Study of Beam Dynamics in JINR Phasotron

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Joint Institute for Nuclear Research, Dubna

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Phasotron and medical applications

I.V.Kurchatov and
V.P. Dzhelepov

Synchrocyclotron "Phasotron"

The First Accelerator in Dubna

Constructed in frames of the Soviet Atomic Project, commissioned in 1949, still in operation

M. G.Meshcheryakov

Machine parameters:

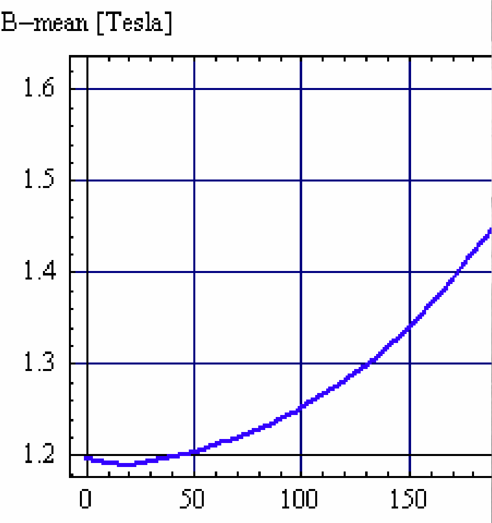
- Protons
- 660 MeV
- 3 μA – extraction

Research program:

- ✓Muon-catalysis
- ✓Pion & muon physics
- ✓Nuclear physics

Main application:

Cancer therapy



Magnetic field via

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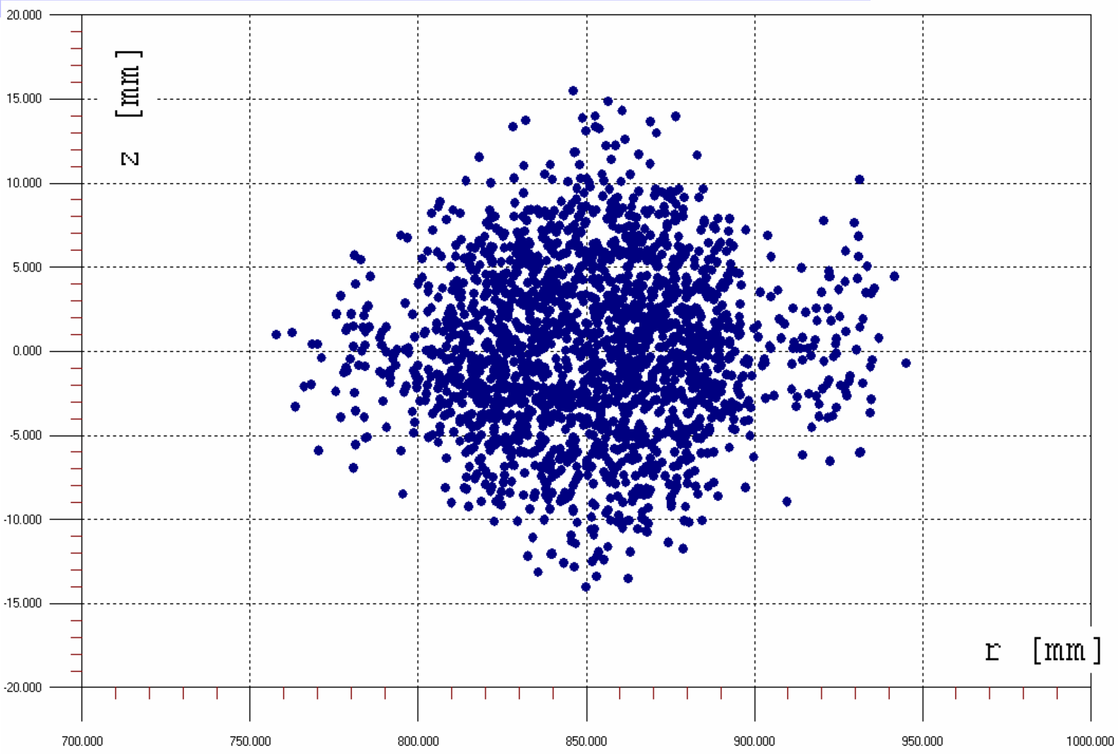
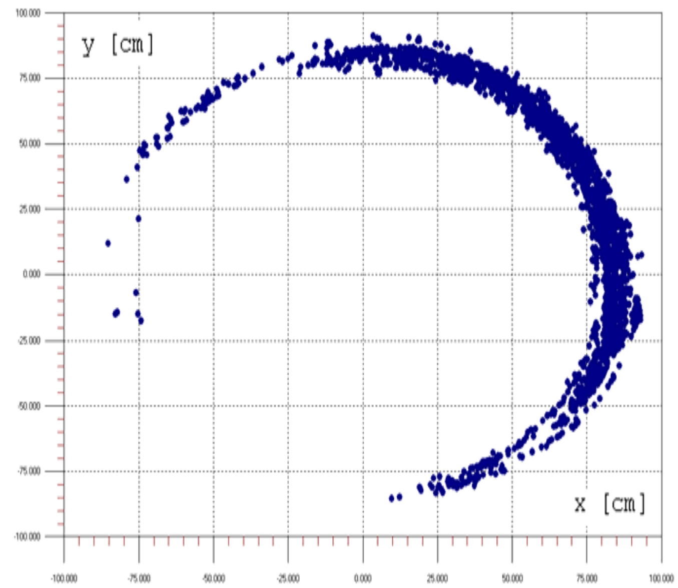
Beam dynamics calculation



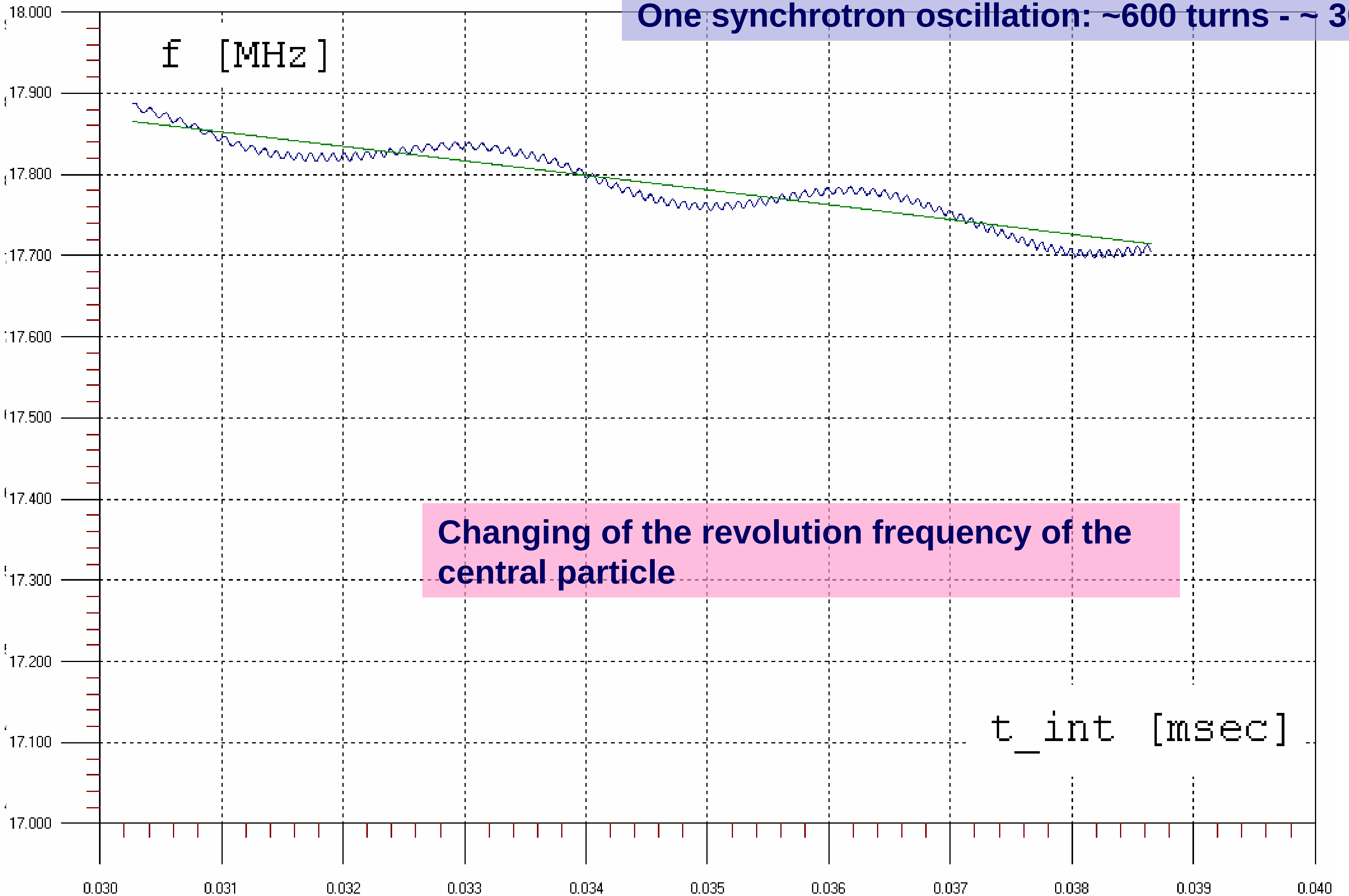


Acceleration of 2000 particles (without space charge effects) from radii of ~100cm till to entrance in the extraction system

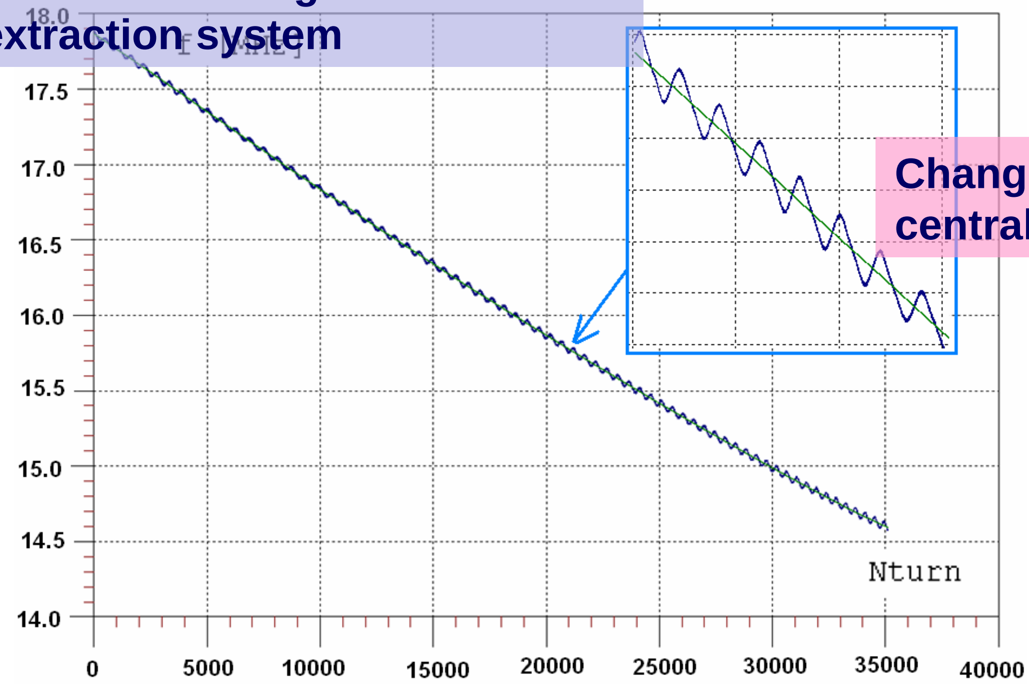
Initial data taken from calculations of beam dynamics during first 3000 turns after ions source taken in account effects of the space charge

1500 turns from the bunch start

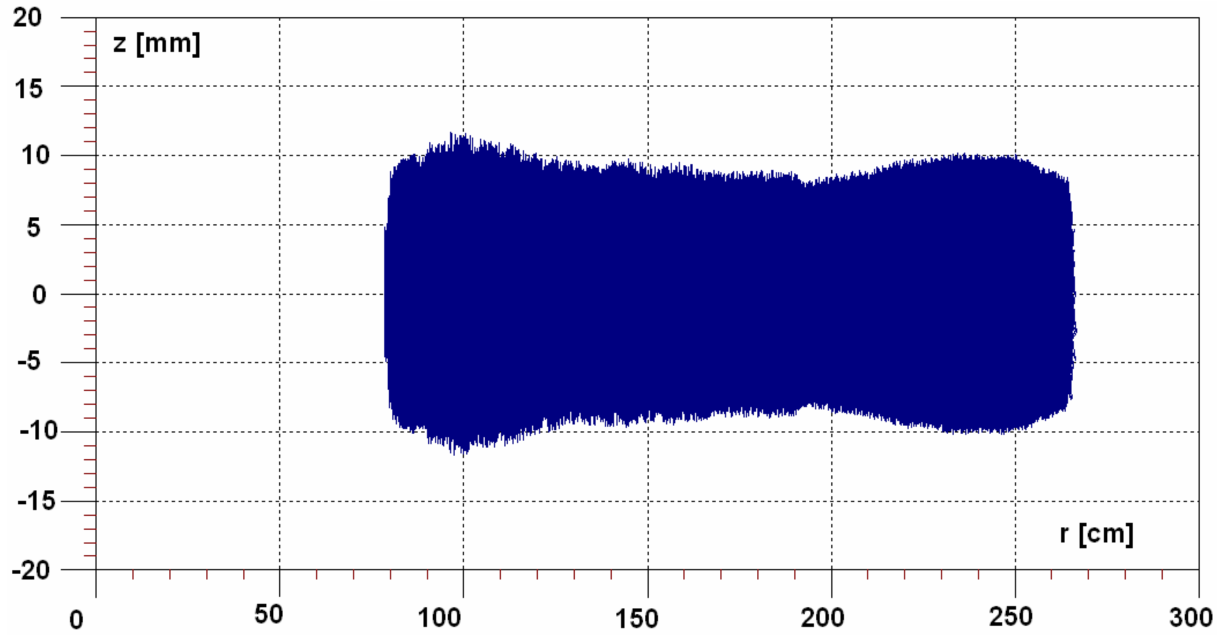
One synchrotron oscillation: ~600 turns - ~ 30μs



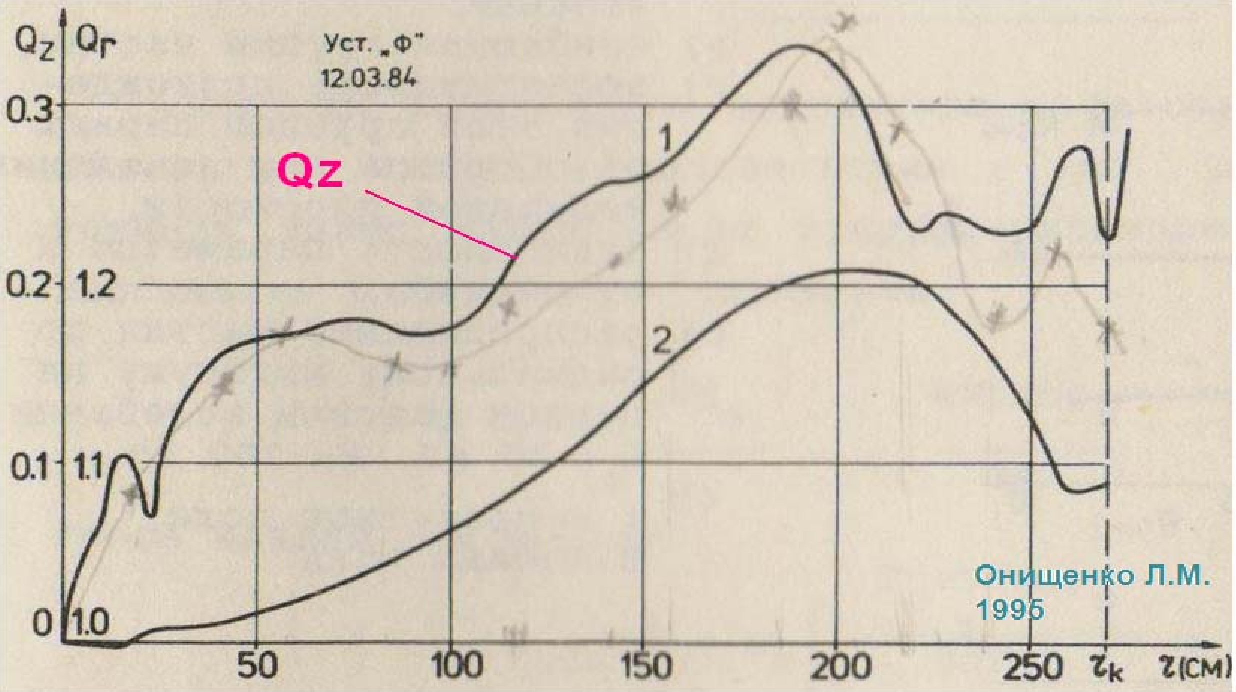
40 000 turns to get the extraction system

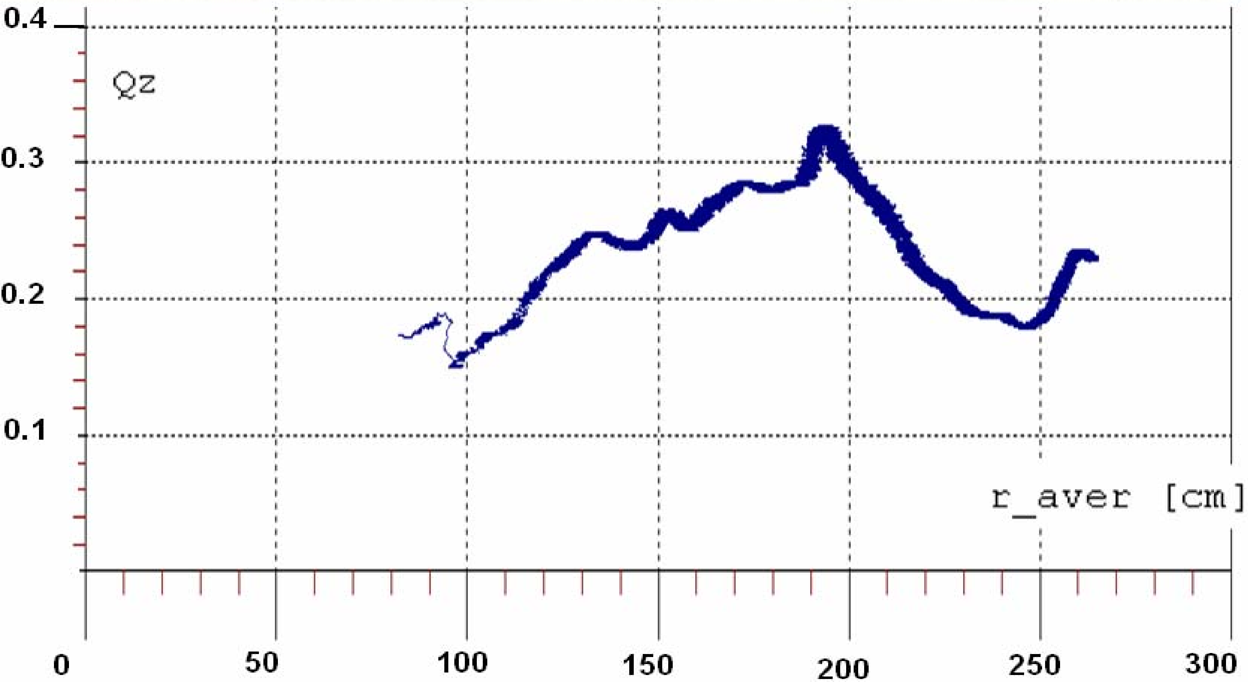


Changing of the revolution frequency of the central particle



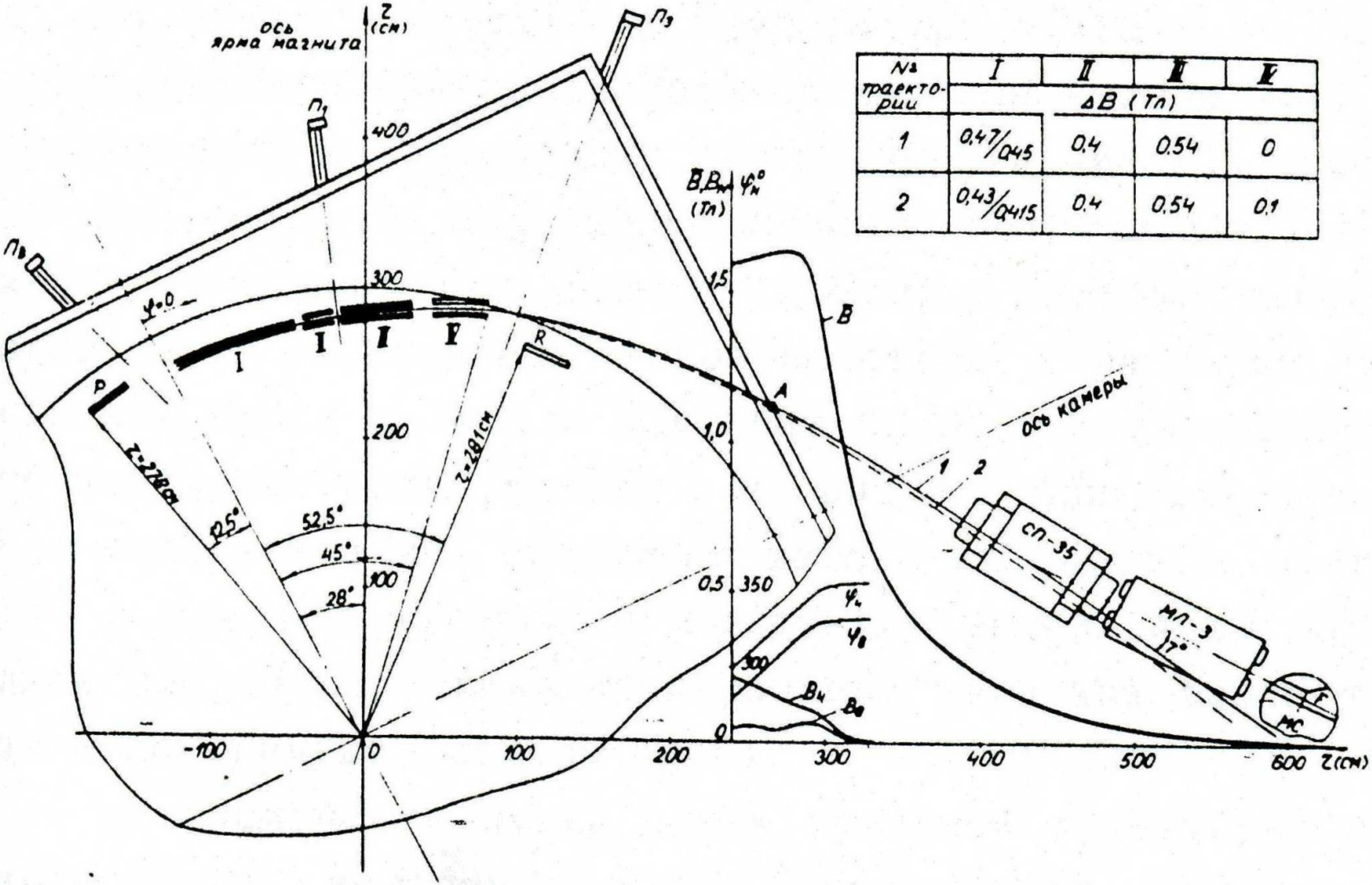
Vertical motion amplitude ±10mm





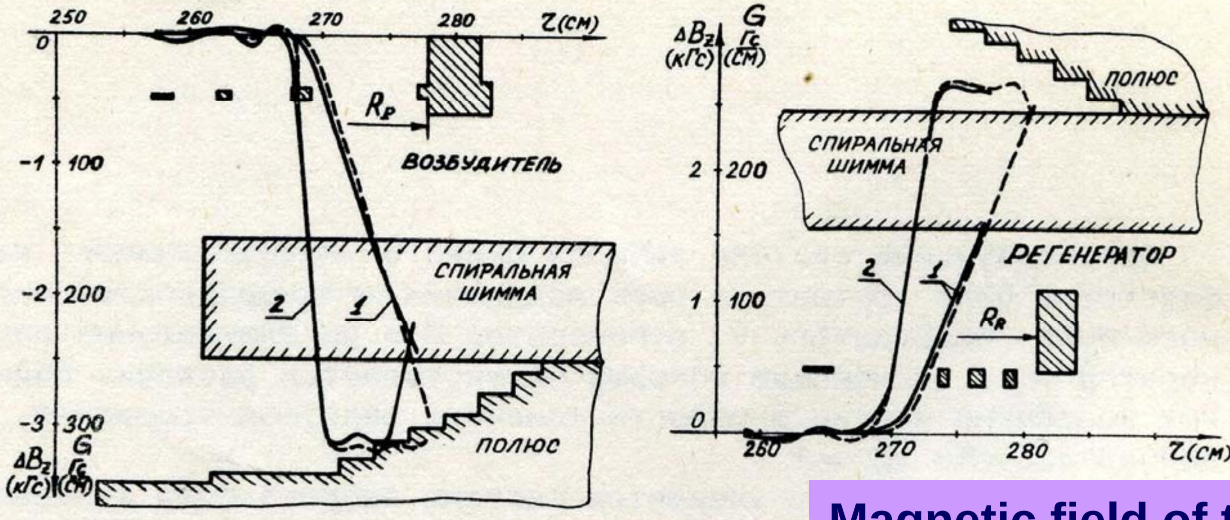
Frequency of the betatron oscillations basing of the analysis of the measured magnetic field map

Vertical betatron frequency for the equlibrium accelerated particle in during modeling of the acceleration



№ траектории	I	II	III	IV
	ΔB (Тл)			
1	0,47/0,45	0,4	0,54	0
2	0,43/0,415	0,4	0,54	0,1

Extraction system scheme of JINR Phasotron P-peeler, R-regenerator, I, II, III, IV – sections of the extraction channel

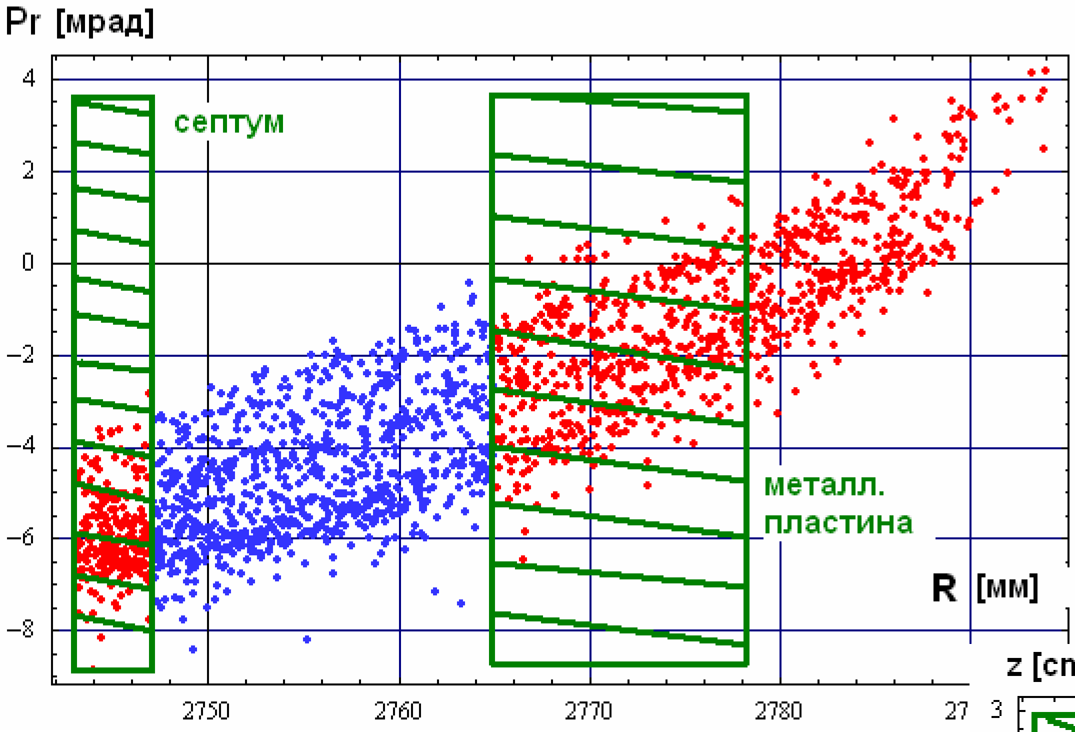


Magnetic field of the peeler & regenerator (1) and its gradient (2)

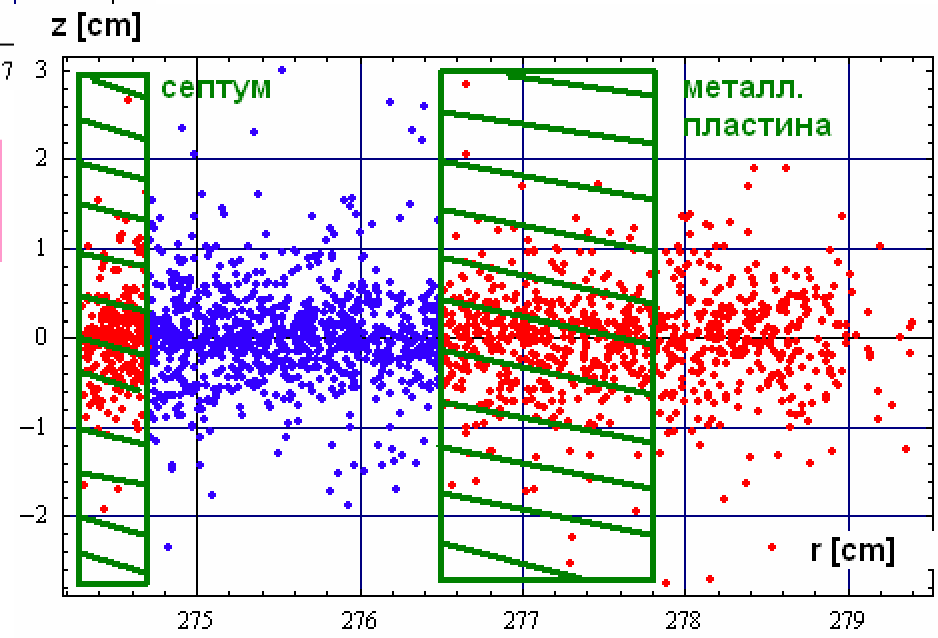
Параметры элементов систем заброса и вывода.

Параметры	ЖТС		Ферромагнитные секции системы вывода			Возбудитель	Регенератор
	1	2	3	4	5	6	7
φ_1, °	1.0	9.8	20.0	25.2	36.5	348.0	50.7
φ_2, °	9.8	18.7	24.7	35.8	44.7	353.7	56.4
ΔB, kG	-4.7	-4.5	-4.0	-5.4	0.0	-2.48	2.16
dB/dX, kG/cm	0.15	0.03	-0.1	-0.1	1.0	-0.31	0.27
Гор. апертура, см	1.8	1.8	2.2	2.6	5.0	11.0	13.0
R_1, см	275.6	276.2	279.5	282.3	291.0	272.5	274.5
R_2, см	276.2	279.0	282.0	290.5	299.0	272.5	274.5

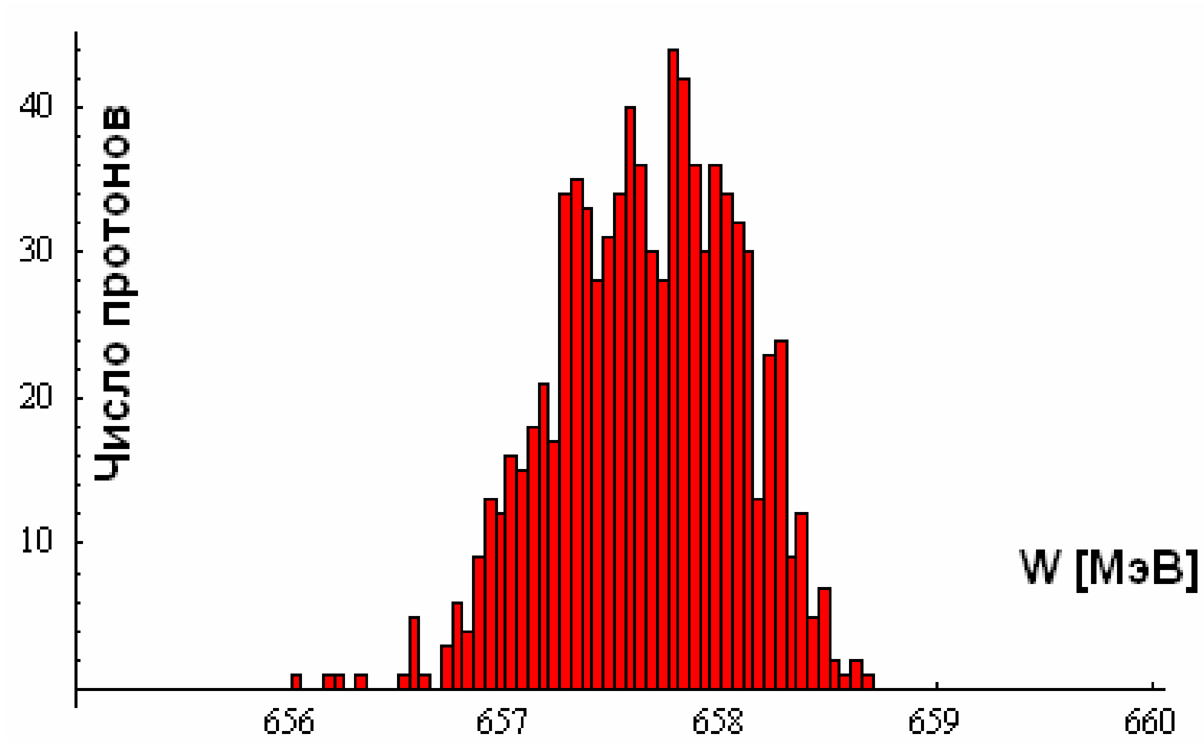
В Таблице R_1, R_2 – радиусы середин апертур элементов на входе и выходе по движению пучка. Магнитные поля элементов указаны для середин их апертур.



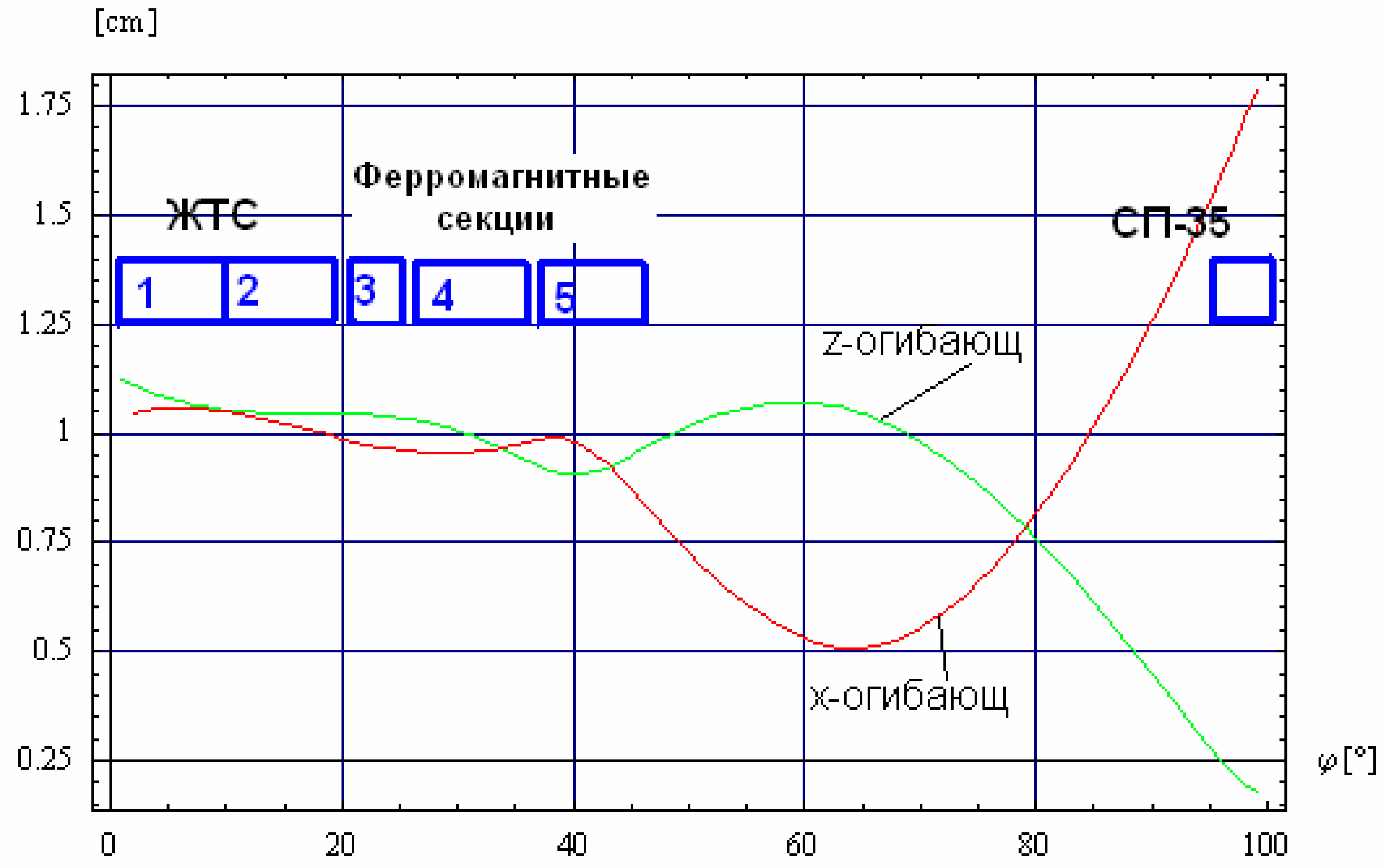
Particles positions at the R-Z-plane at the entrance in to extraction system



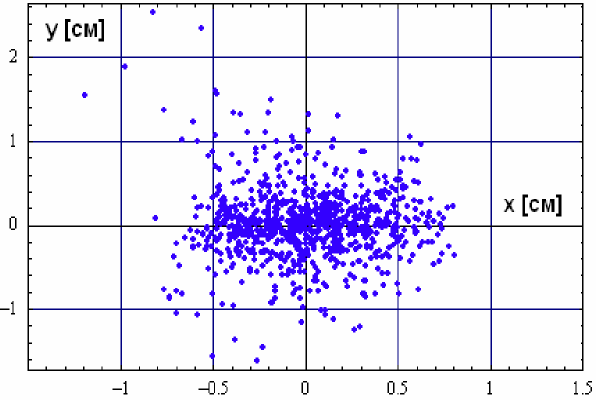
Particles positions at the radial phase-plane at the entrance into the extraction system

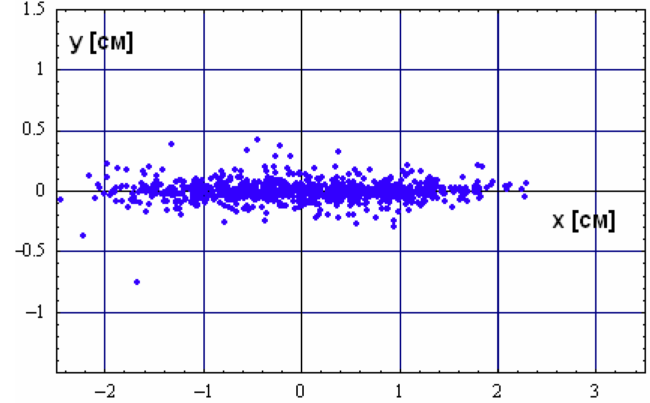


Particles energy distribution at the entrance to the extraction system

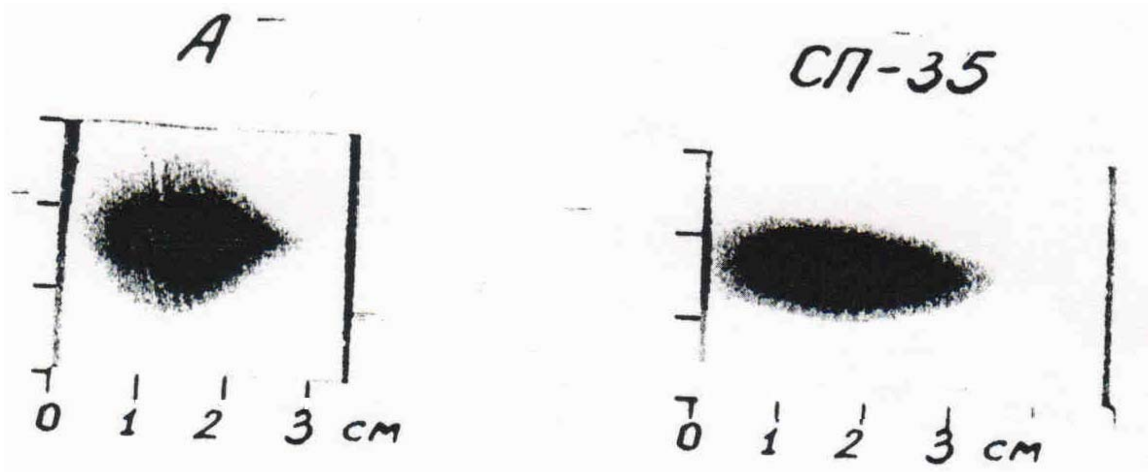


2σ-rms-beam-envelopes inside Phasotron extraction channel





Профили пучка в точке А (см. Рис 1) и на входе в магнит СП-35 полученные расчетным способом



Автографы пучка в точке А (см. Рис 1) и на входе в магнит СП-35 экспериментально полученные [3] при запуске Фазотрона ОИЯИ

Beam portraits at the entrance to the extraction channel are obtained.

The beam extraction efficiency is about **40%.**

Beam tracking inside the channel carried out.

Calculated beam transverse parameters are in agreement with **~20%** accuracy with the experimental data.

Developed code can be used for optimization of JINR Phasotron extraction system or to study the beam dynamics in other sinchrocyclotrons.

IBA Superconducting Synchrocyclotron for Proton Therapy: Central Region Design

E. Pearson, W. K… …a-worldwide.com)
M. Conjat… …ww.aima.fr)

Introduction

The first IBA superconducting …
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need for a more compact and l…
therapy product. The S2C2 is a 2…
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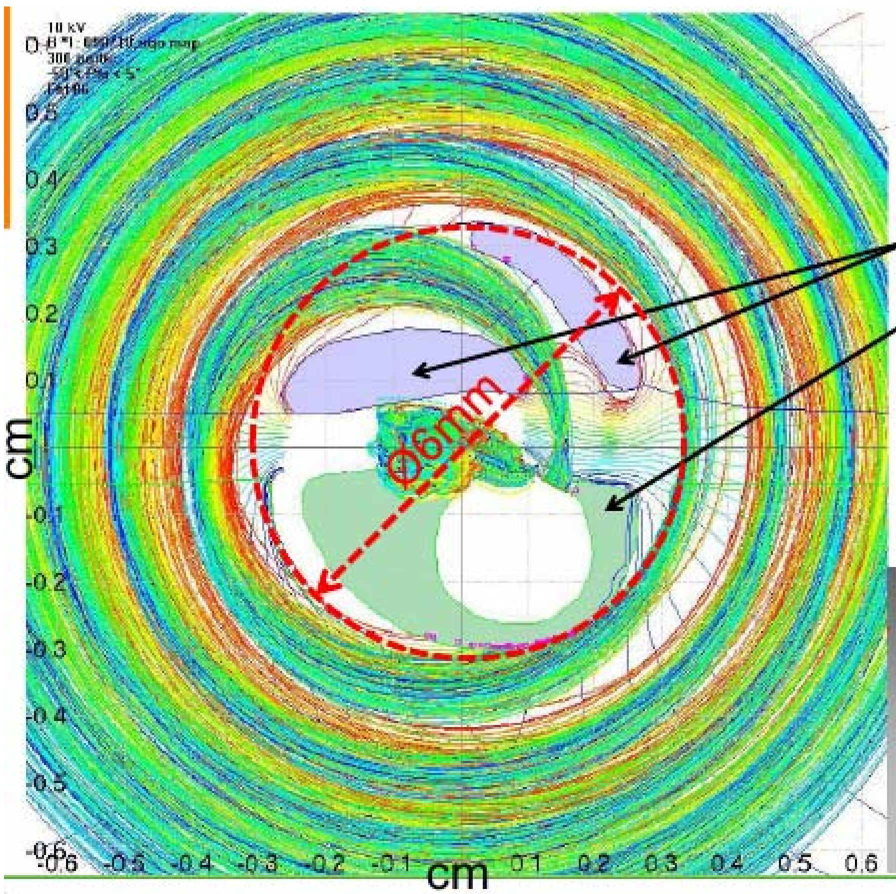
Capture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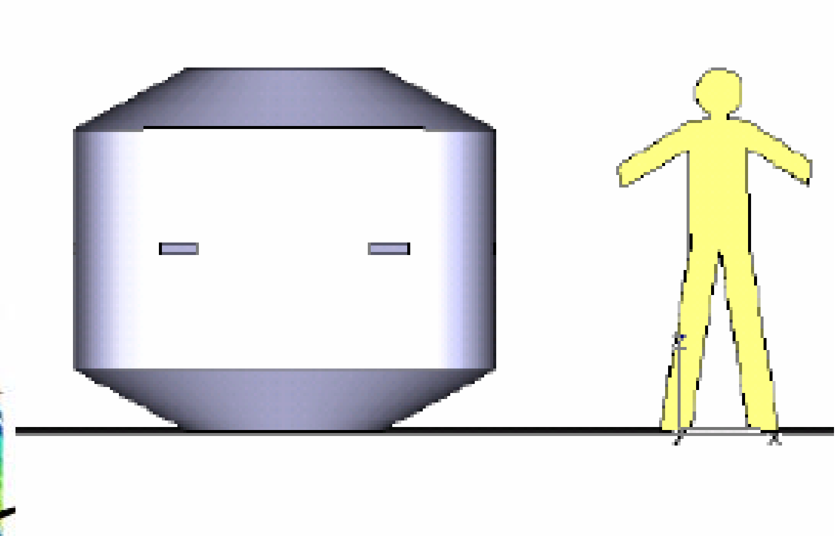


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"Throughout my career, I have been convinced that proton therapy adoption was limited by the enormous size and complexity of the proton source and associated beam transport and delivery systems. We have developed technology that simplifies proton therapy installations, making them comparable to conventional radiation therapy devices. This now makes proton therapy readily available to pediatric and adult cancer patients who can benefit from this remarkable therapy." **Kenneth Gall, Ph.D., Co-Founder and Chief Technology Officer**

TriNiobium Core™

Mevion has designed a high-energy proton source that has dramatically reduced the size, cost, and complexity of proton acceleration; the world's first superconducting synchrocyclotron. The enabling technology is the TriNiobium Core™, an industrially used superconducting metallic compound called TriNiobium Tin (Nb_3Sn) that is at the center of the accelerator. Powered by the TriNiobium Core, this revolutionary proton accelerator is only 6 ft (1.8 m) in diameter, but can generate 250 MeV protons capable of reaching targets as deep as 32 cm. With this dramatic size reduction, the proton source is coupled to a high-precision beam delivery and shaping device, and tightly integrated with the most advanced clinical systems.

The MEVION S250 Proton Therapy System is USFDA 510(k) cleared and complies with MDD/CE requirements.

Спасибо за внимание