# Cassegrain and Gregorian Reflector Antenna Modeling with MLFMM LE-PO Hybrid Solvers

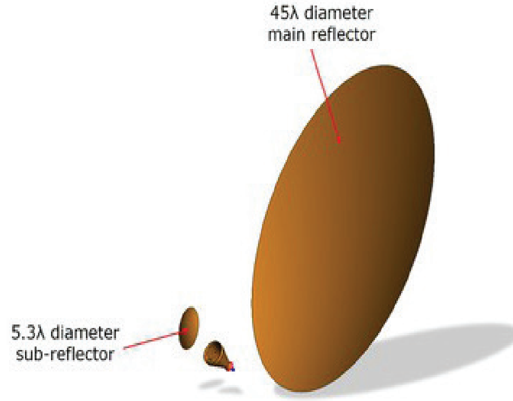
This white paper demonstrates that the MLFMM-LE-PO hybrid formulation is a very efficient and accurate method for analysis of large reflector antennas.

## Introduction

Reflector antennas are a well known class of antenna, with a wide variety of applications, which include satellite communications, radio astronomy and radar. Due to their large physical size and typically high frequency of operation they are as a rule electrically very large. When analyzing such antennas their very large electrical size can be solved with full-wave solvers, but even the very efficient multilevel fast multipole method (MLFMM) may require large computational resources to solve the problem. FEKO's hybridization of the MLFMM and large element-physical optics (LE-PO) make it possible to solve such problems efficiently within fairly modest computational resources.

Cassegrain and Gregorian antennas are a typical example of the problems and technology application mentioned here. Such antennas consists of:

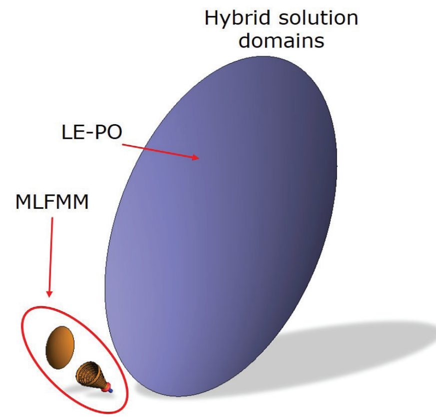
- A parabolic main reflector
- A hyperbolic (Cassegrain) or elliptic (Gregorian) sub-reflector
- A horn antenna illuminating the sub-reflector
- The sub-reflector pre-shapes the wave front as transmitted by the horn antenna before the main reflector shapes the wave font into a highly focussed main beam.




Antenna Magus was used to design such an antenna for operation at 10 GHz, a typical frequency for both radar and radio astronomy applications. This specific design realized a main reflector of 45λ diameter, sub-reflector of 5.3λ diameter and an axial choke conical horn antenna in offset Gregorian configuration. The total surface area of metallic faces in this model is roughly 1.28 m².

## Simulation Setup and Computational Resource Requirements

The antenna described above was setup for both MLFMM and hybrid MLFMM-LE-PO solution. This setup allows the comparison of the MLFMM-LE-PO hybrid formulation to the mathematically rigorous MLFMM full wave formulation. The MLFMM is regarded as the benchmark solution in both accuracy and resource requirements.




In the case of the mixed MLFMM-LE-PO simulation the feed horn and hyperbolic sub-reflector was treated with the MLFMM, while the main reflector was treated with LE-PO. The MLFMM region was meshed with a CADFEKO "Coarse" density of 1/8λ, while the LE-PO main reflector was meshed to 1/2λ, which represents the geometry of the face to a high degree of accuracy. The comparative MLFMM only region was also meshed with a CADFEKO "Coarse" density of 1/8λ. The resulting number of metallic edges (unknowns) are summarized below.

| Number of metallic edges in mesh | | | |
|---|---|---|---|
| *Model* | *MLFMM* | *LE-PO* | *Total* |
| Full MLFMM | 447,545 | 0 | 447,545 |
| Hybrid MLFMM-LE-PO | 31,315 | 26,304 | 57,619 |

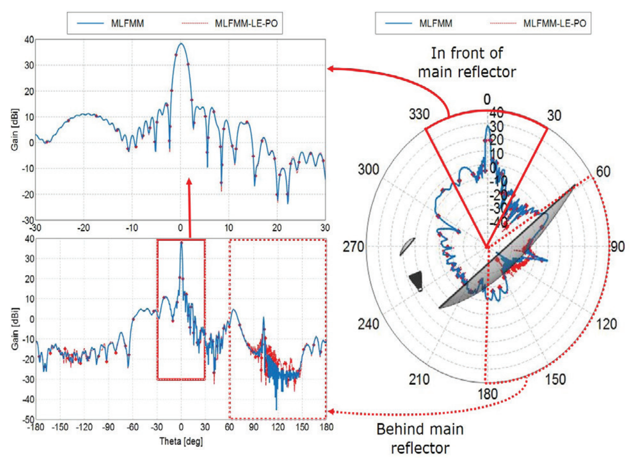
The simulation platform for this investigation was a workstation with 2x Quad Core Intel Xeon E5606 CPUs running at 2.13 GHz, supported by 72 GByte RAM. Both simulations were performed using 4 cores in parallel. A summary of simulation resources for the respective simulations is presented below.

| Computational resources used for simulations | | |
|---|---|---|
| *Model* | *RAM (GByte)* | *Run-time (s)* |
| Full MLFMM | 14.2 | 1,899 |
| Hybrid MLFMM-LE-PO | 1.5 | 4,120 |

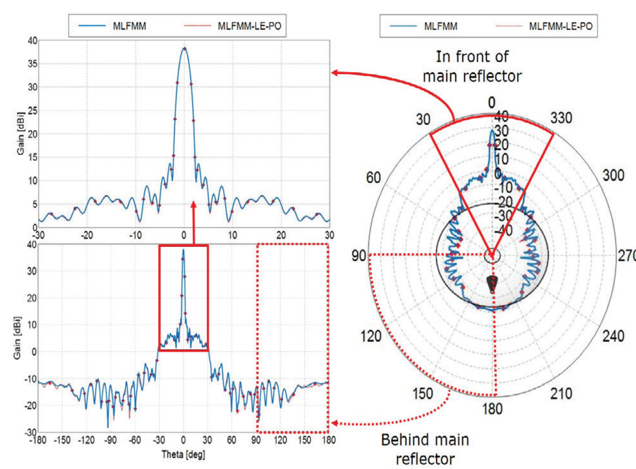
Note that although the hybrid solution was somewhat slower in this comparison, it uses significantly less memory to solve the problem. The saving in memory puts the solution of such problems firmly within the abilities of standard desktop computers, as opposed to expensive workstations.

## Result Comparison

The following comparisons for both the H-plane and E-plane pattern cuts demonstrate excellent agreement between the MLFMM reference solution and the hybrid MLFMM-LE-PO solution. The hybrid MLFMM-LE-PO is thus validated as a fully accurate solution, which can very efficiently solve such demanding problems on modest computer resources.




*H-plane comparison of results: MLFMM vs. hybrid MLFMM-LE-PO*




*E-plane comparison of results: MLFMM vs. hybrid MLFMM-LE-PO*