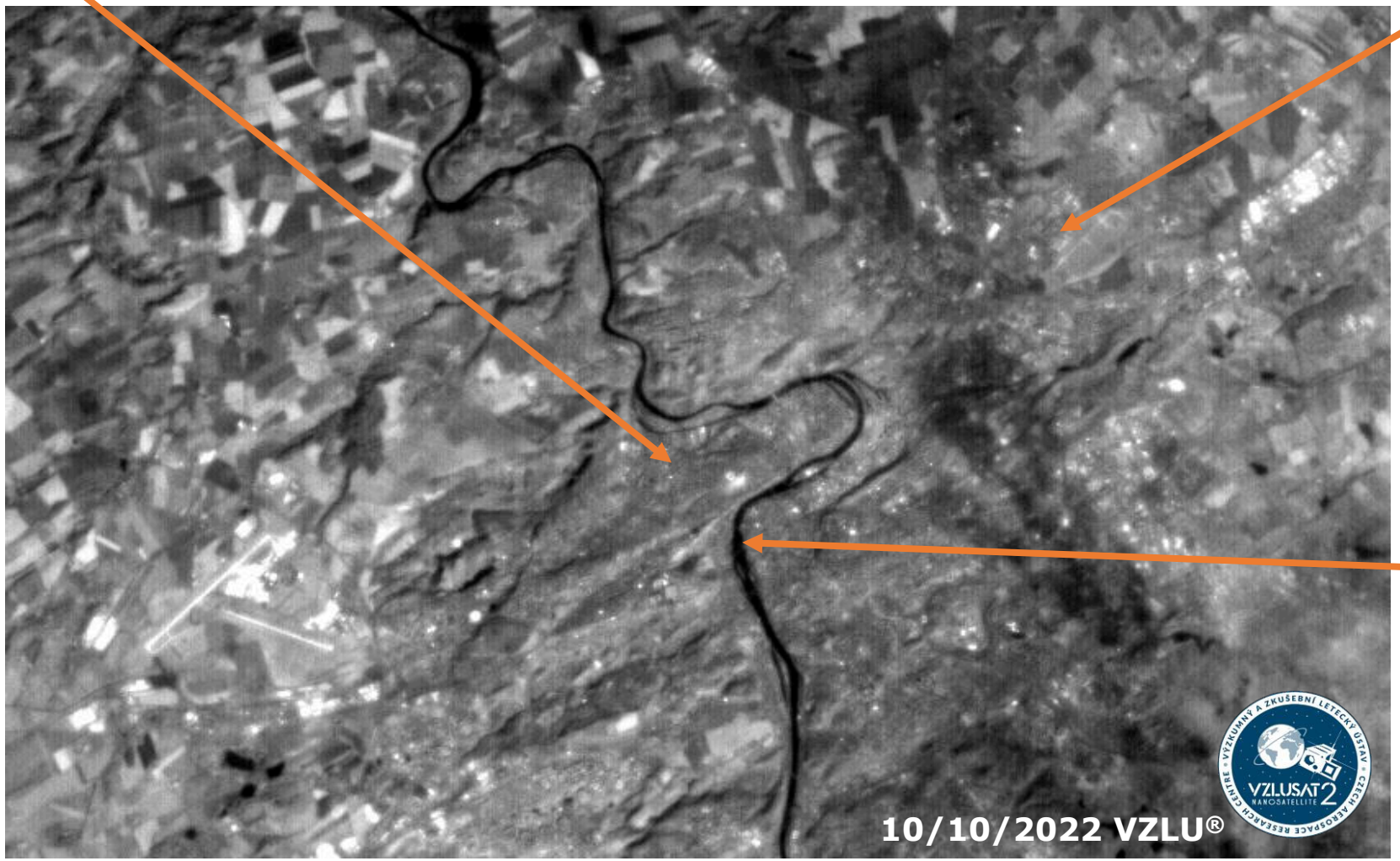
CubeSat microsatellite demonstrator with X-ray optical payload

Vladimír Dániel

VZLU CubeSats VZLUSATs



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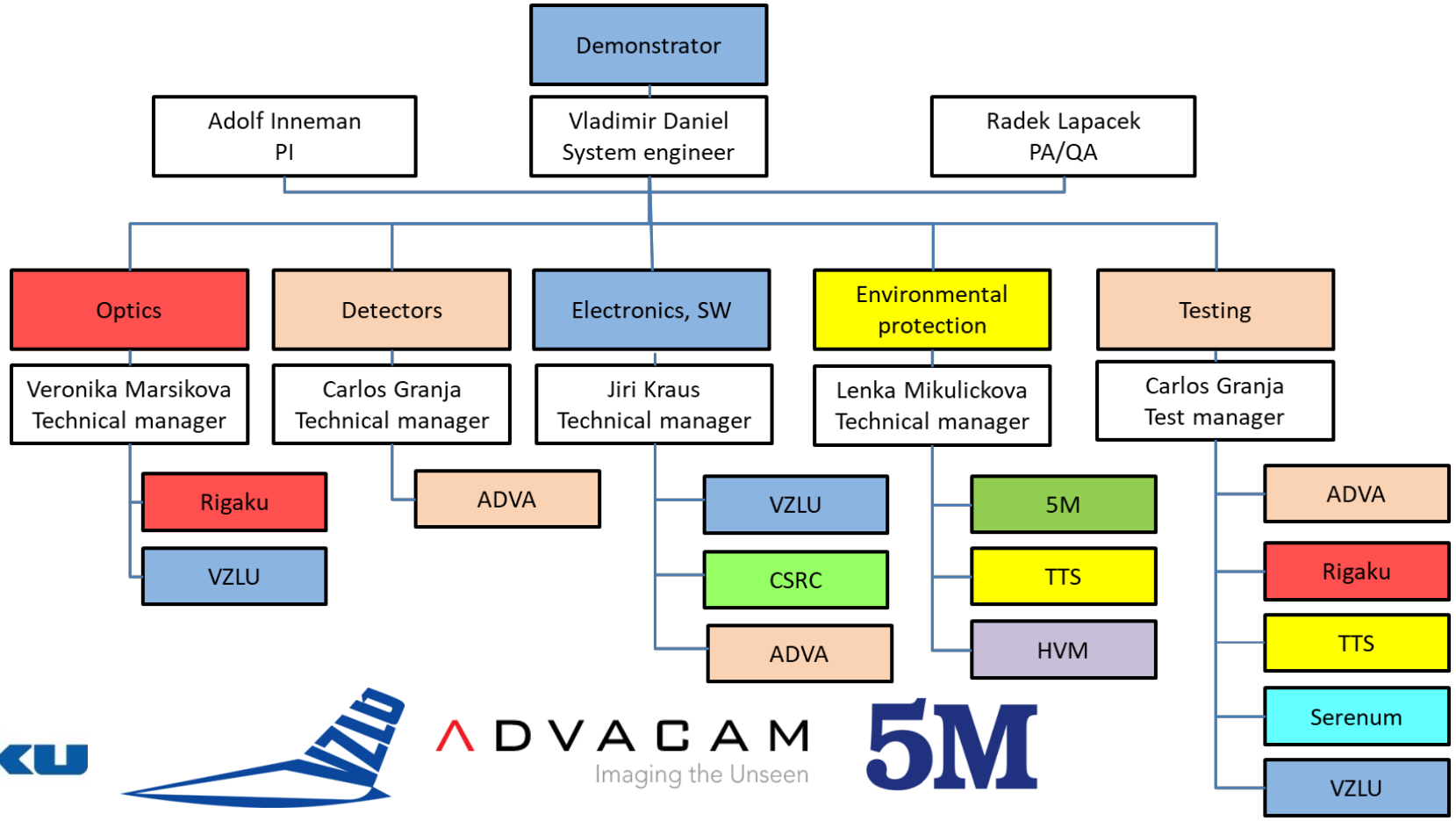

Rigaku

VZLU

ADVACAM
Imaging the Unseen

5M

THIN FILM TECHNOLOGICAL SERVICE

CSRC

HVM PLASMA

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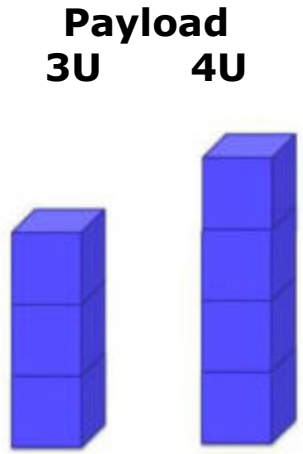
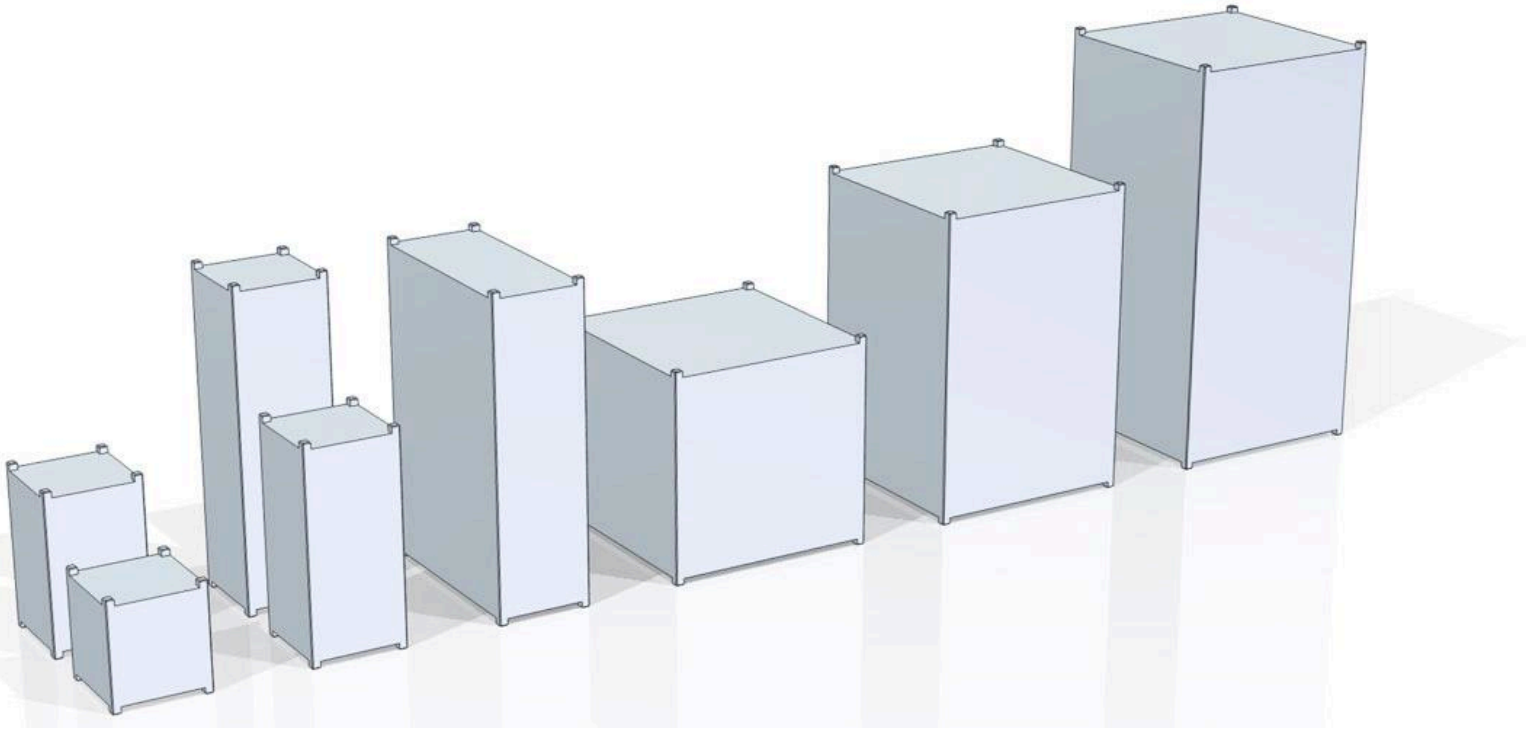
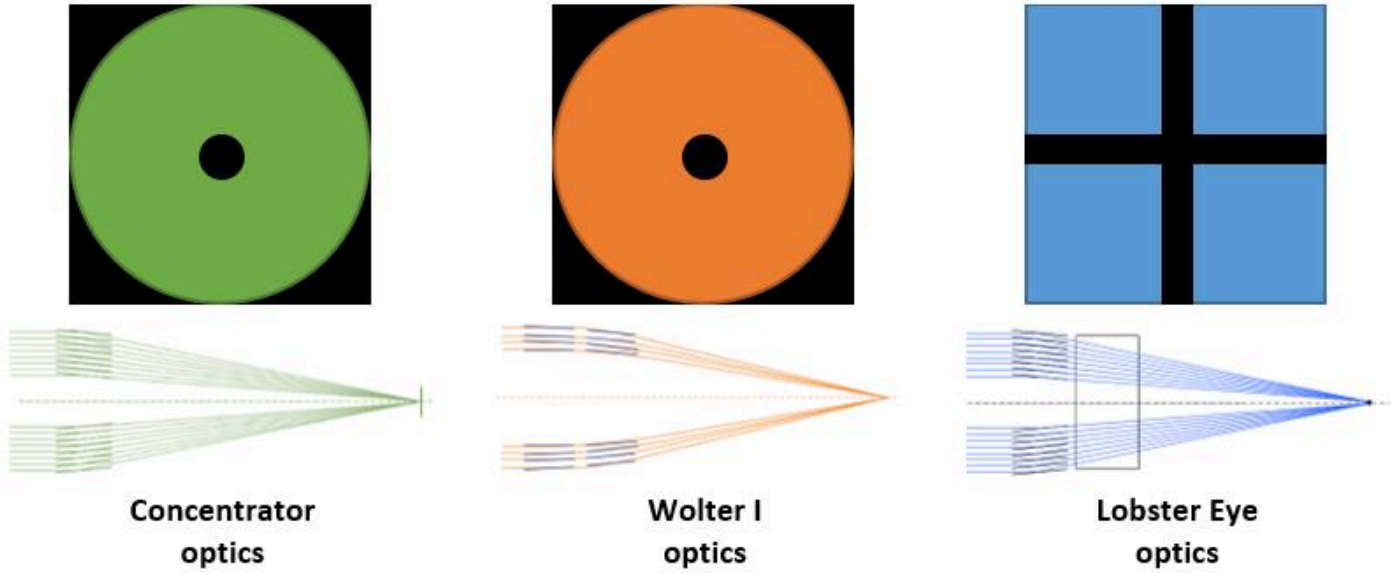
CubeSat microsatellite demonstrator with X-ray optical payload



- SR-CTP demonstrator structure
- **2D X-ray LE (Lobster Eye) optics**
- Radiation composite **shielding**
- **Detector** board with **Timepix3**
- Processing board for the Timepix3 detector (nominal and redundant)
- Outgassing sensor
- **X-ray Spectroscope** (detector and processing board)
- SO (Spectroscope & Outgassing) Computer board



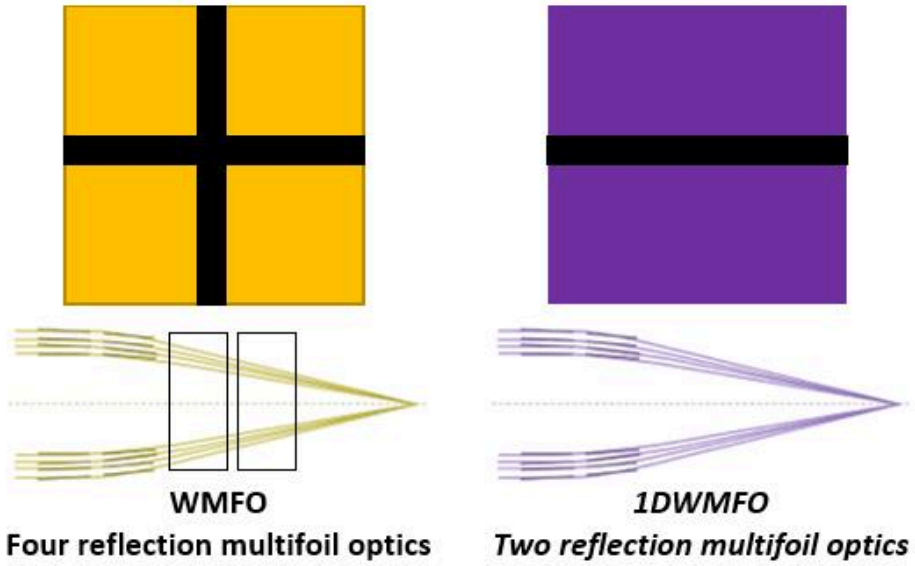
Short focal length X-ray optical concepts



Concentrator optics

Wolter I optics

Lobster Eye optics

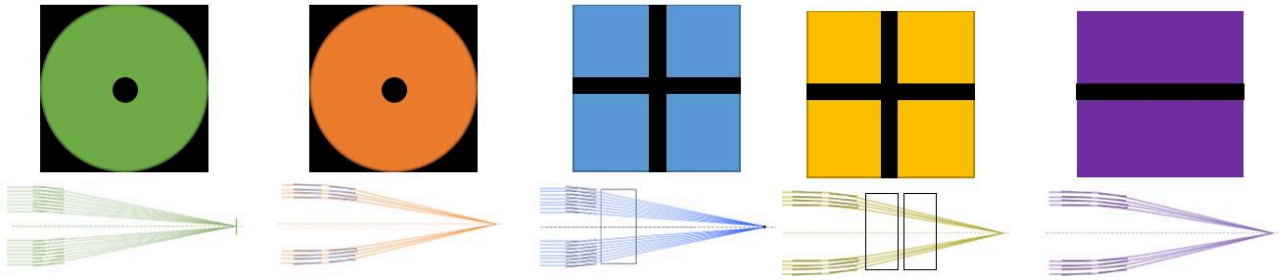


WMFO
Four reflection multifoil optics

1DWMFO
Two reflection multifoil optics

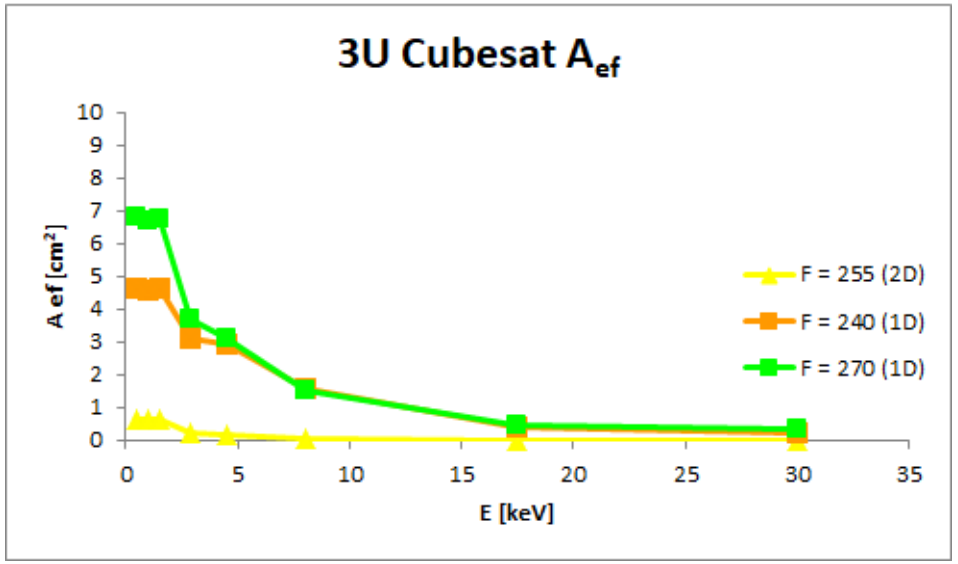
- Total reflection
- Black part of aperture cannot be used for focusing.
- Inner circle or cross is caused by small incident angle requiring extremely long optics close to optical axis.

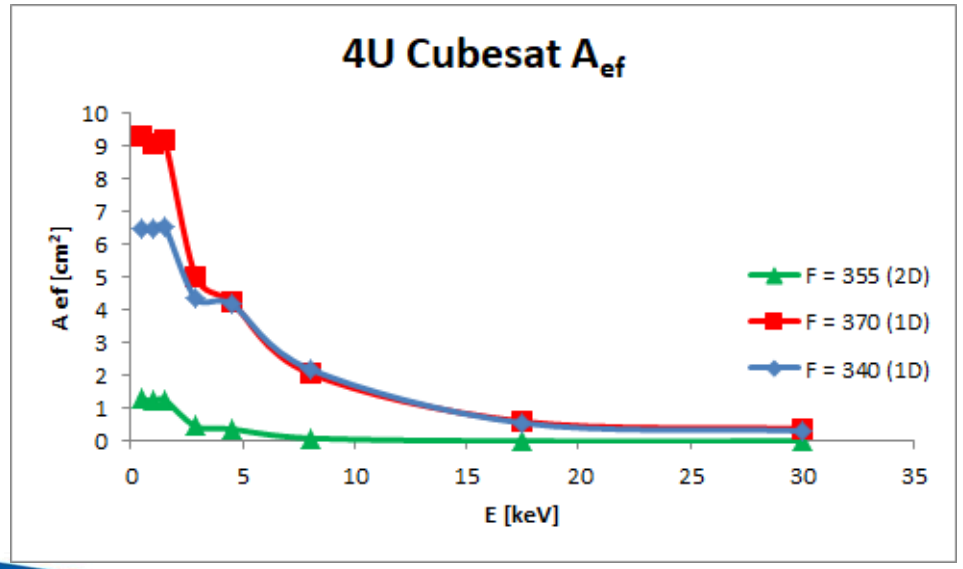
Short focal length X-ray optical concepts

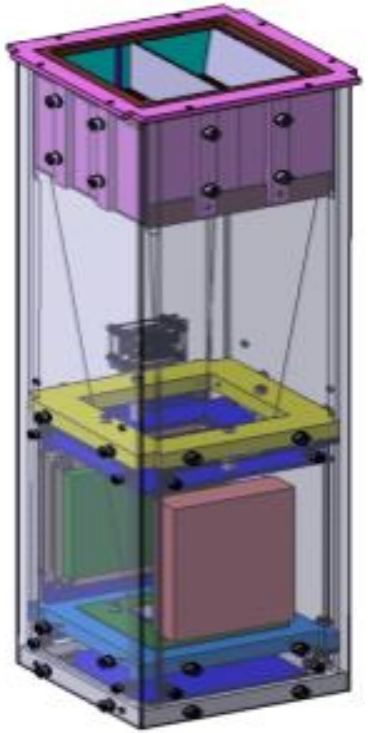


	Concentrator	Wolter I	LE	WMFO	1DWMFO
System	1 reflection	2 reflections	2 reflections	4 reflections	2 reflections
Incident angle	alpha/2	alpha/4	alpha/2	alpha/4	alpha/4
Foil convergence length [mm]	776	1552	776	1552	1552
Focal length [mm]	388	388	388	388	388
Diameter [mm]	16 to 56	16 to 56	8 to 56	8 to 56	12 to 56
Effective area [cm^2]					
@1keV	14.02	16.44	11.17	13.49	15.87
@2keV	8.17	16.96	6.59	14.77	16.62
@3keV	3.57	14.60	2.97	12.55	15.16
@4keV	1.56	9.43	1.46	7.99	11.71
@5keV	0.54	6.02	0.76	5.12	9.00
@6keV	0.14	3.95	0.39	3.40	6.99
@7keV	0.02	2.62	0.19	2.36	5.51
@8keV	0.00	1.65	0.08	1.60	4.23
@9keV	0.00	0.11	0.00	0.28	1.08
@10keV	0.00	0.05	0.00	0.22	0.82

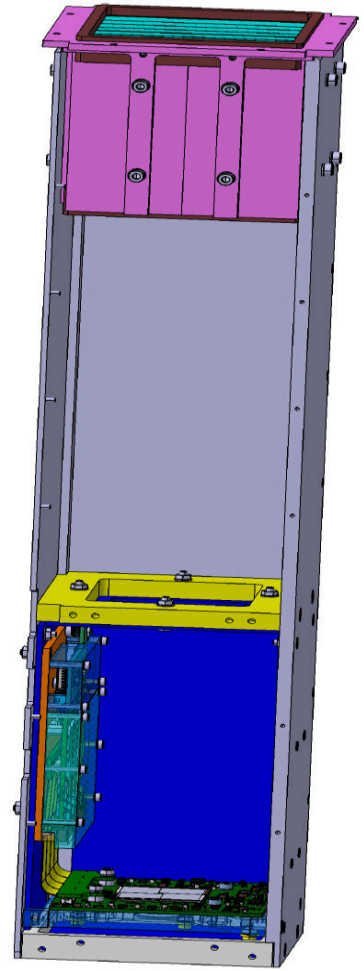
X-ray optical payload Effective area



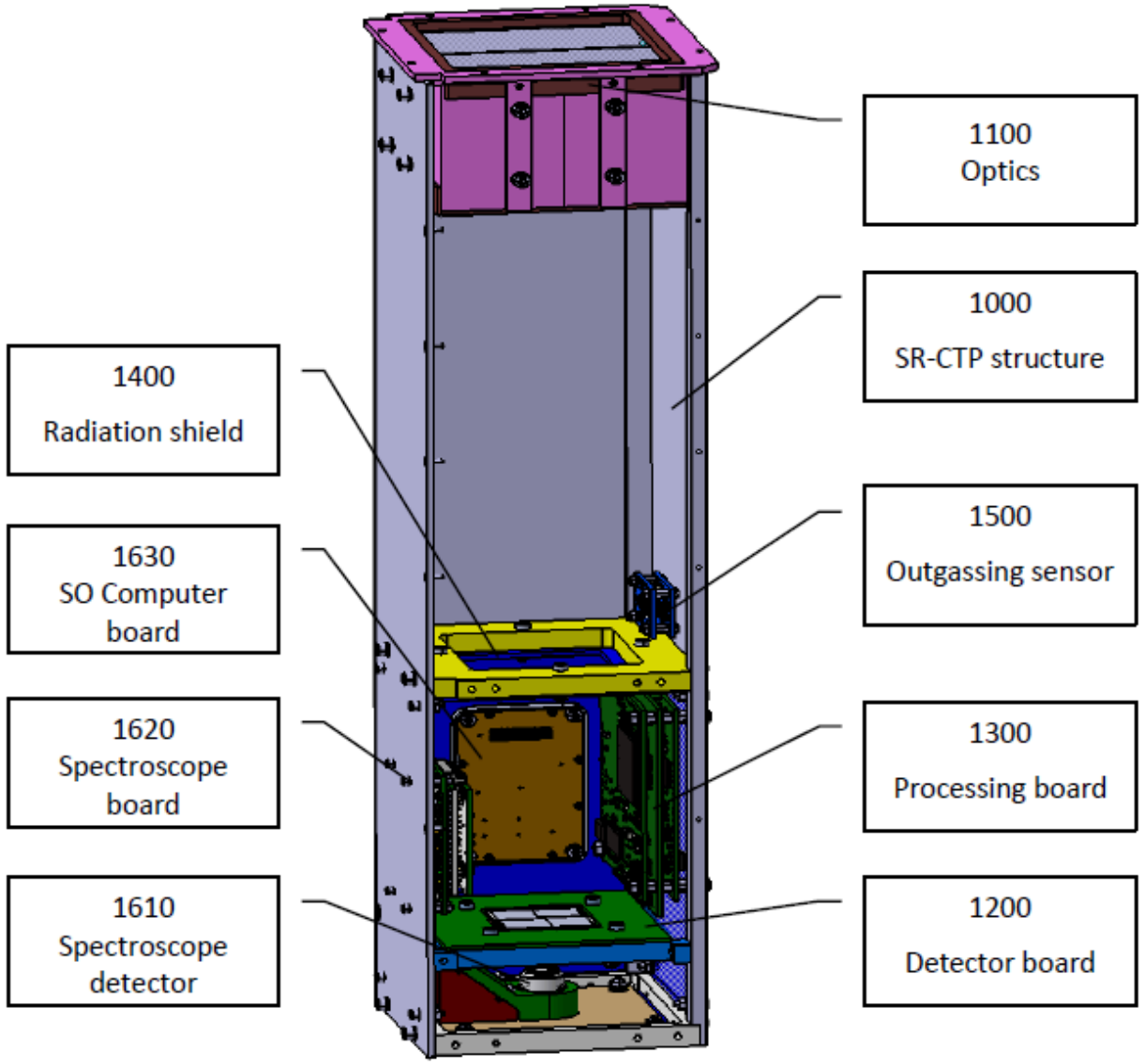




Payload
3U or 4U



Demonstrator of X-ray optical payload



- SR-CTP demonstrator structure
- **2D X-ray LE (Lobster Eye) optics**
- Radiation composite **shielding**
- **X-ray pixel Detector** board with **Timepix3**
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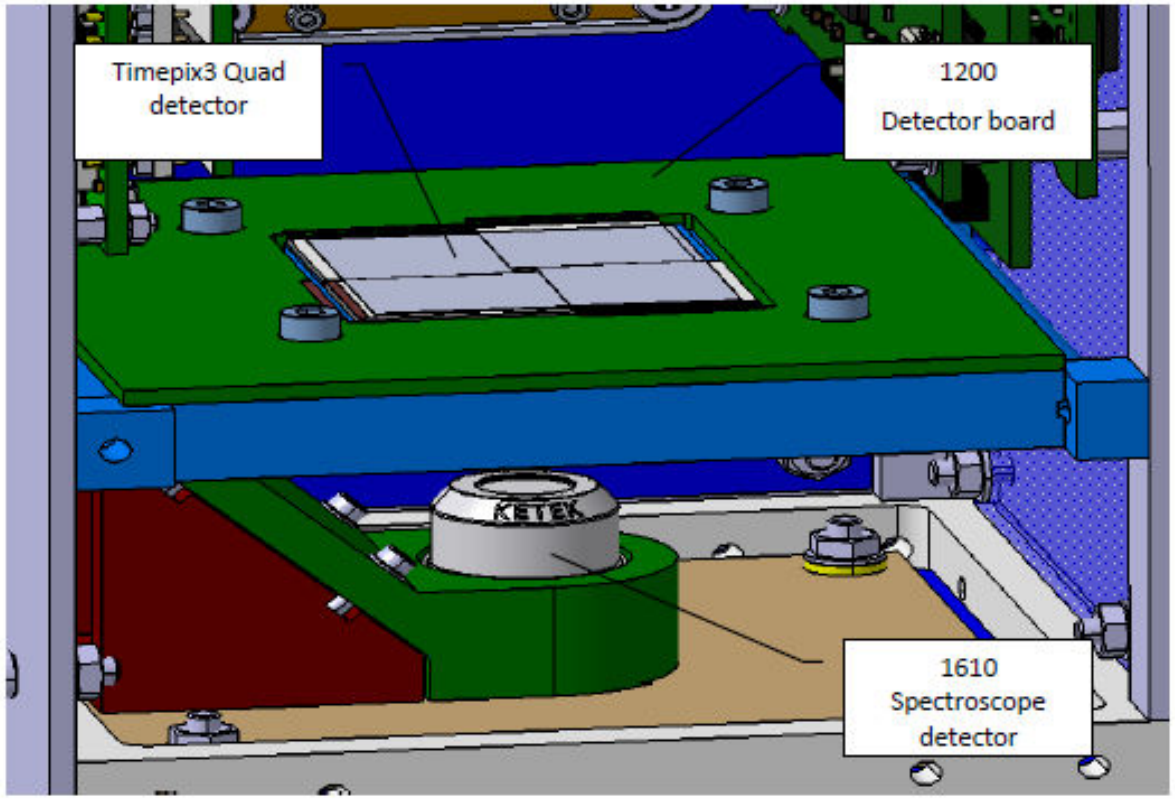
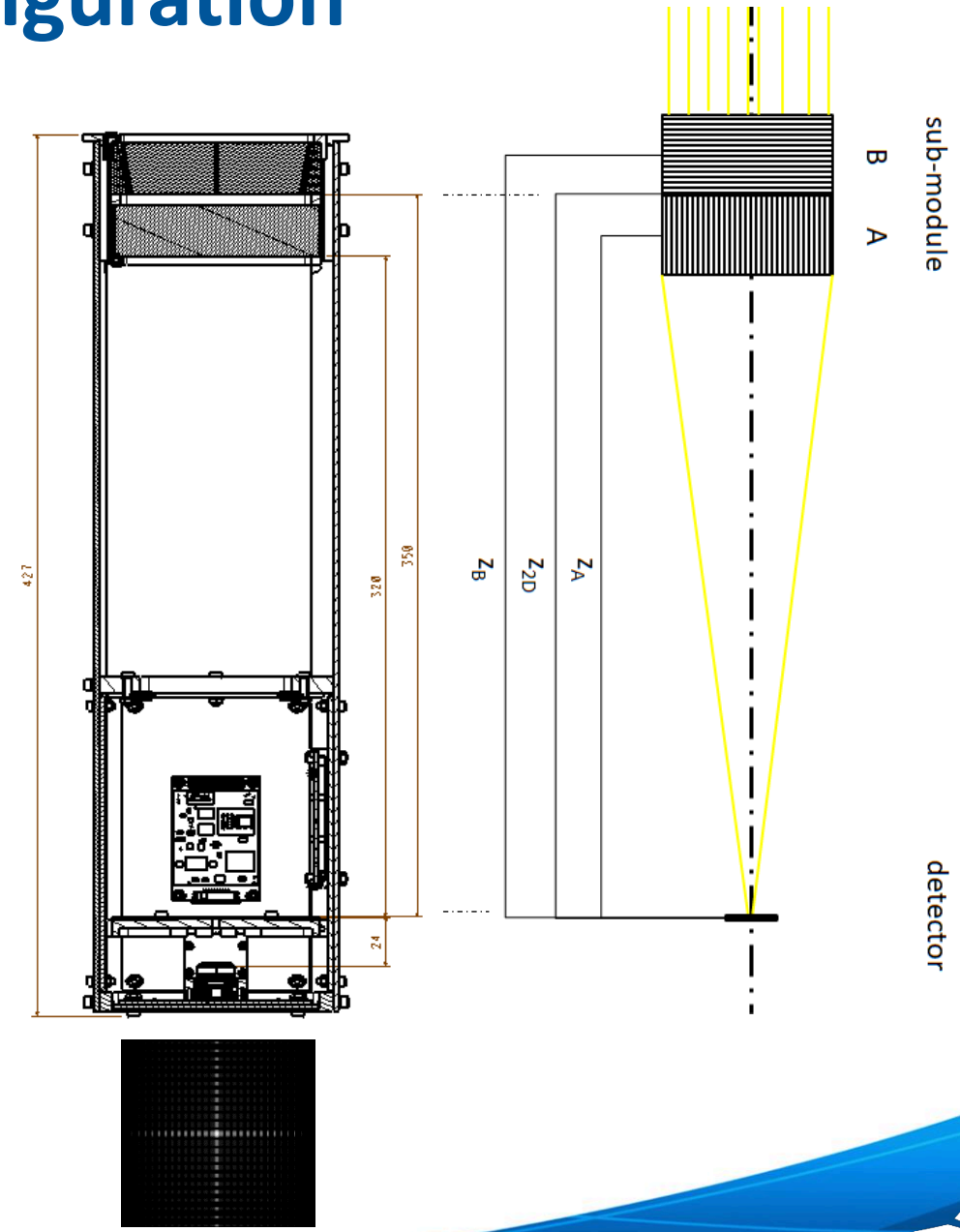
Detectors configuration

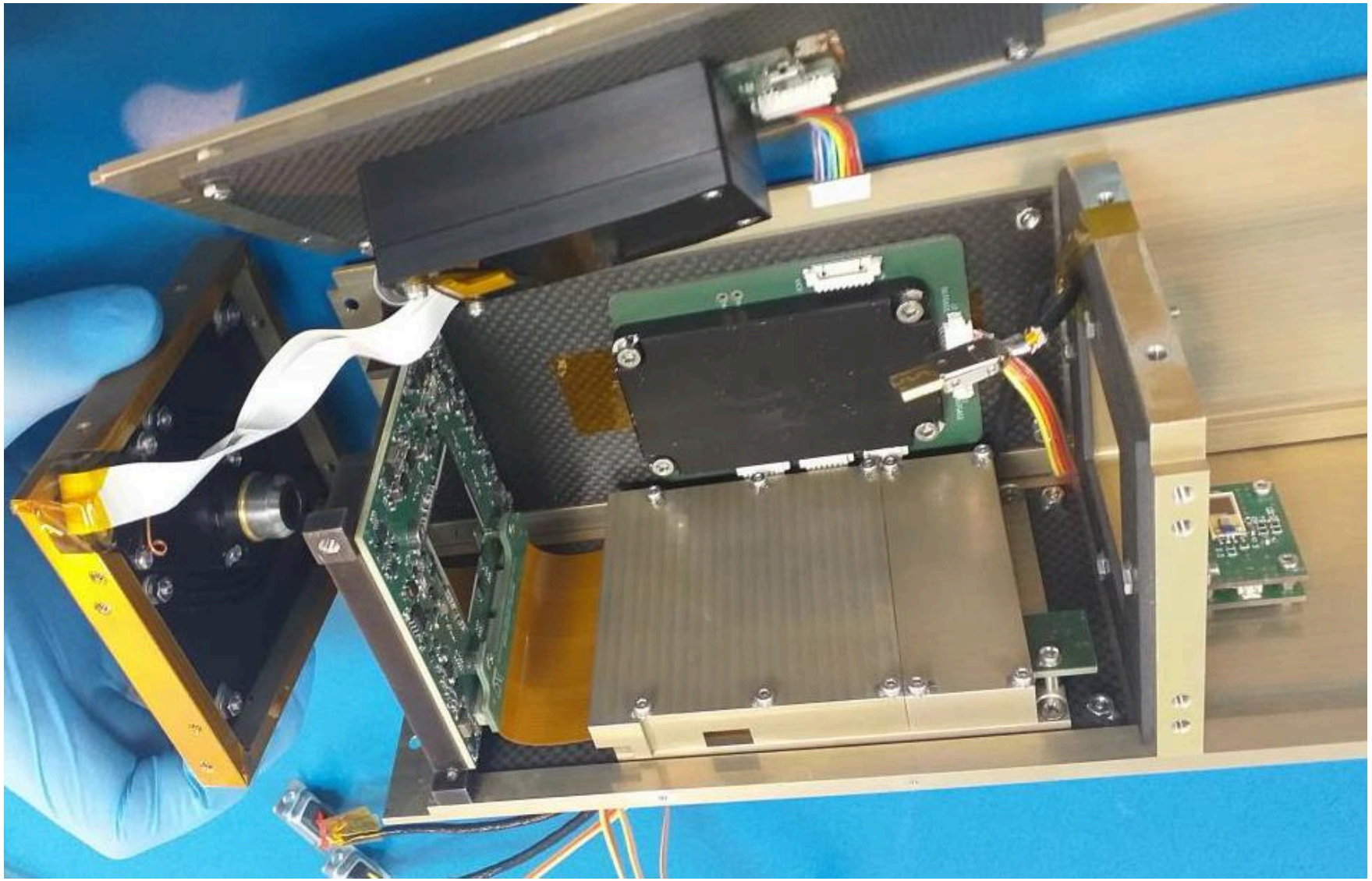
The designs of the LE:

- the LE optics for larger CubeSat (**4U** i.e. F = 355 mm)
- Module A f = 340mm
- Module B f = 370mm





Detectors configuration



- wide FOV Timepix3 quad pixel detector
- in-axis FOV SDD spectroscope detector
- entrance aperture of 6.9 x 6.9 cm.

TPX3 quad is used for GRB source refinement localization. The spectroscope is placed in the centre axis of telescope with only in-axis FOV for following observation.

X-ray optical payload demonstartor

Property	Value
Telescope outer dimension	100x100x450 mm
Focal length	355 mm
Optical aperture	69 x 69 mm
Aperture area	43 cm^2
Effective aperture area	28 cm^2
Field of view	5.8x5.4 deg
Angular resolution @ 4.5 keV	4.4 arcmin
FWHM @ 4.5 keV	200 µm

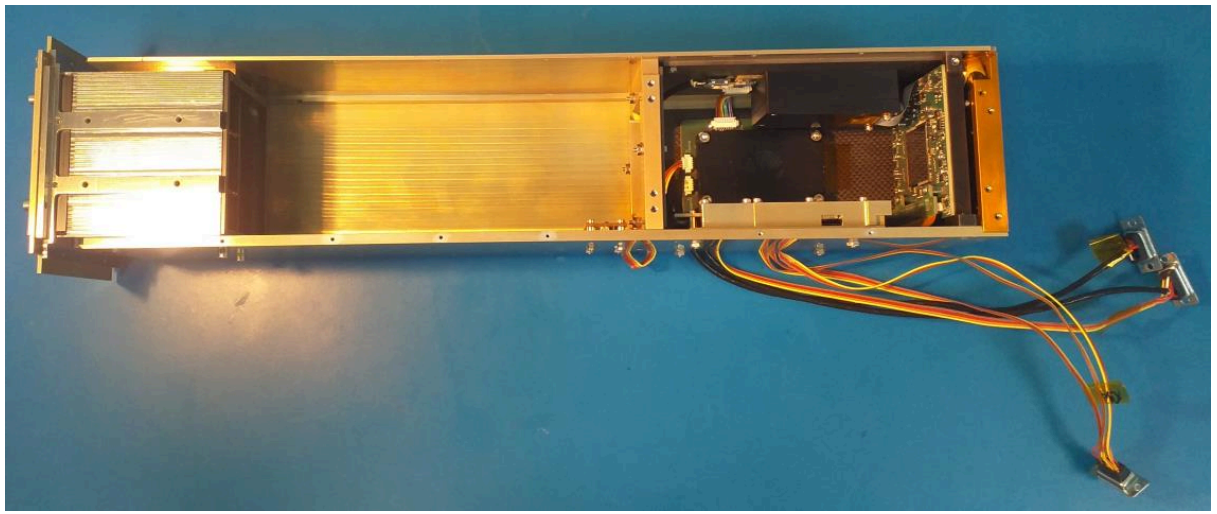
Table 3-1: The parameters of the SR-CTP 4U telescope demonstrator system

Parameter	Value
Detector type	TPX3 ASIC chip
Conformation of chips	Quad
Detector material	Si
Thickness of Si layer	100 µm
Pixel size	55µm
Energy band	2-30keV
Energy resolution	<8%

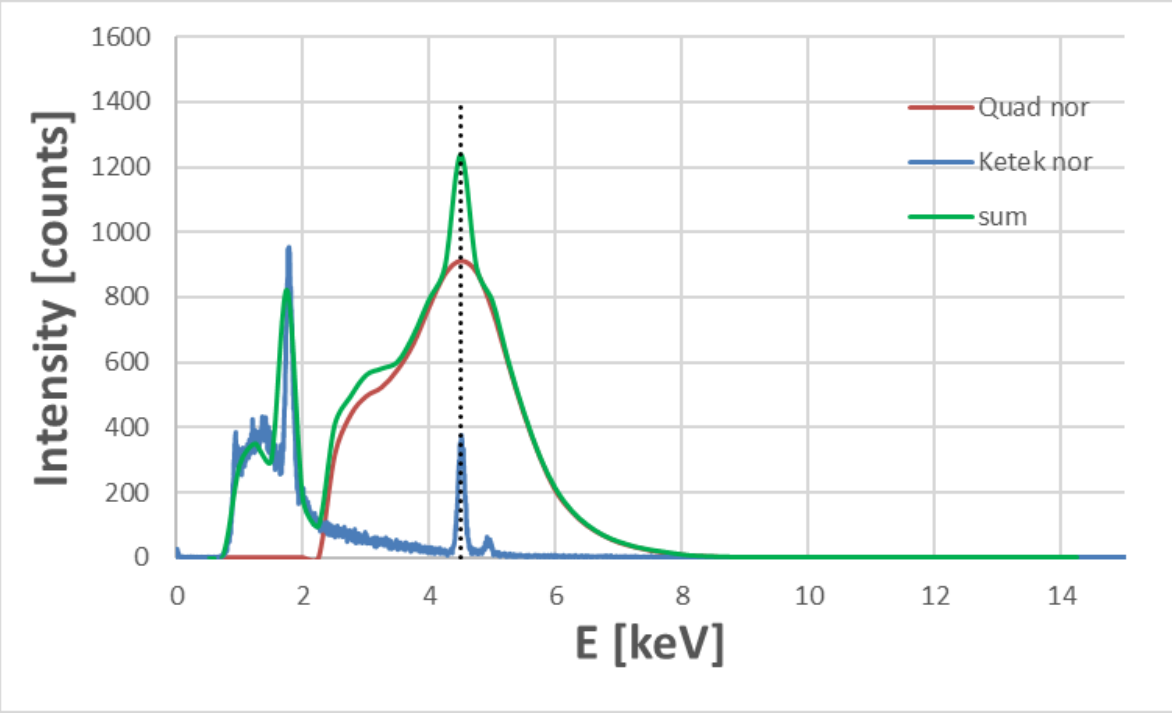
Table 3-3: The basic parameters of focal detector Timepix3

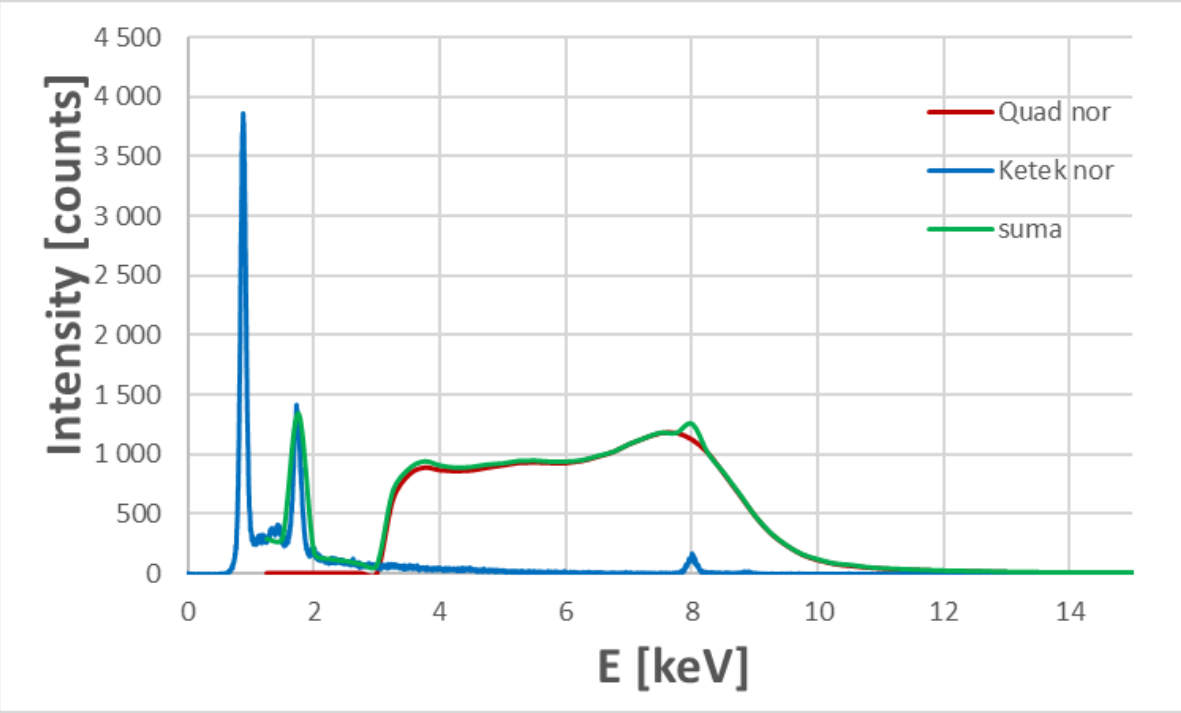
Parameter	Value
Detector type	SDD
Detector material	Si
Thickness of Si layer	450 µm
Effective detector area	7mm^2
Cooling system	Active
Field of view	10arcmin
Effective area	30cm^2
Energy band	0.1-60keV
Energy resolution	135eV

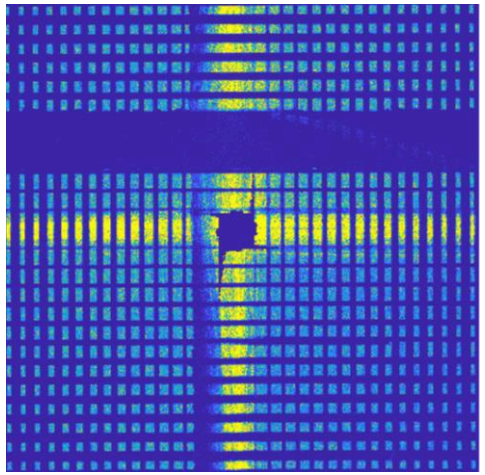
Table 3-4: The basic parameters of spectroscope



X-ray optical payload demonstartor

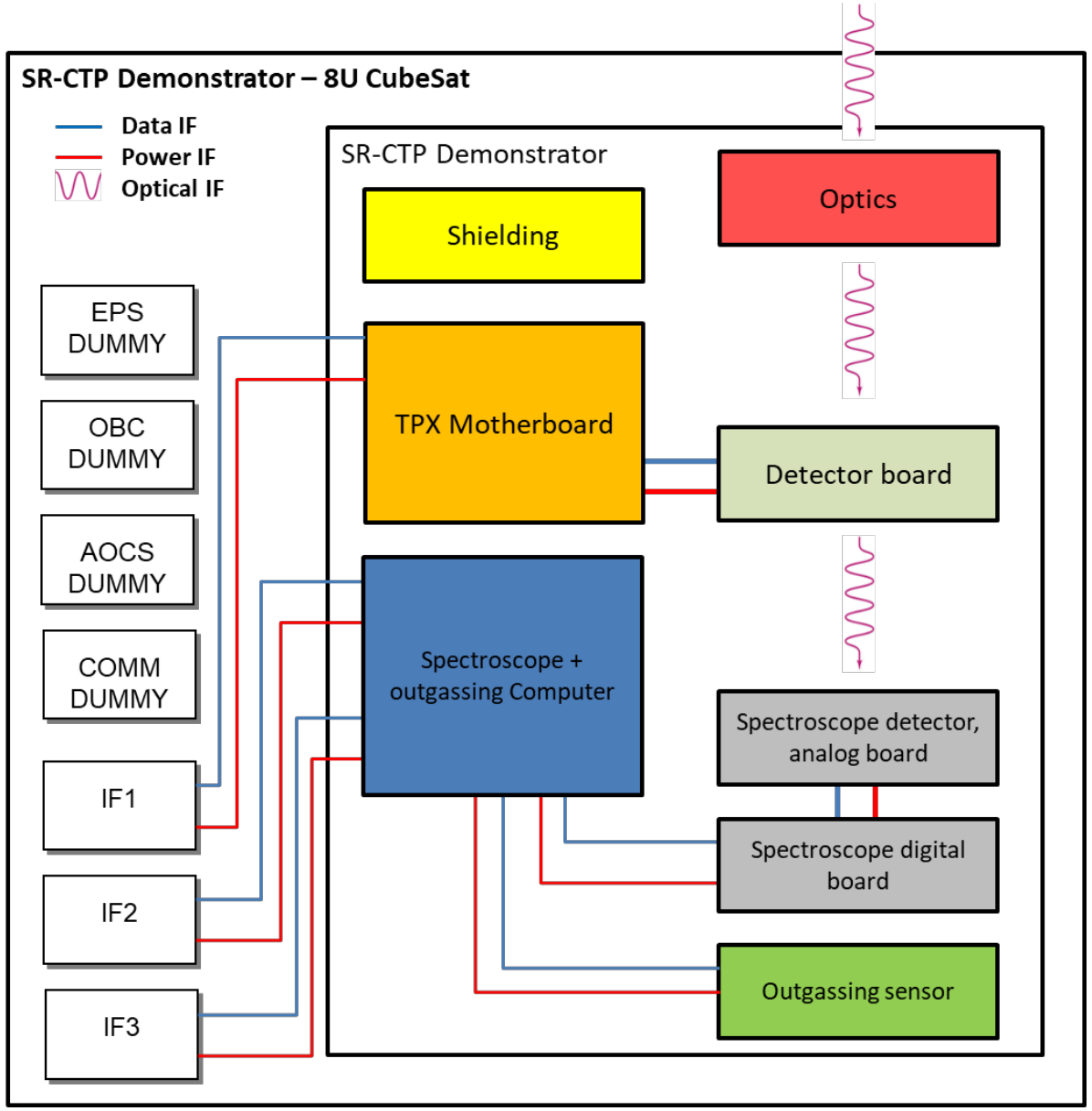






	Ti (4.5 keV)	Cu (8.0 keV)
• Focused beams	x1	x1
• Direct beams (collimator)		
• + cross	x5	x4

CubeSat microsatellite demonstrator



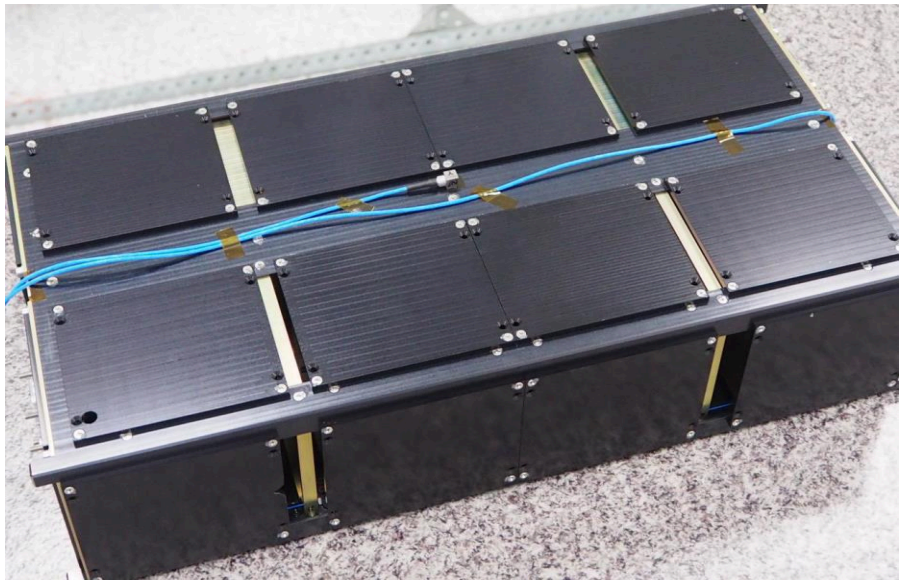
A. Advanced radiation shielding materials and components (composite panels)
B. Wide field-of-view and high angular resolution X-ray
   optics system for space borne experiments
C. Miniaturized high-performance radiation detector
   platforms for small spacecraft and CubeSats
D. Radiation adapted protective electronics
E. Assembled payload 2D X-ray optical telescope (consisting of items B, C, D above)
F. Build a higher generation Czech CubeSat at EM level for demonstration and qualification of radiation components (A, F) and platforms (E = B + C + D) developed in this project

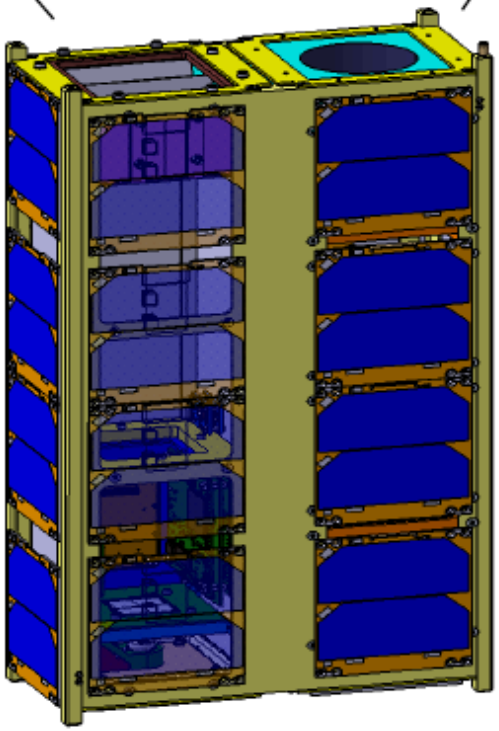
CubeSat microsatellite demonstrator

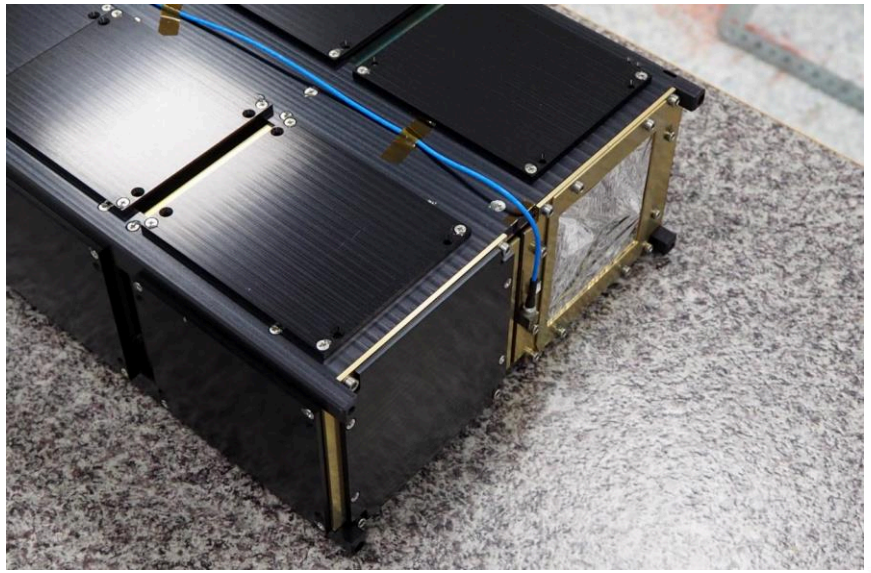
4U SR-CTP 2D LE X-ray telescope demonstrator

8U CubeSat nanosatellite

4U for BUS subsystems



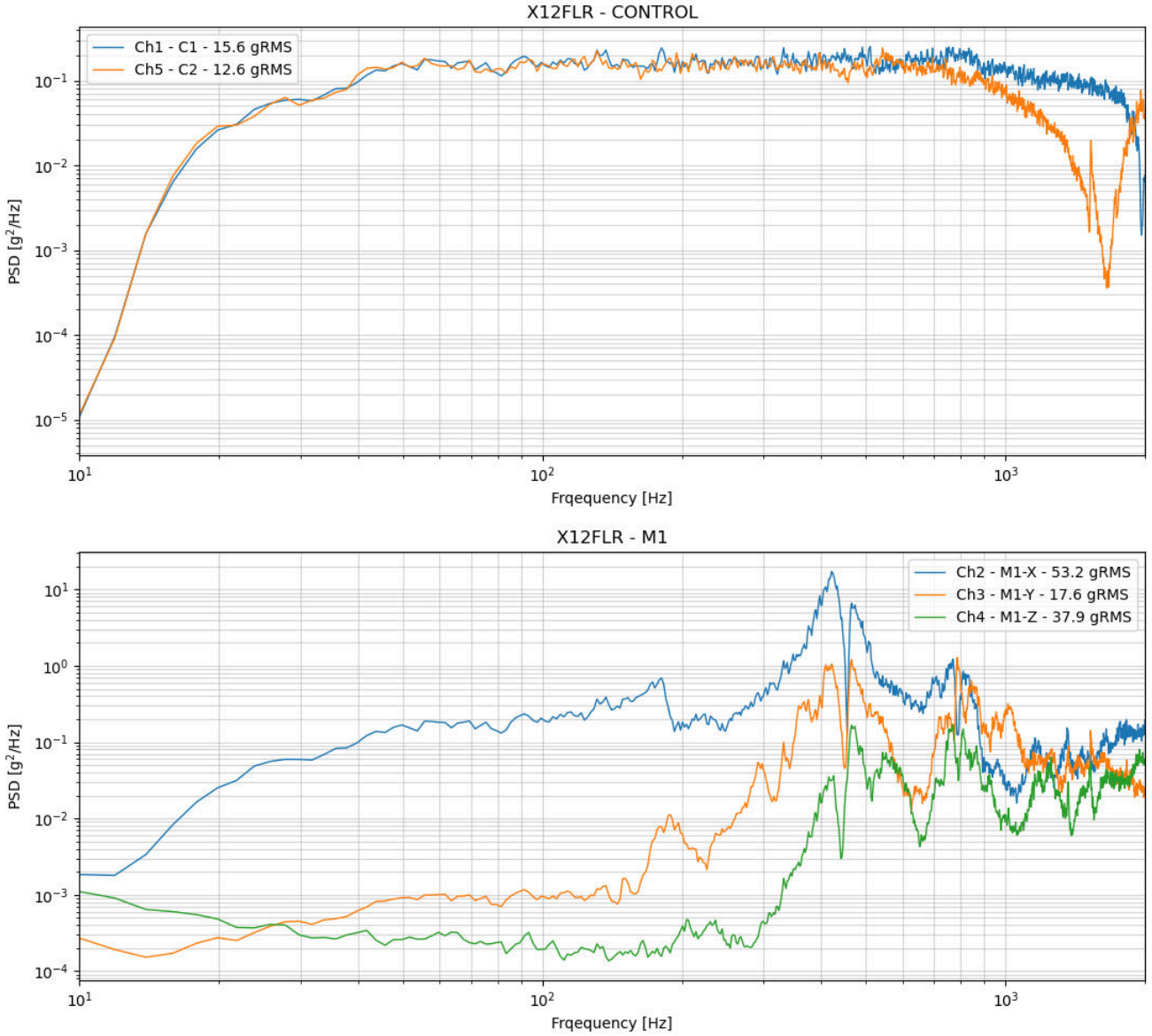


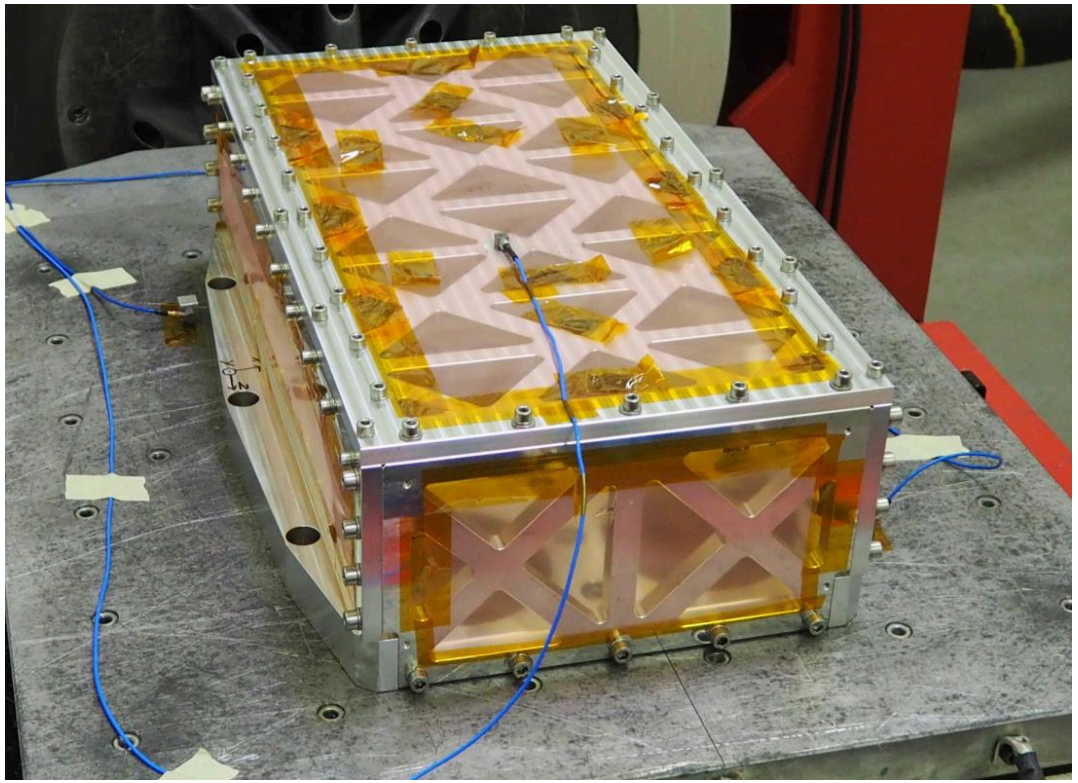


Test campaign

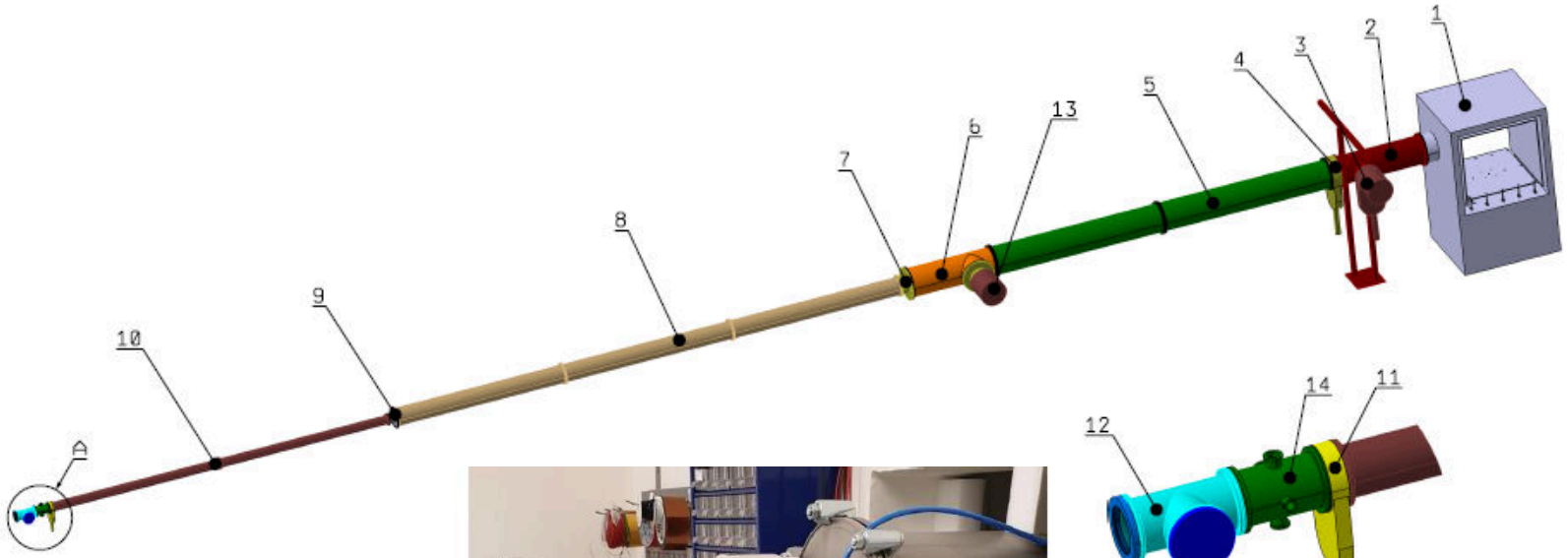
Test	Description	Responsible	Test facility
Physical properties	Mass, CoG	VZLU	
FFT	Full functional test	VZLU/ADV/RITE	VZLU Cleanroom
Radiation performance (Quad #1)	Electrons (8 – 30 MeV)	VZLU/ADV	Electrons, E range 8-30 MeV, Microtron accelerator, Nucl. Phys. Inst. Czech Acad. Sci. Prague
Radiation performance (Quad #1)	Protons (16.5 MeV and 20.8 MeV)	VZLU/ADV	Protons, E range: 16.5 MeV and 20.8 MeV, Cyclotron accelerator, Nucl. Phys. Inst. Czech Acad. Sci. Prague
Vibration (Quad #1)	Launch vibration	VZLU	VZLU Test
Optical and X-ray (Quad #2)	Vacuum tunnel functional performance test	RITE/VZLU	VZLU X-ray tunnel Panter facility (MPI)
Thermovacuum cycling (Quad #1)	P< 10-3Pa, -20 °C to +50 °C	VZLU/RITE	VZLU Cleanroom
RH-SEE (Quad #0)	p, (SEE 200MeV)	VZLU/ADV	Proton Therapy Centre Prague
RH-TID (Quad #1)	Gamma rays (60Co/137Cs)	VZLU/ADV	Nucl. Phys. Inst. Czech Acad. Sci. Prague
FFT	Full functional test	VZLU/ADV/RITE	VZLU Cleanroom

Vibration Test campaign

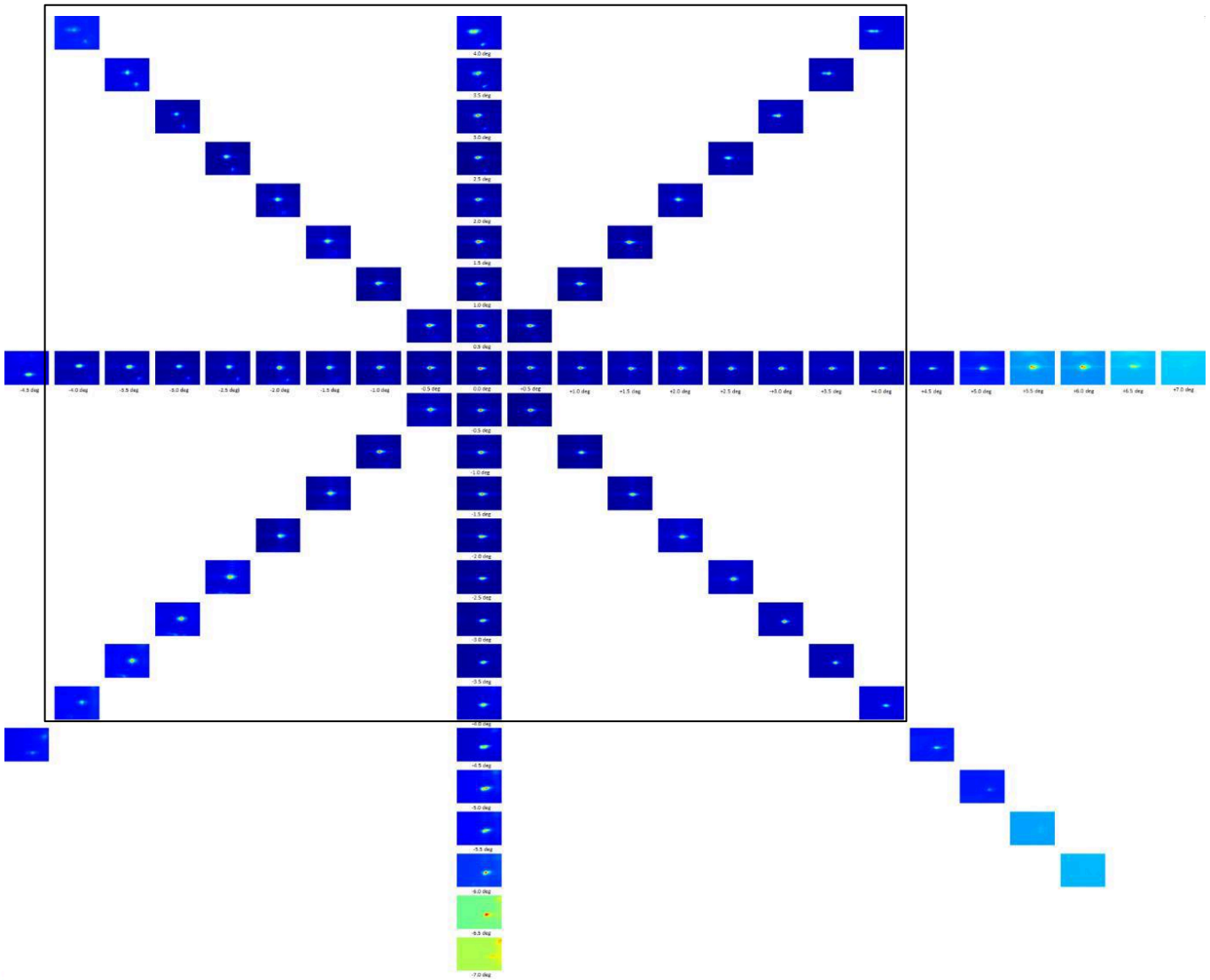


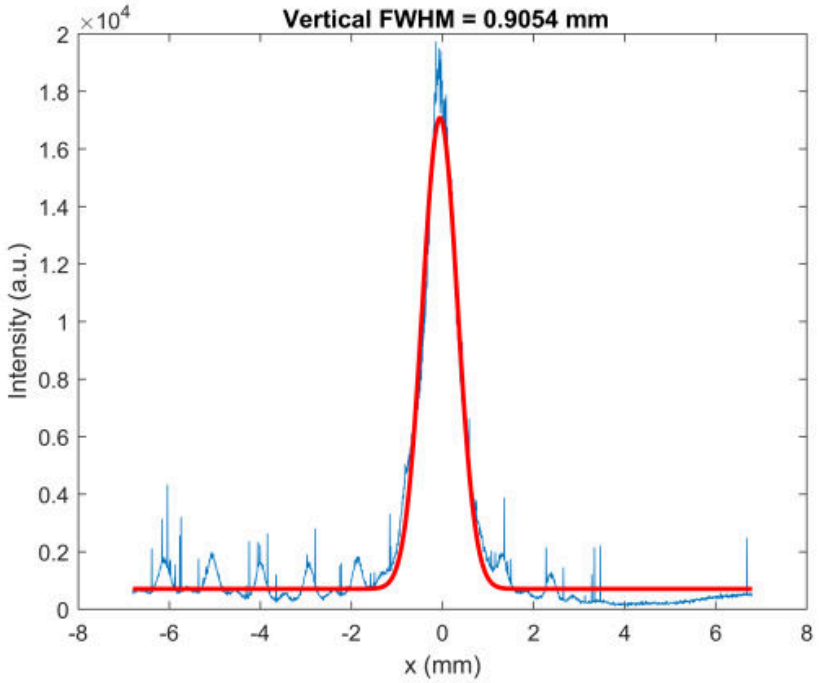


X-ray Test campaign



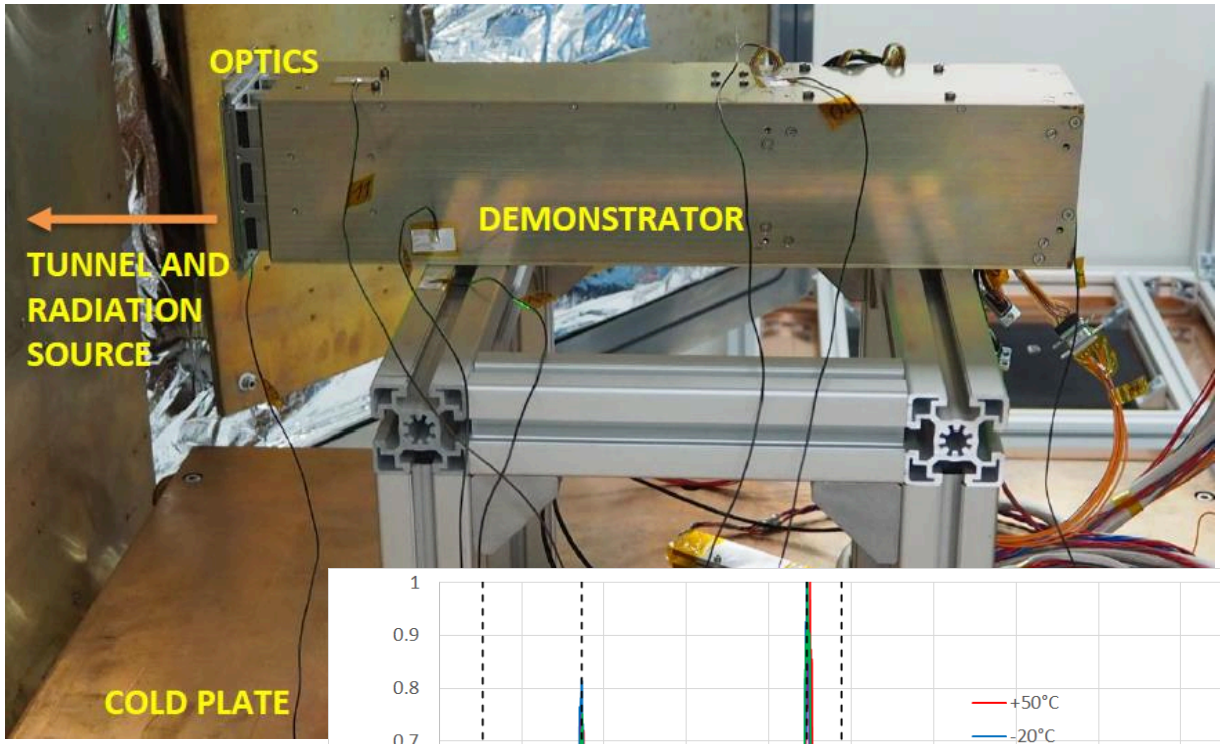
X-ray Test campaign

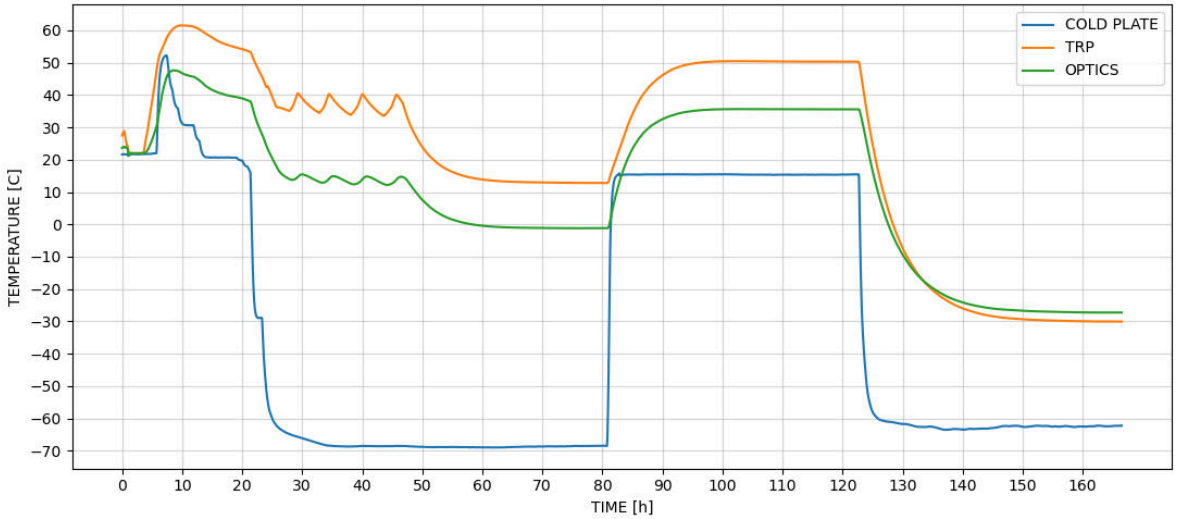


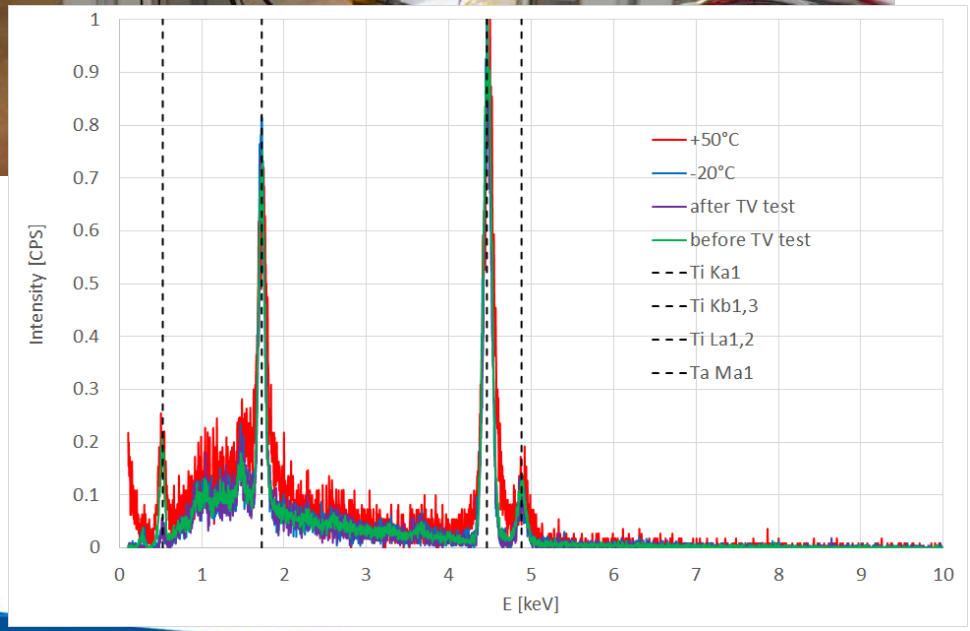


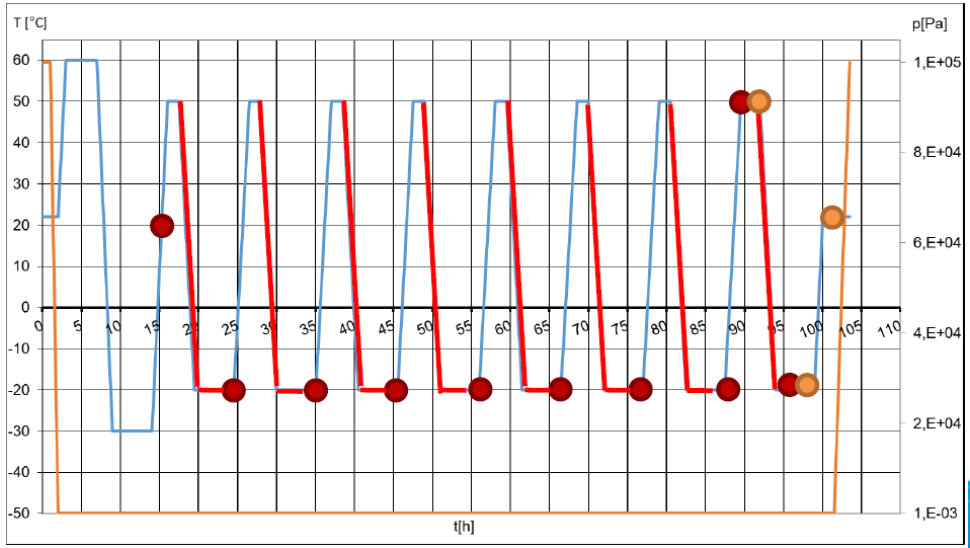
The best 2D image of the focus and vertical profile. The FWHM is 0.9 mm (7.7 arcmin) @ 4.5 keV in the vertical direction.

TVC Test campaign



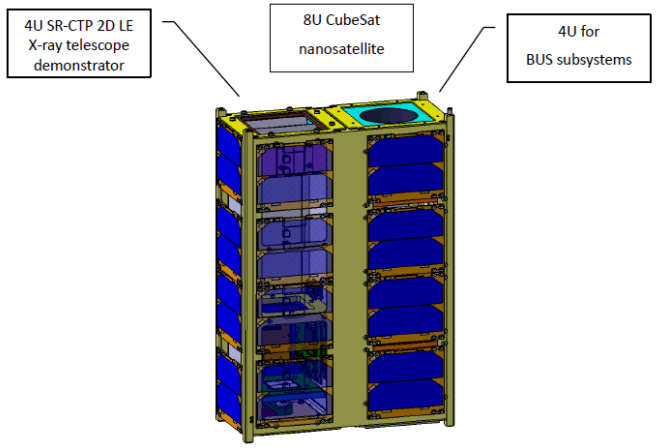


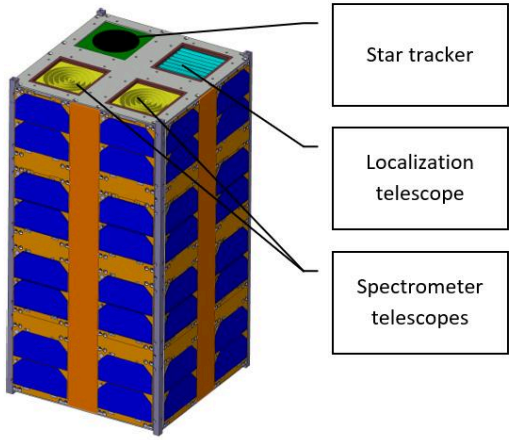




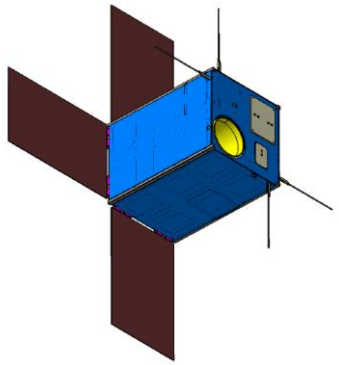
Conclusions/Future plans

X-ray concepts

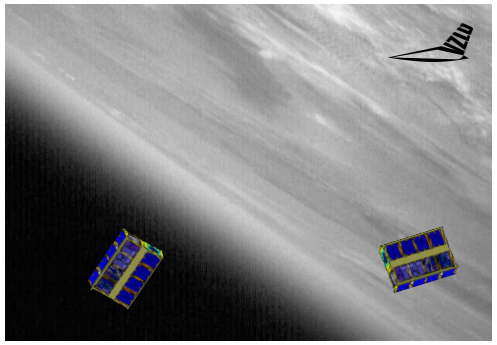




Future VZLU flights

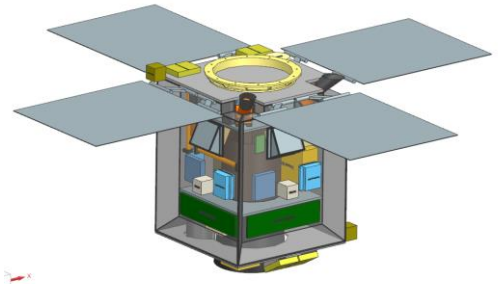


12U EO CubeSat
Launch 2024

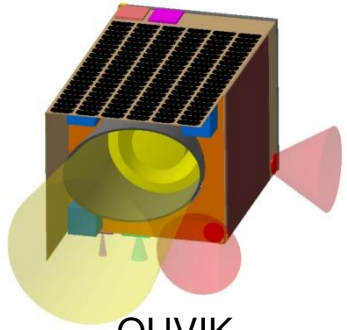


VZLUSAT3A and B
6U IOD CubeSats
Launch 2025-2026

Future VZLU flights under selection



AMBIC
EO microsatellite
Launch 2027



QUVIK
Kilonovae microsatellite
Launch 2027

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