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# CYCLOTRON SYSTEM C-250

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# Basic requirements of the technical task

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| | ***Technical task*** | ***Final project*** |
|---|---|---|
| *Type of accelerated parts* | *Protons* | *Protons and $H^-$* |
| *Beam energy, МэВ* | *30, 50 MeV – discrete values*<br>*70-250 МэВ – smooth regulation* | *30-250 МэВ – smooth regulation* |
| *Accelerated beam current, uA* | *0,05 - 5* | *0,05 - 5* |
| *Accelerator operating mode* | *Pulse and continuous* | *Pulse and continuous* |
| *Number of beams of the transport system* | *3* | *3* |
| *Lifting system of the upper half yoke* | *Presence* | *Presence* |
| *Magnetic system* | *“Warm”* | *“Warm”* |

# Accelerators for proton therapy


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*+ small size*
*+ relative simplicity of design*

***- low intensity of accelerated current***
***- no energy regulation***

| *Varian ProBeam* | ***Model*** | *IBA C235* |
|---|---|---|
| *250* | ***Energy of protons, MeV*** | *235* |
| *4* | ***Induction, T*** | *2,1* |
| *90* | ***Magnet weight, t*** | *200* |
| *3,1* | ***Magnet diameter, m*** | *4,3* |

# Cyclotron in Triumf laboratory, Vancouer, Canada

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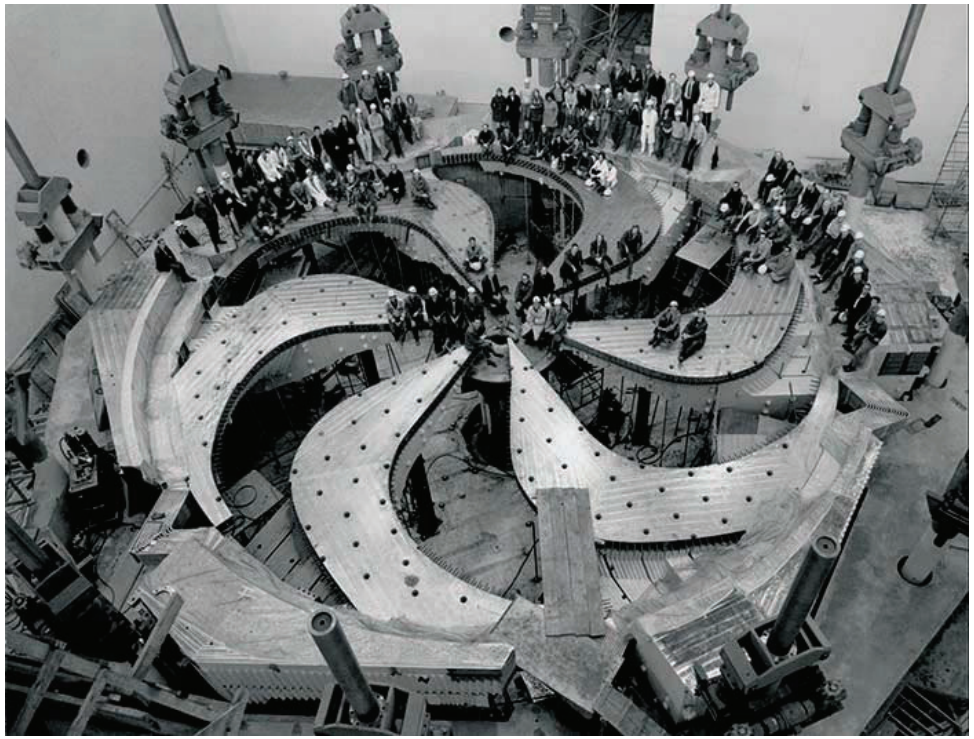
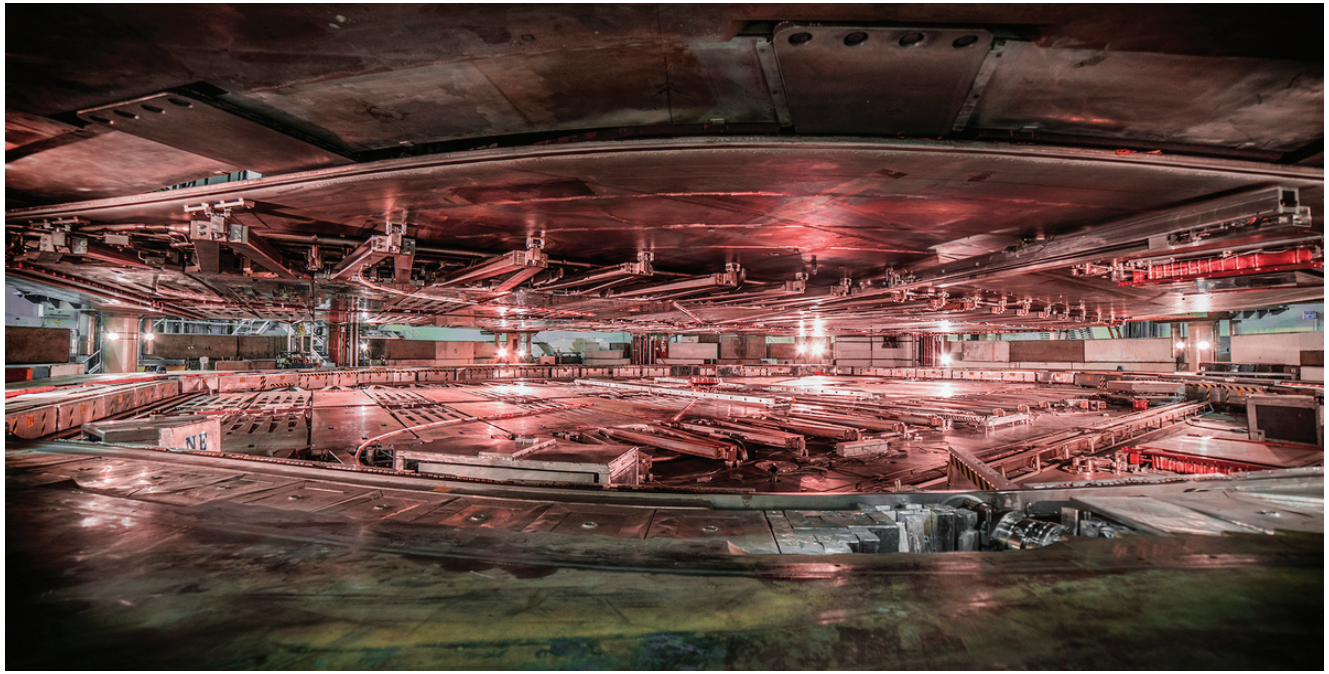


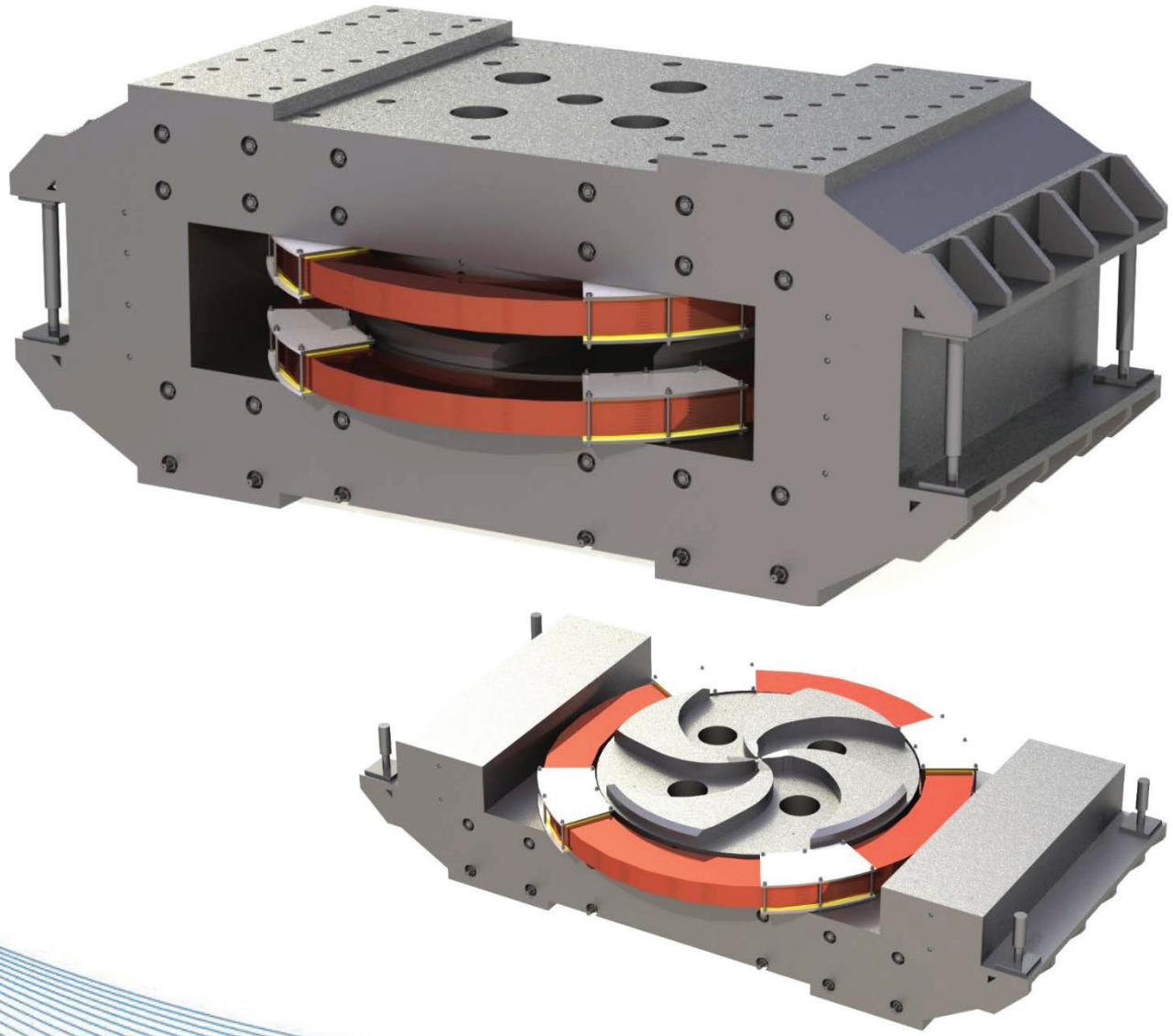
*pole tip of cyclotron*



*inside the accelerating chamber*

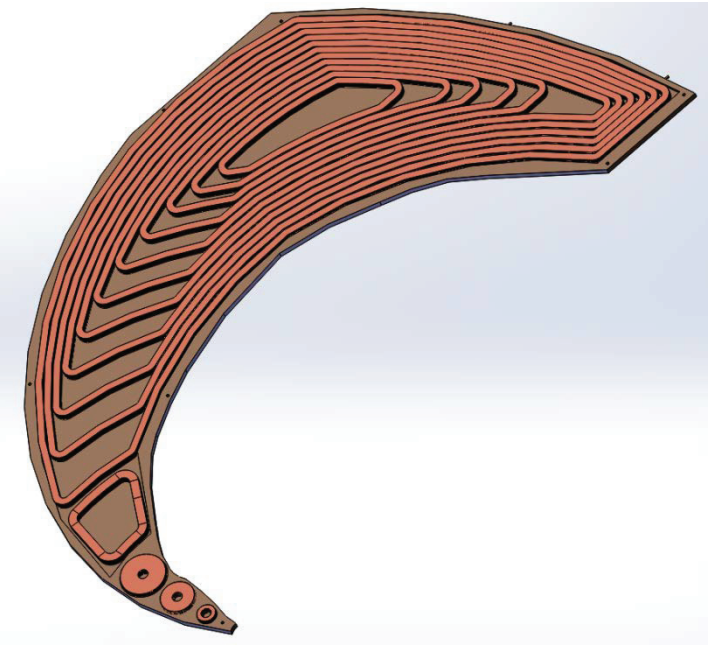
| *Type of accelerated parts* | *$H^-$* |
|---|---|
| *Energy, MeV* | *520* |
| *Pole diameter, m* | *18* |

# Electromagnet of cyclotron C-250



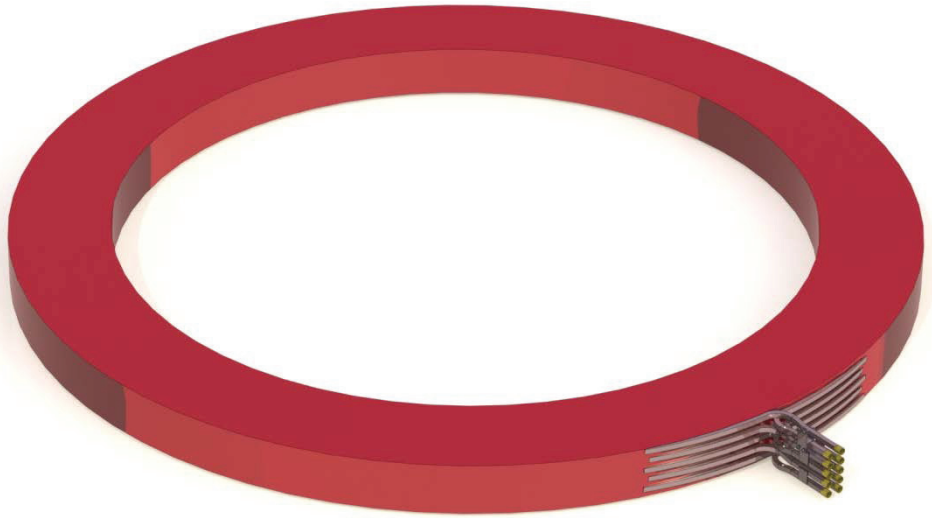
| | |
|---|---|
| *Magnet dimensions, mm* | *8,1x4x3,6* |
| *Weight of steel, t* | *720* |
| *Weight of copper, t* | *36* |
| *Pole diameter, m* | *4* |
| *Air gaps, sector/valley, mm* | *100/500* |
| *Induction in the center, T* | *0,8 - 1,08* |
| *Max consumption power, kW* | *104* |
| *Number of correction coils* | *15x8* |

# Magnetic coils



## Correction coils

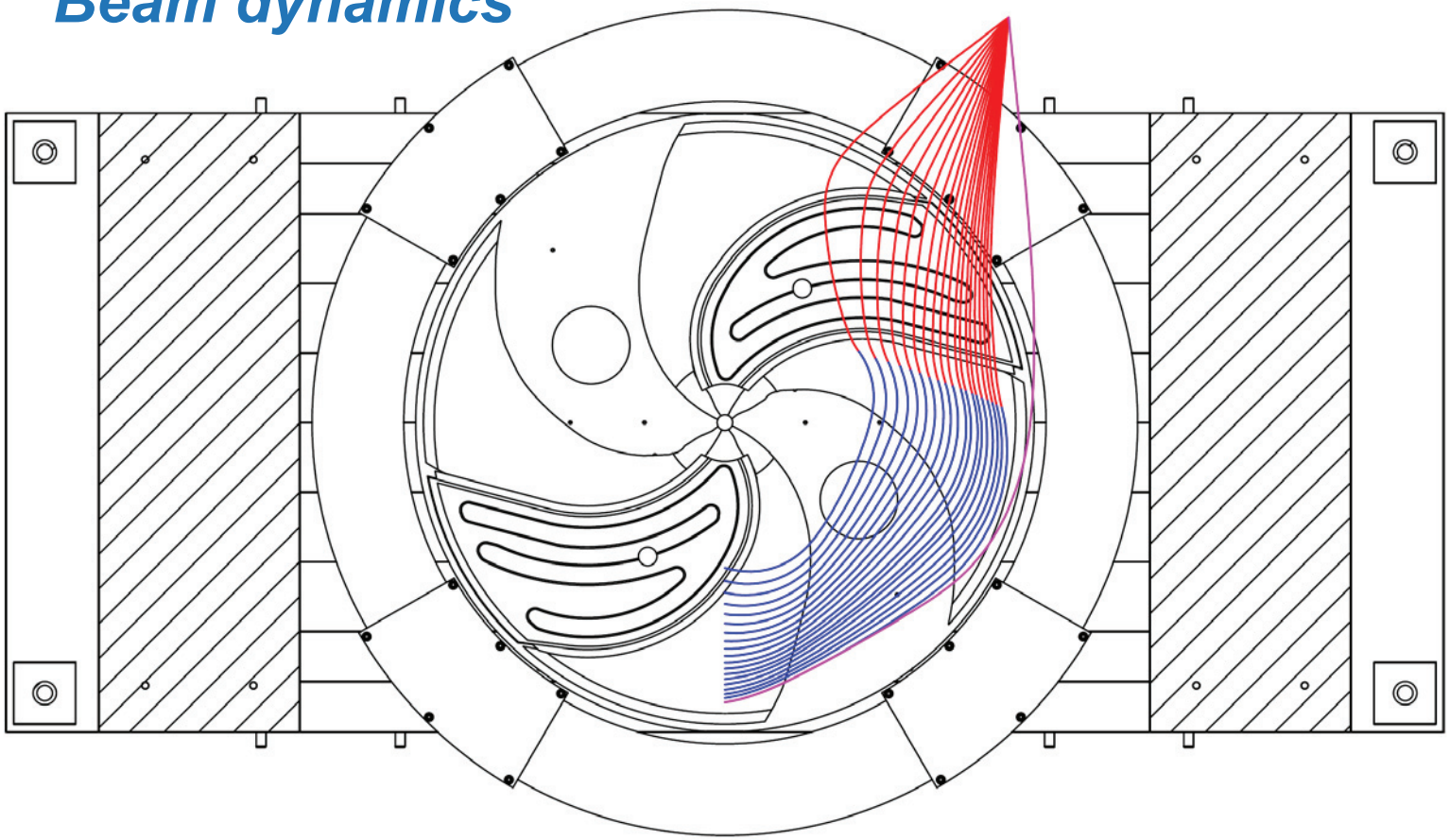
| | |
|---|---|
| Number of correction coils | 15 on each sector, 8 sets |
| Total consumption power of correction coils, kW | 16 |
| Coils construction | Set of 15 coils for each sector in a common vacuum housing |
| Cooling type | Water |



## Main coils

| | |
|---|---|
| Diameter, mm | 5350 |
| Weight, t | 18 |

# Beam dynamics



$H^-$ ions before stripper

Protons after stripper

Protons ejected by deflector

| Energy, MeV | Up to 120 | 120 - 250 |
|---|---|---|
| Type of accelerated parts | H- | Protons |
| Extraction method | Stripper | Deflector |
| Type of extracted parts | Protons | Protons |

# Accelerating system

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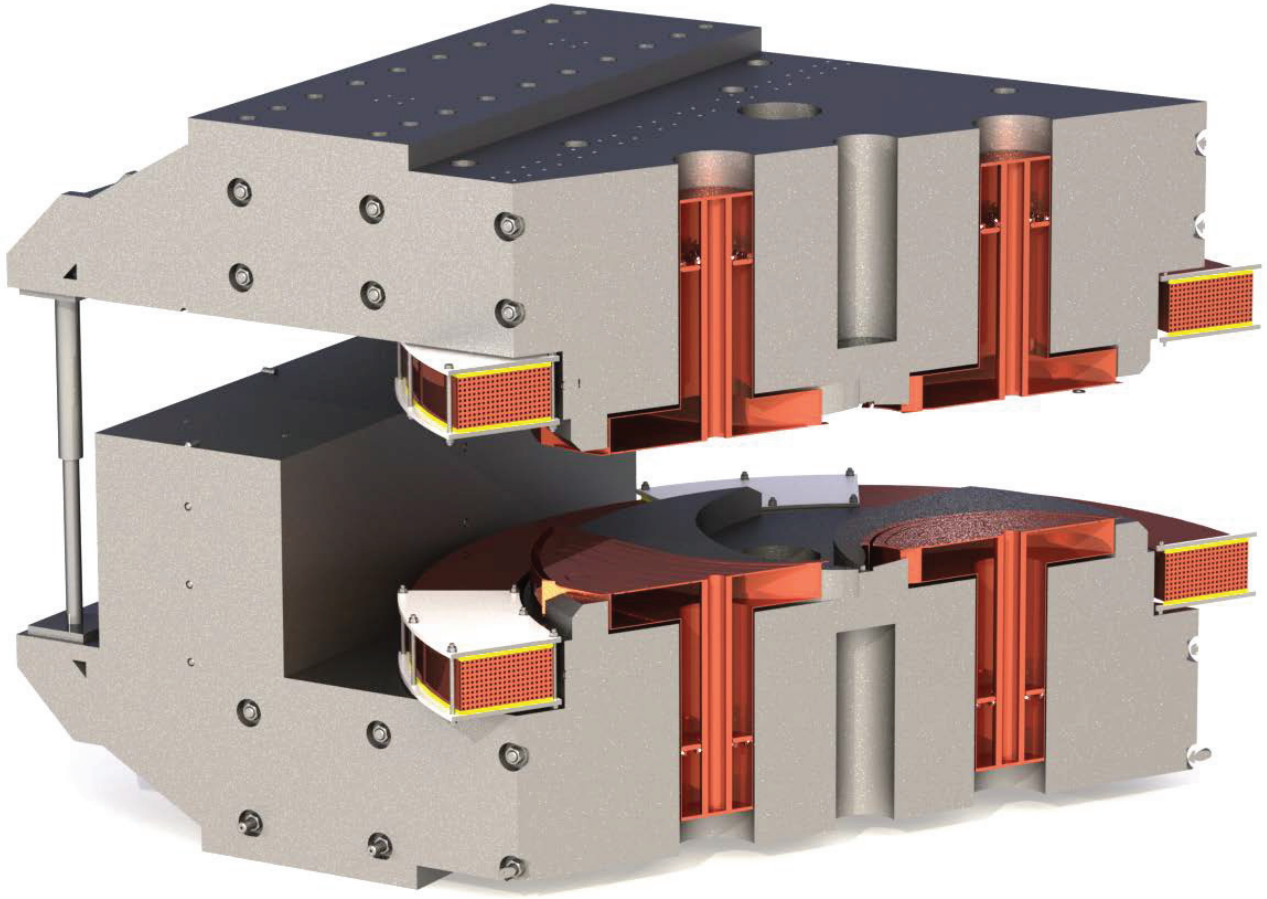


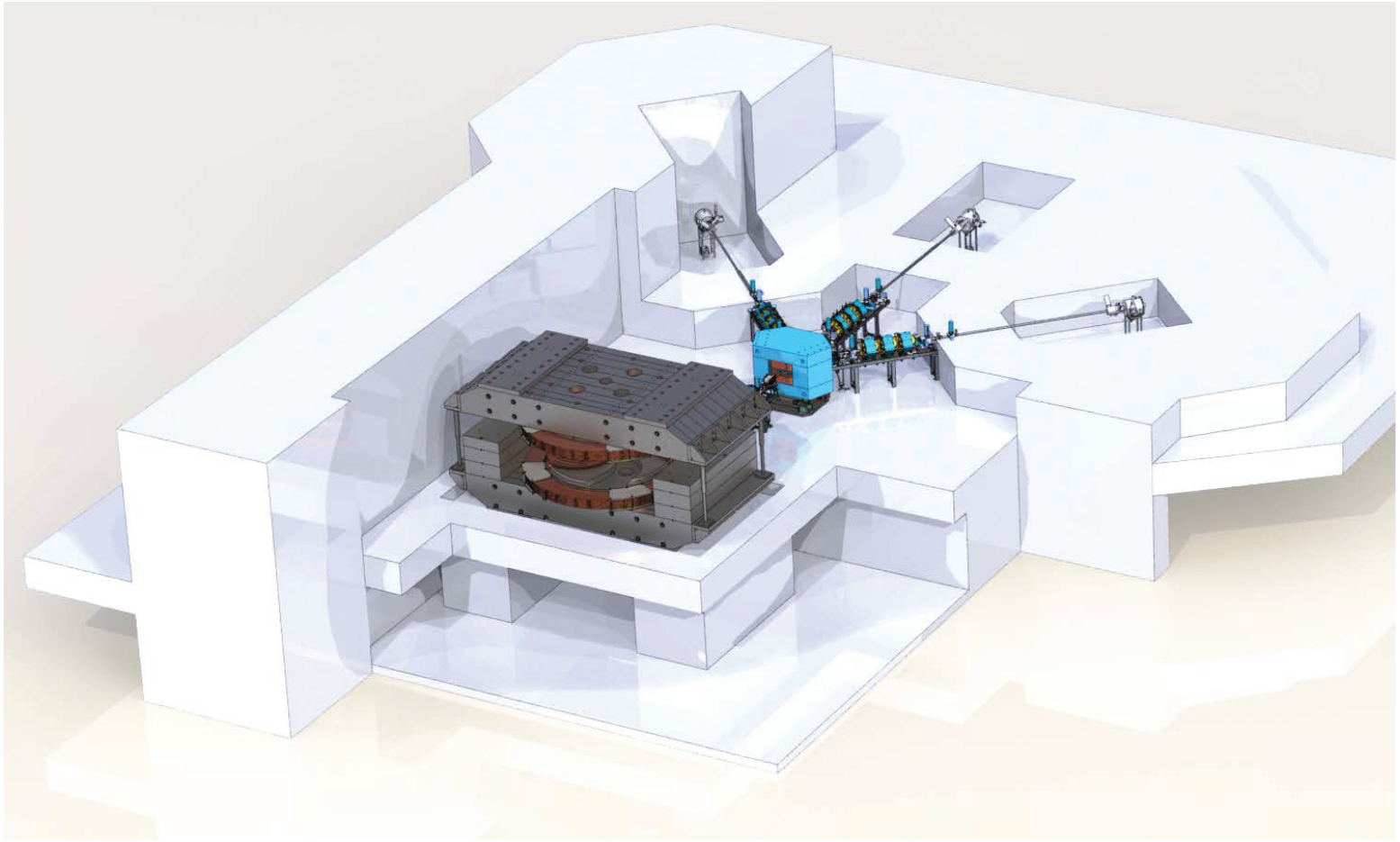
| | |
|---|---|
| *Number of resonators* | *2* |
| *Construction of resonators* | *Vertical dee stems, delta electrodes* |
| *Harmonic* | *2* |
| *Operating frequency range, MHz* | *24 – 32,4* |
| *Active lose power, kW* | *52 – 32* |
| *Accelerating voltage, kV* | *100* |
| *RF system output power, kW* | *60* |

# Injection system

*As a basis is taken the developed and tested Sample of the ion source*

| *Ion source type* | *Internal ion source* |
|---|---|
| *Beam current from ion source, uA* | *50* |
| *Working gas* | *Hydrogen* |
| *Way of ntroducing the ion source in accelerating chamber* | *Radial* |
| *Cooling type* | *Water* |

# Beam transport system



| | |
|---|---|
| *Number of beam output from the cyclotron* | *1* |
| *Number of switching electromagnet* | *1* |
| *Switching magnet weight, t* | *39* |
| *Switching magnet working angles, °* | *±45* |
| *Number of beams of transport system* | *3* |
| *Number of eletromagnetic lenses* | *11* |
| *Number of corrector* | *4* |
| *Internal diameter of the pipes of transport system, mm* | *100* |

# Elements of beam transport system

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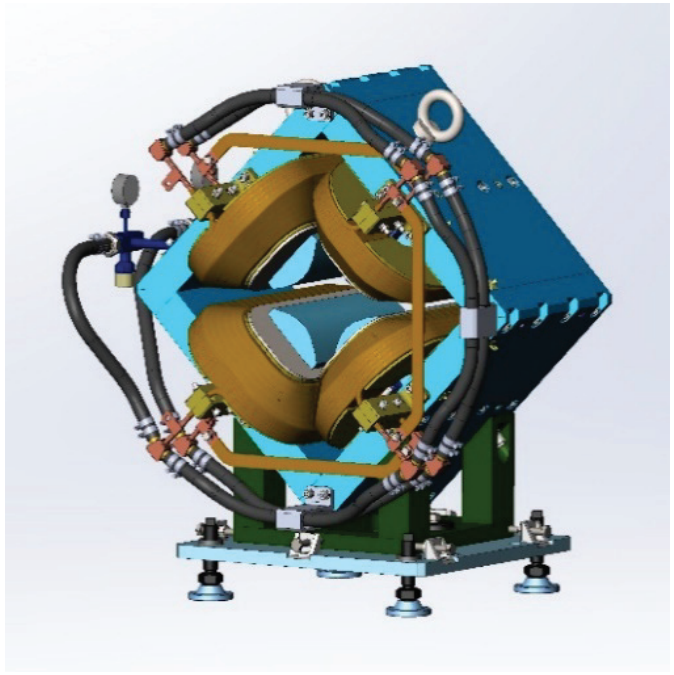
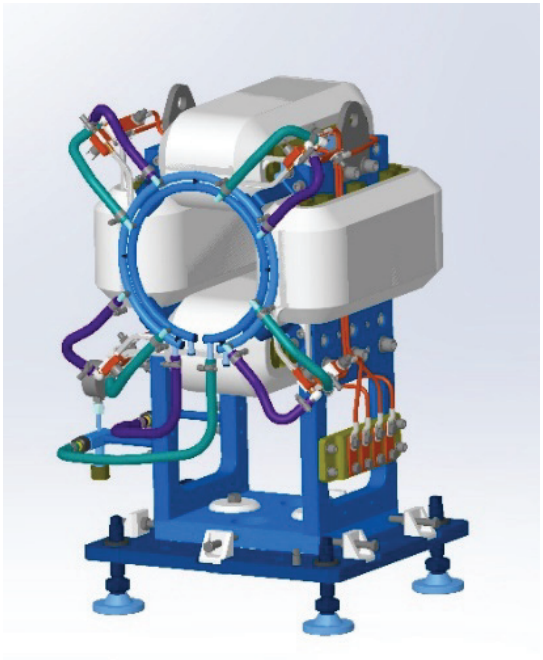
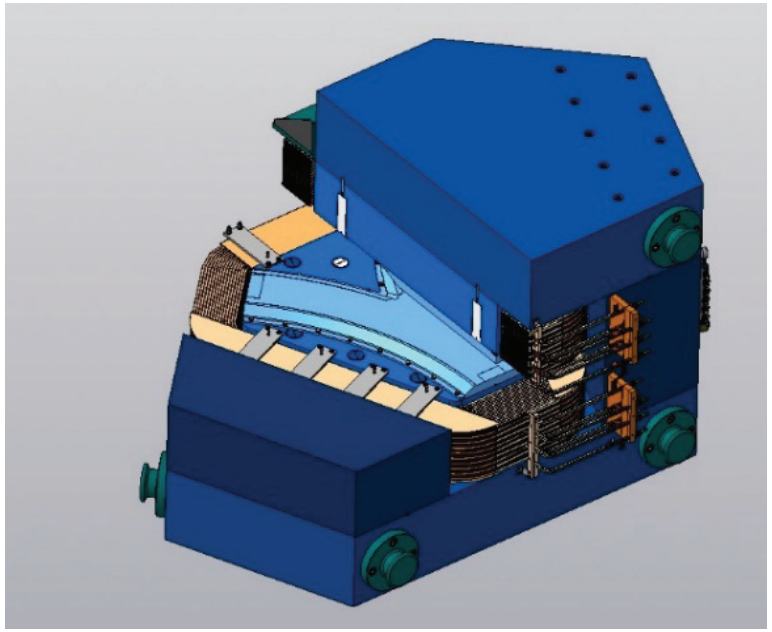


*Electromagnetic lens*



*Corrector*



*Switching electromagnet*

# Vacuum system

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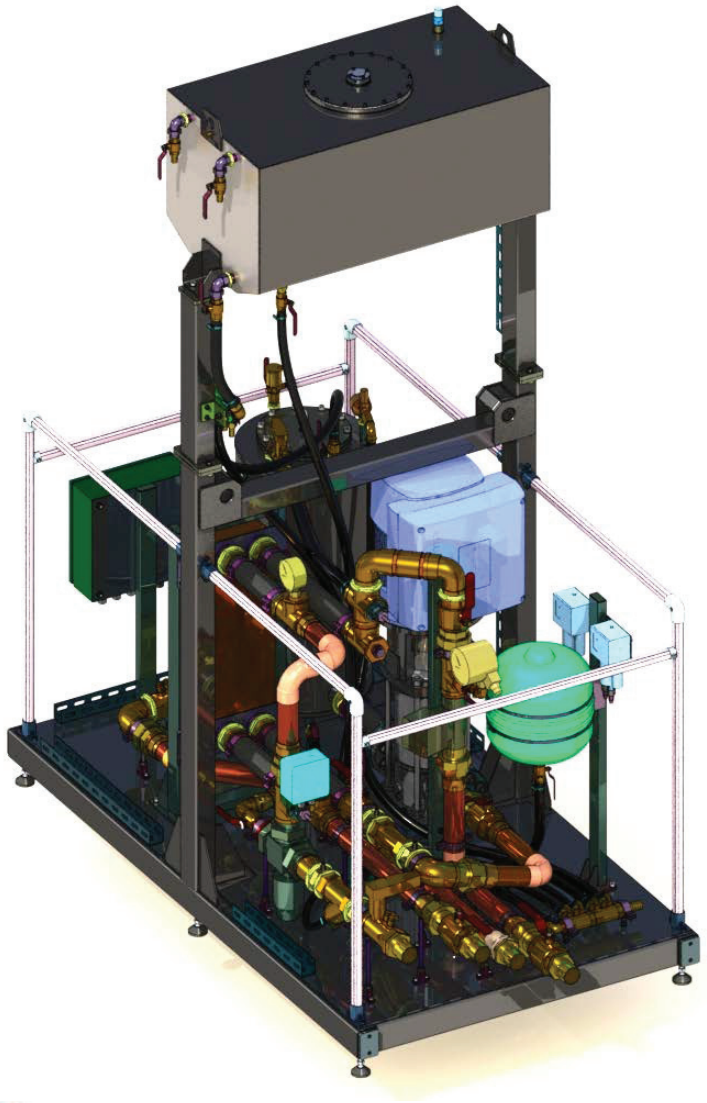
| | |
|---|---|
| *Cyclotron operating vacuum, torr* | *$5 \cdot 10^{-7}$* |
| *Beam transport system operating vacuum, torr* | *$5 \cdot 10^{-6}$* |
| *Forevacuum pumps type* | *Oil-free scroll* |
| *High vacuum cyclotron pumps type* | *Cryogenic* |
| *Cyclotron high vacuum pumping speed (for hydrogen), l/s* | *30 000* |
| *High vacuum beam transport system pumps type* | *Diffusion stream-oil with cryogenic trap* |
| *Type of vale and gate control* | *Pneumatic* |

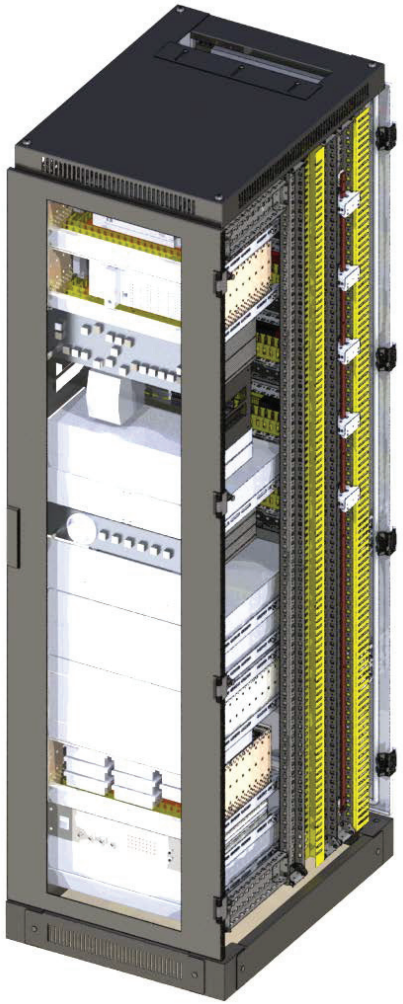
# Water cooling



Блок водяного охлаждения

| | |
|---|---|
| *Number of coolingcircuits* | *2* |
| *Coolant of external circuit* | *Water* |
| *Coolant of internal circuit* | *Distillate* |
| *Temperature of coolant in internal circuit, $^{0}$C* | *15-20* |
| *The amount of heat removed by the cooling system, kW* | *About 320* |

# Automatic control system



Cyclotron control rack

— *automatic control of all cyclotron systems;*
— *the ability to control the vacuum system and cyclotron devices in manual mode;*
— *system of interlock and alarms;*
— *recording and storage cyclotron operating parameters;*
— *possibility of remote access to the cyclotron control system.*

# *In conclusion*

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*— creation of a facility with such parameters in terms of proton beam intensity and energy regulation in a wide range is being implemented for the first time and will create unique opportunities for research;*

*— it is worth noting the technical solution that implements the acceleration of two types of particles, this will reduce the beam loss during extraction and narrow the range of regulation of the magnetic field and RF system;*

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# Thank you for your attention

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