Some issues on reliability and project of a proton-therapy facility ?

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Centre de Protonthérapie – Orsay

JUAS 2013

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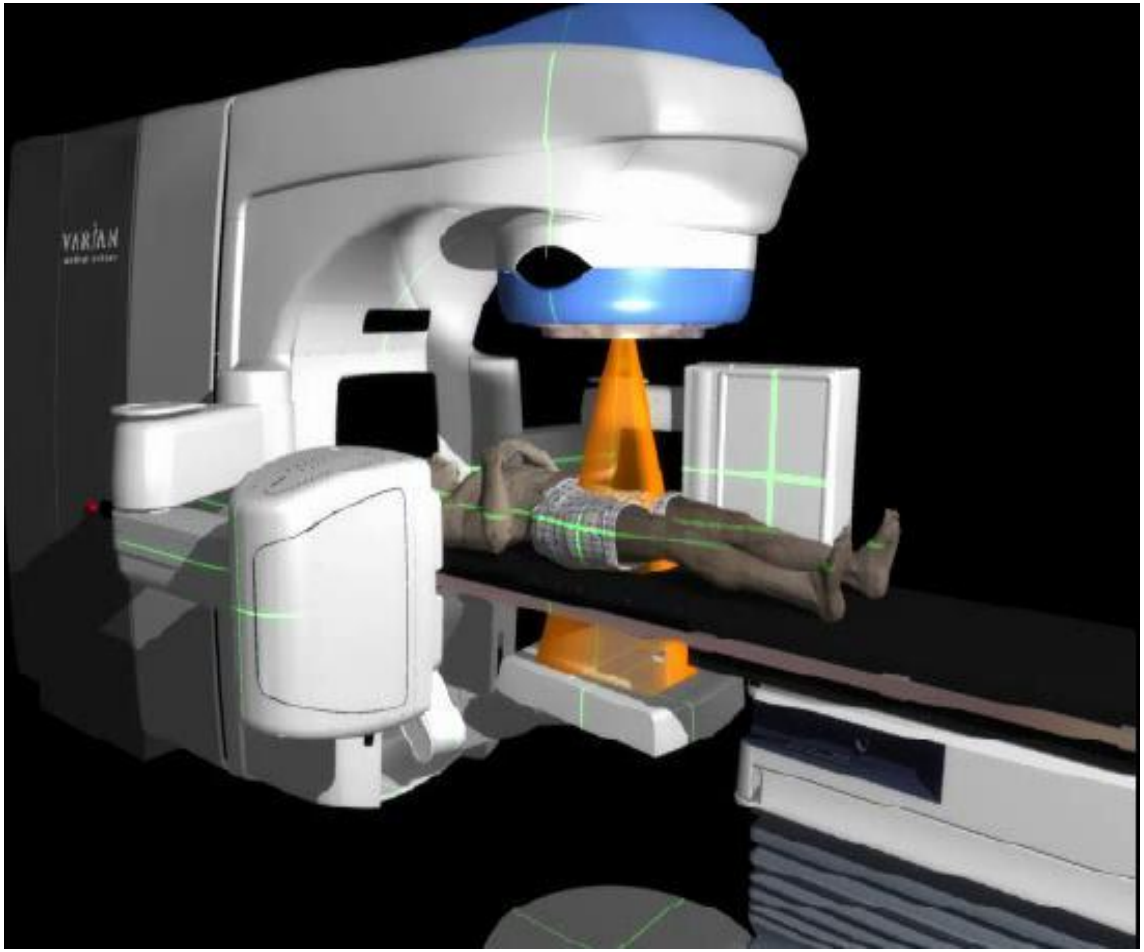
Radiation therapy (based en X or e^- 6-20 MeV)



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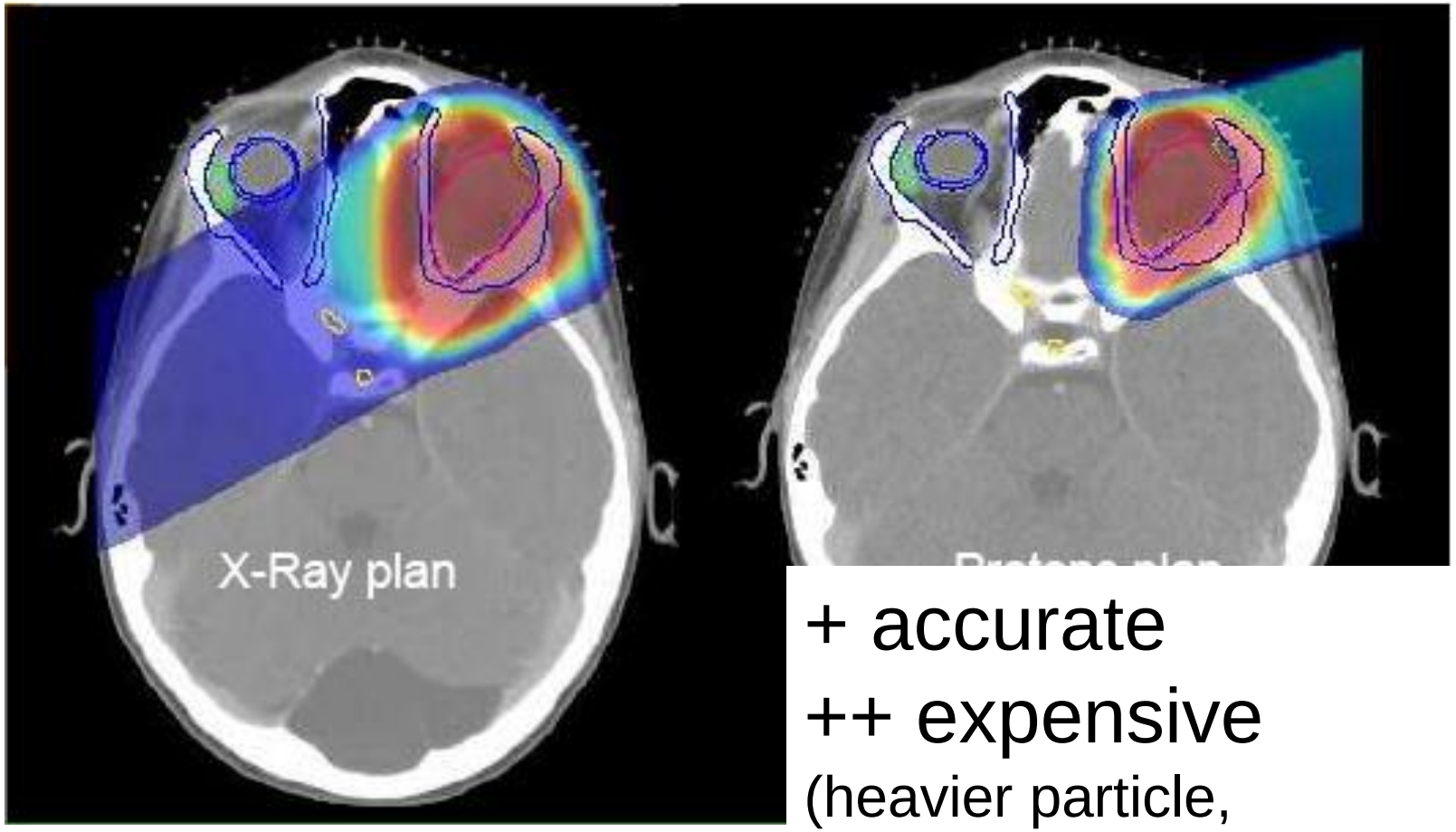
Radiation therapy with protons



+ accurate

++ expensive

(heavier particle,
more accurate treatment)

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Cycle of treatment

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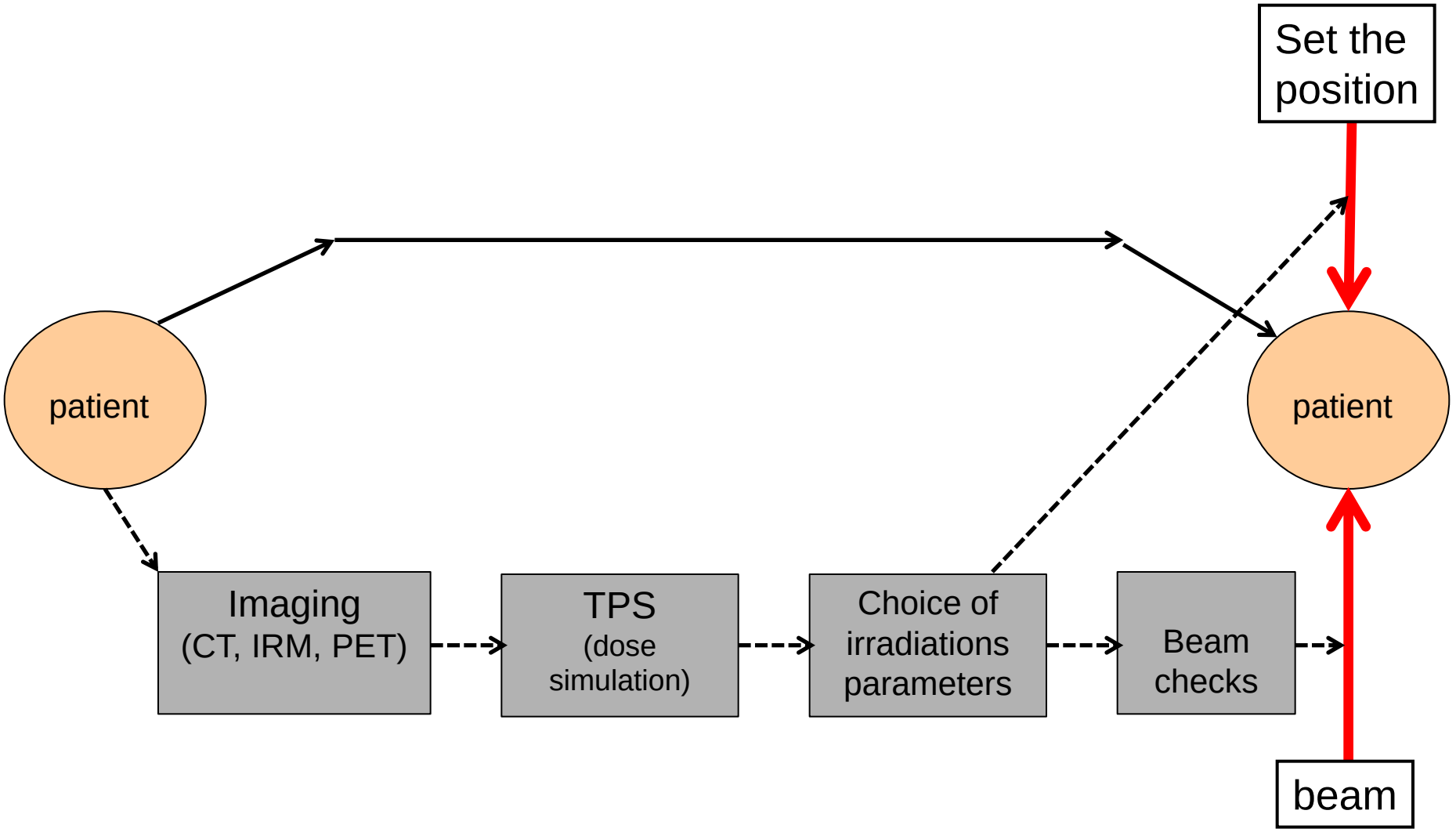

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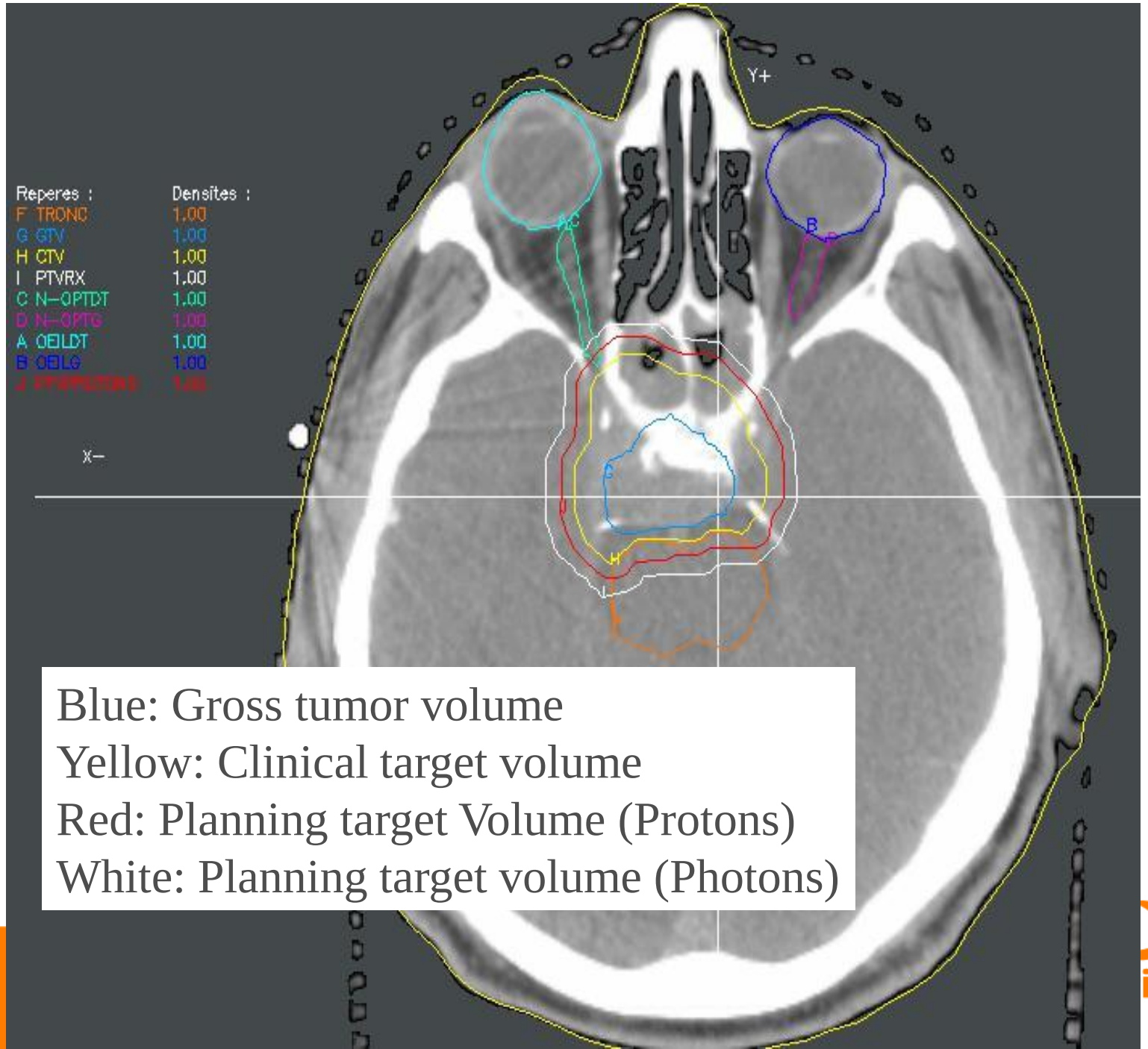
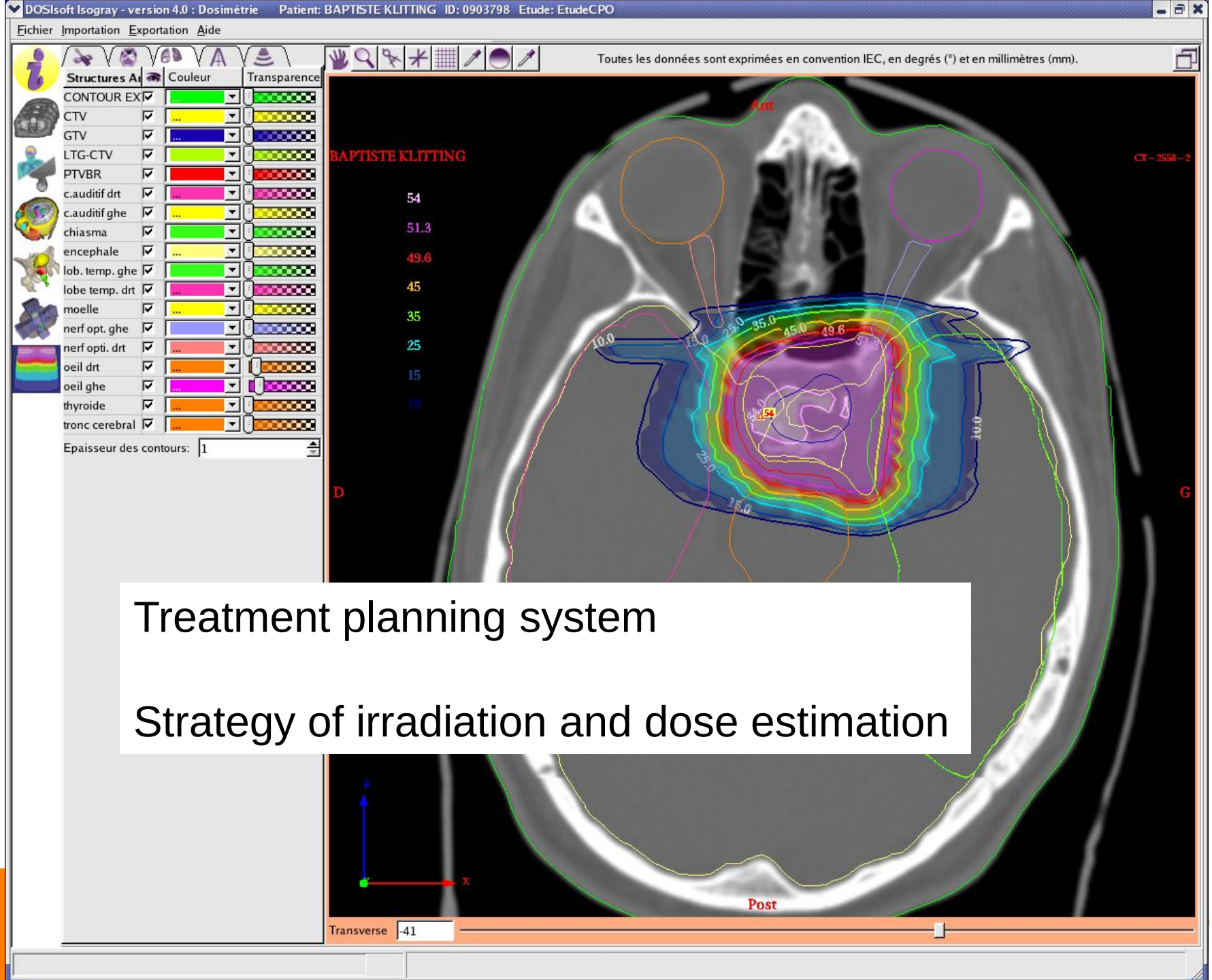
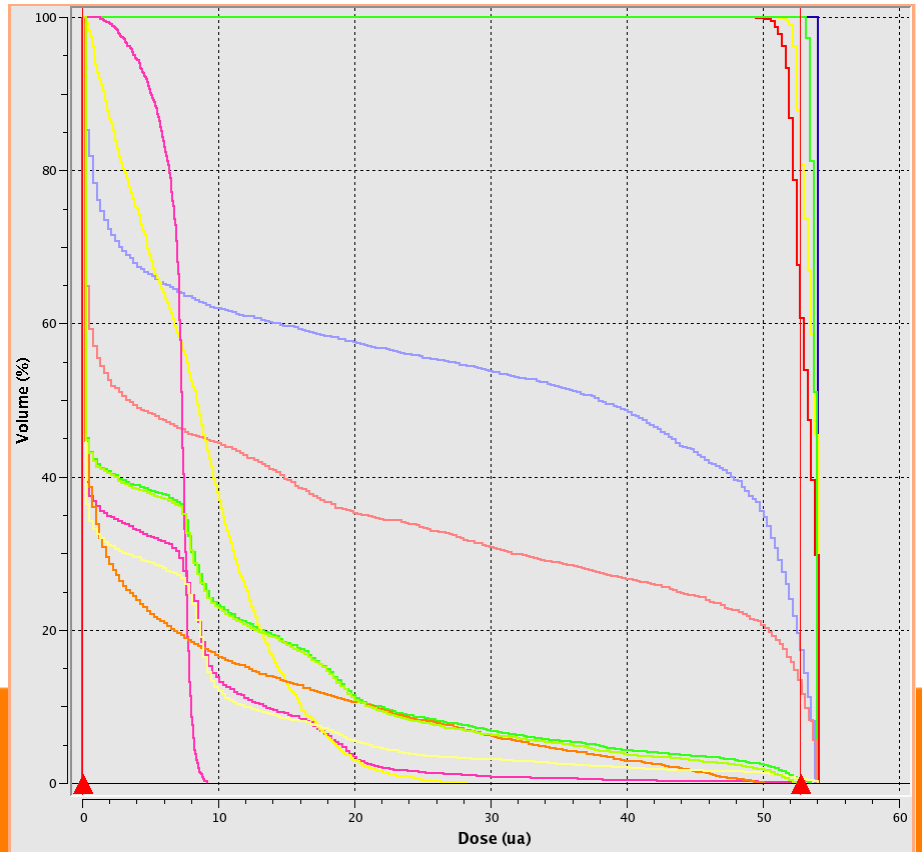


Blue: Gross tumor volume
Yellow: Clinical target volume
Red: Planning target Volume (Protons)
White: Planning target volume (Photons)


DOSIsoft Isogray - version 4.0 : Dosimétrie Patient: BAPTISTE KLITTING ID: 0903798 Etude: EtudeCPO
Fichier Importation Exportation Aide
Toutes les données sont exprimées en convention IEC, en degrés (°) et en millimètres (mm).
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
BAPTISTE KLITTING
54
51.3
49.6
45
35
25
15
10
Ant
Post
D
G
CT - 2558 - 2
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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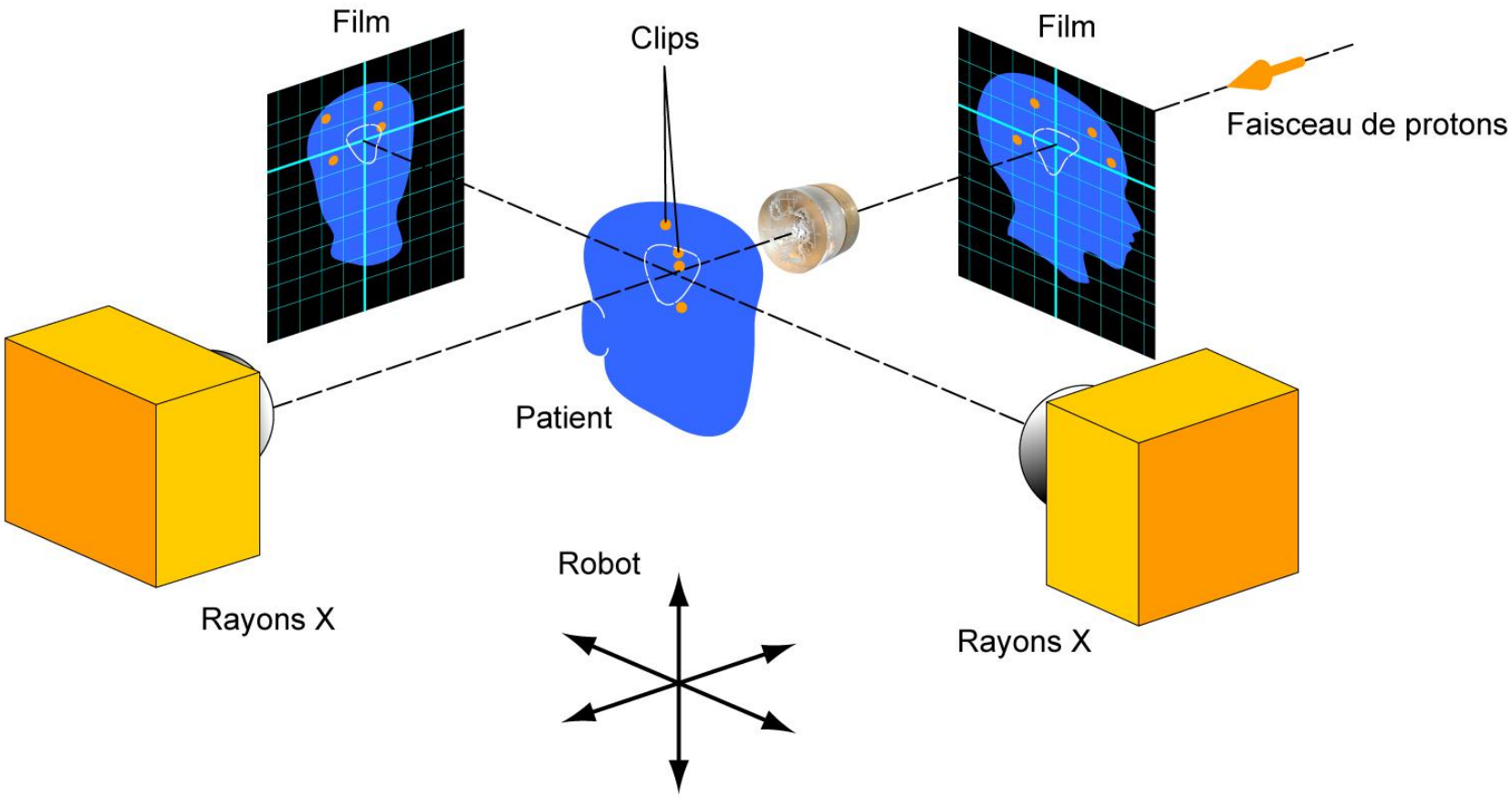
Patient positionning



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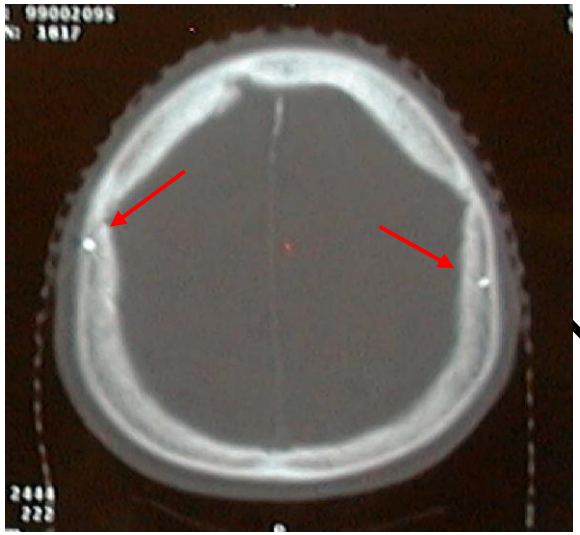
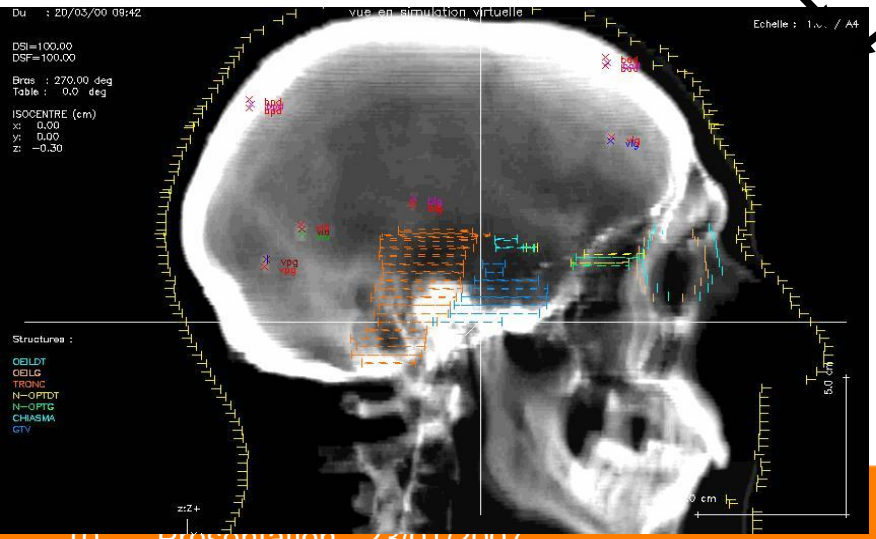
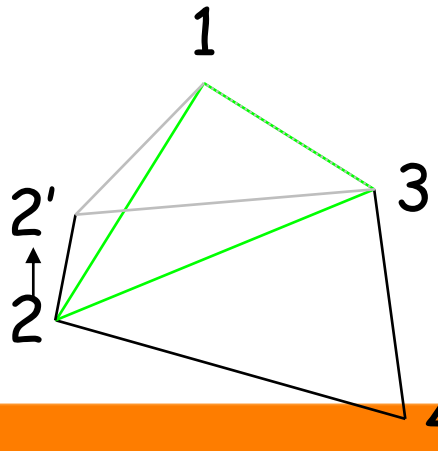
Stereotactic alignment: daily set-up







« Rotaplus » program

-Virtual triangles between gol
seeds (DRRs)…

-Compared with actual position
orthogonal X-Rays

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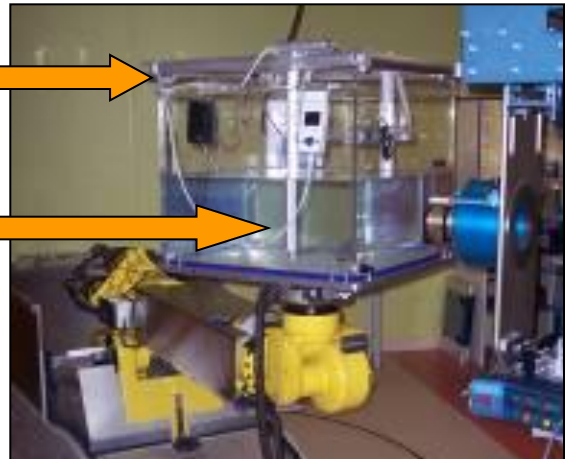
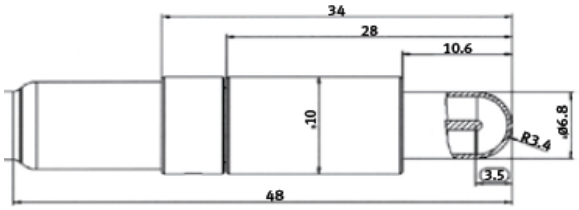
Daily dose measurement

Water tank

Electrometer



Routine Ionisation chamber
CC13 IBA Dosimetry



Model CC13 (formerly IC-15, IC-10)
Volume: 0.13 cc
Sensitivity: 0.044 nC/cGy
Active length: 5.8 mm
Inner diameter: 6.0 mm
Wall: C552, 0.4 mm thick, 70 mg/cm²
Electrode: C552, 1 mm diameter

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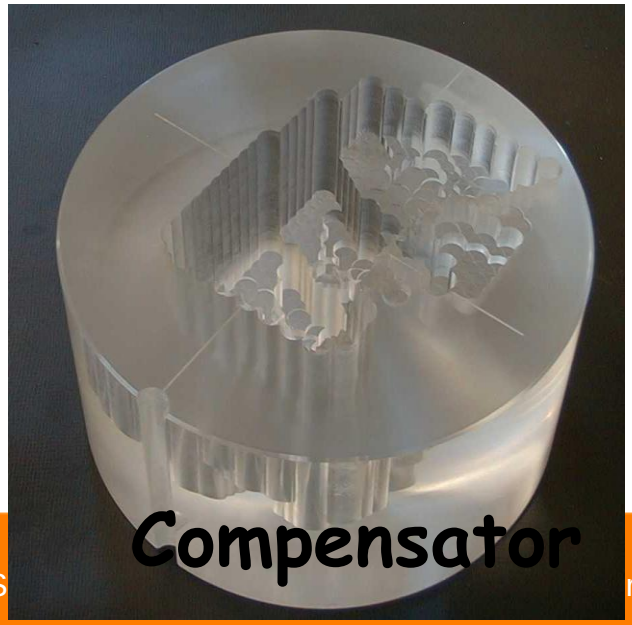
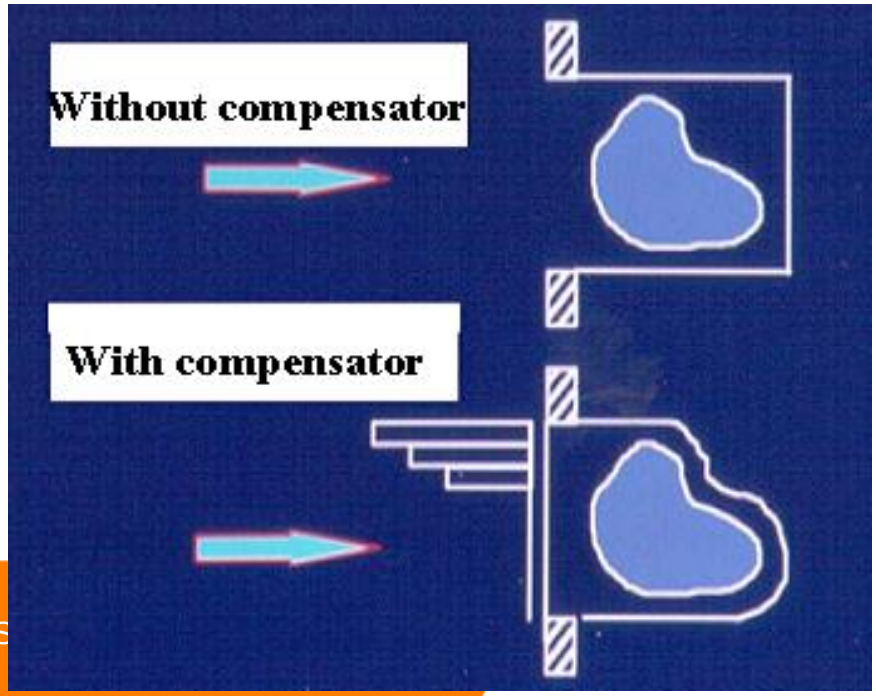
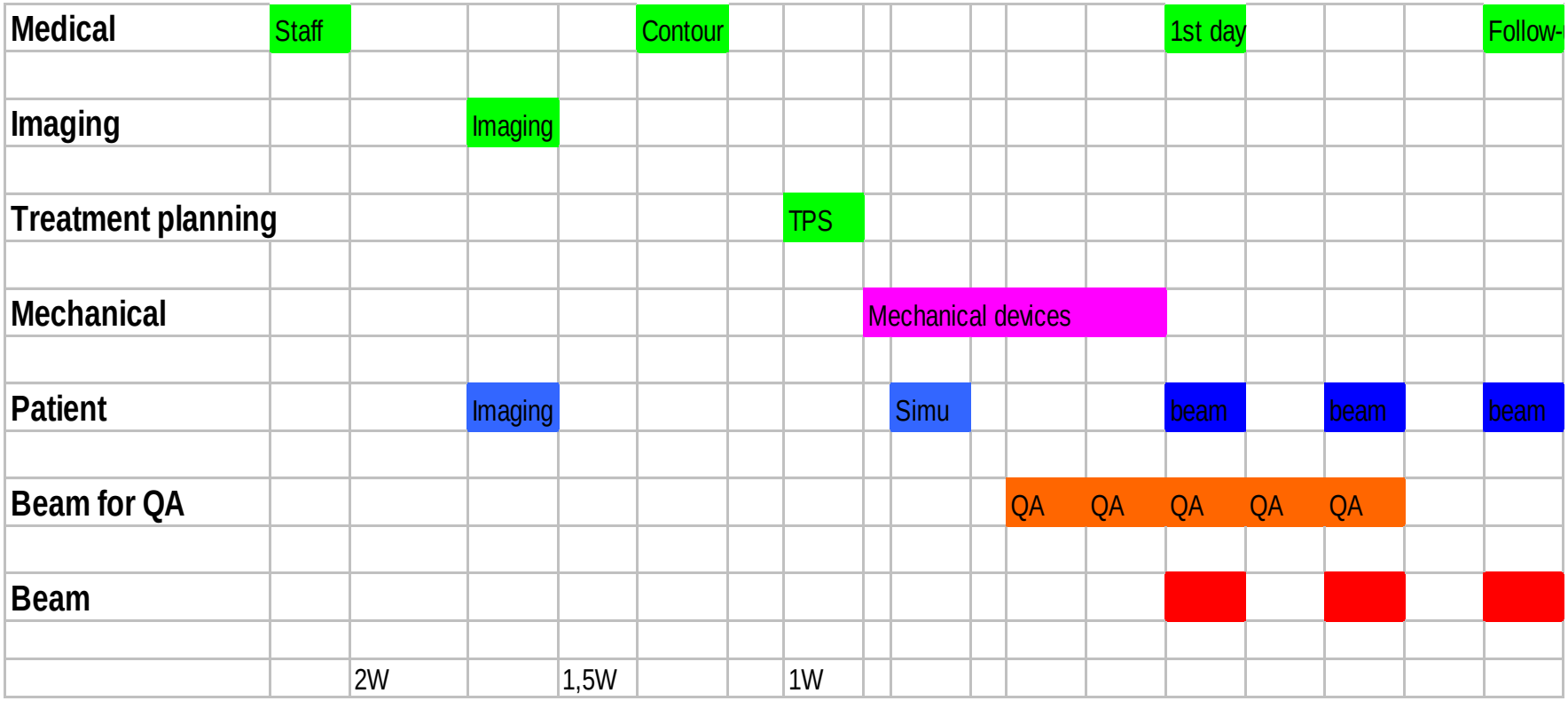
Beam's « shaping »: *passive double scattering*





Preparation and treatment



« W » = 1 week

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Le Centre de Protonthérapie d'Orsay of Institut Curie

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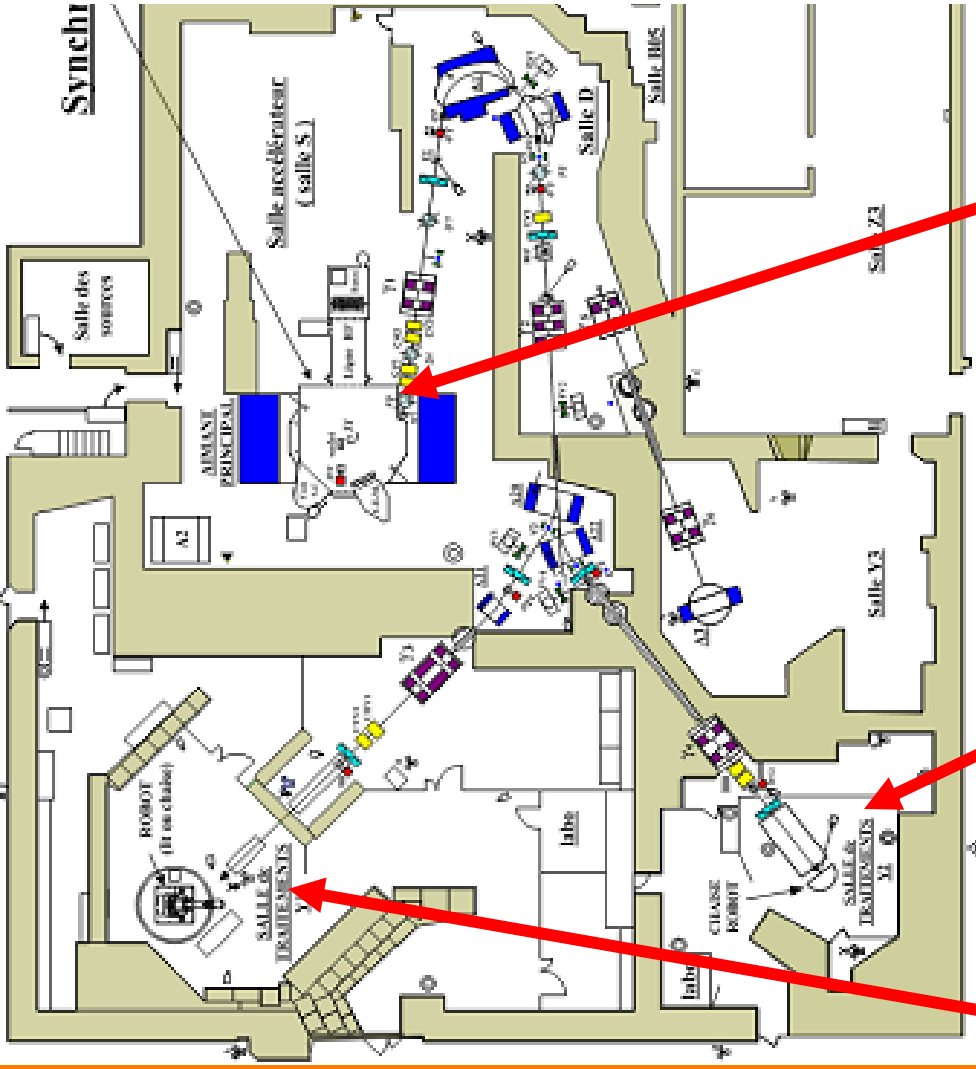
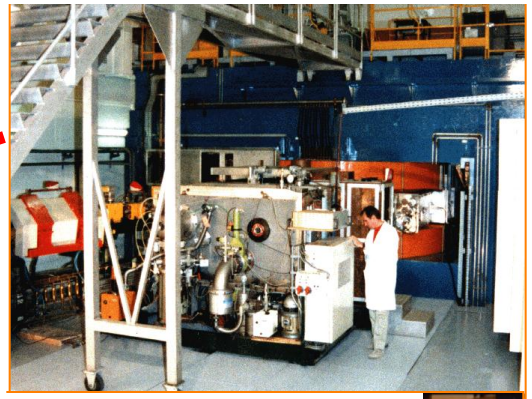
Institut Curie- Centre de protonthérapie – Orsay (35 persons, 14 for technical)

Starts 1991. Patients treated, + 3500 eye

Synchrocyclotron 200Mev

+ 500 head&neck





Small fields room

Large fields room

The medical specifications

	2006 (fixed beam)	2010 (with a gantry)
Eye Tumours	240	240 – 300
Base of skull	90	160 – 200
Children	10	100 – 130
Others	-	80 – 100
TOTAL	340	580 – 730

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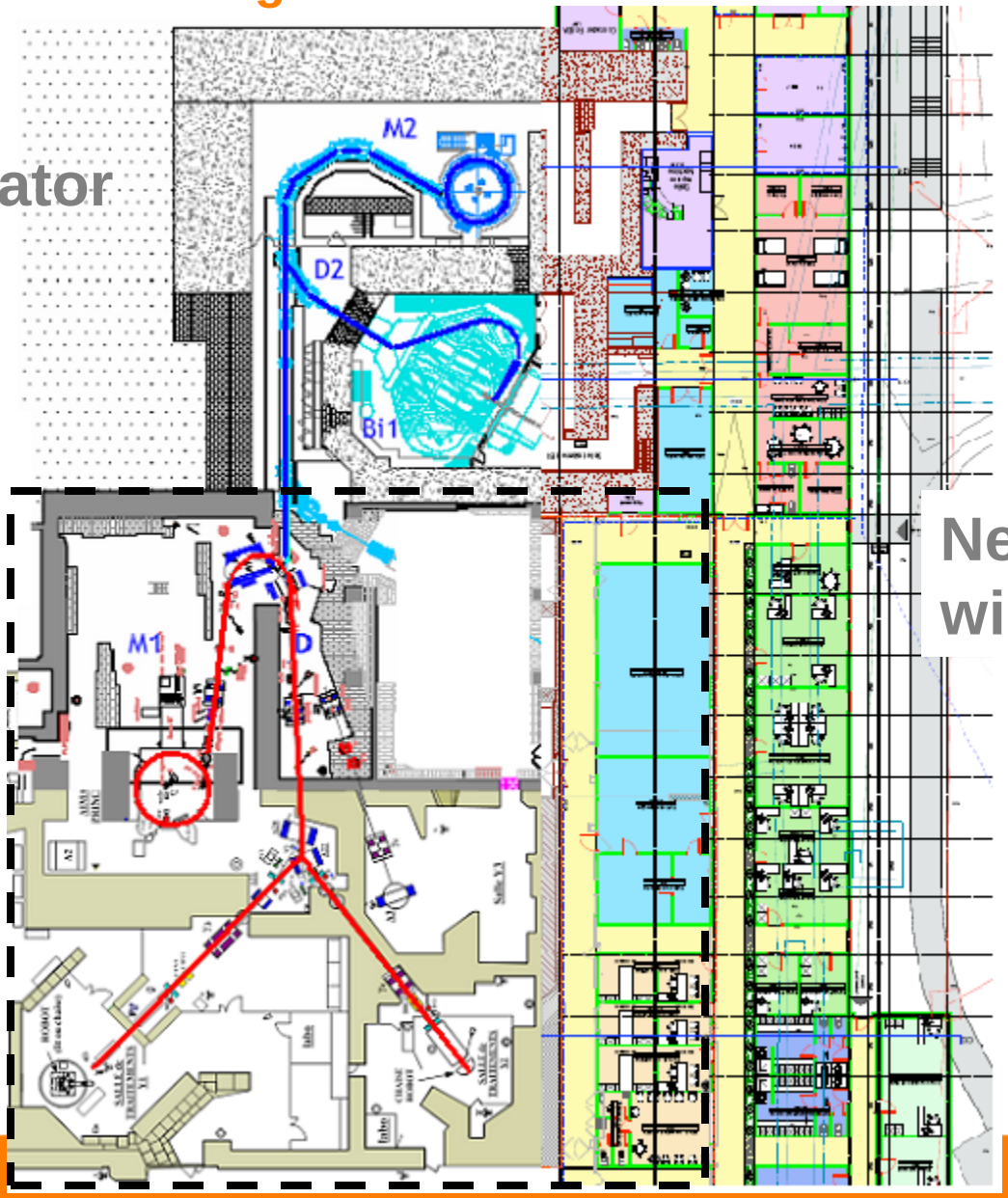
The project in building : extension and renovation of the facility

New accelerator
+ gantry
+ beamlines



New medical wing

Existing Facility

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Accelerator (230 MeV, 500nA)

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The cyclotron

Energy: 230 MeV
Courrent max: 500 nA
Minimum: 0,1 nA
Emittance: 12 pi.mm.mrad
External magnetic diameter: 434 cm
Total magnetic height: 210 cm
Total weight of magnet: 220 tons
Electrical consumption: 446 KW

Harmonique mode: 4
Frequency: 106,1 Mhz
Voltage on Dee (extraction) 130 kV peak

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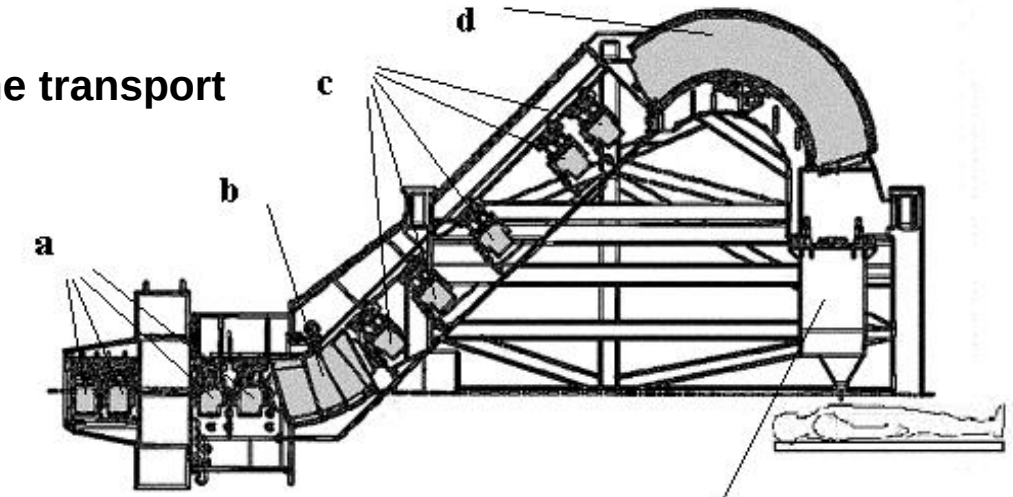
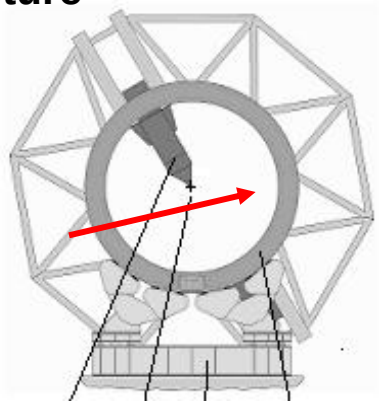
Gantry (120 tons, D = 10,5m)

Beam line transport



Rotation structure



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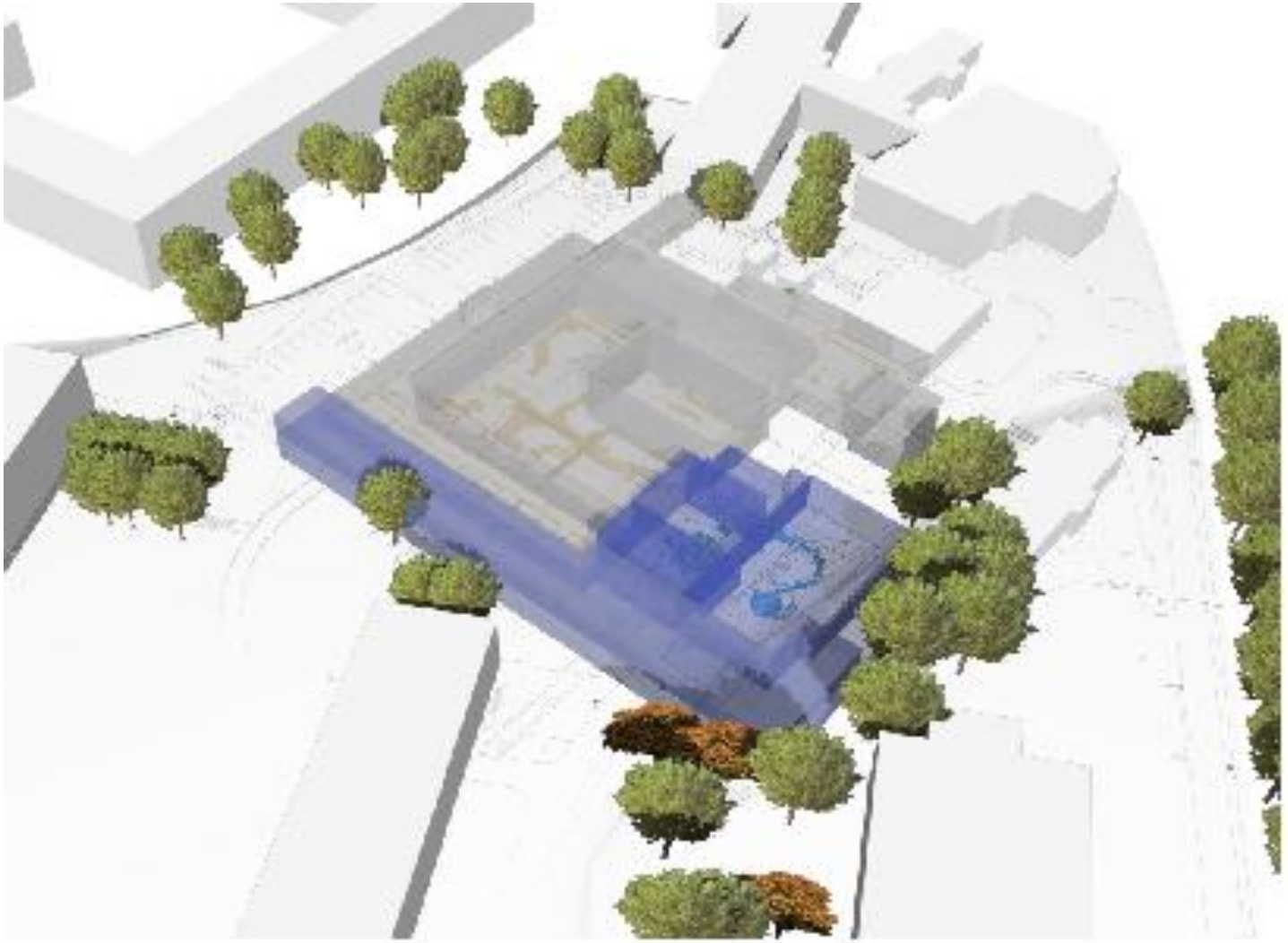
Building integration in the Campus



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CHARGE 300Kg max.

Some accelerator and beam issues

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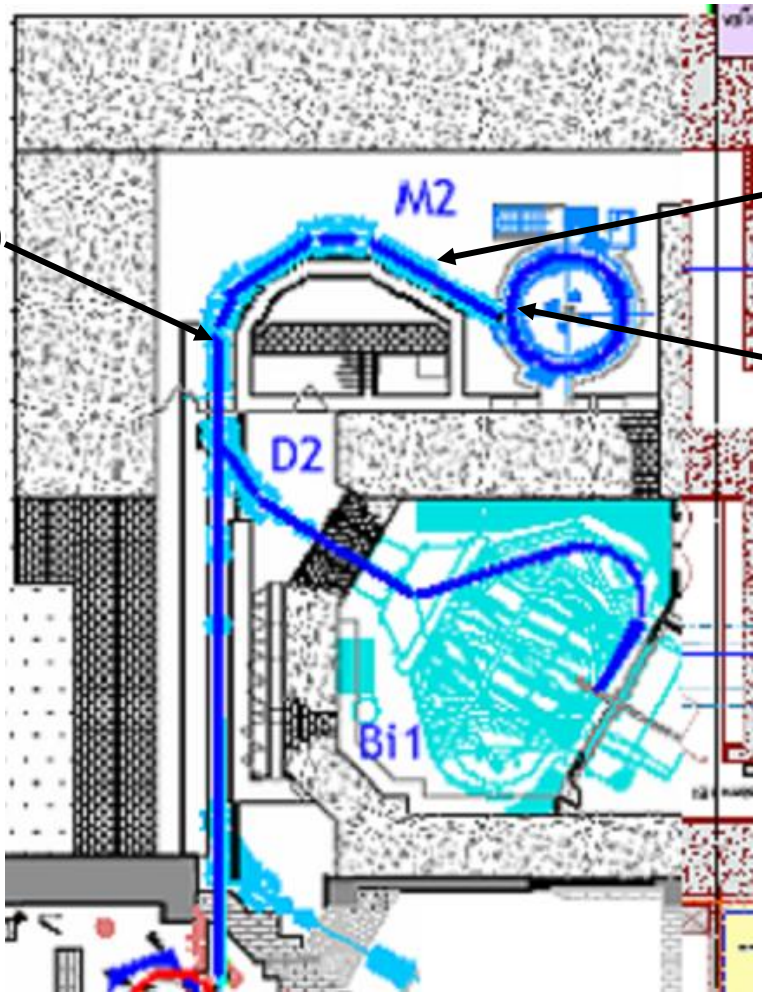
Case of a cyclotron + Energy Selection System (IBA, Varian)

Variable energy
(same emittance)



degrador

Fixed energy

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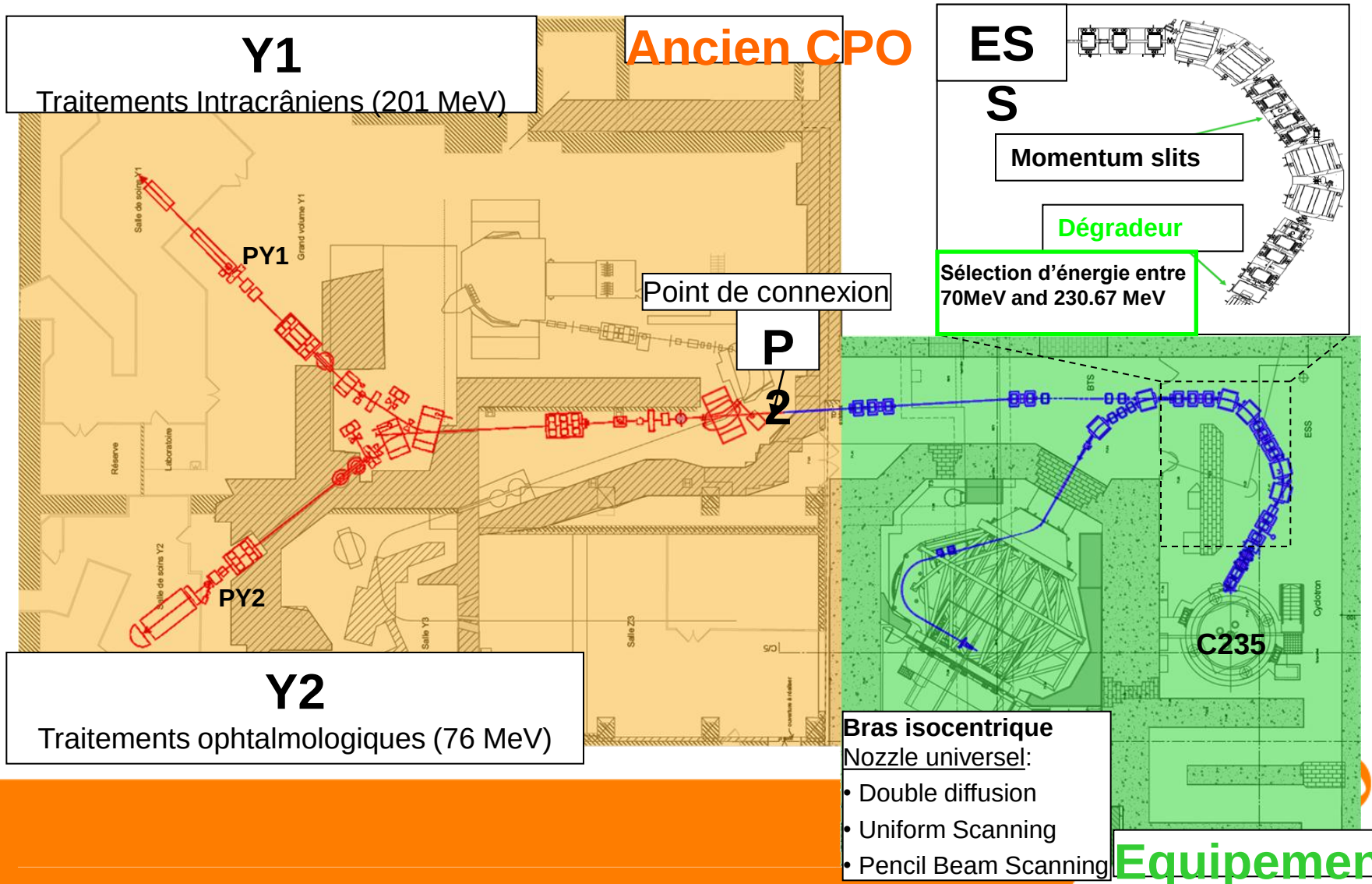
Map of Centre de Proton thérapie d'Orsay



Modifications of cyclotron (IBA) to improve extraction efficiency

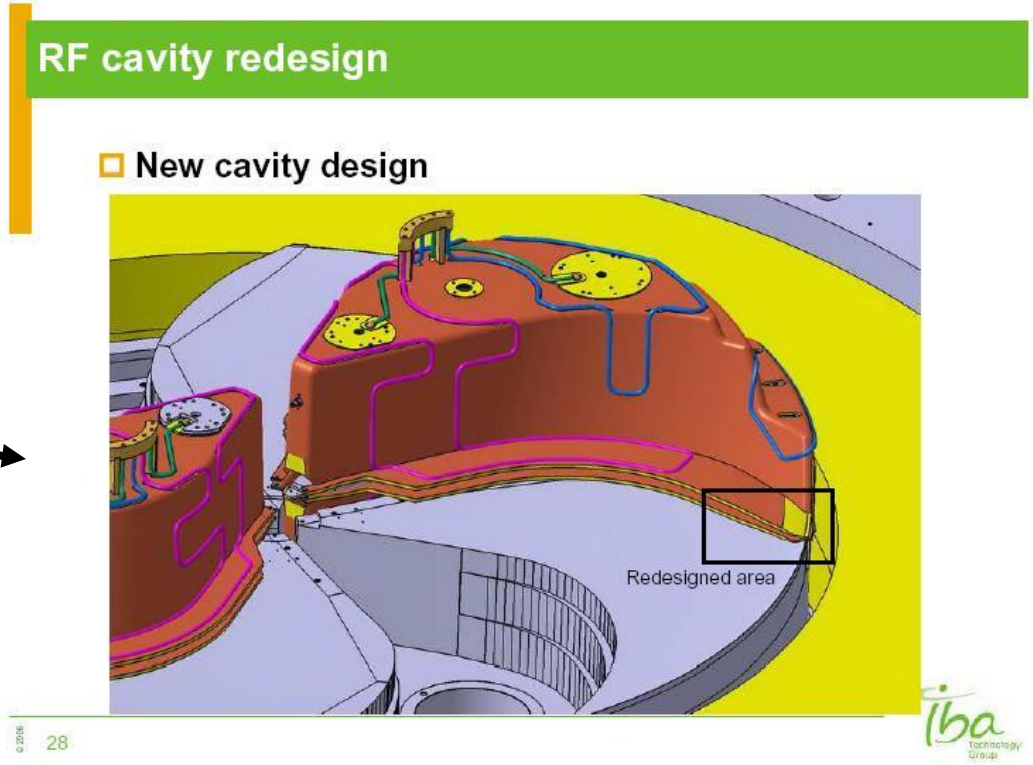
- mapping et shimming more accurate

- new deflector

- new cavity

- Control of intensity via tension Dee

1. + dynamic control of the beam
2. supress of dark current



P. Verbruggen (IBA)

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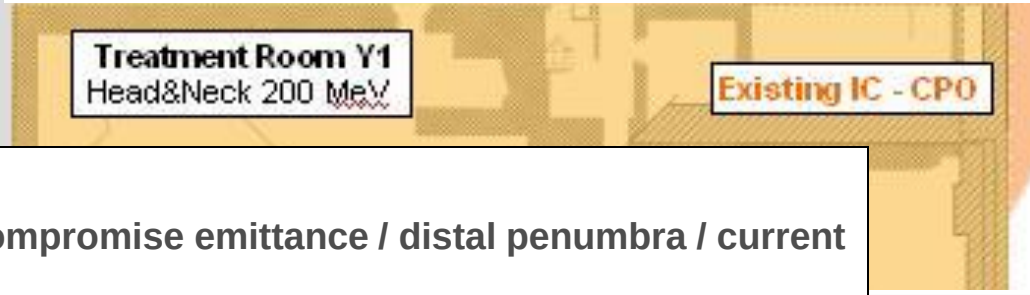
Beamline problematics



Compromise emittance / distal penumbra / current

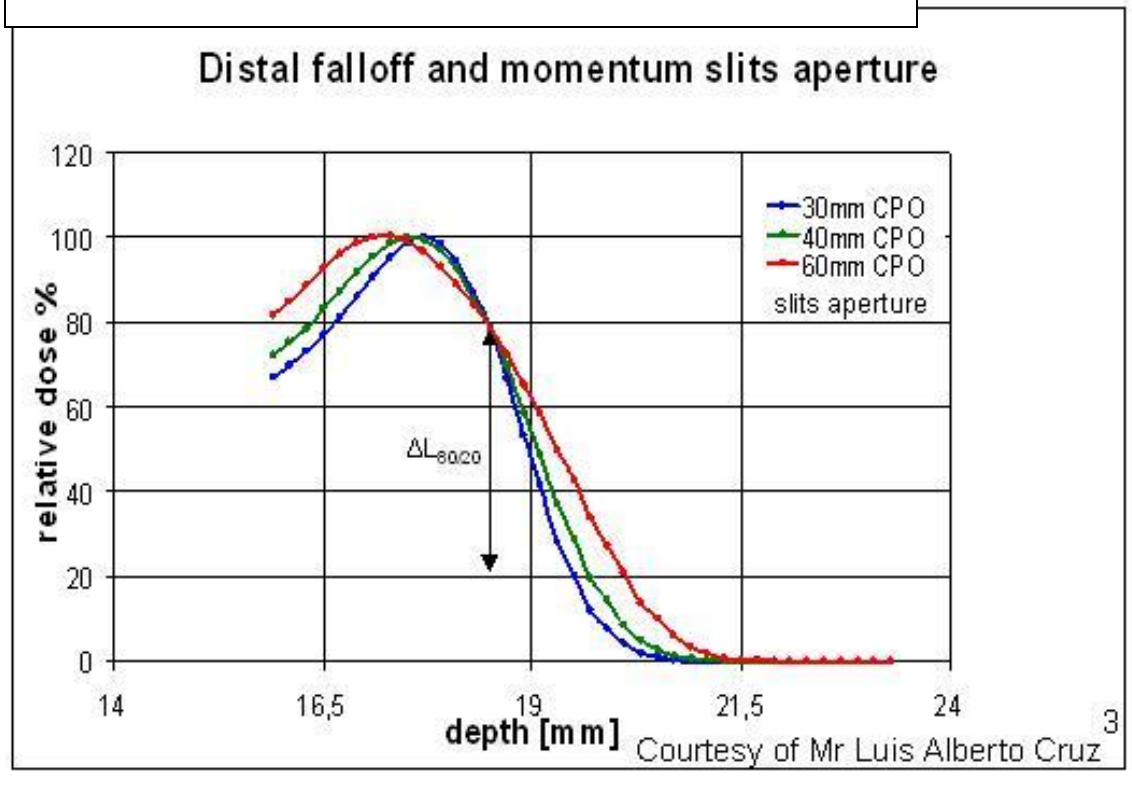


Fig. 1: Extension project

The ESS allows beam energy selection (degrader) and achromatic beam.

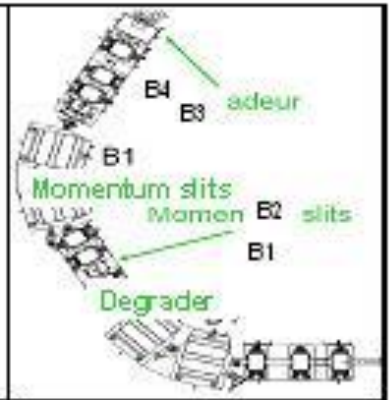


Fig. 2: ESS

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Reliability for protontherapy

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Uptime and reliability for protontherapy (1/2)

Beam time during a day

beam quality control (beam, accessories) 15 min – 1 hour (p)

1 minute per treatment

So beam is used only 10 % of the time

- no treatment during the night

⇒ **1. Short breakdowns manageable, (%adaptative maintenance)**

Overall time of treatment for a patient:

32 x 2 Gy (WE excluded), about 2 months

⇒**2. Long maintenances or breakdown**
very disturbing for the medical planning

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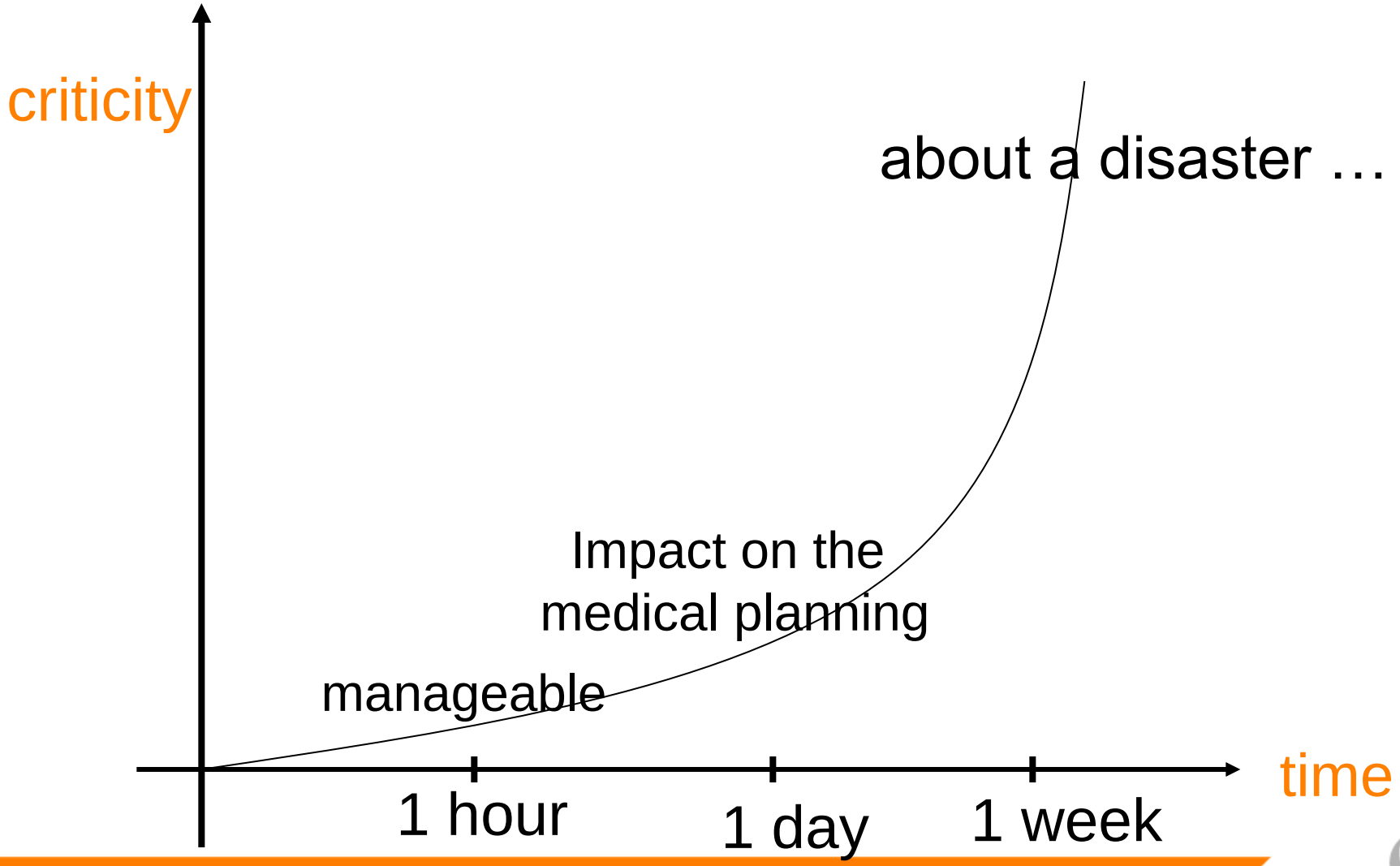
Criticity of breakdowns in a radiotherapy facility



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Uptime and reliability for protontherapy (2/2)

3. Do not forget the basics of maintenance: inspection, neatness, preventive (screw on electrotechnical), understand the drifts, …

4. Manage the paradoxal situation:

- **Developing is good for maintenance**

(learning by doing, renovation, upgrade, …)

- **Developing is bad for maintenance**

(perturbations, safety, non « factory » approach, …)

5. Organization during the corrective maintenance:

Filter of « emotive » information from the medical service

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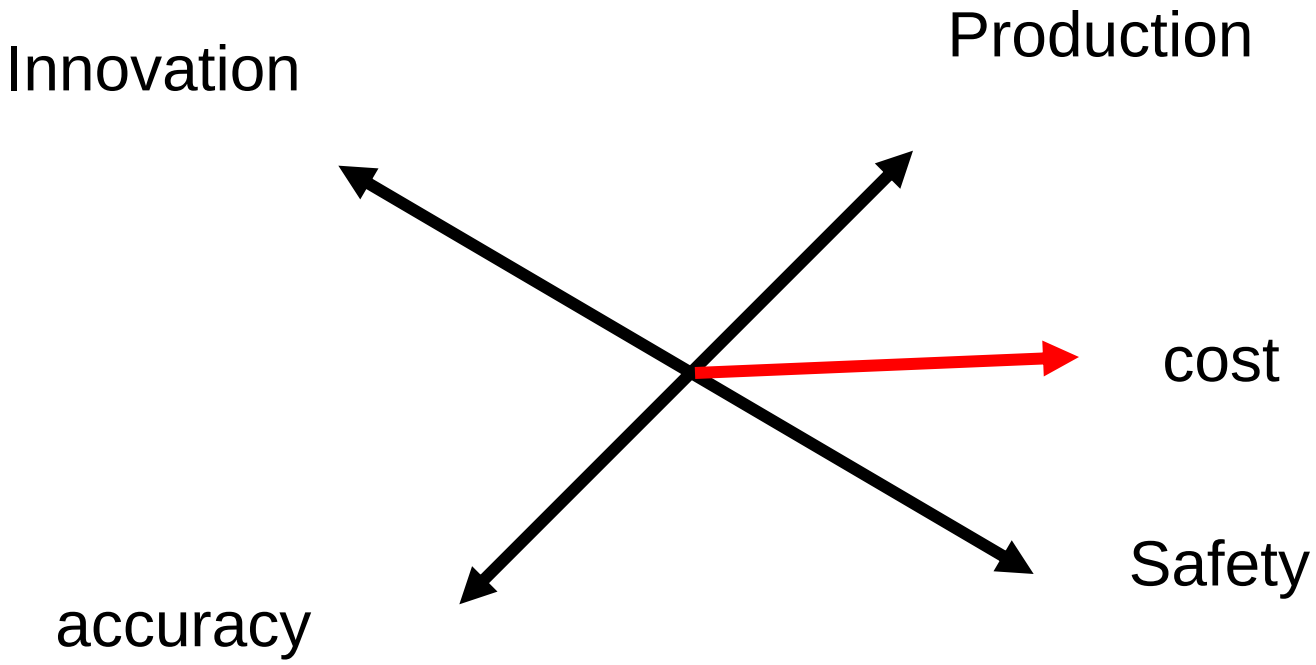
Protontherapy: a « teenager » field ?



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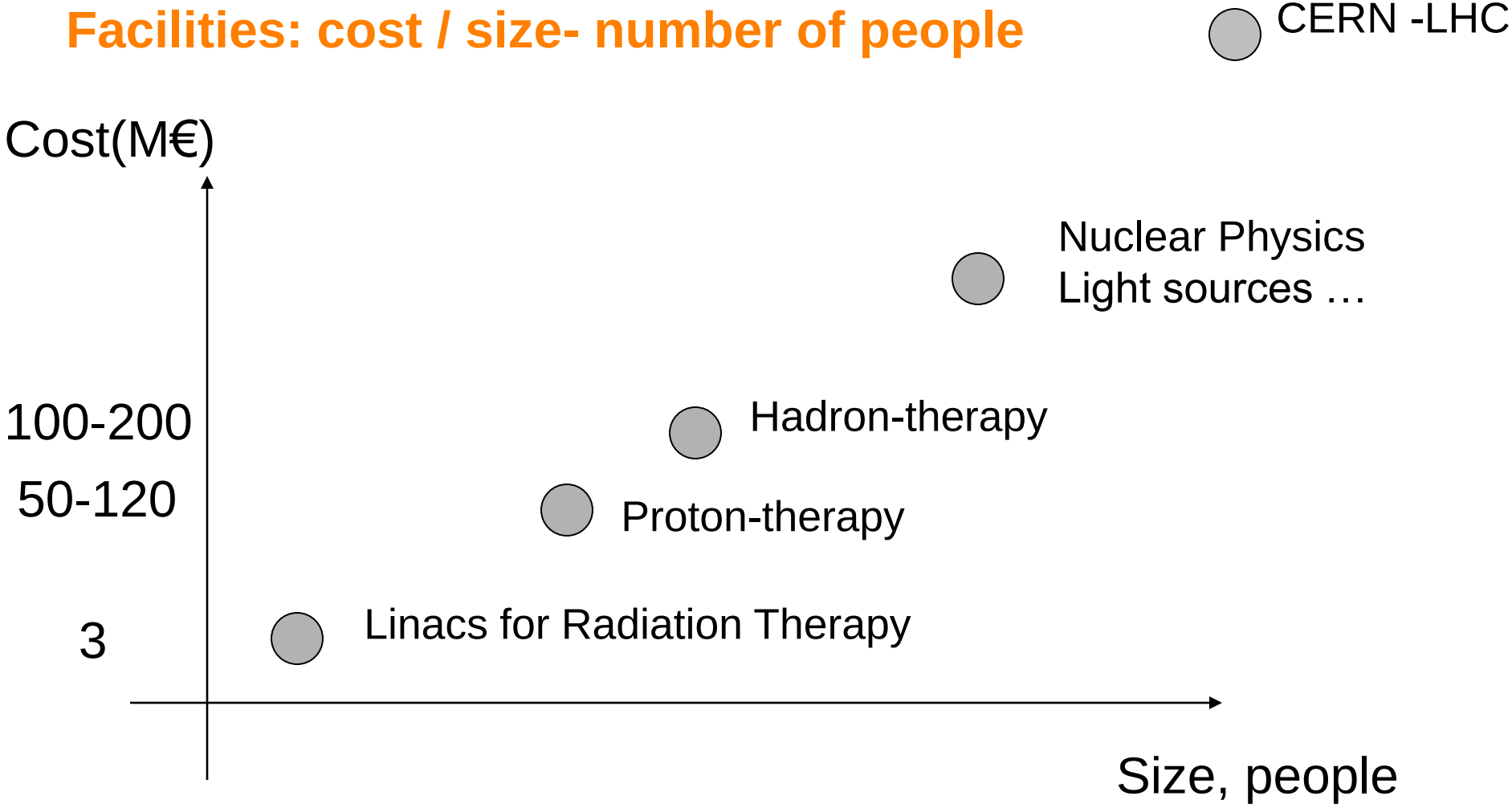
Facilities: cost / size- number of people



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Maintenance

Electricity + cooling (1.5 MWH)
Building Facilities
Accelerator Technologies
Beamlines + PowerSupplies
Control & IT systems
Imaging&robotics
mechanical
Dosimetry&instrumentation
…

3 treatments rooms

Smaller than light sources
Big diversity

2h Monday + Thrusday Morning
4h some Saturday Morning
1,5 days each 3 months
8 days each year

50 weeks of treatments / year

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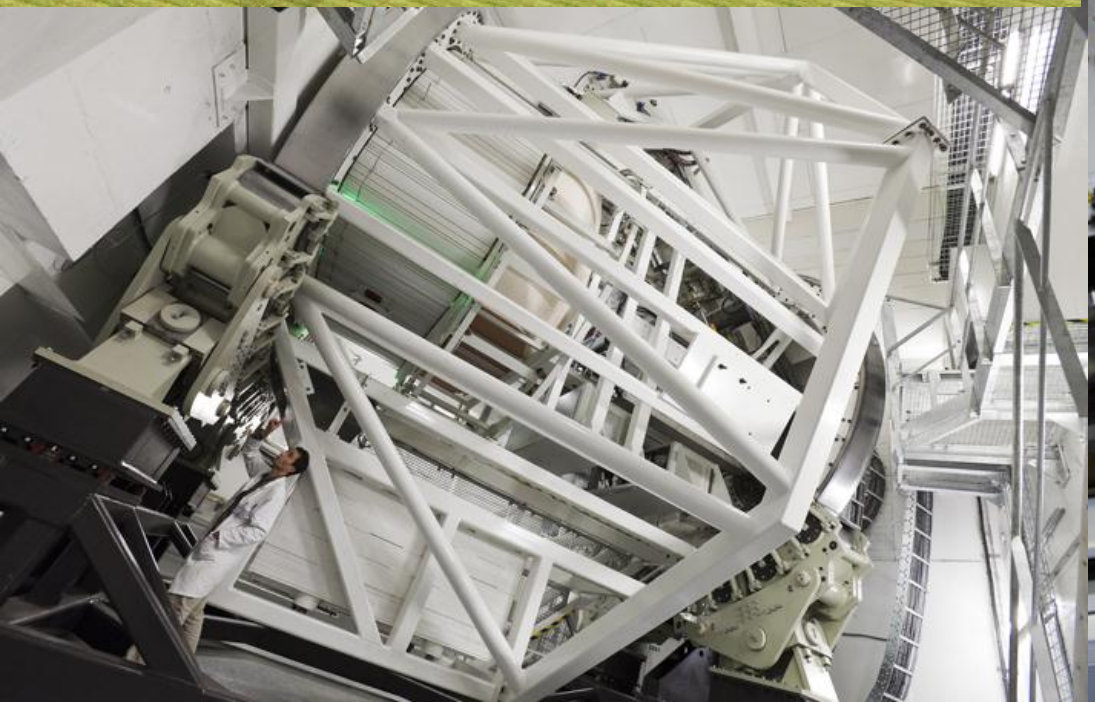
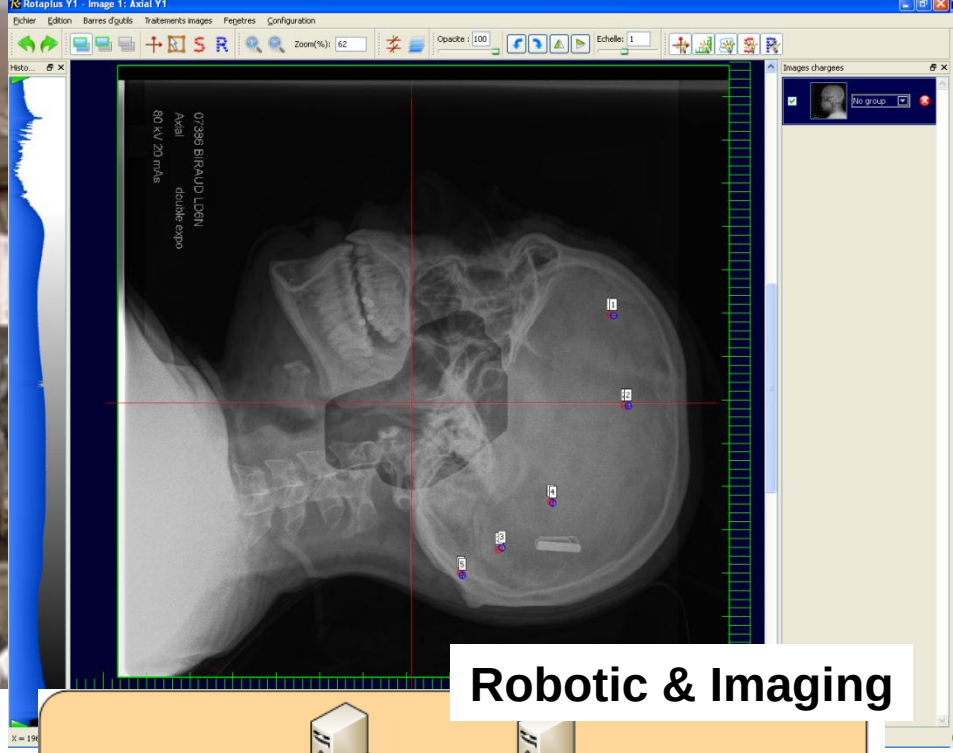
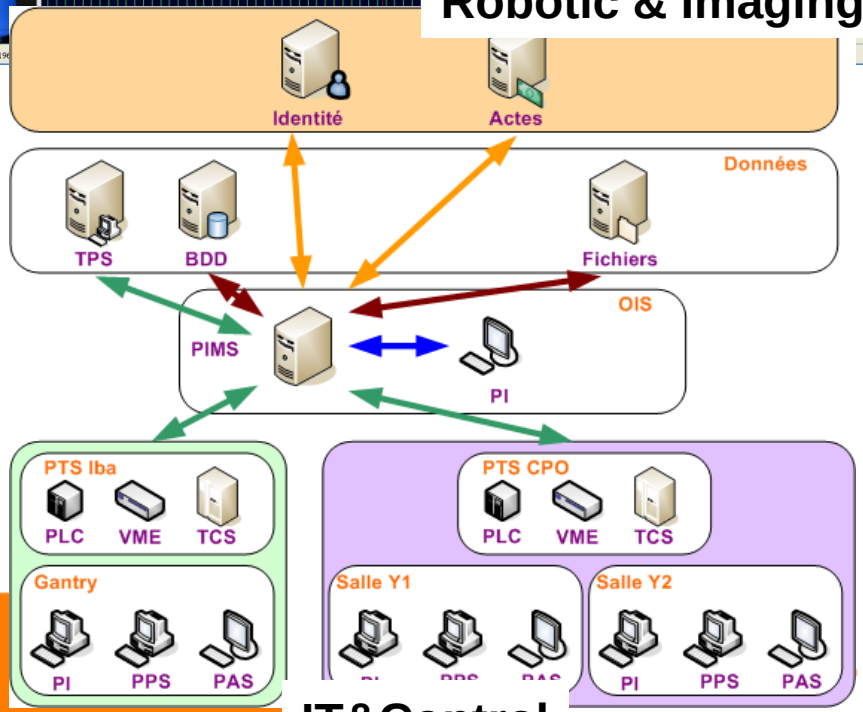


Cyclotron&Beamline)



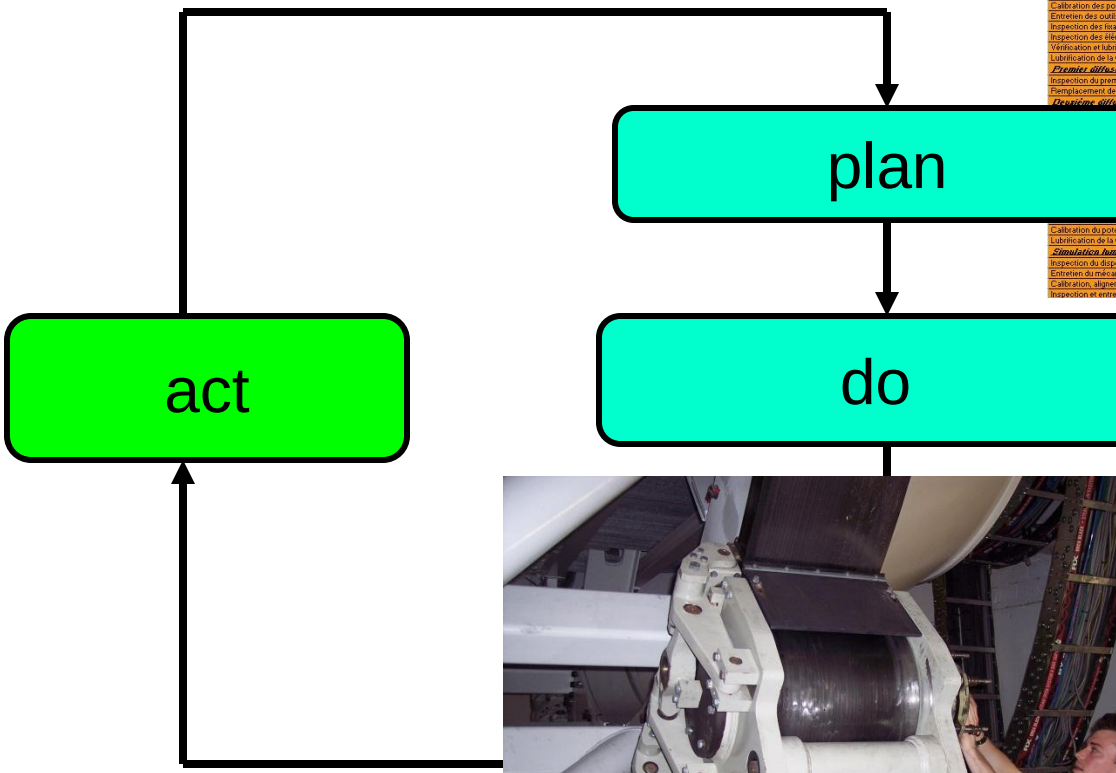
Robotic & Imaging

R&D physics &Technology



IT&Control

Example 1: maintenance on mechanical



Institut Curie - Centre de Protonthérapie - Maintenance Database Lin — today 23 03 11 — PAP start 19/02/2009 — PAT start 01/04/2009

Titre des procédures	rocedure	v.	durée	today (Mois	System	Salle (s)	lieu	condition	nexigenti	Type	Date	next dat
Extrémité du bras isocentrique (Nozzle & Snout)												
Contrôle de la connectique et des réglages de l'extrémité du Nozzle (snout)	12915	A	1h	1 à 3	Nozzle	Gantry	Snout			mécaélec	20 11 10	
Contrôle des connexions de puissance électrique du nozzle	12917	B	1h 30'	6	Nozzle	Gantry	Snout		photos ?	élec	01 07 10	
Inspection des sous systèmes du nozzle	12919	B	?	6	Nozzle	?	?	Pas de notice !!!		?		
Calibration des potentiomètres de l'extrémité du nozzle de la gantry	13901	B	30' 1h 30'	6	Nozzle	Gantry	Snout			mécaélec	08 10 10	
Entretien des outils de transport et d'installation de l'extrémité du nozzle (snout)	13837	B	50'	6	Nozzle	Gantry	Snout			méca	30 08 10	
Inspection des fixations sur le nozzle	12900	B	30'	6	Nozzle	Gantry	Nozzle			méca	17 09 10	
Inspection des éléments anti rotation de l'extrémité du nozzle	13831	B	1h	6	Nozzle	Gantry	Snout			méca		
Vérification et lubrification des éléments de positionnement du snout	13675	B	30'	6	Nozzle	Gantry	Snout			méca	16 09 10	
Lubrification de la vis de translation de l'extrémité du nozzle	13834	B	30'	6	Nozzle	Gantry	Snout			méca	10 06 10	
Premier diffuseur												
Inspection du premier diffuseur	12790	C	20' 3h	6	Nozzle	Gantry	RT Snout			mécaélec	25 10 10	
Remplacement des roulements des Lollipops du premier diffuseur	12793	B	1h	6	Nozzle	Gantry	Nozzle			méca		
Deuxième diffuseur												
[illegible]ur	13803	B	20' 3h	6	Nozzle	Gantry	Nozzle			mécaélec	30 10 10	
[illegible]ème diffuseur	13806	B	20'	6	Nozzle	Gantry	Nozzle			méca	30 10 10	
deuxième diffuseur	12899	B	1h 1h 10'	6	Nozzle	Gantry	Nozzle			mécaélec	08 10 10	
[illegible] variables												
[illegible]e de profondeur	13801	B	20' 3h	6	Nozzle	Gantry	RT Snout			mécaélec	25 10 10	
[illegible]roir du modulateur variable	12794	B	20'	6	Nozzle	Gantry	Nozzle			mécaélec	11 12 10	
[illegible]dulateur variable de profondeur	13825	B	30'	6	Nozzle	Gantry	Nozzle		photos ?	élec	23 03 10	
[illegible]ement du modulateur variable	13907	B	10'	6	Nozzle	Gantry	RT Snout			mécaélec	08 10 10	
[illegible] la petite roue du modulateur variable	13910	D	1h	6	Nozzle	Gantry	Snout			mécaélec	25 10 10	
[illegible] la petite roue du modulateur variable	13796	B	1h	6	Nozzle	Gantry	Snout			mécaélec	11 12 10	
[illegible]dulateur variable de profondeur	12799	B	30'	6	Nozzle	Gantry	Nozzle			méca	11 12 10	
Calibration du potentiomètre de réglage de la grande roue du modulateur variable	13838	B	20' 30'	6	Nozzle	Gantry	Snout			mécaélec	08 10 10	
Lubrification de la vis de réglage du collimateur variable	13823	B	1h 30'	6	Nozzle	Gantry	Nozzle			méca	30 08 10	
Simulation lumineuse, tubes RX et chambres d'ionisation												
Inspection du dispositif d'éclairage (fibre optique, simulation lumineuse)	13828	B	30'	6	Nozzle	Gantry	Snout			mécaélec	23 12 10	
Entretien du mécanisme introduction / retraction du tube RX du nozzle	12916	B	45'	6	Nozzle	Gantry	Nozzle			mécaélec	16 09 10	
Calibration, alignement et tests (rayons X	12291	A	3h	3	quatsoz	Gantry	quatre nozzle		photos ?	mécaélec	08 09 09	
Inspection et entretien des câbles HT des tubes à rayons X	18822	A	2h	6	quatsoz	Gantry	quatre nozzle			méca	30 10 10	

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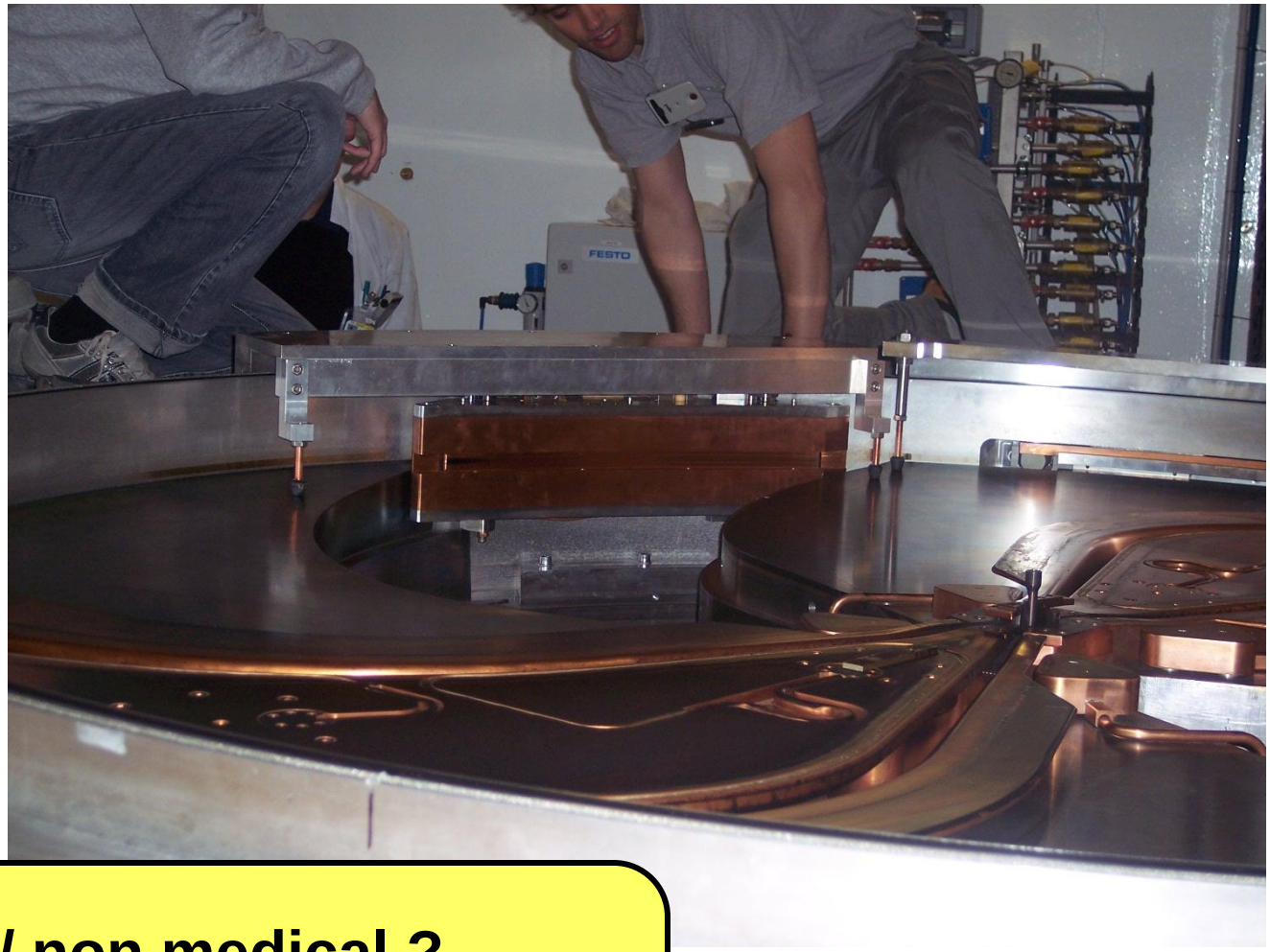
Example 2: work on sensible part of the machine



Medical / non medical ?
Who will aware the impact on beam ?
Who will define the test ?

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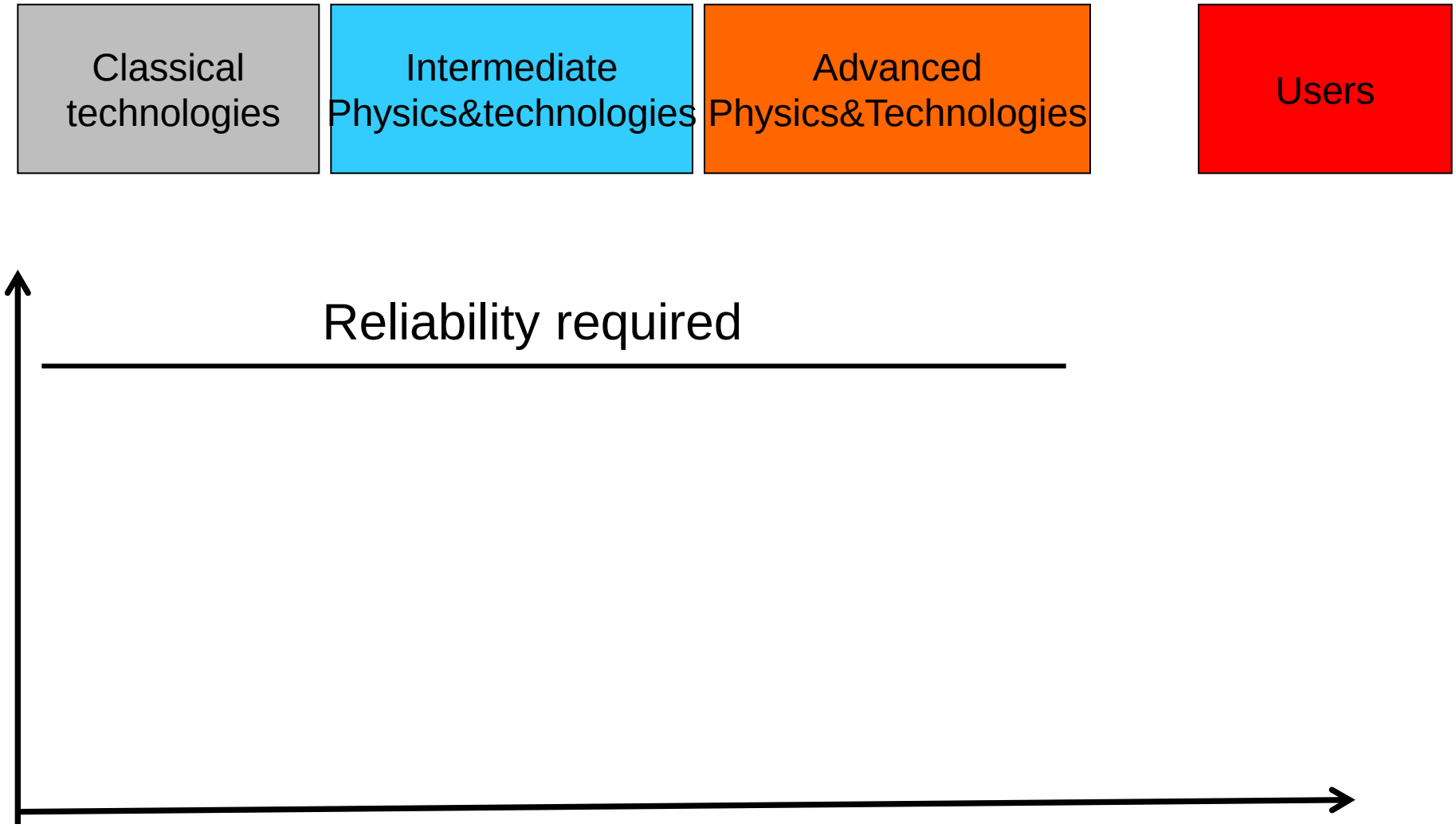

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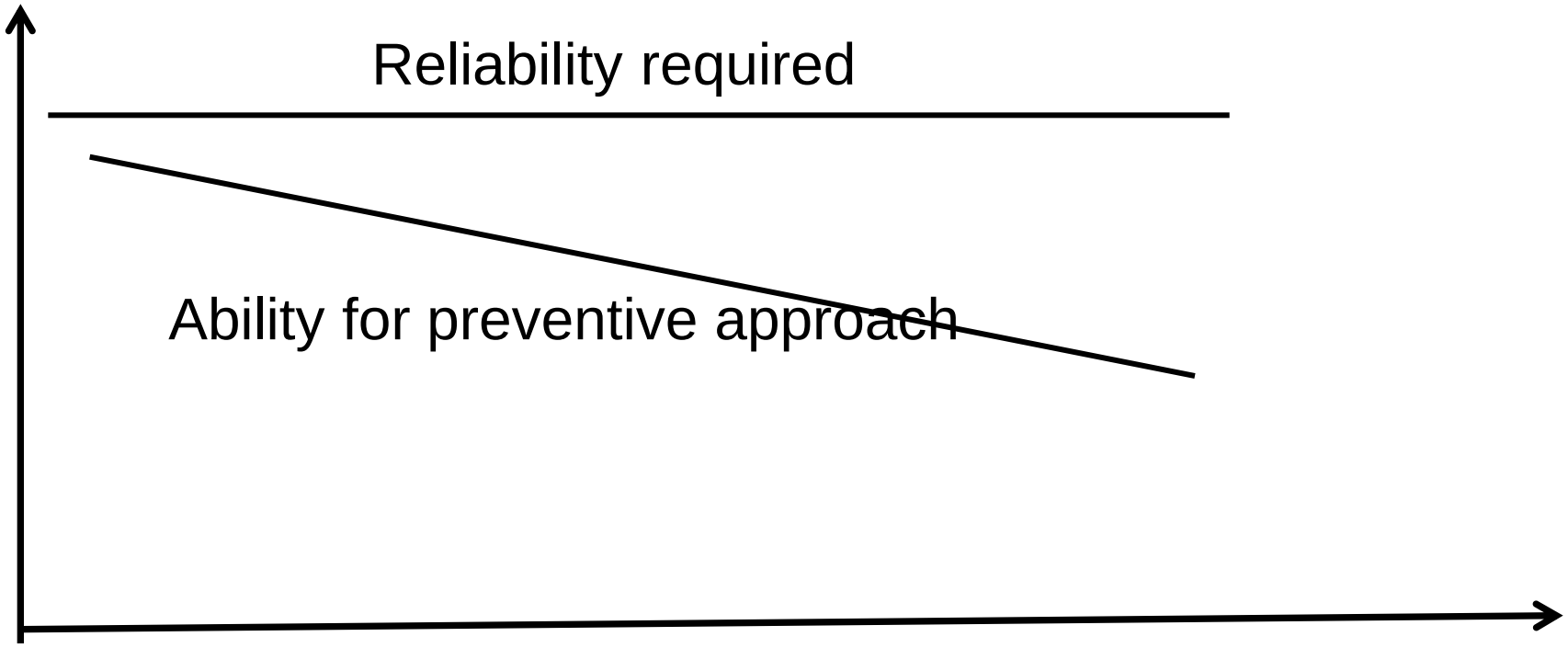
Classical technologies

Intermediate Physics&technologies

Advanced Physics&Technologies

Users



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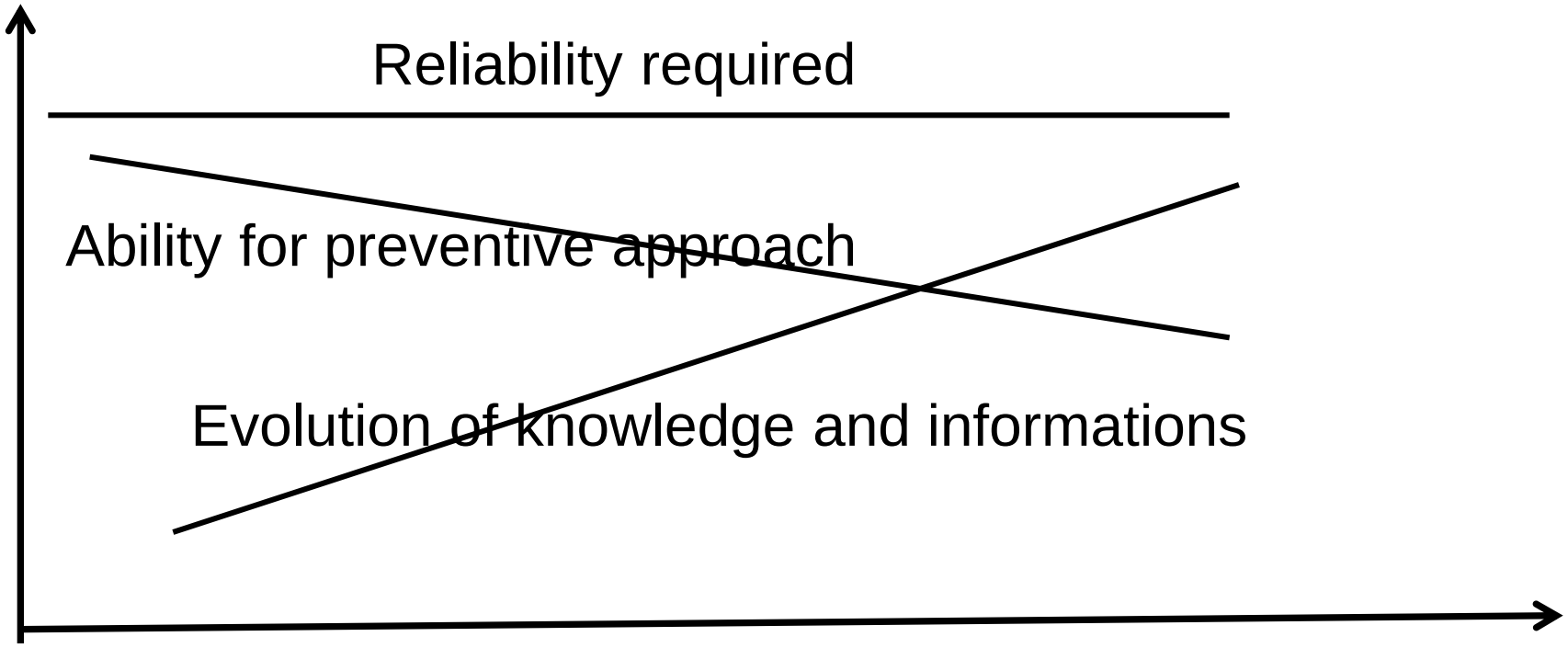
Classical technologies

Intermediate Physics&technologies

Advanced Physics&Technologies

Users



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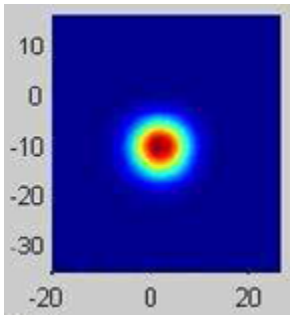
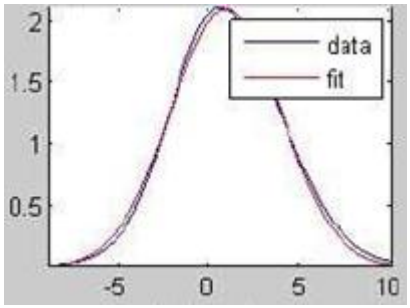
2013-2014 migration to PBS

PBS = Pencil Beam Scanning

Pencil Beam

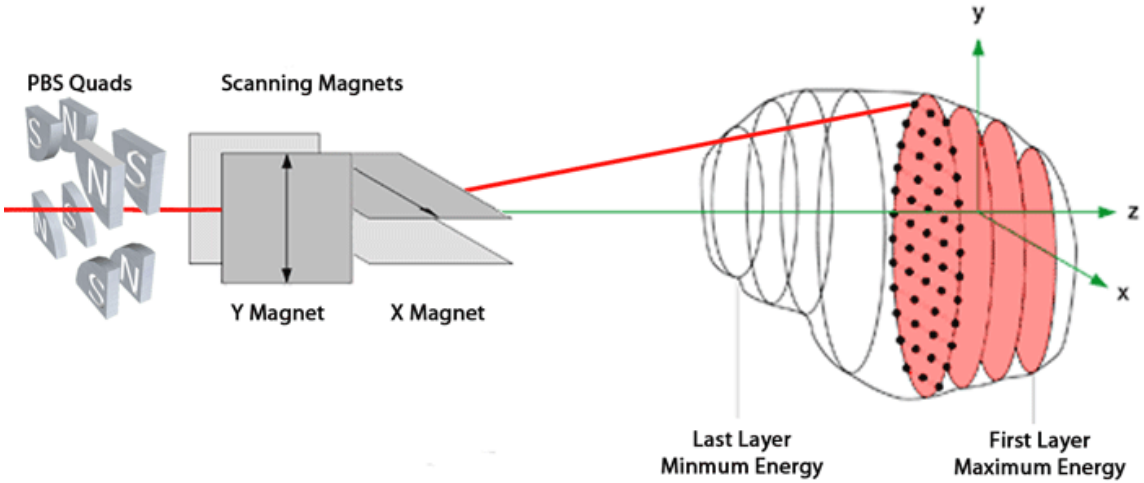
Spot size from 3 to 8 mm (sigma)





Scanning

Scan in both direction to cover the tumor



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Nouveau Centre de Protonthérapie

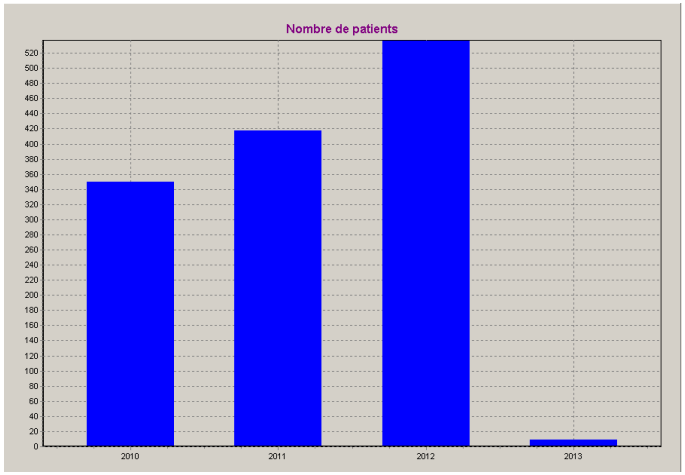
1er treatment ophtalmo: july 2010

1er treatment gantry: october 2010

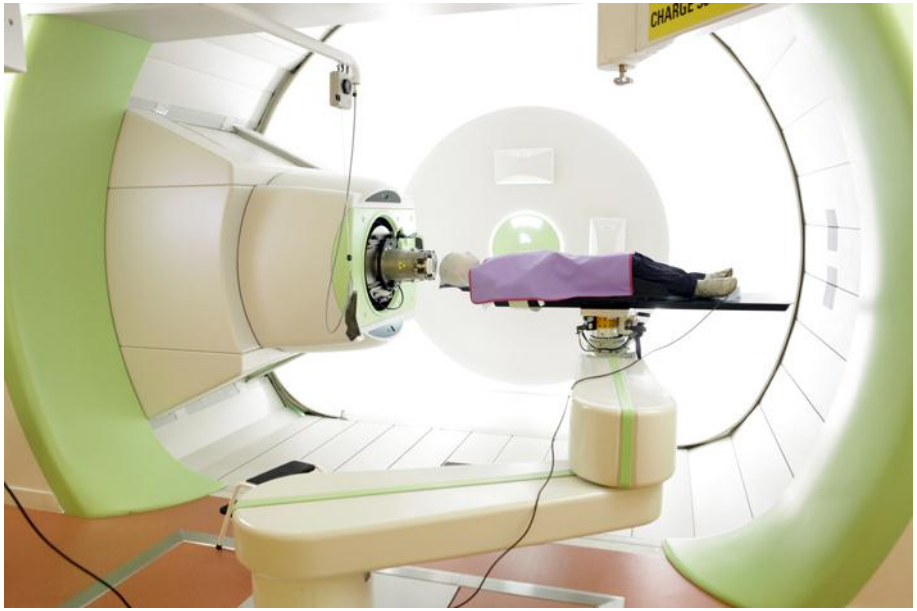
1er treatement fix beamline: july 2011

5 days/50 weeks / year

+6000 fractions



2012



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Thank you !

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