VLBI telescopes gravitational deformations investigated with terrestrial surveying methods

P. Sarti[1], C. Abbondanza[1], L. Vittuari[2], M. Negusini[1]

[1]Istituto di Radioastronomia – INAF, Bologna
[2]DISTART – Università di Bologna, Bologna

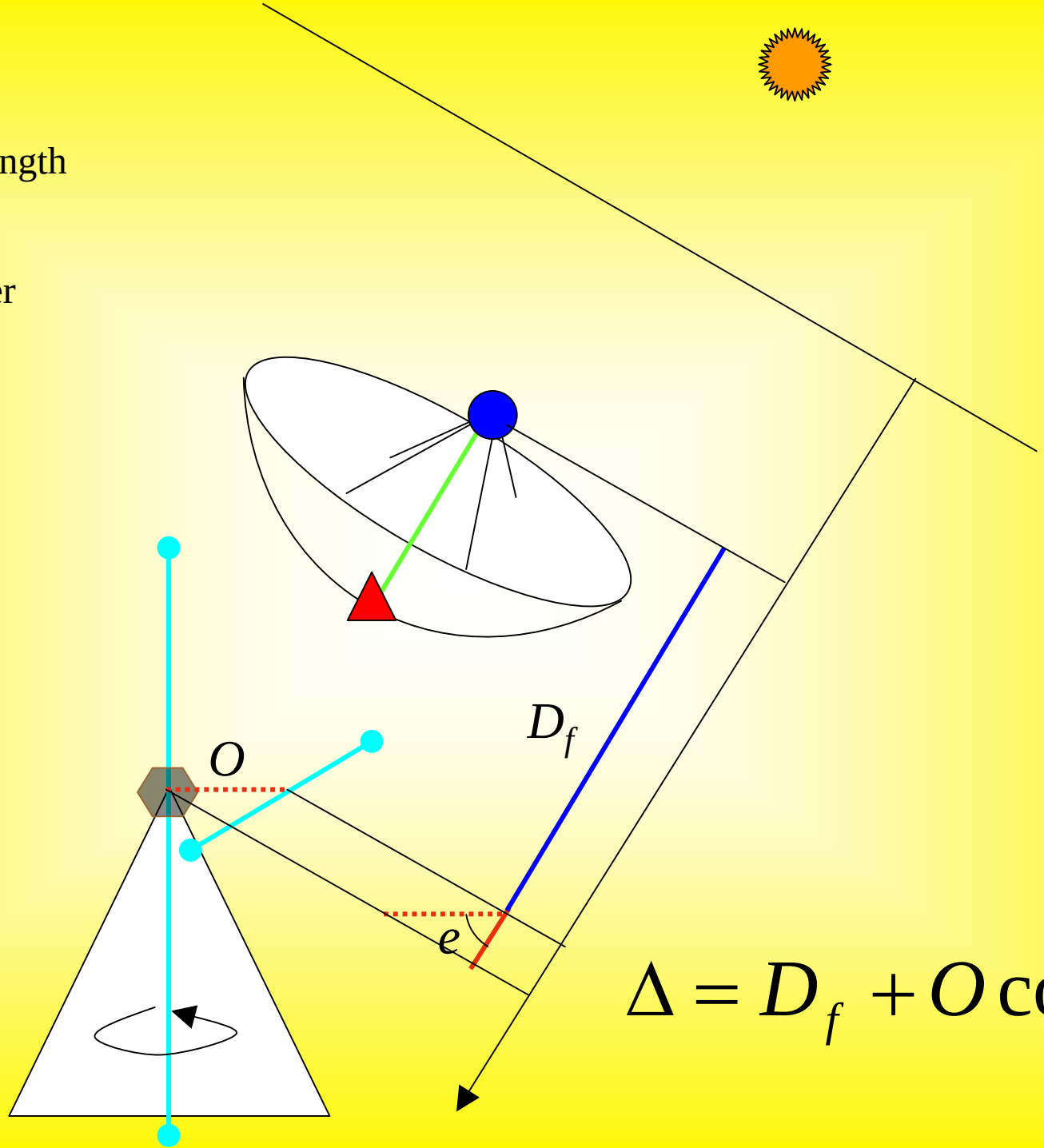
Summary

- VLBI telescopes' reference point:
  - Definition
  - Stability
- Investigation on gravitational deformations affecting Medicina's VLBI telescope:
  - Terrestrial measurements:
    - Topography
    - Laser scanning
  - Finite Element Model
- An elevation-dependent signal path correction model:
  - Combination of deformations
  - Signal path variation

Focal length

Receiver

Vertex

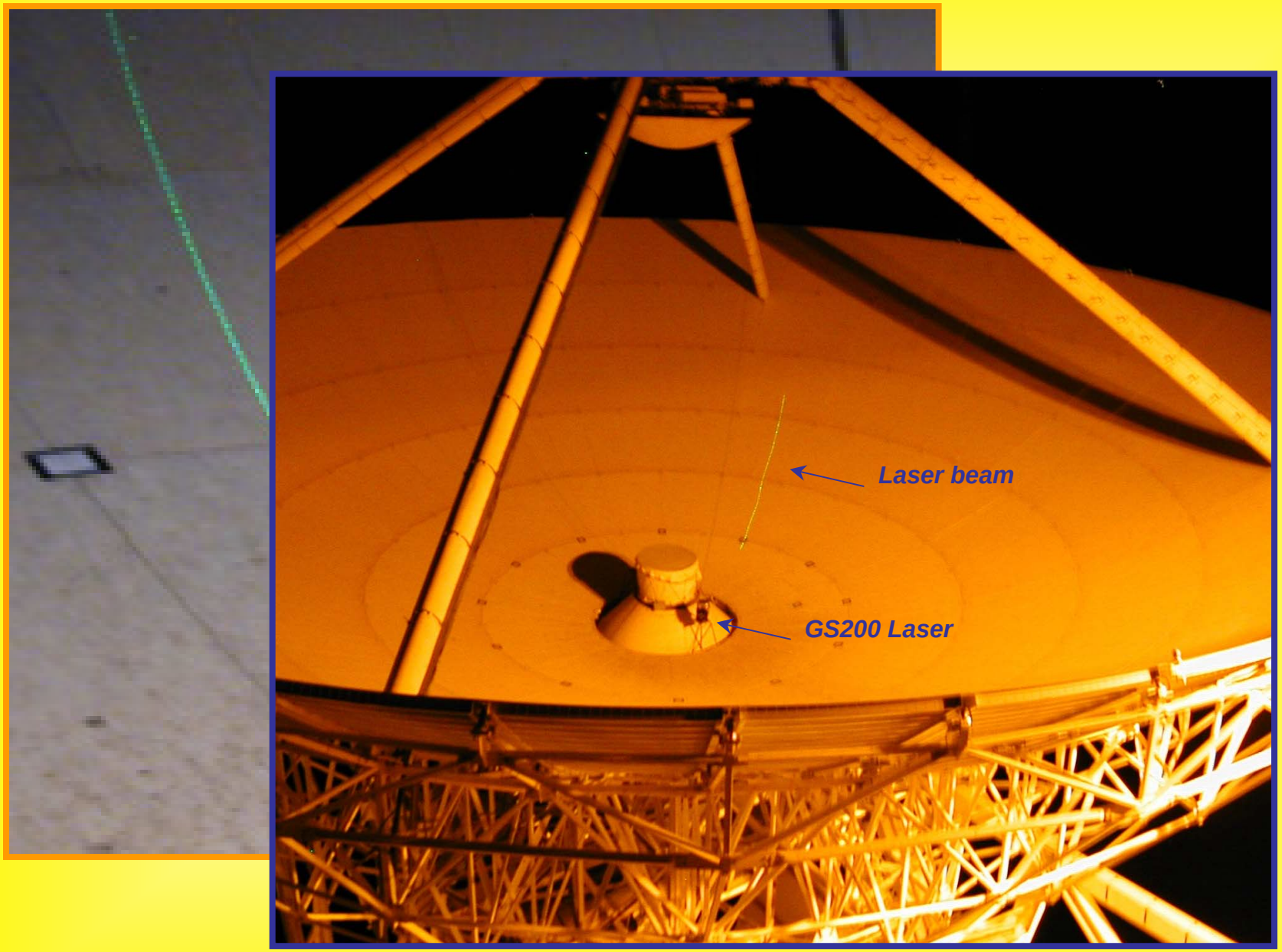


$$\Delta = D_f + O\cos e$$

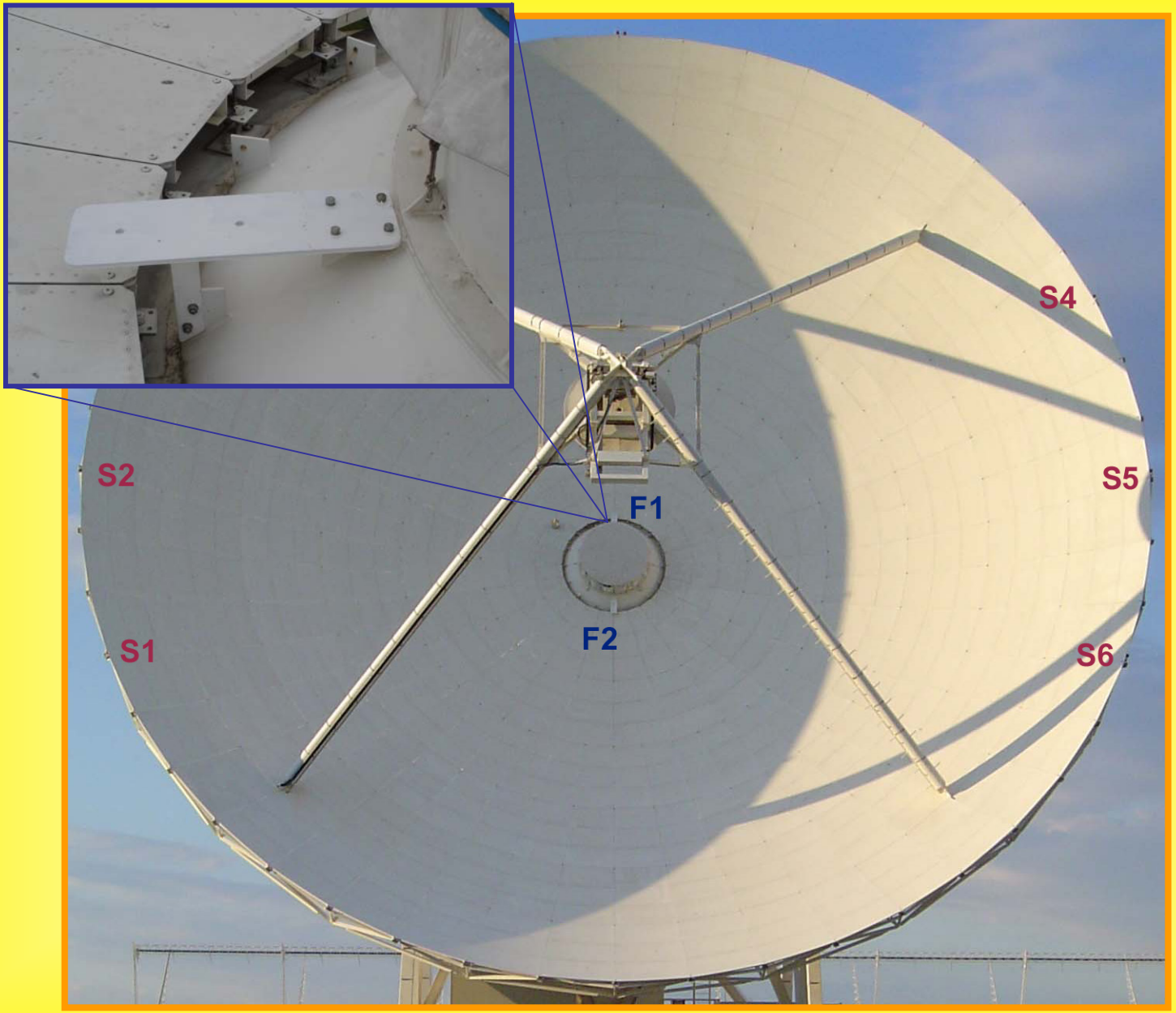
Clark and Thomsen 1988

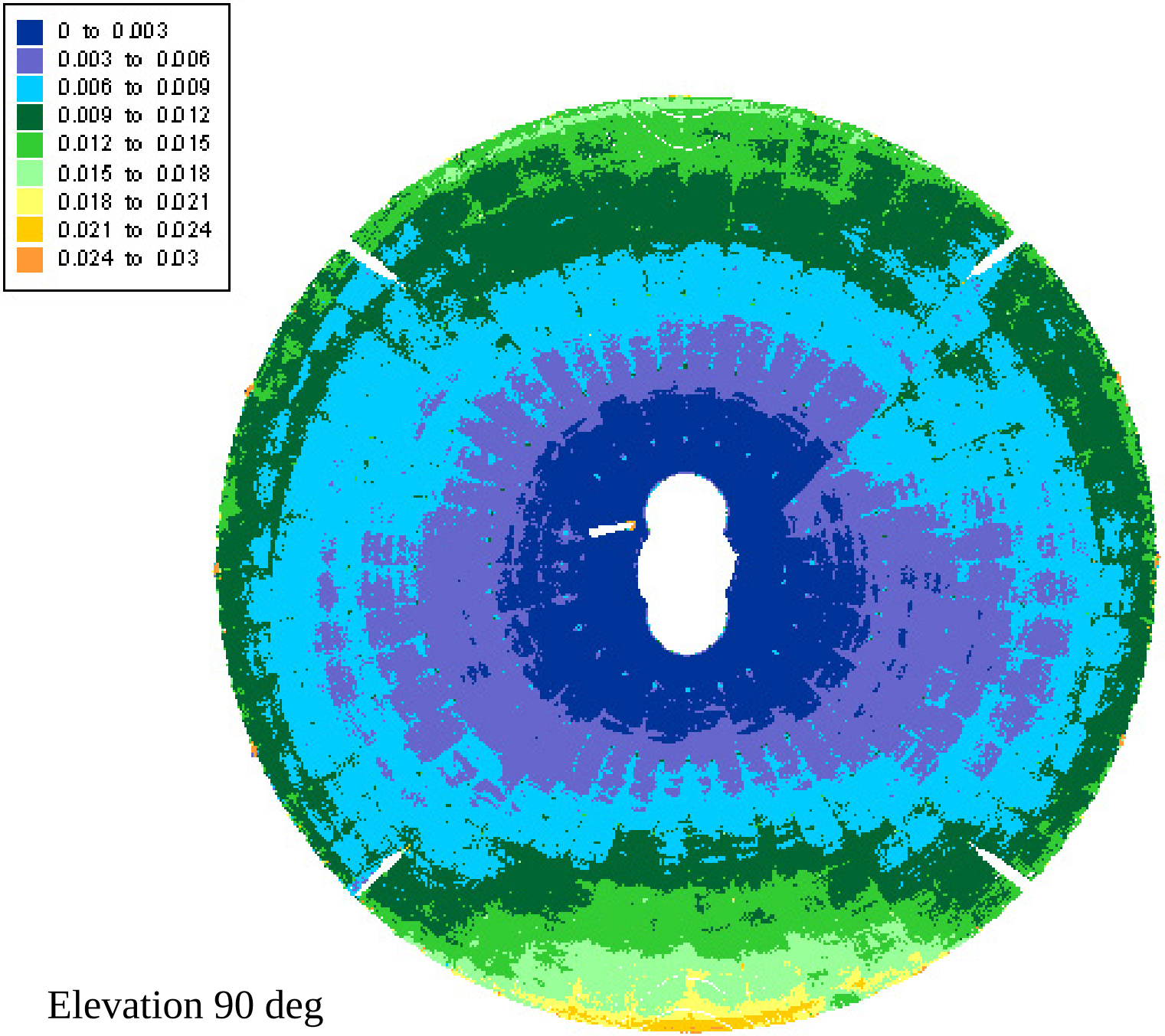
$$\Delta L = \alpha_F \Delta F + \alpha_R \Delta R + \alpha_V \Delta V$$

$$\Delta F$$

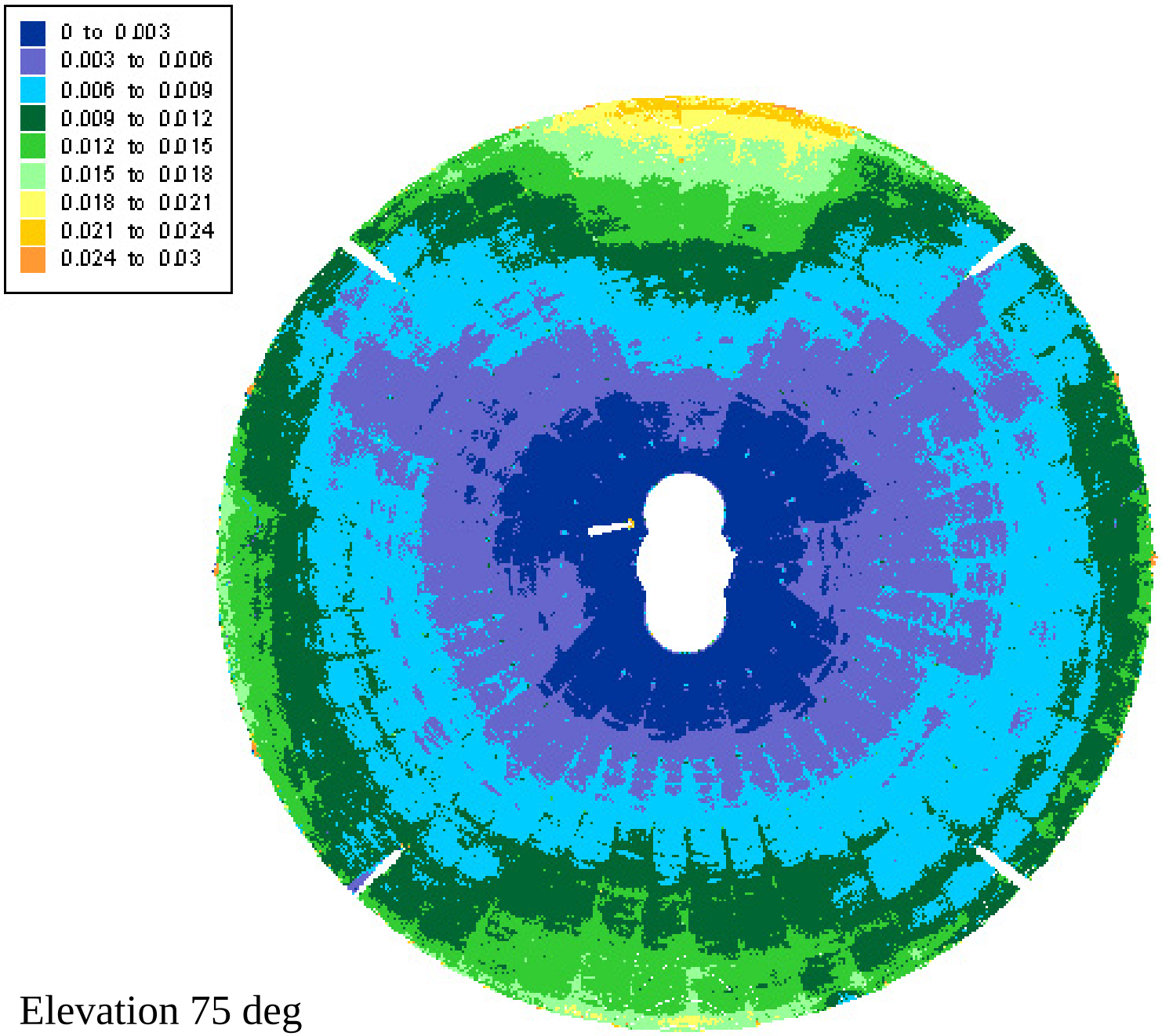

Laser beam
GS200 Laser

Standpoint

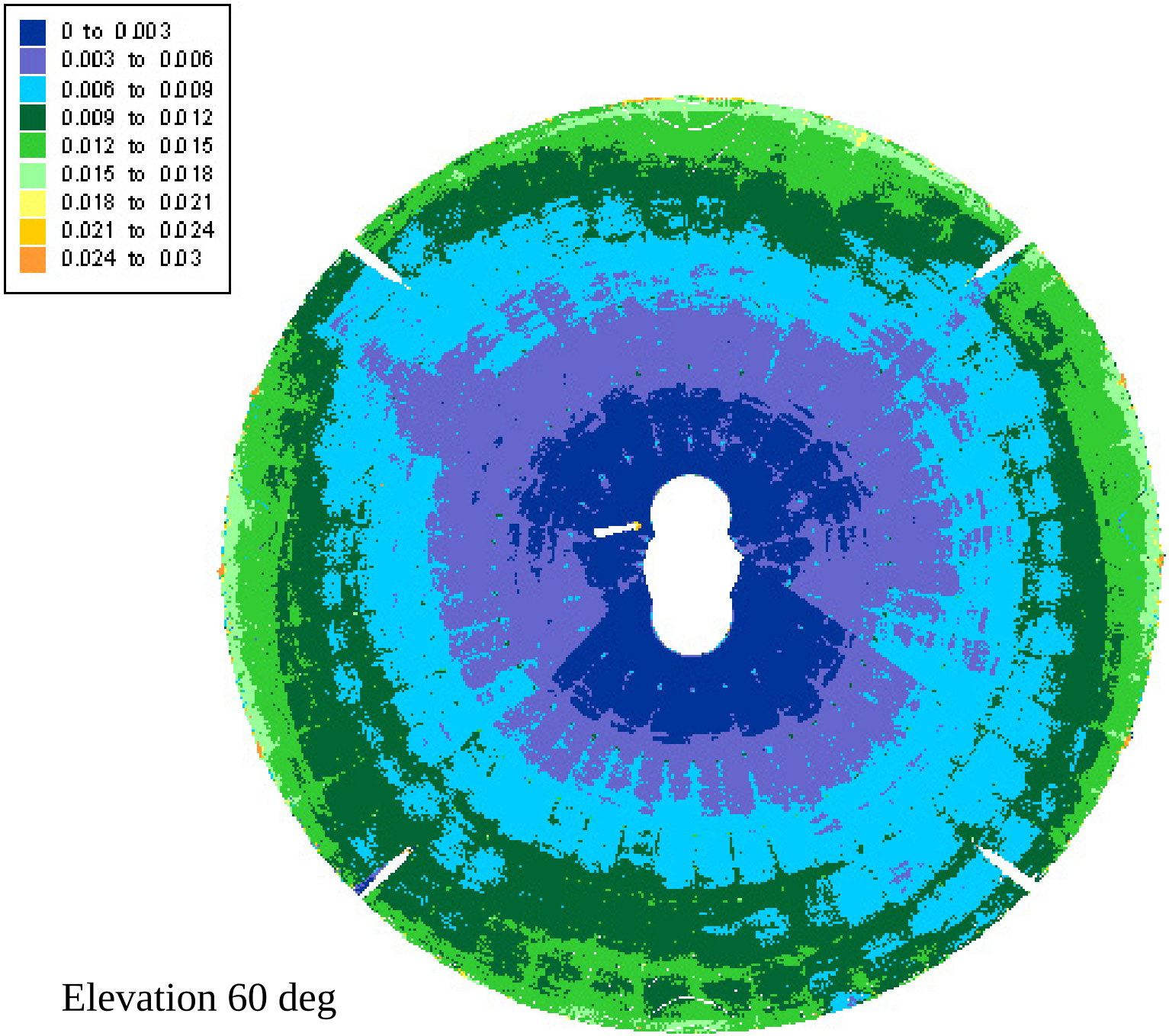




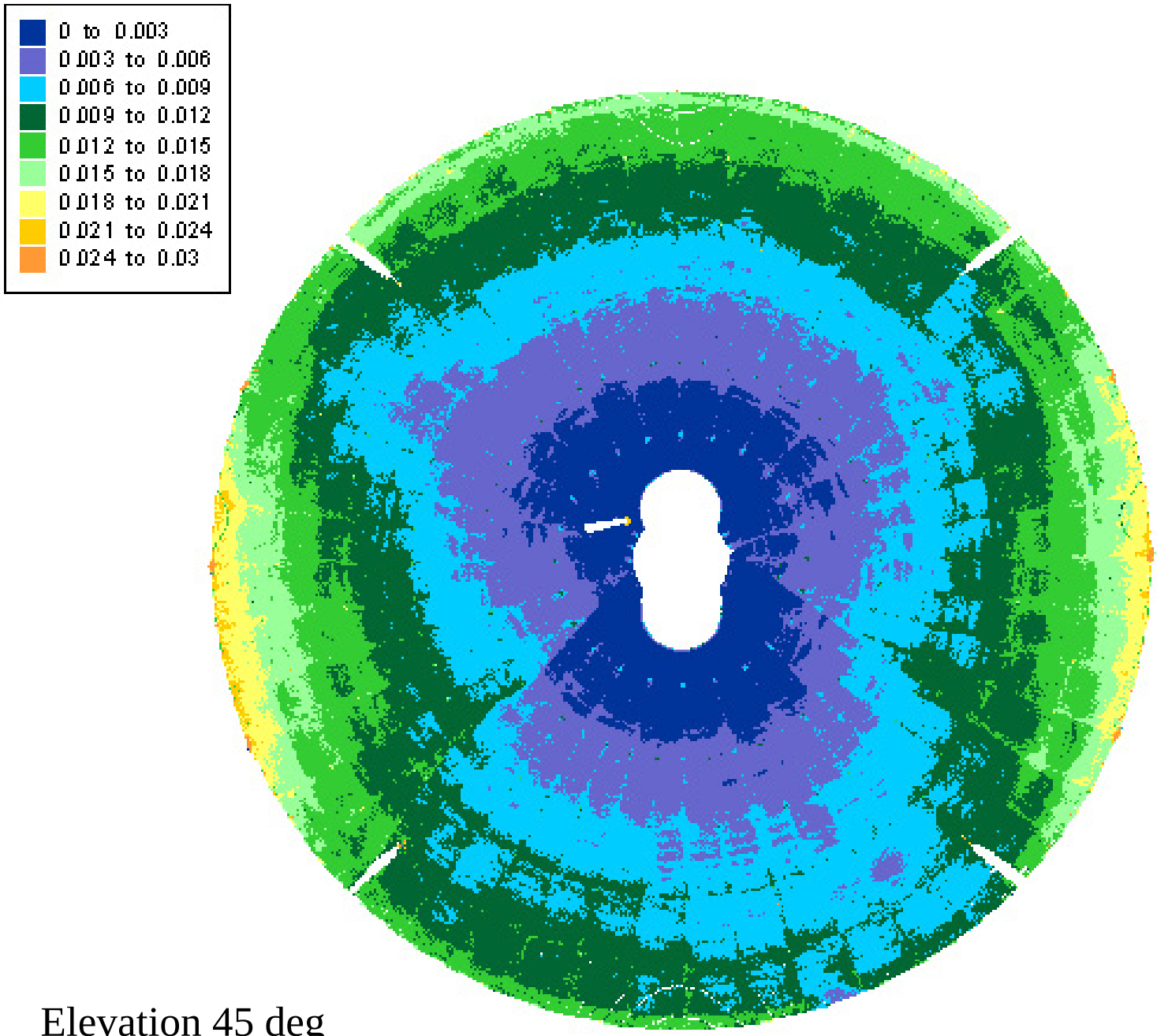
Elevation 90 deg



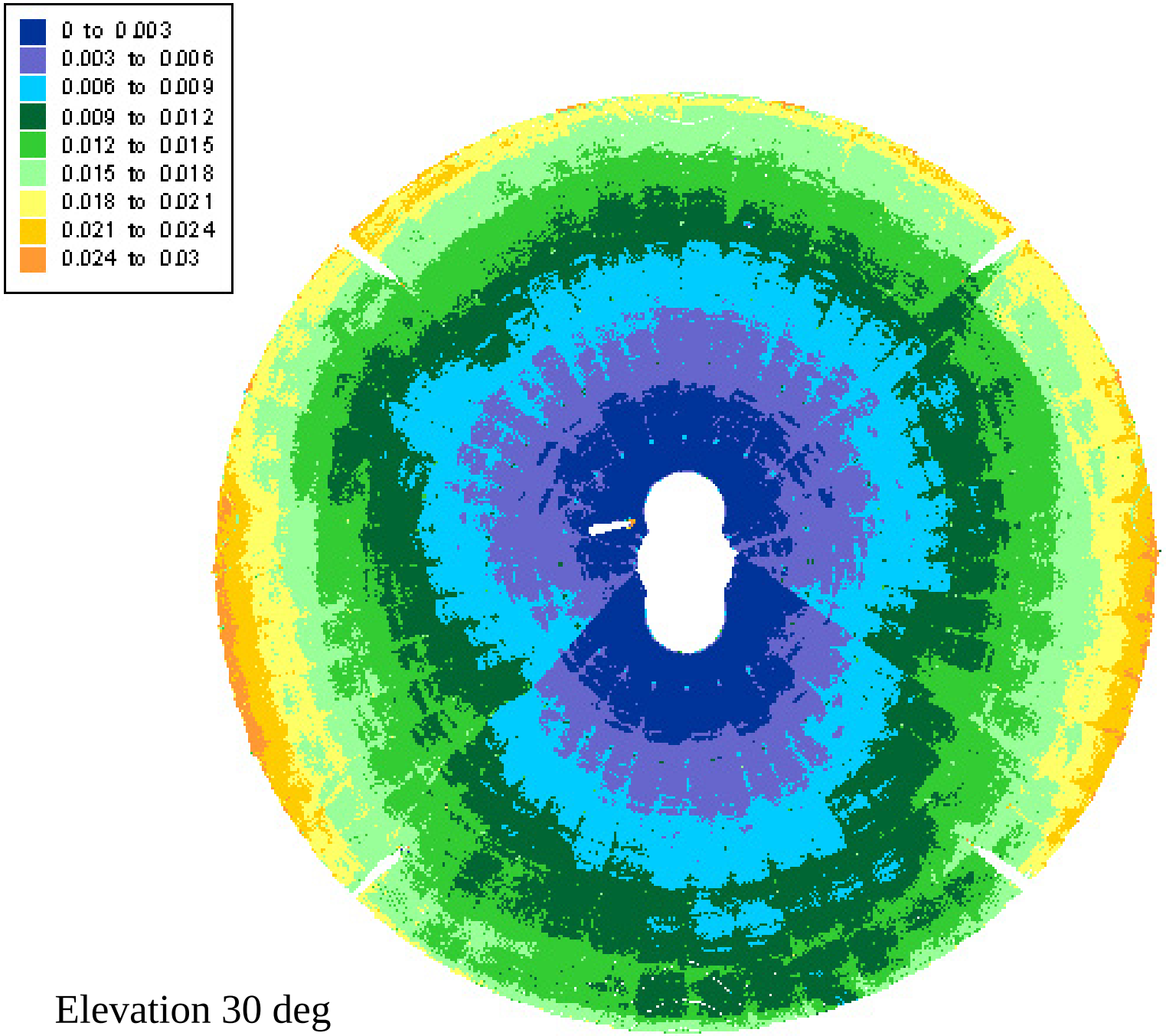
Elevation 75 deg



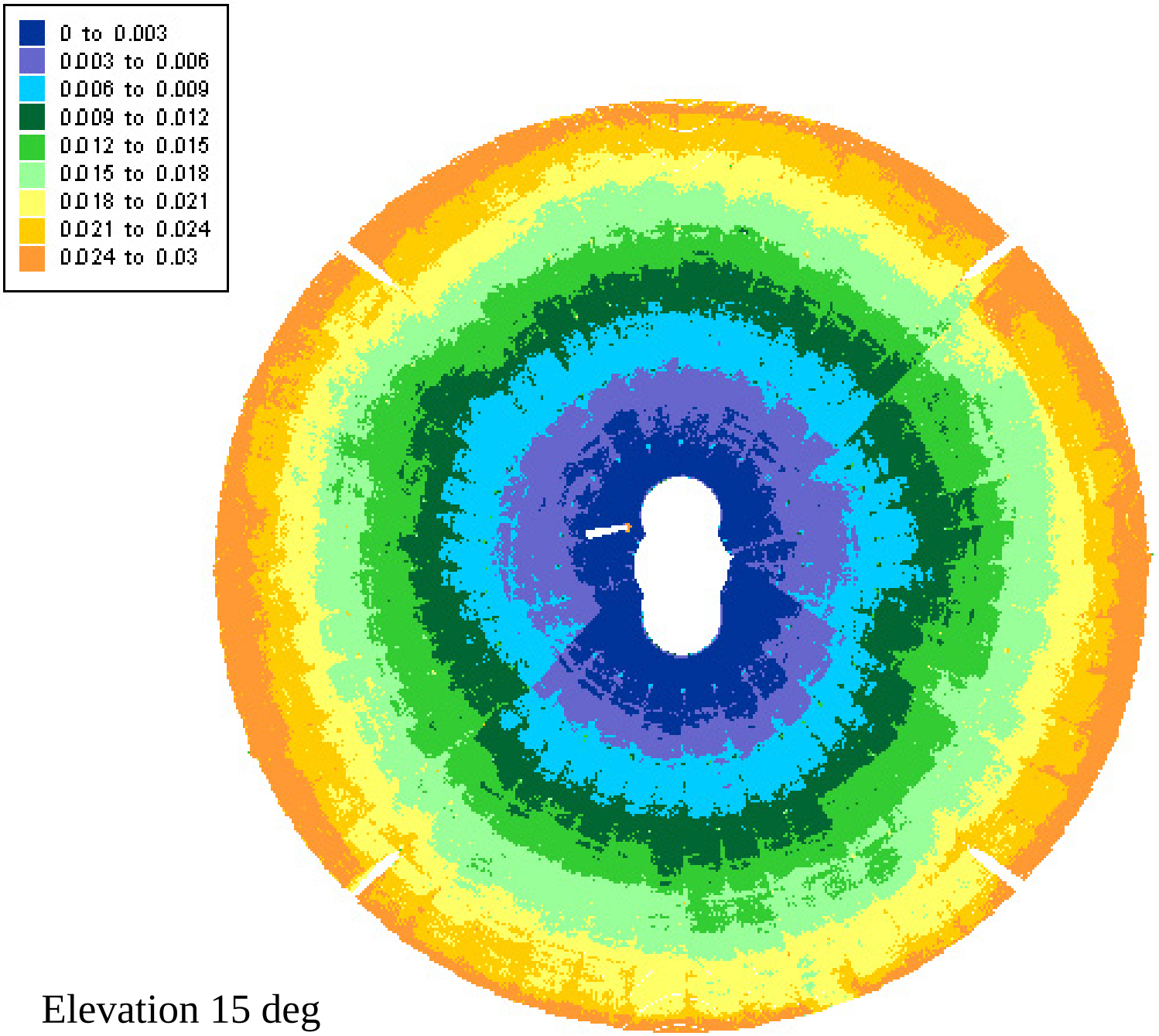
Elevation 60 deg



Elevation 45 deg



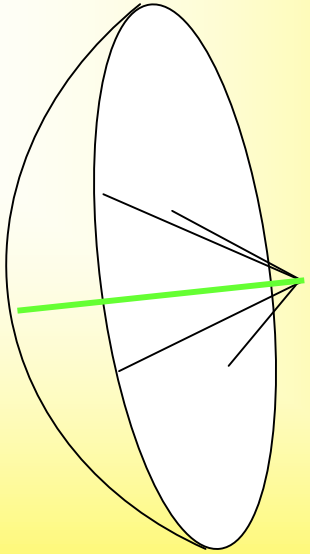
Elevation 30 deg



Elevation 15 deg

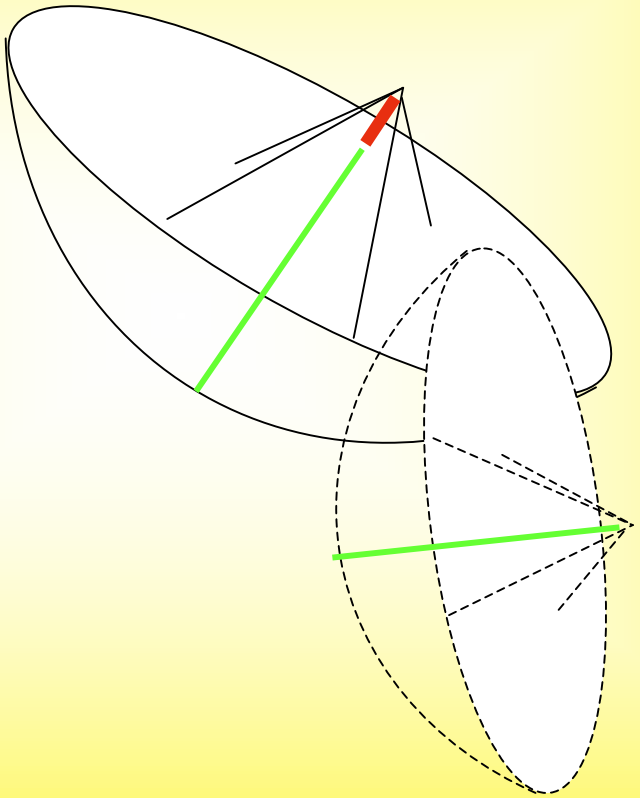
Focal length variation

g

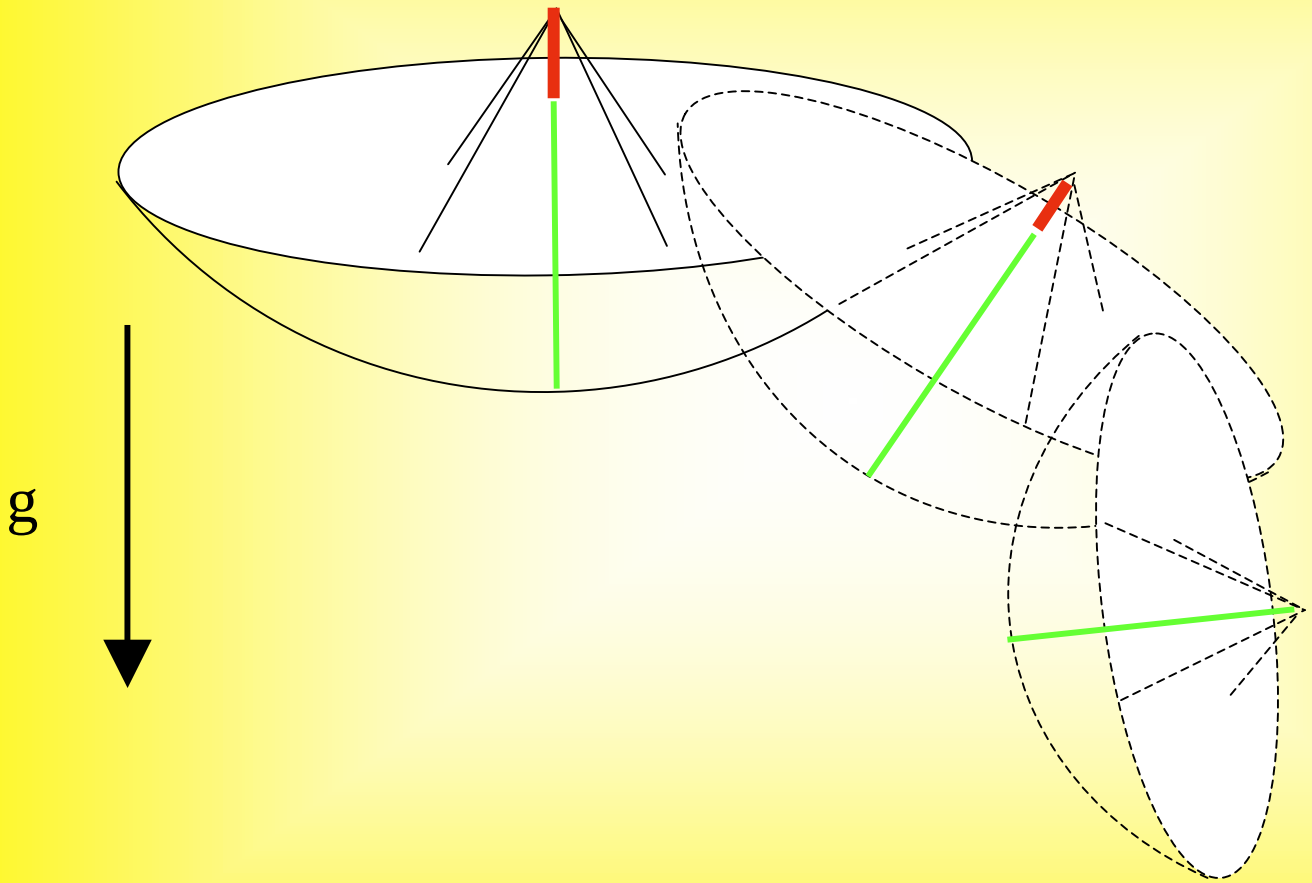


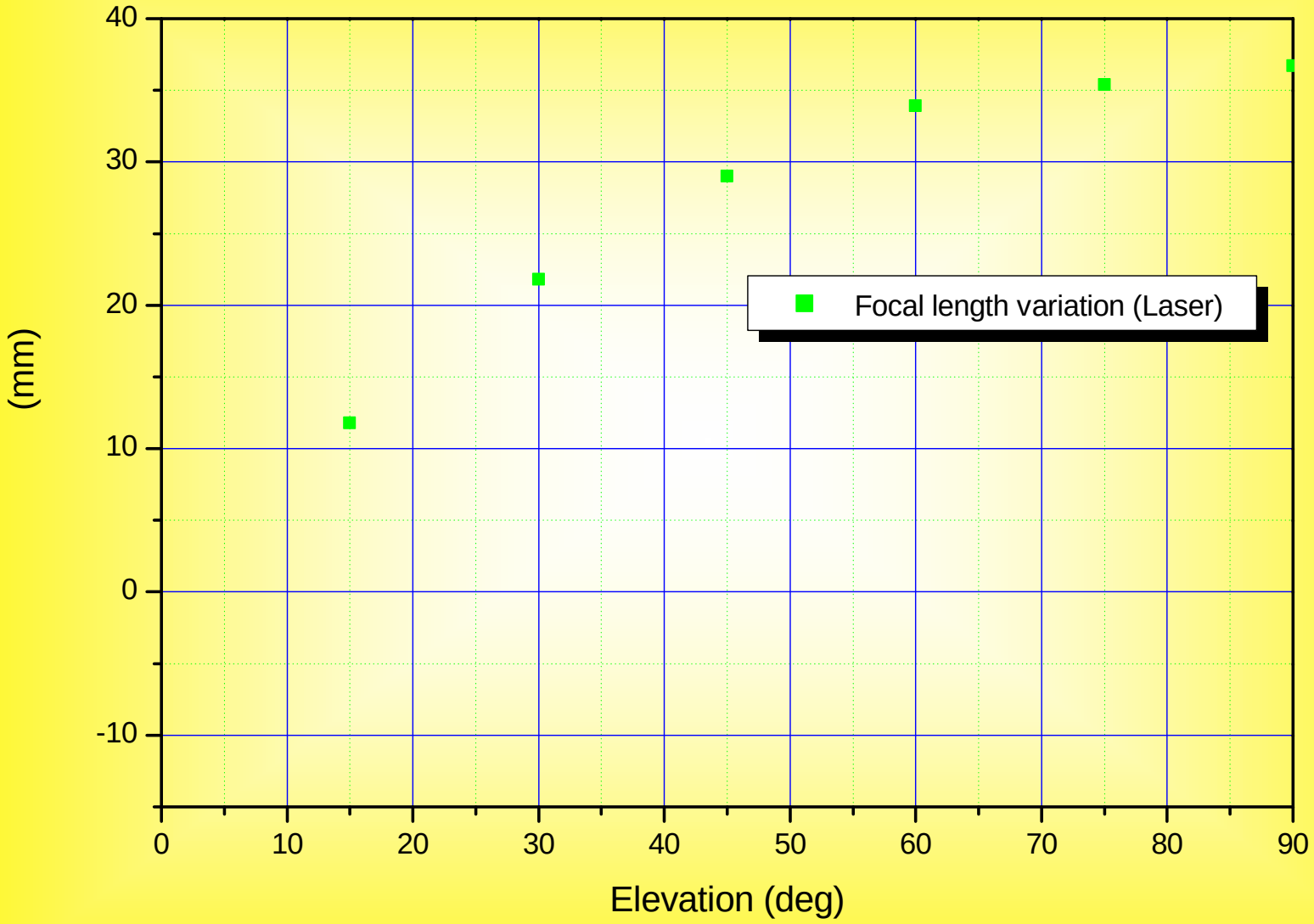
Focal length variation

g



Focal length variation

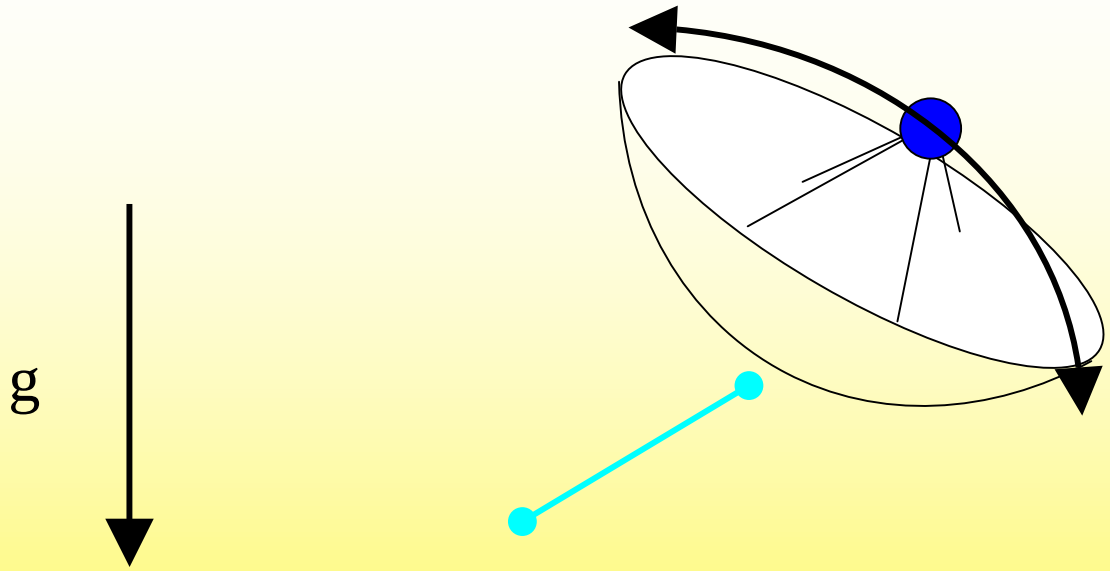



40
30
20
10
0
-10
(mm)
0
10
20
30
40
50
60
70
80
90
Elevation (deg)
Focal length variation (Laser)

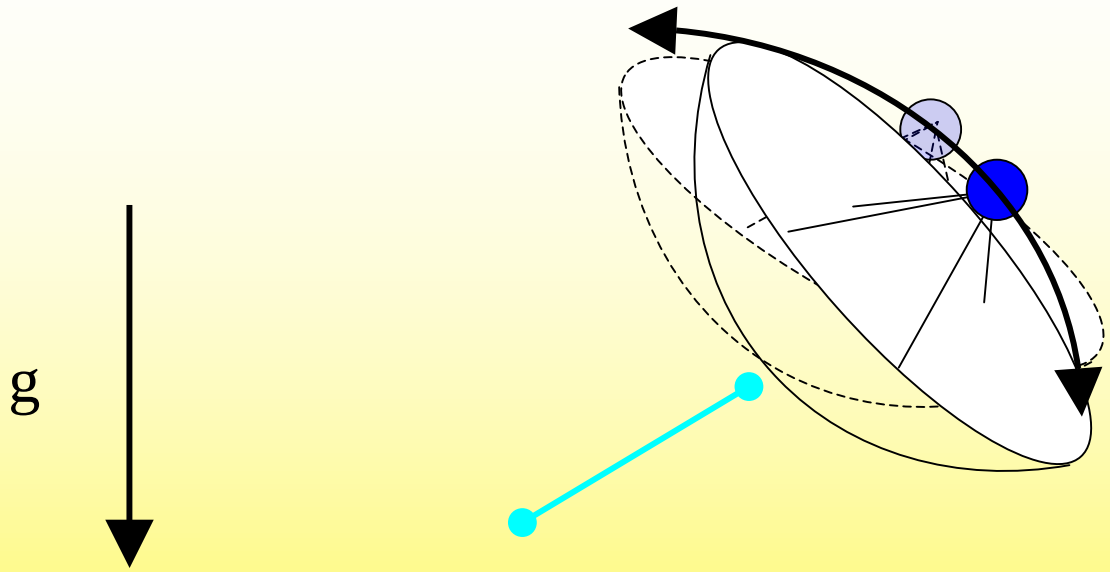
$$\Delta L = \alpha_F \Delta F + \alpha_R \Delta R + \alpha_V \Delta V$$

$$\Delta R$$

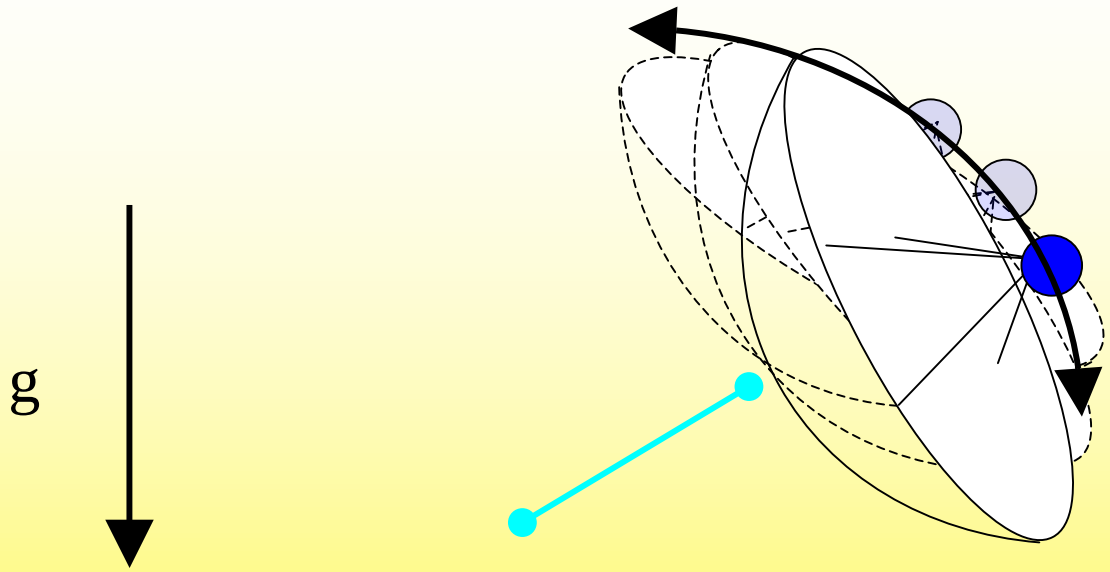
Displacement of the receiver



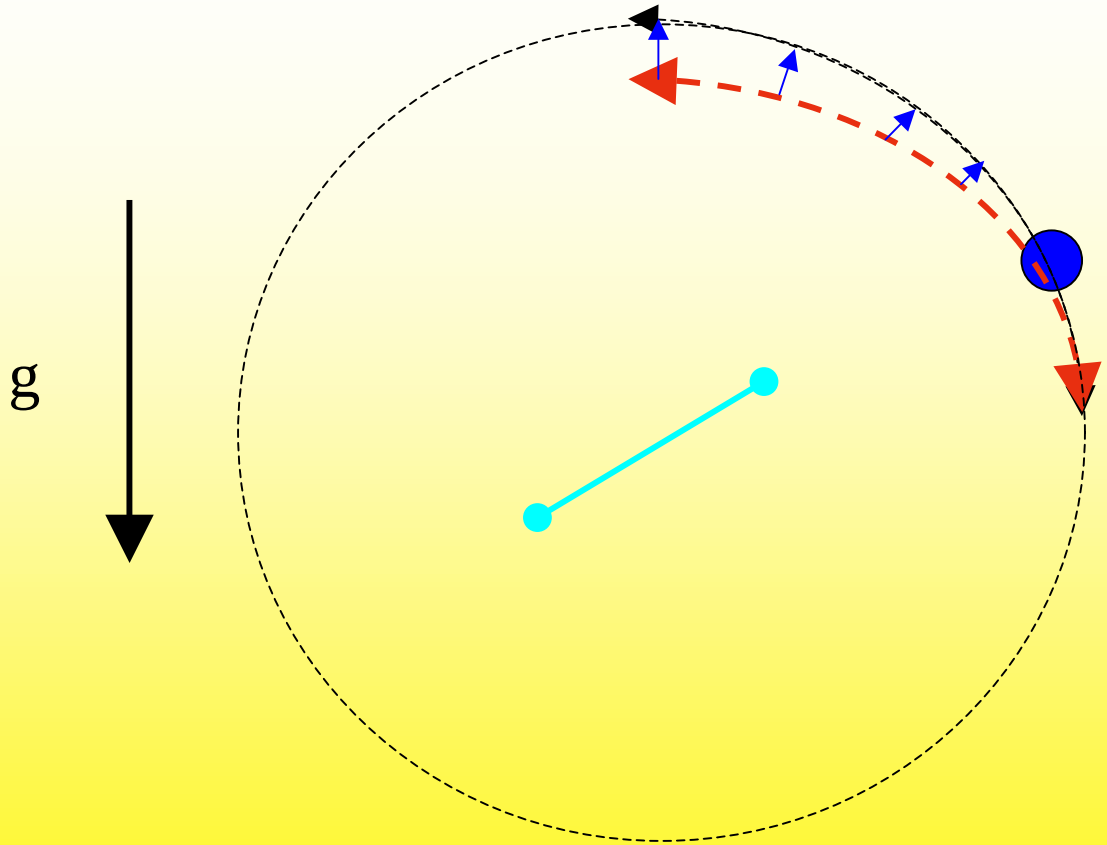
Displacement of the receiver



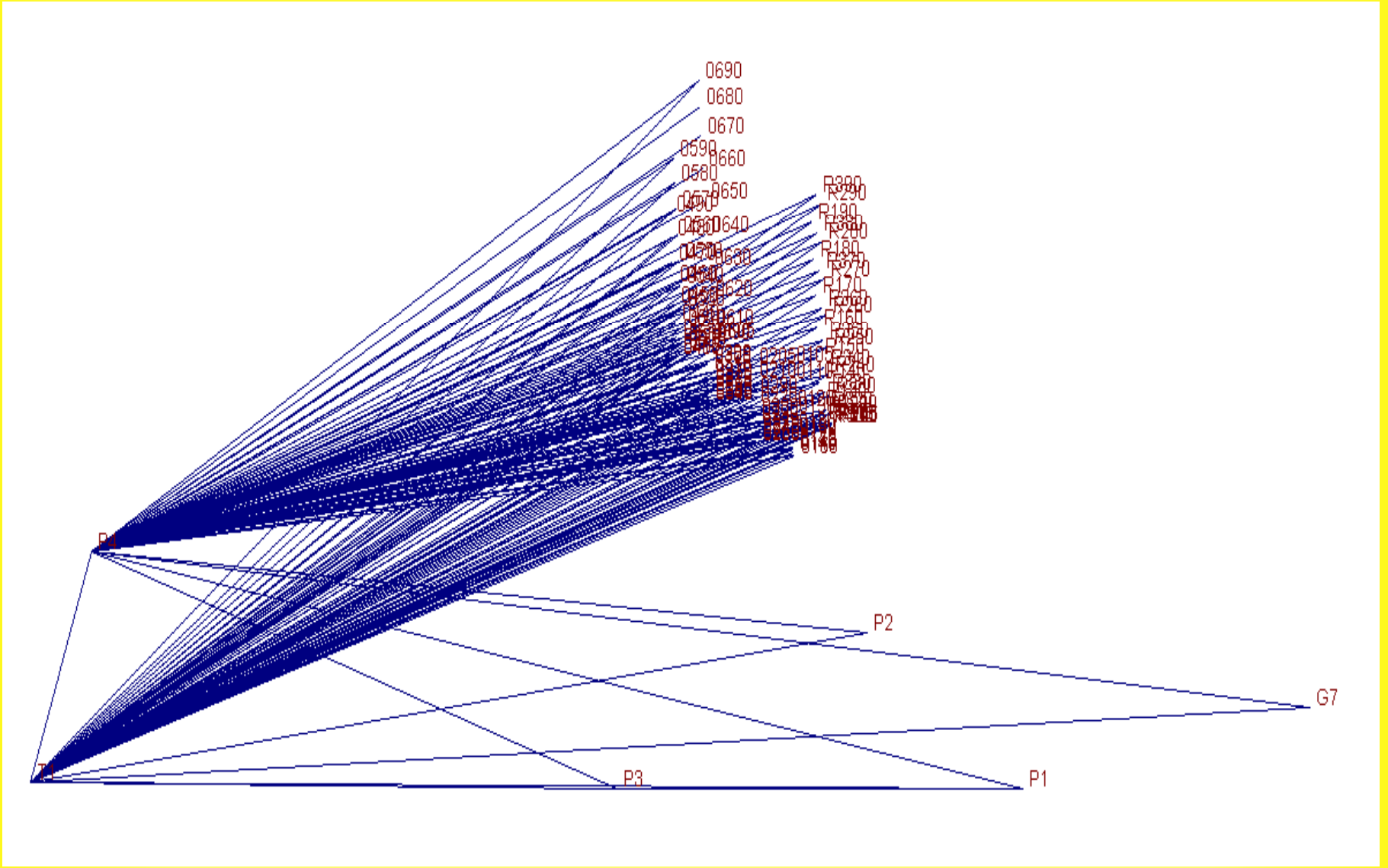
Displacement of the receiver

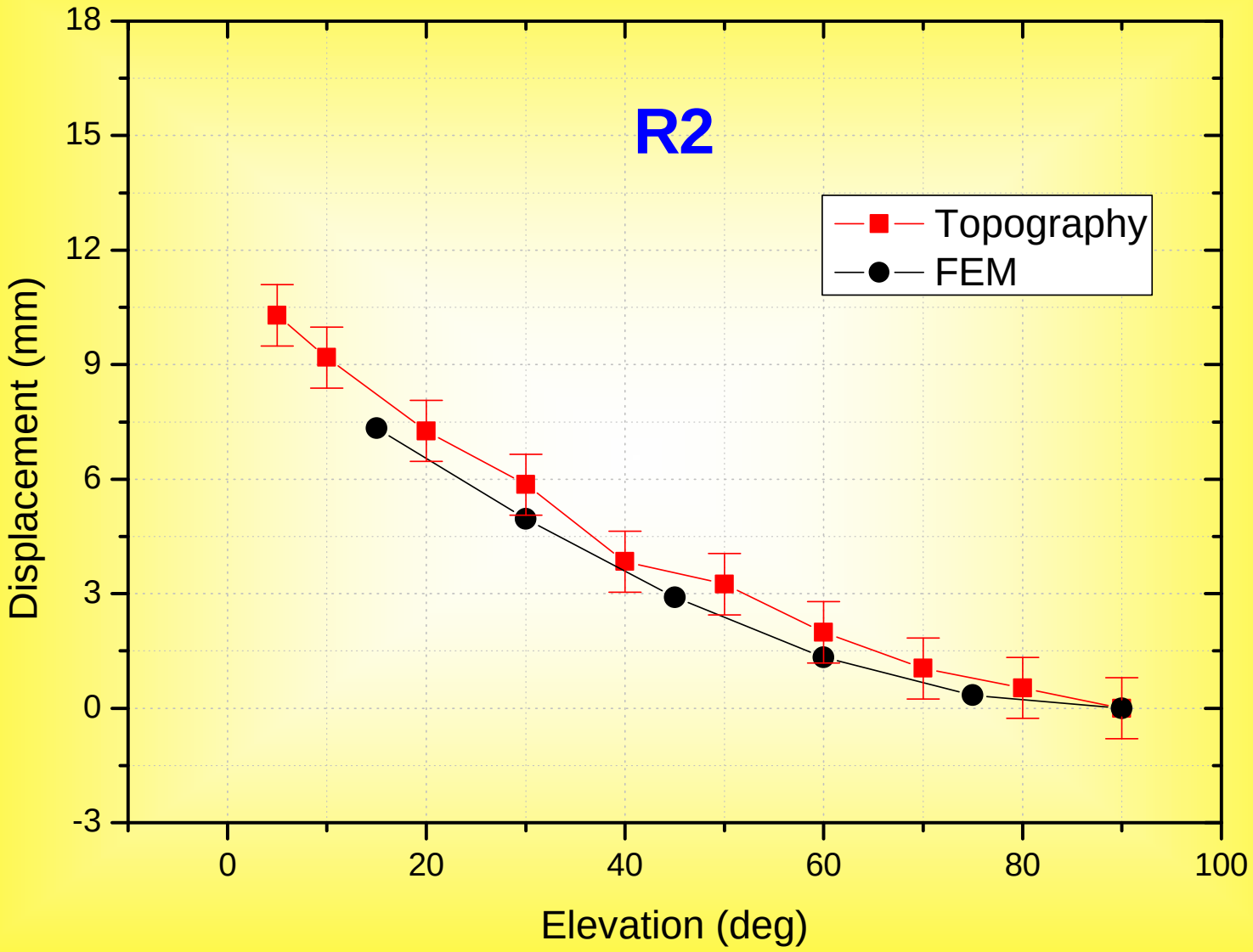


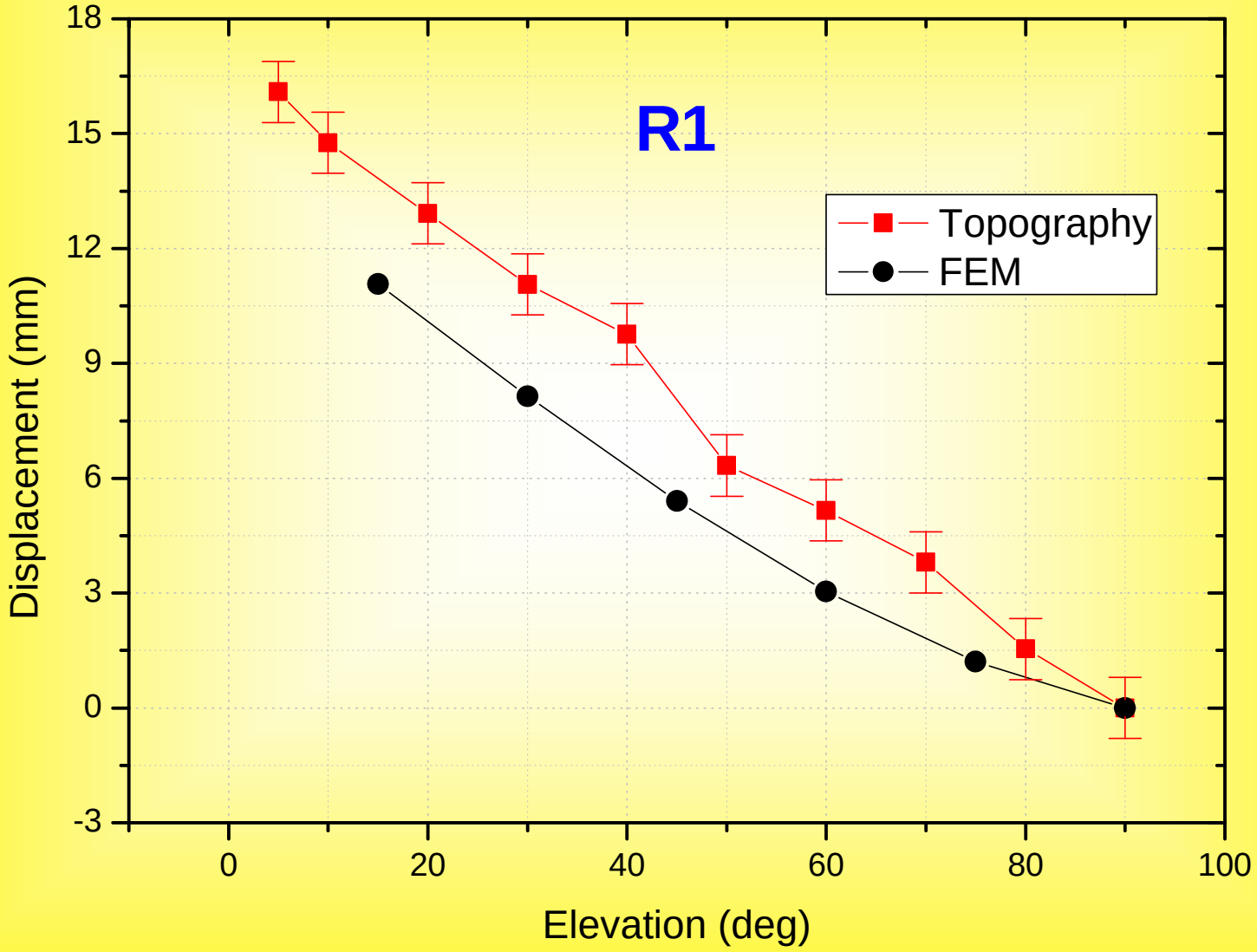
Displacement of the receiver

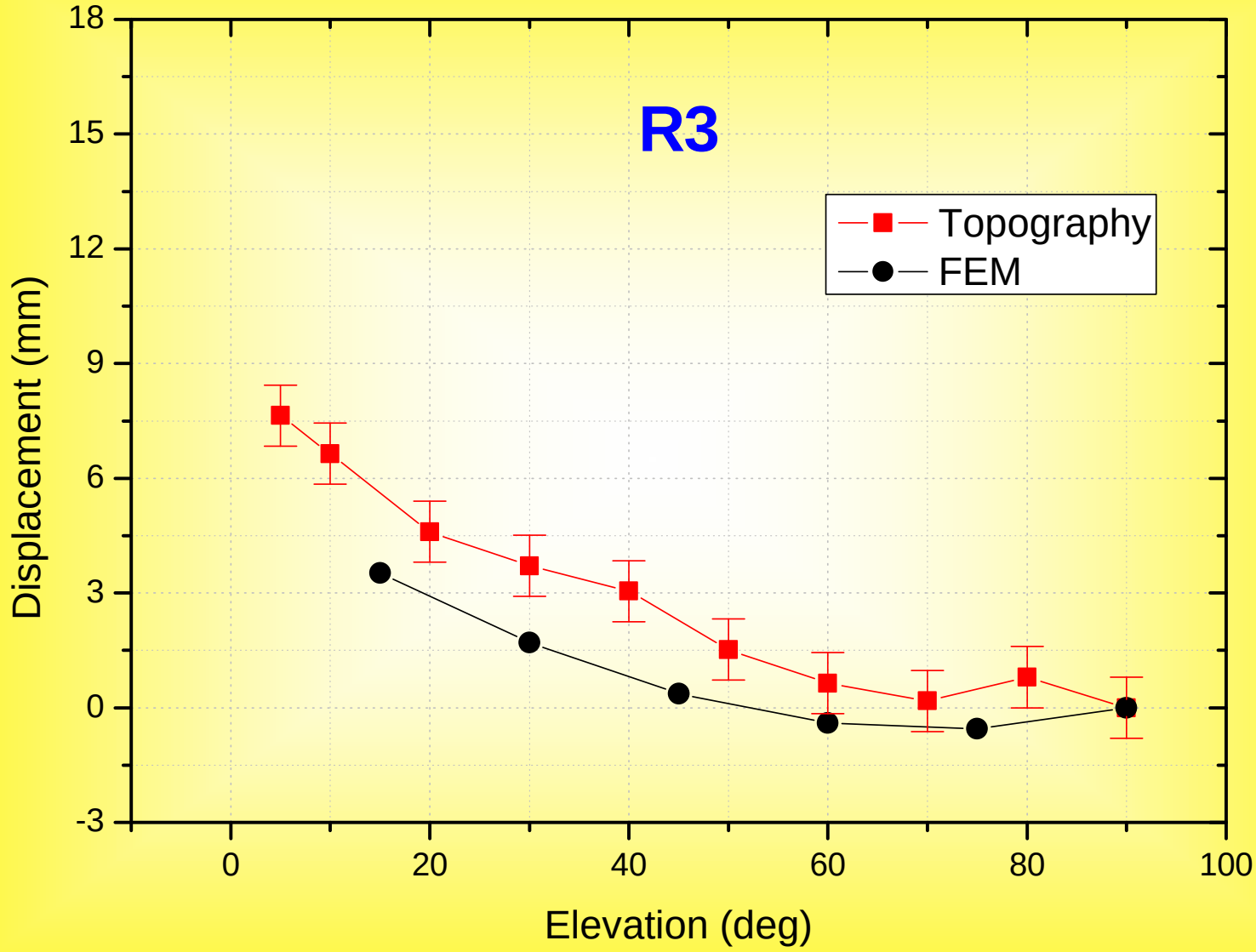


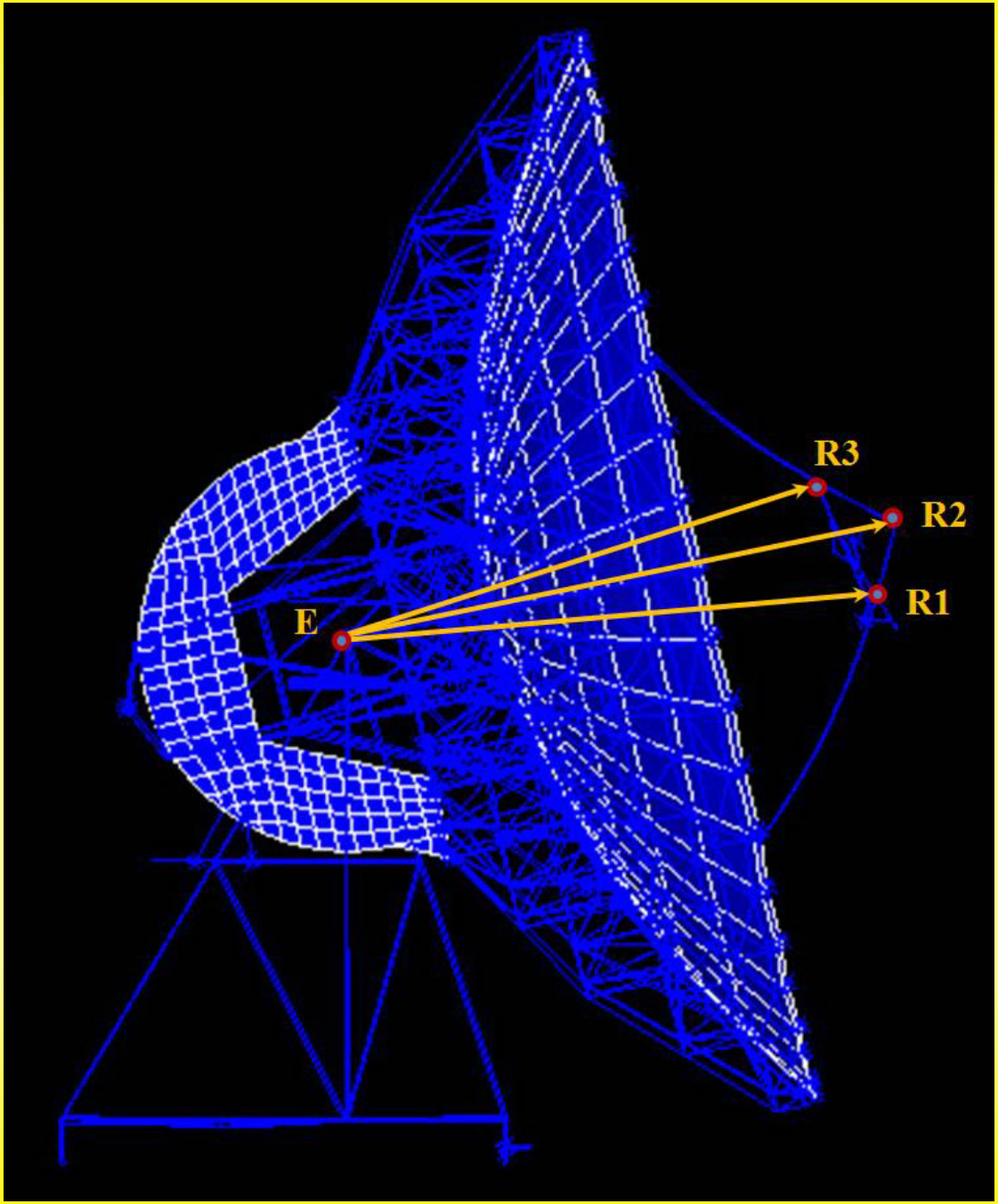

R3
R2
R1

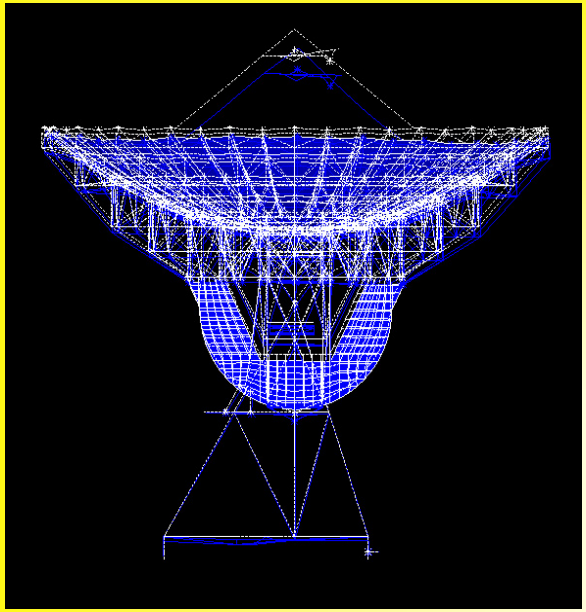
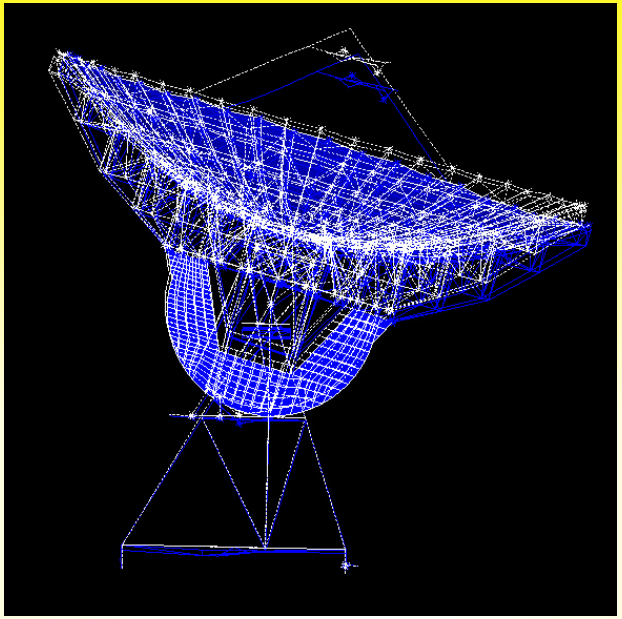
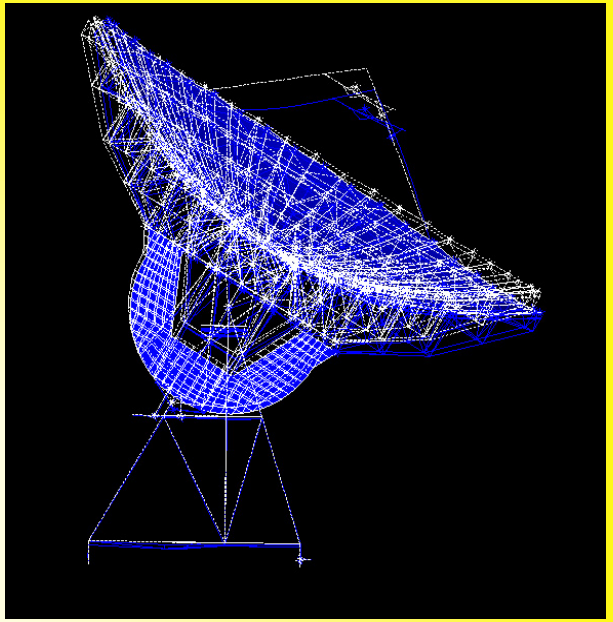
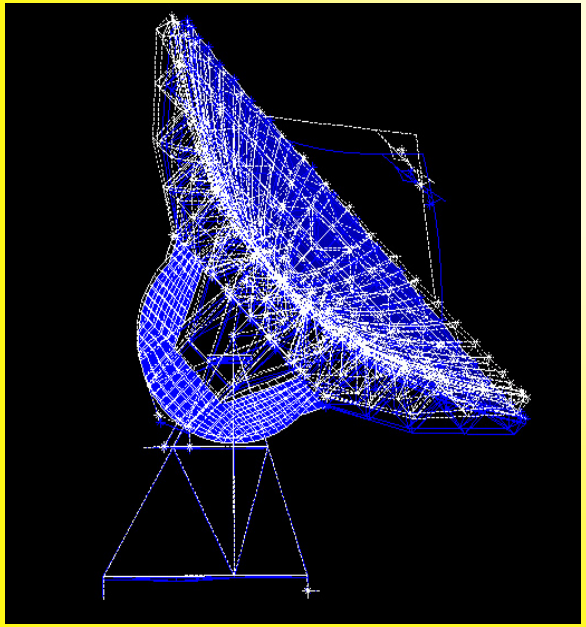
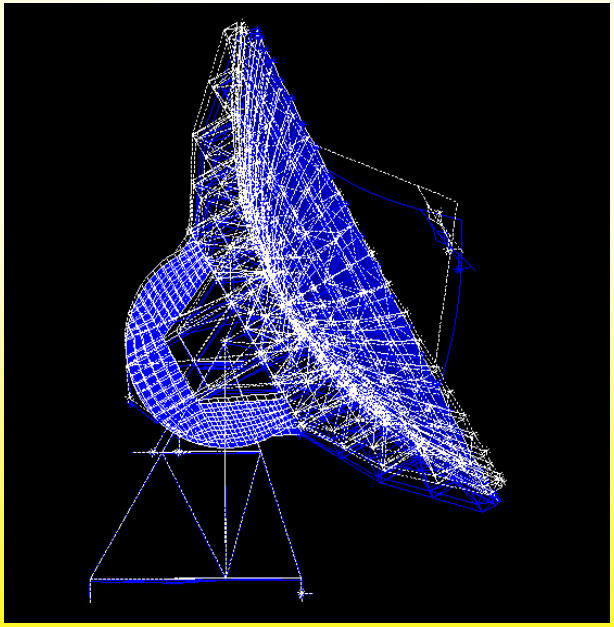
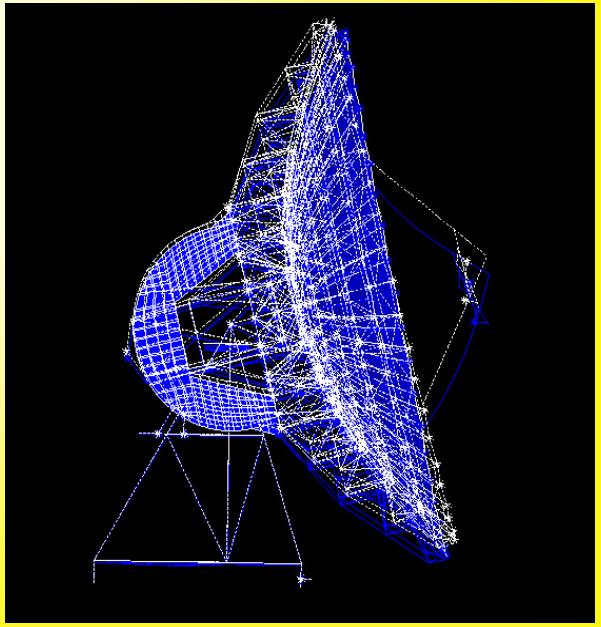

0690
0680
0670
0660
0650
0640
R390
R290
R190
R270
R170
R160
P2
G7
P3
P1

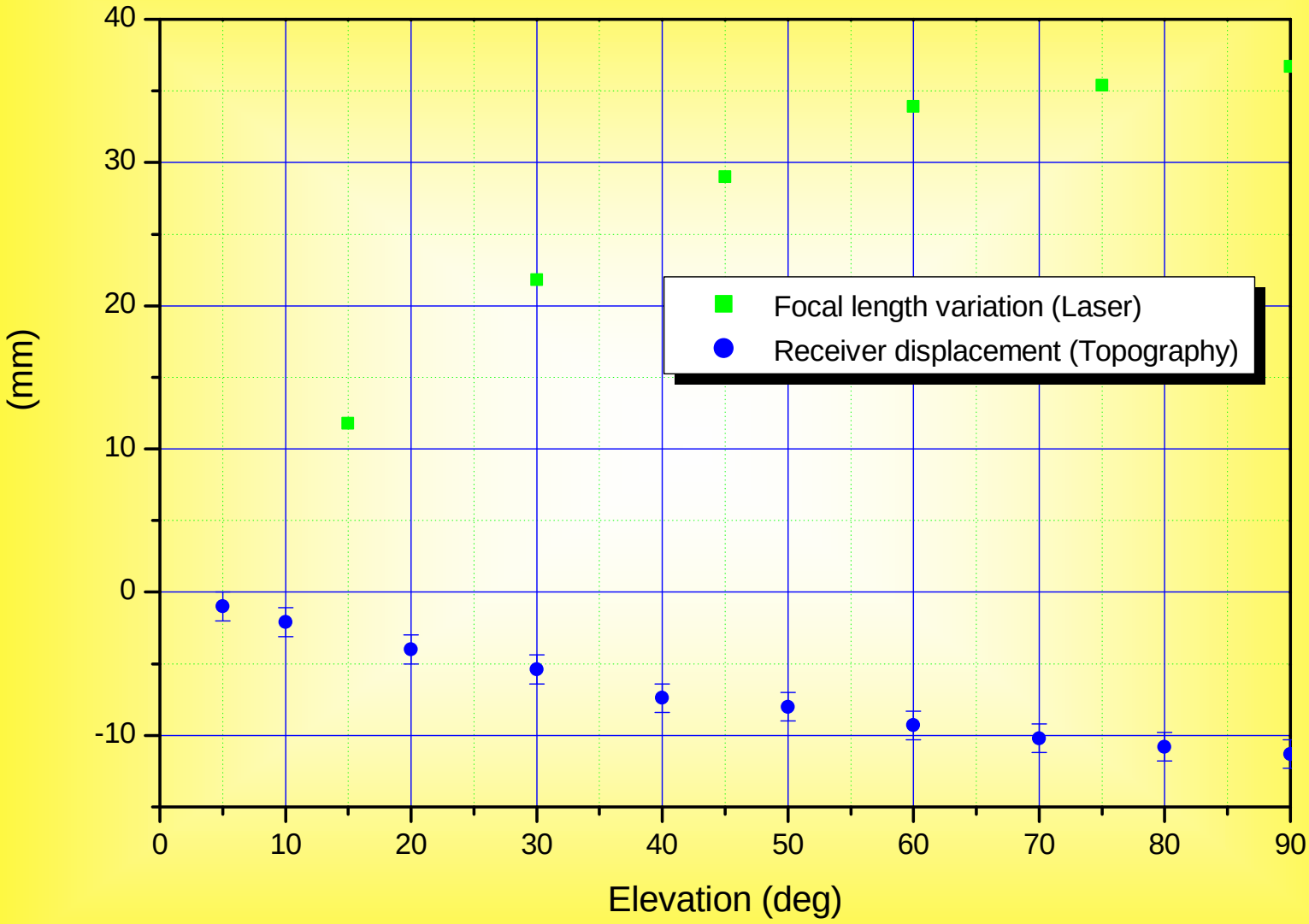

R2
Topography
FEM
Displacement (mm)
Elevation (deg)
18
15
12
9
6
3
0
-3
0
20
40
60
80
100


R1
Topography
FEM
Displacement (mm)
Elevation (deg)
18
15
12
9
6
3
0
-3
0
20
40
60
80
100


R3
Topography
FEM
Displacement (mm)
Elevation (deg)
18
15
12
9
6
3
0
-3
0
20
40
60
80
100

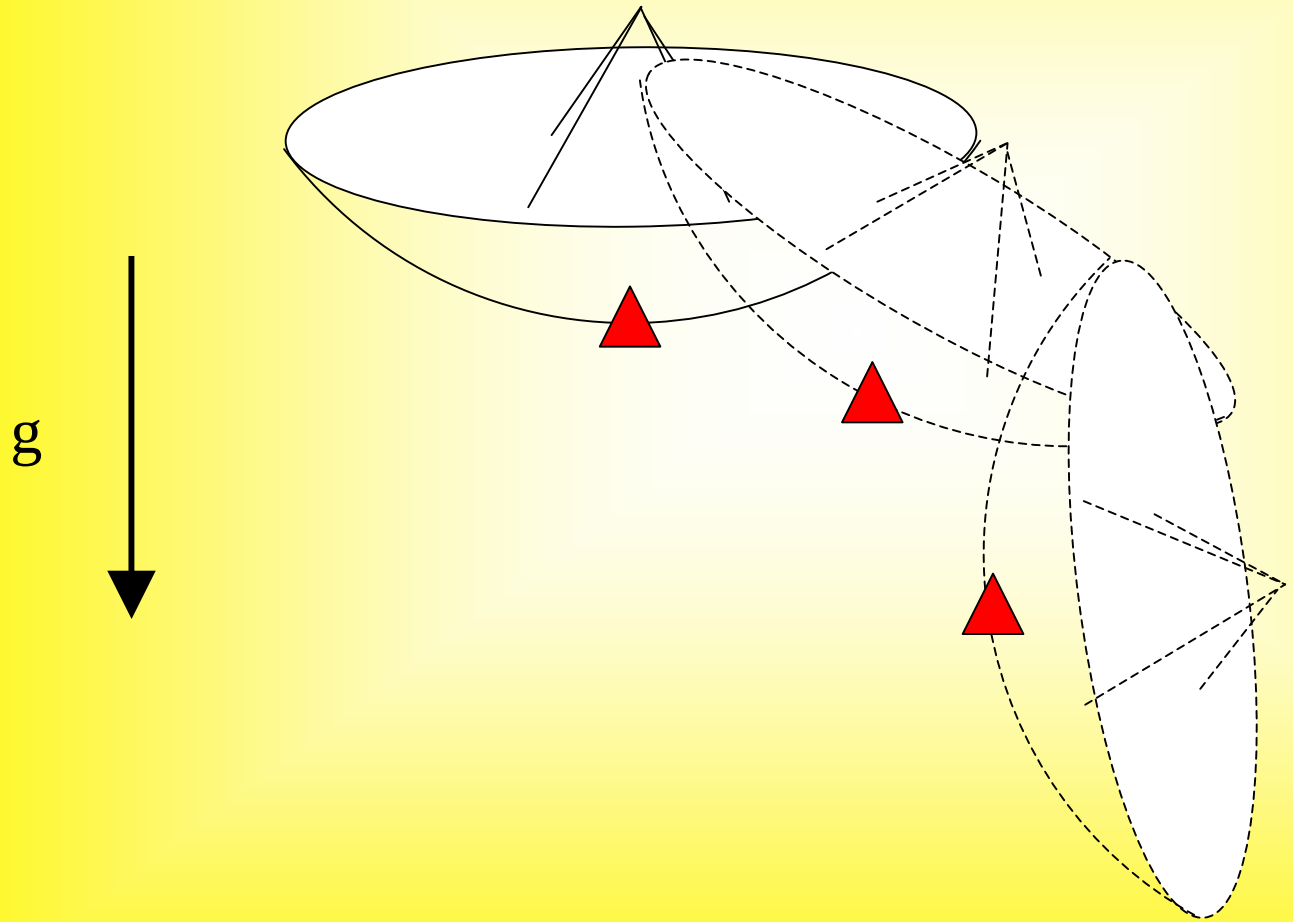

R3
R2
R1
E

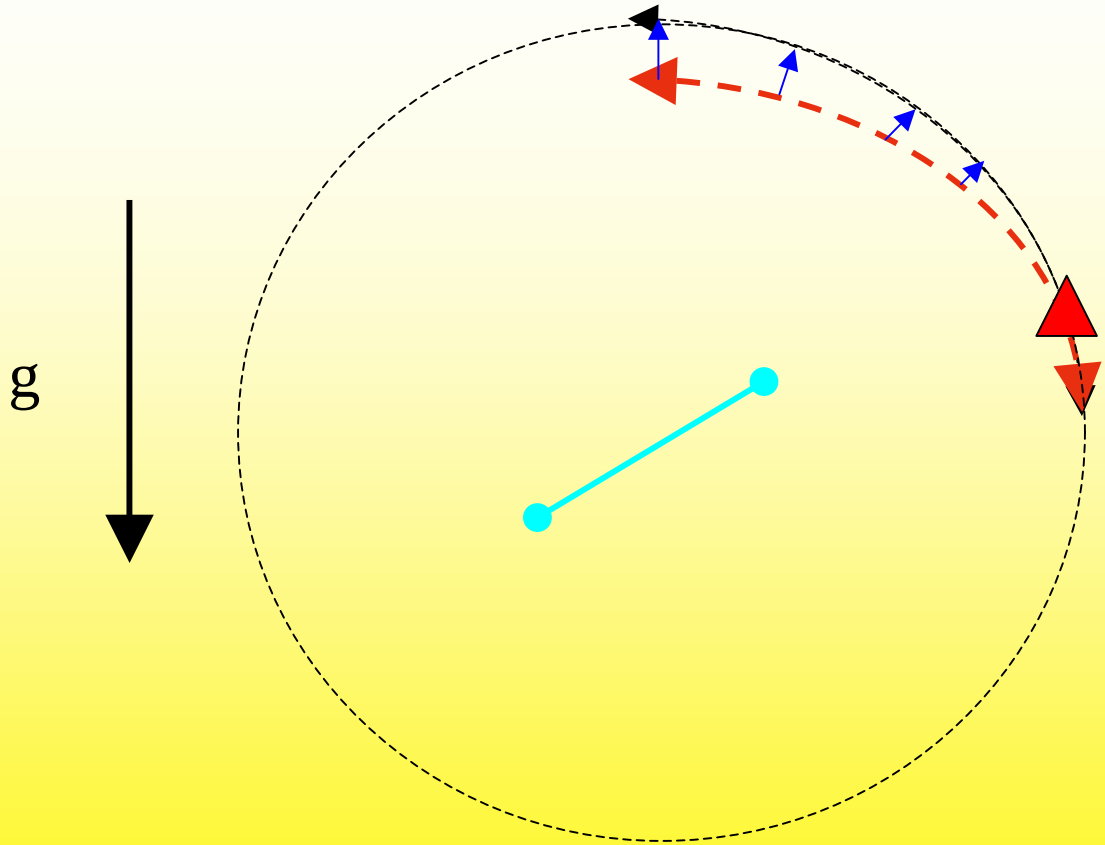

40
30
20
10
0
-10
(mm)
0
10
20
30
40
50
60
70
80
90
Elevation (deg)
Focal length variation (Laser)
Receiver displacement (Topography)

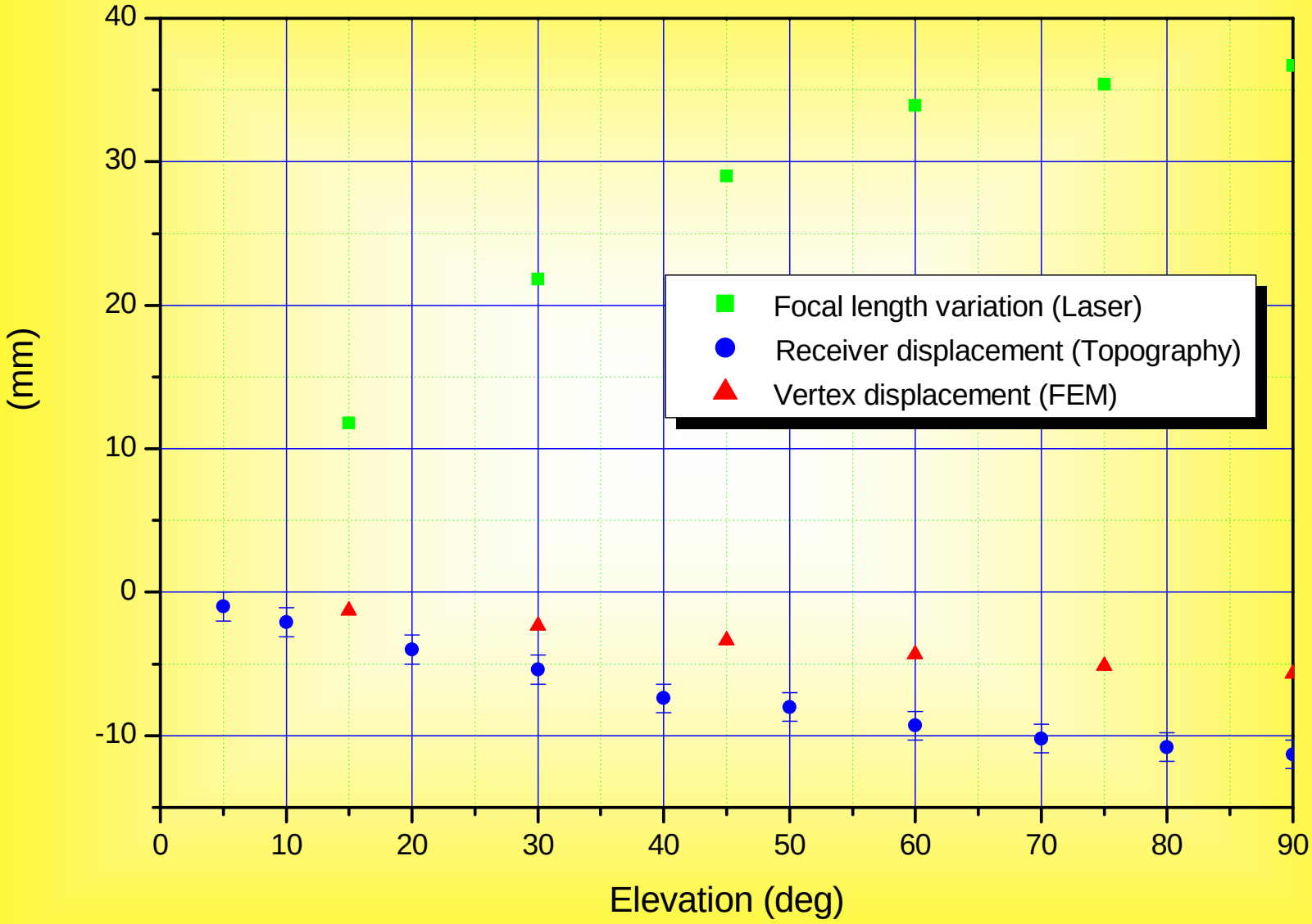
$$\Delta L = \alpha_R \Delta R + \alpha_V \Delta V + \alpha_F \Delta F$$

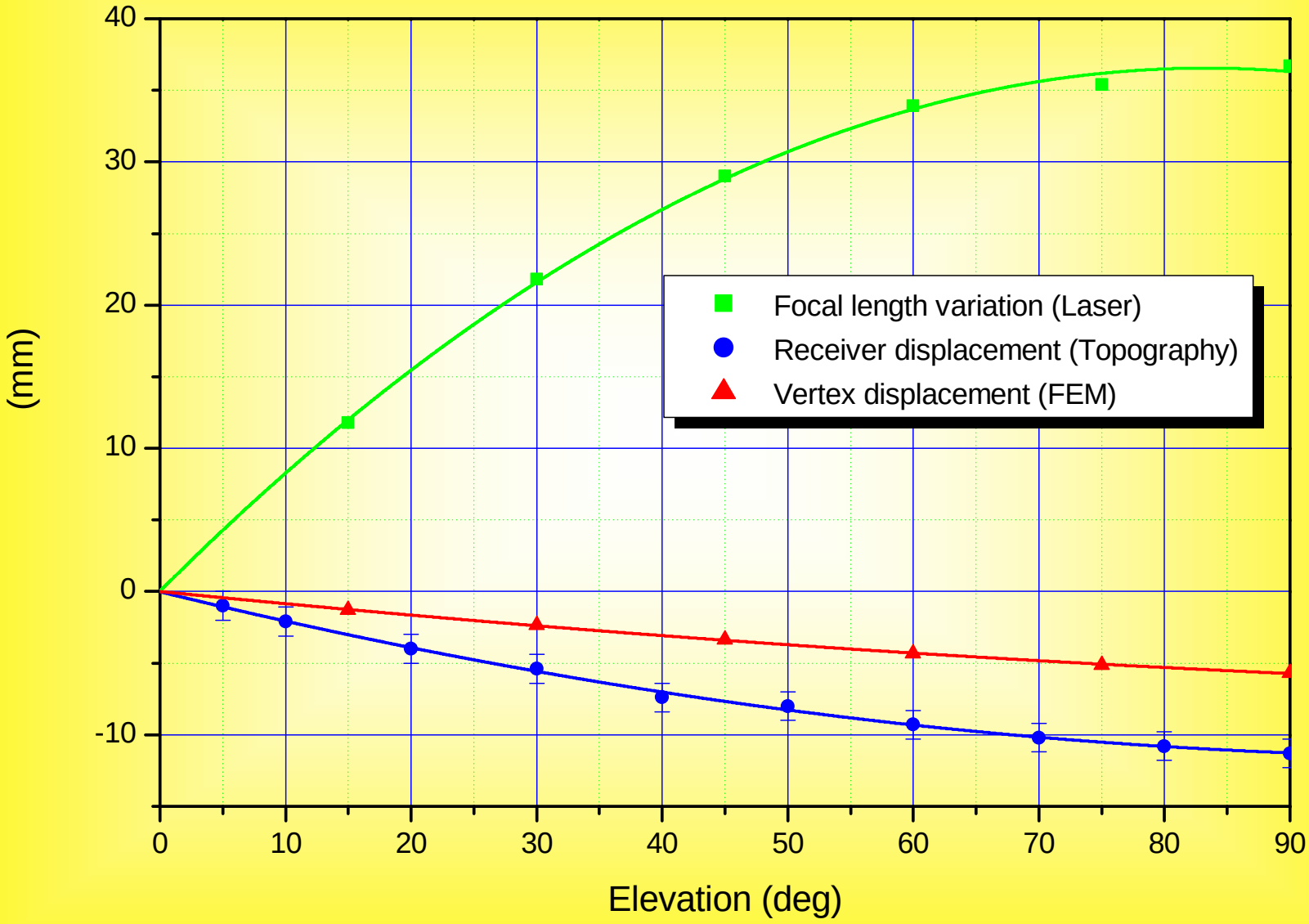
$$\Delta V$$


g

Displacement of the vertex




40
30
20
10
0
-10
(mm)
0
10
20
30
40
50
60
70
80
90
Elevation (deg)
Focal length variation (Laser)
Receiver displacement (Topography)
Vertex displacement (FEM)

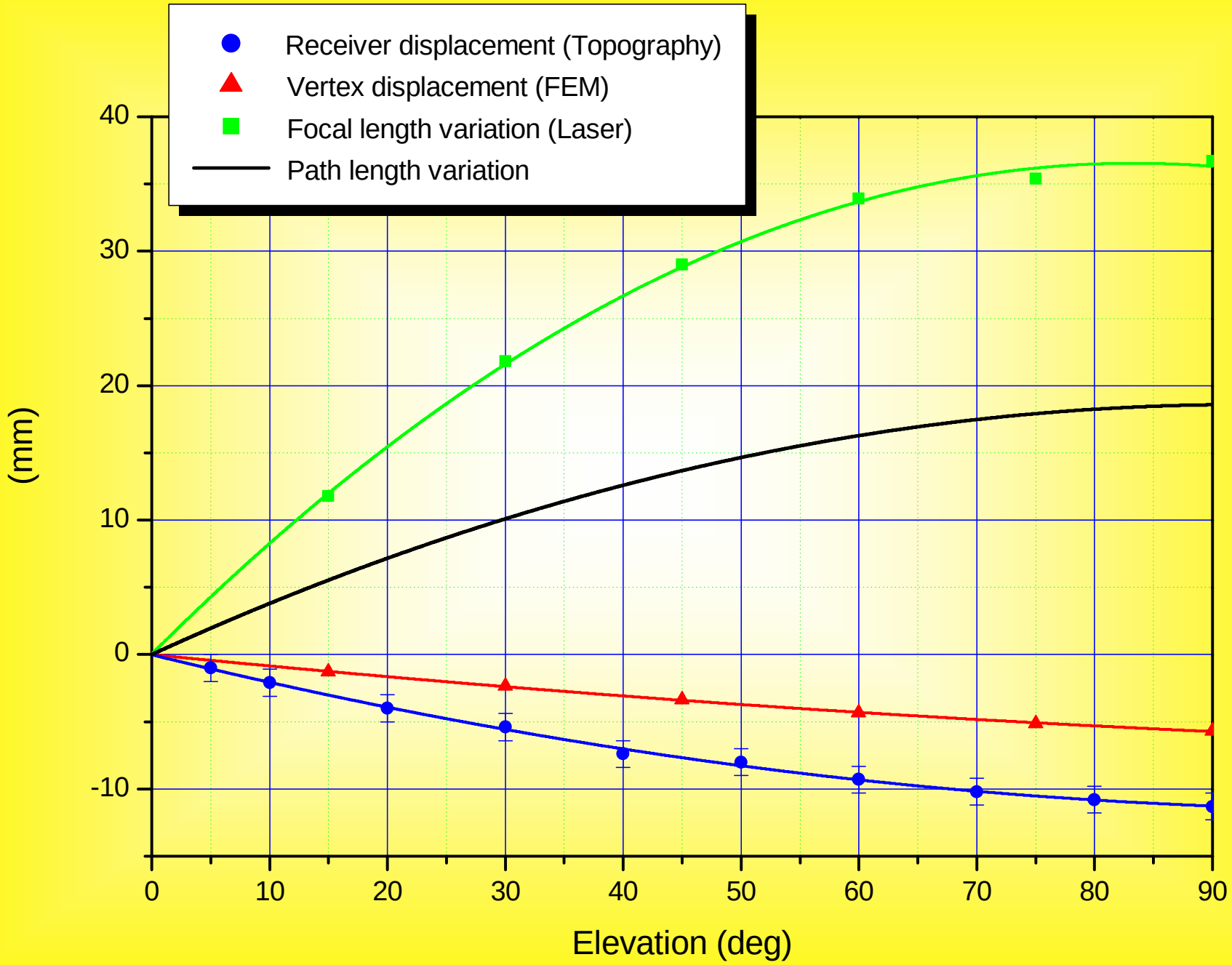

40
30
20
10
0
-10
(mm)
0
10
20
30
40
50
60
70
80
90
Elevation (deg)
Focal length variation (Laser)
Receiver displacement (Topography)
Vertex displacement (FEM)

$$\Delta L = \alpha_R \Delta R + \alpha_V \Delta V + \alpha_F \Delta F$$

$$\alpha_R = \frac{8 f^2}{r_0^2} \ln\left(1 + \frac{r_0^2}{4 f^2}\right) - 1 = 0.56$$

$$\alpha_F = 1 - \alpha_R = 0.44$$

$$\alpha_V = -1 - \alpha_R = -1.56$$


Receiver displacement (Topography)
Vertex displacement (FEM)
Focal length variation (Laser)
Path length variation
40
30
20
10
0
-10
(mm)
0
10
20
30
40
50
60
70
80
90
Elevation (deg)