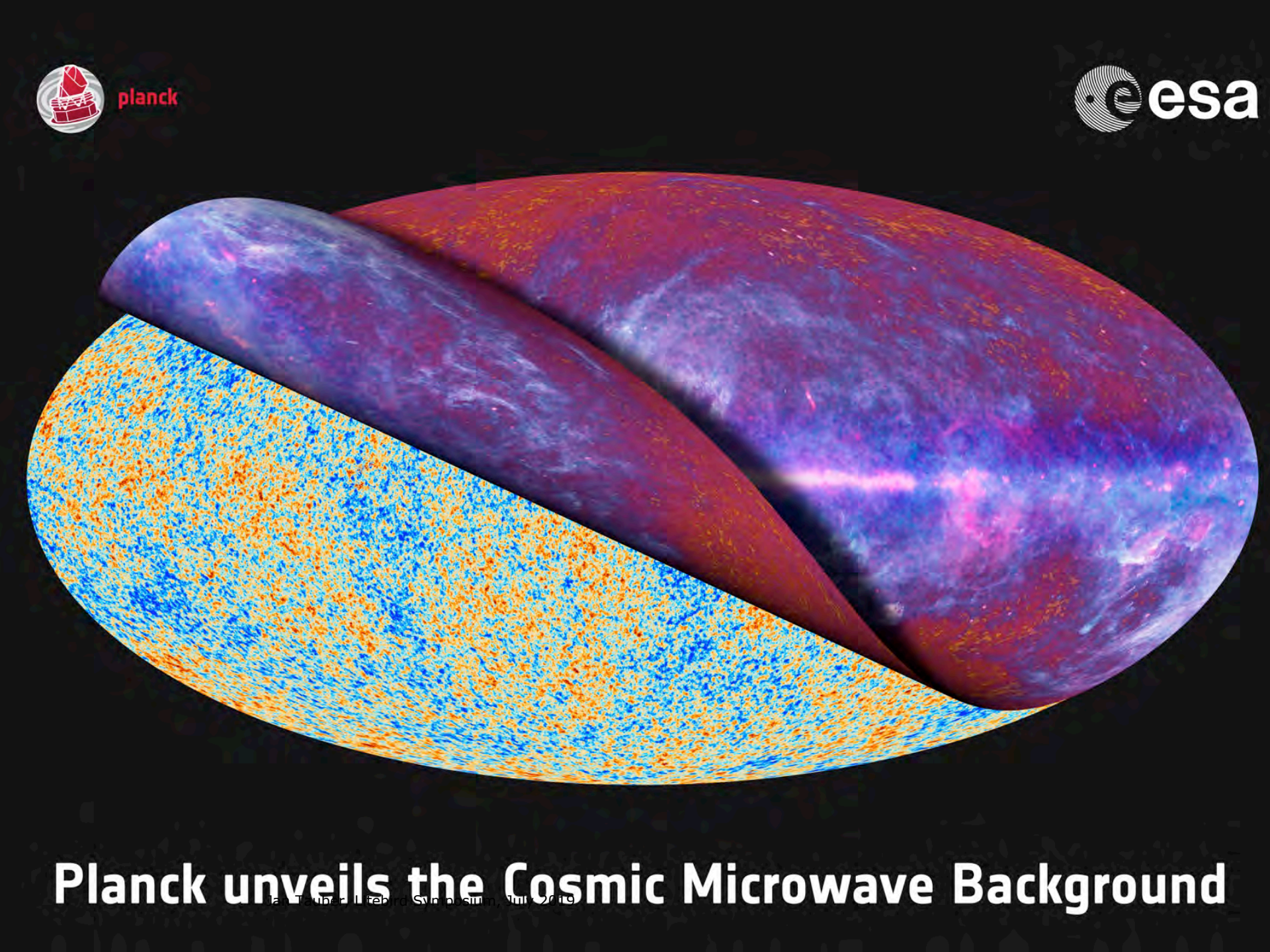
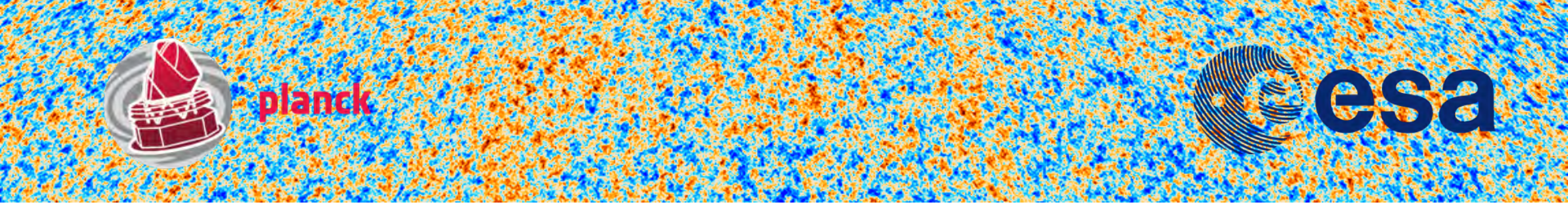

planck
esa
Planck unveils the Cosmic Microwave Background



Lessons learned from Planck

Litebird Kickoff symposium:

ISAS/JAXA 1-2 July 2019

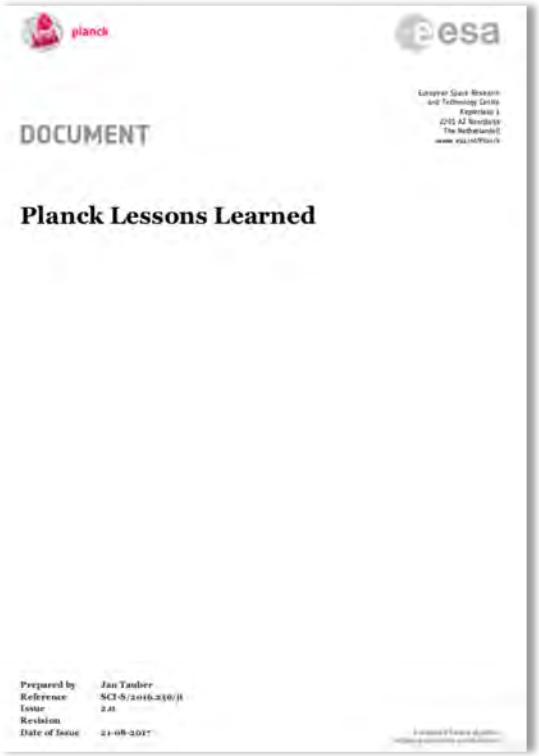
Jan Tauber

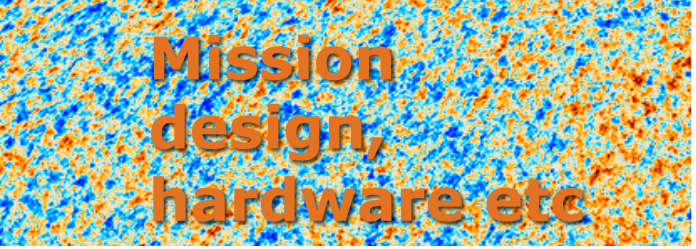
Planck Project Scientist

European Space Agency

Introduction

- The Planck Science Team has extracted major Lessons Learned from its ~20-year experience
  - Biassed by own circumstances
  - Emphasis on "negative" stories
- Planck LL may apply to high-sensitivity surveys where systematic effects are dominant
- the report can be found at: https://www.cosmos.esa.int/web/planck/lessons-learned





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- Many lessons related to specific technologies
- Applicable only to specific experiments

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Designing surveys

- Null tests are fundamental
- Redundancy enables null tests
- The number of possible data cuts / consistency tests grows exponentially with redundancy
- Long-lived experiments (or extensions) with very high levels of redundancy are a “requirement” – not a wish

Systematic effects

- It is very difficult to predict in advance which systematics will hit you
  - Test, test, test - in as representative conditions as possible
  - Measure, measure, measure
    - long and complex CPV phase
- Need to think in advance about dealing with every potential effect, no matter how tiny
  - As data processing advances, ever smaller and subtler effects will become dominant
- Gather as much data (science, ancillary) as you can
- Be ready to throw away your pipeline and start from scratch

Data processing

- "understanding the data" must be the top priority
  - Science is a guide and a test but should not be the driver
  - It gets more difficult over time as effects become subtler and more interconnected
- keeping parallel pipelines is an important principle but has significant disadvantages
  - It means additional effort and resources
  - Cooperation vs competition…
  - Cross-comparing results is really difficult
- Full "blinding" is only possible to a limited extent if one aims to reach ultimate sensitivity in the presence of systematic effects
  - But full transparency / exposure is possible and effective
- "Secondary" science is an important bonus but can be a big overhead – boundaries need to be spelled out early

Simulations

- Simulations are essential for
  - Testing pipelines
  - Evaluating systematic effects
  - Estimating uncertainties
- The simulations needed have to range widely in complexity and for some uses need to be produced in numbers of $>10^3$ – 10^4 – 10^5 ?
- Planck – with ~70 detectors – was barely able to produce enough simulations for its needs
- Future experiments - with $>>10^4$ detectors – will face a massive need
- Use of supercomputers requires dedicated expertise and management

Other experiments

- We learn a lot by comparing results to other experiments
  - … but it requires specific expertise
- By extension, incorporating results from other experiments requires making very-well-educated choices
- Make a clear distinction between “own” results and “combined” results

Collaboration aspects

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Large scientific collaborations are increasingly the norm

- They require specific management – a big overhead
- Responsibilities have to be handed out and results assessed
    - Technical
    - Operational
    - Infrastructural
    - Scientific

  Transparency and flexibility are essential
- "rules" need to be agreed by all
    - Secrecy (?)
    - Access to data
    - Publication
    - Authorship
    - External collaborations
    - ...

Collaboration aspects

- Internal flow of information has to be actively managed
  - Lots of meetings
  - reports
  - Repositories, e.g. wikis etc
  - …
- Internal milestones must be spelled out taking into account
  - Data product generation timescales
  - Science / writing papers
  - Data product public release dates
- Rewards have to be managed
  - Young scientists…
- Warning: the last years are the most difficult ones

Data distribution

- The data needs to be distributed in a form that it can be “easily” used
- The data products need to be designed at an early stage and should be compatible with the latest concurrent experiments
- The products need to be validated
    - They should have been used for science
    - They need to be physically checked
- The products need to be documented adequately
    - Explanatory documentation is **not** the same as Papers !
- The means of distribution should be up to current standards
    - And should be kept up to date
- The data product users need to be supported by experts

Writing and publishing papers

- Publication of papers is closely tied to data releases
  - Hard deadlines and tight coordination
  - Public release before journal acceptance
- The production of Collaboration papers requires very close management
  - writing is a distinct “task”
  - Internal reviewing is also a separate task
  - The entire Collaboration must be involved
- An Editorial Board composed of respected senior scientists has been an essential element of the Planck process
  - Many eyes temper big statements…
  - It is beneficial to separate ultimate decision-making from the editorial function

Public communications

- Cosmology is very attractive to the public
  - But beware of going out too fast with great discoveries…
- Dedicated resources and expertise are needed
- Different parties need to be coordinated
  - Agencies
  - Institutes
  - Individuals
- Finding the right messages for a wide audience is not easy: boldness vs cautiousness
- Driving PR by events (e.g. launch, data releases) is practical but should be complemented with a more "continuous" series of communications

Wrapping up

- Planck is an experimental and scientific success story
  - it exceeded all expectations
- New data products are still being generated
- The CMB delivers mature / precision science
  - a lot remains to be done
- The Planck teams are still around to talk about good and bad experiences
  - Talk to them !

The scientific results that we present today are a product of the Planck Collaboration, including individuals from more than 100 scientific institutes in Europe, the USA and Canada

Planck is a project of the European Space Agency, with instruments provided by two scientific Consortia funded by ESA member states (in particular the lead countries: France and Italy) with contributions from NASA (USA), and telescope reflectors provided in a collaboration between ESA and a scientific Consortium led and funded by Denmark.

Thank you