Part II:
Back and forth beetween accelerators and an application

same cases of Particle Therapy

Here are the main slides used as support of the lecture
The main part of this part of the lecture was done on the dash board

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Summary of this part

- **Particle Therapy: rationale and history (quick remind)**
- **Time for patient and treatment (fews basics)**
- **Practical situations for:**
  - How providing beam to therapy users ?
  - Why synchro-cyclotron is back ?
  - some strange results observed after a radiobiology test on pencil beam scannning ?
  - Maintenance: same approach as radiation therapy ?

Particle Therapy
short rationale and history

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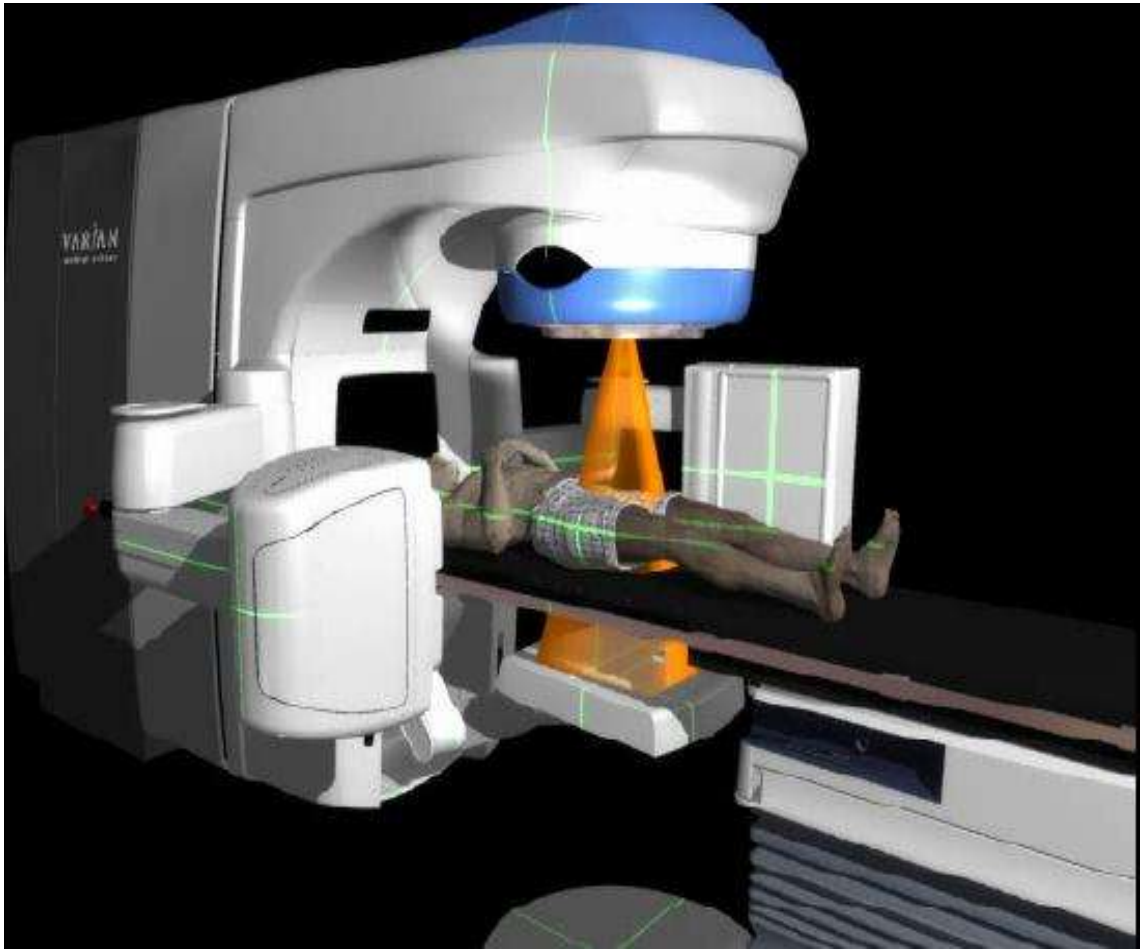
Radiation therapy (based en X or e^- 6-20 MeV)



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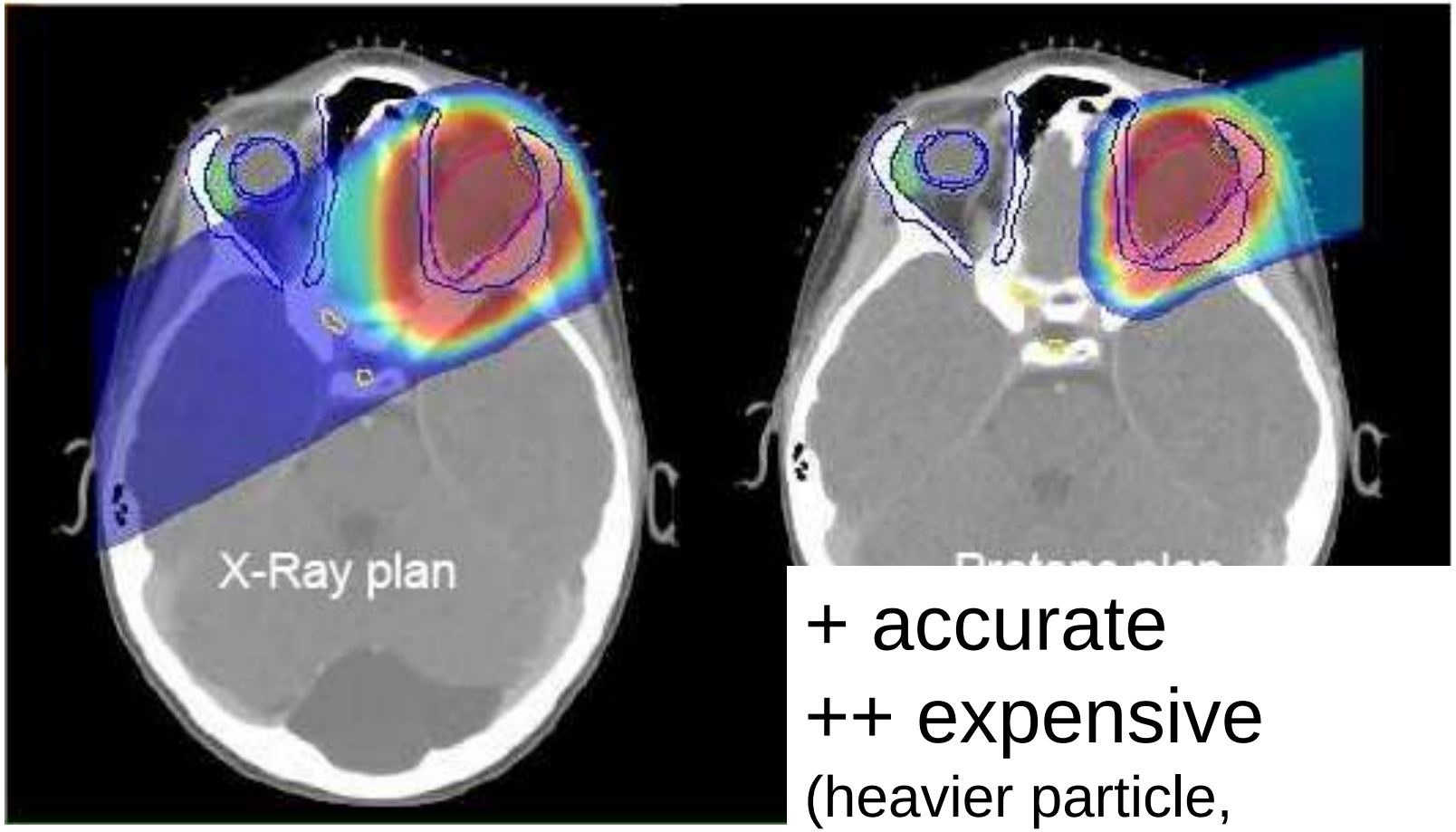
Radiation therapy with protons



+ accurate

++ expensive

(heavier particle,
more accurate treatment)

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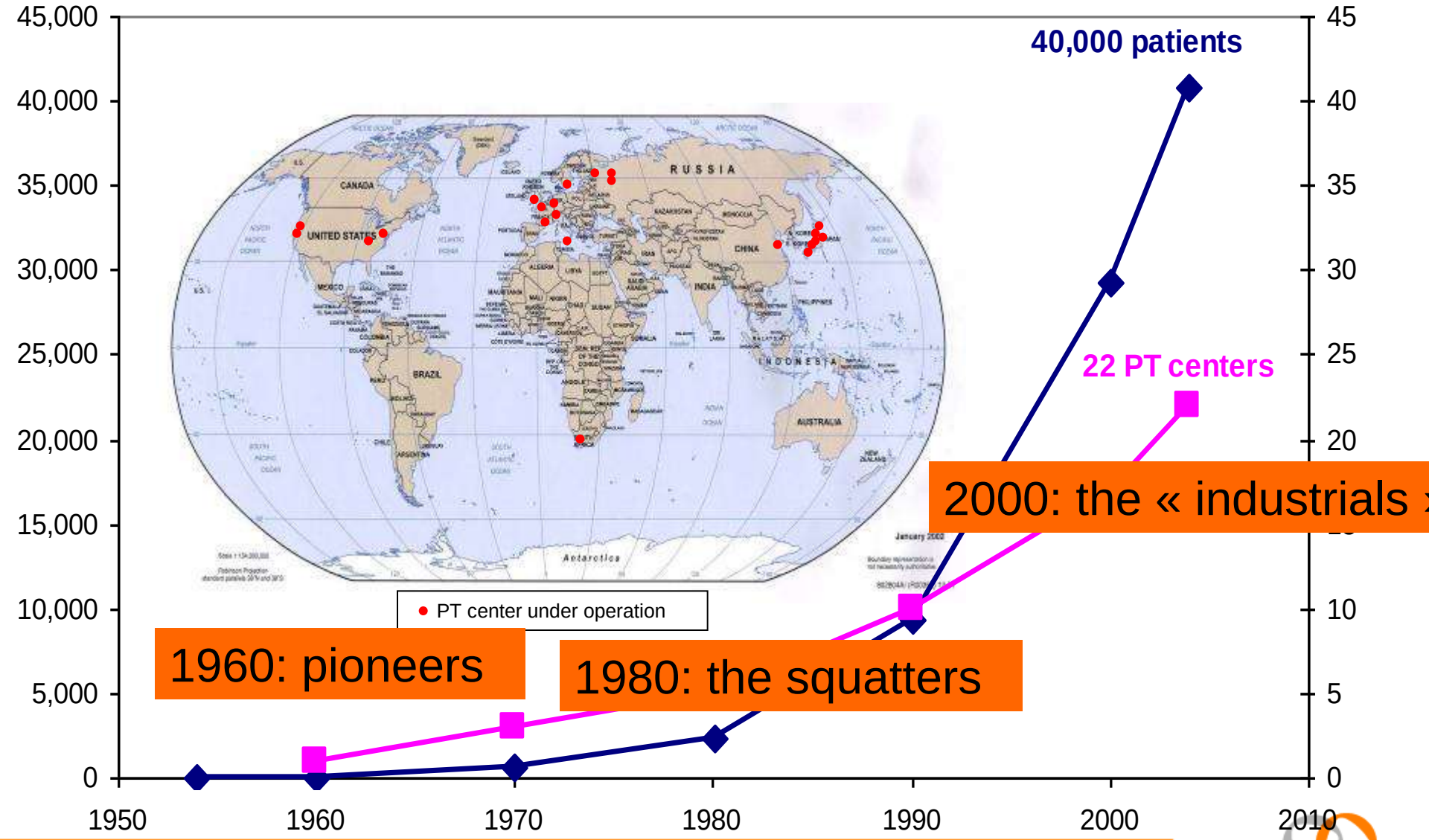
Protontherapy < 1% of radiation therapy



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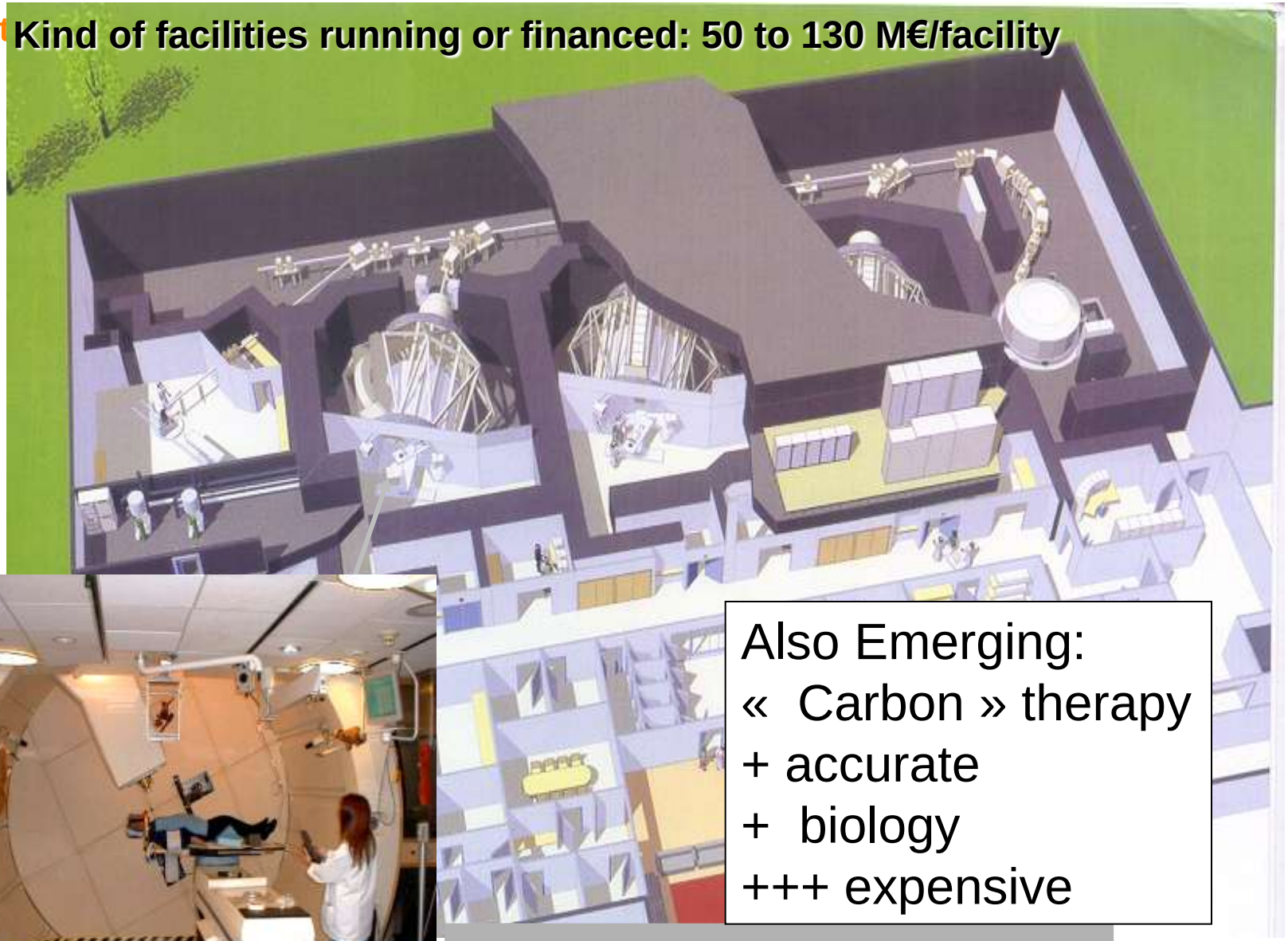
Kind of facilities running or financed: 50 to 130 M€/facility



Also Emerging:
« Carbon » therapy
+ accurate
+ biology
+++ expensive

6 companies offer turn-key centres

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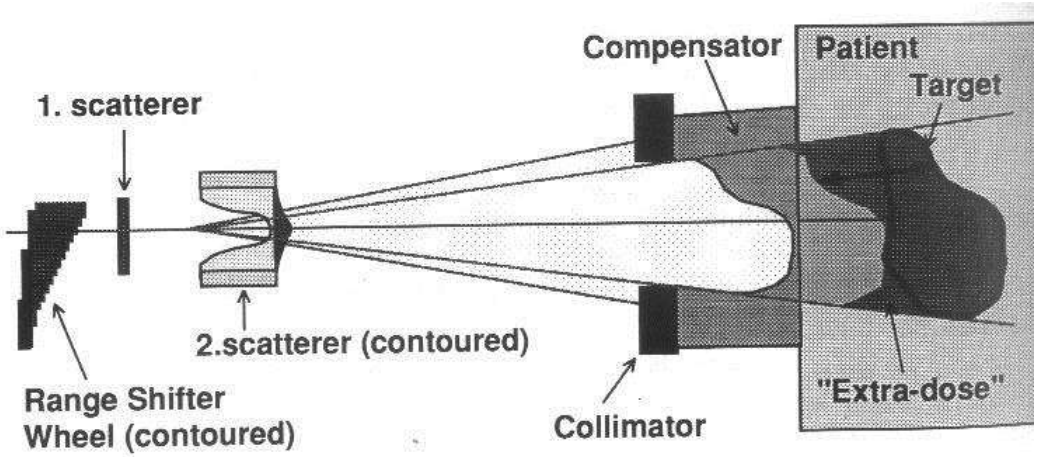
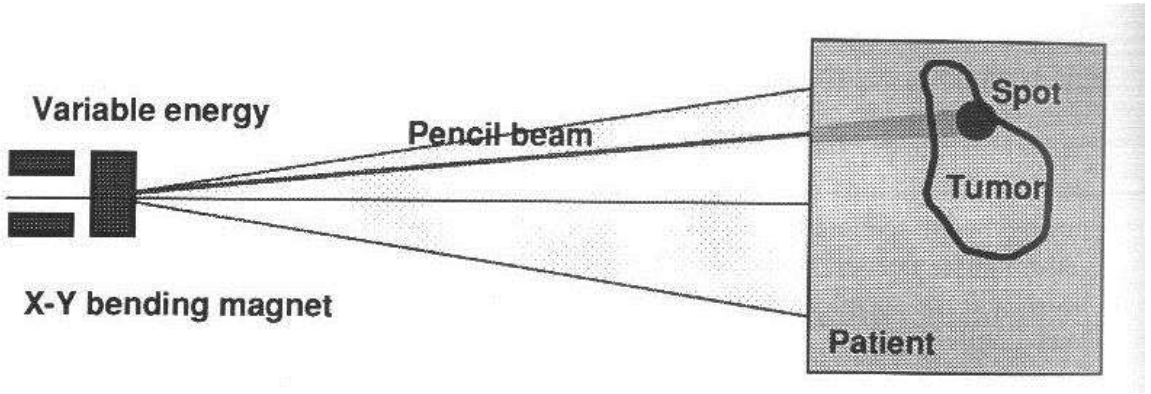
Beam shaping

Passive scattering



Active beam scanning



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Cycle of treatment

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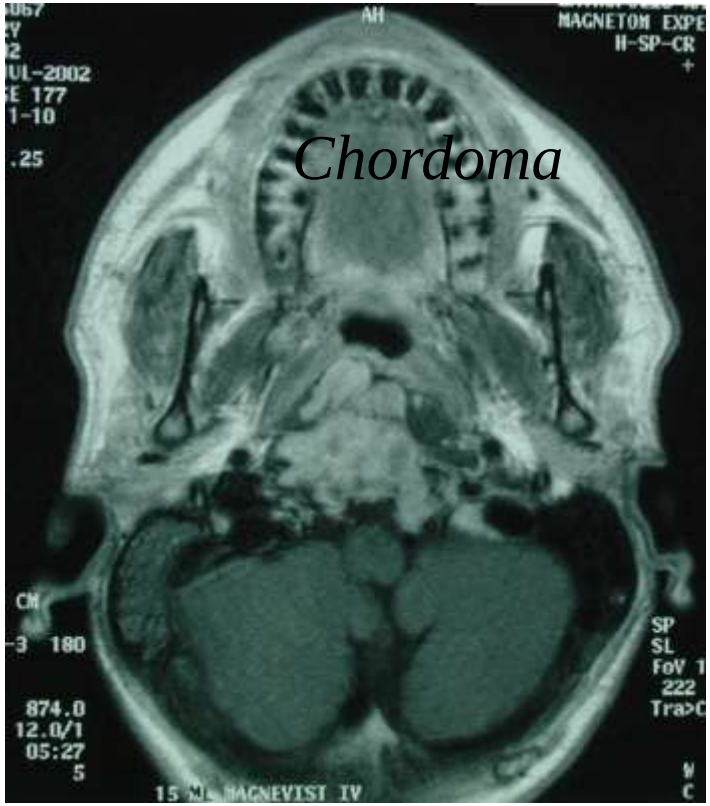
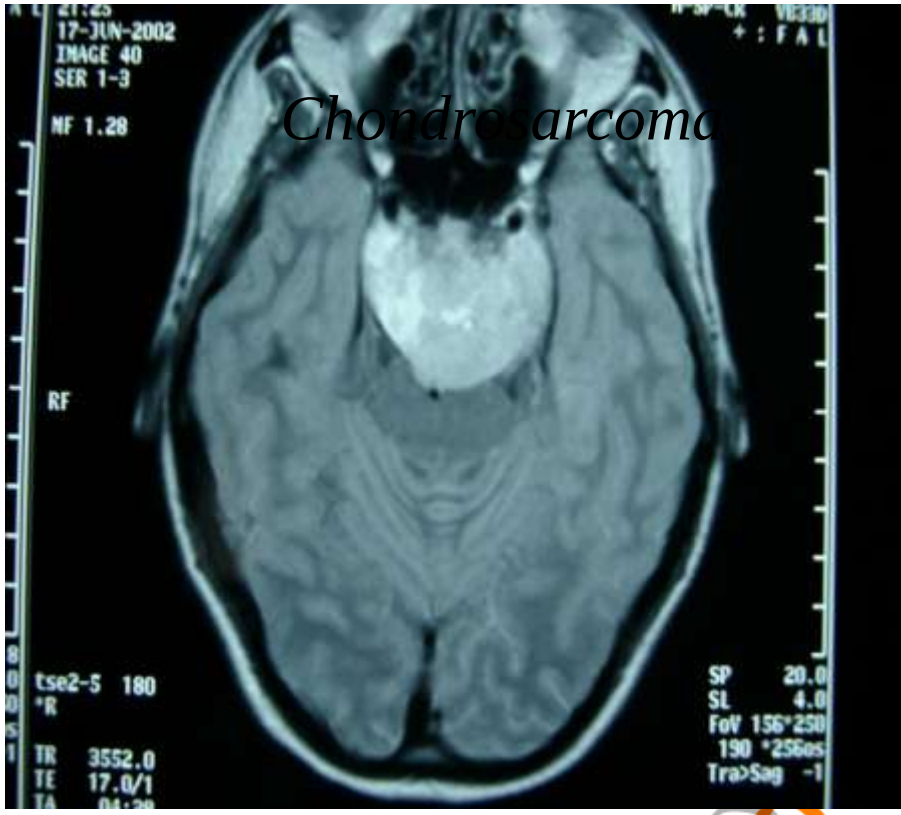
Example: sarcomas of skull base





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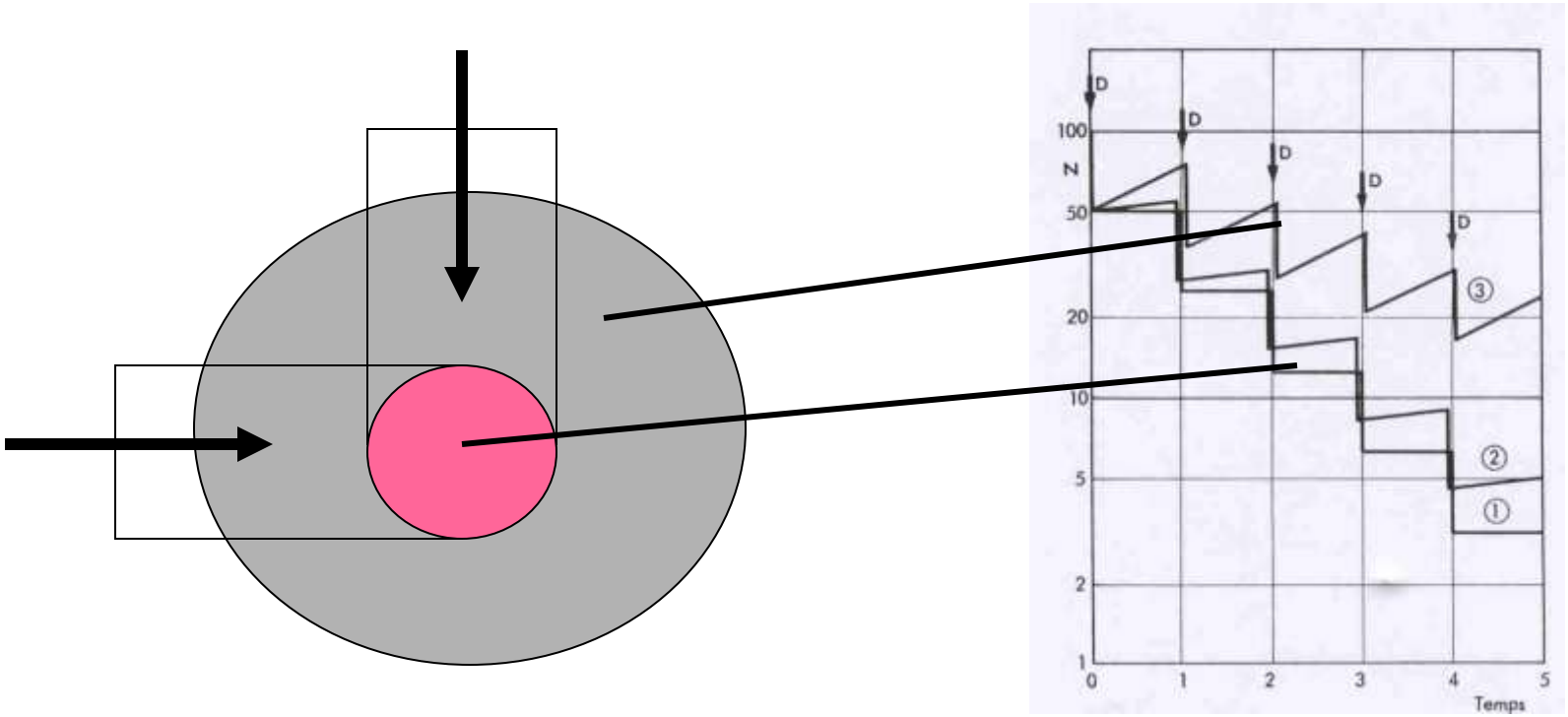
Basis of radiotherapy

1. Multi-porting

2. Fractionation
for differential effect
(typical: 2 Gy/day)



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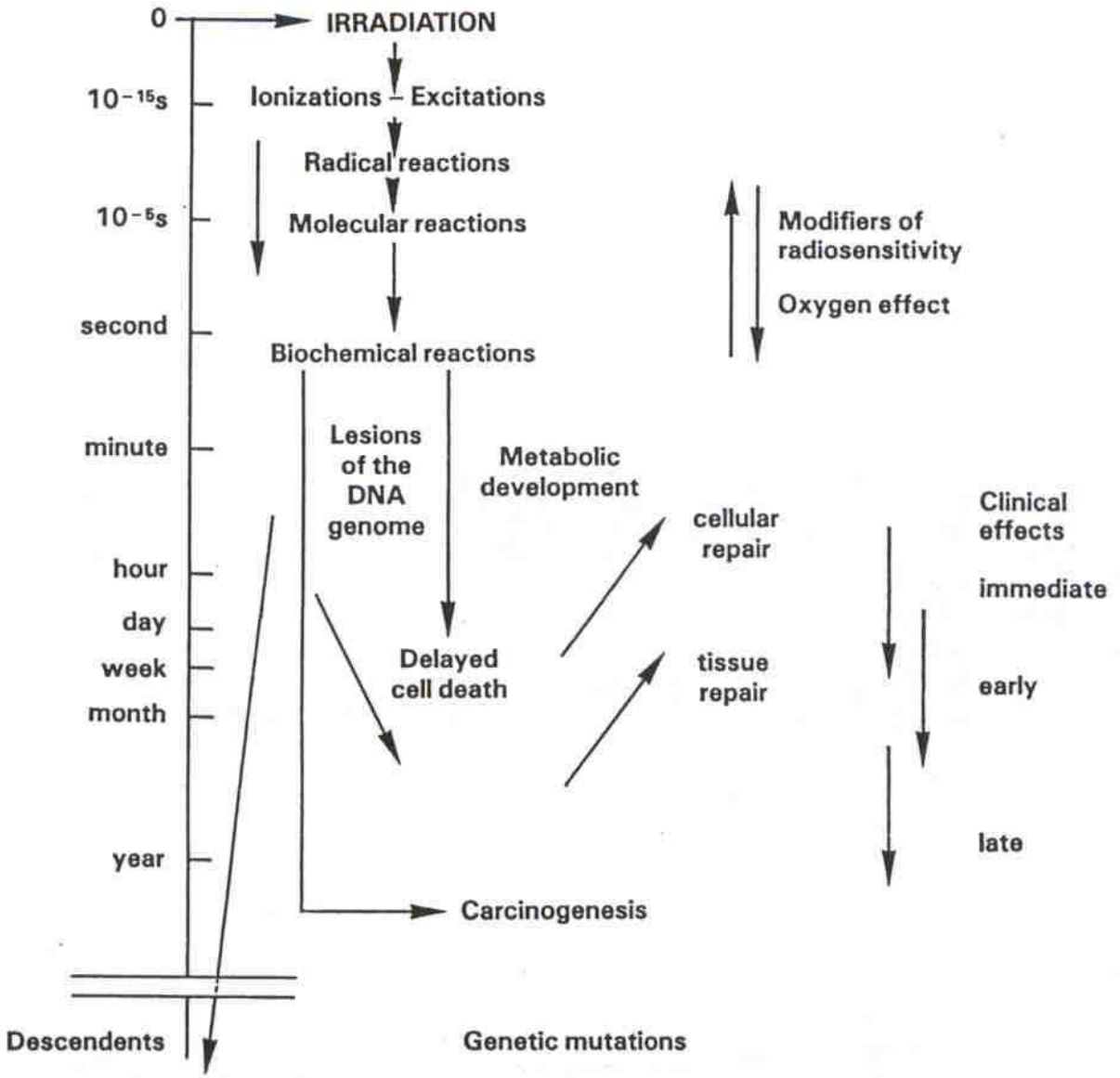
phenomena occurring after irradiation
(from J. Gueulette- Tubiana)



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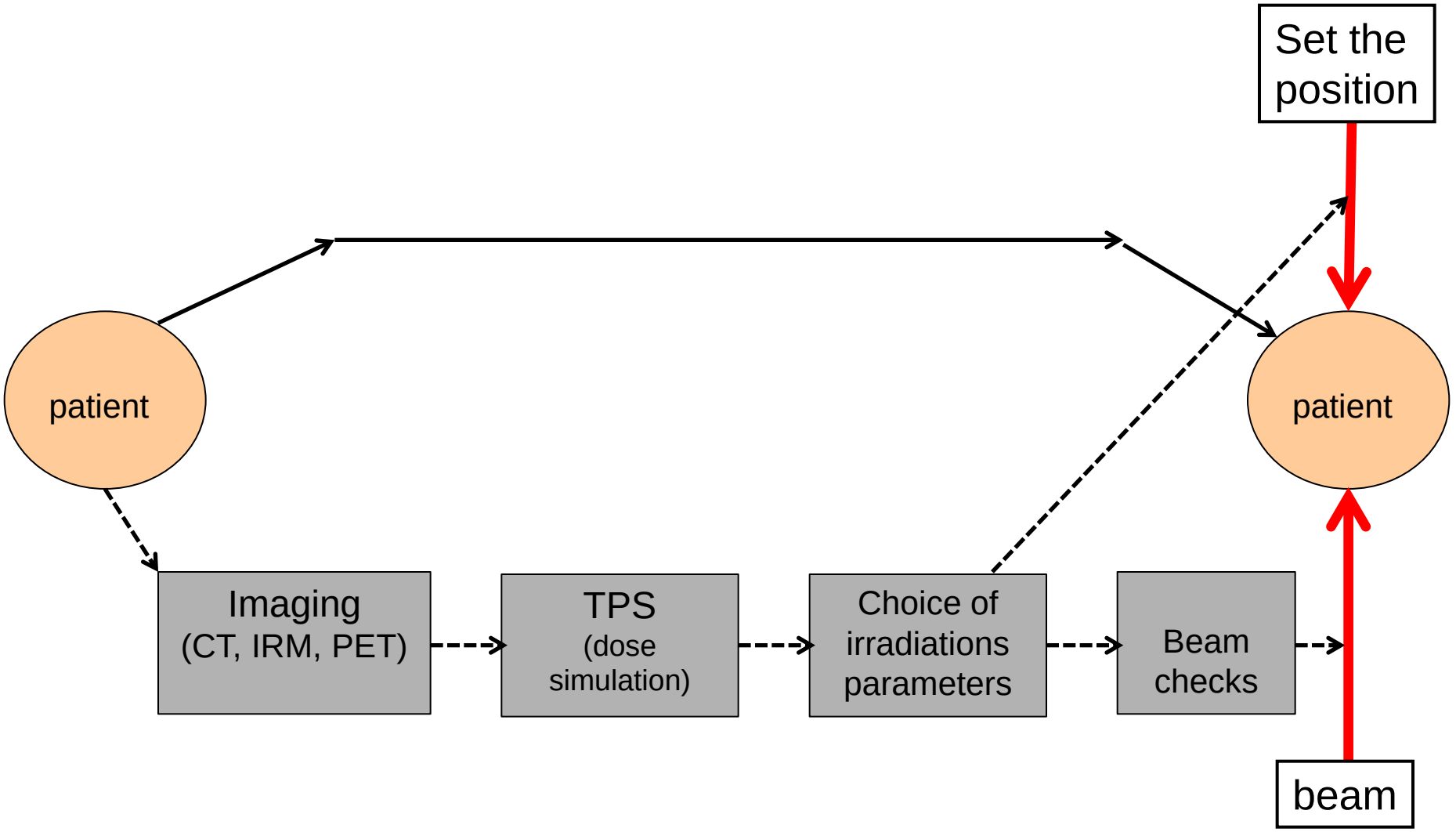

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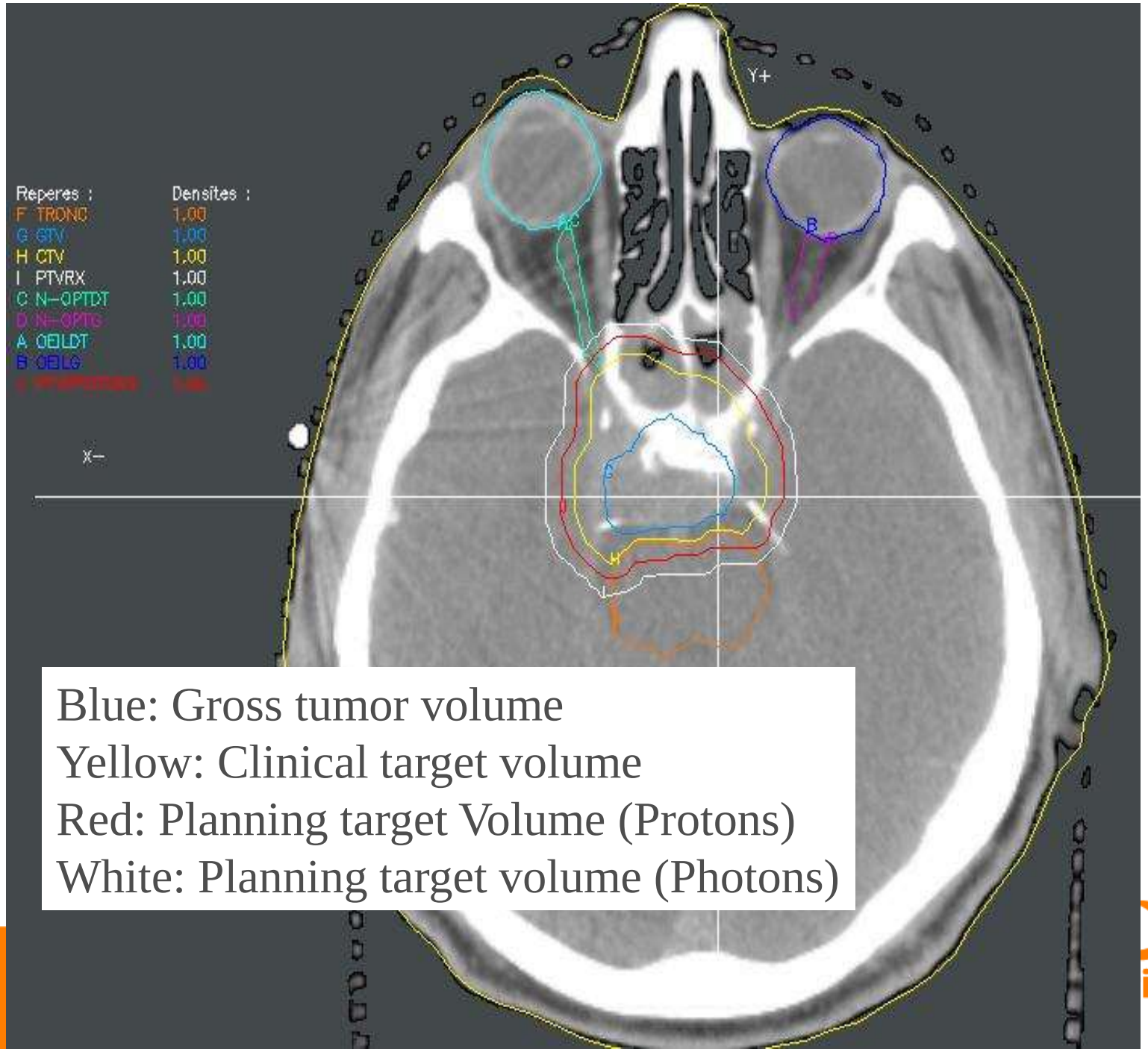
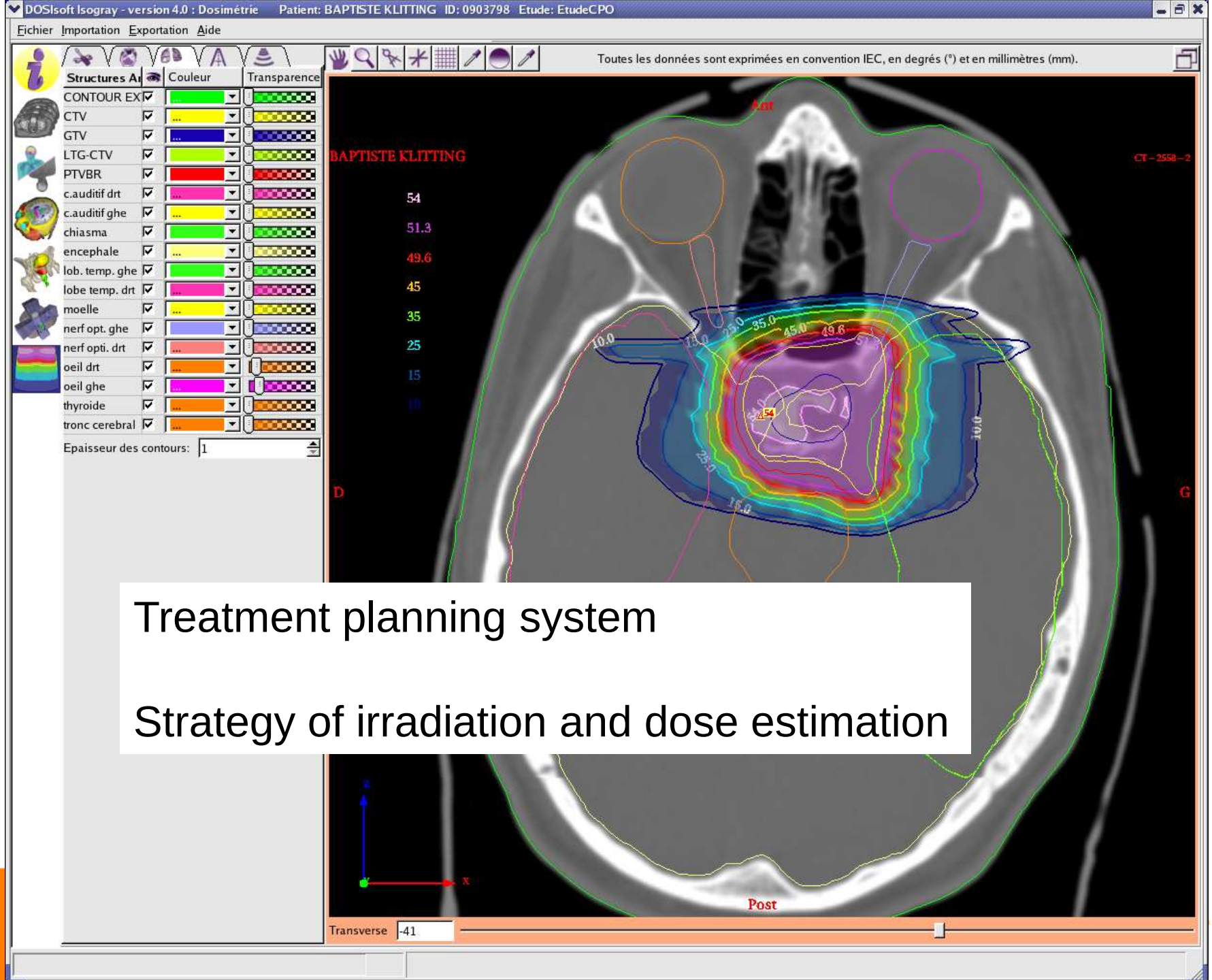
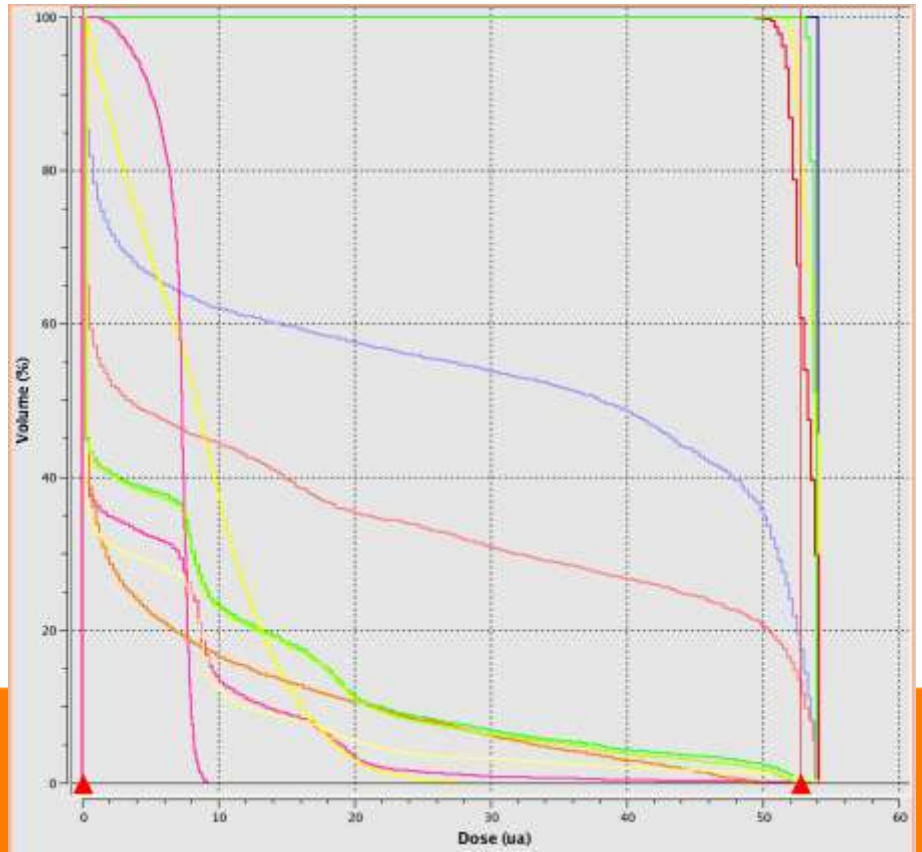


Blue: Gross tumor volume
Yellow: Clinical target volume
Red: Planning target Volume (Protons)
White: Planning target volume (Photons)


DOSIsoft Isogray - version 4.0 : Dosimétrie
Patient: BAPTISTE KLITTING ID: 0903798 Etude: EtudeCPO
Fichier Importation Exportation Aide
Structures Ar
Couleur
Transparence
CONTOUR EX
CTV
GTV
LTG-CTV
PTVBR
c.auditif drt
c.auditif ghe
chiasma
encephale
lob. temp. ghe
lobe temp. drt
moelle
nerf opt. ghe
nerf opti. drt
oeil drt
oeil ghe
thyroide
tronc cerebral
Epaisseur des contours: 1
Toutes les données sont exprimées en convention IEC, en degrés (°) et en millimètres (mm).
BAPTISTE KLITTING
54
51.3
49.6
45
35
25
15
10
Ant
Post
D
G
Transverse -41
Treatment planning system
Strategy of irradiation and dose estimation

	1	2	3	4	5	6	7	8	9	10
Structure	GTV	CTV	PTVBR	chiasma	nerf opt. ghe	nerf opti. drt	lob. temp. ghe	lobe temp. drt	c.auditif ghe	c.auditif drt
Vol. Géom. (cm3)	1.5	13.4	22.3	0.2	0.9	0.9	115.8	126.2	0.5	0.5
Points Aléatoires	2187	2793	2964	1746	2067	2067	3640	3683	1958	1956
Dose Min. (u.a.)	53.86	50.86	49.08	52.85	0.00	0.00	0.00	0.00	0.11	1.03
Dose Max. (u.a.)	54.06	54.10	54.10	53.99	53.82	53.93	53.55	53.10	28.31	9.23
Dose Med. (u.a.)	53.99	53.62	53.04	53.60	37.76	3.09	0.01	0.00	8.30	7.29
Dose Moy. (u.a.)	53.99	53.36	52.91	53.57	28.53	18.01	7.17	4.06	8.47	6.89
Ecart Type	0.03	0.66	0.92	0.25	23.05	21.82	12.17	6.93	5.50	1.32
Borne Dose Min. (u.a.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Borne Dose Max. (u.a.)	52.70	52.70	52.70	52.70	52.70	52.70	52.70	52.70	52.70	52.70
Vol. sélection (cm3)	0.0	2.8	9.4	0.0	0.7	0.8	115.3	126.2	0.5	0.5
Vol. sélection (%)	0.0	21.0	42.0	0.0	83.8	88.3	99.5	99.9	100.0	100.0



11	12	13	14	15
oeil drt	oeil ghe	tronc cerebral	encephale	LTG-CTV
7.0	6.1	25.2	1465.6	113.7
2592	2554	3007	5754	3631
0.00	0.00	0.00	0.00	0.00
0.00	0.00	50.08	54.01	52.70
0.00	0.00	0.04	0.00	0.01
0.00	0.00	5.11	4.35	6.92
0.00	0.00	10.80	9.11	11.70
0.00	0.00	0.00	0.00	0.00
52.70	52.70	52.70	52.70	52.70
7.0	6.1	25.2	1457.5	113.7
100.0	100.0	100.0	99.4	100.0

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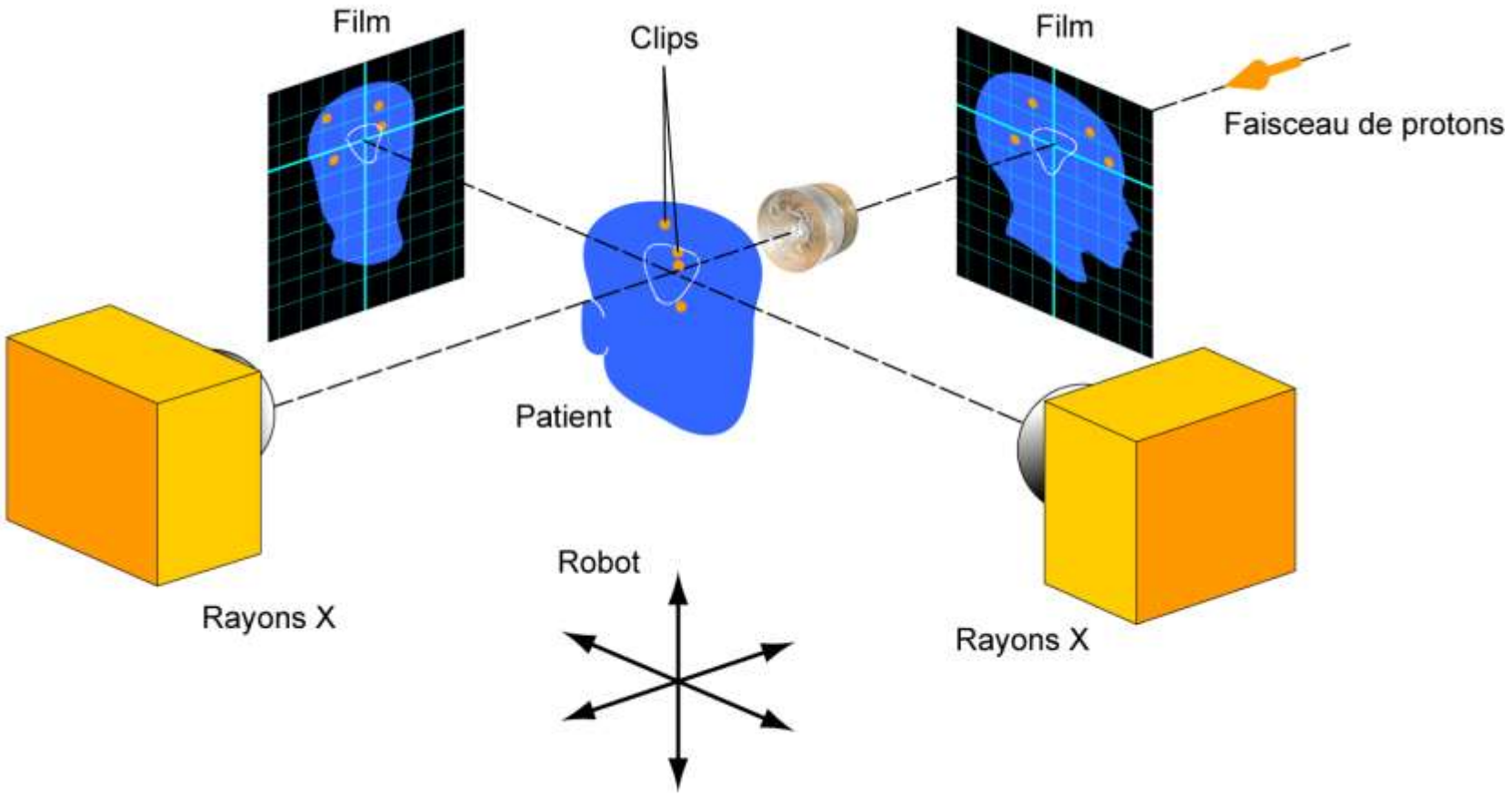
Patient positionning



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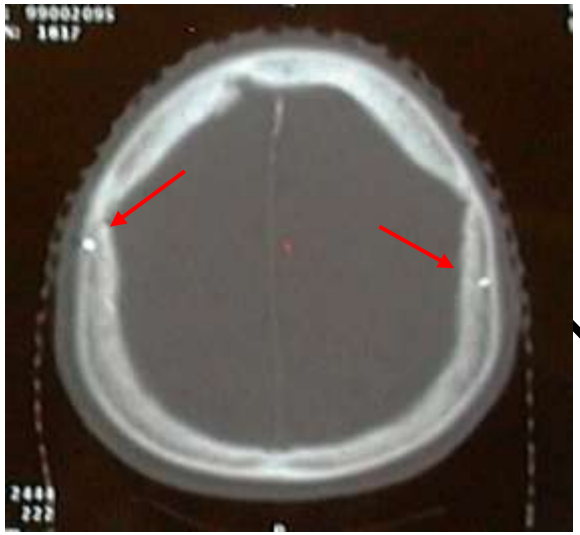
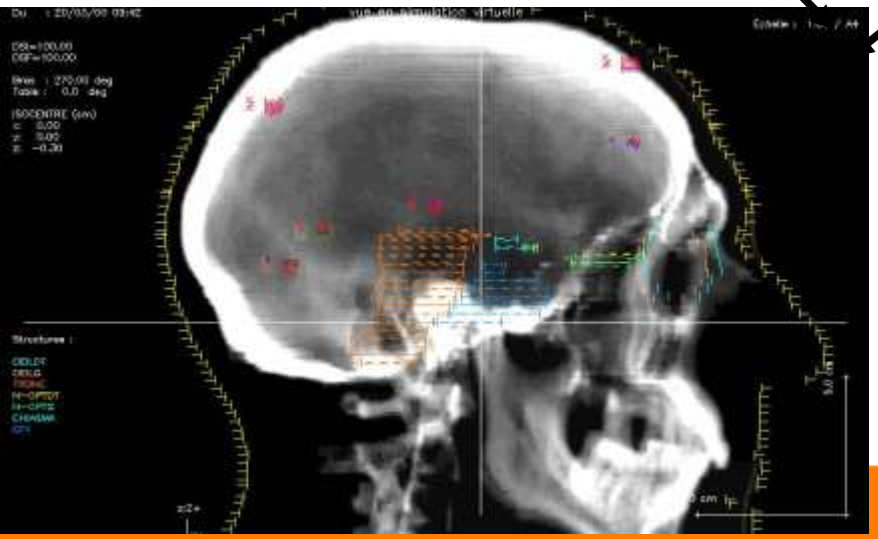
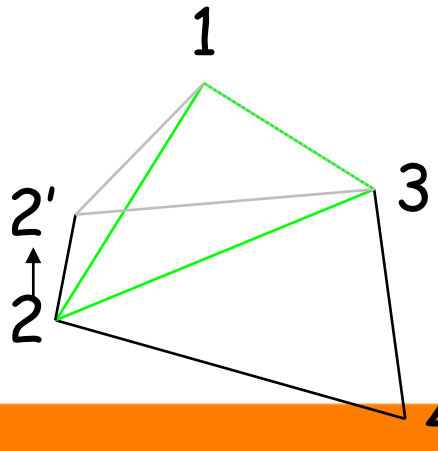
Stereotactic alignment: daily set-up







« Rotaplus » program:
-Virtual triangles between gol seeds (DRRs)...

-Compared with actual positio orthogonal X-Rays

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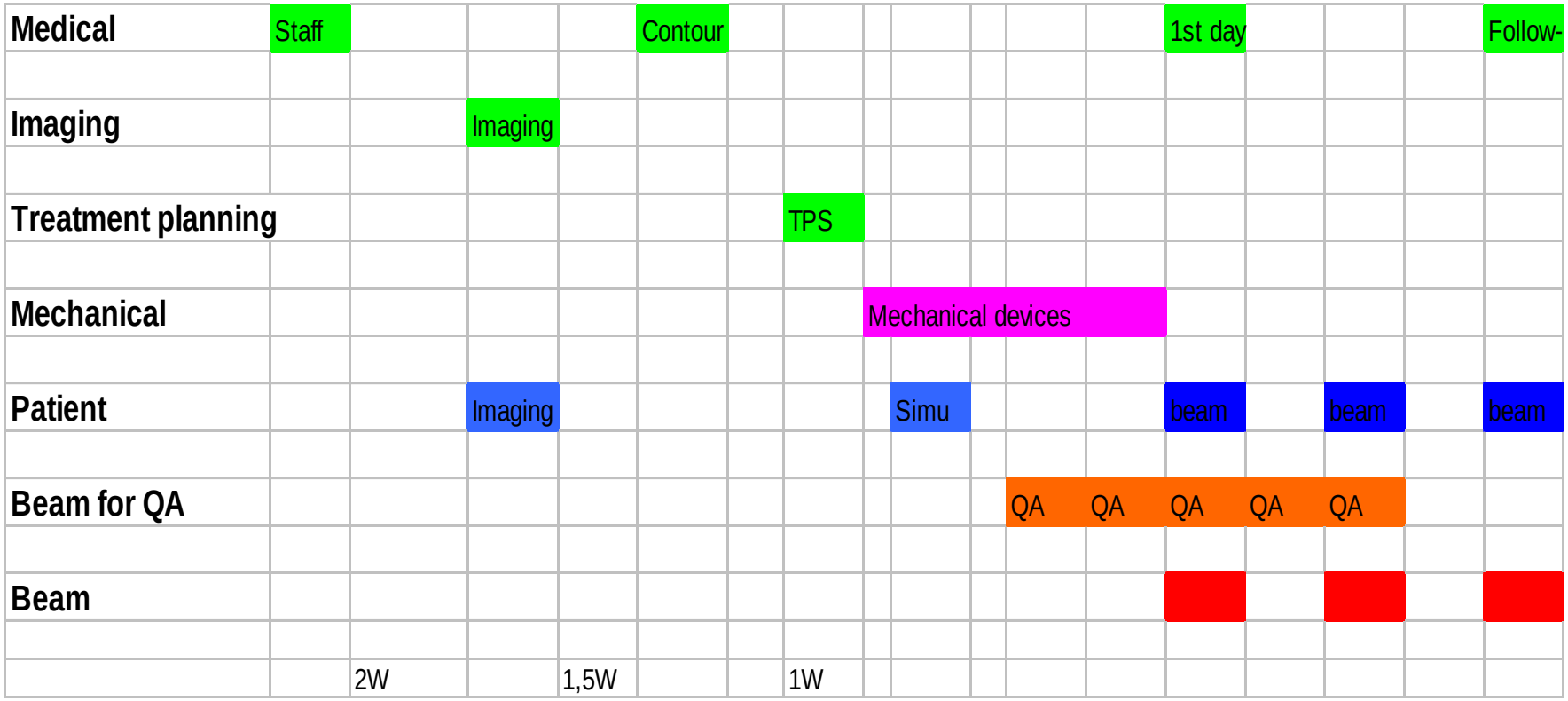
Preparation and treatment



« W » = 1 week

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Time for patient and treatment (radiation therapy)

Each session (daily) is a 2 Gy fraction
(1 min for beam, 20 min for positioning)

The duration of the preparation process (imaging, TPS, …) is beetween 2 and 6 weeks

Duration of a treatment is typically 6 weeks

The classical parameters of follow-up are local control and survival rate

« Scientific » results are considered for a minimum of 5 years of follow-up

For accelerator: therapy is a long-term process
i.e. reliability and workflow

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Providing beam for treatment

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That are the questions

Properties of the beam	Needs	Beam production device 1	Beam production device 2	…
Range				
(acuracy)				
Intensity				
(acuracy)				
Shape&position				
(accuracy)				

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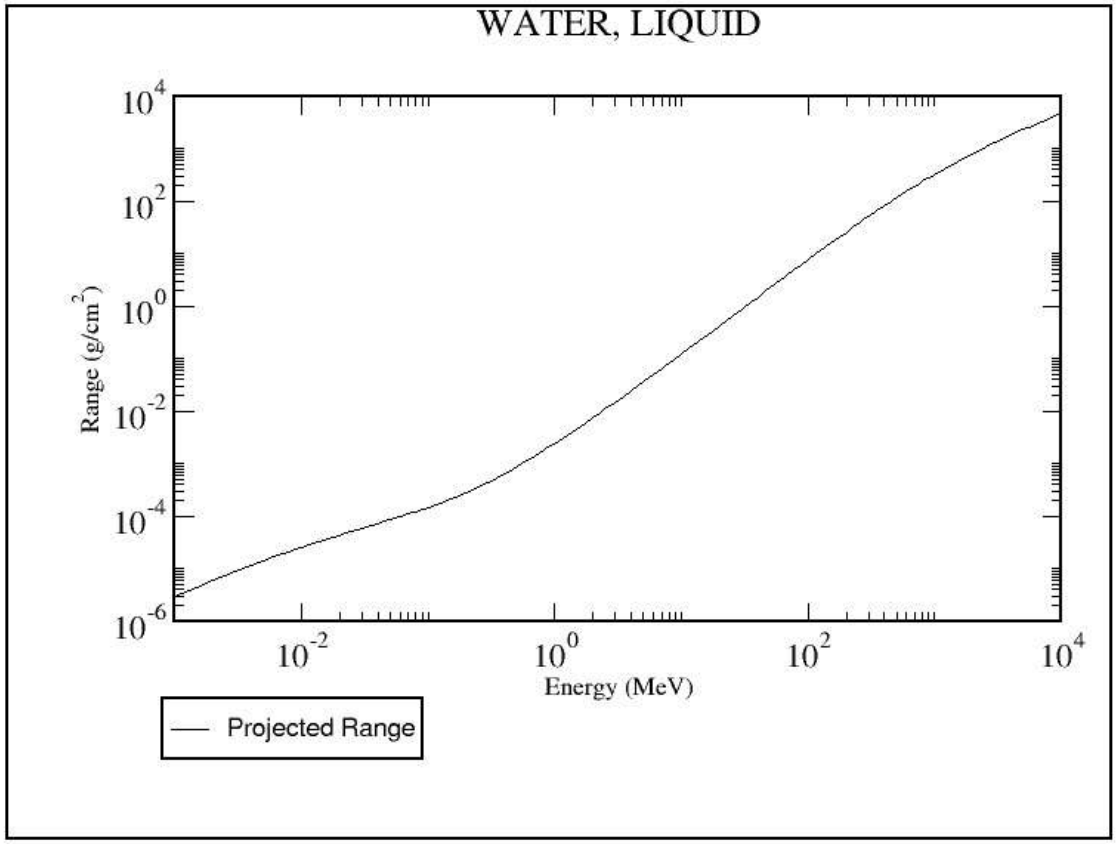
http://physics.nist.gov/PhysRefData/Star/Text/PSTAR.html

PSTAR : Stopping Power and Range Tables for Protons



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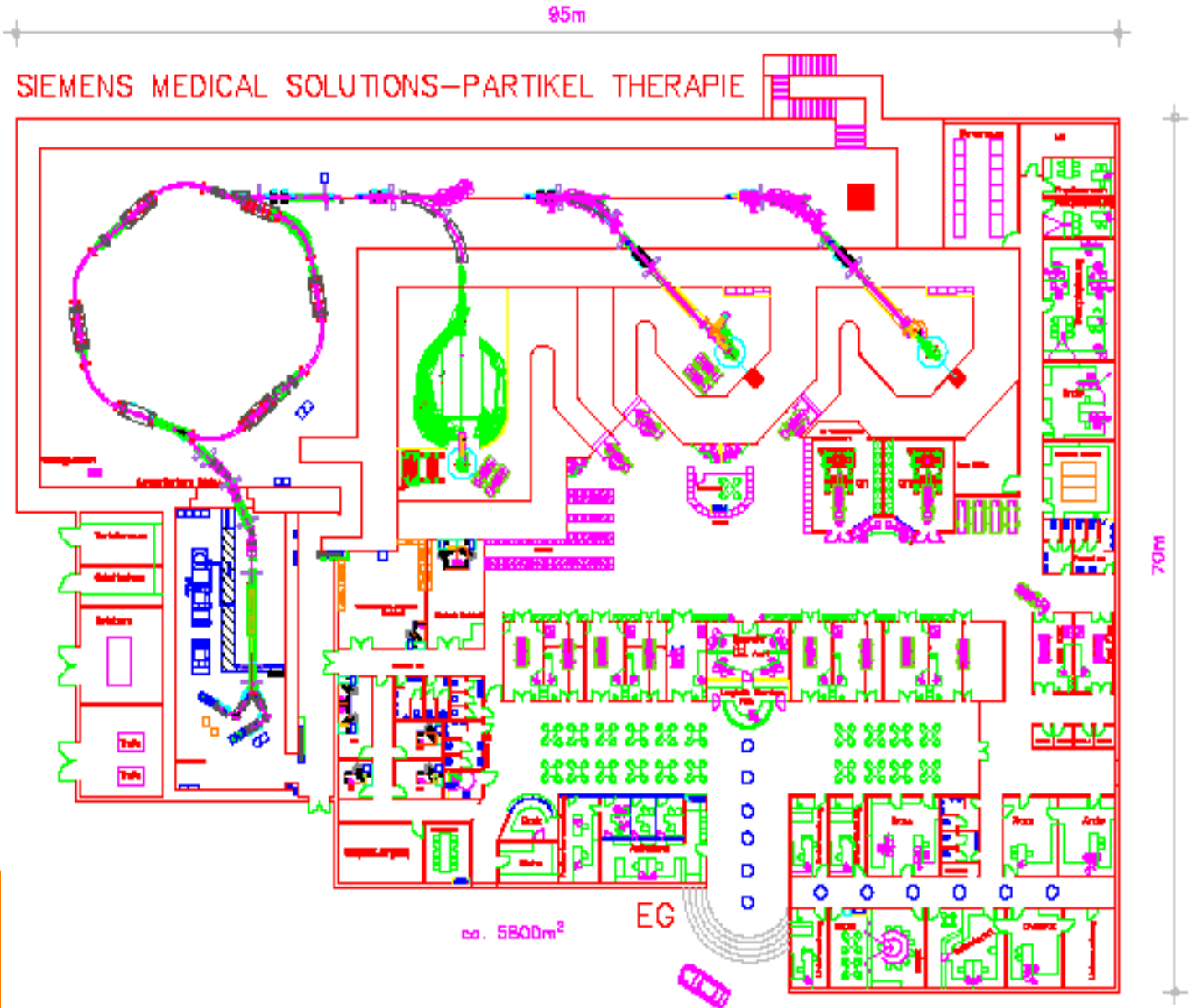
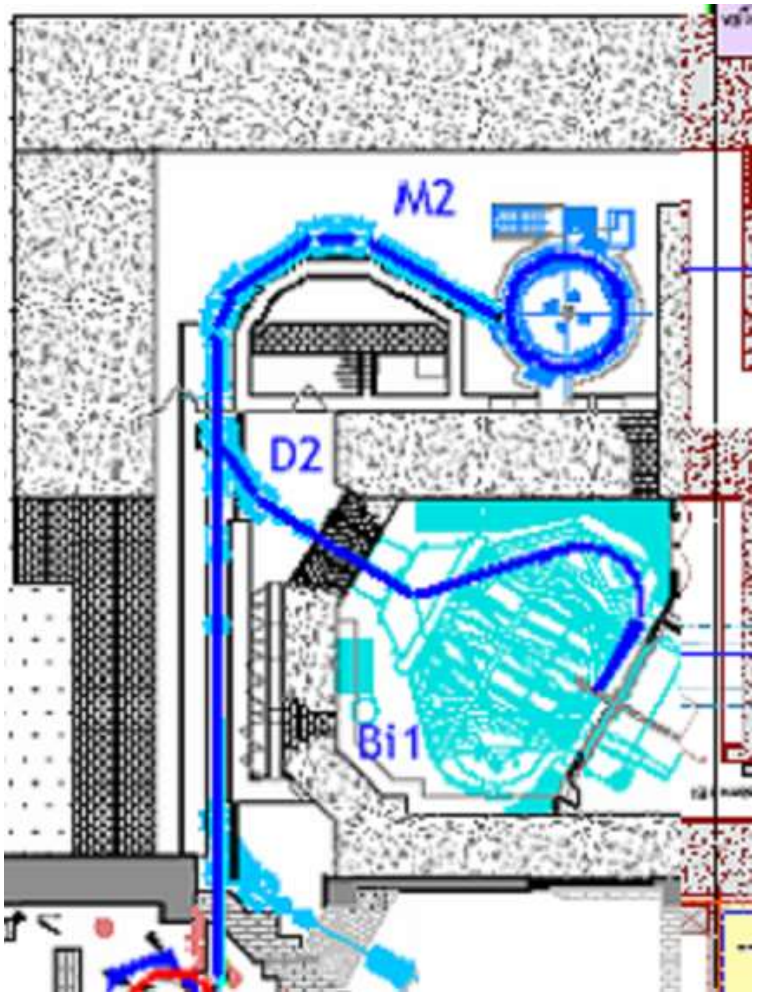
Case of a synchrotron (Siemens, Hitachi, Mitsubishi)



Case of a cyclotron + Energy Selection System (IBA, Varian)



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Properties of the beam	Needs	By synchrotron	By cyclotron + energy selection system
Range	32 cm (230-250 MeV)	Last magnetic field	B. Ro for cyclotron + Magnetic field of ESS
(acuracy)	<0,2%	Of the field (easy)	B. Ro + slits (easy)
Intensity	0- 10 nA	0-100nA (ion source+extraction) Difficult for small	0-500nA (ion source+extraction) stable
(acuracy)	+/- 5% Or ++ for PBS	Tuning of both difficult	Easy To be tuned …
Shape&position	1. Passive 2. Scanning	1. Easy, No strong links with machine 2. Beam transport + scanning magnets	
(accuracy)	1. Medium 2. high	Linked with extraction	mainly linked with ion source

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Time for the beam

Duration of a treatment (passive): 1 minute

active scanning: 1 - 10 minutes

95% of the beam is for Beam tuning and QA of the fields

The micro and macro structure of the beam has no signficant effect on the radiobiology consideration (in protontherapy)

Energy is, by design (almost), a stable parameter

Control of the current is one the challenge for novel techniques

Why synchro-cyclotron is back ?

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Some strange results observed after a radiobiology test on pencil beam scannning

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Modifying or not the design of a standard

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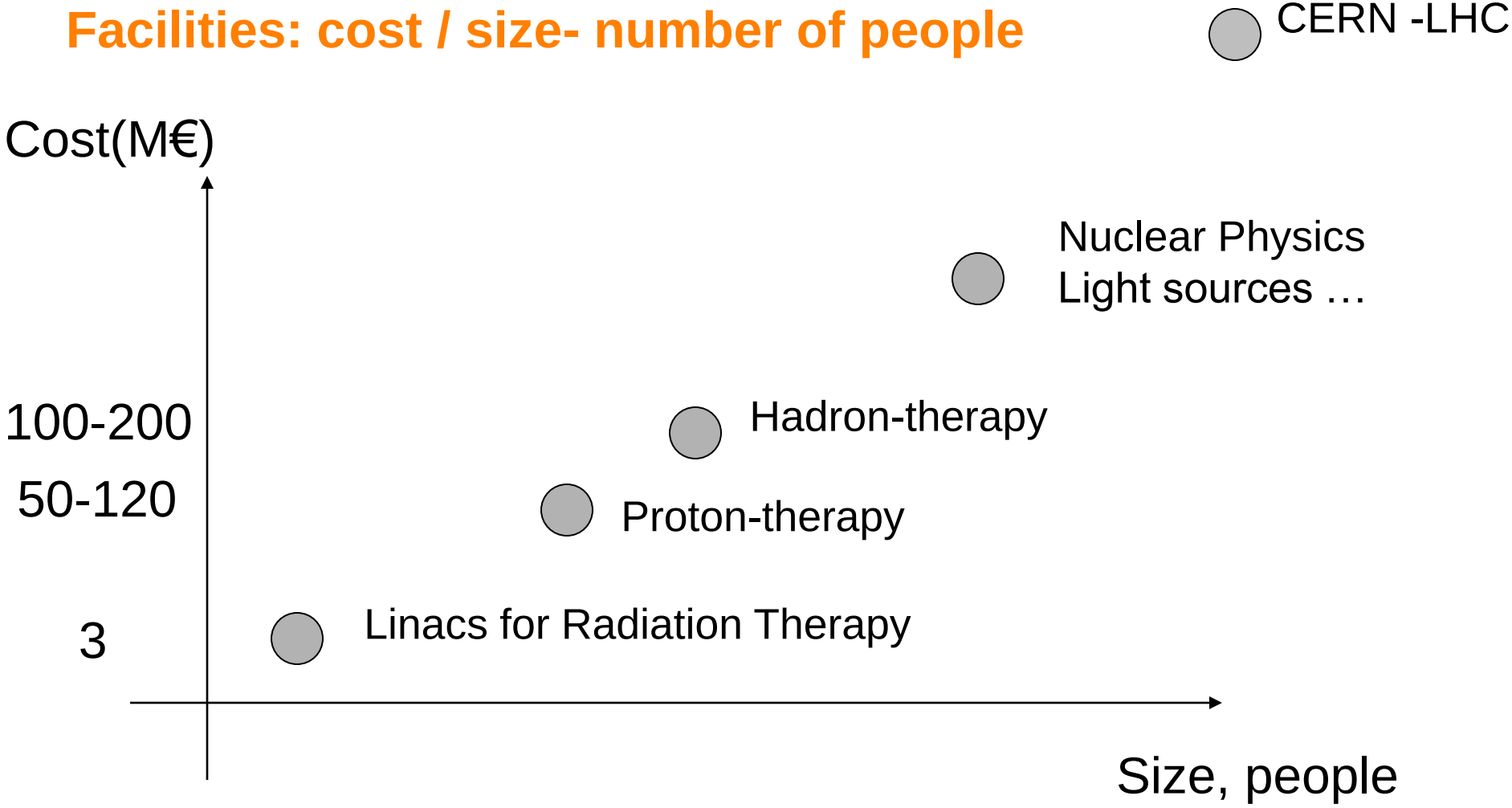
Facilities: cost / size- number of people



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Maintenance and radiation therapy

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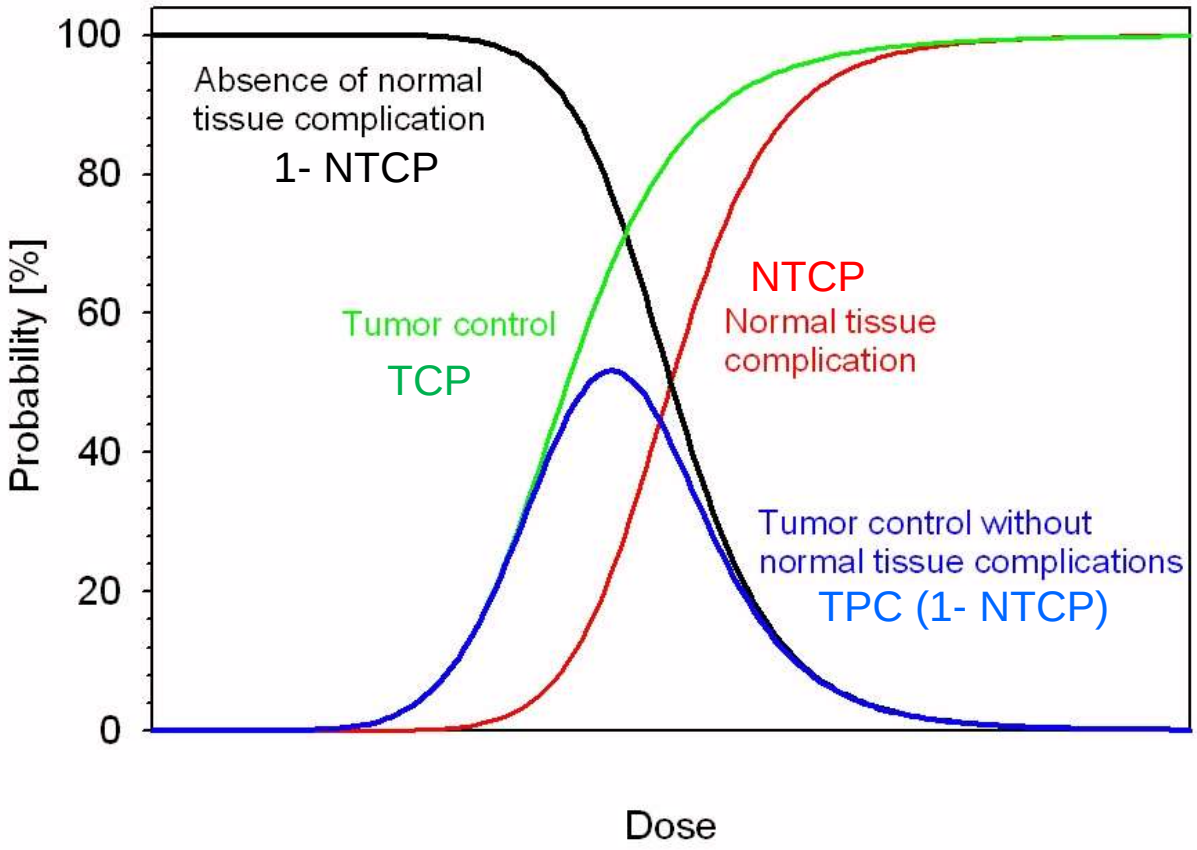
Quantification of the control without complications



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Model of decision

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Henry Mintzberg: different kinds of coordination

- **Mutual adjustment**
- **Direct supervision**
- **Standardization of work processes**
- **Standardization of outputs**
- **Standardization of skills**
- **Standardization of norms**

Thank you for your attention

Questions ?

More about protontherapy @ http://ptcog.web.psi.ch/

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