Soft X-ray polarimeter-spectrometer SOLPEX

M. ŚTEŚLICKI¹, J. SYLWESTER¹, S. PŁOCIENIAK¹, J. BĄKAŁA¹, Ż. SZAFORZ¹,², D. ŚCIŚŁOWSKI¹, M. KOWALIŃSKI¹, J. HERNANDEZ¹, Ś.V. KUŽIN³, S. SHESTÓV³

1. Solar Physics Division, Space Research Centre Polish Academy of Sciences, Wroclaw, Poland
2. Astronomical Institute, University of Wroclaw, Wroclaw, Poland
3. Lebedev Institute, Russian Academy of Sciences, Moscow, Russian Federation
Motivation

Reliable detection of X-ray polarization provides unique, yet unexplored tool of studying non-isotropic distribution of particles in the solar corona.

Ubiquitous presence of collimated non-thermal electron beams during flare impulsive phase is indispensable in order to explain observed patterns of hard X-ray flare emission.

The X-ray polarization measurements have unique potential to constrain processes leading to the electron beaming and define the orientation of magnetic field loops with respect to line of sight.
ISS Nauka module

Nauka (Russian: Нау́ка; lit. Science), also known as the Multipurpose Laboratory Module (MLM) or FGB-2, (Russian: Многофункциональный лабораторный модуль, or МЛМ), is the major Russian laboratory module which will take the place of Pirs.

SUN-pointing platform will be attached to NAUKA

MLM Nauka module arrives to RKK Energia’s KIS test facility in Korolev on Dec. 14, 2012.
Credit: RKK Energia
Is ISS a good observing platform?

- Easy access to ISS, instrument mounting by cosmonauts
- Possibility of using large instruments
- No substantial limitation on power
- Large volumes of data storage on „popular” media
- Possibility of „repairs” and memory module transport to the ground
- Rough Pointing- few arcmin due to ISS motions
- Spacecraft day/night shifts (16 nights/24h)
- Vignetting by various ISS structures: only ~10 min of uninterrupted measurements per orbit possible
SUN-pointing platform - Kortes

Block of detectors – vacuum space outside the ISS on 2D-platform

Block of electronics – inside the ISS

Block of FIAN detectors:
- 3 telescopes – 195, 304 and 584 Å
- 2 spectroheliographs 180-210 Å & 280-330 Å
- X-ray spectropolarimeter SolPEX (0.5-22 keV)
SolPEX objectives

Measurements of polarization in soft X-ray continuum emission and possibly in selected emission lines (1-2% detection limit) (B-POL)

Measurements of X-ray spectra evolution with very high time resolution (0.1 s) rotating drum spectrometer (RDS) - idea proposed by Stefan Płocieniak

Imaging the soft X-ray Sun with moderate spatial (~20arcsec) and high time resolution (0.1 s) pin-hole imager (PHI)
**General view**

**Pin-hole imager**

Rotating, bent-crytal Bragg spectropolarimeter with capillary 2D collimator and precision (arcsec) pointing device

Rotating drum, flat crystal, multiple band Bragg-crystal spectrometer

Front-end open-space electronics

**Design:** Jarek Bąkała SRC PAS, Solar Physics Div.
Pin-hole imager

Focal length  ~60cm
Spatial resolution:
- 1 mm² hole ~2 arcmin
- 20 x 20 pixel area
Solar diameter: ~200 x 200 pixels
FoV: 38 arcmin x 150 arcmin

Primary role: localize sources (AR & flares) on the disk in the instrument coordinate system
Secondary: detect active phenomena on the disk, analyse individual lightcurves for separate AR
Easy concept: pin-hole and a CCD detector (256 x 1024 pixels 26 µ)
Image readout: each ~0.2 s
Will provide positions [x,y] of more prominent individual sources (resolution ~1.5 arcmin).
Limited spectroscopy, similar to RHESSI at lower energy range (Fe XXV and Fe/Ni line groups distinguishable)

Energy range: 1-10 keV, dE: ~1 KeV

Purpose: Locate the X-ray source on the Sun
Rotating polarimeter unit

- Si 111 bent crystal at the Brewster angle ~45°
- CCD detector
- Rotating at 1 rev./s
- Pointed using pin-hole image
Spectro-Polarimeter monocrystal wafer: cylindrical Si 111

- 2d=6.271 Å
- Spectral range: 3.940 - 4.505 Å
- Radius of curvature: 610.0 mm
- Crystal length & width: 85.5 & 31 mm
- Calculated ideal FWHM & Resolution: 4.4 arcsec ~ 0.0005 Å

< line thermal widths

courtesy Žaneta Szoforz
Why this selection?

Continuum and line emission should be prominent for a wide range of physical conditions on the Sun i.e. AR and/or flares.

Clean spectral range in the vicinity of the lines, allowing for separate measurements for the continuum and line rotationally modulated pattern.

Average solar flare spectra, obtained by the RESIK instrument.
A very high time resolution (0.1s) spectroscopy for flares

New concept: Stefan Płocieniak SRC PAS

Fast rotating drum equipped with 6 different crystals and 1 pair of identical Si crystals in the Dopplermeter orientation Bragg-illuminate the ”standard” SDD detectors’
Rotating Drum Flat spectrometer unit

Thanks to the rotation photons are being „reflected“ from the crystal.

By monitoring the photon arrival time, accurate „intercept“ angle can be estimated & converted to wavelength

Histogram spectrum will be revealed with sufficient amount of detections

Fast rotating (10 rev/s) drum with a set of 8 crystals (4 pairs of identical flat monocrystals in Dopplerometer configuration)

4 large area ~0.25cm² PIN detectors
Summary

Placing the instrument onboard ISS provides a unique opportunity for testing new measurement ideas.

Detailed ground calibration & alignment & testing (innovative) procedures are necessary.

New measurement techniques can be tested and interesting flare physics can possibly be revealed.
Thank you