Dragone Telescope Trade-off Study

Young + Hanany

Actions from Last Week

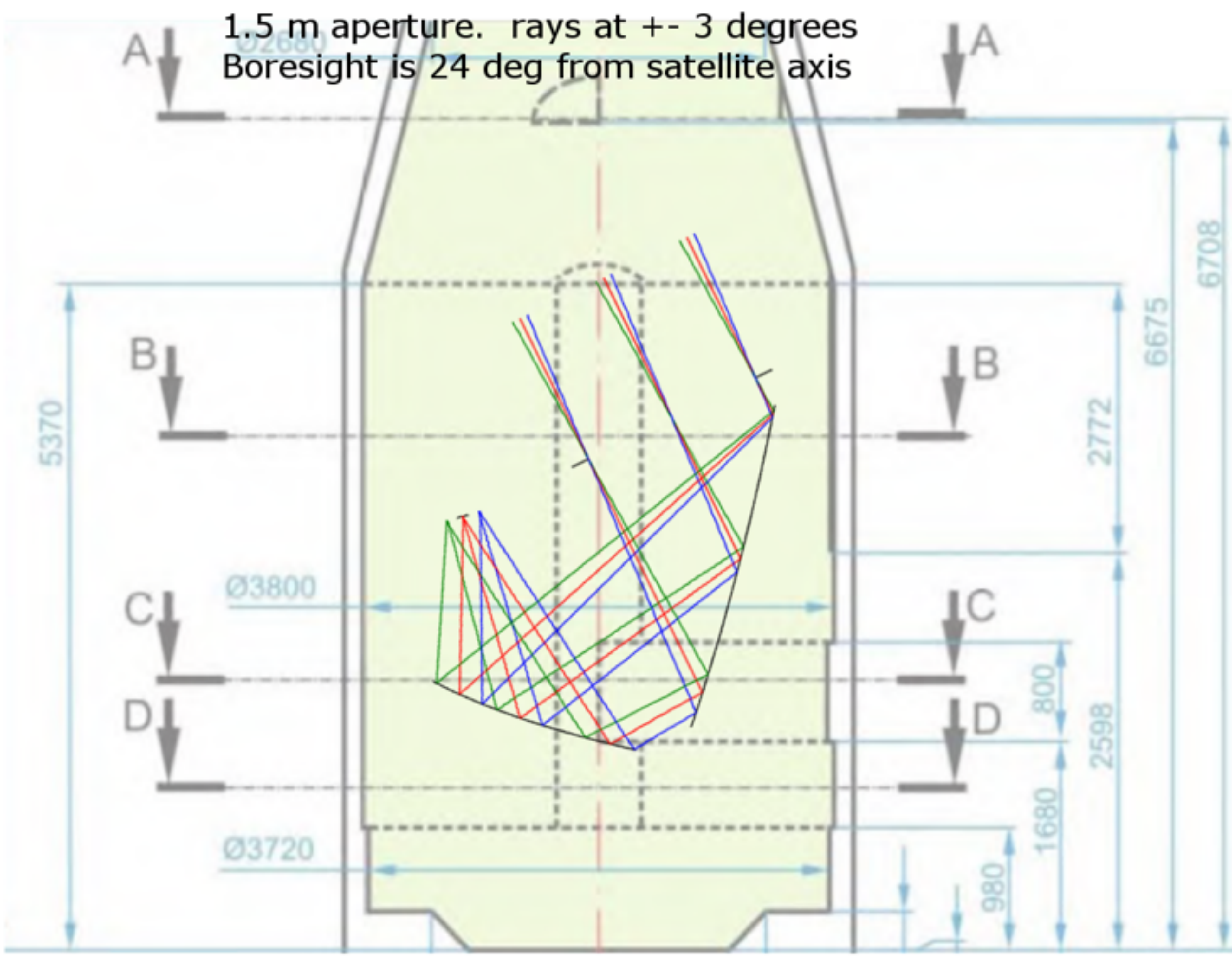
- Provide 1.5 m open dragone design to Neil
  - Status: complete
- Investigate folding the focal plane
  - Status: not doable with current 1.5 m aperture design
- 1 m vs. 1.5 m in terms of # of feeds
  - Status: no gain; see slide 3 (note: for non-optimized systems)
- Set off-axis angle to 24 degrees
  - status: slide 4
  - Can provide solid model
  - Need to check extent of primary in/out of page.
- Provide FOV as a function of frequency
  - Status: Slide 5 (for core light, non-optimized)
  - Need to check whether satisfies requirements
  - Need to provide for core extended

- Other trade-offs?
  - 1 m vs. 1.5 optimized: is there net gain in # of pixels?
  - 1 m vs. 1.5 m optimized: is the gain in volume (for folding the optics) worth the reduction in resolution?

of pixels vs aperture size

- Assumption: pix. linear size scales linearly with f#
- # of pixels = [linear FOV](rad)*platescale (cm/rad) / [pix. linear size] (cm)
- plate scale = f# * [aperture diameter](cm)
- # of pixels = [linear FOV](rad)*f#*[aperture diameter] (cm/rad) / [pix. linear size] (cm)
- empirical: [linear FOV] scales inversely with [aperture diameter]
    - (for non optimized systems)
- [pix. linear size] scales linearly with f#, so for fixed f#, [f#/pix.linear size] is fixed.
- Conclusion: for fixed f#, # of pixels are fixed

Boresight Angle at 24 deg.



Available FOV vs. Frequency

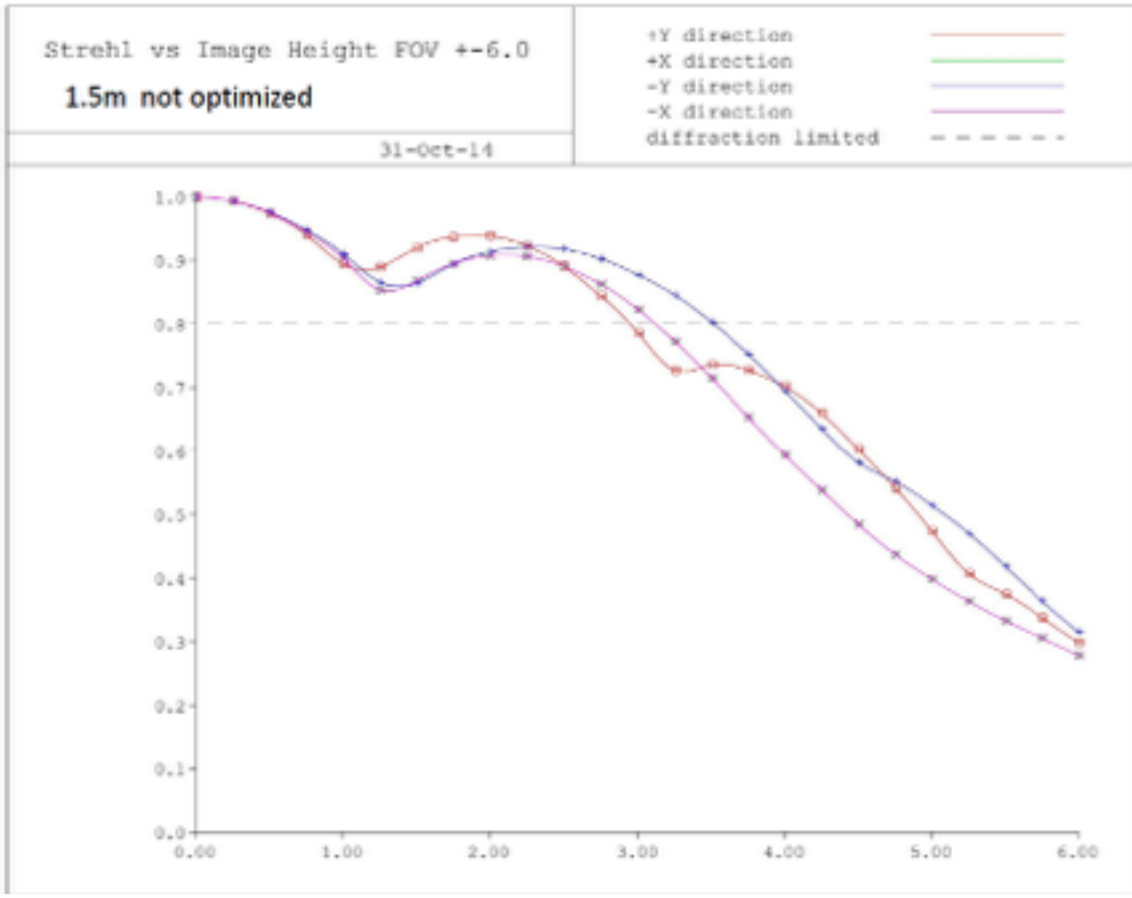
Frequency	N_detectors (2 x N_horns)	Lambda	Beam size	Linear FOV, Az	Linear FOV, El	Focal Plane Diameter	
						Az	El
(GHz)		(mm)	(arcmin)	(deg)	(deg)	(cm)	(cm)
60	*10*	5	21.0	10.8	12	47	52
90	*30*	3.333333333	14.0	8.8	9.4	38	41.5
130	160	2.307692308	9.7	7	7.2	30	31.5
160	260	1.875	7.9	5.8	6.1	26	27
220	200	1.363636364	5.7	4.4	4.6	20	20.2
340	40	0.882352941	3.7	3	3	13	13.3
450	20	0.666666667	2.8	2.4	2.3	10.2	10.2
600	20	0.5	2.1	1.8	1.75	7.8	7.7

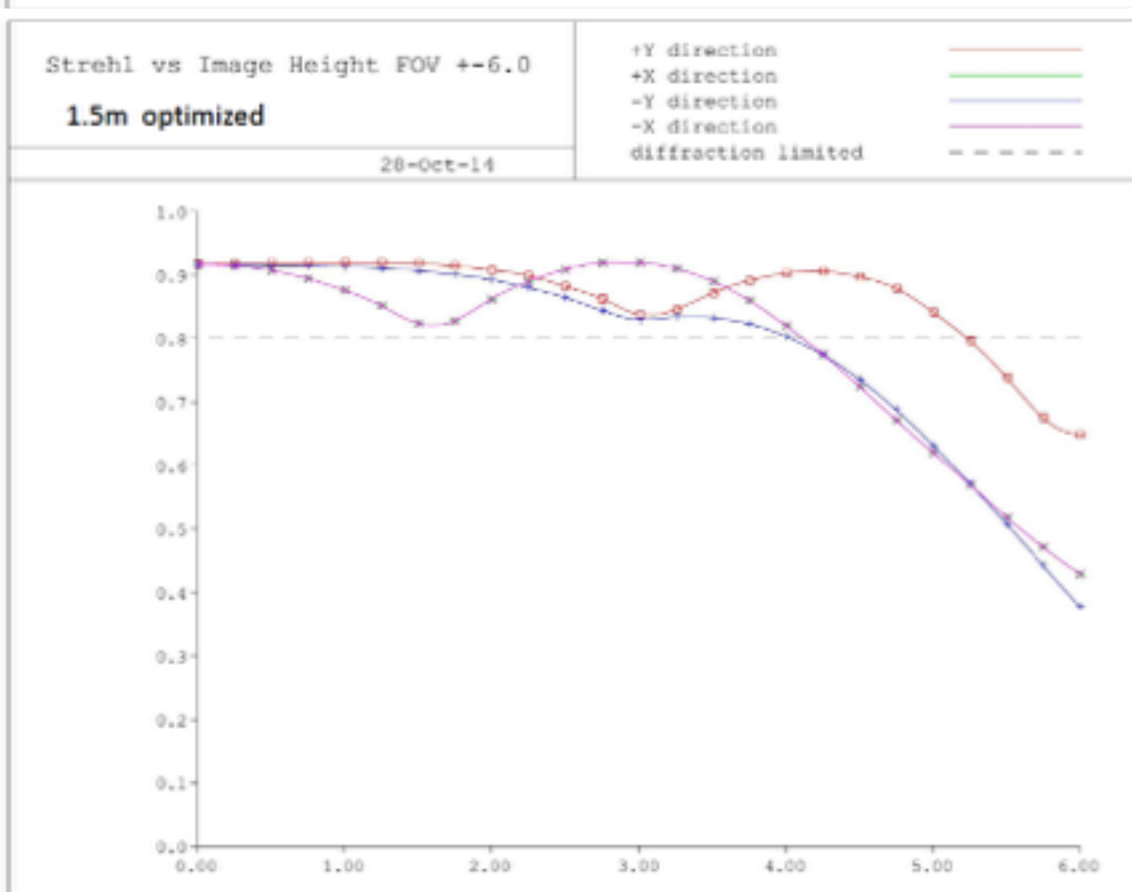
Common Threads

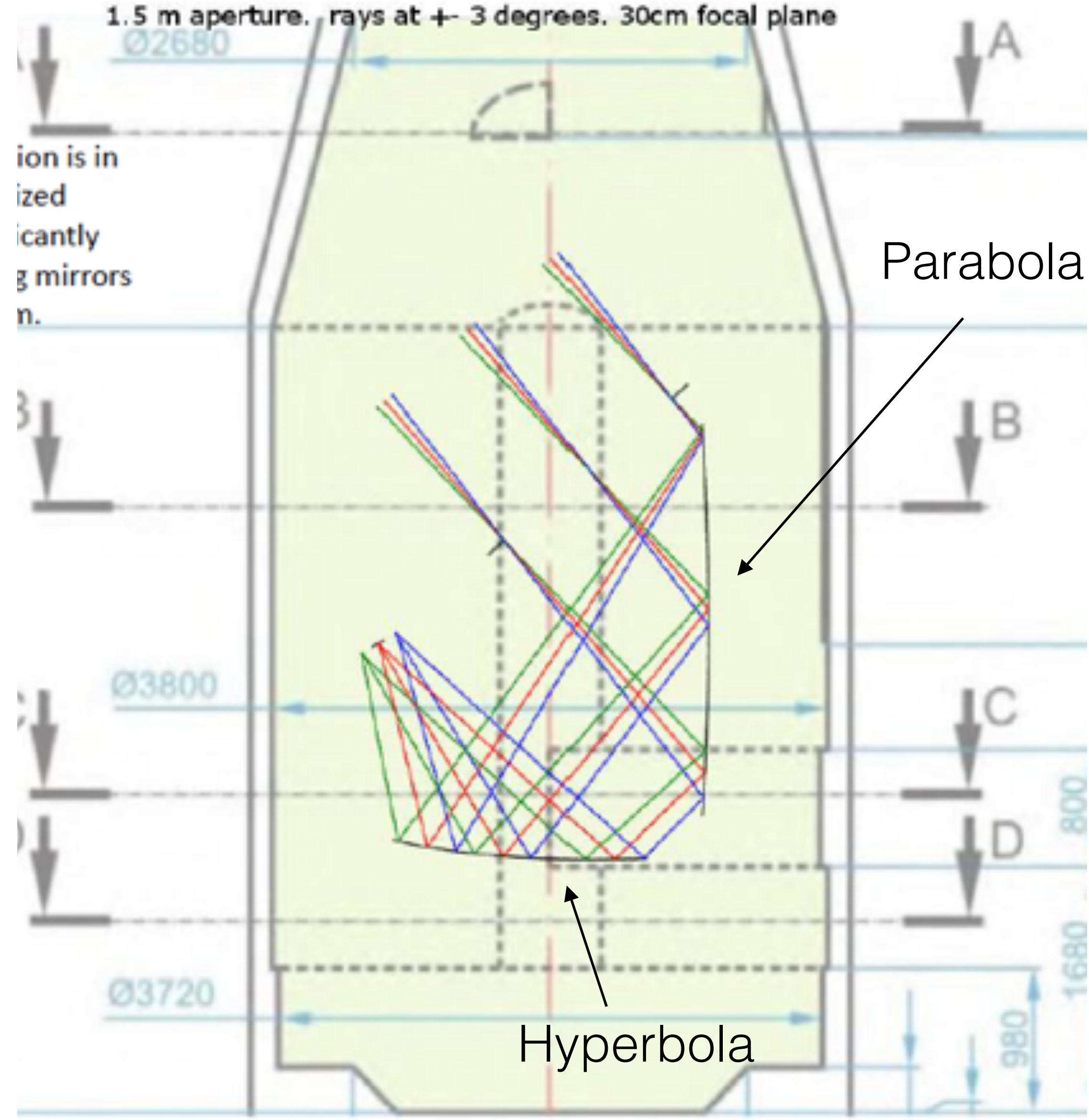
- Compare crossed, front-fed, and Gregorian Dragone designs
- All f#~2
- No reimaging optics
- Use plain conics, and optimize with higher order aspherics at 150 GHz (more details in additional slides)
- Fit 1.5 m aperture in shroud

Slides from Last Week

Front Fed Dragone - I - Front Stop

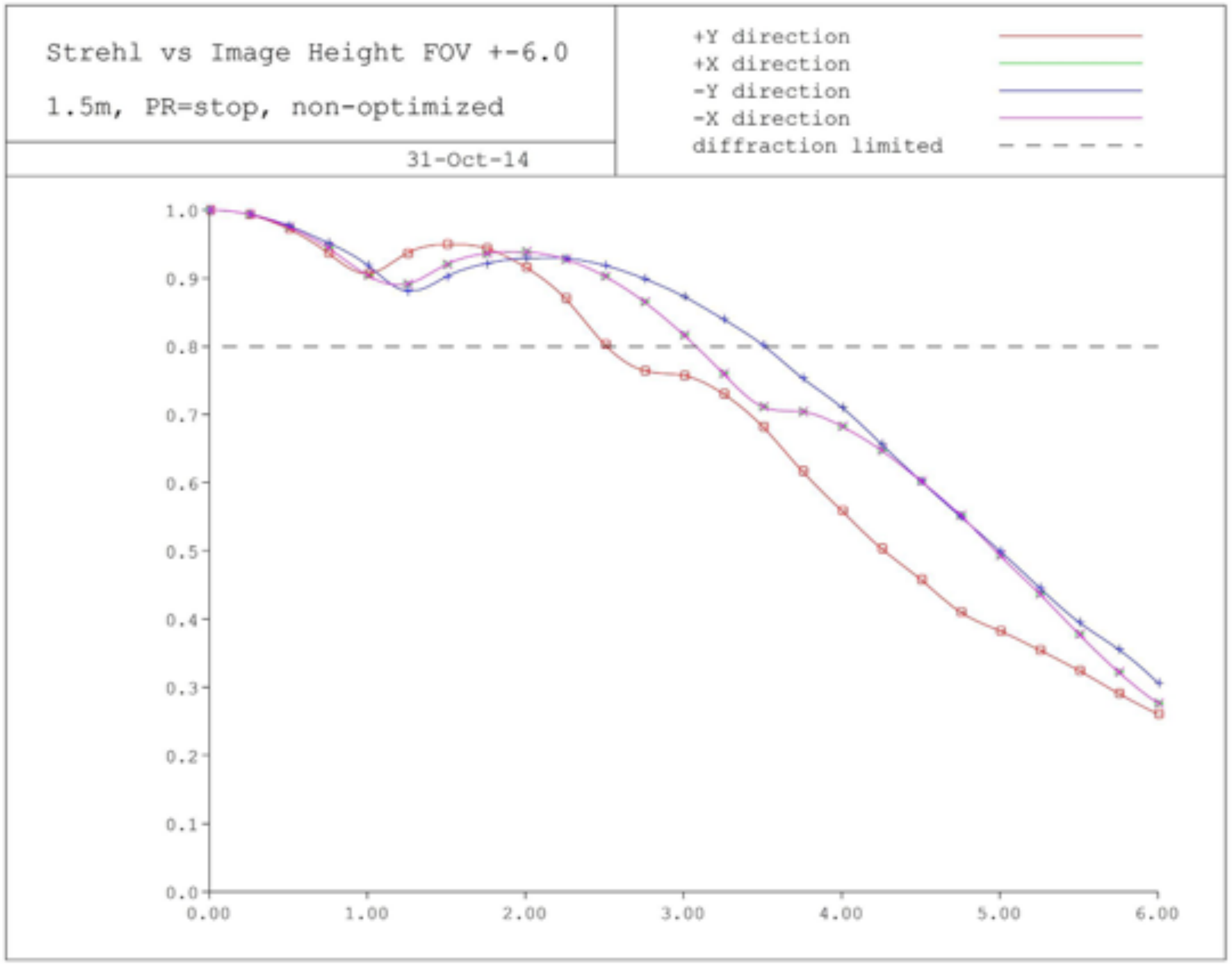


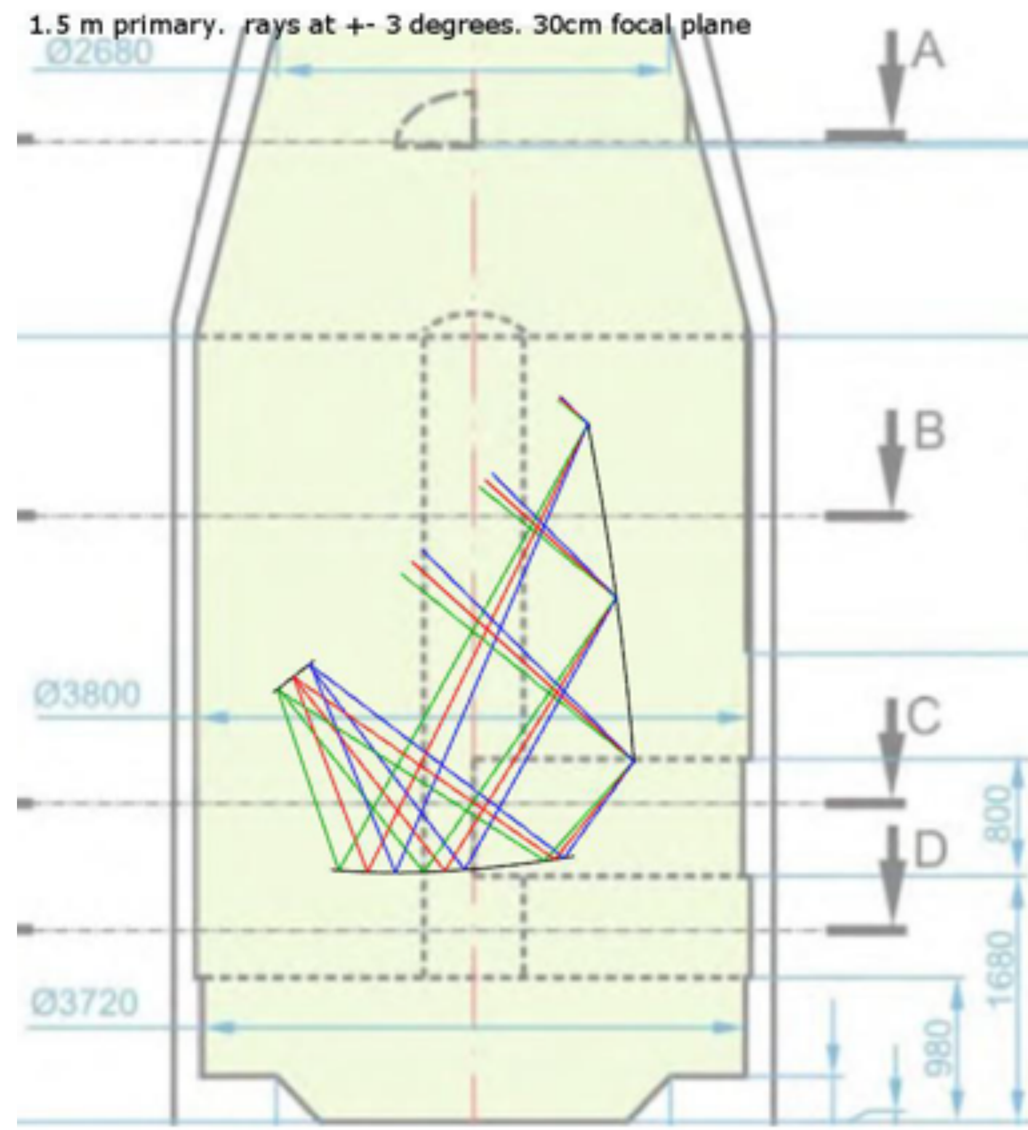




- f#=~2
- 6 deg FOV above Strehl 0.8 (@ 150 GHz) not optimized
- 8 deg FOV optimized
- plate scale = 4.4 cm/deg

Front Fed Dragone - II - Primary Stop

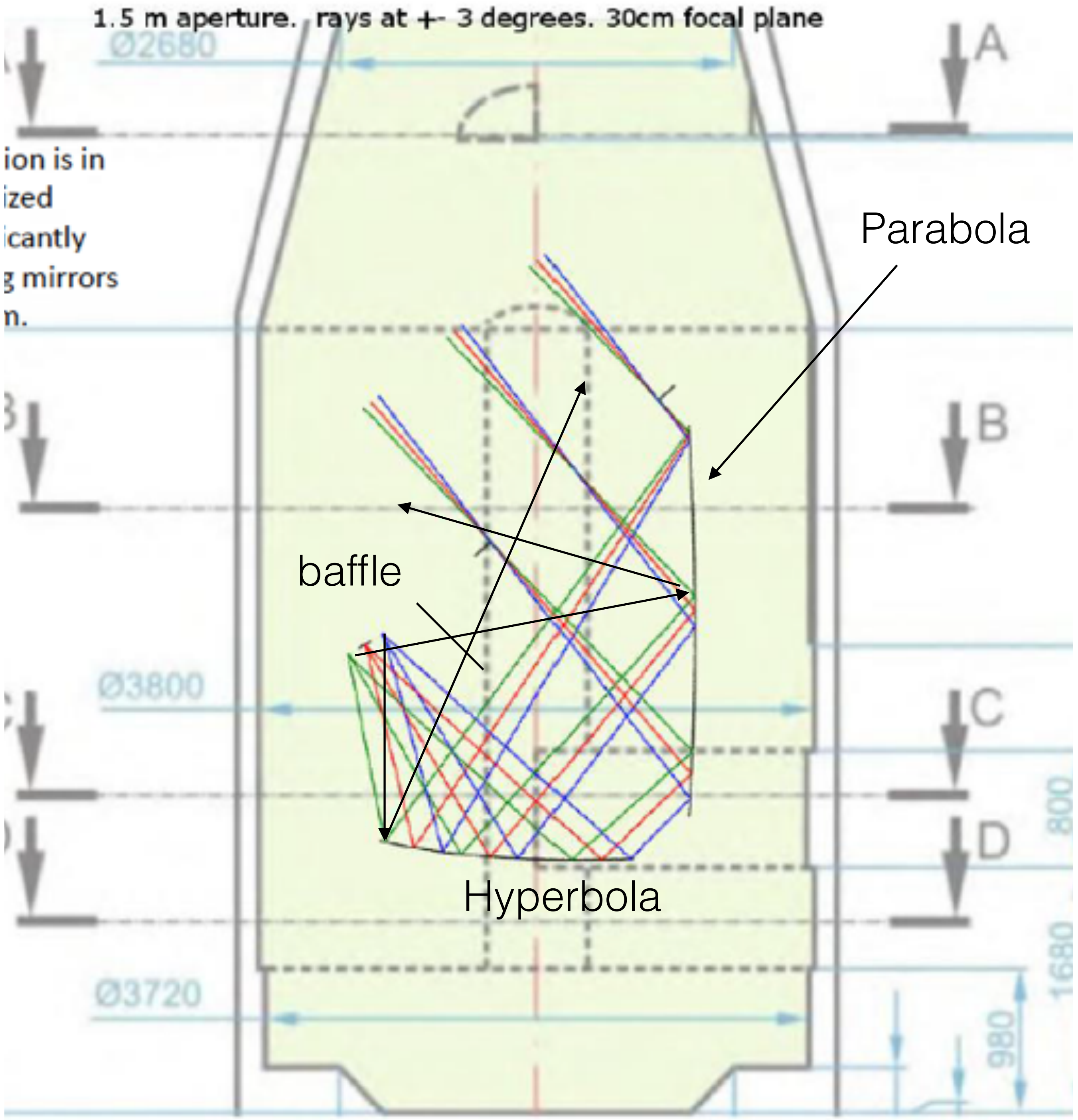




- Not Optimized
- f#=~2
- Conclusion 1: For non-optimized telescopes FOV largely independent of stop location
- Plate scale = 4.2 cm/deg

Front Fed Dragone - Sidelobs

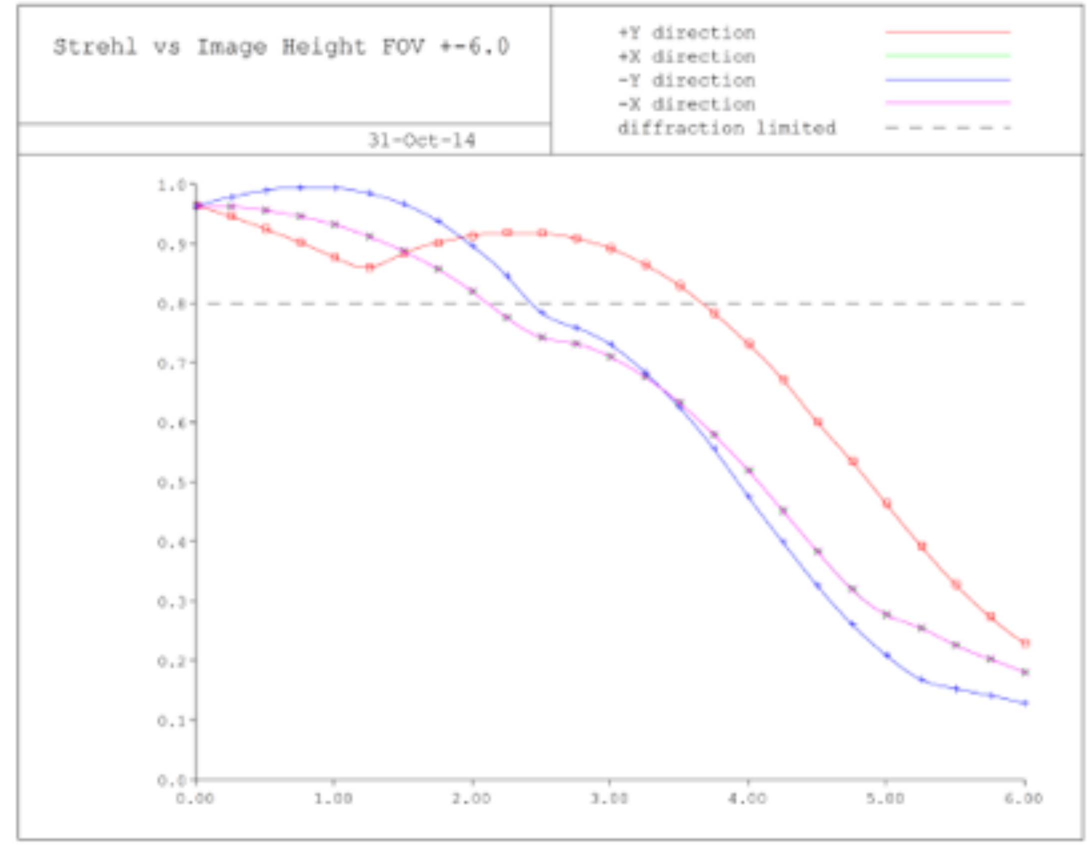
- At first look sidelobes appear to be manageable.



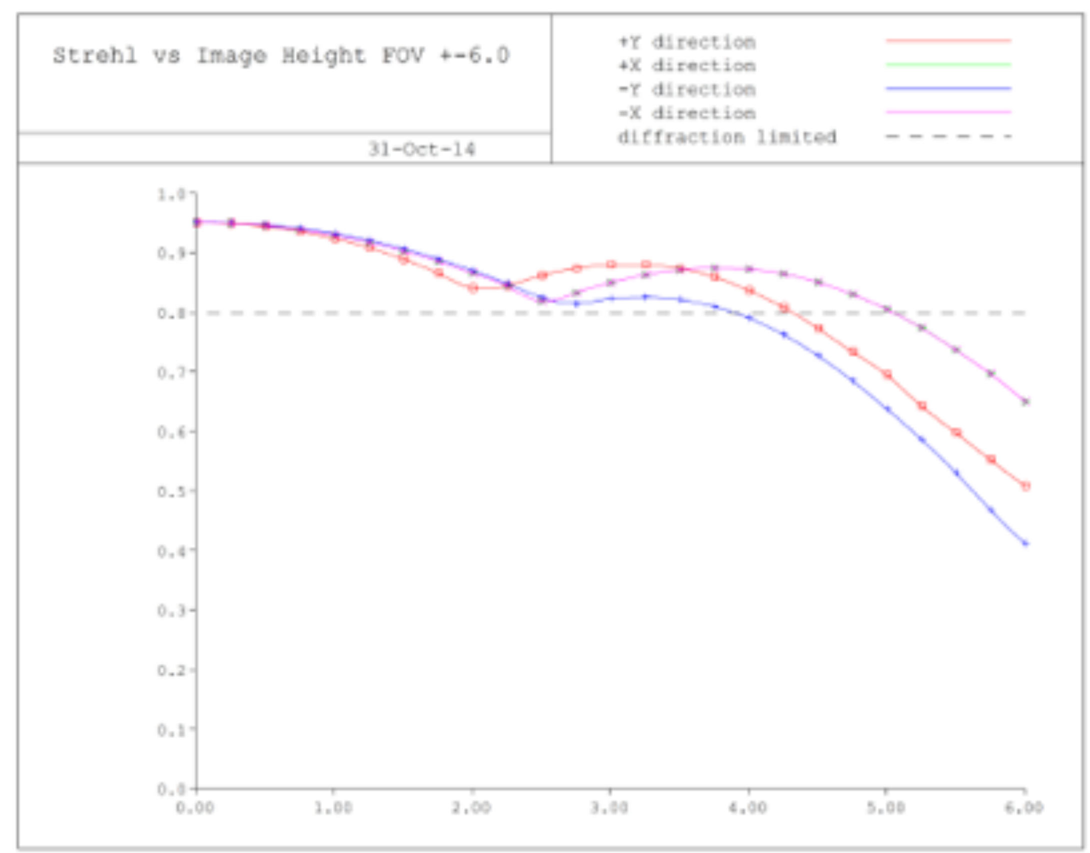
Gregorian vs. Front-Fed Dragone

- Same aperture (1 m)
- Both not optimized
- Plate scale = 3.2-3.3 cm/deg
- EBEX (Gregorian, telescope only): 5 deg FOV
- Front Fed: ~8 deg FOV
- Conclusion 2: comparing 1 m to 1.5 m (not optimized) looks like throughput is conserved. There is gain in FOV at expense of beam size.

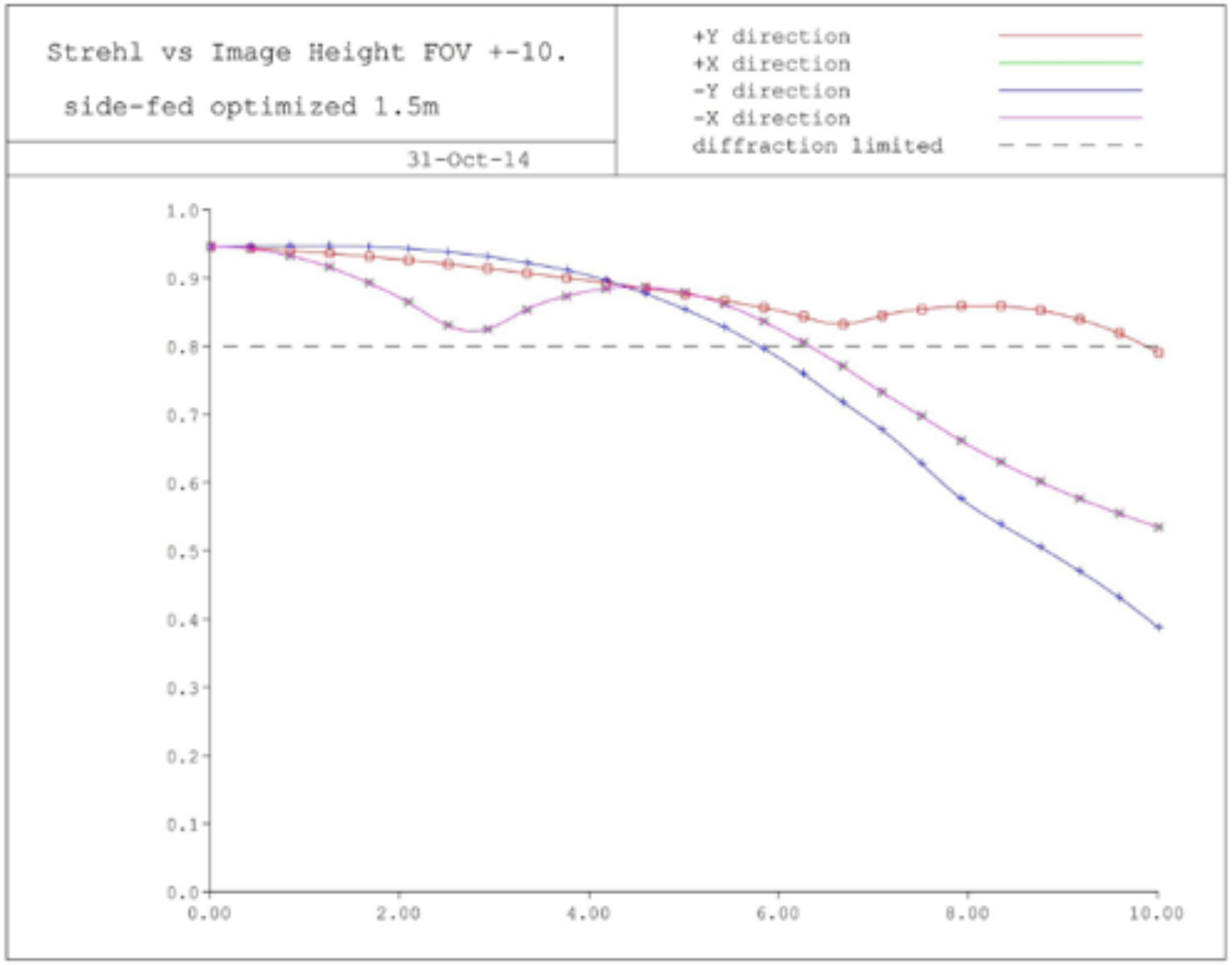
FOV of EBEX mirrors, 1m aperture

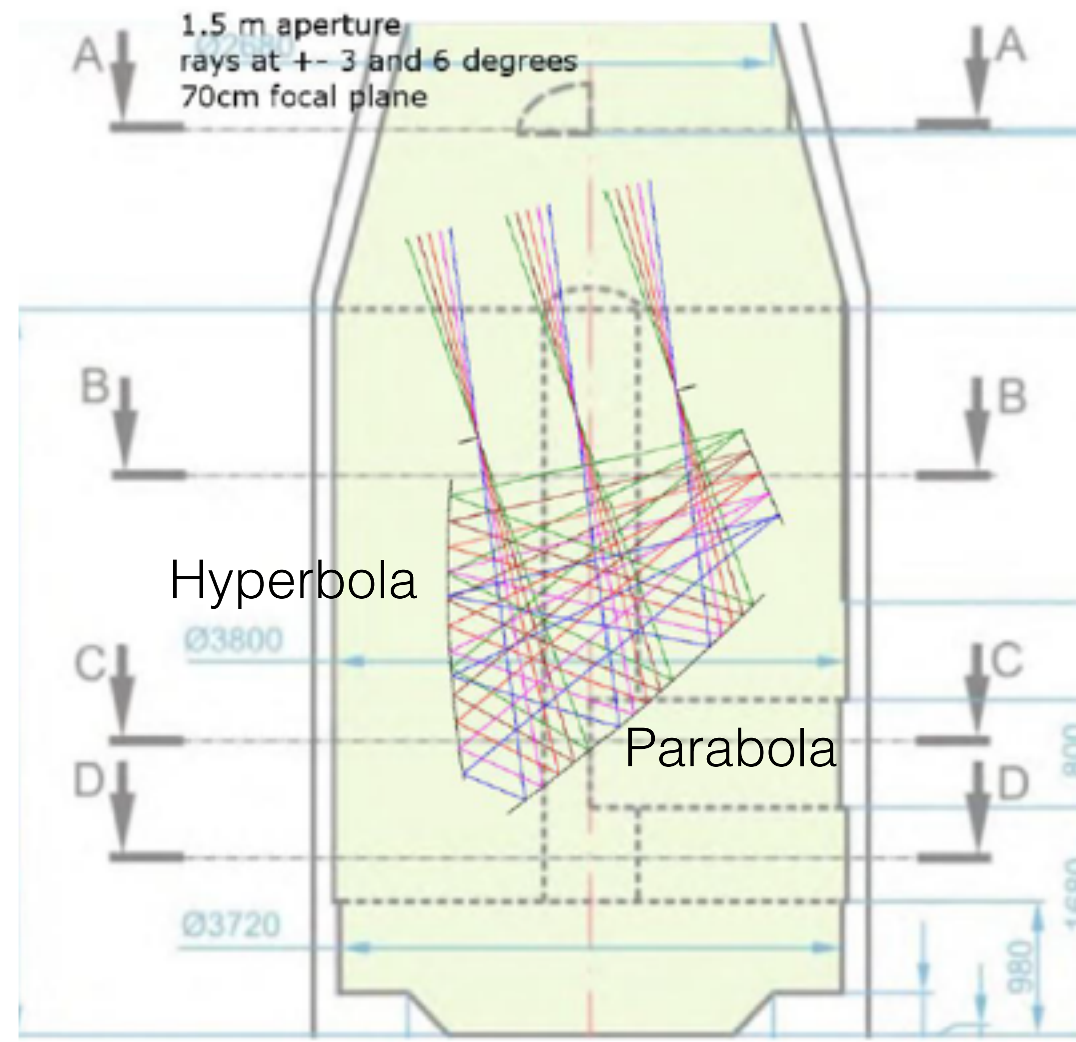


FOV of 1m front fed x-dragone



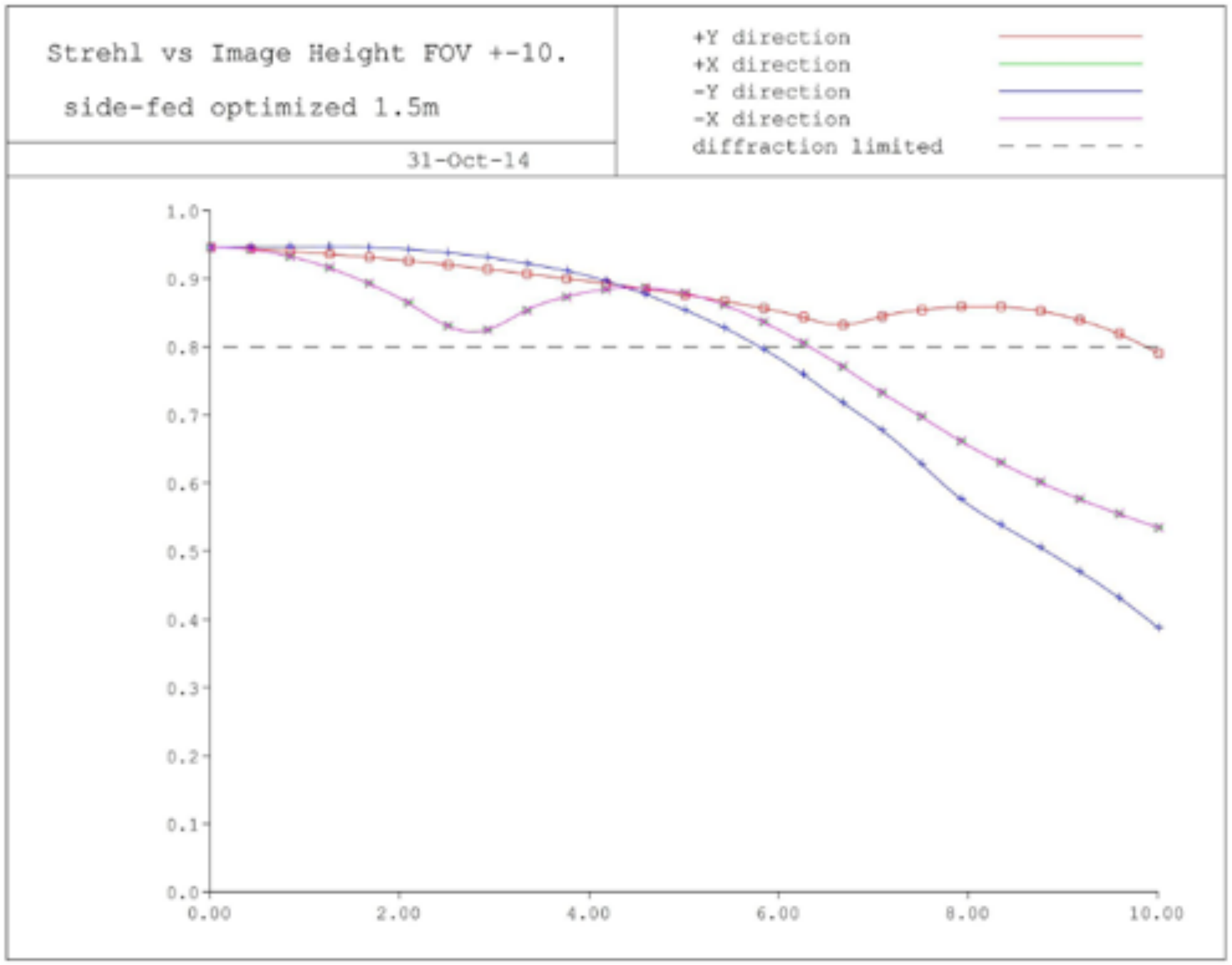
Crossed Dragone - Front Stop

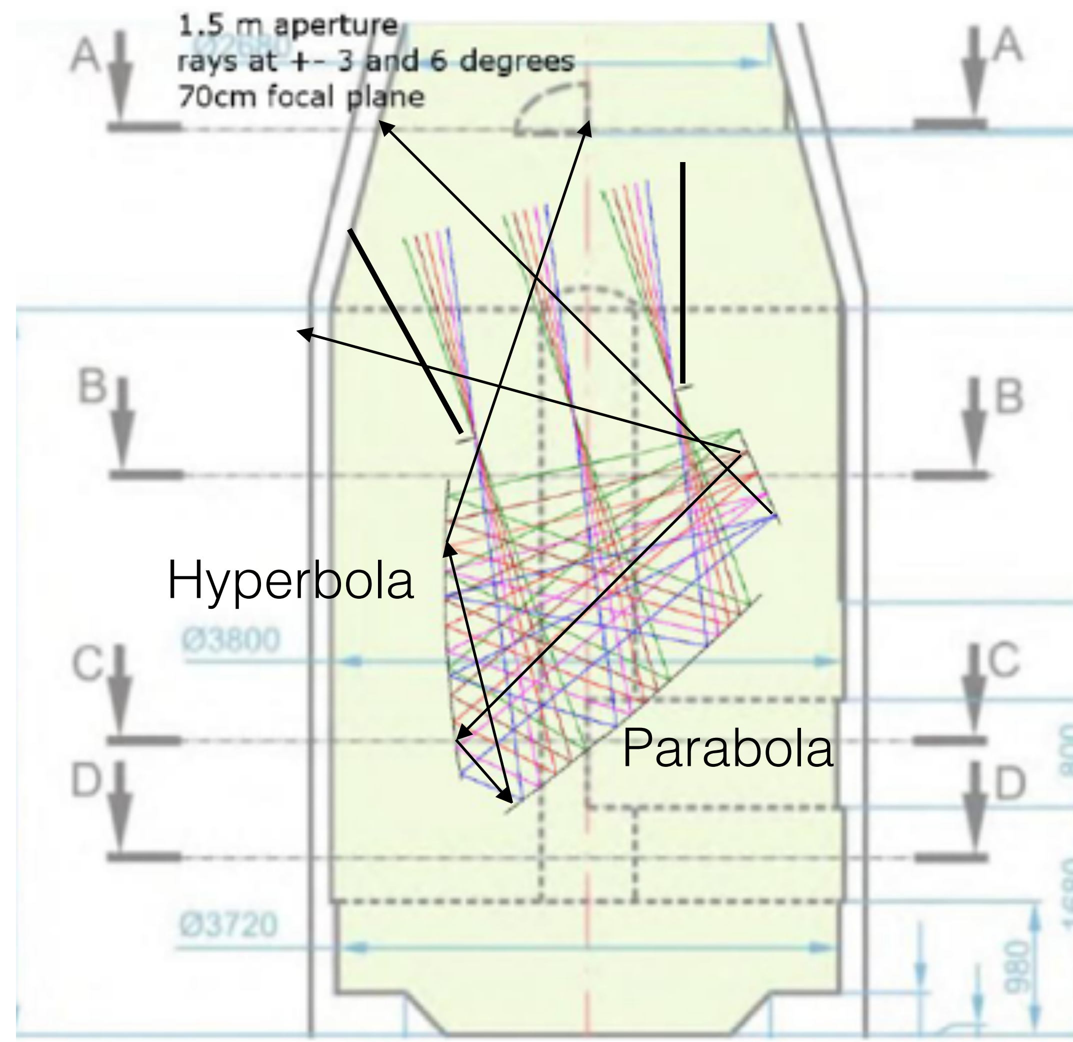




- Optimized
- f#=2.7
- 6 deg FOV
- But note differences in f#. If normalize back to f#=2, [(2/2.7)*6]=4.4 deg FOV
- Conclusion 3: DLFOV increases somewhat faster than f#.

Crossed Dragone - Stray Light





- Issues
  - Three bounces
  - Direct view of sky
- Would further increasing f# solve the issue?

Cold Aperture Stop for COrE+

- Why aperture stop? To control sidelobes by controlling the illumination on the primary mirror.
- Why cold? To reduce loading on the detectors
- Does COrE+ need a stop?
  - Depends on how beams are coupled to free space
  - Planck does not have a stop. WMAP did not have a stop. Beams are coupled with feedhorns. Sidelobes are measured sufficiently well for mission goals.
  - For COrE+ Sidelobes will need to be measured as well, modeled and accounted for.
  - Are asymmetrical beams an issue? To first order no, if the asymmetry is the same for both polarization states then no beam leakage of T to P.

Now Studying

- Fix f# at 2
- Optimize the 1 meter version
  - front fed: check for FOV
  - crossed Dragone: check for stray light
- Check stray light with side-fed Dragone
- Performance vs. Frequency

Additional Slides

Optimization

- optimize WFE over FOV
  - uniform distribution of fields
- adding aspherics, adjusting defocus and mirror curvatures, and allowing one of the Dragone angles to vary