

Electromagnetic analysis at corrugated horn antenna for interferometer system on the QUEST spherical tokamak

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1. Introduction

- A round-trip interferometer system has been being developed but the effect on the intensity that passes through the quartz window has not considered yet.
- The purpose on this study is to confirm the effect of quartz window to the beam intensity.

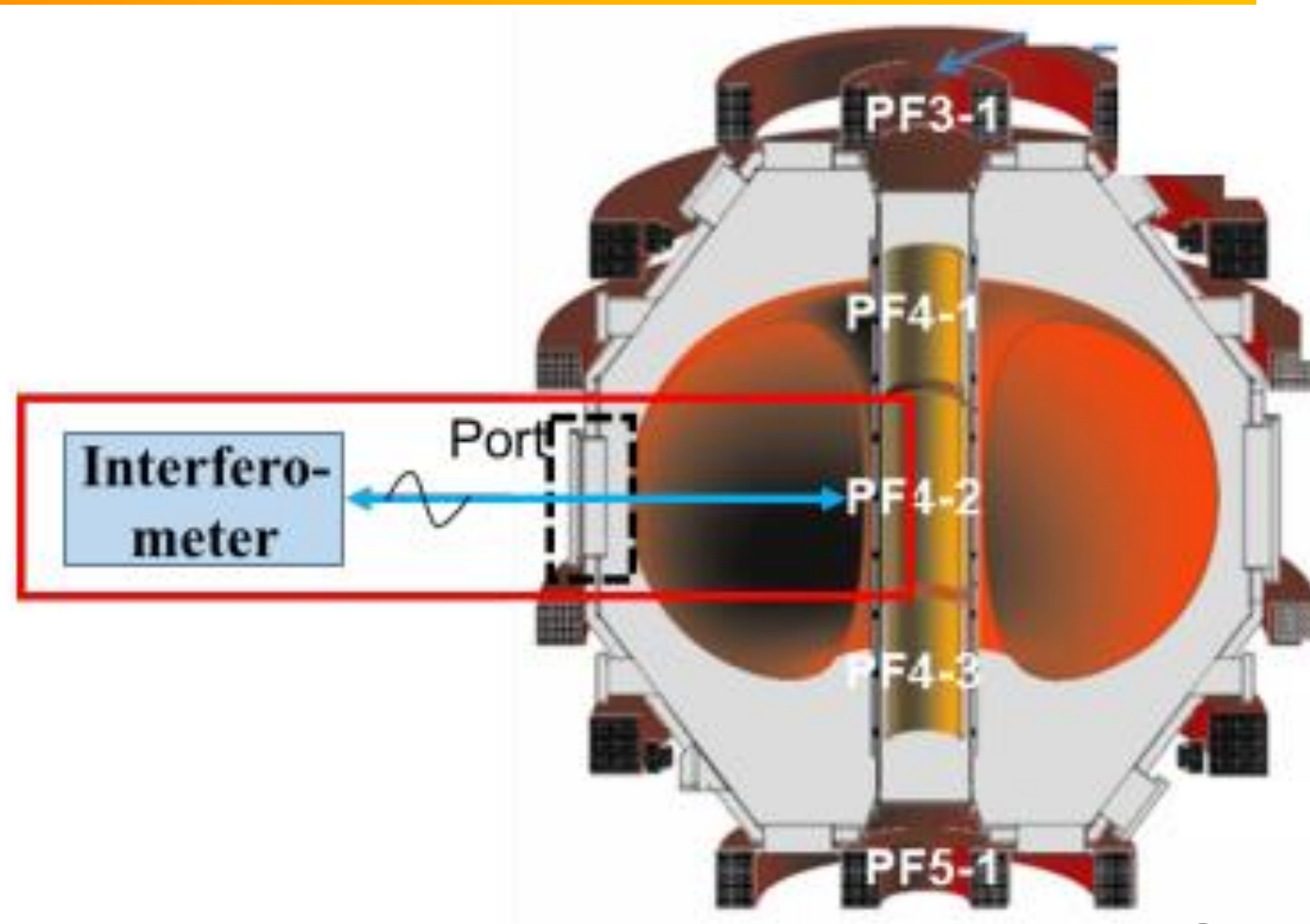


Fig.1 The interferometer system in QUEST

2. A round-trip Interferometer

- A millimeter wave of 75 GHz excited by the oscillator is picked up by the directional coupler and move back and forth along the plasma path by the launcher system, and is picked up again by the another directional coupler.
- Differential phase evolution between two-picked up waves express the density evolution in the plasma.
- The launcher system consists of a corrugated horn antenna, quartz, two quasi-optical mirrors, and a reflector on the center post.

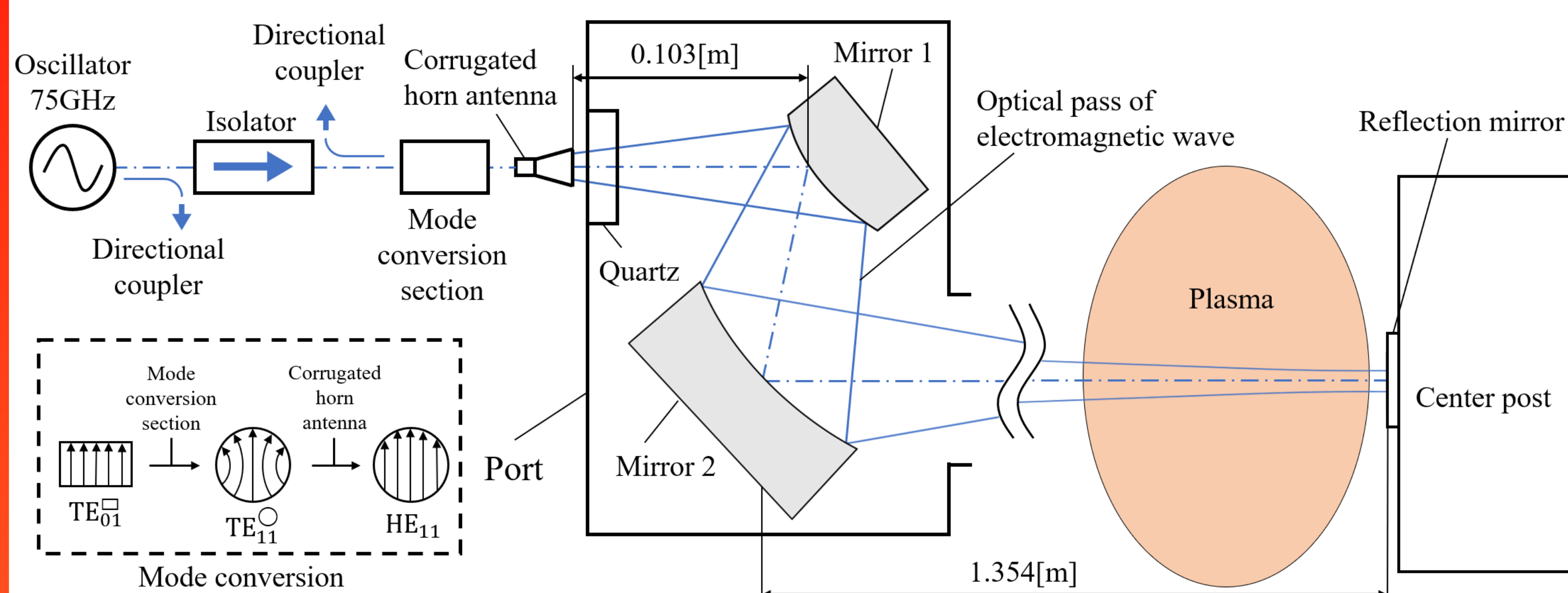
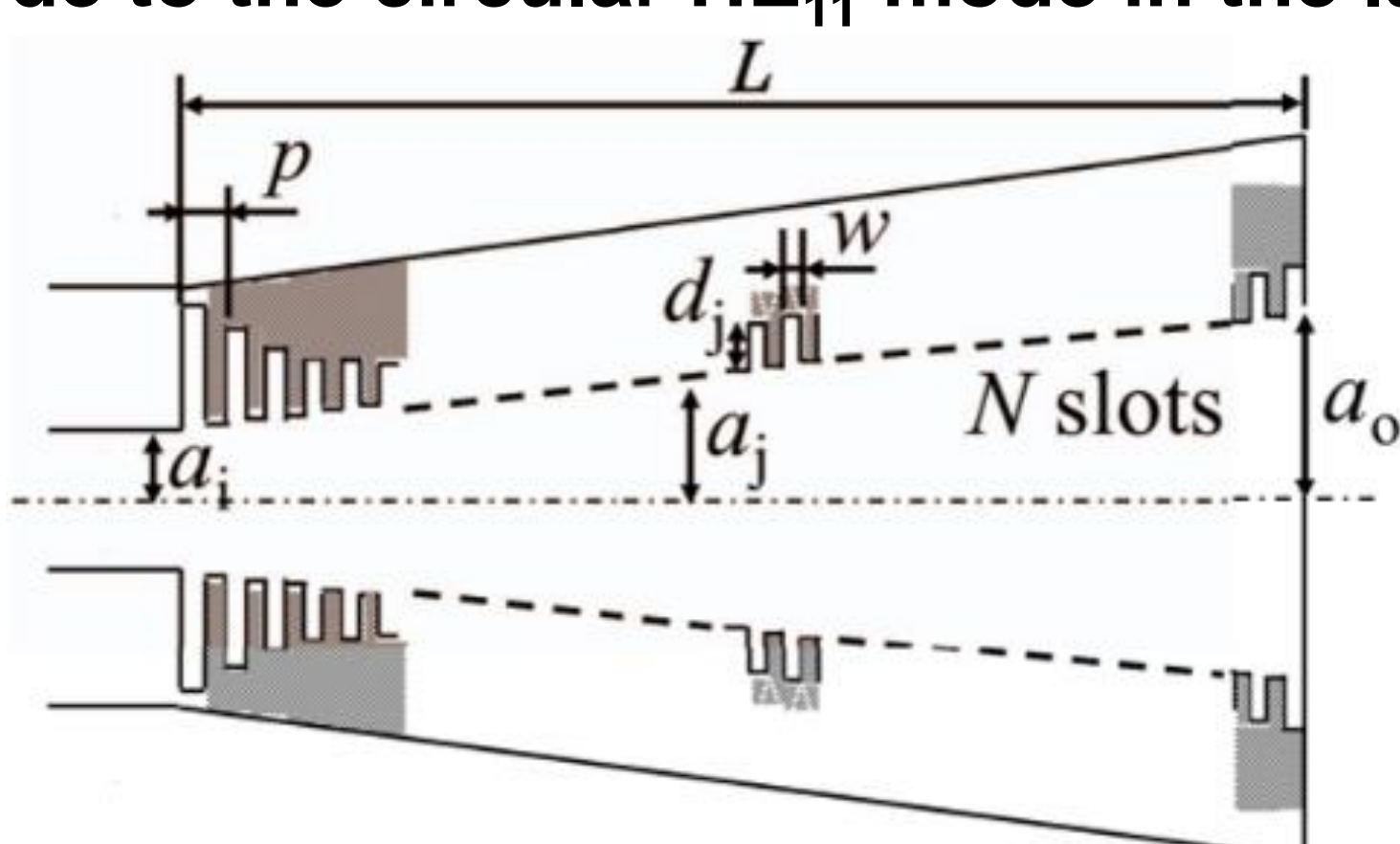


Fig.2 Outline of the round-trip interferometer

3. Corrugated horn antenna

- Corrugated horn antenna is a circular horn antenna with a circumferential groove caved into its inner wall as shown in Fig.4.
- Convert the mode of electromagnetic waves from the circular TE₁₁ mode to the circular HE₁₁ mode in the launcher system.



Design parameters:
 a_i : Aperture radius of the inlet
 a_o : Aperture radius of the outlet
 p : Pitch
 w : Slot Width
 d : Depth

$$a_i = 1.59 \text{ mm}, a_o = 8.6 \text{ mm}, p = 0.67 \text{ mm}, w = 0.47 \text{ mm}, d = 0.74 \text{ mm}$$

Fig.3 Corrugated geometry for mode conversion

4. Analysis conditions

- Simulation with COMSOL Multiphysics 6.0

$$|\vec{E}(r, \phi, z)|^2 = \sqrt{|\vec{E}_r(r, \phi, z)|^2 + |\vec{E}_{phi}(r, \phi, z)|^2 + |\vec{E}_z(r, \phi, z)|^2}$$

- Excitation the circular TE₁₁ mode electromagnetic waves of 75.09 GHz at the feed port of the antenna.

- The quartz is cylindrical, 12mm tick, 70mm in diameter, and has a refractive index of 1.97.

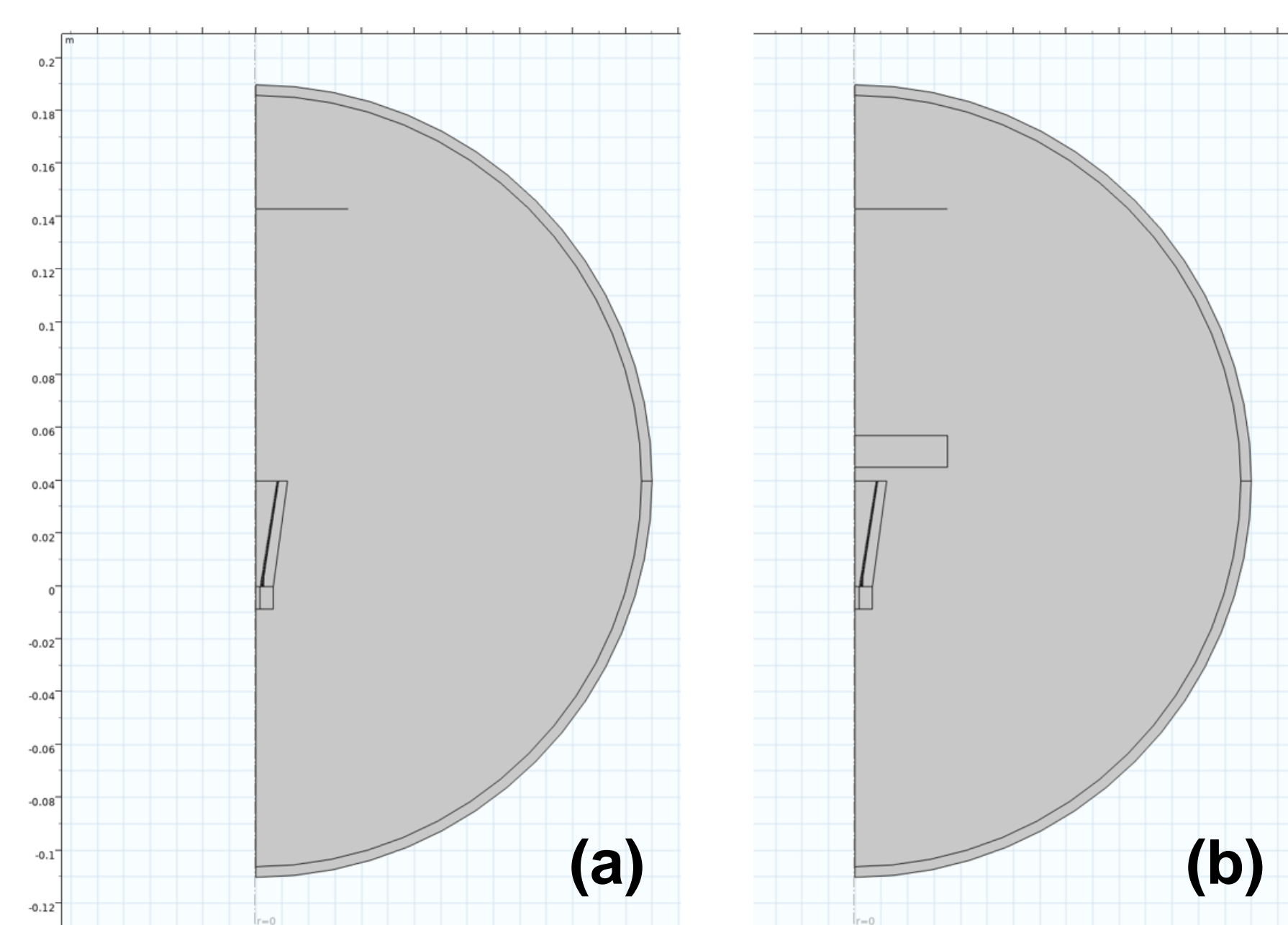
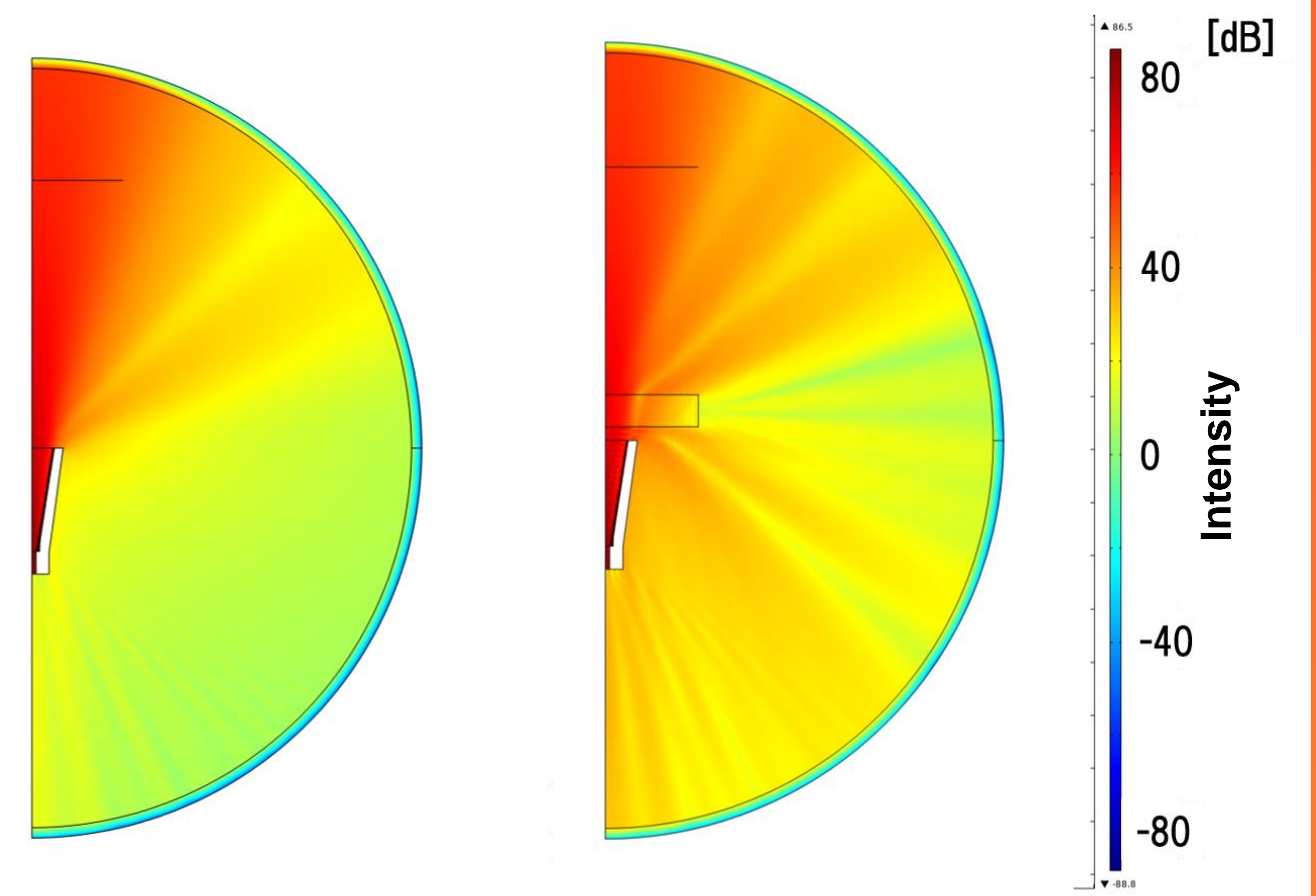


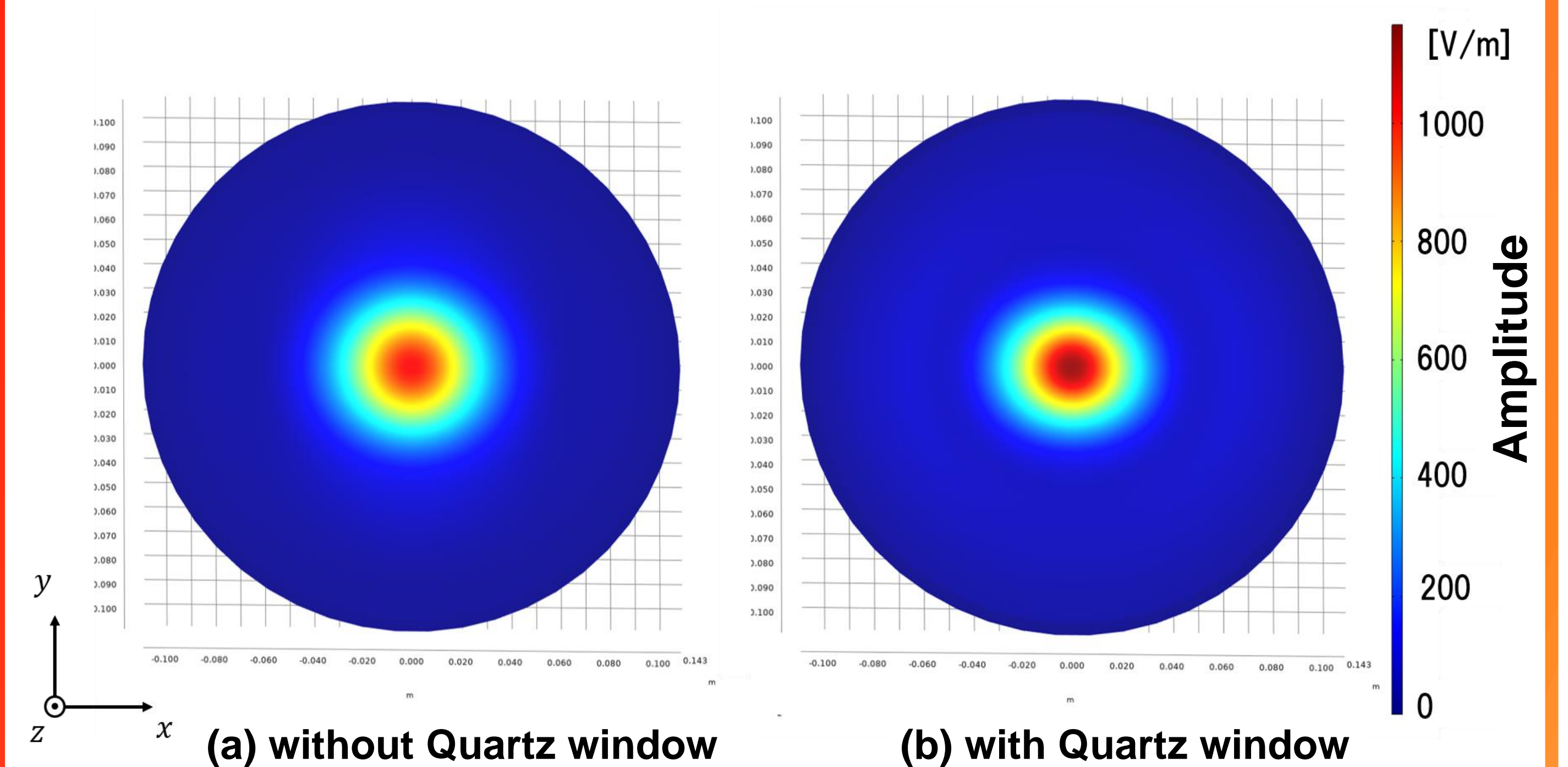
Fig.4 The geometry model. (a) without Quartz window, (b) with Quartz window

5. Results of analysis

- As shown in Fig.5, quartz window causes some of the electromagnetic waves emitted from the antenna to be refracted, changing their direction of travel toward the antenna's central axis, and some to be reflected, strengthening the electric field behind the antenna.
- The analysis results shown in Fig.6 and Fig.7 indicate that the electric field distribution after passing through quartz window is elliptical in shape because the transmittance differs in the X-axis and Y-axis directions due to the effect of polarization direction.



(a) without Quartz window (b) with Quartz window
Fig.5 Electric field distribution (horizontal cross section)



(a) without Quartz window (b) with Quartz window
Fig.6 Electric field distribution at the position of Mirror (vertical cross section)

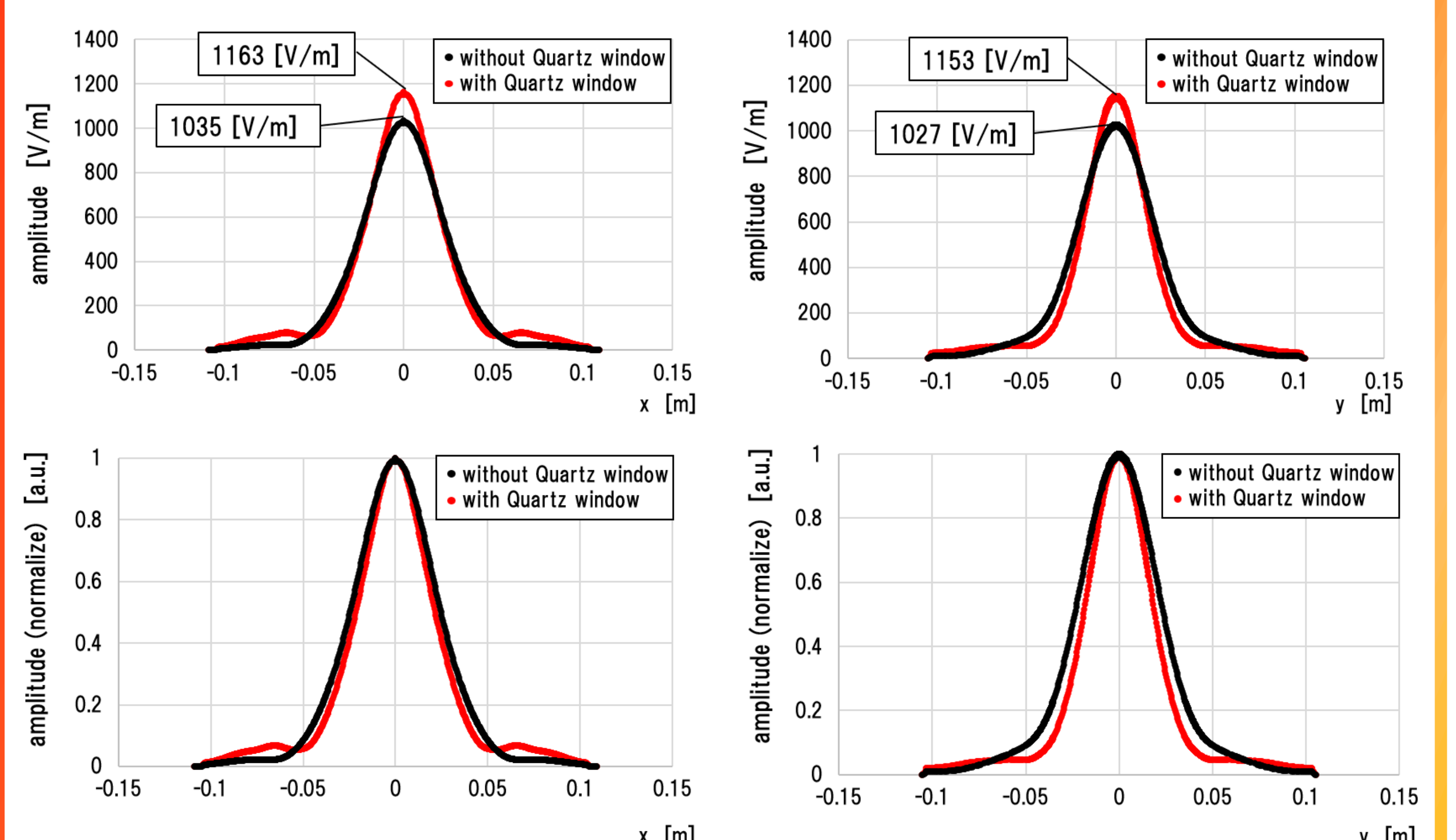


Fig.7 Electric field distribution on x-axis and y-axis at the position of Mirror1

6. Conclusions and future works

- The result of this analysis show that the quartz has a impact on the millimeter wave of the launcher system.
- Find a new beam calculation method that takes quarts into account, Designing the quasi-mirrors with the new method.