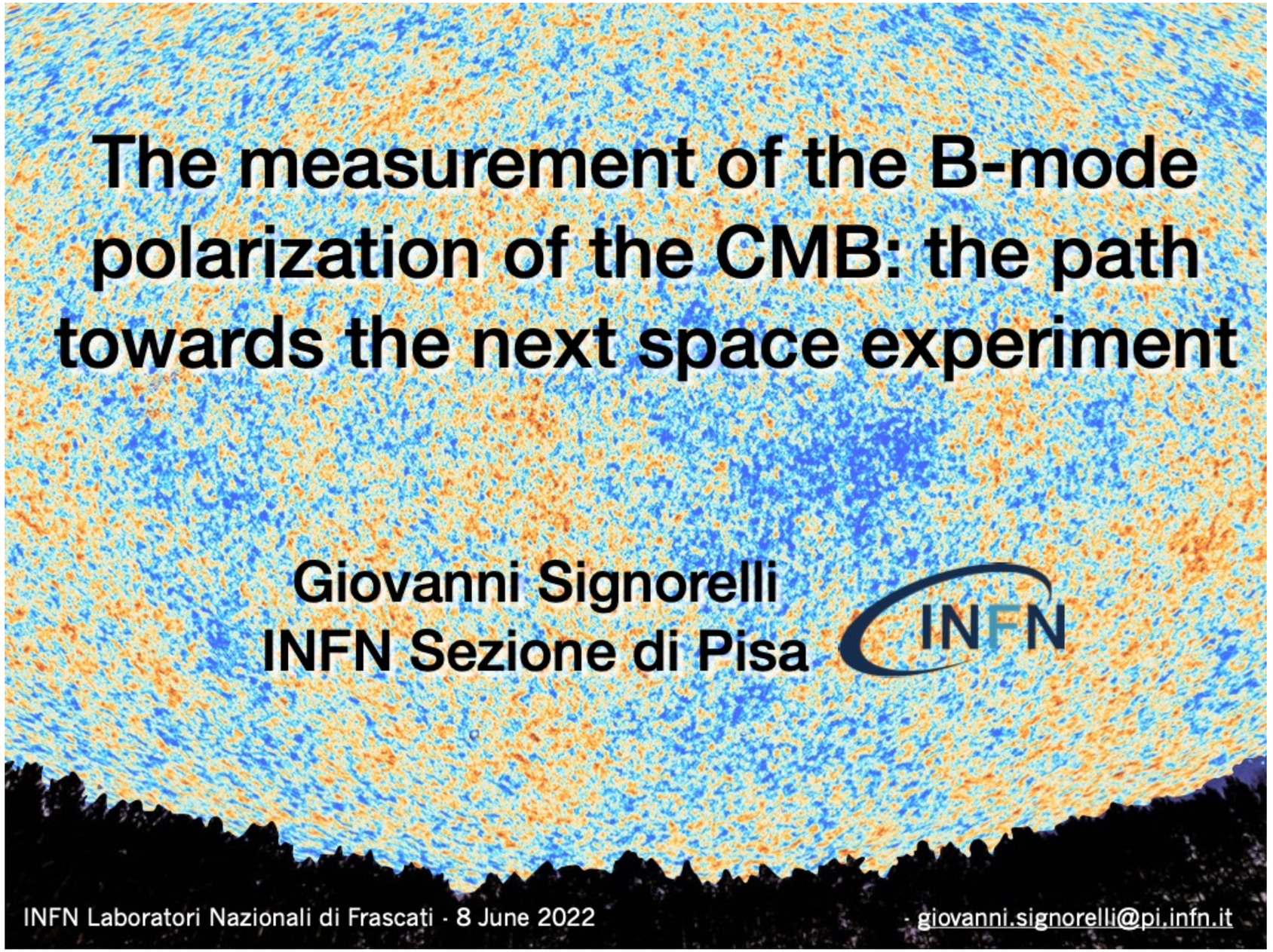
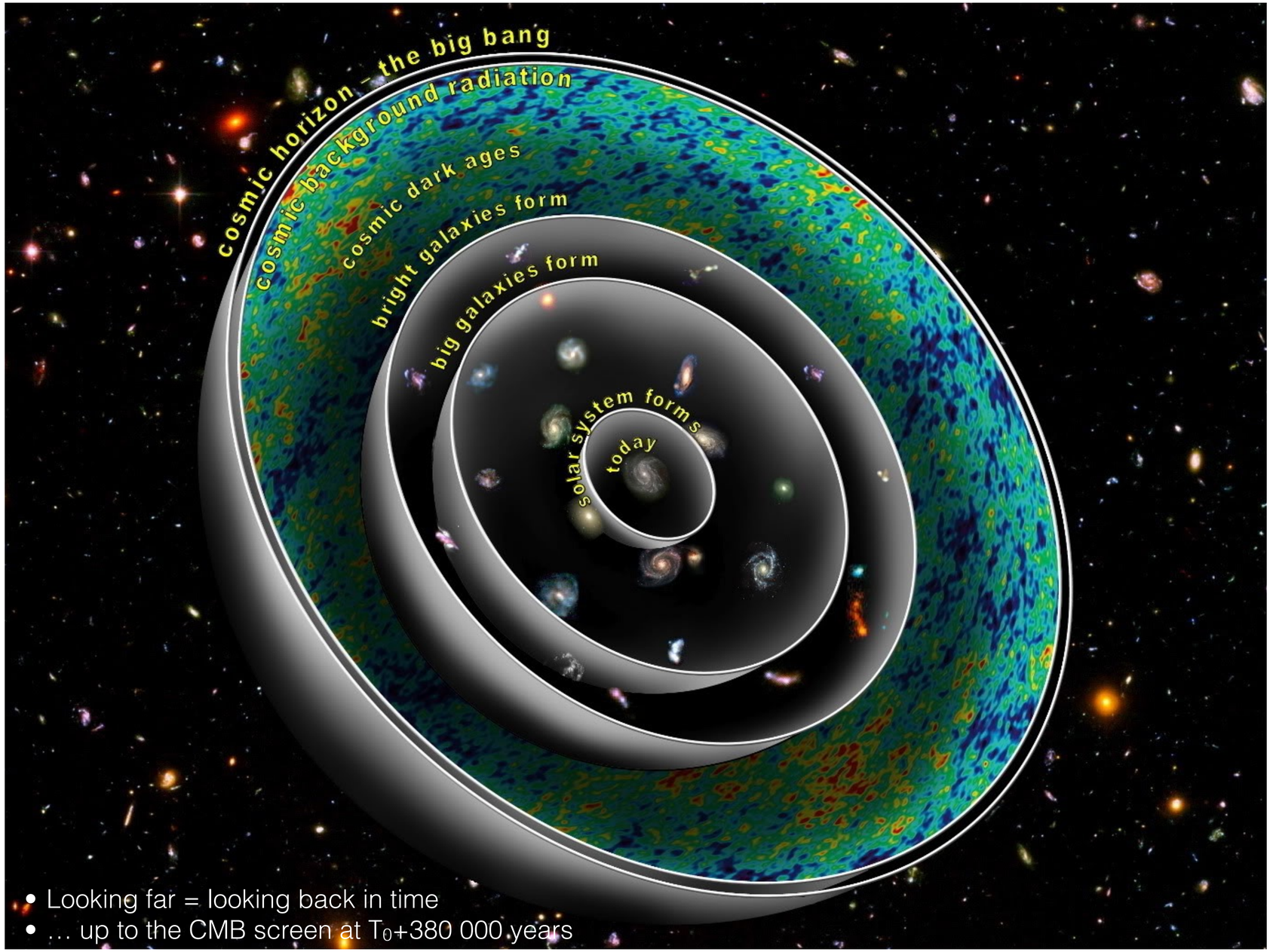
LiteBIRD(-LNF):

the measurement of the B-mode polarization of the CMB

(Luca Porcelli for the Local Participants)



Slide courtesy: G. Signorelli.



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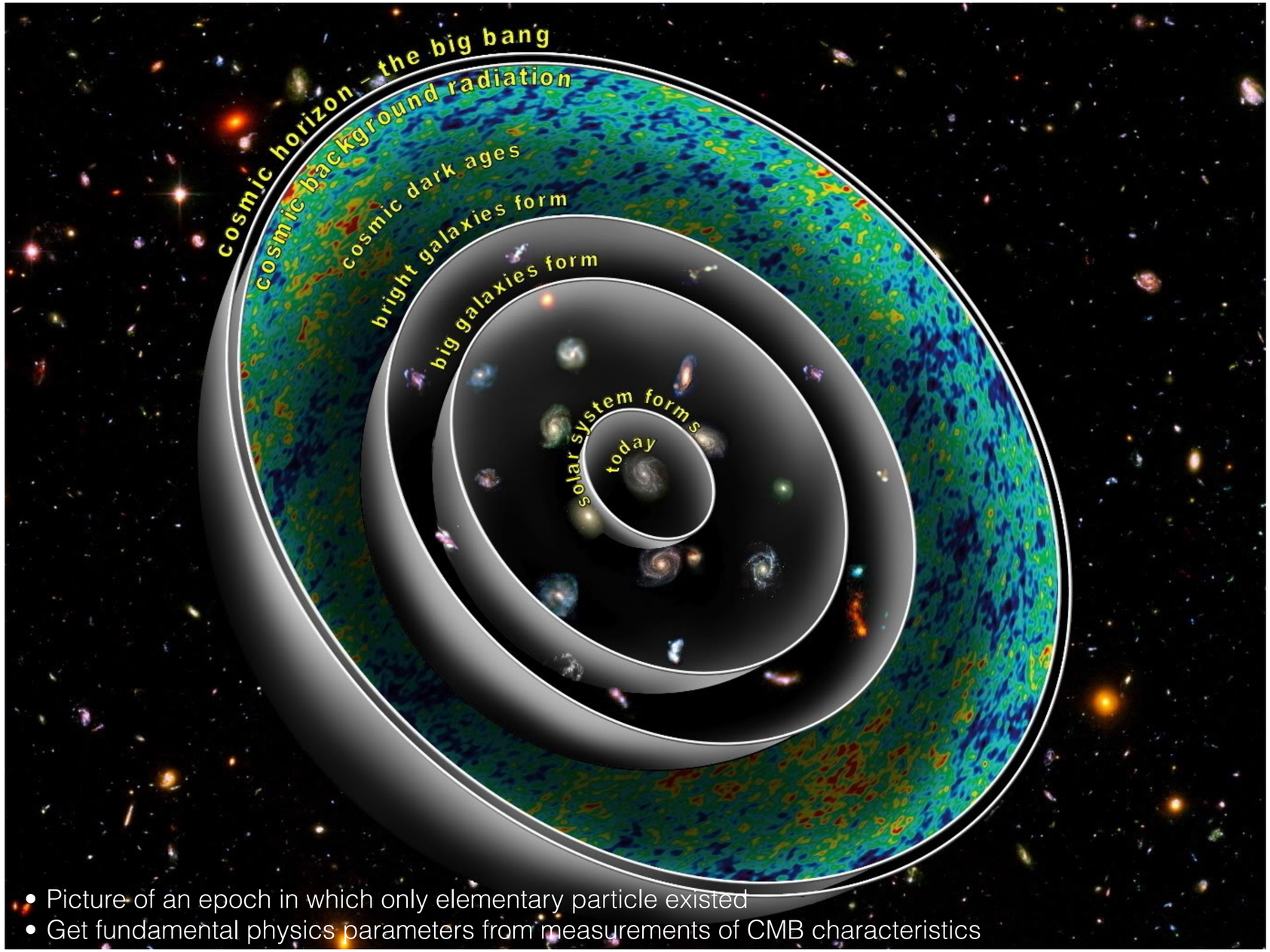
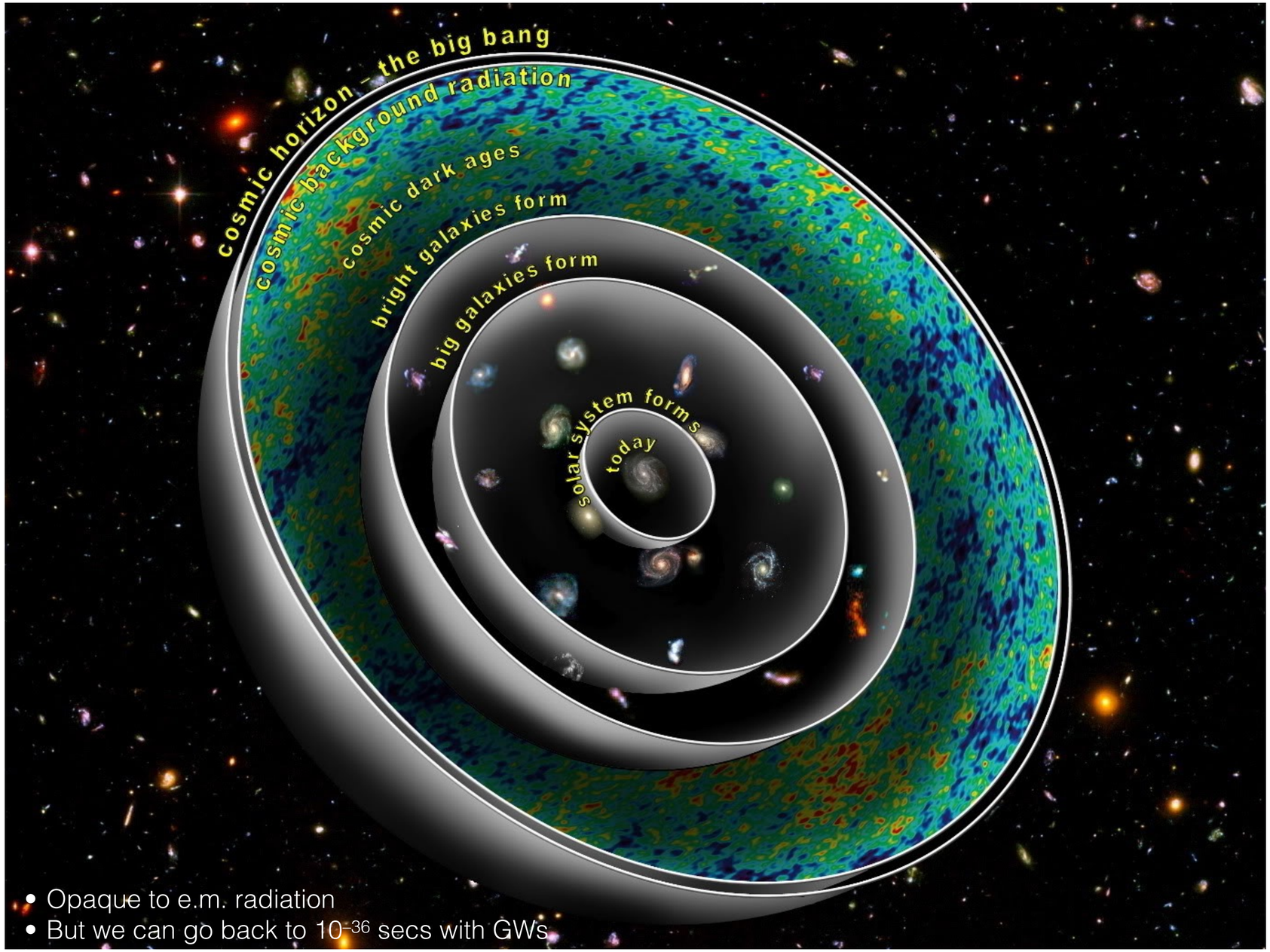


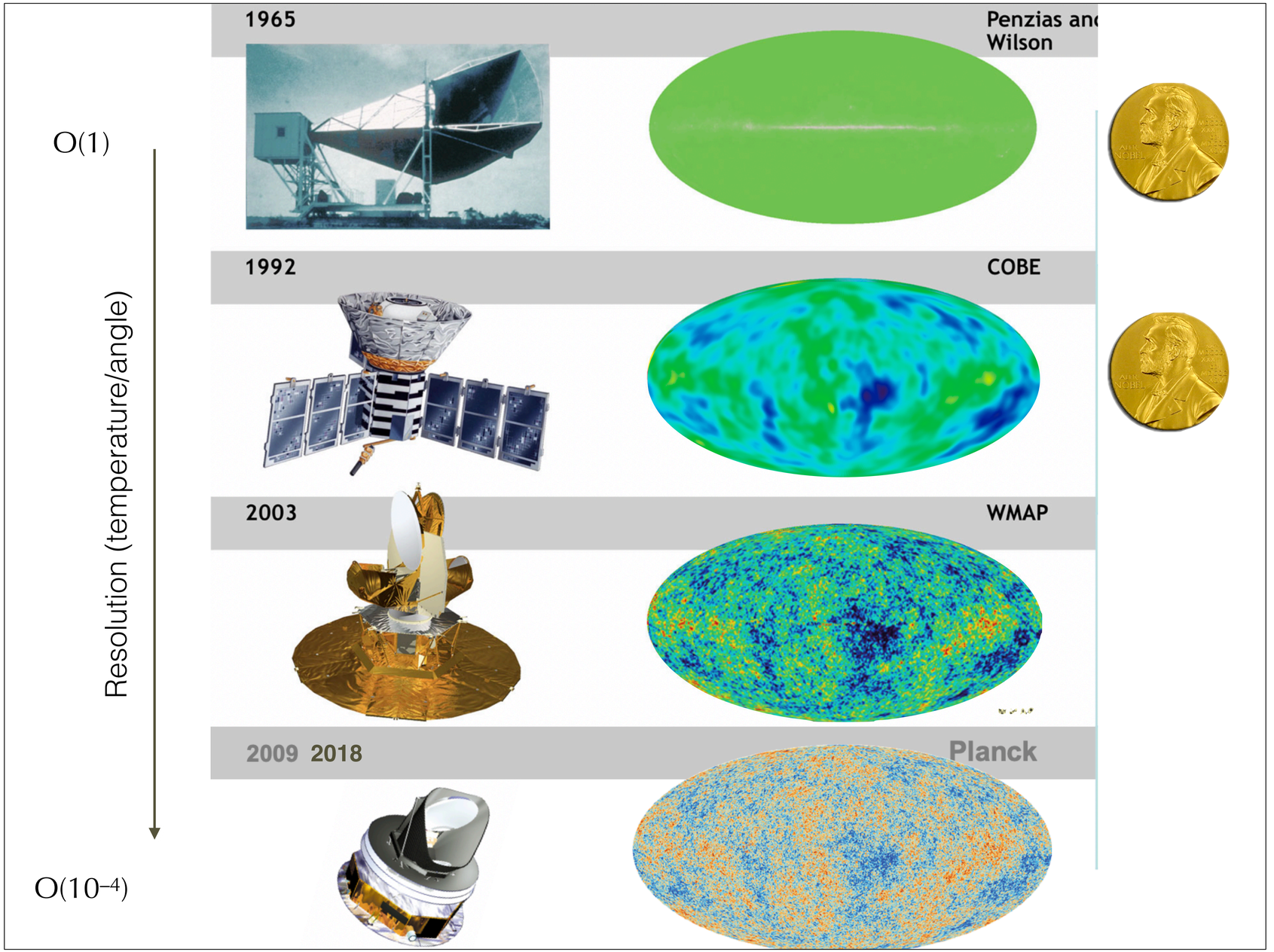
- Picture of an epoch in which only elementary particle existed
- Get fundamental physics parameters from measurements of CMB characteristics

Slide courtesy: G. Signorelli.



- Opaque to e.m. radiation
- But we can go back to 10^{-36} secs with GWs

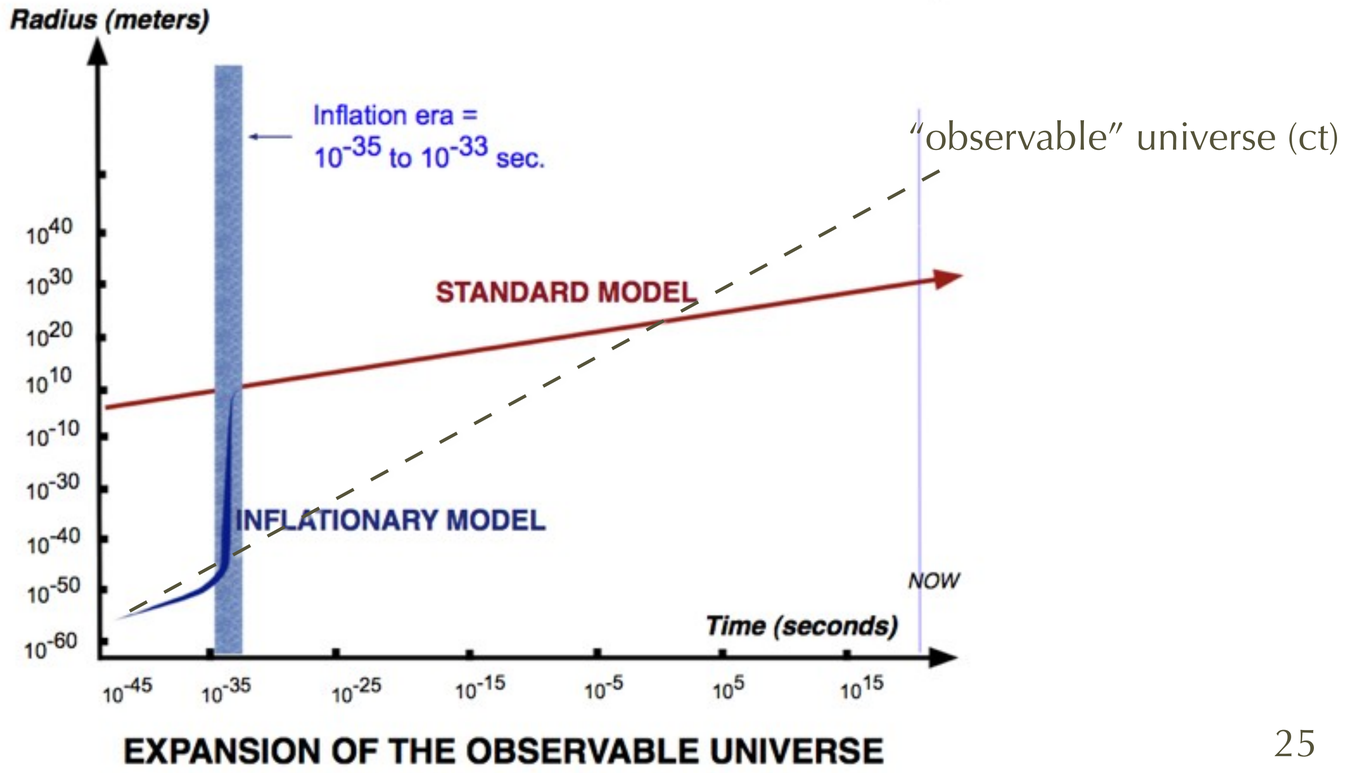
Slide courtesy: G. Signorelli.



Slide courtesy: G. Signorelli.

Isotropy… too much!

- Same temperature (to 10^{-3}) in regions of the Universe that have never been in causal contact
- One of the reasons to develop the cosmological inflation paradigm
  - superluminal expansion of metrics happened between 10^{-36} and 10^{-33} sec. after the Big Bang at E ~ 10^{16} GeV



EXPANSION OF THE OBSERVABLE UNIVERSE

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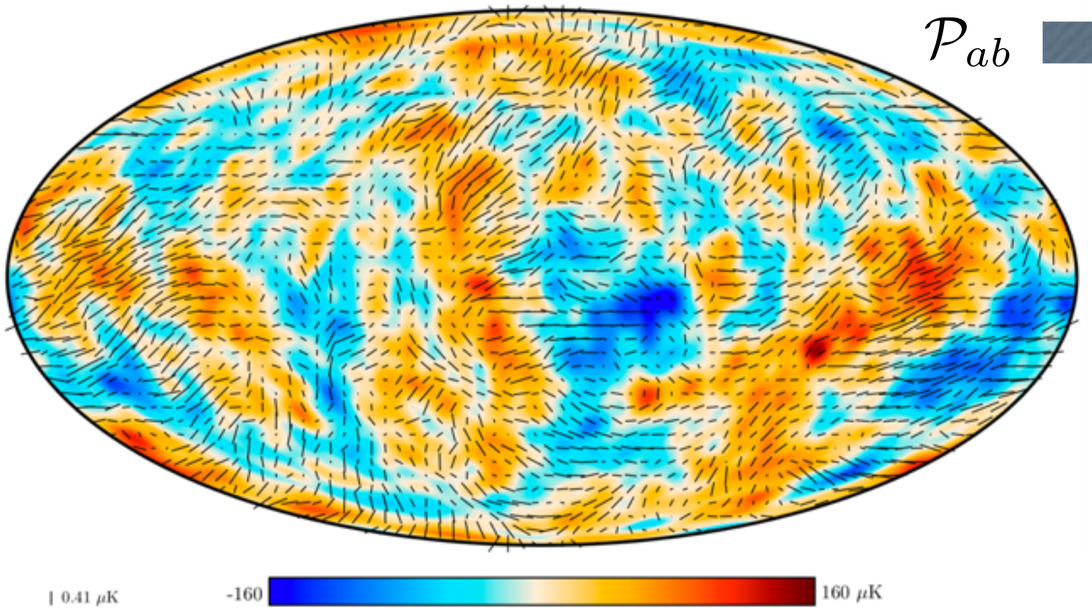
Slide courtesy: G. Signorelli.

How do we measure polarization?

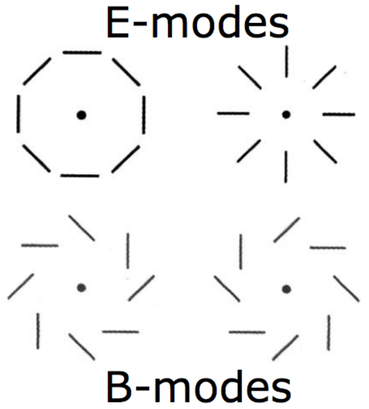
- Monopole term: 2.725 K blackbody — $O(1)$
- Dipole term: 3.355 mK — $O(10^{-3})$
- Anisotropy: 100 μK rms — $O(10^{-4})$
- Tensor perturbations produce a background of primordial gravitational waves — $O(10^{-6 \div 7})$
  - E-mode polarization: 3 μK rms
  - B-mode polarization: <500 nK rms



$\mathcal{P}_{ab}$

$$E \sim \partial_a \partial_b \mathcal{P}_{ab}$$

$$B \sim \epsilon_{ac} \partial_b \partial_c \mathcal{P}_{bc}$$



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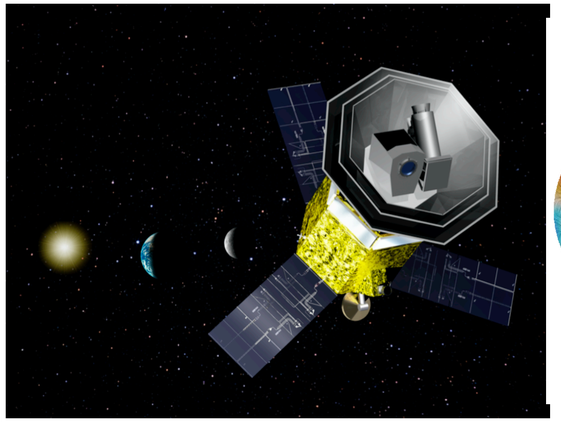
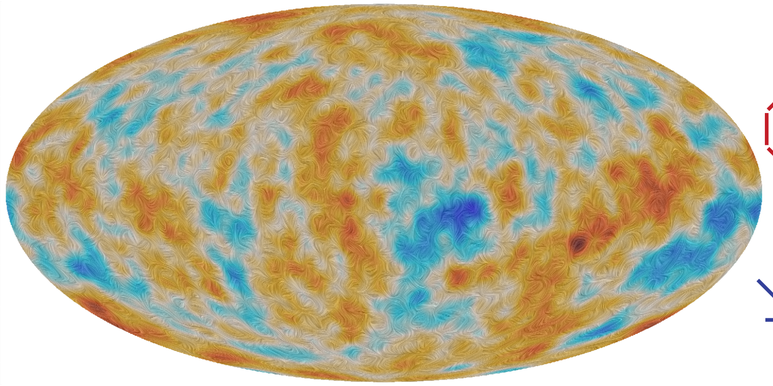
Slide courtesy: G. Signorelli.

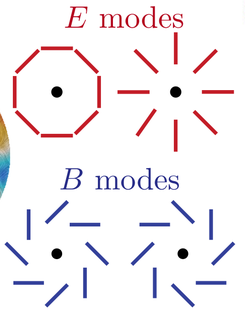
LiteBIRD overview

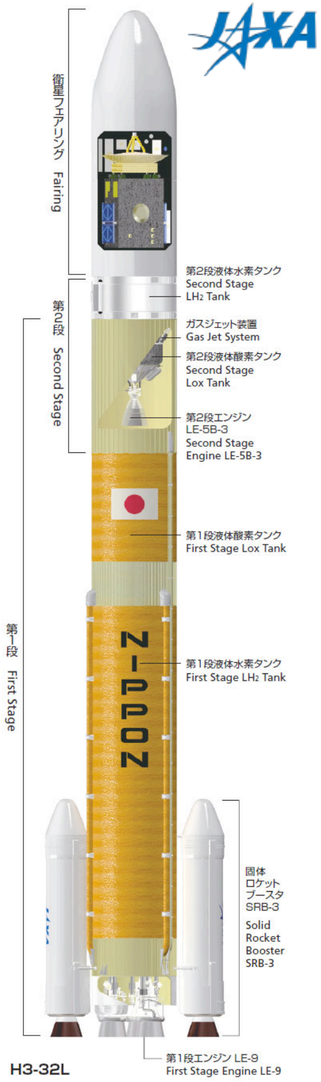
- Lite (Light) satellite for the study of *B*-mode polarization and Inflation from cosmic background Radiation Detection
- JAXA's L-class mission selected in May 2019
- Expected launch in late **2029** with JAXA's H3 rocket
- **All-sky 3-year survey**, from Sun-Earth Lagrangian point L2
- Large frequency coverage (**40–402 GHz**, 15 bands) at **70–18 arcmin** angular resolution for precision measurements of the **CMB *B*-modes**
- Final combined sensitivity: **2.2 μK·arcmin**

📖 Hazumi+ SPIE 2020









Slide courtesy: G. Signorelli.

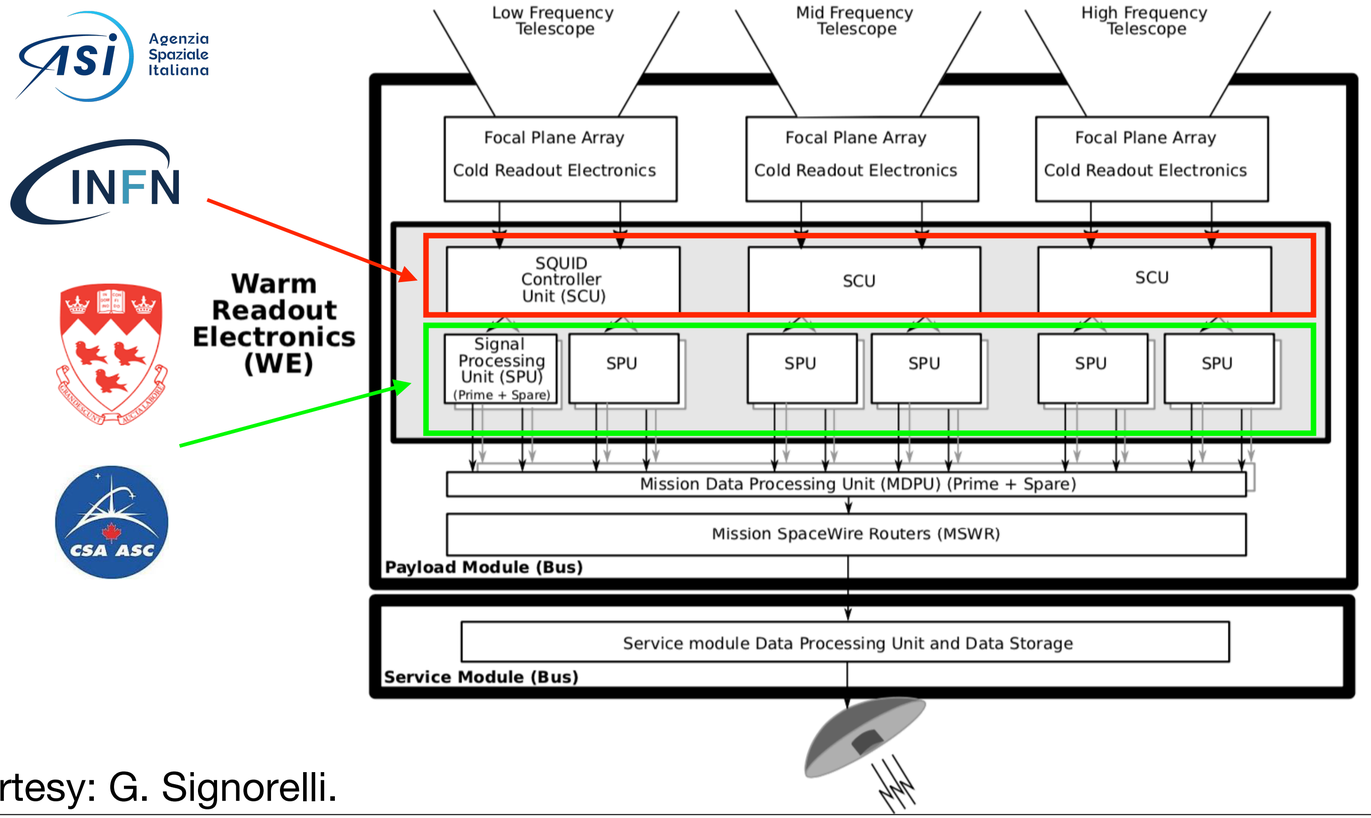
LiteBIRD readout system: INFN contributions

INFN is part of the ASI-lead italian contribution

- hardware and software/simulation/analysis
- PI(lead), MIB, FE, MI, TS, RM1, RM2

Two main hardware contributions:

- SQUID Controller Unit (SCU) for 3 telescopes: electronics, thermo-mechanical design, interfaces, shielding
- Flight qualification of critical components: in particular, DAC LTC1668 (required, but not qualified yet)

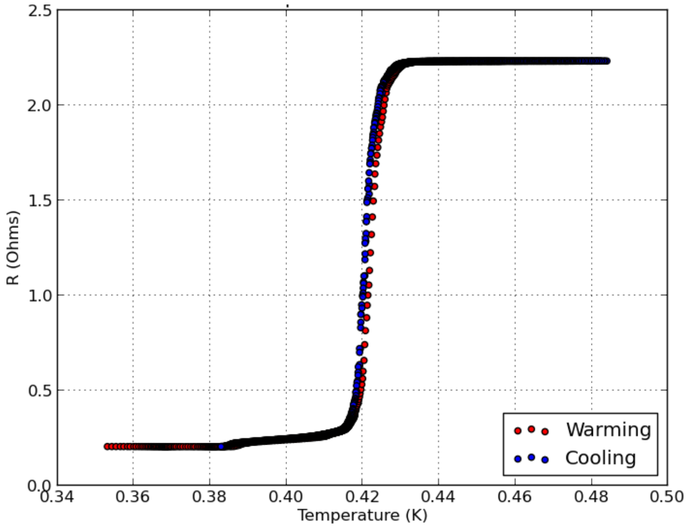


Slide courtesy: G. Signorelli.

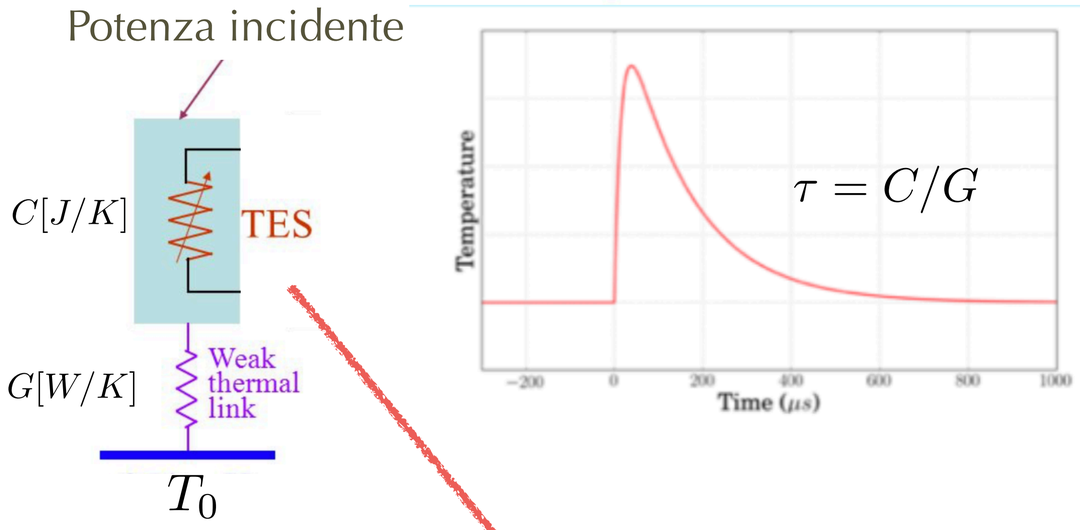
Transition-Edge Sensors

- "Thermometers" that enable us to measure tiny temperature variations
- Superconducting films at their phase transition

steep $R(T)$

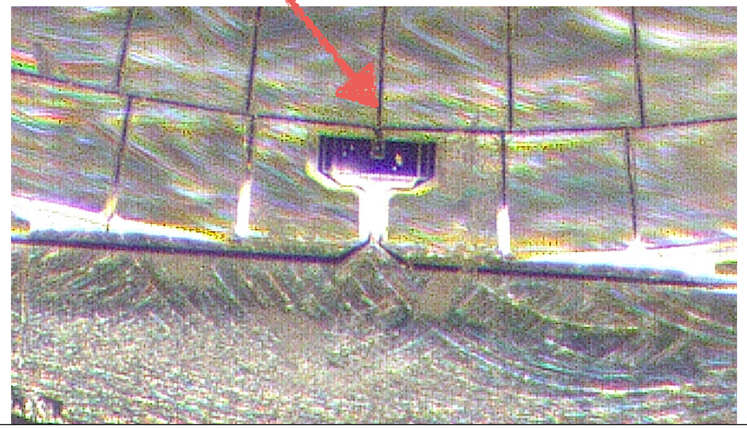


$$P_{\text{ott}} = C\frac{\mathrm{d}T}{\mathrm{d}t} + G\,(T - T_0)$$



$$\frac{10\ \Omega}{1\ \mathrm{mK}} = 10^4\ \Omega/\mathrm{K}$$

$$100\ \mathrm{nK} \Rightarrow 1\ \mathrm{m}\Omega$$



Slide courtesy: G. Signorelli.

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Proposed Activity @ INFN-LNF

Foreseeable activity as of today:

- (Non)destructive irradiation testing @ X-Lab (Dabagov and Hampai), with extrapolation at longer wavelengths, and X-ray circuitry diagnostics on specifically dedicated and instrumented optical bench.
- Thermal balance test and correlation to models with the software Thermal Desktop (thanks to the ‘pocket’ cryostat belonging to INFN, and whose responsible is Giovanni Delle Monache).
- Involvement in data analysis, modelling and simulations for the physical processes of interest, at ‘cosmological’ level, with Luca Porcelli and if a PhD student of Unical will join the team.
- Involvement in PA/QA of the flight hardware.
- Possibility of hiring PhD students, thanks to the involvement of Sandra Savaglio (Unical).

Proposed Team and FTE Sharing

Team Members as of today:

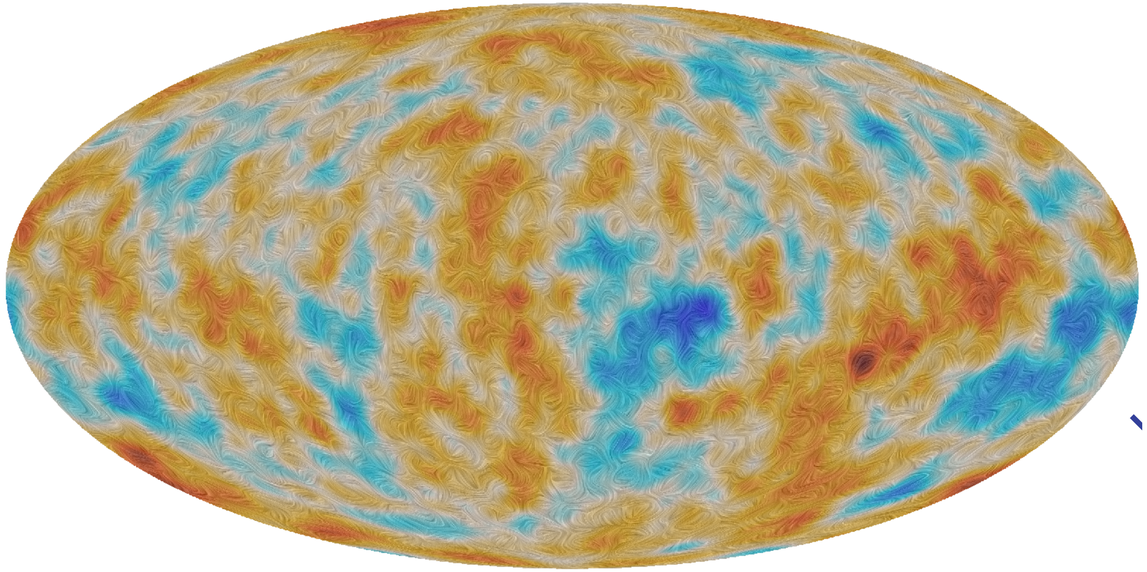
- Luca Porcelli (Staff Researcher - III Level - LR) = 40% FTE.
- Sultan Dabagov (Executive Researcher - I Level) = 40% FTE.
- Dariush Hampai (Staff Technologist - III Level) = 40% FTE.
- Valeria Guglielmotti (Postdoctoral Researcher) = 40% FTE.
- Giovanni Delle Monache (Staff Technologist - III Level) = 40% FTE.
- Sandra Savaglio (Full Professor @ Unical) = 30% FTE.

We are very open to people and ideas, and very welcoming for inclusion of further team members here at INFN-LNF.

LiteBIRD-LNF x 2023

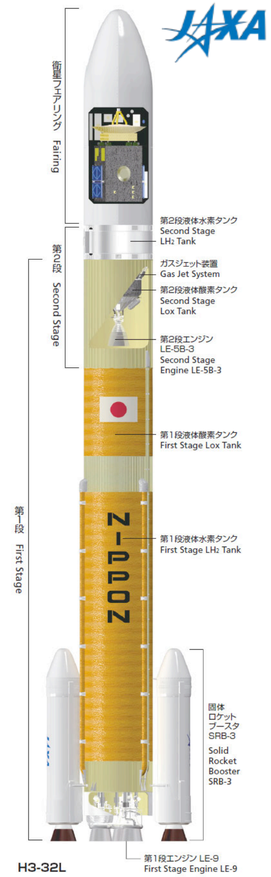
Objective: starting up the local activity and ‘properly’ joining the wider collaboration.

- **2022 Results:**
  - N/A.
- **2023 Objectives:**
  - Starting up the local activity.
  - Joining the wider collaboration.
  - Starting the setup a (non)destructive irradiation testing chain and procedure for the electronics of interest @ X-Lab.
  - Starting the setup and instrumentation of the ‘pocket’ cryostat for tests on the electronics of interest.
  - Starting the teaming with the wider collaboration in order to get involved in data analysis, modelling and simulations for the physical processes of interest, at ‘cosmological’ level.



LiteBIRD-LNF x 2023

Objective: starting up the local activity and ‘properly’ joining the wider collaboration.



- **FTE (LNF):** L. Porcelli (RL, 40%), S. Dabagov (40%), D. Hampai (40%), V. Guglielmotti (40%), G. Delle Monache (40%) + S. Savaglio (Unical, 30%) = 2.0 FTE (2.3 FTE)

- **Richieste CSN2 2023 (TBD):** ~~missioni 10k, consumo 40k, altri cons 5k, inventario 40k, license SW 20k, apparati …k, servizi …k~~

- **Richieste LNF 2023 (mesi-uomo):** Elettronica 0.5; Impianti Fluido 0.5; Criogenia 0.5

- **Fondi Esterni:** N/A