



Associazione  
Italiana  
Radioterapia  
Oncologica

*Gruppo Interregionale Piemonte, Liguria e Valle d'Aosta*



## L'adroterapia : indicazioni, vantaggi e risultati preliminari di tossicità e risposta

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Centro Nazionale di Adroterapia Oncologica

**42 centri di protoni**

(USA 14, Europa 12, Giappone 8, .....)

**6 centri di Ioni carbonio**(Giappone 3,  
Europa 2, Cina 1)

**3 centri (protoni+ ioni carbonio)**

**24 centri di protoni nei prox 3 anni**

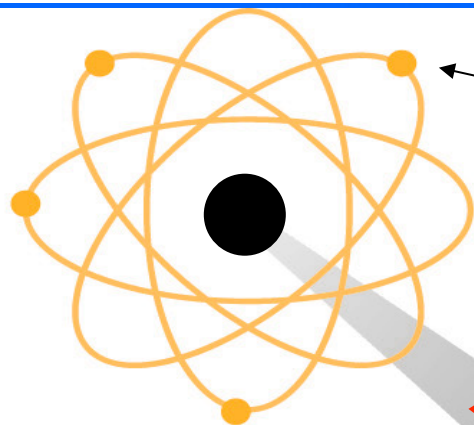
**107.792 pazienti trattati**

**93.452 con Protoni,  
10.753 con Carbonio**

**+ 46.000 negli ultimi 5 anni  
≈ 10.000 pazienti per anno**







Elettroni (raggi X):  
radioterapia convenzionale

Adroterapia

Lo ione carbonio è 12×2000 volte  
più pesante dell'elettrone



**Nucleo del Carbonio**  
fatto di 6 protoni (p)  
e 6 neutroni (n)

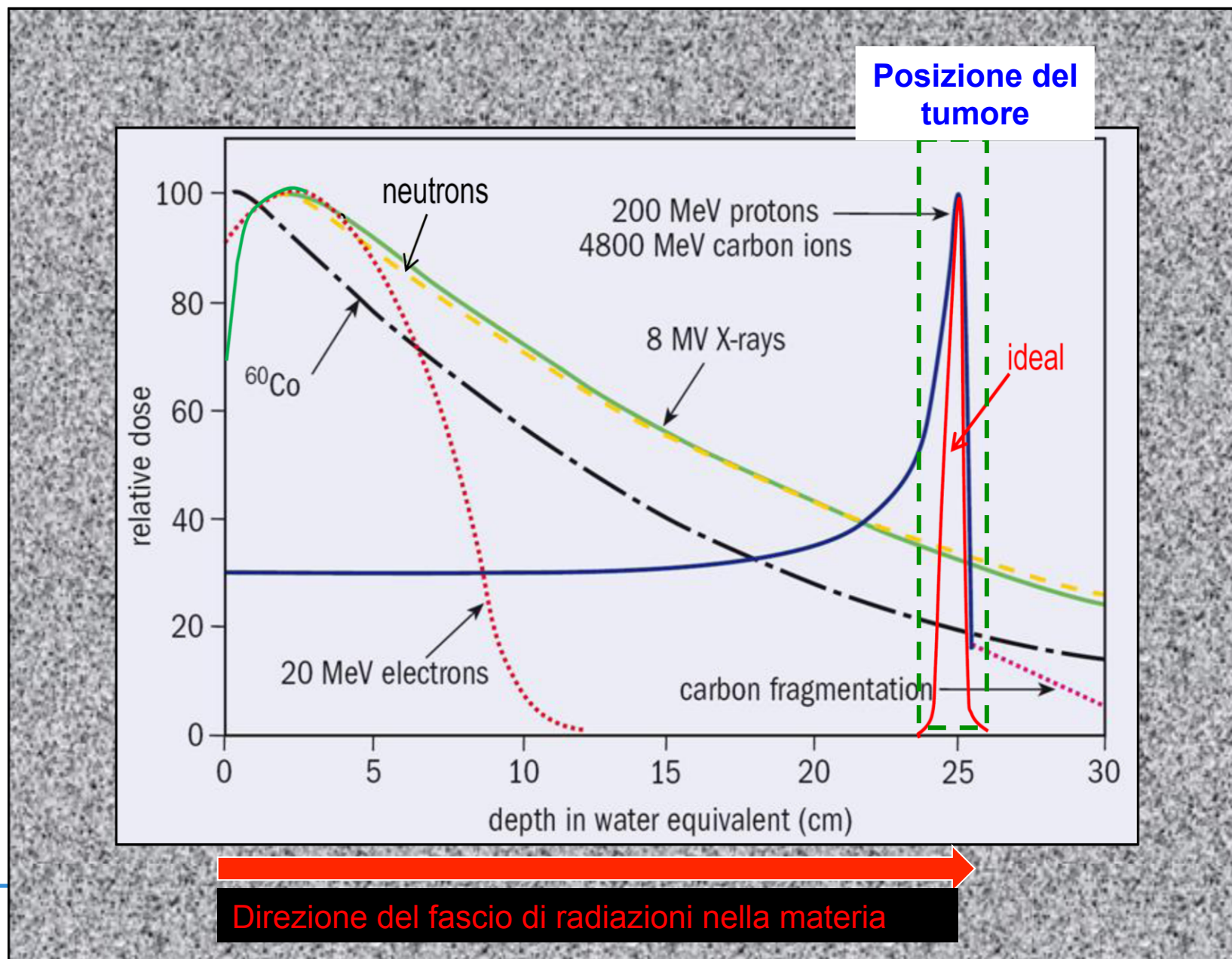


Nucleo più semplice:  
il **protone** (p)

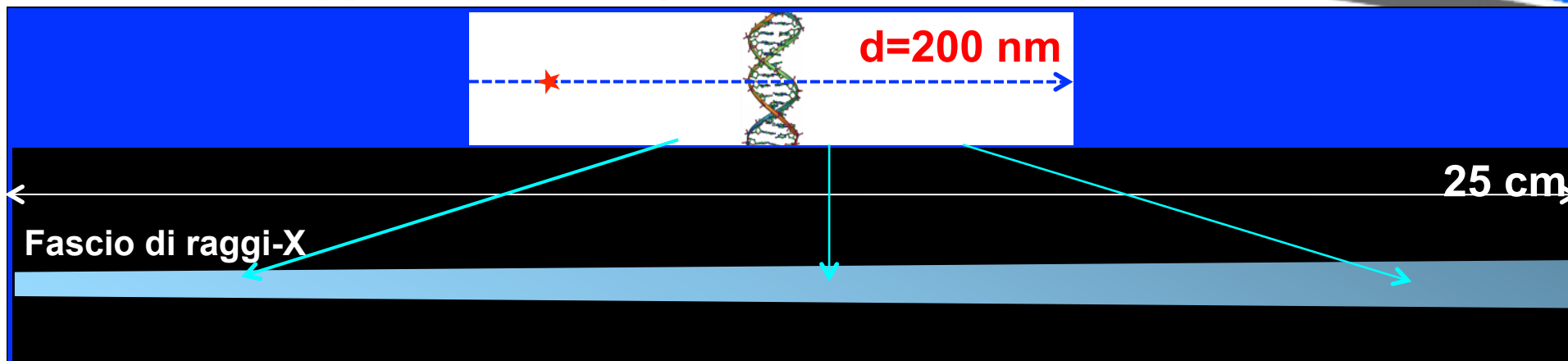
Il protone è 2000 volte più pesante dell'elettrone

# Adroterapia ?

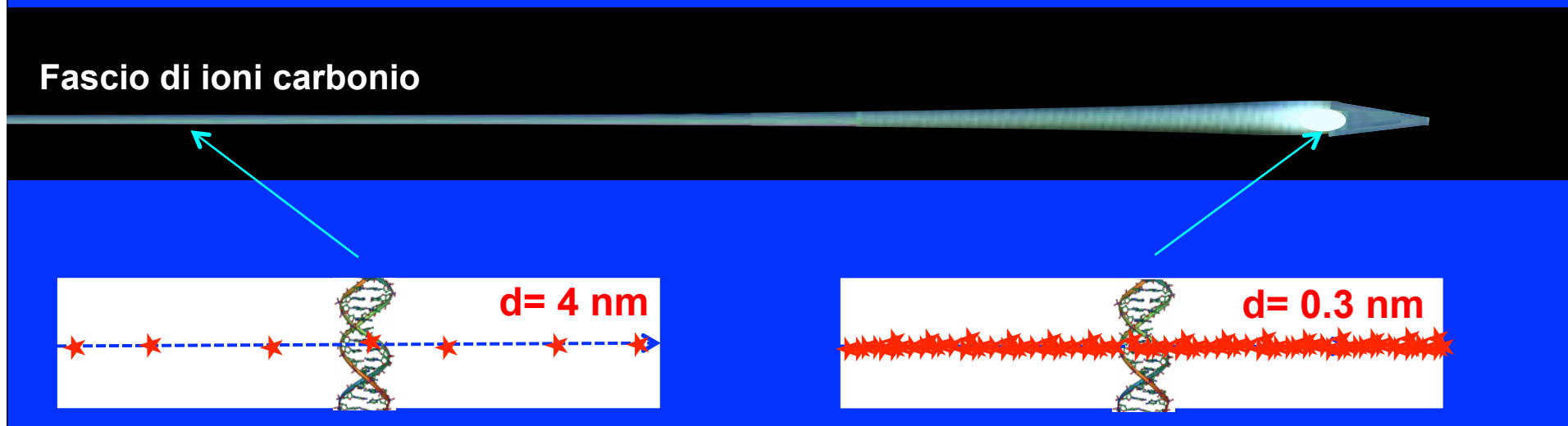
# Precisione dell'adroterapia



## Raggi X: danno sparso e azione indiretta



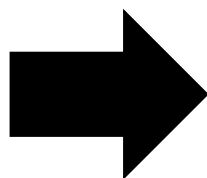
## Ioni carbonio: danno concentrato e azione diretta





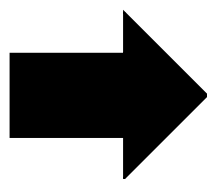
## *Adroterapia consente di trattare casi “difficili”*

**PRECISIONE**



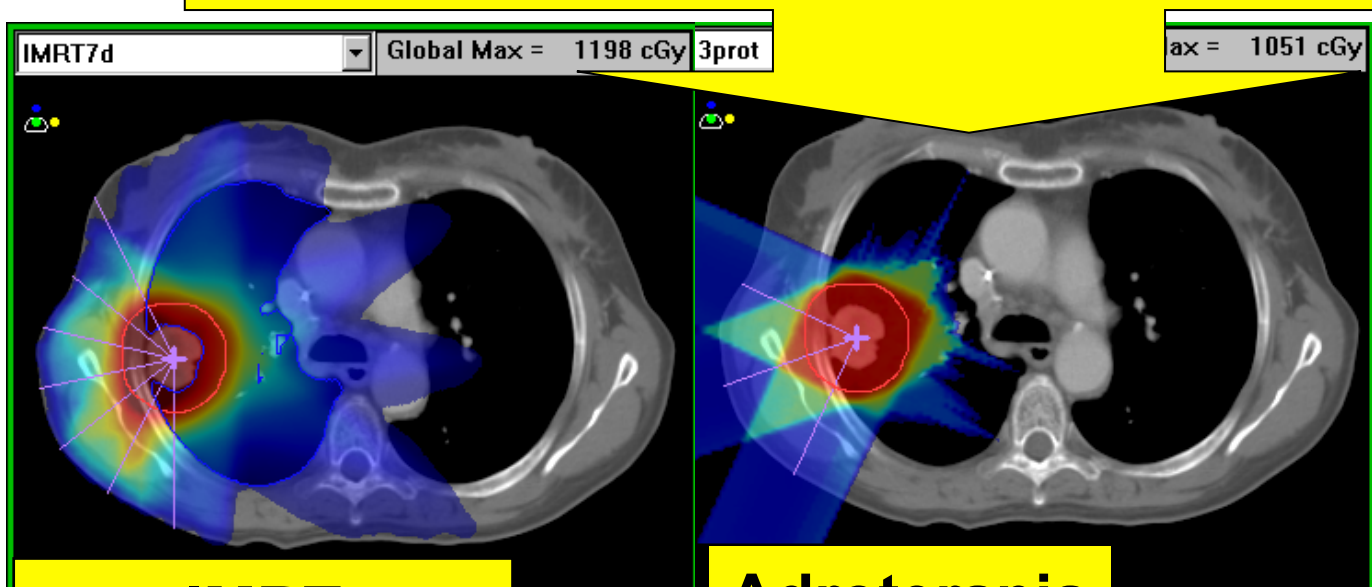
**Tumori vicini ad organi critici**

**EFFICACIA**



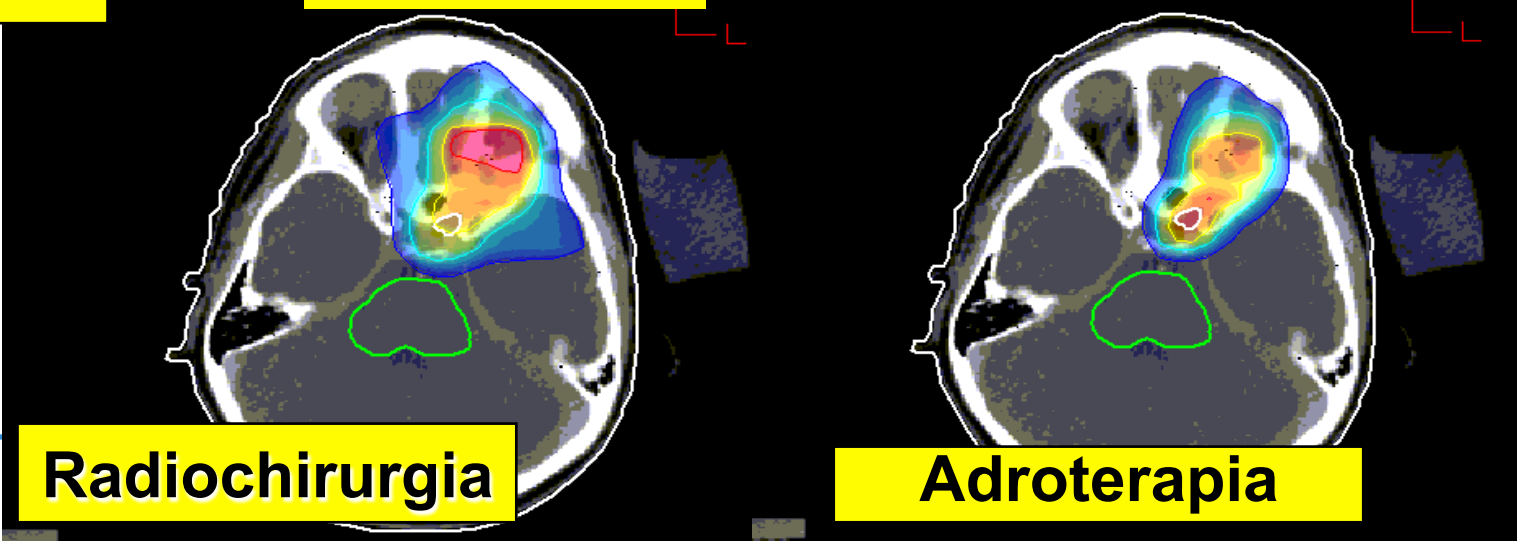
**Tumori radioresistenti,  
che non rispondono  
alla radioterapia convenzionale**

# Selettività fisica



IMRT

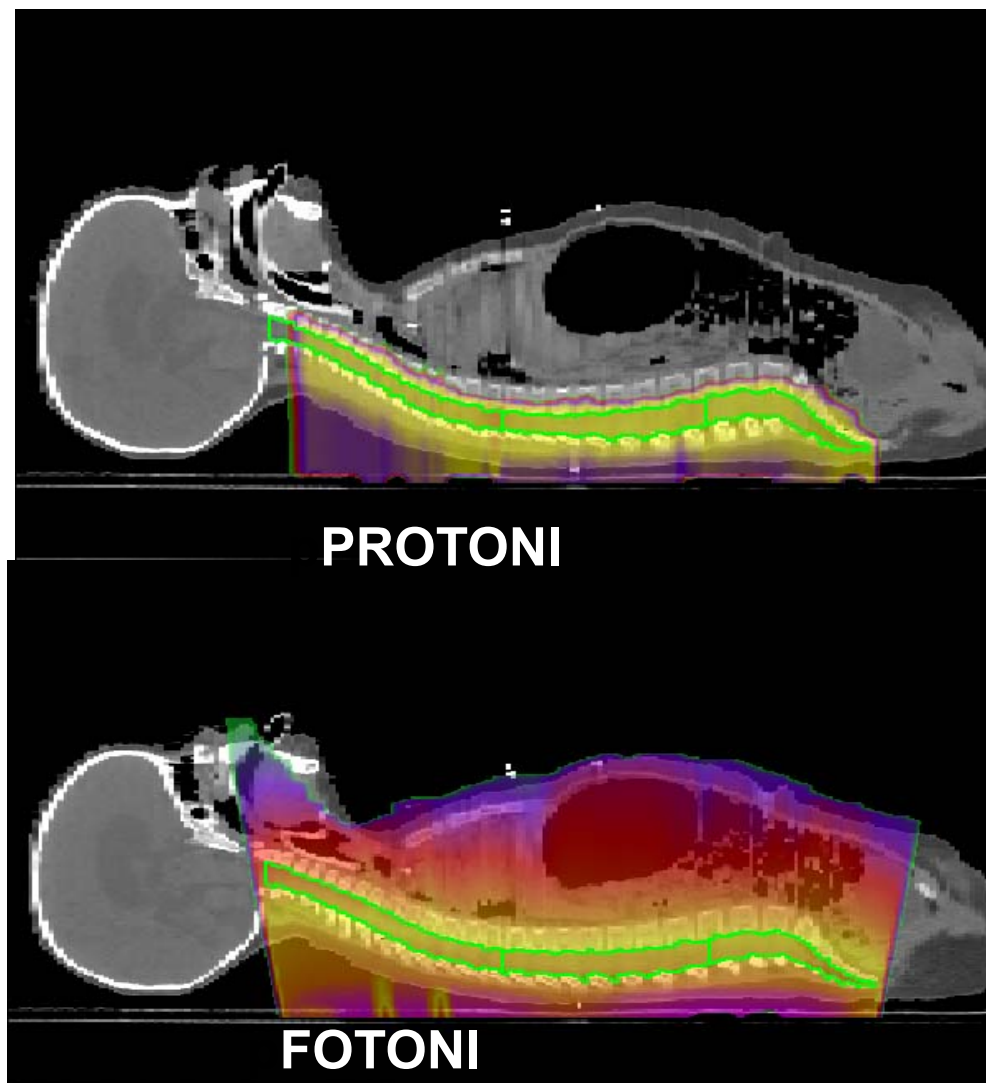
Adroterapia



Radiochirurgia

Adroterapia

# Protoni in tumori pediatrici

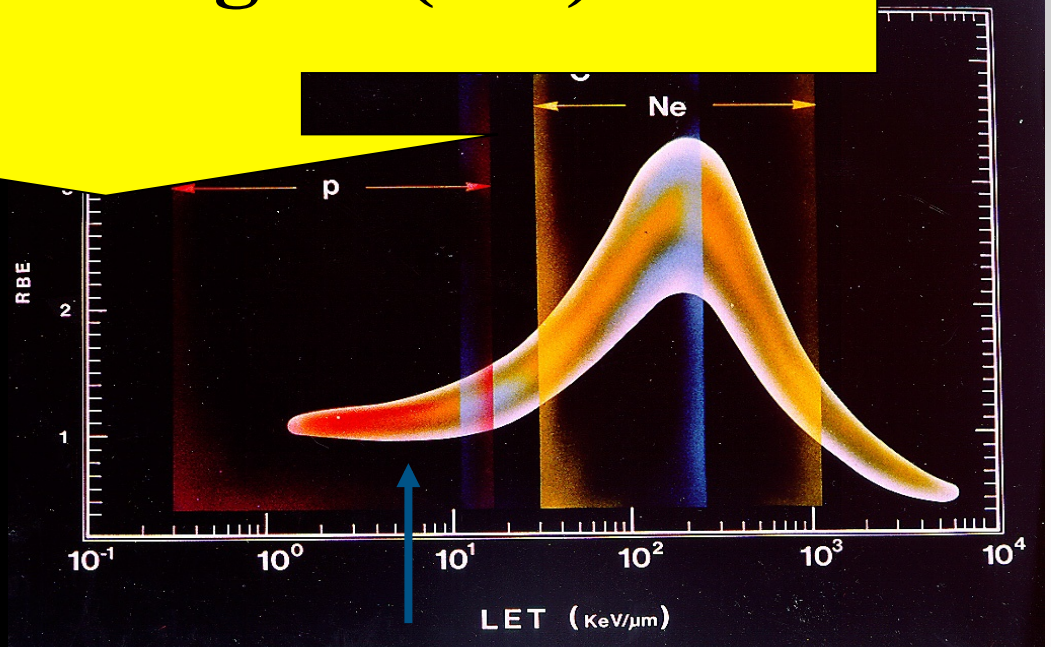
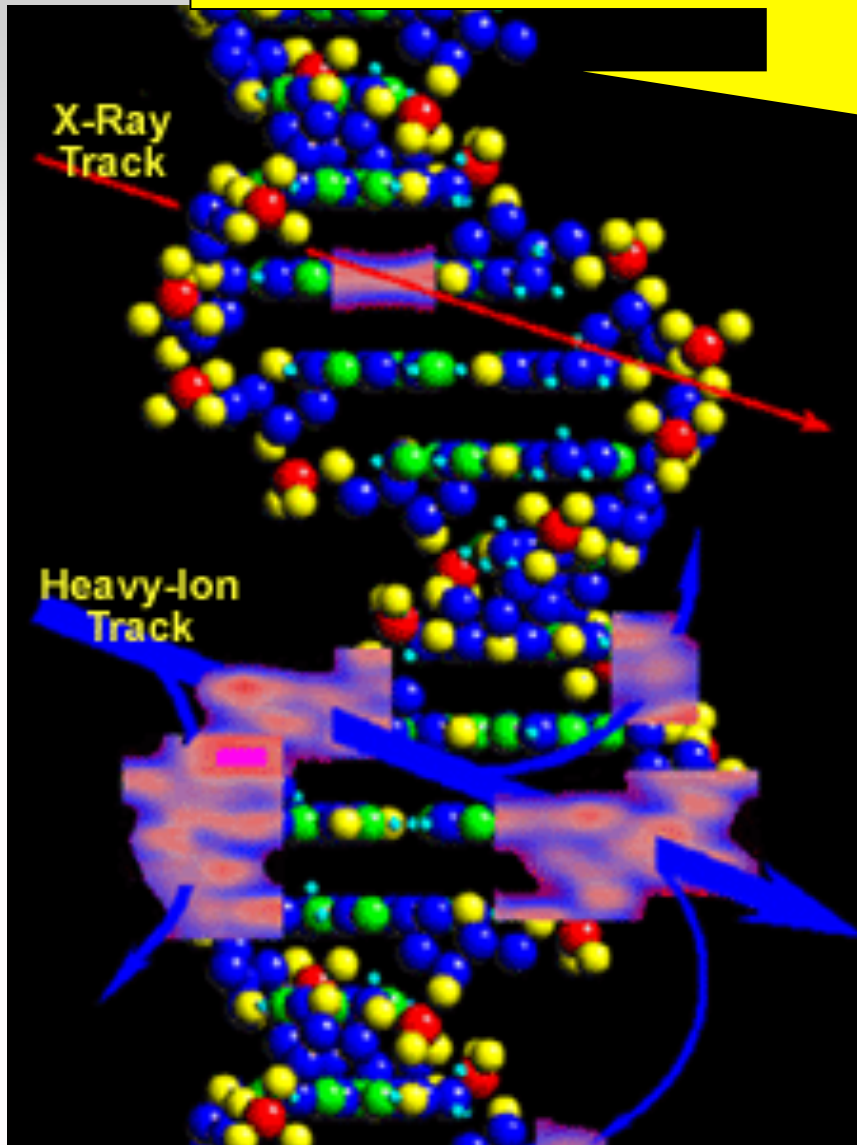


	<u>X-ray</u>	<u>IMRT</u>	<u>Protoni</u>
<b>CTV</b>	<b>90%</b>	<b>90%</b>	<b>90%</b>
<b>Heart</b>	<b>18.2</b>	<b>17.4</b>	<b>0.1</b>
<b>Right lung</b>	<b>3.5</b>	<b>21.9</b>	<b>0.1</b>
<b>Esophagous</b>	<b>11.9</b>	<b>32.1</b>	<b>10.2</b>
<b>Stomach</b>	<b>3.7</b>	<b>20.6</b>	<b>0.1</b>
<b>Right kidney</b>	<b>3.3</b>	<b>29.8</b>	<b>0.1</b>
<b>Transvers colon</b>	<b>2.6</b>	<b>18.0</b>	<b>0.1</b>

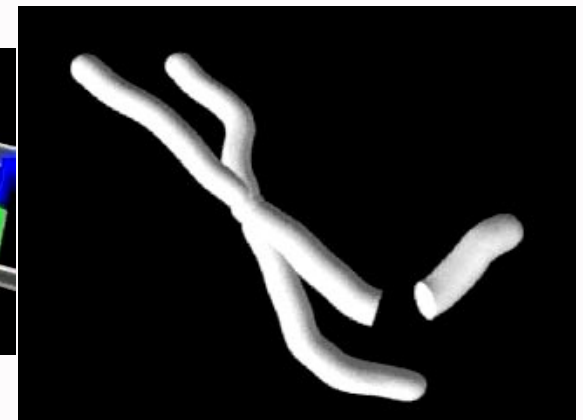
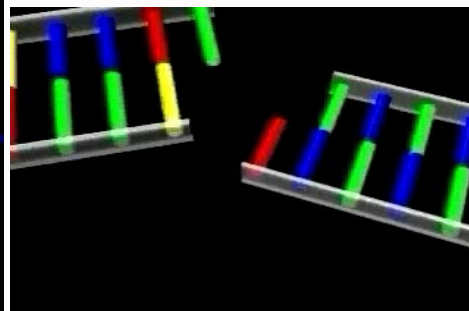


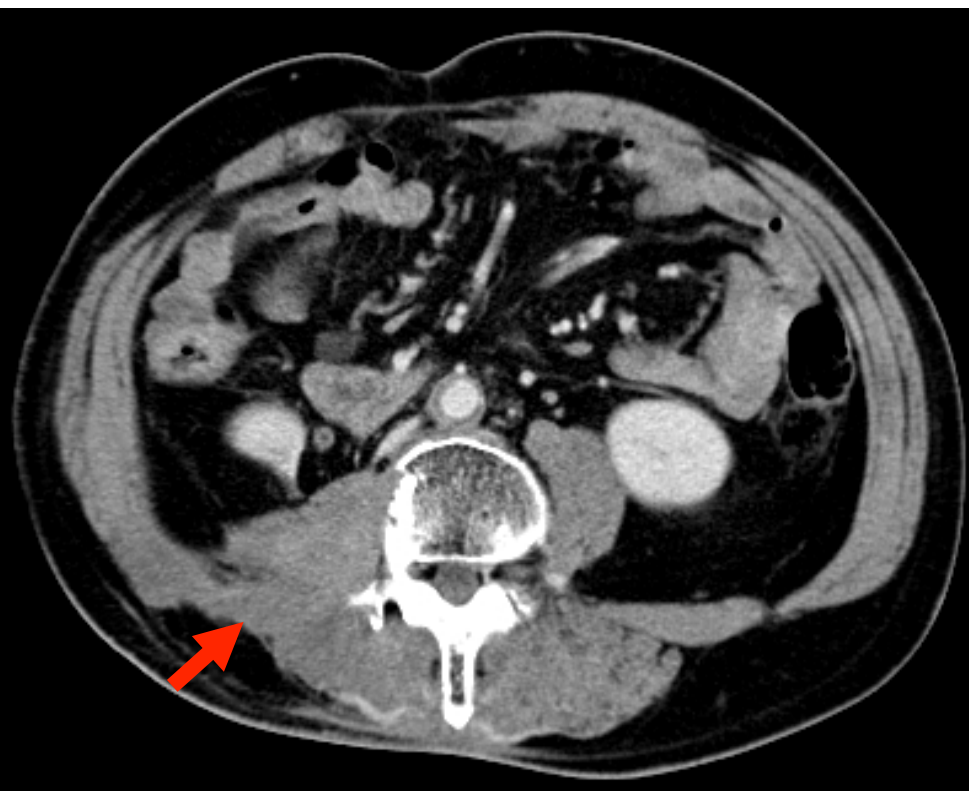
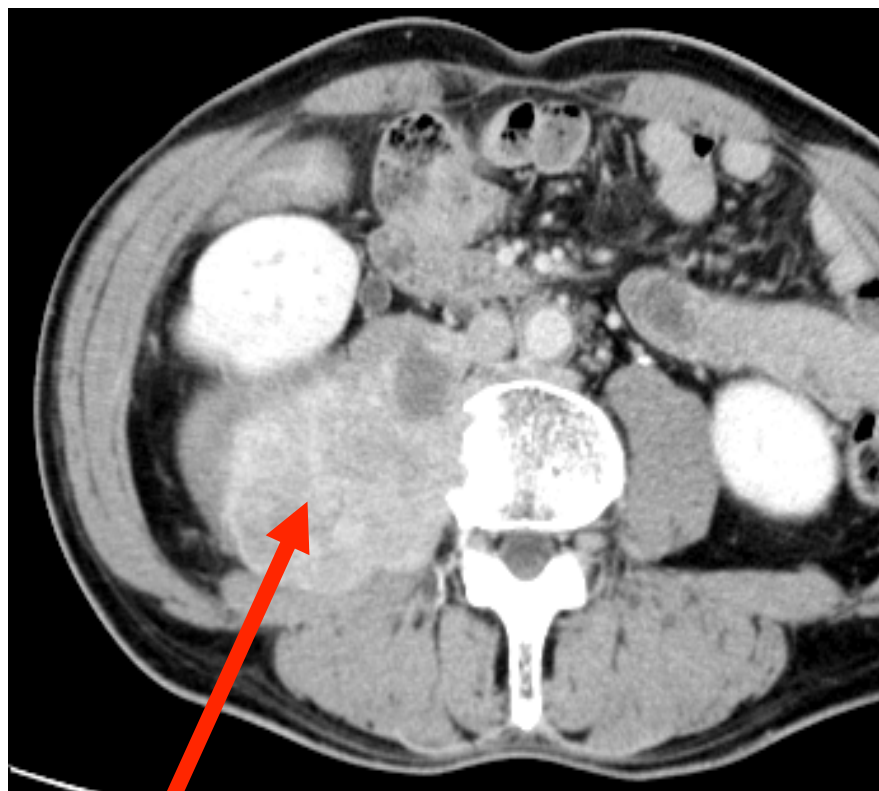
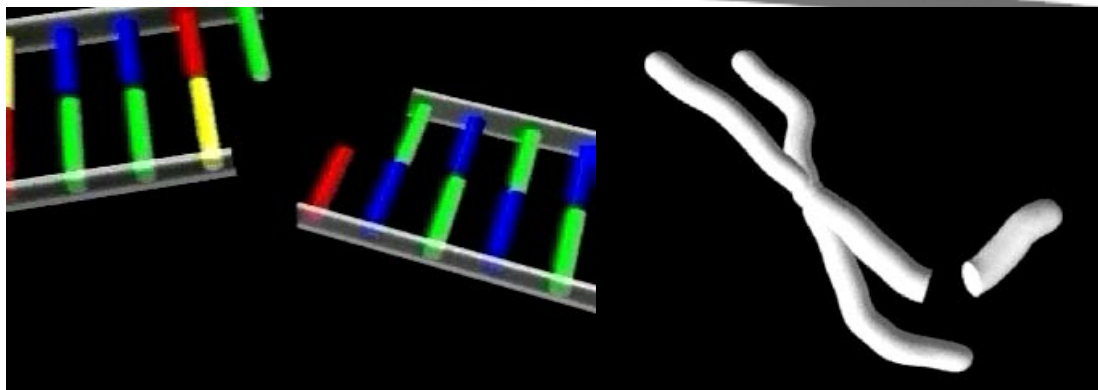


# Efficacia Biologica (C12)



$$10 - 20 \text{ keV}/\mu\text{m} = 100 - 200 \text{ MeV}/\text{cm} = \\ 20 - 40 \text{ eV}/(2 \text{ nm})$$





# Which tumors might benefit of high LET particles?

**Radioresistant for genetic alteration**

Up-regulated oncogenes

Mutated tumor suppressor genes

Dis-regulated apoptosis

**Radioresistant for intratumoral micromilieu**

Deprivation of oxygen

Up-regulated defense system

High angiogenic potential

**Radioresistant for proliferation status**

High content of quiescent cell clones

Slow proliferation activity



**Italia**

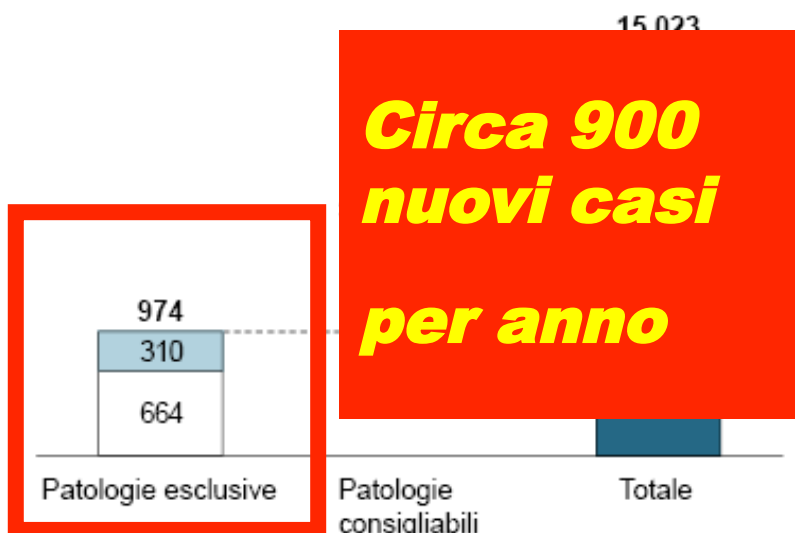


# Working Group 1998, 2003, 2008, 2009

Si stima che in Italia ci siano 15.000 casi l'anno di pazienti che richiedono un trattamento con protonterapia

Domanda di trattamenti con protonterapia in Italia

Numero di pazienti all'anno in Italia con patologie trattabili con proton terapia [2008]



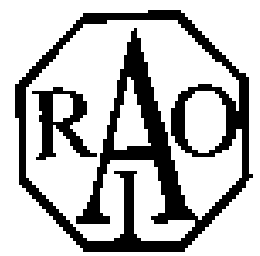
**Circa 900 nuovi casi per anno**

Fonte: Airo

- Cordoma**
- Condrosarcoma**
- 250 nuovi casi/anno**
- Melanoma oculari**
- 300 nuovi casi/anno**
- Tumori solidi pediatrici**
- 180 nuovi casi/anno**

Co...  
 • Le... melan... delle pato... cranica e dell... condro... tronco... tumor... cratici, g... pediatrici  
 • Le principali pr... risulta parti... tumori al... al fega...  
 • In futu... del ca... proton... oncologica

**Italia**

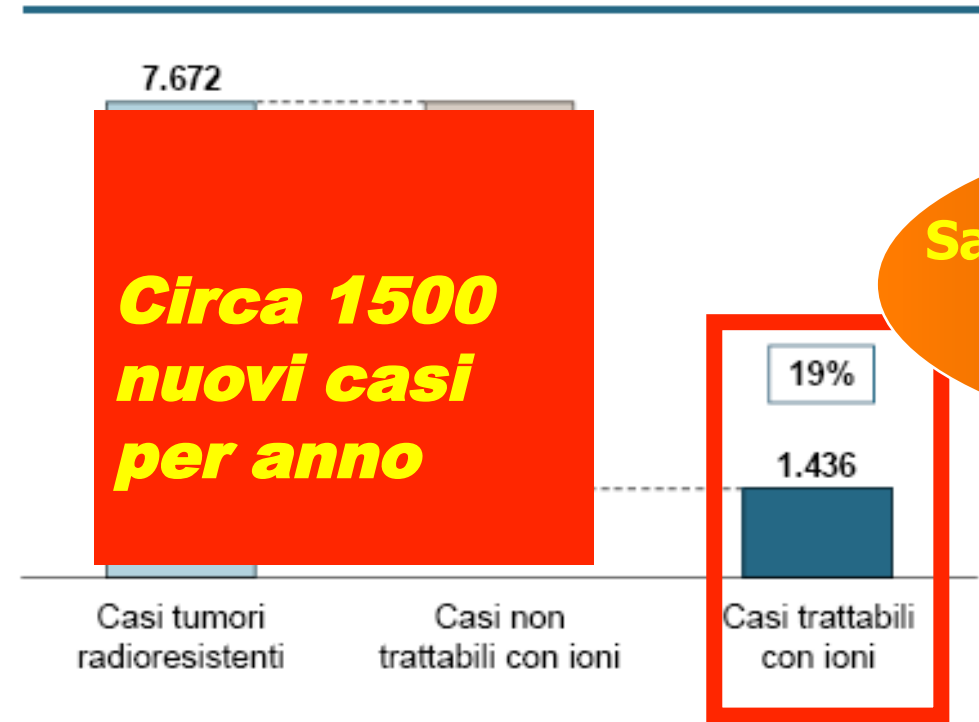


# Working Group 1998, 2003, 2008, 2009

Le terapie con ioni di carbonio potrebbero essere adottate in quasi il 20% dei casi di alcune categorie di tumori radioresistenti

Domanda di trattamenti con ioni Carbonio in Italia

Numero di pazienti all'anno in Italia con tumori radioresistenti [2008]



**Head&Neck**  
**No SC carcinoma**  
**350 nuovi casi/anno**

**Sarcomi ossei e delle parti molli**  
**520 nuovi casi/anno**

**Prostata**  
**Fegato e Pancreas**  
**"Selected cases"**

Fonte: Airo

Table I: "Consolidated" indications resulting from ETOILE's work

<i>Tumour location</i>	<i>Detailed definition of indications</i>	<i>Recommended form of hadron therapy</i>	<i>Estimated incidence<sup>§</sup> (cases/year in France)</i>
Salivary gland (parotid gland) tumours	Inoperable tumours <u>or</u> refusal of surgery <u>or</u> R2 resections <u>or</u> local recurrences <sup>¶</sup> All types of histology: adenoid cystic carcinomas, mucoepidermoid adenocarcinomas, acinar cell carcinomas, etc.	Carbon alone or in combination with a dose of locoregional photon therapy	≈ 100
Paranasal sinus tumours	Inoperable tumours <u>or</u> refusal of surgery <u>or</u> R2 resections <u>or</u> local recurrences Adenocarcinomas and adenoid cystic carcinomas	Carbon alone in primary location	≈ 250
Adenoid cystic carcinomas with skull base involvement	Inoperable tumours <u>or</u> refusal of surgery <u>or</u> R2 resections <u>or</u> local recurrences	Carbon alone in primary location	≈ 10
Malignant mucosal melanomas (primarily ENT)	Any location without immediately threatening metastasis Tumour without surgery if possible <u>or</u> emergency after R2 resections or non-irradiated local recurrence	Carbon alone in primary location; urgent treatment	≈ 40
Chordomas at the base of the skull, spine and sacrum	Any clinical presentation	Carbon <u>or</u> proton therapy alone in primary location	≈ 30–50
Chondrosarcomas of the axial skeletal	Base of skull	Proton therapy alone in primary location	≈ 20
	Spine and sacrum	Proton therapy <u>or</u> carbon alone in primary location	<10
Soft-tissue (non-retroperitoneal) sarcomas	Weak-grade M0, any histology, any location Unresectable <u>or</u> surgery refused <u>or</u> "definitive R2": R2 with no possible repeat surgery or R2 following repeat surgery or local recurrence in R2 resection	Carbon alone in primary location	≈ 100
Retroperitoneal sarcomas	Non-threatening M+ with incapacitating T or rT		≈ 80
	Following local recurrence <u>and</u> surgical resection: R0 or R1 and M0 (for unresectable T and R2, see above)		≈ 40
	Initial status R1 M0		
Soft-tissue sarcomas of the head, neck and limbs	"Definitive R1": R1 resection with no acceptable possibility for repeat surgery		≈ 200
Osteo- and chondrosarcomas (any location except axial skeleton)	Tumours without surgery <u>or</u> resections: R2, M0 M+ accepted for osteosarcomas only Discussion according to grade		≈ 10
Pelvic recurrence of rectal adenocarcinomas	Unresectable unifocal locoregional pelvic recurrences in irradiated or non-irradiated location, <u>and</u> M0 (CT, liver MRI, PET)	Carbon alone	≈ 200
Hepatocellular carcinomas	Single hepatocellular carcinoma, $\phi > 4-5$ cm, unresectable, M0, not suitable for conventional treatment methods or photon therapy, no threatening comorbidity	Carbon alone in primary location	≈ 50

**Notes:**

<sup>§</sup>The annual estimated incidence is the estimated total annual number of tumours that match the detailed descriptions. This is the maximum recruitment potential. It does not take into account feasibility of treatment or the care services actually available.

<sup>¶</sup>Local recurrence is taken to mean the reappearance of the tumour in its primary location, with no other regional or metastatic manifestation.

1150 pz



Table II: "Prospective" indications resulting from ETOILE's work

<i>Tumour location</i>	<i>Detailed definition of indications</i>	<i>Recommended form of hadron therapy</i>	<i>Estimated incidence<sup>5</sup> (cases/year in France)</i>
Non-small cell lung cancer	Inoperable initial status, stage (UICC/AJC 1997) IA and IB: T1T2N0 (CT, PET) M0 (brain MRI); purely endobronchial tumours excluded Second cancer in patients who underwent radiotherapy and/or pneumonectomy >2 years ago; inoperable stage I Inoperable initial status, stage (UICC/AJC 1997) IIB–IIIB limited to T3T4N0 (CT, PET) M0 (brain MRI); purely endobronchial tumours excluded Second cancer in patients who underwent radiotherapy and/or pneumonectomy >2 years ago; inoperable stage II	Carbon alone in primary location with respiratory gating	≈ 750–1000
Nasopharynx	Any histology Strictly local recurrences <sup>8</sup> after initial radiation	Protons or carbon	≈ 10
High-grade gliomas (grade 3 or glioblastomas)	Recurrence after initial radiotherapy +/- chemotherapy and progressing during chemotherapy Initial treatment, possibly following surgery	Carbon alone in primary location	≈ 50 ≈ 300
Epidermoid ENT carcinomas	Unresectable recurrences or second location, in irradiated area and M0 (CT, liver MRI, PET) (proposal to be assessed) Initial status T3–T4, N ≤2, M0 of the oropharynx or oral cavity (proposal to be assessed)	Carbon alone	≈ 500
Prostate adenocarcinomas	Intermediate risk groups: T2b, T3a/b and (PSA 10–20 and/or Gleason ≥7) and pN0	Comparison IMRT ± hormone therapy versus carbon versus protons	≈ 1000
Highly radioresistant tumours of the digestive tract	Unresectable single nodular bile duct cancer or pancreatic adenocarcinoma, M0, not previously irradiated and not progressing during chemotherapy after 4–6 months M0 endocrine tumour of the pancreas, progressing after multiple treatments: isotopic and/or chemotherapy and somatostatin	Carbon alone or in combination with dose of locoregional photon therapy Carbon alone in primary location	≈ 900 ≈ 20

3600 pz

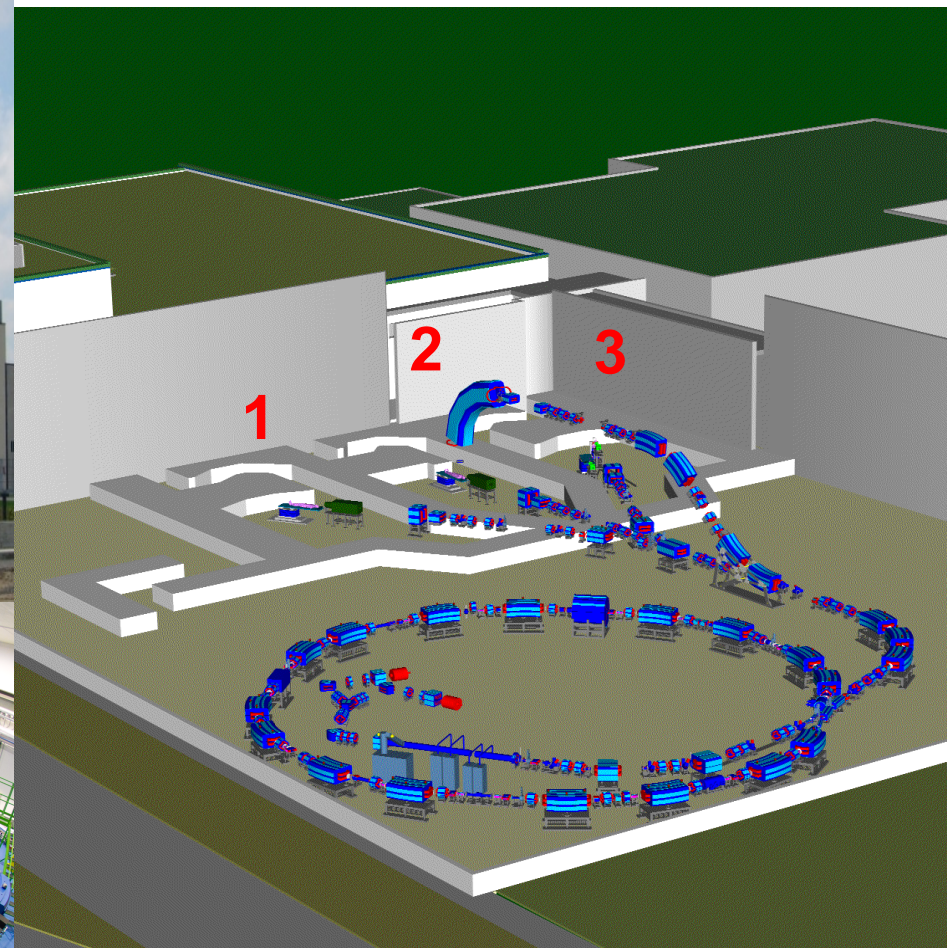
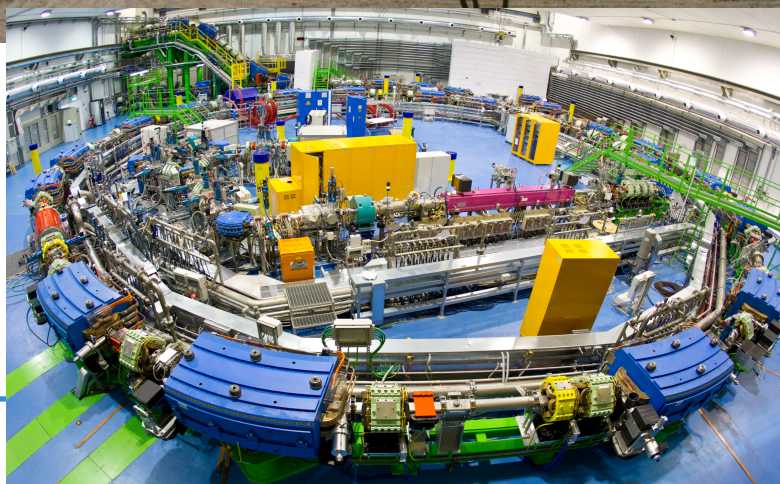
Table III: "Exceptional" indications proposed by ETOILE

<i>Tumour location</i>	<i>Detailed definition of indications</i>	<i>Recommended form of hadron therapy</i>	<i>Estimated incidence<sup>5</sup> (cases/year in France)</i>
Paediatric tumours	Large (more than 100 or 200 ml, depending on age), inoperable Ewing's sarcomas of the pelvis Aggressive chordomas in small children (<3–4 years) Unresectable pelvic osteosarcomas	Carbon alone in primary location	<100
Various locations, highly functional	Benign tumours or locally-invasive malignant tumours that are incapacitating and have a high risk of local recurrence (desmoid tumours, neurinomas, schwannomas, meningiomas, etc.)	Carbon alone	Very rare

100 pz

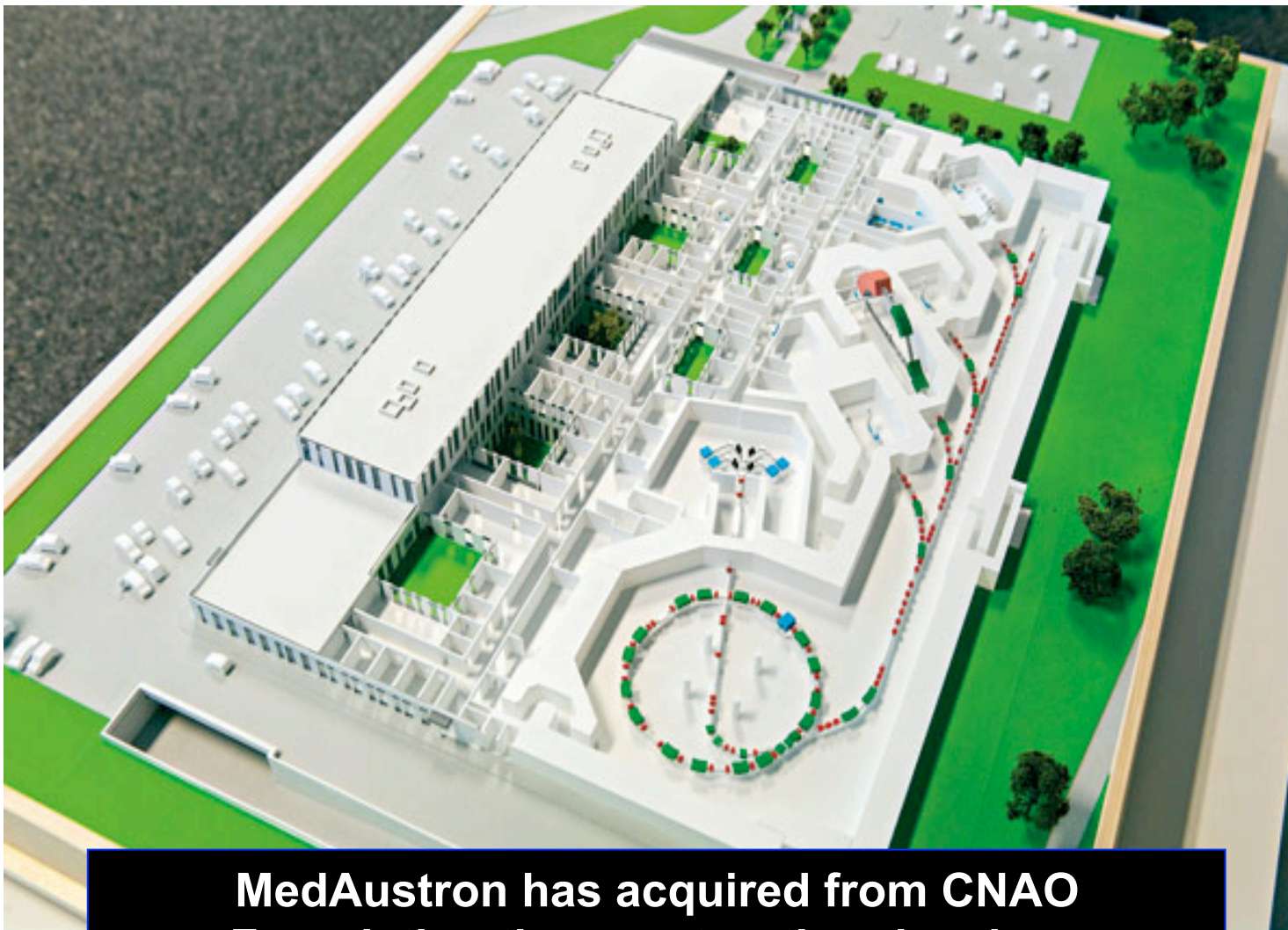


# CNAO a Pavia

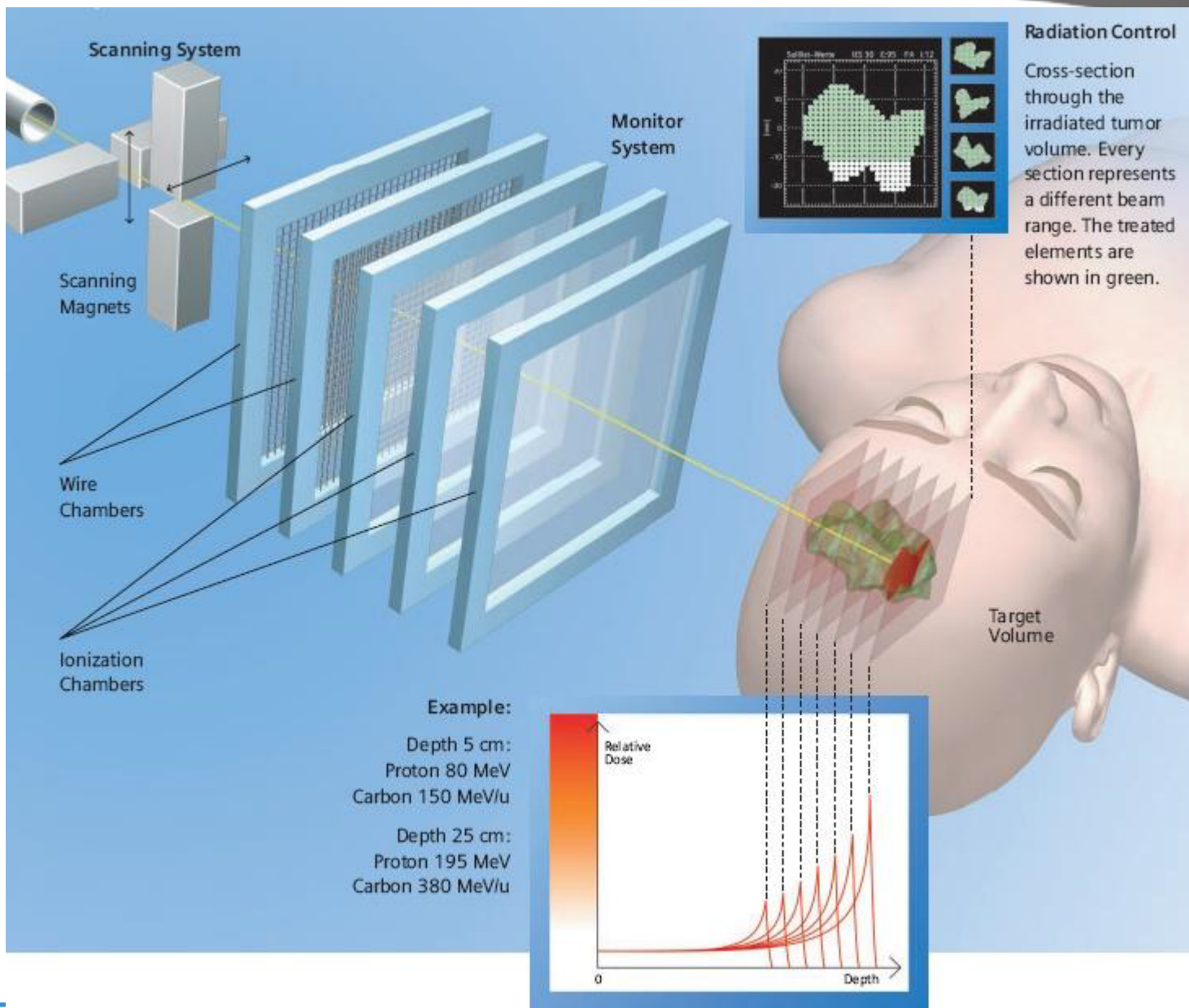


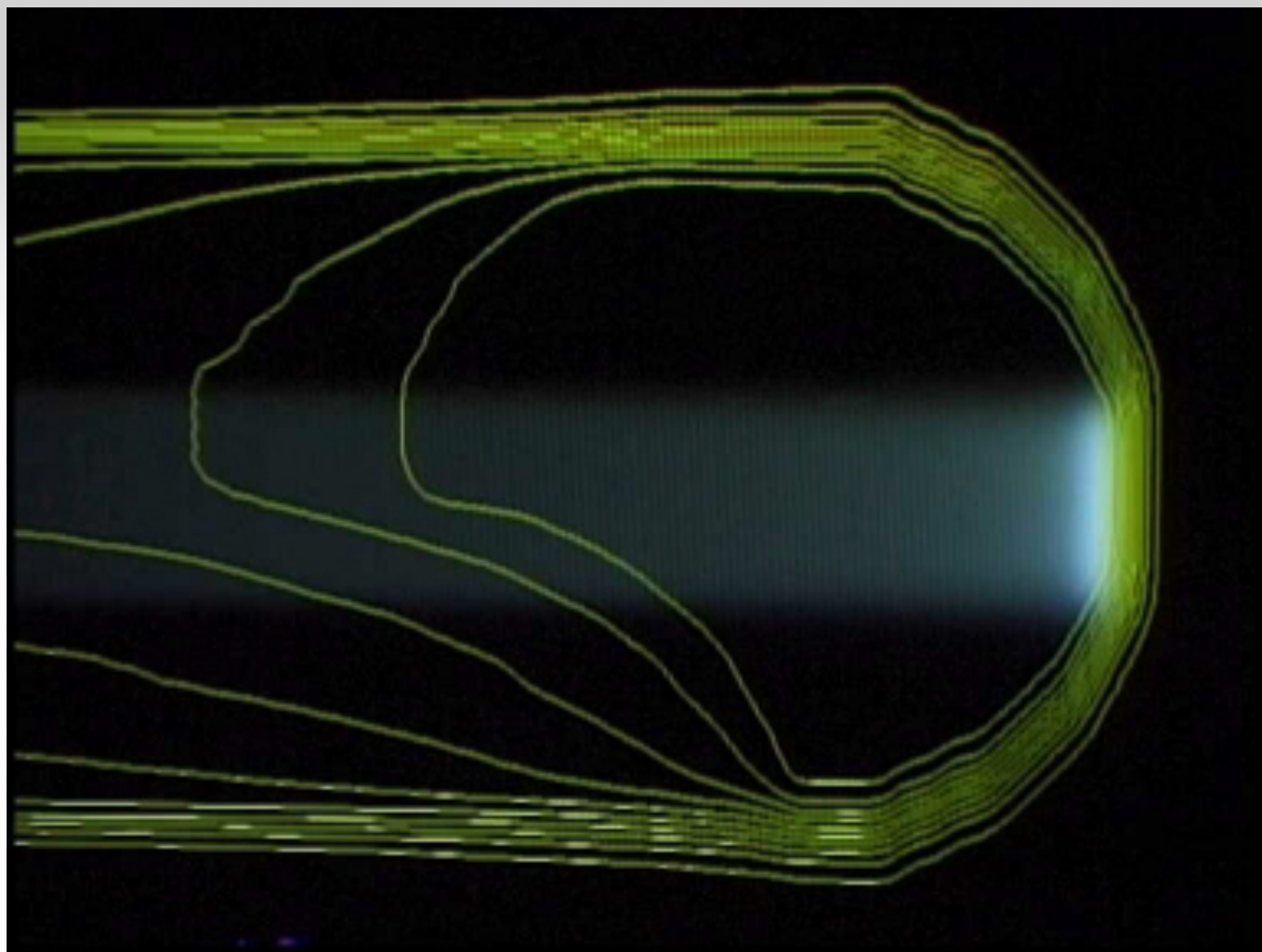


## MedAustron promoted and participated in PIMMS

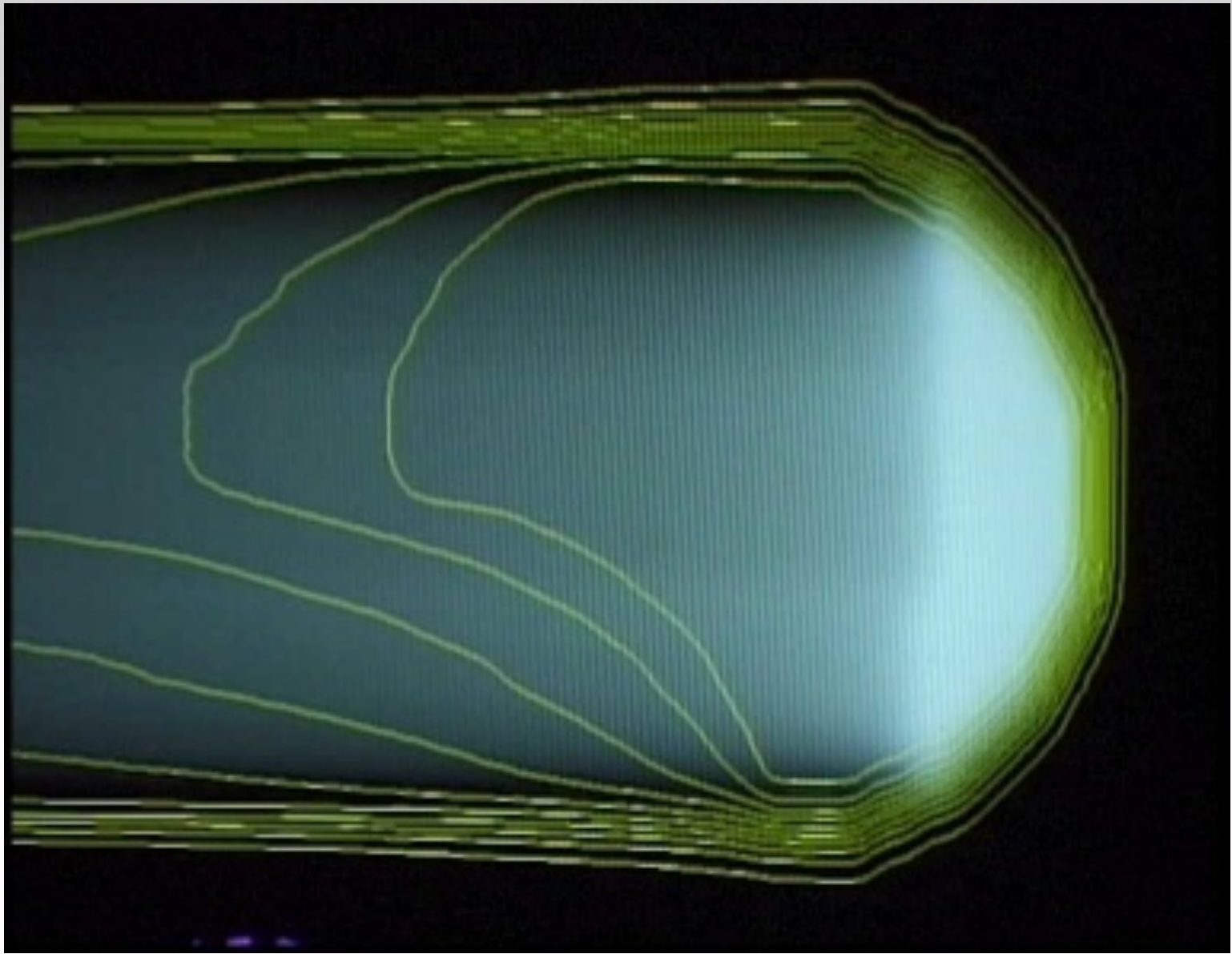


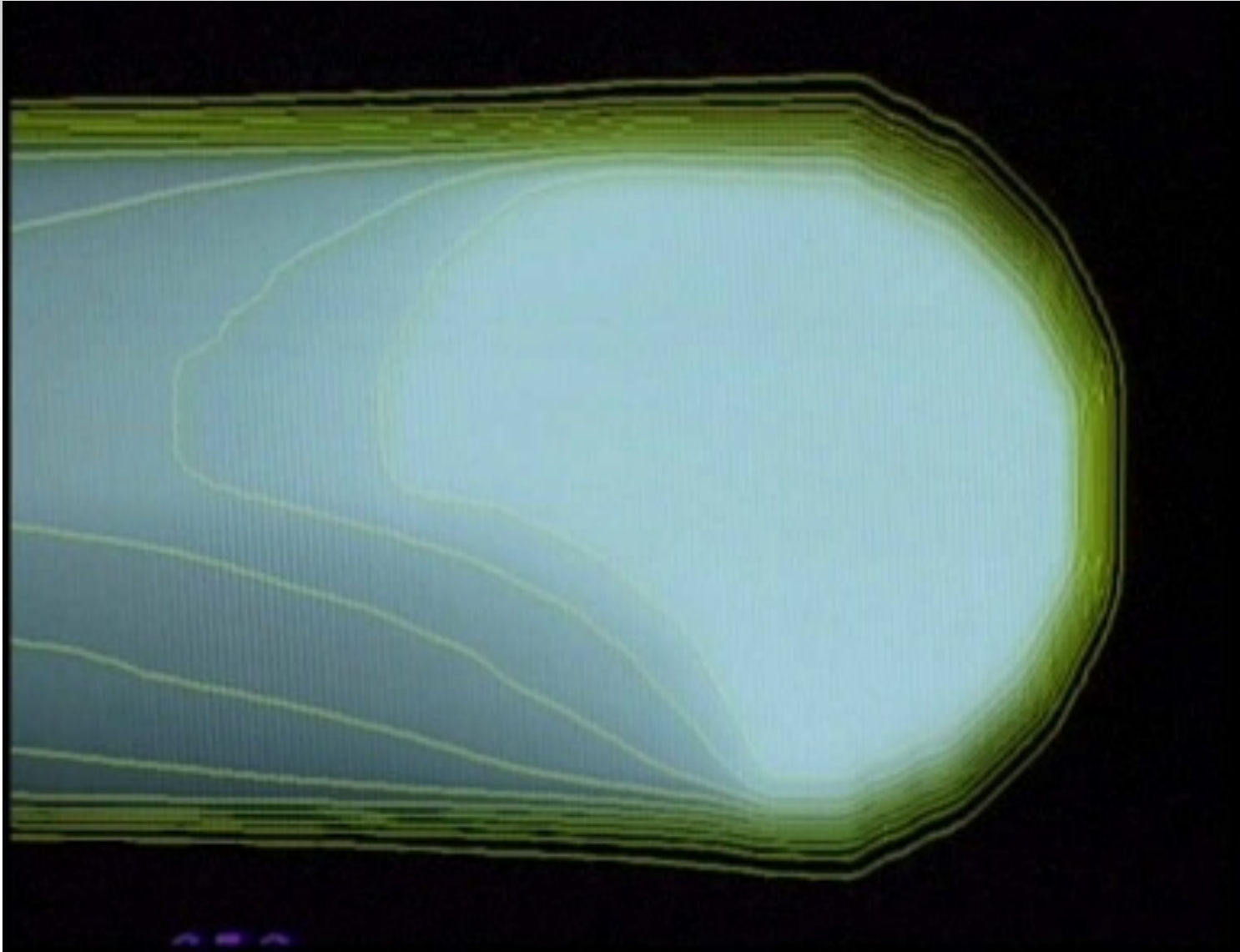
**MedAustron has acquired from CNAO Foundation the construction drawings**











### 3D Real-time IR Optical Tracking (OTS)

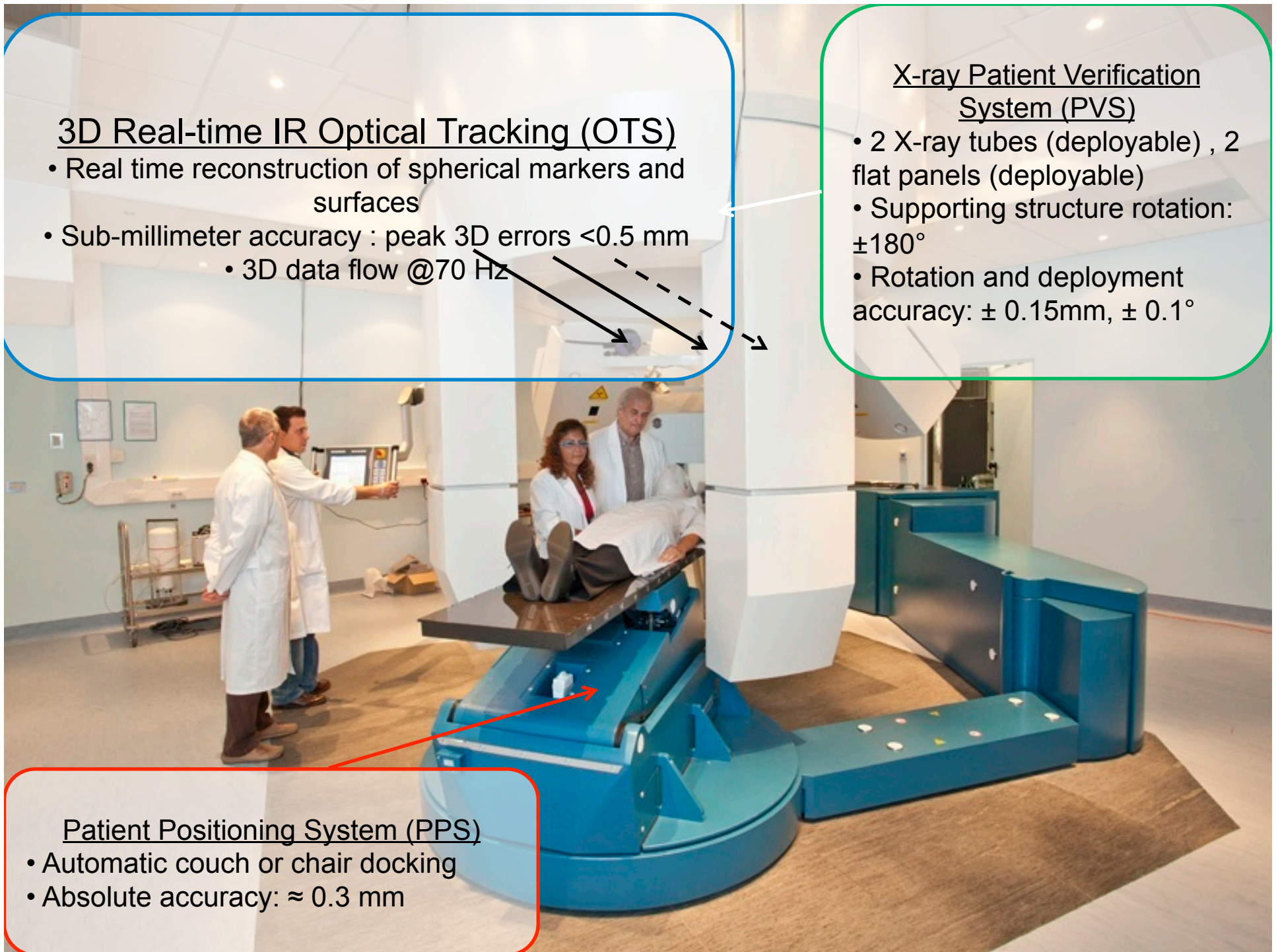
- Real time reconstruction of spherical markers and surfaces
- Sub-millimeter accuracy : peak 3D errors <math><0.5\text{ mm}</math>
  - 3D data flow @70 Hz

### X-ray Patient Verification System (PVS)

- 2 X-ray tubes (deployable) , 2 flat panels (deployable)
- Supporting structure rotation:  $\pm 180^\circ$
- Rotation and deployment accuracy:  $\pm 0.15\text{mm}$ ,  $\pm 0.1^\circ$

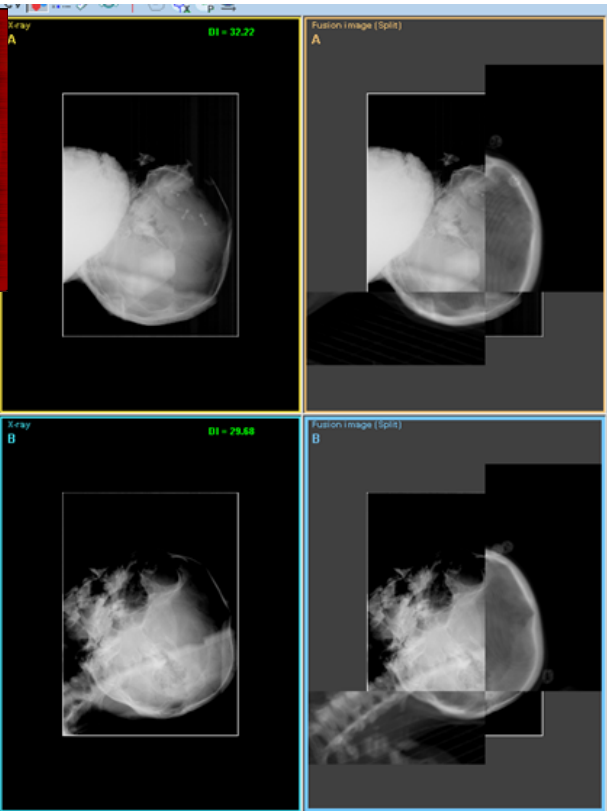
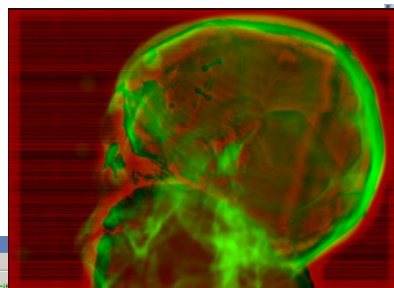
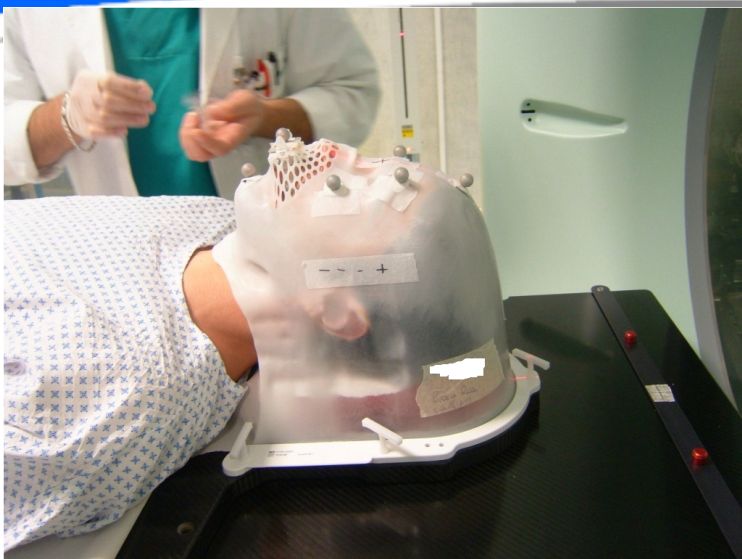
### Patient Positioning System (PPS)

- Automatic couch or chair docking
- Absolute accuracy:  $\approx 0.3\text{ mm}$





# Optical & X-ray tracking per la verifica del set up



File Acquisition Graphics View Help

09.11.2011 12:30:34 Guido Baroni logged in Administrator

Treatment Data

Patient Name: [redacted]

Patient Sex: M

Date of Birth: 1-1-1985

Patient ID: [redacted]

Study Description:

SOPInstanceUID: 1.2.840.11385.4.5952.40.482751200060770766.1004982304949

Treatment support: TABLE

Number of Beams: 3

Treatment Sequence: I-3940:TX

Volume Center: X=9999.0 Y=9999.0 Z=9999.0

Isocenter: X=0.0 Y=-273.0 Z=0.0

Indexing position: F10 Bar DISTAL

Table Lateral [mm]: 3.8

Table Longitudinal [mm]: -1123.6

Table Vertical [mm]: -104.1

Table Pitch [deg]: 0.4

Table Roll [deg]: -0.8

Table Rotate (Yaw) [deg]: 71.7

Acquisition Data

Acquired Frames: 762

Displayed Frames: 506

Saved Frames: 94

Sample Rate [Hz]: 1.4

Lock PPS/Treat Enable

Correction Parameters

X(RCS): -1.0 [mm]

Y(RCS): -0.3 [mm]

Z(RCS): 0.4 [mm]

Pitch(RCS): -0.5 [deg]

Roll(RCS): 0.8 [deg]

Rotate(RCS): -1.4 [deg]

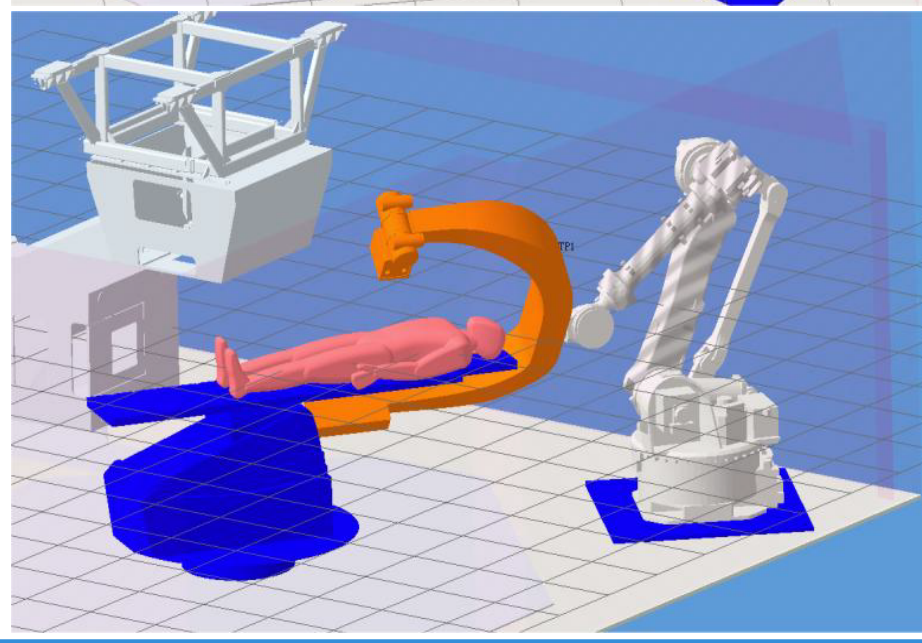
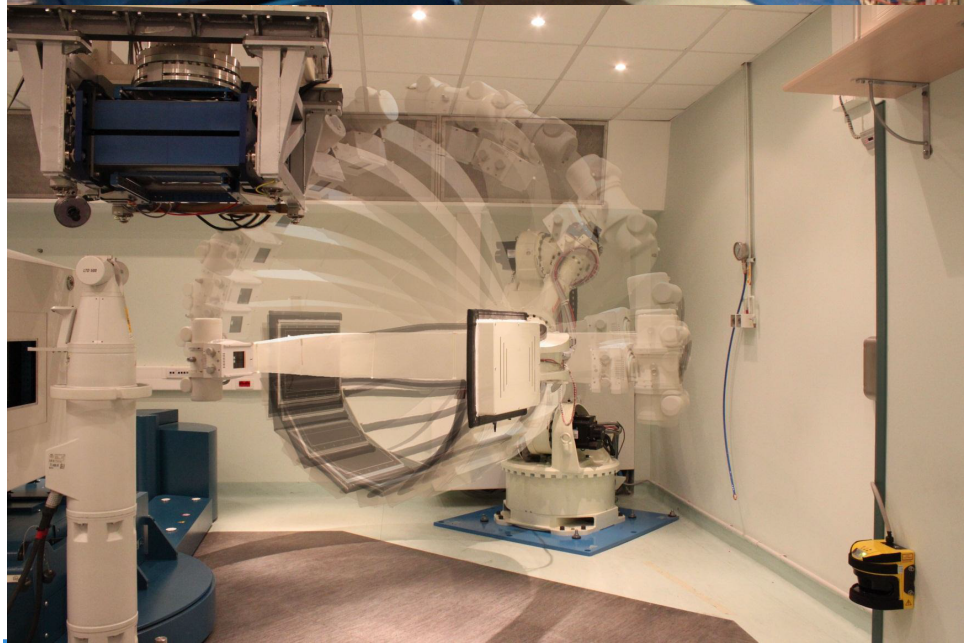
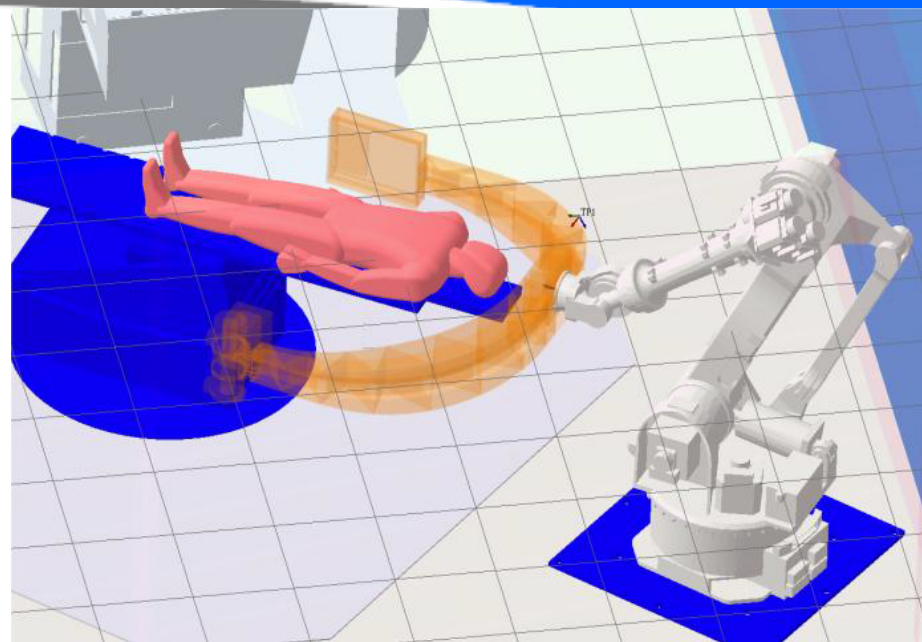
Send Correction to PPS

M6 49

M7 40

Z (RCS) [mm] Y (RCS) [mm] X (RCS) [mm] 3D [mm]



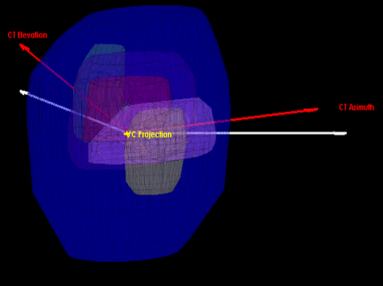




The screenshot displays a complex medical software interface for CT intensity editing and registration. The interface is organized into several main sections:

- Top Left:** Two histograms for 'CT INTENSITY EDIT' and 'CBCT INTENSITY EDIT'. The first histogram shows a peak at approximately 1024, with a level slider set to -1024:1550. The second histogram shows a peak at approximately 244, with a level slider set to -244:520.
- Top Middle:** A 'Sagittal' view of a CT scan with a red dashed box indicating a region of interest. The X-axis is labeled 'X: 55.66 mm'.
- Top Right:** An 'Axial' view of a CT scan with a red dashed box indicating a region of interest. The Z-axis is labeled 'Z: -102.00 mm'.
- Middle Left:** A 'Coronal' view of a CT scan with a red dashed box indicating a region of interest. The Y-axis is labeled 'Y: 0.00 mm'.
- Middle Right:** A 'Sagittal' view of a CBCT scan with a red dashed box indicating a region of interest. The X-axis is labeled 'X: 55.66 mm'.
- Far Right:** An 'Axial' view of a CBCT scan with a red dashed box indicating a region of interest. The Z-axis is labeled 'Z: -102.00 mm'.
- Bottom Left:** A registration plot showing 'Auto-registration' with a graph of intensity differences. Below the graph, 'Manual transform' parameters are listed:  $TX [mm] = 0.456317$ ,  $TY [mm] = -0.248079$ ,  $TP [mm] = 0.701237$ ,  $Rotate [^\circ] = -0.206976$ ,  $Tilt [^\circ] = -0.416553$ , and  $Roll [^\circ] = -0.0818366$ . A 'Reset' button and 'Accept - Send OTS' option are also present.
- Bottom Middle:** A 'Patient Loaded' status panel with the following information: PatientName: [redacted], PatientID: A140673, PatientSex: M, PatientAge: [redacted], PatientBirthDate: 19650720, SeriesNumber: 1, SeriesDescription: Supino, StudyID: [redacted], PatientOrientation: HFS. Below this is another 'CT INTENSITY EDIT' histogram with a level slider set to -1024:1550.
- Bottom Right:** A 3D visualization of the CT and CBCT volumes, showing their relative positions and orientations within a 3D coordinate system.
- Bottom Center:** A 'Patient Information' panel with 'Region of Interest' coordinates (219,727; 219,727; 260; 219,727; 219,727; 260) and 'Auto-registration' parameters.
- Bottom Far Left:** An 'Imaging Isocenter' panel with a red crosshair icon and 'X' 'Y' 'Z' labels.

3D Reconstruction of Eye Structures - Viewer RTRSTRUCT.dcm Loaded



**Fulcrum Properties**

	X [mm]	Y [mm]	Z [mm]
Original ISO Position	-31.31	-80.84	30.48
GET Current Fulcrum	0	0	0
SET Right Fulcrum	FULCRUM OK		

**Virtual Camera Properties**

RESET View    Azimuth [°]    Elevation [°]

GET Current View	-30.0	10.0
SET Virtual Camera View	-30	10

Manual Reverse Mode:  Flip BEV X     Flip BEV Y

CTV Expansion in the ISO Frame:  Activate expansion

CLEAN Viewer    Margin [mm]    3

**Patient-CT Transformation Matrix: Tr (Row,Column)**

	1	2	3	4
1	0.8440	-0.5000	0	12.2047
2	0.5000	0.8529	0.1724	-79.2081
3	0	-0.1724	0.9648	44.0547
4	0	0	0	1

**Plan summary**

Day: 05-Mar-2014 11:02

Patient's Name: [REDACTED]

Patient ID: 1208401

Patient's Birth Date: 17-07-1970(74y)

Patient's Sex: M

Referring Physician's Name: [REDACTED]

Name of Physician Reading Study: FG

Operator's Name: [REDACTED]

TFS Target Volume [cc]

CTV: 0.286

GTV: N.A.

PTV: 1.152

Involved Eye:  L     R

Eye of Fixation:    

**Patient Gazing Angles (Patient's POV)**

30.0° on his LEFT

10.0° DOWN

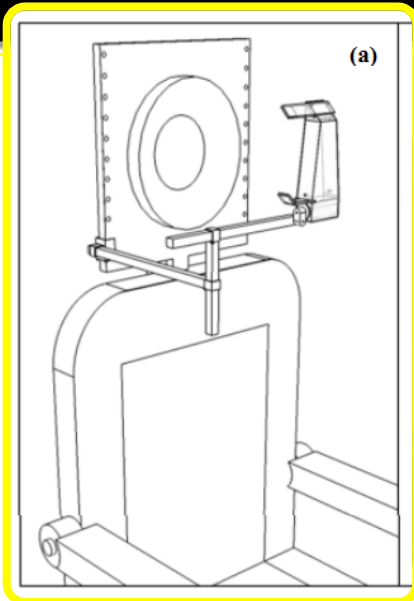
Activity Log

Virtual Cam View SET    EXIT

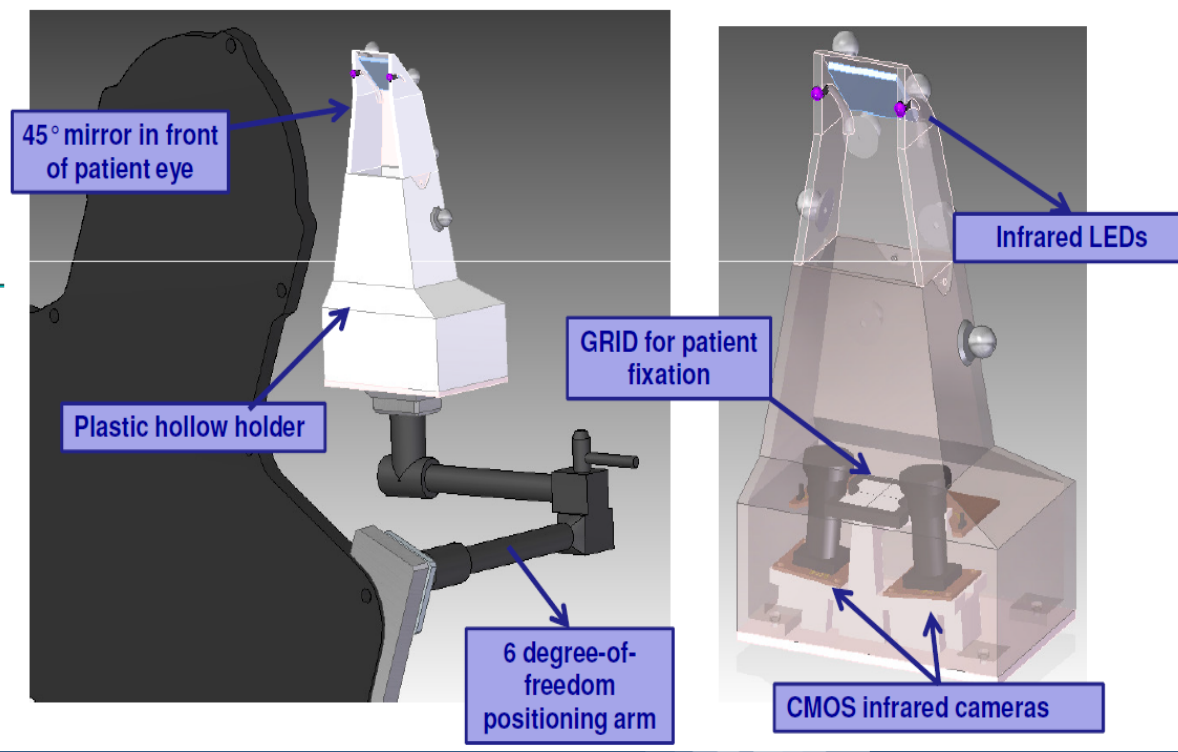
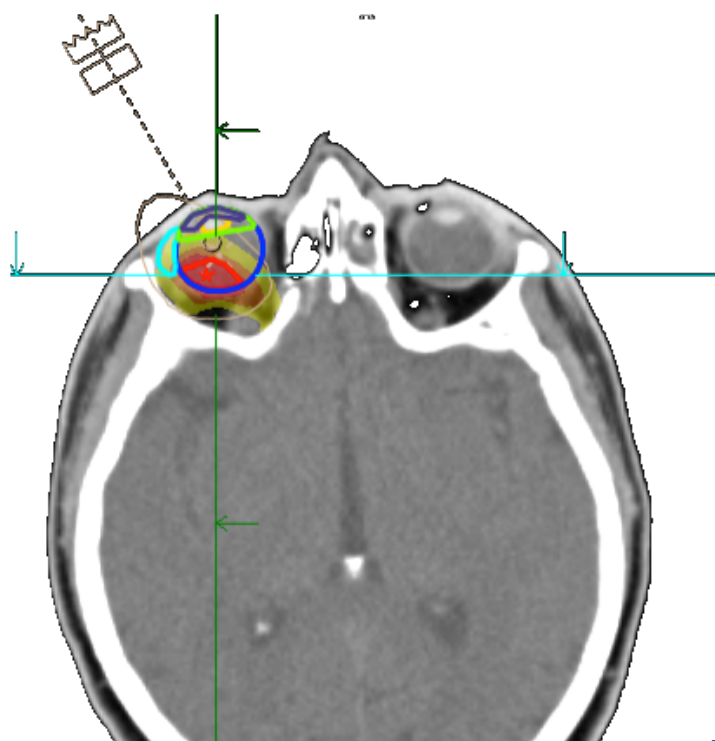
**Plot Editor:**  Axes     Grid     Box

**Legend:**

- CTV
- Globe
- Lens
- Optic Nerve
- Ant Chamber
- PTV
- Isocenter
- Target



# Non invasive eye tracking system for intraocular tumor localization in proton therapy treatment



POLITECNICO DI MILANO





**ITALIAN NETWORK**

An aerial perspective of a modern, multi-story building complex with a mix of brick and white facades. The building is surrounded by green lawns, trees, and a paved area. A large, semi-transparent orange circle is overlaid on the right side of the image, containing text. At the bottom, a dark blue horizontal bar contains the text 'INTERNATIONAL NETWORK' in white.

**ULICE**

**Norway**

**France**

**INTERNATIONAL  
NETWORK**





[direzionemedica@cnao.it](mailto:direzionemedica@cnao.it)  
[serviziomedico@cnao.it](mailto:serviziomedico@cnao.it)



**Prima Visita Virtuale**



Tel 0382 078963



**Protocolli CNAO**



**Prima Visita**

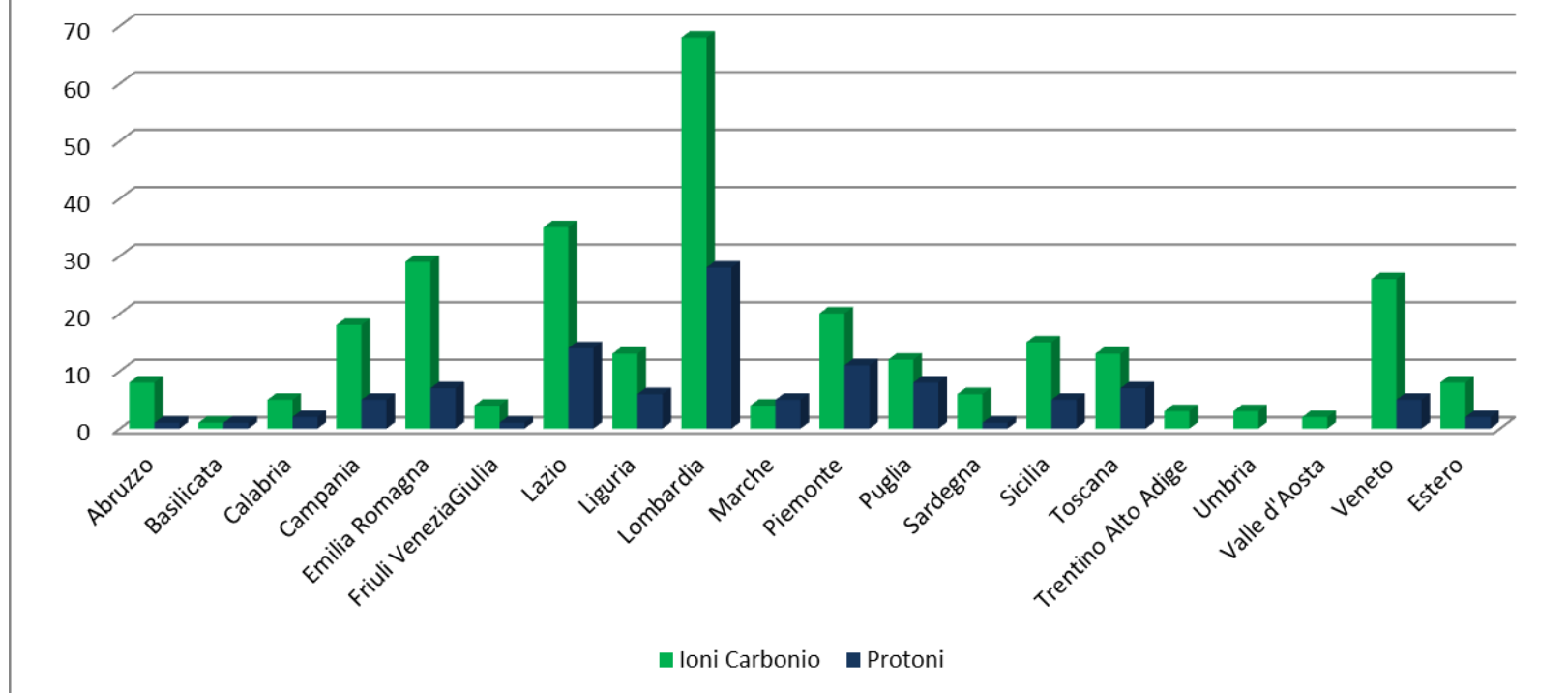


<http://folder.cnao.it>

### Distribuzione geografica dei pazienti del CNAO

22 Settembre 2011 – 21 Novembre 2014

Totale 402 pazienti (133 in sperimentazione + 252 post sperimentazione  
+ 17 compassionevoli)



•**Protoni:** 109 pazienti

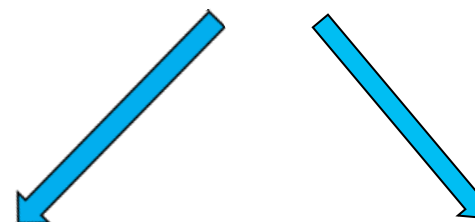
•**Carbonio:** 293 pazienti



**Weekly internal Board**



**Waiting list**



**Avvio procedure per  
trattamento  
radiante**



**Settimane  
o mesi**



**REGIONI**

## Numero Contatti Servizio medico 1233

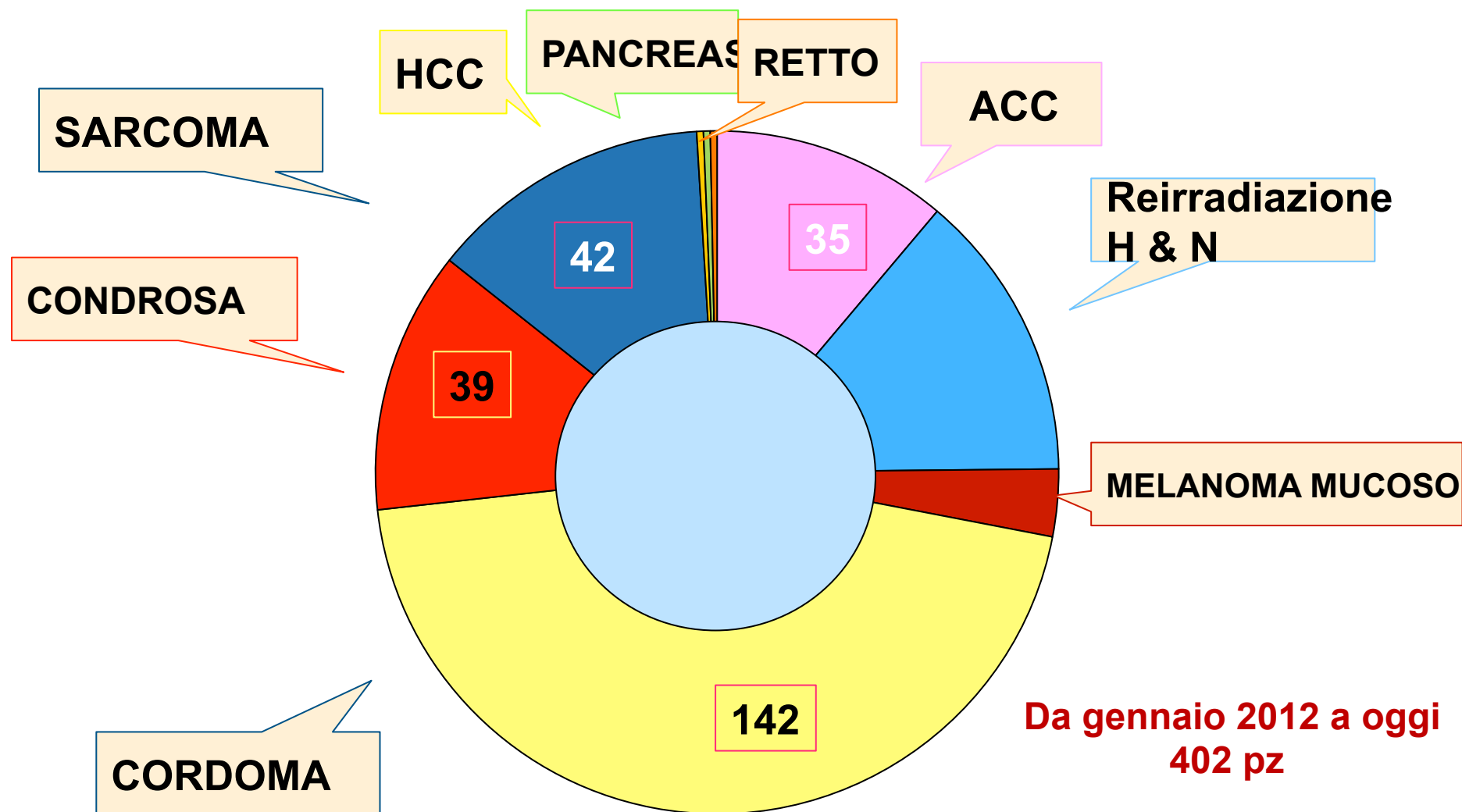
MACRO CATEGORIA	CATEGORIA	2014
VISITE	PRIME VISITE	481
	ESAME DOCUMENTAZIONE CLINICA	263
<b>Totale VISITE PRELIMINARI</b>		<b>744</b>
IMAGING	PET	54
	RM	599
	TAC	399
<b>Totale IMAGING per ADROTERAPIA</b>		<b>1.052</b>
SEDUTE ADROTERAPIA	PROTONI	1.103
	IONI CARBONIO	3.380
<b>Totale SEDUTE</b>		<b>4.483</b>
ADROTERAPIA ALTRO	DEFINIZIONE DEL VOLUME BERSAGLIO E DEGLI ORGANI A RISCHIO	250
	FUSIONE DI IMMAGINI PER PREPARAZIONE PIANO DI TRATTAMENTO	250
	SISTEMA DI IMMOBILIZZAZIONE PERSONALIZZATO	265
	STUDIO FISICO-DOSIMETRICO	250
	VISITE CONTROLLO	1.309
	INIEZIONI FARMACI SPECIFICI	8
	MEDICAZIONI	13
	<b>Totale ALTRE PRESTAZIONI per ADROTERAPIA</b>	
<b>Totale ADROTERAPIA</b>		<b>7.879</b>
IMAGING	RM	962
	TAC	48
<b>Totale IMAGING</b>		<b>1.010</b>
VISITE	VISITE CONTROLLO	1.010
<b>Totale PRESTAZIONI DI FOLLOW UP</b>		<b>2.019</b>
<b>TOTALE PRESTAZIONI</b>		<b>10.642</b>

## Attività Clinica :

- **Cordoma e condrosarcoma**
- **Tumori delle ghiandole Salivari**
- **Sarcoma delle parti molli**
- **Melanoma mucoso**
- **Recidive di Adenoma pleomorfo**
- **Meningioma**
- **Tumori dell'orbita (melanomi dell'occhio)**
- **Tumori avanzati della testa e del collo**
- **Tumori della prostata ad alto rischio**
- **Tumori del pancreas inoperabili**
- **Epatocarcinoma**
- **Re-irradiazione delle recidive di tumori del retto**
- **Re-irradiazione di tumori della testa e del collo**

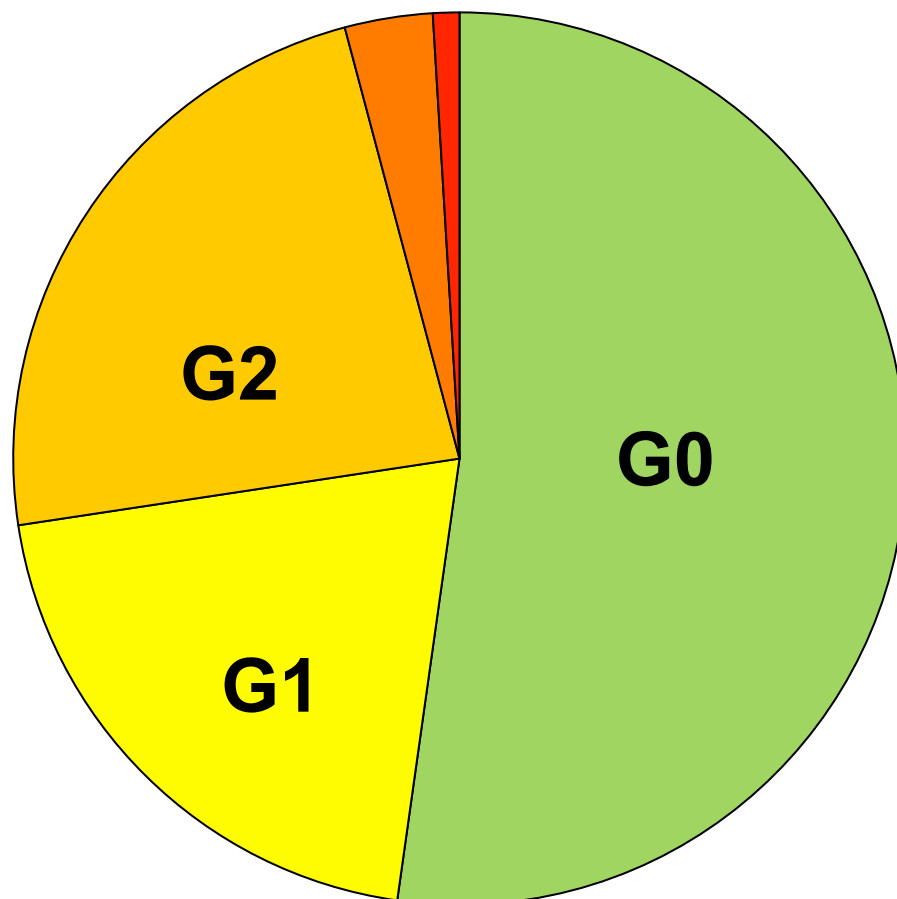


# Patologie trattate con Adroni al CNAO di Pavia



Da gennaio 2012 a oggi  
402 pz

# Tossicità acuta secondo criteri CTCAE

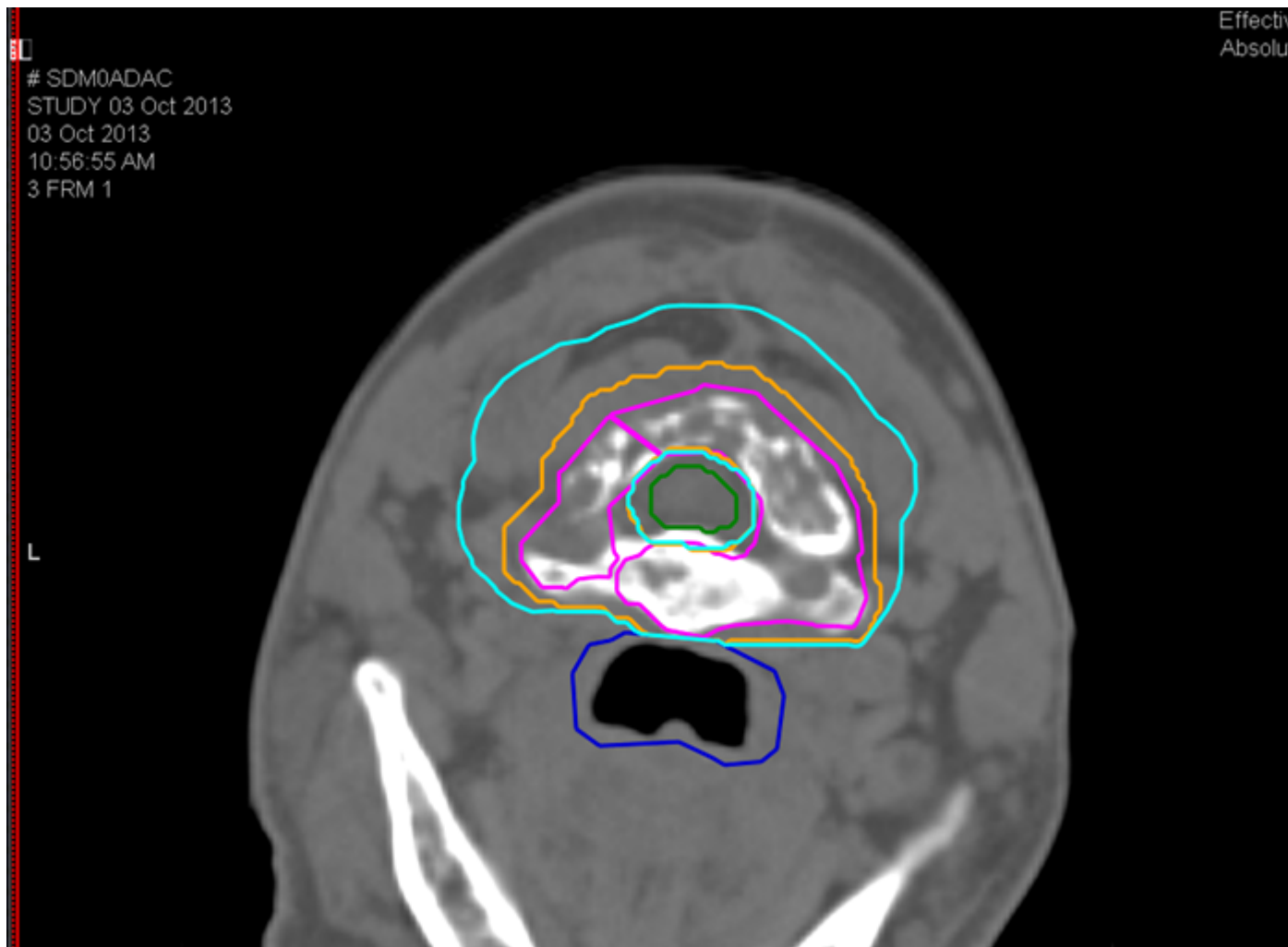


402 pazienti trattati

- G0
- G1
- G2
- G3
- G4

Sono compresi i ri-trattamenti radianti

# osteosarcoma di basso grado delle vertebre cervicali, C1-C2 56 anni maschio





SI SIEMENS

SIEMENS

### Tx Planning

**Define Tx Plan**

**Optimization**

**Review Compare**

**Fx Sequence**

New Fx   Add To Fx

**Plan Selection**

**FxSomma**

- CTV Id-prv4mm + GTV-P  
9\*4.6GyE
- GTV-PRV cord 4 mm + C  
7\*4.6GyE
- II Tempo
- II Tempo

**Review**

FxSomma   eff

**Comparison**

None

Archive results from current

**RT Navigator Dialog**

- Name
- cord 1 mm
- CTV hd-PRV4mm
- CTV high dose
- CTV Id-prv4mm
- CTV low dose ok
- faringe
- fusion
- GTV
- GTV-PRV cord 4 mm
- PRV cord\_4 mm
- PRV cord\_5 mm
- PTV high dose
- PTV low dose
- skin
- tronco

**Dose Profile**

Dose in GyE

Distance in cm

Ok

CENTRO NAZ. ADROTERAPIA ONCOLOGIA

Sensation Oper

FxSomma

Effective

Absolute

20.00 Gy

26.00 Gy

30.00 Gy

40.00 Gy

50.00 Gy

60.00 Gy

67.00 Gy

75.00 Gy

100% = ??? Gy

\* Loc. = 78.34 Gy

\* Glob. = 82.62 Gy

W 8

C 3

**CIRT 73.6 GyE**  
**16 frazioni IMPT**

SI SIEMENS

SIEMENS

Tx Planning

RT Navigator Dialog

Define Tx Plan

SIEMENS

CENTRO NAZ. ADROTERAPIA ONCOLOGIA

Sensation Oper

FxSomm

Tx Planning

Define Tx Plan

Optimization

Review Compare

RT Navigator Dialog

Name

- cord 1 mm
- CTV hd-PRV4mm
- CTV high dose
- CTV ld-prv4mm
- CTV low dose ok

**G1 eritema al termine di CIRT**

**1 anno malattia stabile**

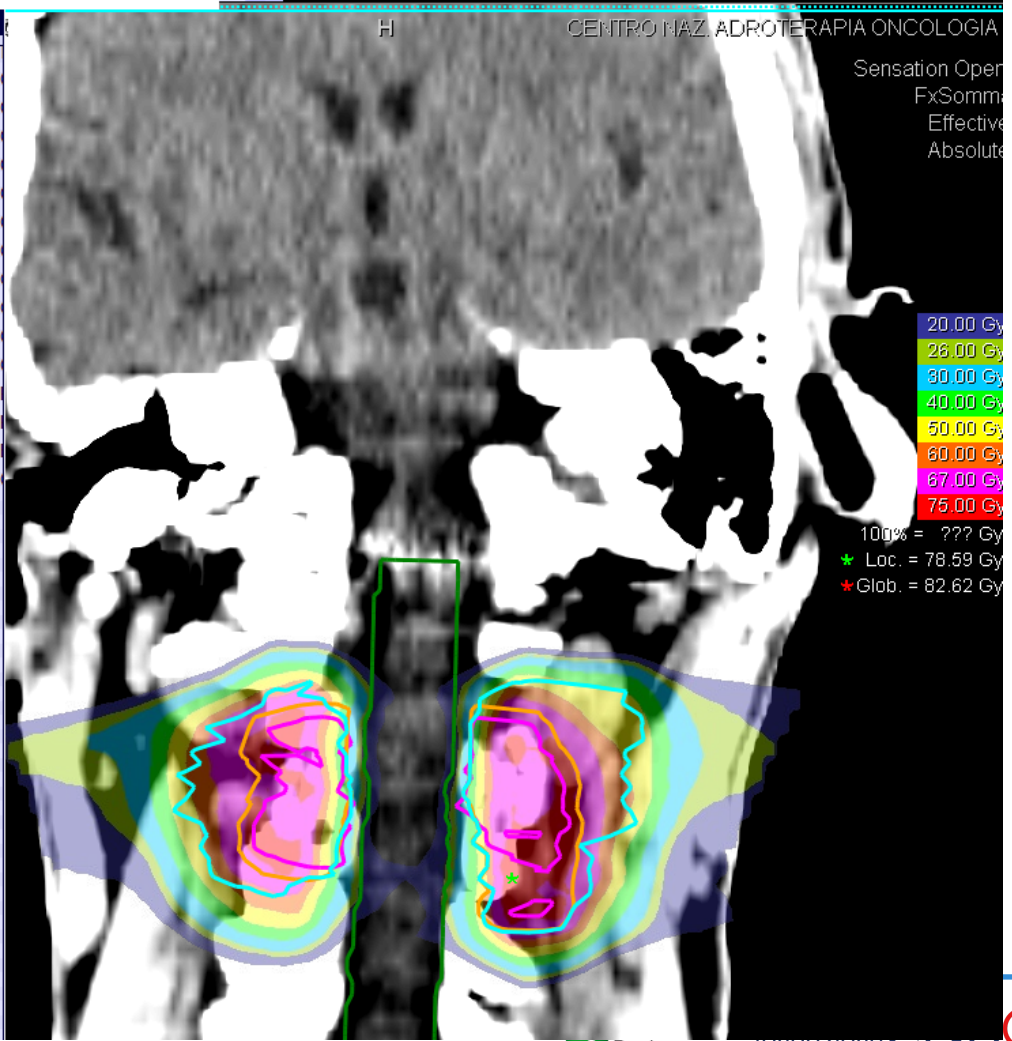
Review

FxSomma

eff

**Analogo caso del NIRS in risposta dopo 7 anni**

**Imai et al. Lancet Oncology 2006**

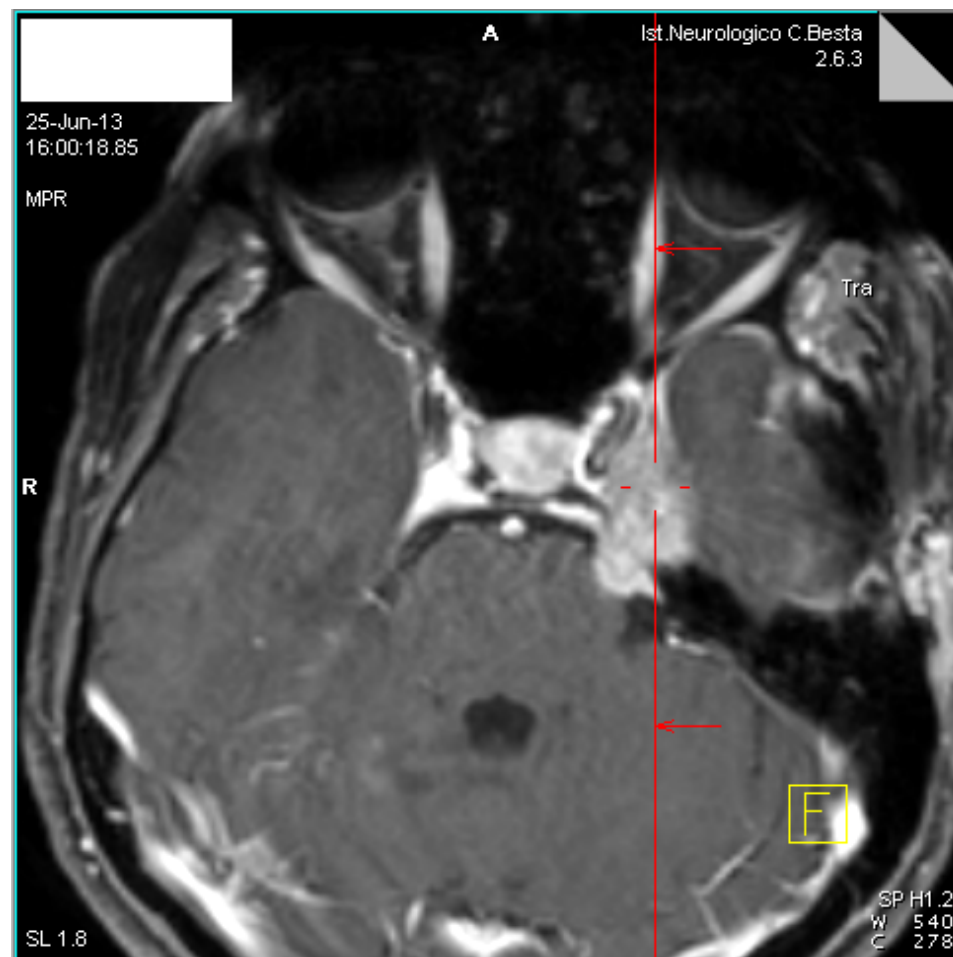


RT Navigator

## Pre- CIRT

**Donna di 62 anni**  
**Carcinoma adenoido-cistico del**  
**cavo di Meckel**

**21/05/2013** craniotomia temporale  
e biopsia

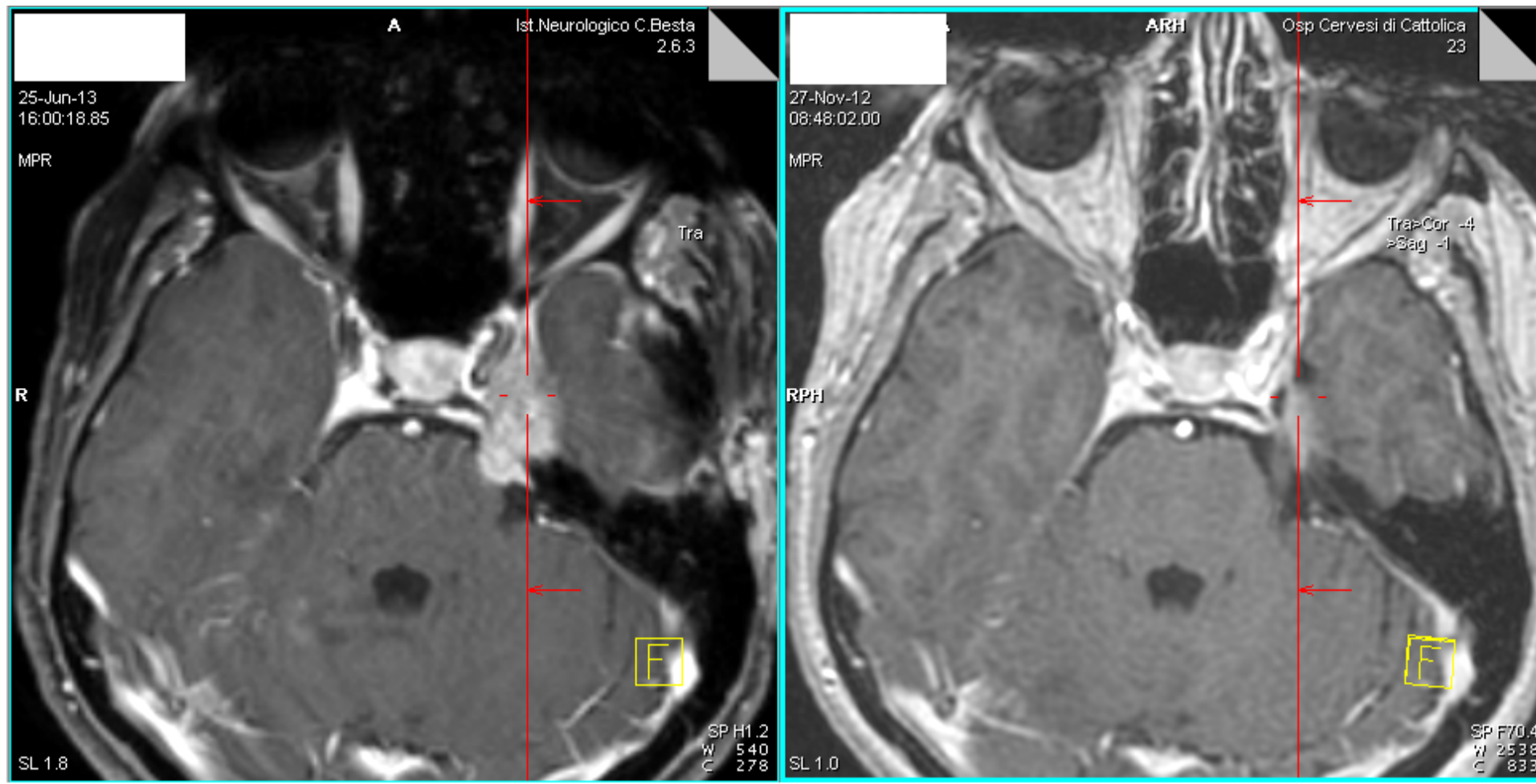




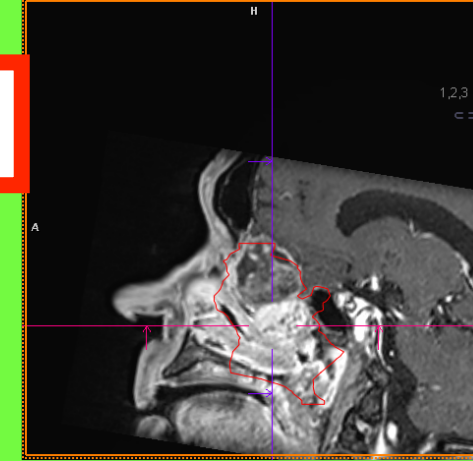
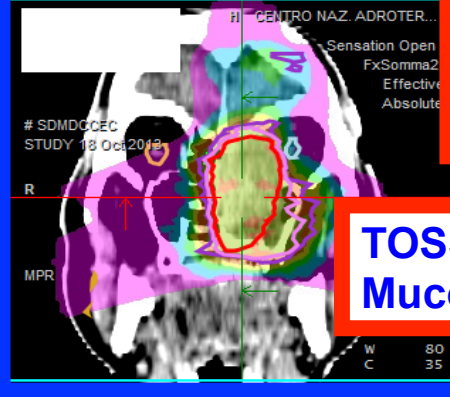
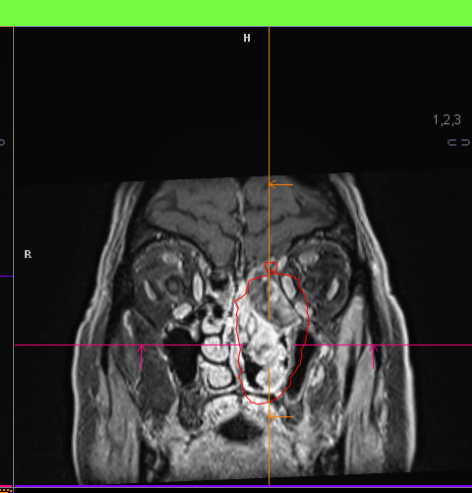
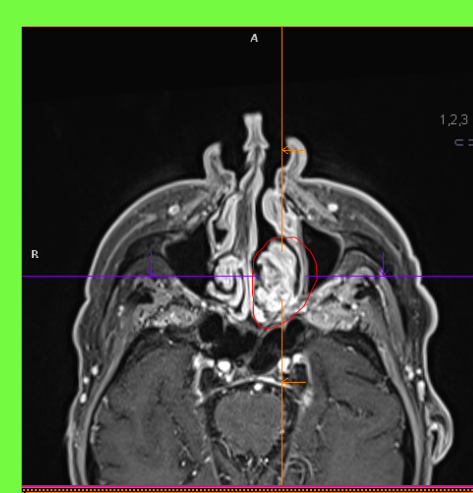
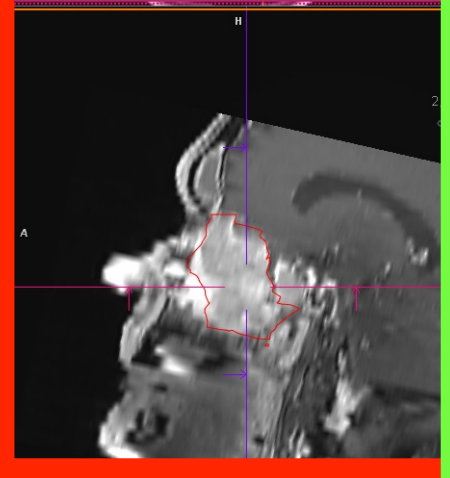
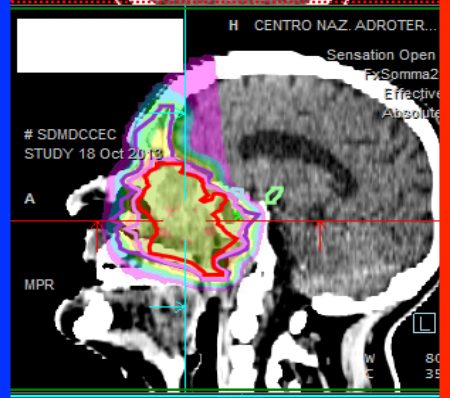
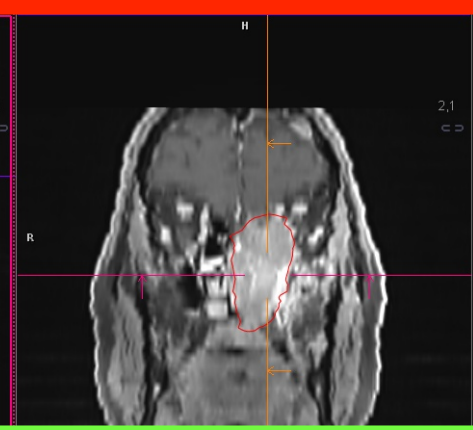
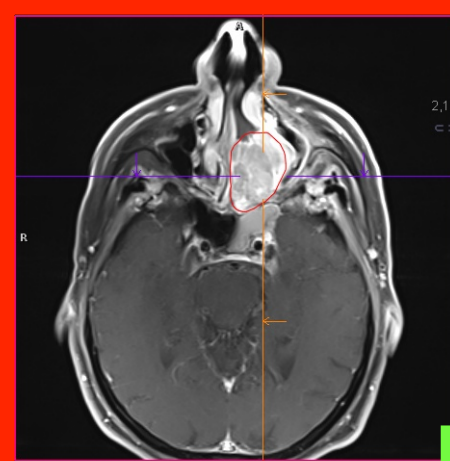
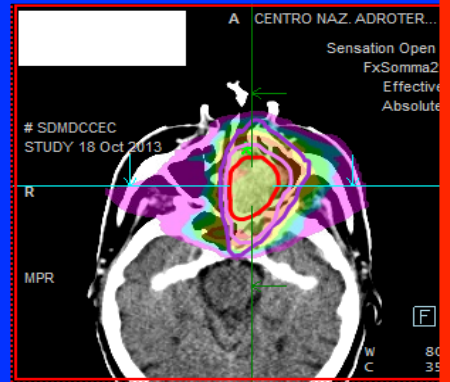
# CIRT: 68.8 Gy(RBE) (4.3 Gy(RBE)/frazione, 16 frazioni, 4 frazioni/weekly



# Maggio 2014 ( 9 mesi) controllo radiologico di malattia confermato dalla MRI. Tox tardiva G0



**Dopo 3 mesi  
Risposta parziale**



**TOSSICITA' a fine CIRT:  
Mucosite G2 Eritema G1**

**Pz con Melanoma Mucoso  
inoperabile**



Durante CIRT



Fine CIRT



Mucosite G2

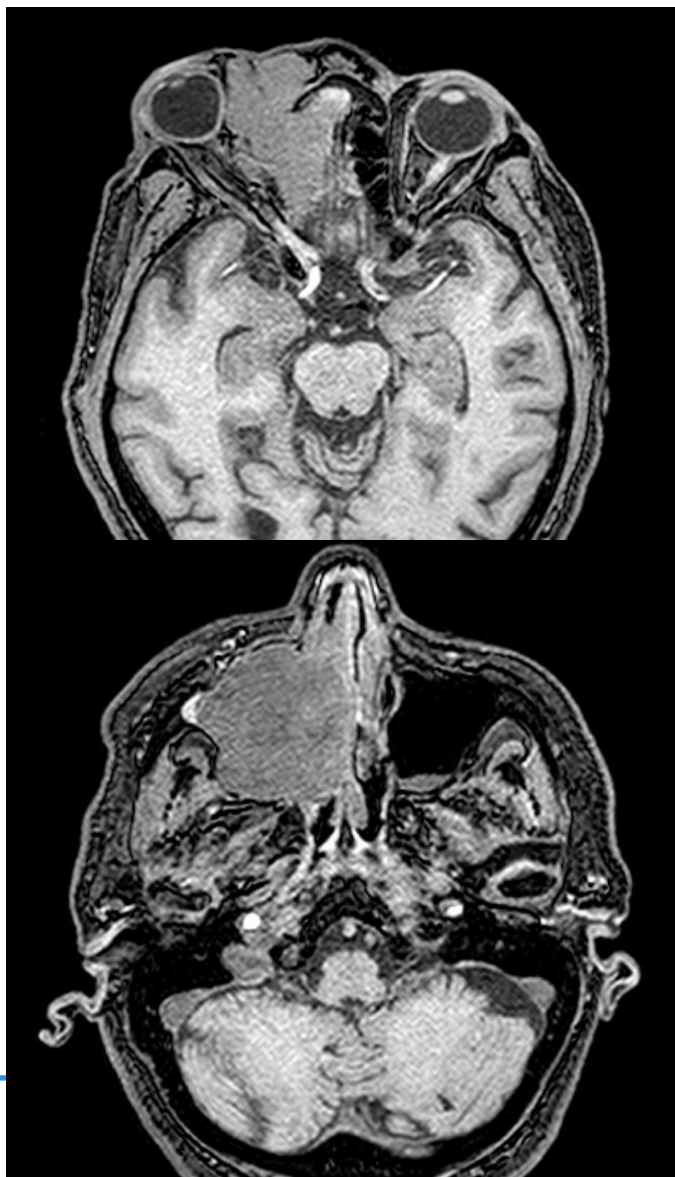
Eritema G1



9 mesi

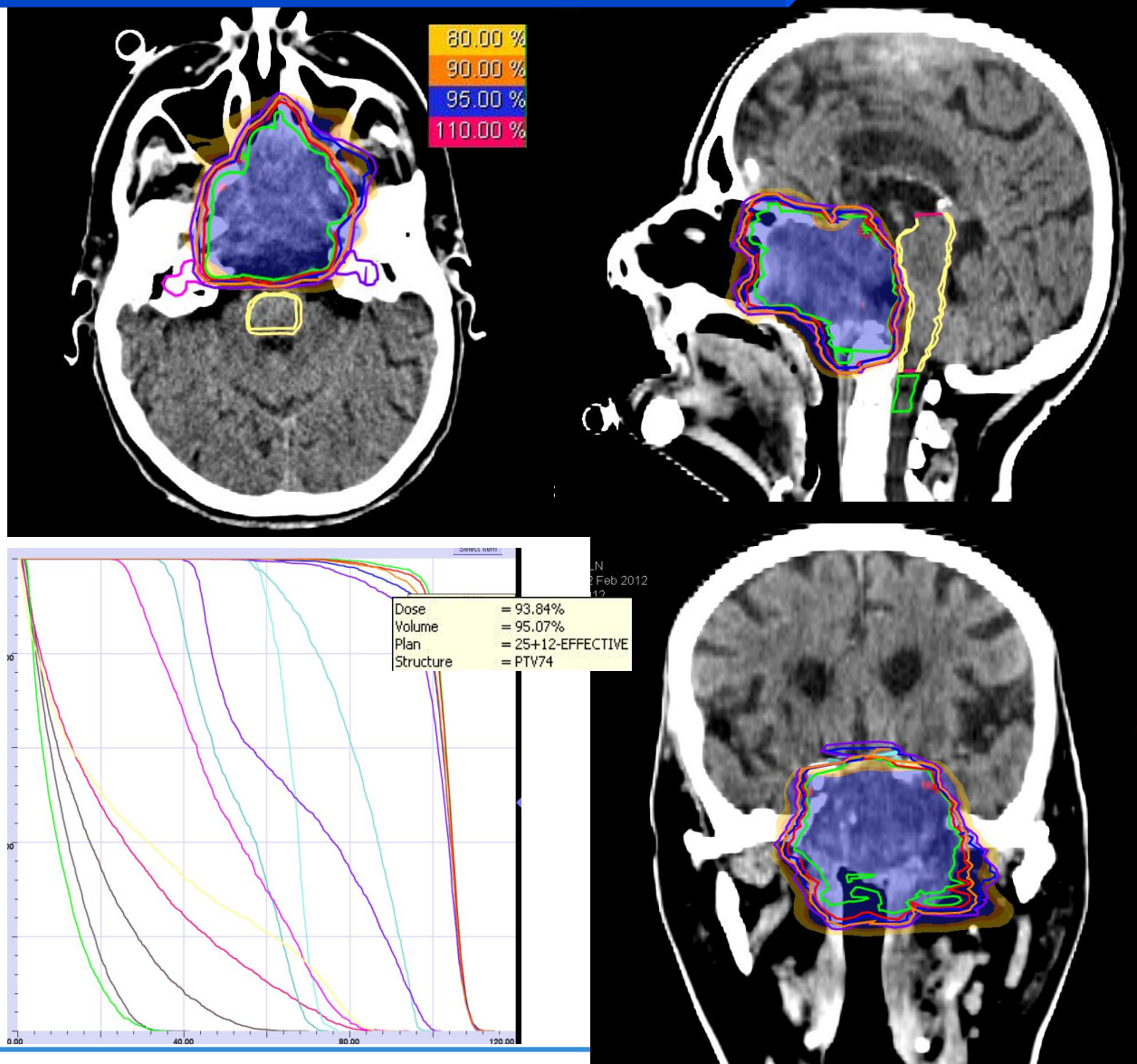
## paziente analogo sottoposto a chirurgia demolitiva: RNM preoperatoria

## esiti dell'intervento





# SKULL BASE CHORDOMA: Proton therapy

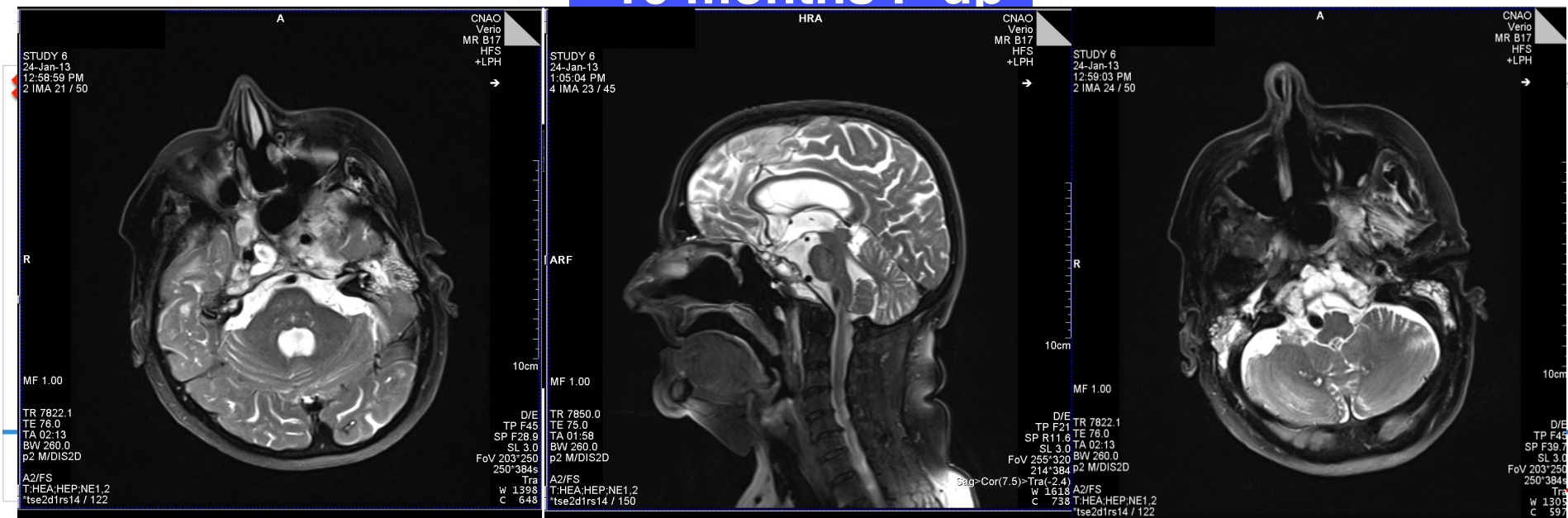




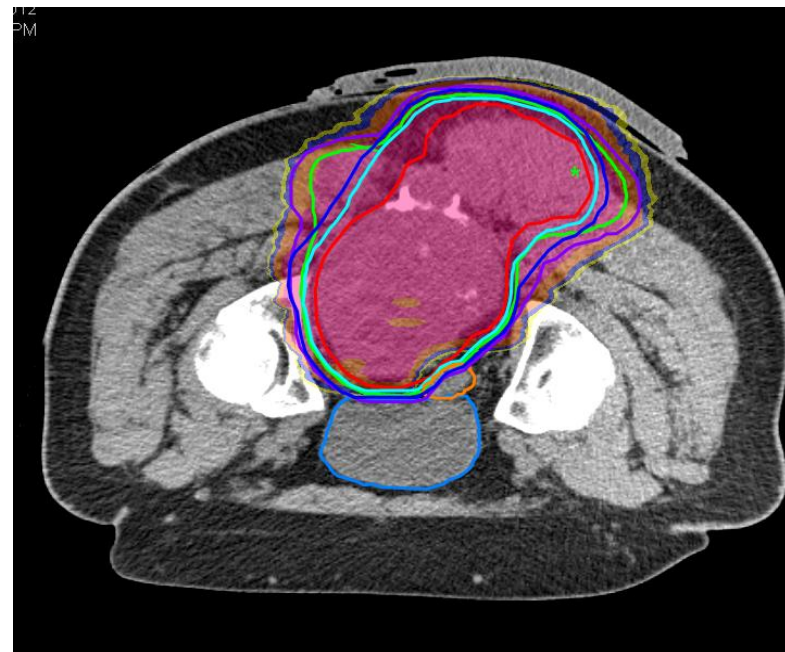
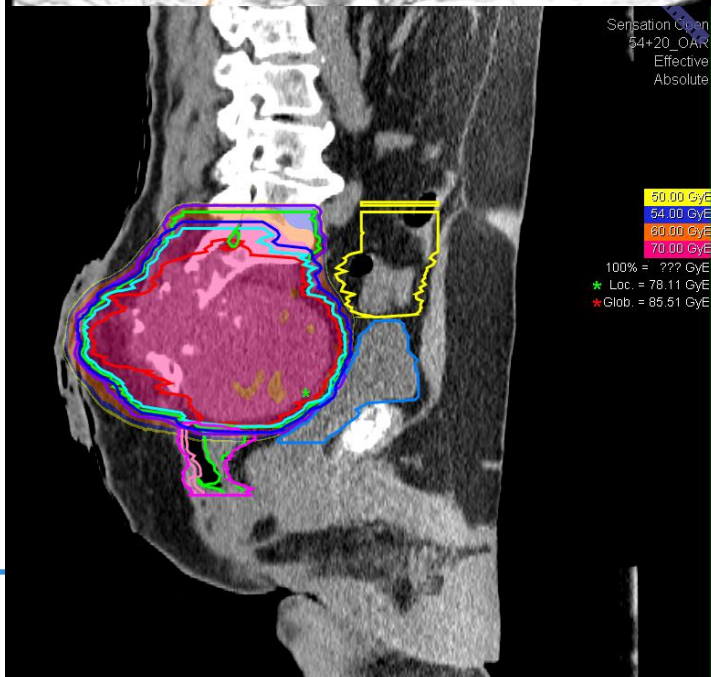
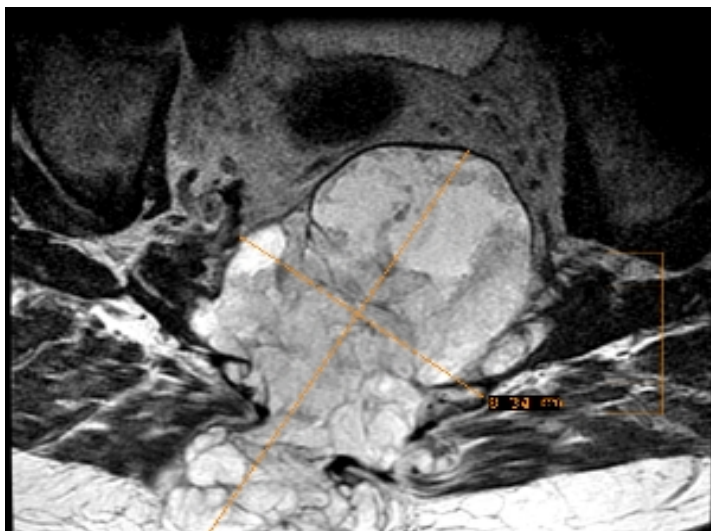
# SKULL BASE CHORDOMA: Proton therapy



## 10 months F-up



# CORDOMA SACRALE: Terapia con Ioni Carbonio



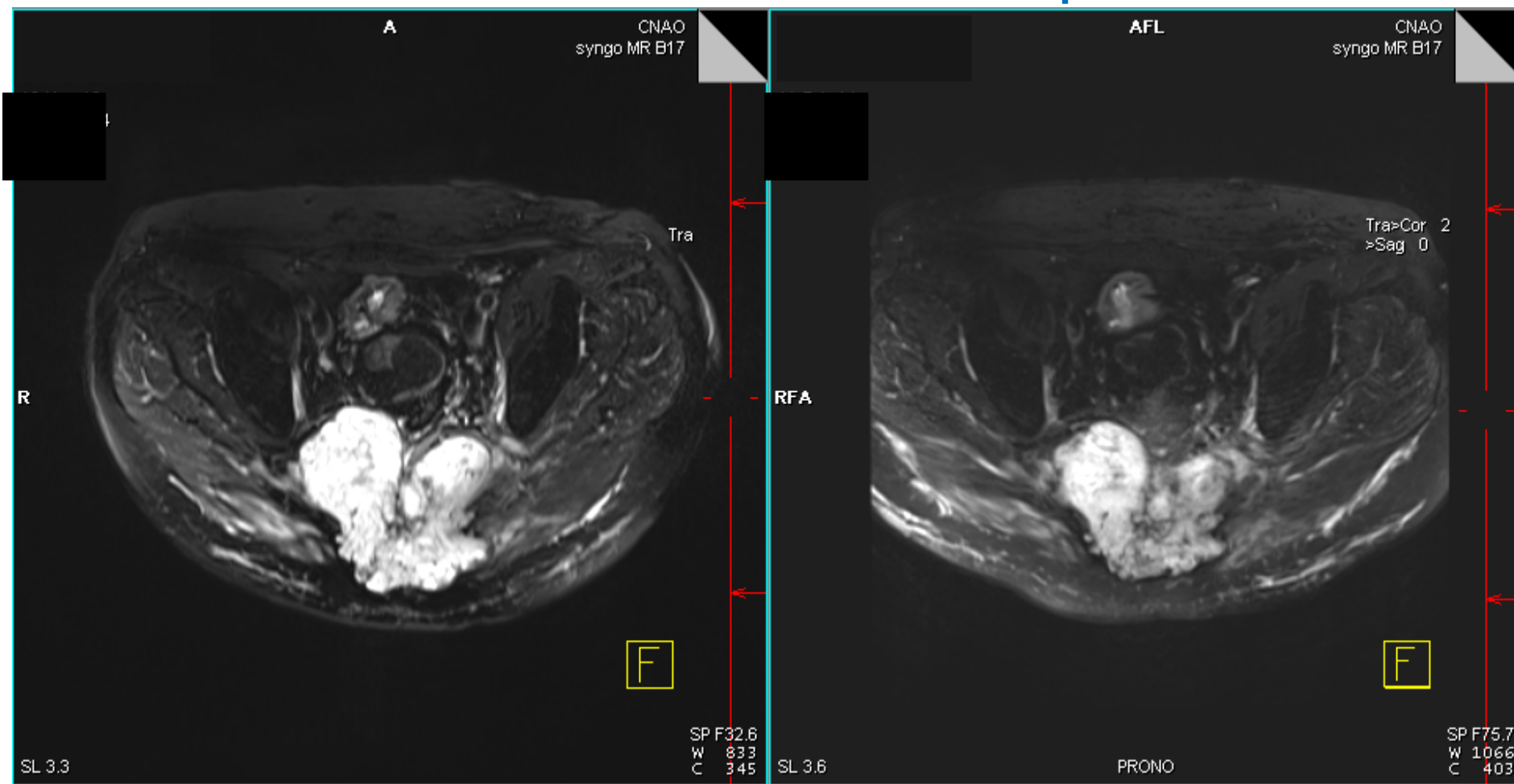
**Cordoma sacrale  
49 anni maschio**

**G2 tossicità cutanea**



Prima del

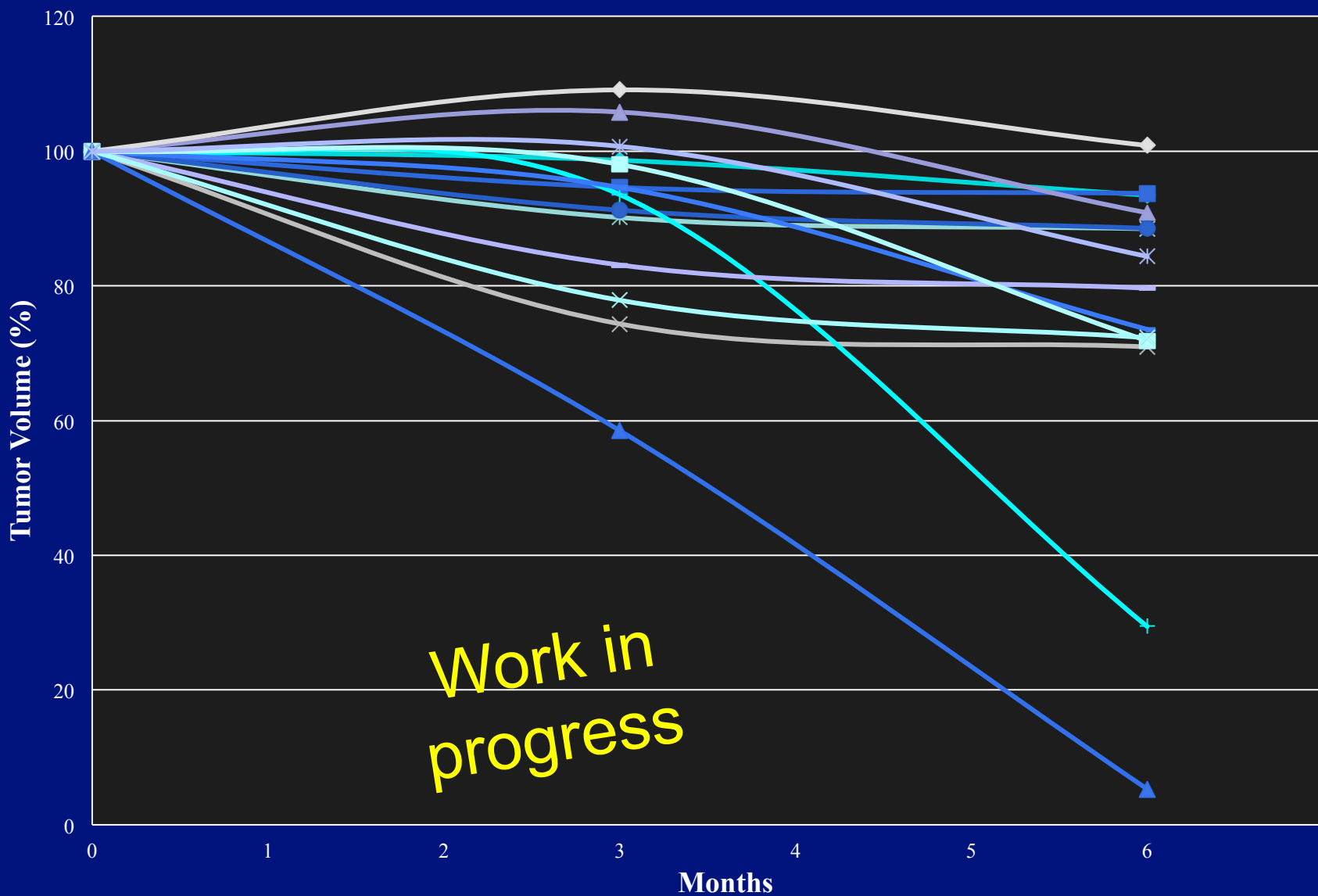
1 anno dopo il trattamento



**Dopo 1 anno dal trattamento residua ipoestesia alla gamba sx : G1 tossicità, miglioramento della funzione urinaria e della continenza rettale, scomparsa del dolore, il paziente sta seduto senza problemi e cammina per 15-20 minuti**



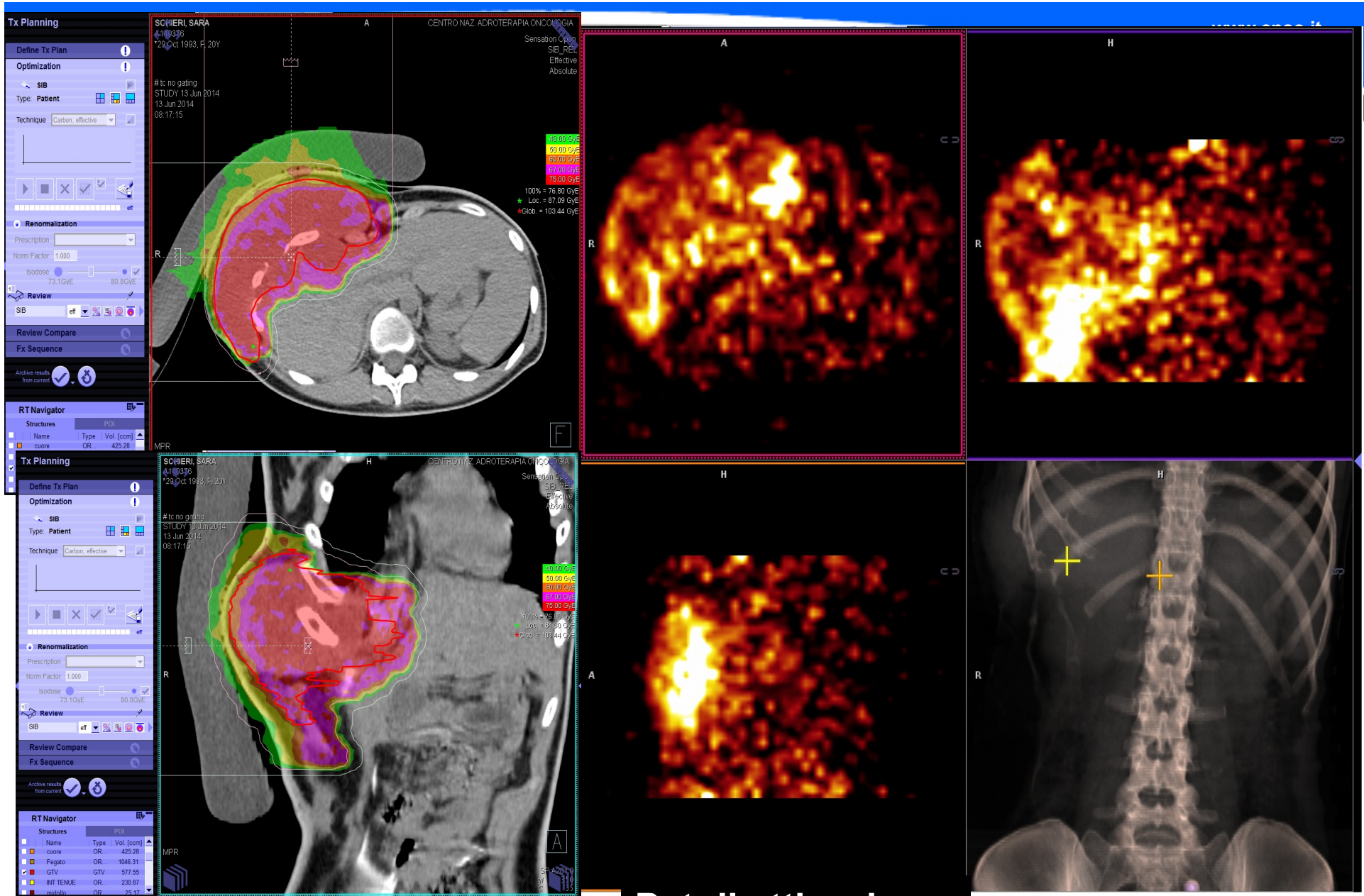
### Volumetric changes of tumor after treatment (volume cc)



Work in progress

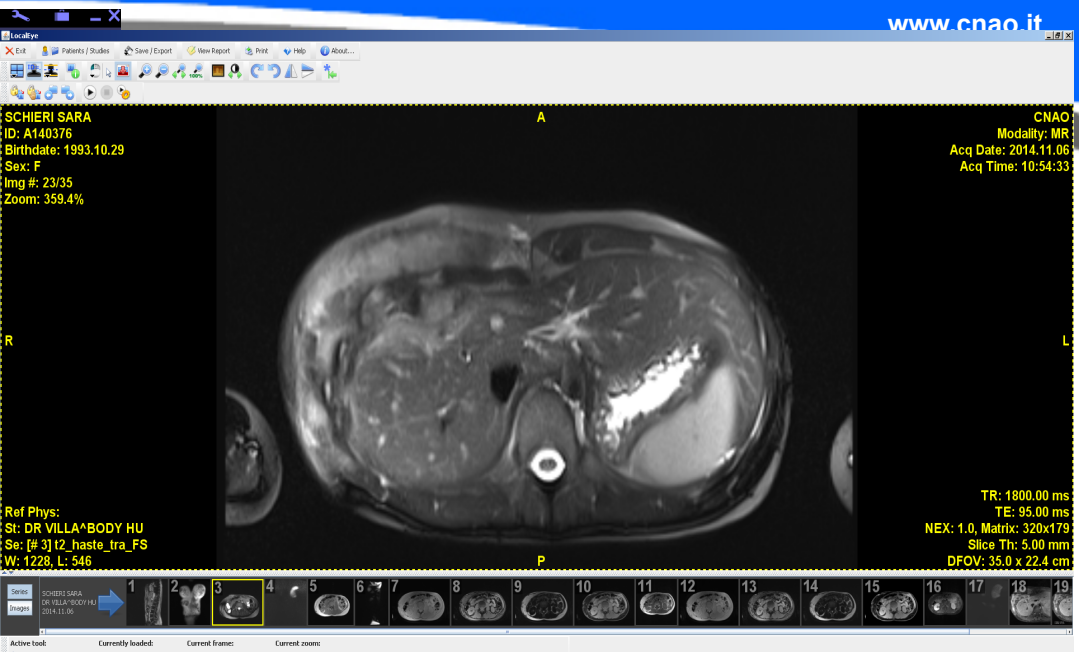
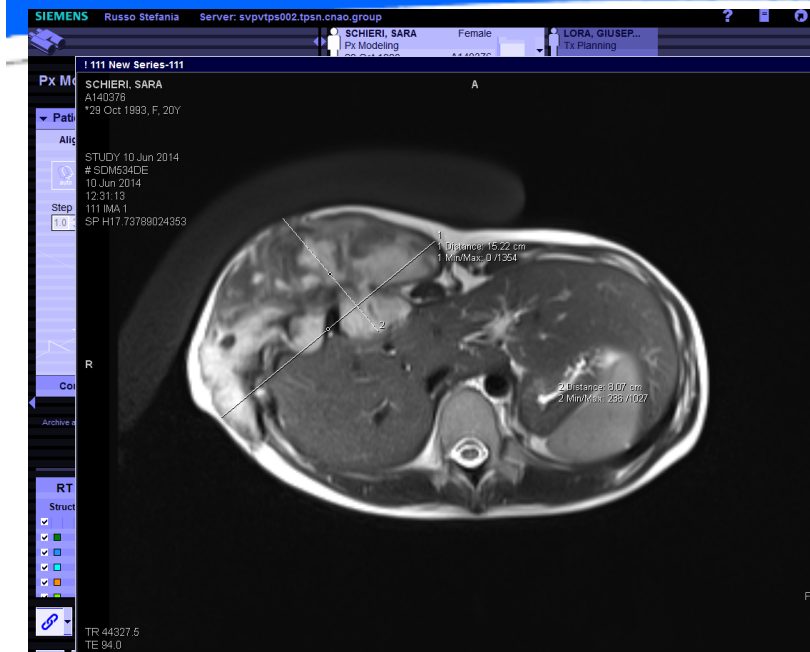
**CIRT**  
**76,8 GyE/**  
**16 frazioni**

Structure	Type	Vol. [ccm]
cuore	OR	425.28
Fegato	OR	1045.31
GTV	GTV	577.55
INT TENUE	OR	230.87
midollo	OR	25.17



**Pet di attivazione  
9 minuti dopo RT**

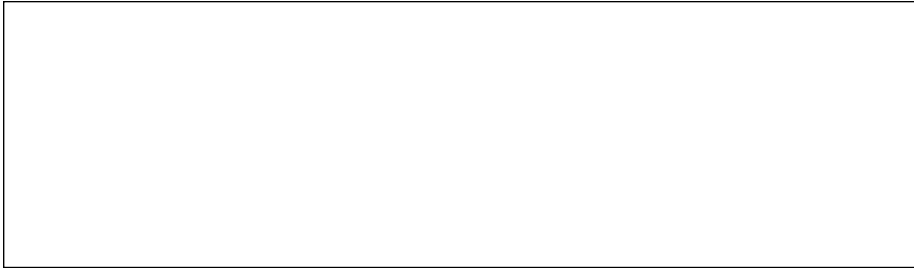




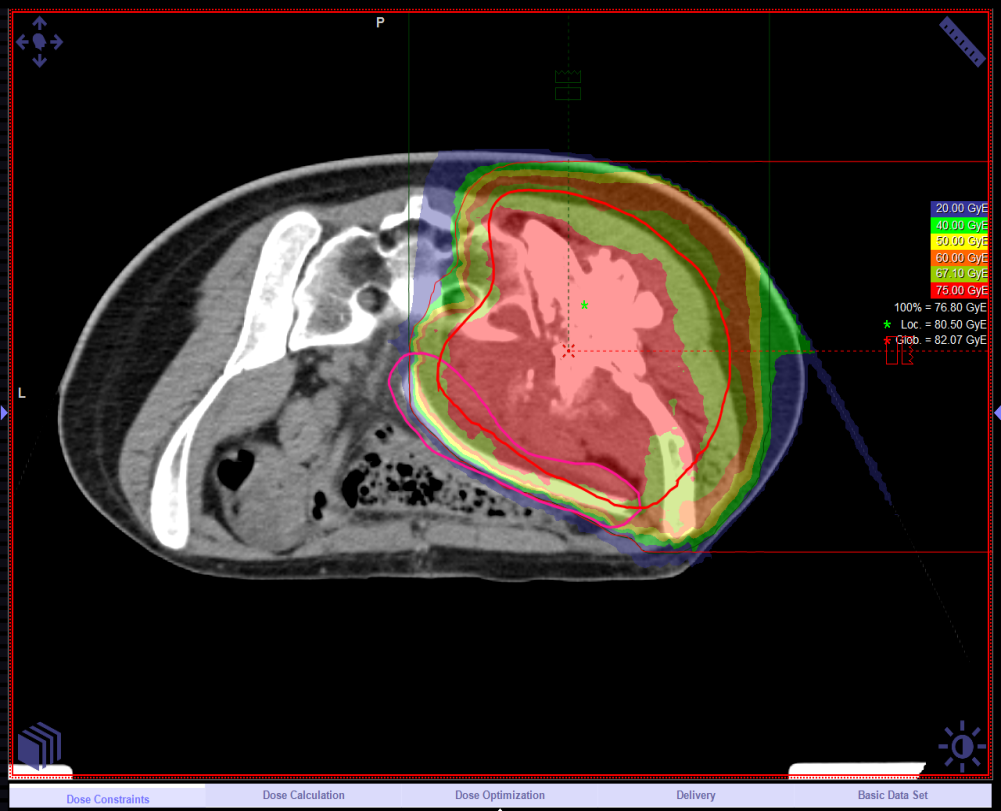
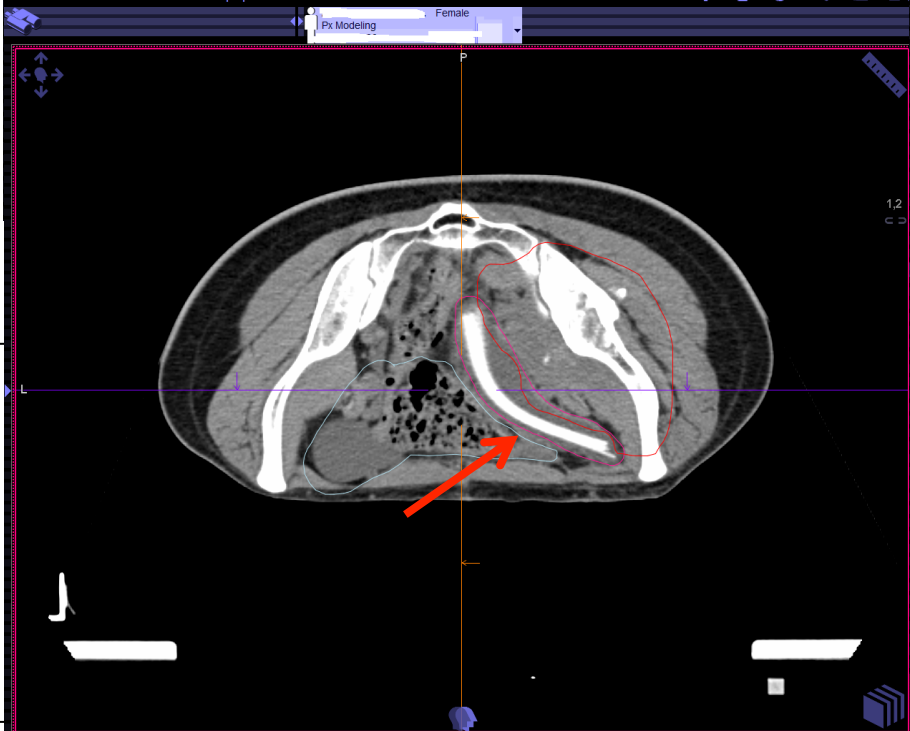
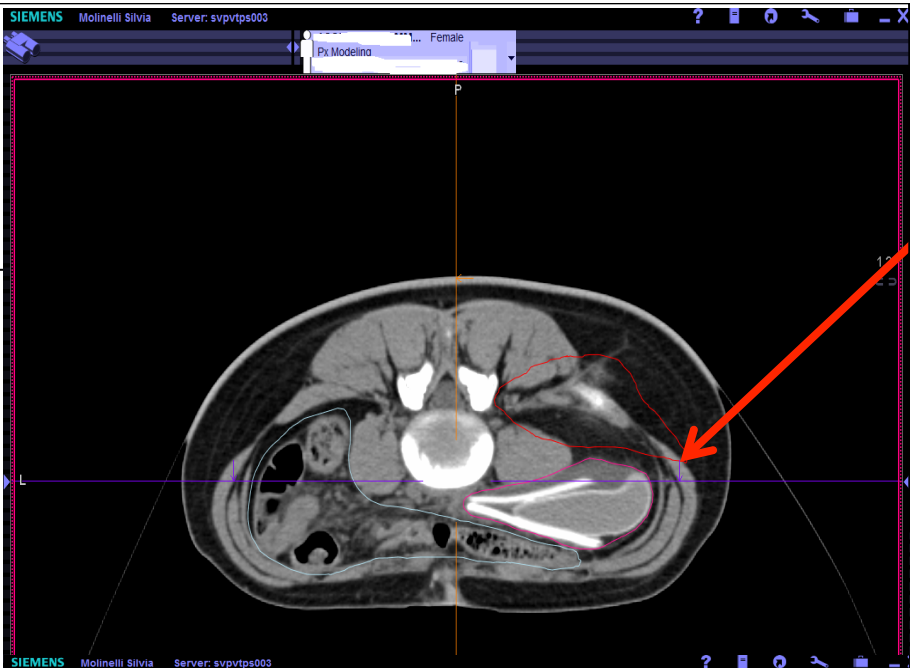
# Controllo dopo 3 mesi dal trattamento





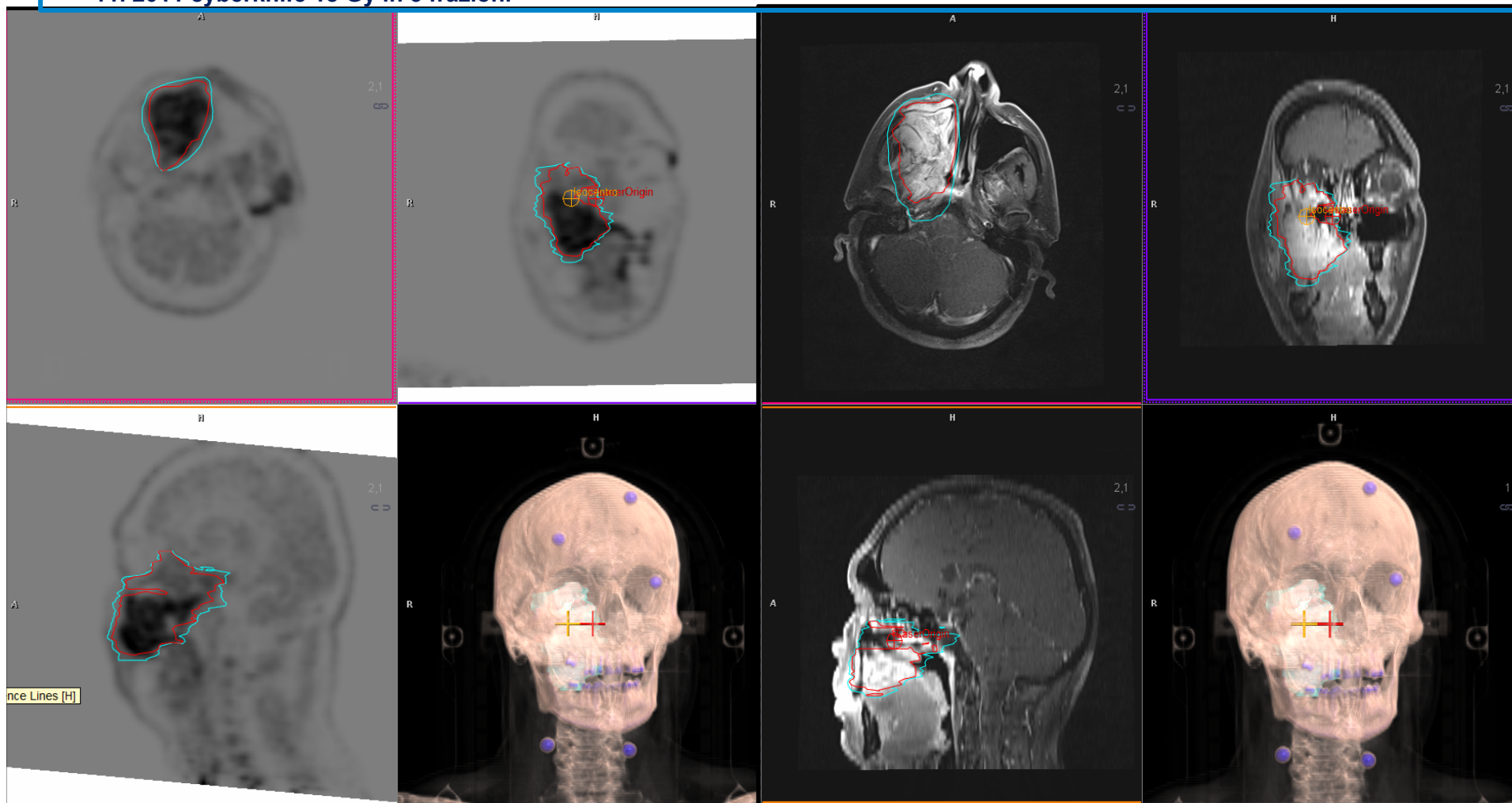


# spacer



# Reirradiazione

- 50 anni maschio carcinoma adenoido- cistico orbita destra, seno mascellare e fossa pterigoidea
- 2010 cyberknife 24 Gy in 4 frazioni
- 10. 2011 50 Gy IMRT in 25 frazioni
- 11. 2011 cyberknife 18 Gy in 3 frazioni

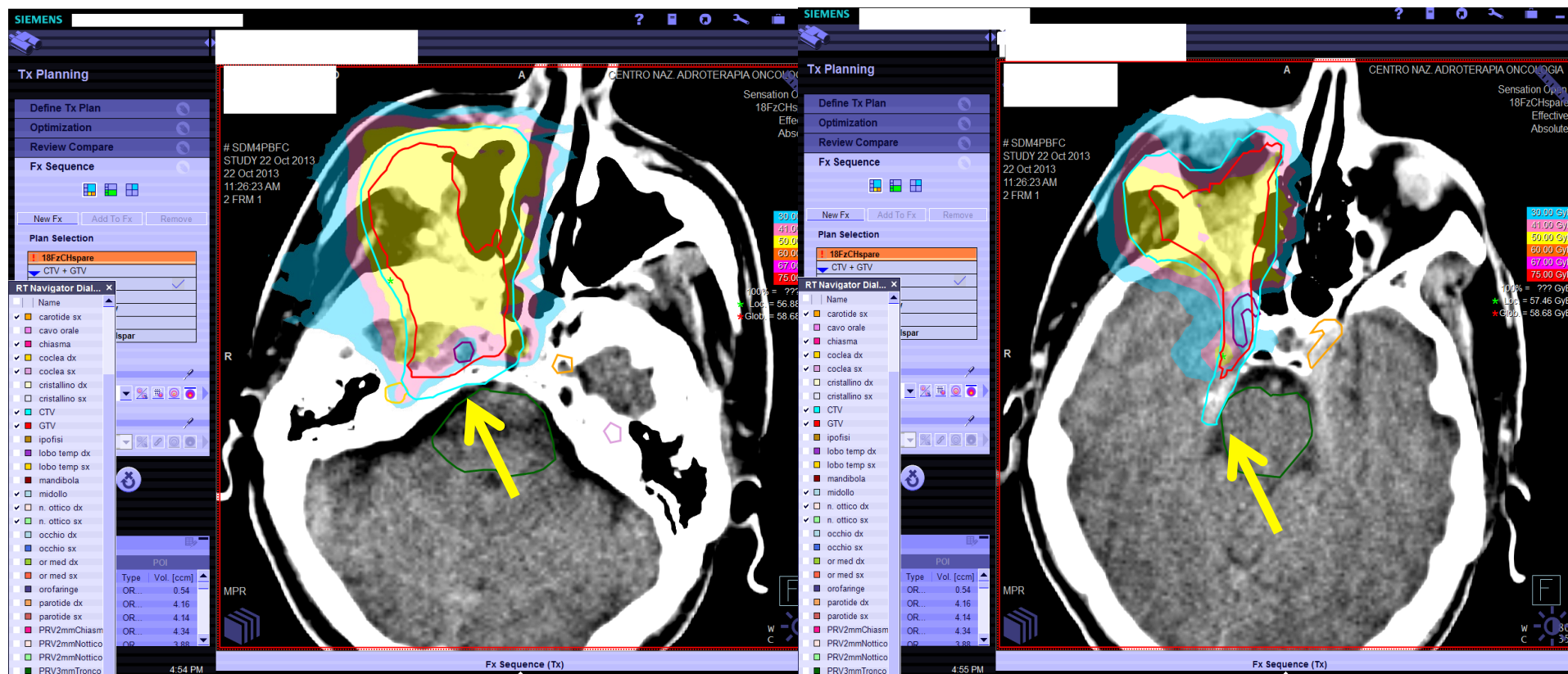




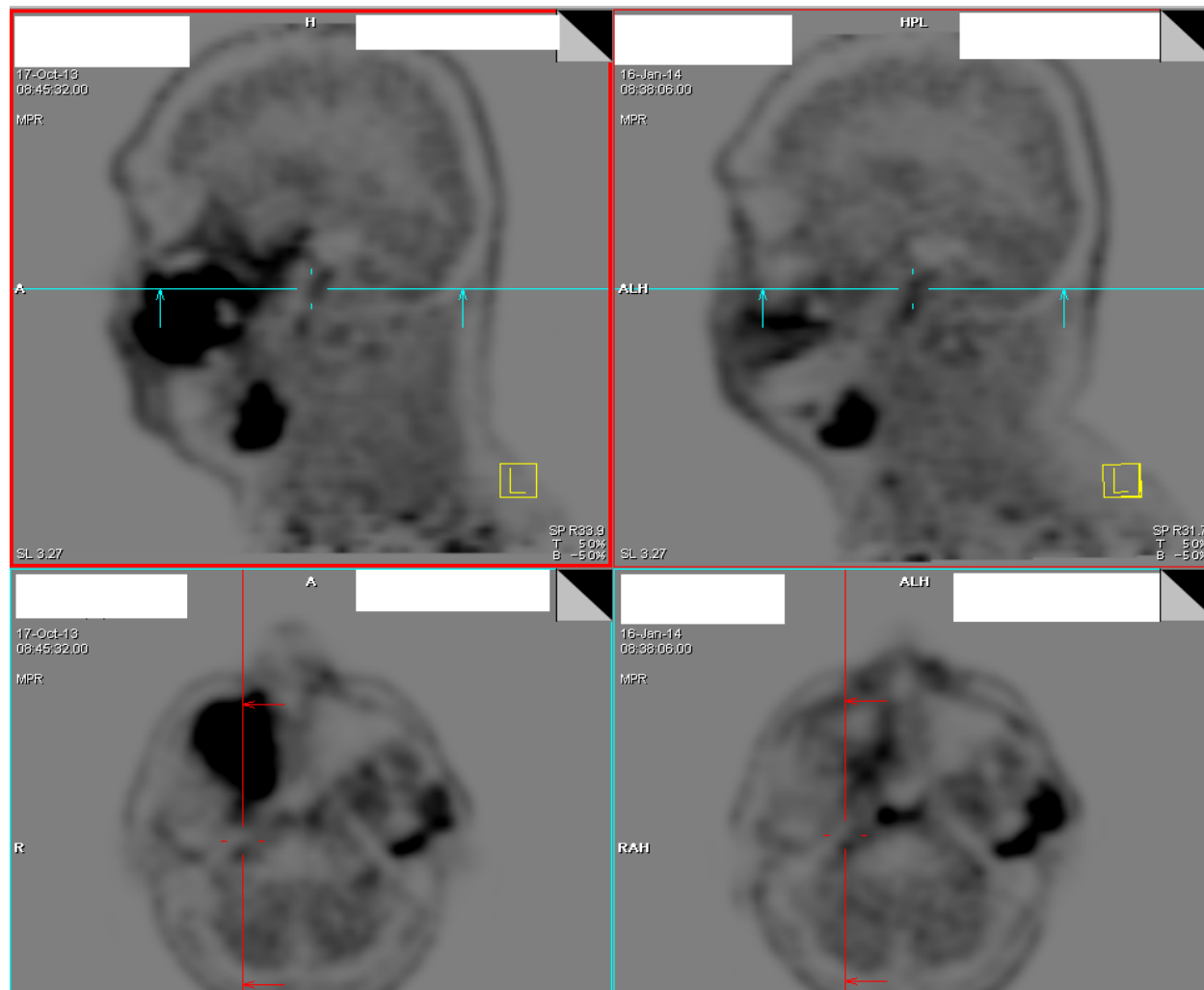
# Reirradiazione

## Risparmio Selettivo della Carotide

## Risparmio Selettivo del tronco cerebrale



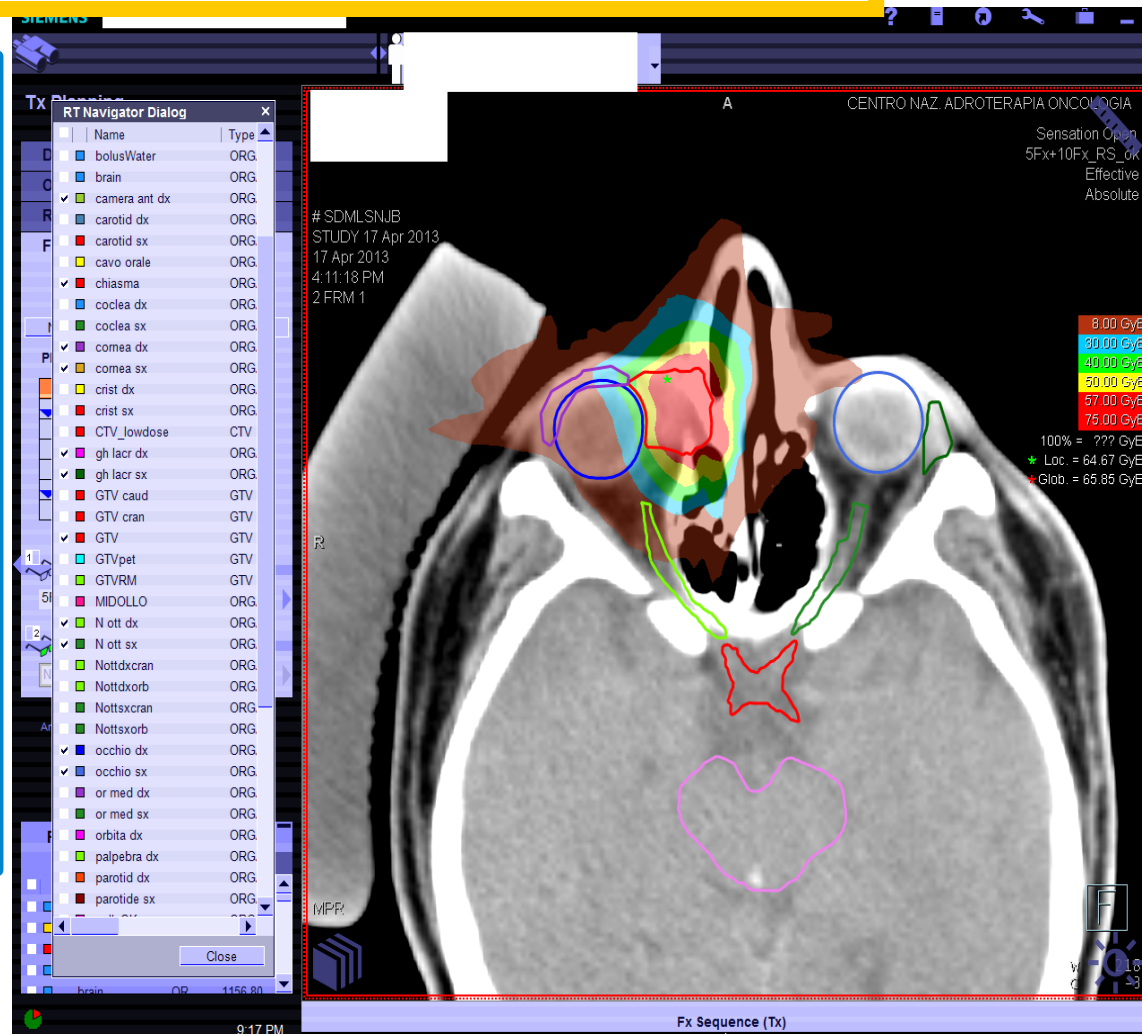
# PET (C11-Metionina) 1 mese dopo



**Ridotto uptake  
del radionuclide**

# Reirradiazione

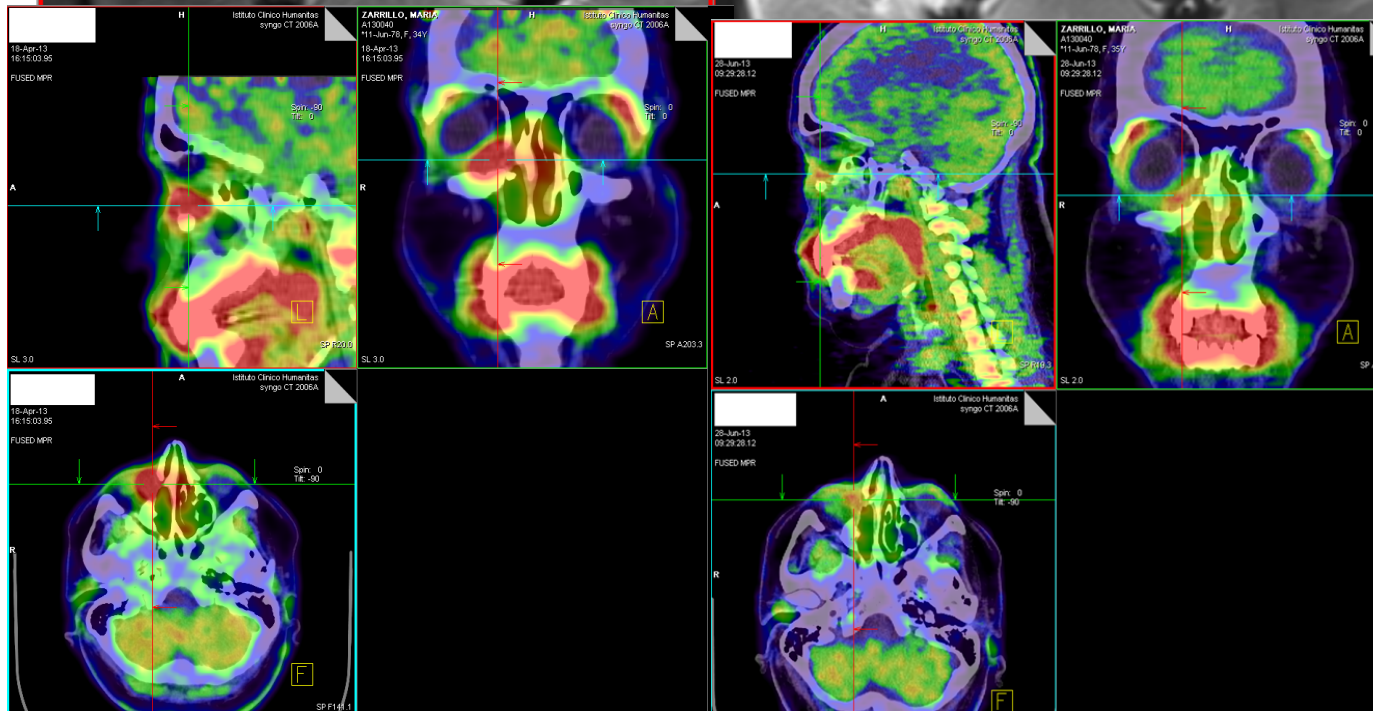
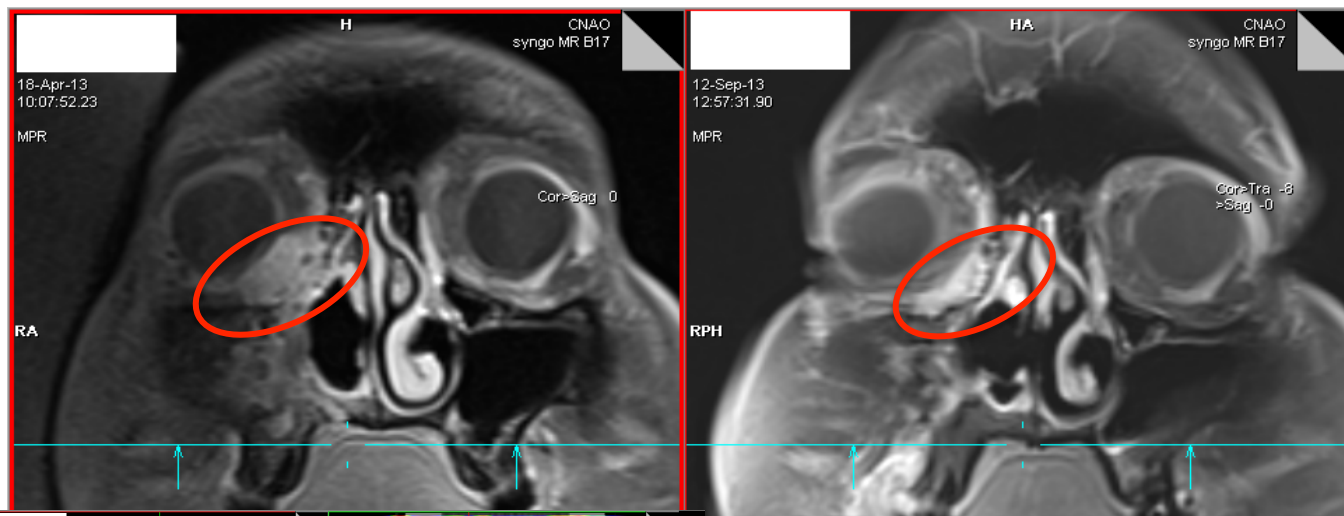
- 2006: diagnosi di ACC cavità nasale-rinofaringe
- 2006 RT 50 Gy in 25 fr.
- 2009: diagnosi 3 mts polmonari
- 2009 lobectomy
- 2012: MRI lesione solida di 17 mm in regione orbitaria ds in contatto con il globo oculare → ripresa di malattia
- 01/2014 chirurgia
- PET C11 Met → positiva





# Aprile 2013

# Settembre 2013



## Reirradiazione



**Fine del trattamento  
G1 eritema e congiuntivite**



**3 mesi dopo  
G0**

Il trattamento con ioni carbonio è stato impiegato:

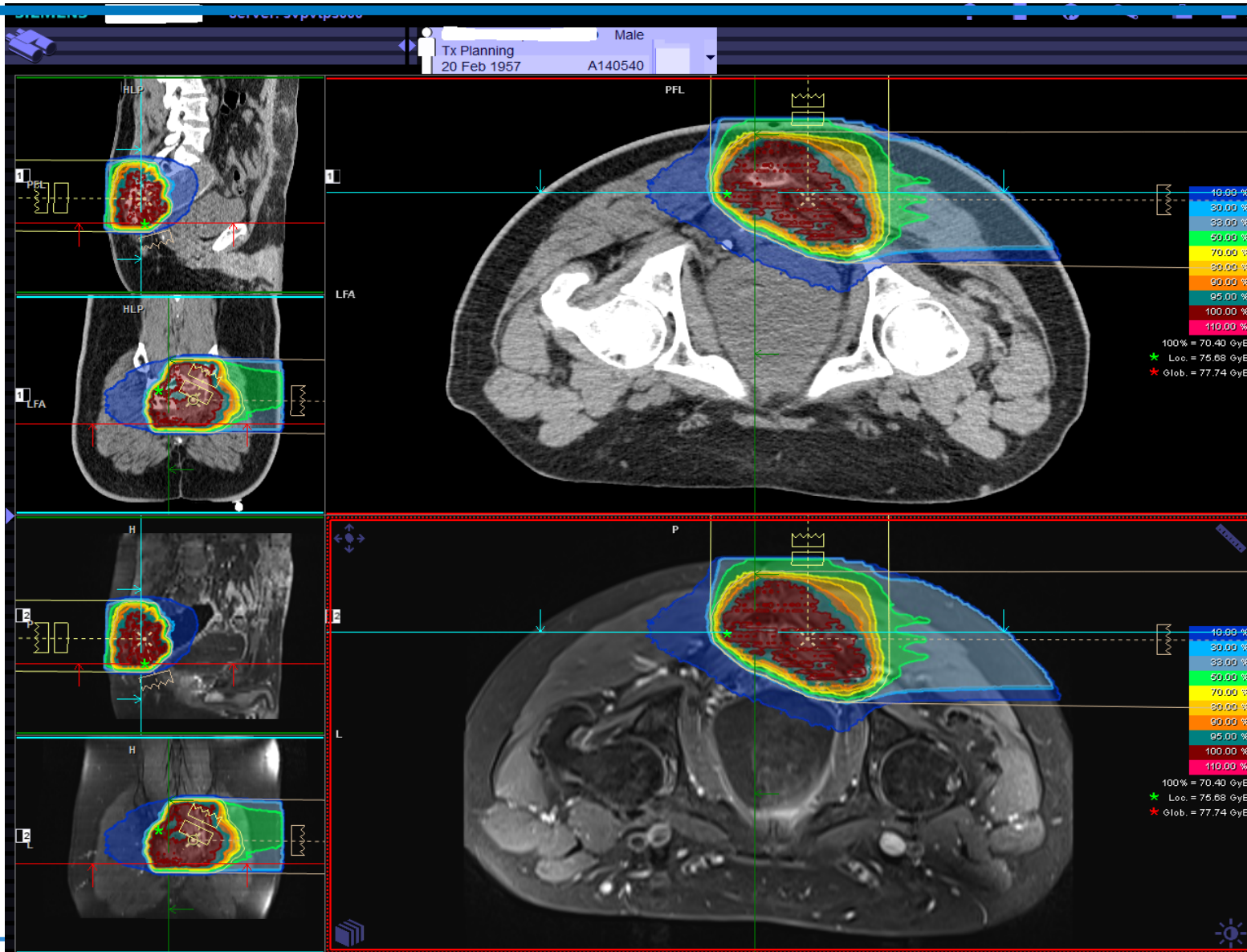
- per la sua elevata efficacia in ACC
- per l'ottima conformazione della dose al bersaglio che ha permesso la preservazione dell'occhio

## *Risultati dell' Adroterapia nelle recidive locali da carcinoma del retto*

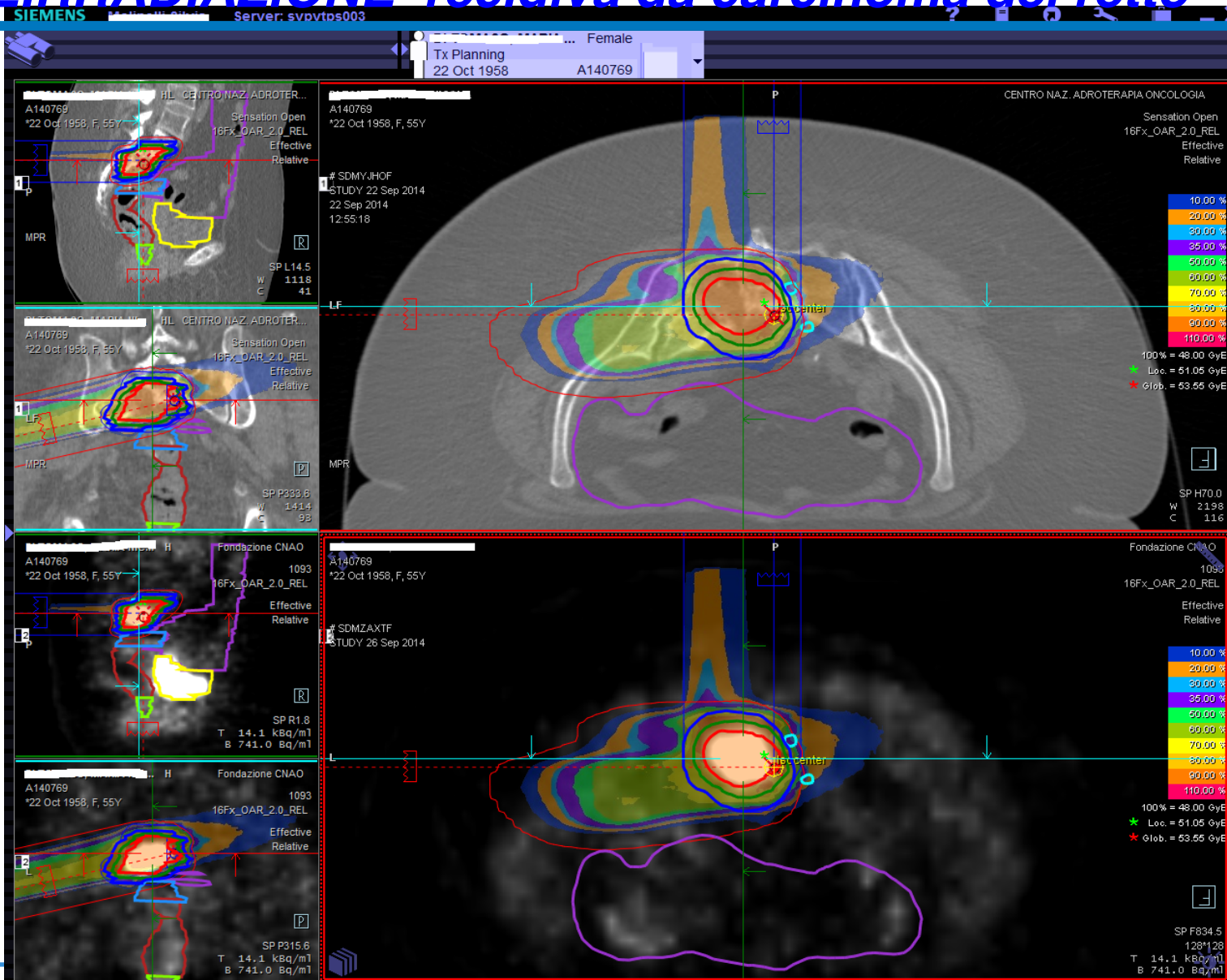
		n	Treatment	Survival Rate		Local Control
				2y	5y	
Lybeert M	1992	76	RT	61%(1y)	3%	28%(3y)
Knol HP	1995	50	RT	27%	8%	-
Kim MS	2008	23	RT	82%	23%	74%(5y)
Lee JH	2011	22	RT	66%	40%	56%(5y)
Wanebo	1999	53	Surgery	62%	31%	
Morja	2004	48	Surgery	76	36	
Melton	2007	29	Surgery	65	20	
<b>NIRS</b>	<b>2011</b>	<b>107</b>	<b>73.6</b>	<b>87%</b>	<b>45%</b>	<b>95%(5y)</b>



# REIRRADIAZIONE recidiva da carcinoma del retto



# REIRRADIAZIONE recidiva da carcinoma del retto

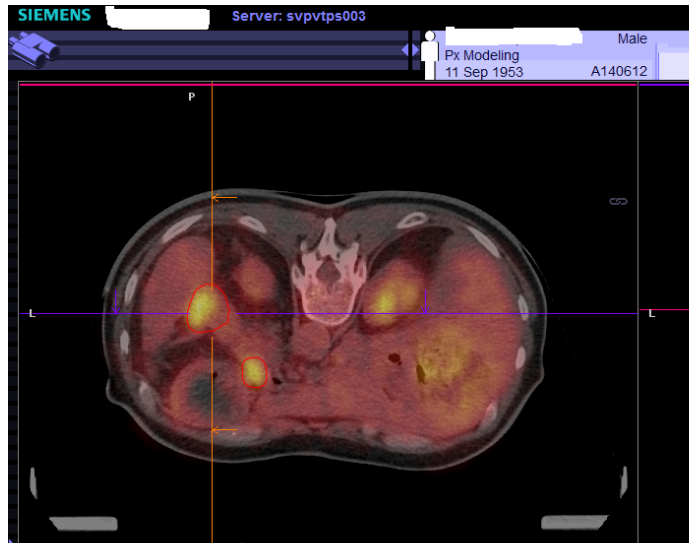


## **GEM+CIRT** carcinoma del pancreas localmente avanzato

	Year	n	Treatment	Dose	Survival	
					1yr	2yr
ECOG	2008	34	GEM+RT	50.4Gy	50%	12%
		37	GEM	-	32%	4%
Ishii	2010	50	GEM	-	64%	14%
Sudo	2011	34	S-1+RT	50.4Gy	71%	25%
Small	2011	28	GEM+BZ* +RT	36Gy/15fr.	45%	17%
Schellenberg	2011	20	GEM+ SBRT	25Gy/1fr.	50%	20%
<b>NIRS</b>		<b>34</b>	<b>GEM+CIRT</b>	<b>45.6-52.8 GyE</b>	<b>72%</b>	<b>68%</b>



# Pancreas



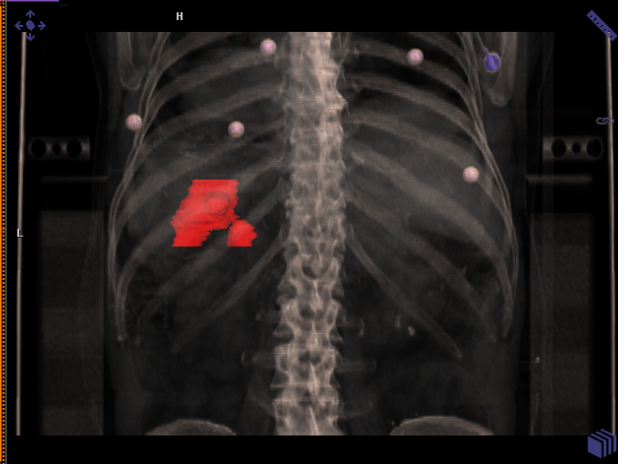
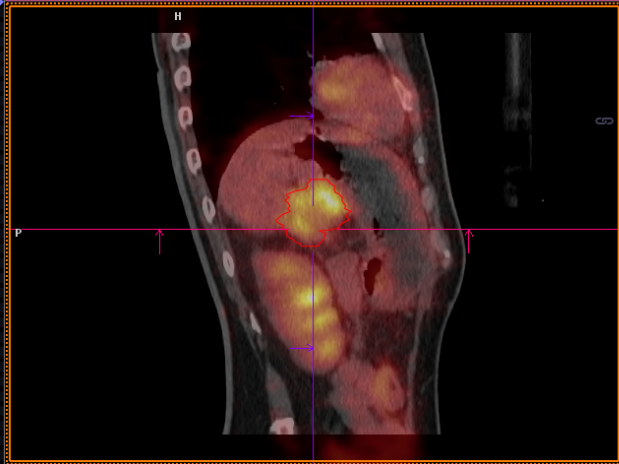
SIEMENS Server: svpvtps003

Tx Planning 11 Sep 1953 A140612 Male

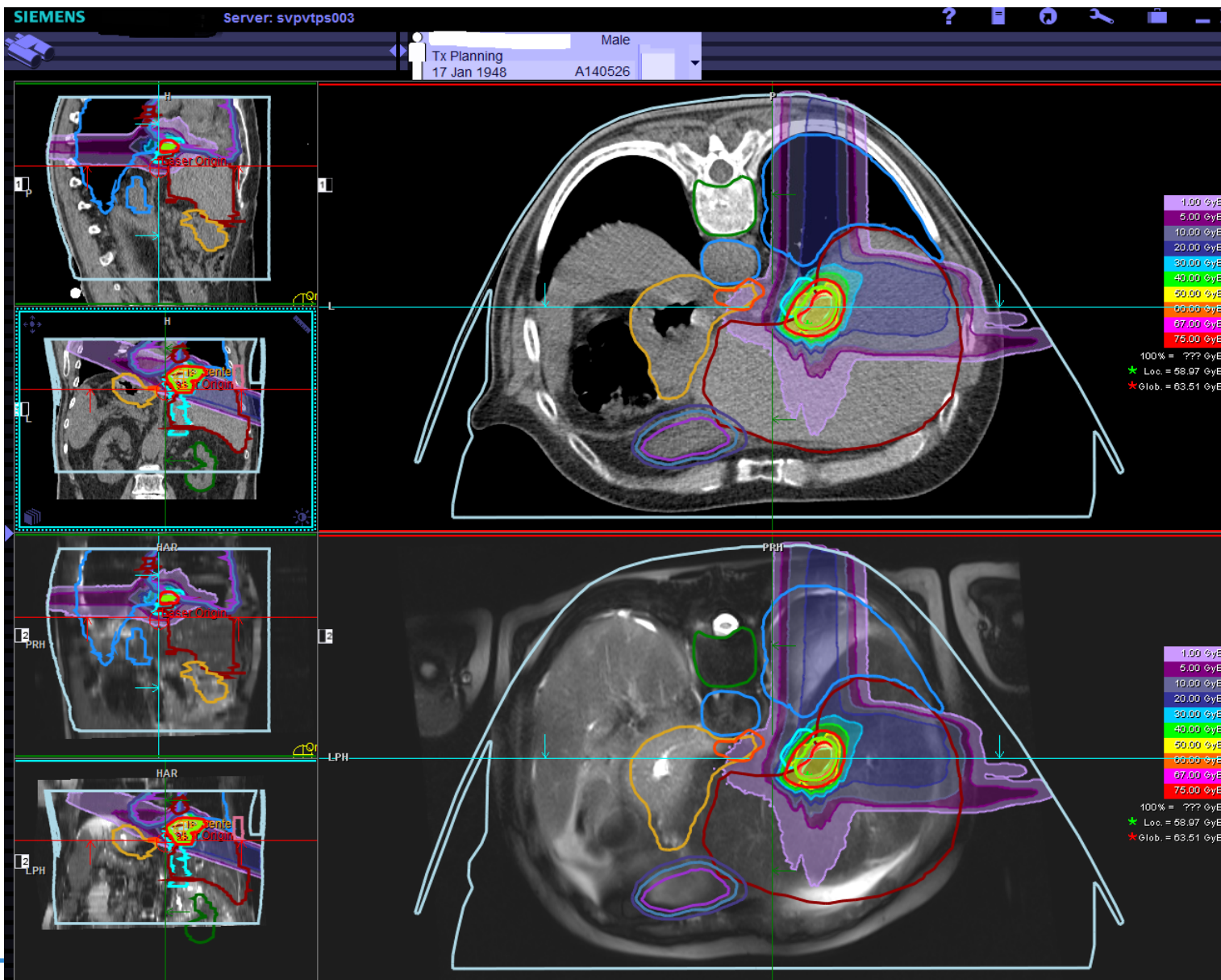
80.00 %  
90.00 %  
95.00 %  
100.00 %  
110.00 %

100% = 38.40 GyE  
\* Loc. = 40.85 GyE  
\* Glob. = 41.49 GyE

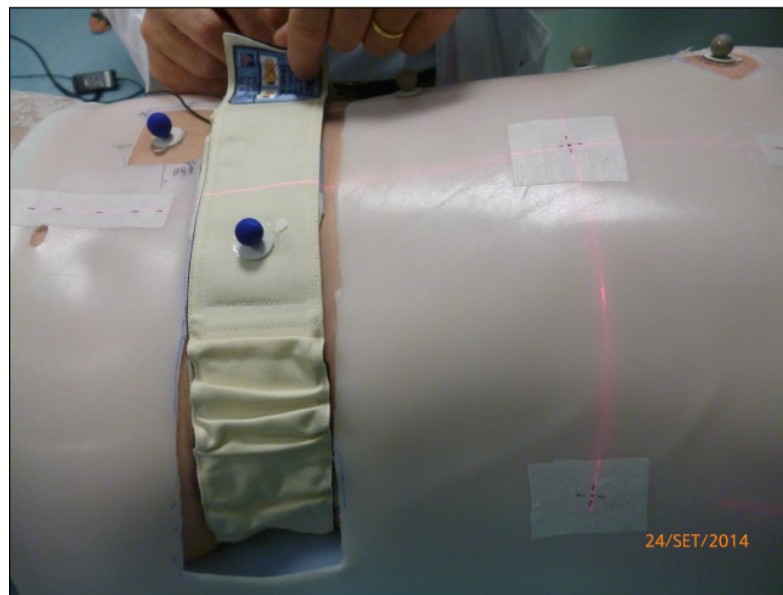
Targets				Non Targets			
Volume	Dose GyE	Vol. [%]	Weight	Volume	Dose GyE	Vol. [%]	Weight
<input checked="" type="checkbox"/> PTV	30.00	MinDose	1.00	<input checked="" type="checkbox"/> stomaco3...	30.00	MaxDose	150.00
<input checked="" type="checkbox"/> PTV	40.00	MaxDose	10.00	<input checked="" type="checkbox"/> stomaco3...	28.10	1.52	150.00
<input checked="" type="checkbox"/> GTV	30.00	MinDose	1.00	<input checked="" type="checkbox"/> ansa3035	30.00	MaxDose	150.00
<input checked="" type="checkbox"/> GTV	40.00	MaxDose	10.00	<input checked="" type="checkbox"/> ansa3035	26.00	7.00	200.00
<input type="checkbox"/> CTV	30.00	MinDose	1.00	<input checked="" type="checkbox"/> NoB1	5.00	10.00	120.00
<input type="checkbox"/> CTV	40.00	MaxDose	10.00	<input checked="" type="checkbox"/> NoB2	5.00	8.00	120.00
<input checked="" type="checkbox"/> GTV	38.40	50.00	10.00	<input checked="" type="checkbox"/> PRVansa	35.00	MaxDose	150.00
<input checked="" type="checkbox"/> GTV	36.89	71.66	10.00	<input checked="" type="checkbox"/> PRVstoma...	35.00	MaxDose	150.00
<input checked="" type="checkbox"/> ITV CTV3...	30.00	MinDose	1.00	<input checked="" type="checkbox"/> PRVansa	33.00	3.00	200.00
<input checked="" type="checkbox"/> ITV CTV3...	40.00	MaxDose	10.00	<input checked="" type="checkbox"/> PRVstoma...	33.00	3.00	200.00
<input checked="" type="checkbox"/> ITV CTV3...	38.00	50.00	10.00				



# HCC



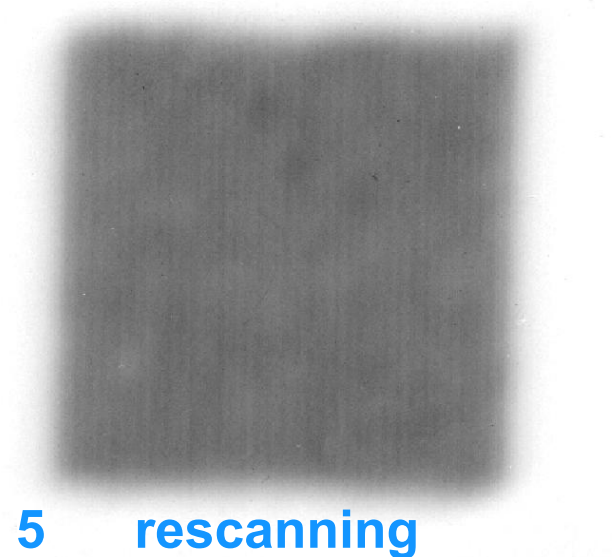
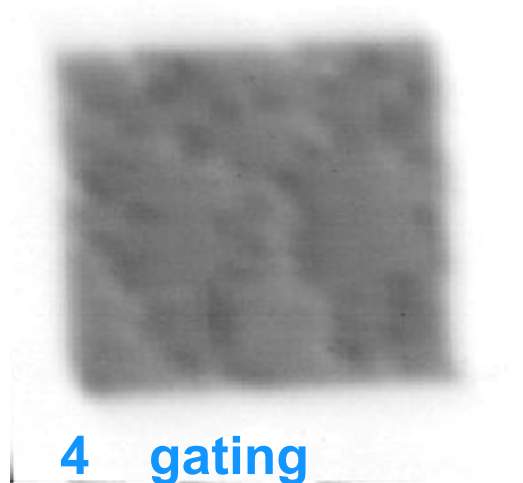
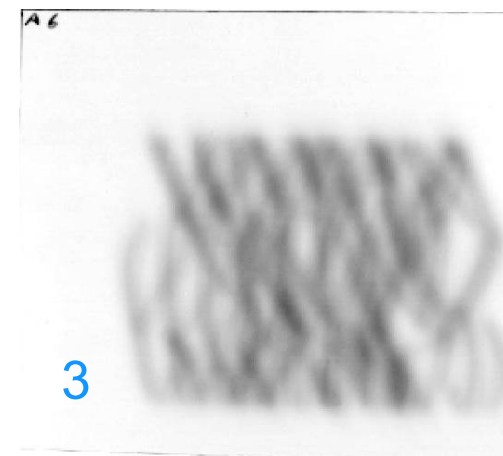
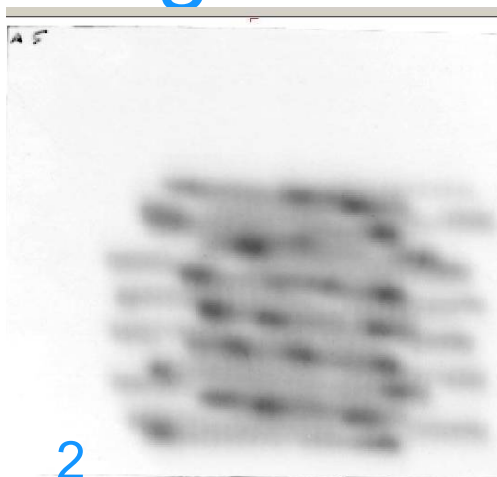
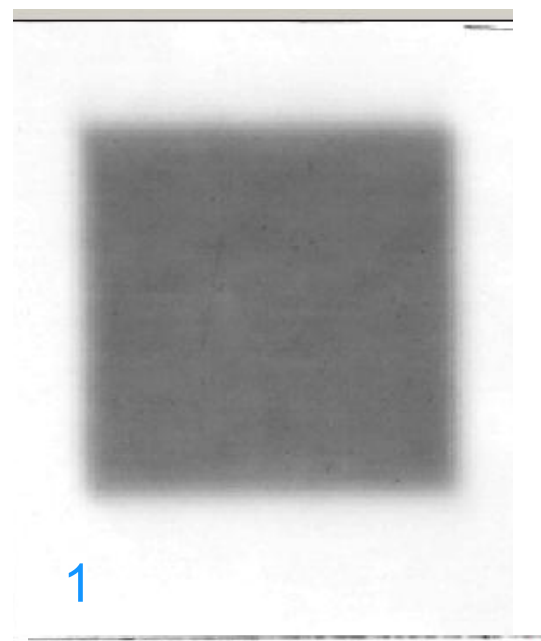
## Moving organs: 4-D treatment strategies at CNAO



- Riduzione movimento respiratorio (meno di 5 mm) usando **maschera termo-plastica** o fascia di compressione
- **Multiple porte di entrata (2-3) e trattamento frazionato**
- **Gating** (ref. phase: max espirio; ANZAI system and OTS) + **rescanning (N=5)**



# Organ motion management





- **Future direzioni**
- **Ipofrazionamento con Protoni**
- **Studio di fase III: protoni / ioni Carbonio vs RT convenzionale (ACC e Sarcomi)**
- **Melanoma del retto e della vagina**
- **Linfomi**
- **Ritrattamento di neoplasie cerebrali**
  
- **Neoplasie polmonari avanzate**
- **Pazienti Pediatrici**
- **Studio di fase III : ioni Carbonio vs RT/CT in pancreas localmente avanzato**
  
- **Attivazione di linea sperimentale**  
**Studi di efficacia di nuove particelle**



**“C’è vero progresso solo quando i vantaggi di una nuova tecnologia diventano per tutti**

**H. Ford**

**Grazie per l’attenzione**