Report back from
Small Aperture Telescopes - Parallel

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Tuesday March 9, 3:30-5:00 ET

Optics - *Abby Vieregg / Paul Grimes / Scott Paine*

Lens material

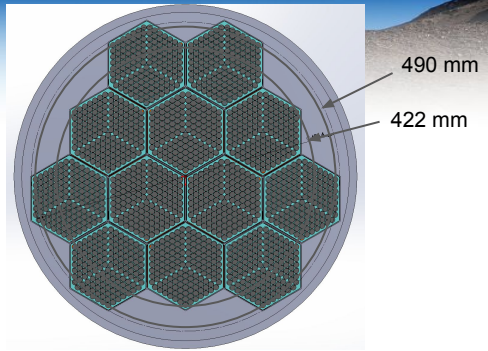
With the recent adoption of HDPE as LF and MF baseline lens material, why is alumina still under consideration?

- HDPE designs depend on curved focal plane for good performance. This is a new development needing further study including system impacts.
- Pending results of test program in progress, uncertainties remain regarding HDPE loss relative to alumina and silicon, and relative risks from birefringence and scattering.
  - Alumina is baselined for IR filter so will be part of this testing anyway.
- Poor thermal conductivity of HDPE relative to alumina is not a concern.

HF baseline material remains as silicon, restricting element diameters.

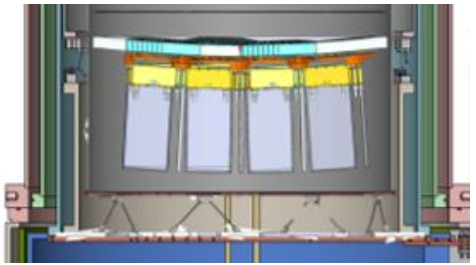
- This could change based on HDPE and alumina loss measurements.
- Have candidate HDPE design, alumina design would be easier to optimize.

Optics - Curved focal plane



This is a new development. What is the impact on focal plane packaging?

- Tilt angles to approximate the curved focal plane are quite small.
- Spacing is set by front edges of the feedhorn blocks, and rear edges will actually gain a bit of clearance.

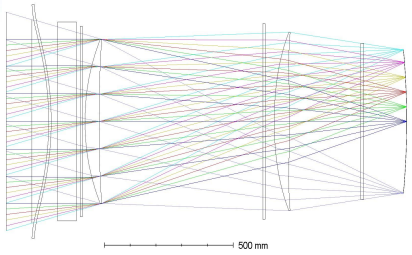


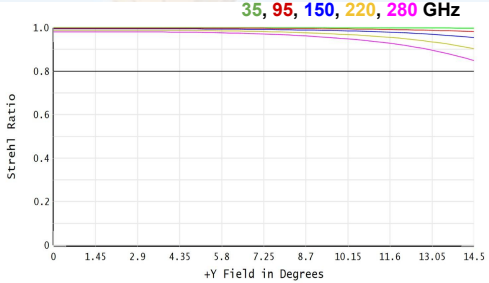
Will the planar tiles approximate the spherical focal surface well enough?

- This has not yet been simulated, but Tony has done a hand analysis that indicates that performance should be good.
- A follow up analysis in Zemax should be performed as a check
- GRASP/PO to follow in coming months (as PBD matures)

HDPE Lens Design

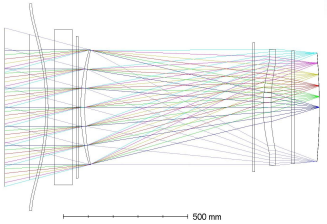
Slides from Fred Matsuda

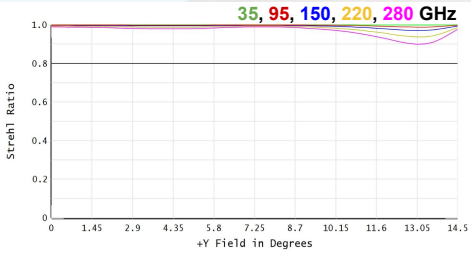




- FP diameter: 490 mm
- Strehl ratio: > 0.84
- Optical length: ~1554 mm
- Lens thickness (center)
  - Objective: ~55 mm
  - Field: ~59 mm
- Telecentricity: ≲ 1.6 deg
- F# (sine def)
  - F# avg (sagittal and tangential):
    1.71 (center) ~ 1.80 (edge)
  - Sagittal and tangential difference:
    $|\Delta(F_{sag}\text{-}F_{tan})| \lesssim 0.10$

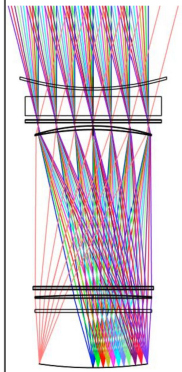
Silicon Lens Design

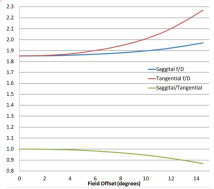




- FP diameter: 422.35 mm
- Strehl ratio: > 0.89
- Optical length: ~1264 mm
- Lens thickness (center)
  - Objective: ~16 mm
  - Field: ~30 mm
- Telecentricity: ≲ 1.6 deg
- F# (sine def)
  - F# avg (sagittal and tangential):
    1.79 (center) ~ 2.07 (edge)
  - Sagittal and tangential difference:
    $|\Delta(F_{sag}\text{-}F_{tan})| \lesssim 0.34$

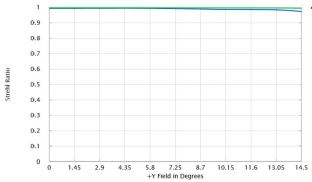
Two Lens design with Thin Silicon Lenses





- 445 mm lens diameter
- Blank thickness < 50 mm
- Lens 1 is 12 mm thick
- Lens 2 is 9 mm thick and is plano-convex
- Detector diameter 414 mm curvature R = 1470 mm
- Strehl > 0.97 @ λ 1mm

from Tony Stark



Does Strehl > 0.95 matter? What does?

- Aperture illumination symmetry/uniformity (f/D, …)

Tony emphasized: **FP dia & f/D ↔ aperture dia & FOV**

- Gaps between modules directly cost SAT mapping speed → strong motivation to minimize gaps

Curved focal plane designs remain telecentric.

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

Slide from Fred Matsuda

Last bullet on horn coupling requires a joint effort with Modules group in near future

- We have a preliminary feed design, but need horn optimization by frequency

Optics - Other ideas and questions

Have hybrid designs using different materials for lens1/lens2 been studied?

- No, but they could be. Tony has considered doing this.
- Would need to see a clear benefit to offset cost/complexity

Could performance be improved by adding power to the planar filter elements?

- In principle, yes, but thickness is chosen to minimize signal loss once IR blockage is satisfied, leaving little thickness available for figuring.

The baseline alumina filter looks thick at 10 mm. Is this optimized?

- Not strictly, but incremental sanity checks by Lingzhen show it isn't far off. This will be studied further.

Window, Filter and Lens materials are all being measured for loss, index and scattering performance at relevant temperatures.

Cryostat - *Akito Kusaka / Joe Saba*

Do we have multiple potential vendors for DRs?

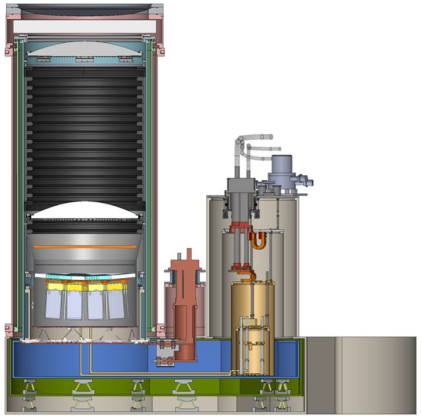
- Yes, we are trying to keep design compatibility with at least several vendor DR inserts / GHSs

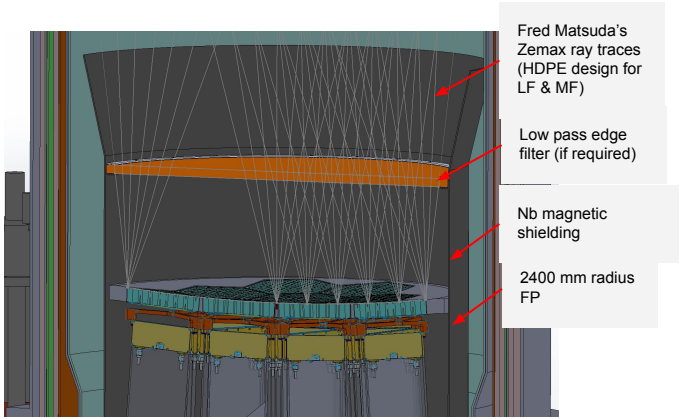
Cryostat prototype plan (quickly follows CD-1)

1. Thermal validation (incl. IR filter prototypes)
2. Integration, mag & RF shielding
3. Pre-production detector module/RO test

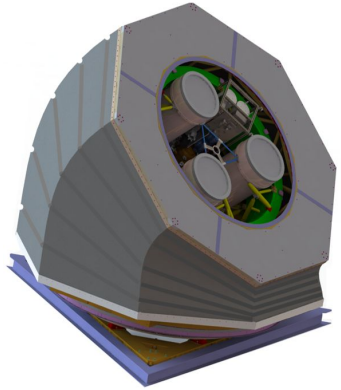
Module mounting:

- Need to ensure fasteners are concealed.





Mount - *Clem Pryke*



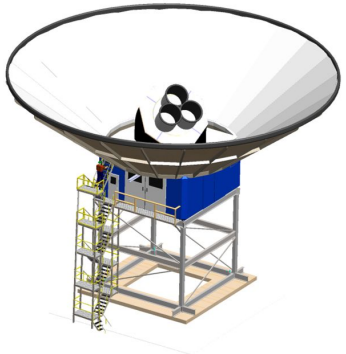
Rotary helium joint lifetime expectancy (from J.Carlstrom)?

- Fielded units are working, some seal better than others. Engineering needed to ensure ours will be trouble-free

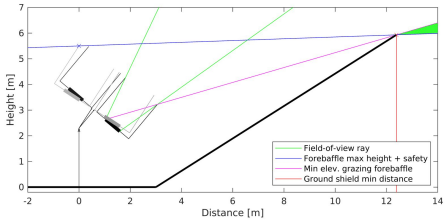
How do we set the turnaround time / acceleration requirement?

- Mechanical spec. high, but actual will be guided by experience and system-level test during N.A. mount/cryostat integration.

Groundshields - *Ben Schmitt*



No questions in parallel, but evident that use of this (proven) geometry is a design driver for us.



Calibration plan - *Kirit Karkare*

Soliciting community input on SAT Calibration apparatus

Will need to identify flowdown:

- calibrations driven by requirements

Due to time, deferred detailed discussion to the next SAT WG mtg (March 22)