ATLAS Probe Optical Design

Robert Content et al.
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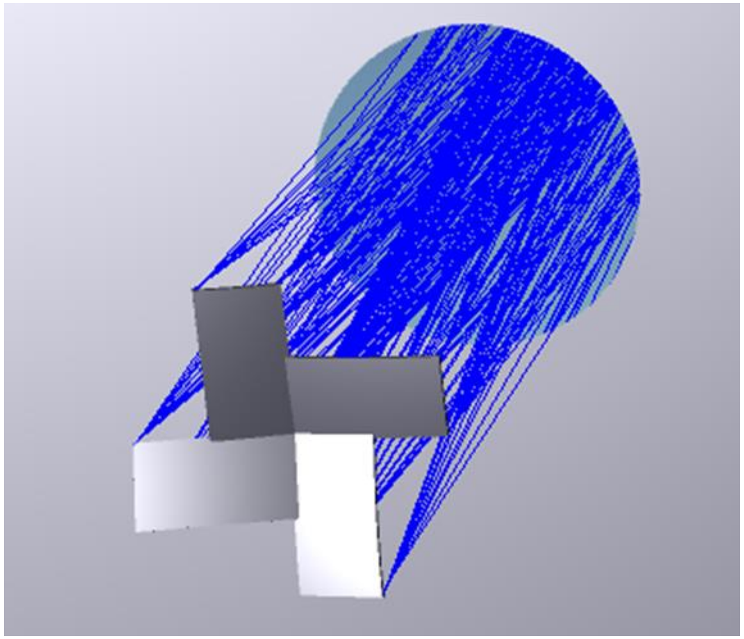
ATLAS Probe Design Basics

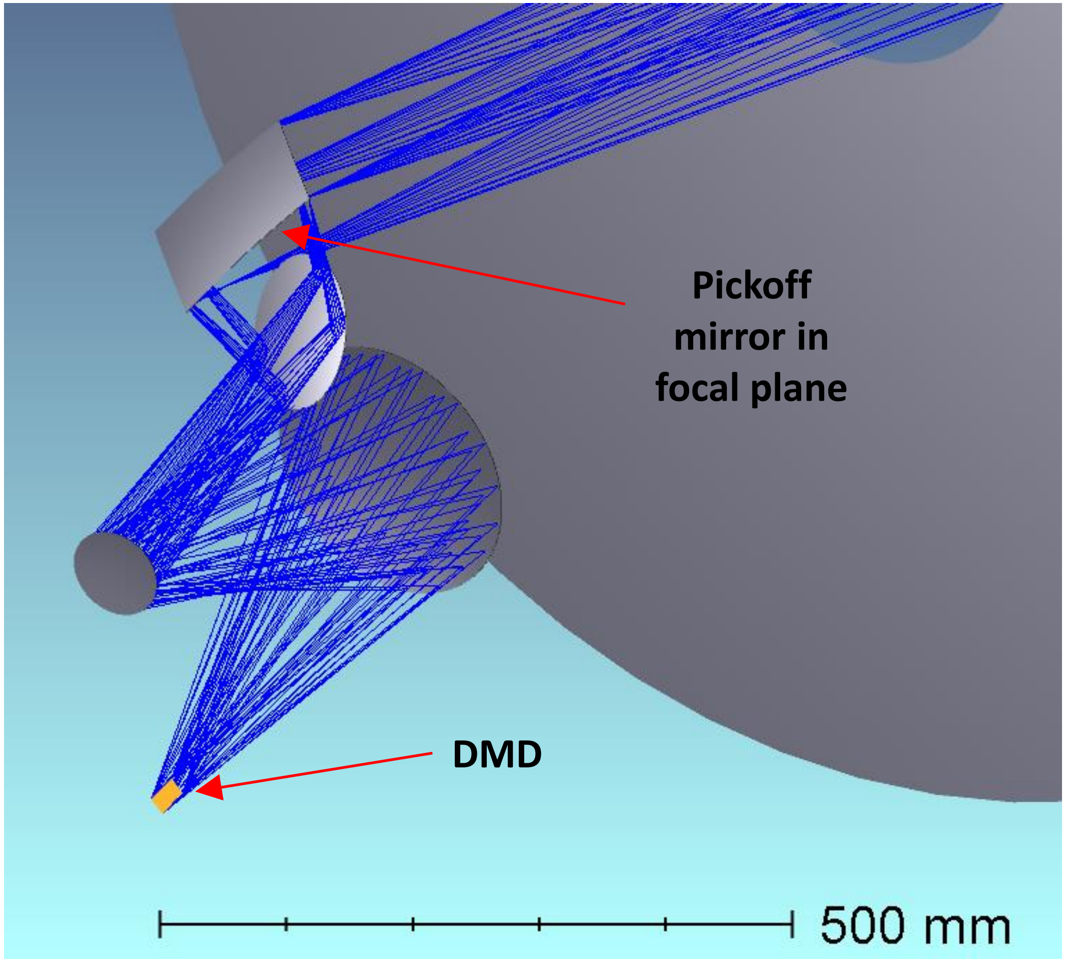
- λ=1-4μm.
- FoV=0.4 deg^2, larger than circular field with D=0.7 deg.
- R=1015 (average).
- Telescope: Modified Ritchey-Chrétien.
    - Primary: D=1.5 m, F/1.6.
    - Secondary: D=19% of primary → 3.7% obscuration only.
- Use prims, not gratings.
- Slit size: 0.75” x 0.75”.
- Spectral elements 2 pixel wide including aberrations.
- Spatial elements slightly smaller than 2 pixels (to fit completely on detector).
- 4 identical arms with fore-optics, DMD and spectrograph.
- Spectra 1333 pixel long.
- Detector 4k x 4k.
- 10 μm pixel.
- Imaging done by changing one prism per arm with other optical element.
- All mirrors complex aspheres but manufacturers have done that before.

ATLAS Probe: Pick-off & Fore-optics



"Flower" pick-off with 4 "petals" behind hole in primary

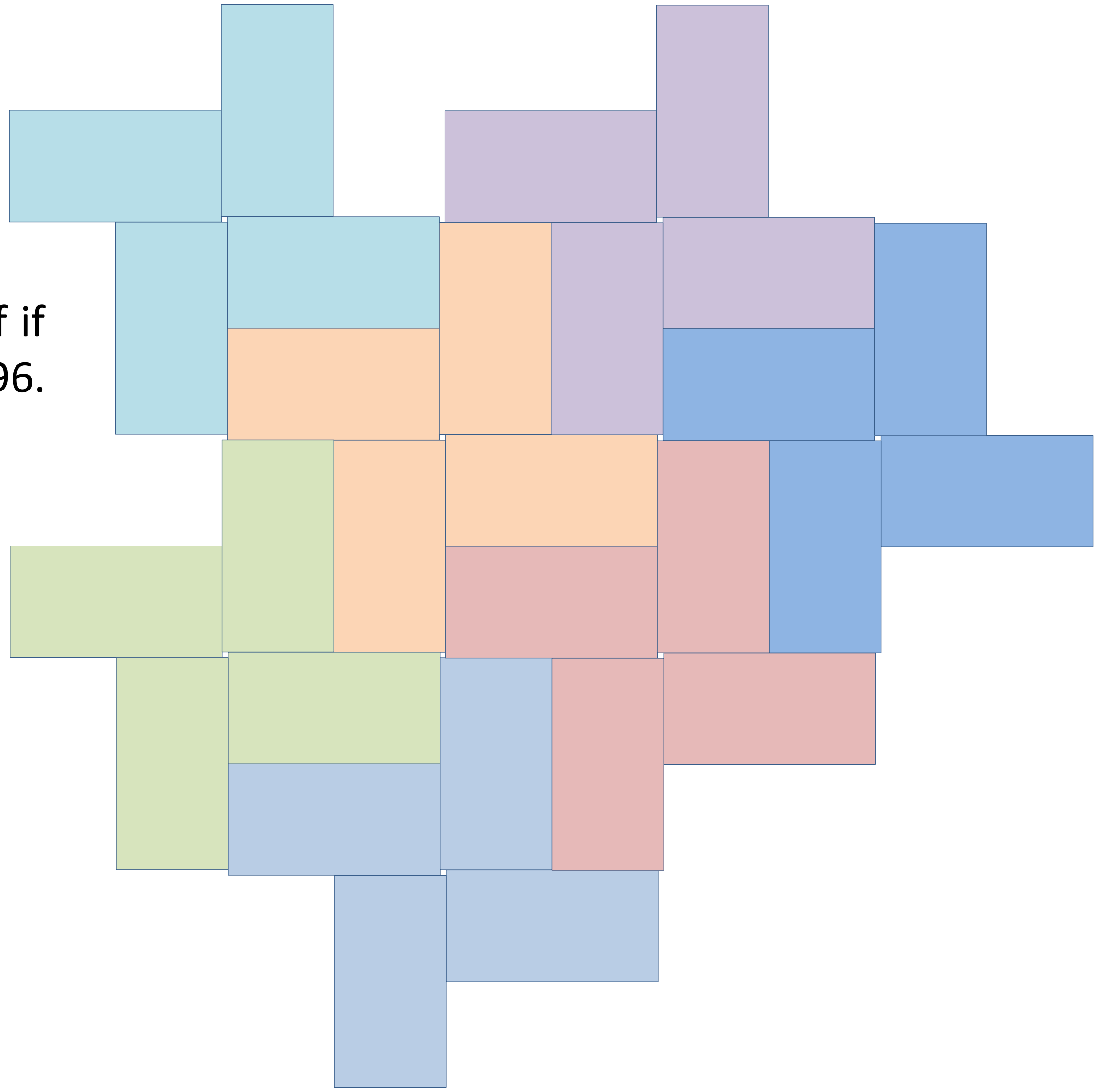
Image quality on DMD is < 1/2 micromirror GEFWHM.



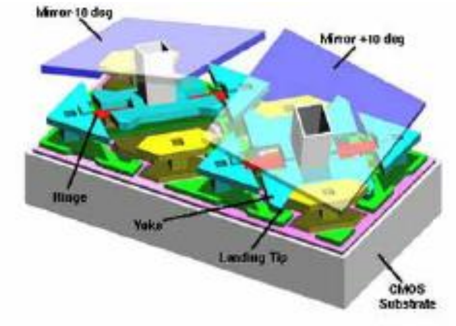
Pick-off petal, fore-optics and DMD

ATLAS Probe: Tiling of the Sky

Tiling of the sky with a 4-petals pickoff if each petal has an aspect ratio of 1.896. The loss of coverage is only 0.07%.

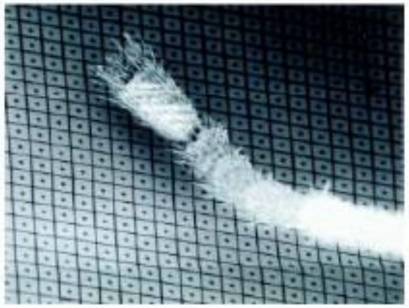


ATLAS Probe: DMD

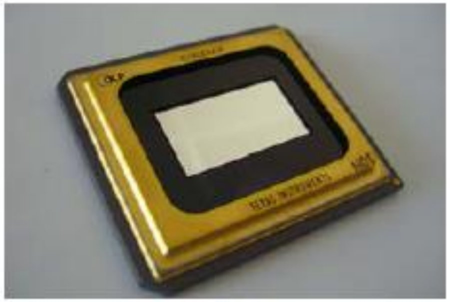


Typical substructure of a TI DMD

Tilt +/- 12º along one diagonal of micromirror

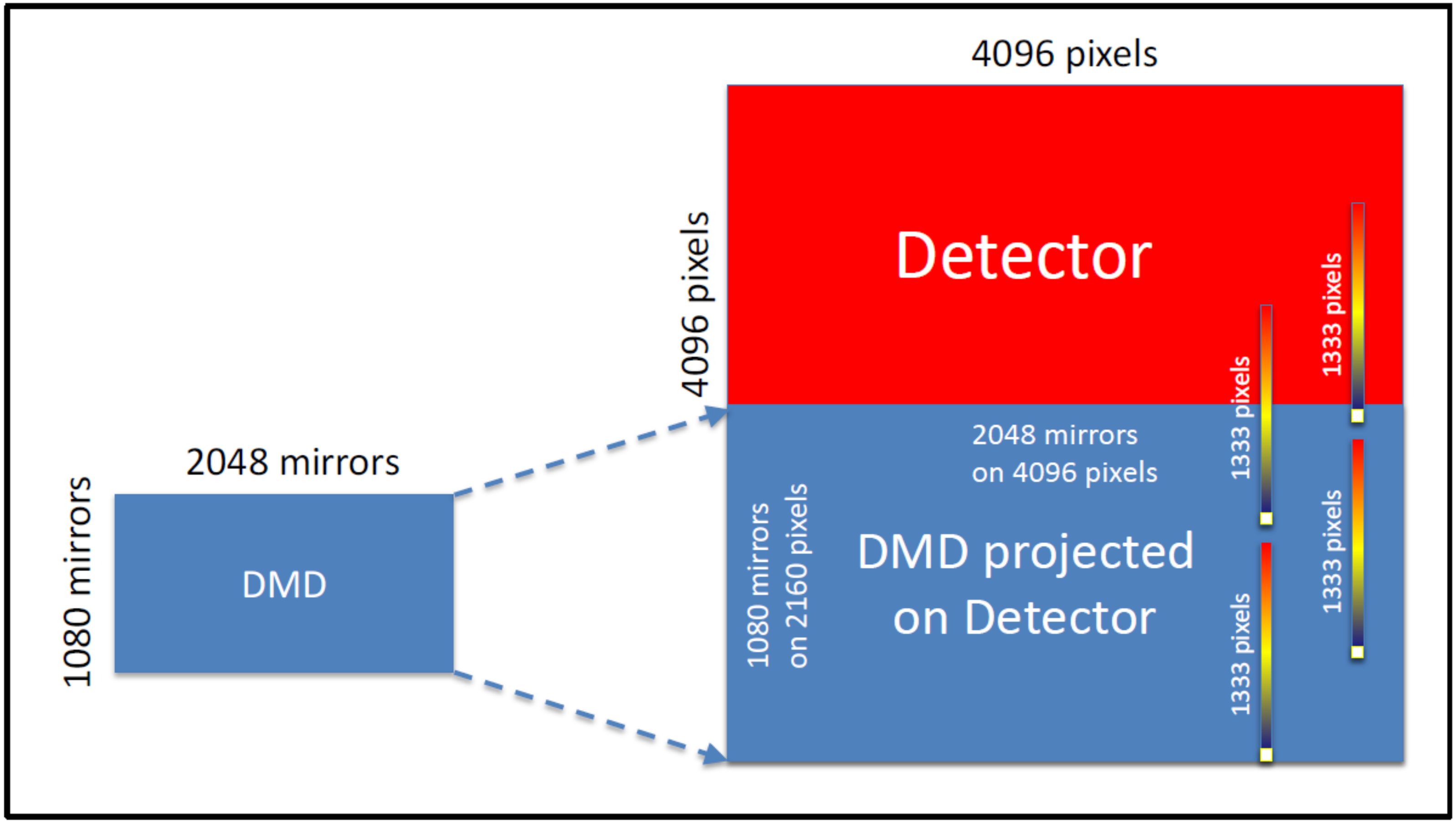


DMD array with an ant leg for comparison
Micromirror size: 13.7 µm



Packaged DMD CINEMA (2048 ×1080) device

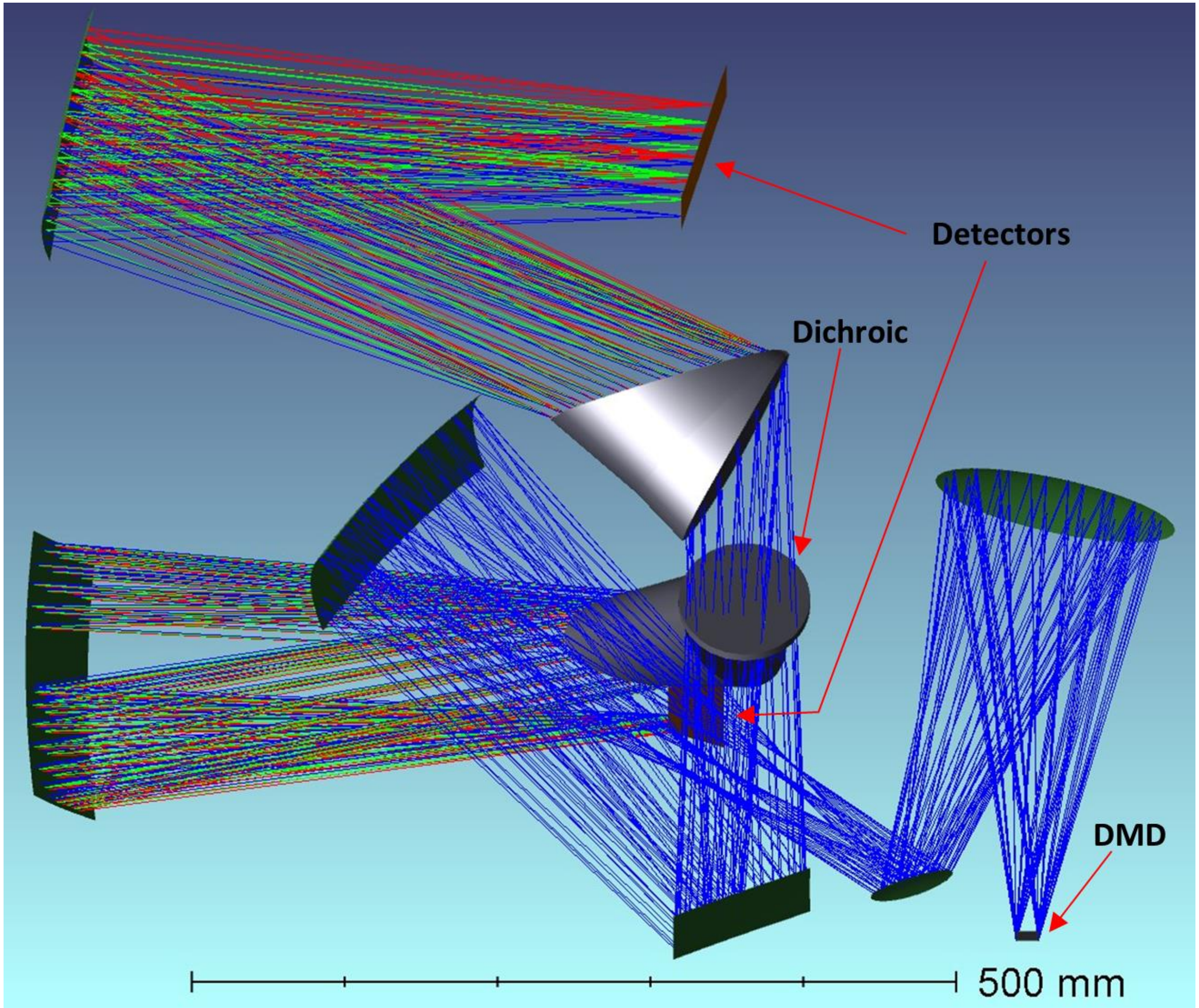
ATLAS Probe:


4096 pixels
Detector
4096 pixels
1333 pixels
1333 pixels
2048 mirrors
1080 mirrors
DMD
2048 mirrors
on 4096 pixels
1080 mirrors
on 2160 pixels
DMD projected
on Detector
1333 pixels
1333 pixels

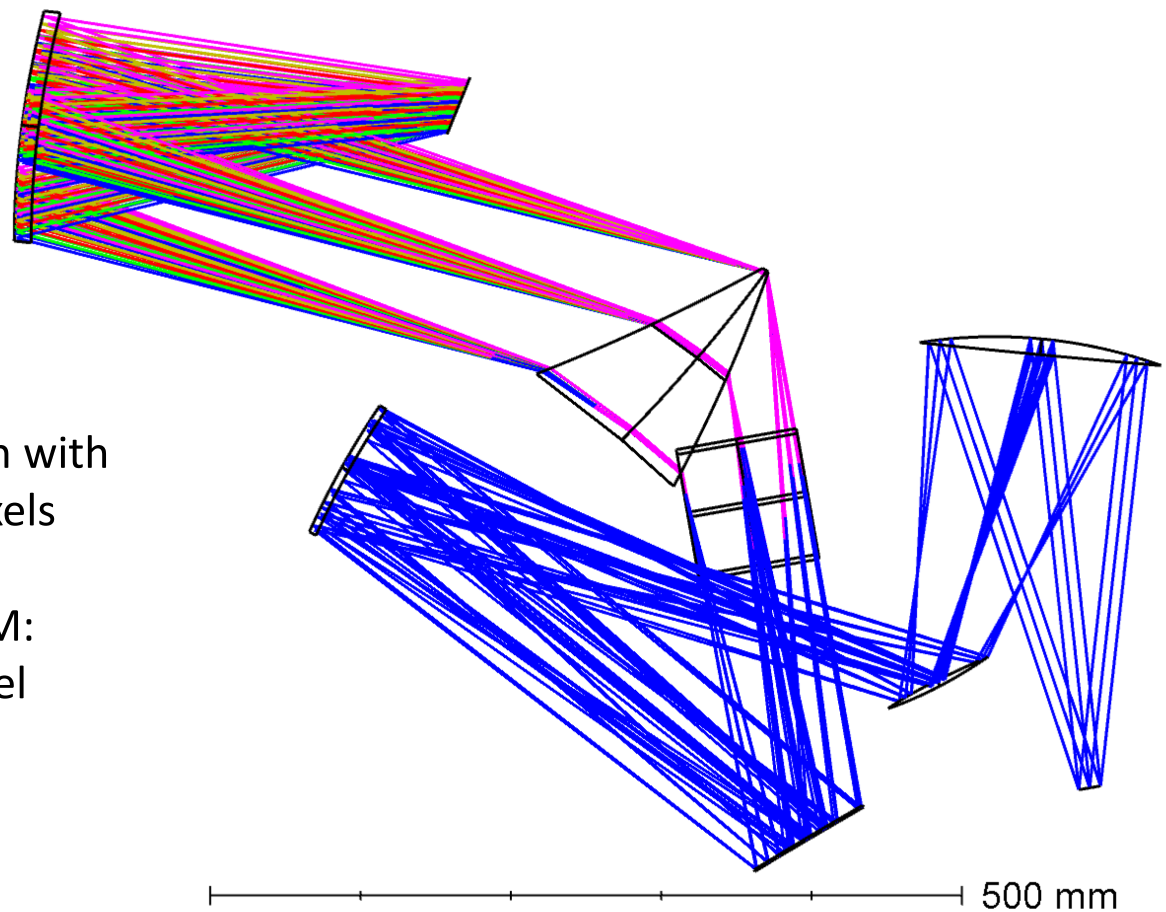
ATLAS Probe: Spectrograph

Design with
18 µm pixels

Blue camera
behind the
dichroic



ATLAS Probe: Spectrograph



Latest design with
10 µm pixels

GEFWHM:
1.07 pixel

ATLAS Probe: Advantages of prisms over Gratings

- **Much better transmission especially at the extreme wavelengths; important for the large bands of ATLAS Probe.**
- **No same-bandwidth parasite orders that cross-contaminate aligned spectra. At its worst with ATLAS Probe.**
- **Bandwidth can be larger than factor of 2 between extreme wavelengths. Blue camera bandwidth of present design is 1 µm to 2.1 µm.**
- **Resolution more uniform → smallest R larger for same average.**
- **Dichroic cannot cut exactly at the edge wavelength, a small common bandwidth is necessary. Gratings would loose a small bandwidth centred at 2 µm.**
- **No need for sorting order filter.**

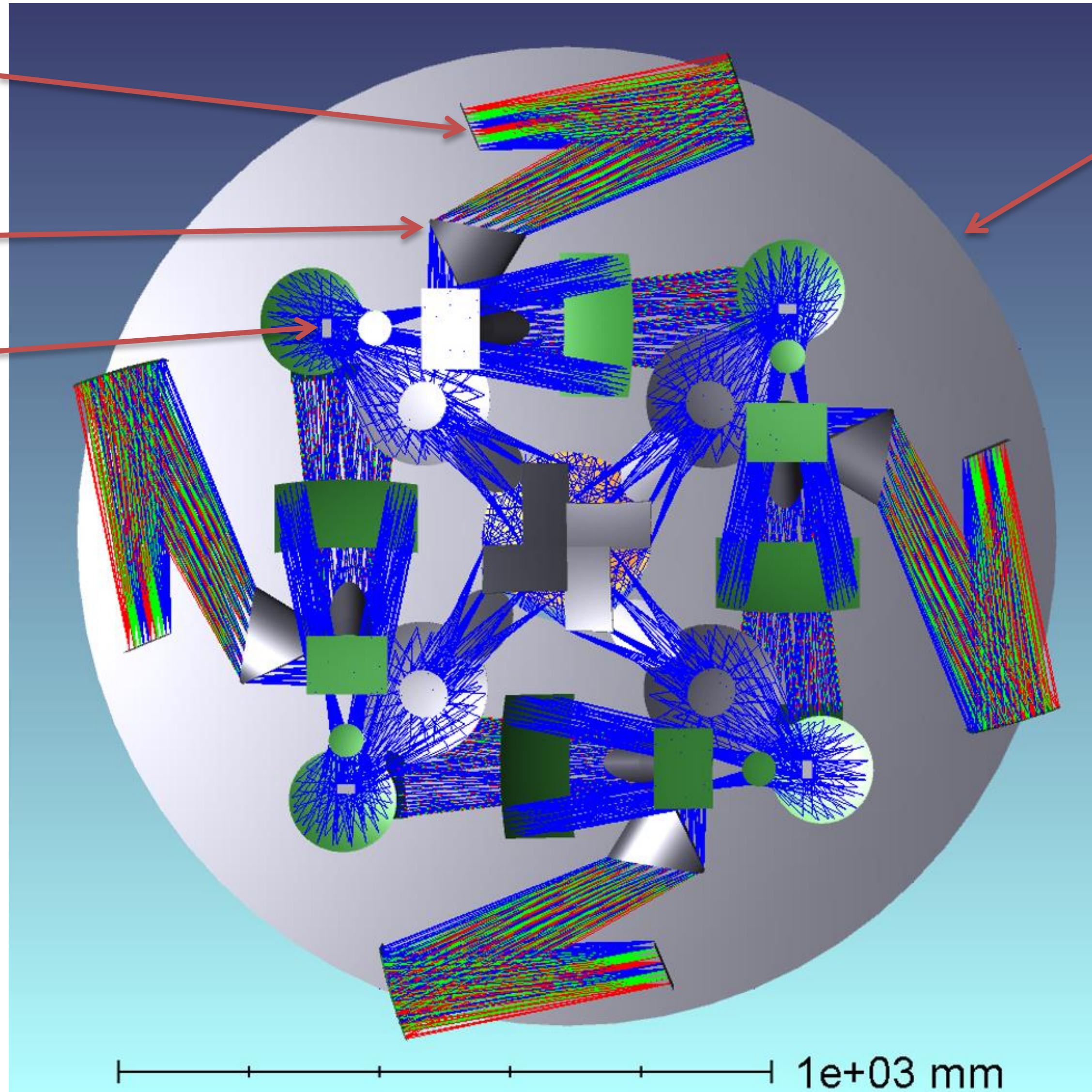
ATLAS Probe:
Preliminary Optical Design

Detector

Prism

DMD

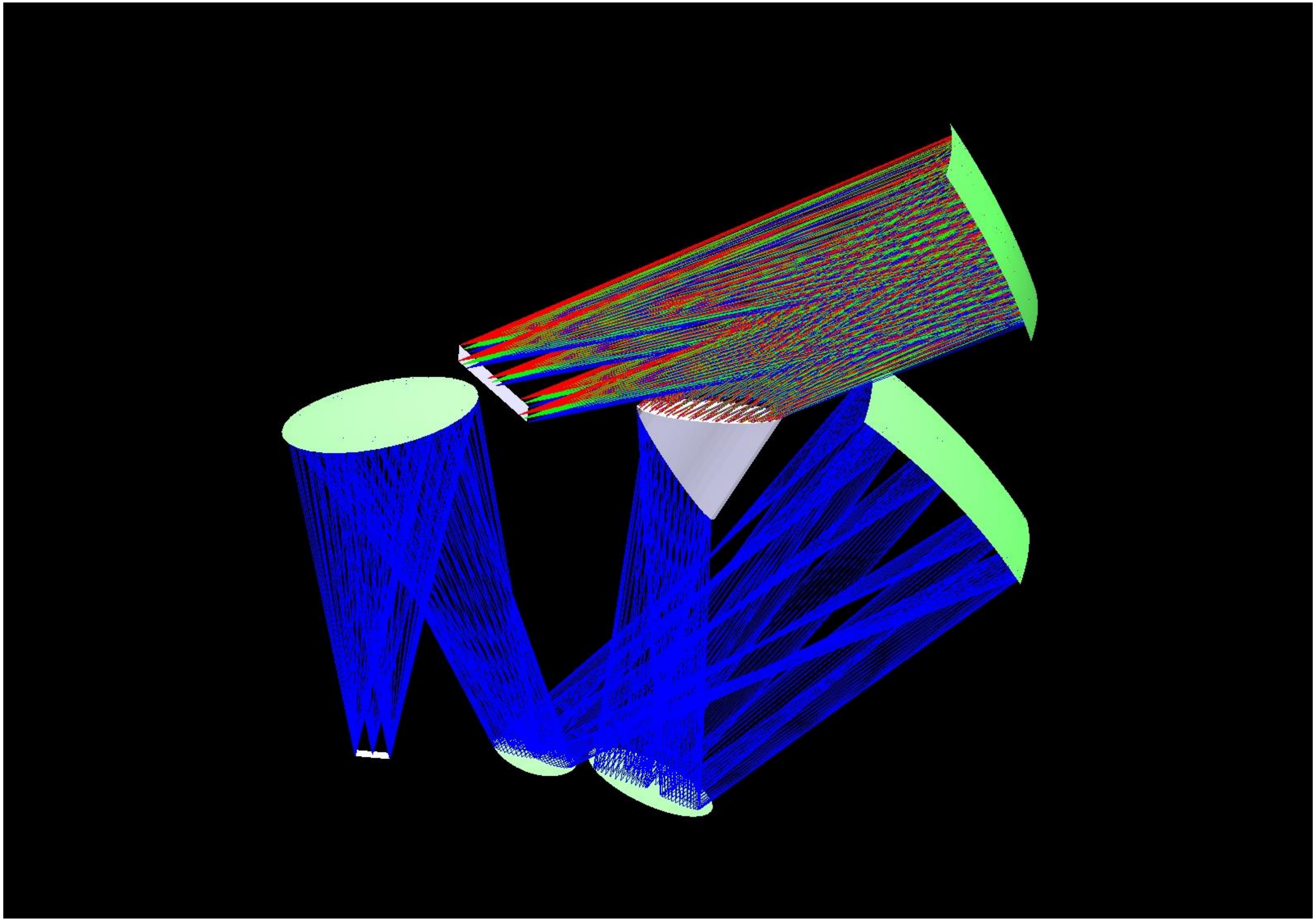
1.5m primary



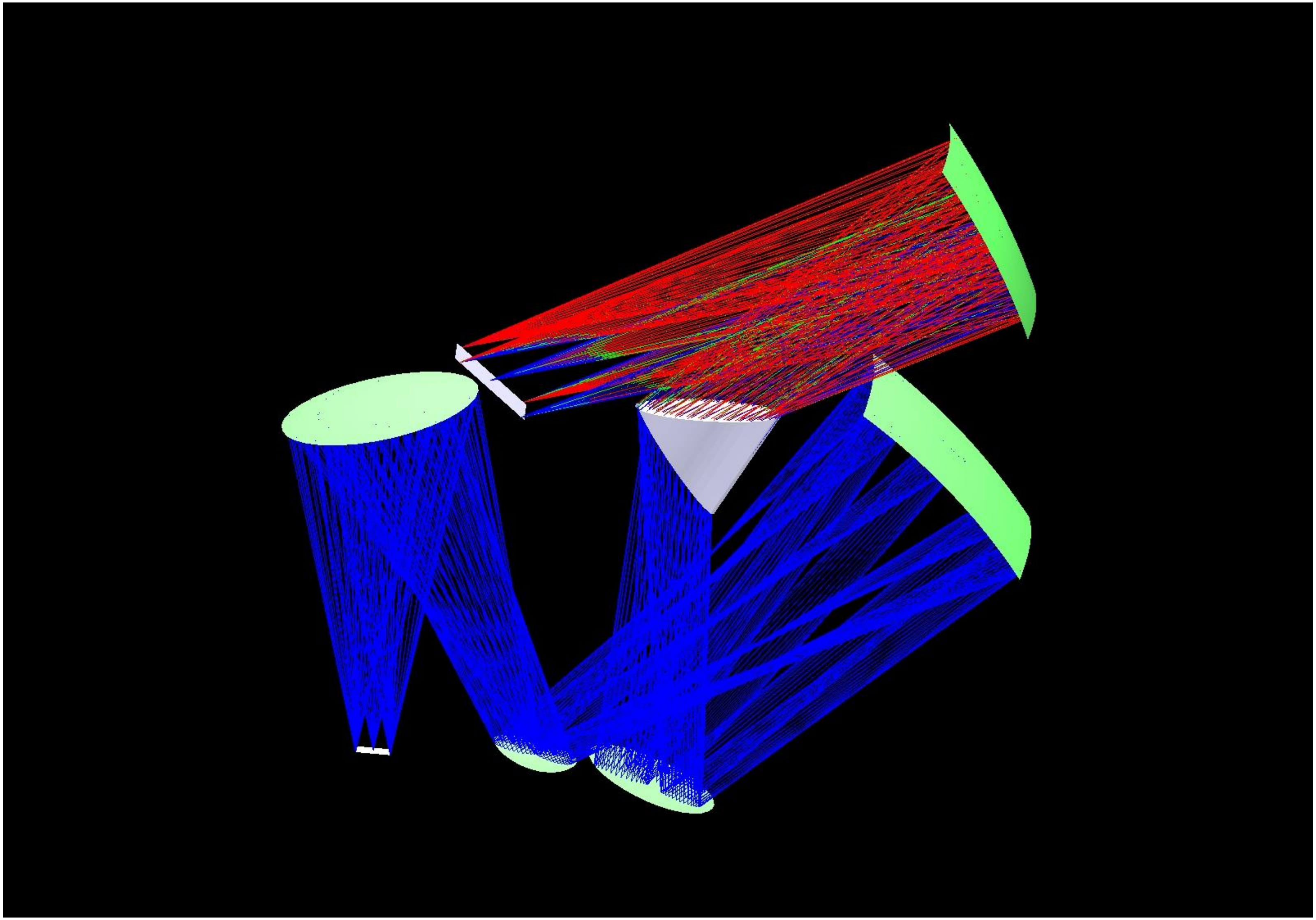
Design with
18 μm pixels

Red camera
hidden

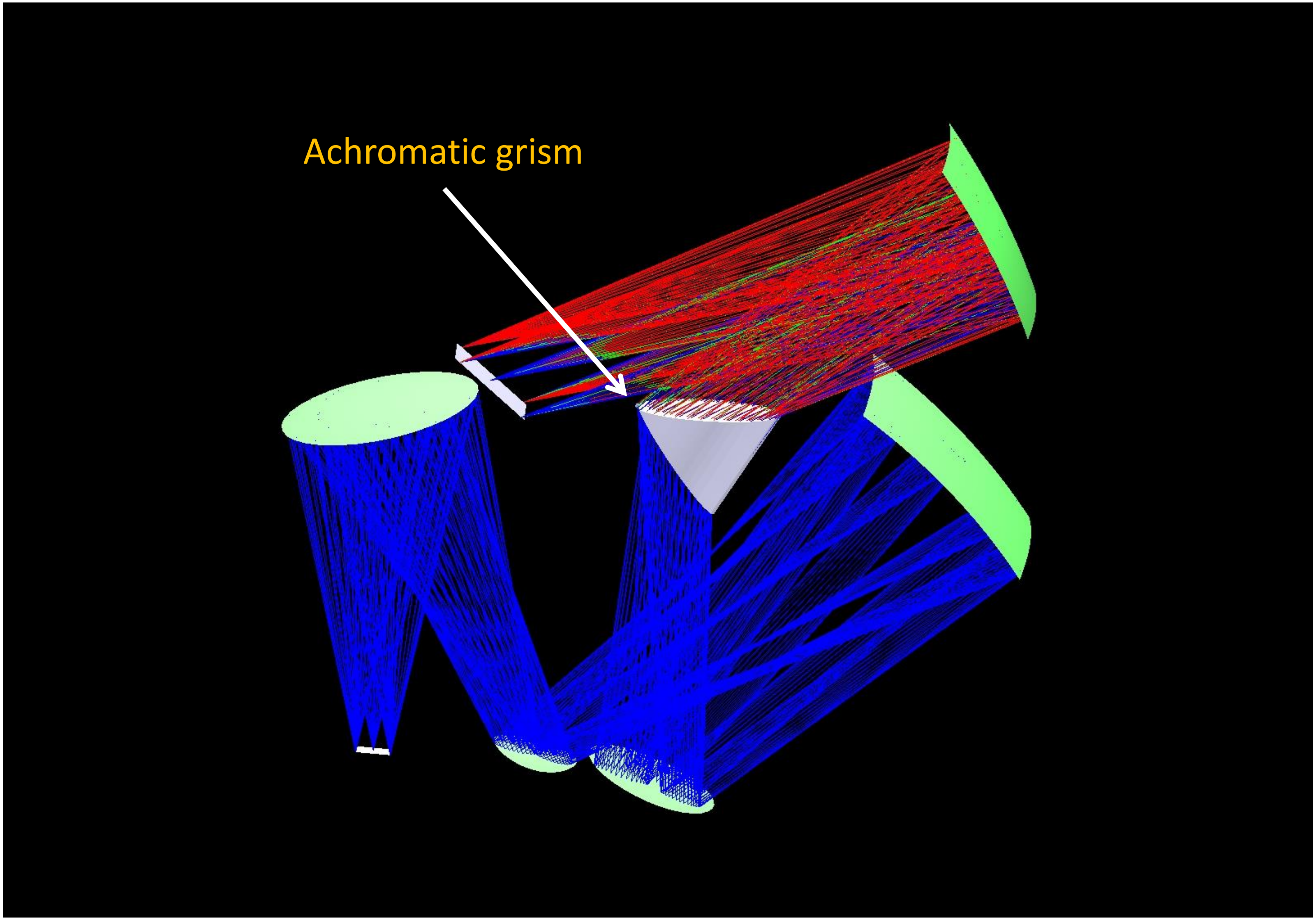
ATLAS Probe:
Origin: EUCLID Spectrograph



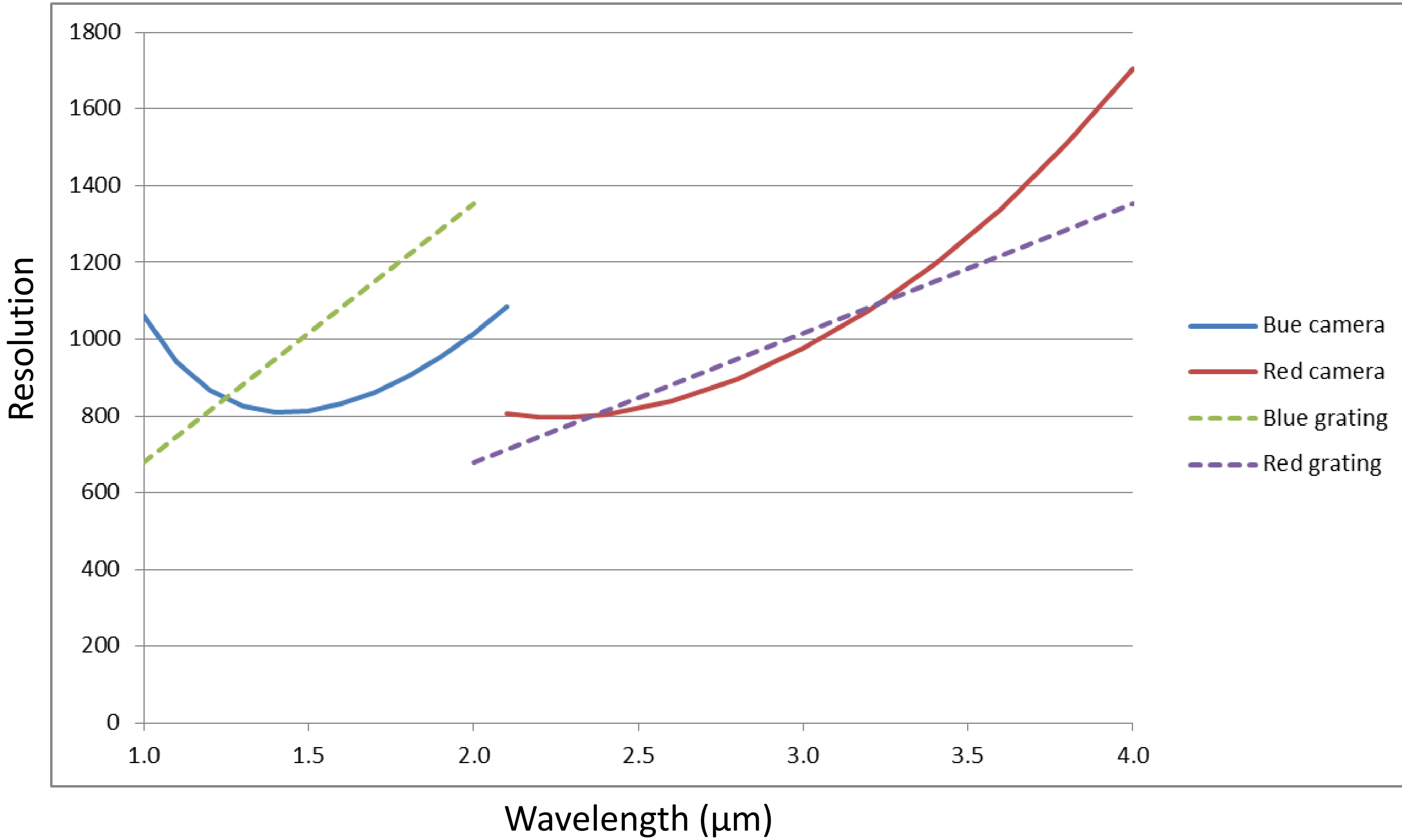
ATLAS Probe: Origin: Imaging Mode



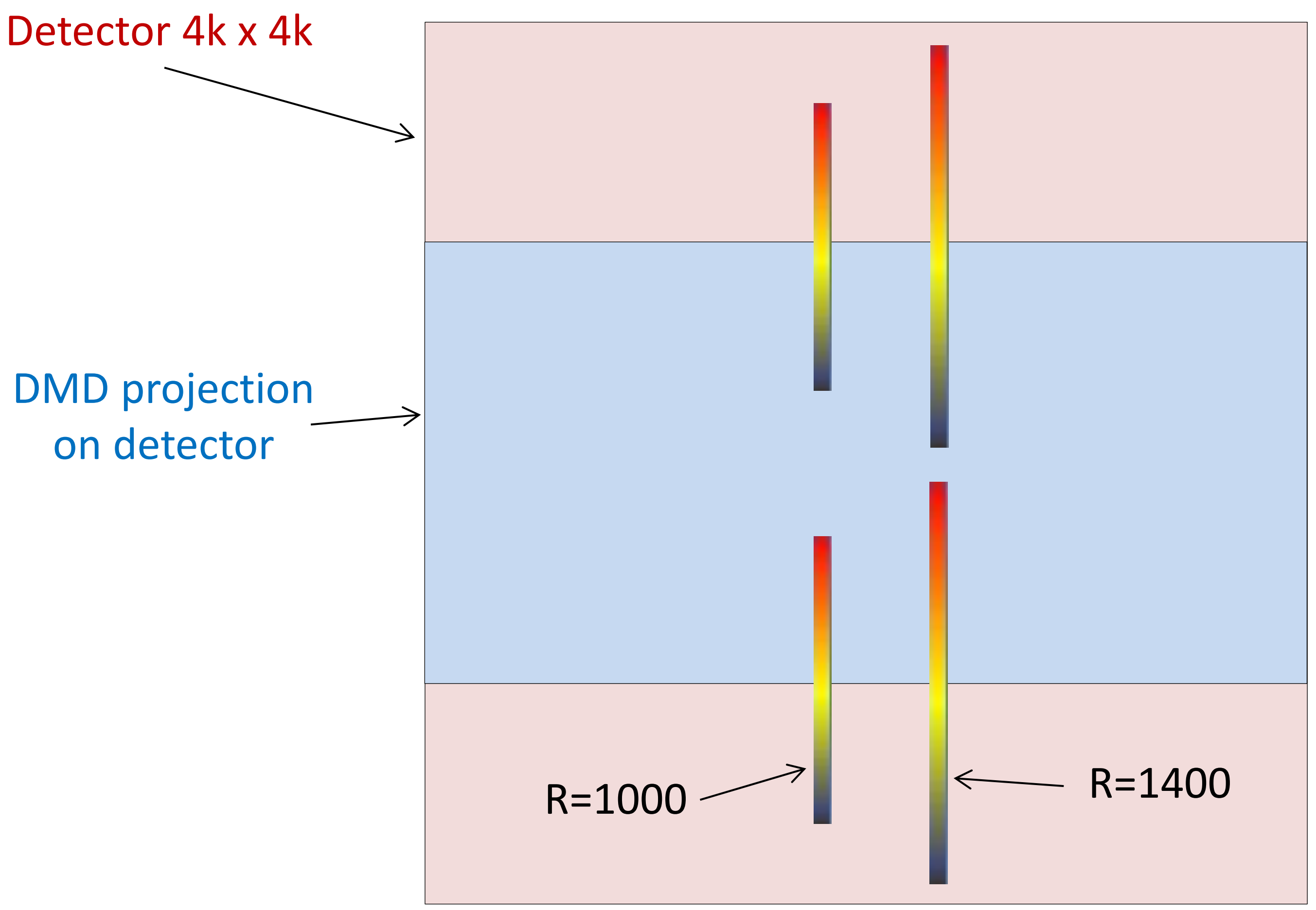
ATLAS Probe:
Origin: Imaging Mode



ATLAS Probe: Spectral Resolution



ATLAS Probe:
40% Higher Resolution



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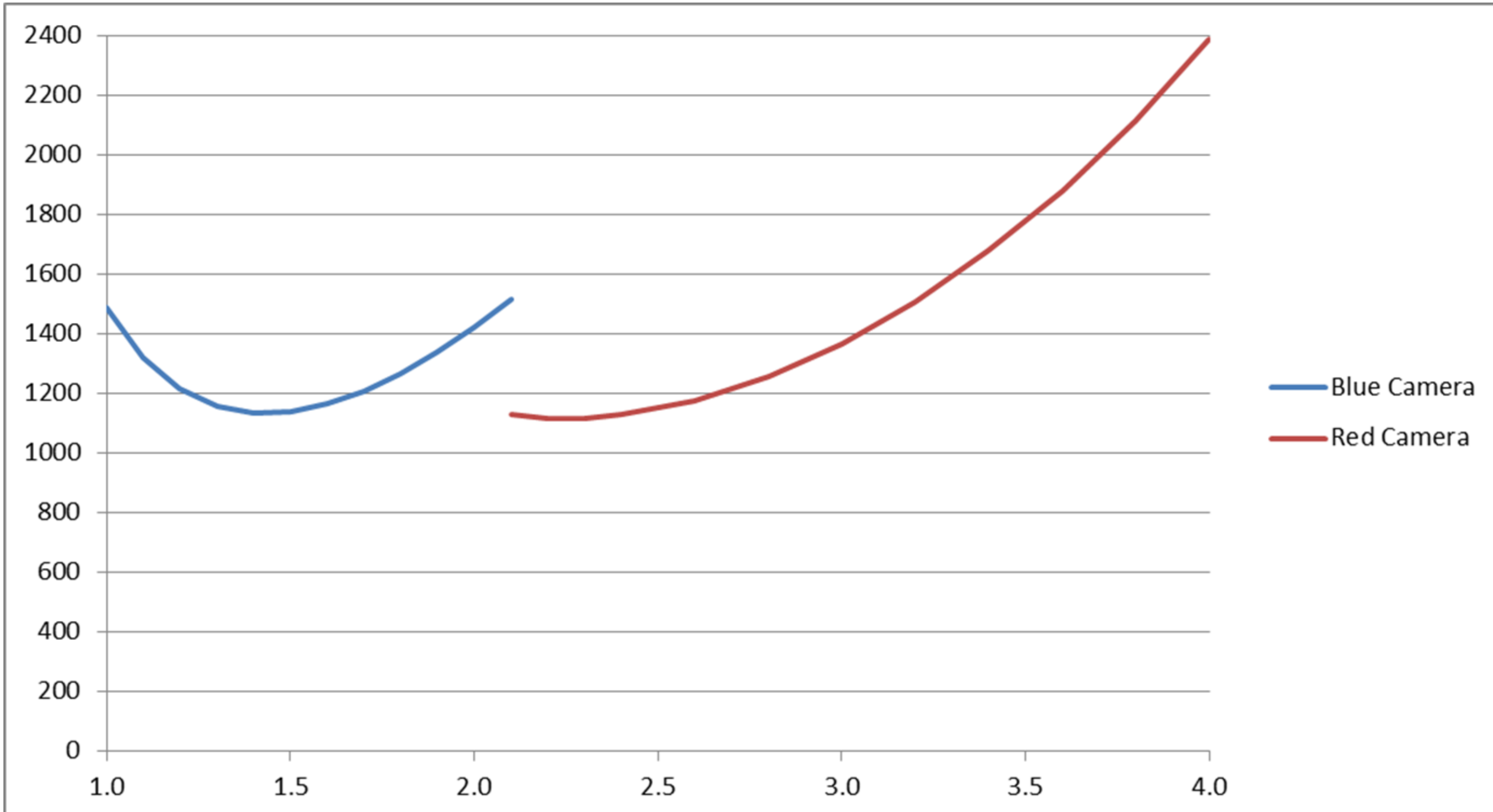

ATLAS Probe: Higher Resolution

- Pushing present design to the limit:
  - R 40% larger.
  - No more than one spectrum per column.
- How?
  - Larger prism (presently 160 mm x 160 mm x 80 mm).
  - Two smaller prisms.
- Third camera:
  - Difficult to find the space.
  - Expensive.
- Larger detectors may permit to go to more than 40% larger.

ATLAS Probe: Conclusion on Optical Design

We already have a very advanced design with good enough image quality thanks in part to the work done for SPACE and EUCLID.

Future development of the design:

- Higher spectral resolution.
- Cost optimization.
- More degrees of freedom by placing the optics not all in the same plane.
- If new DMDs with larger micromirrors, possible design without fore-optics.
- More complex telescope to remove fore-optics?