



**О ходе работ по Соглашению с Китаем по
медицинскому циклотрону SC202 и
подготовке планов его установки в ЛЯП.
Сохранение и развитие протонной терапии в
ОИЯИ**

*Ширков Г.Д.
февраль 2017*



Proton therapy in JINR

- 1967 – the beginning of the research on proton therapy;
- 1968 –1974 – first 84 patients treated with protons;
- 1975 –1986 – upgrading of accelerator and construction of a multi -room Medico -Technical Complex (MTC);
- 1987 -1996 – treating of 40 patients with protons;
- 1999– inauguration of a radiological department of the Dubna hospital;
- Since 2000 - treating of patients with tumors seated in the head, neck and thorax.

The technology of conformal three-dimensional proton therapy is realized on the JINR medical-technical accelerator complex which includes the synchrocyclotron, the beam delivery systems and medical cabins.

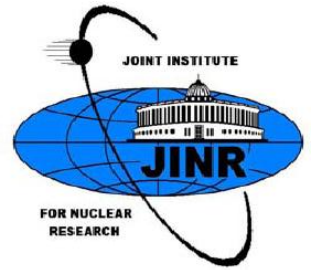
Contract between IBA and JINR has been signed in April 2011 in the presence of His Majesty Crown Prince Philippe (the King presently) of Belgium



Collaboration on Hadron Therapy between JINR and IBA



- Technical design of the world first superconducting carbon cyclotron C400 (2005-2009)
- Modernization of serial proton cyclotron C230 – C235 V3 (2007 – 2009);
- Creation at JINR of a site for C235 V3 assembling and testing (2009);
- Scientific Collaboration Agreement between IBA-JINR in order to assemble, tune and test the C235 V3 at JINR in 2011-2012

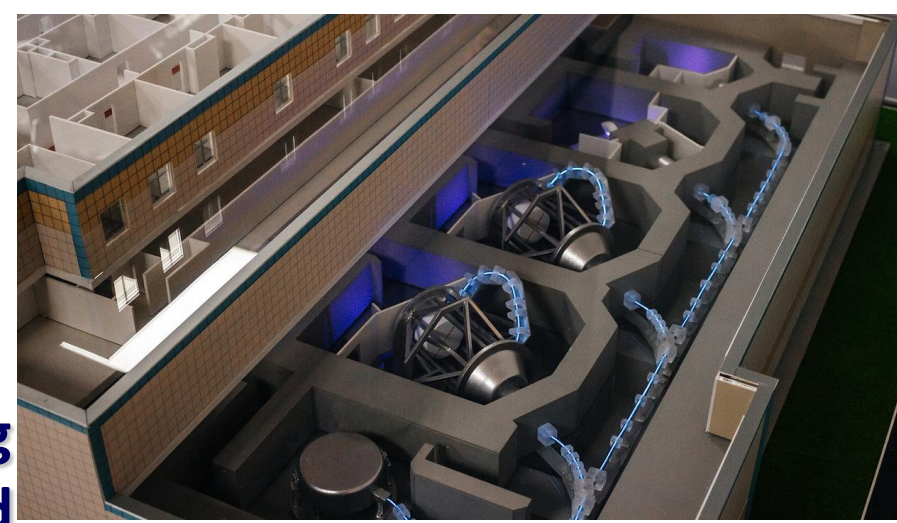


Pit for C235 assembling, tuning and testing at JINR



- building floor reinforcement
- foundation under vault
- special plates inside the foundation for cyclotron feet
- technological pit

C235 V3 designed in IBA-JINR Collaboration was assembled, tuned and tested at JINR in 2012 and has been installed on the working position in Dimitrovgrad on 14.10.2016





Collaboration JINR-ASIPP in the Frame of NICA Mega Science Project

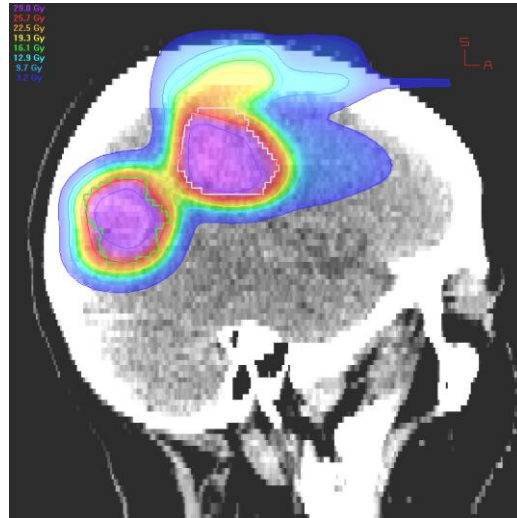
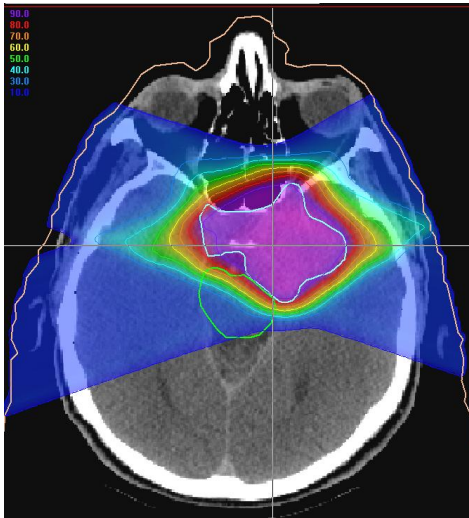
- JINR experience: cyclotron design, treatment
- ASIPP experience: TOKAMAK, superconductivity etc...



EAST Tokamak
50 mln K for 2 minutes



Proton therapy in JINR Medico-technical complex. Phasotron was used for proton therapy since 1968



Treatment in JINR uses mostly beams under 200 MeV energy

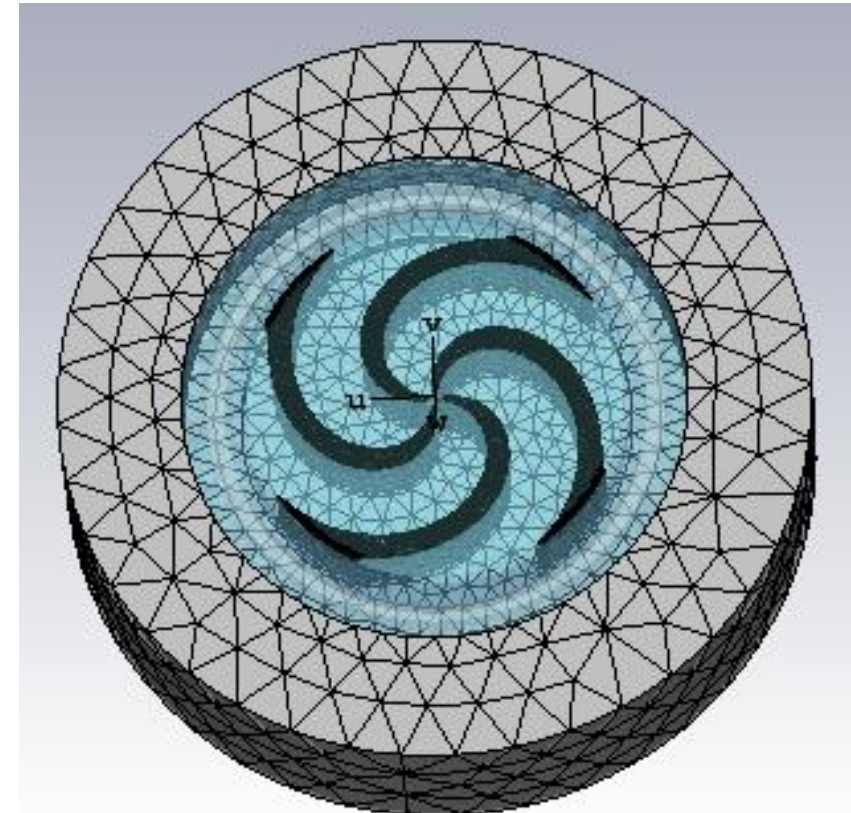
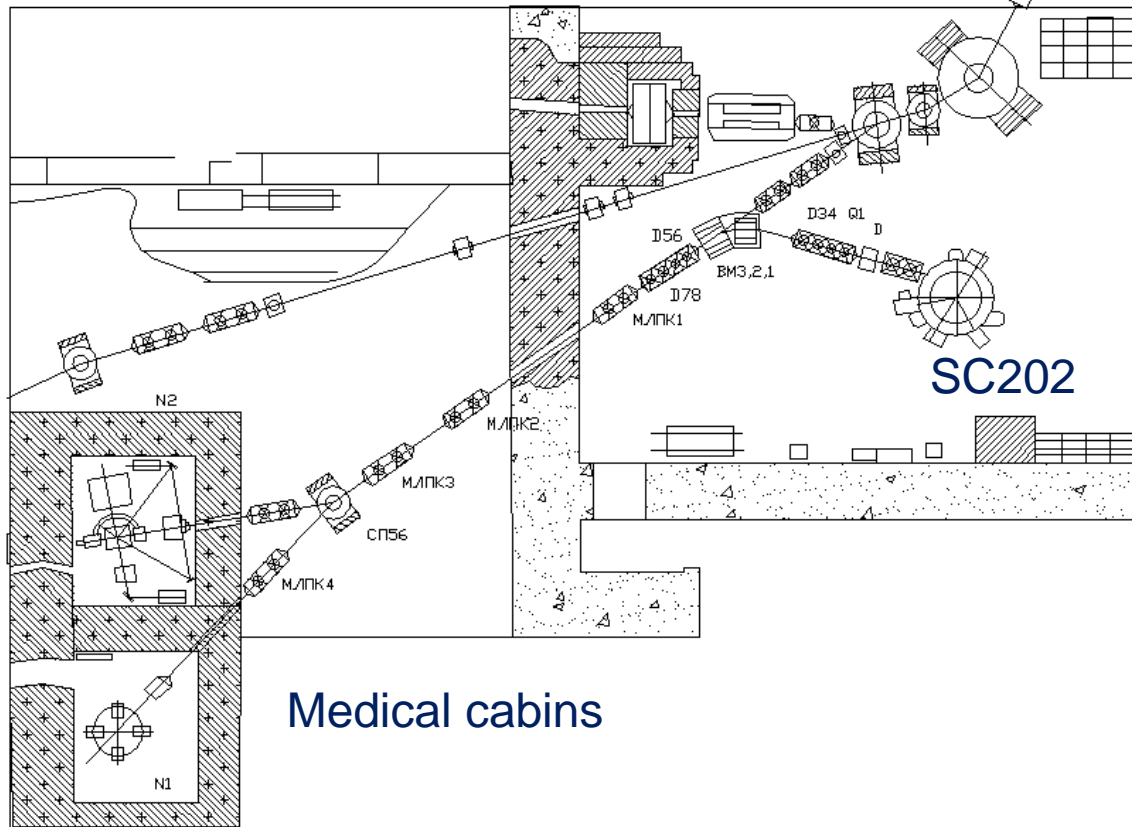


Dubna Phasotron
Originally build in 1949
Modernised in 1984



Collaboration of JINR (Dubna, Russia) and ASIPP (Hefei, China). Superconducting cyclotron SC202 for proton therapy.

JINR MTC

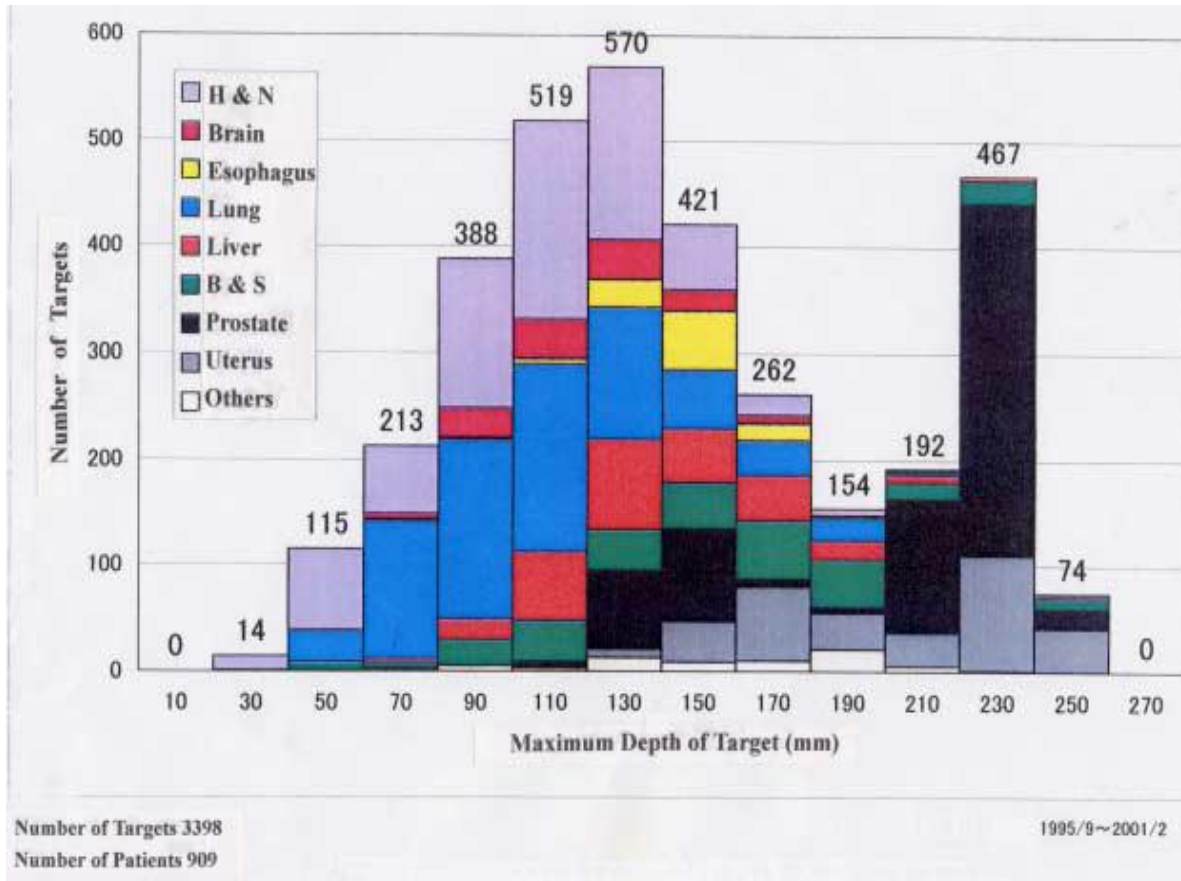


Computer model SC202

The SC202 cyclotron is under development by JINR and ASIPP. SC202 will provide acceleration of protons up to 200 MeV in 2018. We are planning to manufacture two cyclotrons: one will operate in Hefei cyclotron medical center, the other will replace Phasotron in JINR Medico-technical complex.



Why energy is about 200 MeV ?



Yasuo Hirao, RESULTS FROM HIMAC AND OTHER THERAPY FACILITIES IN JAPAN, Cyclotrons and Their Applications 2001, AIP Conference Proceedings;2001, Vol. 600 Issue 1, p8.

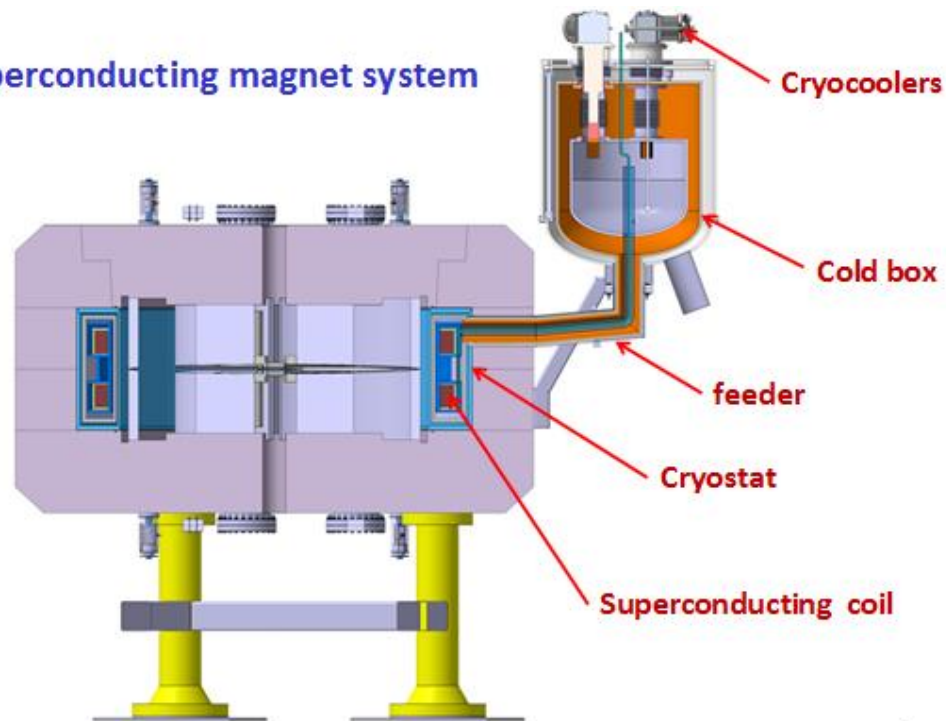
In JINR beams under 200 MeV!

Eye melanoma treatment – 60 MeV
Degrading the energy from 250 MeV down to 60 MeV reduces the current of the beam



Superconducting cyclotron

Superconducting magnet system



Magnet type	Compact, SC coil, warm yoke
Pole diameter (m)	1.22
Magnet diameter (m)	2.5
Magnet height (m)	1.7
Average magnetic field (R_o/R_{extr}) (T)	3.0/3.6
Cryostat and coils weight (t)	5
Total magnet weight (t)	55
RF cavities	warm
Number of cavities	2
Operating frequency, MHz	90
Harmonic number	2 nd



Milestones

1. The physical design final report of SC202 before the end of Feb. 2017;
2. The technical drawing of SC202 will be fully implemented by ASIPP with the assistance of JINR;
3. Manufacturing of SC202 systems and elements of two accelerators will be provided by ASIPP during the 2017-2018; the experts of JINR will take part in in this work at ASIPP site to ensure the manufacturing according to the requirements;
4. Magnet mapping and shimming, assembling, tuning and testing of SC202 will be provided by JINR and ASIPP for two accelerators.
5. The parties express their interest to continue the common investigations on hadrons therapy in particular on the superconducting carbon Cyclotron.



Shedlule of SC202 in 2017

		一月Jan	二月Feb	三月Mar	四月Apr	五月May	六月June	七月July	八月Aug	九月Sep	十月Oct	十一月Nov
	物理和工程设计 Physical and engineering design		final report delivery to ASIPP									
	RF			加速腔mockup加工测试完成Accelerating cavity mockup processing testing completed			LLRF debugging with dummy Load	D腔calibration件加工完成, 开始低功率测试 calibration of Dee cavity processing completed, start low power test		RF源交货: -9月 RF source delivery		
									D腔calibration件和射频源联合调试开始-9月 joint debugging of Dee cavity calibration and RF source			
铁系统场整定 magnet system setting	磁铁magnet		合同签订(含MC) The contract signing (Including the MC)	材料验收Material acceptance and measure the B-H curve	第一轮初加工启动 the first round of pretreating startup					开始磁场垫补 Start Magnetic shimming		开始第二套加速器的磁场垫补 shimming for second sc202 machine
	磁测magnetic measurement	Bz主磁场挂招标Bid inviting of Bz main magnetic field		Bz主磁场签订合同 The contract signing of Bz main magnetic field					Bz主磁体测试系统, Bz main magnet system			
				Engineering Design of Br measurement					Br主磁体测试系统, 自主研制完成并测试 Br test system, self-developed completed and tested			
					Engineering Design of Br measurement			MC磁场测试系统, 自主研制完成并测试 MC magnetic field test system, self-developed completed and tested				
	超导磁体与低温系统 Superconducting magnets and cryogenic systems	临时测试平台招标开始: 水冷机组的采购(GM压缩机和电源所需) 线圈试绕+绕制 Temporary test platform bidding began; The purchase of water chilling unit (GM compressor and the power needed); Coil winding	冷箱招标Cold box bidding	线圈绕制完成; 测试平台集成完成 Coil winding completed; Test platform integration completed		线圈测试结束Coil testing completed	超导磁体与低温系统集成 Superconducting magnets and cryogenic system integration	超导磁体与低温系统测试 Superconducting magnets and cryogenic system test				
			偏转板结构设计完成	磁通道结构设计					加工结束			



JINR's Duties

- The final report of SC202 physical design should be delivered to ASIPP before the end of February 2017;
- The optimization of physical design should be continuously proceeded without influence of the SC202 main schedule for 2017 including the magnet shimming in September 2017;
- JINR is ready to contribute the manpower on the engineering design, magnetic mapping and commissioning to provide the schedule of SC202 on time;
- The engineering design (ESD system, magnetic channels, and beam probes for extraction) of the beam extraction needs to be provided by JINR before 1 April 2017.
- JINR agreed to provide more manpower to support the SC202 team in ASIPP.



ASIPP's Duties

- The 3D model and the technical drawing of SC202 will fully be implemented by ASIPP with the assistance of JINR;
- The SC magnet manufacturing should be fully completed and it's test is supposed to be implemented by ASIPP in Hefei before 15 August 2017.
- The mapping and shimming of magnetic field should be implemented by ASIPP;
- The following component of SC magnet equipment will be delivered to JINR not later than Aug. 2018, if the shimming work will be properly proceeded according to the schedule:
 - One set of yoke and sectors after shimming;
 - SC coils and cryostat system;
 -
- The delivery of following components will be provided by ASIPP according to the progress of the collaboration in 2018.
 - Power supply for the SC magnet;
 - Vacuum chamber and vacuum pumps;
 - All elements of the Cyclotron extraction system with drive system for them;
 - Control system of the SC magnet;
 - Ion source.



Long Term Collaboration with ASIIPP

1) Personal Exchange

- a) Ph.D., postgraduate and student exchange.
- b) Visit researchers. Both parties will continue to send principal researchers to join the projects.
- c) Set up the joint clinician program, strengthen the medical person communication including proton therapy physicist, therapist, dosimetrist etc. Both parties will send their medical personal to join the operation and patient therapy with proton facilities at JINR and SC202 at Hefei.

2) Superconducting carbon ion cyclotron

- Both parties agree to start the investigations on carbon cyclotron in 2018. JINR will be in charge of the physics design and interfaces for engineering.

3) Hadron Therapy

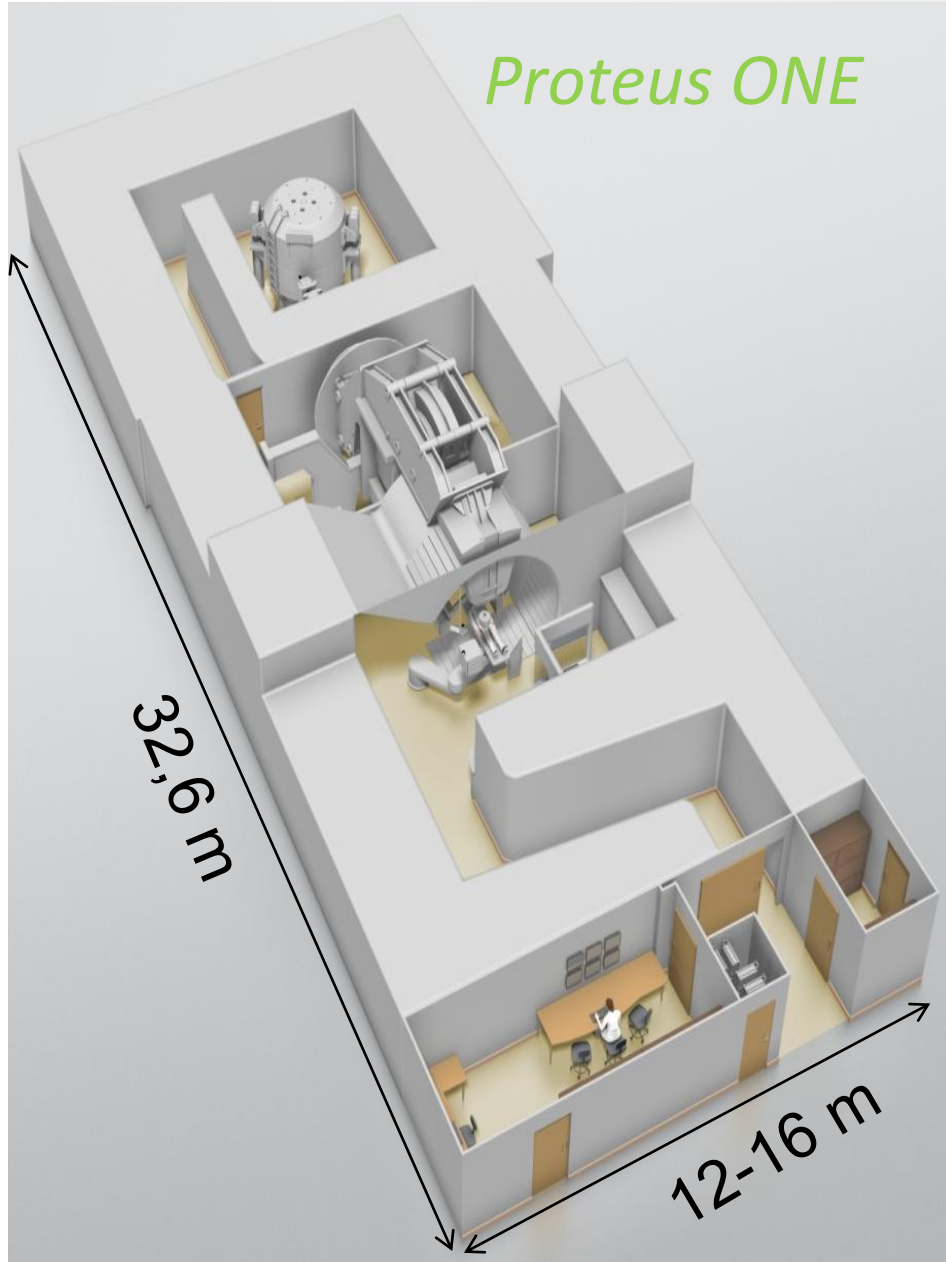
- Set up joint medical research group focusing on the establishment of quality assurance (QA) and treatment code & standards.

4) Superconducting application

- Both parties agree to continue the collaboration on superconducting application such as accelerator, superconducting magnetic energy storage, high magnetic field MRI and etc.

Proton Therapy Strategy at JINR

Proteus ONE



«MIN Programm»:

SC202 instead of Phasotron.

«MAX Programm»:

Medical center with proton therapy outside the JINR territory on the base of Compact IBA Synchrocyclotron *Proteus ONE*

Future Programm:

Carbon Experimental Therapy with NICA Booster ???



Possible places for Dubna Center of Radiation Medicine based on the Proteus ONE

MSCh-9

Profilaktory



RosOES ?