SAT Zemax Lens Design Update

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Optics Design

- Optics designs for
  - LF (30/40 GHz), MF (85/145 and 95/155 GHz), and HF (220/270 GHz)
  - Two lens designs (objective and field)
  - Three candidate lens materials (exact index values need to be updated)
    - HDPE (index = 1.55)
    - Alumina (index = 3.10)
    - Silicon (index = 3.40)

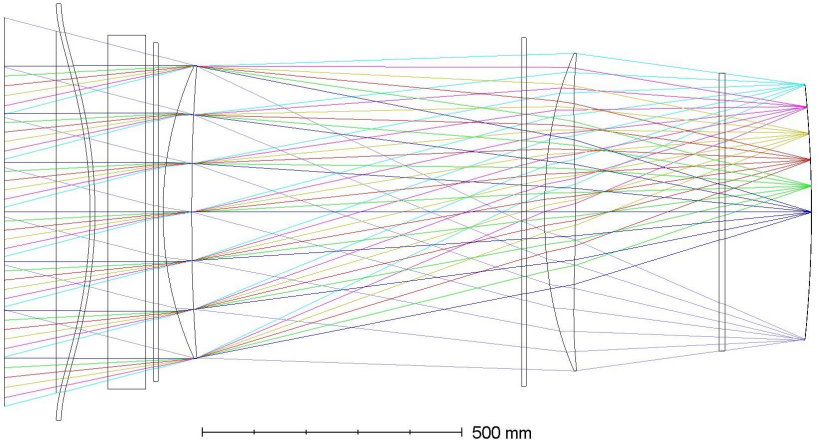
- Preliminary Baseline Design
  - FOV: 29 degrees
  - LF and MF tubes
    - HDPE lenses → large diameter, proven AR coating technology
    - Focal plane: 490 mm
  - HF tubes
    - Silicon lenses → low loss at high frequencies
    - Focal plane: 422 mm

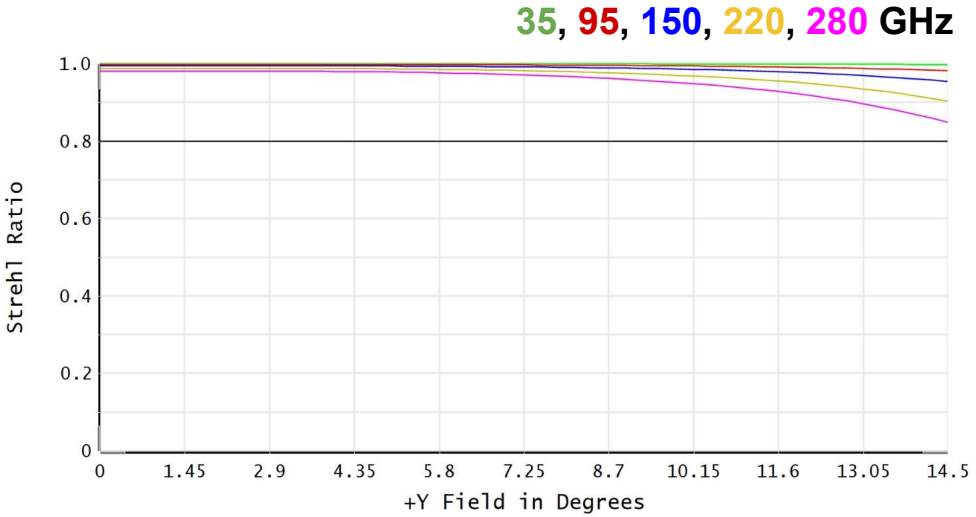
Design Requirements

- FOV diameter: 29 degrees
- Focal plane
  - Curvature: ~2400 mm
    - Study by Tony: link
  - LF/MF diameter: 490 mm
  - HF diameter: 422 mm
- Aperture stop located behind objective lens

- HDPE / Alumina lens designs
  - Aperture stop diameter: 560 mm
  - Optical diameter: 610 mm
- Silicon lens design
  - Aperture stop diameter: 440 mm
  - Optical diameter: 445 mm

HDPE Lens Design

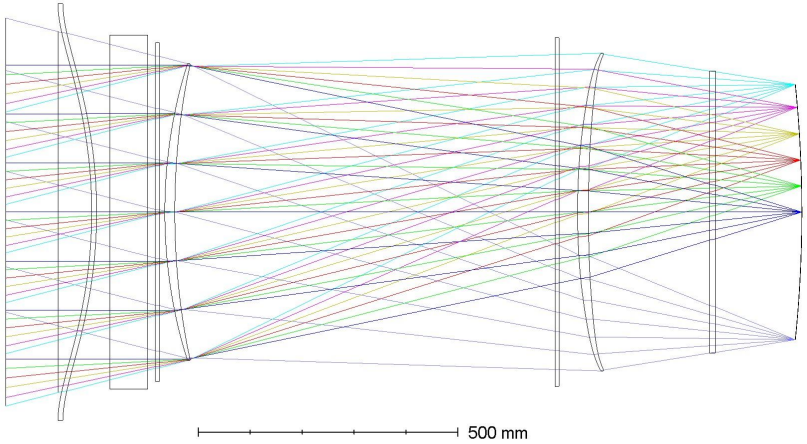


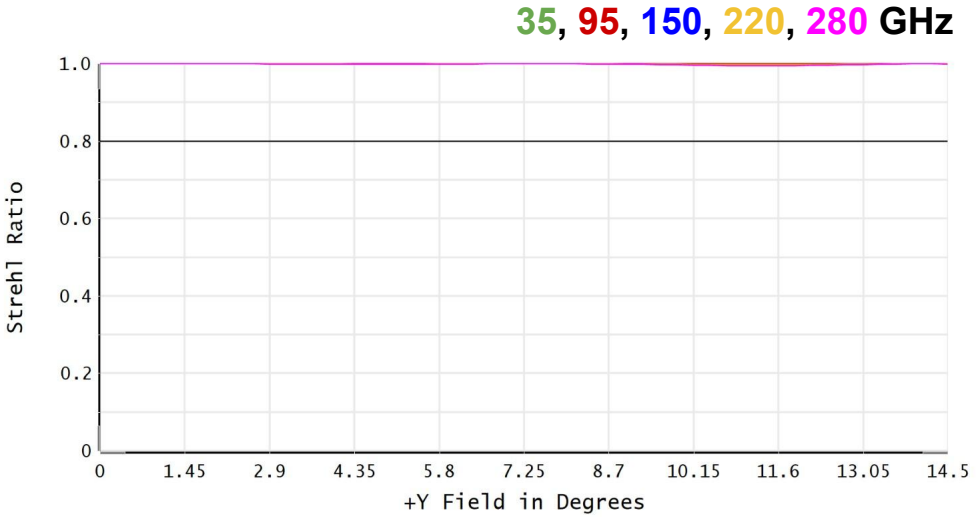


- FP diameter: 490 mm
- Strehl ratio: > 0.84
- Optical length: ~1554 mm
- Lens thickness (center)
  - Objective: ~55 mm
  - Field: ~59 mm

- Telecentricity: $\lesssim$ 1.6 deg
- F# (sine def)
  - F# avg (sagittal and tangential): 1.71 (center) ~ 1.80 (edge)
  - Sagittal and tangential difference: $|\Delta(F_{sag}-F_{tan})| \lesssim 0.10$

Alumina Lens Design

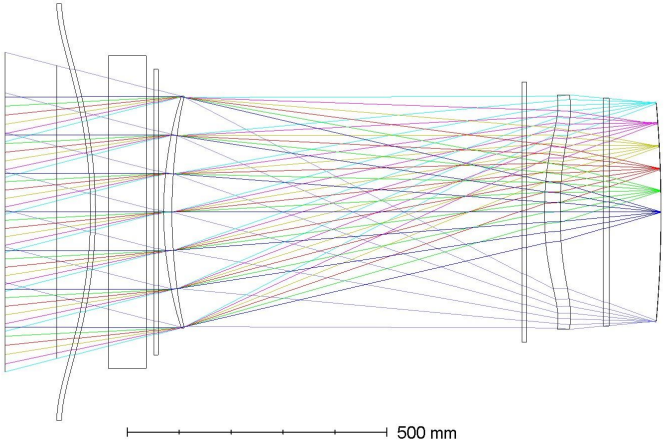


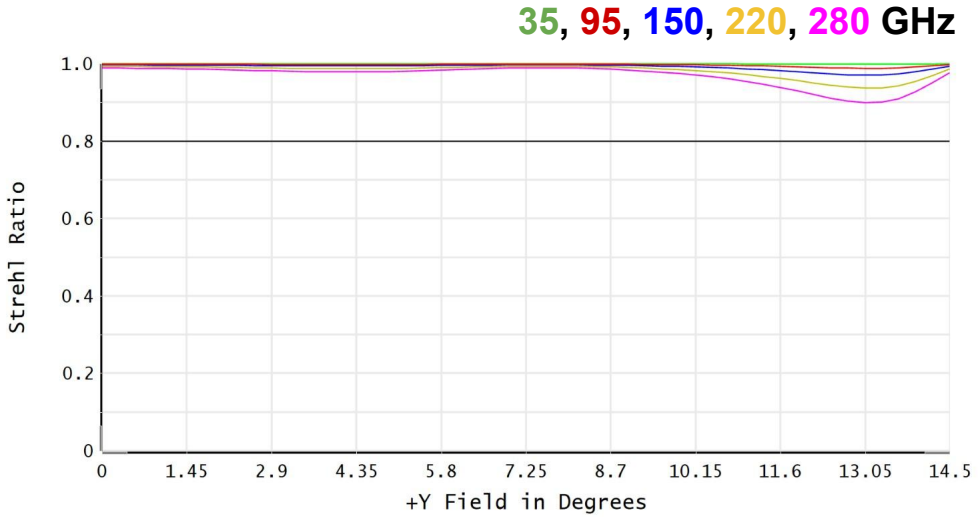


- FP diameter: 490 mm
- Strehl ratio: > 0.99
- Optical length: ~1533 mm
- Lens thickness (center)
  - Objective: ~19 mm
  - Field: ~21 mm

- Telecentricity: $\lesssim$ 0.2 deg
- F# (sine def)
  - F# avg (sagittal and tangential): 1.69 (center) ~ 1.79 (edge)
  - Sagittal and tangential difference: $|\Delta(F_{sag}-F_{tan})| \lesssim 0.12$

Silicon Lens Design





- FP diameter: 422.35 mm
- Strehl ratio: > 0.89
- Optical length: ~1264 mm
- Lens thickness (center)
  - Objective: ~16 mm
  - Field: ~30 mm

- Telecentricity: $\lesssim$ 1.6 deg
- F# (sine def)
  - F# avg (sagittal and tangential): 1.79 (center) ~ 2.07 (edge)
  - Sagittal and tangential difference: $|\Delta(F_{sag}-F_{tan})| \lesssim 0.34$

Preliminary Conclusions

- LF / MF designs
  - HDPE design
    - High optical performance but requires thick (~60 mm) lenses
    - HDPE lenses are most conservative choice due to proven AR coating technology
  - Alumina design
    - Highest optical performance with margin
      - Flat focal plane is potentially also sufficient
    - AR coating R&D on-going

- HF designs
  - Silicon design
    - High optical performance but F# uniformity is larger than other designs
      - Mainly constrained by maximum silicon lens size (~445 mm optical)
      - Third lens (like SO) may help with this but needs study to confirm
    - Known lowest loss (out of the candidate materials) at HF
    - Focal plane size limited (~422 mm) due to lens size as well
  - Possible candidate: HDPE design
    - If ~60 mm thick HDPE lenses are proven acceptable in terms of loss
    - Requires detailed cold loss measurements

- F# and detector coupling needs to be verified / optimized in near future