

The Bragg solar X-ray spectrometer **SolpeX**

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Motivation

- Detection of X-ray polarisation 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 (vide RHESSI results)
- No systematic, accurate measurements of the solar soft X-ray polarization have been performed yet
- Reliable measurements are available from laboratory (EBIT – Beiersdorfer et al. 1996)

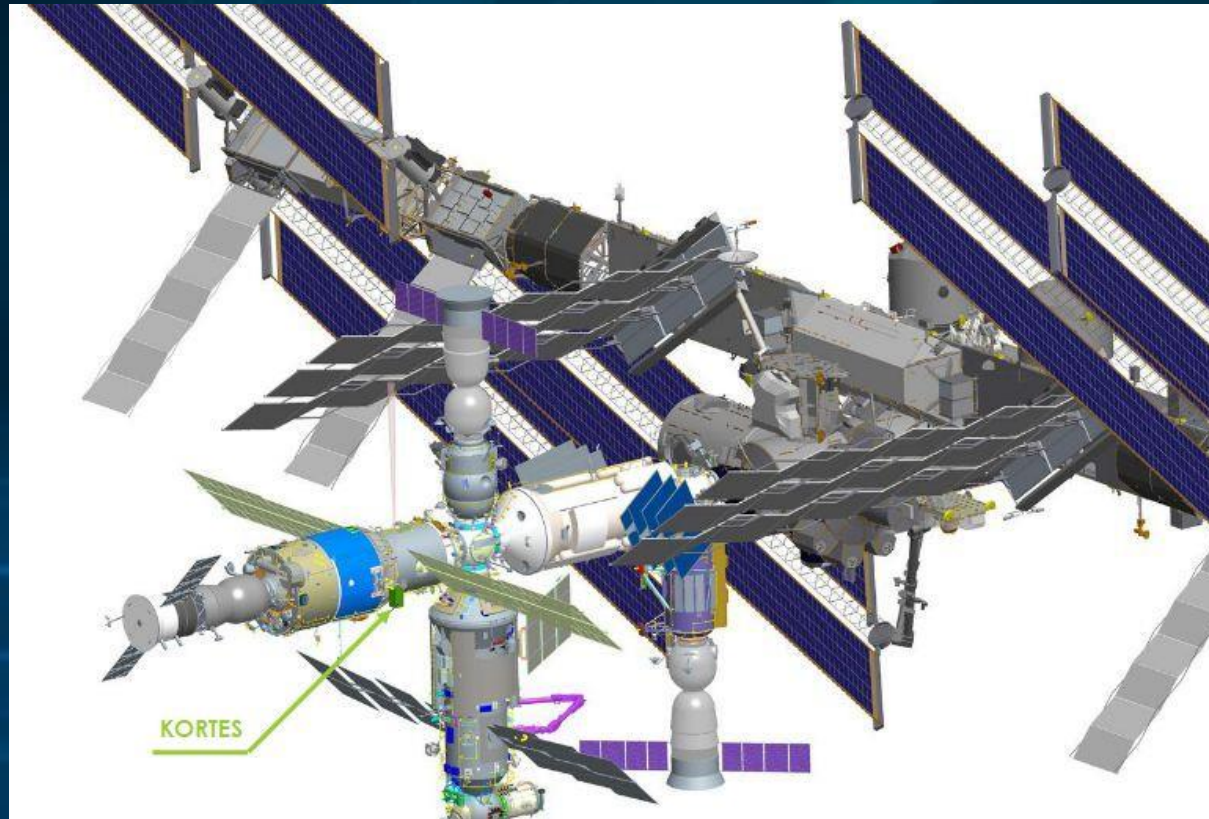
SolpeX - Solar Polarimeter in X-rays

Science & measurements:

- Detect polarisation of solar soft X-ray emission at ~ 3 keV during impulsive flares
- Determine azimuth & directivity of the non-thermal electron beam
- Record context impulsive phase X-ray spectra using novel flat crystal drum spectrometer

Kortes on the ISS

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

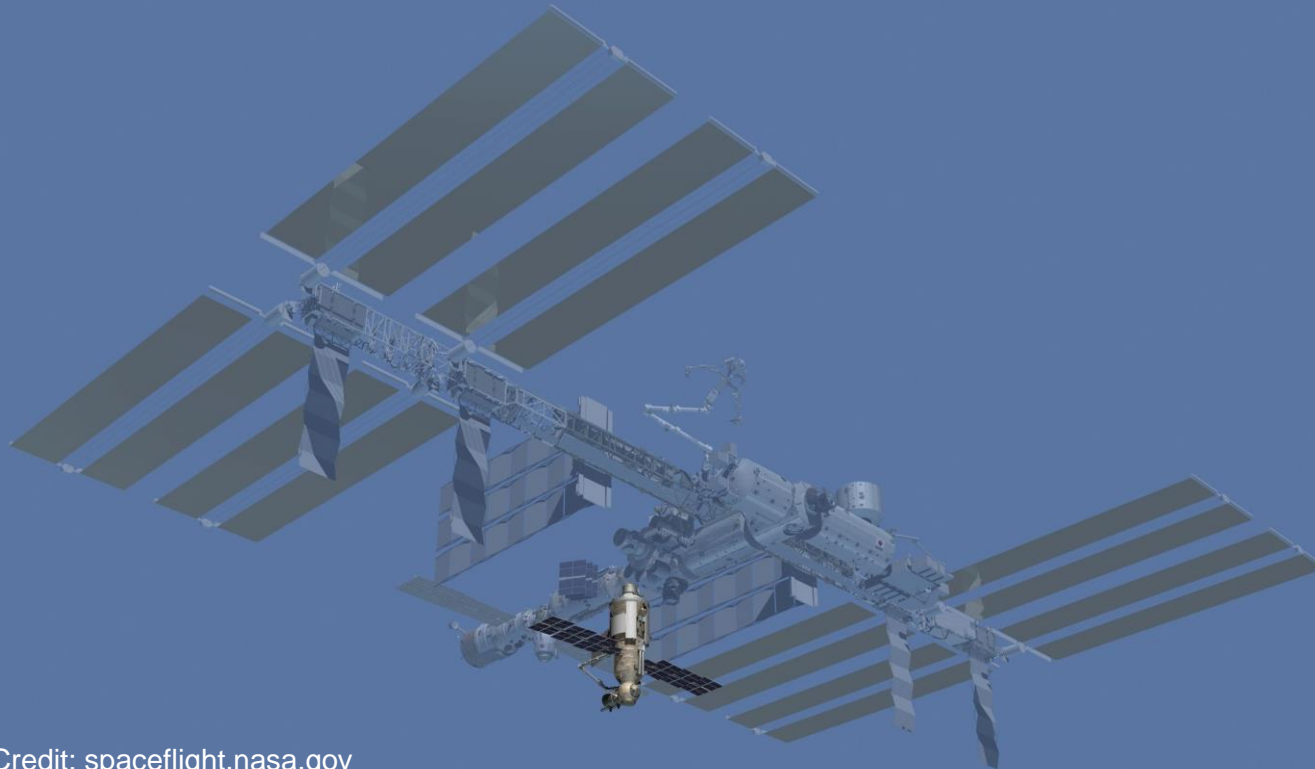


Block of FIAN detectors:

- 2 telescopes – 171 and 304 Å
- 2 spectroheliographs 180-210 Å & 280-330 Å
- X-ray spectropolarimeter SolPEX (0.5-15 keV)

Nauka module

Nauka 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.



Nauka is expected to be launched in December 2017

SUN-pointing platform will be attached to Nauka

ISS as a Sun experiment platform ???



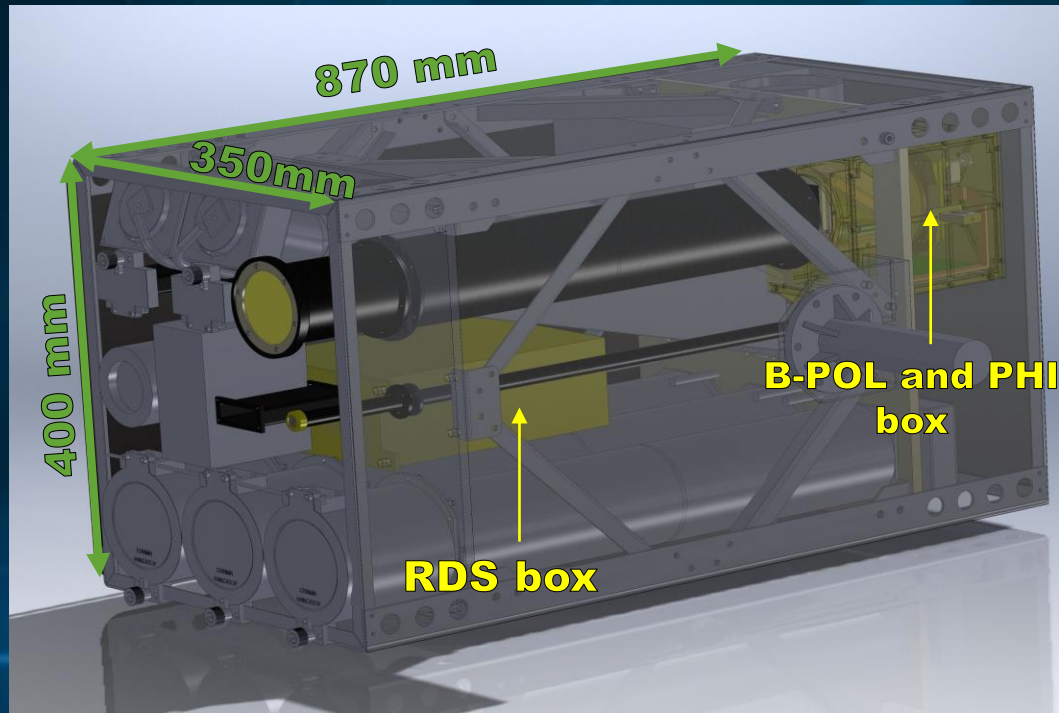
ISS as a Sun experiment platform ???

- “Easy” delivery, mounting by astronaut
- Large data volumes available
- Non-restrictive power limits
- Larger size & mass of instruments possible
- Repairs, transport to ground possible

ISS as a Sun experiment platform ???

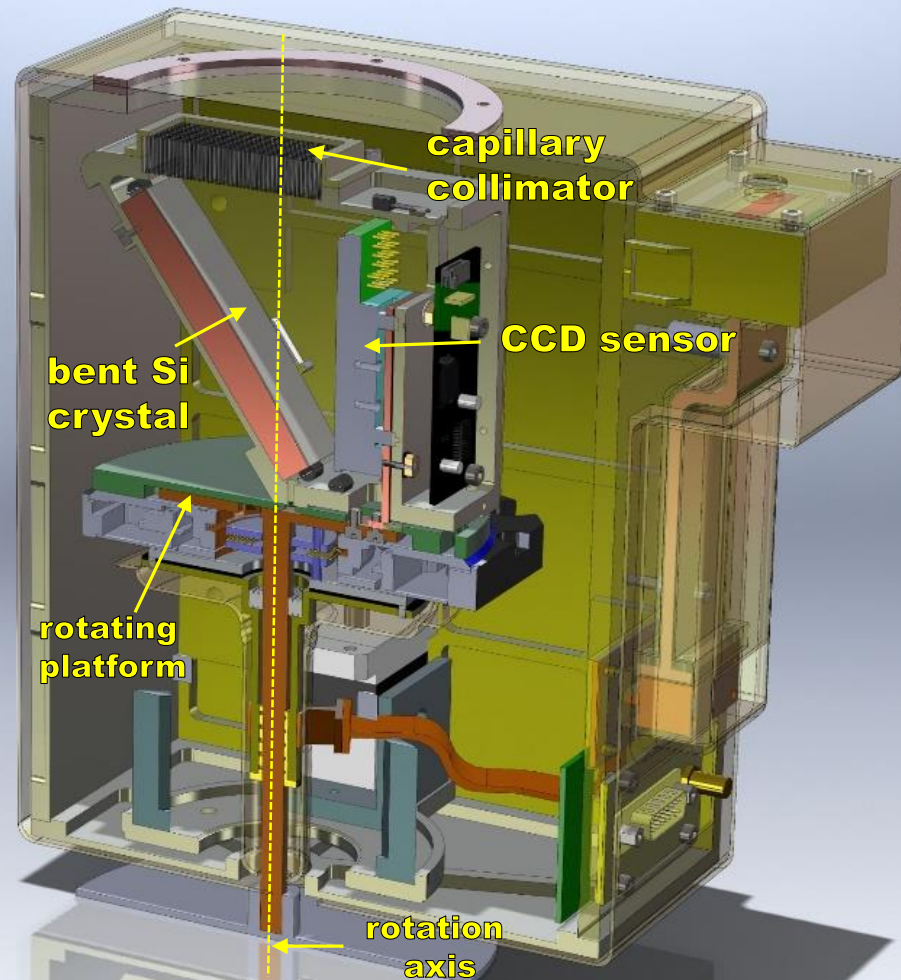
- “Easy” delivery, mounting by astronaut
- Large data volumes available
- Non-restrictive power limits
- Larger size & mass of instruments possible
- Repairs, transport to ground possible
- Only 10-12 min of uninterrupted measurements per orbit due to day/night shifts and other ISS elements
- Rough pointing due to ISS motions

Solpex inside Kortes

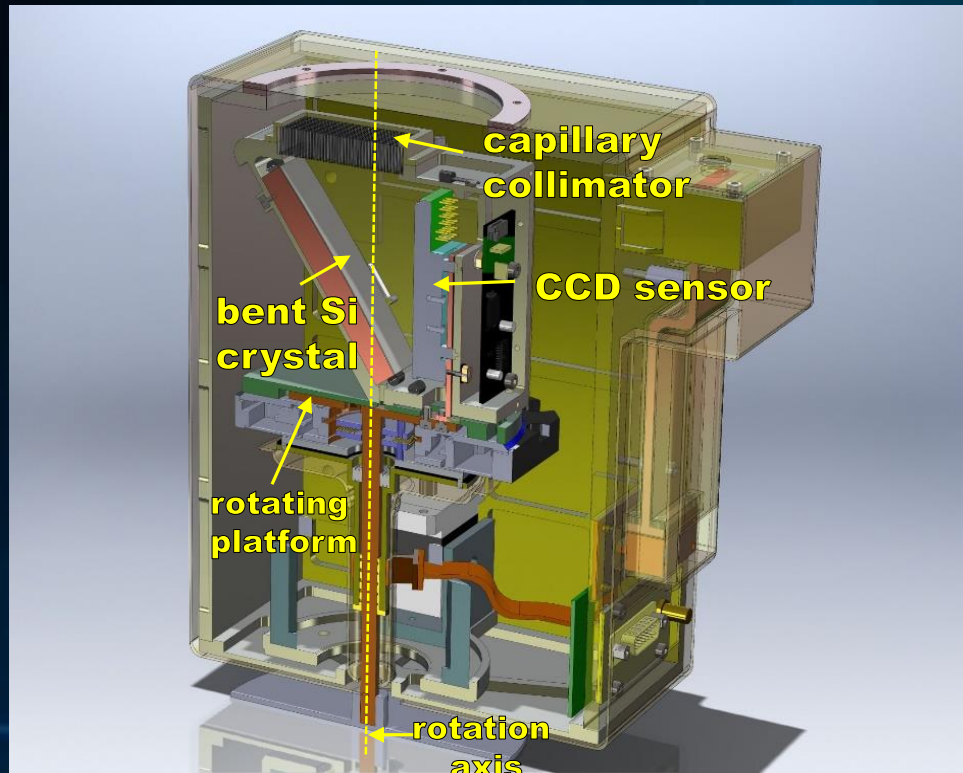


- **B-POL** (Bragg Polarimeter) - the soft X-ray polarimeter with 1-2% linear polarization detection limit,
- **RDS** - fast-rotating drum X-ray spectrometer with very high time resolution (0.1s),
- **PHI** - a simple pin-hole soft X-ray imager-spectrometer with moderate spatial (~ 20 arcsec), spectral (0.5 keV) and high time resolution.

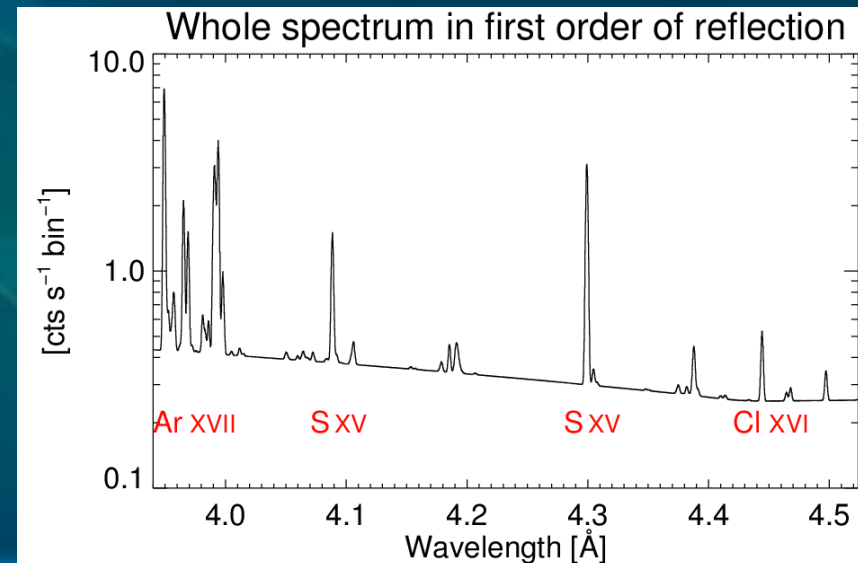
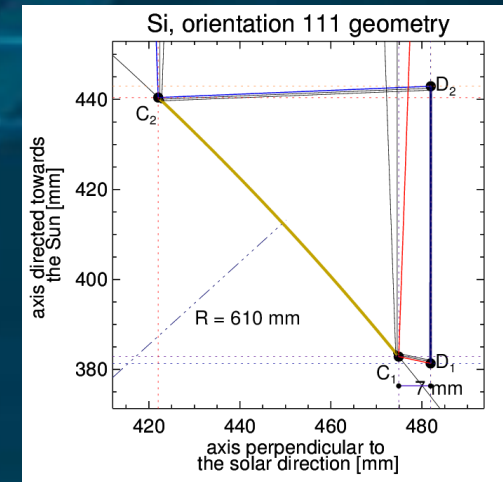
Bragg polarimeter - B-POL



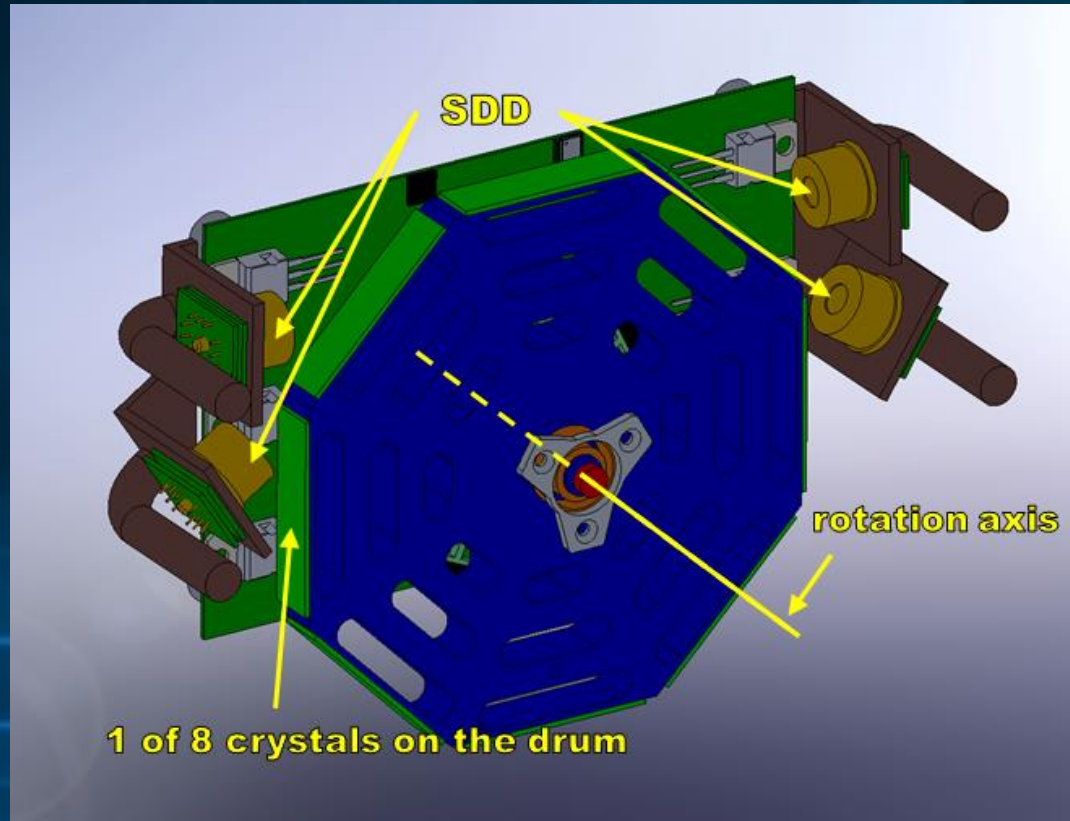
Bragg Polarimeter - B-POL



- Brewster angle of incidence = 45°
- 1 rotation per second,
- Spectral range $3.9 \text{ \AA} - 4.5 \text{ \AA}$

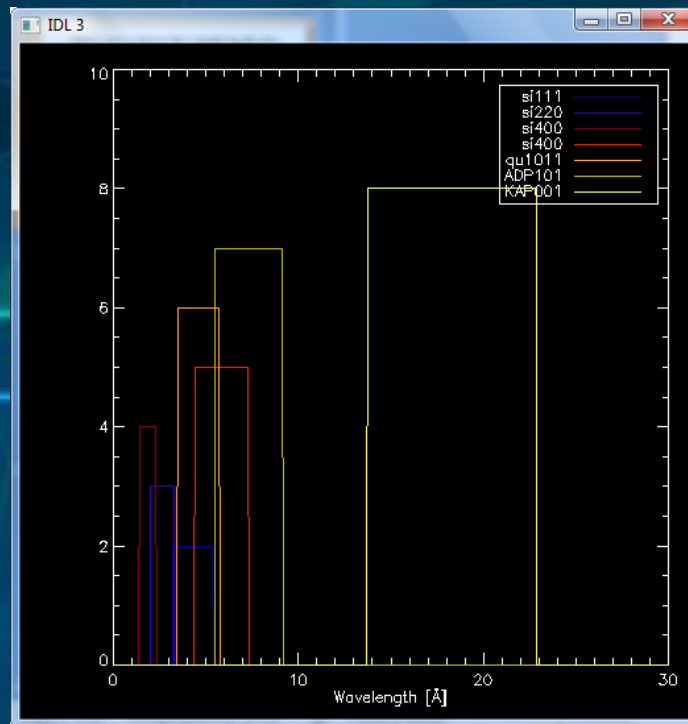


Rotating Drum Spectrometer - RDS



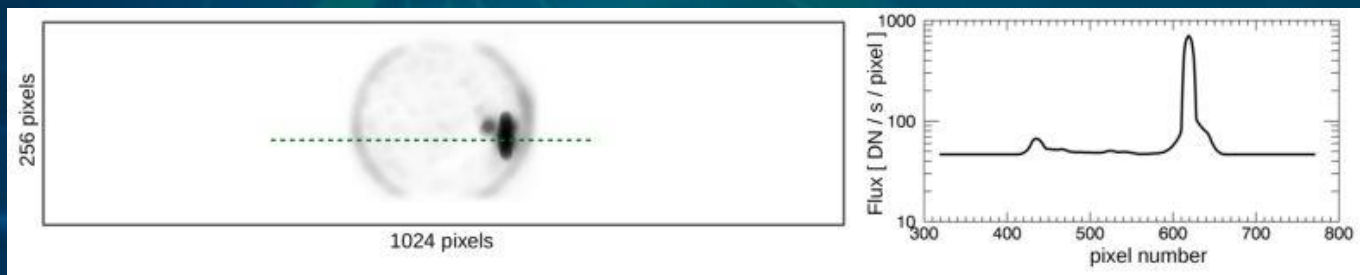
Crystals for RDS

No	Crystal	Orientation	2d [Å]	Wavelength range 1 [Å]	Wavelength range 2 [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

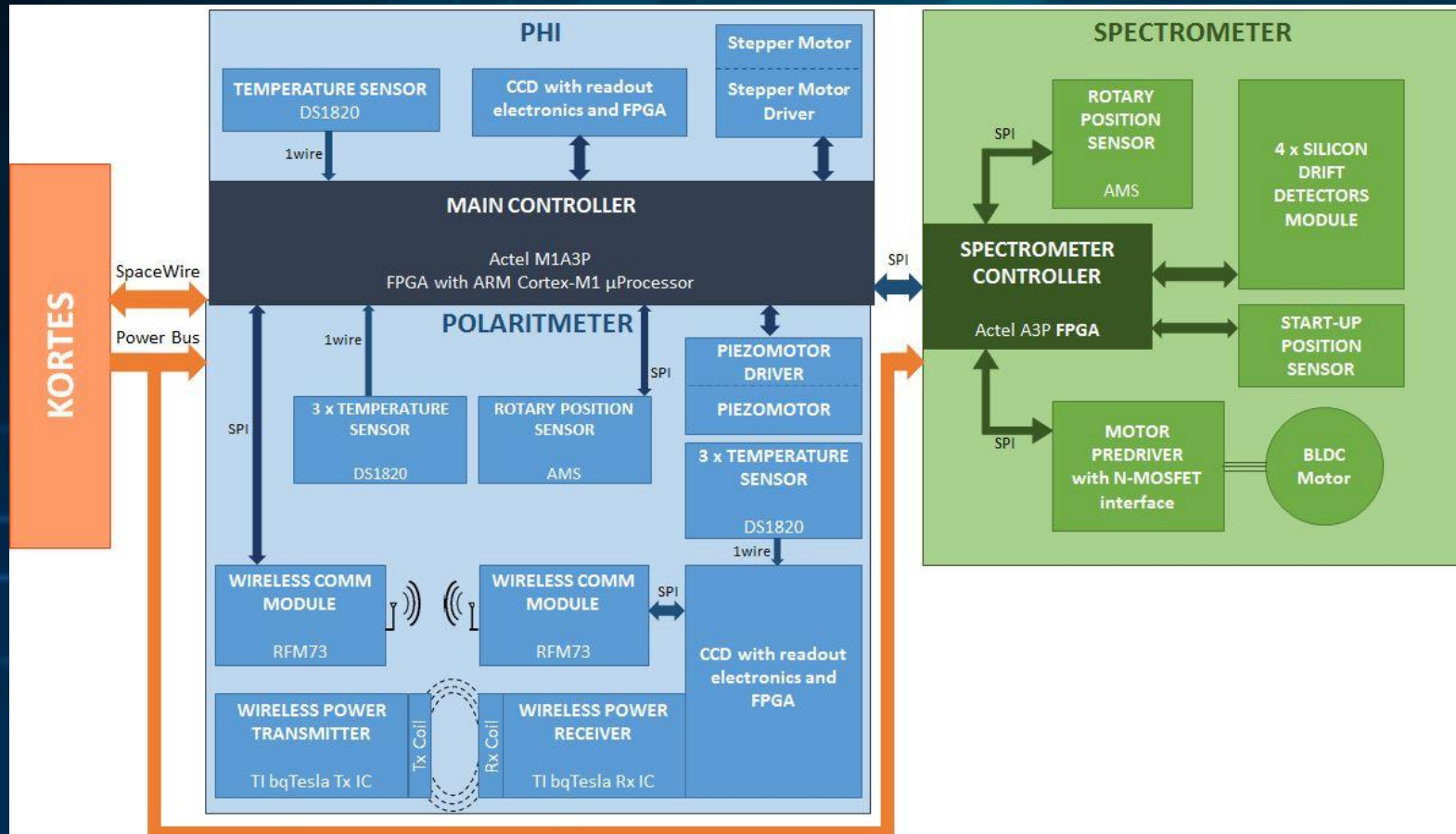


Pin Hole Imager - PHI

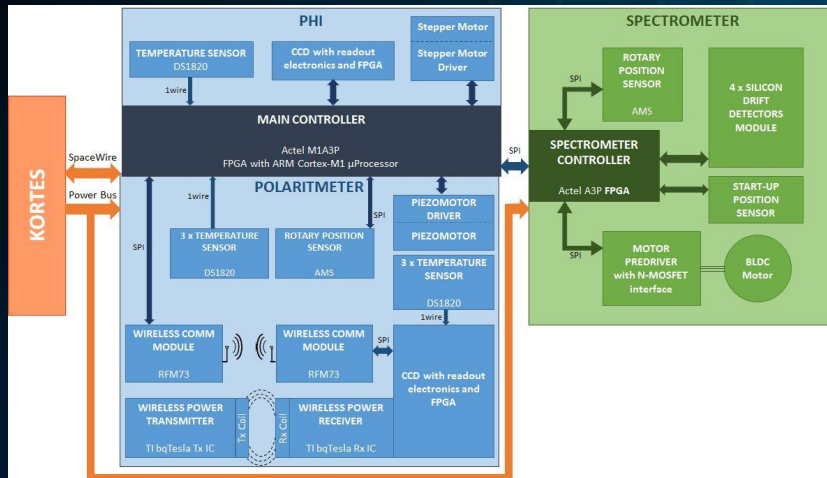
- To localize solar fares or other sources in the instrument coordinate
- Able to measure individual lightcurves and moderate spectra for individual separate sources.
- Focal length of the imager is about 60cm and the image will be produced on CCD detector.
- Additionally the diameter of the pin-hole can be adjusted, depending on the activity of the source.



Electronic Functional Outline



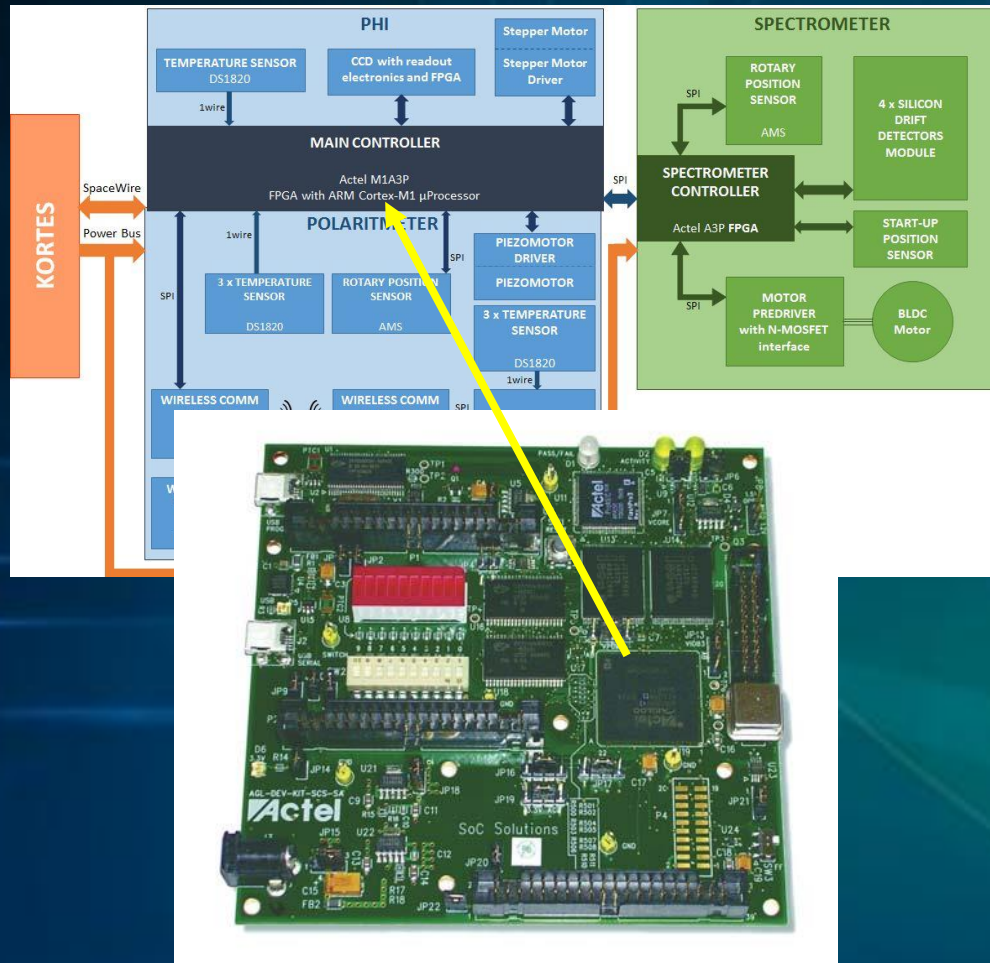
Electronic Functional Outline



- e2v back illuminated CCD261-84 - 2048 x 4096 pixels of 15 μ m size
- e2v back illuminated CCD3011 – 256 x 1024 pixels of 26 μ m size
- for both of them Correlated Double Sampling (CDS) technique is used

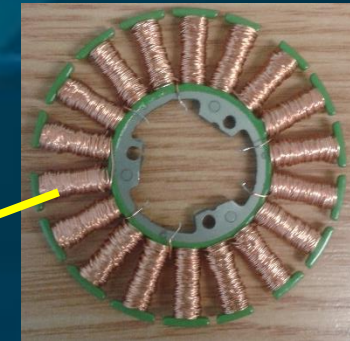
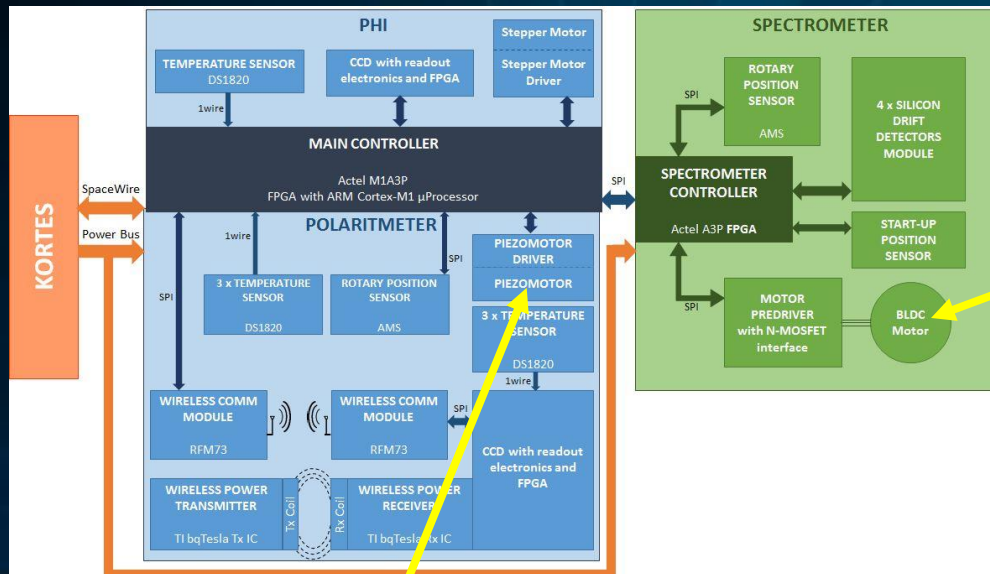
- 3 x Ketek SDD VITUS H50 with 12.5 μ m Beryllium window
- Amptek SDD with 250 nm Aluminum coated 90 nm Silicon Nitride window for low energy range coverage.
- To all of them Amptek A250 Charge Sensitive Preamplifier will be utilized as state-of-the-art integrated circuit.
- further signal processing will be performed on the FPGA, one for all SDD's

Electronic Functional Outline



- M1A3PL-DEV-KIT as a baseline design
- Flash-based FPGA
- One-chip softcore Cortex-M1 processor
- Other FPGAs in project from the same product family (different size, without Cortex-M1 core enabled)

Electronic Functional Outline

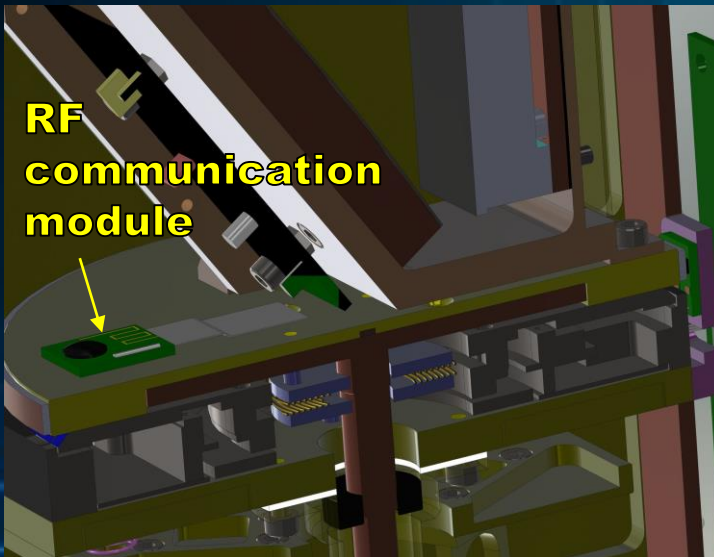


- Low profile
- Clear aperture 20 mm
- Low jitter (18 windings)



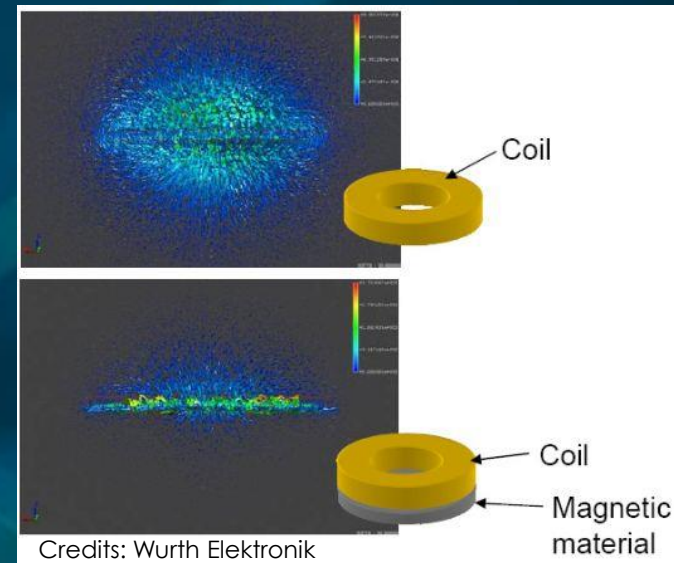
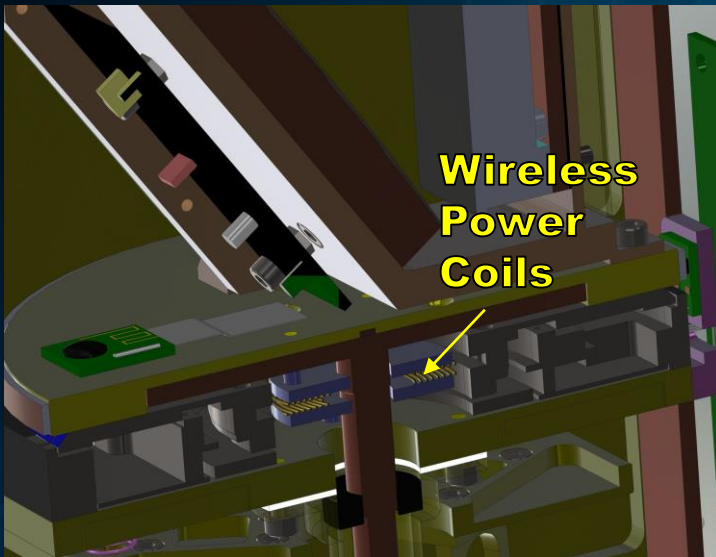
- Low profile: Only 14 mm height
- Max. velocity 720 $^{\circ}$ /s
- Clear aperture 36 mm
- Self-locking, no heat generation at rest, no servo jitter

Wireless Data Transfer



- Gaussian Frequency Shift Keying (GFSK) transceiver (Time Division Duplex (TDD) utilized)
- working on 1 MHz channel in 2400 - 2483.5 MHz band
- compact size (12.8mm x 16.8 mm together with PCB antenna)
- ability to data throughput up to 2 Mbps in burst mode
- less than 0.1W power consumption

Wireless Power



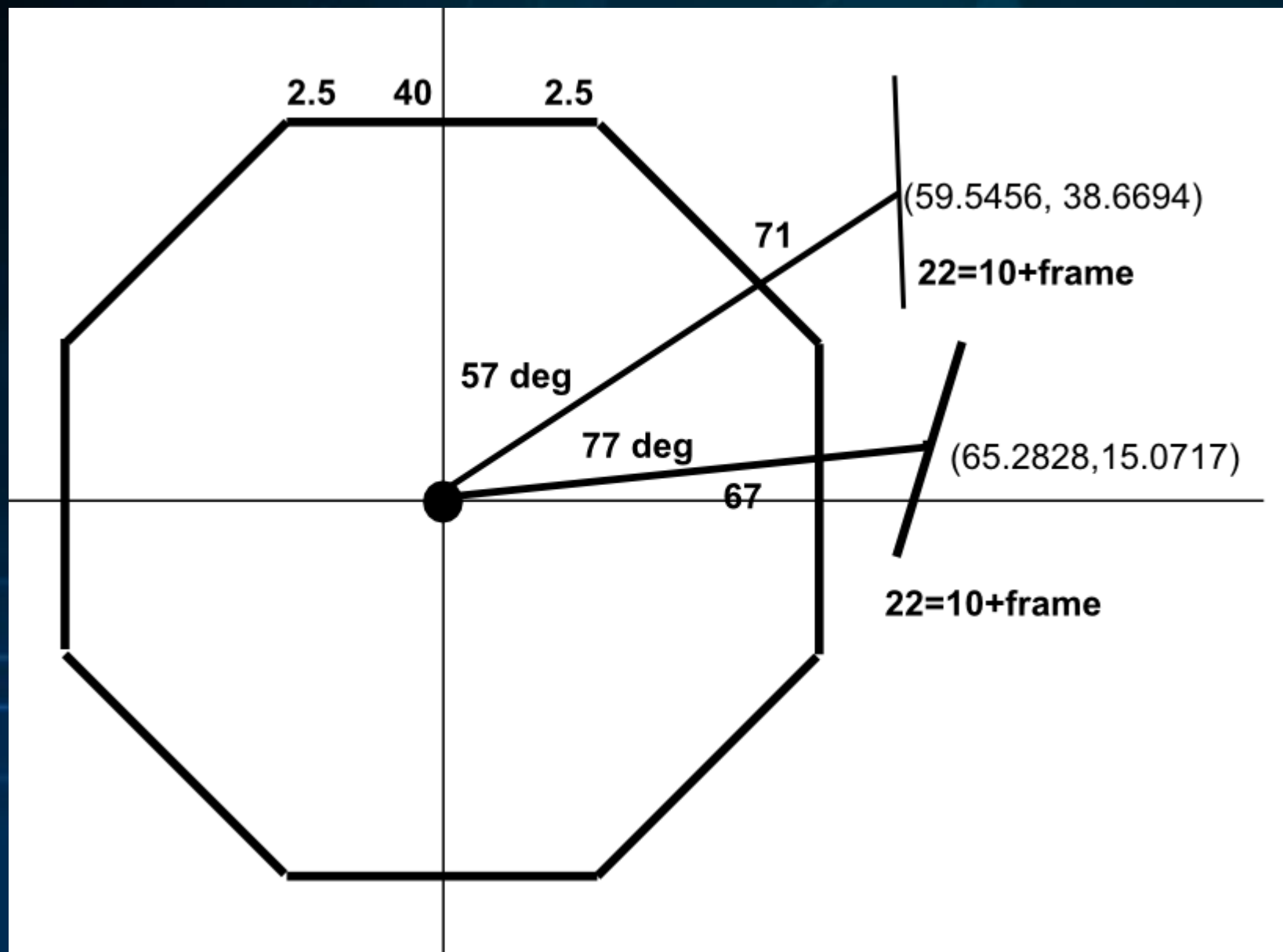
- Up to 5W of power transfer
- Flexible shielding required to avoid eddy currents in instrument and improve coupling
- Control electronics based on TI bqTesla ICs

Summary

- SolpeX – is the X-ray solar polarimeter based on bent crystal Bragg reflection concept.
- Context X-ray spectra will be observed using flat monocrystals fixed to the rotating drum.
- It will be launched to ISS within Russian Kortes module.
- It is a good „playground” which demonstrates our ideas and prepares us for the next solar missions.
- Very short time to launch, we count on our team experience.

Reference

Sylwester, J., et al., "SolpeX: the soft X-ray flare polarimeter-spectrometer for ISS," Proc. IAU Symposium, 305, submitted



New calculation for rotating drum- Ketek det 1

Detector:

Effective size– 10 mm

Total size– 22 mm

Coordinates of the center of the detector : (59.5456,38.6694)

Coordinates of the edges of the detector : (59.3536,49.6672)(
59.7376,27.6709)

Distance from the center of the detector to the axis of rotation = 71
mm

The angle of the center of the detector from the direction of the Sun
= 57 deg

Detektor slope= -89.0 deg

Crystal= 40 mm

Crystal frame=2.5 mm

