Soft X-ray polarimeter-spectrometer SOLPEX

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Motivation

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

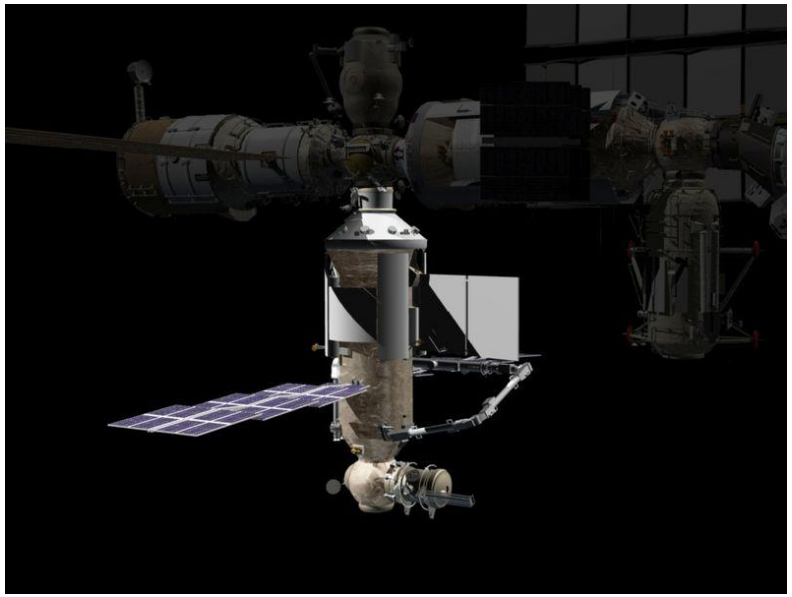
Ubiquitous presence of collimated non-thermal electron beams during flare impulsive phase is indispensable in order to explain observed patterns of hard X-ray flare emission

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

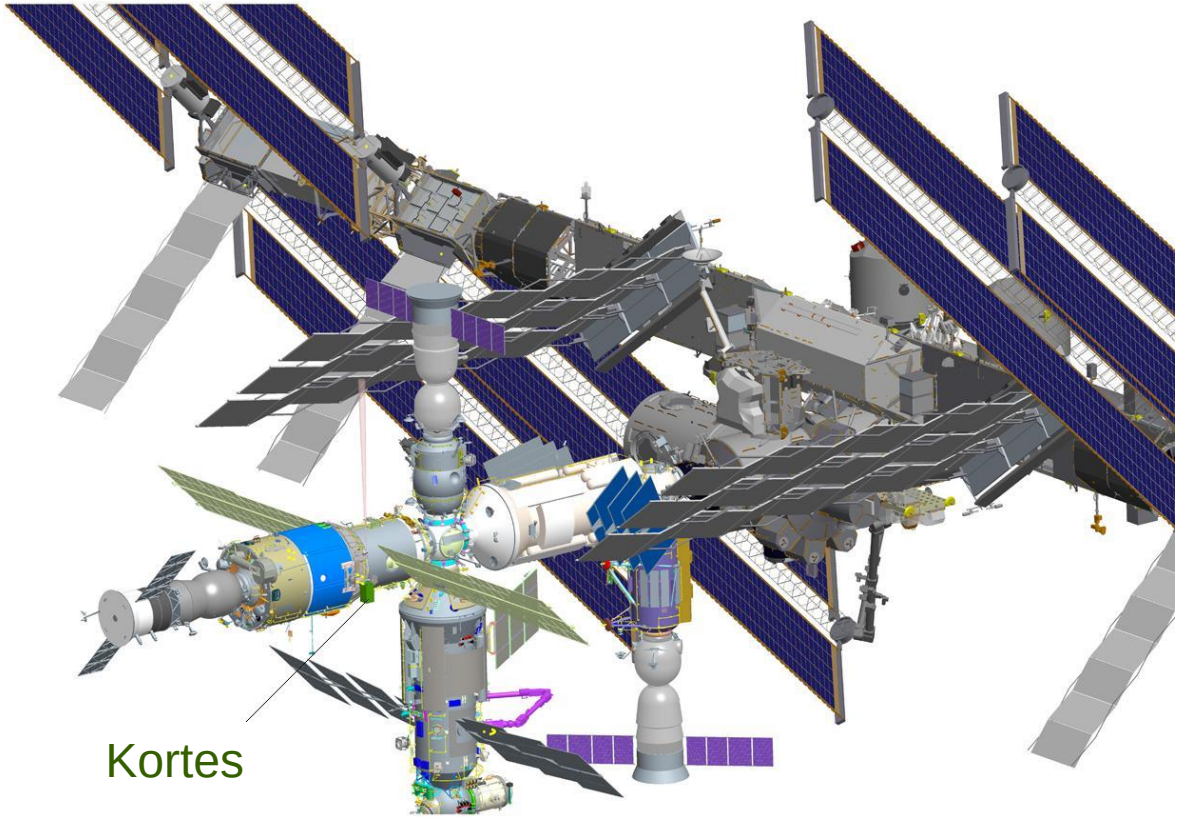
SUN-pointing platform - Kortes

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)



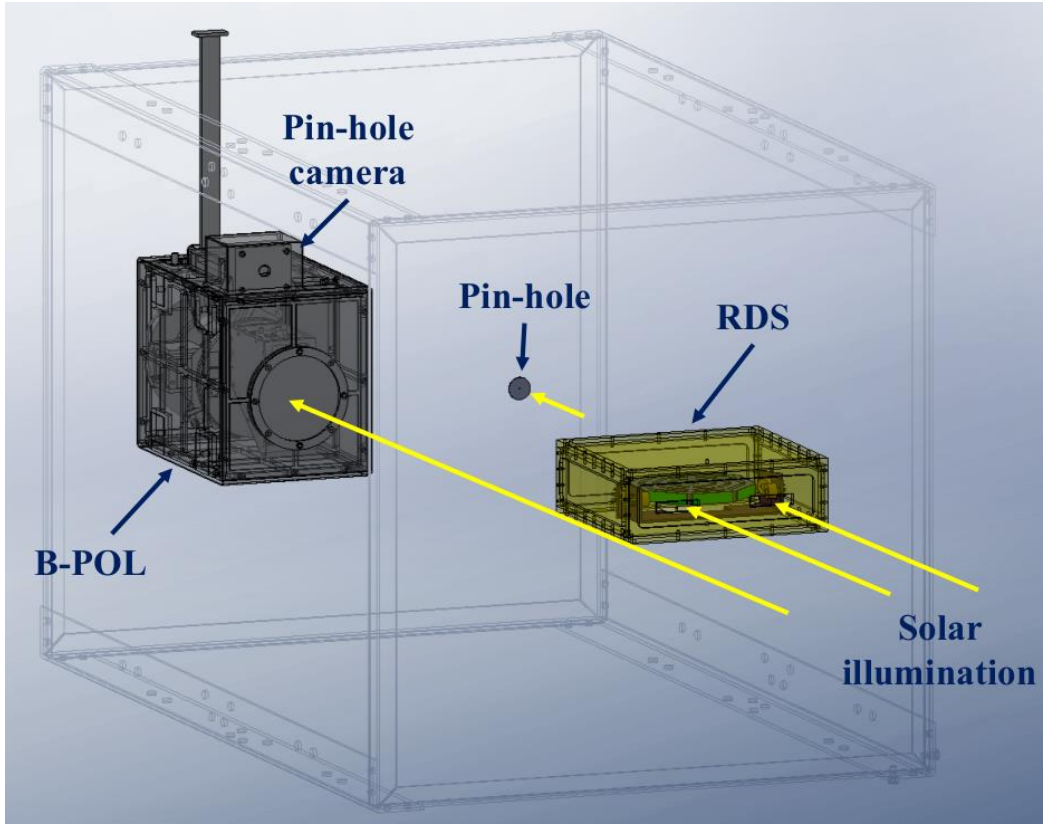
SolPEX objectives

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



Design: Jarek Bąkała SRC PAS, Solar Physics Div.

Pin-hole imager

Rotating, **bent-crystal 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

Pin-hole imager

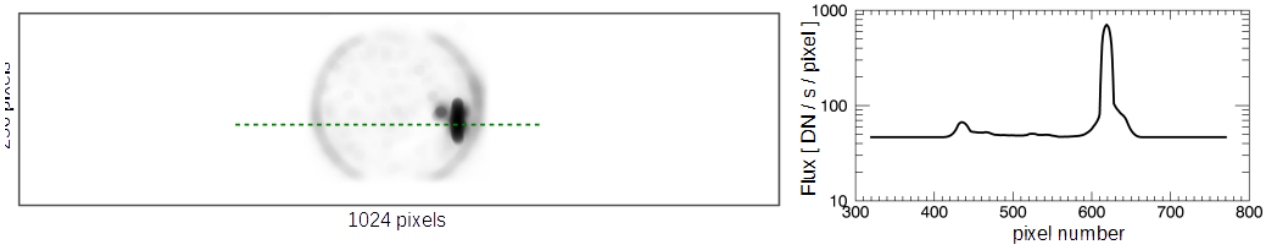
Focal length ~60cm

Spatial resolution:

- 1 mm^2 hole ~2 arcmin
  - 20 x 20 pixel area

Solar diameter: ~200 x 200 pixels

FoV: 38 arcmin x 150 arcmin



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

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)

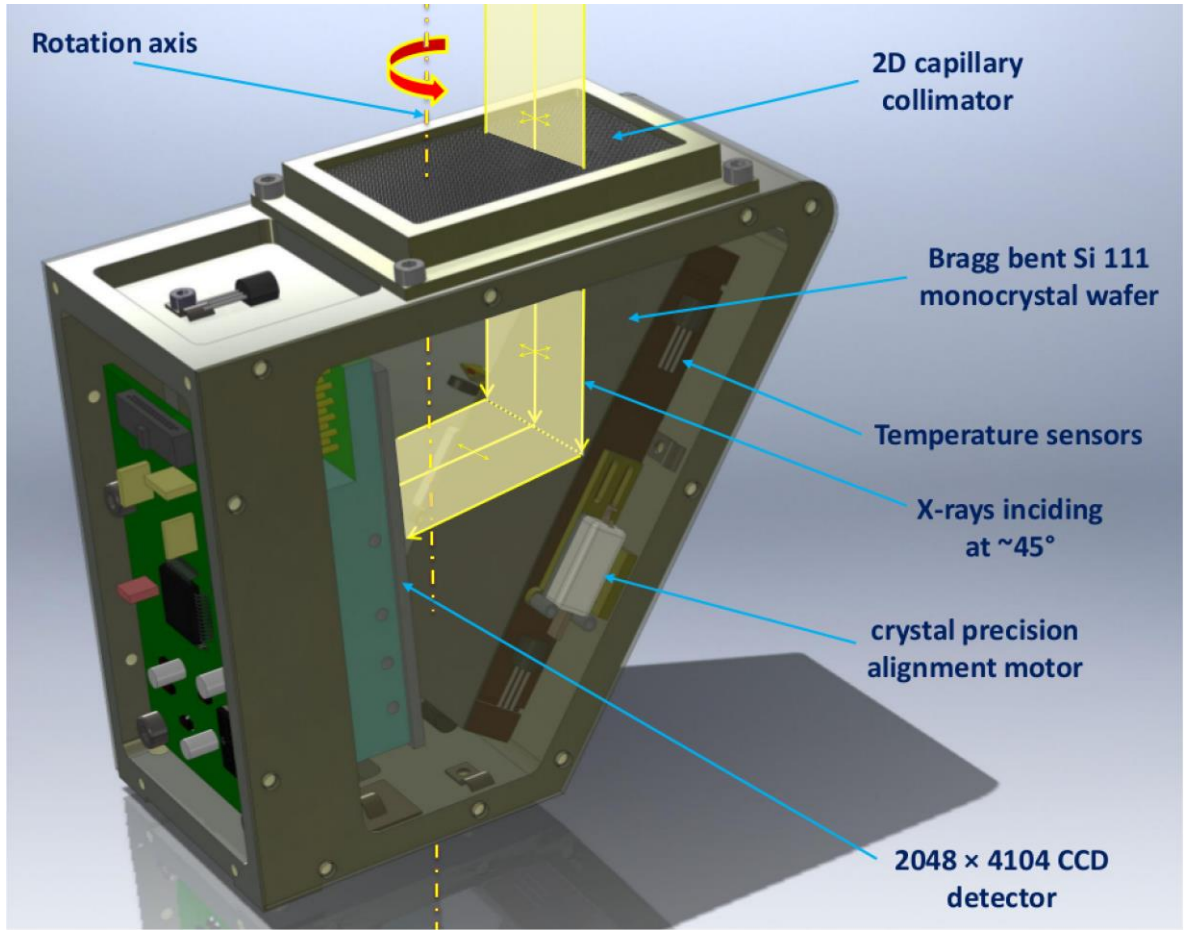
Image readout: each ~0.2 s

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)

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

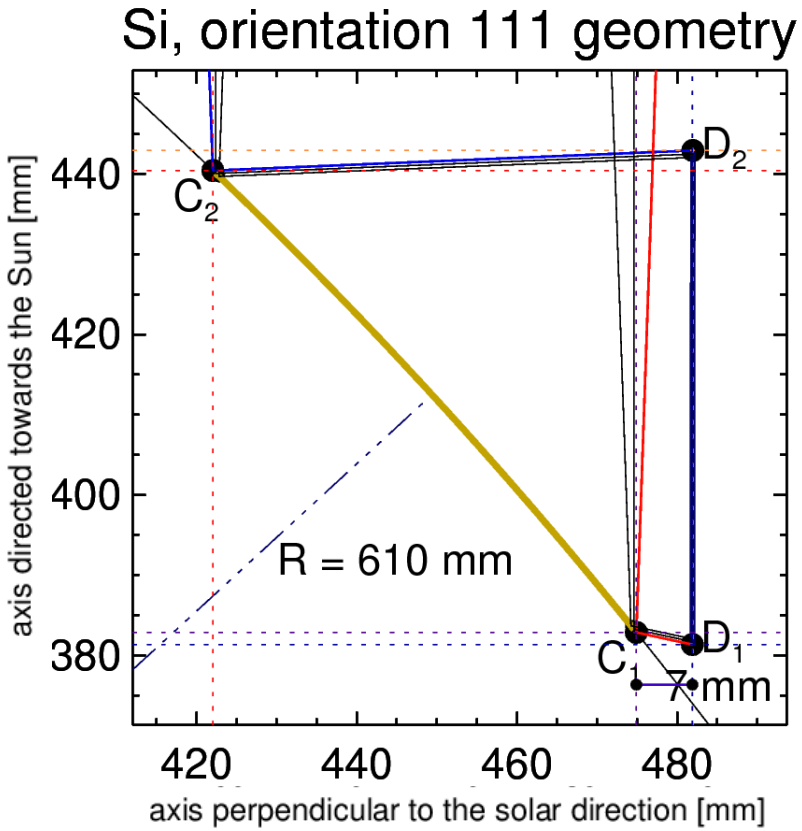
Spectral range:
3.940 - 4.505 Å

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 wdths

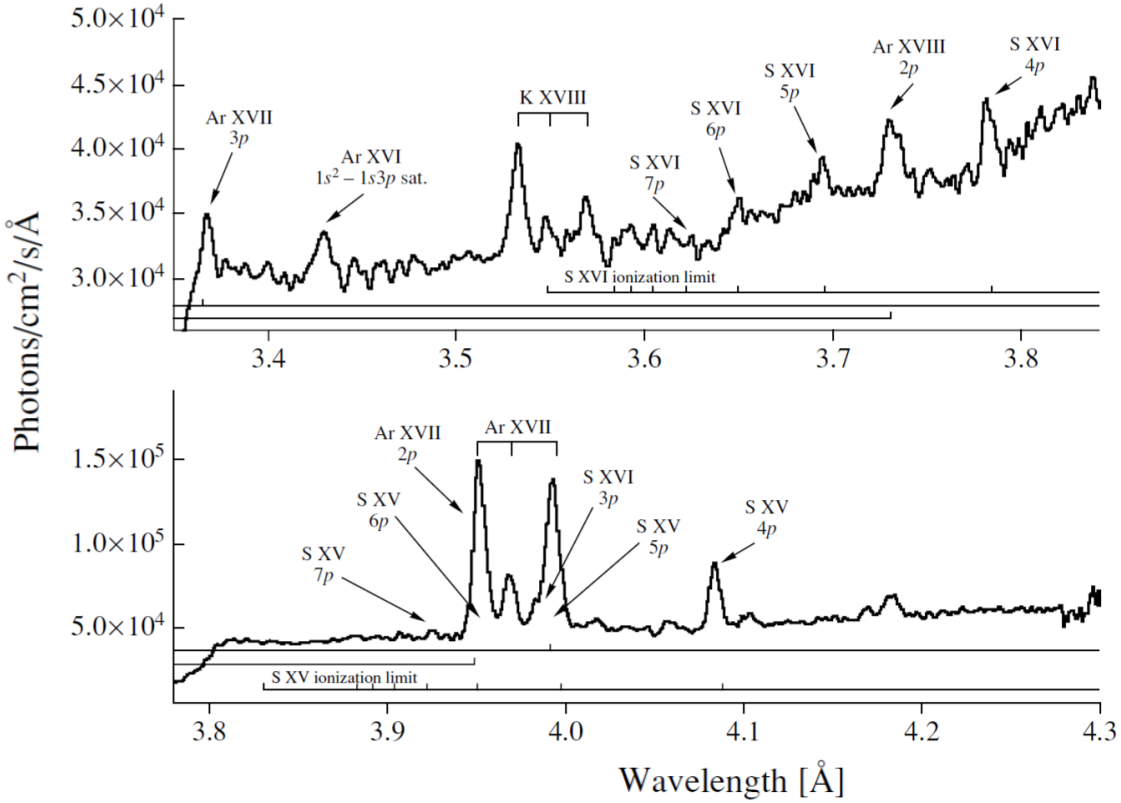


courtesy Żaneta Szoforz

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

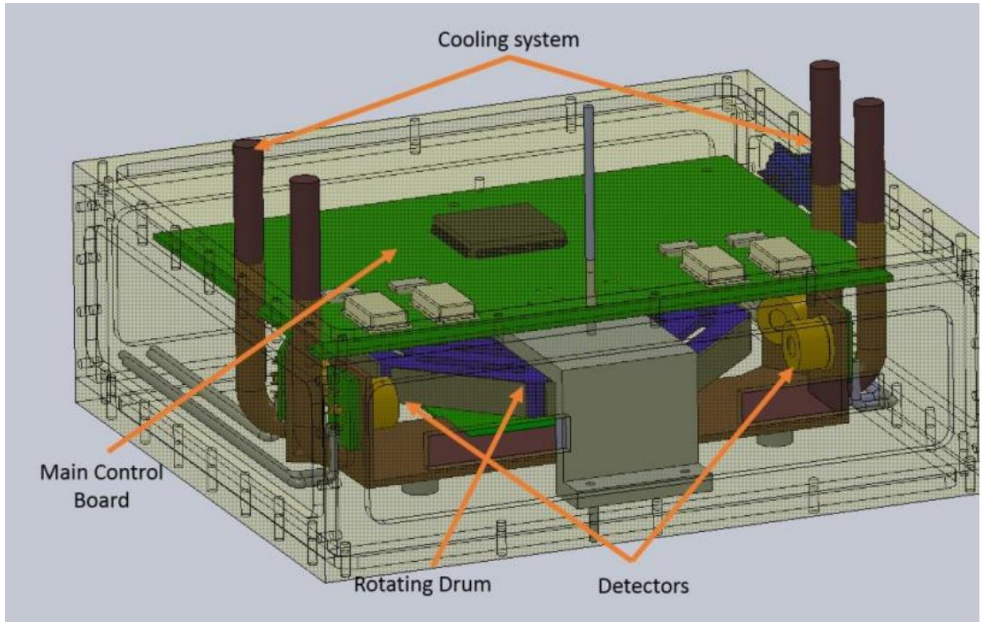


Sylwester et al. (2005)

Average solar flare spectra, obtained by the RESIK instrument

A very high time resolution (0.1s) spectroscopy for flares

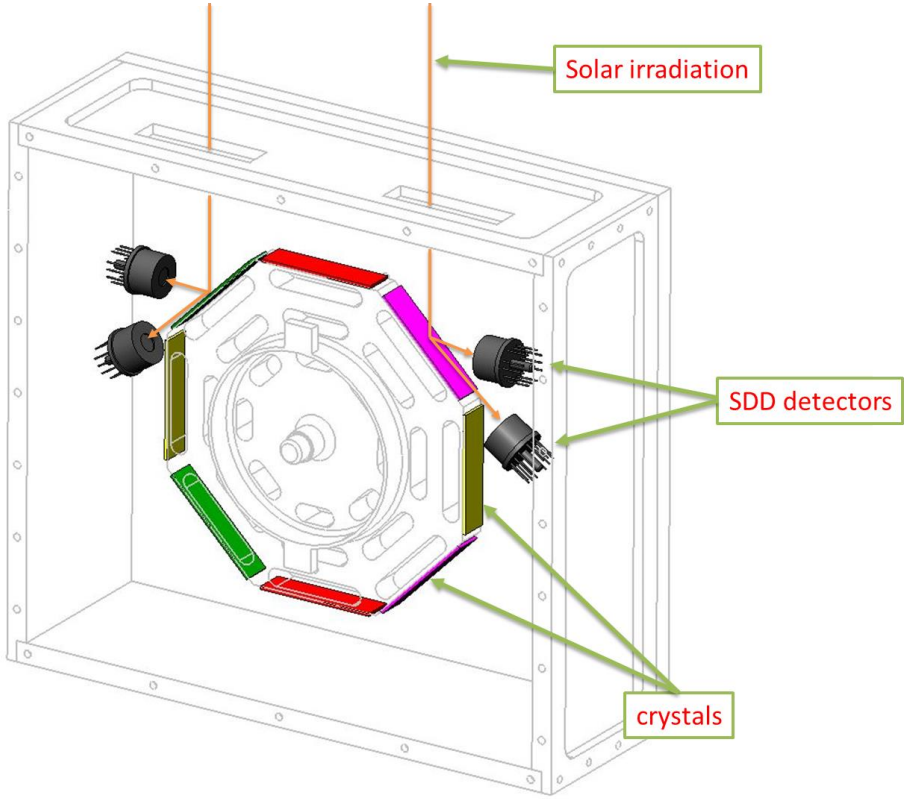
New concept: Stefan Płocieniak SRC PAS



Fast rotating drum equipped with 6 different crystals and 1 pair of identical Si crystals in the Dopplerometer orientation Bragg-illuminate the ”standard” SDD detectors’

No	Crystal	Orientation	2d [Å]	Detector 1 wavelength range [Å]	Detector 2 wavelength range [Å]
1.	Si	400	2.715	1.397 – 2.331	0.27 – 1.796
2.	Si	220	3.840	1.977 – 3.298	0.391 – 2.541
3.†	Si	111	6.271	3.228 – 5.385	0.639 – 4.150
4.	Quartz	10-11	6.684	3.441 – 5.740	0.681 – 4.423
5.	Quartz	10-10	8.514	4.383 – 7.312	0.868 – 5.635
6.	ADP	101	10.648	5.482 – 9.145	1.086 – 7.047
7.	KAP	001	26.640	13.717 – 22.880	2.718 – 17.631

Rotating Drum Flat spectrometer unit



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 ~0.25cm^2 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