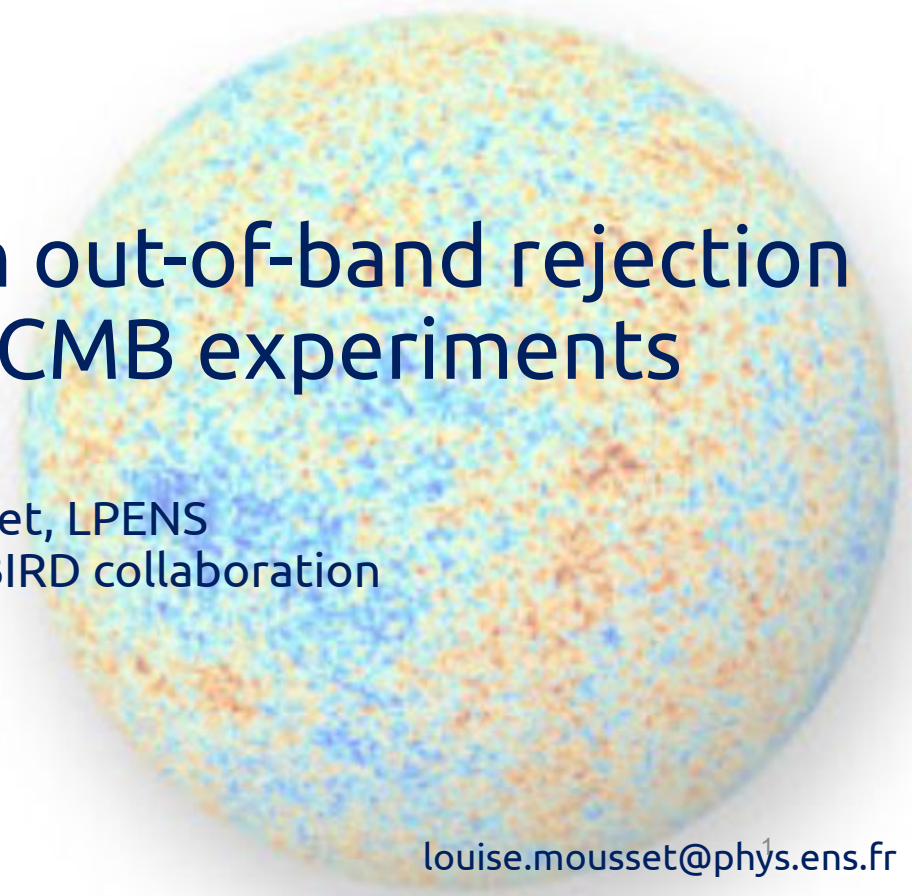
# Setting requirements on out-of-band rejection for next generation CMB experiments



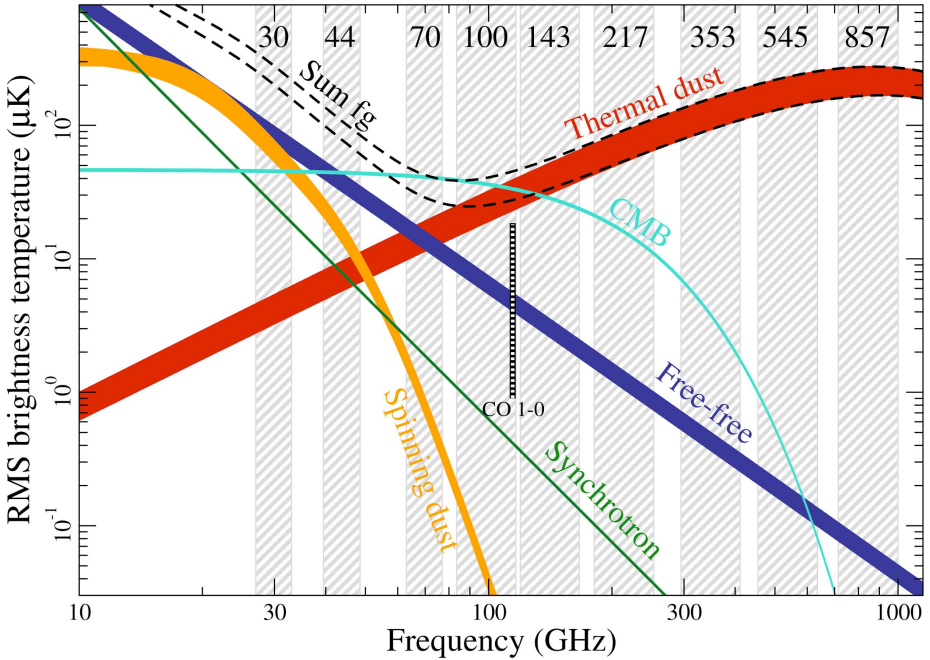
Louise Mousset, LPENS
on behalf of the LiteBIRD collaboration

louise.mousset@phys.ens.fr

# Objective

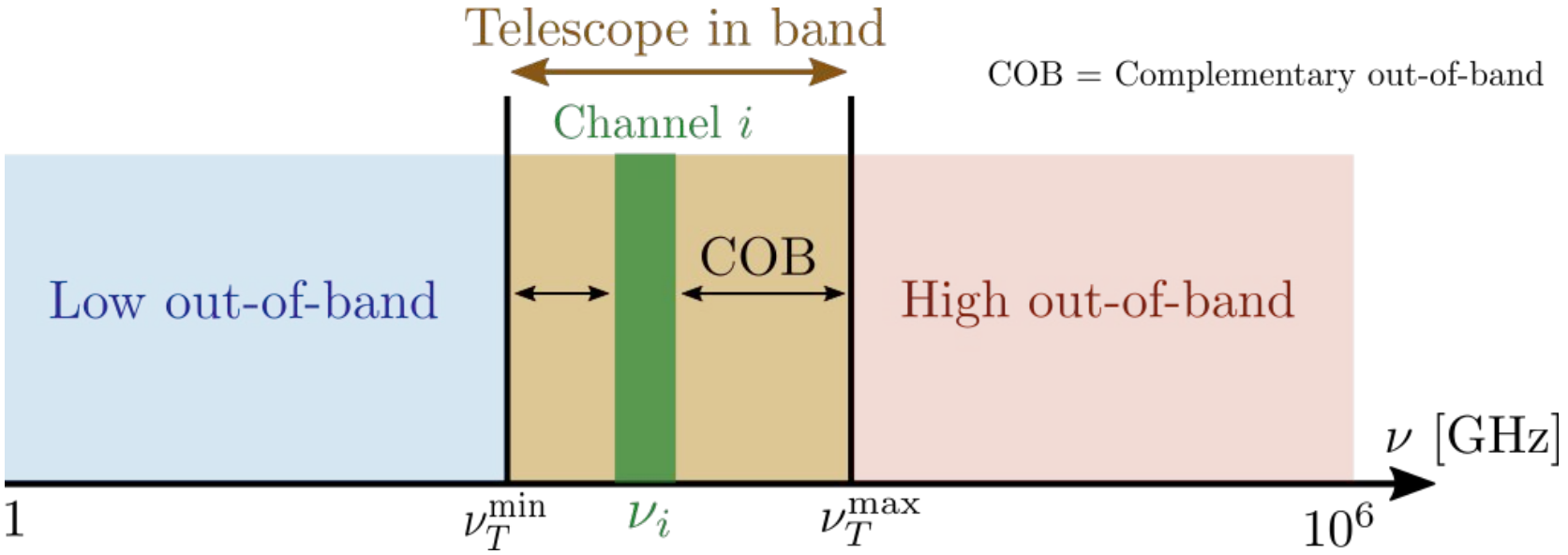
We observe the CMB among many astrophysical foregrounds.

How to define the instrument bandpass and the **filtering scheme** ?



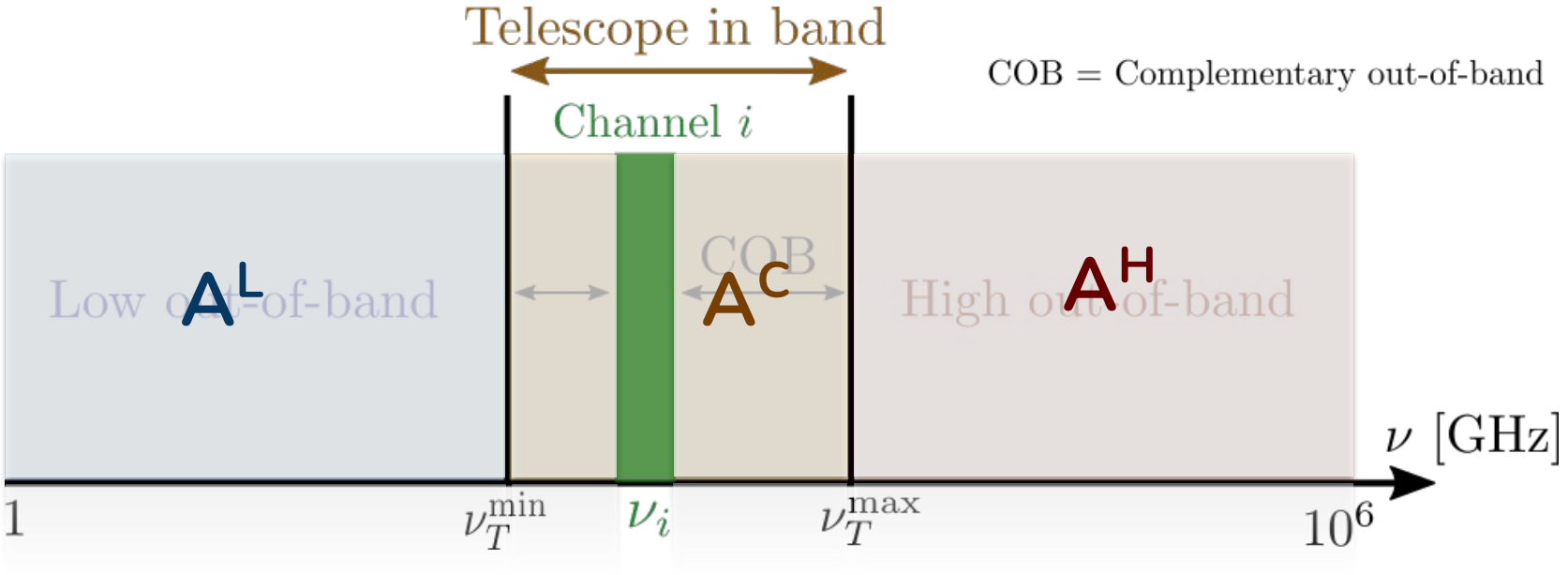

# Definitions and assumptions

We consider frequencies from 1 to $10^6$ GHz split in several domains.

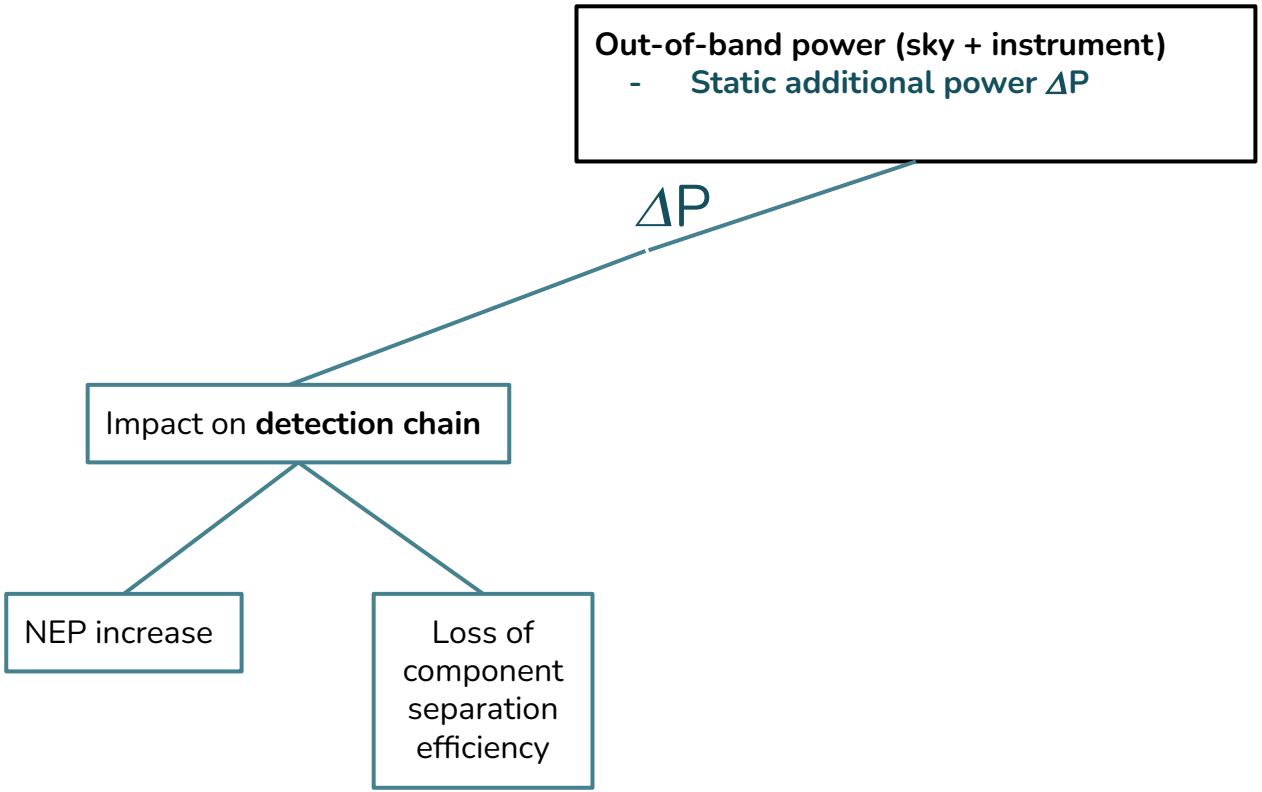


# Definitions and assumptions

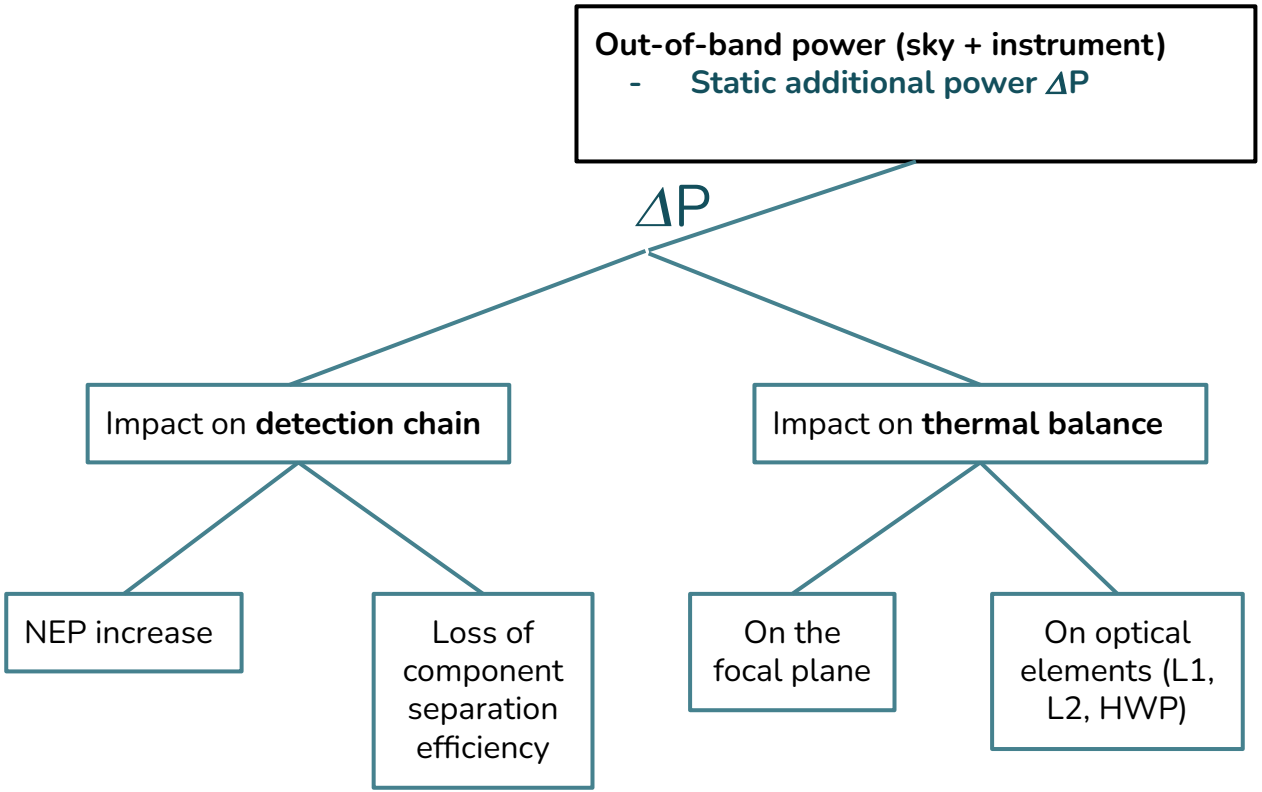
The goal is to constrain the **attenuation factors** $A^L$, $A^C$ and $A^H$, assumed to be constant in each domain.



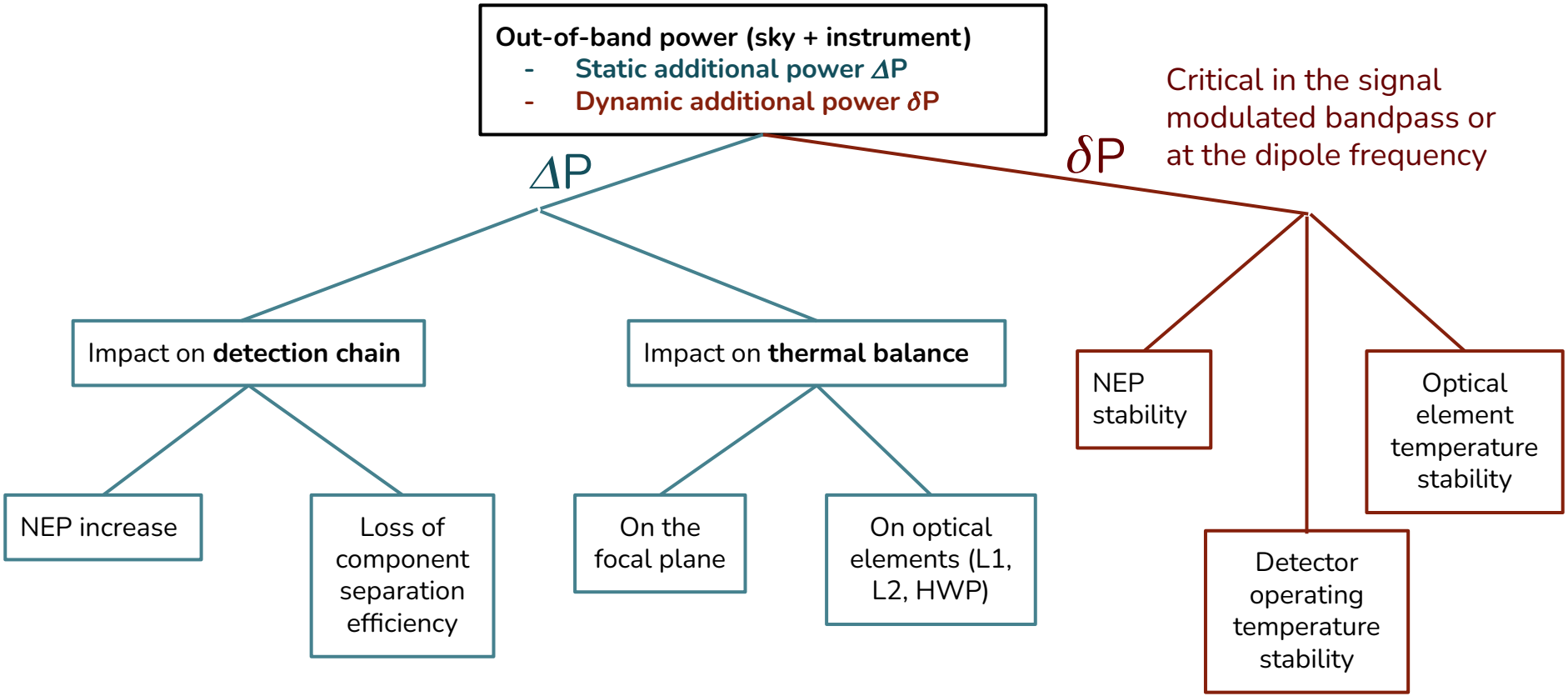
# Impact of out-of-band power



# Impact of out-of-band power



# Impact of out-of-band power



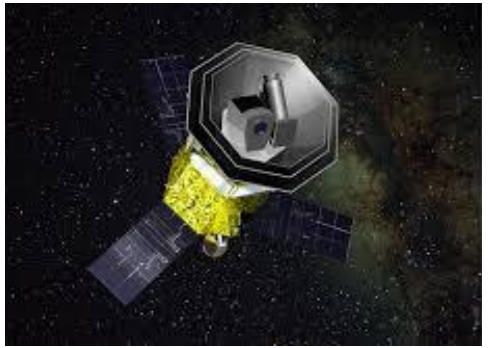
# Methodology

Main scientific driver:

$$\delta r < 0.001$$

?

Instrumental design



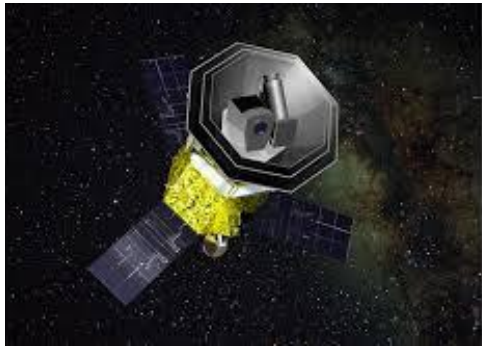
# Methodology

Main scientific driver:

$$\delta r < 0.001$$

?

Instrumental design



Assumptions on $A^L$, $A^C$, $A^H$
Sky model
Instrument model

Performance code

Performance forecasts:
- detector sensitivity
- thermal balance
- uncertainty on r

Requirements on $A^L$, $A^C$, $A^H$

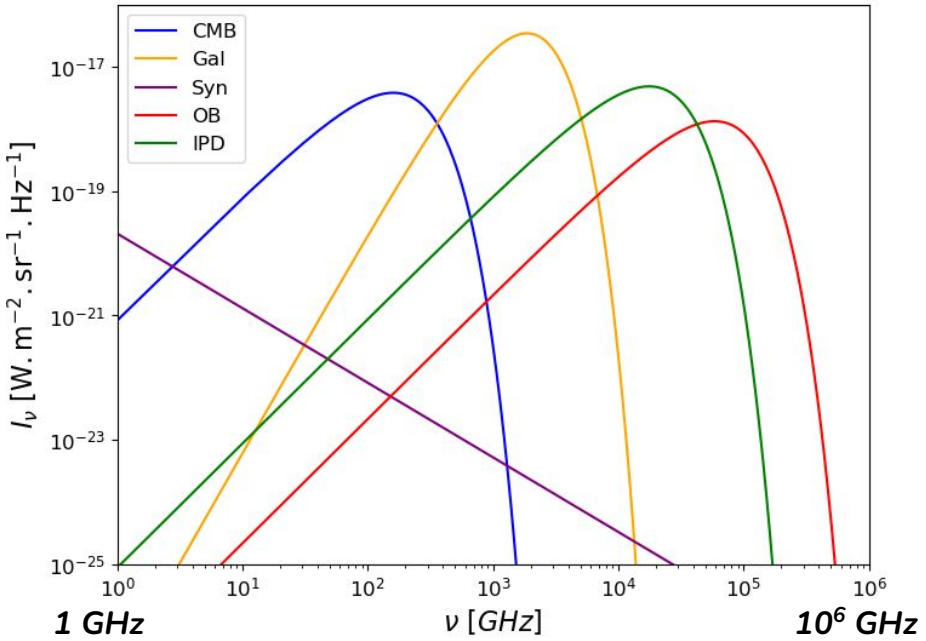
# Sky modelling

We consider 5 components :

- CMB
- Thermal Galactic dust emission
- Synchrotron emission
- Interplanetary dust (IPD)
- O and B stars

The SED amplitudes are scaled on available measurements taking into account the beam of the instrument.

**Spectral radiance [W/m$^2$/sr/Hz]**
**(example for a 1° beam)**



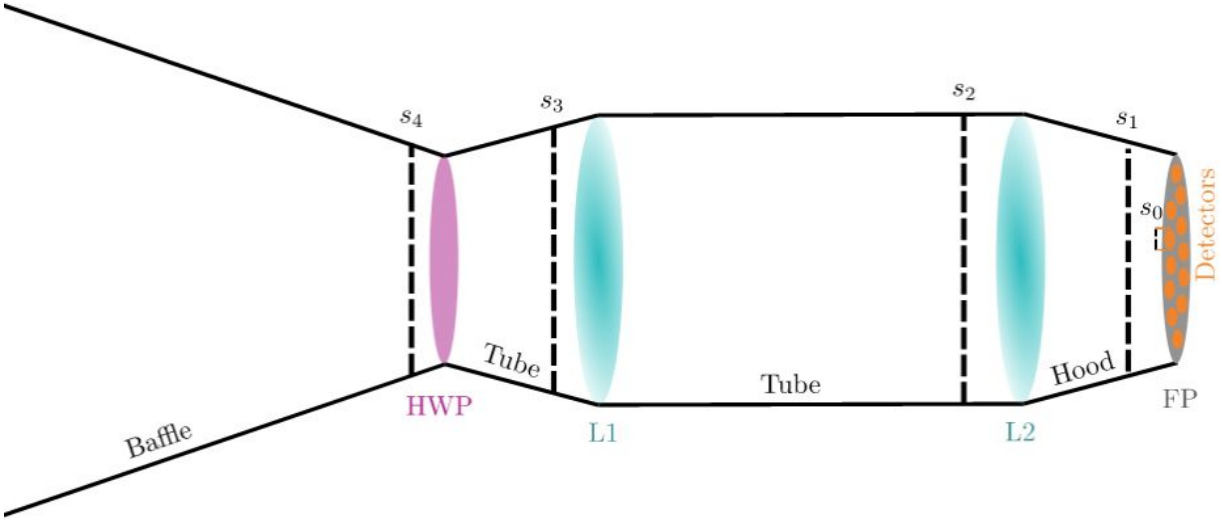
# Simple refractive design

Mechanical and optical elements:

- Two lenses L1 and L2
- One half-wave plate (HWP)
- A focal plane (FP) paved with detectors
- Baffle + Tube + Hood
- Hypothetical filters at positions s0 (on-chip), s1, s2, s3, s4

Cryogenic systems not modeled

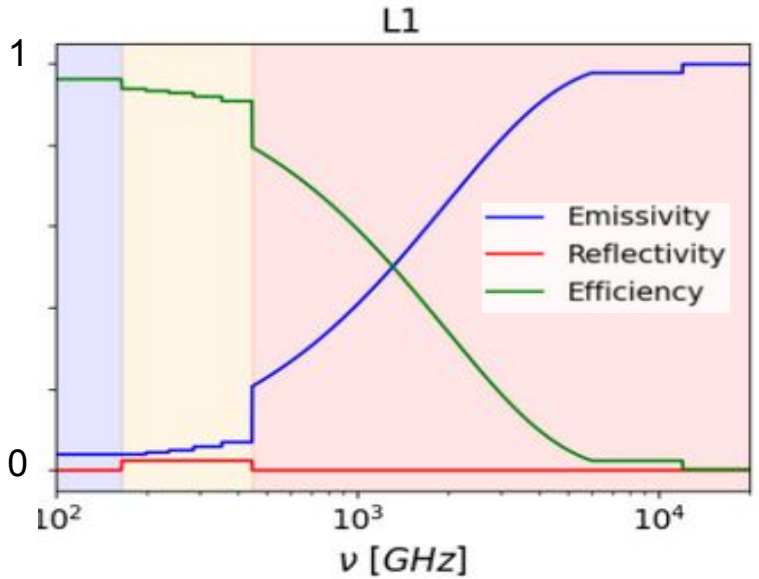
Instrumental emission => Black body at the element temperature



# Optical model

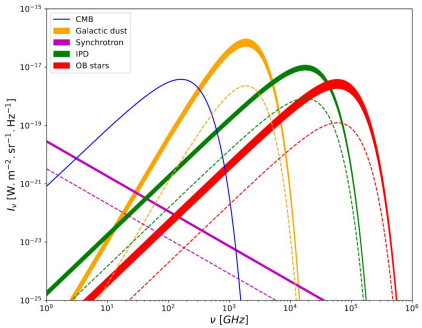
Each optical element is modeled in terms of emissivity, reflectivity and efficiency such as

$$E(\nu) + R(\nu) + \varepsilon(\nu) = 1$$

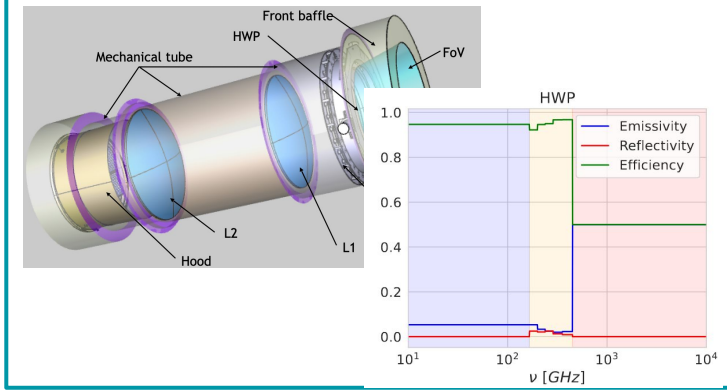


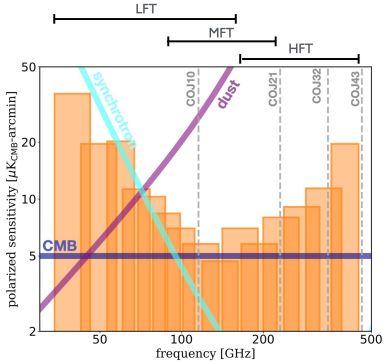
# Performance code overview

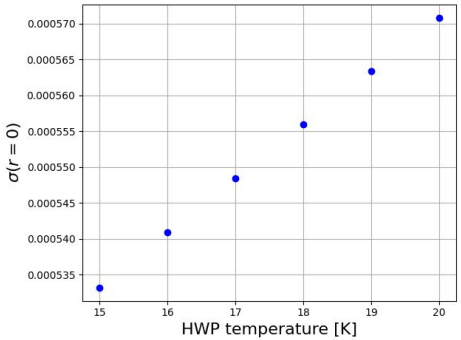
Sky model




Instrument model



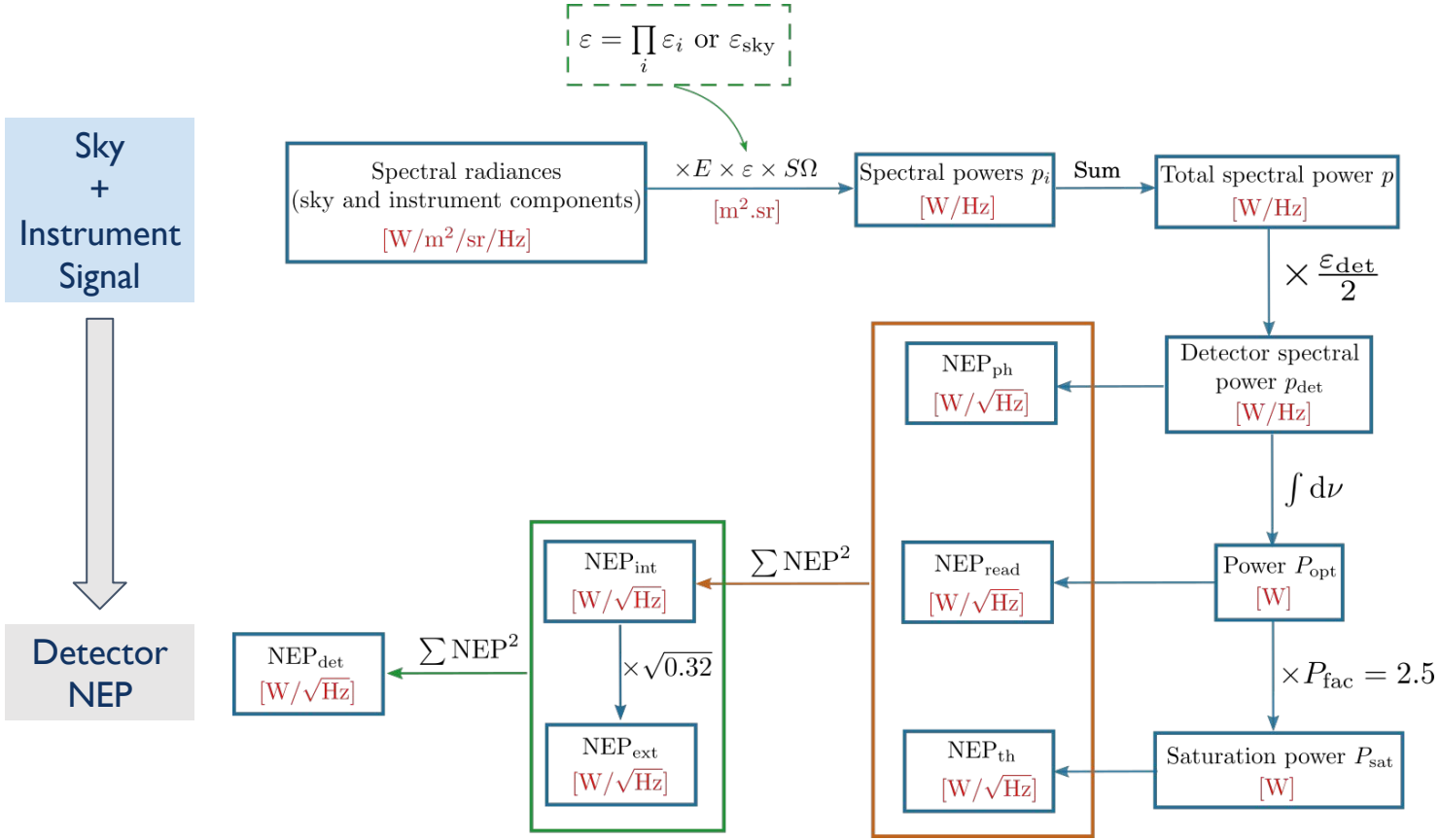




Sensitivities [μK-arcmin]

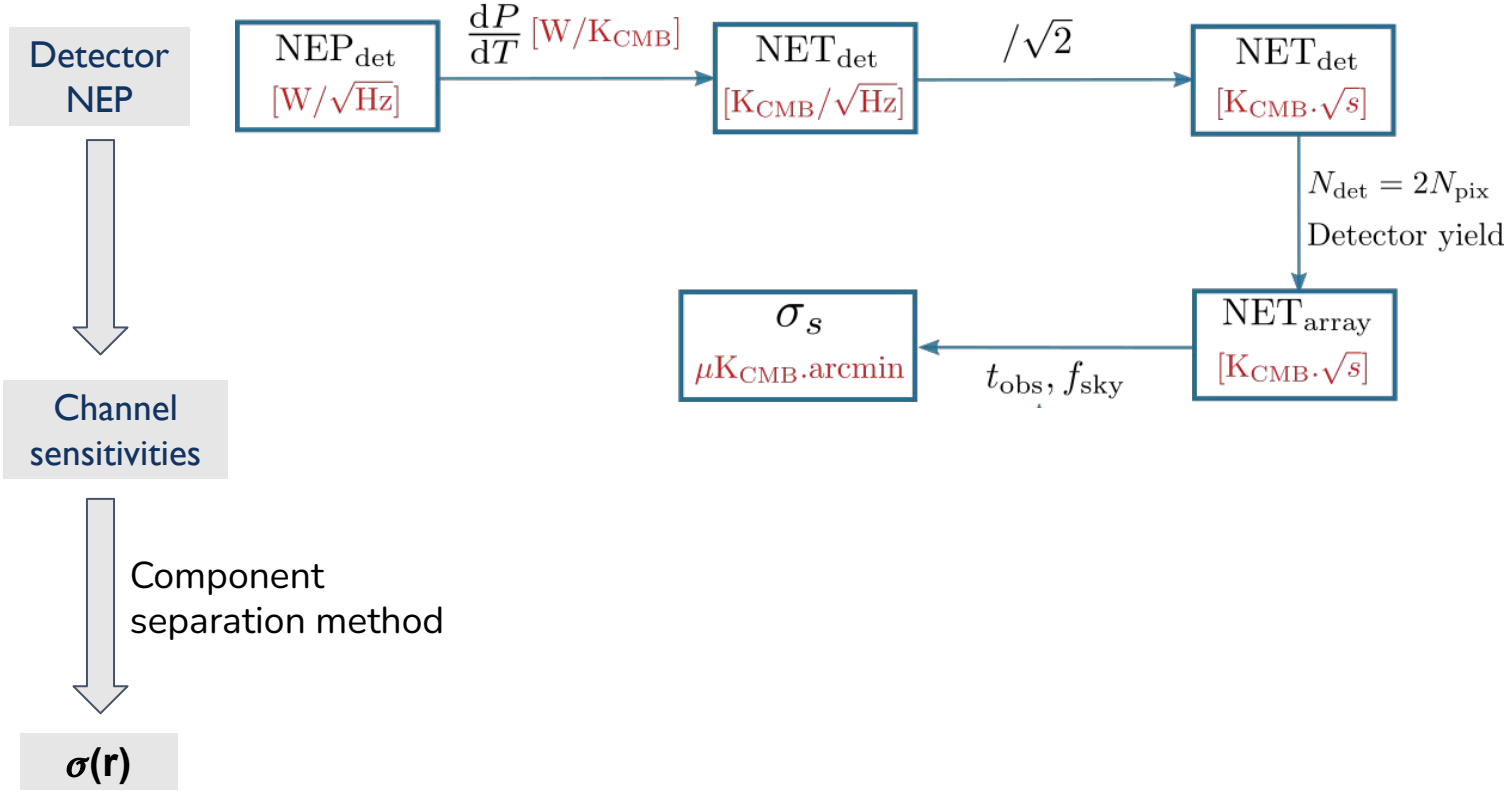
$\sigma(r)$

**Performance computation**

# Performance code: detector NEP computation

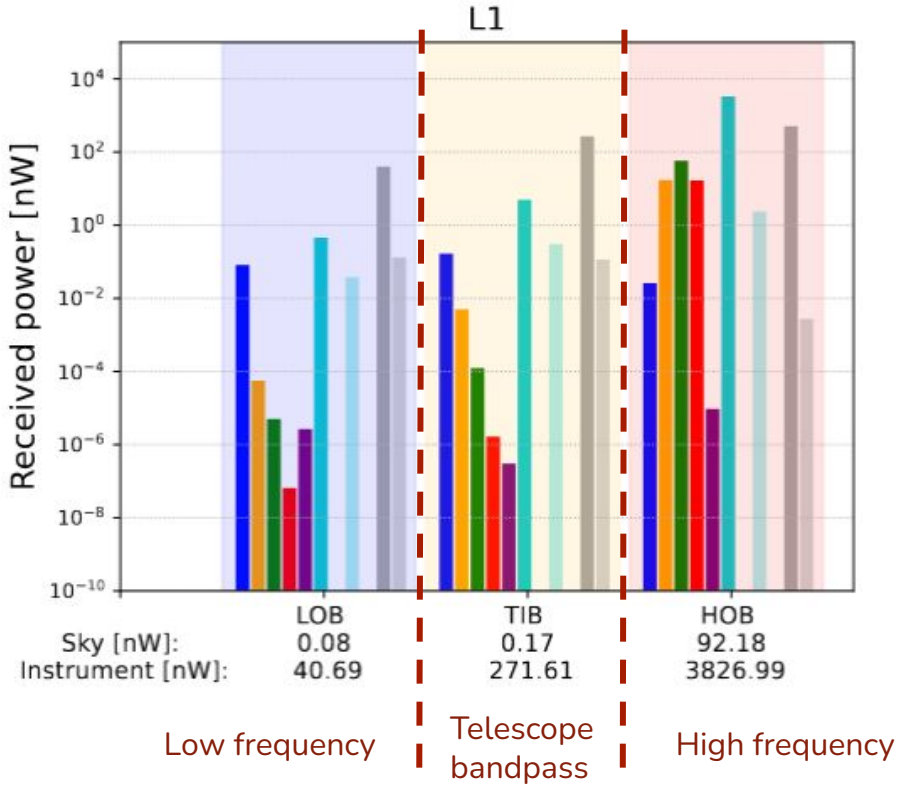


# Performance code: channel sensitivities and $\sigma$(r)

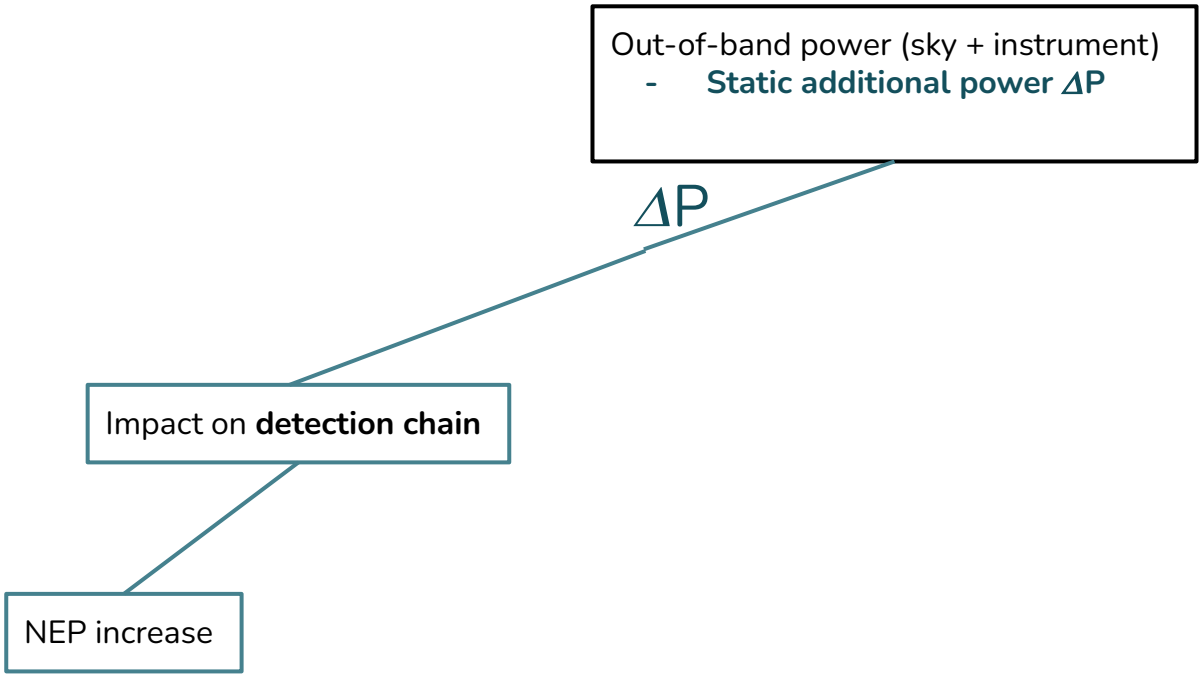


# Performance code: thermal balance control

**Radiative heat load on L1 from sky and instrument components :**

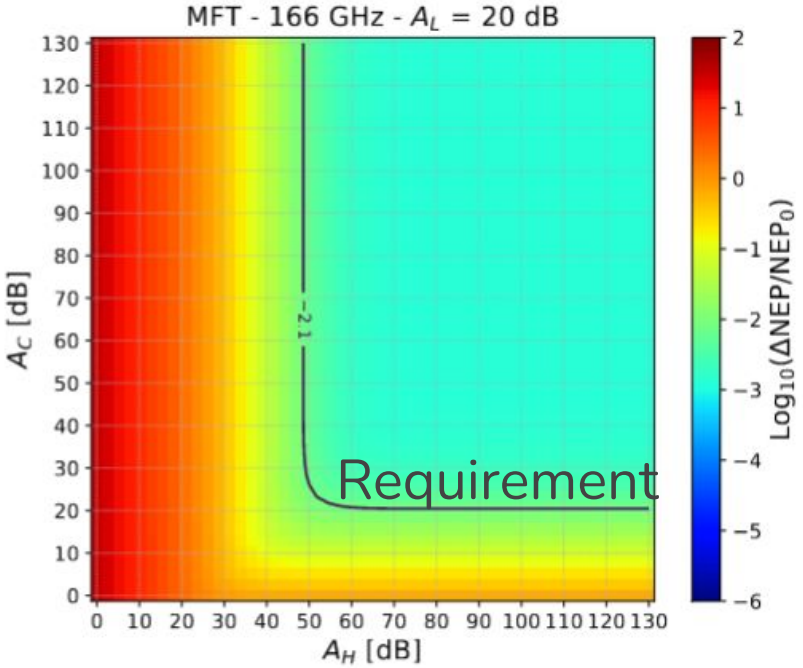



# Impact of out-of-band power



# Additional NEP and corresponding requirements

$$\delta r < 0.001 \longrightarrow \Delta\mathrm{NEP} \leq 0.14\,\mathrm{aW}/\sqrt{\mathrm{Hz}}$$




Reference NEP with no out-of-band power

Requirements on $A_L$, $A_C$ and $A_H$

# Summary

- I presented a general approach to set requirements on out-of-band rejection level for a CMB instrument.

- This method was applied to the LiteBIRD instrument design and the results will be published in a paper.

- This work was accompanied by the development of the performance code for the instrument, now available within the collaboration and still in development.

*Thank you for your attention !*

*Backup slides*

# Noise budget allocation