**Focus Measurement for the Fore-optics of CHAI**

**The optics**

The fore-optics of the CHAI receiver is used to converge the output beam of the SIS mixer and match the receiver beam to the required telescope illumination angular range. Since the pixel spacing is 10mm which is fixed by the mixer Mechanical design, the modification of the mixer beam changes the ratio of pixel spacing () and the reciver beam waist () that is related to the ratio of telescope beam spacing () on the sky to the beam angular size ().

A red pipe with brown and tan background

Description automatically generated with medium confidence

Figure 1. 3D model and Gaussian beam propagation of the Fore-optics of CHAI.

The fore-optics uses the Cassegrain layout (**Fig.1**), one ellipsoid reflector and a hyperboloid mirror, to individually convert 0.916mm beam waist of the mixer to 3.333mm for each pixel at 475GHz. If assuming the illumination edge taper is around 18dB**,**  and ,are respectively:

The schematic of the optics is shown in Fig. 2.

A diagram of a graph

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5

21.21

11.052

8.696

Figure 2. Schematic of the Fore-optics.

The uncertainty of the position of the beam waist of the mixer horn causes significant changes in the beam waist position of the optics, which may affect the telescope focusing and reduce the efficiency. Therefore, the beam waist position of the mixer horn must be measured experimentally.

**Method and 1:3 Scale-up Model.**

We scale up the fore-optics and mixer horn, making them three times larger than the original model, because the large model can provide a larger margin for tolerating the measurement errors. The operating wavelength is also scaled up to 1.89mm (158.333GHz). Fig. 3 is the optics of the scale model.

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Figure 3. 1:3 scale-up model.

The position of the input beam waist can be derived from the best focus for a source located close to the optics. Tuning the distance between the feedhorn and the optics until the maximum power is measured, we consider the point is the best focus. Fig. 4 illustrates the simulation results depicting the variation in the best focus point with respect to different separation distance between the source and detector. Then the optimal feedhorn position

A graph with colored lines and numbers

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Figure 4. Best focus positions for the source at distances of 0.5, 0.75, 1.5, 2.5 and 1000 meters.

can be calculated theoretically.

The inaccuracy in the feedhorn beam size may also affect the measurement. Luckly, the simulations indicate that the beam size changes don’t impact the beam focus measuring, see Fig. 5. But the curv

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**Experimental Setup**

The desired input beam waist location can be deduced by measuring the best focus for the source close to the fore-optics such as 0.7, 1.0 and 2 meters.