SPECTRE: A Wide Bandwidth High Throughput Spectrograph Concept

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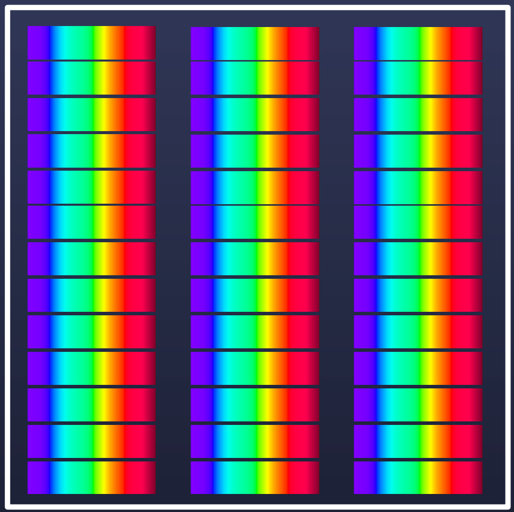
Challenge: Better than SpeX

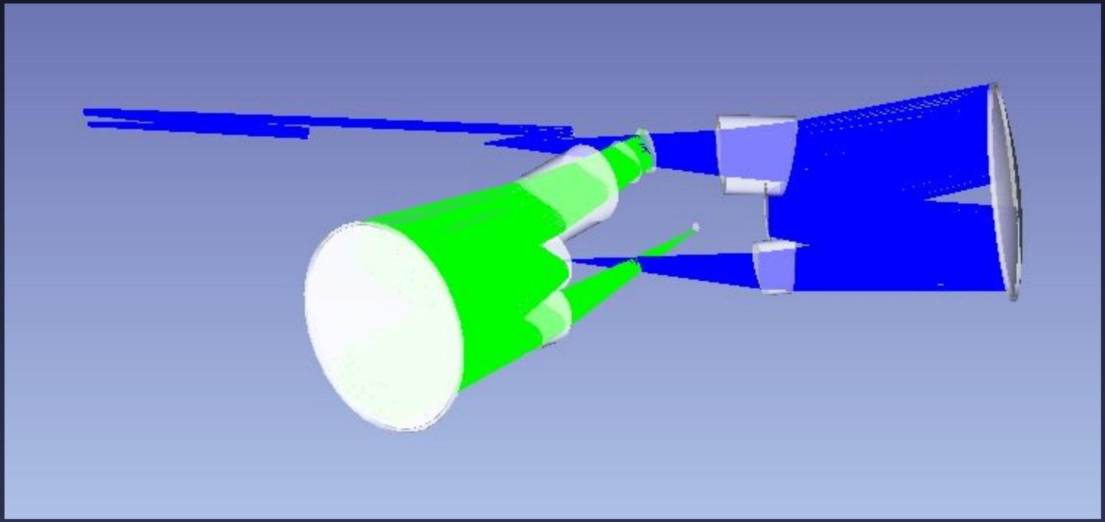
- What is the best thing we could build to characterize asteroids?
- Can something be sufficiently better than SpeX to be worth building?
- Magic SpeX/prism: $\Delta J=1.6$, $\Delta H=0.7$, $\Delta K=0.6$
- Need to optimize:
  - Throughput
  - Read noise
  - Bandwidth
  - Field of view

SPECTRE Design Study

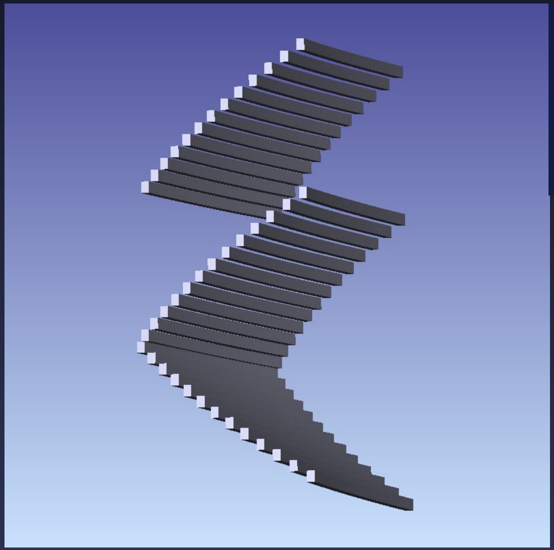
- Science goals: Quickly characterize asteroids (especially NEAs) and astrophysical transients
- Low resolution prism spectrograph: R~100
- High throughput: ~70%
- Wide bandwidth: 0.36 μm to 4 μm simultaneous
- Uses one image slicer IFU with 7″ x 7″ FOV
    - No slit losses
    - No image rotator
- Dichroic splits the optical (0.36 to 0.85 μm) and IR channels (0.85 to 4 μm)
    - May need to split between near-IR and thermal-IR to mitigate scattered light
- Each detector will have a 3x13 grid of spectra
- 1 K detectors (SAPHIRA for near-IR)



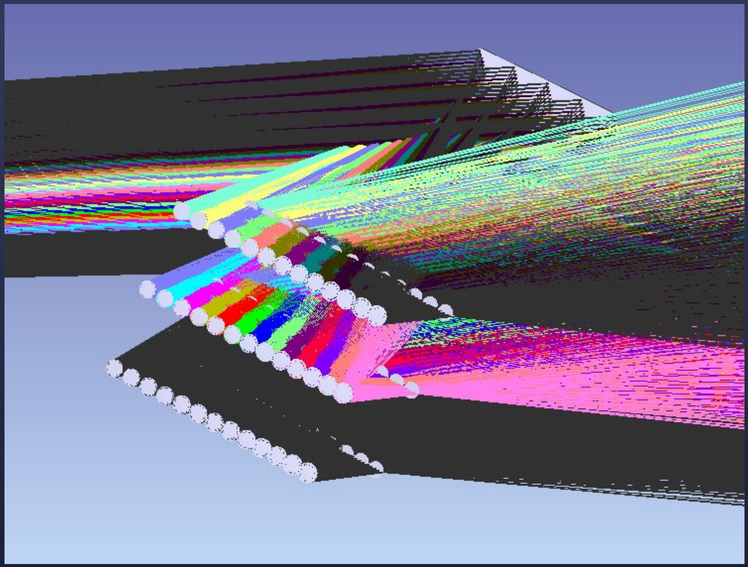
Grid of spectra on the detector



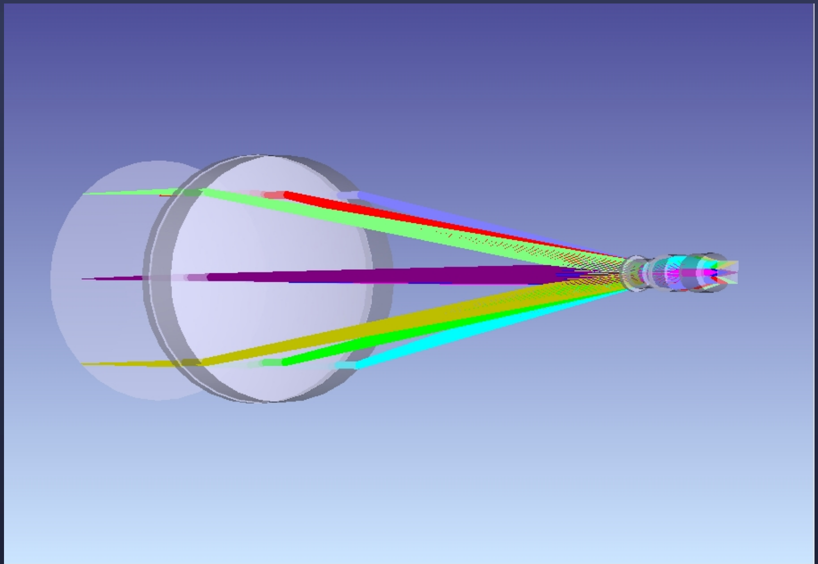
The two channels together



39 image slicer mirrors



Three tiers of sub-pupil mirrors



Refractive 3’ FOV acquisition camera

SPECTRE: How Will It Work?

- No moving optics. Compact and rigid.
  - No flats or arcs during the night → more time on science target .

- Detectors: 1K CCD and 1K HAWAII/SAPHIRA array
  - 1K arrays reduce cost
  - 1K SAPHIRA: No read noise, can bin down spectra without losses

- 7″ IFU
  - No slit losses
  - Enables ‘point-and-shoot’ observing
  - Map a planet much faster than slit scanning

- 3′ FOV visible light acquisition and guide camera
  - Rapid target acquisition: enough stars to platesolve
  - Guiding on field stars for moving or static targets
  - Similar to MORIS, w/ 1K CCD

SPECTRE: How Will It Work?

- High dynamic range in the IR
  - IR Array gets reset more frequently in the thermal region while allowed to integrate in the read noise limited region
- On target guiding for fast moving targets
  - Real-time image cube reconstruction in a moving window on the data stream from the IR detector to allow on-target guiding for rapidly moving targets
- Software
  - Need real time data reduction pipeline for first light, and for on-target guiding. Probably hardest part of project.

Comparison with SpeX

- Coverage in the optical
- 0.5 magnitudes at JHK
- 0.8 magnitudes at L
- Higher observing efficiency
  - Open shutter time on SpeX: 60%

Band	SpeX	Spectre
U		18.7
B		20.5
V		20.1
R		19.8
I	18.0	19.0
J	17.0	17.5
H	15.7	16.3
K	15.6	16.0
L	11.0	11.8

Magnitudes for S/N=100 in 1 hr

What Would You Use It For?

- Rapid characterization of survey targets
  - Asteroids
  - Kuiper Belt Objects
  - Brown Dwarfs
  - Transients
    - SN type characterization
- Survey of hydrated minerals in asteroids
- Spectroscopic variability of young stars or AGN

Conclusion

- Resolution R~100
- Simultaneous coverage from 0.36 to 4 μm
- Throughput ~70 %
- Low (zero) noise detectors
- 7″ x 7″ Field of View
- 3′ acquisition/guide field
- Guiding for fast moving targets
- No moving optics

Multi-color Imager

- Lower resolution, wider field of view
- Project many images onto one detector
- No dichroics, higher throughput
- 3 detectors, 9 or 16 channels each
- R~10-15