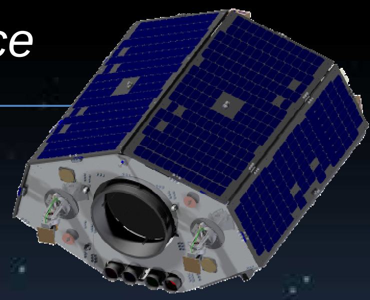
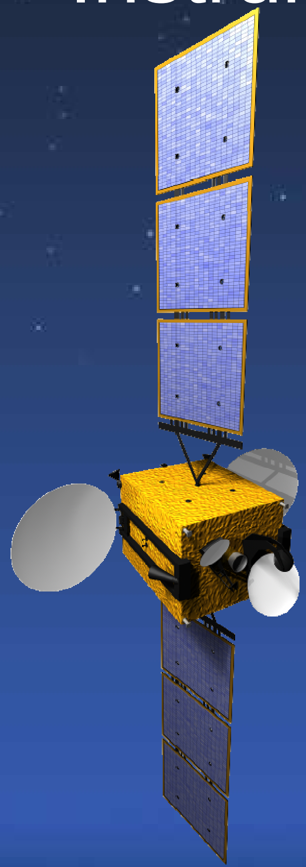
SURREY SATELLITE TECHNOLOGY LTD *Changing the economics of space*



Instrument Options for CarbonSat and FLEX

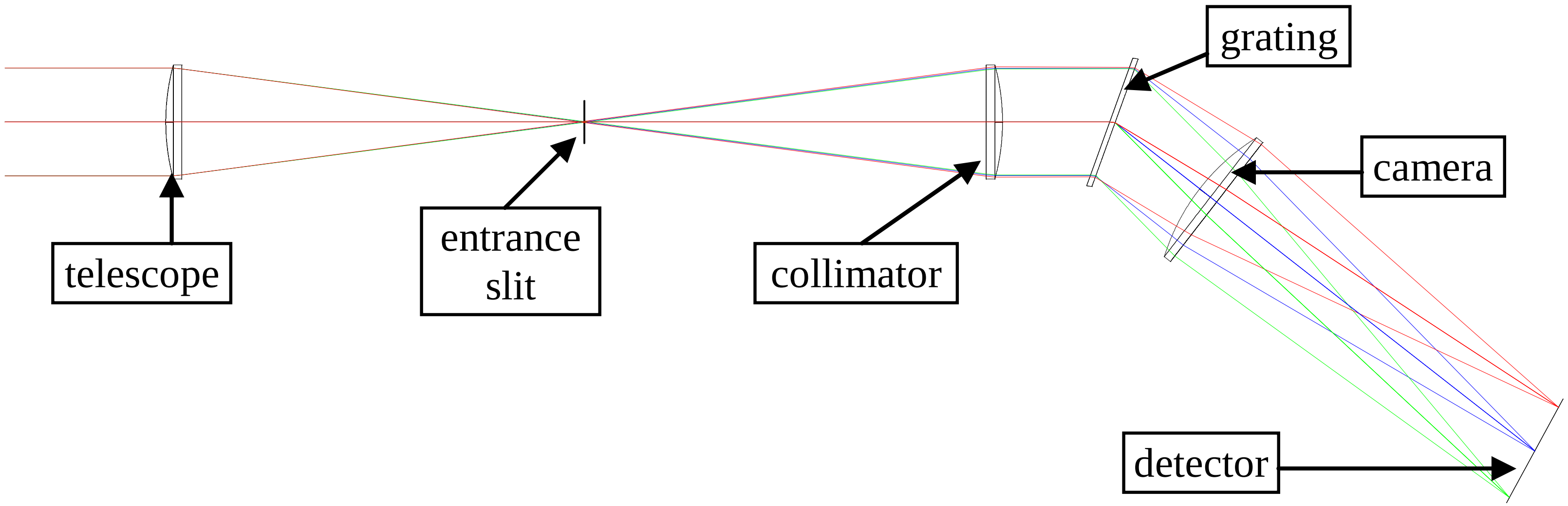
Dan Lobb, SSTL



NCEO/CEOI Joint Science Conference, Warwick, 7th September, 2011

Overview

- Instruments for Carbonsat and FLEX will (almost certainly) be imaging spectrometers operating in pushbroom imaging mode
- Carbonsat will need 3 separate spectrometers for NIR, SWIR-1 and SWIR-2 bands
- FLEX will need visible/NIR spectrometers for two different spectral resolutions and signal-to-noise ratio (SNR) requirements



This talk gives a brief outline of spectrometers we are likely to propose

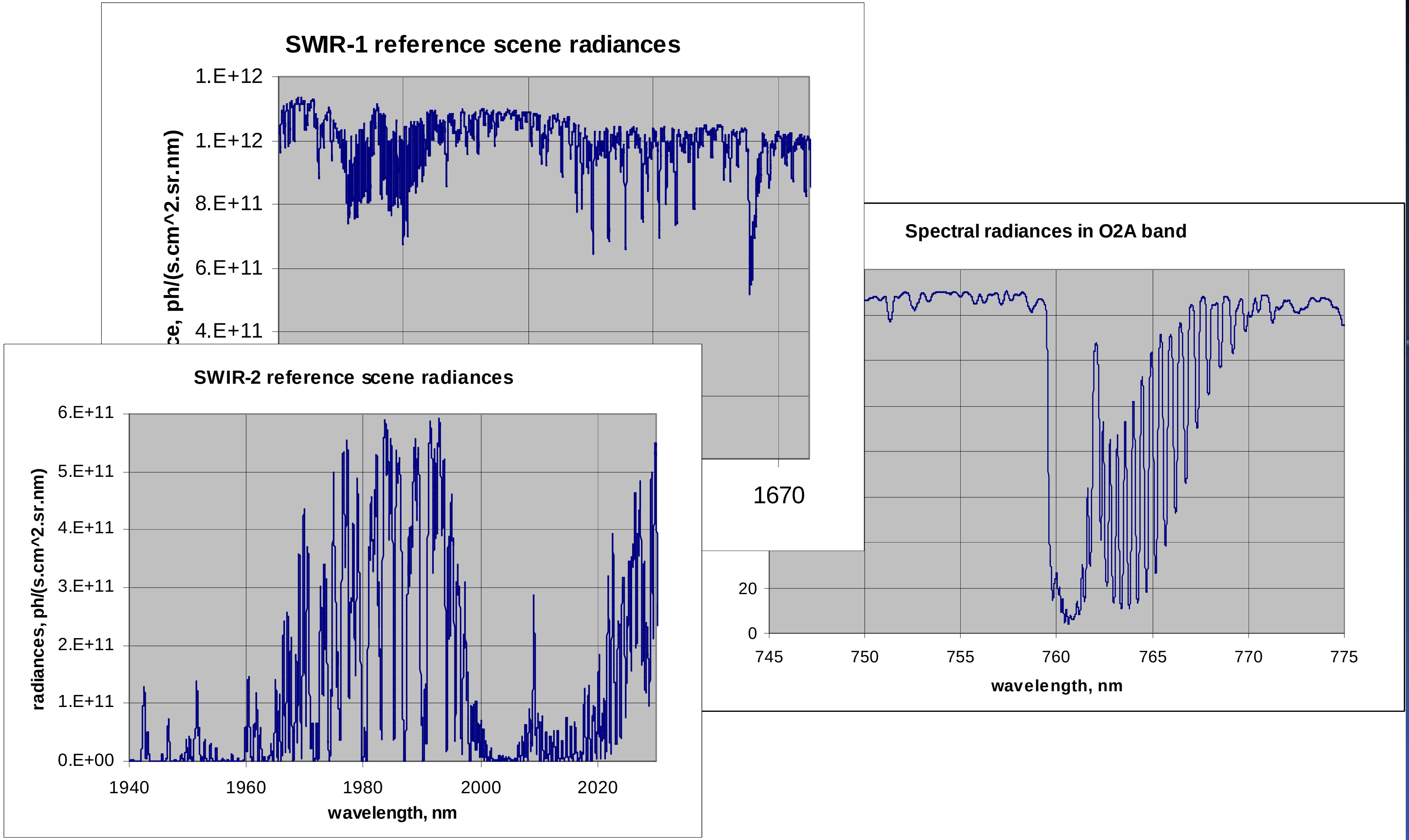
Bands and detectors

- Carbonsat SWIR bands
  - SWIR-1: 1559nm - 1675nm at 0.3nm resolution
  - SWIR-2: 2043nm - 2095nm at 0.13nm resolution
  - Factor >2.5 oversampling
  - Very similar to bands currently required for ESA's Sentinel 5
- SWIR detectors
  - Probably Mercury-Cadmium-Telluride (MCT) area-array detectors with at least 1000 x 250 image-area pixels (spectral x spatial)
  - There are detectors close to these requirements from Sofradir and AIM in Europe
- Carbonsat and FLEX visible/NIR bands
  - Oxygen-A band (both): ~ 756nm to 773nm
    - Resolution 0.3nm at high SNR for FLEX
    - Resolution 0.045nm for Carbonsat (factor >2.5 oversampling)
  - Oxygen-B band (FLEX): ~ 685nm to 700nm 0.3nm resolution
  - Wide-band (FLEX): ~520nm to 800nm (resolution <1nm)
- Visible/NIR detectors
  - Area-array silicon CCDs (charge-coupled devices)
  - Special detector developments will probably be needed for suitable formats, read-out rates etc.

NIR spectrometer designs

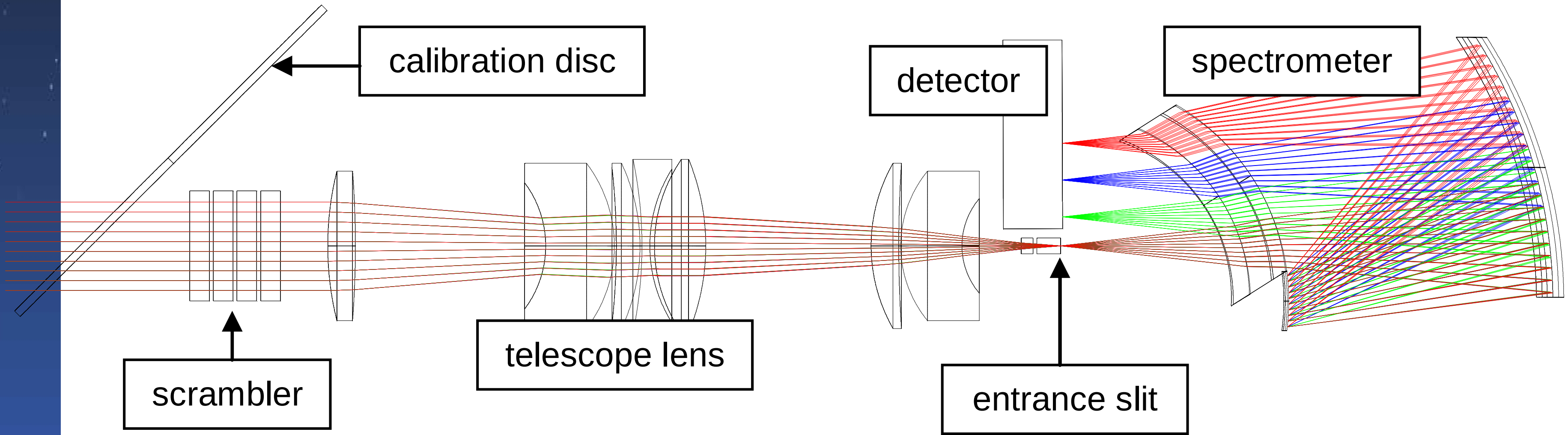
- Diffraction gratings and spectrometer size
  - Spectrometer size is driven by optics throughput requirements (aperture x field) and spectral resolution – high dispersion can limit focal lengths
  - Large light throughput required for FIMAS – etendue 0.05 mm^2.sr – with moderate spectral resolution
  - 0.045nm resolution for CarbonSat – but much lower throughput: ~0.0001 mm^2.sr at 2km resolution
  - Both NIR spectrometers can use front-reflecting or transmission gratings at moderate size – immersed gratings not essential
  - CarbonSat NIR spectrometer may be quite small
- Strong emphasis on stray light control for high-resolution O_2A and O_2B bands – tends to favour concentric spectrometers

Earth spectral radiances

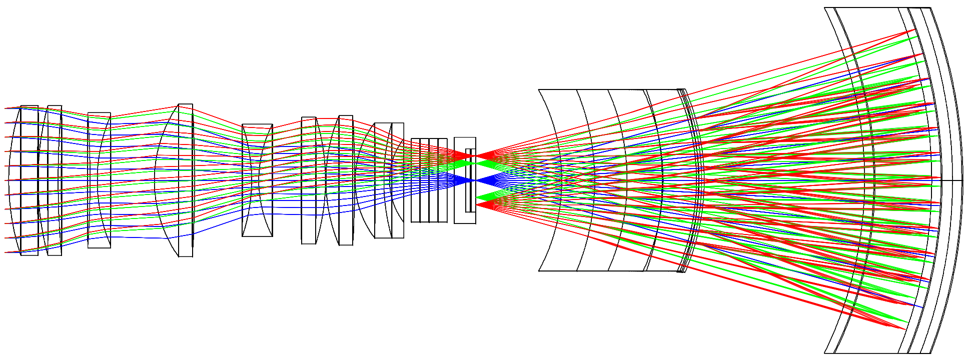


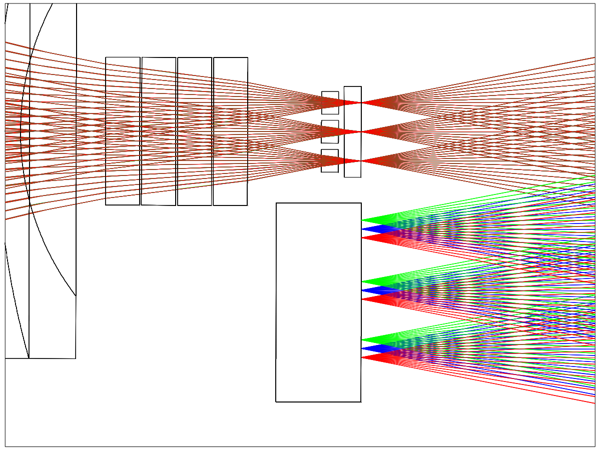
FLEX (FIMAS) wide-band system

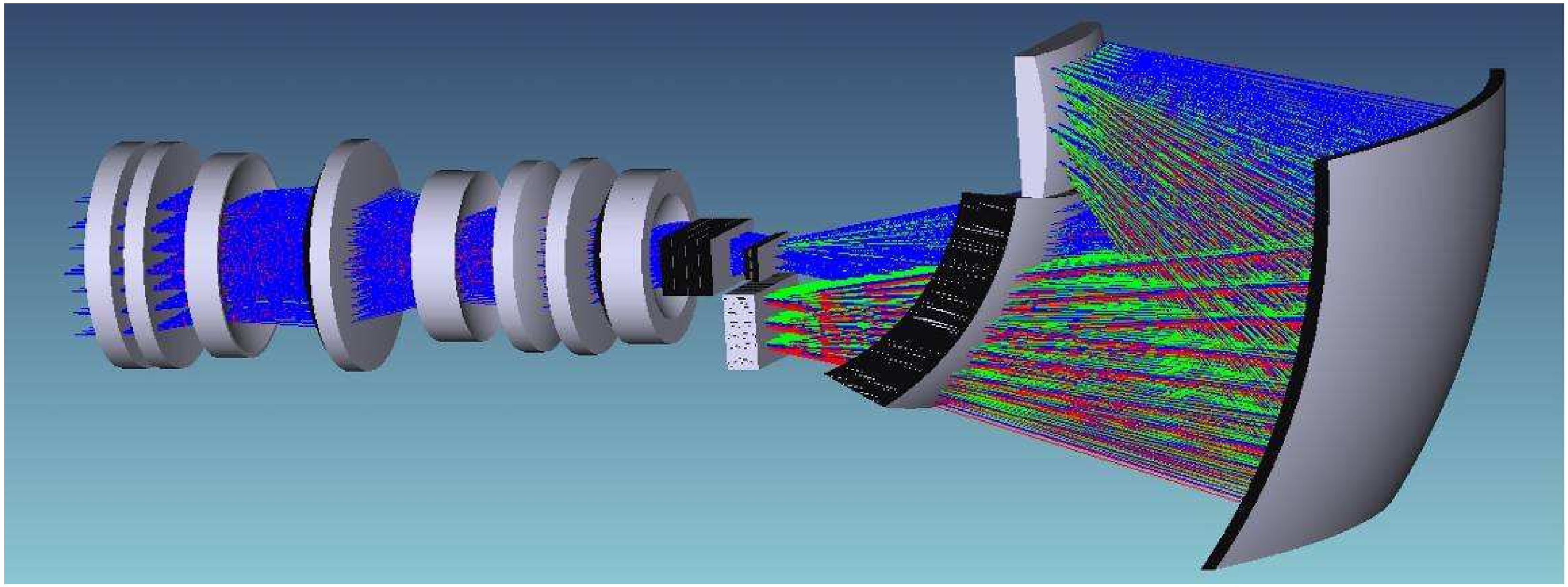
- Lens telescope and concentric spectrometer
- Includes solar calibration diffuser
- Provides 0.5nm resolution over 520nm to 800nm band



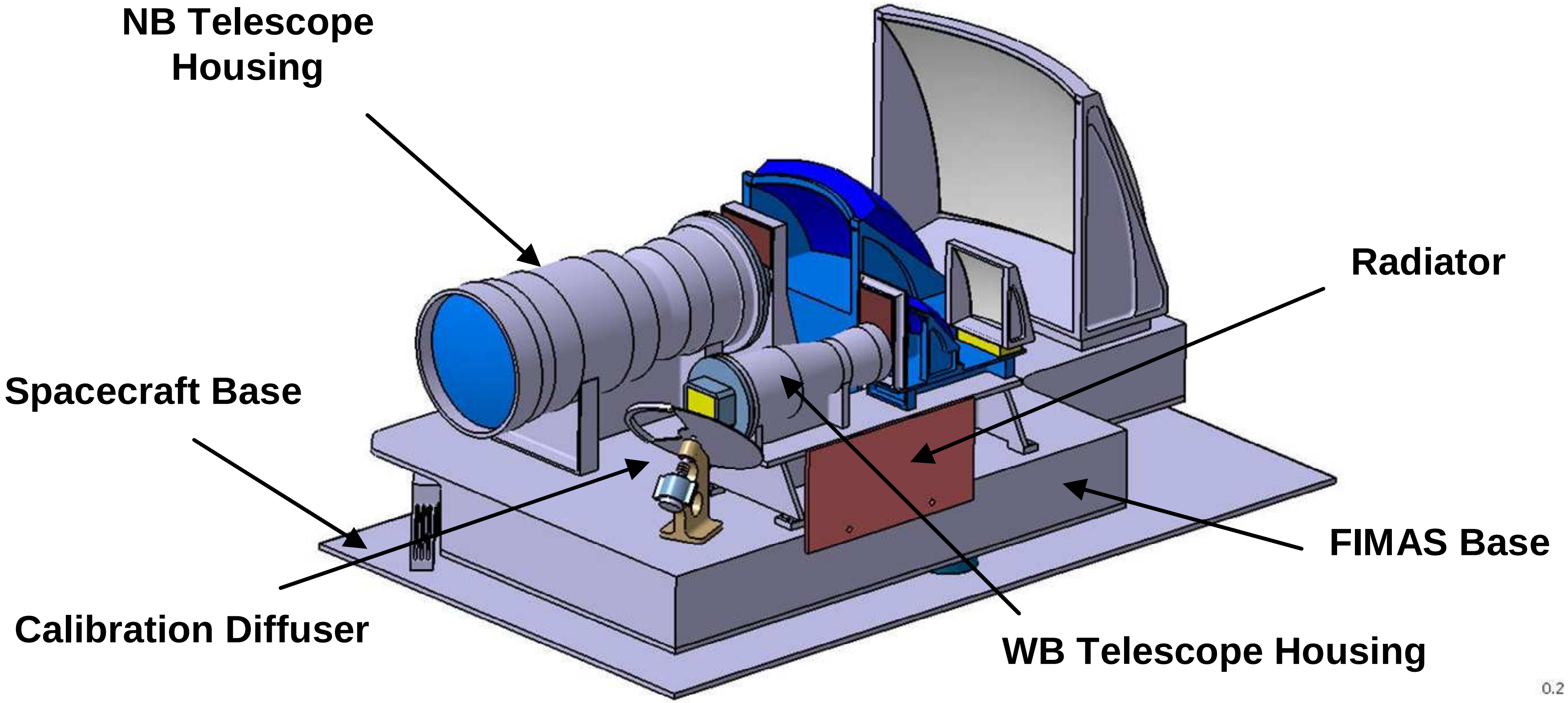
FIMAS optics – narrow-band







FIMAS optics assembly

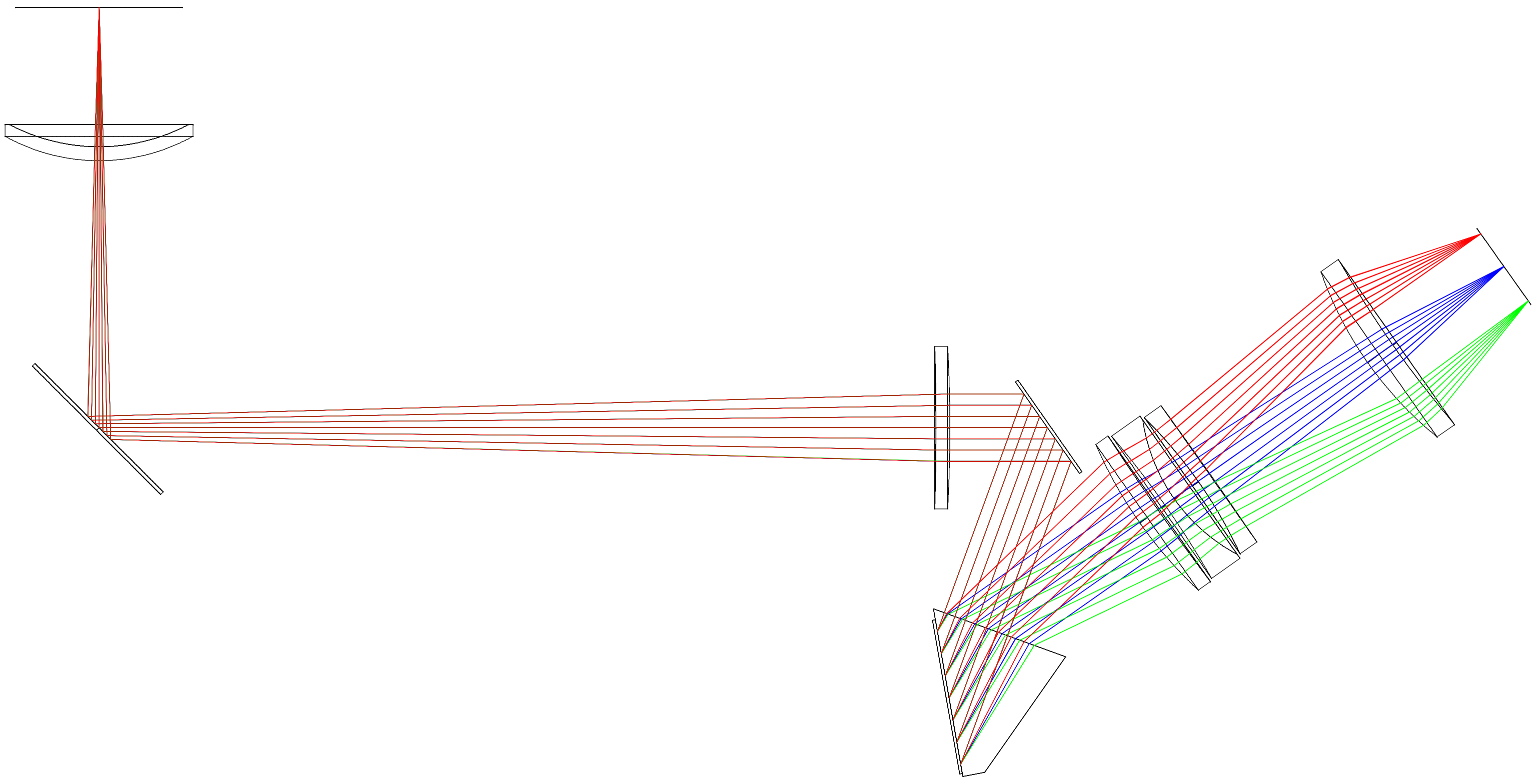


SWIR spectrometer designs

- Carbonsat requirements are very similar to those for ESA S5 SWIR bands
- High dispersion will be useful to limit focal lengths and sizes of optics and gratings
- Cooling:
  - Detectors will require cooling to <150K
  - SWIR 2 spectrometer preferably cooled to <240K
  - Active and passive cooling options
  - Optics should be configured to place detectors close to a cold-space radiator

Spectrometer using a silicon immersed grating

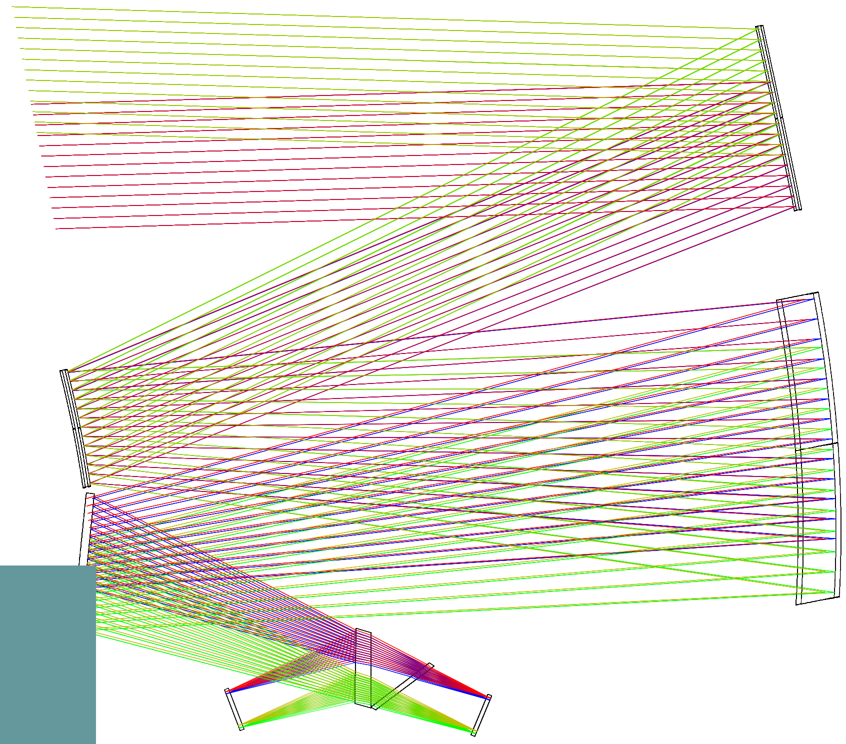
- This is an early spectrometer design for the SWIR-3 band of TROPOMI (S5 precursor)
- The grating is produced by anisotropic etching of crystal silicon to produce a 55° blaze
- Similar gratings and lenses are likely to be used for CarbonSat SWIR-1 and SWIR-2 bands

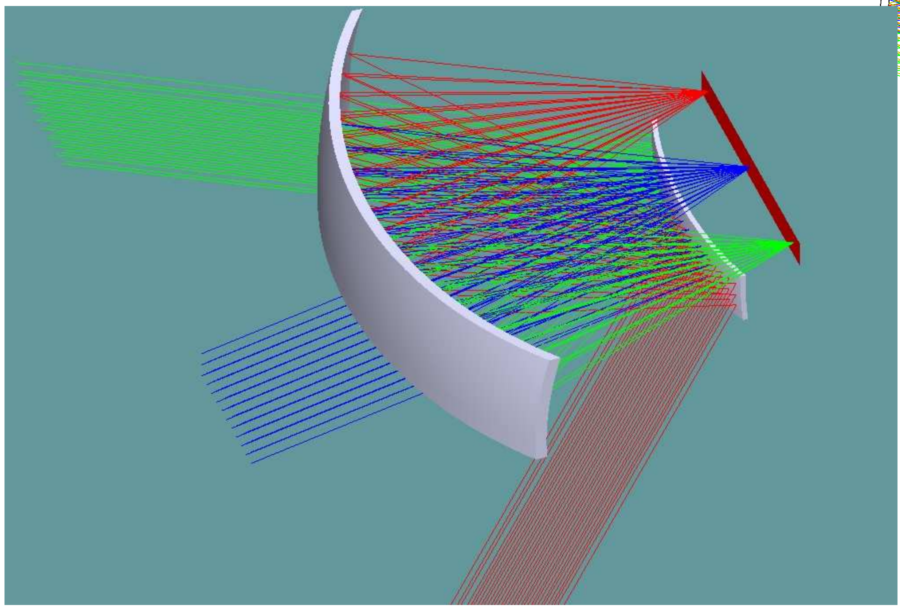


CarbonSat design strategies

- Separate gratings, camera lenses and detectors will be used for the 3 bands – otherwise there are very wide options
- The main trade-off in system design: there are options to use some common optics feeding the spectrometers
  - Common or separate: telescopes / entrance slits / collimators
  - Dichroic splits and blocking filters after telescope, slit or collimators
  - Trade-off against stray light issues
- Telescope designs
  - Field of view is moderate for CarbonSat (~500 km swath)
  - A mirror (common) telescope can be used
  - Lenses also quite easy for separate telescopes
- A diffuser – deployed in sunlight in front of the telescope – will be used to provide calibration of Earth images against solar irradiance
- Advantages of common optics
  - A main advantage of common telescope is use of a common sun-calibration system
  - Some advantages in spatial registration between bands

Mirror telescopes options





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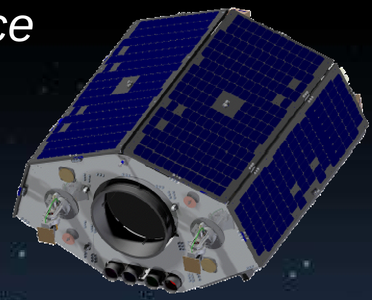
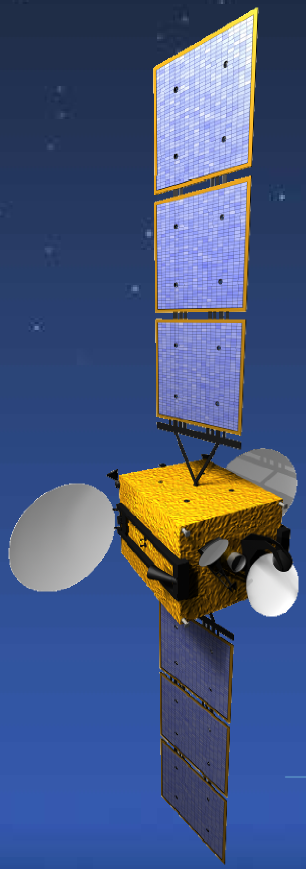


Thank You



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