# Characterization of the Lite BIRD telescope using Physical Optics simulation


**K. KIMURA (1), M. INOUE (1), M. ITO(1), H. OGAWA(1), T. ONISHI (1), Y. SEKIMOTO (2), J. INATANI (2), S. KASHIMA (2), T. MATSUMURA (3) , T. NISHIBORI (4) , H. SUGAI(5) , N. KATAYAMA (5) , I. OHTA (6) , H. ISHINO (7) , M. HAZUMI(5) (8)**

**E-mail: Kimura@p.s.osakafu-u.ac.jp**

**(1)Osaka Prefecture University**
**(2)National Astronomical Observatory of Japan (NAOJ)**
**(3)Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency (JAXA)**
**(4)Research and Development Directorate, Japan Aerospace Exploration Agency (JAXA)**
**(5)Kavli Institute for the Physics and Mathematics of the Universe (Kavli-IPMU)**
**(6)Konan University**
**(7)Okayama University**
**(8)High Energy Accelerator Research Organization (KEK)**

# Overview

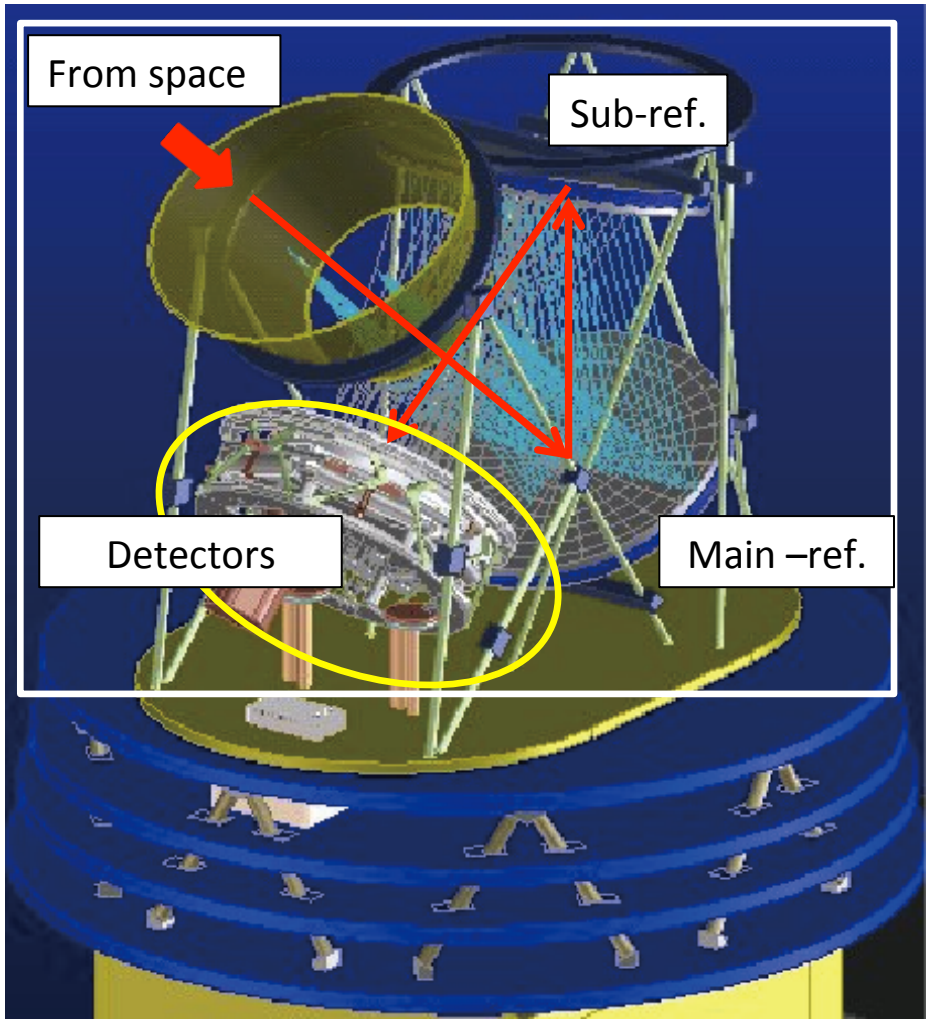
1. Introduction
2. GRASP simulation
3. Scale model measurement
4. Summery

# Overview

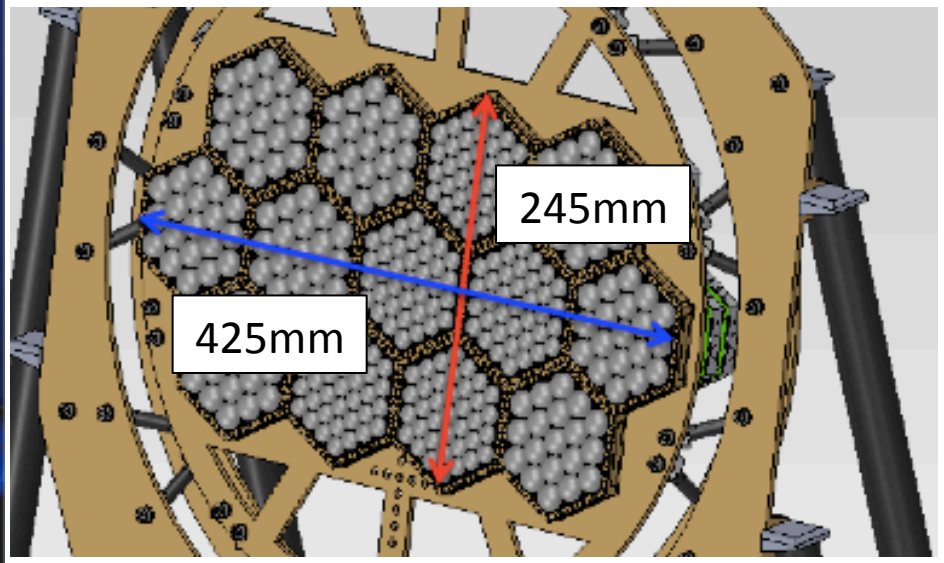
1. Introduction
2. GRASP simulation → **Inoue-san poster**
3. Scale model measurement → **Ito-san poster**
    1. Phase retrieval method
    2. Preliminary results
4. Summery

# 1) Introduction

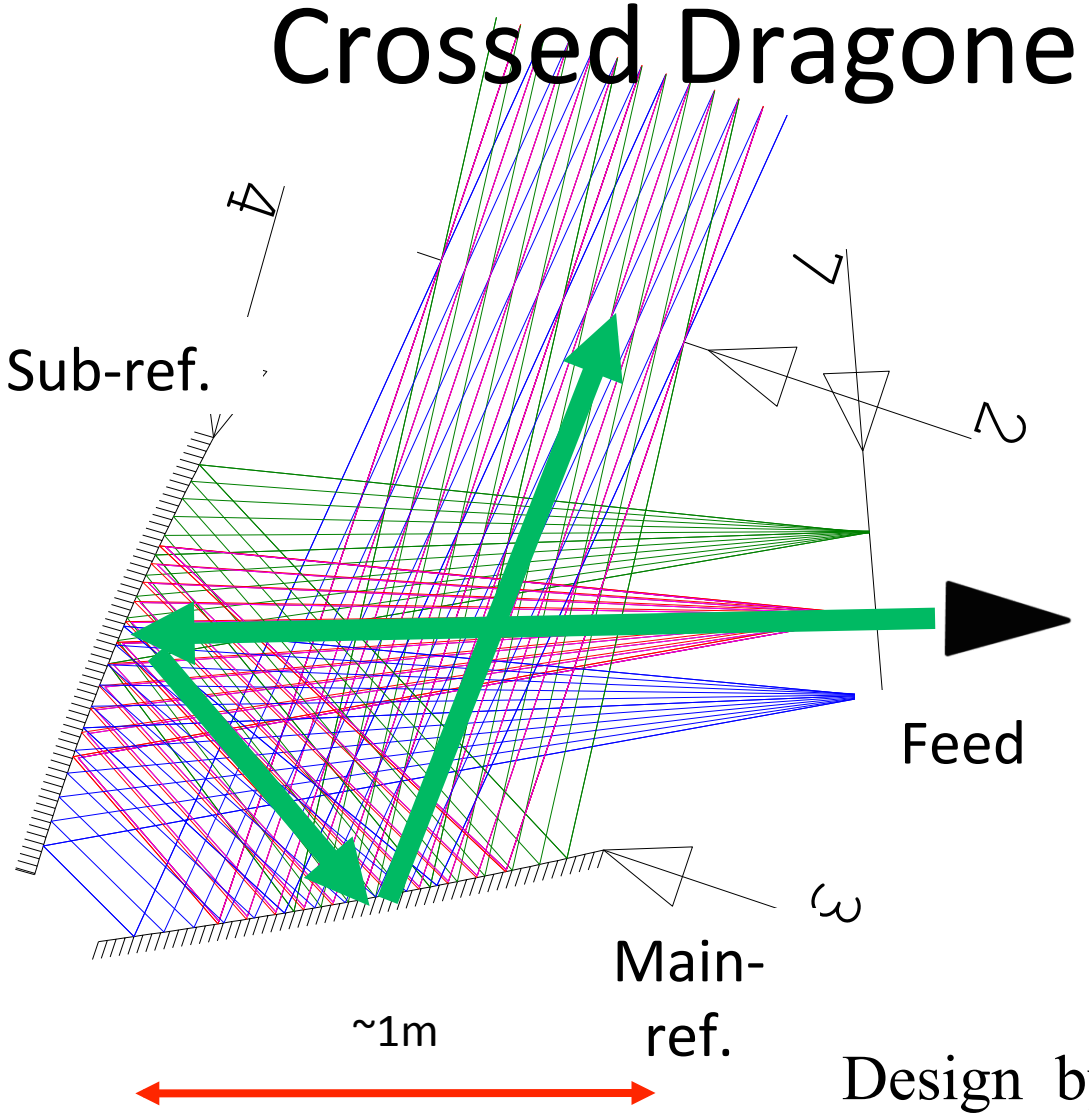
# LiteBIRD antenna




– Focal size
  245mm×425mm
– Antenna size
  less than 1.6m×1.6m



# Crossed Dragone antenna




Crossed Dragone antenna

>merit
large focal plane area
compact size

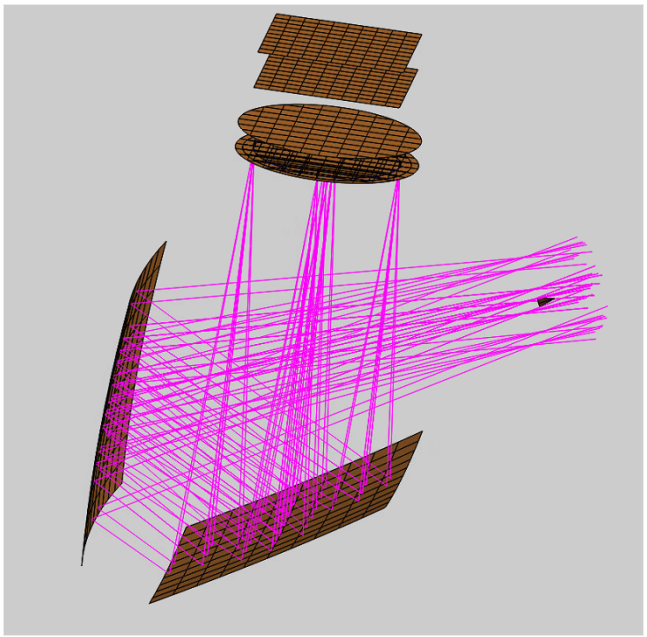
>demerit
Multiple reflection
Stray light

Design by CODE V and Light Tools
(Main study is Kashima san)
Simulation by CODE V, Light Tools
and **GRASP**

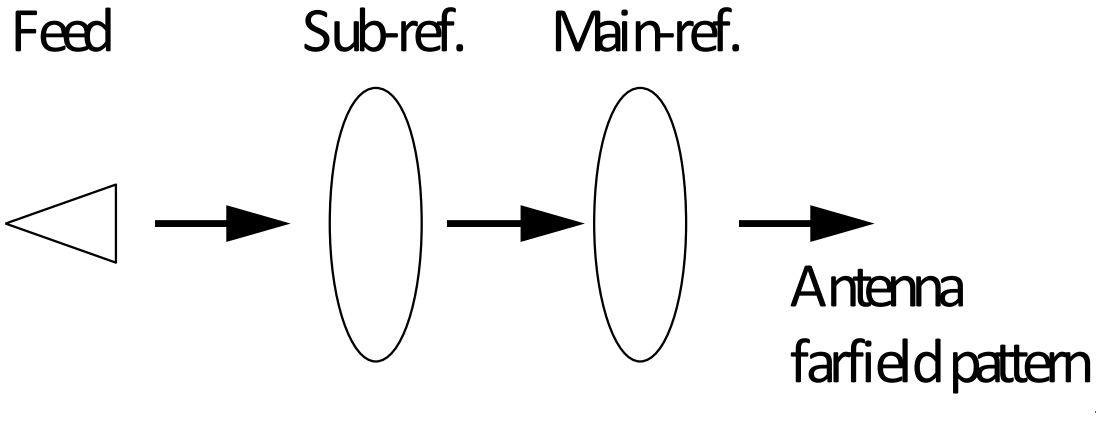
# 2) GRASP simulation

# GRASP software

- GRASP(General **Reflector Antenna** Software Package) is simulation software used by Physical optics.
- Ticra company. @Denmark



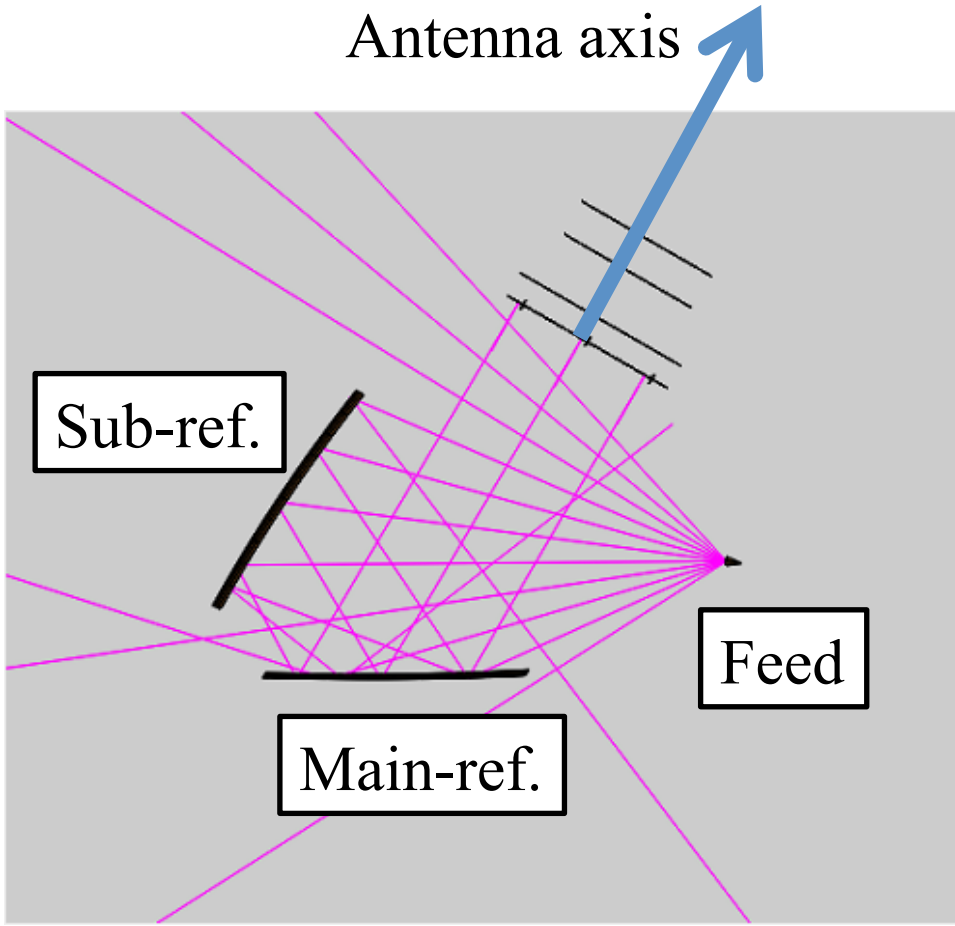
A reflective wave is calculated from an incident wave every mirror.



# Lite BIRD GRASP simulation

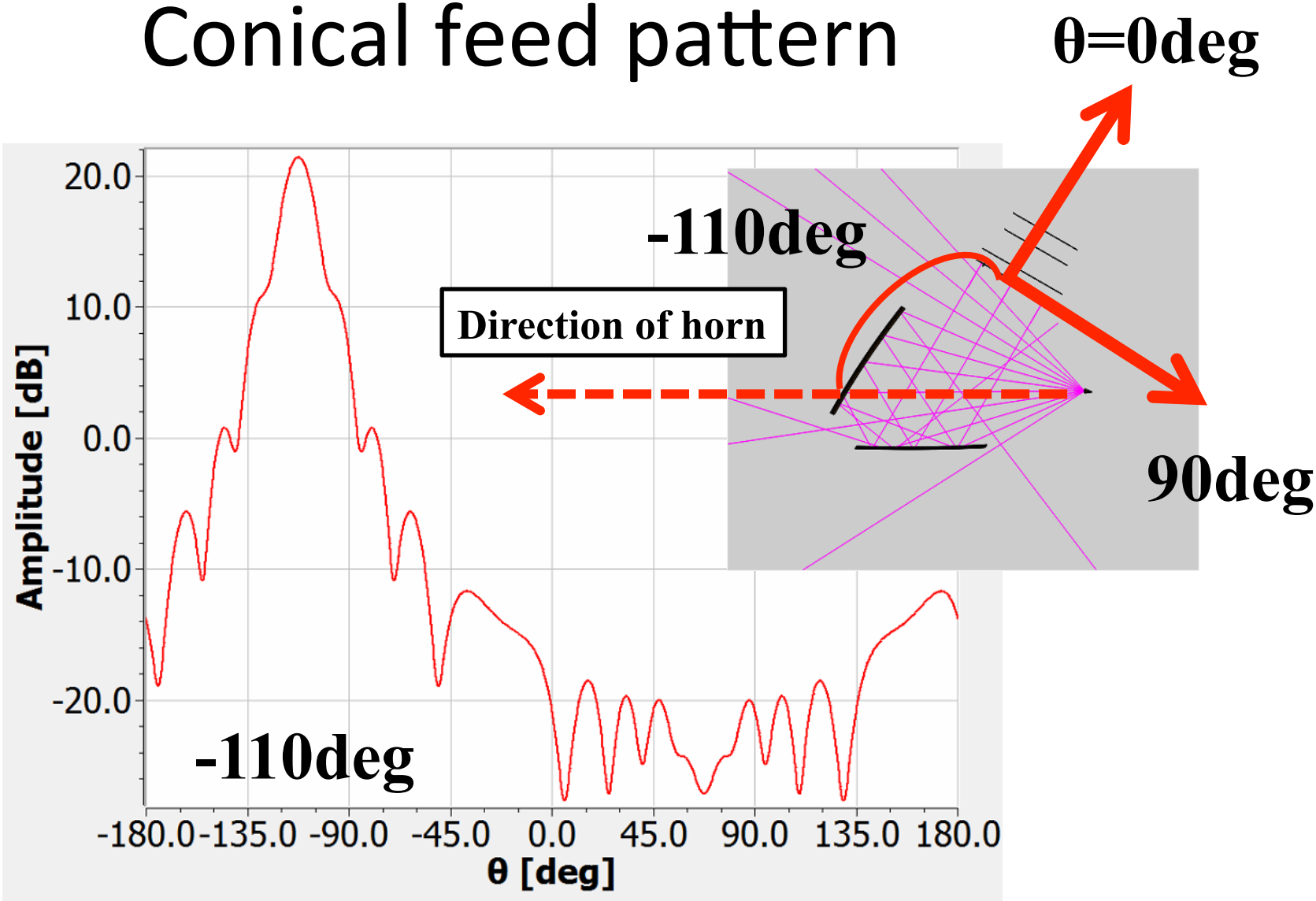
- Simulation condition
  1. Mirrors only
  2. Mirrors with aperture
  3. Mirrors with Hood
  4. Side baffle

Freq. 60 GHz
Feed Conical horn
Optical paths 11 paths
Horn position is center




Now, PO+PTD only (without Multi GTD)

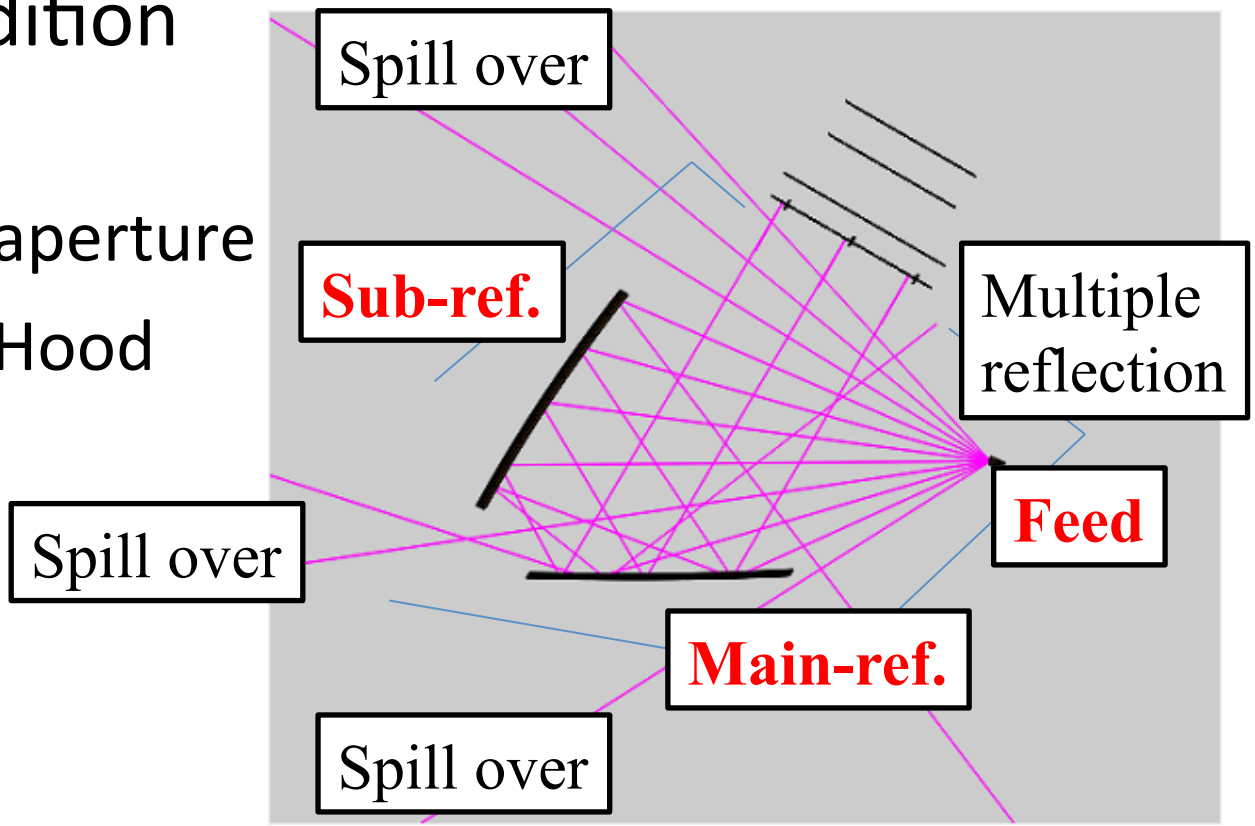
# Conical feed pattern




Conical horn feed used it as the worst case that a side robe was big.

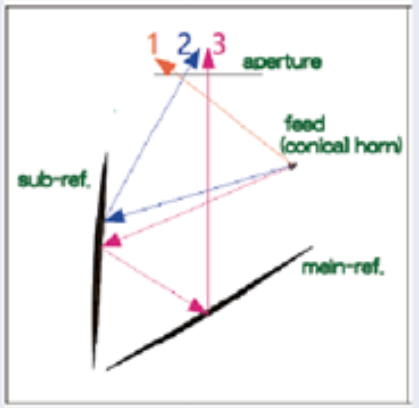
# Lite BIRD GRASP simulation

- Simulation condition
  1. **Mirrors only**
  2. Mirrors with aperture
  3. Mirrors with Hood
  4. Side baffle



# Optical path

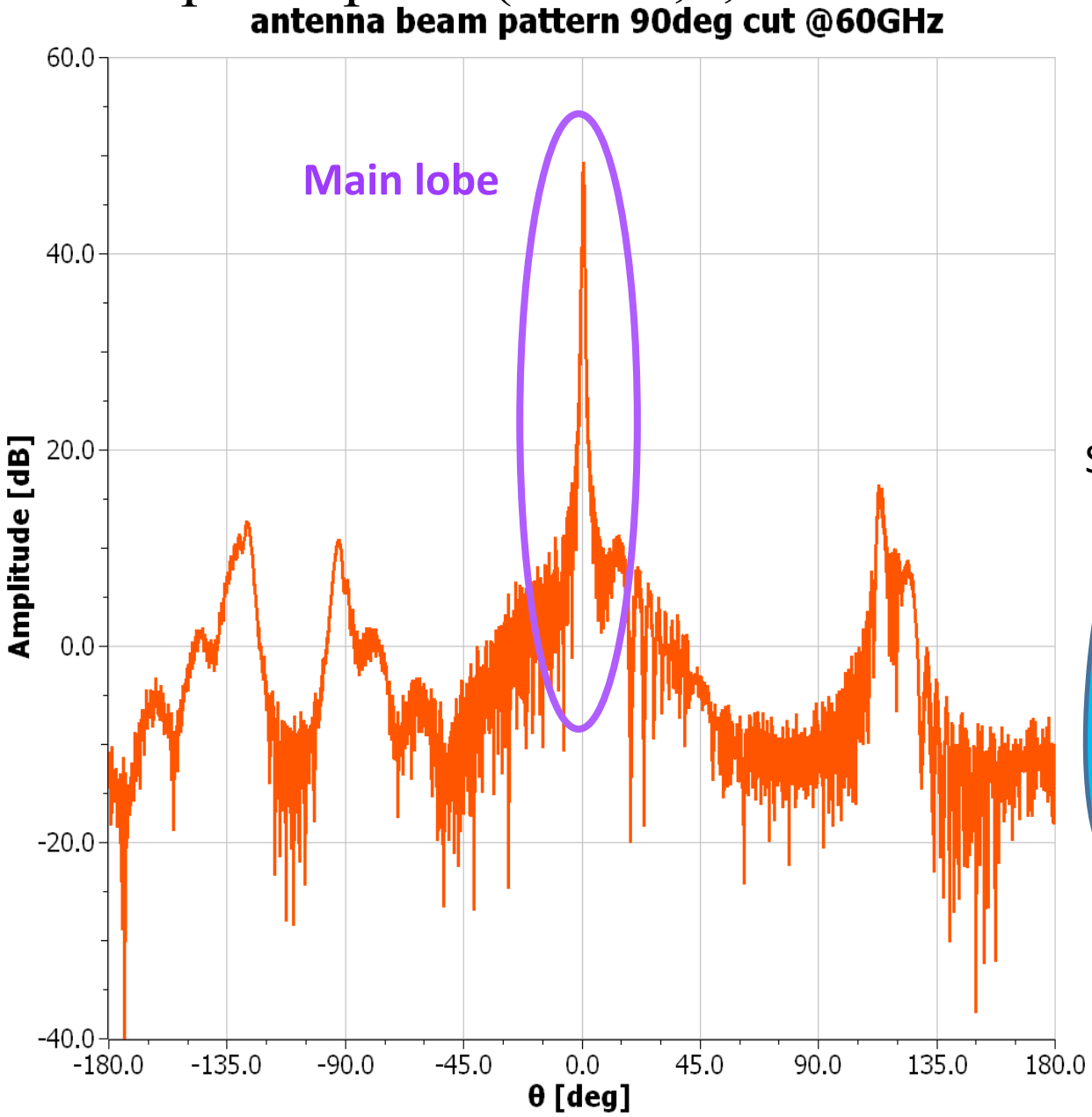
| | Reflection paths → | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Case 1 | feed | Sky | | | | | | |
| Case 2 | feed | sub ref . | Sky | | | | | |
| Case 3 | feed | sub ref . | main ref . | Sky | | | | |
| Case 4 | feed | sub ref . | main ref . | sub ref . | Sky | | | |
| Case 5 | feed | sub ref . | main ref . | sub ref . | main ref . | Sky | | |
| Case 6 | feed | main ref . | Sky | | | | | |
| Case 7 | feed | main ref . | sub ref . | Sky | | | | |
| Case 8 | feed | main ref . | sub ref . | main ref . | Sky | | | |
| Case 9 | feed | main ref . | sub ref . | main ref . | sub ref . | Sky | | |
| Case 10 | feed | main ref . | sub ref . | main ref . | sub ref . | main ref . | Sky | |
| Case 11 | feed | main ref . | Sub ref . | main ref . | sub ref . | main ref . | sub ref . | Sky |

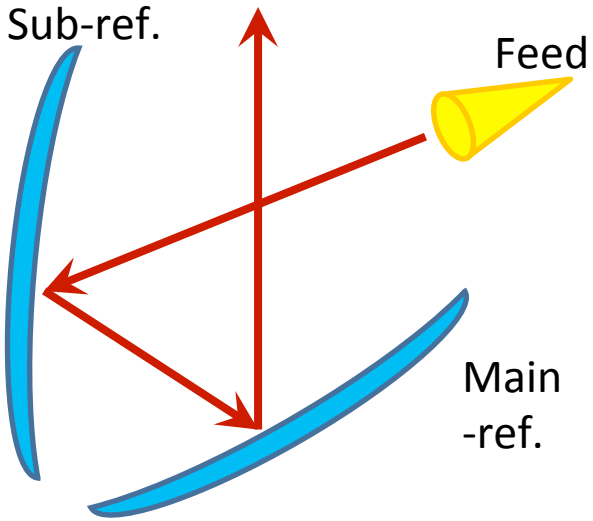



examples of multi path

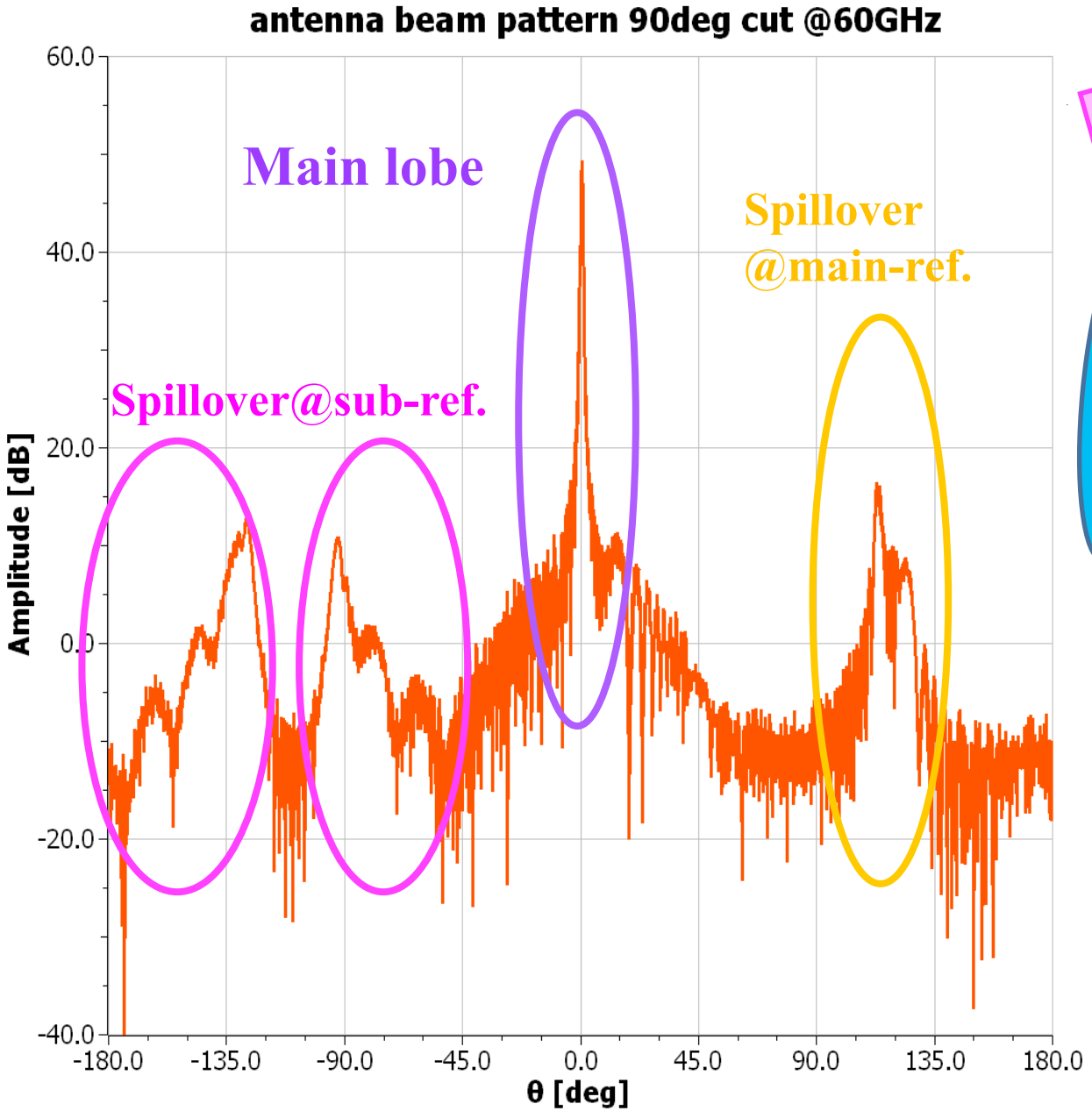
# Antenna beam pattern

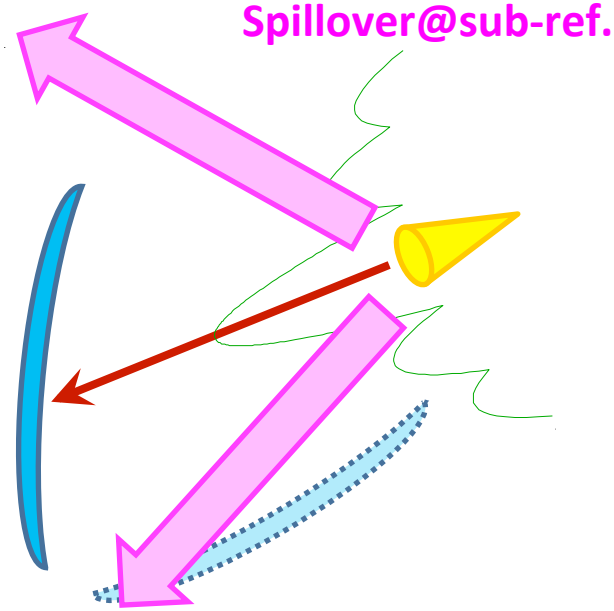
## Optical path (Case1,2,3 feed -> Sub-ref. -> Main-ref.)

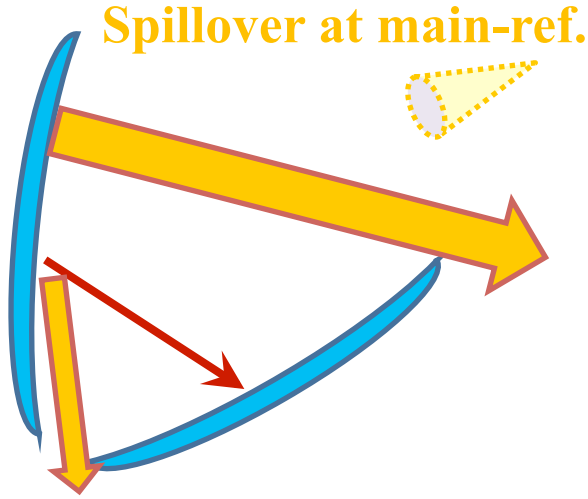


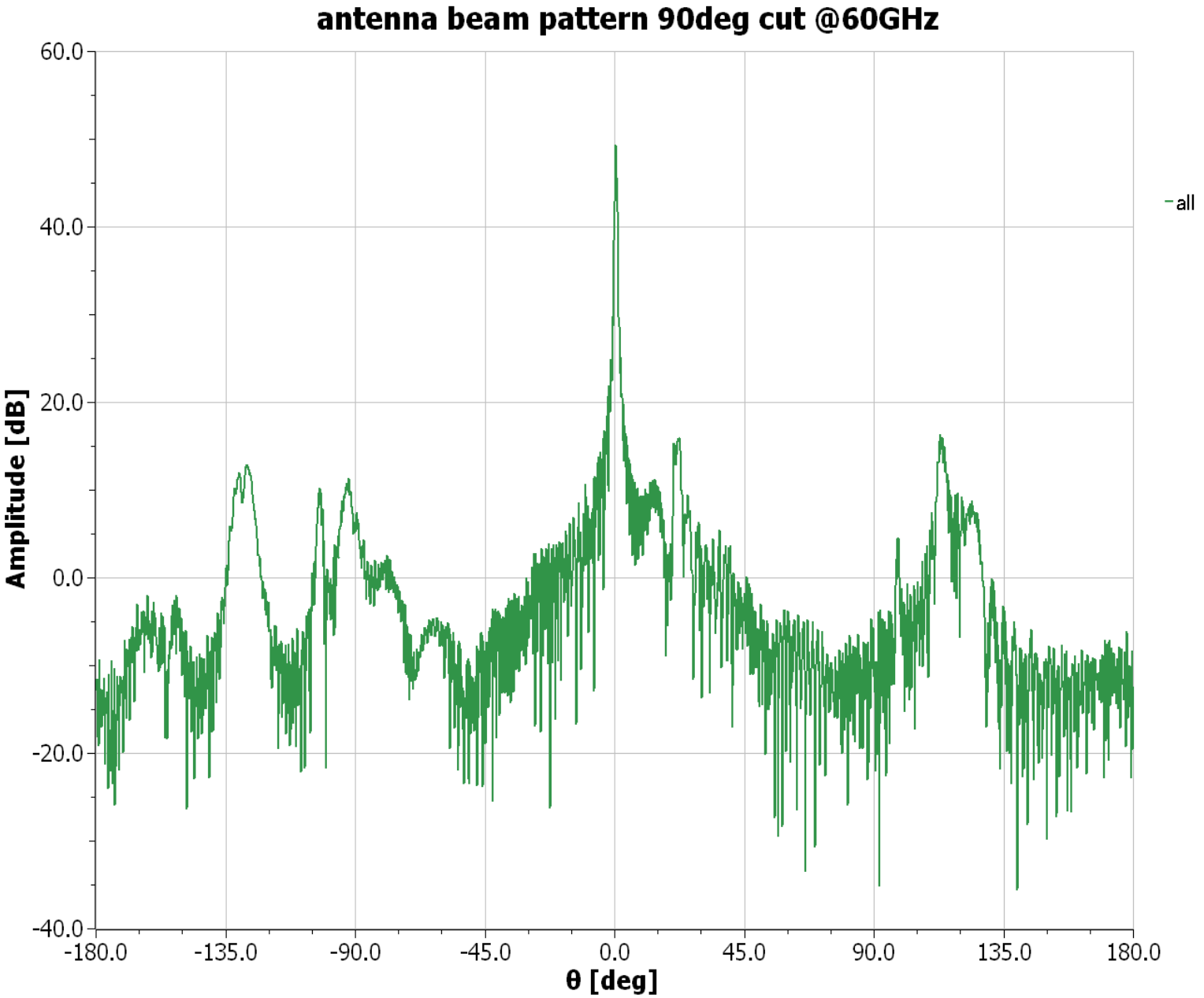
# Antenna beam pattern
# Optical path (feed -> Sub-ref. -> Main-ref.)



# Antenna beam pattern
# Optical path (Case1+2+.....+11)



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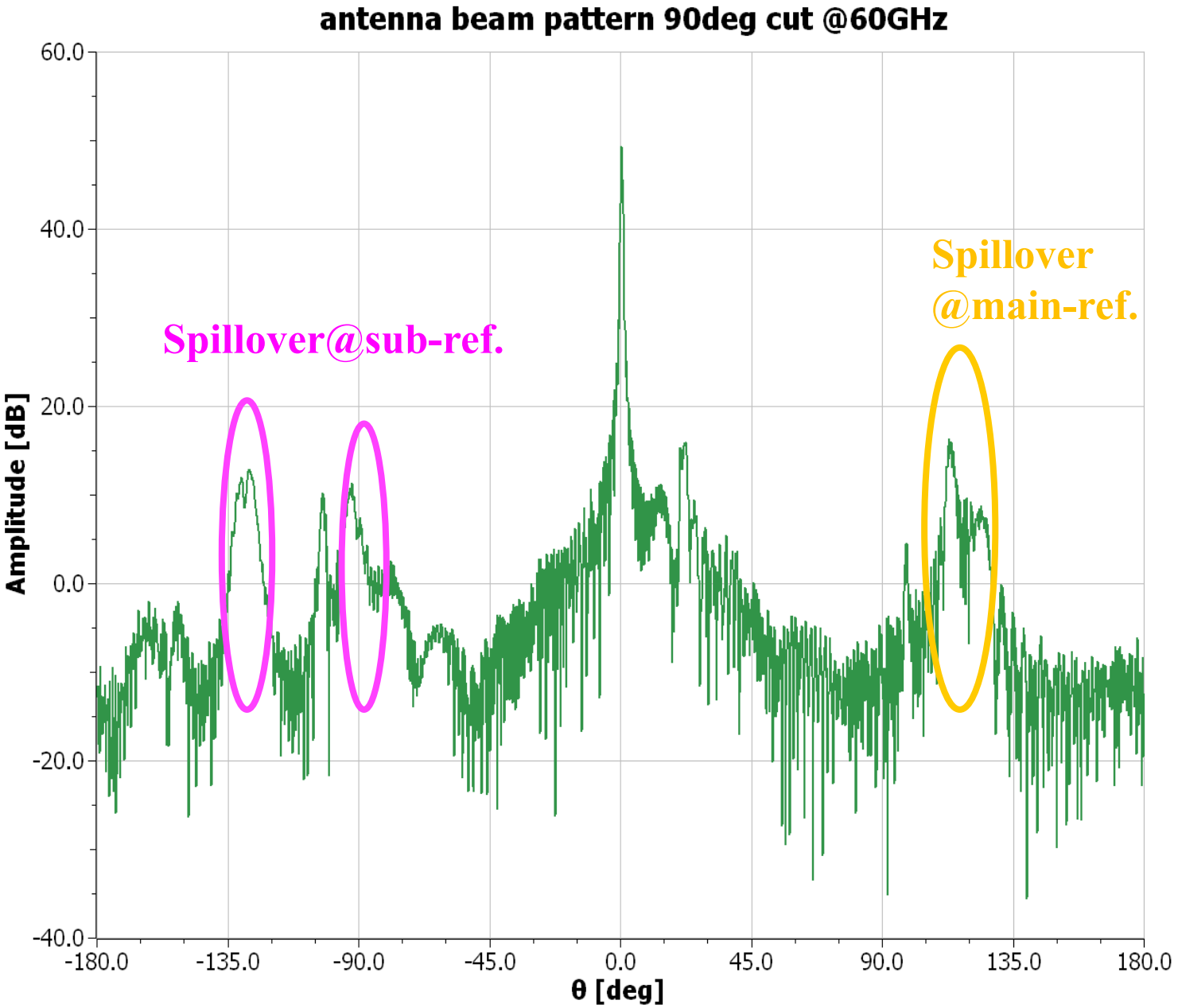

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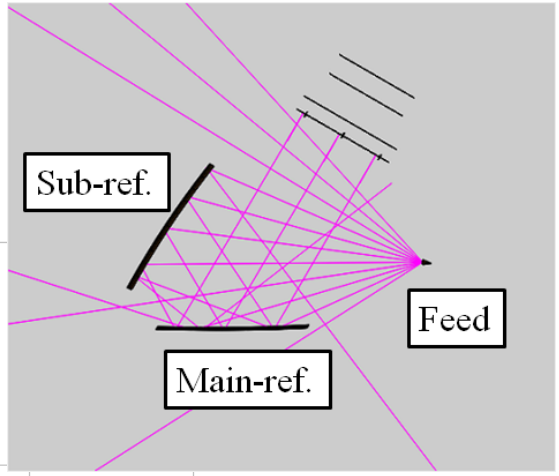
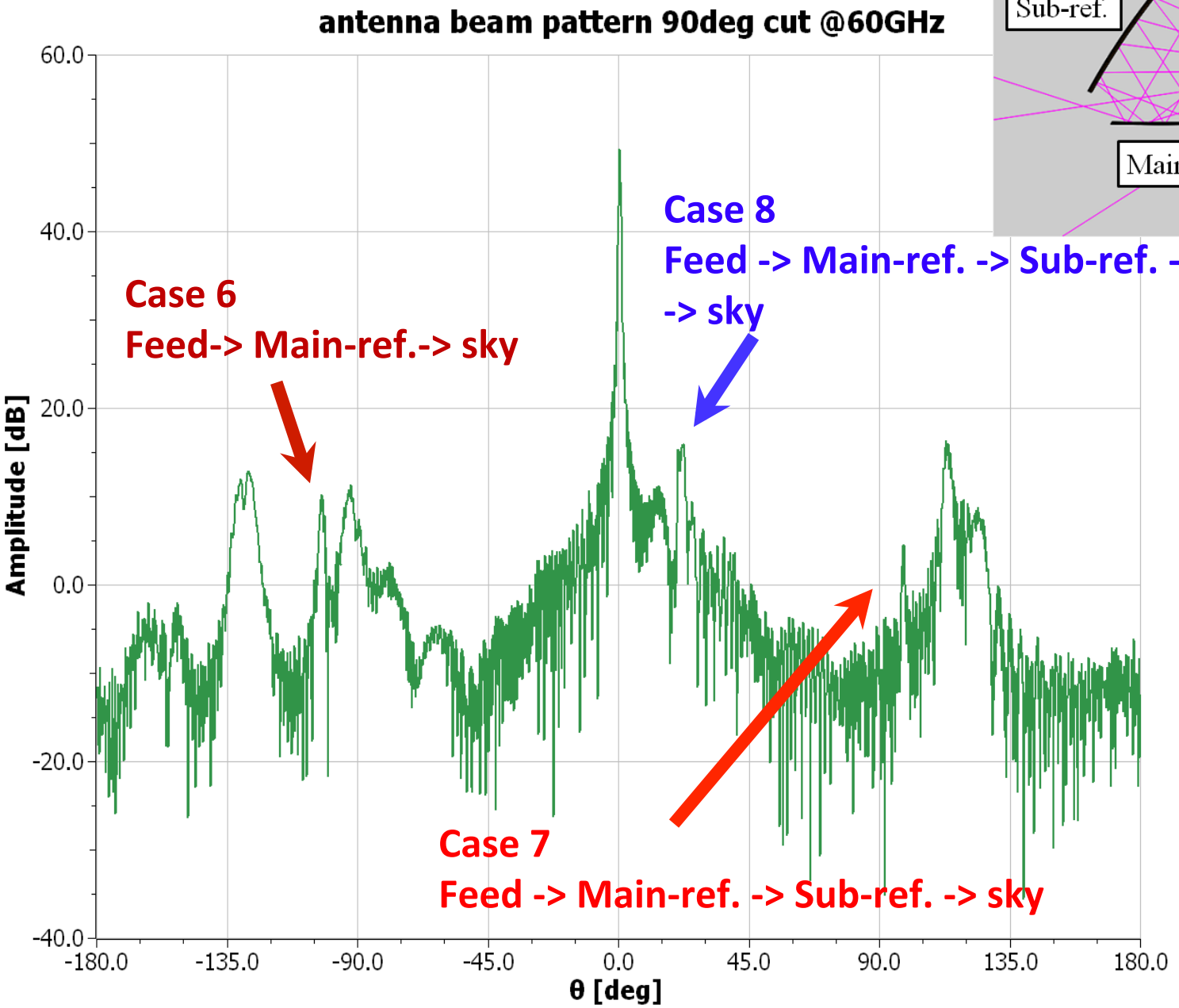


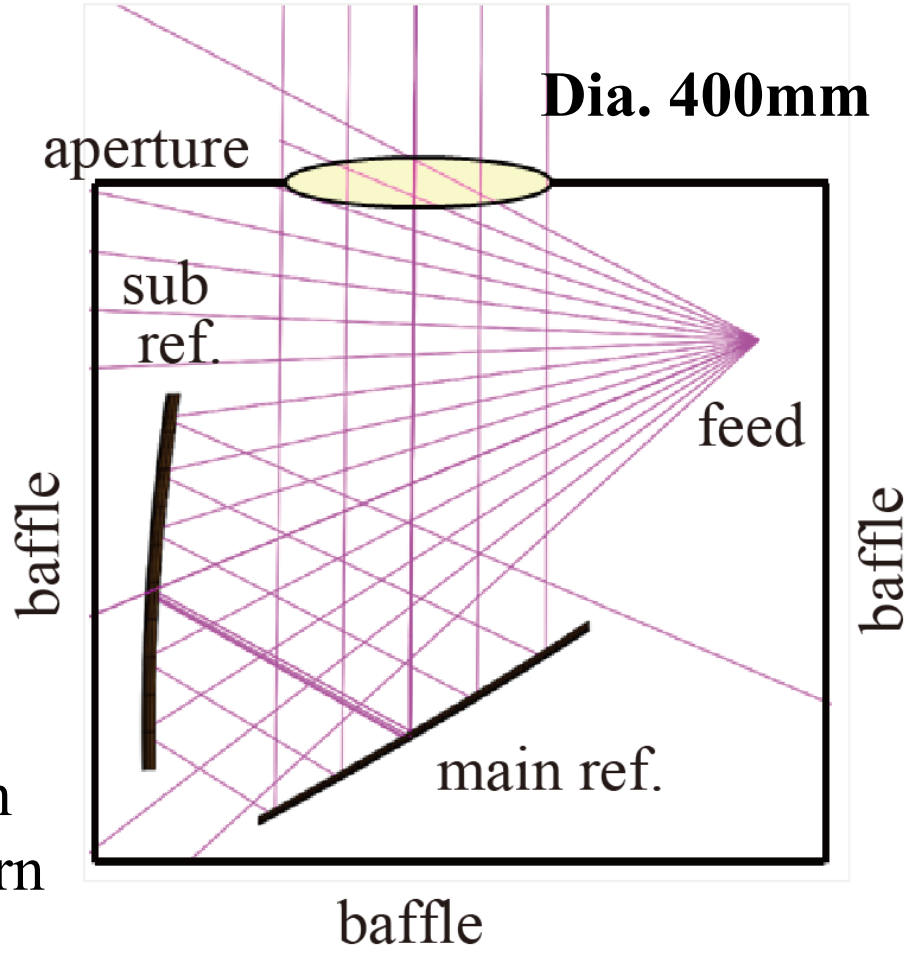
# Lite BIRD GRASP simulation

- Simulation condition
  1. Mirrors only
  2. **Mirrors with aperture**
  3. Mirrors with Hood
  4. Side baffle

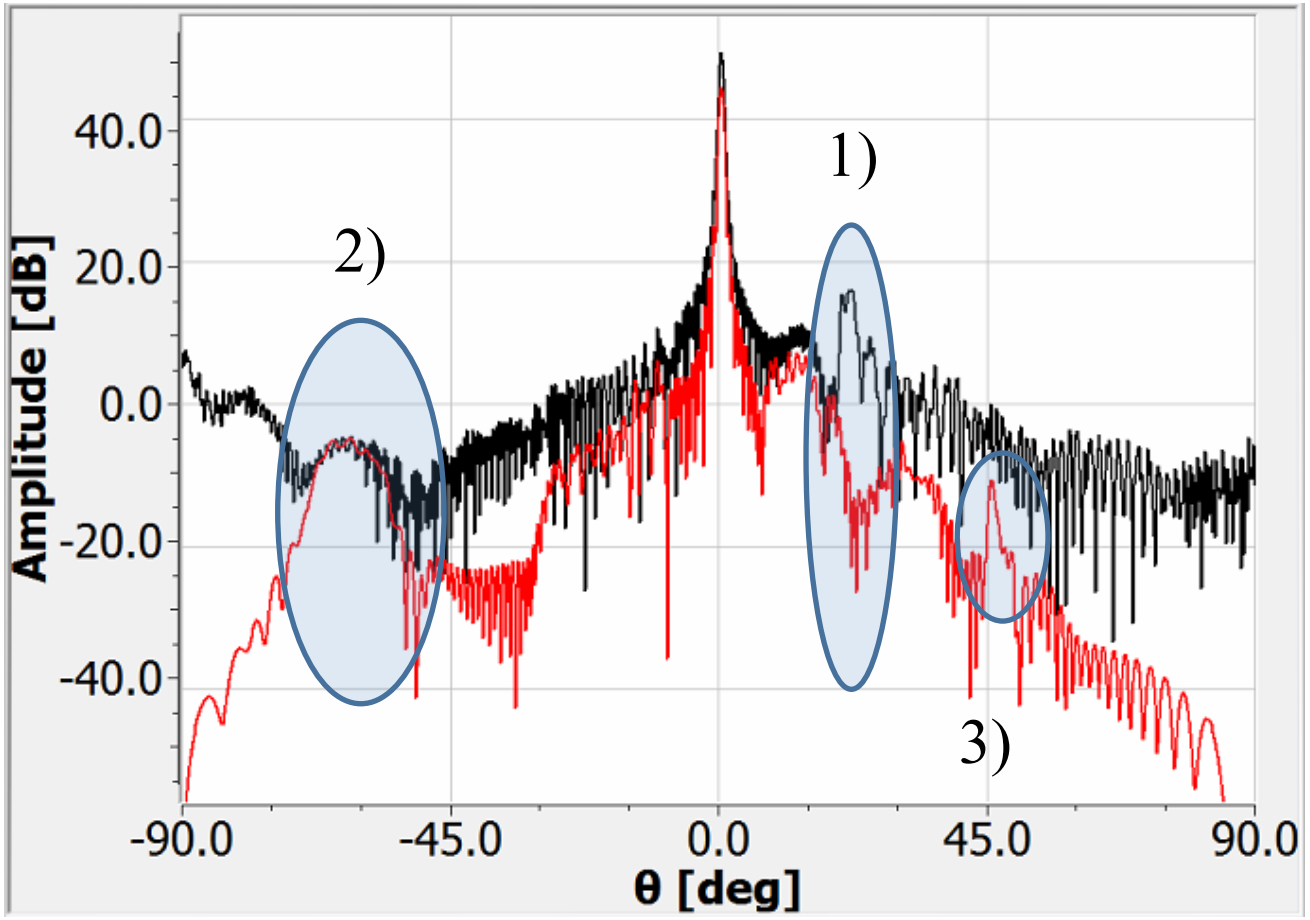
Sum()

Case 1
Case 2
Case 3
.....
Case11

Aperture => Beam pattern
(truncation)



# Antenna beam pattern
# Optical path (Case1+2+…..+11)




Black : mirrors only
Red: with aperture

1)
Side lobe pattern
by Case 8 is reduced.

2)
Influence of spillover
is left a little.

3)
Pattern of Case 11?
appeared

Case11 horn – main – sub – main – sub – main – sub - sky

# Lite BIRD GRASP simulation

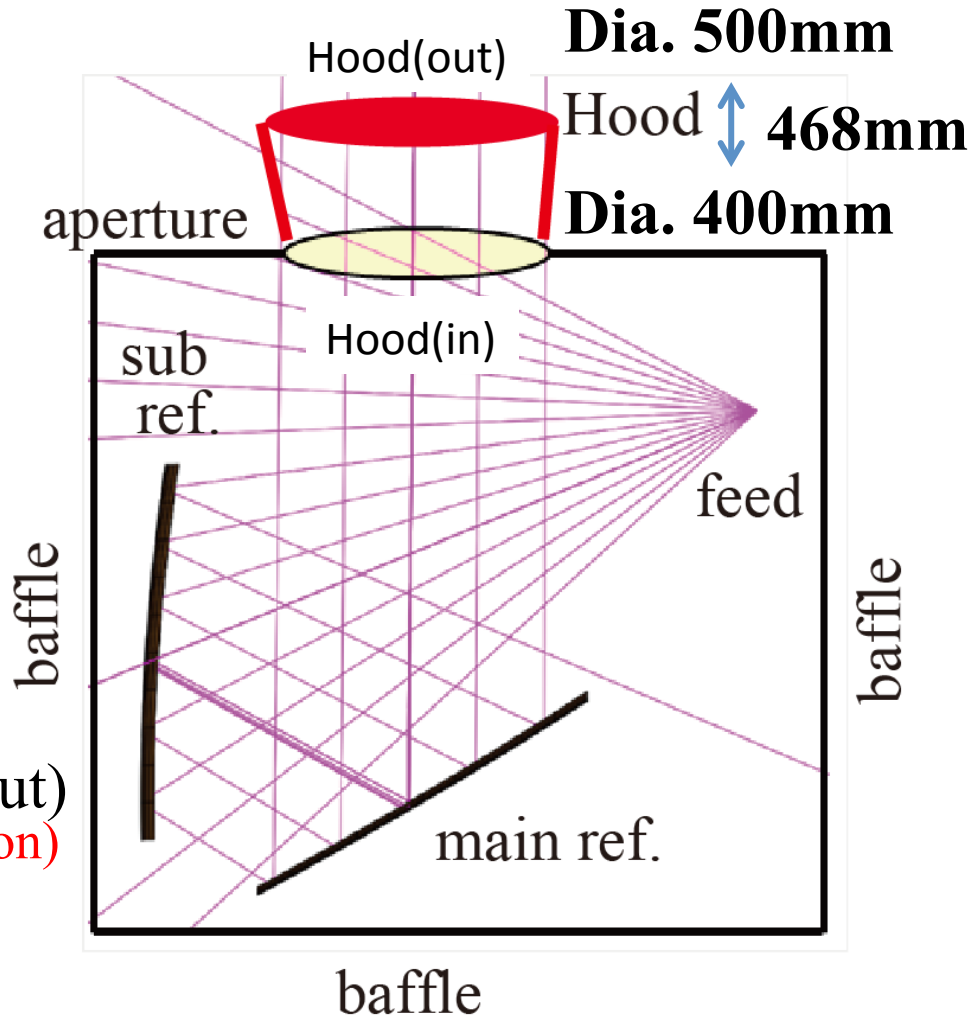
- Simulation condition
  1. Mirrors only
  2. Mirrors with aperture
  3. **Mirrors with Hood**
  4. Side baffle

Sum()

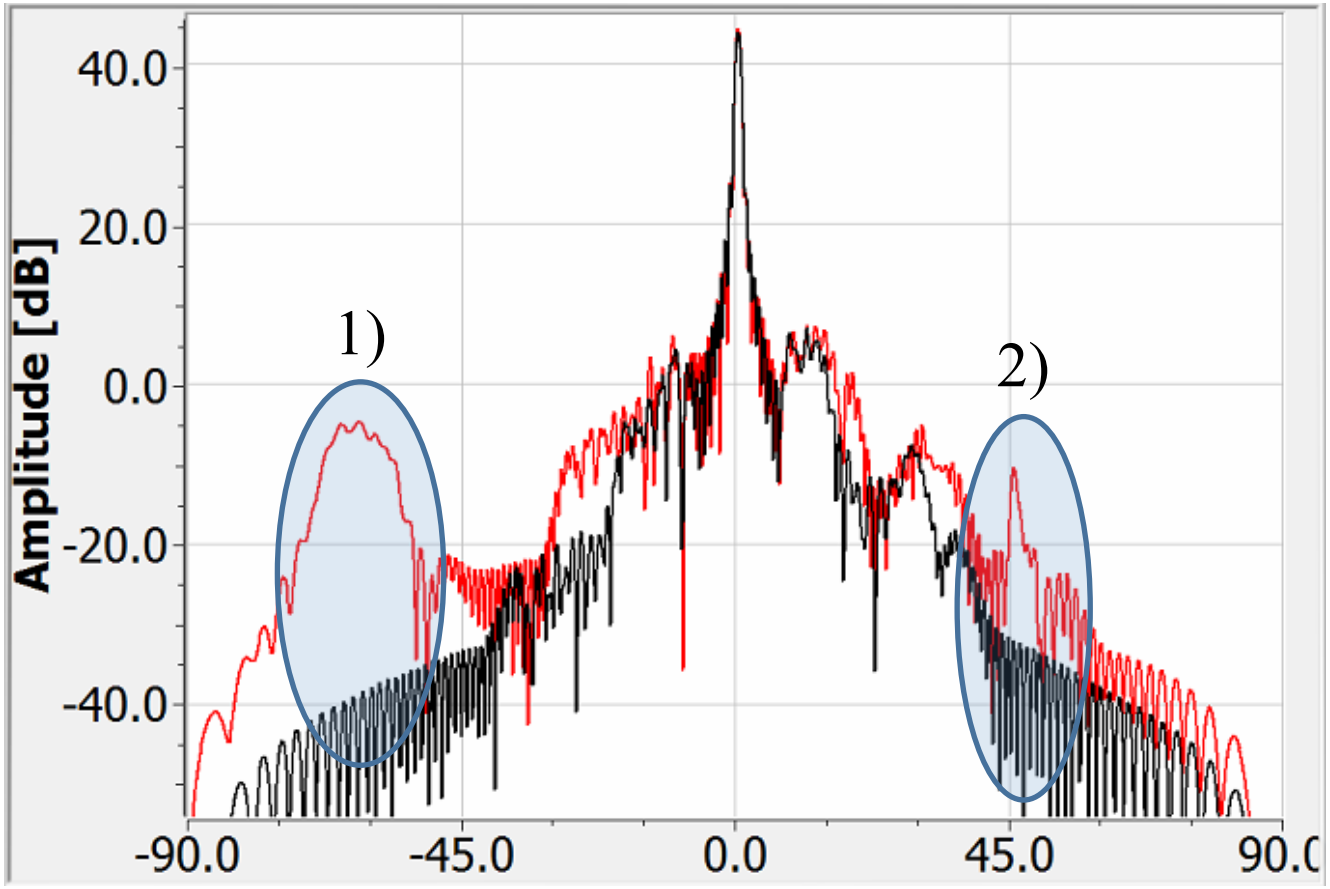
Case 1
Case 2
Case 3
……
Case11

Hood(in)=>Hood(out)
(truncation) (truncation)

=> Beam pattern



# Antenna beam pattern
# Optical path (Case1+2+…..+11)




Red: with aperture
Black : with Hood

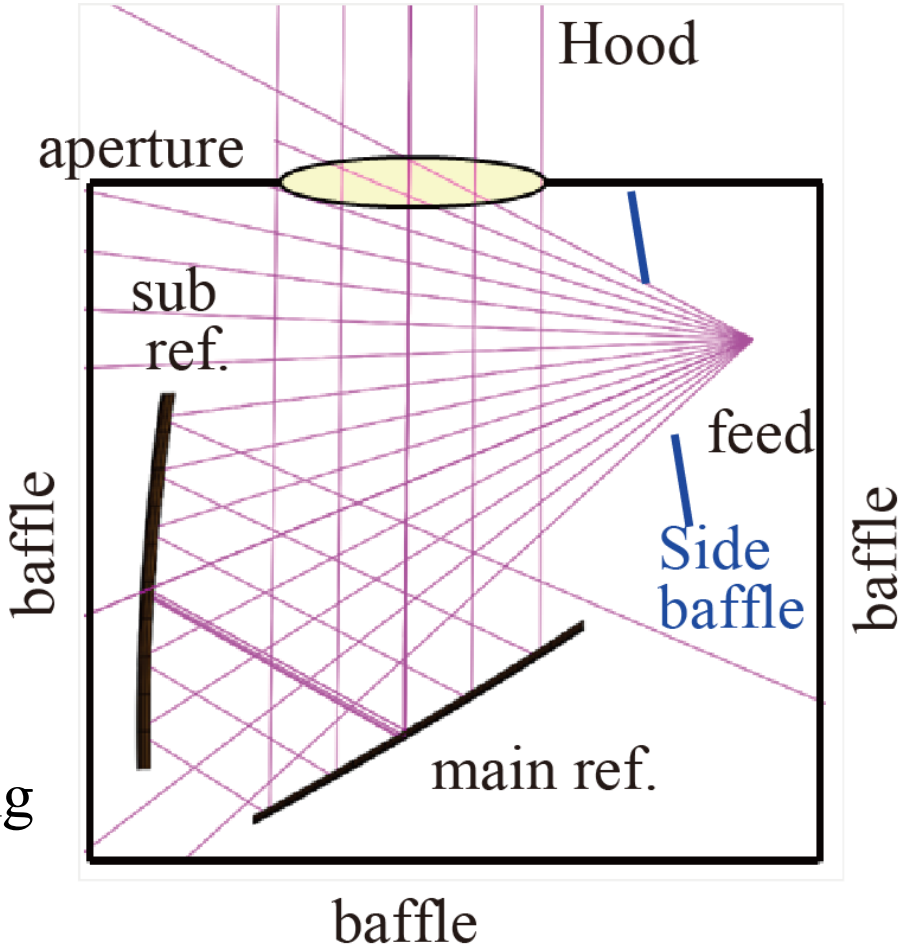
1)
Spillover of feed became extinct

2)
Also, Case 11 pattern became extinct

3)
The antenna size became big by putting a hood.

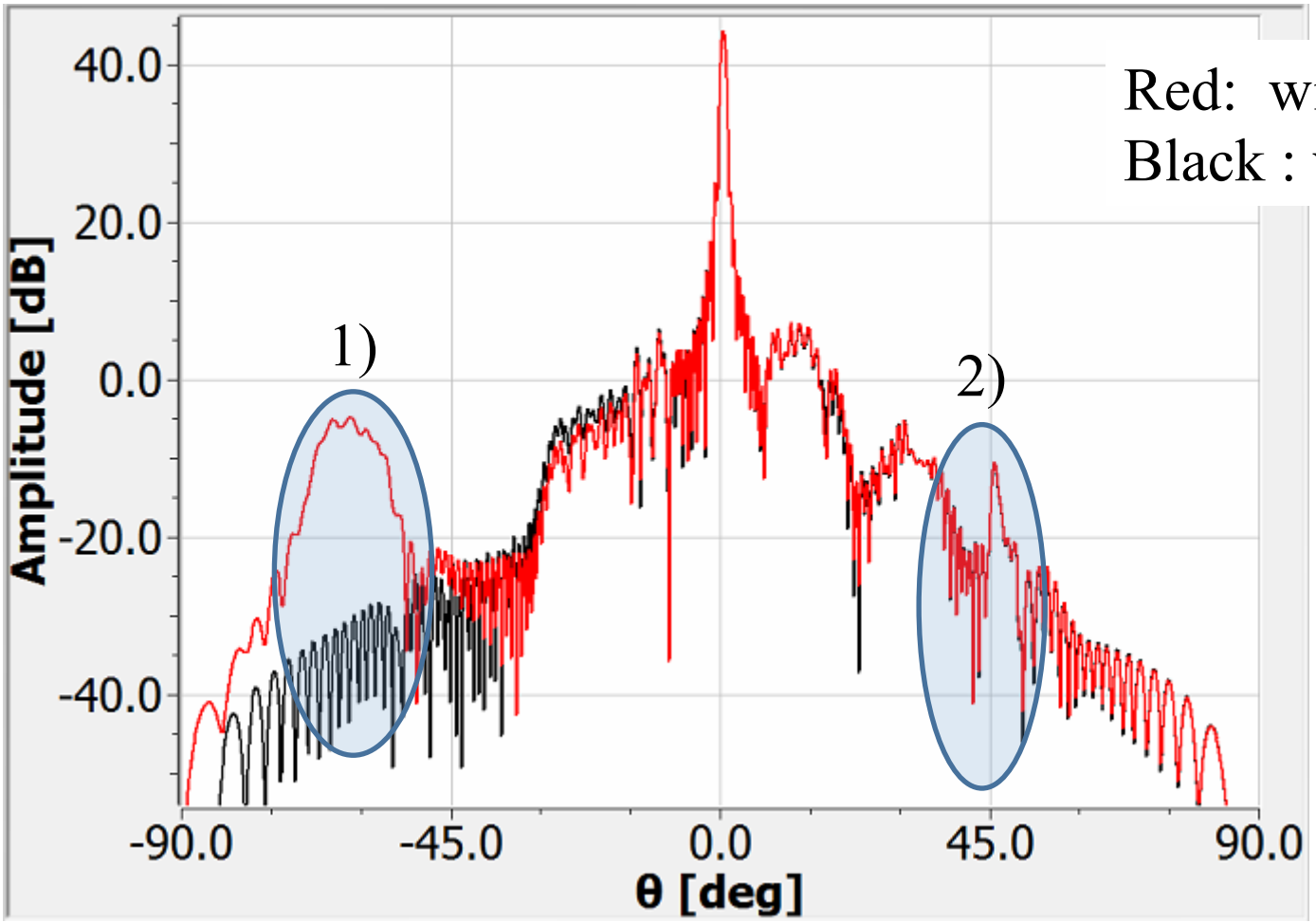
# Lite BIRD GRASP simulation

- Simulation condition
  1. Mirrors only
  2. Mirrors with aperture
  3. Mirrors with Hood
  4. **Side baffle**




We installed Side baffle in front of feed that reduced influence of a multiple reflection by terminating a spillover of feed.

# Antenna beam pattern
# Optical path (Case1+2+…..+11)




Red: with aperture
Black : with Side baffle

1)
Spillover of feed became extinct like with hood.

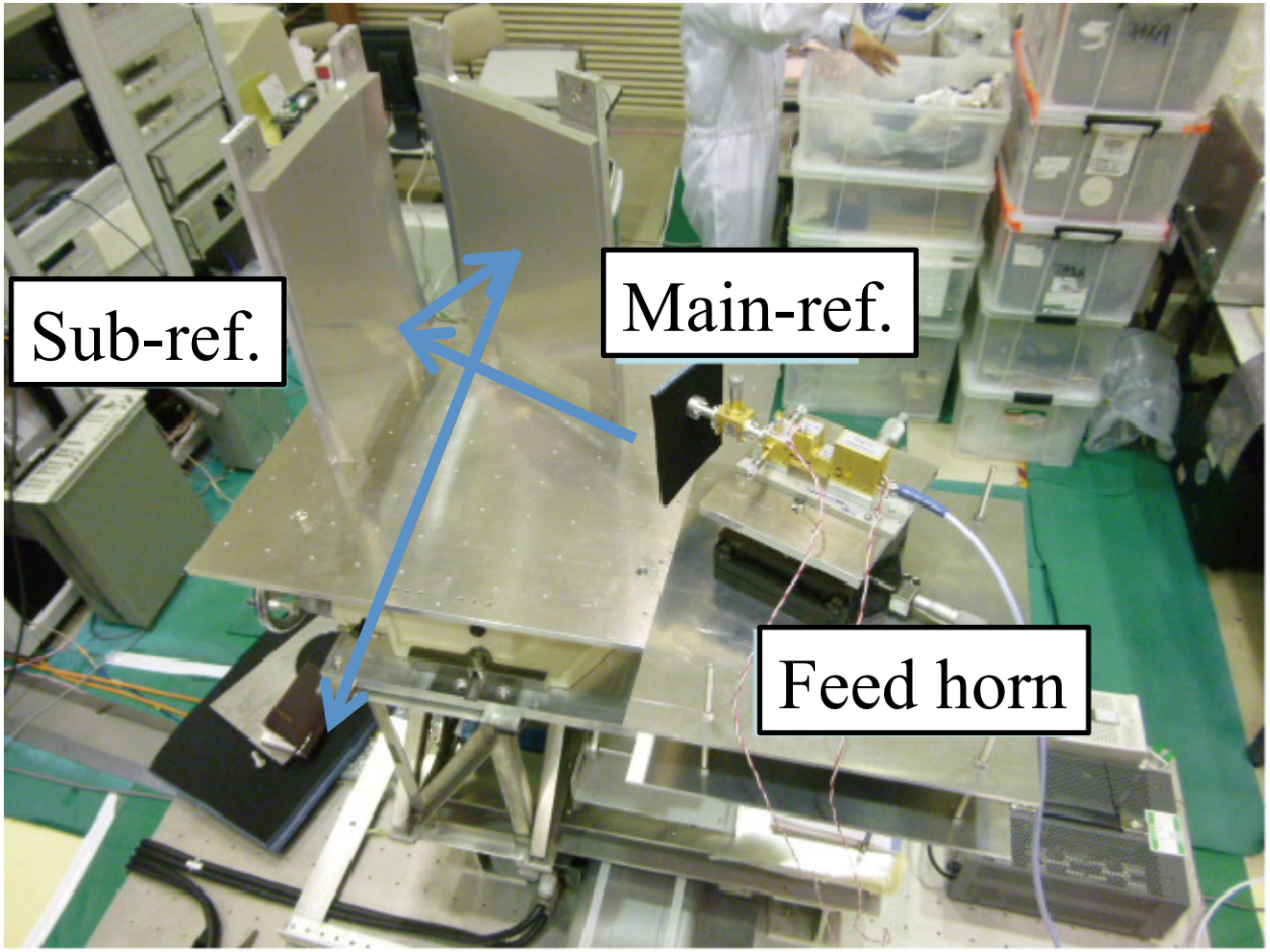
2)
There is still Case 11.

# 3) Scale model measurement

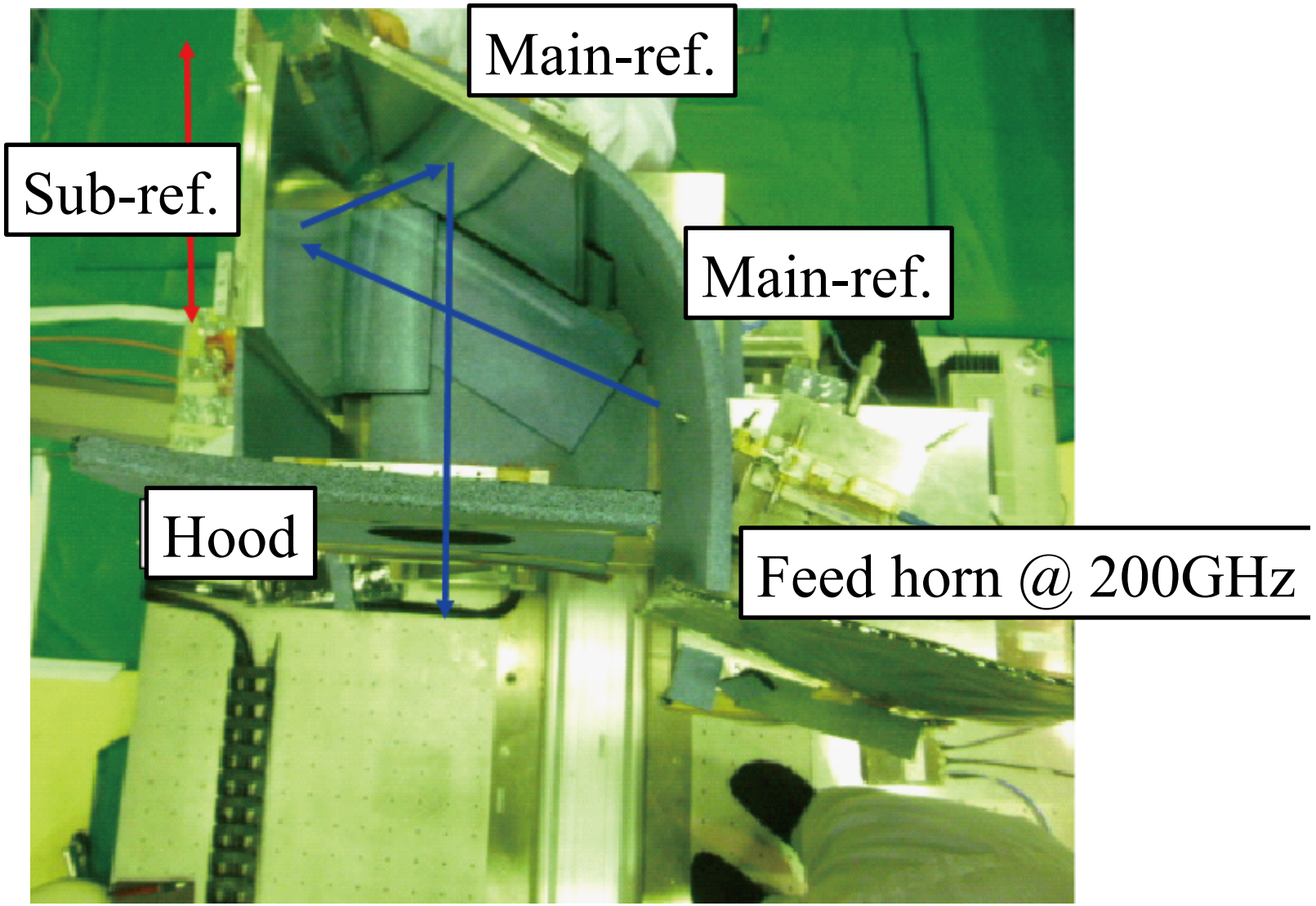
- We produce 1/3 models of a LiteBIRD Crossed Dragone antenna and evaluate of an optical characterization.
  - Small model => easy handing, low cost
  - Frequency => 60 GHz band *3 => 200 GHz band

- purpose
  - Confirmation of simulation(multiple reflection etc.)
  - Design of hood, baffle, side-baffle, etc.

# 1/3 Scale model



# 1/3 Scale model with absorber

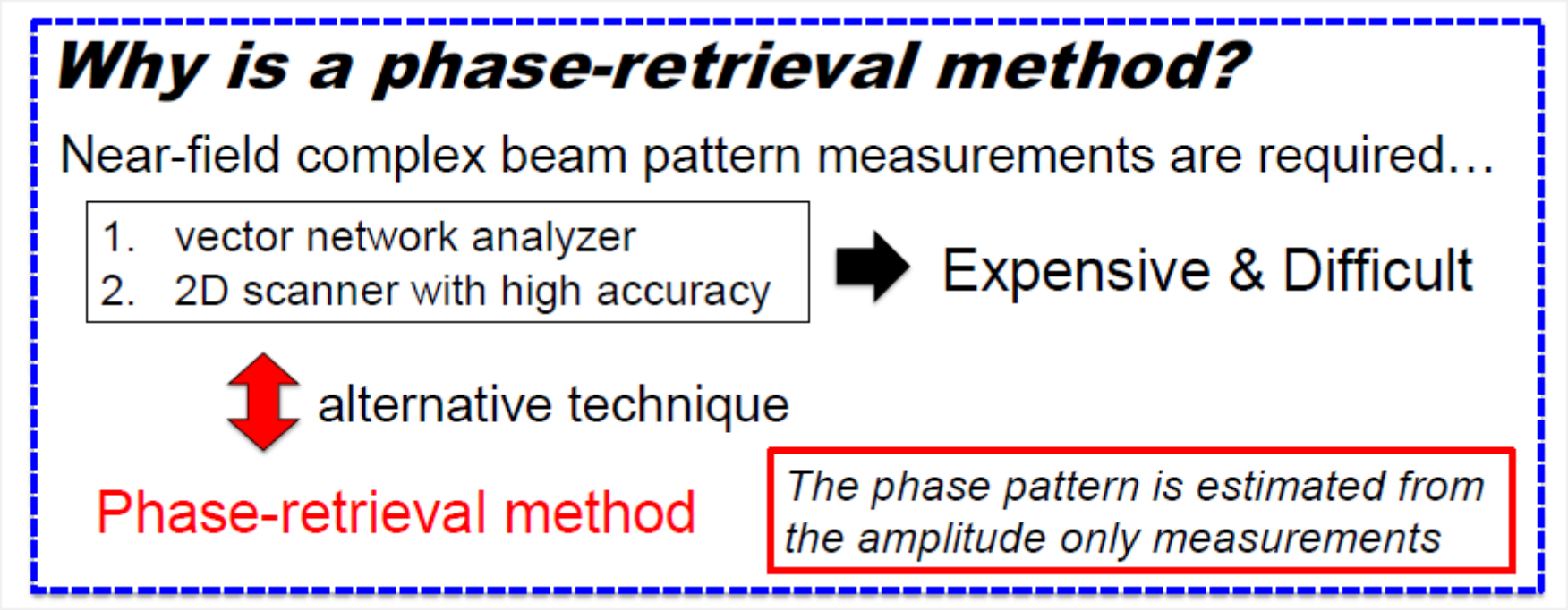


# Phase retrieval method

1)Measurement of Beam pattern at far field

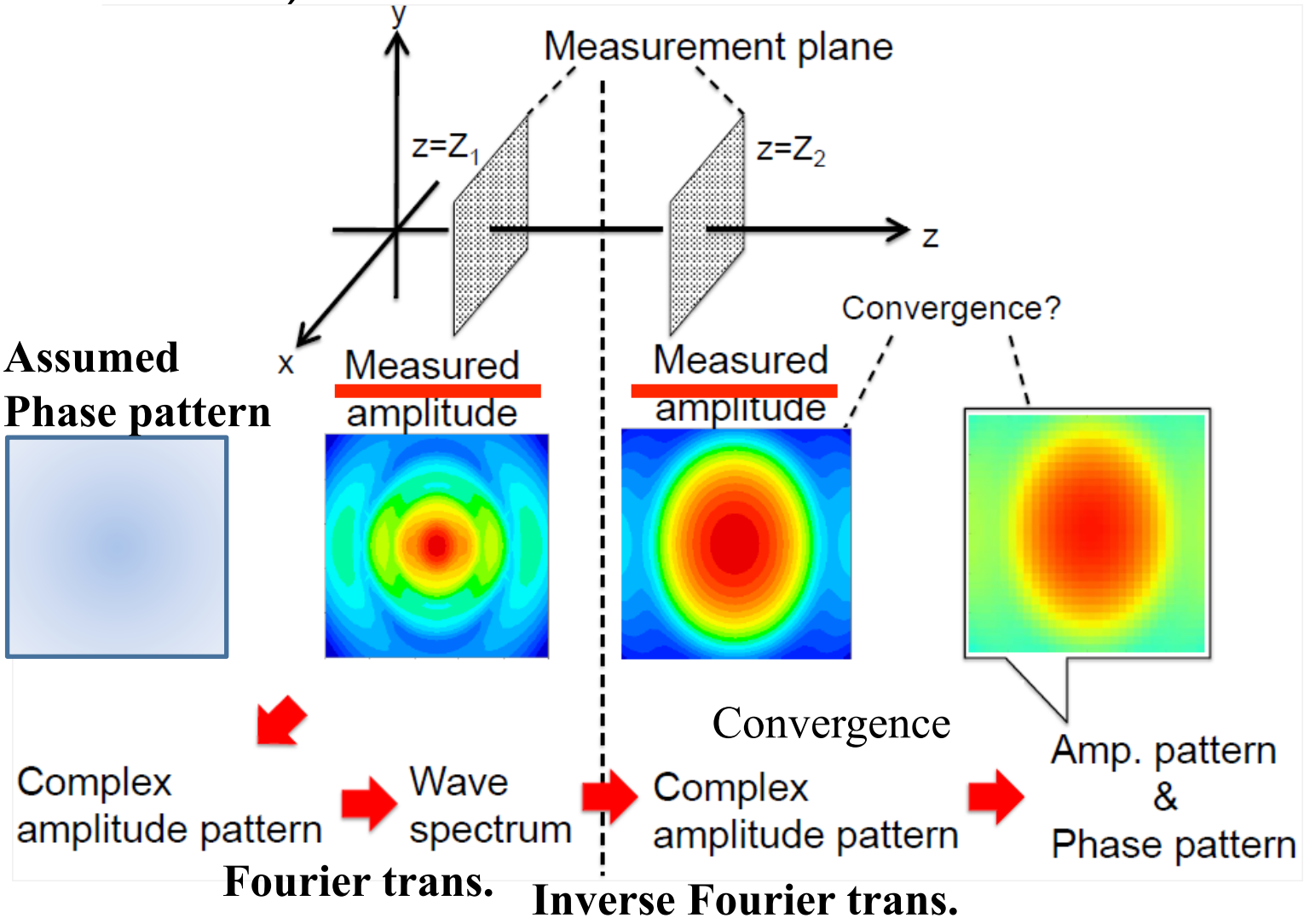
=> we need a big measuring system.

2)Measurement of Beam pattern at near field



# 3) Scale model measurement

## 1) Phase retrieval method



# Preliminary results

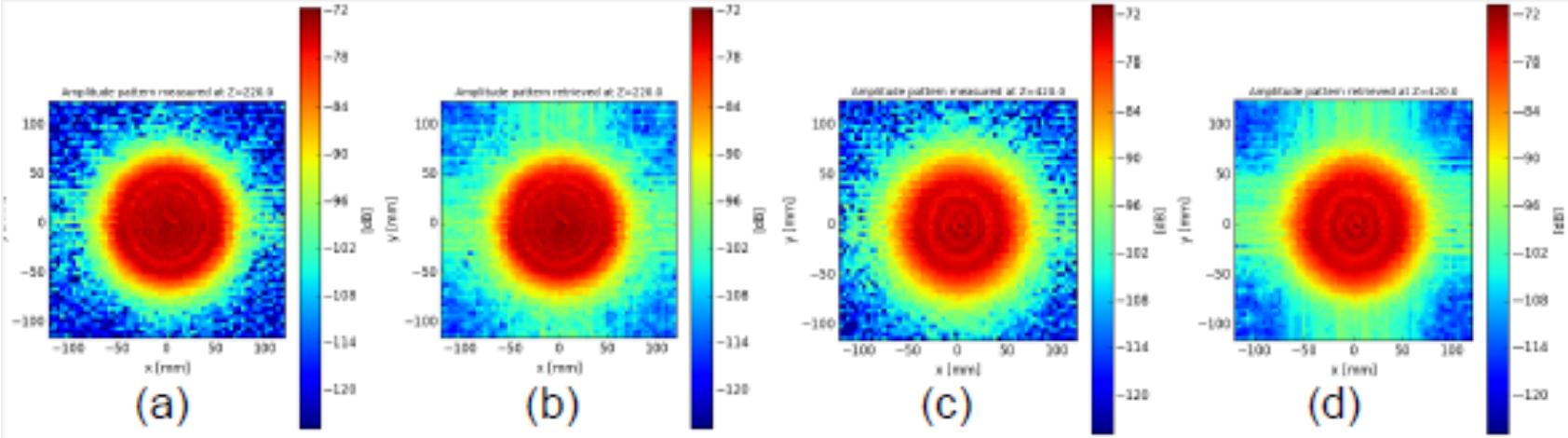



Fig. 4 Measured and retrieval amplitude at z=220 mm and 420 mm
(a) measured at z=220 mm (b) retrieved at z=220 mm
(c) measured at z=420 mm (d) retrieved at z=420 mm

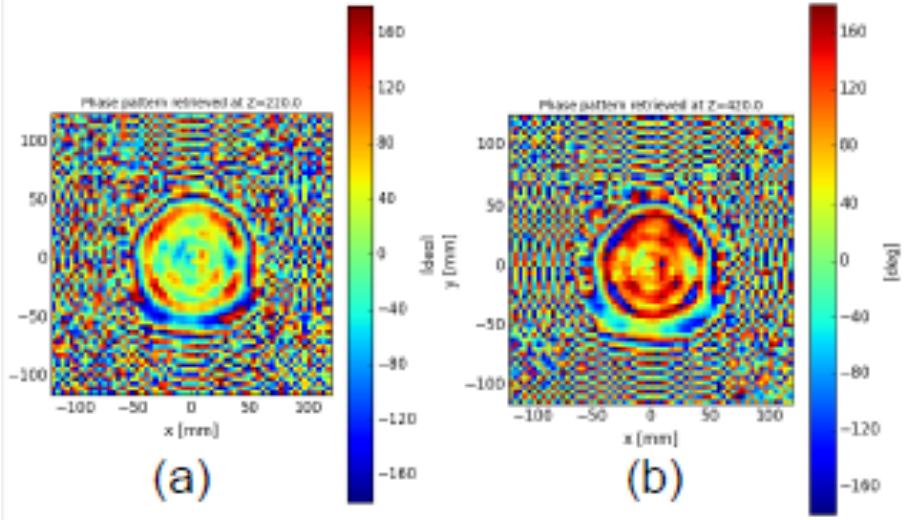



Fig. 5 Estimated phase pattern at
(a) z=220mm (b) 420 mm

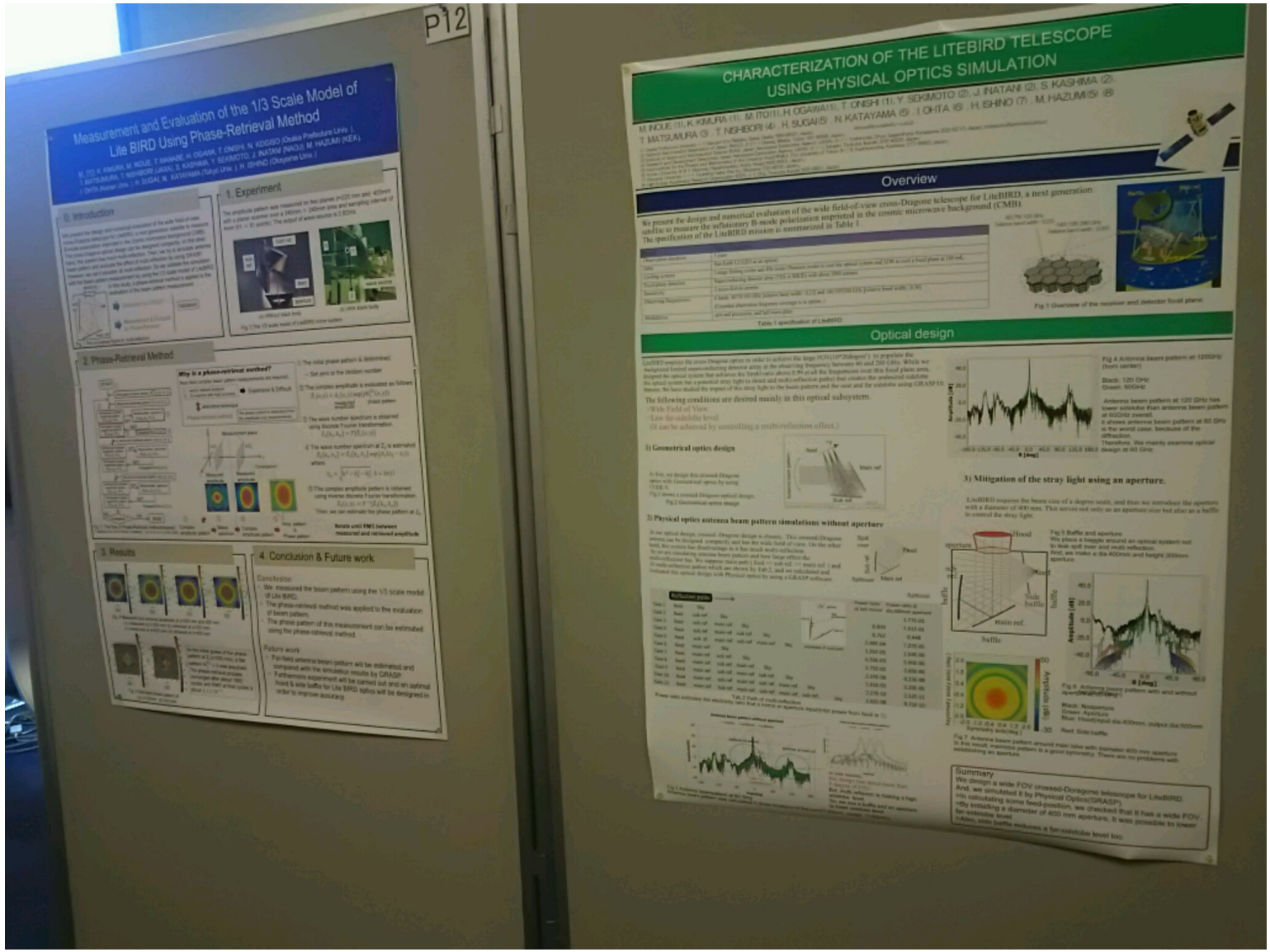
As the initial guess of the phase pattern at $Z_1$(z=220 mm), a flat pattern $\Phi_1^{(0)} = 0$ was assumed. The phase-retrieval process converged after about 1000 cycles and RMS at final cycles is about $1.1 \times 10^{-9}$.

# 5) Summery

- We calculated an antenna beam pattern of Crossed Dragone antenna for Lite BIRD by GRASP(Physical optics method).
  - By installing a diameter of 400 mm aperture, it was possible to lower far-side lobe level.
  - Also, Side baffle reduces a far-side lobe level too.

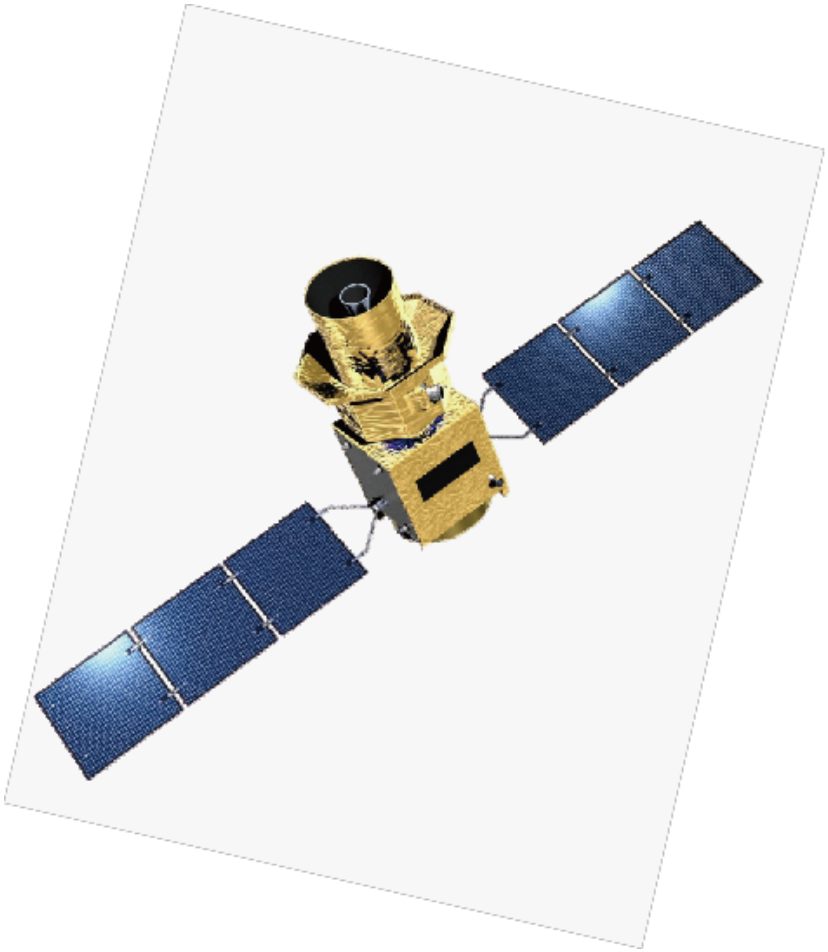
- We fabricated and measured the beam pattern using the 1/3 scale model antenna.
  - The phase-retrieval method was applied to the evaluation of beam pattern.
  - Now, we are preparing the measurement and analysis.

# Posters




**Ito–san poster**
**1/3 scale model**

**Inoue–san poster**
**GRASP simulation**



I'd like to finish by thanking you
for your attention.