

ASTENA mission concept: an Advanced Surveyor For Transient Events and Nuclear Astrophysics

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On behalf of a larger collaboration

ASTENA mission concept

Two instruments: 1) **Narrow Field Telescope** (NFT, 50 – 700 keV, 30'' Angular Resolution, 4' FOV); 2) **Wide Field Monitor Imager and Spectrometer** (WFM-IS, 2 keV – 20 MeV, 1' Point Source Localization Accuracy, 2 sr FOV) (Fig. 1). Submitted to ESA for its new long term program «Voyage 2050».

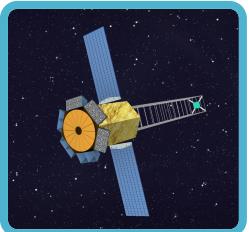


Fig. 1: Artistic representation of ASTENA in-flight configuration

Scientific Goals

1. Deep study of Gamma-Ray Bursts (prompt and afterglow) and other high energy transients (emission spectrum, localization, polarization etc.). See white paper from Guidorzi et al. [1].
2. Unprecedented study of nuclear astrophysics (Supernovae lines, 511 keV line from the galactic center region, etc.). See white paper from Frontera et al. [2].
3. And more (x-ray binaries, magnetars, Active Galactic Nuclei, spectroscopy and polarization, etc.)

For WFM-IS description and performances, see white paper [2].

In view of the ASI call for a small Italian mission, we describe NFT, that we intend to propose as a pathfinder of ASTENA.

The Narrow Field Telescope

Focusing optics

Based on a Laue lens, that focus X-/Gamma-rays by exploiting Bragg's diffraction in transmission configuration.

Crystal material: bent Si(111) and Ge(111) crystals. Focal length = 20 m (Fig. 2)

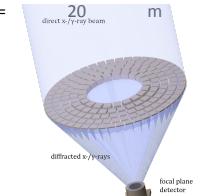


Fig. 2: Schematic concept of a Laue lens

Focal plane detector

Segmented CZT (higher efficiency) or HPGe (higher energy resolution) with 3D position sensitivity (cross section of 8 x 8 cm², thickness of 8 cm). Position resolution of 0.3 mm, and high energy resolution (@511 keV, CZT: 1%; HPGe: 0.4%) (Fig. 3).

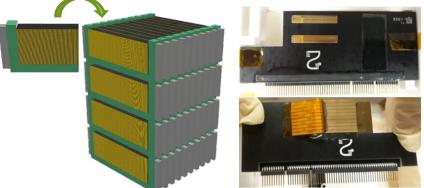


Fig. 3: Left, Monte Carlo model of a possible detector configuration based on CZT modules. Right: 3D-CZT sensor prototype [4]

NFT Capabilities

Imaging performance and effective area

Through simulations: evaluation of the PSF (Fig. 4), lens effective area and focal plane detector efficiency (Fig. 5).

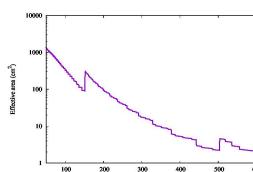


Fig. 5: Left, Effective area/keV of ASTENA/NFT. Right: focal plane detector efficiency for 8 cm thickness of CZT and HPGe. For the HPGe, we will increase the thickness to 10 cm

Continuum and line sensitivity

Thanks to the combination of innovative technologies, ASTENA/NFT will bring a quantum leap in continuum and line sensitivity in the field of soft gamma-ray astronomy (Fig. 6, Fig. 7).

For the polarimetric capabilities, see poster by Moita et al., “Polarimetric prospects of the Narrow Field Telescope aboard the ASTENA mission concept”

Bibliography

- 1 - Guidorzi et al., A deep study of the high energy transient sky, DOI: 10.1007/s10686-021-09725-9
- 2 - Frontera et al., Understanding the origin of the positron annihilation line and the physics of supernova explosions, DOI: 10.1007/s10686-021-09727-7
- 3 - Frontera and Von Ballmoos, Laue Gamma-Ray Lenses for Space Astrophysics: Status and Prospects, DOI: 10.48550/arXiv.1007.4308
- 4 - Caroli et al., 3DCaTm: a 3D Cadmium Zinc Telluride spectroscopic module for hard X- and Y-ray astronomy, DOI: 10.36116/MEMSAIT_93N2_3.2022.26

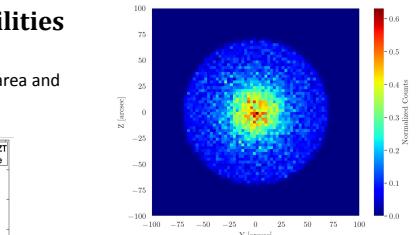


Fig. 4: Simulated PSF of a Laue lens made of Ge crystals working in the energy range 50–700 keV

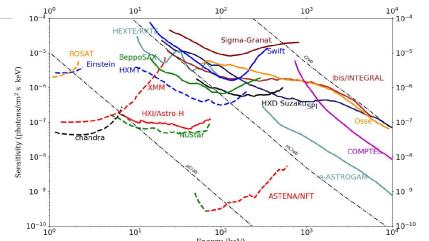


Fig. 6: 3 σ Continuum sensitivity for NFT ($\Delta T = 10^5$ s, $\Delta E/E/2$)

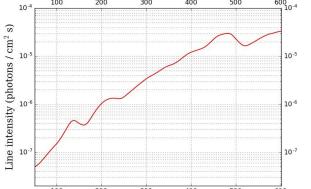


Fig. 7: 3 σ Line sensitivity for NFT ($\Delta T = 10^5$ s)