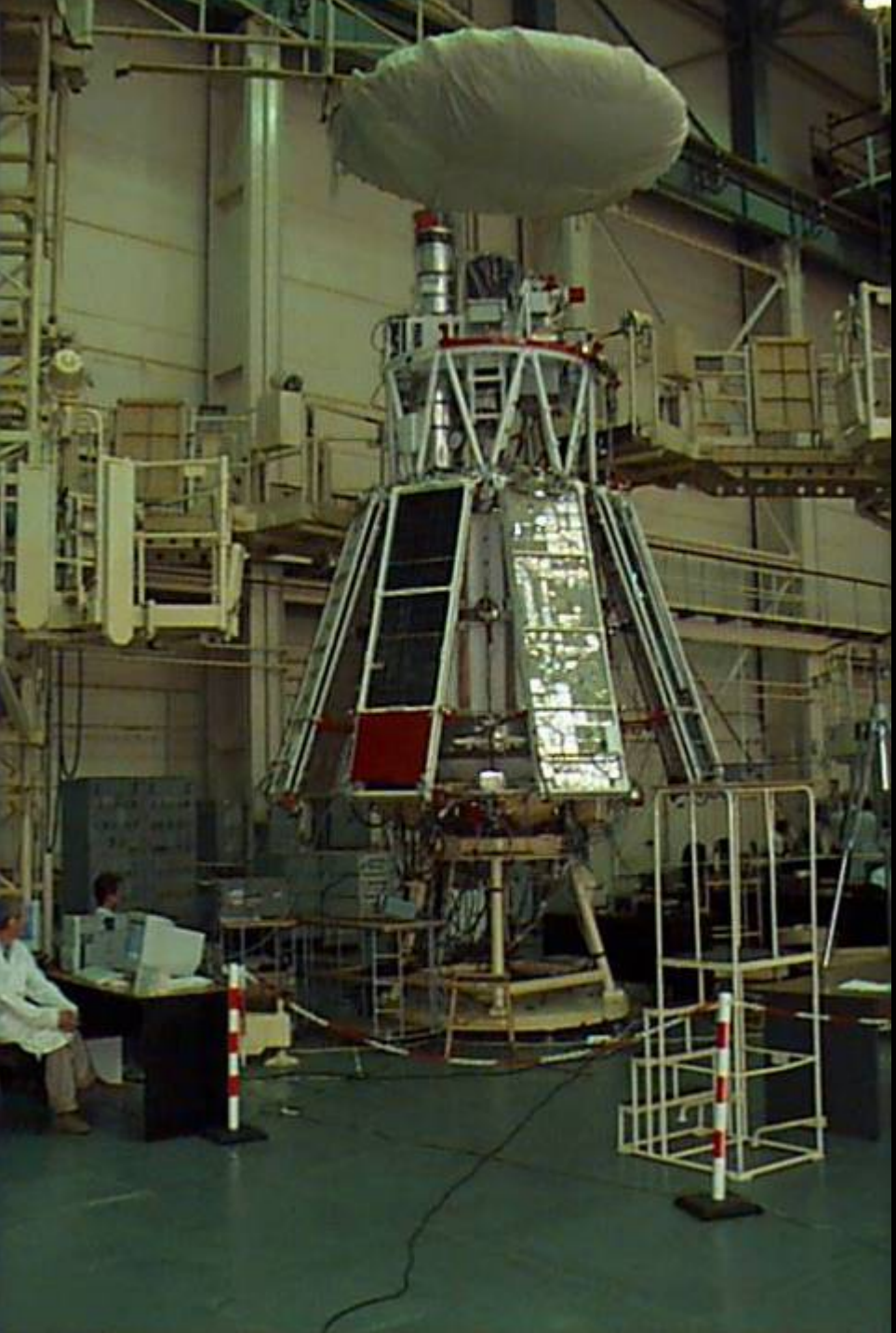

Solar flares temporal profiles thin structure on timescales 33-92 sec in various energy bands by data of AVS-F apparatus onboard CORONAS-F satellite

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AVS-F (amplitude-time Sun spectrometry) apparatus

↓

CORONAS-F satellite

↓

II in the frameworks of the International program

is intended to study characteristics

-fluxes of hard X-rays, γ-rays and neutrons from the solar flares

-to detect other non-stationary fluxes of γ-rays

Complex ORbiting ObservatioNs of the Active Sun

July 31 2001- December 6 2005
circular orbit oriented towards the Sun with
inclination ~82.5°,
period ~90 min
altitude ~500 km (2001)
and ~270 km (end of 2005).

NORAD catalog number 26873, International Designator 2001-032A

AVS-F apparatus - electronic system

for data treatment using signals

➢SONG-D detector (SINP MSU),

↓

CsI(Tl) ∅ 20 cm and 10 cm height

γ-rays analysis

2-260 MeV

0.1-20 MeV

January 2005 calibration

neutrons flux

E>30MeV

➢XSS-1 detector (SSR RAS, MEPhI),

↓

CdTe 4.9 mm x 4.9 mm

for X-ray analysis

3-30 keV

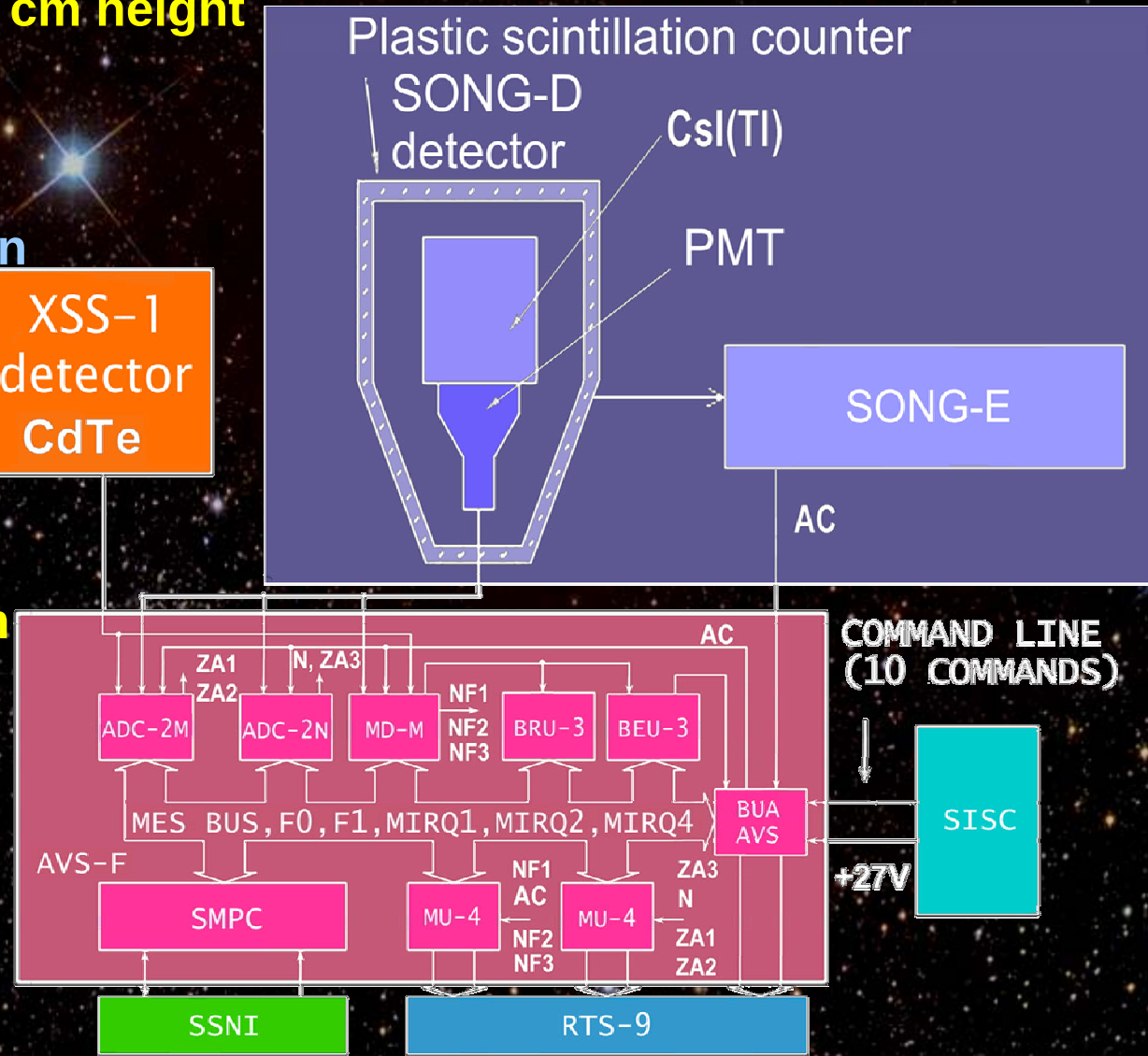
ground calibration

➢ anticoincidence signal

↓

plastic scintillation counter of the SONG-D.

The system energy resolution was 13.0% for γ-quanta from ^{137}Cs (Eγ=0.662 MeV).

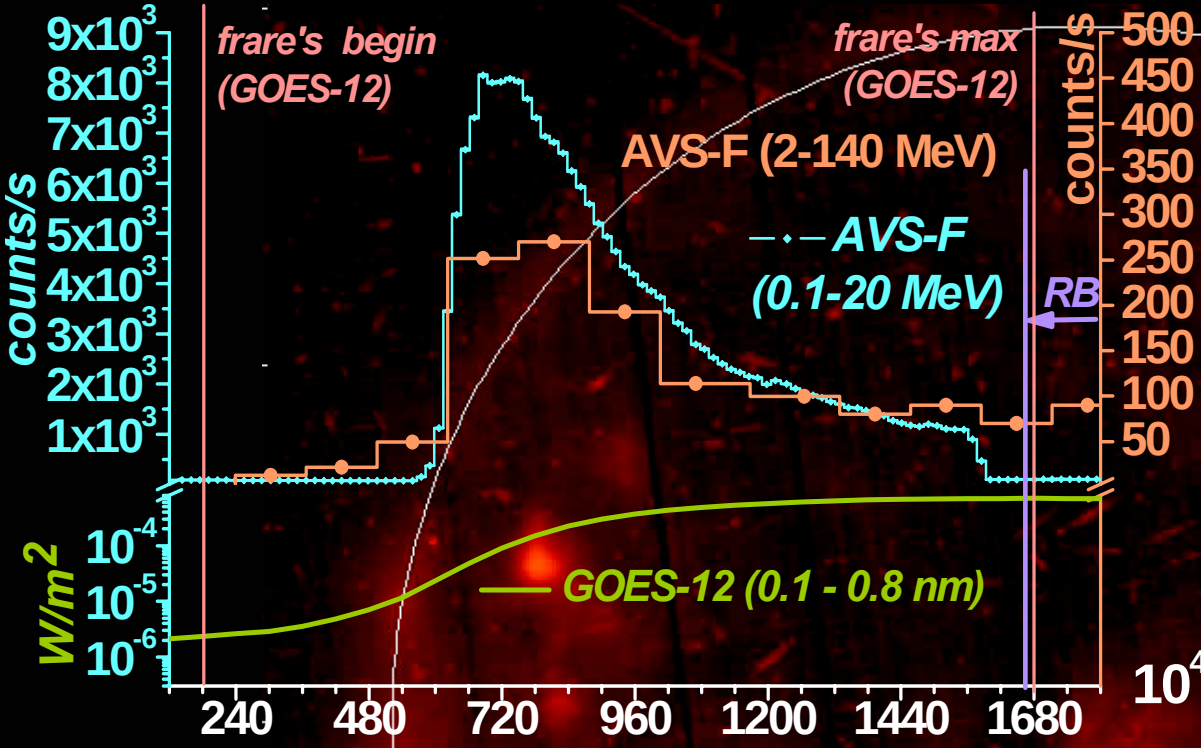


January 2005 → more than 20 solar flares (M and X) were observed by GOES, RHESSI, and other.

6 solar flares ← AVS-F apparatus

The characteristics of solar flares detected by AVS-F apparatus during January 2005.

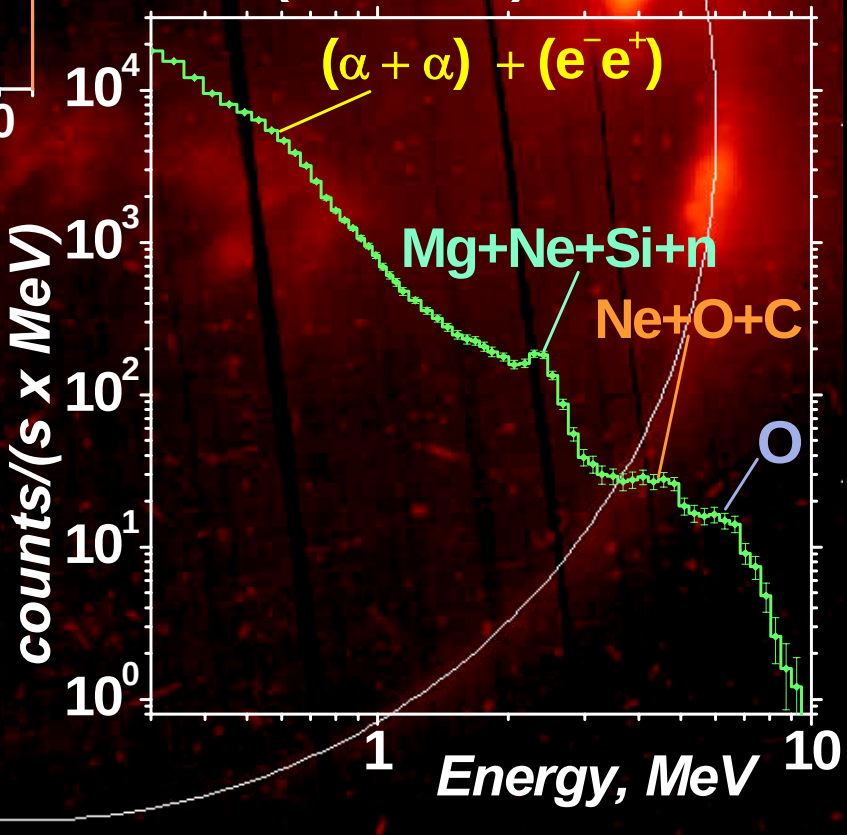
Date	Flare's begin and end time by GOES data	Flare's γ-emission begin and end time by AVS-F data	Class	Active region's number	Coordinates	Comments
15.01	22:25-23:31	22:56:31-23:05:51	X2.6	10720	N15W05	Observed in polar cap
17.01	06:59-10:07	09:51:13-09:58:40	X3.8	10720	N15W25	Observed in equatorial region
20.01	06:36-07:26	06:43:16. -06:59:51	X7.1	10720	N14W61	
09.01	08:25-09:09	08:51:58-08:53:02	M2.4	10719	S09E69	Flare's begin and end were during CORONAS-F satellite pass through Radiation Belt
19.01	07:00-07:54	07:40:39-07:42:31	M2.4	10720	N16W53	
19.01	08:03-08:40	8:05:18-8:13:50	M6.7	10720	N15W51	



January 20 2005 solar flare X7.1

06:36UT - 07:26UT (GOES data),
max - 07:01UT

Source NOAA 10720 (N14 W61).

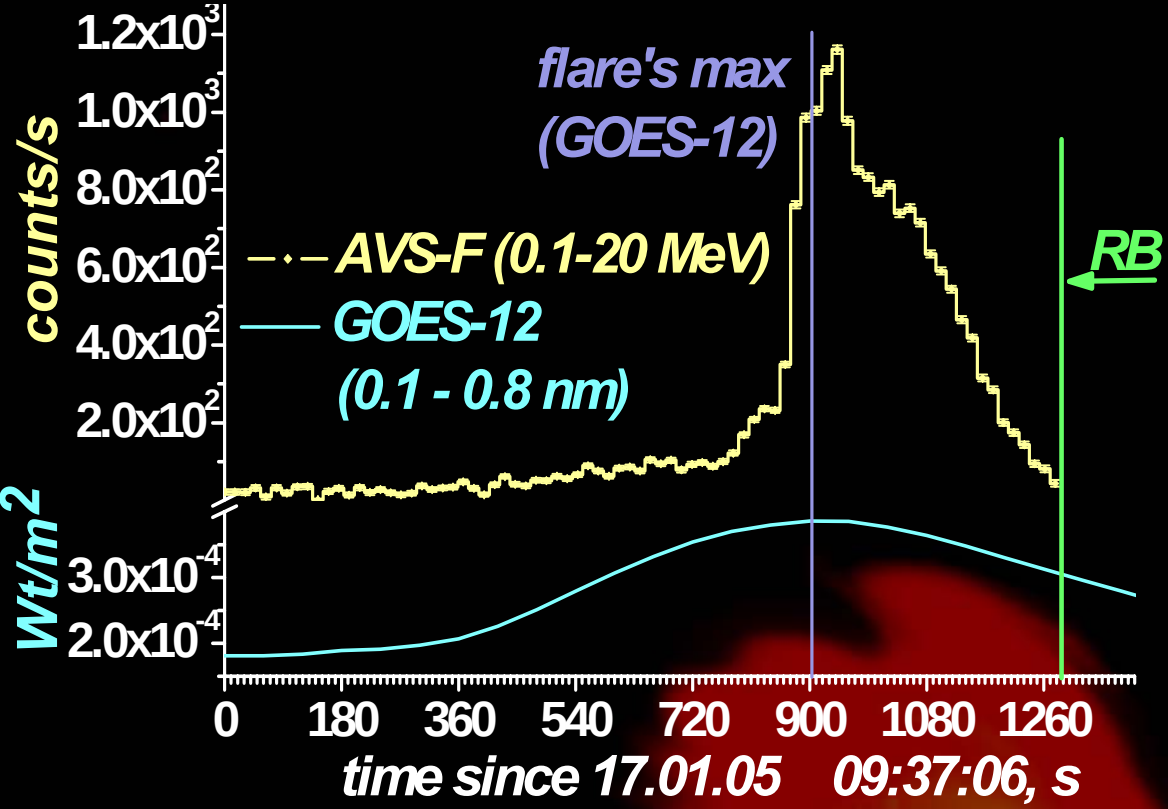


This flare was accompanied by:
protons and neutrons events
(which were most intensive ones for period of the last 15 years)
and CME

γ-emission of this flare was observed by AVS-F apparatus in equatorial region of satellite orbit during X-ray emission rise by GOES data.

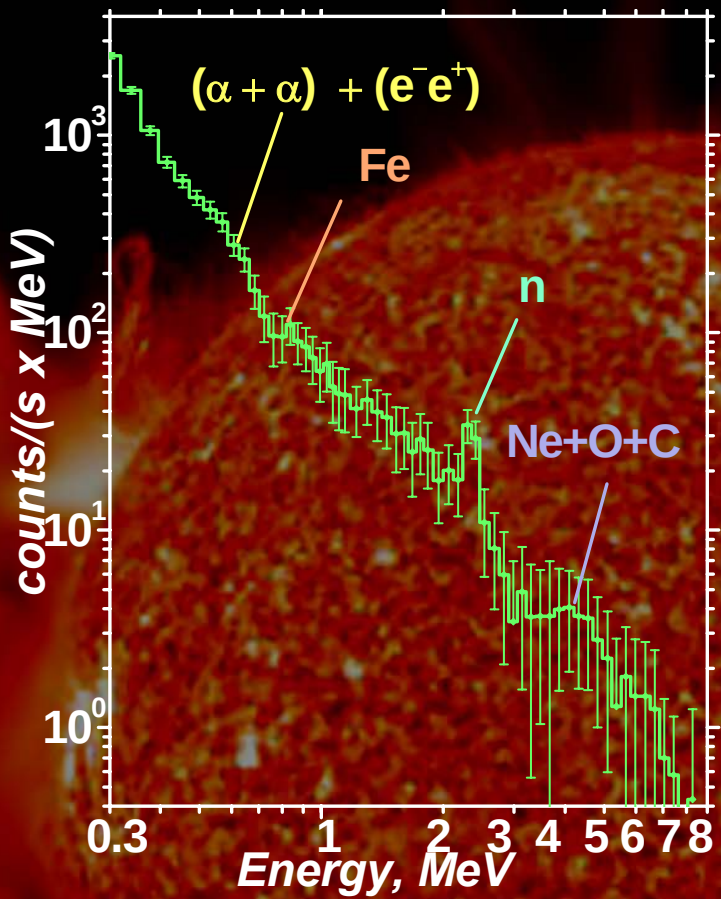
January 17 2005
solar flare X3.8

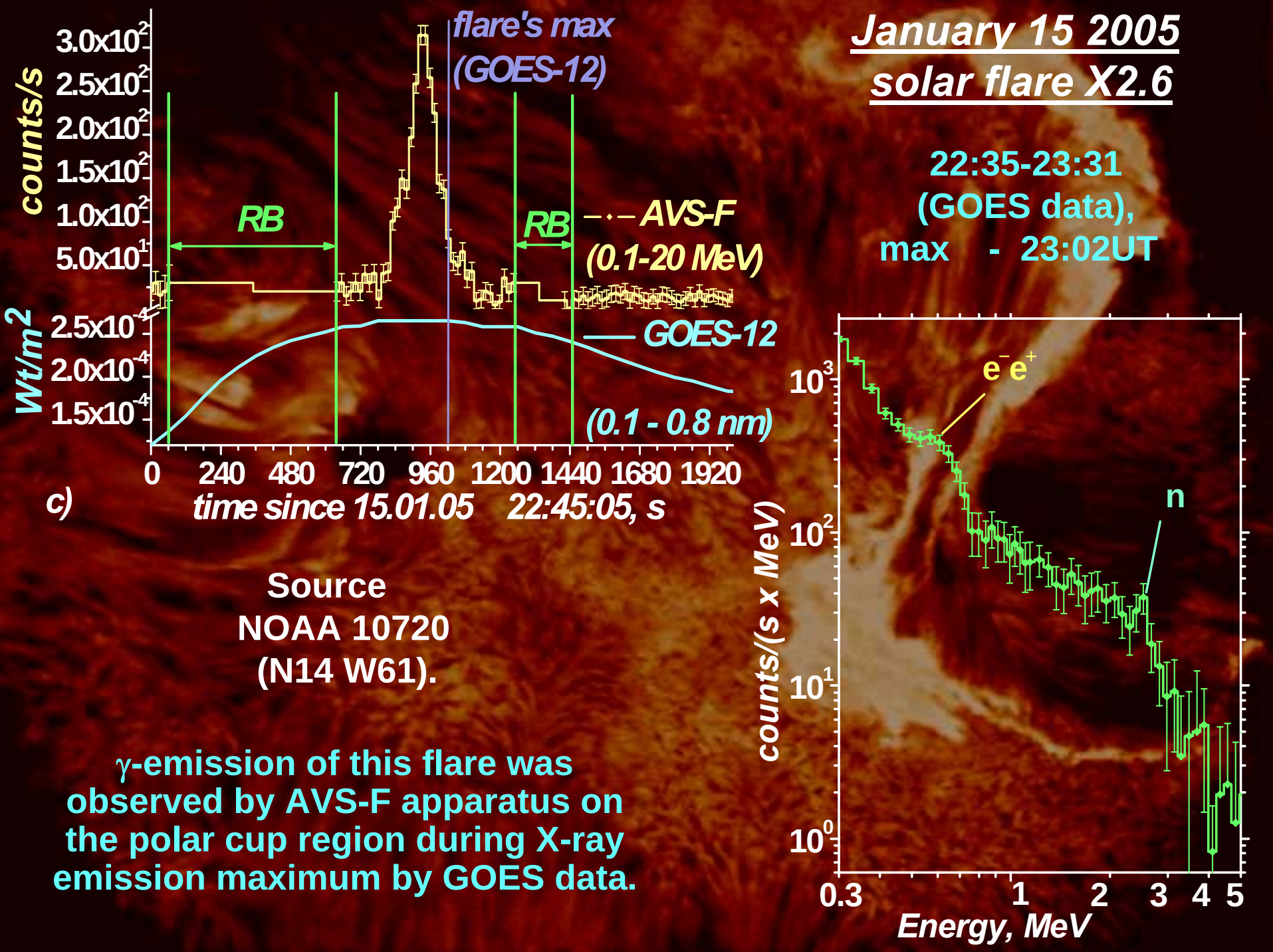
06:59-10:07
(GOES data),
max - 09:52UT



Source
NOAA 10720
(N14 W61).

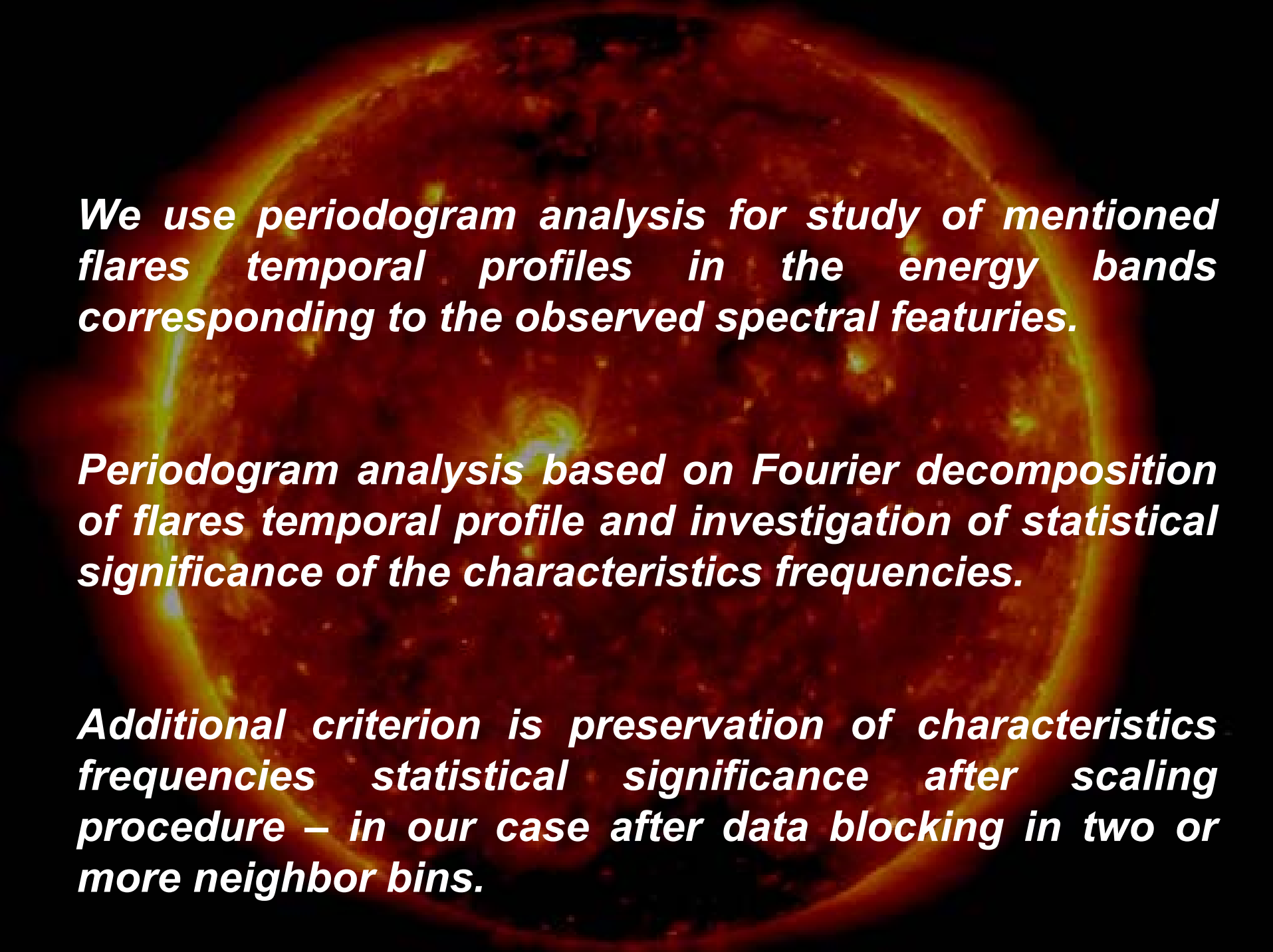
γ-emission of this flare was observed by AVS-F apparatus in equatorial region of satellite orbit too during X-ray emission maximum and droop by GOES data.




January 15 2005
solar flare X2.6
22:35-23:31
(GOES data),
max - 23:02UT
flare's max
(GOES-12)
RB
RB
AVS-F
(0.1-20 MeV)
GOES-12
(0.1 - 0.8 nm)
counts/s
Wt/m2
3.0x10^2
2.5x10^2
2.0x10^2
1.5x10^2
1.0x10^2
5.0x10^1
2.5x10^-4
2.0x10^-4
1.5x10^-4
0
240
480
720
960
1200
1440
1680
1920
time since 15.01.05 22:45:05, s
c)
Source
NOAA 10720
(N14 W61).
γ-emission of this flare was observed by AVS-F apparatus on the polar cup region during X-ray emission maximum by GOES data.
e⁻e⁺
n
counts/(s x MeV)
10^3
10^2
10^1
10^0
0.3
1
2
3
4
5
Energy, MeV

Spectral features of discussed solar flares.

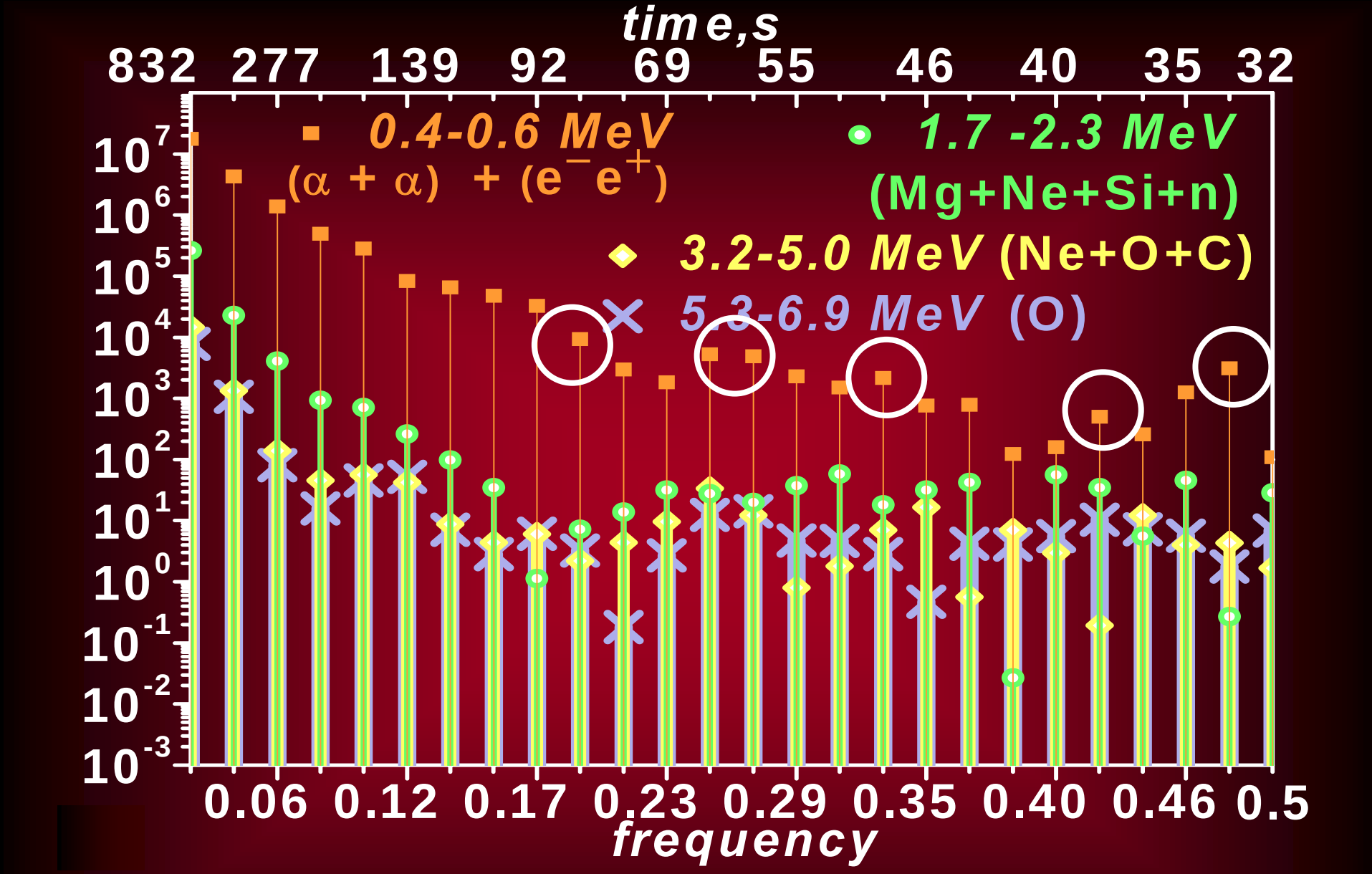
Date	Spectral features and it's energy band, MeV
20.01	$\alpha\alpha$ + e^+e^- (0.4-0.6), ^{24}Mg+^{20}Ne+^{28}Si + neutron capture (1.7–2.3), ^{20}Ne+^{16}O+^{12}C (3.2-5.0), ^{16}O (5.3-6.9)
17.01	$\alpha\alpha$ + e^+e^- (0.4-0.6), ^{56}Fe (0.7–0.9), neutron capture (1.7–2.3), ^{12}C (3.6-5.0)
15.01	e^+e^- (0.5-0.6), neutron capture (2.0–2.3)



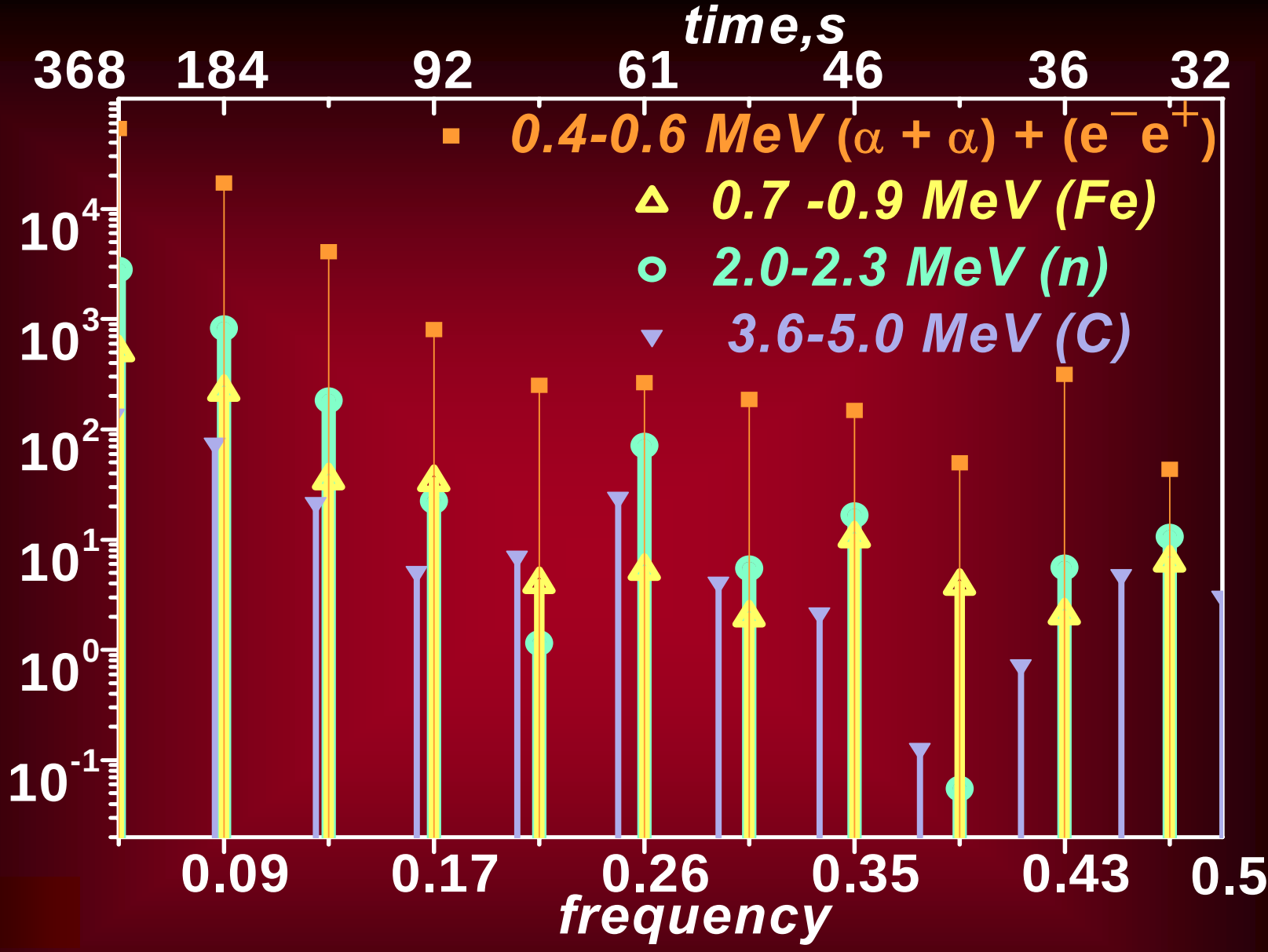
We use periodogram analysis for study of mentioned flares temporal profiles in the energy bands corresponding to the observed spectral featuries.

Periodogram analysis based on Fourier decomposition of flares temporal profile and investigation of statistical significance of the characteristics frequencies.

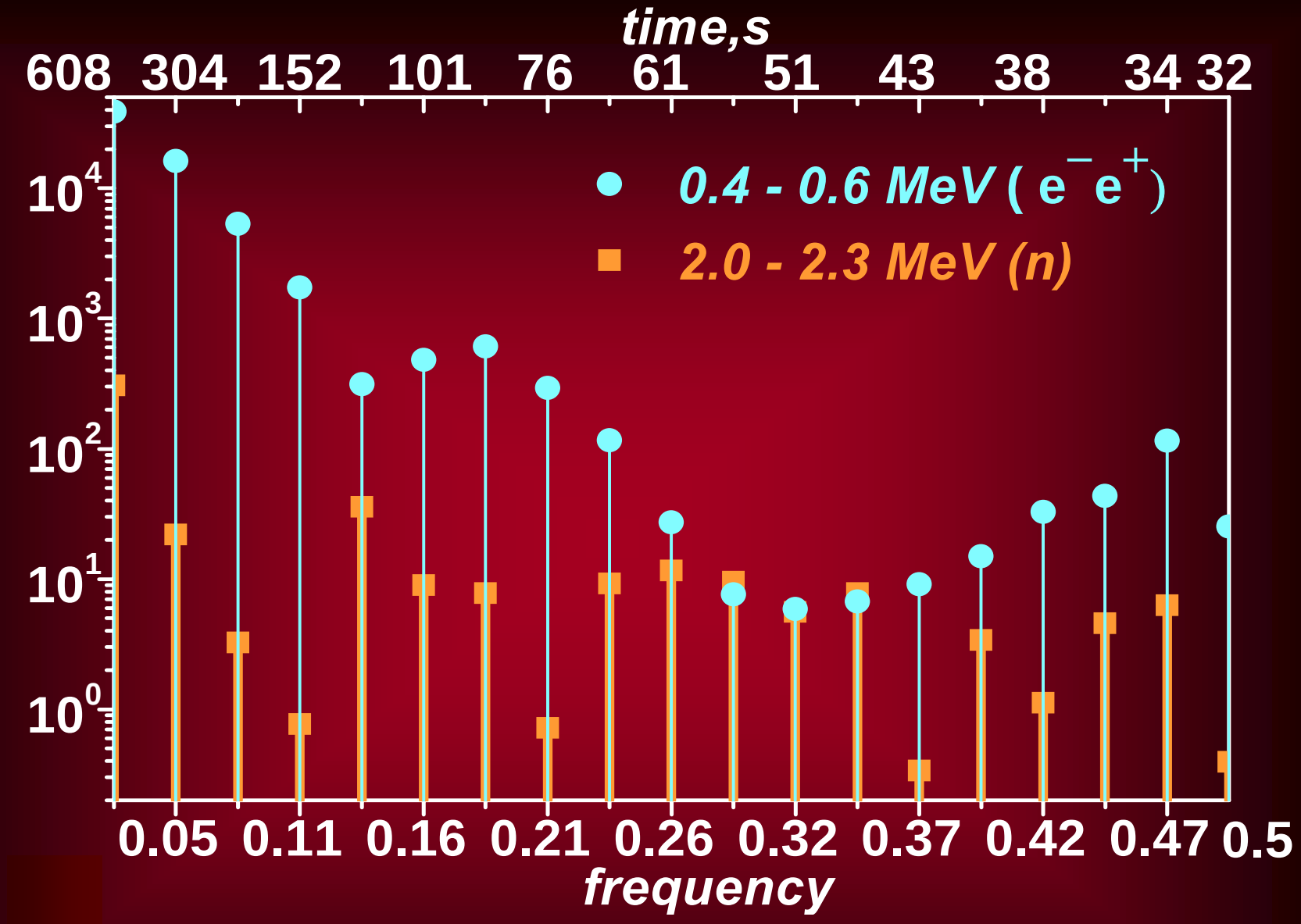
Additional criterion is preservation of characteristics frequencies statistical significance after scaling procedure – in our case after data blocking in two or more neighbor bins.



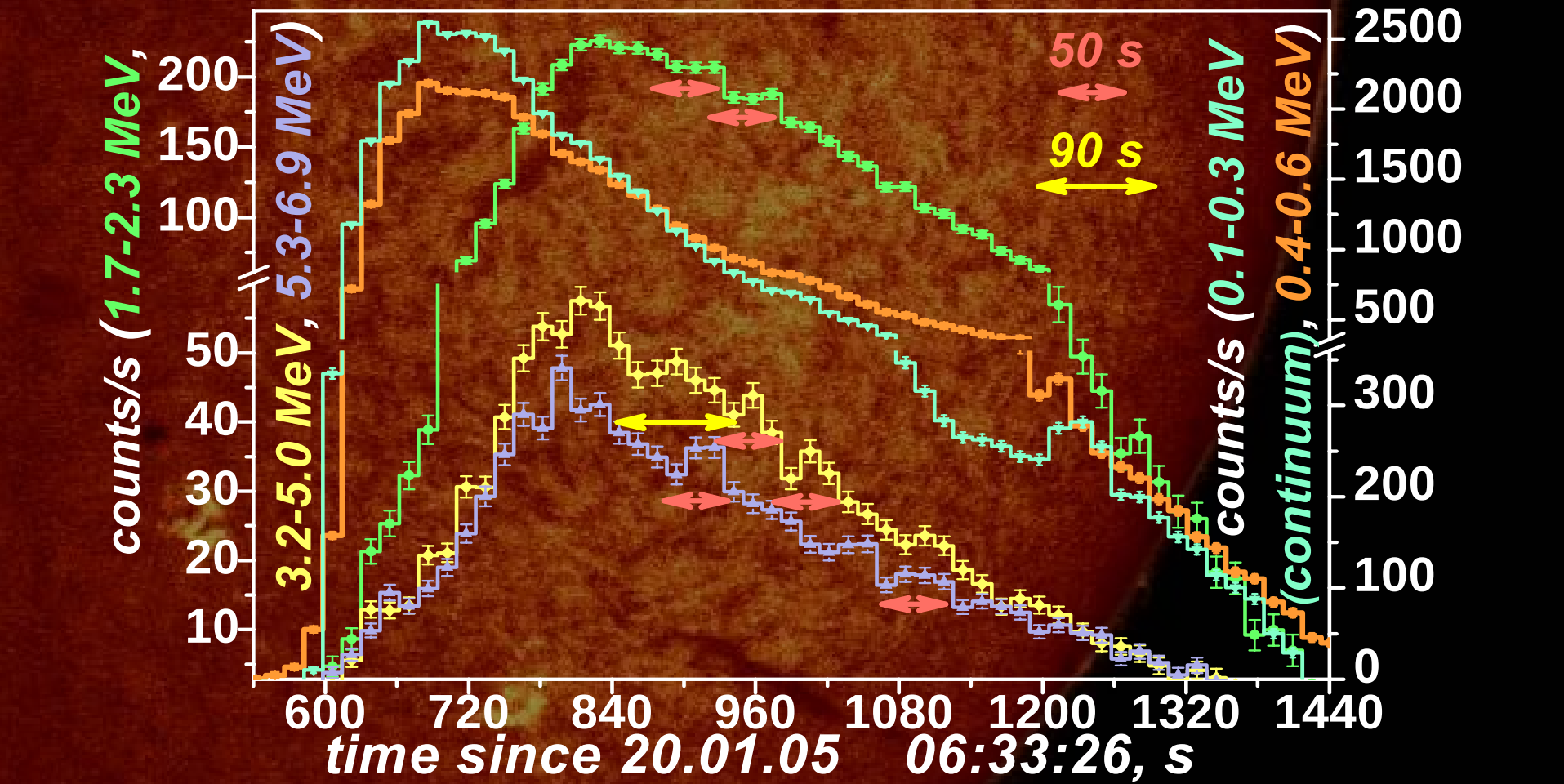
Periodogram for January 20 2005 solar flare temporal profiles in energy bands corresponding to observed spectral features



Periodogram for January 17 2005 solar flare temporal profiles in energy bands corresponding to observed spectral features

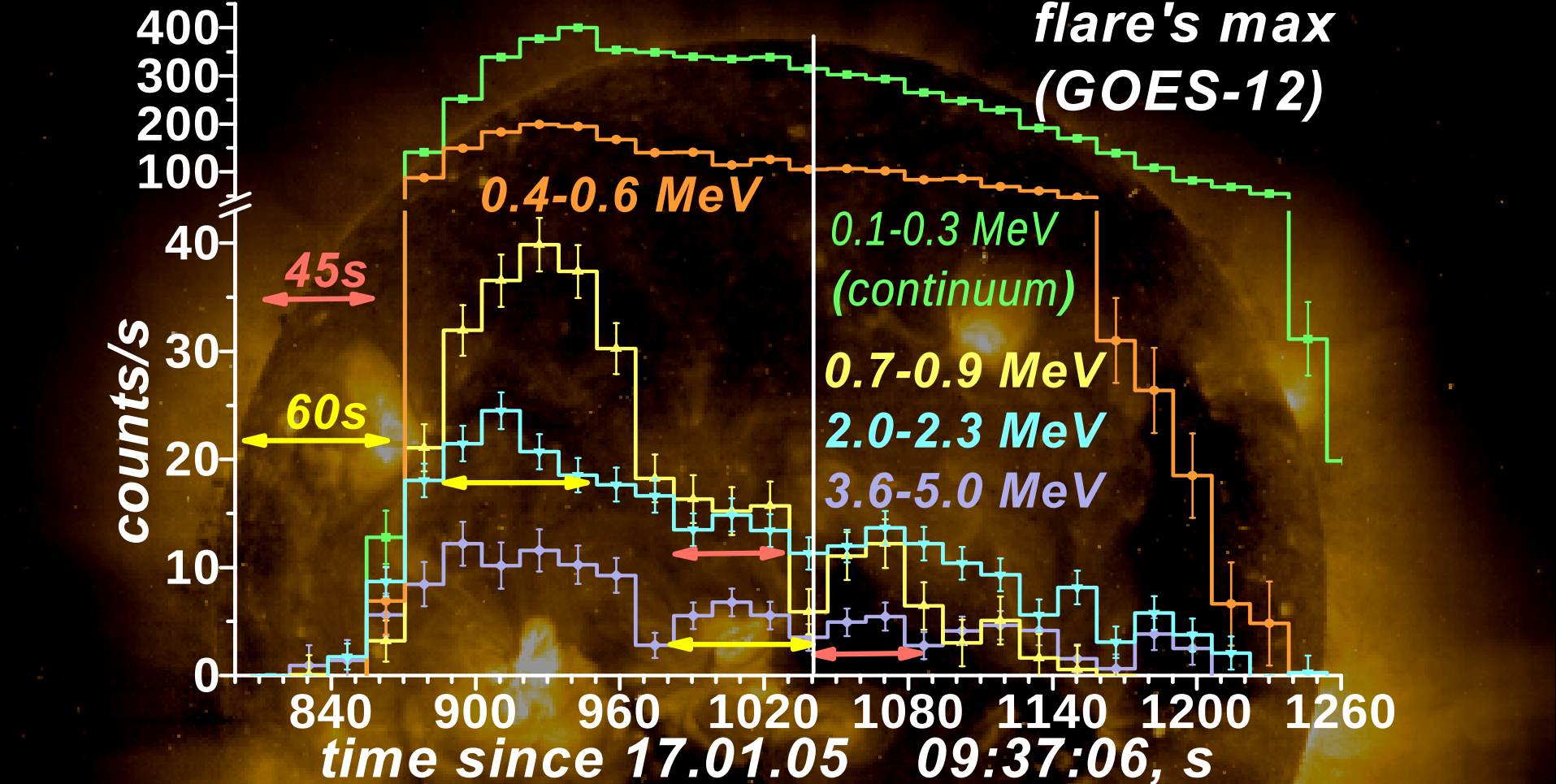


Periodogram for January 15 2005 solar flare temporal profiles in energy bands corresponding to observed spectral features



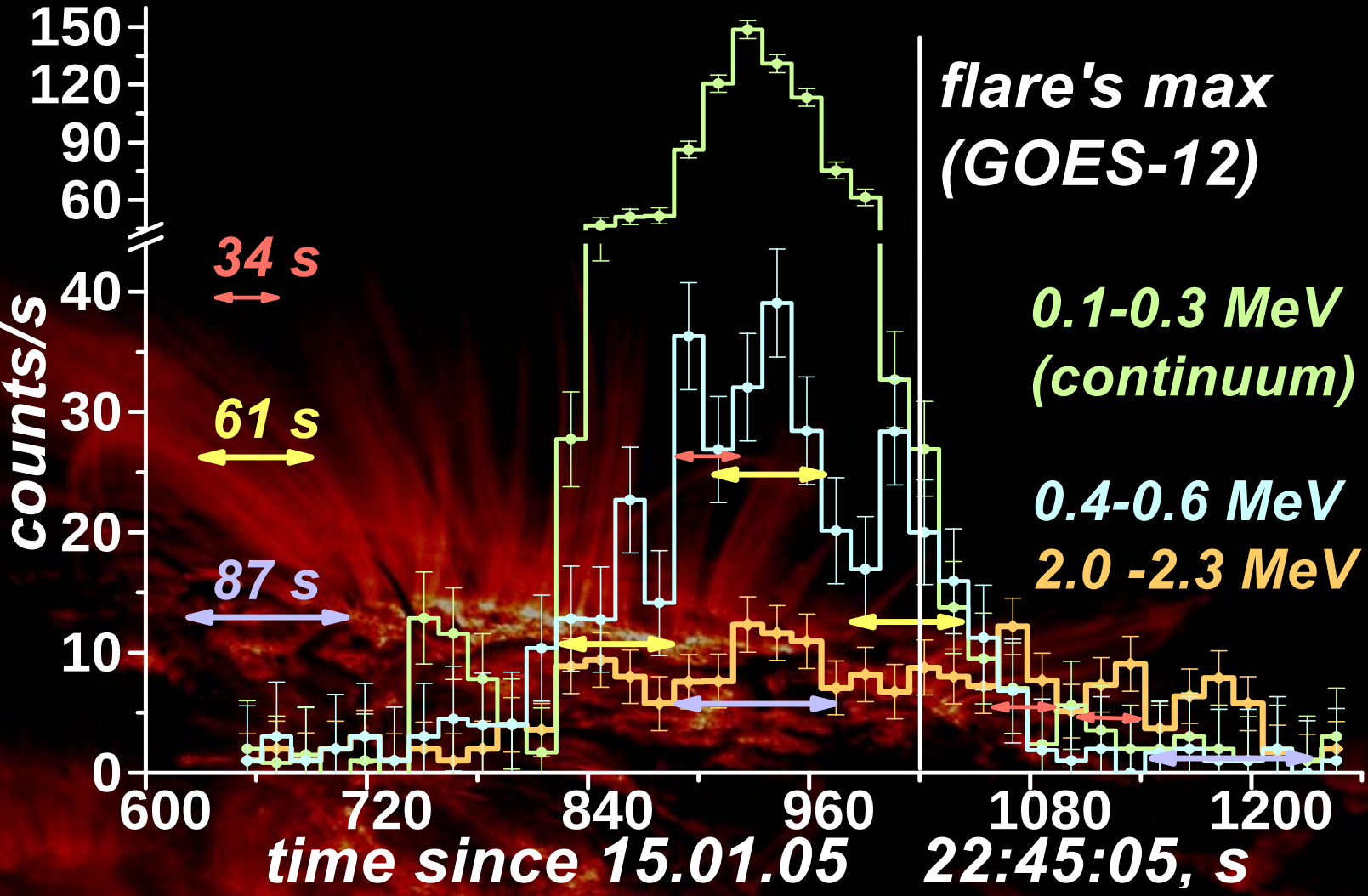
Characteristic timescales of January 20 2005 solar flare temporal profiles.

E, MeV	Characteristic timescales, s					
0.4-0.6	83	64	49	44	38	33
1.7-2.3	69	52	44	40	35	–
3.2-5.0	92	46	42	36	–	–
5.3-6.9	92	59	44	38	–	–



Characteristic timescales of January 17 2005 solar flare temporal profiles.

E, MeV	Characteristic timescales, s		
0.4-0.6	83	37	–
0.7-0.9	69	46	33
1.7-2.3	92	46	33
3.2-5.0	92	35	–



Characteristic timescales of January 15 2005 solar flare temporal profiles.

E, MeV	Characteristic timescales, s			
0.4-0.6	61	47	41	34
2.0-2.3	87	34	–	–

Conclusions

The wide range temporal profiles of January 20, 17 and 15 2005 solar flares time structure by AVS-F data is very simple with one maximum.

But temporal profiles structure is more complex in energy bands corresponding nuclear lines, positron line and neutrons capture line observed in these flare energy spectra. There are two maxima at solar flare January 20 temporal profile in energy band 0.4 – 0.6 MeV which correspond to maxima in range 0.1 – 0.3 MeV. In other energy bands one main maximum was observed on all discussed solar flares temporal profiles but thin structure with characteristic timescales 33-92 sec is presented on them in energy bands corresponding observed spectral features exclude 0.1-0.3 range (continuum). Periodogram analysis confirmed existence of such structure (confidence level is 99%).

The models of particles acceleration processes during solar flares should take into account the existence of such temporal structure.

In AVS-F apparatus used CsI instead widely used NaI because 2 light-output components with different fluorescence decay times τ_{fast} ~ 0.5-0.7 μs and τ_{slow} ~ 7 μs

↓

allow to recognize high energy γ-rays and n in this type detectors.

neutral radiation → secondary charged particles in detector material.

high energy γ-rays

↓

relativistic e^+e^-- pairs

n

↓

p^+ and α-particles

$$R = \frac{Qslow}{Qfast}$$

depends on ionization of the interacting particles

R ~ 1 for relativistic particles down to 0.25 for α (E_α ~ 10 MeV

The method → integration → signal from the SONG-D photomultiplier's preamplifier for two different time intervals T1 (from 0-0.2 μs after the pulse leading edge to 10 μs → *Qtot= Qslow+ Qfast* ~ whole energy deposition) and T2 (starts from 1-1.2 μs after the pulse leading edge and lasts up to 10 μs → *Qslow).*

Qtot and *Qslow/Qtot* were recorded for each registered event in special matrix.