



→ **14TH SPACECRAFT CHARGING
TECHNOLOGY CONFERENCE**

**External and Internal Spacecraft Charging Effects and
Mitigation Techniques. Russia's Approach**

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Multi-step method to safeguard the spacecraft as adopted in Russia

The first step is the choice of materials for external surface of SC

Expressions for calculation of maximal electric fields in the polymers under electron irradiation:

$$\mathbf{F}_{\max} = \mathbf{I}_0/\gamma_d \text{ or } \mathbf{F}_{\max} = \mathbf{I}_0/\gamma_r \quad \text{for non penetrating irradiation or}$$

$$\mathbf{F}_{\max} = \mathbf{S}_0 \mathbf{h}/2\gamma_r \quad \text{for homogeneous irradiation;}$$

\mathbf{I}_0 is the electron current density, A/m²;

\mathbf{S}_0 is the electron injection rate, A/m³;

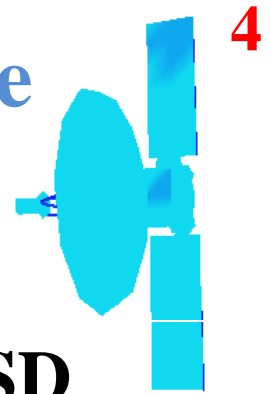
\mathbf{h} is the polymer thickness;

γ_d and γ_r are dark and radiation-induced conductivities $\Omega^{-1}\text{m}^{-1}$;

Detail [Thursday, 10 a.m., Tyutnev]

At present, we do not have polymers for external surface fully protected from ESD and we can only reduce the frequency and power of ESD.

The second step is a calculation of the potential relief of SC



The main task is to define the sites of possible ESD

[posters 10, 11
Novikov]

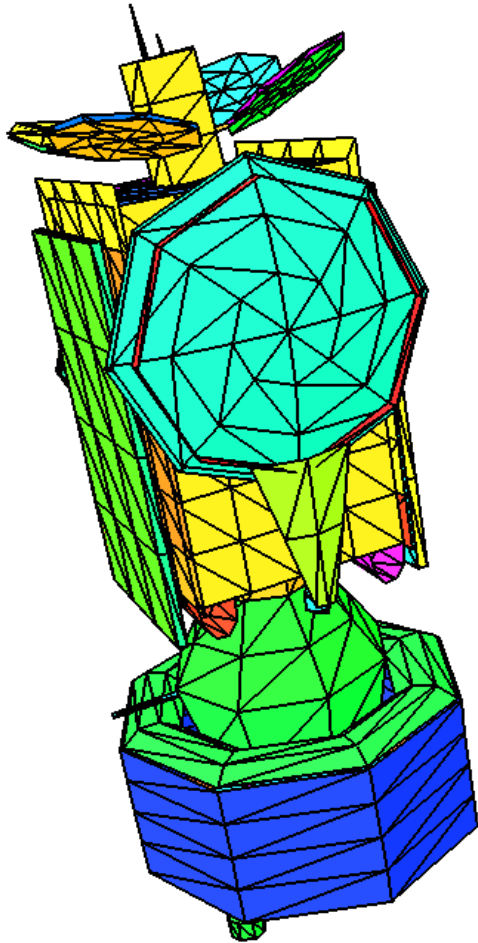
Russian
COULOMB-2
(Lev Novikov et al.)

American
NASCAP

European
SPIS-5

Japanese
MUSCAT

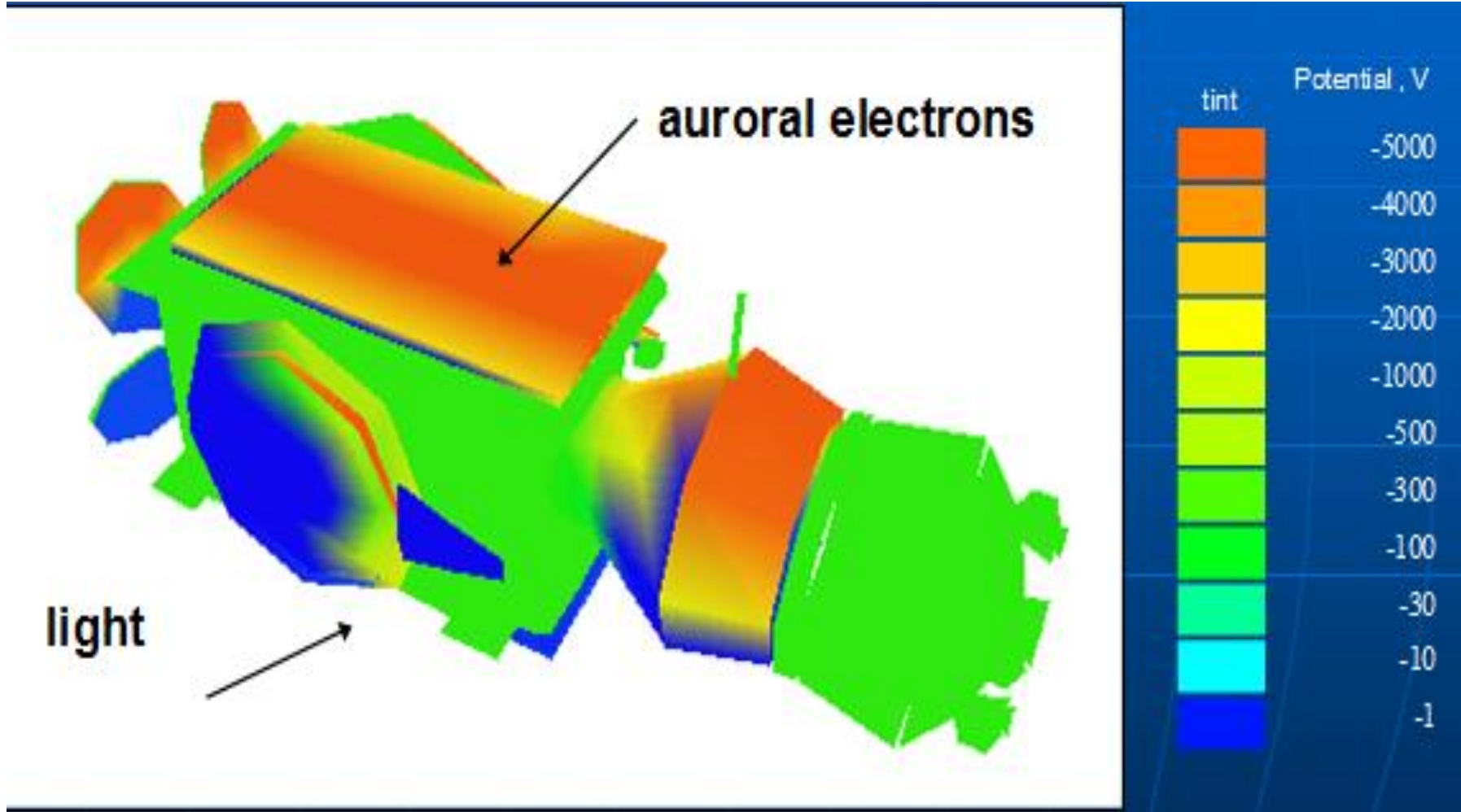
3D SC geometrical model



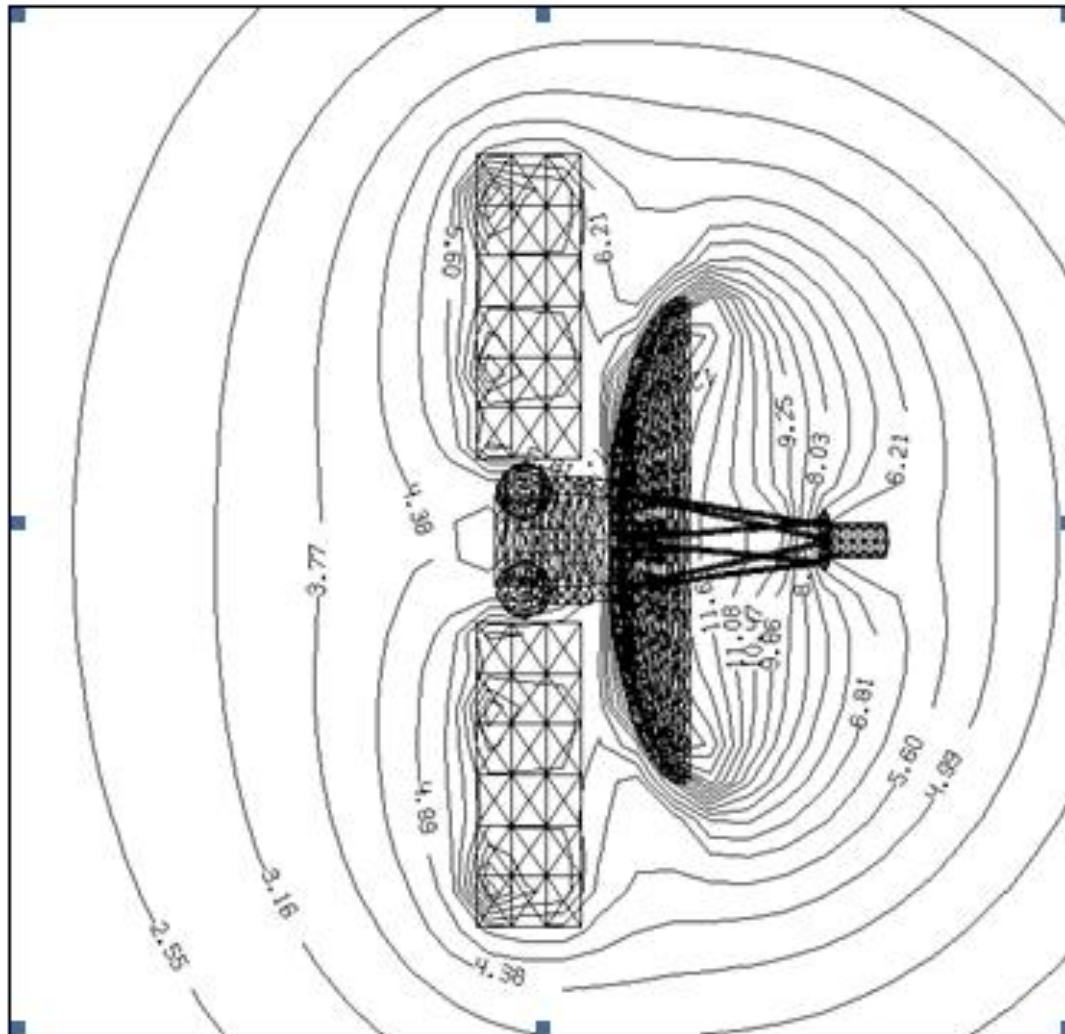
COULOMB-2

- Basic set of simple figures (~200-300)
plate, cylinder, sphere, cone...
- 2D surface grid (~2000-5000 nodes)

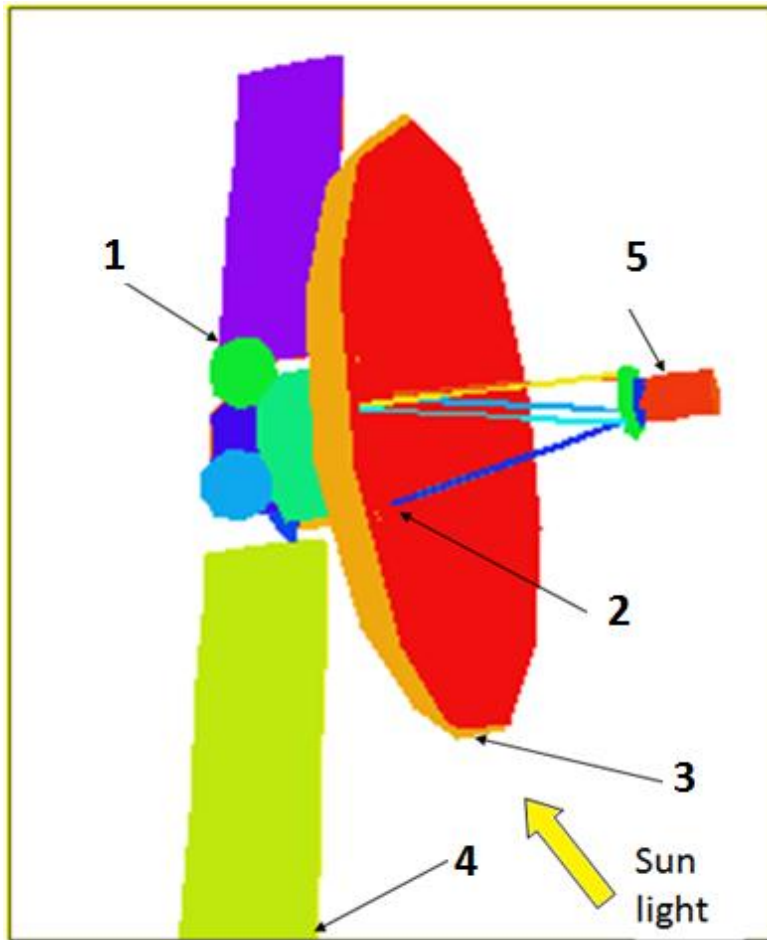
Example of the potential relief of SC, software COULOMB-2



The structure of isolines of electric field in the 7 SC «Spektr-R» charging in hot magnetosphere plasma.



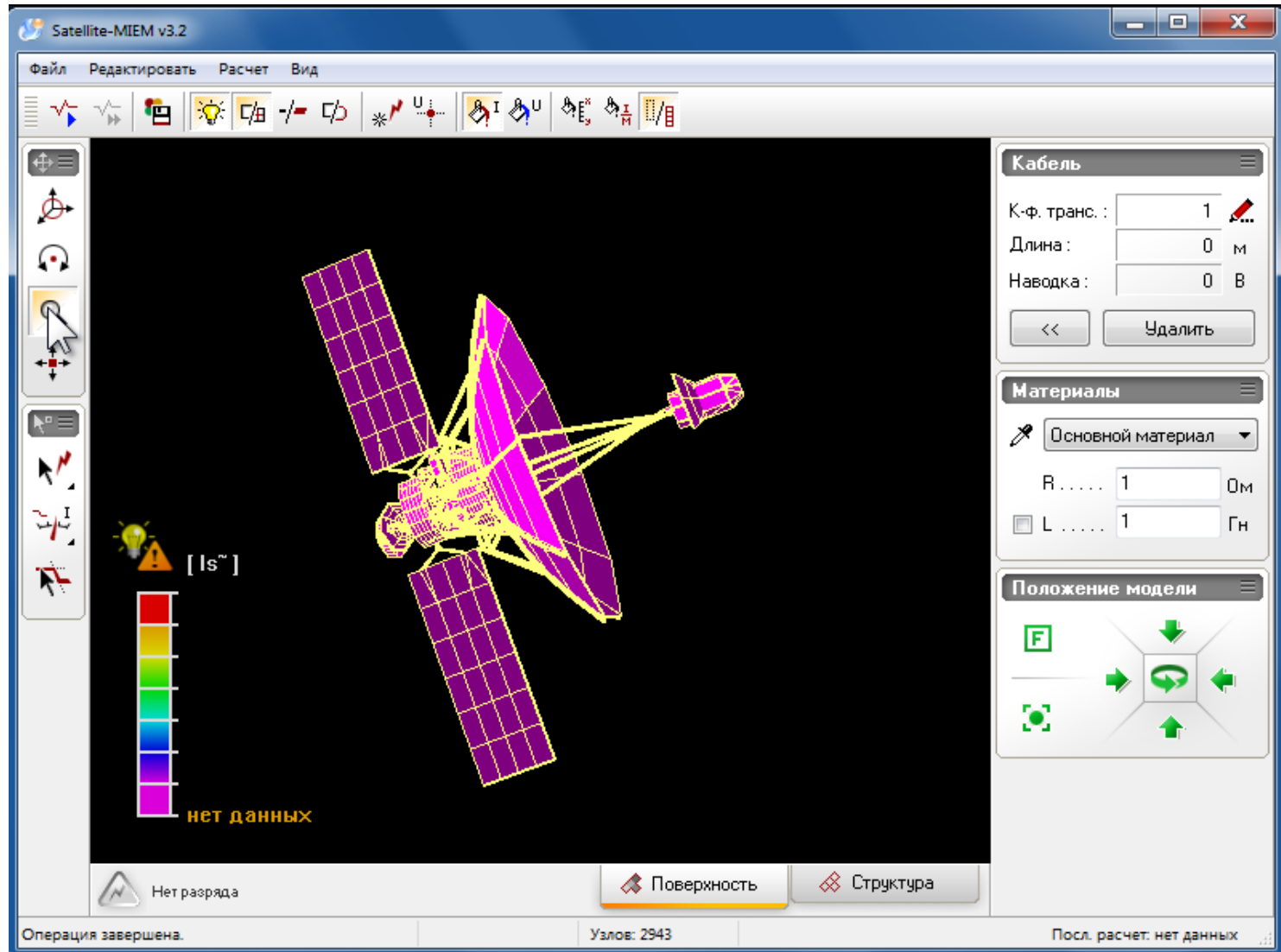
The sites of possible ESD on the surface of the "Spectr-R" SC marked with numbers



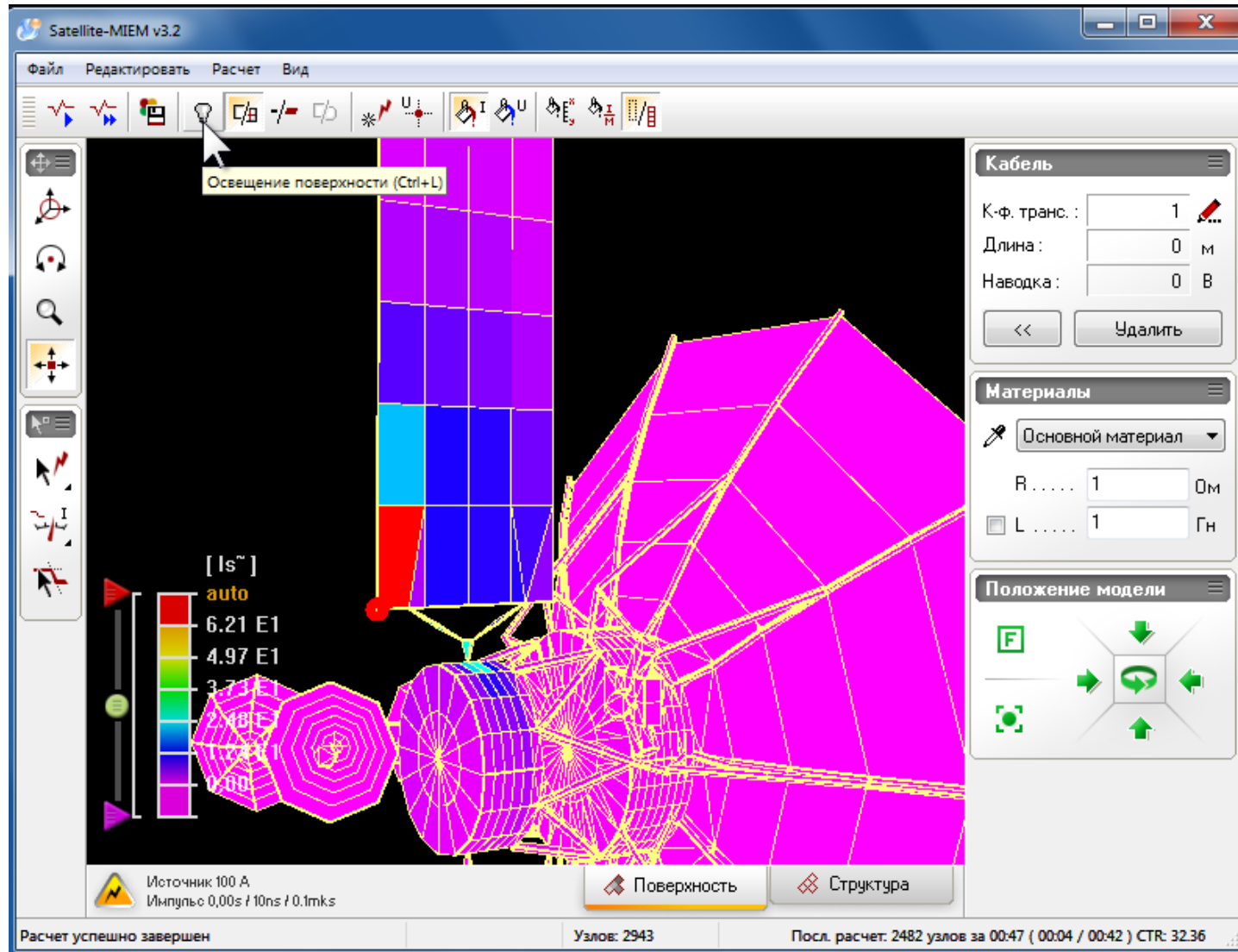
The goal has been reached

The sites (1-5) of possible ESD are defined

"Satellite-MIEM" computer code to calculate the pulse voltage value in the cable of the Spektr-R SC and in the electronics inputs



The site of possible ESD and the calculation of current distribution from this ESD on "Spectr-R" SC



The parameters of the electrostatic discharge (the amplitude of the pulse current and its form)

Параметры расчета

Параметры расчета | Настройки ядра

Задайте параметры расчета:

Источник тока: 100 A

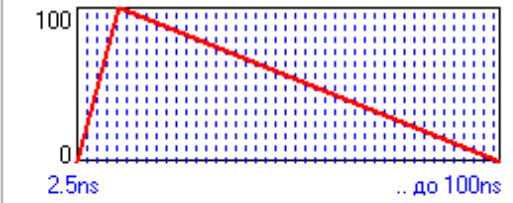
Источник ЭДС: 100 B

Подать импульс

Начало: 0 c

Пик: 10ns c

Спад: 100ns c



Шаг (с): 2.5ns | Конец (с): 100ns | Макс. шаг (с): UIC

Интервал расчета: 2.5ns

Подключить к каждому узлу

R_gr 1K Ом | C_gr 1 Ф

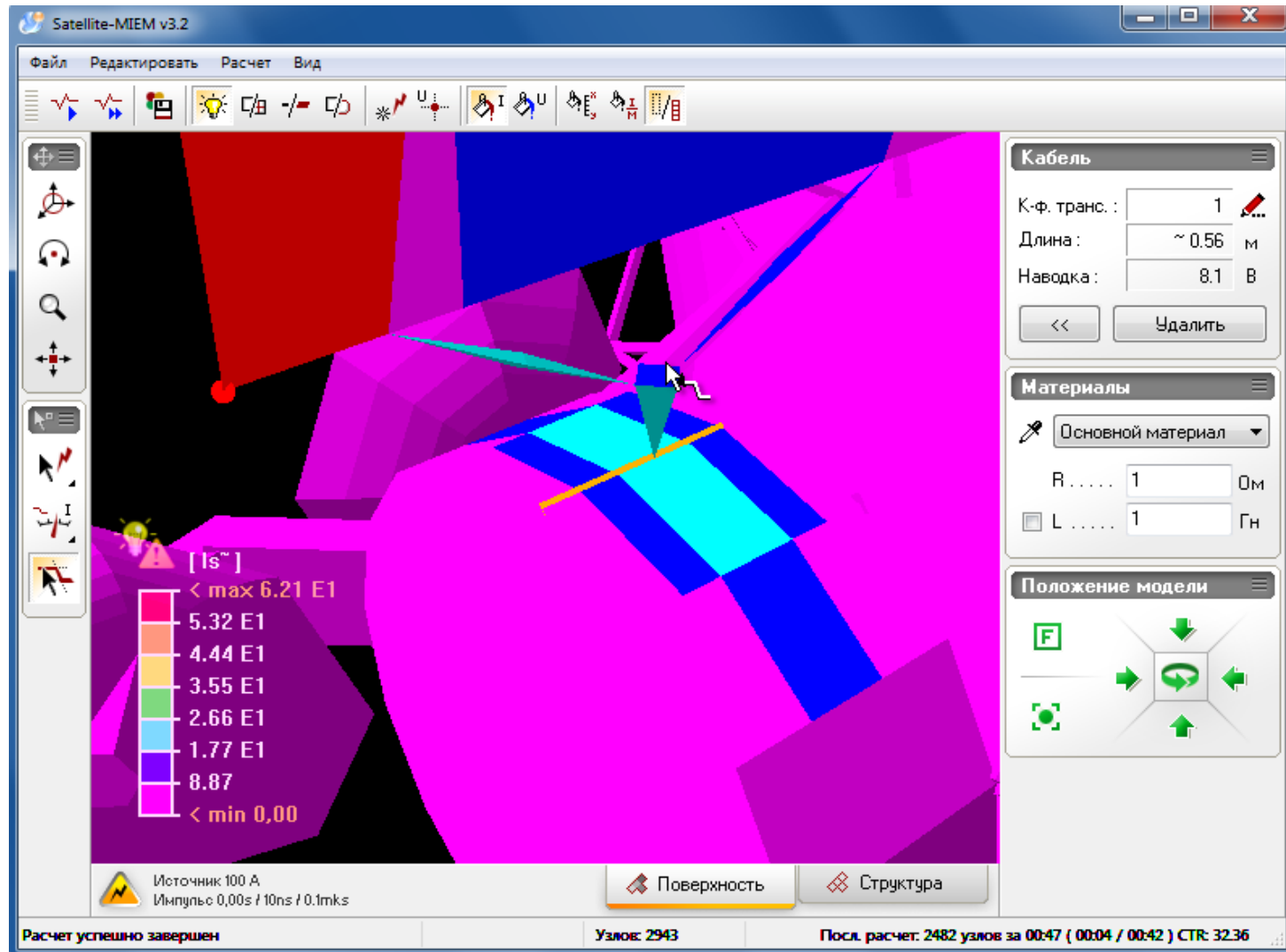
Тип геометрических фигур

Четырехугольники (преимущ.) | Треугольники


i Для проведения расчета будет запущено внешнее приложение.
Расчет может занять длительное время!

Расчет | Отменить

The cable on the surface of SC «Spectr-R» and the calculated value of the voltage pulse in this cable



Conclusions

- **We define the levels of voltage pulses in the inputs electronic devices at the stage of preliminary design of SC**
 - **On the basis of these data we produce electronic devices resistant to voltage pulses from ESD**
 - **After that we may start conducting the SC bench tests for ESD resistance.**
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Thank you for attention!

