Optical Response Simulation for ASTRO-G Laser Reflector Array

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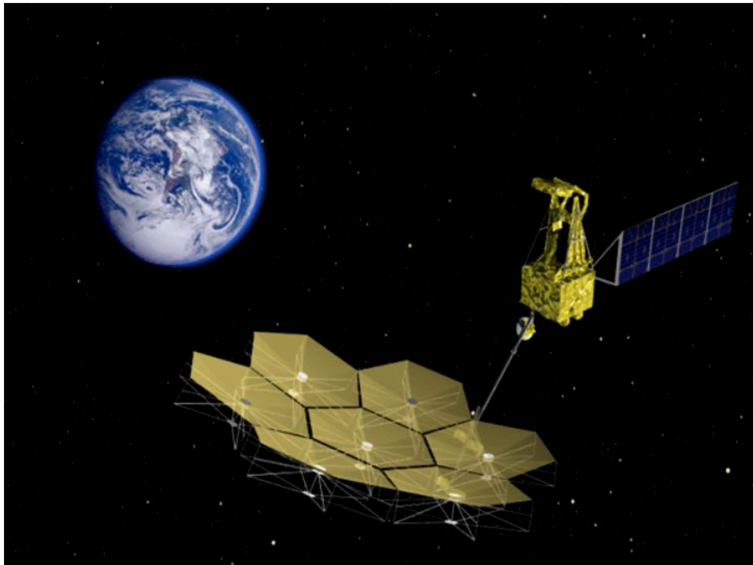


16th International Workshop on Laser Ranging, Poznan, 13-17 Oct , 2008.

ASTRO-G Highly Elliptic Orbit

ASTRO-G (VSOP-2)

Launch: FY2012 (5-year mission)
9.6-metre antenna
Highly elliptic orbit: 1000 x 25000 km altitude
Observation bands: 8.4, 22 and 43 GHz
High frequency, High resolution and High sensitivity

4 x GPS (+Galileo?) Receiver

Effective <3000-5000 km only (1 hr per 7.5 hrs).
Sidelobe? One-frequency use?

1 x SLR Retroreflector Array ← This talk

Should be effective 1000 km to 25000 km
More than a cal/val instrument

4-D Simulation of CCR Response

4-Dimensional Function:

Angle of incidence and azimuth (2-D)
Velocity aberration (2-D)

Software development for Single CCR Response (ongoing)

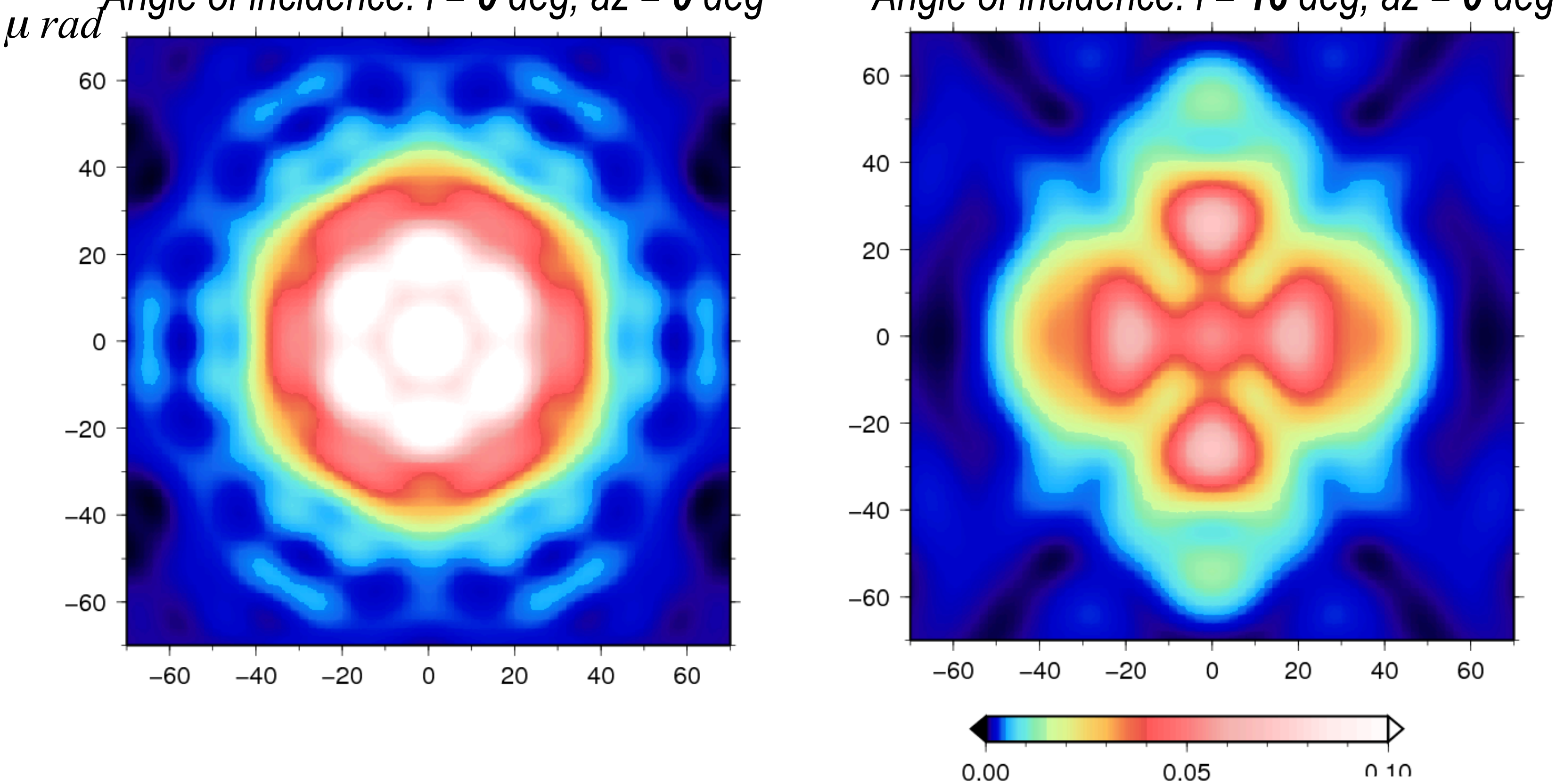
- Language: C#
- Input:
  - CCR Shape, Optical Index, Coat, Size, Recession, Dihedral angle
  - Laser wavelength, Polarisation
- Output:
  - Far-field amplitude
    - Grid size: 2-deg for angle of incidence, 2-μrad for velocity aberration
    - > 2 GB in ASCII Text, > 100 MB in Binary (NetCDF) file
  - Computation time: 6 to 14 hours per reflector … needs optimisation

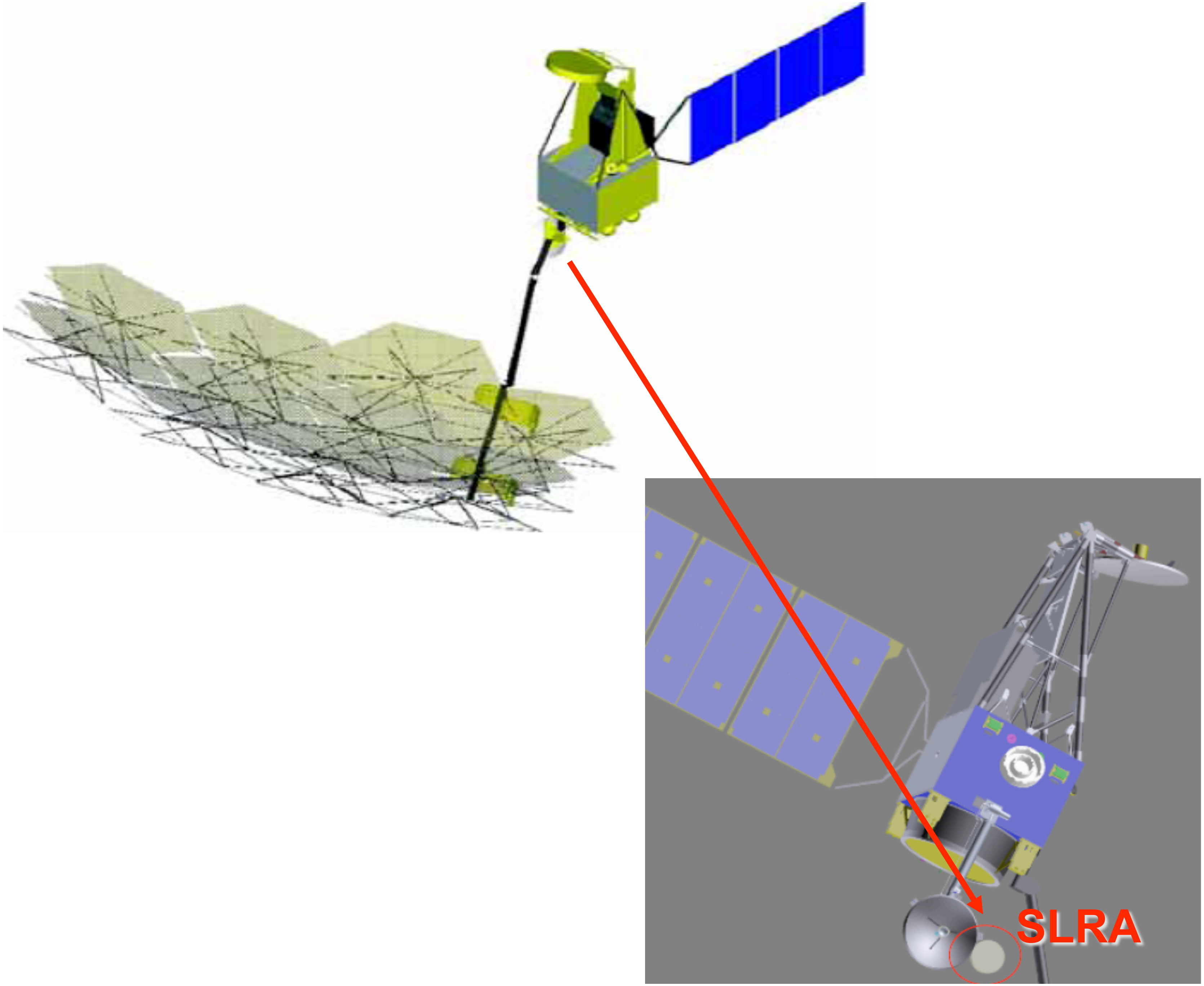
Far Field Diffraction Pattern (examples)

38 mm uncoated CCRs, Dihedral angle = 0.75”

Circular polarisation

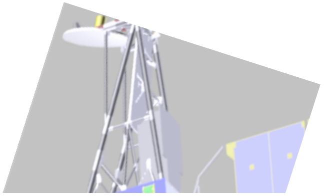
Angle of incidence: i = ***0*** *deg, az =* ***0*** *deg*   *Angle of incidence: i =* ***16*** *deg, az =* ***0*** *deg*




SLRA

Problem 1: Angle of Incidence

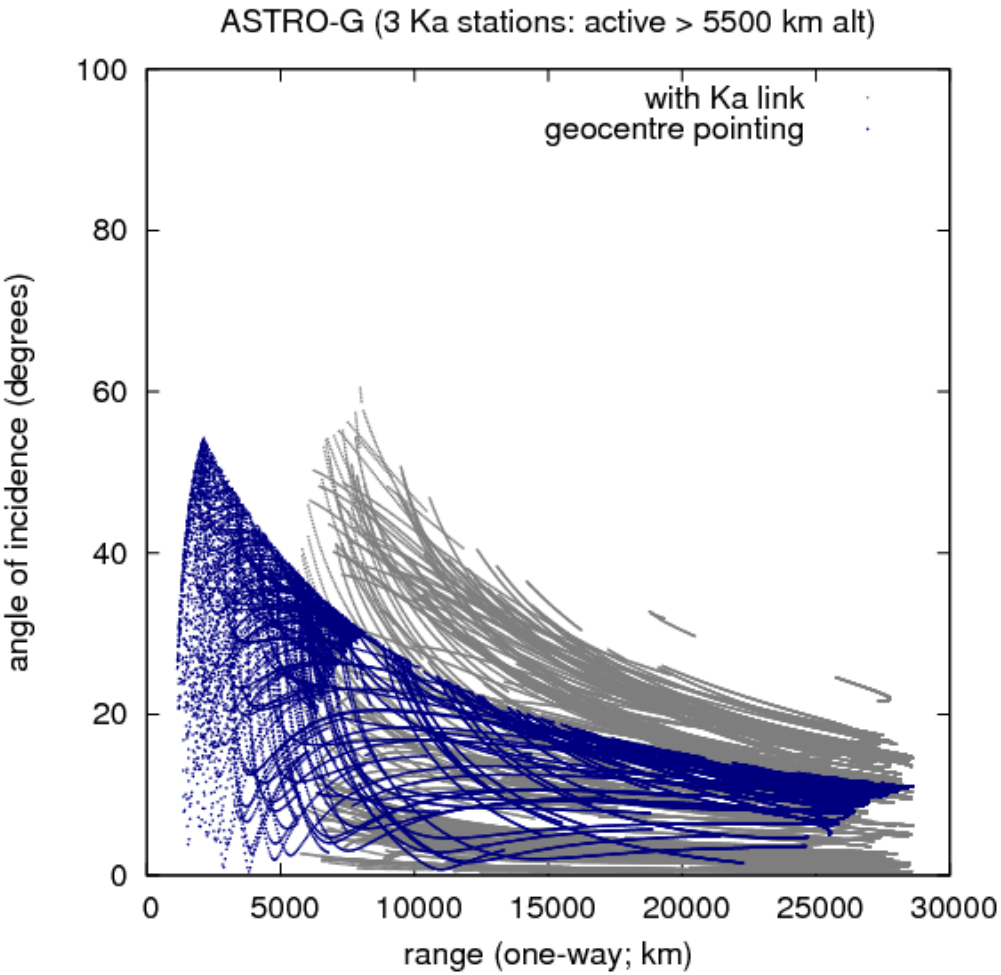
Orientation of ASTRO-G



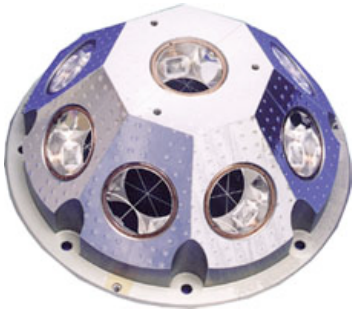
9.6-m antenna points stars
by changing the satellite attitu

Ka antenna points one of Ka s
only when it is visible (> 5 de
above 5500 km
Otherwise,
Ka antenna points the geocer

SLR array sync. with Ka antenn



Reflector Array for LEO and GNSS

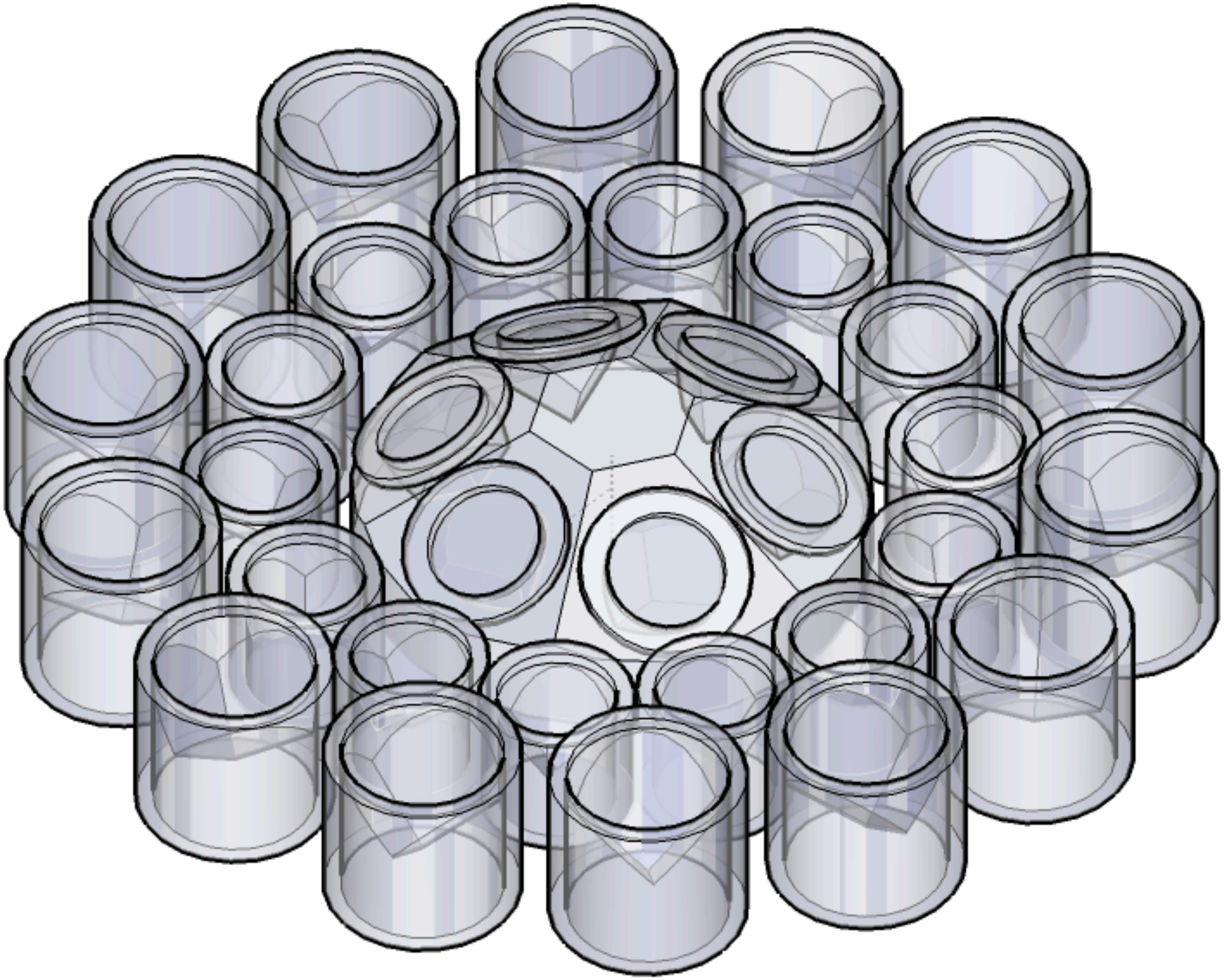


ALOS
720 km circular orbit

GPS
20000 km circular orbit

Retro pictures: © ILRS Web

Reflector Array: Basic Design

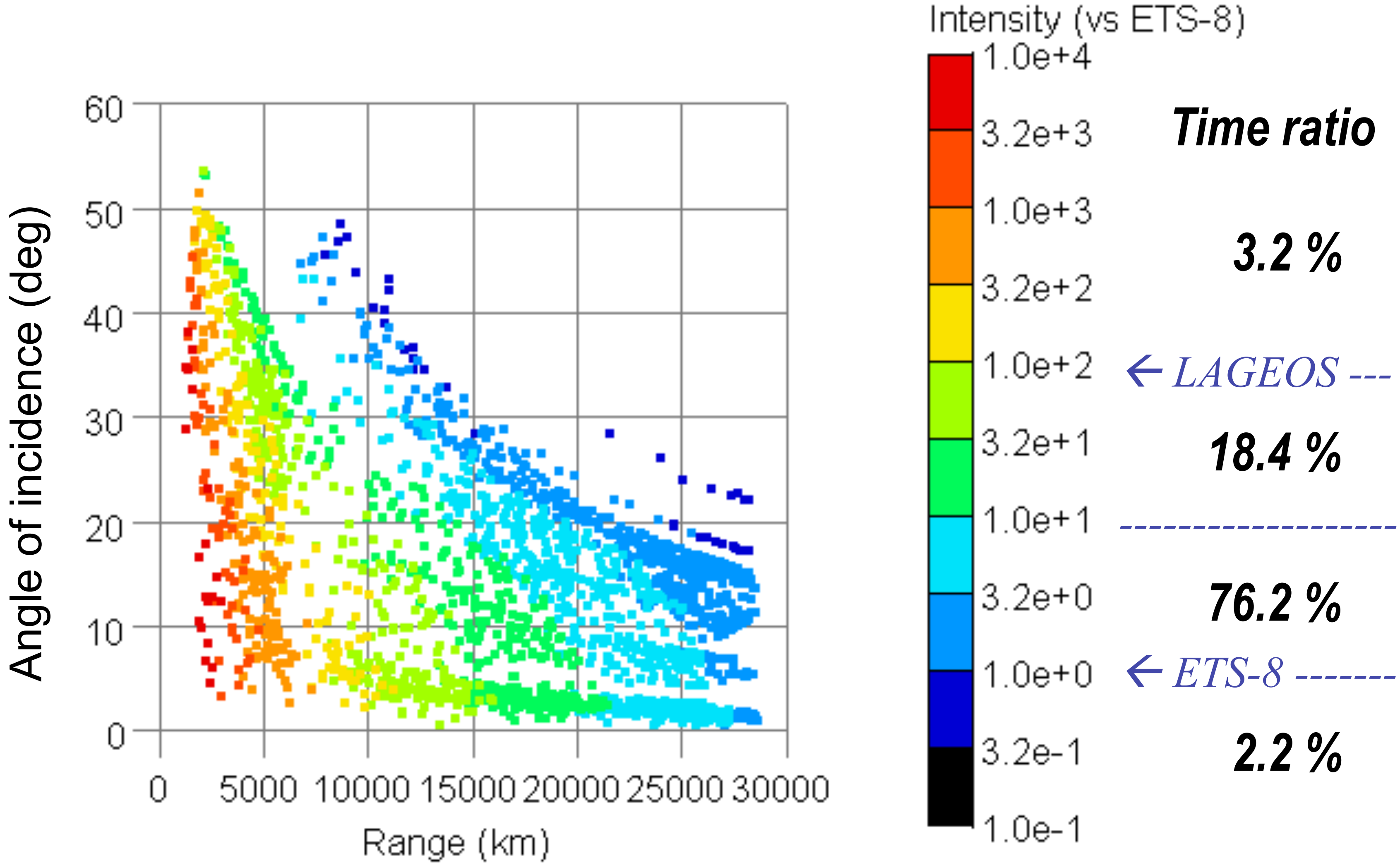


Centre:
6 x
28 mm coated CCRs
Slanted by 30 deg

Inner Ring:
14 x
28 mm uncoated CCRs

Outer Ring:
14 x
38 mm uncoated CCRs

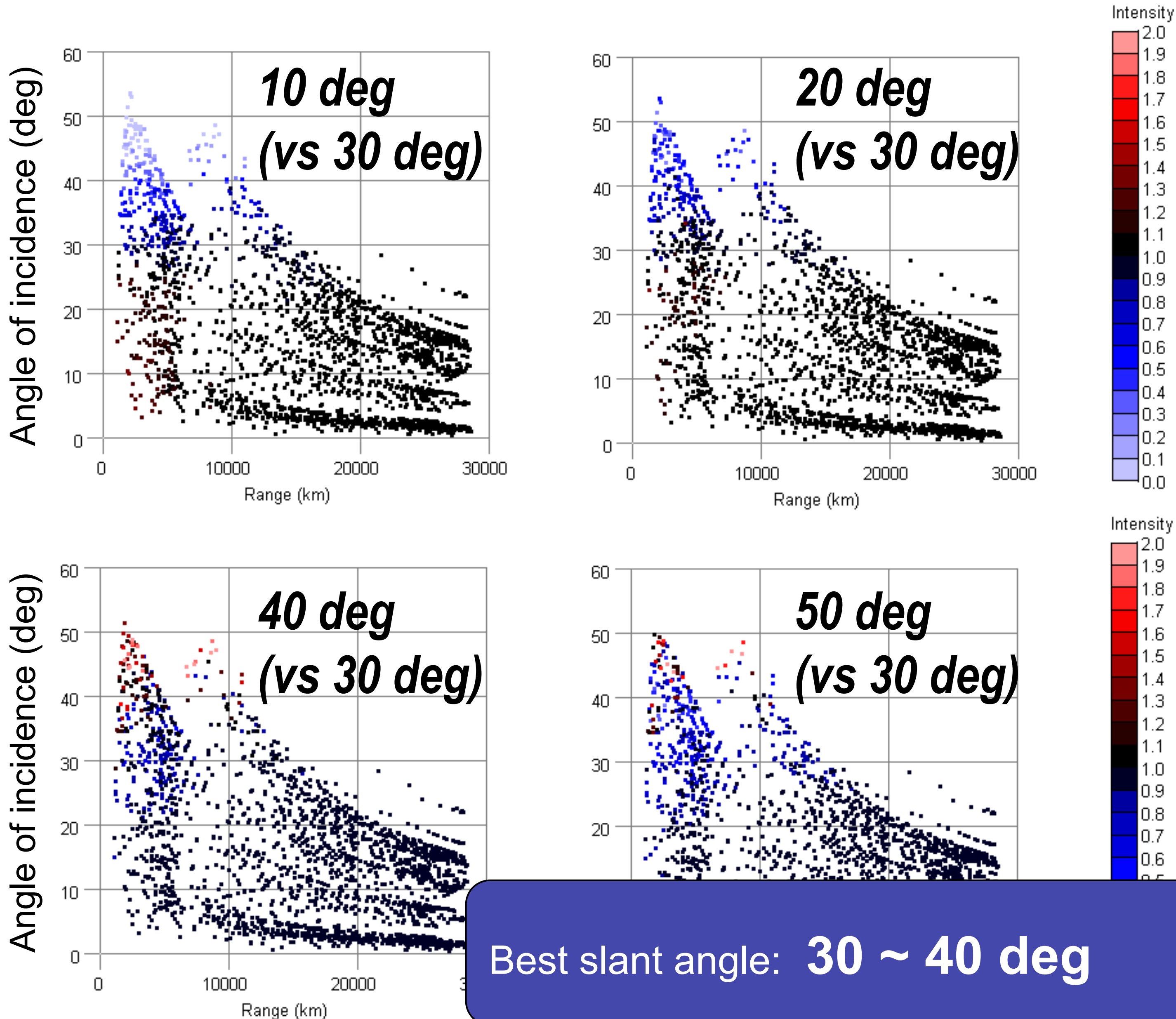
Intensity: ASTRO-G vs ETS-8



ETS-8 intensity: assuming a 30.5 N station (Tanegashima)

Slant angle of centre reflectors

Nominal
30 deg



Best slant angle: **30 ~ 40 deg**

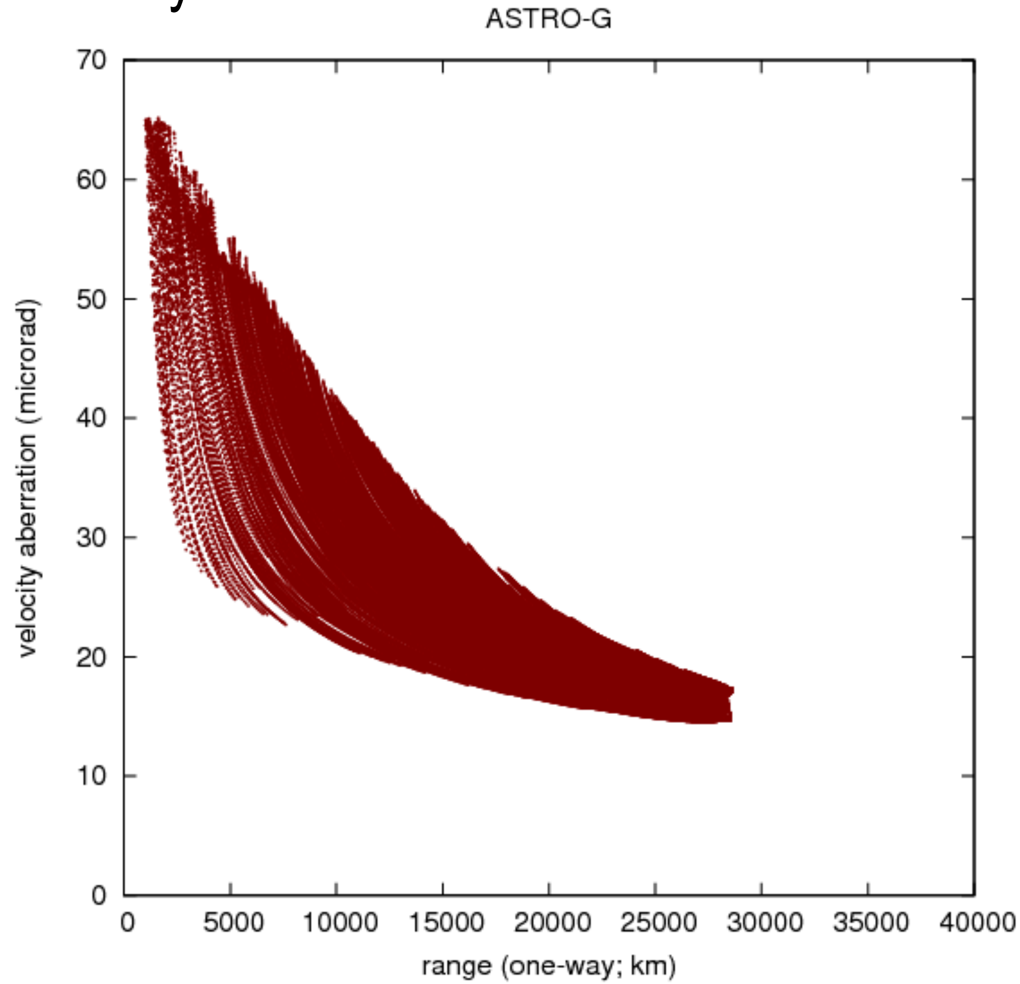
Problem 2: Velocity Aberration

Large Velocity Variation of ASTRO-G

2.2 km/s (apogee) to 9.4 km/s (perigee)

Unprecedented wide range of velocity aberration!

15 to 65 microrad



Reflector Array: Dihedral Angle

Centre:
6 x
28 mm coated CCRs
Inclined by 30 deg

Dihedral angle
~ **2.0”**

Inner Ri
14 x
28 mm uncoated CCRs

Dihedral angle
< **0.75”**

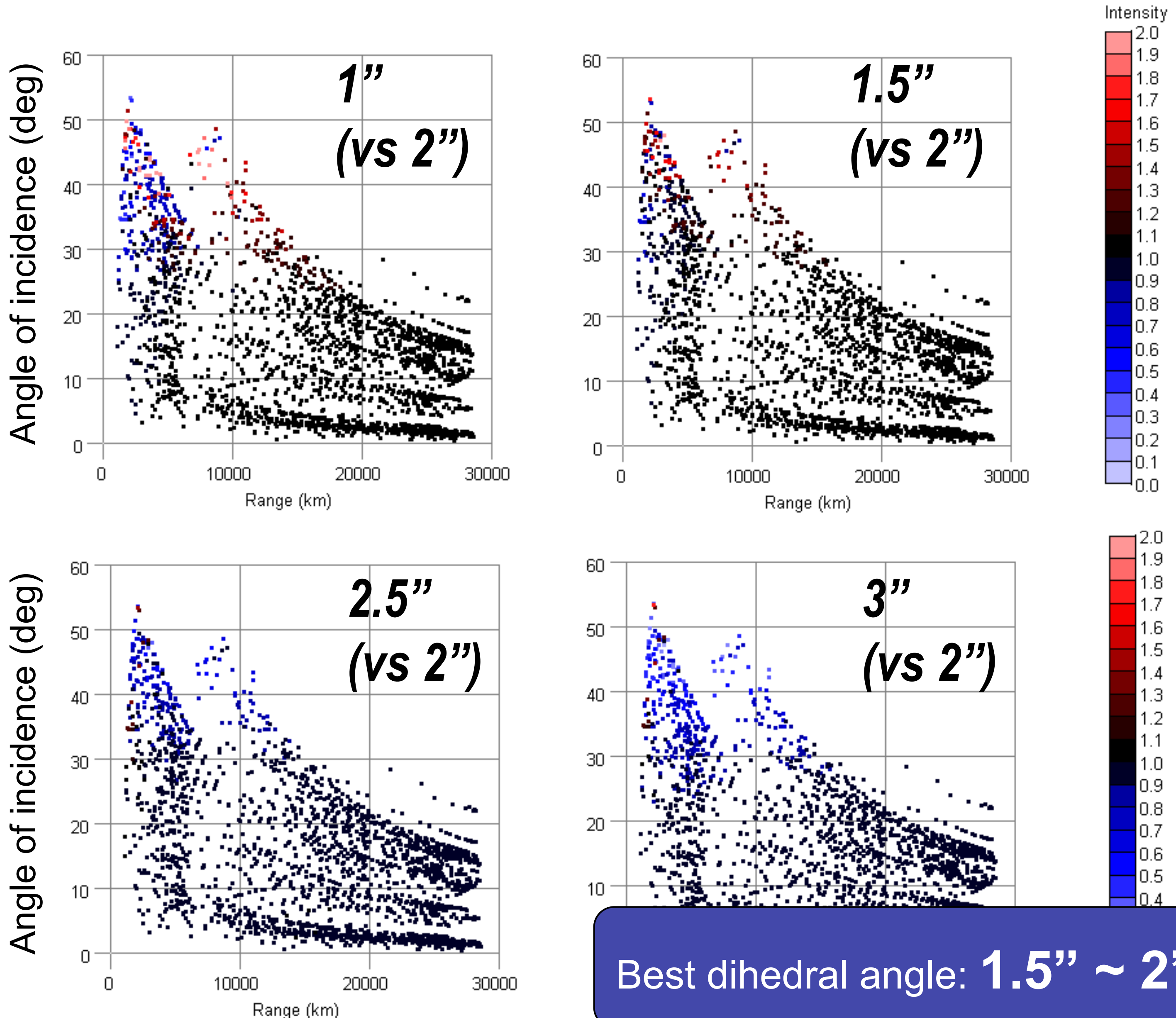
Outer Ri
14 x
38 mm uncoated CCRs

Dihedral angle
< **0.75”**

cf. Dihedral angle ~ **1.25” (LAGEOS)**
~ **0.50” (ETS-8)**

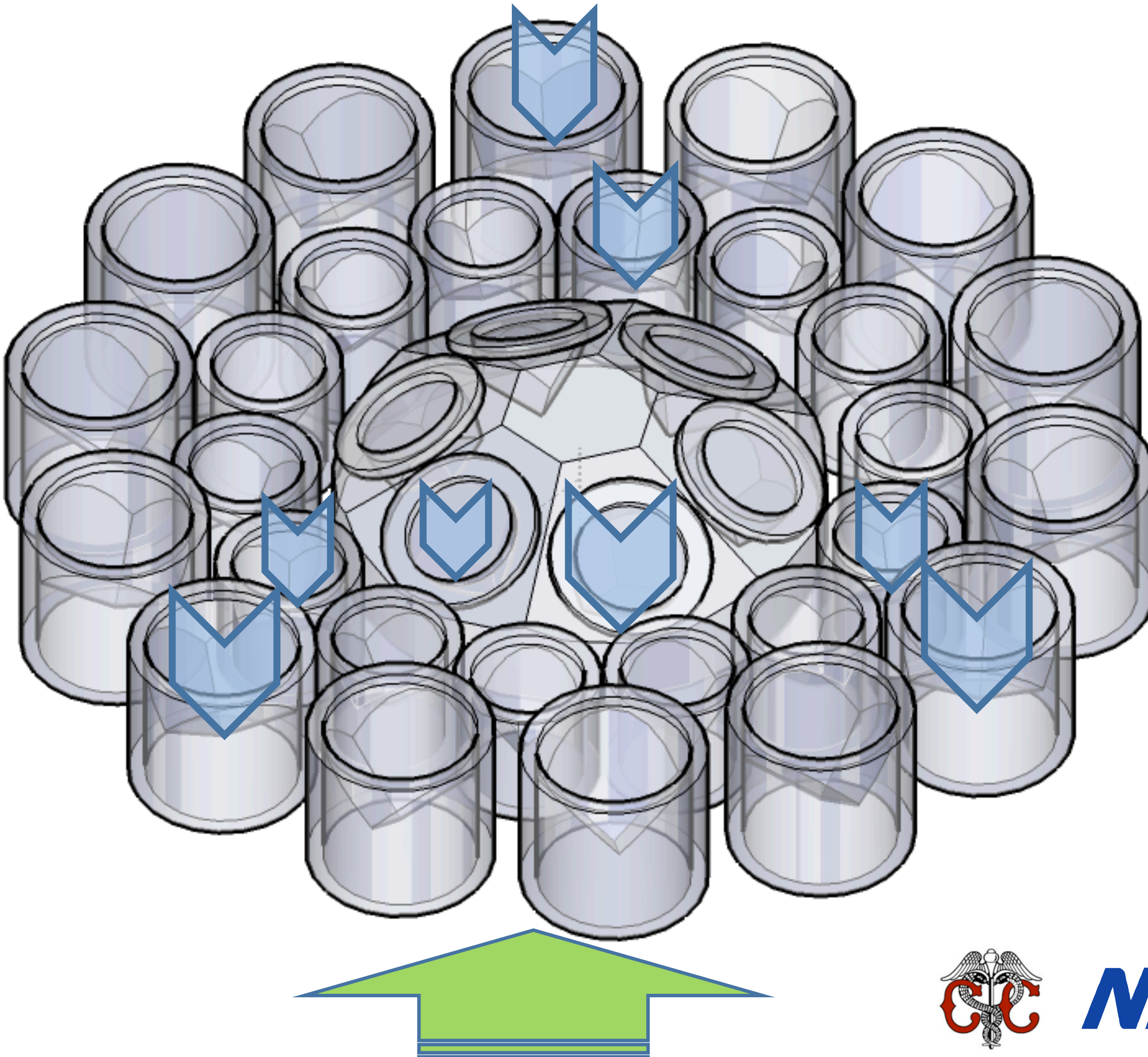
Dihedral angle of centre reflectors

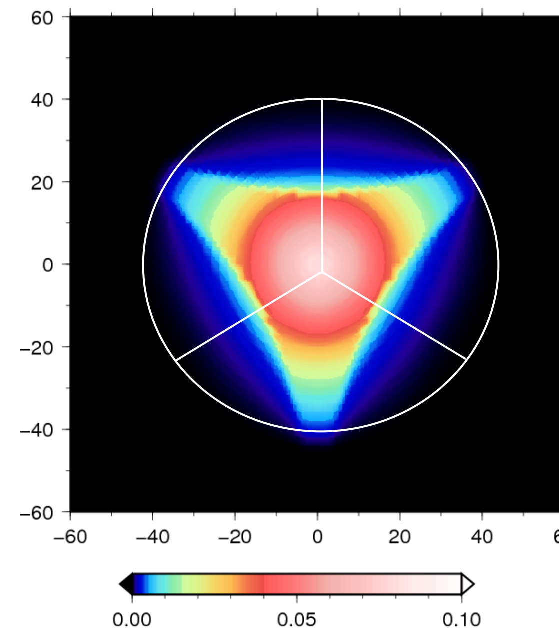
Nominal
2.0”



Best dihedral angle: **1.5” ~ 2”**

Reflector Array: Orientation & Double Pulse

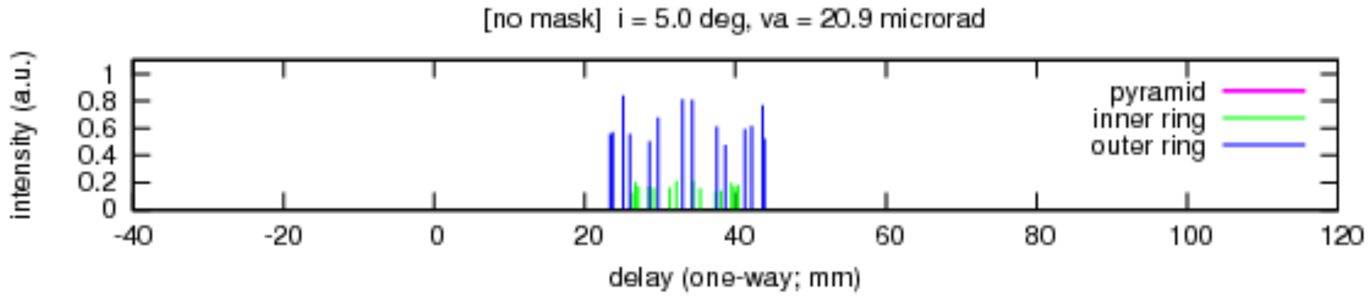


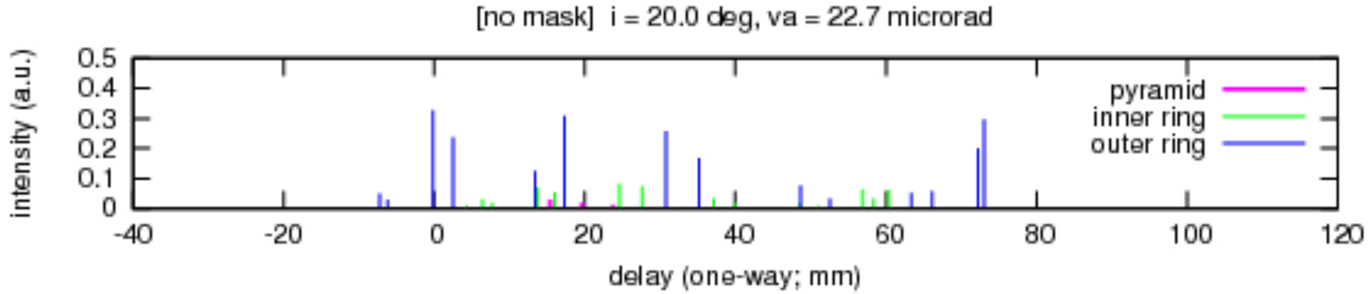


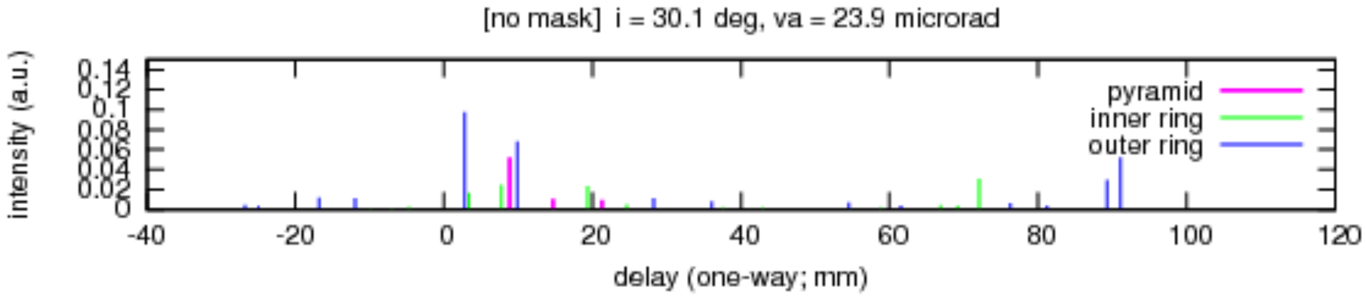
Single Reflector
(uncoated)

Strong 120-deg
az-dependence

Problem 3: Double pulse



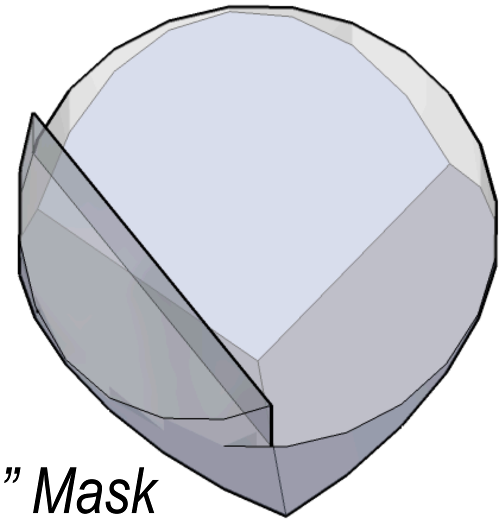




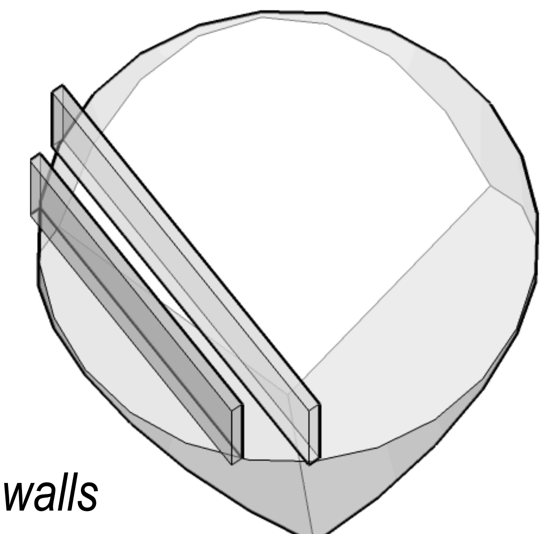
Mask Ideas

Precision
vs
Intensity

"Flat" Mask



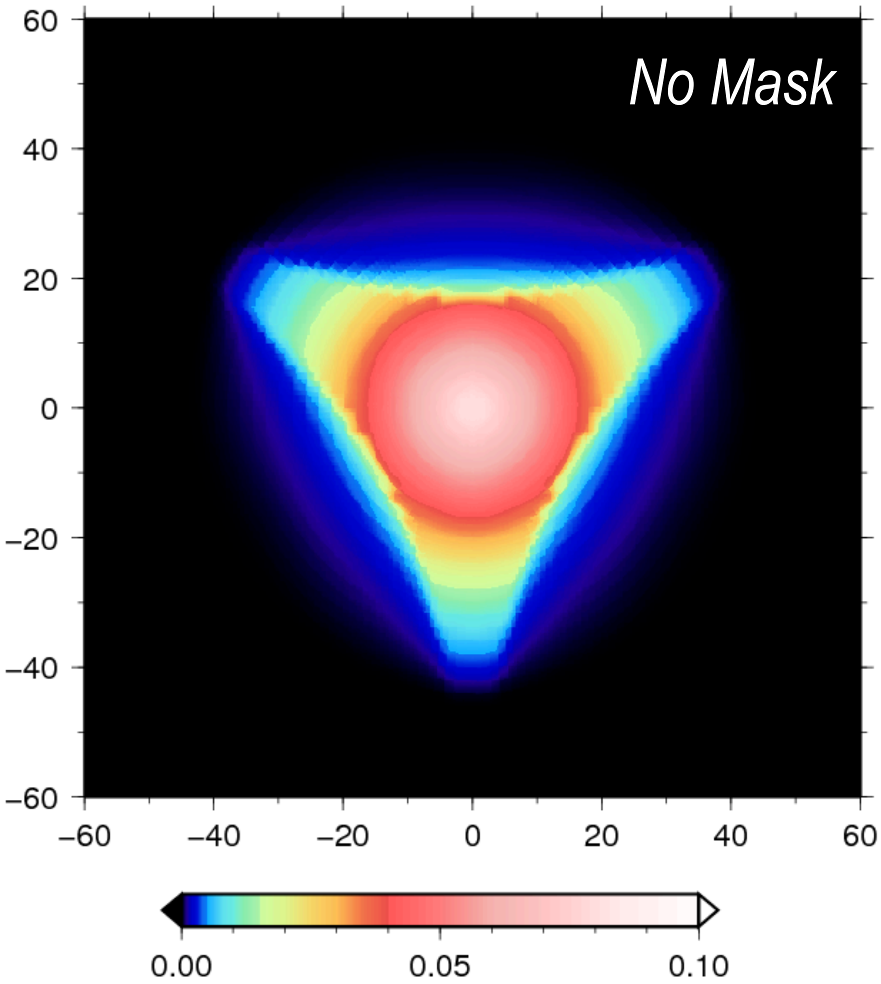
"Delta" Mask

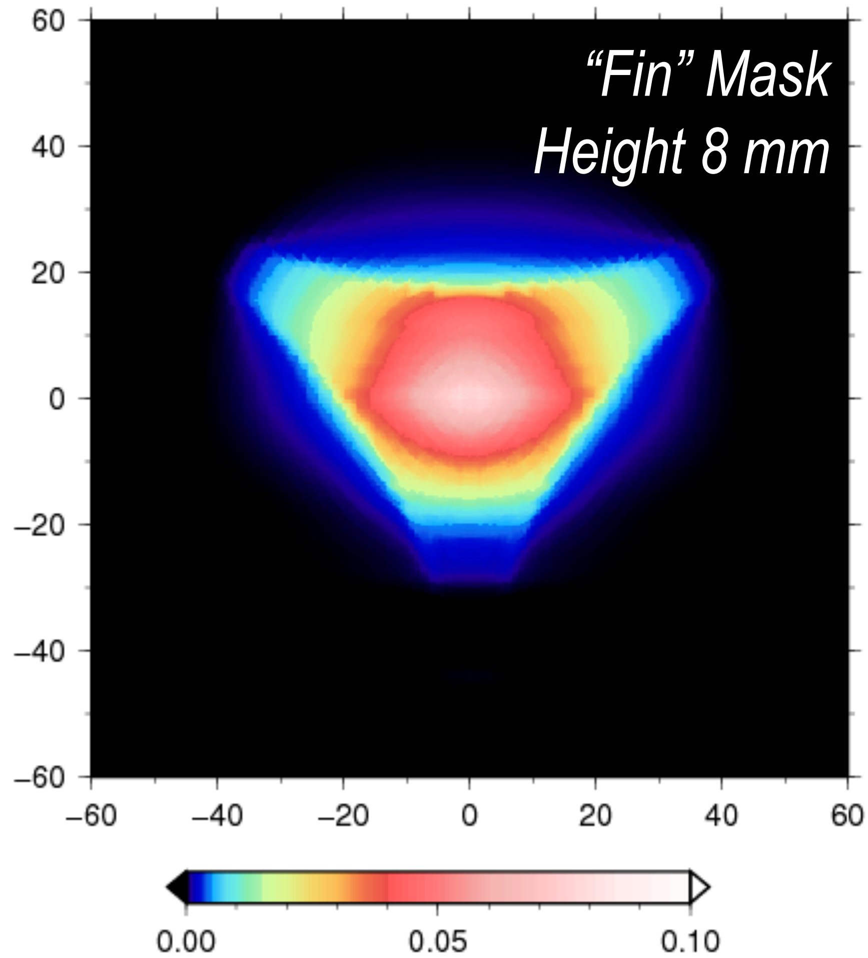


"Fin" Mask

Two x-mm height walls at 0.25 r and 0.5 r

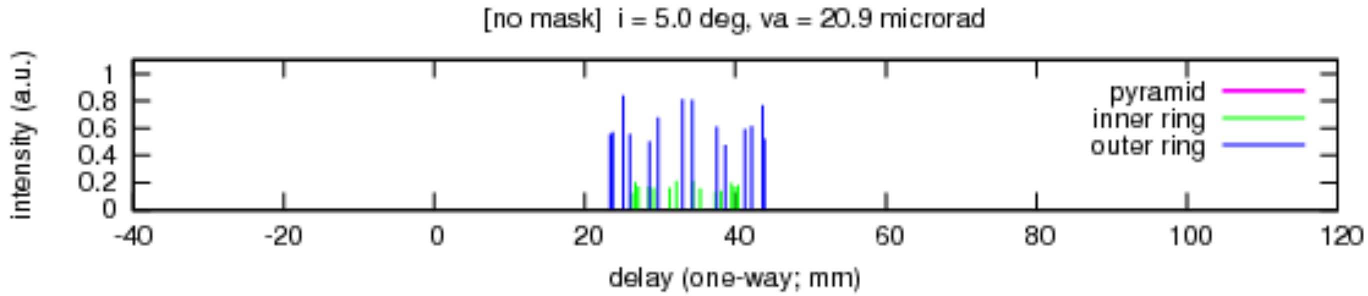
Effect of masks

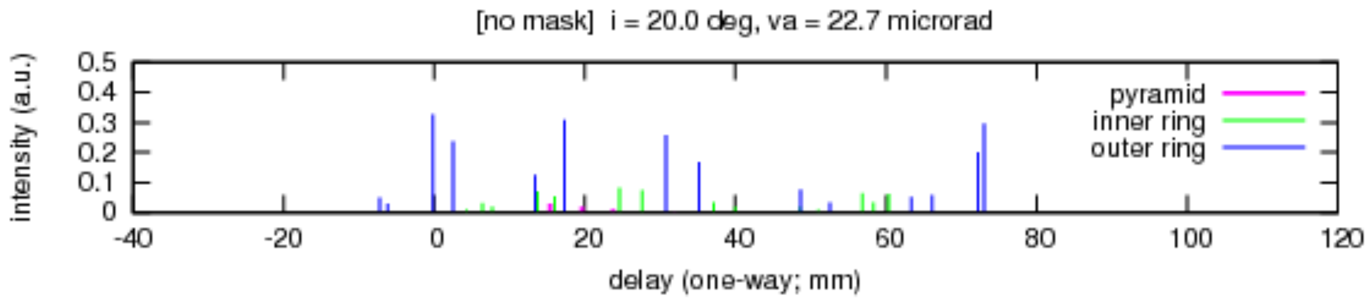


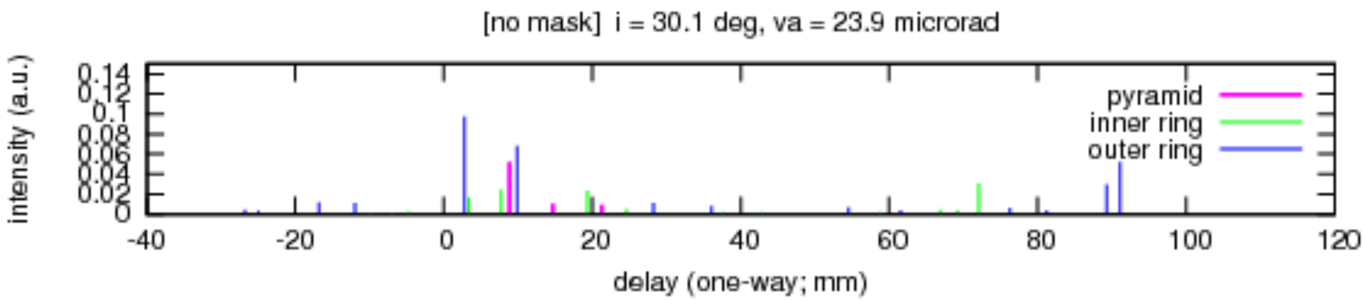


Problem 3: Double pulse

No Mask

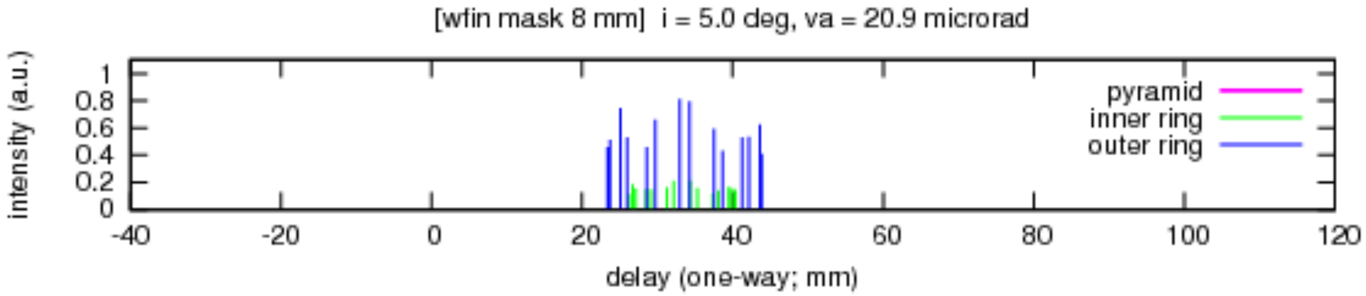


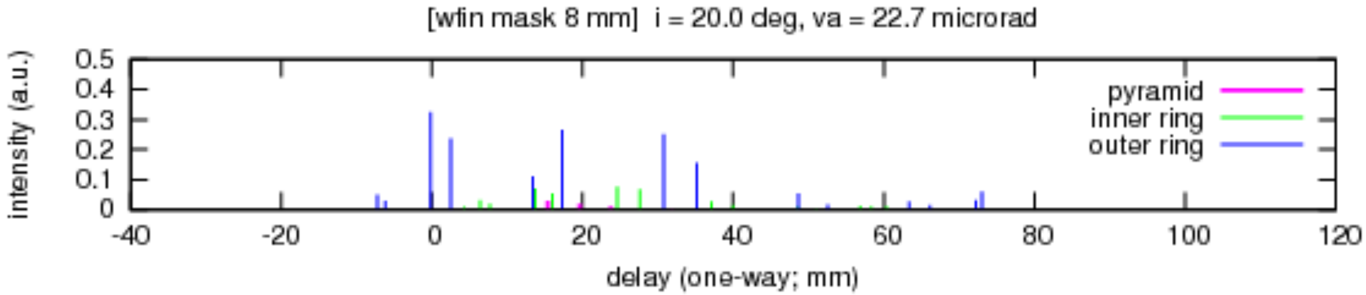


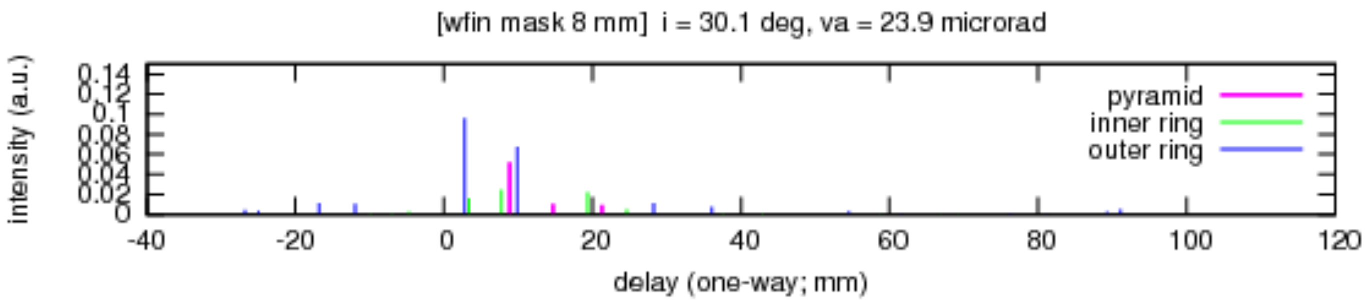


Double pulse eliminated!

Fin
8 mm
Height







Summary

Array design

Mixture of LEO-type and GNSS-type

Return Intensity: Mostly stronger than ETS-8, Huge variation in time

Plenty of new problems/concepts due to its orbit

Angle of incidence

Velocity aberration

Double pulse elimination

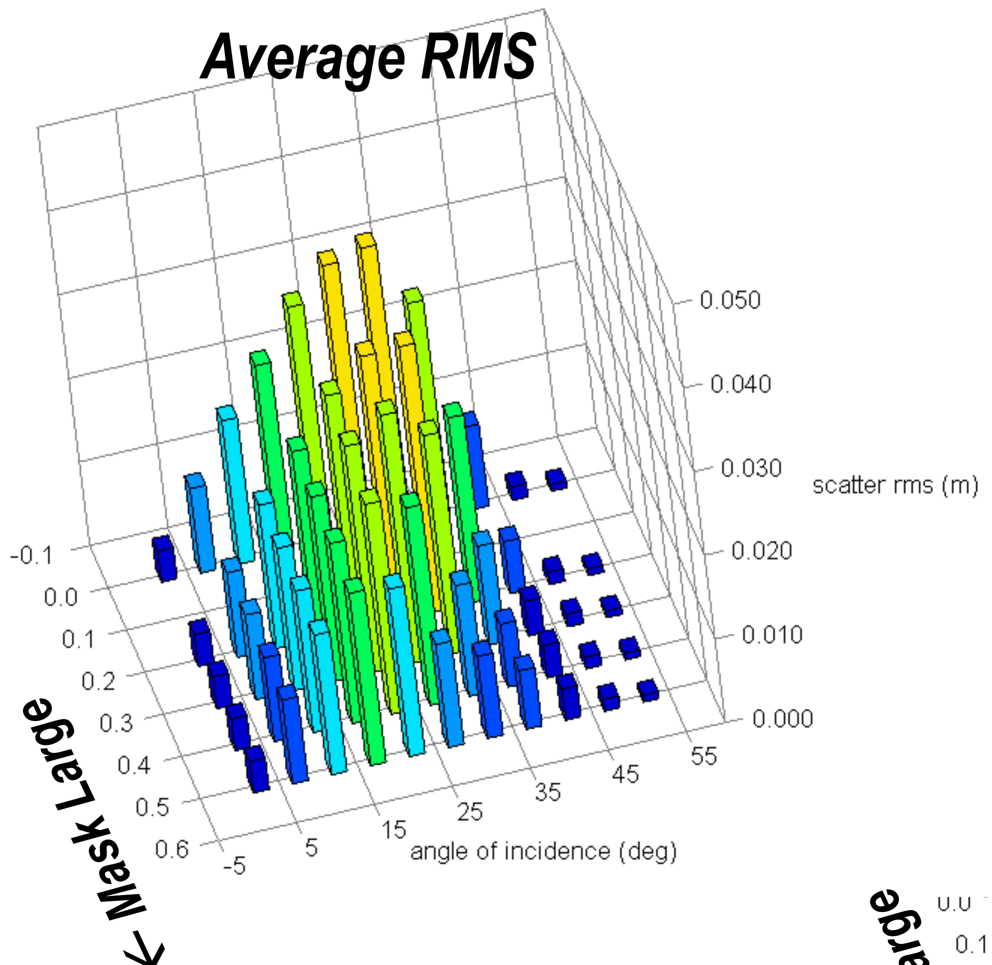
Basic design done, but still needs fine tuning

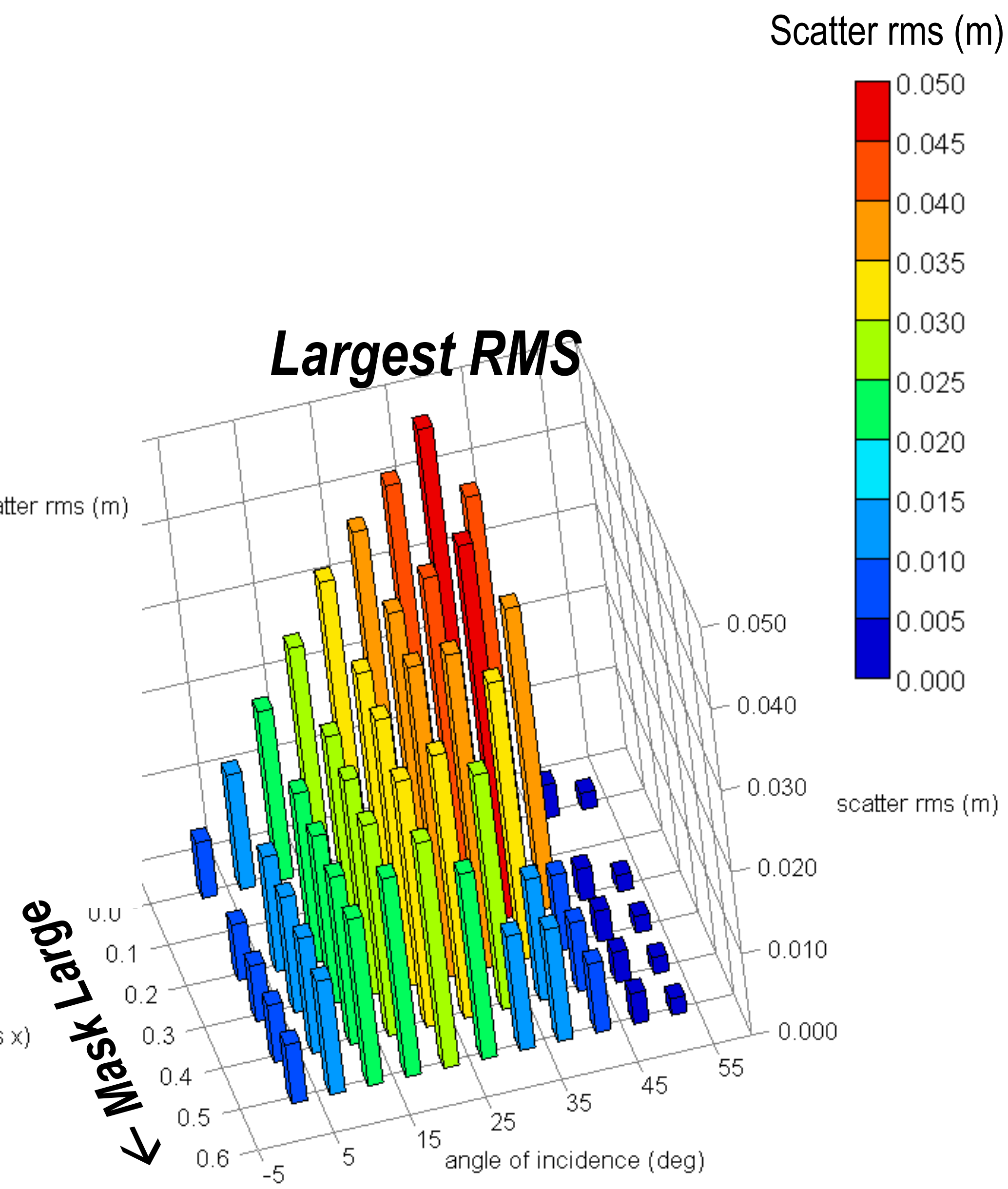
We sincerely hope your supports to this challenging target.

Laser ranging helps blackhole studies for the first time ever!

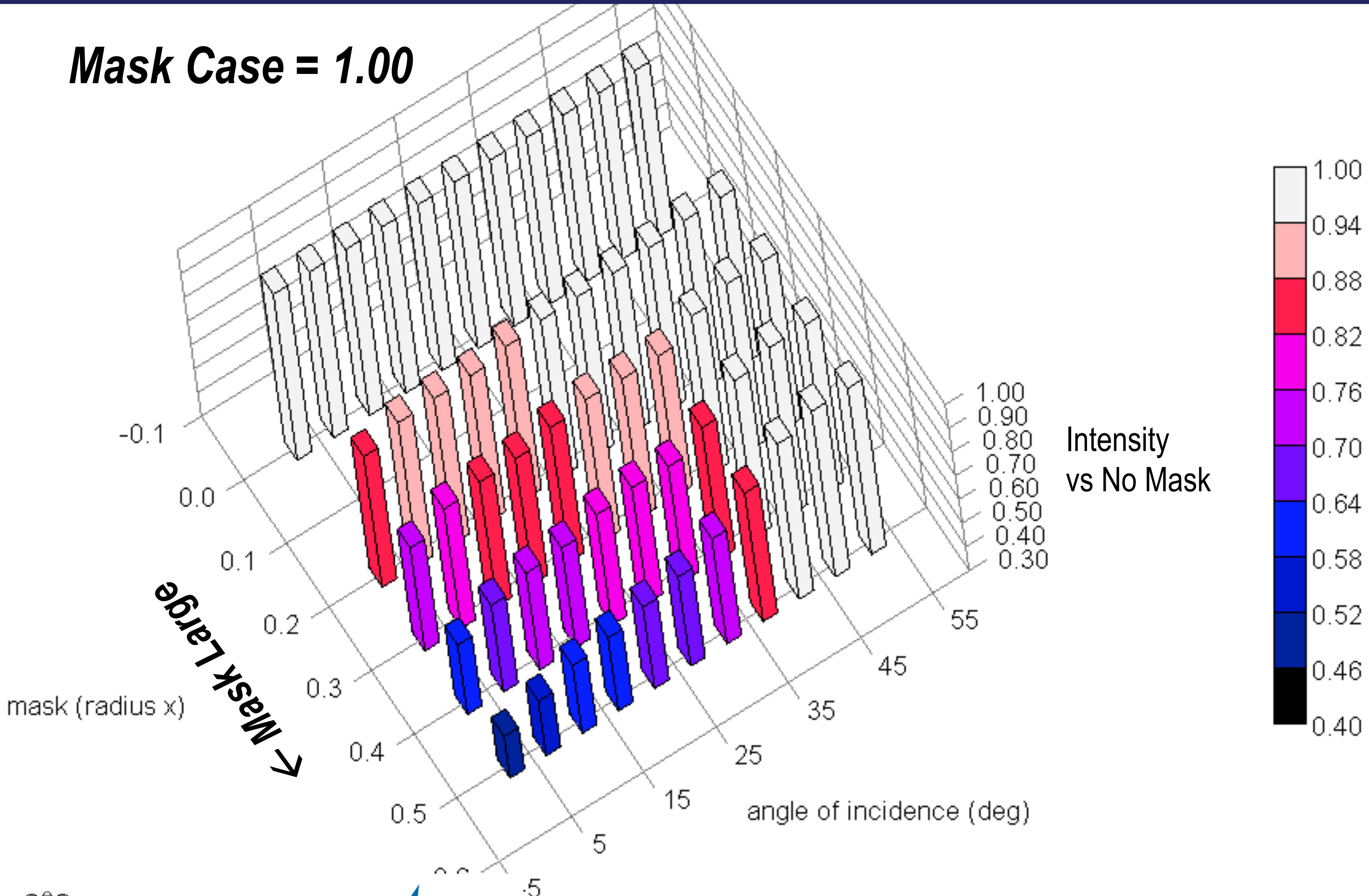
(But its launch is FY2012 = still 4 years ahead)

Flat mask cases: Scatter RMS

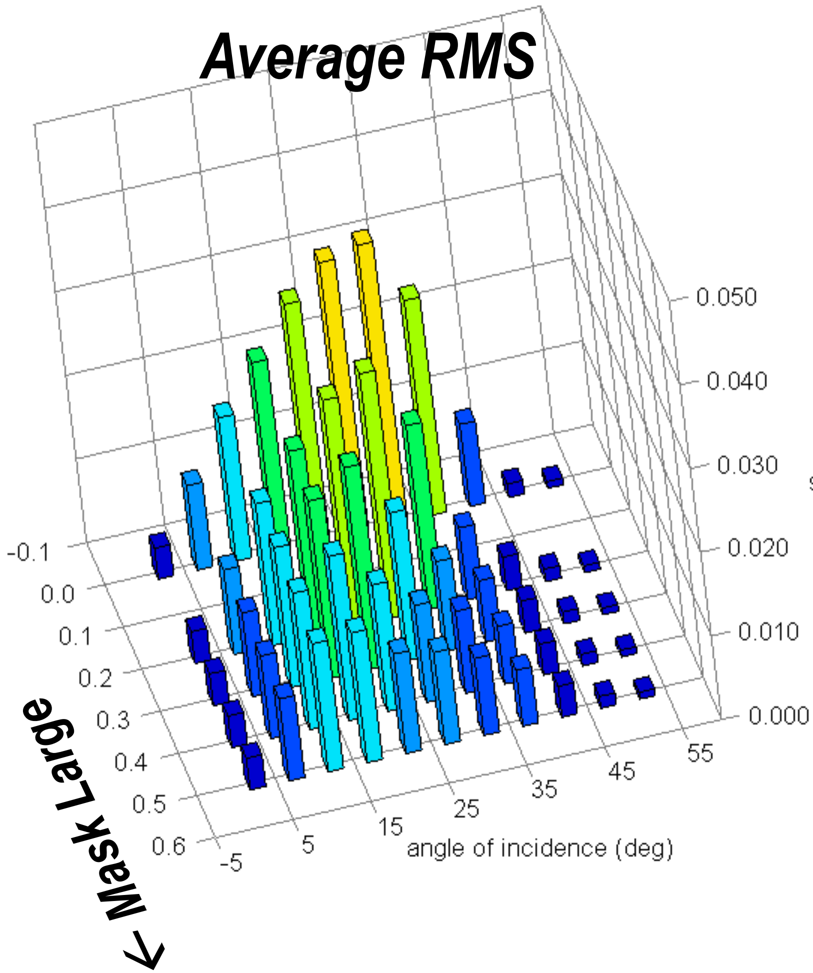


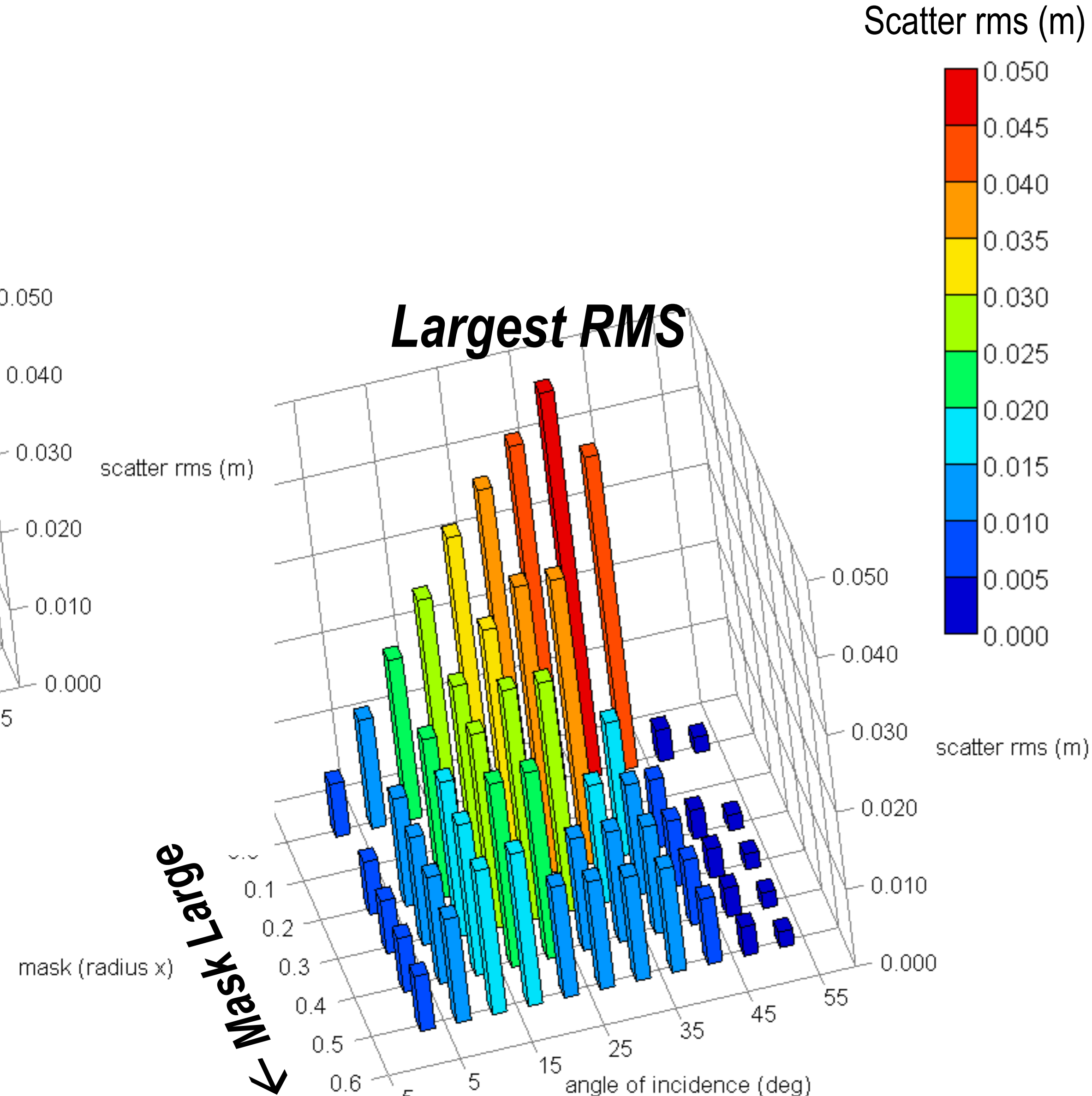


Flat mask cases: Intensity



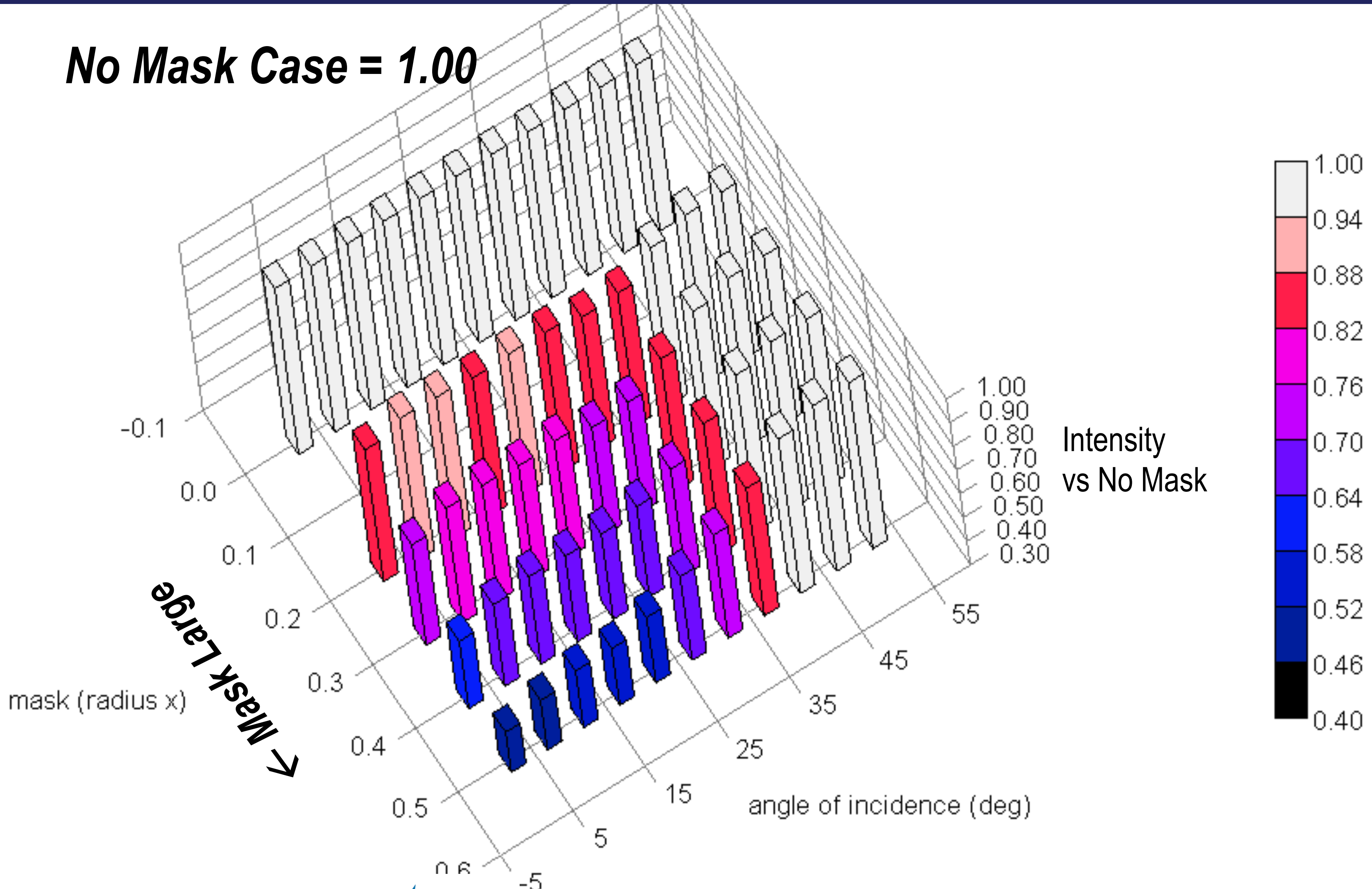
Delta mask cases: Scatter RMS



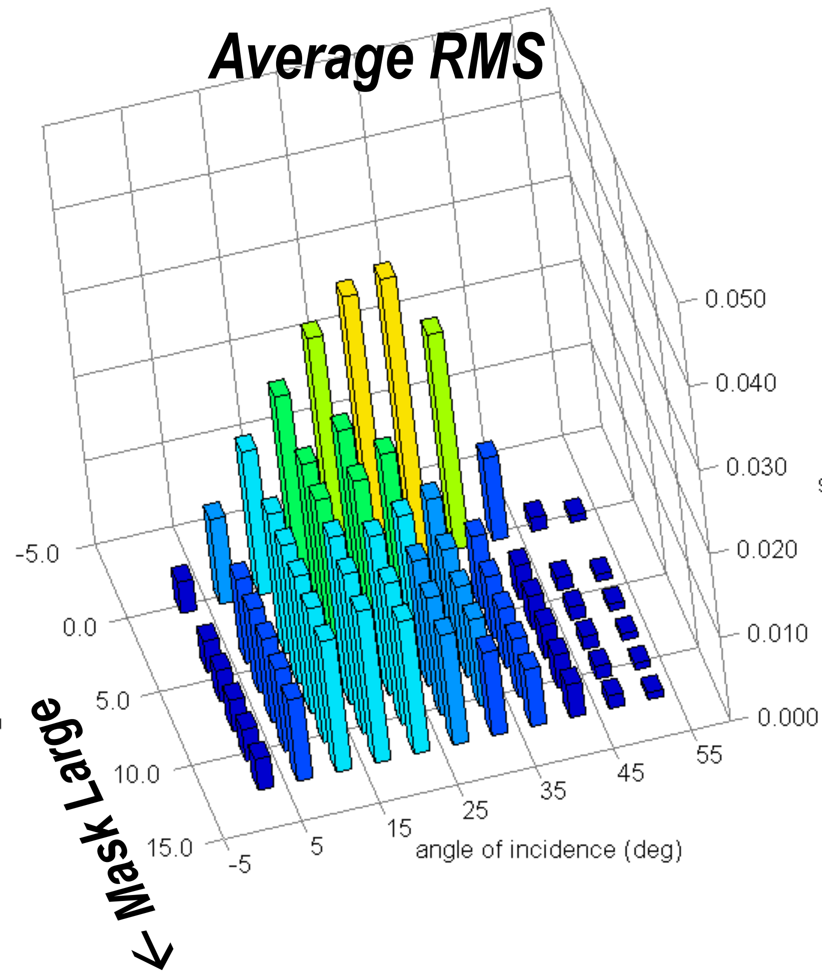


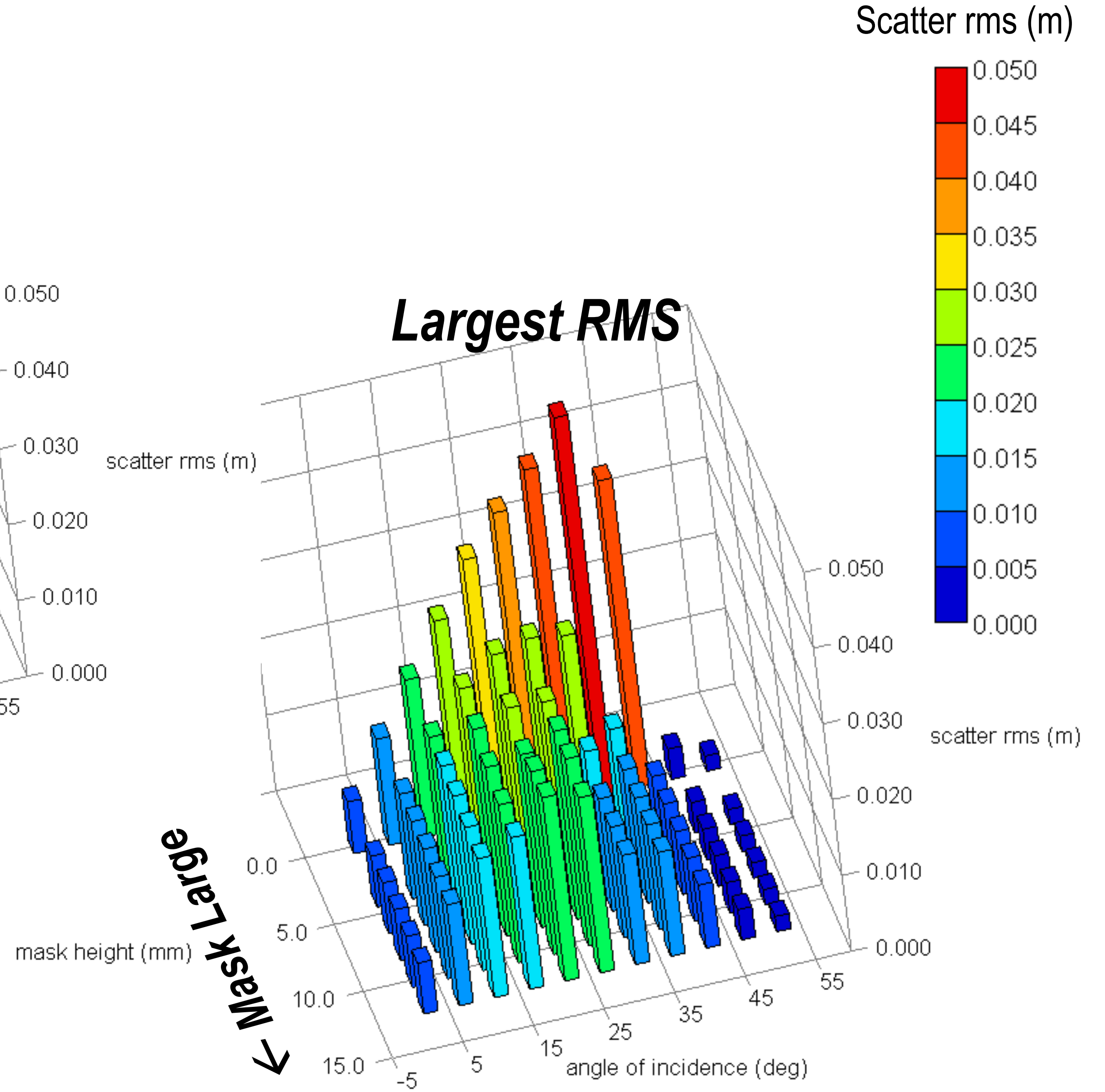
NICT JAXA

Delta mask cases: Intensity



Fin mask cases: Scatter RMS





NiCT JAXA

Fin mask cases: Intensity

No Mask Case = 1.00