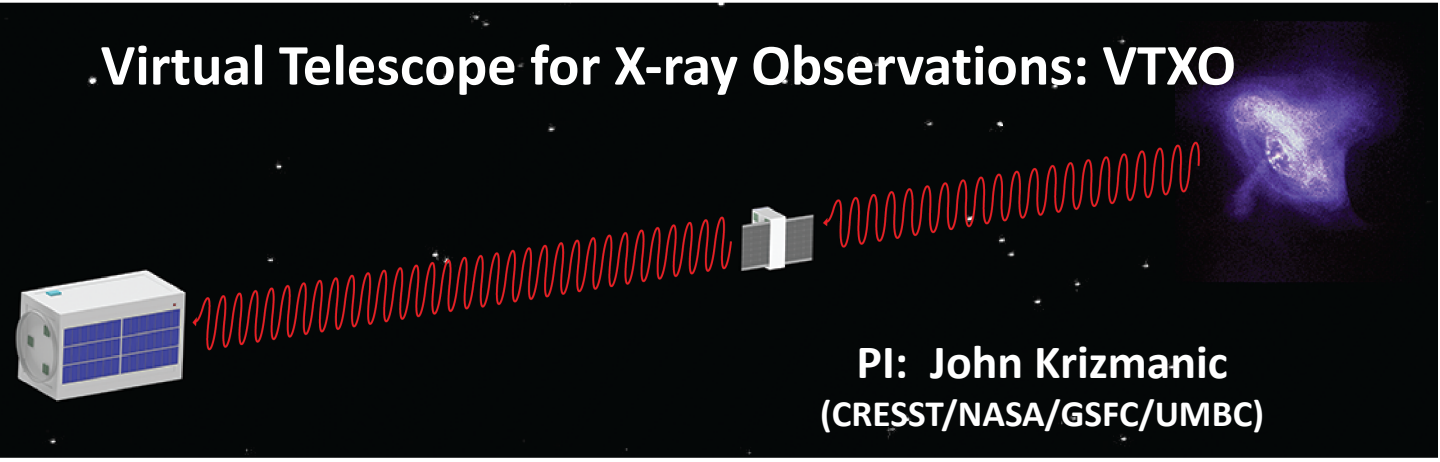
Virtual Telescope for X-ray Observations: VTXO



PI: John Krizmanic
(CRESST/NASA/GSFC/UMBC)

Mission Description

Precision formation flying of a OpticsSat with X-ray Phase Fresnel Lens (PFL) Optics and a DetectorSat with an X-ray camera forming a 1 km focal length X-ray telescope with **55 milli-arcsecond angular resolution and 8 arcsecond FoV**

Science Objectives

Image environments ×10 closer to compact X-ray sources

- Sco X-1: X-ray telescope PSF calibration
- Cyg X-1 & GRS 1915+105: jet structure in X-ray Novae
- Cyg X-3, GX 5-1, Cen X-3: dust scattering halos
- Crab PWN: structure in accelerator termination shock
- Eta Carinae: bow shock location in colliding wind
- γCas: spatial scale of X-ray emission

Mission Specs

- ESPA-ring deployment on rideshare
- Orbit: 90,000 km × 600 km perigee
- Orbit fraction above rad belts: >50%
- Observation time: 10 hours/32.5 hr orbit
- DetectorSat: ESPA-class (50 × 40 × 80 cm^3)
- OpticsSat: 6U Cubesat
- Mission Lifetime: ~250 days

X-ray Telescope Specs

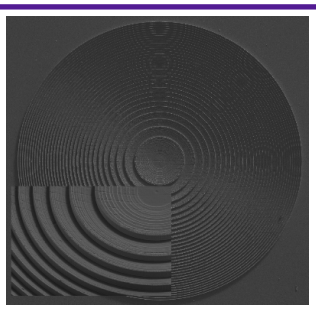
Three different PFL Optics:

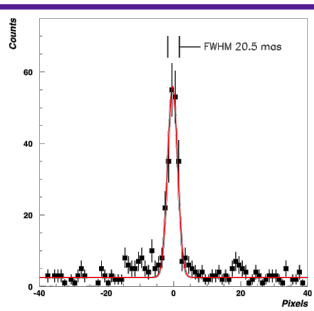
- PFL#1 Energy: 4.5 ± 0.15 keV
- PFL#2 Energy: 6.7 ± 0.15 keV
- PFL-Achromat Energy: 4 - 6 keV
- PFL Diameter: 3 cm
- PFL Efficiency: 30%
- PFL Focal Length: 1 km

X-ray Camera: Teledyne H2RG HyViSI

Observation time for 1000 VTXO counts in the energy band 4.5 +/- 0.15 keV

Source	Flux (mCrabs)	Obs Time (hr)
Sco X-1	8000	0.2
GX 5-1	1260	1.5
GRS 1915+105	450	4.2
Cyg X-3	390	4.9
Cyg X-1	350	5.4
Crab Pulsar	100	19
Cen X-3	90	21
γCas	13	146
Eta Carinae	4.2	452

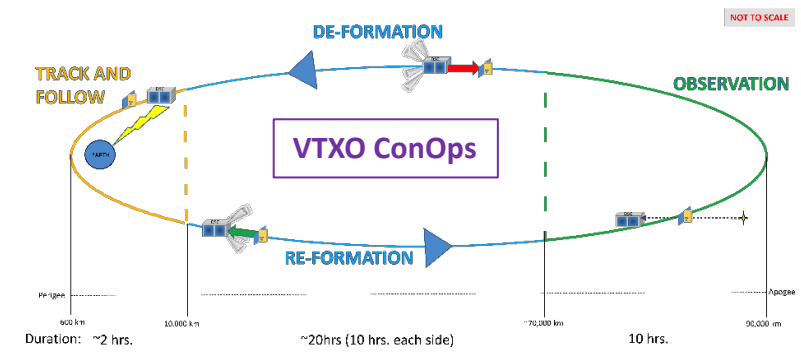




PFL Imaging Performance

Ref: Krizmanic et al. (2009)

Design Energy: 8 keV
Material: Silicon
PFL Diameter: 3 mm
PFL Efficiency: 36%
PFL Focal Length: 110.5 m
Diffraction-limit PSF: 15.9 mas

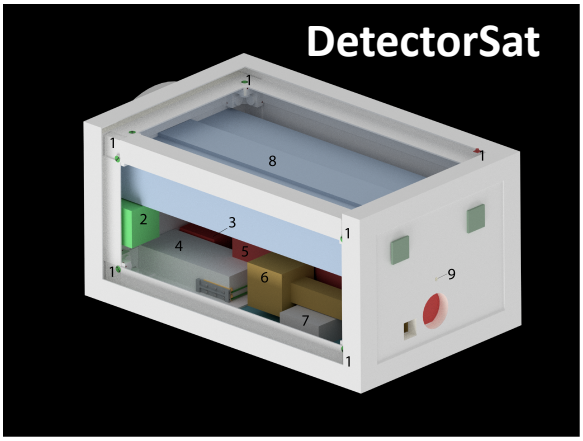


S-band radios provide inter-satellite data link and ranging.
~30 kbps ground com bandwidth around apogee.
GPS positions and velocities available for entire orbit, resolution reduced above GPS constellation.

ConOps

- Loose formation leaves perigee.
- Science formation forms in ~10 hr to 1 km focal length at 5 hr before apogee:
  - Thrusters keep image on X-ray camera within ± 5 mm for ±5 hr around apogee.
  - Navigation filter uses NISTEx-II star tracker & Nav sensors also imaging beacons on OpticsSat to obtain 53 mas telescope pointing resolution.
- Formation relaxes moving to perigee.
- Ground com occurs before perigee.
- Process repeats.

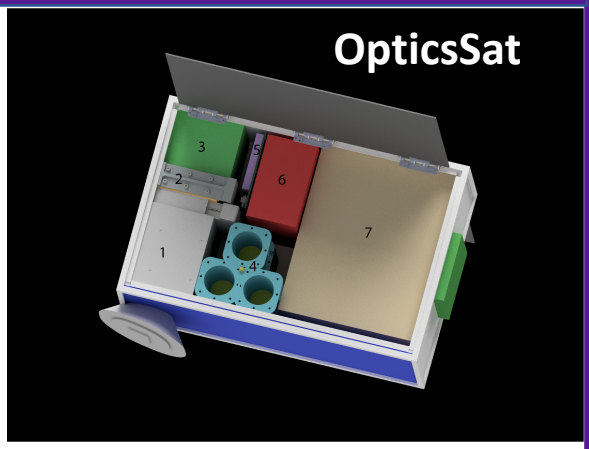
Spacecraft



DetectorSat:
Dry Mass: 72 kg
Wet Mass: 109 kg
Power: 48 W

OpticsSat:
Dry Mass: 9.7 kg
Wet Mass: 12 kg
Power: 24 W

Telemetry:
200 Mbits/orbit



1 VACCO 3-nozzle cold gas thruster; 2 SWIFT SLX radio; 3 Batteries; 4 Avionics bus/shielding; 5 NISTEx-II interferometric start tracker; 6 X-ray camera assembly; 7 Instrument electronics/shielding; 8 VACCO cold gas generator; 9 X-ray camera/star tracker viewing ports.

1 BCT XACT-50 (star camera FoV shown by cone); 2 GPS receiver; 3 SWIFT SLX radio; 4 PFL assembly and laser beacon; 5 EPS unit; 6 Batteries; 7 VACCO cold gas MiPS

VTXO AS³ Team

Principle Investigator: John Krizmanic[1]

Science Team: Mike Corcoran[2], Alice Harding[3], Chris Shrader[2]

Engineering Team: Neerav Shah[3], Steve Stochaj[4], Phil Calhoun[3], Lloyd Purves[3], Cassandra Webster[3], Kyle Rankin[4], Daniel Smith[4], Asal Nasari[5], Laura Boucheron[4], Krishna Kota[4], Hyeongun Park[4]

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3 NASA/Goddard Space Flight Center
4 New Mexico State University
5 Space Dynamics Laboratory

AS³ Summary

Spacecraft, flight dynamics, and GN&C finalized in weeklong MPL study at Wallops.

SmallSats use components with flight heritage to the best extent possible.

NISTEx-II Interferometric star tracker operational on ISS STP-H6 platform.

Small charged particle radiation detector included to verify rad environment during science observations.

Mission costing performed by GSFC CEMA office using MPL-developed MELs and Price-H parametric cost model with cost risk analysis: Mission Cost estimate is ~40% above $35M.