EME antenna and Jupiter noise on 77 GHz

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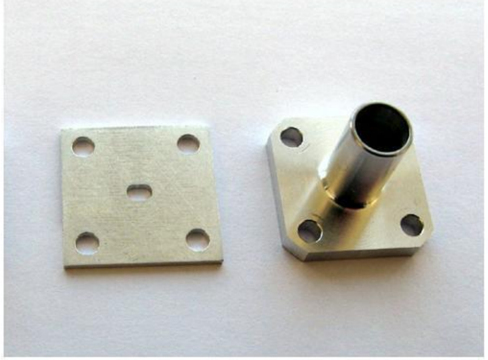
EME 2014
Pleumeur-Bodou (France)

Antenna

Offset dish

Material	2.5 mm Al
Diameter	2400 mm
Focal length	1380 mm

HPBW	0.11°
Gain	62.5 dBi

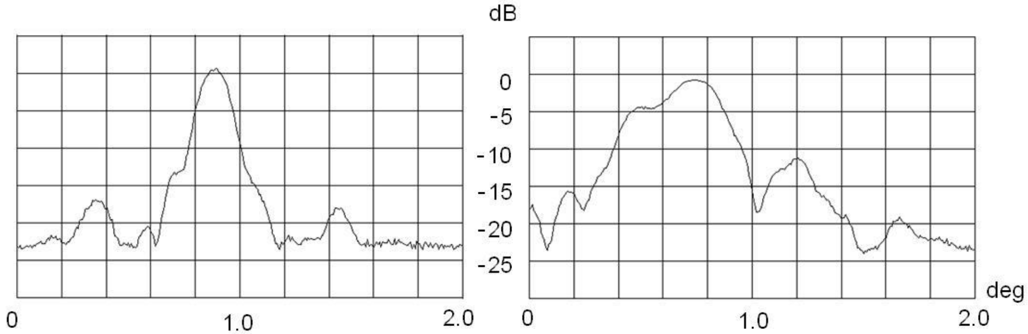


Skobelev DMH (RA3AQ)

First antenna pattern measurement

November 2010

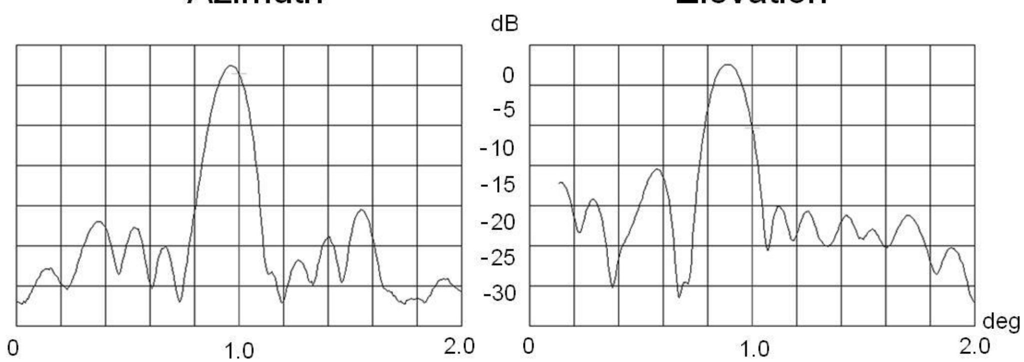
Azimuth Elevaion



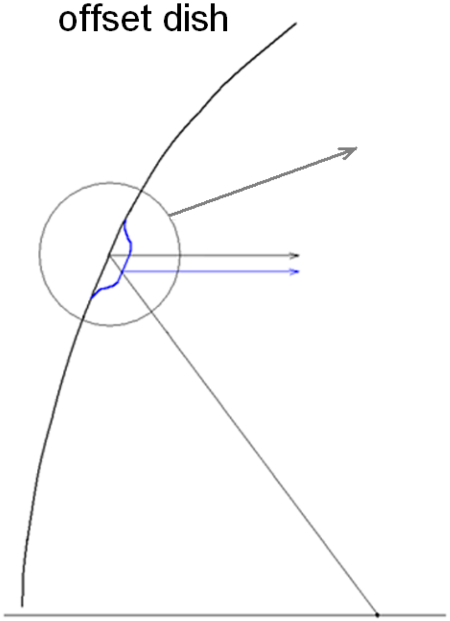
First simple dielectric lens

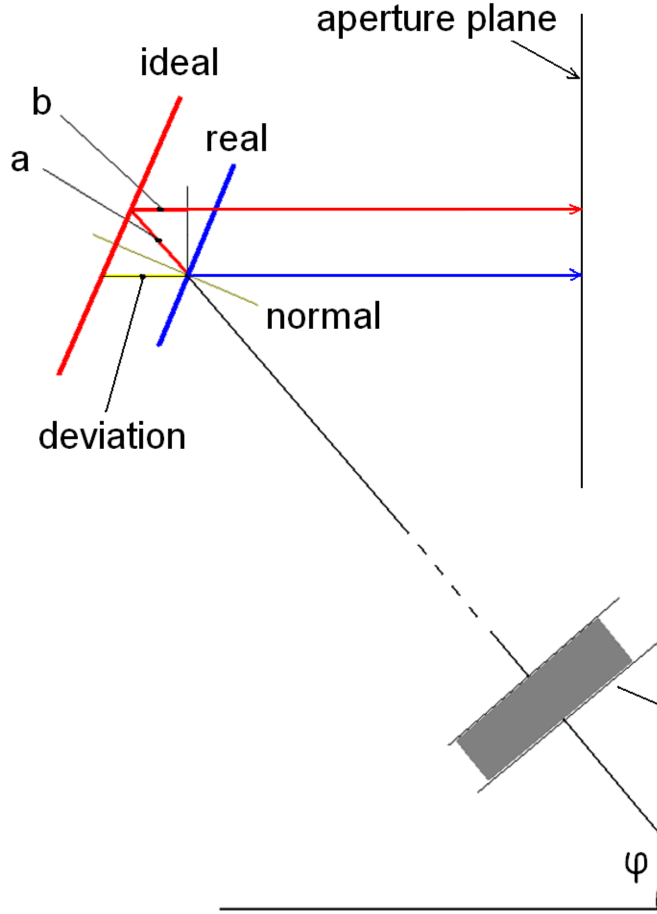
June 2011

Azimuth Elevation



Dielectric lens





d - axis deviation

δ - wave path deviation

$\delta = a + b;\ \ a = d;\ \ b = d\cos\varphi$

$$\boxed{\delta = -d(\cos\varphi + 1)}$$

δ' - add path in dielectric

$$\boxed{\delta' = h(\sqrt{\varepsilon} - 1)}$$

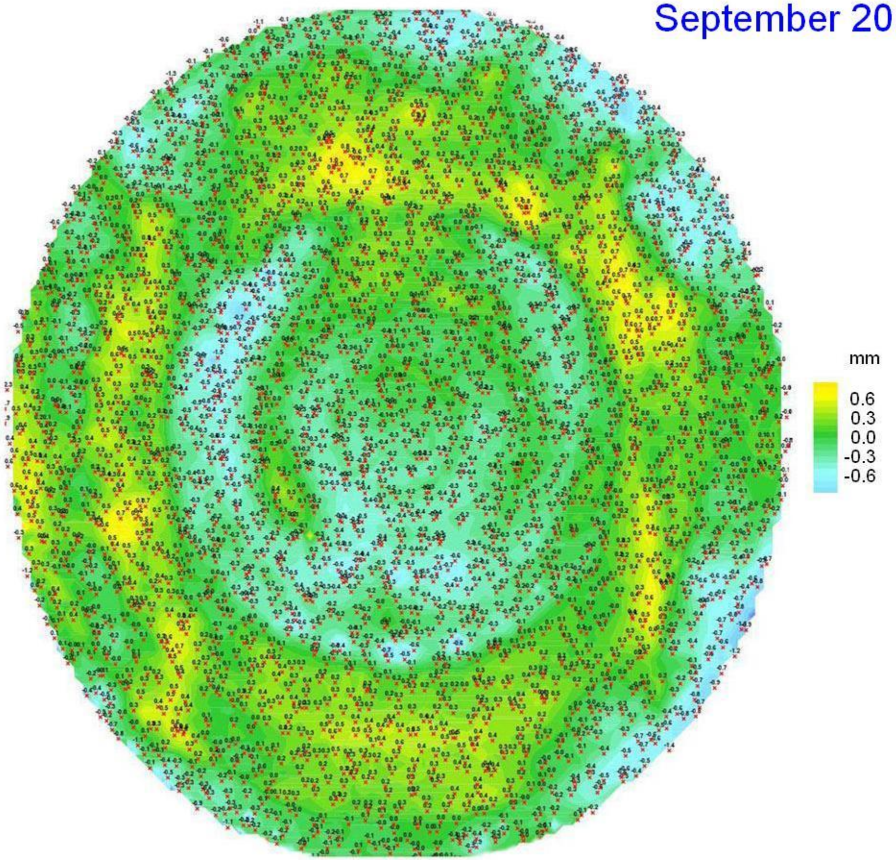
To compensate deviation: $\delta + \delta' = 0$

$$\boxed{h = \frac{d(\cos\varphi + 1)}{(\sqrt{\varepsilon} - 1)}}$$

Map of deviations

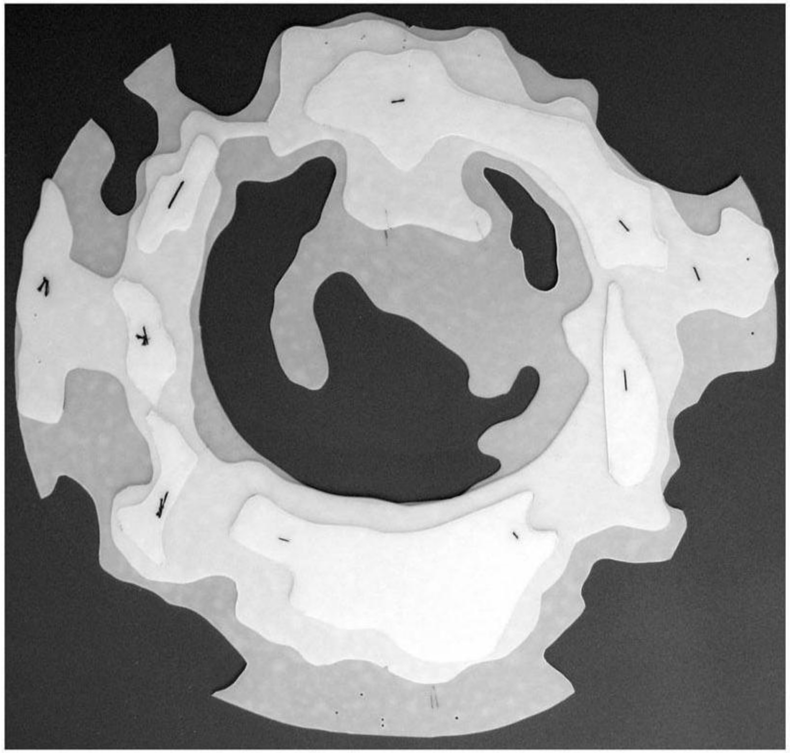
RMS = 0.31 mm

September 2011



Dielectric lens

Three 1 mm PTFE layers



Ruze Equation

$$L_R = -685\left(\frac{rms}{\lambda}\right)^2 \text{ (dB)}$$

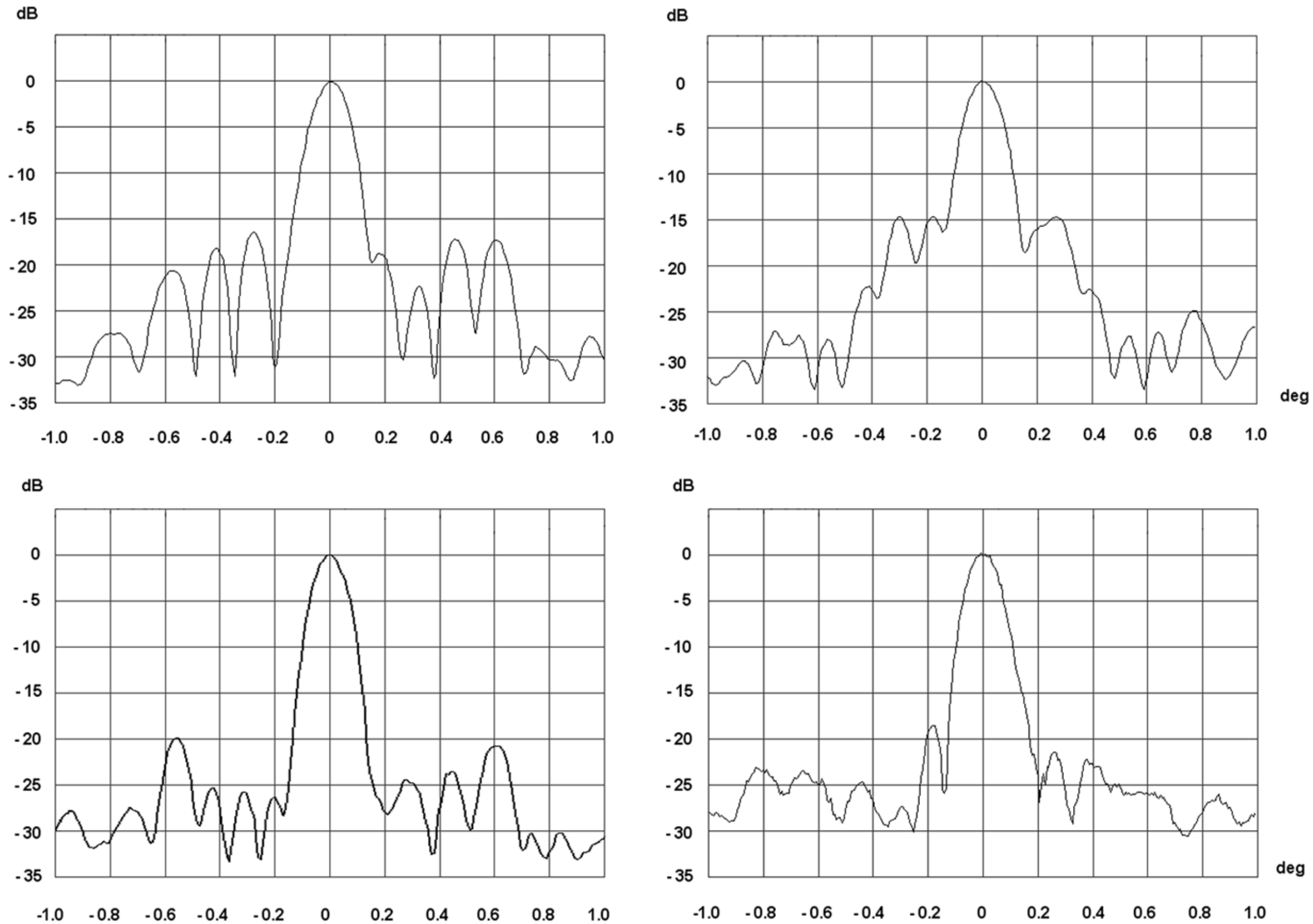
$$L_R = -685\left(\frac{0.31}{3.9}\right)^2 = \text{- 4.3 dB (gain loss)}$$

Feed in new position

Optimized after 3D scan

Azinuth

Elevation

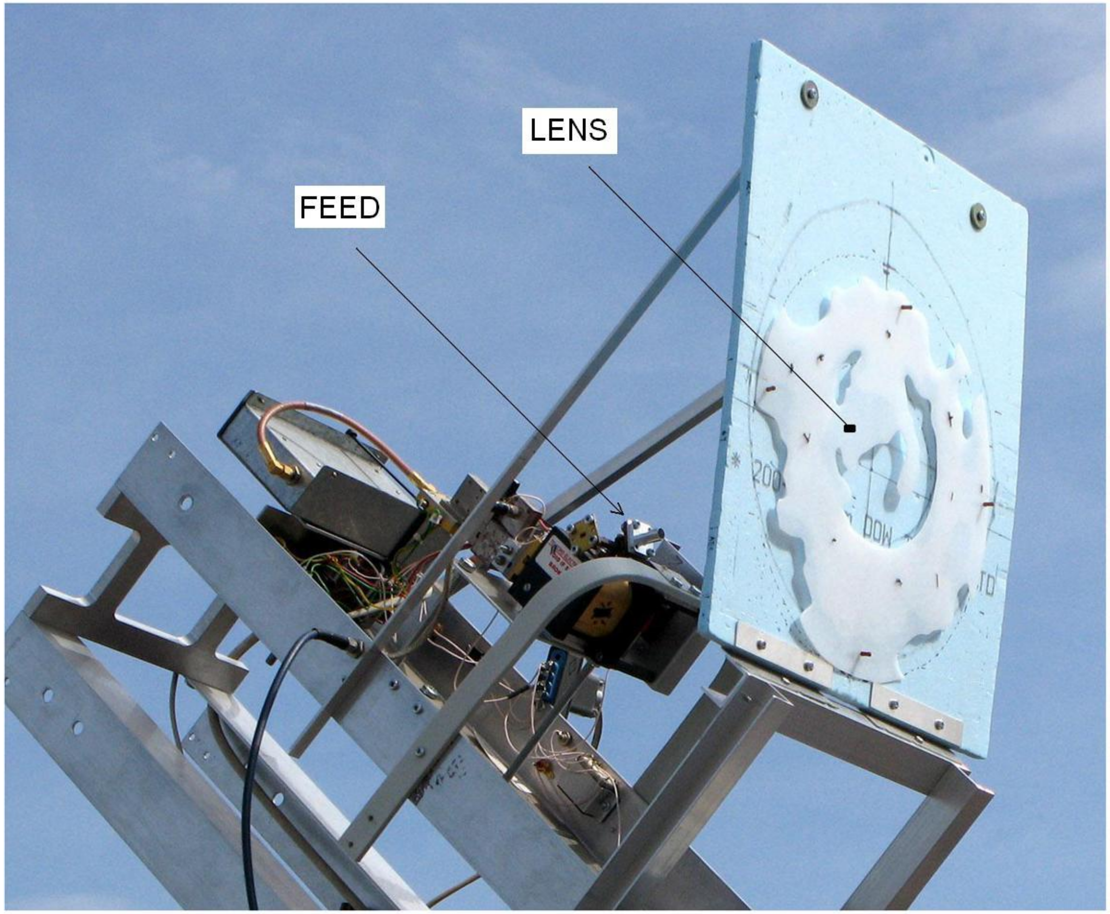


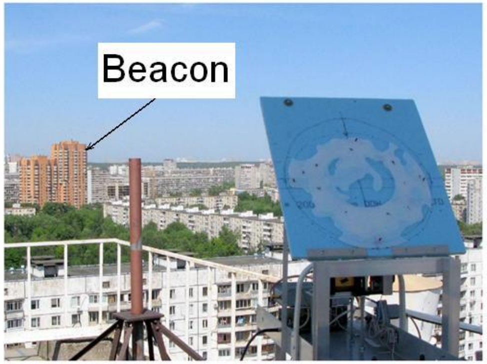
No lens

Dielectric lens

Feed and Lens

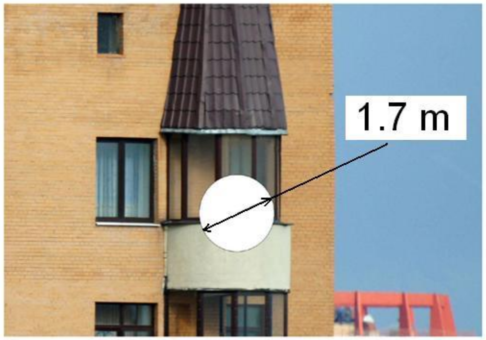
Beacon





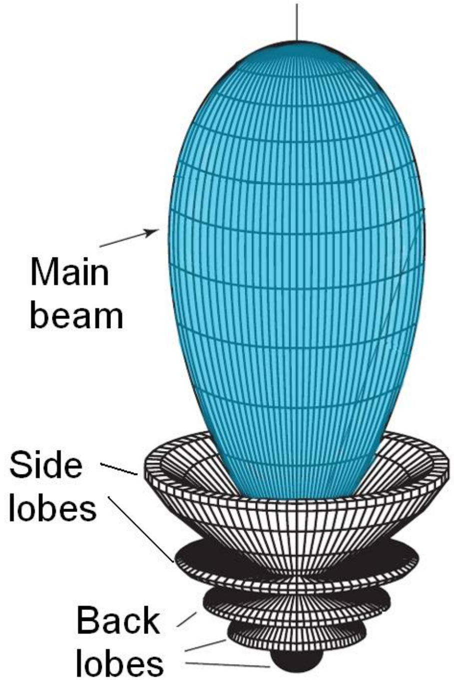
BW = 0.11°

beam spot at 890 m distance

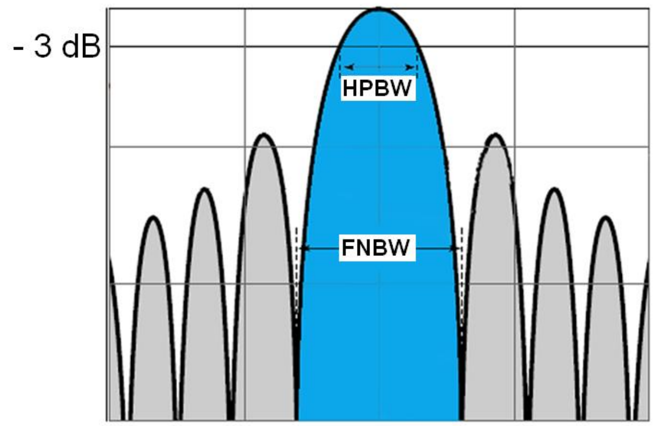


Main beam efficiency (ε_M)

The part of the total radiated (received) energy of an antenna that is contained in the main beam.



$$\varepsilon_M = \frac{\int_{MB} P_n(\theta,\Phi)\, d\Omega}{\int_{4\pi} P_n(\theta,\Phi)\, d\Omega}$$



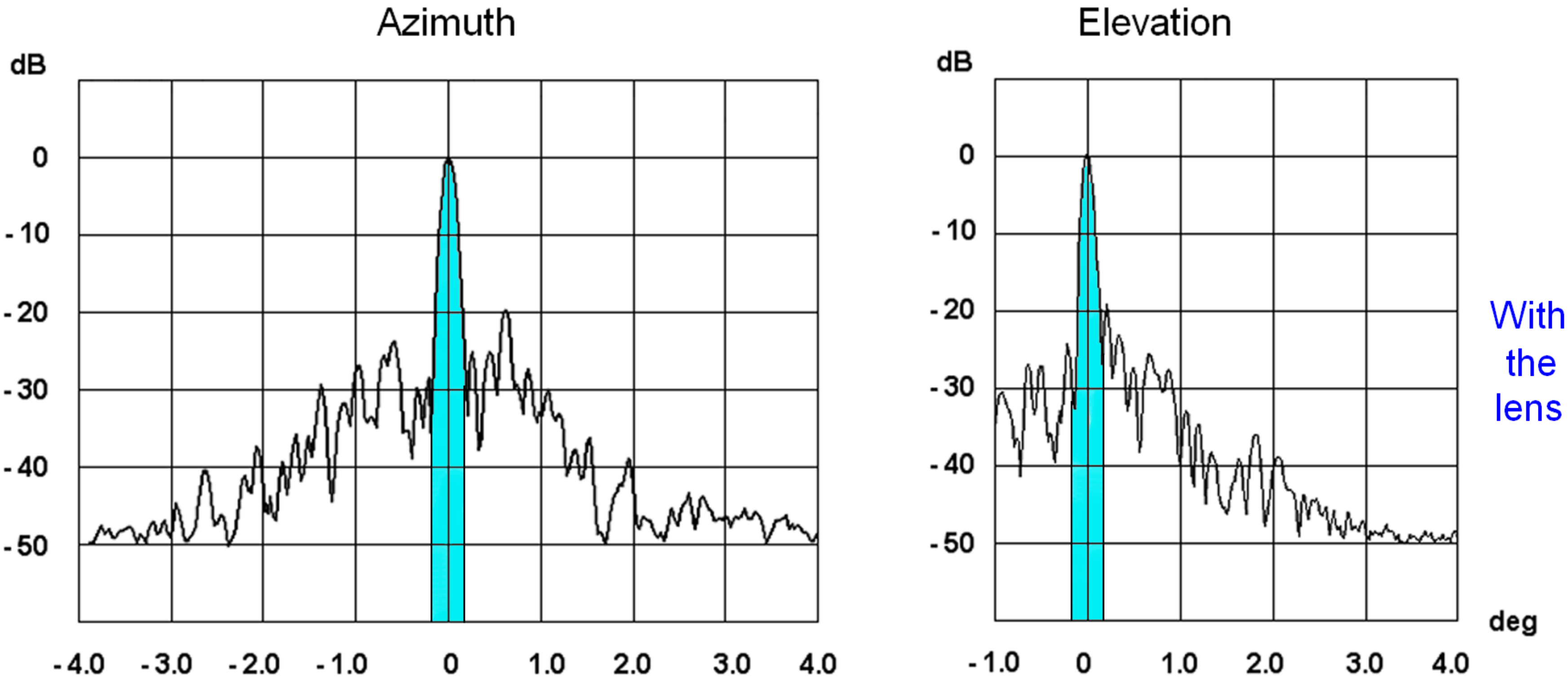
$$G_A = \frac{4\pi A}{\lambda^2}\,\varepsilon_{APP}\,\eta = \pi^2\left(\frac{D}{\lambda}\right)^2 k\,\varepsilon_M\,\eta\ ;$$

$\varepsilon_{APP} = k * \varepsilon_M$; $k = 0.8$ for my DMH feed ;

$$G_A \approx 8\left(\frac{2400}{3.88}\right)^2 \varepsilon_M\ ;$$

$$G_A \approx 3\,060\,000 * \varepsilon_M$$

Antenna pattern for -50 dB noise floor



The integration of patterns gives the following results for ε_M – main beam efficiency:

Antenna without lens $\varepsilon_M = 0.60$

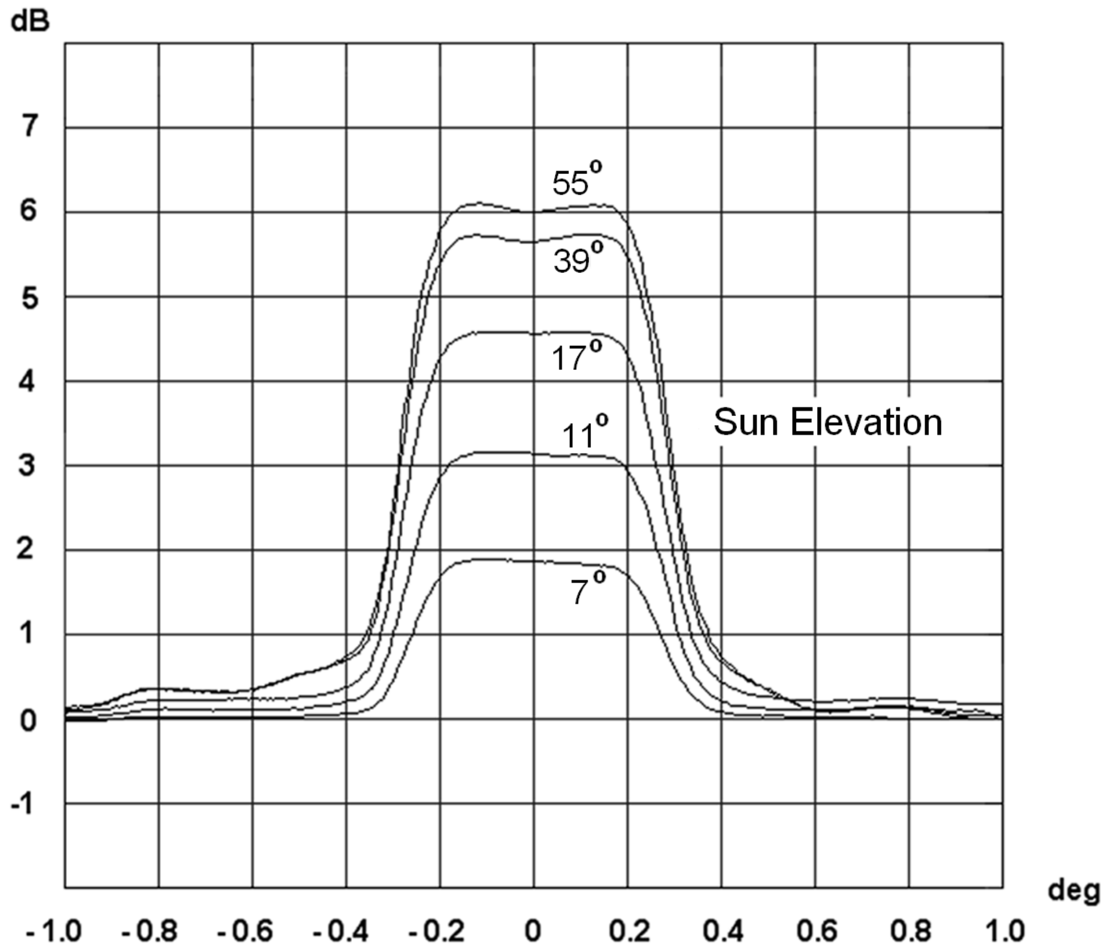
Antenna with the lens $\varepsilon_M = 0.66$

The lens benefit is approximately equal to 0.4 dB

Calculated beam efficiency $\varepsilon_M = 0.87$.

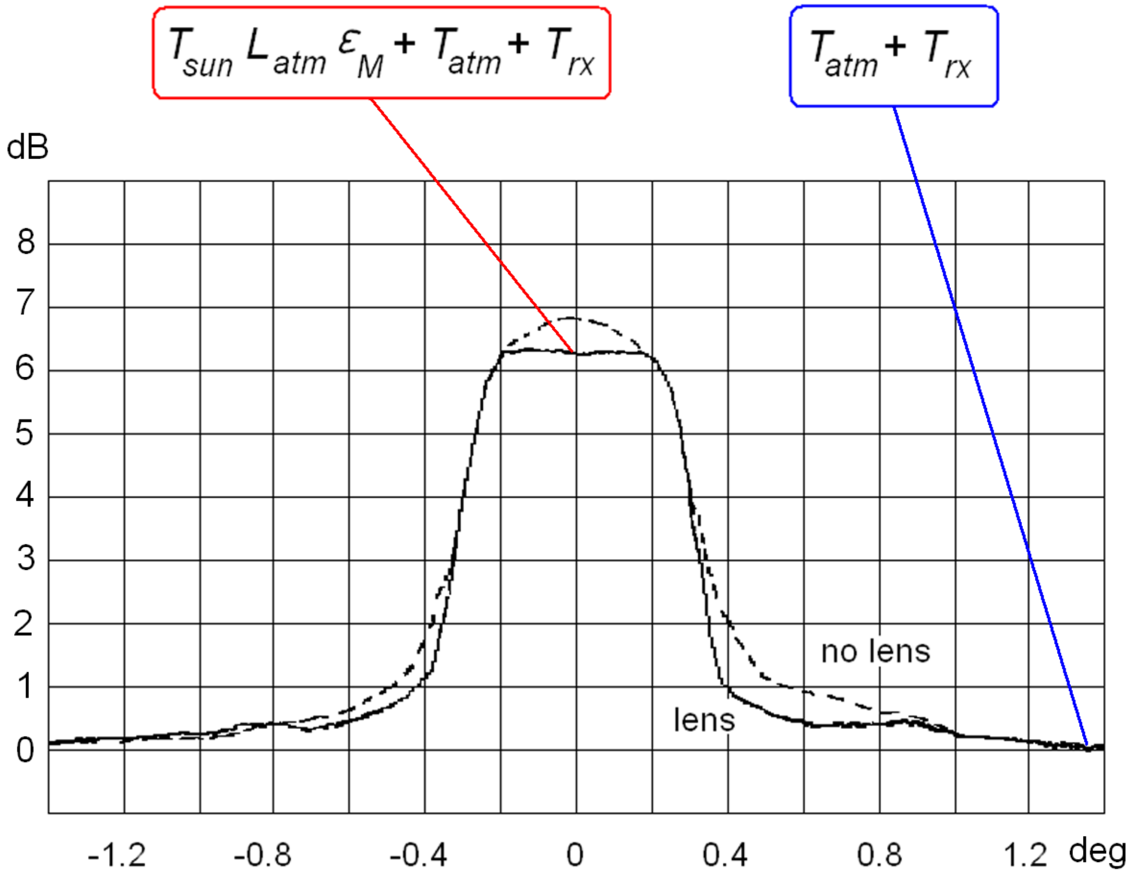
Beam efficiency and gain degradation -1.2 dB

Sun noise (1)



with dielectric lens

Sun noise (2)



$$Y_{sun} = \frac{T_{sun} L_{atm} \varepsilon_M + T_{atm} + T_{rx}}{T_{atm} + T_{rx}}$$

Main beam efficiency

$$\varepsilon_M = \frac{(T_{atm} + T_{rx})(Y_{sun} - 1)}{T_{sun} L_{atm}}$$

$Y_{sun} = 4.3$ (6.3 dB)

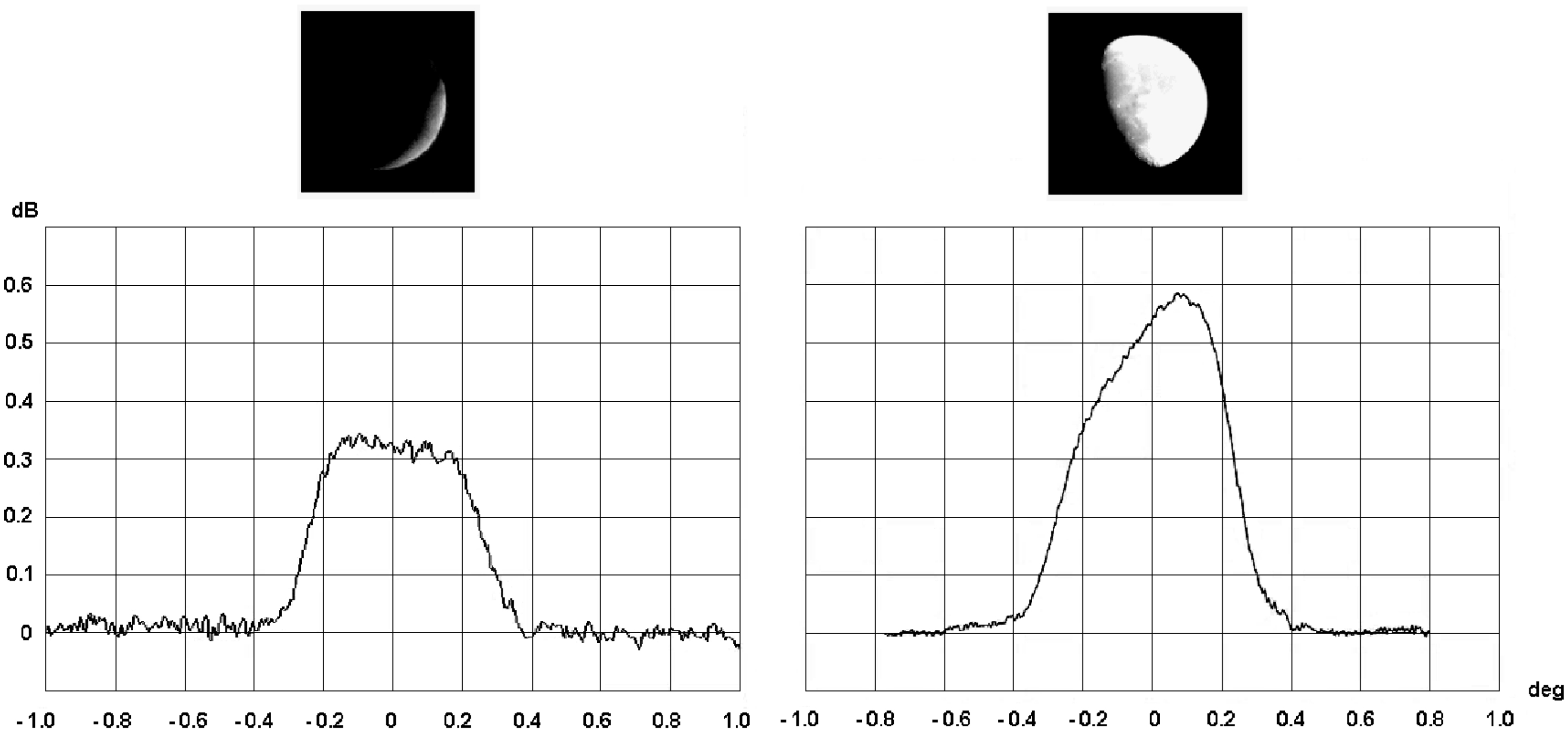
$T_{rx} = 1030K$

$T_{atm} = 70K$ $L_{atm} = 0.77$

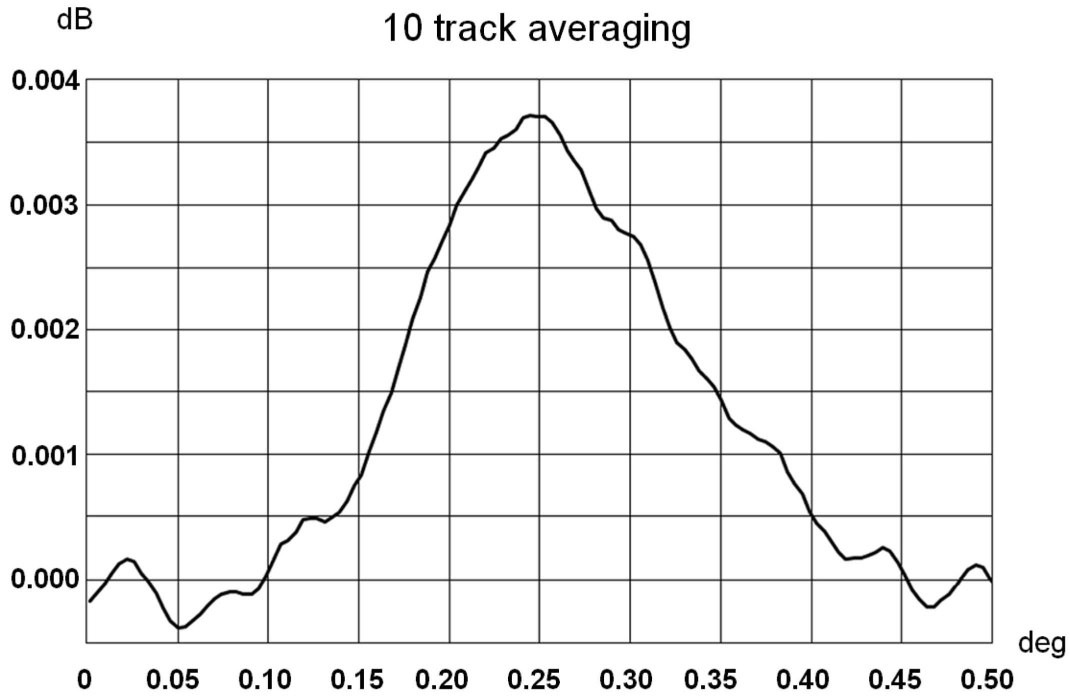
$(27^{\circ}C, 38\%, 55^{\circ}$ elev)

$\varepsilon_M = 0.65$ $T_{sun} = 7250K$

Moon noise


dB
0.6
0.5
0.4
0.3
0.2
0.1
0
-1.0 -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8 1.0
-1.0 -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8 1.0
deg

Jupiter noise



Date 01.02.2014

Temperature -14°C

Humidity 50%

Ant elevation 45°...50°

Sys noise temperature

Radiometer RAD2

(LC Technologies)

BW = 40 MHz

Antenna HPBW 400"

Jupiter angular size 44"

Jupiter noise calculation: $T_{JUPITER} \approx T_{NEW\ MOON} \approx 140K$; $Y_{NEW\ MOON} = 0.33$ dB;

$$Y_{JUPITER} = Y_{NEW\ MOON} * \left(\frac{44''}{400''}\right)^2;$$

$$Y_{JUPITER} = 0.004 \text{ dB}$$

CONCLUSION

- For 77GHz band EME you need expensive antenna with extremely high accuracy of the reflector surface and quite a large size.
- It is possible to use available low-cost antennas with necessary check of the antenna pattern.
- It is possible to compensate the surface deviations with help of special dielectric lens.
- The Sun is easy to use celestial source for antenna testing on 77GHz. Sun noise tests are very informative.
- Using Jupiter as a point source for EME antenna test is yet questionable.