# Some approach diagnostic electric and kinetic parameters dusty plasma system

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Near the moon surface as a result of interaction with the electrons and ions of the surrounding plasma, as well as under the influence of solar radiation, dust particles acquire an electric charge and become one of the important components of the environment, significantly affecting its properties and dynamics [1].

In the experimental modeling of the near-surface exosphere of the Moon under laboratory conditions, an important condition is the diagnosis of the characteristics of the dusty plasma environment. Of course, the most popular is the visualization of the process, but to understand the changes taking place inside dusty plasma cloud for our experimental chamber we also is used the Langmuir probe and electroinduction grids, tubes or plates. However high voltage when we create dusty plasma and another source of noise have the bad influence during electric measure. Equally important is the use of piezodetectors as low-noise targets for measuring the pulses of the dust component of the lunar dusty plasma environment.

1. Fortov V. E., Ivlev A. V., Khrapak S. A. et al. Complex (dusty) plasmas: Current status, open issues, perspectives // Phys. Reports. 2005. V. 421. No. 1–2. P. 1–103.

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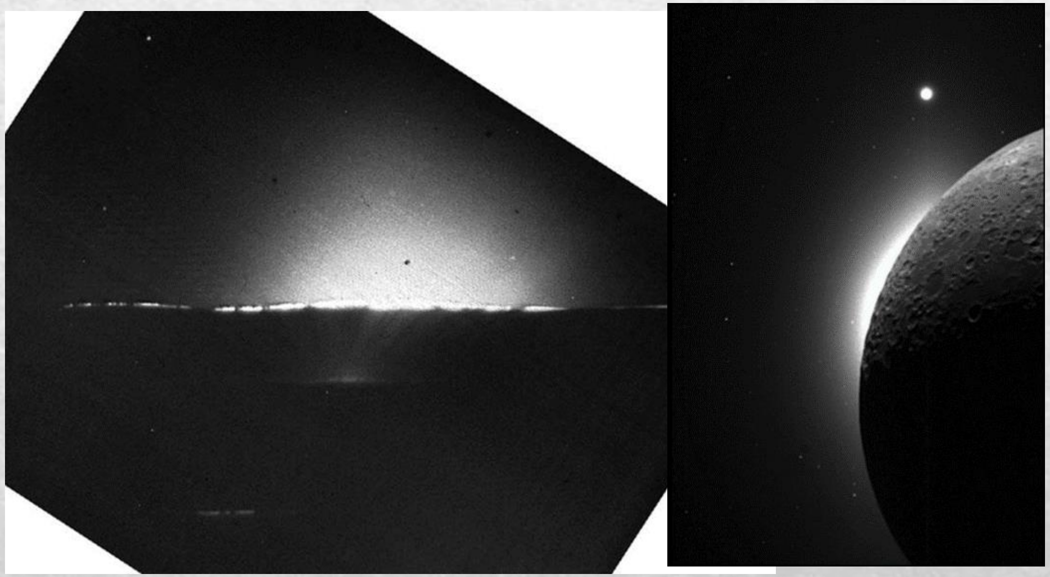
Moon dusty plasma scheme [Halekas et al., 2015]



Dust scattering of the sun beyond the horizon, Surveyor (Rennilson and Criswell, 1974) left, Clementine Lunar Orbiter (1994) right

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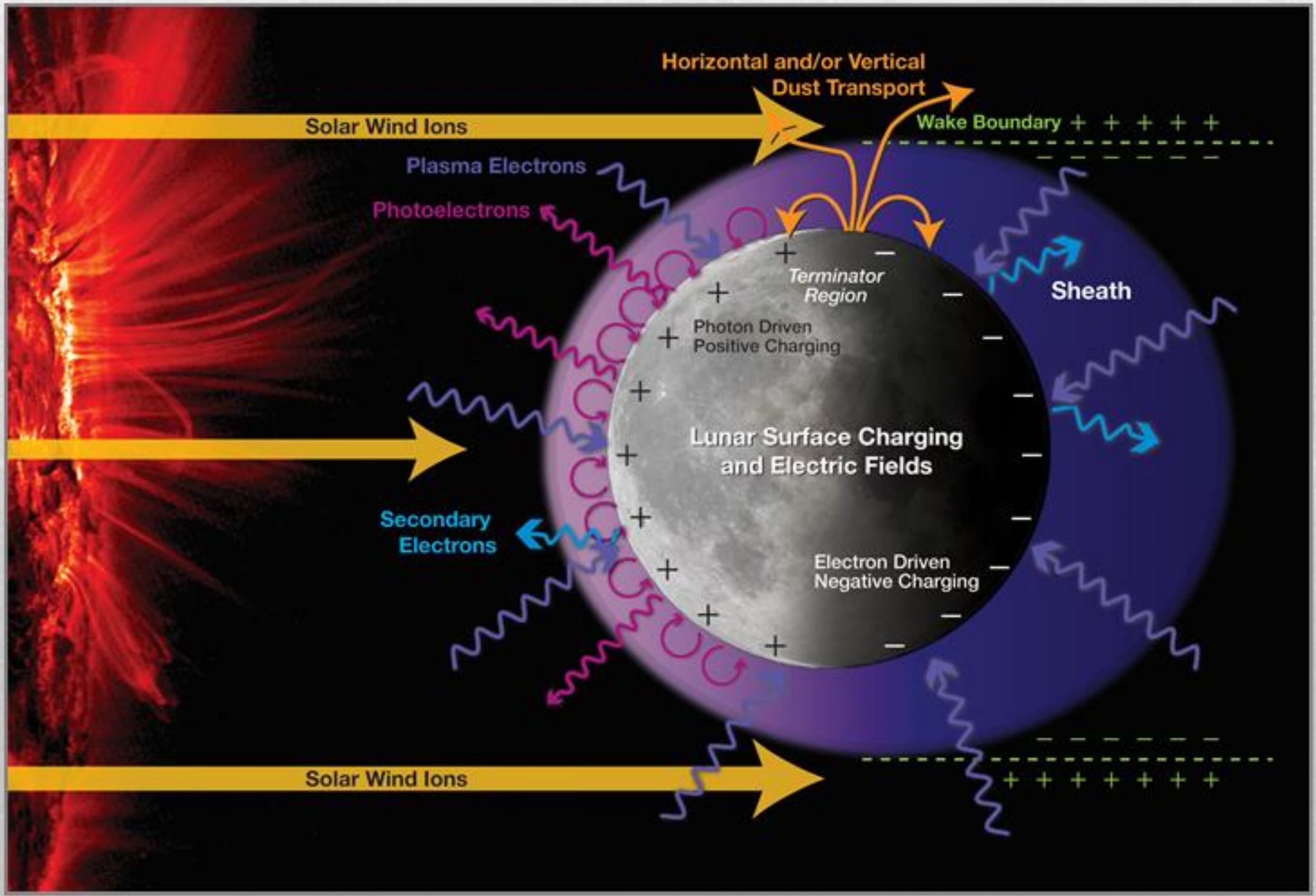


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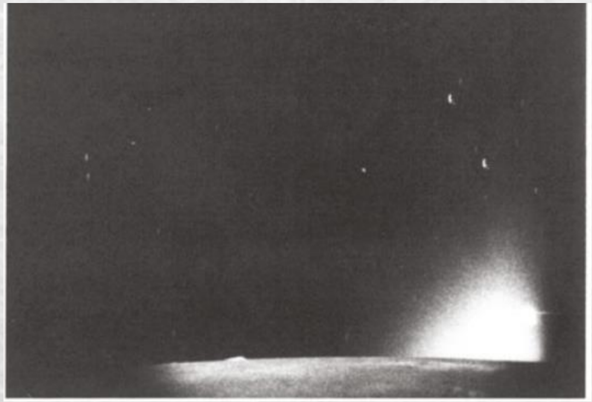
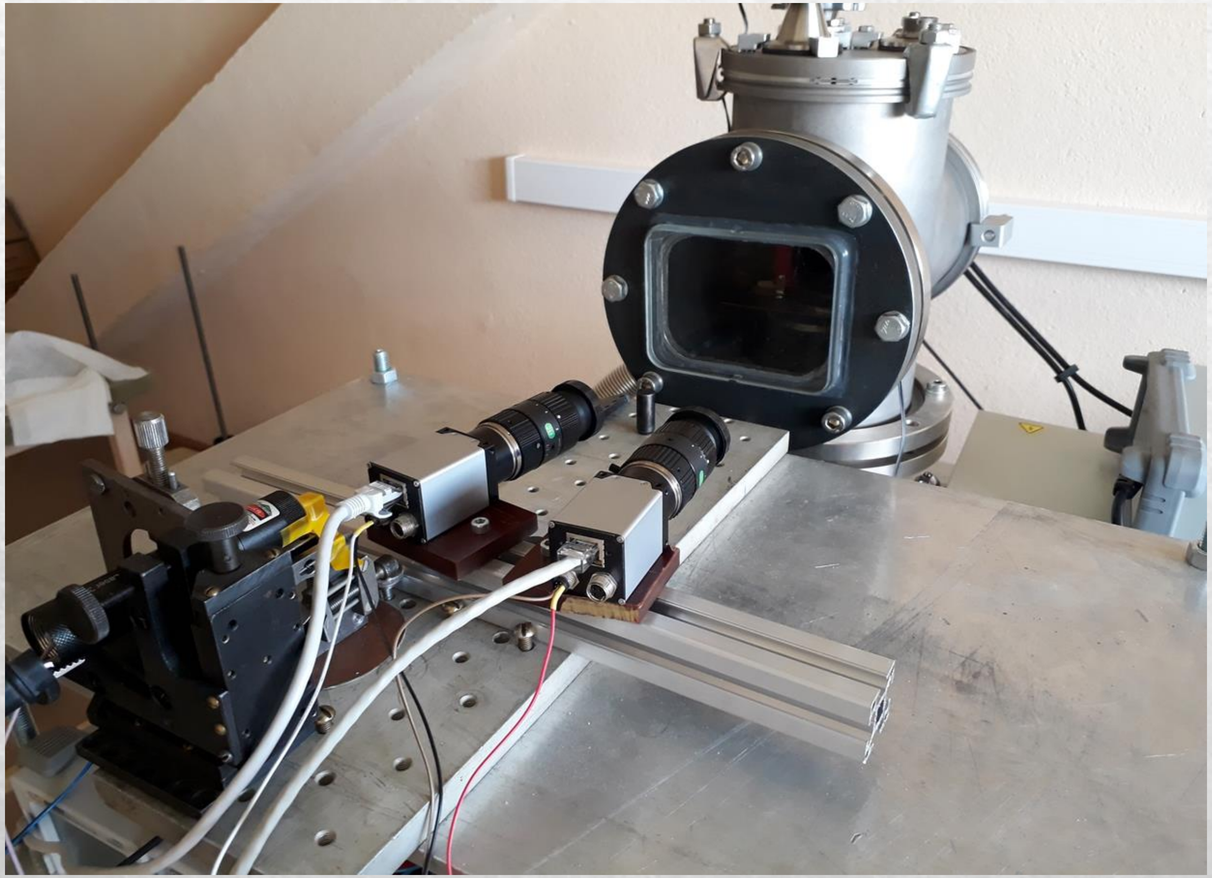


The intersection of the Sun's F - corona and the "Zodiac Glow" above the lunar horizon. Ecliptic along the line of Mercury and Regulus (2 objects at the top right) (photo: NASA, Worden , no. AG 15-98-13311, Apollo 15, flight, 1971).

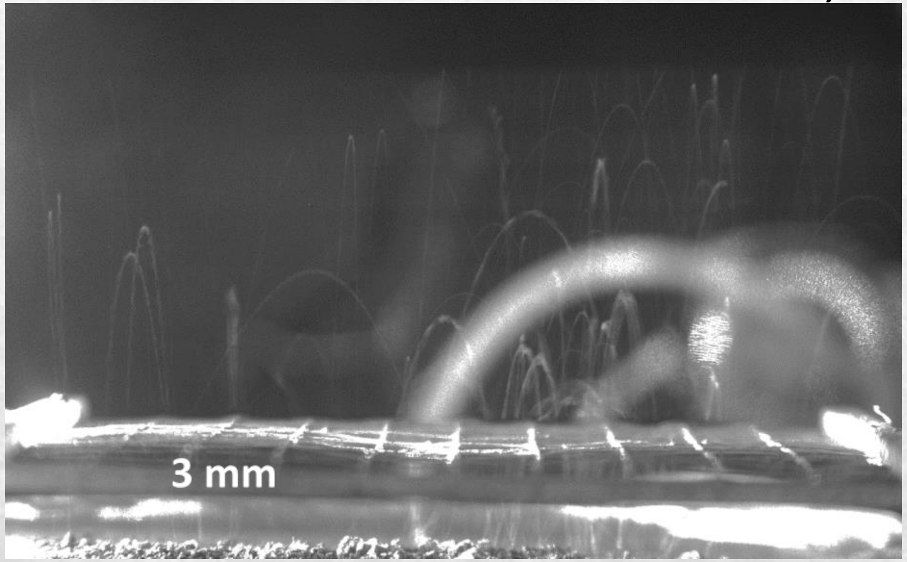
Photo of the Clementine space probe (1994) – "zodiac glow" over the lunar horizon (Cooper et al. 1996). The object on the left is Venus. The moon in the light reflected from the Earth.

In the experimental modeling of the near-surface exosphere of the Moon under laboratory conditions, an important condition is the diagnosis of the characteristics of the dusty plasma environment.

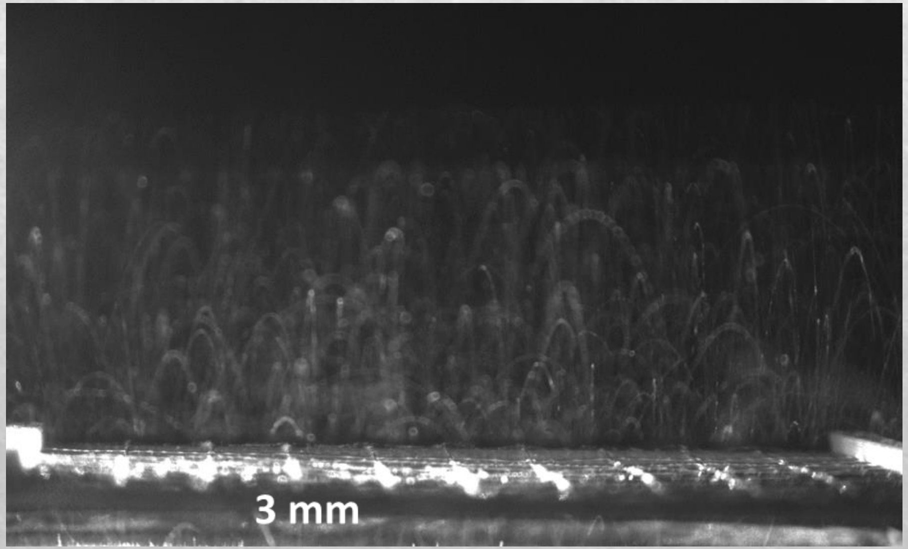
# Laboratory simulation of space dust levitation in an electric field (the visualization of the process)

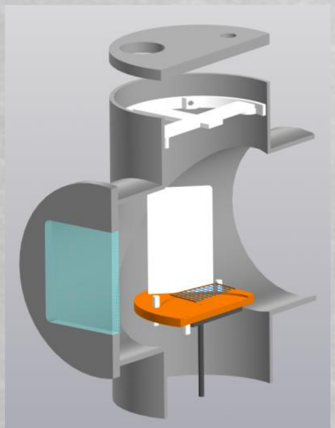


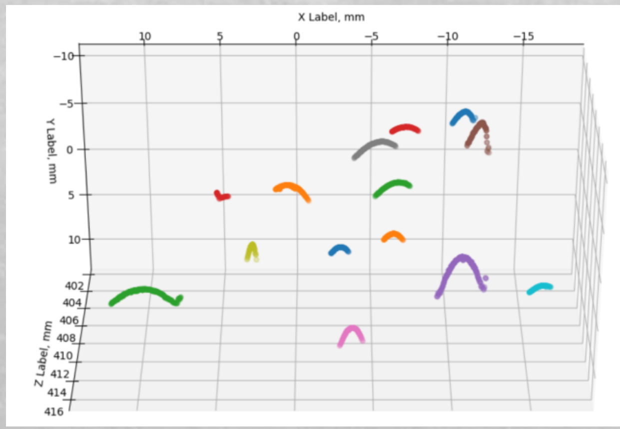
5,0 kV

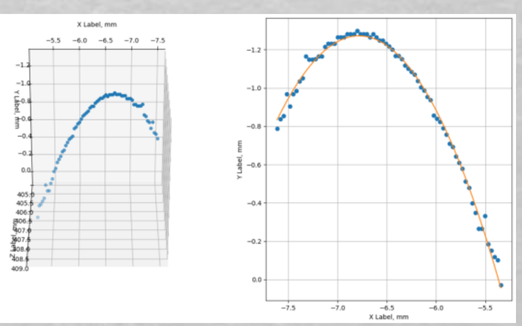



8,0 kV



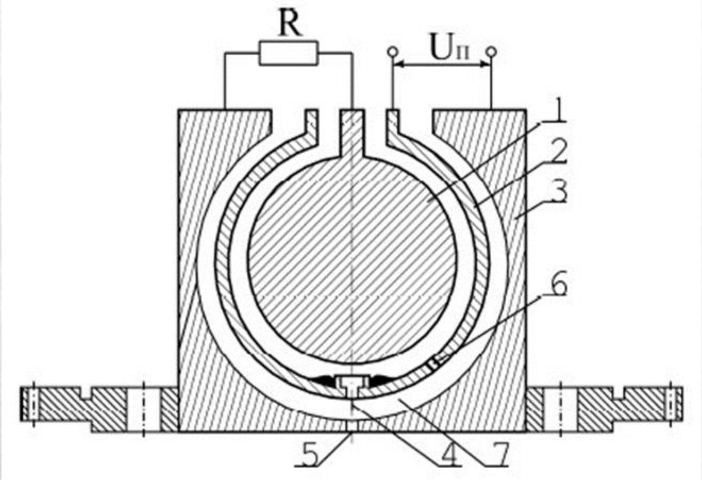





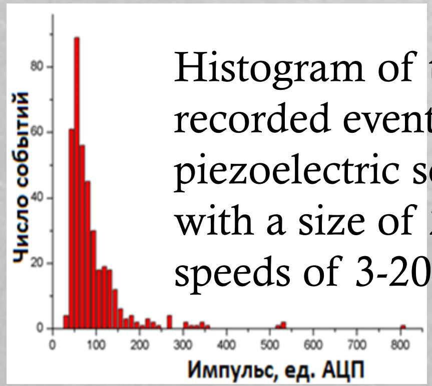




Restoring particle flight tracks

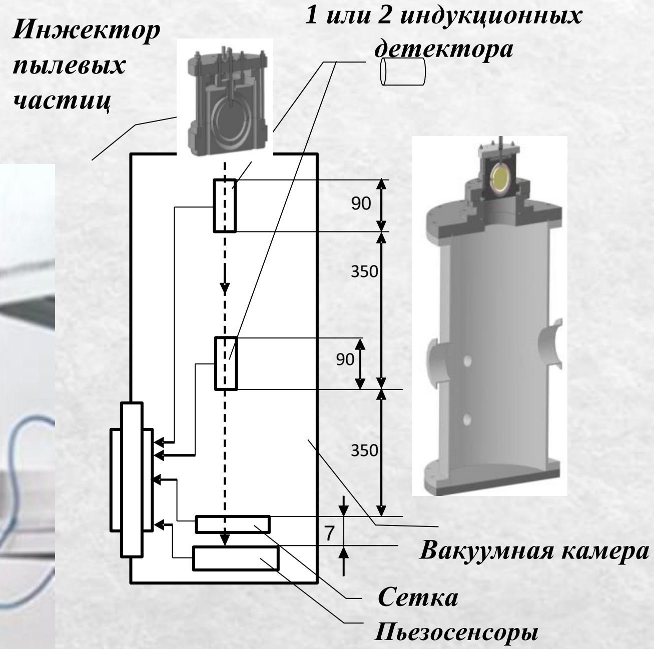
# Another camera for simulating dusty plasma flows for the Moon



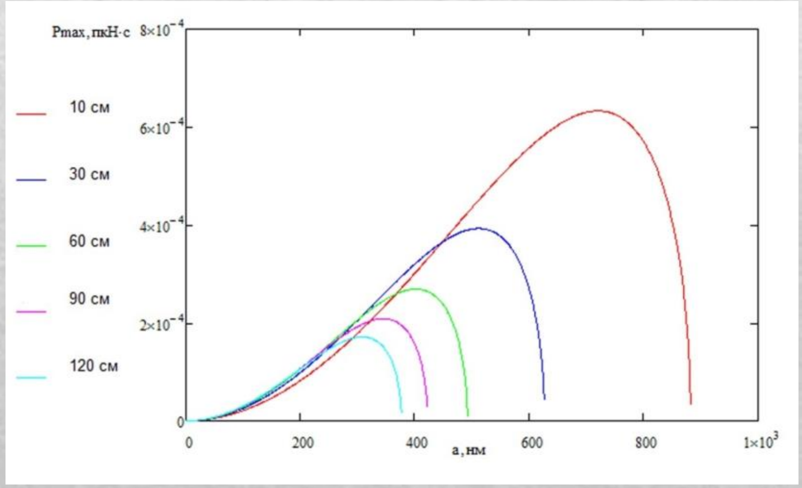

Design of the charged particle injector with a constant voltage on the hopper electrode:1-hopper electrode, 2-charging electrode, 3-housing, 4-needle, 5 – outlet, 6-hole between the hopper and charging chambers, 7-charging chamber




Histogram of the number of recorded events by a piezoelectric sensor of particles with a size of 20-40 microns at speeds of 3-20 m/s



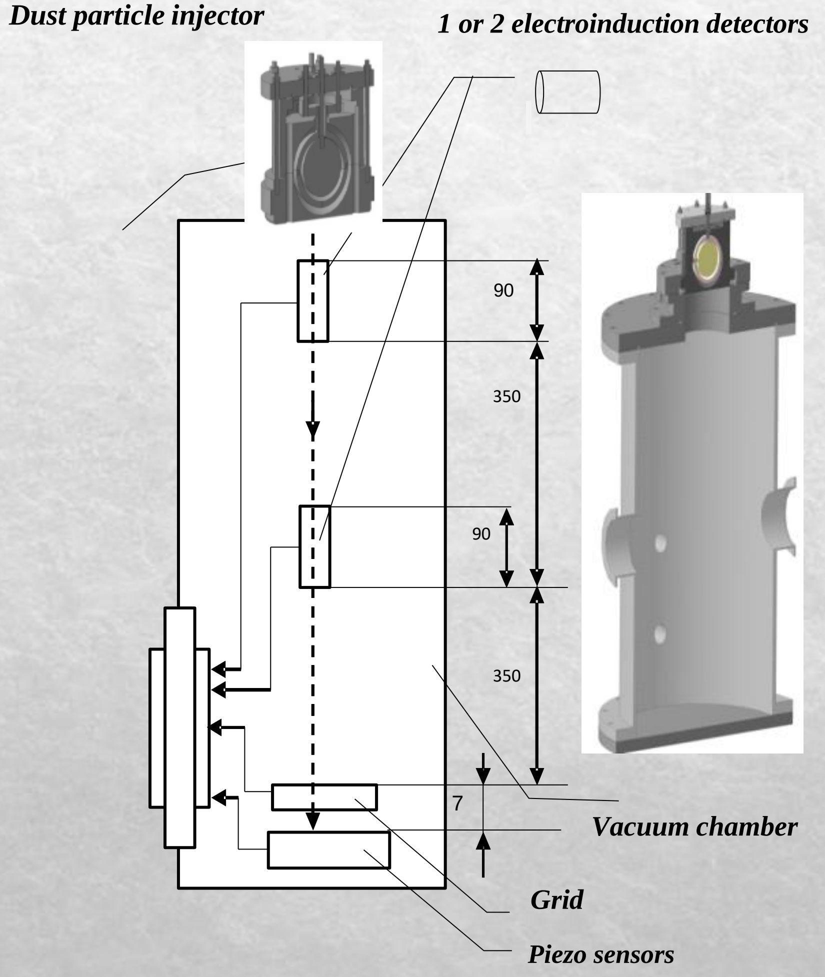

The particle momentum values, depending on their size, for heights x=10 cm (red curve), 30 cm (blue curve), 60 cm (green curve), 90 cm (purple curve), and 120 cm (blue curve).



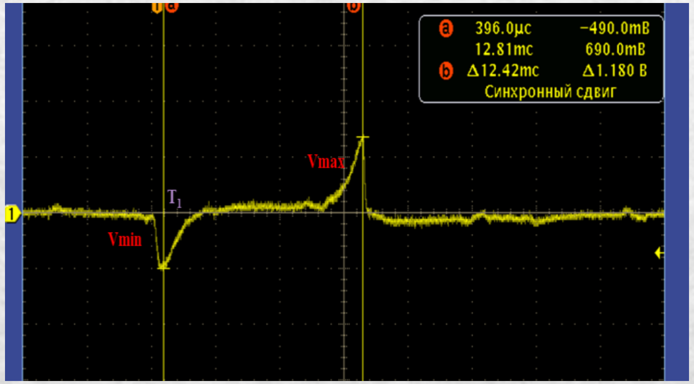

Dependence of the momentum of particles with size (a) on the distance from the surface (x)of Moon

$$P(a,x) = m_d \sqrt{2V_0^2 \frac{m_e}{m_d} Z_d(a,x) \ln\left(1+\frac{x}{r_d}\right) - 2gx}$$

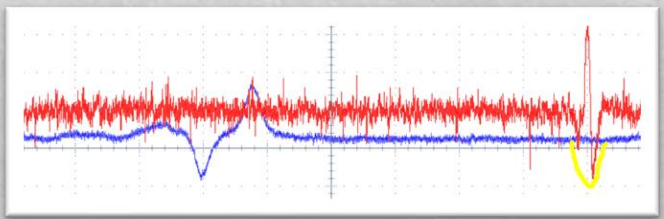
For understanding the changes taking place inside dusty plasma cloud for our experimental chamber we also is used the electroinduction grids, tubes or plates




Induction detectors measure the charge and velocity of particles in the chamber




The signal of the induction detector during the passage of a charged particle



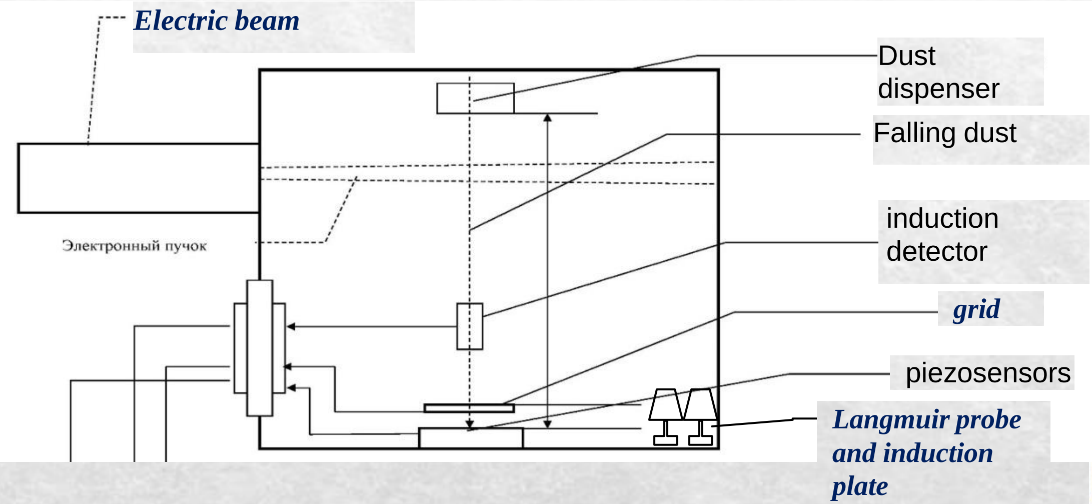
Vacuum chamber with dust injector (event with a frequency of 0.1 - 30 Hz)

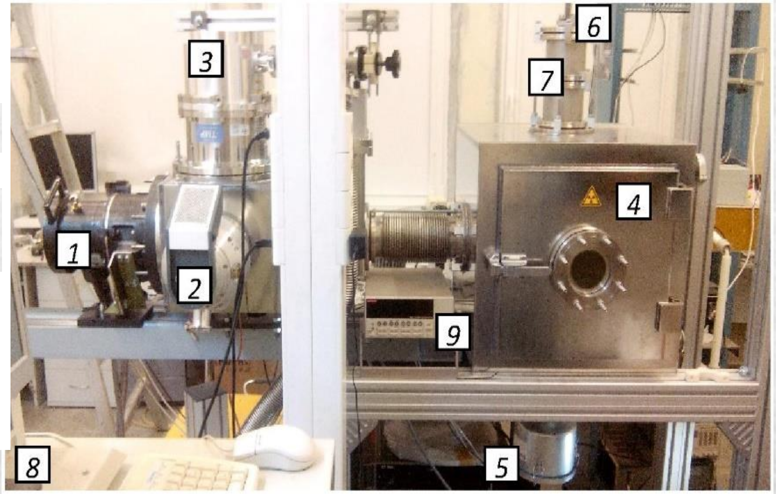
Comparison of signals from the grid (red) and induction detectors (blue) for a speck of dust with a charge of ~$10^{-16}$ K

# Langmuir probe tests in JIHT

Measured range: plasma potential +/- 88 V

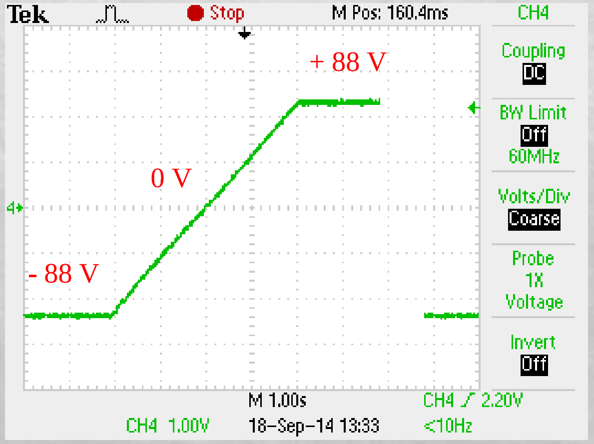
## ❖ *Equipment of JIHT RAS*



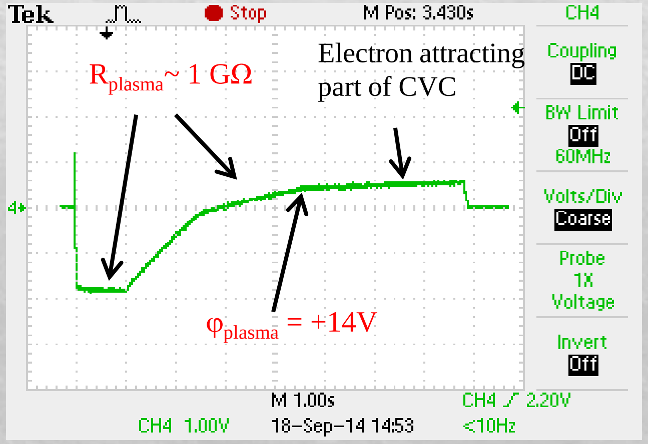




Experimental scheme for measuring the parameters of a dust plasma in the interaction of dust particles and an electron beam

Equipment:
(1) – electron beam gun with plasma cathode;
(2) – slave turbomolecular pump($10^{-3}$ Pa);
(3) – master turbomolecular pump ($10^{-4}$ Pa);
(4) – main vacuum chamber;
(5) – additional vacuum chamber;
(6) – dust dispenser;
(7) – silo;
(8) – computer-driven control system;
(9) – electrometer.

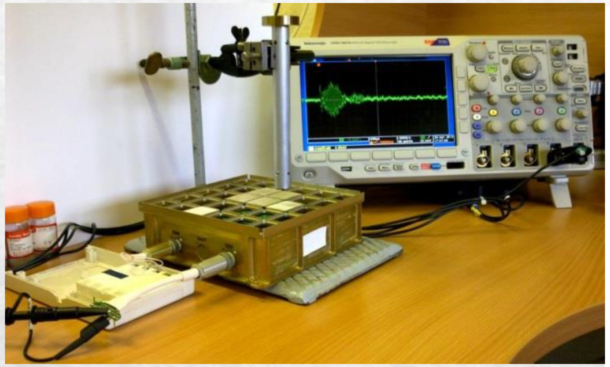


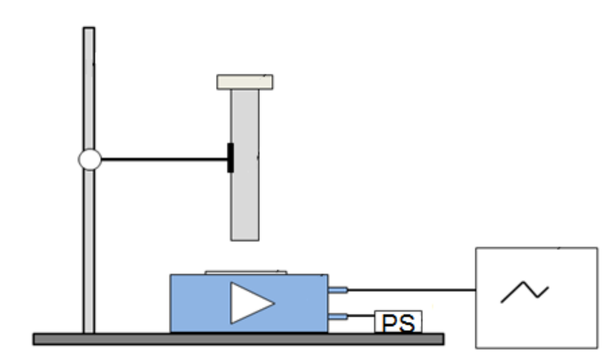

I-U characteristics of the Langmuir probe in a vacuum chamber without a beam

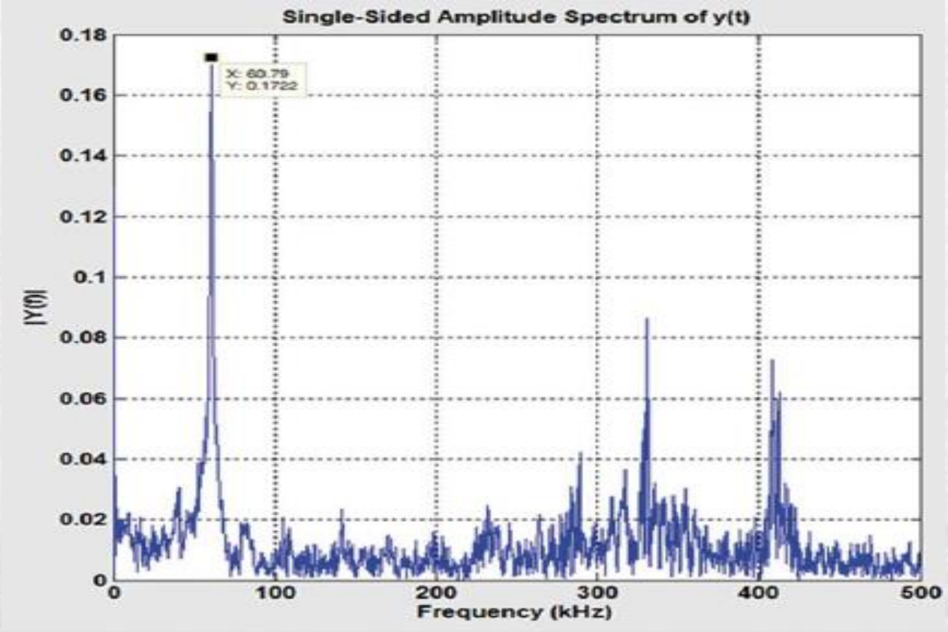



I-U characteristics of the Langmuir probe in a vacuum chamber with an electron beam ($E_{beam}$=3 keV, $I_{beam}$ =0.5 мА)

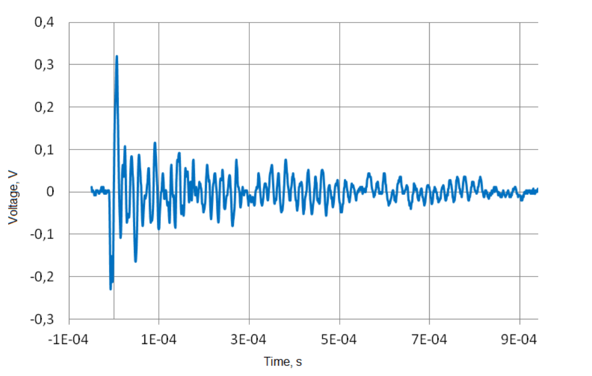
# Testing piezoceramic sensors



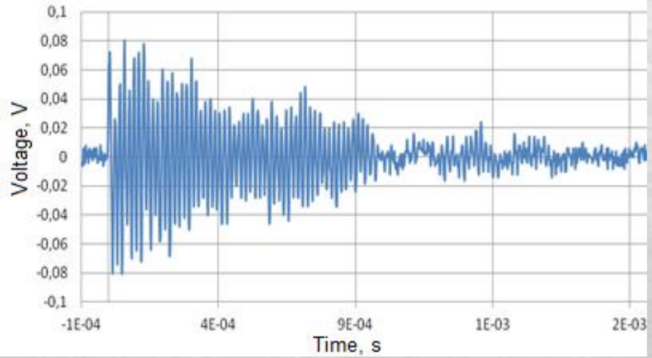


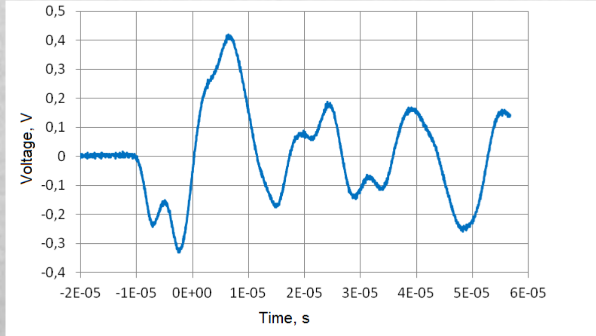

PZT19 signal



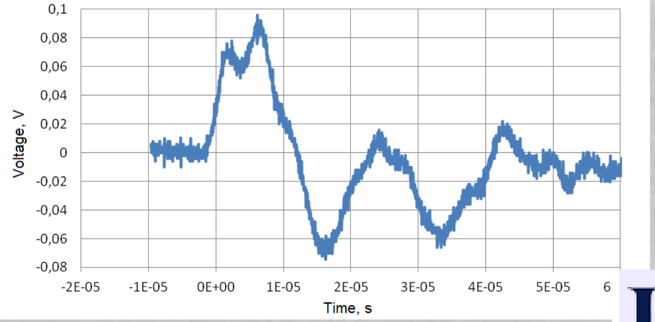

PZT36 signal



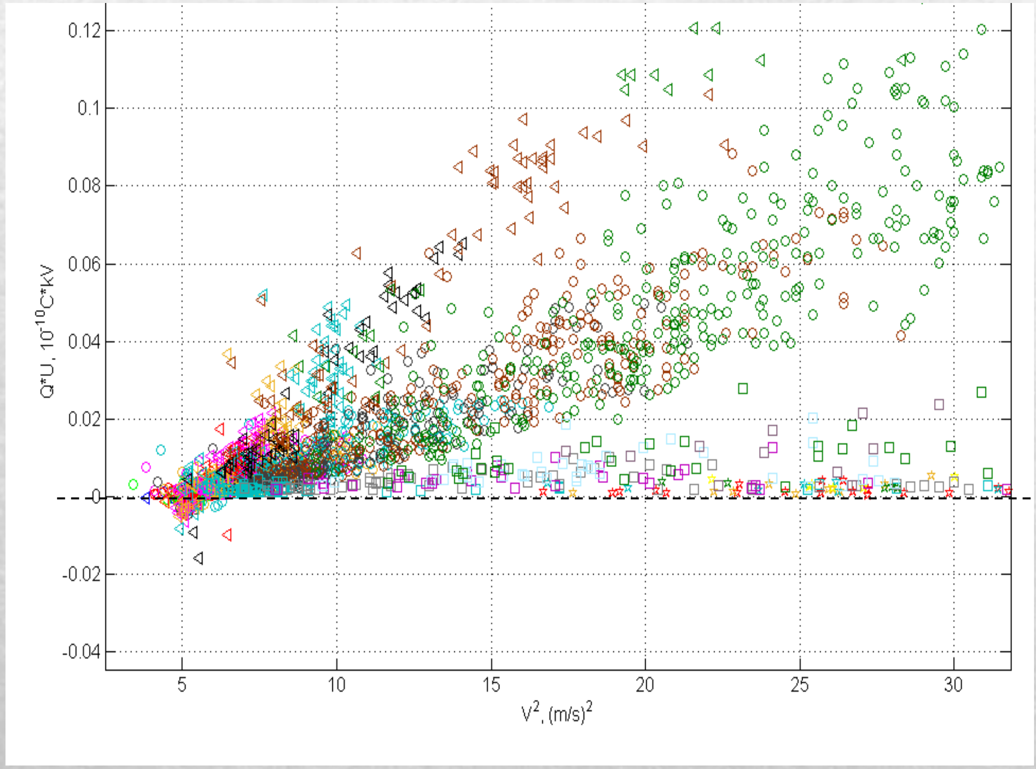

PZT19 first peak

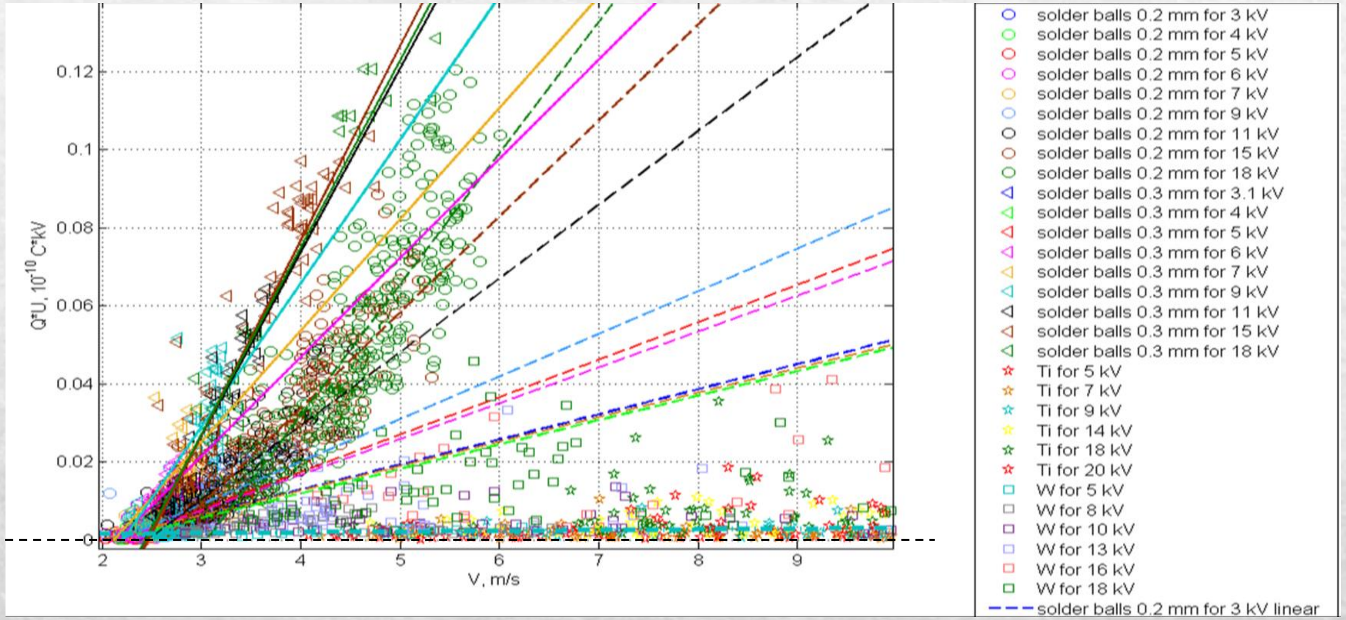



PZT36 first peak

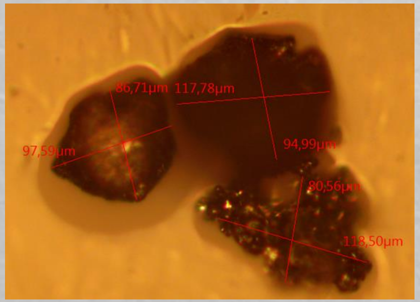


## Calibration of equipment for functional tests of the PmL device (QU ~ $mv^2$) by a set of dust particles

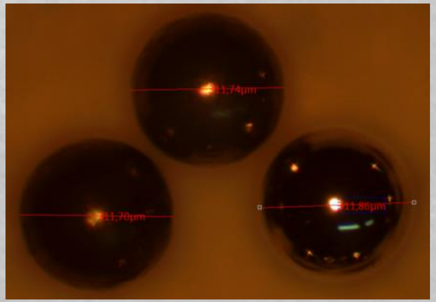


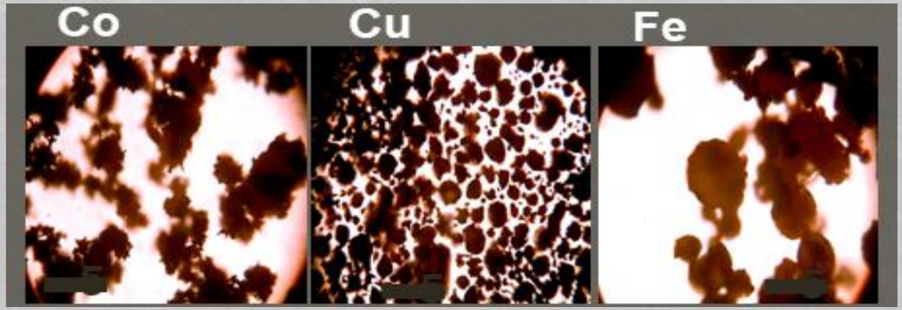




W

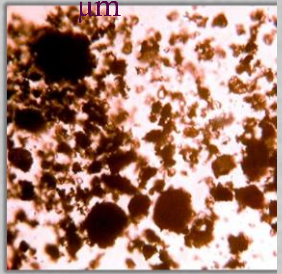


Solder Balls 37 % Pb, 63% Sn

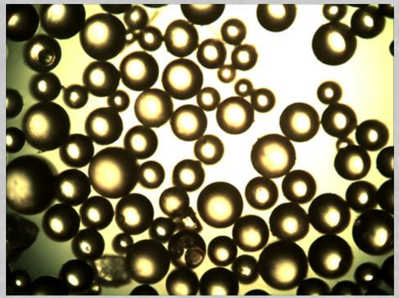




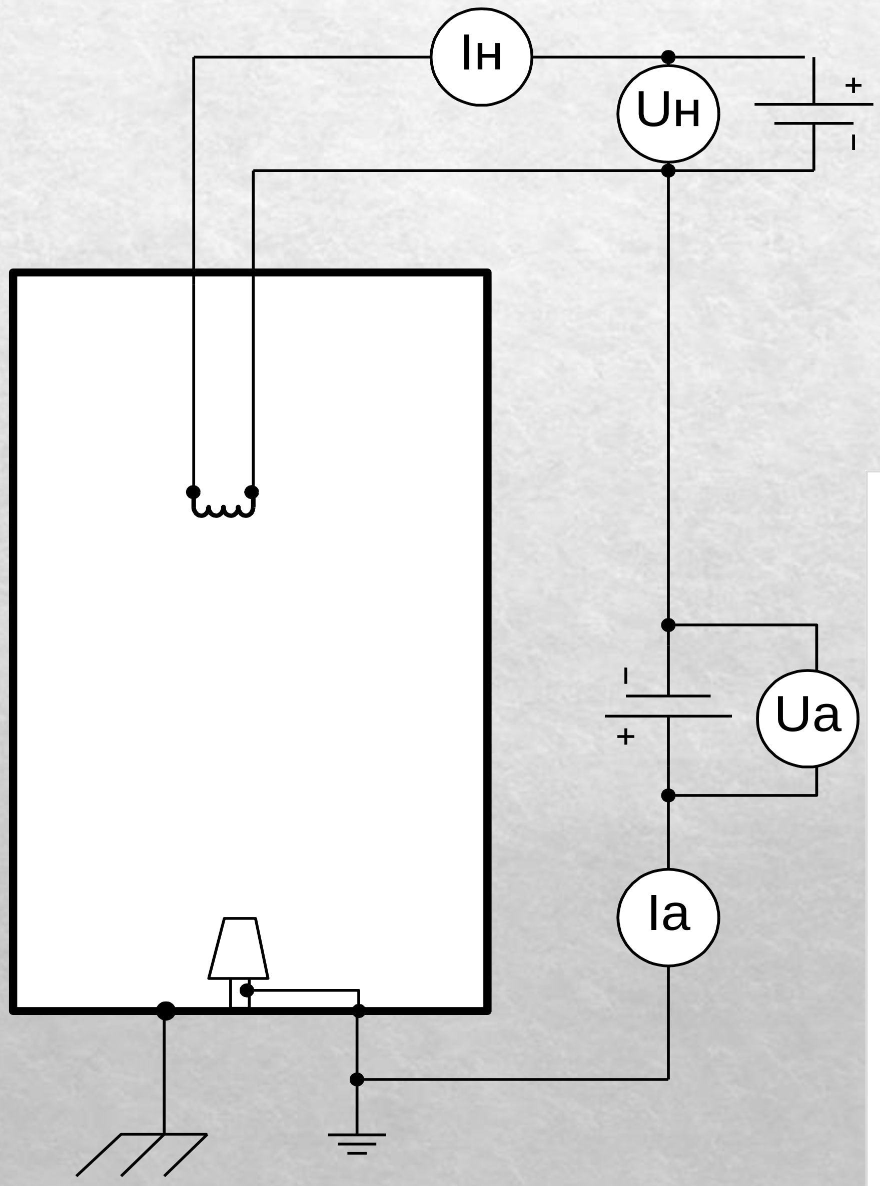

Ni – 10 µm



Glass balls $SiO_2$

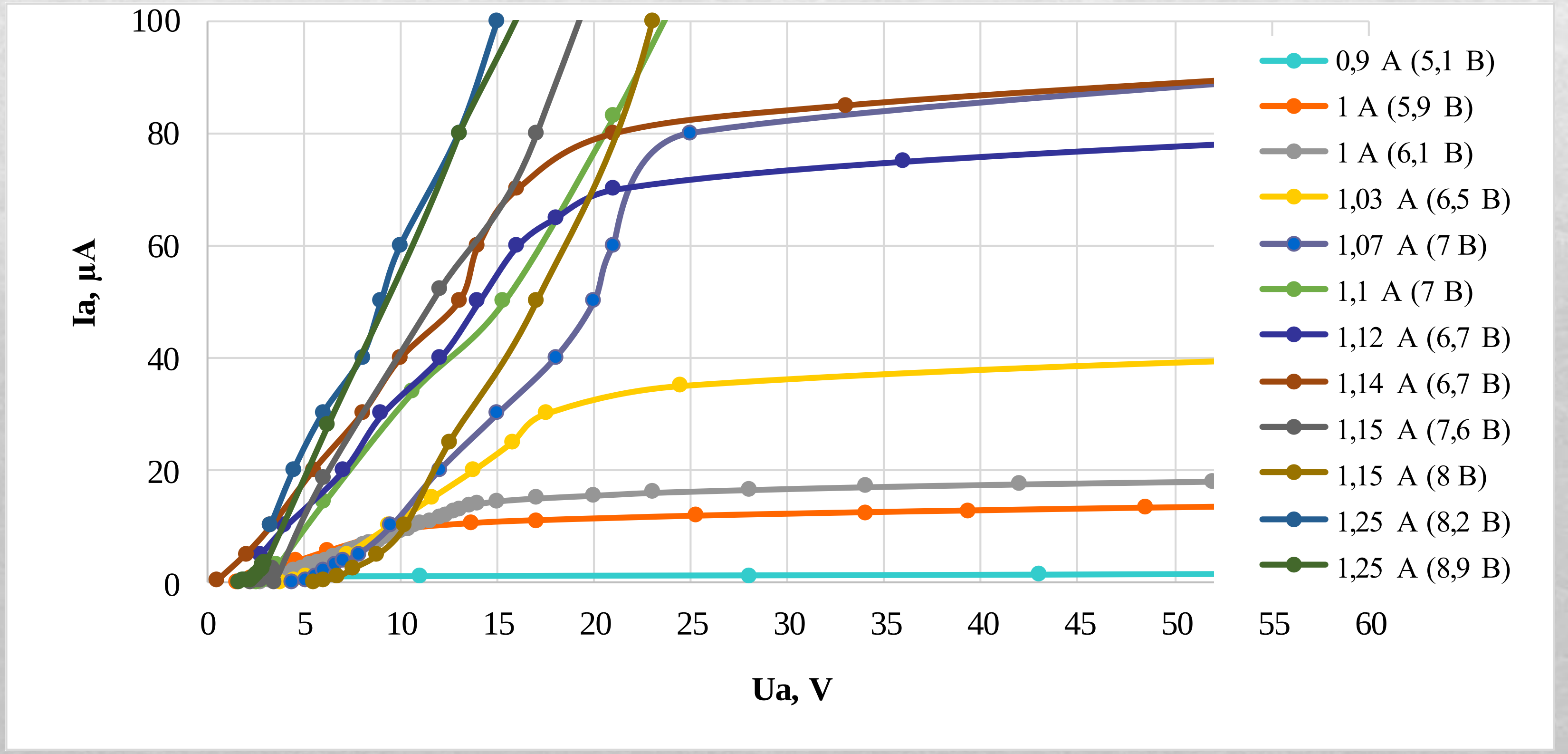


# Thermal emission

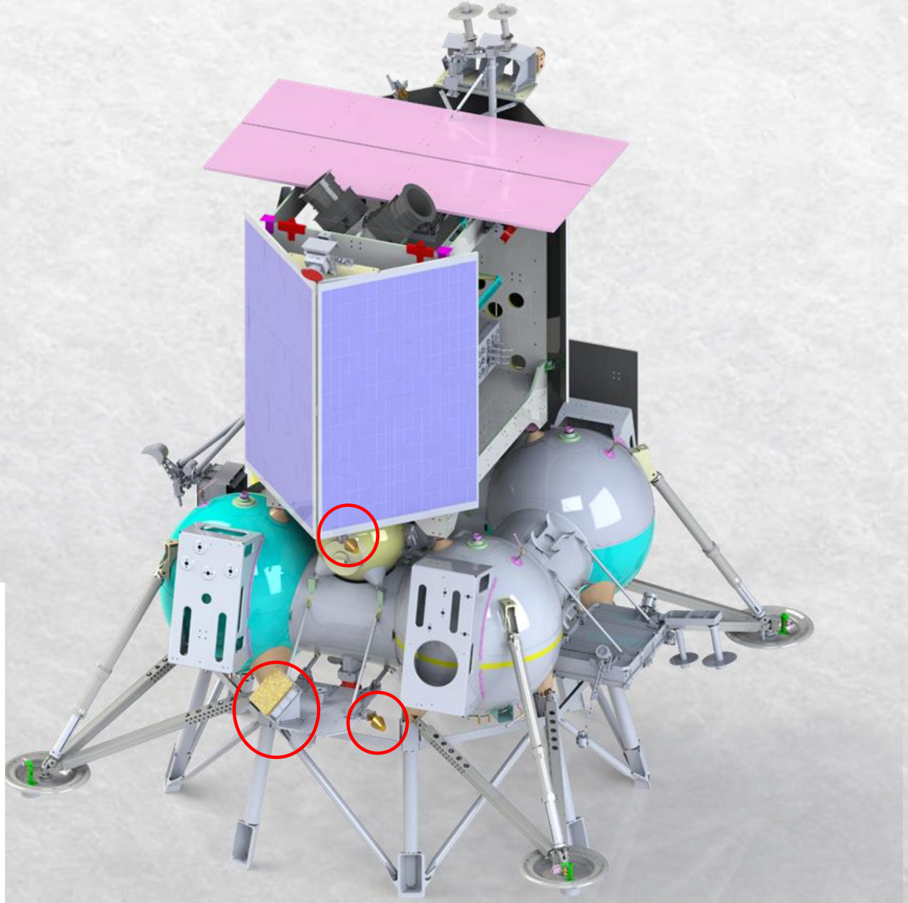



- Electron source: W filament
- $T_e$ = 4,3..50 eV
- Pressure: $10^{-3}$ torr
- $T_w$ = 2800..3300 K

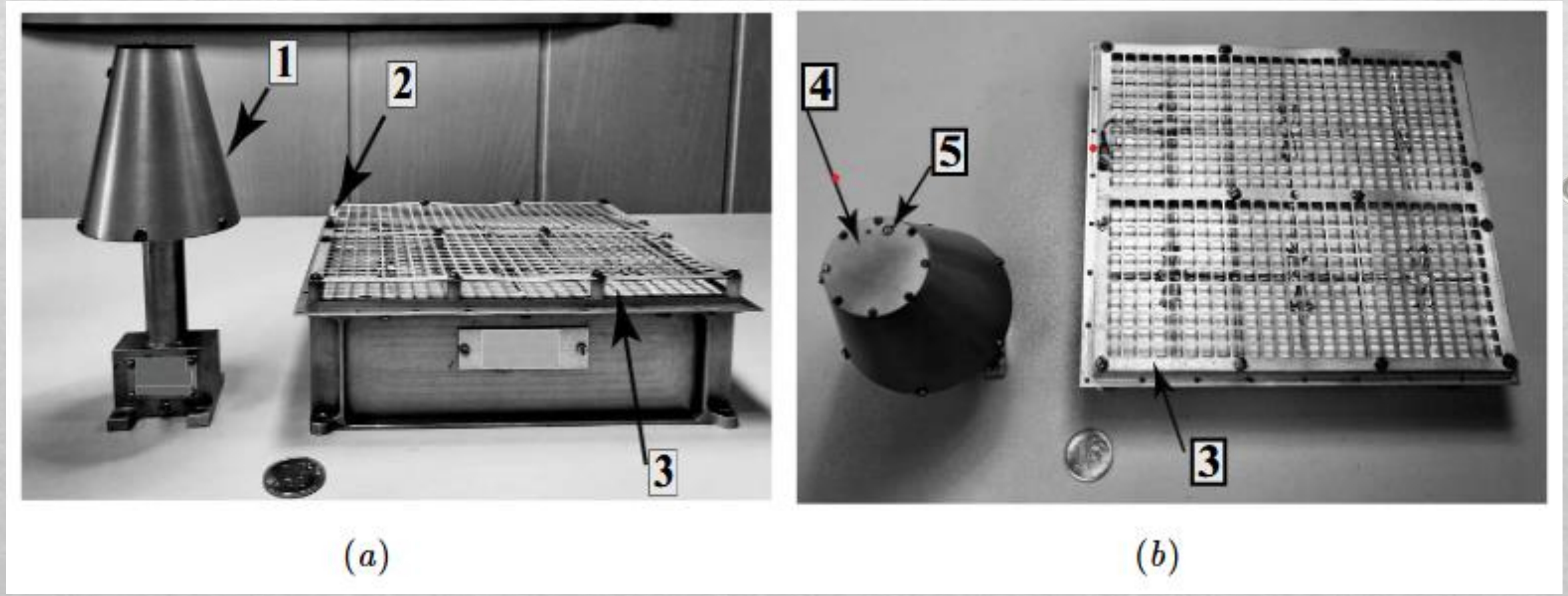
$$T = \frac{R - R_0}{\alpha \cdot R_0} + T_0$$



## The launch of the Luna-25 spacecraft is announced in October 2021



Dust instrument the PmL




(a) Face view and (b) top view of the electrostatic field sensor (on the right) and impact sensor (on the left). Numbers indicate the PmL detectors: 1—charge-sensitive shaped electrode; 2—charge-sensitive grid; 3—impact piezoelectric sensor; 4—planar Langmuir probe; 5—additional electrode.

## Conclusions

1. Near the moon surface as a result of interaction with the electrons and ions of the surrounding plasma, as well as under the influence of solar radiation, dust particles acquire an electric charge and become one of the important components of the environment, significantly affecting its properties and dynamics [Fortov V. E., Ivlev A. V., Khrapak S. A. et al. Complex (dusty) plasmas: Current status, open issues, perspectives // Phys. Reports. 2005. V. 421. No. 1–2. P. 1–103.].
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4. Equally important is the use of piezodetectors as low-noise targets for measuring the pulses of the dust component of the lunar dusty plasma environment.


Thank you for your attention