MAXIMAL ENERGY OF SOLAR ACCELERATORS: EVIDENCE FROM SPACE BORN AND EARTH'S SURFACE MEASUREMENTS

A. Chilingarian, N. Bostanjyan, H. Rostomyan

TePa 2013 — Thunderstorms & Elementary Particle Acceleration

Nor Amberd, Armenia, September 9-13

ABSTRACT

On January 20, 2005, 7:02-7:04 UT the Aragats Multidirectional Muon Monitor (AMMM) located at 3200 m registered enhancement of the high energy secondary muon flux (threshold ~5 GeV). The enhancement, lasting 3 min has statistical significance of ~4σ and was related to the X7.1 flare seen by the GOES, and very fast (>2500 km/s) CME seen by SOHO. Worldwide network of neutron monitors detects Ground Level Enhancements (GLE) #69 arriving very fast after flare; recovered energies of solar protons demonstrate rather hard spectra prolonged up to 10 GeV. The solar proton spectrum incident on the Earth's atmosphere was simulated and transport till AMMM detector located under 14 m of soil and concrete. The most probable minimal solar proton energy corresponding to the measured 5 GeV muon flux is within 20-25 GeV. On March 7, 2012 Large aperture telescope of Fermi gamma-ray observatory detected the ever highest energy gamma rays from the Sun with energy about 4 GeV. The minimal energy of the solar protons accelerated during the flare and producing 4 GeV gamma rays should be ~25 GeV. Thus, both measurements with secondary muons and gamma rays prove maximal energy of solar accelerators not smaller than 25 GeV.

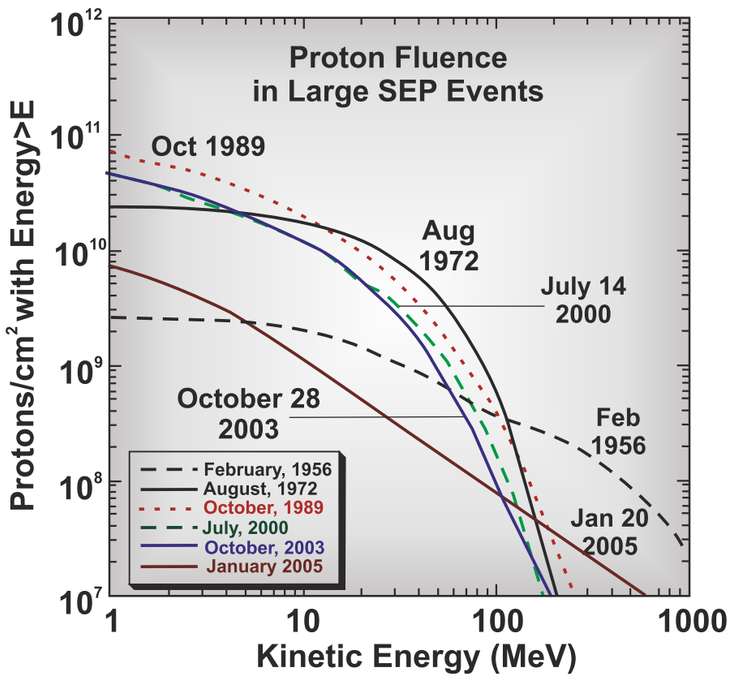

Figure 1: Solar Energetic Particles (SEP) events of last 60 years.

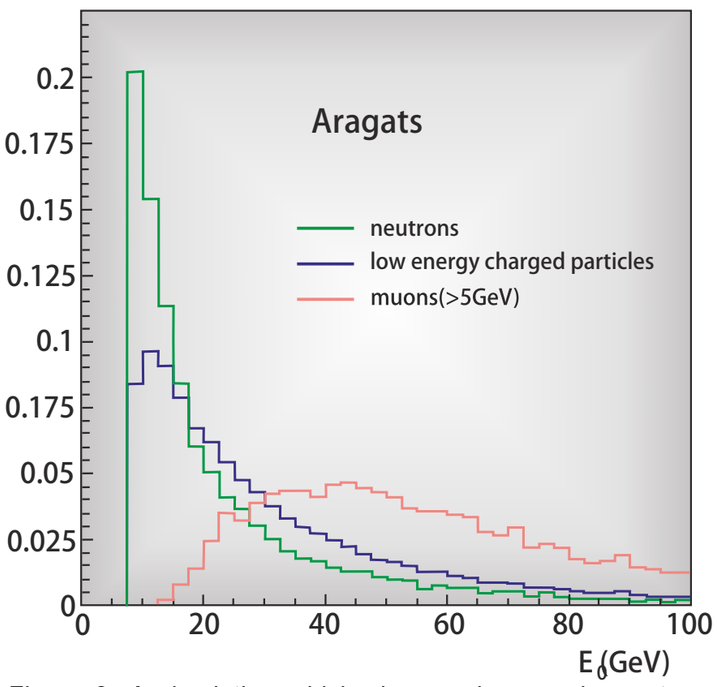

Figure 2: A simulation which shows primary solar proton energy, it is above 25 GeV.

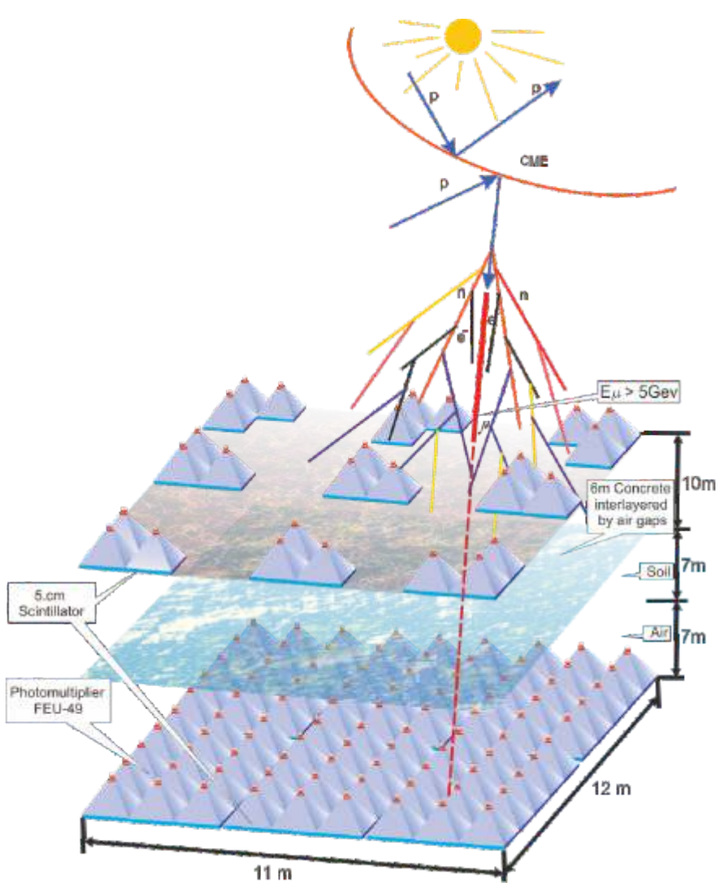

Figure 3: Aragats Multidirectional Muon Monitor (AMMM). AMMM is located under 14 m of soil and concrete in the underground hall of former ANI experiment and include 42 1 m² area and 5 cm thick plastic scintillators.

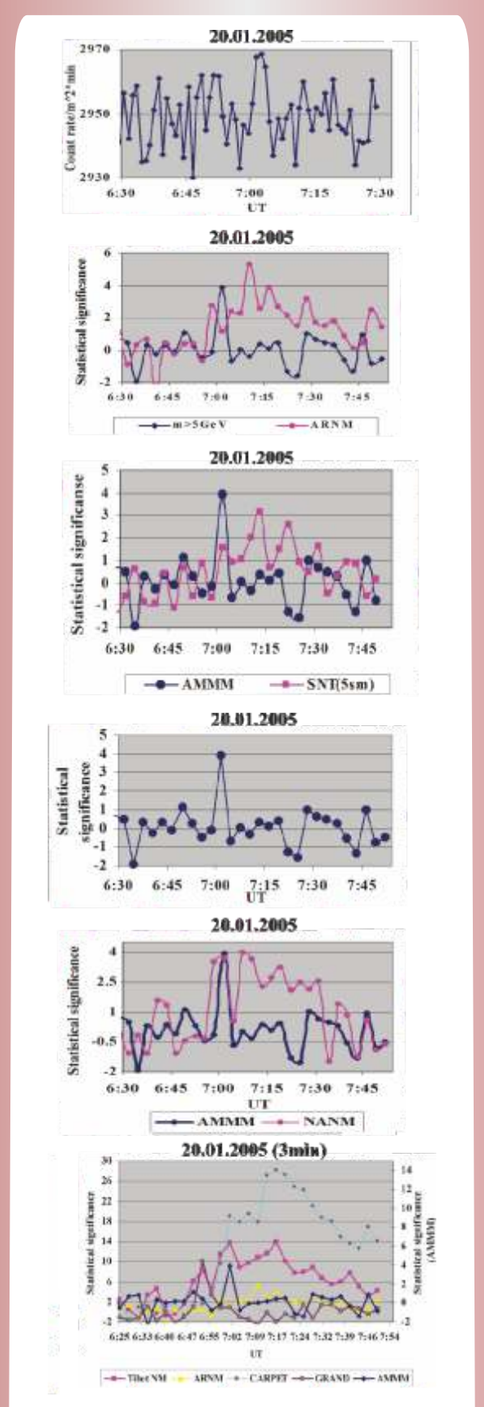

Figure 4: AMMM Detection of GLE 20 January 2005

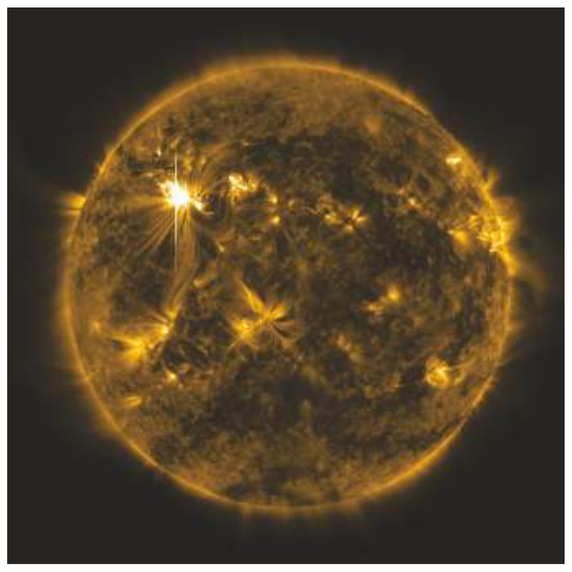

Figure 5: Sun produced powerful solar flare rated as X5.4 (based on the peak intensity of its X-rays) on March 7,2012.

Figure 6: During a powerful solar blast on March 7, NASA's Fermi Gamma-ray Space Telescope detected the highest-energy light ever associated with an eruption on the sun. The discovery heralds Fermi's new role as a solar observatory, a powerful new tool for understanding solar outbursts during the sun's maximum period of activity.

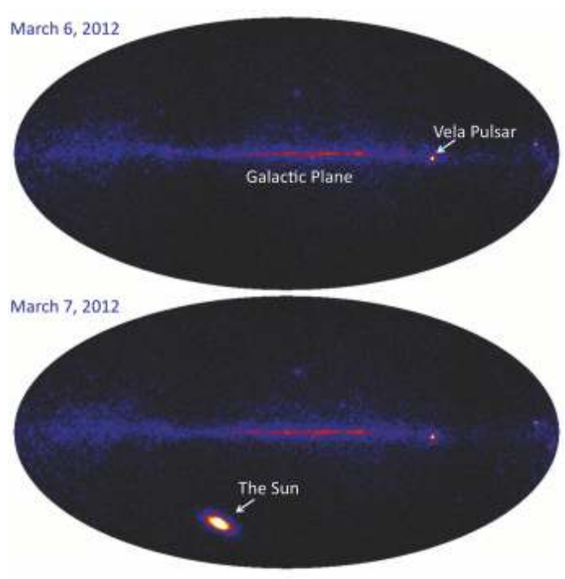

Figure 7: At the flare's peak, the LATdetected gamma rays with energy of 4 GeV, setting a record for the highest-energy light ever detected during or just after a solar flare. The flux of high- energy gamma rays, beyond 100 MeV, was 1,000 times greater than the sun's steady output. The March 7 flare also is notable for the persistence of its gamma-ray emission. Fermi's LAT detected high-energy gamma rays for about 20 hours, two and a half times longerthan any event on record.

REFERENCES

- *N. Kh. Bostanjyan, A. A. Chilingarian, V. S. Eganov, G.G. Karapetyan; On the production of highest energy solar protons at 20 January 2005, Advances in Space Research 39 (2007) 1456-1459.*
- *A. Chilingarian; Statistical study of the detection of solar protons of highest energies at 20 January 2005, Advances in Space Research 43 (2009) 702-707.*

Yerevan Physics Institute,
Alikhanyan Brothers 2,
Yerevan 0036, Armenia
http://crd.yerphi.am/Conferences/tepa2013/home

A. ALIKHANYAN National Laboratory