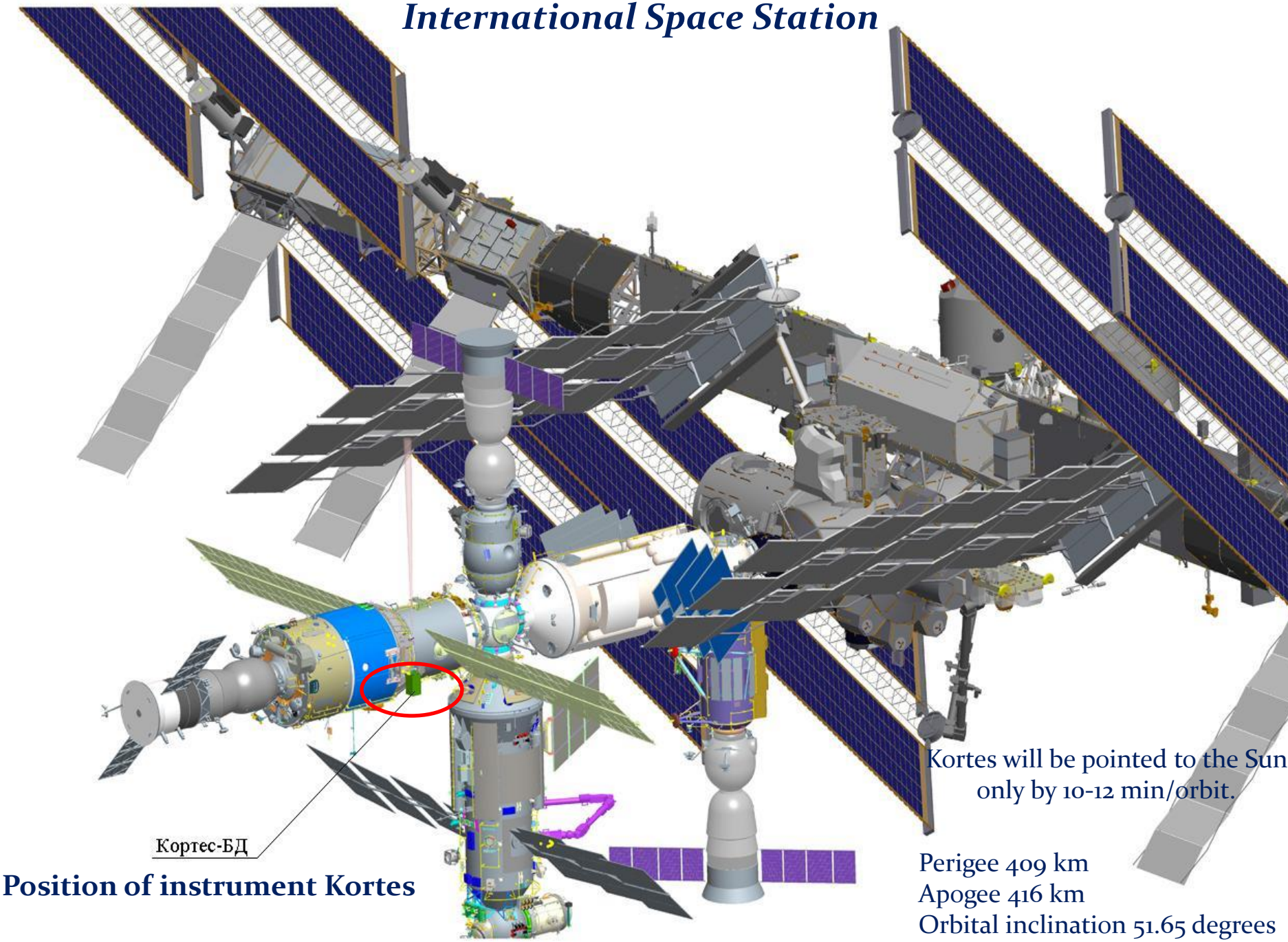
Mechanical solutions for two advanced solar Bragg-reflection instruments: SolpeX and ChemiX

J. Bąkała[1], J. Sylwester[1], M.Siarkowski[1], Ż. Szaforz[1], M. Kowaliński[1]
Z. Kordylewski[1], U. Kaszubkiewicz[1]
S. Shestov[2], O.V. Dudnik[3]

[1]Space Research Center of Polish Academy of Sciences, Wrocław, Poland
[2]P.N. Lebedev Physical Institute, Russian Academy of Sciences
[3]V.N. Karazin Kharkov National University, Svobody Square, 4, 61022 Kharkov, Ukraine,

Special thanks for Anetta Owczarek

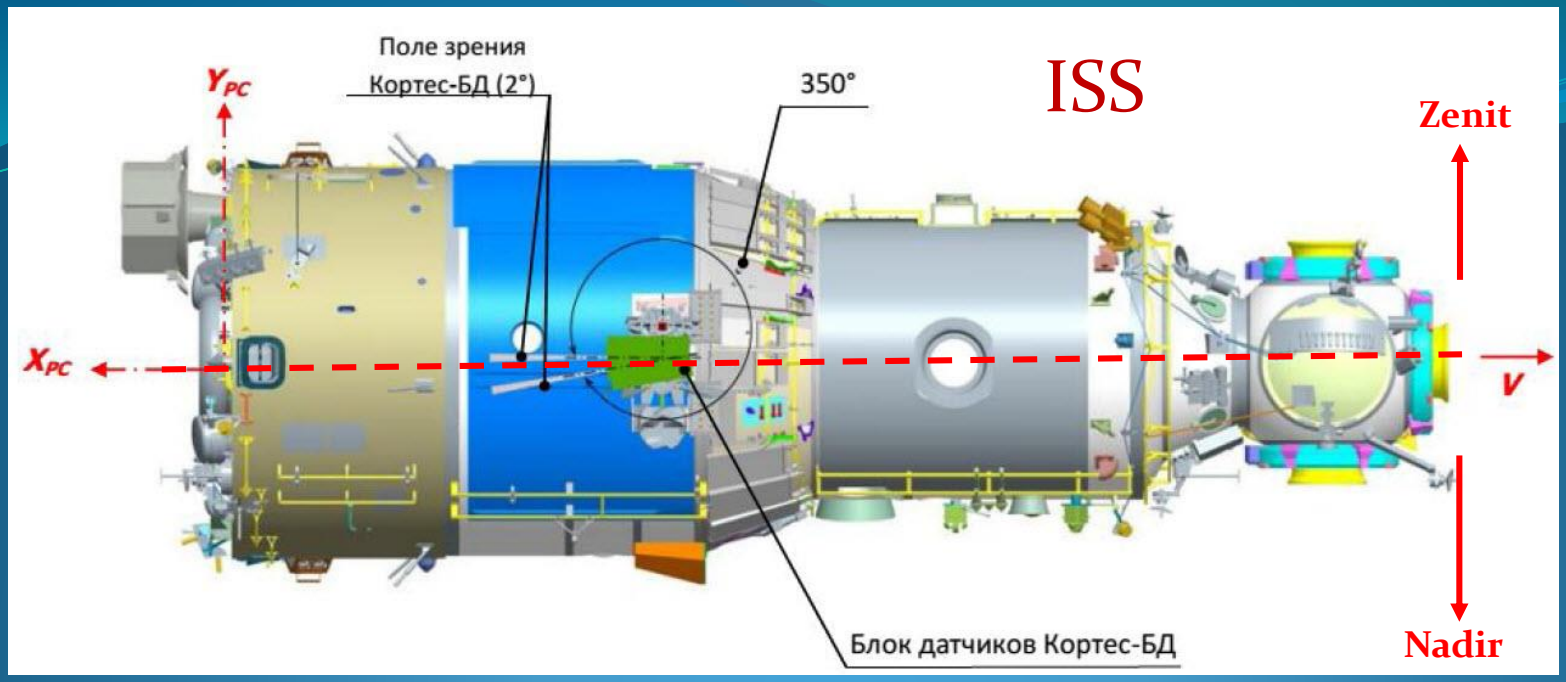
International Space Station

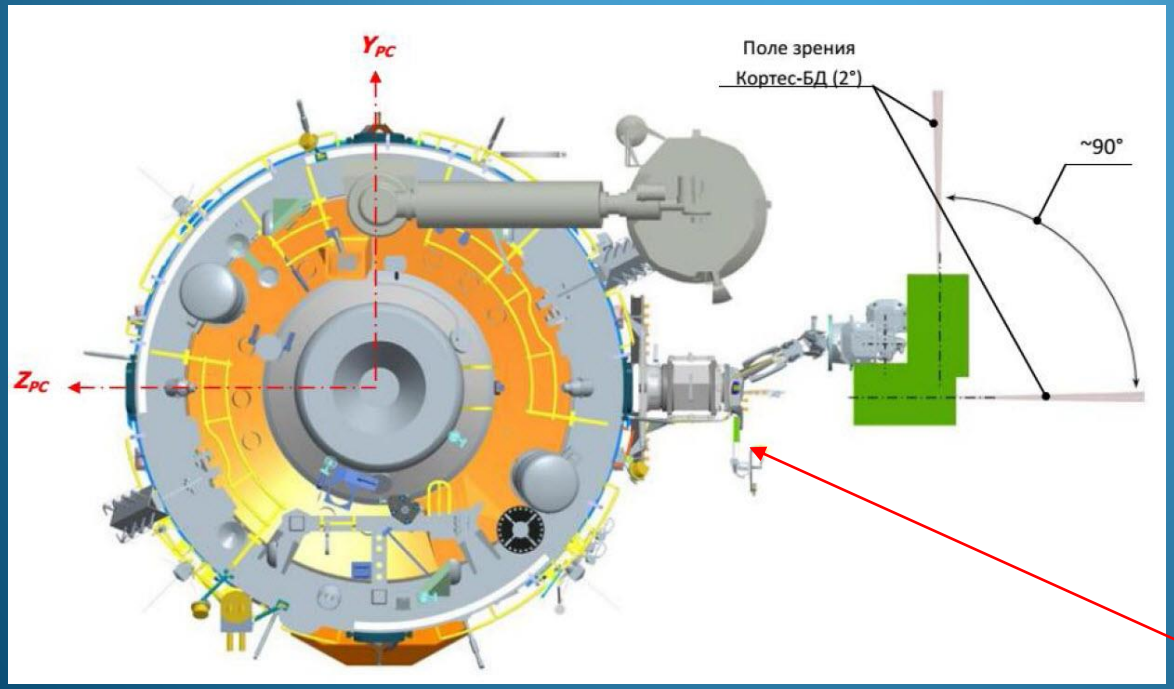


Position of instrument Kortes

Kortes will be pointed to the Sun only by 10-12 min/orbit.

Perigee 409 km
Apogee 416 km
Orbital inclination 51.65 degrees
Orbital period 92.69 minutes


Поле зрения
Кортес-БД (2°)
350°
ISS
Zenit
Y_{PC}
X_{PC}
V
Блок датчиков Кортес-БД
Nadir


Y_{PC}
Поле зрения
Кортес-БД (2°)
~90°
Z_{PC}

KORTES

EUV
entrance filter

B-POL

600mm

Toward Sun

RDS

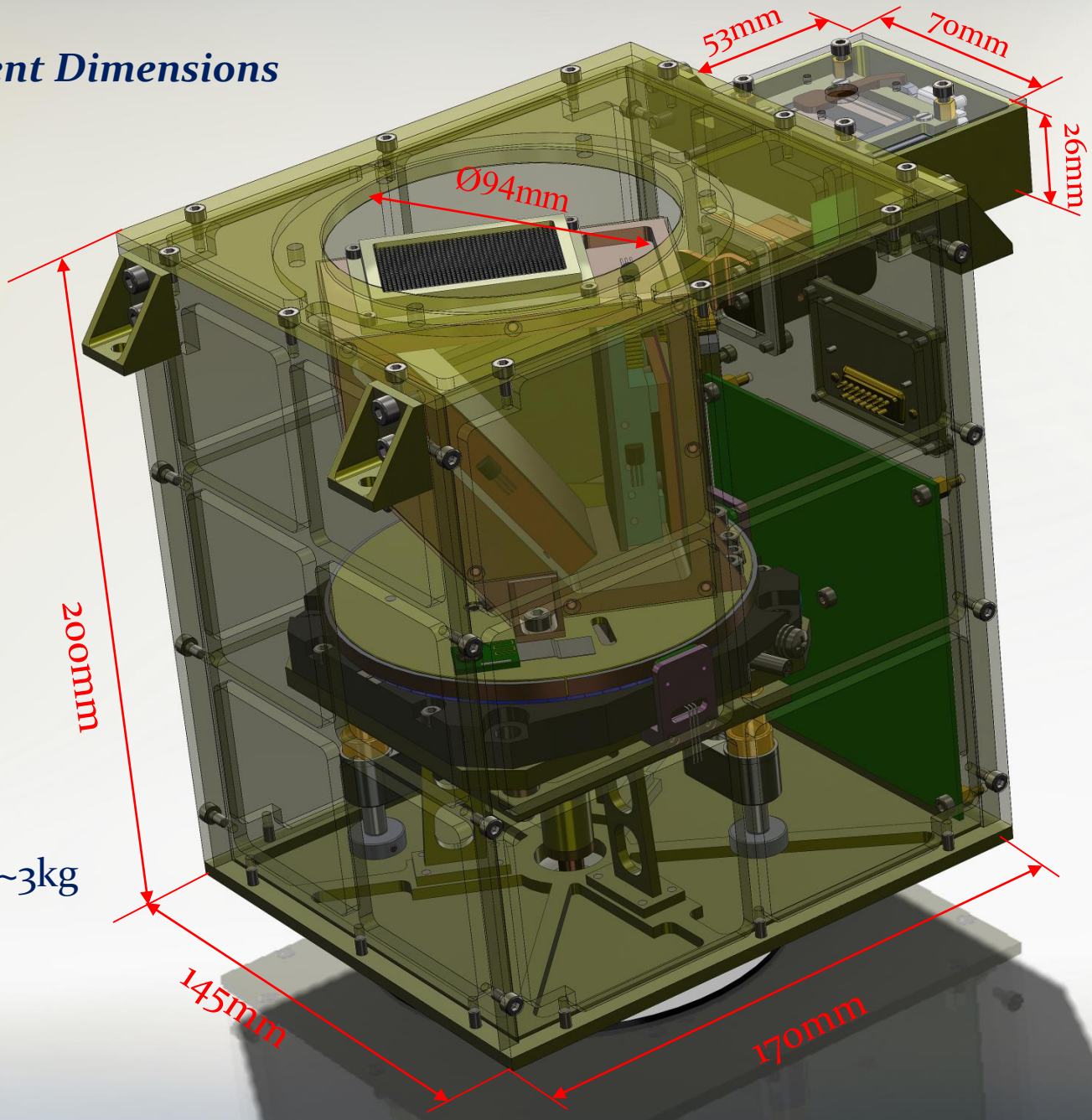
Colimator
with 1mm² pinhole

B-POL will be used to measure the degree of linear polarization of the soft X-ray radiation of solar flares.

Kortes Dimensions:
870 x 500 x 450

B-POL (Bragg POLarimeter)

Instrument Dimensions



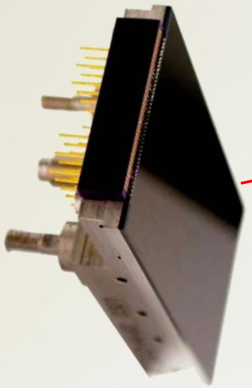
The total mass ~3kg

Detailed Construction of B-POL

CCD30–11 Back Illuminated

Active pixels 1024 x 256
Pixel size 26 x 26 μm

System Calibration Fe^{55}



CCD261-84
Active pixels 4104 x 2048
Pixel size 15 x 15 μm

Connector

System Pinhole & Detector

Block Crystal & Detector

Entrance Capilary Mesh

Electronic plate

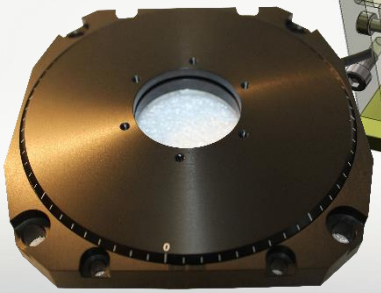
CCD

Electronic plate

Bent monocrystal wafer of large area 3 x 10 cm

Double WiFi system

Precision rotation motor



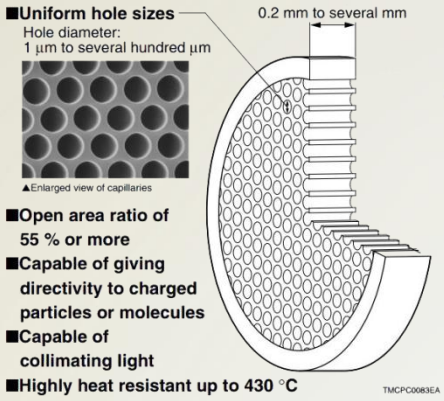
Copper thermal strap

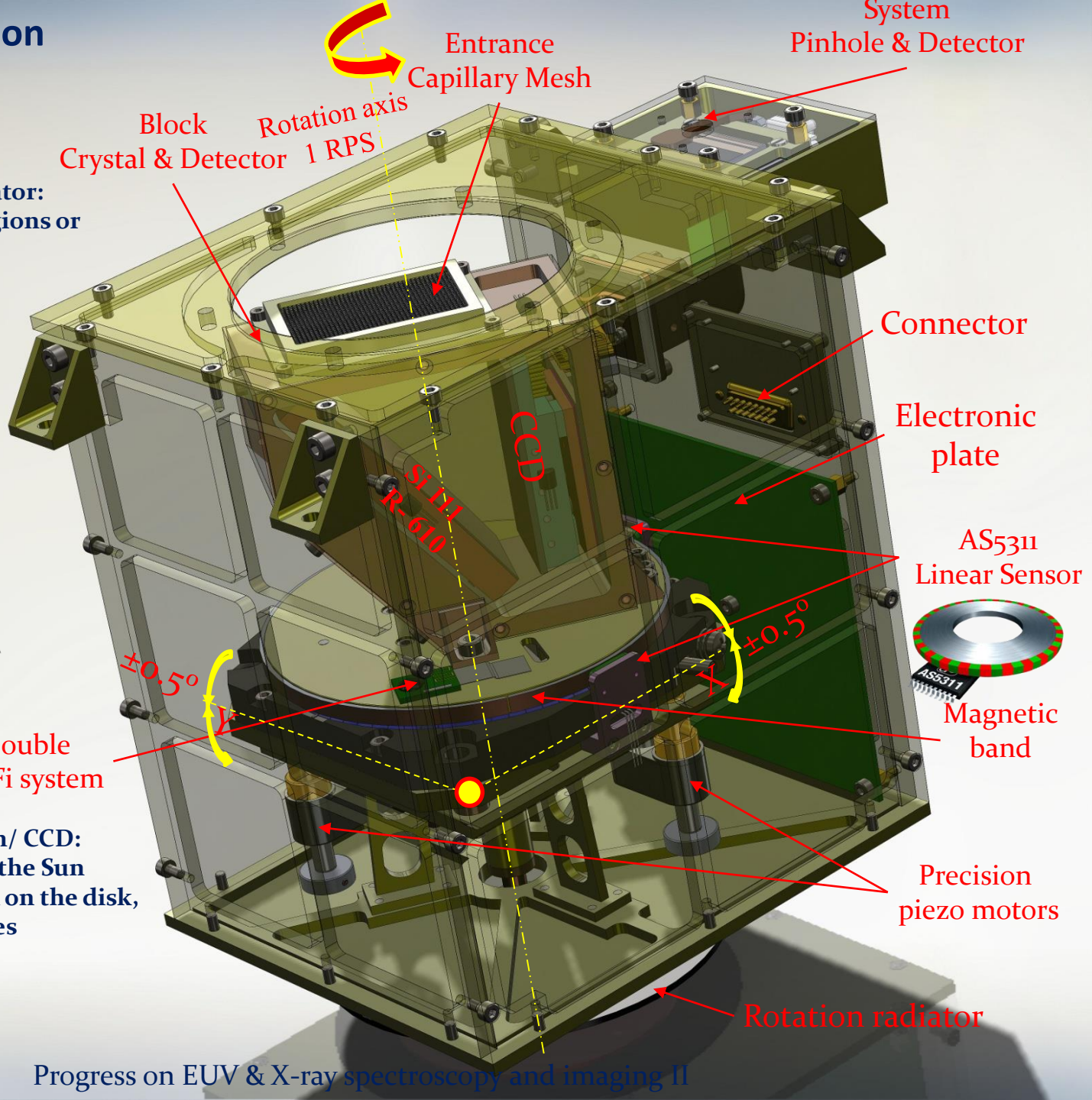
Precision piezo linear actuators

Detailed Construction of B-POL

Purpose of the capillary colimator:

1. **Selecting isolated active regions or flare**
2. **FOV: ~2 arcmin**





Purposes of the Pinhole System/ CCD:

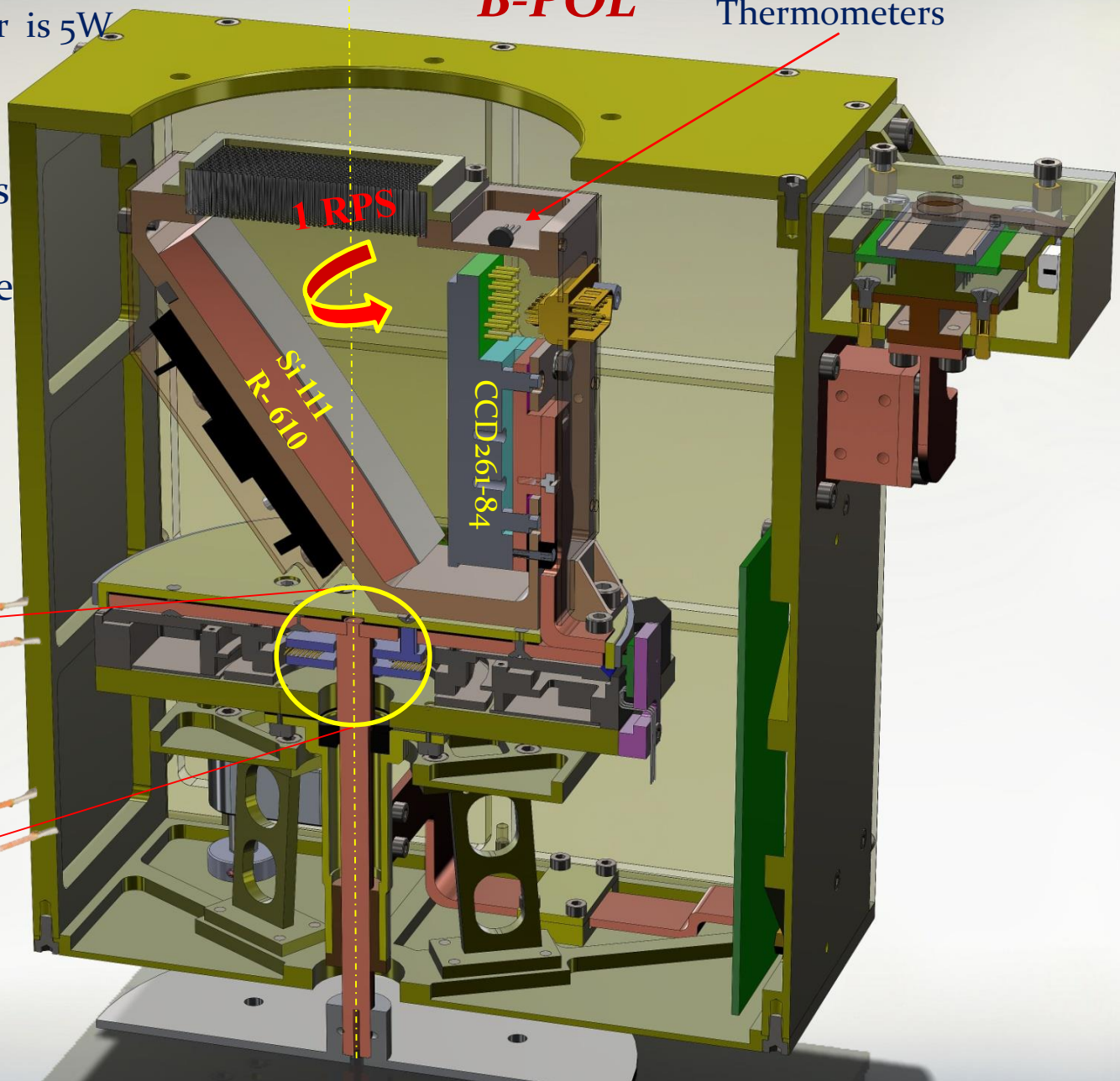
1. **Locating the X-ray source on the Sun**
2. **Detecting active phenomena on the disk, analyzing individual lightcurves**
3. **Image readout: each 0.2 s**

Wireless Power Transfer System

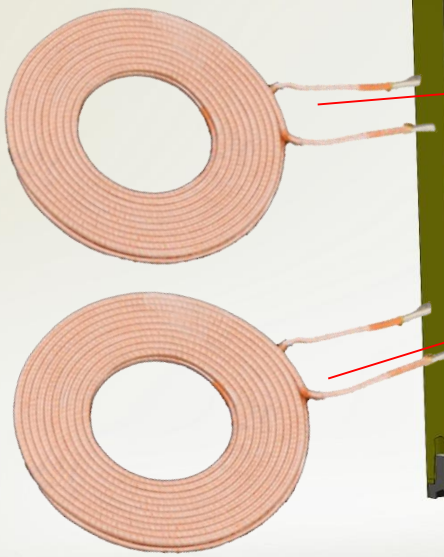
Polarimeter B-POL

Maximum supply power is 5W

1. 1- CCD
2. 6- Thermometers
3. 2- Wifi system
4. 1- Electronic plate



Receive coil



Transmit coil

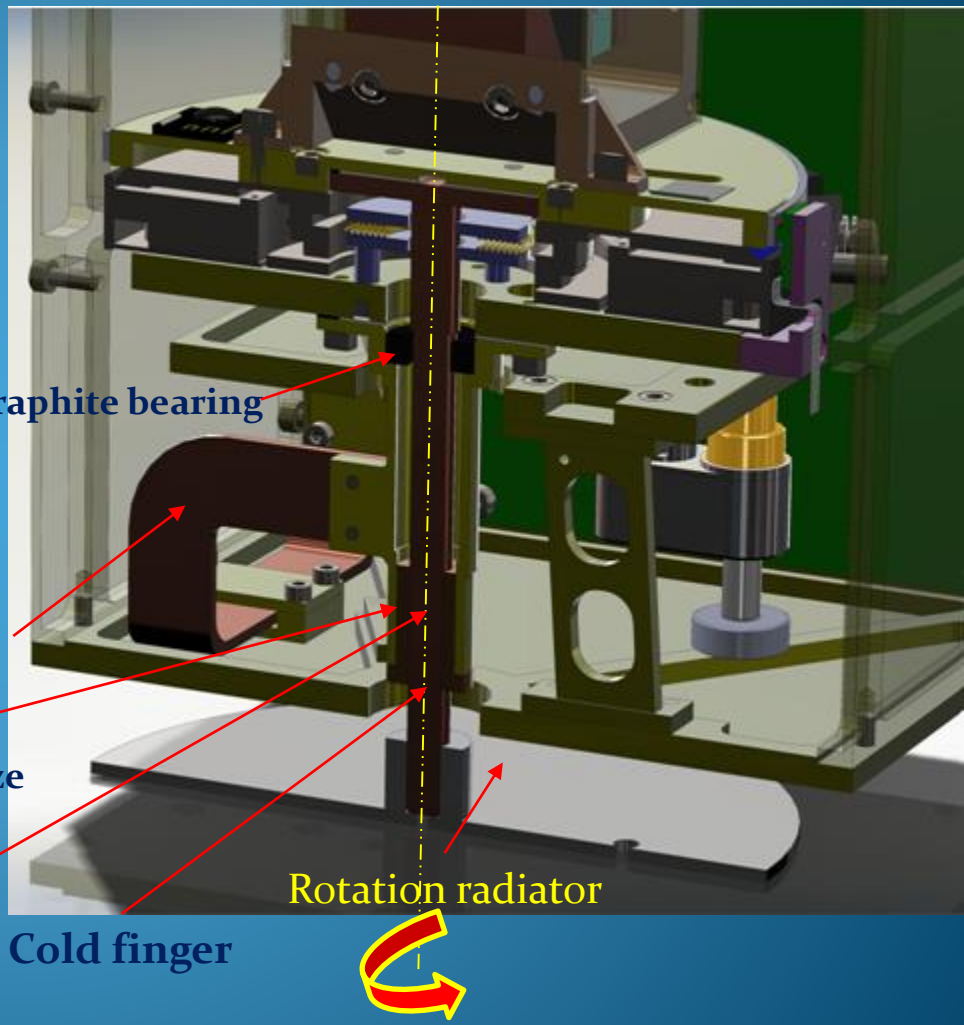
The cooling system of the B-POL instrument

Currently, we make simulations in order to select the cooling system:

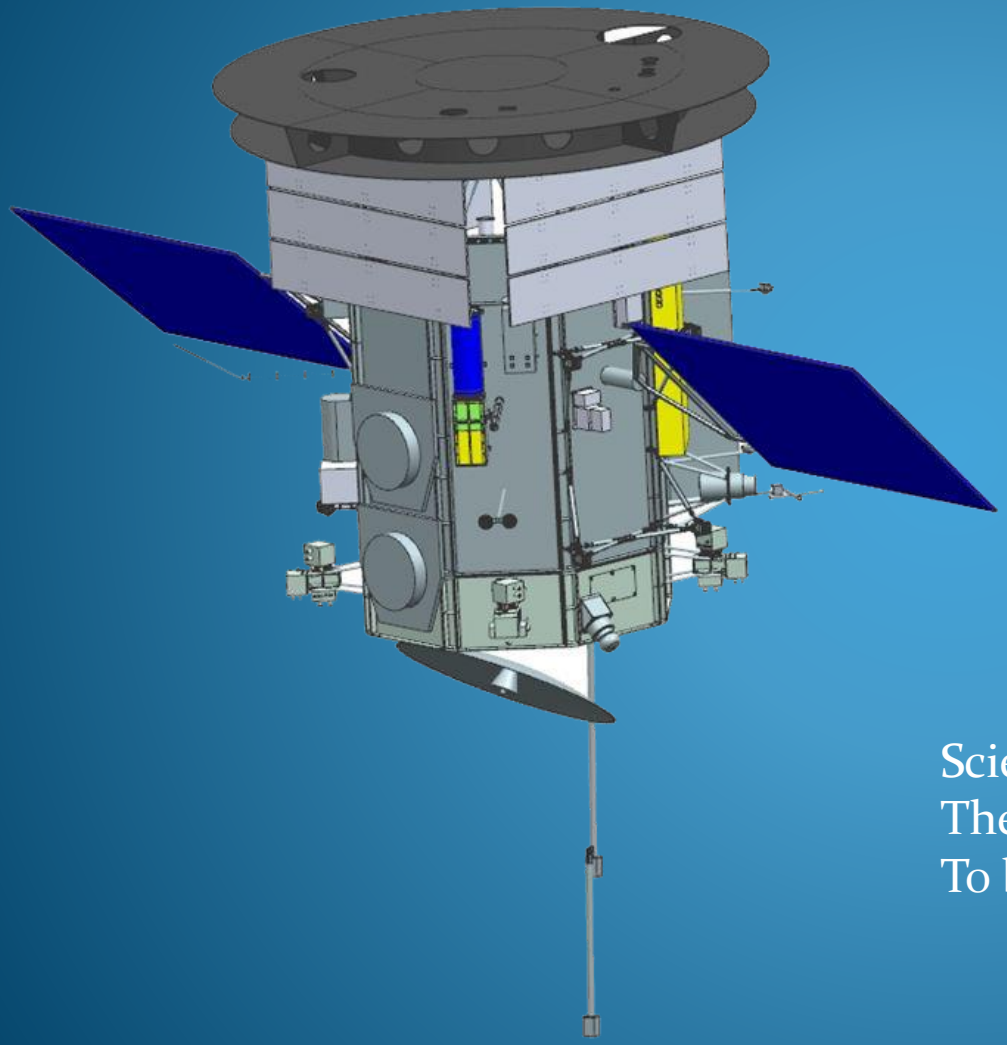
The first cooling system it's rotation radiator.

The second cooling system is dual system to transfers the heat through graphite bronze bushing / graphite bearing and rotation radiator.

The third cooling system replaces cold finger for heat pipe.



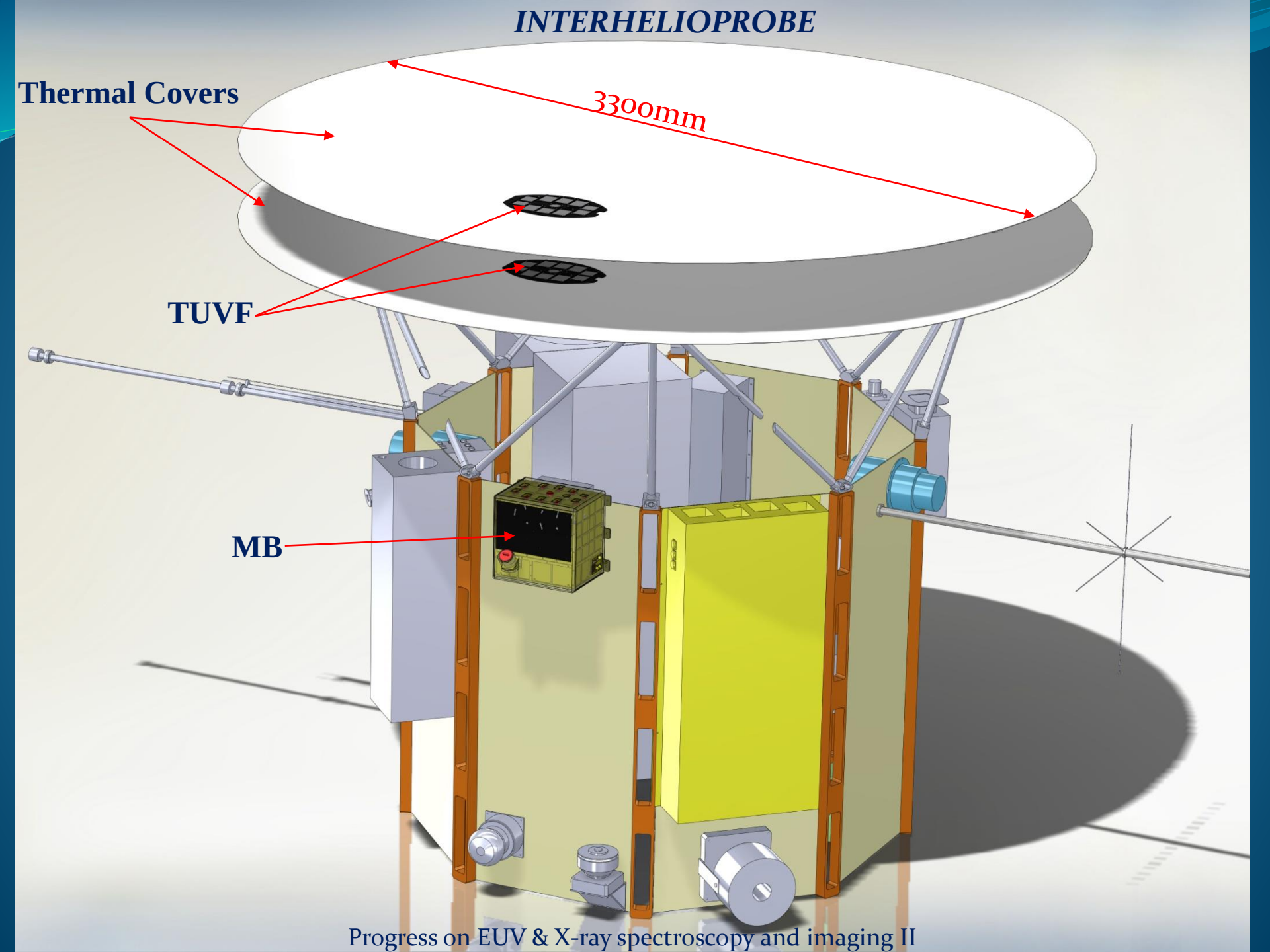
The Interhelioprobe ChemiX



The Interhelioprobe (IHP) Mission is among the most advanced astrophysical project of Russian space exploration program, the intention of which is to explore the space in the immediate vicinity of the Sun as close as ~60 solar radii. Such a close proximity of the vantage point will allow for the first time the solar surface to be observed with a spatial resolution ~4 times better than from 1 AU, and which is even more important, to measure fluxes of the solar radiation ~10 times stronger than at Earth.

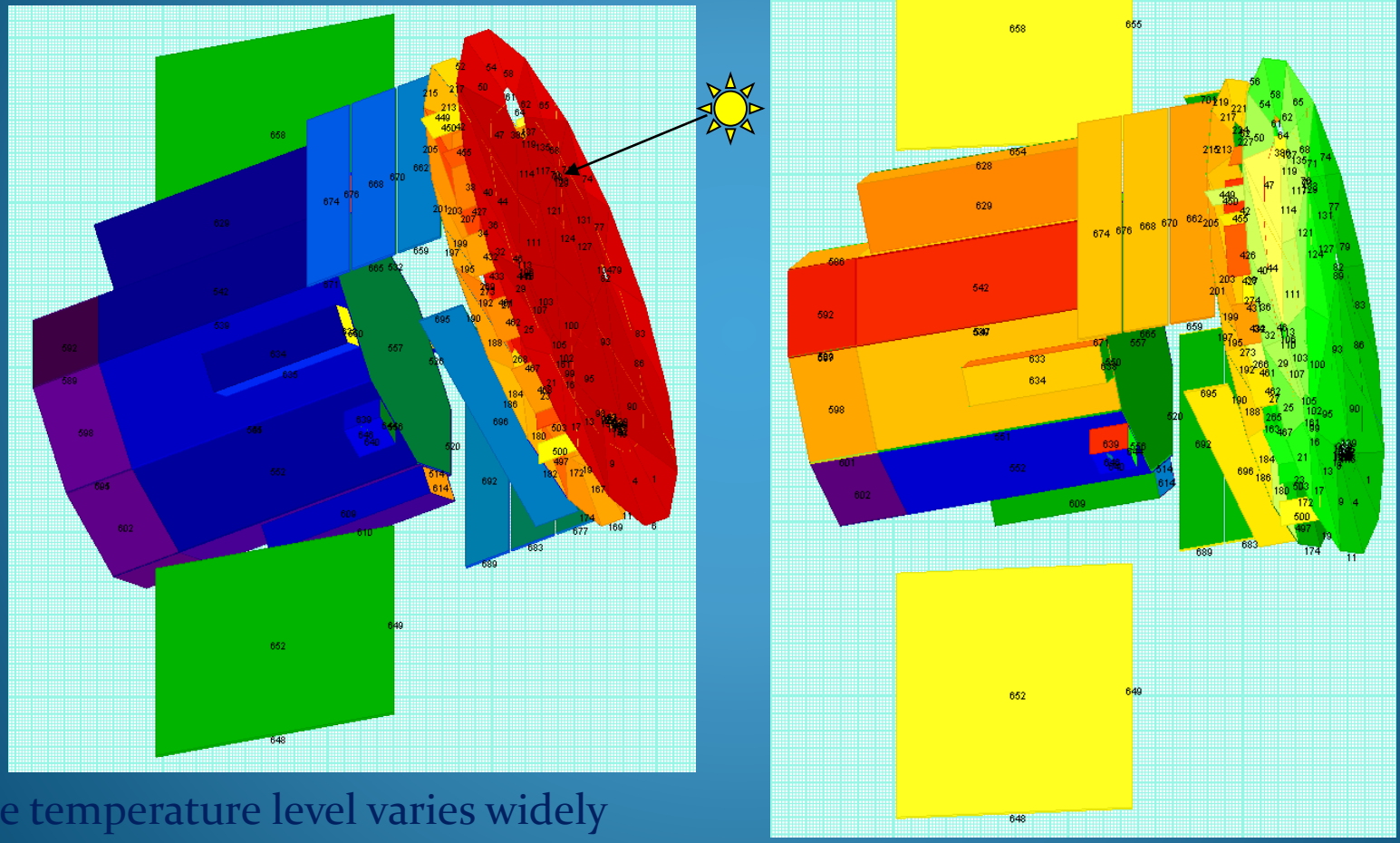
Scientific instruments	160kg
The total mass of the satellite	1860kg
To be launched in	2025/2026

INTERHELIOPROBE



Interhelioprobe
thermal model

Distribution of temperature on the satellite Interhelioprobe, depending on the position of the sun.



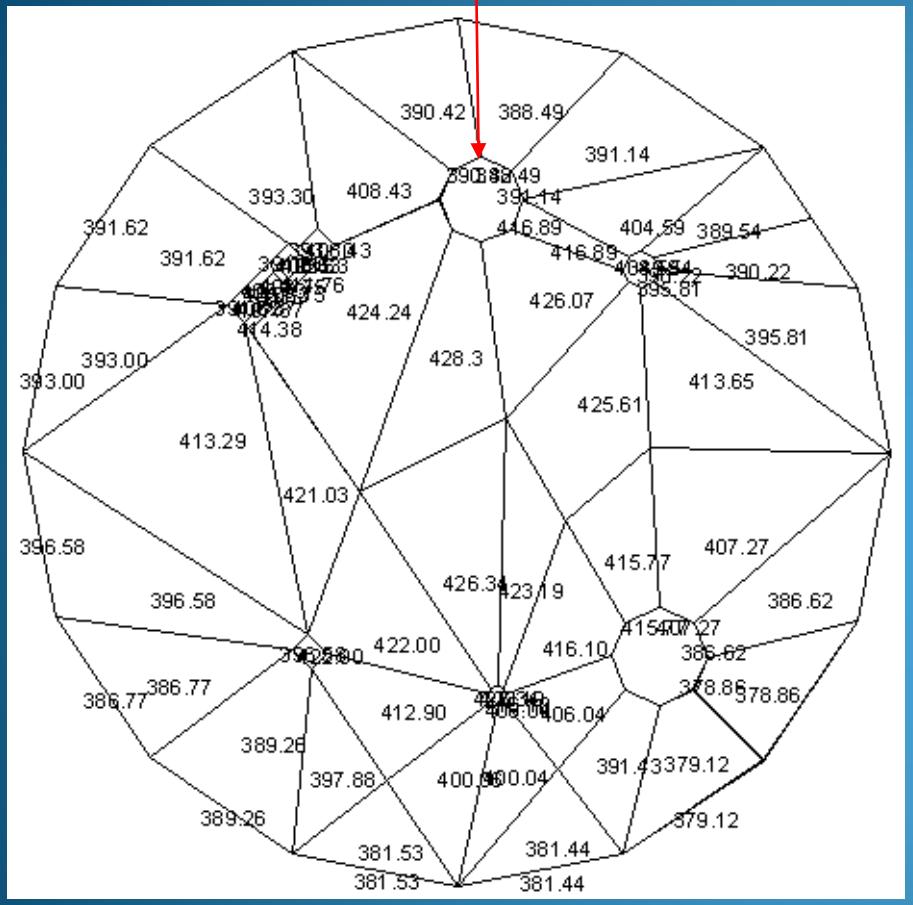
The temperature level varies widely depending on the orientation of the spacecraft (-100ºC…+450ºC)

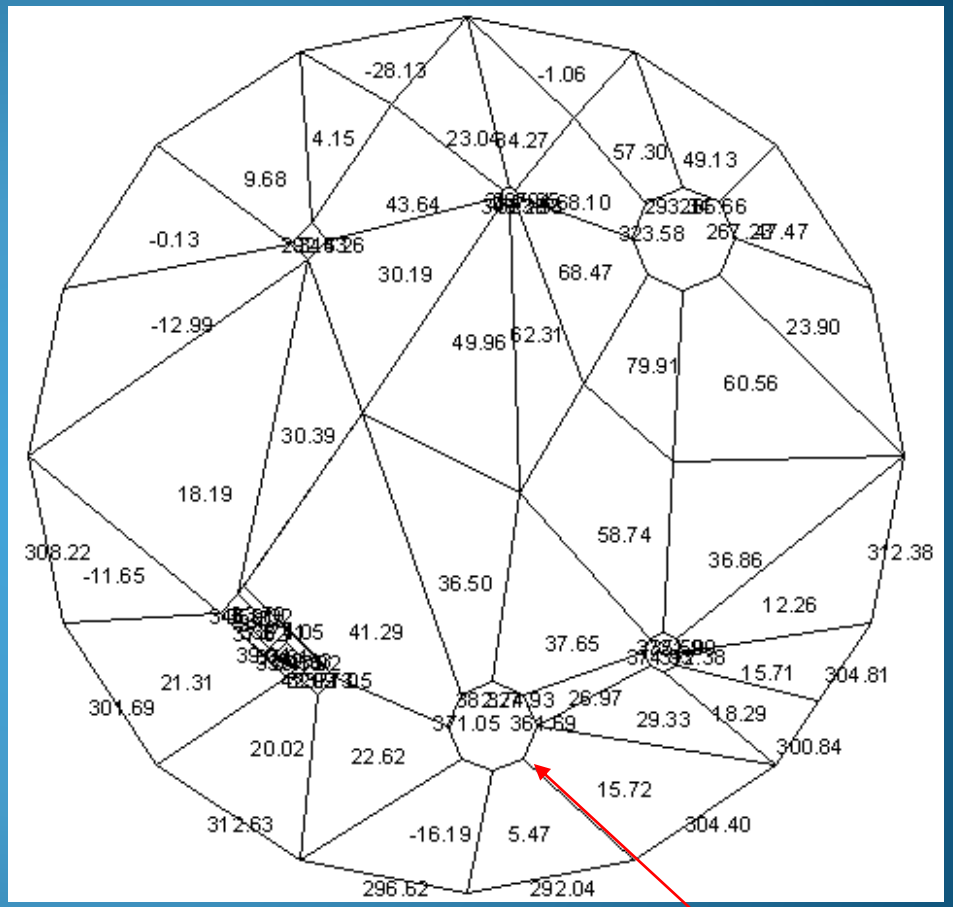
Temperature shield

+X

ChemiX
entrance window

-X
ЭВТИ

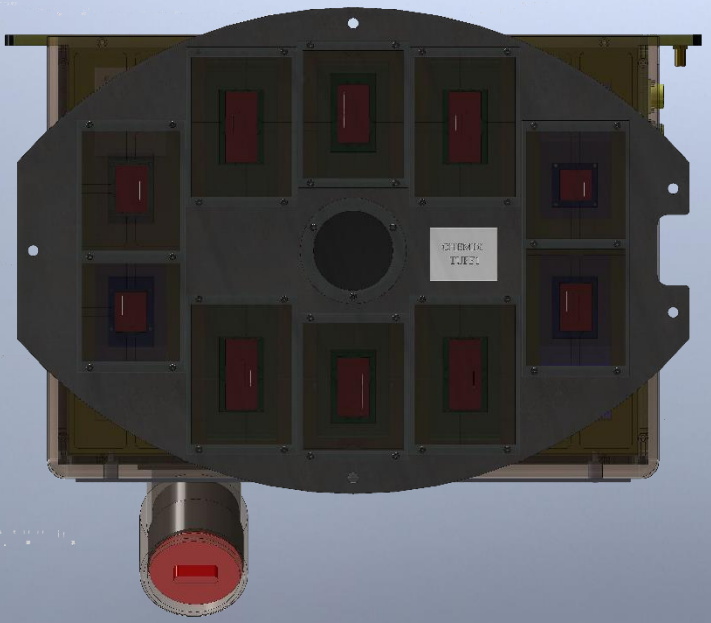


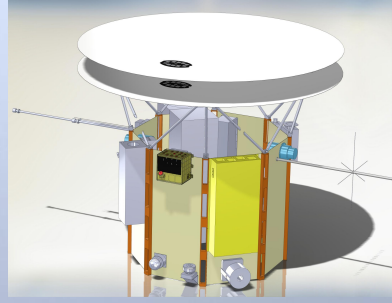


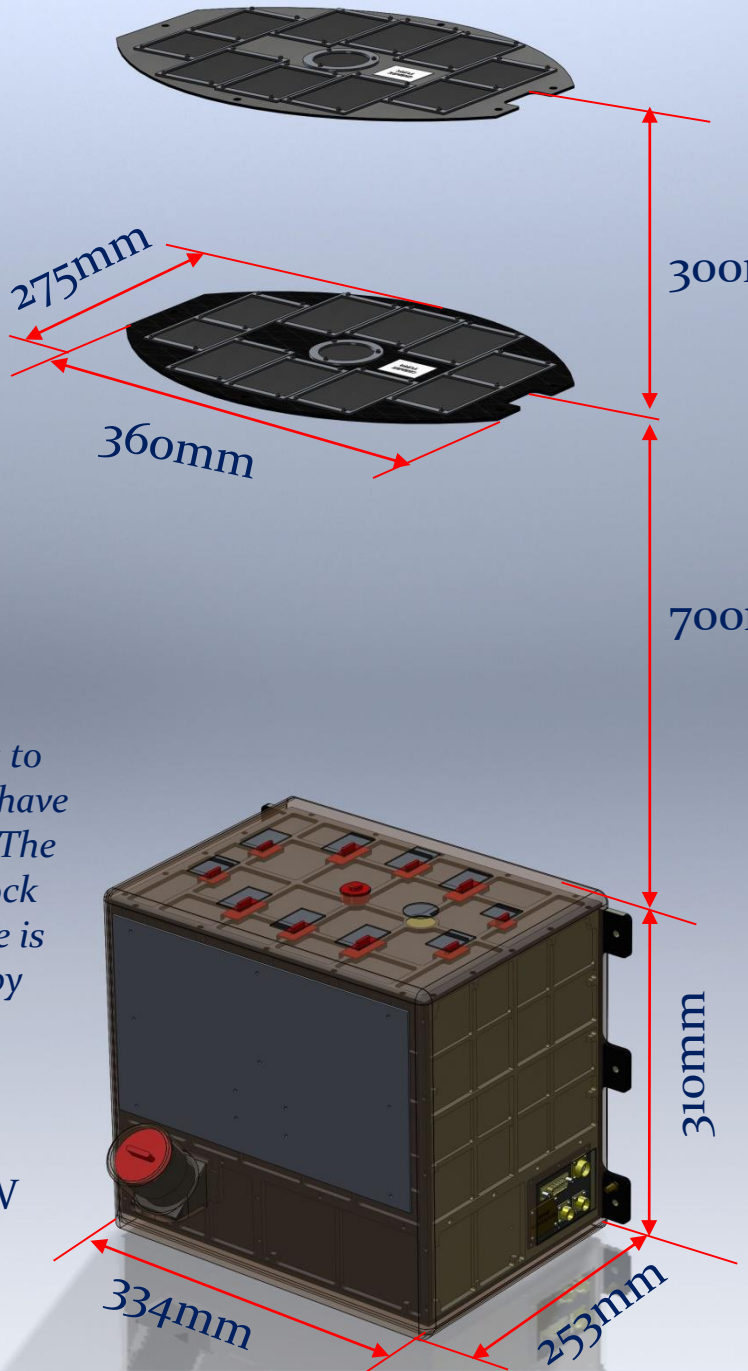
Верхн экр макс -	+428ºC
Верхн экр мин	+379ºC
Нижн экр макс	+382ºC
Нижний экр мин	+266ºC
Нижн экр ЭВТИ макс	+79.9ºC
Нижн экр ЭВТИ мин	-28.1ºC

ChemiX
entrance window

View of ChemiX from the direction of the Sun.



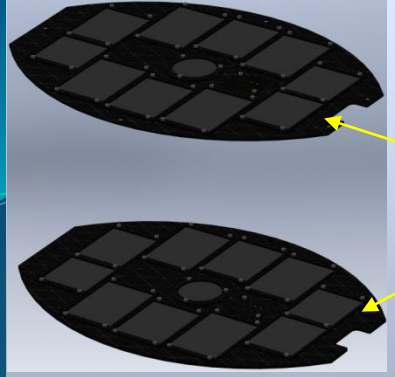




General view of the ChemiX Bragg spectrometer (right). The upper two panels are the filter boards to be mounted on the mission thermal screen. They have to withstand harsh thermal conditions (~400 C). The crystals and detectors are mounted within the block placed ~1m behind the filters. The red-capped tube is the particle detector system, under development by the Ukrainian Kharkiv group led by Dr. Dudnik.

Dimensions of the ChemiX instrument

1. Average power consumption of 10 W
2. Telemetry above 20 MB/day
3. The total mass of 6kg

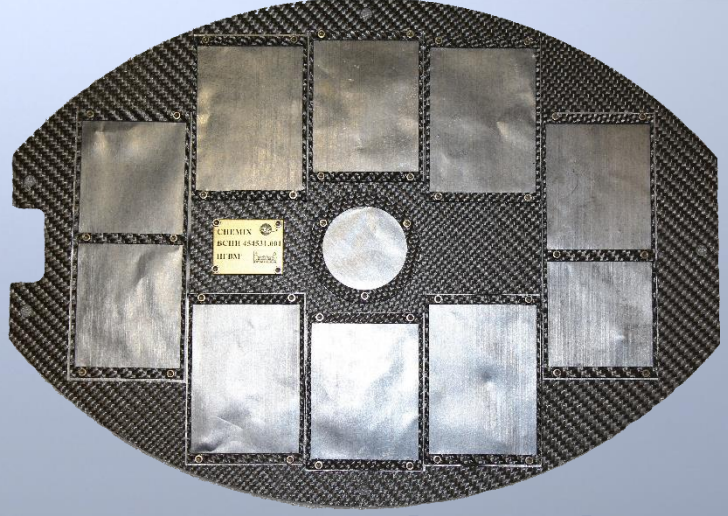


Front X-ray window

TUVF

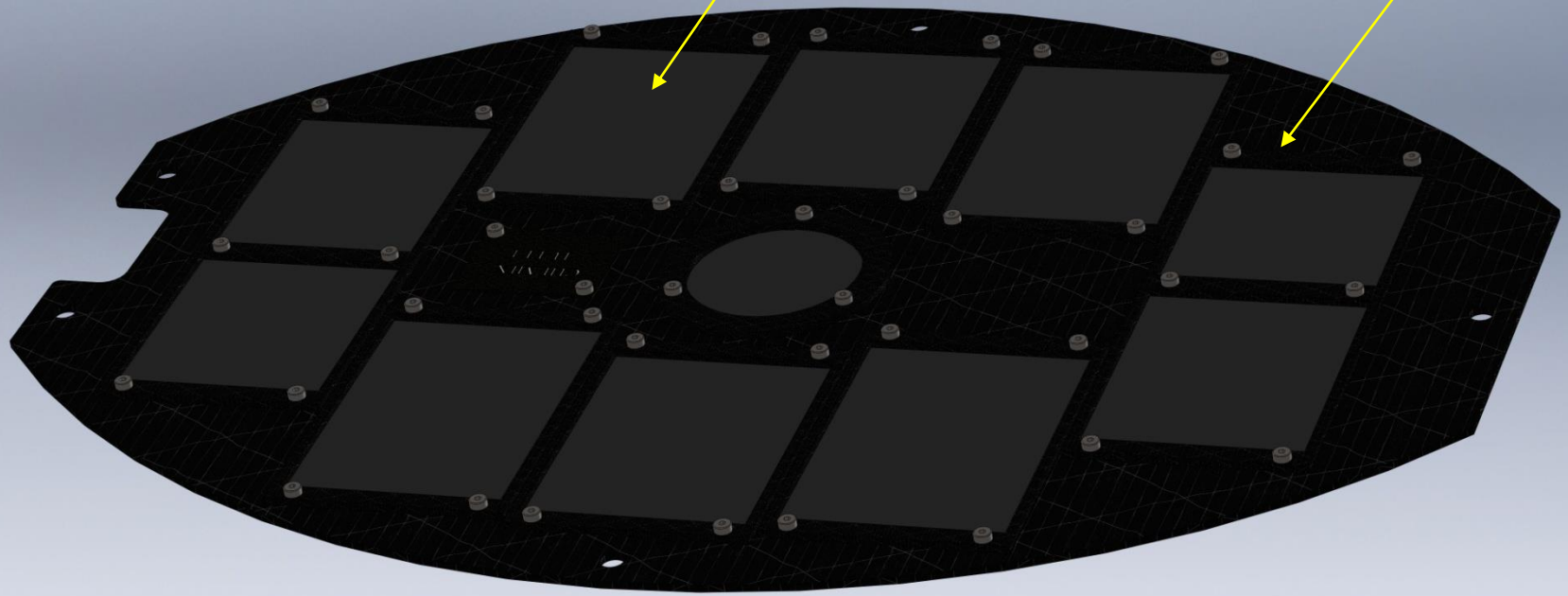
Dual Thermal Filters

Rear X-ray window



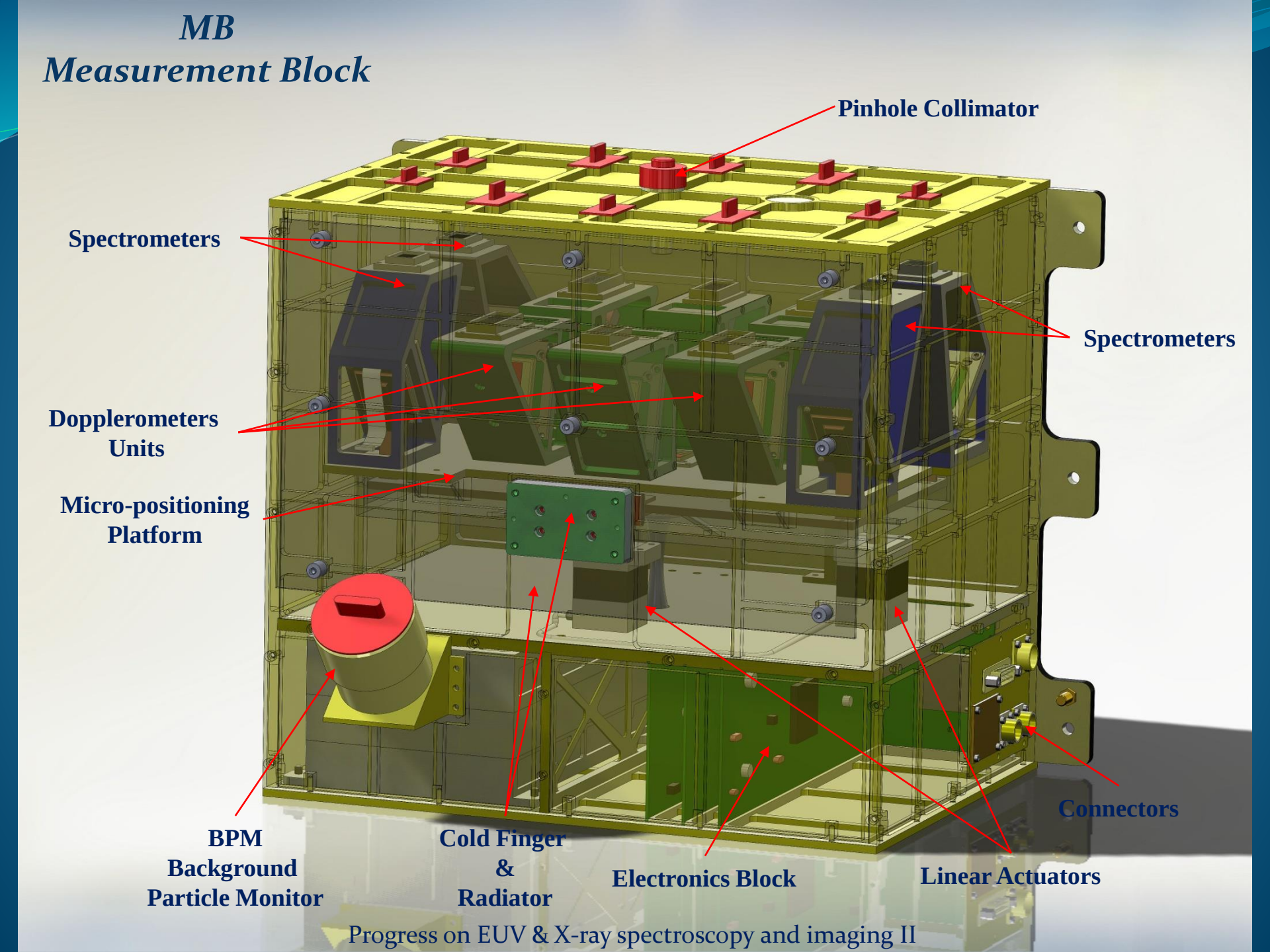
Graphite Foils

Carbon-Carbon composites



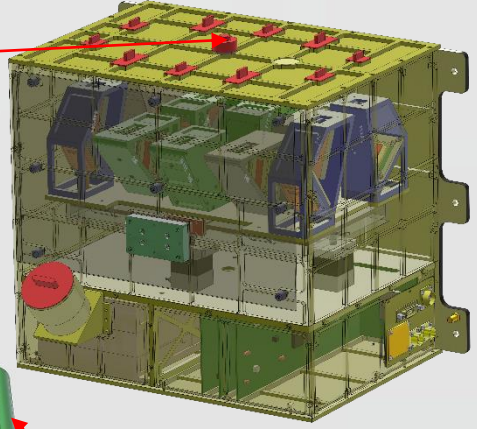
Thermal shield and X-ray filters consisting of two sections (front and rear). The main function of these two layers is to block the thermal load of solar radiation on the instrument and prevent the heat to penetrate down to the S/C.

MB
Measurement Block



Spectrometers

Pinhole Collimator

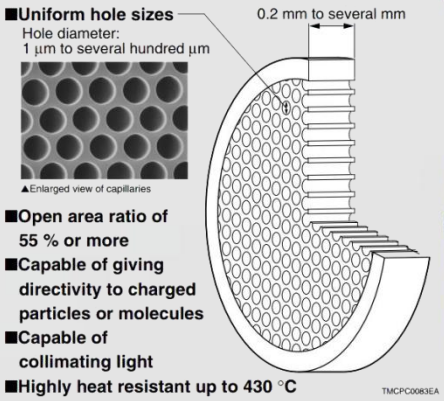


Dopplerometers Units

Dopplerometers Units

CCD pinhole

Capillary plates



Cold Finger

The **pin-hole imager** with the aperture of the order of 1 mm^2 which projects the real-time X-ray solar image on the CCD.

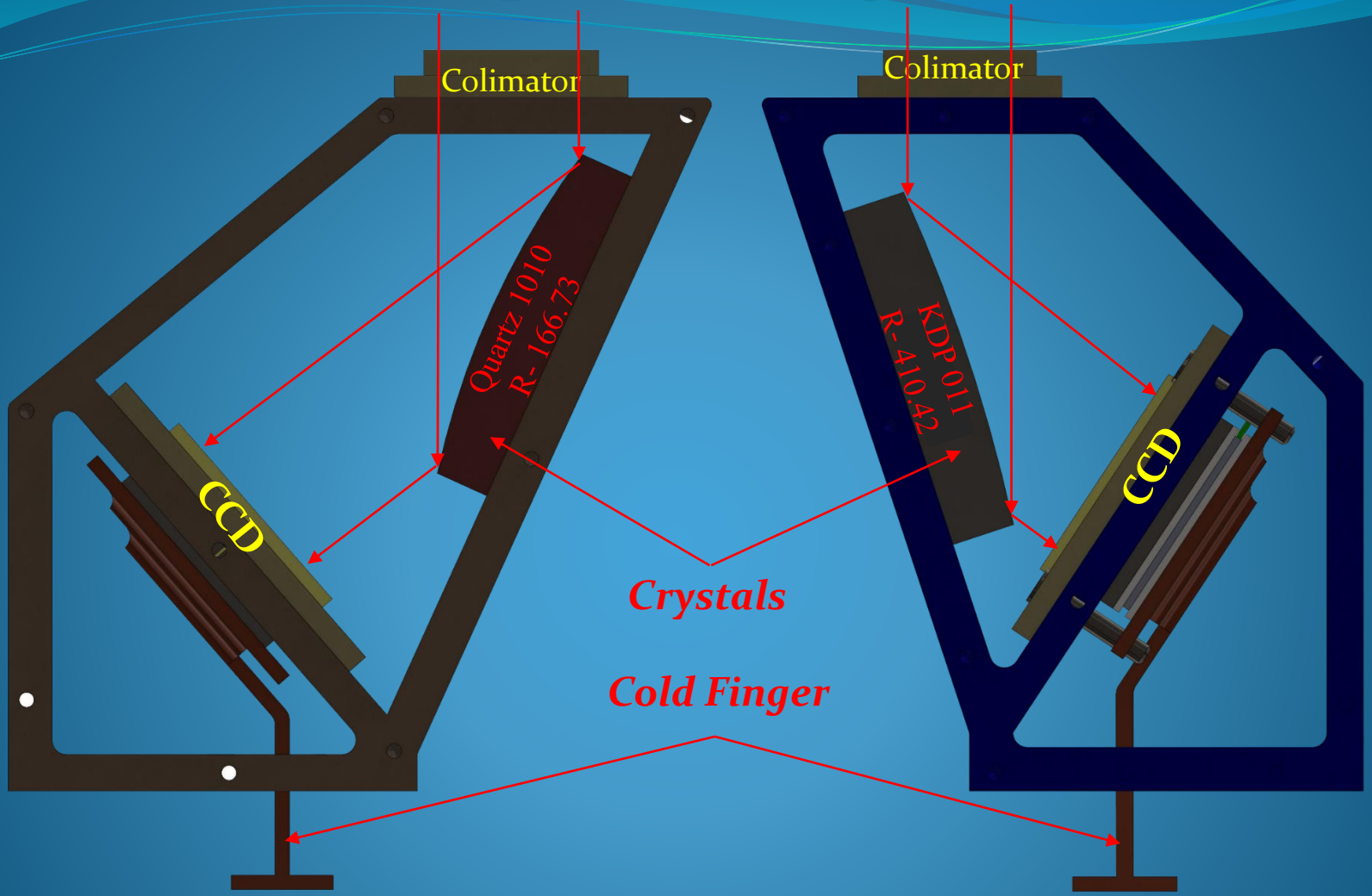
Their main function of the capillary is to limit the field of view (FOV of ~3 arcmin2) of solar X-ray illumination.

Micro-positioning Platform

Spectrometers

Coldplate

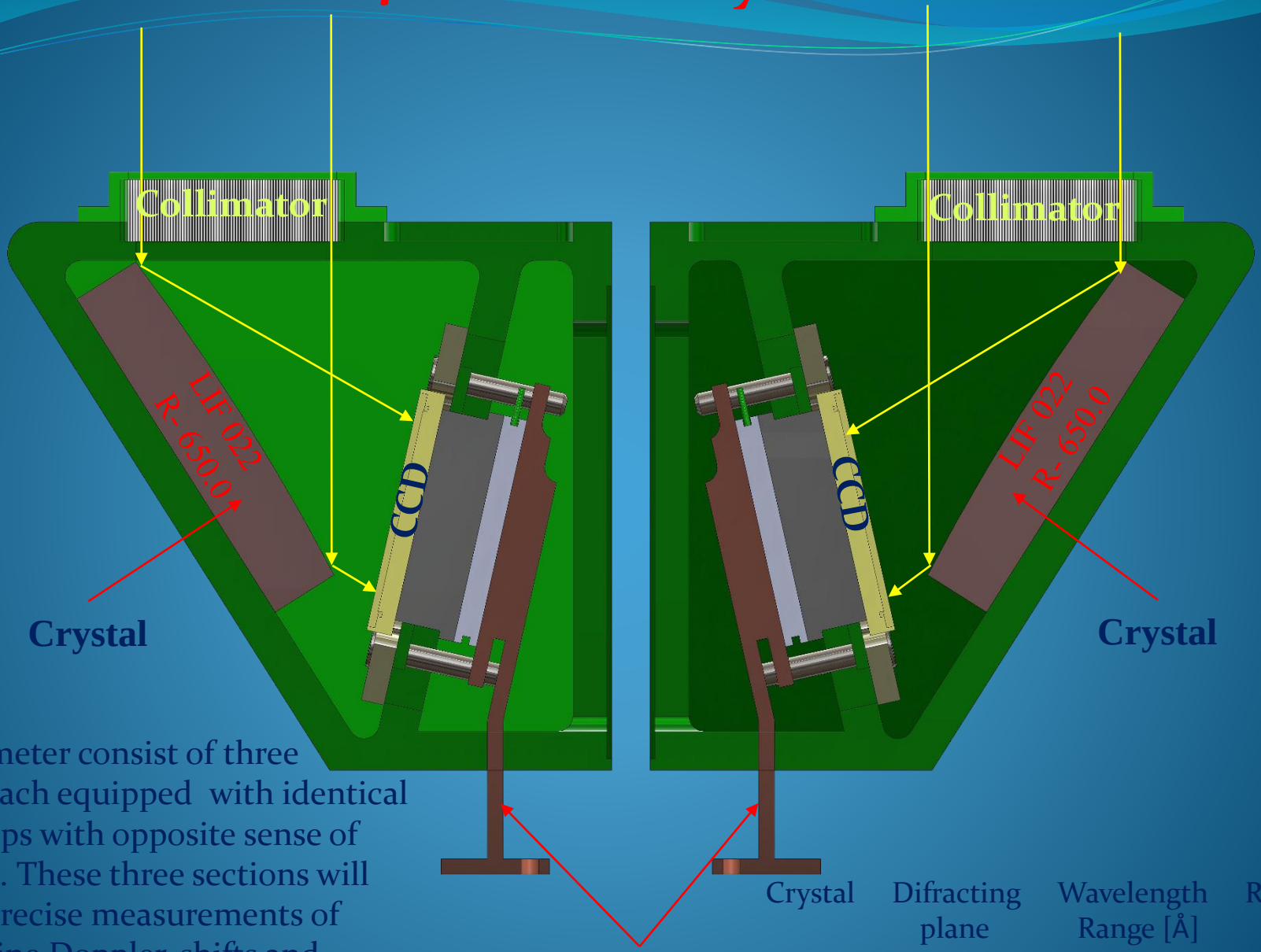
Spectrometer System



Four sections of the spectrometer cover the spectral range from approx. 1.5 Å to 9 Å

Crystal	Difracting plane	Wavelength Range [Å]	Radius
Si	111	1.500-2.713	176.000
Quartz	1010	2.700-4.304	166.729
KDP	011	4.290-5.228	410.425
KAP	001	5.200-8.800	364.731

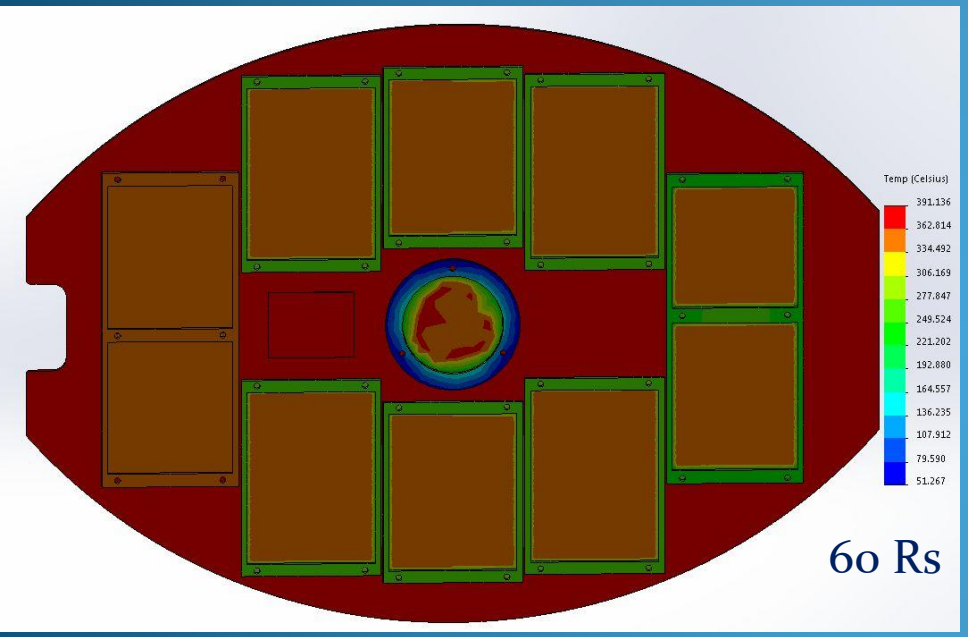
Dopllerometers System



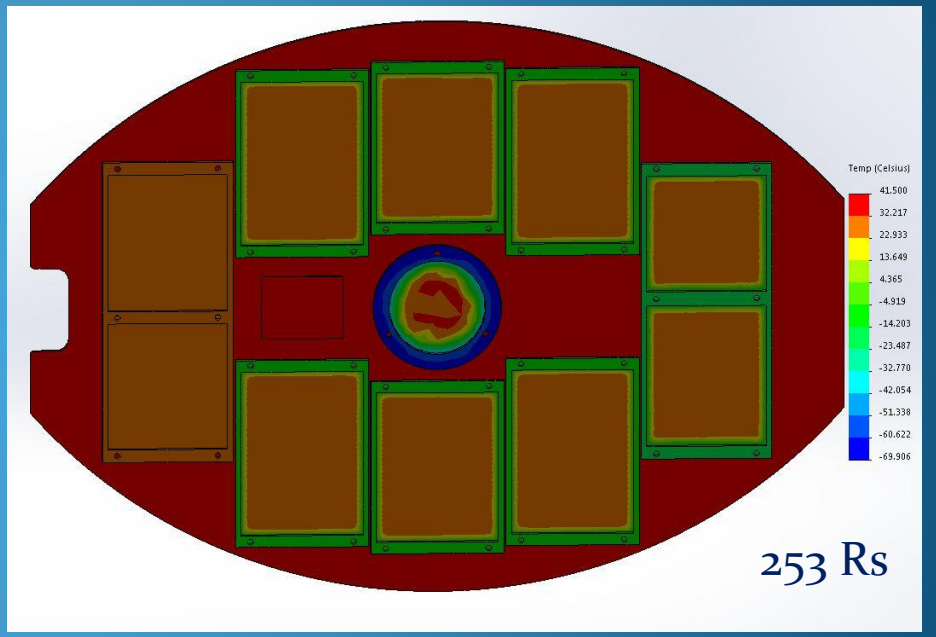
Dopplerometer consist of three sections, each equipped with identical crystal strips with opposite sense of dispersion. These three sections will allow for precise measurements of emission line Doppler-shifts and profiles.

Crystal	Difracting plane	Wavelength Range [Å]	Radius
LiF	022	1.835-1.949	650.0
Si	111	3.150-3.324	2500.0
Si	111	3.900-4.080	1000.0

Preliminary simulation of the thermal shield



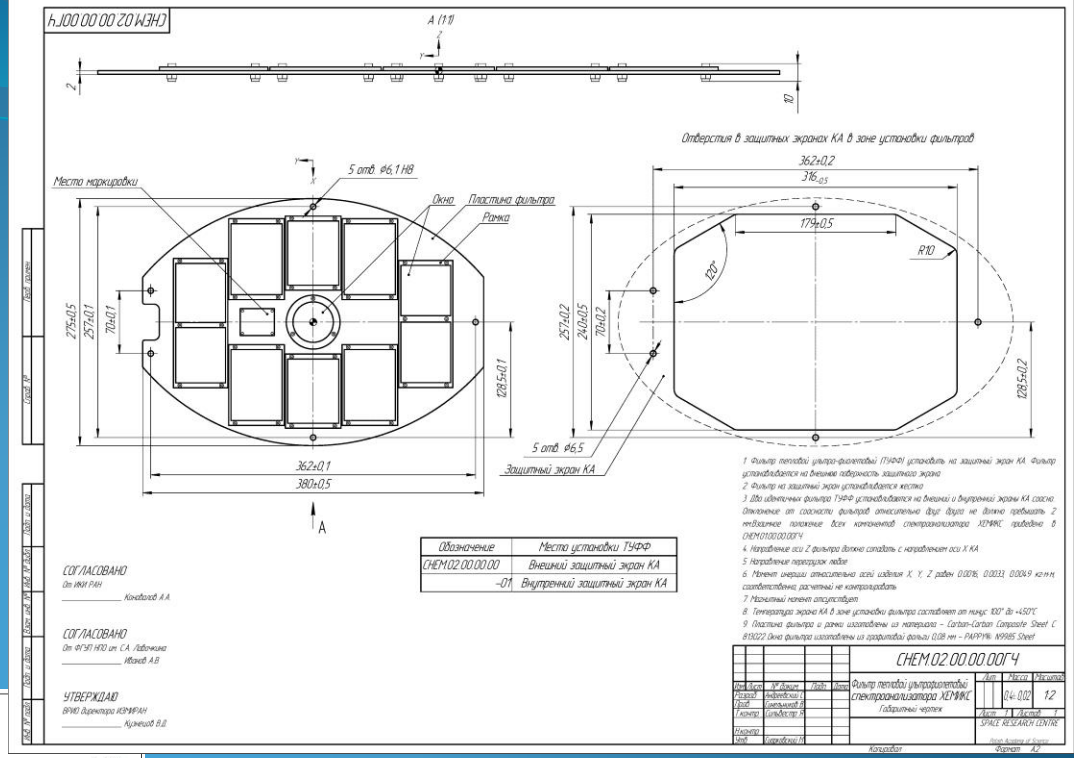
Solar Flux at distance 60Rs is 17.5KW/m²

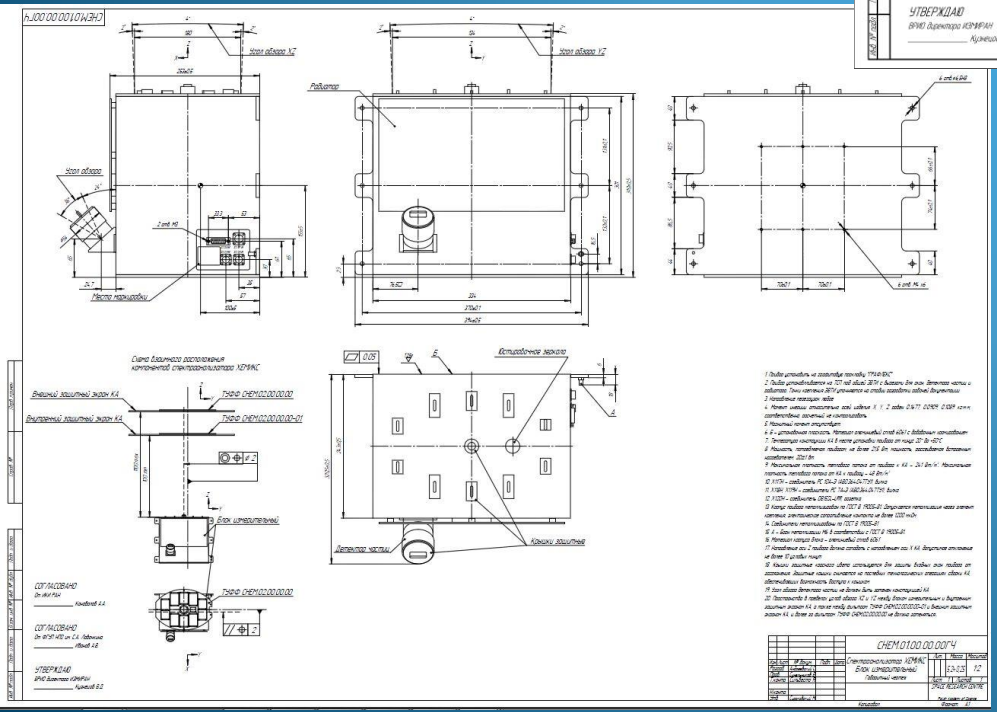


Solar Flux at distance 253Rs is 950W/m²

What has been done at this stage

We made and sent Cad documentation to Russian. Documentation was accepted by Russian part.



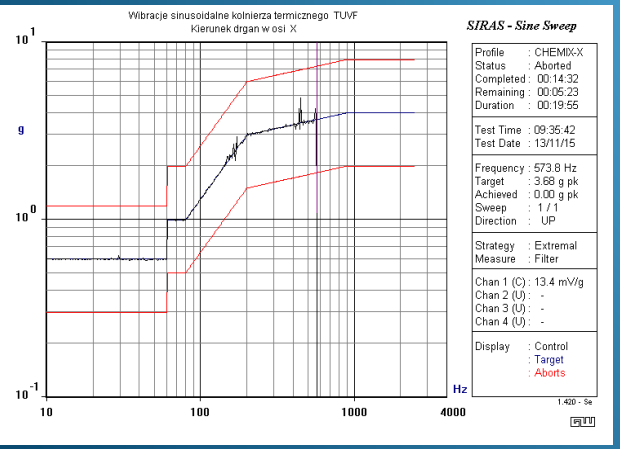


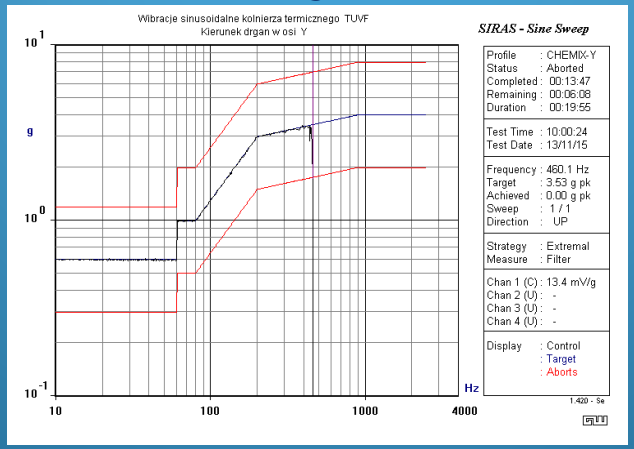
We performed the Vibration endurance test

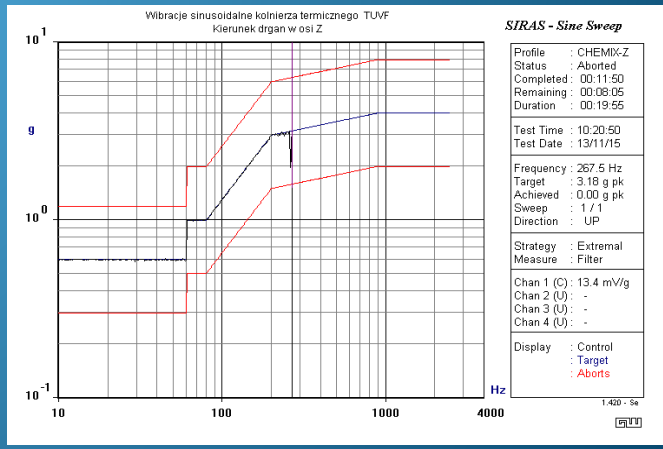
Axis X

Axis Y

Axis Z



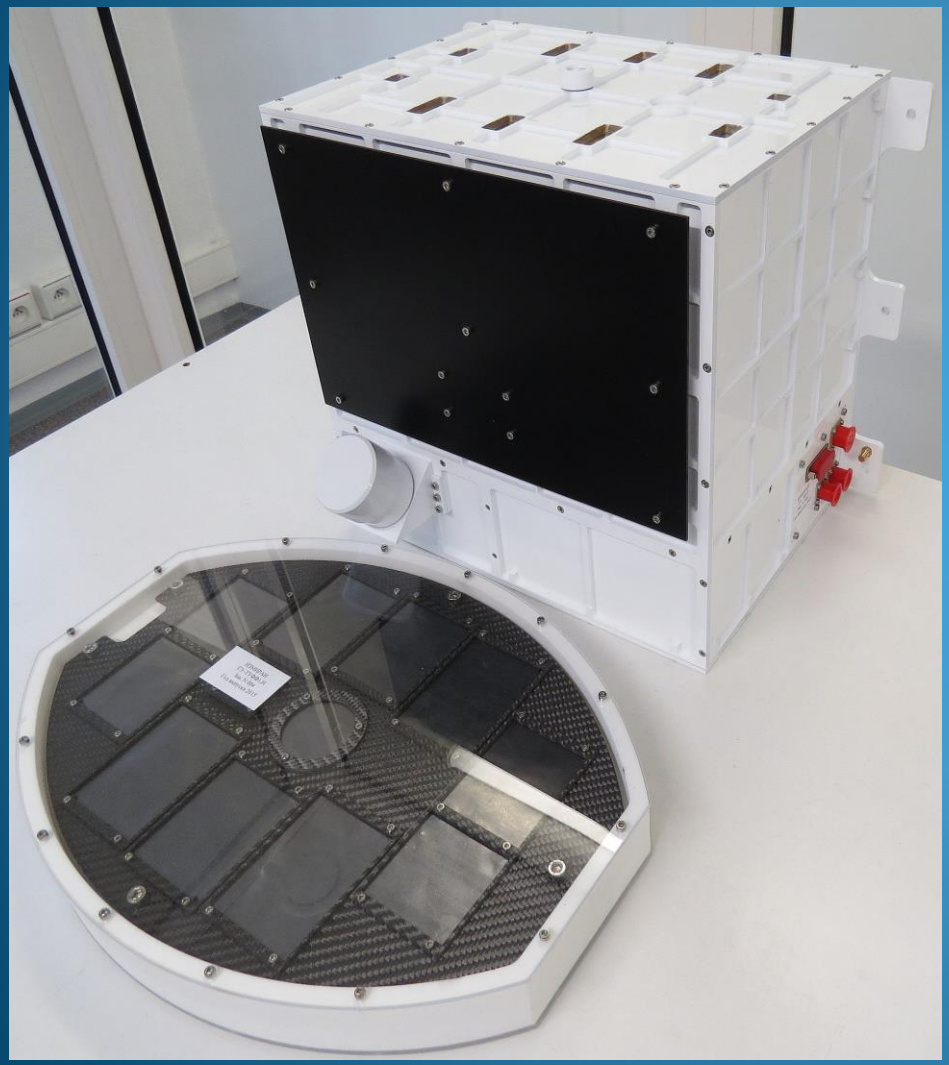




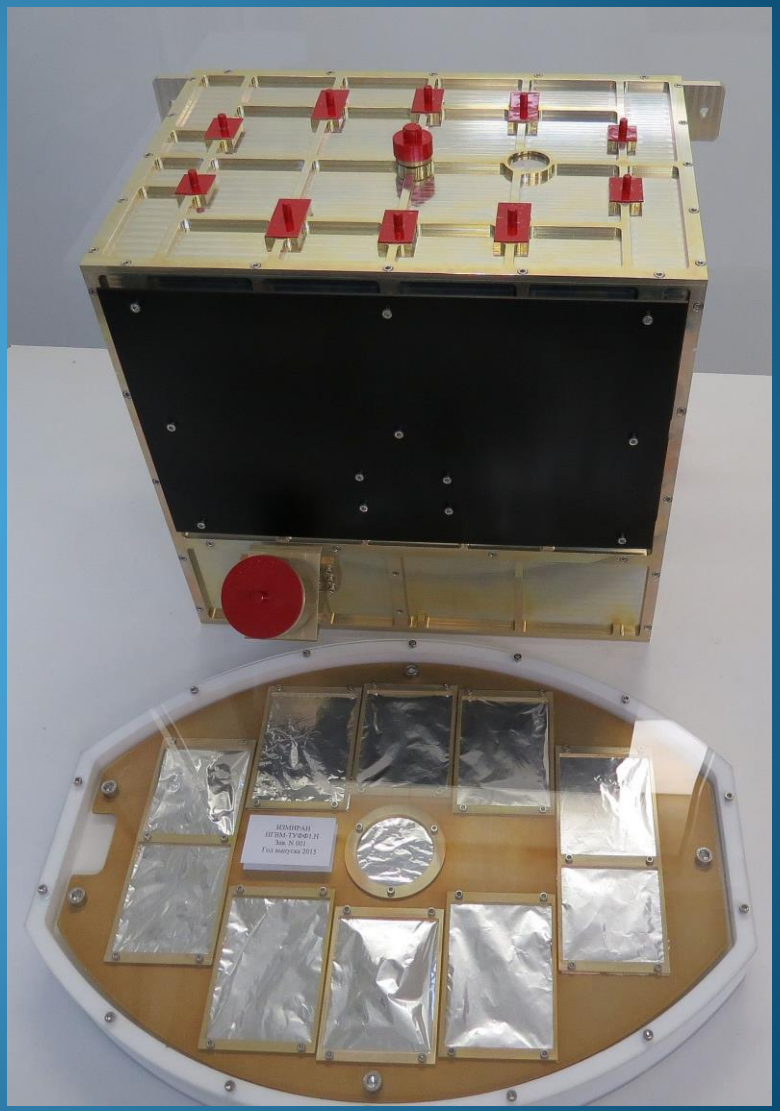
Hz	10 - 60	60 - 80	80 -200	200 - 900	900 -2500
g	0.6	1.0	1.0 - 3.0	3.0 - 4.0	4.0

What has been done at this stage

We have made and sent to Russia two models. All models are made in flight version



Thermal model



Dimensional and Weight model

Thank you for your attention!