33 Всероссийской конференции по космическим лучам (Дубна, 11-15 августа 2014)

ID: 151

Анализ возрастаний космических лучей, зарегистрированных в октябре-ноябре 2013 г.

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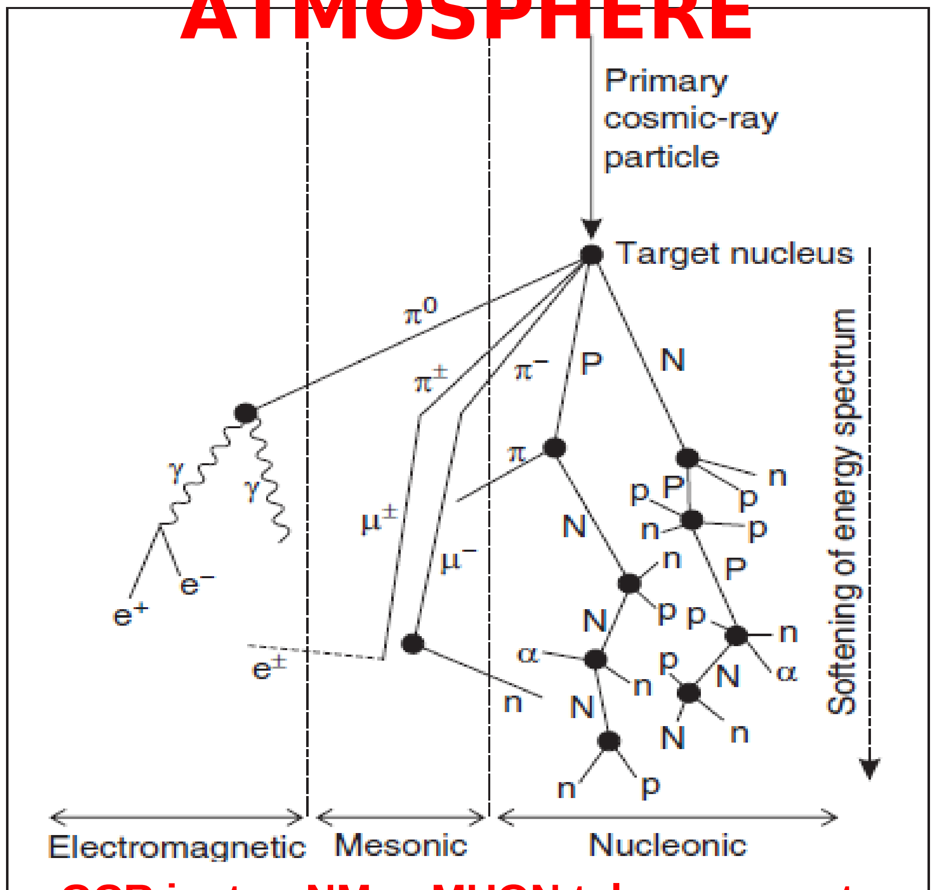
Абстракт

В работе представлены результаты анализа вариаций космических лучей и солнечной активности в период октябрь-ноябрь 2013 г. Используются данные измерений космических лучей, полученные на мировой сети наземных НМ (NMDB), в земной атмосфере на радиозондах, а также зарегистрированные детектором космических лучей (детектор GCR), установленном в CERN для проведения работ по проекту CLOUD. Анализ солнечной (вспышечной) активности выполнен по данным наблюдений солнечного Н-альфа, рентгеновского, гамма и радиоизлучения на наземных установках и на космических аппаратах (GOES, FERMI и др.). Особое внимание уделено возрастаниям космических, зарегистрированным GCR детектором 15 октября и 19 ноября 2013 г. Характеристики этих событий схожи с возрастаниями, зарегистрированными ранее 7 марта 2011 г. и 23 января 2012 г. детектором КОВЕР, расположенным на астрономическом комплексе CASLEO в Аргентине. В работе рассмотрена возможная связь таких возрастаний космических лучей, как с вспышечной активностью Солнца, так и процессами в земной атмосфере.

COSMIC RAY TRANSPORT IN THE ATMOSPHERE

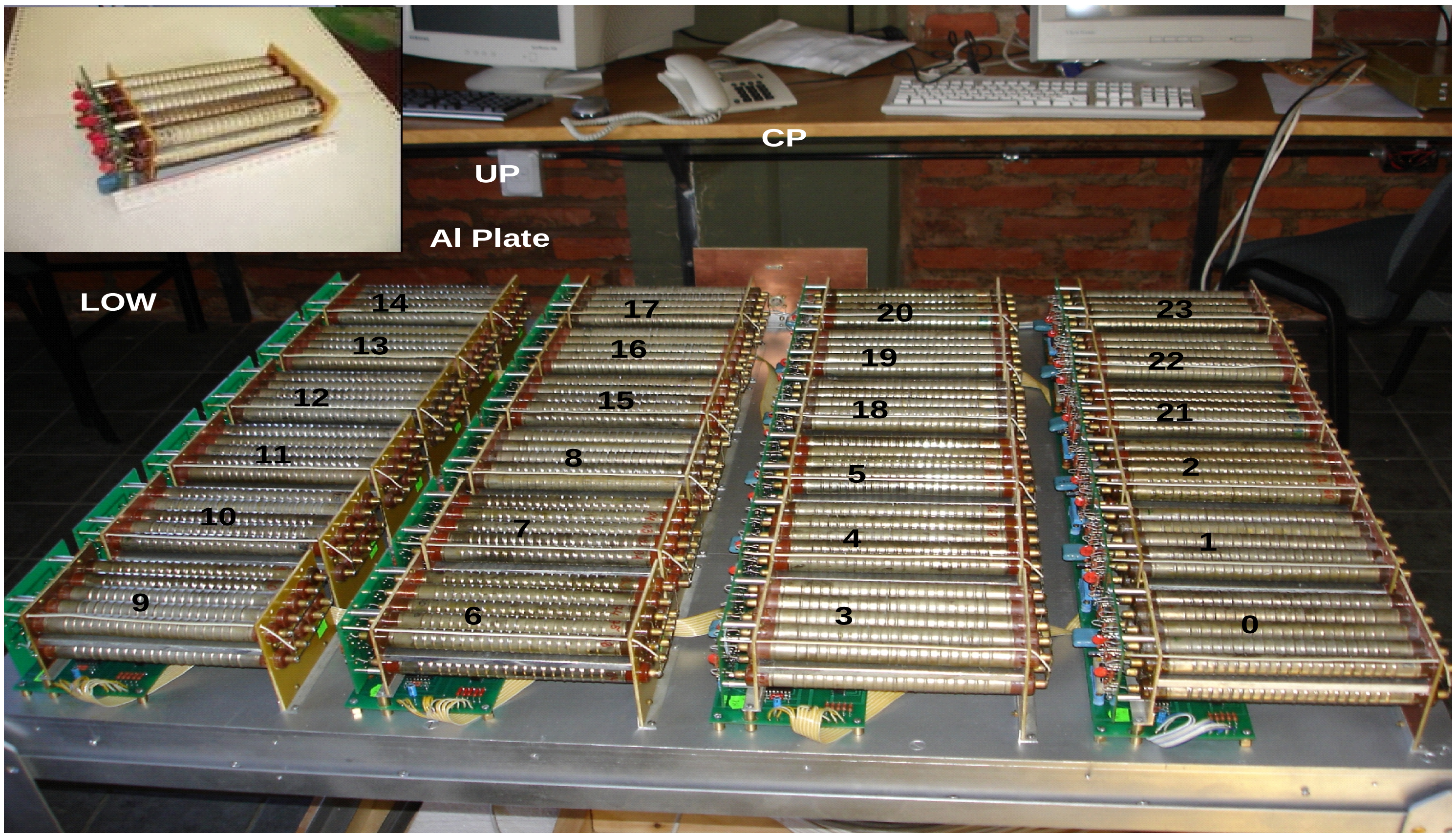


GCR instr., NMs, MUON telescopes, etc.

Fig. 1.2. The secondary cosmic ray cascade in the atmosphere. Abbreviations used: n, neutron, p, proton (capital letters for particles carrying the nuclear cascade), α, alpha particle, $e^{\pm}$, electron or positron, γ, gamma-ray photon, π, pion, μ, muon. After Simpson and Fagot (1953), discussion in the text.

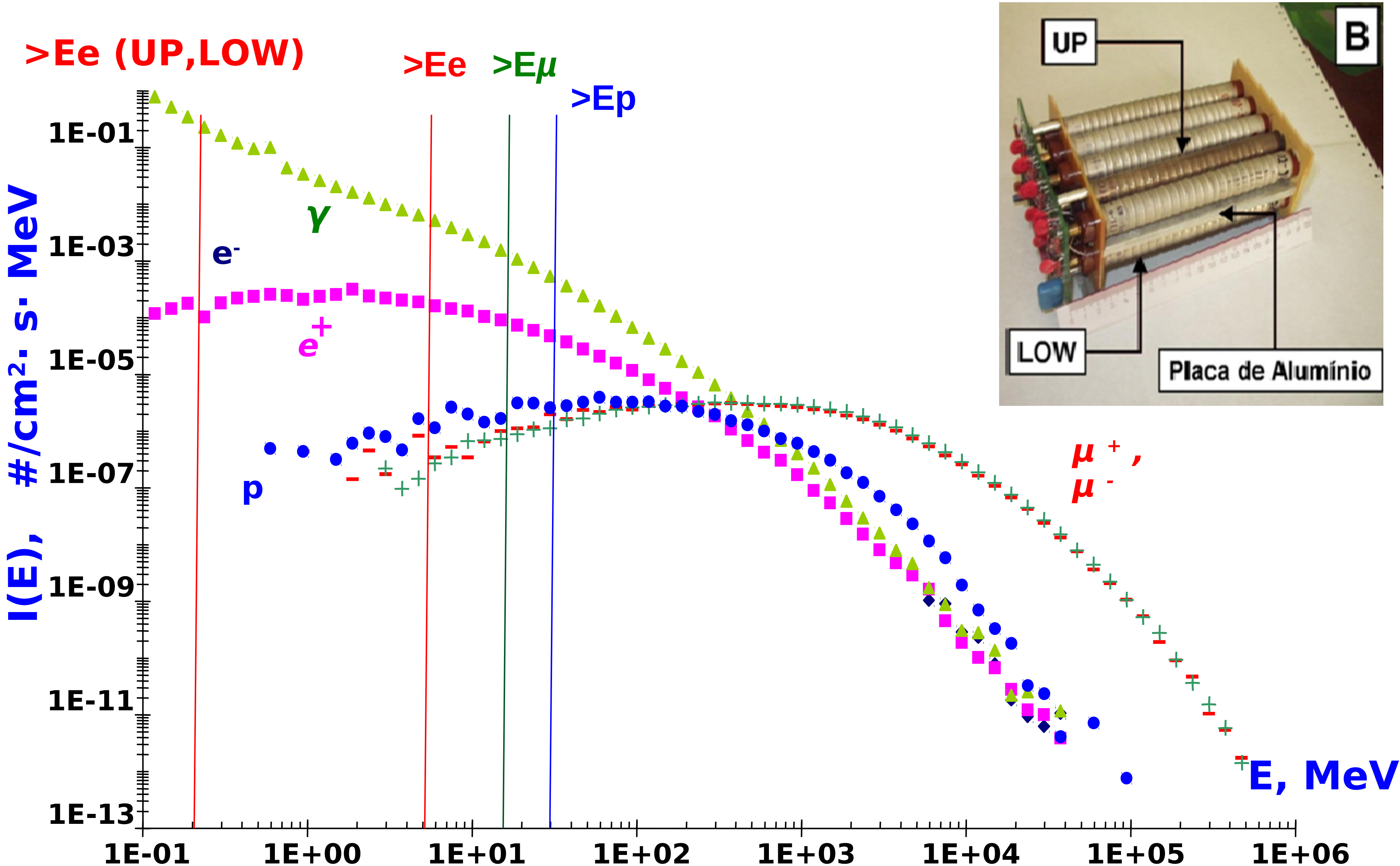
Cambridge University Press 978-0-521-87380-2 - Cosmogenic Nuclides: Principles, Concepts and Applications in the Earth Surface Sciences, Tibor J. Dunai

Астрономический комплекс
(El Leoncito, CASLEO, Argentina)
ARPET (Ковер) cosmic ray detector



UP, LOW : e> 0,2 MeV, p> 5 MeV , ɣ> 0,02 MeV

TEL: e> 5 Mev, p > 30 MeV, μ>15



Differential Energy Spectra of Secondaries - p, e^-, e^+, μ^+, μ^-

and gamma at atmospheric depth $X=800$ g·см$^{-2}$

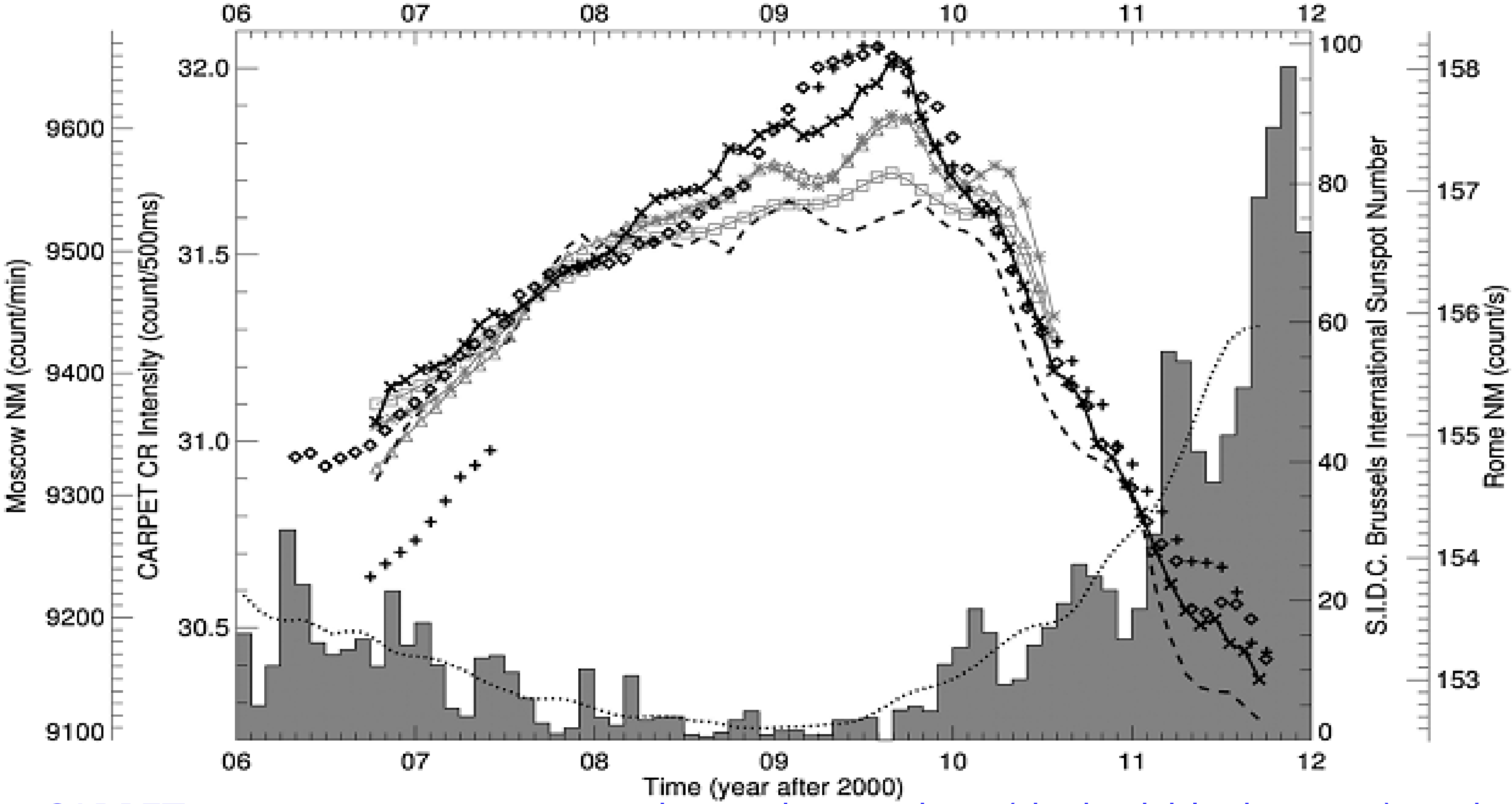
- Analysis of atmospheric pressure and temperature effects on cosmic ray measurements, R. R. S. De Mendonça, J. -P. Raulin, E. Echer, V. S. Makhmutov, and G. Fernandez, J. GEOPHYS. RES.: SPACE PHYSICS, VOL. 118, 1403–1409, doi:10.1029/2012JA018026, 2013

[4] The pressure effect on secondary cosmic ray variations has been known for a long time. *Myssowsky and Tuwim* [1926] and *Steinke* [1929] are among the first who have studied the relation between cosmic ray time variations and atmospheric pressure changes. The barometric effect is experimentally determined by equation (1):

$$\left(\frac{\Delta I}{I}\right)_P = \beta \cdot \Delta P \tag{1}$$

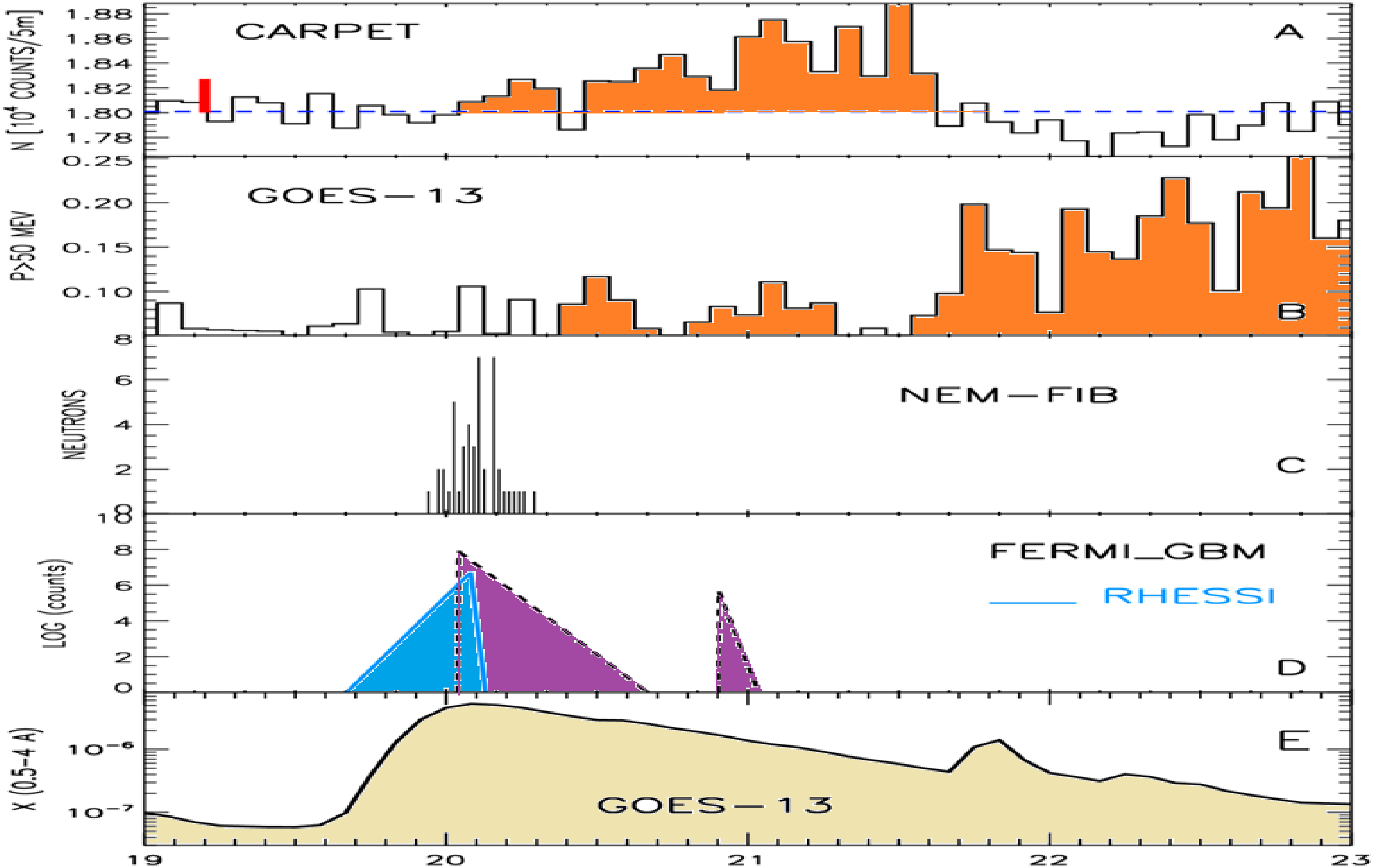
where $(\Delta I/I)_P$ is the normalized deviation of the cosmic ray intensity related with the pressure effect, ΔP is the atmospheric pressure deviation and β is the barometric coefficient, which depends on many factors, such as the nature of the secondary component and the altitude where the observation is performed [*Dorman*, 2004]. Atmospheric

LONG-TERM COSMIC RAY VARIATIONS RECORDED BY "CARPET"



The CARPET temperature uncorrected cosmic ray data (dashed black curve) and the corrected data using: first method (grey curve with squares), second method (grey curve with triangles), and third method (grey curve with asterisks) observed between 2006 and 2010. The black curve with crosses shows the fourth method corrected cosmic ray data and the grey histograms and black dotted curve shows the monthly mean and 13 months smoothed Brussels Sunspot Number. The bar in the left upper corner indicates the upper limit of the RMS estimated on daily mean data. The Moscow and Rome Neutron Monitors measurements (diamonds and plus symbols respectively)

RECENT RESULTS …



7 - MARCH - 2011, time UT

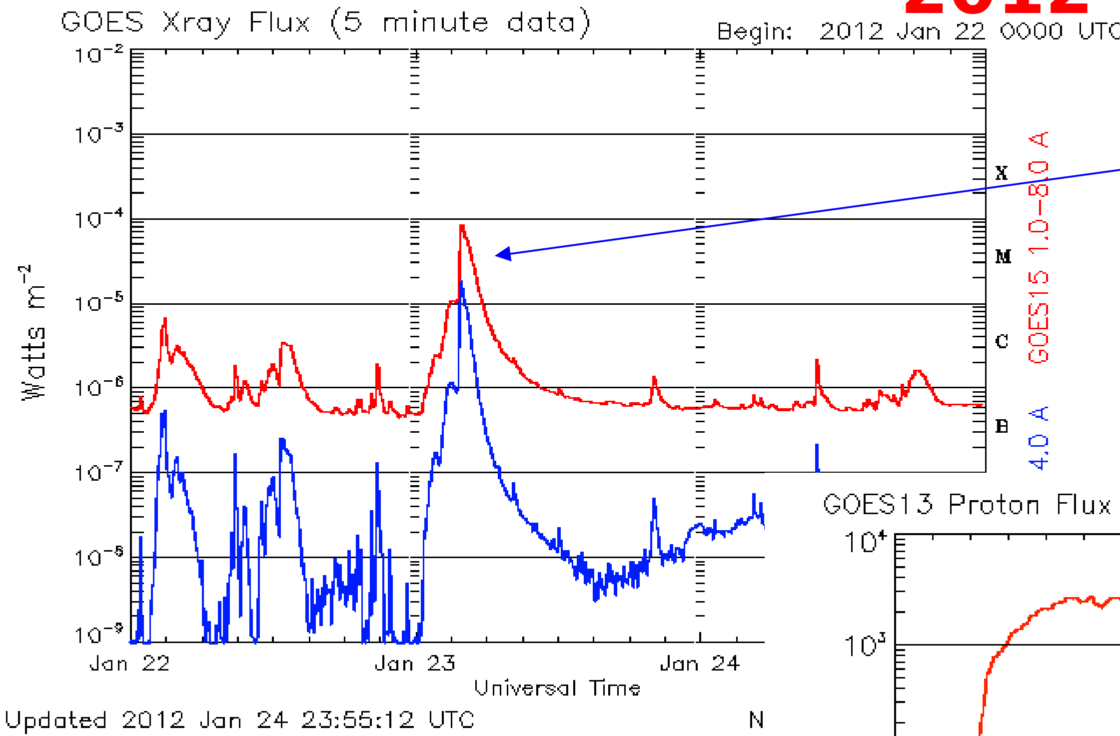
Solar flare event on March 7, 2011. Panel A: 5 min TEL channel records of the CARPET. Vertical red bar at left shows 3 r.m.s of the data during preflare period (19-20 UT). B: time profile of > 50 MeV proton flux (p/cm2·s·sr) as recorded onboard GOES-13 [4]. C: solar neutron observations by NEM-FIB detector onboard ISS [6]; D: FERMI-GBM (12-25 keV) and RHESSI (100-300 keV) solar burst observations [7]. E: solar X-

During a powerful solar blast on March 7, NASA's Fermi Gamma-ray Space Telescope detected the highest-energy light ever associated with an eruption on the sun.

The powerful March 7 flare, which earned a classification of X5.4 based on the peak intensity of its X-rays, is the strongest eruption so far observed by Fermi's Large Area Telescope (LAT).

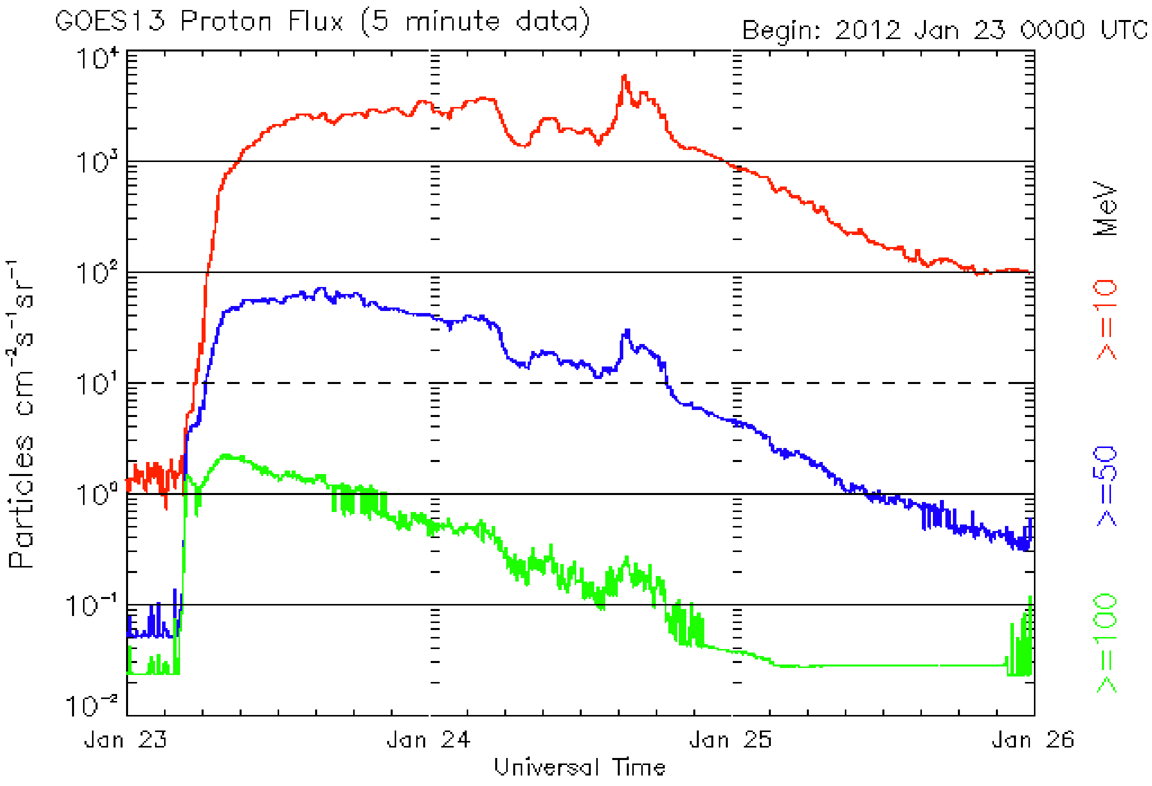
The flare produced such an outpouring of gamma rays -- a form of light with even greater energy than X-rays -- that the sun briefly became the brightest object in the gamma-ray sky.

Solar Particles Event on 23 January 2012

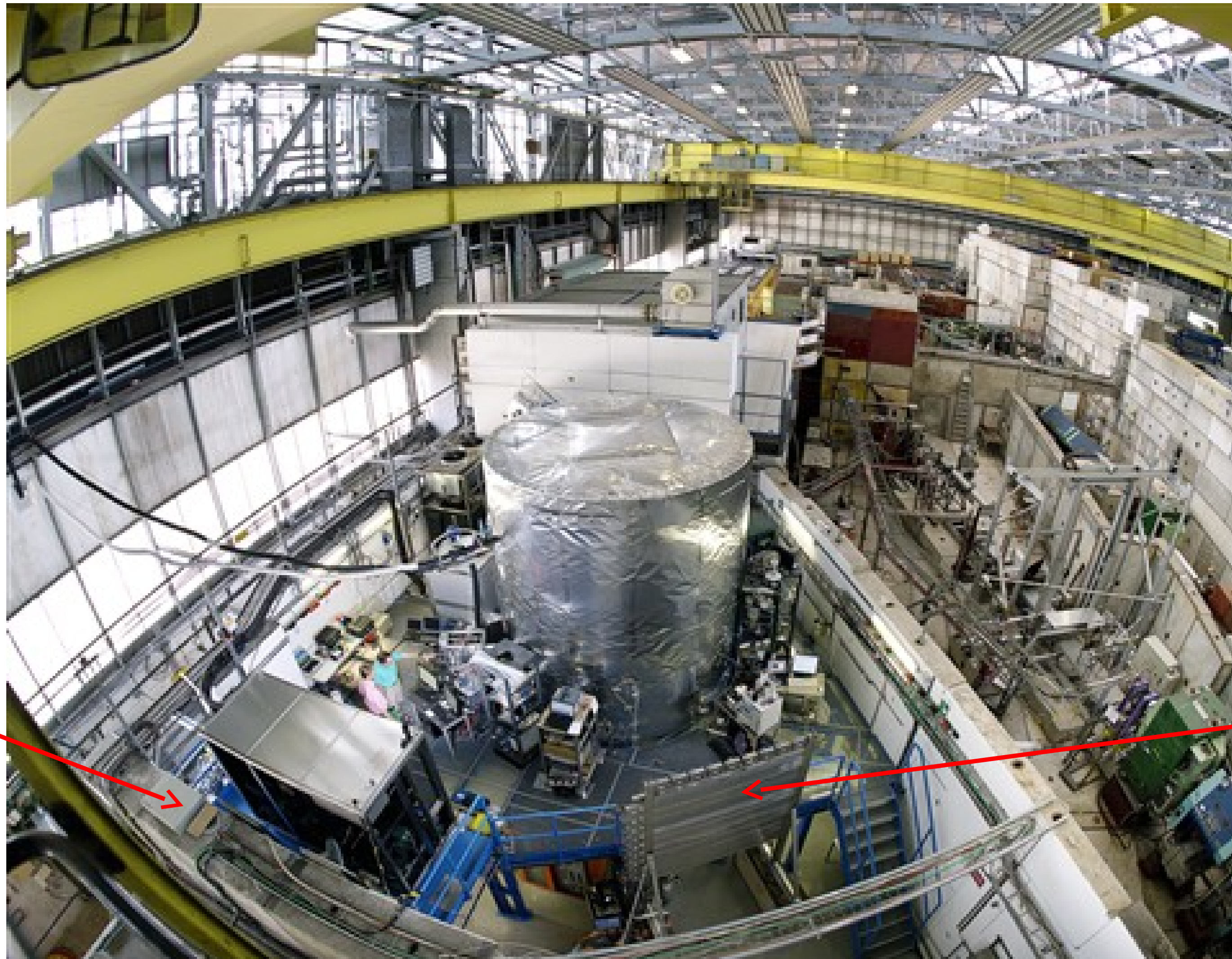


M8.7, N28W20, AR 11402

0338 - 0359 - 0434 UT



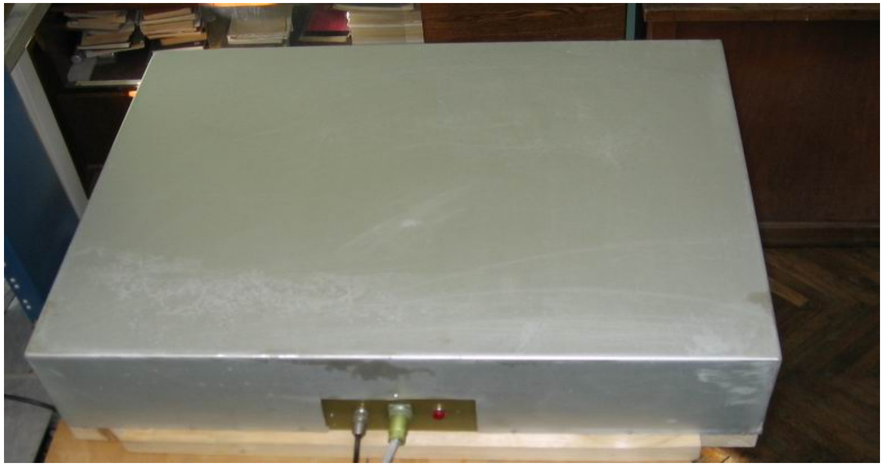
Эксперимент CLOUD в ЦЕРНе (2006 – н.в.)

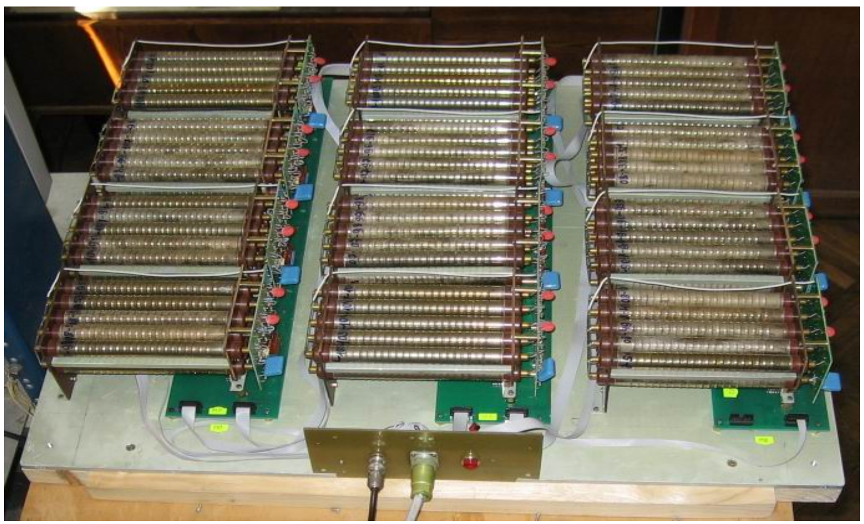


ковер

годоскоп

GCR counter





- UP (top), LOW(bottom) and TEL channels of the GCR device

  (120 counters).

- Integration time:

  25 ms – 5 s;

  500 ms - standard

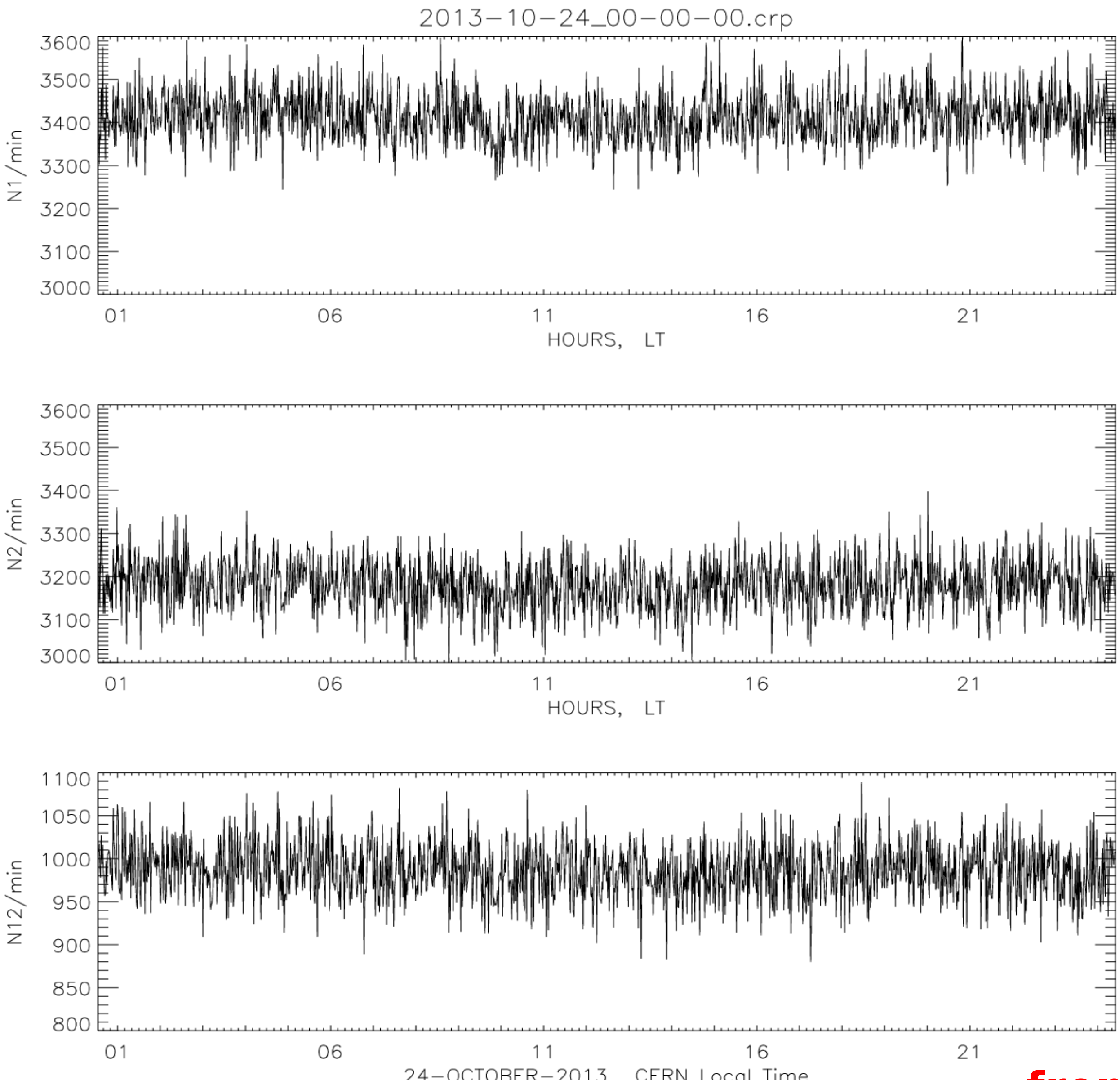
- PC online data visualisation and recording.

- Continuously operates since july’09 at CERN

Dimensions: 750 X 610 X 170 mm; ~ 22 kg

Вариации космических лучей в октябре-декабре 2013 г.

STANDARD DAILY RECORDS



LT=UT+
1(2)

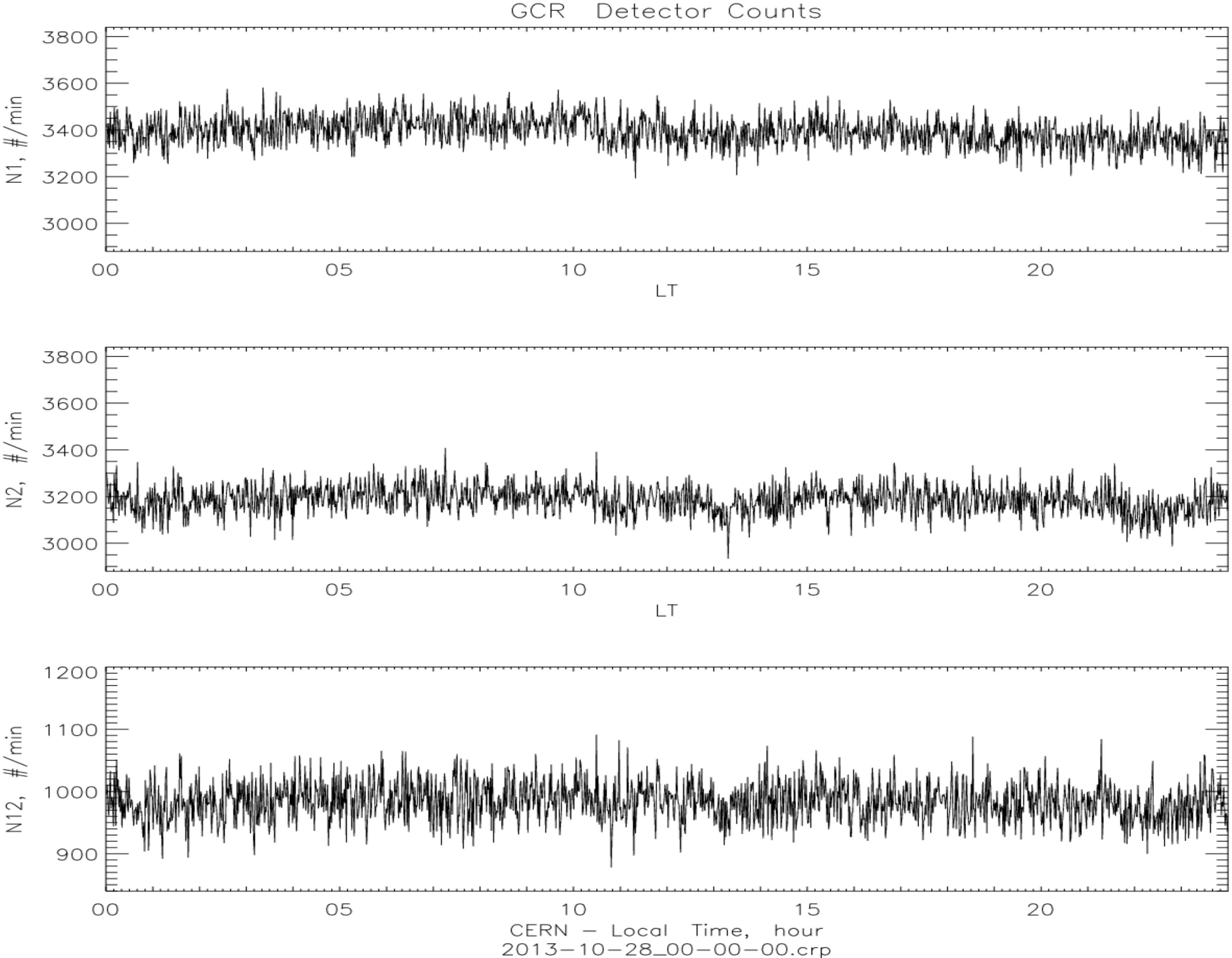
original data file:
2013-10-24_00-00-00.c

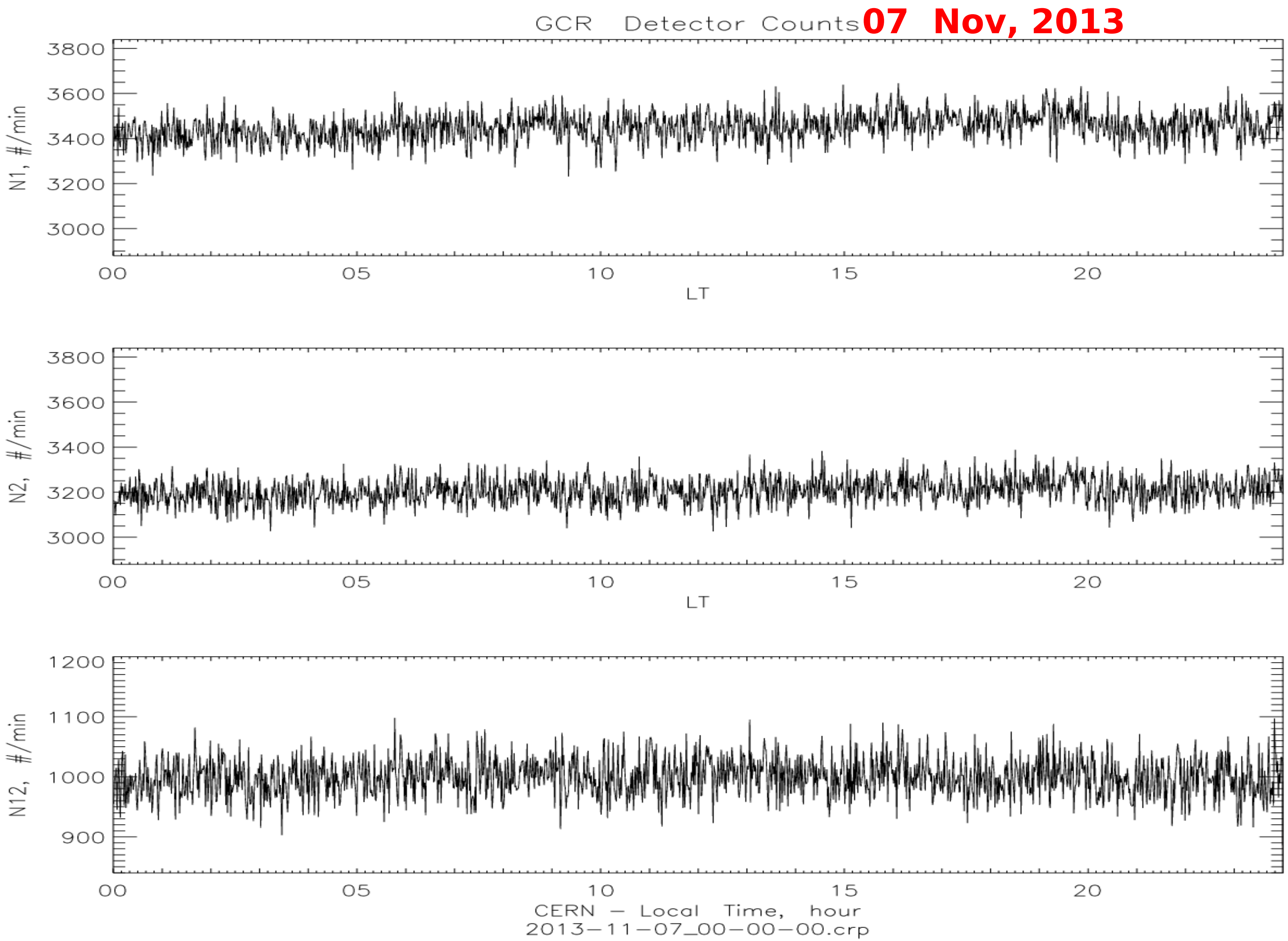
data plot:
GCR_plot_2013-10-24.p

Database:

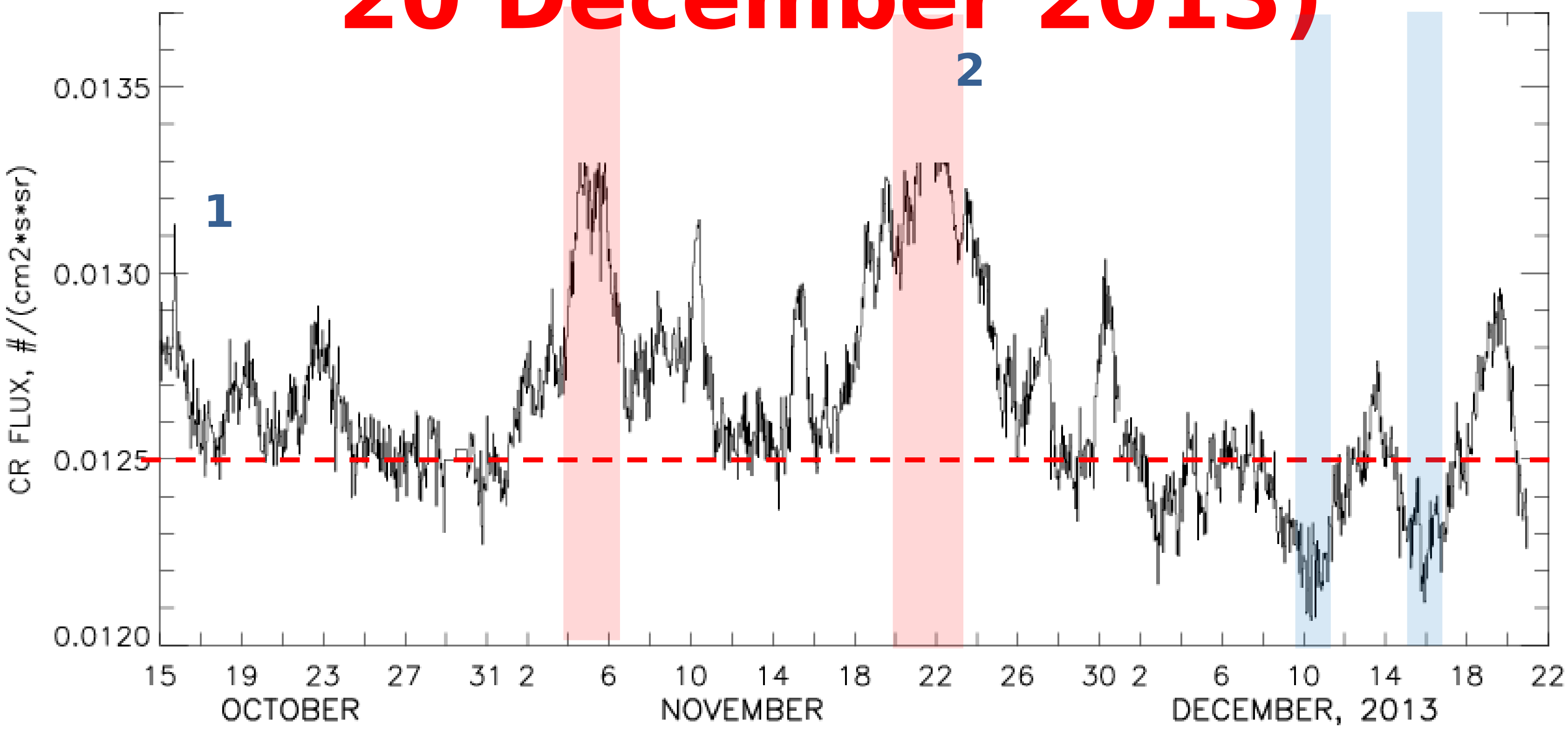
from 15-Oct-13 to 13-Dec-

28 - Oct - 2013


GCR Detector Counts
3800
3600
3400
3200
3000
N1, #/min
00
05
10
15
20
LT
3800
3600
3400
3200
3000
N2, #/min
00
05
10
15
20
LT
1200
1100
1000
900
N12, #/min
00
05
10
15
20
CERN – Local Time, hour
2013–10–28_00–00–00.crp


GCR Detector Counts 07 Nov, 2013
N1, #/min
3800
3600
3400
3200
3000
00
05
10
15
20
LT
N2, #/min
3800
3600
3400
3200
3000
00
05
10
15
20
LT
N12, #/min
1200
1100
1000
900
00
05
10
15
20
CERN – Local Time, hour
2013–11–07_00–00–00.crp

GCR detector records at CERN (15 October – 20 December 2013)

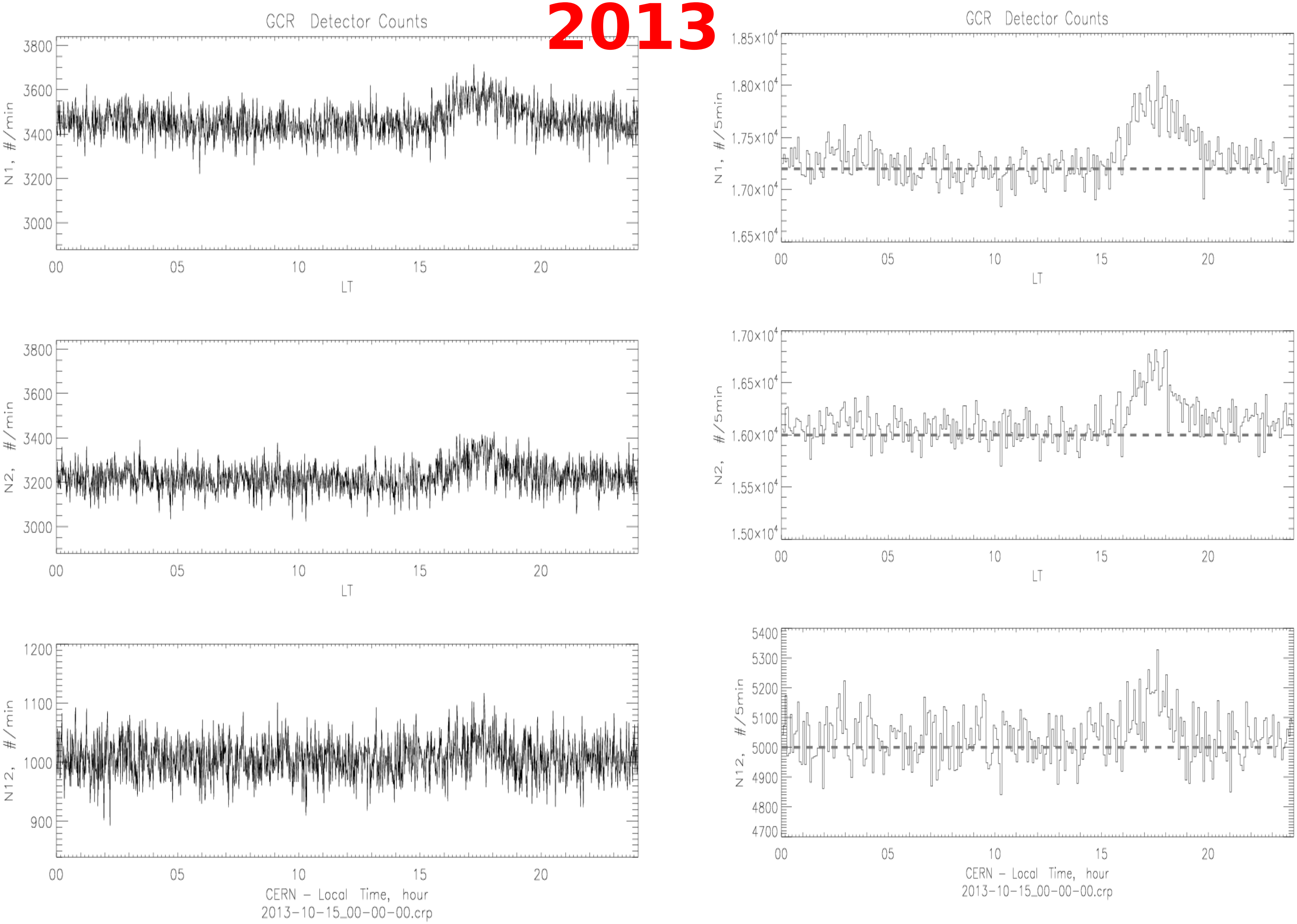


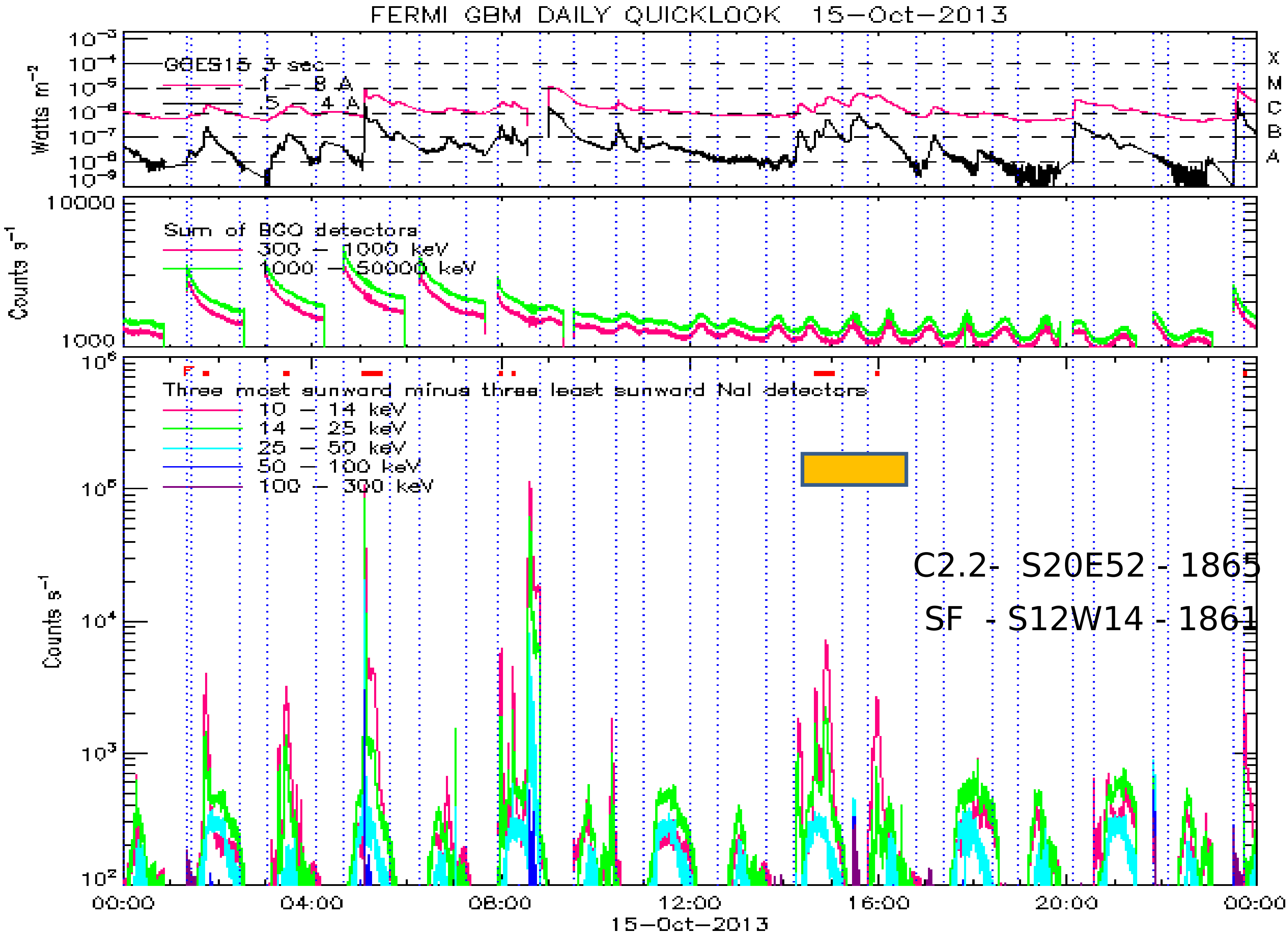
+ 6; 8 %
- 3 %

ionisation by CRs in the chamber ?

15 OCTOBER 2013 EVENT

15 - OCTOBER - 2013





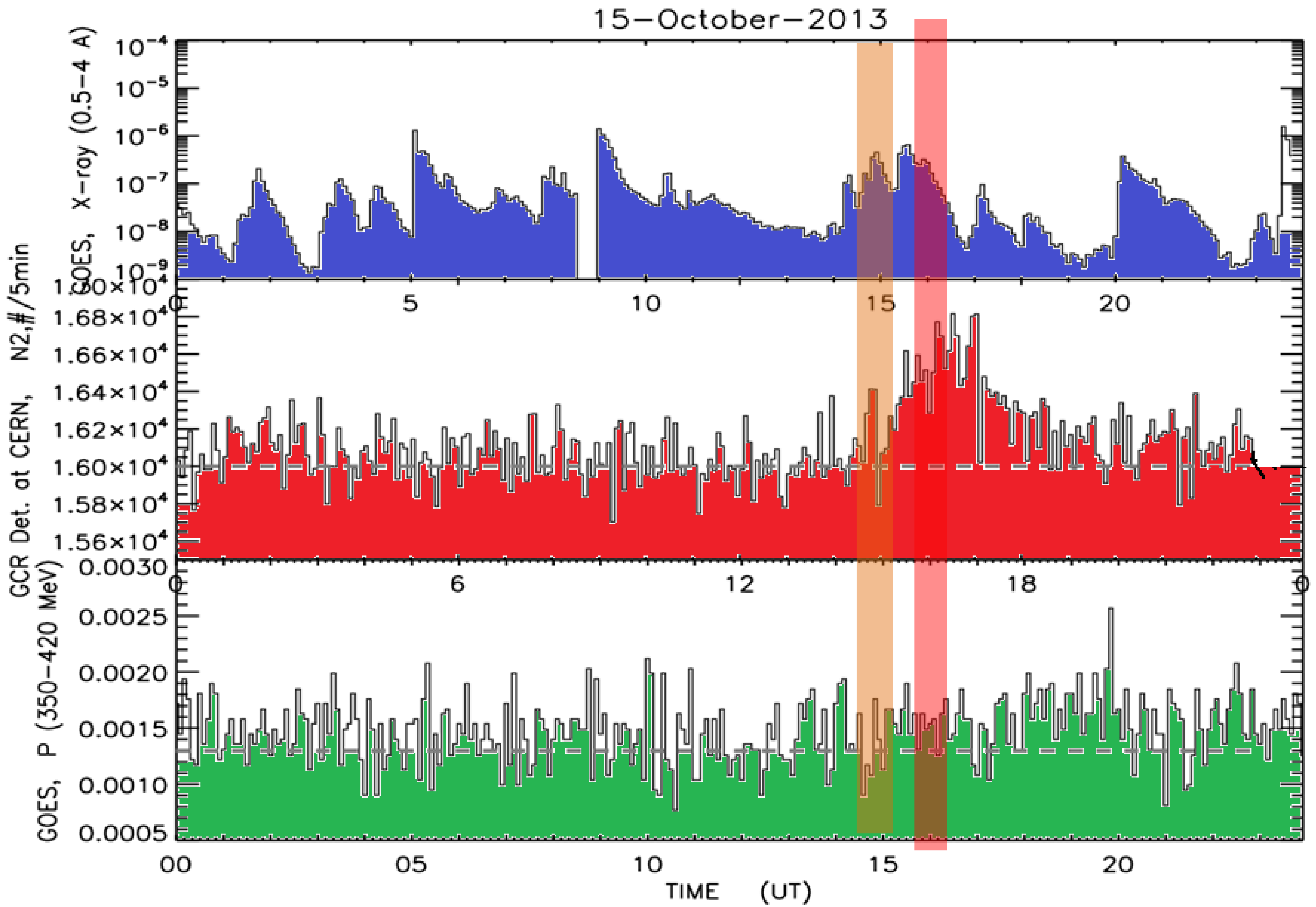
FERMI GBM DAILY QUICKLOOK 15-Oct-2013
GOES15 3 sec
1 – 8 A
.5 – 4 A
Watts m^{-2}
X
M
C
B
A
Sum of BGO detectors
300 – 1000 keV
1000 – 50000 keV
Counts s^{-1}
Three most sunward minus three least sunward NaI detectors
10 – 14 keV
14 – 25 keV
25 – 50 keV
50 – 100 keV
100 – 300 keV
C2.2- S20E52 - 1865
SF - S12W14 - 1861
00:00
04:00
08:00
12:00
16:00
20:00
00:00
15-Oct-2013

131015_0142 15-Oct-2013 01:42:12 01:44:56 01:47:52 340 1966
95972 n5 n4 n2 n3 13101522
131015_0325 15-Oct-2013 03:25:00 03:26:02 03:29:22 262 1491
55663 n0 n1 n3 n6 131015_0504 15-Oct-2013 05:04:42
05:06:09 05:27:08 1346 118795 9692292 n5 n3 n1 n4 bn131015212

131015_0758 15-Oct-2013 07:58:49 07:59:51 08:02:10 201 2216
49936 n5 n4 n2 n3 13101530
131015_0813 15-Oct-2013 08:13:30 08:13:59 08:17:56 266 3040
94527 n5 n4 n3 n1

**131015_1437 15-Oct-2013 14:37:51 14:38:49 14:44:33 401 2313
127891 n5 n3 n1 n4 131015_1447 15-Oct-2013
14:47:29 14:53:29 15:03:23 954 3025 323978 n5 n4 n2 n3
131015_1555 15-Oct-2013 15:55:55 15:56:56 16:00:25
270 934 33967 n5 n1 n3 n0 13101553**

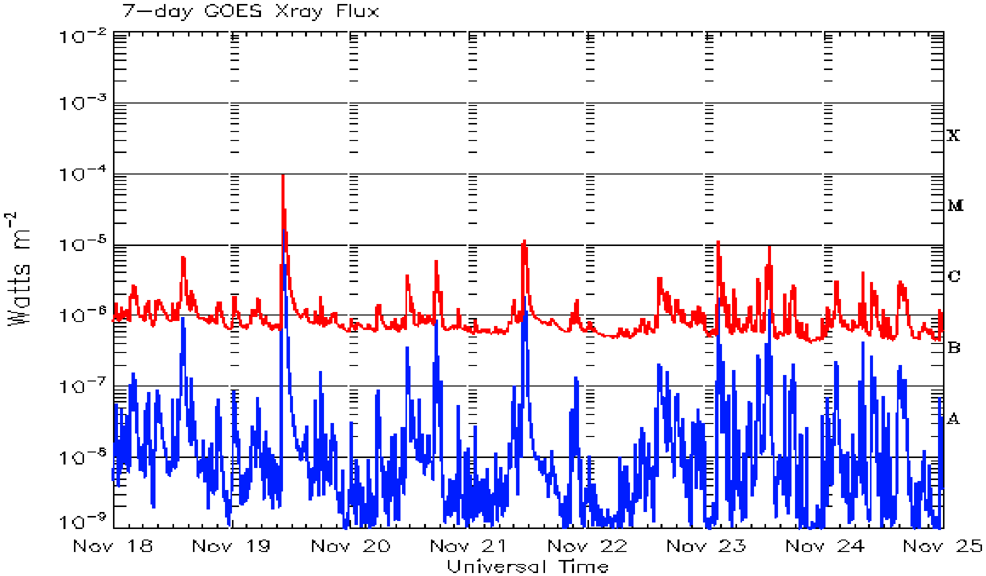
131015_2343 15-Oct-2013 23:43:57 23:44:21 23:46:53 176 852
16104 n5 n1 n3 n4 13101570

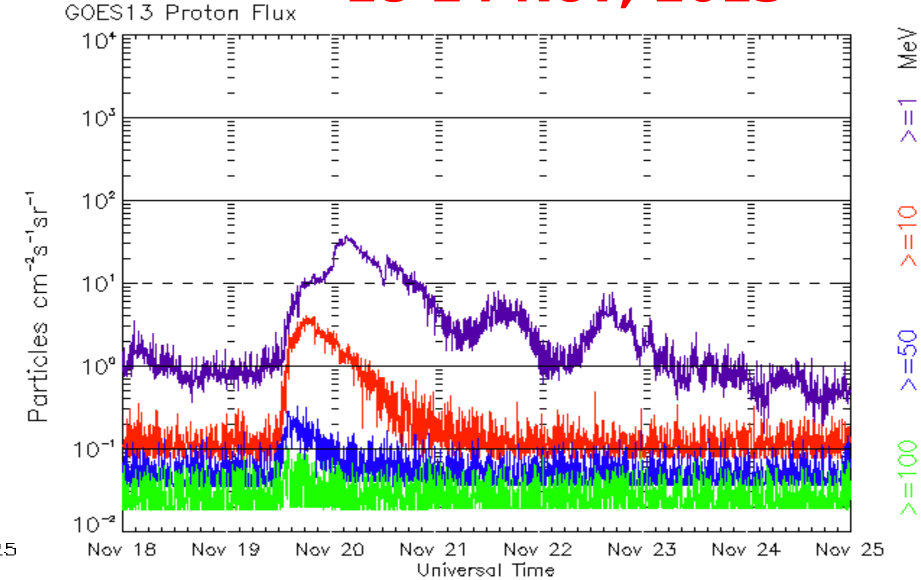


15−October−2013
GOES, X−ray (0.5−4 A)
GCR Det. at CERN, N2,#/5min
GOES, P (350−420 MeV)
TIME (UT)

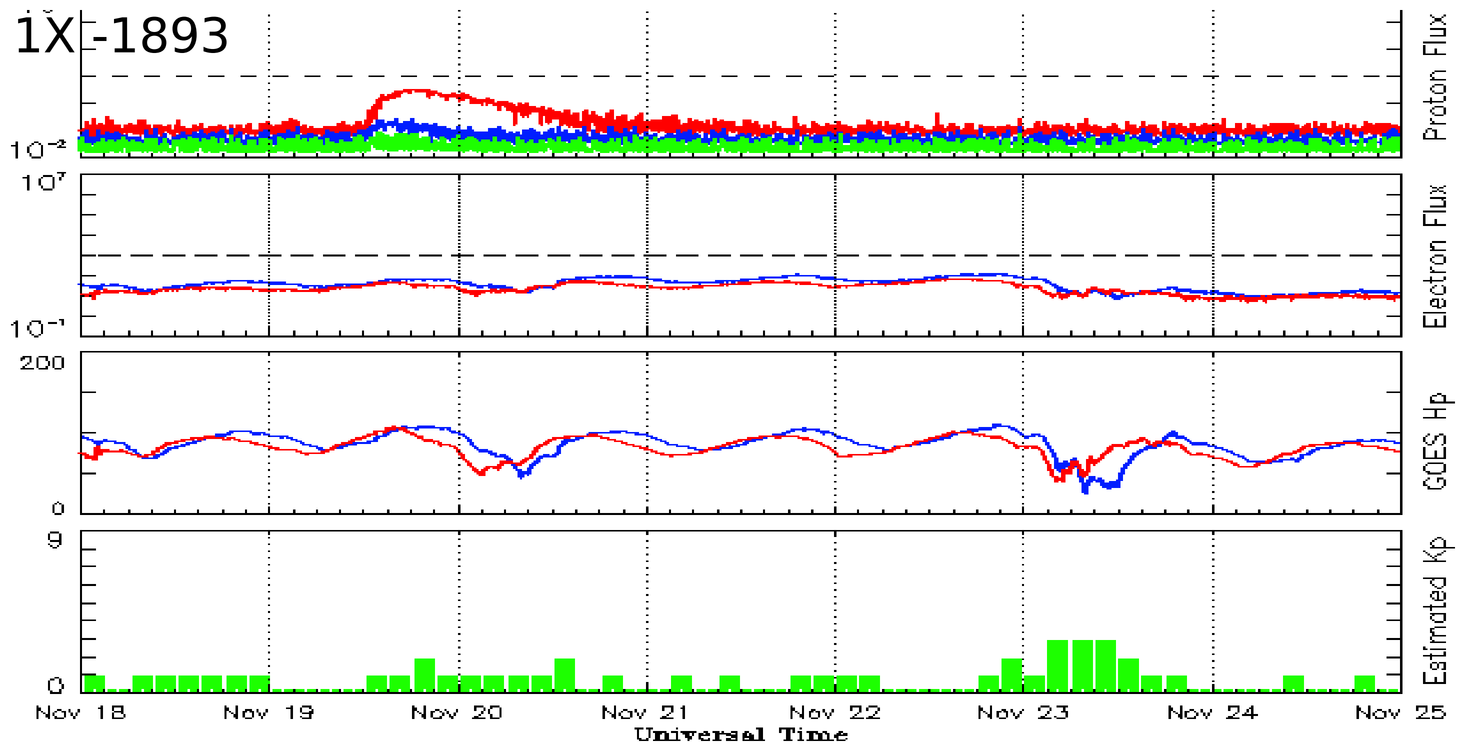
19 NOVEMBER 2013 EVENT

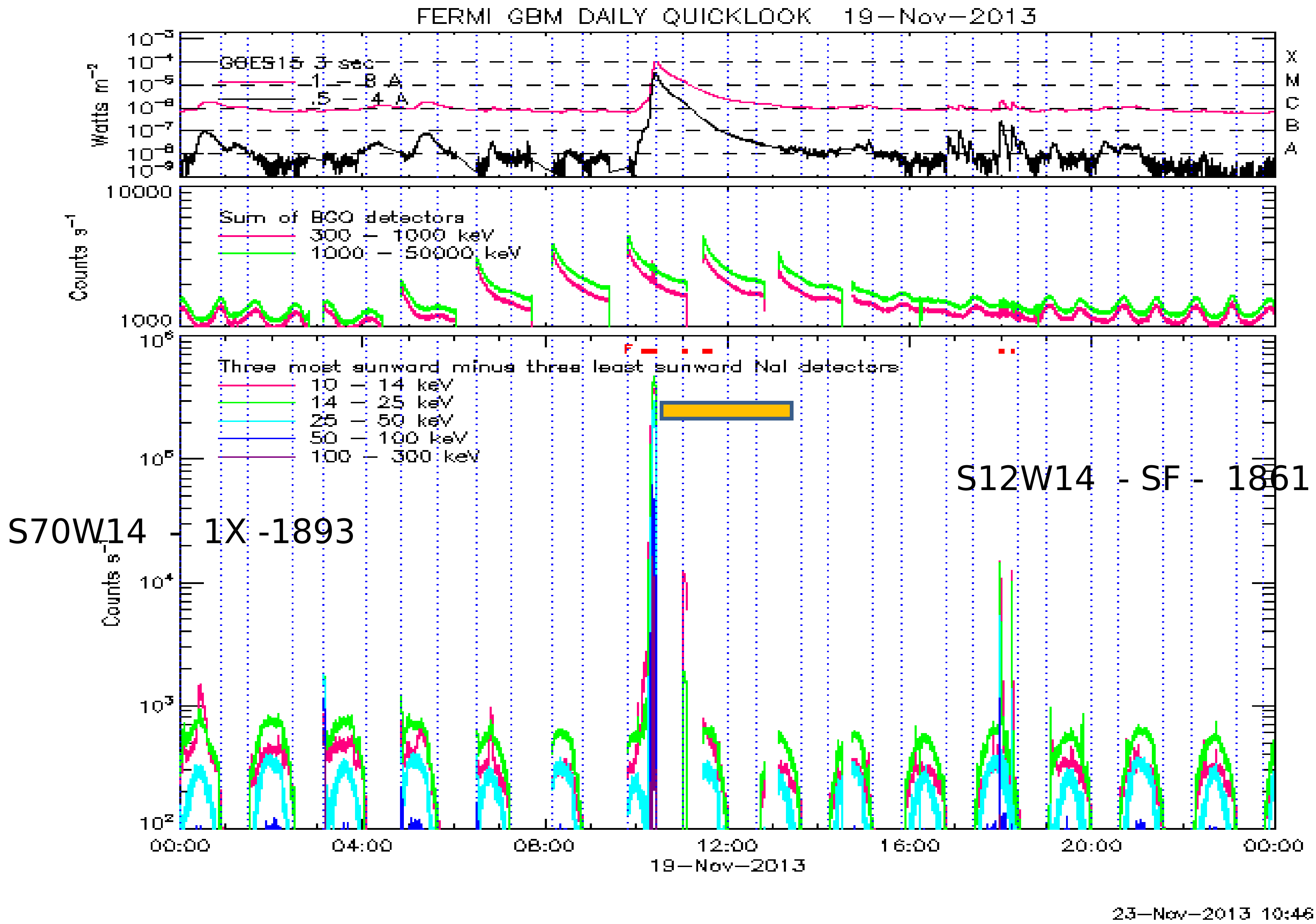
18-24 Nov, 2013

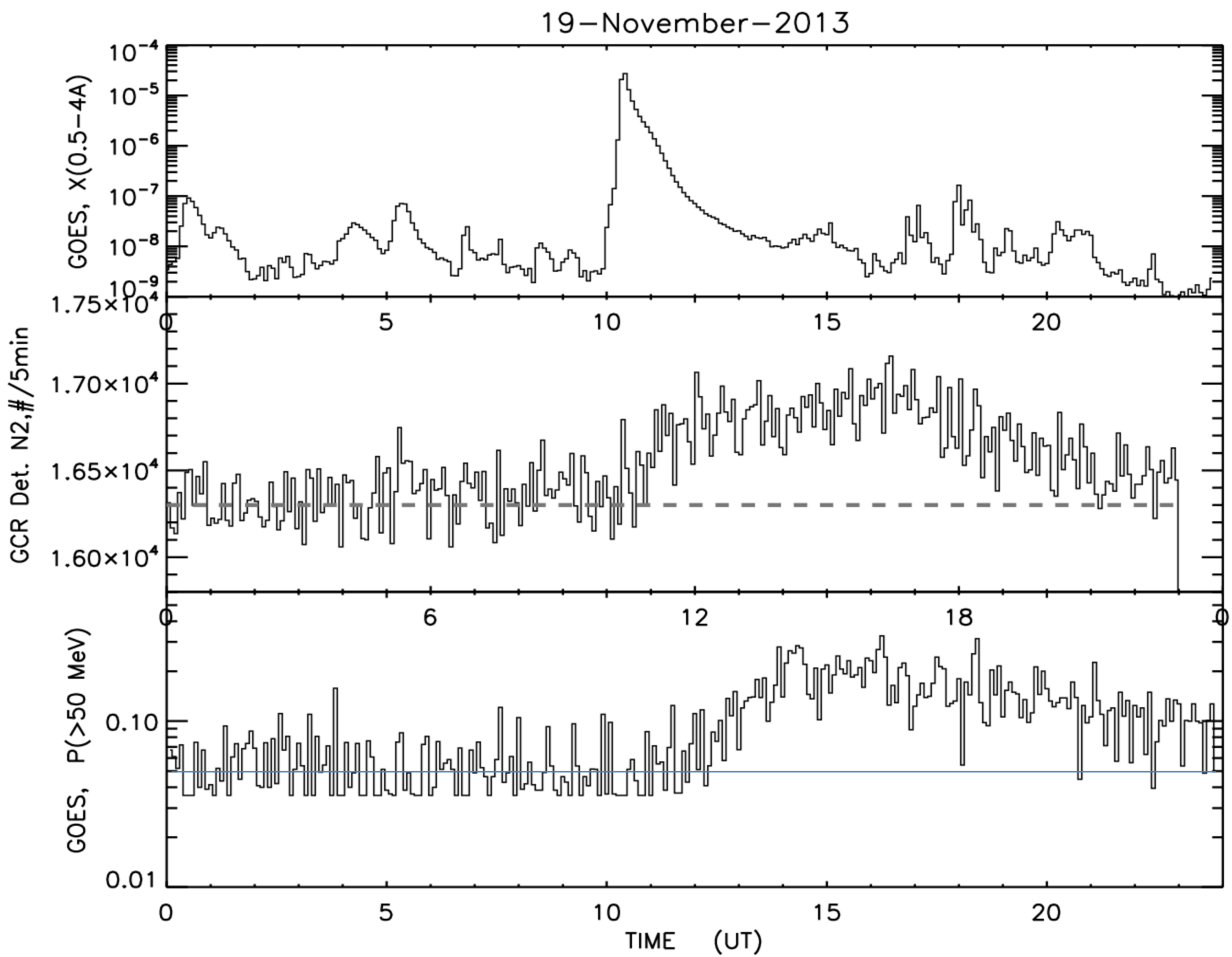




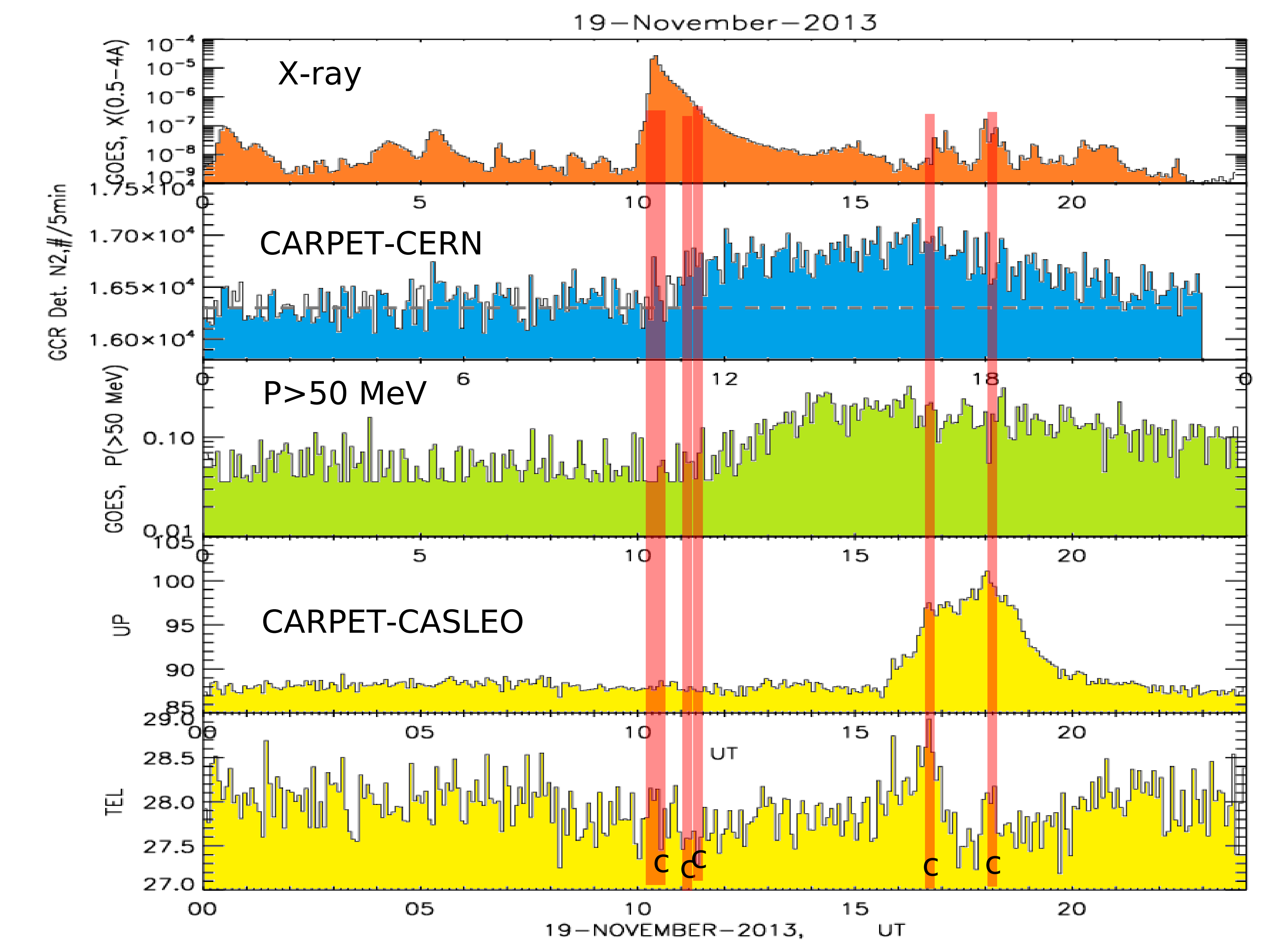
S70W14 - 1X -1893




FERMI GBM DAILY QUICKLOOK 19−Nov−2013
GOES15 3 sec
1 − 8 A
.5 − 4 A
Watts m⁻²
X
M
C
B
A
Sum of BGO detectors
300 − 1000 keV
1000 − 50000 keV
Counts s⁻¹
Three most sunward minus three least sunward NaI detectors
10 − 14 keV
14 − 25 keV
25 − 50 keV
50 − 100 keV
100 − 300 keV
S12W14 - SF - 1861
S70W14 - 1X -1893
00:00
04:00
08:00
12:00
16:00
20:00
00:00
19−Nov−2013
23−Nov−2013 10:46



19−November−2013
GOES, X(0.5−4A)
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
GCR Det. N2,#/5min
1.75×10^{4}
1.70×10^{4}
1.65×10^{4}
1.60×10^{4}
GOES, P(>50 MeV)
0.10
0.01
0
5
10
15
20
6
12
18
TIME (UT)



19-November-2013
X-ray
GOES, X(0.5-4A)
CARPET-CERN
GCR Det. N2,#/5min
P>50 MeV
GOES, P(>50 MeV)
CARPET-CASLEO
UP
TEL
UT
C
19-NOVEMBER-2013, UT

SUMMARY

- **Solar and geomagnetic activity at ~ "quiet" level during**
  15 Oct. – 20 Dec. 2013:

  (a) no STRONG solar proton events observed in the Earth's environment
  (b) no significant FDs of galactic cosmic rays

- **Small cosmic ray count increase (~ 4 -6 %) was recorded by GCR**
  on 15 Oct. (15-20 LT), 19 Nov. (11-20 LT), 22-Nov. (5-24 LT)

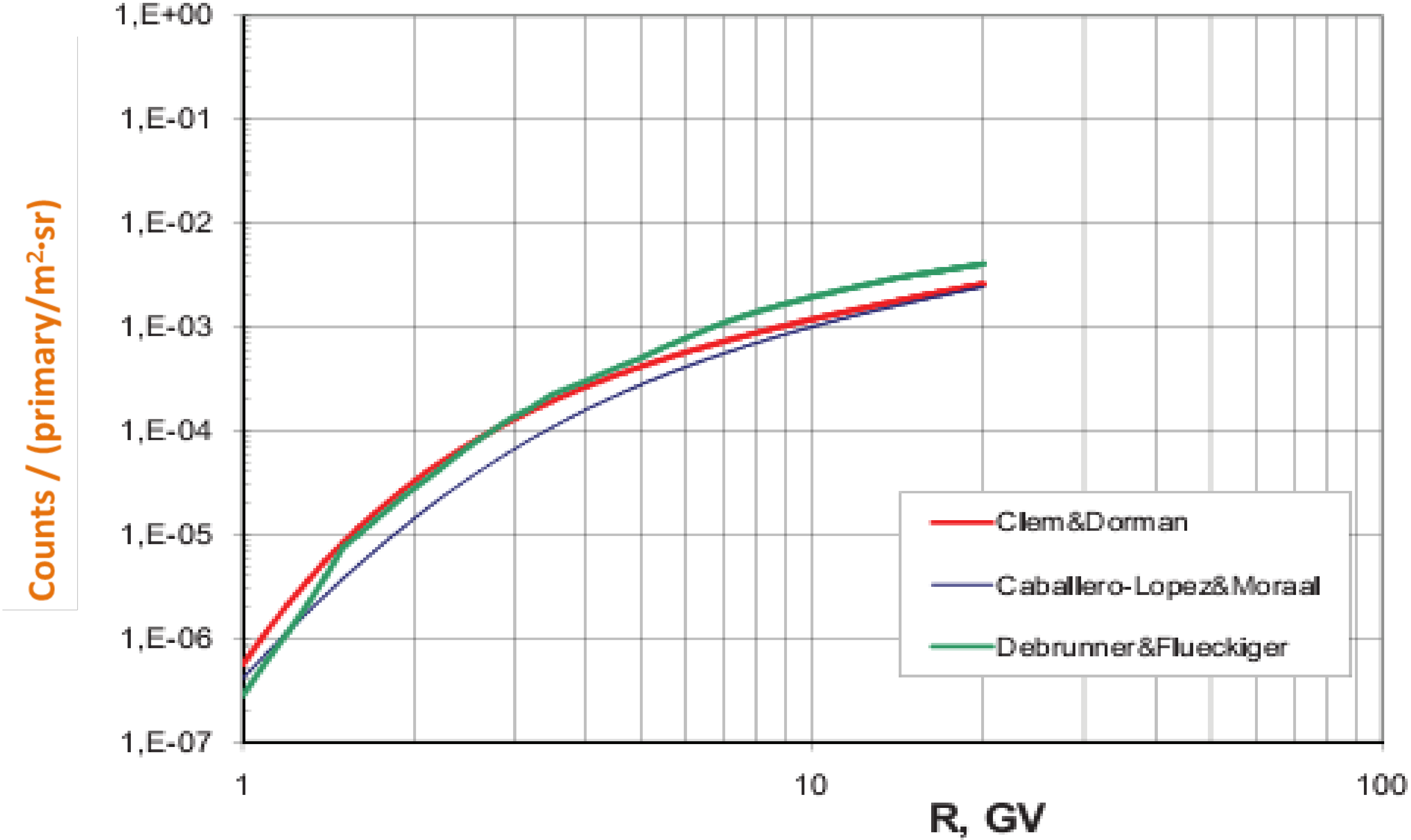
Early, count rate of the CARPET (KOBEP) was detected

Спасибо !

To determine an expected relative count rate increase produced by these incident protons in the ground-based **neutron monitor records**, we have used a well-known equation,

$$N = \int_{Rc}^{Rmax} m(R,x) \cdot J(R) \cdot dR$$

where N is a count rate of NM at selected geomagnetic lo-cation characterized by certain geomagnetic cuttoff rigid-ity Rc, m(R,x) is a specific yield functions for protons. J(R) is a rigidity spectrum of incident solar proton flux at the top of the atmosphere in the proton rigidity range from Rc up to Rmax. There are a few estimations of the m(R,x) and some of them are presented in Figure 2 [21]. We used the set of m(R,x) given in the paper [22] to estimate relative in-creases of NM counting rates caused by proton fluxes de-scribed by (1) and (2) with intermediate spectrum in be-tween



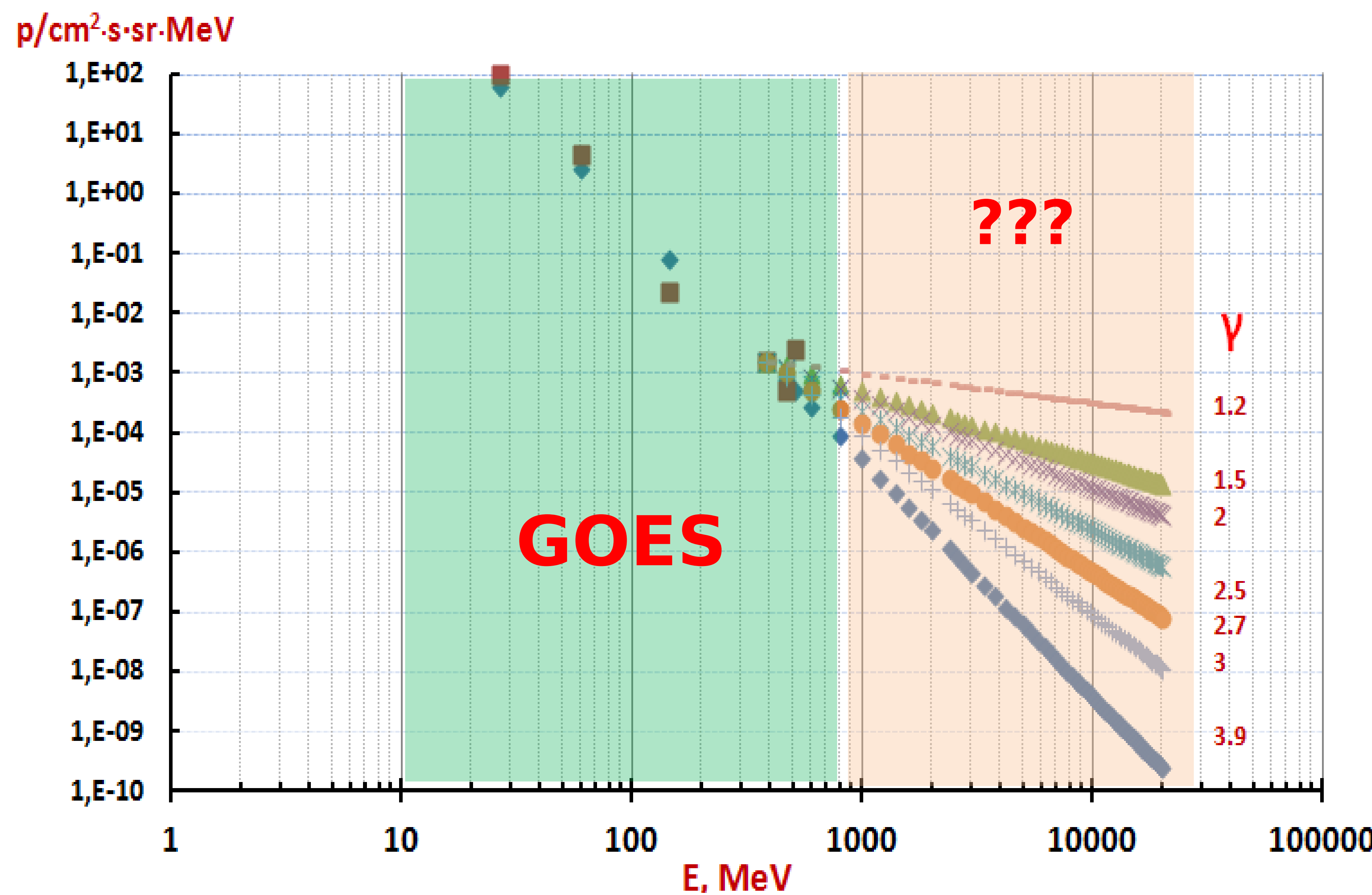
The specific yield functions presented in *R. A. Caballero-Lopez and H. Moraal, J.Geophys. Res.117 (2012) A12103 doi:10.1029/2012JA017794*.

We used in calculations a set of m(R,x) determined in *J.M. Clem, L.I. Dorman, Space Sci. Rev. 93 (2000) 335-359.*

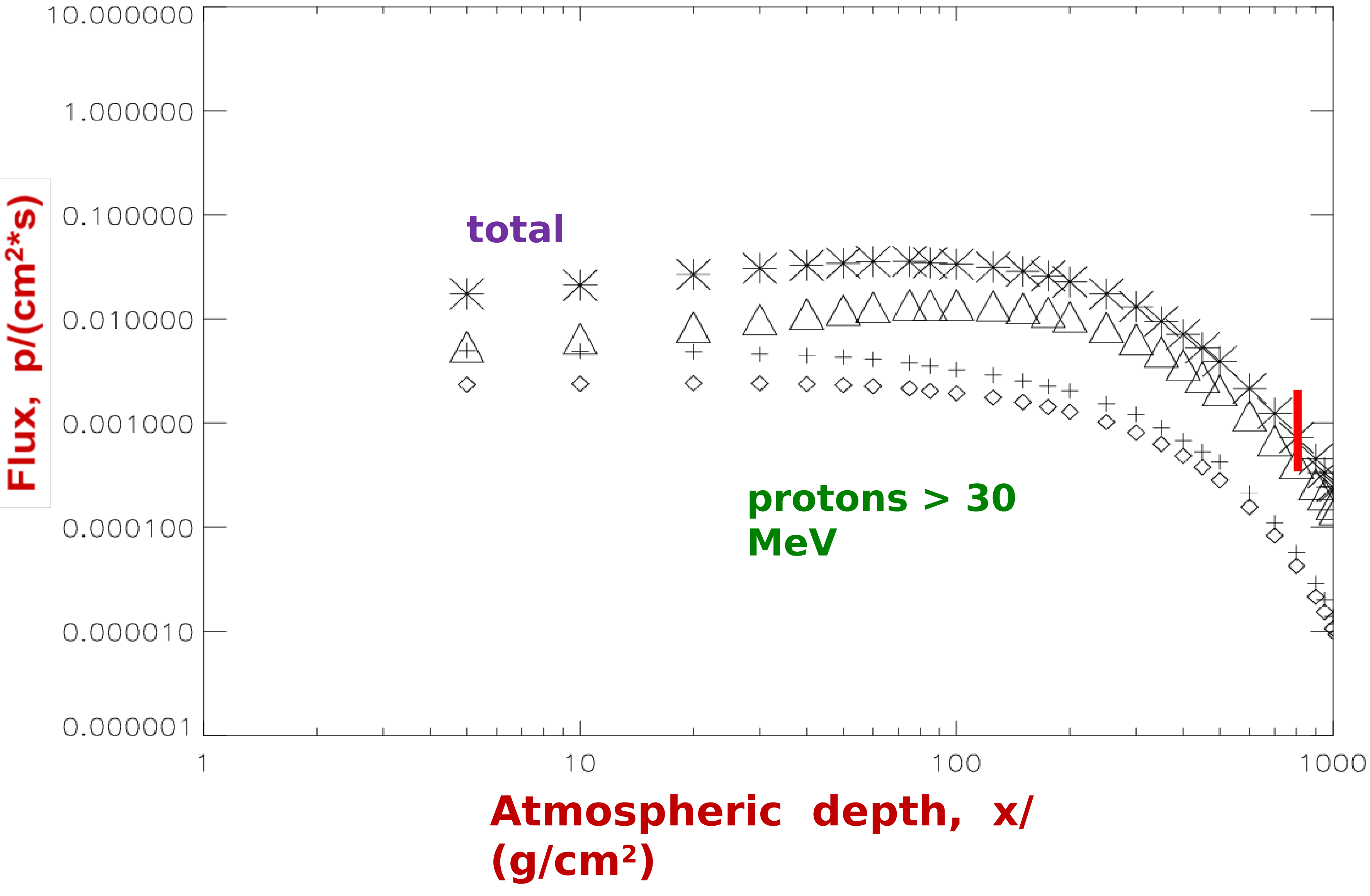
Rc, GV	0.5	2.4	9.6
dN/N_b, %	5.5±0.5	4.5±0.5	1.6±0.5

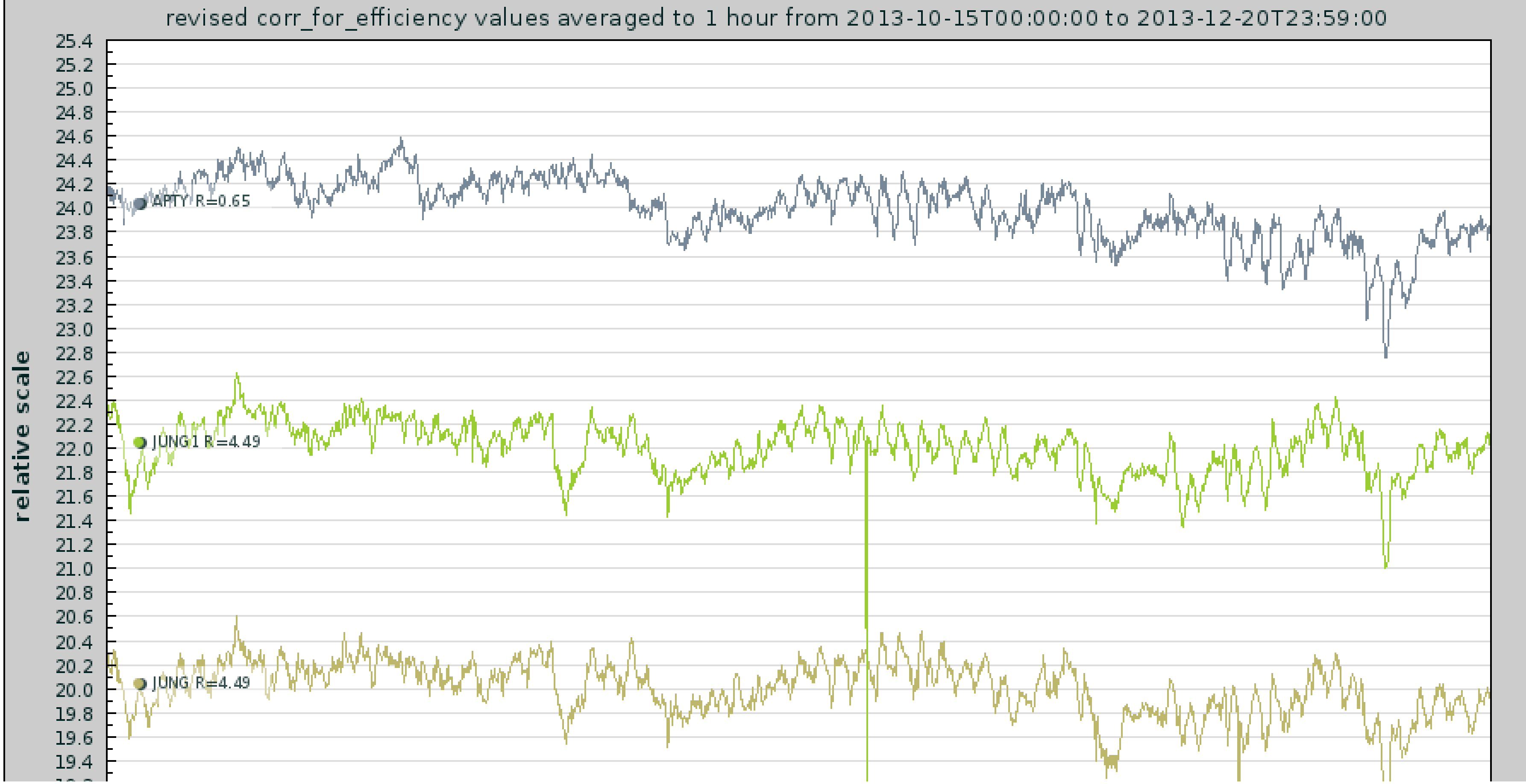
Table 1: Expected increase of NM counts produced by the incident solar proton flux characterized by energy spectra in the form $J(E) = 3{\cdot}10^7{\cdot}E^{-3.9}$ for 5 - 900 MeV range, $J(E) = 1.6{\cdot}10^3{\cdot}E^{-2.5}$ for 0.9 - 9 GeV and $J(E) = 1.5{\cdot}10^4{\cdot}E^{-2.7}$ for 9 - 15 GeV energy range.

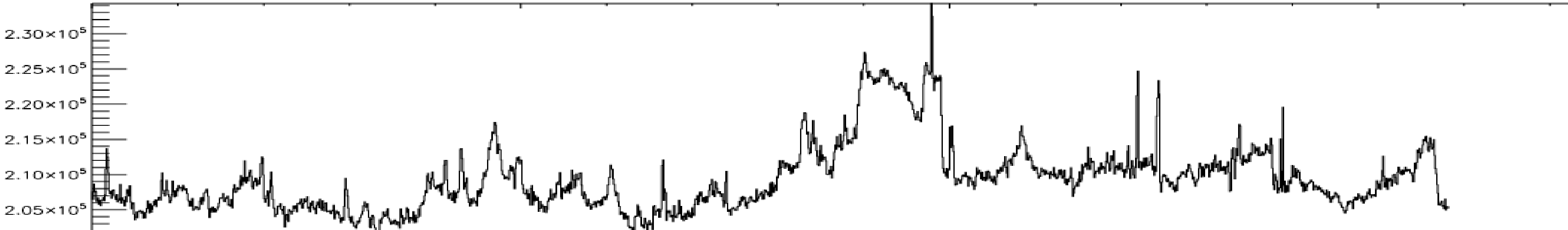
olar proton spectra on 23-JAN-2012; dI/dE=A



Secondary particles produced by primary solar protons in the Earth's atmosphere




revised corr_for_efficiency values averaged to 1 hour from 2013-10-15T00:00:00 to 2013-12-20T23:59:00
relative scale
APTY R=0.65
JUNG1 R=4.49
JUNG R=4.49
25.4
25.2
25.0
24.8
24.6
24.4
24.2
24.0
23.8
23.6
23.4
23.2
23.0
22.8
22.6
22.4
22.2
22.0
21.8
21.6
21.4
21.2
21.0
20.8
20.6
20.4
20.2
20.0
19.8
19.6
19.4


2.30×10⁵
2.25×10⁵
2.20×10⁵
2.15×10⁵
2.10×10⁵
2.05×10⁵

Summary

As a preliminary result we conclude:

(1) count rate of the CARPET (KOBEP) was detected during 07.03.2011, 23.01.2012, 15.10.2013, 19.11.2013. We suggest this increases is the indication of the long-lasting presence of high-energy solar protons entering the Earth‘s atmosphere (or unknown reasons ?).

(2) independent results of the analysis of VLF propagation data and riometer records during these events support this conclusion [24].

(3) the study of the low ionosphere behavior during the SPEs that occurred on 23 January 2012, strongly suggests that it was disturbed by few GeV protons in Antarctica and at lower latitudes in the South America region.

(4) the ionospheric absorptions detected with the riometer and VLF propagation measurements done at two differ-ent sites with high geomagnetic cutoff rigidity is an evi-dence of >10 GeV protons penetrating into the Earth’s atmosphere. The long-duration of the absorption effects on 23 January (from 03:30 to 10:00 UT) also suggests long-lasting presence of higher-energy protons in the Earth’s atmosphere. This suggestion is supported by significant in-creases of cosmic rays detected with CARPET cosmic ray device. A similar case was observed early during the solar flare event detected by the CARPET instrument on March 7, 2011 [4].