Application of thermoelectric oscillations in a lithium niobate single crystal for particles acceleration and generation

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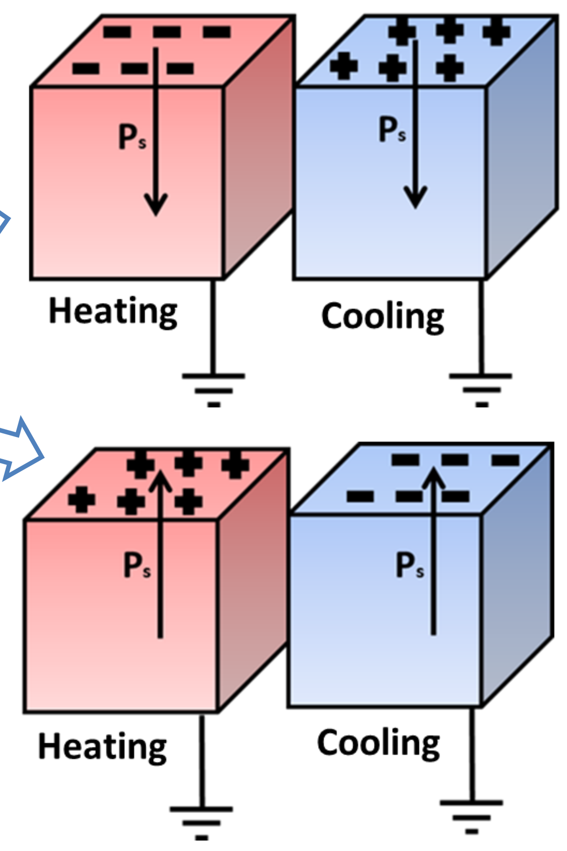
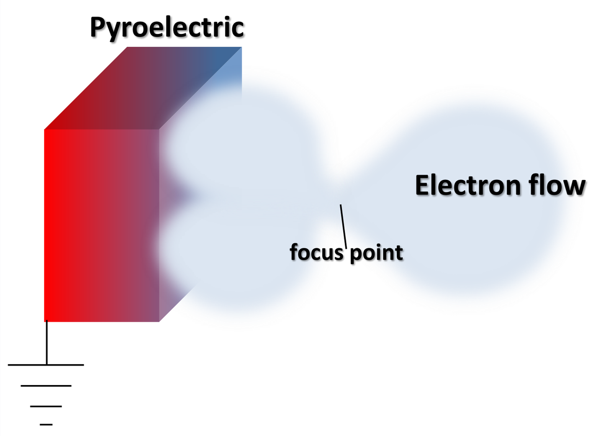
PYROELECTRIC EFFECT AS A WAY FOR PARTICLE GENERATION

- **Pyroelectric effect consists in an appearance of surface charge on a specific faces of sample while temperature of sample is changed**
- **Polarity of charge depends on orientation of spontaneous polarisation vector of sample and type of thermal excitation (heating or cooling)**
- **Such properties exhibit a variety of materials including single crystal of niobate lithium ($LiNbO_3$)**
- **If pyroelectric effect occurs while pyroelectric sample is in vacuum surrounding, then surface charge is not screened and becomes a source of high electric field with strength about 10^5 V/cm**



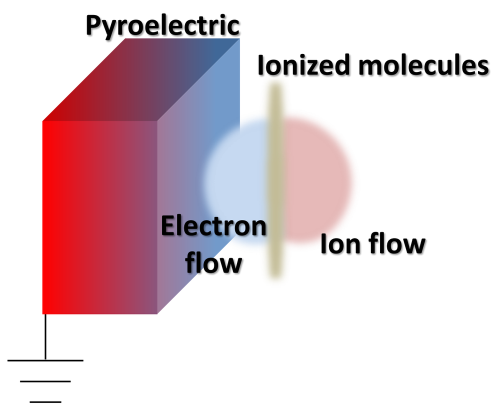
There are two different ways of particle generation due to pyroelectric effect

CASE OF NEGATIVE CHARGE ON THE SURFACE OF PYROELECTRIC



- **Due to the effect of ferroelectric electron emission electrons are emitted from negatively charged surface and accelerated towards to pyroelectric**
- **Emitted electron flow are self-focused due to the features of charge distribution on the pyroelectric's surface**

CASE OF POSITIVE CHARGE ON THE SURFACE OF PYROELECTRIC



- **The molecules of residual gas are ionized by high electric field due to the pyroelectric effect**
- **Electron and positive ion particle flow are formed and accelerated in different directions**

THERMOELECTRIC OSCILLATIONS IN PYROELECTRICS

Generated surface current due to pyroelectric current can be expressed as $$i_{pyr} = pA\frac{dT}{dt}$$

p is a pyroelectric coefficient, A is area of surface of sample, dT/dt – a law of changing temperature of sample

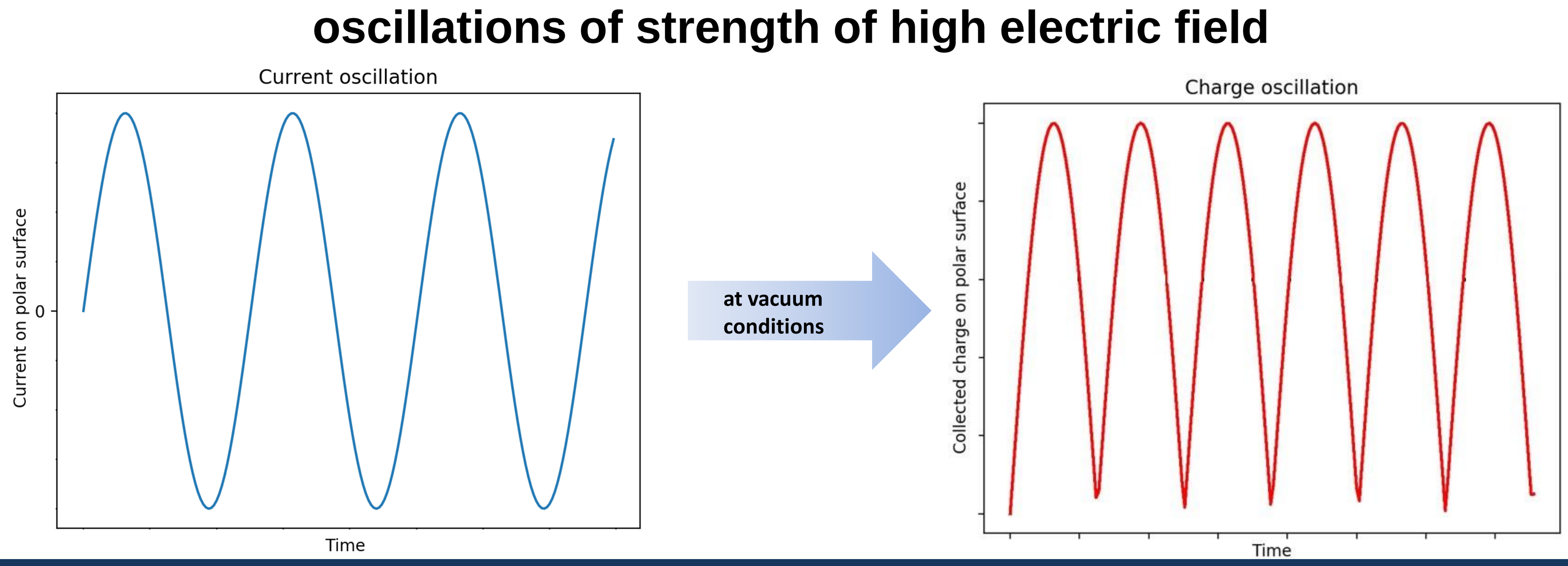
If temperature of pyroelectric is changed as $$T(t) = T_0 + T_1 \sin \omega t$$

T_0 is a initial temperature of a sample, T_1 is an amplitude of temperature oscillations, ω is a frequency of oscillations

Then pyroelectric current can be rewritten as $$i_{pyr} = pAT_1\omega \cos wt$$

SUCH MODE OSCILLATIONS OF GENERATED PYROELECTRIC CURRENT AND TEMPERATURE OF PYROELECTRIC SAMPLE CALLED <u>THERMOELECTRIC OSCILLATIONS</u>

In vacuum surrounding conditions generated current accumulated on pyroelectric's surface causing oscillations of surface charge and oscillations of strength of high electric field

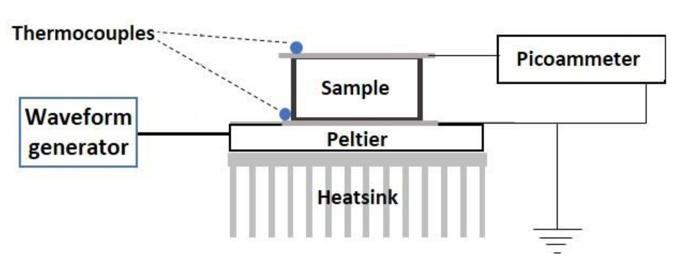


MAIN GOAL – OBTAINING OF PARTICLE FLUX GENERATED DUE TO PYROELECTRIC EFFECT IN MODE OF THERMOELECTRIC OSCILLATIONS

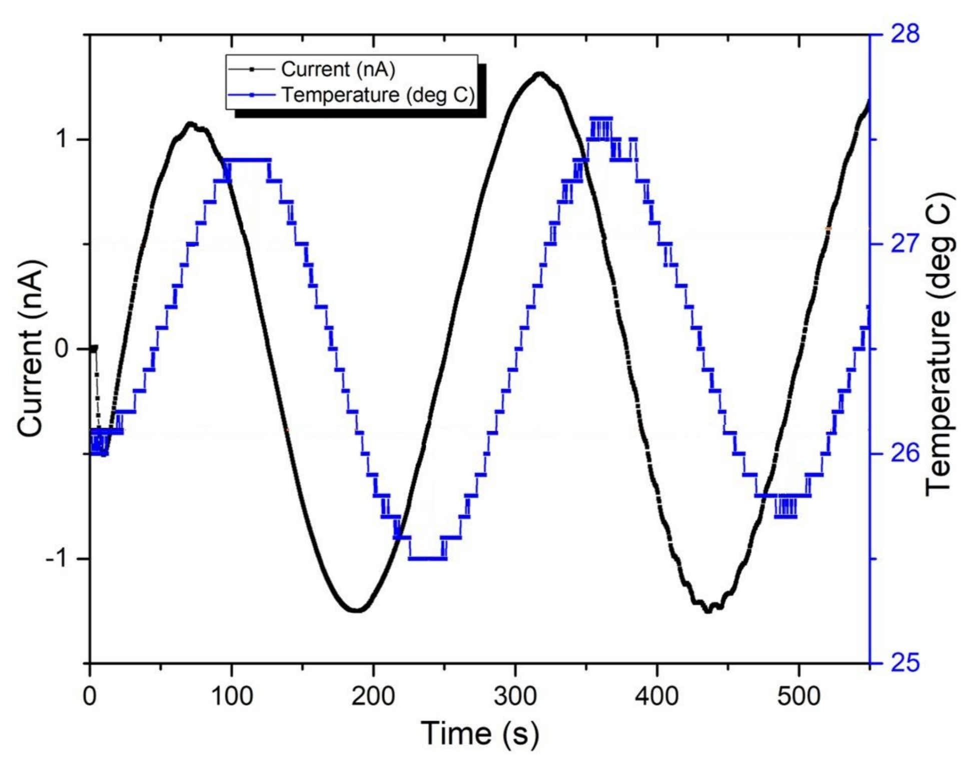
RESULTS OF EXPERIMENT

Measurement of generated pyroelectric current

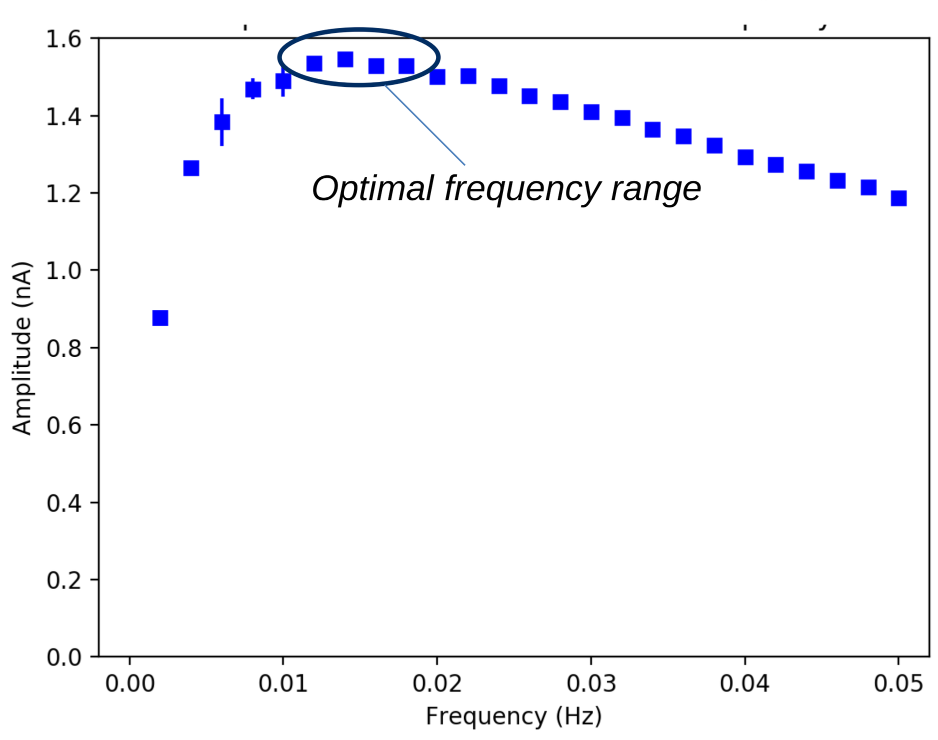
Scheme of measurement



Typical oscillation curves of current and temperature at 6 mHz frequency of oscillation

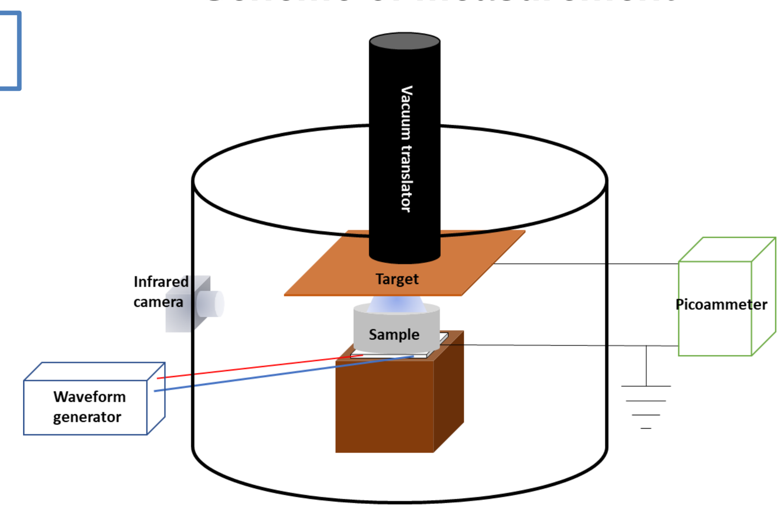


Dependence of amplitude of current oscillations on the frequency

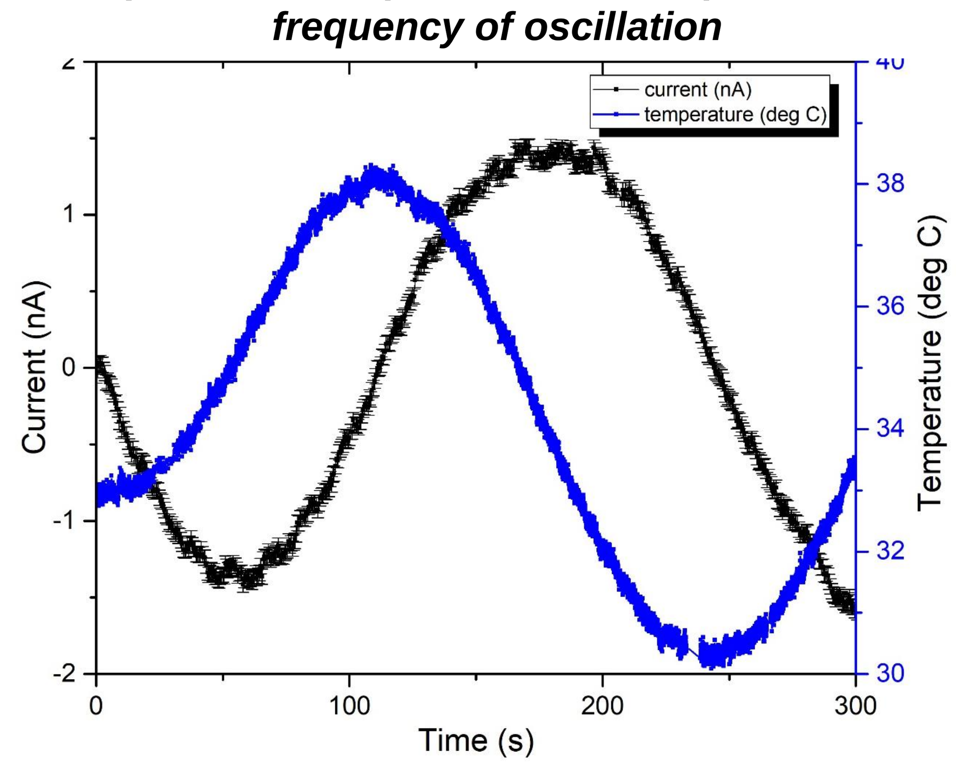


Measurement of particle flux current

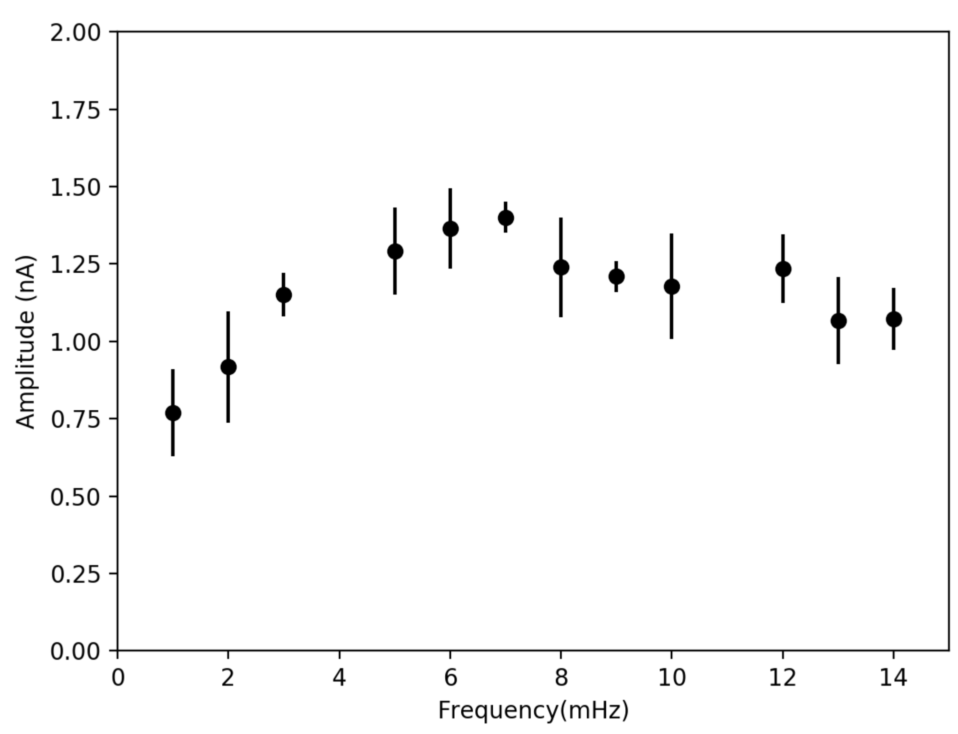
Scheme of measurement



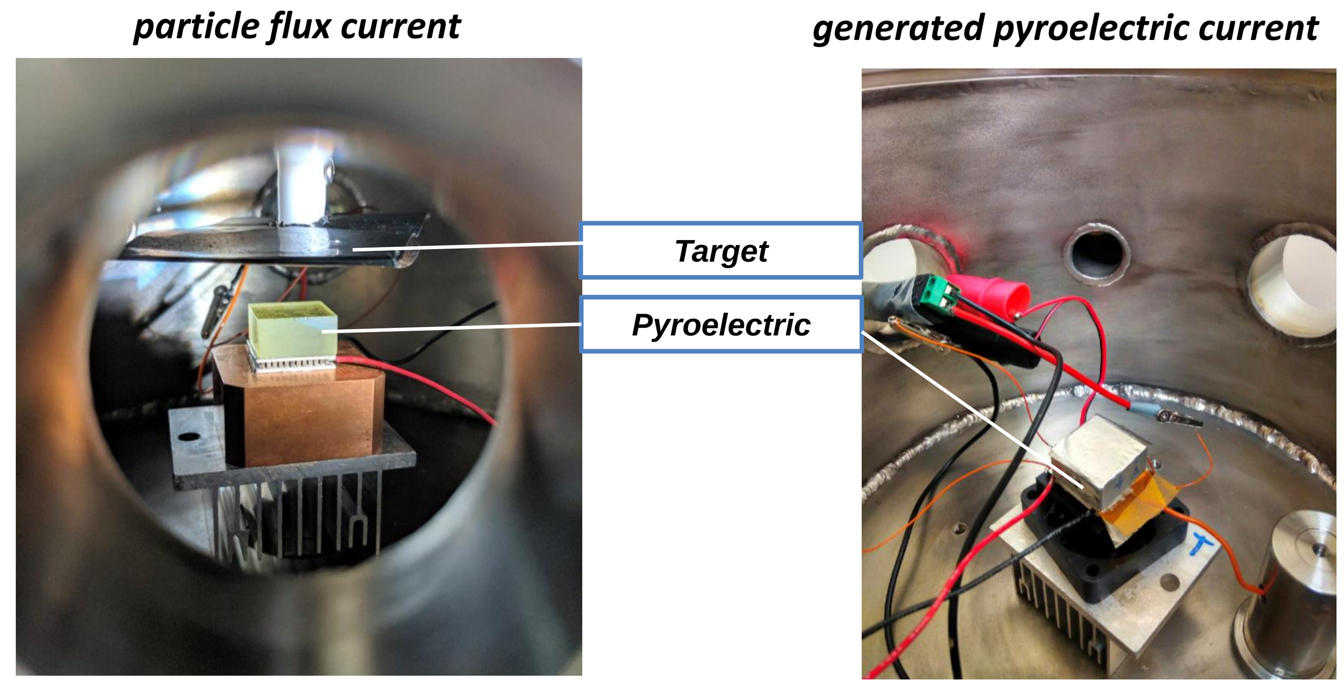
Typical curves of generated particles current and temperature of top surface of sample at 8 mHz frequency of oscillation



Dependence of amplitude of oscillations of generated particles flux on the frequency



Experimental setup for measurement of particle flux current *Experimental setup for measurement of generated pyroelectric current*



DETAILS OF EXPERIMENT

	Measurement of pyroelectric current	Measurement of particle flux current
Amplitude of power wave, W_{RMS}	2	2.7
Measured frequency range, mHz	1 - 50	1 - 15
Pressure, Torr	760 (Atmospheric)	0.5 – 1.3
Maximal peak-to-peak amplitude of temperature oscillations (at top surface of pyroelectric sample), degrees	3.5	14
Distance from pyroelectric to target, mm	-	11
Area of top surface of pyroelectric, mm²	400	400

CONCLUSION

- **Sinusoidal changing temperature of sample of lithium niobate initiates oscillations of electric current which generated due to the pyroelectric effect**
- **There are some optimal frequency range with maximal amplitude of generated pyroelectric current**
- **First measurements show that in vacuum conditions a mode of thermoelectric oscillation in lithium niobate sample leads to generation electrons and positive ions flux with the same frequency**
- **Next step is a determination of energy of particles in generated flux and relation between oscillation generated pyroelectric current and generated particle flux**