1. Introduction
Adaptive optics (AO) systems improve the capabilities of ground-based observatories by correcting the atmospherically-aberrated wavefronts. Incorporating photonics helps simplify many aspects of a conventional AO system. The photonic integrated circuit (PIC) reported here is proposed as an alternative for deformable mirrors (DM) in AO systems. It uses grating couplers to couple the beams focused by a lenslet array into single-mode waveguides where the fields are phase-matched using phase shifters and then coherently combined using beam combiners. This combined field is then coupled from the output waveguide to a single-mode fibre (SMF).

This project is concerned with modelling the devices, specifically the SMFs, output tapered waveguide, beam combiners and the grating coupler based on the design used for the fabrication of the PIC. The models will help estimate the performance of the system before the experiments are carried out and would inform the design of the next-generation circuits.

2. Methods
RSoft photonics simulation package was used to simulate the field propagation through the designed model of the device. The package uses the Finite-difference time-method (FDTD) to solve Maxwell’s equations and calculate the electromagnetic fields.

These models are then used in an end-to-end simulation of the complete AO system. It starts with the production of a turbulent field of the size of the telescope aperture of diameter \( D = 0.4 \) m using a phase screen generator. The atmosphere is modelled for Fried’s parameter ranging over a range. The generated field is then propagated from the atmospheric layer to the entrance pupil of the receiving telescope. Then, the spots at the focal plane of the square lenslet array is calculated using Fourier optics. A model of the grating coupler then couples each of the focal fields into single-mode beams. These coupled beams are then matched in phase and the corrected beams are coherently combined.

3. Results
The end-to-end simulation was done for Fried parameter ranging from 0.05m to 0.15m at wavelength of 1550nm for a telescope aperture of 0.4m. The simulations were done for the case of 4x4 and 8x8 sub aperture cases with results from the two cases shown in figure 6.

References