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6th International Symposium “METROLOGY OF TIME AND SPACE"

PHYSICAL PACKAGE FOR ON BOARD PASSIVE HYDROGEN MASER FOR GLONASS MISSION (DESIGN AND EXPERIMENTAL RESULTS)

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Technical requirements

Relative frequency stability: 1s – <7e-13
100s – <7e-14
1day – <5e-15
freq. drift - <1e-14/day

- Mechanical strength: static >10g
shocks >150g
vibration >10g
- Size/weight: 180mm x 360mm x 560mm/ 25kg
- Power consumption: 35 W
- Life time: 13.5 years
- Possibility to operate both in vacuum and under atmospheric pressure

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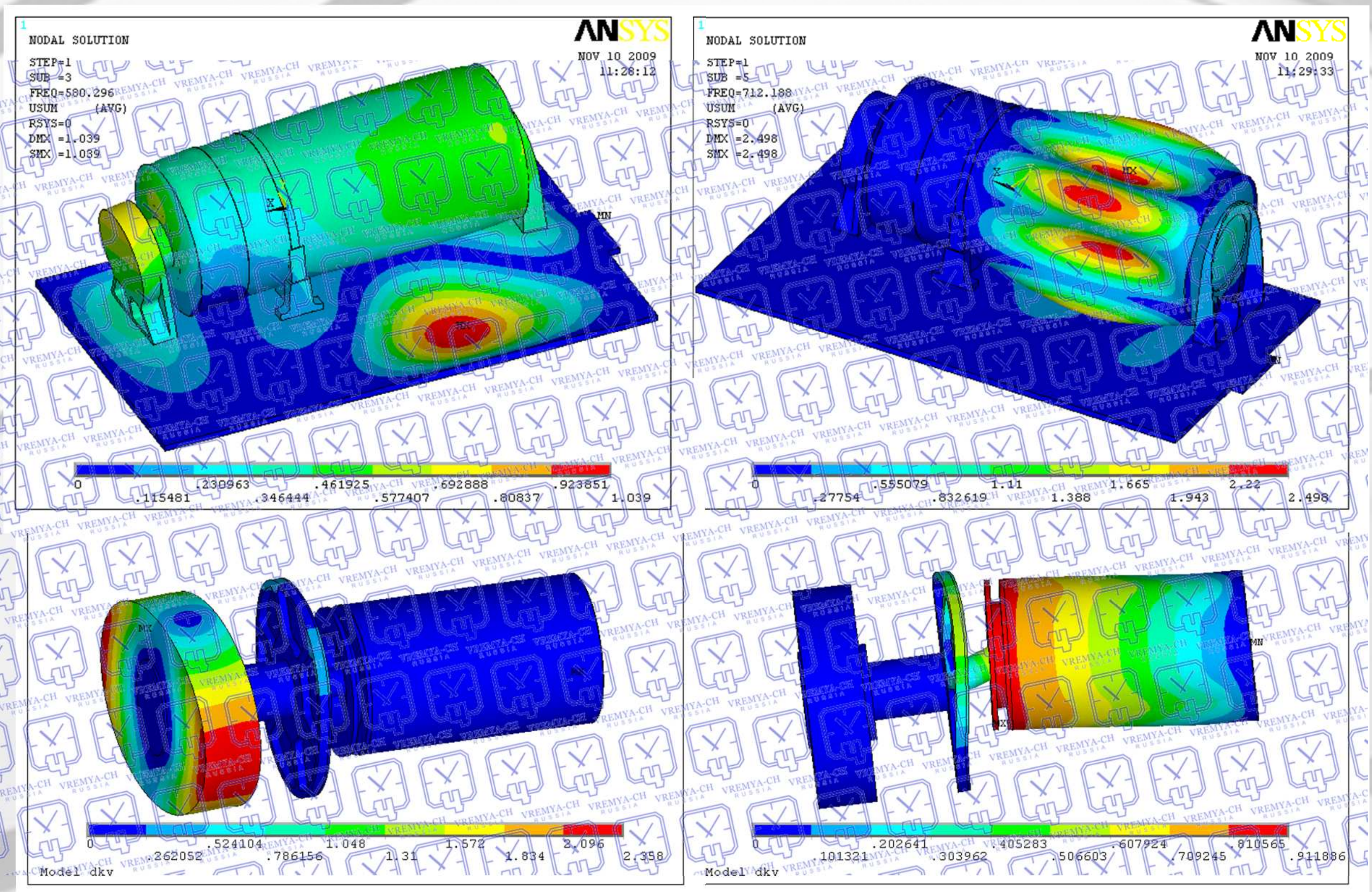
The main problems, necessary to be solved

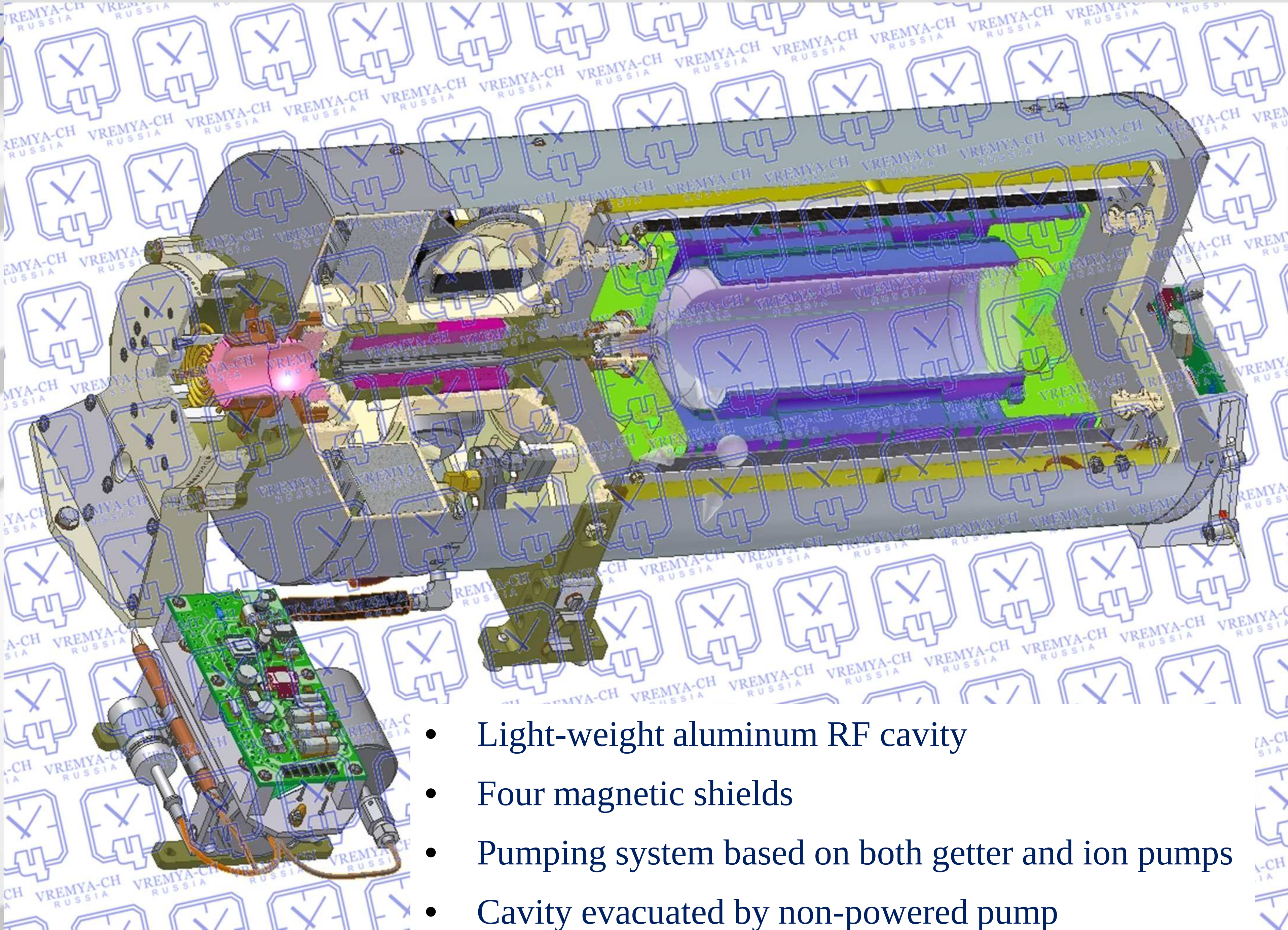
- Increase of mechanical rigidity
- Increase of guaranteed lifetime of unattended operation
- Correspondence to specifications both when operating in the air and in vacuum
- Short time period for developing (about 2 years)

Mechanical tensions modeling



Nodes: 33447

Elements: 17431



- Light-weight aluminum RF cavity
- Four magnetic shields
- Pumping system based on both getter and ion pumps
- Cavity evacuated by non-powered pump
- Extremely strong architecture

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Limitations in time of unattended operation

	Requirements	Theoretical estimation	Experimental estimation
Quantity of molecular hydrogen (40 litre* bar)	13,5 years	20 years	> 17 years
Absorption ability of the getter pump (40 litre* bar)	13,5 years	17 years	> 18 years
Lifetime of ion pump	13,5 years	18 years	Impossible to fulfill

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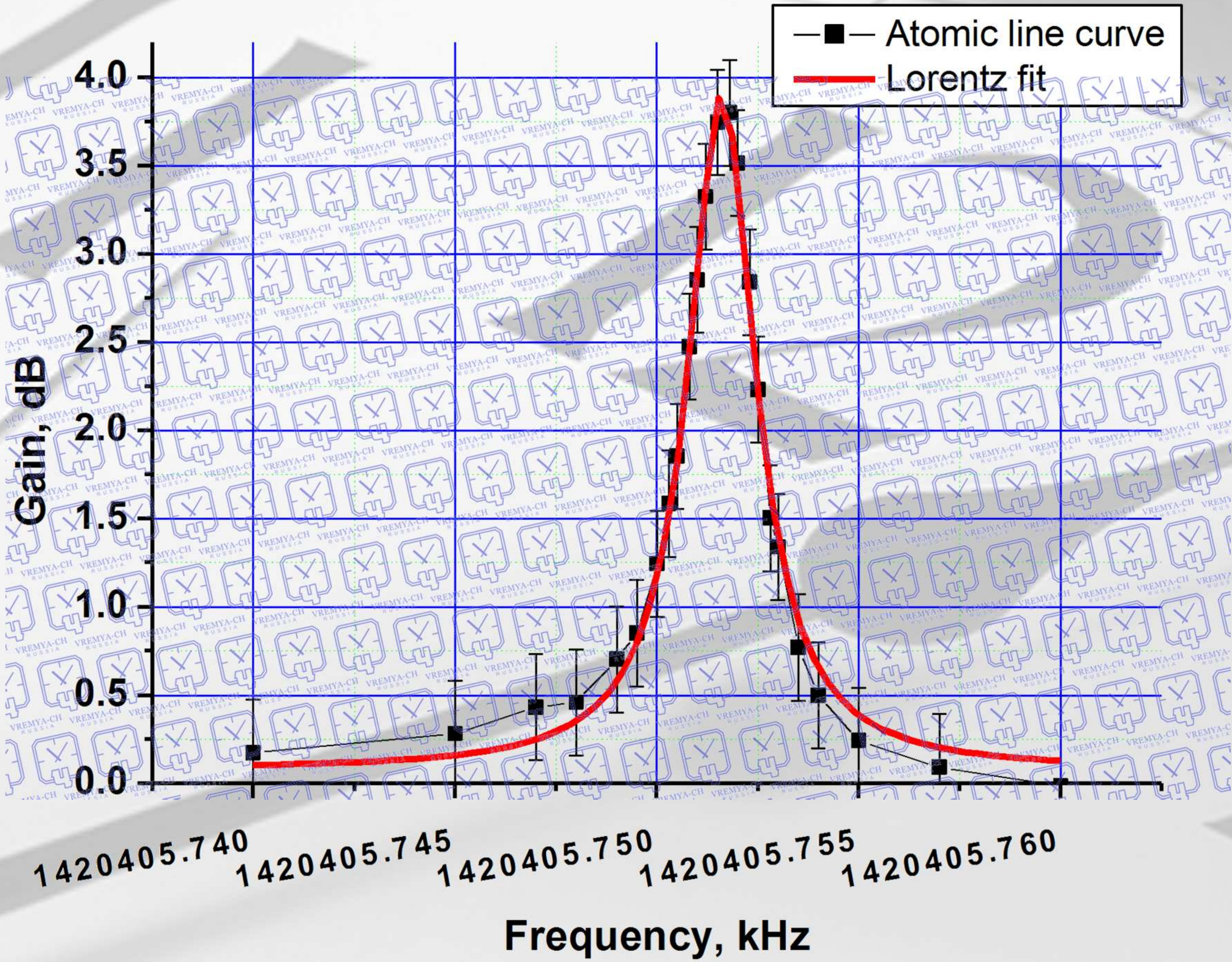
Discriminator main parameters



fo=1420405.751 kHz
Δf=1.74 Hz
Q_L≈7.1e8

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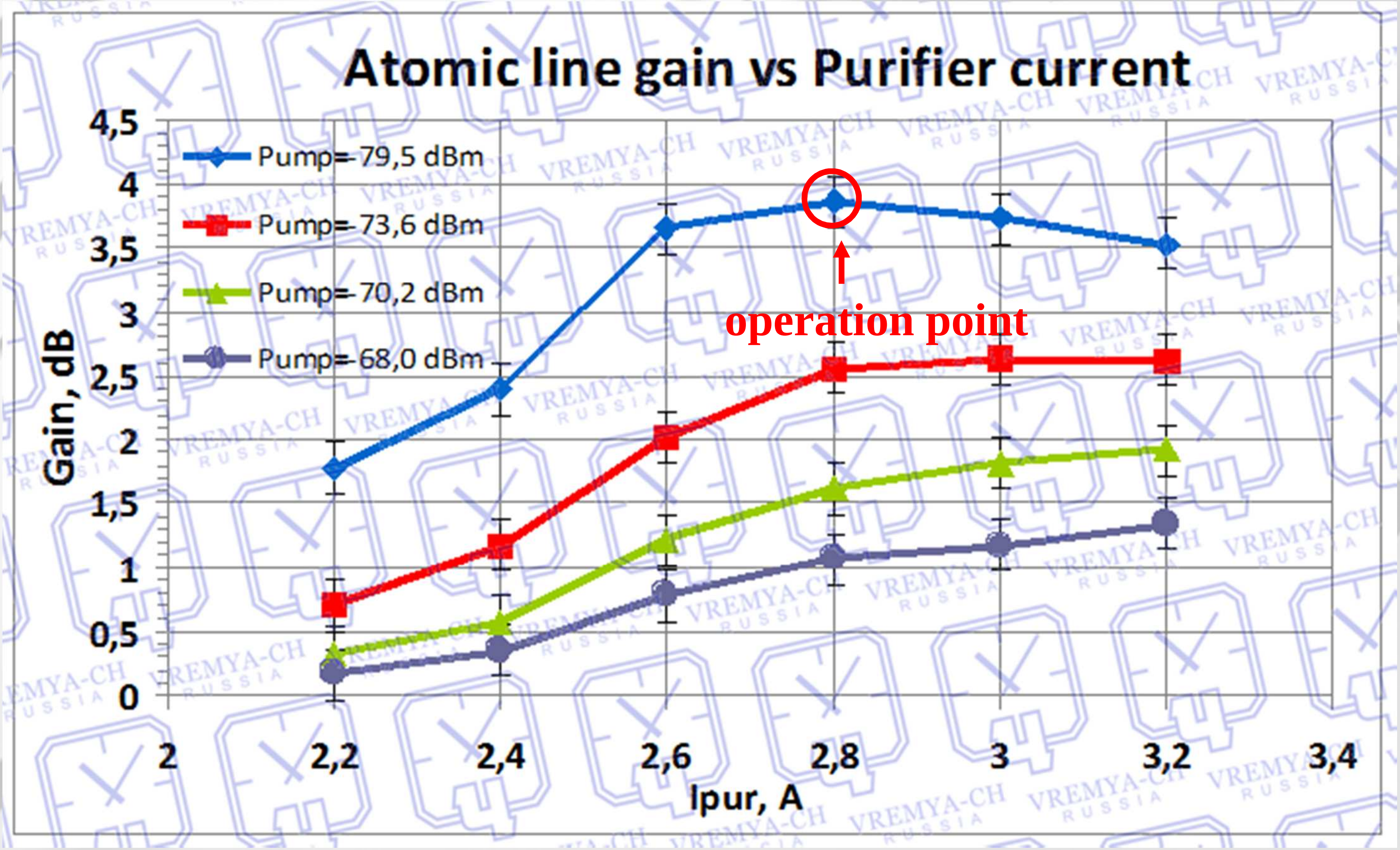
Discriminator main parameters



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Theoretical frequency stability estimation

$$\sigma_y(\tau) = \sqrt{\frac{k_s kTF}{2A_c}} \frac{\left(1+S_0-\alpha\right)^2}{Q_0\alpha\sqrt{S_0\left(1+S_0\right)}} \tau^{-\frac{1}{2}}$$

$$A_c = \frac{4\beta_1\beta_2}{\left(1+\beta_1+\beta_2\right)^2}$$

Typically cavity power attenuation:
A_c=0.04 (i.e. 14dB)

$$\boldsymbol{\sigma_y(\tau) = 3.86\times10^{-13}\tau^{-\frac{1}{2}}}$$

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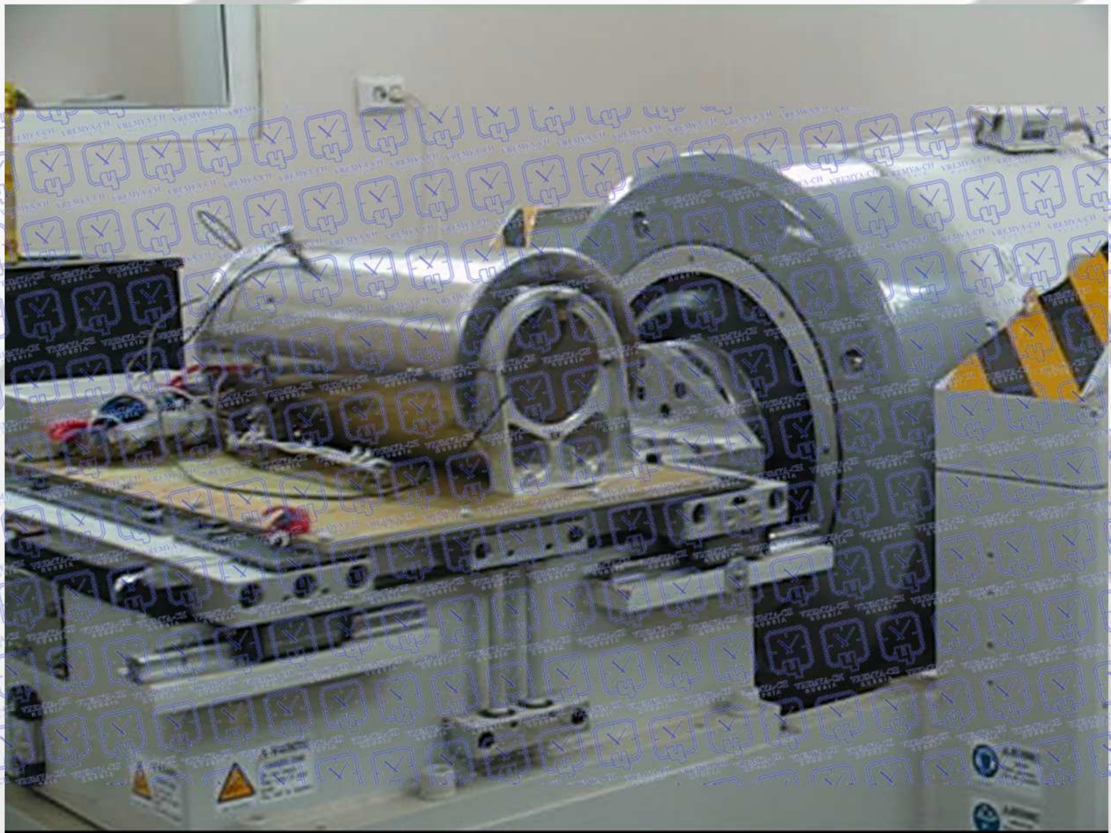
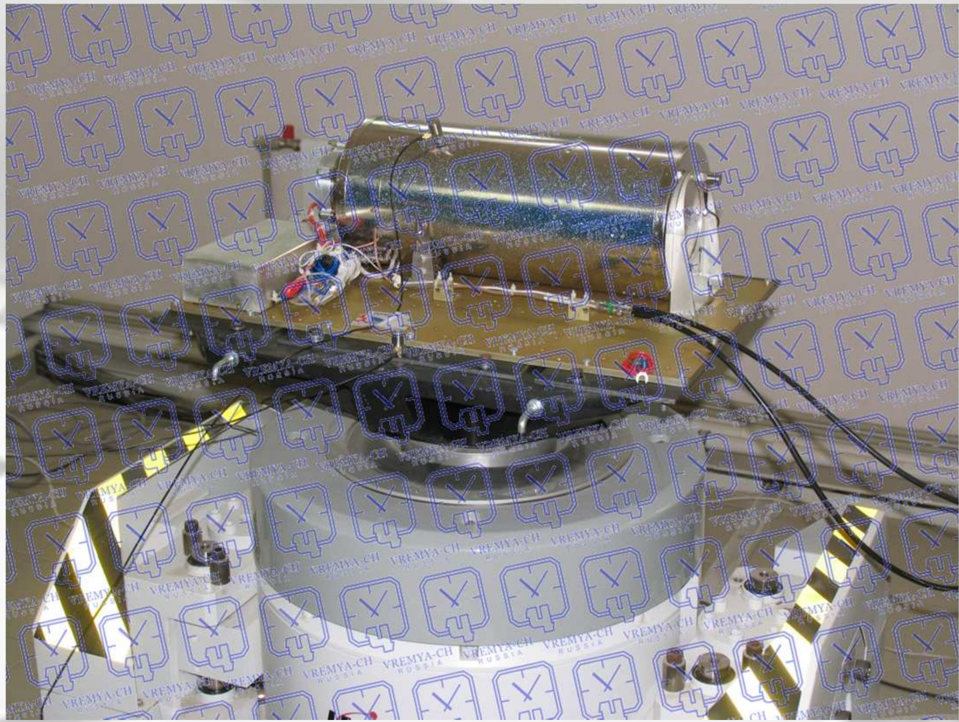
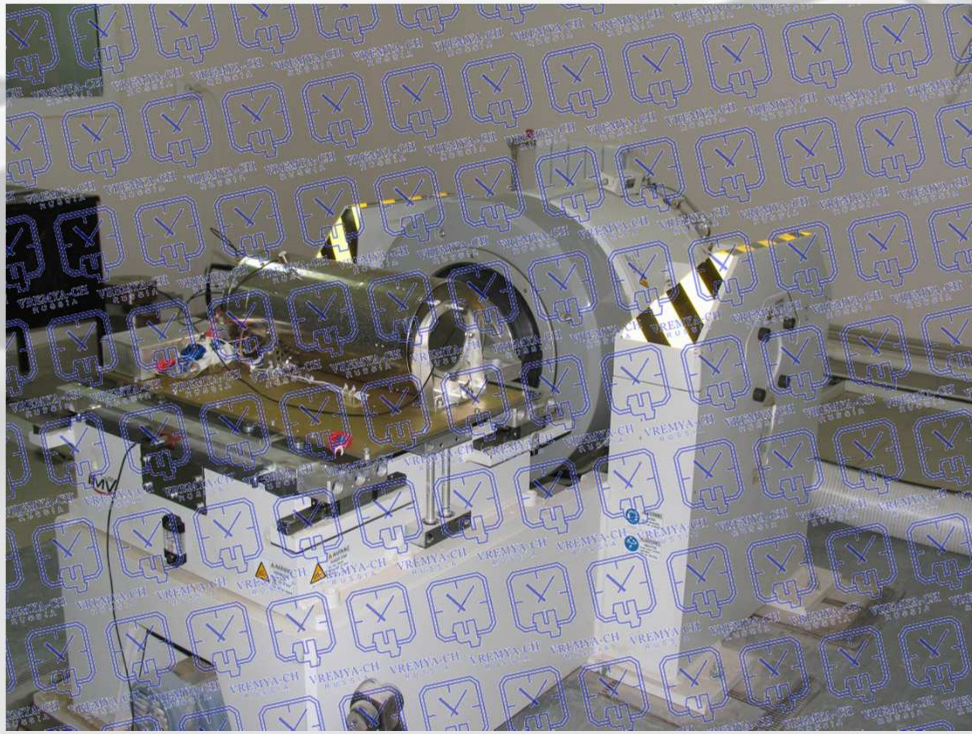
Shock and vibration mechanical tests







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Testing under operation conditions
vacuum: P<1e-7 mbar
temperature: T=25±0.1 °C

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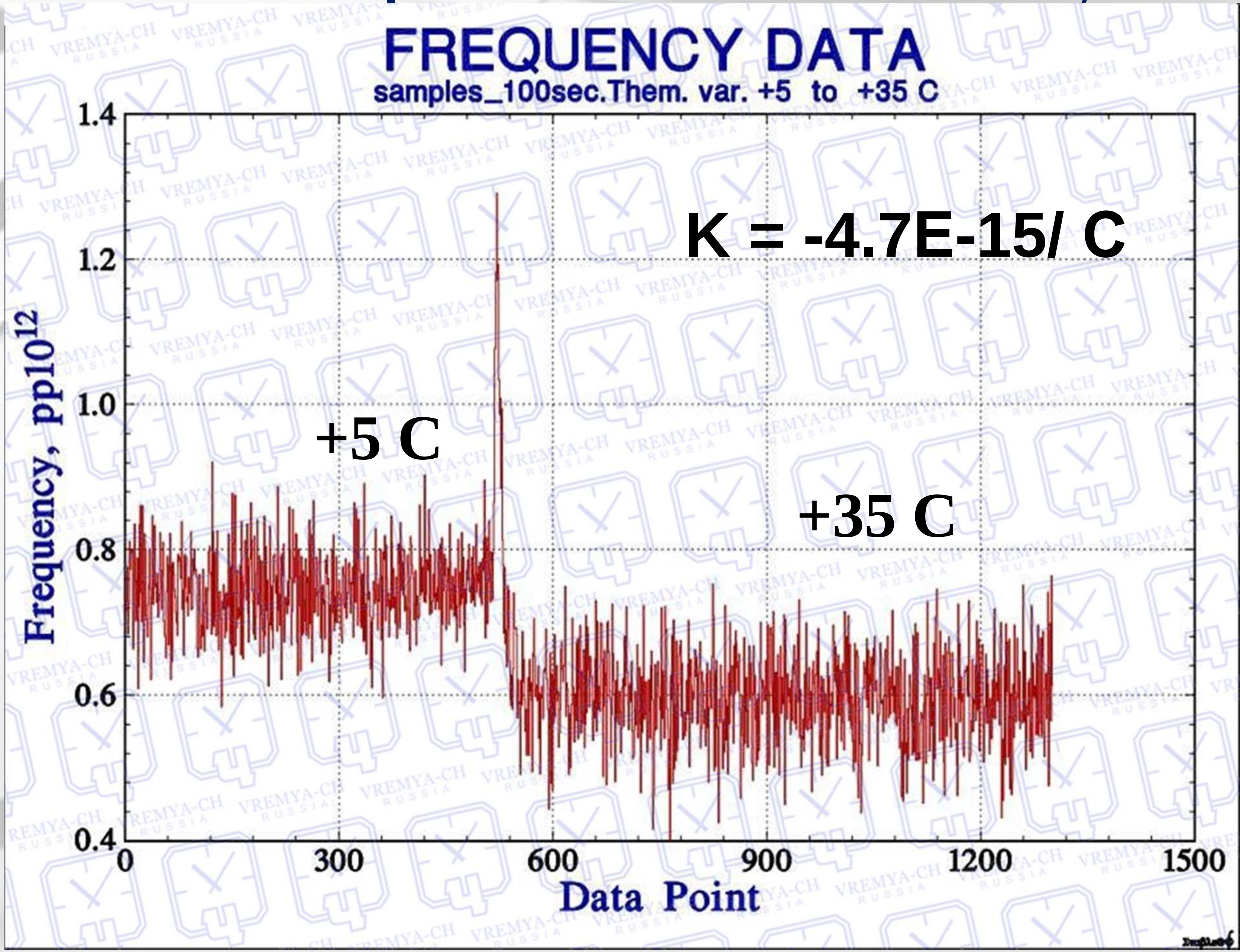
Temperature sensitivity



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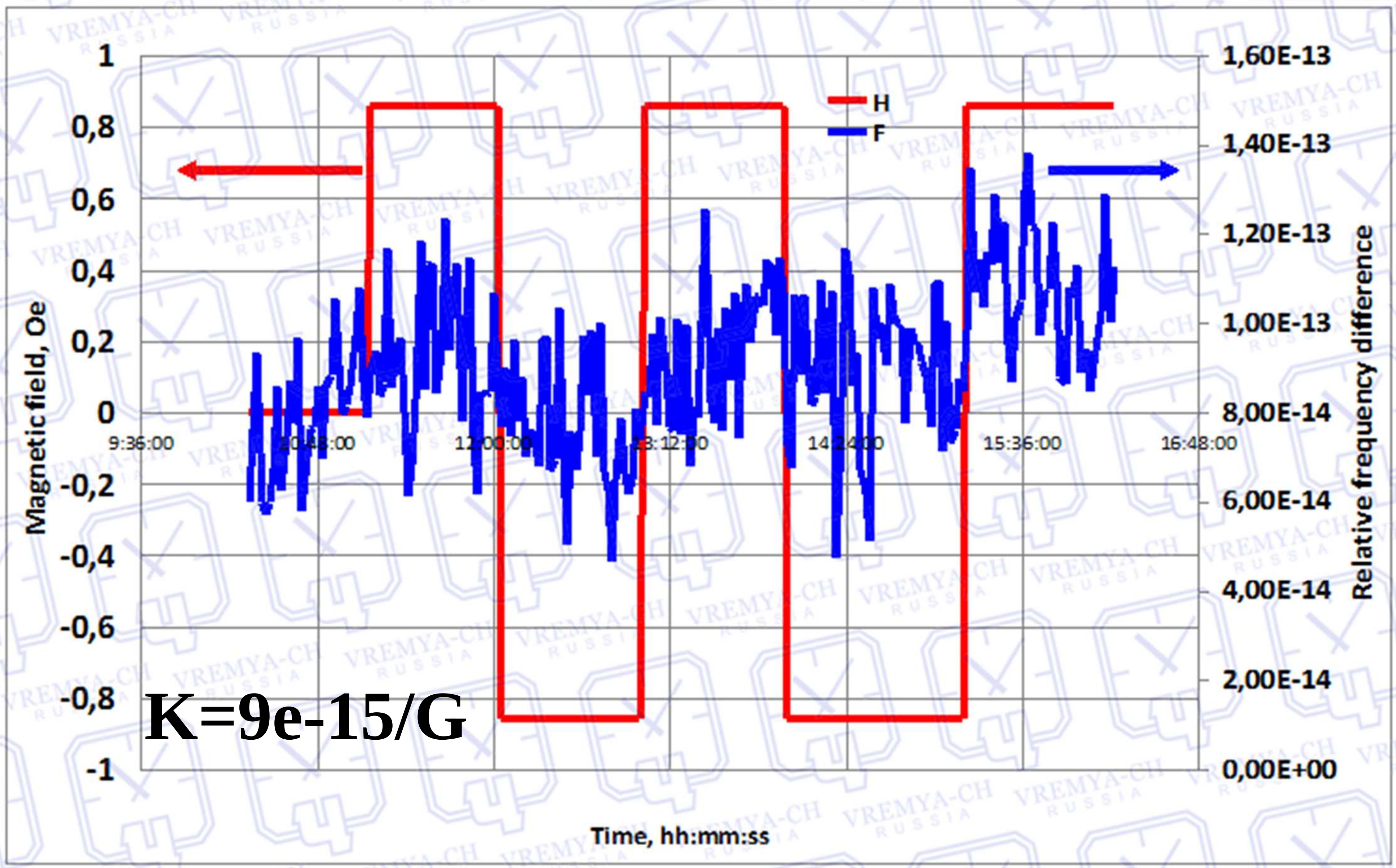
Magnetic sensitivity



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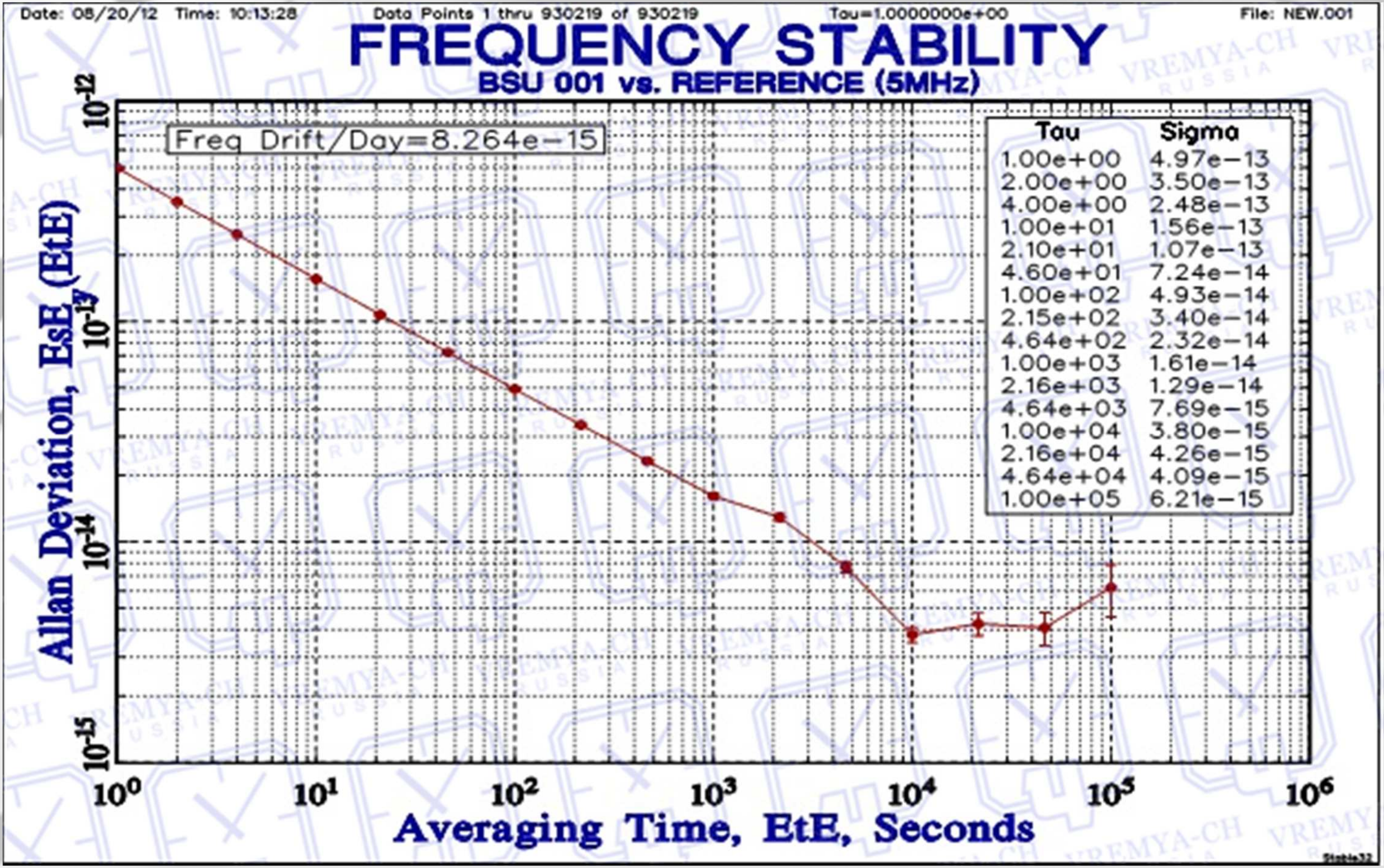

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Current situation of the project

- 2 units on long-term testing
- 2 units being prepared for space launching
- 2 units on docking testing

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Summary

- In the course of development work there was created a discriminator, which fully satisfies the customer’s requirements
- The work on modernization and enhancement of output properties is in progress

Thank you for your attention!