A LENS ANTENNA SYSTEM STUDY FOR FUTURE CMB POLARISATION PROJECTS

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INTRODUCTION

The next generation of instruments dedicated to the Cosmic Microwave Background Radiation (CMBR) polarisation measurement will require large focal planes involving several thousands of pixels. Future lens-based telescopes configurations(such as LSPE, SPIDER) might be a strong alternative to the reflector based ones (PLANCK, WMAP) which suffer from feed blockage and off-axis structure. However, their readiness level is deemed low in terms of RF performance knowledge and hence they are being studied in order to understand their systematic effects such as aberrations and cross-polarisation. The work presented here introduces RF simulations using Method of Moments (MOM). These simulations are also compared to experimental data gathered on a representative lens system (lens and feed-horn) for which the co- and cross-polarisation beam pattern has been measured.

REFLECTIVE CONFIGURATION	REFRACTIVE CONFIGURATION
generally off-axis	on-axis
more weight	mass and space advantage
low losses	lens absorbtion creates loss
well known systematic effects(in model and measurements)	need material knowledge and model to predict performances
much experience from CLOVER and PLANCK	partial experience from QUAD, BICEP
no chromaticity	chromatic aberrations

Table 1 : ***The table summarizes a general comparison between the reflective and refractive optics configurations.***

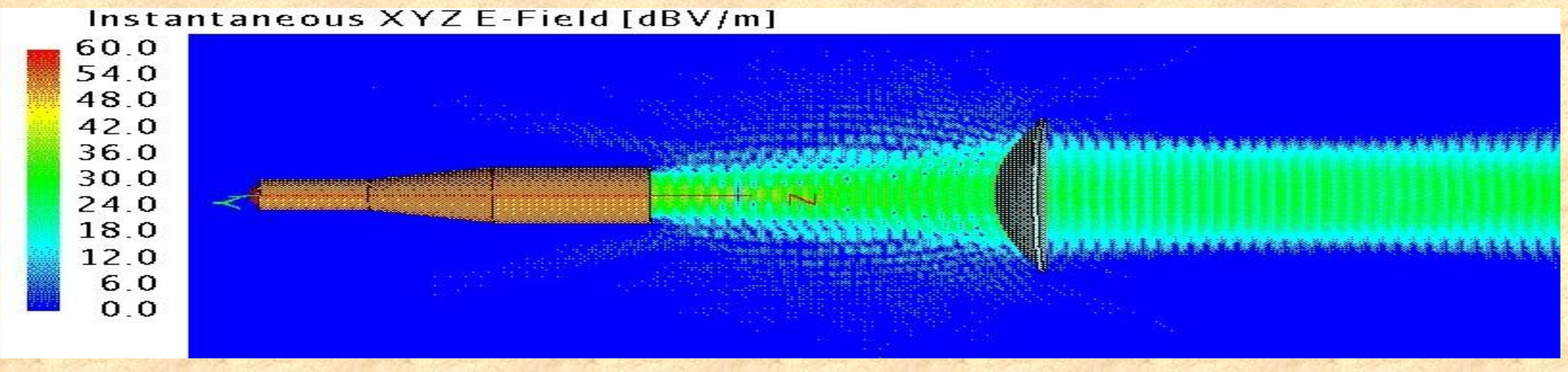

Figure 2: ***The field propagation after transmission from the lens antenna and the corrugated feed horn antenna. The plane phase surfaces are generated.***

LENS SIMULATIONS

A software package does not exist for modelling the entire optics of a telescope simultaneously. Physical optics software package such as GRASP can accurately predict the co- and cross-polarisation beam patterns of a reflective telescope configuration down to a dynamic range of -60 to -80 dB. For refractive elements, there is a lack of modelling tools with sufficient accuracy for B-mode polarisation instruments although dielectric lenses have been modelled by either ray-based optics or Gaussian beam optics. For this reason, a full wave solution method, Method of Moments (MOM) has been chosen to model for a horn-lens system.

- **HDPE dielectric (ε=2.34, tanδ=0.0002) , D=47 mm (~20 λ)**
- **f# = 1.45 (very high Edge Taper (ET) illumination)**

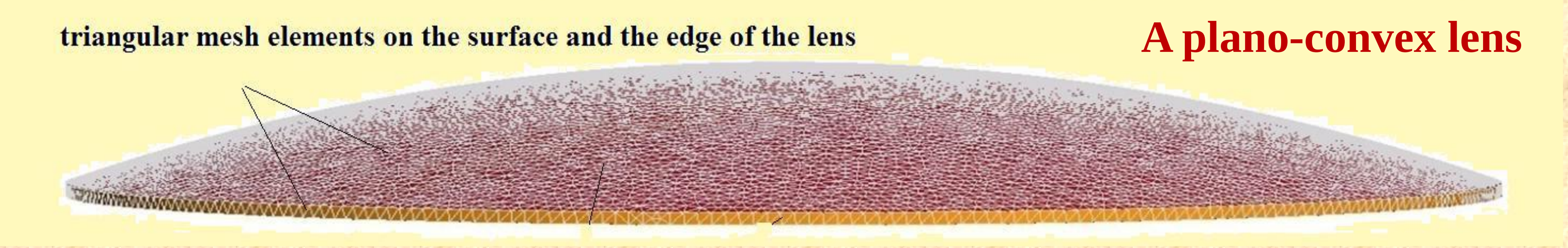

Figure 1: ***Surface Equivalent Principle (SEP) of MOM in FEKO***
The SEP introduces an equivalent of electric and magnetic currents on the surface of a closed dielectric body. It is a convenient model for a homogenous material made lens.

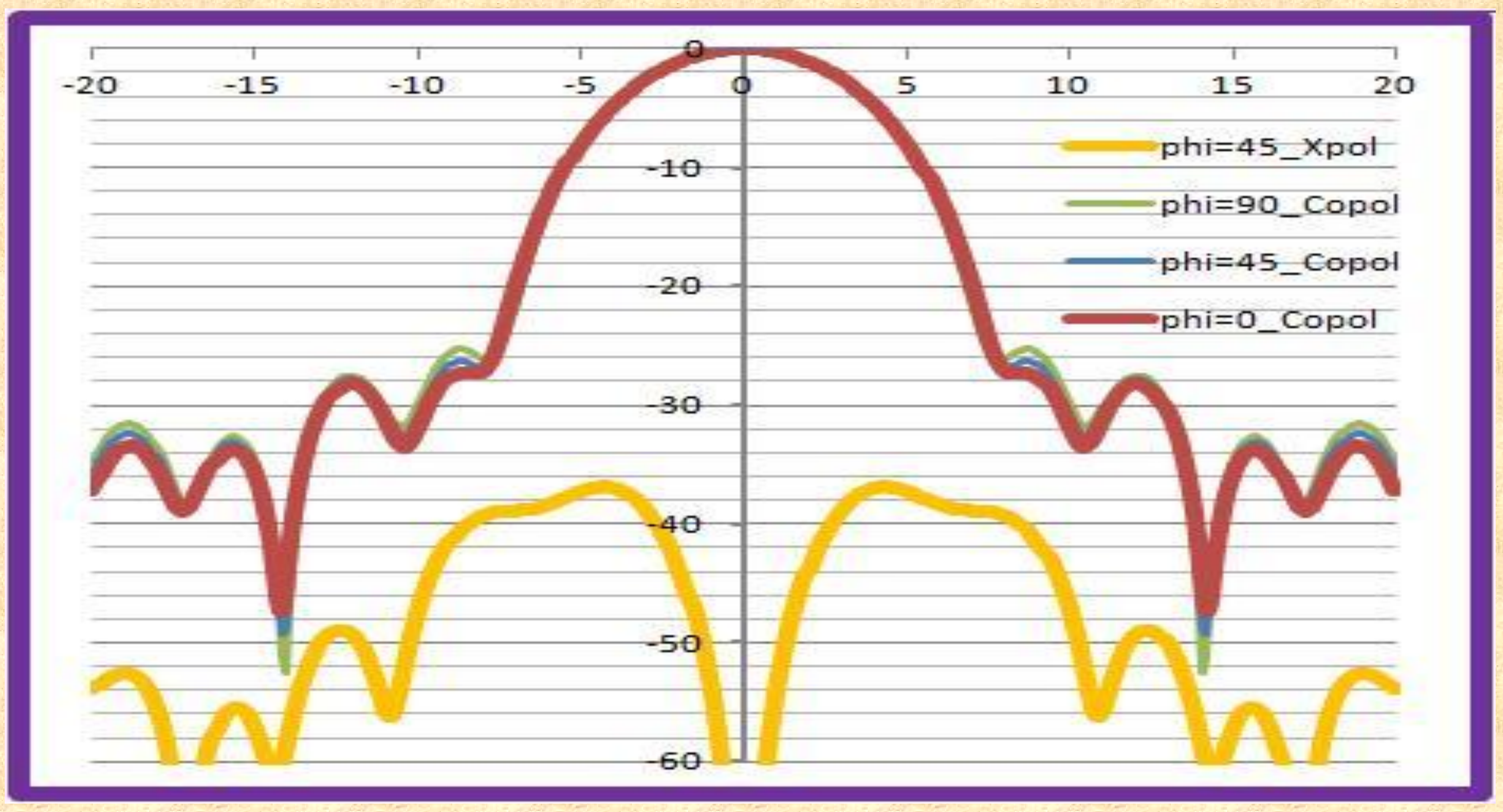

Figure 3: ***The co- and cross-polarisation beam predictions of E(Phi=90), H(Phi=0) and Diagonal (Phi=45)planes calculated from MOM model in FEKO.***

LENS ANTENNA MEASUREMENTS

THE EXPERIMENTAL SETUP

The co- and cross-polarisation measurements have been carried out using a Vector Network Analyser (VNA) . The VNA ports support rectangular WR10 waveguides (75-110 GHz) coupled to a waveguide transition to match the circular waveguide of the 82-112 GHz corrugated feed horn antennas. The overall measurement set-up allowing the beam pattern characterisation of lens and feed horn is shown in the figures below.

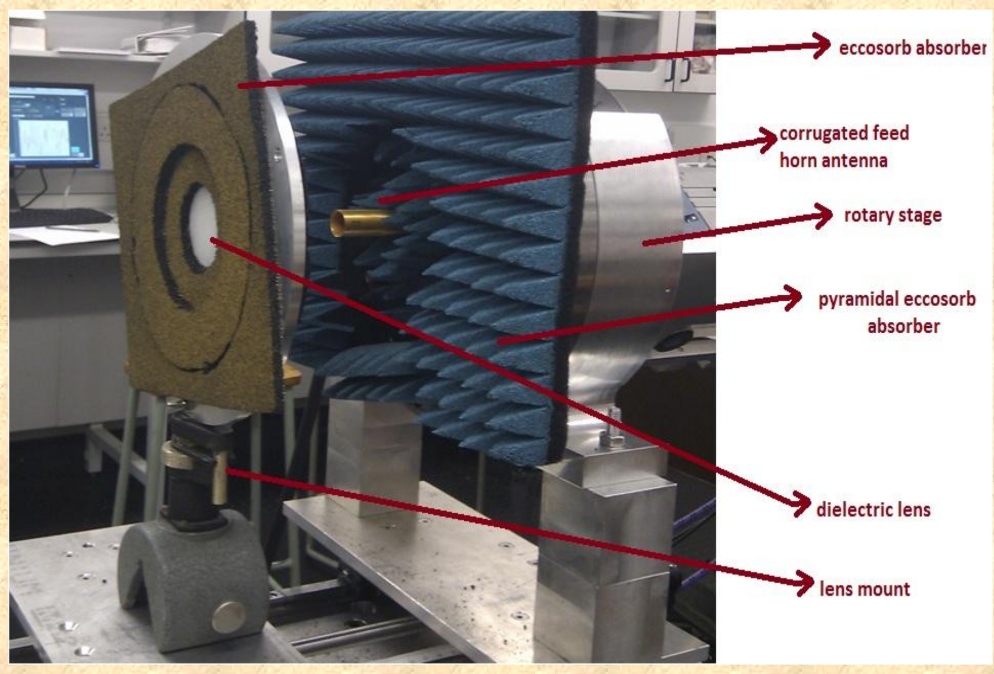

Figure 5: ***A representative lens with a diameter of 47 mm was chosen to perform far-field measurements in our indoor facility. The far field is about 1.5 meter. A motorised rotary stage allows field pattern cuts (E, H and Diagonal cuts) to be measured.***

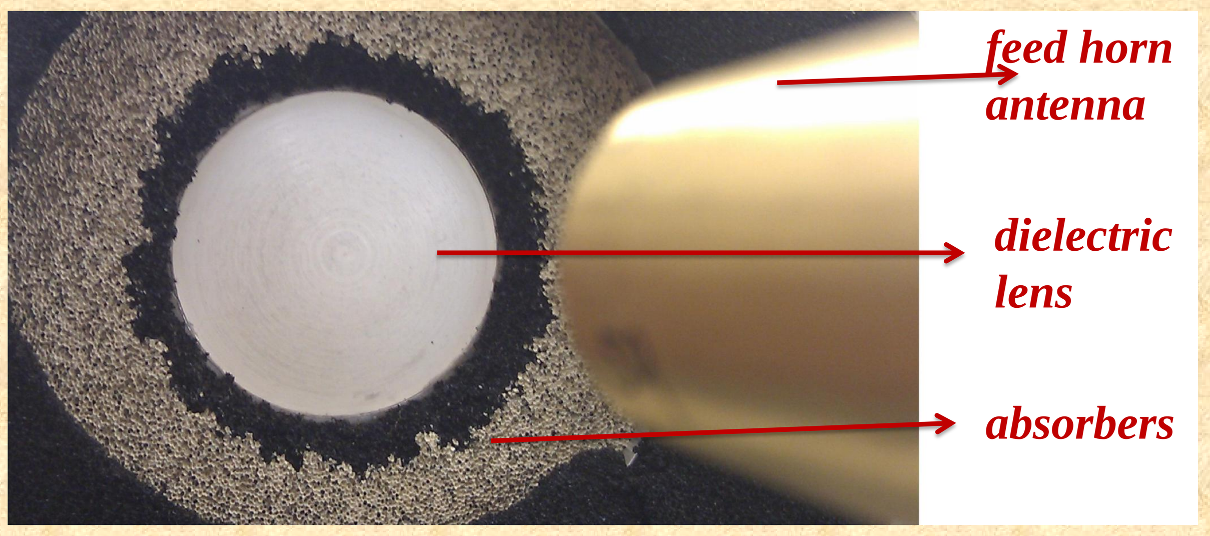

Figure 6: ***The lens is illuminated with an Edge Taper of 40 dB at 19^0. 99% of the power is concentrated within the lens aperture . The metal plate behind the RF absorbers defines the beam diameter.***

OVERALL RESULTS

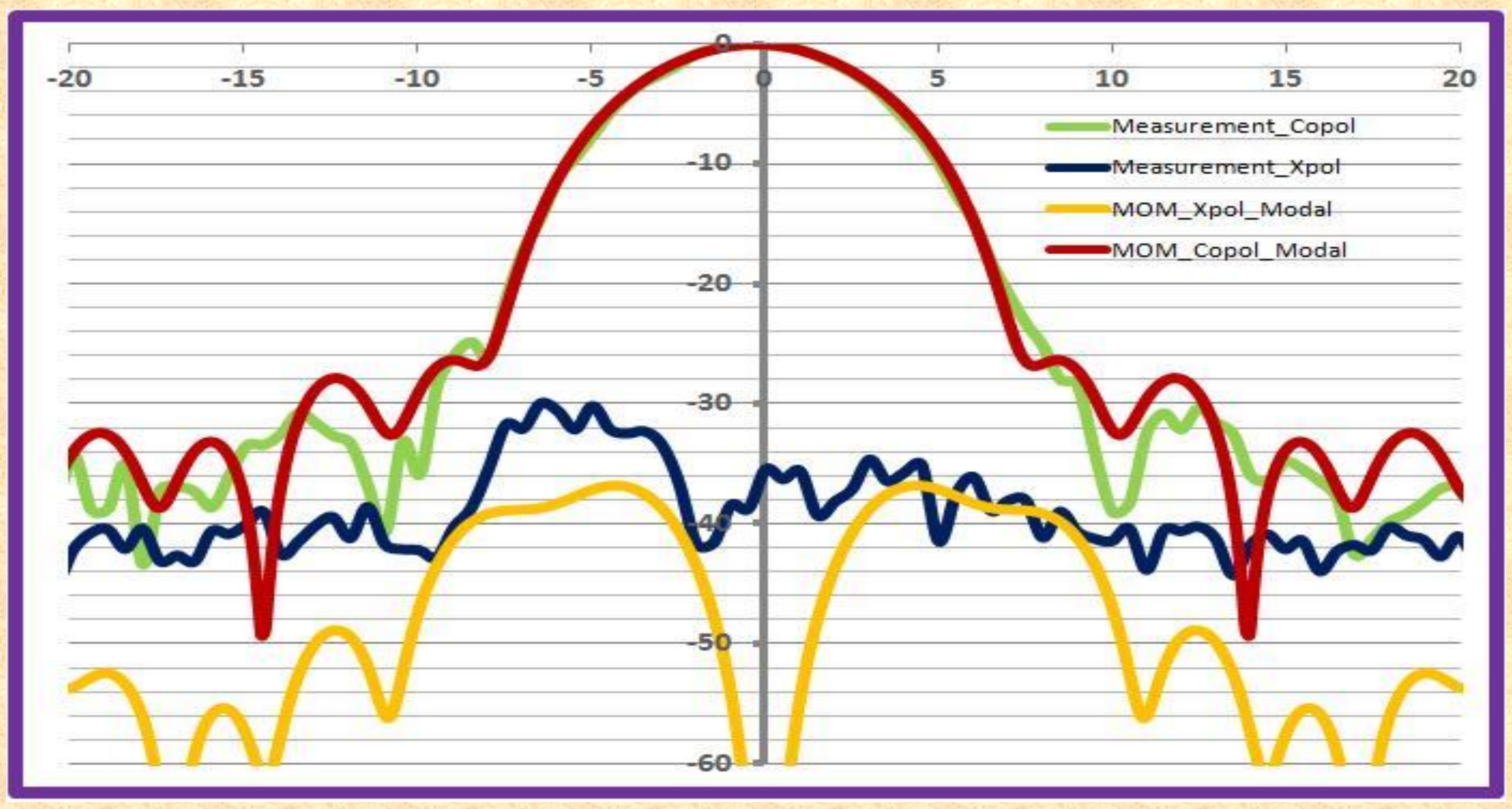

Figure 7 : ***The measurements were taken for the co- and cross-polarisation diagonal cuts and compared to the calculated beam patterns obtained with FEKO.***

CONCLUSIONS

In the frame of systematic effects due to optics, we are conducting a study of refractive based telescope for the next generation of CMB polarisation projects. We have presented simulations compared to preliminary experimental characterisation of co- and cross-polarisation beam patterns of a representative lens-feed horn system. Simulations were performed using Method of Moments with the FEKO software. The model compares very well with the experimental data as far as the main lobe is concerned: The co-pol. matches down to -30dB. The measured cross-pol. is consistent with the model but other effects due to the manufacture, and the test set-up needs to be better understood.

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Reference:
http://www.feko.info/

Information
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