SAT and LAT Designs and Considerations

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SAT design and considerations

Goals:

- ~ double white-noise mapping speed per tube
  (relative to 2022 AoA Alt3 "scaled optics" SAT design),
  in order to make the number of tubes required, and the operation time, reasonable.

- keep atmosphere from spoiling P noise at relevant scales

- prevent systematics from corrupting data, or overly reducing good data fraction/sensitivity

SAT design

Increasing white noise mapping speed => smaller horns

- side effects include:
  - More spillover on cold aperture stop, need to control that power
  - larger edge taper on cold aperture stop, need to control that power
  - more detectors == more readout (heat+complexity+cost)
  - less optical efficiency => lower Psat detectors, lower NEPs

Beating the atmosphere => polarization modulation (eg HWP=Halfwave Plate)

- side effects include:
  - new systematics to consider
  - perhaps some improvements in old systematics

Beating systematics => ?

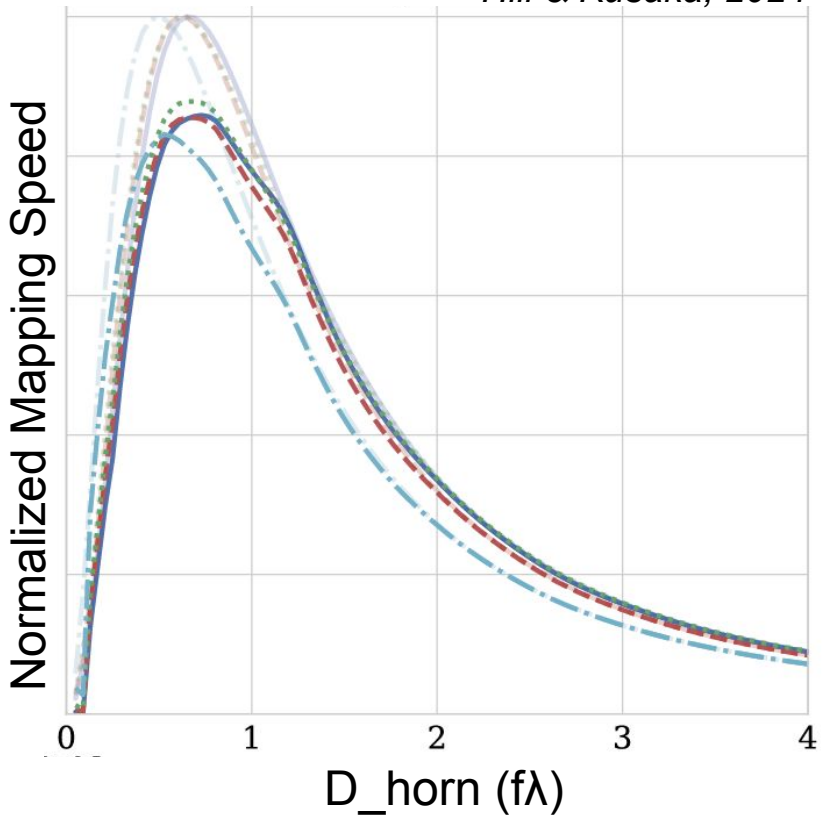
- Need to think anew about shielding, sun/moon avoidance, thermal variations, time constants/etc…

SAT design

Increasing white noise
mapping speed =>

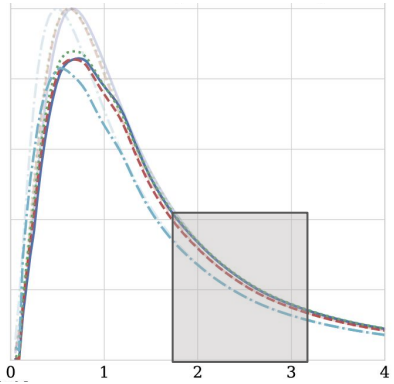
smaller horns

Hill & Kusaka, 2024



SAT design

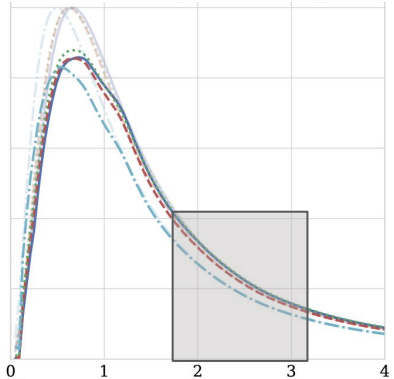
Increasing white noise mapping speed => smaller horns

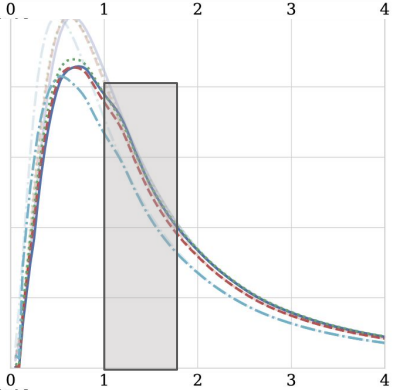


	LF		MF1		MF2		HF	
Band center (GHz)	24.75	36.5	85	145	95	155	227	285.5
Lambda_center (mm)	12.1	8.2	3.5	2.1	3.2	1.9	1.32	1.05
Old Design (2022 AoA)								
f-number	1.45							
Horn diameter (mm)	30.7	30.7	9.35	9.35	8.79	8.79	5.05	5.05
Horn diameter (f-lambda)	1.75	2.58	1.83	3.12	1.92	3.13	2.64	3.31
Cold stop efficiency	0.86	0.92	0.84	0.93	0.86	0.92	0.93	0.97

SAT design

Increasing white noise mapping speed => smaller horns





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Cold stop efficiency	0.86	0.92	0.84	0.93	0.86	0.92	0.93	0.97
"Max mapping speed"								
f-number	1.85							
Horn diameter (mm)	19.0	19.0	5.05	5.05	5.05	5.05	5.05	5.05
Horn diameter (f-lambda)	1.08	1.59	0.99	1.68	1.10	1.80	2.64	3.31
Cold stop efficiency	0.3	0.63	0.27	0.6	0.32	0.65	0.88	0.92

SAT design - "max mapping speed estimates"

2022 AoA had "scaled down optics tubes" with reduced FPU size; this put an additional penalty on detector count. Thus, here we see even greater mapping speed improvements than predicted from the previous plots.

GHz	S4_max+HWP, Atacama, pwv = 993 u, elev = 50	(max/scaled_optics) ms_ratio
25	LF_1	1.37
36	LF_2	5.12
85	MF_1_1	2.06
95	MF_2_1	2.07
145	MF_1_2	3.86
155	MF_2_2	3.51
227	HF_1	1.64
285	HF_2	1.61

More details here:
https://docs.google.com/spreadsheets/d/1IQkLHaHVXY3PYwOX8wwmGBYgh3uDkrNFeum5Wnx9UVg/edit?usp=sharing

SAT design - implcations/side-effects of smaller horns

- Different relative mapping speeds in dichroic paired channels; how does this affect optimal tube distribution? Should we build some 150/220 tubes?

- Potential systematics:
  - LF/MF: More spillover on cold aperture stop, need to control that power
  - LF/MF: larger illumination of cold aperture stop rim, need to control that power

- Less optical efficiency in LF/MF =>
  - lower optical power => lower Psats and lower NEPs

- Closer packing of beams on sky => possibly more correlated atmosphere

- Higher channel count per wafer => more readout, more data volume

SAT design - other issues

1:30pm breakout tomorrow: "Chile SAT Design and Considerations" [Conveners: Kovac and McMahon]

Beating the atmosphere:

- How well do polarization modulators work?
  - *[See upcoming talks by Adrian Lee and Yunyang Li]*
- Do we know we need them?
- Polarized atmospheric noise ("Q noise")
  - *[See the upcoming talk by Anna Coerver]*

Beating systematics:

- HWP-induced systematics
- What beam/sidelobe systematics, if any, do they improve?
- ?

LAT designs and considerations

We have two LAT designs, and need at least 3 LATs.
We have two survey types: "wide Neff/legacy" and "deep for delensing".

Question: Should all LATs be of the same design, or are there significant benefits of bespoke designs for those surveys? *Per-detector mapping speeds are nearly identical.*

CD-LAT:

- 6m => better angular resolution, better for "wide/Neff"
- panel gaps => more sidelobe issues
- image quality => concentrate higher frequencies at center of FOV
- (quasi) boresight rotation

TMA-LAT:

- 5m, fine for delensing
- no panel gaps
- better image quality, no restrictions on where to put high frequency tubes
- (limited, true) boresight rotation