Detection of high energy solar protons during ground level enhancements

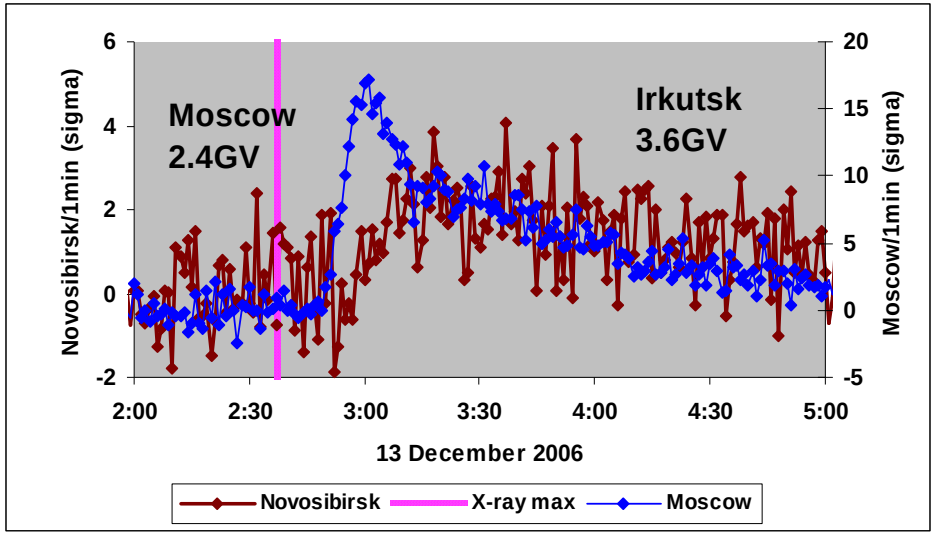
G.G. Karapetyan

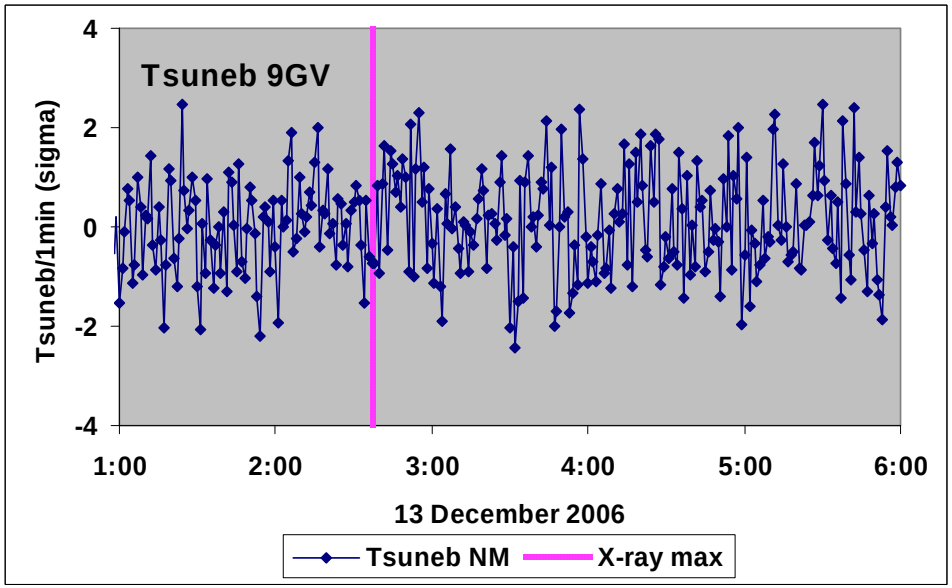
Alikhanian Physics Institute

Enables to estimate:

- Maximal energy of solar protons
- Spectrum of GLE

Middle and low latitude monitors

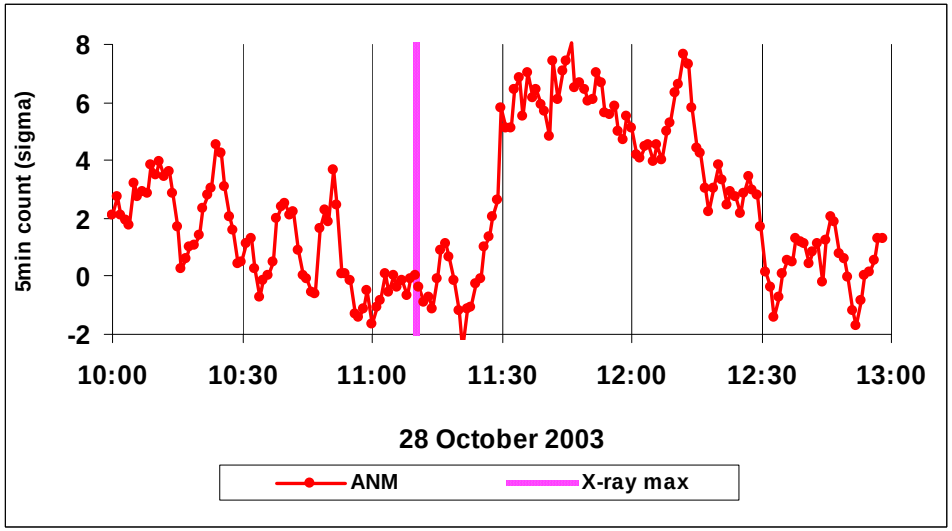


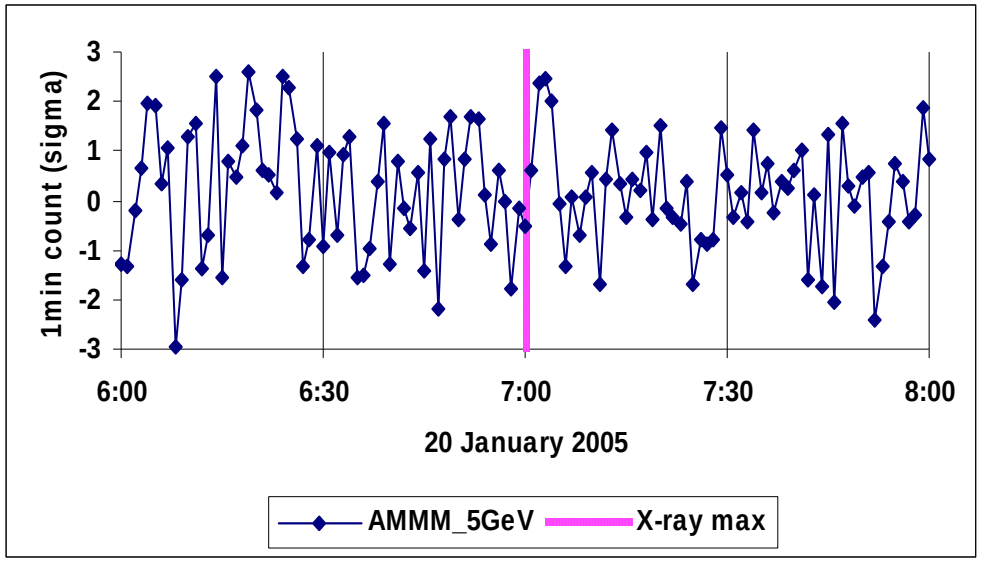


Problems of weak GLE signal detection

- Slow drift of mean count
- Unknown onset time
- Unknown duration
- Estimation of probability of error

Strong GLE signal





How many trials one should perform when searching weak GLE signal?

- ***NM with rigidity ~6…12GV***

Duration up to 25 min

Onset time ~ 10…50min after X-ray maximum

Number of trials ~ 1000

- ***AMMM_5GeV, corresponding to ~30GeV primary protons***

Duration up to 7min

Onset time ~ 1…15min after X-ray maximum

Number of trials ~100

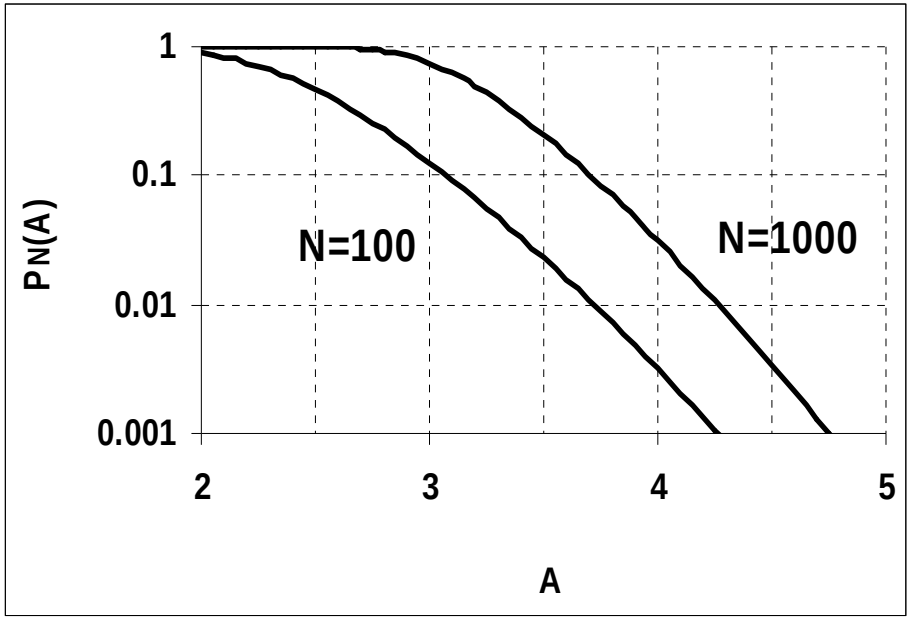
Probability of error $P_N(A)$

$P_N(A)$ is the probability that the value A has originated by the chance.

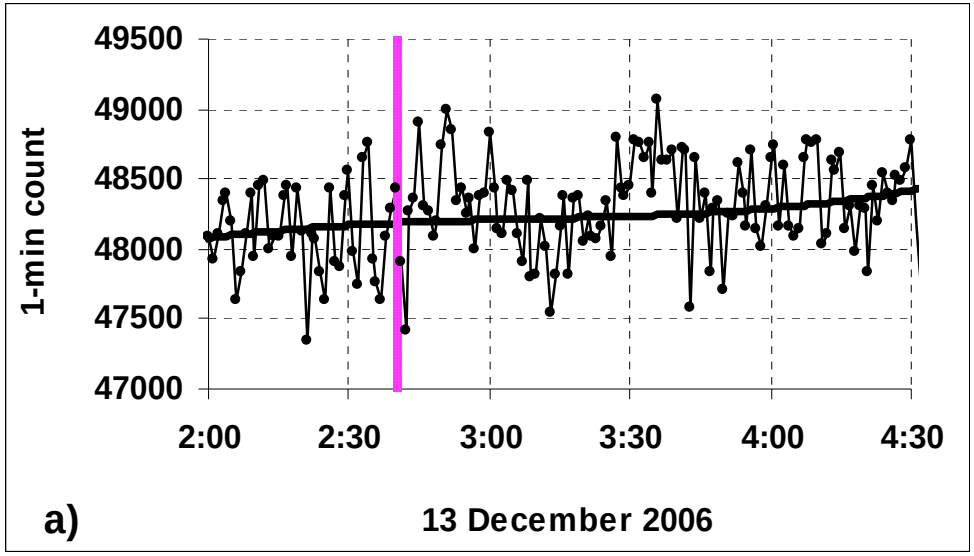
$$G(A) = \int_{-\infty}^{A} g(x)dx$$

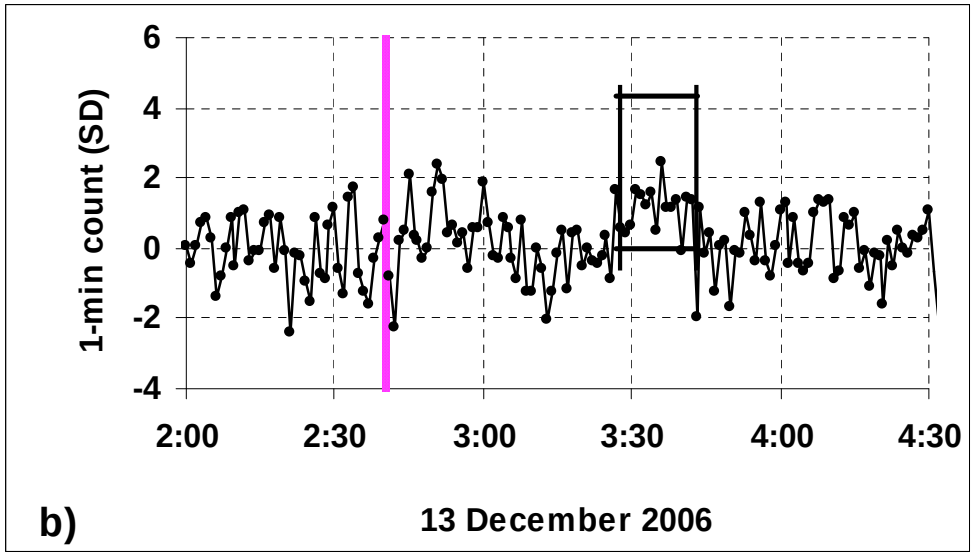
$G(A)^N$ is the probability that all N terms are smaller than A

$P_N(A)=1 - G(A)^N$



ANM count at GLE-70 13 December 2006





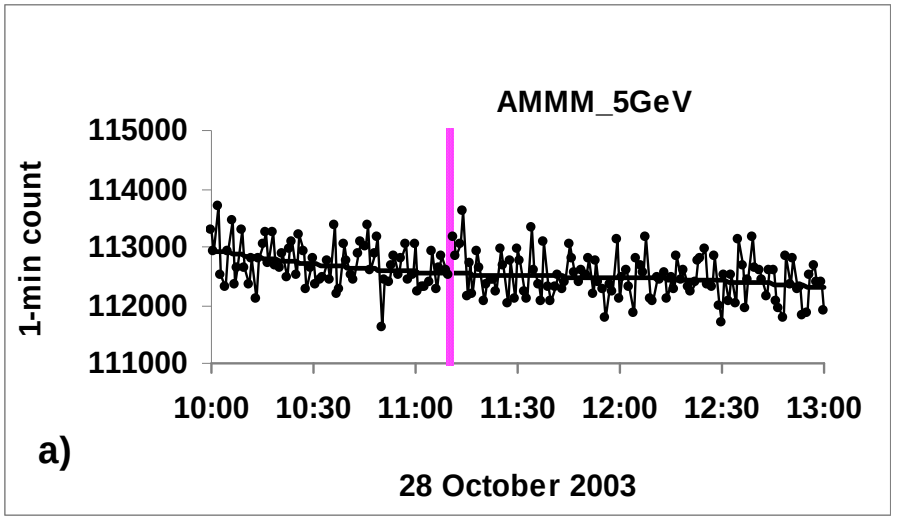
3:27 – 3:43

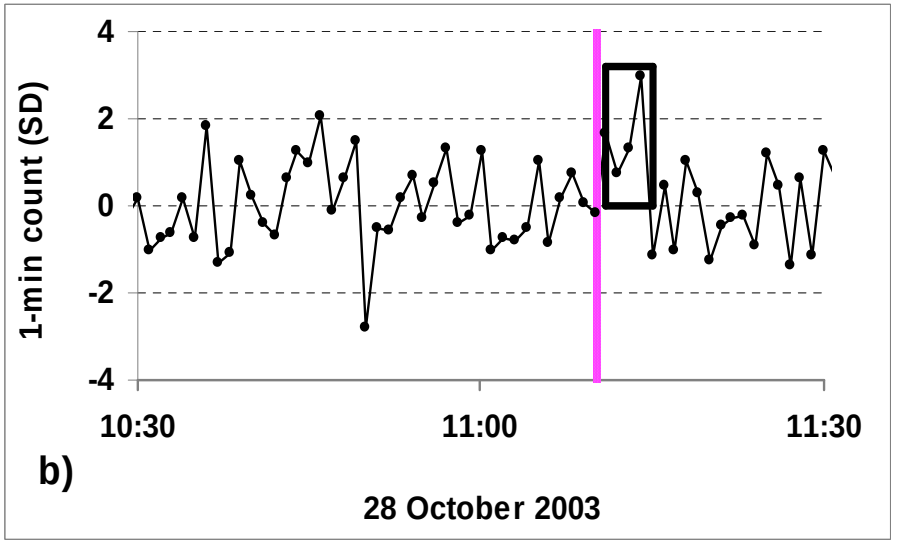
$P_{1000}(4.3) \sim 0.0085$

GLE-70 13 December 2006

Monitor	Rigidity (GV)	Time interval of maximal SS	Maximal SS (σ)	PE
Alma-Ata NM	6.5	3:02 – 3:26	5.1	1.7×10^{-4}
Aragats NM	7.1	3:27 – 3:43	4.3	0.0085
Aragats MMM	7.1	3:28 – 3:41	3.6	0.15
Hermanus NM	4.9	2:59 – 3:08	3.7	0.10
Hermon NM	11	3:12 – 3:23	3.5	0.21
Tsuneb NM	9.1	2:44 – 2:58	3.4	0.29
Baksan NM	5.6	2:51 – 2:56	3.3	0.38
Tbilisi NM	6.7	3:06 – 3:22	< 3	
Athens NM	8.7		< 2.5	

Detection of >5GeV muons during GLE-65





11:11 – 11:15

$P_{100}(3.2) \sim 0.07$

CONCLUSIONS

- Weak GLE signal must be searched by using moving averaged counts
- 90% confidence limit for 6…12GeV protons detection is determined by ~3.7σ, whereas for 20…30GeV protons - by ~3.1σ
- AMMM registered >5GeV muons during GLE 65 at 28 October 2008. It means the presence of 20…30GeV protons
- In 23rd cycle there were 2 events with 20…30 GeV protons: 28 Oct 2008 and 20 Jan 2005.