Extended Detector Cutoff Considerations

WFIRST Project Office

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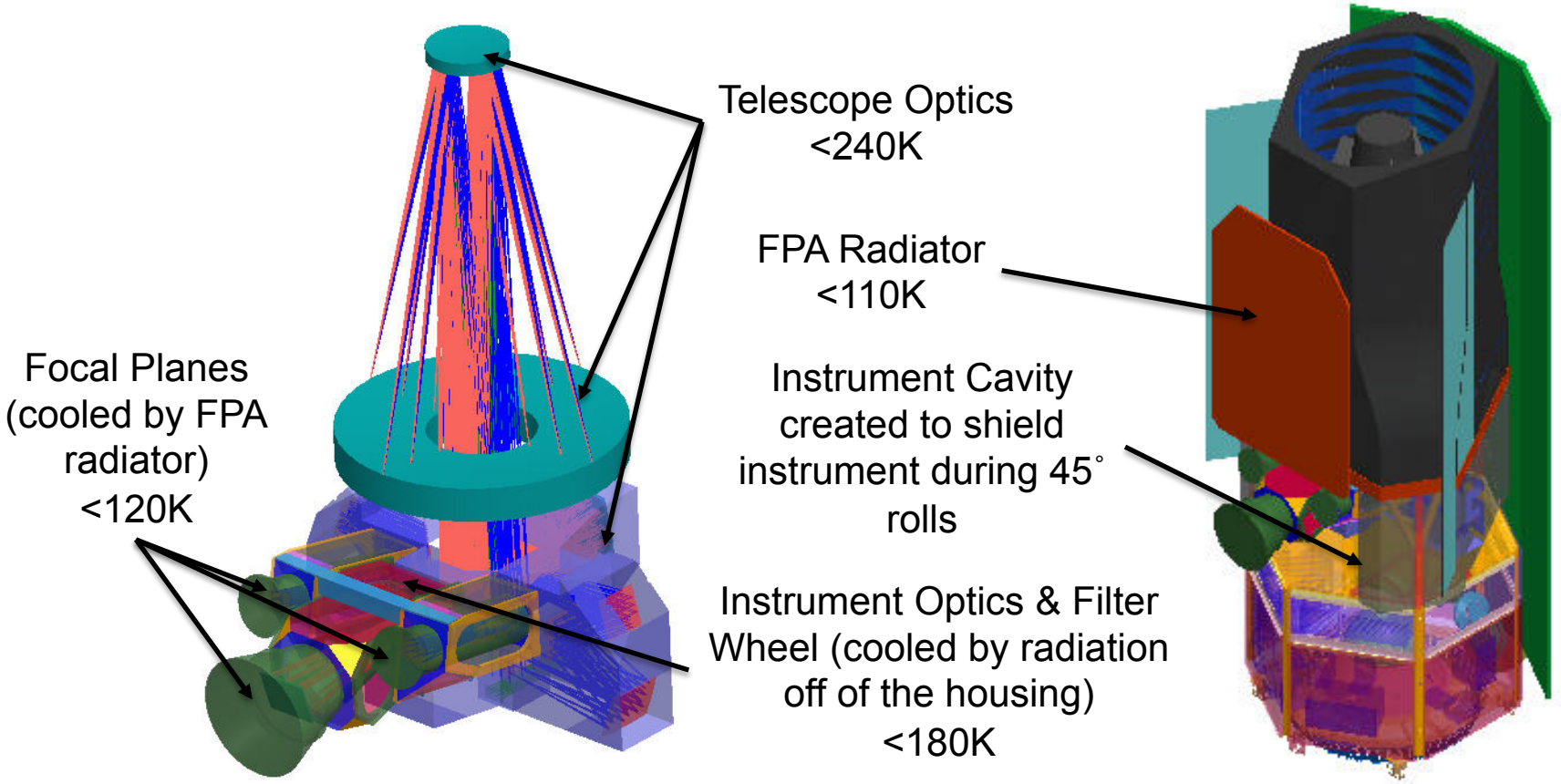
WFIRST Payload

- Detector baseline: H2RG with 2.1 μm cutoff based on current EDU development activities
  - Testing on devices to date indicate excellent performance
- Payload thermal zones based on 2.1 μm cutoff



2.5 Micron Cutoff Wavelength Design Impacts

- Imaging Channel
  - A longer imaging channel cutoff wavelength can be viewed as having impacts in a few categories.
  - Detector dark current:
    - At a given temperature, the dark current will increase for longer cutoffs.
      - For 2.0 μm to 2.5 μm at 120K, dark current increase is on the order of ~100x.
      - To keep the same dark current, the temperature would have to be decreased by ~ 20-30K.
        - » The detector Focal Plane Array (FPA) is already the coldest component, and would require a radiator area increase by ~2.5x to achieve this lower temperature.
      - A dark current increase will affect all observations in all wavelength bands.
  - Instrument/detector cavity (FPA to cold pupil):
    - The optical beam fills only a small solid angle at the detector.
    - Most of the detector solid angle views an effective instrument cold shroud temperature.
      - This thermal radiation is absorbed over the entire pass band of the detector.
      - With the addition of 2.0 μm to 2.5 μm band with a 180K shroud, the in-band internal emissions increase is on the order of ~2000x.
      - To keep the same cold shroud contribution, the temperature would have to be decreased by ~35K.
        - » Would require detailed modeling of a specific design to validate the performance feasibility
  - Telescope:
    - The filters will only allow in-band radiation to reach the detectors from upstream optical components.
    - The WFIRST DRM has no filters that pass radiation beyond 2.0 microns.
    - If we add filters that pass radiation between 2.0 and 2.5 microns, the background in this band will be ~100x higher than the Zodiacal background (when keeping the telescope and optics temperature constant).
    - This extra background only affects observations made in the 2.0 to 2.5 micron filters band pass.

      Options:
      - Accept telescope internal emissions noise in 2.0 to 2.5 band.
      - Cool telescope by ~40K to make its internal emissions a fraction of Zodi min (design, fabrication, test implications).

2.5 Micron Cutoff Wavelength Design Impacts

- Imaging Channel (continued)

  - Filters:
    - The extension of band pass to 2.5 microns will require at least one or perhaps two additional filters.
      - Requires increasing the size of an already large filter wheel assembly,
      - Or tradeoffs with other filter requirements,
      - Or two filter wheel assemblies.
    - The filter wheel mechanism(s) become more challenging.
      - Design and test temperatures must be lowered to be consistent with instrument/detector cavity temperature.
      - Schedule impact of colder testing.

- Spectrometer Channel
  - Trade study required to evaluate fabricating two kinds of detectors with different cutoffs vs. increased cooling for spectrometer channel.
  - Optical material properties shortcomings in the 2.0 to 2.5 band make extending performance into the 2.0 to 2.5 micron band very challenging.
  - Assumption used here is that the same detectors as the imager will be used, band limited to 2.1 micron cutoff if necessary.

Cost Impacts From Extension To 2.5 Microns

- Rough cost estimate for extending imager long-wavelength coverage from 2.0 microns to 2.5 microns: $50M to $80M

- Rough estimate does not entertain extended spectrometer channel band pass.
- Assumption is that appropriate additional cooling for the spectrometer channels would be included for devices with 2.5 micron cutoff, while maintaining the 2 micron science band pass cutoff.

- Considerations
  - Increase in focal plane arrays radiators cooling power (size vs heatpipes etc.)
    - Labor, fabrication, test, FOV constraints vs observatory pointing
  - Lower telescope temperature
    - Material, parts, processes qualification assurance
    - Cryo figuring of optics, test, metrology
    - Additional assembly-level test time
  - Extended observatory thermal vacuum testing
  - Larger filter wheel or 2 filter wheels
  - Colder filter wheel(s)
  - Additional filters to cover 2.0 to 2.5 micron band