

System

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Outline

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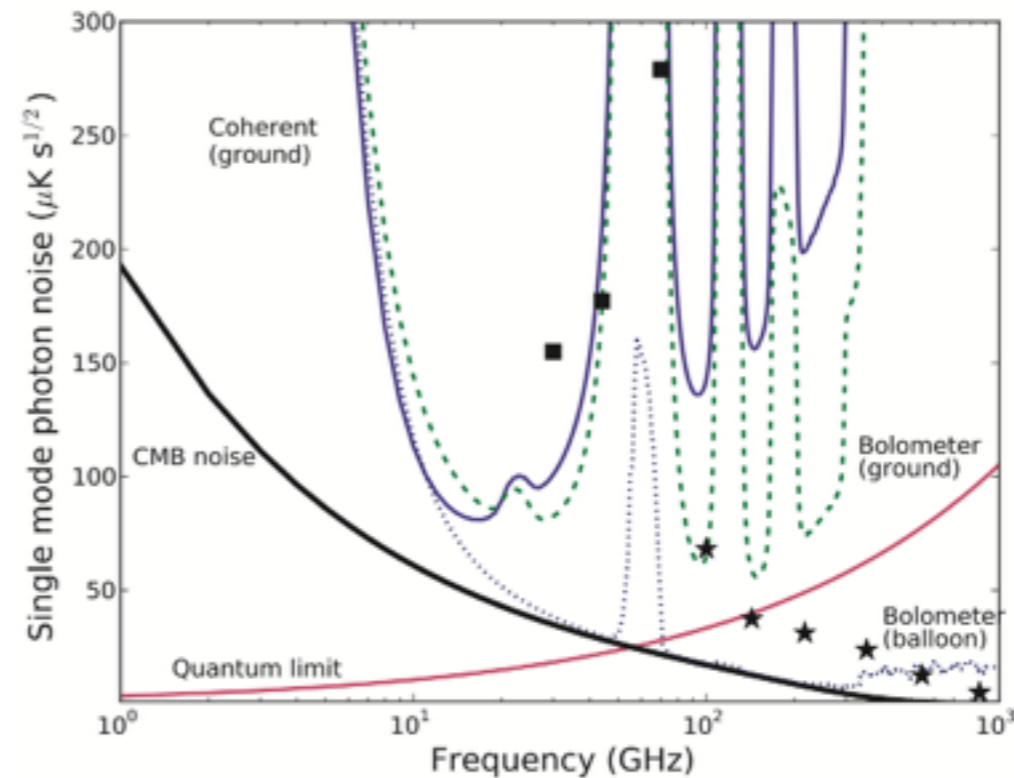
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Different classes of instruments

- The aperture size impacts the angular resolution, hence the science that can be addressed.
- Balloons and satellites are limited to $\sim 3\text{m}$ primaries, ie 3arcmin at 100GHz .
- Recap on pros and cons of ground based observatories, satellites and balloons:
 - atmosphere, sensitivity, mission duration, power, maintenance...

Strategy over 10 years

- Working towards a long term satellite or replicating flights or telescope on a short time scale ?

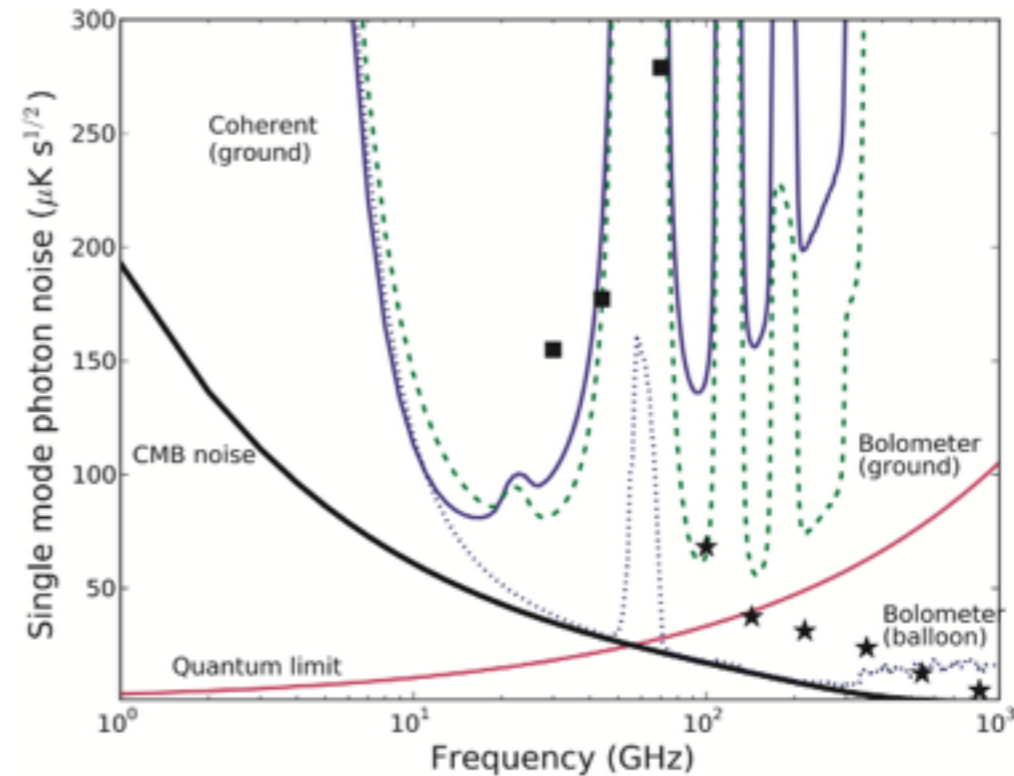


	Balloon	Ground Based Telescope	Satellite	25 Ground Based Telescopes
150 GHz				
2 weeks	100	500	100	100
1 year	100	100	20	20
5 years	60	40	9	9
10 years	40	30	6	6
280 GHz				
2 weeks	100	3000	100	600
1 year	100	600	20	100
5 years	60	300	9	50
10 years	40	200	6	40

Table 1: Comparison of noise integration versus time for ground, balloon, satellite and massively replicated ground telescopes at a typical CMB frequency (150 GHz) and a dust frequency (280 GHz). We here assume that the virtual focal planes of these instruments are the same and vary only the atmospheric noise and the integration time. This table takes 100 as a reference number describing sensitivity for a two week balloon experiment. It assumes that noise integrates like $1/\sqrt{t}$ and that a balloon can have at most one flight every two years. Relative noise at 150 GHz and 280 GHz are scaled from Fig. 16 (Hanany et al. 2013).

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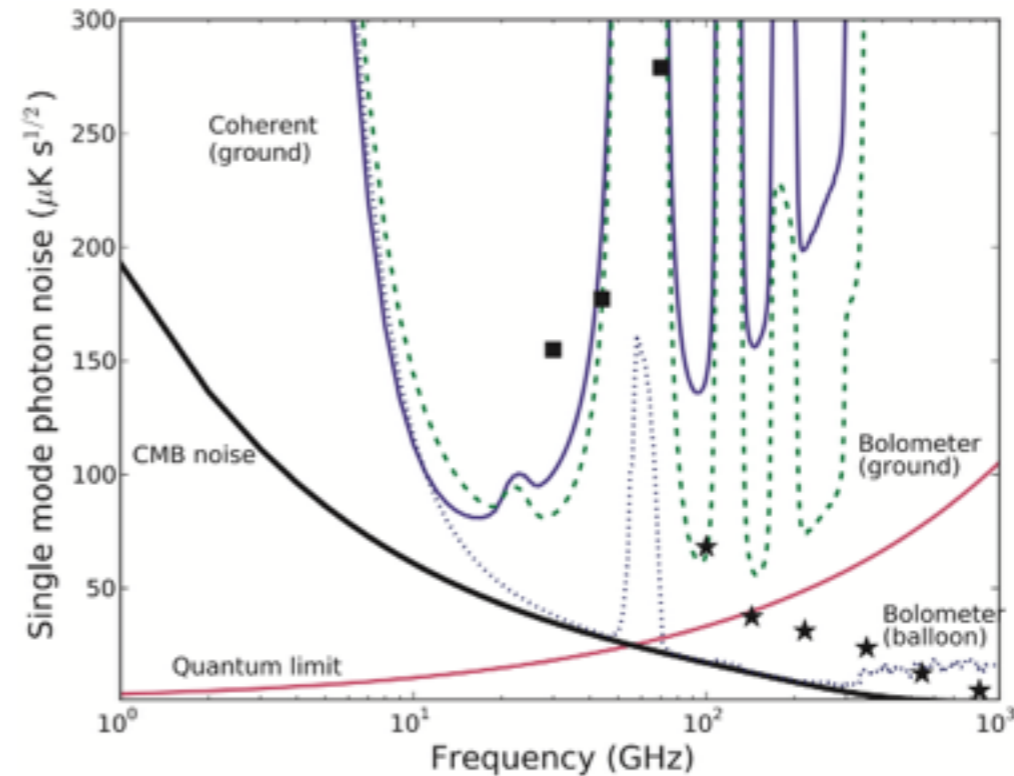


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- Over 10 years:
 - 150GHz: 25 GBT are competitive (S4)

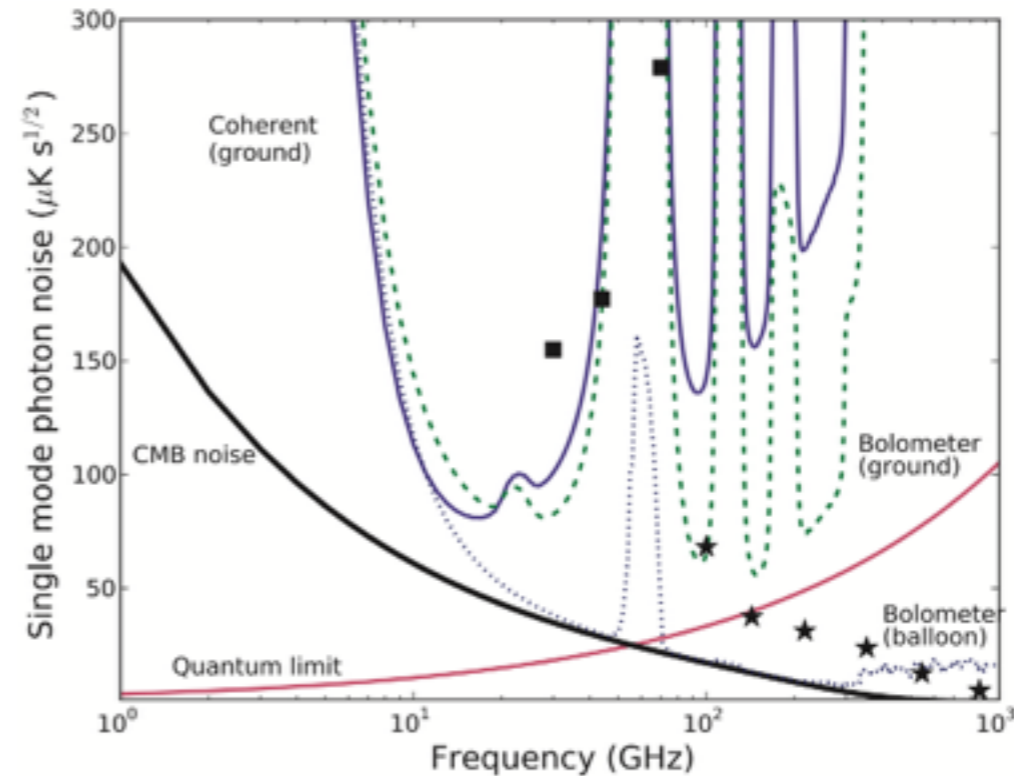


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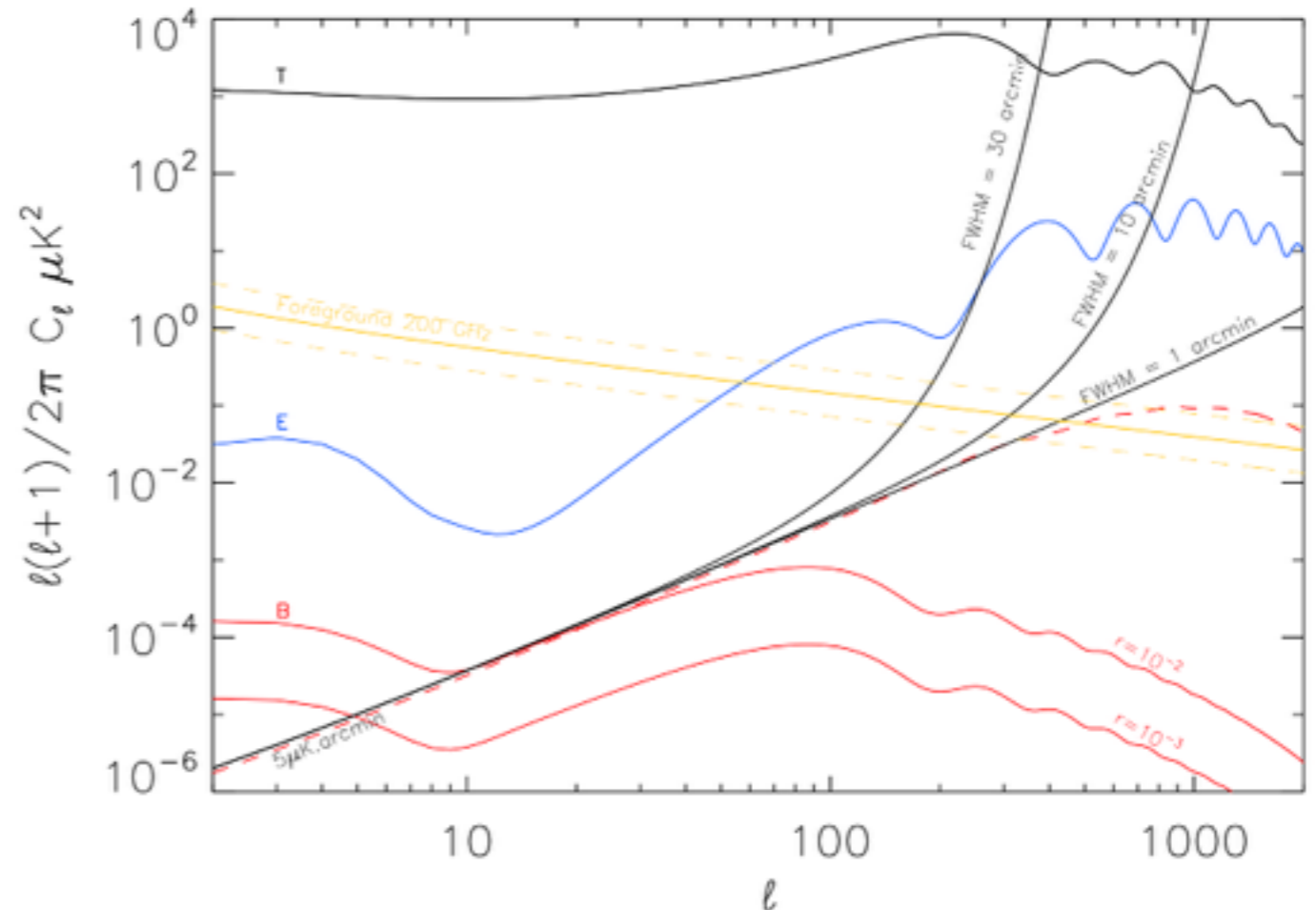
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Focal plane unit

- Measure of polarization:
 - polarization at the detector level
 - use of an analyzer
 - modulation w/o rotating Half Wave Plate (step/continuous)
- Wavelength coverage
 - filters / multichroic detectors / spectrometers
- Sensitivity and optical coupling
 - horns / filled arrays / multiplexing

Systematic effects (1/2)

- Depending on the r target and the observed angular scales, what are the bare requirements in terms of systematics rejection ?
- + beam asymmetry
- + diff. pointing...

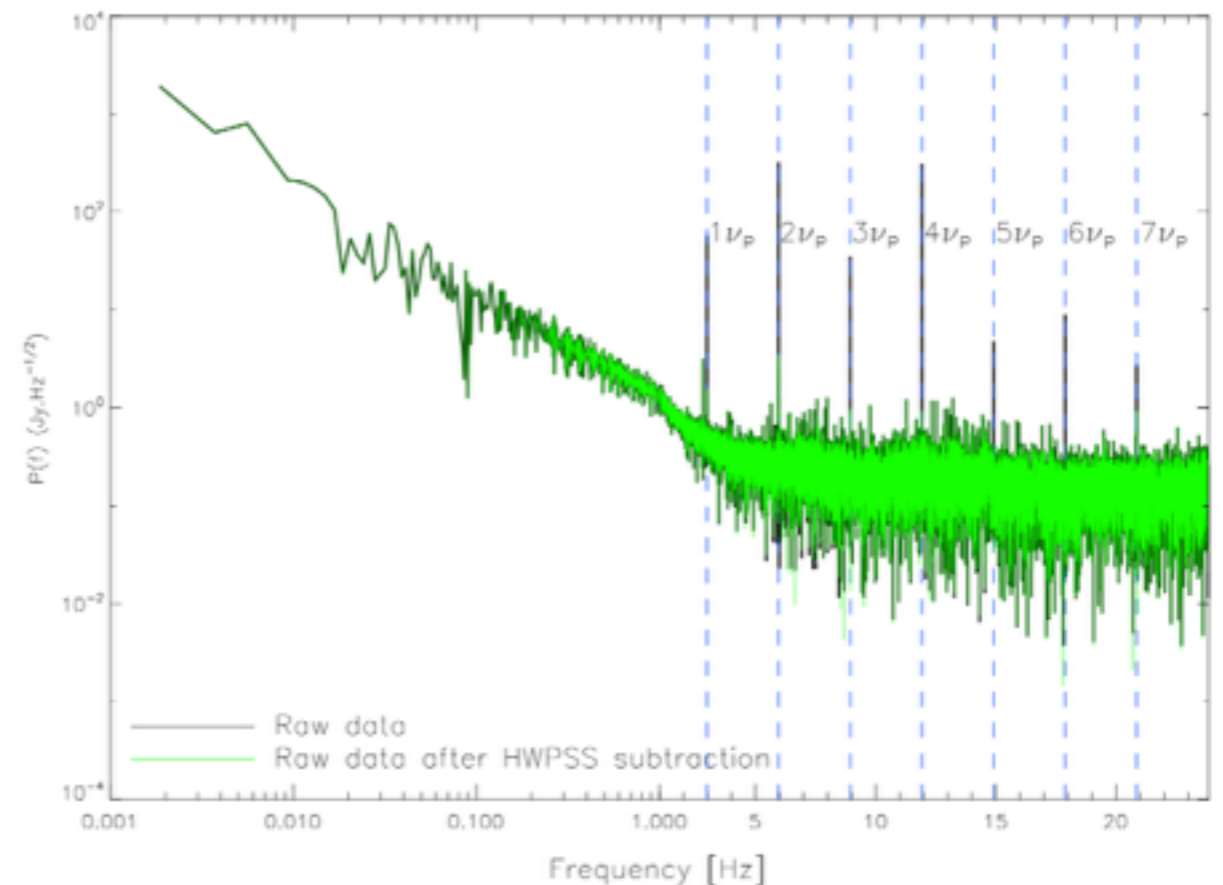
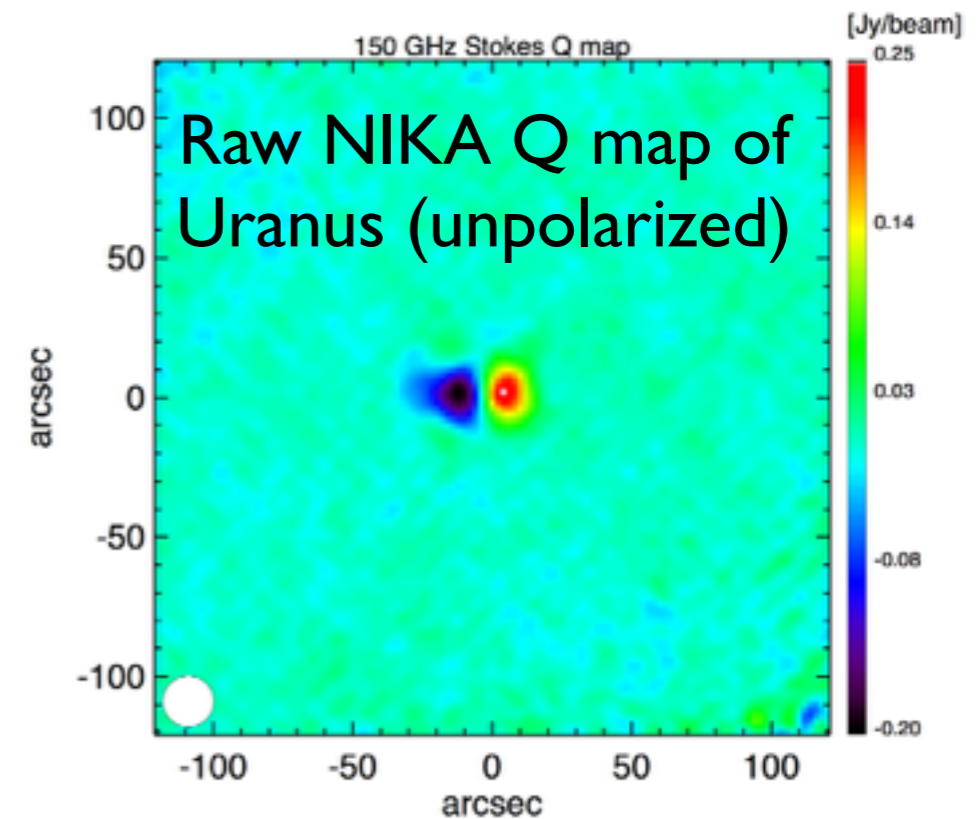


	$\ell = 3$		$\ell = 80$	
	$r = 10^{-2}$	$r = 10^{-3}$	$r = 10^{-2}$	$r = 10^{-3}$
I to Q, U	1.2×10^{-4}	3.7×10^{-5}	1.8×10^{-4}	5.8×10^{-5}
Q, U mixing (deg)	0.575	0.182	0.356	0.113
Foregrounds residuals (200GHz)	0.003	0.001	0.022	0.007
Lensing residuals	-	0.663	0.201	0.063

Systematic effects (2/2)

- « Leakage »
 - bandpass mismatch
 - optical leakage (BICEP, QUAD, NIKA, PILOT...)

- HWP Synchronous Signal (Maxipol, EBEX, NIKA)



Conclusion

- High resolution belongs to G. B. Telescopes
- High sensitivity belongs to BSO and satellites, in particular at high frequencies
- S4 is competitive with a satellite on a 10 year timescale at 150GHz
- « classic » and « new » systematics need to be controlled to exquisite levels
- Fourier Transform Spectrometers are the most suited to CMB spectrum measurements
- Recommendation: develop optical simulations of integrated instruments