Data acquisition system for Aragats Solar Enviromental 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-Terresterial 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 acqusition 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 registrered 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].

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

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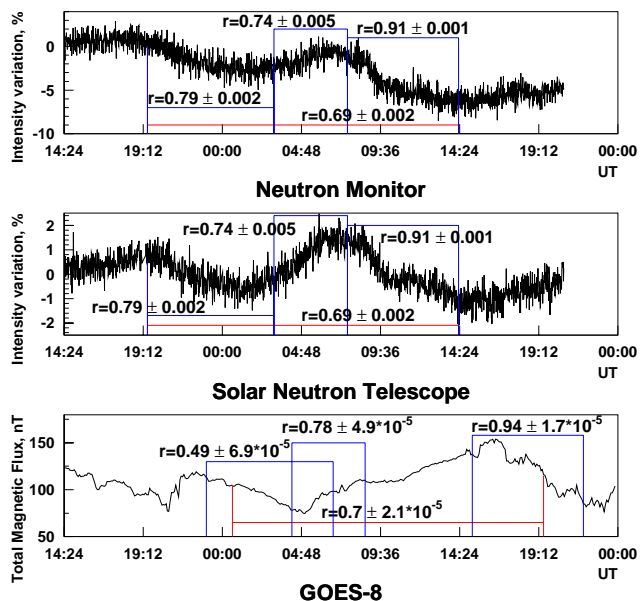
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region behind the powerful interplanetary shock, or with viewing particles reflected from the shock [7, 8].

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:

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

where x_i and y_i are the N point intervals of the NM and SNT one-minute Time Series (TS). The quantities μ_x, σ_x and μ_y, σ_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 ethernets.

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

LAN	*Internal bandwidth, Mbps*	*Number of computers*	*Radio-modem*	*Bandwidth to Yerevan LAN, Mbps*	*Distance, km*
Yerevan	10/100	15/8	Aironet BR100 Arlan 655	-	-
Aragats	10	6	Aironet BR100	2	45
Nor-Amberd	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

RADIO-MODEM	Frequency range, MHz	Radio transfer type	Modulation type	Power Output, mW	Maximum transfer rate, $Mbps$	Maximum distance (at 1Mbps),km
BR100	2400-2497	DSSS	DBPSK, DQPSK	100	2	40
BR500	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 debuging possibilities.

Table 3: Characteristics of detectors

Detector	Quantity	Altitude (m, above sea level)	Detector surface (m^2)	Rate of data acquisition (B/min)	Energy threshold (MeV)
Aragats Solar Neutron Telescope	1	3200	4	2400	50,100,150,200
Aragats Neutron Monitor	1	3200	18	128	50
Nor-Amberd Neutron Monitor	1	2000	18	128	50
Nor-Amberd Muon Telescope	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[2] sattellites will be continuously monitored. Acquisition of continuosly renewed data-sets and

Table 4: Servers

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

development of the current Solar Energetic Phenomenon models with complex calculations requaired 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 traning accelerator [12] we will obtain necessary computing performance for accurate reliable and timely warning service. The data and pictures from Nor-Amberd NM[3] and Aragats SNT[4] 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.

Acknowledgment

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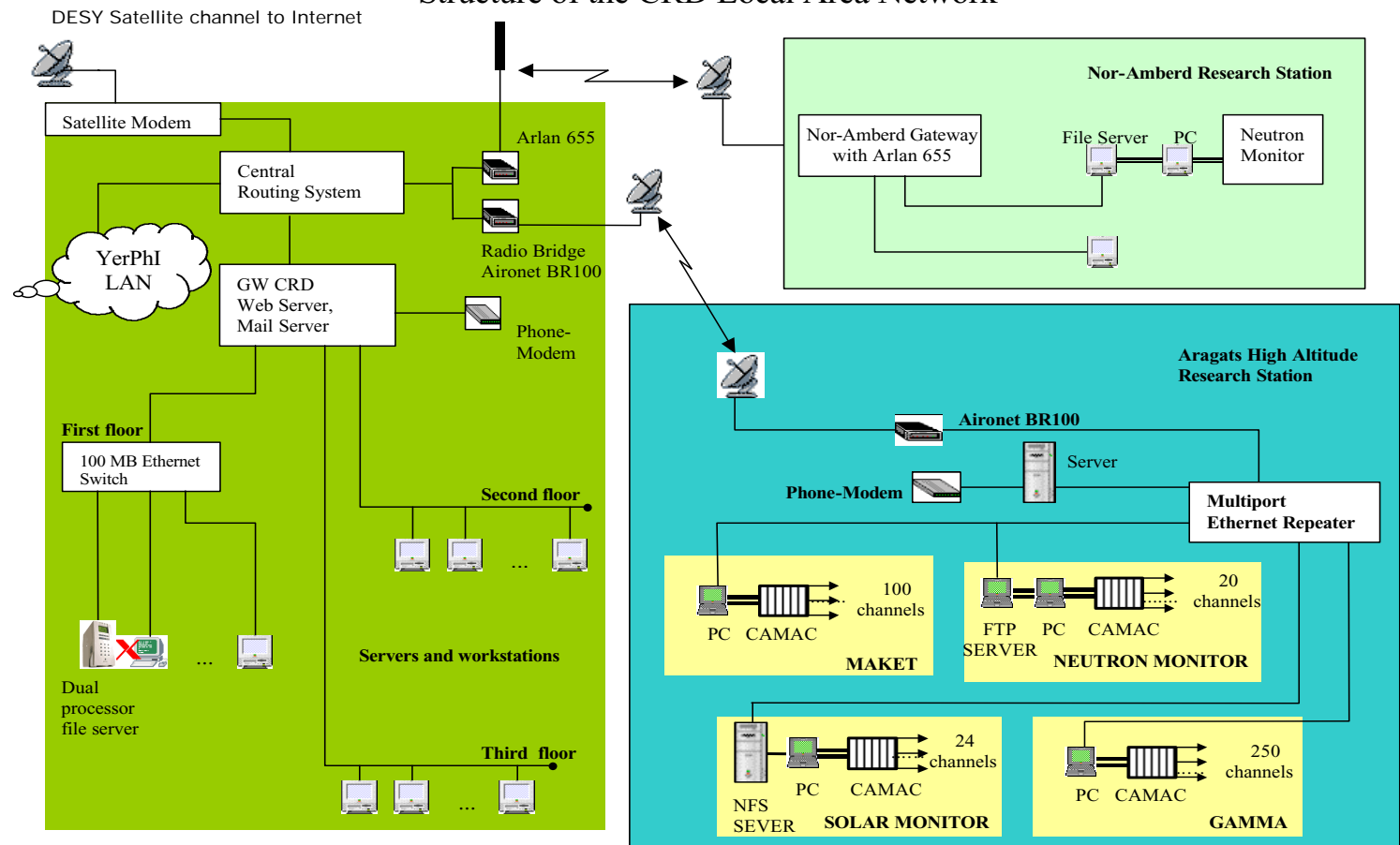
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Structure of the CRD Local Area Network

DESY Satellite channel to Internet

Satellite Modem

Central
Routing System

Arlan 655

YerPhI
LAN

GW CRD
Web Server,
Mail Server

Radio Bridge
Aironet BR100

Phone-
Modem

First floor

100 MB Ethernet
Switch

Second floor

Servers and workstations

Dual
processor
file server

...

Third floor

...

February-2000

Nor-Amberd Research Station

Nor-Amberd Gateway
with Arlan 655

File Server PC

Neutron
Monitor

**Aragats High Altitude
Research Station**

Aironet BR100

Phone-Modem

Server

**Multiport
Ethernet Repeater**

PC   CAMAC

100
channels

MAKET

FTP
SERVER

PC   CAMAC

20
channels

NEUTRON MONITOR

NFS
SEVER

PC   CAMAC

24
channels

SOLAR MONITOR

PC   CAMAC

250
channels

GAMMA

Figure 2: Scheme of CRD LAN .