

LiteBIRD System Definition

Masashi Hazumi
(KEK and Kavli IPMU)

December 14, 2015

LiteBIRD working group

128 members, international and interdisciplinary (as of Dec 14, 2015)

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S. Nakamura
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R. Stompor

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T. Kisner
A. Kusaka
A. Lee(US PI)
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P. Richards
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X-ray
astrophysicists

JAXA engineers

IR astronomers

CMB experimenters

Super-conducting
detector developpers

Outline

Note there was a talk on Mission Definition on Saturday Dec. 12.

1. Recap of Mission Definition
2. Summary of Pre-phase-A Studies
3. Phase-A Overview

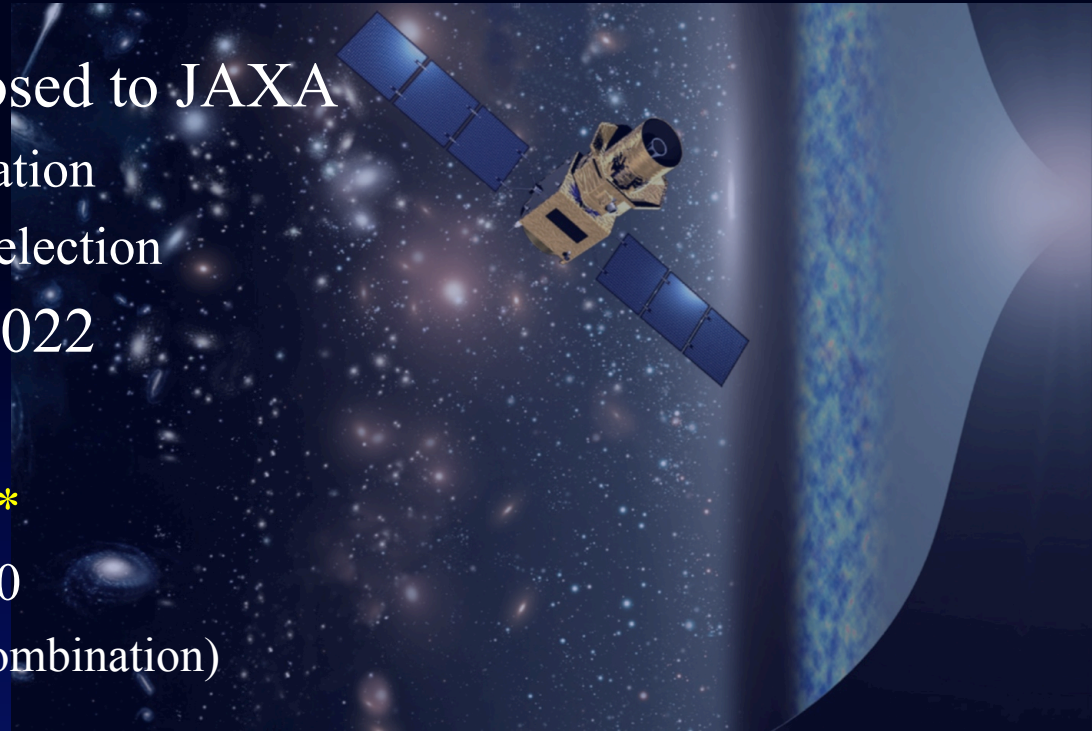
This talk is an introduction to many specific technical talks that will be given in this workshop.

1. Recap on Mission Definition

LiteBIRD Mission Summary

Lite (Light) Satellite for the Studies of **B**-mode Polarization and Inflation from Cosmic Background **R**adiation **D**etection

- CMB B-mode satellite proposed to JAXA
 - Also to NASA for US participation
 - Both proposals passed initial selection
- Proposed launch year: JFY 2022
- Mission Requirements
 - Total uncertainty on $r < 0.001^*$
 - Multipole coverage: $2 \leq \ell \leq 200$
 - Each bump (reionization, recombination)
with $>5\sigma$ if $r > 0.01$
- Orbit: L2
- Observing time: 3 years



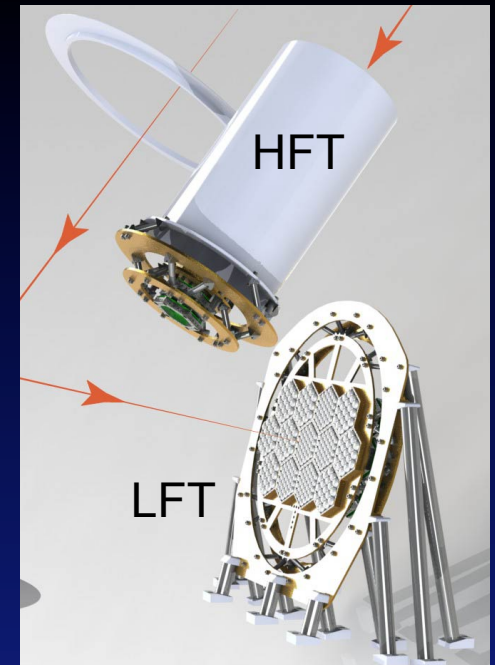
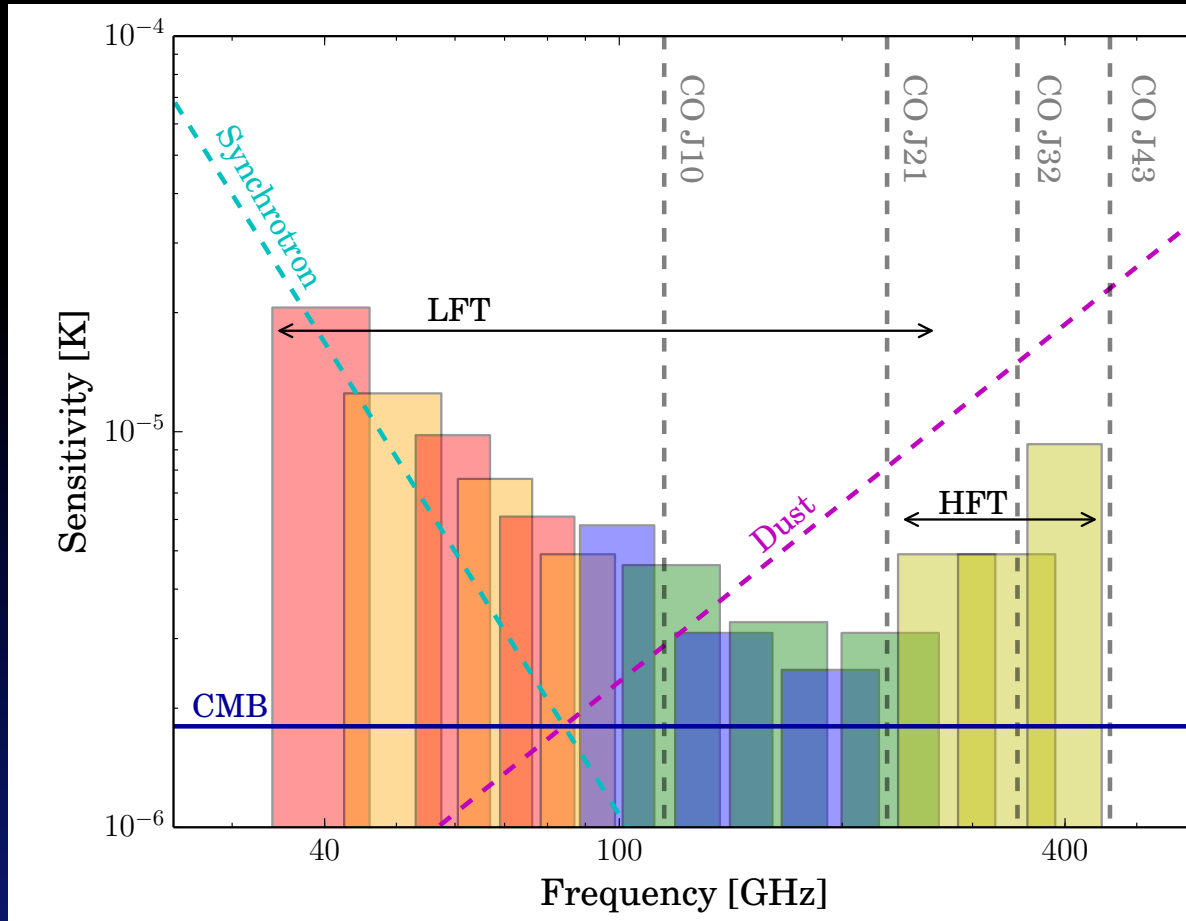
***Our current studies yield**
 $\sigma(r) = 2 \times 10^{-4}$ (for $r=0$)
for 3 year observation

15 frequency bands as global Phase-A baseline

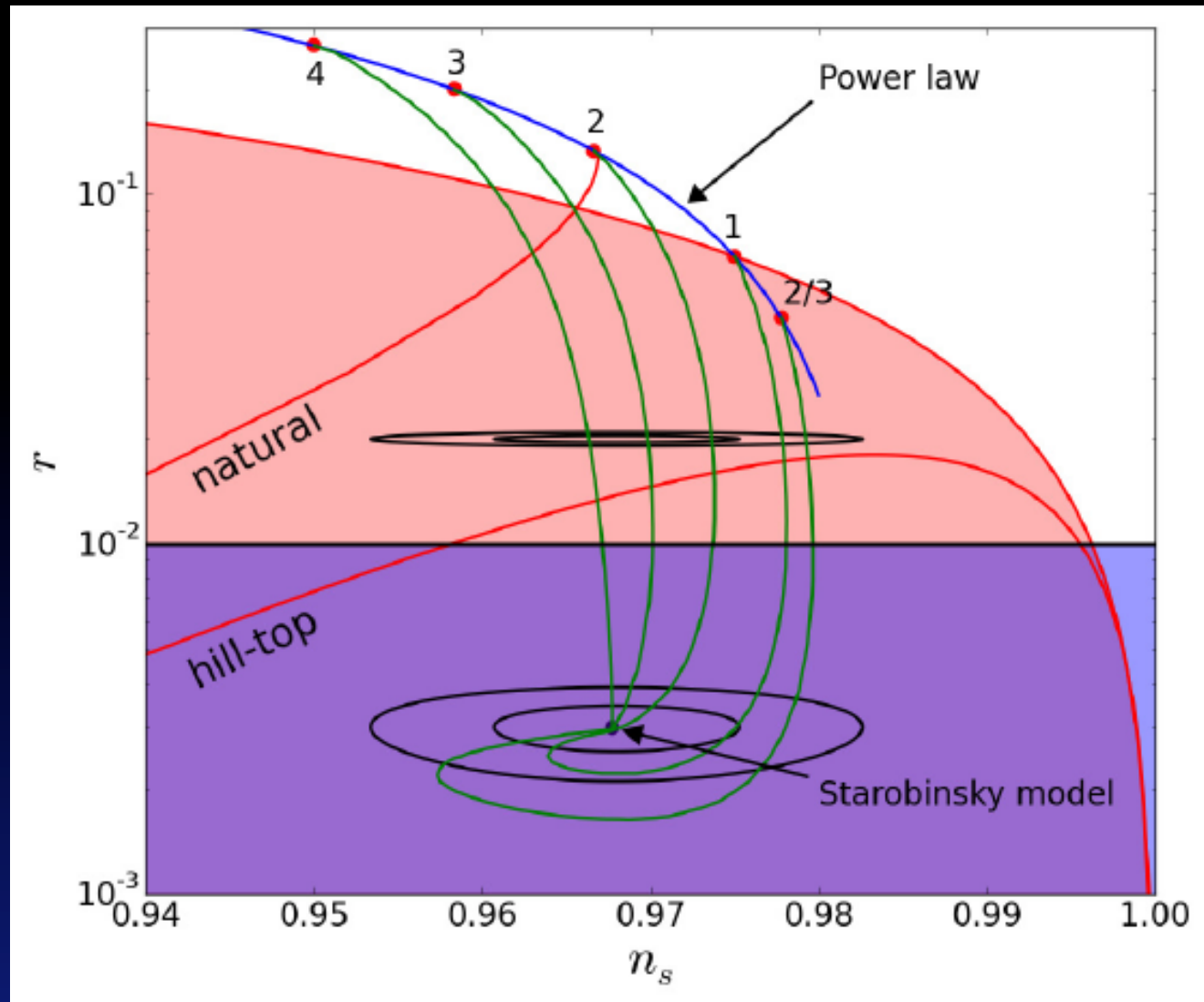
Polarization sensitivity

2.4 $\mu\text{Karcmin}$

(3 year operation,
including margin)

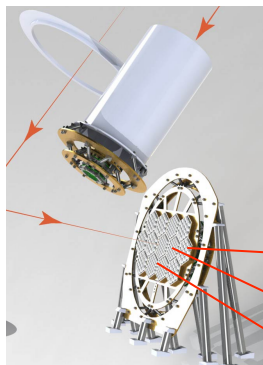


LiteBIRD constraints on r vs. n_s plane (15 bands)



2. Summary of Pre-phase-A Studies

Multi-chroic focal plane detectors

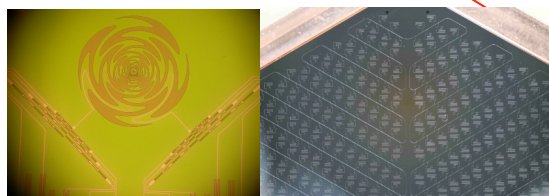


Lenslet

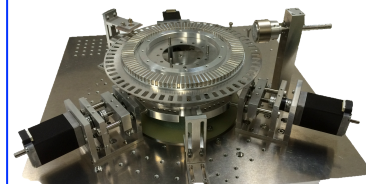


TES

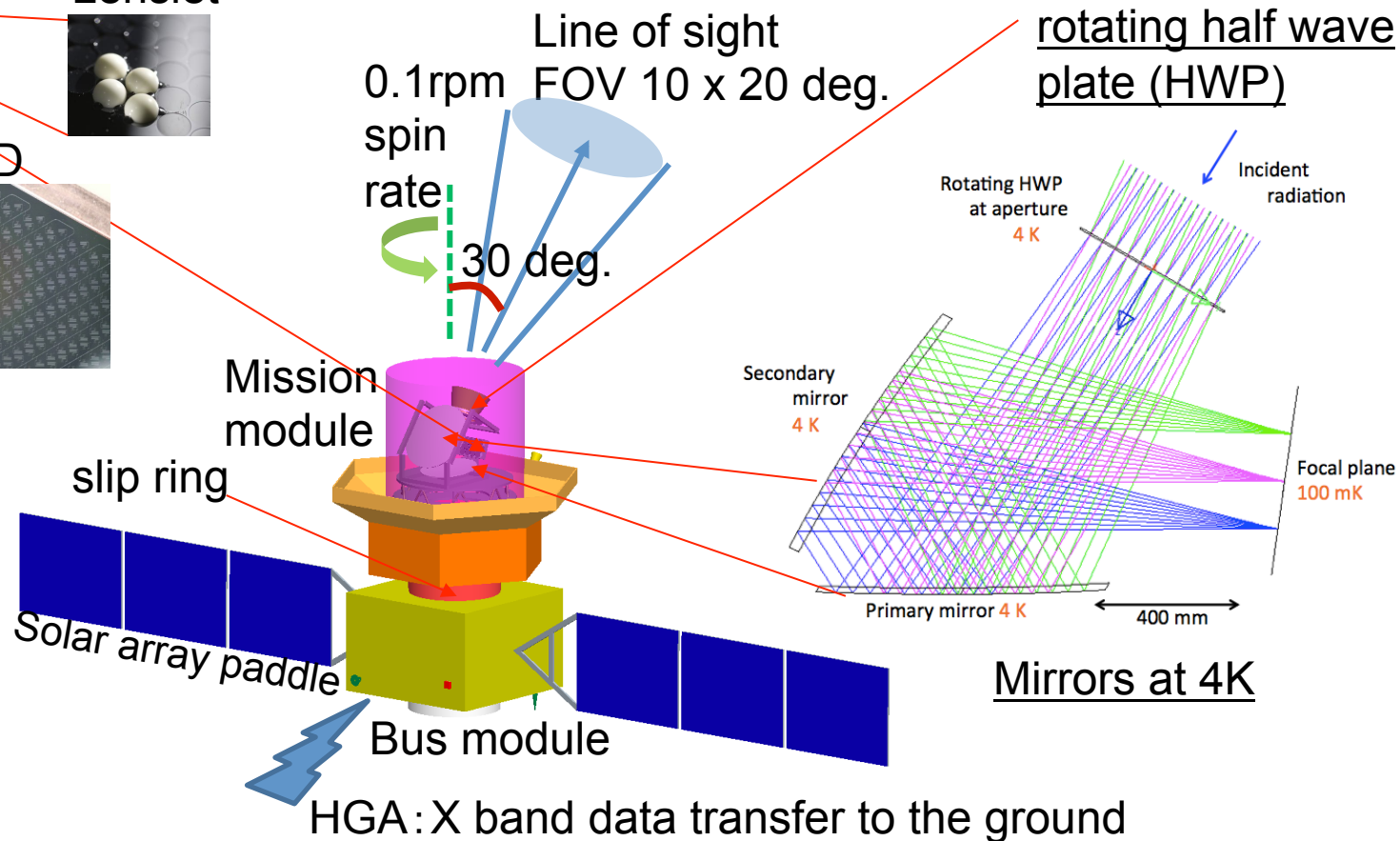
MKID



- Mission module benefits from heritages of other missions (e.g. ASTRO-H) and ground-based experiments (e.g. POLARBEAR).
- Bus module based on high TRL components

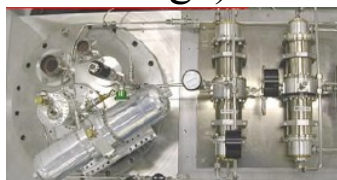


Continuously-rotating half wave plate (HWP)

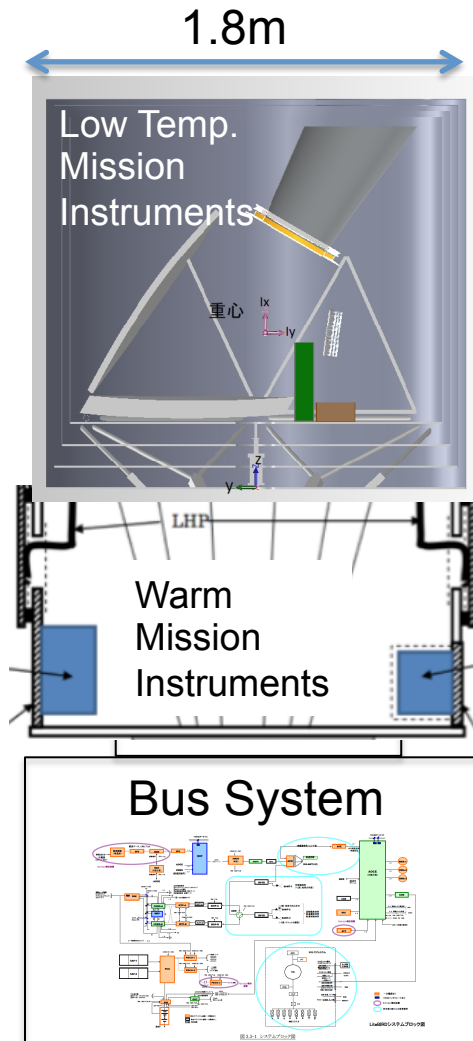


Cryogenics

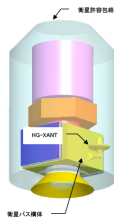
■ JT/ST and ADR (ASTRO-H heritage)



LiteBIRD block diagram

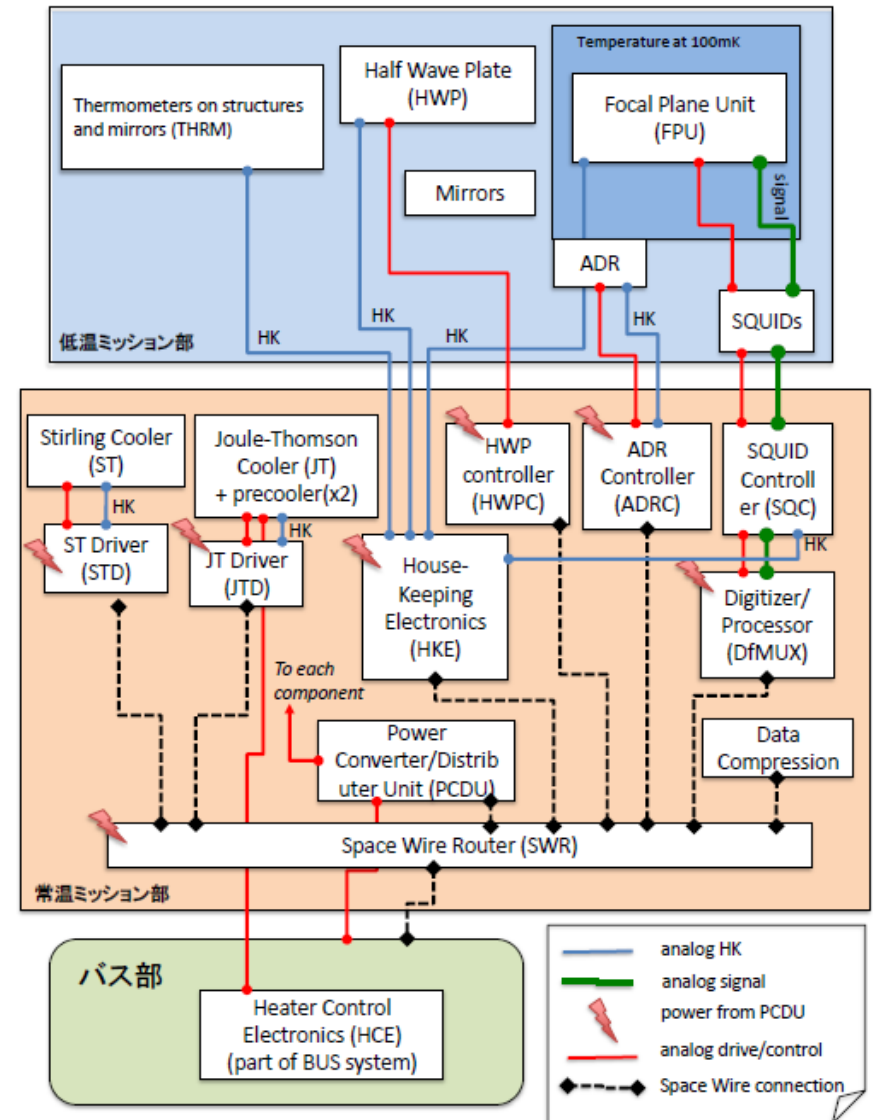


Fit in H2 envelope

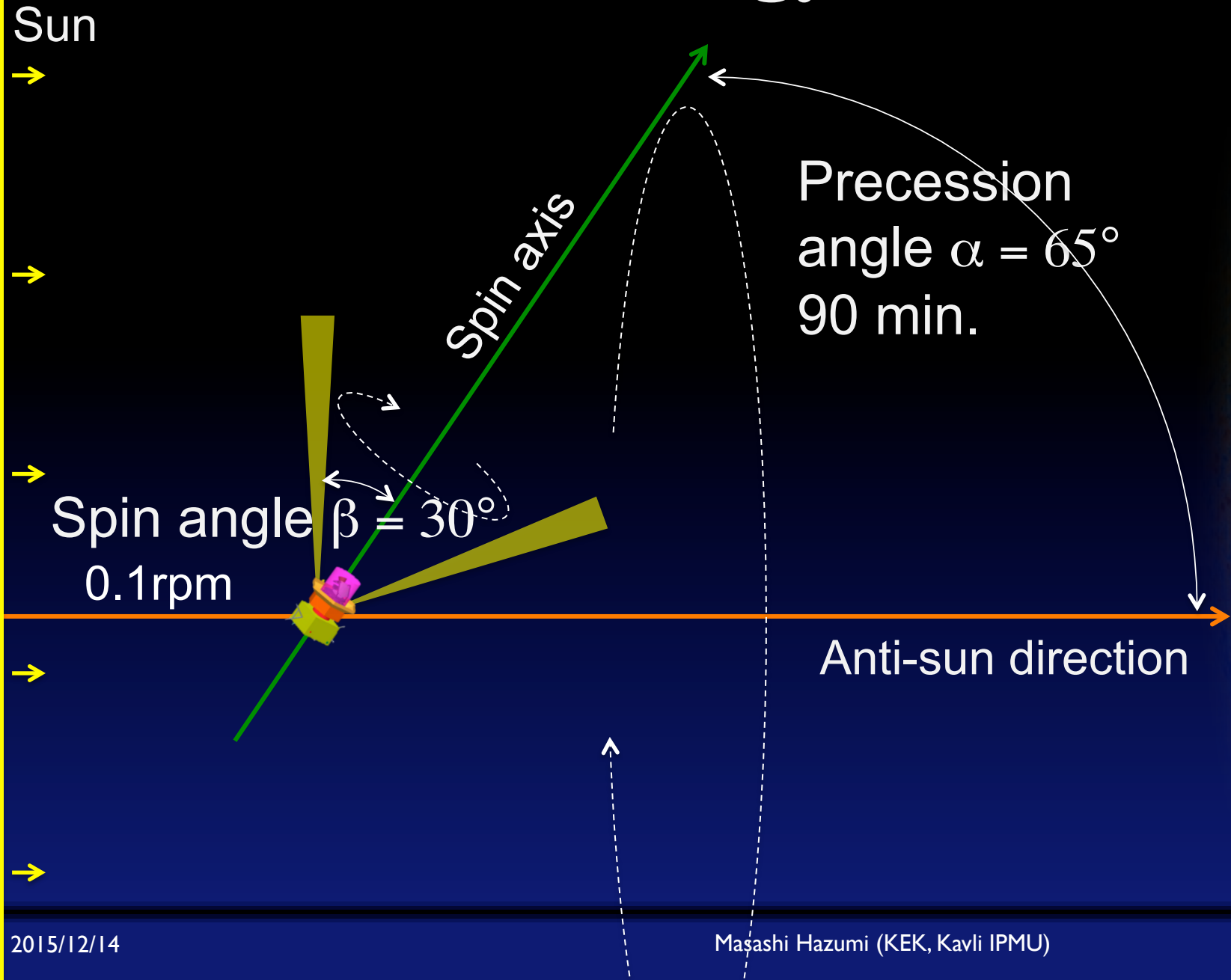


LiteBIRD block diagram

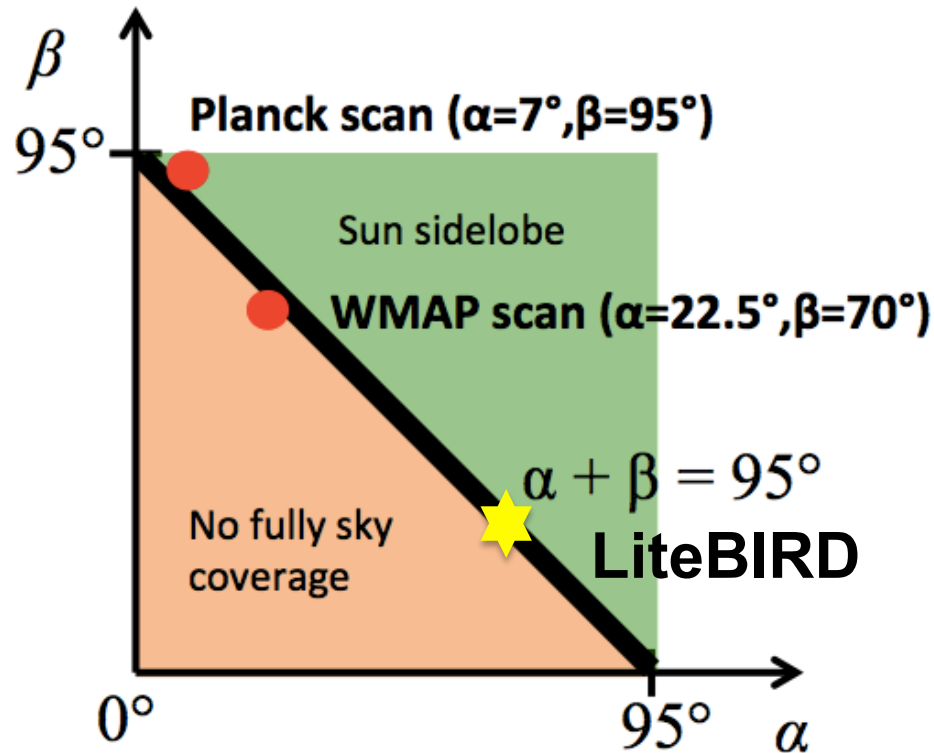
TES option



Scan strategy at $L2$



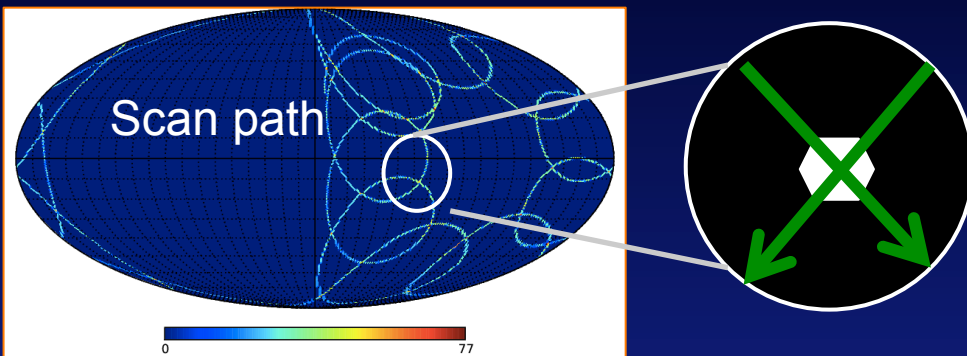
Scan strategy



$\alpha + \beta \geq 90^\circ$ for full sky

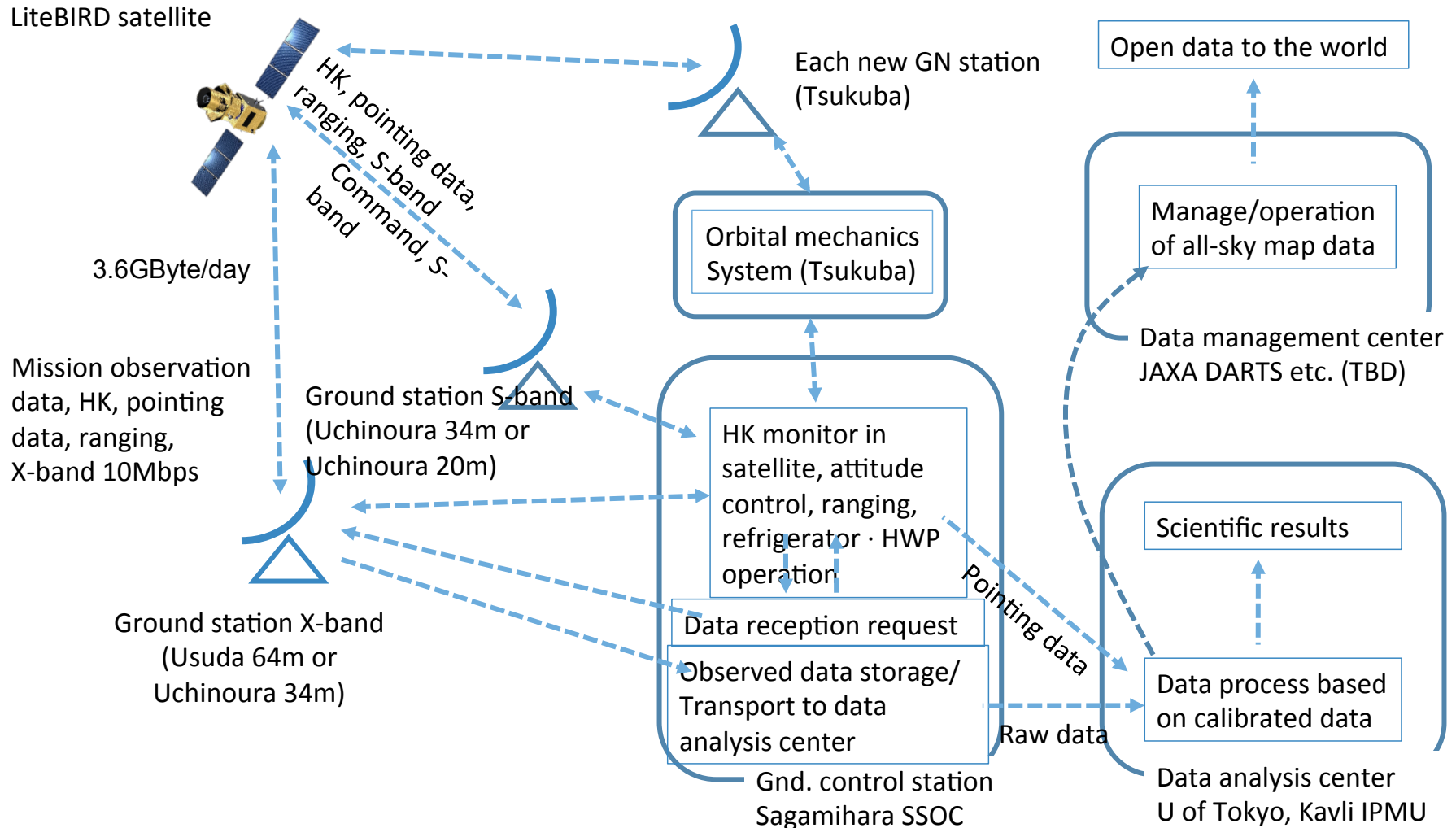
$\alpha + \beta \leq 95^\circ$ from thermal/optical requirements

$(\alpha, \beta) = (65^\circ, 30^\circ)$ chosen to minimize the effect of E to B leakage due to pointing bias

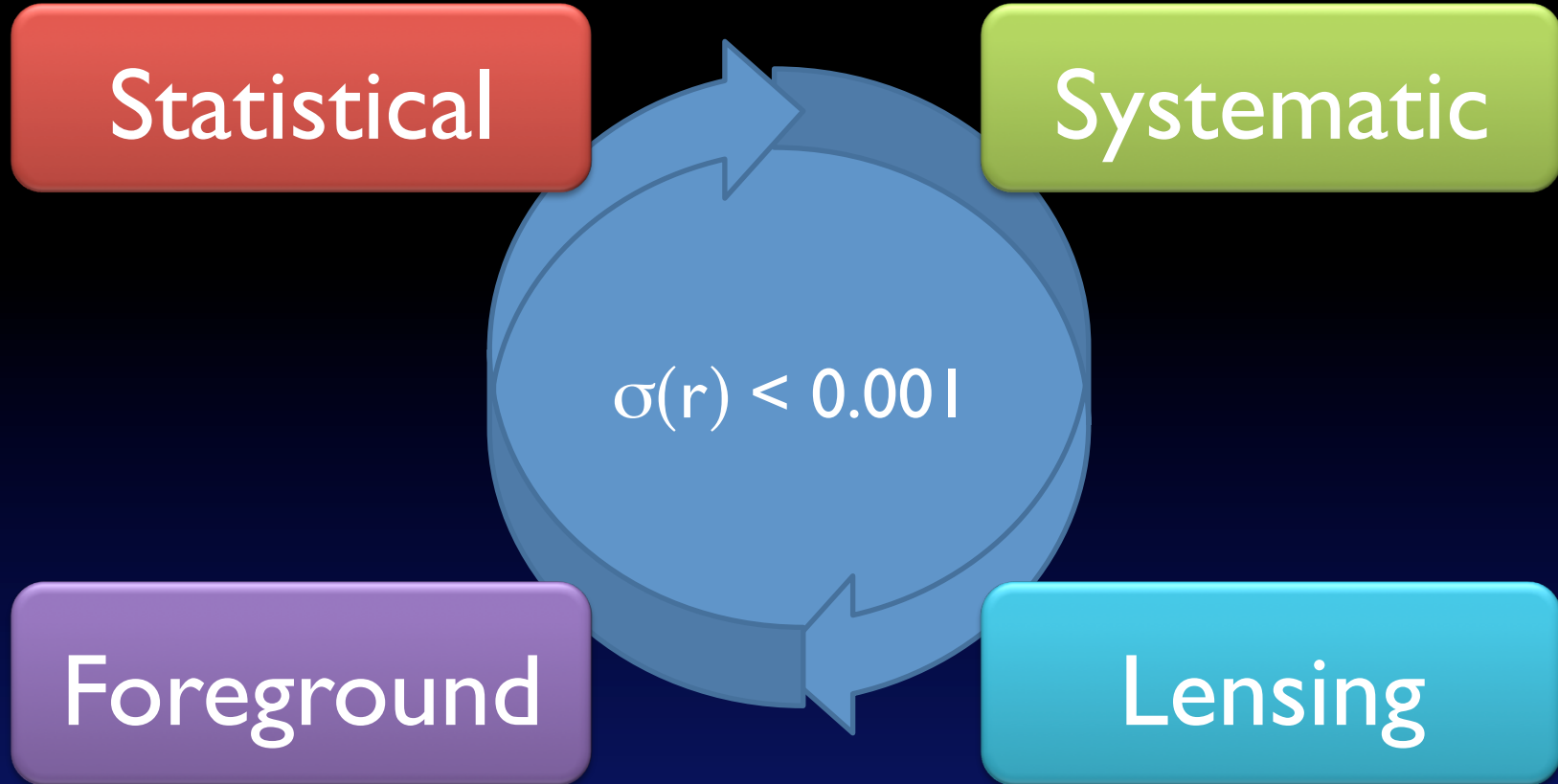


Good crosslink reduces pointing bias w/ multiple measurements

Operation concept



Road to achieve the full success

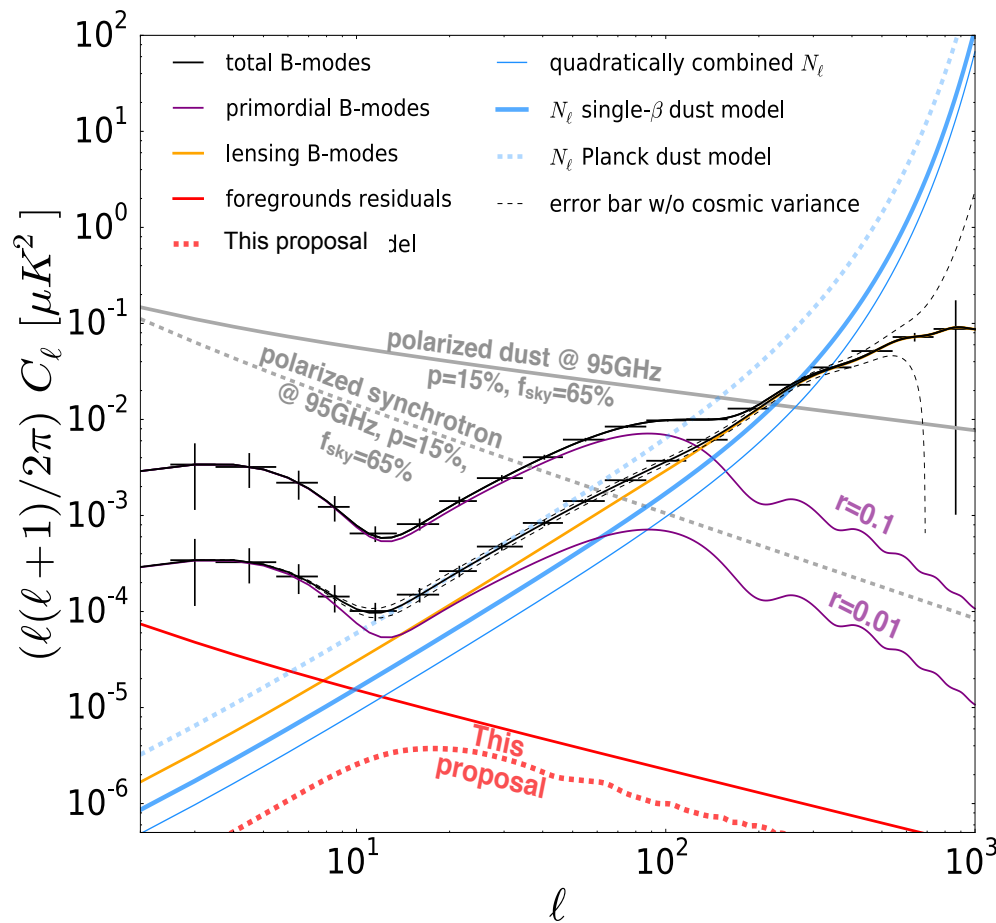


Observer bias as the 5th element → mitigation by e.g. blind analyses

LiteBIRD Sensitivity (15 bands)



J. Errard



$$\sigma(r) = 0.45 \times 10^{-3}$$

for $r = 0.01$, including foreground removal*, cosmic variance and delensing w/ CIB**

$$r < 0.4 \times 10^{-3} \text{ (95\% C.L.)}$$

for undetectably small r

$$\text{Note: } \sigma(r=0) = \delta r = 2 \times 10^{-4}$$

$$\sigma_{\text{sys}}(\text{total}) = 1.1 \times 10^{-4} \quad \text{R. Nagata}$$

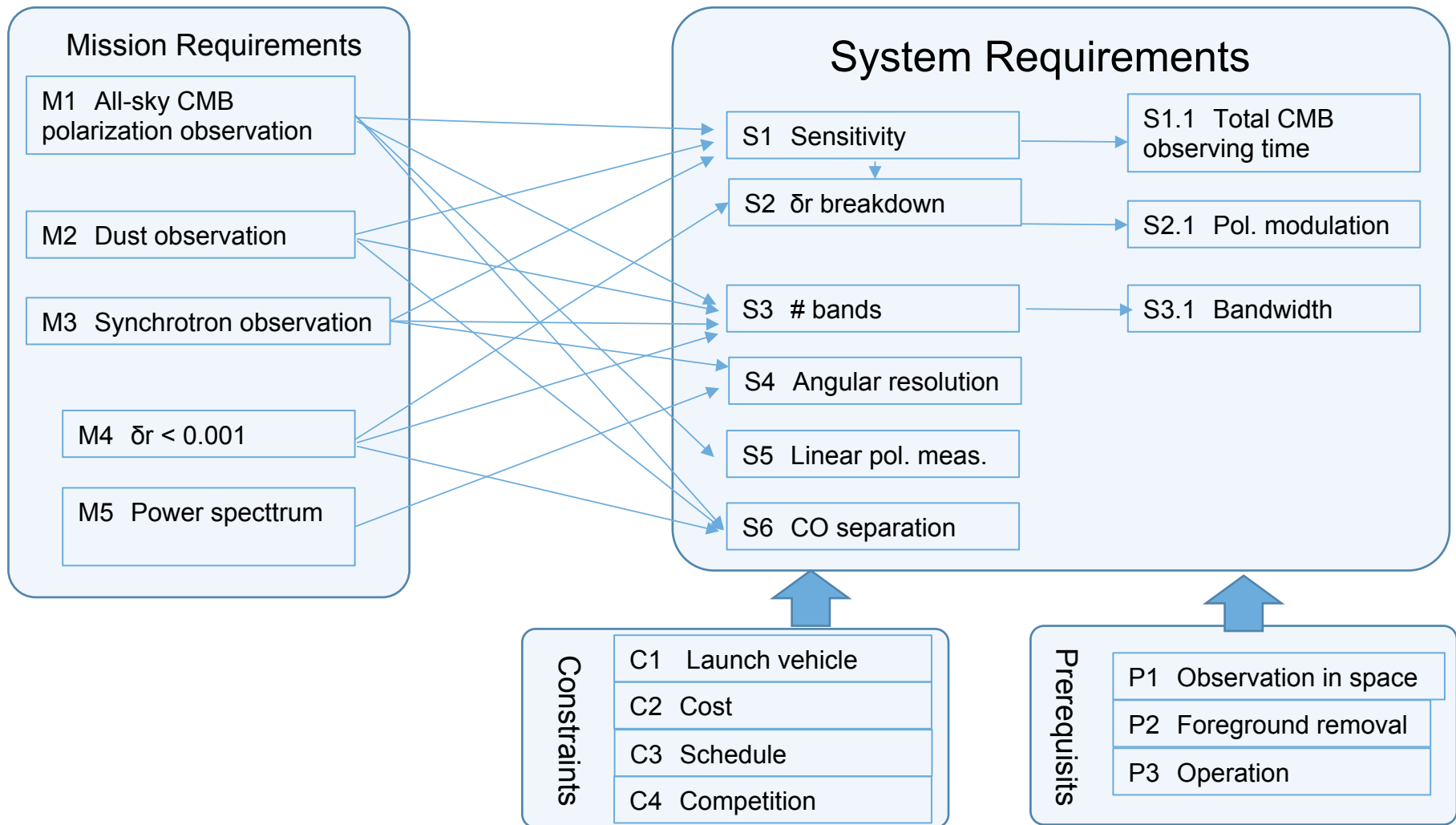
Source	Expctd. error	Reasoning
Pointing	0.23 arcmin	Star tracker spec.
Angle calibration	1 arcmin	C_l^{EB} method
Absolute gain	0.6%	CMB dipole
Diff. gain	0.43%	
Diff. beam width	<1%	Optical simulation, HWP experience
Diff. ellipticity	<1%	
Diff. pointing	<1%	

* Foreground residual estimation with Errard et al. 2011, Phys. Rev. D 84, 063005

plus a new method (this proposal, another paper in preparation)

** "Delensing the CMB with the Cosmic Infrared Background", B. D. Sherwin, M. Schmittfull arXiv:1502.05356

Top-level system requirements



Launch Vehicle

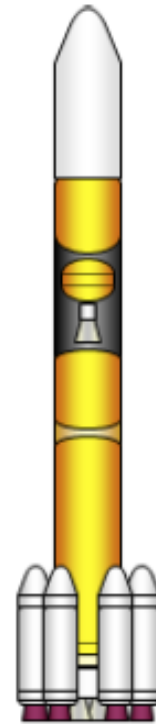


H-II A

- First Flight in 2001
- **23** successful launches/24
- Latest one: GPM
- GTO 4-6 ton class capability

H-II B

- First Flight in 2009
- **4** successful flights/4 of 16.5 ton HTV to ISS
- GTO 8 ton class capability



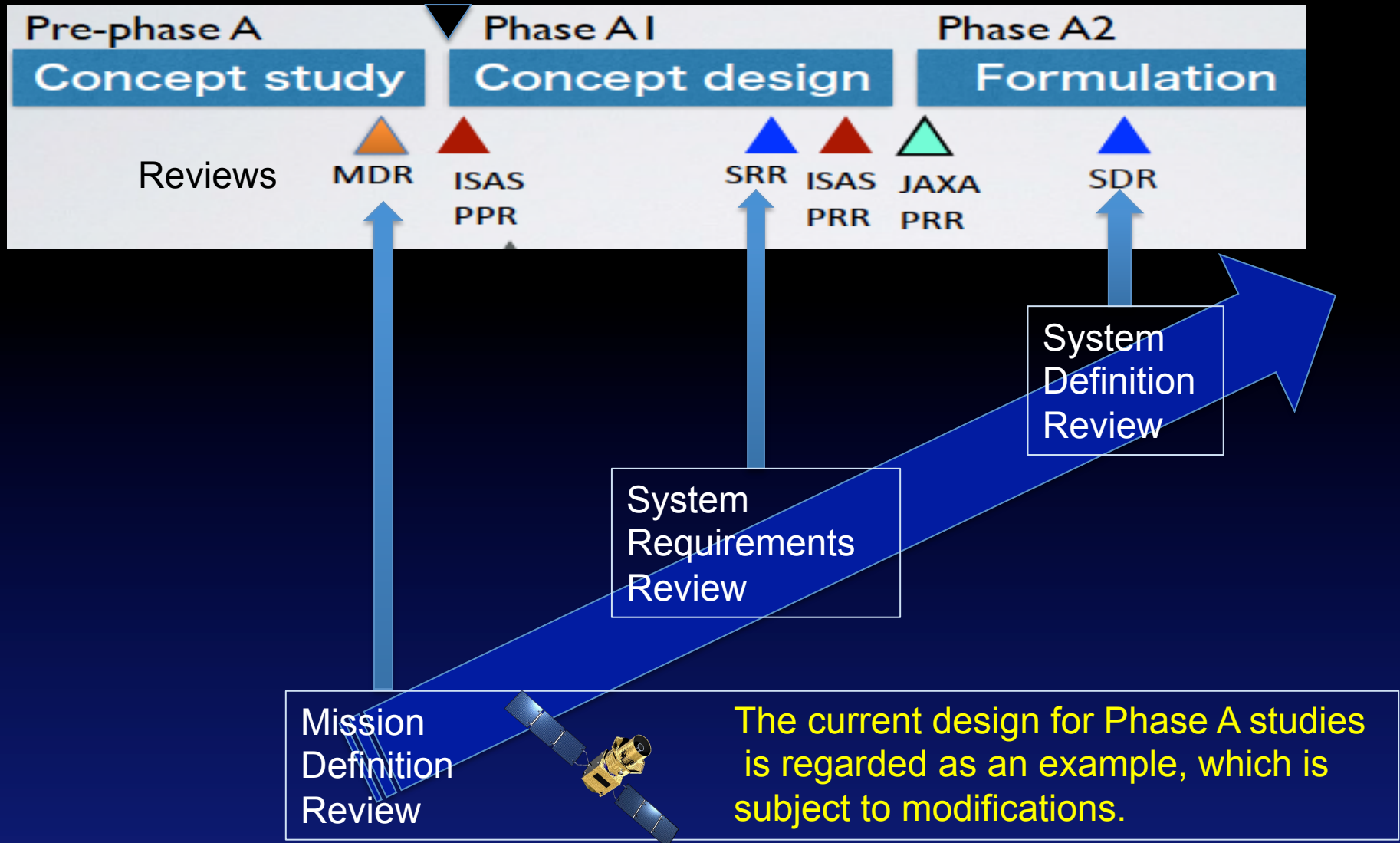
H3

- First test launch in 2020
- $\frac{1}{2}$ cost w/ same capability (comparison w/ H-II B)

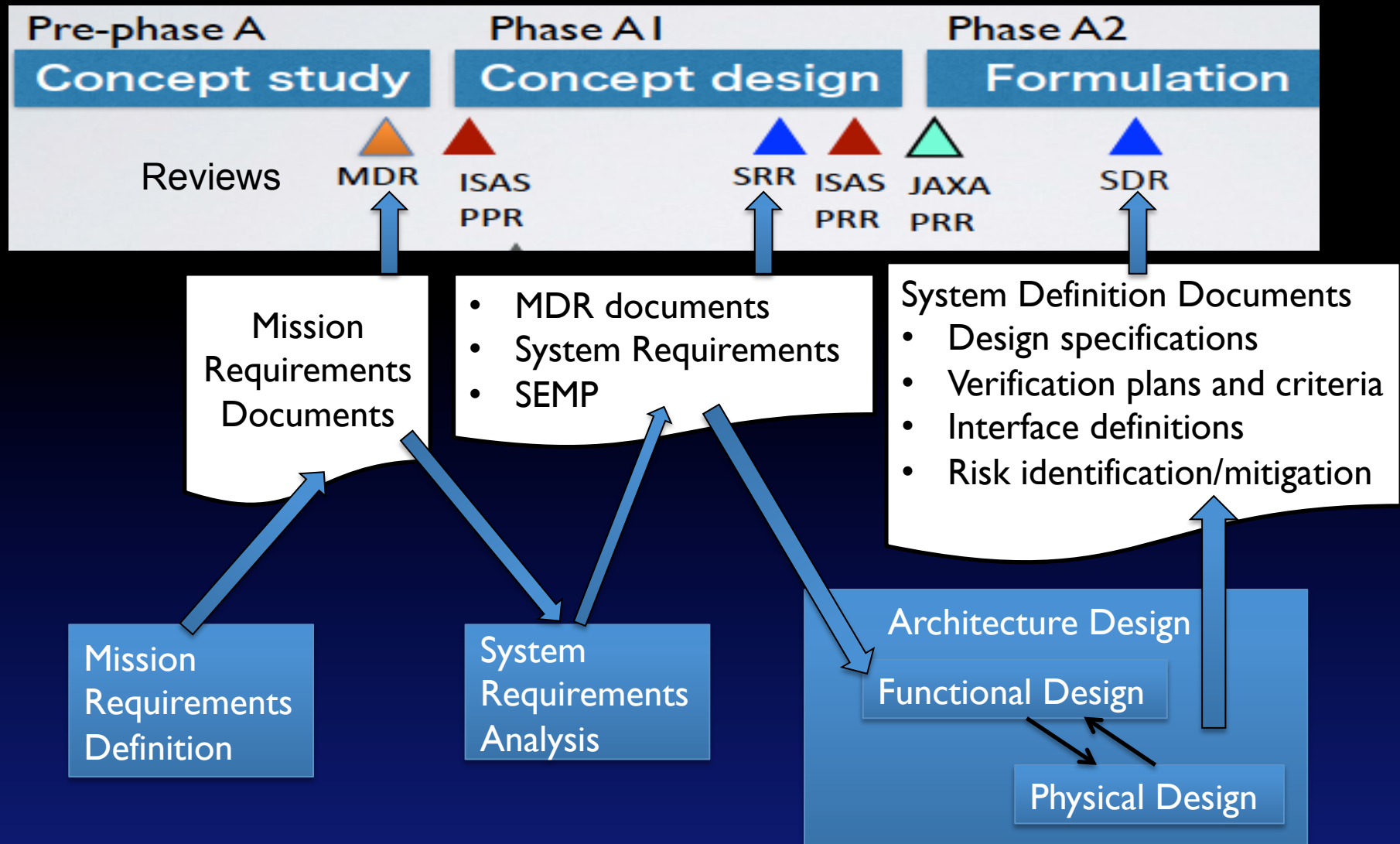
3. Phase-A Overview

JAXA initial phases of space science missions

LiteBIRD

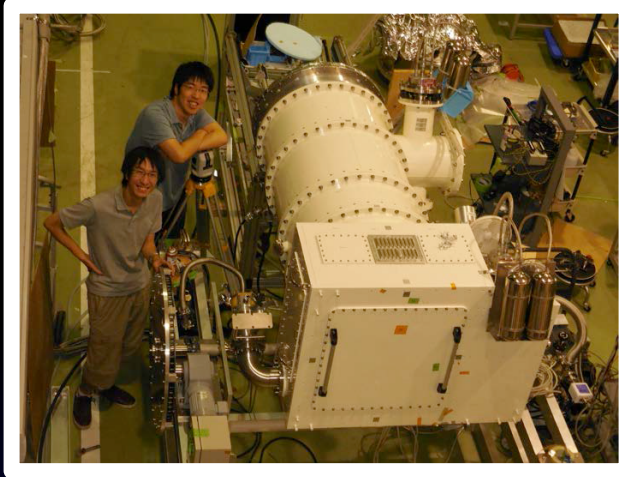


Systems Engineering of LiteBIRD



Testing and integrations

POLARBEAR2 integration is ongoing at KEK with sub-K cryogenic system and UC Berkeley TES bolometers.



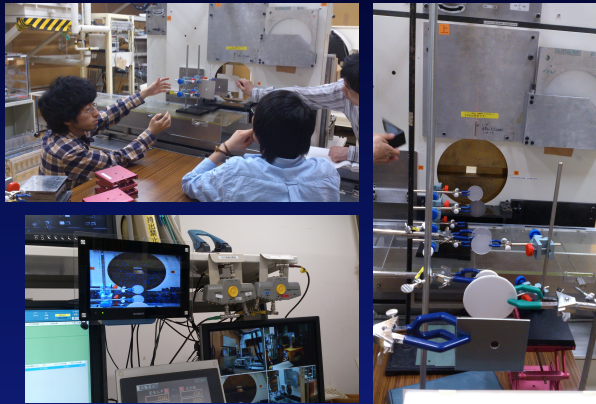
LiteBIRD has members with the CMB instrument integration expertise, satellite integration expertise, HEP radiation expertise together with the fully equipped facilities.



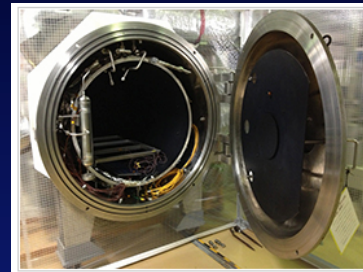
JAXA 13-m diameter space chamber

Astro-H test is done here.

Proton irradiation tests at HIMAC

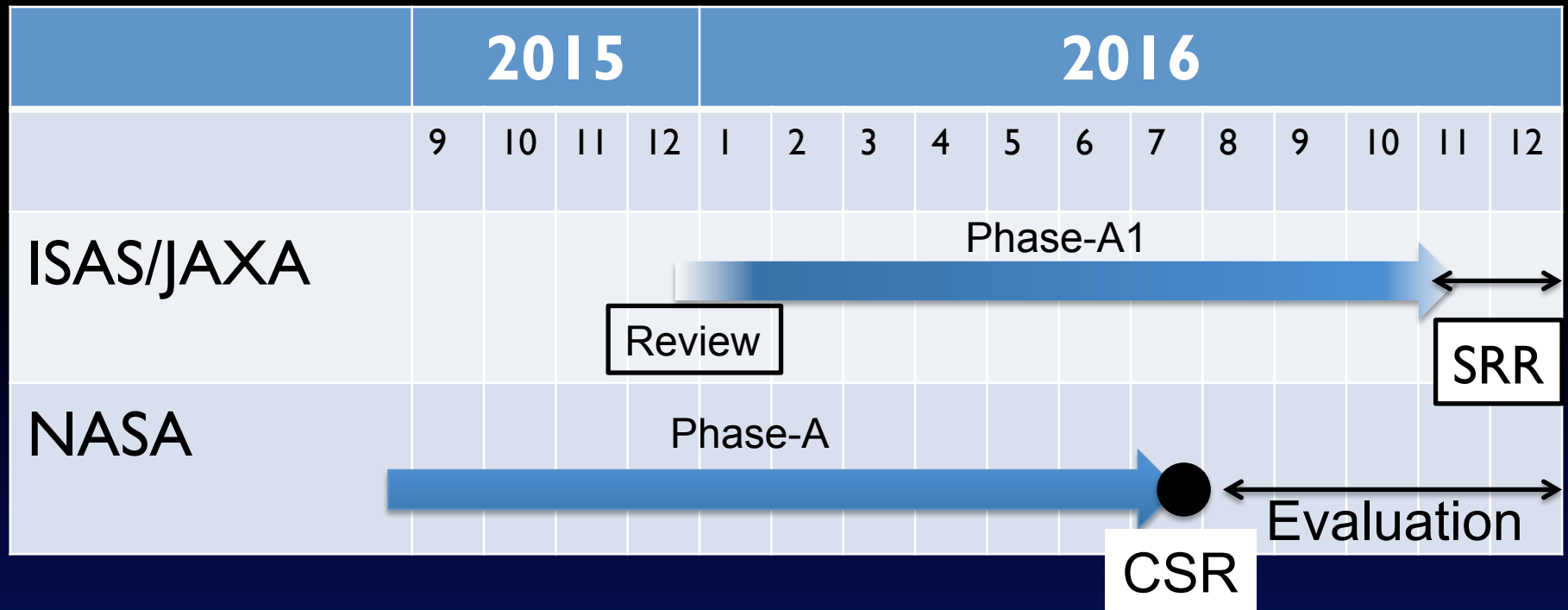


JAXA 6-m diameter space chamber



JAXA 1-m diameter space chamber

Provisional Phase-A Timeline in 2016



LiteBIRD Phase-A Organization

LiteBIRD

ISAS/JAXA phase-A1 team

- System Integration
- Bus system
- Mission instruments ($\geq 4K$)
 - Optics
 - Precoolers

NASA phase A team

- Mission instruments ($< 4K$)
 - Focal plane
 - Sub-K cooling system

External Collaborators

- Partial access rights to LiteBIRD internal information

Point-of-Contacts (POCs)

- International Collaboration and Leadership:
Masashi Hazumi and Adrian Lee
- Project Management:
Tadayasu Dotani and Peter Harvey
- Technical Coordination:
Tomo Matsumura and Kam Arnold

LiteBIRD Joint Study Groups (JSGs)

- Foreground conveners:
Nobu Katayama and Julian Borrill
- Systematics conveners:
Hirokazu Ishino and Chao Lin Kuo

