TES bolometer arrays for SPIDER

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JPL/Caltech

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The SPIDER & Detector Team

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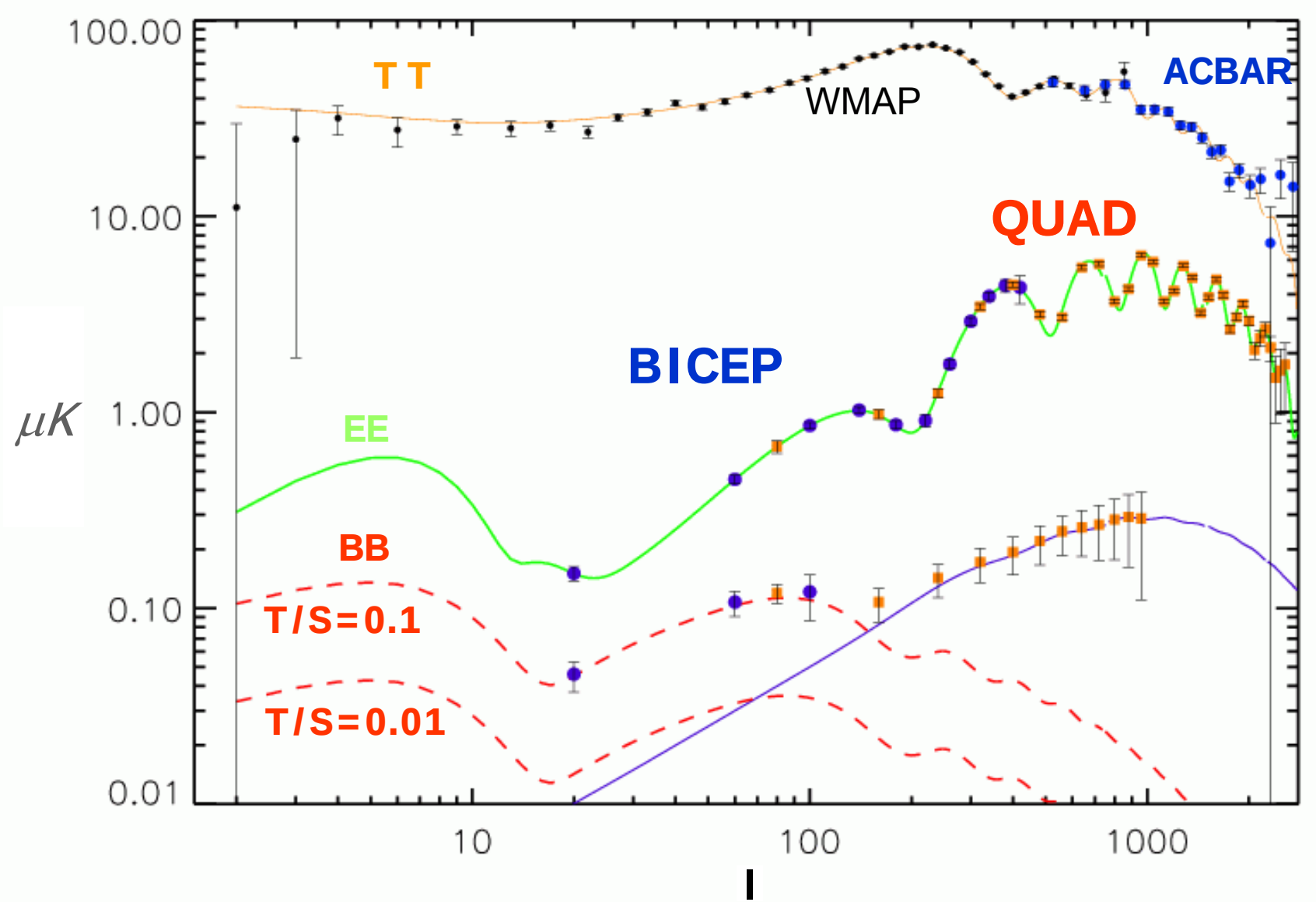
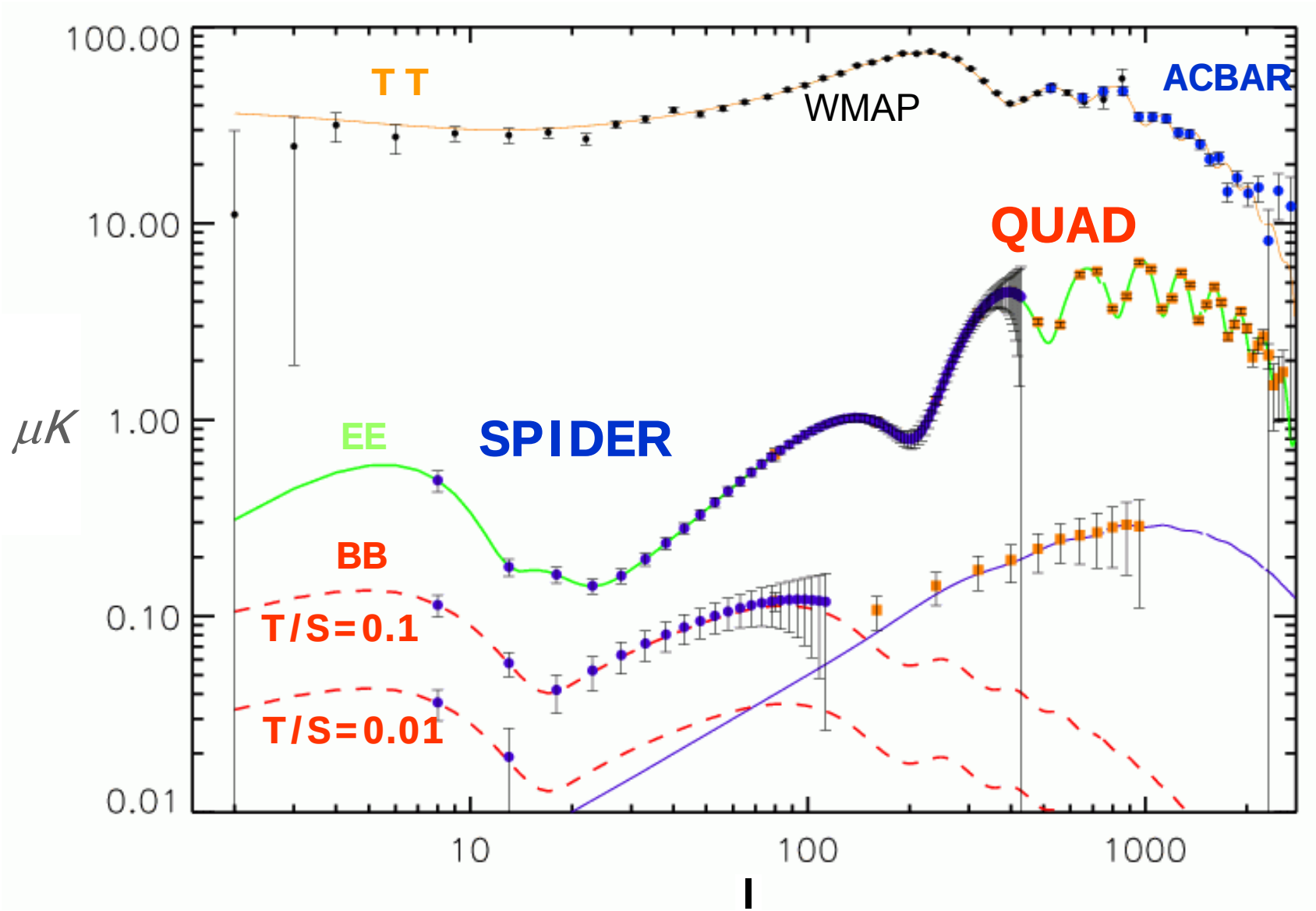
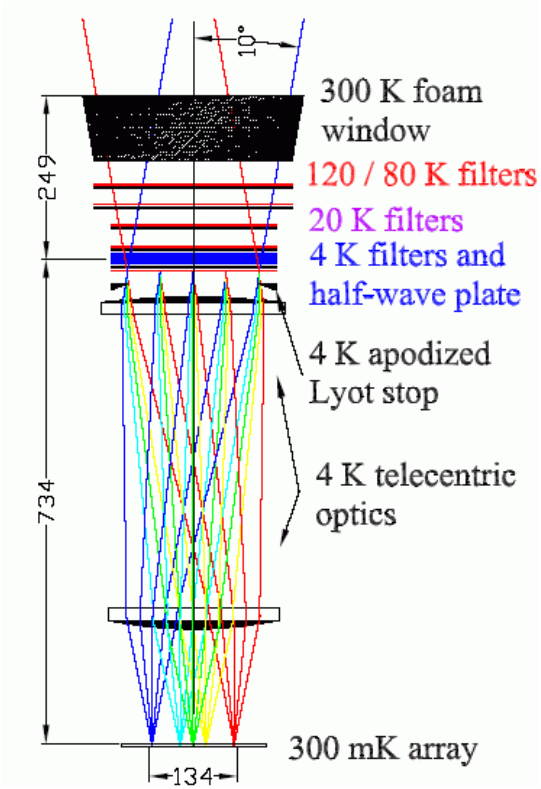
BICEP, QUAD… what next?

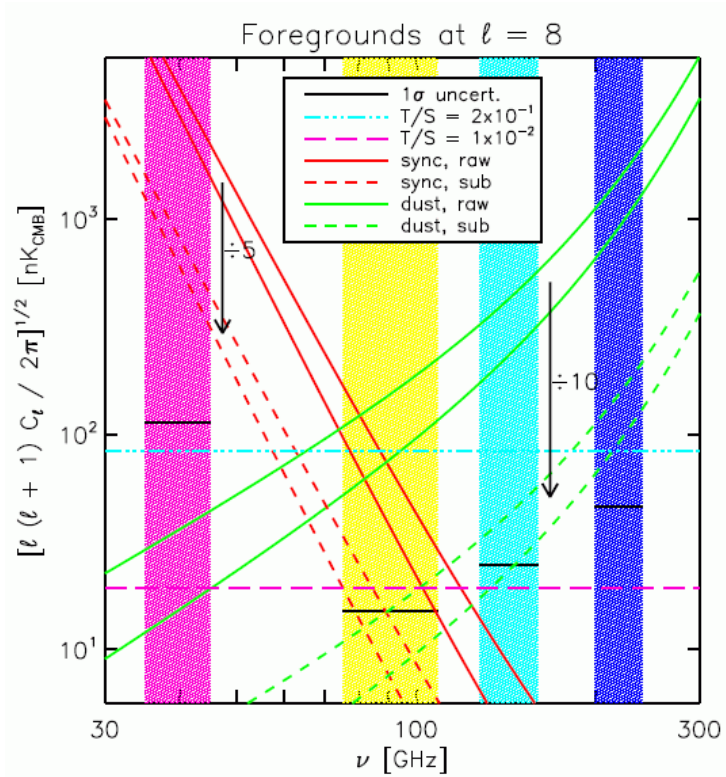


SPIDER


100.00
10.00
1.00
0.10
0.01
μK
10
100
1000
l
TT
WMAP
ACBAR
QUAD
EE
SPIDER
BB
T/S=0.1
T/S=0.01

Systematics/foregrounds control

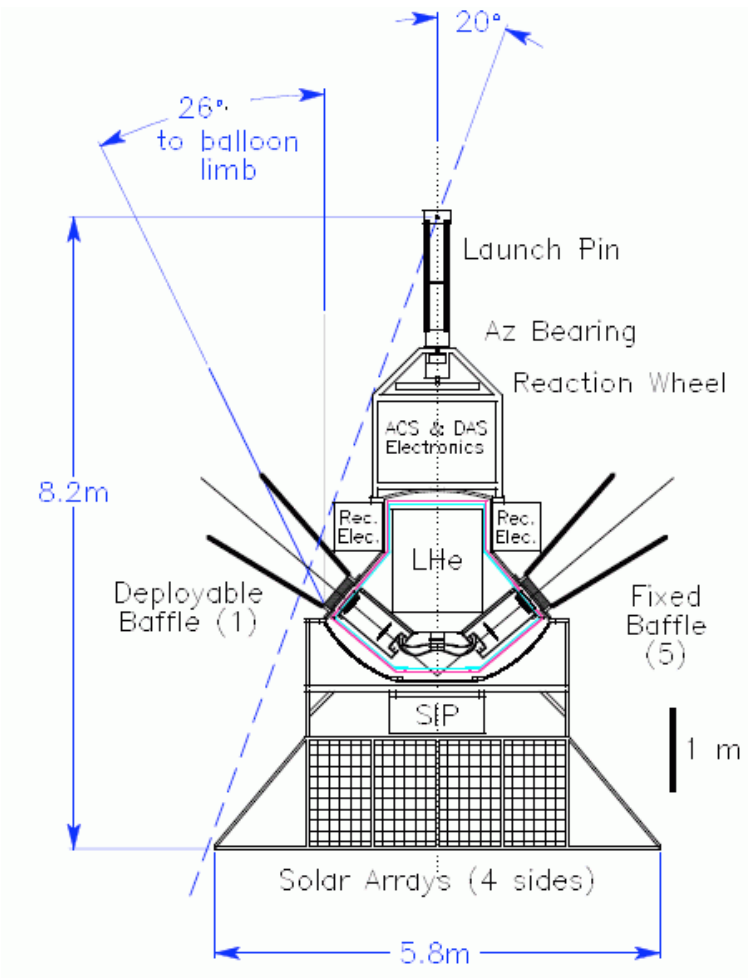




- Sidelobe control
- Polarization modulation
- Map coverage/redundancy
- Pre-flight characterizations
- Cooled optics

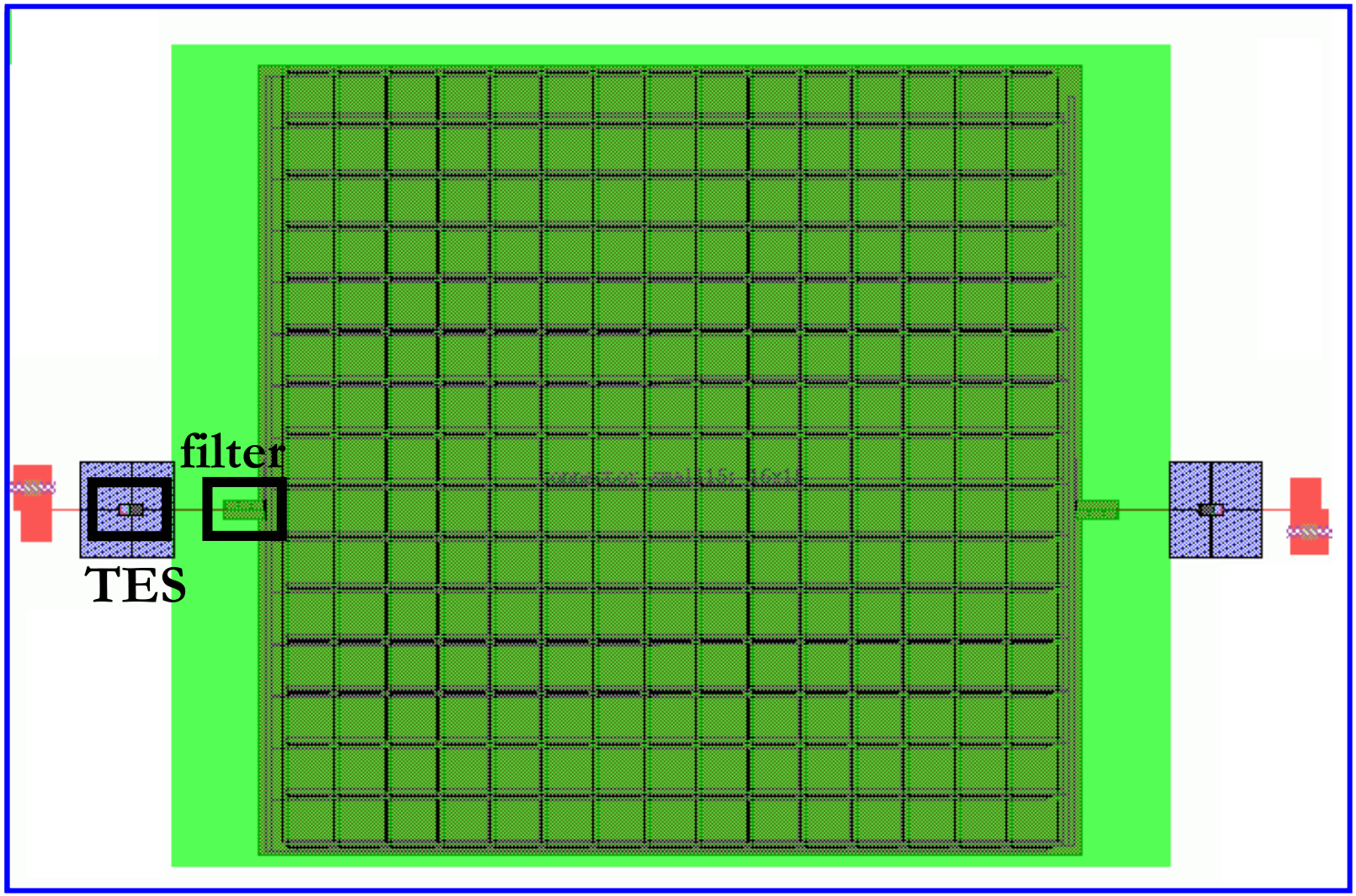
- Wide frequency coverage
- Synchrotron emission monitor
- Dust emission monitor
- High S/N foreground measurements in all bands

SPIDER specifications

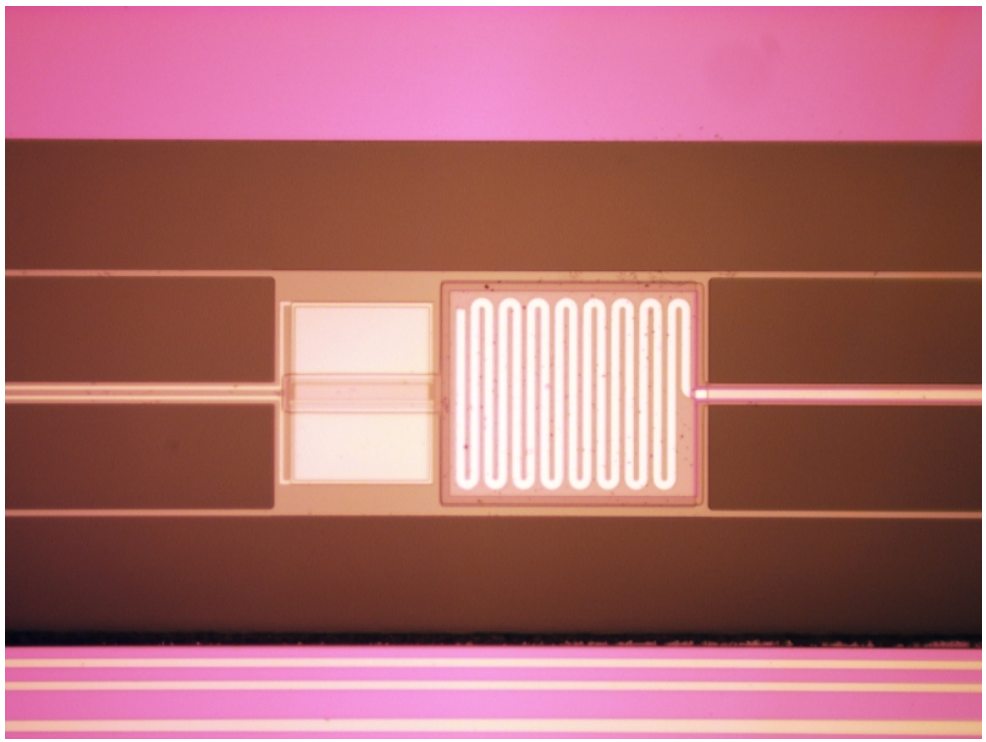


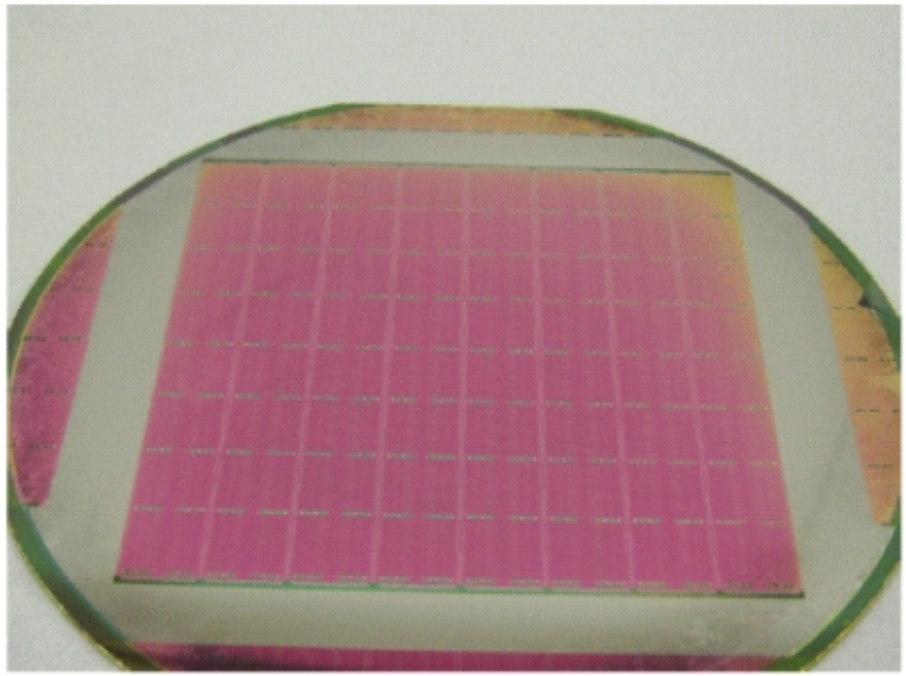
Resolution	1 degree at 90GHz
Sky coverage	50%, constant EL scans
Balloon flight	20+ days, launched from Australia
Bands	40,92,145,220 GHz (6 separate telescopes/windows)
# of detectors	1856
Cryogenics	LHe Dewar+He3 fridge
Schedule	Fall 2009: test flight December 2009: LDB flight

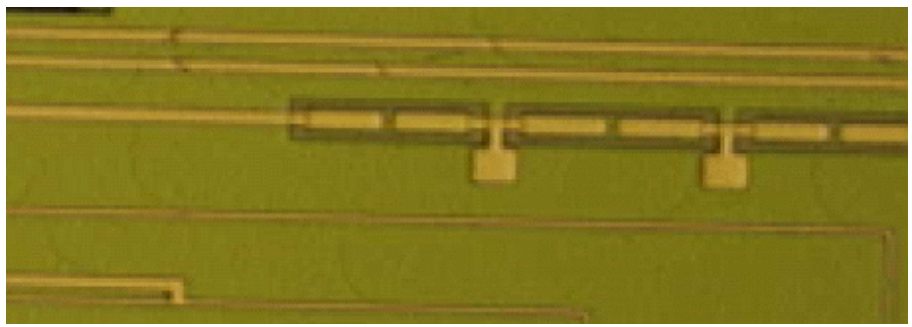
Antenna-Coupled TES polarimeter

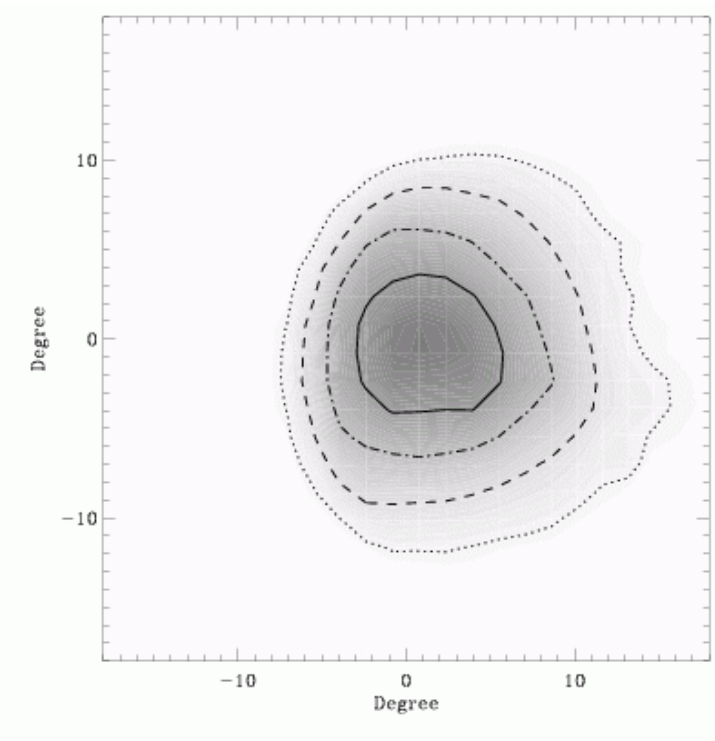


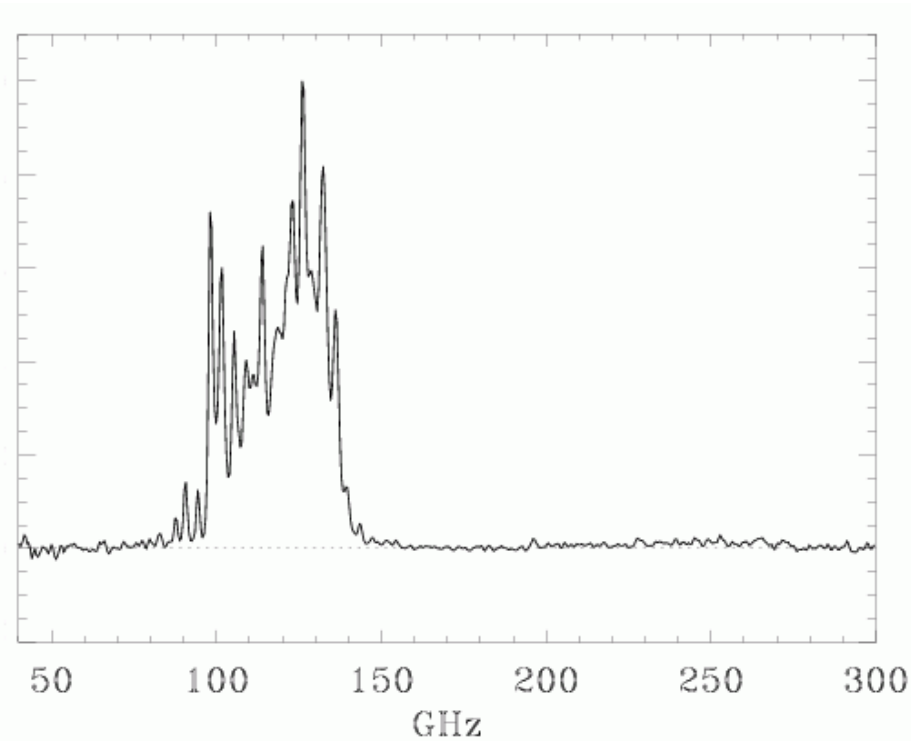
Device Pictures

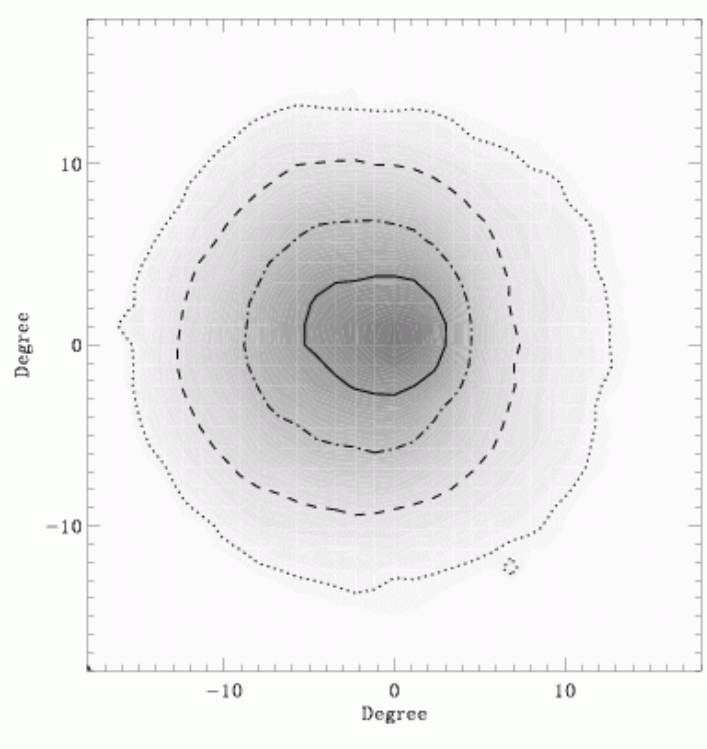







10
0
−10
Degree
−10
0
10
Degree


50
100
150
200
250
300
GHz


10
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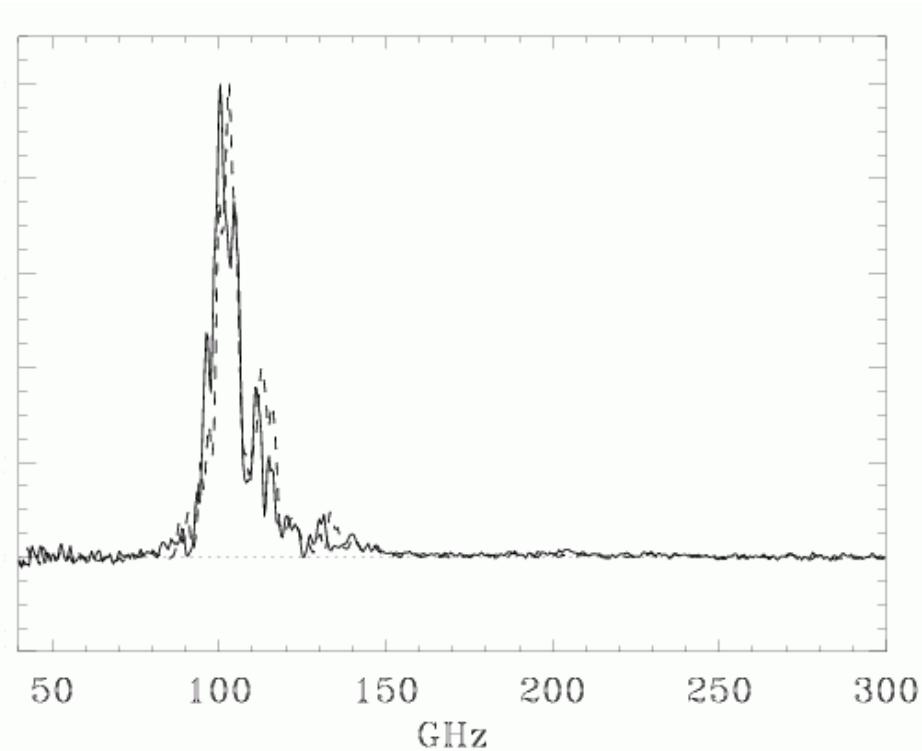

50
100
150
200
250
300
GHz

SPIDER Sensitivity Calculation

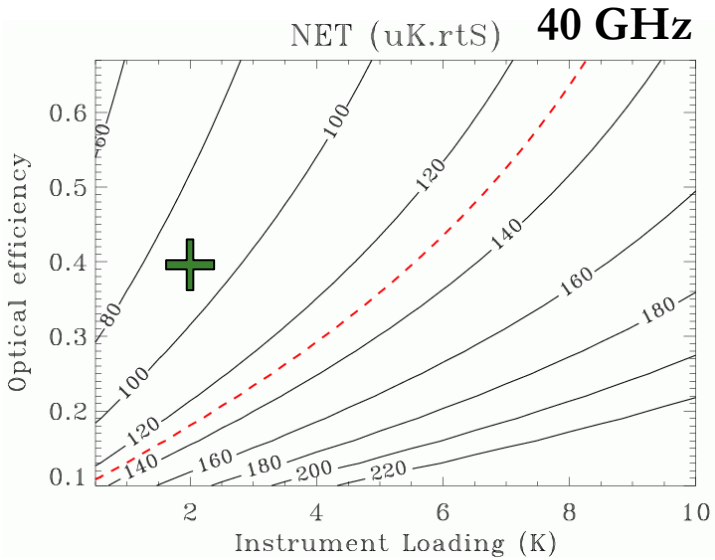
SPIDER Focal Plane

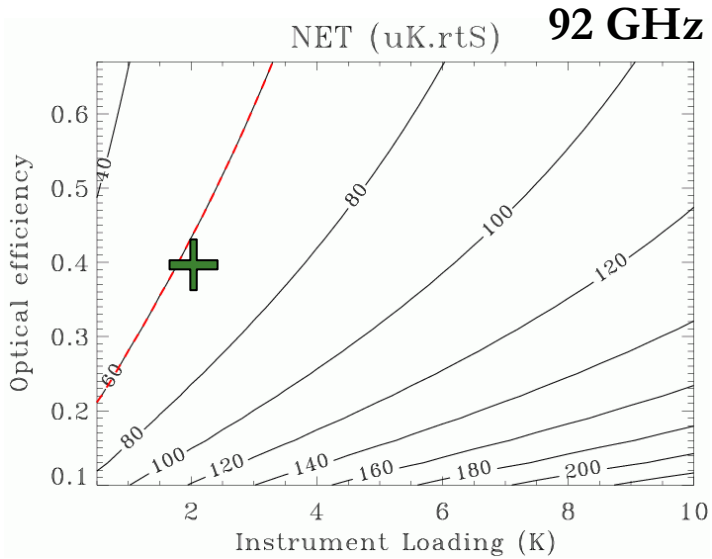
Observing Band (GHz)	Bandwidth (GHz)	Beam FWHM (arcmin)	Number of Spatial Pixels	Number of Detectors	Single-Detector Sensitivity ($\mu K_{CMB}\ s^{1/2}$)	Instrument Sensitivity ($\mu K_{CMB}\ s^{1/2}$)
40	10	145	32	64	130	16.3
84		69	128	256		
92	33	63	128	256	60	3.8
100		58	128	256		
145	32	40	256	512	80	3.5
220	40	26	256	512	150	6.6

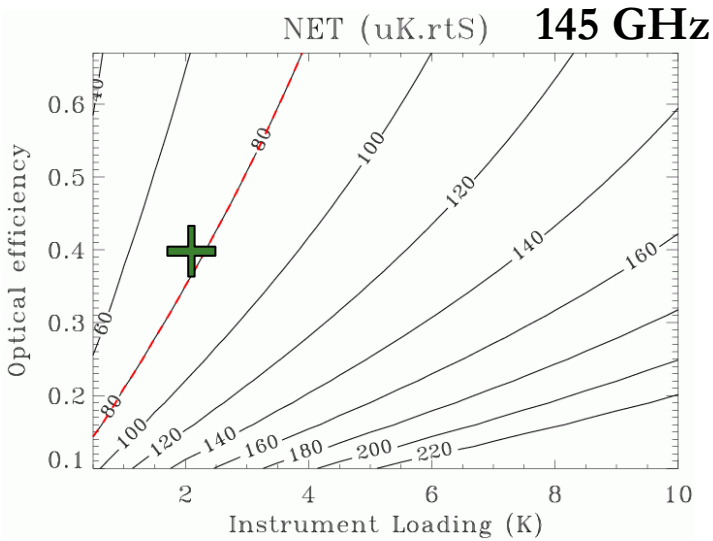
Table 1: Observing bands, pixel and detector counts, and single-detector and instrument sensitivities. The latter is obtained by dividing the single-detector sensitivity by $\sqrt{N_{det}}$. A total of 1856 detectors are distributed between the six telescopes.

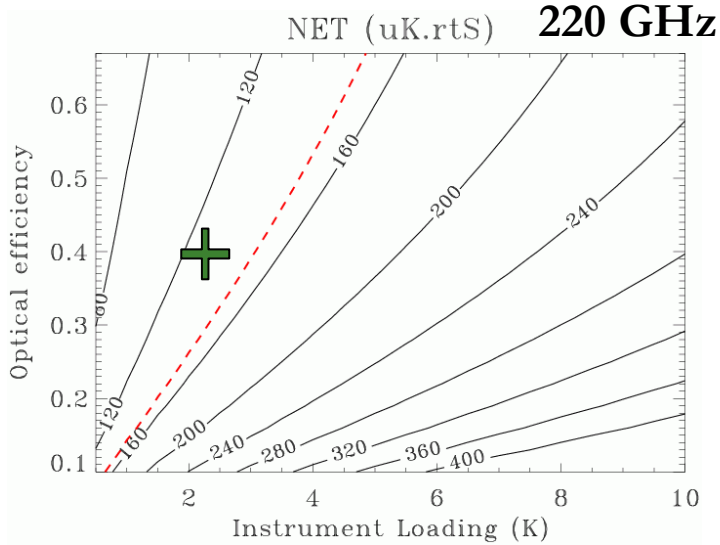
- Bands are chosen to minimize/subtract the foreground contaminations from Galactic synchrotron and dust emissions.
- Large number of detectors are necessary to achieve the required sensitivity

SPIDER Sensitivity (I)









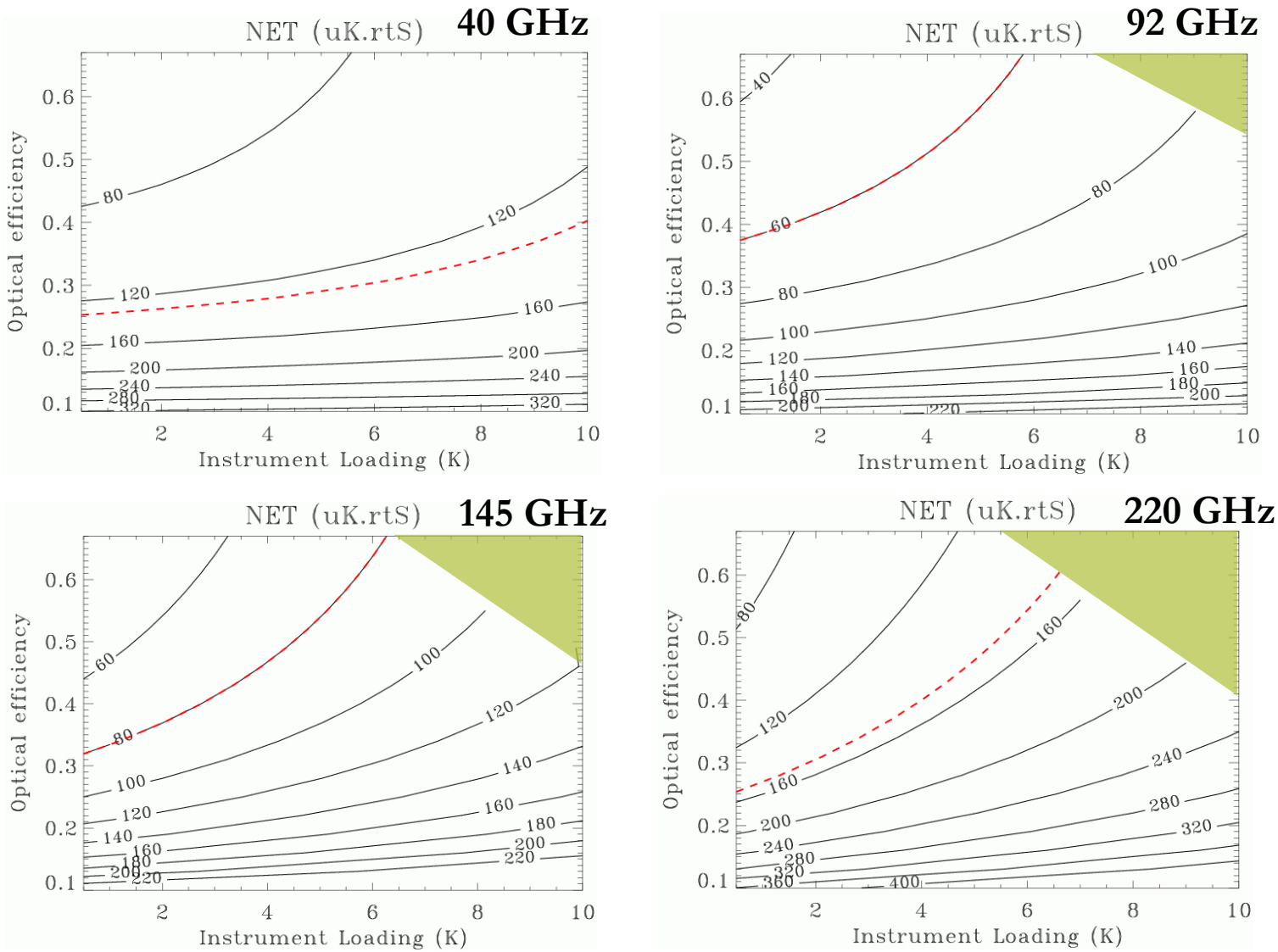
T_c=420 mK, T_b=250 mK
Varying G, P=4Q

SPIDER Sensitivity (II)

Frequency (G Hz)	NEP_g (Possion and Bose) (10^{-18} W/√Hz)		NEP_{bolo} (10^{-18} W/√Hz)	NET (mK.√s)	t_e (ms)	G_{420mK} (pW/K)
40	4.8	4.3	11	96	3.3	13
92	10.6	5.6	18	71	1.5	31
145	13.3	5.1	20	90	1.5	34
220	17.0	4.9	23	152	1.4	39

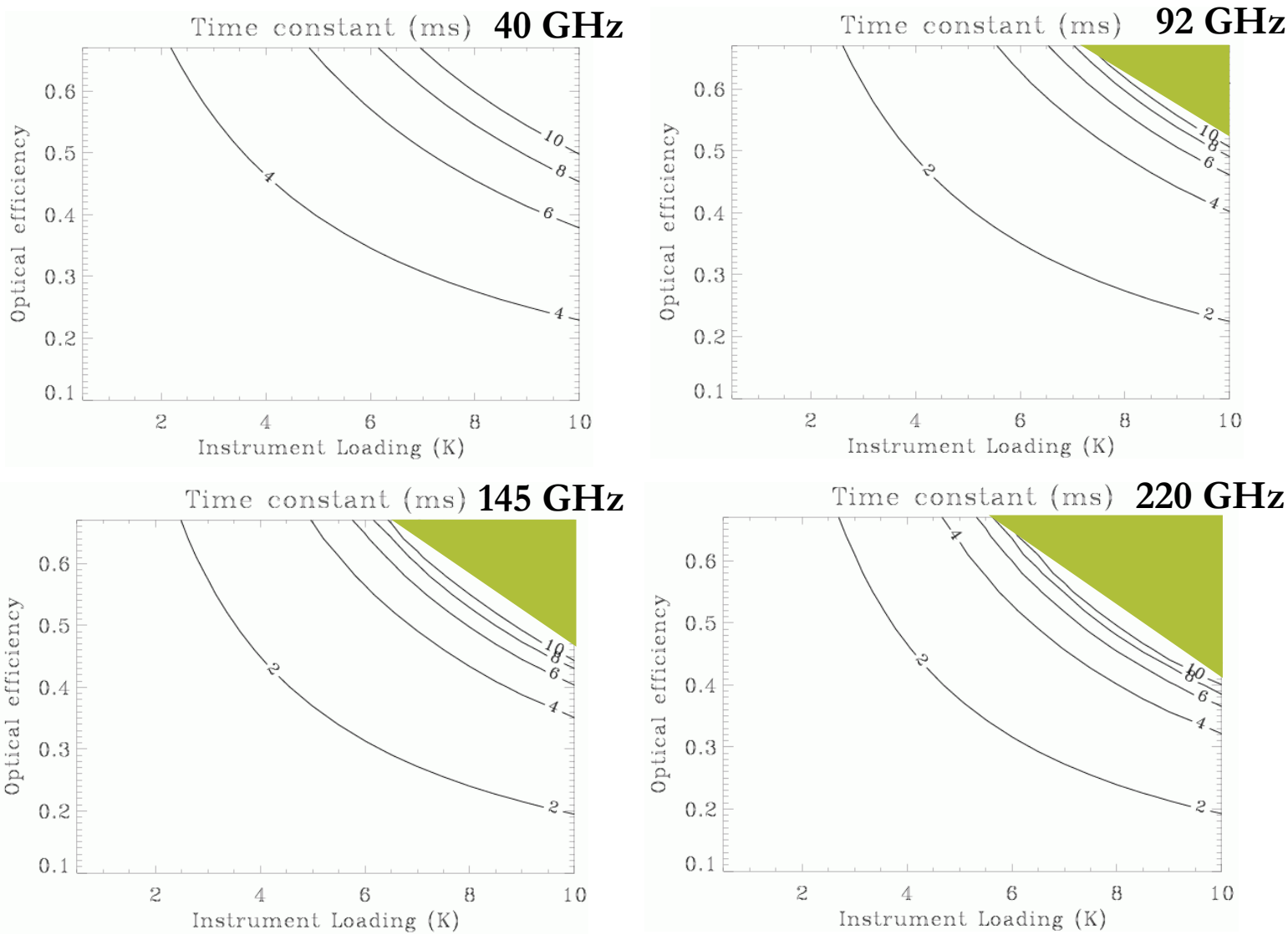
Calculated for $T_{instrument}$=5 K, h=30%, a=100
MUX noise negligible if $R_{TES} \leq 0.1$ W

SPIDER Sensitivity (III)



Calculated for $T_{instrument}$=2 K, h=40%, a=100

SPIDER time constants



Calculated for $T_{instrument}$=2 K, h=40%, a=100