

# Data acquisition system for Aragats Solar Environmental Center

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## Abstract

Solar Flares (SF) and Coronal Mass Ejection (CME)–pose a serious threat to the performance of working space systems, causing anomalies in their operation. Consequently predictions of solar activity are important for various technologies, including operation of low-Earth orbiting satellites, electric power transmission grids, high-frequency radio communications and navigation systems.

Cosmic Ray Division (CRD ) started project of monitoring Solar-Terrestrial connections with facilities of the high altitude stations Nor-Amberd and Aragats located at Mt. Aragats. In this article we'll discussing current status of CRD LAN , and possibilities for on-line data acquisition and continuous forecast of sever geomagnetic and Solar radiation storms.

## 1 Forecasting of the geomagnetic and radiation storms

The project is aimed to establish the Space Environment Center (SEC) that will detect and on-line analyze the correlation between intensity

of the high-energy Cosmic Ray (CR) fluxes and potentially dangerous geomagnetic and radiation storms [1]. Center will issue warnings for extreme disturbances caused by Solar Energetic Phenomena (SEP) likely to affect people and equipment in space [2, 3].

Two existing Neutron Monitors (NM), a muon telescope (MT) and a Solar Neutron Telescope (SNT) [4] operating on Aragats research stations will provide accurate detection of very low fluxes of the most energetic solar particles and modulation effects of Solar events. Simultaneous operation of these facilities provide unique opportunity to precise the energy of registered particles [5]. The correlation of the SEP with intensity of the Galactic Cosmic Ray (GCR) flux and direct detection of the high-energy protons and neutrons emitted during CME provide firm ground for specification and forecasting of the effects of tremendous explosions on the Solar surface [6].

The Forbush Decrease (with significant lasting many days decrease of overall CR intensity) is accompanied by rather complicated short term sequence of intensity fluctuations. This highly anisotropic pre-cursors are connected either with particle trajectories that trace to the CR depleted

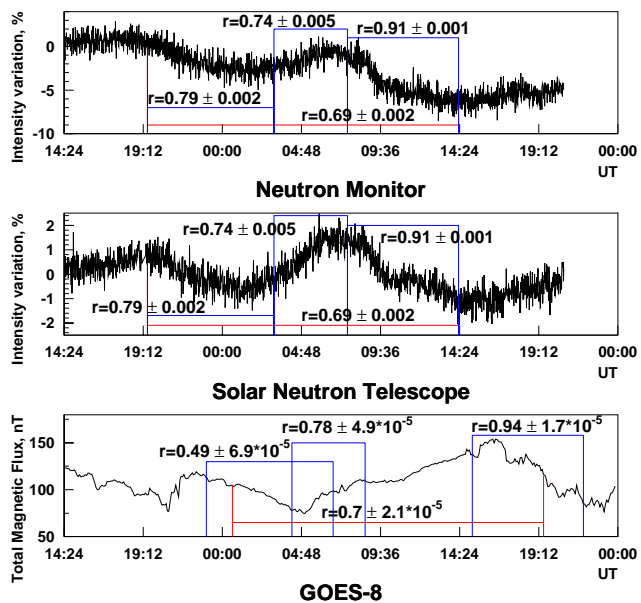


Figure 1: Comparison of SNT with NM and magnetometer of the GOES-8 satellite.

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region behind the powerful interplanetary shock, or with viewing particles reflected from the shock [7, 8].

A very complicated shape of the Fd events with several decreases and increases is an appropriate test for comparing the NM and SNT data.

The cross-correlation coefficients with lag  $k$  are calculated by the formula:

$$r_k(x, y) = \frac{\sum_{i=1}^N (x_i - \mu_x)(y_{i+k} - \mu_y)}{(N - 1)\sigma_x\sigma_y} \quad (1)$$

where  $x_i$  and  $y_i$  are the  $N$  point intervals of the NM and SNT one-minute Time Series (TS). The quantities  $\mu_x, \sigma_x$  and  $\mu_y, \sigma_y$  are the correspondent mean values and variances of chosen TS intervals, comprising  $N$  counts. The  $k$  value of the lag is optimized to give maximal correlation. For most cases of TS  $k=0$ , indicating the consistency of data from both installations. As one can see from fig. 1 data of GOES-8 have a lag about several hours.

Therefore ground observation of the variations of Cosmic Ray fluxes make it possible to issue alerts to avoid imminent hazard of an upcoming Solar storm. The energetic particles reach the Earth 30-60 minutes earlier than the main flow of the lower energy (fig.1), but much more intense, and therefore, more dangerous particles [9]. Within this time the tasks of data acquisition, event building and display, as well as multidimensional correlation analysis [10], and estimation of SEP model parameters have to be performed. The reliable specification of the SEP and operational forecasting service will be established as an output of the continuously monitoring system.

## 2 Scheme of CRD LAN

CRD LAN is part of YerPhi LAN connected via 128 kbps satellite channel to the Internet. YerPhi LAN connects 7 buildings in Yerevan and a few hundreds of machines connected via 10 and 100 Mbps ethernet.

Nor-Amberd and Aragats research stations of CRD located up on Mt. Aragats, at altitudes of 2000 and 3200m a.s.l., are connected through radio-modems to the CRD LAN . Aragats LAN is connected to Yerevan via Aironet BR100 radio-modems (connection speed 1 Mbps). Nor-Amberd LAN is connected to Yerevan with Arlan 655 radio-modems. Planed to be replaced with Aironet BR500 (see tab.1). Radiomodem BR100 last 2 month, in spite of very severe climatic conditions, provide reliable and fast data transfer from Aragats station.

Table 1: Specifications of CRD LAN 's

| <i>LAN</i>        | <i>Internal bandwidth, Mbps</i> | <i>Number of computers</i> | <i>Radio-modem</i>         | <i>Bandwidth to Yerevan LAN, Mbps</i> | <i>Distance, km</i> |
|-------------------|---------------------------------|----------------------------|----------------------------|---------------------------------------|---------------------|
| <i>Yerevan</i>    | 10/100                          | 15/8                       | Aironet BR100<br>Arlan 655 | -                                     | -                   |
| <i>Aragats</i>    | 10                              | 6                          | Aironet BR100              | 2                                     | 45                  |
| <i>Nor-Amberd</i> | 10                              | 3                          | Arlan 655                  | 2                                     | 35                  |

Aironet's BR100, BR500 series bridges uses Direct Sequence Spread Spectrum (DSSS) radio transmission type. They have ability reliable support connection at  $2Mbps$  up to 40km with  $21dBi$  solid dish antenna (diameter 61cm).

As shown in the scheme of LAN (see fig.2) radio-modems connected to CRD LAN via YerPhi LAN. Cause of existing internal traffic among computers of CRD ,CRD LAN's will be separated from YerPhi LAN, to reduce the load of traffic and will be connected to YerPhi LAN via gateway of CRD .

Table 2: Specifications of Radio-Modems

| <b>RADIO-MODEM</b> | <b>Frequency range, MHz</b> | <b>Radio transfer type</b> | <b>Modulation type</b> | <b>Power Output, mW</b> | <b>Maximum transfer rate, Mbps</b> | <b>Maximum distance (at 1Mbps), km</b> |
|--------------------|-----------------------------|----------------------------|------------------------|-------------------------|------------------------------------|--|
| <b>BR100</b>       | 2400-2497                   | DSSS                       | DBPSK, DQPSK           | 100                     | 2                                  | 40                                     |
| <b>BR500</b>       | 2400-2497                   | DSSS                       | DBPSK, DQPSK, CCK      | 100                     | 11                                 | 40                                     |

### 3 Data acquisition system

Characteristics of detectors are described in the table 3. Data acquisition of Neutron Monitors (see fig.2) consist of two computers. One i286 with counter with ISA bus interface running MS-DOS, registred data each minute and stores to local hard disk every 10 minutes. It connects via COM port with i486, running Linux. Every 10 mintes i486 reads data from i286 (without interrupting data acquisition) and stores to its local hard disk. i486 is configured with FTP-server facilities, which enables access to stored new data any time.

Data acquisition system for The Solar Neutron Telescope [4] consist of two computers (see fig.2). NEC i386 with PC-CAMAC interface running DOS, every 3 minutes writes 10-secondly data via NFS on the hard disk of Celeron-433 PC, running Linux. This Linux server also have FTP-server facilities. NEC i386 connected through COM port with GPS and stores precise time for each event.

For the time synchronization at least 3 GPS-es will be installed, one for each subLAN (i.e. Yerevan, Aragats, Nor-Amberd). The GPS-es will be connected to Linux-servers with NTP-server (Network Time Protocol). With such service we will be able to synchronize time of any computer up to millisecond.

To increase reliability and stability of these systems, we plan in future use one i486 PC running Linux with PC-CAMAC interface as registration device. This solution will provide remote control and on-line debugging possibilities.

Table 3: Characteristics of detectors

| <b>Detector</b>                        | <b>Quantity</b> | <b>Altitude (m, above sea level)</b> | <b>Detector surface (m<sup>2</sup>)</b> | <b>Rate of data acquisition (B/min)</b> | <b>Energy threshold (MeV)</b> |
|--|-----------------|--------------------------------------|---|---|-------------------------------|
| <b>Aragats Solar Neutron Telescope</b> | 1               | 3200                                 | 4                                       | 2400                                    | 50,100,150,200                |
| <b>Aragats Neutron Monitor</b>         | 1               | 3200                                 | 18                                      | 128                                     | 50                            |
| <b>Nor-Amberd Neutron Monitor</b>      | 1               | 2000                                 | 18                                      | 128                                     | 50                            |
| <b>Nor-Amberd Muon Telescope</b>       | 1               | 2000                                 | 12                                      | 128                                     | 25                            |

### 4 On-line data analysis

The main server installed in CRD is the computer server in Yerevan performs following services: gateway (router), name-server, firewall and proxy (cache) server, mail-server, CRD HTTP server, on-line data analysis and display. Each 10 minutes server automaticaly transfer data from on-line computers at Aragats stations, performs routine operations (error correction, correction of data

according to measured pressure, summaries of all detector channels) updates the files and pictures available from CRD Home Page. Calculations of the gradients of intensity changes and correlation of the intensity variations for all 4 installations and with magnetic flux and radiation intensity of GOES<sup>2</sup> satellites will be continuously monitored. Acquisition of continuously renewed data-sets and

Table 4: Servers

| <i>Server</i>                 | <i>RAM<br/>(MB)</i> | <i>CPU<br/>(MHz)</i> | <i>Storage<br/>(GB)</i> |
|-------------------------------|---------------------|----------------------|-------------------------|
| <i>Yerevan central-server</i> | 128                 | 266                  | 6.4                     |
| <i>Aragats SNT-server</i>     | 64                  | 487                  | 9.1                     |
| <i>Nor-Amberd NM-server</i>   | 16                  | 66                   | 1.                      |
| <i>Aragats NM-server</i>      | 16                  | 66                   | 1.                      |

development of the current Solar Energetic Phenomenon models with complex calculations required greatly enhanced computer systems at the core of the space weather forecasting service. To assure this we plan to use the neural information technologies using the special hardware (SAND1 neurochip) [11] as net training accelerator [12] we will obtain necessary computing performance for accurate reliable and timely warning service. The data and pictures from Nor-Amberd NM<sup>3</sup> and Aragats SNT<sup>4</sup> are available on-line. Aragats NM will be attached on-line in March 2000. In the table 4 characteristics of servers involved in data acquisition and display are shown.

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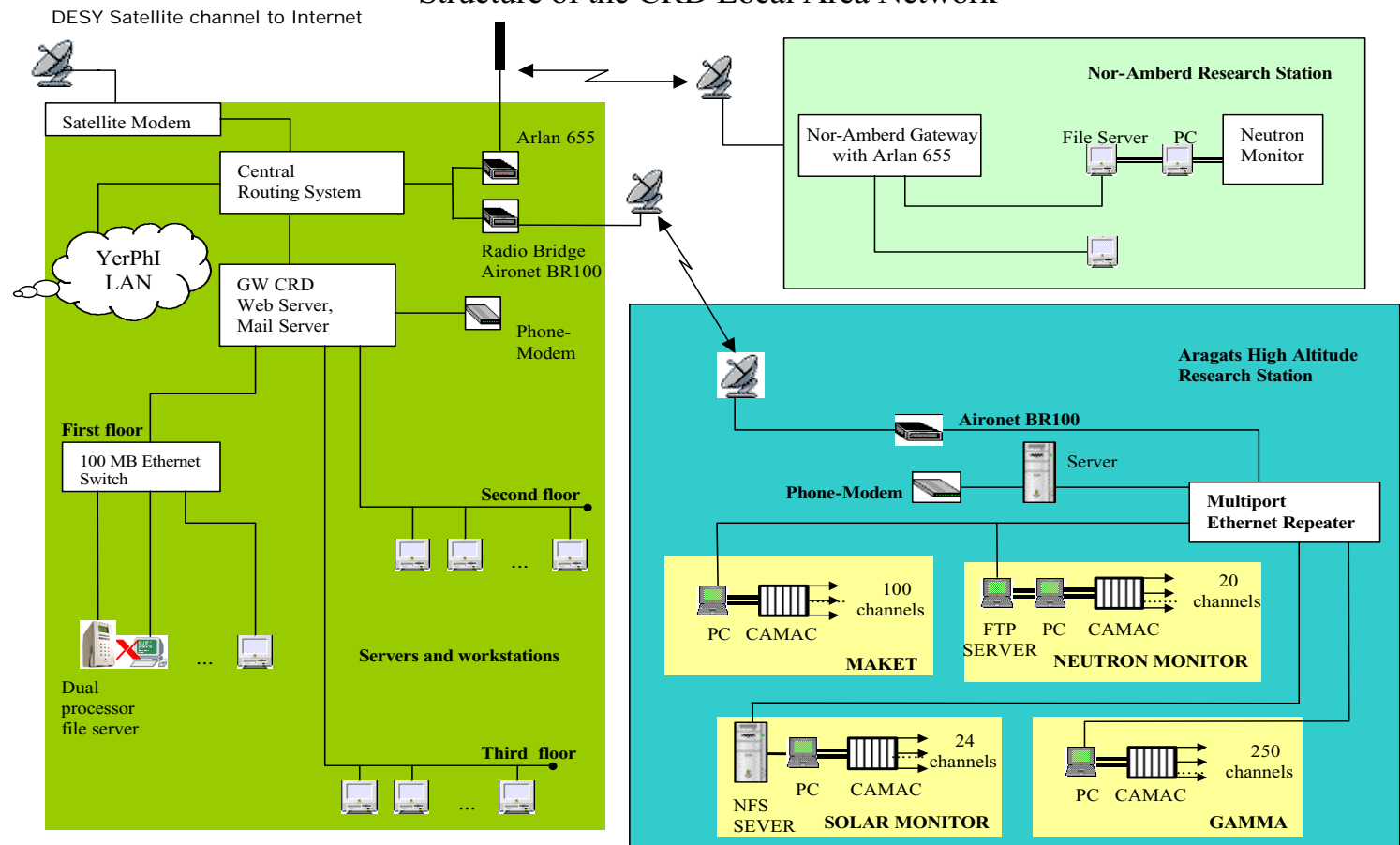
<sup>2</sup><http://julius.ngdc.noaa.gov:8080/production/html/GOES/index.html>

<sup>3</sup><http://crdx5.yerphi.am/neutron/index/html>

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## Structure of the CRD Local Area Network



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Figure 2: Scheme of CRD LAN .