INTEGRAL upper limits on gamma-ray emission associated with the gravitational wave event GW150914

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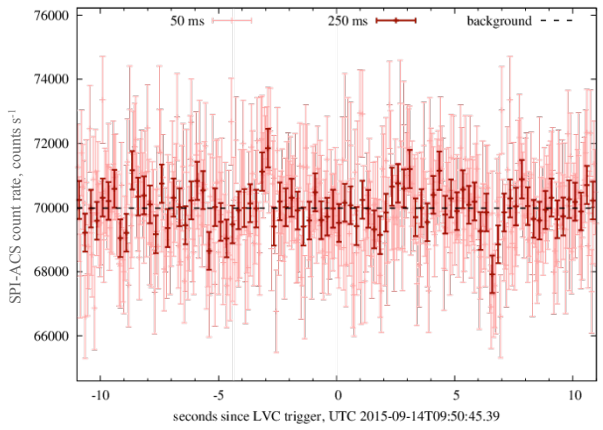
Savchenko et al. 2016, ApJL, 820, L36

Using observations of the INTErnational Gamma-Ray Astrophysics Laboratory (INTEGRAL), we put upper limits on the gamma-ray and hard X-ray prompt emission associated with the gravitational wave event GW150914, discovered by the LIGO/Virgo collaboration. The omni-directional view of the INTEGRAL/SPI-ACS has allowed us to constrain the fraction of energy emitted in the hard X-ray electromagnetic component for the full high-probability sky region of LIGO trigger. Our upper limits on the hard X-ray fluence at the time of the event range from $F_\gamma = 2 \times 10^{-8}$ erg cm^{-2} to $F_\gamma = 10^{-6}$ erg cm^{-2} in the 75 keV - 2 MeV energy range for typical spectral models. Our results constrain the ratio of the energy promptly released in gamma-rays in the direction of the observer to the gravitational wave energy $E_\gamma/E_{GW} < 10^{-6}$.

Searching for a counterpart



The INTEGRAL collaboration has signed a memorandum of understanding with the LIGO-Virgo collaboration to follow-up the GW triggers with its X-ray and gamma-ray instruments.

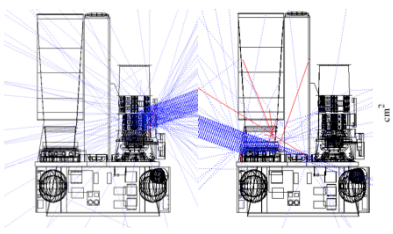
SPI-ACS was operating nominally at the time of the LIGO trigger on 2015-09-14 at 09:50:45 UTC, yielding an uninterrupted count rate from 33 hours before to 19 hours after the event. The background was stable and low, with a rate of ~ 7×10^4 counts/s. The noise at every time scale can be described by a Gaussian process (Savchenko et al. 2012, A&A, 541A, 122S).

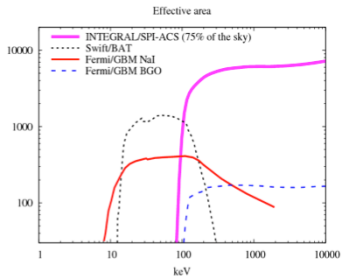
We investigated the light curve at −30 to +30 s from the trigger time on 5 time scales from 0.05 to 10 s, the expected accretion time scales in the compact binary coalescence (Lee & Ramirez-Ruiz 2007, NJPh, 9, 17L). **We do not detect any obvious signal coincident with the GW trigger**.

Response simulation and verification

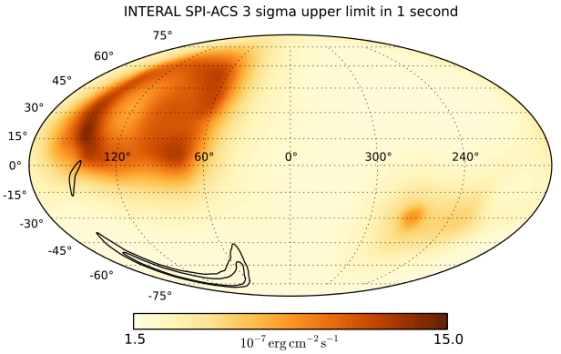
The response of SPI-ACS is affected by the surrounding satellite structure and the other INTEGRAL instruments. We developed a GEANT3 Monte-Carlo model based on the INTEGRAL mass model (based on Sturner et al. 2003, A&A, 411L, 81S). We verified that the response is valid for the bursts detected simultaneously by SPI-ACS and other detectors to an accuracy better than 20%.

A dedicated intercalibration study between **INTEGRAL/SPI-ACS**, **Fermi/GBM**, and **Konus-Wind** is ongoing.





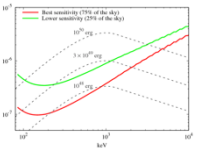
Upper limits



(Band model with: $\alpha = -0.5$, $\beta = -2.5$, $E_{peak} = 1000$ keV)

THREE SIGMA UPPER LIMIT ON THE POSSIBLE GAMMA-RAY COUNTERPART FLUENCE

Time scale (seconds)	total counts	fluence (erg cm^{-2}) best 95%	fluence (erg cm^{-2}) worst 5%
10	4319	$3.5 - 4.5 \times 10^{-7}$	$1.1 - 1.4 \times 10^{-6}$
1	1410	$1.3 - 1.5 \times 10^{-7}$	$3.7 - 4.7 \times 10^{-7}$
0.25	727	$5.8 - 7.6 \times 10^{-8}$	$1.9 - 2.4 \times 10^{-7}$
0.1	200	$1.6 - 2.1 \times 10^{-8}$	$5.2 - 6.6 \times 10^{-8}$
0.05	220	$1.8 - 2.3 \times 10^{-8}$	$5.7 - 7.3 \times 10^{-8}$



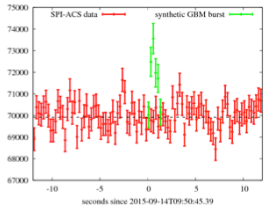
SPI-ACS covered about 95% of the GW150914 localization with near-optimal sensitivity, and the 5% with a sensitivity factor 3 lower (darker area). The limit depends, on the incident spectrum **(see the range of the limits in the Table)**.

INTEGRAL/IBIS constrains fluence in 570 keV - 1200 keV energy range at a level of **2.5×10^{-7} erg cm^{-2} and 6.5×10^{-7} erg cm^{-2}** assuming durations of **1 s and 10 s**, respectively.

Implications and conclusions

Using **INTEGRAL/SPI-ACS** we set an upper limit on the ratio of the energy directly released in gamma-rays in the direction of the observer in association with GW150914 to the gravitational wave energy **$E_\gamma/E_{GW} < 10^{-6}$** ($E_\gamma$ in 75-2000 keV). This result is compatible with the expectation of negligible electromagnetic counterpart to binary BH coalescence.

Our upper limit is in disagreement with the Fermi/GBM detection of a possible EM counterpart 0.4 s after the GW (Connaughton et al 2016, arXiv:1602.03920) for all their allowed fit parameters. In the plot, we show an estimate of the expected SPI-ACS signal if the GBM event were of a cosmic origin.



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