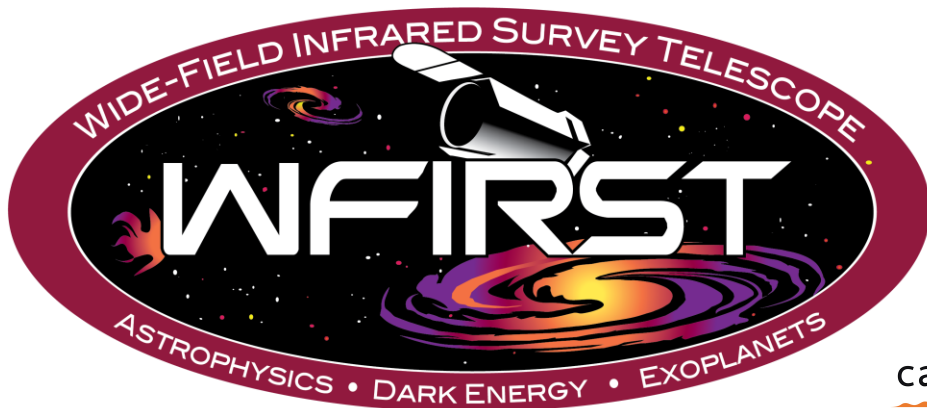




The WFI Relative Calibration System for WFIRST



Ray Wright and Gregory D. Wirth
Ball Aerospace

Maxime Rizzo
Conceptual Analytics

Phil Scott
*Space Dynamics Laboratory
Utah State University*

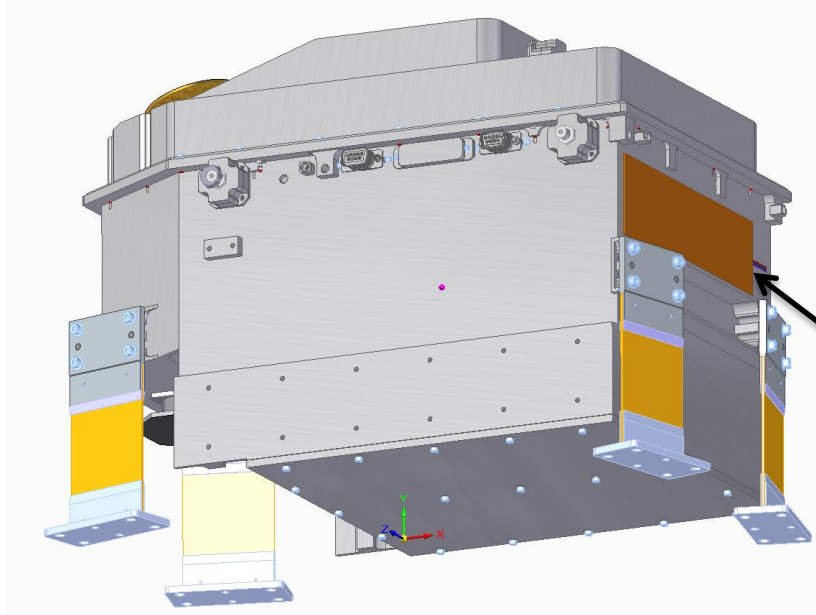
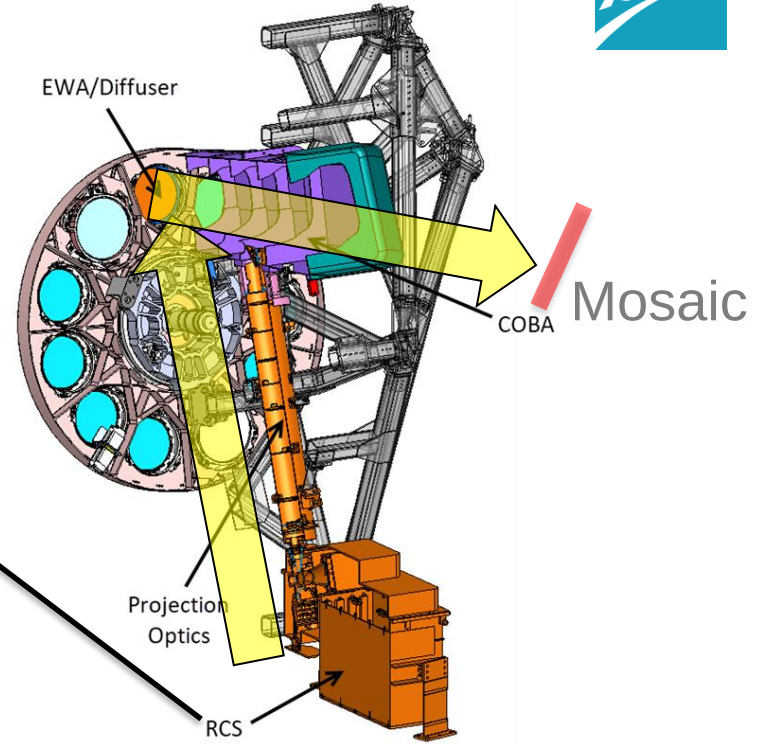


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9/20/2020



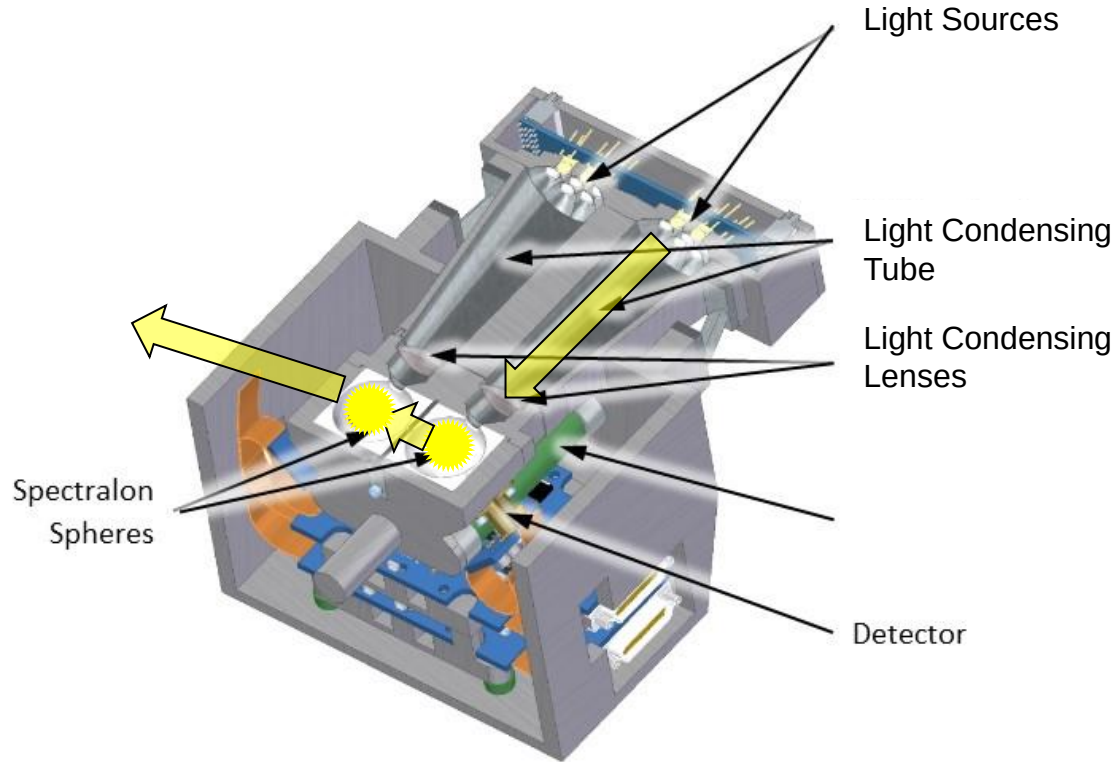
The Relative Calibration System provides calibration light to the FPA





Key and Driving Requirements

#	Relative Calibration System Requirement
1	Illuminate all pixels in the Focal Plane
2	Illumination in all 6 WFI imaging bands
3	Illumination is smooth across the focal plane ($<0.05\%$ / pixel)
4	Illumination is flat within factor of <2 peak to valley
5	Illumination incidence angle range is the same as science light
6	Illumination temporally stable to $<1\%$ peak-to-valley per 300s exposure
7	Provide ~ 4.5 -5 orders of magnitude of dynamic range in any 5 out of 6 bands
	Minimum: ~ 0.3 ph/pix/sec (zodi)
	Maximum: $\sim 10,000$ -25,000 ph/pix/sec, band-dependent
8	Mean flux ratio between illumination levels known to 0.14% in all bands and over the full illumination range
9	Enable lamp-on/lamp-off capability in all bands
	Maximum flux >1000 ph/pix/sec



Initial Design



Engineering Challenges

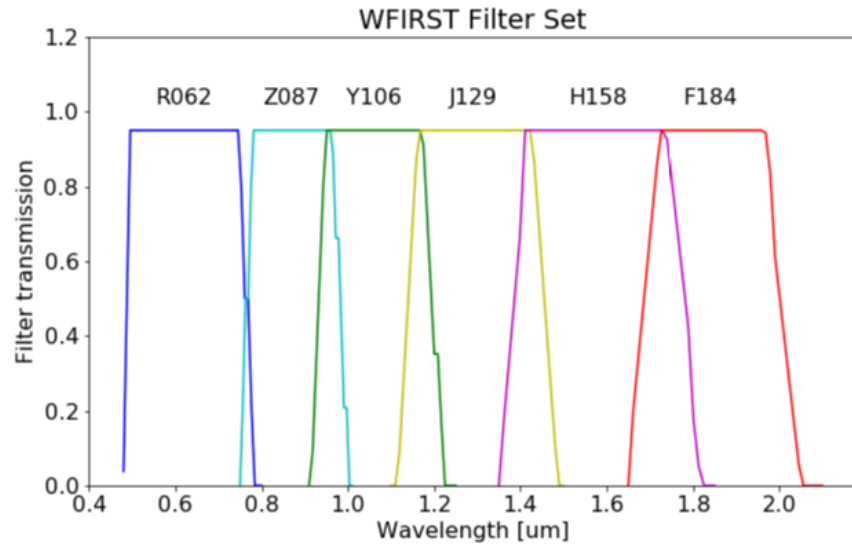
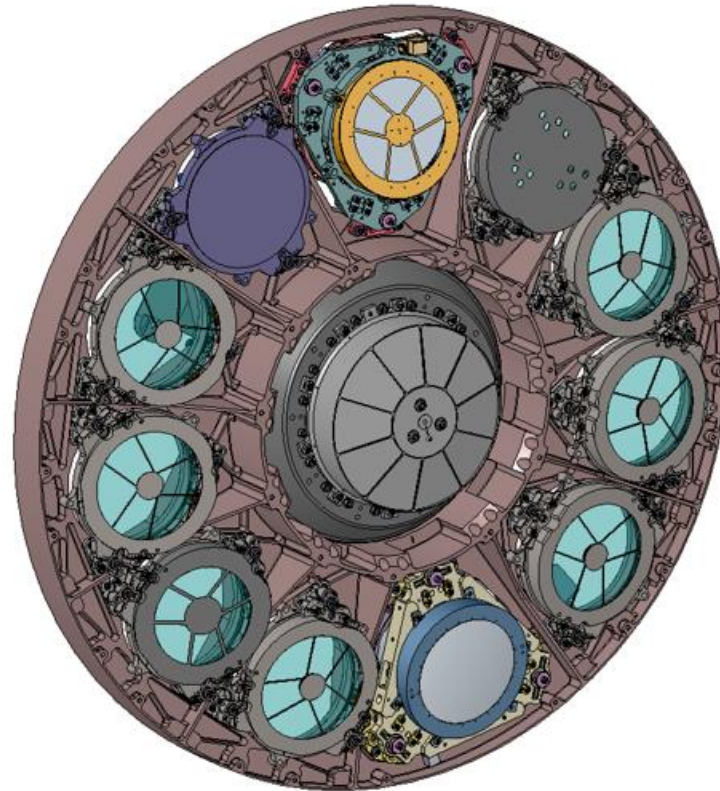
Match LED
Wavelengths to
filters

Deliver more
light to
integrating
spheres

Simplify
assembly and
integration

Increase
calibration light
at the FPA

Filter Profiles



Element Wheel Assembly

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LEDs vs Laser Diodes

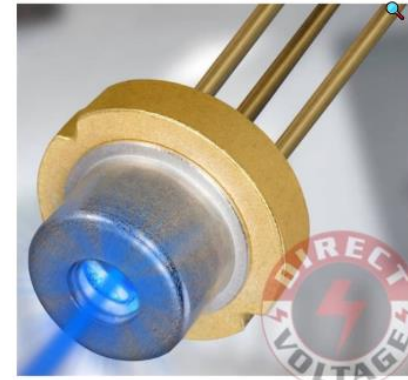
LEDs

- Benefits
  - Typically long lifetimes
  - Mature technology
- Concerns
  - Hard to locate strong sources at longer wavelengths
  - Form factor may present sphere injection space issues



Laser Diodes [Single or Multi-Mode]

- Benefits
  - Readily available at most wavelength bands
  - Variety of power levels
  - Variety of packaging options
    - Fiber coupled may minimize port areas
    - Free space offers increase in power
- Concerns
  - Mode hopping presents stability concerns
  - Creates a speckle field in the integrating sphere that may cause large non-uniformity issues at the apertures and fiber entrances





Engineering Challenges

Match LED
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Output flux levels

Concerns

- Not enough light is entering the integrating sphere
  - Power constrained
  - Thermally constrained
- Condensing tubes are losing too much light

Trade Charter

Alternate Path Tasks	Description
COTS LEDs	Can Commercial Off The Shelf parts produce enough light at the right wavelengths?
RCS diffuser	Is the pattern of light reflected off the diffuser sufficiently bright, uniform, and smooth?
LED-in-a-sphere	Would mounting the LEDs directly into the integrating sphere improve the flux?
f/# considerations	Would faster optics yield better performance?



Outcome of Trade

Option	Description	Status
Custom LEDs	Use multi-die LEDs packaged by Vendor for Ch 2-6	Recommended
Gold collection optics	Use gold coating on collection cone from LEDs to integrating sphere	Recommended
COTS LED	Use COTS LEDs for Ch 1	Recommended if LEDs pass reliability testing and analysis
F/2.1 Projection Optics	Implement F/2.1 collection optics from integrating sphere to mirror	Recommended
F/1.4 Projection Optics	Continue development of F/1.4 projection optics as backup option if Optodiode LEDs fail reliability	Conditionally recommended, see section 3

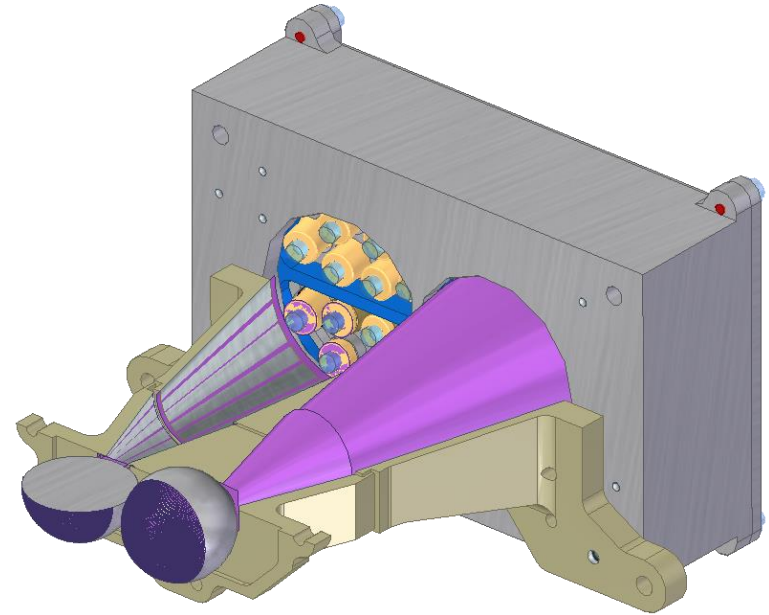
LED Choices [Trade]



Consideration	Preferred Option	Rationale
Space Qualification	Custom	Both options need to survive a rigorous qualification campaign
Wavelength	Custom	Die and filter selection allow greater design space in achieving the desired wavelength
Power	Custom	Control number of die within LED package and still meet output flux requirement
Availability	COTS	Likelihood of more suppliers increases availability likelihood reducing schedule risk
Design Risk	COTS	Parts do not require design and manufacture phase. Parts can immediately undergo qualification tests

Condensing Tube Update [Trade Update]

- Gold plating the condensing tube improves reflectivity
- Removing the condensing lens eliminates reflection losses





Engineering Challenges

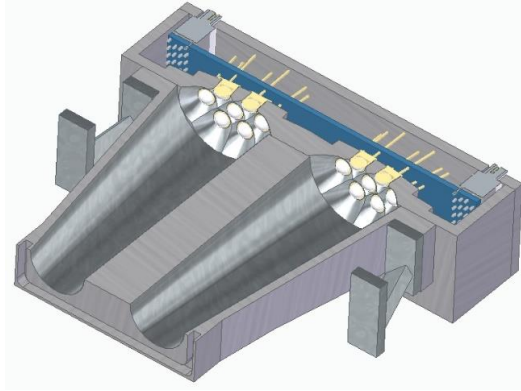
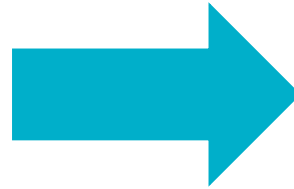
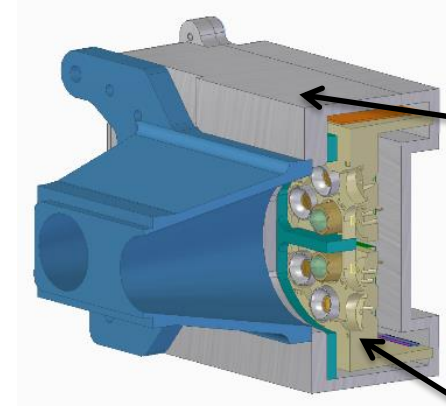
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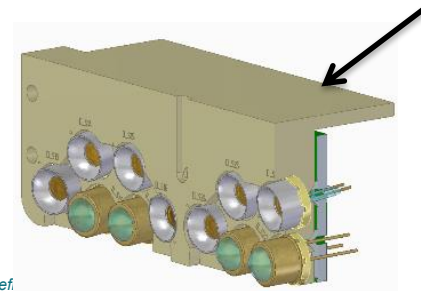
Increase
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Modular Design



Removable
LED Module

Single Side LED Plate



- Original Design
  - Single PCB made for all primary and redundant LEDs
  - Chassis housing required many installation steps



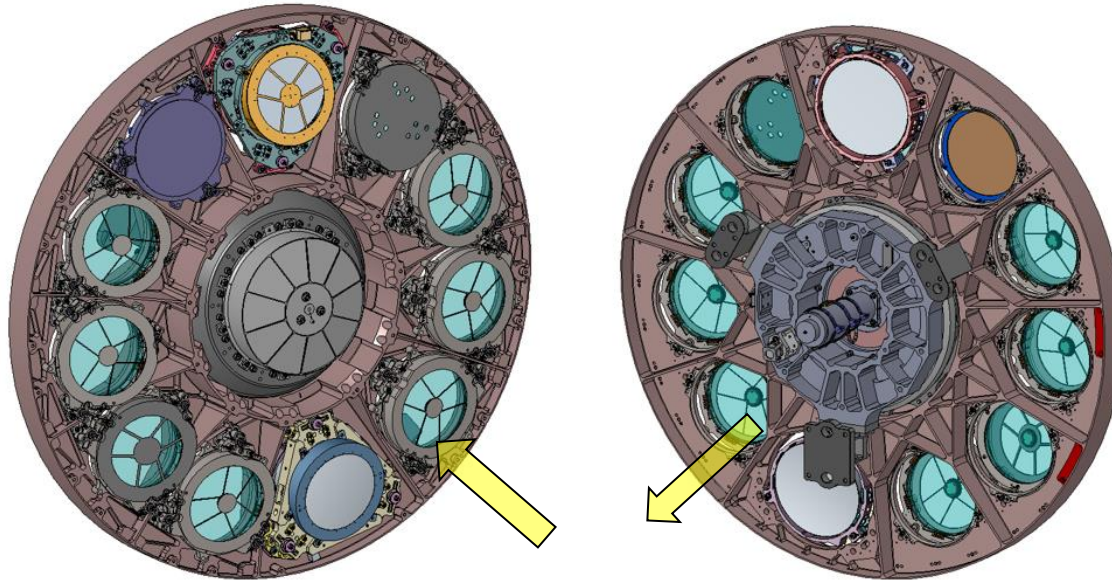
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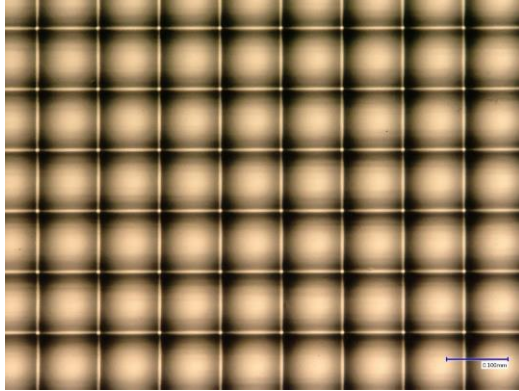


Lamp On/Lamp Off [LOLO] Mode supports count-rate non-linearity measurements

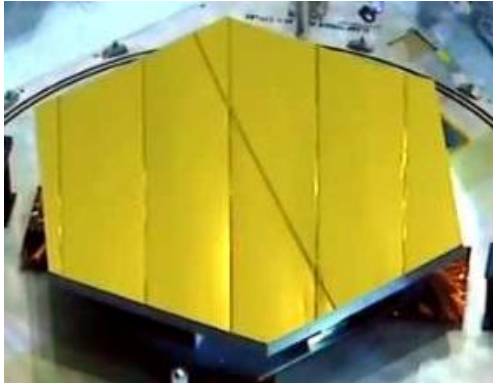
Each science filter includes a pupil obscuration mask to limit thermal emission from the secondary mirror and support structure. A small diffuser on each mask allows RCS light to illuminate the FPA while observing the sky.

LOLO Material Trade

Micro Mirror



Monolithic Mirror



Engineered Diffuser



- Three reflectors were studied
  - Monolithic Mirror
  - Micro Mirror array
  - Engineered Diffuser

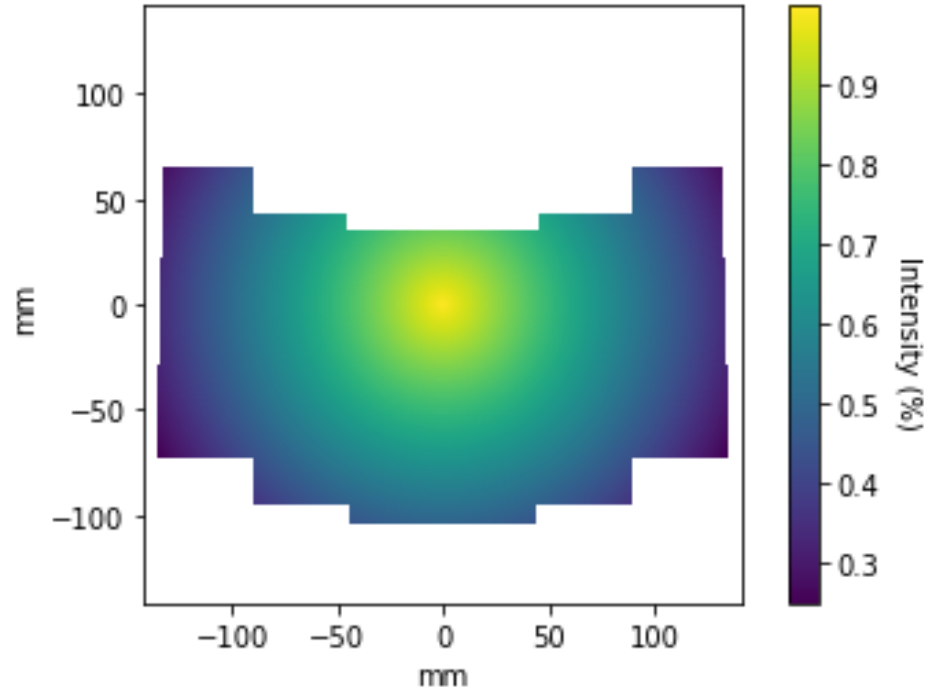
Engineered Diffuser

Beam reflected from the diffuser is narrower than the typical Lambertian from Spectralon, concentrating more light on the FPA

Provides ~6.6 times flux rate compared to Spectralon

Takes advantage of the increased flux output from the LED trade study

Provides better array of science angles to the FPA compared to the other mirrors





Results

- The flexibility of the team with its broad range of knowledge has led to rapid design improvements
- Ball, SDL, and NASA have worked seamlessly and tirelessly to create innovative solutions to both technical and schedule challenges
- Each design change creates a more robust system that will be able to meet its challenging calibration requirements