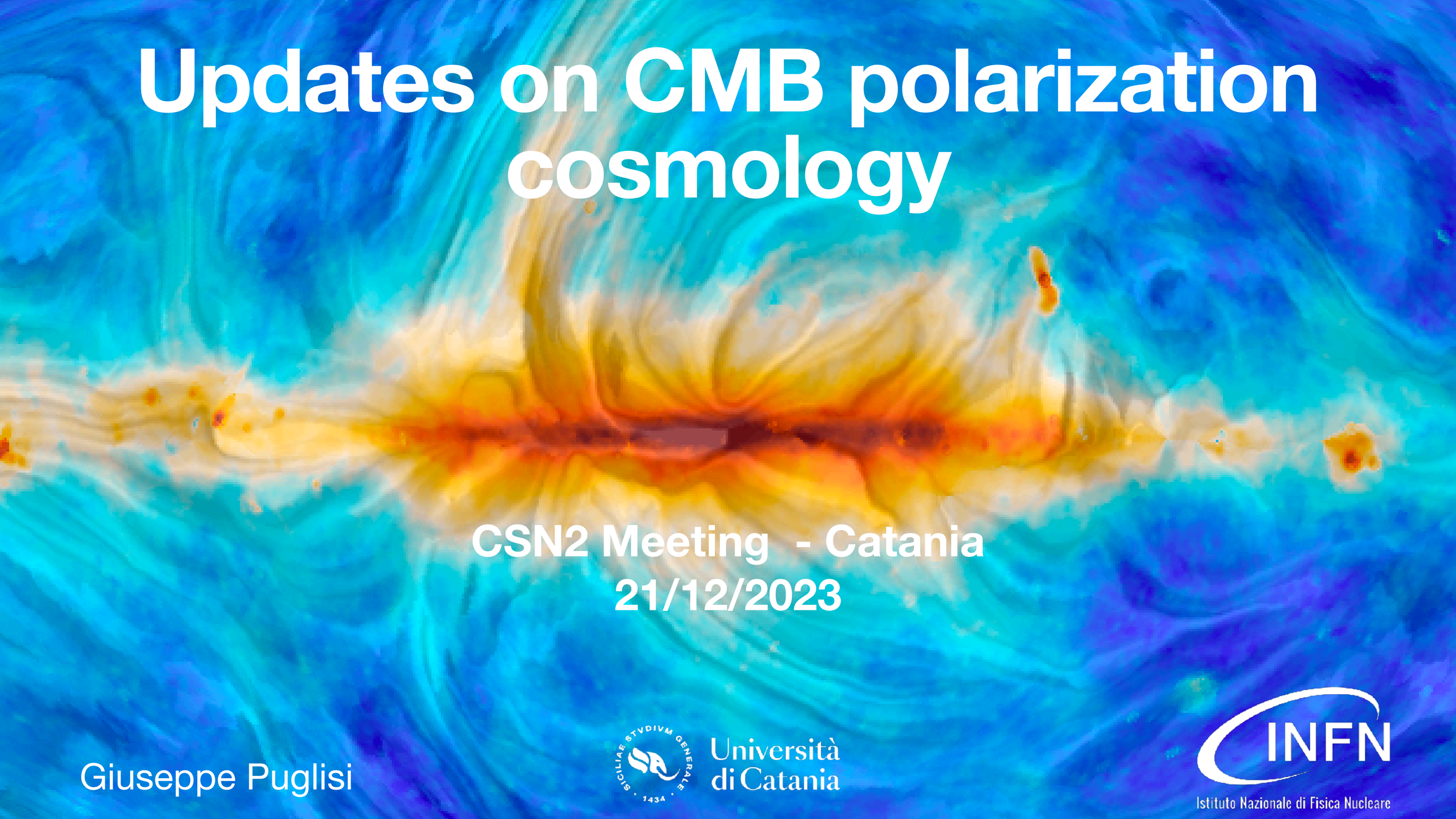
Updates on CMB polarization cosmology



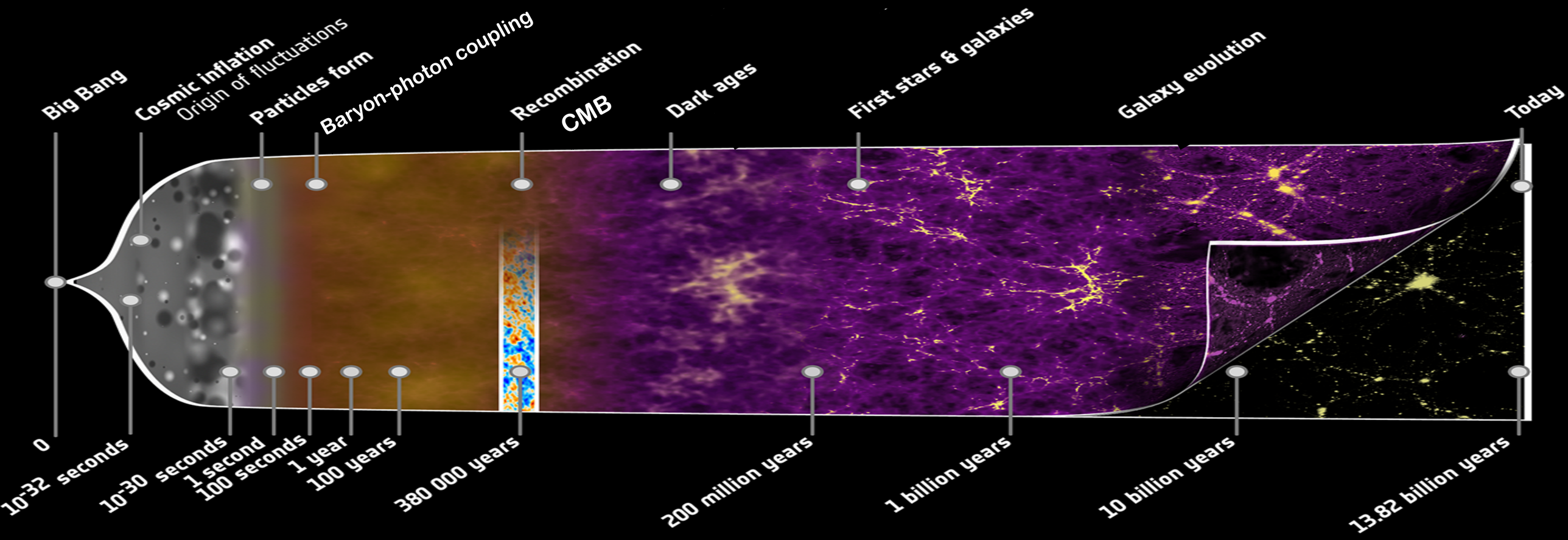
CSN2 Meeting - Catania
21/12/2023

Giuseppe Puglisi

Università di Catania

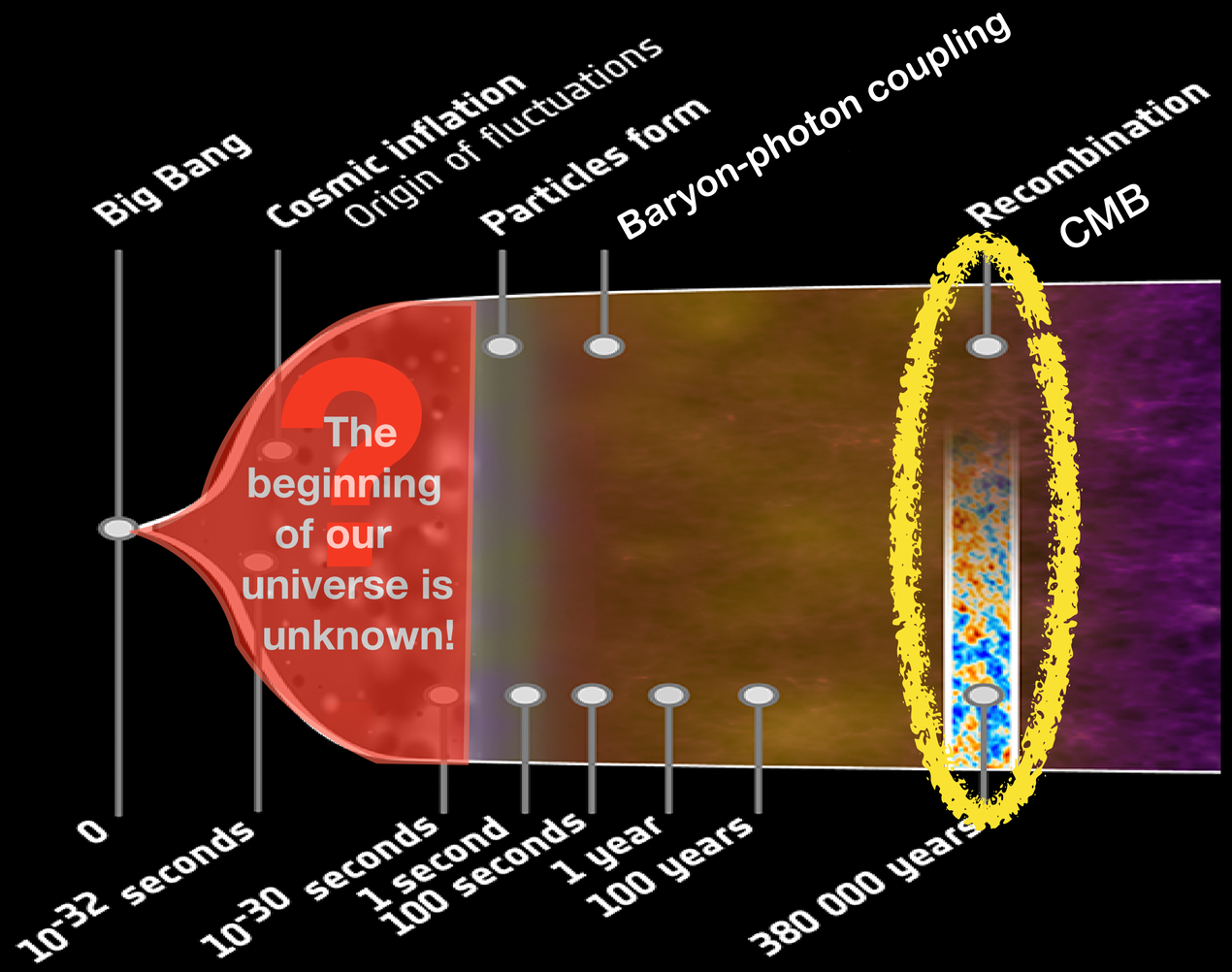
INFN
Istituto Nazionale di Fisica Nucleare

The Standard model of Cosmology: ΛCDM



Credits: ESA & *Planck Collaboration*

The Standard model of Cosmology: ΛCDM



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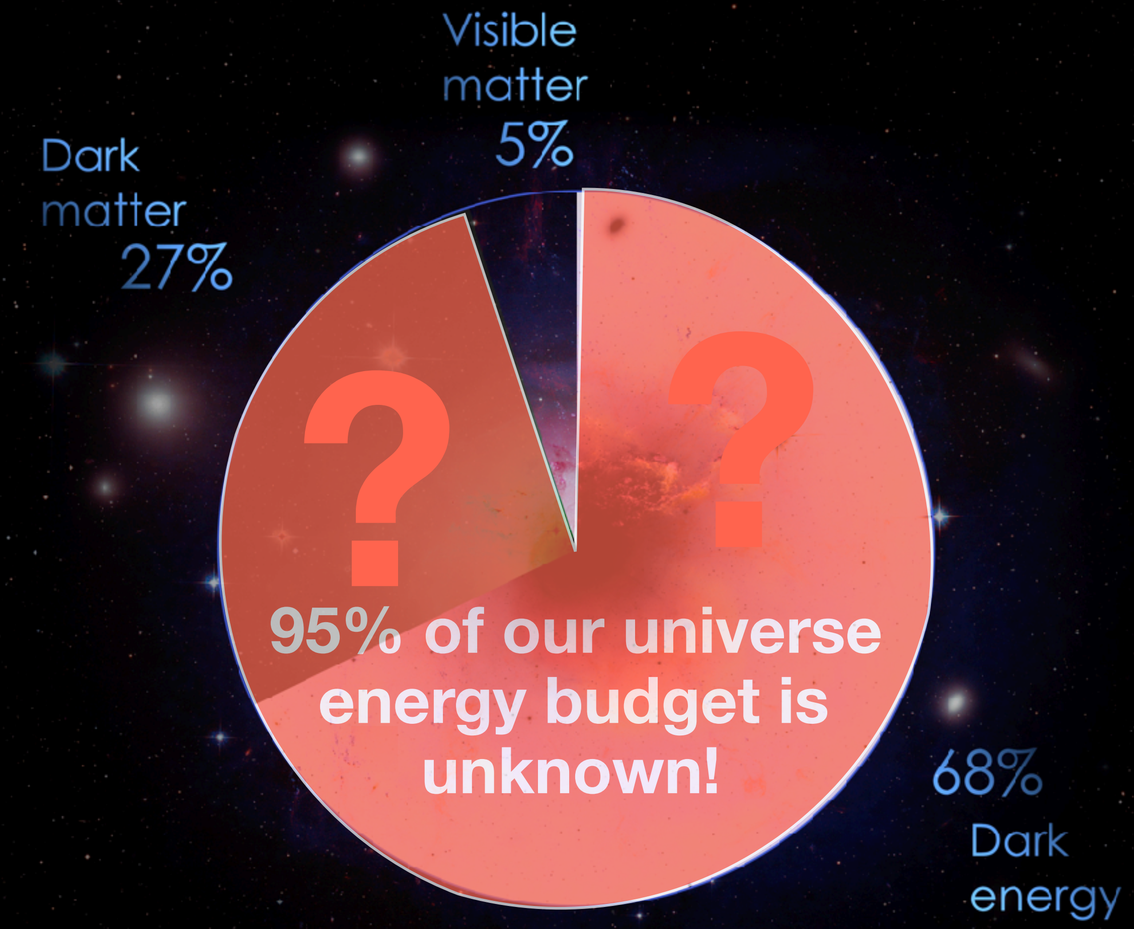


Credits: ESA

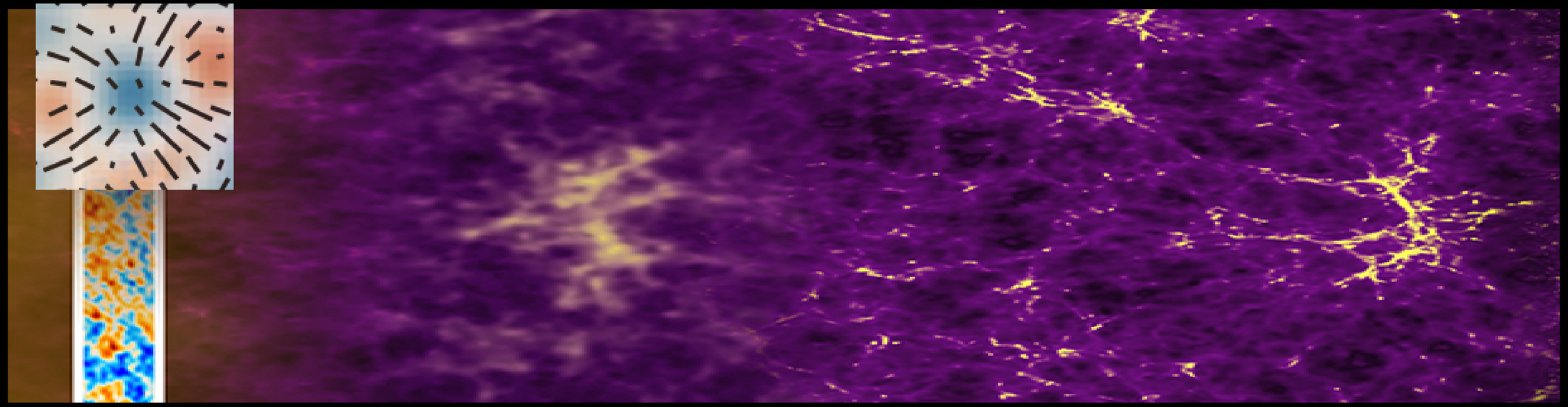
Polarization Cosmic Microwave Background

CMB in a nutshell:

- Black-body emission at T~2.7 K (Penzias &Wilson 1965)
- Emission peaks at 100 GHz (3mm)
- Anisotropies $\delta T \sim 100 \mu K$ (COBE 1992)

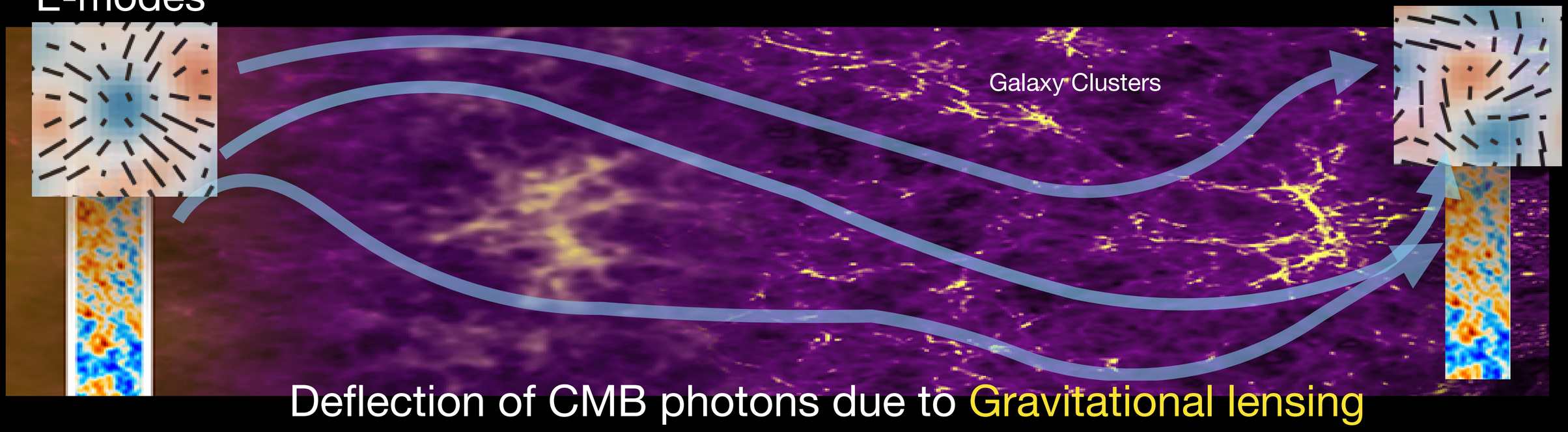
CMB Polarization firstly detected by DASI (Kovac et al. 2002)

E-modes



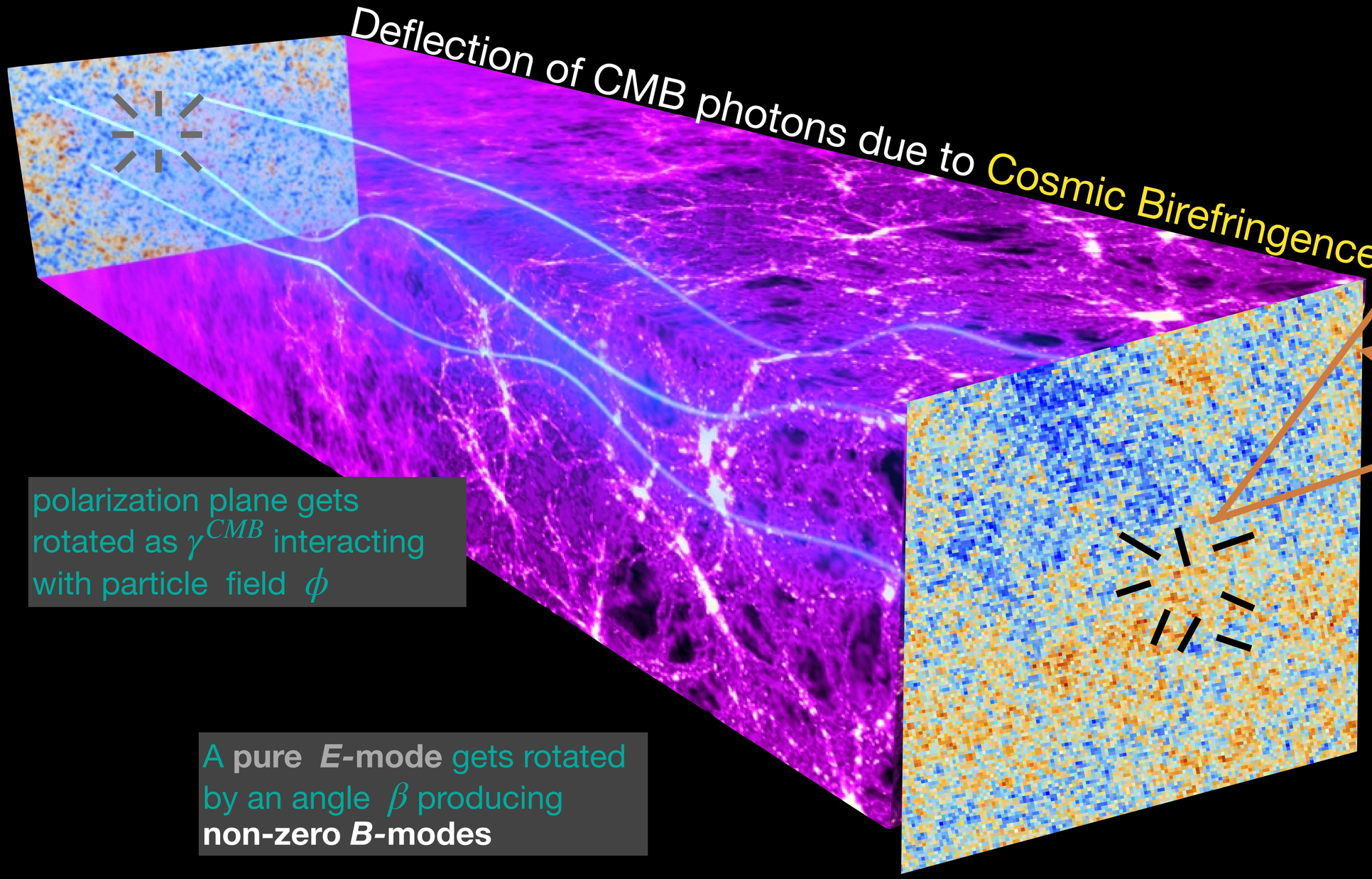
Polarization Cosmic Microwave Background

Large scale structures (e.g. galaxy clusters) gravitationally distort the CMB anisotropies, ⇒ **lensing B-modes**



Lensing B-modes firstly detected by Polarbear Collaboration 2014

What are Dark Matter and Dark Energy made of?



polarization plane gets rotated as γ^{CMB} interacting with particle field ϕ

A **pure *E*-mode** gets rotated by an angle β producing **non-zero *B*-modes**

Eskilt&Komatsu (2022) claimed a 3.6σ of $\beta = 0.34^{\circ}$, using *Planck/WMAP* CMB polarization data

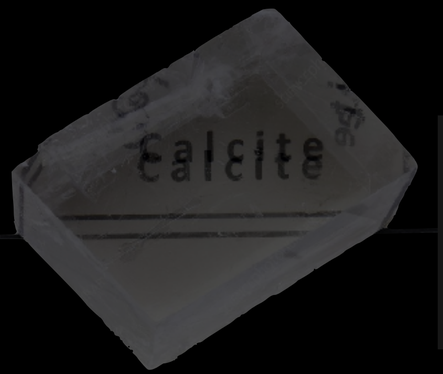
What are Dark Matter and Dark Energy made of?

If confirmed, we could explain 95% of the energy -matter budget in the universe.

Deflection of CMB photons due to Cosmic Birefringence

$\beta \neq 0$

polarization plane gets rotated as γ^{CMB} interact with a pseudo-scalar field ϕ



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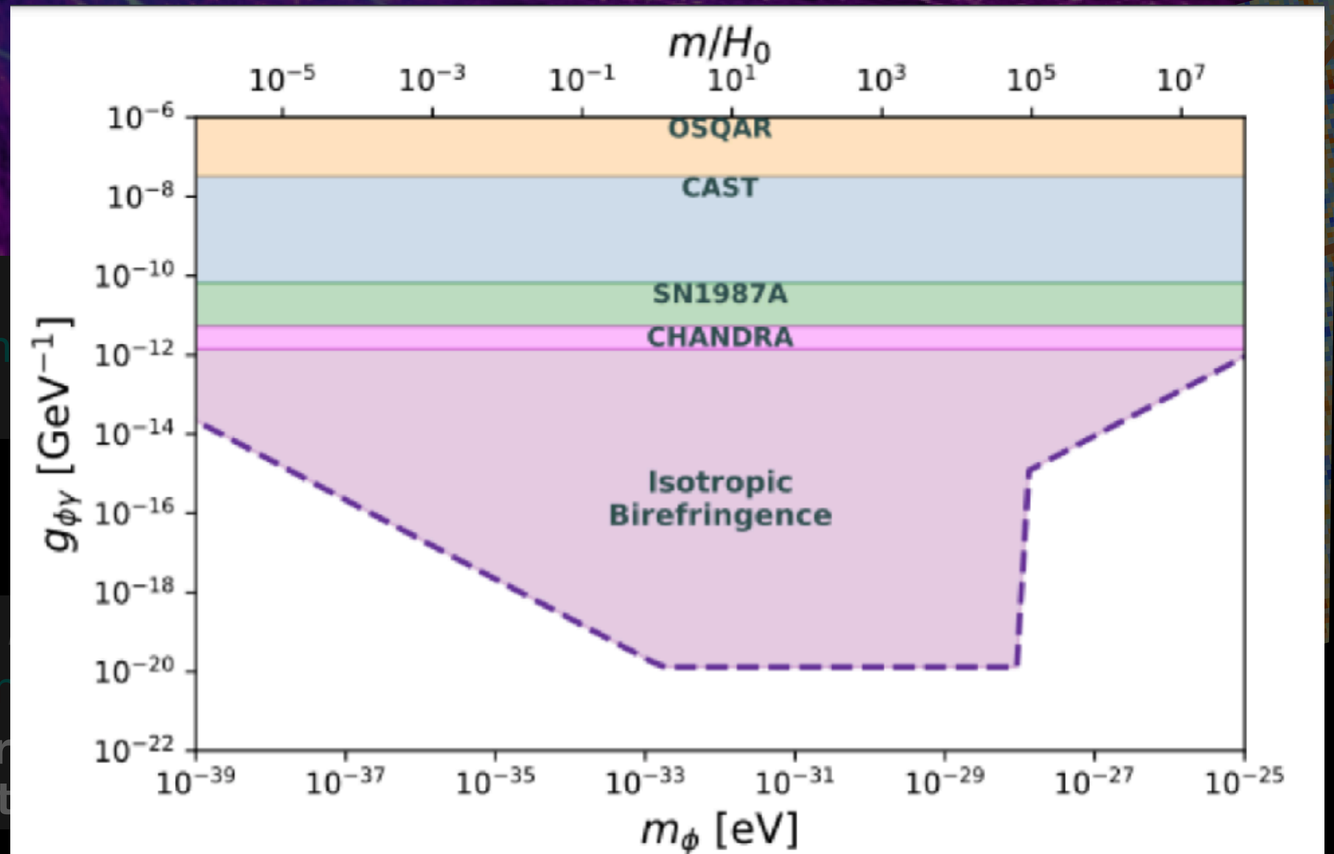
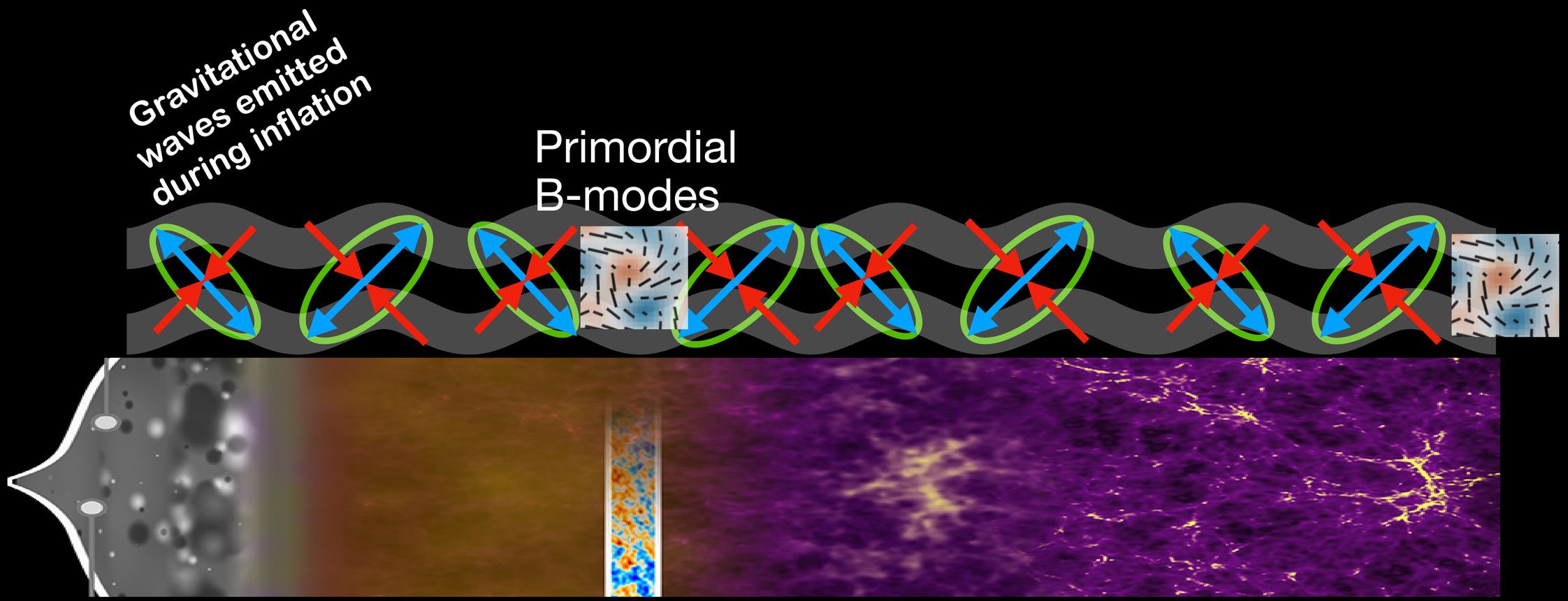


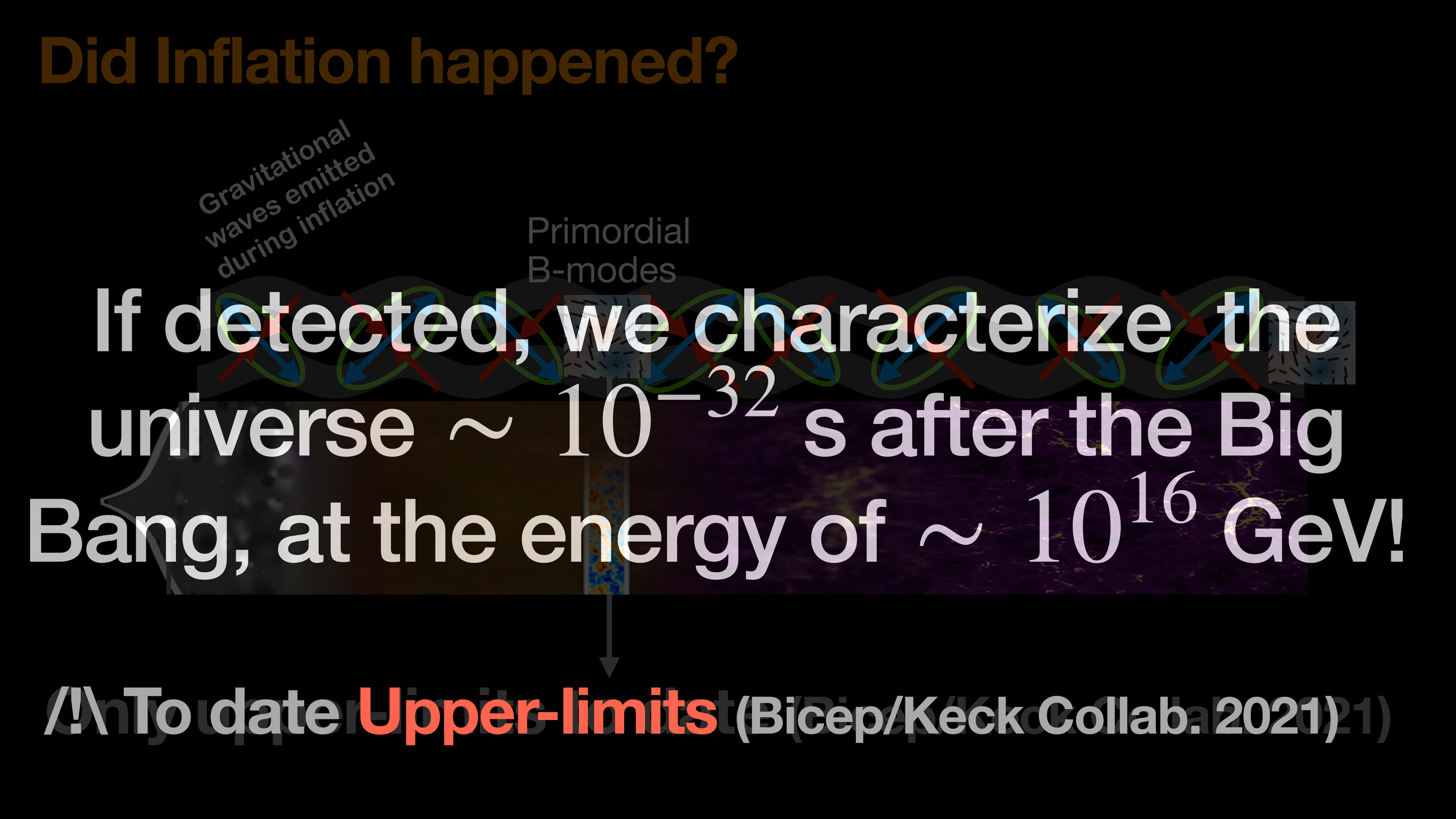
Eskilt&Komatsu (2022) claimed a 3.6σ of $\beta = 0.34^\circ$, using *Planck/WMAP* CMB polarization data

$\Longrightarrow m_\phi \sim 10^{-23}\,\mathrm{eV}$

Did Inflation happened?



Did Inflation happened?

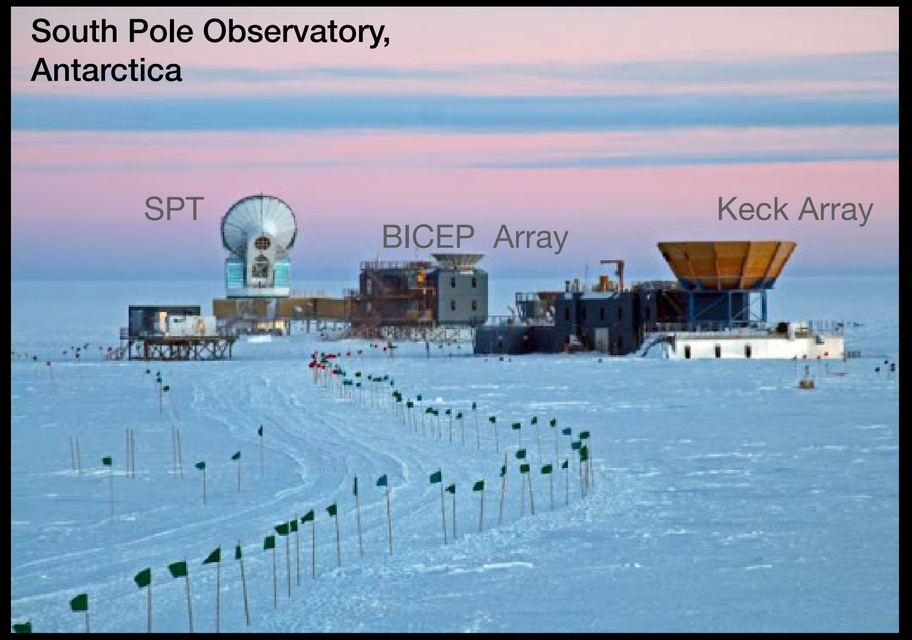


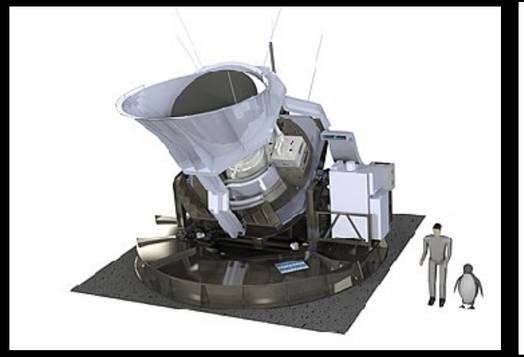
If detected, we characterize the universe $\sim 10^{-32}$ s after the Big Bang, at the energy of $\sim 10^{16}$ GeV!

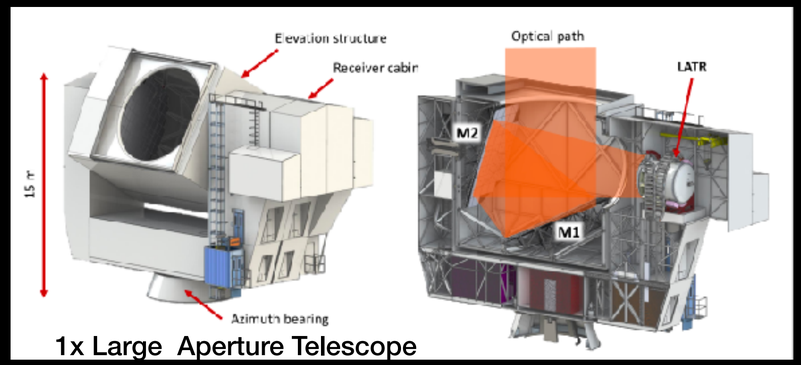
/!\ To date **Upper-limits** (Bicep/Keck Collab. 2021)

CMB forthcoming experiments

Ground-based







>100,000 detectors observing at:

- multiple resolutions (both degree and arcminute)
- Multiple frequency bands 20-200 GHz

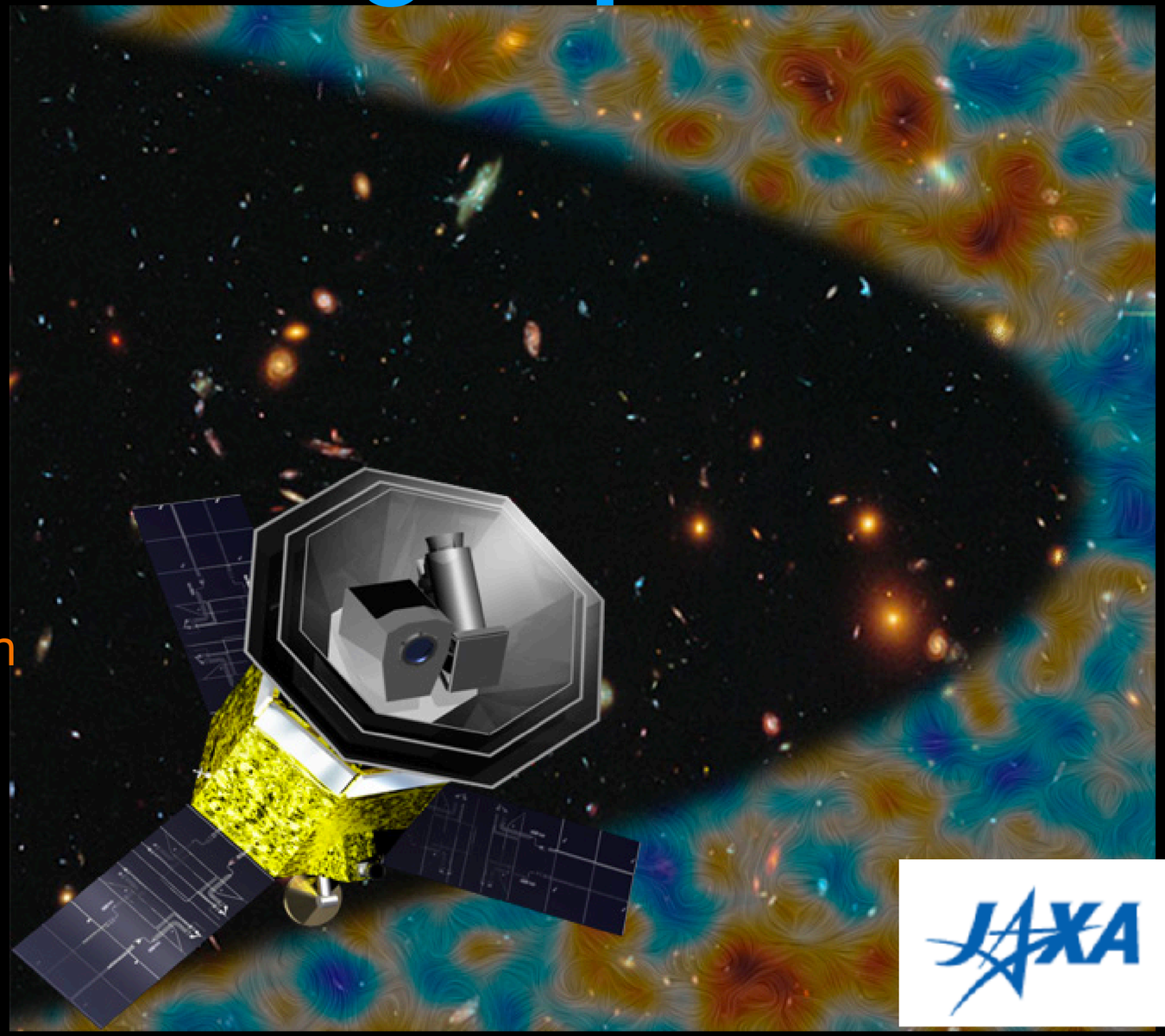
CMB forthcoming experiments

Space-mission

LiteBIRD

r~0.001 at >5σ C.L.

- 22 frequency bands (40-400 GHz)
- 10-70 arcmin resolution
~4500 detectors



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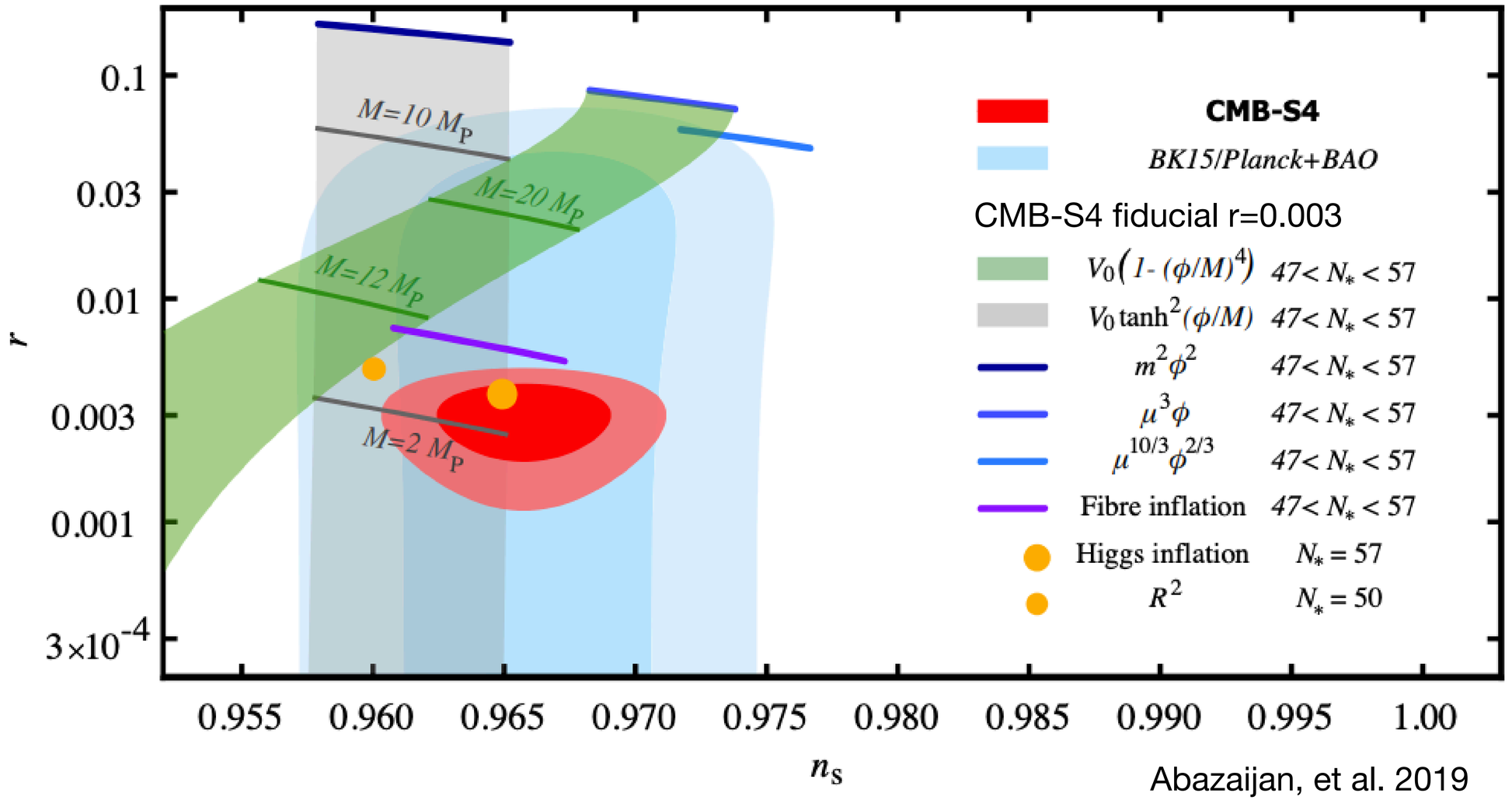
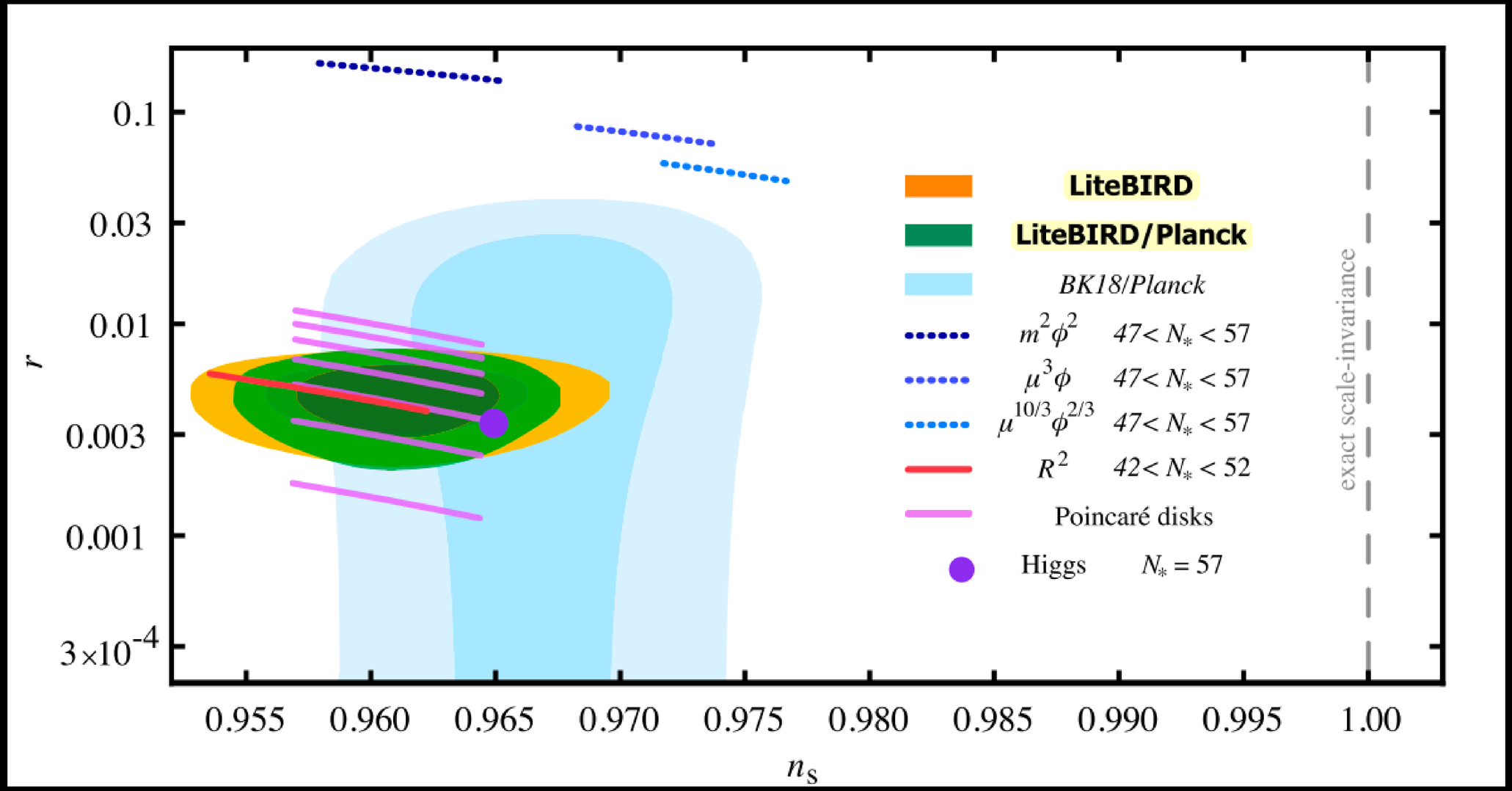
CMB-Stage 4 forecasts on *r*



Abazajian, et al. 2019

LiteBIRD forecasts on *r*



Summary

- **Coming soon:** new data will bring to 5σ the claim of Cosmic birefringence
- In the coming decade Litebird and CMB-S4 will achieve first light to set stringent constraints on tensorial perturbations, $r \sim 0.001$ at 5σ C.L., shedding light to the universe state at 10^{16} GeV
- Multimessenger Astrophysics (microwave): Tidal Disruption Events, Stellar Flares, Variable AGNs

Thank you