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 cm³)
- 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

<table>
<thead>
<tr>
<th>Source</th>
<th>Flux (mCrabs)</th>
<th>Obs Time (hr)</th>
</tr>
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<tbody>
<tr>
<td>Sco X-1</td>
<td>8000</td>
<td>0.2</td>
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<tr>
<td>GX 5-1</td>
<td>1260</td>
<td>1.5</td>
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<tr>
<td>GRS 1915+105</td>
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<td>4.2</td>
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<td>Cyg X-3</td>
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<td>Cyg X-1</td>
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<td>5.4</td>
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<td>Crab Pulsar</td>
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<td>19</td>
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<tr>
<td>Cen X-3</td>
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<td>21</td>
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<tr>
<td>γCas</td>
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<td>146</td>
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<tr>
<td>Eta Carinae</td>
<td>4.2</td>
<td>452</td>
</tr>
</tbody>
</table>

PFL Imaging Performance

- 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

Ref: Krizmanic et al. (2009)
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

VTXO AS³ Team

Principle Investigator: John Krizmanic¹
Science Team: Mike Corcoran², Alice Harding³, Chris Shrader²
Engineering Team: Neerav Shah³, Steve Stochaj⁴, Phil Calhoun³, Lloyd Purves³, Cassandra Webster³, Kyle Rankin⁴, Daniel Smith⁴, Asal Nasari⁵, Laura Boucheron⁴, Krishna Kota⁴, Hyeongun Park⁴

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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.