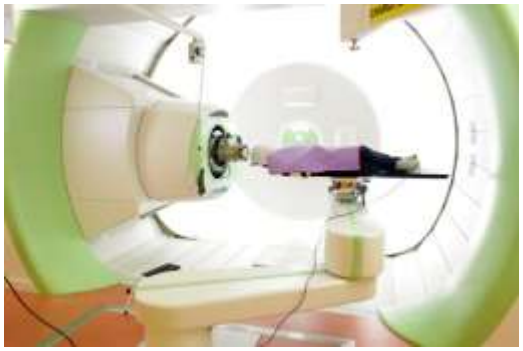
PATIENT WORKFLOW IN THE ORSAY PROTONTERAPY CENTER (CPO)



Sabine DELACROIX

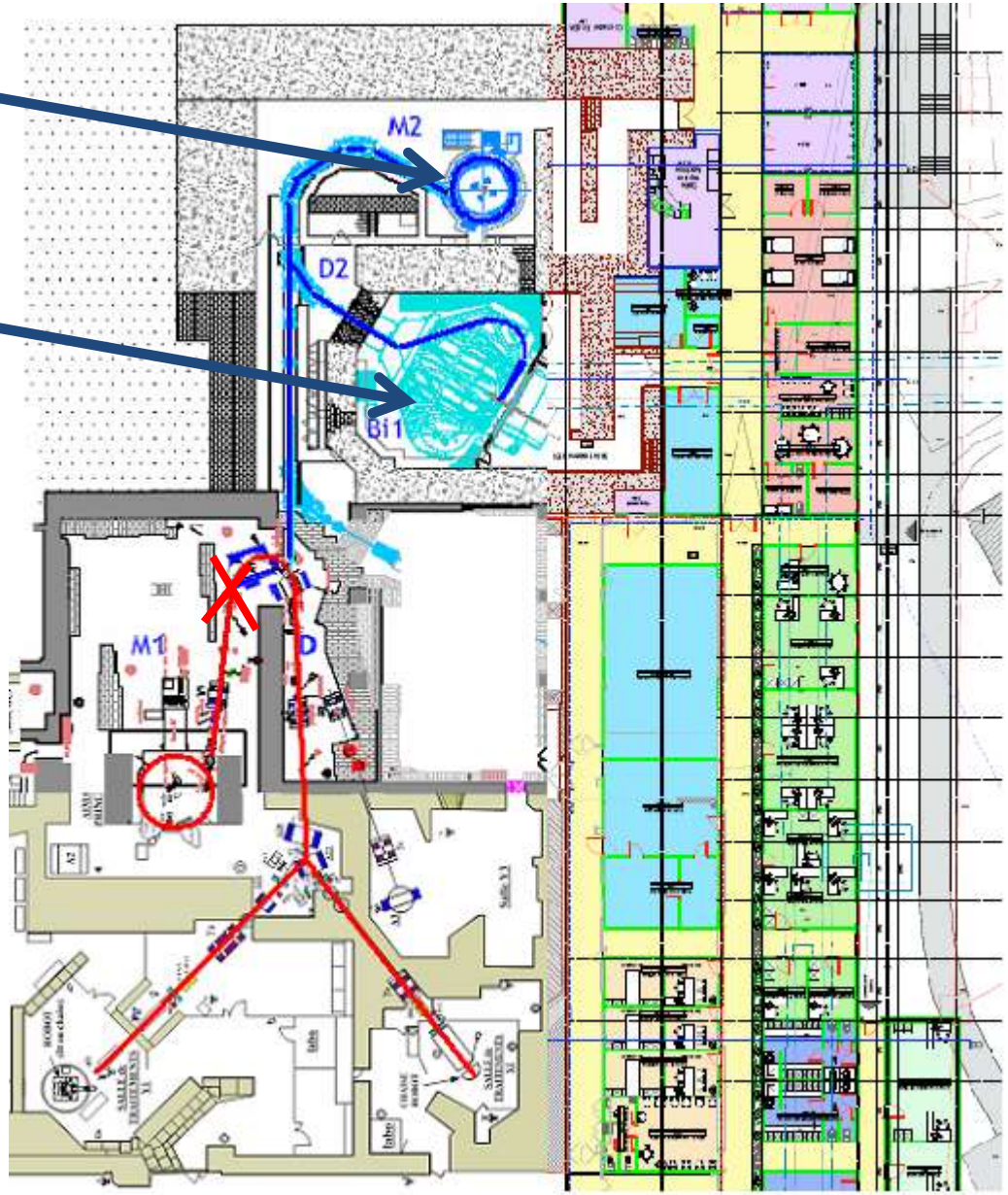
CERN ACCELERATOR SCHOOL
ACCELERATOR FOR MEDICAL APPLICATION
Vienna Austria 26 May – 5 June 2015

THE ORSAY PROTONTHERAPY CENTER

- Created in 1991 (1 synchrocyclotron + 2 fixed beam lines)
- Upgraded in 2010 (1 cyclotron+ 1 gantry and a medical area)
- Connexion to the existed fixed beam lines

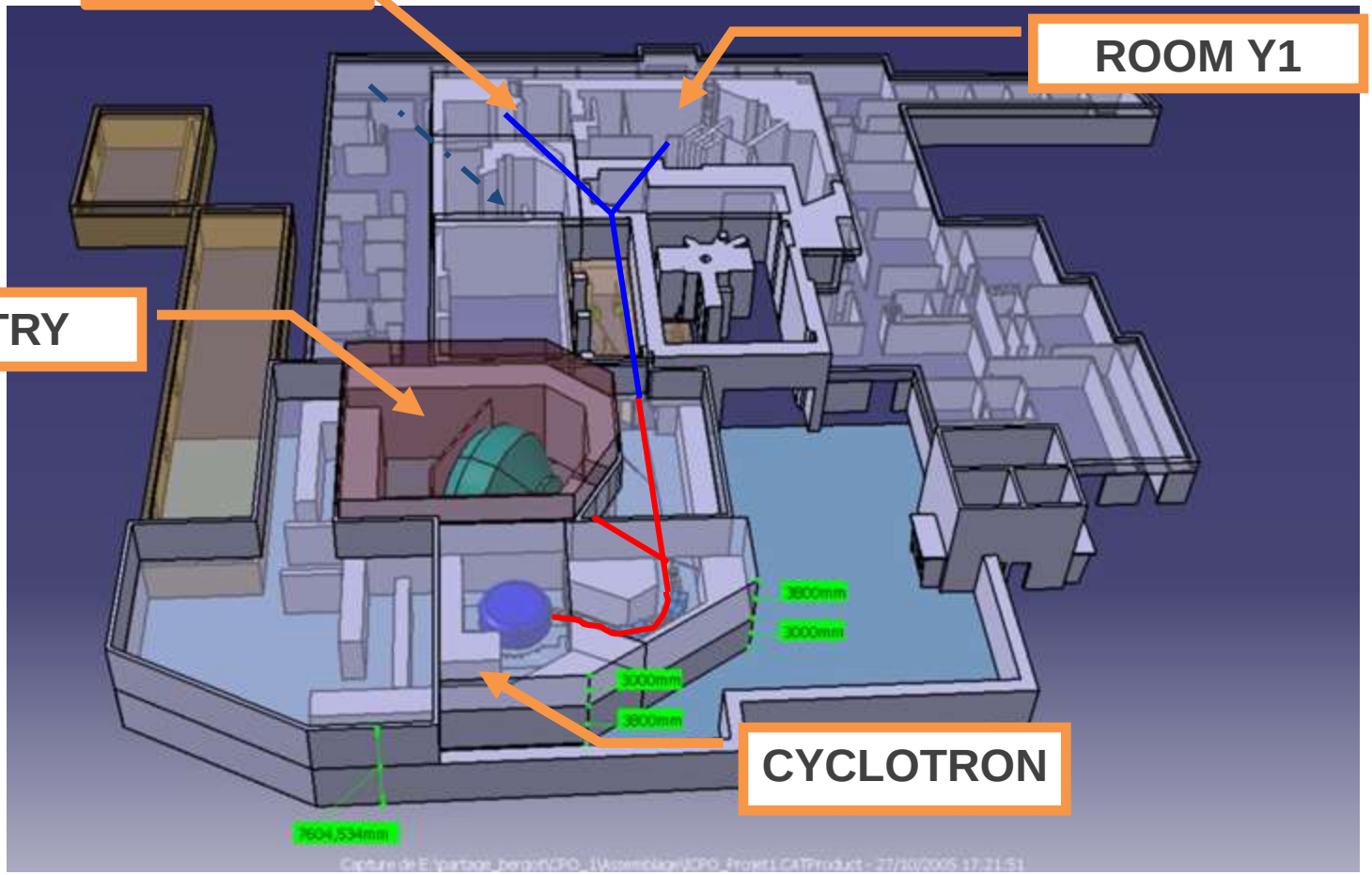
Cyclotron

Gantry



Medical area

THE CURIE INSTITUTE PROTONTHERAPY CENTER



CLINICAL INDICATIONS

7010 Patients treated from Sept. 1991 to Dec. 2014:

- Ocular tumors (5433 patients treated from Sept 1991 to Dec 2014)
- Base of skull :Chordomas, chondrosarcomas, méningiomas…
(1558 patients treated from Dec 1993 to Dec 2014 included 392 children)
- Rachis : 19 patients treated from Jan 2013 to Dec 2014

EUROPEAN PROTONTHERAPY OVERVIEW

Data from the Particle Co Operative Group/ Up date April 2015

COUNTRY	WHO, WHERE	MAX ENERGY (MeV)	BEAM DIRECTIONS	START OF TREATMENT	TOTAL PATIENTS TREATED (DEC 2014)
ENGLAND	CLATTERBRIDGE	62	1 HORIZ	1989	2626
FRANCE	CAL NICE *	65	2 HORIZ	1991	5204
FRANCE	CPO ORSAY	230	1 GANTRY 2 HORIZ	1991	7004
GERMANY	HZB BERLIN	250	1 HORIZ	1998	2525
GERMANY	RPTC MUNICH	250	4 GANTRIES 1 HORIZ	2009	2307
GERMANY	HIT HEIDELBERG	250	1 GANTRIES 2 HORIZ	2009	824
GERMANY	WPE ESSEN	230	4 GANTRIES 1 HORIZ	2013	139
GERMANY	PTC DRESDEN	230	1 GANTRY	2014	First patient
ITALY	INFN CATANIA	60	1 HORIZ	2002	350
ITALY	CNAO PAVIA	250	3 HORIZ 1 VERT	2011	111
ITALY	APSS TRENTO	230	2 GANTRIES 1 HORIZ	2014	5
POLAND	IFJ PAN KRAKOW	60	1 HORIZ	2011	85
SWEDEN	UPPSALA	200	1 HORIZ	1989	1431
SWITZERLAND	PSI VILLINGEN	250	2 GANTRIES 1 HORIZ	1984	7364

* New facility under construction/ start of treatment planned in 2016

ROOM Y2/ OPHTHALMIC TREATMENTS

Robotic positioner (2006)

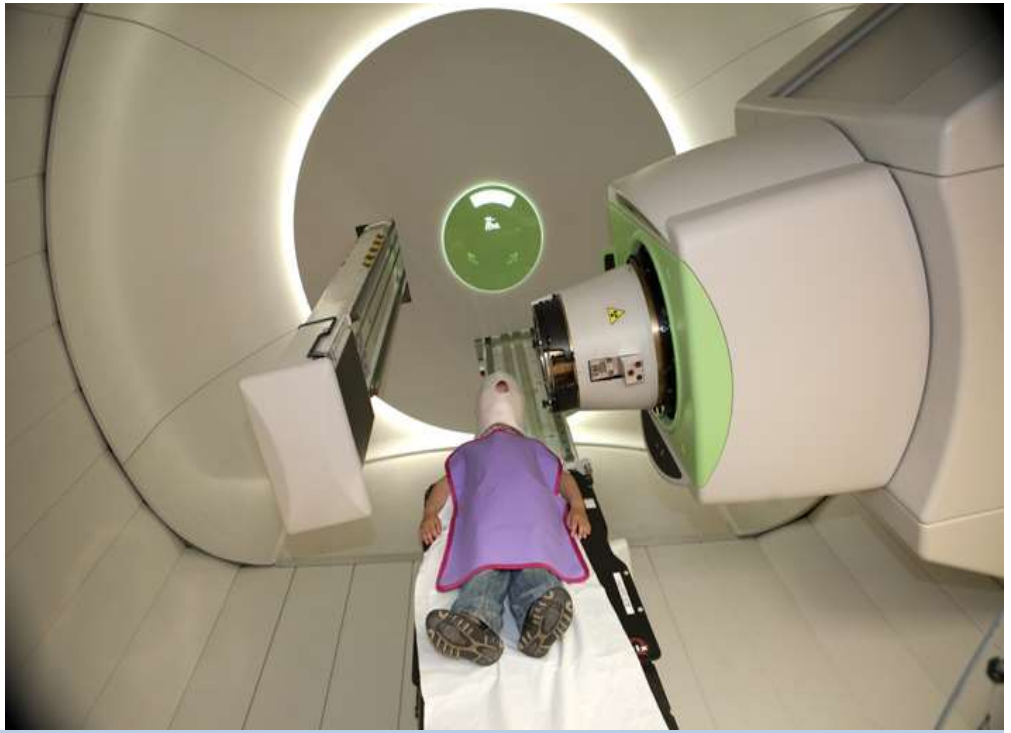
- **Industrial parallel Fanuc design (robustness)**
- **6 DOF (1 extra axis for complete top rotation)**
- **Accuracy : +/- 0.1mm, +/- 0.1°**
- **Security hardware (speed, acceleration, collision)**

ROOM Y1/ BASE OF SKULL TREATMENTS

- Robotic positioner (1994)

- 6 DOF (including pitch & roll)
- Couch, chair or QA water phantom
- Industrial Fanuc design
- Security hardware (speed, acceleration, collision)

GANTRY



Robot Forte Isocentric motion (+/- 0.5 mm) inside treatment volume 6 DOF : pitch & roll (+/- 15°)

MAINTENANCE SCHEMA

LOCAL TEAM:14 technicians and engeneers

IBA TEAM : 3 engineers

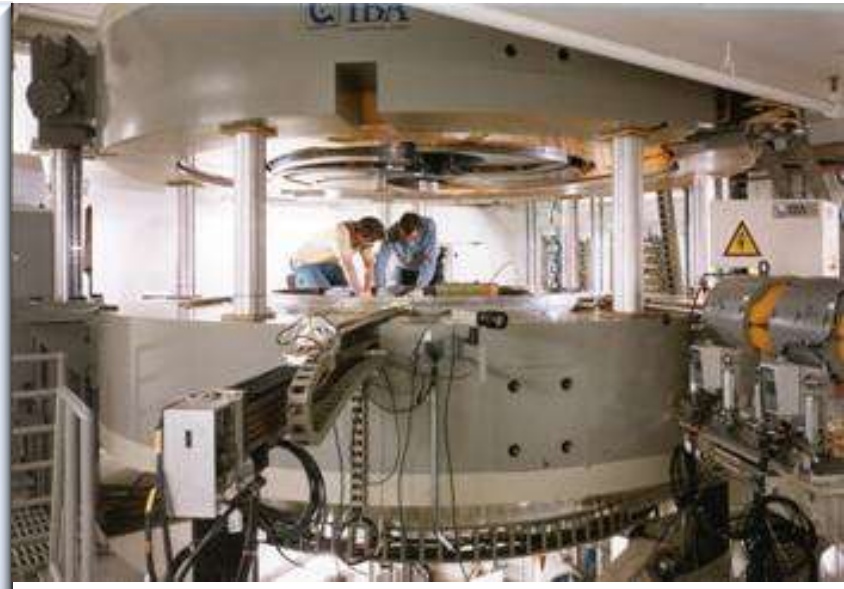
ON CALL STAFF 24/7 (2 T ECH+1PHYSICIST)

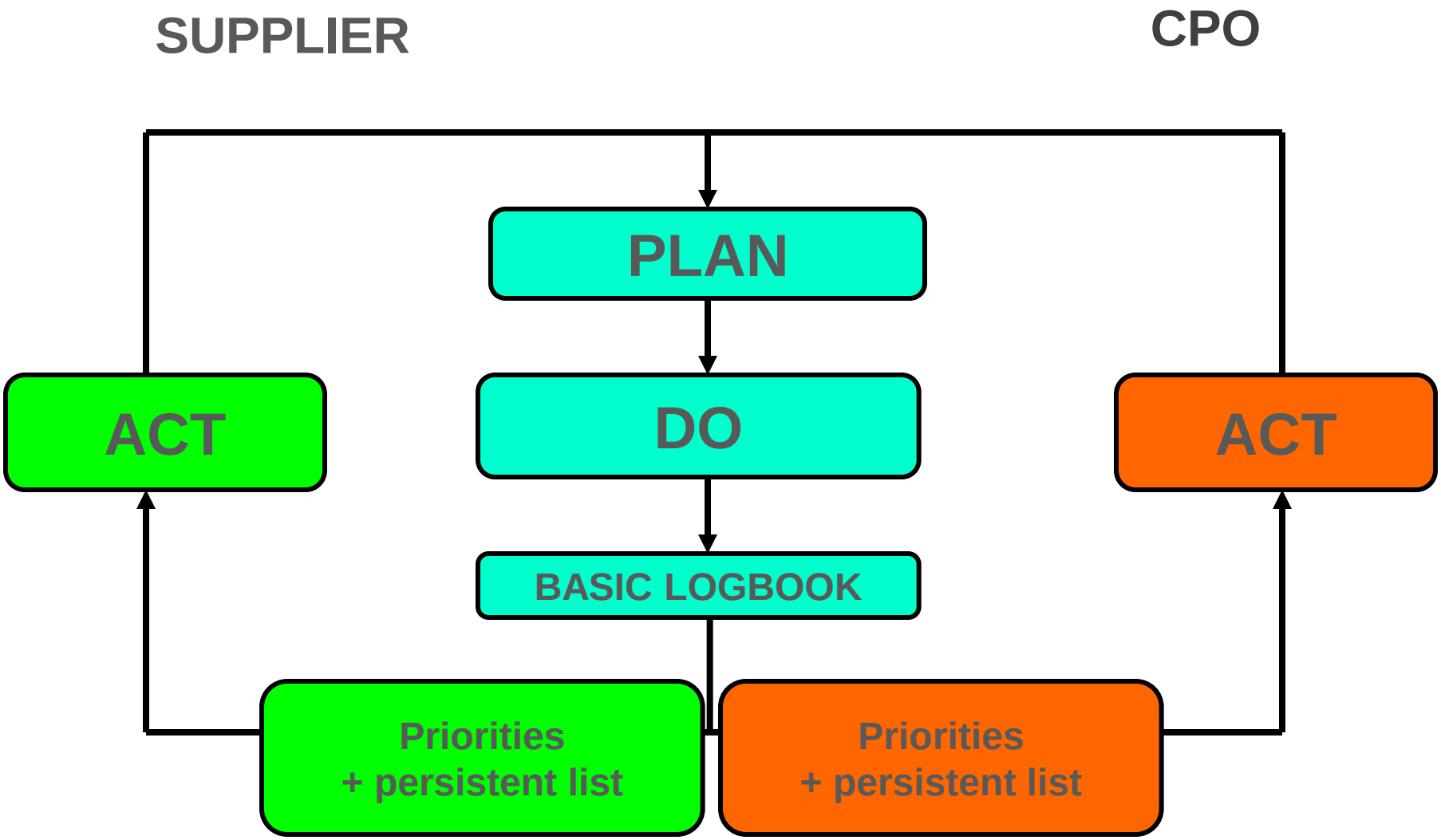
WEEKLY:
2h on Monday and Thursday morning
4h on Saturday morning when needed

QUATERLY: 1.5 days every 3 months

YEARLY: 1 week if necessary

After 4 years of ramp-up,
Up-time 2014 : 97.8%
(2.2% of patients rescheduled)

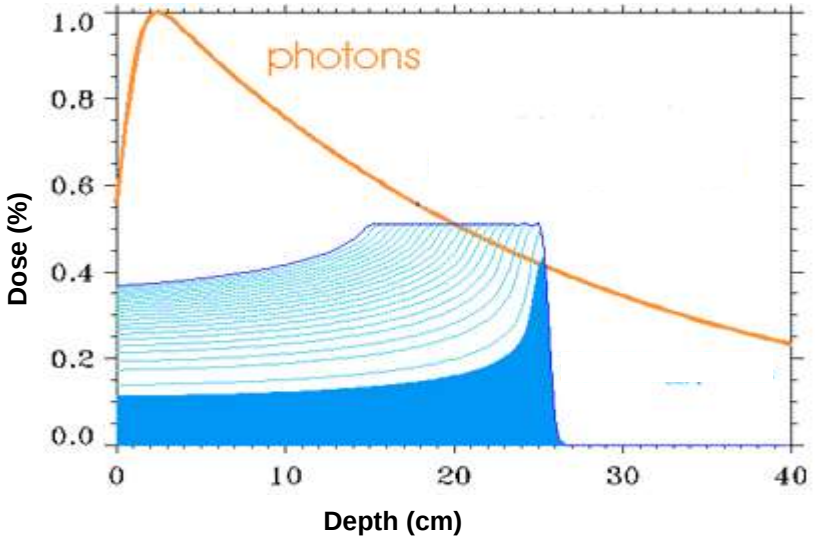


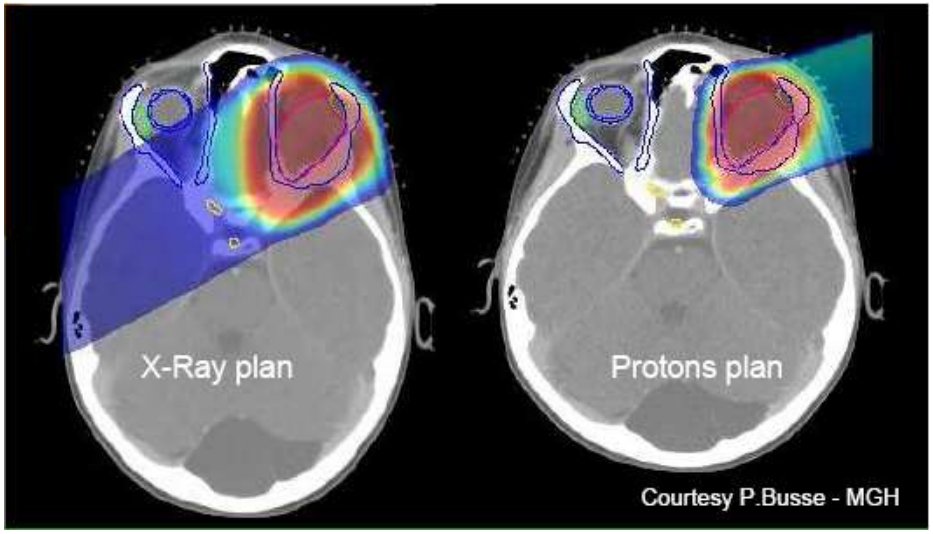


Weekly follow-up of unwanted events and failures requiring associated working groups

BALLISTIC ADVANTAGES OF PROTONS

- Fixed range
- Small lateral penumbra
- High gradient of dose in the distal Bragg peak





CLINICAL ADVANTAGES OF PROTONS

- **Ability to treat tumors close to critical organs (optic nerve, macula, brain stem, optic chiasm, spinal cord,…)**
- **Possibility to increase the dose delivered to tumors to improve the local control**

Paediatric cancers :

- **Higher radiosensitivity for normal tissues**
- **Tumors are often more radiosensitive**

Protons can:

- **Decrease dose to normal tissues by 50-70%**
- **Decrease side-effects and complications such as:**
  - Growth impairment
  - Hormone deficiency
  - Impaired cognitive development
  - Impaired visual acuity
  - Hearing troubles

Protons could:

- **Reduce Secondary Cancer Risk**

BEAM SET-UP

Passive Beam

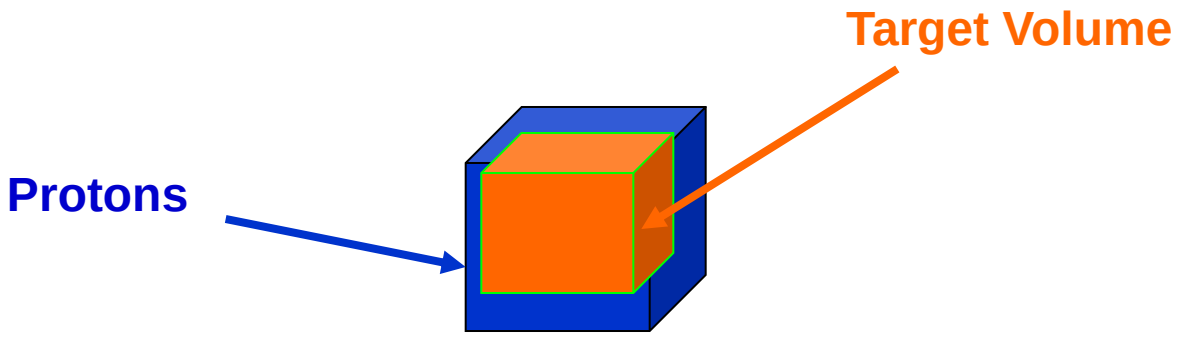
Additional time in the workflow to check the accessories

Scanning Beam

Quality control

TREATMENT PROCESS

- Beam set-up
- Reconstruction of the target volume
- Matching the beam shape with the target volume with a high accuracy

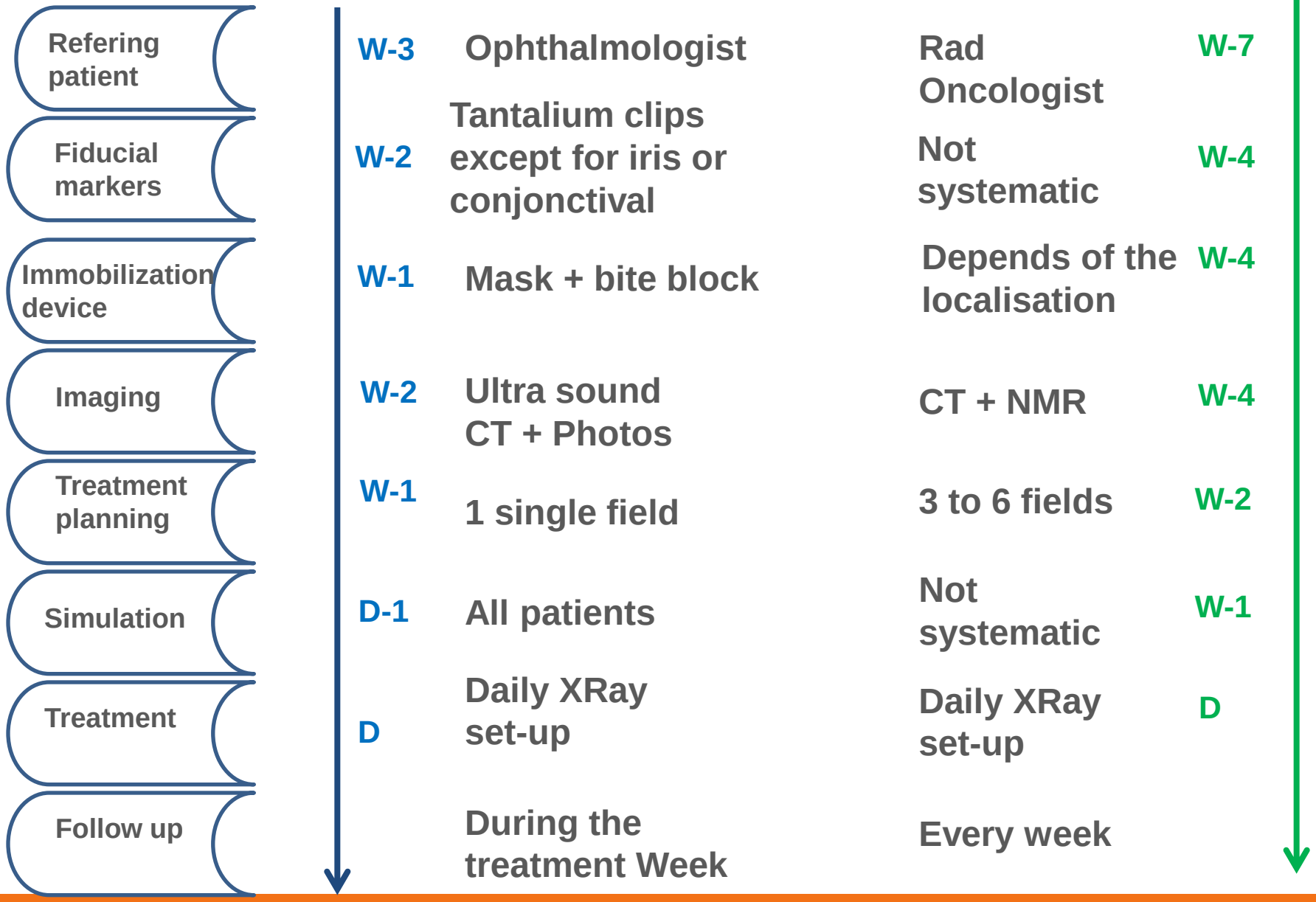


PATIENT WORKFLOW

PATIENTS WORKFLOW

- **Ophthalmic treatment:**
  - 4 to 8 fractions
  - Small target volume
  - High dose per fraction/high dose rate

- **Other localisations:**
  - Up to 35 fractions
  - Photon component may be added
  - Standard doses and dose rates
  - Children (some of them under total anaesthesia)

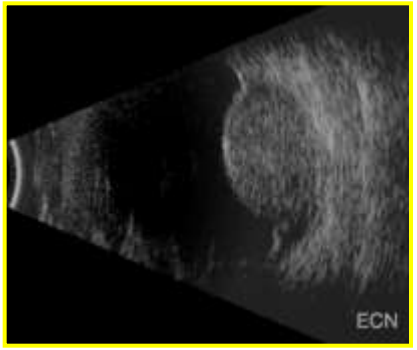

OPHTHALMIC TREATMENTS
OTHER TREATMENTS
Refering patient
Fiducial markers
Immobilization device
Imaging
Treatment planning
Simulation
Treatment
Follow up
W-3
Ophthalmologist
W-2
Tantalium clips except for iris or conjonctival
W-1
Mask + bite block
W-2
Ultra sound
CT + Photos
W-1
1 single field
D-1
All patients
D
Daily XRay set-up
During the treatment Week
W-7
Rad Oncologist
W-4
Not systematic
W-4
Depends of the localisation
W-4
CT + NMR
W-2
3 to 6 fields
W-1
Not systematic
D
Daily XRay set-up
Every week

OPHTHALMIC PROCESS/ IMAGING

- **Diagnostics:** routine consultation with an ophthalmologist

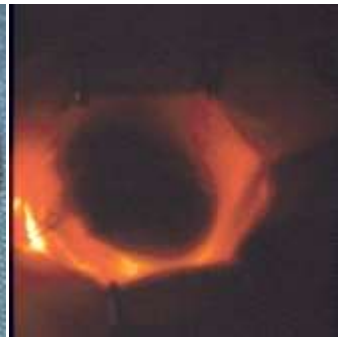
- **Consultation** to confirm the diagnostics (decision of treatment with protons/ Ophthalmologist & Radiation oncologist)

- **Ultrasounds:**
  - Tumor shape (diameters and thickness)
  - Ocular biometry (eyeball diameter)

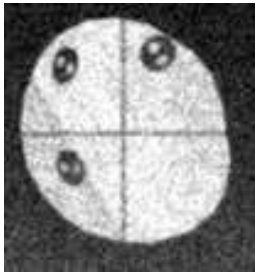


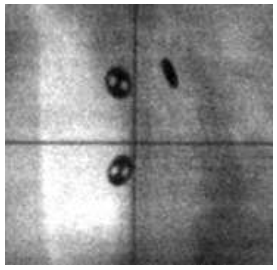
OPHTHALMIC PROCESS/ SURGERY AND IMMOBILIZATION DEVICE

- **Fiducial markers around the tumour base (under total aneasthesia)/ transillumination:**
  - Distances clips-tumor
  - Limbus diameter



- **Immobilization and positionning devices:**
  - Mask+bite block
  - Eye retractors
  - PPS





- **X Ray**

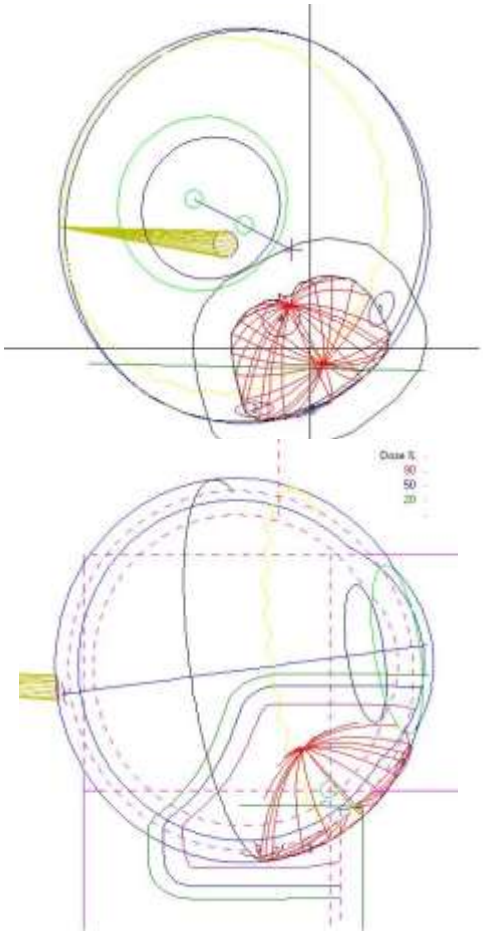
OPHTHALMIC PROCESS/ TREATMENT PLANNING

3D reconstruction of the tumor

Choice of the eye position

Eye ball preservation
- Avoid to irradiate full anterior chamber volume
- Reduce irradiated eye volume
- Avoid lacrymal gland

Vision preservation (if possible)
- Avoid optique nerve
- Avoid macula



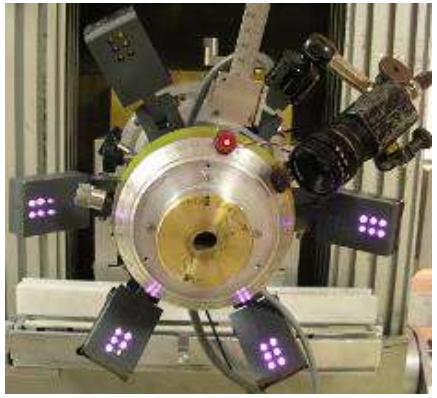
Beam eye view

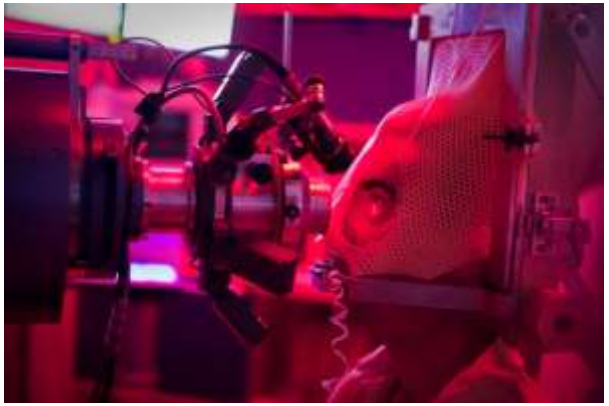
Lateral eye view

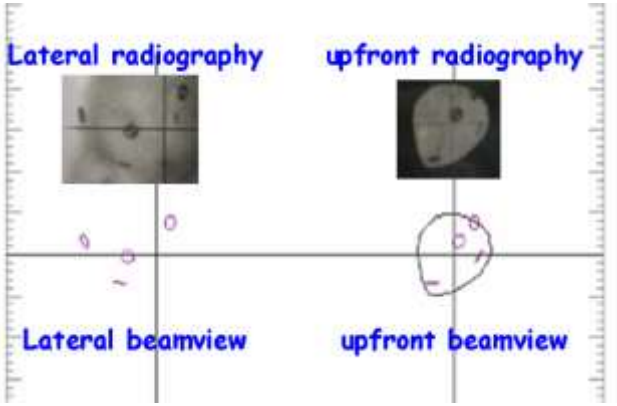
OPHTHALMIC PROCESS/ SIMULATION

Simulation:

- Validation of the Treatment Planning
- Measurement of the eyelids and curvatures of the eyeball

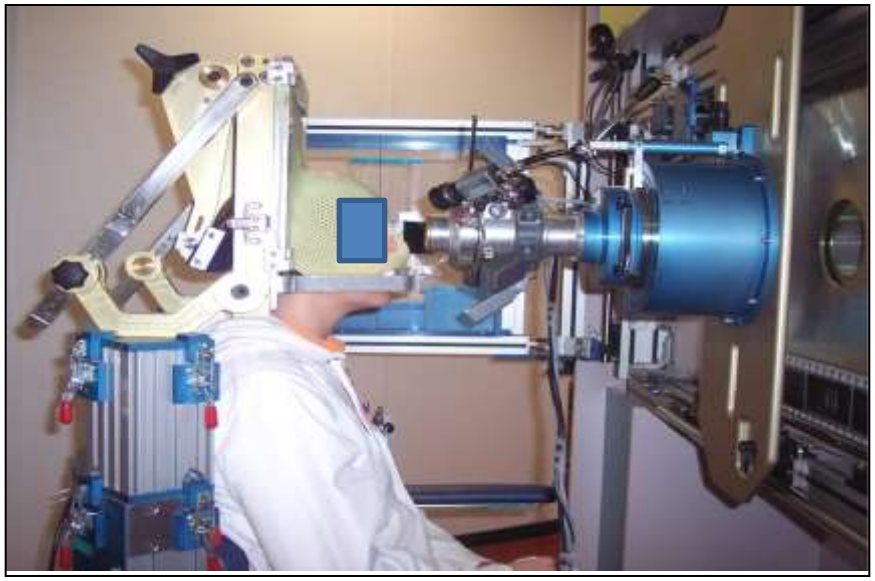


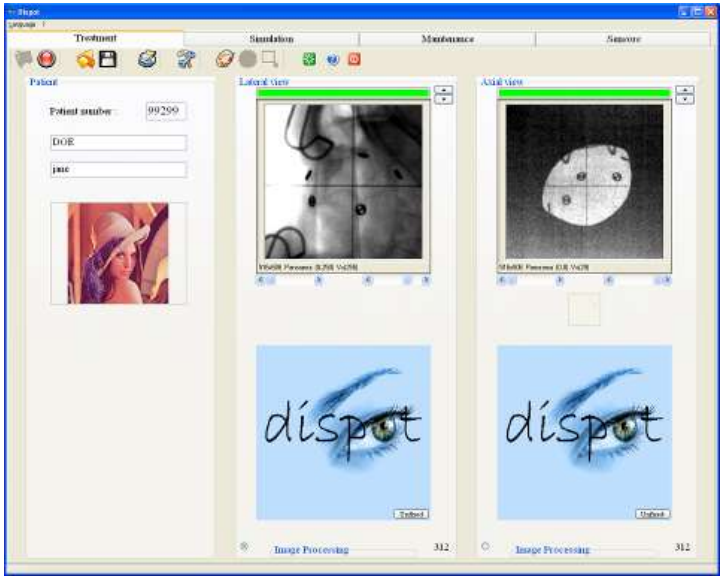




OPHTHALMIC PROCESS/ TREATMENT

- **Treatment**





- **Daily set-up with X Ray**
- **Control of patient and eye position with cameras**

OPHTHAMIC PROCESS/ FOLLOW - UP

- During the treatment week (ophthalmologist)
- At 1 month, 6 months , 1 year
- Once a year
- Ultrasound/ Visual control

OTHER LOCALISATIONS

OTHER LOCALISATIONS/ FIDUCIAL MARKERS

- **Fiducial markers/ Local anaesthesia**

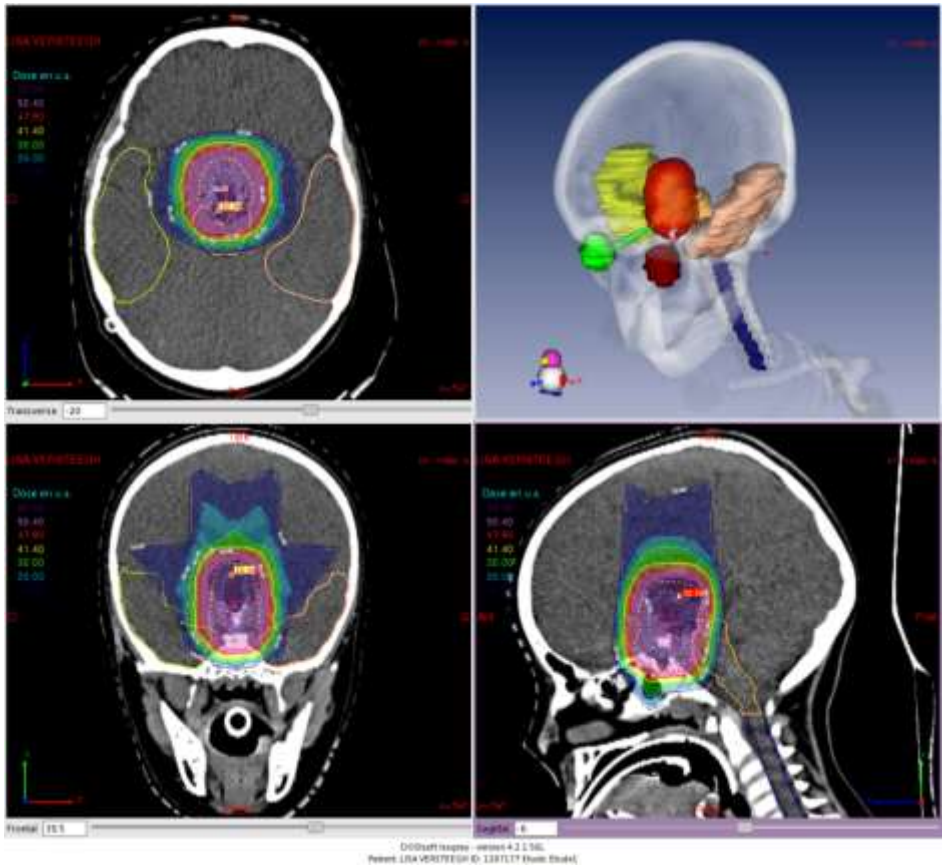
OTHER LOCALISATIONS/ IMMOBILIZATION DEVICES

OTHER LOCALISATIONS / TREATMENT PLANNING

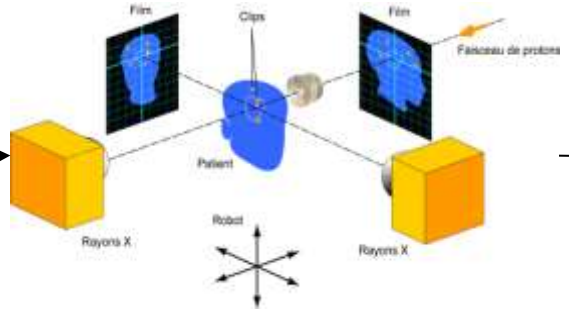
- CT SCAN
- NMR
- FUSION
- Delineation of the tumor and critical organs/ Oncologist

- Ballistic of irradiation: done by physicist or technologist/check by physicist/ Approved by physician

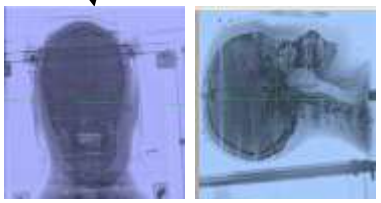
- Simulation



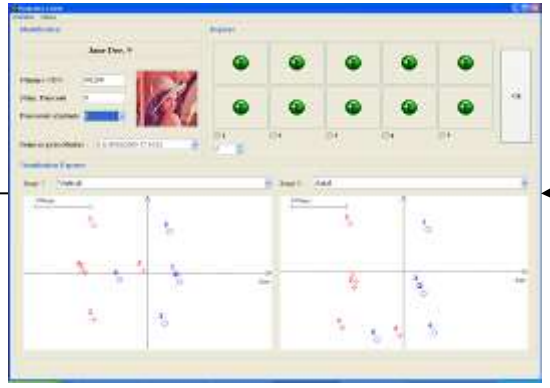
OTHER LOCALISATIONS/ PATIENT SET-UP



Two orthogonal films



Films Digitalisation



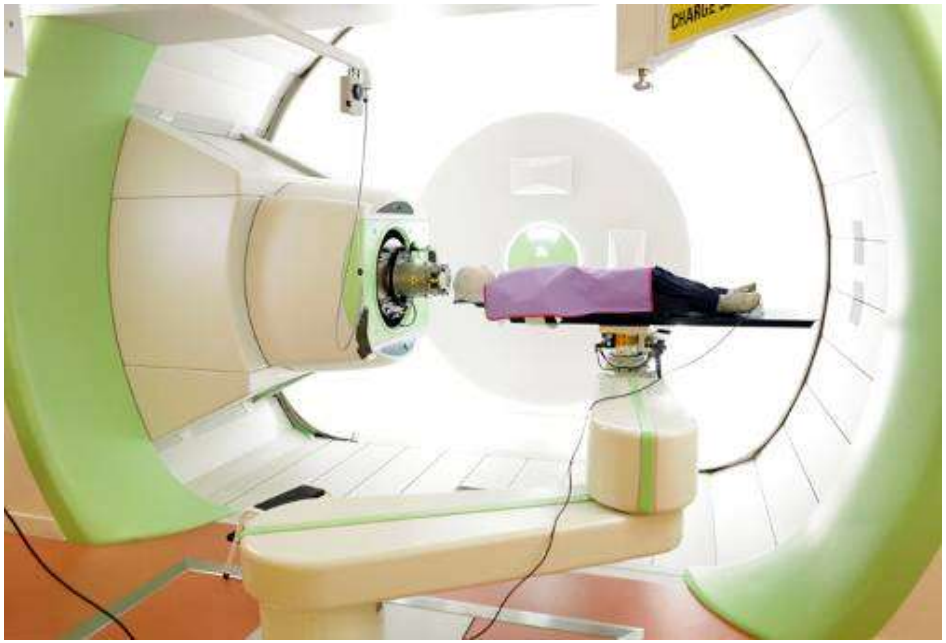
corrections

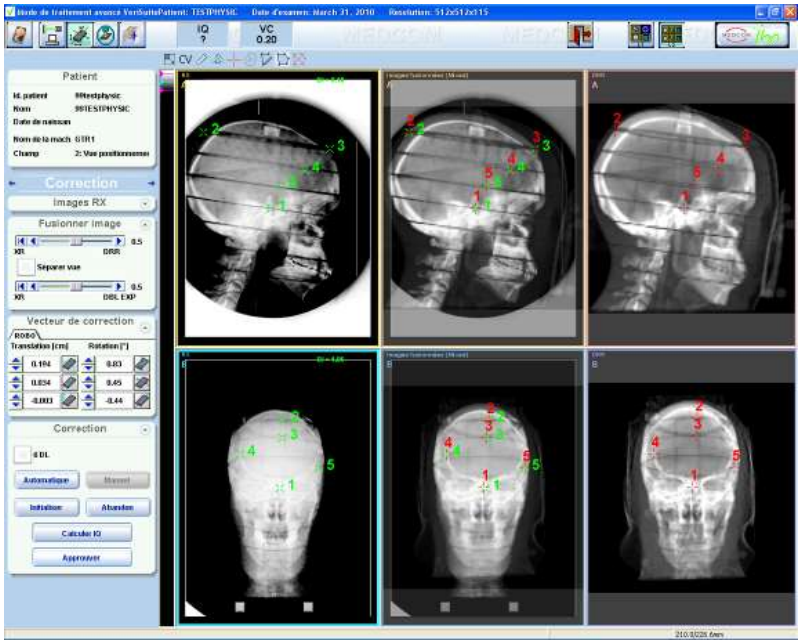
Sent data to PPS

Si < à 1,5mm Et 1,5°

Treatment

OTHER LOCALISATIONS/ PATIENT SET-UP





Patient alignment in Gantry room Orsay
VERISUITE (by MEDCOM)

- **Fiducial markers matching**
- **Anatomical manual matching**

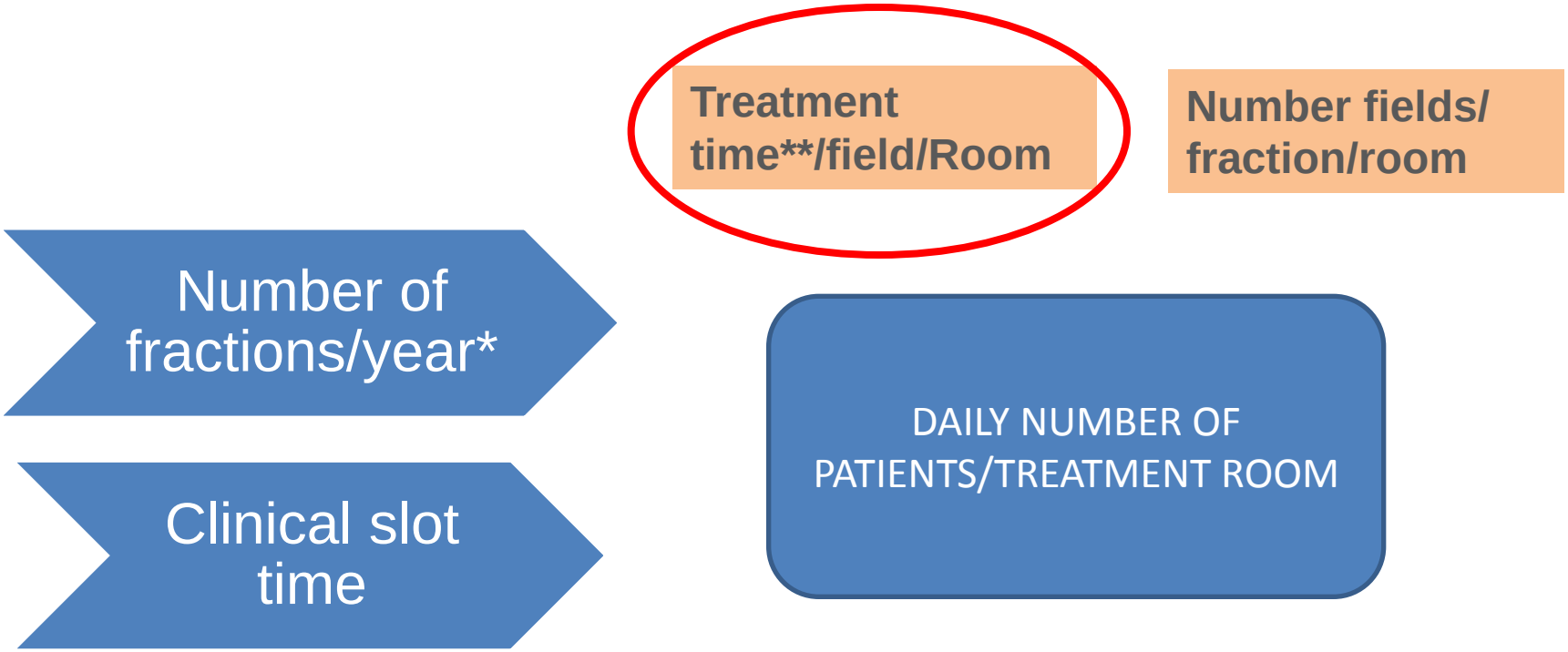
TREATMENT UNDER TOTAL ANAESTHESIA

- Children under 5 years old
- 2 to 6 children per day
- 2 fields/day (1 hour set-up and treatment)
- Induction and wake -up in the treatment room
- Follow-up in the wake-up room (1 nurse)
- Breakfast in the wake-up room

WAKE -UP ROOM

HOW CAN WE OPTIMIZE THE WORKFLOW?

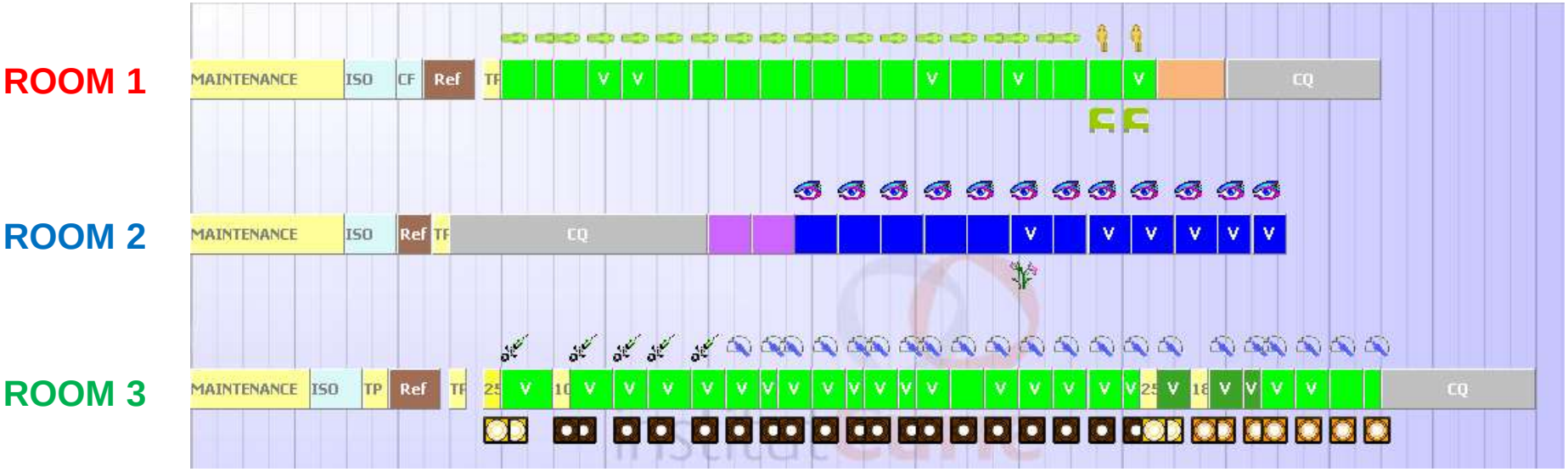
CLINICAL OBJECTIVES



*** Estimate the number of treatment days (Holidays/ Breakdown /Maintenance)**

****Treatment time: set-up + beam**

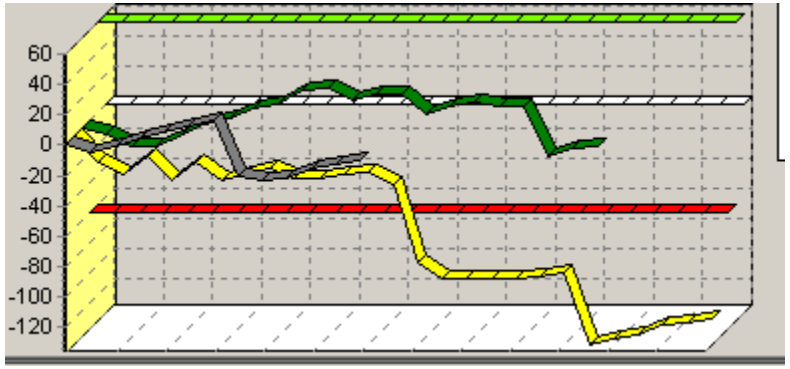
DAYLY PLANNING



Activities scheduled in one room:

- Beam tuning
- Reference morning checks
- Periodic checks
- Snout changes
- Simulations/ Treatment/ Treatment under total aneasthesia
- QC/ PHYSICS TESTS/ MAINTENANCE

REAL DAYLY PLANNING (Example)



	Delay
ROOM 1	11 min
ROOM 2	10 min
ROOM 3	120 min

CAUSES OF DELAY:

- Patient (stress, general state, weariness…)
- Organization (bad transfer of information, staff planning…)
- Devices
- Soft

The challenge is to match the real planning with the predictable one

KEY PERFORMANCE INDICATORS (KPI)

- **LEAN PROCESS:**

We defined a nominal workflow : any deviation from this situation has to be registered

  - In each treatment room the technologists, physicists, physicians can declare any unexpected event in an excel file

  - Every week an analysis of all the problems is done and,*if necessary*, a working group is initiated

  - The different events are dispatching to the referents (Mechanical, software ingeneer…)

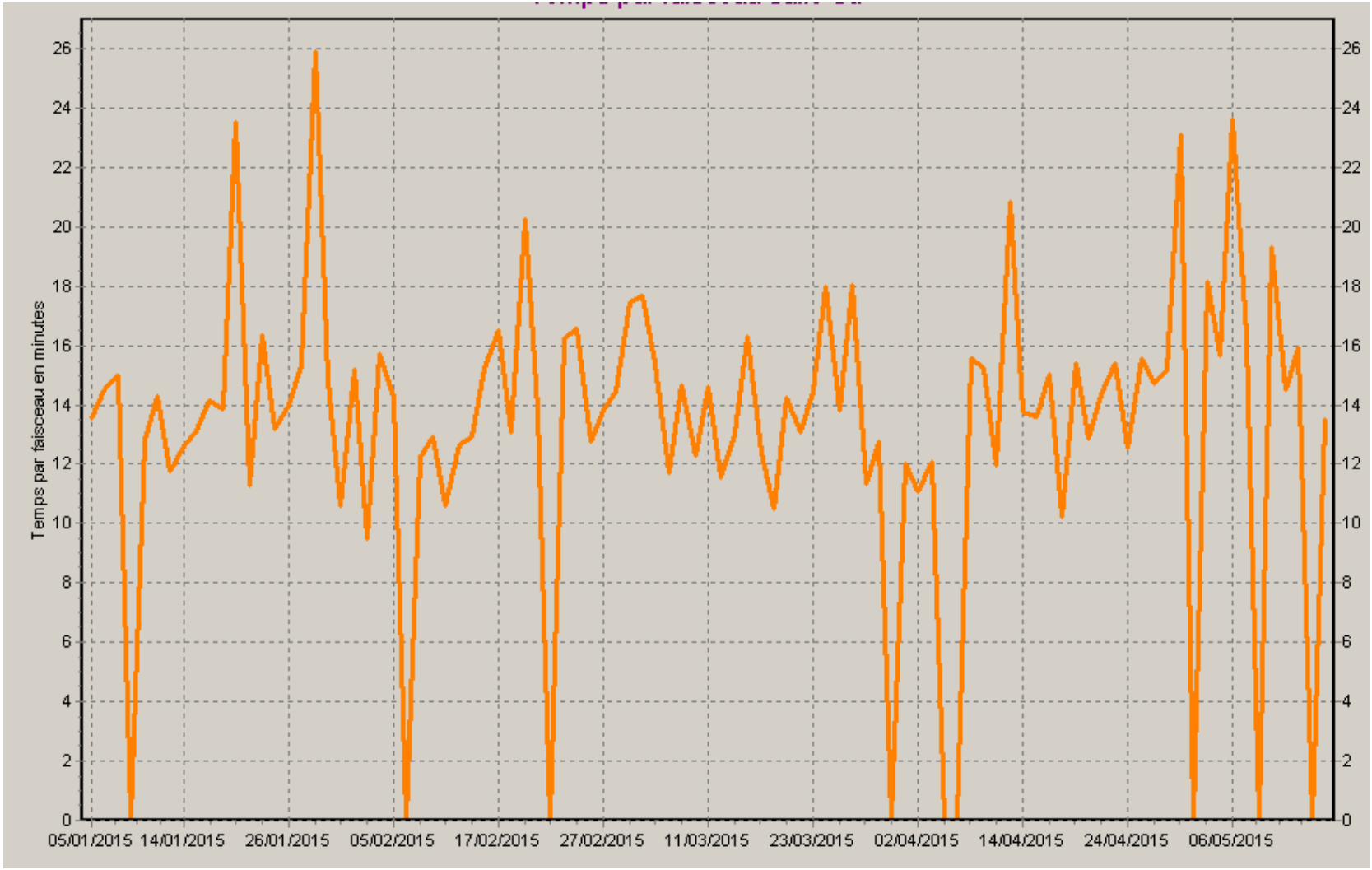
- **The planning is ajusted to the real treatment time**

SYSTEM OF DECLARATION

DATE	TIME	TIME (END)	DECLAR	STEP OF THE PROCESS	TYPE OF EVENT	DETAILS
29/04/2015	10:22	10:22	SO/PB	Patient set-up	Verisuite	
30/04/2015	09:23	09:26	VM/PBI	Patient set-up	Flat panel	
05/05/2015	09:18	09:25	VM/SO	Patient set-up	Hand pendant	
06/05/2015	10:05	10:15	VM/SO	Patient set-up	Contention	
05/05/2015	10:28	10:35	IL CB	Room set-up	Cyclotron	
12/05/2015	09:54	09:55	sl/so	Patient set-up	Asterope	
19/05/2015	09:02	09:02	SL/PB	Treatment	Organisation	

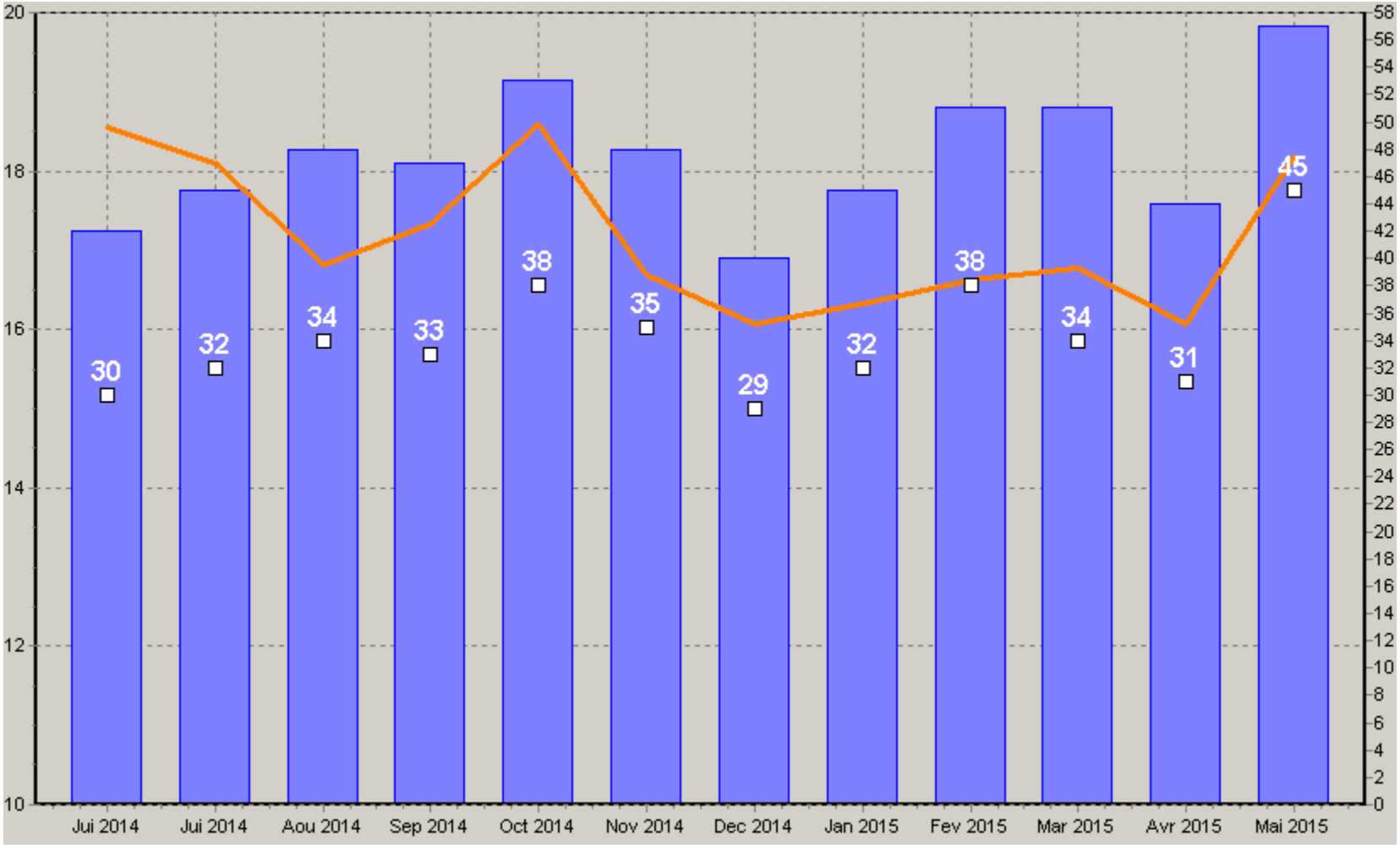
- Select IBA or CPO
- The event leads or not to additional X Ray
- The event leads or not to cancel the treatment of the day

AVERAGE TREATMENT TIME IN THE GANTRY



14,7min/ field today **17,2min in 2012** **45 in 2010**

PATIENT SCHEDULE



NON PREDICTIBLE EVENTS

The patient schedule can be modified due to:

- Change in the chemotherapy protocol
- Physical state of the patient
- Need of surgery
- Grow up of the target volume
- …

CONCLUSION

- The respect of the delay of each step of the process (imaging, delineation, QC…) is important to control the patients workflow

- The dayly planning needs to be continuously ajusted with the real data

- The collect and the analysis of the unexpected events:
  - Improve the treatment process
  - Help to reduce the level of stress of the team
  - Involve the staff in the process of optimization

  But the patient is in the center of the process and we need time to share with him and to listen to him.

THANKS FOR YOUR ATTENTION