Mapping the hot gas in the Universe with LiteBIRD

MD
On behalf of the “SZ"-WG
With material from M. Remazeilles


LiteBIRD
PPC
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
EXCELENCIA MARÍA DE MAEZTU
EXCELENCIA SEVERO OCHOA
FAU
FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG
Forskningsrådet
The Research Council of Norway
NASA
Goddard
Space Flight Center
GSSI
GRAN SASSO SCIENCE INSTITUTE
INSTITUTO DE ASTROFISICA DE CANARIAS
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
Jet Propulsion Laboratory
California Institute of Technology
KEK
KIPAC
KMI
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
NÉEL institut
NIST
Norwegian Directorate for Higher Education and Skills
OAC
岡山大学
OKAYAMA UNIVERSITY
International Center for Quantum-field Measurement Systems for Studies of the Universe and Particles
POLITÉCNICA
idr
RWTH AACHEN UNIVERSITY
SAPIENZA
UNIVERSITÀ DI ROMA
SISSA
SORBONNE UNIVERSITÉ
SRON
SSDC
Stockholm University
公立諏訪東京理科大学
Suwa University of Science
TOR VERGATA
UNIVERSITÀ DEGLI STUDI DI ROMA
UCL
UBC
THE UNIVERSITY OF BRITISH COLUMBIA
UC
UNIVERSIDAD DE CANTABRIA
Università di Catania
University of Colorado Boulder
UKRI
Science and Technology Facilities Council
ULB
UNIVERSITÉ LIBRE DE BRUXELLES
Universidad de La Laguna
MANCHESTER 1824
The University of Manchester
UiO : University of Oslo
UNIVERSITY OF OXFORD
IN SUPREMÆ DIGNITATIS
1343
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

Mapping the hot gas in the Universe

Team Members

Nabila Aghanim, Tony Banday, Soumen Basak, Elia Battistelli, Paolo de Bernardis, Caterina Chiocchetta, Jens Chluba, Marco De Petris, Marian Douspis, Ricardo Tanausú Génova Santos, Tijmen de Haan, Diego Herranz, Elena de la Hoz, Eiichiro Komatsu, Luca Lamagna, **Gemma Luzzi**, Juan Macias-Perez, Enrique Martínez-González, Silvia Masi, Marina Migliaccio, Toshiya Namikawa, Gianluca Polenta, **Mathieu Remazeilles**, José Alberto Rubiño Martín, Laura Salvati, Hideki Tanimura, Patricio Vielva, Nicola Vittorio, Joern Wilms

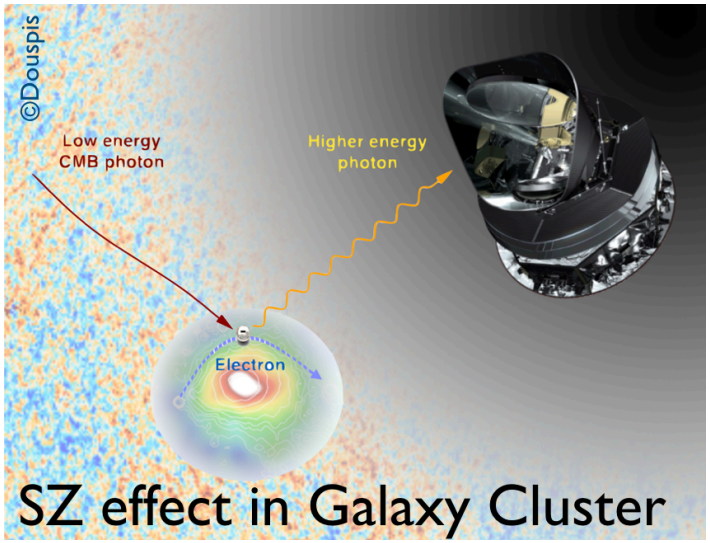
Article

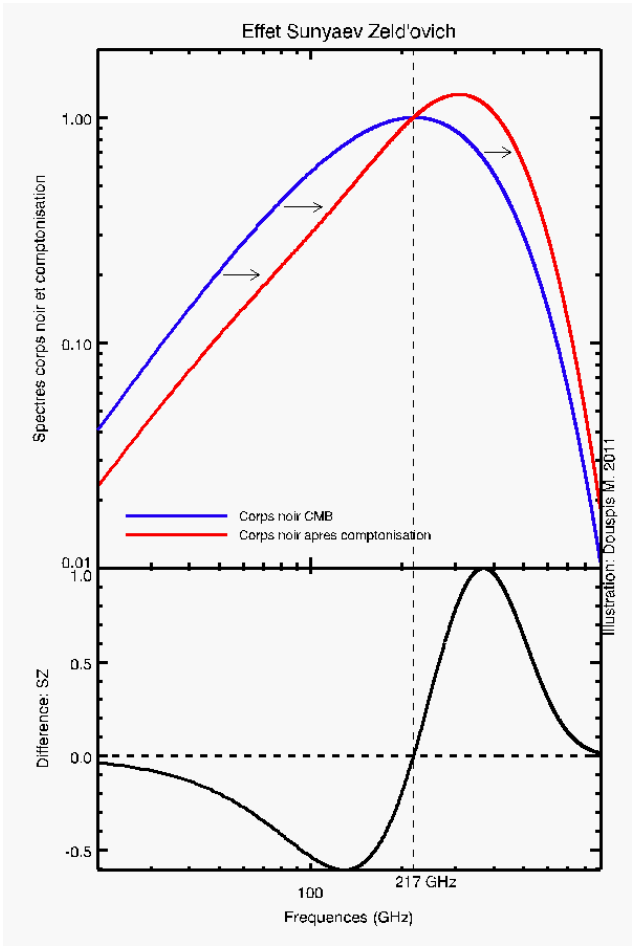
"LiteBIRD Science Goals and Forecasts. Mapping the Hot Gas in the Universe"

Internal review: finalizing, submission: soon

SZ EFFECT: HOT BARYON TRACER

Inverse Compton distortion = Sunyaev-Zeldovich effect





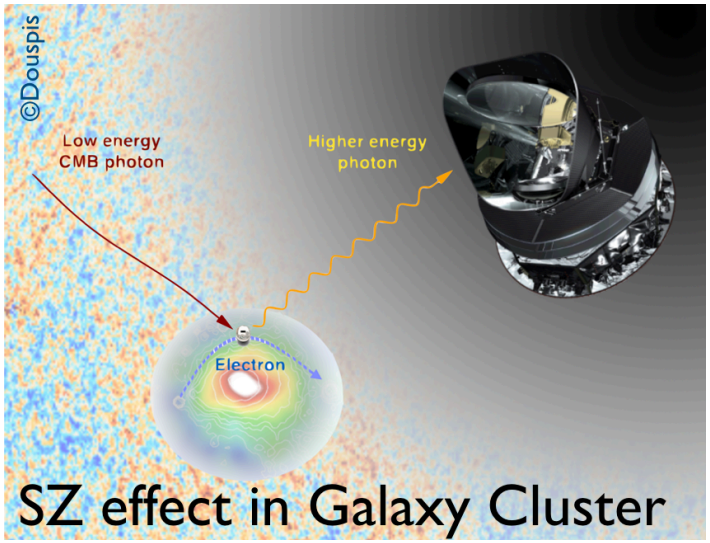
R. A. Sunyaev

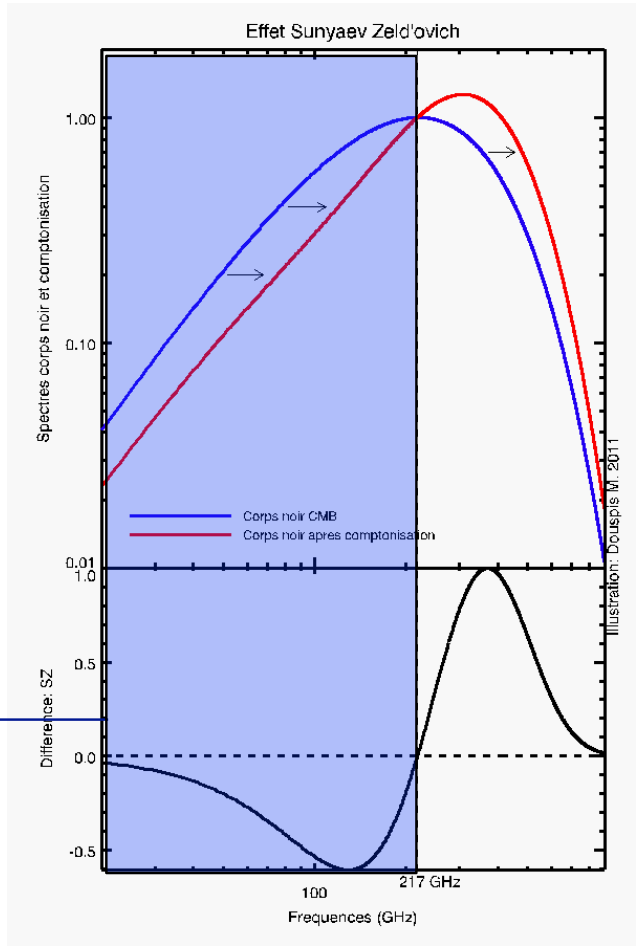
Ya. B. Zeldovich

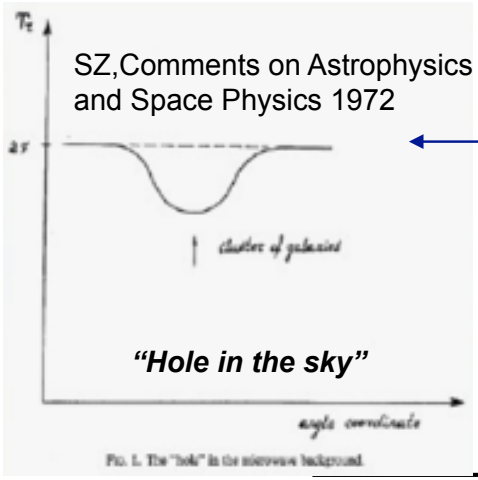
$$y = \int \frac{k_B T_e}{m_e c^2} n_e \sigma_T dl$$

SZ EFFECT: HOT BARYON TRACER

Inverse Compton distortion = Sunyaev-Zeldovich effect







R. A. Sunyaev

Ya. B. Zeldovich

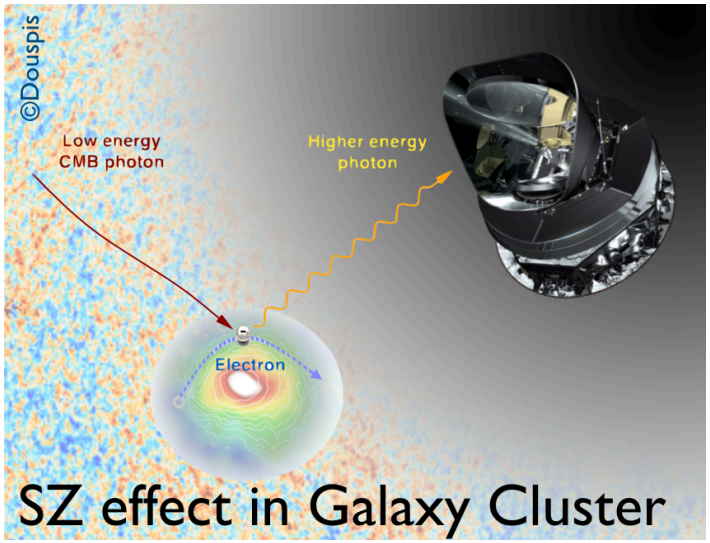
$$y = \int \frac{k_B T_e}{m_e c^2} n_e \sigma_T dl$$

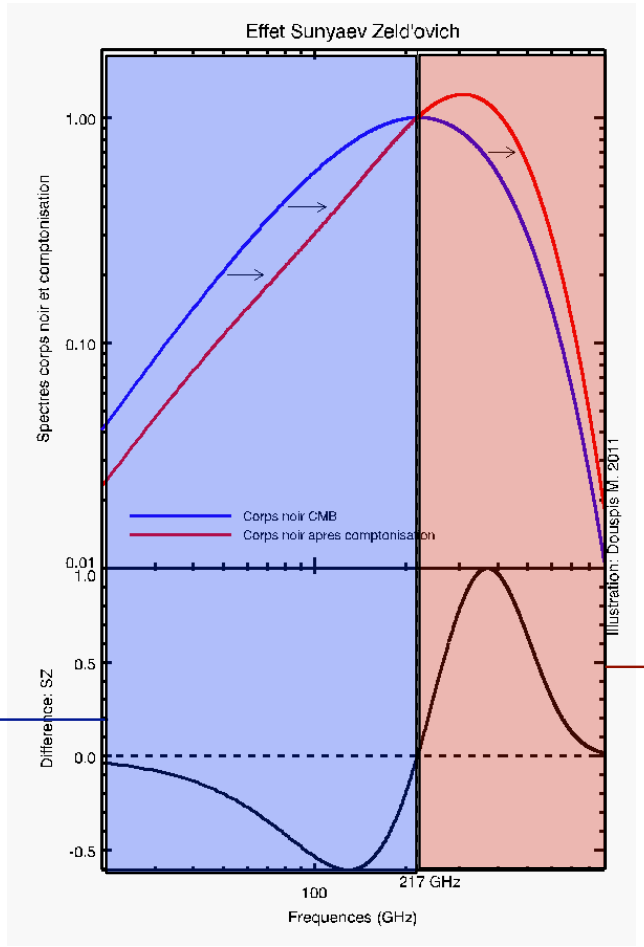
SZ EFFECT: HOT BARYON TRACER

Inverse Compton distortion = Sunyaev-Zeldovich effect

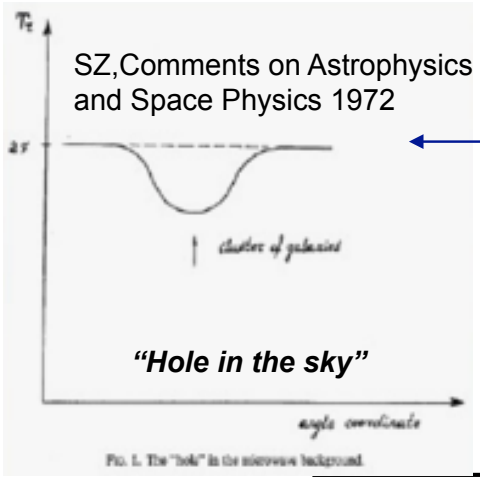
R. A. Sunyaev

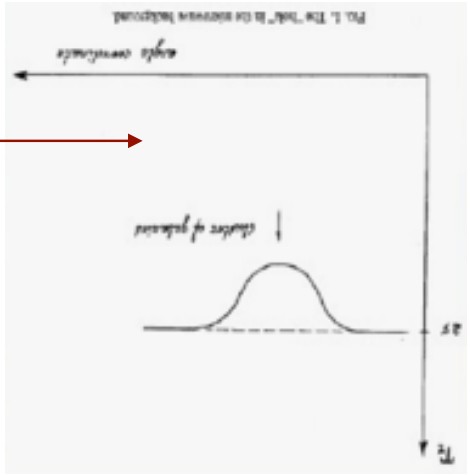
Ya. B. Zeldovich



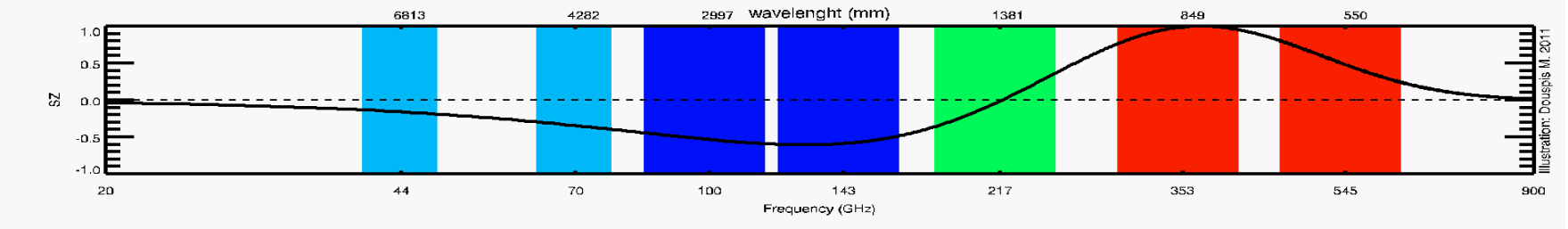


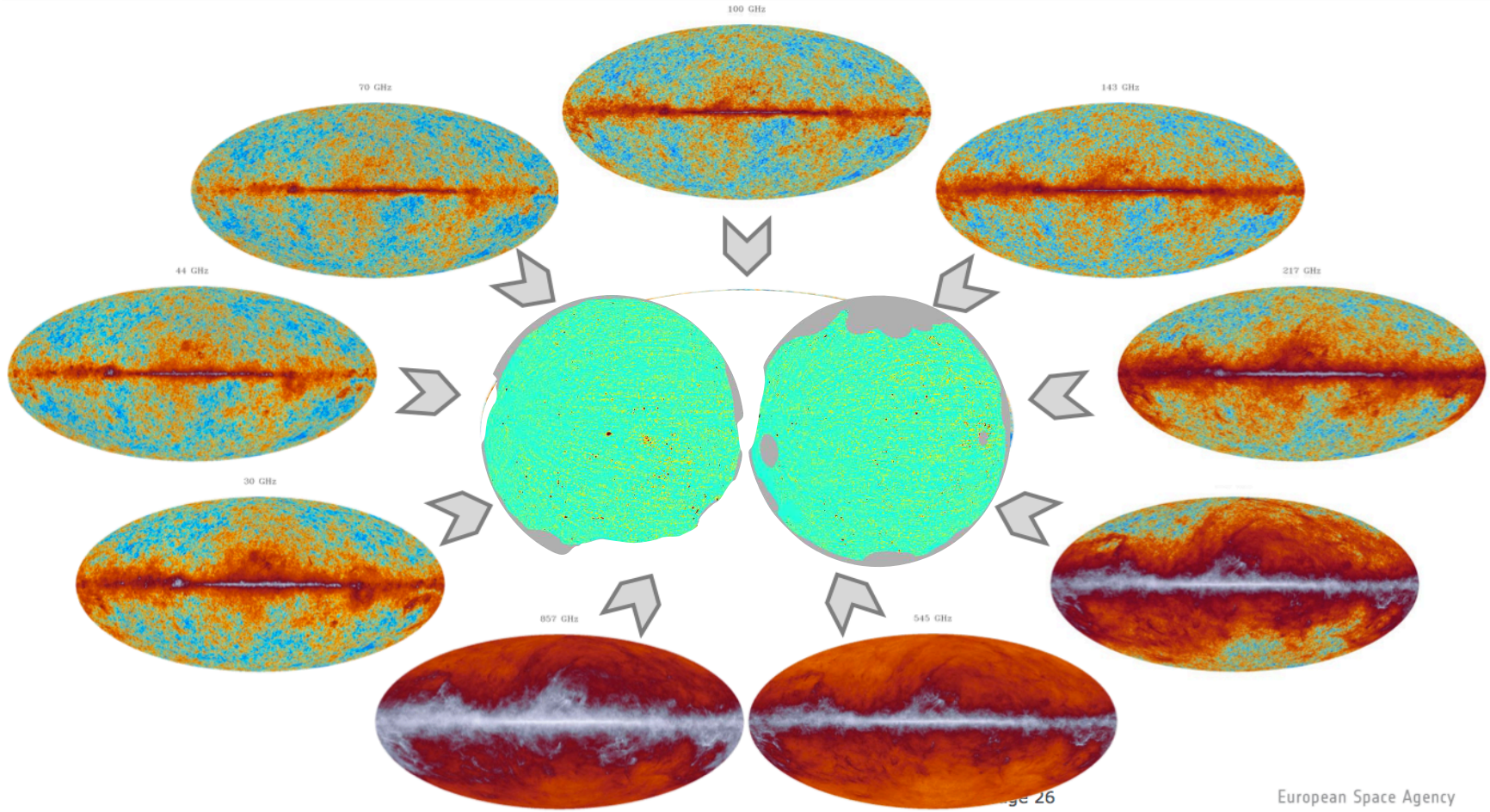
$$y = \int \frac{k_B T_e}{m_e c^2} n_e \sigma_T dl$$





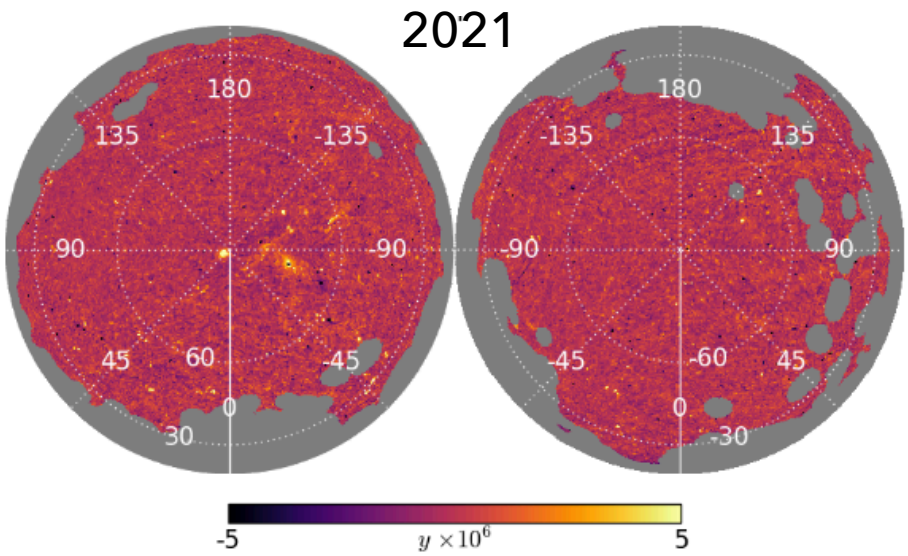
BUILDING Y-MAP

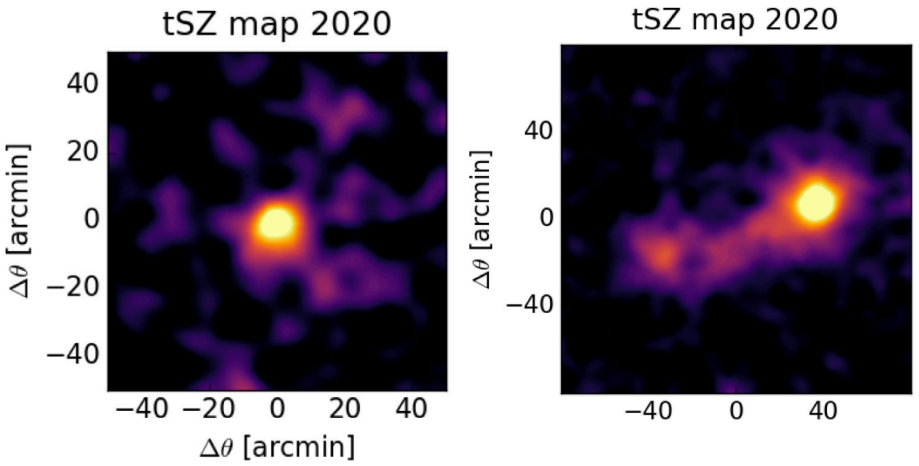




PLANCK YMAP : 2014 - 2016 → 2021

- Adapted component separation based on :
  - Constraints on emission spectra
  - Localisation in multiple domain
  - 100:857Ghz maps
- First SZ map on ~50% of the sky



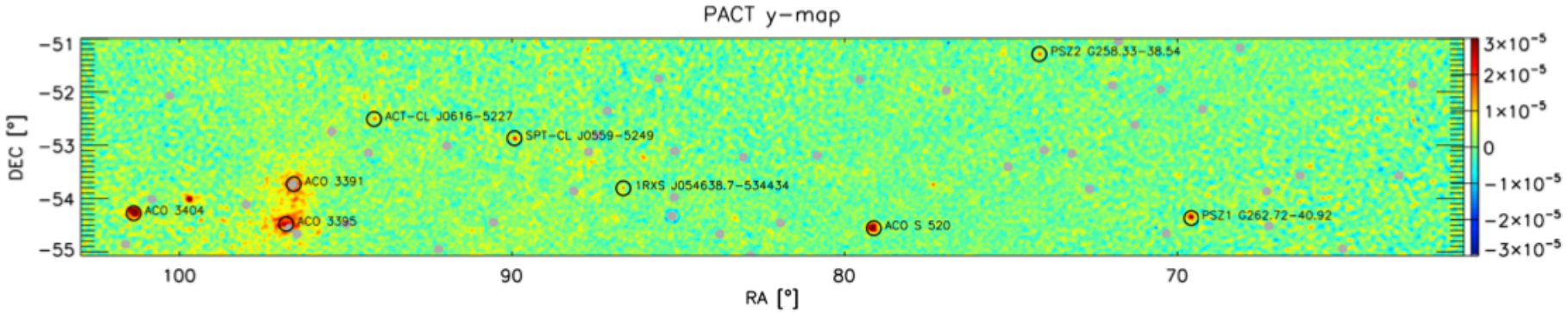


Planck 2014, Planck 2016
Tanimura et al. 2021

Other yMap

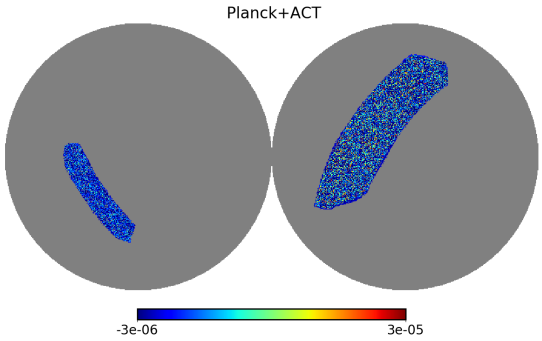
- Planck + ACT: PACT map: 1st combination of CMB exp.

Aghanim *et al 2019*



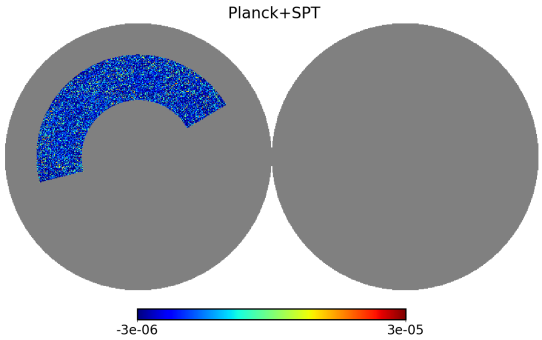
- Planck+ACT

Madhavacheril et al 2020



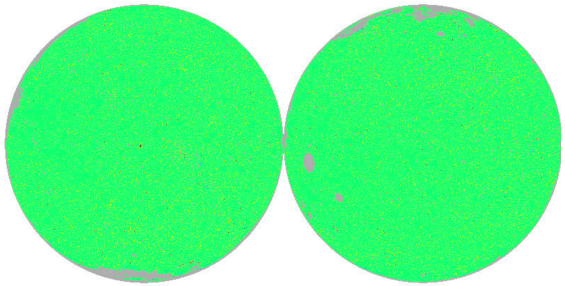
- Planck+SPT

Bleem et al 2021

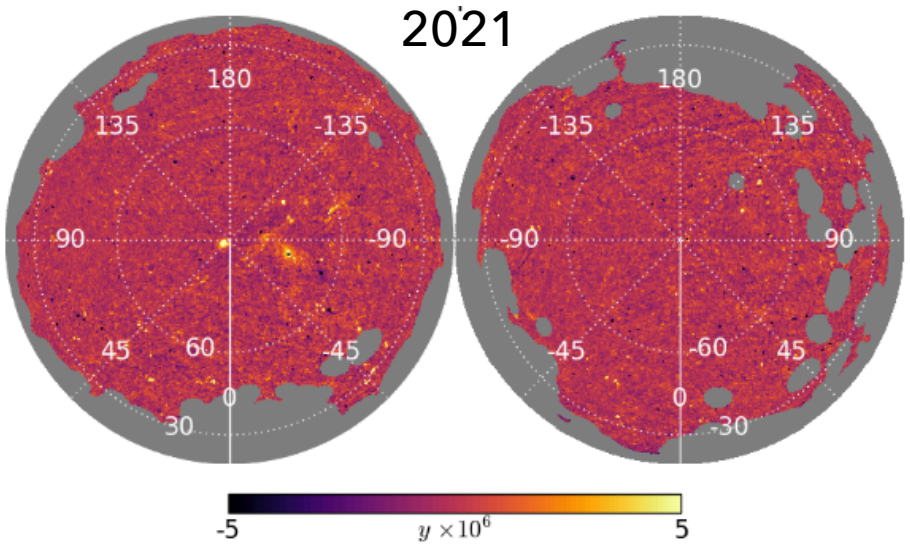


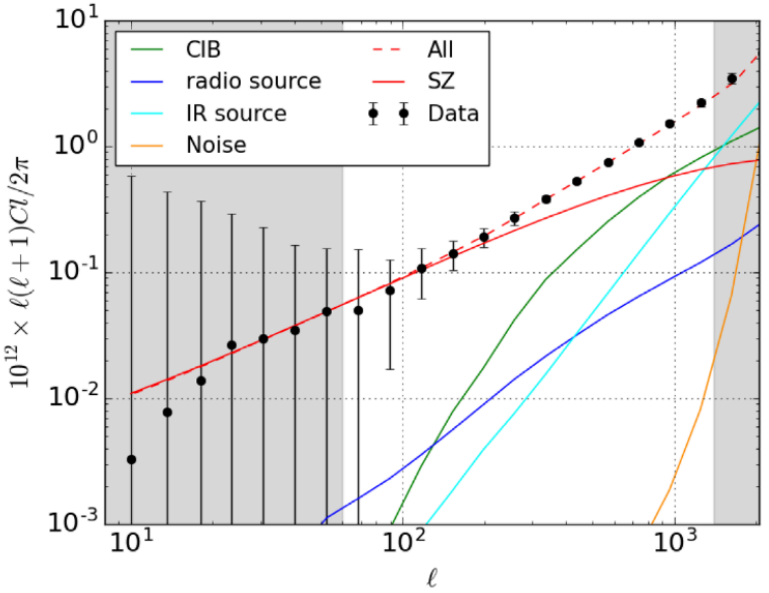
- MILCANN

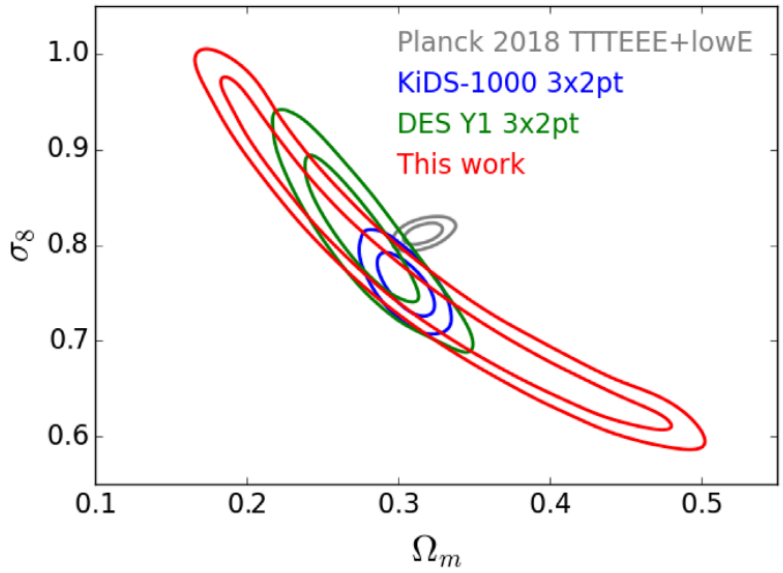
Hurier, Aghanim, Douspis 2021

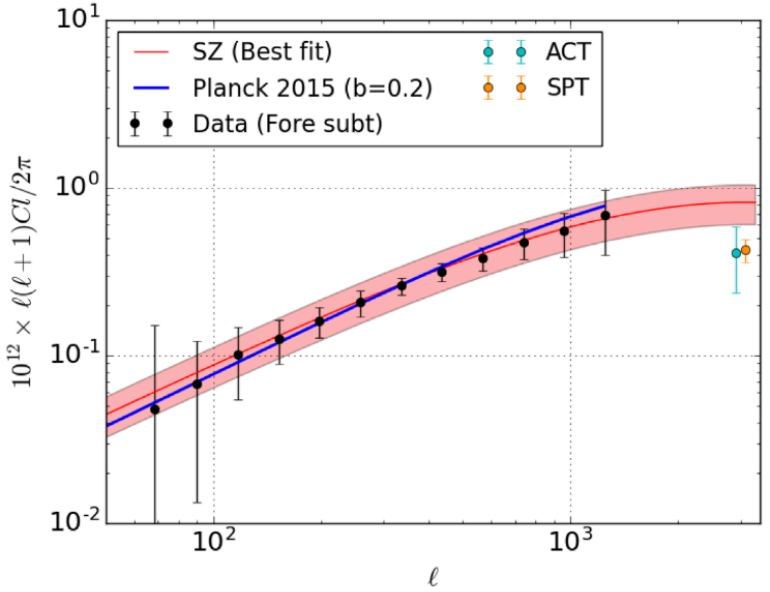


COSMOLOGY FROM YMAP : 2021



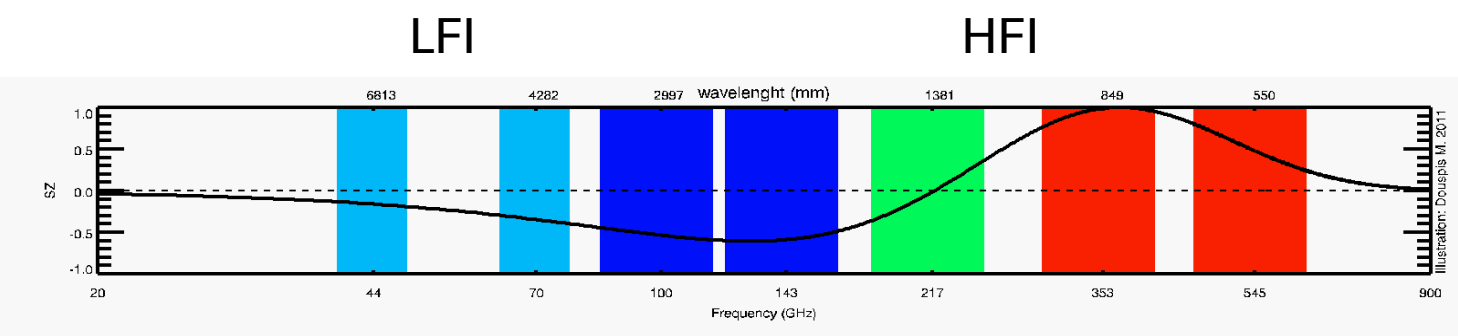


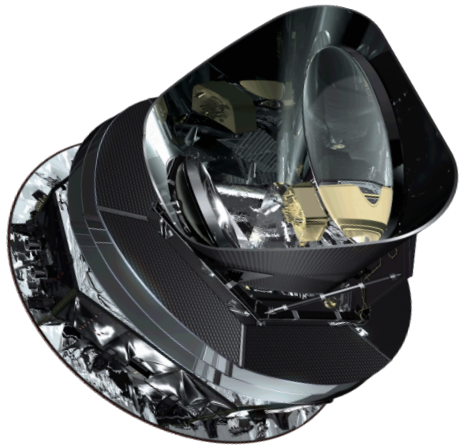


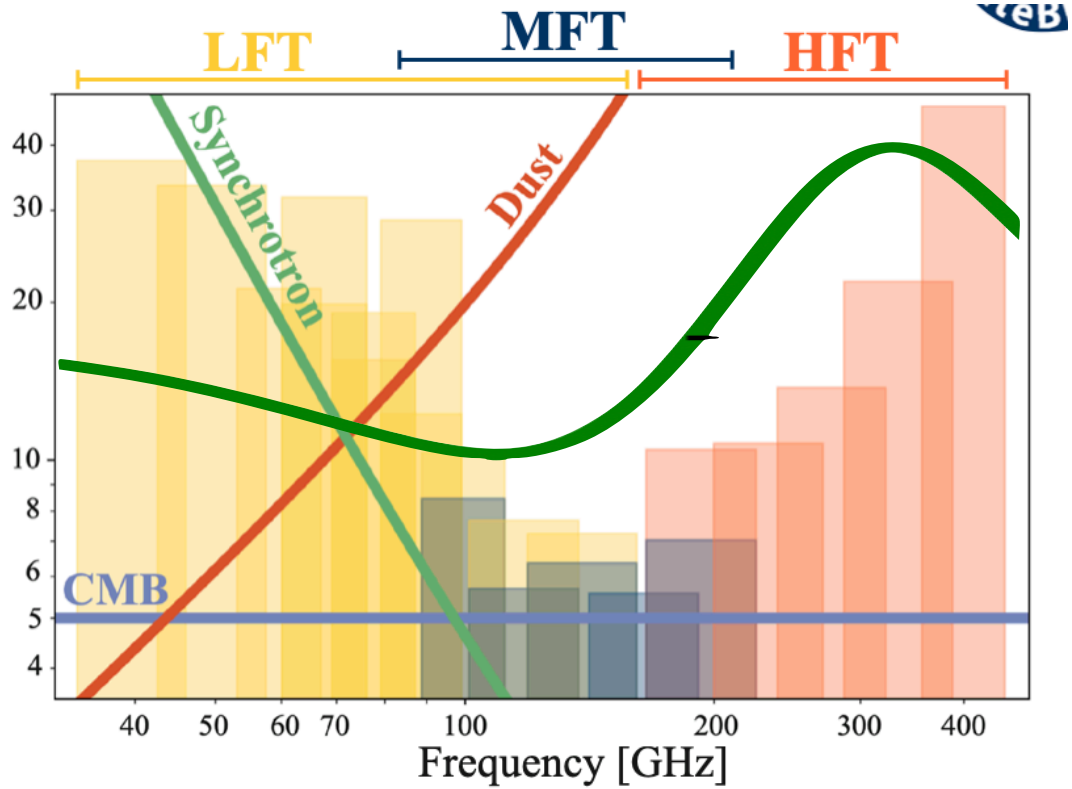


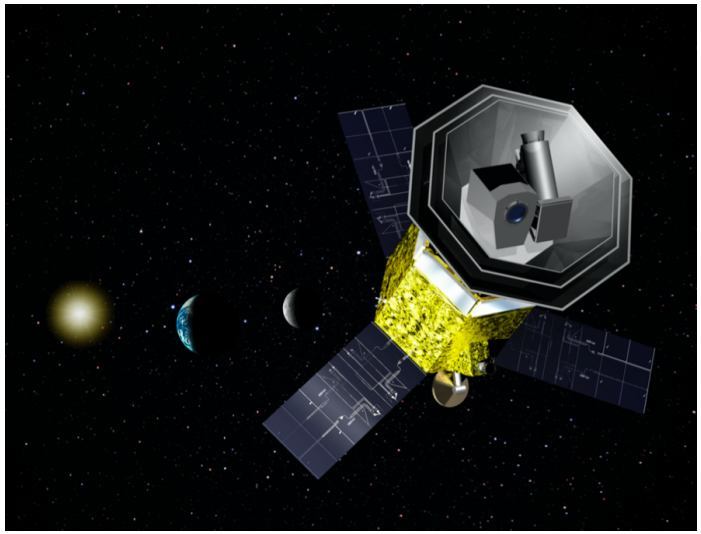
***Tanimura** et al. 2021*

LiteBIRD vs Planck

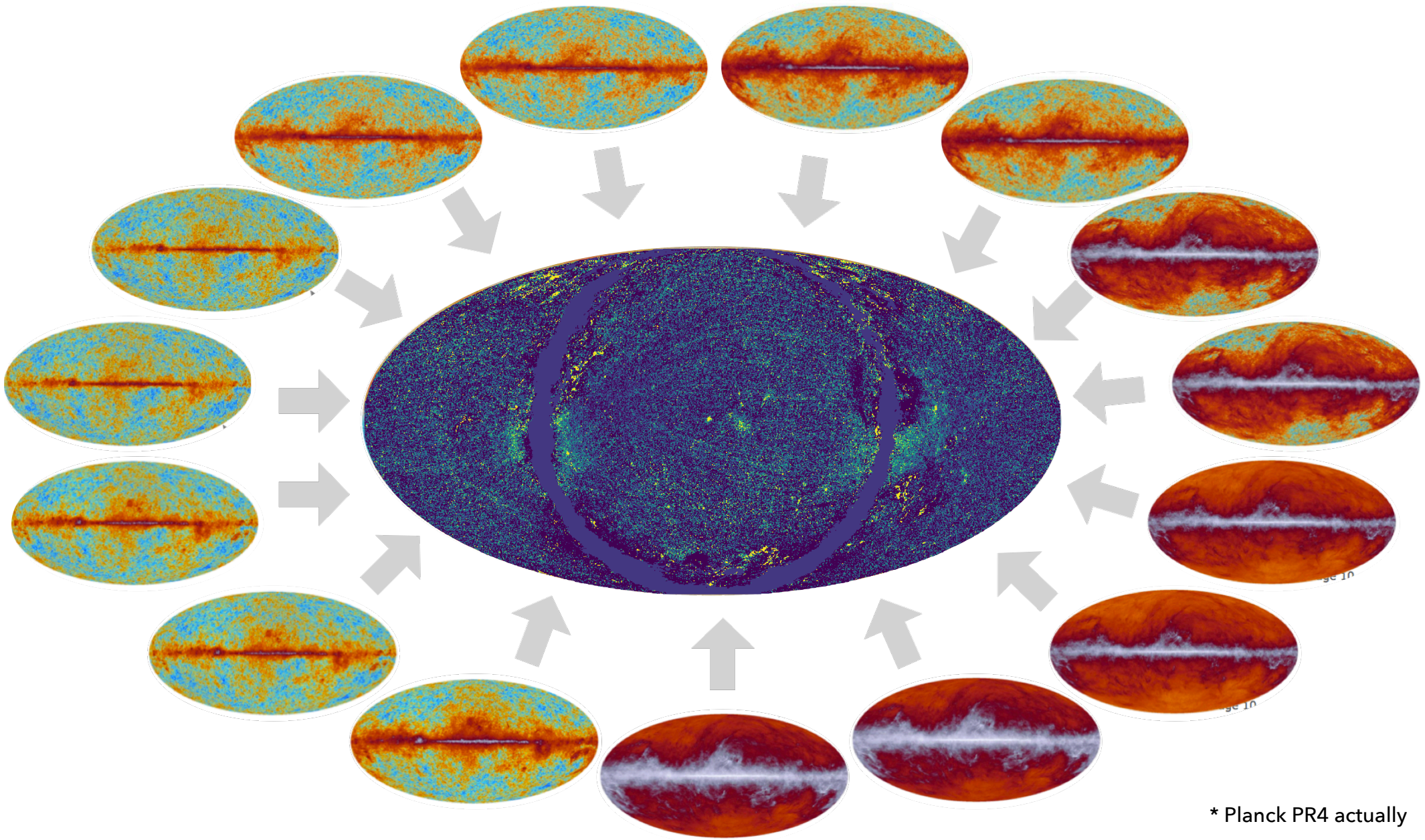








LiteBIRD-SZ*



* Planck PR4 actually

LiteBIRD

- Sky simulations from PSM *Delabrouille et al. 2013*
  - CMB, tSZ, kSZ, CIB, points sources
  - Dust, free-free, synchrotron, AME
  - LiteBIRD noise models
- Advantage of number of bands in ILC
  - Needlets ILC *Remazeilles et al. 2011*
- Much lower noise level in LiteBIRD ymap
  - $\sigma_{\text{LiteBIRD}} = \sigma_{\text{Planck}} / 10$
- large scales only

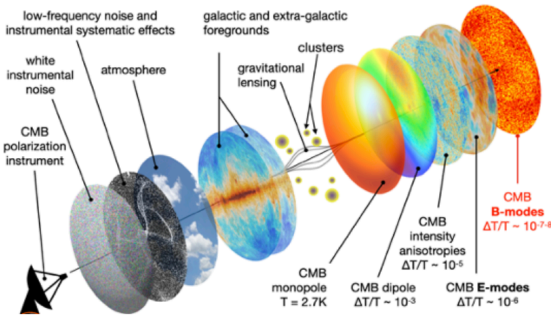
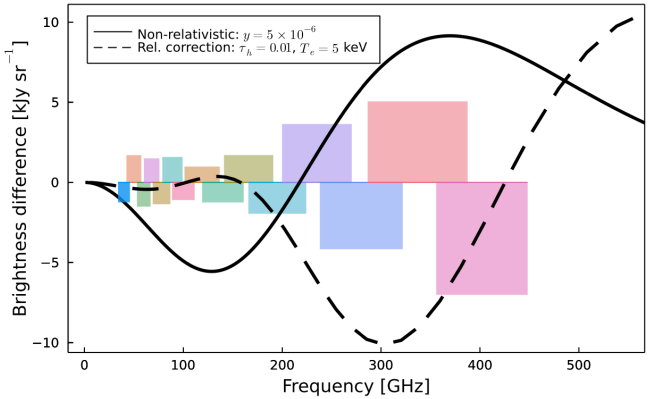
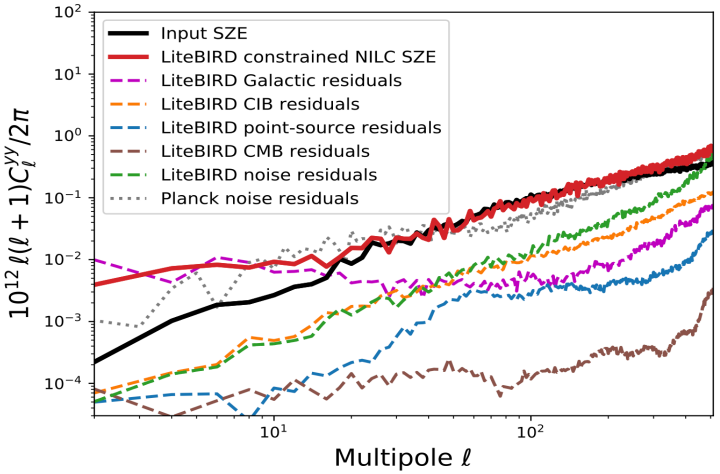


Image credit: Josquin Errard





LiteBIRD, PTEP, 2022

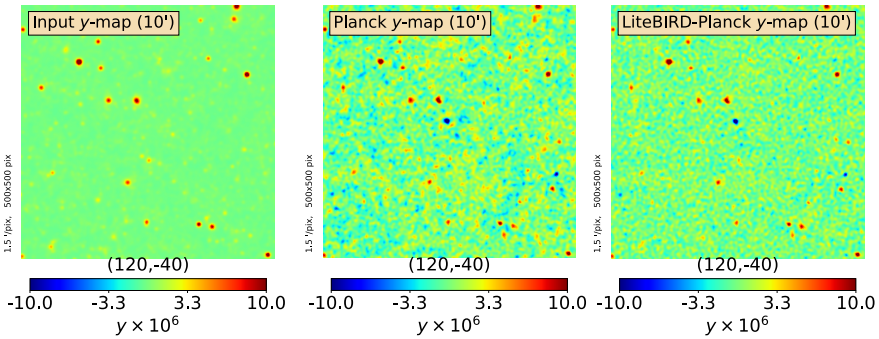
LiteBIRD+Planck

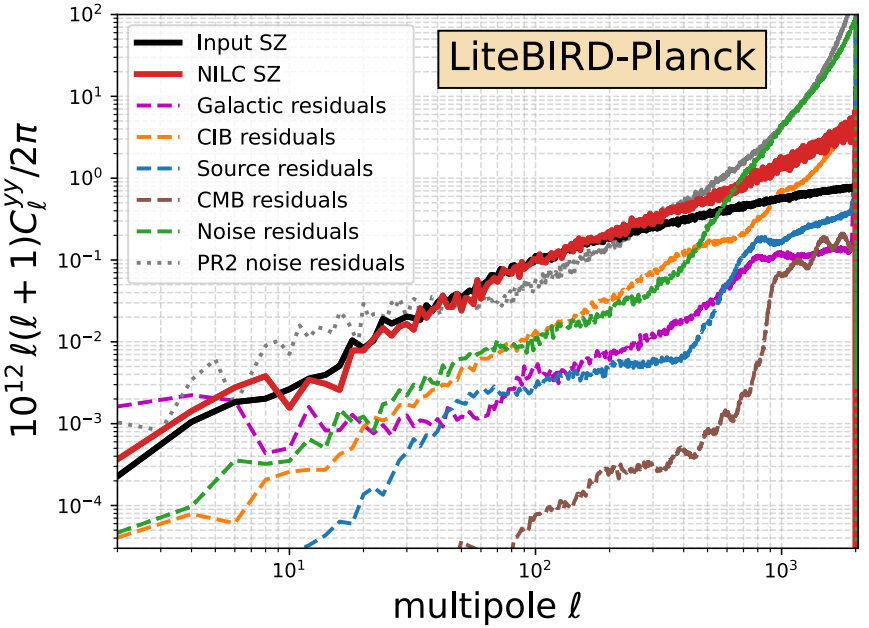
- Combined component separation
  - *Planck*+LiteBIRD
  - large/small scales
  - more frequency bands

➡ less noise

➡ less foregrounds contamination

➡ larger clean sky fraction





📖 *LiteBIRD: Remazeilles+ JCAP 2024*

WG ACTIVITIES

Current

- finalizing article review
  - maps
  - 1D pdf
  - power spectrum
  - effect of 1/f noise
  - cosmological parameters
  - SZ from patchy reionisation

Future

- relativistic SZ
- constraints beyond LCDM
- cross correlations
- ...

LiteBIRD for SZ studies

- Improve ×10 the noise in the SZ map wrt Planck
- Produce a high-fidelity SZ map over the full-sky essentially free of contamination at $\ell < 200$
- Test theories of structure formation via hot-gas tomography from SZ × galaxy surveys correlations
- Search form WHIM in filaments connecting clusters
- Study an inhomogeneous reionization process via cross-correlations of SZ × CMB optical depth
- Measure the mean gas Te via the relativistic SZ
- Improve constraints on $S_8 = \sigma_8(\Omega_m/0.3)^{0.5}$ by 15%