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SphinX: a solar fast soft X-ray spectrophotometer

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Abstract. The science goals and construction details are given of a new design, Polish X-ray spectrophotometer. It will be incorporated within the Russian TESIS X-and EUV complex aboard the forthcoming *CORONAS-Photon* solar mission. SphinX will use PIN silicon detectors for high time resolution (0.01 s) measurements of the solar spectra of quiet and active corona in the range 0.5 - 15 keV. A new filter-fluorescence target concept will be employed to allow for a fast photometry of the solar X-ray flux variations in selected, well defined narrow spectral bands including the Fe XXVI and Fe XXV iron line groups.

Keywords. Sun: X-rays, spectrophotometer, high time resolution.

Measurements of the X-ray variability of the Sun are of basic importance for studies of the activity, flares and the space weather. The bulk of coronal thermal plasma of temperatures between 1 - 50 MK contributes to the emission in the soft X-ray band. Observations of the spectral variability in the range from 0.5 keV to 15 keV provide the basis for determinations of coronal average temperature, emission measure and related thermodynamic characteristics for non-active corona and flares in particular. For more than 30 years, *GOES* X-ray ion chambers observed the Sun in two spectral bands 0.5 - 4 Å and 1 - 8 Å (3 - 24 keV and 1.5 - 12 keV respectively). These continuous measurements constitute the reference database as concerns recent solar activity observations. However they lack information at both the low- and high- activity conditions (below A and above

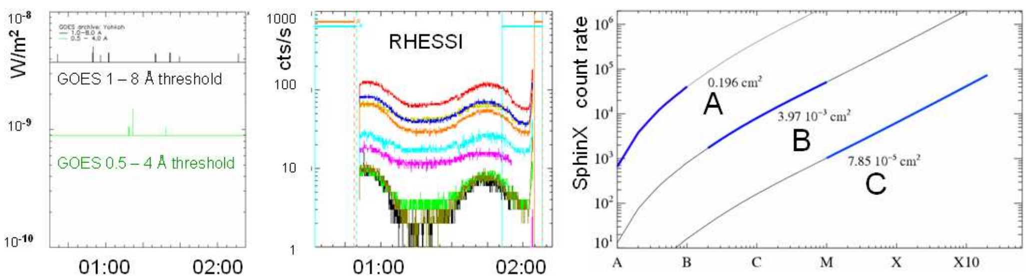

Figure 1. Example of the measurements taken by *GOES* (left) and *RHESSI* (centre) for the period of low solar activity on 2006 March 6. No solar soft X-ray signal has been detected by *GOES* above the corresponding thresholds. For *RHESSI*, the observed modulation is entirely due to the variations of the orbital background at this times. In the case od SphinX detector A (right), the expected solar signal will be ∼1000 cts/s for a corresponding activity level. The expected orbital background rate is ∼10 cts/s.

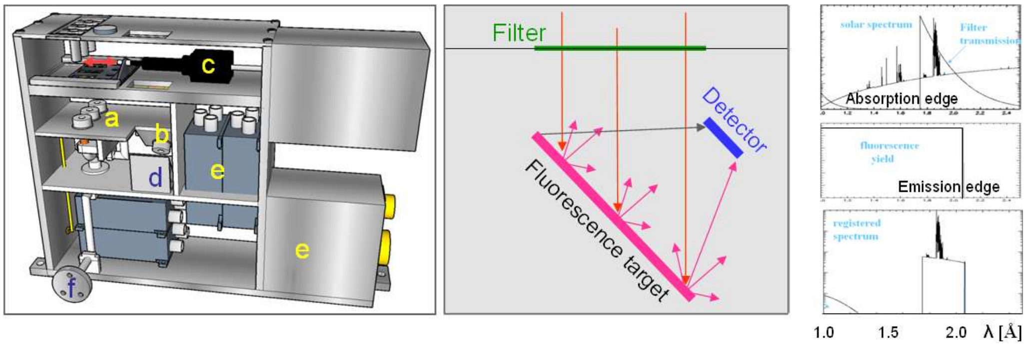

Figure 2. left: Design of SphinX with main components indicated: a) three spectrophotometric detectors, b) narrow-band detector, c) shutter, calibration aperture & their motor d) filter-fluorescence section e) electronics with microcontroller f) cooling heat pipe; **centre**: principle of narrow band filter (NBF); **right:** solar X-rays transmitted through the filter contain predominantly the radiation above the wavelength of specific absorption threshold. They illuminate the fluorescence target and only those wavelengths above the fluorescence threshold contribute to the scattered flux measured by the detector. In respect with the system acts as the narrow-band filter with precisely defined knife-edge sharp energy boundaries.

X10 class). The other active solar spectrometer (*RHESSI*) lacks sensitivity at the lower energy end, below 3 keV. For the illustration, in figure 1 we present example measurements taken by *GOES* and *RHESSI* for selected, very low solar activity period. It is seen that the X-ray signal measured does not show-up above the background. During the forthcoming Russian-lead solar space mission *CORONAS-Photon*, it is necessary to have a possibility of taking precise measurements of the solar variability in the soft X-ray range, also during periods of very low activity, as the launch is scheduled for 2007/2008. Therefore, the Wrocław Solar Physics Division Team at the Space Research Centre developed a concept of sensitive spectrophotometer **SphinX** (**S**olar **p**hotometer **in X**-rays). This proposed instrument has recently been incorporated within the TESIS complex, a part of the *CORONAS-Photon* payload. **SphinX** incorporates four PIN, pure silicon, 500 μm thick detectors (AMPTEK XR-100CR) equipped with Be 12.5 μm filters. Three of them with apertures of 19.6, 0.4 and 0.078 mm^2 measure the solar X-ray fluence from events of the *GOES* class as small as A (rate: 1000 cts/s, largest aperture) up to X40 (rate: 10^5 cts/s, smallest aperture) over 256 energy bins. The dynamic range covers 7 orders of magnitude with the statistical accuracy better than 1%. Individual photon arrival times are to be known to within 1 μs and the spectra are to be taken 100 times per s. The fourth detector measures instantaneous narrow-band fluxes in three wavelength bands: 1.74 - 2.07 Å, 2.50 - 3.08 Å and 7.95 - 9.54 Å hundred times per s using novel measurements concept explained in the centre of figure 2. The overall absolute calibration of the detectors is to be performed using BESSY synchrotron beams to the accuracy of better than 5%. In-flight corrections for long-term detectors' energy gain variations are envisaged thanks to original system of solar induced illumination arising from the set of semi-transparent fluorescence foils. A special shutter motor opens these fluorescence foils occasionally. The overall data rate from **Sphinx** is expected to be not less than 20 MB/24$^{\mathbf{h}}$, limited only by the on-board computer storage and telemetry resources.

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