«XIII Zababakhin Scientific Talks»
Snezhinsk, Chelyabinsk region, Russia, March 20-24, 2017

ON STUDY PLANETO-PHYSICAL PROPERTIES OF ASTERIODS AND COMET NUCLEI

Vadim A. Simonenko[2], A. V. Zaitsev[1],

D. V. Petrov[2], V. N. Nogin[2], V. P. Elsukov[2],

D. A. Krasnoslobodtsev[2], A. I. Soroka[3]

1. Non-profit organization «Center of planet protection», Khimki, Russia
2. Russian Federal Nuclear center – Zababakhin Research Institute of Technical Physics, Snezhinsk, Russia
3. JSC «Spatial information systems», Moscow, Russia

г. Снежинск
2017

Introduction

1.Properties of NEO attract attention of investigators from the first discussions of hazards and prevention of space collisions (for us – from the end of 80-s).

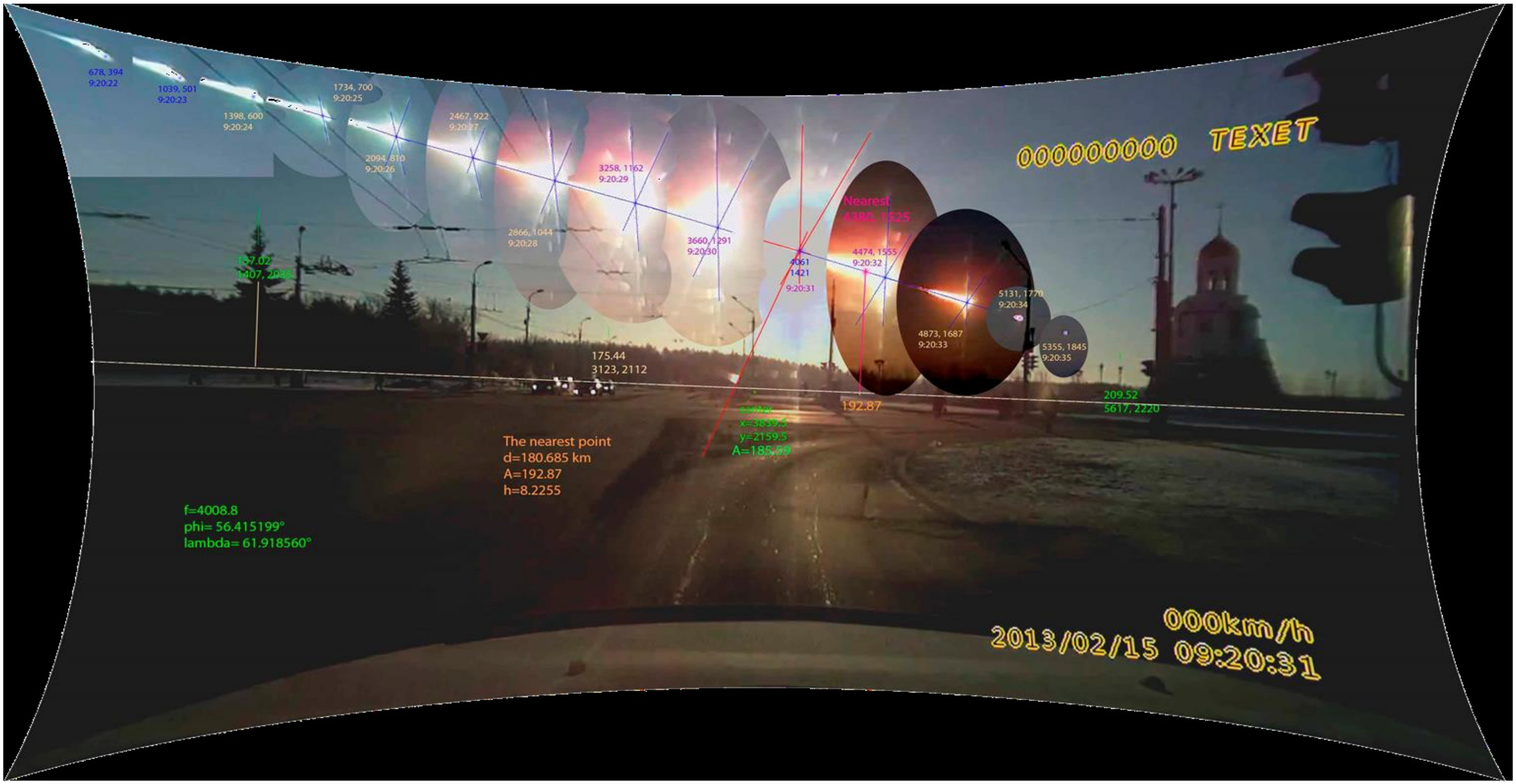
2.Currently we have rich (though incomplete) observational and experimental data, that is why we need to treat this issue from new positions.

3.Reasoning of the processes that accompany the fall of Chelyabinsk meteorite gives special stimulus for new discussions.

4.If in earlier considerations, the boundary of danger was at the level of typical sizes of 100 m for stone bodies, the analysis of Chelyabinsk event provokes to transfer it to the level of 20 m.

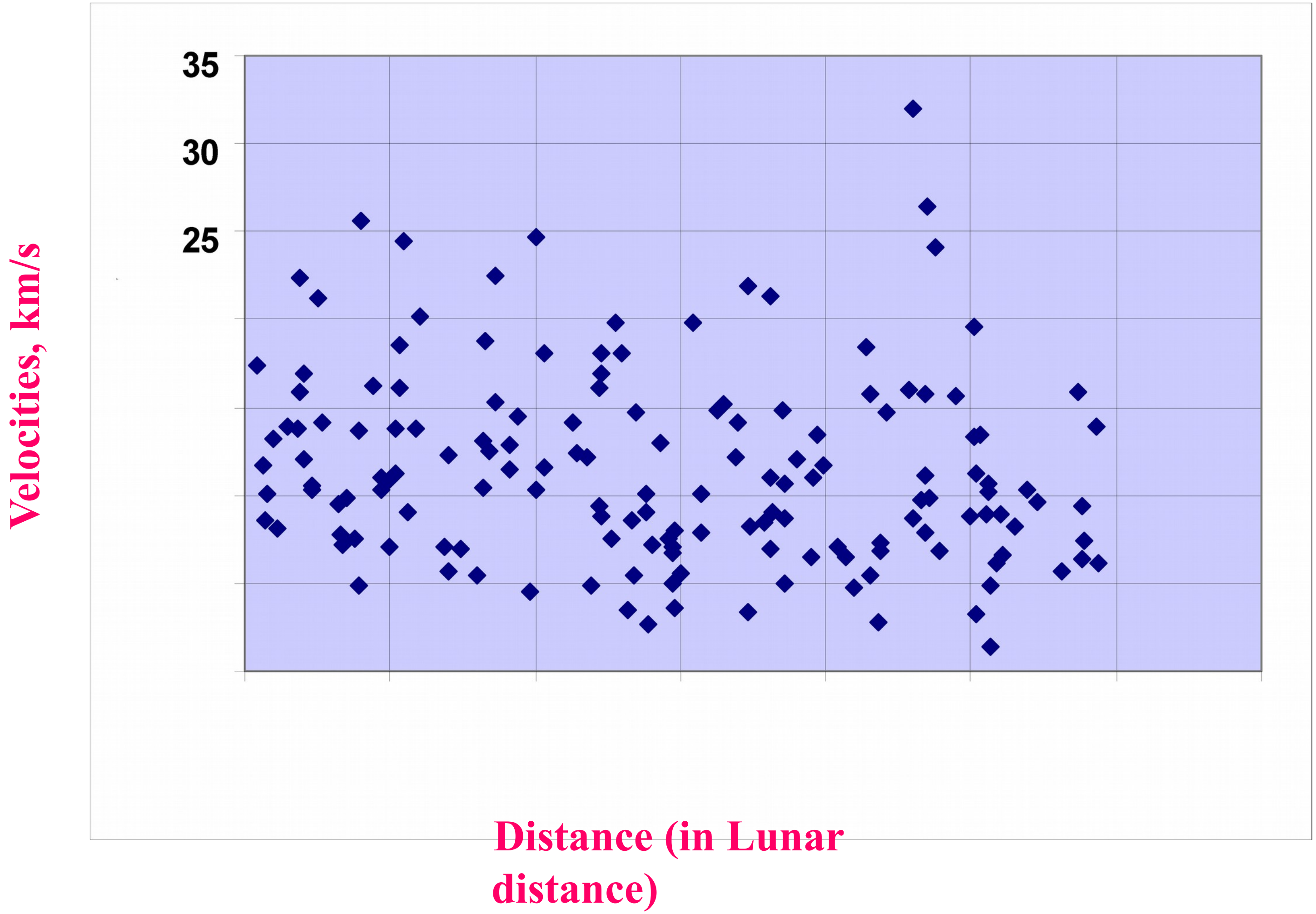
5.From another hand, the flights of such bodies near the Earth are frequent events. Besides the danger, they allow to get essential information about their properties and test the means of space navigation.


Перпендикуляр
A=197.72
h=27.3
Минимальное расстояние до трека 21.4 км,
Ход ударной волны 65 сек, время 9:21:20
Широта 54.723416, долгота 61.263172
Солнце на высоте 0.28 градуса по азимуту 111.93
Смещение облака по азимуту 150 на 592 метра
4369 пикселей на 180 градусов
0.0412 градуса на пиксель
59.4
107.72
62.7
Перпендикуляр
A=200.52
h=26.3

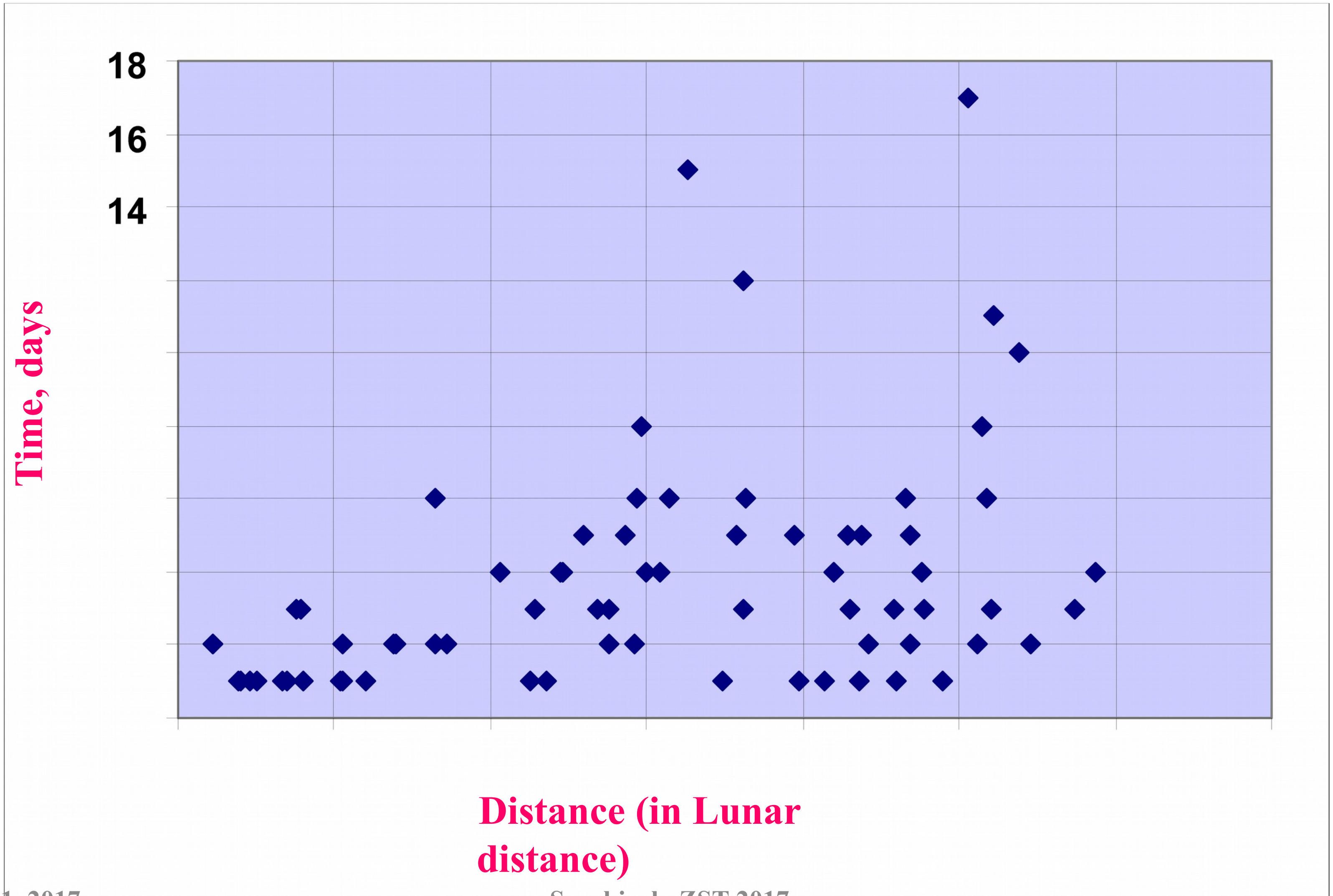

678, 394
9:20:22
1039, 501
9:20:23
1398, 600
9:20:24
1734, 700
9:20:25
2094, 810
9:20:26
2467, 922
9:20:27
2866, 1044
9:20:28
3258, 1162
9:20:29
3660, 1291
9:20:30
4061
1421
9:20:31
Nearest
4380, 1525
4474, 1555
9:20:32
4873, 1687
9:20:33
5131, 1770
9:20:34
5355, 1845
9:20:35
000000000 TEXET
157.02
175.44
3123, 2112
x=3839.5
y=2159.5
A=185.59
192.87
209.52
5617, 2220
The nearest point
d=180.685 km
A=192.87
h=8.2255
f=4008.8
phi= 56.415199°
lambda= 61.918560°
000km/h
2013/02/15 09:20:31

Data of observation and space navigation

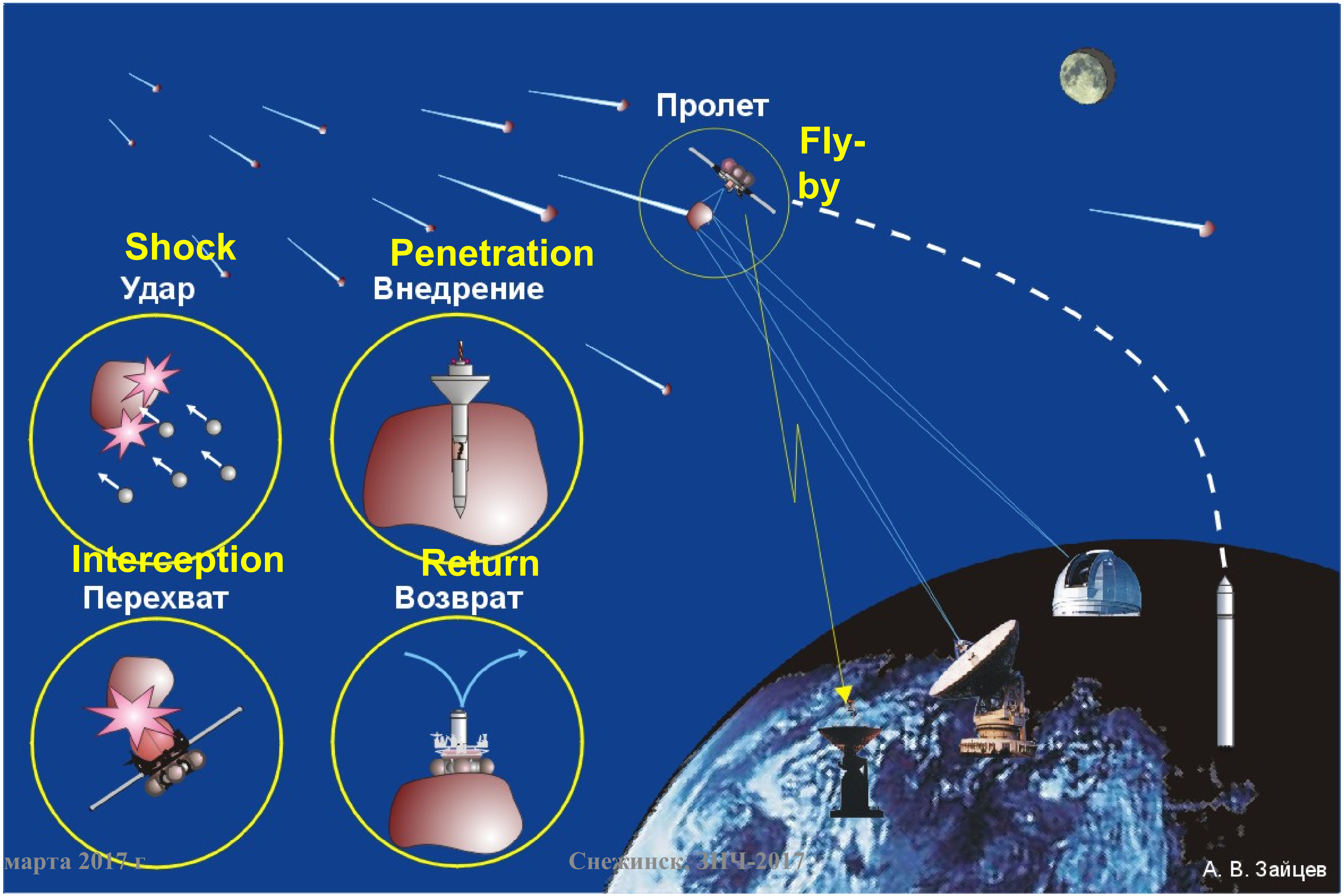
Fly-by velocities of NEAs in gravitation sphere of the Earth in 2016



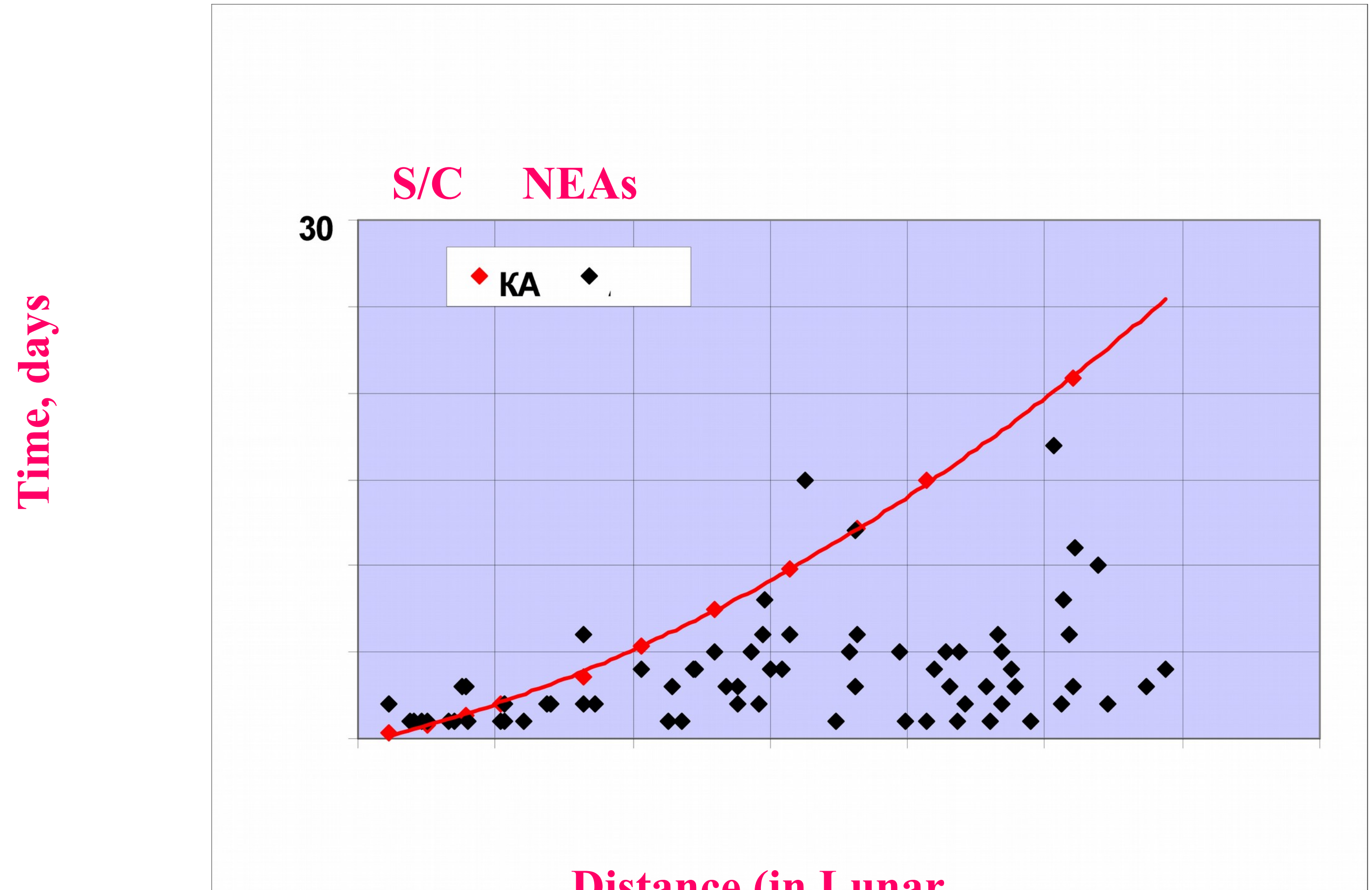
Time from detection of NEAs before their approach to the Earth



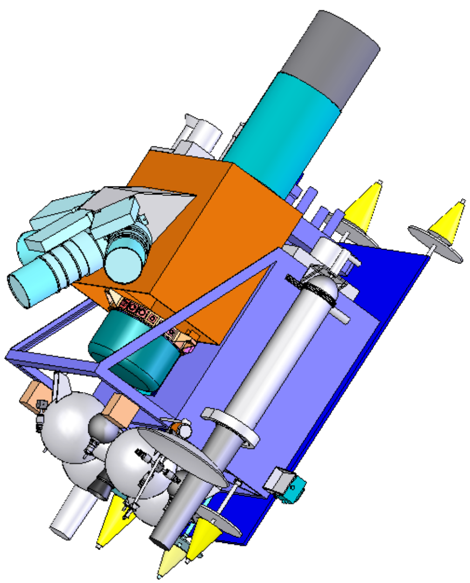
Demonstrational experiment «Space Patrol»

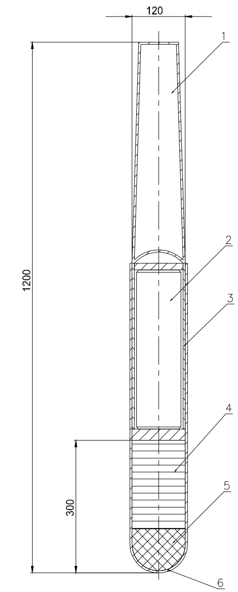


Time of approach NEAs and S/C flight to them



S/C-reconnaissance with penetrators





S/C mass - 262 kg
including:
kinetic load of apparatus - 48 kg
2 penetrators - 30 kg

1 - **Tail part**
2 - **Service equipment**
3 - **Case**
4 - **Damper**
5 - **Heat protection**
6 - **Nose**

Prototypes of the penetrators

Low-Speed penetrators

Низкоскоростные
пенетраторы

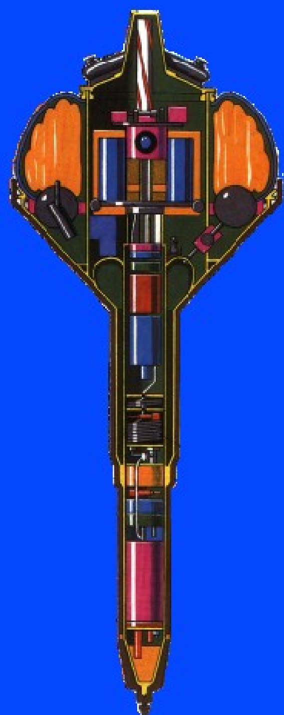
Масса - 115 кг
Масса КНА - 5 кг
Скорость внедрения - 80 м/с

Масса - 250 кг
Масса пенетратора - 30 кг
Масса КНА - 4 кг

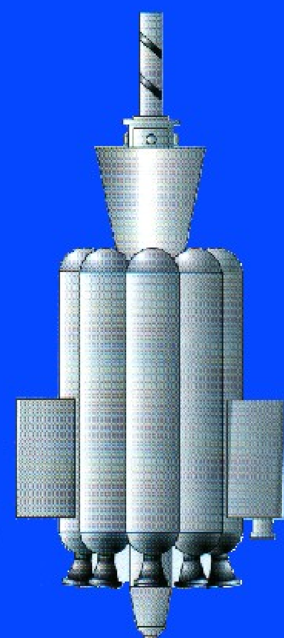
High-Speed penetrator

Высокоскоростной
пенетратор

Масса - 15 кг
Масса КНА - 1,7 кг
Скорость внедрения - 2 600 м/с

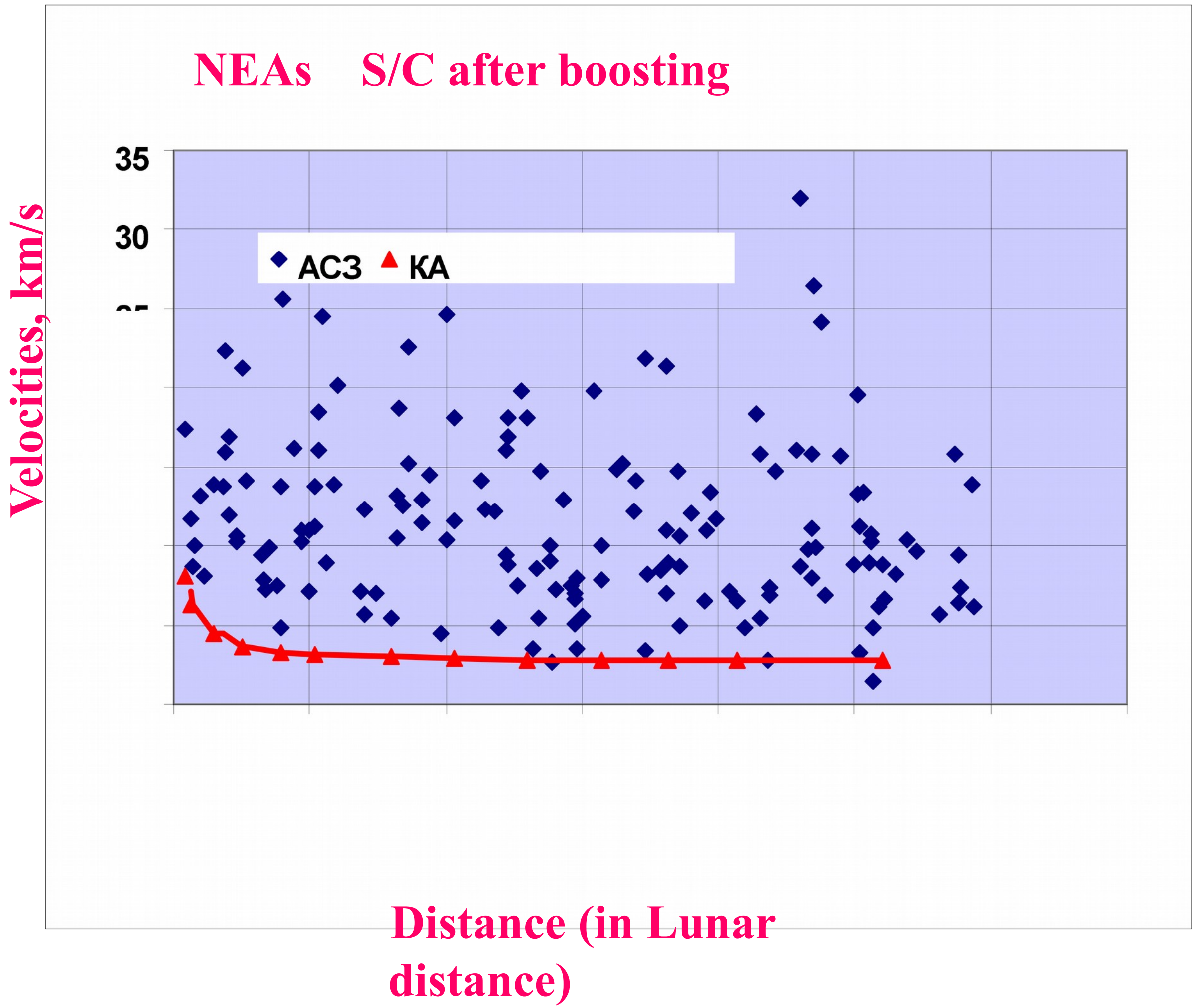


“Марс-96”

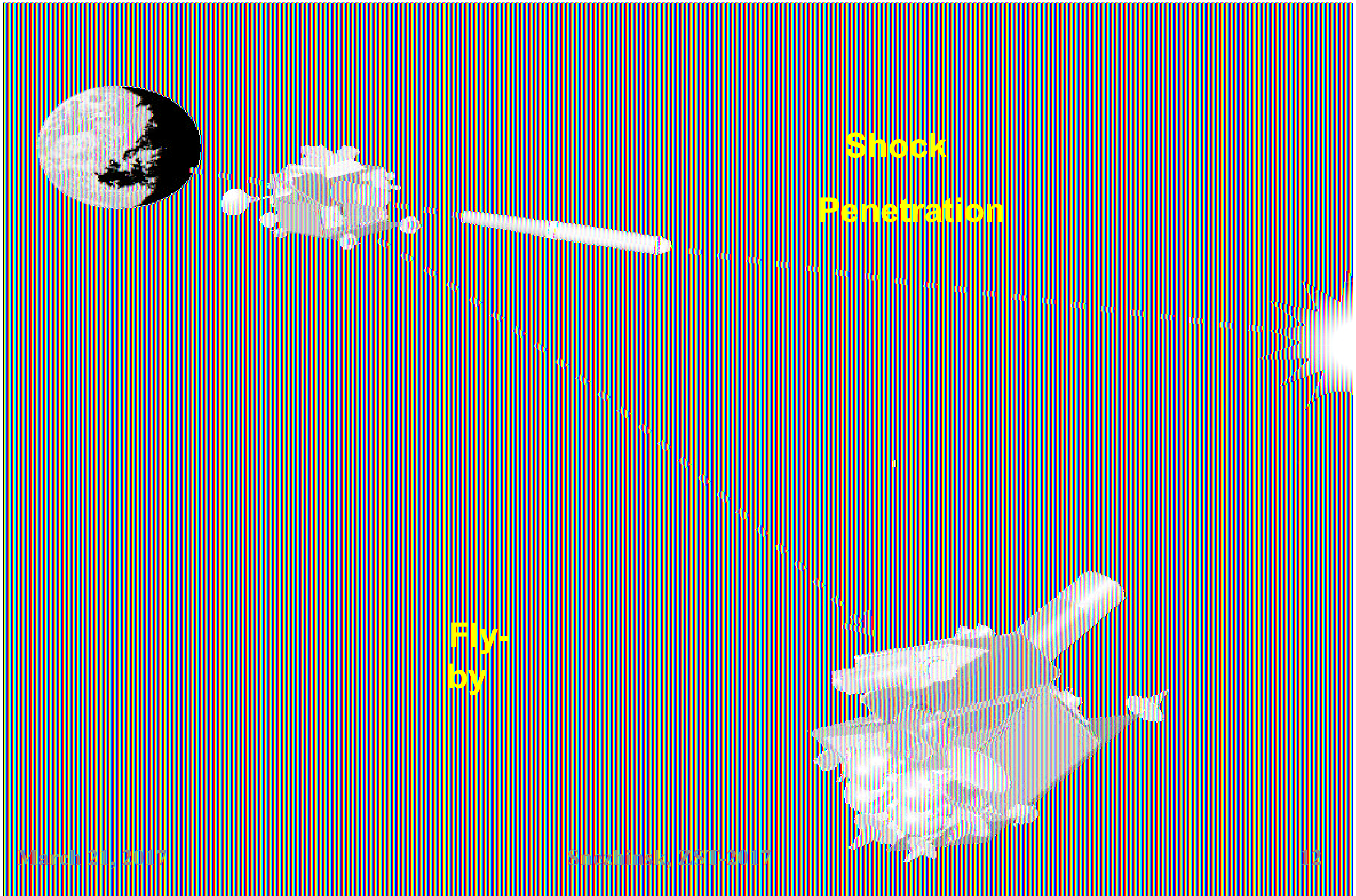


“Луна-Глоб”

Velocities of the S/C-reconnaissance and NEAs



«Impact» («Penetration») and «Fly-by» experiments



Investigation into object properties and development of kinetic impact means

Gravitation measuring tool

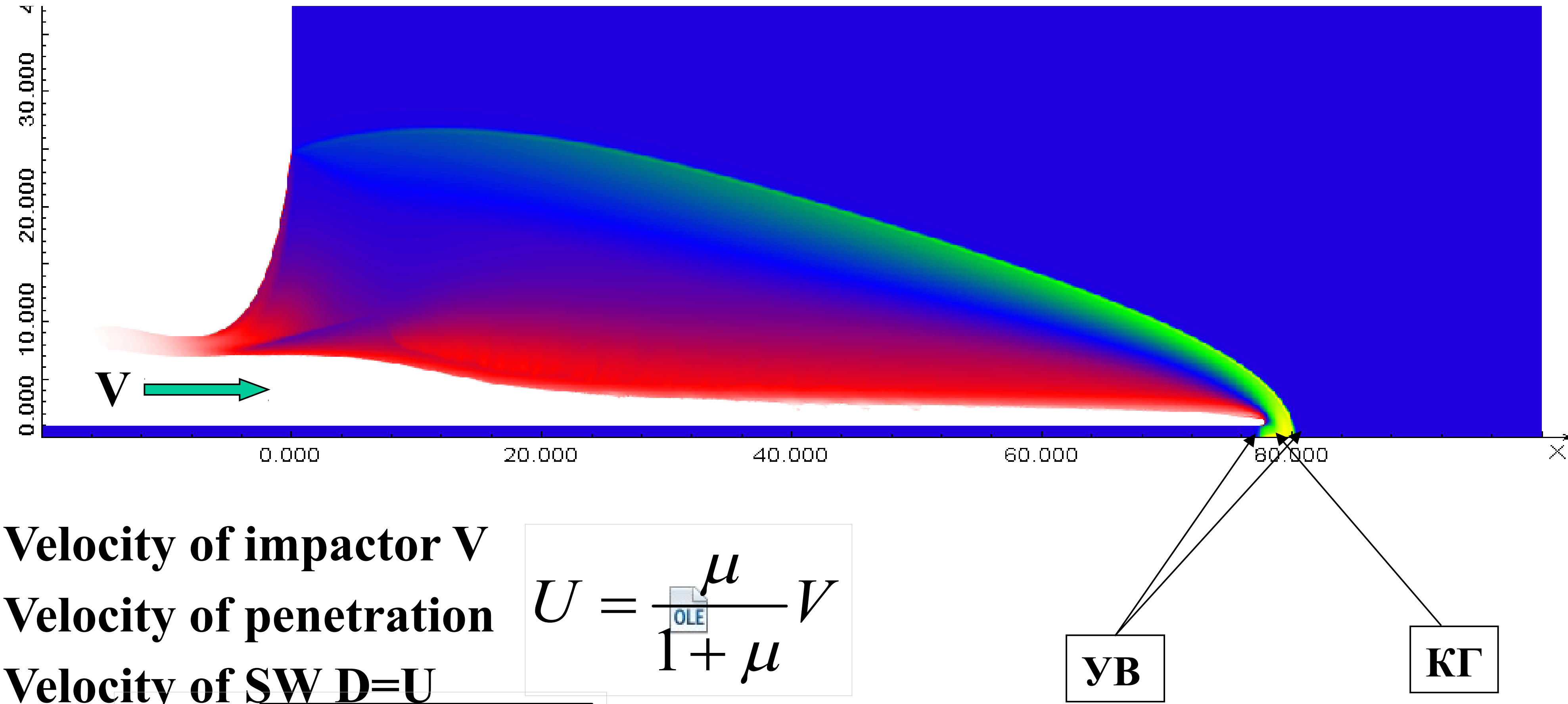
Mass: 4 kg

Power: 30 W

Range : 50-100 km

Accuracy: 0,001-0,0001 E

Stationary supersonic penetration



Velocity of impactor V

Velocity of penetration

$$U = \frac{\mu}{1+\mu} V$$

Velocity of SW D=U

$$\mu = \sqrt{\frac{\rho_c \left(2 - {}^{1}\!/_{\delta_c}\right)}{\rho_n \left(2 - {}^{1}\!/_{\delta_n}\right)}}$$

V.P.Elsukov, V.N.Nogin, M.Yu.Naumenko, V.A.Simonenko, V.L.Sorokin
IX ZST(2007)

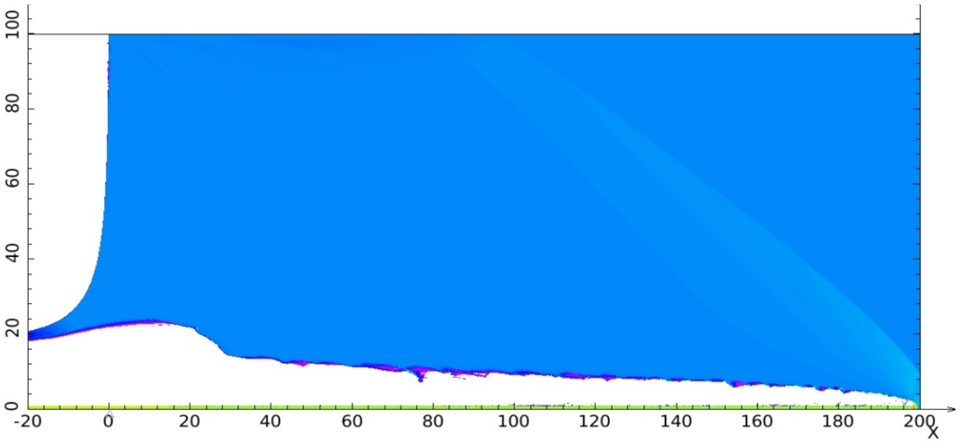
Numerical modeling

Task: to assess the state of cavity and possible ground influence on penetrator integrity

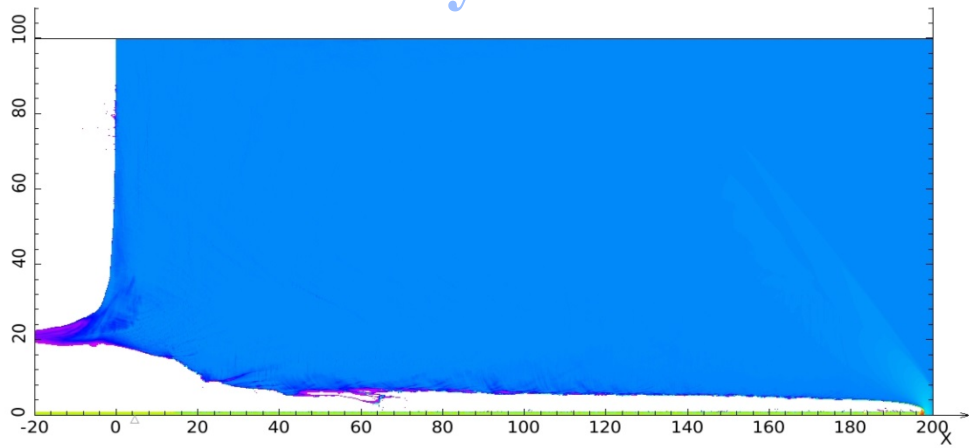
Set-up of calculations

- 2D complex MECH
- A rod with diameter R=1cm and length L=100cm
- Velocity of the rod V=10km/s
- Material of the rod – steel (density 7.8г/cm^3)
- Ground density 2.65g/cm^3 (granite)
- EOS of the substance of Mie-Gruneisen type with parameters selected by experimental data
- Yield stress and spallation ground strength were varied

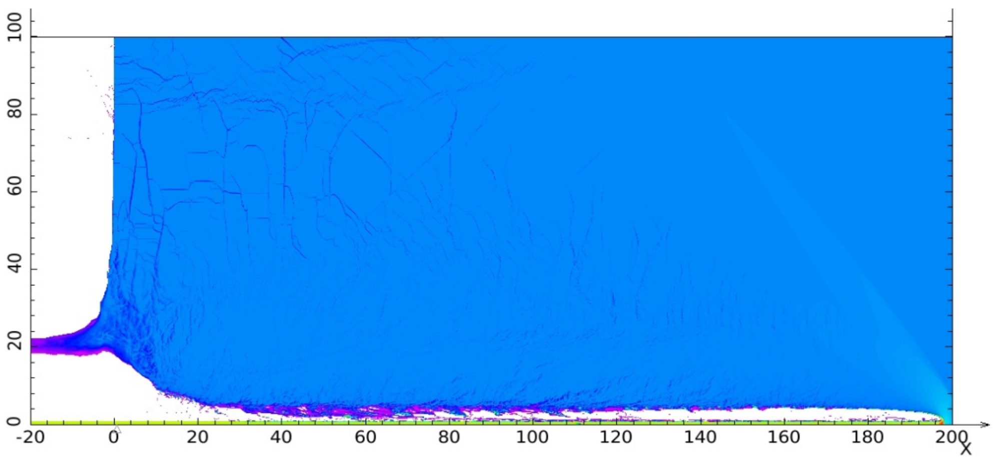
Yield stress influence on the cavity size



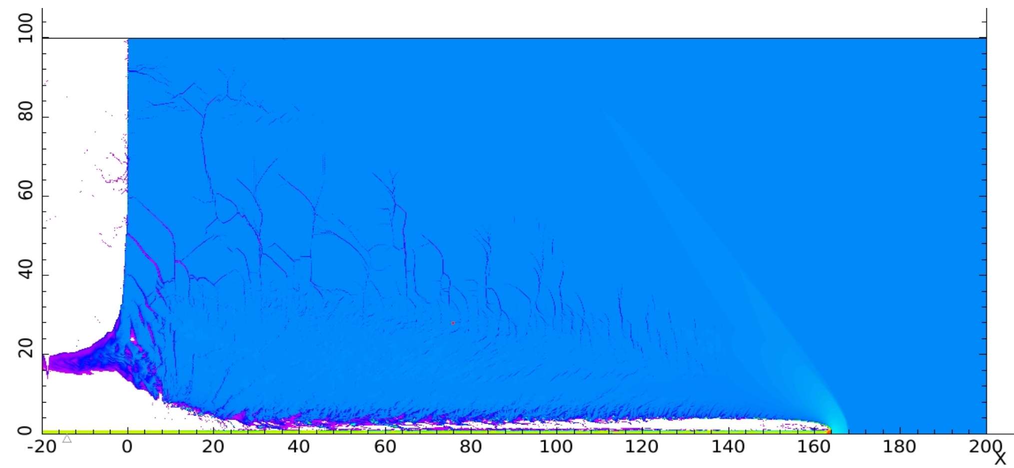
Y = 0 (without elas.plast.), Pcr= - 0.015, t = 320 μs



Y = 2, Pcr= - 0.015, t = 320 μs

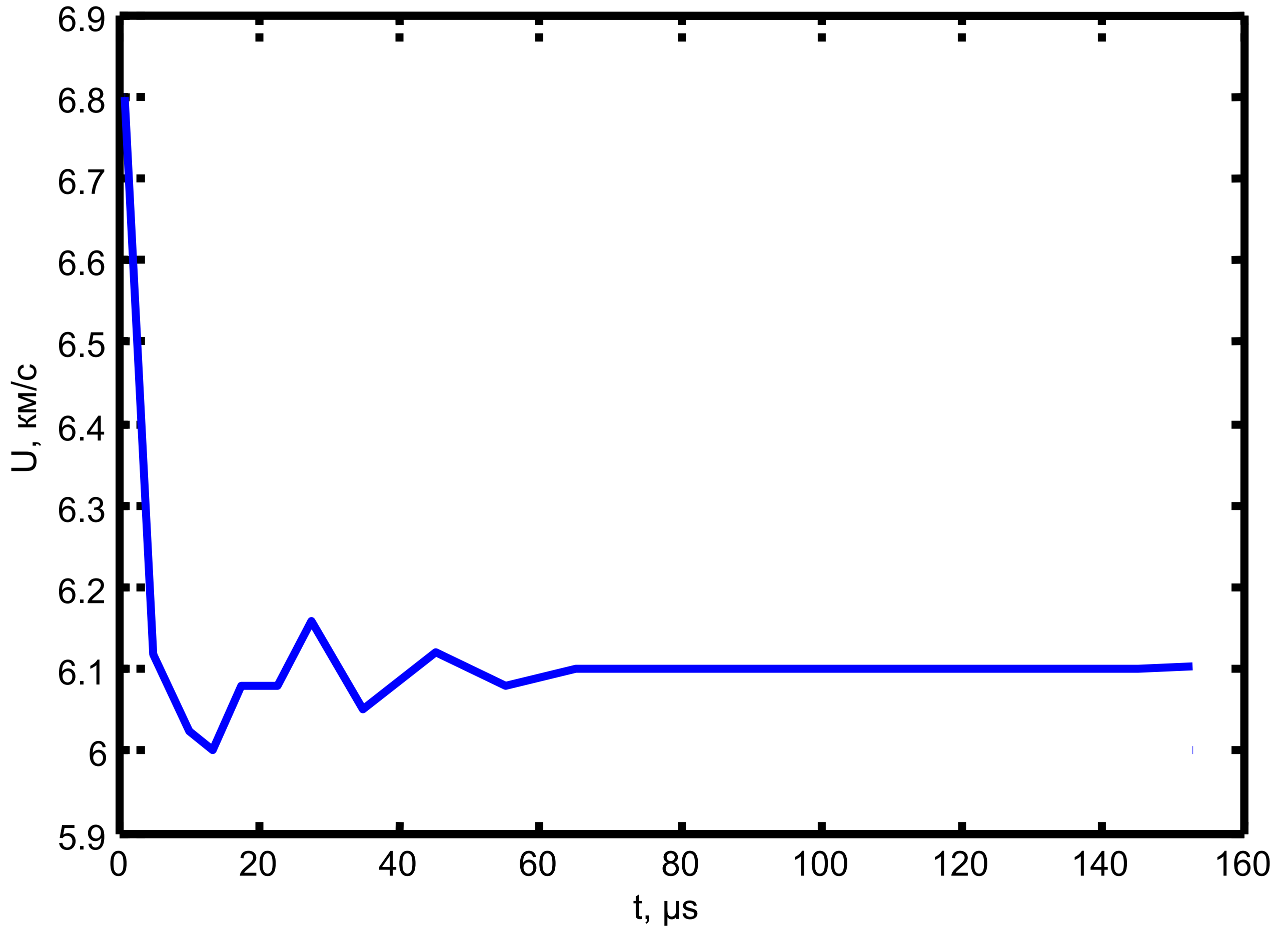


Y = 2, Pcr= - 0.2, t = 320 μs



Y = 2, Pcr= - 0.5, t = 265 μs

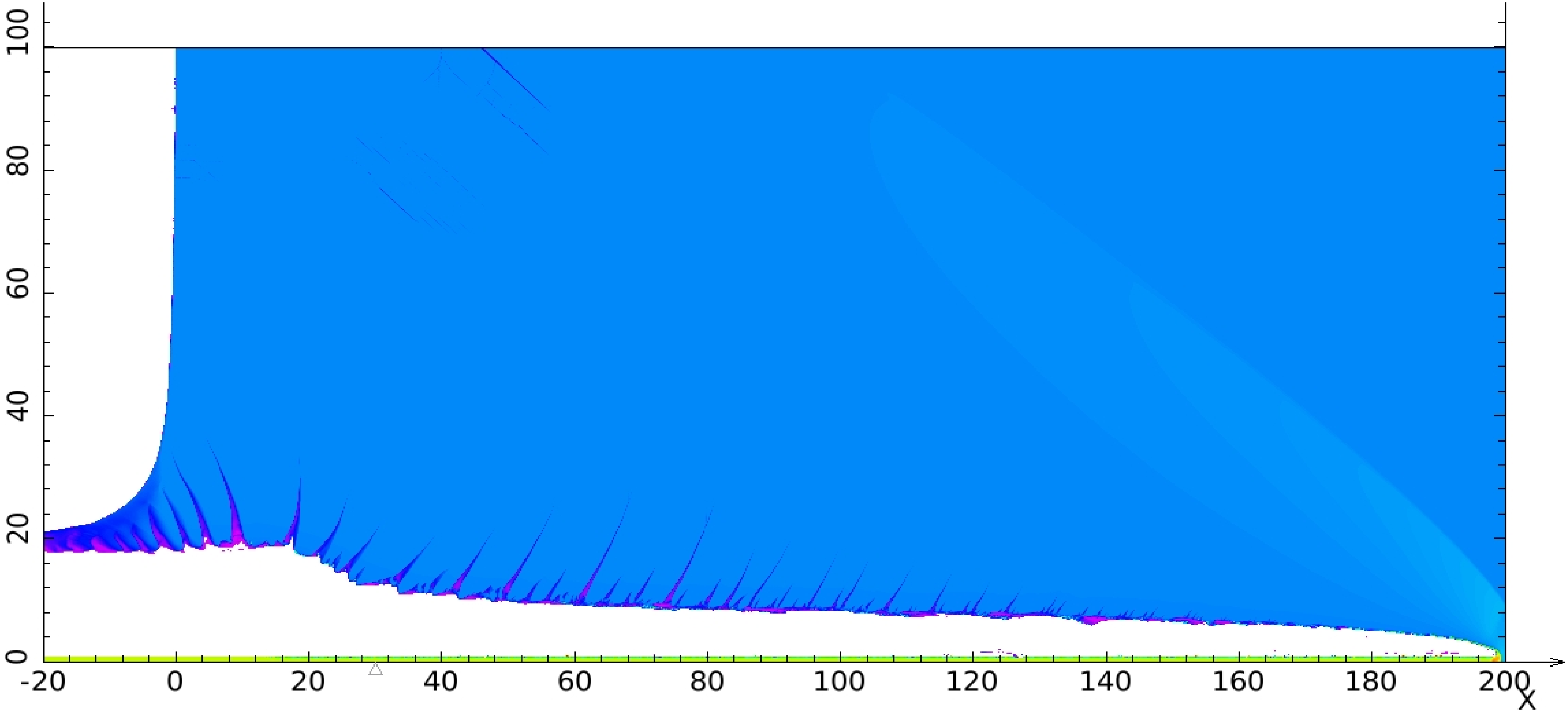
Field of densities (R=1cm)



Dependence of penetration velocity on time

V=10km/s, ground density 2.65g/cm³

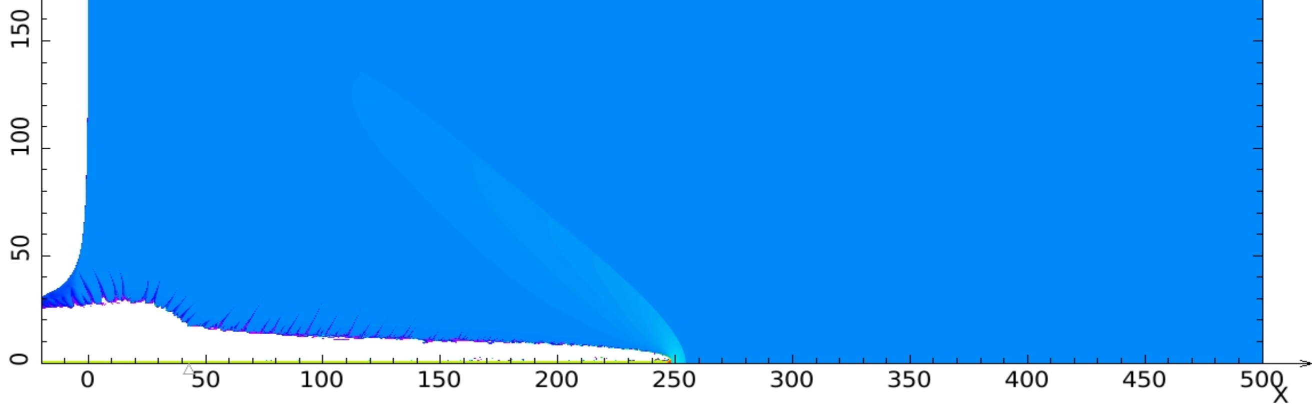
$U_{incompres.\ liq.}$=6.3km/s



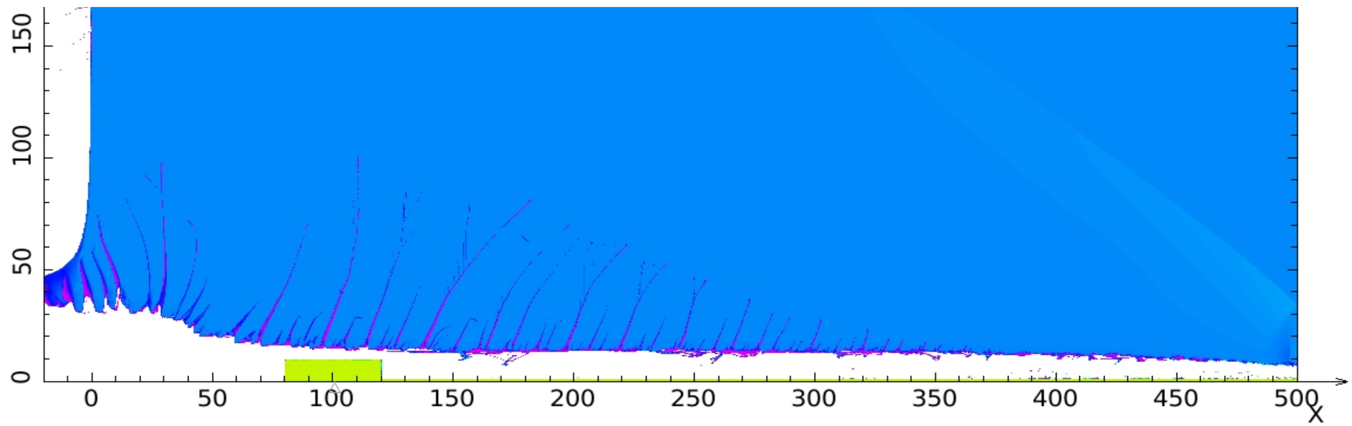
Y = 0.2, Pcr= - 0.2, t = 320 μs

Field of densities (R=1cm)

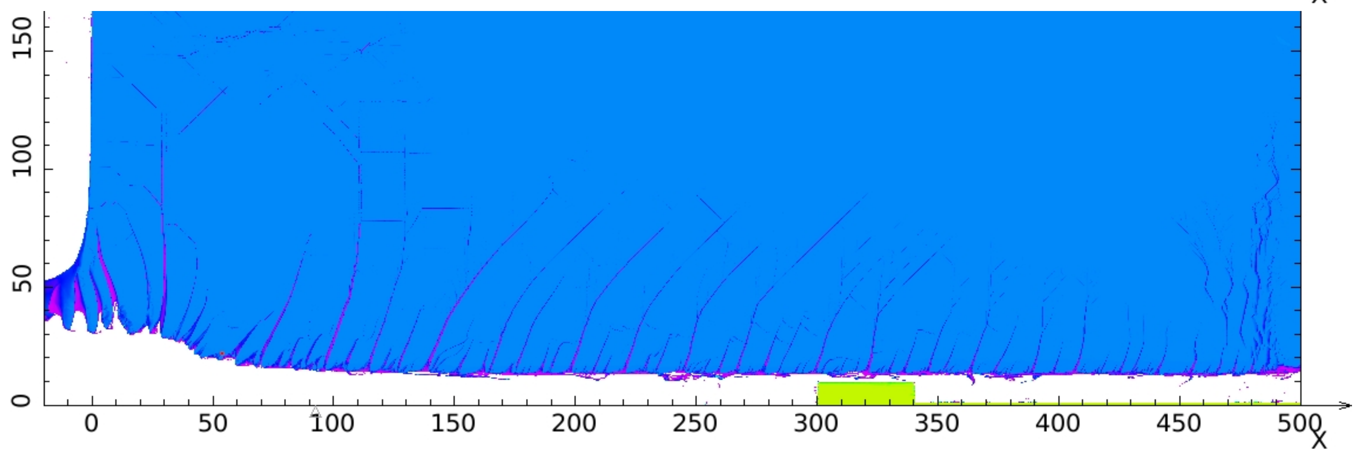
t = 400 μs



t = 830 μs

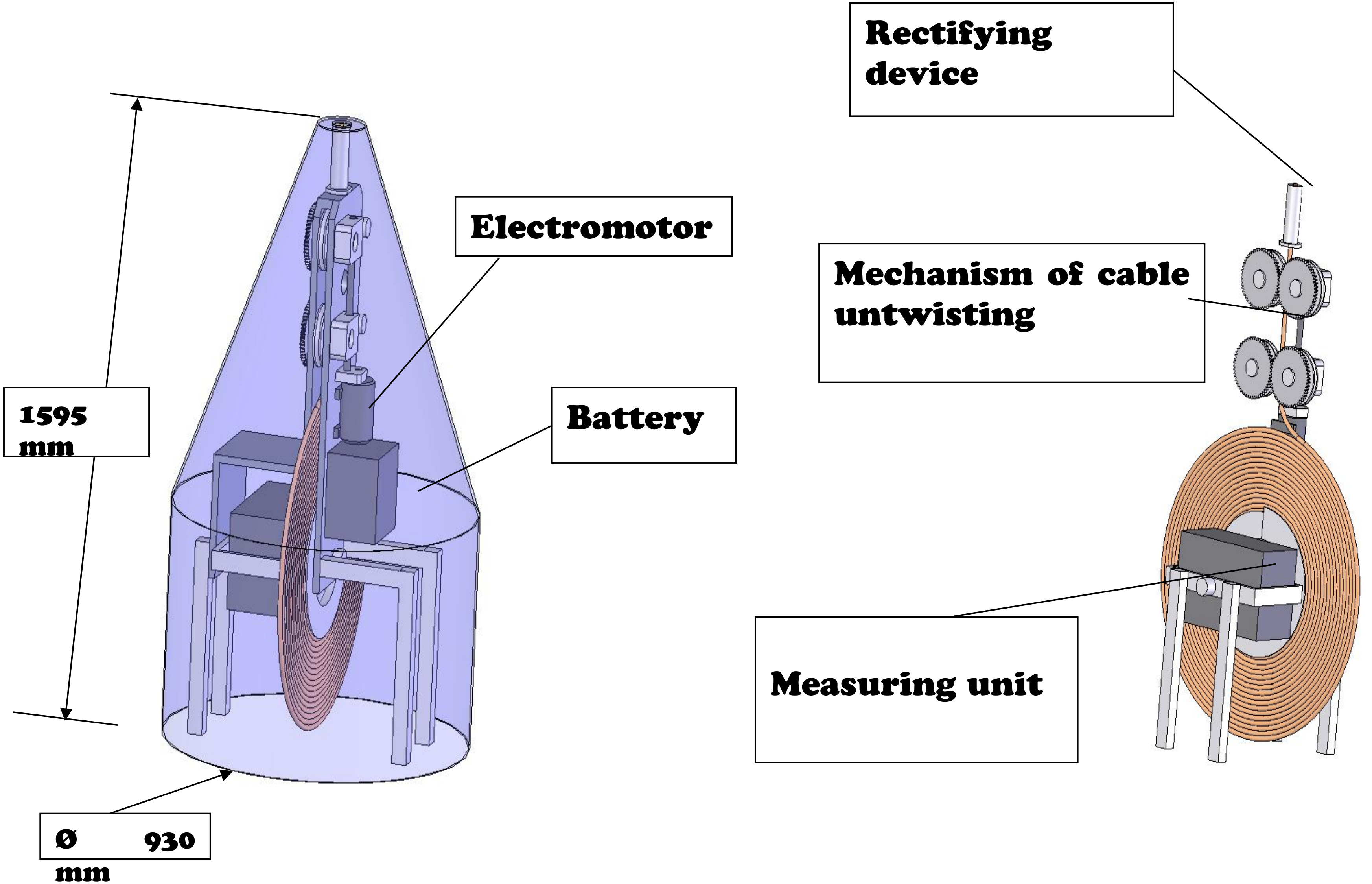


t = 1050 μs



Field of densities (R=1.5cm)

General view of antenna module



The contents of engineering model of an asteroid

1. Orbital movement
2. Planeto-physical parameters (figure, rotation etc.)
3. Mass, density, field of gravity
4. Structure of surface
5. Structure of subsurface
6. Photometric characteristics
7. Radio-physical characteristics
8. Ground composition and properties
    1. Information on large-scale distribution of mass can be obtained by gravimetric method (including tomography)
    2. By internal structure with the help of high-speed collisions by cumulative rod
    3. Created channel can be used for location in diagnostic equipment and means of additional tests

Development of technology for kinetic impact on NEO

NEO energy and mass at various densities and effective diameters.

№	ρ g/cm³	D m	M kt	E Mt TE	Note
1	3	18	10	0,5	Chel.
2	3	38,8	100	5,0	Tun.
3	1	83,4	333	16,6	Tun.
4	2	83,4	667	33,3	
5	3	83,4	1000	50	KI boundary
6	3	179,3	10000	500	Loc. boundary

1. Probable boundaries of KI application with up-to-date engineering – in region # 1÷2.
2. In perspective, we may cover #3÷5.
3. Bin lines #2÷3, there is Tunguska fall.
4. Line #6 corresponds to earlier determined boundary of local catastrophies.

1. ***Frequent flights of small bodies give favorable conditions for investigation into their properties and KI technologies.***
2. ***This creates good basis for organizing real protection with the help of KI against dangerous objects and is essential technological backup for creating protection against big objects that require using nuclear explosion.***

Conclusion

1.Growth of number of detected NEAs permits to study their properties when they approach the Earth.
2.Existing technologies permit to organize wide spectrum of expeditions, which will investigate NEOs – from remote studies up to direct (contact) including delivery of ground samples to the Earth.
3.Existing and promising gravigradient technologies permit to passively and remotely determine (with error1-5%) the mass, tomography of dense nonuniformity and angle velocity of NEOs and comet nuclei rotation.
4. In dynamic experiments, it is possible to provide collision velocities from tens of meters per second up to tens kilometers per second.
5.At high velocities of approaching, one can obtain data about properties of comprising rocks under dynamic loading in natural conditions of the object and about the character of possible destruction under kinetic impact.
6.Realization of such investigation program opens new possibilities for studying NEOs properties and developing methods of neutralization of potentially dangerous collisions.

THANK YOU FOR YOUR ATTENTION