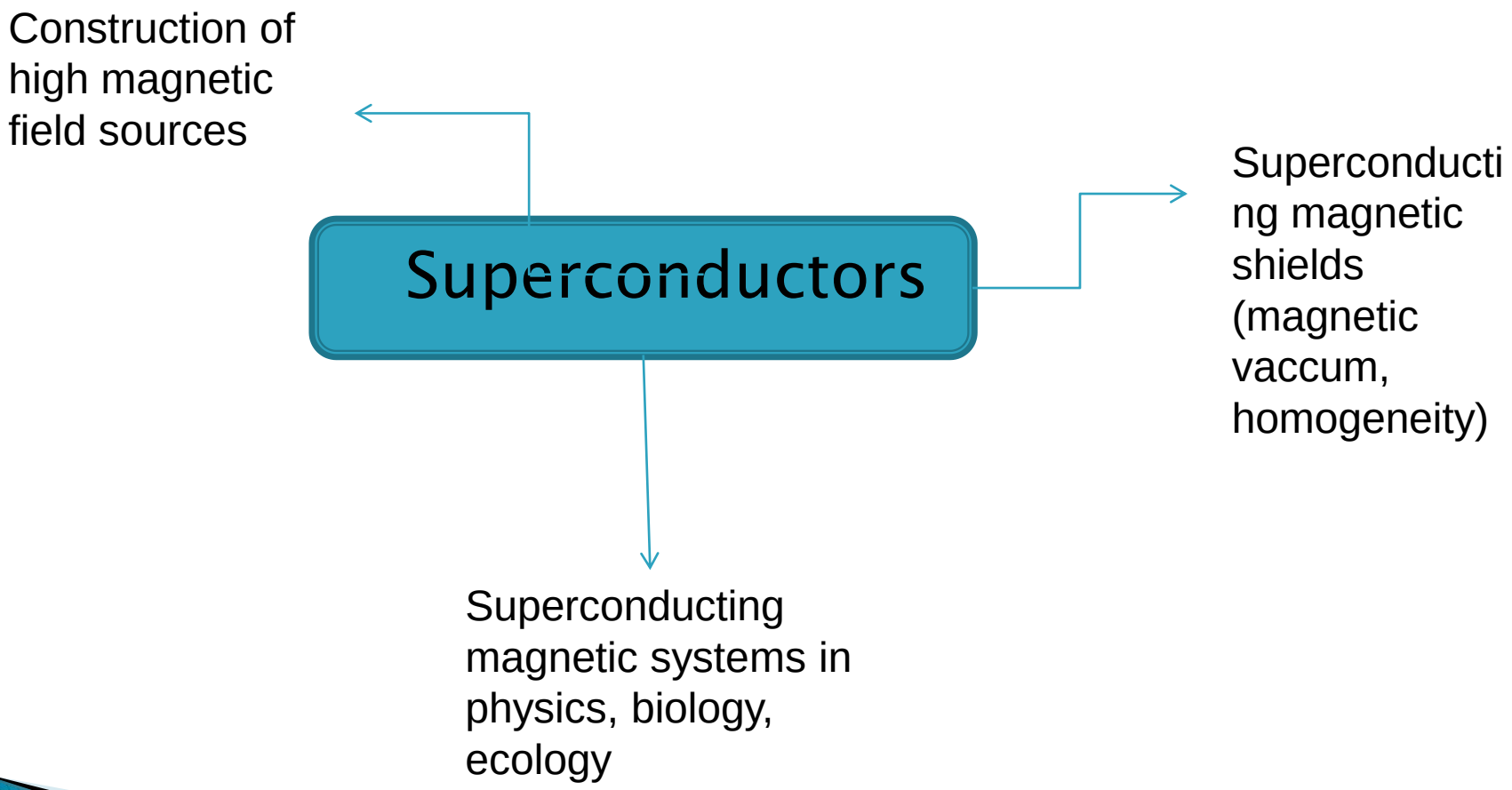
Application of superconductors in medicine

Krzysztof Malinowski
Lublin University of Technology
Biomedical Engineering

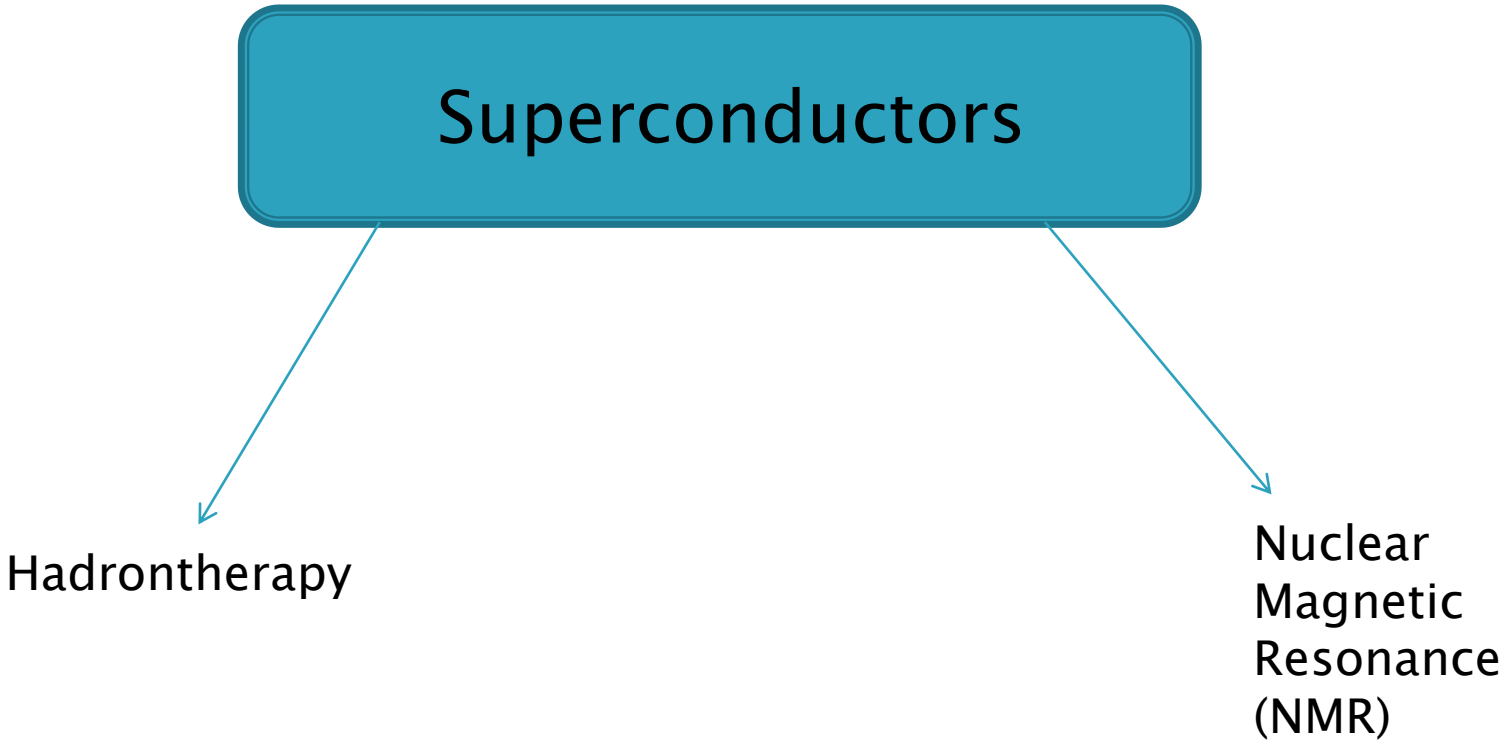
Aplication of superconductors



Magnetism in life organisms

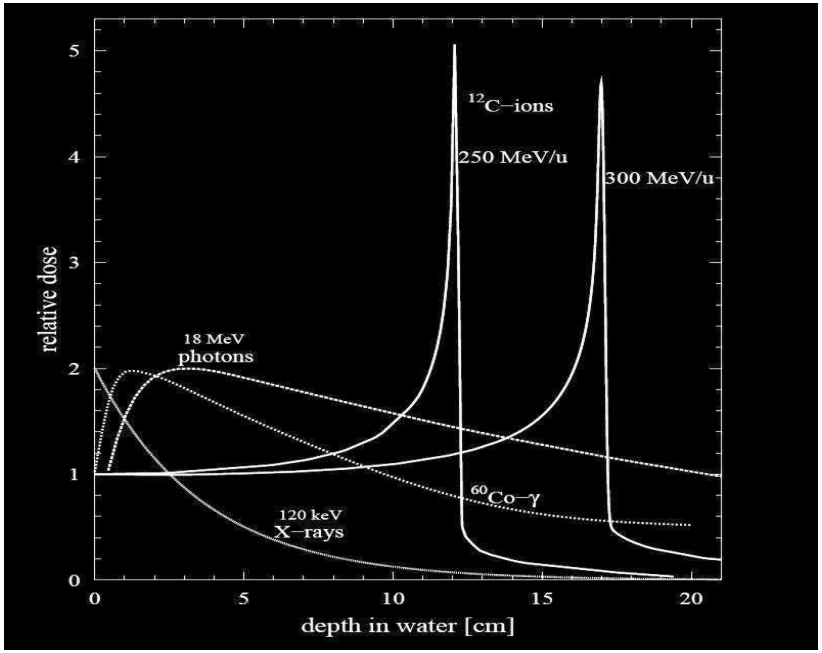
- Global magnetic field value changed from 1 to 0,5 G in past 10,000 years
- Reaserch proves that influence of high and low magnetic field is seen in next generations
- Safe value for life origanisms is 1000G
- Changes in organism behaviour seen with 100G

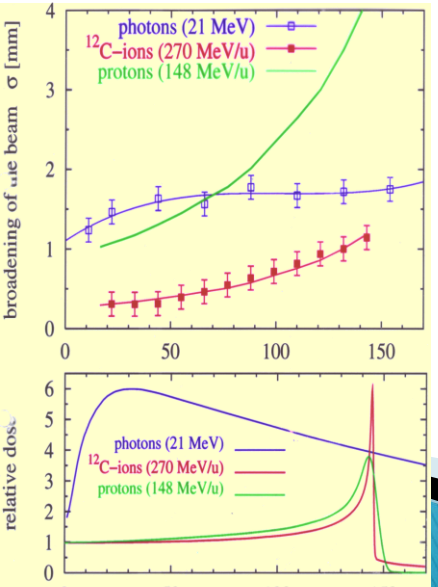
Medicine


Superconductors
Hadrontherapy
Nuclear Magnetic Resonance (NMR)

Basics of hadrontherapy

- Quick
- Safe
- Most efficient

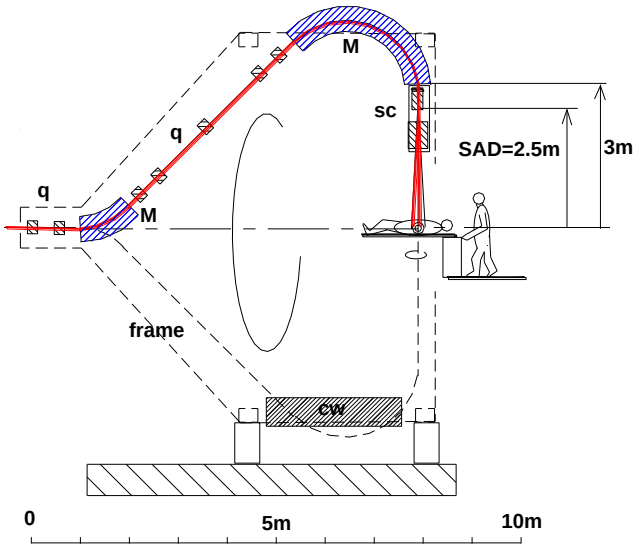


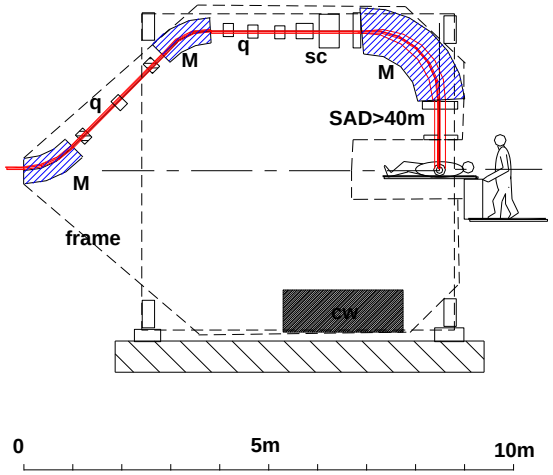


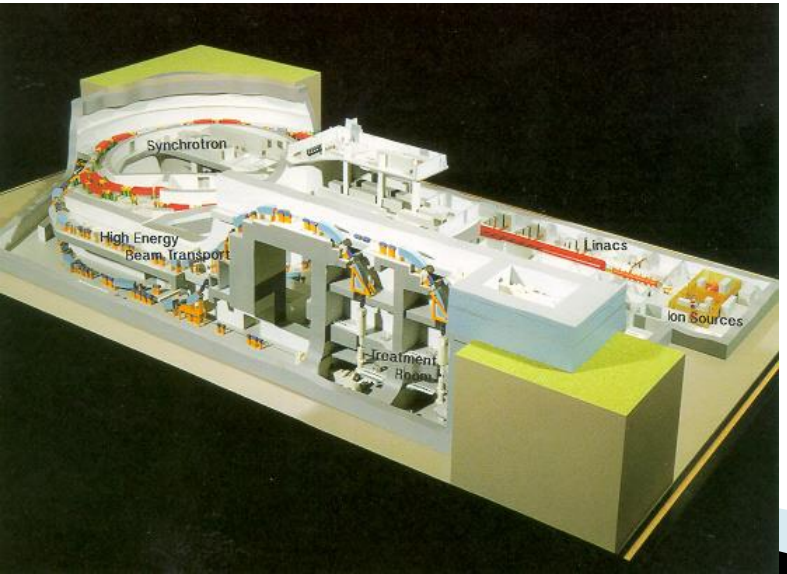
Restricions:

- Absolute immobility of patient
- Head area only
- Lot of human resources

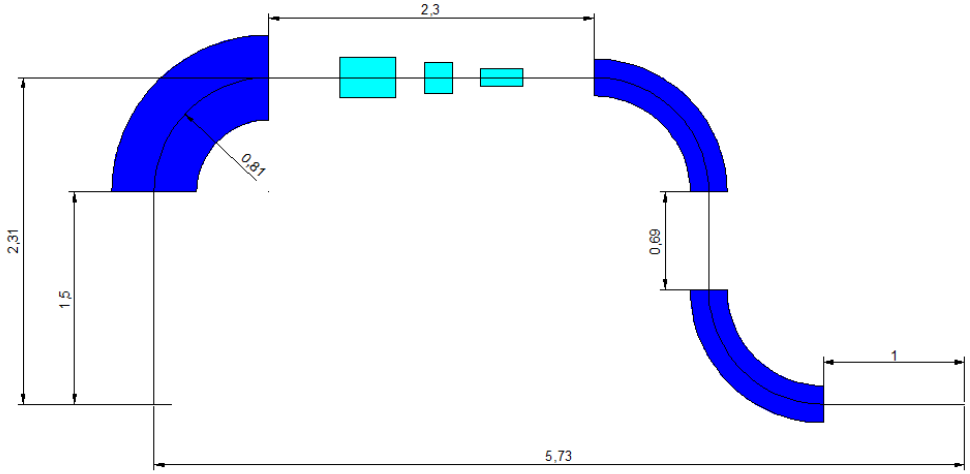
(Classic) GANTRI system







- Most common in hadrontherapy
- House-size
- Weight of 1000 tons (treatment room)
- Needs conventional shielding



GANTRI megnetic structure.

CM1 - CM3 – combiend electromagnets, SM1 - SM3 – scanning magnets.

Name.	Effective lenght, m	Magnetic field	Aperture, mm
CM1, CM2	1, 272	Dipol component 3 T; Quadrupole component ±7 T/м; Hexapole component ±20 T/м^2	R30 (round)
CM3	1, 272	Dipol component 3 T; Quadrupole component ±3 T/м; Hexapole component ±20 T/м^2	R130 (round)
SM1	0,3	±0,5	60 × 60 (square)
SM2	0,2	±0,5	120 × 60 (recatangle)
SM3	0,4	±0,5	140 × 110 (recatangle)

GANTRI magnets parametres

Parameters	Units
Particle type	p
Max. Proton energy	250 MeV
Min. Proton energy	60 MeV
Beam diametr	3÷10 mm
Max. Induction of magnetic field	3 T
Non-homogeneity of magnetic field	No more than10^{-3}
Max. scannig size	20×20 cm
Pacient position	horizontal, stationary
Angle of turning	360°
Size specification:	
-Diametr	5.6
-Lenght	7.5
Projected mass	85 t
electromagnets mass included	21 t

SuperGANTRI system

1, 2, 3 - dipole magnets;

4 - focusing magnet;

5 - scanning magnet;

6 - sealing of helium tubes;

7 - sealing of vacuum tube;

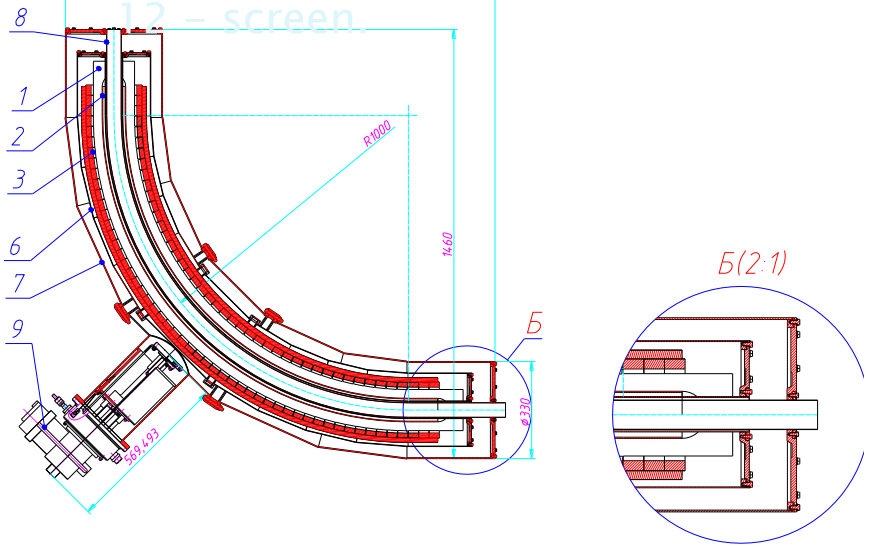
8 - electric sliding connection;

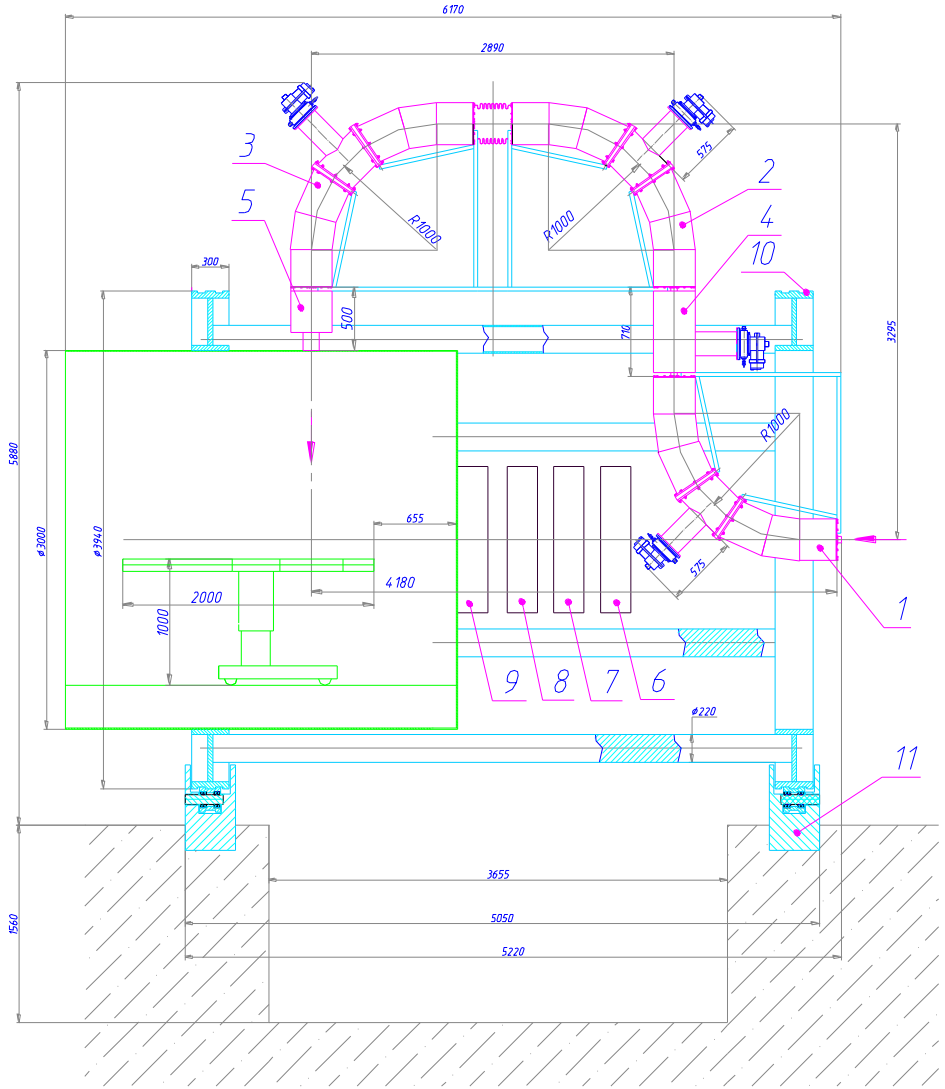
9 - electric sliding connection of cold head valves;

10 - frame of GANTRY;

11 - support of frame wheels;

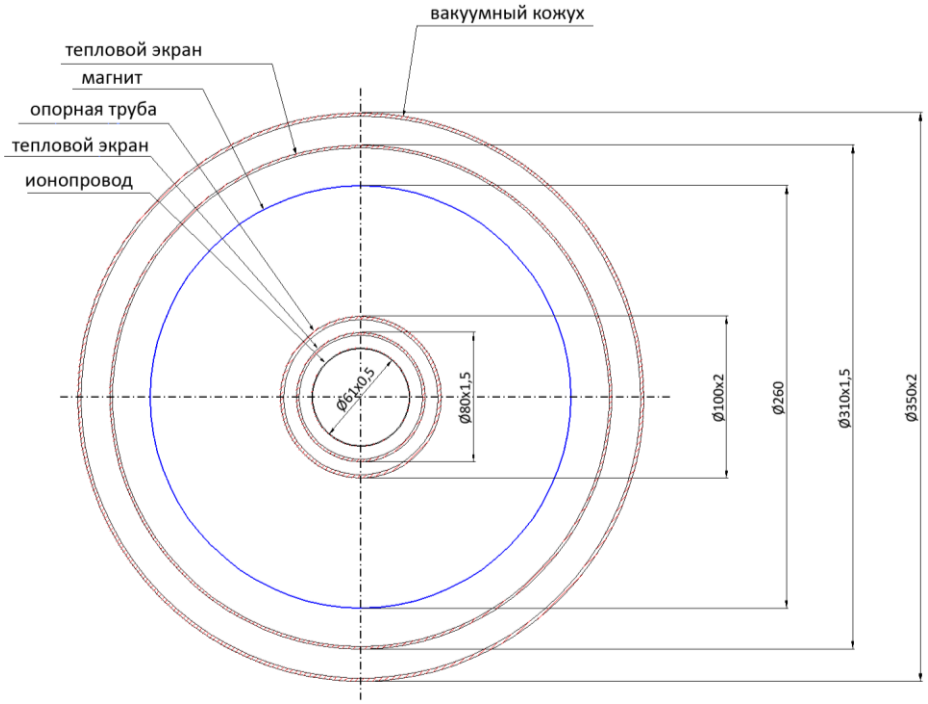
12 – screen.

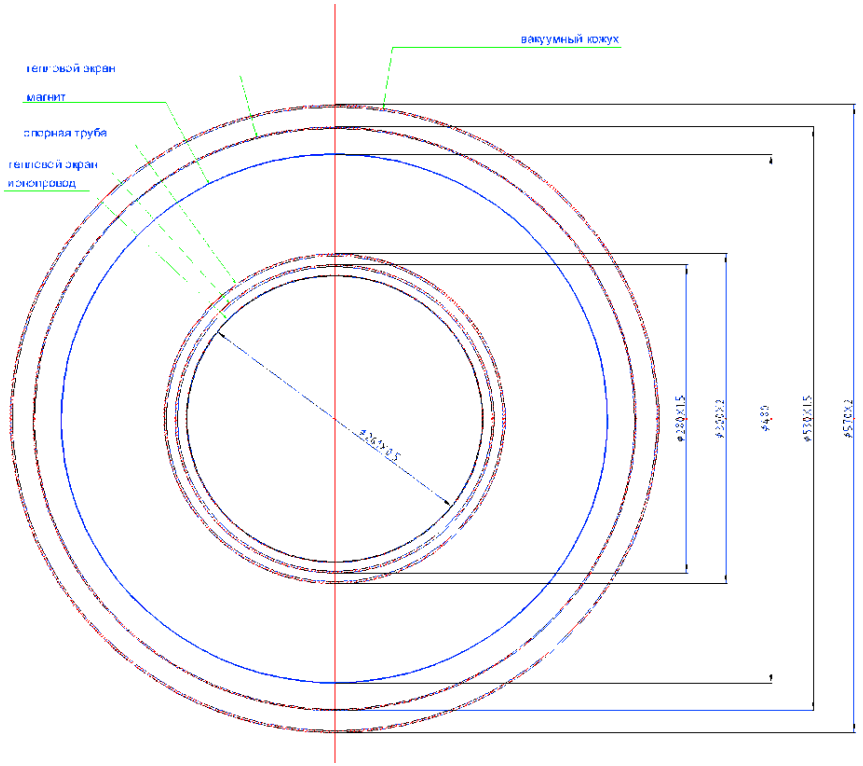




For carbon therapy project

SC electromagnets cross section

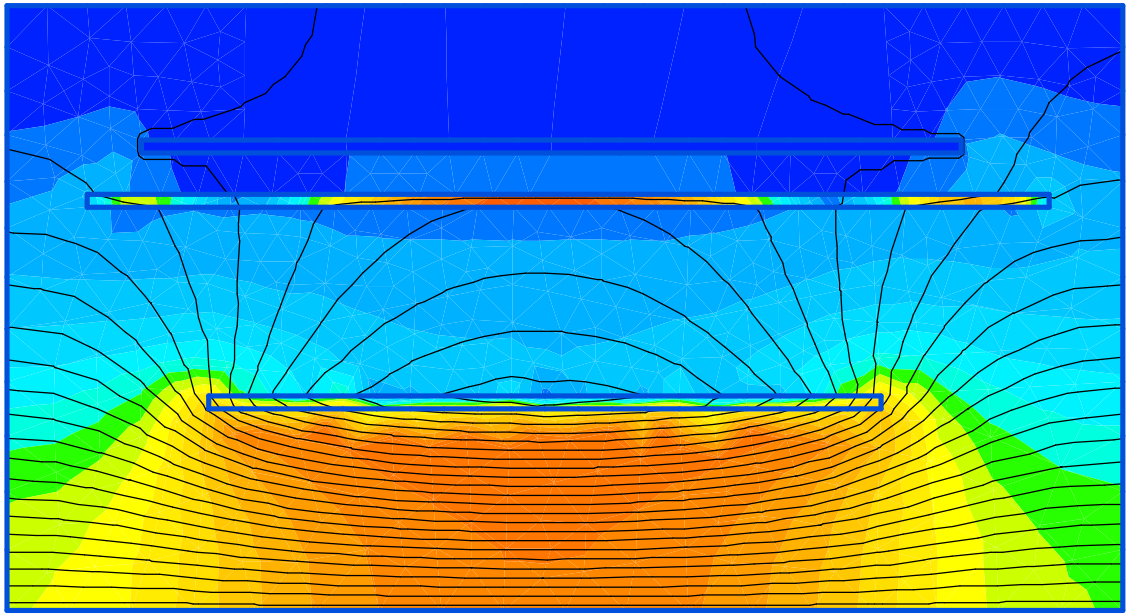




in radius r=30cm mag. field reaches B=0,2T outside

Electromagnetic field characteristic with combined magnetic shielding

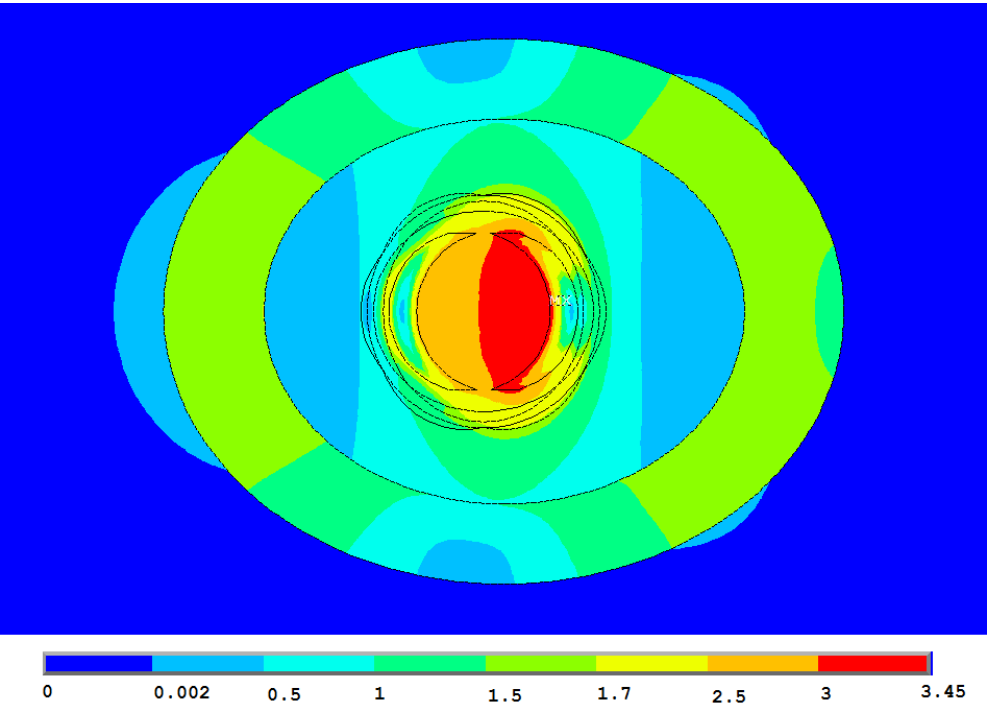
- One of the shielding is steel shield (greatly reduced mass)
- Superconducting shield os HTS



Outsied of ion channel
B=0,2T
Combined steel and sc shield let magetic field reduce to <0,05T

In this construction is used Closed shielding

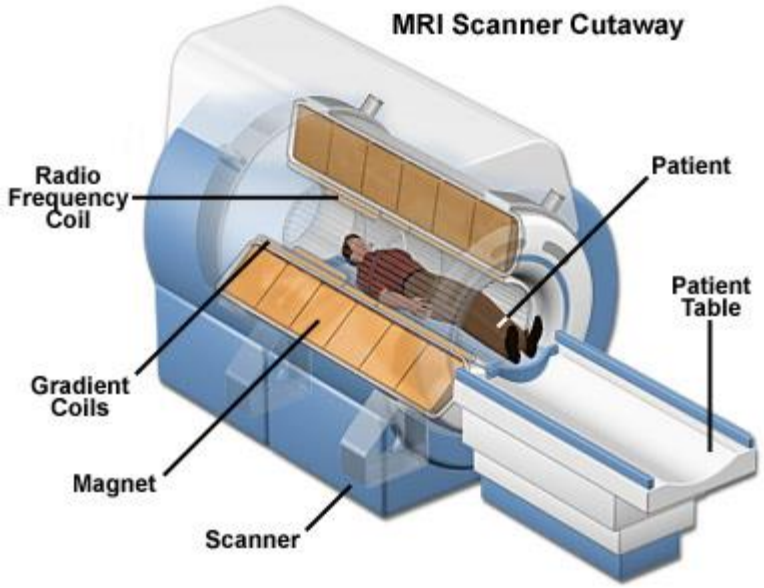
Magneti field in combined shielding

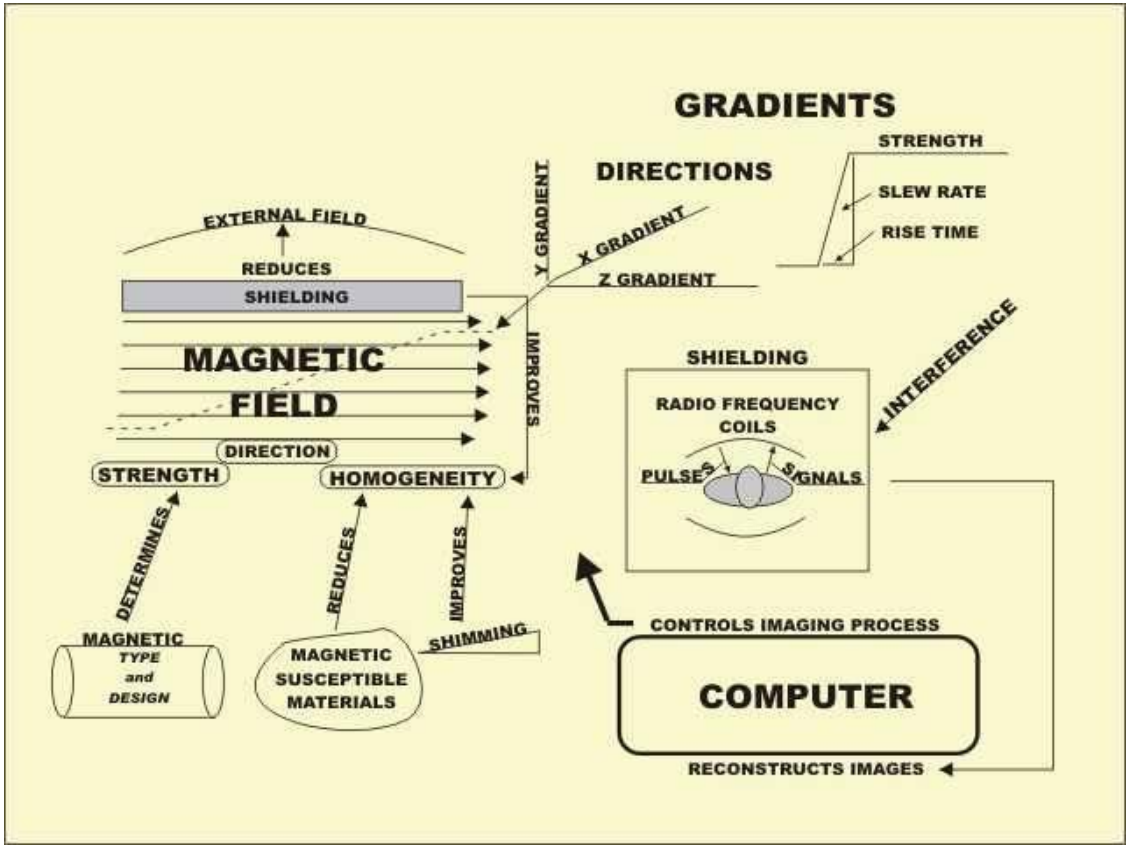


Final effect of constructed sields
Magnetic field outside casing **B < 0.002 T**, (inside casing B< 1.7 T, inside superconducting winding Bmax = 3.452 T

Magnetic resonance

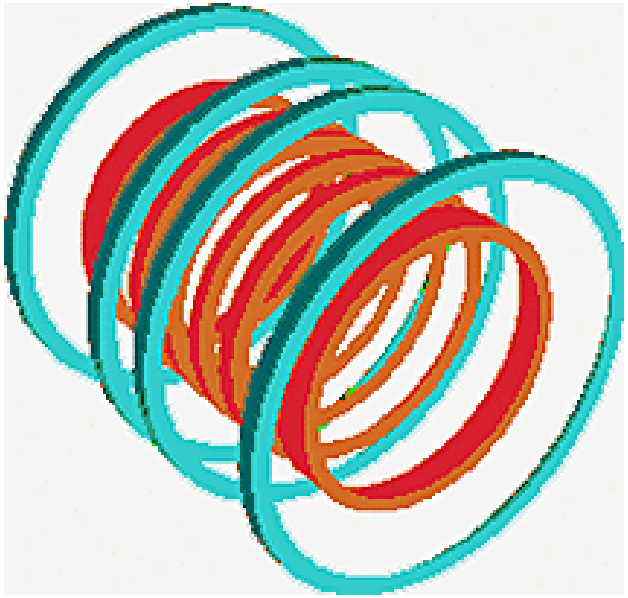
- Higher magnetic field value improves quality of imaging
- Quality of imaging depends on homogeneity of magnetic field





Magnetic shielding

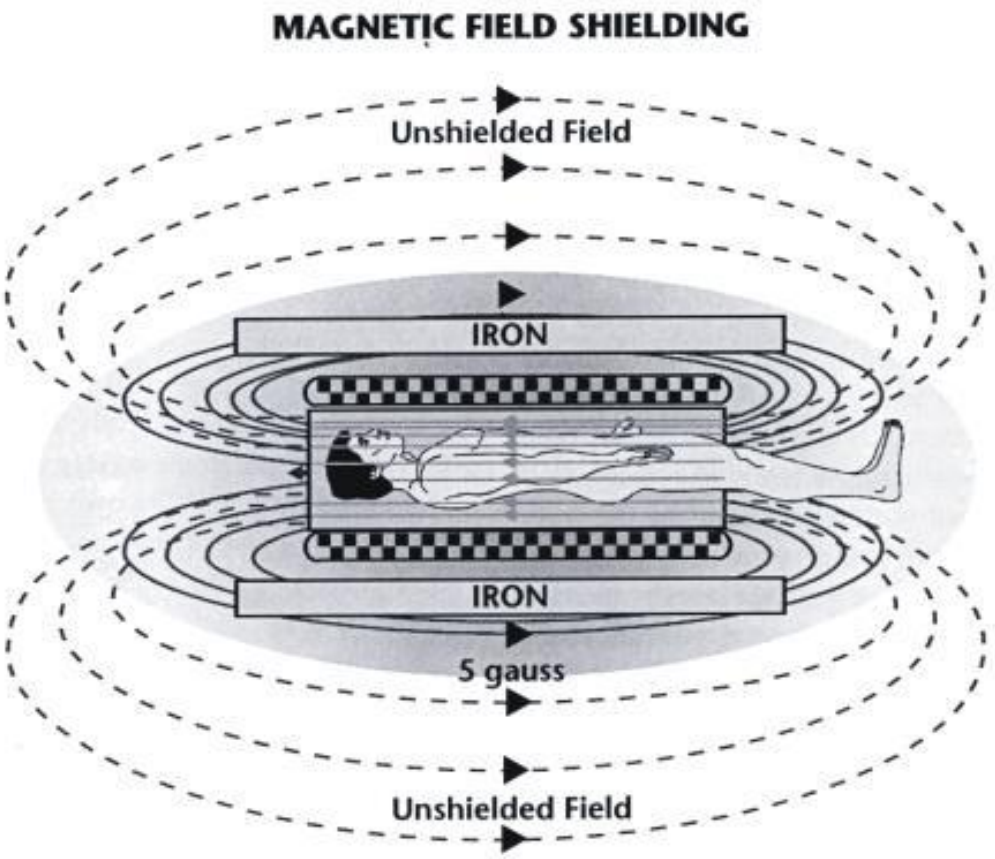
- Protect equipment
- Protect personell
- Purpouse of magnetic shielding is to reduce fringe fields



Passive: Shieldieng by a ferromagnetic material (steel plates/tubes)
Active: Shieldieng with opposin magnetic field vector

Homogeneity

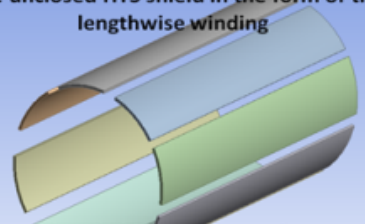
For MRI it is demanded that homogeneity of maganetic field will be no more than 10^{-3}
For acquiring this effect we need to change configuration of main magnet winding . (Hard and expensive)
It can bo passed by application of unclosed shielding.



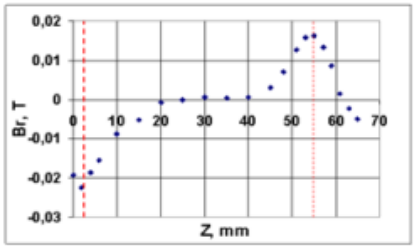
Un-closed shielding

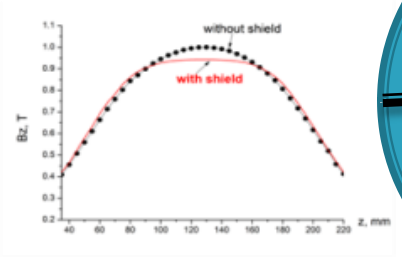
Unclosed shield: what is it ?

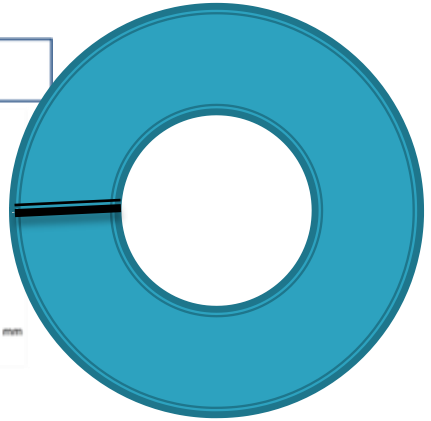
The unclosed HTS shield in the form of the lengthwise winding



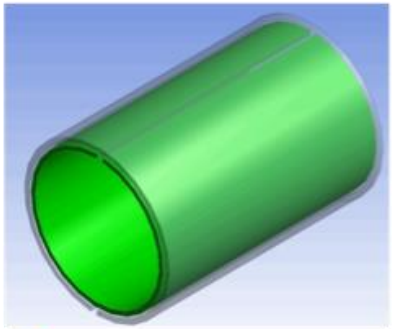
➢The unclosed shield screens only magnetic field perpendicular component at the centre and transmits the longitudinal component.







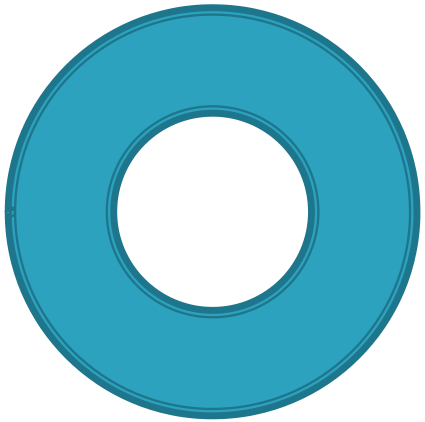
LTS shield



➢ The LTS shield is a multilayer unclosed winding made of the superconducting foil.

Material

superconductor- NT-50
foil thickness 20 μm



Summary

- Humans live in constant magnetic filed. Lack of it or too high values may have negative influence our body.
- Superconductors finds more and more applications in field of medical devices.
- Further reaserch in hadrontherapy may provide treatment for every kind of cancer.
- Properties of superconductors may be revolutionary for medicine.

Thank you for your attention ☺