230 GHz Frequency Independent Sidecab Optics
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CSO 230 GHz Rx –MEMO II
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In order to establish frequency independent sidecab optics at the CSO, (No changes to the observatory optics) three optical configurations have been analyzed.

Red Curve: A single lens (mirror) directly in front of the mixer scalar feedhorn.
Disadvantage: frequency dependent telescope optics.
Advantage: Compact.
This is the present configuration at the CSO.

Green Curve: A two lens (mirror) Gausian* telescope configuration. Though frequency independent by itself, when propagated thru the telescope there remains some frequency dependence. The primary reason is the frequency dependent location of the horn's phase center. (As the frequency increases, the phase center moves toward the throat of the horn). It is important to realize that this effect can be compensated by physically moving the cryostat, relative to the 5th mirror, with frequency.

$$wo(\lambda) := \frac{0.644 \cdot a}{1 + \left[\frac{\pi \cdot (0.644 \cdot a)^2}{\lambda \cdot Rh}\right]^2}$$

$$zc(\lambda) := \frac{Rh}{1 + \left[\frac{\lambda \cdot Rh}{\pi \cdot (0.644 \cdot a)^2}\right]^2}$$

The horn waist *wo* is primarily determined by the *a*, the aperture of the Horn, but also to a lesser extend by the operating frequency. Same is true for *zc*, the location of the phase center inside the scalar feedhorn.

Blue Curve: A two lens (mirror) configuration optimized to give frequency independent illumination (Fig. 1). The frequency dependent effect of *zc* is to a large extend cancelled out.

*A Gausian beam telescope has the two lenses (mirrors) separated by the sum of their focal length, and has the input waist located at the focal point of one of the lenses.

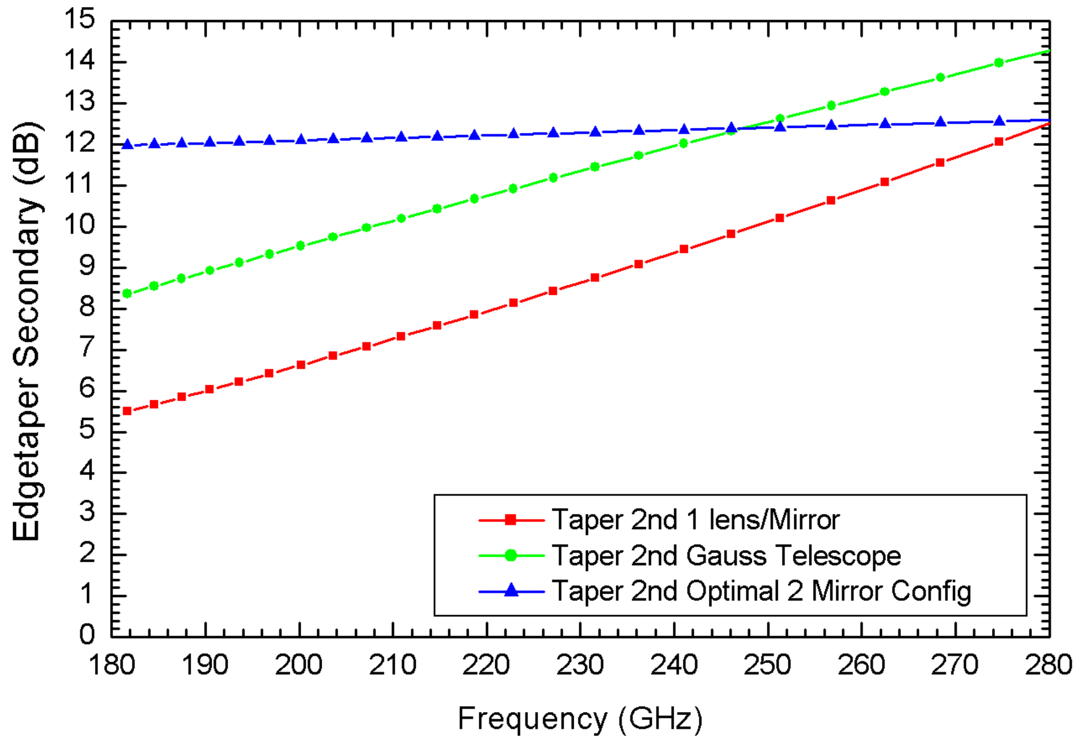

Fig. 1. Calculated edgetaper for the present, one lens, receiver sidecab optics configuration (red). A two mirror "Gaussian telescope" configuration (green), and a special two mirror configuration (blue) that has been optimized to provide frequency independent illumination.

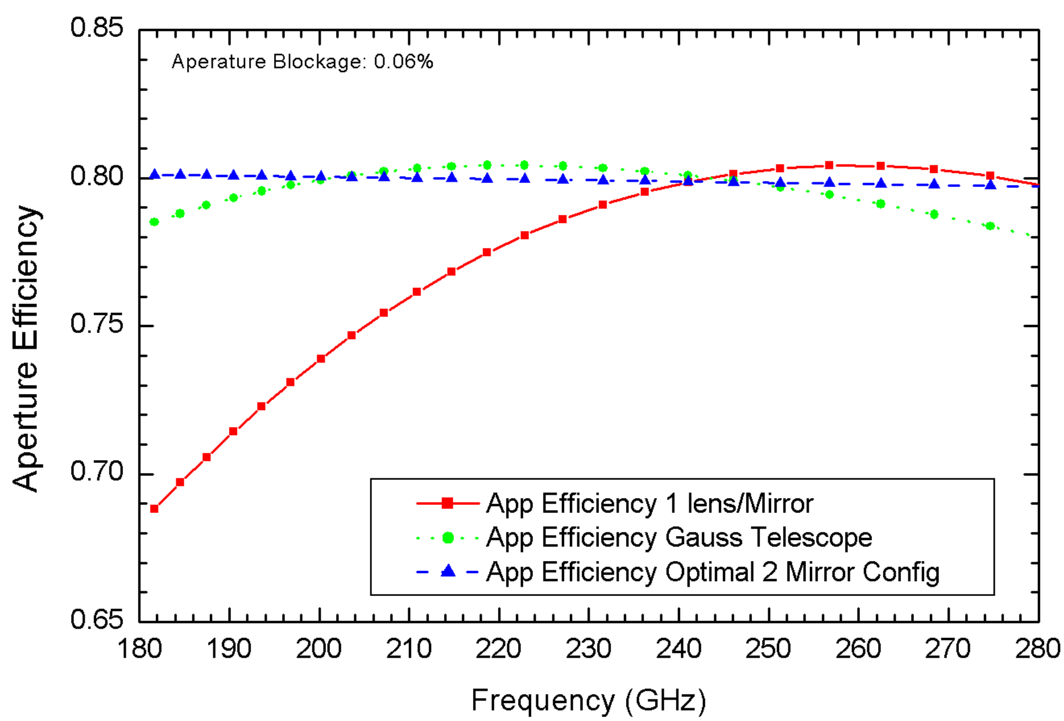

Fig. 2. Calculated Aperture efficiency for the present, one lens, sidecab receiver optics configuration (red). A two mirror "Gaussian telescope" configuration (green), and a special two mirror configuration (blue) that has been optimized to provide frequency independent illumination

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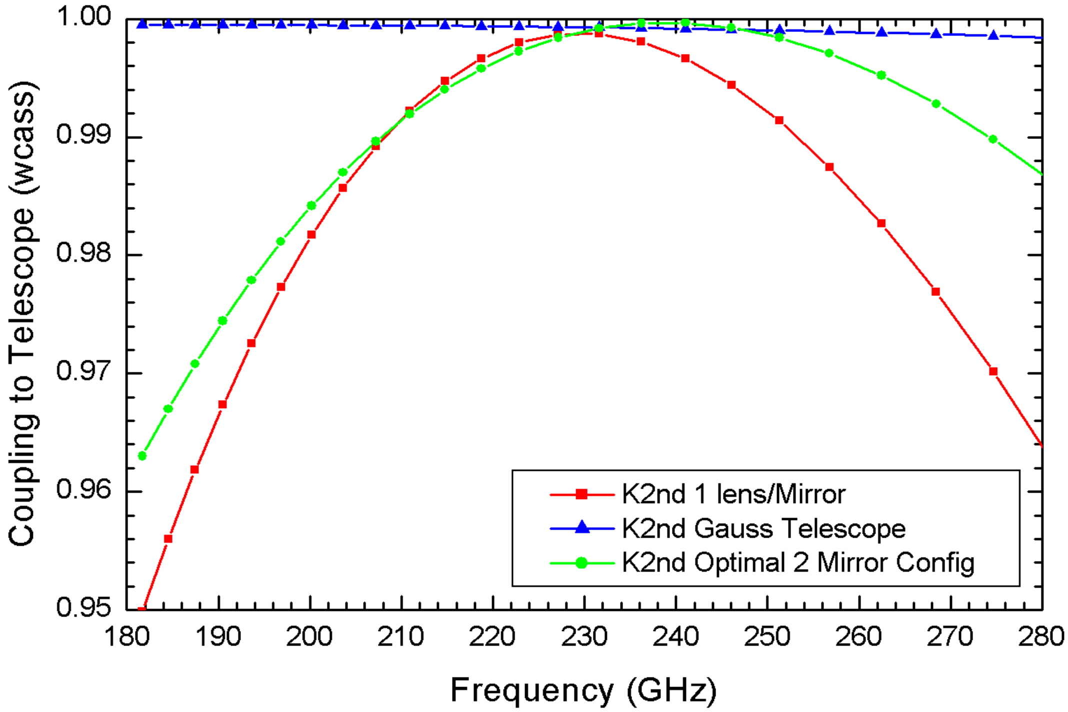

Fig. 3 Calculated Telescope coupling efficiency for the present, one lens, sidecab receiver optics configuration (red). A two mirror "Gaussian telescope" configuration (green), and a special two mirror configuration (blue) that has been optimized to provide frequency independent illumination.

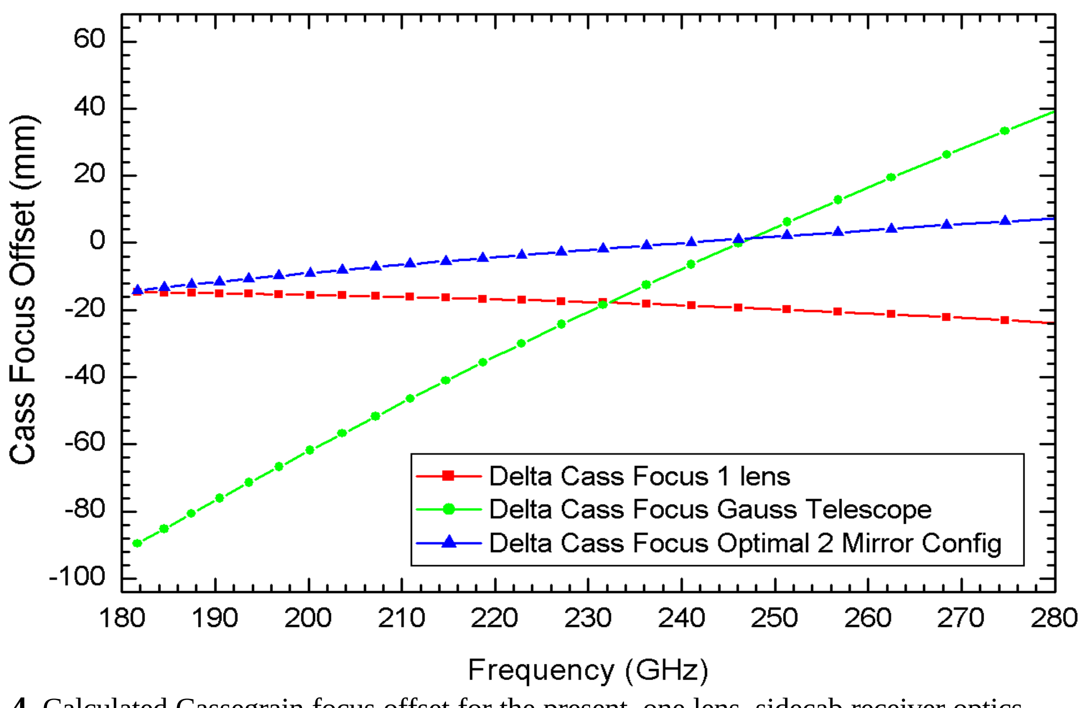

Fig. 4. Calculated Cassegrain focus offset for the present, one lens, sidecab receiver optics configuration (red). A two mirror "Gaussian telescope" configuration (green), and a special two mirror configuration (blue) that has been optimized to provide frequency independent illumination. Offset errors can be taken out with the Secondary focus offset, however it may be more practical to Minimize variation by design.

To Summarize:

- **Make the instrument focus frequency dependent by either:**

  a) Use of two cooled mirrors in a “Gaussian Telescope” configuration
  (This requires the dewar to be moved with frequency)

  b) A special combination of two cooled mirrors to give frequency independent Telescope illumination.
  (Does <u>not</u> require the dewar to be moved).

Naturally option “b” is ideal, and I will try to incorporate it into the new Sidecab receiver layout.