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Development of the magnetic system for new DECRIS-PM ion source.

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Super Heavy Element Factory

To enhance the efficiency of experiments for next few years it is necessary to obtain accelerated ion beams with the following parameters:

- Ion energy 4÷8 MeV/n
- Ion masses 10÷238
- Beam intensity (up to A=50) 10 pμA
- Beam emittance less 30 π mm×mrad
- Efficiency of beam transfer >50%

DC-280 Cyclotron - Basic Technical Solutions

Parameter DC280	Goals
High injecting beam energy (up to 100 kV)	Shift of space charge limits by a factor of 30
High gap in the centre	Space for a long spiral inflector
Low magnetic field	Large starting radius. Good orbit separation. Low deflector voltage
High acceleration rate	Good orbit separation.
Flat-top system	High capture. Single orbit extraction. Beam quality.

DC-280 Cyclotron

All PM ECRISs advantages:

low power consumption, low pressure in the cooling water system, simplified operation, etc.

Significant drawbacks of all permanent magnet ECRISs:

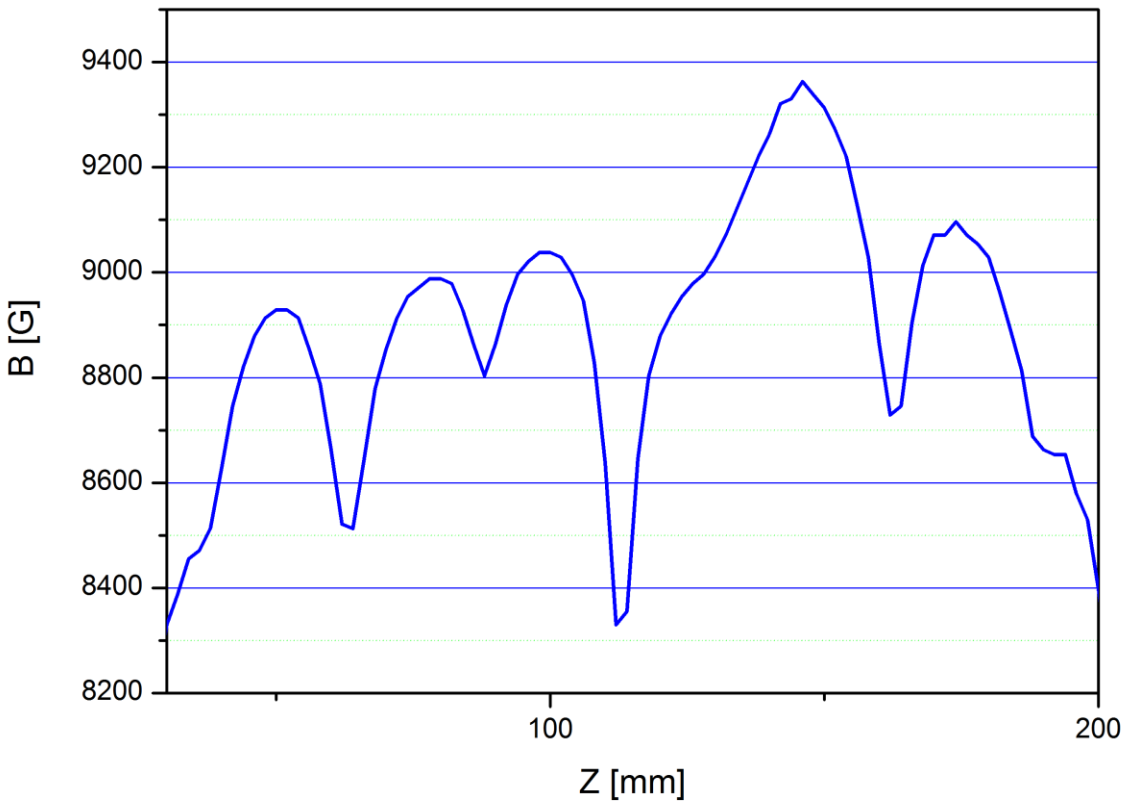
- the fixed distribution of the magnetic field and comparatively low field strength →

  system should be strongly optimized for the desired operation mode.

- Strong forces acting between the individual parts of the system →

  the correction of the magnetic field after the assembly of the magnetic system is practically impossible without the degaussing of it.

With the gaps of about 0.1 mm the oscillations in the magnetic field measured at a distance of 3 mm from the pole are around 10%.

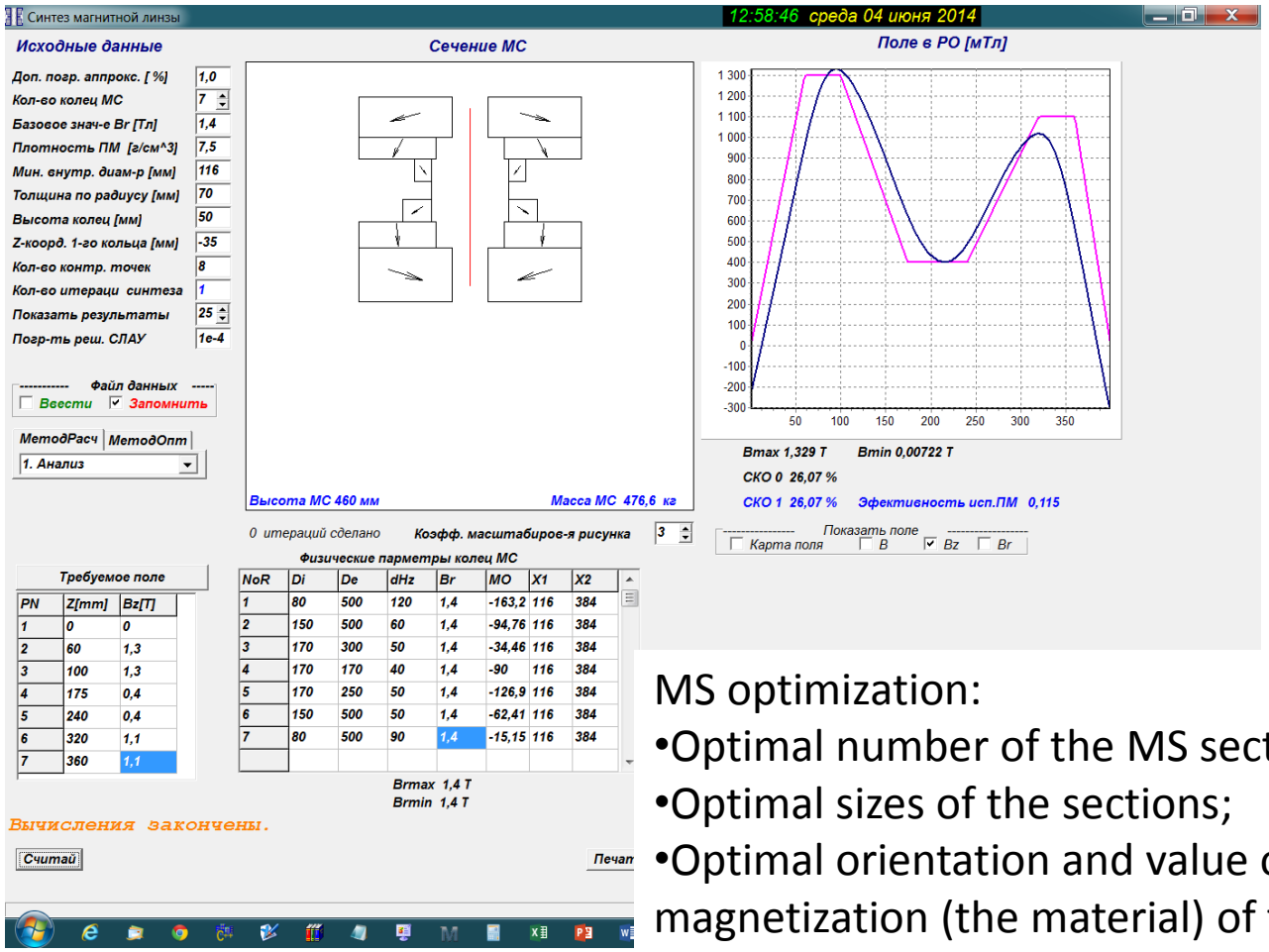


Parameters of DECRIS-PM.

Frequency	14 GHz
B_{inj}	≥ 1.3 T
B_{min}	0.4 T
B_{extr}	1.0 ÷1.1 T
B_r	1.05÷1.15 T
Plasma chamber internal diameter	70 mm

It is desirable to provide a possibility for correction in the case of finding an inconsistency between the measured and desired magnetic fields!!!

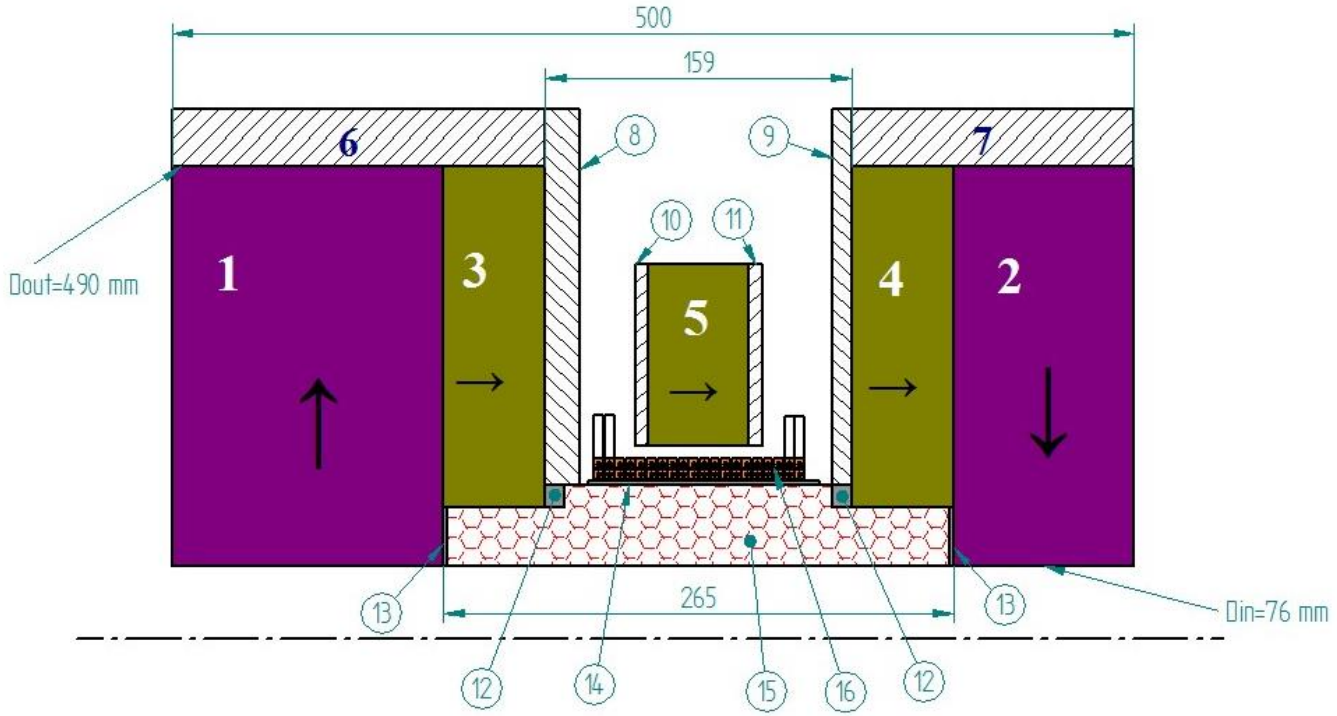
Nickolay I. Klevets, Optimal design of magnetic systems, Journal of Magnetism and Magnetic Materials 306 (2006) 281–291



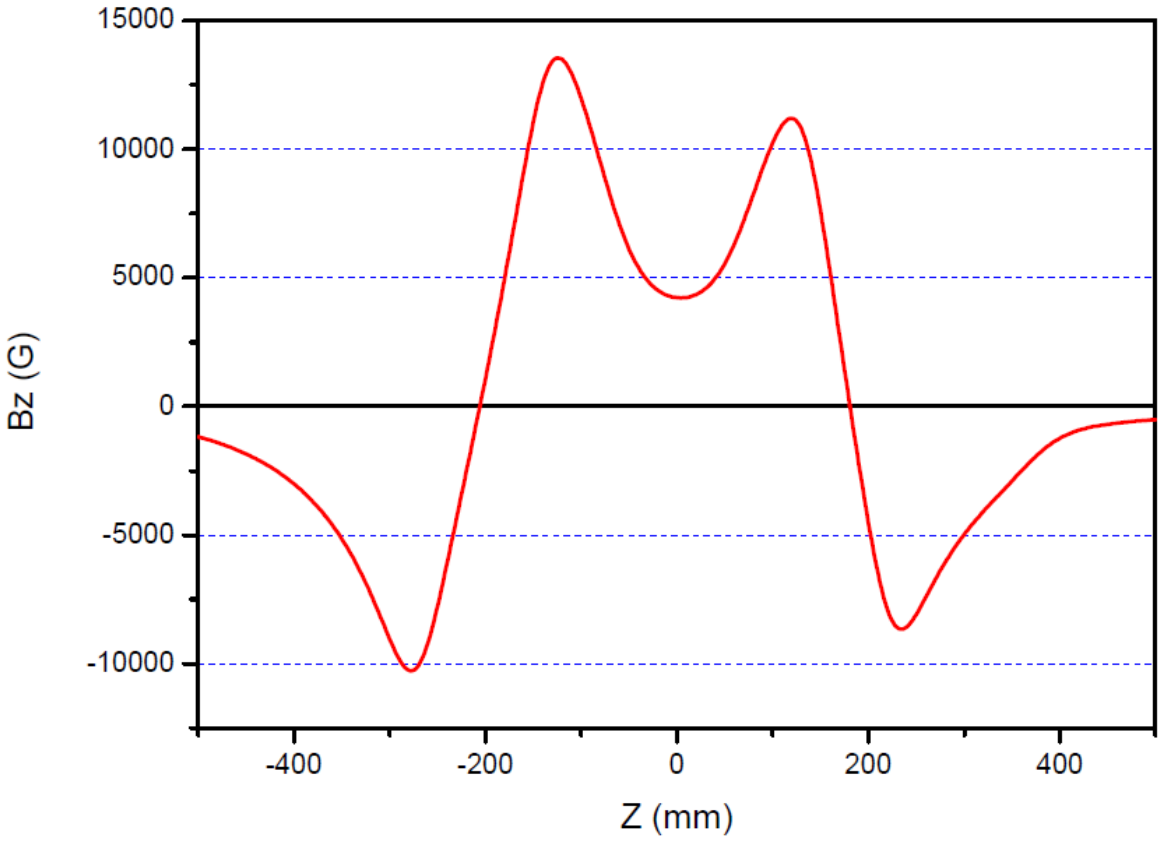
MS optimization:

- Optimal number of the MS sections;
- Optimal sizes of the sections;
- Optimal orientation and value of the magnetization (the material) of the sections.

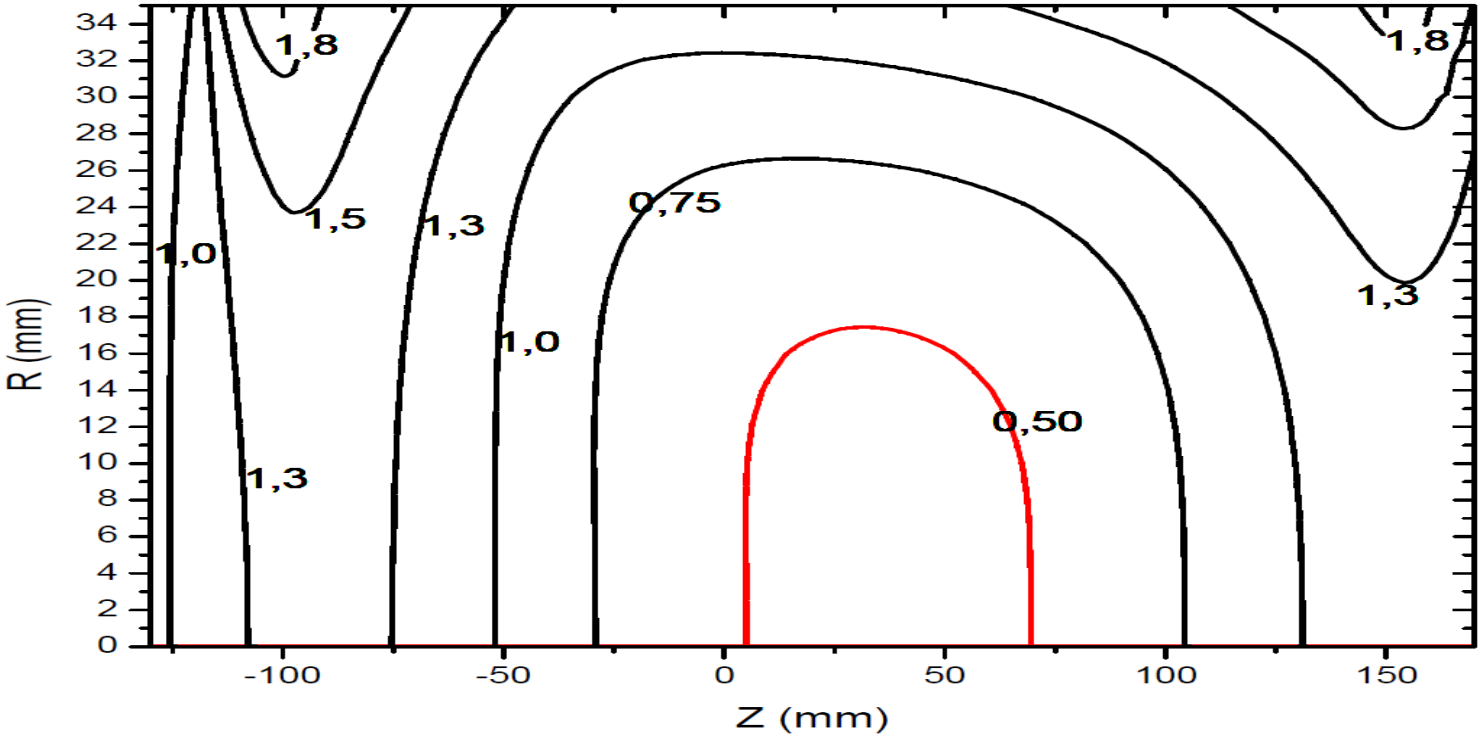
Magnetic structure of DECRIS-PM



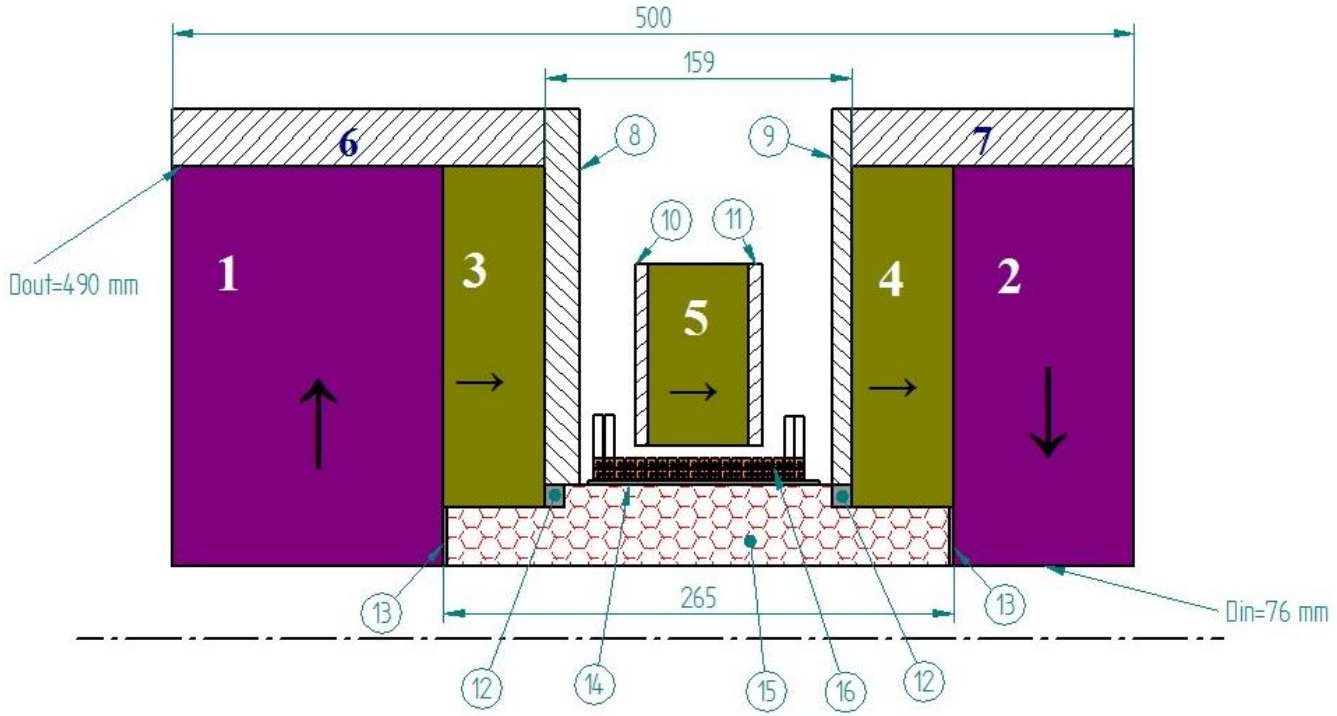
Calculated axial magnetic field distribution



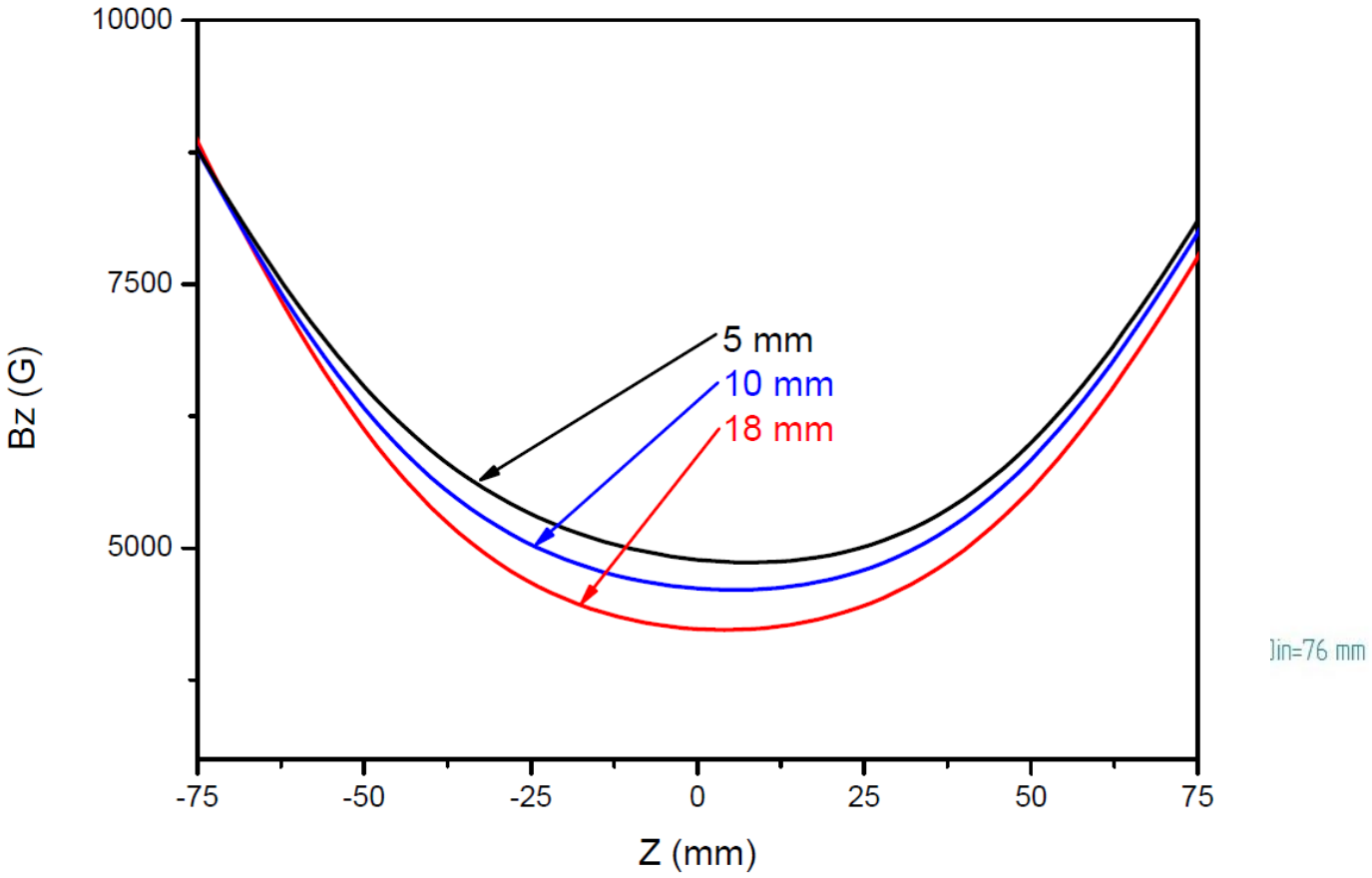
3D calculation



Magnetic field correction



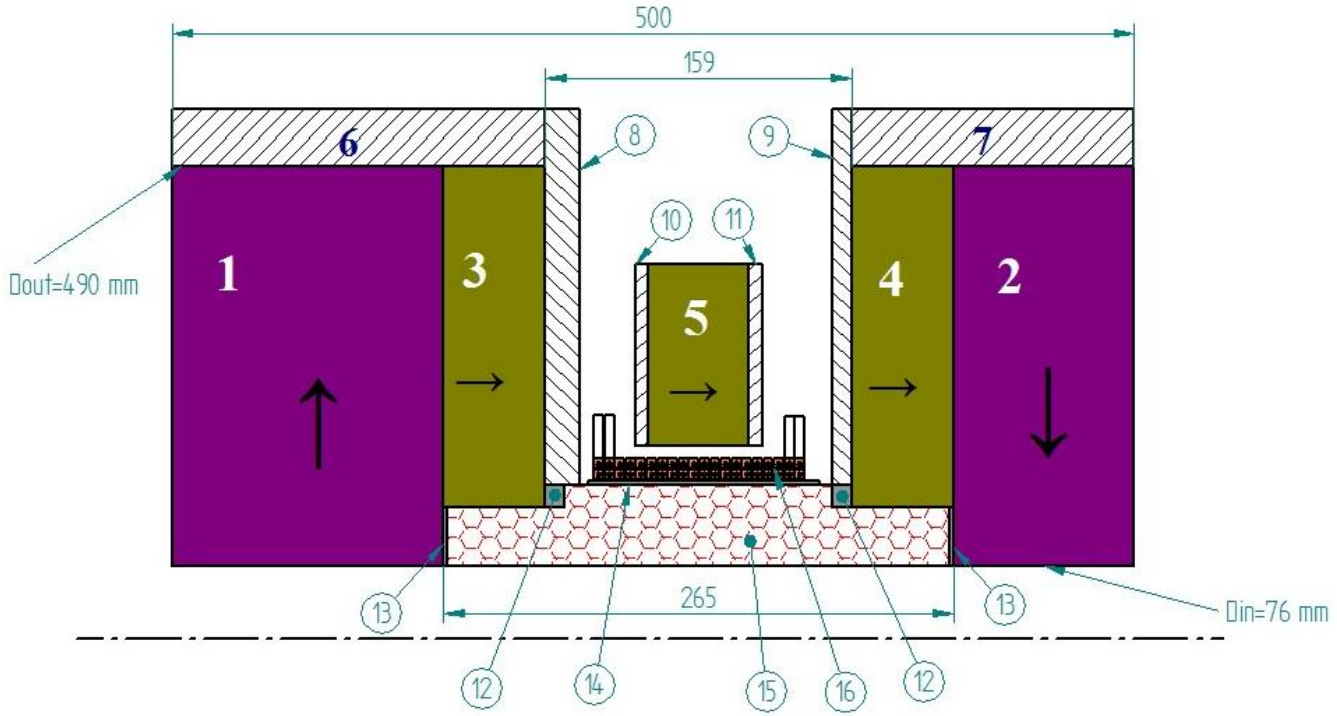
Magnetic field correction



The assembling procedure is planned to be the following:

- the extraction and injection groups of magnets are assembled
- the axial magnetic field in each group is measured separately.
- The total magnetic field is calculated basing on the real magnet properties.
- When necessary, dimensions of soft iron component are defined as the final step.

Coil effect


500
159
6
7
8
9
10
11
1
3
4
2
5
Dout=490 mm
Din=76 mm
265
13
13
12
14
15
16
12

Coil effect

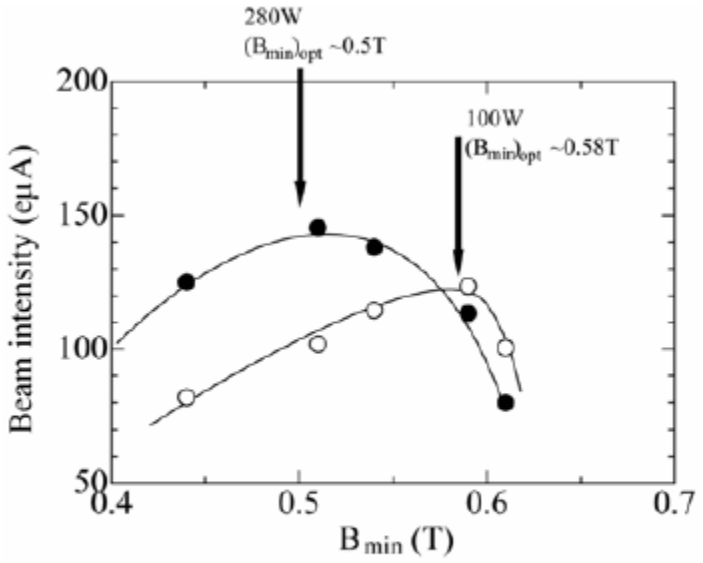
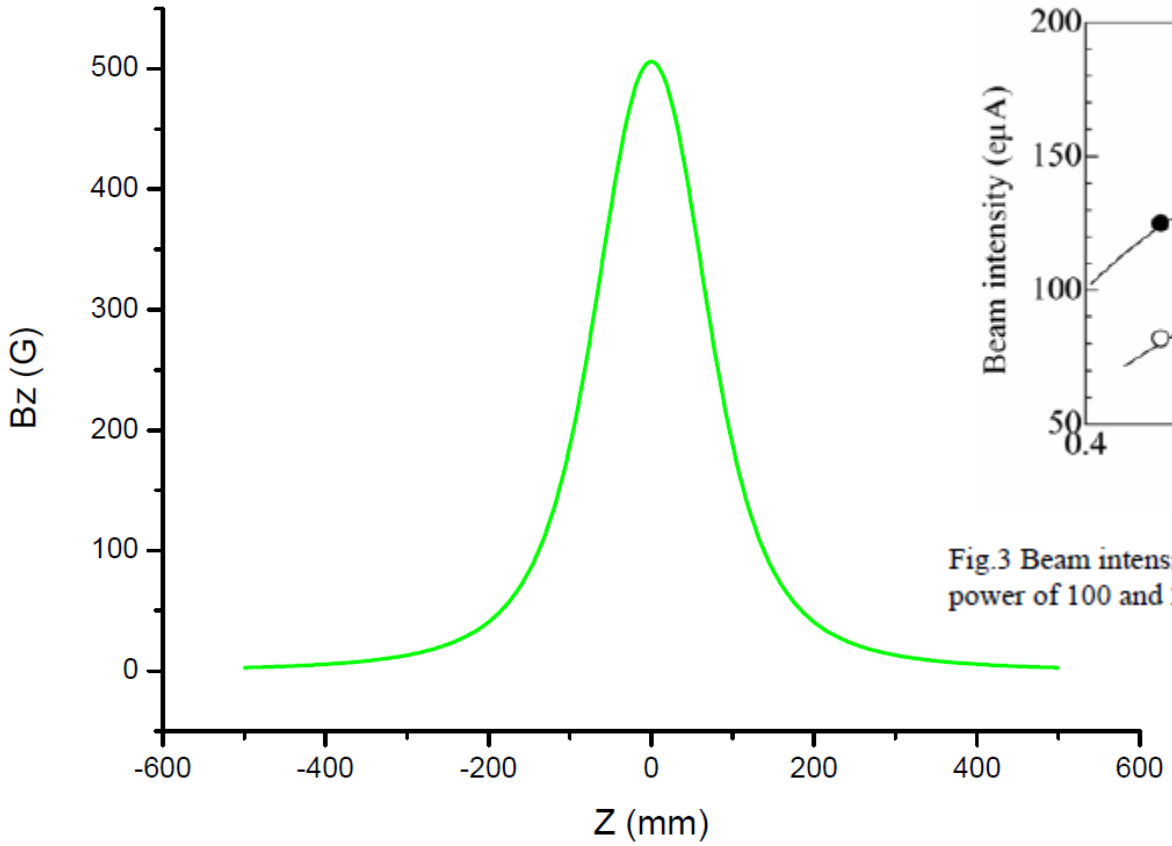
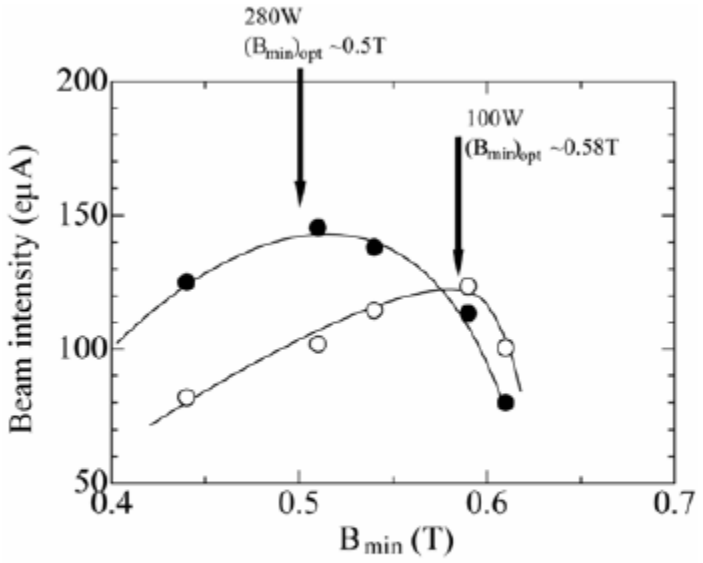


Fig.3 Beam intensity of Ar^{9+} as a function of B_{min} at the RF power of 100 and 280 W.

Coil effect





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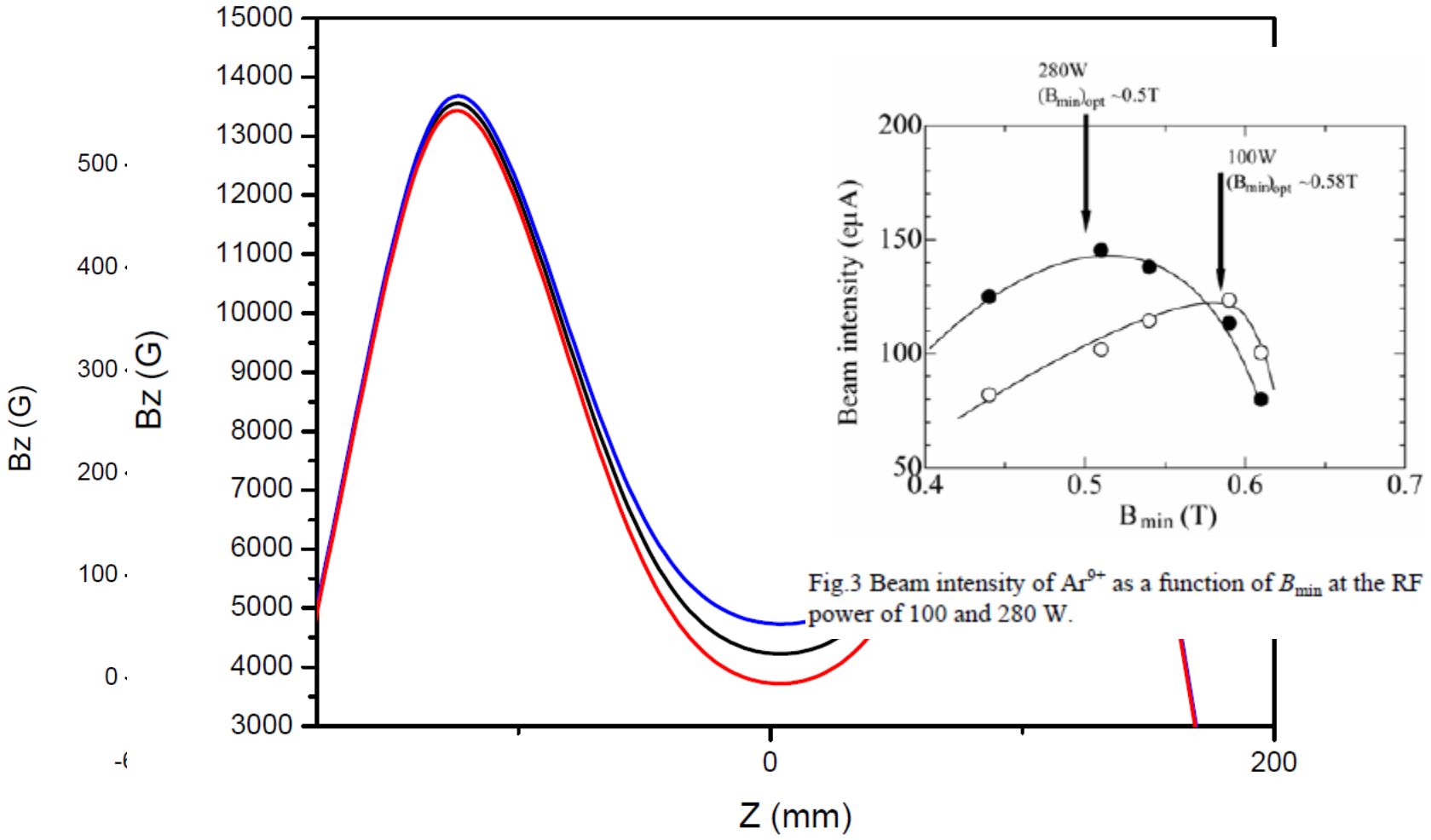
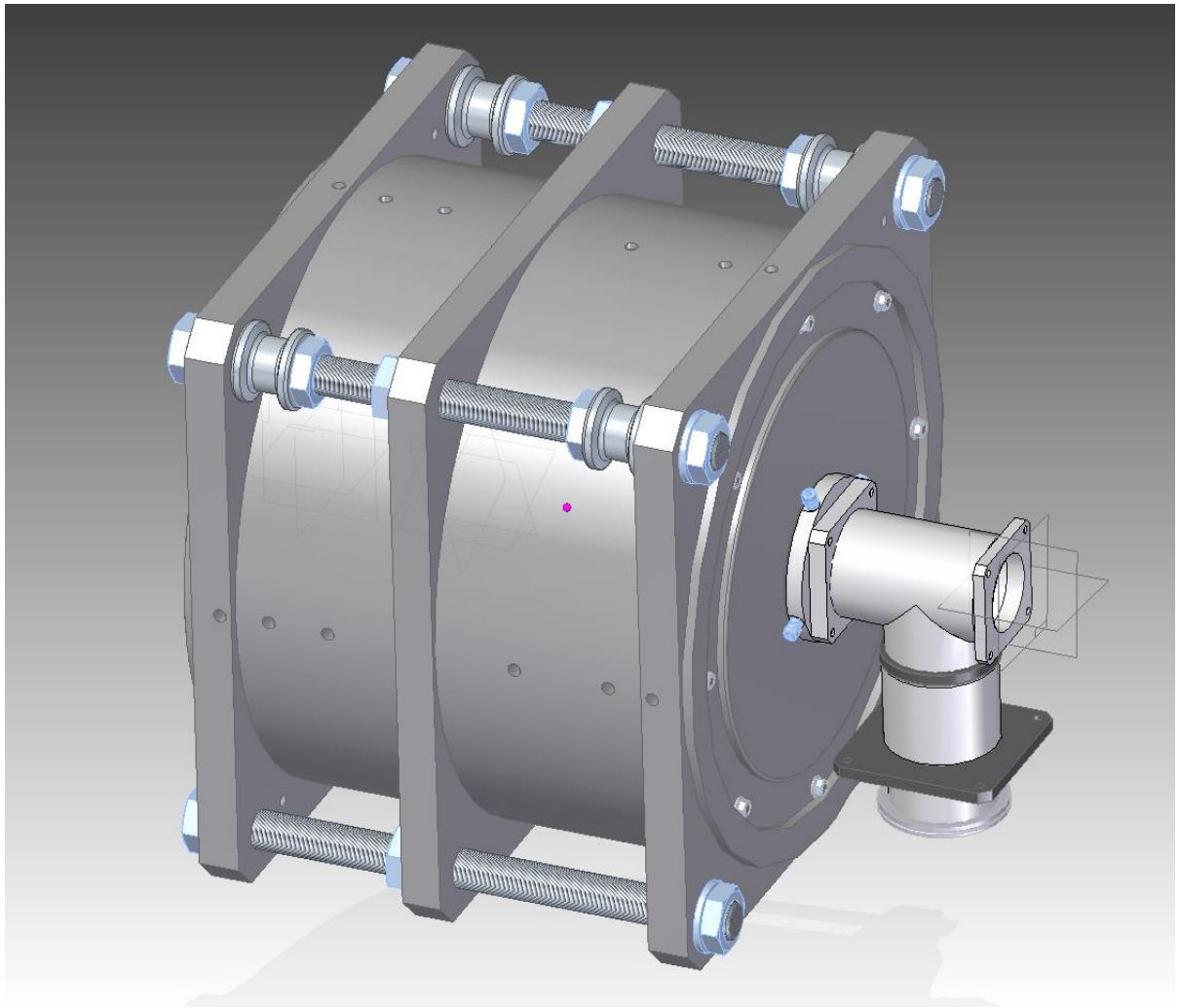


Fig.3 Beam intensity of Ar^{9+} as a function of B_{min} at the RF power of 100 and 280 W.

The total weight of the permanent magnets is around 525 kg and total weight of the system is about 1000 kg.



Conclusion

•A new all-permanent magnet ECR Ion source DECRIS-PM had been designed to be used at the high voltage platform of DC-280 cyclotron.

• Combination of the permanent magnet rings and soft iron plates makes the magnetic structure more flexible.

• The additional electric coil in the structure centre makes the on-line tuning possible.

•Manufacturing of the system is planned to be finished in the end of 2014.

Thank you!