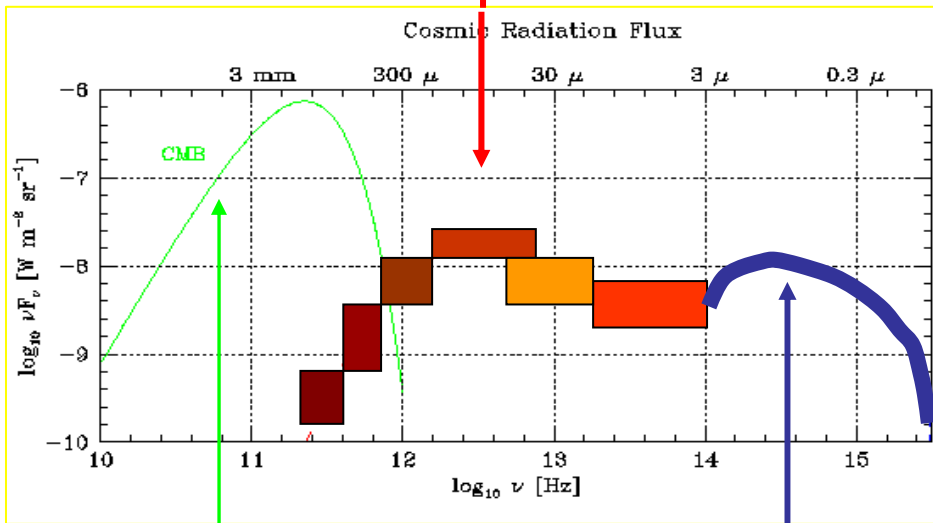


- does the mass depend on age, spectral type, location?
- is our Solar System unique in having low dust mass?
- (interval between catastrophic collisions)
- how is debris (and hence asteroids) related to the presence of planets?
- Complete inventory of the constituents of exo-planetary systems

# Galaxy formation



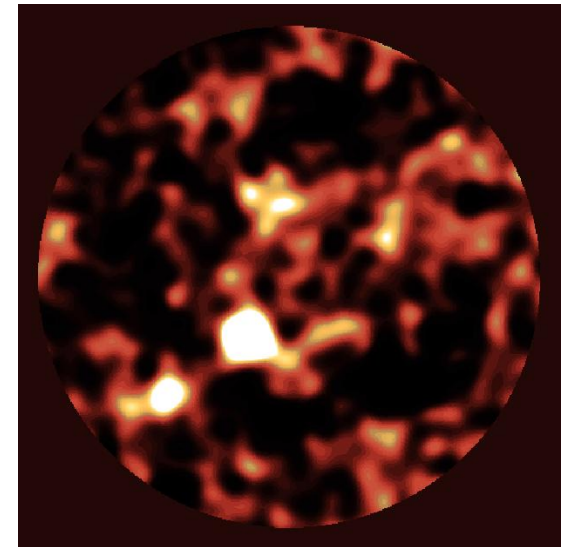
Photospheric light  
reprocessed by dust  
in Galaxies



Microwave background

↔ Stellar photospheres

SCUBA HDF  
(850 $\mu$ m)



➤ SCelt provides spatial resolution

# Star formation history

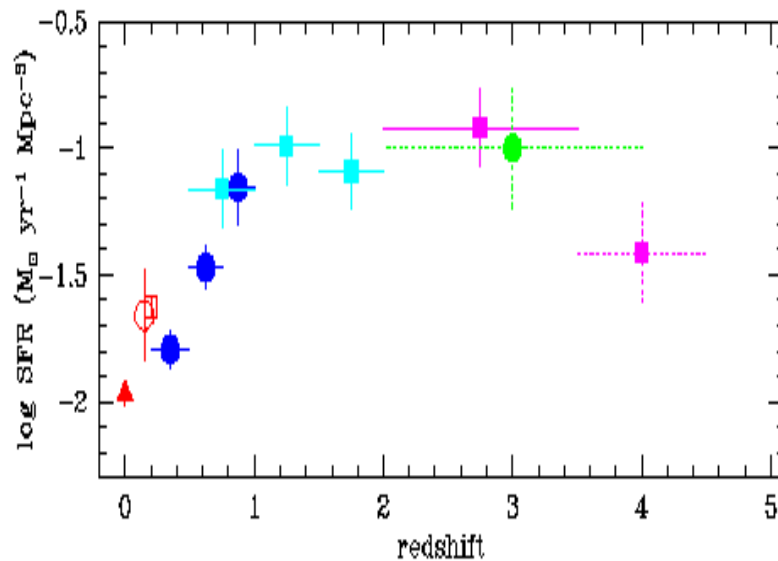


SCelt:

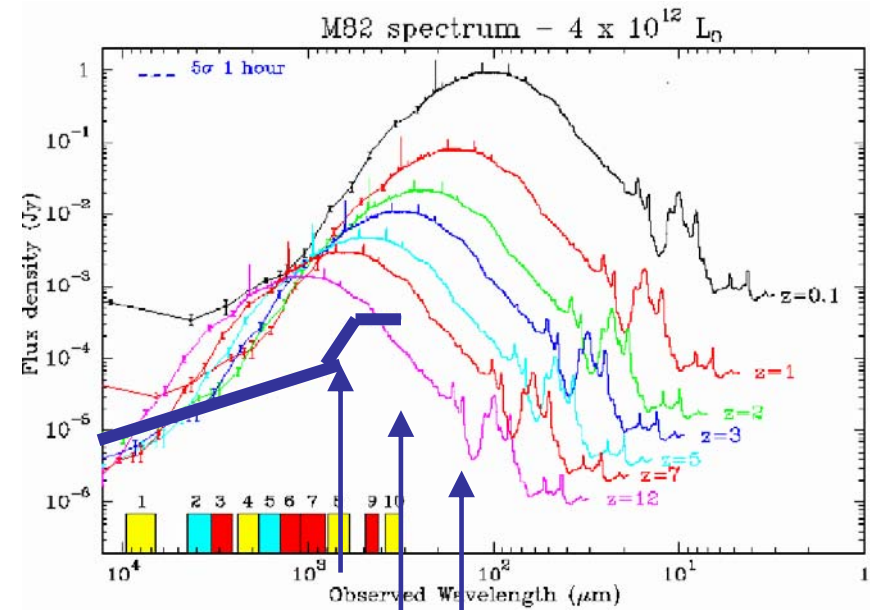
- samples star formation rate
- flux weakly affected by  $z$
- submm colours  $\rightarrow$  estimate of  $z$

SED peak at:

$z = 0.7$	170 $\mu\text{m}$
$z = 1.5$	250 $\mu\text{m}$
$z = 2.5$	350 $\mu\text{m}$
$z = 4$	500 $\mu\text{m}$



star formation rate vs. redshift



SCelt

# Early galaxy & star formation



- Galaxy formation: hierarchical?
  - SFH: to  $z=20$  and burst or gradual?
  - Relation of CMB structure and cluster formation?
  - Relationship between submm galaxies and present galaxies?
- **SCELT will be able to detect the Milky Way to  $z \sim 5$**

# SCELT specifications and requirements



# SCELT specifications and requirements



- Beam size: 1" - 2" (-> 30-50m)
- 2 -3 wavebands simultaneously (850, 450 & 350, 200 $\mu$ m)
- Background limited
- Shortest wavelengths required (good submm site)
- Field of view 5'x5'
- Nyquist sampled pixels: 20,000-100,000 per wavelength
- Sidelobes <1%, surface roughness

# SCELT design

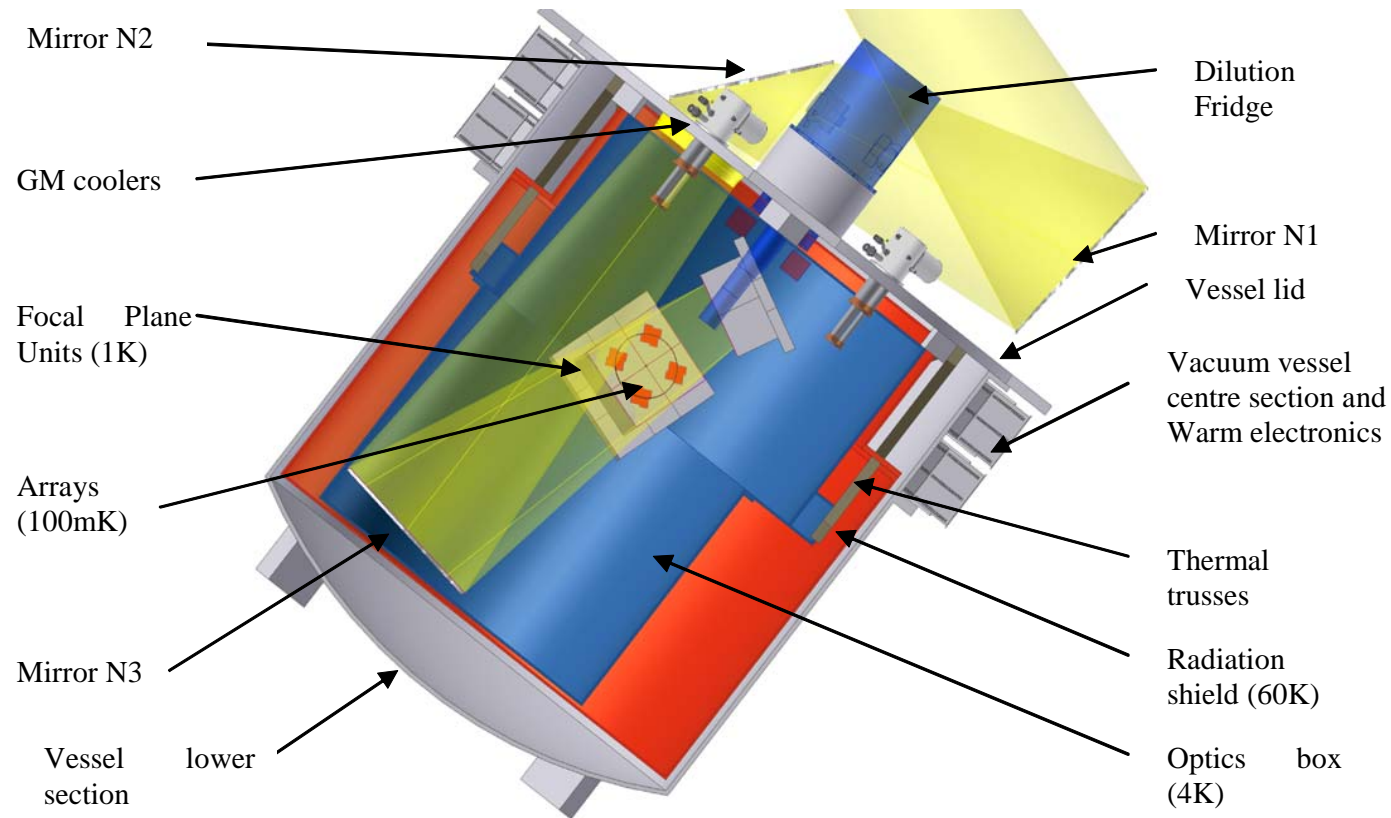


Based on SCUBA-2 :

- Uses TES detectors, 5000 pixels
- 60, 4, 1K & 80mK stages



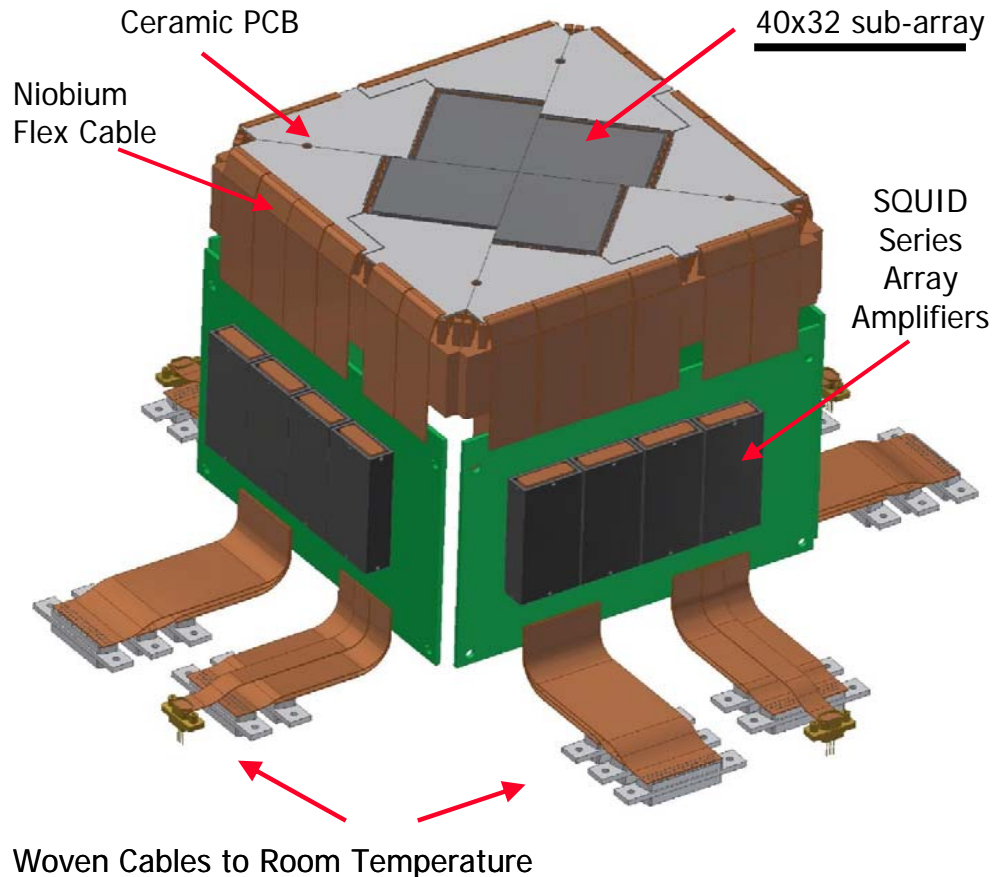
# SCELT cryostat



3 focal plane units: for simultaneous 450, 350 $\mu$ m and ?  $\mu$ m  
weight: 4-6t  
height: 2m



# SCELT baseline detectors

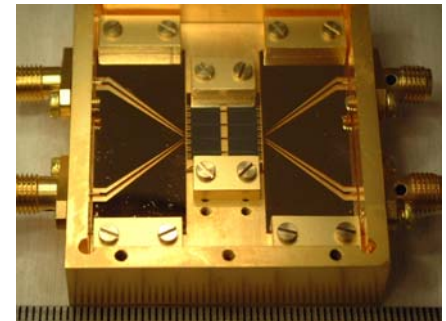
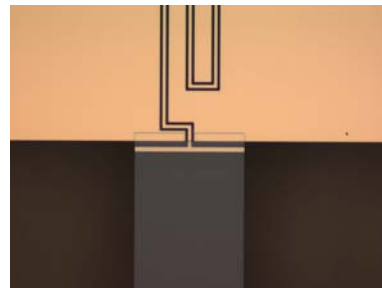
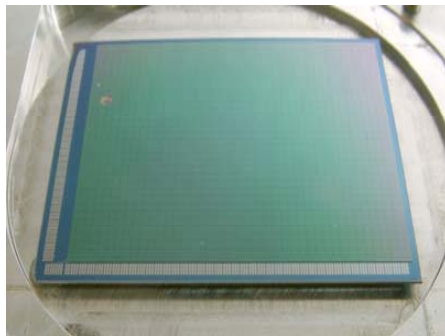
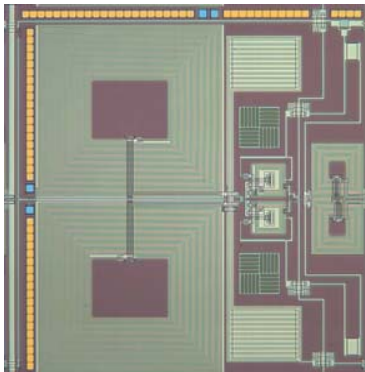


TES detector array unit  
(x4 per focal plane for SCELT)

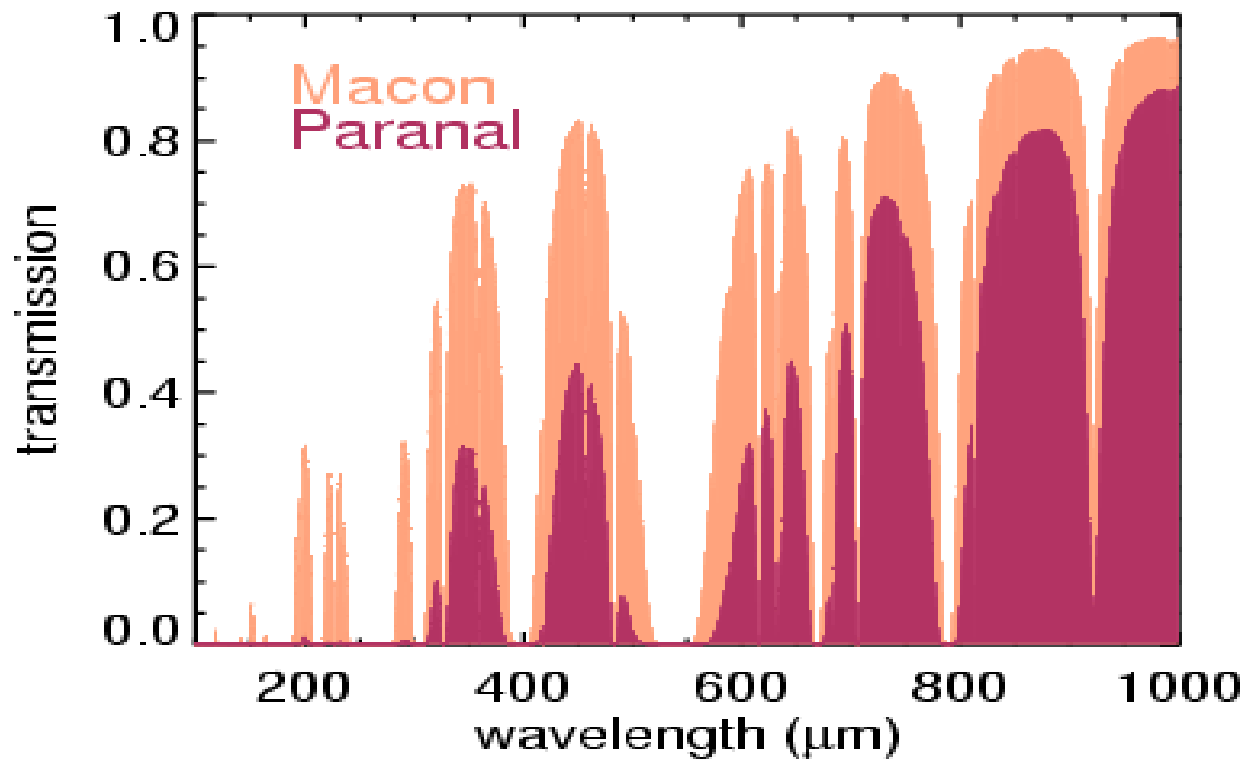
# Detector options



TES/Squid readout (baseline)	KIDs (option)
Known technology	R & D required (MRAO, Caltech)
High wire count -> High heat load	Frequency multiplexed -> fewer wires -> complex electronics.
Complex multi-layer design	Simpler to manufacture large arrays
Fraction of FoV covered ~30%	Could fully populate FoV



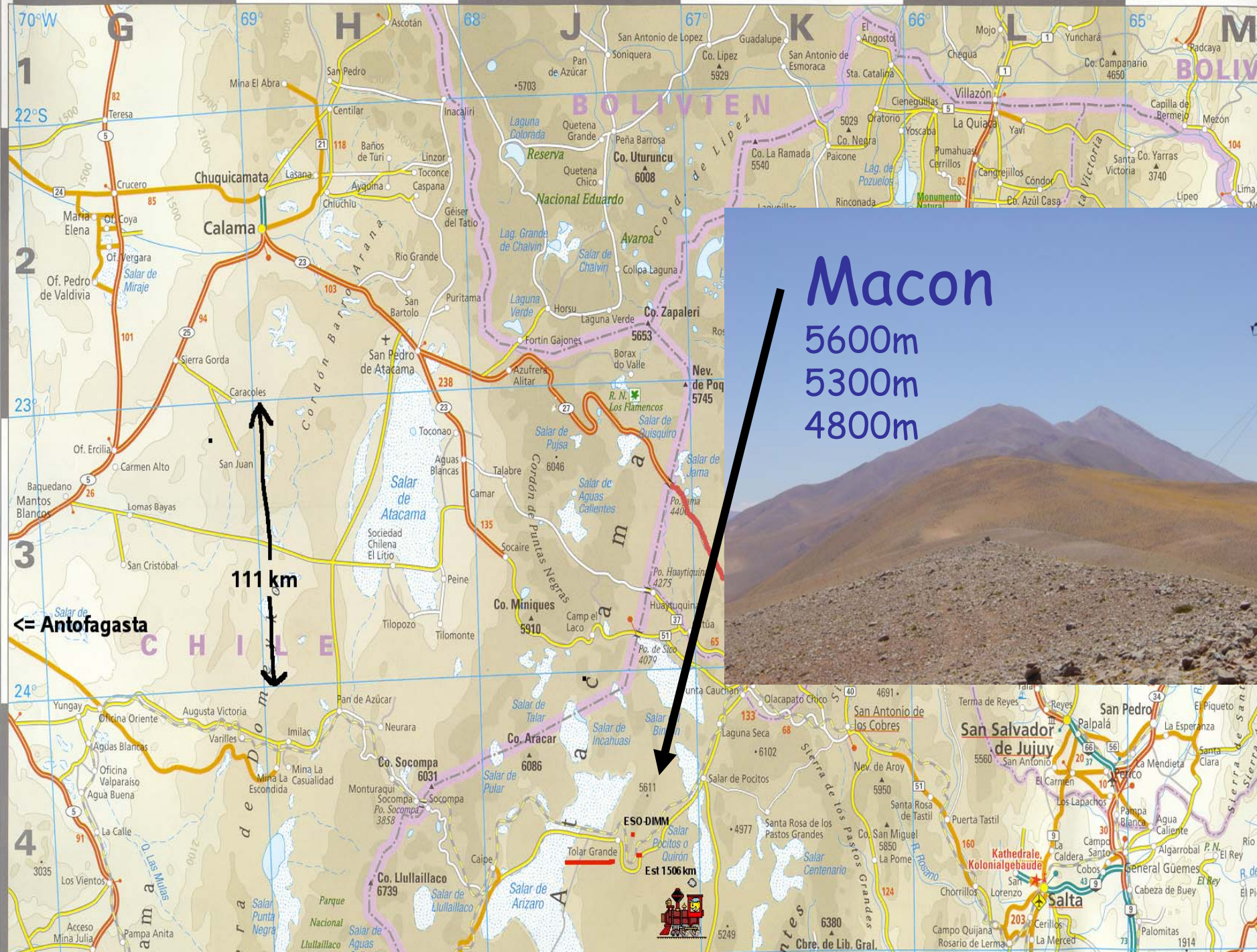
# ELT site



Paranal:  
2640m  
284K  
1.5mm (pwv)

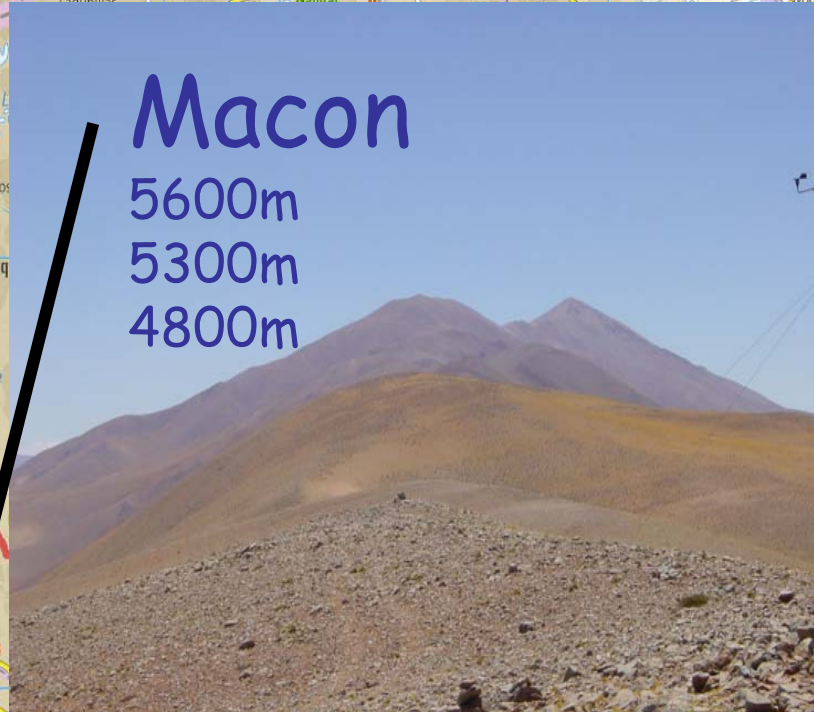
Macon:  
5050m  
268K  
0.5mm (pwv)





# Macon

5600m  
5300m  
4800m



111 km

<= Antofagasta



# SCELT performance at Macon<sup>\*</sup>



wavelength	850 $\mu$ m	450 $\mu$ m	350 $\mu$ m	units
no.of pixels	40000	80000	80000	
pfov	2.5	1.3	1.0	arcsec
resolution	5	2.6	2.1	arcsec
sensitivity	0.3	0.6	1	mJy/10 $\sigma$ /1h/ pixel
confusion limit	0.1	0.18	0.16	mJy (1 $\sigma$ ,30b)
field of view	300	300	300	arcsec
Imaging	4	8	12	1deg <sup>2</sup> mJy/10 $\sigma$ /1h

<sup>\*</sup> 42m ELT, 0.5mm pwv

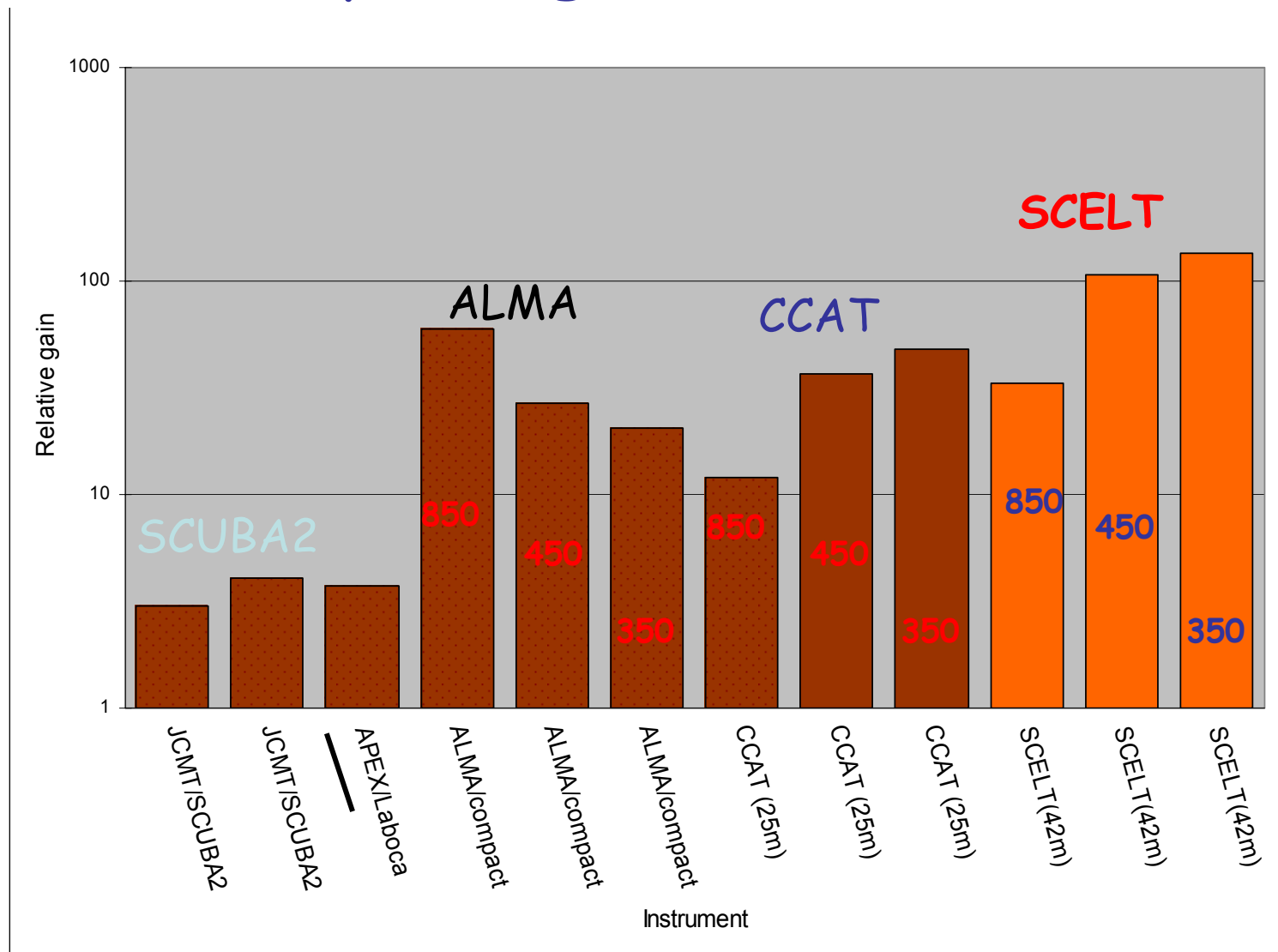
# Effects of site and telescope diameter



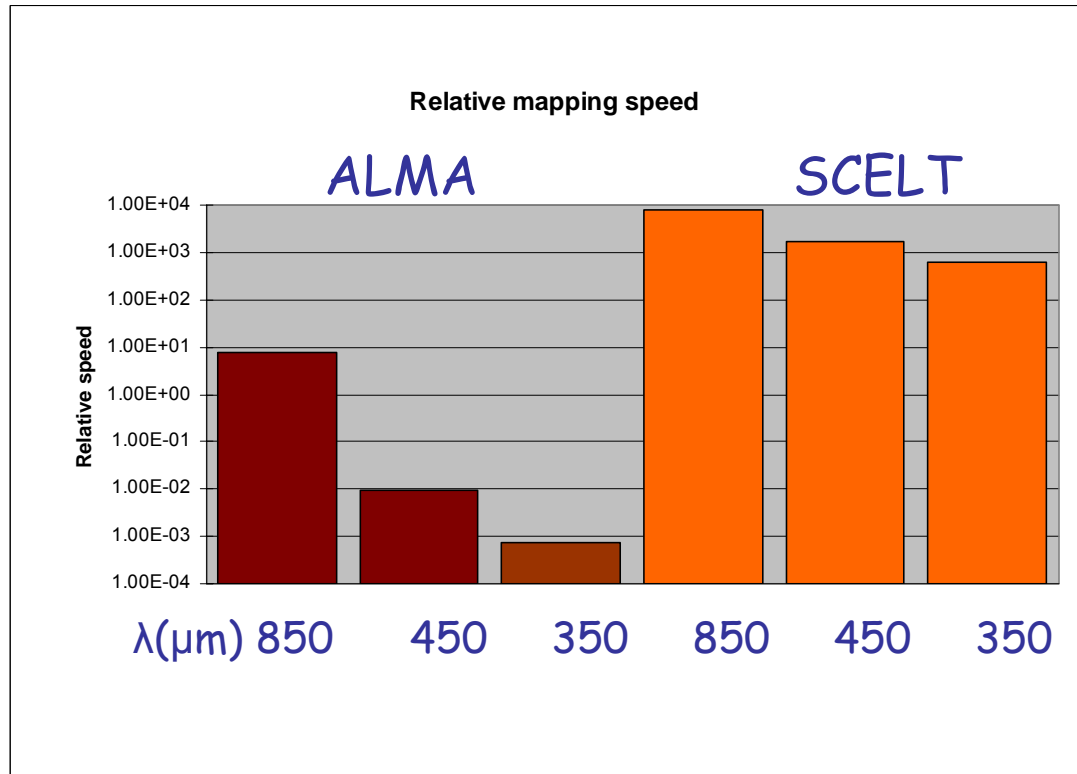
Telescope (diameter)	Site	Assumed PWV/mm	NEFD (Jy/Hz <sup>0.5</sup> )			
			850 $\mu$ m	450 $\mu$ m	350 $\mu$ m	200 $\mu$ m
JCMT (15m)	Mauna Kea (4200m)	1.0	20	60	110	(6500)
CCAT (25m)	Cerro Chajnantor (5600m)	0.5	5	11	18	200
ELT (42m)	Macon (5000m)	0.5	2	4	6	60
ELT (42m)	Paranal (2500m)	1.5	2.5	20	35	(12000)



# Sensitivity to a given dust mass



# Mapping speed



SCelt mapping speed is:

$10^3$ - $10^6$  times faster than ALMA



# SCELT and ALMA complement

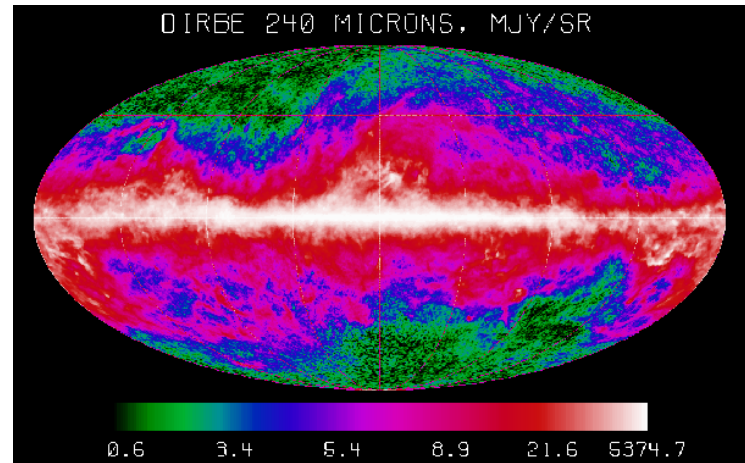
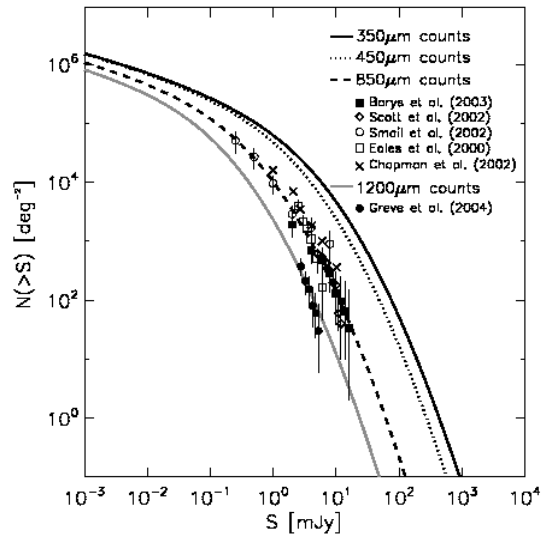


	SCELT (42m)	ALMA (1-10km)
	450 $\mu$ m	450 $\mu$ m
Resolution (")	4	0.1-0.01
Mapping speed (time per deg <sup>2</sup> to 10 $\sigma$ of 0.3mJy)	20nights	30,000yr
Strength	- Widefield mapping - <b>Source finder</b>	High resolution targeted observations

# Confusion !



2 main sources: high-redshift objects and galactic cirrus



**SCelt**

**1  $\sigma$  / 30 beam  
confusion limit**

850 $\mu$ m	450 $\mu$ m	350 $\mu$ m
100 $\mu$ Jy	180 $\mu$ Jy	160 $\mu$ Jy

# Telescope diameter viz. confusion

Telescope diameter	Confusion limit at 850 $\mu$ m (1 $\sigma$ / 30 beam, $\mu$ Jy)	Time to 3x confusion limit	
42m	100	36 min	SCELT
25m	900	18 min	CCAT
15m	5000	4 min	JCMT

# SCELT status



## Science:

- Solar type systems up to tens of pc
- Milky Ways throughout the Universe
- ALMA source finder

42m ELT + 5000m Macon

- ☺ most sensitive
- ☺ large area mapping
- ☺ low confusion limit

But:

- ELT site selection open
- not in ELT instrument studies

=> Requires "noise" from community