PATIENT WORKFLOW IN THE ORSAY PROTON THERAPY CENTER (CPO)

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THE ORSAY PROTON THERAPY 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
THE CURIE INSTITUTE PROTON THERAPY CENTER

ROOM Y2

ROOM Y1

GANTRY

CYCLOTRON

THE CURIE INSTITUTE PROTON THERAPY CENTER
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 PROTON THERAPY OVERVIEW**

Data from the Particle Co Operative Group/ Update April 2015

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

* New facility under construction/ start of treatment planned in 2016
Robotic positioner (2006)
- Industrial parallel Fanuc design (robustness)
- 6 DOF (1 extra axis for complete top rotation)
- Accuracy: +/- 0.1 mm, +/- 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)
Robot Forte Isocentric motion (+/- 0.5 mm) inside treatment volume 6 DOF: pitch & roll (+/- 15°)
MAINTENANCE SCHEMA

LOCAL TEAM: 14 technicians and engineers

IBA TEAM: 3 engineers

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

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
Passive Beam

Additional time in the workflow to check the accessories

Scanning Beam

Quality control
• 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)
<table>
<thead>
<tr>
<th>Week</th>
<th>Ophthalmic Treatments</th>
<th>Other Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>W-1</td>
<td>Mask + bite block</td>
<td>Rad Oncologist</td>
</tr>
<tr>
<td>W-2</td>
<td>Tantalium clips except for iris or conjonctival</td>
<td>Not systematic</td>
</tr>
<tr>
<td>W-3</td>
<td>Ophthalmologist</td>
<td>Depends on localisation</td>
</tr>
</tbody>
</table>

- **Imaging**
  - Ultra sound
  - CT + Photos

- **Treatment planning**
  - 1 single field

- **Simulation**
  - All patients

- **Treatment**
  - Daily XRay set-up

- **Follow up**
  - During the treatment Week

- **Immobilization device**
  - W-7

- **Fiducial markers**
  - W-4

- **Refering patient**
  - W-1

- **D-1**
  - All patients
  - Daily XRay set-up

- **Weekly**
  - W-2
  - W-3
  - W-4

- **Tantalium clips**
  - Except for iris or conjonctival

- **Fiducial markers**
  - Depends on localisation

- **Mask + bite block**
  - Not systematic

- **Imaging**
  - CT + NMR

- **Treatment planning**
  - 3 to 6 fields

- **Simulation**
  - Not systematic

- **Weekly**
  - Daily XRay set-up

- **Follow up**
  - Every week
• **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)
• Fiducial markers around the tumour base (under total anaesthesia)/ transillumination:
  ▪ Distances clips-tumor
  ▪ Limbus diameter

• Immobilization and positionning devices:
  ▪ Mask+bite block
  ▪ Eye retractors
  ▪ PPS

• X Ray
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
Simulation:
- Validation of the Treatment Planning
- Measurement of the eyelids and curvatures of the eyeball
• 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
• Fiducial markers/ Local anaesthesia
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
Two orthogonal films

Si < à 1,5mm Et 1,5°

Sent data to PPS

Films Digitalisation

corrections
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

Number of fractions/year*

Clinical slot time

Treatment time**/field/Room

Number fields/fraction/room

DAILY NUMBER OF PATIENTS/TREATMENT ROOM

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

**Treatment time: set-up + beam
Activities scheduled in one room:

- Beam tuning
- Reference morning checks
- Periodic checks
- Snout changes
- Simulations/ Treatment/ Treatment under total anesthesia
- QC/ PHYSICS TESTS/ MAINTENANCE
### REAL DAILY PLANNING (Example)

<table>
<thead>
<tr>
<th>Room</th>
<th>Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room 1</td>
<td>11 min</td>
</tr>
<tr>
<td>Room 2</td>
<td>10 min</td>
</tr>
<tr>
<td>Room 3</td>
<td>120 min</td>
</tr>
</tbody>
</table>

#### 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 engineer…)

• The planning is adjusted to the real treatment time
### SYSTEM OF DECLARATION

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

- 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

14.7 min/ field today  17.2 min in 2012  45 in 2010
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 daily planning needs to be continuously adjusted 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