Numerical Modeling of 3D Field Distribution of the SP–57 Magnet for the MARUSYA setup

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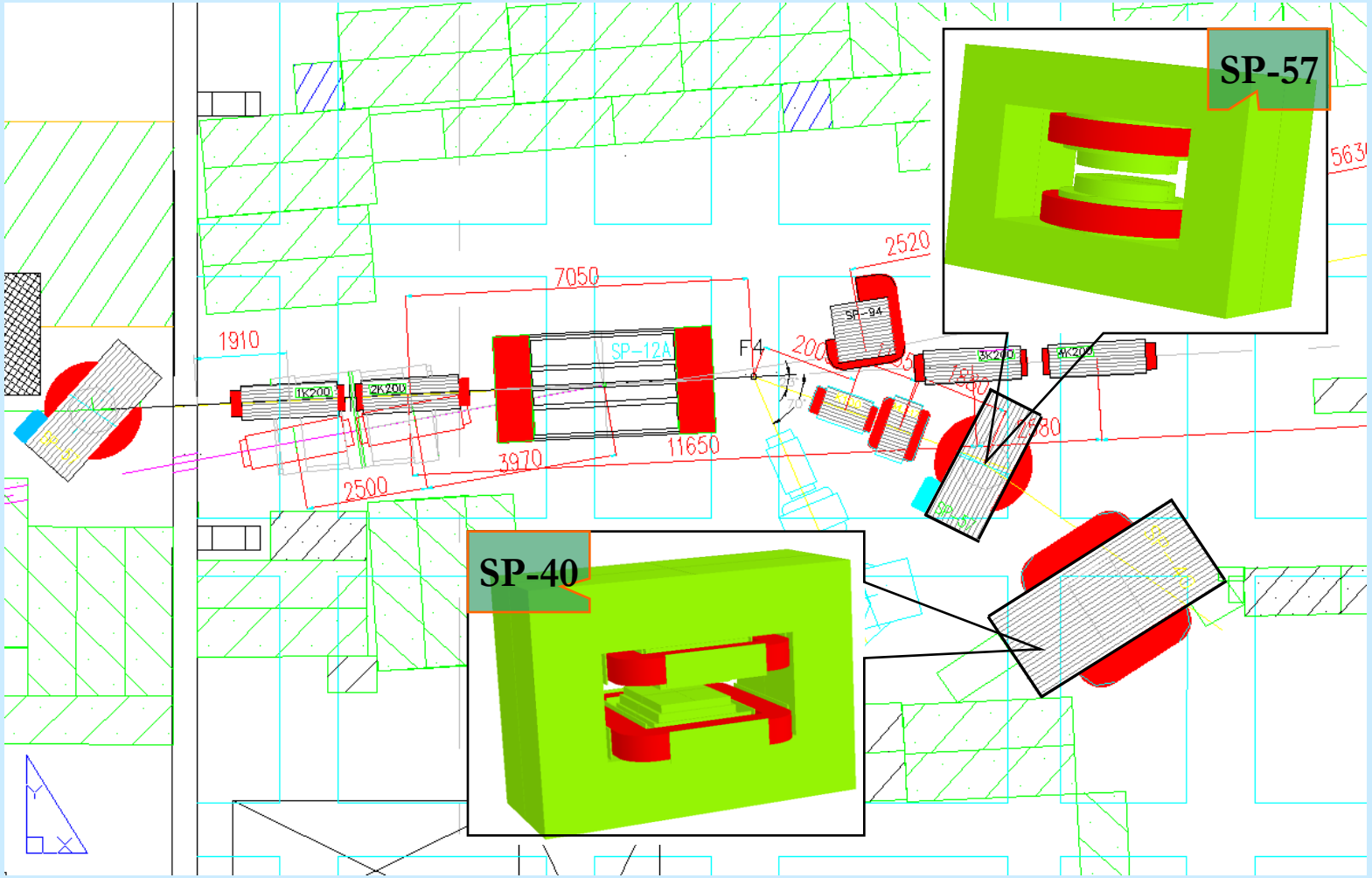
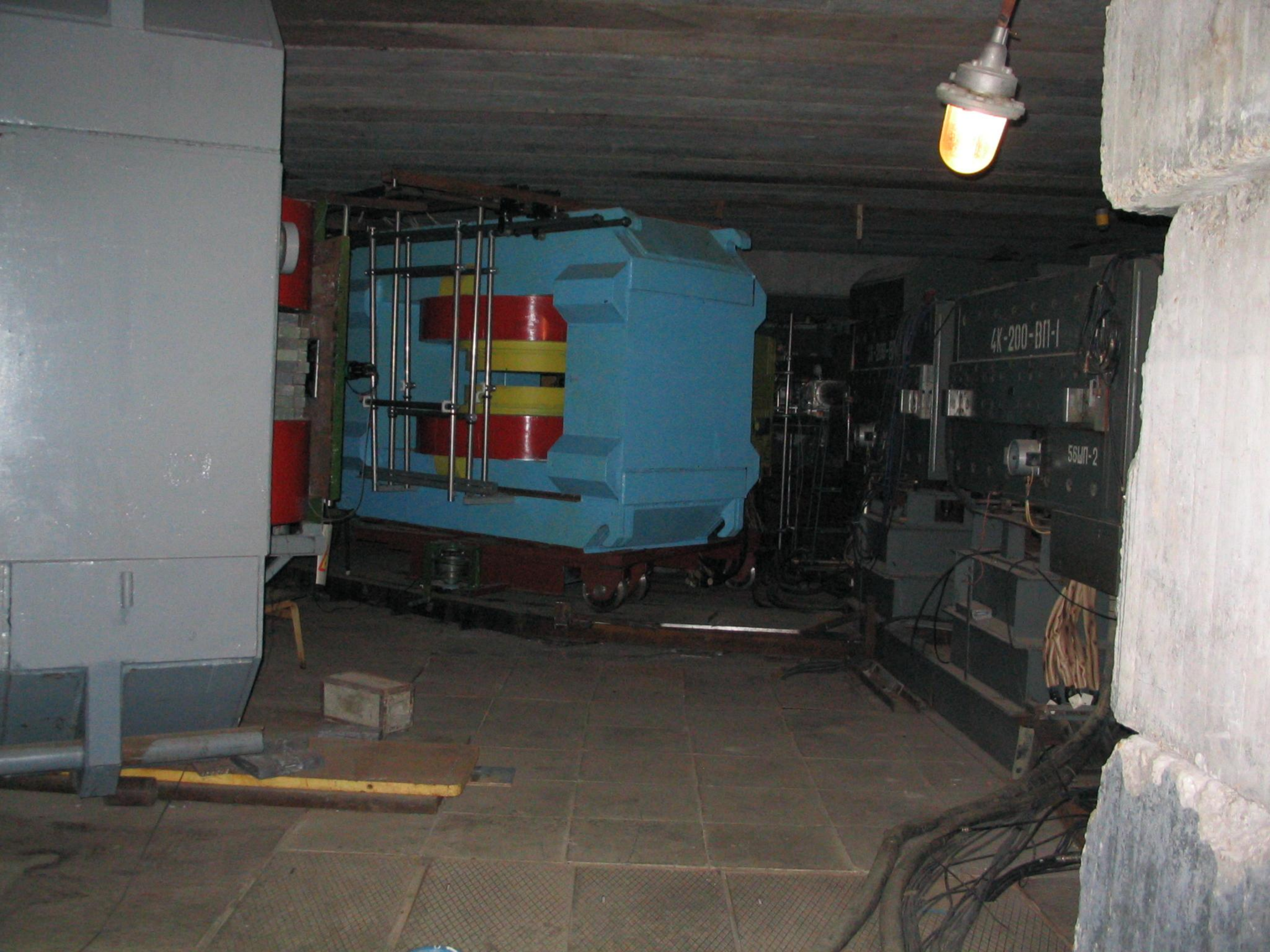
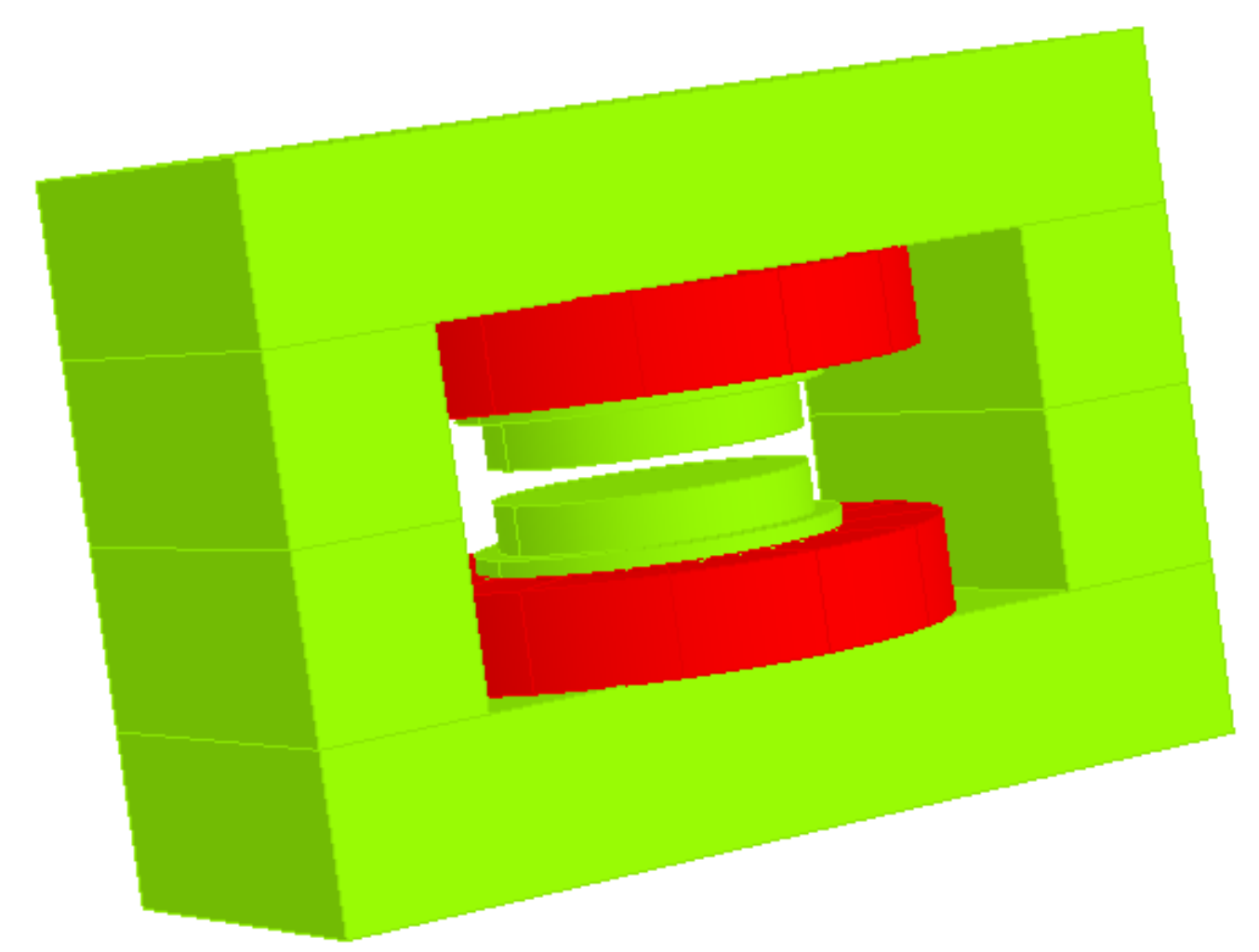
General view of MARUSYA setup

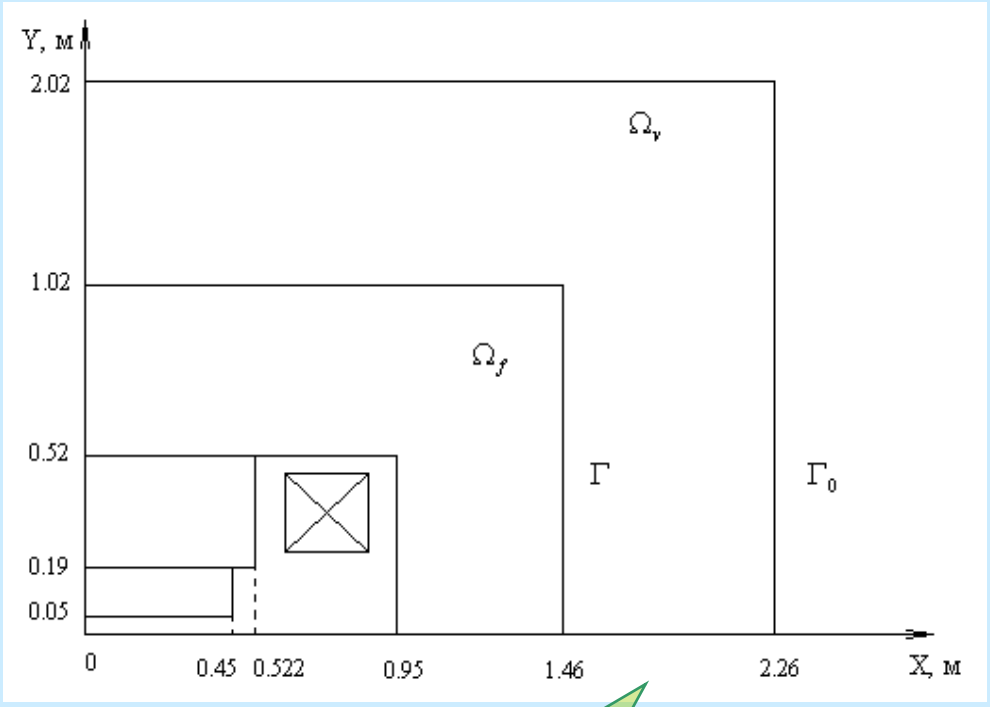



4К-200-ВП-1
5БШП-2

General view of spectrometric magnet SP-57

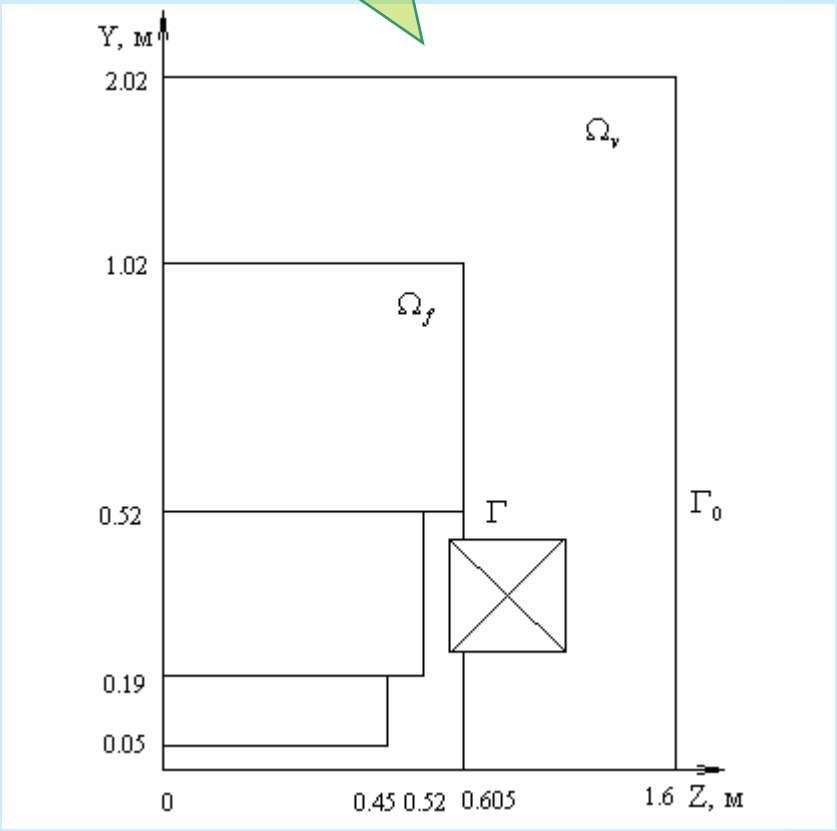


Calculating area 1/8 part of magnet



plane XOY

plane YOZ



Mathemtical formulation of the magnetostatic problem

$$div\vec{B}(p)=0 \quad rot\vec{H}(p)=\vec{J}(p), \quad p\in\Omega$$

$$\vec{B}=\mu_0\mu(H)\vec{H}$$

$$B_{fn}=B_{vn} \quad H_{f\tau}=H_{v\tau}$$

Statement of a problem with two scalar potentials

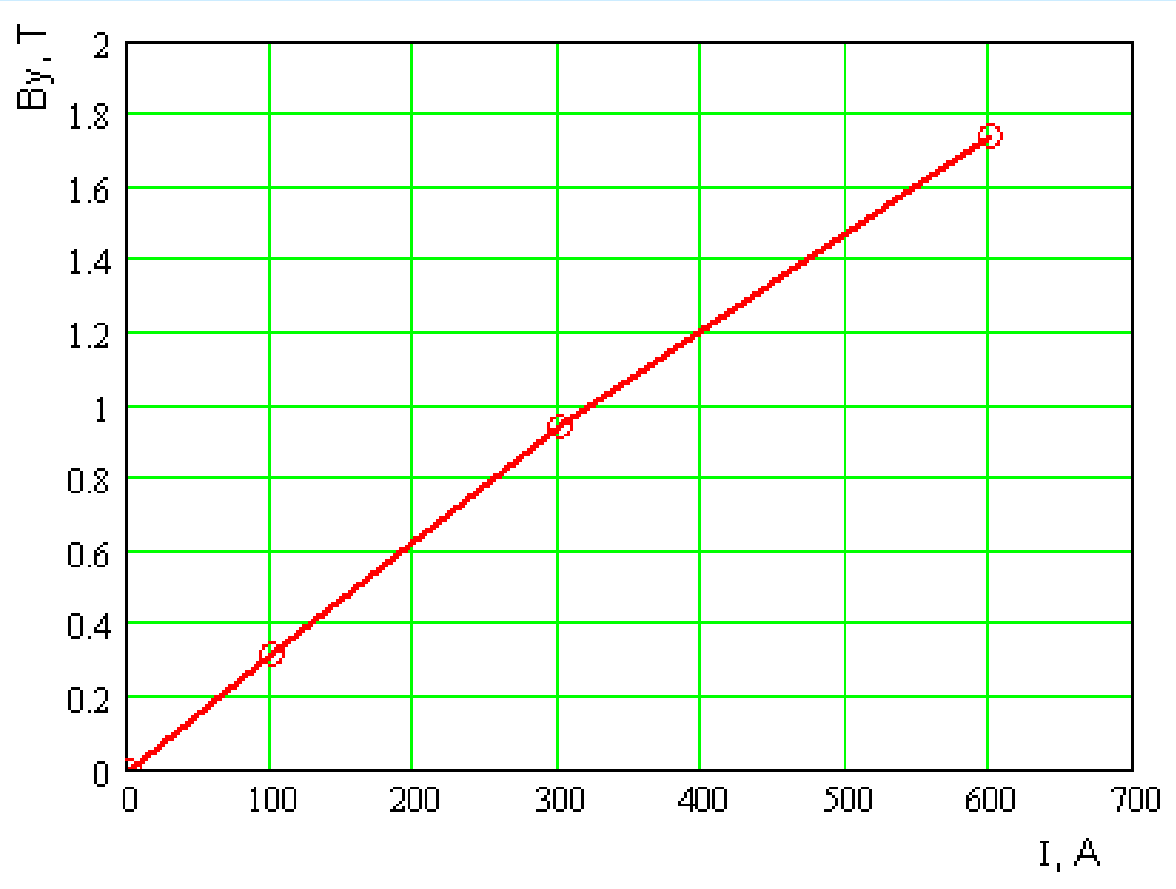
$$\vec{H}(p) = \vec{H}_c(p) - \nabla\varphi(p), \quad p \in \Omega_v$$

$$\vec{H}(p) = -\nabla\psi(p), \quad p \in \Omega_f$$

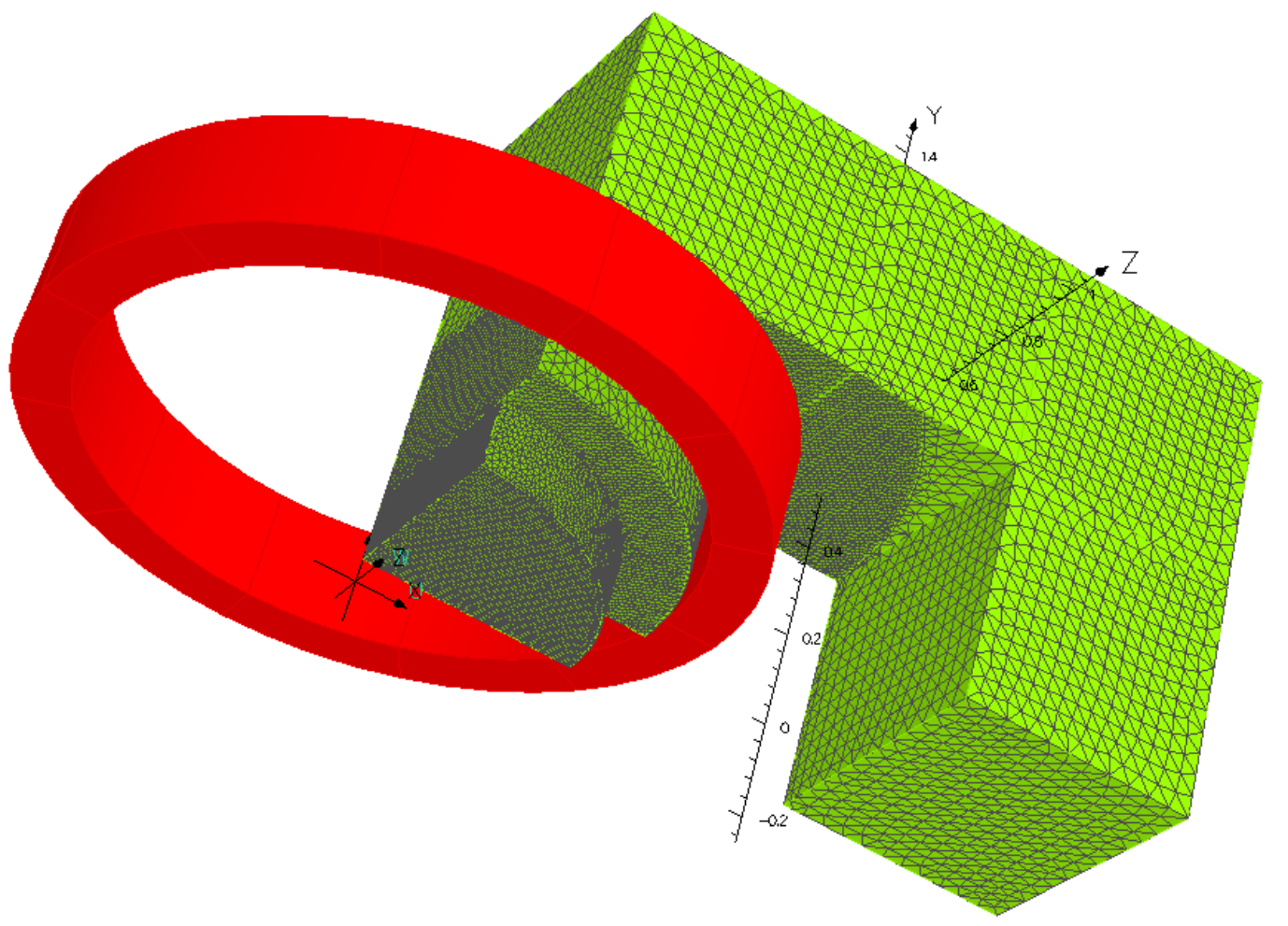
$$\vec{H}_c(p) = \frac{1}{4\pi}\int_{\Omega_c}\left[\vec{J}(q), \nabla_q \frac{1}{r_{pq}}\right] d\omega_q$$

$$\begin{cases} div\left[\mu\left(|\nabla\psi|\right)\nabla\psi(p)\right] = 0, \quad p \in \Omega_f \\ \Delta\varphi(p) = 0, \quad p \in \Omega_v \\ \psi(p) - \varphi(p) = -\int_{Q}^{p} \vec{H}_c d\vec{l}, \quad p \in \Gamma \\ \mu\left.\frac{\partial\psi}{\partial n}\right|_{\Gamma_+} = \left.\frac{\partial\varphi}{\partial n}\right|_{\Gamma_-} - \left.\left(\vec{H}_c, \vec{n}\right)\right|_{\Gamma_-} \end{cases}$$

Curve of excitation for magnet SP-57



Symmetry 1/8



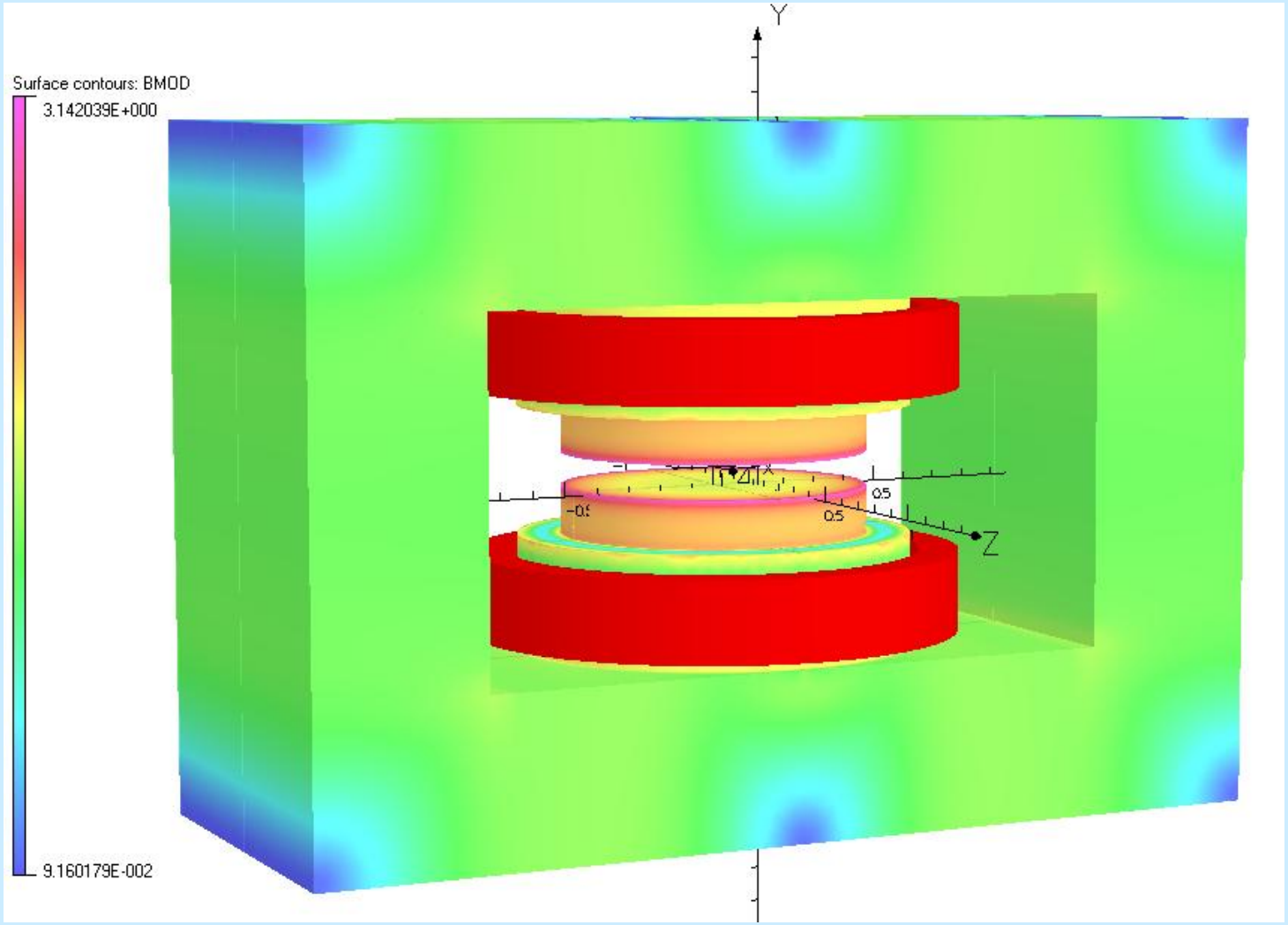
System of coordinates

The calculation grid in the aperture was following:
along X from 0 to 0.90 m, step hx=0.01 m
along Y from 0 to 0.10 m, step hy=0.01 m
along Z from 0 to 1.50 m, step hz=0.01 m

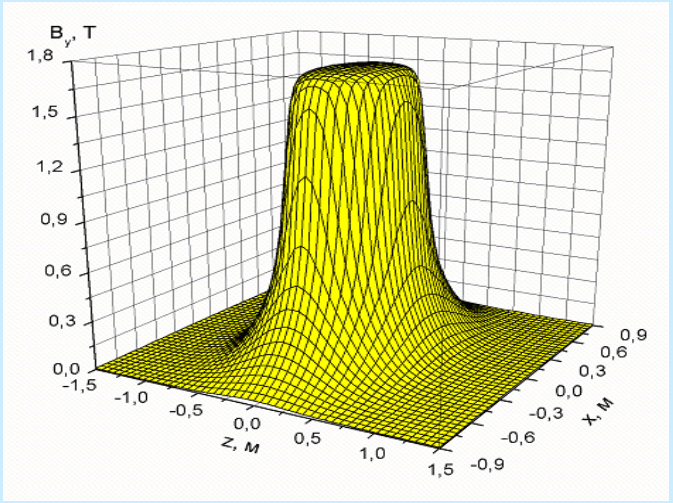
The grid of measurements was following:
along X from -0.64 to 0.56 m, step hx=0.02 m
along Y from -0.03 to +0.03 m, step hy=0.03 m
along Z from -0.77 to 0.77 m, step hz=0.01 m

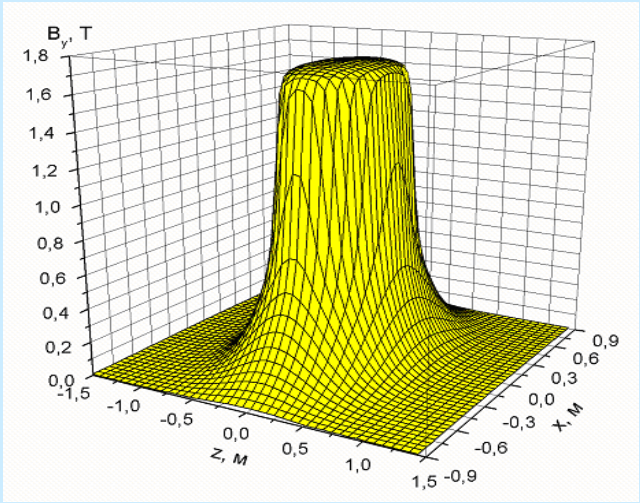
Data are represented in system of coordinates in which the axis Z is directed on a beam of primary particles flying on a target, and axis X perpendicularly upwards to median plane, and the axes forms the right three of vectors. The beginning of system of coordinates is the center of a magnet SP-57.

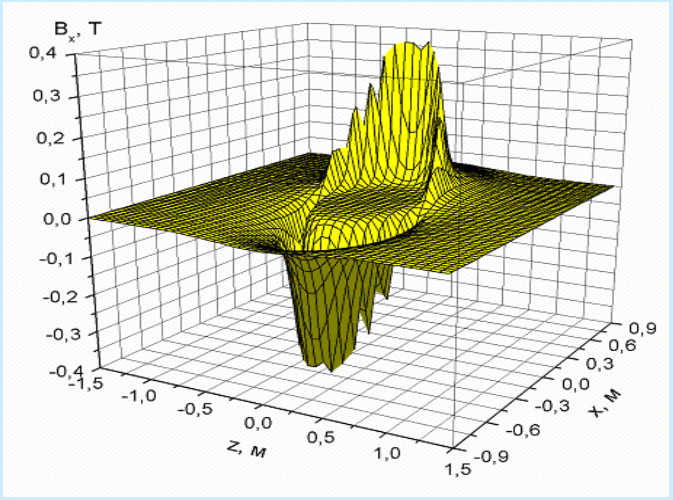
Results of calculations.

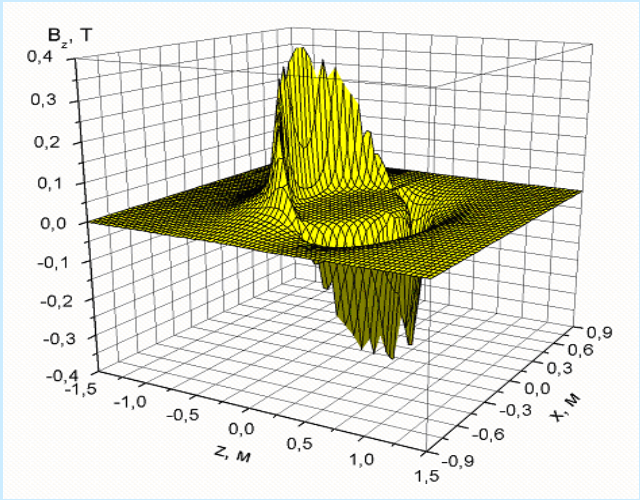


Results of calculations.



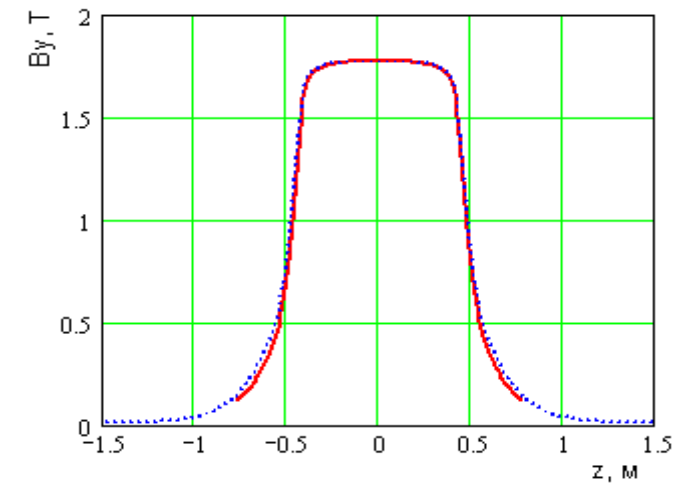


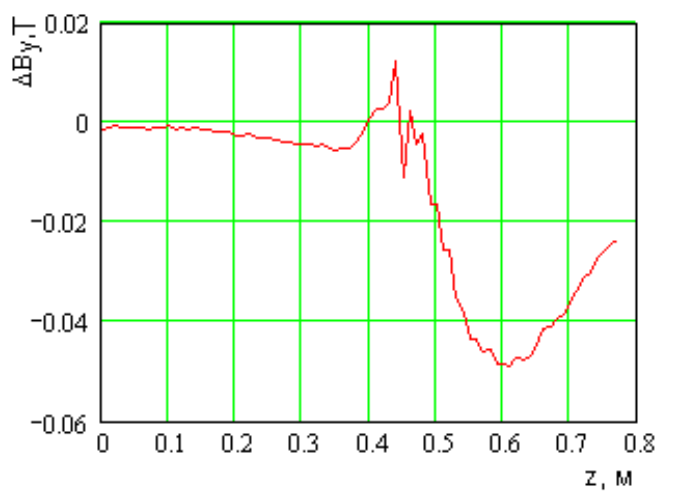


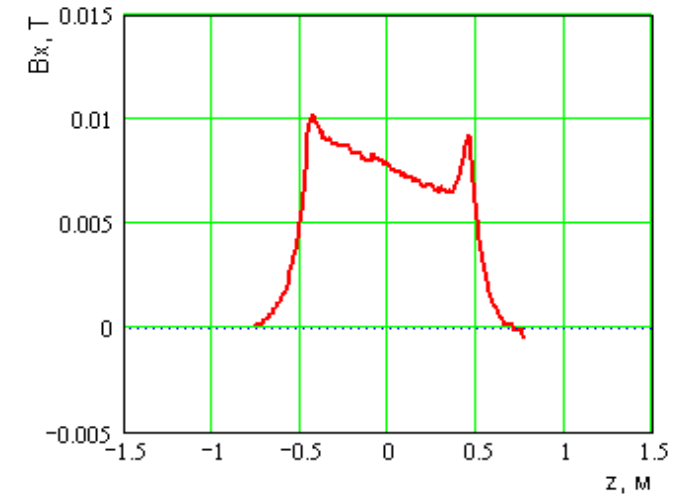


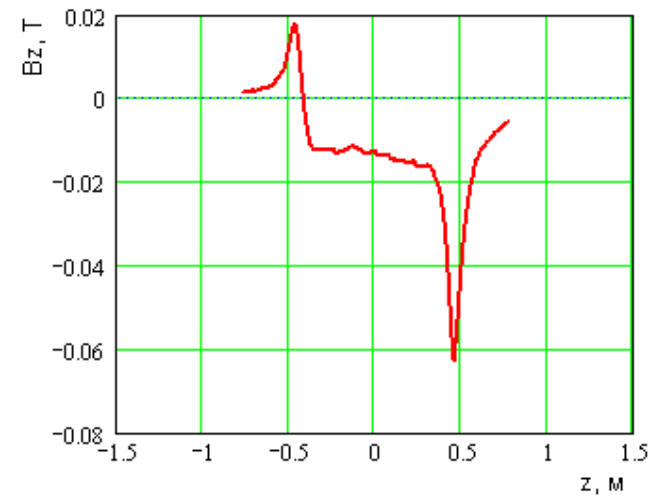
Space distribution a component B_y, B_x, B_z of a magnetic field SP-57

Comparison with the measured data



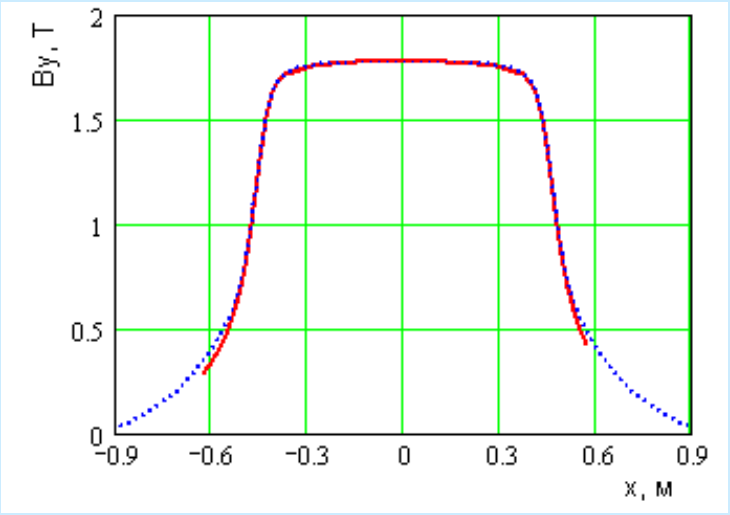


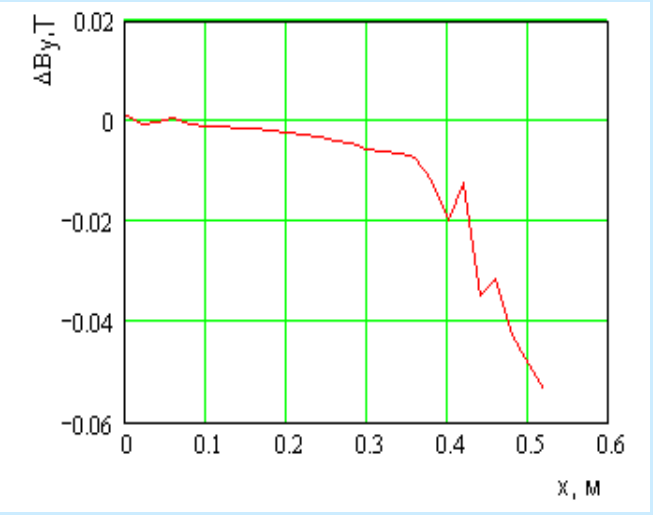


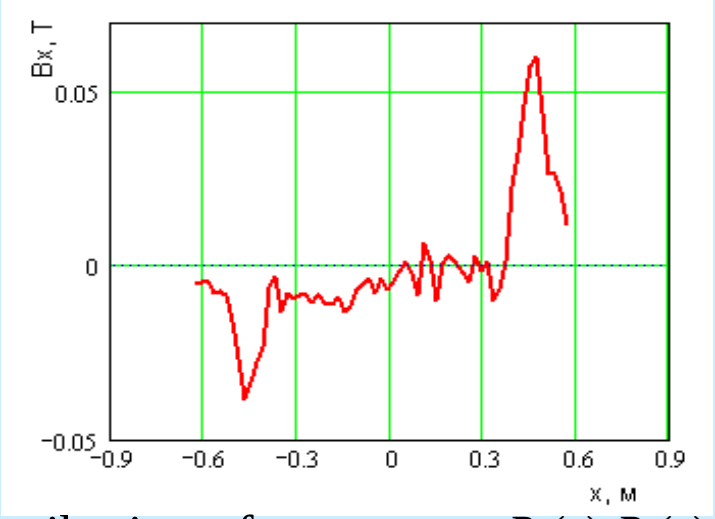


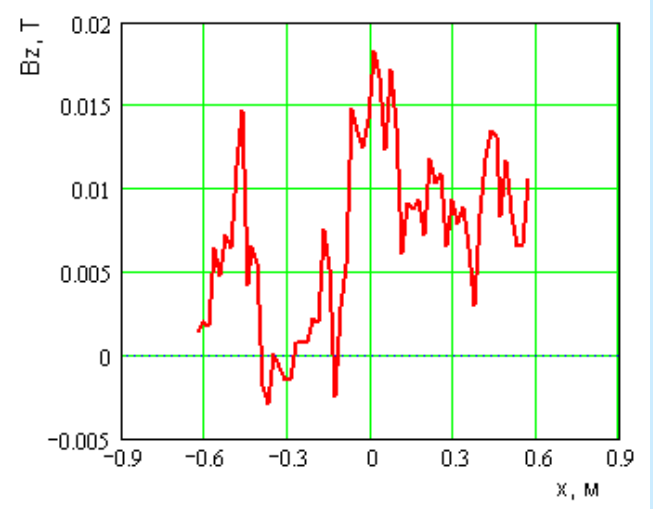
Distribution of component $B_y(z), B_x(z), B_z(z)$ with fixed x = 0, y = 0 m (median plane, centre of magnet) and difference of a basic component ΔB_y

Comparison with the measured data



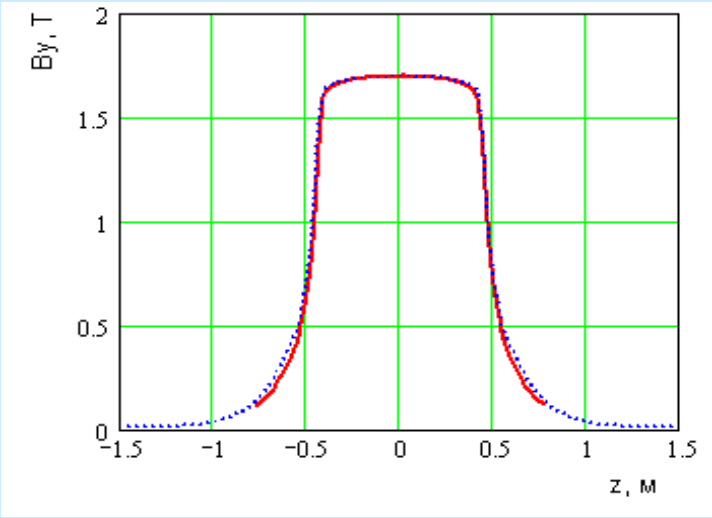


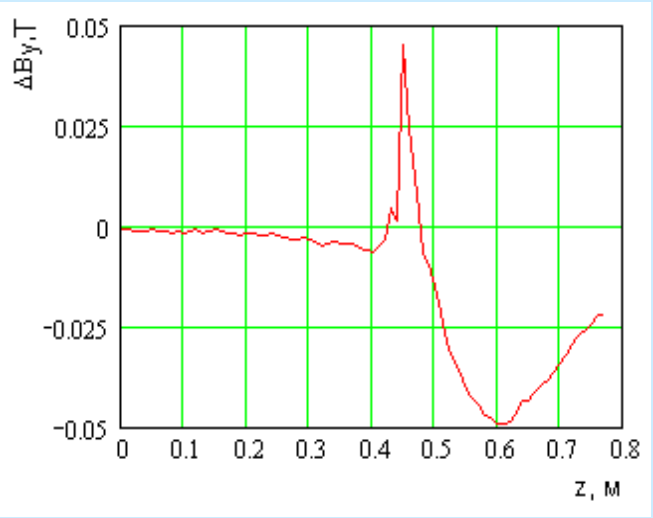


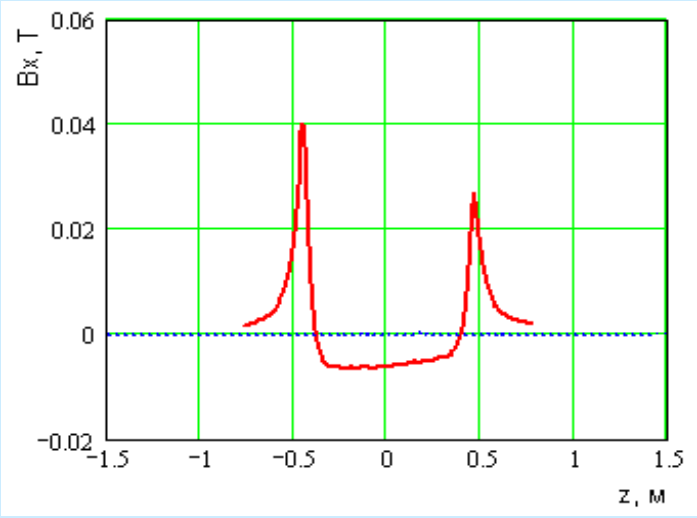


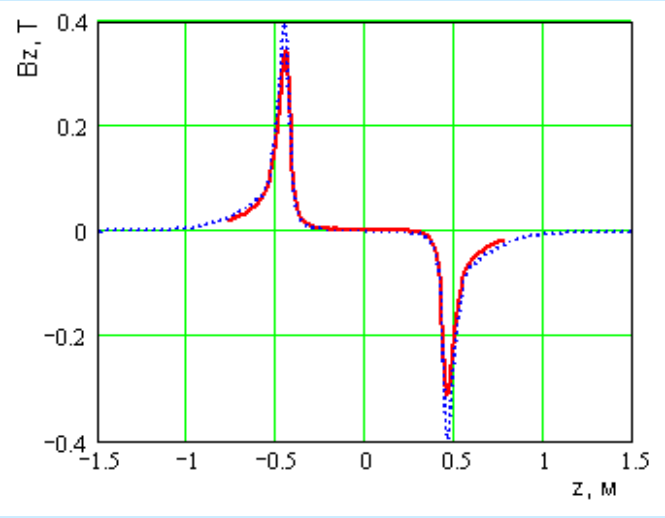
Distribution of component $B_y(z), B_x(z), B_z(z)$ with fixed y = 0, z = 0 m (median plane, centre of magnet) and difference of a basic component ΔB_y

Comparison with the measured data



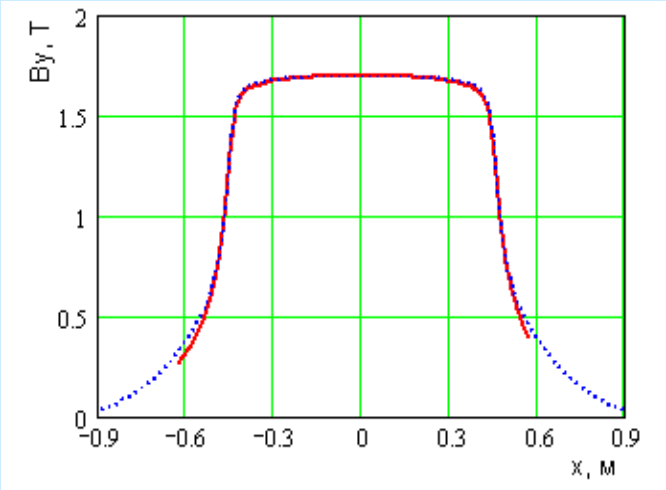


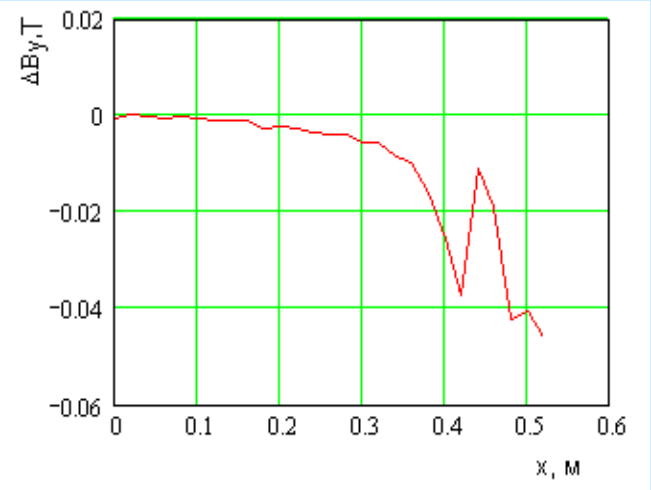


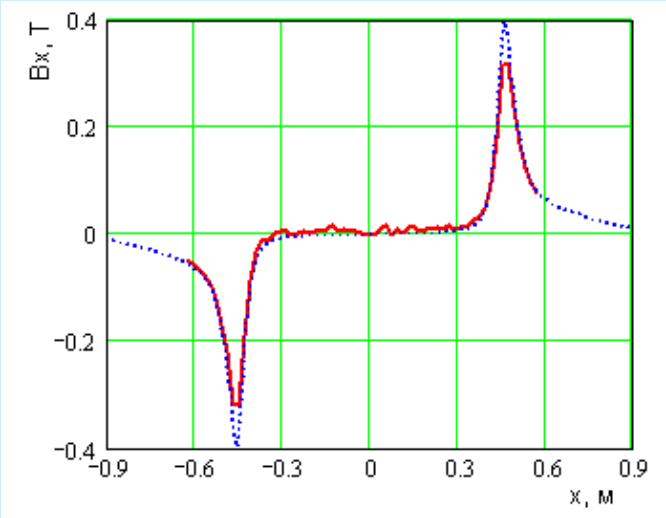


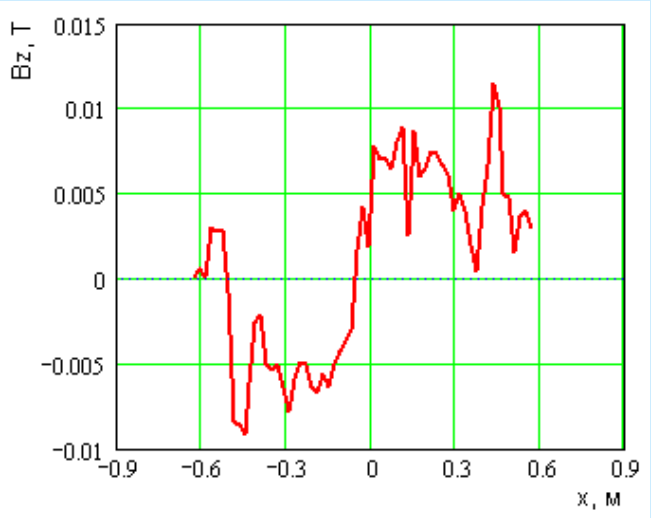
Distribution of component $B_y(z), B_x(z), B_z(z)$ with fixed x = 0, y = 0.03 m and difference of a basic component ΔB_y

Comparison with the measured data

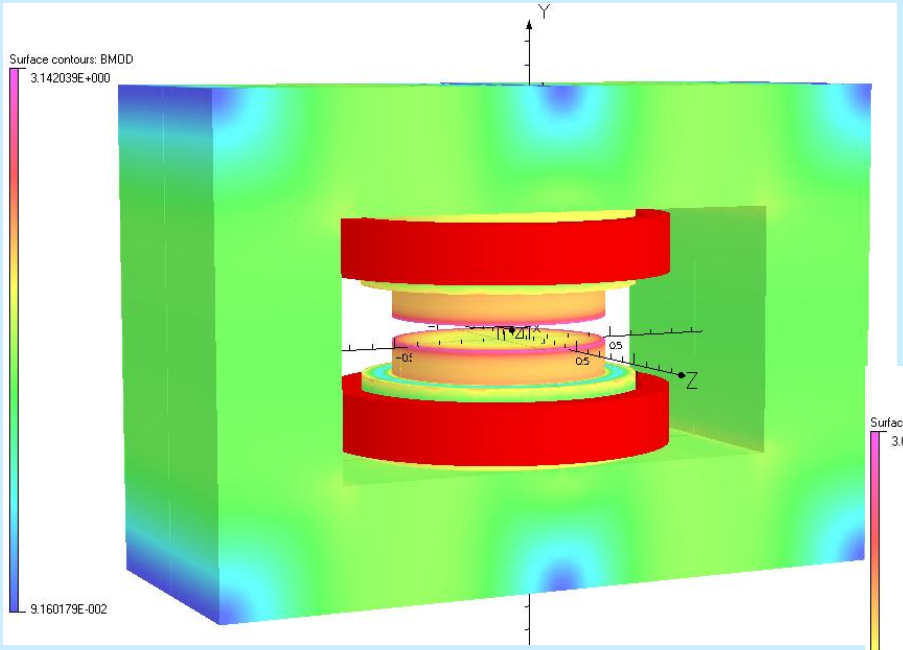


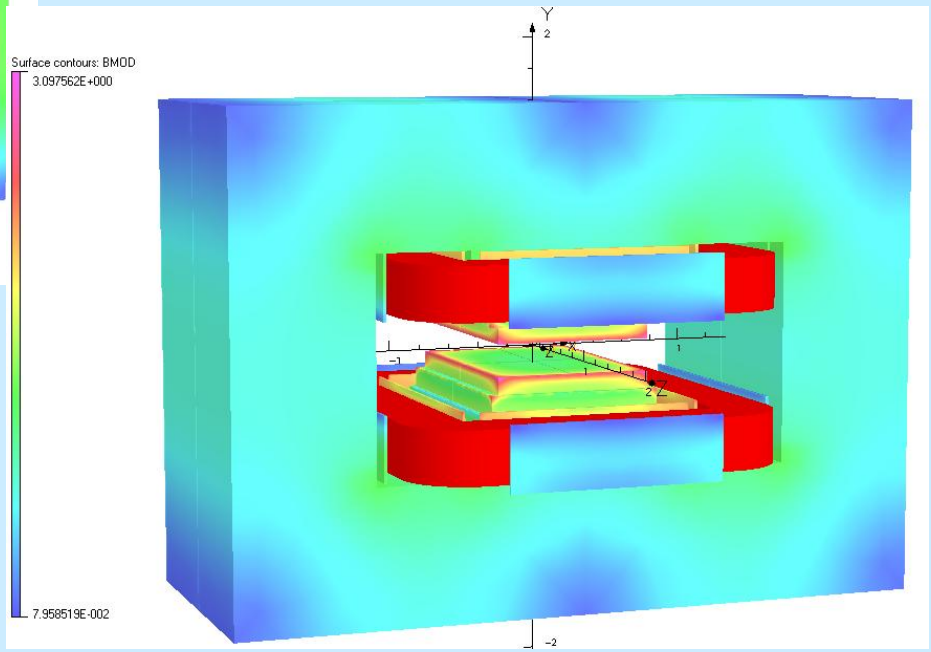






Distribution of component $B_y(z), B_x(z), B_z(z)$ with fixed y = 0.03, z = 0 m and difference of a basic component ΔB_y


Surface contours: BMOD
3.142039E+000
9.160179E-002
Y
Z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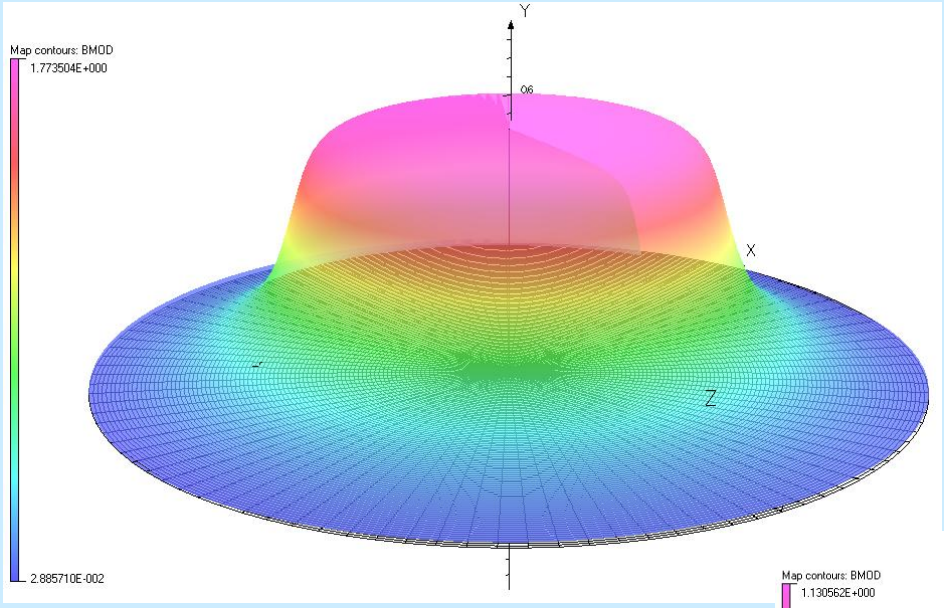
Y
Z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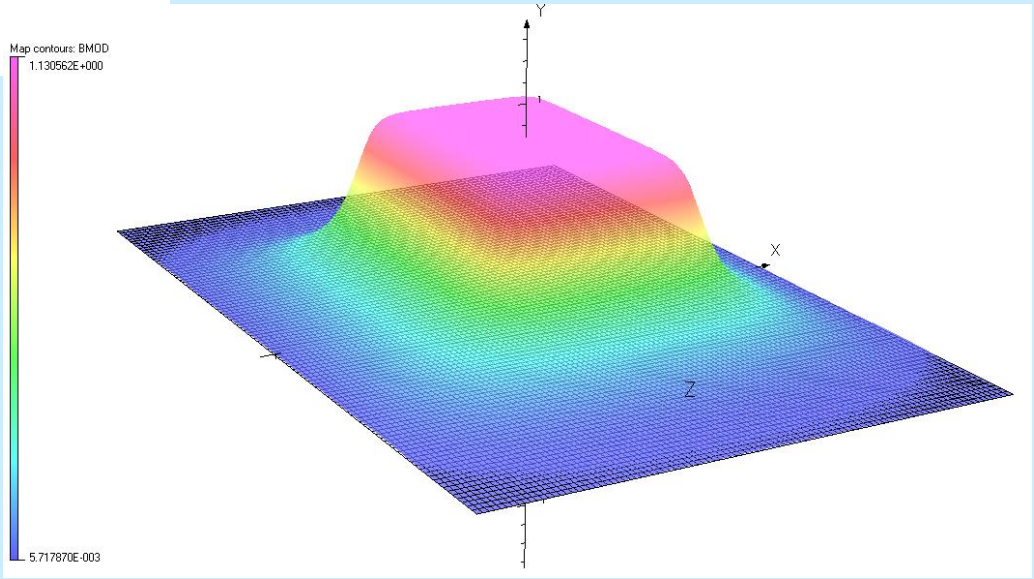
2.885710E-002
Y
X
Z


Map contours: BMOD
1.130562E+000
5.717870E-003
Y
X
Z

Conclusion

- Calculating map of a magnetic field of the spectrometer MARUSYA is by received in full volume

  (-0.90 m≤X≤0.90 m,-0.5 m≤Y≤0.5 m, 1.50 m≤Z≤1.50 m)

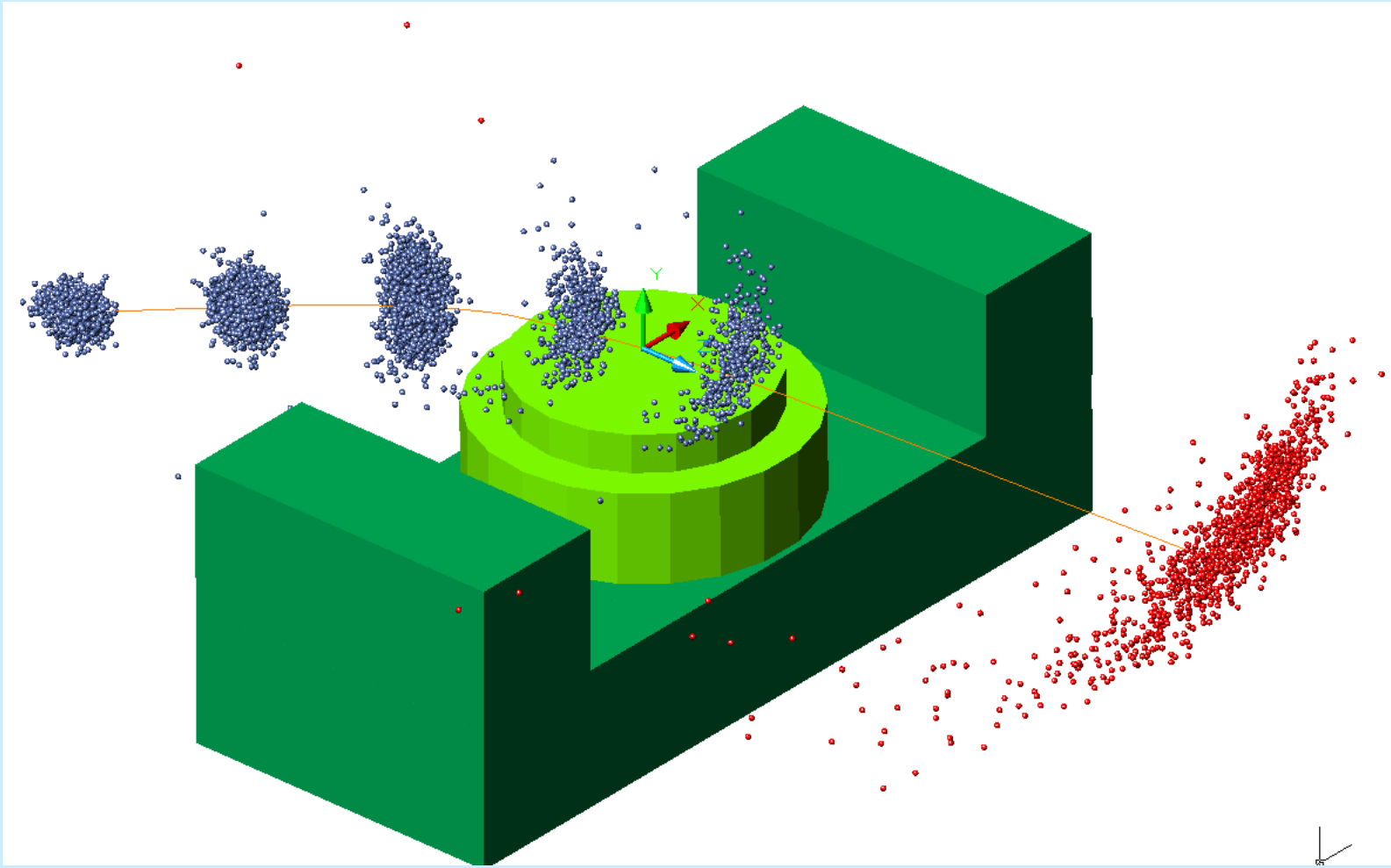
- Comparison of calculating distribution of a magnetic field with the measurements of field of a magnet SP- 57 is resulted

- Carried out research allows to make the conclusion that it is possible to create a calculating map of a magnetic field in a range of working fields (up to 2 T)

Literature

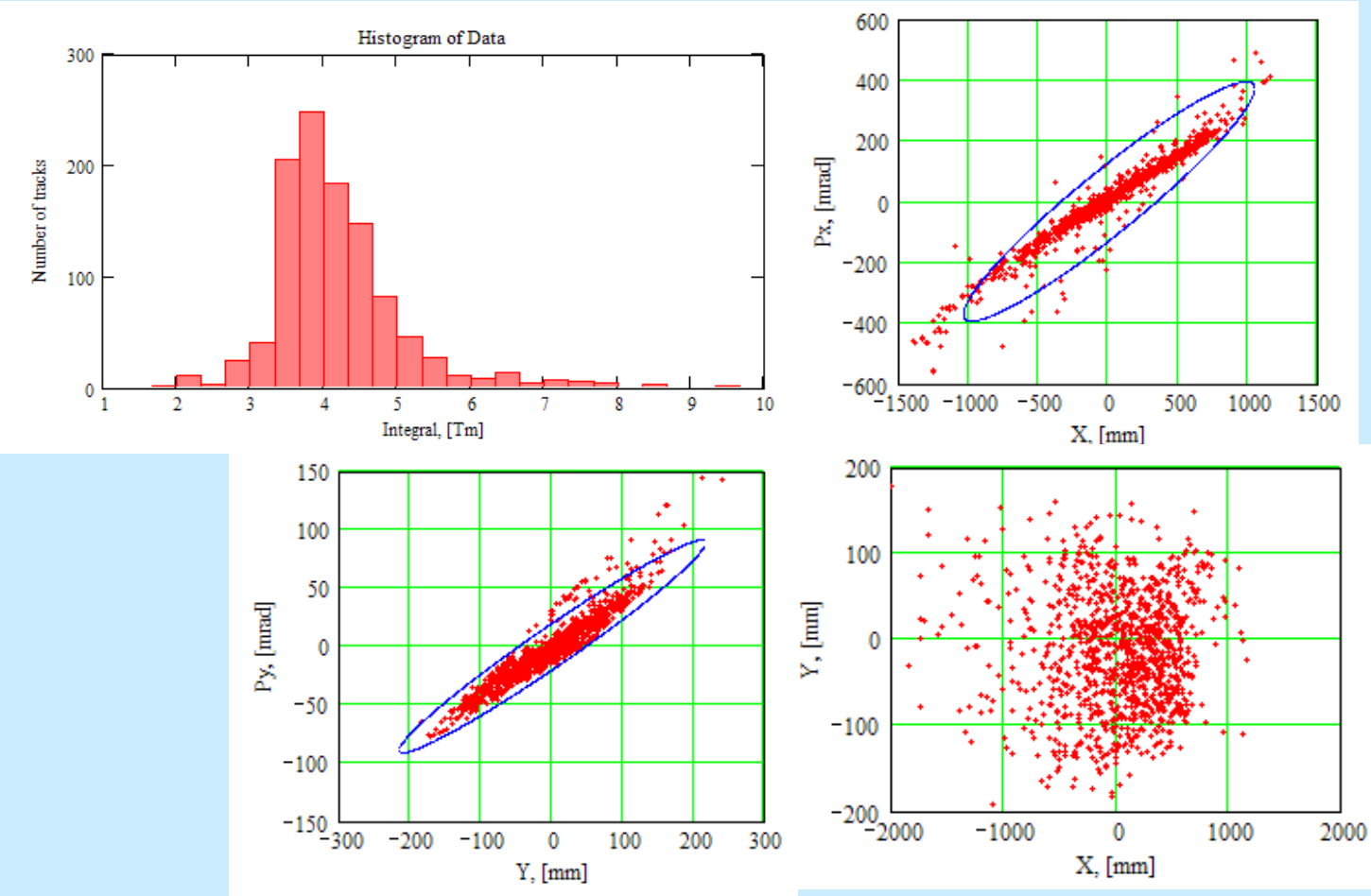
- [1] Балдин А.А. … , И.П. Юдин Измерение объемной карты магнитного поля для магнитооптического спектрометра «МАРУСЯ» // ОИЯИ, Р13-2006-67. Дубна, 2006.
- [2] А.А. Балдин, … , И.П. Юдин Численное моделирование распределения поля магнита СП–40 установки “МАРУСЯ” и сравнение результатов с экспериментальными данными // ОИЯИ, Р11-2006-99, Дубна, 2006, 14с

Bunch passes through SP-57 magnet

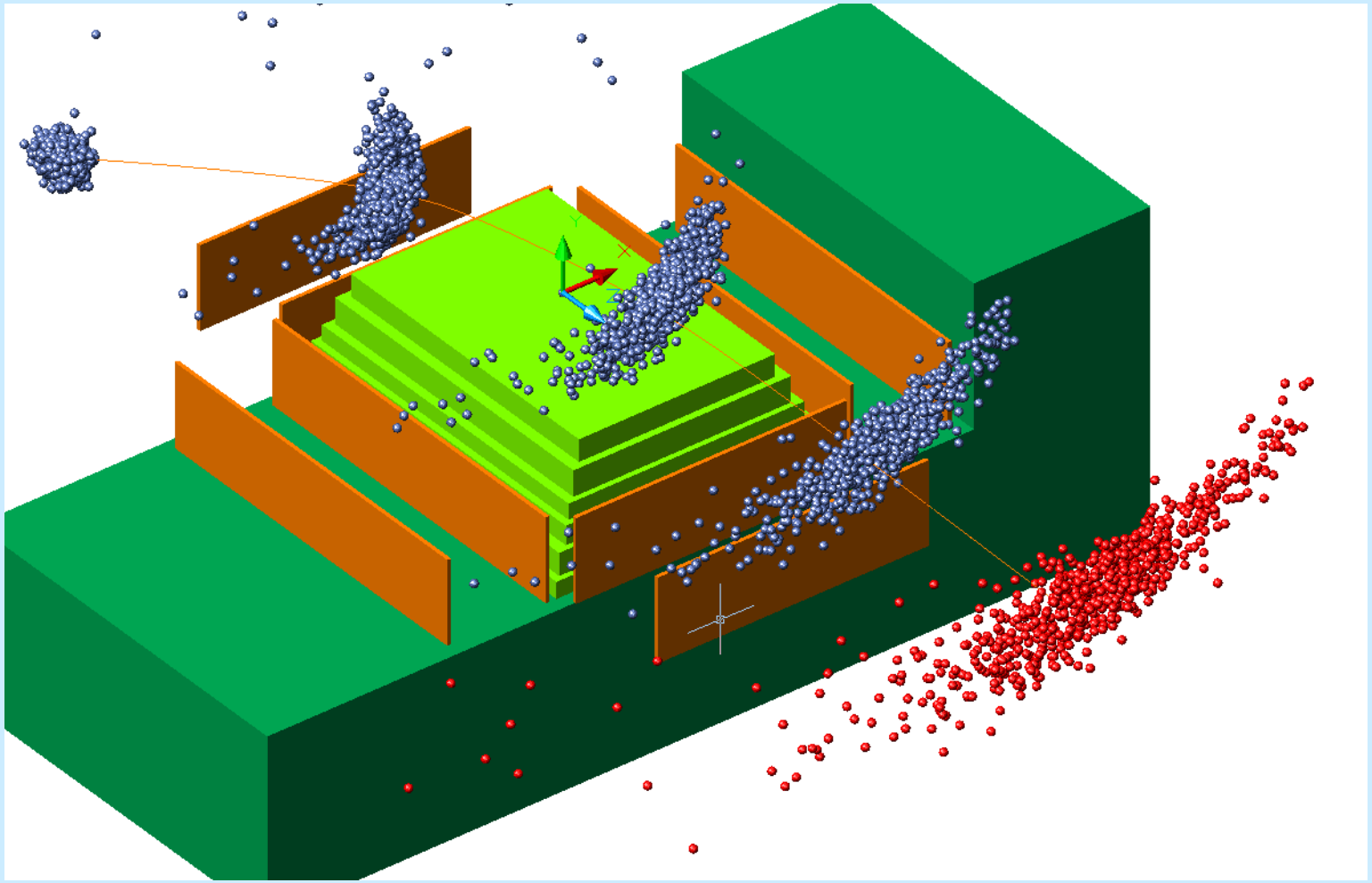


Final position of the bunch

SP-57 magnet, I=600A



Bunch passes through SP-40 magnet



Final position of the bunch

SP-40 magnet, I=600A