Contribution ID: **7** Type: **Original Talk**

PROTON ACCELERATION RATE REQUIRED FOR THE GLE EVENTS OF THE 24th AND 25th SOLAR CYCLES

The AntiCoincidence Shield of the SPectrometer on the INTEGRAL (ACS SPI) records primary and secondary HXR with energies E >100 keV. The secondary HXR is due to galactic and solar CR protons. The ACS SPI is a perfect instrument for studies of temporal relation between solar HXR flares and associated solar proton enhancements. The onset of a significant increase in the ACS SPI count rate of concurrently or after a solar HXR burst might be considered as a moment of the first solar protons arrival to the Earth's orbit with energy less than 430 MeV — the atmospheric cutoff. In some GLEs, the increases in the count rate of the ACS SPI detector are observed earlier than the GLE onset registered by NMs, (GLE71) but in some other GLEs the situation is opposite (GLE72). The delayed response of NM's may indicate the reversal velocity dispersion due to the small acceleration rate. The proton acceleration rate (effective electric field) was estimated from a time difference between the onset of >100 keV electron emission and the SEP onset observed by ACS SPI as well as neutron monitors network in cases of GLEs. The earlier onset of GLEs in comparison with ACS SPI proton enhancement corresponds to acceleration of observable by NMs amount of protons in the flare impulsive phase. In these cases the ACS SPI solar proton enhancement is visible later due to high solar HXR background. The later onset of GLEs in comparison with ACS SPI proton enhancement correspond to acceleration of very small amount of protons above their atmospheric cutoff during the flare impulsive phase. The ACS SPI solar proton enhancement is visible earlier due to better sensitivity to protons of energies below the atmospheric cutoff. The majority of solar protons responsible for the 73rd, 74th, 75th and 76th GLE events (the GLE events of the 25th cycle up to May 2025 have been accelerated in rather weak electric fields and as a result look like subGLE events of the 24th cycle.

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Session Classification: Cosmo- and geophysical aspects of cosmic rays at the ground level

Track Classification: Cosmo- and geophysical aspects of cosmic rays at the ground level