**NuSTAR**

the Nuclear Spectroscopic Telescope Array

Kristin K. Madsen & Fiona Harrison, Caltech Institute of Technology

The Nuclear Spectroscopic Telescope Array will be the first focusing telescope to image the hard X-ray (6 - 80 keV) sky. NuSTAR is a NASA Small Mission Explorer (SMEX). Using focusing optics with multilayer coating for enhanced reflectivity at high energies, NuSTAR will provide an unprecedented combination of sensitivity, spectral and angular resolution.

### NuSTAR Science

The hard X-ray band is a natural and underexploited window on compact objects: the first priority of NuSTAR will be to identify and study black holes and other collapsed stars on all scales. NuSTAR will accomplish this goal through a series of deep surveys of Galactic and extragalactic fields. Massive Black Holes NuSTAR will survey the NDWFS and GOODS fields to identify the faint extragalactic X-ray sources.

NuSTAR will also make sensitive observations for the first time in the band where the XRB spectrum peaks. It will detect and localize more than three hundred hard or obscured AGN (a factor >20 more than currently known), measuring X-ray spectra and, through coordinated multiview observations, redshifts and host properties.

**Supernovae**

Seed the interstellar medium with the heavy elements formed in the quasiequilibrium conditions of stellar burning and in the non-equilibrium conditions of the explosion itself. A detailed understanding of the explosion dynamics could be obtained from spatially resolved abundance maps of remnants. A particularly valuable isotope is $^{44}$Ti, with half-life $\tau \approx 85$ yr. In core collapse events, the predominant production of $^{44}$Ca, as $^{44}$Ti, occurs during $\alpha$-rich freeze-out around the mass cut, between the innermost ejecta and the material that falls back to form a collapsed remnant. This location implies that $^{44}$Ti production and ejection are very sensitive to the explosion mechanism and ejecta dynamics.

NuSTAR will measure and map the $^{44}$Ti lines at 68 and 78 keV in historic remnants: Cas A, SN1987A, Tycho, Kepler.

**The inner few hundred parsecs around the Galactic center (2 by 0.8 degrees) contains ~1% of the Galactic stellar mass, and up to 10% of its massive, young stars. Known sources in this luminosity range include accreting white dwarfs (specifically, intermediate polars), high- and low-mass X-ray binaries (HMXBs and LMXBs), rotation-powered pulsars, and magnetars. This region also contains unique high-energy features, such as mysterious magnetic radio filaments, light echoes from past outbursts of the supernovae black hole Sgr A*, and a TeV source coincident with Sgr A**.

NuSTAR will survey the inner ~1 by 1 degree of the Galactic center.

**Focal Plane**

NuSTAR will fly two focal planes using Cadmium Zinc Telluride (CdZnTe) pixelated detectors which provide excellent spectral resolution and high quantum efficiency detectors which provide excellent spectral and angular resolution.

Focal length = 10.14 m

<table>
<thead>
<tr>
<th>Type</th>
<th>Spectral Resolution</th>
<th>Spatial Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Optics**

The grazing incidence optics use of a Wolter-I conical approximation type. These segmented optics are based on the High Energy Focusing Telescope, HEFT, mission optics, shown left. The optics are composed of low surface roughness 0.21 mm thick borosilicate glass, slumped into conical shape. NuSTAR will utilize multilayers of the type W/Si and Pt/C to extend the energy range up to 78 keV.

NuSTAR is a partnership among Caltech, the Jet Propulsion Laboratory, Columbia University, the Danish National Space Center, Goddard Space Flight Center, Lawrence Livermore National Laboratory, Stanford Linear Accelerator Center, U.C. Santa Cruz, Sonoma State University, and U.C. Berkeley as well as industry teams at Orbital Sciences Corporation, and ATK Goleta, CA.