WFIRST
Wide-Field Infrared Survey Telescope

The Wide Field Infrared Survey Telescope (WFIRST)

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The Science Definition Team

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Our Process

The Interim Design Reference Mission (IDRM)

- Using JDEM-Ω as a baseline, and existing, "ready-to-fly" technology only –

-Report released in July, 2011

Final DRM's (2) by June 2012

1: Completion of the IDRM identifying potential cost savings

2: Develop a final DRM for WFIRST that does not duplicate the capabilities of Euclid and LSST. Assess options for meeting all of the New World New Horizon requirements with the combination of Euclid, LSST, and a WFIRST DRM

The IDRM

Off – Axis Three Mirror Anastigmat Design with field pickoffs to tailor the plate scale for imaging and spectroscopy

Supernova spectroscopy performed through insertion of prism as a “filter” in the imaging channel

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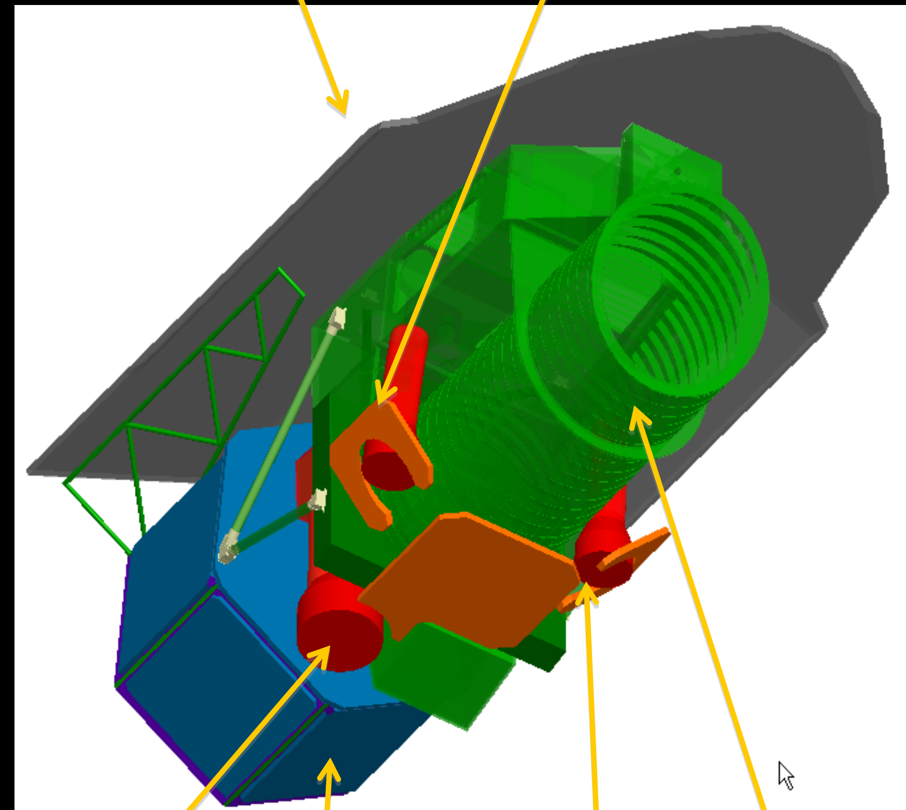
- 1.3m unobscured TMA telescope; 220K;
- **<u>3 channels, 2 focal lengths</u>**
- 7x4 + 2(2x2)=**<u>36 H2RG arrays</u>**
- **<u>SpC</u>**= opposed dispersions,
  - 1.1-2.0μm, R ~ 200
  - 0.26 deg^2 active area (each) @ 0.45”/pixel
- **<u>ImC</u>**= filter wheel w/5 filters +
  - SN prism: (R ~75) 0.6-2.0 μm,
  - 0.291 deg^2 active area @ .18”/pixel

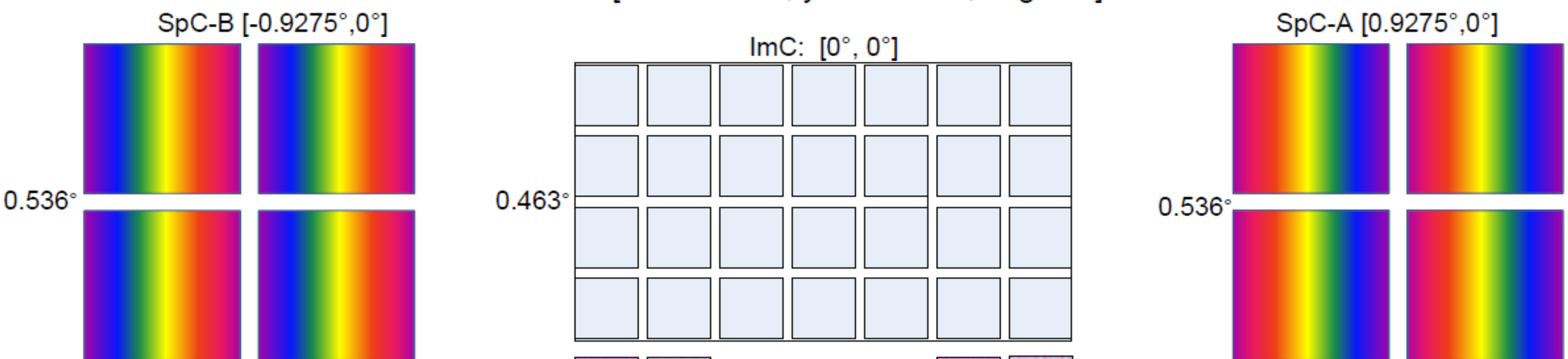


Channel field layout for WFIRST IDRM-1

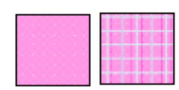
Moon (average size seen from Earth)

The Fields of view of the imaging channel (ImC), spectroscopy channels (SpCs), and guiding modes (FGS) are shown to scale with the Moon, HST, and JWST. Each square is a 4Mpix vis-NIR sensor chip assembly (SCA)

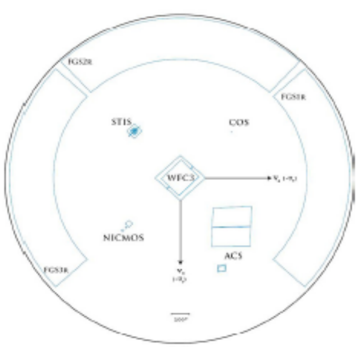
ImC: 7x4 @ 0.18"/p; SpC 2(2x2)@0.45"/p
[xfield center, yfield center, degrees]



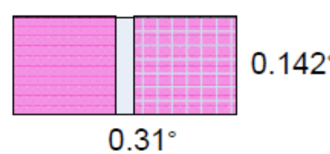
0.802°



Outrigger fine guidance sensors



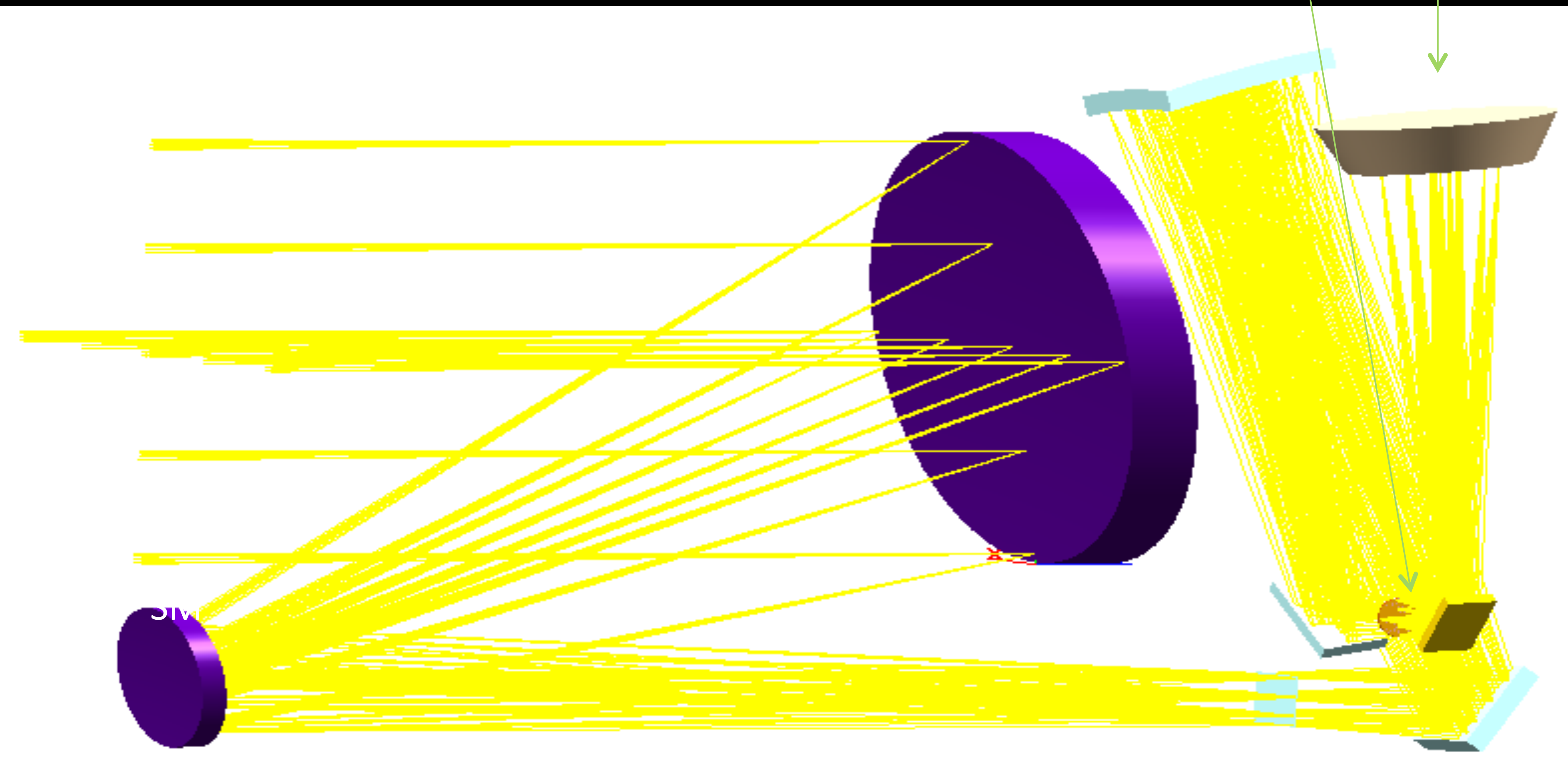
HST [all instruments]



Auxiliary Fine Guidance System: 2@0.25"/p [0°, -0.6°]

JWST [all instruments]

Imaging Channel Layout



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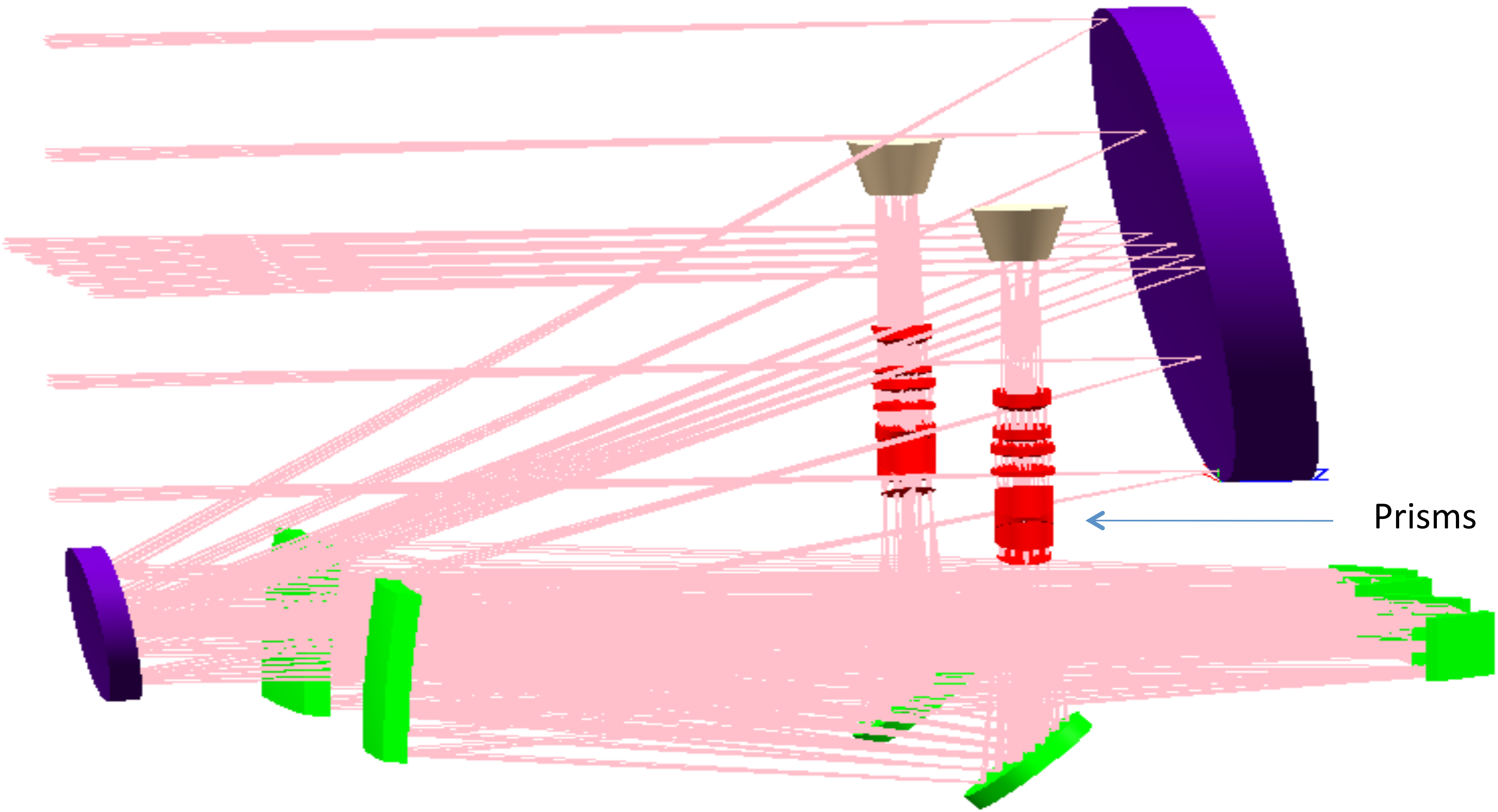
Spectrograph Channels Layout



Design Trade 1: Single Channel option

- Initial motivation: reduce complexity and cost while maintaining scientific performance
- Only one array of detectors used for all survey science: WFIRST now operates in either imaging survey mode or spectroscopic mode – not both simultaneously – but with a larger, single field

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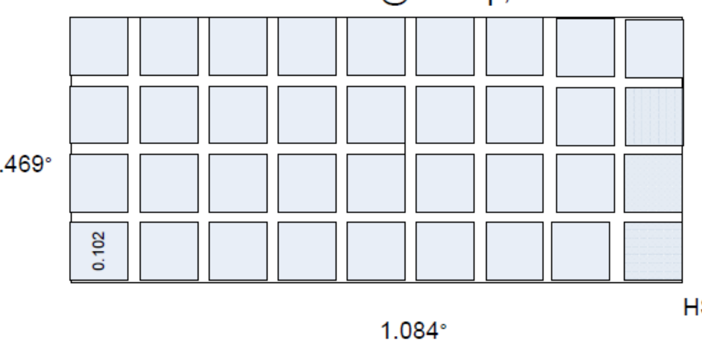
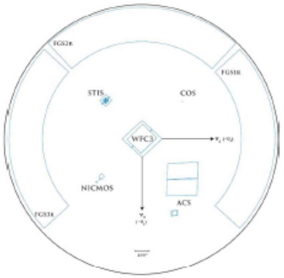
H2E1 layout

Channel field layout for WFIRST "H2E1"

The Field of view of the single imaging & spectroscopy channel is shown to scale with the Moon, HST, and JWST. Each square is a 4Mpix vis-NIR sensor chip assembly (SCA)

ImC: 9x4 @ 0.18"/p;



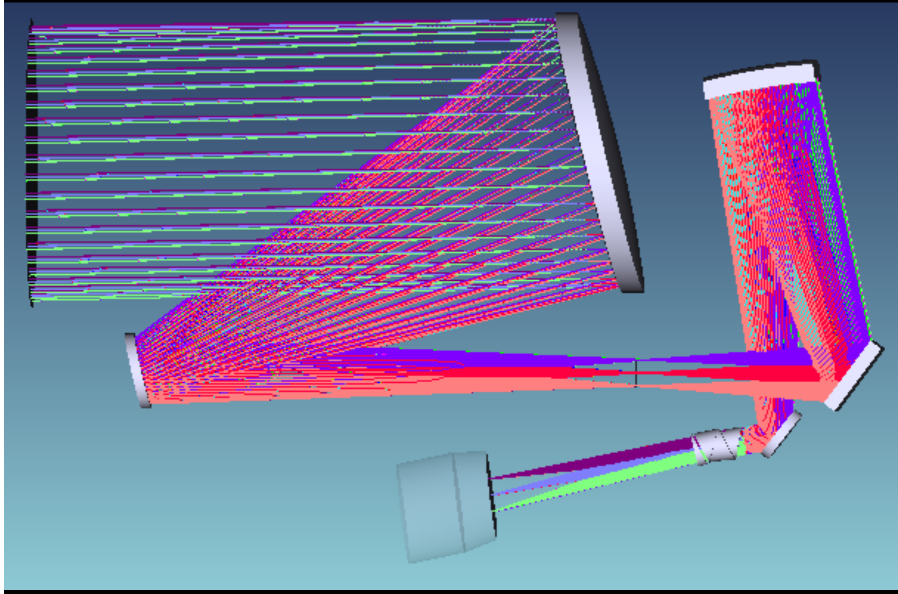


HST [all instruments]

Each square shown is physically a 2040 x 2040 x 18um HgCdTe array [H2RG-18]

JWST [all instruments]

Moon (average size seen from Earth)



Optical ray trace layout for H2E1

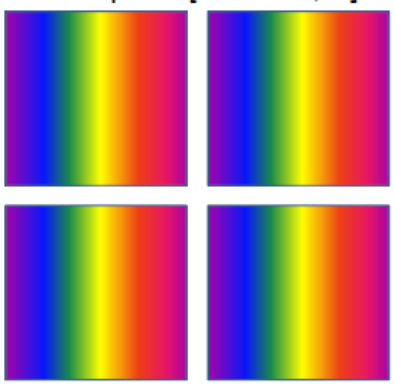
Channel field layout for WFIRST IDRM-1

Moon (average size seen from Earth)

The Fields of view of the imaging channel (ImC), spectroscopy channels (SpCs), and guiding modes (FGS) are shown to scale with the Moon, HST, and JWST. Each square is a 4Mpix vis-NIR sensor chip assembly (SCA)

ImC: 7x4 @ 0.18"/p; SpC 2(2x2)@0.45"/p
[xfield center, yfield center, degrees]

SpC-B [-0.9275°,0°]

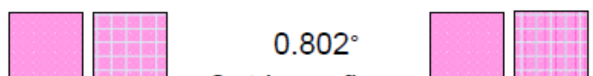


0.536°

0.536°

ImC: [0°, 0°]

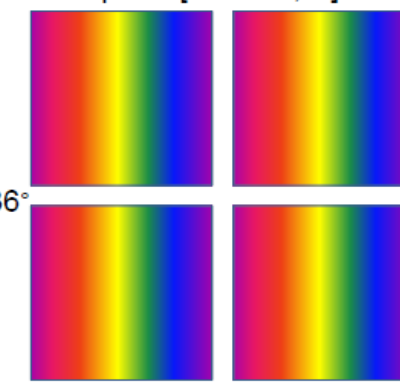
0.463°



0.802°

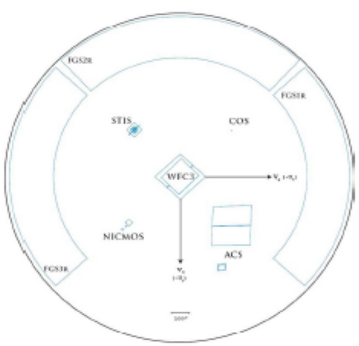
Outrigger fine guidance sensors

SpC-A [0.9275°,0°]

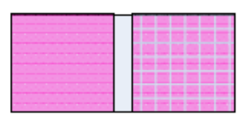


0.536°

0.536°



HST [all instruments]



0.142°

0.31°

Auxiliary Fine Guidance System: 2@0.25"/p [0°, -0.6°]

JWST [all instruments]

Single vs. dual channels

- The loss of simultaneity does not completely make up for the increased field area
- It wins for microlensing, assuming identical time allocation
  - **<u>H2 single channel design returns 17% less science in 8% less time</u>**

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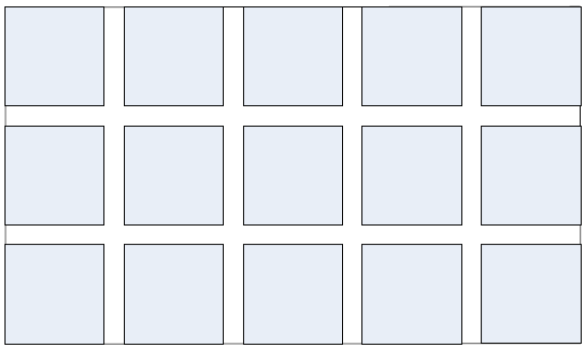
Consider using H4RG-10 devices instead (4K X 4K X 10 μm pixels)

Channel field layout for WFIRST "H4E1"

The Field of view of the single channel which can be used in imaging (Im), BAO spectroscopy (Sp), or SN spectroscopy (SNSp) mode is shown to scale with the Moon, HST, and JWST. Each square is a 16Mpix vis-NIR sensor chip assembly (SCA), 10 um pixels

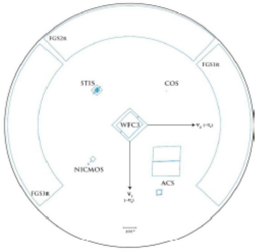
5x3 @ 0.17"/p, 0.557 sq.deg, gaps are 20% of chip width to allow smooth filled survey

0.655°



1.117°

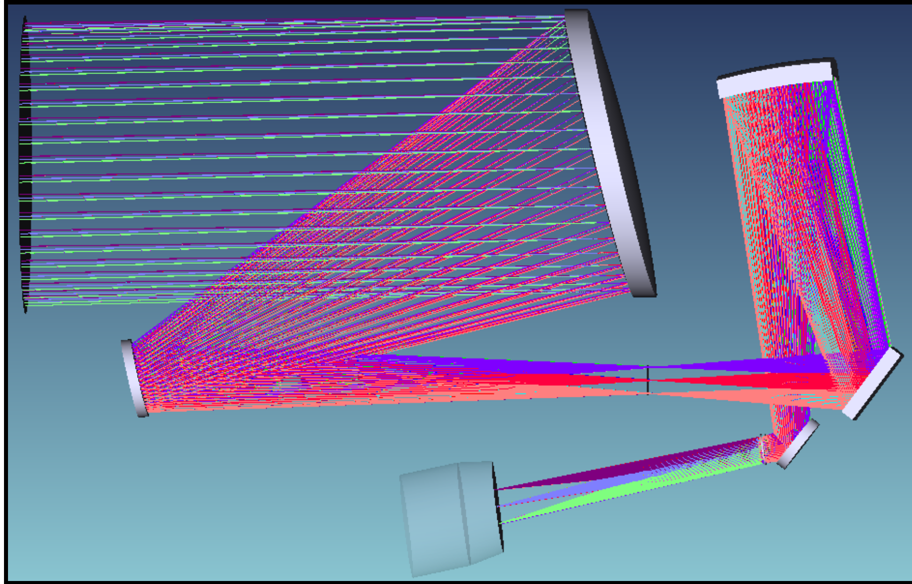
Moon (average size seen from Earth)



HST [all instruments]

JWST [all instruments]

Optical ray trace layout for H4E1



{prisms not shown}

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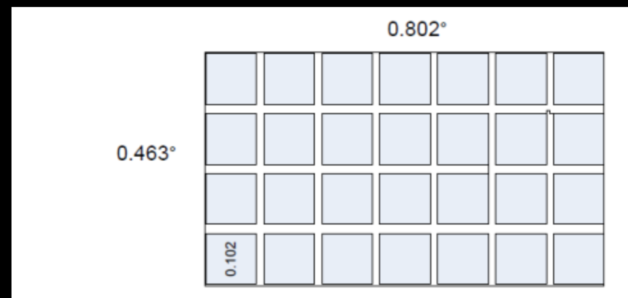
H4RG(-10) Provides Potential Simplifications For The Imaging FPA

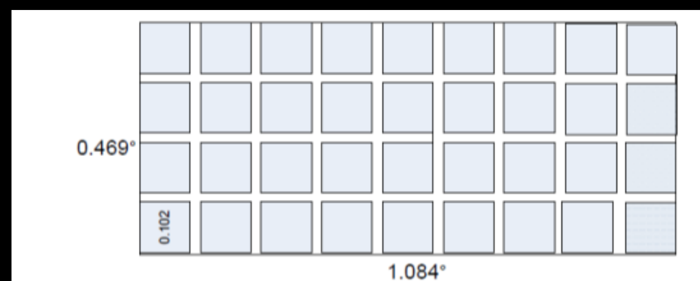
H2RG is 2040 x 2040 18um pixels

IDRM ImC: 7x4 H2RG(-18) @ 0.18”/p, 0.291 deg^2, 117Mpix



FPA 27x17 cm

H2E1: 9x4 H2RG(-18) @ 0.18”/p, 0.375 deg^2, 150Mpix



FPA 39x17 cm

H4RG(-10) is 4088 x 4088 10um pixels

H4E1: 5x3 H4RG(-10) @ 0.17”/p, 0.559 deg^2, 250Mpix

FPA 24x14 cm

- Single channel advantages
  - Imaging surveys in particular benefit from increased field
  - Increased flexibility and efficiency
    - All pixels used all the time
    - Each measurement can have optimized exposure time
  - Decreased complexity and mass can result in savings
    - Goal is decreased cost while maintaining scientific performance
- Single channel disadvantages
  - Loss of simultaneous opposed SpC dispersions
  - Loss of simultaneous imaging and spectroscopy in wide survey
  - Prisms are more complex than in baseline
  - Additional mechanism routinely used in instrument [prism wheel]

H4RG-10 design is win-win*

- With larger sky coverage per exposure, science is accomplished more rapidly – by reallocating the survey modes between SpC and ImC appropriately:
  - **H4-10 single channel design returns 8% more science in 8% less time**

* H4RG devices are not currently flight ready

Identified future trade studies

A) SN spectroscopy through IFU rather than a prism inserted into imaging channel

- Results in higher quality spectra resulting in better sub typing of SN – reduced systematic errors in SN studies
- Should relax pointing repeatability requirements on S/C, currently one of the technical tall poles
- Added expense of building and integrating IFU

Identified future trade studies

B) Extend operational bandpass to 2.5 μm

- Makes IR devices easier to procure as 2.5 μm is an industry standard
- Further differentiates WFIRST from Euclid by extending to higher redshifts
- May drive thermal design depending on acceptable level of thermal background at longest wavelengths

Responding to the DRM2 charge

- *Develop a final DRM for WFIRST that does not duplicate the capabilities of Euclid and LSST. Assess options for meeting all of the New World New Horizon requirements with the combination of Euclid, LSST, and a WFIRST DRM. Assess the science impact of such options*

Responding to the DRM2 charge

- The SDT has formed a subcommittee to make recommendation(s) to the full SDT about the appropriate way to respond to this charge

- Possible capabilities that could be dropped in response to the DRM2 charge:
  - BAO (spectroscopic survey)
  - Weak Lensing (imaging survey)
  - Both BAO and WL

  - SN, μlensing and the NIR survey are not part of the Euclid primary science objectives, and are not duplicative (in my opinion)

Drop BAO

- In either (H2 or H4) one channel design, this would eliminate the need for the prisms and corrective optics associated with the BAO survey, and possibly reduce the number of "filter wheels" from 2 to 1.
- In the IDR, this would save 8 detectors, and all the optics uniquely associated with the SpC.
- The BAO survey requirements do not drive the system level requirements on the S/C or operations

Drop Weak lensing

- Weak Lensing places the tightest constraints on the system level performance in terms of stability and calibration.
- Assuming that we maintain the requirement of a NIR survey, eliminating the WL lensing will allow some currently undetermined cost savings through relaxation of system level requirements.

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Drop Both BAO and WL

- The need for SN science, μlensing studies, and a NIR survey still dictate a 1m class 3-mirror anastigmatic telescope with a large focal plane array.
  - Pricing of comparable missions using the same cost algorithms as WFIRST show costs still exceed $1B.

Alternative: Drop "Nothing"

- The charge is clear that the scientific requirements of NWNH must still be met, with the combination of Euclid, LLST, JWST and WFIRST.
- The recent NRC report is equally clear that Euclid does not meet the NWNH requirements:
  - *"Euclid on its own does not provide a viable alternative for achieving the broader NWNH goals for the WFIRST mission, nor does it achieve the more ambitious goals for WFIRST's dark energy measurements"*

Alternative: Drop No DE approaches

- Additionally, the NRC report states:
  - "*Euclid's and WFIRST's measurements are <u>not duplicative</u> and the combinations will be more powerful than any single measurement.*" (My emphasis)
- It could be argued that only a "*fully capable*" WFIRST is compliant with the DRM2 charge.

Alternative: Go to single channel

- One of Euclid's capabilities is the ability to perform simultaneous BAO and weak lensing
- A single channel WFIRST would not have this capability – but would be a more flexible scientific observatory. Making the missions approach their observing scenarios with different capabilities should maximize the net scientific return of both missions.
- The SDT will be considering these options carefully over the next few months.

Conclusions

- The SDT will completing it efforts by June 30, 2012, and is scheduled to be disbanded at that time.
- Our primary objective is to find a mission that can meet requirements laid down by NWNH and be programmatically viable given the resources available and the diverse needs of the agency and the community.