Crystal Eye

A wide view of the Universe in high energy

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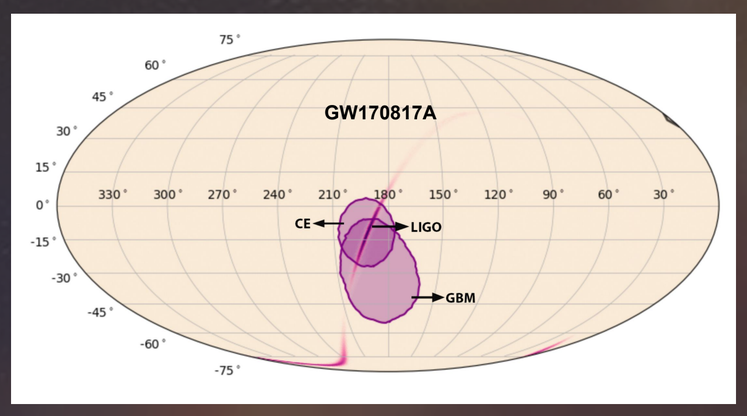
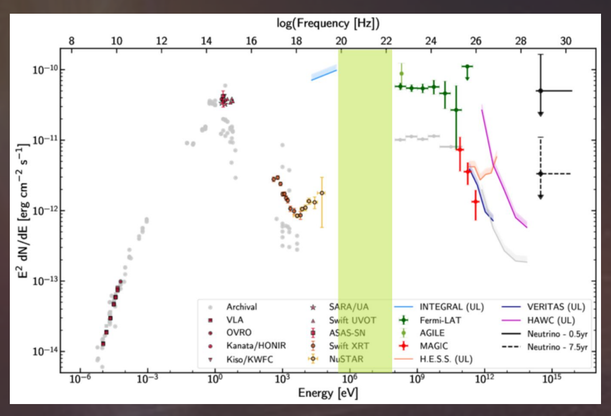
Abstract

Crystal Eye is a novel concept of space-based all sky monitor for the observation of about 10 keV - 30 MeV photons exploiting a new detection technique, which foresees enhanced localization capability with respect to current instruments. This is now possible, thanks to the use of new detector materials and sensors. The primary scientific goal is the detection of the electromagnetic signals from the extreme phenomena in the Universe. To enhance the scope of the multimessenger study of these phenomena, the experiment will provide an alert to both space and ground based experiments. A full scale model of the Crystal Eye detector is now under design and construction. Moreover, a smaller prototype has been set up to fly aboard of the Space Rider (ESA) on a LEO orbit (400 km, 5.3° of inclination) for two months in 2025. We present here the Crystal Eye mission concept and performance.

Science Goals

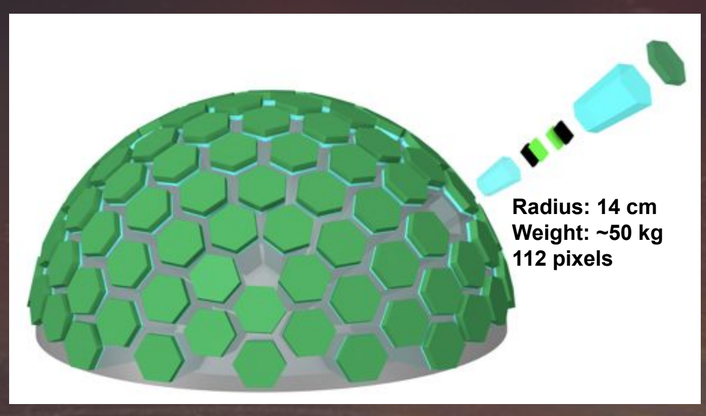
■ Wide field and precise monitoring and localization of astrophysical transient phenomena to help the multimessenger scientific studies. ■ Study the interesting and diverse astrophysical phenomena in the keV and low MeV region exhibiting spectral features which are, to date, not extensively measured. ■ Primary scientific targets of the instrument are GRBs, GW electromagnetic counterparts and other transients, accreting systems, supernovae and particular γ emission lines.





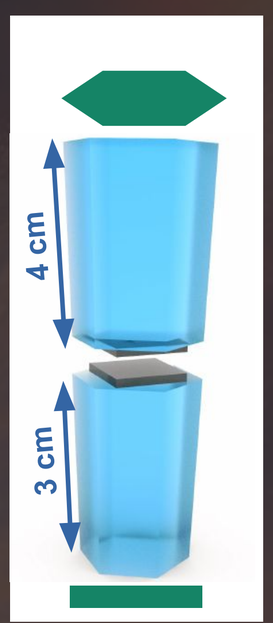
Features

■ All sky monitor active in the range 10 keV - 30 MeV.
■ Wide FOV: ~ 6 sr.
■ Full sky coverage.
■ Very large effective area: ~ 5 times Fermi-GBM at 1 MeV.
■ High localization capability: few degrees.



Highly efficient, low cost, compact device – today this innovative observation technique is feasible, thanks to the use of new sensors and materials.

The Pixel



■ **Pixel FOV:** 2.5°x2.5°.

■ **LYSO crystals** (in cyan) read by Hamamatsu MPPC arrays (in gray).

■ **Material:** LYSO → high photon absorption probability and light yield, fast time response, self radiation calibration, low intrinsic noise rate

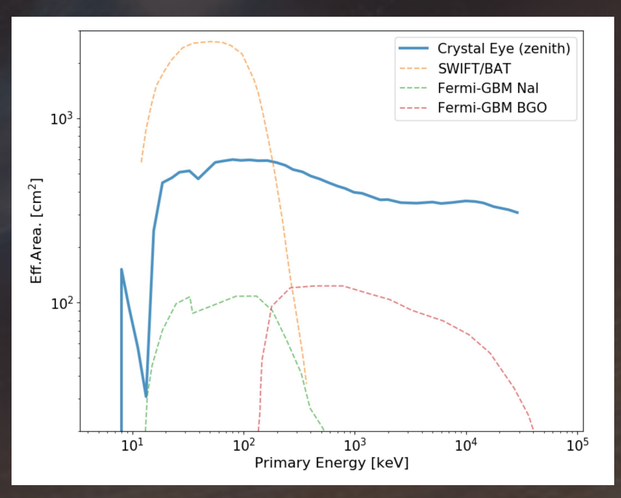
■ **Photodetectors:** 4x4 SiPM array (MPPC 3x3 mm^2, 50μm pitch)

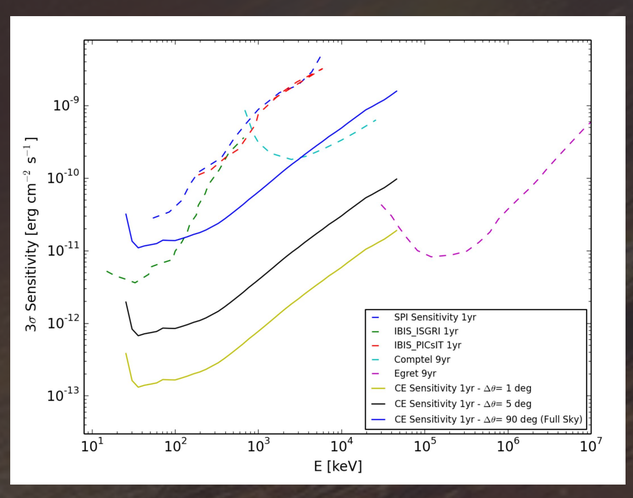
■ **Anticoincidence** (BC408 plastic scintillator) for charged cosmic-ray rejection.

→ Tile on the top of the UP crystal.
→ Continuous layer at the bottom of the DOWN crystal.
→ Acts as a localizer for hard X-rays

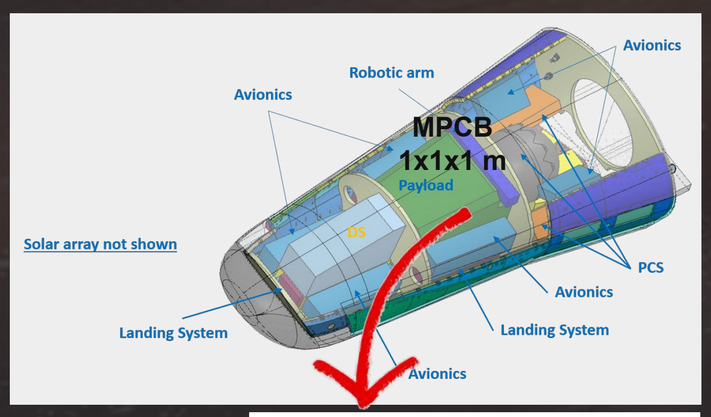
Effective Area and Sensitivity

■ Geant4 based simulation with trigger selection implemented to study Crystal Eye performances.
■ The efficiency changes little with the zenith angle, thanks to the symmetrical design of the detector.
■ Effective area in the zenith direction and detector sensitivity with 1 year exposure is shown here.

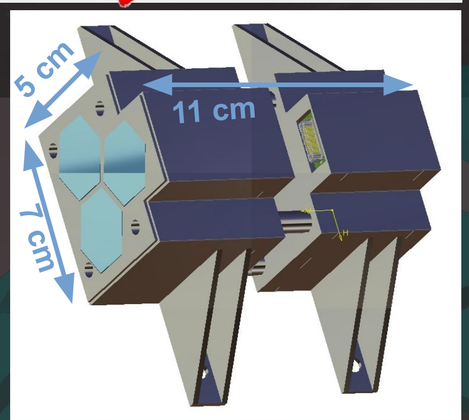




WINK: The Crystal Eye Pathfinder

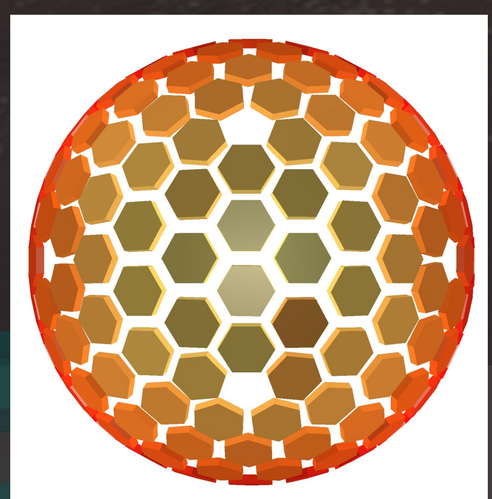


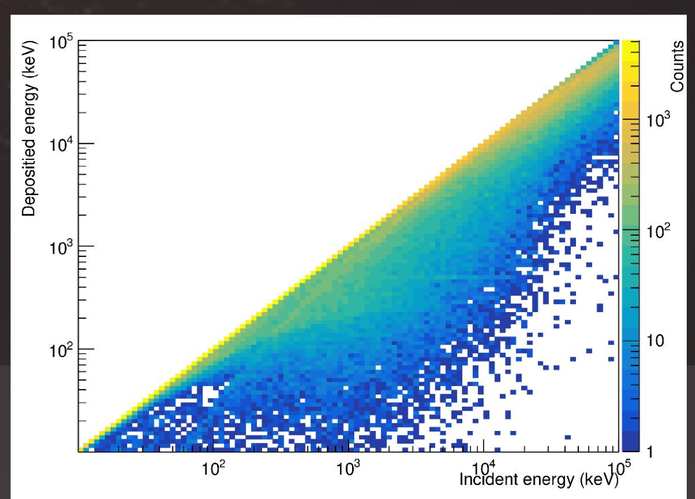
■ **Space Rider** is an uncrewed robotic laboratory by ESA with pointing capabilities and its maiden flight will be in 2025.
■ Will stay in low orbit for about two months.
■ **WINK** will be made of 3 full scale Crystal Eye pixels, to enable technologies for a future full scale mission while observing deep space and Earth.
■ The position requested for WINK in the Multy Purpose Cargo Bay (MPCB) of Space Rider will ensure a 30° of FOV.
■ WINK will be hosted on a thermal plate.



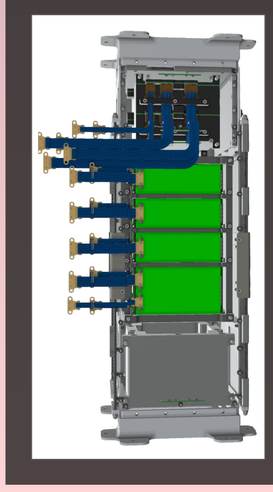
Energy Depositions in Pixels

■ Geant4 simulation is used to study and optimize the detector characteristics. ■ The energy deposition profile in different crystals for isotropic photon flux and the corresponding energy response in the LYSO crystal are shown here.



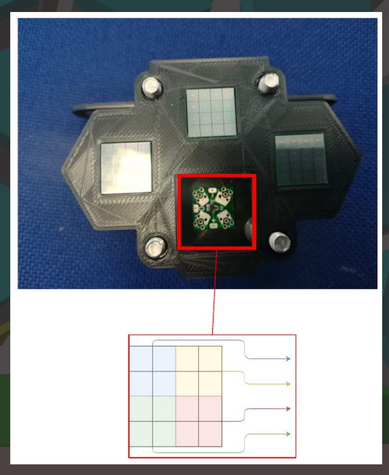


ZIRÉ: The Crystal Eye Pathfinder



■ **ZIRÉ** detector in the **NUSES** mission uses the similar material (LYSO) for its calorimeter as **Crystal Eye** along with other sub-detectors for the accomplishment of its mission.
■ One of the primary science goals is to study the transient astrophysical phenomena in about 0.1-50.0 MeV photons.
■ The technological advancements can be used for the mutual benefits of both the detectors.

The Engineering Model



First Prototype of a Custom DAQ