Development of the Hadrontherapy Complex at the Phasotron in the Dzhelepov Laboratory of Nuclear Problems

G.V.Mytsin

Milestones of activity:

1967 – the beginning of the research on proton therapy;

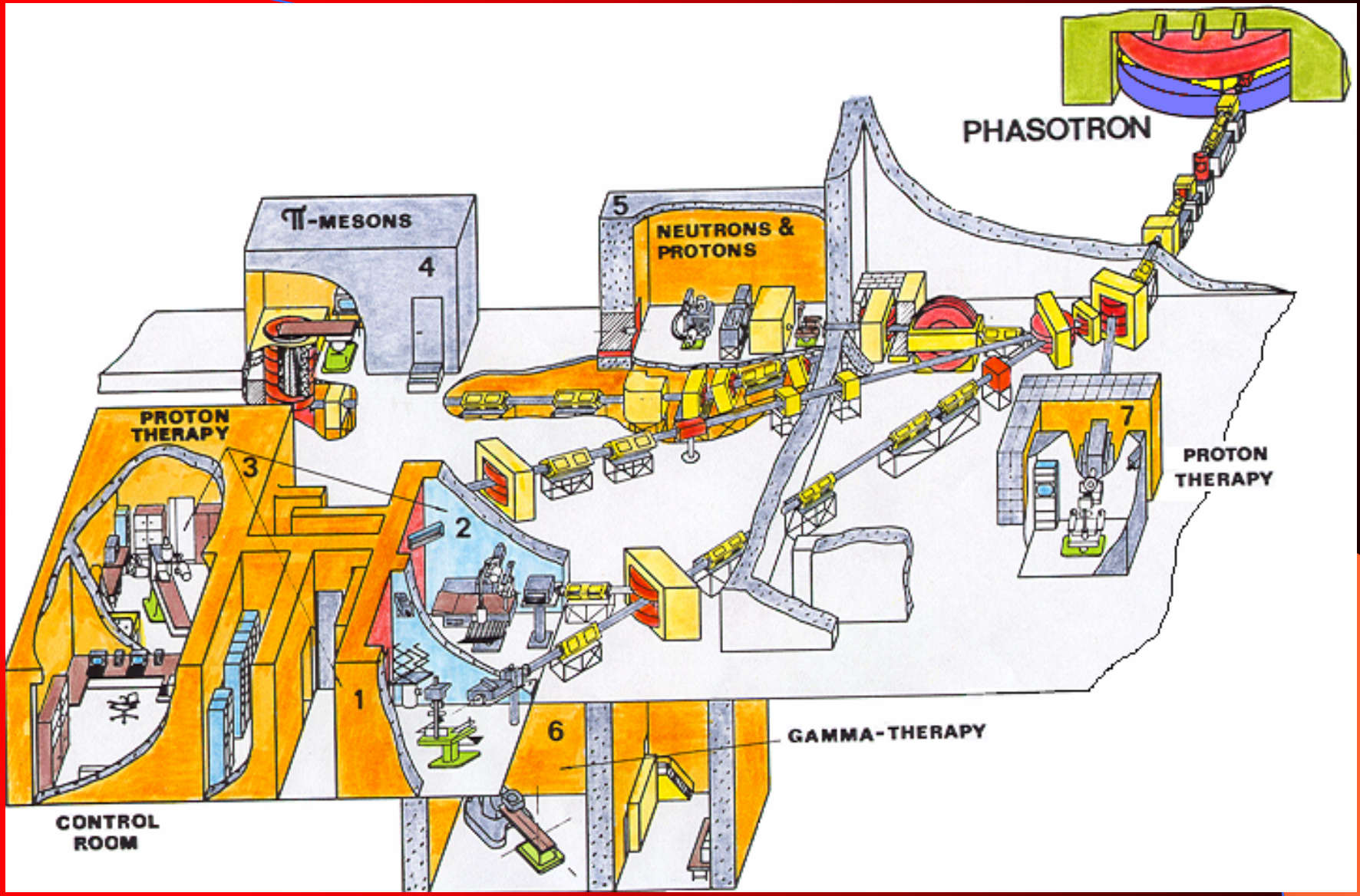
1968 –1974 – first 84 patients treated with protons;

1975 –1986 – upgrading of accelerator and construction of a multi-room Medico-Technical Complex (MTC) for hadron therapy;

1987-1996 – treating of 40 patients with protons, mostly with uterine cervix cancer;

1999, December – inauguration of a radiological department of the Dubna hospital;

1999-2002 - treating of 124 patients with tumors seated in the head, neck and trunk and 3D conformal proton therapy of intracranial targets.



A multi-room Medico-Technical Complex for radiotherapy with hadron beams from Phasotron of DLNP JINR.

Treatment room No 1 for proton therapy of tumors seated in the head, neck, and trunk.

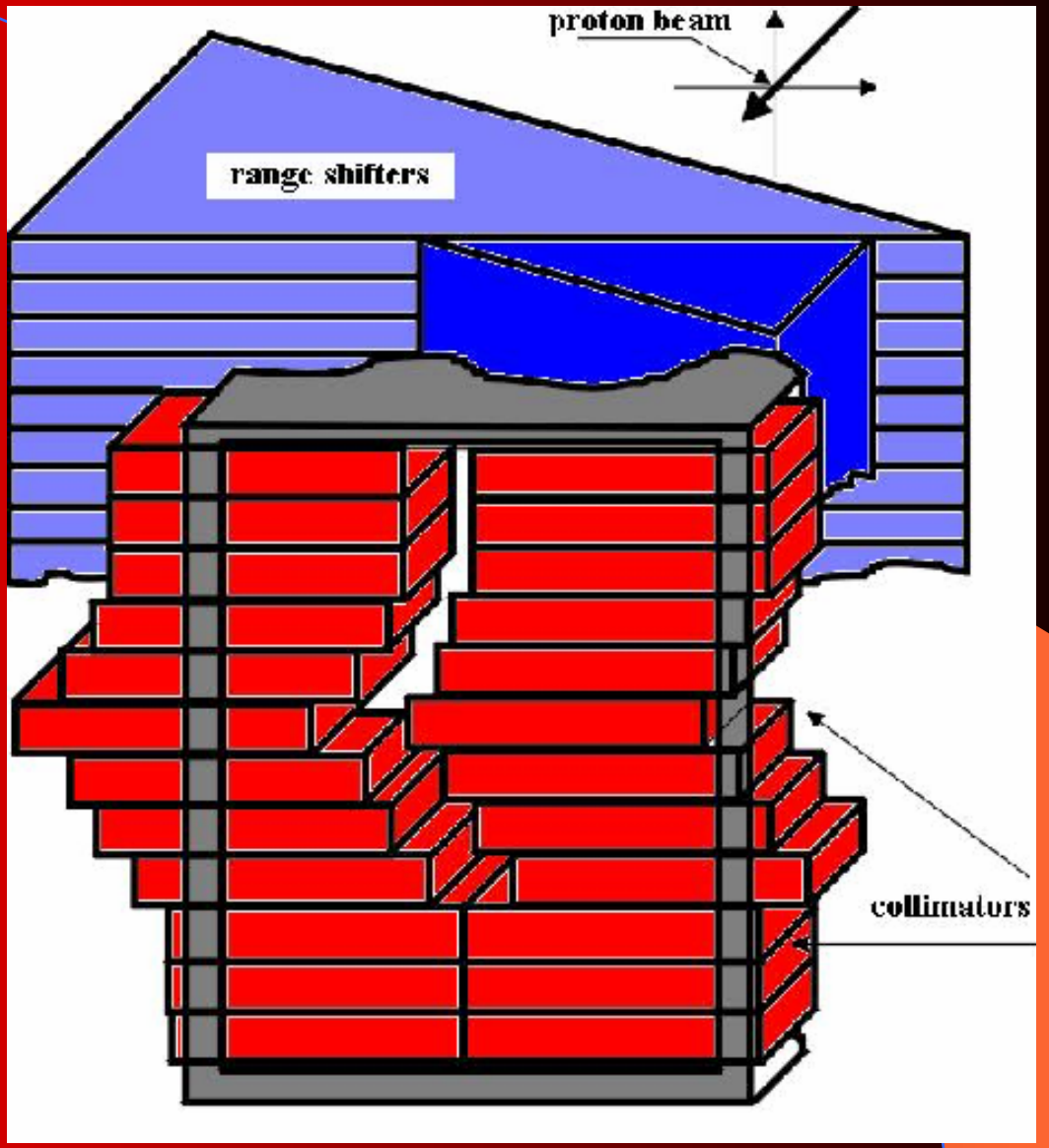
Room No 2 is intended for treatment of gynaecological tumours, such as uterine cervix cancer, with a proton beam.

Room No 3 allows stereotactic convergent irradiation of small intracranial targets with a narrow 660-MeV proton beam by the so-called "shoot-through" technique.

Room No 4 is supplied with a separated negative pion beam of adjustable energy from 30 to 80 MeV.

Room No 5 accommodates a high energy therapeutic neutron beam to be used, both independently and in combination with a proton beam, for treatment of large radioresistant tumours.

Proton irradiation is performed by a dynamic system consisting of 14 layers multileaf collimator and range shifter controlled via computer.



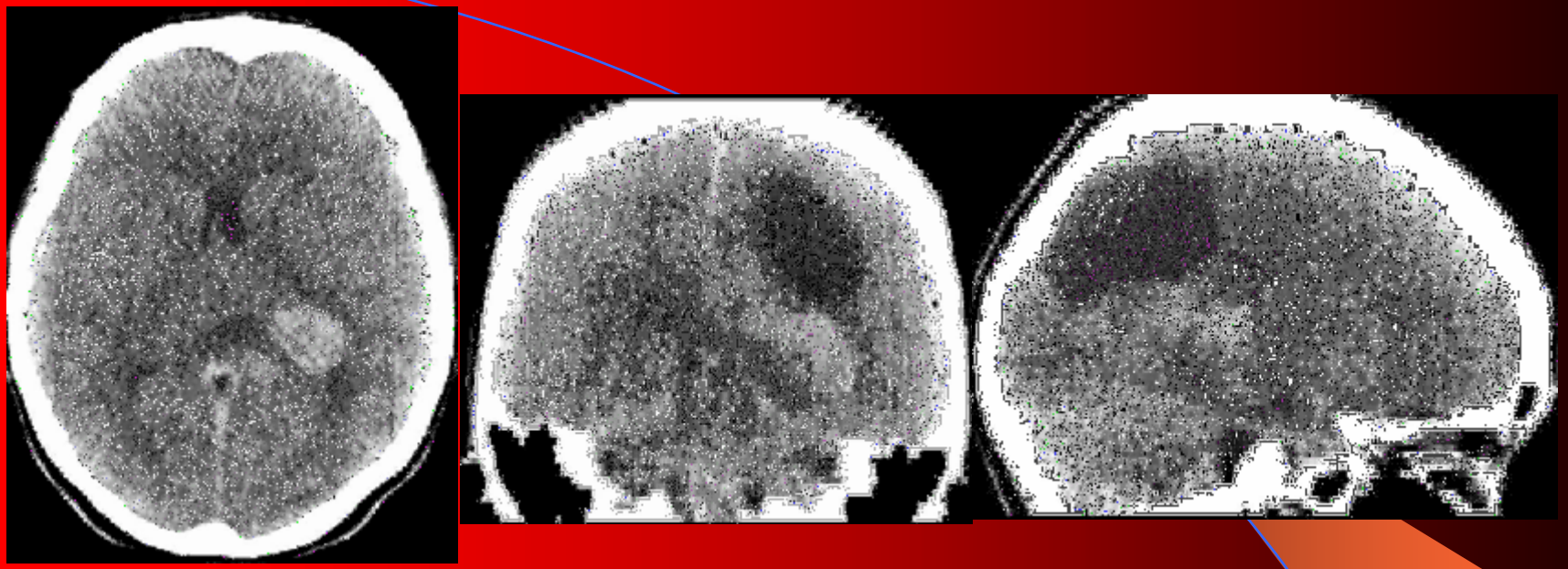
The standard unite "Rokus-M" for external gamma therapy with Co-60 is installed in room No 6 and is used as a back-up radiation source and for combined treatment methods.

Room No 7 is intended for proton radiotherapy of eye tumours.

Technological stages of proton 3-D conformal radiation therapy

1. **Immobilization of treatment area.**
2. **Diagnostic imaging and CT-slices transferring to 3D treatment planning system.**
3. **Three-dimensional computer treatment planning.**
4. **Manufacturing of individual beam modifying devices: complex shape collimators, compen-sating boluses.**
5. **Realization and verification of treatment plans.**

Manufacturing of individual immobilization mask from perforated thermoplastic.

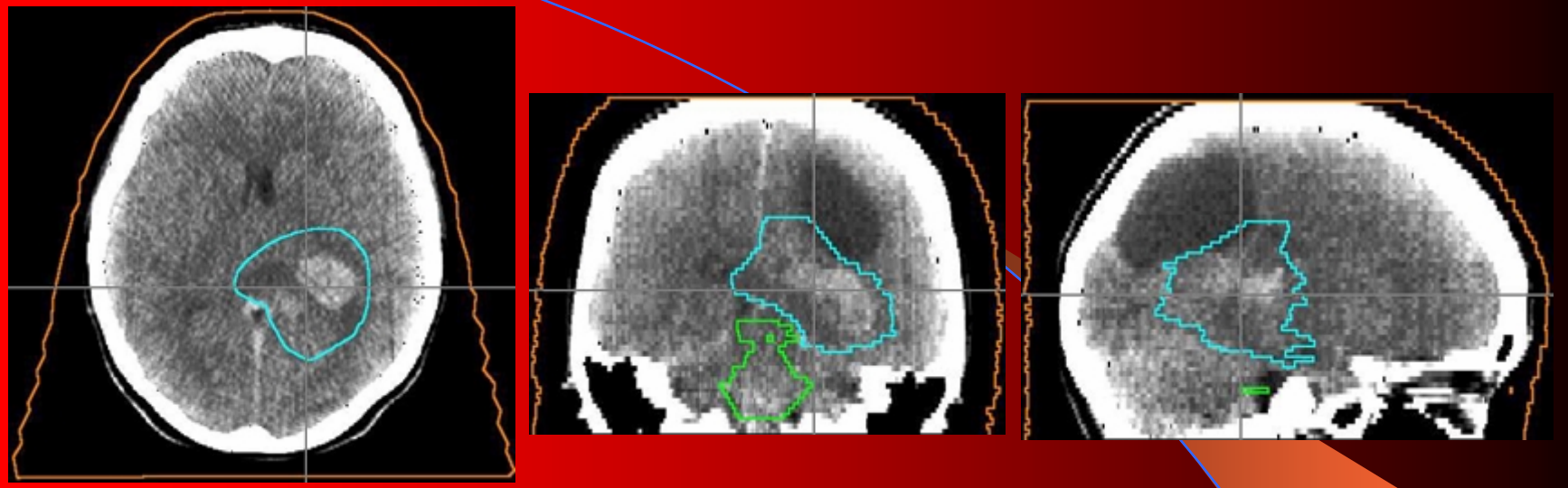


Computed tomography (CT) of an area to be irradiated is performed and transferred to the treatment planning system. Slice thickness - 2 mm, number of slices - 70-90. CT provides data about topography and density of tissues.

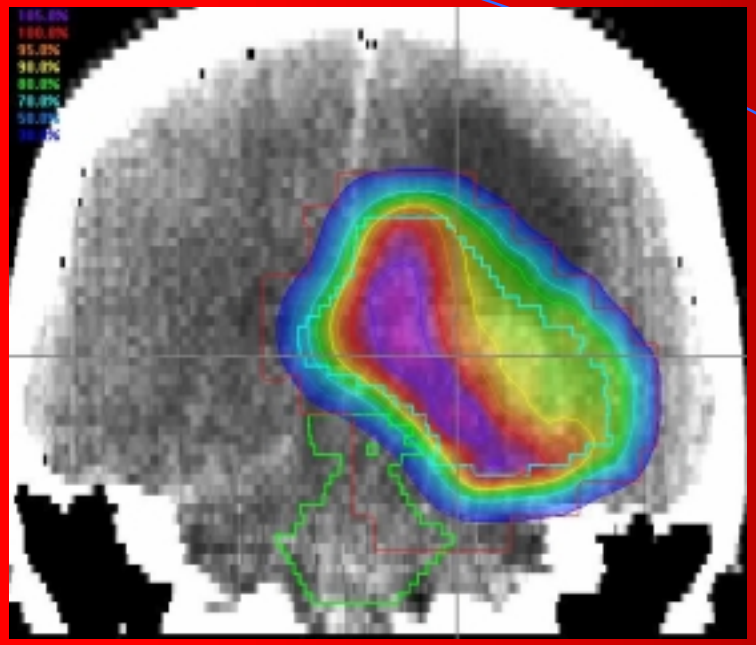
Magnetic Resonance Imaging (MRI) is additional valuable study and provides superior quality for soft tissue imaging.

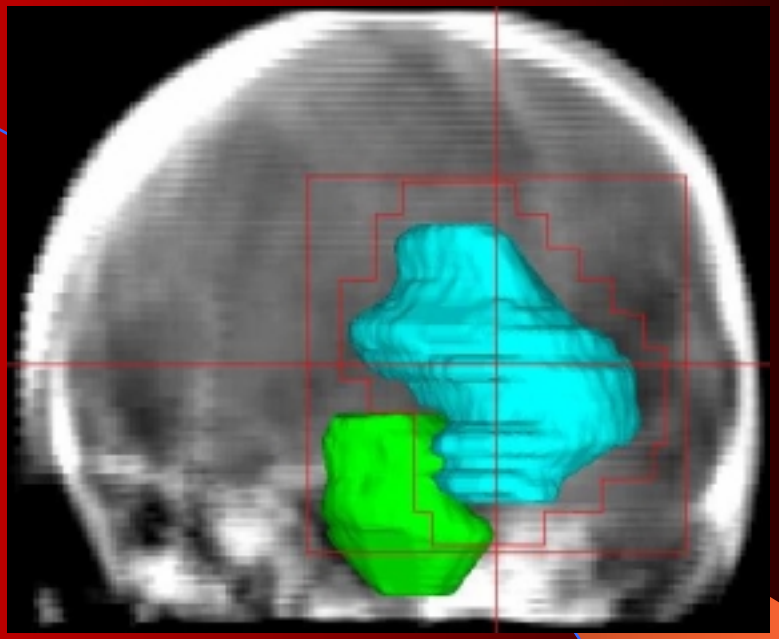
Three-Dimensional Computer Treatment Planning

We use three-dimensional treatment planning system "TPN" that has been developed at the Loma Linda University Medical Center, California, USA. TPN is a comprehensive 3D system that utilizes the latest advances in radiation therapy technology. The system has been modified to incorporate the Dubna proton beams. A set of dosimetric expe-riments has been performed to verify calculation algorithm with good coincidence of calculated and measured dose distributions.

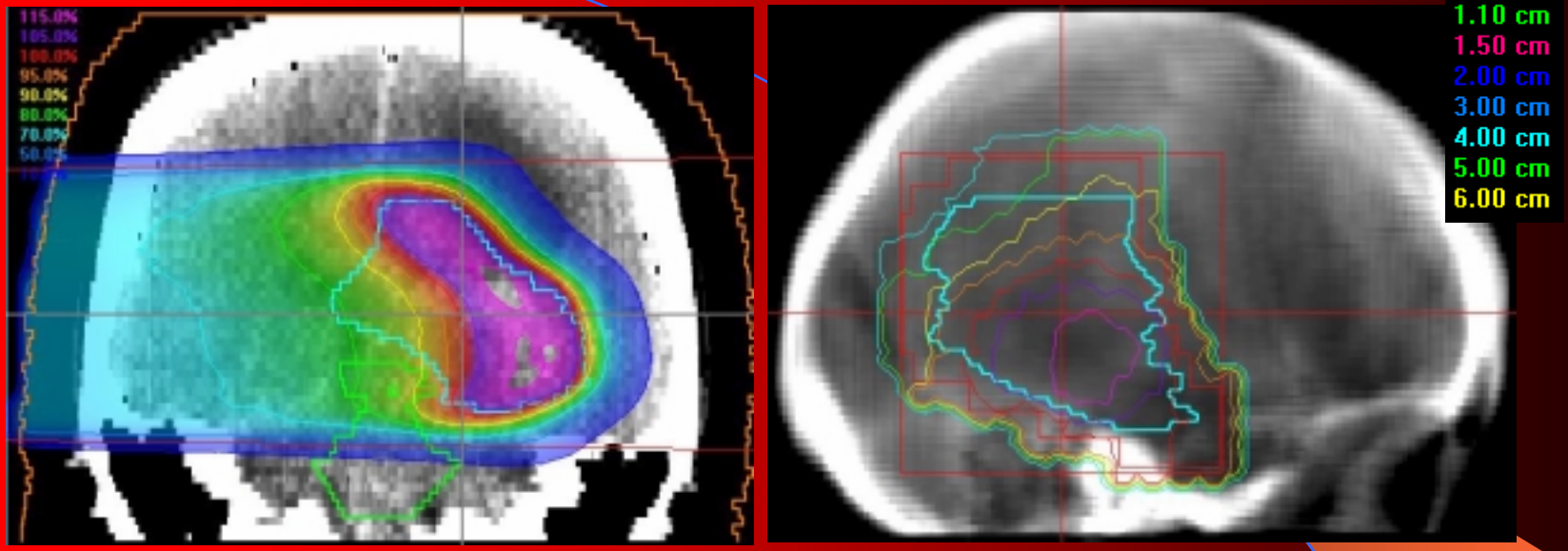


On each slice radiation oncologist outlines target-tumor (blue color - intracerebral tumor) and critical structures-organs (green color - brainstem). As a result the relevant volumetric structures are generated in planning system.

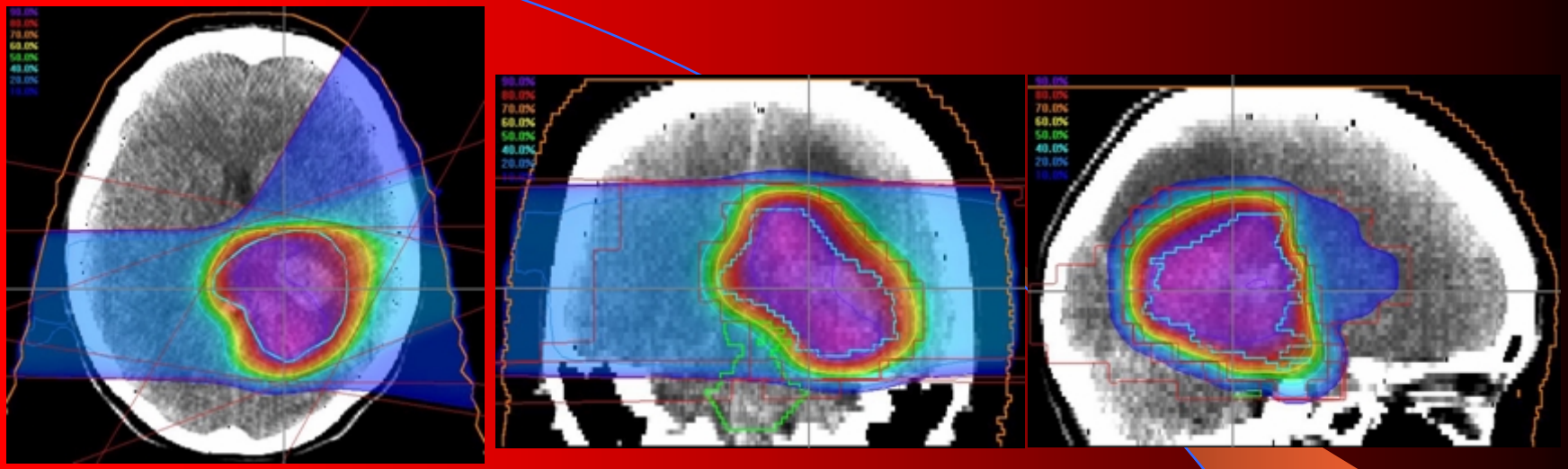




Treatment planning system generates 3D-model of outlined structures. Beam's-eye-view function and digitally reconstructed radiographs (DRRs) allow to have a look to the irradiated anatomy from the beam direction and define complex shape proton beam by a multy-leaf or cerrobend collimator.

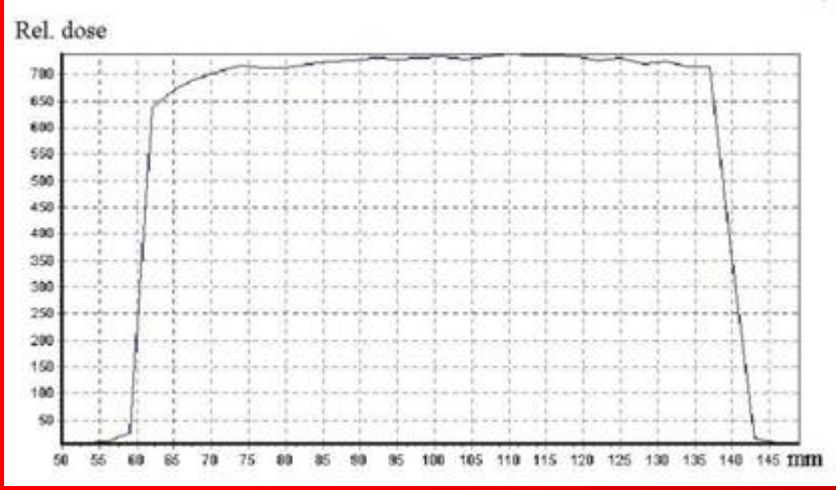


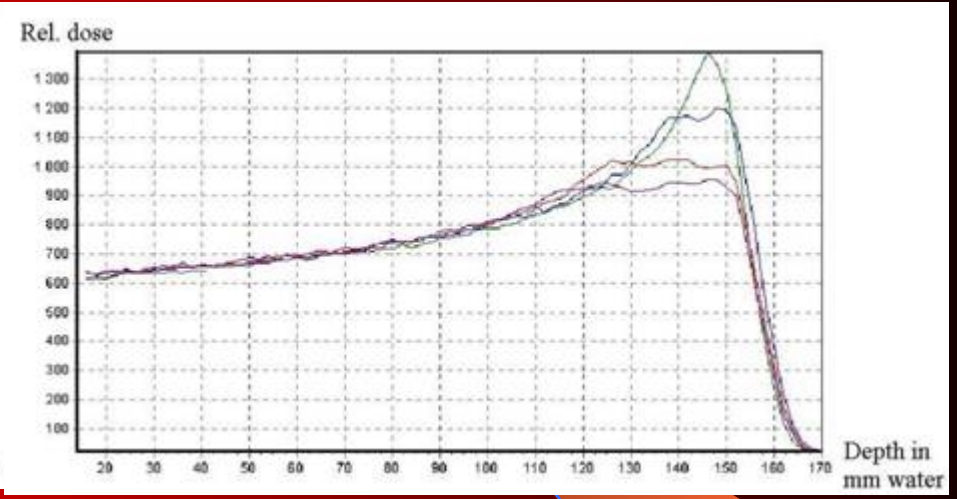
In order to make proton beam conformal to distal margin of the target volume (left picture), planning system calculates 3D range shifter - bolus. Bolus scheme together with beam aperture and DRR skull film are shown in the right picture.



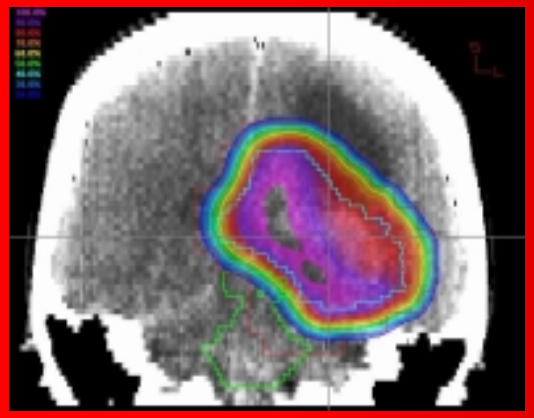
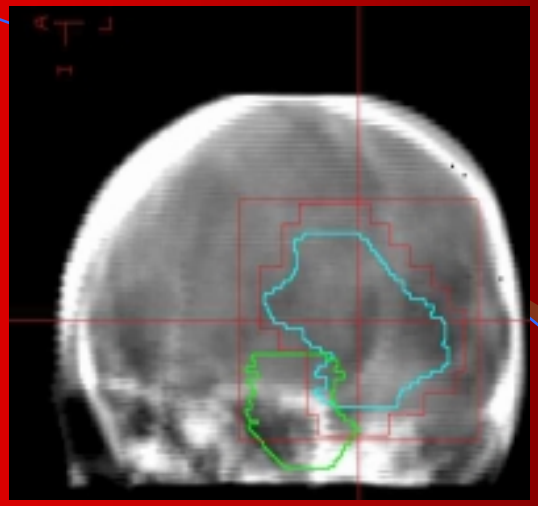
All 3D-designed individual beams (4 in this case) are summated to the treatment dose distribution. Sections through the dose distribution could be visualized at the three orthogonal planes - axial, coronal and sagittal.

Last step of preparation– manufacturing of individual collimators and boluses in the workshop of MTC.





Every day before each treatment session the profiles, depth-dose distributions and dose rate are checked and than are controlled during irradiation of patients.


Sequential stages of realization and verification of the proton treatment plan.

Left - dose distribution at the coronal plane;
Center - digitally reconstructed radiograph of the skull from the beam direction with projection of the target and collimator;
Right - aligning X-ray film at the time of treatment.
Position of the beam in relation to the bone landmarks exactly corresponds to treatment plan.

Early clinical and imaging results demonstrated that developed treatment technique provides precise dose deliverance to the prescribed target volume.