

Heavy Ion Therapy Masterclass School

Student's session

# Virtual visit to CNAO: clinical activity

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*CNAO, National Center of Oncological Hadrontherapy*



Not-for-profit private Foundation  
Created by the Italian Ministry of Health in **2001**  
with the purpose to build and run a hadrontherapy Centre

**2011** First patient  
(**1991** Amaldi launched the idea)



**20**  
Vent'anni di Cnao.

## Phases of CNAO

Phase 0: organization



Years: 2002 - 2004

Phase 1: construction



Years : 2005 - 2010



CNAO

## Phases of CNAO

Phase 0: organization

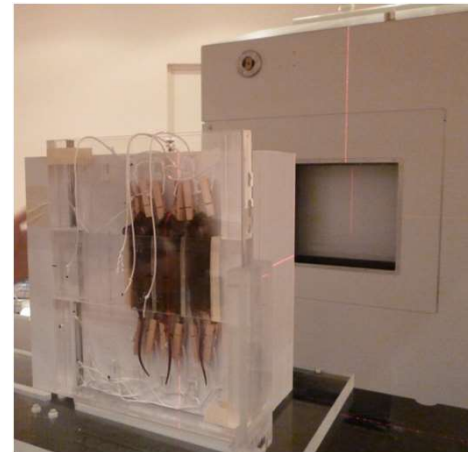
➡ Years: 2002 - 2004

Phase 1: construction

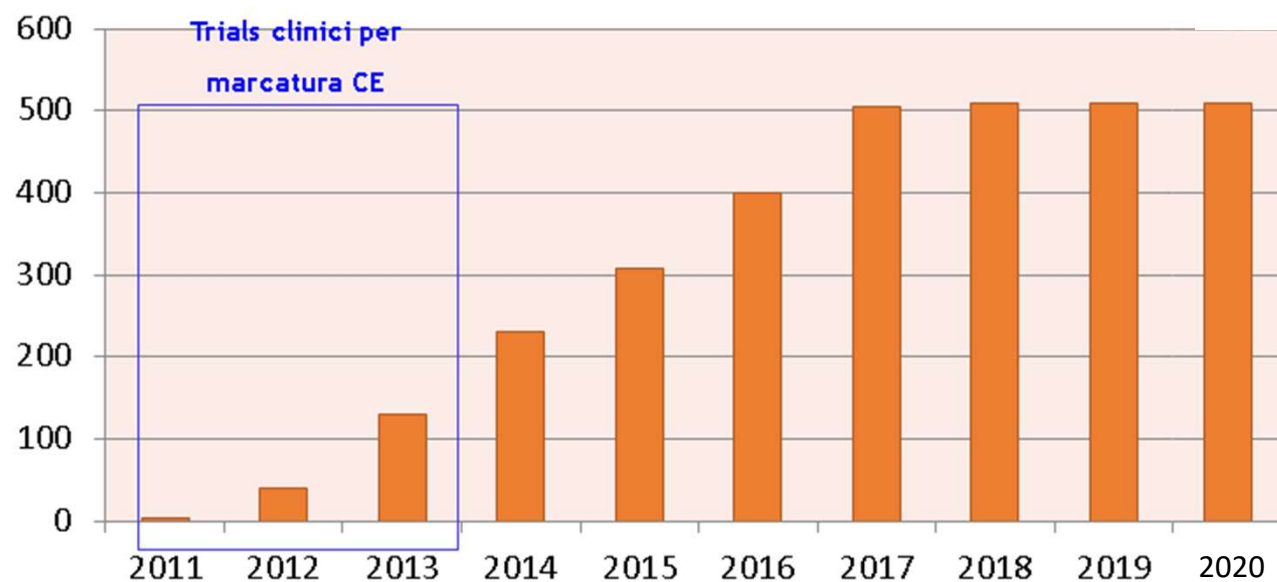
➡ Years : 2005 - 2010

Phase 2: experimental

➡ Years: 2010 - 2013 179 patients



## CNAO: patients per year



Clinical Phase  
(National Health System)  
Started since January 2014

## Essential Levels of Assistance (LEA)

1. Chordoma & chondrosarcoma base/spine
2. Meningiomas
3. Brain tumors (trunk)
4. ACC Salivary Glands
5. Orbit tumors including eye melanoma
6. Sinonasal carcinoma
7. Soft Tissue & bone Sarcoma (every sites)
8. Recurrent tumors (retreatment)
9. Patients with immunological disorders
10. Pediatric solid tumors
11. Tumors for which hadrontherapy guarantees a better dose distribution wrt the best alternative providing a 10% better result in terms of NTCP or TCP

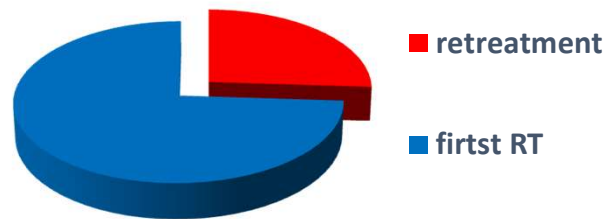
In Italy (60 million inhabitants) estimated cases 1-10:

**Protons:** about 5.000 patients/year

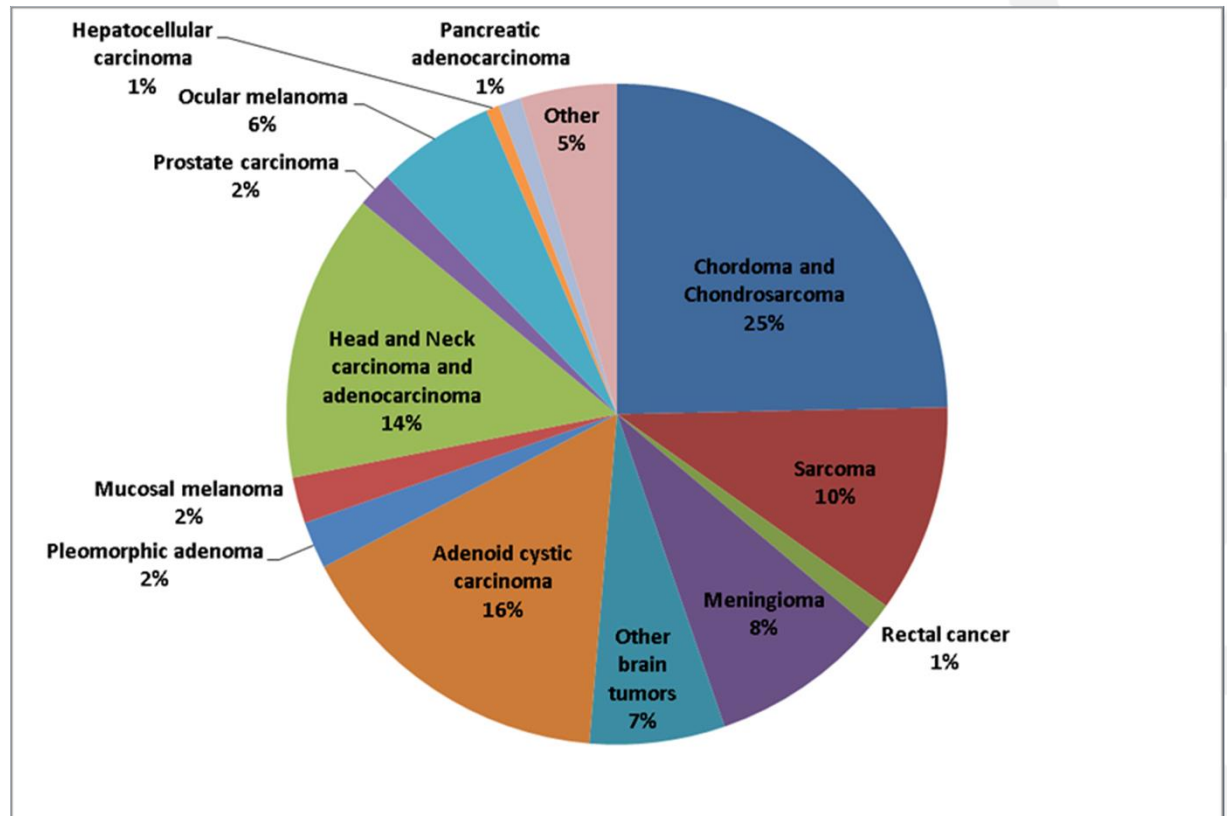
**Carbons:** about 1.000 patients/year

## Patients 3208

Type of treatment



- ✓ Radio resistant tumors
- ✓ Complex shape tumors
- ✓ Located close to critical structures

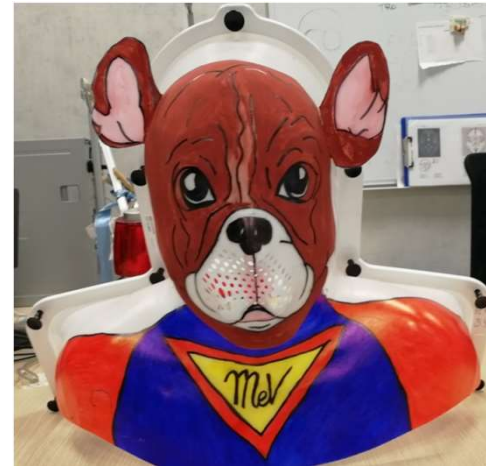


## Preparatory examinations and the simulation

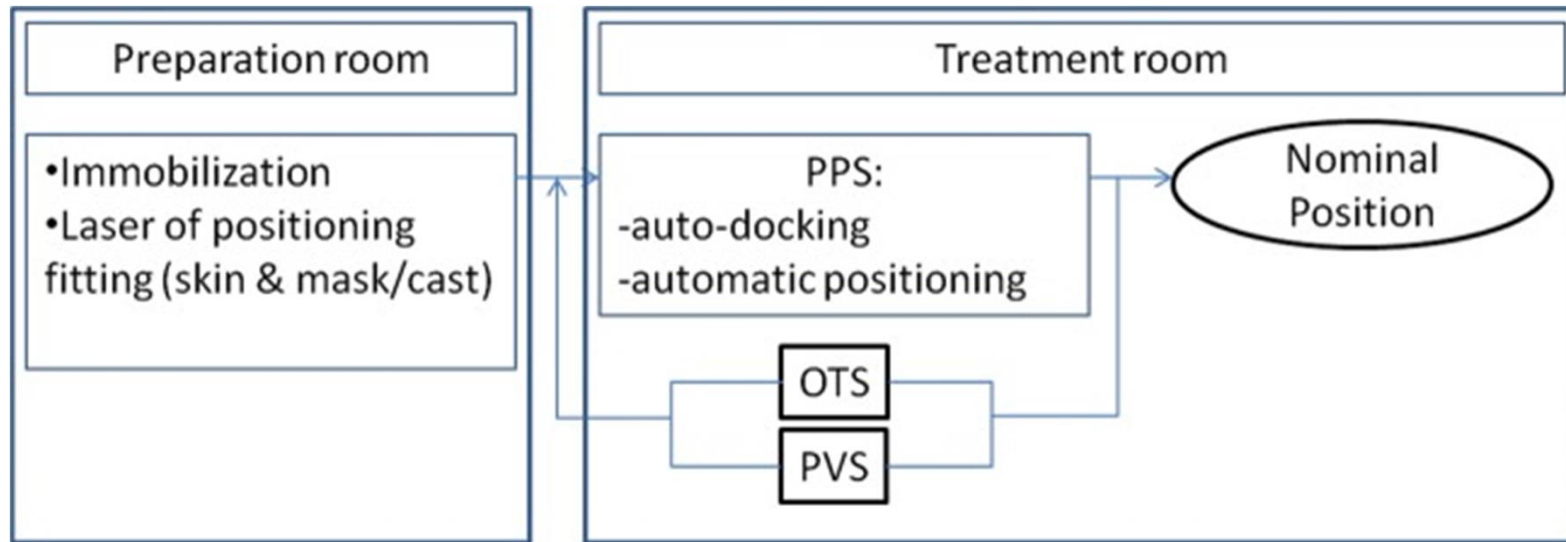
### Immobilization devices: personalised thermoplastic masks and pillows



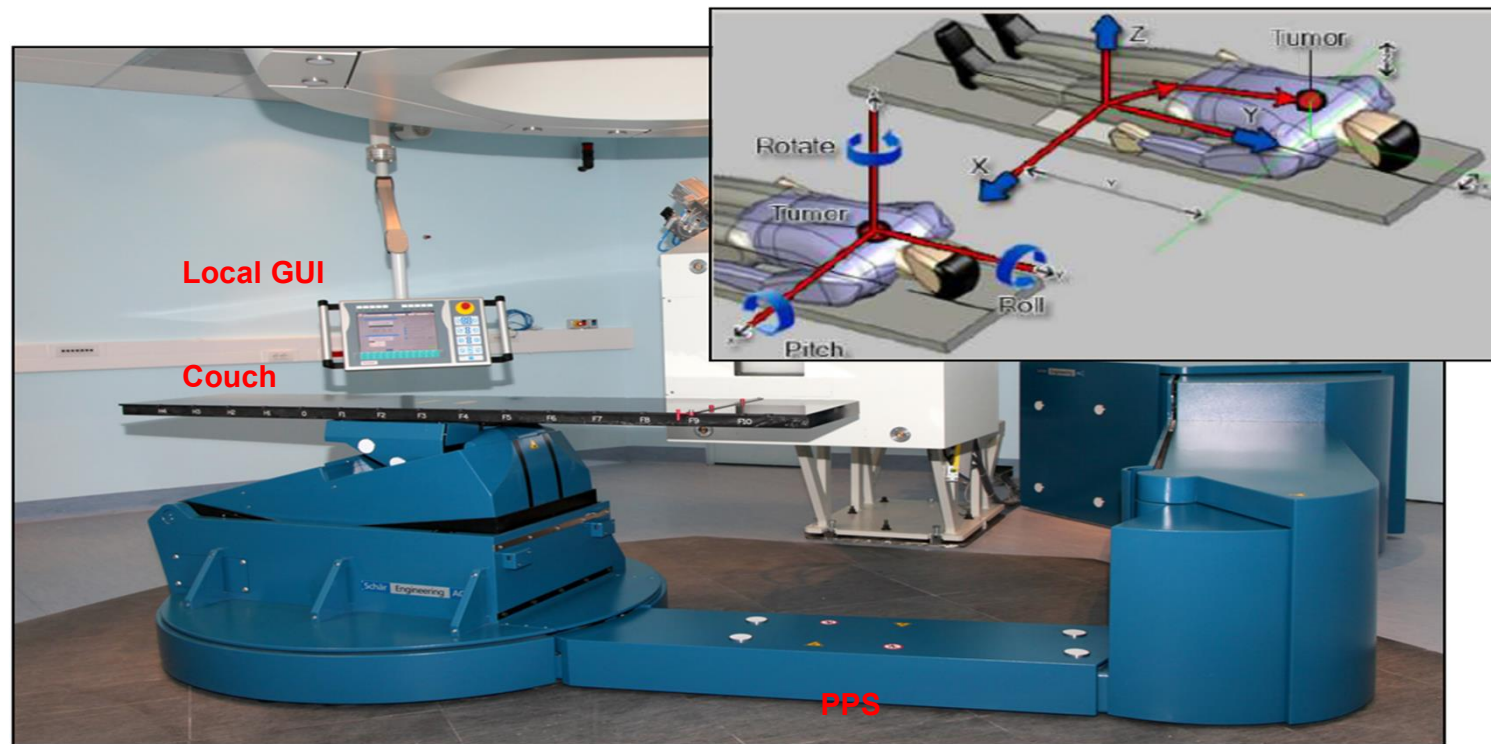
## Special patients: pediatric patients



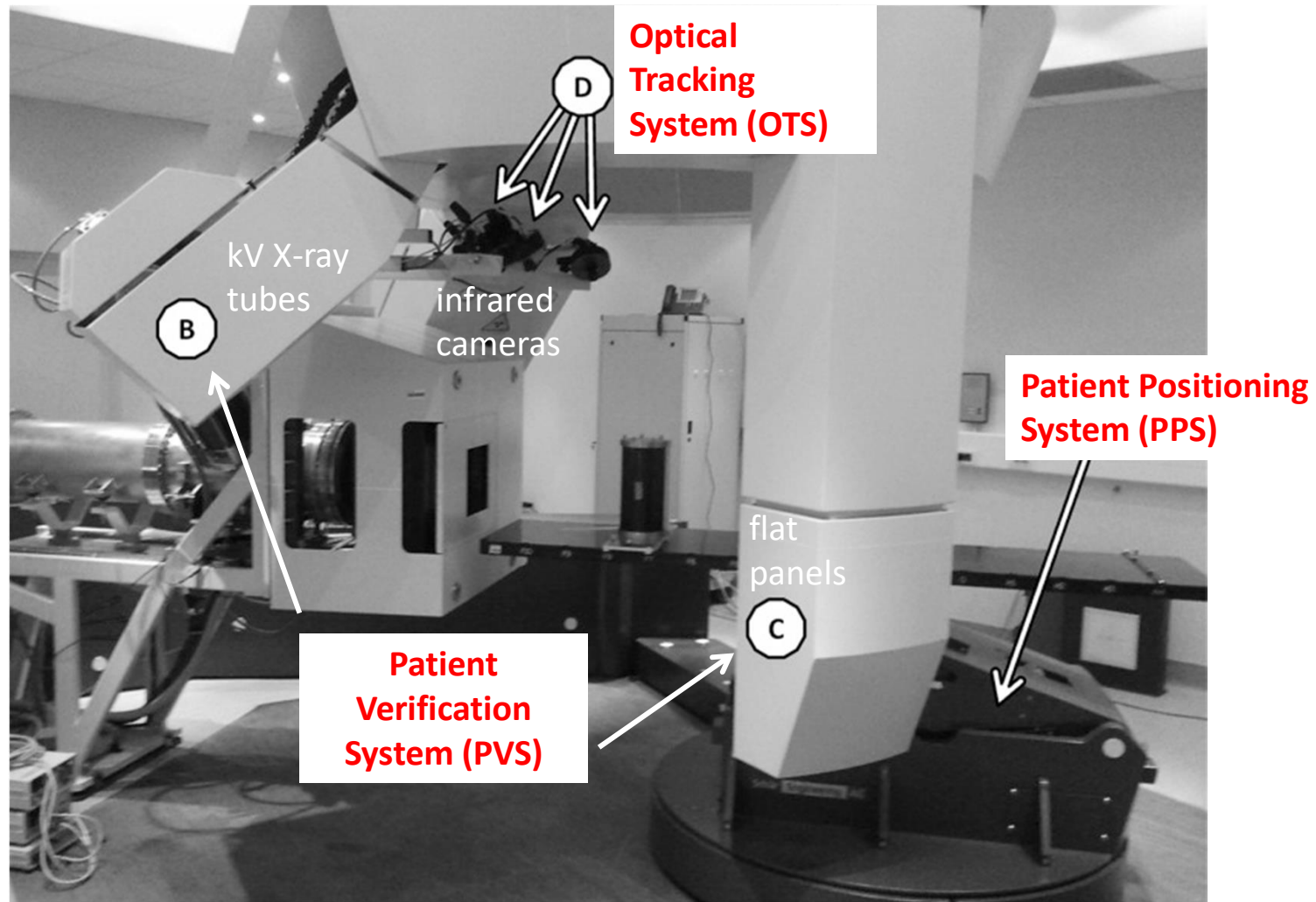
## The path of the patient - preparation



Patient workflow performed at the CNAO before the dose delivery. The patient is immobilized outside the treatment room and afterwards is introduced into the treatment room, docked to the PPS and driven to the planned position for treatment. Only then, corrections (firstly from the OTS and secondly by the PVS) are applied and repeated if needed. Once this process is concluded, the patient is in the expected (or nominal) position and the dose can be delivered.



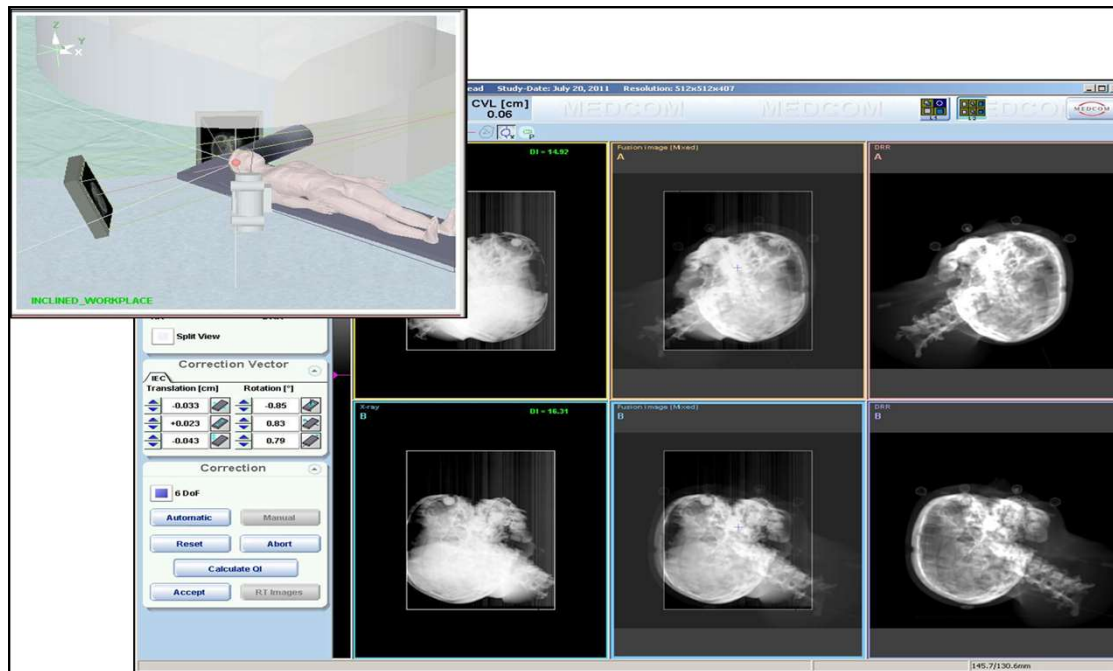
CNAO treatment rooms are equipped with robotic Patient Positioning Systems (PPSs), which feature highly accurate six-degrees-of-freedom patient handling in a large working volume



Desplanques M et al, *J Radiat Res.*

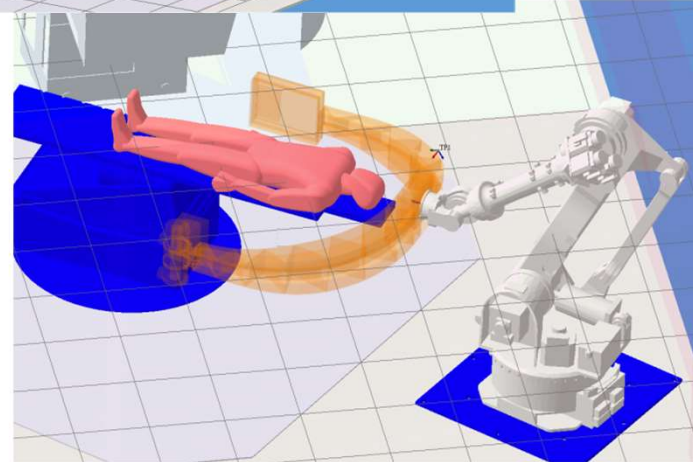
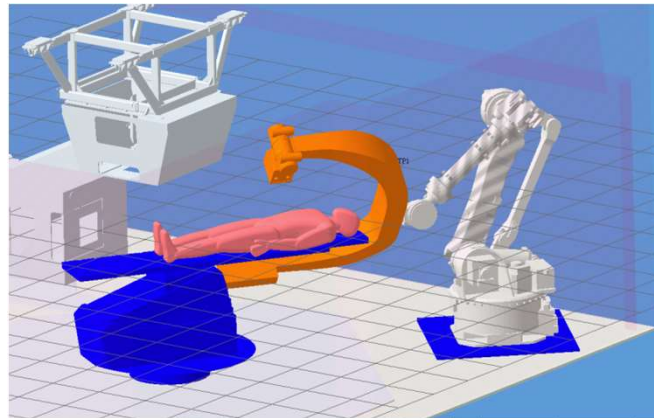
# PVS: Patient Verification System

X-ray images are taken through the Patient Verification System or PVS, which will be compared with the images reconstructed by the simulation CT scan

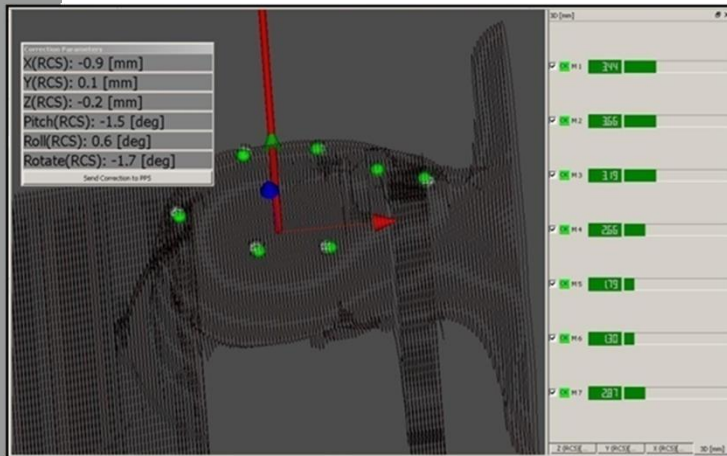


accuracy 0.3 mm

## PVS: Patient Verification System



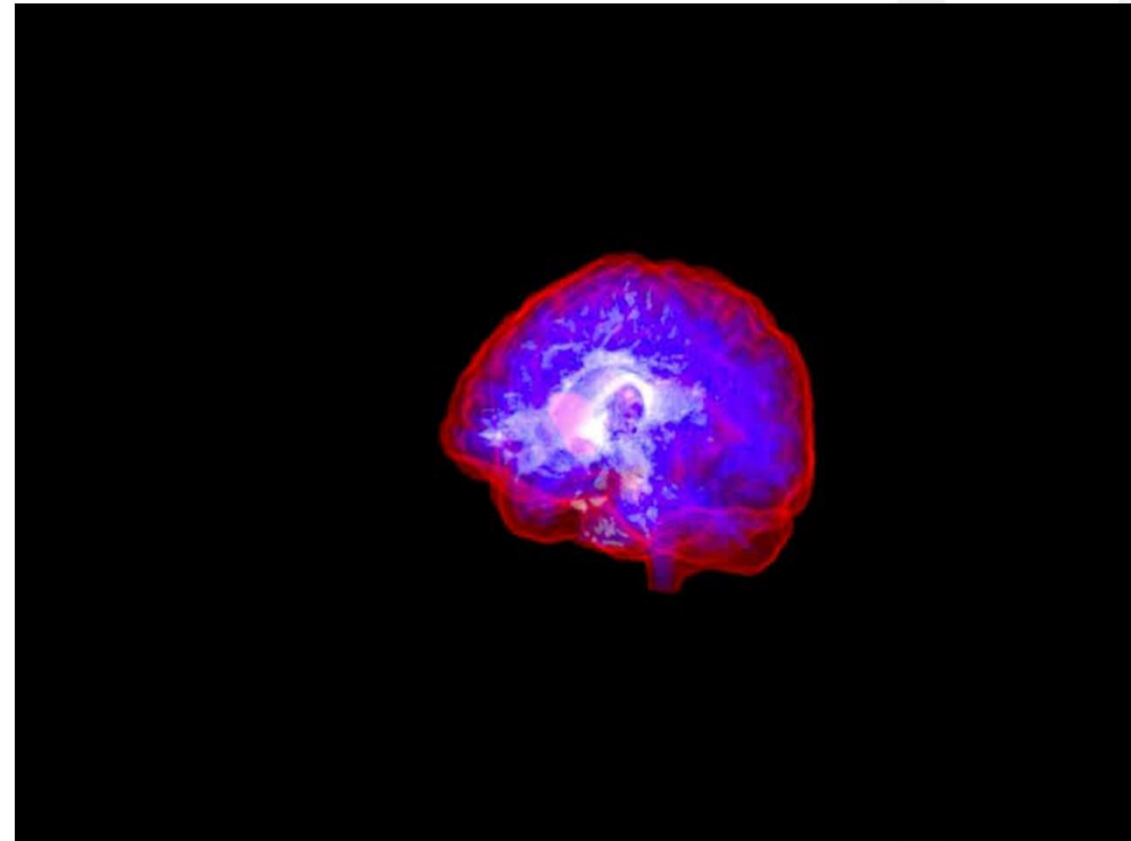
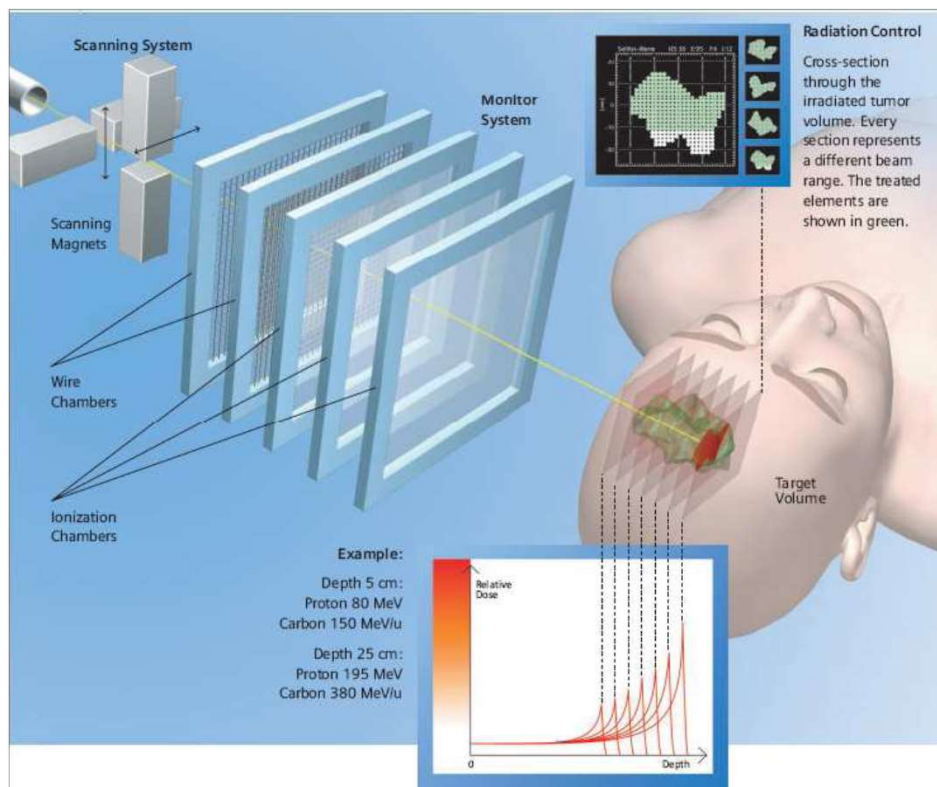
# OTS: Optical Tracking System

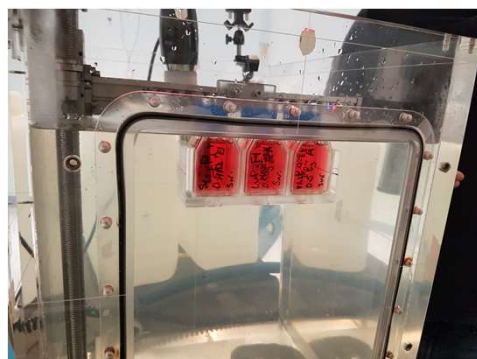
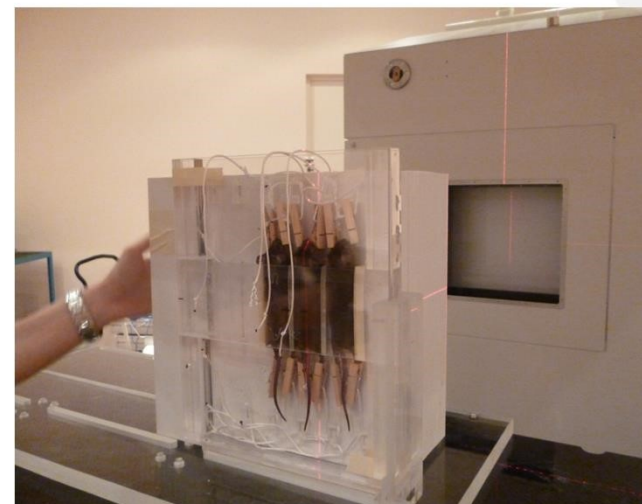


The **Optoelectronic markers** are stuck to mask and recognized by 3 infrared cameras (**Optical Tracking System or OTS**), which are necessary to check the patient's position before and during treatment

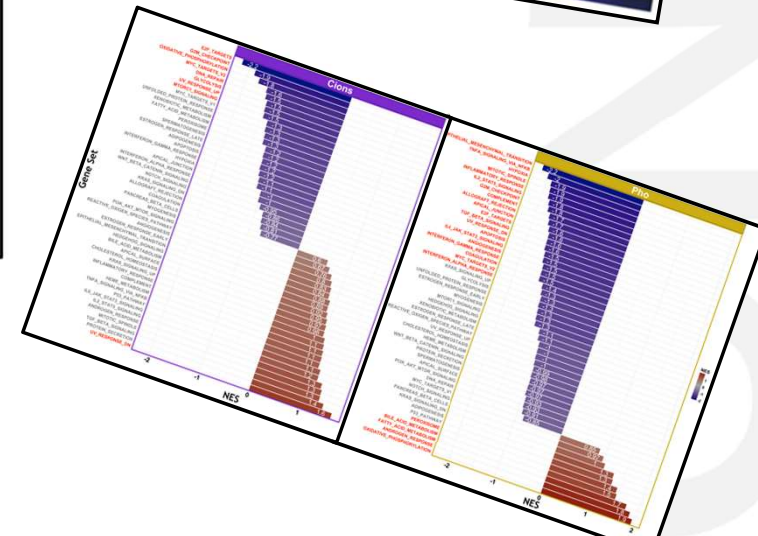
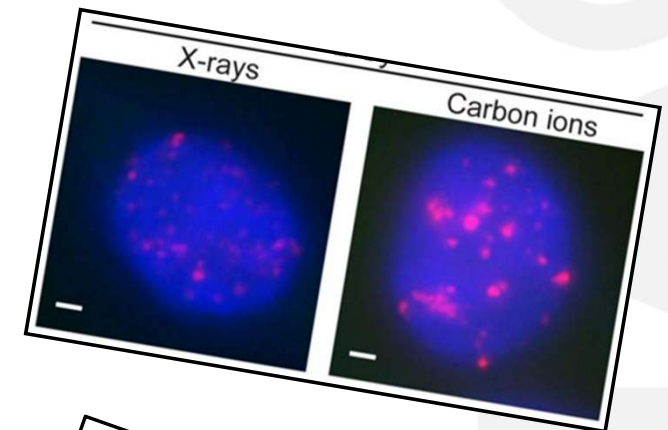
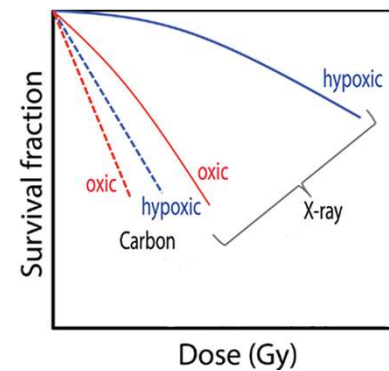
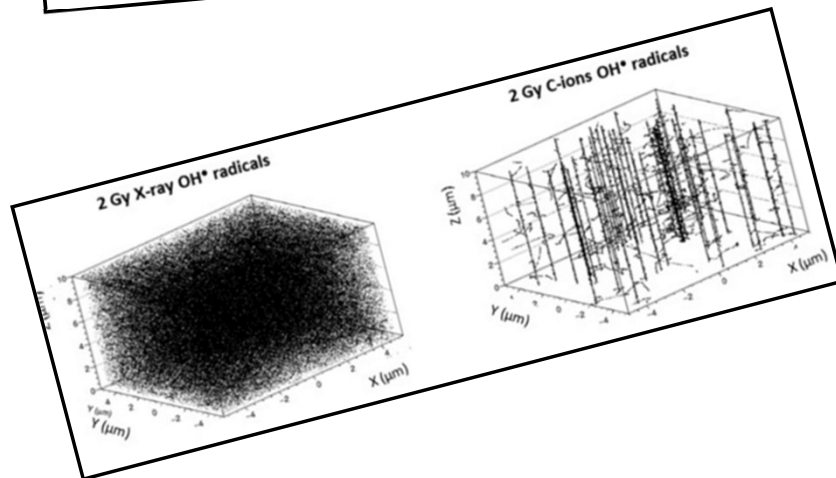
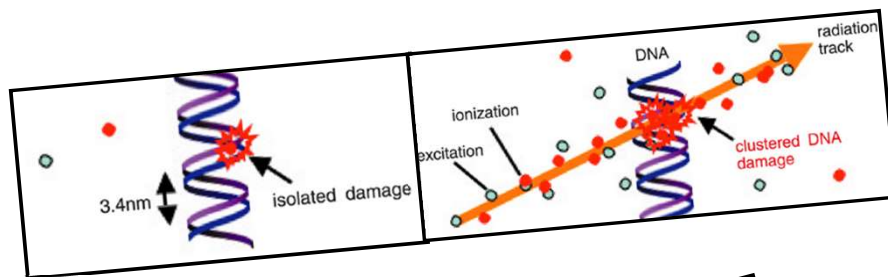


**The irradiation begins.** The treatment plan subdivides the lesion in various slices. The particle beam irradiates one slice after the another, following the commands determined by the treatment plan



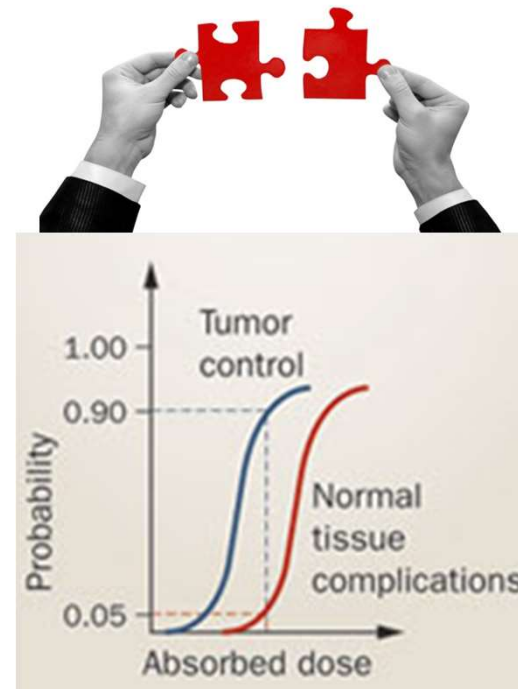


Radiobiology of densely ionizing radiation is so markedly different than X-rays that charged particles should be regarded in radiotherapy in much the same way as a “different drug” is treated in medical oncology



## ONGOING OPEN QUESTIONS:

- Combined treatments
- Immune response
- Second cancer induction
- Normal tissue response
- ...new ions?



Although heavy-ion therapy has provided favorable clinical outcome with irradiation alone, the suitability of particle beam irradiation for combination with other therapeutic modalities such as chemotherapy, endocrine therapy, low LET radiation (“boost protocols”) and biological therapies warrants extensive studies, in the context of both enhancing tumor control and reducing normal tissue complications.

***Thank you for listening***

**Questions??**

