The Role of LiteBIRD in the Age of Discovery

G. Galloni
on behalf of the
LiteBIRD Collaboration

GRaviCon 2026

APC
ASI
Berkeley UNIVERSITY OF CALIFORNIA
BERKELEY LAB
UNIVERSITÀ DEGLI STUDI DI MILANO BICOCCA
CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD
cea
Centre Pierre Binétruy CNRS • Berkeley
cnes
cnrs
CSA ASC Canada

CSIC Consejo Superior de Investigaciones Científicas
CSL CENTRE SPATIAL DE LIÈGE
ENS PSL
erc European Research Council Established by the European Commission
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EXCELENCIA SEVERO OCHOA
FAU FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG
Forskningsrådet The Research Council of Norway
GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

NASA Goddard Space Flight Center
GSSI GRAN SASSO SCIENCE INSTITUTE
INSTITUTO DE ASTROFISICA DE CANARIAS IAC
IAP
IAS Orsay
IFCA Instituto de Física de Cantabria
ifpU
IJCLab Irène Joliot-Curie Laboratoire de Physique des 2 Infinis

INFN
INAF ISTITUTO NAZIONALE DI ASTROFISICA
IPMU
IPNS 素粒子原子核研究所 Institute of Particle and Nuclear Studies
irap astrophysique & planétologie
JAXA
NASA Jet Propulsion Laboratory California Institute of Technology

NATIONAL INSTITUTE OF TECHNOLOGY KAGAWA COLLEGE 香川高専
KEK
KIPAC
Kobayashi-Maskawa Institute Nagoya University
LMU
LPSC GRENOBLE | MODANE

MAX-PLANCK-INSTITUT FÜR ASTROPHYSIK
McGill
Maynooth University National University of Ireland Maynooth
名古屋大学 NAGOYA UNIVERSITY
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NIST

Norwegian Directorate for Higher Education and Skills
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SSDC SPACE SCIENCE DATA CENTER
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UCL
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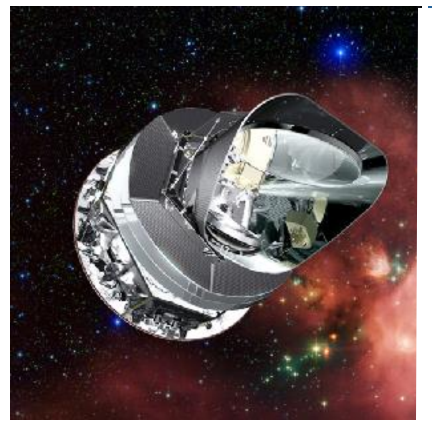
MANCHESTER 1824 The University of Manchester
UiO : University of Oslo
UNIVERSITY OF OXFORD
UNIVERSITÀ DI PISA
Università degli Studi di Ferrara
UNIVERSITÀ DEGLI STUDI DI MILANO
UNIVERSITÀ DEGLI STUDI DI PADOVA
THE UNIVERSITY OF TOKYO
UNIVERSITY OF TORONTO

LiteBIRD

LiteBIRD Joint Study Group

Around 400 researchers from **Japan**, **Europe** and **North America**

Team experience in CMB experiments, X-ray satellites and other large projects (ALMA, HEP experiments, …)

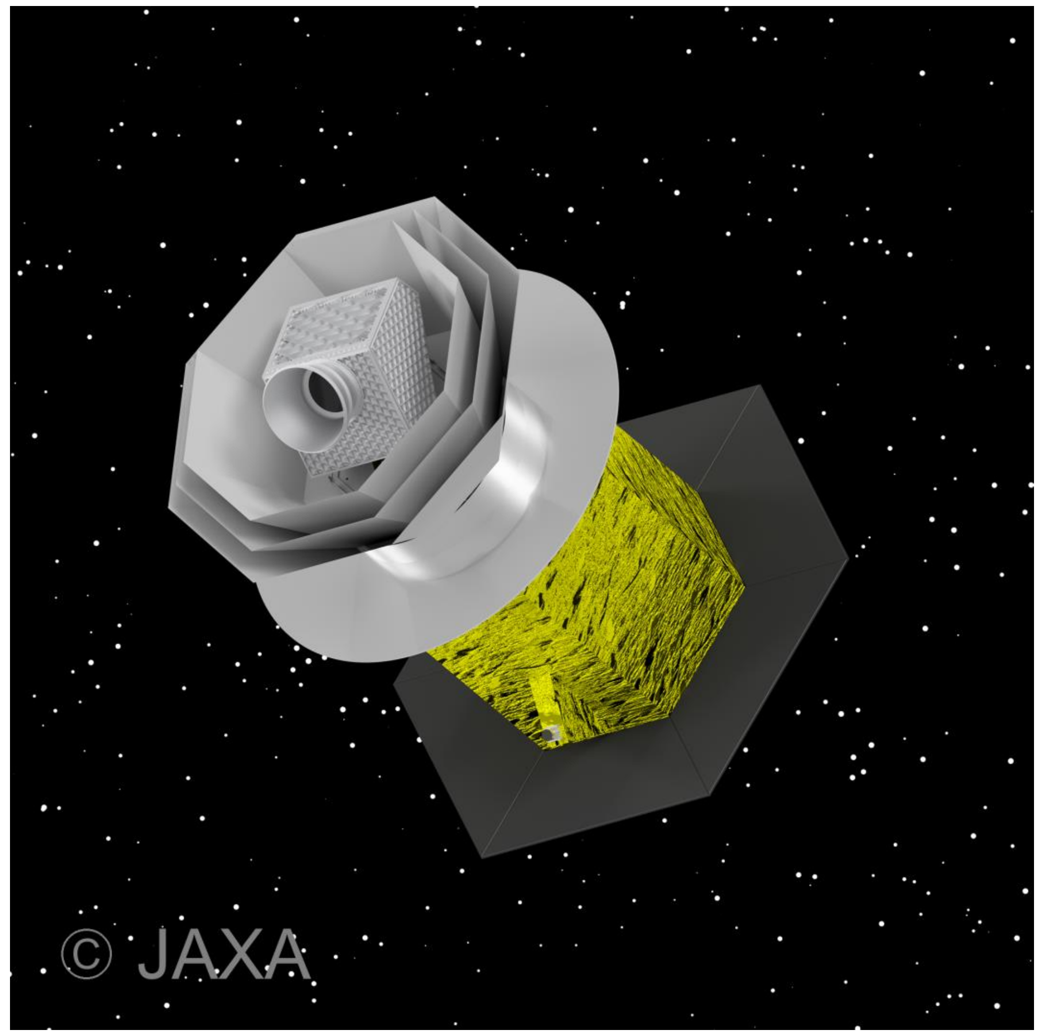


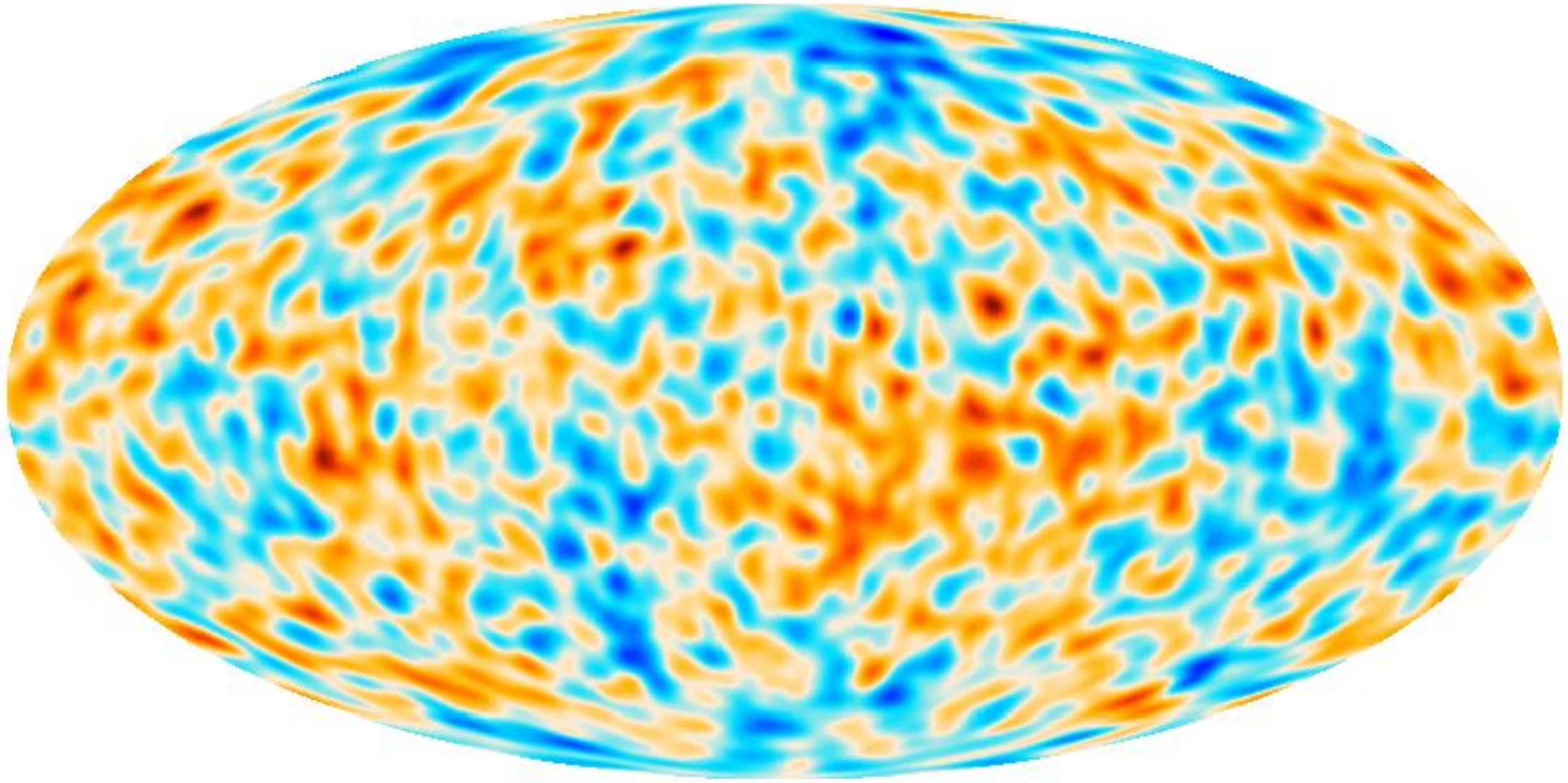
***LiteBIRD* Global F2F meeting**
Jan 26 - 30, 2026 at Kavli IPMU (Tokyo)

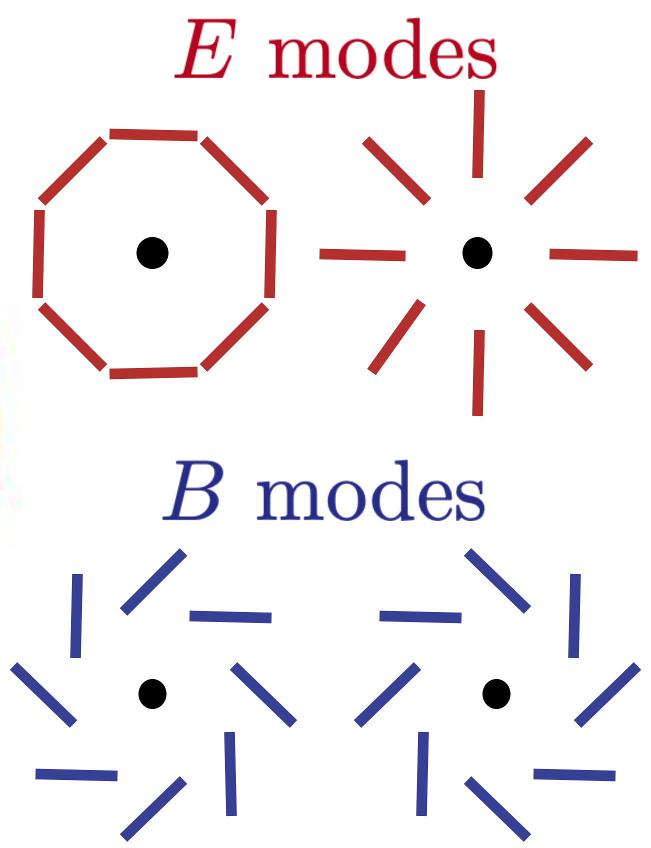
LiteBIRD overview

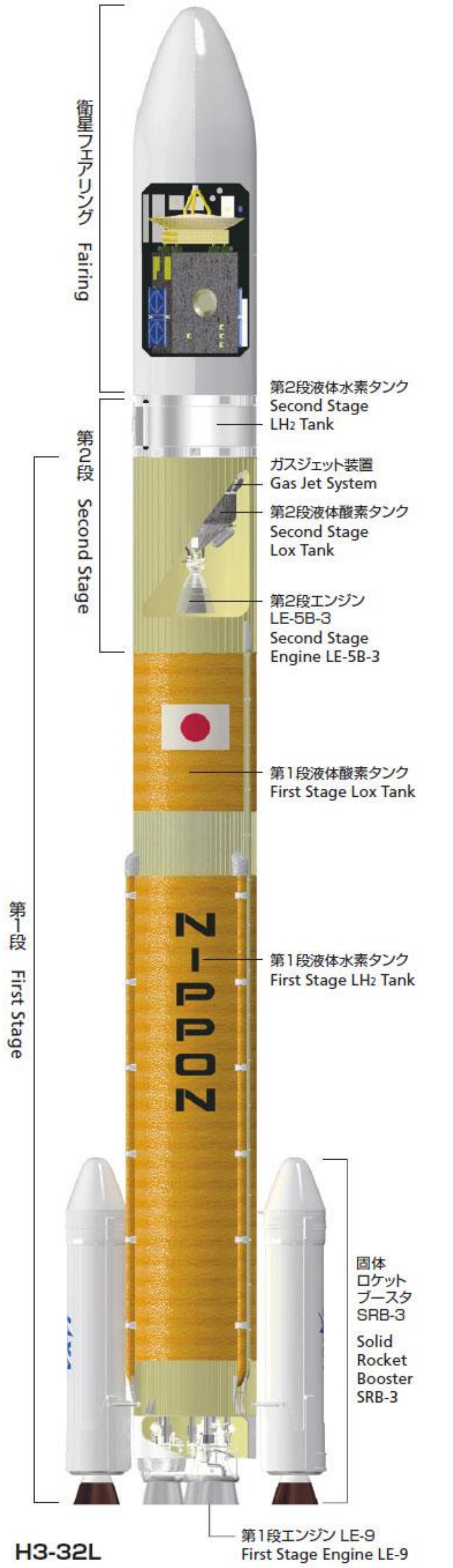
- Lite (Light) spacecraft for the study of *B*-mode polarization and Inflation from cosmic background Radiation Detection
- JAXA's L-class mission was selected in May 2019 to be launched by JAXA's H3 rocket on JFY2036
- Scientific goals: create all-sky, multi-band ultra-sensitive **microwave polarization maps**, test **inflationary models** through the measurements of **primordial gravitational waves**, and provide new insights into cosmology, particle physics and astrophysics
- **All-sky 3-year survey**, from Sun-Earth Lagrangian point L2
- Large frequency coverage (**40–402 GHz**) at **70–18 arcmin** angular resolution for precision measurements of the **CMB *B*-modes**
- Final combined sensitivity: **2.2 μK·arcmin**

LiteBIRD collaboration PTEP 2023









The challenge of B-modes detection

- The *B*-mode signal is expected to have an amplitude at least 3 orders of magnitude below the CMB temperature anisotropies
- *LiteBIRD* is targeting a sensitivity level in polarization ~30 times better than Planck
- This extremely good statistical uncertainty must go in parallel with exquisite control of:
  1. **Instrument systematic** uncertainties
  2. **Galactic foreground** contamination
  3. **“Lensing B-mode signal”** induced by gravitational lensing
  4. Observer biases

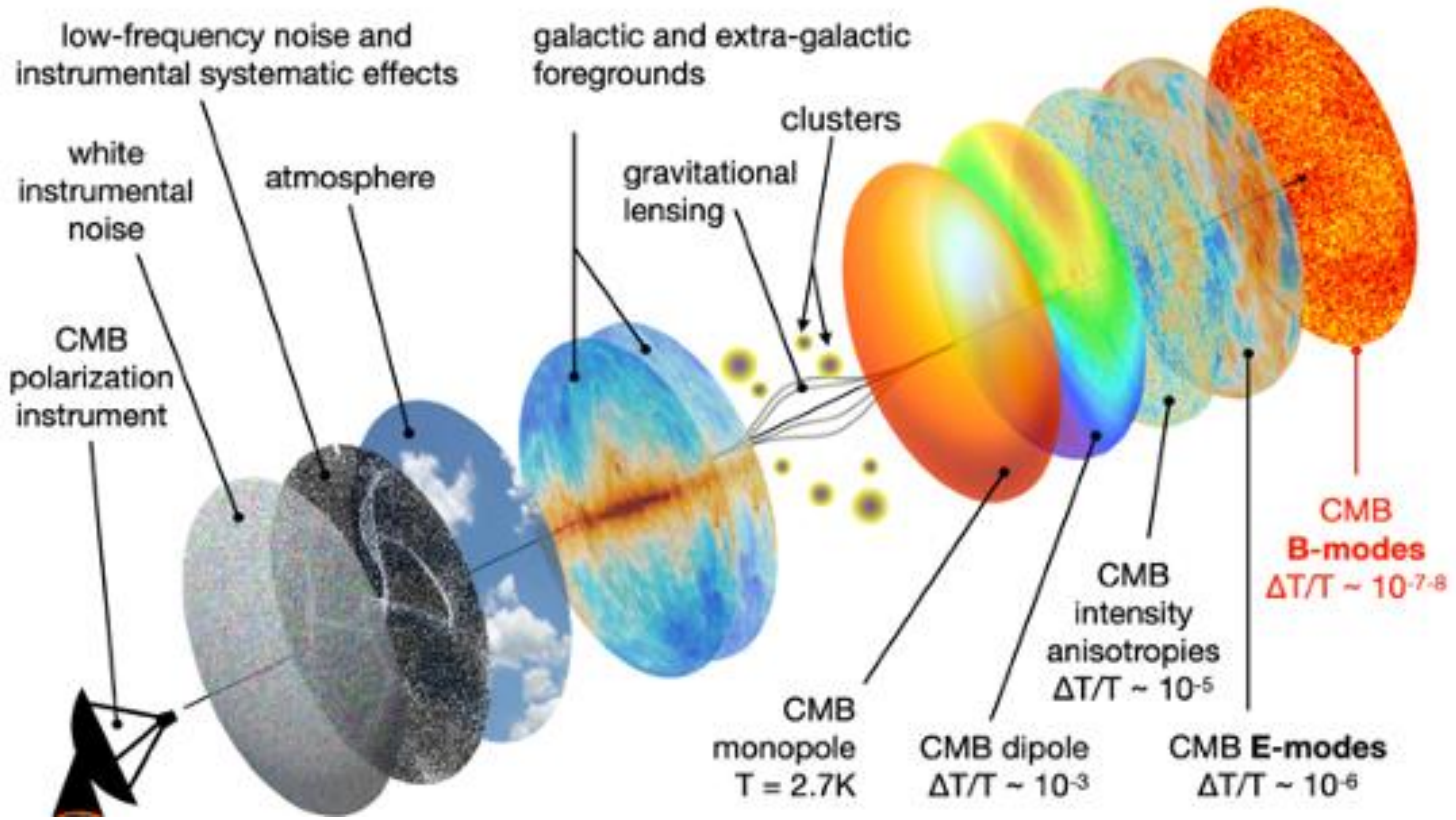
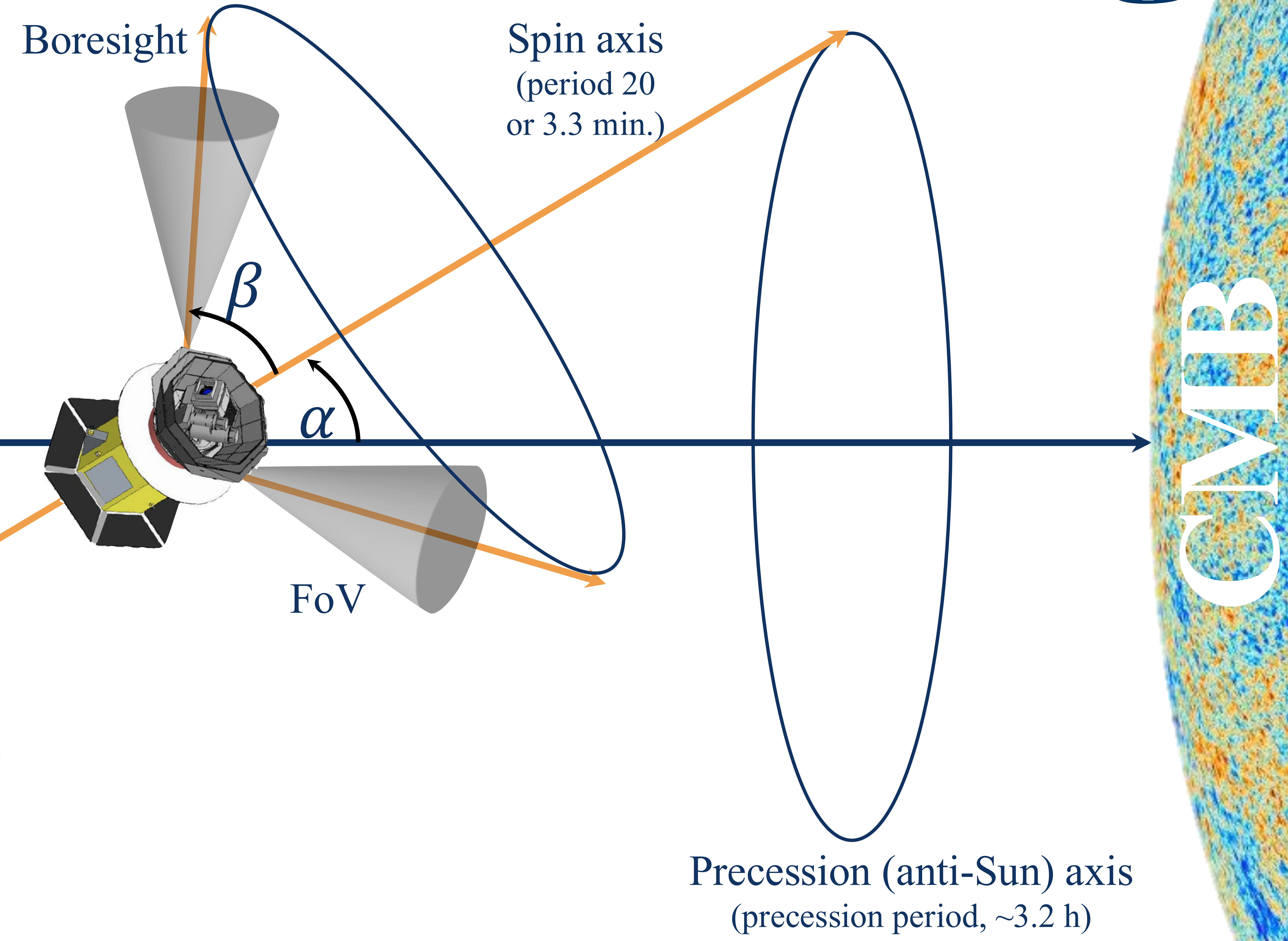
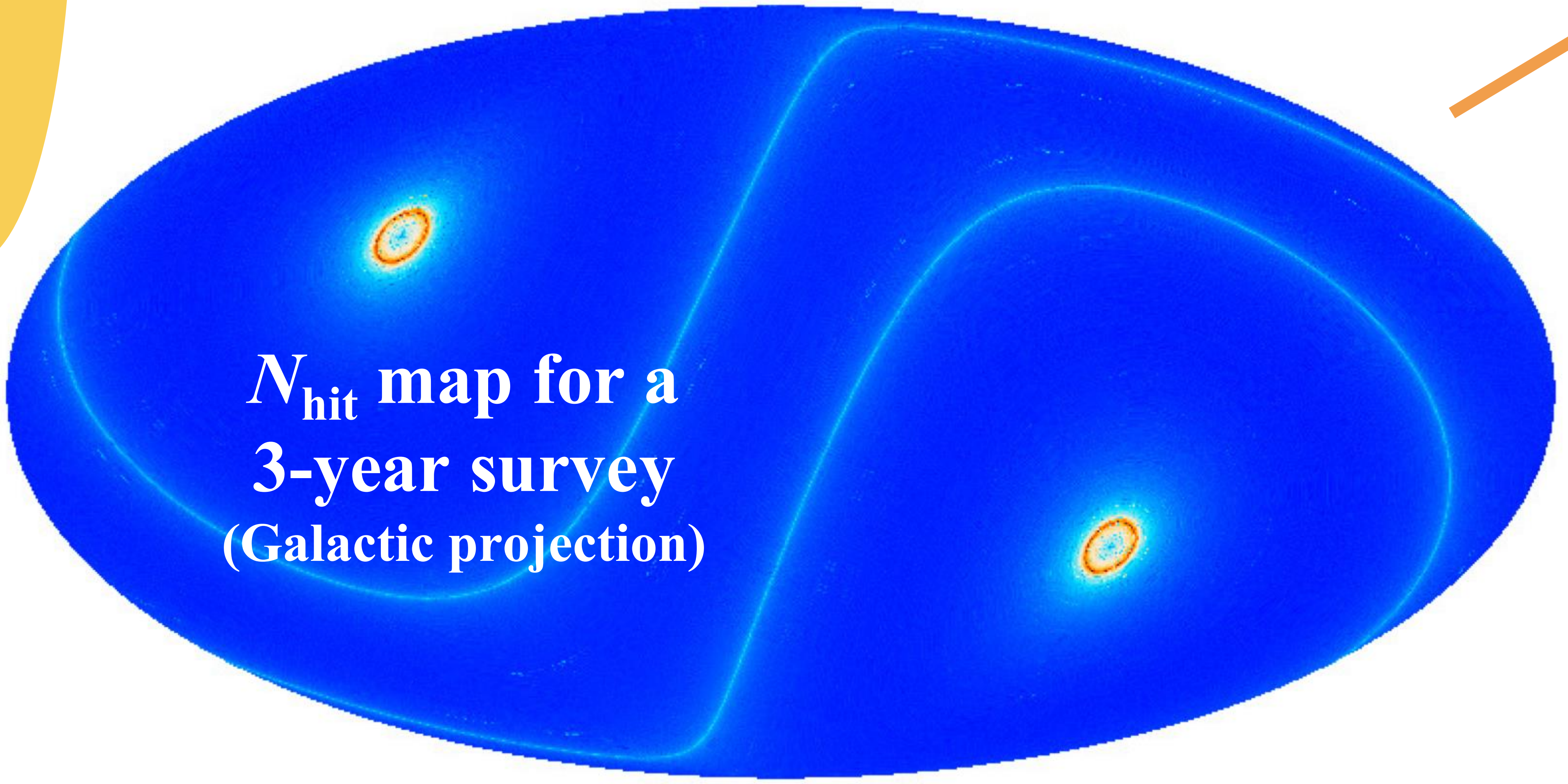


Image credit: Josquin Errard

LiteBIRD scanning strategy

- 3-year survey, Sun-Earth L2 Lissajous orbit
- Precession angle: $\alpha = 37.5°$
- Spin angle: $\beta = 57.5°$





LiteBIRD reformation phase

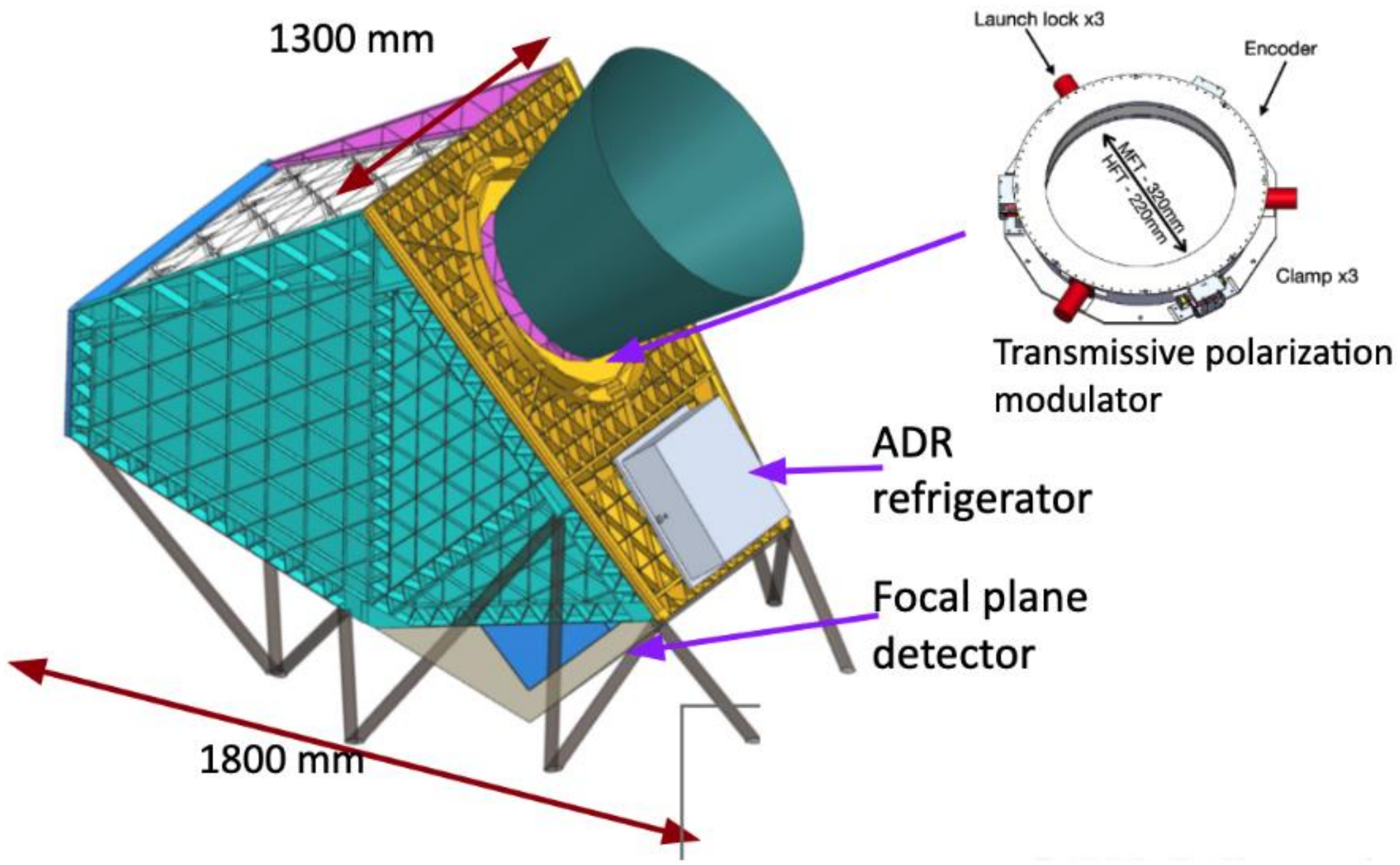
- *LiteBIRD* has been under **rescope studies to consolidate the mission's feasibility while keeping the same scientific objectives**
  - Revisit the error budget
  - **Simplify the mission configuration** (one single telescope instead of three; try to use existing technologies)
  - **Simplify the cryogenic chain**
  - Detectors to be procured by Europe
  - New HWP design based on stacking 6 plates in Pancharatnam configuration, providing large bandwidth
- JAXA Key Decision Point #2 passed successfully (Sept 2025)
- JAXA Mission Definition Review #2 scheduled for July 2026
- Targeted launch date JFY2036
- **Two different configuration options** now being considered, both based on single Crossed-Dragone reflective telescope
- Option 1 (no HWP) requires a faster spin rate to minimize 1/f noise
- Option 2 is based on the possibility of using a wider-band HWP

Option 1

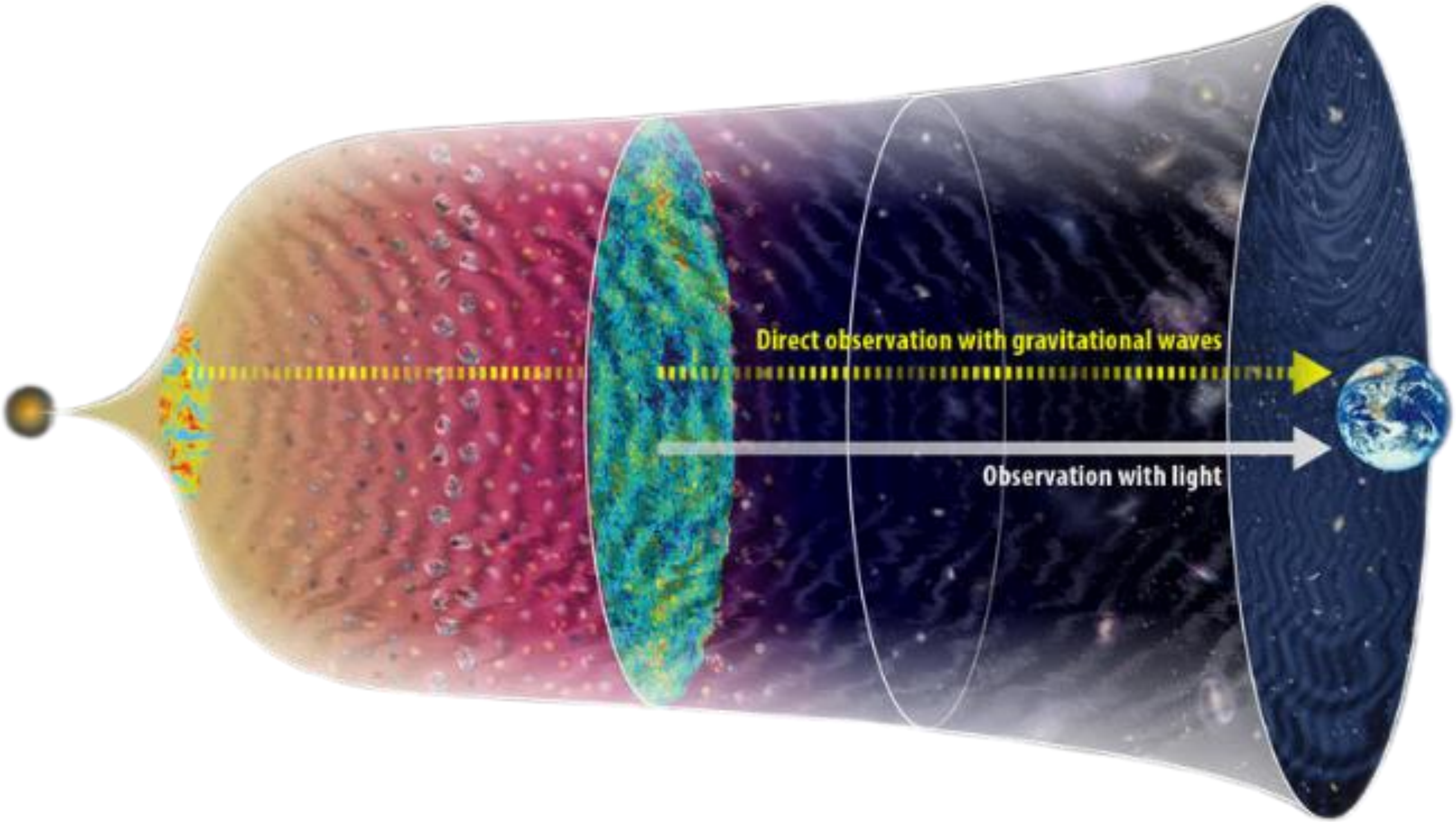
- Aperture 500 mm
- 40-570 GHz
- No HWP
- Spin rate 0.3 rpm

Option 2

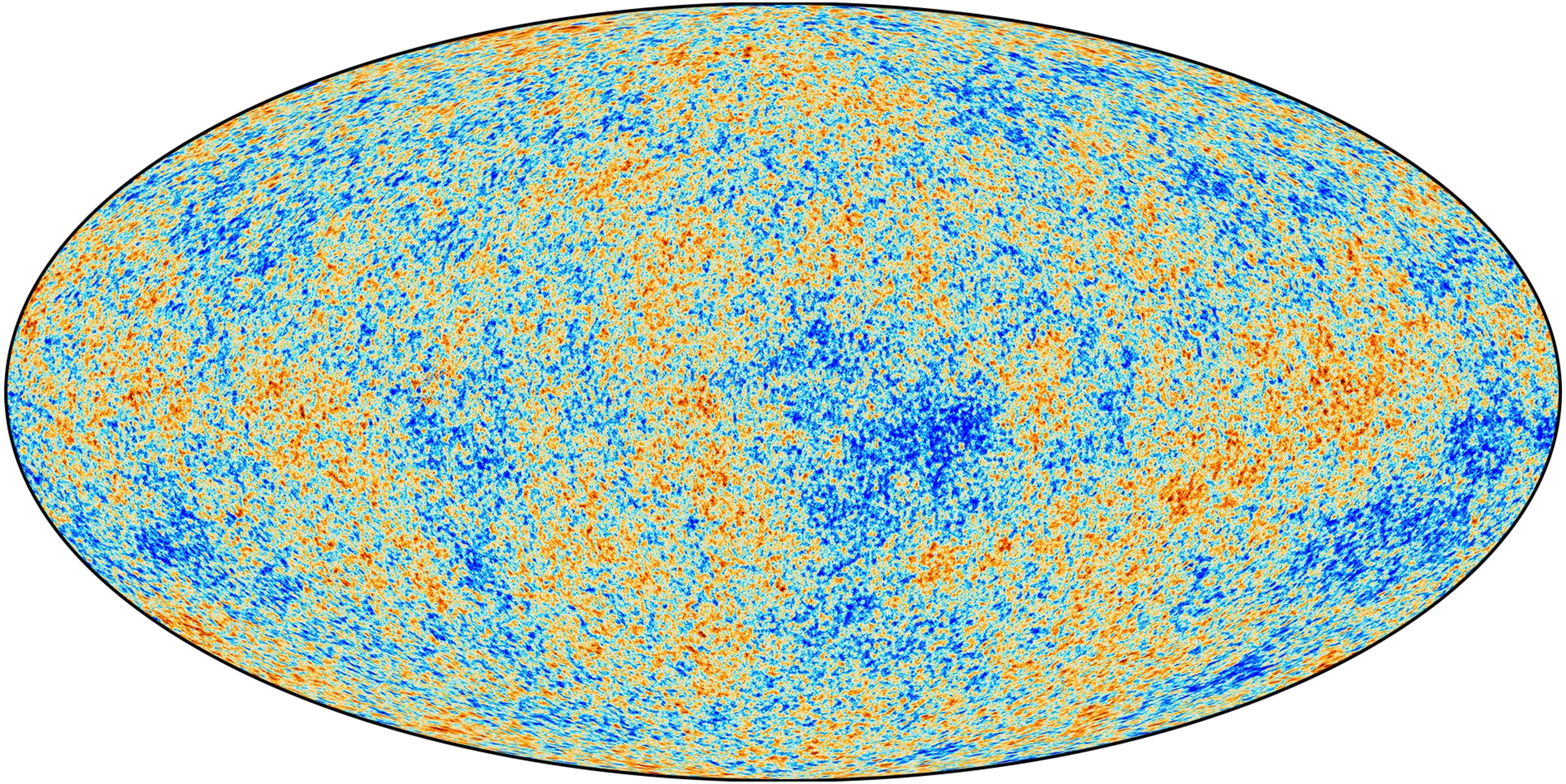
- Aperture 500 mm
- 40-402 GHz
- Transmissive HWP
- Spin rate 0.05 rpm



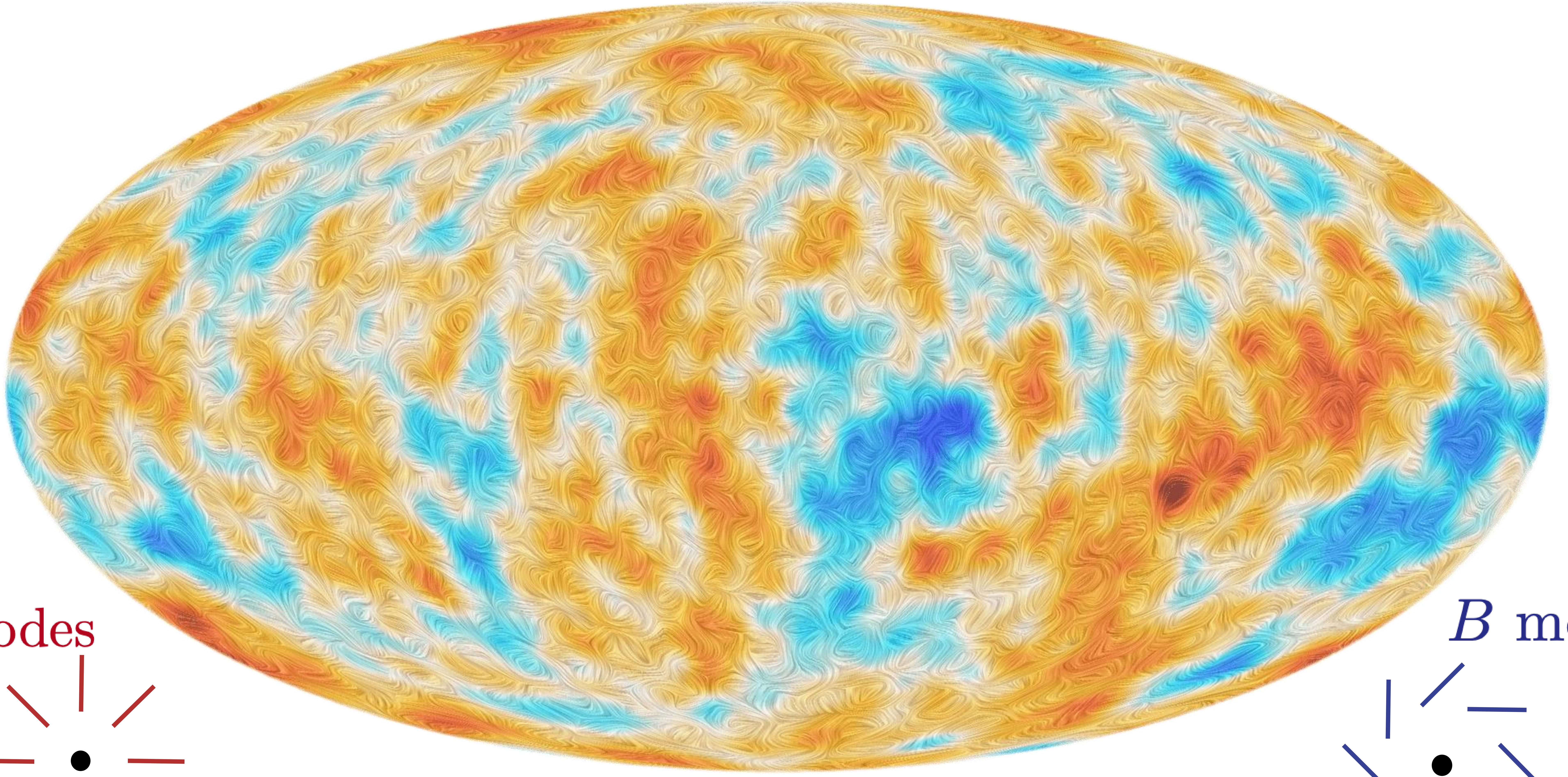
A "bit" of background



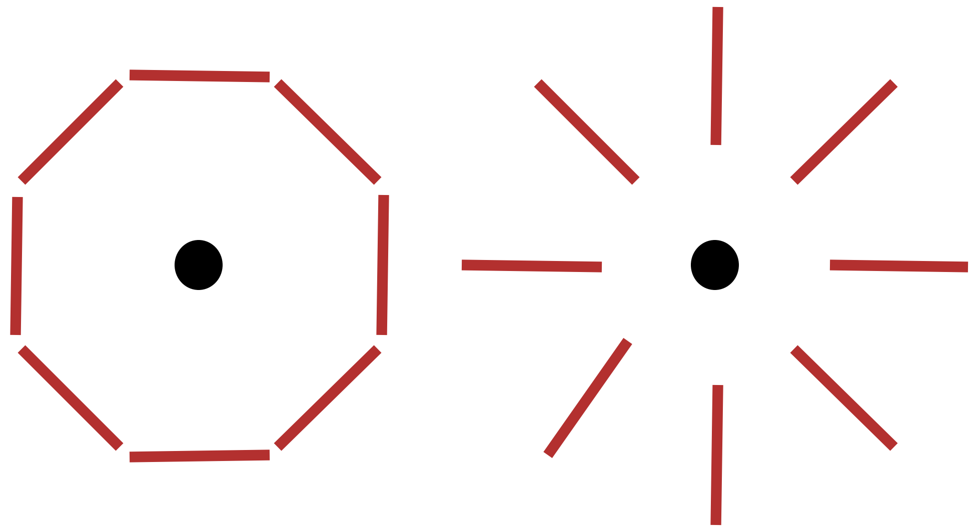
CMB Temperature



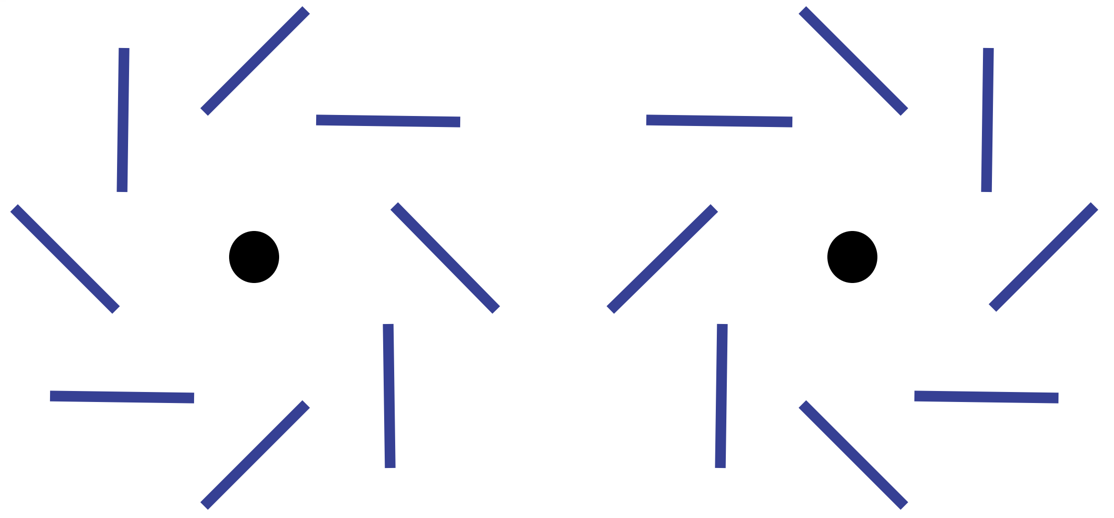
CMB Polarization



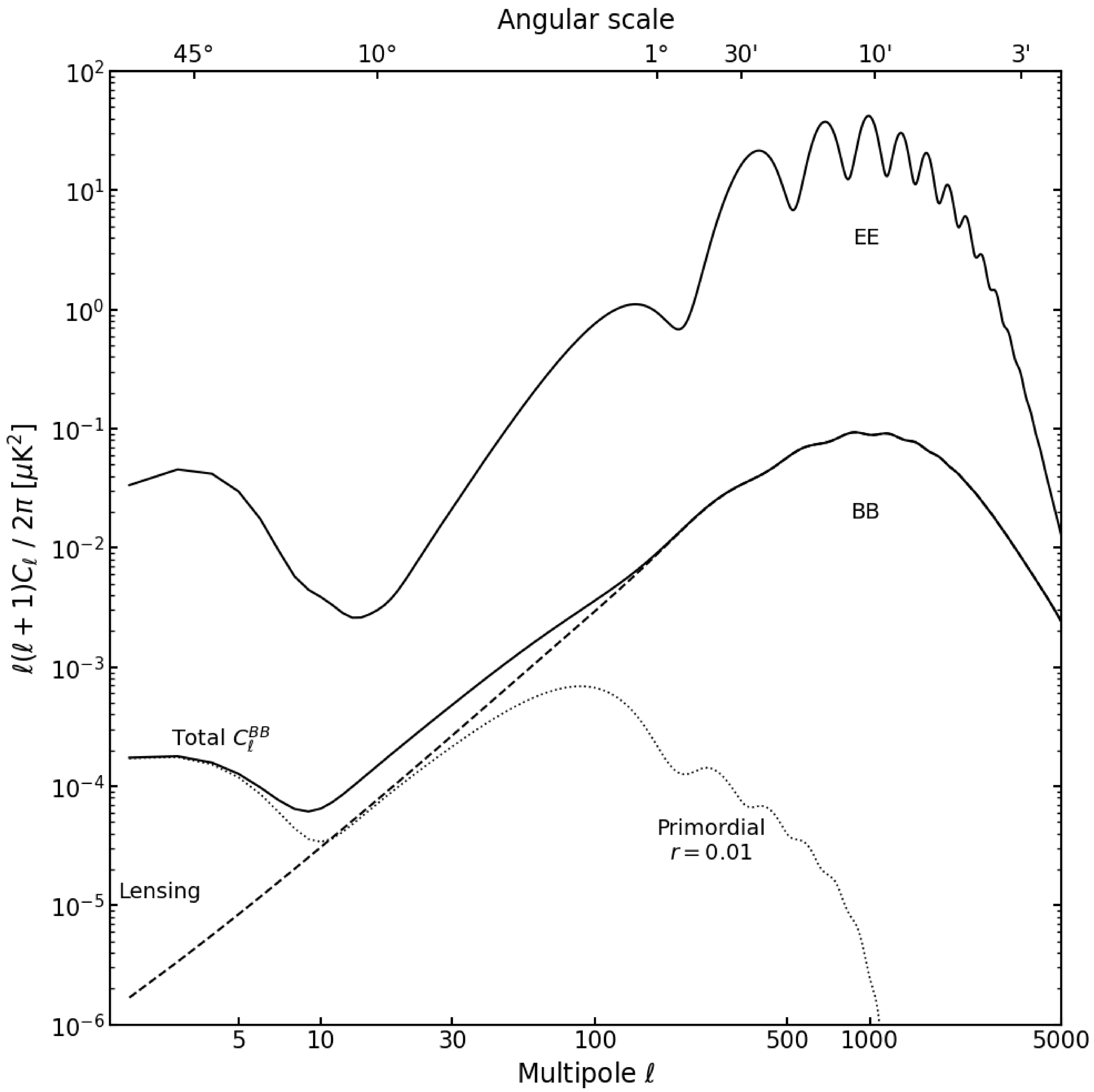
E modes



B modes



Polarization Angular Power Spectra



Scalar power spectrum

$$P_s(k) = A_s\left(\frac{k}{k_*}\right)^{n_s-1}$$

Tensor power spectrum

$$P_t(k) = rA_s\left(\frac{k}{k_*}\right)^{n_t}$$

$n_t \sim 0$

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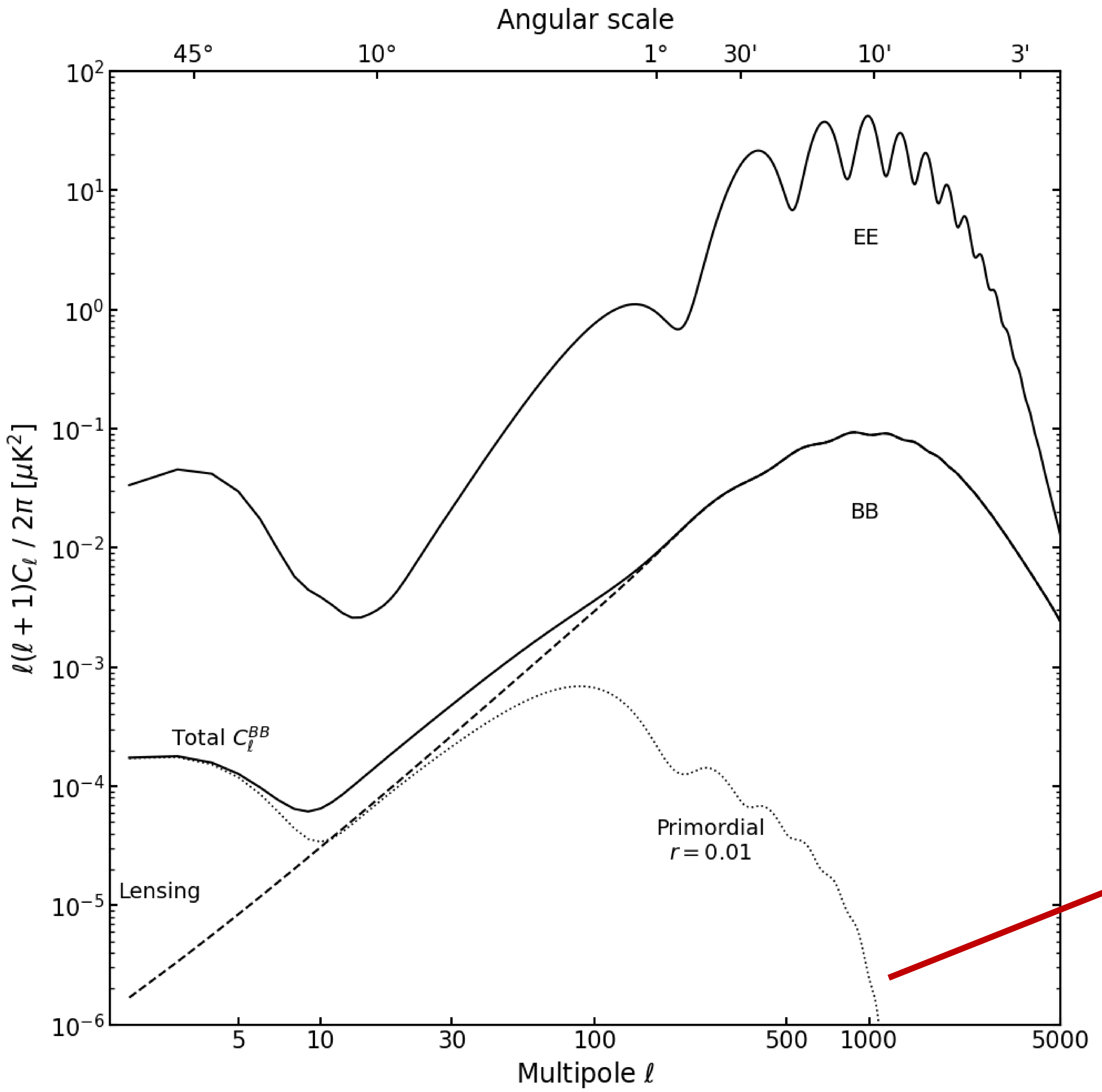

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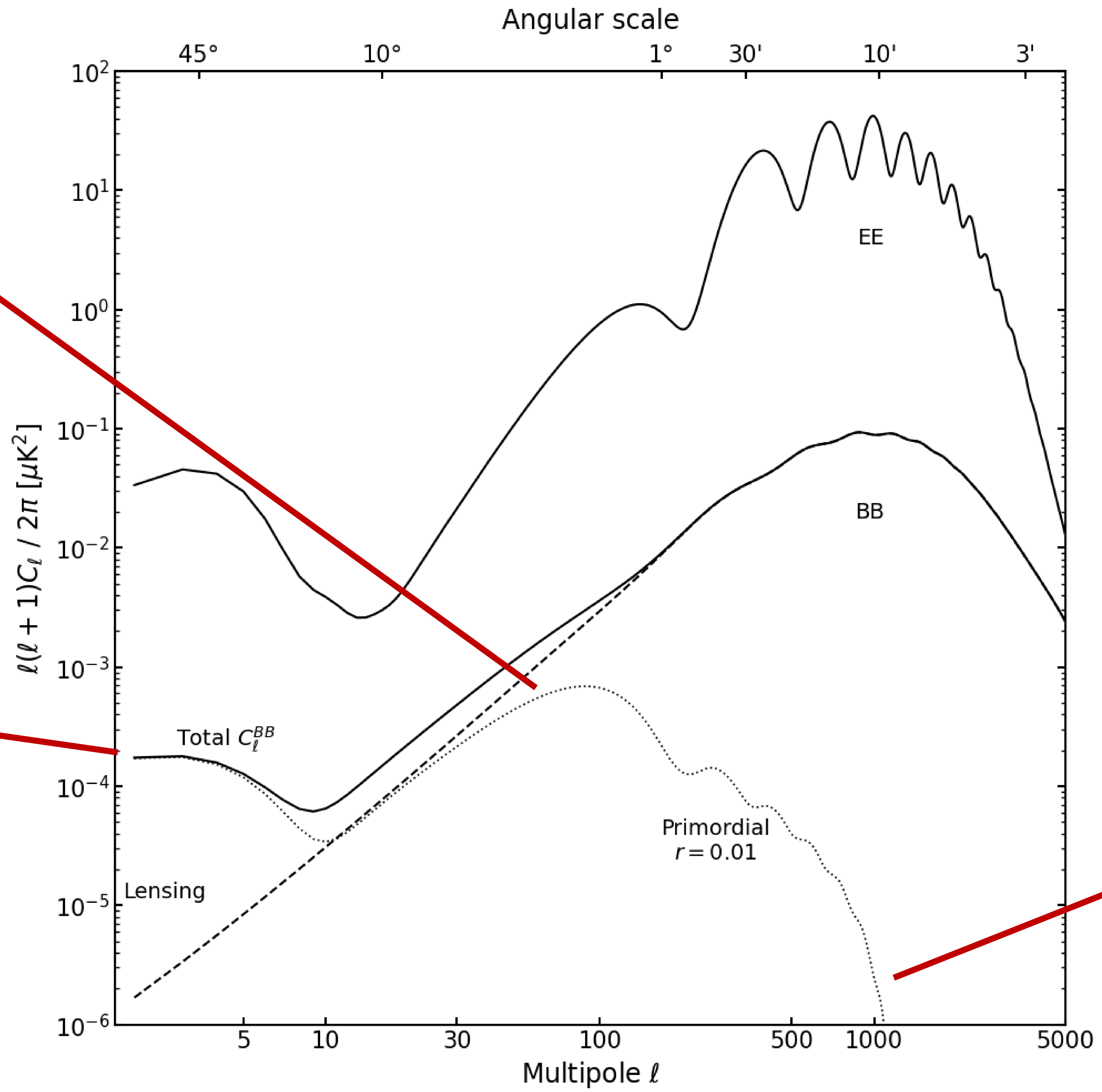
Polarization Angular Power Spectra

Recombination bump
- Sourced by scattering at recombination surface
- Lives at the degree scale

Reionization bump
- Sourced by Thompson scattering after the Universe gets reionized
- Lives at large scales



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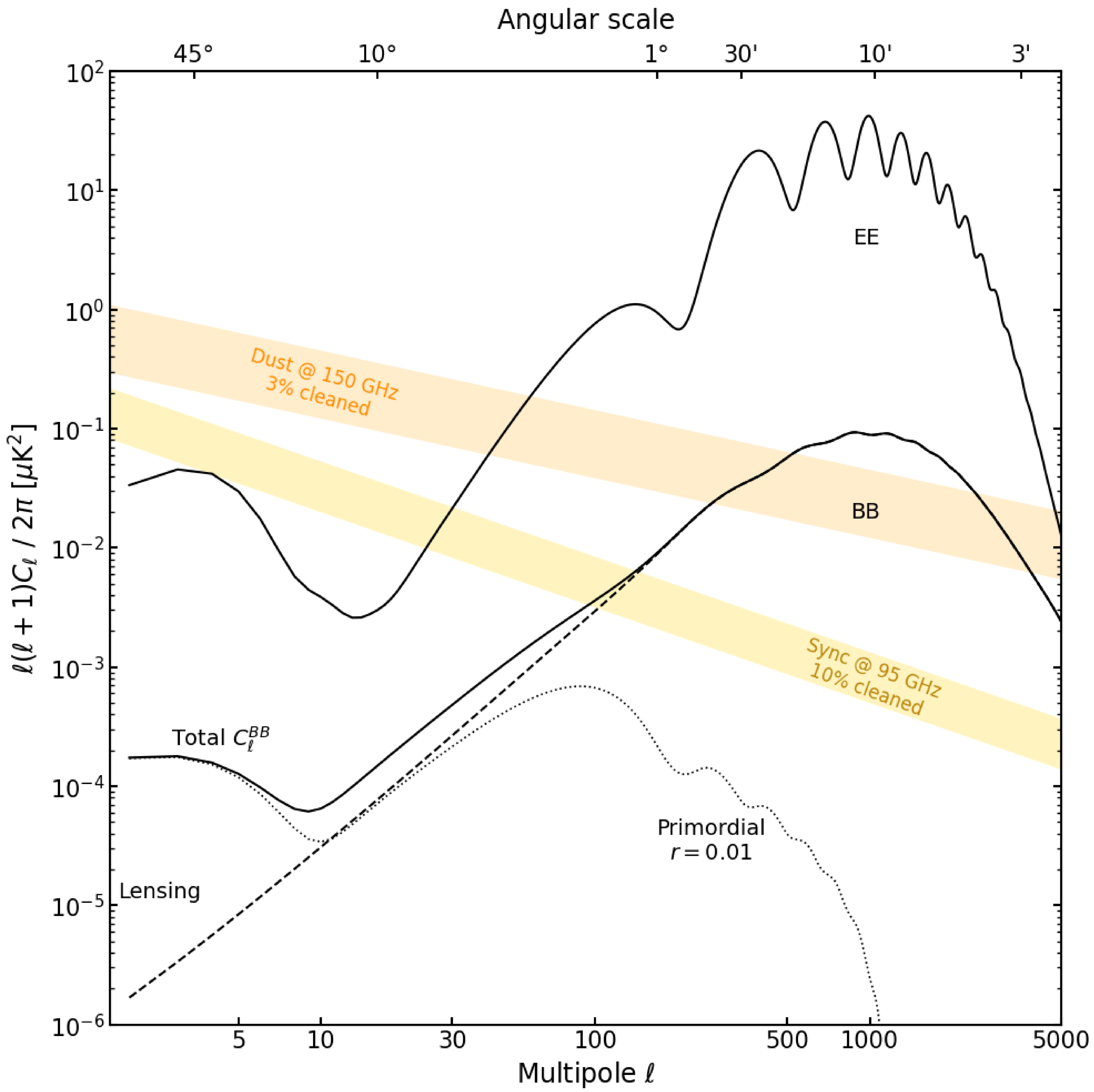

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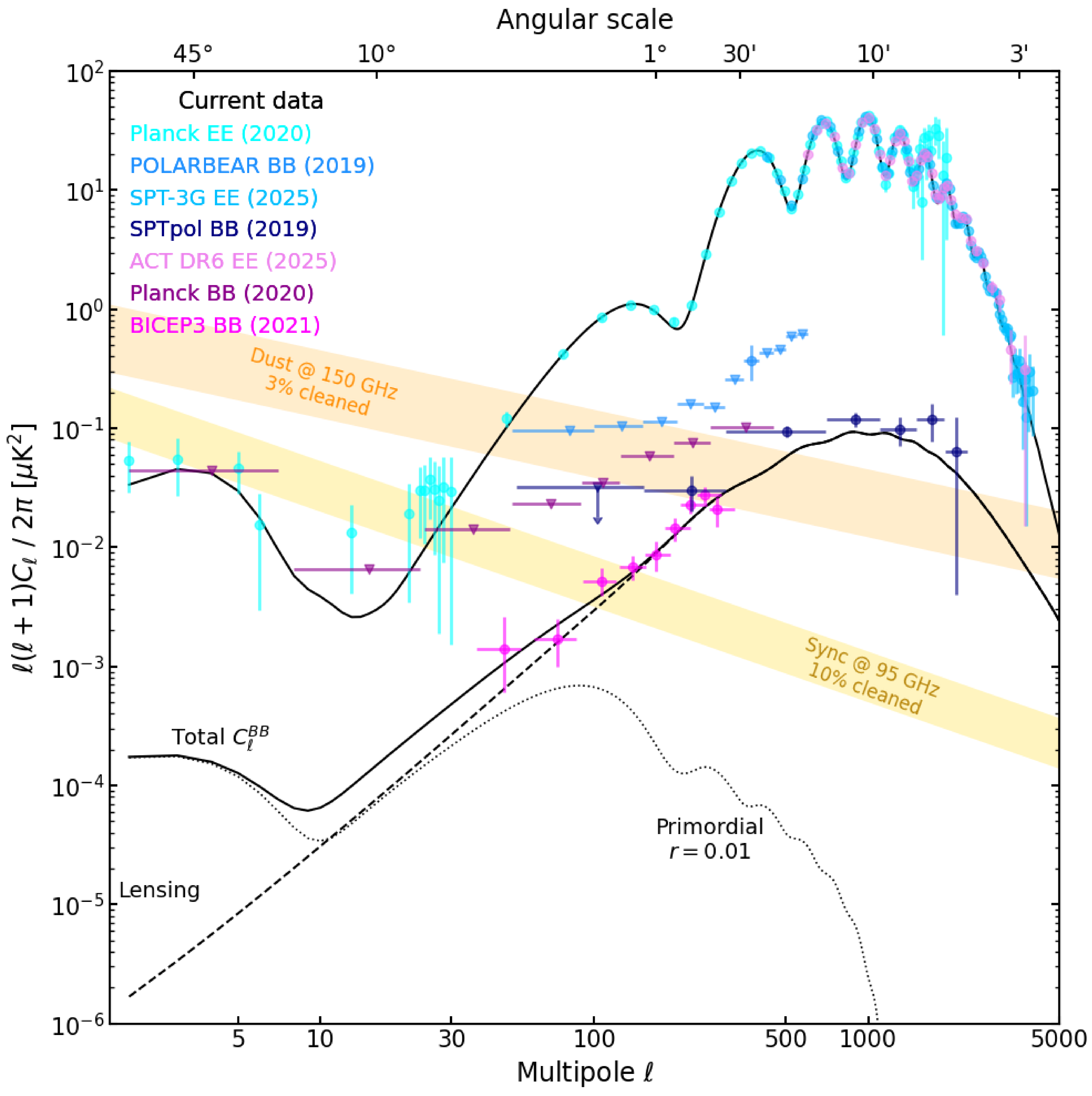
Some available data



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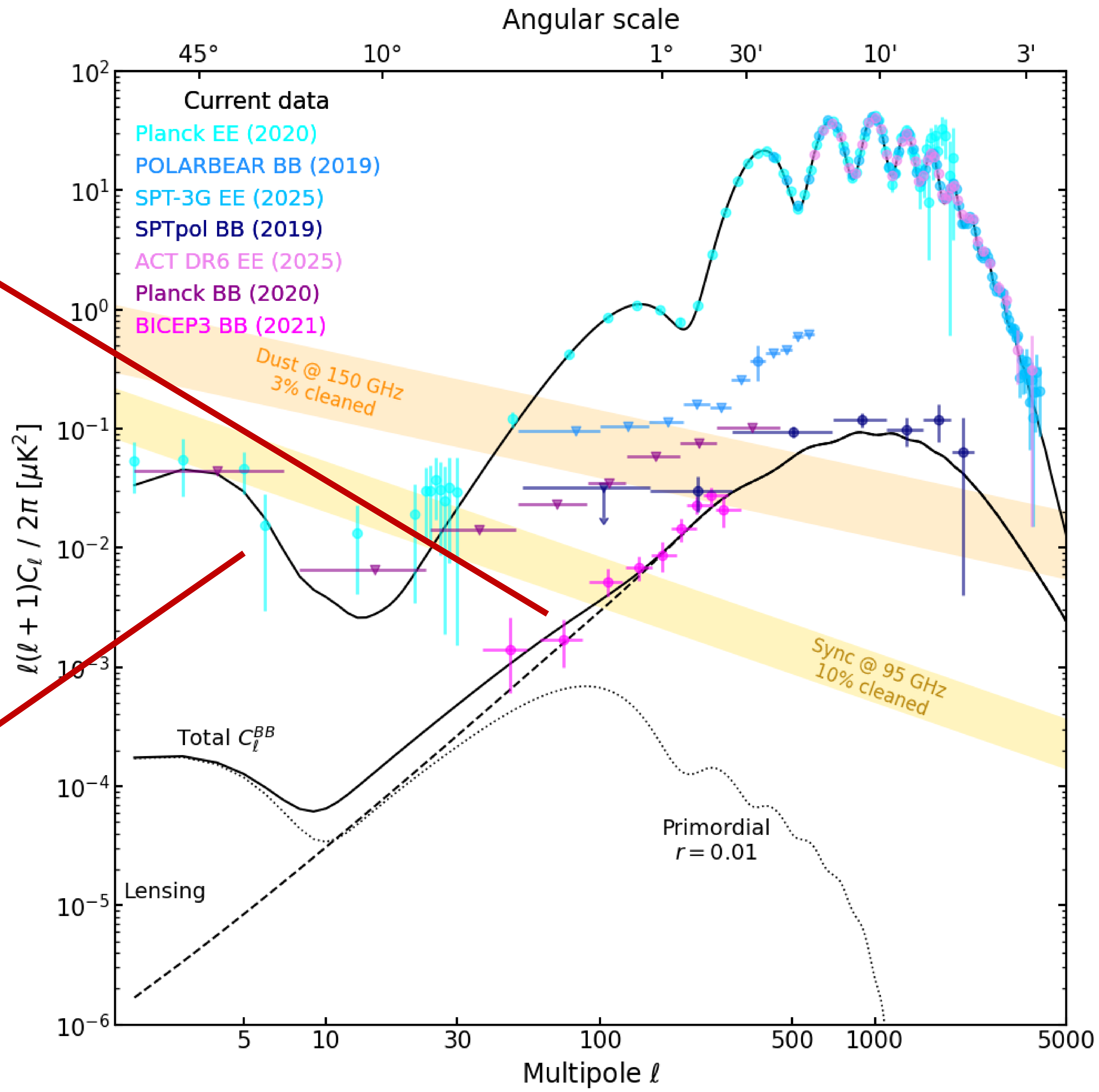
Some available data

BICEP/Keck Array provides the best constraints on primordial BB

- Cover multipoles from ~40 to ~400



Planck helps with the largest scales

- Only upper bounds of angular spectra
- Also TT and EE constrain a bit because tensors would contribute to those spectra too

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$n_t \sim 0$

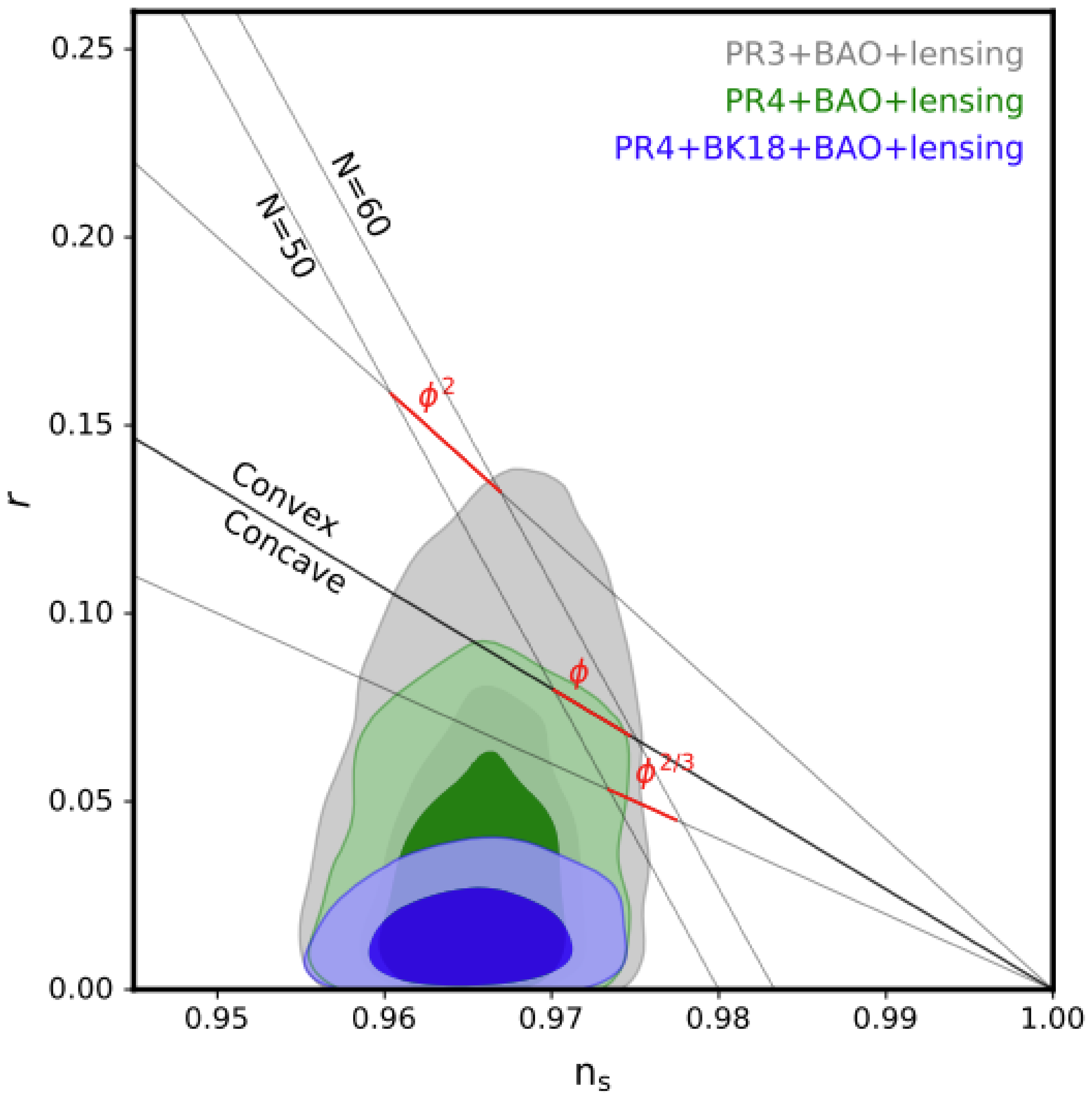
Results for slow-roll inflation

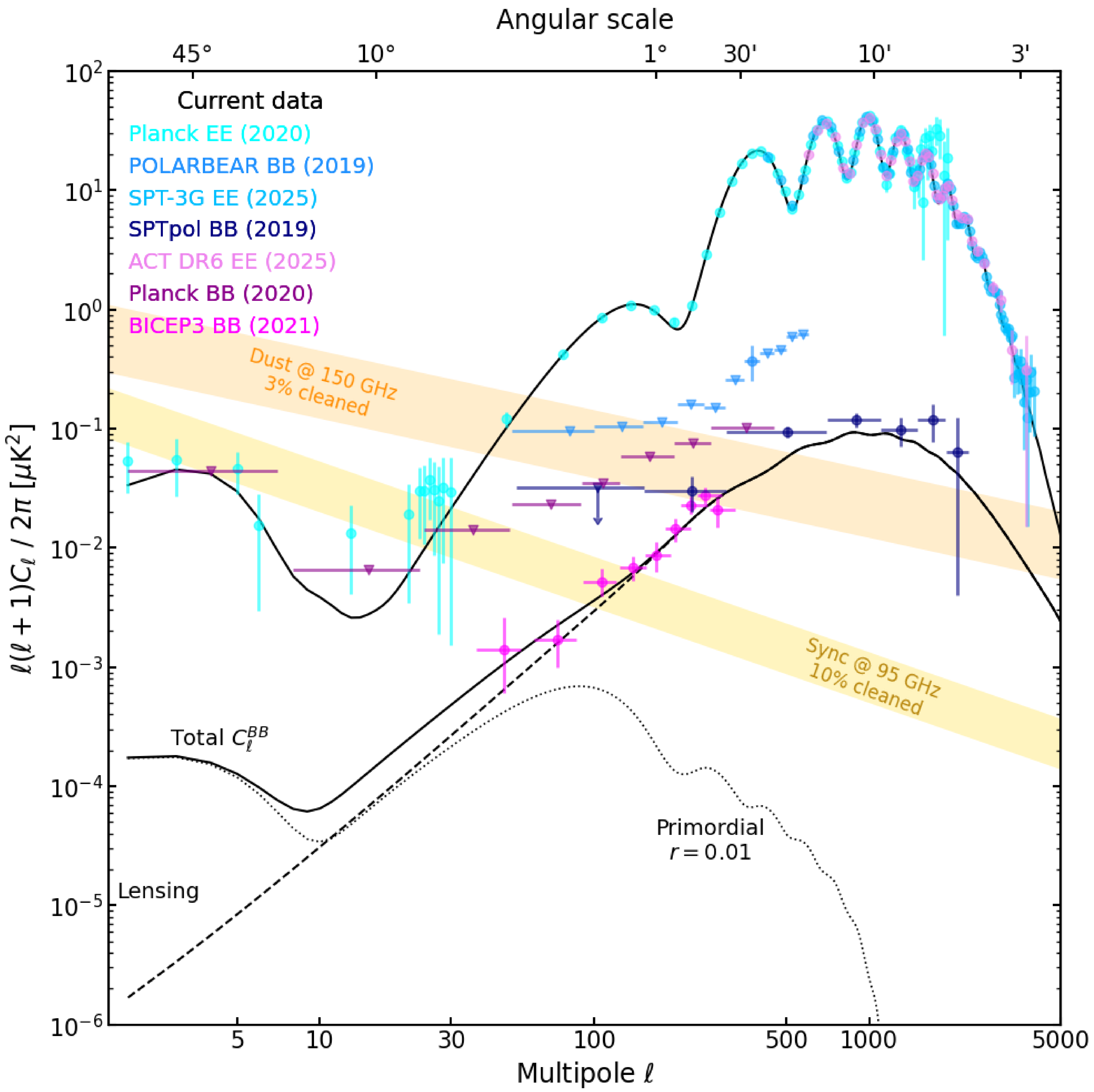
- Current best constraint: $r < 0.032$ (95% C.L.)

(📖 Tristram et al. 2022, combining BK18 and Planck PR4)

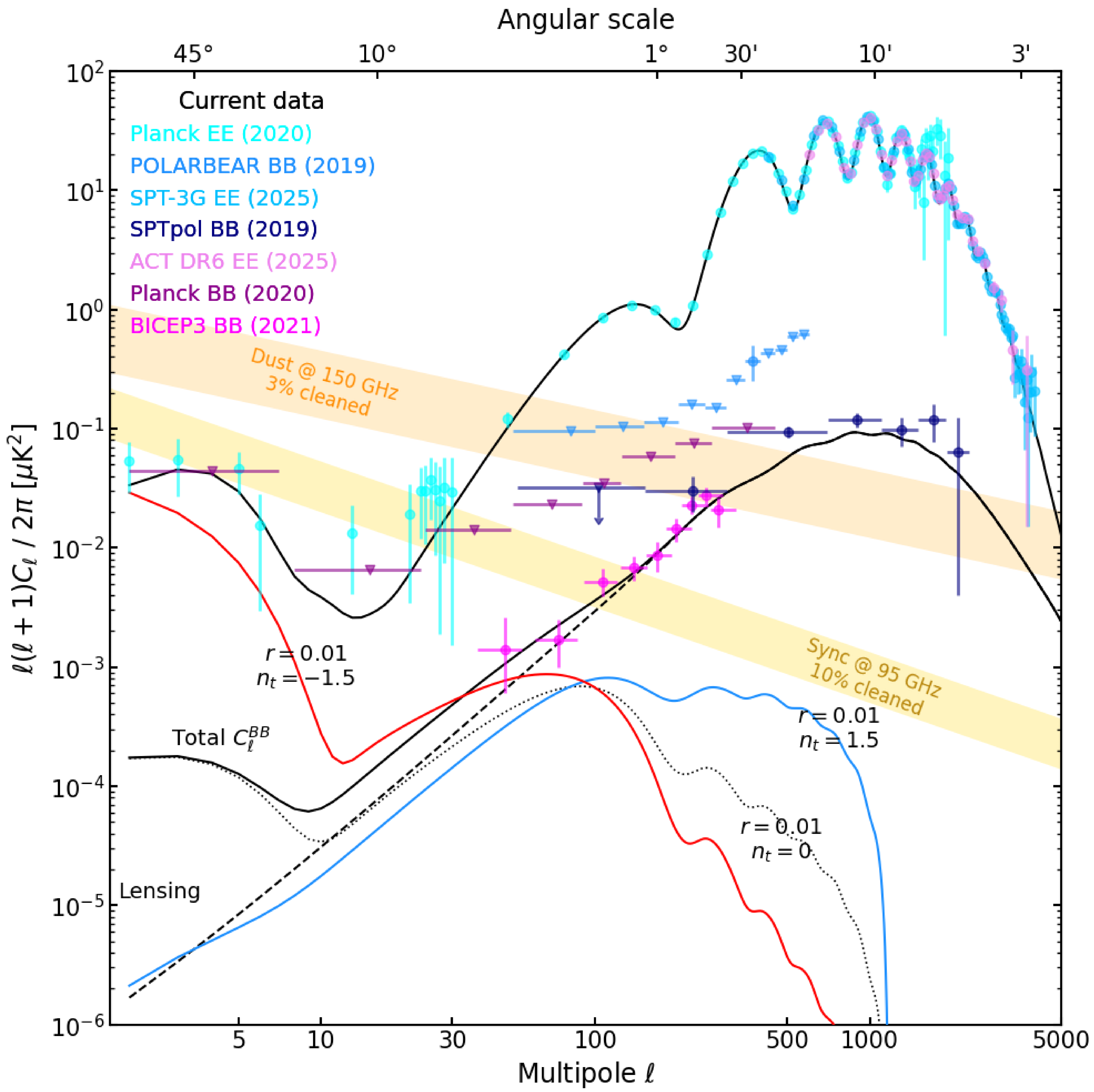
This gives the best constrain r < 0.032 (95% C.L.) assuming $n_t = 0$

📖 Tristram+ JCAP 2022





What if we let n_t free to vary?



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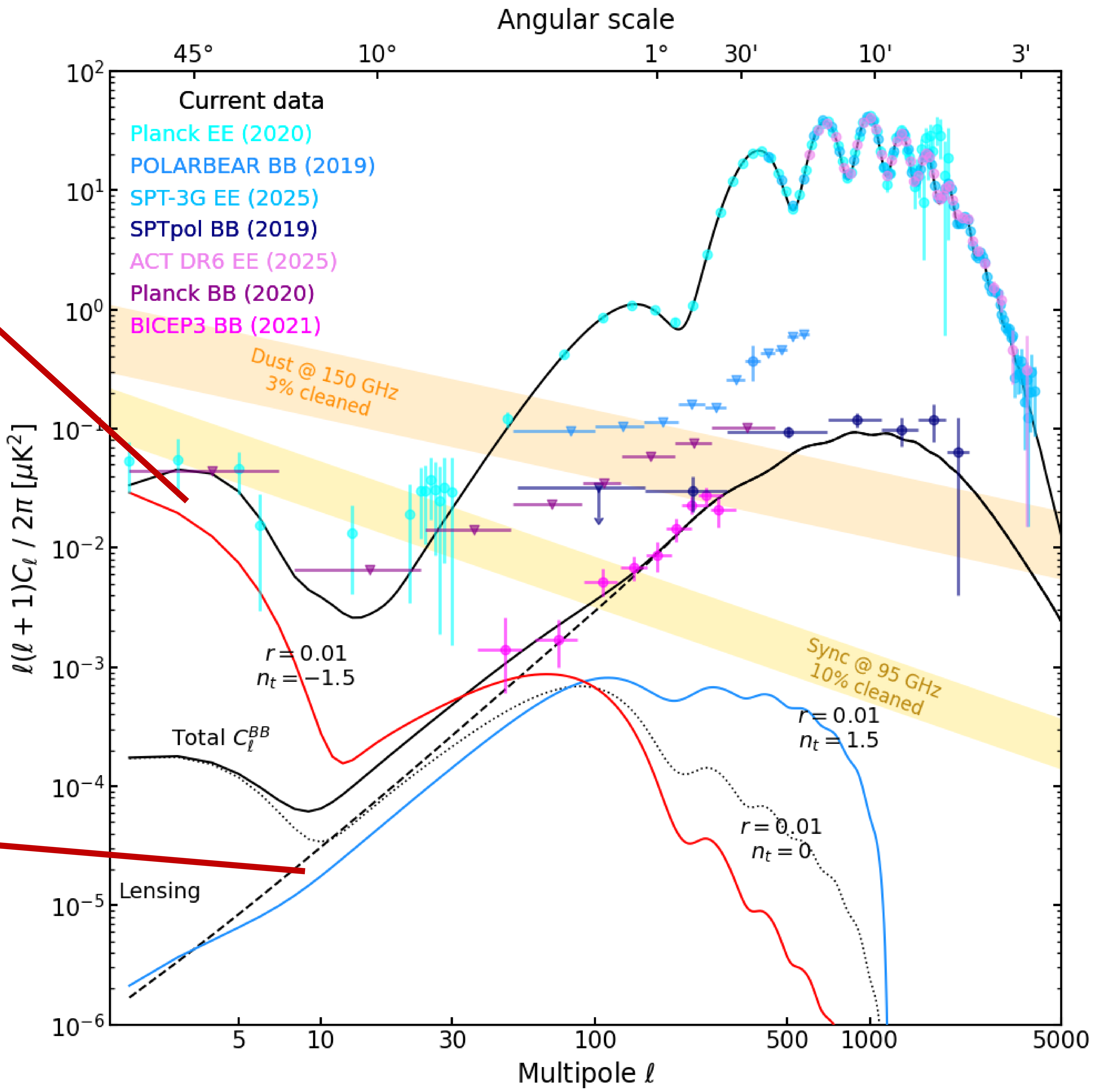
$n_t \neq 0$

The relation between r and nt is a smoking gun of the inflationary model!

What if we let n_t free to vary?

Red tilts are eventually caught by CMB observations

Blue tilts are very hard to constraints due to lensing contamination



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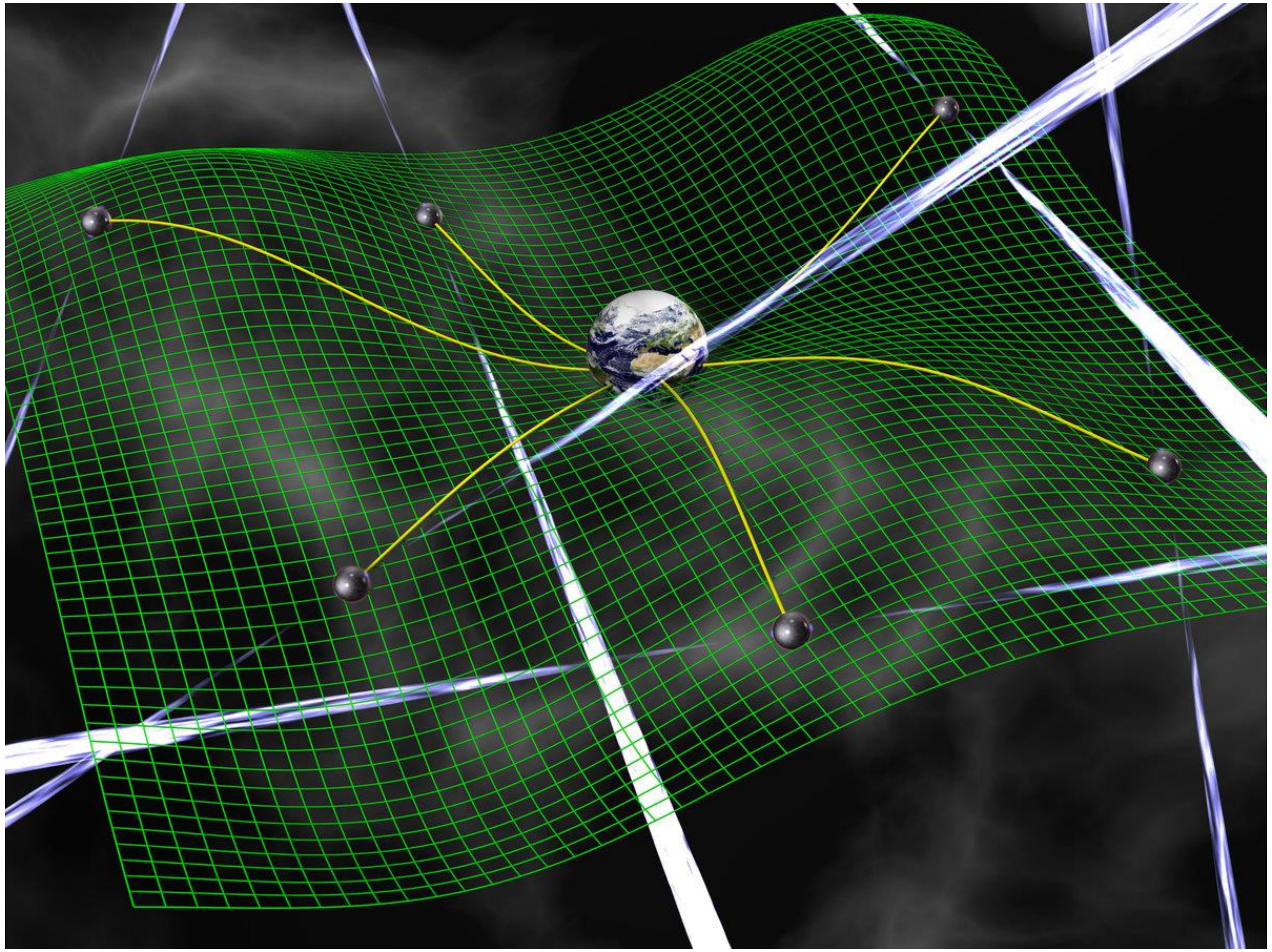
But we do have small-scale observations!

PTAs



LIGO-Virgo-KAGRA

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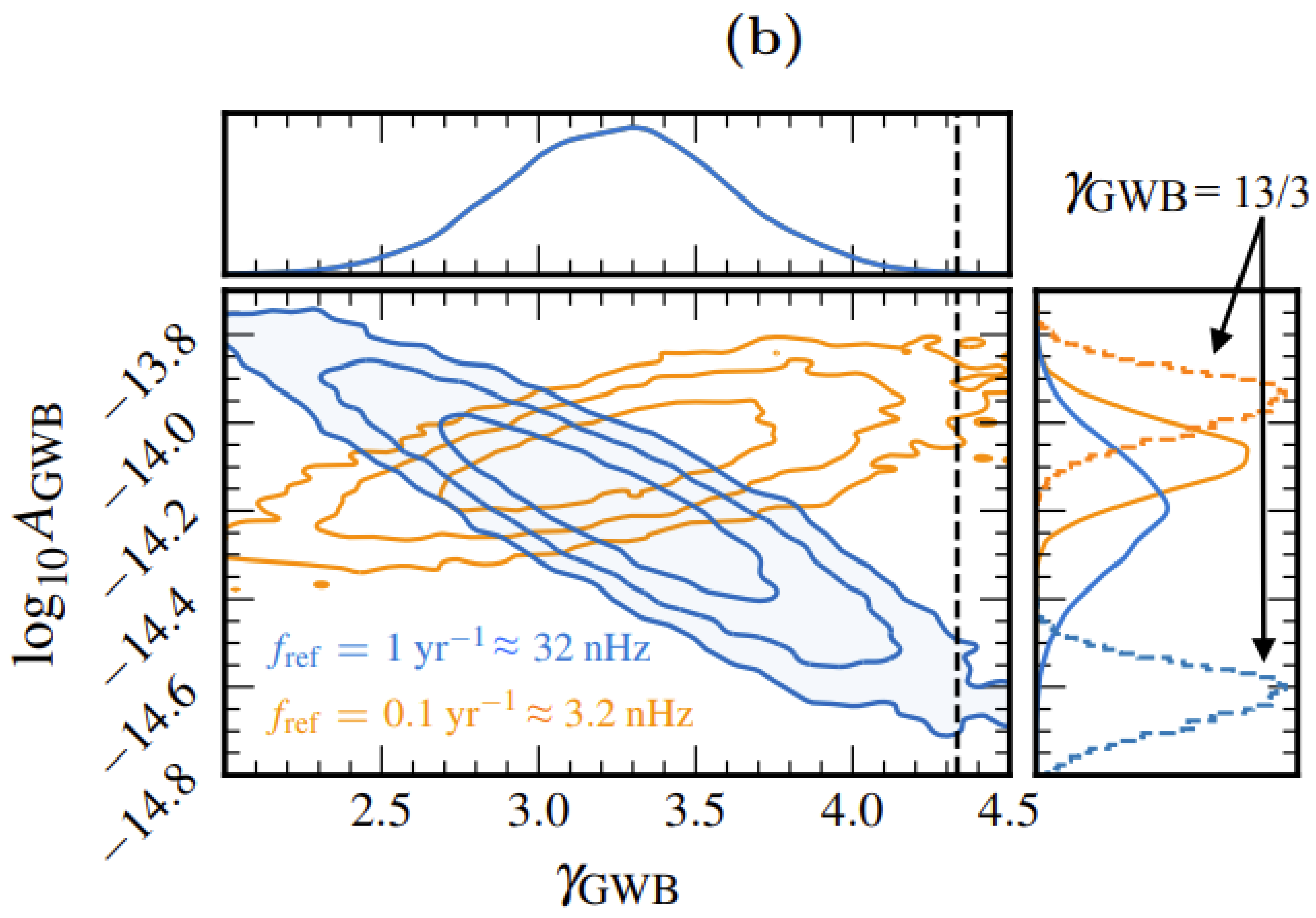
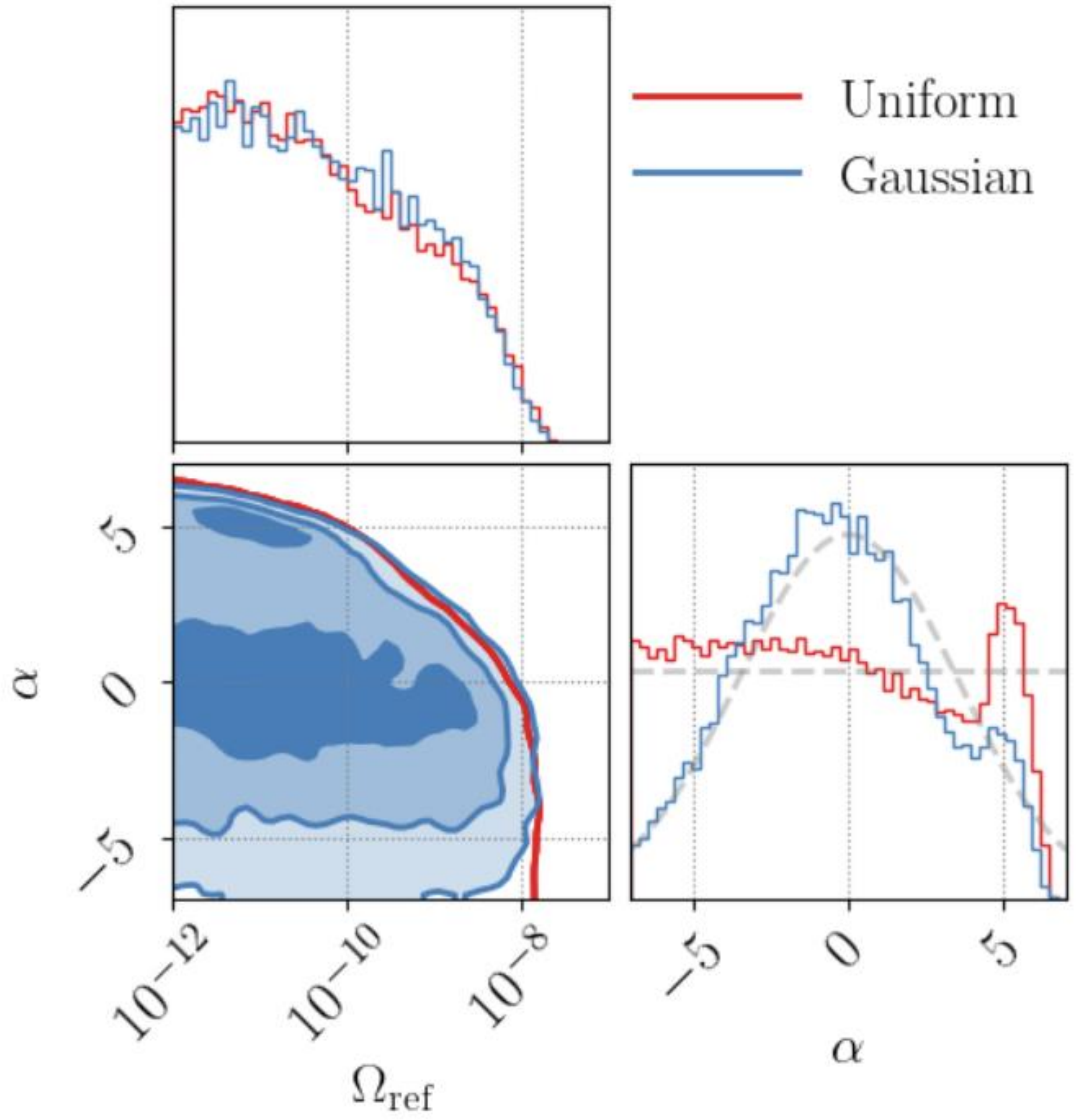
PTAs



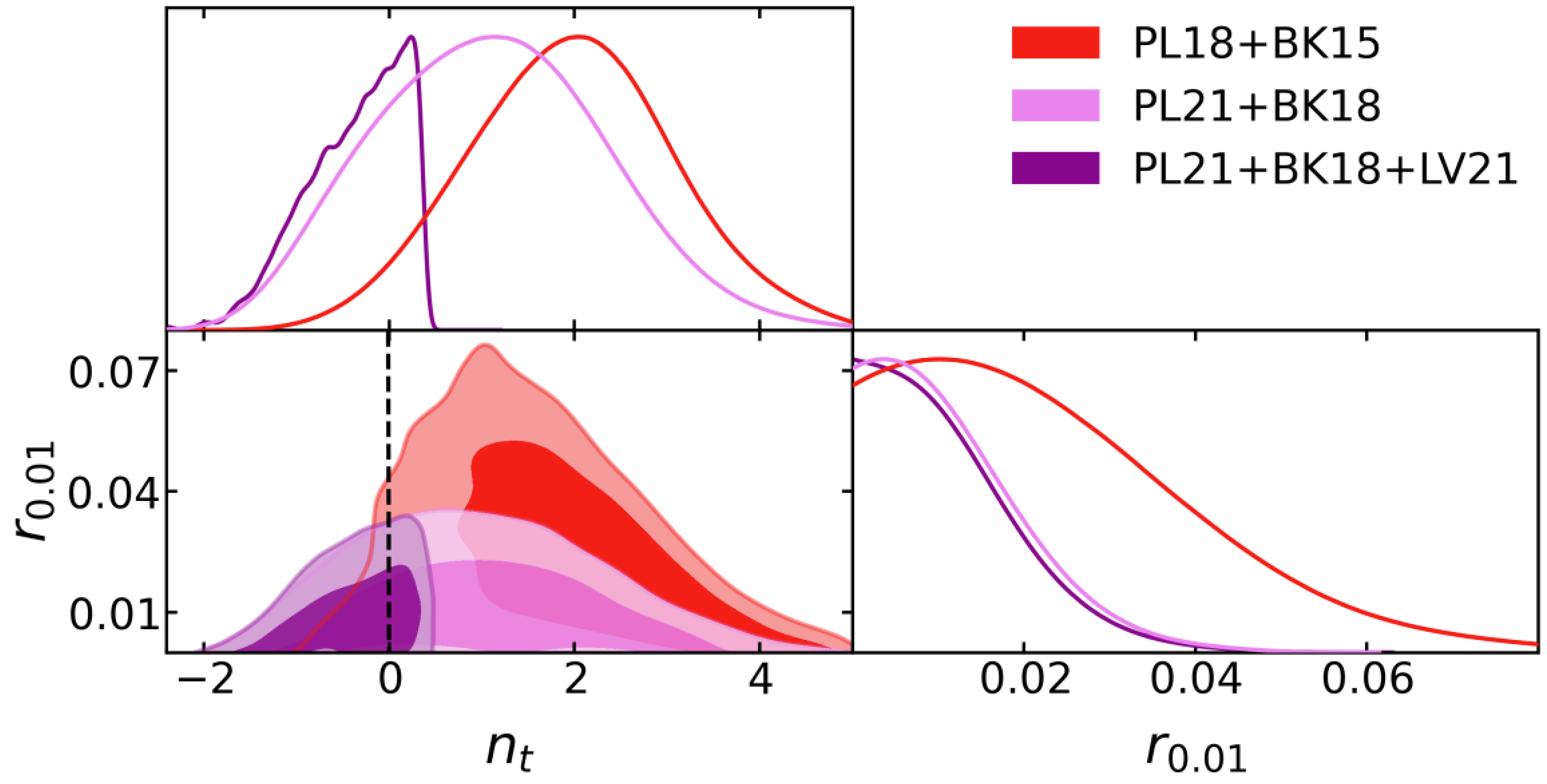
📖 Agazie+ ApJL 2023

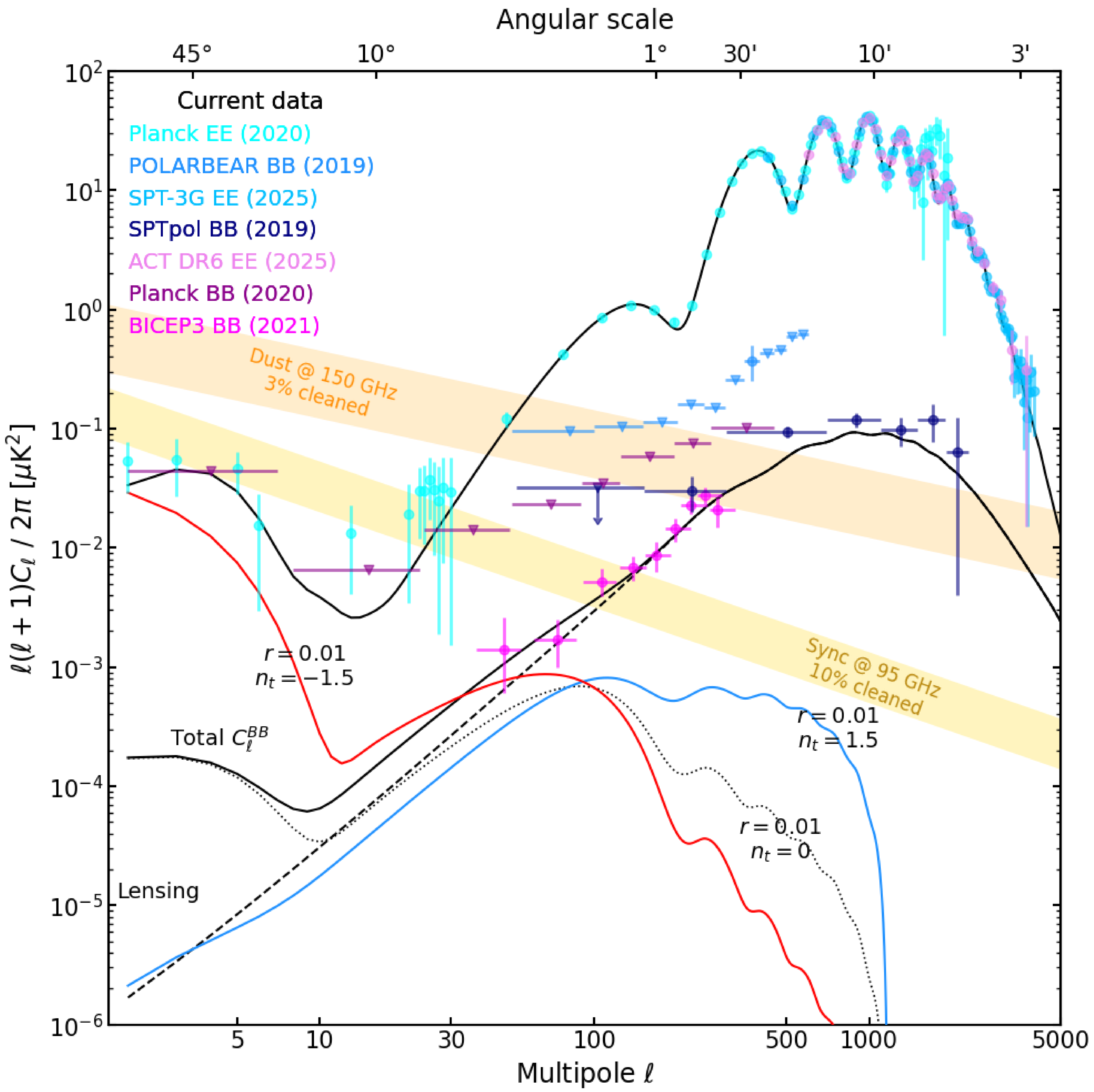
LIGO-Virgo-KAGRA



📖 Abac+ PRD 2025

Results w/o imposing an inflationary model





This gives the best constrain with free n_t:
$r < 0.028$, $-1.37 < n_t < 0.42$ (95% C.L.)

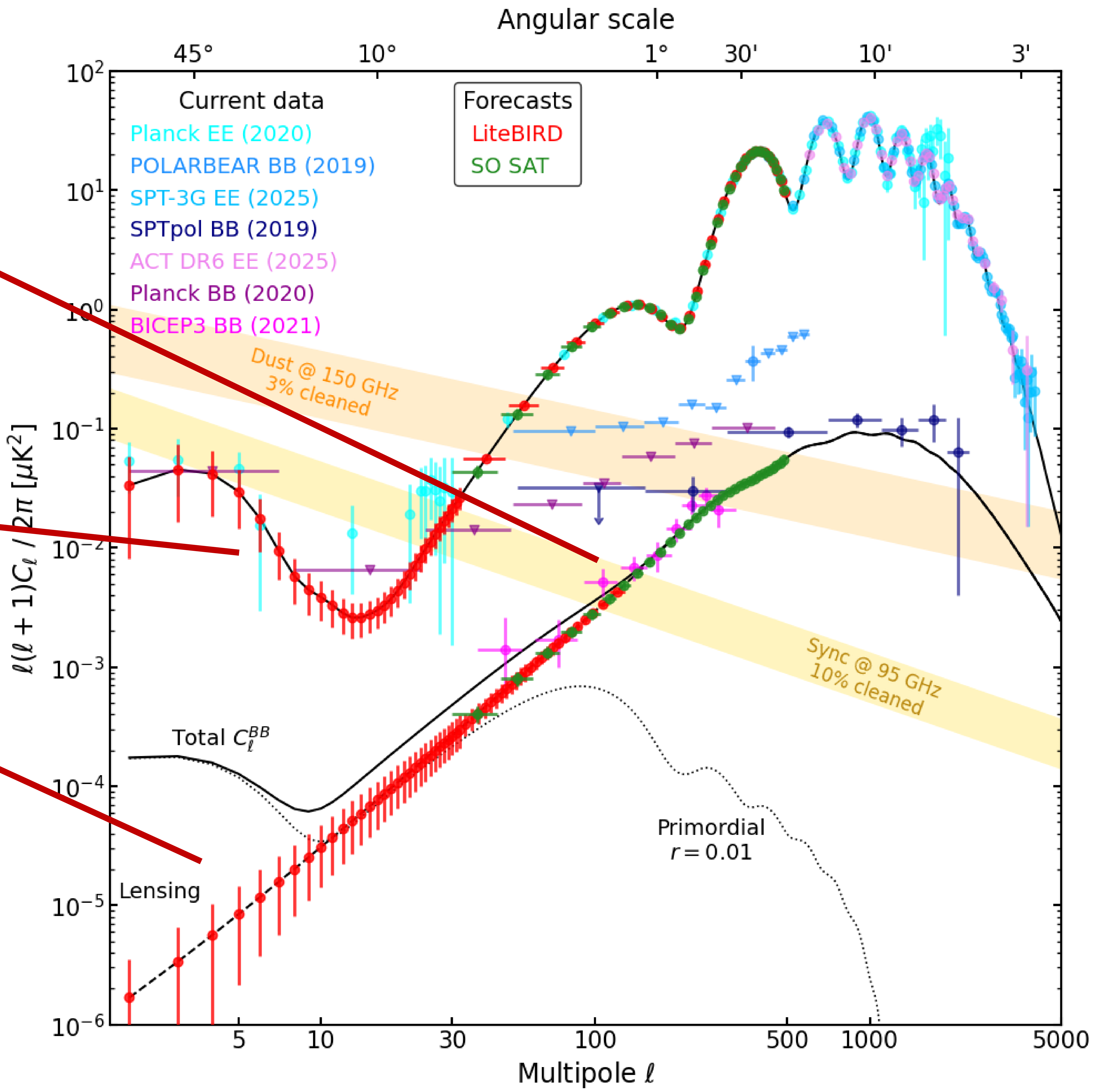
📖 Galloni+ JCAP 2023

LIGO-Virgo-KAGRA plays a vital role in cutting the allowed blue tilts through its upper bound on Ω_{GW}

The future ahead

SO SAT will provide pristine data on the recombination bump
- No delensing in included here

LiteBIRD will access the largest scales with unprecedented precision, while also observing the recombination bump with the same accuracy
- Both bumps in the observational window
- Note the cosmic variance limited observation of EE!



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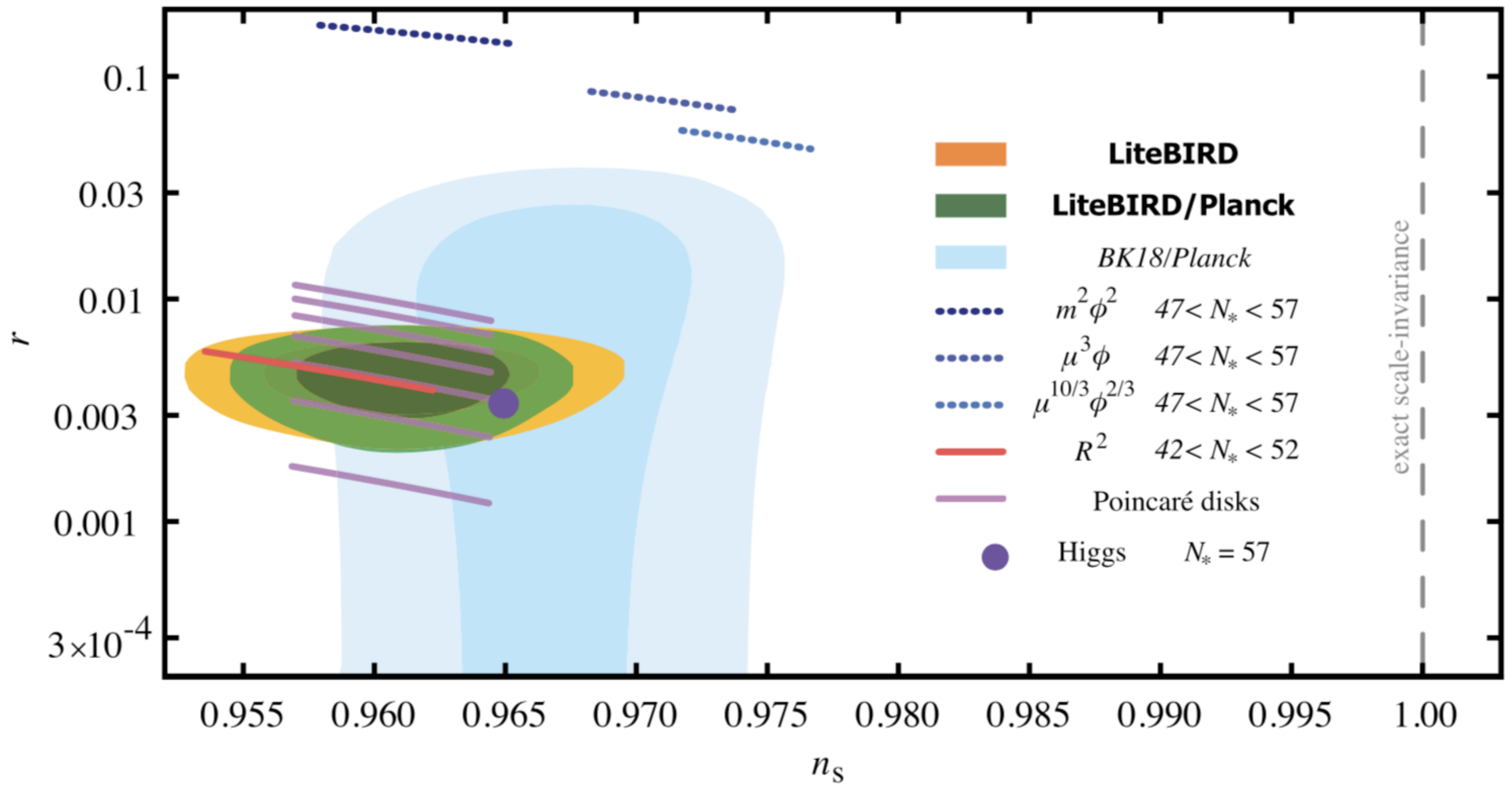
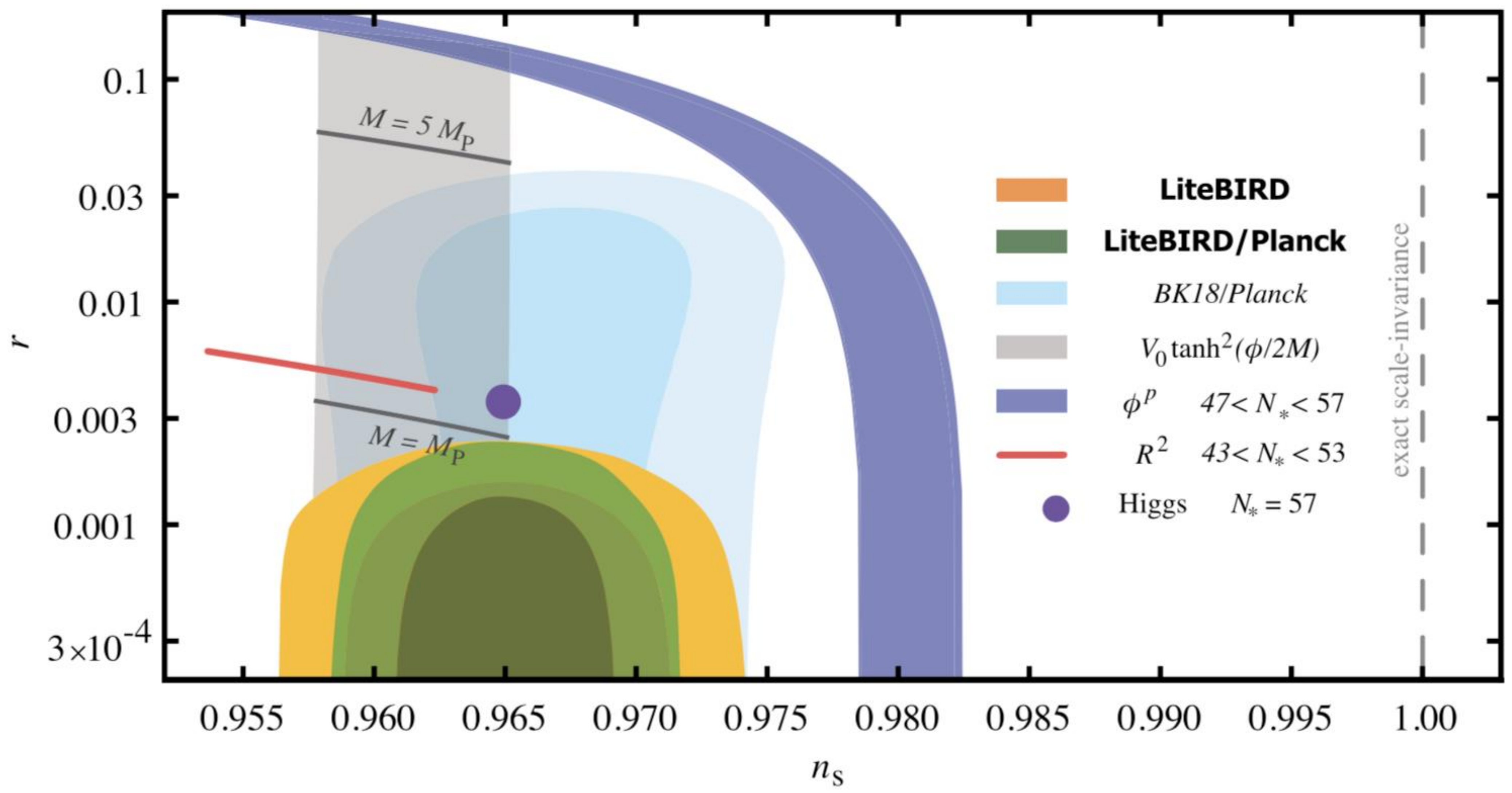
LiteBIRD constraints on inflation

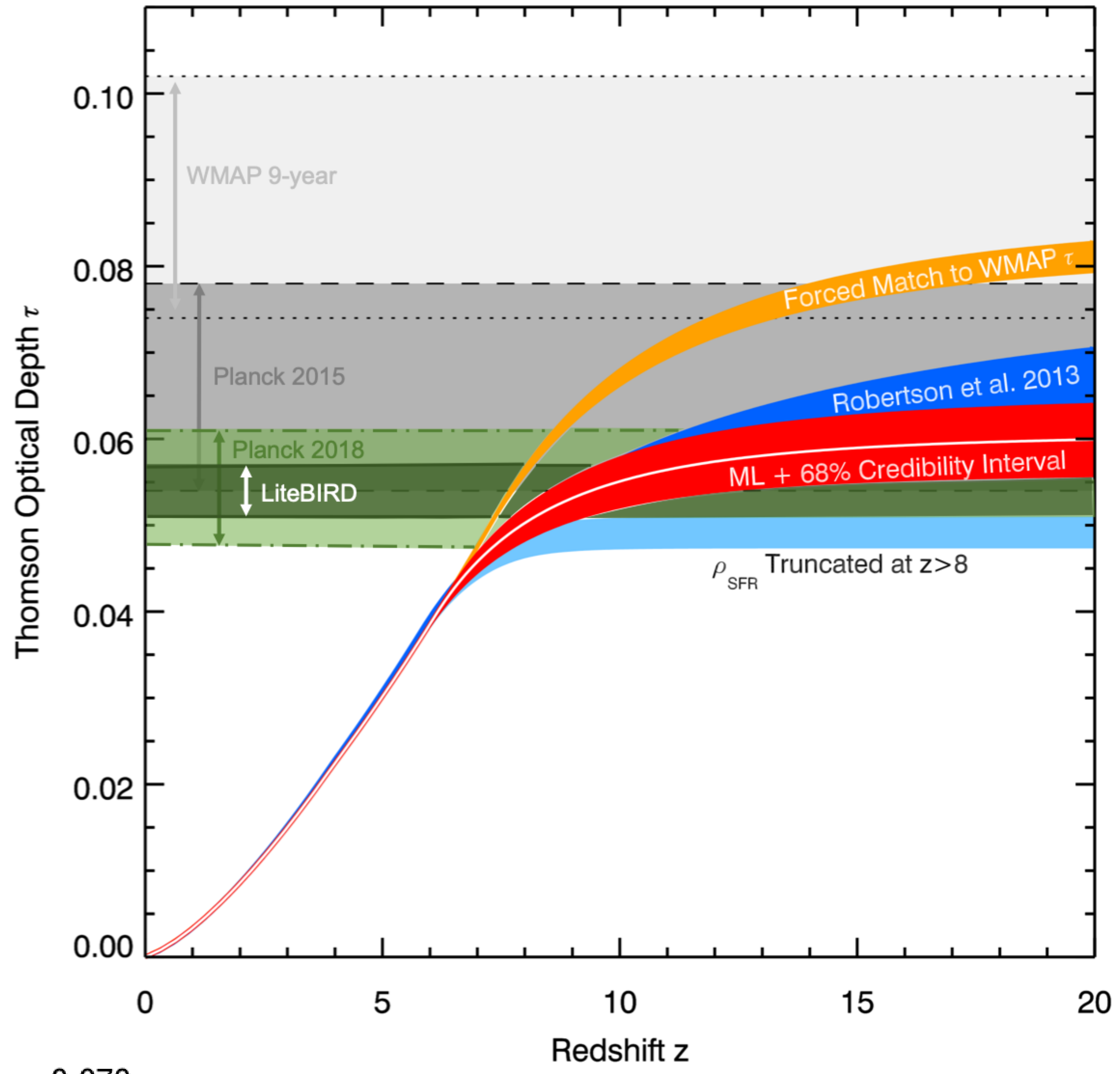
- The final goal is to achieve a statistical uncertainty of σ(r) < 0.001 for r=0
- Huge discovery impact (evidence for inflation, knowledge of its energy scale, and distance traveled by the inflaton…)
- A detection of B-modes by *LiteBIRD* with $r > 0.01$ would imply an excursion of the inflation field that exceeds the Planck mass
  - Such a detection would **constrain theories of quantum gravity** such as superstring theories
- An upper limit from *LiteBIRD* would disfavour the simplest inflationary models, with $M > M_p$
  - This includes the monomial models, α-attractors with a super-Planckian characteristic scale, including the **Starobinsky model** and models that invoke the Higgs field as the inflaton (📖 Kallosh & Linde 2025)



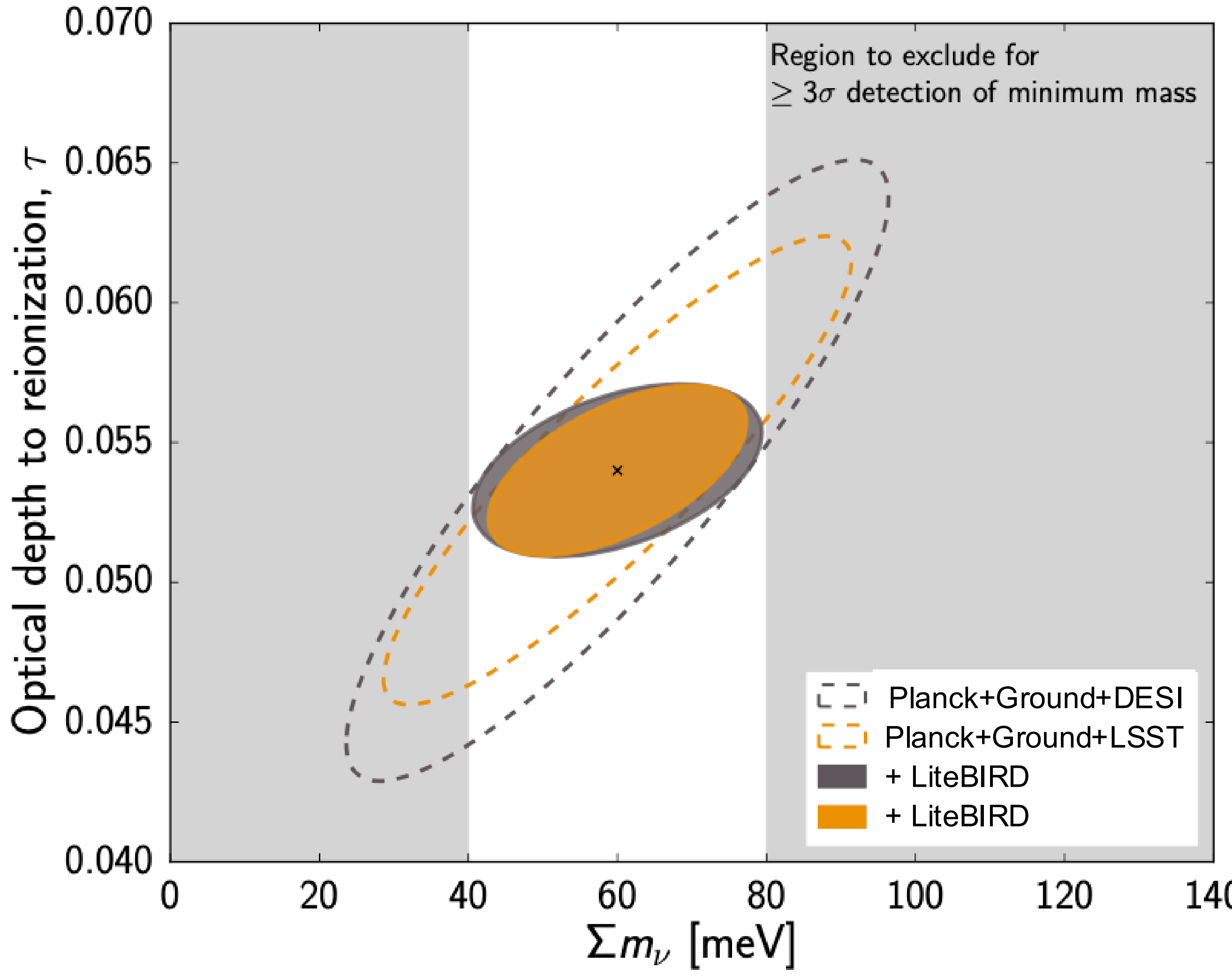


LiteBIRD other science outcomes

- The mission specifications are driven by the required sensitivity on r
- Meeting those sensitivity requirements would allow to address other important scientific topics, such as:
  1. Characterize the B-mode power spectrum and search for source fields (e.g. scale-invariance, non-Gaussianity, parity violation, …)
  2. Power spectrum features in polarization
     - Large-scale ***E*-modes**
     - **Reionization** (improve $\sigma(\tau)$ by a factor of 3)
     - **Neutrino mass** ($\sigma(\sum m_\nu) = 12$ meV) including external data
  3. Constraints on **cosmic birefringence**
  4. **Gravitational lensing**
  5. **SZ effect** (thermal, diffuse, relativistic corrections)
  6. **Anisotropic distortions** of the CMB spectrum
  7. onstraints on **primordial magnetic fields**
  8. Elucidating **anomalies**
  9. Physics of **Galactic emission** mechanisms
  10. Catalogues of polarized **point sources**



Adapted from Robertson +2015



LiteBIRD collaboration PTEP 2023

Conclusions

- Searching for B-modes is one of the challenges of this epoch in Cosmology
- LiteBIRD is one of the main candidates for a detection and the only next-future experiment with access to the large scales
- It is also a compelling case for joint searches given the great complementarity with ground-based experiments
- Even a detection from Earth would be a convincing argument to verify from space
- With a sufficiently strong signal, LiteBIRD could be able to shed light on the specific inflationary model realized by nature detecting n_t
- In other words, LiteBIRD is bound to play a significant role in the Age of Discovery