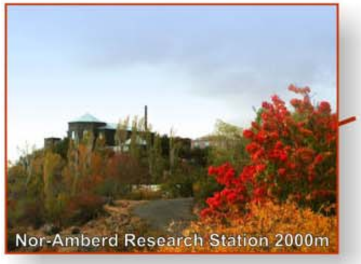
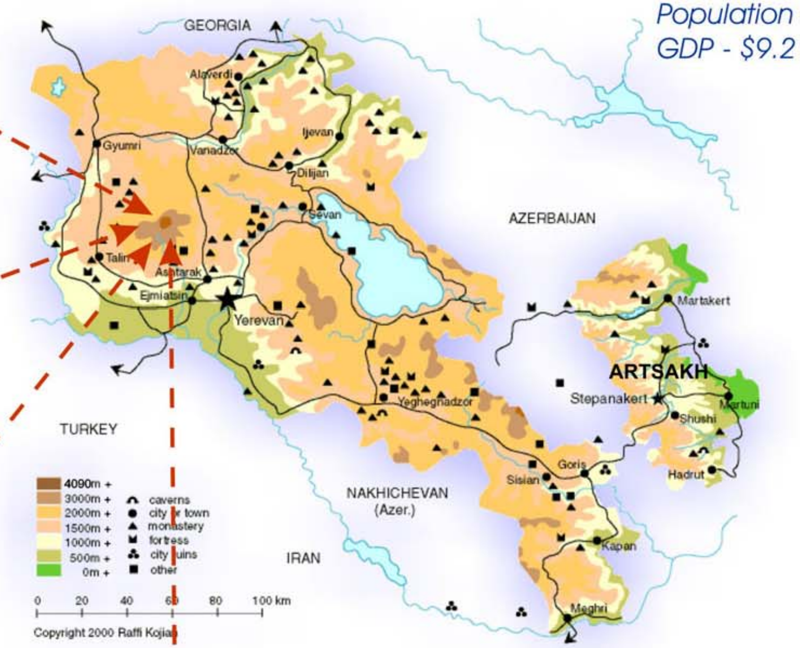
Aragats Space Environmental Center (ASEC): Space Weather Observatory in Armenia

Map of Armenia



Area:
total: 29,800 sq km
land: 28,400 sq km
water: 1,400 sq km

Population - 3.000.000
GDP - $9.2 billion



Mt. Aragats

Aragats, June

Aragats, August

Abram Alikhanov and Artem Alikhanyan

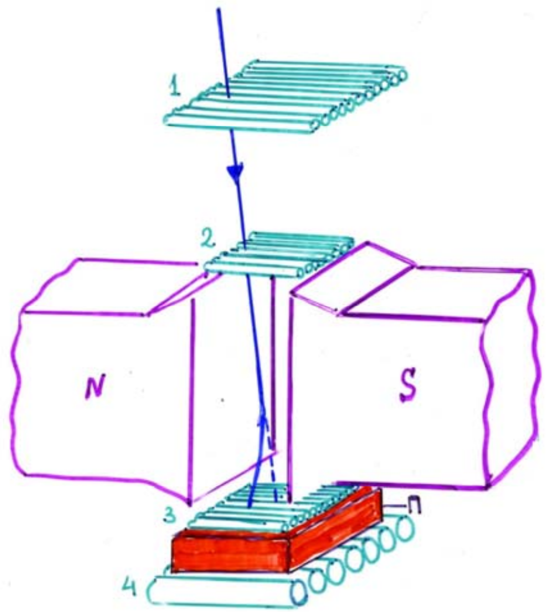
Aragats Research Station

Nor Amberd Research Station

Most Important Achievements

- 1942 – first expedition to Aragats
- 1943 – Organization of the phys.-math. Institute of Arm. Academy of science
- 1945-1955 – Experiments at Aragats with Mass-spectrometer of Alikhanyan-Alikhanov – composition of secondary CR (<100 GeV)
- 1957 – Ionization calorimetry, up to 50 TeV
- 1960 – Construction of Nor Amberd station
- 1970 – Wide-gap Spark Chambers, Alikhanyan, Asatiani
- 1975 – Investigations of horizontal muons
- 1976 – Installation of Neutron Monitors
- 1977 – Investigations of pion and proton fluxes, PION experiment
- 1981 – Start of the ANI Experiment

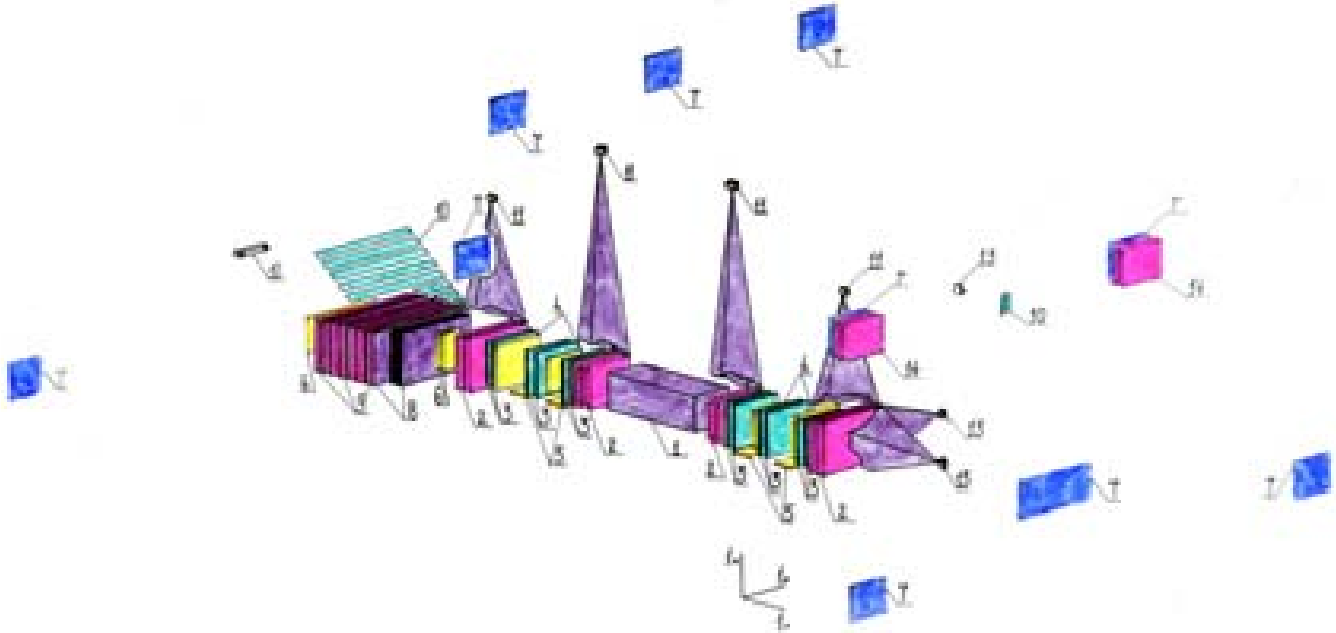
Magnetic Spectrometer of Alikhanov-Alikhanyan: Composition of the secondary Cosmic Rays



Discovery of the THIRD Component of CR – protons, deuterons, neutrons;

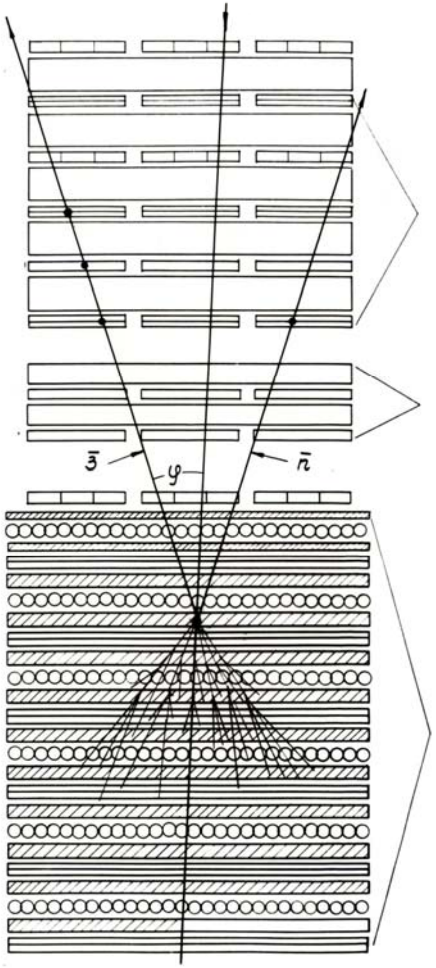
Idea of variety of particles - VARITRONS

MUON Experiment



Measuring fluxes of horizontal muons and charge ratio, multiwire spark chambers, automatic DAQ

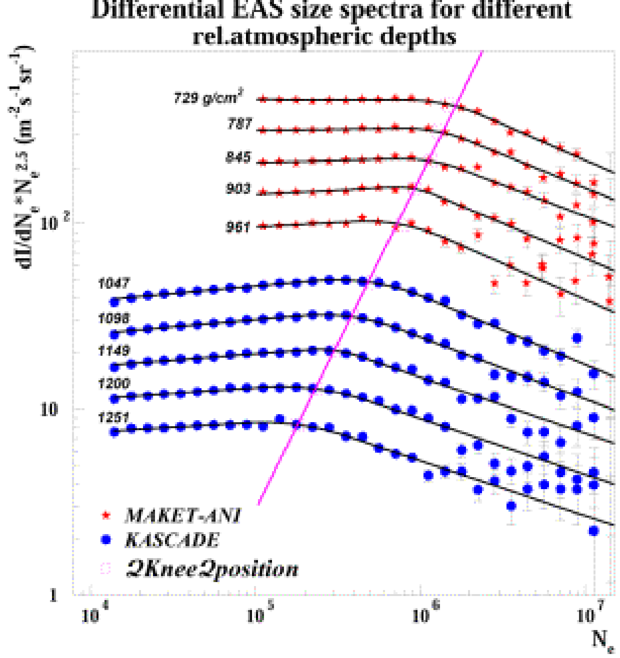
PION Experiment – Measuring of proton and Pion fluxes and some fenomelogical parameters of strong interactions

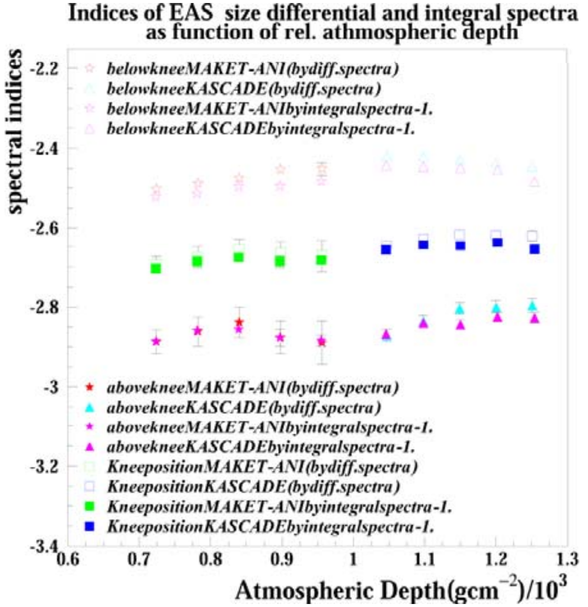


Ionization Calorimetry, particle energy up to 50 TeV; hadron identification with TRD; Computer DAQ – first Armenian mini computer – NAIRI.

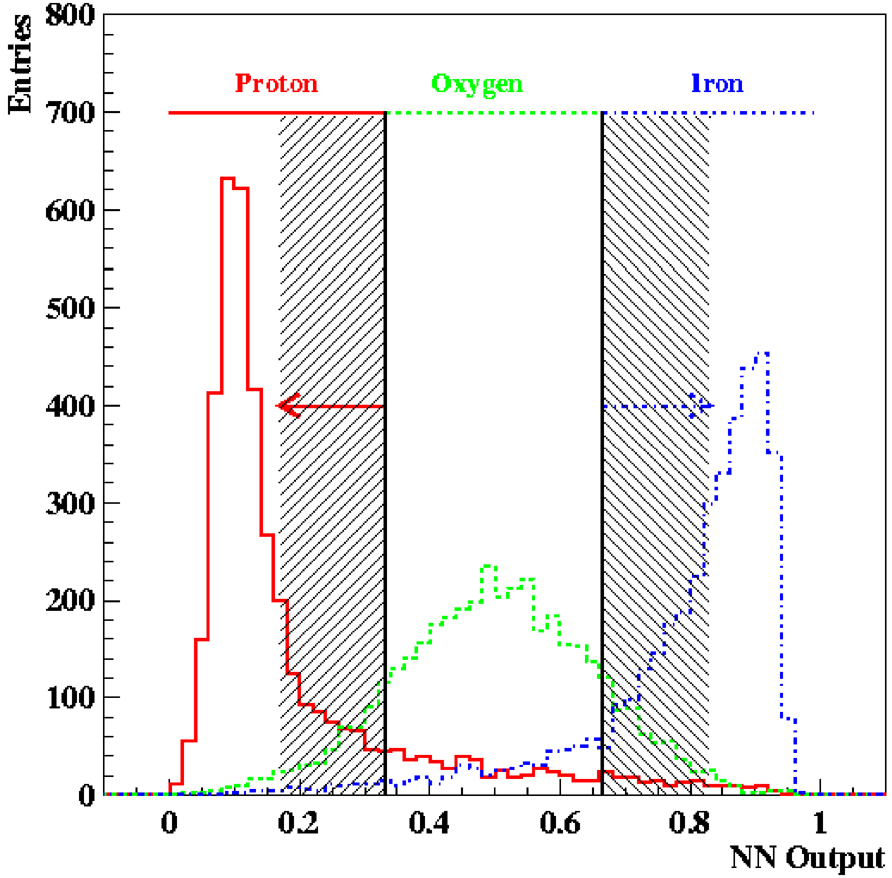
Inelasticity coefficients, cross sections, multiplicities.

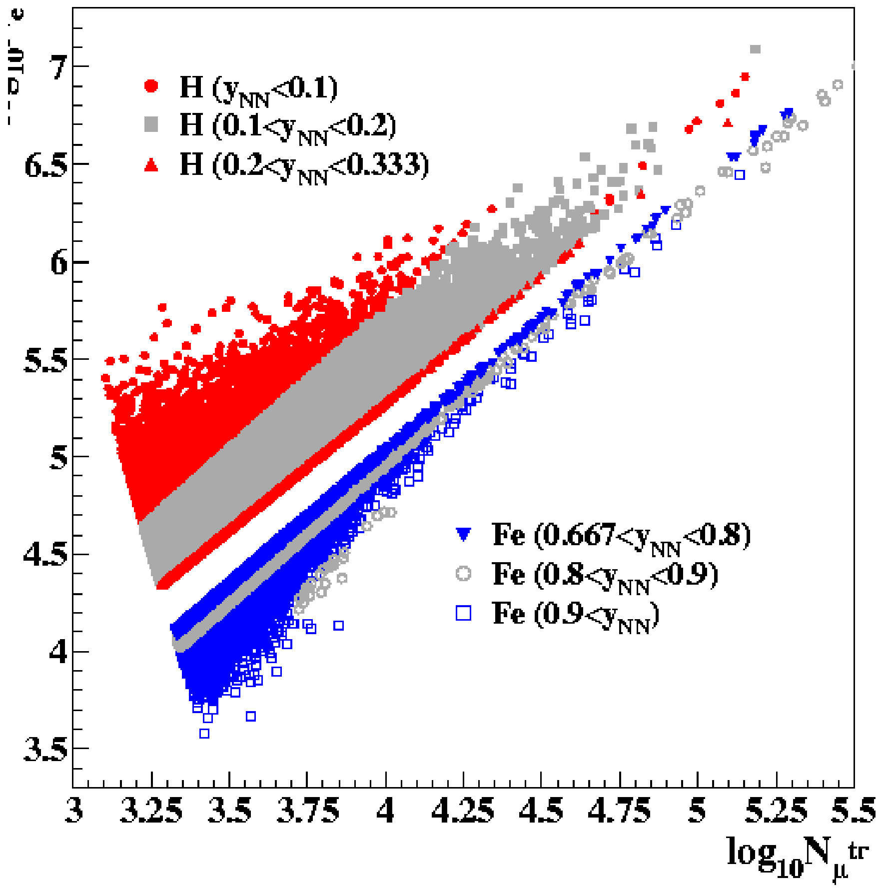
Extensive Air Showers detected by Surface Arrays by ANI and KASCADE collaborations



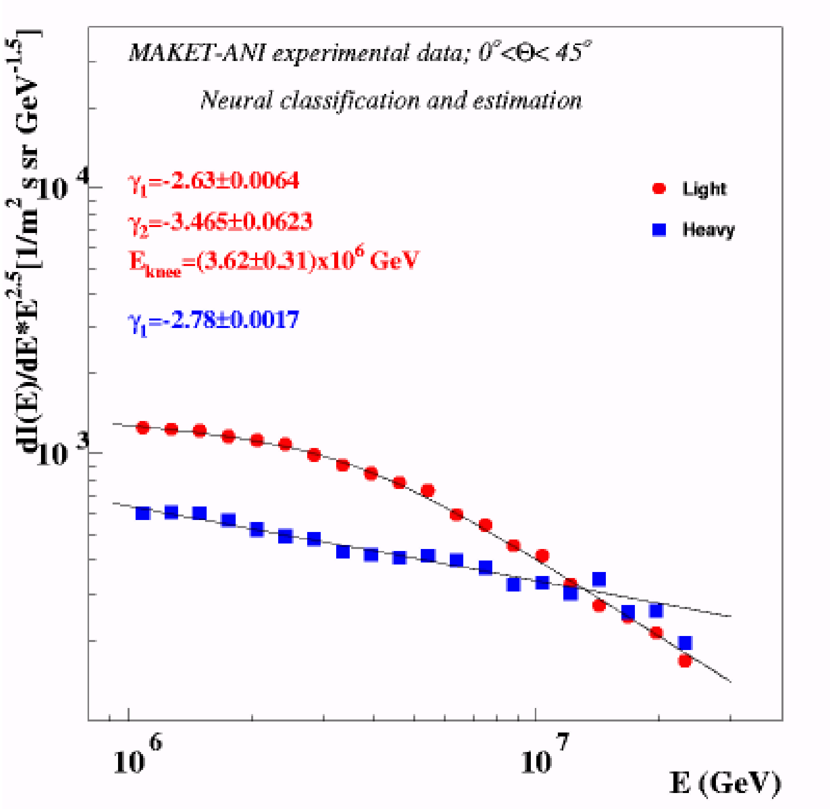


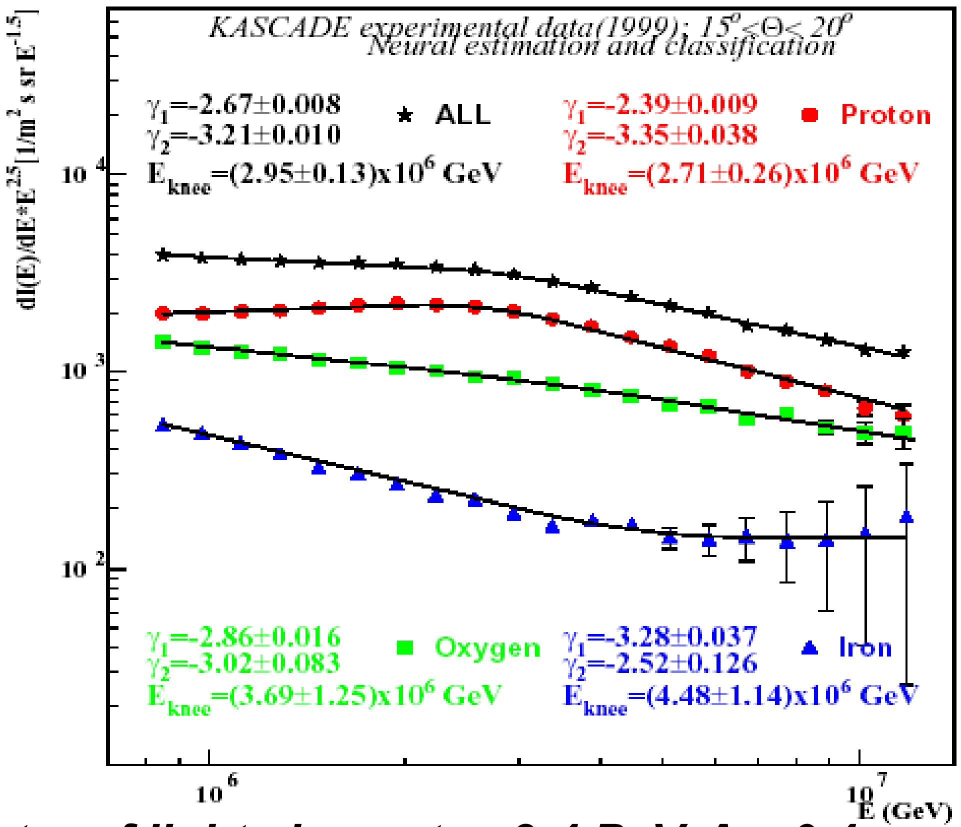
Separation of Primary Cosmic Rays into Nuclear groups by Neural Classification and Estimation – Event-by-event analysis of Extensive Air Showers (Methodology developed by CRD, YerPhI)





Partial Energy Spectra of Light and Heavy CR – first published by CRD, YerPhI





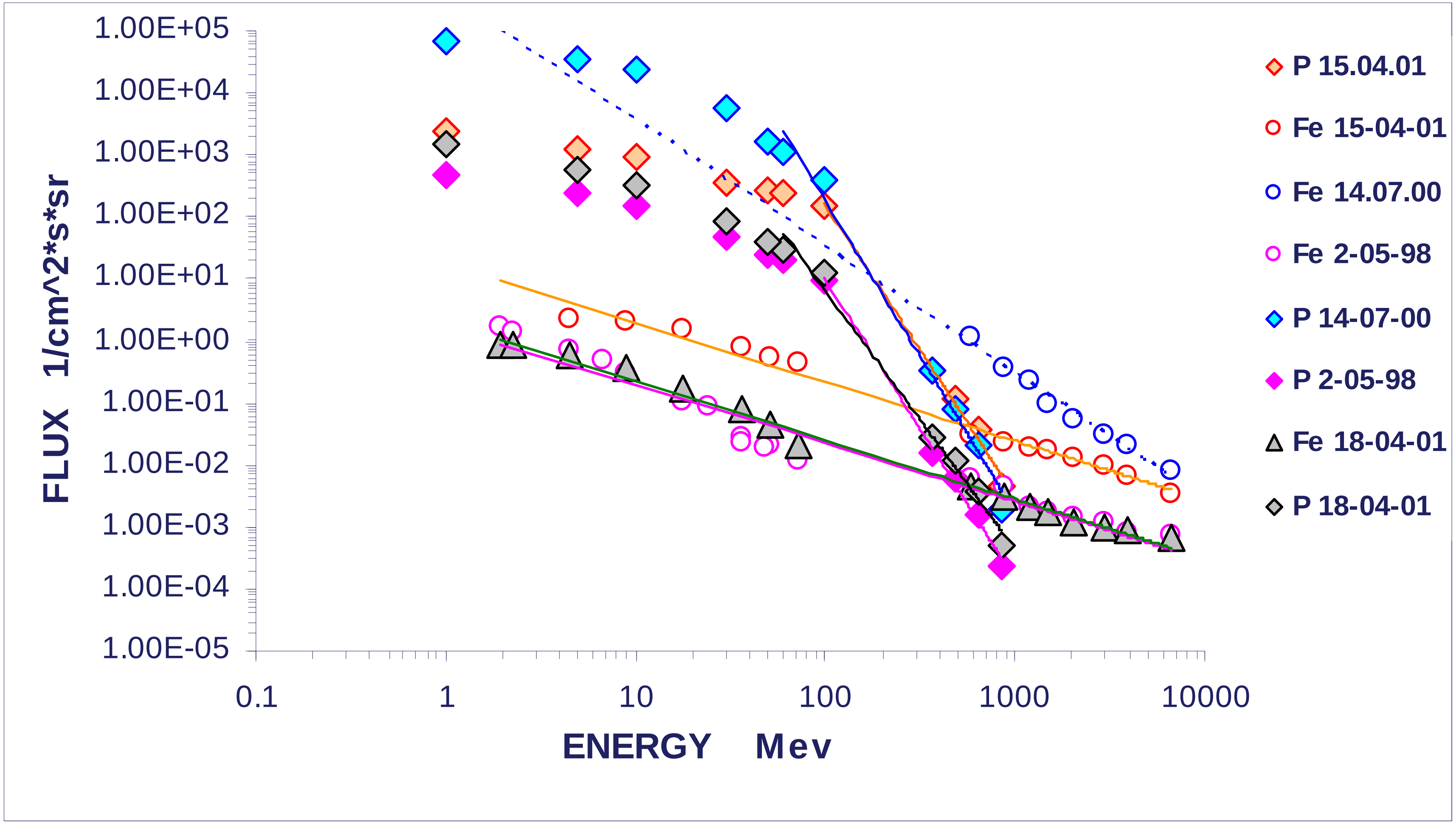
Sharp "Knee" is observed in the spectra of light elements ~3-4 PeV, Δγ~0.4;

No "Knee-like" structure is observed in the Spectra of heavy elements;

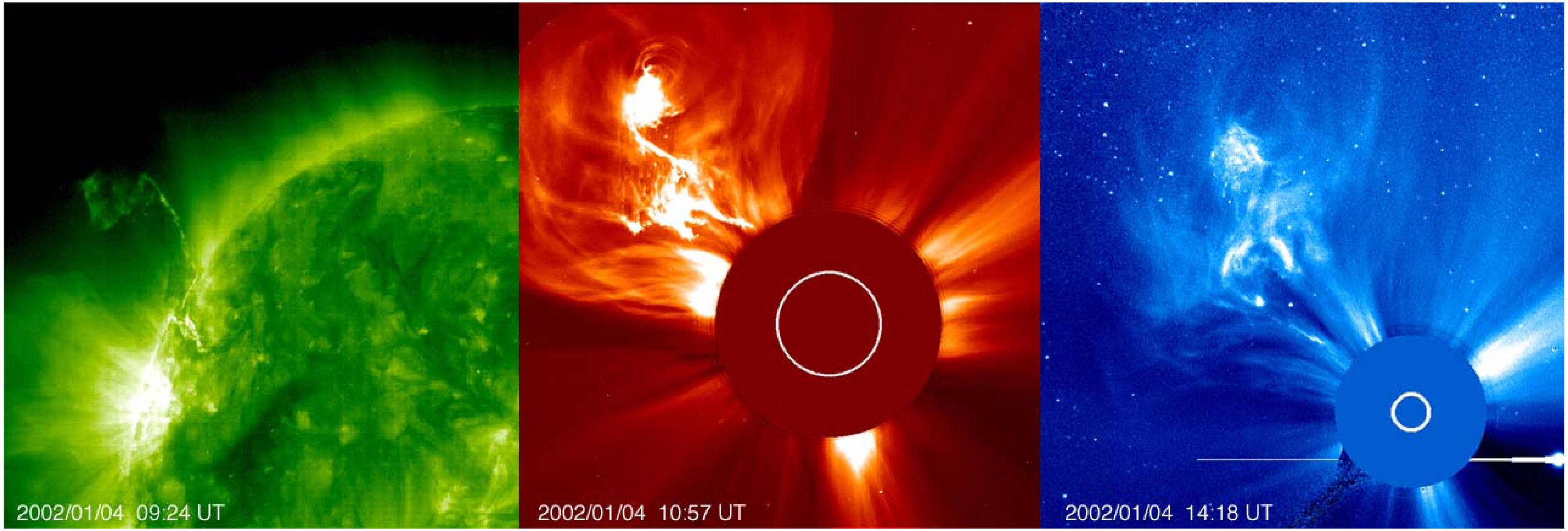
A. Chilingarian, G. Gharagozyan, G. Hovsepian, S. Ghazaryan, L. Melkounyan, and A. Vardanyan, (2004) **Light and Heavy Cosmic-Ray Mass Group Energy Spectra as Measured by the MAKET-ANI Detector,** The Astrophysical Journal, vol. 603, pp. L29

B. A.Vardanyan, T.Antoni, et al. for the KASCADE collaboration, (2003) **Preparation of Enriched Cosmic Ray Mass Groups with KASCADE**, Astroparticle Physics **19**,715

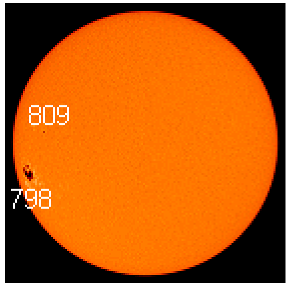
Spectral knees in Solar Ions Fluxes of current 23-rd cycle

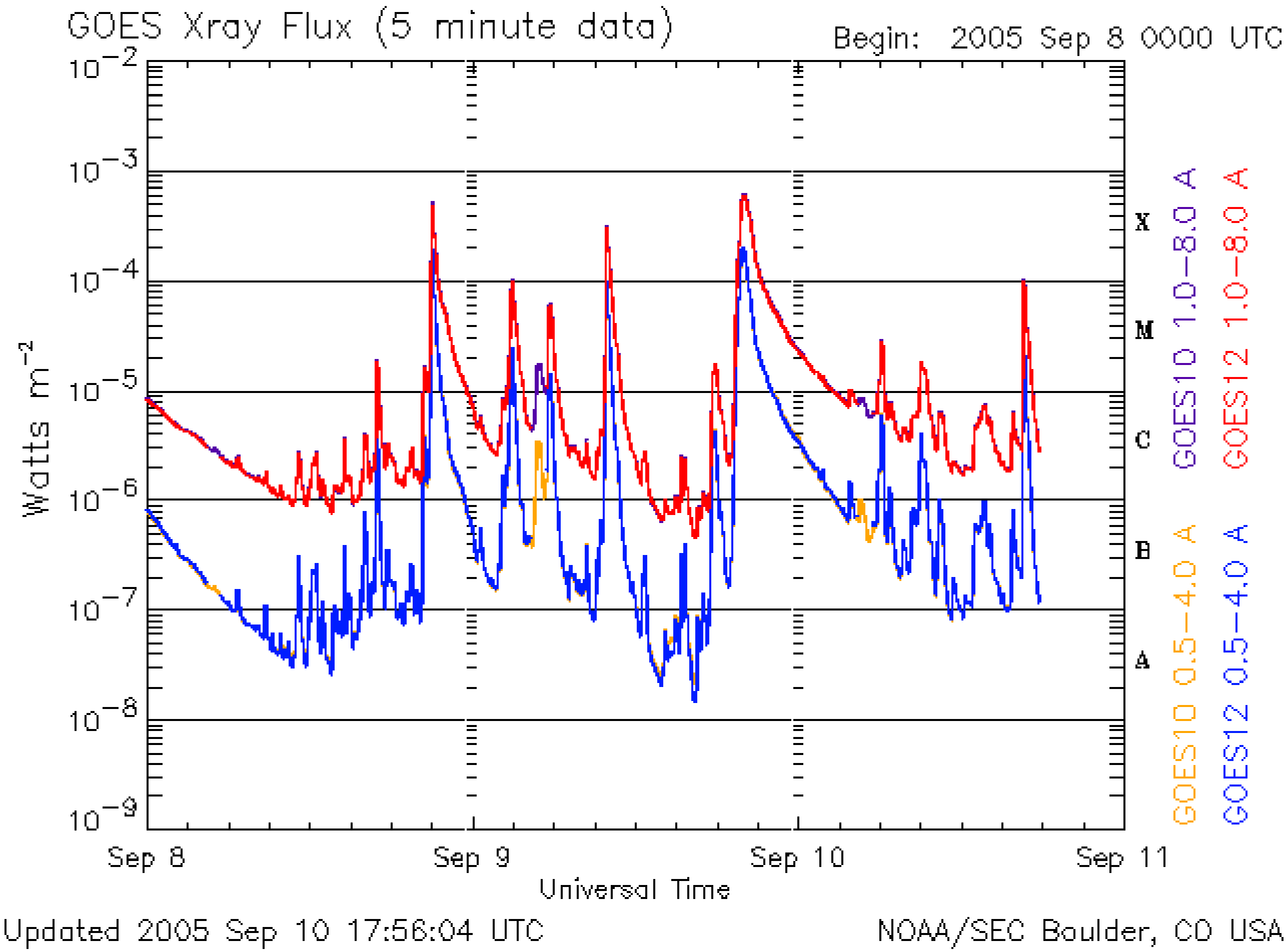


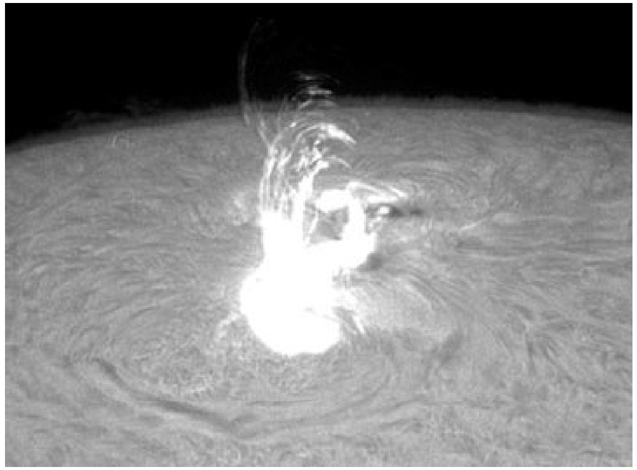
Understanding the way the Sun works is the bottom rung in a ladder to understanding how the rest of the universe works

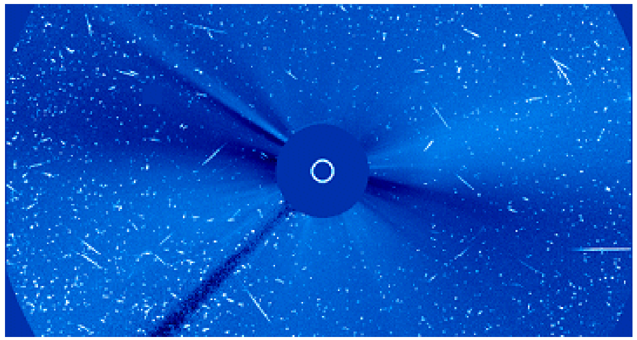


Huge Solar Flares from spot group 798

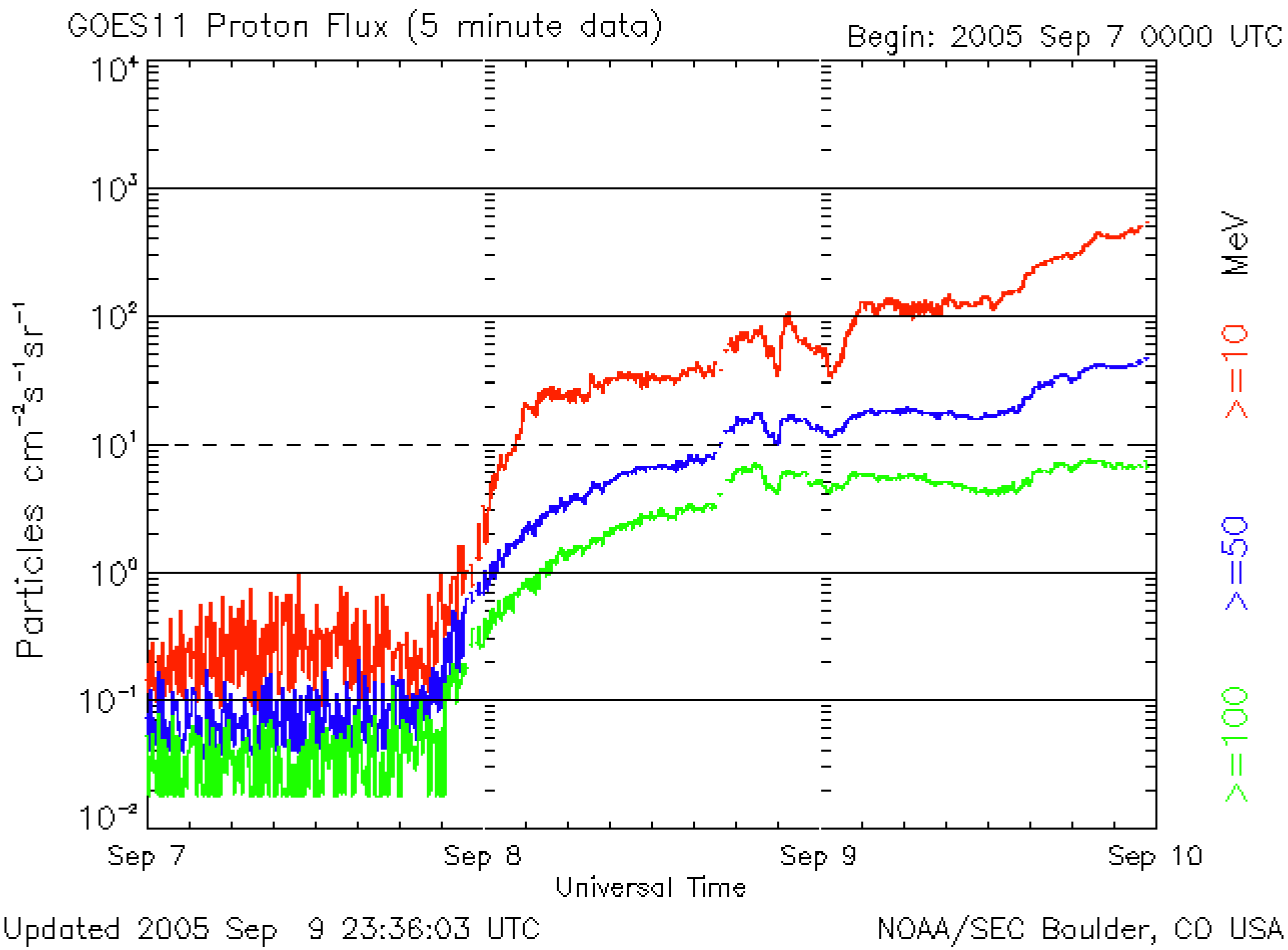






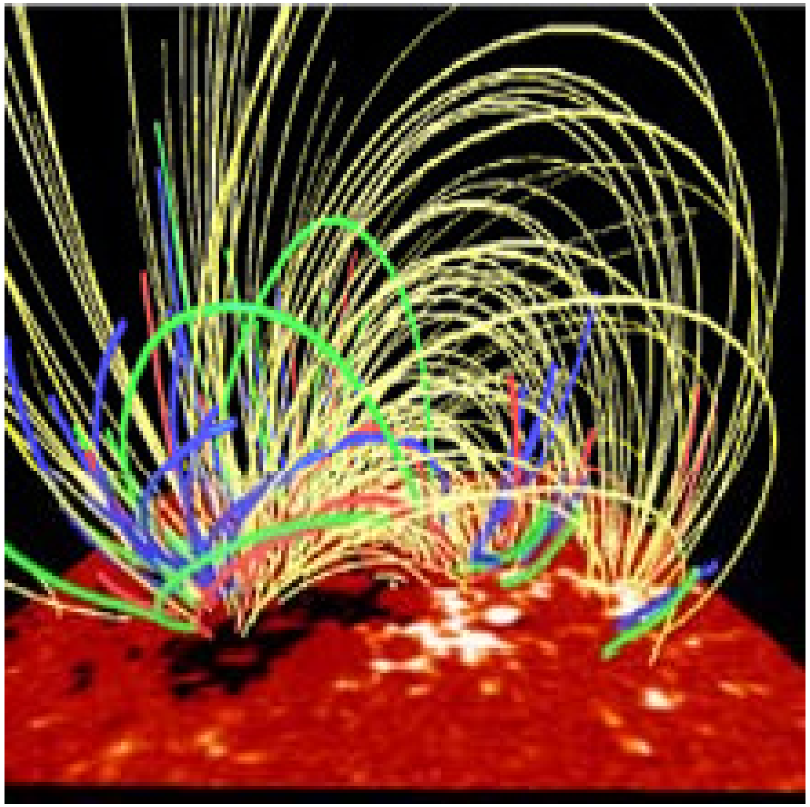


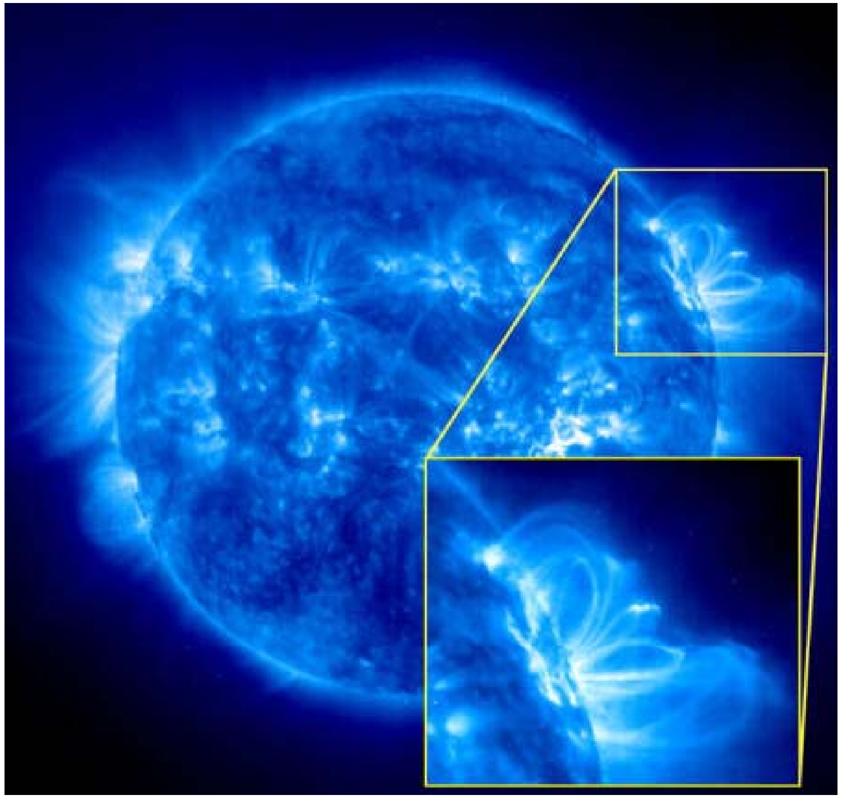
Ongoing Radiation Storm (S2)



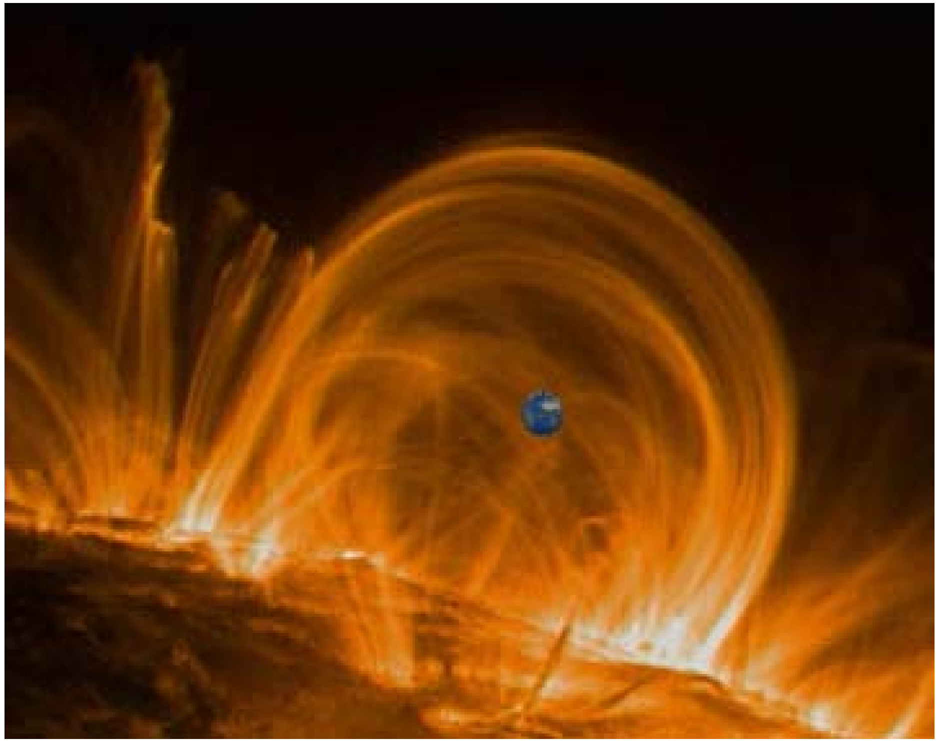
Start of   Solar Physics Week

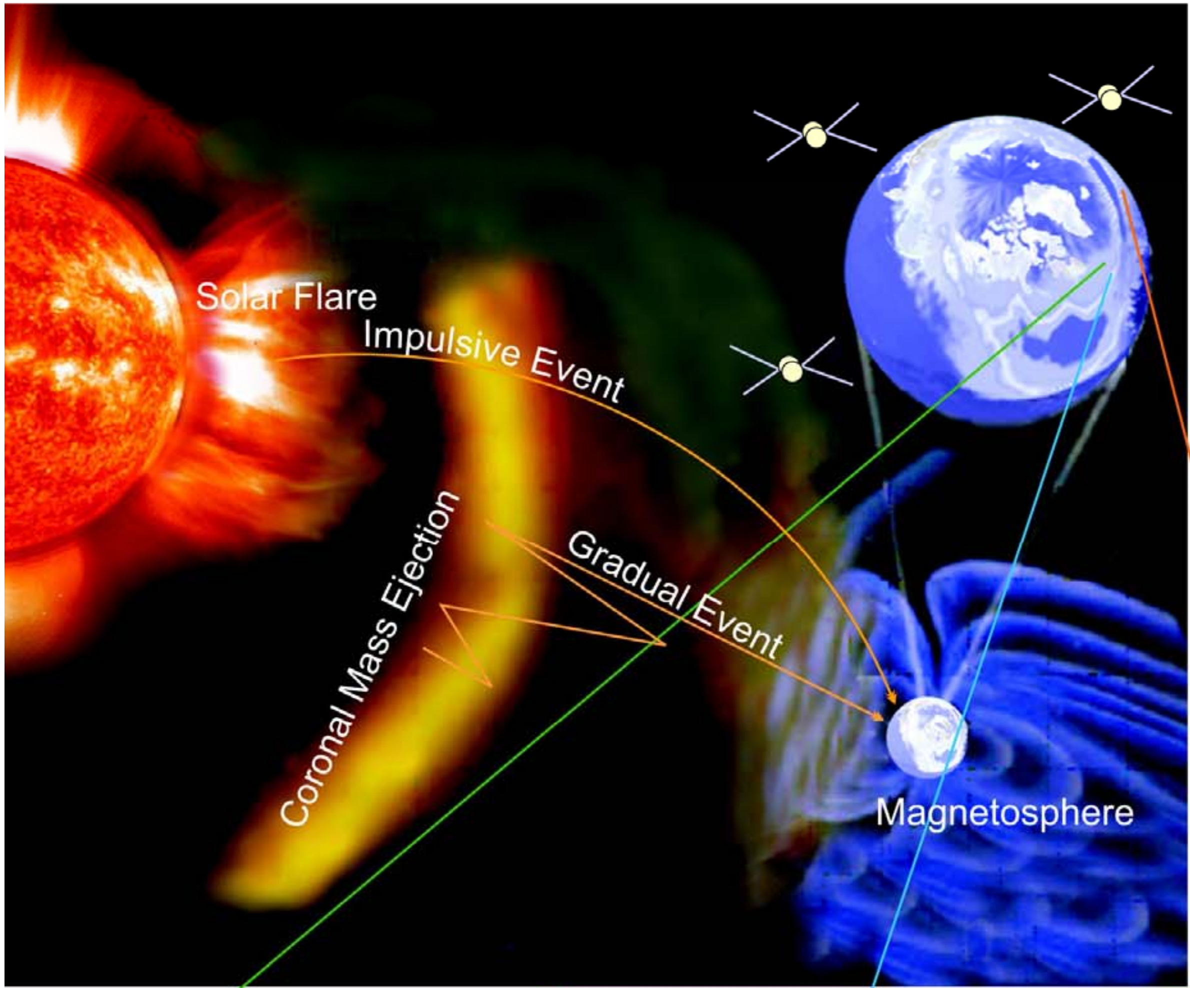
Solar Energy is stored in the Magnetic Loops

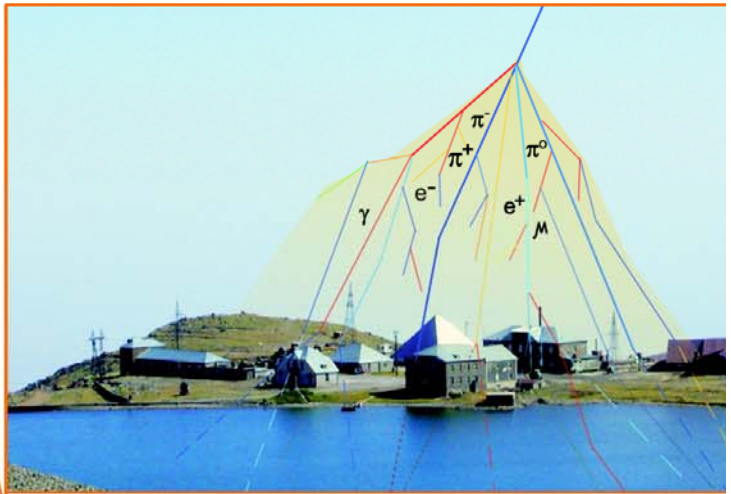


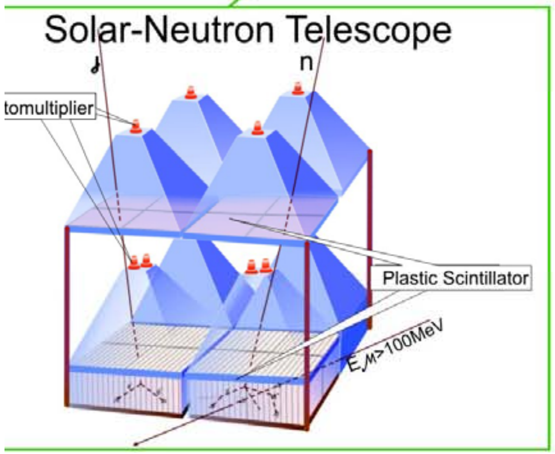


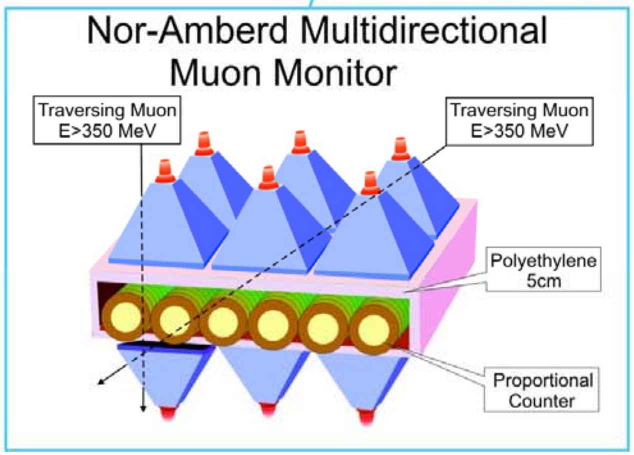
Solar Magnetic Loops – up to 200,000 km long, Solar Flare energy ~ 10^{32} erg – most energetic processes in Solar System; Current in reconnection point ~10^5-10^6 amper





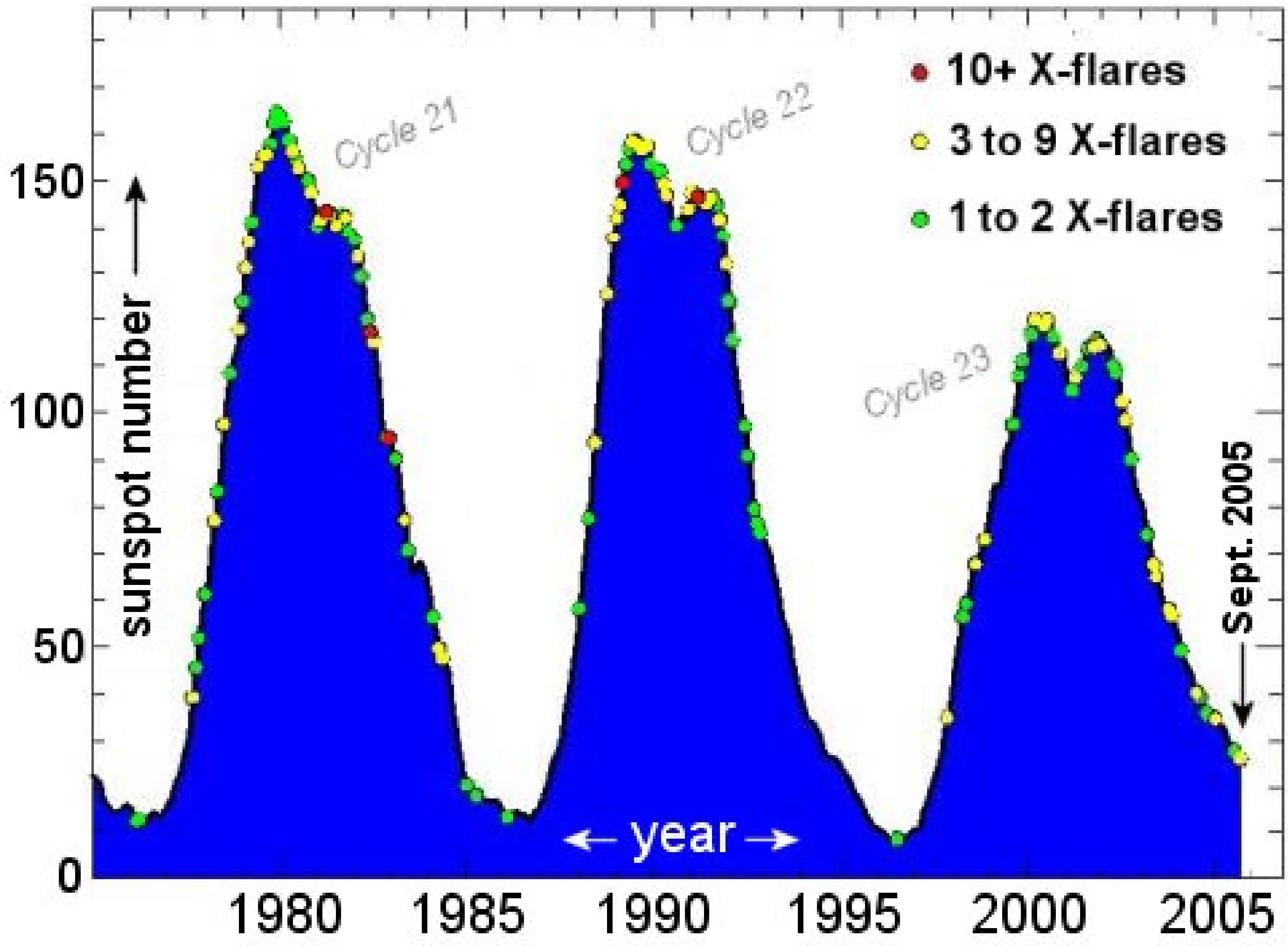


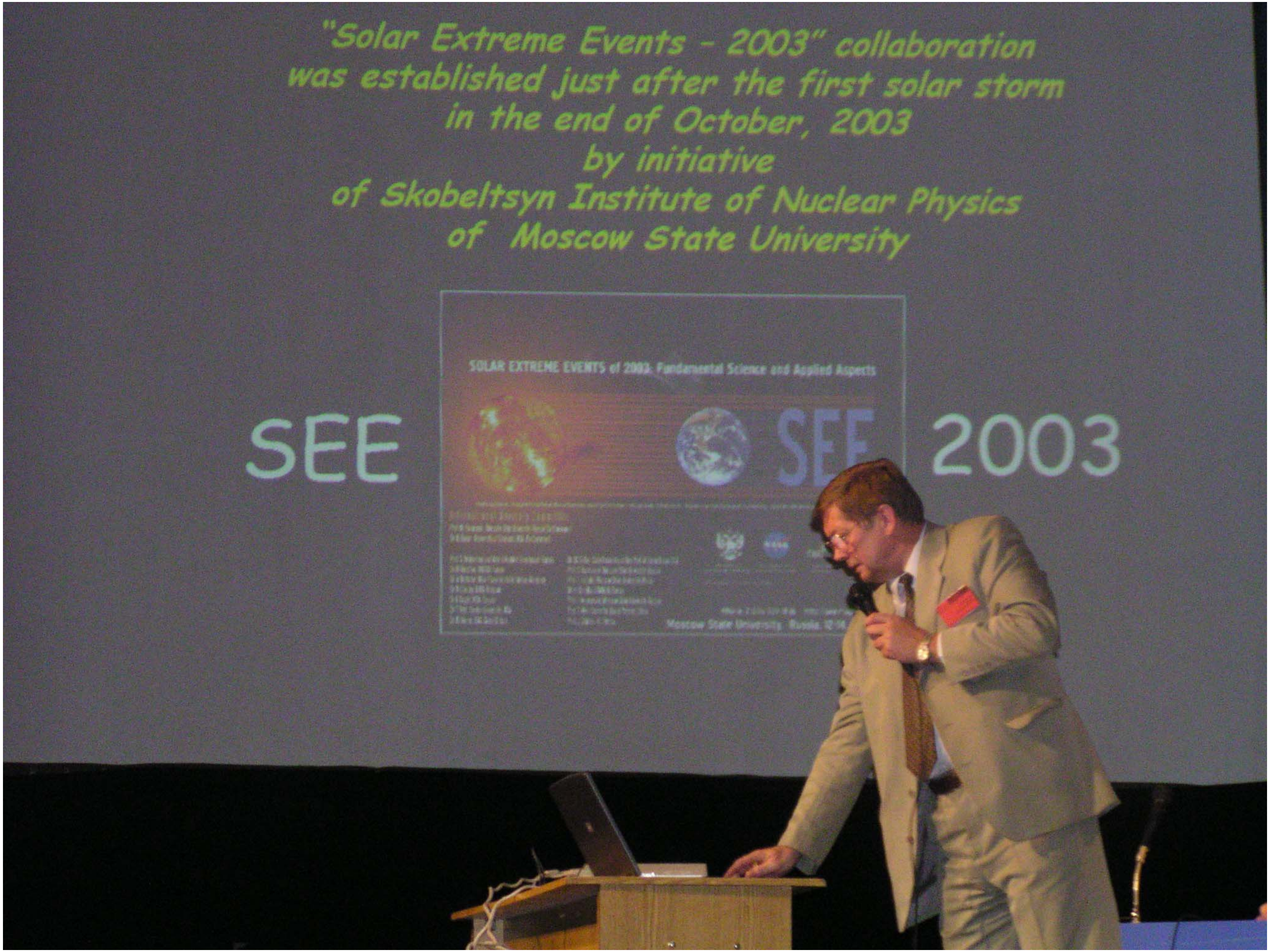




High energy cosmic rays open a window for the exploration of the d and forceful processes in the far-corners of the universe. The A Space-Environmental Center (ASEC) of the Cosmic Ray Division in Ar http://crdlx5.yerphi.am, conducts research in the field of Galactic Cosmi and Solar Physics. The two research stations, at 3200m and 2000m el on Mt. Aragats, are equipped with modern scientific detectors and instr which allow the scientists to make new discoveries in high energy astrop The ASEC explores the activity of our own star, the Sun, and is dev Space Weather forecasting and early warning systems and technique strategic geographic coordinates of the ASEC research stations and the based particle detector systems developed by the ASEC scientists, c with data from detectors in space and on the ground, will allow the intern community to develop a reliable and global Space Weather forecasting to protect astronauts and satellites in space and power grids on the grou

Solar Minimum Explodes




"Solar Extreme Events - 2003" collaboration
was established just after the first solar storm
in the end of October, 2003
by initiative
of Skobeltsyn Institute of Nuclear Physics
of Moscow State University
SOLAR EXTREME EVENTS of 2003: Fundamental Science and Applied Aspects
SEE
SEE
2003
Moscow State University

CRD Research Profile

- Cosmic Ray Astrophysics – Research of Cosmic Ray Sources and Acceleration Mechanisms by ground based surface detectors.
- Solar Physics – Detection on Earth by neutron monitors and muon telescopes Solar Energetic Particles.
- Monitoring and Forecasting of the Space Weather.
- Multivariate Data Analysis - Monte Carlo Statistical Inference

Space Weather Observatory at Aragats mountain in Armenia*

A.Chilingarian[a], K.Arakelyan[a], K.Avakyan[a], V.Babayan[a], N.Bostanjyan[a], S.Chilingarian[b], V.Danielyan[a], A.Daryan[a], A.Egikyan[a], V.Eganov[a], G.Gharagyozyan[a], S.Ghazaryan[a], T.Hairapetyan[a], A.Hovhanissyan[a], T.Hovhannisyan[a], G.Hovsepyan[a], V.Ivanov[a], G.Karapetyan[a], G.Kostanyan[a], L.Kozliner[a], N.Gevorgyan[a], H.Martirosyan[a], L.Melkumyan[a], M.Nazaryan[a], A.Reimers[a], G.Rostomyan[a], S.Tserunyan[a], Kato[c], K.Munakata[c], S.Yasue[c], M.Zazyan[a].

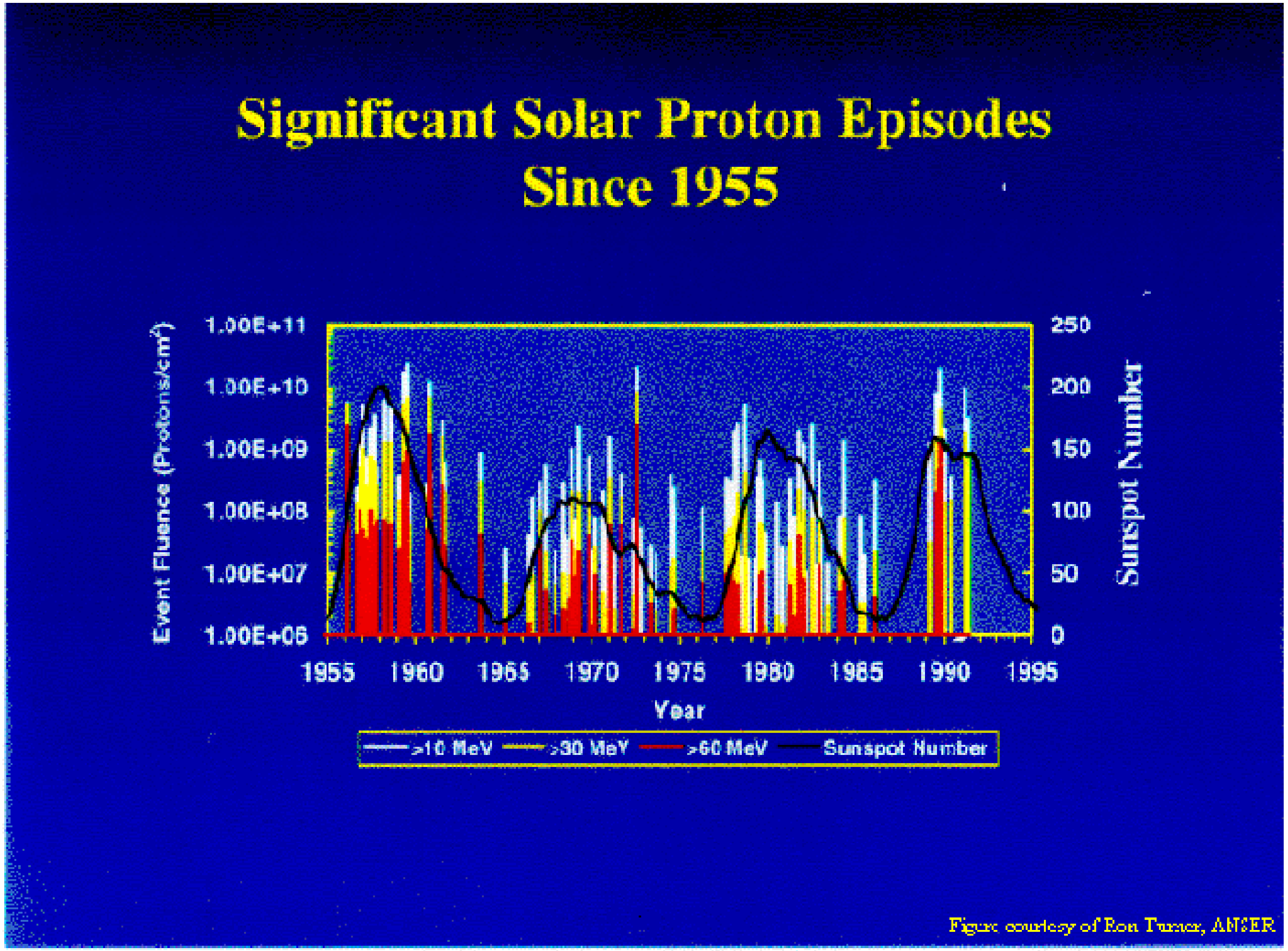
(a) Alikhanyan Physics Institute, Yerevan, Armenia, Alikhanyan Brothers 2, Yerevan 375036, Armenia
(b) Institute for Data Processing and Electronics of Research Center, Hermann-von-Helmholtz Platz 1, Karlsrue, Germany
(c) Department of Physics, Faculty of Science, Shinshu University, Matsumoto, Nagano 390-8621, Japan

***A.Chilingarian for the ASEC team, (2005)**

Correlated Measurements of Secondary Cosmic Ray Fluxes

by the Aragats Space-Environmental Center Monitors, **NIM-A,** 543, **483-496.**

Solar Energetic Proton (SEP) Events



Aragats Space-Environmental Center

- Measure as much as possible secondary CR fluxes with different energy thresholds;
- Monitor not only changing count rates, but also correlations between changing CR fluxes;
- Measure directional information;
- Use same detectors for both SW and high energy CR studies;
- Perform simulation of the time-series registered by the ASEC monitors;
- Correlate surface and space-born detectors data assessable from the Internert;
- Be part of world-wide networks;
- Provide forecasting and alerts on severe conditions of the SW.

List of ASEC Monitors

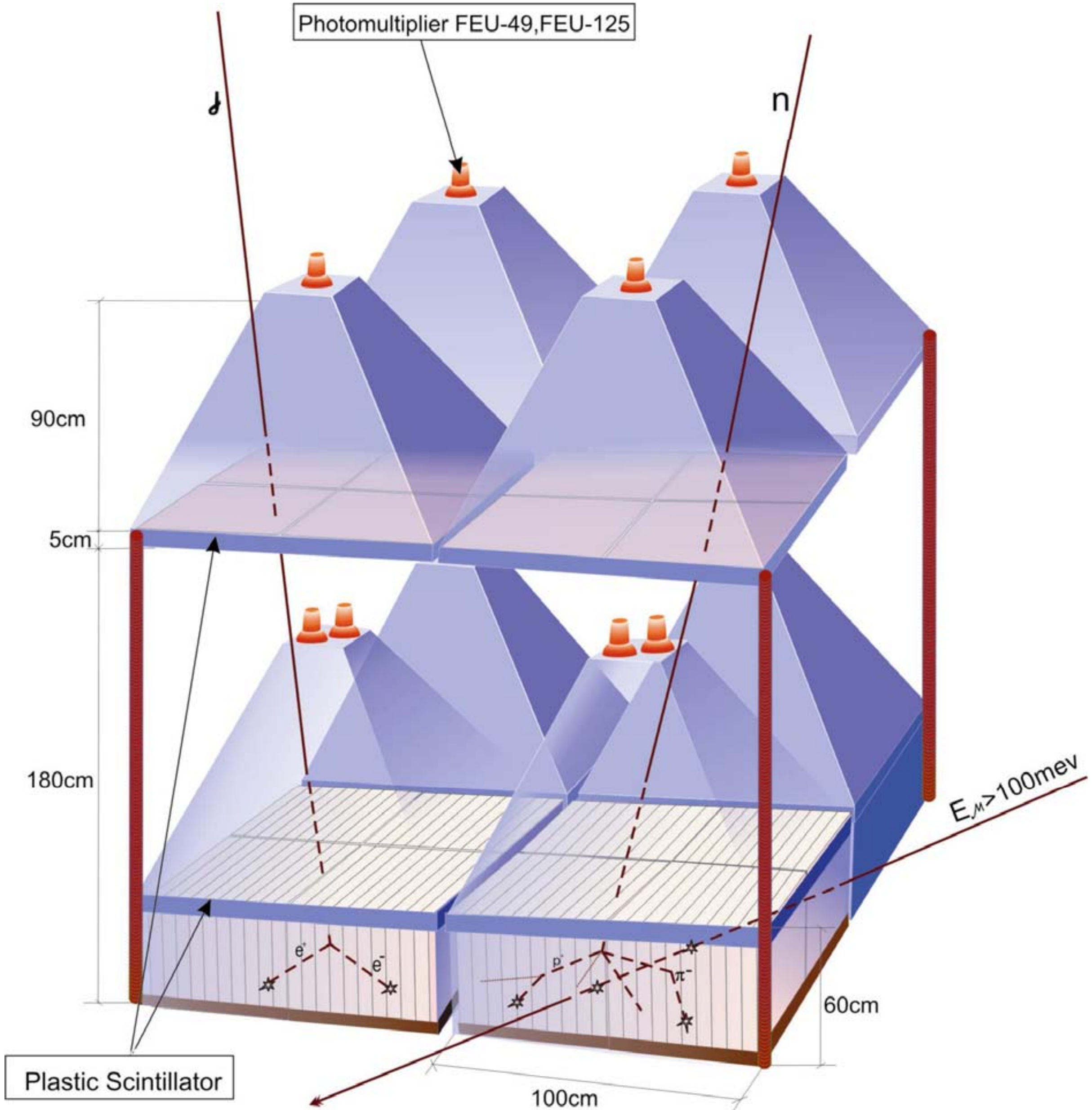
Detector	Altitude *m*	Surface m^2	Threshold(s) *MeV*	Operation	Count rate (min^{-1})
NANM (18NM64)	2000	18		1996	2.5×10^4
ANM (18NM64)	3200	18		2000	6.2×10^4
SNT-4thresholds +	3200	4-60cm thick	130,240,420,700	1998	$4.2\times 10^{4*}$
veto		4- 5cm thick	10		1.2×10^5
NAMMM	2000	5 + 5	$10 + 350^{***}$	2002	$2.5 \times 10^{4**}$
AMMM	3200	48	5000	2002	$1.2 \times 10^{5**}$
MAKET-ANI	3200	6 x 16 groups	10	1996	1.5×10^5

*Count rate for the first threshold; near vertical charged particles are excluded

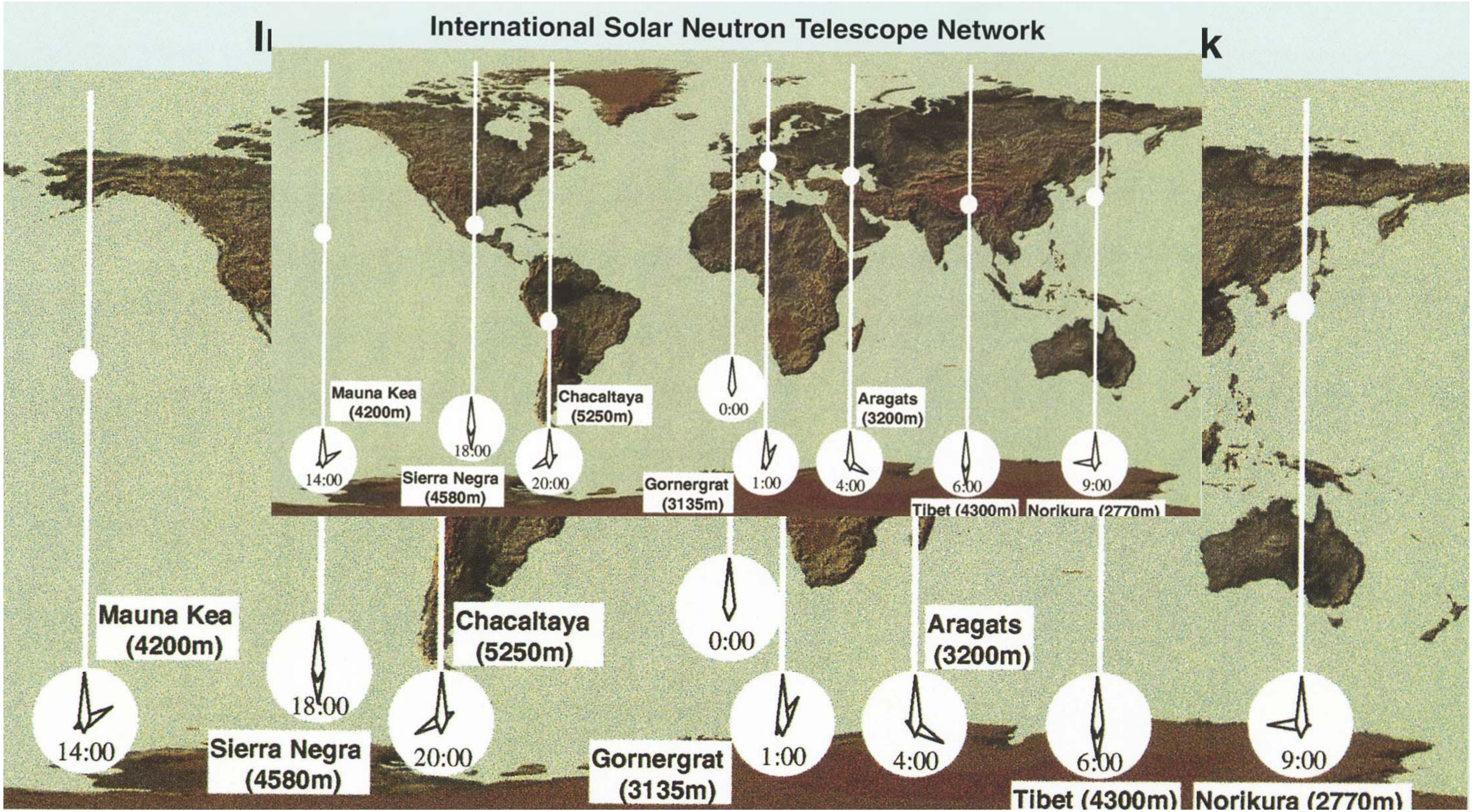
**Total count rate of 48 muon detectors from 100

*** First number – energy threshold for the upper detector, second number - bottom detector.

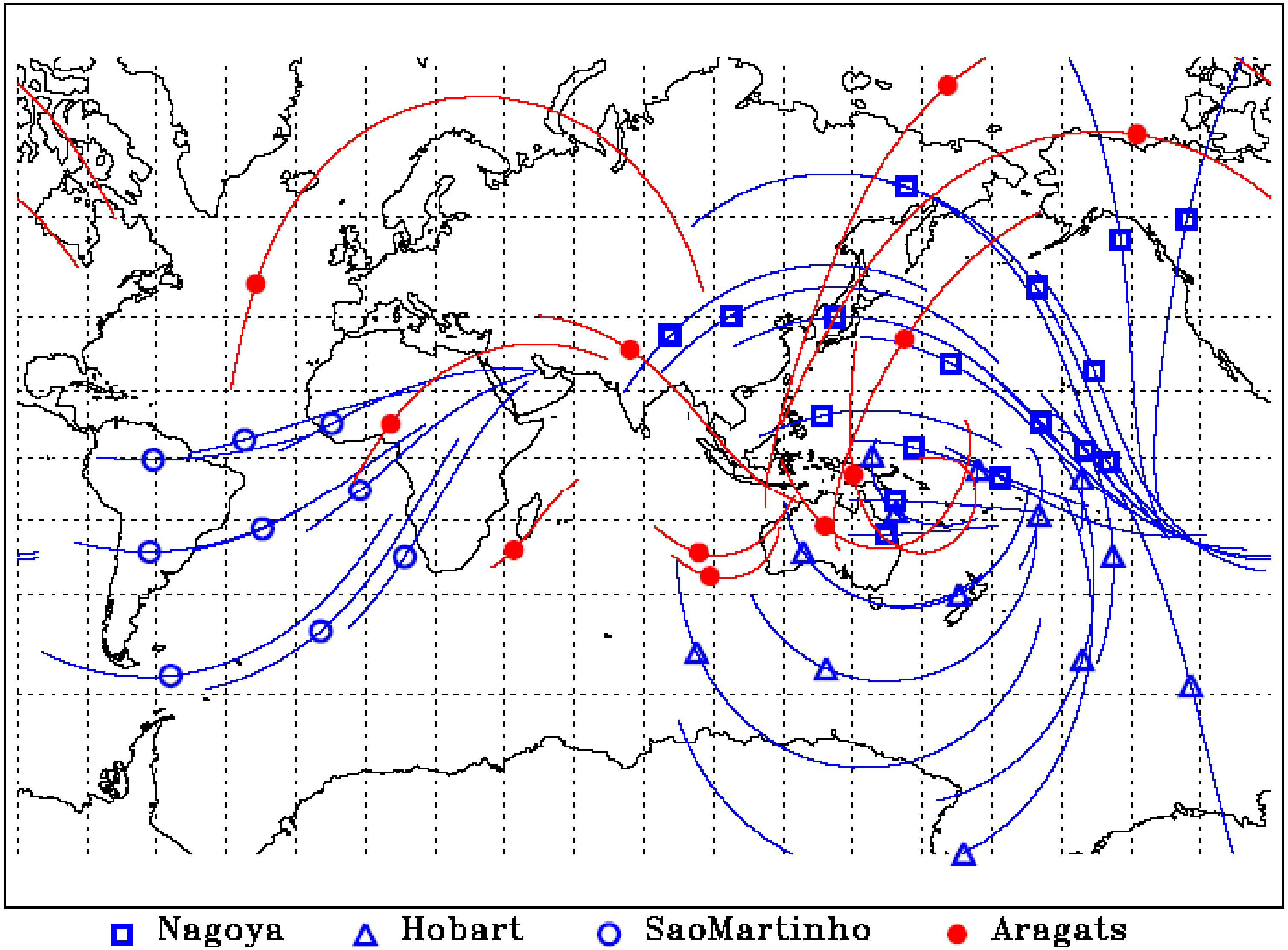
Solar Neutron Monitor



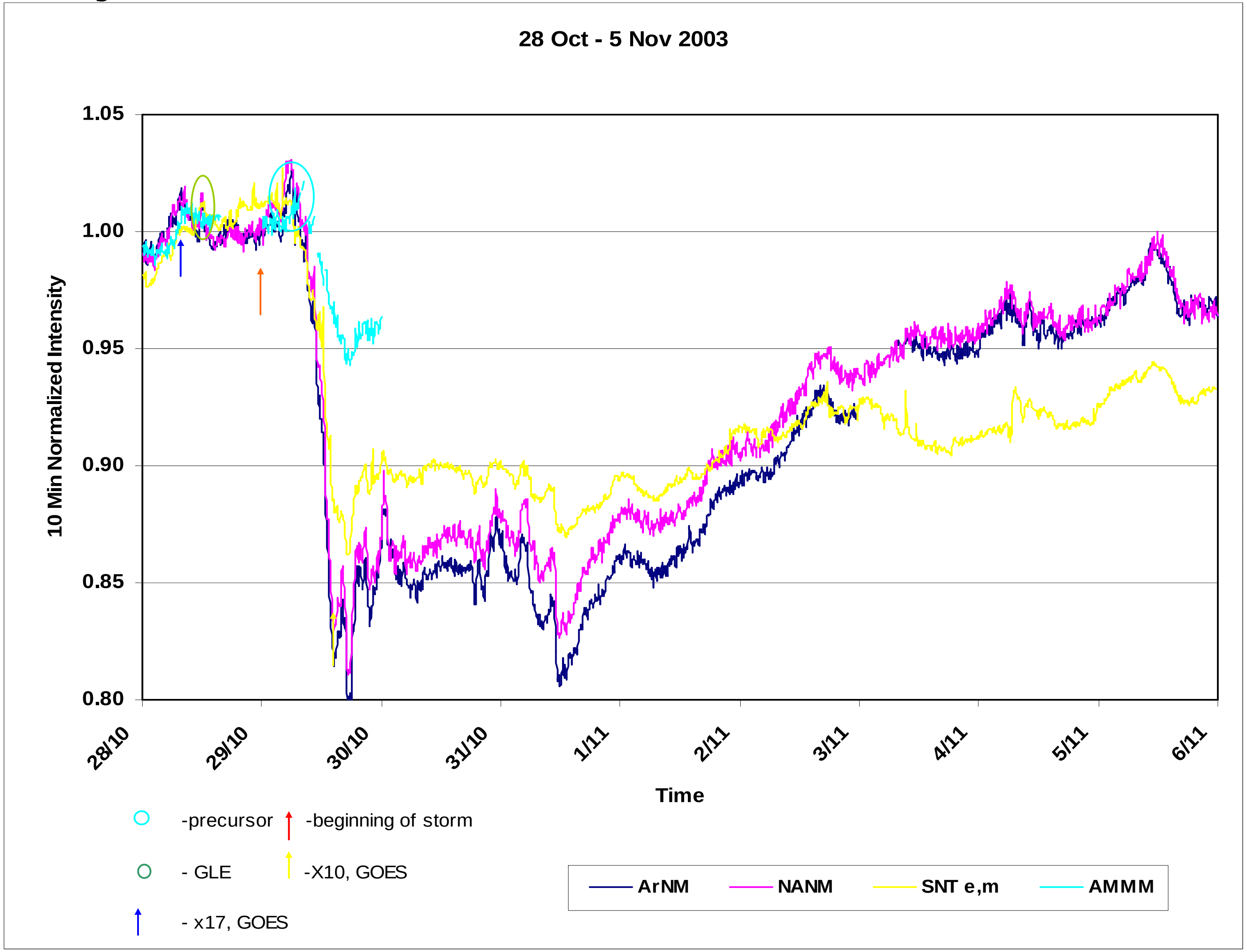
Worldwide network of neutron detectors



Worldwide network of muon detectors



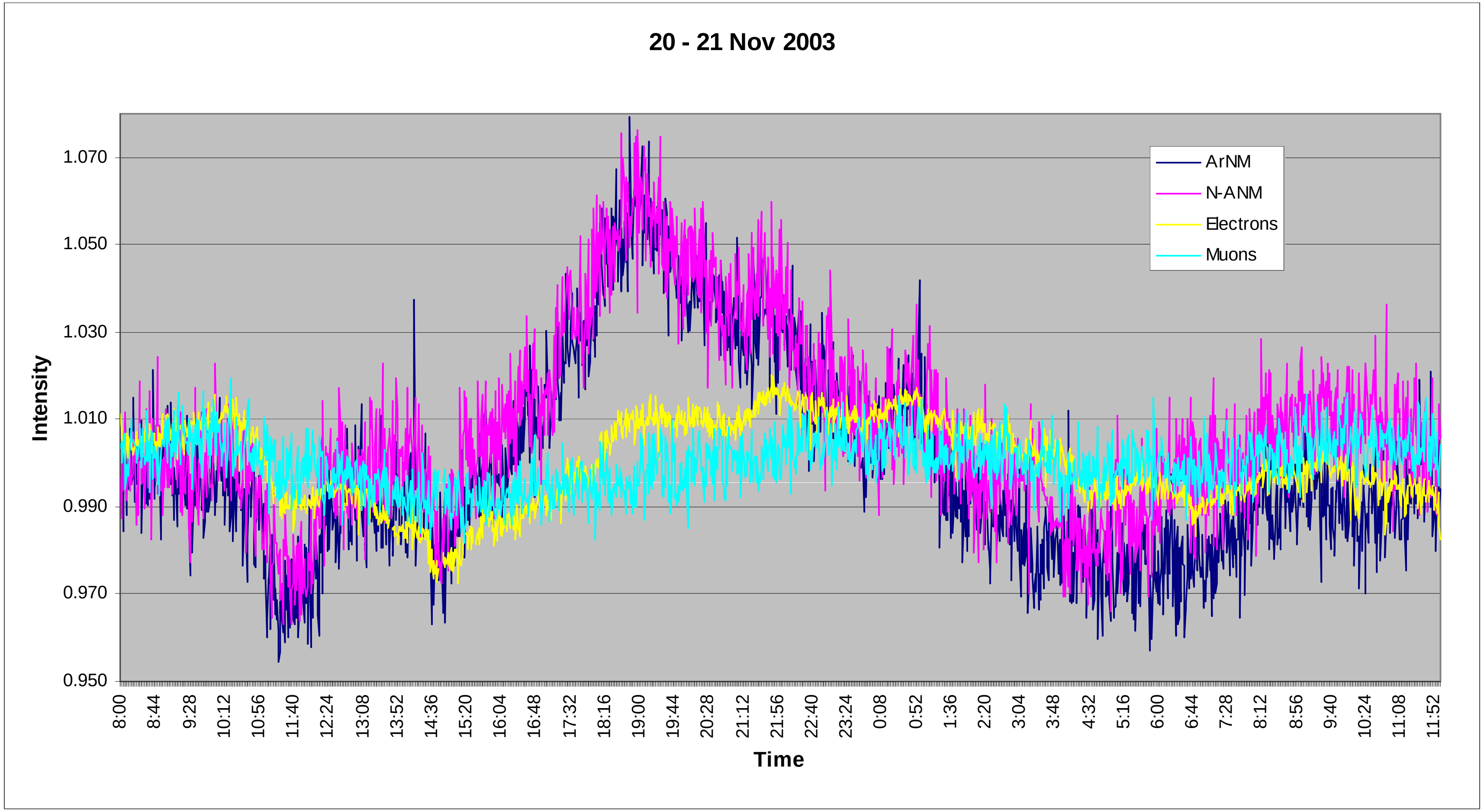
Famous "Halloween" events of 2003, detected in electron & muon and neutron fluxes by ASEC monitors at different altitudes



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**

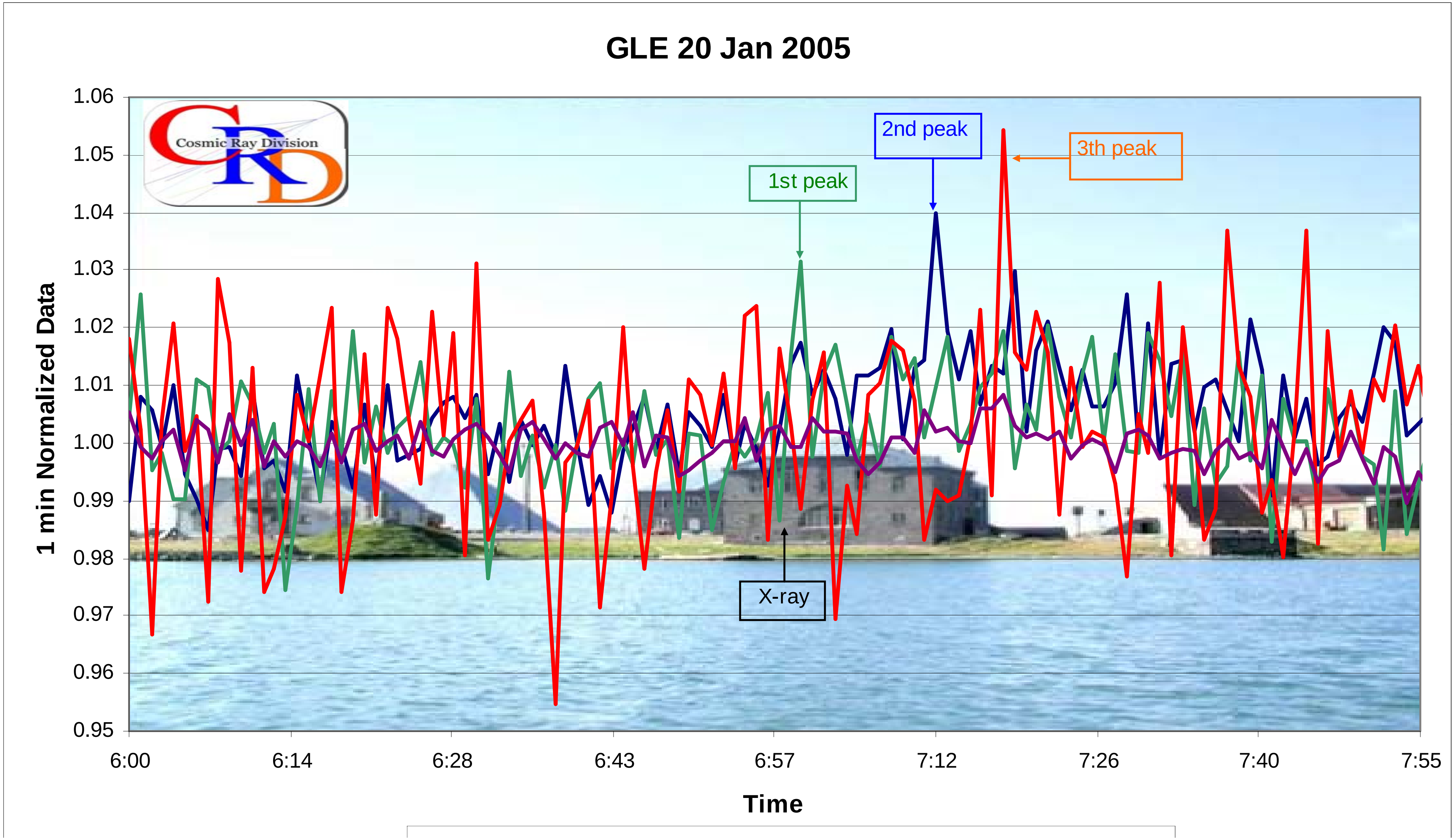
Geomagnetic Disturbance of 20 November

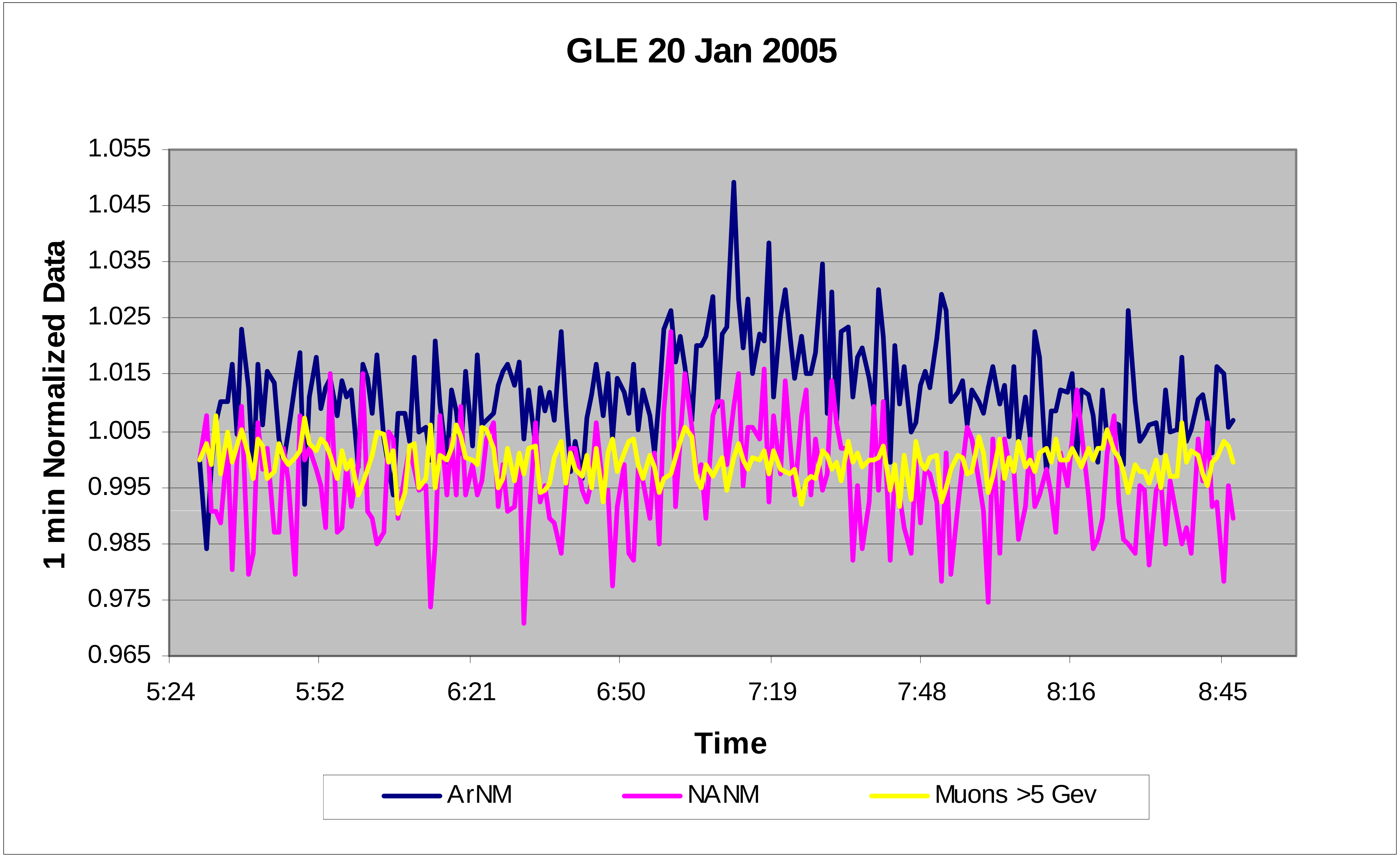


Correlation Matrix of ASEC monitors for 20-21 November 2003 г. (14:40 – 6:00), Geomagnetic Storm

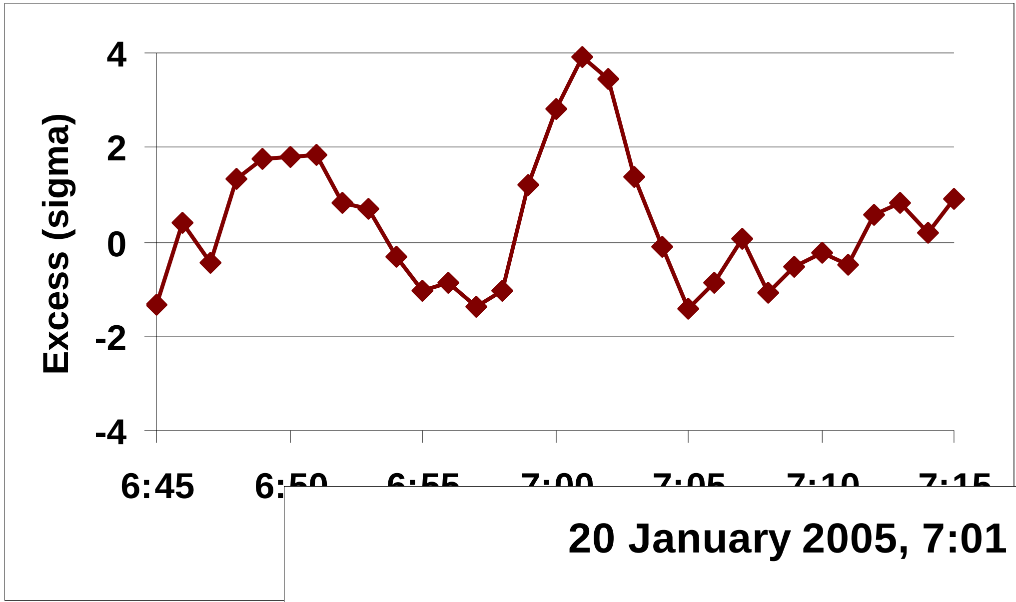
	ArNM	NANM	AMMM	SNTe,μ	SNT thr1	SNT thr2	SNT thr3	SNT thr4
ArNM	1	0.89	-0.01	0.47	0.81	0.85	0.67	0.38
NANM	0.89	1	-0.04	0.44	0.79	0.83	0.65	0.35
AMMM	-0.01	-0.04	1	0.53	0.14	-0.04	0.13	0.13
SNTe,μ	0.47	0.44	0.53	1	0.62	0.36	0.50	0.36
SNT thr1	0.81	0.79	0.14	0.62	1	0.87	0.72	0.43
SNT thr2	0.85	0.83	-0.04	0.36	0.87	1	0.81	0.48
SNT thr3	0.67	0.65	0.13	0.50	0.72	0.81	1	0.68
SNT thr4	0.38	0.35	0.13	0.36	0.43	0.48	0.68	1

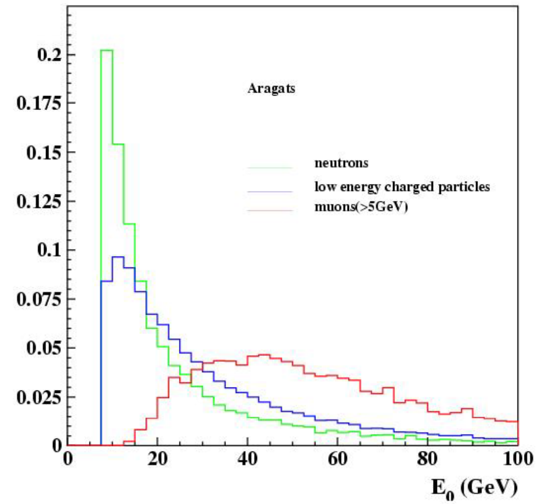
Largest Ground Level Enhancement (GLE) in nearly half a century: 20 January 2005, as detected by ASEC monitors

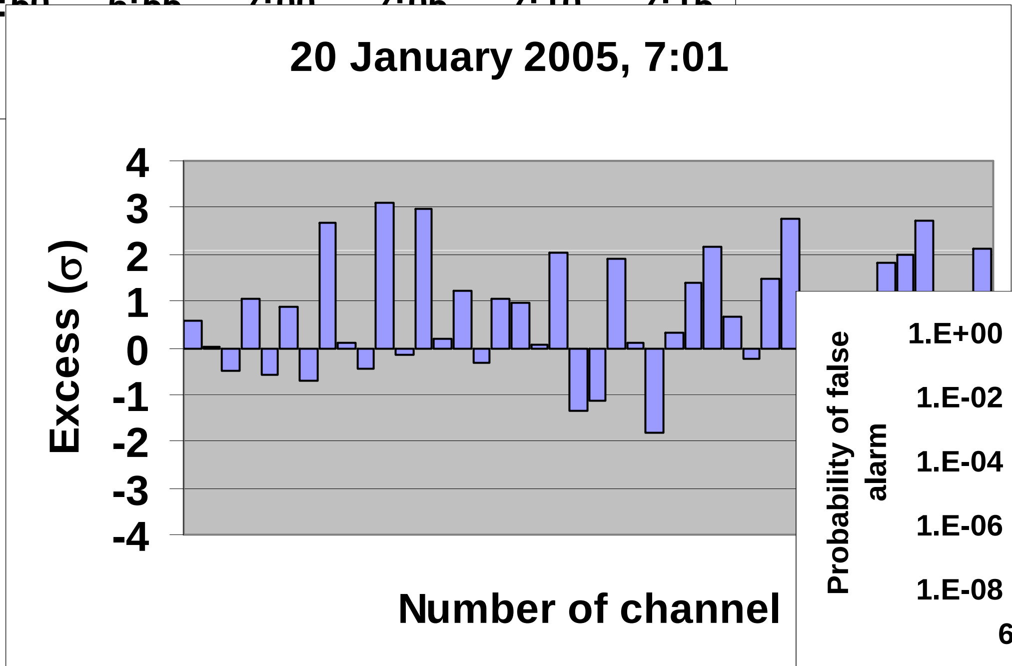


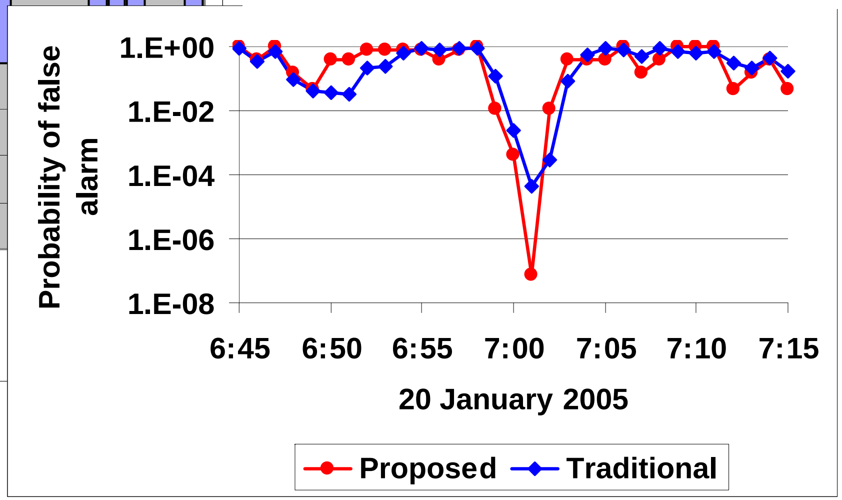

GLE 20 Jan 2005
1 min Normalized Data
1.055
1.045
1.035
1.025
1.015
1.005
0.995
0.985
0.975
0.965
5:24
5:52
6:21
6:50
7:19
7:48
8:16
8:45
Time
ArNM
NANM
Muons >5 Gev

January 20, 2005, >5GeV muons

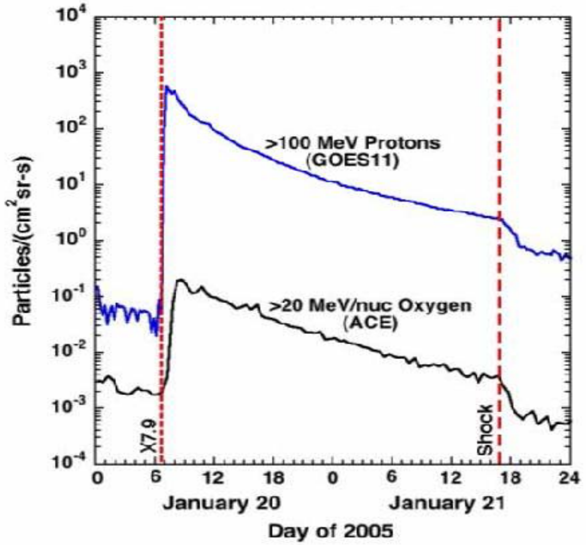


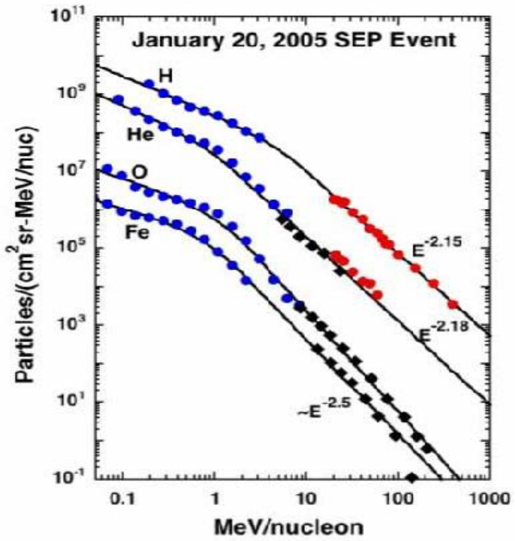






Spectra at ~10 GeV



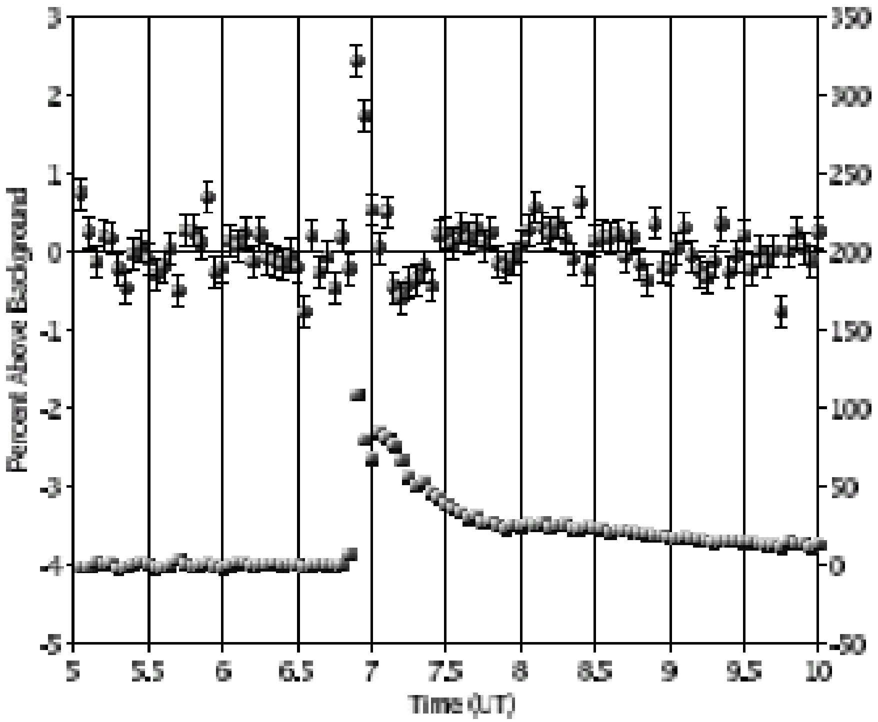


I(E) = A* E**(-γ)
part/(m2 sr s GeV)

γ	R(Ar/NM/ NANM)
4	1.19
5	1.26
6	1.29
7	1.30
Exp.	1.24

γ	Aragats NM	Nor-Amberd NM
4	105%	88%
5	10.5%	8.5%
6	1.4%	1.1%
7	0.15%	0.12%
Exp.	1.52%	1.23%

A 9.9sigma excess is seen in the single muon countingrate of GRAND detector from 6:51–6:57.

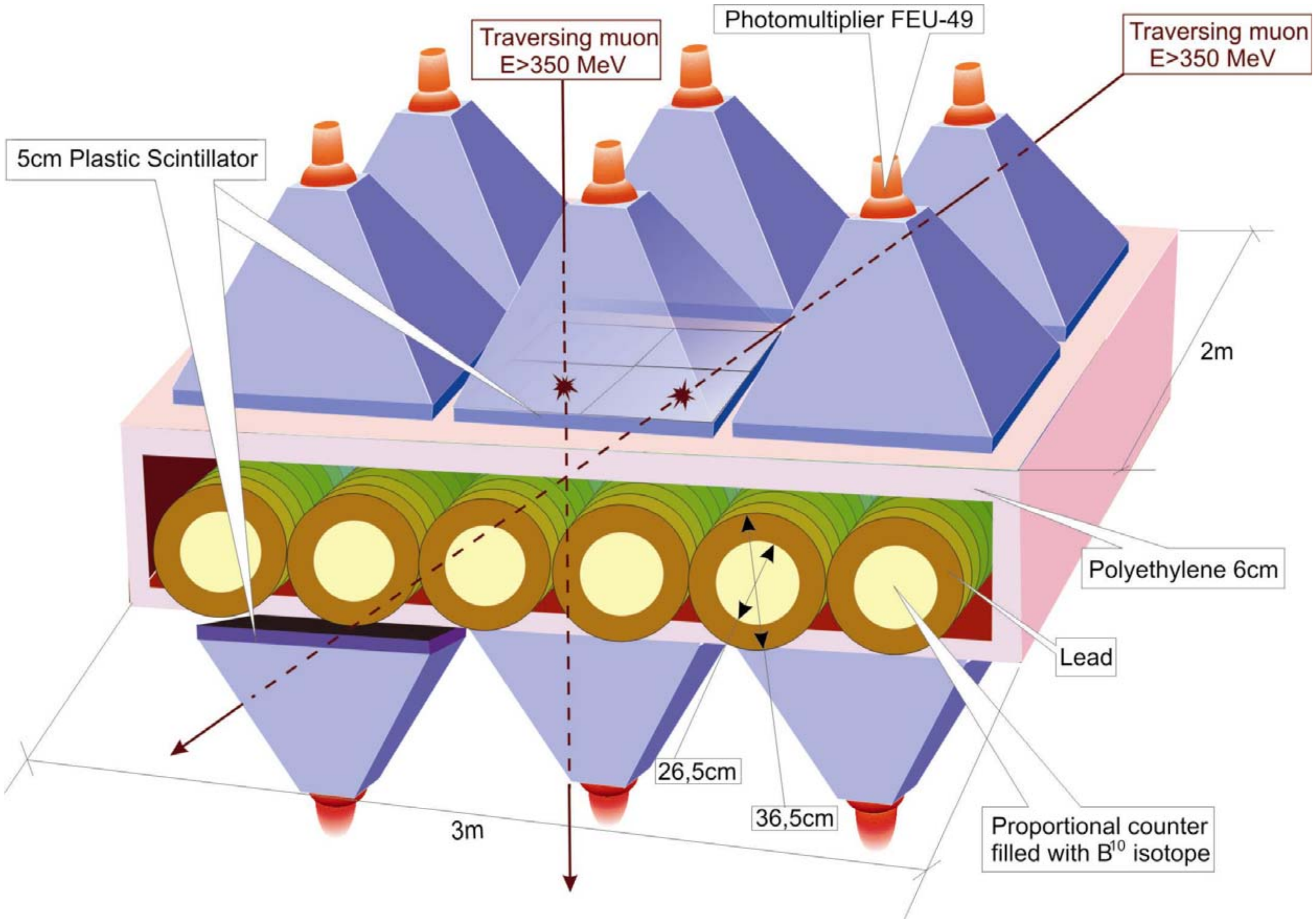


Data from Project GRAND (Rc ~2.1GV, left scale) and Newark neutron monitor (Rc ~ 0.8 GV squares, right scale) in threeminute bins as a percentage deviation from background.

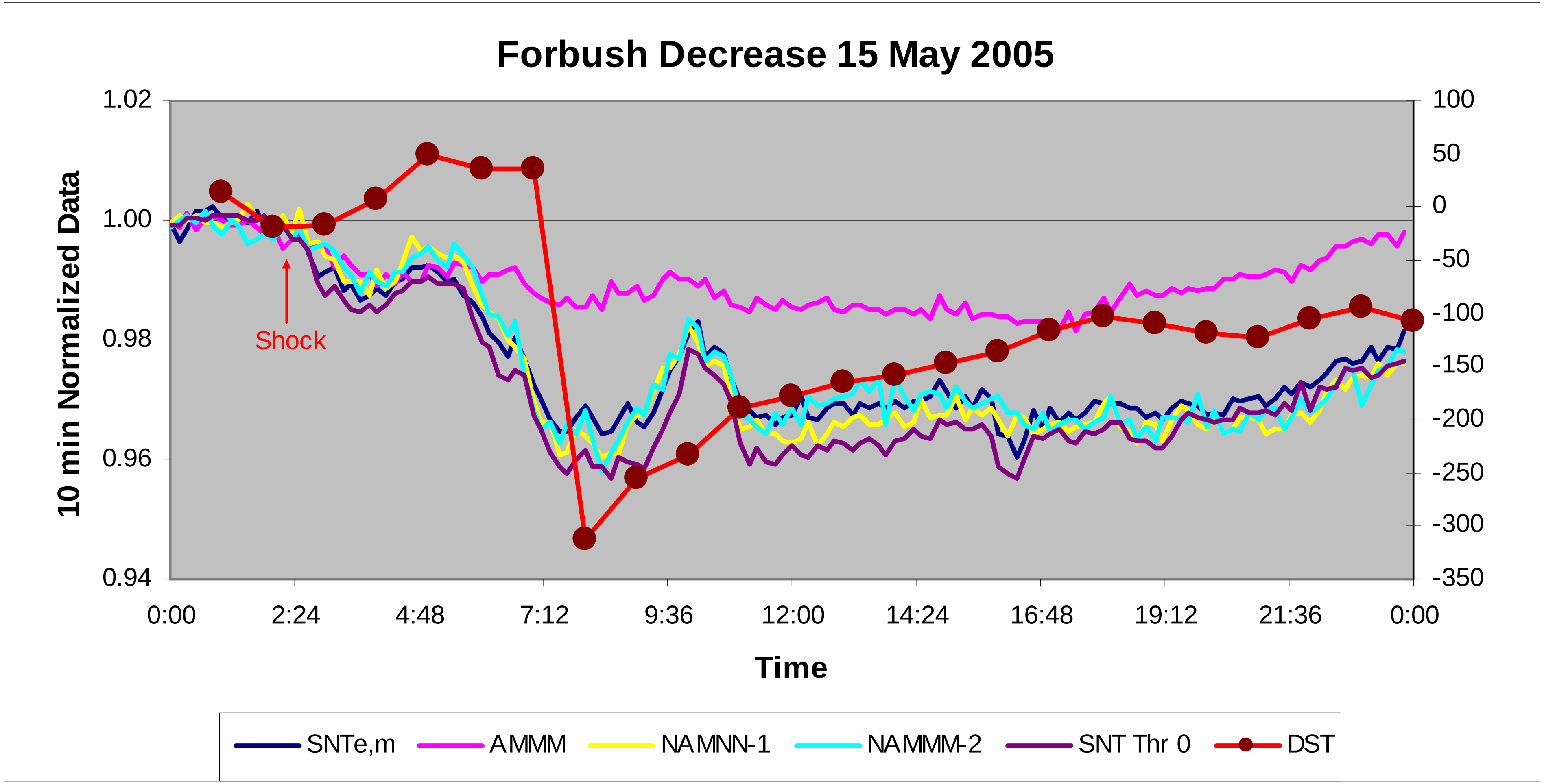
For galactic cosmic ray energy spectra, our median primary energy is **52 GeV** (K. Munakata, private communication, 2004), but this **would be lower for the softer spectrum expected for particles emitted from the sun during a flare**.

The FLUKA Monte Carlo code is utilized to predict GRAND's response toprimary hadrons and gamma rays. Assuming a primary spectral index of 2.4, the peak sensitivity is for a primary energy of **10 GeV**, whether it be a gamma rayor hadronic primary.

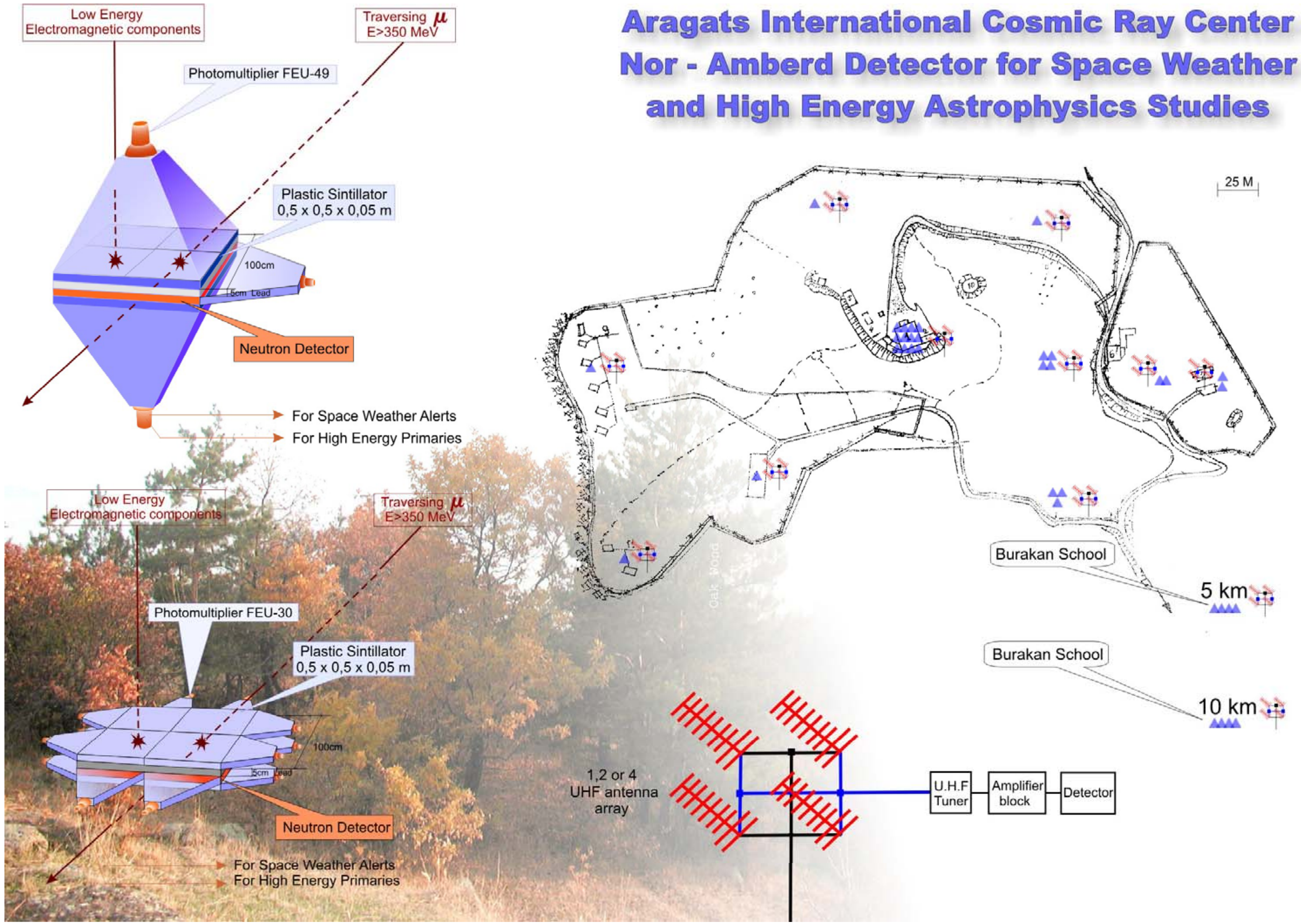
Nor Amberd Multidirectional Muon Monitor



Fd from 15 May 2005 as detected by the ASEC monitors (charged particles detectors)



Aragats International Cosmic Ray Center
Nor - Amberd Detector for Space Weather and High Energy Astrophysics Studies



International Heliophysical Year: IHY: 2007

- "Heliophysical" is an extension of the word "Geophysical", extending the connections from the Earth to the Sun & interplanetary space. The 2007 "IHY" activities will build on the success of IGY 1957 by continuing the legacy of system-wide studies.
- The objective of the IHY is to discover the physical mechanisms at work which couple the atmosphere of the Earth to events that drive them from the heliosphere. The systematic global study of this connection is to be the central theme of the IHY:
- To obtain a coordinated set of observations to study at the largest scale the solar-generated events which affect life and climate on Earth.
- To document and report the observations and provide a forum for the development of new scientific results utilizing these observations.
- To foster international cooperation in the study of heliophysical phenomena now and in the future.
- To communicate the unique scientific results of the IHY to the interested scientific community and to all peoples of Earth.
- More information from: http://ihy.gsfc.nasa.gov/

SPACECRAFT OR OBSERVATORY	INSTRUMENT OR OBSERVATION TYPE	INSTRUMENT EXPERT/ PLANNING CONTACT
Advanced Composition Explorer (ACE)	Cosmic Ray Isotope Spectrometer (CRIS)	Eric CHRISTIAN
	Electron, Proton and Alpha Monitor (EPAM)	Eric CHRISTIAN
	Magnetometer (MAG)	Chuck SMITH
	Solar Energetic Particle Ionic Charge Analyzer (SEPICA)	Eberhard MOEBIUS
	Solar Isotope Spectrometer (SIS)	Eric CHRISTIAN
	Solar Wind Electron Proton Alpha Monitor (SWEPAM)	Eric CHRISTIAN
	Solar Wind Ion Composition Spectrometer (SWICS)	Eric CHRISTIAN
	Solar Wind Ions Mass Spectrometer (SWIMS)	Eric CHRISTIAN
	Ultra Low Energy Isotope Spectrometer (ULEIS)	Eric CHRISTIAN
 Aragats Space Environmental Center (ASEC) of Alikhanian Physics Institute, Armenia	Neutron Flux Monitor, Multidirectional Muon Monitor and Surface Scintillation Array	Ashot CHILINGARIAN
Astronomical Observatory in Ulaanbaatar, Mongolia	Solar Telescope Coronagraph	Damdin BATMUNKH
Australian Government IPS Radio and Space Services	Interplanetary Scintillation and Geomagnetic Observations	Philip J. WILKINSON
Big Bear Solar Observatory (BBSO)	H Alpha Imager	
Bruny Island Radio Spectrometer (BIRS)	Radio Spectrometer	
CANOPUS Project	Ground-Based Magnetometer Array	Ian MANN

Solar Extreme Events: Fundamental Science and applied Aspects (SEE - 2005)

International Symposium Nor Amberd, Armenia 26 - 30 September 2005

Topics

- Energetic processes on the Sun during the extreme events
- Propagation of the solar energetic particles and interplanetary CMEs
- Magnetospheric response to the solar extreme events
- Methodologies of forecasting of space weather conditions Effects of Space Weather on technology infrastructure and human environment

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