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# Status of the russian satellite project "CORONAS-PHOTON" for study of solar flare hard radiation

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**Abstract.** CORONAS-PHOTON mission is the third satellite of the Russian CORONAS program on the Solar activity observations. The main goal of the CORONAS-PHOTON mission is the study of the Solar hard electromagnetic radiation in the wide energy range from Extreme UV up to high energy gamma - radiation (~2000MeV). It is adopted as a part of Russian Federal Program of Fundamental Space Researches.
Satellite has Solar orientation. Orbit: circular, 500km height, inclination 82degrees. Launching date 2005.

## 1 Introduction

During last decade impressive results were received in EUV and X-ray regions due to high successful mission YOHKOH and SOHO. But in nuclear gamma-ray and especially high-energy (>100MeV) regions the existing data is limited. Several flares with high-energy gamma-rays observed by EGRET, GAMMA-1, GRANAT revealed some peculiarities (very long duration of high energy gamma-radiation, electron emission dominated flares ets.).

Only a few data exist on solar neutron registration in space.

CORONAS-PHOTON is the Russian mission adopted as the third in the CORONAS satellite series. This mission consists of coordinated set of instruments that will investigate the spectrum and temporal characteristics of solar radiation in wide energy region from EUV up to high energy gamma-rays (2000MeV). Additionally there are two instruments for charge particle investigations.

Originally mission was adopted for launch during the present Solar max period. But due to financial problems the optimal lunching time is loosed. According to the revised satellite research program the launch date is 2005. The instruments is being party modernizing.

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## 2 Main scientific objects

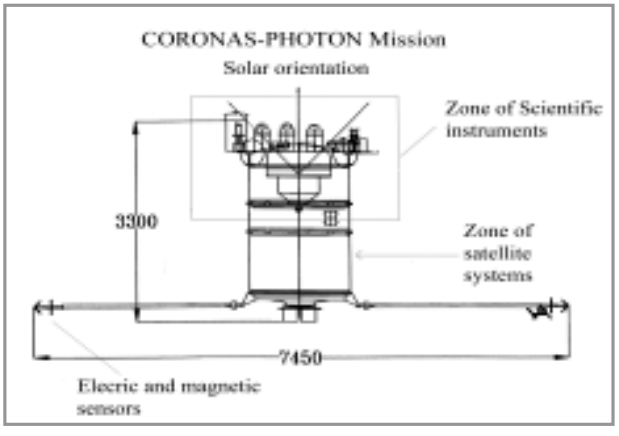
*Goal of the project:*

Investigation of the process of energy accumulation and its transformation to the energy of accelerated particles during solar flares, study of the acceleration mechanisms, propagation and interaction of the fast particles in the solar atmosphere.

Study of Solar activity correlation with physical-chemical processes in Earth upper atmosphere.

*Main objectives of the mission* are:

- study of the dynamics of energy spectra of electromagnetic radiation in a wide energy range from 1keV to 2000MeV;
- nuclear gamma-lines spectroscopy;
- detection of solar neutrons with energies higher 5MeV;
- measurement of linear polarization and rapid variability of hard X-ray emission during the flares;
- monitoring of the Solar extreme ultra-violet (EUV), soft and hard X-ray emissions;
- detection of electrons, protons and nuclei in orbit;
- monitoring of Earth upper atmosphere by occultation measurements of EUV and soft X-rays radiated by the quite Sun.



## 3 CORONAS-PHOTON mission summary

### 3.1 Payload

| Instrument | Measured radiation | Organizations | Weight kg |
|---|---|---|---|
| **High energy radiation spectrometer NA-TALYA-2M** | gamma-rays 0.3 – 2000MeV; neutrons 20 – 300MeV | Moscow State Engineering-Physics Institute (MEPhI); Lebedev Physical Institute (FI RAN) Moscow; | 360.0 |
| **Low energy gamma-ray telescope RT - 2** | phoswich mode15 – 150keV ; spectrometric mode100 – 2000keV | TATA Institute of Fundamental Research (TIFR), Bombay | 68.0 |
| **Hard X-ray polarimeter PENGUIN** | Soft X-ray radiation 1 – 10keV Hard-X-ray polarization measurement 20 – 150keV; X-ray & gamma-ray spectroscopy 0.15 – 5MeV; neutrons 5 – 50MeV | Ioffe Physical-Technical Institute, St-Petersburg; MEPhI | 29.5 |
| **Fast X-ray monitor FXM** | Hard X-ray 20 – 500keV with sub-msec temporal resolution | MEPhI | 10.5 |
| **Solar and cosmic gamma-burst spectrometer KONUS-RF** | Hard X-ray & gamma-ray spectroscopy 0.10 – 12MeV | Ioffe Physical-Technical Institute, St-Petersburg | 31.5 |
| **Multi-channel Extreme-ultra-violet and soft X-ray monitor EUV-PHOKA** | spectral windows: <10nm, 17 – 25nm, 30 – 35nm (HeII), 50 – 65nm (HeI), 70 – 90nm (OII – OIV) 121.6nm (Lyman-α), visual band | MEPhI; Astrophysical Institute, Potsdam; Fraungofer Institute IpM, Freiburg | 10.0 |
| **Energetic particle analyzer ELECTRON-5-PESKA** | e : 0.2 – 2MeV p : 1.0 – 150MeV α : 1.5 – 50MeV/nucleon Nuclei (Z <26) 2.0 – 50MeV/nucleon | Institute of nuclear physics of Moscow State University; University de Alkala, Madrid | 16.0 |
| **Energetic particle telescope STEP-F** | e : 0.15 – 10MeV p : 4.0 – 62MeV α : 15.5 – 245.5MeV | Kharkov State University | 7.5 |
| **Electromagnetic complex REIS** | electric fields 0.1 – 1kHz; magnetic fields 5 – 1000Hz | Institute for Terrestrial Magnetism and Radiowave propagation (IZMIRAN), Troitsk, Moscow region | 24.0 |

### 3.2 Spacecraft

| | | |
|---|---|---|
| Orientation of longitudinal axis to the Sun direction (at the day part of orbit) Destabilization from the Sun direction during the night time period | Absolute pointing accuracy ±10' Accuracy of the stabilization 0.3'/sec | Posteriori pointing accuracy ≤1.5' |
| Electric power (total) | 775 Watts | |
| Nominal mission lifetime | 3 years | Extended 5 years |

### 3.3 Orbit and Launcher

Circular 500±10 km. Accuracy of the satellite position measurement: along the orbit, in any direction -70m (2σ), Accuracy of absolute time registration - 1msec (1σ).
Orbit inclination $82.5^0$

Launcher: Cyclon-3M

At the moment the satellite-launcher system for the mission has extra 300kg payload capability. The satellite construction allows to install additionally three sub-satellites 75kg each. These four sub-satellites would be commercial load of the mission.

## 4…Main instruments parameters

### 4.1 Instruments for electromagnetic and neutron registration

**NATALYA-2M**

Detector type: 16 crystals CsI(Tl), size 380x80x45cm assembled in 4 rows and cowed by anticoincidence scintillator dome.
Square 1216$cm^2$, thickness 18 cm.
Energy resolution 9.9% @ 662keV (measured)
≤30% in band 50 – 2000MeV
Neutron registration efficiency ~3% @$T_n$=14.9MeV with efficiency of neutron /γ separation ~$10^3$. The ratio between fast and slow components is used to registered (n,p; n,α; n,d; n,t) reactions in the detector. For accurate neutron/γ separation the three dimension spectra are accumulating.
Active gain stabilization better 1% due to high stable light-diodes and radioactive source.
Temporal measurements have thee modes: normal, flare and burst.

**RT-2**

Detector type: Three separate phoswiches 3mmNaI(Tl)/ 25mmCsI(Na) with passive and active shielding, diameter 11.7cm each. Unshielded angles of view are different: 2x2, 3x3 and 5x5 degrees respectively.
Efficiency square 75$cm^2$ for γ-radiation 15 – 100keV.
Energy resolution better 16.5% for 60keV.

**PENGUIN**

Detector type: Central p-terfinil crystal (ϕ140x100mm) surrounded by cylindrical set of six CsI(Tl) crystals. This composition is covered by plastic coincidence counters.
Liner polarization measurement is based on scattering of photons in the central crystal. Degree of polarization is defined by anisotropy of scattered photon registration. Coincidence between central scatter and any CsI(Tl) crystal reduce background count rate.
Effective square for scattered photons is 20$cm^2$. For intense flare the 10% degree of polarization can be measured with absolute accuracy 1%.
Low energy recoil produced by neutrons (a few MeV's) interaction can be distinguished from fast secondary electrons by pulse shape discrimination.

**FXM**

Detector type: $YAlO_3$(Ce) scintillator crystal (ϕ60x10mm) with fast decay lightout (24nsec) is used to avoid the count rate latching for very intense events.
Temporal measurements of sub-msec variation (at high confidence level).

**KONUS-RF**

Detector type: one NaI(Tl) detector (ϕ127x76.2mm) is oriented to the Sun, another one (ϕ200x50mm) in opposite direction for solar and burst observations.
Energy resolution 8% @662keV for solar detector and
11% @662keV for antisolar one.

**EUV-PHOKA**

Detector type: Seven 'absolute" photodiodes AXUV-100 type covered by filters for different wavelength windows. Each square is 1$cm^2$. Field of view 3x3 degrees.

### 4.2 Instruments for charge particle measurements

**ELECTRON-5-PESKA**

Detector type: telescope of four semiconductor detectors.
Their squares are 9$cm^2$, 6$cm^2$, 9$cm^2$ and 9$cm^2$ respectively.
E – dE/dx ratio is used for particle separation. Angle of view 50 degrees SΩ=1$cm^2$.
Charge resolution 0.5e.
Energy resolution 30keV for $\alpha$-particle in measurement energy region.

**STEP-F**

Detector type: telescope of semiconductor strip detectors, telescope square 36$cm^2$.
Angular resolution 8degrees.