Medical accelerators

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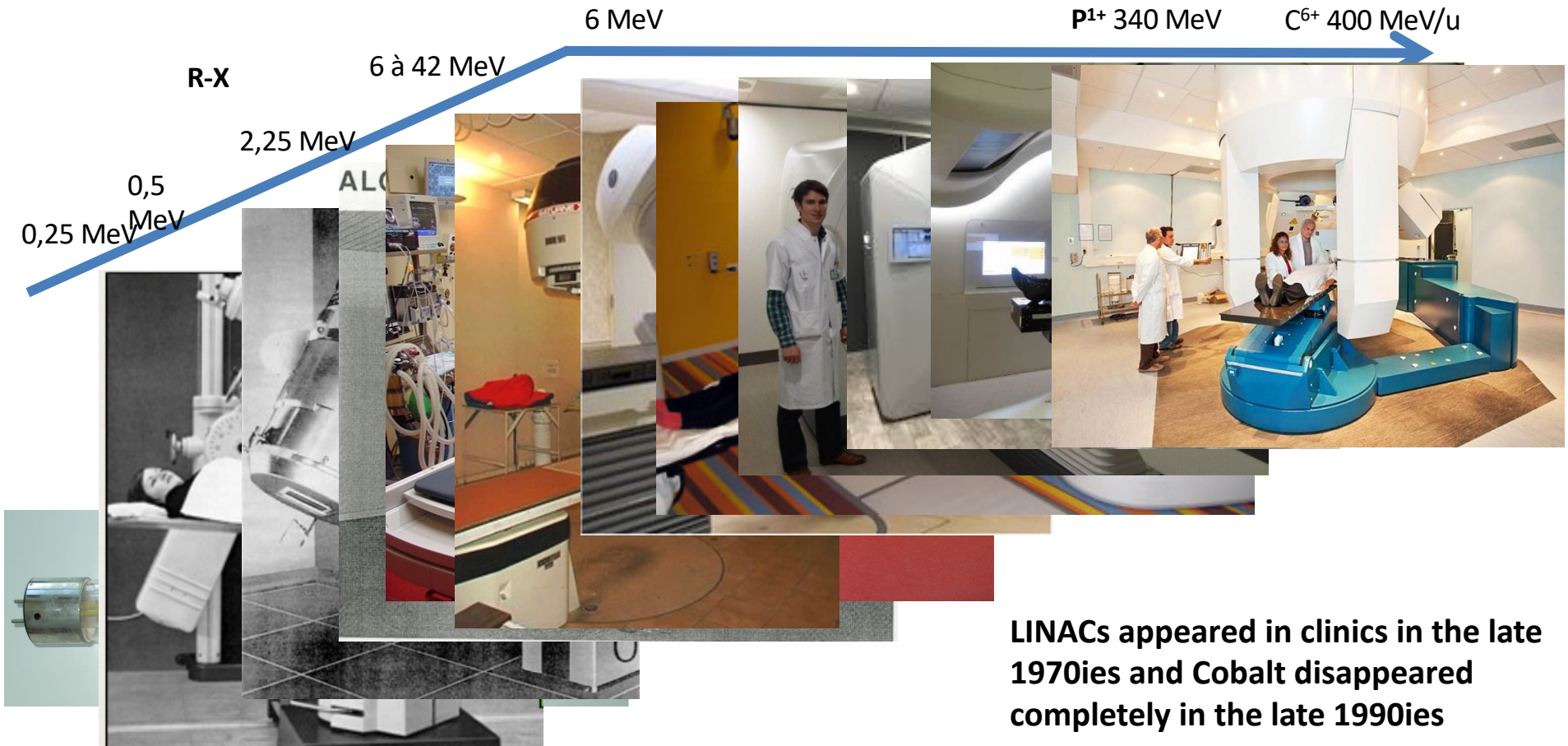
CHU de Grenoble-Alpes

LPSC workshop March 2026

Out line

- A short history
- The present main types of medical accelerators
- The recent evolutions
- How it works
- Perspectives for new machines

Radiotherapy developed continuously along more than a century gaining power then versatility and accuracy. The life time of a current machine is about ten years.



LINACs appeared in clinics in the late 1970ies and Cobalt disappeared completely in the late 1990ies

The 6 MV LINAC is presently the universal tool of radiotherapy and is operated in very different ways: open machines, closed machines with only coplanar beams, helicoidal machines and robotic machines

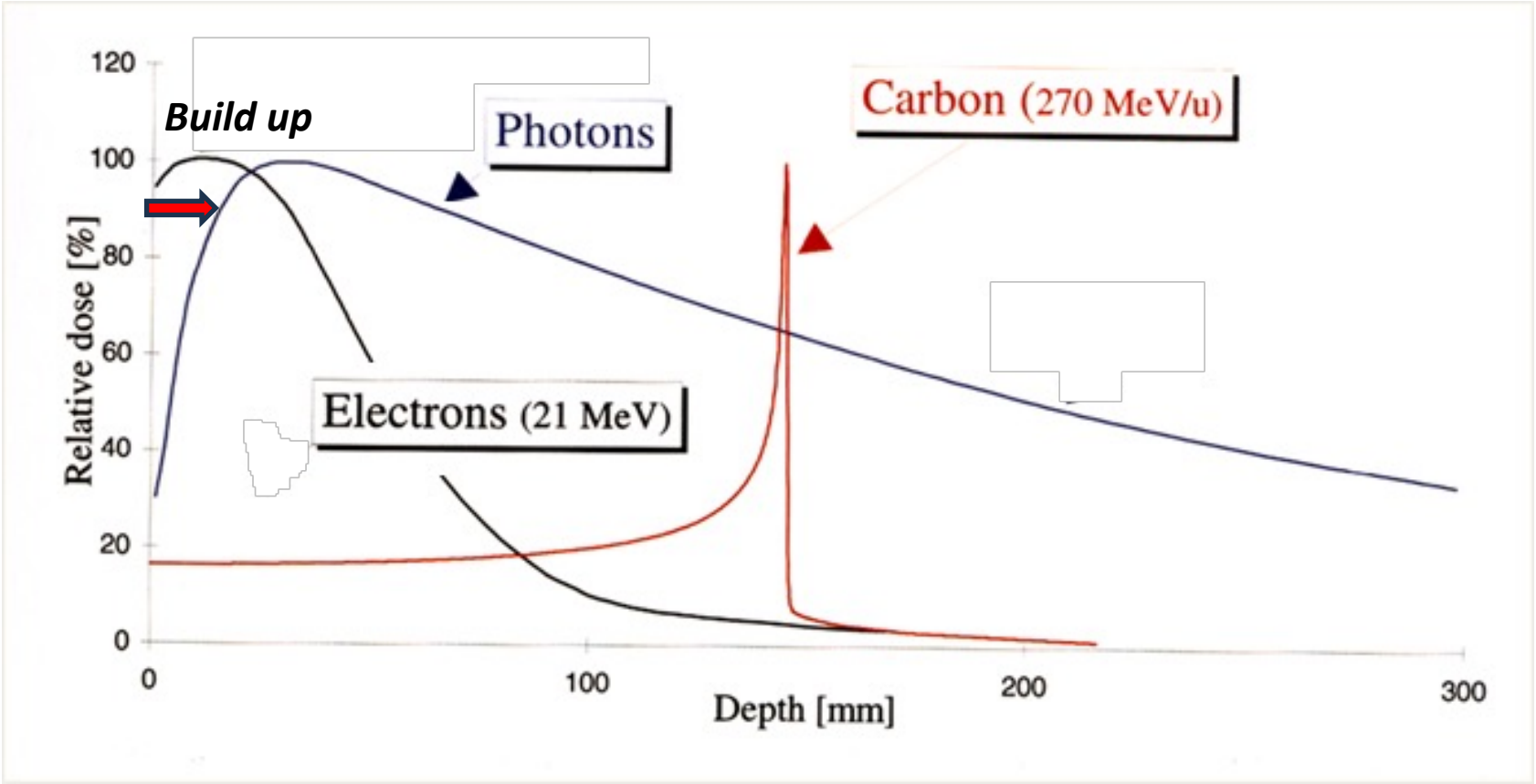
Elekta IGRT

Halcyon ®

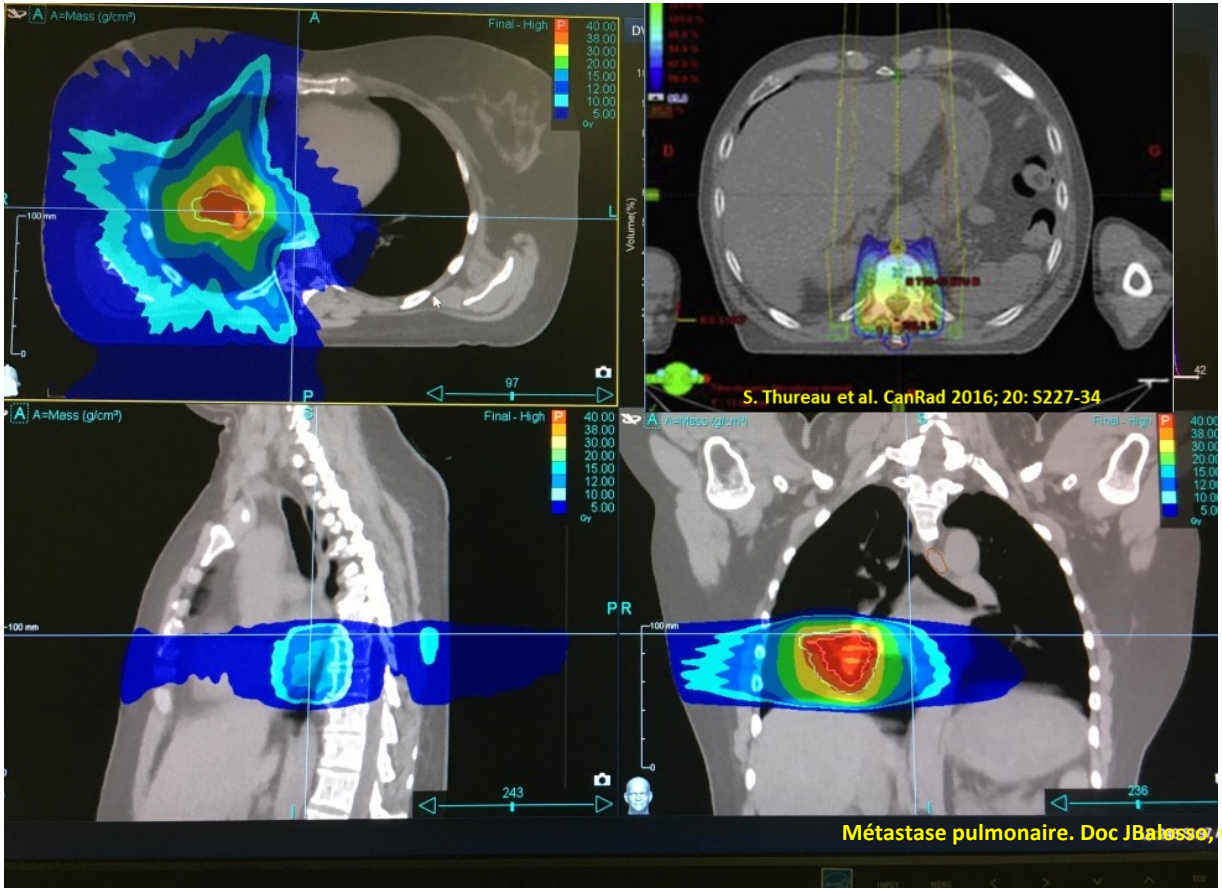
Tomotherapy ®

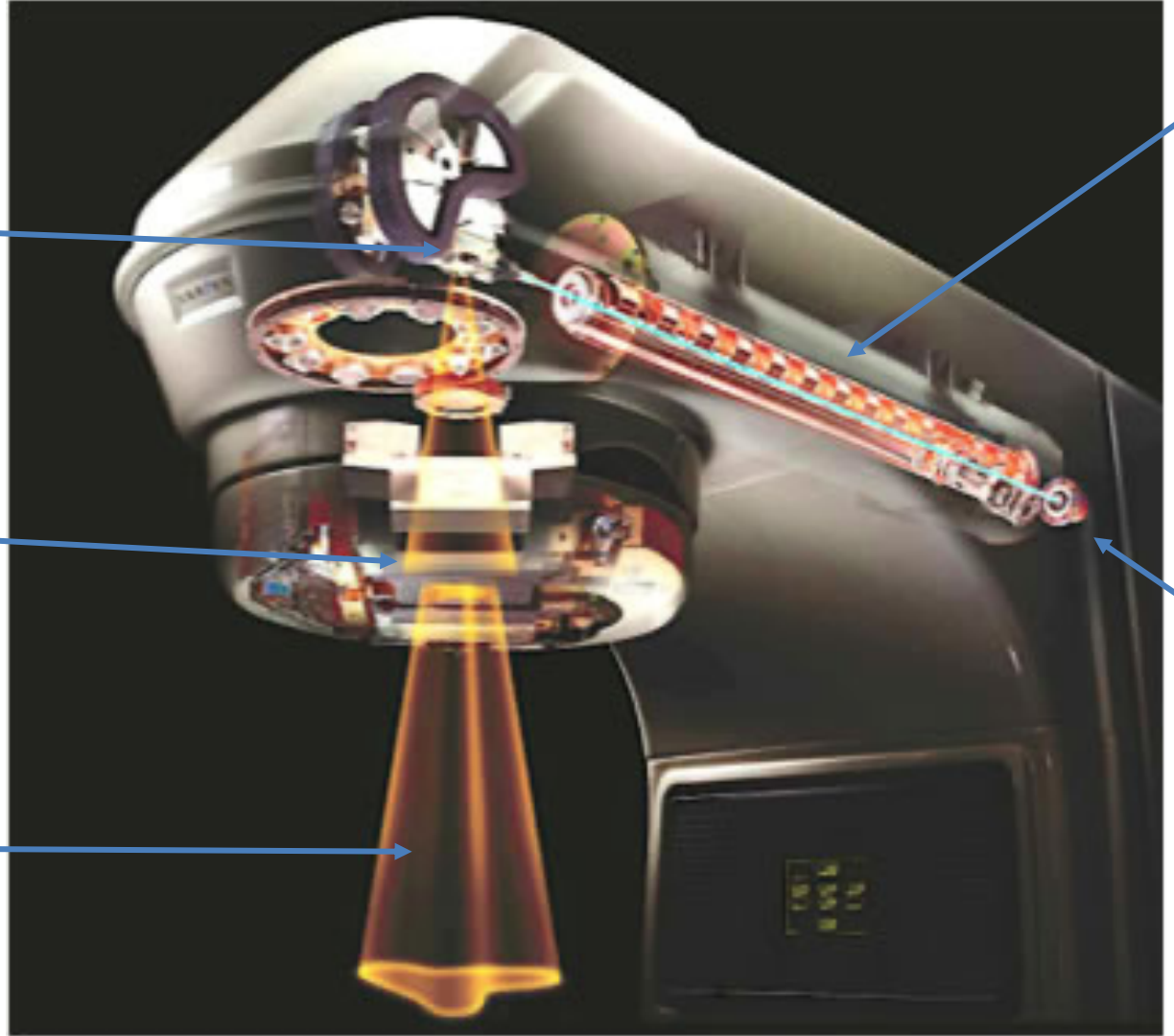
Cyberknife ®

Why after huge energies as 18, 21 and even 42 MeV of max. energy LINAC have decreased and stabilized at 6 MeV (which gives, by the way, a beam quality absolutely similar to ^{60}Co ?



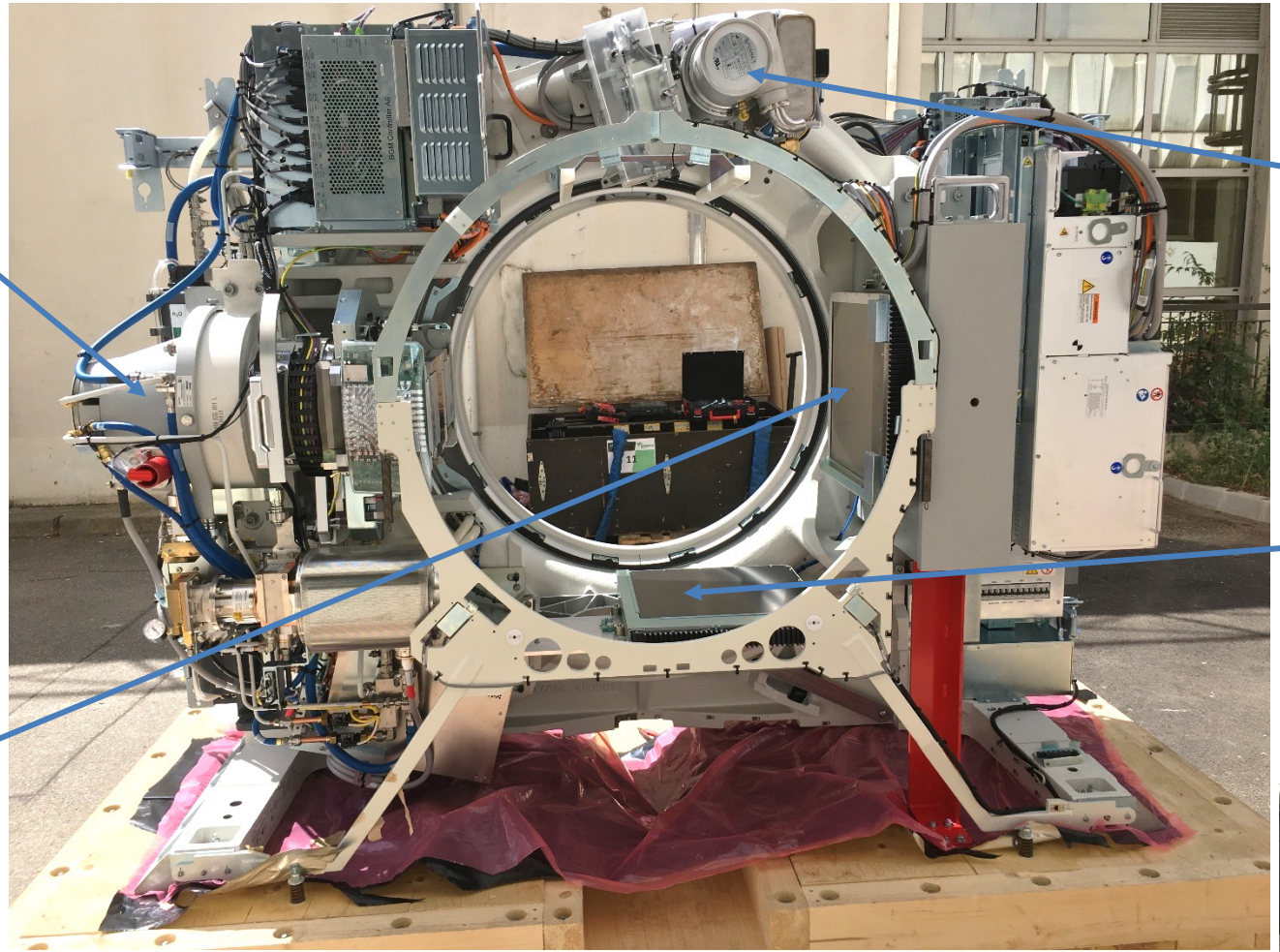
6 MV allows accurate dosimetric calculations in almost every situations as here in lung, bone or soft tissues.




X ray source
Multi-leaf-collimator (MLC)
Medical X-ray beam
Electrons' LINAC
Electrons' source


Low E X-ray source for CBCT
CBCT receptor
Treatment head
High energy portal imager

Halcyon®

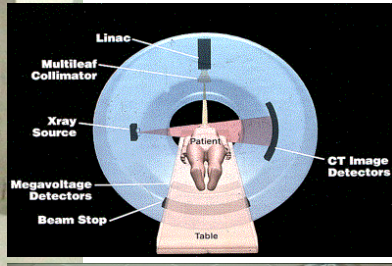

6MV
Linac
High
energy
portal
imager
Low E X-ray
source for
CBCT
CBCT
receptor

TOMOTHERAPY®

6MV
Linac

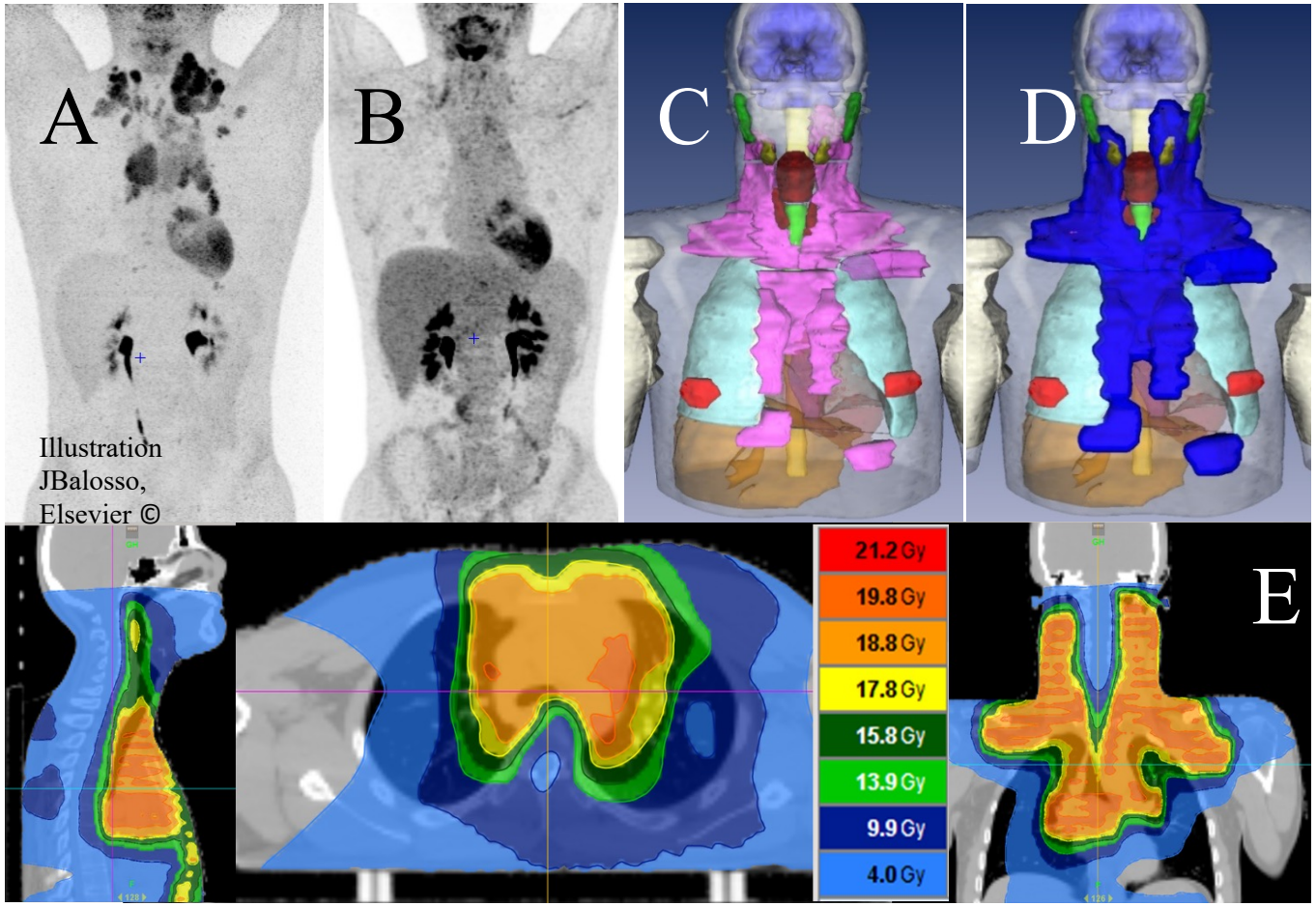
High
energy
detector
for MVCT

Second generation:
with a built-in CTscan



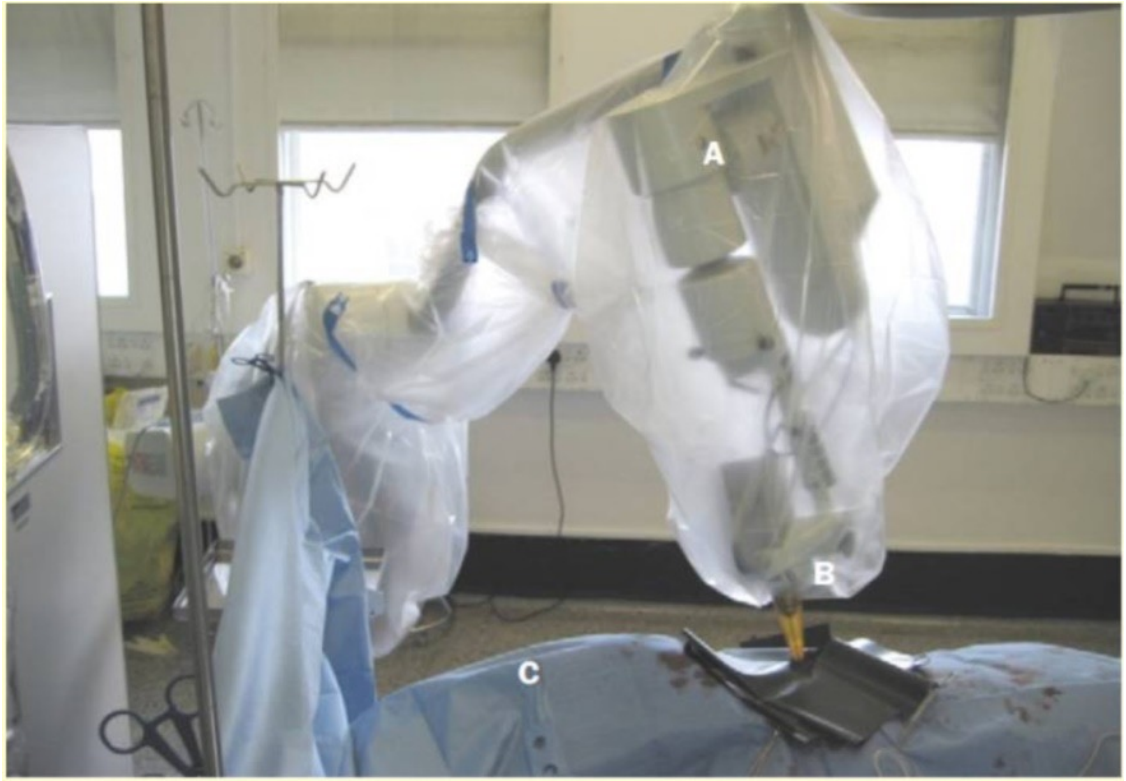
How is a TOMOTHERAPY ® working?

Commercial presentation

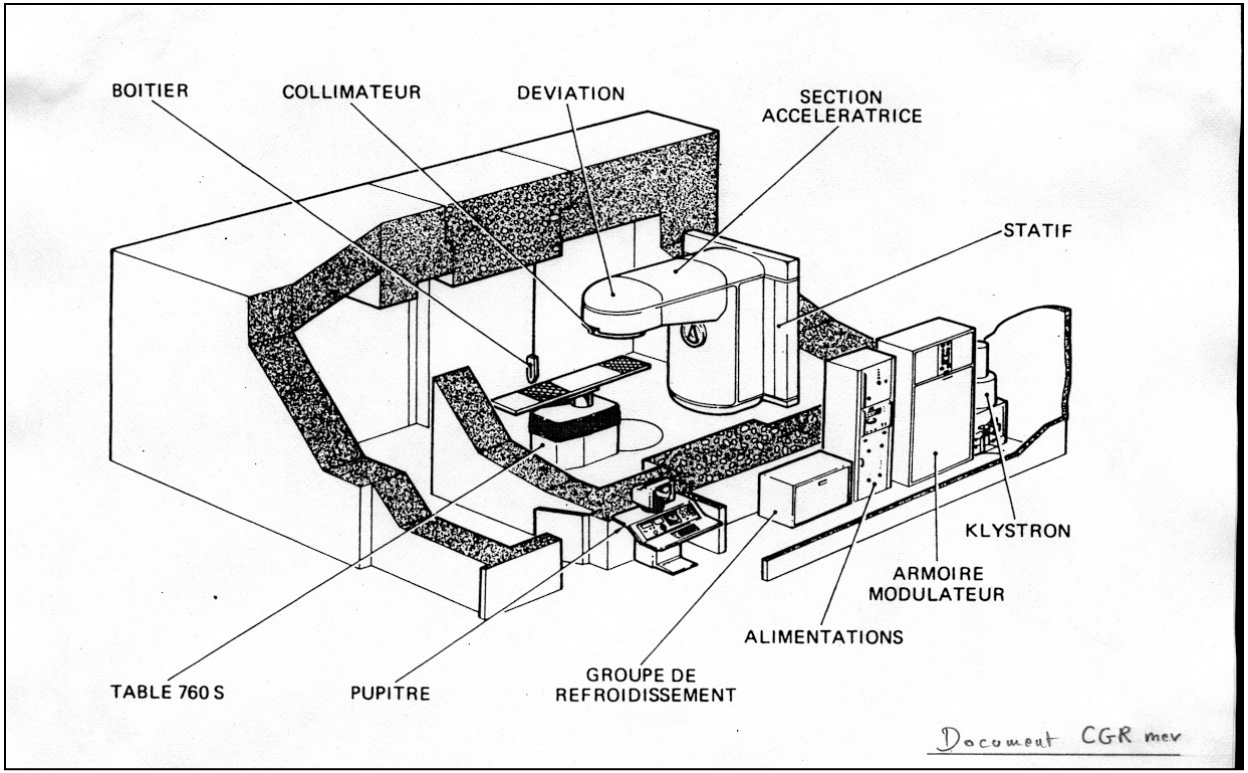


Very large volumes can be irradiated by Tomotherapy: here an Hodgkin disease

There are also very small electron accelerators as this one of 15 to 20 cm for intra-operative radiotherapy

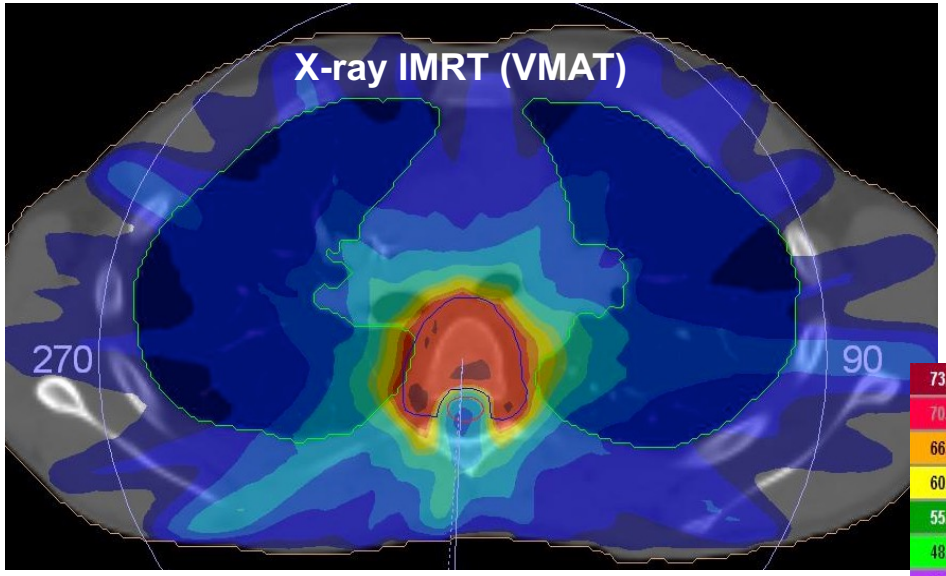


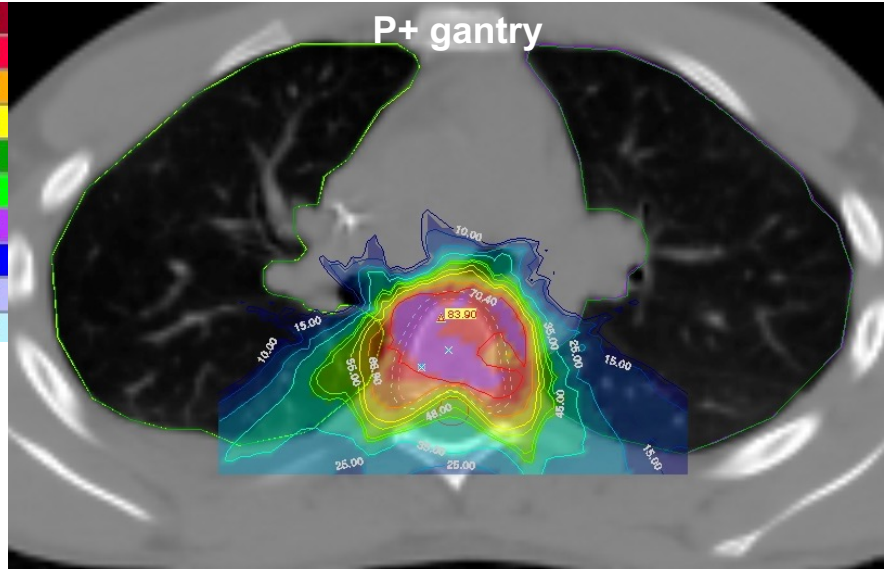
Zeiss Intrabeam®

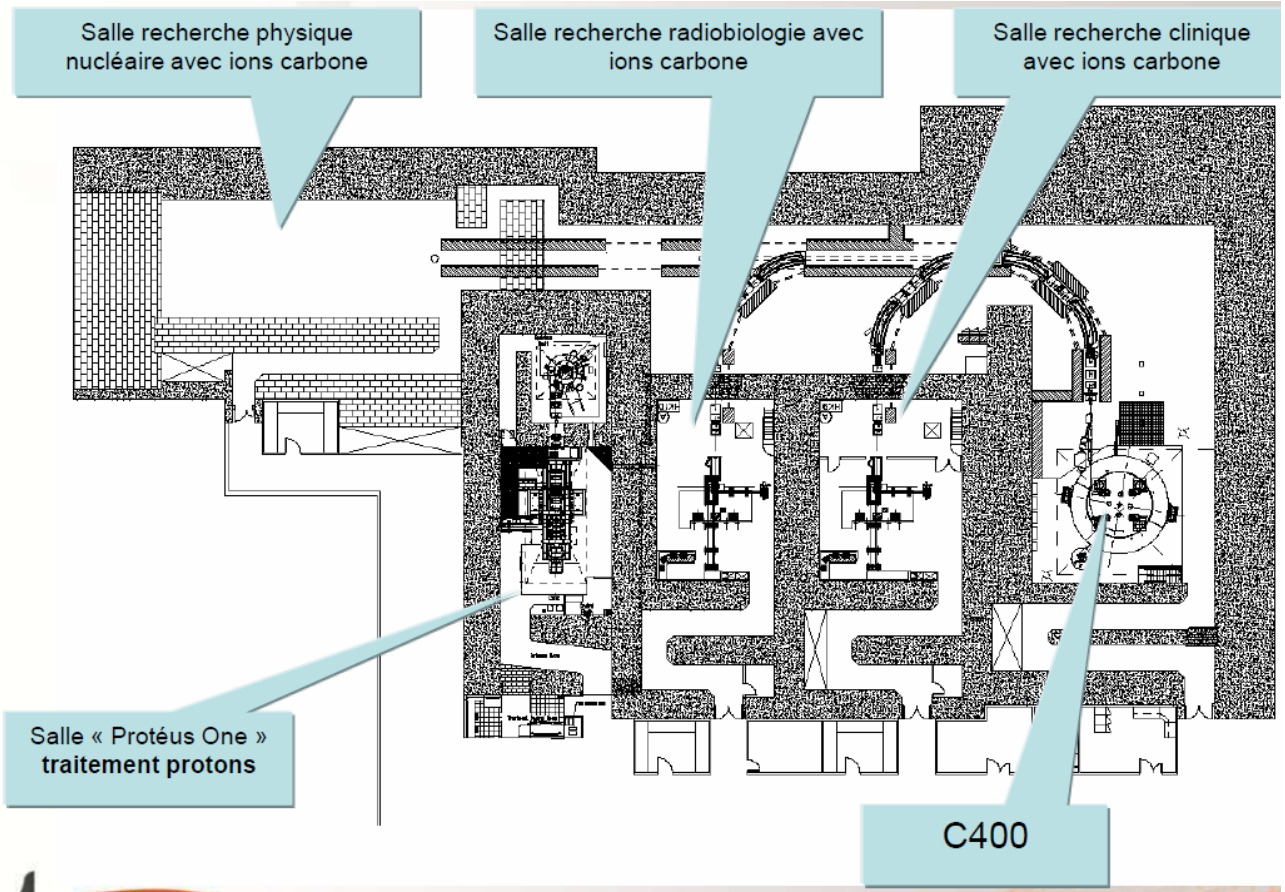


The general infrastructure around a LINAC

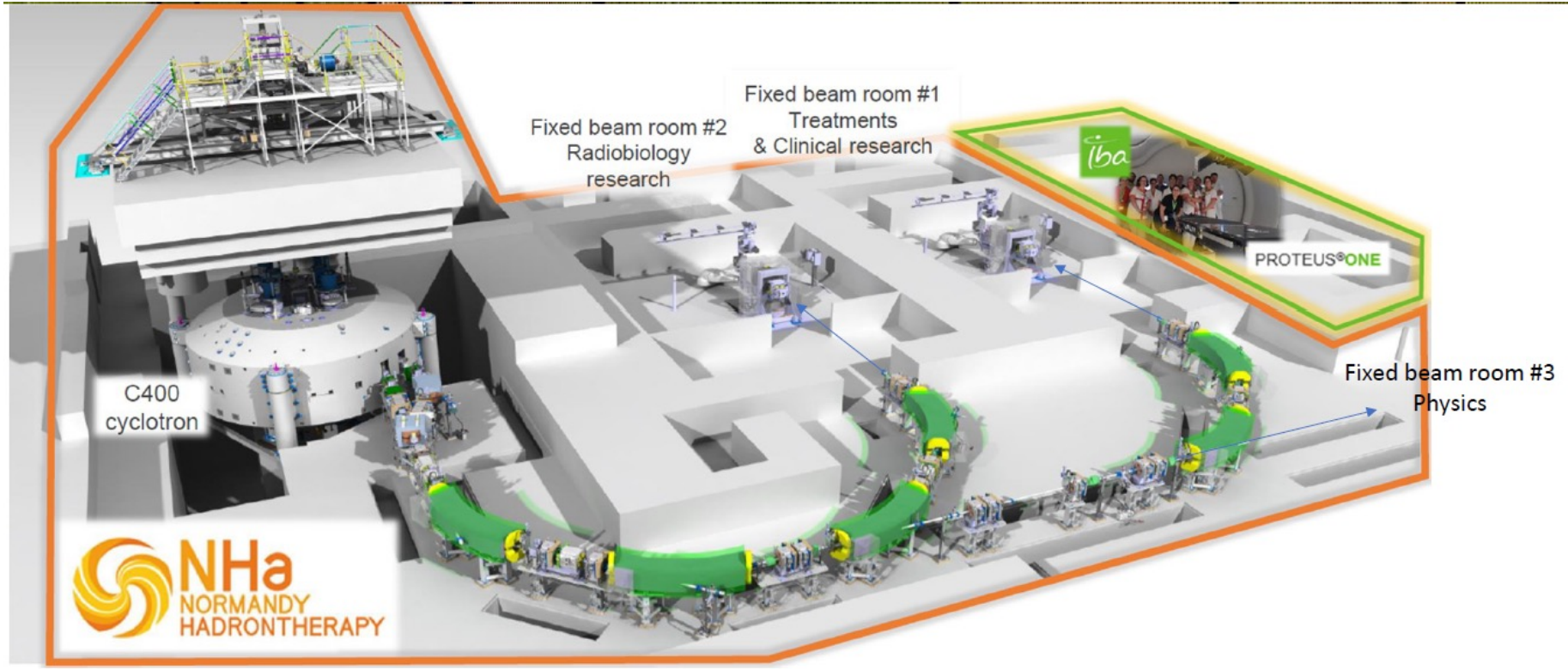
X-ray IMRT versus ion-beam therapy







Archade
ADVANCED RESOURCE CENTRE FOR HADRONTHERAPY IN EUROPE


Fixed beam room #2
Radiobiology
research
Fixed beam room #1
Treatments
& Clinical research
iba
PROTEUS®ONE
C400
cyclotron
Fixed beam room #3
Physics
NHa
NORMANDY
HADRONTHERAPY

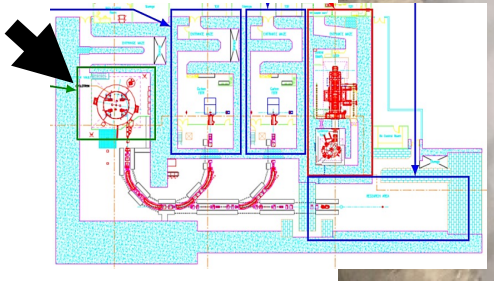
The ProteusOne® treatment room of CYCLHAD in Caen

L'accélérateur (S2C2) du Proteus One

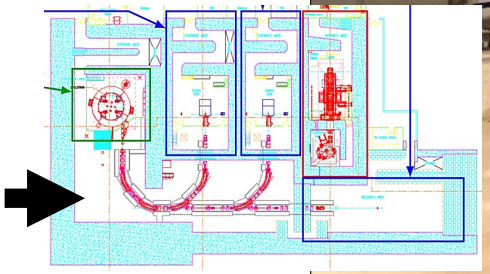
Gantry du Proteus One

February 2024 the first pieces of the C400 cyclotron are delivered into the CYCLHAD building in Caen

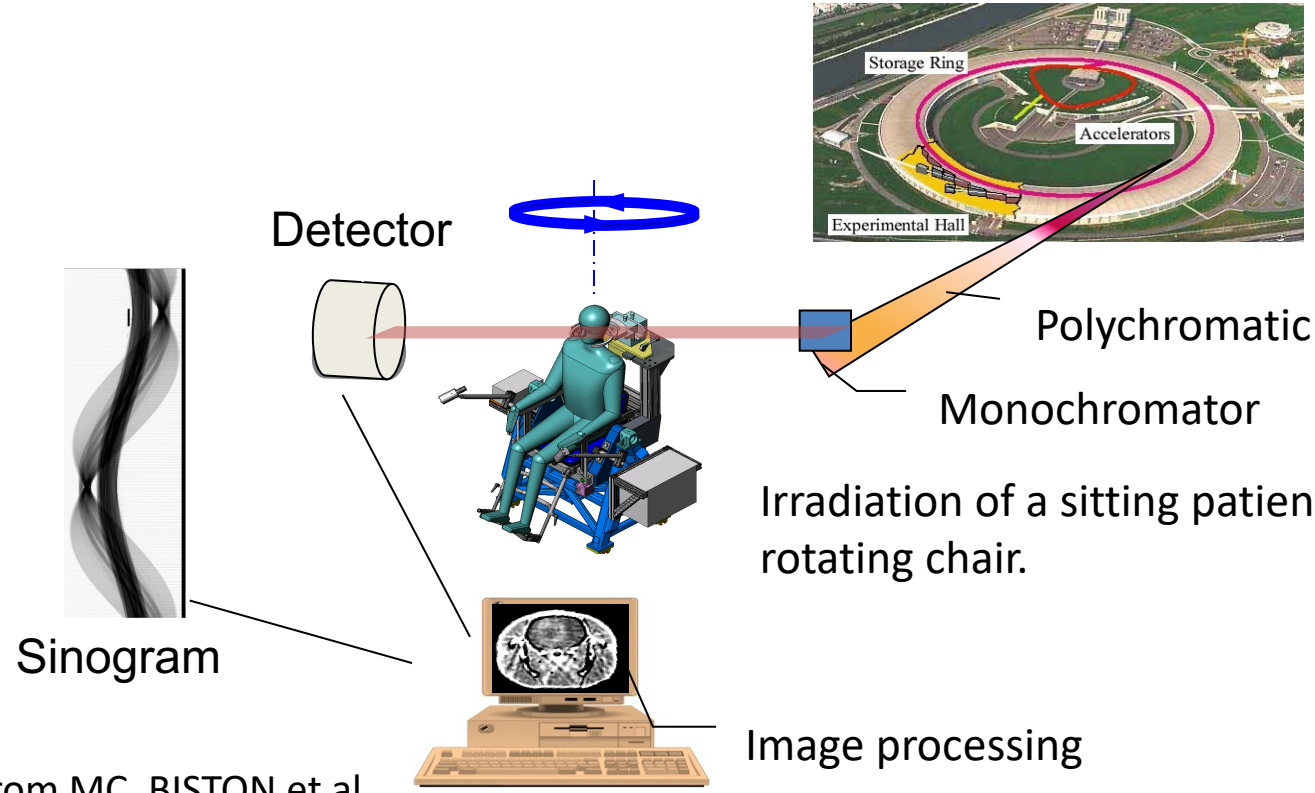
Feb 2024



May 2024, begining of the installation of the beam lines, here the first bend.

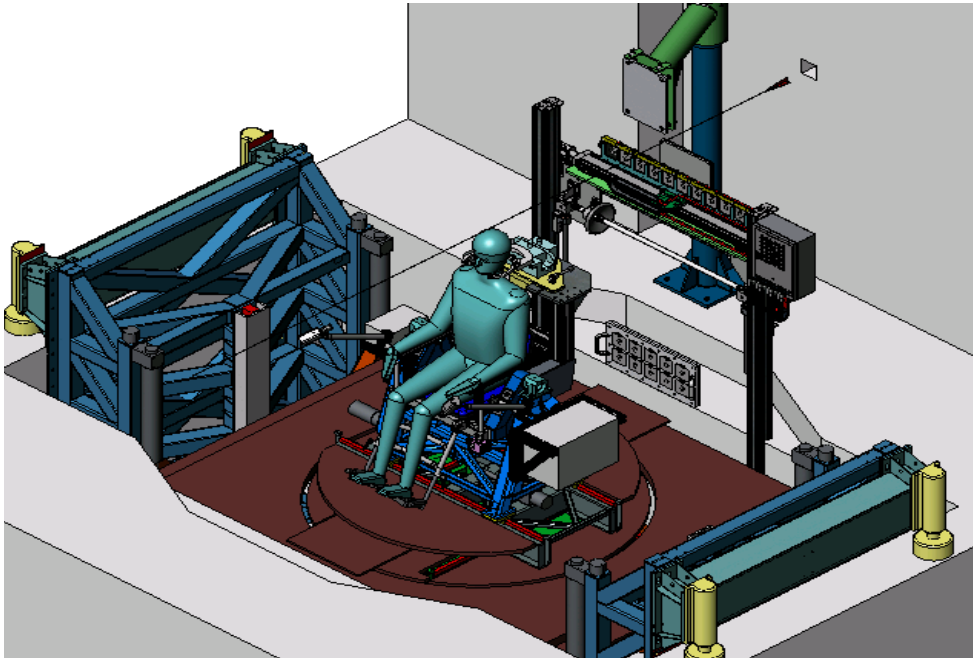


An originality of Grenoble: the ESRF used for monochromatic X-ray beam for experimental radiotherapy

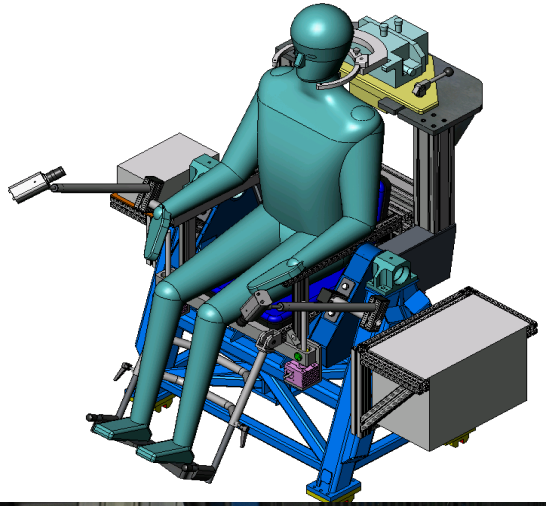


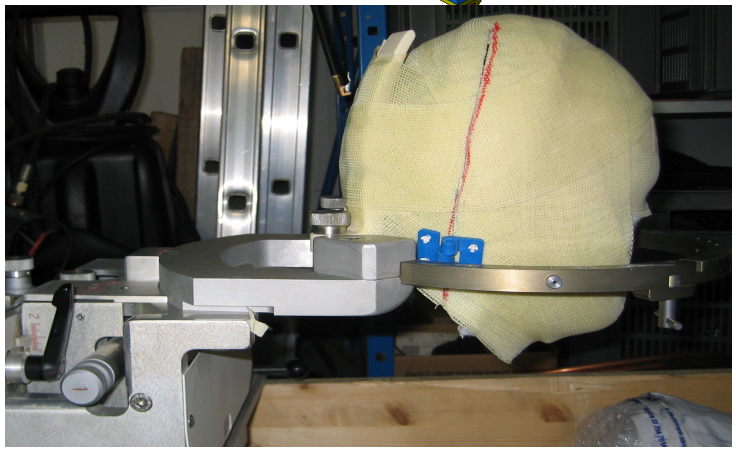
Redraw from MC. BISTON et al.

The patient holding system…



Technical set-up, patient safety

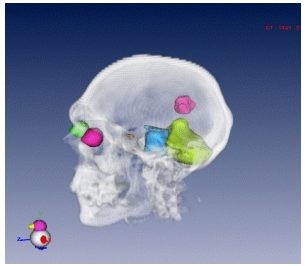


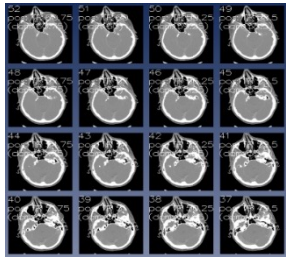


Patient head positionning system

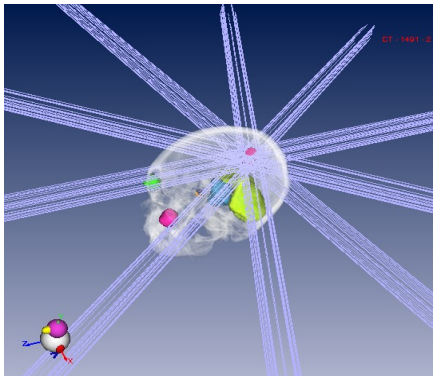
A specific MC calculation module has been introduced in the TPS for the SSRT clinical trials

Patient model and contouing made at the hospital on an SRT TPS

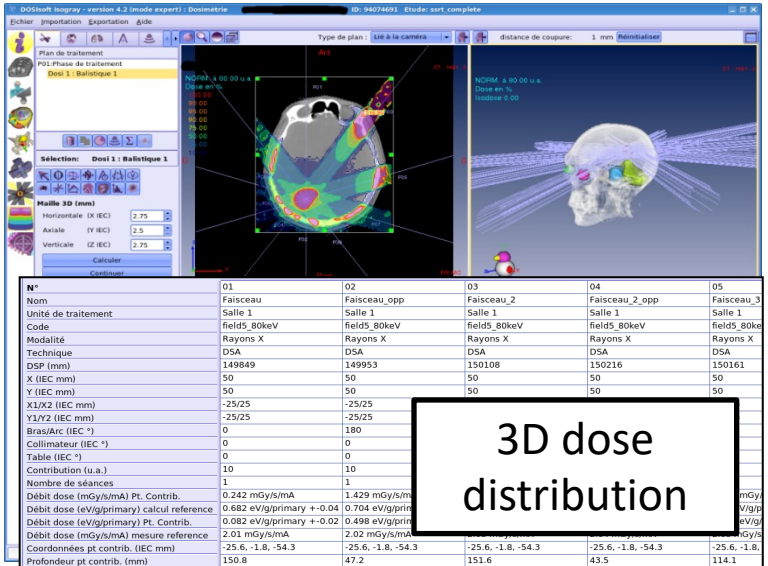




CT scan made at the hospital



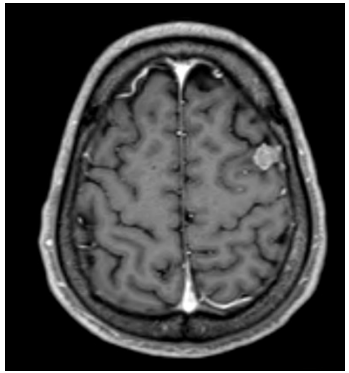
Irradiation plan calculated at ESRF

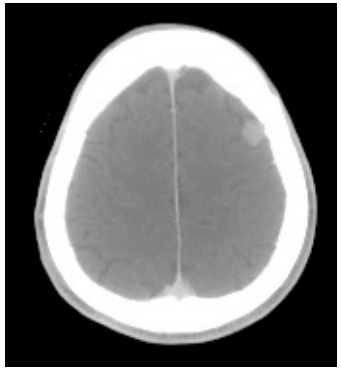


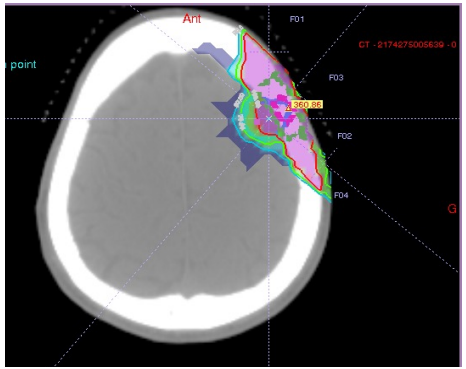
N°	01	02	03	04	05
Nom	Faisceau	Faisceau_opp	Faisceau_2	Faisceau_2_opp	Faisceau_3
Unité de traitement	Salle 1	Salle 1	Salle 1	Salle 1	Salle 1
Code	field5_80keV	field5_80keV	field5_80keV	field5_80keV	field5_80ke
Modalité	Rayons X	Rayons X	Rayons X	Rayons X	Rayons X
Technique	DSA	DSA	DSA	DSA	DSA
DSP (mm)	149849	149953	150108	150216	150161
X (IEC mm)	50	50	50	50	50
Y (IEC mm)	50	50	50	50	50
X1/X2 (IEC mm)	-25/25	-25/25			
Y1/Y2 (IEC mm)	-25/25	-25/25			
Bras/Arc (IEC °)	0	180			
Collimateur (IEC °)	0	0			
Table (IEC °)	0	0			
Contribution (u.a.)	10	10			
Nombre de séances	1	1			
Débit dose (mGy/s/mA) Pt. Contrib.	0.242 mGy/s/mA	1.429 mGy/s/m			
Débit dose (eV/g/primary) calcul reference	0.682 eV/g/primary +-0.04	0.704 eV/g/prim			
Débit dose (eV/g/primary) Pt. Contrib.	0.082 eV/g/primary +-0.02	0.498 eV/g/prim			
Débit dose (mGy/s/mA) mesure reference	2.01 mGy/s/mA	2.02 mGy/s/mA			
Coordonnées pt contrib. (IEC mm)	-25.6, -1.8, -54.3	-25.6, -1.8, -54.3	-25.6, -1.8, -54.3	-25.6, -1.8, -54.3	-25.6, -1.8,
Profondeur pt contrib. (mm)	150.8	47.2	151.6	43.5	114.1
Dose/séance pt contrib. (Gy)	1.375	1.375	1.375	1.375	1.375
Dose/séance indicative (Gy)	56.1306	6.6419	57.5722	8.9843	25.024
Nb s*mA par seance	5689.02 s*mA +- 1261.37	962.31 s*mA +- 97.09	6240.75 s*mA +- 1400.49	893.88 s*mA +- 87.27	3099.12 s*

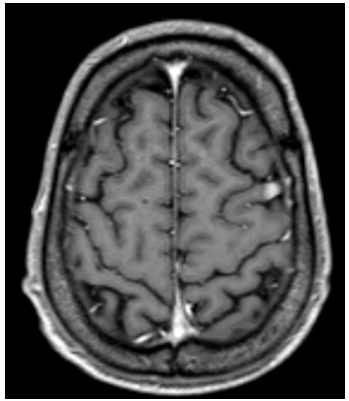
3D dose distribution

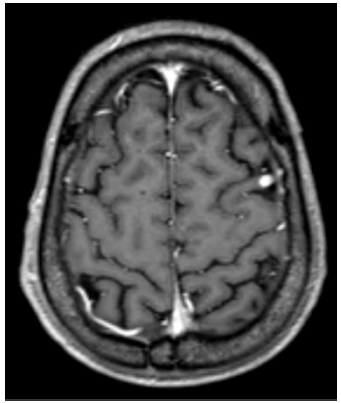
The first patients: patient n°6











Man 51 years old, with brain metastasis of invasive lung cancer (T4)
SSRT and conventional RxT
June 2013

MR follow-up 2 & 3 months later after SSRT and radiation therapy, at 9 months the lesion was not any more visible

Perspectives

- Increasing dose rates of electrons' LINAC for photon high dose rate radiotherapy: FLASH
- Decreasing investment and operating costs of protons and light ions accelerators for hadrontherapy
- Developing cost effective multi-ions accelerators
- May be developing very fast VHEE accelerators for *deep FLASH therapy*
- LASER acceleration ?

Thank-you for your attention, questions ?