

Radiation oncology ophthalmic center based on the C-80 accelerator at the NRC "Kurchatov Institute" – PNPI

Minkin D.Y., Maksimov V.I.* , Ivanov E.M.* , Khoroshkov V.S.** , Klenov G.I.** ,
Chernykh A.N.**

National Research Center "Kurchatov Institute"

* NRC "Kurchatov Institute" – PNPI

**NRC "Kurchatov Institute" - ITEP

- **history and statistics;**
- **proton oncophthalmology technology – treatment stages;**
- **the main achievements;**
- **radiation oncology ophthalmic center based on the C-80 accelerator at the NRC "Kurchatov Institute" – PNPI.**

Proton oncophthalmology

Start – 1976 in USA, MGH/MEEI, Harvard Cyclotron;

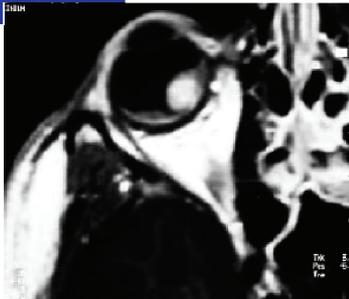
since 1977 - in Russia, ITEP;

since 1984 – in Europe, PSI;

Currently, 65 centers of PRT are operating, 7 of them are specialized oncophthalmological centers;

In Russia today:

- more than 1200 patients treated at ITEP
- since 2016 in Obninsk there is a single-cabin facility of PRT (made in Protome), on which individual exposures of intraocular neoplasms are performed



Proton Radiation Therapy for Ocular Tumors

- **Diagnosis;**
- **Surgery to document tumor extension and placement of fiducial markers;**
- **Simulation and radiographic measurements of markers;**
- **Treatment planning;**
- **Fabrication of individual collimators and bolus;**
- **Positioning;**
- **Radiotherapy (4-5 fractions);**
- **Follow-up.**

Diagnosis

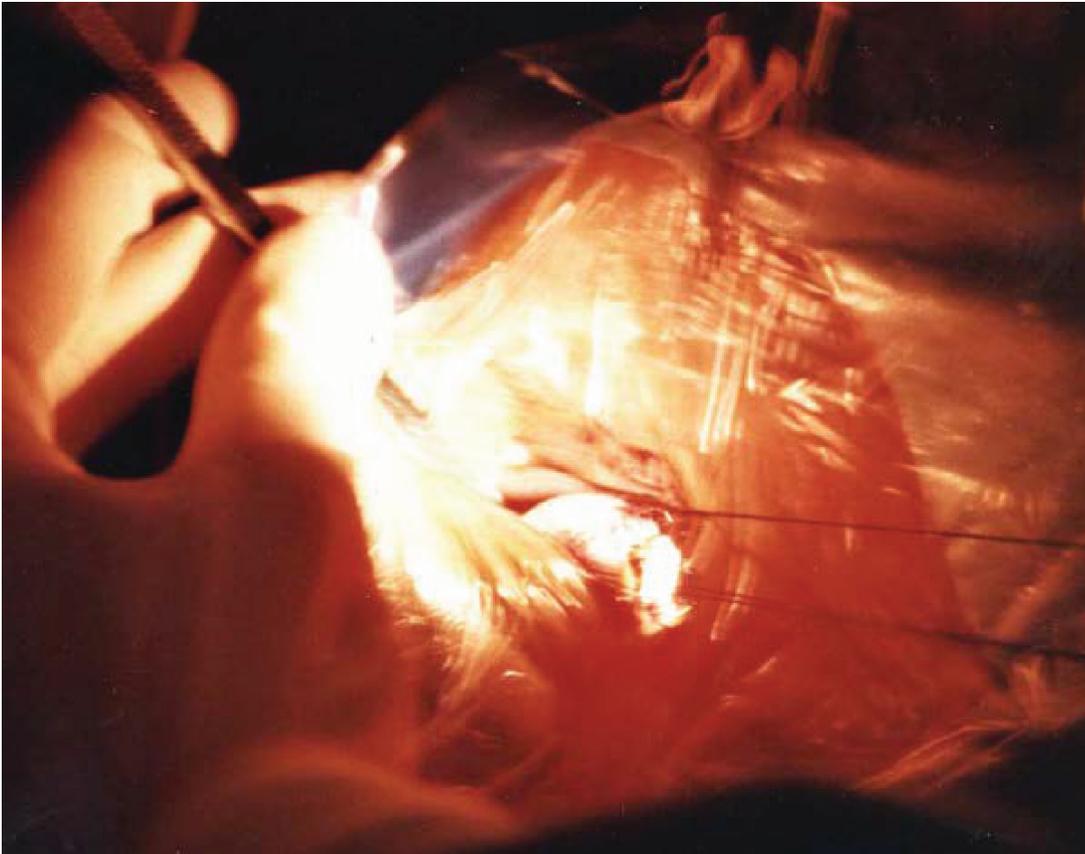
Primary symptom: reduced/disturbed vision



Surgery to document tumor extension and placement of fiducial markers



With trans-illumination the tumor throws a shadow on the sclera: the tumor base



Hôpital Jules Goriot
Clinique Ophtalmologique Universitaire
CHU de Bordeaux, Professeur L. Kaprielian

STALDER ALDIS
ALIS D&S BELLOS-11, 2012
CH 1308 Courmouza-Genève
0287700018

CHIRURGIE OCULAIRE
OPHTHALMOLOGUE
OPHTHALMOLOGUE

Date: 10.04 Opérateur: Z. G. A. A. S.
Anesthésiste: B. L. J. Y.
NO ALI ALI Bando de l'opération: 321 226
Diagnostik: Myopie Hémorragie Métrorragie DMLA Juvénile Base d'ulcère

OD OS
Insérer une pupille Insérer pupille Insérer iris Insérer LC Insérer IR
Diagnostic tumor (des autres): Diagnostic tumoral en cours:

Observation pré-opératoire: au livre sur

Pie to pie: DMLA DMLA DMLA DMLA DMLA

Identification: oui non Diaprise: D&S H&A
Autisme Différence base végétative: Différence oculaire:

Clap	Distance Tumeur	Distance Lente	Distance Lentille	Distance Subconjunctive	Clap	Distance
1	0,5	4			1-3	16
2	0			1,5	2-4	18,5
3	2,5					
4	1					
5						
6						
7						

États Lésionnels: Tumeur vésiculaire Tumeur en partie vitrée Tumeur vésiculaire Tumeur métrorragique

Localisation: Par l'opérateur Ophtalmologiste

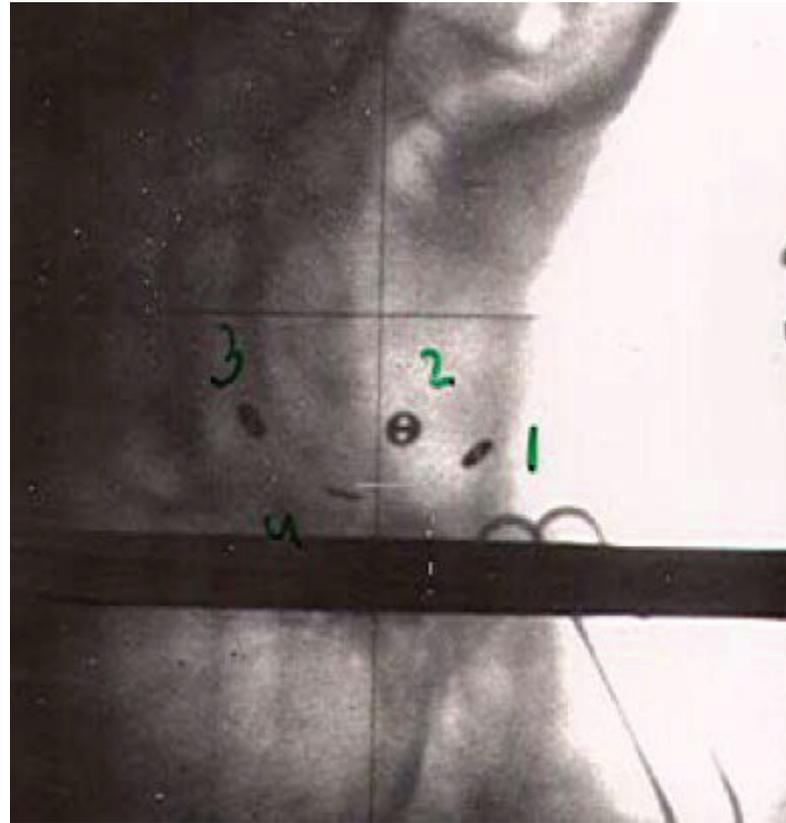
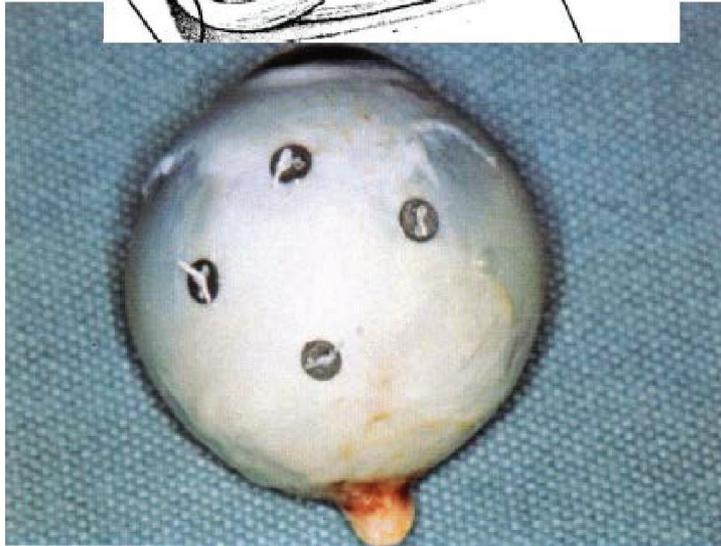
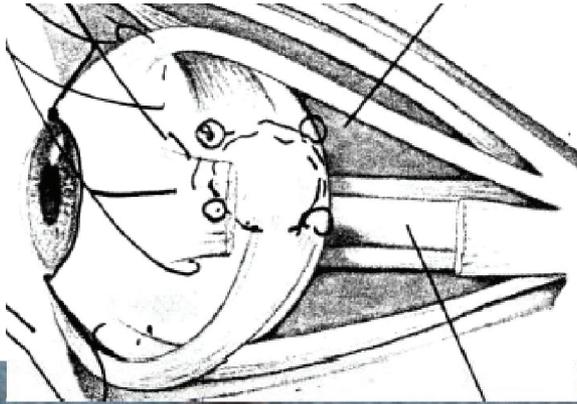
Remarques: 6.10.04 3.0.04

Libre au regard: 10.04.04 20.04.04 1984

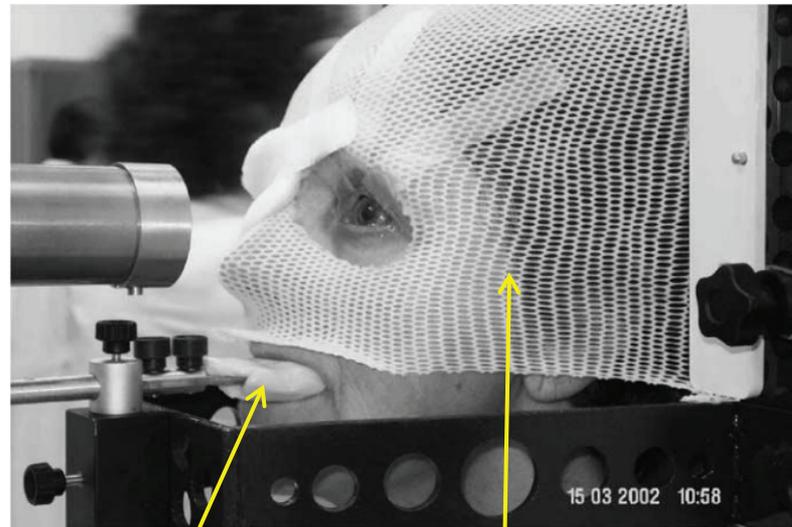
Date: 9.8.04
Age: 63
Sexe: M
Diamètre de l'œil: 12

Examen pré-op: A5
Longueur axiale: 24,1
Remarques:
Signature: [Signature]

Tumor base is delineated with tantalum clips



Positioning in front of the beam



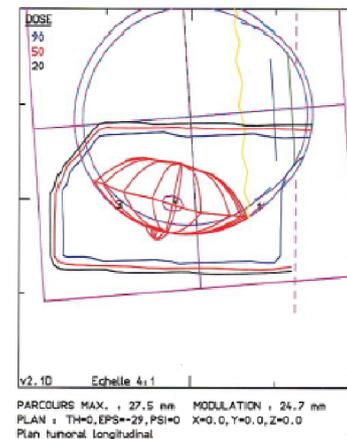
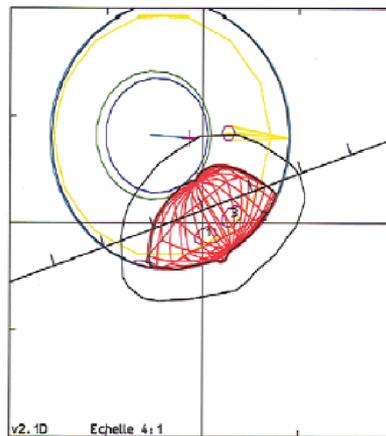
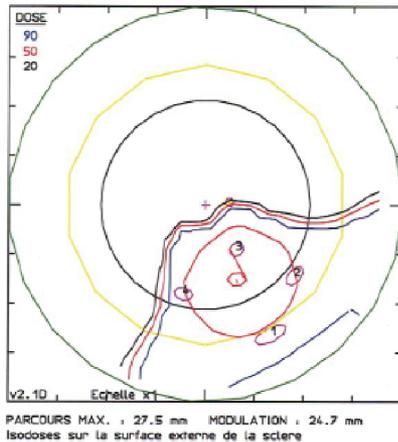
Bite block

Face mask

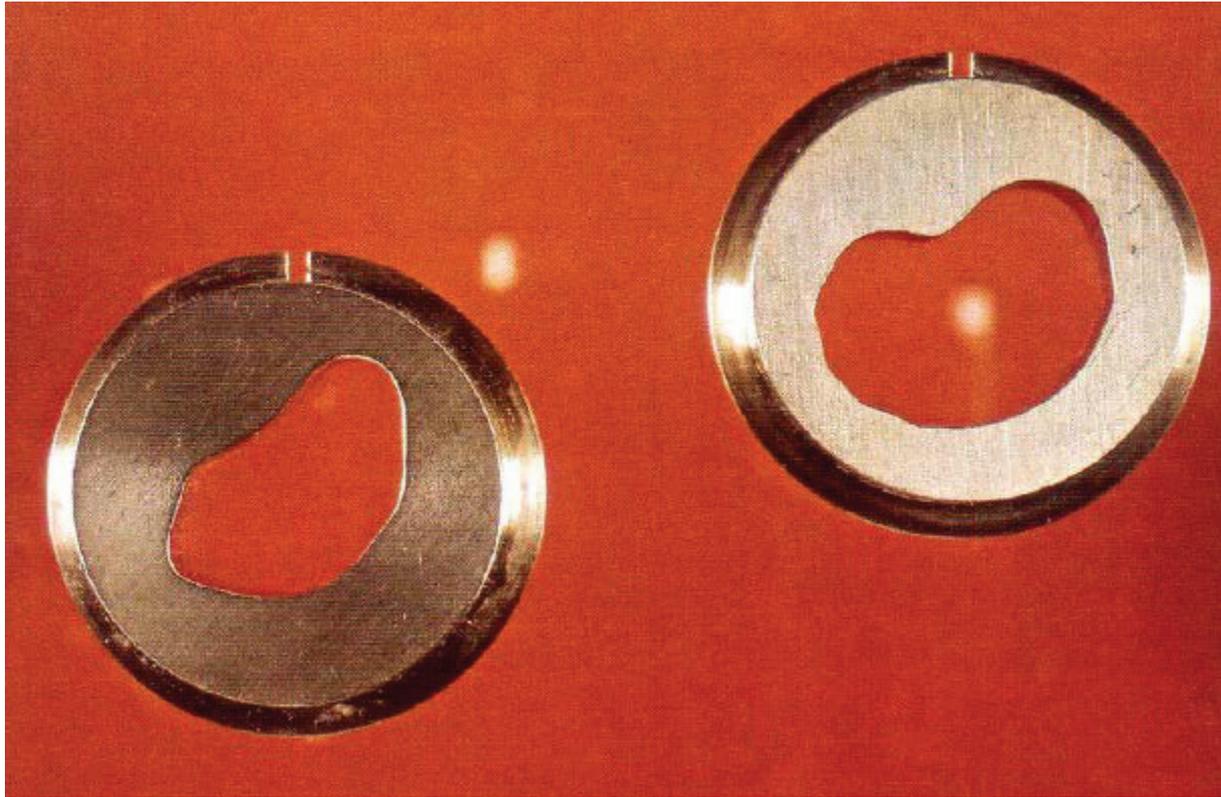
Treatment planning

- Tumor drawn based on clinical date;
- Determine optimal eye position;

Main planning conditions: lateral margin 2 mm, distal margin 2.5 mm and maximum distance between the macula and the optical disk.



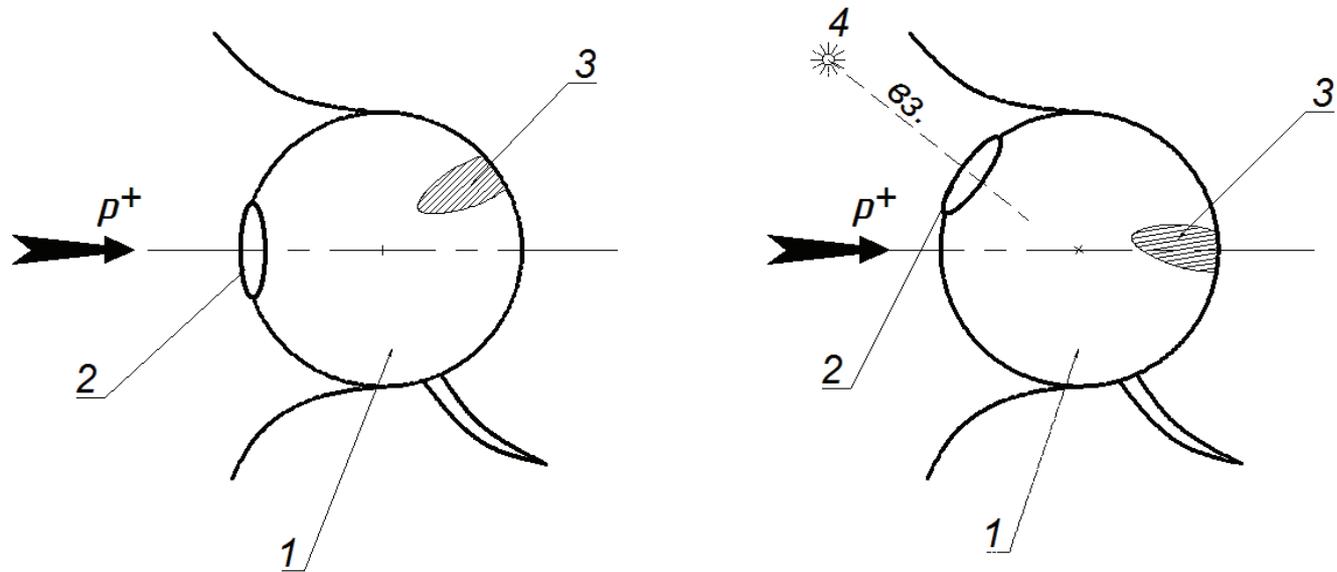
Fabrication of individual collimators



The composition of the positioning system:

- laser positioning system;
- fixation point;
- X-ray positioning system.

Fixation point



1. eyeball;
 2. pupil;
 3. Intraocular tumor;
 4. Fixation point;
- p^+ – axis of the proton beam;
 B_3 – direction of gaze.

X-ray positioning system

Hôpital Jules Gonie
 Clinique Ophtalmologique Universitaire
 Rue Des Belles-Fleurs 8
 CH 1206 Chêne-Boulevard
 0277333333

STAUDER ALDIS
 CH 1206 Chêne-Boulevard
 0277333333

Date: 10.04.04
 Opérateur: Z. G. H. A. B. C.
 Anesthésiste: B. G. P.
 226

Diagnostik: Myopie Hémorragie Métrorragie Dér. A. J. G. B. a. d. p. a.

OD OS Nasal Temporal Superior Inferior

Diamètre pupillaire Diamètre iris Diamètre

Diamètre tunnel oculaire Diamètre tunnel osseux

Cheraton corneographique: au front sur OS

Fixation: Directe Indirecte Écarts Dér.

Stéréoscopie: oui non Distance: D=15 H=4

Autre: Instructions pour le patient Réflexes des globes Oculaire

Objet	Distance Toimer	Diamètre Linéaire	Diamètre Linéaire (mm)	Distance (mm)	Objet	Diamètre
1	0,3	4				
2	0				1-3	16
3	2,3			1,5	2-4	13,7
4	1					
5						
6						
7						

État de l'émulsion: Tumeur épaisse Tumeur de petite épaisseur Tumeur vasculaire Tumeur choroïdienne

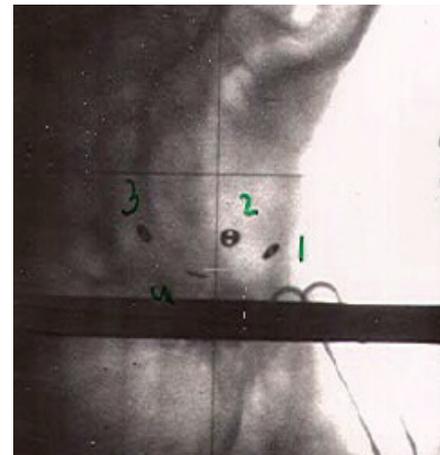
Lésions: Pré-rétinopigmentaire Crapahotopigmentaire

Remarques: hémorragie 3 au on

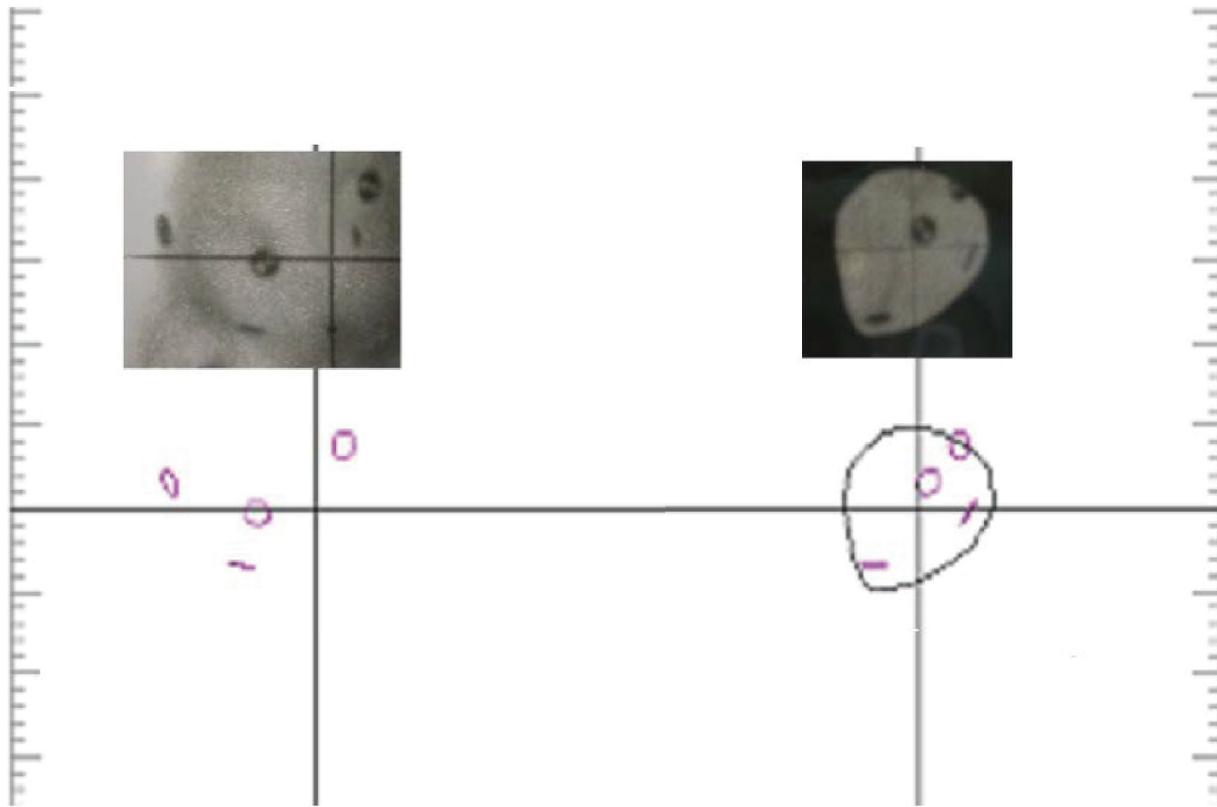
Lin. superoparietale: 100cm 200cm 300cm

Heure: 9.8.04
 Longueur: 1.5
 Diamètre du tube: 12

Exempteur: A. S.
 Longueur tube: 29,1
 Remarque:
 Récepteur:



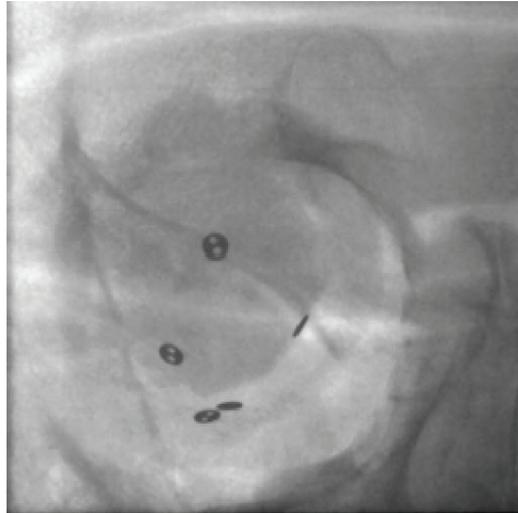
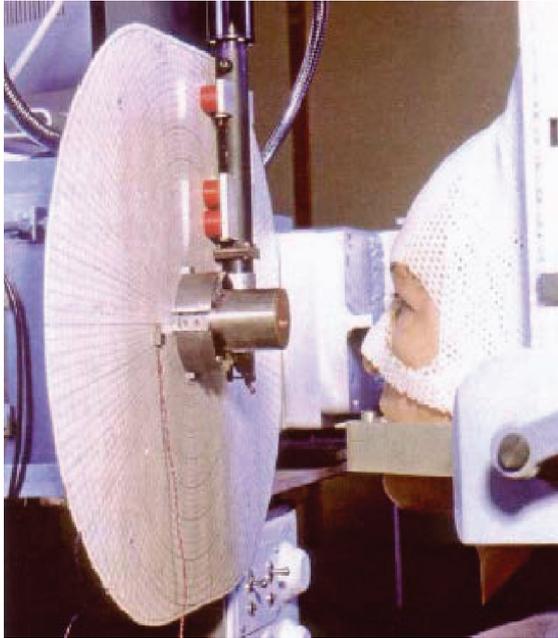
Identifying the clips on X-ray images and determines clip positions



Lateral view

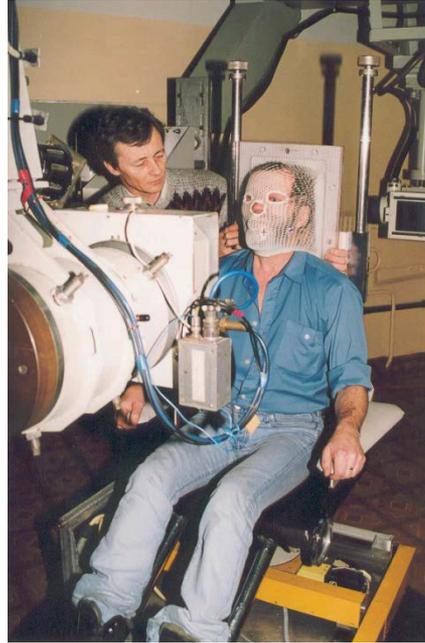
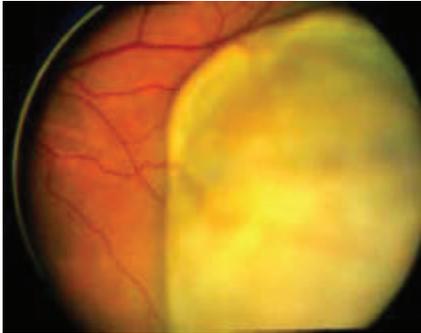
Axial (beam-s eye) view

Eye position adjusted until clips are matched ($<0,2$ mm)



Main achievements

**Ocular fundus
PRIOR to proton therapy**



**Ocular fundus
AFTER proton therapy**



- local tumor control - 98,0%;
- eye preservation - 88,7%;
- preservation of vision – 50%;
- five-year survival rate - 95,0 - 97,0%.

**More than 15,000 patients have been treated worldwide;
over 98% of diagnoses - uveal melanoma.**

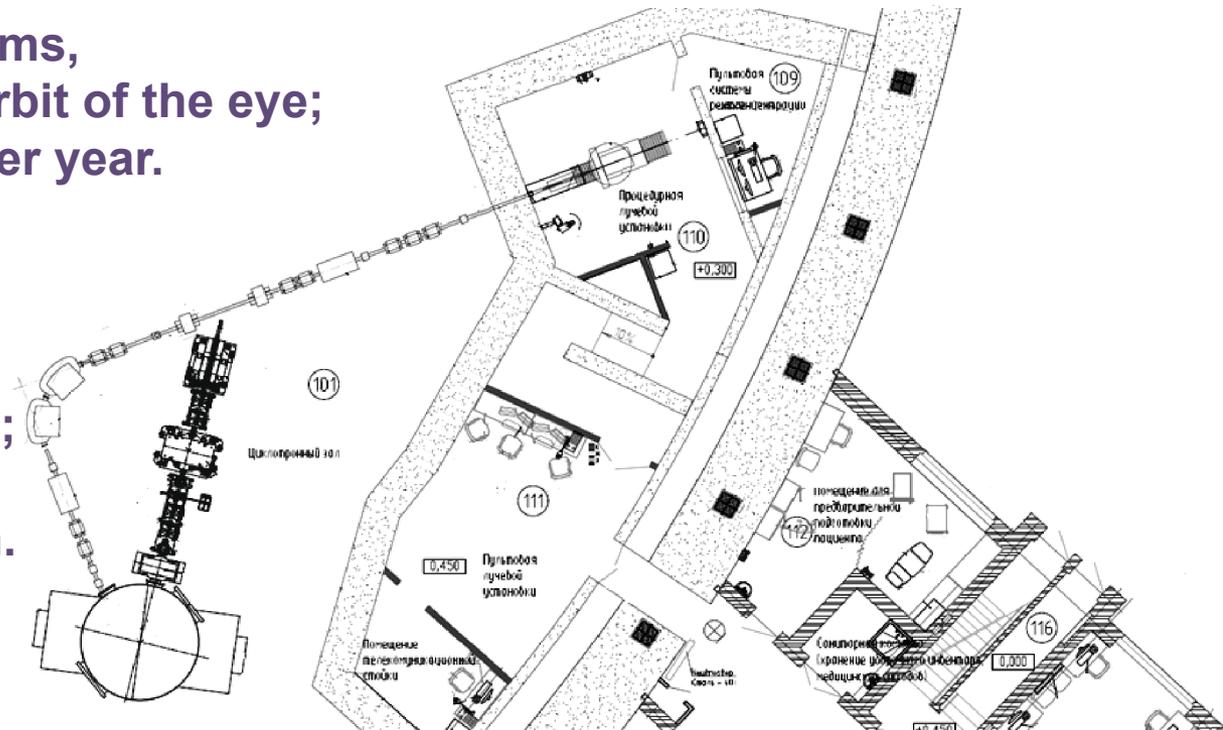
Radiation oncophthalmic center based on the C-80 accelerator at the NRC "Kurchatov Institute" – PNPI

- proton beam energy 70 МэВ;
- passive beam system;
- maximum dose field of radiation 50мм;
- localization:
 - intraocular neoplasms,
 - neoplasms of the orbit of the eye;
- bandwidth of 400 people per year.

- Chair positioner;
- beam delivery system;
- patient positioning system;
- X-ray positioning system;
- treatment planning system.

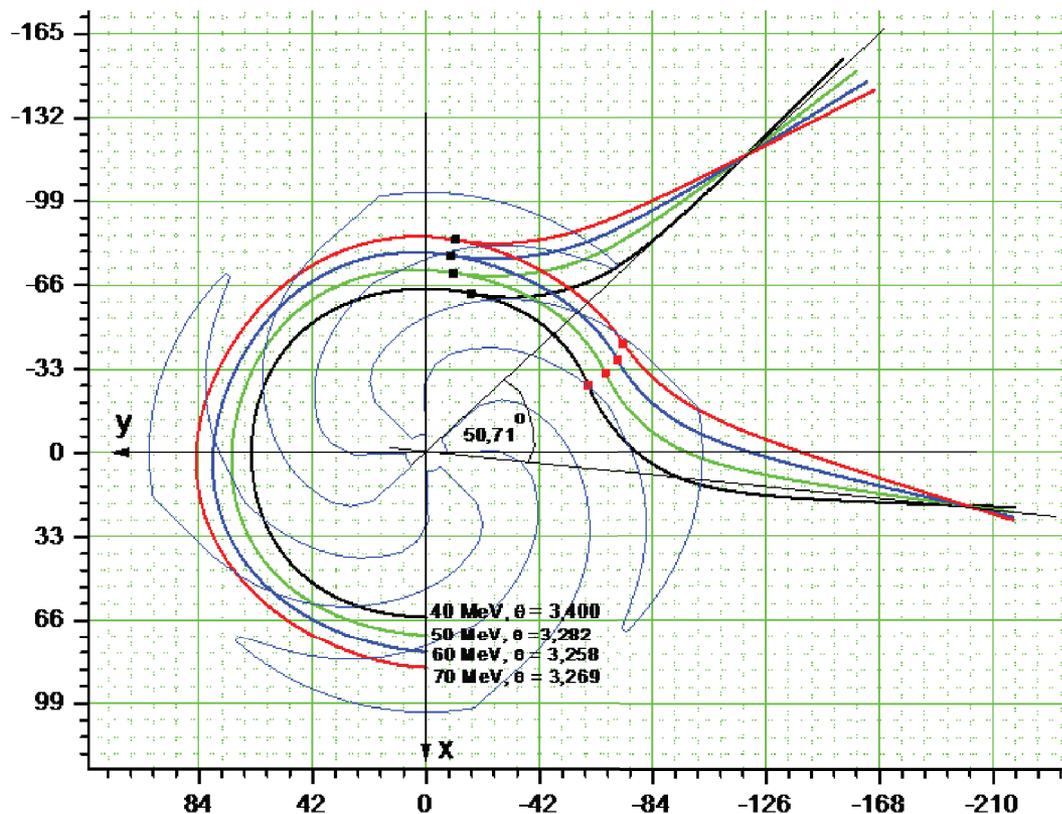
Total area of 630 м²:

- medical part – 255 м²
- physical and technical part – 375 м²



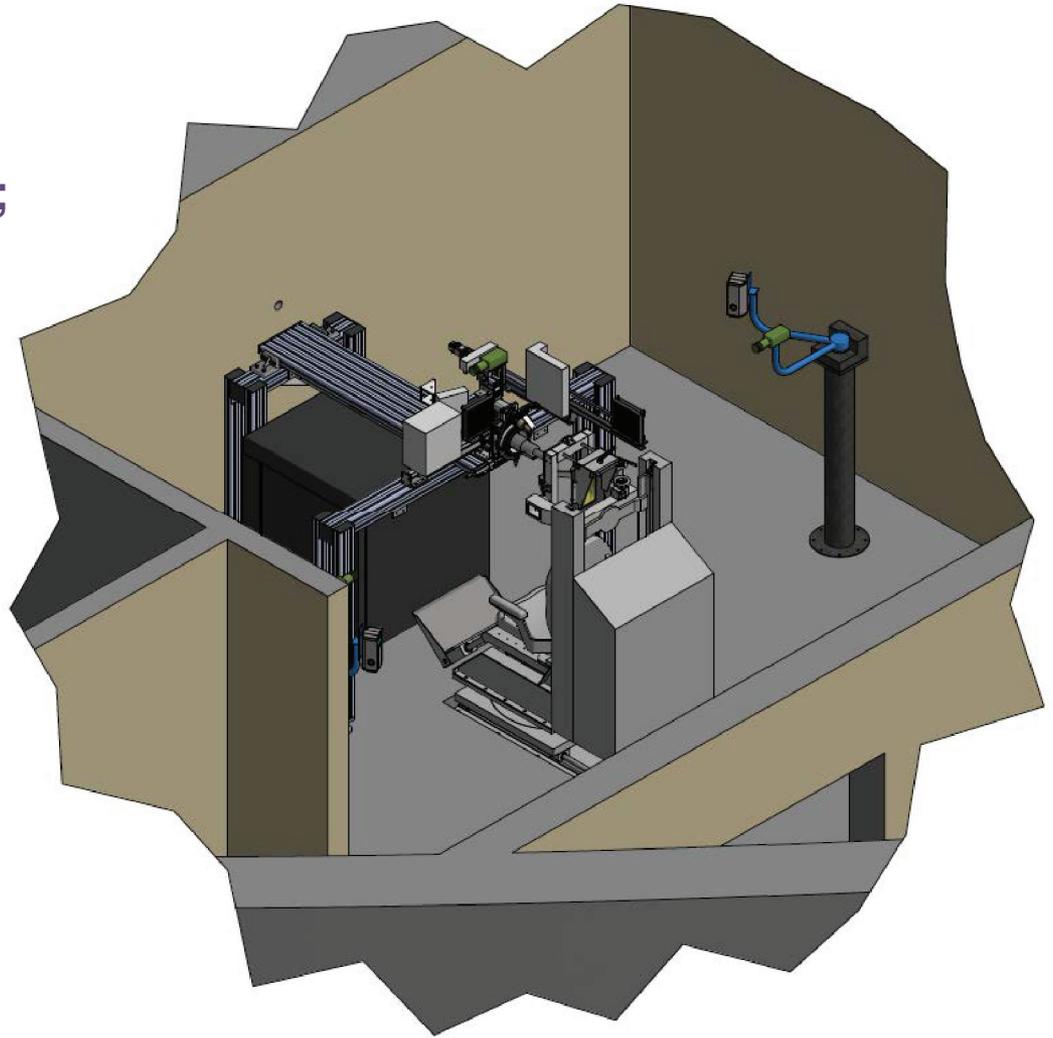
Independent of the therapeutic proton beam output

Estimated and made calculations for the organization of an independent output of a low-intensity (5×10^{10} p/s) proton beam, by introducing the second charge-transfer system of H⁻ ions

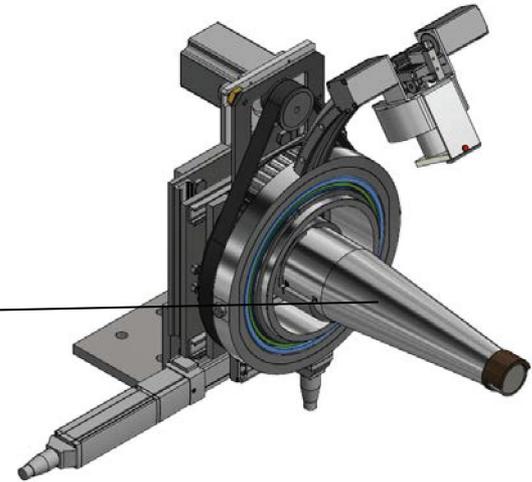
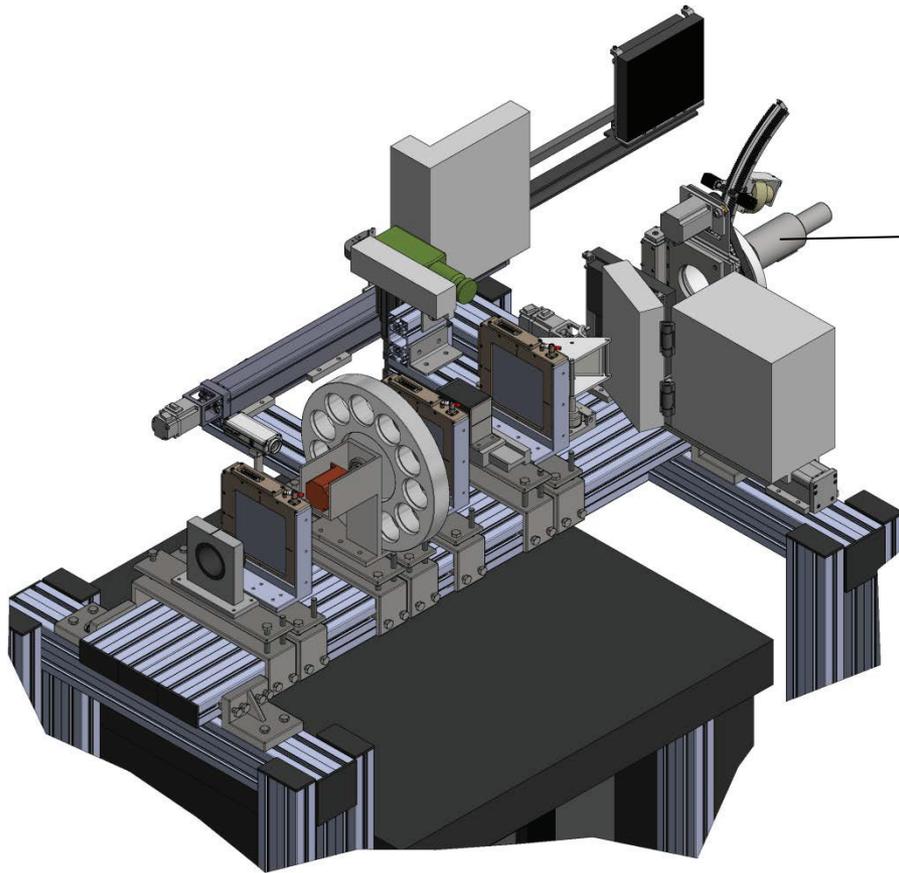


General view of the treatment room

- Chair-positioner;
- beam delivery system;
- patient positioning system;
- X-ray positioning system;



Beam delivery system



- diameter of the dose field 50mm and 30mm;
- maximum proton mileage 4g/cm²;
- lateral decline in dose from 80% to 20% - less than 0.11 cm;
- distal decline in dose from 80% to 20% - less than 0.1 cm;
- irregularity of the dose distribution is not more than $\pm 2.5\%$;
- dose rate of at least 50Gy / min.

Chair positioner

- two job positions:
 - patient position
 - irradiation position
- precision displacement in three coordinates X, Y, Z with an accuracy of 0.1mm;
- independent angular displacement of head holders;
- independent movement of chair elements for comfortable patient accommodation.



Summery

Realization of NRC "Kurchatov Institute" - PNPI research project to develop an oncophthalmological complex of proton beam therapy will provide high-tech care for patients in the whole North-West region of Russia.



Thank you for attention!

