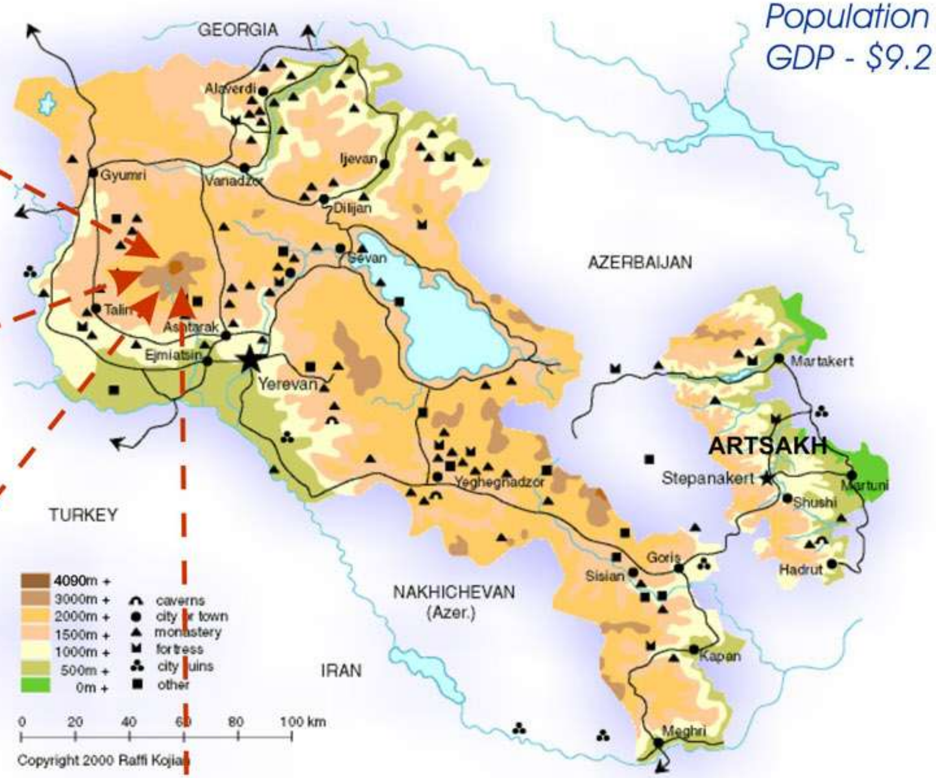
Fundamental science: from idea to Business (commercialization of R&D Results in Armenia)

1. Why (motivation)? Funding suddenly stopped; continue research!
2. How (mechanisms)? Get international grants; develop modern scientific infrastructure; establish well managed organization; be part of world-wide scientific networks; each year enlarge budget; find specific domain where your organization can be world-leader; use and develop modern information technologies;
3. Solve intellectual property problems; solve property problems;
4. Develop strategy of commercialization of products and services

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

Abram Alikhanov and Artem Alikhanyan, First Expedition to Aragats in 1943

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

Nor Amberd Research Station

Aragats Research Station

Opening of the Road to Aragats, May, 2003

Cosmic Ray Division International Projects

CRD

CRDF Grant N AB-2005
Patterns of Gene Expression in Normal and Neoplastic Tissues and Associated Statistical Problems
$38,000

INTAS Infrastructure action Grant
Improvement of the infrastructure of the Aragats international Cosmic Ray Research Center
80,000Euro
2002-2004

NATO Networking infrastructure Grant N 9755436,
Computer network for real-time data transfer using wireless connections
$30,000

NATO Networking infrastructure Grant
Armenian Regional Research and Educational Network Establishment
4,000 Euro

NATO Collaborative Linkage Grant N975954
Construction of reliable data acquisition system for modern Astroparticle Physics experiments $8,000

NATO Collaborative Linkage Grant
Investigation of air shower development in the primary energy region of PeV
1999-2001 $8,000

Armenian-US Bilateral Grants Program
NFSAT Grant
Determination of the Energy Spectrum and Mass Composition of the Primary Cosmic Rays with GAMMA Installion at Mt. Aragats, Armenia $23,000

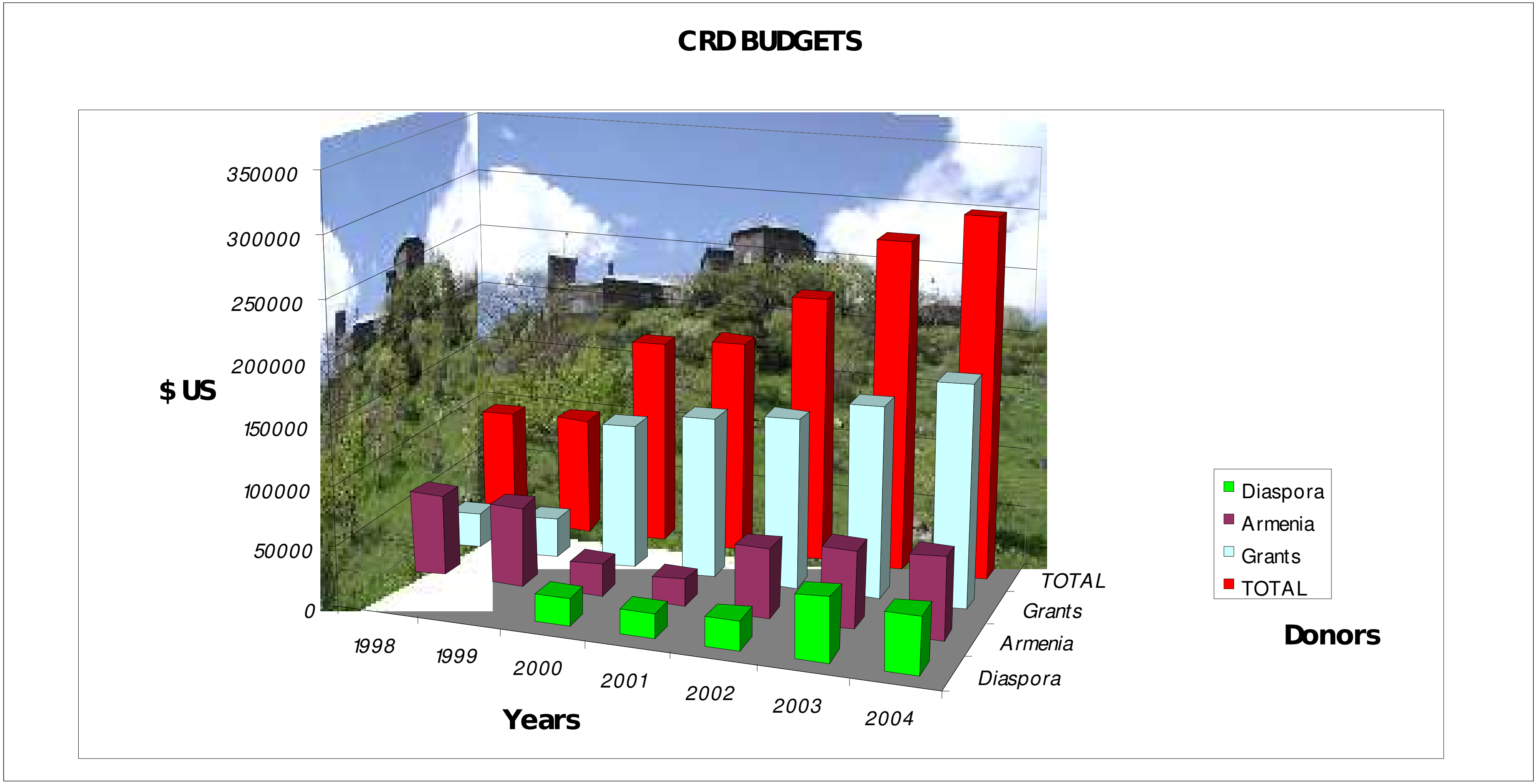
A116: 1997-1999
The Development and Implementation of Applied Neural Information Technologies
$250,000

ISTC A216:2001-2004
Detection of the Neutron Flux from the Solar Flares at the Aragats Cosmic Ray Observatory
$280,000

ICTS A757: 2002-2003
Nonparametric methods of data analysis in Cosmic Ray Astrophysics. An applied theory of Monte Carlo statistical inference.
Monograph $30,000

ISTC A1058 2004-2007
Development of a Prototype Detector System for Space Weather Monitoring and Forecasting World-Wide Network.
$616,000

CRD Funding from Armenian and International Grants 1998-2004



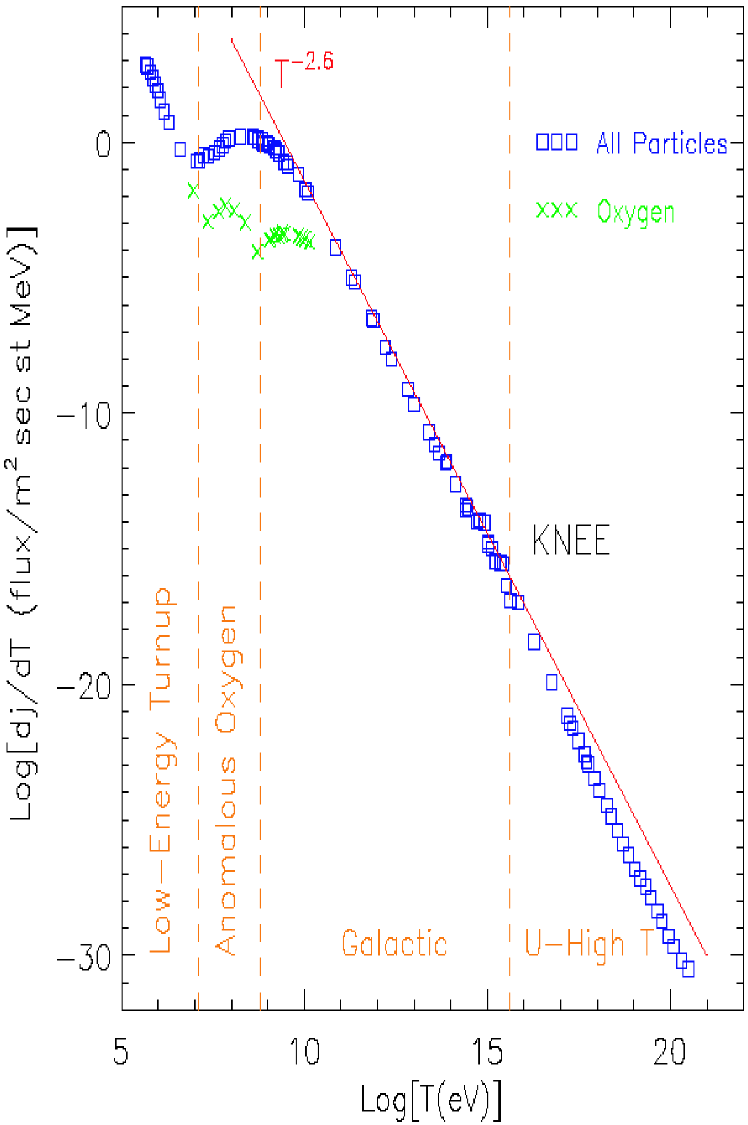
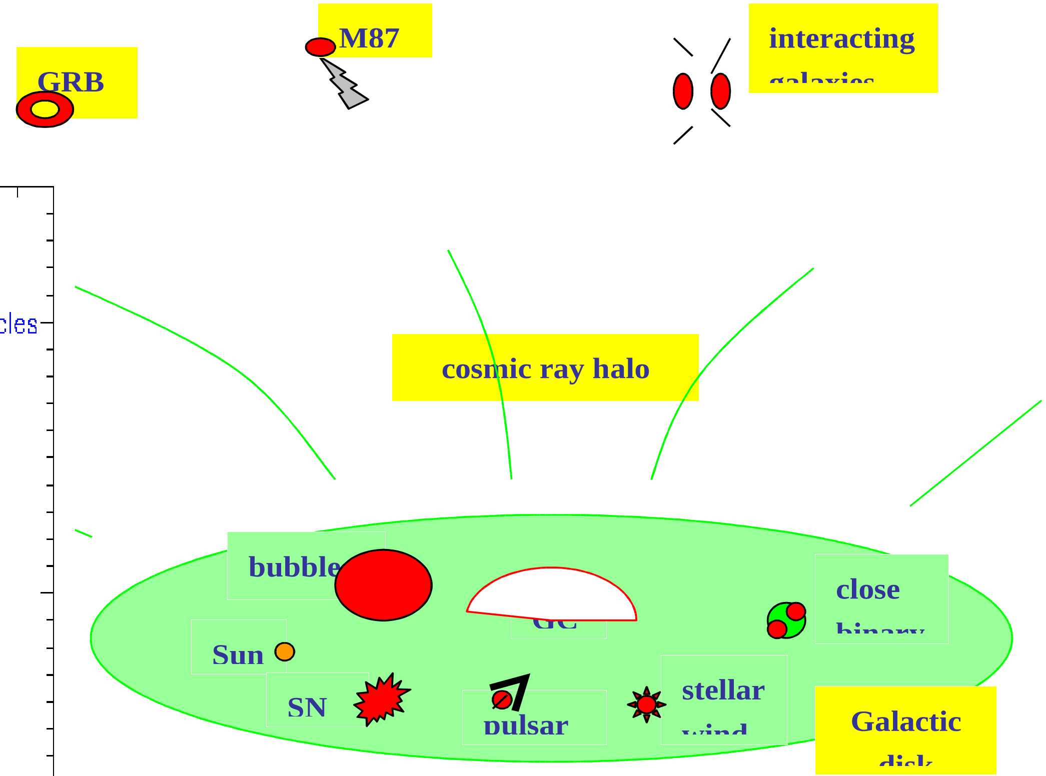


Figure 1 Energy spectrum of cosmic rays measured at the Earth (Jokipii 1989).



We are connected to the Cosmos

- Space-based systems providing critical infrastructure that support the quality of life on Earth. Because of humanity's increasing dependence on space-based systems, spacecraft that can survive and operate through all space environment conditions are required.
- An example of dependence of human technologies on natural catastrophes is the Space Weather. About 1500 satellites are working in space. The cost of building these satellites was $160 billion, launching them into orbit $30 billion. To USA alone the space-born technologies return $225 billion in profits every year and have rapidly become one of largest segments to USA Gross National Product. Space Storms lead to loss of data, degradation of capability, service outages, and, in extreme cases, the loss of satellite.
- It is not possible to achieve cost-effective, "all weather" space systems without accurate knowledge of the Space Weather. Space Storms lead to loss of data, degradation of capability, service outages, and, in extreme cases, the loss of satellite.
- Very few crucial pieces of scientific data are easy to find, and not all essential information is delivered to user in time. The tragic example of December 2004 Tsunami, gives an example of very poor state of distribution of information on upcoming catastrophes. We are developing early warning system on severe Space Storms – our project ***"Data Visualisation Interactive Network for the Aragats Space-environmental Center" –*** *DVIN for ASEC*, was announced as the world's best project in the category of e-science at the first World Summit on the Information Society (WSIS) 2003 in

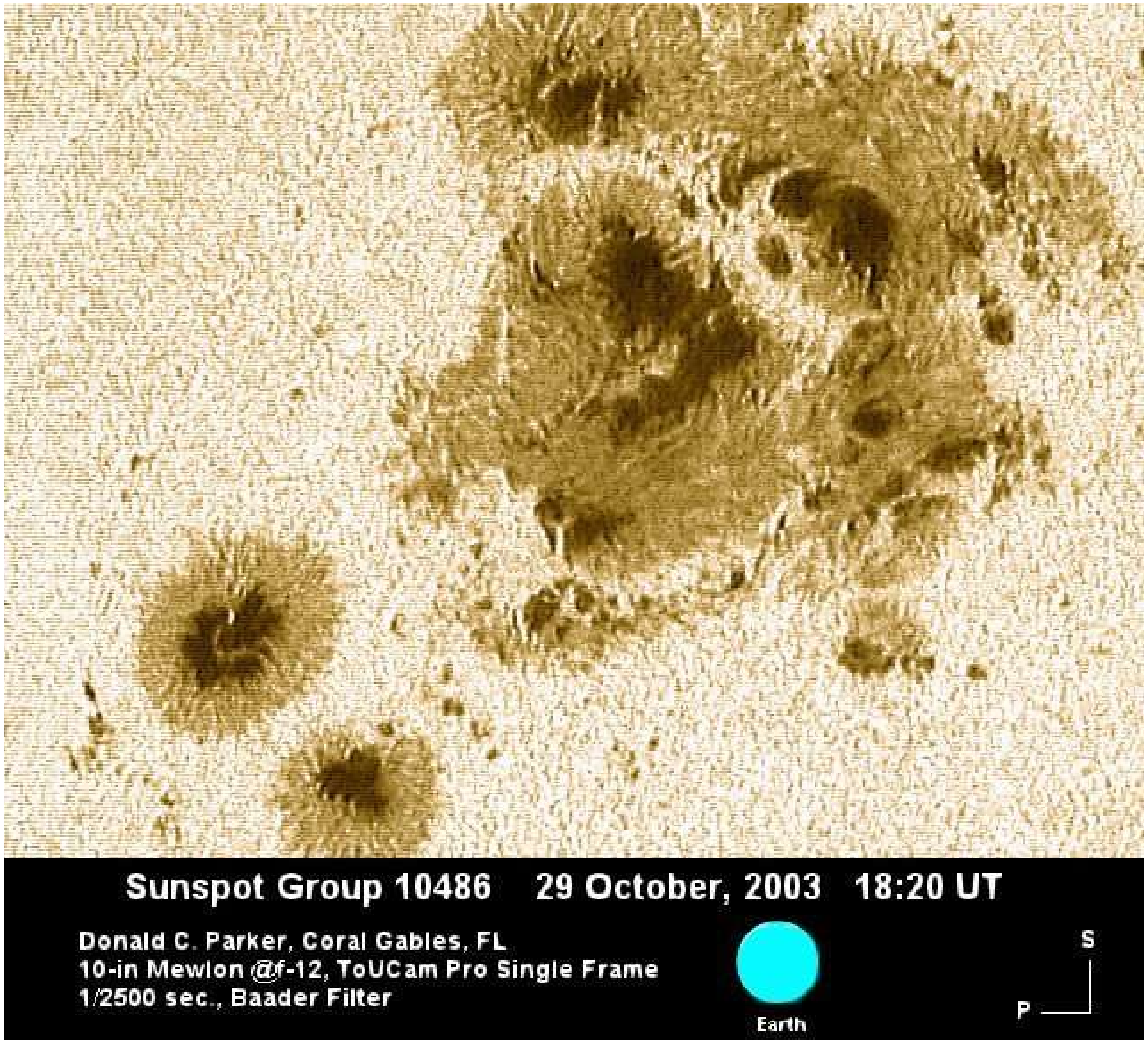
Space Weather can affect satellites

- For semiconductor microelectronics, the electric charge induced when a heavy ion passes through the part, or when particle has a nuclear interaction in the part, is often comparable with the spurious charge moving in device circuits. Thus, the device's state can be changed. This can result in various types of transient or permanent single event effects (SEE) such as upset, latchup or burnout of the device.
- Space weather can raise temperatures in the outer reaches of the atmosphere, causing the atmosphere to expand, snatch satellites from orbit by increasing drag.
- The other main danger to satellites is charging and electrical shorts caused by the magnetic activity and accelerated particles.

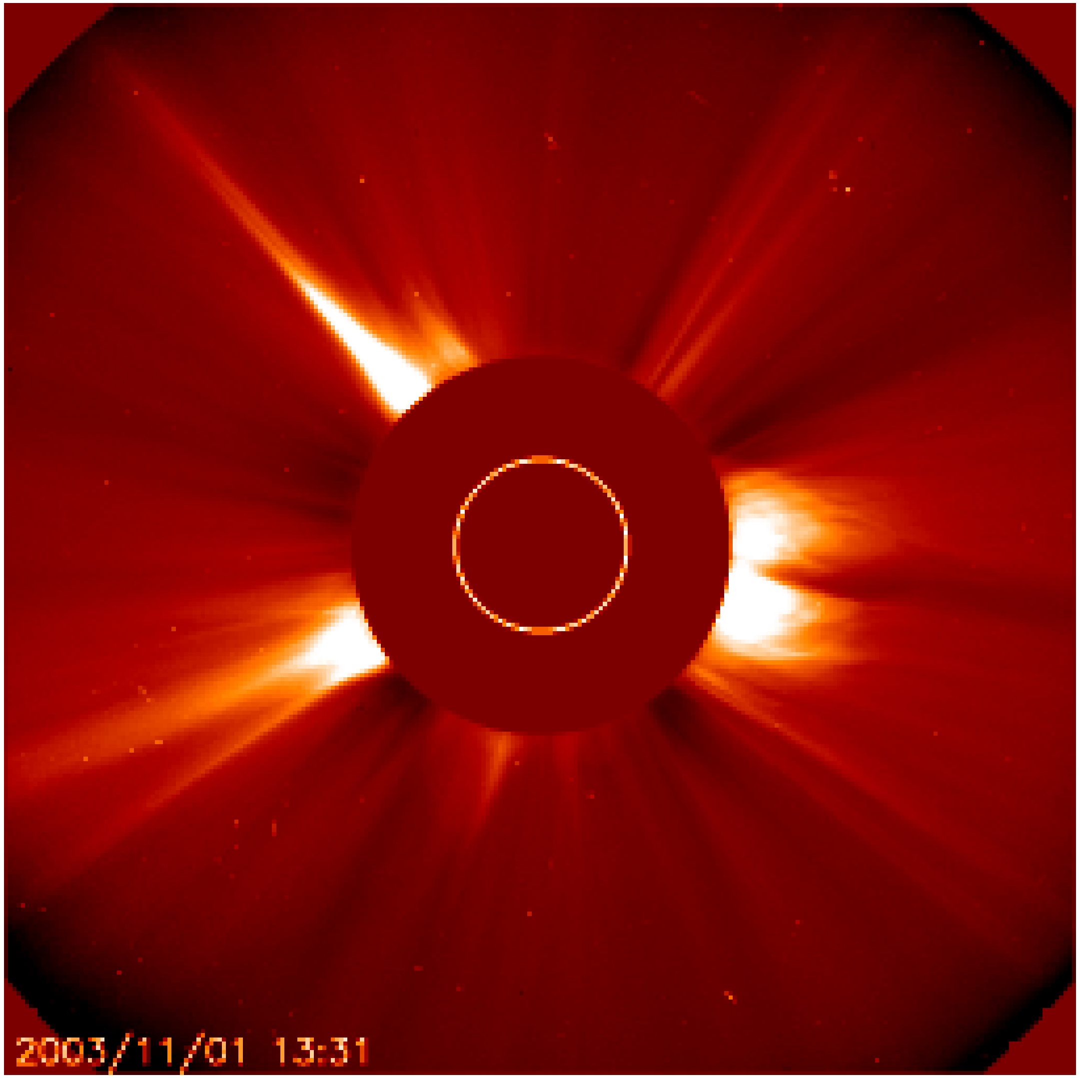
Space Weather can effect everyday lives

- Solar events occur at a magnitude of violent force and energy that equals the power of a billion hydrogen bombs, fortunately people on the ground are not at risk from solar storms, protected by the magnetosphere and atmosphere, but…
- space Storm Causes Power Outages, a power grid in Canada was tripped by a 1989 storm, and electricity to the entire province of Quebec was lost for about 9 hours;
- airline passenger can experience as much radiation as 10 chest X-rays elevated doses of radiation can be experienced on high-altitude flights, caused airlines to reroute commercial flights;
- radio communications were disrupted, at least two key U.S. communications satellites were disabled by solar weather in the late 1990s, causing failures in personal pagers, television broadcast and some airline traffic communications;
- increase the probability of latent cancer formation in the astronaut/space traveler cohort.

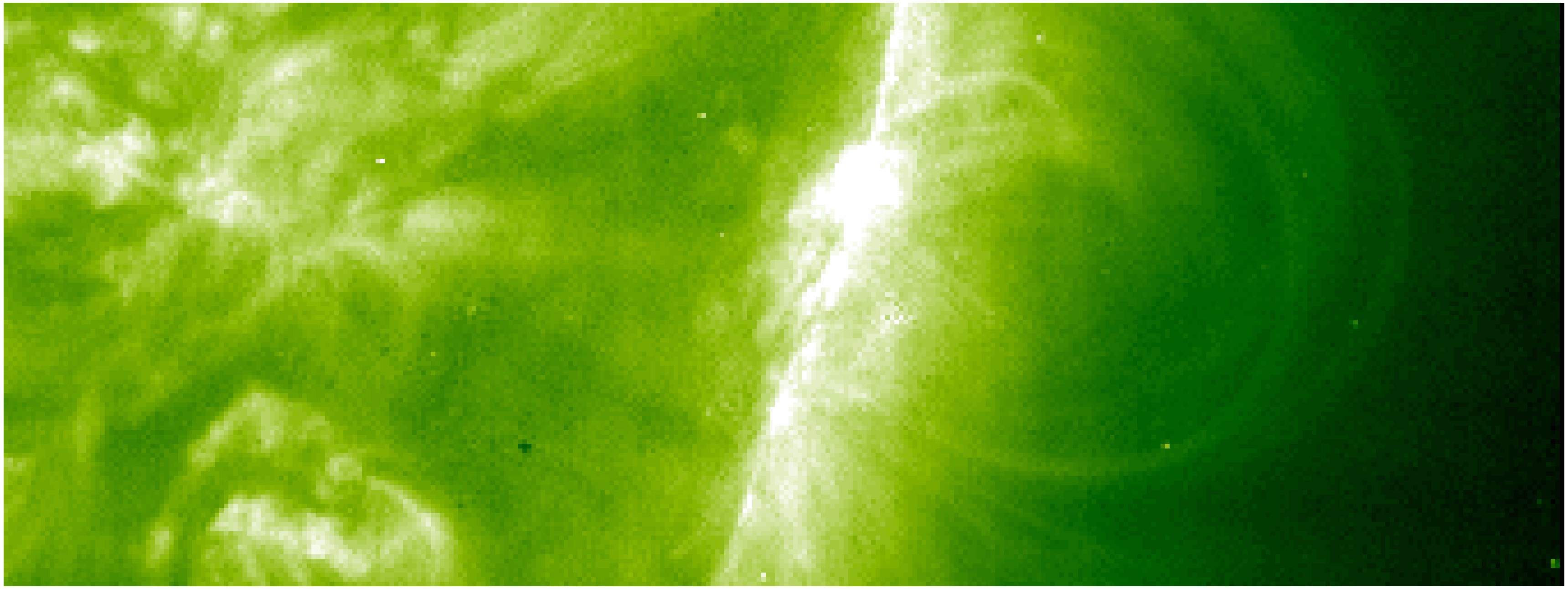
Spot group 486,October 29, 2003



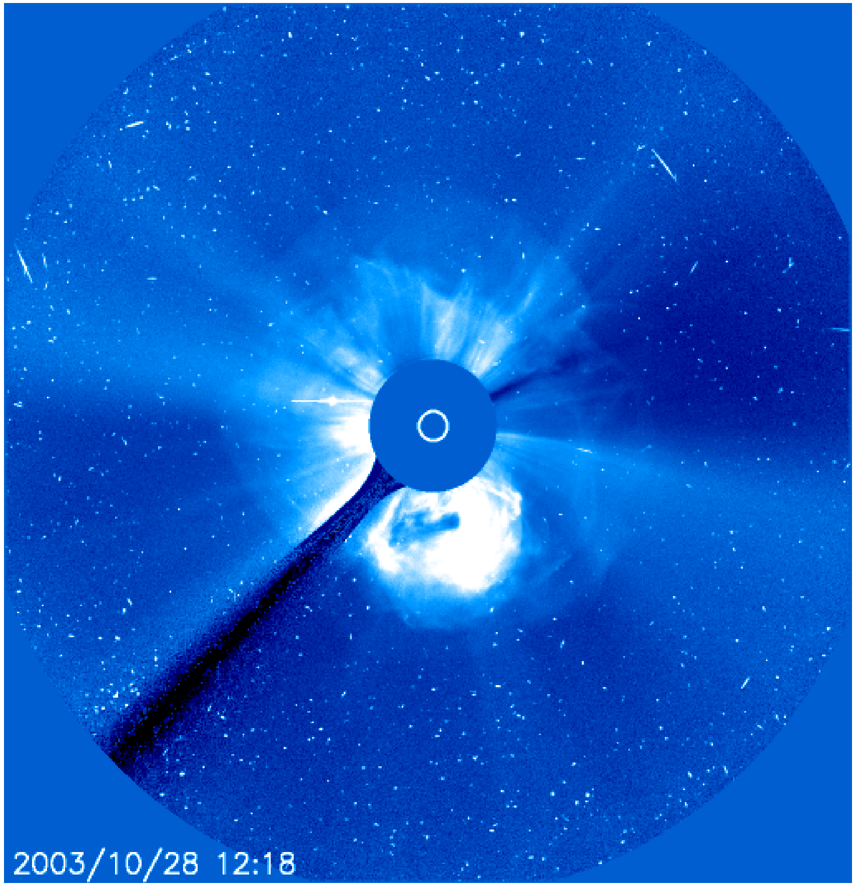
Strongest Flare of Satellite Era

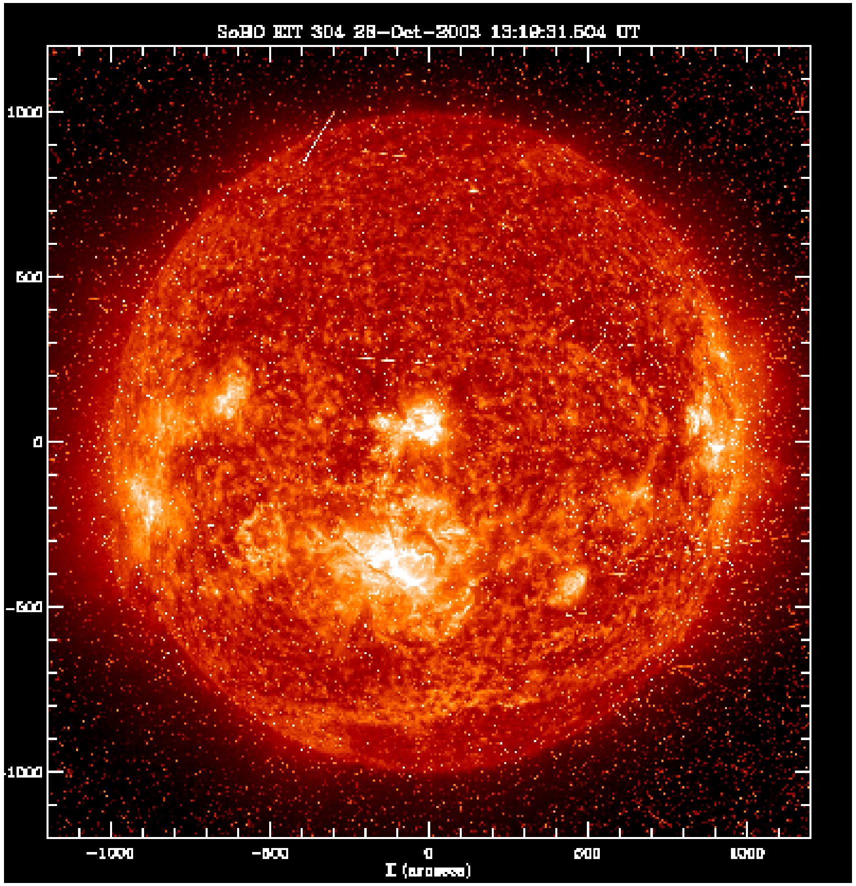


November 4 >X20 = X45 flare

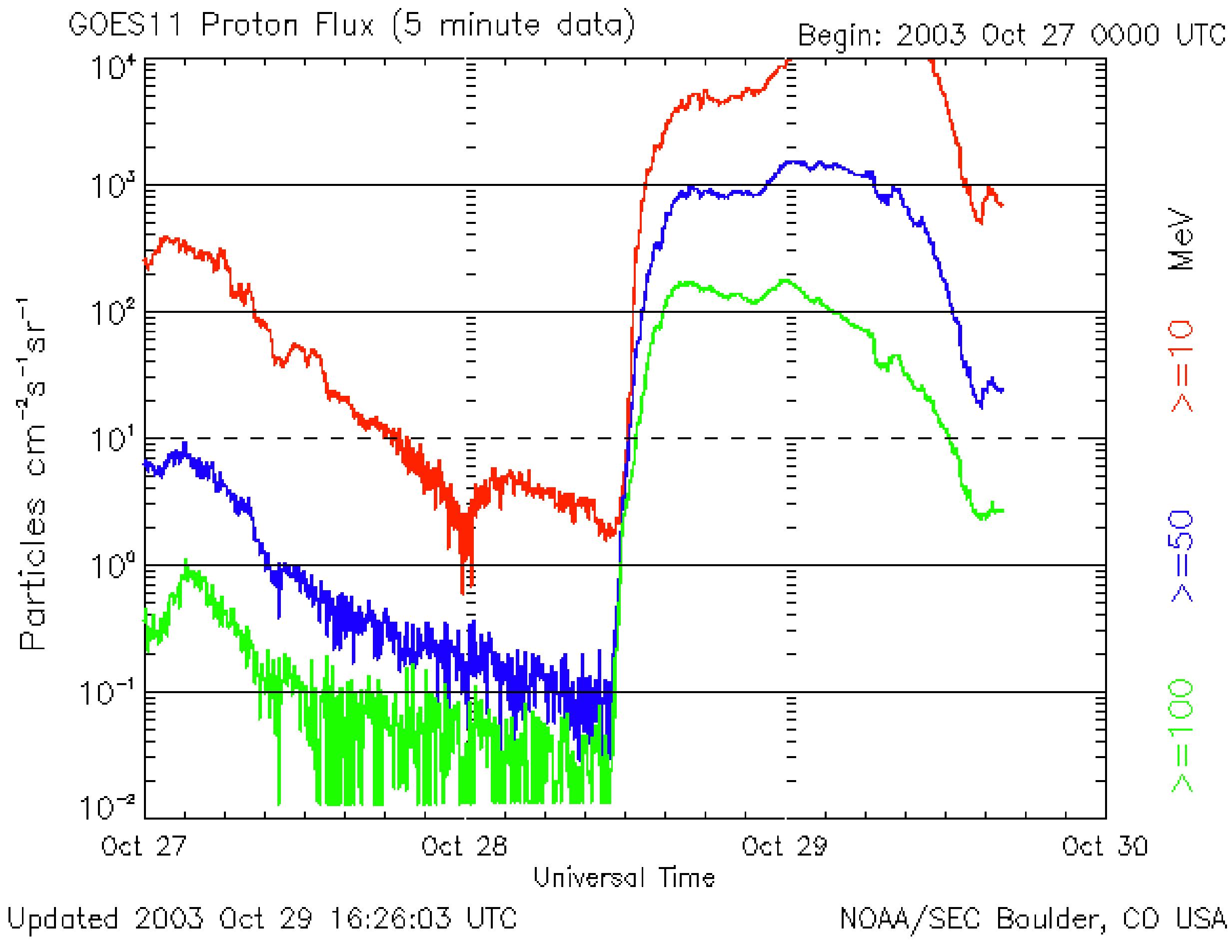


28 October, X17 flare

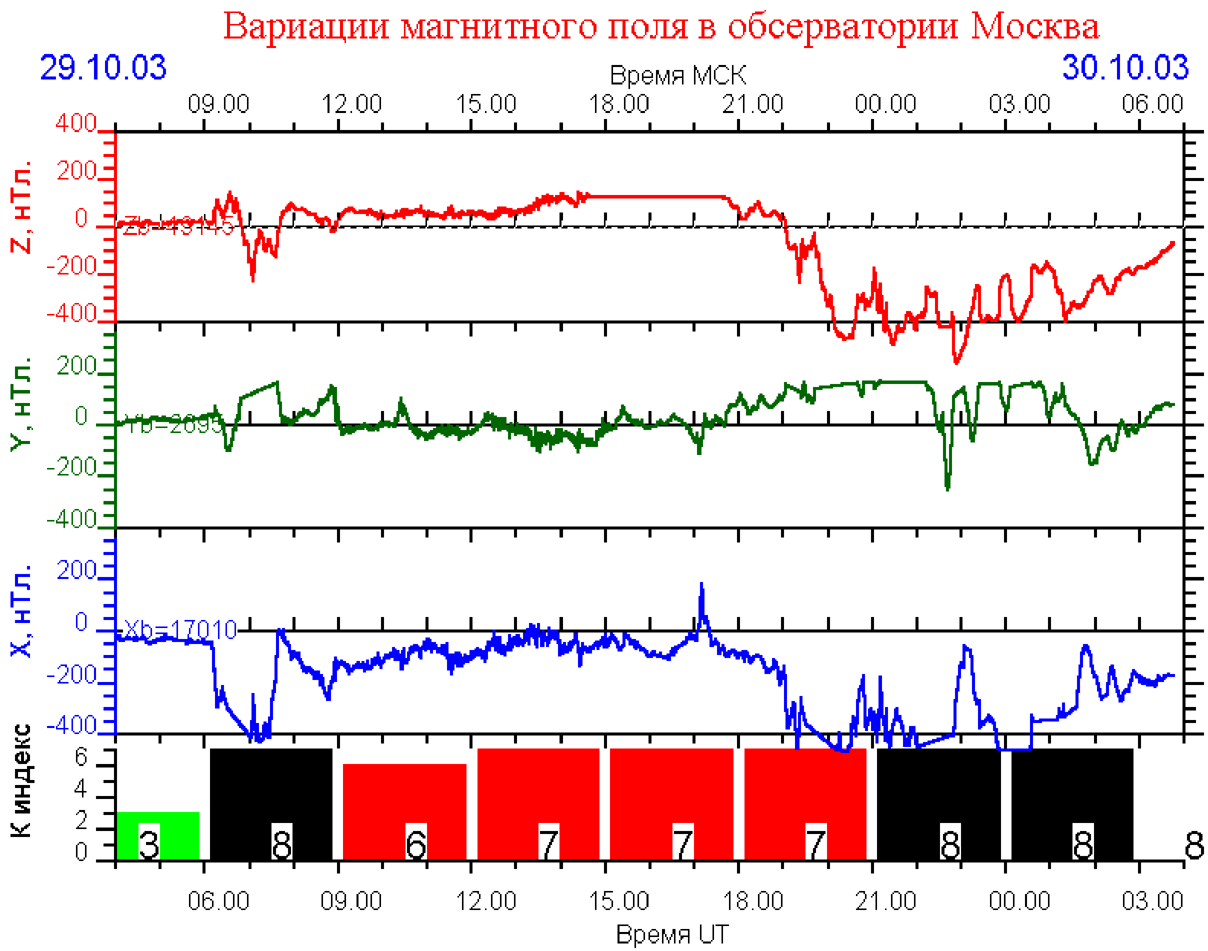




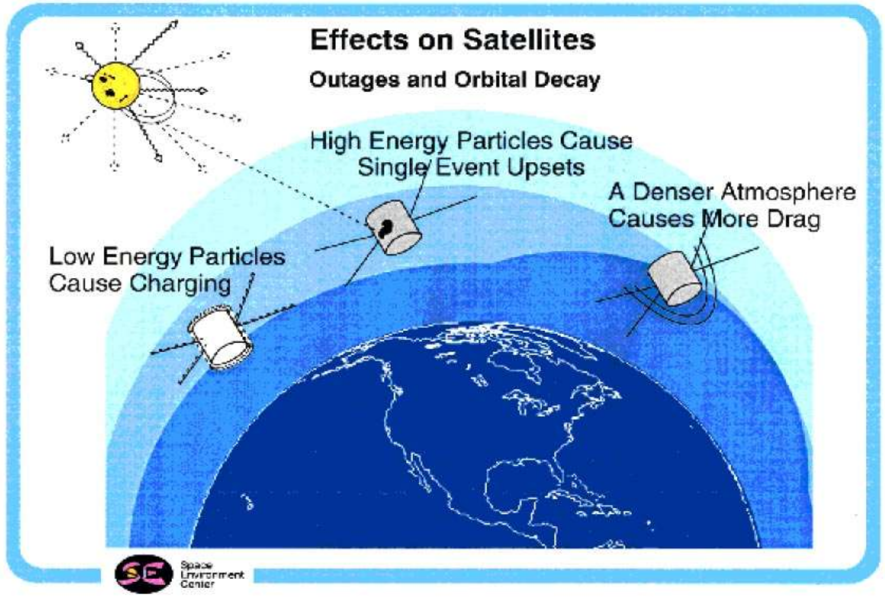
Radiation Storm Registered by the GOES satellite



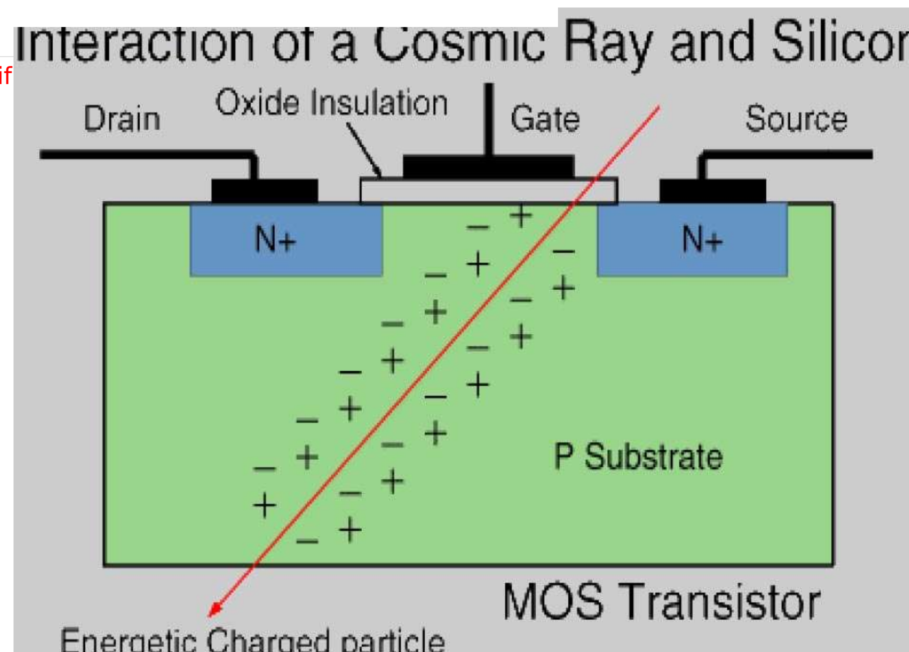
Geomagnetic Storm at 30 October



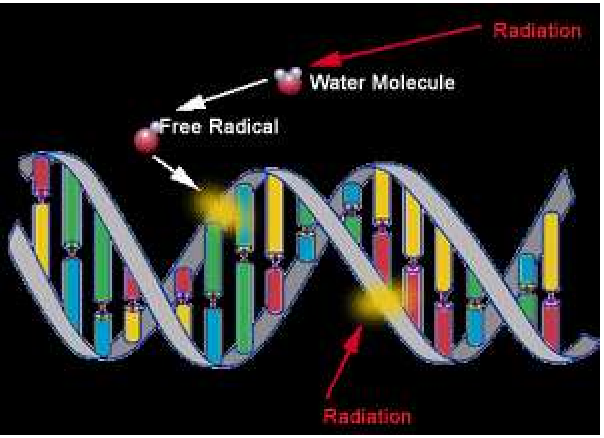
Aurora in October 2003

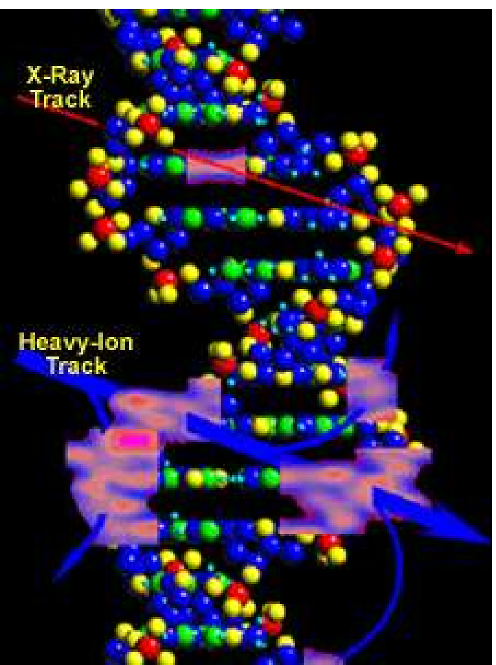


http://science.nasa.gov/ssl/PAD/sppb/Edu/magnetosphere/images/transformer.gif



Why is space radiation an important concern for human spaceflight?





Radiation encountered in space is more effective at causing the type of biological damage that ultimately leads to cancer than gamma or x-rays commonly encountered on Earth.

The water in the organism absorbs a large portion of the radiation and becomes ionized to form highly reactive, water-derived radicals. The free radicals then react with DNA molecules causing the breaking of chemical bonds or oxidation.

The radiation collides with the DNA molecule directly. Cosmic rays from deep space, for instance, are composed of heavier particles than our bodies are used to, and they have little trouble breaking strands of DNA. A cancer can start when altered genes allow the cell and its descendants to multiply too freely.

Organ Specific Exposure Limits for Astronauts

	Blood Forming Organs		Eye	Skin
30 Days	25 rem	30) for men]		
Annual	50 rem	100 – 200 rem [200 +		
Career		7.5 (age – 38) for women]		

Space Weather Effects October-November 2003, Solar spot group 486

- Storm's magnetic orientation was southward, opposite to that of Earth's magnetic field. This opposing setup allows a storm to more intensely penetrate Earth's protective magnetosphere and to threaten satellites and ground communication systems;
- Japanese military satellites costing M140 USD lost;
- Residents of the International Space Station took cover from the storm for several 20-minute periods. They retreat to the Zvezda service module, where radiation protection is the best;
- The last wave was powerful enough to generate a magnetic storm all the way out to Saturn, almost ten times farther from the Sun than Earth is.

Most violent solar storms ever documented

- Sept. 1 and 2 in 1859, that short-circuited telegraph wires and set off fires in the United States and Europe; If the storm of 1859 hit Earth today there is a possibility that it may knock out power grids all over the world and create such severe drag in the orbits of low-altitude communications satellites that they could be permanently lost.
- One in 1972 that reached Earth in only 14 hours, would have been of roughly equal intensity if the direction of its magnetic field had not been parallel to Earth's;
- Another storm stole air from Mars, hinting at where water that was once abundant on the red planet might have gone.

Protective actions after Space Weather Alert

- Satellite operators put satellites to sleep. They rotated some so vulnerable solar panels were better protected, and made arrangements to switch signals to backup satellites if necessary;
- elevated doses of radiation can be experienced on high-altitude flights, caused airlines to reroute commercial flights
- Astronauts should retreat to the most well-protected module

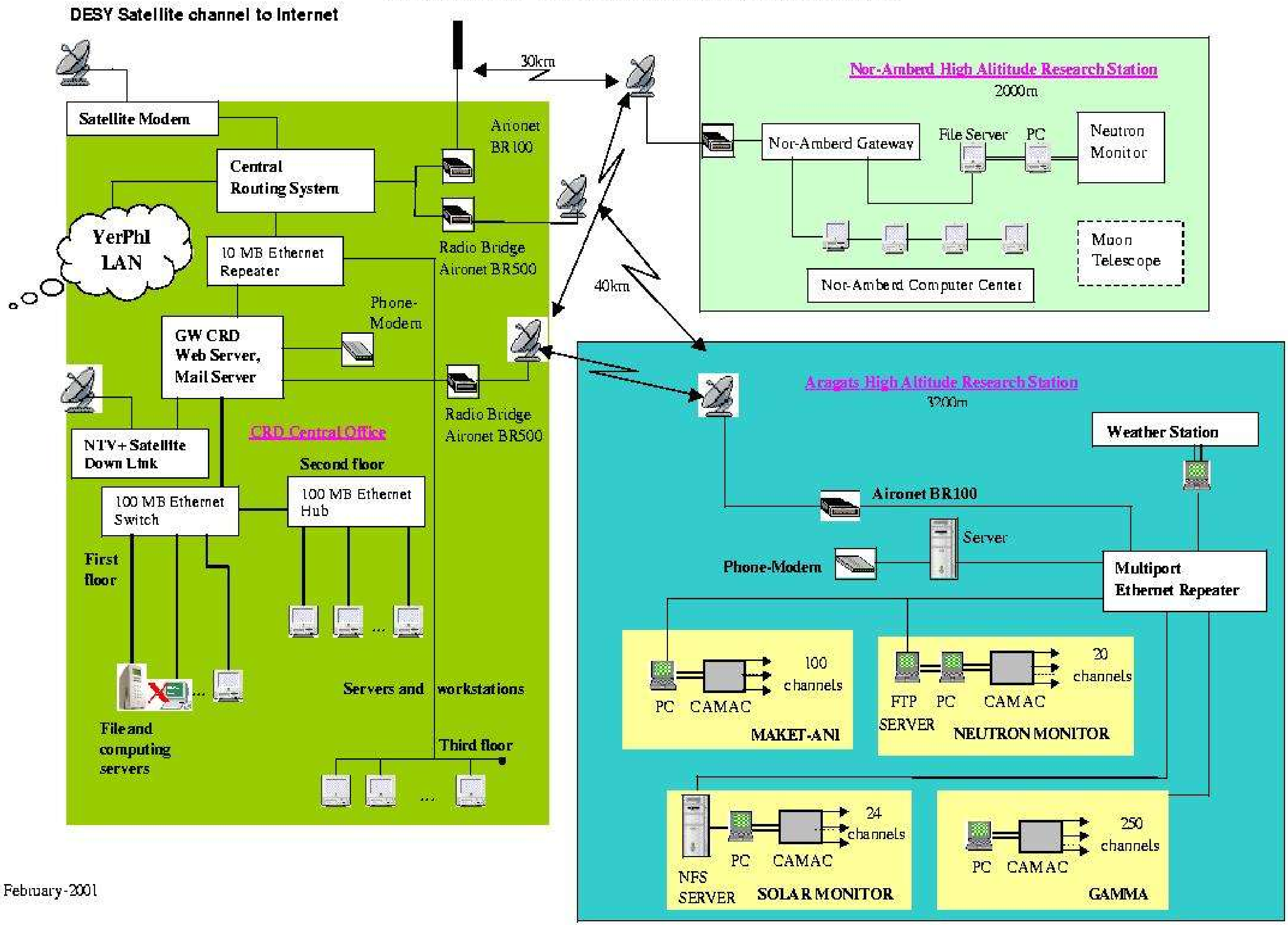
Surface Monitoring of the Secondary Cosmic Ray Fluxes

- Put a satellite closer to the Sun to predict a space storm's magnetic field earlier, but…
- Some instruments aboard SOHO were shut down during powerful flares to prevent damage. Others are operating at reduced capacity;
- Some devices produce less-than-perfect images because they get covered with "snow" that represents the charged particles streaming out from the Sun;
- Most energetic particles detected by surface monitors brings information about upcoming storms 10 hours prior shock arrival

Aragats Space-Environmental Center

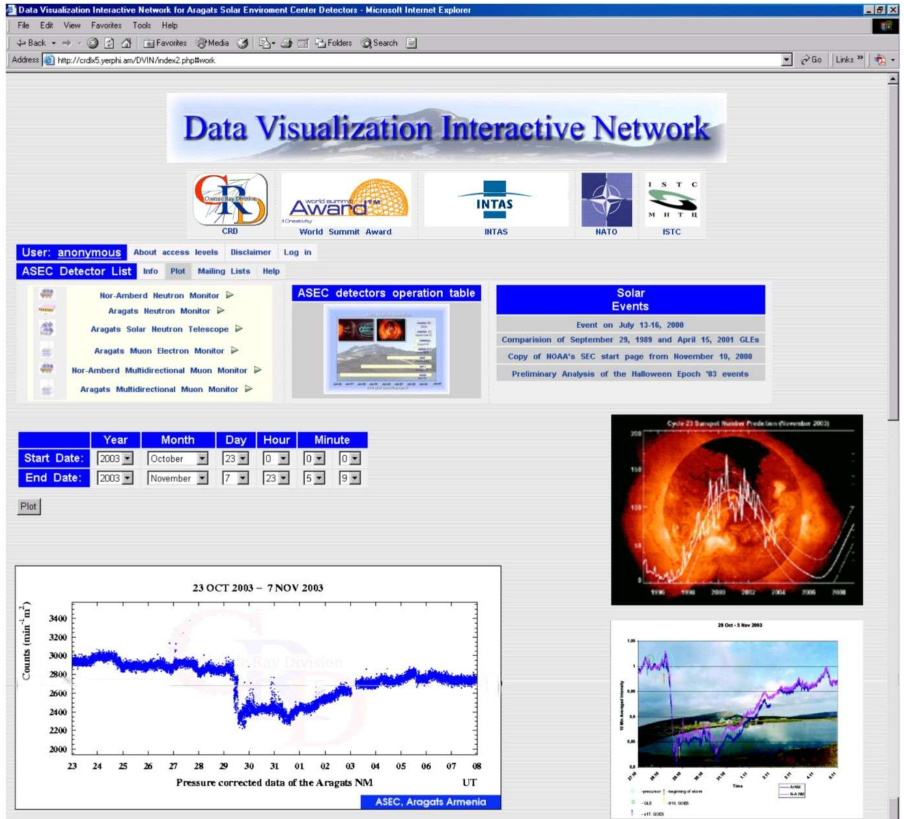
- Measure as much as possible secondary CR fluxes with different energy thresholds;
- Monitor not only changing count rates, but also correlations between changing CR fluxes;
- Measure directional information;
- Use same detectors for both SW and high energy CR studies;
- Perform simulation of the time-series 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.

Structure of the CRD Local Area Network

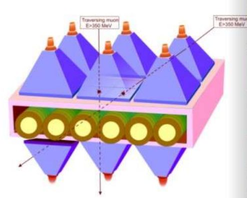


February-2001

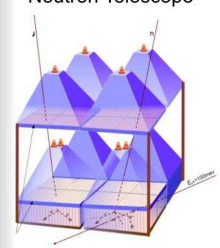
The Data Visualization Interactive Network (DVIN) of the Aragats Space-Environmental Center (ASEC) has been elected by the World Summit Award Grand Jury from 803 nominations presented by 136 countries as one of the 5 best projects in the category of e-Science.



Nor- Amberd Multidirectional Muon Monitor

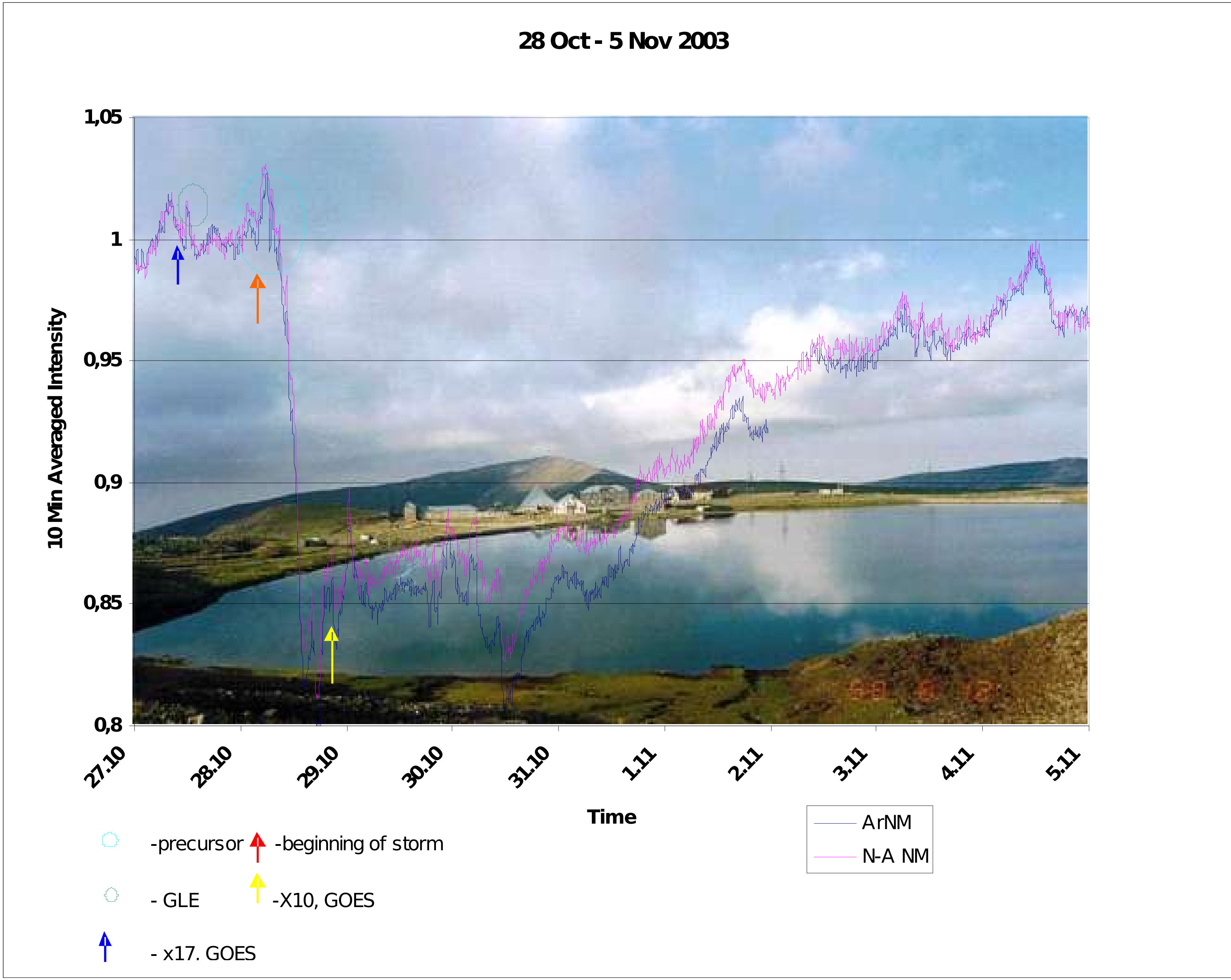


Aragats Solar Neutron Telescope



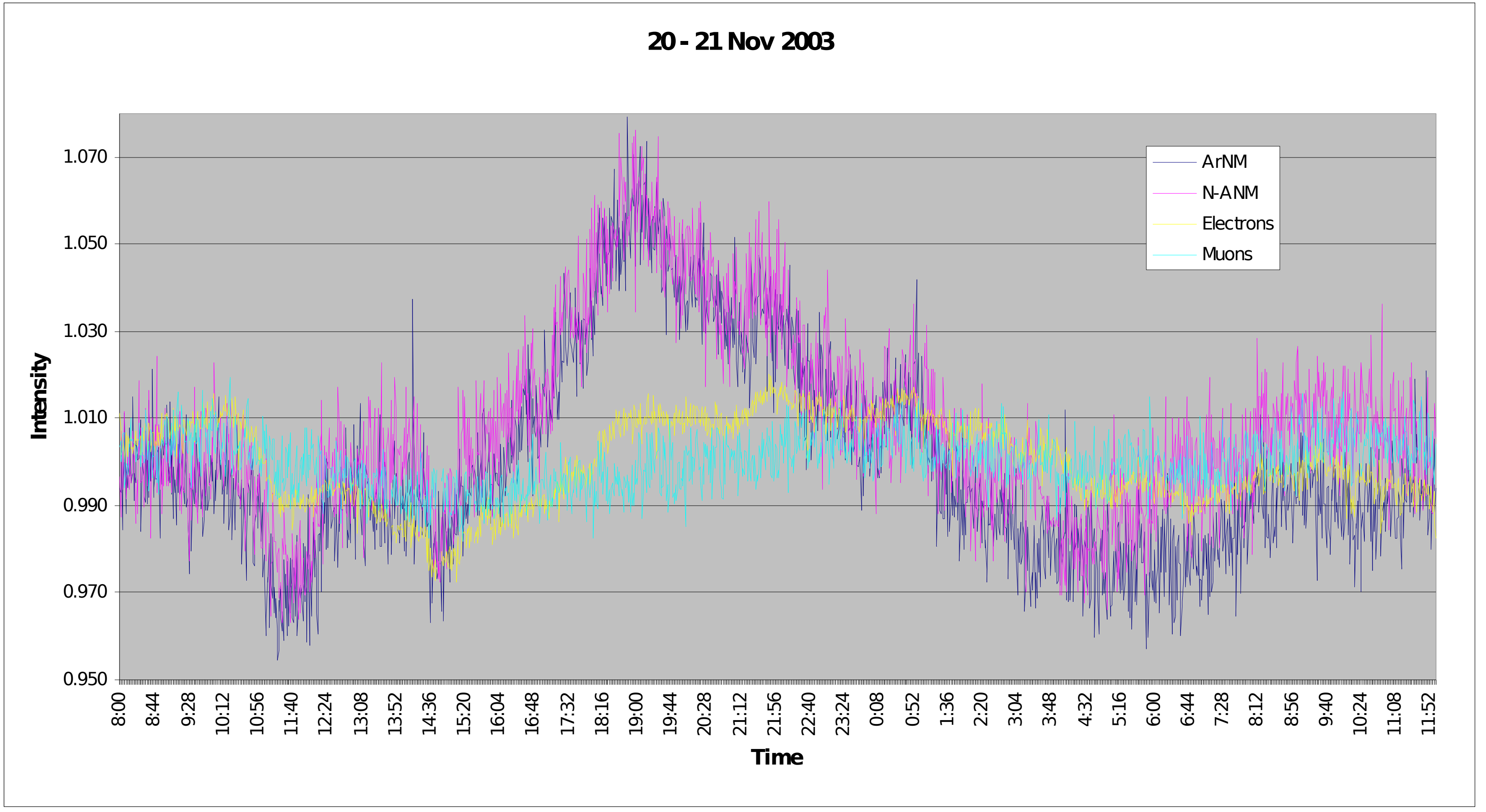
Cosmic Ray Division of Yerevan Physics Institute, Alikhanian Brothers 2, 375036 Yerevan36, Armenia. Tel. +3741-34-43-77, ASEC@crdlx5.yerphi.am
http://crdlx5.yerphi.am

Geneva, December 2003



28 Oct - 5 Nov 2003
1,05
1
0,95
0,9
0,85
0,8
10 Min Averaged Intensity
27.10
28.10
29.10
30.10
31.10
1.11
2.11
3.11
4.11
5.11
Time
ArNM
N-A NM
-precursor
-beginning of storm
- GLE
-X10, GOES
- x17. GOES

Geomagnetic Disturbance of 20 November



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

	ANM	**NANM**	**AMMM**	**SNT**e,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**

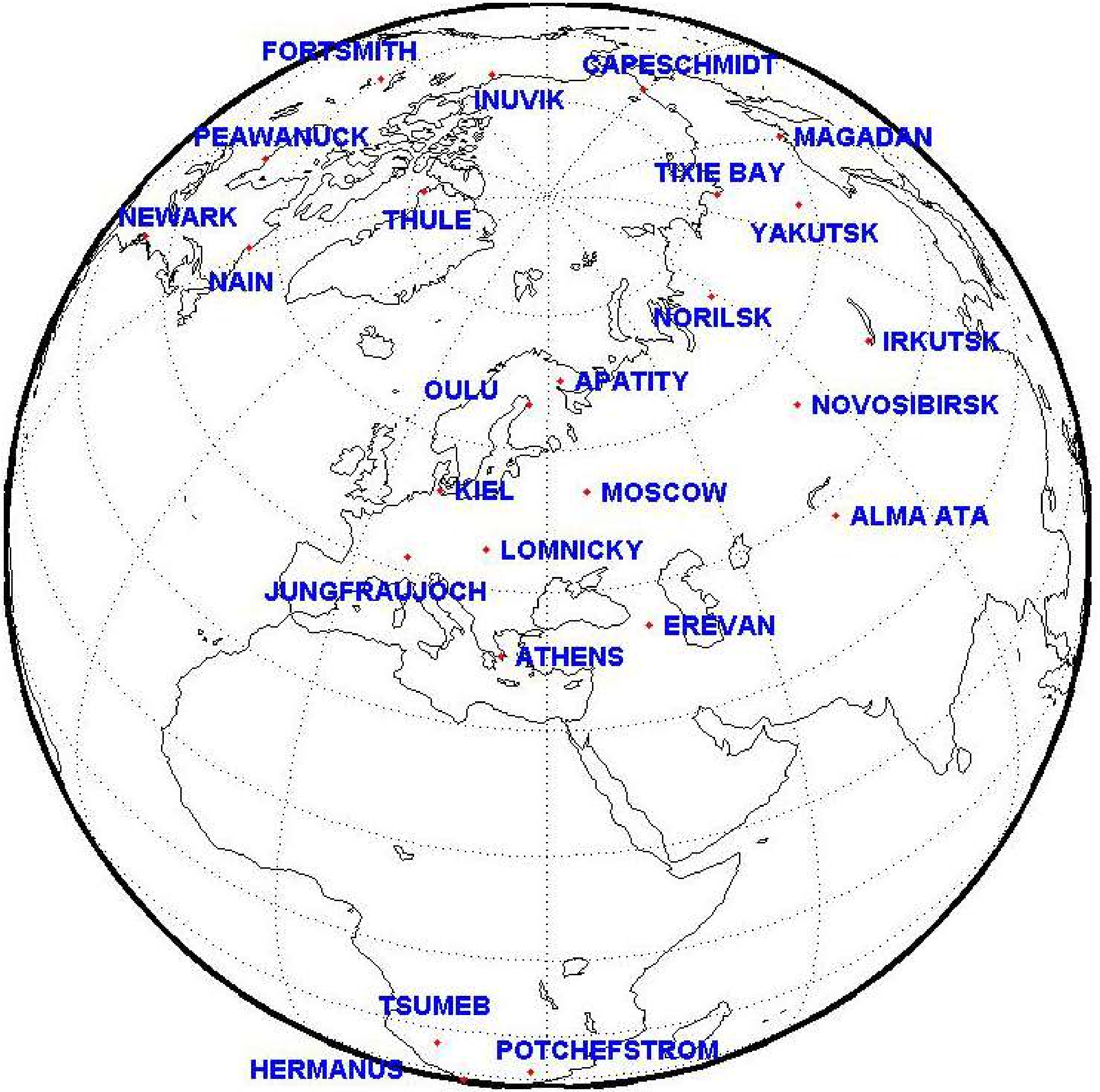
Correlation Matrix of ASEC monitors for 25 January 2003 (No Disturbances of IMF)

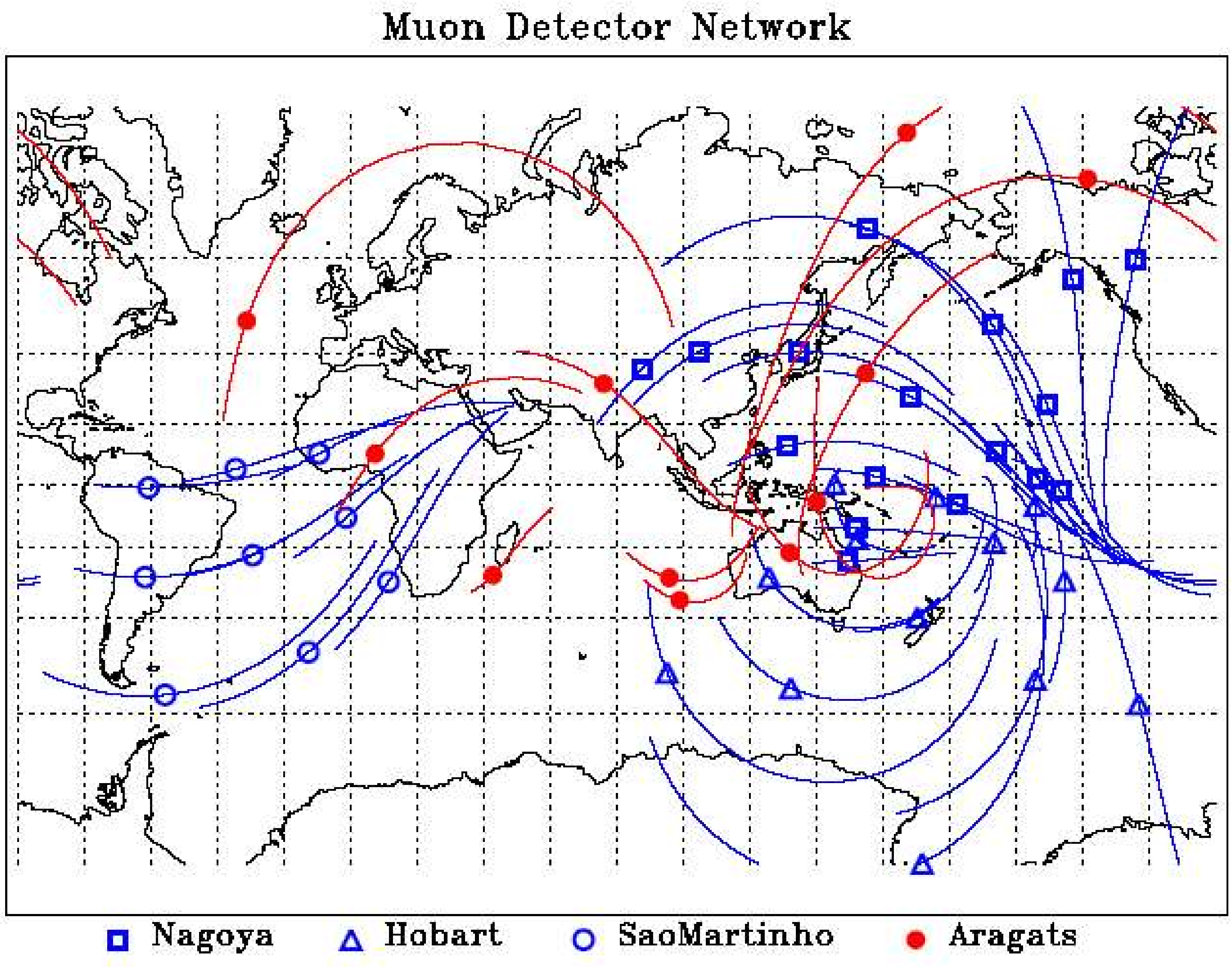
	ArNM	**NANM**	**AMMM**	**SNT**e,μ	**SNT** thr1	**SNT** thr2	**SNT** thr3	**SNT** thr4
ArNM	**1**	0,01	0,03	0,02	0,05	0,04	0,03	0,01
NaNM	0,01	**1**	0,02	-0,01	0,03	-0,04	0,03	-0,02
AMMM	0,03	0,02	**1**	0,12	0,08	-0,04	0,00	-0,04
SNTe,μ	0,02	-0,01	0,12	**1**	0,06	-0,05	-0,01	0,03
SNT thr1	0,05	0,03	0,08	0,06	**1**	0,43	0,31	0,15
SNT thr2	0,04	-0,04	-0,04	-0,05	0,43	**1**	0,42	0,33
SNT thr3	0,03	0,03	0,00	-0,01	0,31	0,42	**1**	0,46
SNT thr4	0,01	-0,02	-0,04	0,03	0,15	0,33	0,46	**1**

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

	ArNM	**NANM**	**AMMM**	**SNT**e,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

Neutron Monitors World-Wide Network

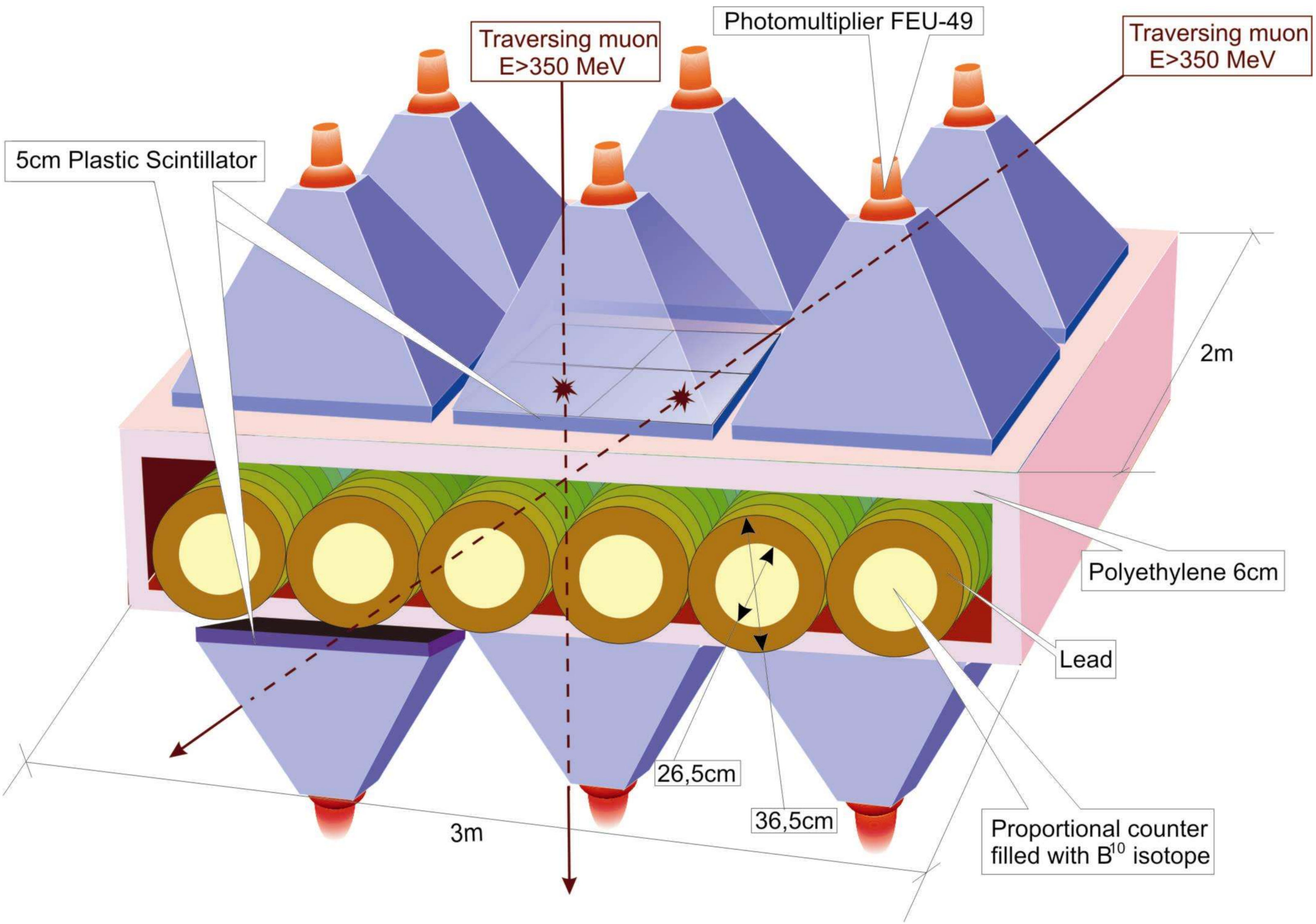



Muon Detector Network
Nagoya
Hobart
SaoMartinho
Aragats

Developing Space Science World-Wide

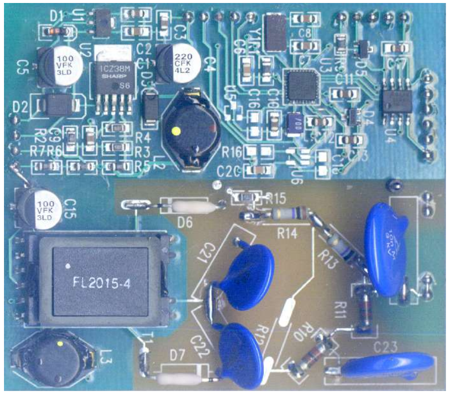
- Most of technical progress in 21 century will come from Space Operations;
- New Space vision has Space Weather research and forecasting as a vital element for Space Operations;
- Information from networks of surface based detectors measuring secondary cosmic rays are compatible to data from space-born particle detectors and can be used for the reliable and timely SW forecasting;
- Developing countries should be a part of such networks to participate in the exploration of the Solar System and Universe;
- Necessary equipment is rather cheap and can be installed in scientific and educational institutions, schools, to make Space Research and Physics

Nor Amberd Multidirectional Muon Monitor



Programmable Regulated High Voltage DC Power Supply (PRHVPS)

The Programmable Regulated High Voltage DC Power Supply is designed to supply high voltage to different electrodes on photomultipliers and various elementary particle detectors



The PRHVPS consists of:

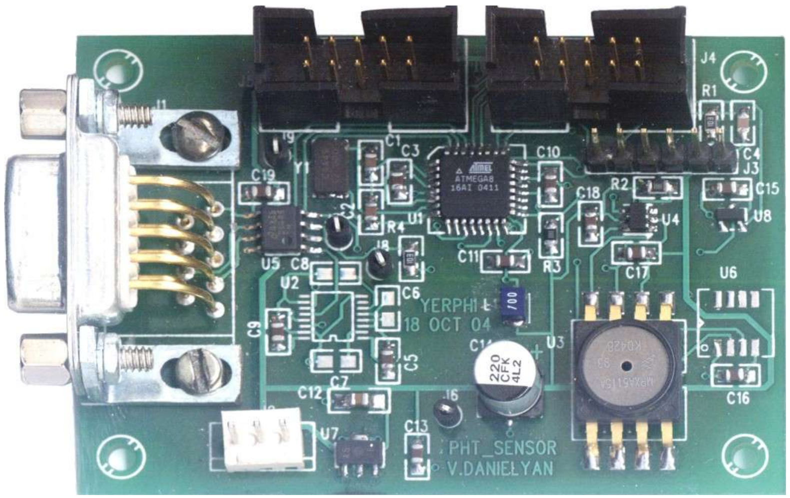
- Current-driven, low-noise sine wave DC/DC converter, with up to 2 stage RC output ripple
- Pulse Width Modulated programmable DC regulator
- Local +5V linear voltage regulator
- ATtiny26 microcontroller
- RS485 interface chip
- Optional temperature sensor

The Printed Circuit Board (PCB) can be assembled with various options for different output polarity, programmable voltage range, and so on. Commercially available components are used to reduce cost and increase reliability.

Specific Features:

- Voltage programming in two hardware selectable ranges ± 900V to 2100V and ±1500 to 3000V in 2V steps
- Output voltage ripple less than 1mV
- Max. output current 1.2 mA for ± 900V to 2100V range; 0.8 mA for ±1500 to 3000V range
- Input voltage from +12V to +15V
- Absolute output voltage regulated to accuracy ±1V
- Optional temperature sensor

The Pressure, Humidity, Tempearature - PHT SENSOR is a general purpose microcontroller unit, designed for environmental measurements: pressure, temperature and humidity.



It can be equipped with two types of temperature sensors: the precise combined Humidity Temperature digital sensor SHT11 and/or the low precision low cost analog temperature sensor LM61C.

In addition to the main sensors mounted on the board, it has two auxiliary connectors with pinned out microcontroller's input/output port pins, which can be used for other measurement and control purposes.

It has two alternative interfaces to integrate it into a system: RS232 and half-duplex RS485.

It has Frequency Modulated (FM) output TTL for compatibility with the existing Cosmic Ray Detector equipment. The frequency is proportional to the measured pressure.

The microcontroller software (firmware) supports all the mentioned sensors and interfaces and can be easily upgraded for additional measurements and control options.

ARMENIAN NEURAL NETWORK CENTER

This is a business proposition to create the Armenian Neural Network Center (ANNC). Proceeding from the problem the customer needs to investigate, we will work with them to help them gather relevant data, then we will provide the solution in the form of ”trained” network software, specific to the problem. The trained network for solving the problem can be easily tested and certified and easily implemented as a decision-making tool at the customer's site. As new data becomes available, the network can be “re-trained” and sent as an upgrade to the user in a very short time. -

Taking into account the positive feedback from current users of our packages in the scientific community, we feel we can apply our expertise in Neural Network solutions to industrial, medical, defense, management, and other users. Problems dealing with stochastic processes in complex nonlinear systems require robust algorithms for effective analysis of large amounts of nonparametric stochastic data. With our experience in writing successful algorithms and successfully implementing them in software, we can offer our expertise to various categories of customers. The solution will be available in user-friendly, ready-to-use format to the customer.

An example of implementing our methods for a practical, and important problem solution is the patent ***“Multivariate random search method with multiple starts and early stop for identification of differentially expressed genes based on microarray data”***, described in a provisional application filed in the United States Patent and Trademark Office on March 1, 2002, and accorded Application No. 60/361,068.In 2004 patent was authorized in US, Canada and Europe under N 03713675/1-24-02-US0305730.

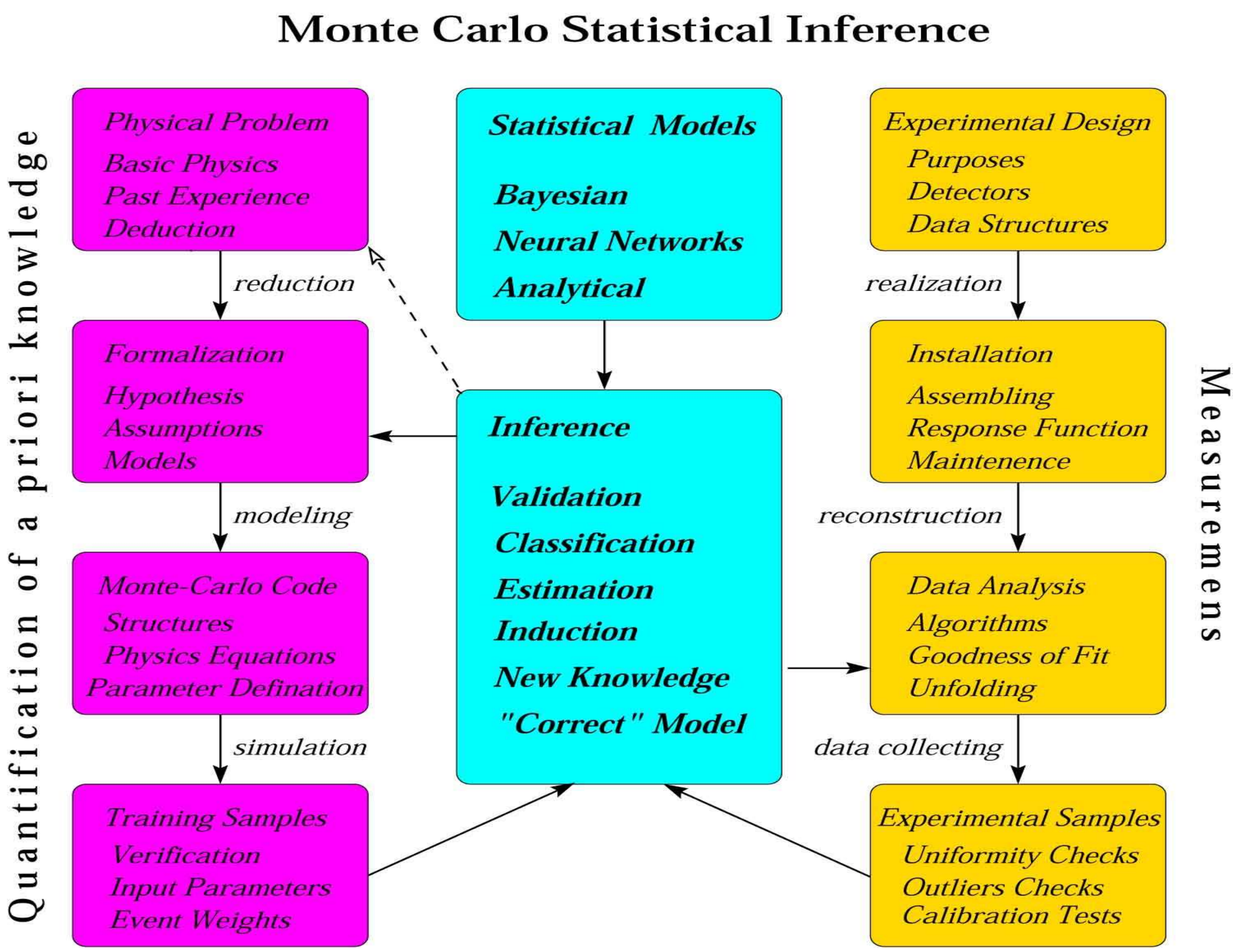
Another our Internet information product – ***“Data Visualisation Interactive Network for the Aragats Space-environmental Center” –*** *DVIN for ASEC*, was officially announced as the world's best project in the category of e-science at the first World Summit on the Information Society (WSIS) 2003 in Geneva, December 9-13.

Brief Explanation:

A large number of processes in science, industry and medicine can be modeled by means of Bayesian statistical paradigm and Artificial Neural Networks. These techniques are employed when dealing with multidimensional and analytically difficult-to-formulate systems and data.

The analysis of the bulk of multidimensional data with high levels of stochastic variability requires development of new, powerful, reliable, and robust analysis and decision-making tools to meet the challenge of understanding and utilizing the abundant amount of information available from numerous sources.

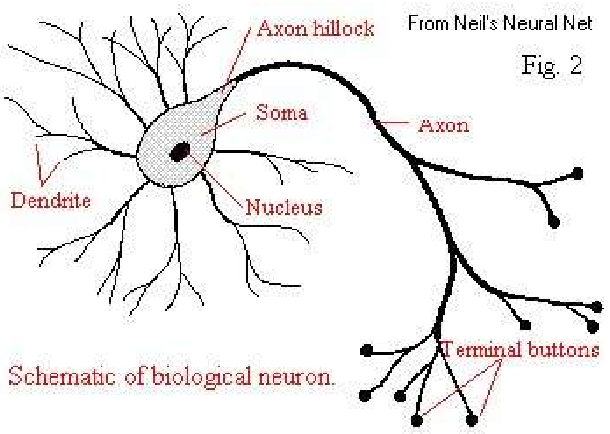
The main goal of the statistical inference in astro-particle physics is the development of high-speed and effective algorithms for the analysis of multidimensional experimental data in several

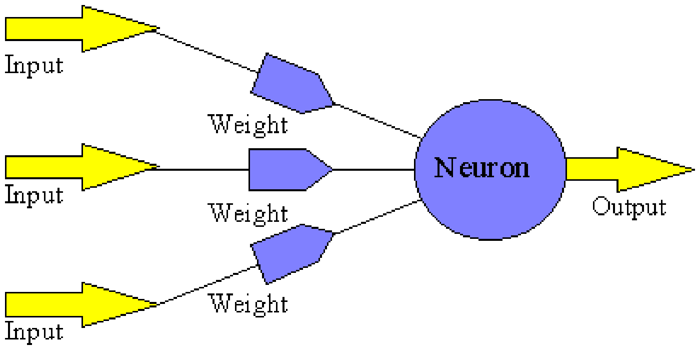

Monte Carlo Statistical Inference
Quantification of a priori knowledge
Physical Problem
Basic Physics
Past Experience
Deduction
reduction
Formalization
Hypothesis
Assumptions
Models
modeling
Monte-Carlo Code
Structures
Physics Equations
Parameter Defination
simulation
Training Samples
Verification
Input Parameters
Event Weights
Statistical Models
Bayesian
Neural Networks
Analytical
Inference
Validation
Classification
Estimation
Induction
New Knowledge
"Correct" Model
Experimental Design
Purposes
Detectors
Data Structures
realization
Installation
Assembling
Response Function
Maintenence
reconstruction
Data Analysis
Algorithms
Goodness of Fit
Unfolding
data collecting
Experimental Samples
Uniformity Checks
Outliers Checks
Calibration Tests
Measuremens

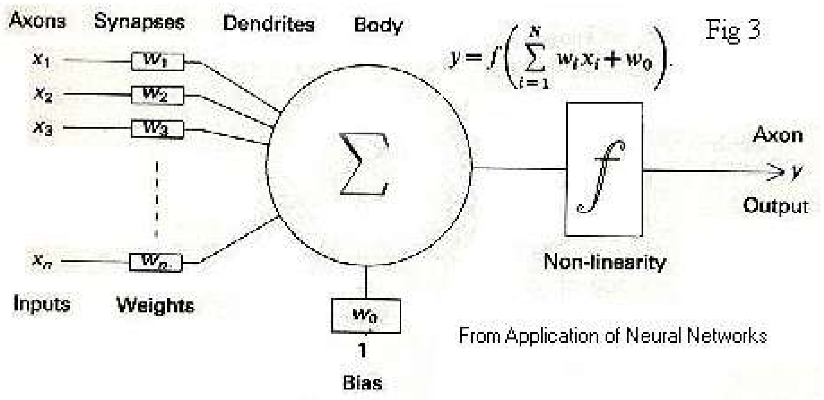
MRSES Principle: One Model Ever Best Trained isn't Enough - use Many

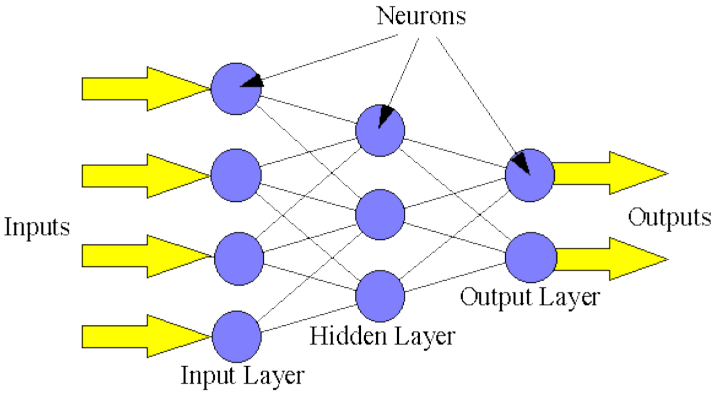
- To control complexity and achieve generalization we have to stop early;
- To scan all local minima we have start training from multiple points using several parameters;
- Use assembly of models not train long one model to avoid overfitting;
- Use appropriate averaging *(adaptation)* of model results not model parameters.

Artificial Neural Network Models

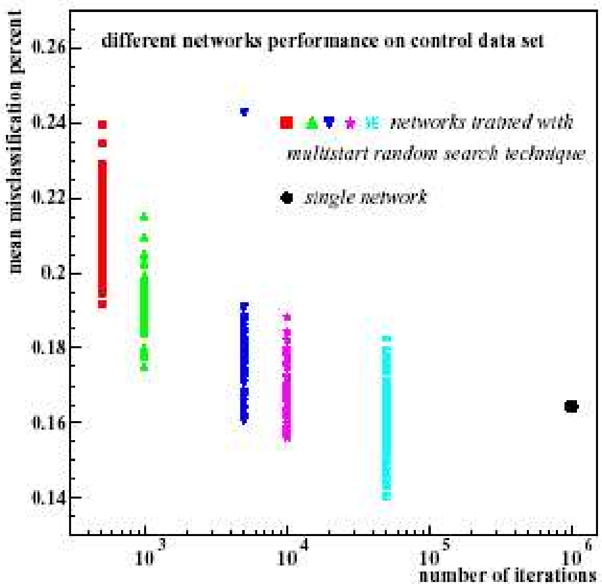


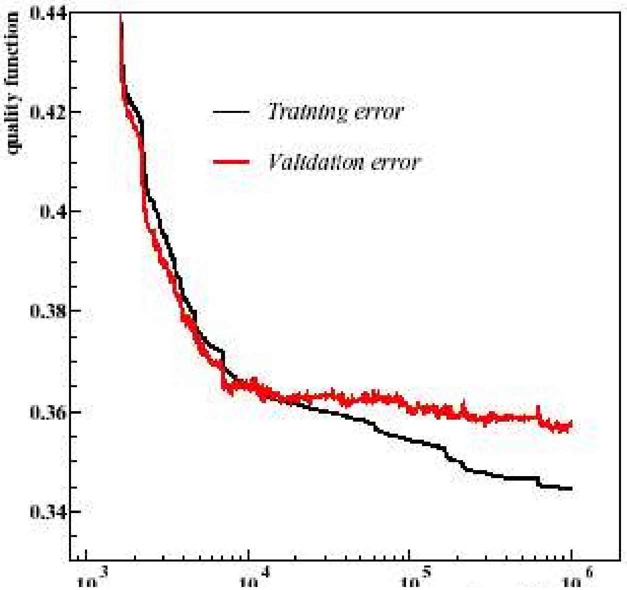


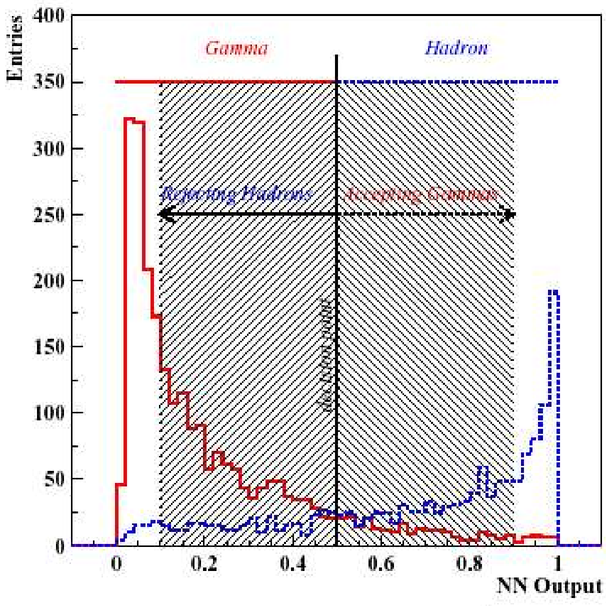


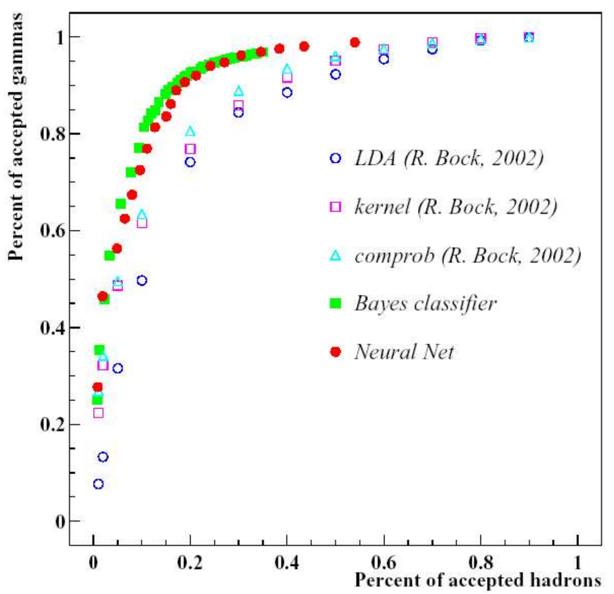


MRSES Training of NN to Reject Hadrom Background in Detecting AGN and SNR

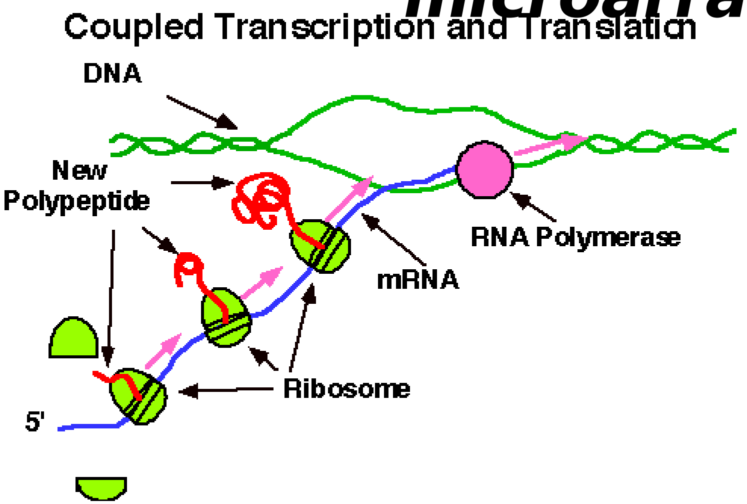


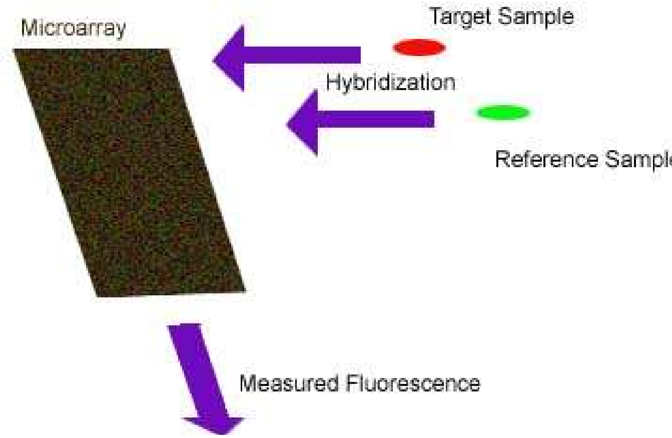


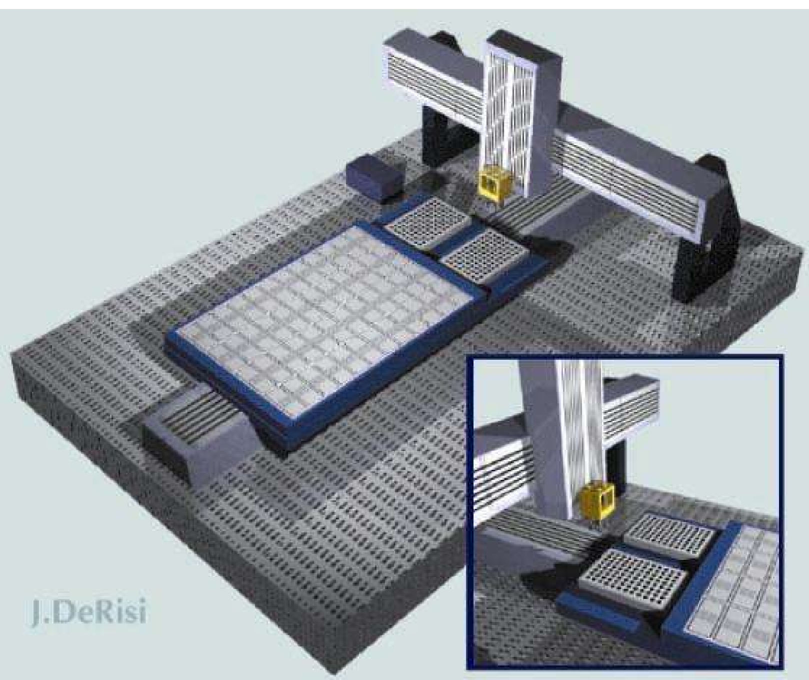


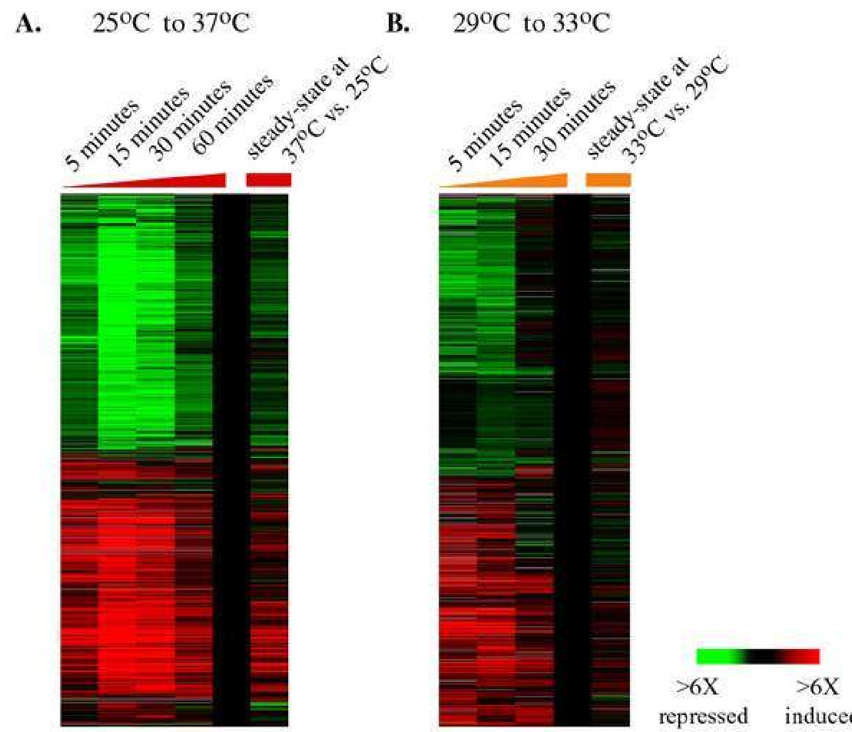


Multivariate random search method with multiple starts and early stop for identification of differentially expressed genes based on microarray data", (USA patent)

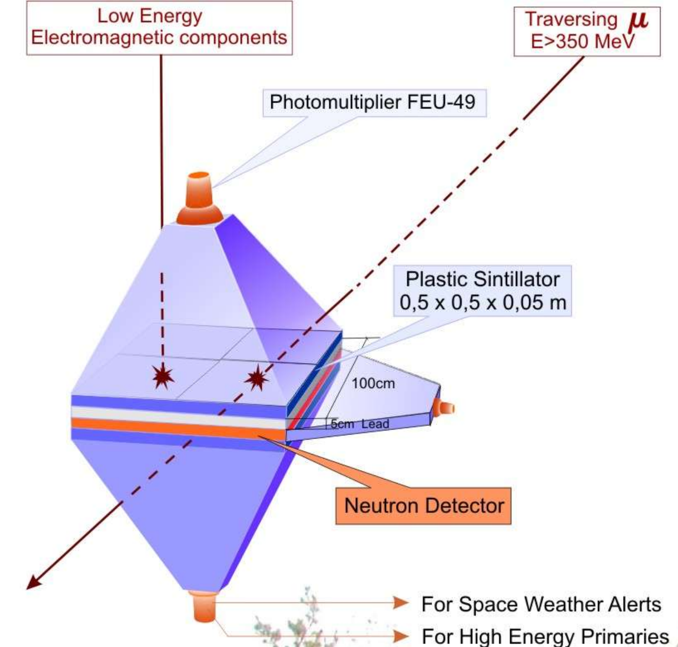


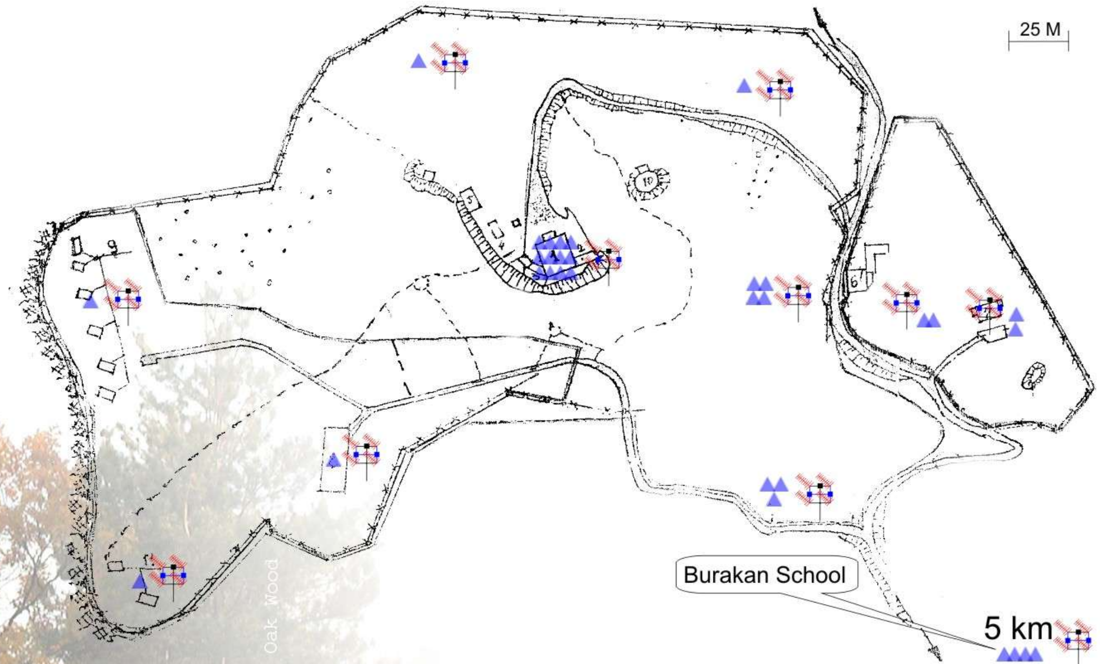


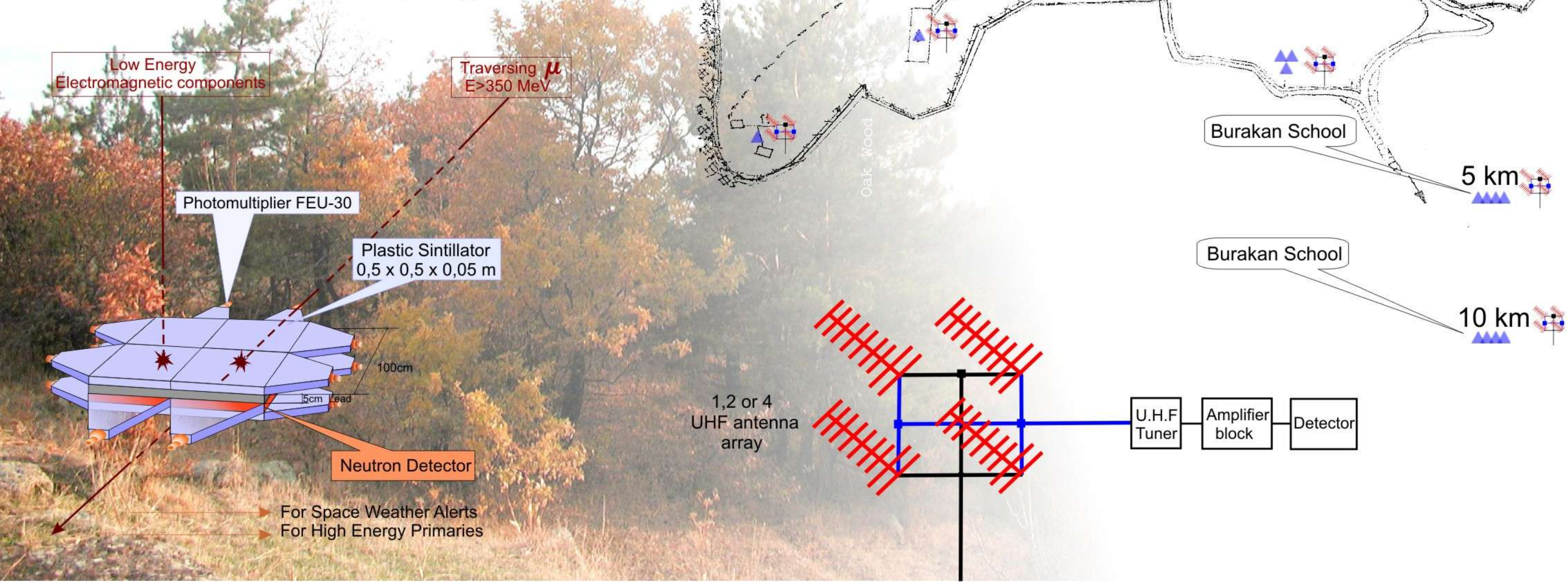




Aragats International Cosmic Ray Center Nor - Amberd Detector for Space Weather and High Energy Astrophysics Studies

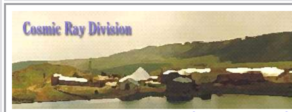






International Heliophysical Year: IHY: 2007

- "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.

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 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

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26 - 30 September 2005

Cosmic Ray Division
Alikhanian Physics Institute

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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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