GROUND LEVEL ENHANCEMENT MEASUREMENTS WITH THE NEUTRON MONITORS. P.-S. Mangeard[1], [1]Department of Physics & Astronomy and Bartol Research Institute, University of Delaware, 217 Sharp Laboratory, Newark, DE 19716 (mangeard@udel.edu).

Introduction: Neutron monitors [1] are ground-based detectors sensitive to the nucleonic components of the particle showers produced by the interactions of the Galactic cosmic rays and SEPs with the Earth's atmosphere. Their response integrates the contributions of particles that exceed the maximum value between the atmospheric rigidity cutoff (~1 GV) and the local geomagnetic rigidity cutoff (0-17 GV).

Solar Energetic Particles (SEPs) are high-energy particles from the Sun that are accelerated during solar flares and coronal mass ejections. The most intense SEP events produce a large number of energetic particles (up to several GeV). Their interaction in the Earth's atmosphere induces a significant raise of the radiation levels on the ground that is detected by the worldwide network of the neutron monitors. Such events are called Ground Level Enhancement (GLE) [2]. The official database of neutron monitor count rates during GLE reports the data from 1956 to the most recent GLE of October 28th, 2021 (https://gle.oulu.fi/).

Space Weather: Depending on their source, intensity, and propagation in the inner heliosphere, solar storms can create hazardous radiation levels for orbiting spacecrafts, satellites, and commercial aircraft on polar routes. Electronics, crews, and passengers are directly affected. Major disruptions of communication and power grid can also occur. To help mitigate these effects, the data from the Simpson neutron monitor network serves as a real-time (within several minutes) alert system [3] for GLE that is used for space weather forecasting.

Solar Physics: Thanks to their large effective area, the neutron monitor network provides continuous and accurate measurements of the time profile of the event seen from different asymptotic directions. The coverage of multiple arrival directions of SEP allows the particles to be propagated back to their source and departure time.

Spectral measurement of the SEPs is important to identify the mechanisms at the origin of the particle acceleration. The neutron monitor data extends the energy range toward high energies than the measurements provided by the space-borne detectors such as GOES and AMS-02.

Multiple ground detectors at the South-Pole: There are two types of neutron monitors located at the South-Pole: a standard 3NM64 [1] and an unleaded array of 12 proportional counter tubes. Each detector has a different response function to the SEPs. Thus, the ratio of their count rates can be used to estimate the spectral shape of the SEPs [4]. In addition, the Cerenkov tank detectors of the cosmic ray air shower array IceTop [5] are sensitive to the most energetic components of the SEPs. The tank detectors have been tuned such that each responds differently to SEPs. It brings additional spectral information. The last three GLEs are being analyzed with a combined dataset [6].

Cross Calibration of AMS-02 and the Neutron Monitors: The stations of the Simpson neutron monitor network are located in a rigidity cutoff range from 0 to 3 GV. At the dawn of the solar cycle 25, the network is operational and well suited for observing the future GLE events. The GLEs of cycle 25 will provide a unique opportunity to realize a precise cross calibration between the neutron monitor data and the differential energy spectrum from AMS-02 below a few GeV. It will greatly enhance the spectral measurements of SEPs when spacecraft data are not available.

Acknowledgments: Submitted on behalf of the investigators of the Simpson Neutron Monitor Network and our international collaborators.

References: [1] Hatton, C. J., and H. Carmichael (1964), *Can. J. Phys.*, *42*, 2443-2472. [2] Poluianov, S.V et al. (2017), *Sol. Phys.* 292**,** 176. [3] Kuwabara T. et al. (2006), *Space Weather*, 4, S10001. [4] Bieber, J. W., & Evenson, P. (1991), *ICRC*, Vol. 3, pp. 129-132. [5] The IceCube Collaboration (2013), *Nucl. Instrum. Methods Phys. Res. A*, Vol. 700, pp.188-220. [6] The IceCube Collaboration et al. (2017), *ICRC*, 132.

Additional Information: You can subscribe to the GLE alert system based on the signal of the neutron monitors operated by the Bartol Research Institute at: http://www.bartol.udel.edu/~mangeard/glealarm/subscribe.html