

Crystal Eye

Science with an all-sky monitor in keV-MeV

R. Sarkar, R. Aloisio, M. Baiocchi, F.C.T. Barbato, E. Casilli, I. De Mitri, and A. Di Giovanni, on behalf of the HE-Exp group
 Gran Sasso Science Institute, Istituto Nazionale di Fisica Nucleare - LNGS; ritabrata.sarkar@gssi.it

Overview

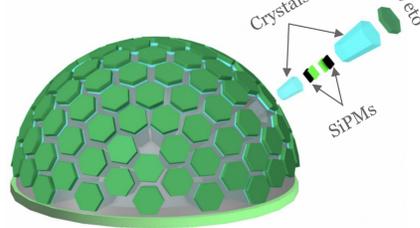
Crystal Eye (CE) is a novel concept of space-based all sky monitor for the observation of about 10 keV - 30 MeV photons exploiting a new detection technique, which foresees an enhanced localization capability with respect to current instruments. The primary scientific goals are:

- The detection of the electromagnetic signals from the extreme phenomena in the Universe in a unique energy range.
- Multimessenger astronomy by providing precise and real-time alerts to both space and ground based experiments.

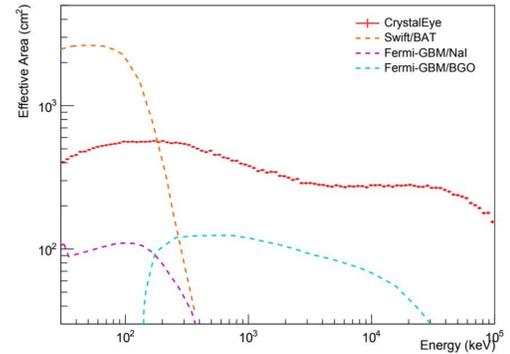
A range of other interesting scientific investigations is also possible using this instrument. A full scale model of the Crystal Eye detector is now under design and construction. Moreover, a smaller prototype is foreseen to fly aboard of the Space Rider (ESA) on a LEO orbit (400 km, 5.3° of inclination) in 2027.

Crystal Eye Detector

- ★ GAGG and LYSO scintillator crystals read by SiPMs
- ★ Veto layers with plastic scintillators
- ★ Wide field of view > 2π sr
- ★ Large effective area: 5×Fermi GBM @ 1 MeV



Effective Area



Multimessenger Astronomy Through High-precision and Real-time location Alert

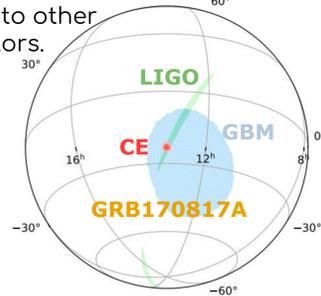
Autonomous prompt alert of the transient detection with sub-second latency

High-precision localization with about a degree of angular resolution

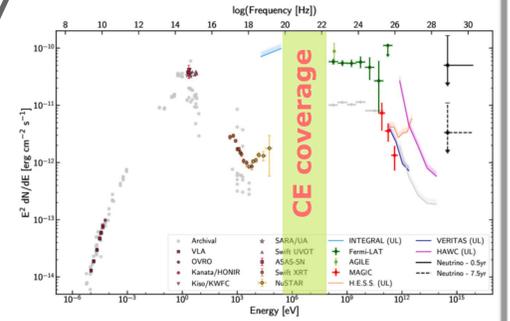


Neural network algorithm onboard the satellite

Localization of GRB170817A compared to other detectors. ~1.21° (1.96°) uncertainty radius for 68% (95%) C.L.



Study of the interesting and diverse astrophysical transient and steady phenomena in the keV and MeV region exhibiting spectral features which are, to date, not extensively measured.

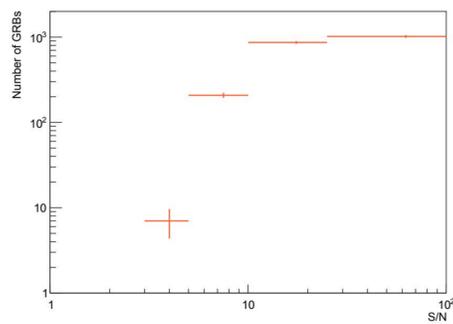
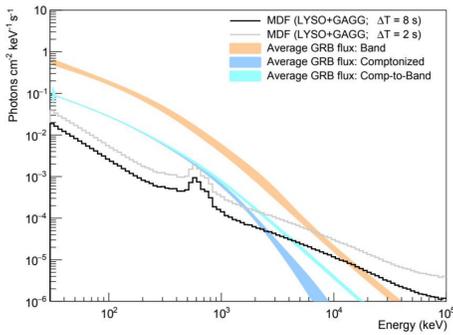


Broadband spectra for the blazar TXS0506+056. (IceCube Collaboration, M. G. Aartse et al. 2018)

Filling the Observation Data Gap in MeVs for Transient and Steady Sources

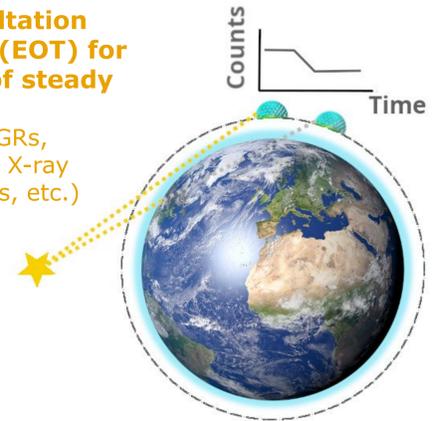
Discovery and Study of Short Duration Transients

Study of the detector sensitivity for the short-duration transient sources (like GRBs) is done by considering orbital background radiation environment at LEO and background sources internal to the detector. The minimum detectable flux (MDF) for different observation time is calculated and shown along with the average GRB fluxes detected by Fermi-GBM.

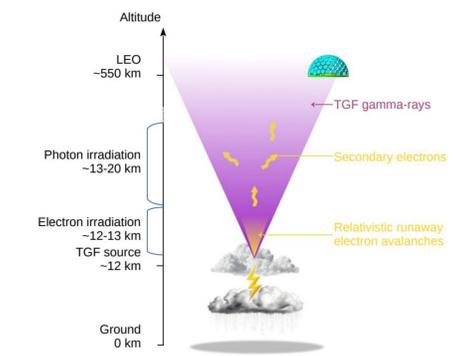


Signal-to-noise (S/N) ratio for all the GRBs (those are detected by Fermi-GBM) gives comfortable value to be detected in CE.

Earth Occultation Technique (EOT) for the study of steady sources (including: SGRs, AGN/Blazars, X-ray binaries, FRBs, etc.)

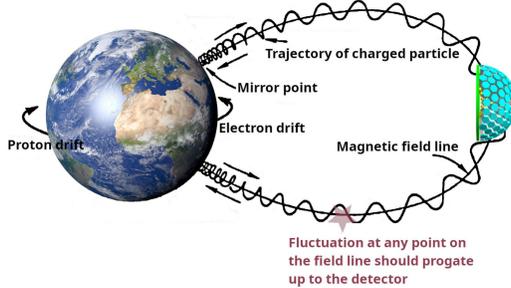


Study of TGFs

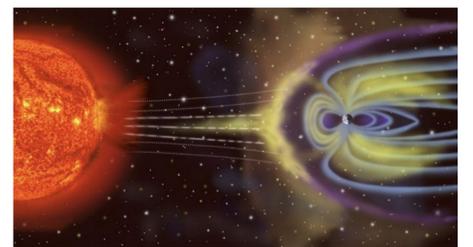


Terrestrial gamma-ray flashes (TGFs) coming from certain angles below the detector can be detected and studied for their spectral and temporal properties.

The anomalous behavior of the trapped charged particles due to some perturbation (e.g., ionospheric disturbances, thunderstorms, solar eclipse, etc.) in the L-shell of the CE detector orbit can propagate through the magnetic field lines and can be detected by CE both during the forward and backward propagation.



Trapped-Particle Phenomena



In-situ measurements of the charged particle distribution in the LEO due to solar energetic particles and coronal mass ejection from the sun, along with the contribution from the cosmic-ray particle interaction near Earth can be studied in the crucial energy range of keV-MeV. The separation of hadronic (mostly protons) and electromagnetic (e⁻/γ) can also be obtained to some extent due to the double layer design of the detector.

Monitoring Space Weather

References

- For more about Crystal Eye: Aloisio, R. et al. *Astroparticle Physics*, Vol 174, 2026, 103171.
- Also see the poster by Barbato et al.

Research Opportunities

- ★ Crystal Eye angular resolution and optimization of the localization algorithm and other science cases.
- ★ Crystal Eye design optimization and test on 20 pixel prototype (co-working with engineers design/simulations)



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