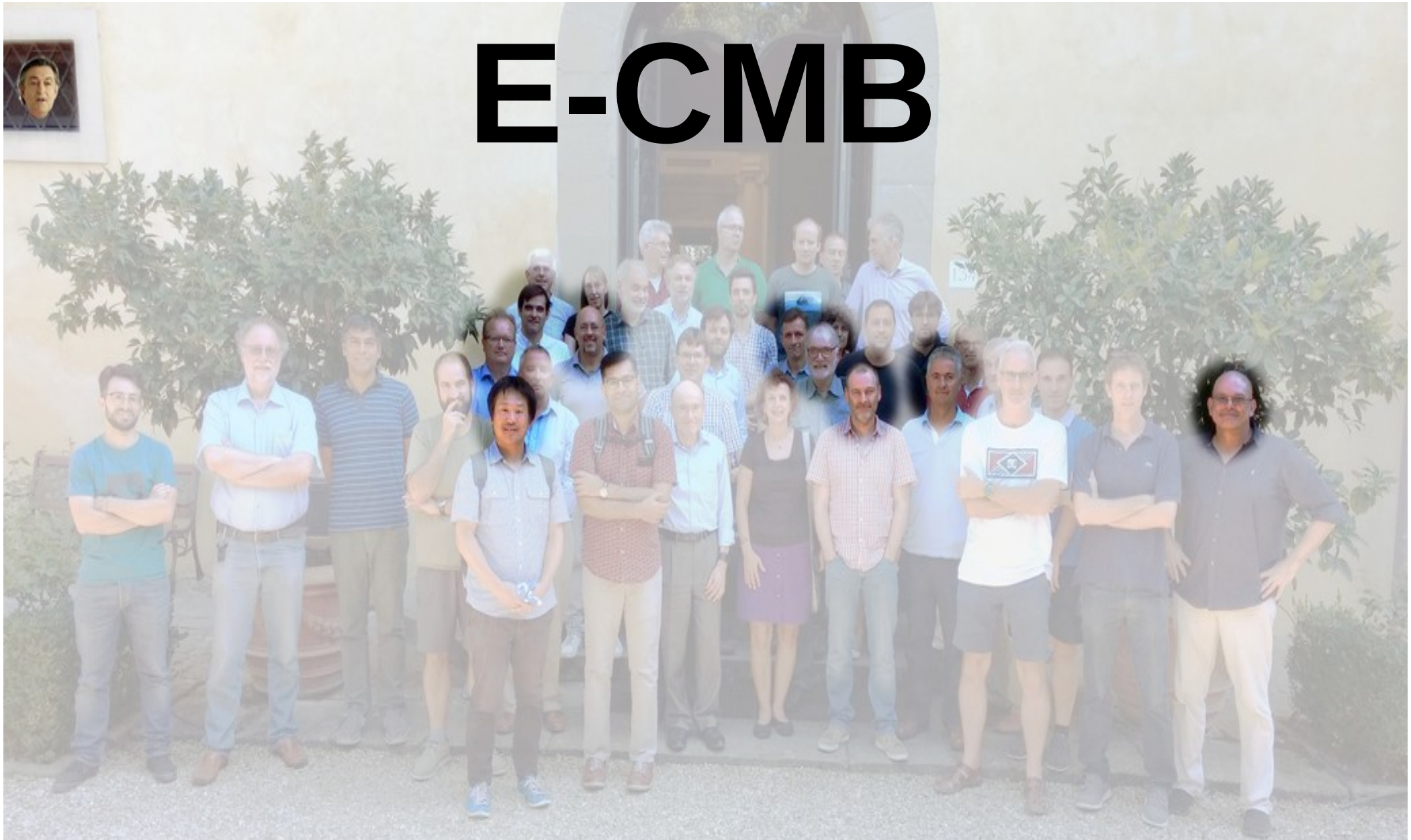
E-CMB

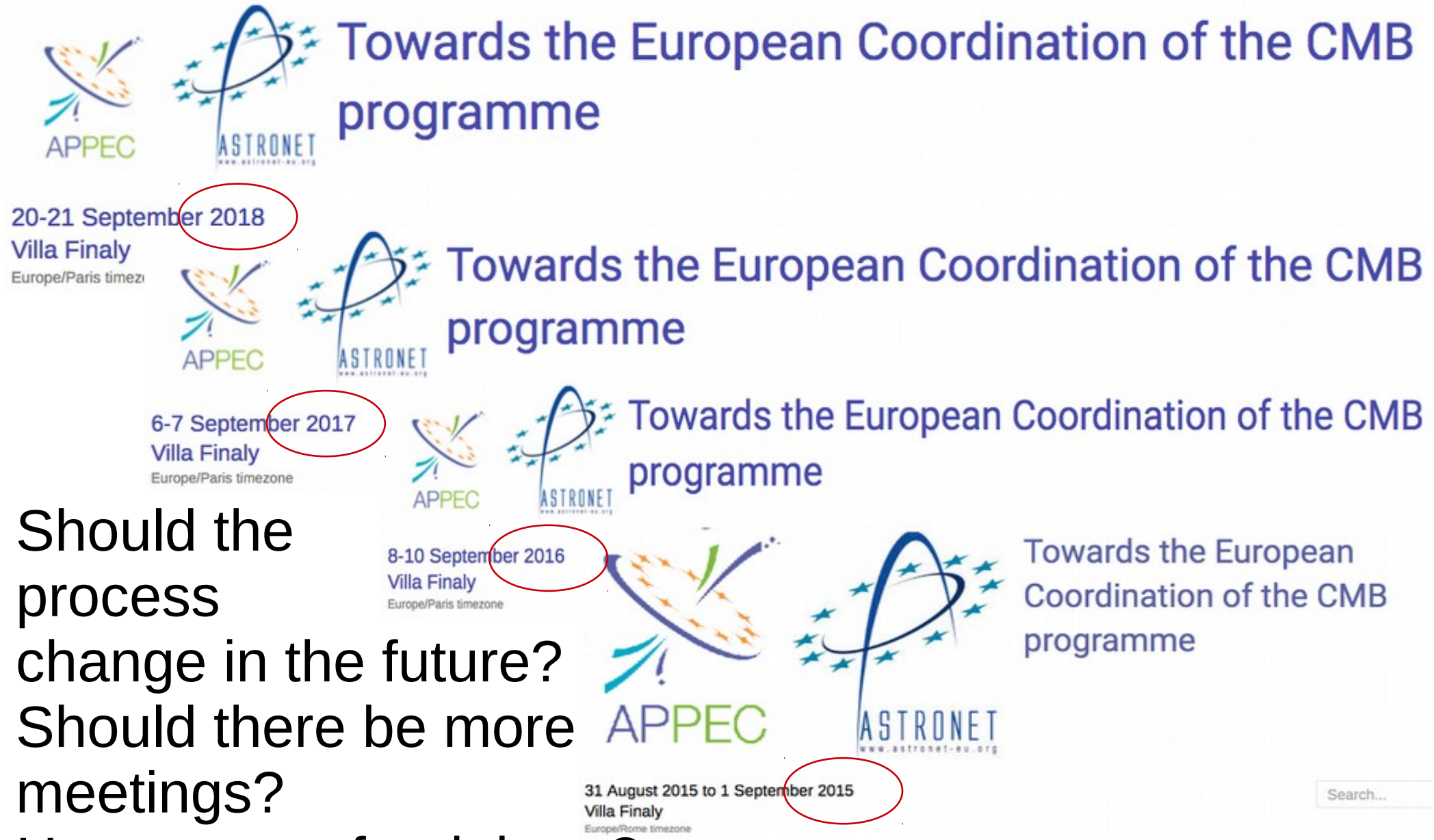


E-CMB Coordinators: Komatsu/Mohr (DE); Martínez-Gonzalez/Rubiño-Martín (ES); Bouchet/Ganga (FR); Baccigalupi/Bersanelli (IT); Brown/Challinor (UK)

E-CMB: About

- https://wiki.e-cmb.org/
- Volunteer Group
- Writing European CMB Community White Paper
- Ground-Based Proselytism
  - Searching synergies with US CMB S4
  - Proposing E4
  - Community meetings (the “Florence Process”)
- Less Work on Space
  - This is an important part of the landscape
  - But there are well-defined frameworks for creating and funding projects
- Less Work on Balloons (& airplanes, etc.)
  - This has been historically important
  - Future investment seems to be lagging?

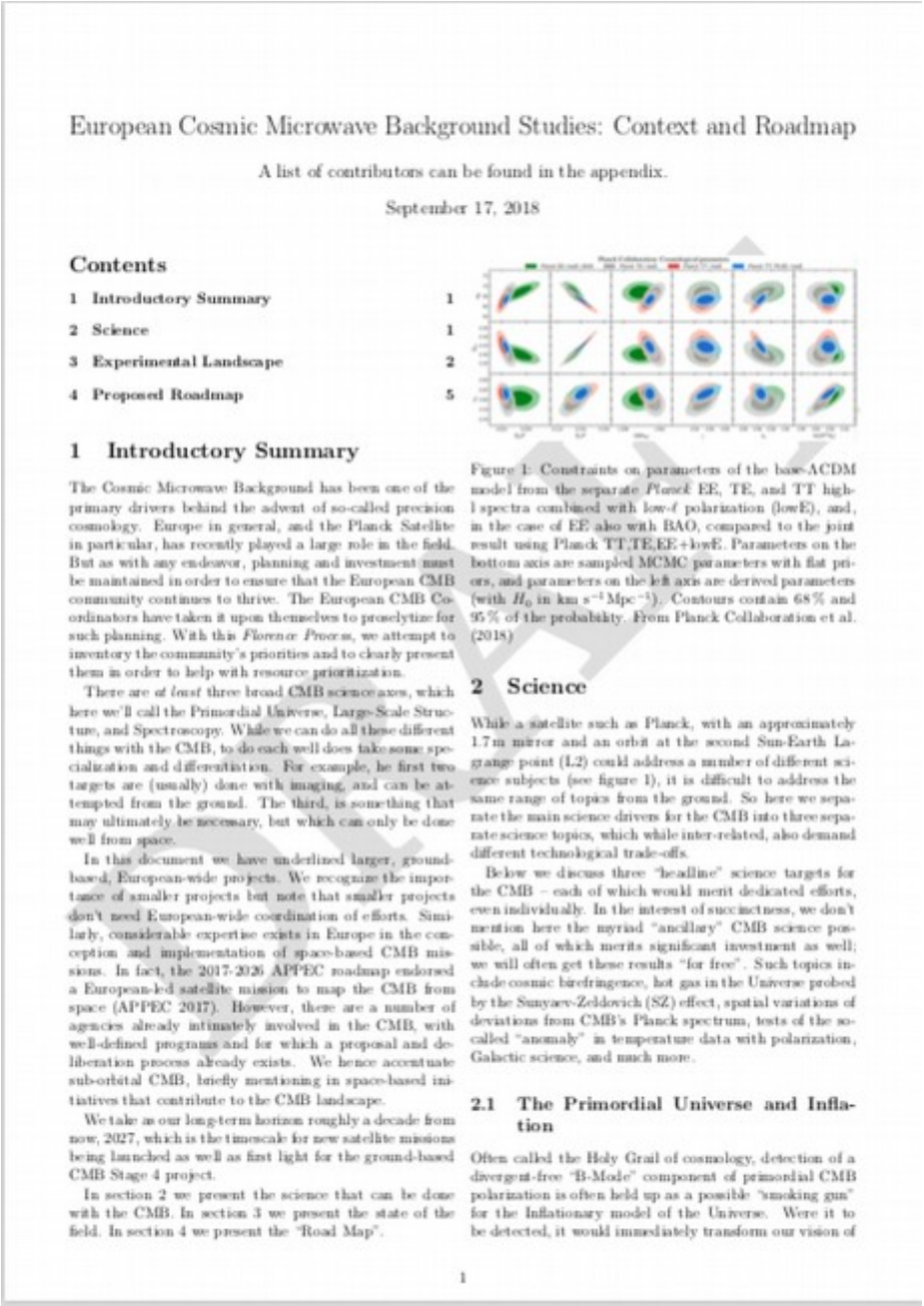
The Florence Process



Should the process change in the future?
Should there be more meetings?
How can we fund them?

Whitepaper/Roadmap

- https://wiki.e-cmb.org/uploads/Main/Whitepaper2018-09-17.pdf
- Should be a “short” document
  - Can we keep it to 10 pages?
  - Perhaps with “supporting addenda”?
- We are working on updates based on Florence progress
  - You can help!
    - Talk to your favorite coordinator!



European Cosmic Microwave Background Studies: Context and Roadmap

A list of contributors can be found in the appendix.

September 17, 2018

Contents

1 Introductory Summary

The Cosmic Microwave Background has been one of the primary drivers behind the advent of so-called precision cosmology. Europe in general, and the Planck Satellite in particular, has recently played a large role in the field. But as with any endeavor, planning and investment must be maintained in order to ensure that the European CMB community continues to thrive. The European CMB Coordinators have taken it upon themselves to proselytize for such planning. With this *Florence Process*, we attempt to inventory the community's priorities and to clearly present them in order to help with resource prioritization.

There are *at least* three broad CMB science axes, which here we'll call the Primordial Universe, Large-Scale Structure, and Spectroscopy. While we can do all these different things with the CMB, to do each well does take some specialization and differentiation. For example, the first two targets are (usually) done with imaging, and can be attempted from the ground. The third, is something that may ultimately be necessary, but which can only be done well from space.

In this document we have underlined larger, ground-based, European-wide projects. We recognize the importance of smaller projects but note that smaller projects don't need European-wide coordination of efforts. Similarly, considerable expertise exists in Europe in the conception and implementation of space-based CMB missions. In fact, the 2017-2026 APPEC roadmap endorsed a European-led satellite mission to map the CMB from space (APPEC 2017). However, there are a number of agencies already intimately involved in the CMB, with well-defined programs and for which a proposal and deliberation process already exists. We hence accentuate sub-orbital CMB, briefly mentioning in space-based initiatives that contribute to the CMB landscape.

We take as our long-term horizon roughly a decade from now, 2027, which is the timescale for new satellite missions being launched as well as first light for the ground-based CMB Stage 4 project.

In section 2 we present the science that can be done with the CMB. In section 3 we present the state of the field. In section 4 we present the "Road Map".

Figure 1: Constraints on parameters of the base-ΛCDM model from the separate *Planck* EE, TE, and TT high-l spectra combined with low-ℓ polarization (lowE), and, in the case of EE also with BAO, compared to the joint result using Planck TT,TE,EE+lowE. Parameters on the bottom axis are sampled MCMC parameters with flat priors, and parameters on the left axis are derived parameters (with H_0 in km s^{-1} Mpc^{-1}). Contours contain 68 % and 95 % of the probability. From Planck Collaboration et al. (2018)

2 Science

While a satellite such as Planck, with an approximately 1.7 m mirror and an orbit at the second Sun-Earth Lagrange point (L2) could address a number of different science subjects (see figure 1), it is difficult to address the same range of topics from the ground. So here we separate the main science drivers for the CMB into three separate science topics, which while inter-related, also demand different technological trade-offs.

Below we discuss three "headline" science targets for the CMB – each of which would merit dedicated efforts, even individually. In the interest of succinctness, we don't mention here the myriad "ancillary" CMB science possible, all of which merits significant investment as well; we will often get these results "for free". Such topics include cosmic birefringence, hot gas in the Universe probed by the Sunyaev-Zeldovich (SZ) effect, spatial variations of deviations from CMB's Planck spectrum, tests of the so-called "anomaly" in temperature data with polarization, Galactic science, and much more.

2.1 The Primordial Universe and Inflation

Often called the Holy Grail of cosmology, detection of a divergent-free "B-Mode" component of primordial CMB polarization is often held up as a possible "smoking gun" for the Inflationary model of the Universe. Were it to be detected, it would immediately transform our vision of

1

Proposals

***E4*: Fourth-generation European infrastructure for studying the birth, evolution, and contents of the Universe using the Cosmic Microwave Background Radiation**

List of participants

Participant Number	Participant Organization Name	Short Name	Country
1	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	CNRS	France
2	UNIVERSITA DEGLI STUDI DI MILANO	Milan	Italy
3	UNIVERSITA DEGLI STUDI DI ROMA LA SAPIENZA	Roma-I	Italy
4	ISTITUTO NAZIONALE DI FISICA NUCLEARE	INFN	Italy
5	INSTITUTO DE ASTROFISICA DE CANARIAS	IAC	Spain
6	AGENCIA ESTATAL CONSEJO SUPERIOR DEINVESTIGACIONES CIENTIFICAS	CSIC	Spain
7	UNIVERSIDAD DE CANTABRIA	UC	Spain
8	CARDIFF UNIVERSITY	Cardiff	UK
9	MAX-PLANCK-GESELLSCHAFT ZUR FORDERUNG DER WISSENSCHAFTEN EV	MPA	Germany
10	NATIONAL UNIVERSITY OF IRELAND MAYNOOTH	NUIM	Ireland
11	NATIONAL OBSERVATORY OF ATHENS	NOA	Greece

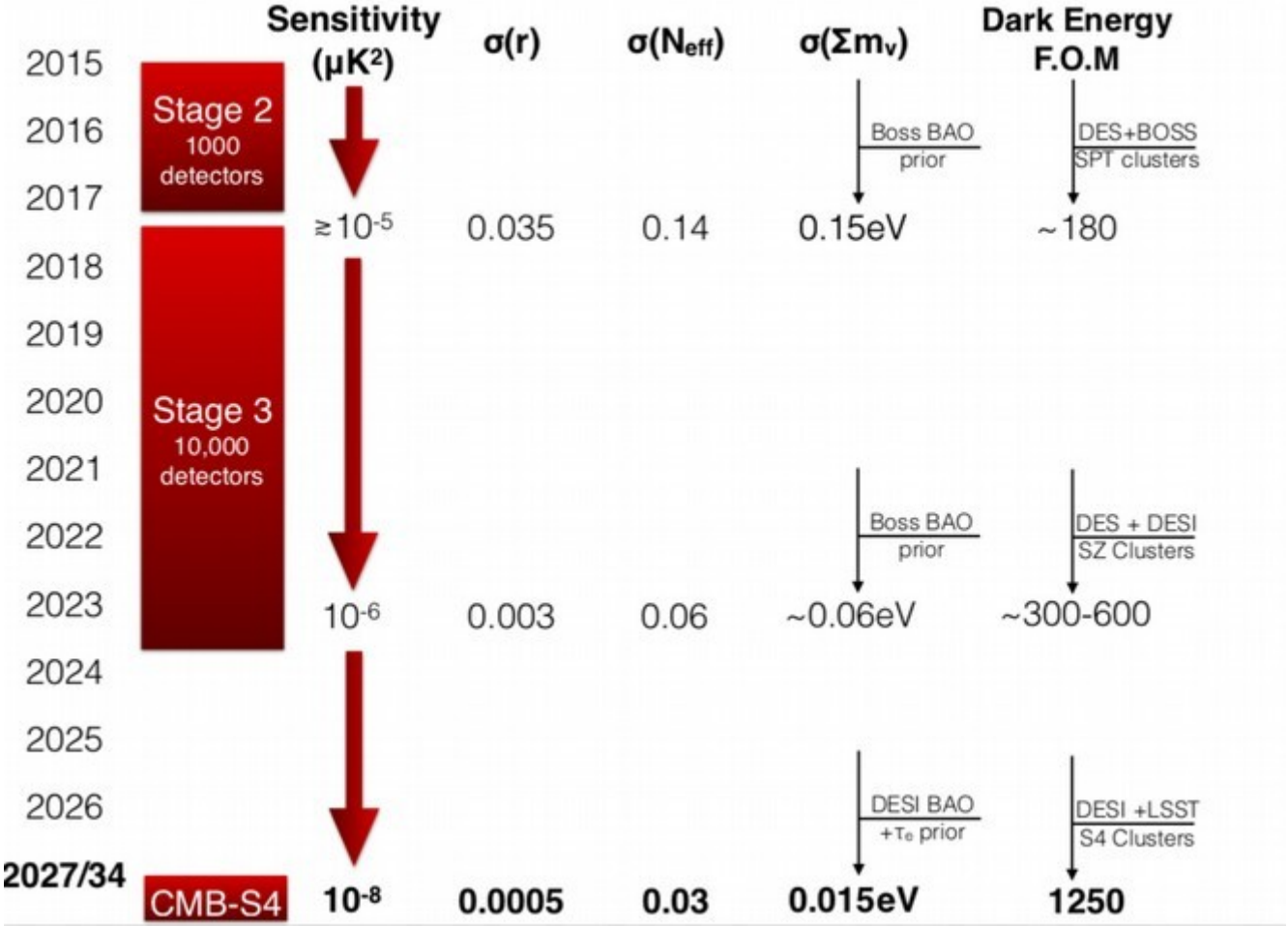
- Was not selected, but showed continued interest (there were over 150 “participants”)
- There have been overtures towards the better-adapted (but more competitive and restrictive) Synergy Grants
- ESFRI?
- https://wiki.e-cmb.org/index.php?n=Main.E4

CMB Stage 4 (https://cmb-s4.org/)

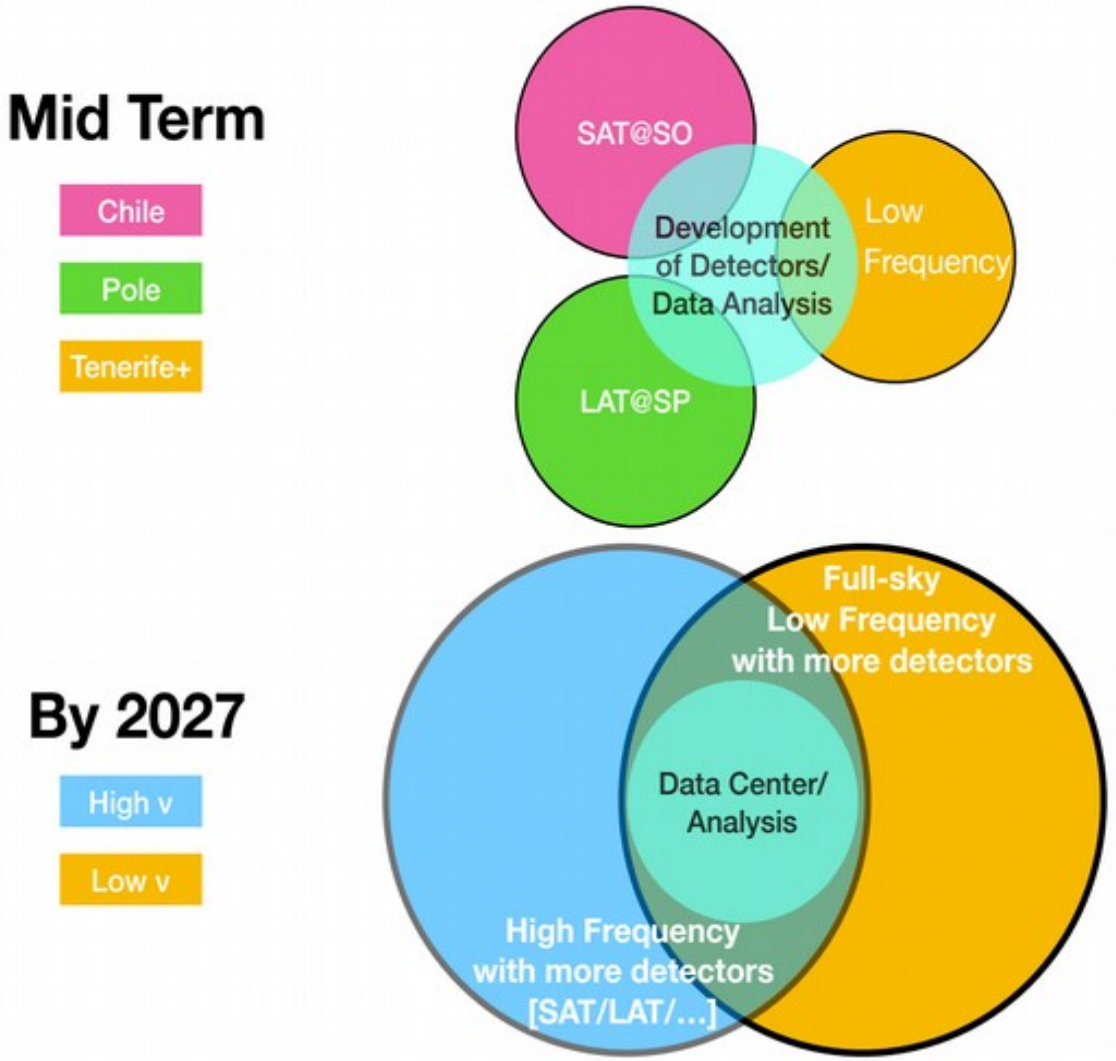
- You've seen Julian Borrill's talk...
- You can join:
  - https://cmb-s4.org/wiki/index.php/Main_Page#Membership

From John Carlstrom:

https://indico.in2p3.fr/event/17625/contributions/63331/attachments/49746/63310/US-Stage3-Efforts-Carlstrom.pdf



Main Axes



- SATs, LATs, & LowNu...
- In the mid-term, the projects are being constructed “bottom-up”
- In the long-term, to succeed, they must accrete support and other resources.

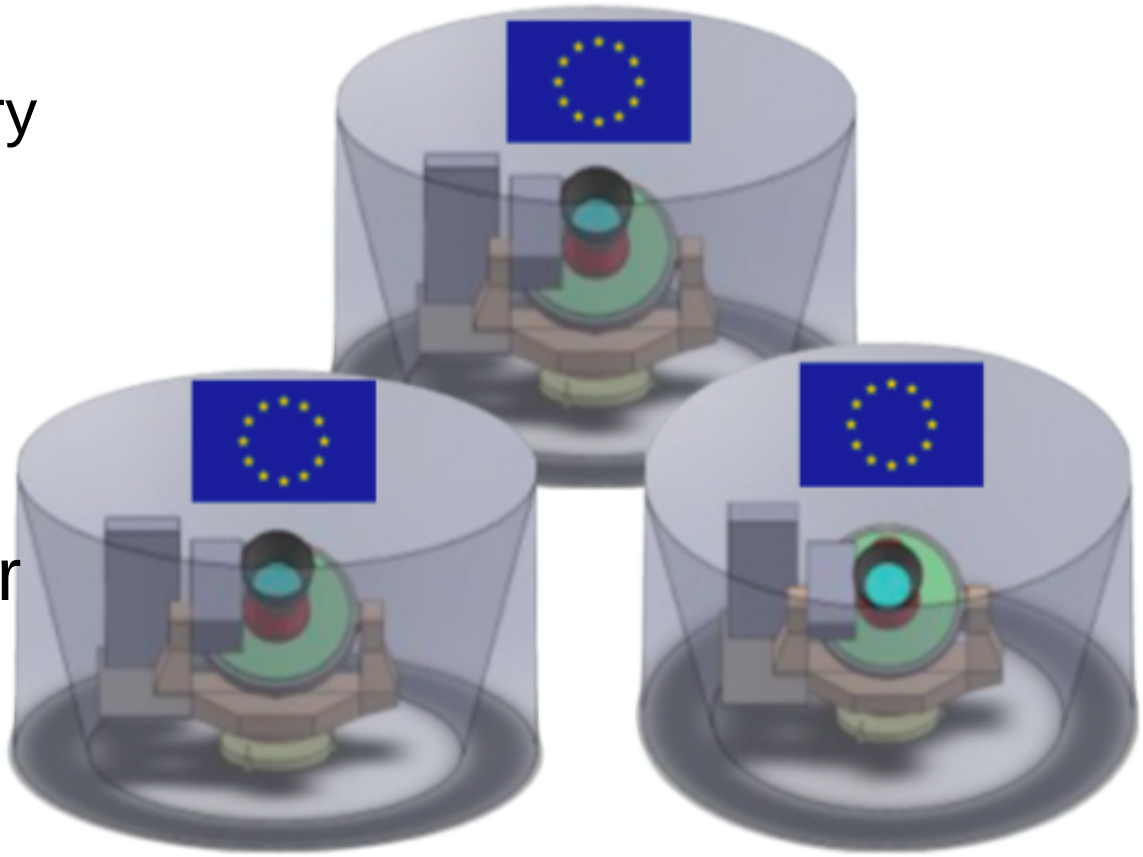
From Eiichiro Komatsu

High-Frequency Work (1)

- Large Apertures
  - Pending German (DFG+Universities) proposal
    - Might know in ~3 months but matching funding needed
  - 5 m Vertex telescope
  - 90-220 GHz Focal Planes
  - Serious letters of interest from potential European collaborators could, perhaps, help
  - What happens to SPT?

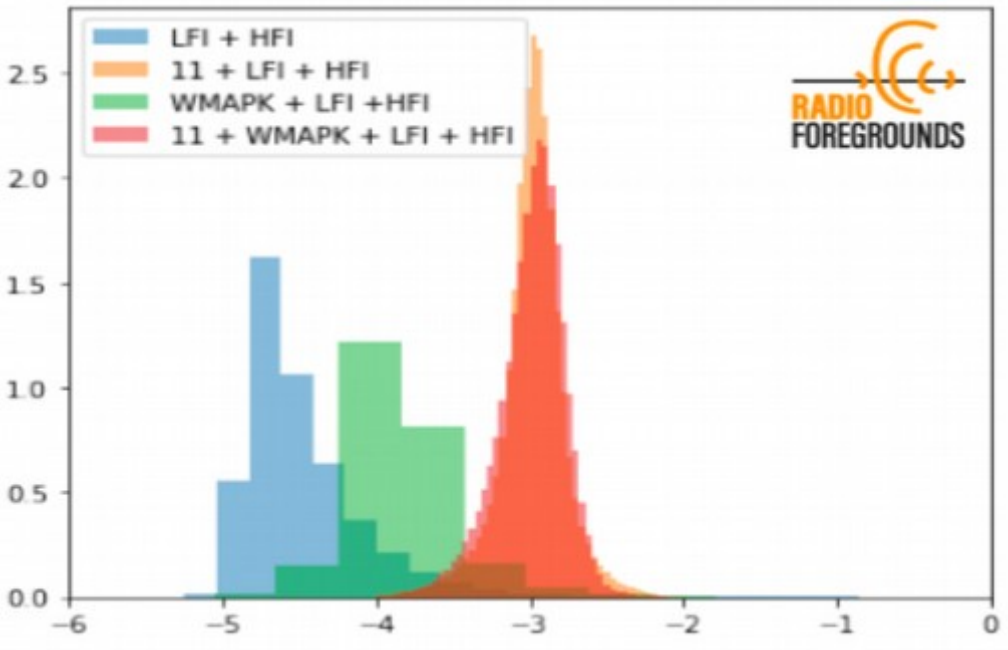
High-Frequency Work (2)

- Small Apertures
  - Pending UK/US proposal
    - For Simons Observatory
      - See Colin Hill's talk
  - BICEP-like (my words)
  - 30,000 detectors in a short time. There is perhaps opportunity for others here (again, my words).
  - Working towards a November 9th deadline
  - Might start in Spring



Low-Frequency Work

- Full Sky Synchrotron Survey
- @ 5-40 GHz
- 40+ GHz is being explored
- Possible German S-Band interest

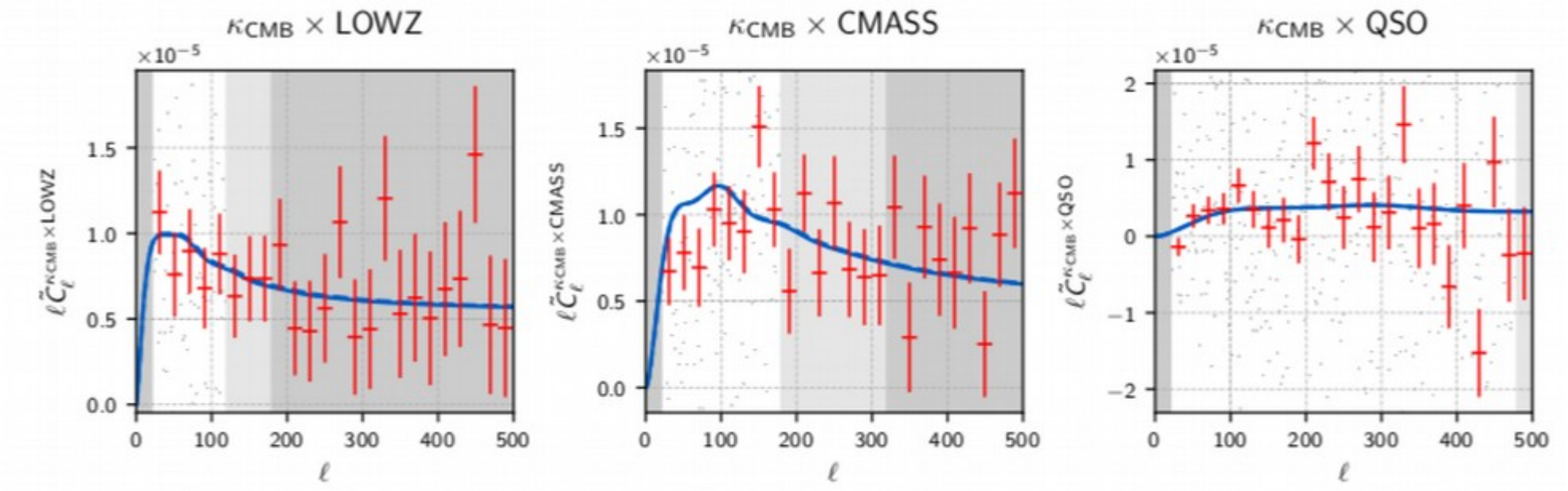


- Southern Sky for S4 (~1500 square degrees)
- Full-Sky for LiteBIRD
- Perhaps an element on an Antarctic LAT for BICEP field coverage?

- You saw Taylor's talk, Rubino-Martin's talk, Mannella's talk;
- You will see Hill-Valler's talk, Jew's talk, Harper's talk, Van Syngel's talk...

Necessary Components

- Data Analysis
  - Euclid?
  - Athena?
  - Tools maintenance?
  - Others?
- Detectors
  - SpaceKIDs – E4KIDS
  - Testing Network?
- What else?!?
  - You tell us...



Spider: an update, with foregrounds (lots of them).

CMB-S4
Princeton Meeting
August 2018

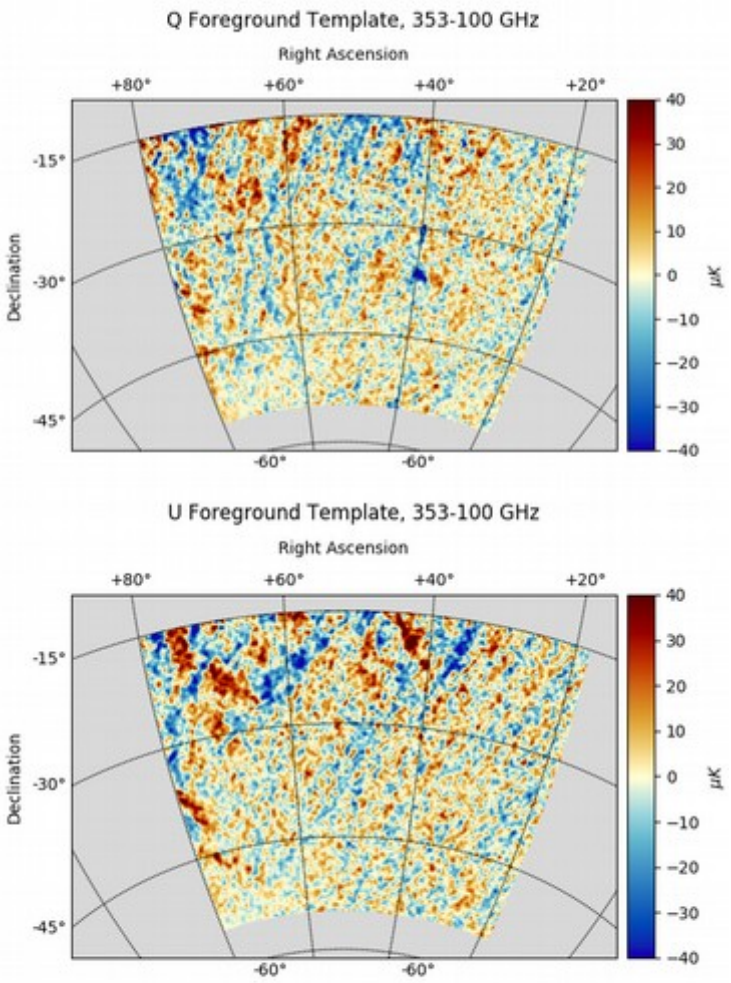
William Jones
Princeton University
for the Spider collaboration

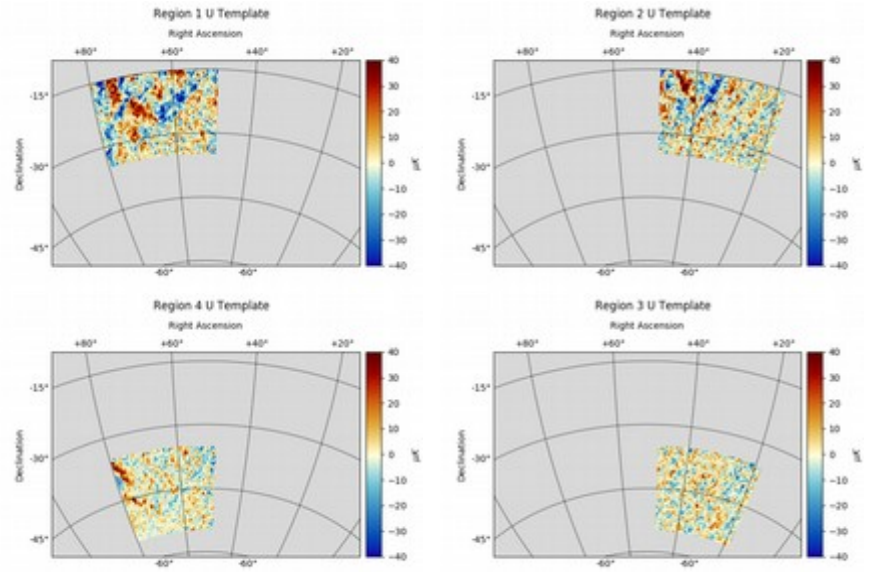
KMG: https://cmb-s4.org/wiki/index.php/File:Cmbs4_aug2018.red.mini.pdf

Spider: Simple Template Removal

Planck dust model: [T_{dust} = 19.6, ß = 1.54]

S150 (S94) / P353 fit coefficient: 0.0432 (0.0163)





- Full field: 0.042 +/- 0.004

(with uncertainty dominated by chance correlations)

- Several sigma variations in this fit coefficient within the field (!)

Spider 2018:
extended frequency coverage

NIST 285 GHz TES arrays
(Hubmayr 2016, Bergman 2017)