Millimetron Workshop
Paris, September 09-11, 09.2019

Vyacheslav Vdovin

on behalf of the Millimetron consortium

ASC&SCAM (Moscow), ISS (Krasnoyarsk), IAP RAS & NNSTU (Nizh.Novgorod)

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Study of the thermal and electrodynamic characteristics of materials and components of the Millimetron space telescope at helium temperatures

Outline

- Introduction: Millimetron is the **CRYOGENIC** telescope
- Objects for terrestrial cryogen characterization
- Development of cryovacuum cameras for terrestrial tests of Mmron components and materials
- Instrumentations and results of cryo tests:

✓ Reflectivity of materials for passive cooling system of Millimetron,

✓ Reflectivity and thermal conductivity of composite materials of a main mirror of Millimetron, microwave properties

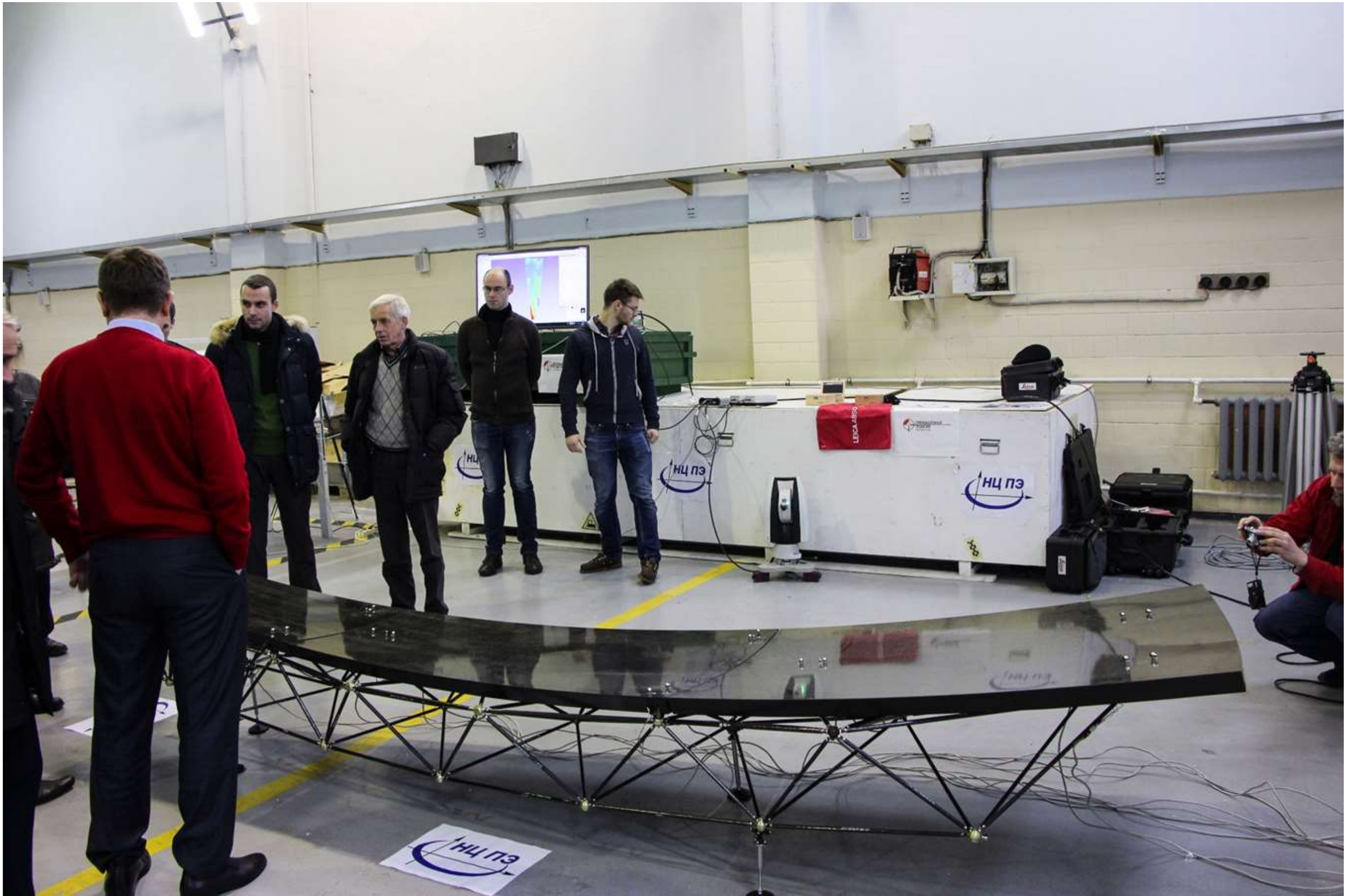
✓ Antenna materials, mechanical & receivers components tests

✓ Vibrations of mechanical coolers & temperature fluctuations of mechanical coolers and methods of their minimizations

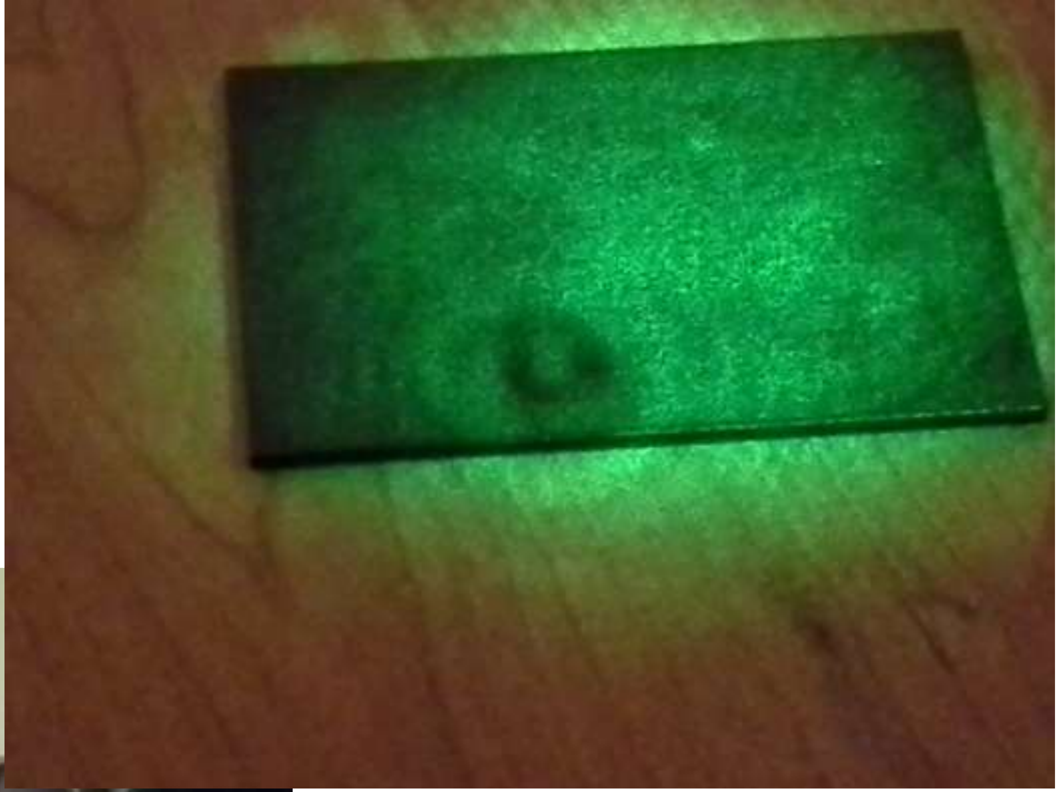
- Conclusion

Different materials & components: scaled models, actuators, hexapods, films, detectors, ect.

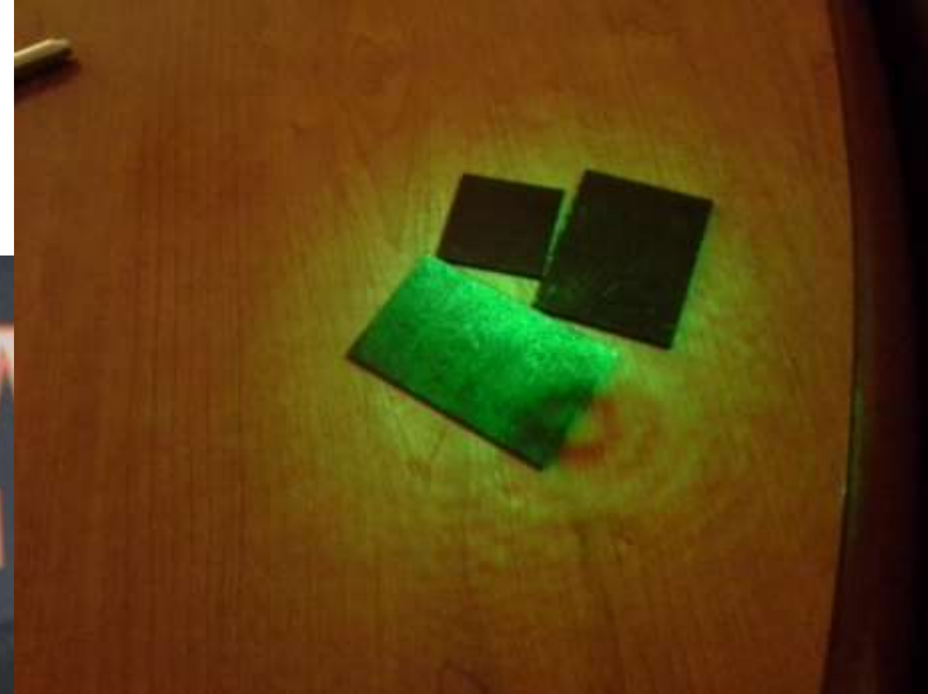
How to cool it down 4K & characterize?

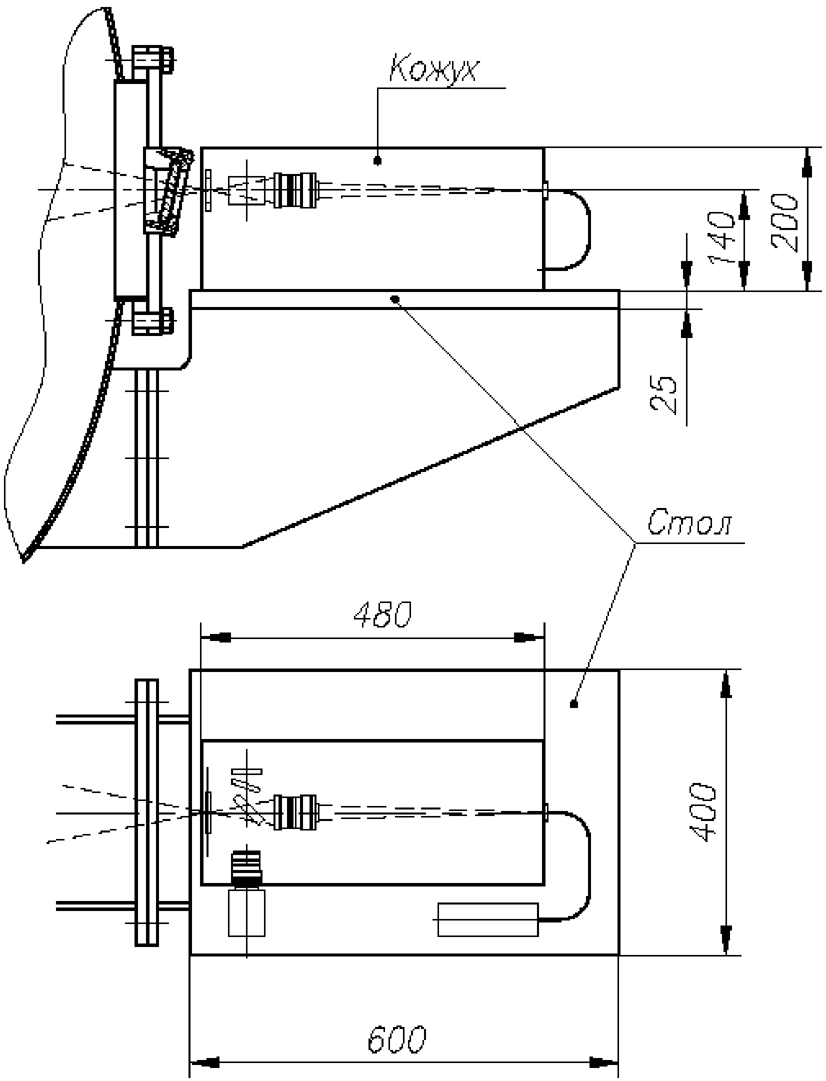


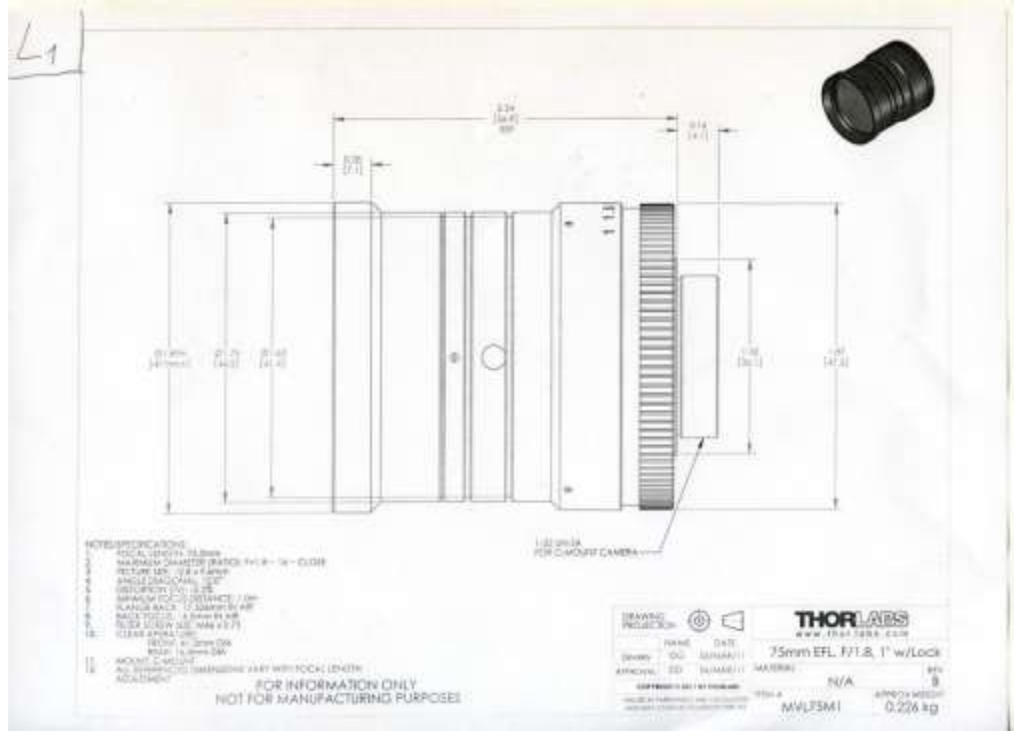
Speckles

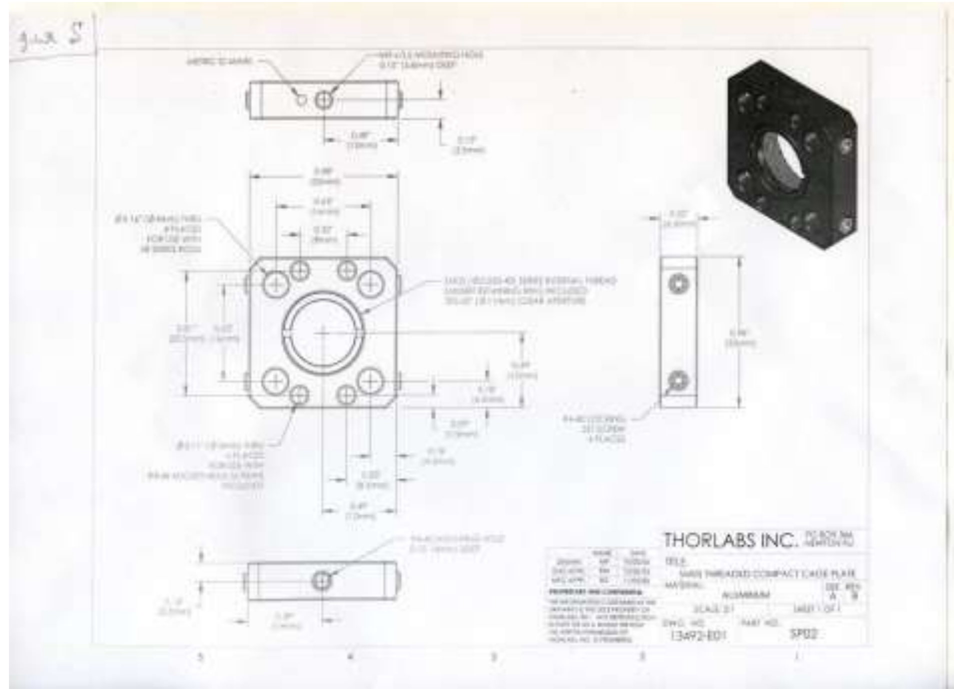


Sufficient scattering for
speckle interferometry

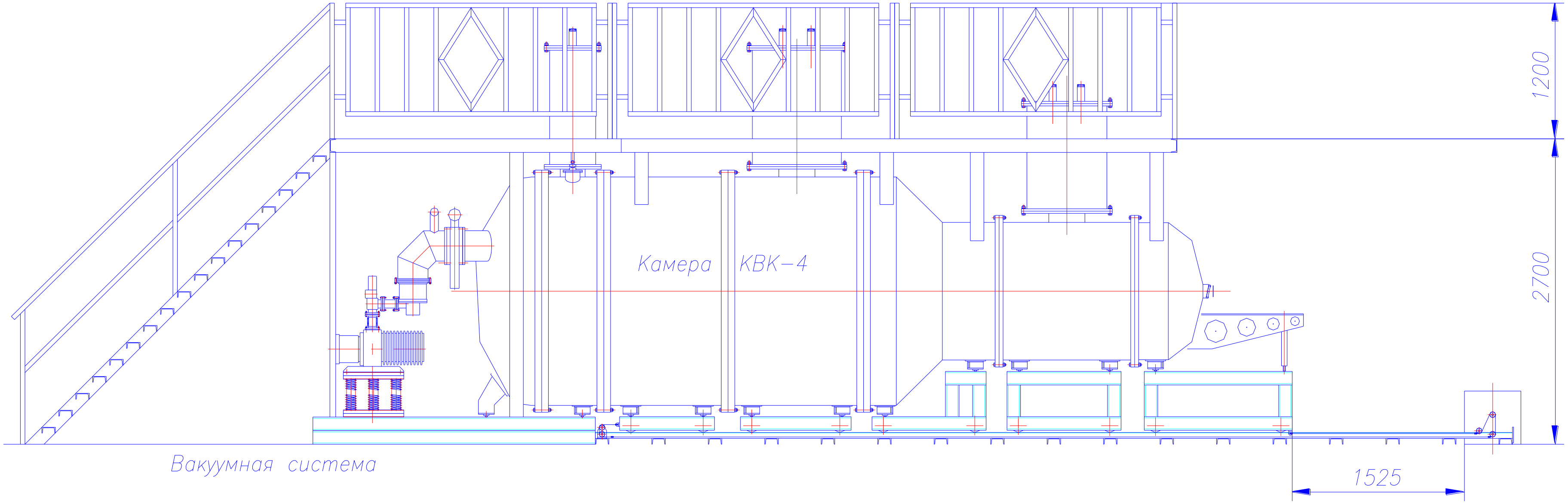



Кожух
Стол
140
200
25
480
400
600

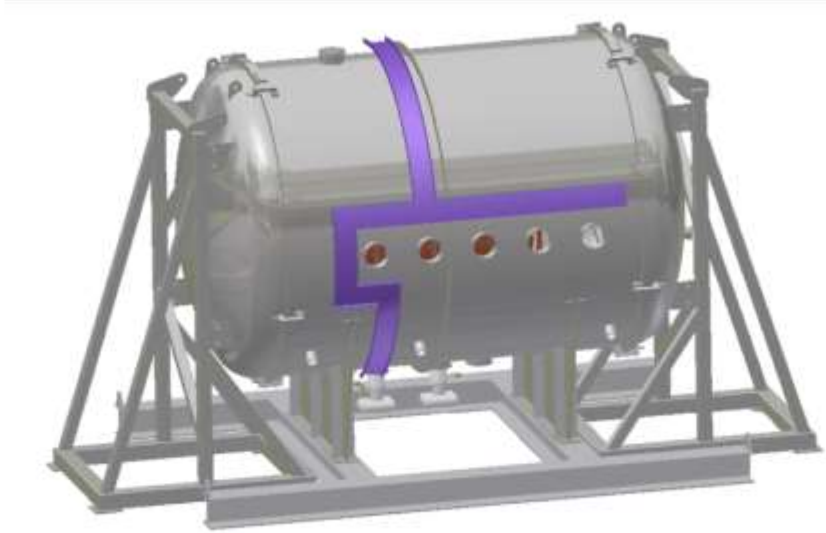

L1
FOR INFORMATION ONLY
NOT FOR MANUFACTURING PURPOSES
THORLABS
75mm EFL, F/1.8, 1" w/Lock
N/A
MVL75M1
0.226 kg

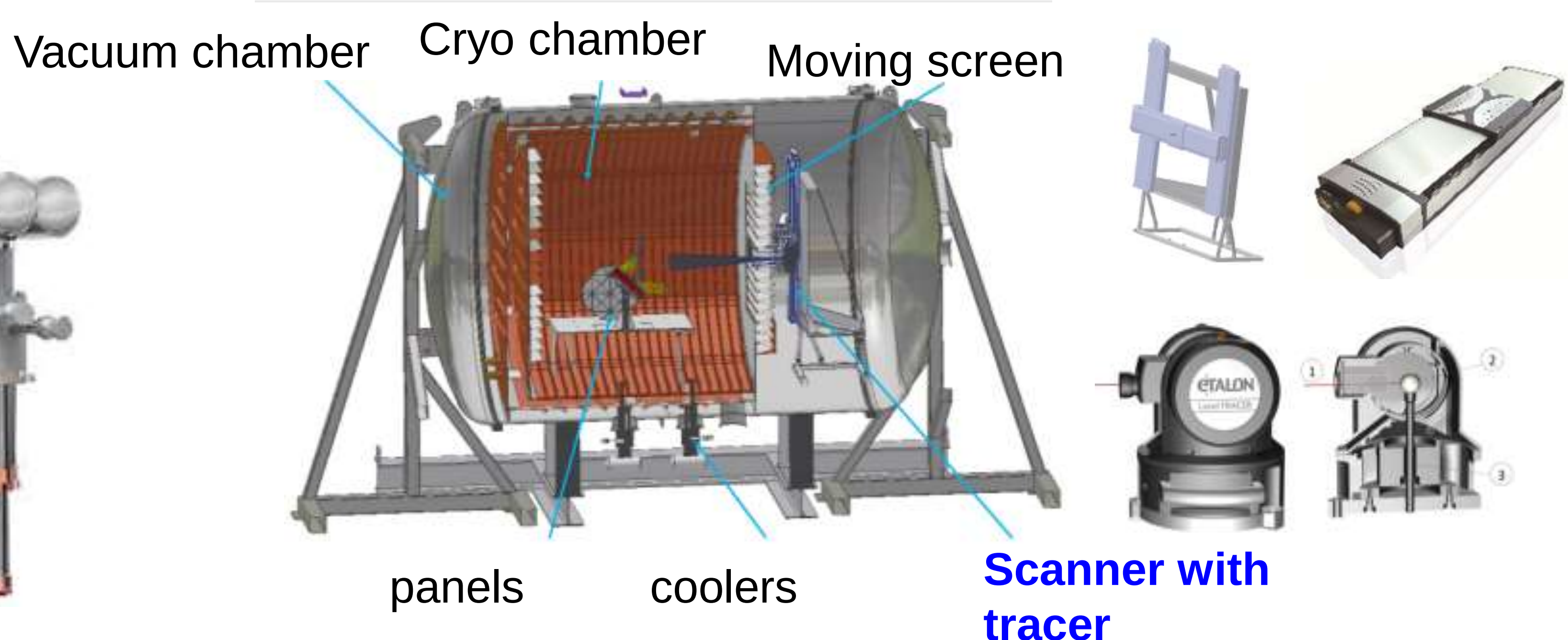

THORLABS INC.
13492-E01
SP02

15 m^3 4K vacuum camera for speckle interferometry of Mmron panels



New equipment and methodology of a characterization of new panels



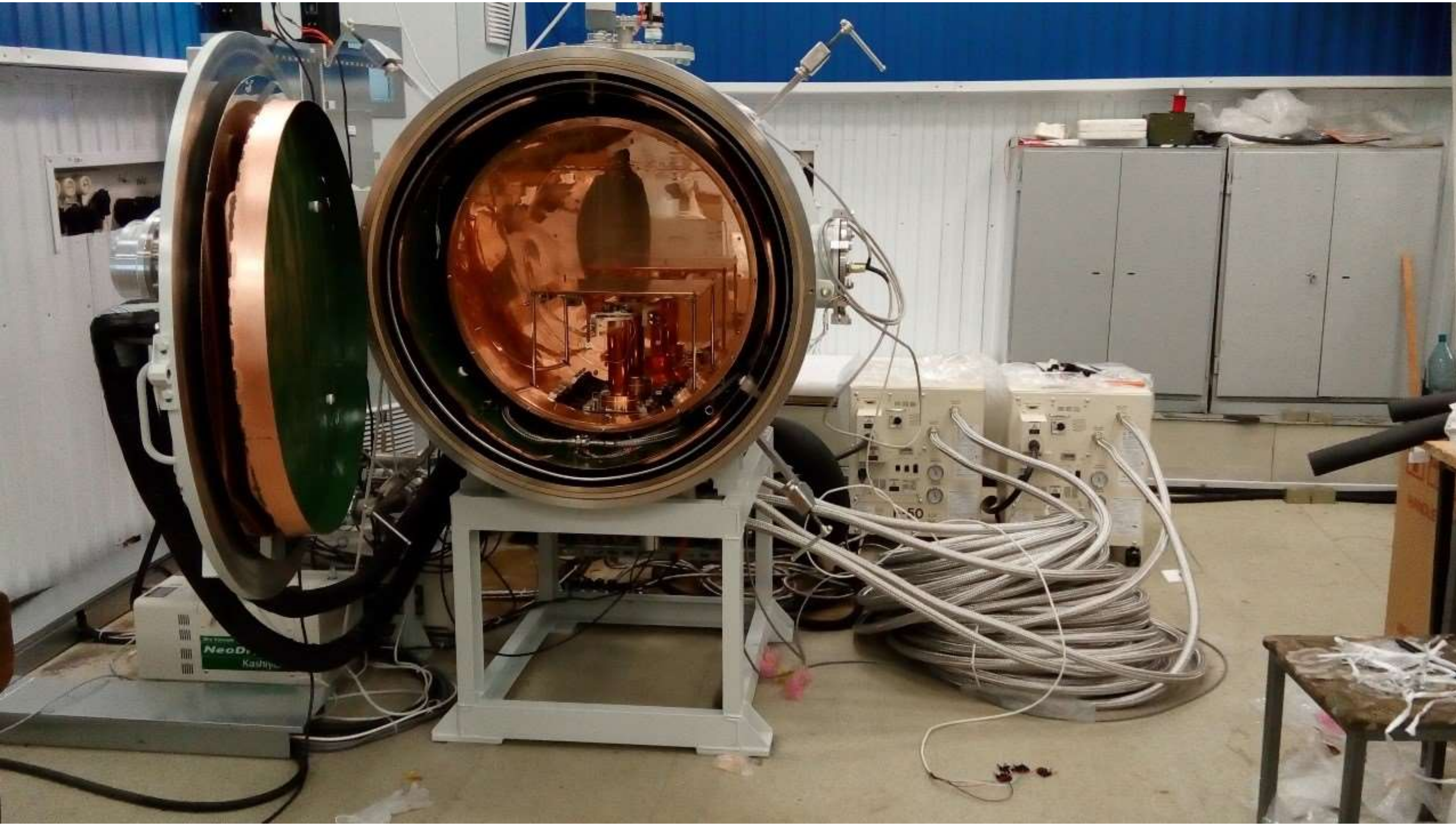


What camera should be used for Mmron components ?

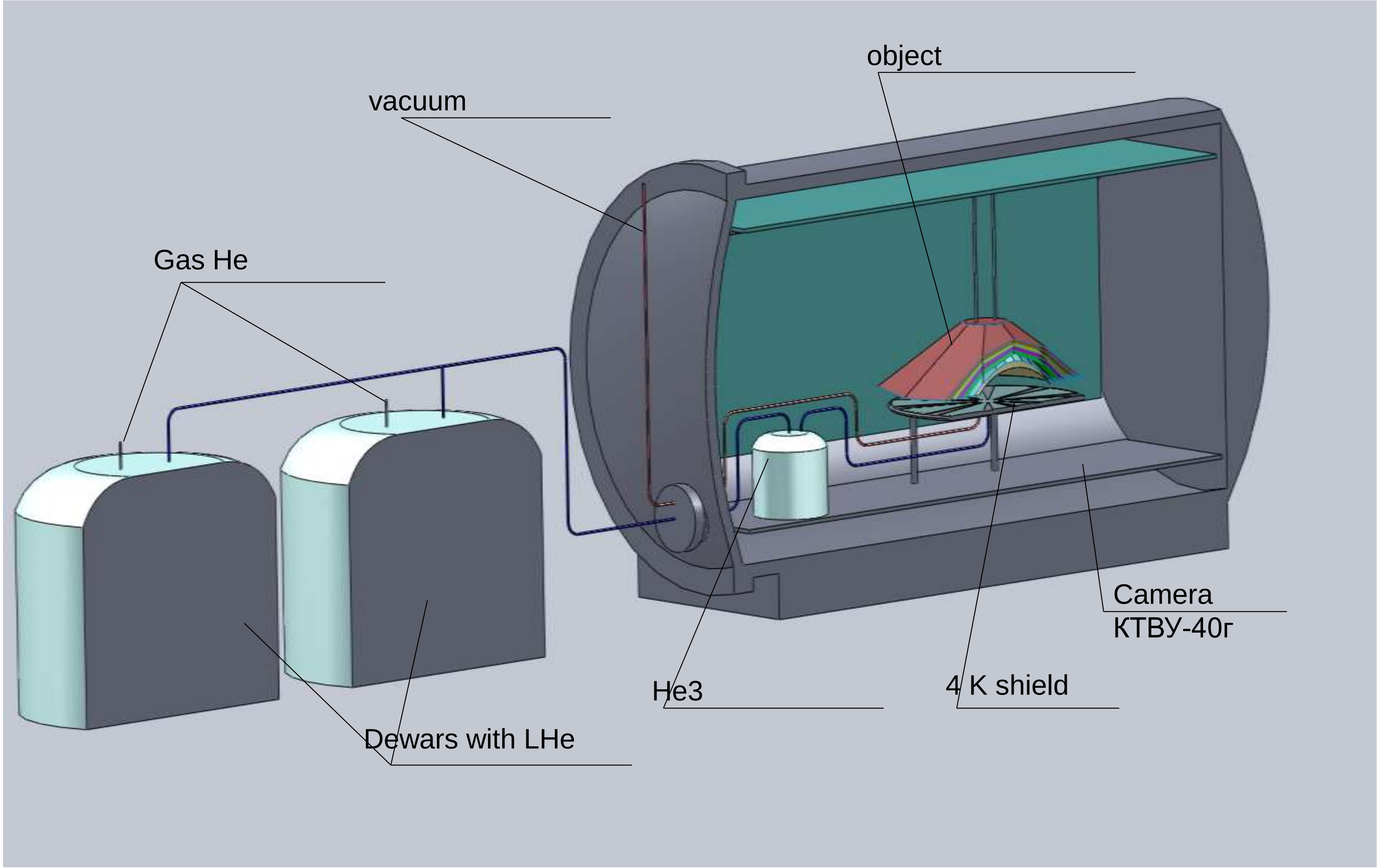
ISS already have and developing now some Cryovacuum cameras

ISS n.a.Reshetnev: Ø700x700 mm
3 -300 K

With Cryotrade Co



Projected ISS cryovacuum camera



IAP RAS & NNSTU have some cameras different dimensions and temperatures including 4K & SubK levels

70K

4 K

0.3 K

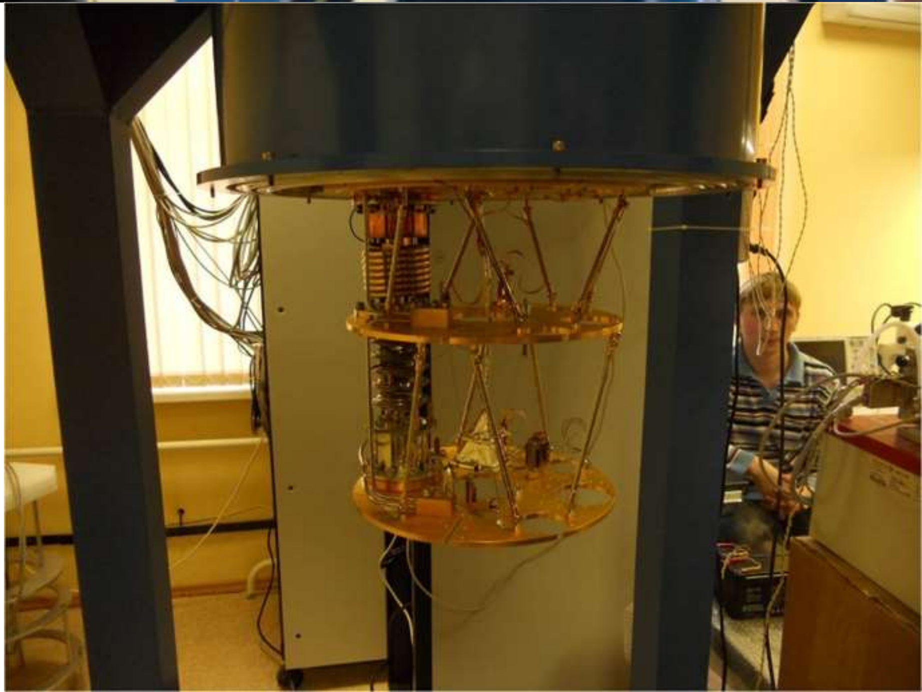

bucket

Triton-200 Oxford Instr.

- <10 mK
- LHe free

+ 0.3 K Oxford System

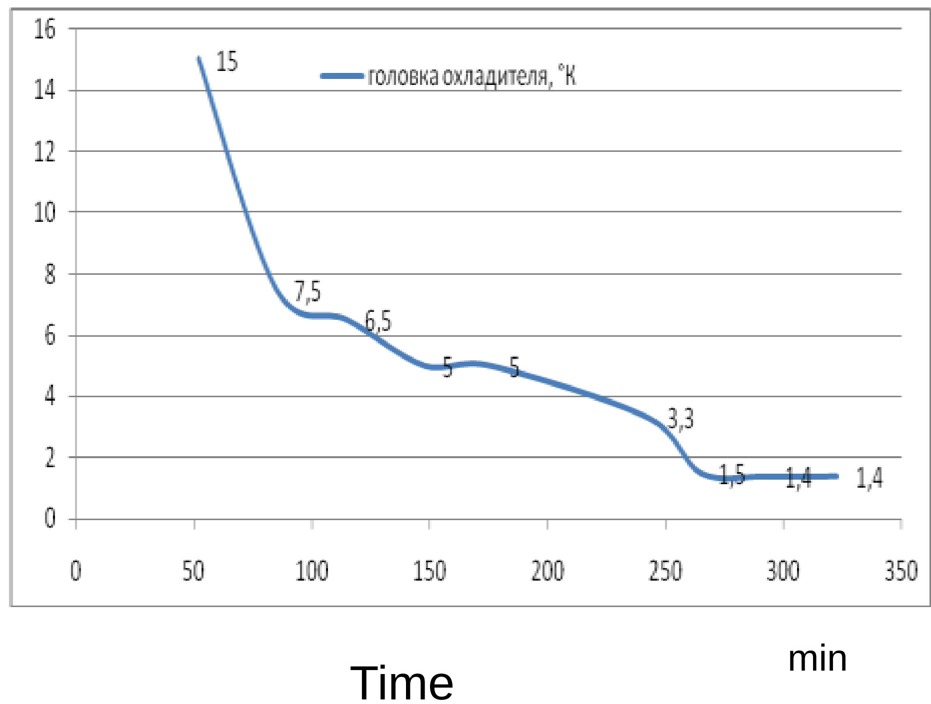
for SC bolometric receivers



4K Camera for cryo THz tests (barrel)

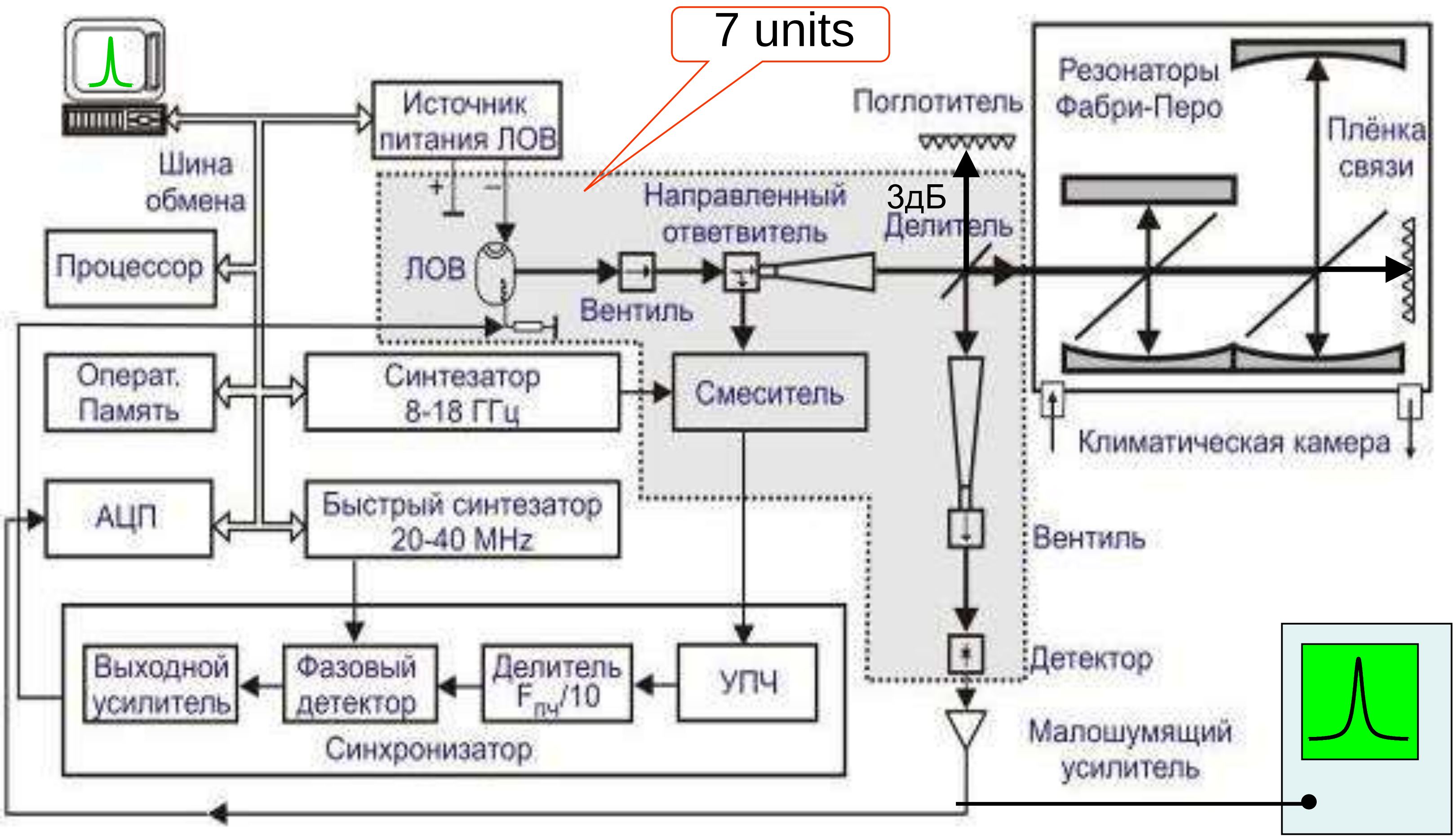
Cryovacuum camera with P 10^{-4} mBar.
Leakage less then 10^{-1} mBar / week

T phys (Janis SRDK-415D) **= 1.4 K.**
Quasioptical windows for THz



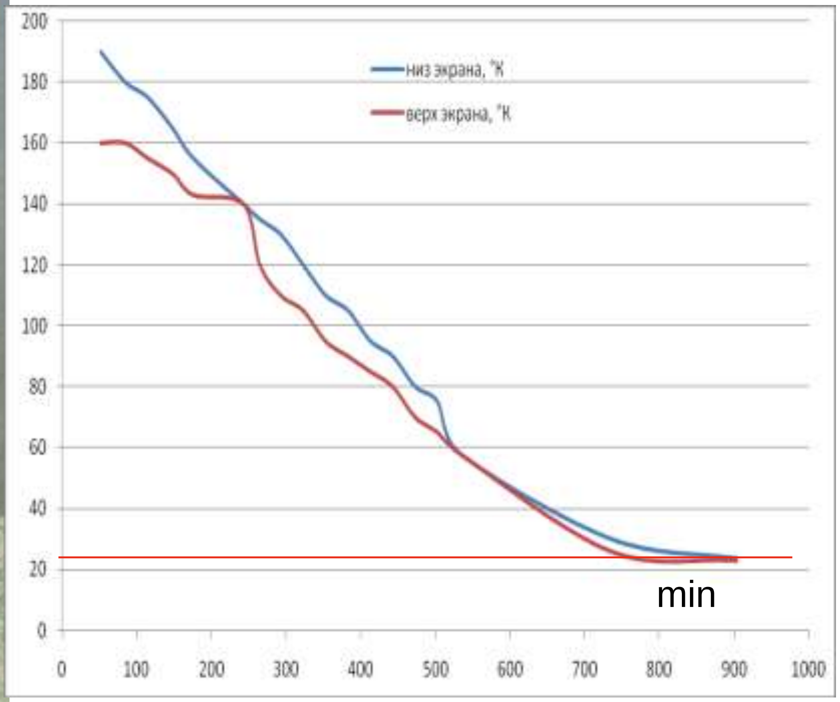
4K cooling system for MM & SubMM tests

Fabry-Perrot 36 – 520 GHz spectrometer



$$S(f) = \left[\frac{A_0}{\Delta f^2 + (f - f_0)^2} \right] \cdot \left[1 + A_1 (f - f_0) \right] + A_2$$

Resonator & Radiation shield



dT less then **0.5 K**.

Materials for cryogenic antenna & radiation screens

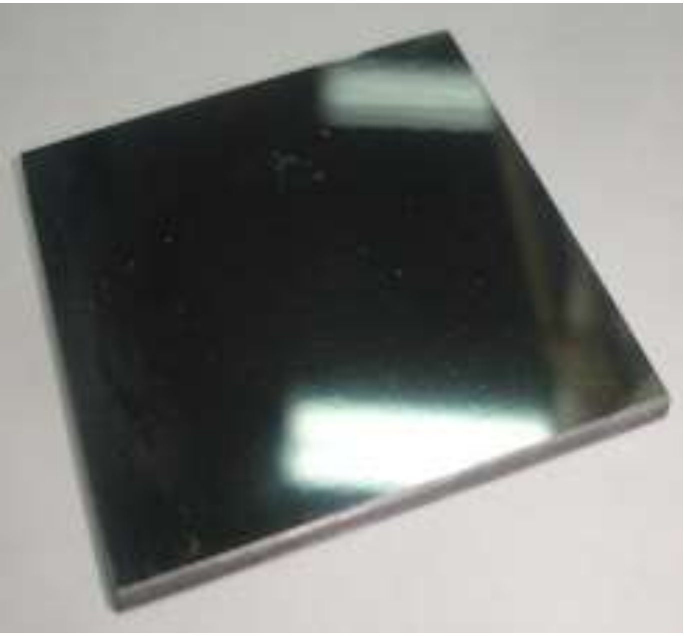
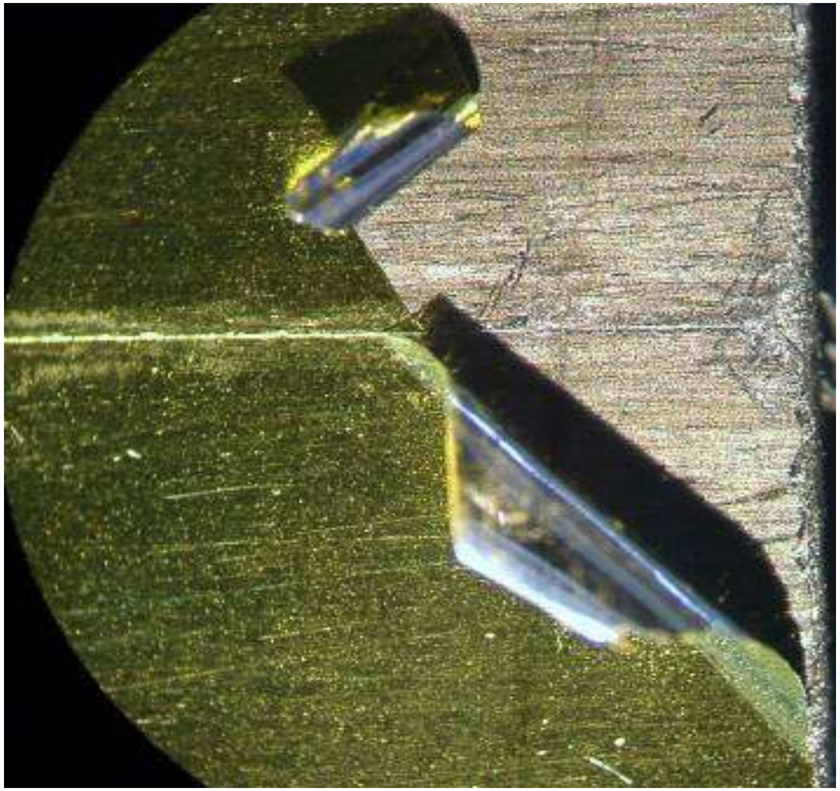
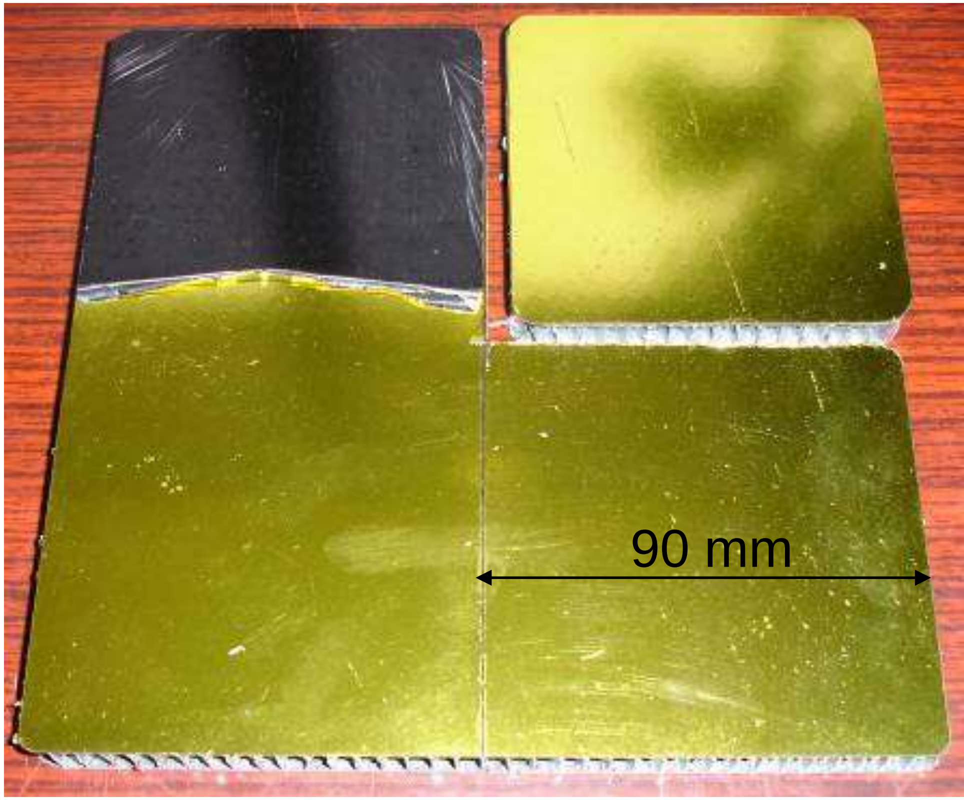


Рис.1 Фото образца №4 в рамке.

Metalized carbon fiber for THz antenna

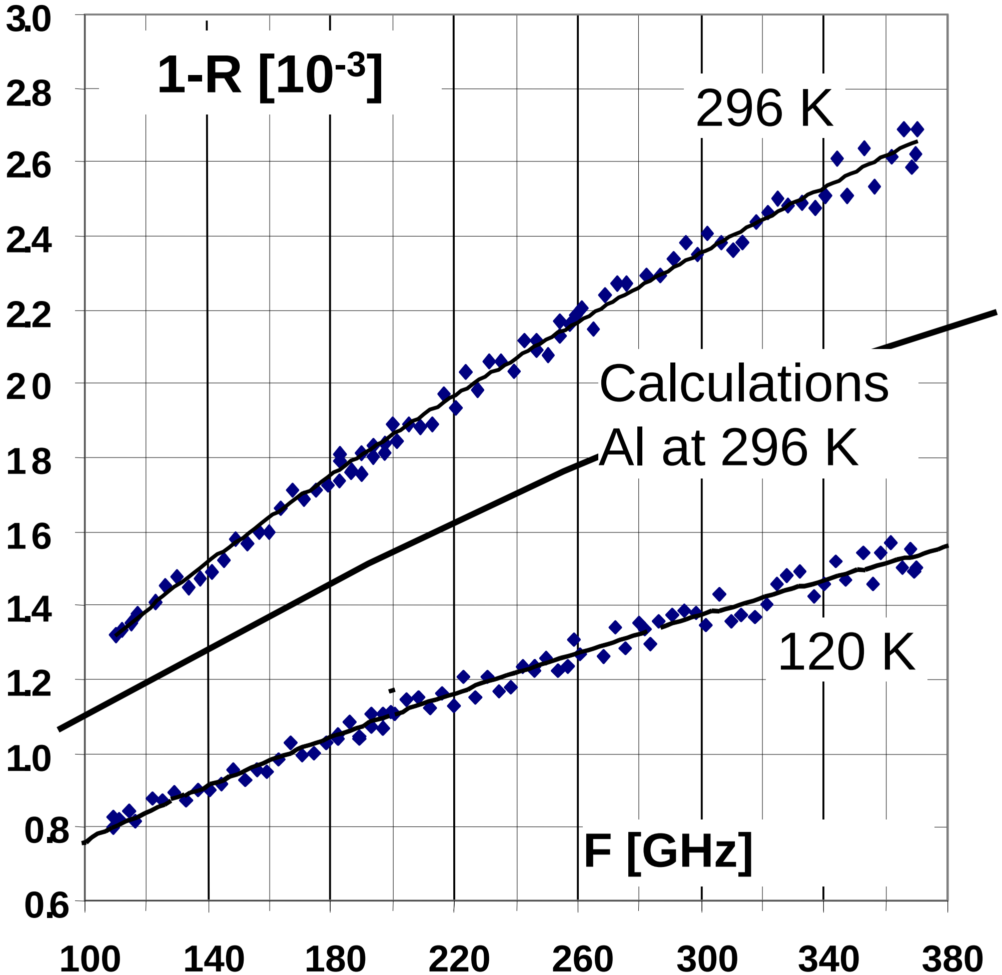
Reflectivity Losses 3% - 4% (fibers are along E)
+ addition 30% losses when fibers are along H.

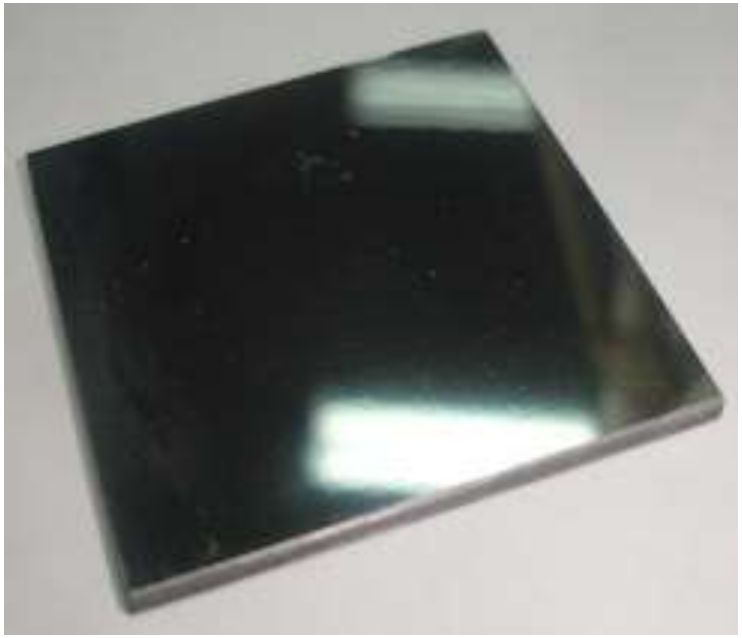




Some results (similar with works for Plank project but T is 4 K)

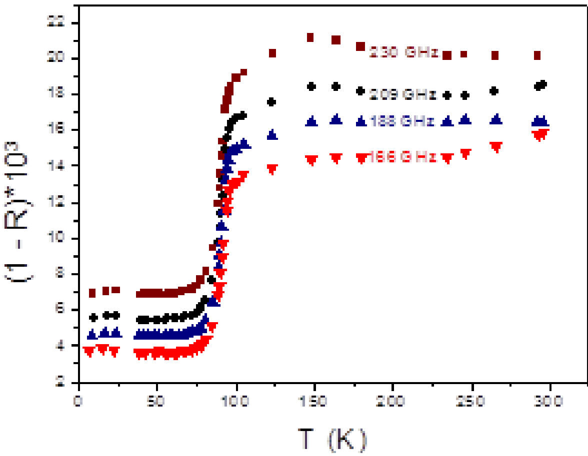
There are some recommendations for designers of the Millimetron have been formulated also

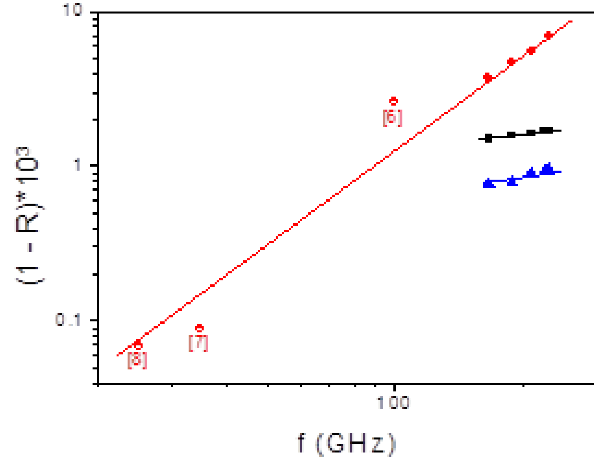




«

HTSC mirror





The reflection loss temperature dependence of $YBa_2Cu_3O_{7-d}$ at different frequencies.

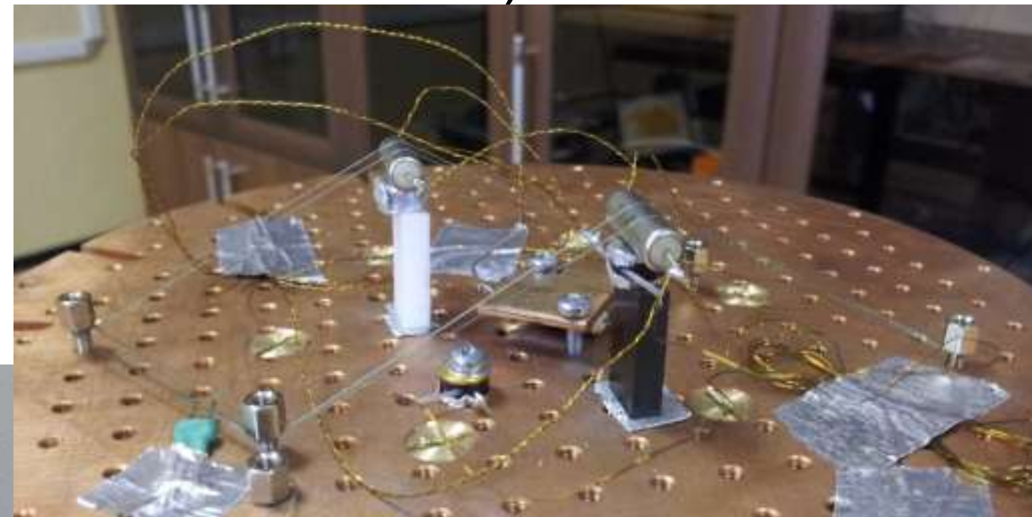
The reflection loss temperature dependence of $YBa_2Cu_3O_{7-d}$ at different frequencies.

The reflection loss frequency dependence at T = 4.2 K. Red solid circles correspond to the data taken in the present study, the red line is the extrapolation with the ~ f^{2} function. Blue triangles and black squares correspond to the oxygen free copper (0.9994), data taken at 4.2 K and 296 K, respectively. Blue and black solid lines are the extrapolations by the $f^{0.5}$ function. The semifilled circles correspond to the data points measured at lower frequencies.

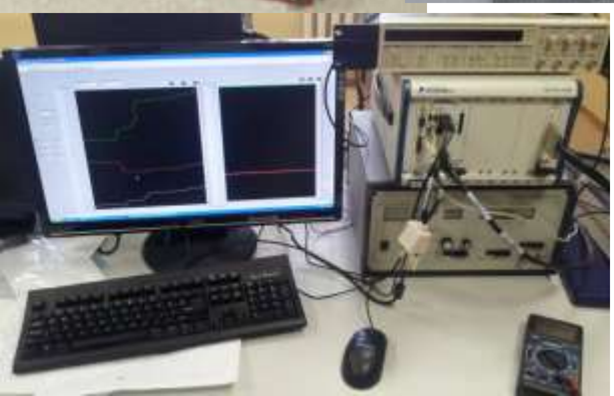
Measurements of thermal conductivity of carbon fiber composite material (main mirror of Millimetron) in the “bucket”

Crymech
Pfeiffer
Lakeshore
CCN hard&soft

$\lambda = Q\,L / S\,(T_1 - T_2)$



P, W	T_1, K	T_2, K	ΔT, K	λ, W/Km
0,0016	25,50	4,14	21,36	0,031
0,0025	27,70	4,15	23,54	0,045
0,0036	30,11	4,17	25,93	0,059
0,0049	32,24	4,19	28,04	0,074



Thermal conductivity have been measured at 40–4K, and recommendations for designers of the Millimetron have been formulated

Cryo actuators problem

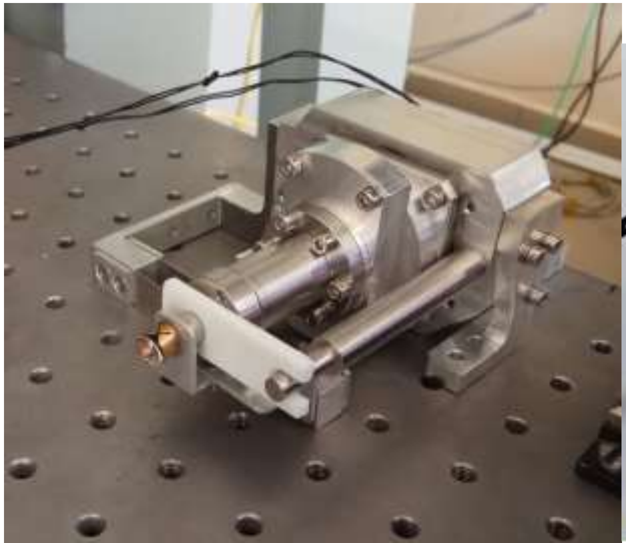
MOOG

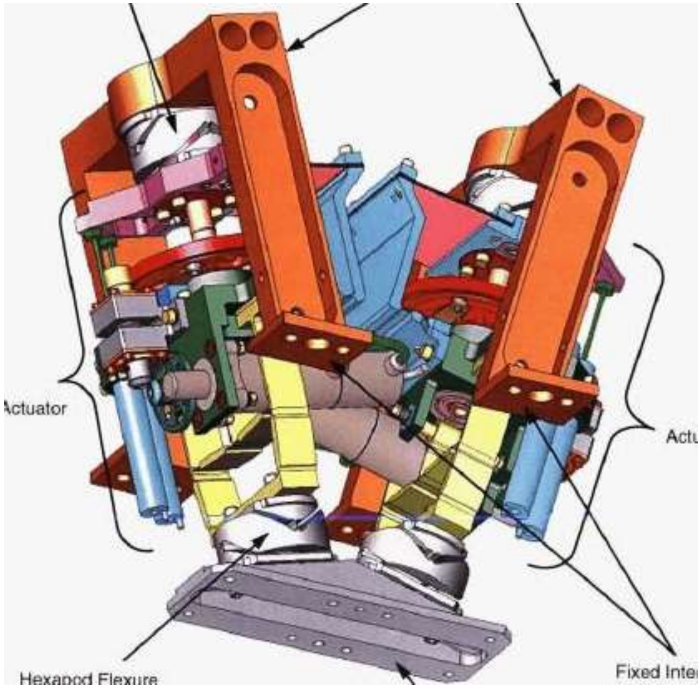
LIDAX

JPE

Requirements:

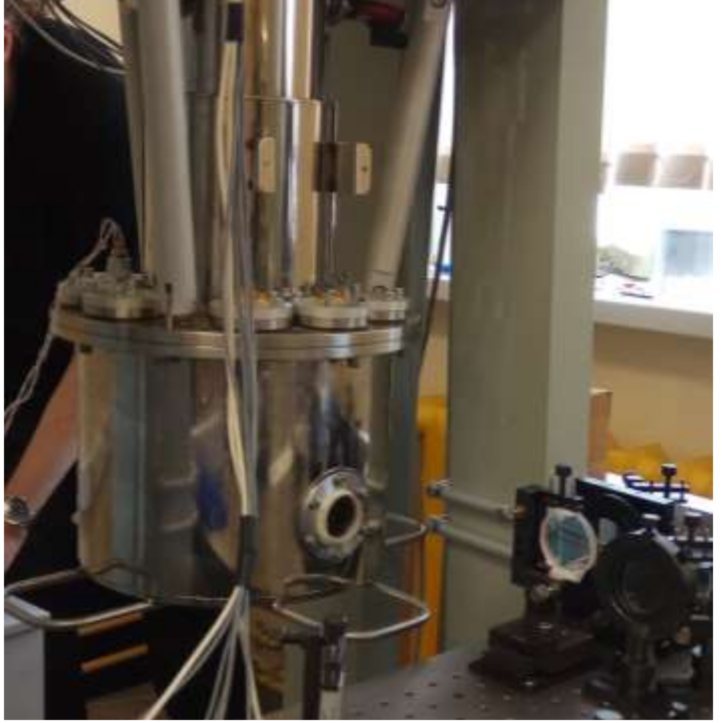
- F	~50 H
- Step	≤ 1 um
- Moving length	± 1 mm
-T	4…293K

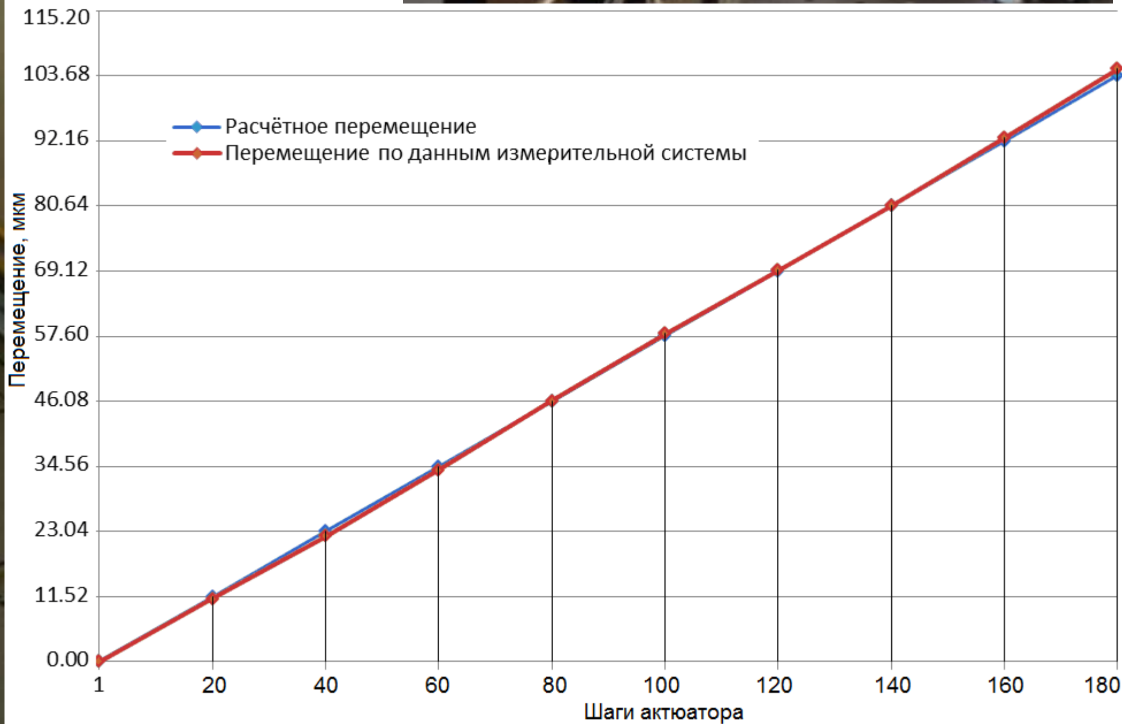


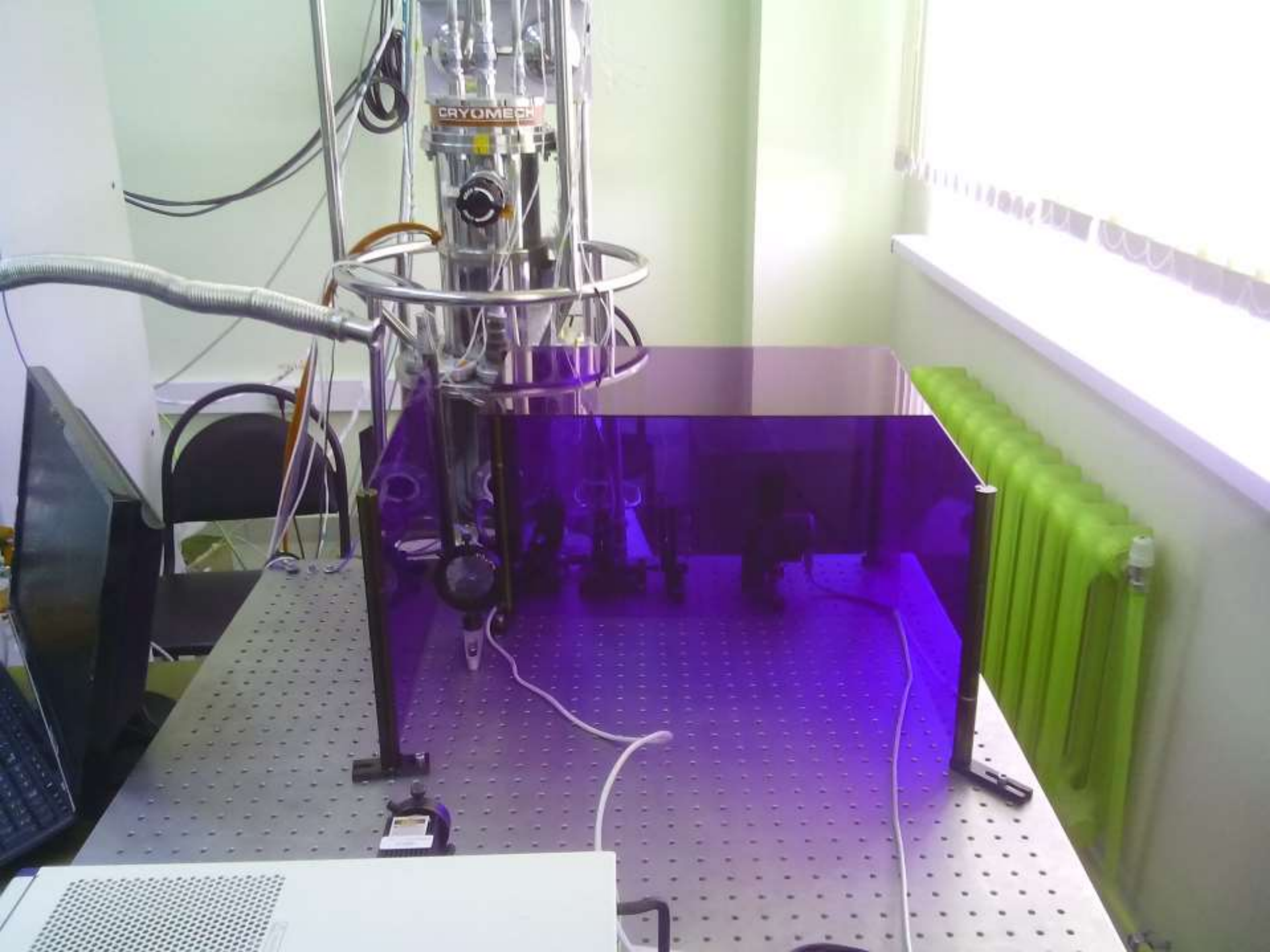


JWST actuator
Phytron

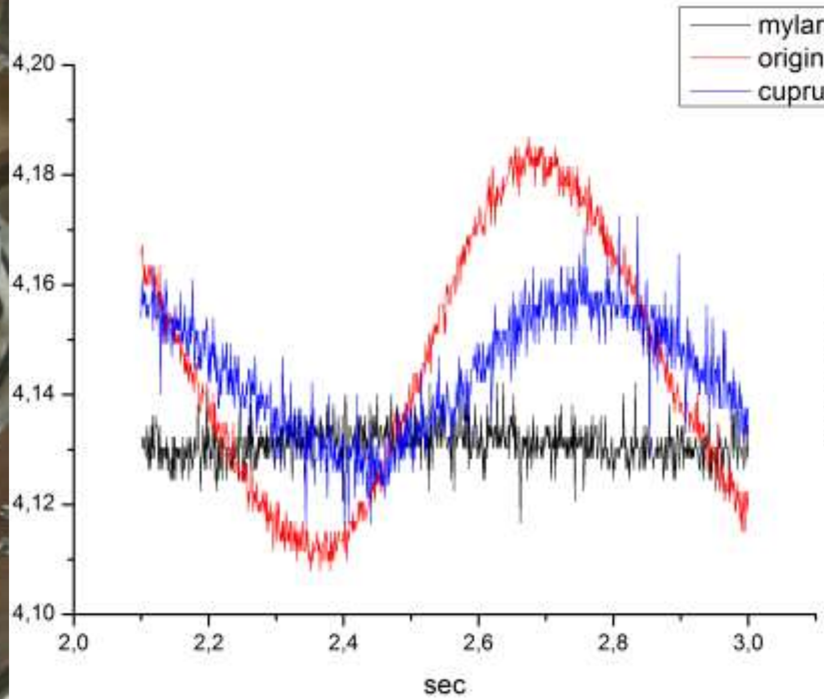
Cryo tests of actuators (bucket)

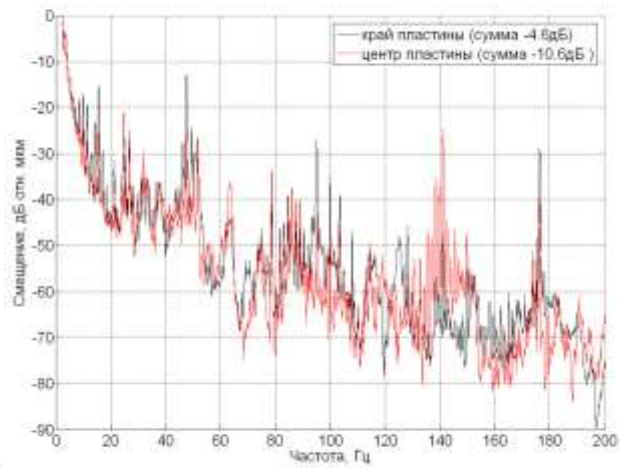


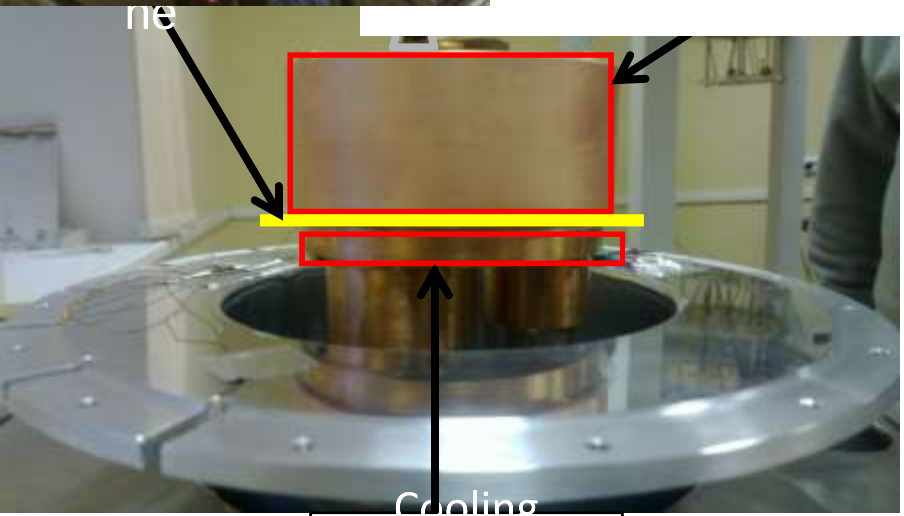


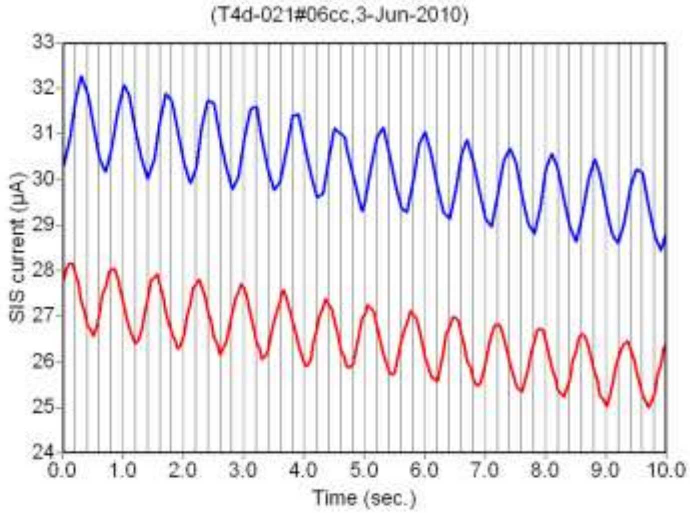

CRYOMECH

Thermal & vibro stability measurements and T- stabilization & vabration damping









Conclusion:

1.Leica LTD600 system (combination of a tracer and interferometer) controlled linear drifts with accuracy ~1.0-1.5 um with vacuum window and working cooler with vibration RMS ~15 um

2.Confirmed Accuracy < 0.6 um

3.Confirmed Repeatability ~1.0-1.5 um

4. Measured this actuator:

General conclusion:

1. There are developed and are in a process of development series of cryo – vacuum cameras, equipped for characterizations of material's and component's performances of the Millimetron cryo telescope and its instrumentation at cryogen temperatures.
2. Optical, mechanical, microwave and thermal performances of materials and components have been measured and some recommendations for designers have been formulated based on presented measurements

Thank you for your attention!