Surface Particle Detectors in Space Weather research and forecast

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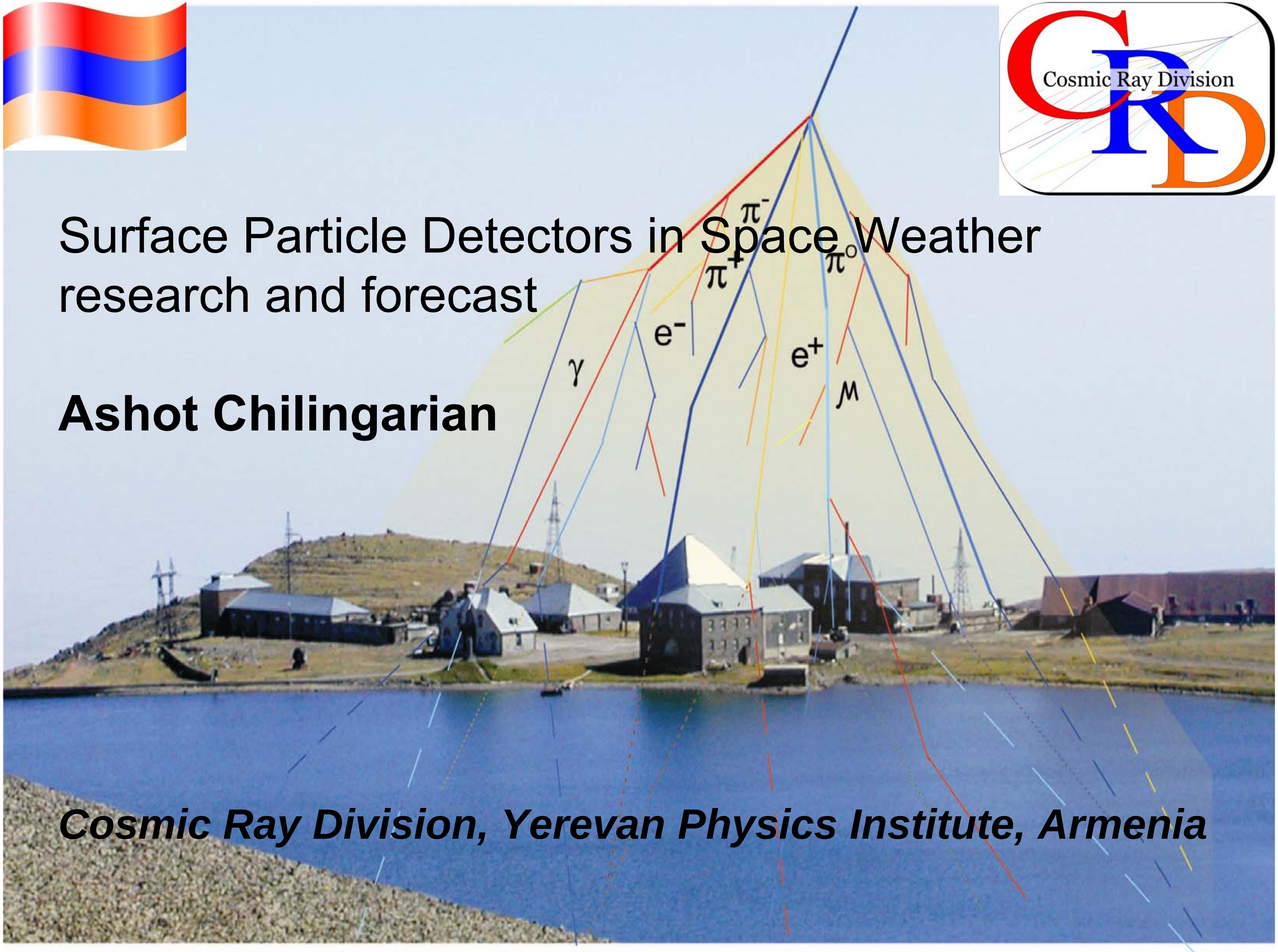
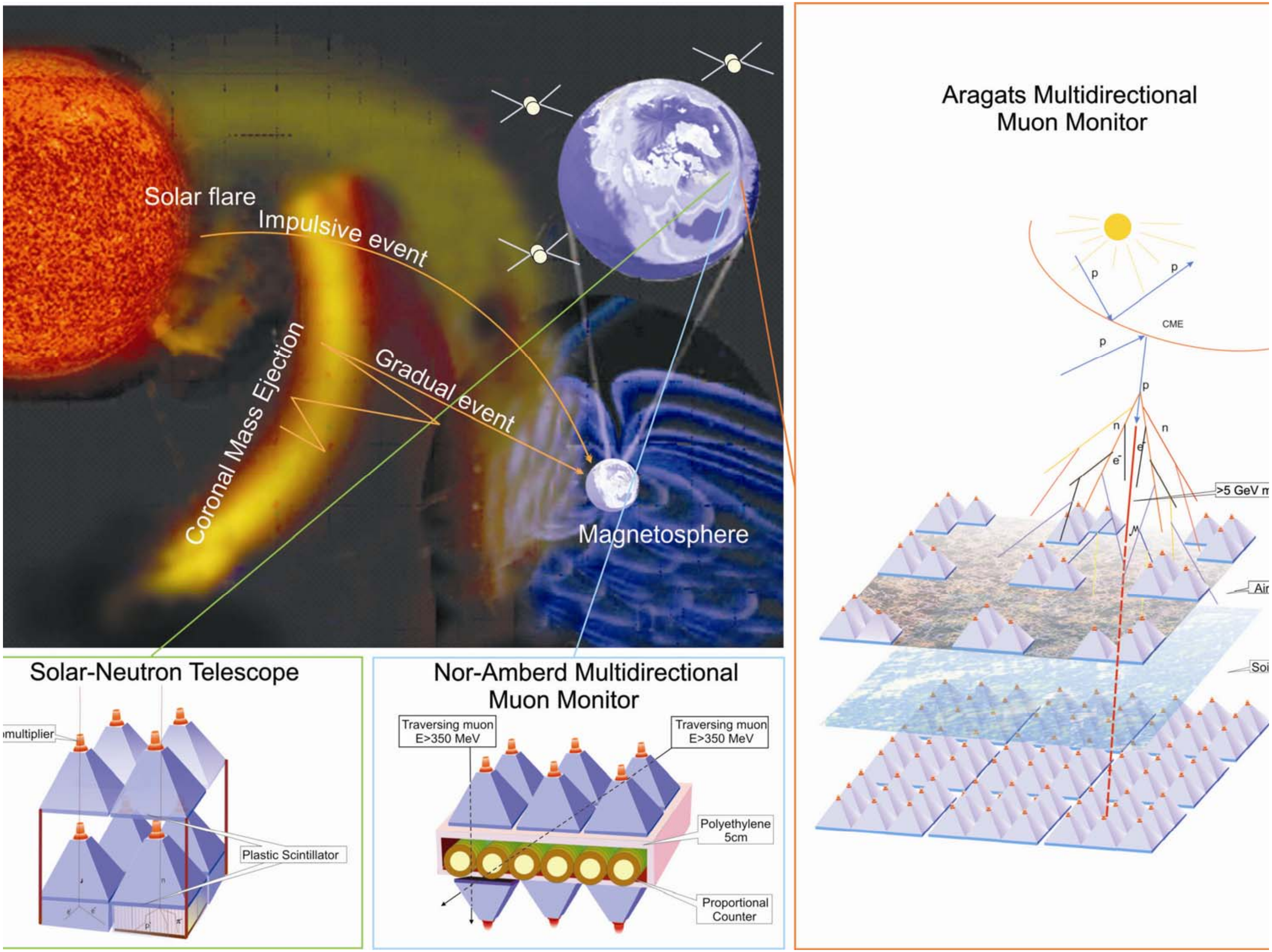
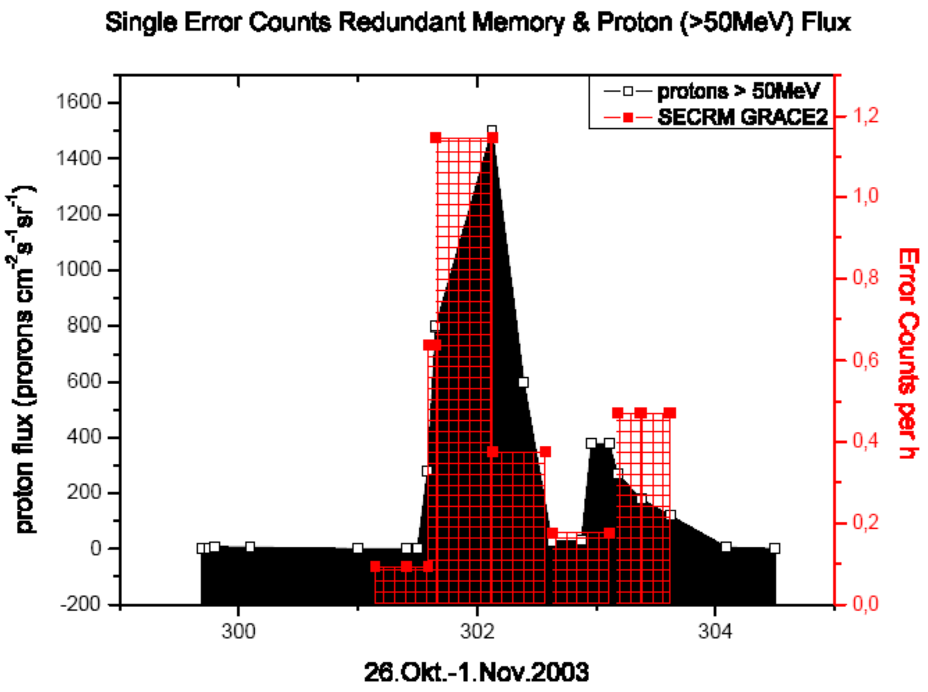
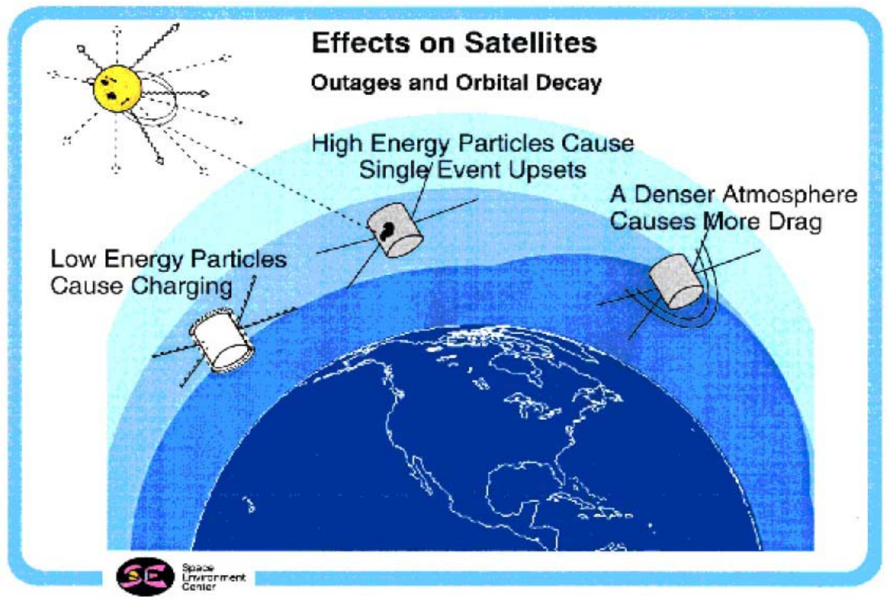
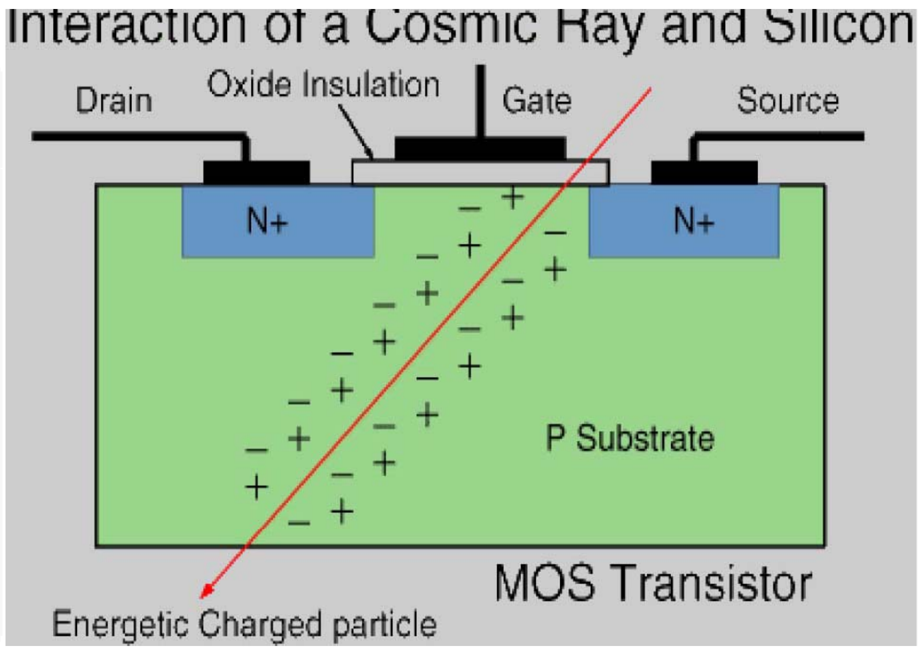



Solar flare
Impulsive event
Coronal Mass Ejection
Gradual event
Magnetosphere
Solar-Neutron Telescope
multiplier
Plastic Scintillator
Nor-Amberd Multidirectional
Muon Monitor
Traversing muon
E>350 MeV
Traversing muon
E>350 MeV
Polyethylene
5cm
Proportional
Counter
Aragats Multidirectional
Muon Monitor
CME
>5 GeV
Air
Soi

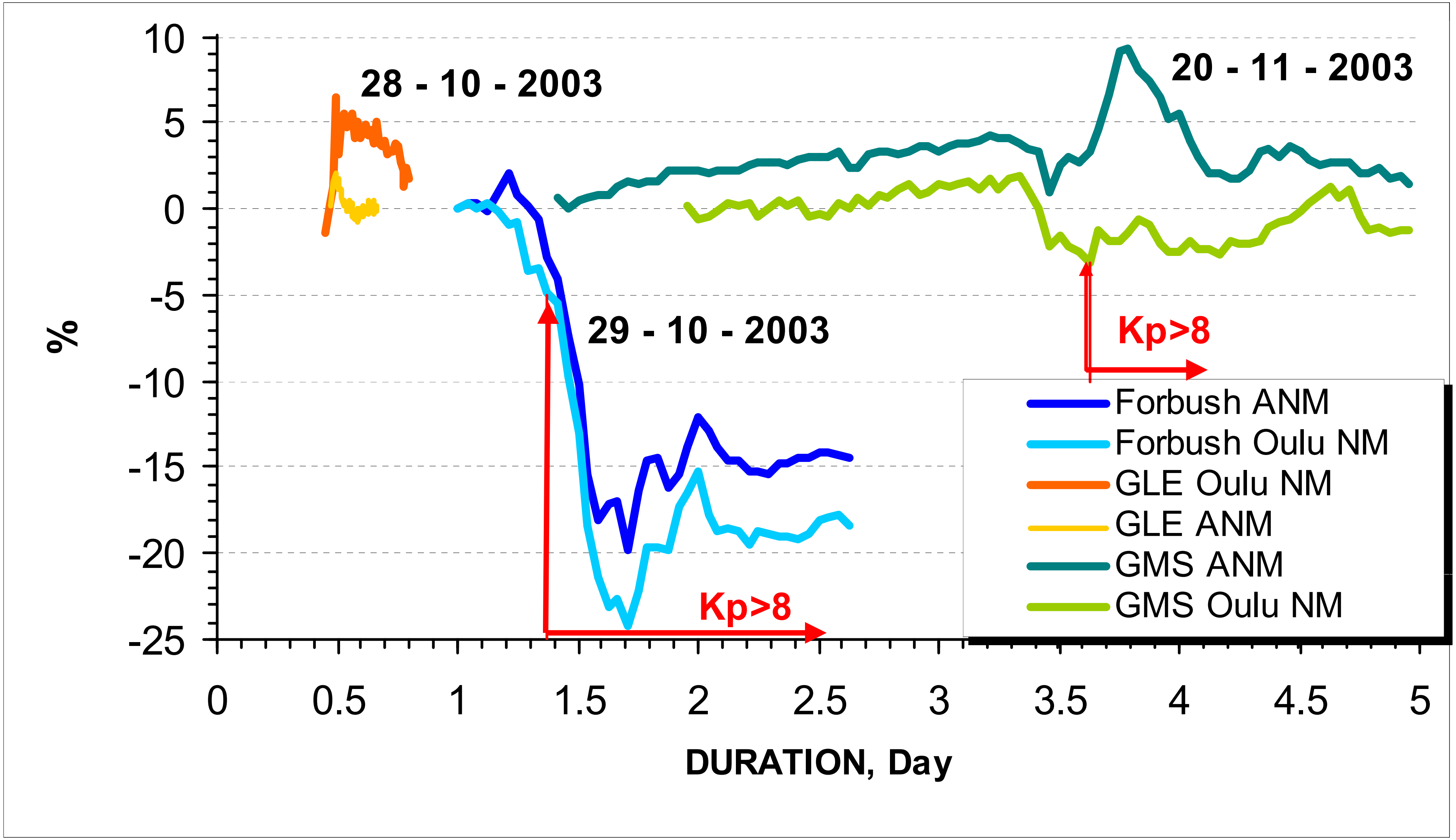

Single Error Counts Redundant Memory & Proton (>50MeV) Flux
protons > 50MeV
SECRM GRACE2
proton flux (protons cm^{-2}s^{-1}sr^{-1})
Error Counts per h
1600
1400
1200
1000
800
600
400
200
0
-200
1,2
1,0
0,8
0,6
0,4
0,2
0,0
300
302
304
26.Okt.-1.Nov.2003


Effects on Satellites
Outages and Orbital Decay
High Energy Particles Cause Single Event Upsets
A Denser Atmosphere Causes More Drag
Low Energy Particles Cause Charging

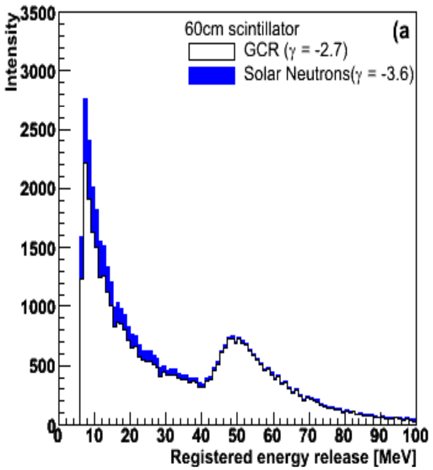

PJM Public Service
Step Up Transformer
Severe internal damage caused by the space storm of 13 March, 1989.

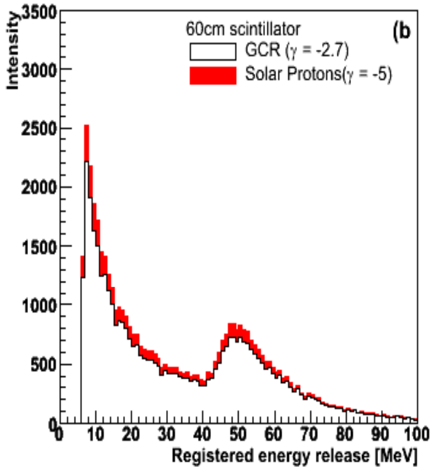

Interaction of a Cosmic Ray and Silicon
Drain
Oxide Insulation
Gate
Source
N+
N+
P Substrate
MOS Transistor
Energetic Charged particle

Solar Modulations Effects

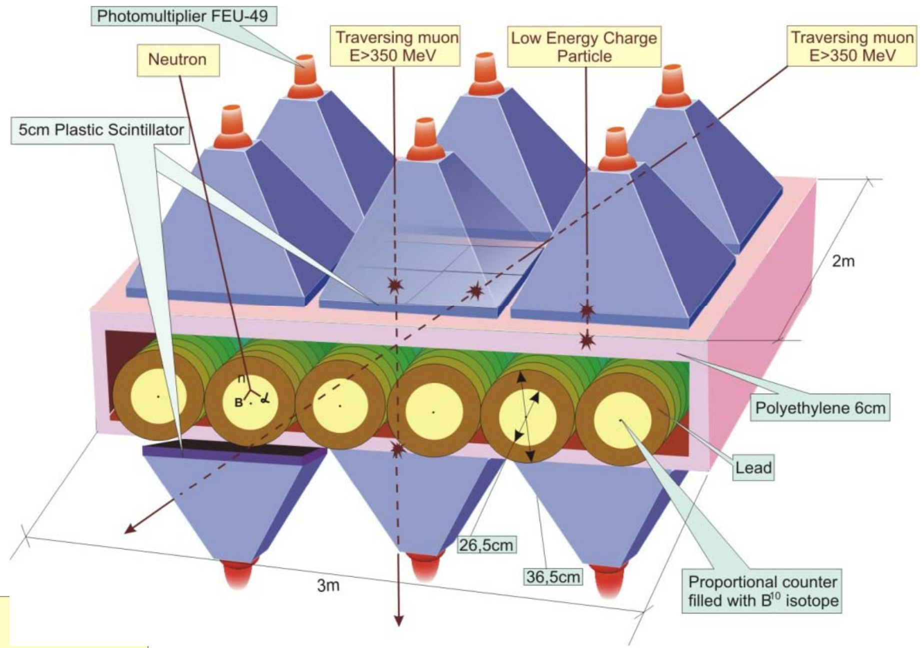


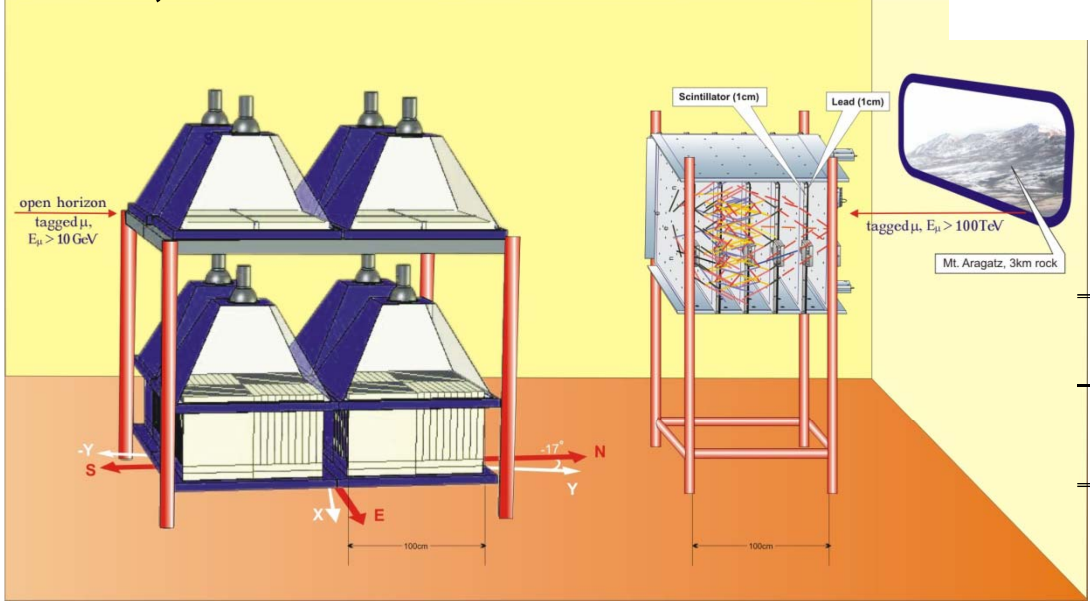
Particle Detectors Operated at Aragats Space Environmental Center (ASEC)





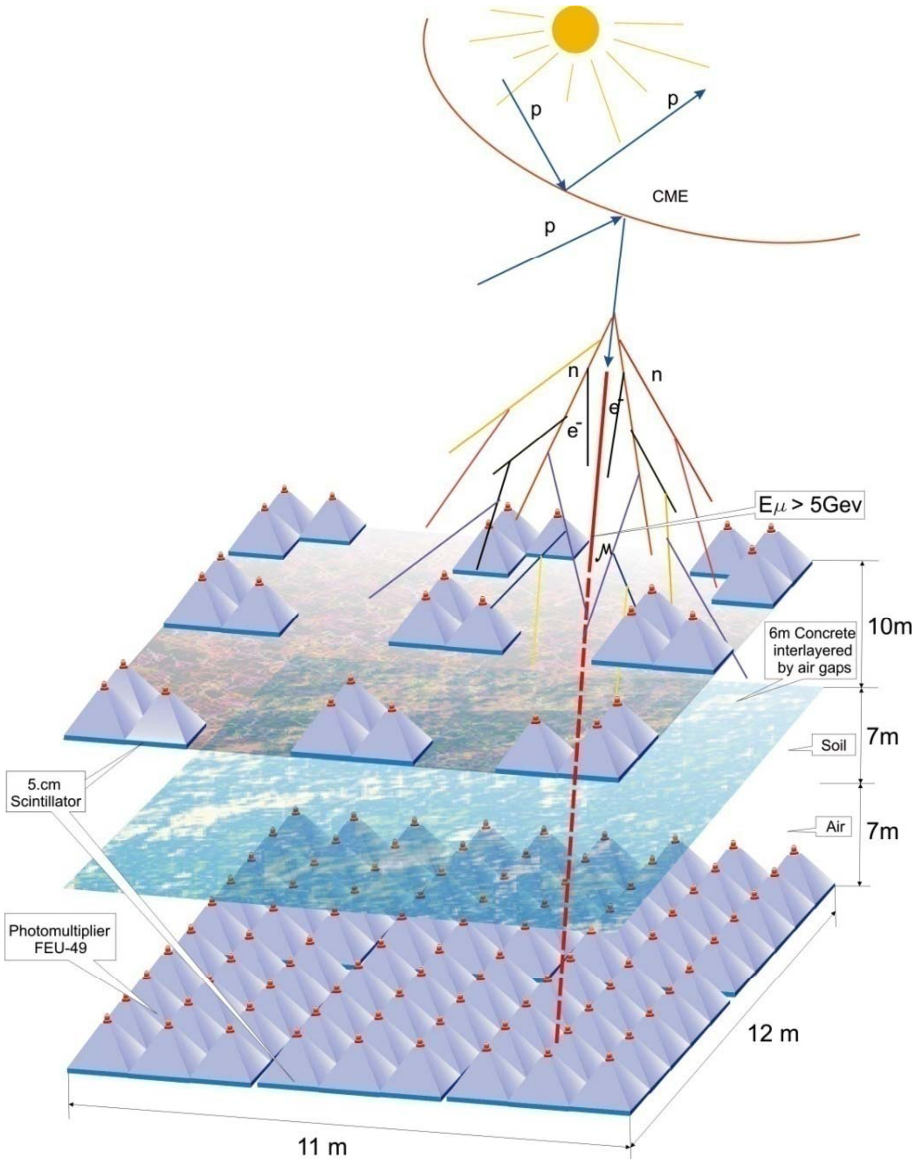
Registered energy deposit corresponding to GCR, Solar Protons and Solar Neutrons.

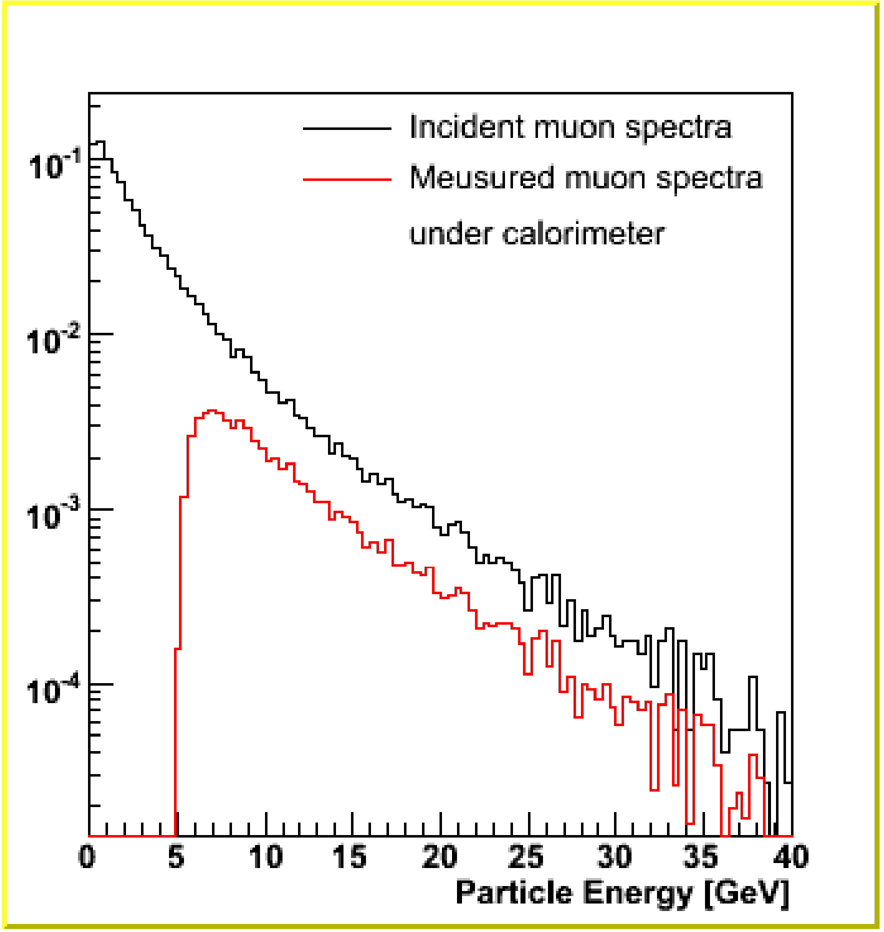




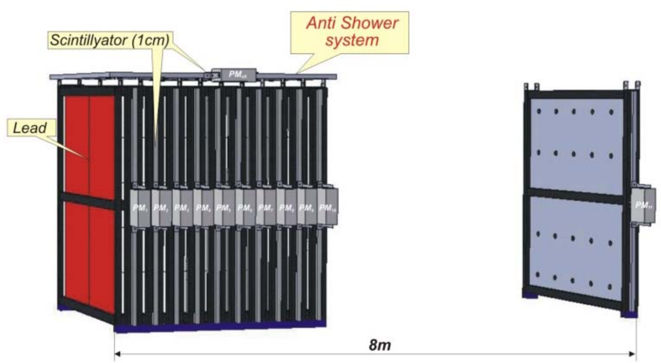
Detector layer	Solar Protons	Solar Neutrons
Upper 5cm scintillator	4.8σ	2.6σ
Middle 25 cm scintillator	1.7σ	6.4σ

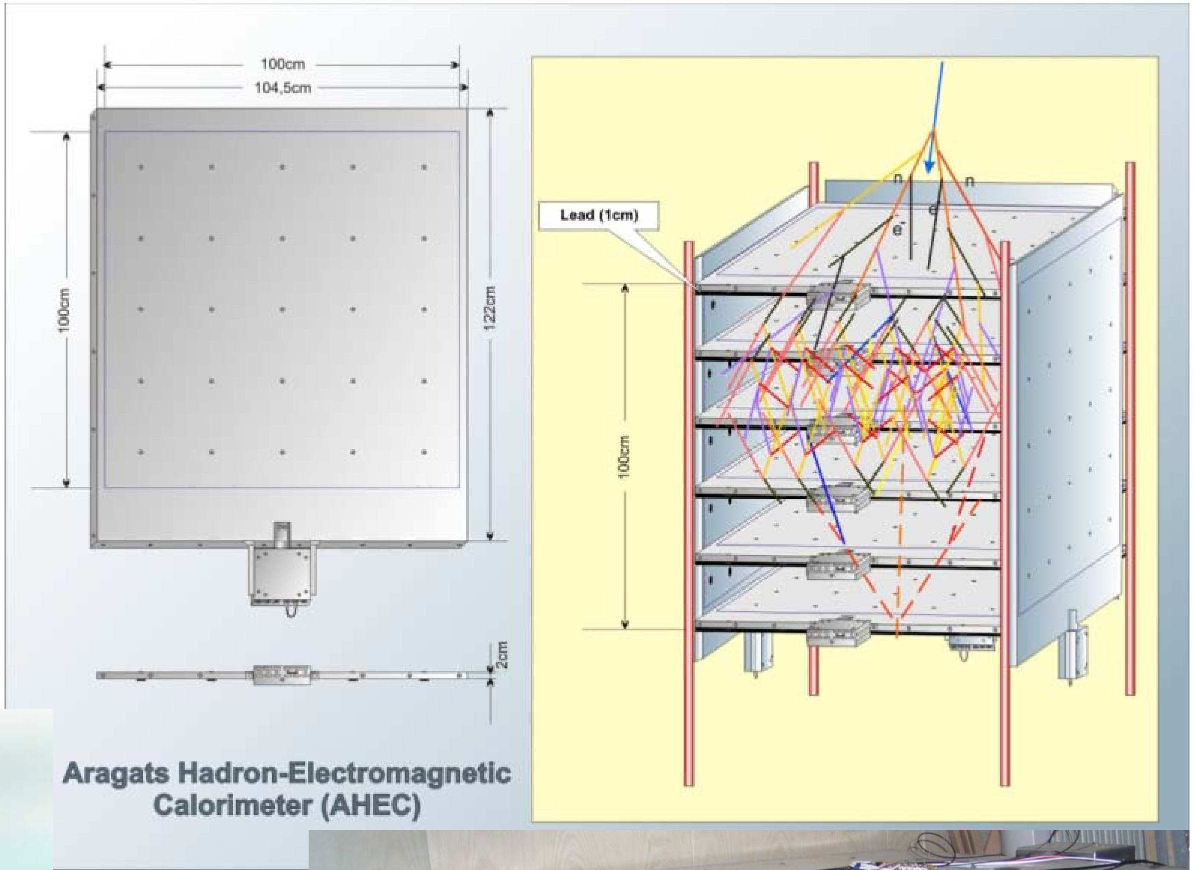
Aragats Underground Muon Monitor (AUMM)



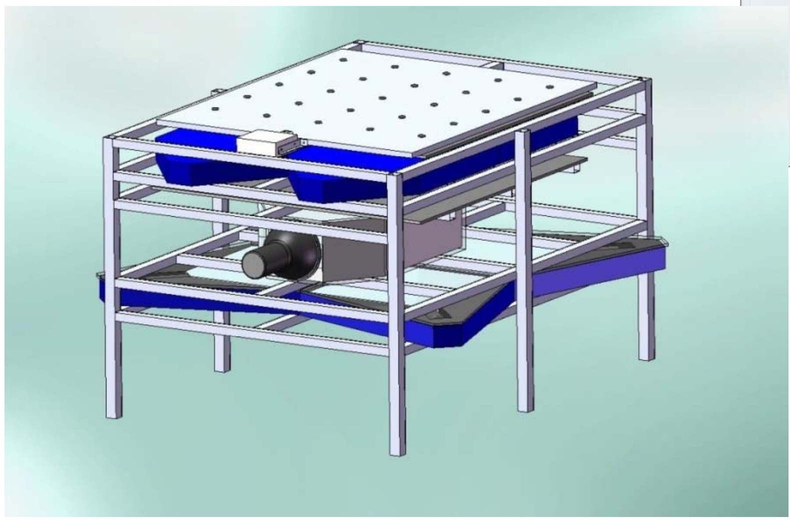


New multilayered particle detectors





Aragats Hadron-Electromagnetic Calorimeter (AHEC)



ASEC advantages

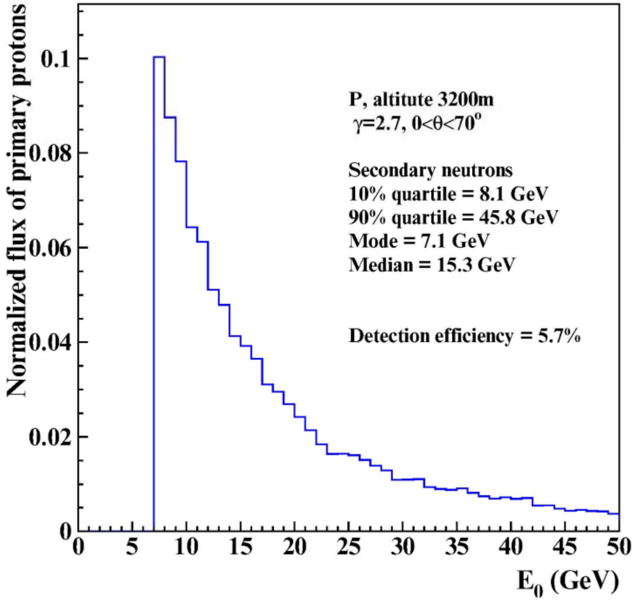
Measuring neutral and charged fluxes provide following advantages upon existing detector networks measuring single species of secondary CR:

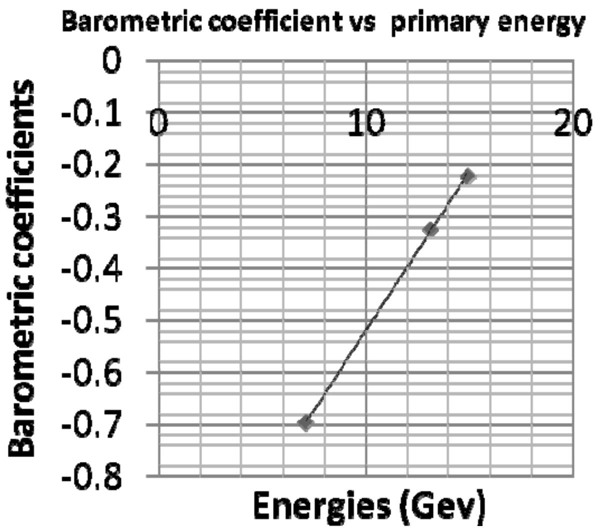
- **Enlarged statistical accuracy of measurements;**
- **Probe different populations of primary cosmic rays with rigidities from 7 GV up to 20-30 GV;**
- **Reconstruct SCR spectra and determine position of the spectral “knees”;**
- **Classify GLEs in “neutron” or “proton” initiated events;**
- **Estimate and analyze correlation matrices among different fluxes;**
- **Significantly enlarge the reliability of Space Weather alerts due to detection of 3 particle fluxes instead of only one in existing neutron monitor and muon telescope world-wide networks.**

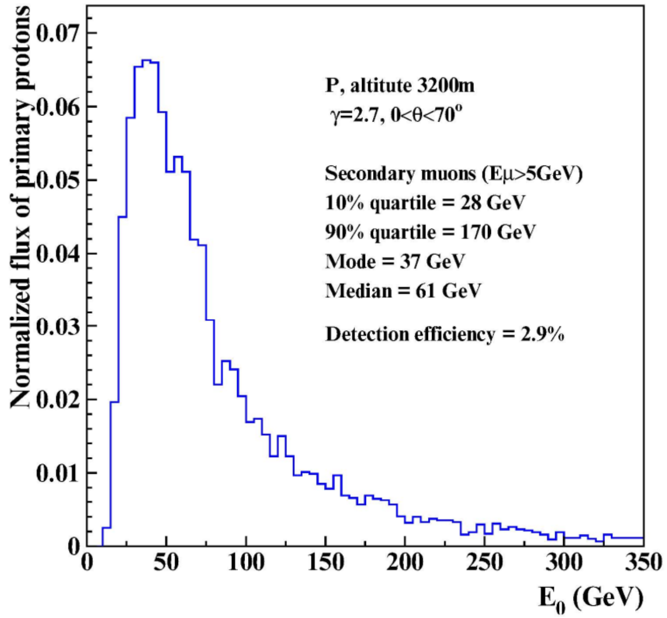
Barometric Coefficient of ASEC Monitors

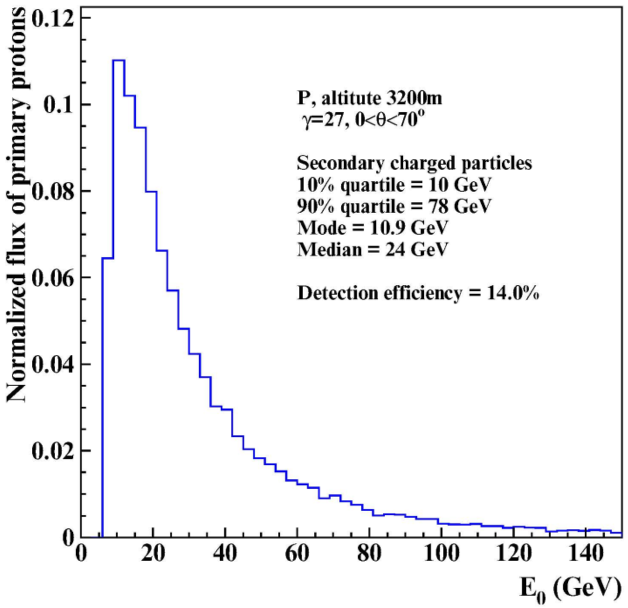
MONITORS	BAROMETRIC COEFFICIENT	ERROR	CORRELATION COEFFICIENT
Nor Amberd neutron monitor 0.4us	-0.695 %/mb	± 0.0133	0.997
Nor Amberd neutron monitor 250us	-0.678 %/mb	± 0.0127	0.997
Nor Amberd neutron monitor 1250us	-0.670 %/mb	± 0.0216	0.995
Aragats neutron monitor 0.4us	-0.730 %/mb	±0.0185	0.997
Aragats neutron monitor 250us	-0.713%/mb	±0.0183	0.997
Aragats neutron monitor 1250us	-0.688%/ mb	±0.0182	0.996
Nor Amberd multidirectional muon monitor(1) (upper layer)	-0.324%/mb	±0.012	0.992
Nor Amberd multidirectional muon monitor(1) (lower layer)	-0.223%/mb	±0.0135	0.987
Nor Amberd multidirectional muon monitor(2) (upper layer)	-0.323%/mb	±0.0136	0.991
Nor Amberd multidirectional muon monitor(2) (lower layer)	-0.225%/mb	±0.0135	0.987
Aragats underground muon monitor E>5 Gev	-0.08%/mb	±7.57E-05	0.924

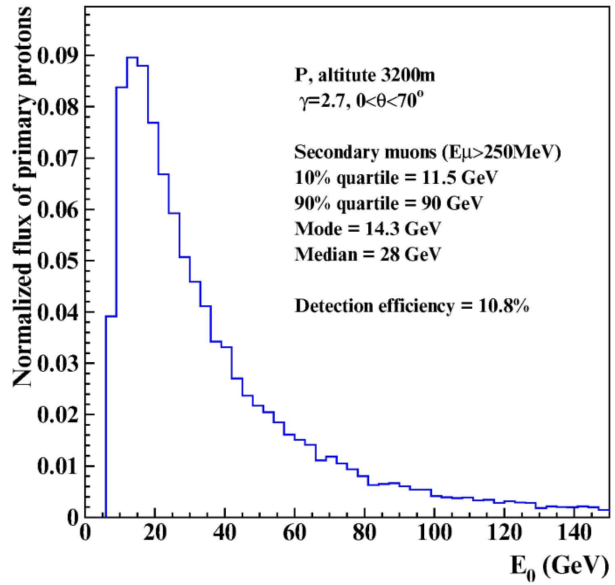
Energy distribution of the GCR protons initiated various secondaries at 3200 m altitude



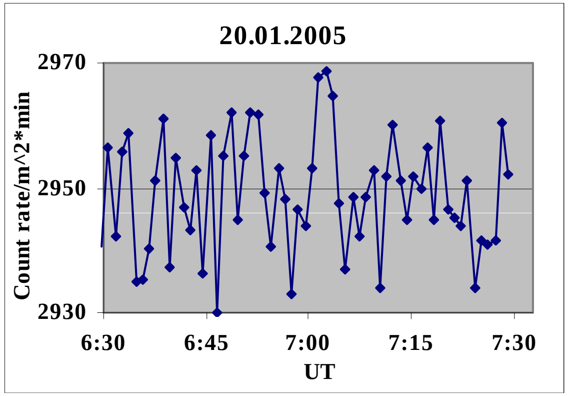


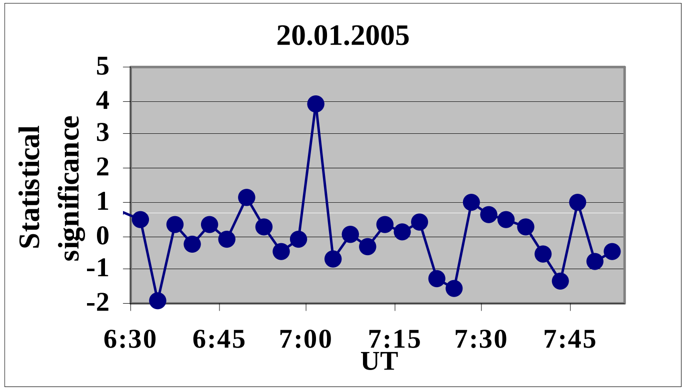




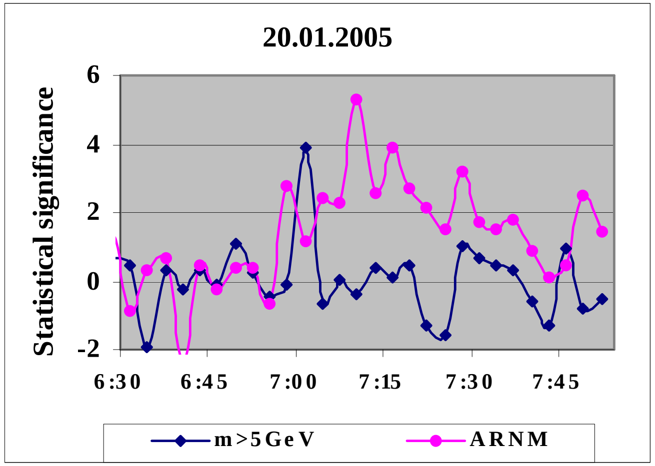


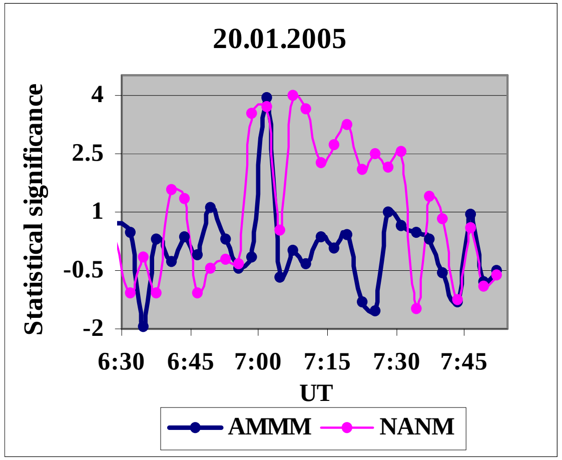
AMMM Detection of GLE 20 January 2005

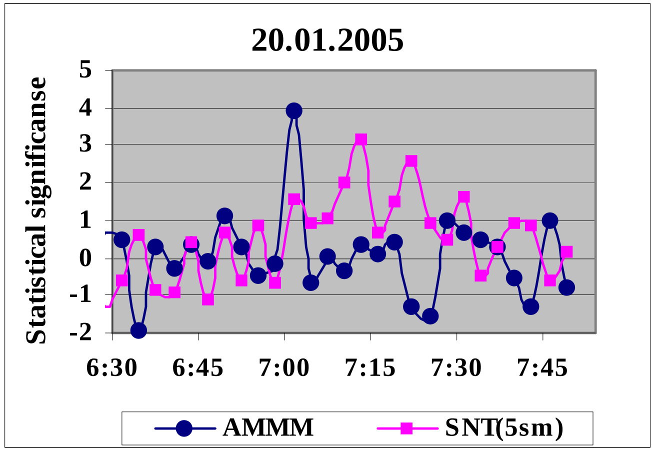




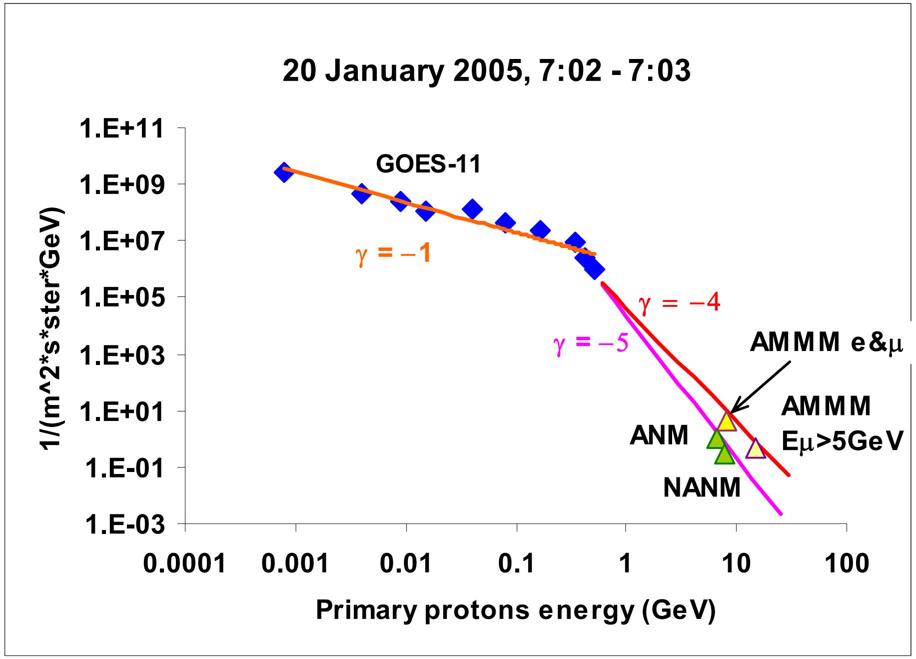
The additional signal at 7:02-7:04 UT equals 2354 (0.644%)
If we adopt the Poisson SD~ 0.164%, significance = 3.93σ

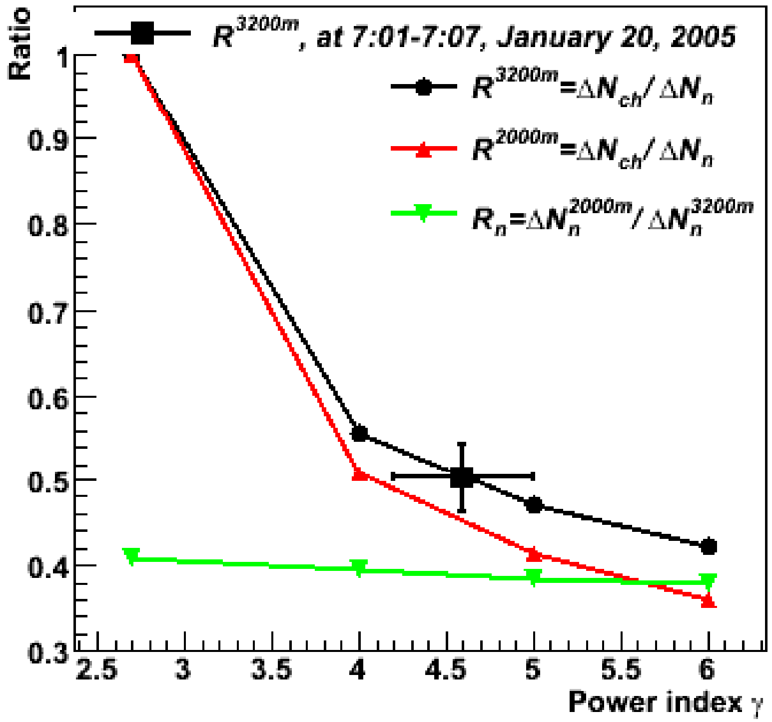






Energy Spectrum of the GLE from 20 January 2005

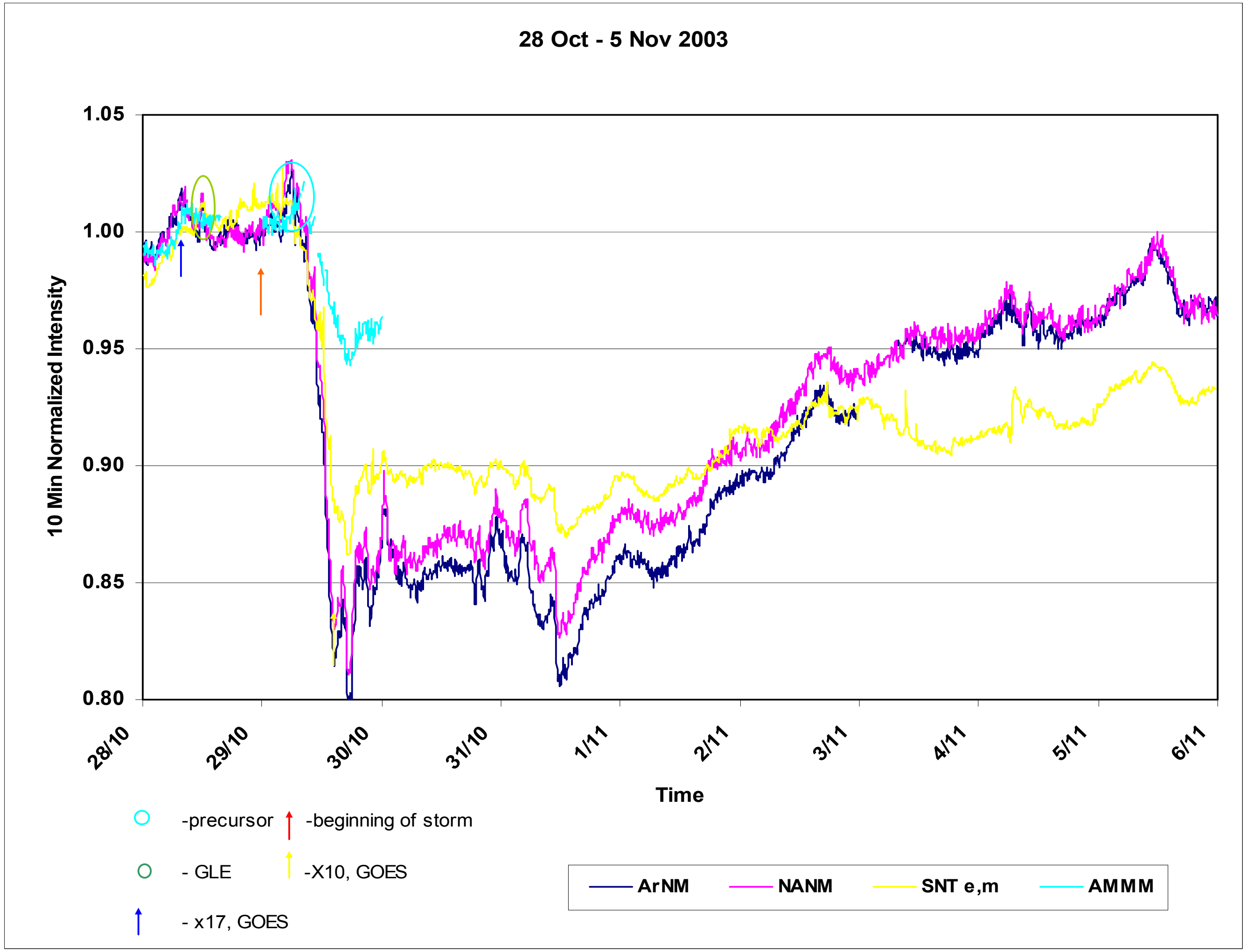




N.Kh. Bostanjyan , A.A. Chilingarian, V.S. Eganov, G.G. Karapetyan, **On the production of highest energy solar protons on 20 January 2005,** Advances in Space Research 39 (2007) 1456–1459

A.A.Chilingarian, A.E.Reimers, **Particle detectors in Solar Physics and Space Weather research**, Astroparticle Physics 27 (2007) 465–472

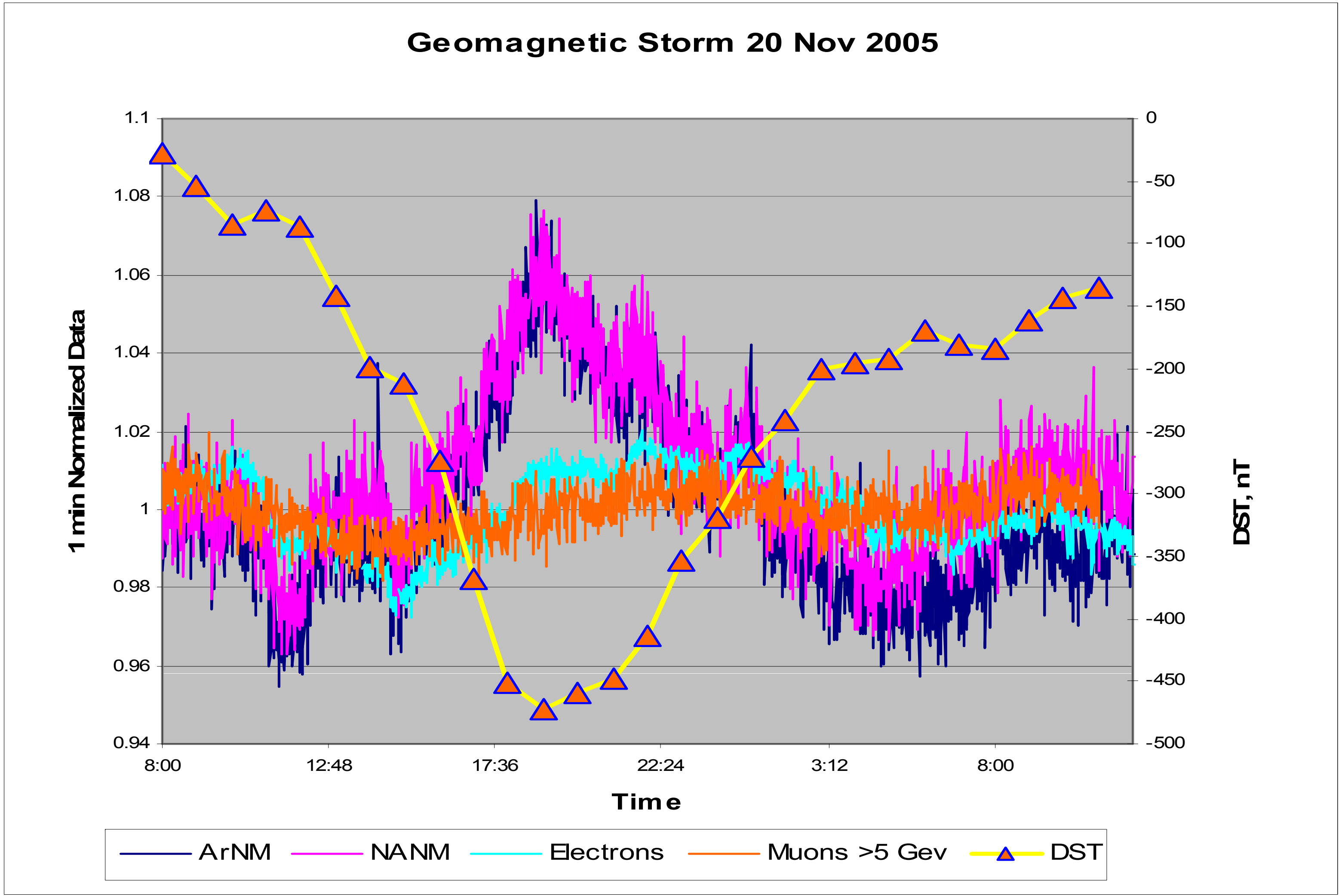
Famous “Halloween” events of 2003, detected in electron & muon and neutron fluxes by ASEC monitors at different altitudes



Correlation Matrix of ASEC monitors for 29 October 2003 (6:09 – 14:39), Fd

	ANM	NANM	AMMM	SNTe,μ	SNT thr1	SNT thr2	SNT thr 3	SNT thr4
ANM	1	1,00	0,97	0,99	0,99	0,97	0,95	0,98
NANM	1,00	1	0,97	0,99	0,99	0,97	0,95	0,98
AMMM	0,97	0,97	1	0,97	0,97	0,95	0,93	0,95
SNTe,μ	0,99	0,99	0,97	1	1,00	0,99	0,97	0,99
SNT thr1	0,99	0,99	0,97	1,00	1	0,99	0,96	0,99
SNT thr2	0,97	0,97	0,95	0,99	0,99	1	0,99	0,99
SNT thr3	0,95	0,95	0,93	0,97	0,96	0,99	1	0,97
SNT thr4	0,98	0,98	0,95	0,99	0,99	0,99	0,97	1

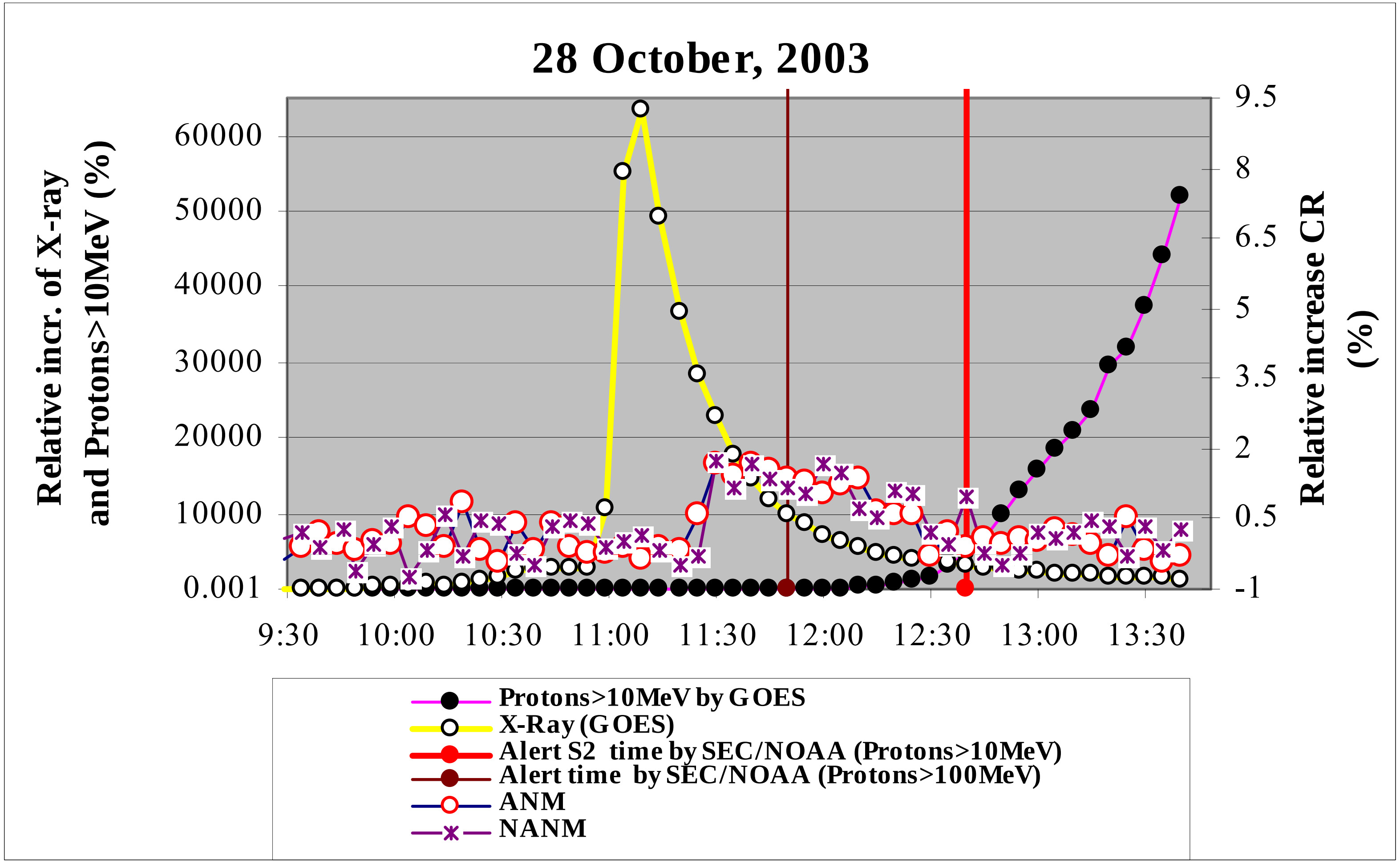
Geomagnetic Disturbance of 20 November 2003



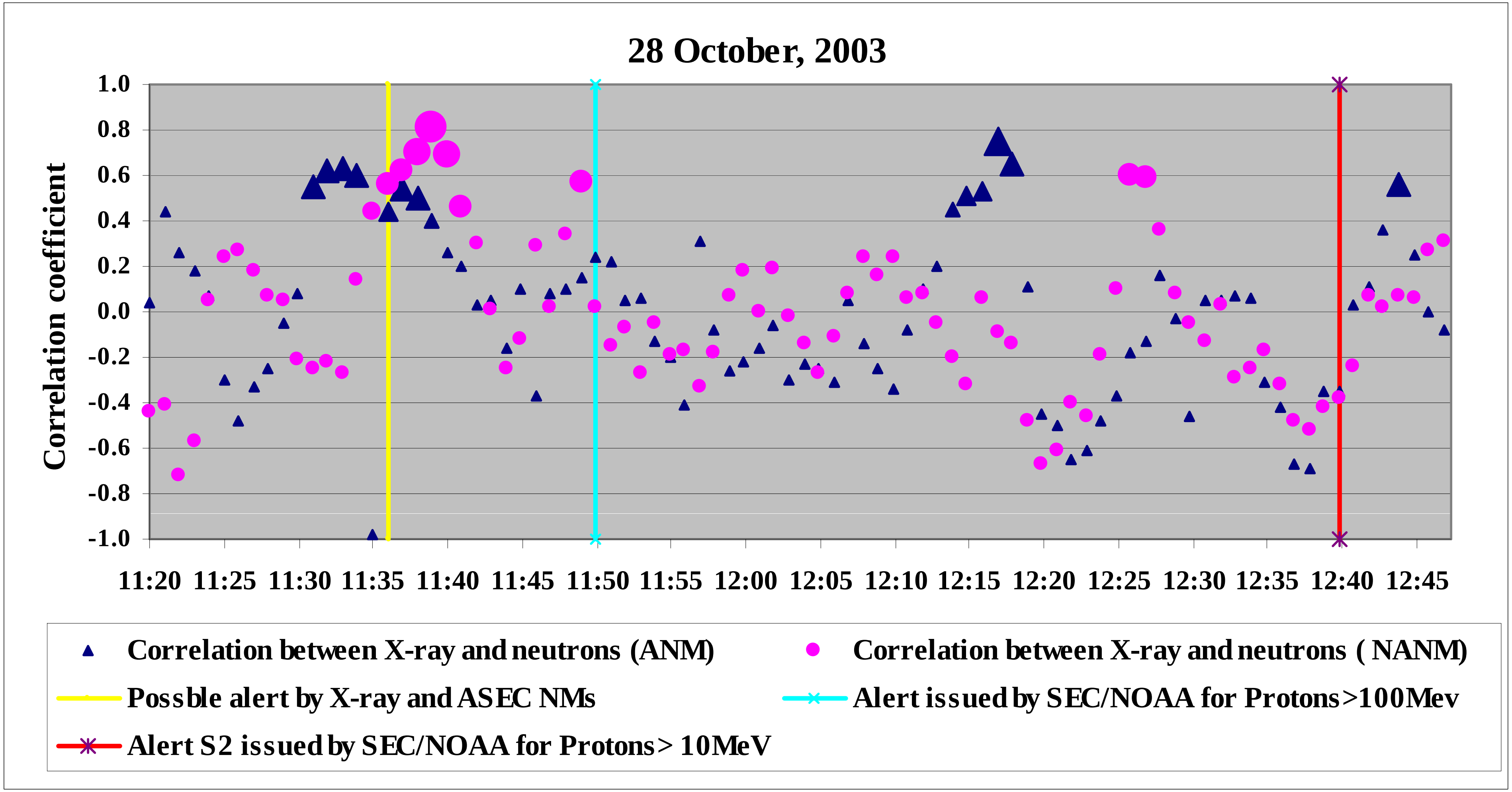
Correlation Matrix of ASEC monitors for 20-21 November 2003 г. (14:50 – 19:10), Geomagnetic Storm

	ArNM	NANM	AMMM	SNTe,m	Thr0	Thr1	Thr2	Thr3	Thr4
ArNM	1.00								
NANM	0.90	1.00							
AMMM	0.29	0.23	1.00						
SNTe,m	0.90	0.88	0.23	1.00					
Thr0	0.91	0.88	0.26	0.91	1.00				
Thr1	0.83	0.82	0.28	0.83	0.88	1.00			
Thr2	0.78	0.78	0.23	0.80	0.81	0.80	1.00		
Thr3	0.65	0.65	0.14	0.65	0.64	0.67	0.76	1.00	
Thr4	0.43	0.43	0.05	0.42	0.43	0.46	0.47	0.62	1.00

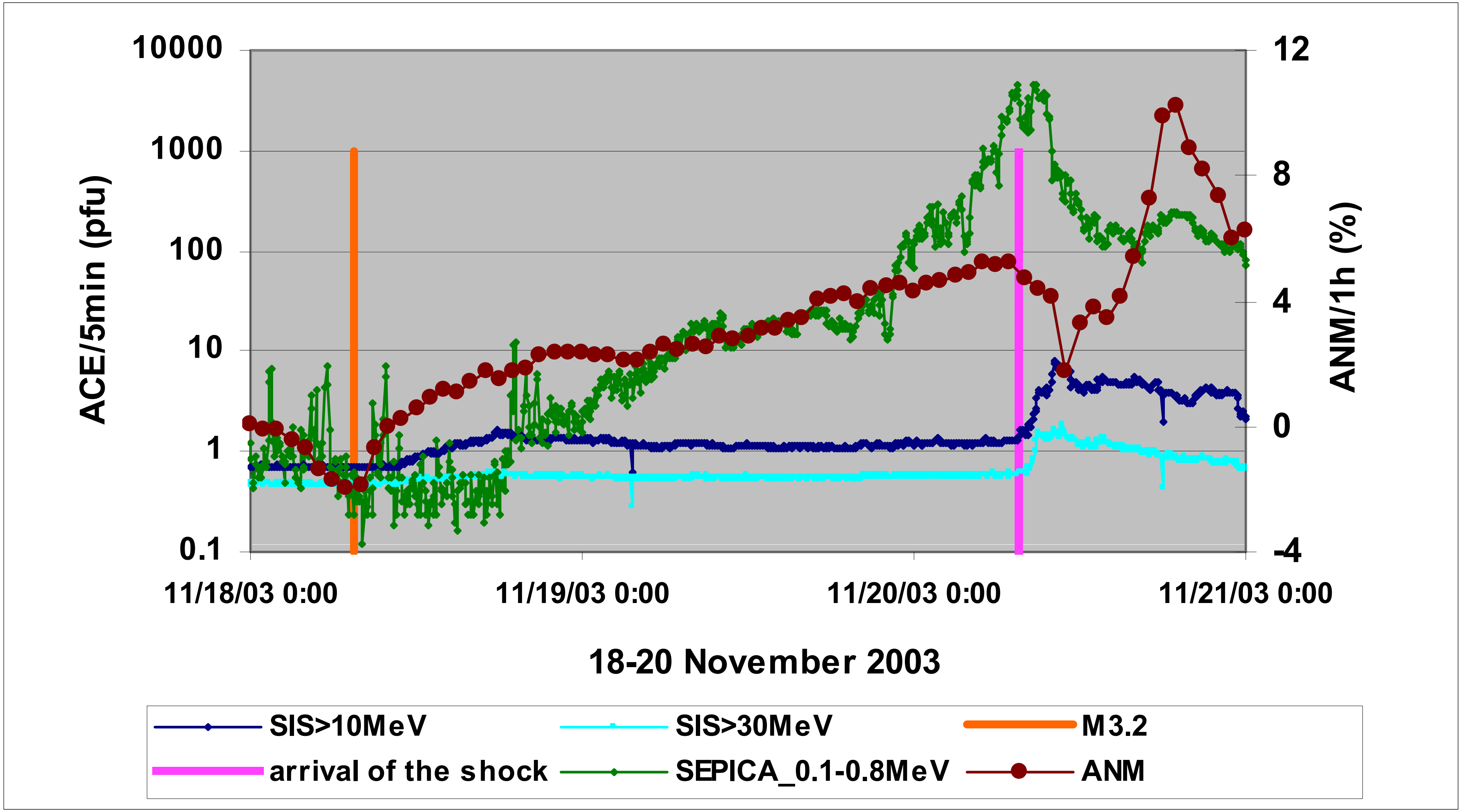
Radiation from 28 October 2003 X14.4 flare (flux maximum at 11:10). SEC/NOAA alerts on 100 MeV protons at 11:50 and S2 alert for 10 MeV protons at12:40. Enhancement of the ANM and NANM) reaches ~1.7% at ~11:35.



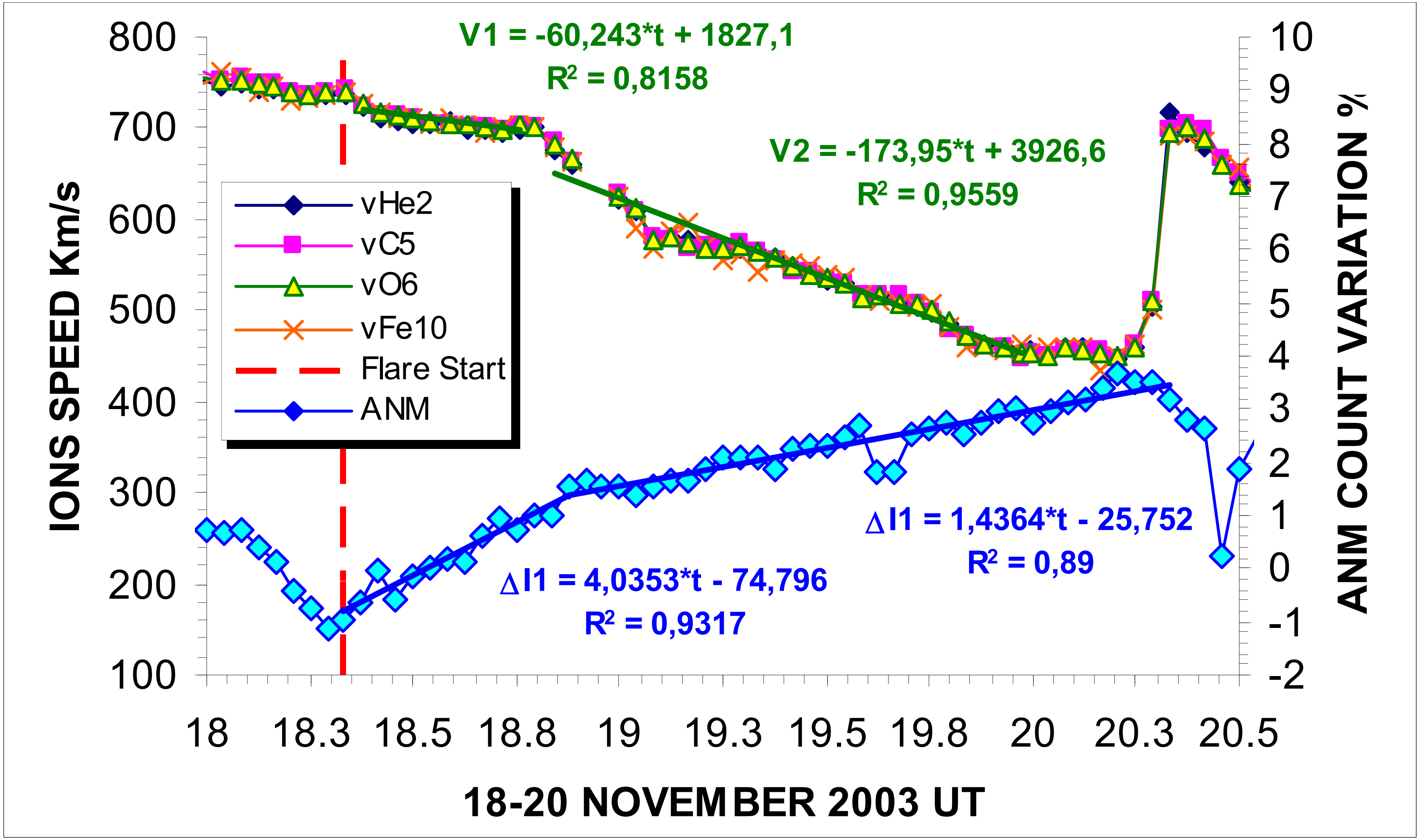
Pattern of correlations between neutron flux and X-ray flux. Correlations are calculated with 1-minute count rates, by memorizing the X-ray 10 minute peak and moving 10 minute intervals of surface particle detector count rates.



ICME modulation effects in KeV; MeV; and GeV particle fluxes

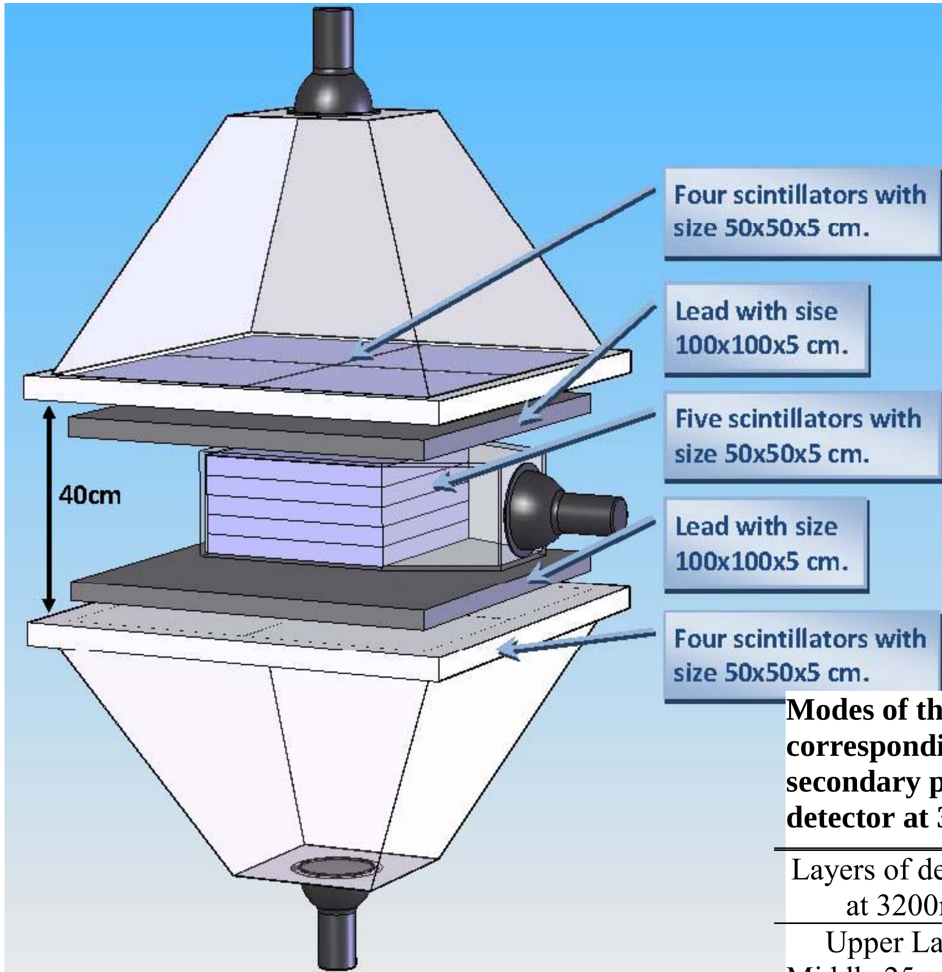


ICME modulation effects on the Solar Wind speed and GeV particles flux



Hybrid Particle Detectors for the Space Environmental Viewing and Analysis Network (SEVAN)

111 ; 101– traversal of high energy muon;
010 – traversal of the neutral particle;
100 – traversal of low energy charged particle.
110 – traversal of higher energy charged particle stopped in the second lead absorber.
001 – registration of the inclined charged particles.



Modes of the GCR Energy spectra corresponding to the different species of secondary particles registered by SEVAN detector at 3200m above sea level.

Layers of detector at 3200m	Mode of the parent ”GCR” Energy spectrum [GeV]
Upper Layer	11.5
Middle 25cm layer	8.5
Down Layer	14.5

Information, detector charts, agreements in:
http://crdlx5.yerphi.am/index.php?Page=/IHY-CRD/SEVAN/&Title=SEVAN

Space Weather Research and Forecasting by Networks of Hybrid Particle Detectors Measuring Neutral and Charged Fluxes

- **24 hour, whole year monitoring of the secondary cosmic rays by networks of particle detectors. Providing data to world-wide networks and partners in real time;**
- **Prepare integrated database of solar events, including parameters of flare, coronal mass ejection (CME), Solar Wind, Interplanetary Magnetic Field (IMF) and geophysical parameters;**
- **Develop Space Weather portal and its mirrors.**
- **Select of the subset of variables from space-born and surface facilities for prognosis of severity of upcoming space storms;**
- **Develop Bayesian statistical models and Neural Net models for the forecasting and estimating severity of Space Storms;**
- **Develop and test Space Weather forecasting methods. Design and implement automatic systems of issuing alerts and warnings**

Post stamp on CRD Participation in IHY 2007

Forecasting of Radiation and Geomagnetic Storms by networks of particle detectors (FORGES-2008)

September 29-October 3, 2008 • Nor Amberd, Armenia

OVERVIEW

The focus of the International Astroparticle Physics Symposium: Forecasting of Radiation and Geomagnetic Storms by Networks of Particle Detectors (FORGES-2008) will be to examine the state and the future possibilities of networks of particle detectors distributed at different latitudes, longitudes and altitudes measuring changing fluxes of neutral and charged particles to forewarn on coming severe radiation and geomagnetic storms.

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- International Heliophysical Year (IHY-2007)
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- European Office of Aerospace Research & Development (EOARD)
- National Foundation on Science and Advanced Technologies (NFSAT)
- Support Committee for Armenia's Cosmic Ray Division (SCACRD)
- Committee on Space Research (COSPAR)

PROGRAM OUTLINE

1. Physics of Interplanetary Coronal Mass Ejections (ICME), their propagation in the interplanetary space and interaction with cosmic rays and magnetosphere; modulation effects posed on the galactic cosmic rays; classification of Geomagnetic Storms (GMSs).

2. Characteristics of ground-based networks of particle detectors; experimental methods of measuring count rates and energies of secondary cosmic rays; efficiency of detecting various species of secondary cosmic rays. Networks monitoring main geophysical parameters.

3. Mathematical methods of the prediction; feature selection; Bayesian and Neural Network models of interpolation and extrapolation; multivariate regression methods.

4. Training of SEVAN (Space Environmental Viewing and Analysis Network) host groups.

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