Operation of the Space Environmental viewing and Analysis Network (SEVAN) in 24-th Solar Activity Cycle

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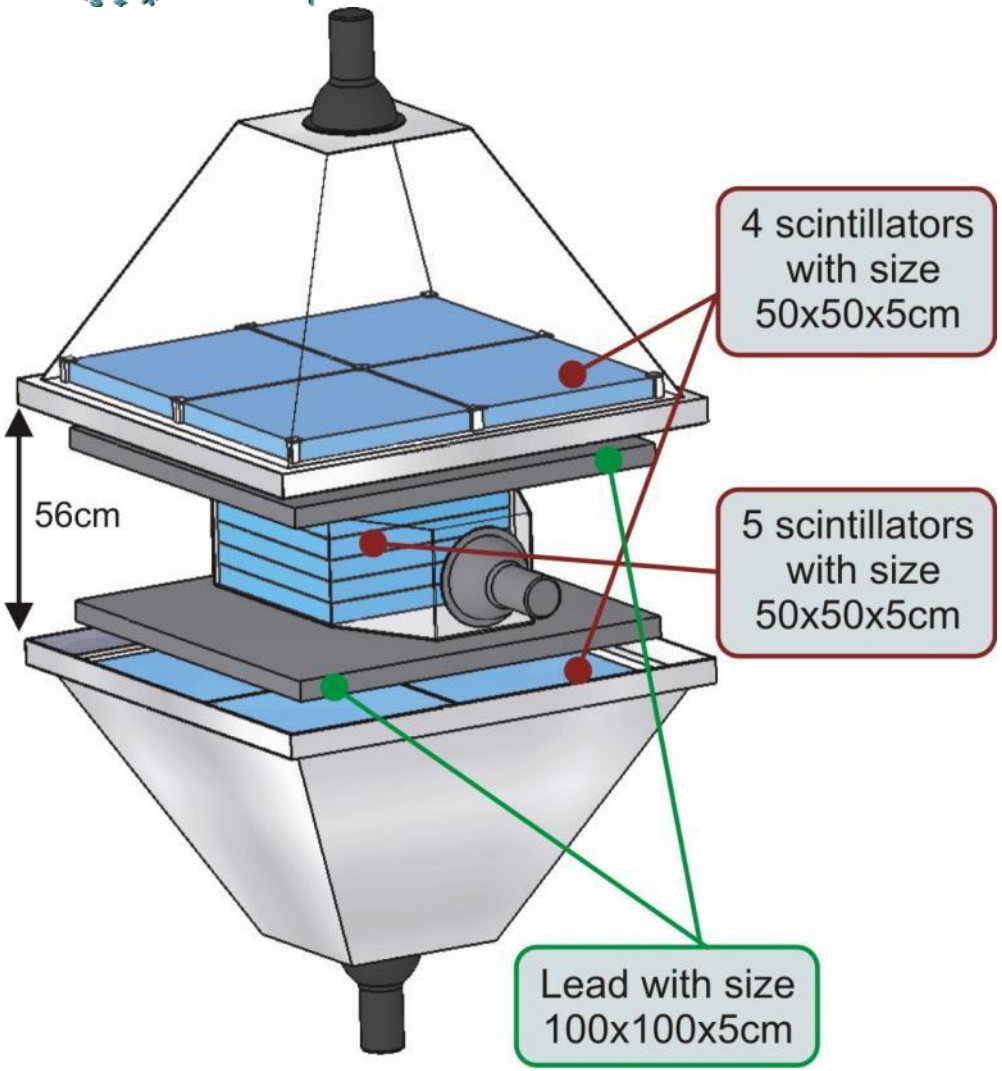
Design of the SEVAN basic unit



100 – traversal of the low energy charged particle (<100MeV);

010 – traversal of the neutral particle;

111 , 101 – traversal of the high energy muon (>250, 200MeV);

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SEVAN home page:
http://crd.yerphi.am/SEVAN_Data

Starting of SEVANs in Bulgaria, Croatia, India and Slovakia

Figure 1. SEVAN Detector in Mussala mountain research station of Nuclear Physics Institute of Bulgarian Academy of Sciences

Figure 2. SEVAN Detector in Zagreb Observatory, Croatia

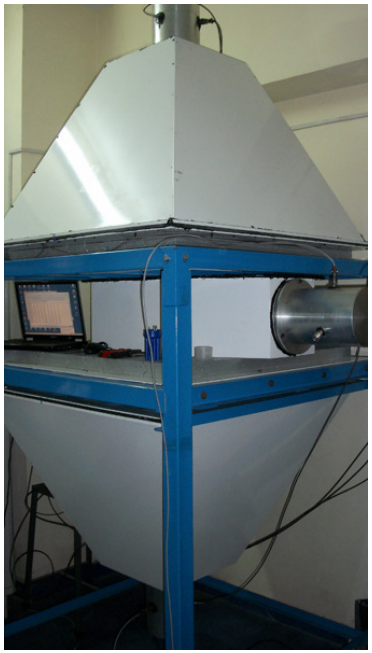


Figure 3. SEVAN Detector in India Jawaharlal Nehru University

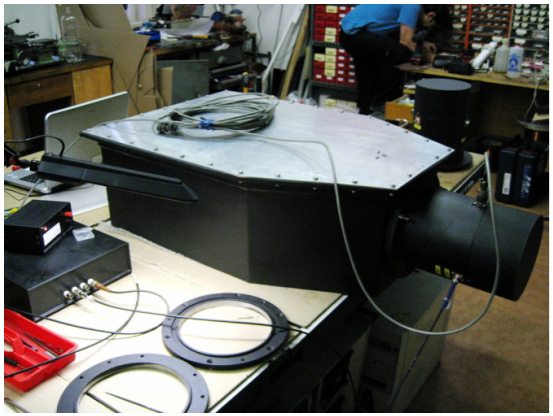
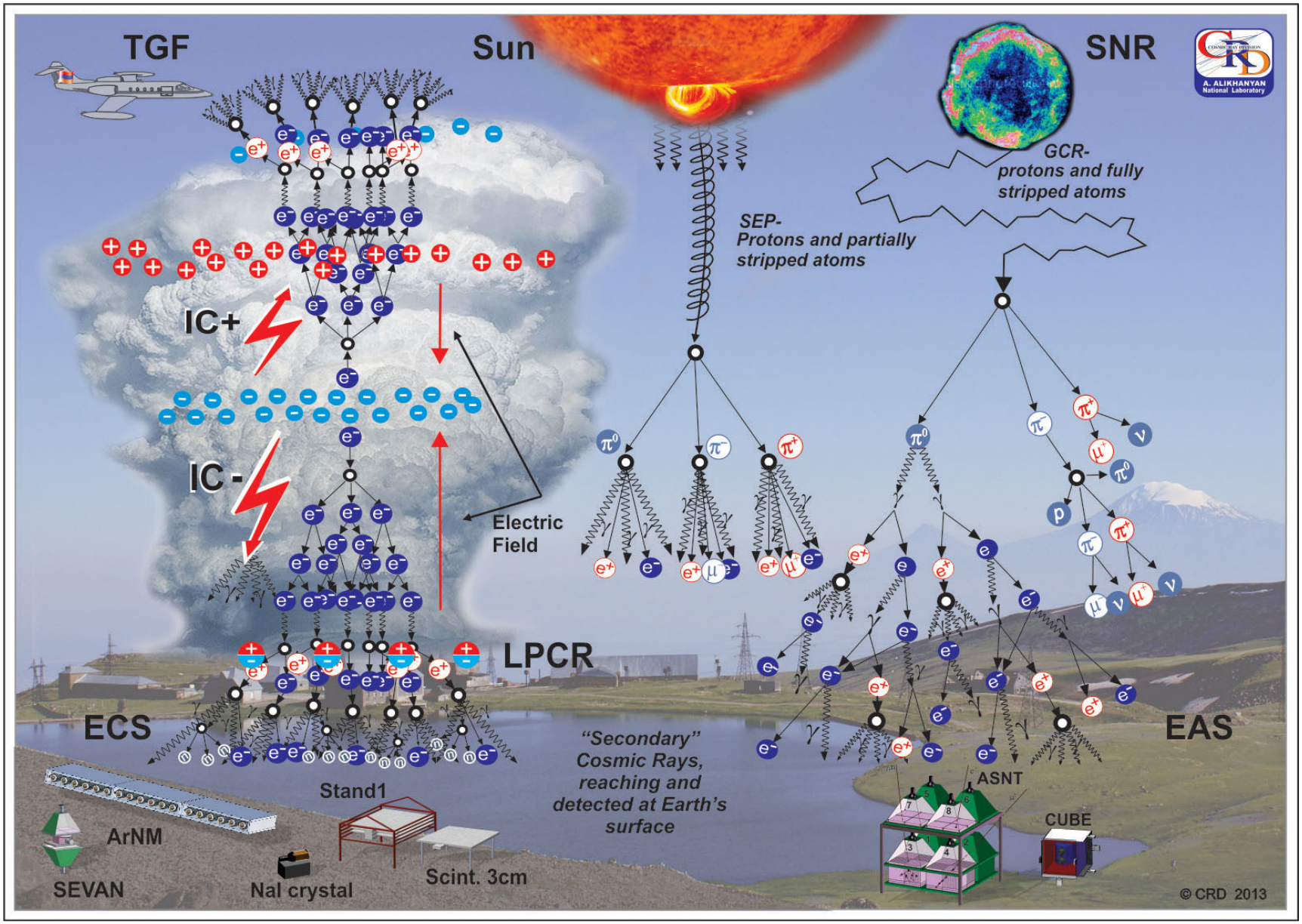


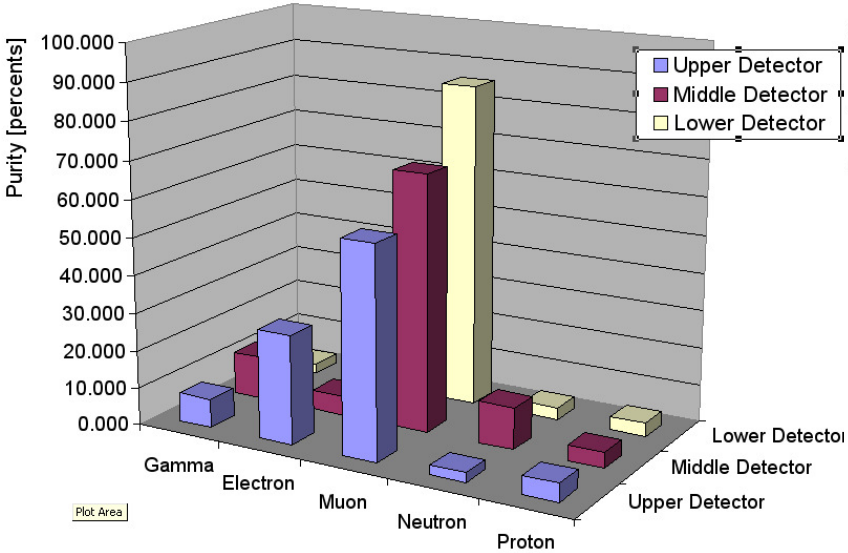
Figure 4. SEVAN Detector in Slovakia,
Lomnicky stit

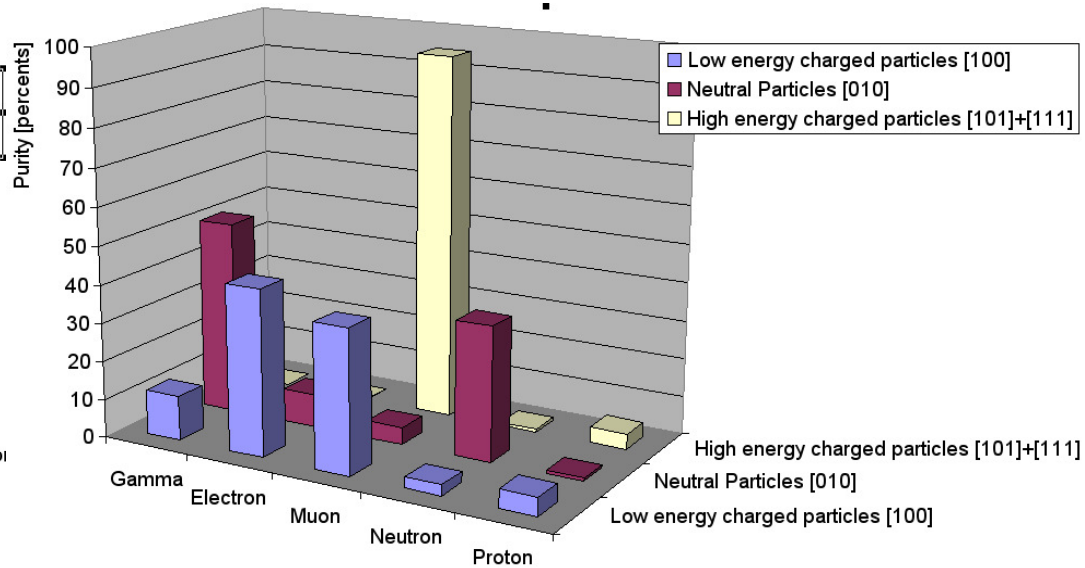
Figure 4 Armenian and Croatian Physicists at Zagreb observatory; from left to right: Armenian and Croatian Physicists at Zagreb observatory: from left to right Darije Maricic, Dragan Rosa, Karen Arakelyan, Gagik Hovsepyan and Ivan Romstajn

Modulation of Galactic Cosmic Rays



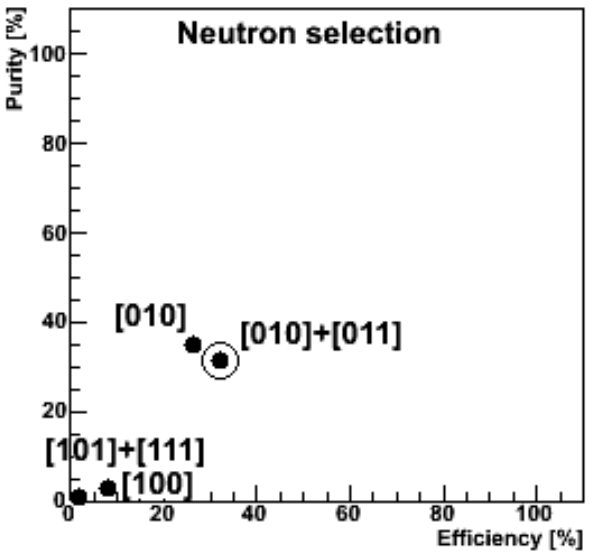
Selection of Secondary Cosmic Rays

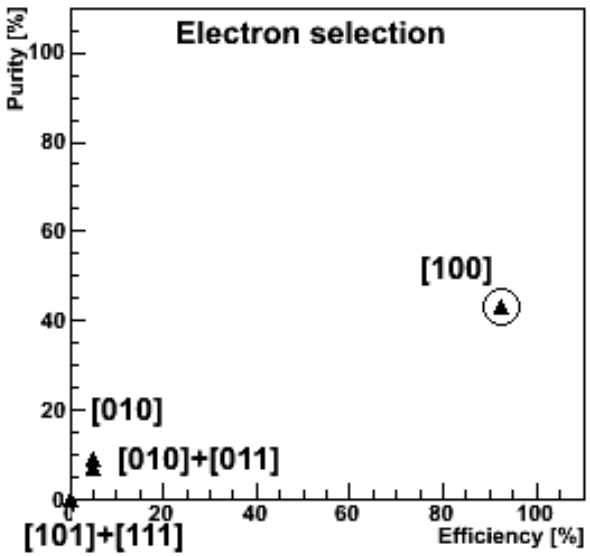


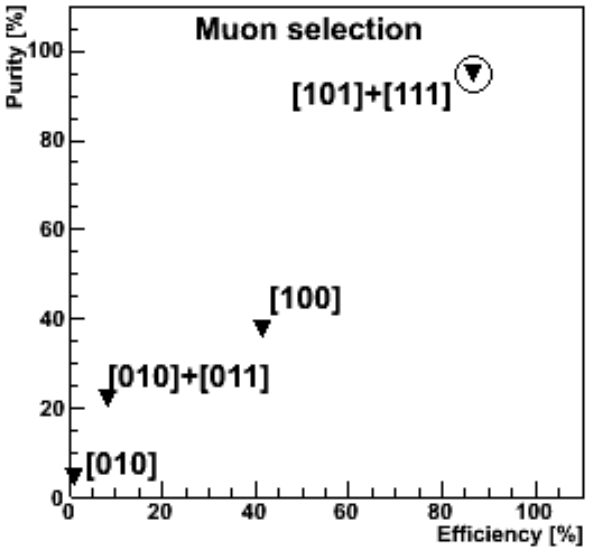


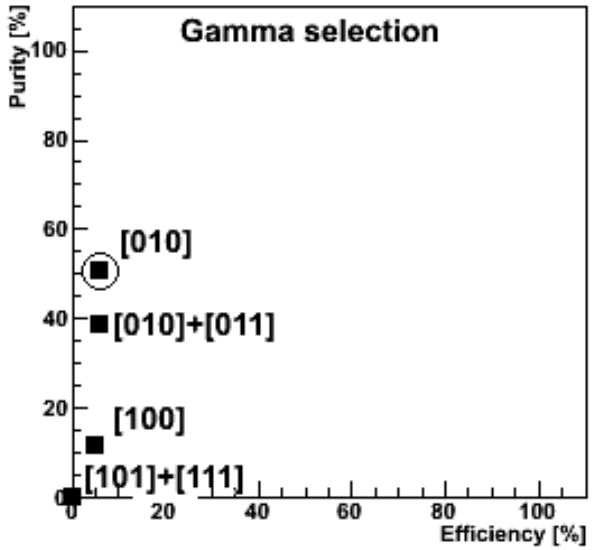
	Gamma ray	Electron	Muon	Neutron	Proton
Registered particles Purity by detecting coincidences					
Low energy charged particles [100]	11.605	43.300	37.380	2.838	4.804
Neutral Particles [010]	50.612	8.837	4.494	**35.071**	0.972
High energy charged particles [101]+[111]	0.002	0.106	94.904	0.808	4.077
Registered particles Purity by count rate of the 3 scintillators					
Upper Detector	7.616	28.952	56.080	2.448	4.814
Middle Detector	11.550	5.223	67.913	**11.038**	4.167
Lower Detector	2.696	4.438	85.873	3.267	3.634

Purity-Efficiency Diagram









SEVAN Count Rates

Aragats 3200 a.s.l.	ArNM 18NM64	SEVAN [100]	SEVAN [010]	SEVAN [111]
Relative Error	0.0068	0.0081	0.0218	0.0192
1/sqrt(N)	0.0049	0.0078	0.0223	0.0194

	YerPhI (1200m)		NorAmberd (2000m)		Aragats (3200m)		Zagreb, Croatia (130m)	Moussala, Bulgaria, (2925 m)
Type of secondary particle	Measured count rate	Simulated count rate	Measured count rate	Simulated count rate	Measured count rate	Simulated count rate	Measured Count rate	Measured count rate
Low energy charged particles (100)	8862±108	7202	11593±161	10220	16581±130	17202	6415±84	17479±136
Neutral particles (010)	363±19	359	690±27	795	2011±46	1584	316±18	1115±38
High energy muon (111 & 101)	4337±67	5477	4473±99	5548	5534±64	8051	3824±64	6315±78

Barometric coefficients, count rates and relative errors of SEVAN monitors

Monitor	Altitude (m)	Rc (Gv)	Barometric Coeff. %/mb	Correlation Coefficient	Count rate [min]	Relative error	$\frac{1}{\sqrt{N}}$
Aragats SEVAN Low energy charged particles (Coincidence 100)	3200	7.1	-0.5±0.018	0.995	15389	0.007	0.0080
Aragats SEVAN High energy muons (Coincidence 111+ Coincidence 101)	3200	7.1	-0.351±0.038	0.96	3868	0.014	0.0161
Aragats SEVAN neutrons (Coincidence 010)	3200	7.1	-0.511±0.018	0.995	1959	0.019	0.0225
Nor Amberd SEVAN Low energy charged particles (Coincidence 100)	2000	7.1	-0.281±0.022	0.957	5941	0.013	0.0129
Nor Amberd SEVAN High energy muons (Coincidence 111+ Coincidence 101)	2000	7.1	-0.242±0.022	0.952	1988	0.026	0.0224
Nor Amberd SEVAN neutrons (Coincidence 010)	2000	7.1	-0.54±0.070	0.899	674	0.037	0.0385
Yerevan SEVAN Low energy charged particles (Coincidence 100)	1000	7.1	-0.3±0.014	0.987	9446	0.010	0.0102
SEVAN High energy muons (Coincidence 111+ Coincidence 101)	1000	7.1	-0.149±0.035	0.765	4714	0.015	0.0145
Yerevan SEVAN neutrons (Coincidence 010)	1000	7.1	-0.4±0.039	0.943	425	0.048	0.0485

2 types of GLE detected by the SEVAN basic unit (simulation)

5min simulated enhancements in the Upper and Middle layers of the SEVAN basic unit.

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

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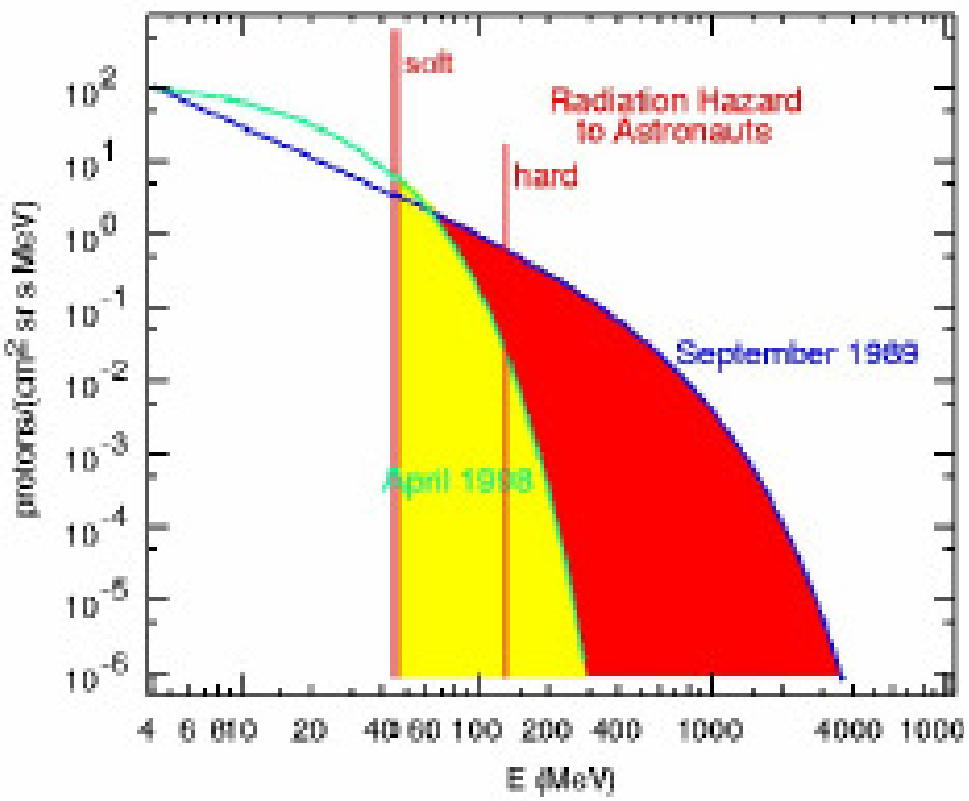
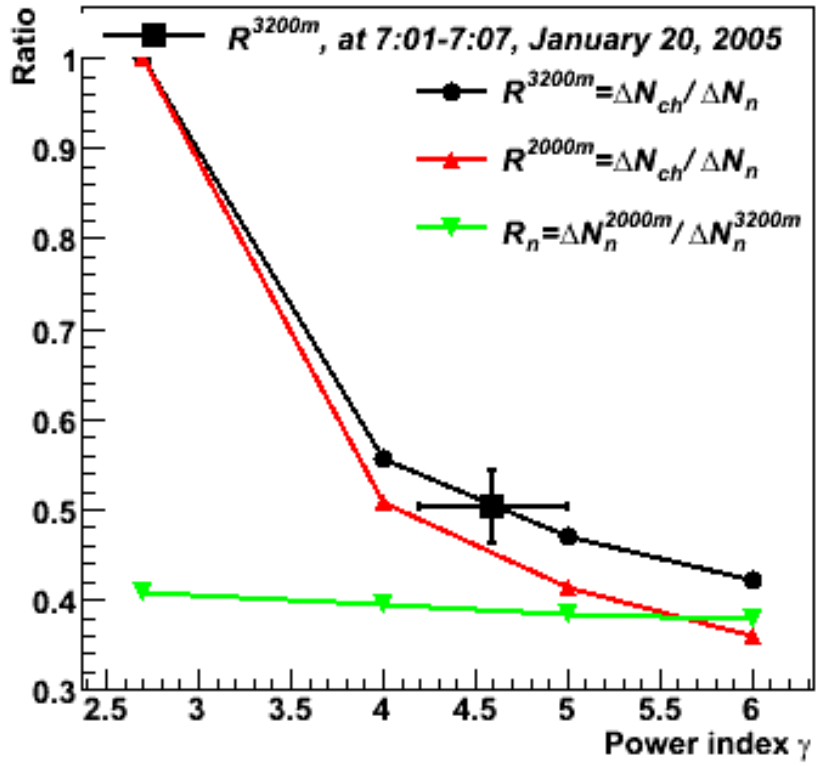
Space Weather alerts: SEVAN can estimate on-line Spectral "knees" of Solar CR

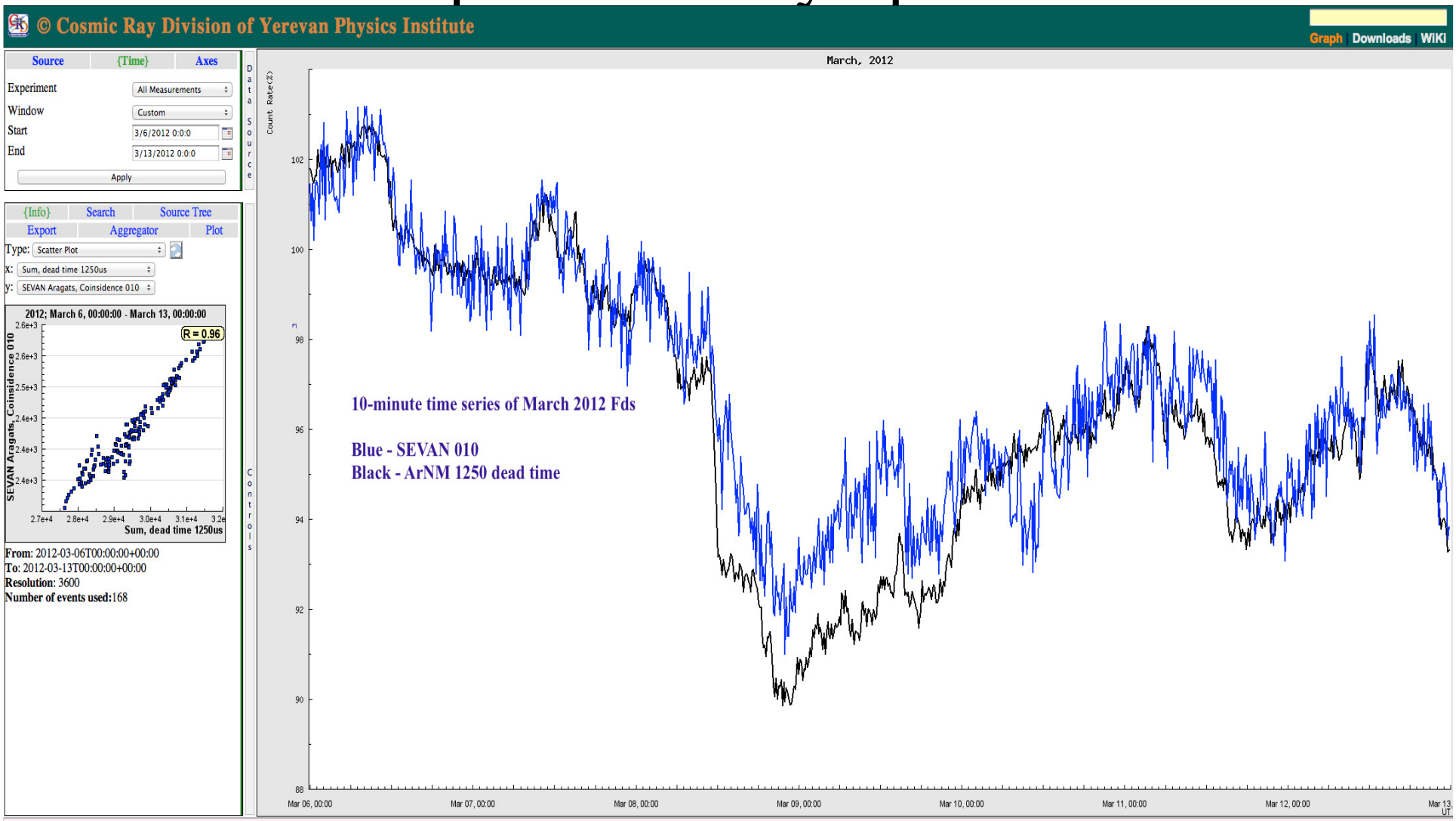


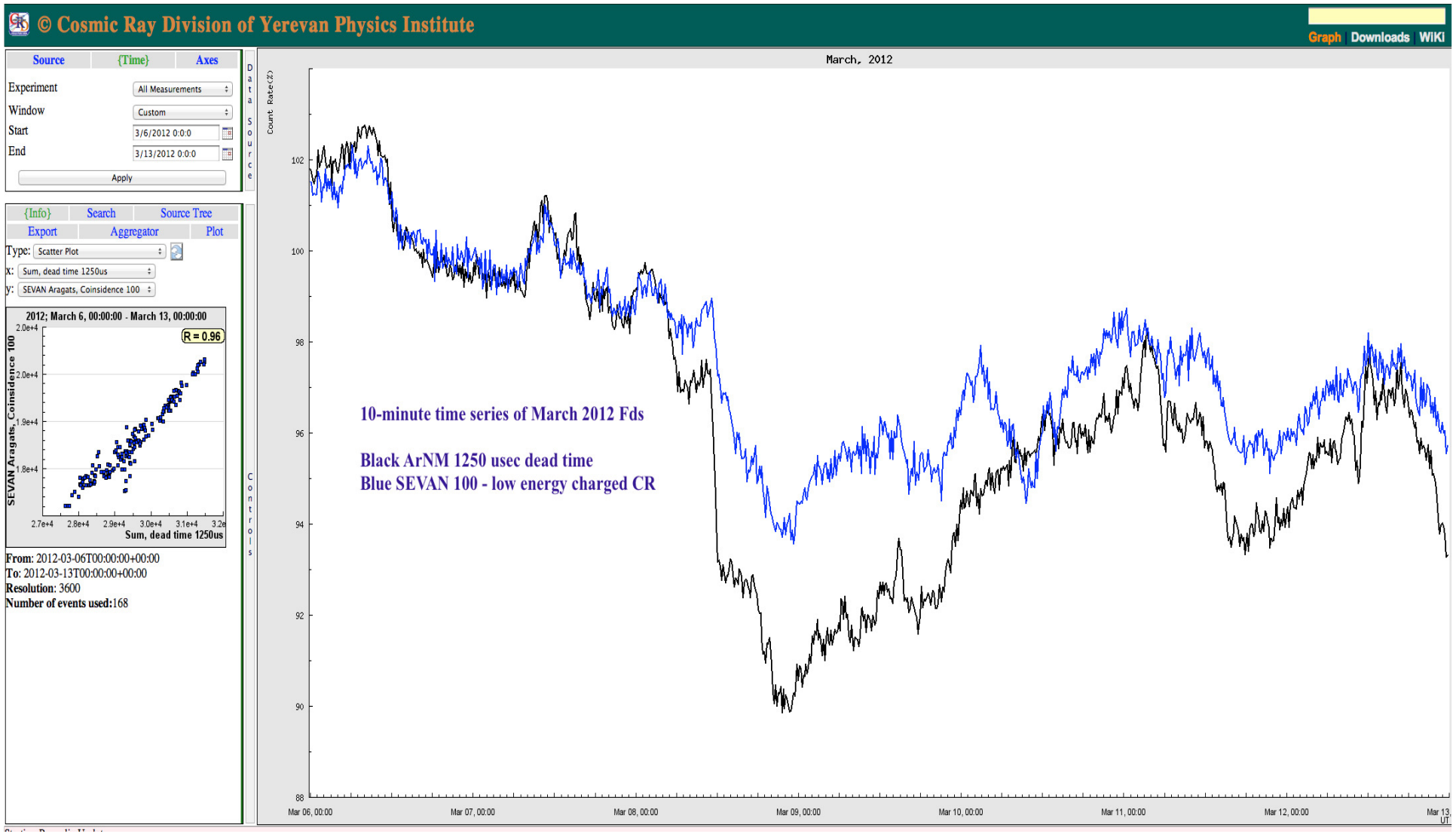


High Solar Activity in March 2012

CME Appearance Date Time [UT]	CME Type	Linear / Apparent Speed [km/s]	Source Location	X-Ray Importance	Flare Onset [UT]	CME Arrival Date Time [UT]
05.03.2012 04:00	Halo	1531	N17E52	X1.1	03:17	**07.03.2012 ~03:47**
07.03.2012 00:24	Halo	2684	N17E27	X5.4	00:02	**08.03.2012 ~10:53**
07.03.2012 01:30	Halo	1825	N17E27	--	--	
09.03.2012 04:26	Halo	950	N17W03	M6.3	03:22	**11.03.2012 ~12:52**
10.03.2012 18:12	Halo	1379	N17W24	M8.4	17:15	**12.03.2012 ~08:45**
13.03.2012 17:36	Halo	1884	N17W66	M7.9	17:12	**15.03.2012 ~12:42**

March 2012 Fd: on-line data from all SEVANs and all NMs in: http://adei.crd.yerphi.am/

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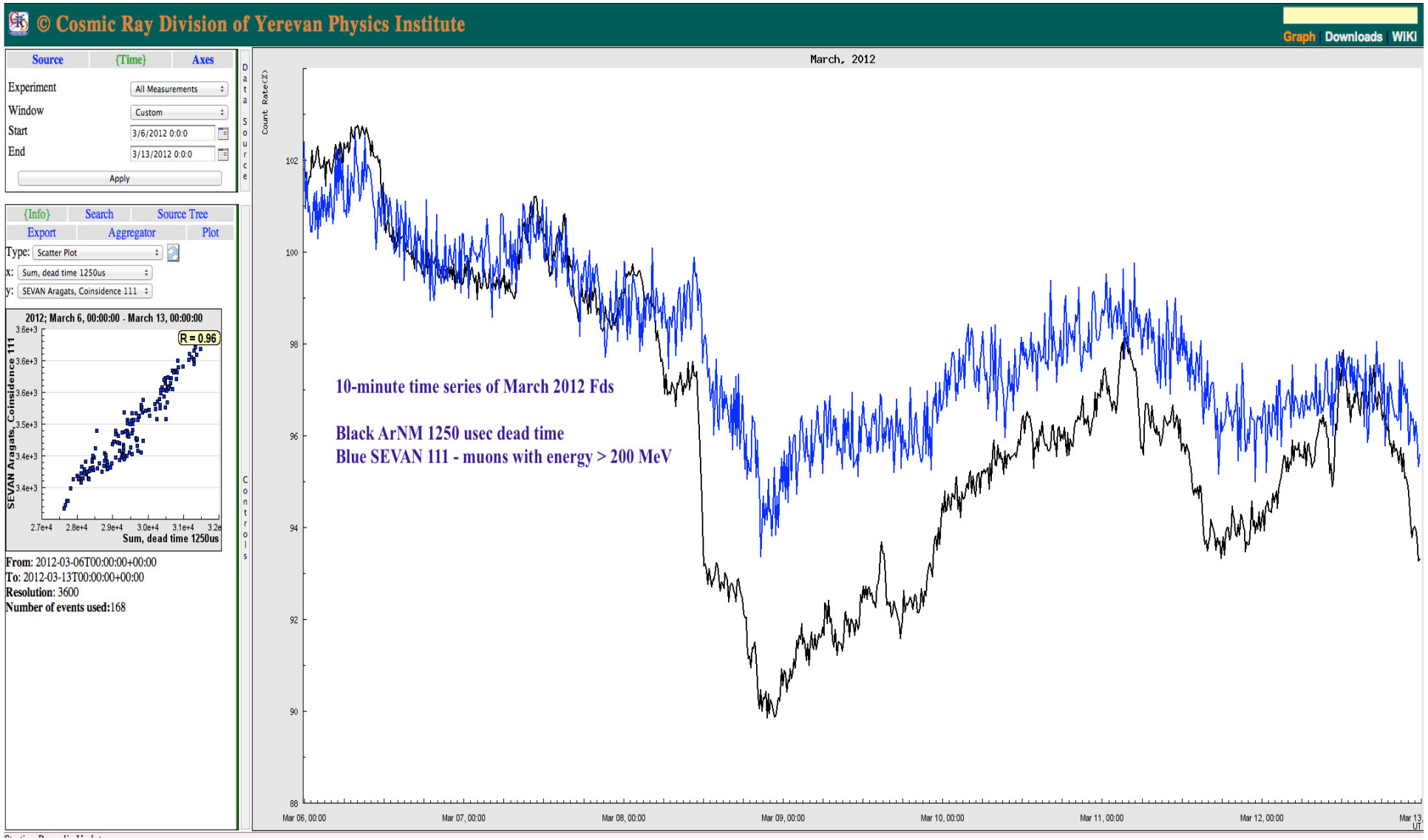
x:
Sum, dead time 1250us
y:
SEVAN Aragats, Coinsidence 100
2012; March 6, 00:00:00 - March 13, 00:00:00
R = 0.96
SEVAN Aragats, Coinsidence 100
Sum, dead time 1250us
From: 2012-03-06T00:00:00+00:00
To: 2012-03-13T00:00:00+00:00
Resolution: 3600
Number of events used: 168
Controls
March, 2012
Count Rate(%)
10-minute time series of March 2012 Fds
Black ArNM 1250 usec dead time
Blue SEVAN 100 - low energy charged CR
Mar 06, 00:00
Mar 07, 00:00
Mar 08, 00:00
Mar 09, 00:00
Mar 10, 00:00
Mar 11, 00:00
Mar 12, 00:00
Mar 13, UT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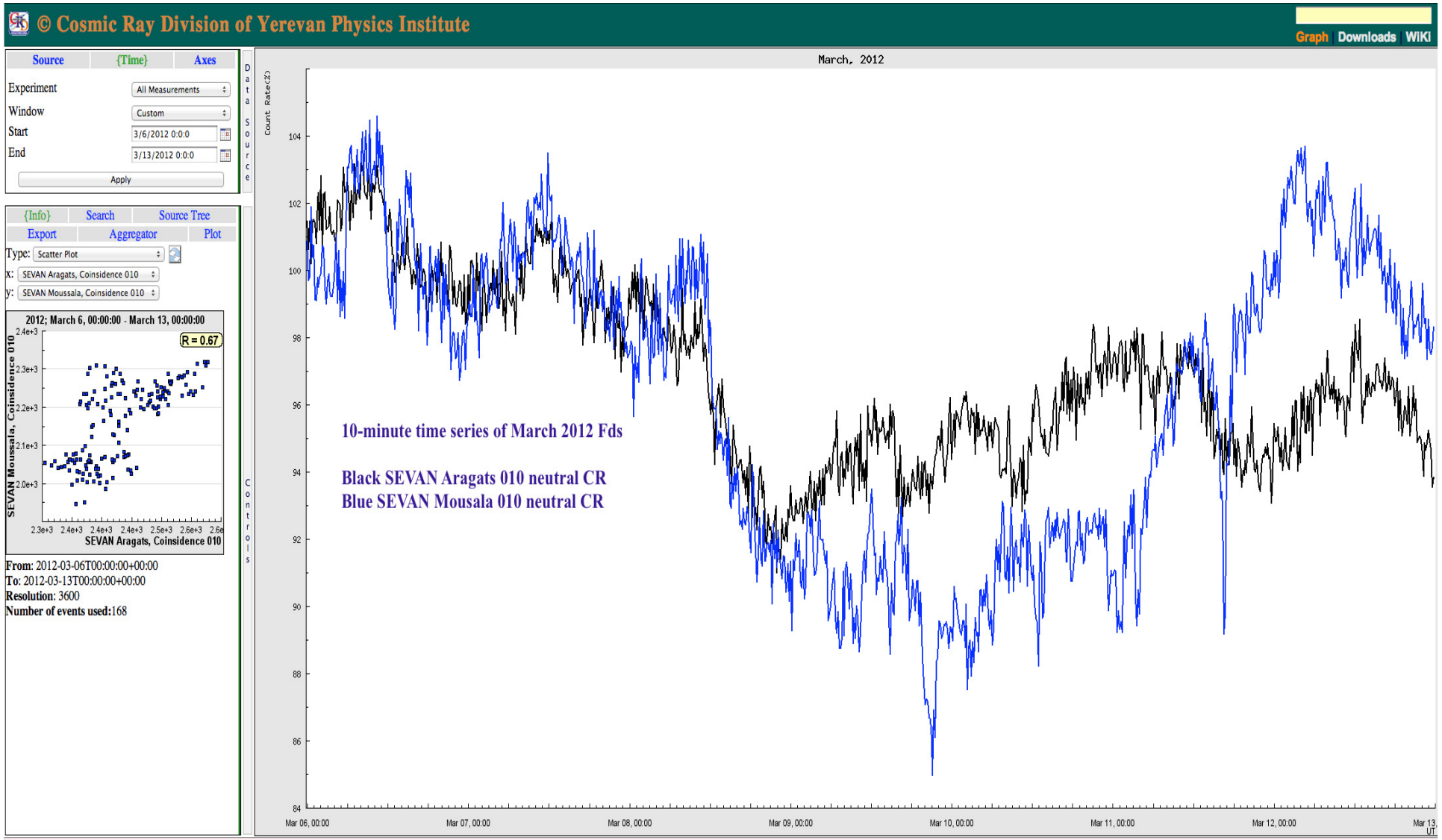
SEVAN Aragats, Coinsidence 111
2012; March 6, 00:00:00 - March 13, 00:00:00
R = 0.96
SEVAN Aragats, Coinsidence 111
Sum, dead time 1250us
From: 2012-03-06T00:00:00+00:00
To: 2012-03-13T00:00:00+00:00
Resolution: 3600
Number of events used:168
Controls
March, 2012
Count Rate(%)
10-minute time series of March 2012 Fds
Black ArNM 1250 usec dead time
Blue SEVAN 111 - muons with energy > 200 MeV
Mar 06, 00:00
Mar 07, 00:00
Mar 08, 00:00
Mar 09, 00:00
Mar 10, 00:00
Mar 11, 00:00
Mar 12, 00:00
Mar 13, UT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y:
SEVAN Moussala, Coinsidence 010
2012; March 6, 00:00:00 - March 13, 00:00:00
R = 0.67
SEVAN Moussala, Coinsidence 010
SEVAN Aragats, Coinsidence 010
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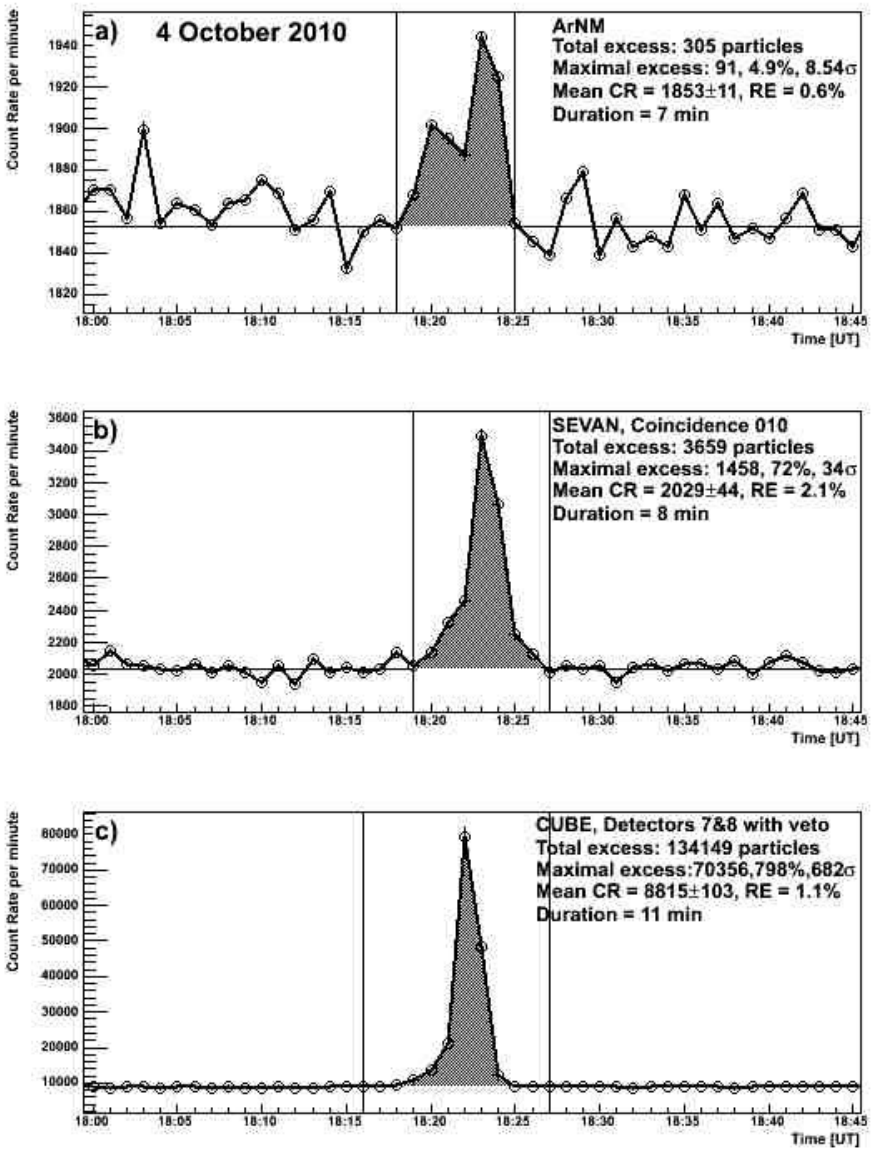
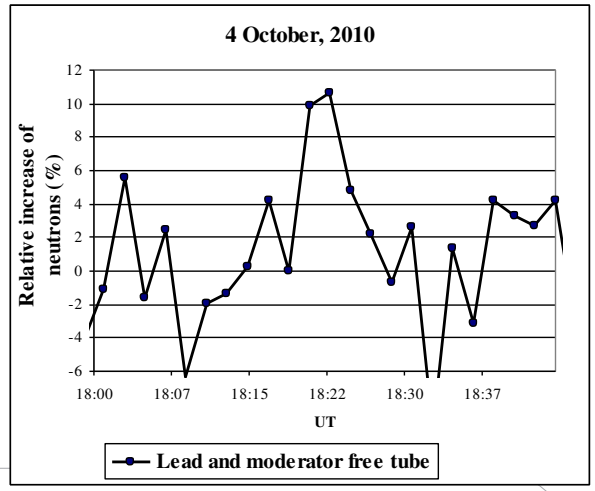
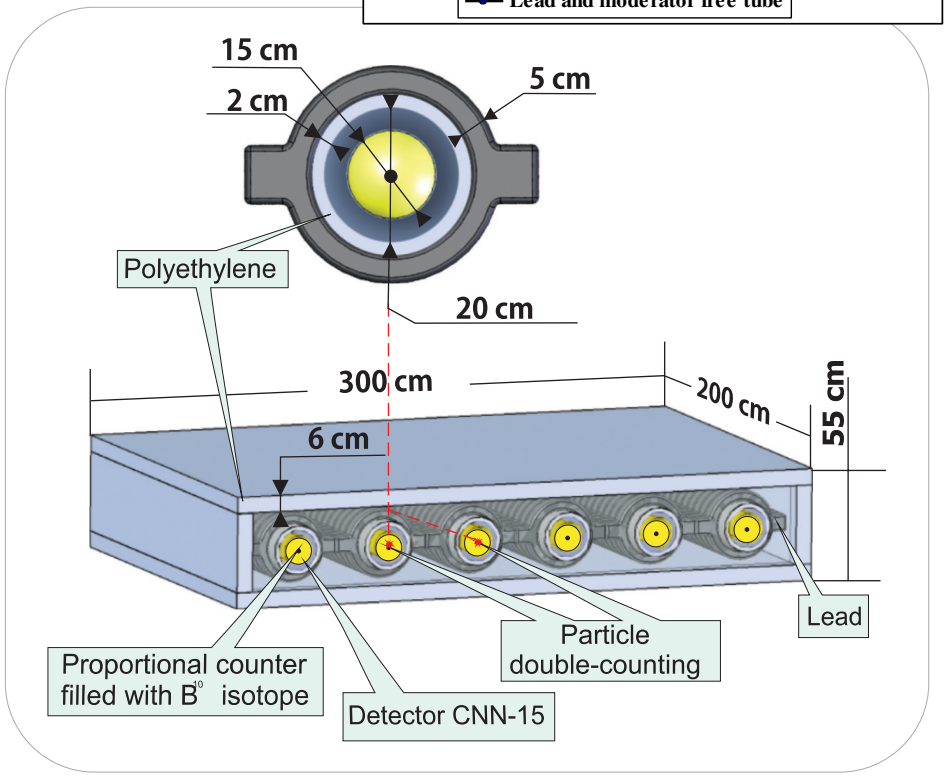
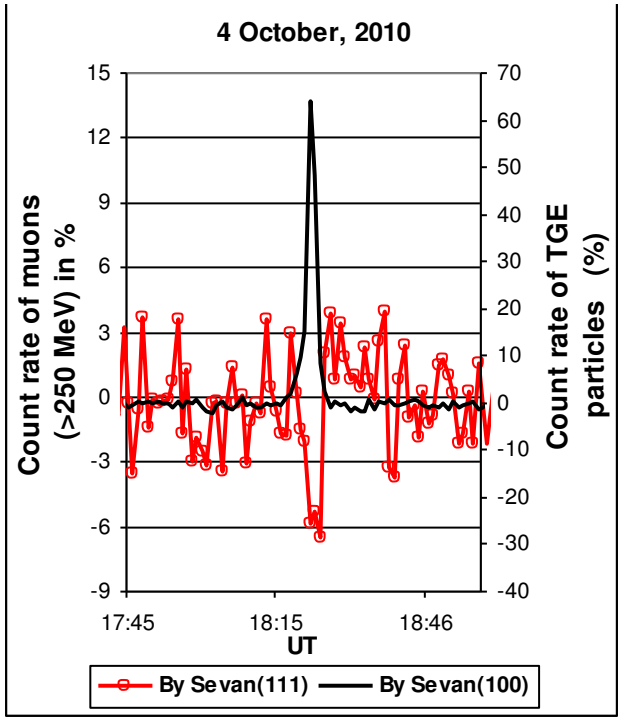
To: 2012-03-13T00:00:00+00:00
Resolution: 3600
Number of events used:168
Controls
March, 2012
Count Rate(%)
10-minute time series of March 2012 Fds
Black SEVAN Aragats 010 neutral CR
Blue SEVAN Mousala 010 neutral CR
Mar 06, 00:00
Mar 07, 00:00
Mar 08, 00:00
Mar 09, 00:00
Mar 10, 00:00
Mar 11, 00:00
Mar 12, 00:00
Mar 13, UT

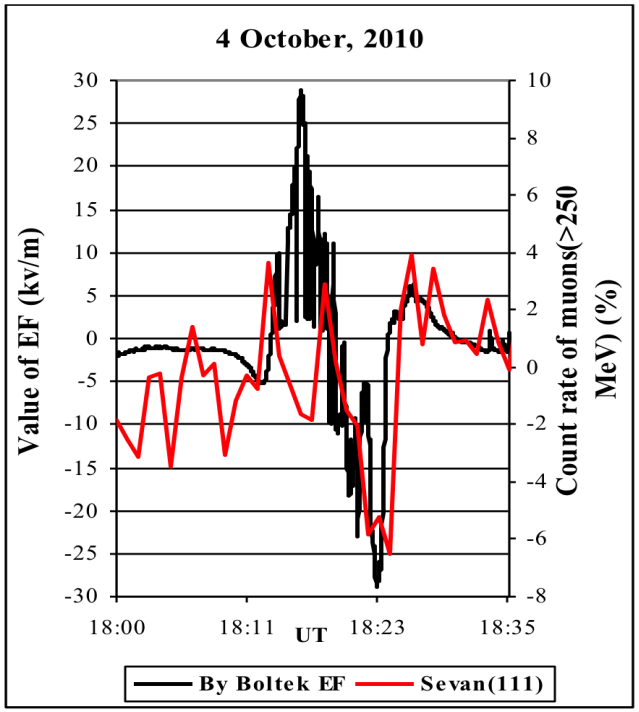
SEVAN calibration with gamma rays from Thunderstorm Ground Enhancements (TGEs): Electrons born gamma rays and gamma rays – neutrons.





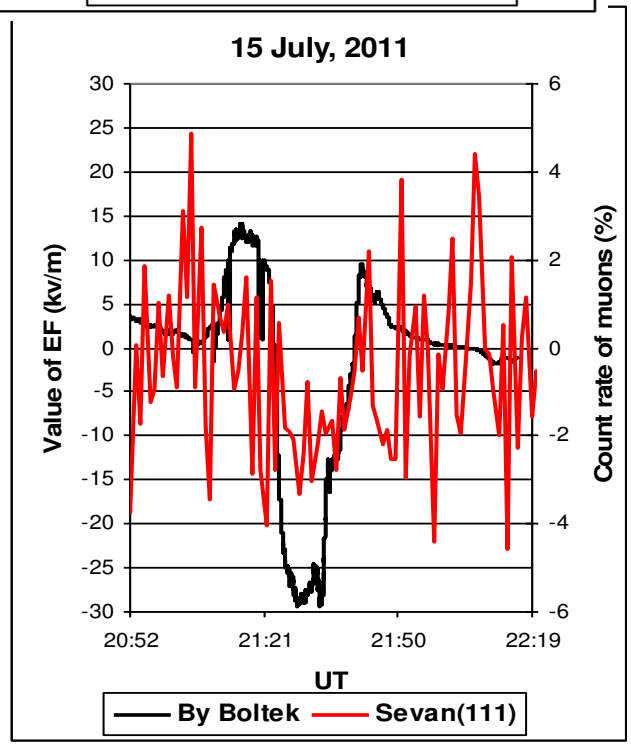


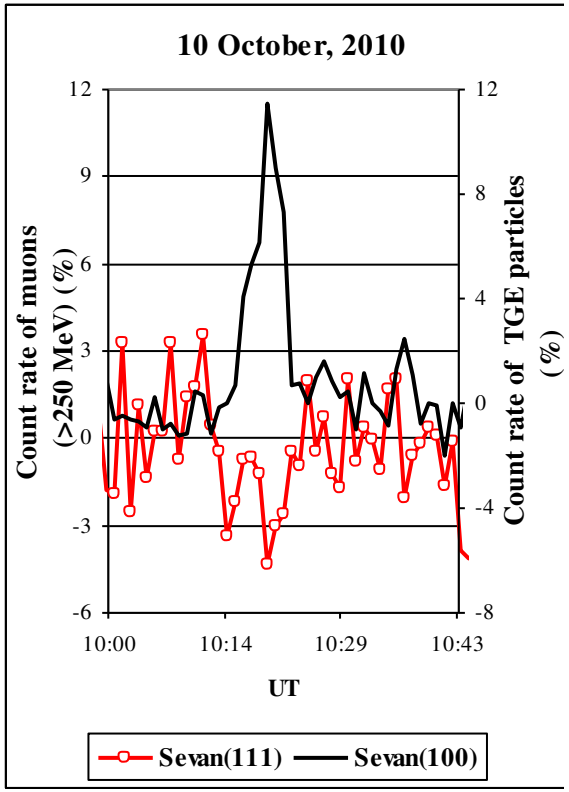




Deficit of high energy muons- positive muons stop: evidence of large potential drop in thundercloud

~5% deficit in muon flux prove existence of large potential drop in thundercloud accelerated electrons in the direction to Earth surface





SEVAN Advantages

The hybrid particle detectors, measuring neutral and charged fluxes provide following advantages upon existing detector networks measuring single species of secondary CR:

- **Cheap and simple operation;**
- **Probe different populations of primary cosmic rays with rigidities from few GV (neutrons) up to 20-30 GV (muons);**
- **Reconstruct SCR spectra and determine position of the spectral "knees";**
- **Classify GLEs in "neutron" or "proton" initiated events;**
- **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.**
- **Detect Thunderstorm Ground Enhancements – both electron and gamma ray fluxes**

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