After Planck Era

The case for a "low-medium elle"
CMB Polarisation space mission

LFI

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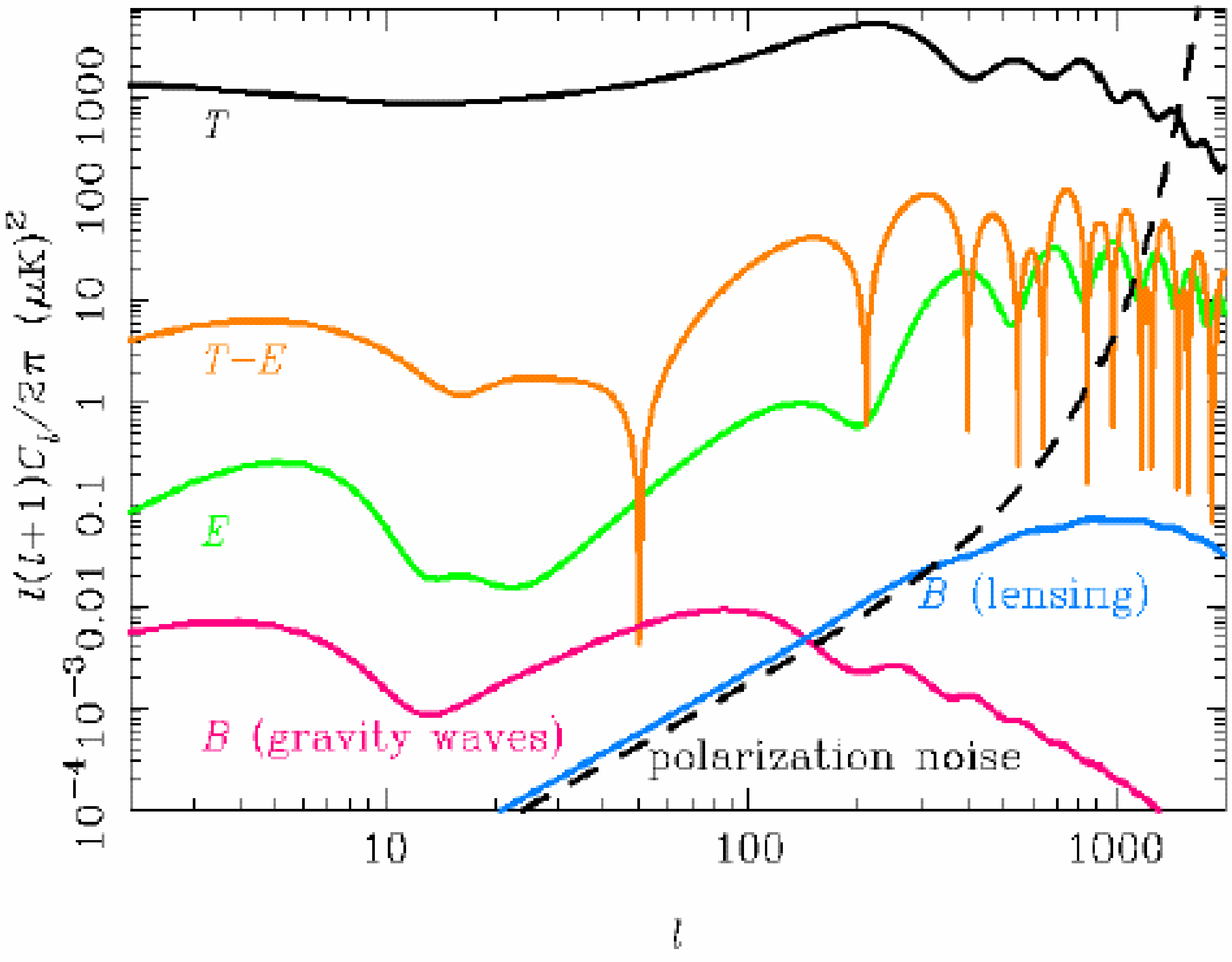
CMB C-elle Spectrum

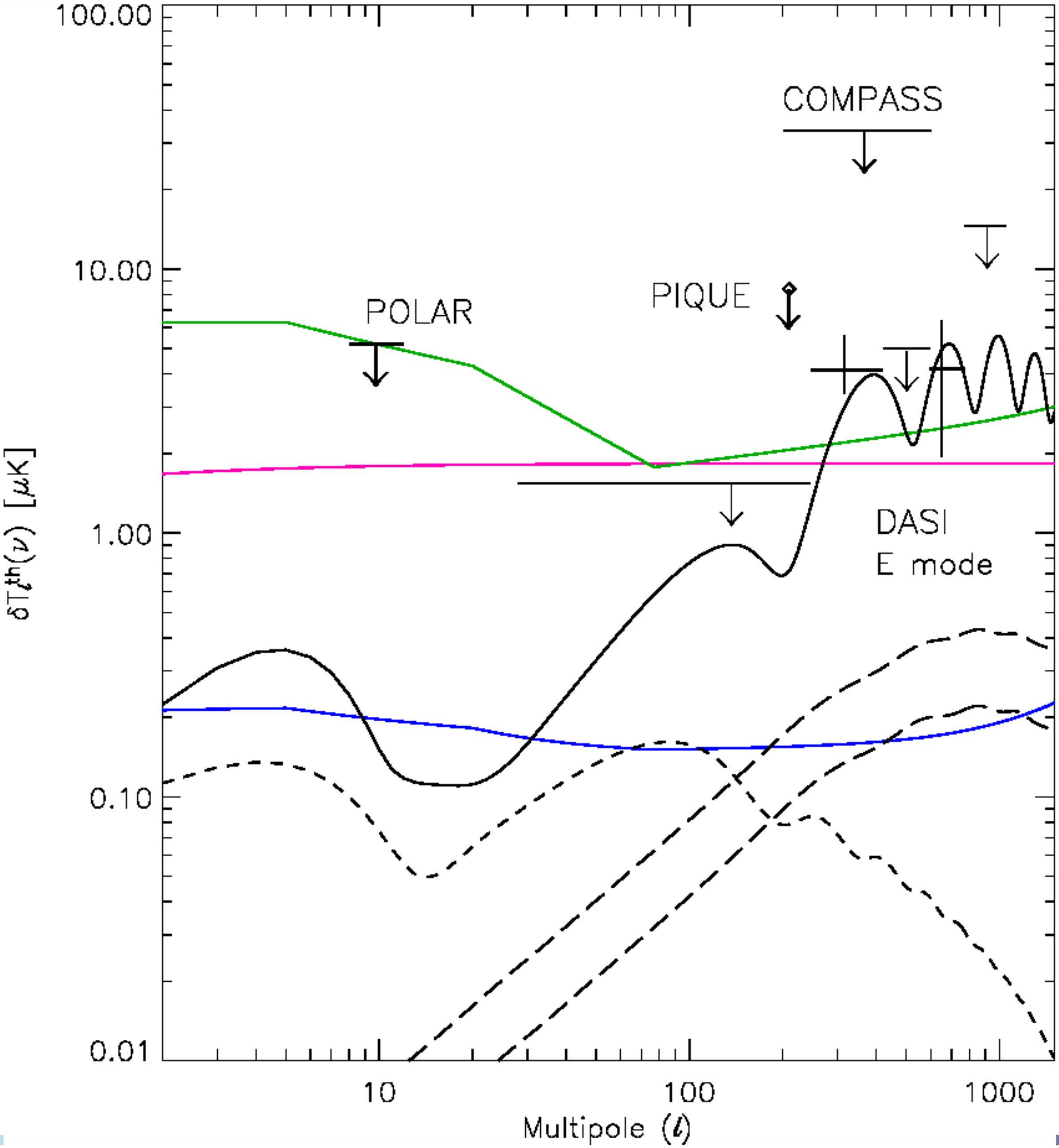


Sensitivity & Requirements

- Sensitivity: 30 times better than Planck
- Number of detectors: approximately 1000
- Galaxy to be measured with high accuracy
- Full sky Pol maps at "many" frequencies around Galactic minimum
- Angular resolution: 0.5 degree
- 4 or more Telescopes: aperture 60 cm
- Systematics: to be controlled at nanoK level

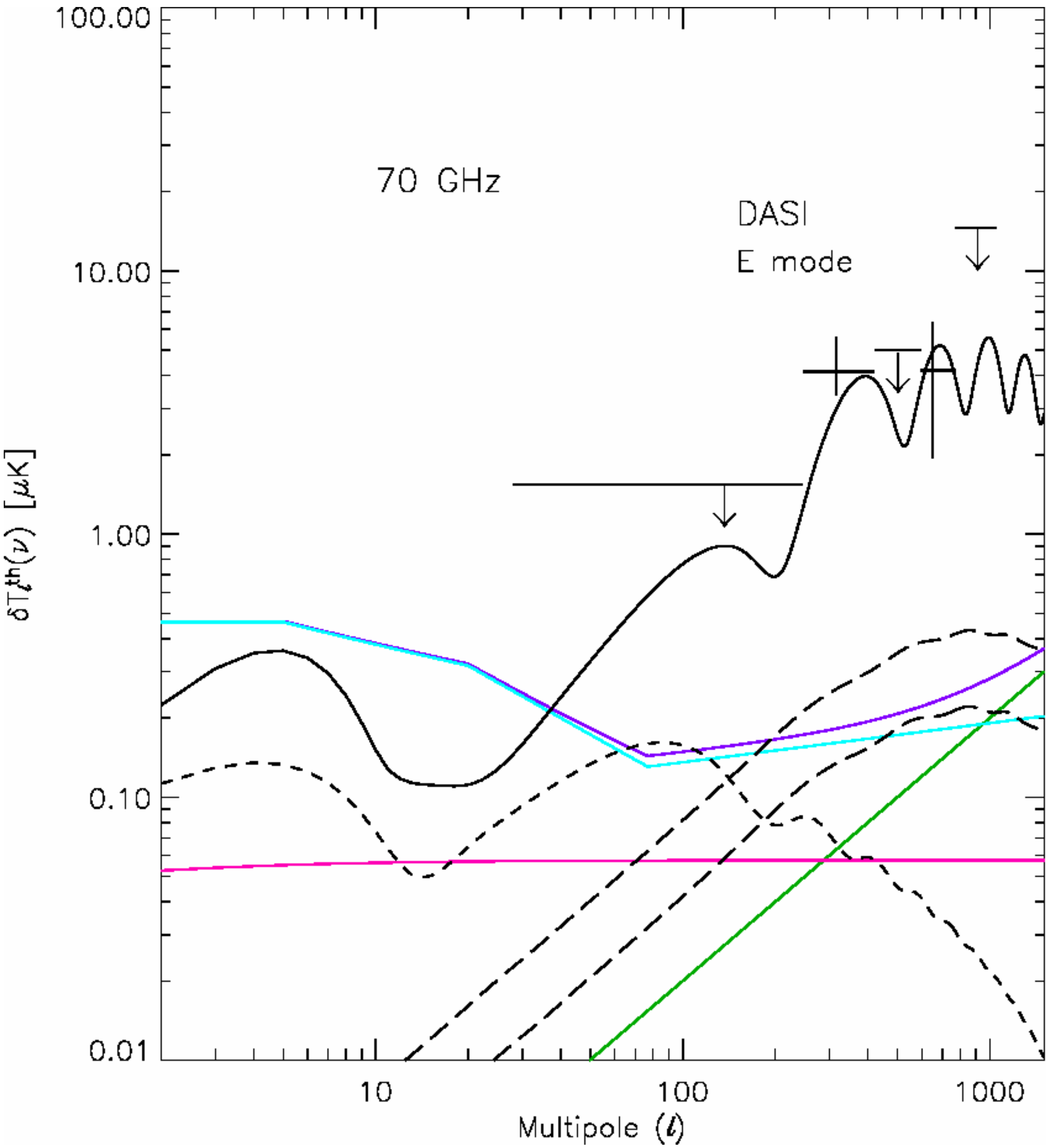
Fundamental Uncertainties

- Cosmic Variance: it cannot be overcome, but it can be dealt rigorously by using ML methods
- Galactic foregrounds is the most critical astrophysical problem
- Systematics are the real issue; understanding and measuring systematics is mandatory for any CMB experiment: it is vital for a “B” space mission



Foregrounds vs elle

Green : 30 GHz
Blue: 100 GHz
Red: 217 GHz



Foregrounds vs elle : Components at 70 GHz

Violet: Total
Blue: Galactic Sync.
Red: Galactic dust
Green: Radio Galaxies (cleaned at F> 200 mJy

TABLE 1

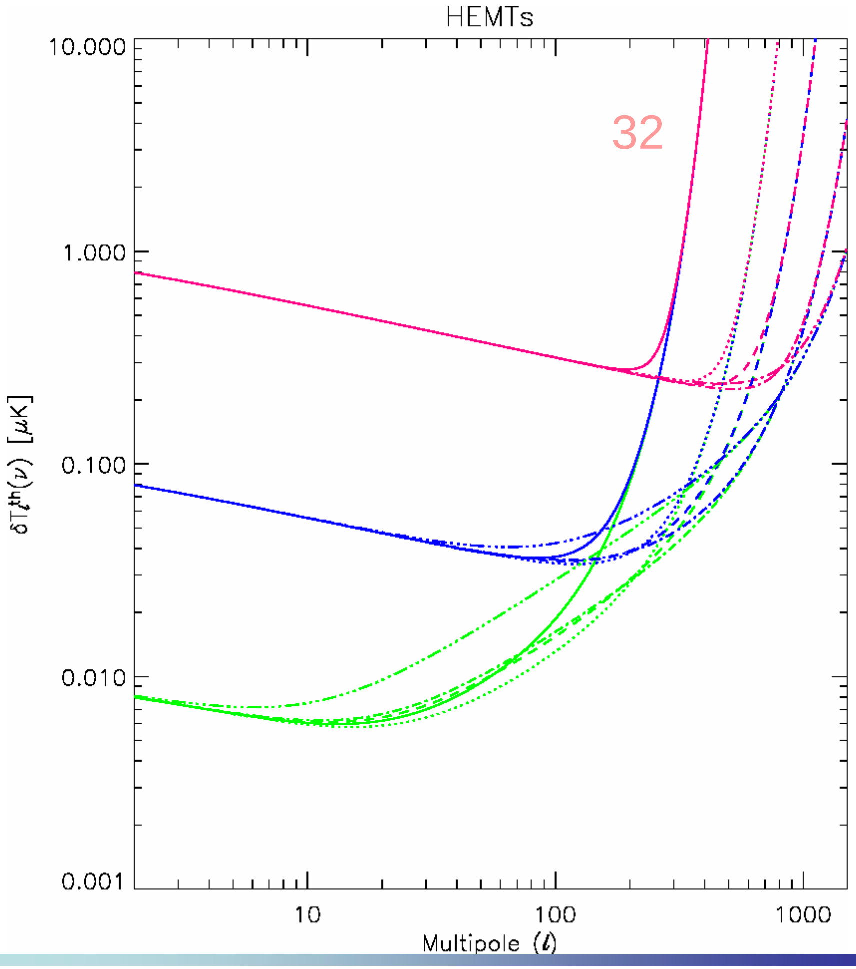
Bolometer & HEMT Sensitivities

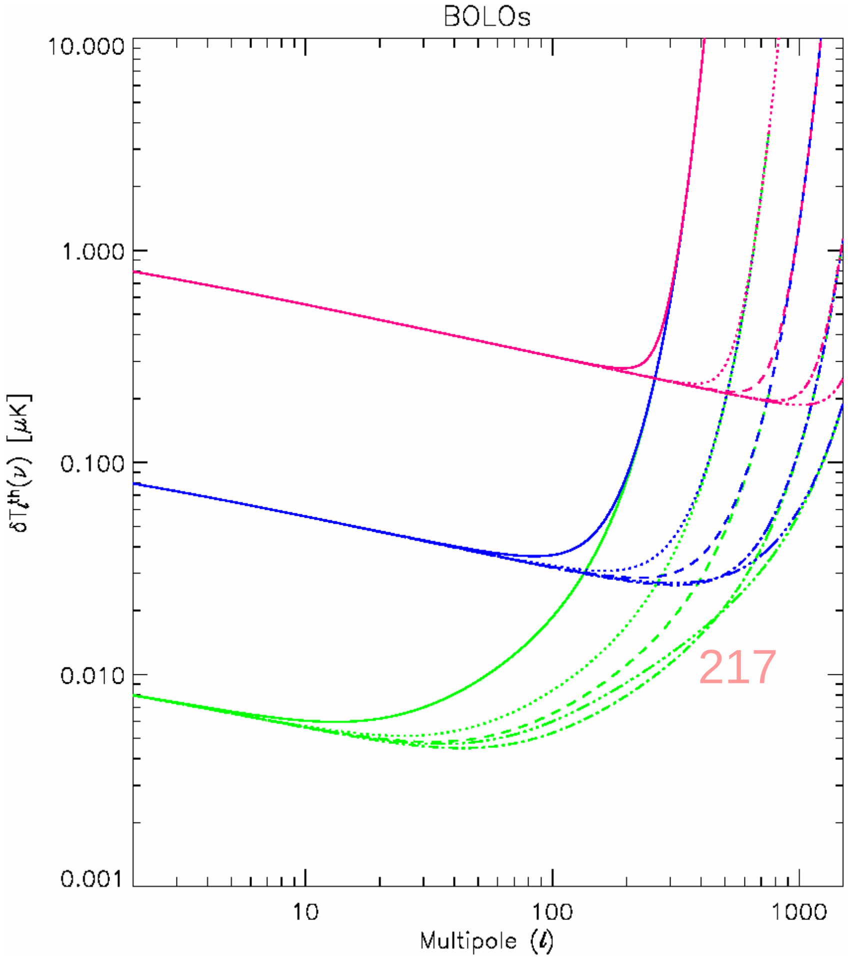
Frequency [GHz]	From Space (~2010) Bolometer $[\mu K\, s^{1/2}]$	From Space (~2010) HEMT/$\sqrt{2}$ $[\mu K\, s^{1/2}]$	From Ground (2004) Bolometer $[\mu K\, s^{1/2}]$	From Ground (2004) HEMT/$\sqrt{2}$ $[\mu K\, s^{1/2}]$
30	39	38	250	120
45	33	42	250	110
70	28	50	250	180
100	28	64	250	204
150	27	100	250	450
220	39	210		
350	130			

[a] Bolometer values from J. Bock, private communication.

[b] The $\sqrt{2}$ in the HEMT values comes from the fact that Q and U can be measured simultaneously behind one feed.

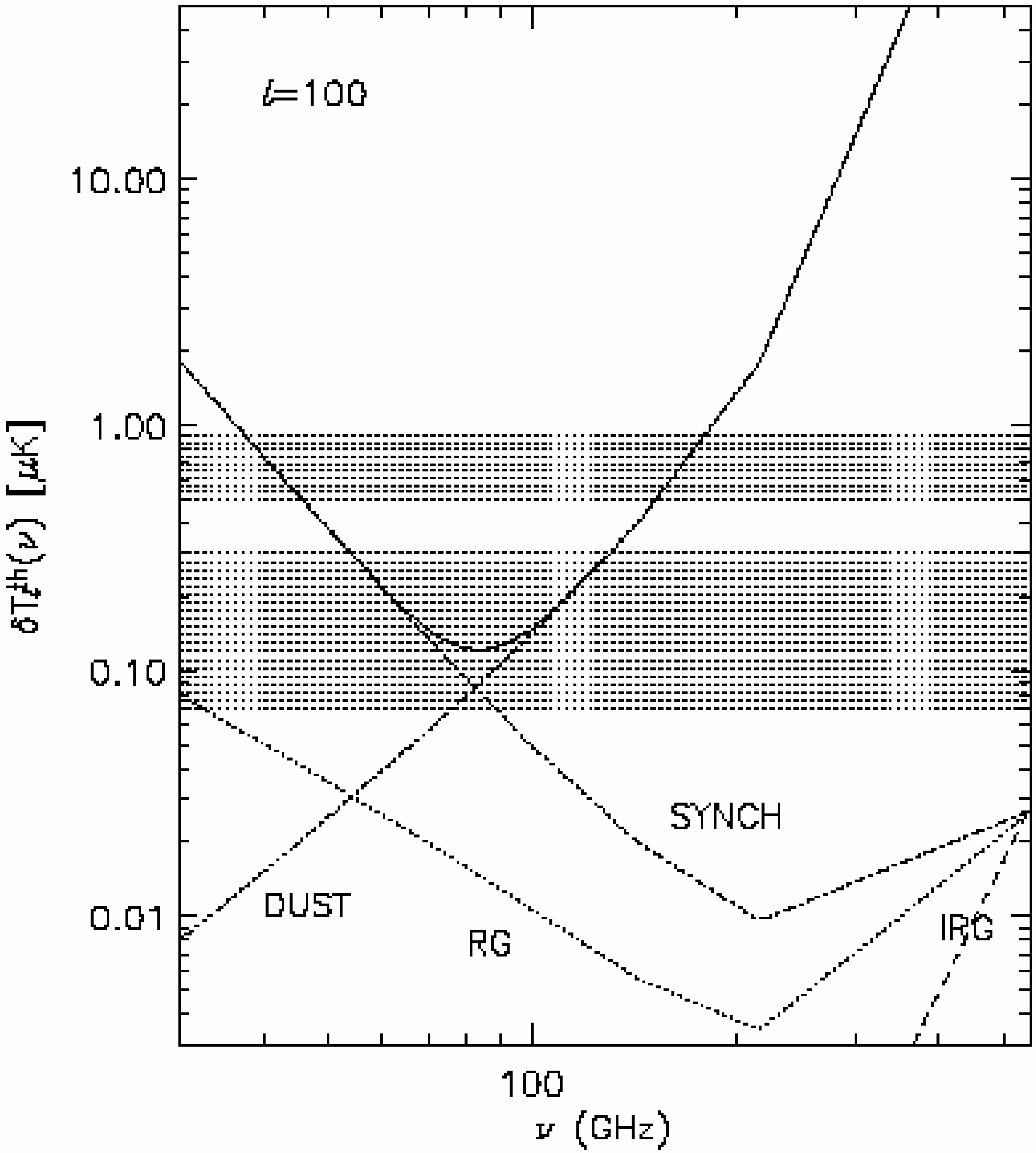
2 years Sensitivity for B: 1, 0.1, 0.01 microK





GALACTIC FOREGROUNDS

- T min (WMAP) = 69 GHz
- P min = 80-85 GHz (TBC)



Galactic foregrounds vs frequency

TABLE 2

OPERATIONAL ADVANTAGES OF HEMT ARRAYS

New View Bolo HEMT	Aspect	Bolometer	HEMT
Equivalent	Array size	Current limit several hundred	Straightforward for thousands
	Physical temperature	150–300 mK	20 K
Not very different	Readout circuits	Complicated cryogenic multiplexers	Room temperature circuit boards
Equivalent	Polarization modulation	Rotating waveplates; Faraday rotators	Electronic, after amplification
Q and U for both	Focal surface real estate	One pixel = Q or U	One pixel = Q and U

HEMT: 500-1000 $ each

Power consumption: today InP 20 mW; in 2 yrs (Antimonide substrate) few mW

Conclusions

- A “CMB B Pol” space mission is feasible
- At “low elle” the cosmic variance dominates (if Foregrounds and Systematics perfectly removed): HEMTs & Bolometers are equally suitable
- At “medium elle” HEMTs are appropriate if “B” is in the range 0.1 microK, Bolometers are needed if “B” is 0.01 microK

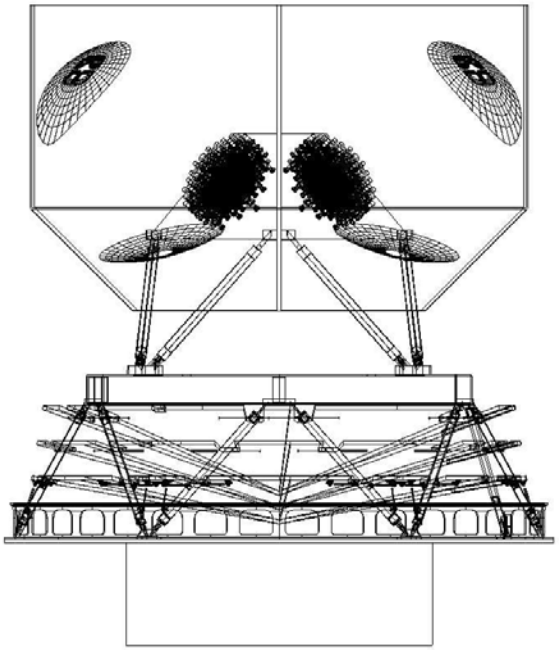


Fig. 4.1-1: Schematical representation of the architecture of the COFIS satellite. The Payload Module is attached on the PRIMA platform, which is represented by a simple box in the lowest part of the sketch. In the bottom part of the figure, three thermal radiators (V-grooves) including their mechanical support structure are represented (the concept is derived from the PLANCK satellite). A stiff hexagonal structure above the V-groove assembly supports the payload, composed by four independent telescopes and their buffles.

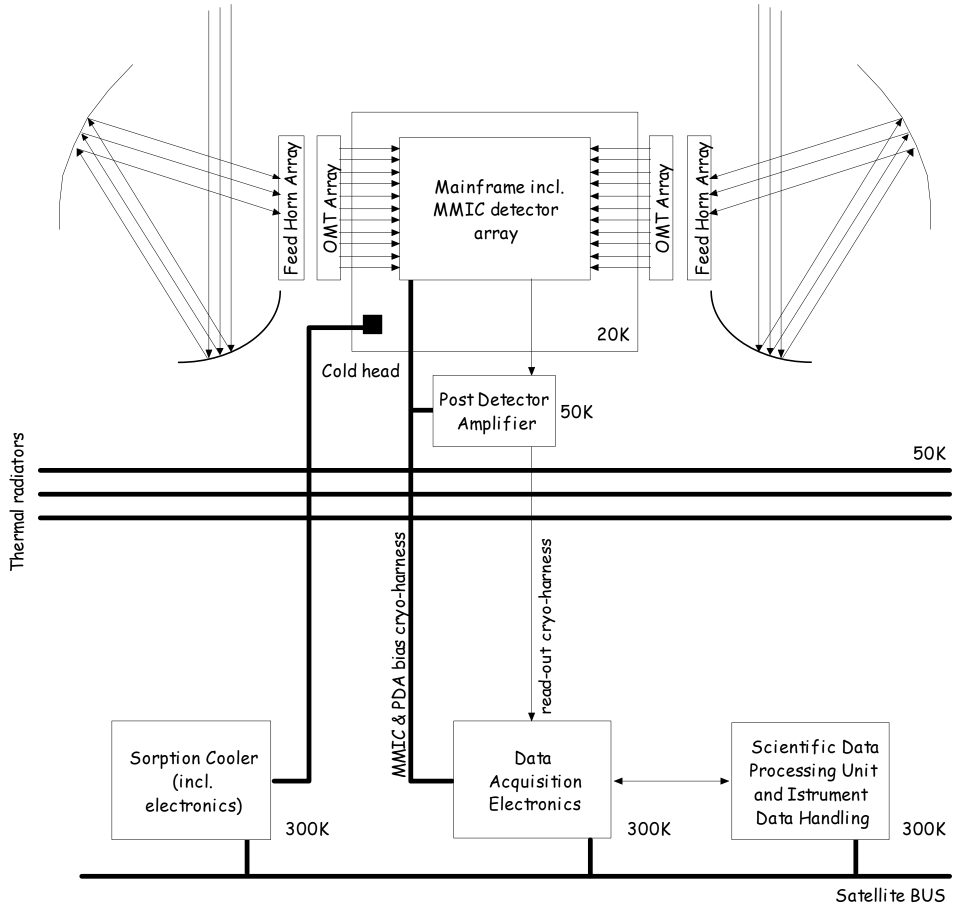


Fig. 4.1-4: Schematic design of the payload architecture. Two of four optics are shown.

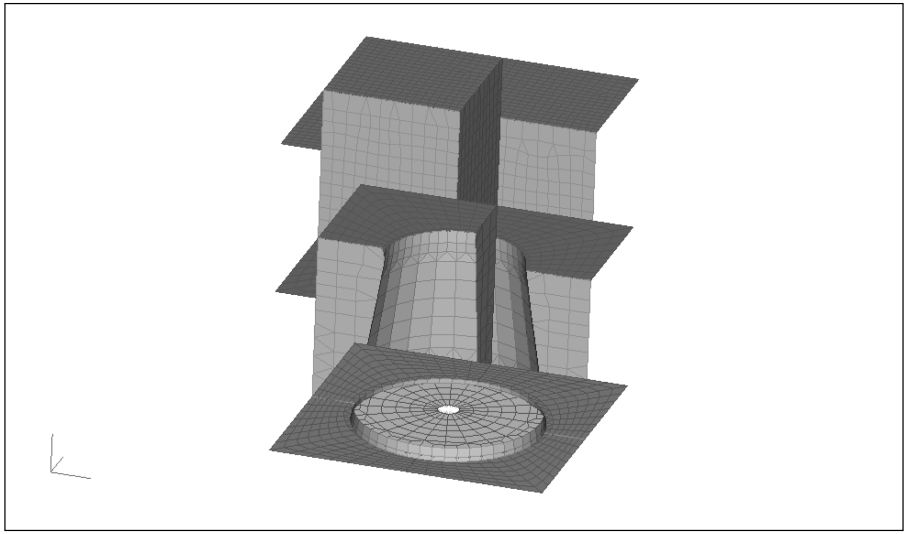
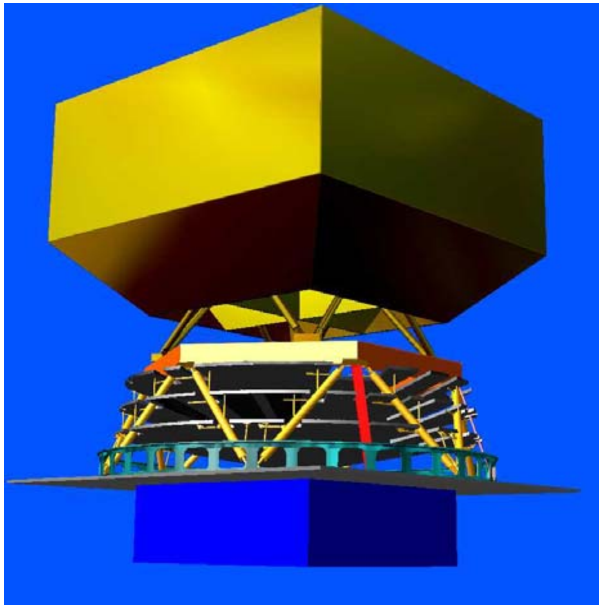


Fig. 4.2-2: PRIMA structure pictorial view.



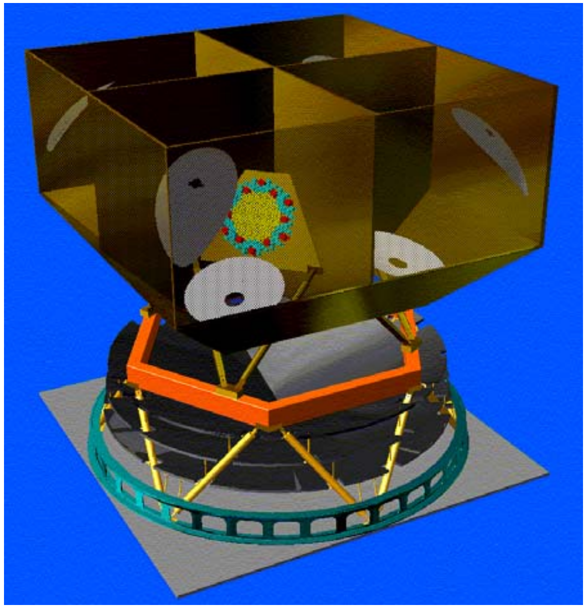
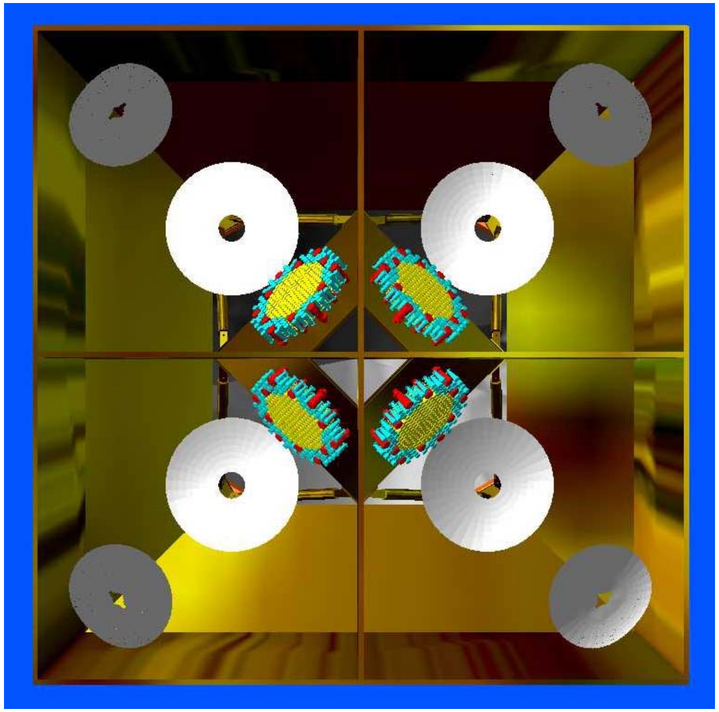


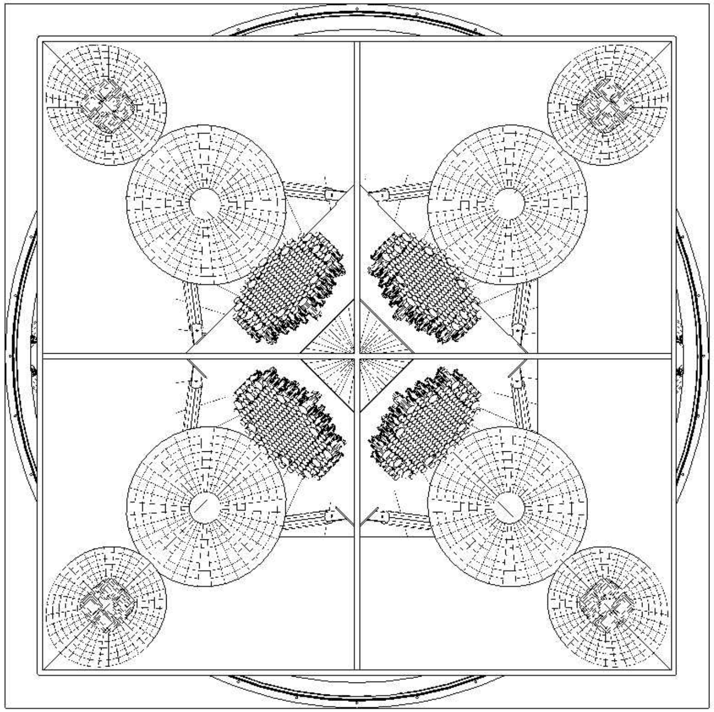
Fig. 4.1-2: COFIS artistic view, including the PRIMA platform, the thermal radiators and the instrument buffles to shield the telescopes.

Fig. 4.1-3: COFIS artistic view including the telescope antennas and part of the mainframe.

Fig. 4.2-1: Top view of the four telescopes of COFIS.

Fig. 4.2-2: Telescope arrangement inside the COFIS payload module.





Frequency	Number	Colour (ref. Fig. 4.2-3)
44 GHz	12	Red
70 GHz	90	Cyan
100 GHz	154	Yellow

Tab. 7-1: Frequency groups for the radiometers.

Fig. 4.2-2: Arrangement of 1000 radiometers (44, 70 and 100GHz) on four focal surfaces.

Fig. 4.2-3: detail of the horn arrangement on one focal surface. 100 GHz horns (yellow) are in the central region, 70 (cyan) and 44 (red) GHz are on the boundary reagion.