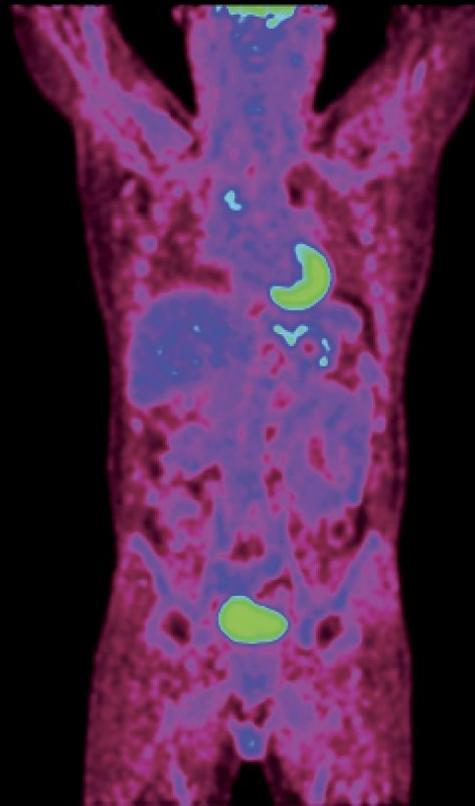


Tutte le mappe dell'adroterapia

Piergiorgio Cerello

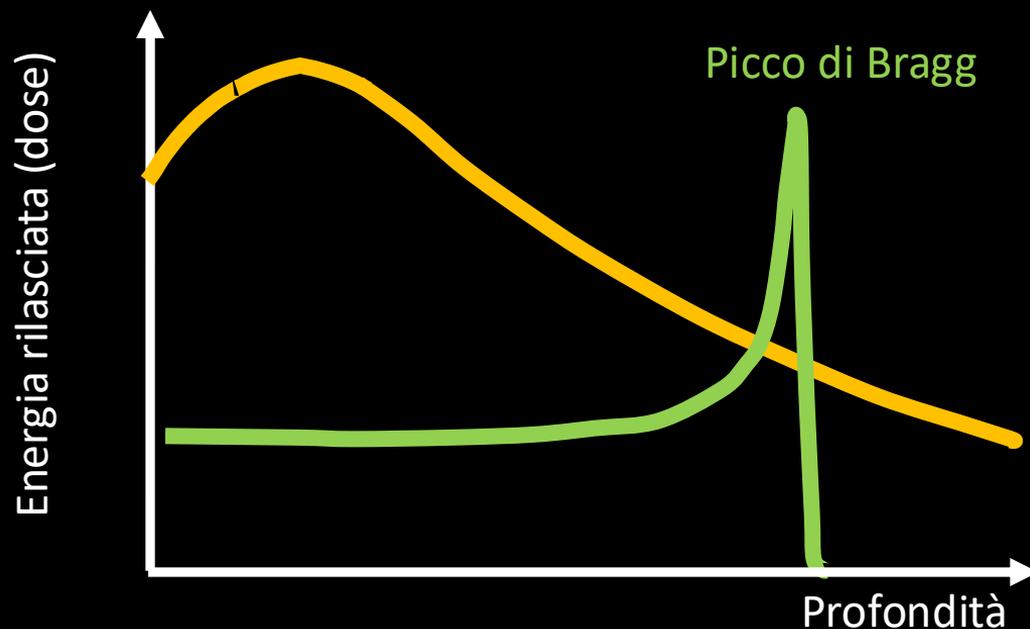
con il contributo di

CNAO
Centro Nazionale di Adroterapia Oncologica

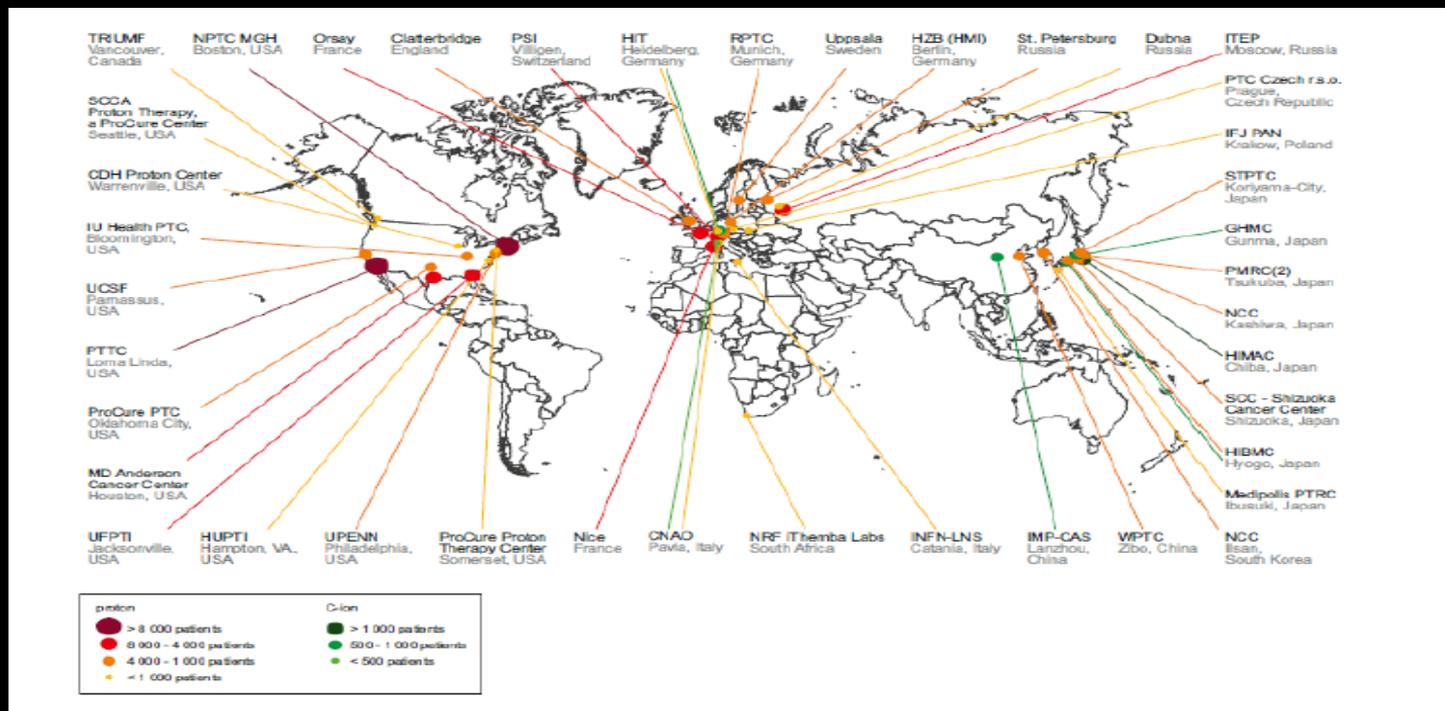


Radioterapia
Raggi X

Adroterapia
Particelle cariche

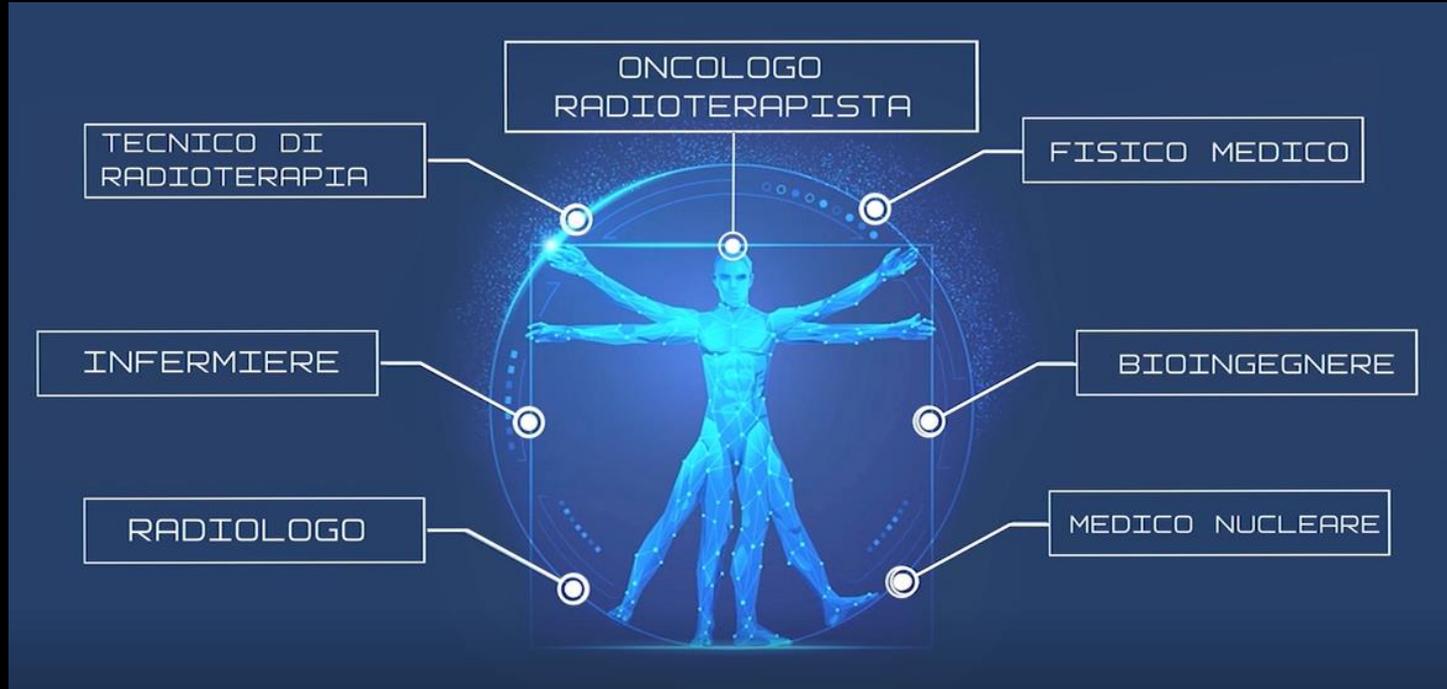


Adroterapia nel mondo



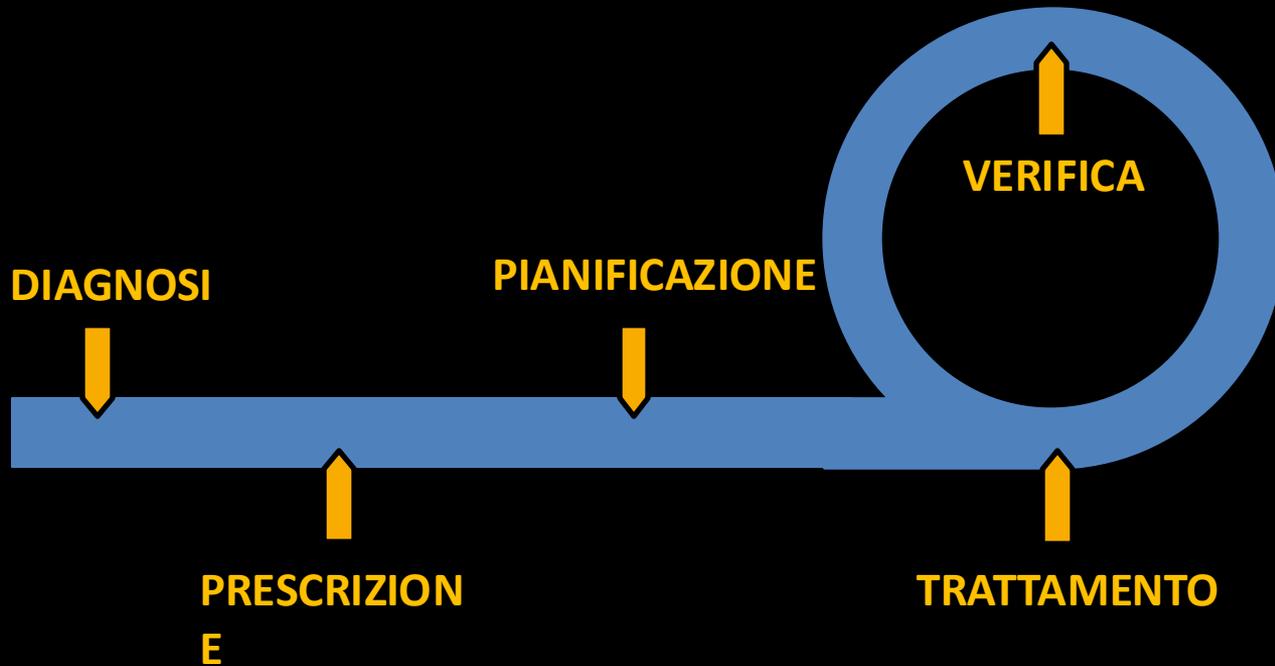
In Italia: CATANA (INFN-LNS, 2002)
 CNAO (Pavia, 2011)
 Centro Protonterapia Trento (2014)

Chi contribuisce

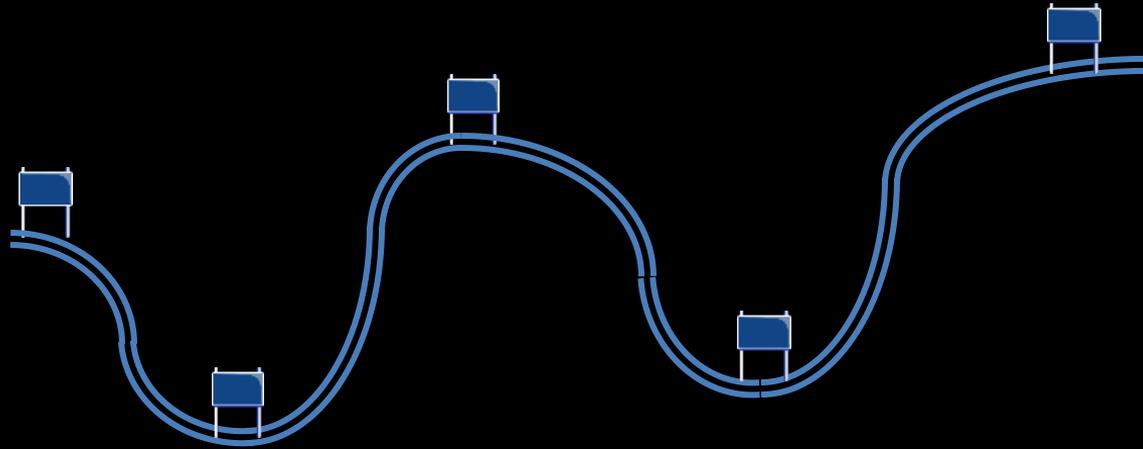


<https://www.youtube.com/watch?v=s1iINDPnqx0>

Quali mappe?



Diagnosi



le mappe dell'adroterapia

Raggi X



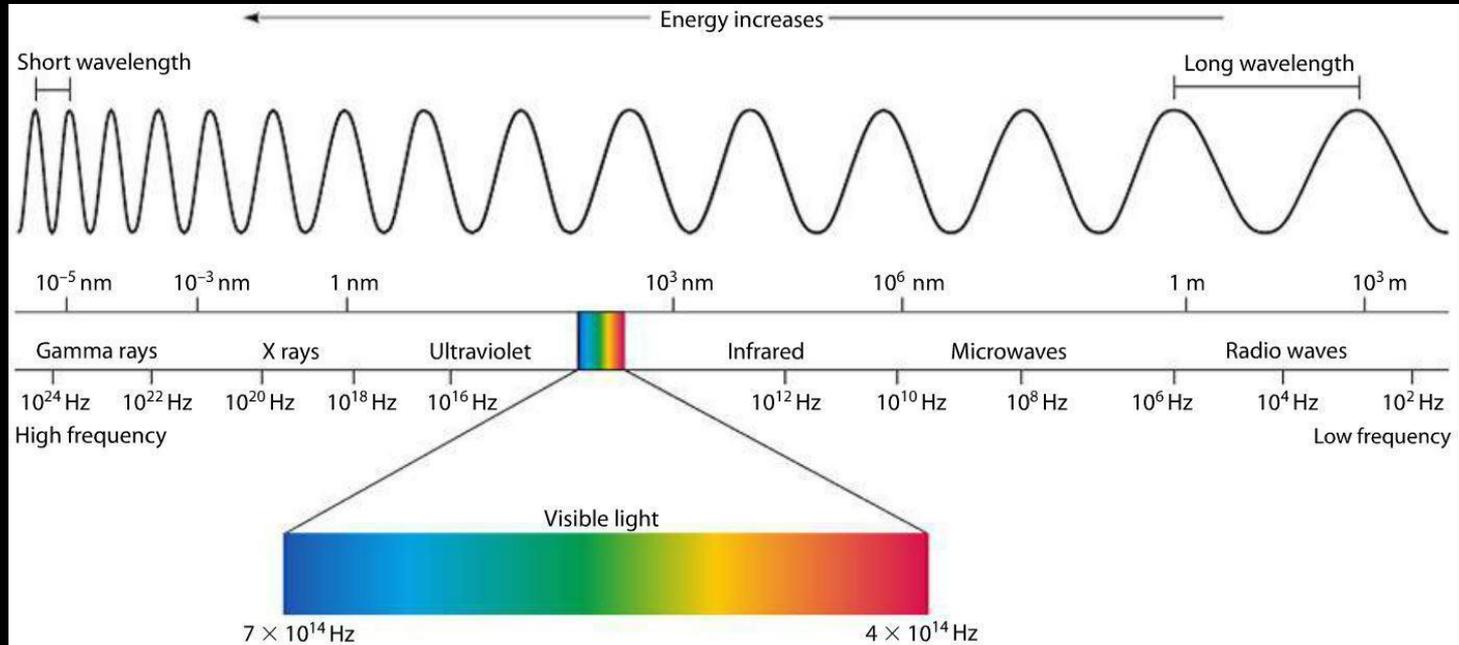
W. Roentgen, 1895

Premio Nobel per la fisica nel
1901

Rinuncia a brevettare la sua
scoperta



Radiazione Elettromagnetica

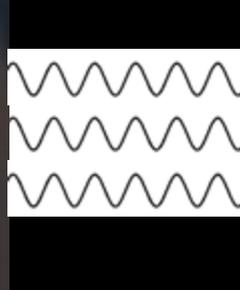
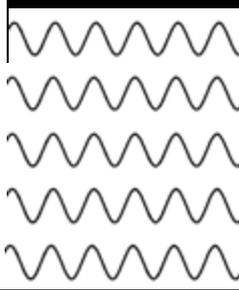


1920: Radioattività *trendy*

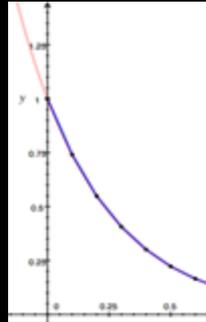


Radiografia

Sorgente



Rivelatore



Guardare
attraverso la
materia!

Radiografia

ieri

&

oggi



Tomografia Computerizzata

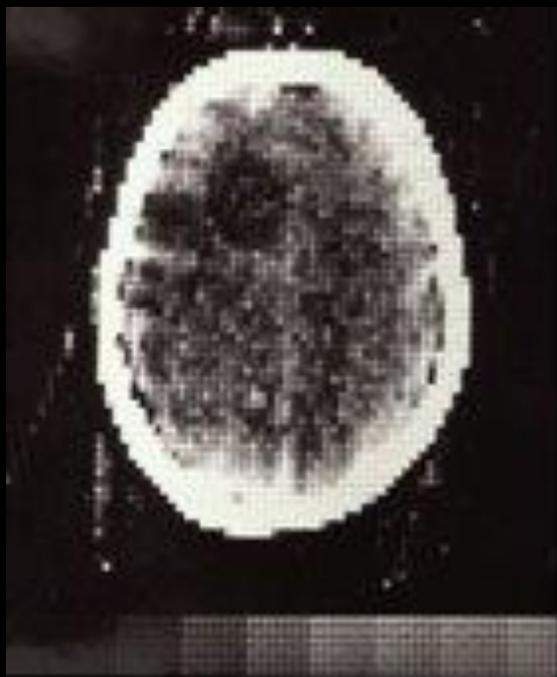


- Godfrey Hounsfield, 1971
- Premio Nobel per la Medicina, 1979 con A. M. Cormack

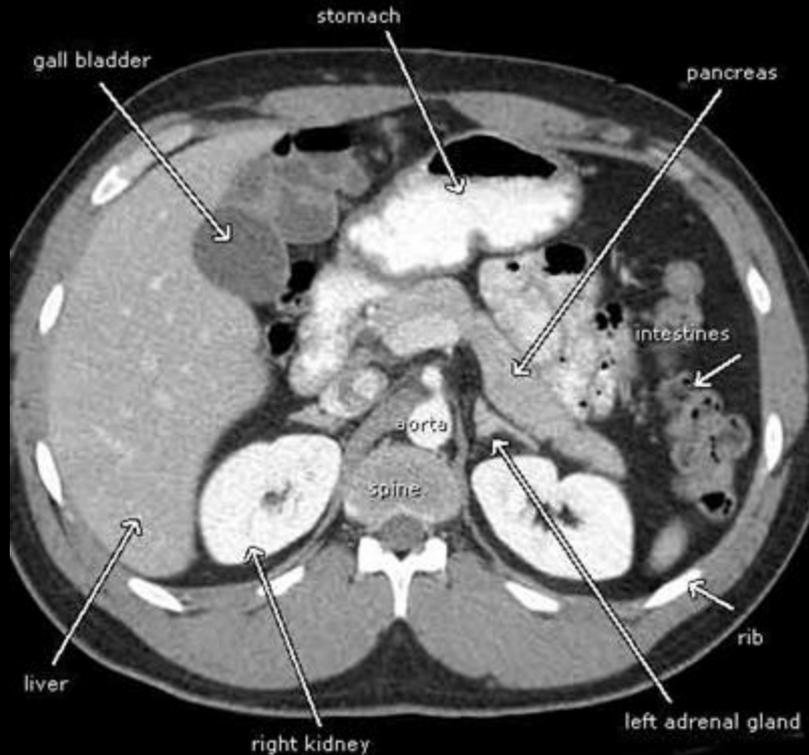


(grazie, Beatles!)

1 Ottobre 1971



Tomografia Computerizzata (CT)



Mappe
Morfologiche

Antimateria

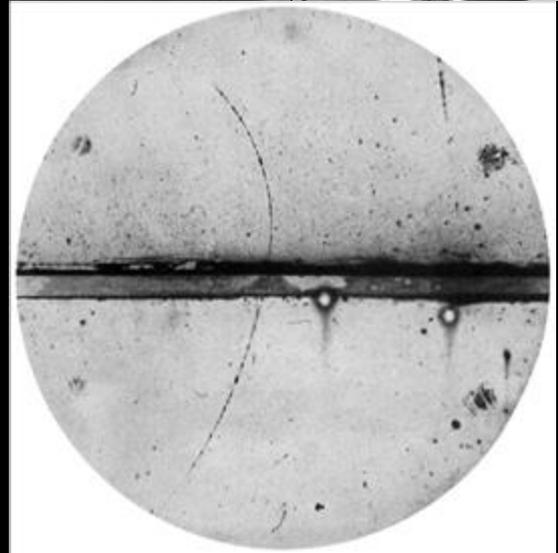
$$(i\partial - m)\psi = 0$$

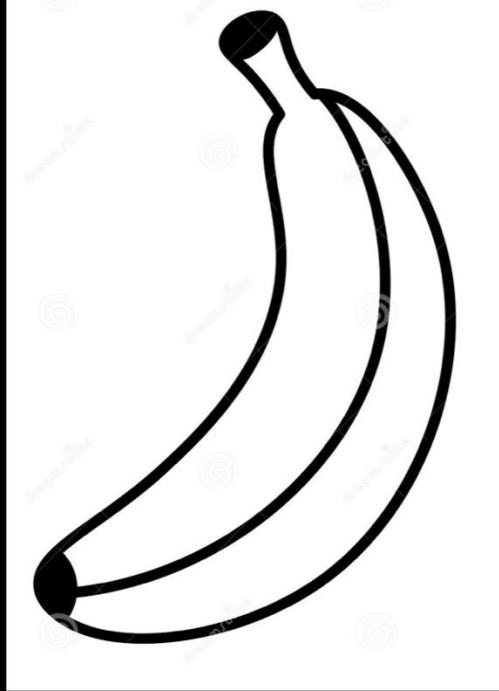
Dirac, 1928

Soluzioni con
energia negativa???

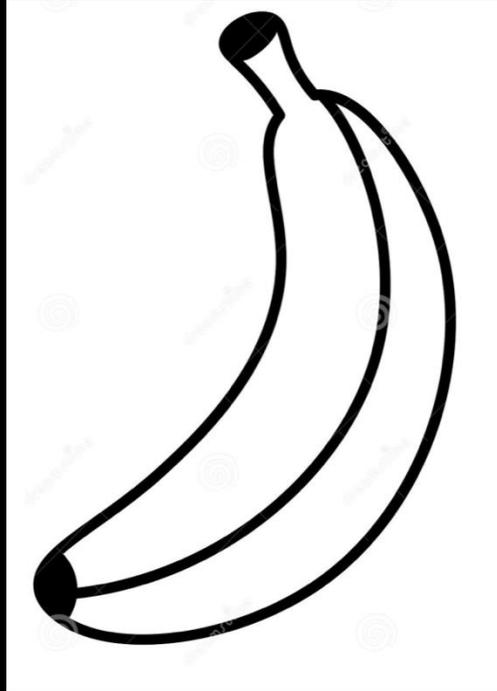
Anderson, 1932

il positrone (e^+)





Sorgenti di positroni...



40K

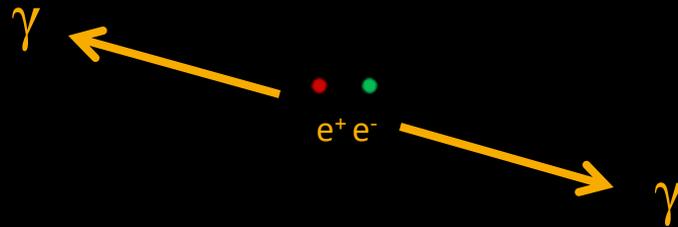
$\sim 300\text{ Bq}$ per una persona di 80 Kg

$1\text{ Bq} = 1\text{ disintegrazione/s}$

Il decadimento β^+



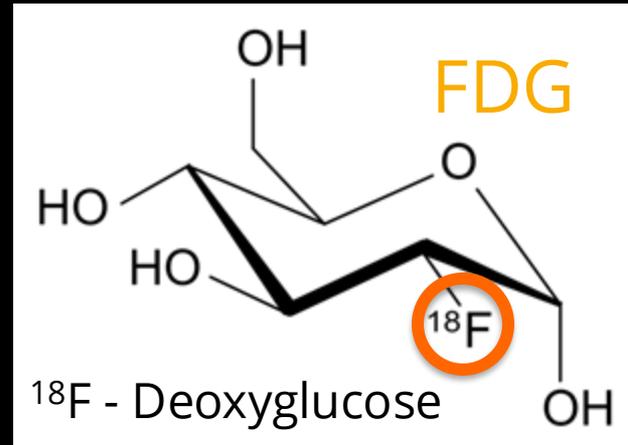
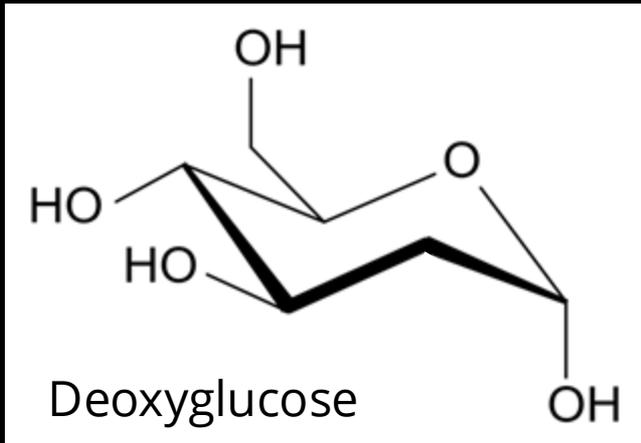
... e l'annichilazione $e^+ e^-$



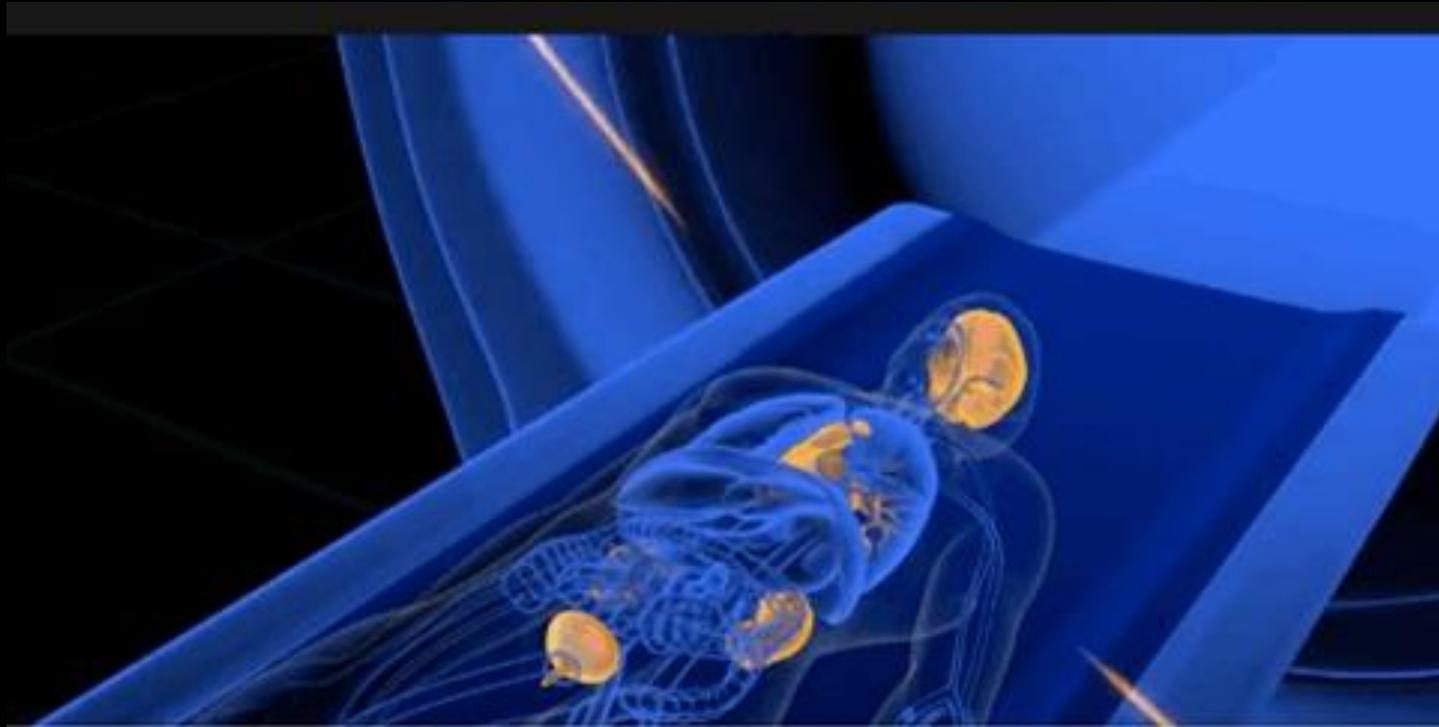
Radiotraccianti

Irene e Frederic Joliot-Curie

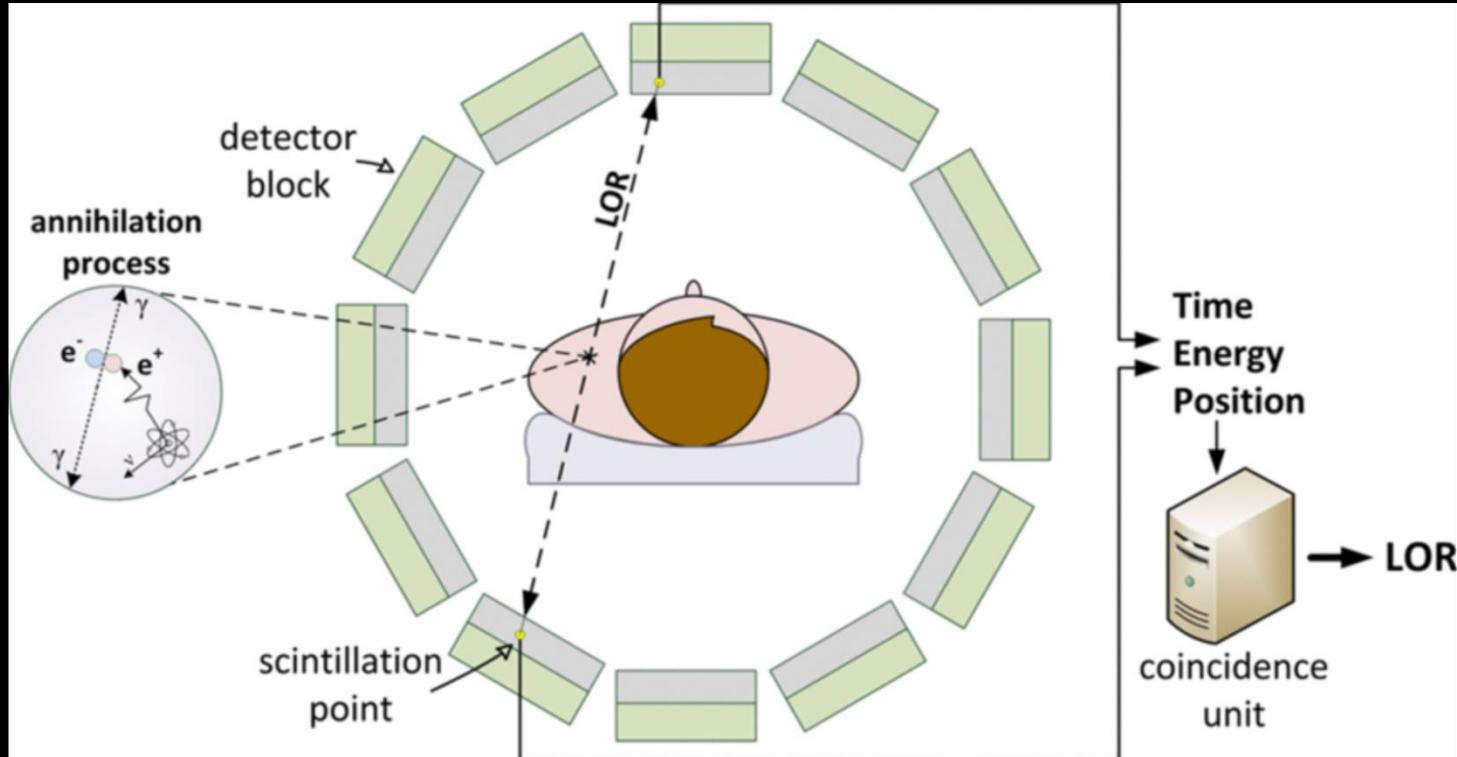
Premio Nobel per la Chimica, 1935



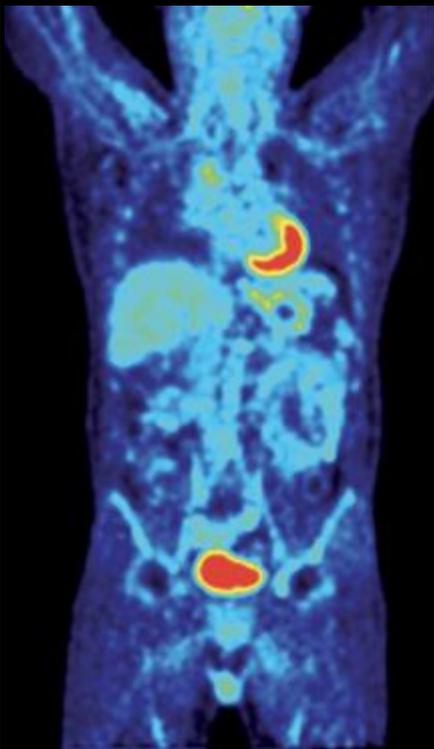
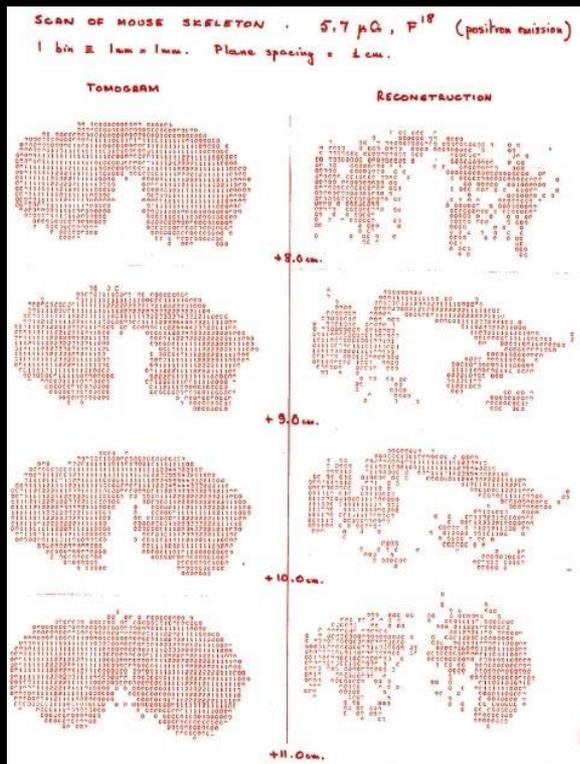
Positron Emission Tomography



Positron Emission Tomography

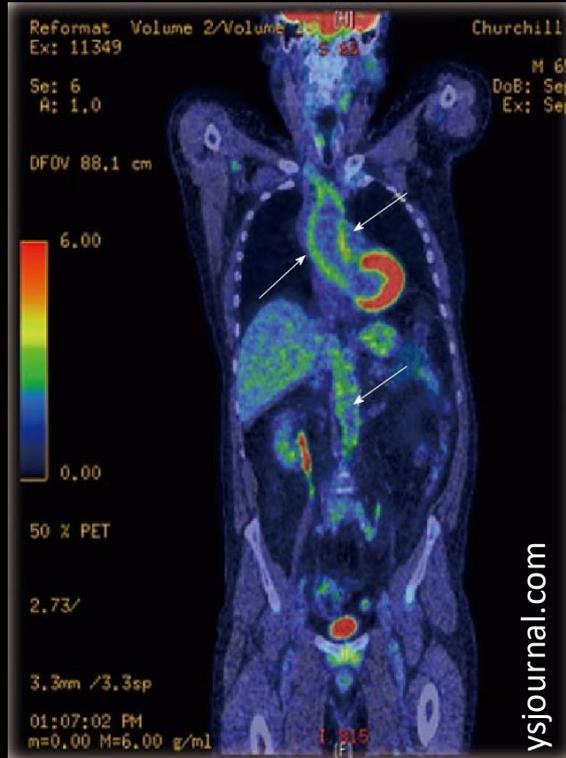


Tomografia a Emissione di Positroni

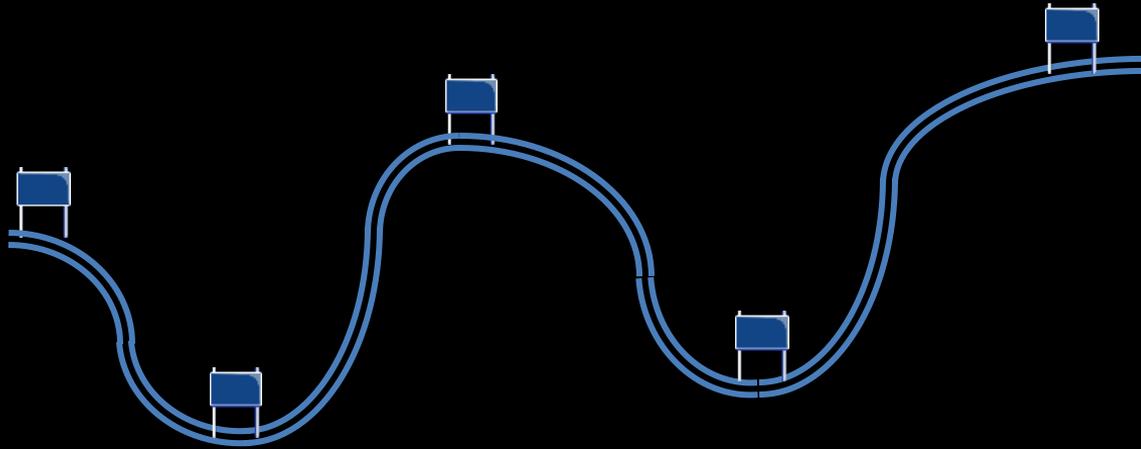


Mappe
Funzionali

Tomografia Ibrida (PET/CT)

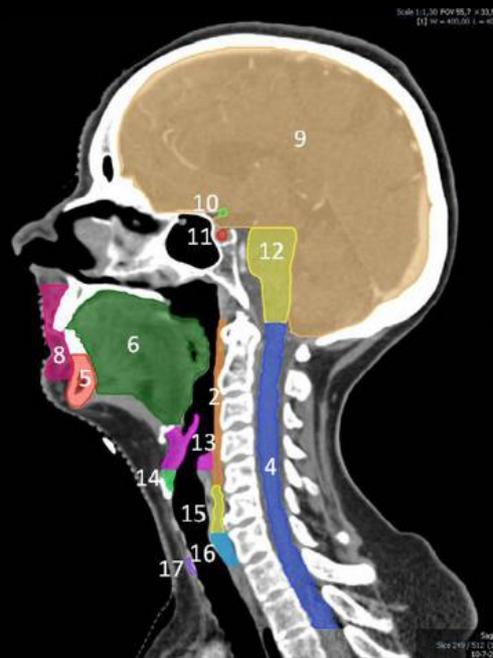
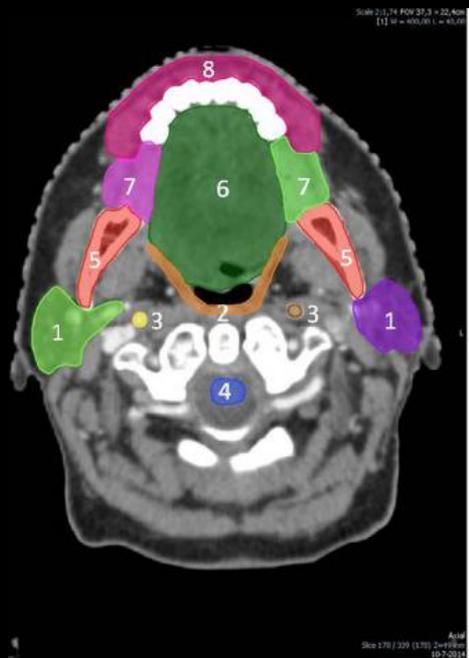


Piano di trattamento



le mappe dell'adroterapia

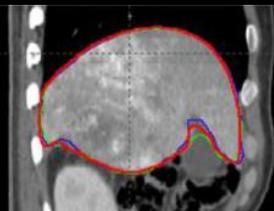
Identifichiamo gli organi



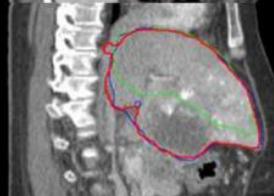
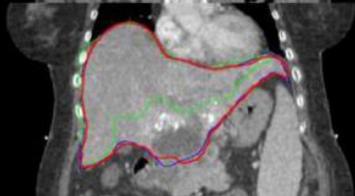
Sulla mappa CT

Confini degli organi e contorni

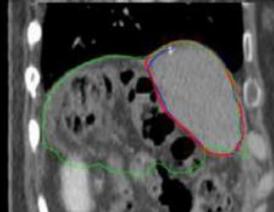
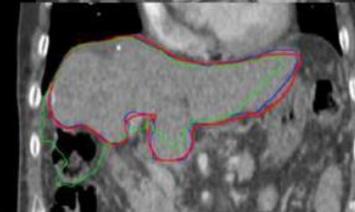
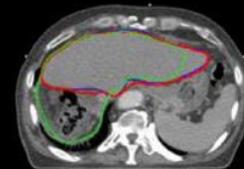
Paziente 1



Paziente 2

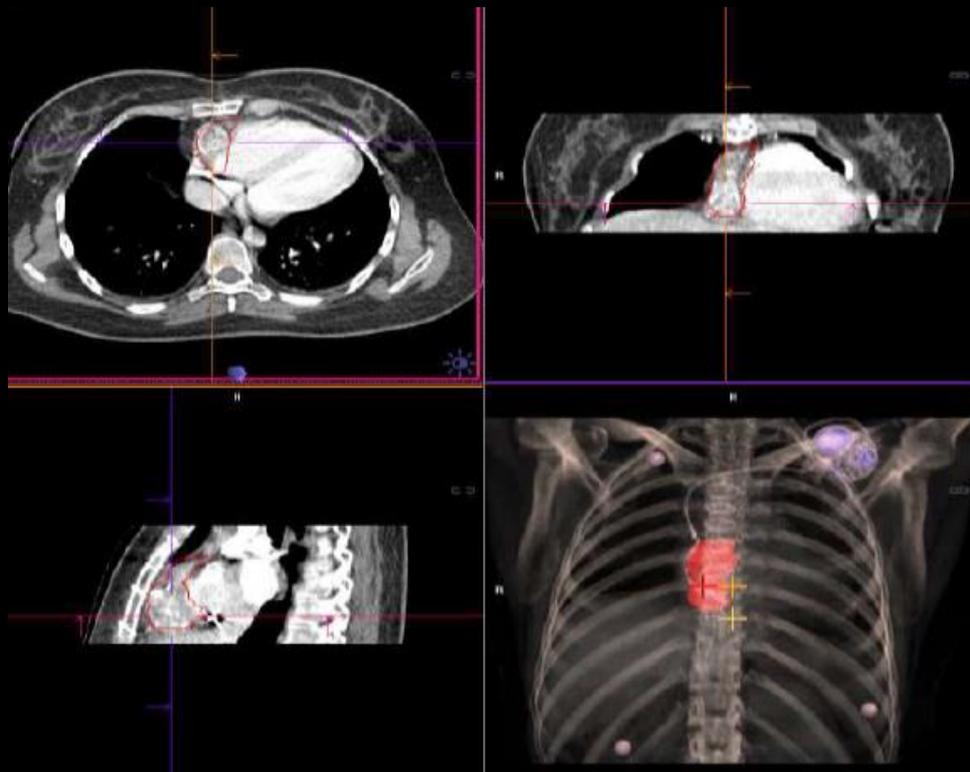


Paziente 3

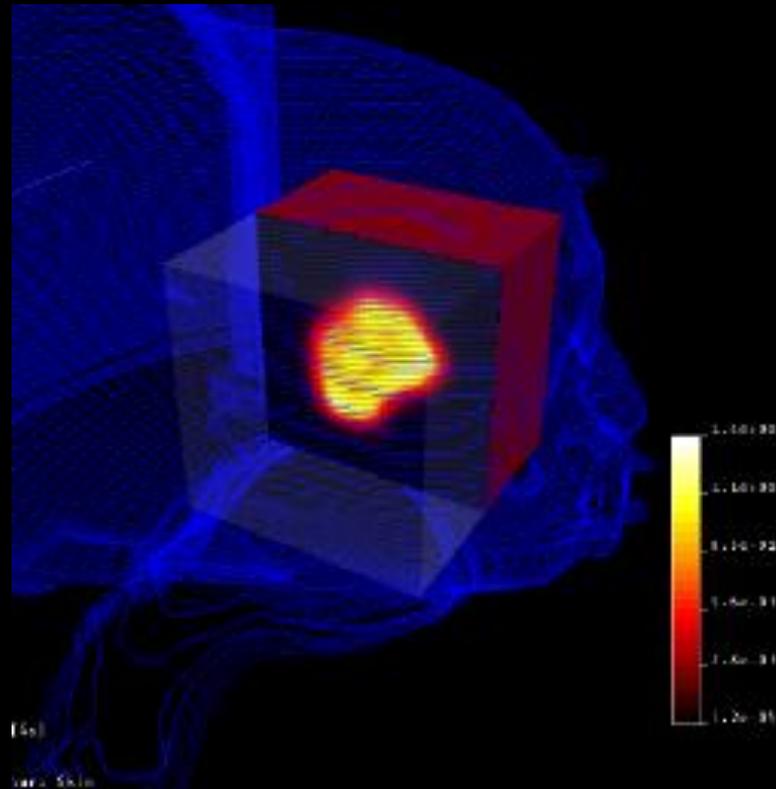


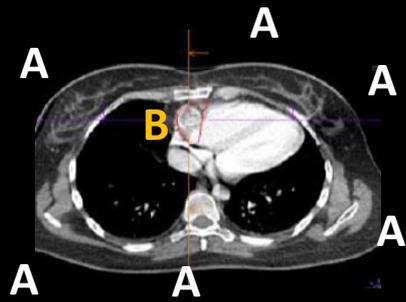
Brouwer et al., Radiotherapy and Oncology 117 (2015) 83–90

Punti di vista

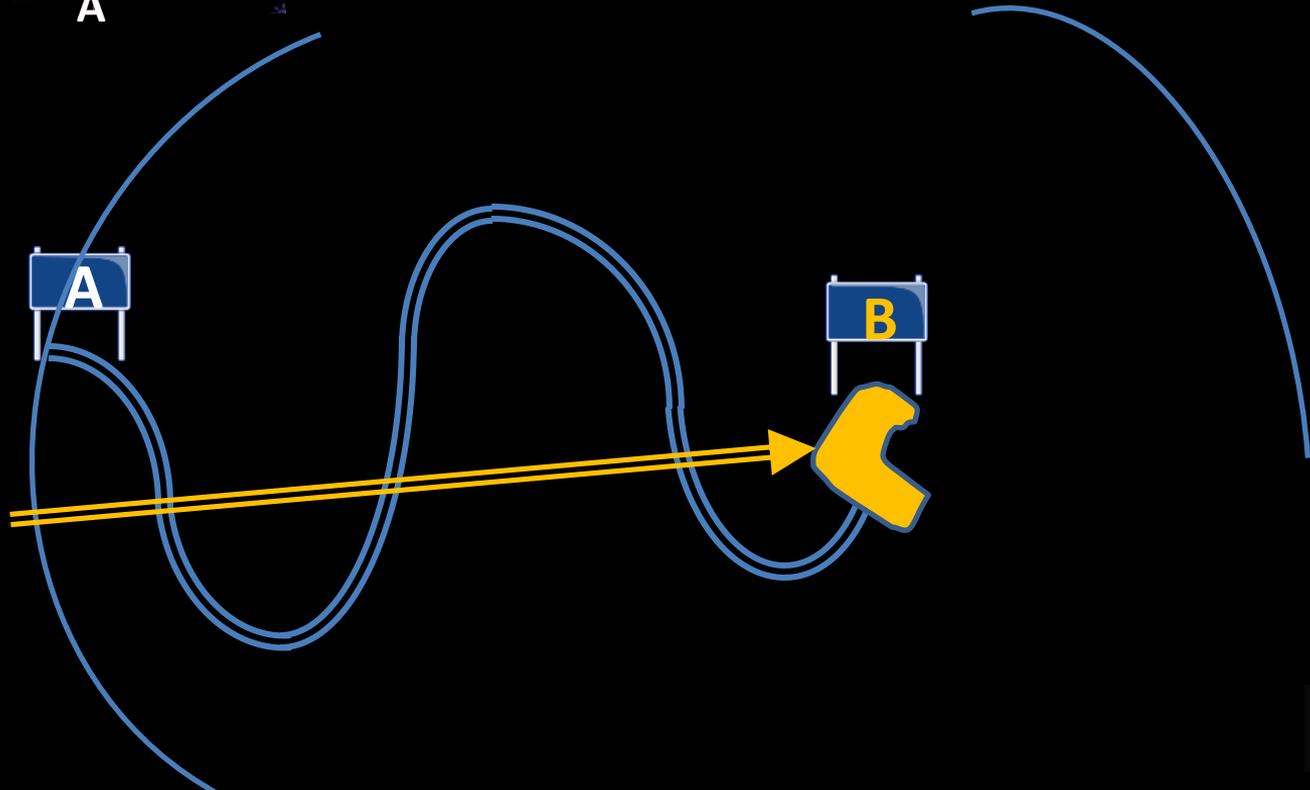


La dose ideale sul volume ideale





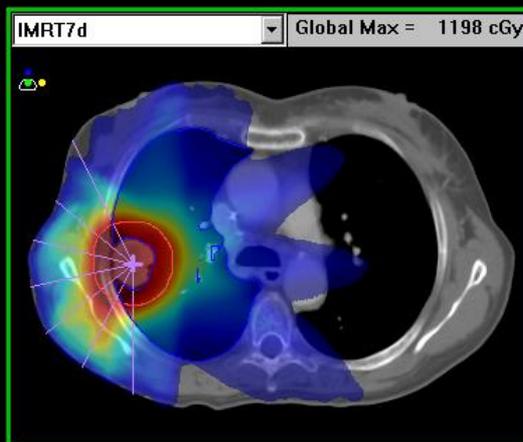
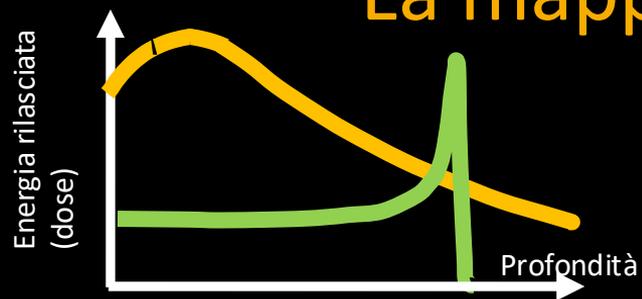
Come raggiungere B?



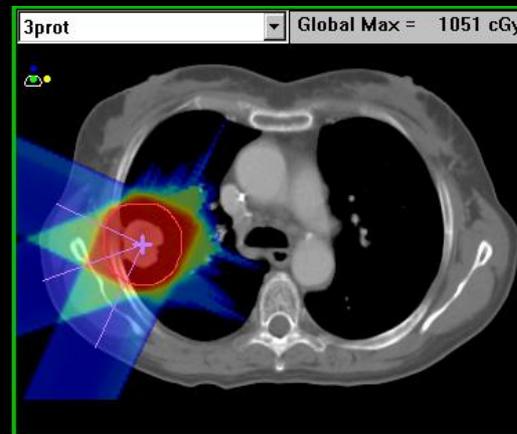
Il piano di trattamento



La mappa di dose

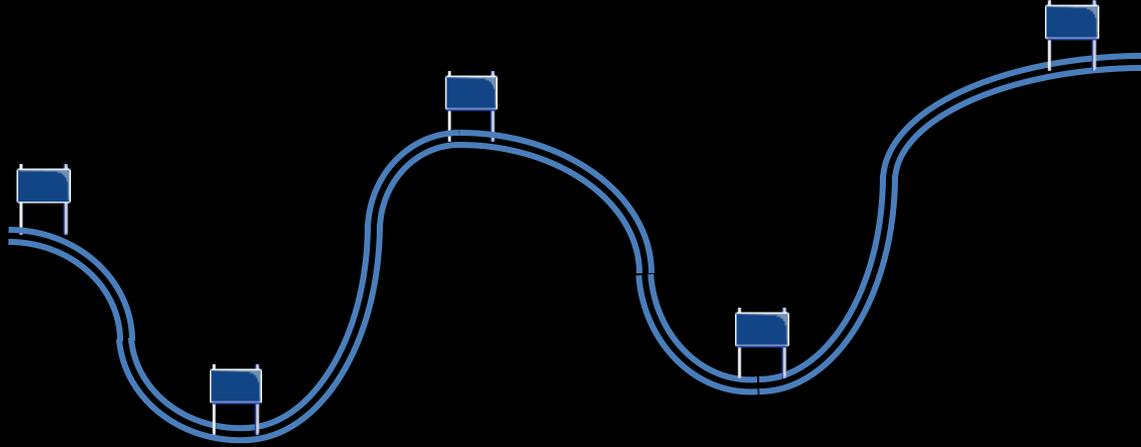


Radioterapia



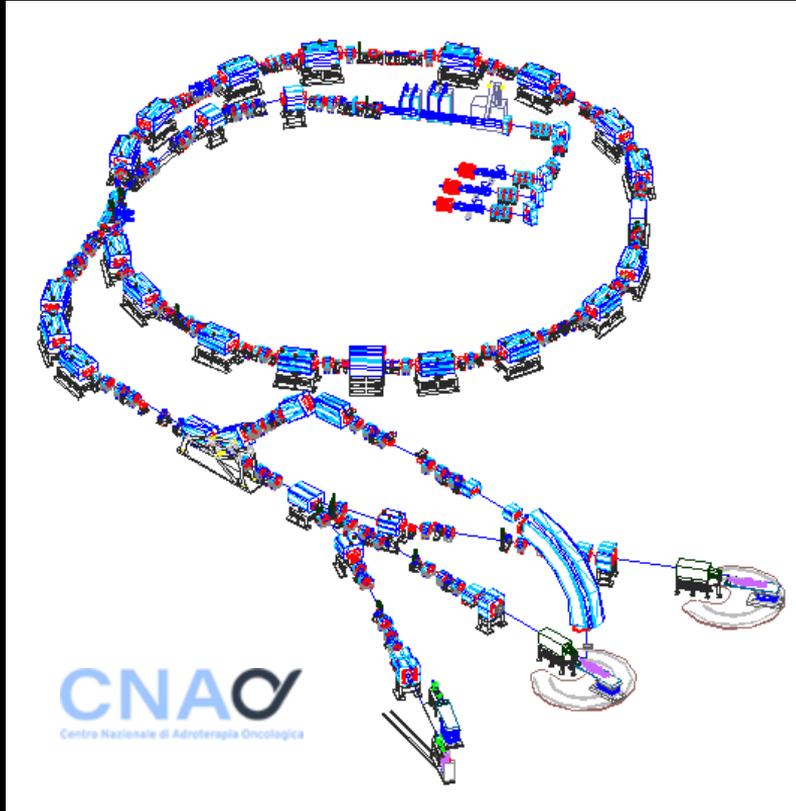
Adroterapia

Trattamento

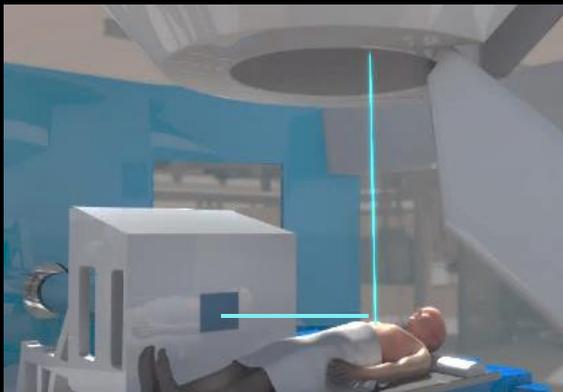


le mappe dell'adroterapia

L'acceleratore (CNAO)

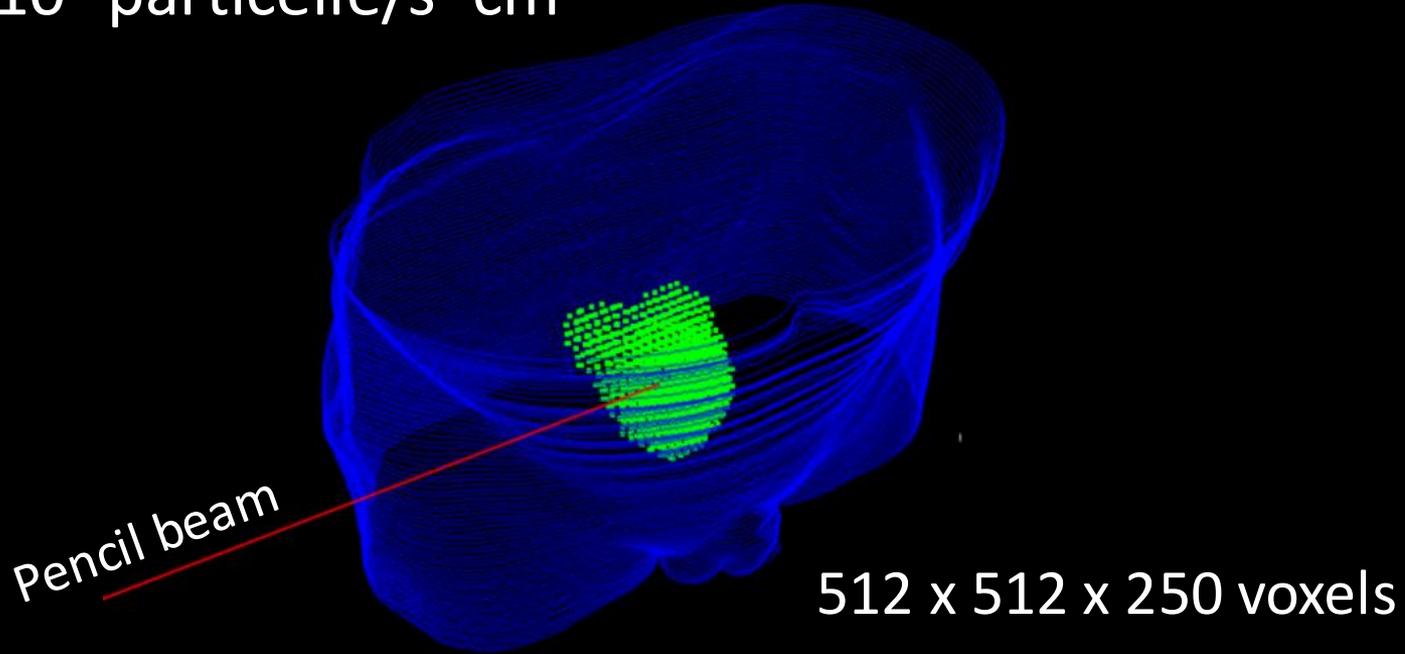


Come scegliere la direzione di ingresso ?



Come raggiungere il bersaglio?

10^8 - 10^9 particelle/s* cm^2

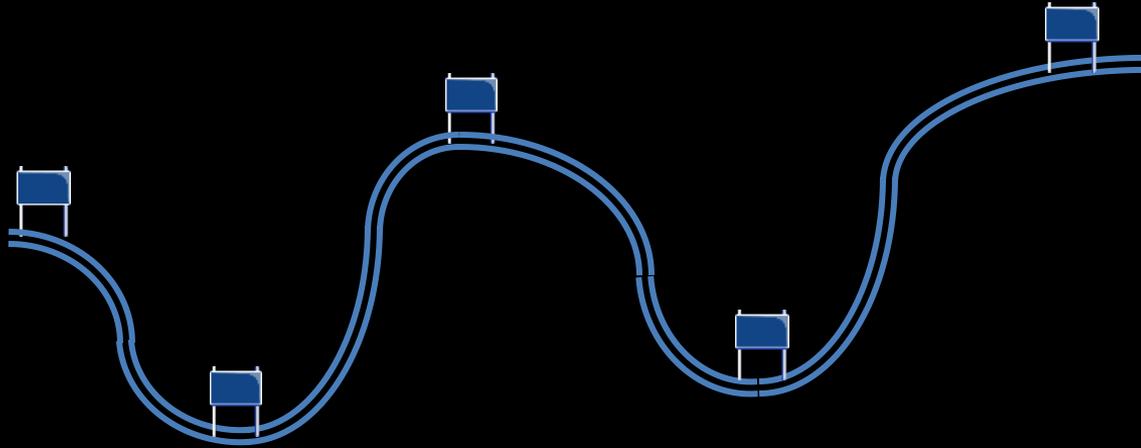


1000 – 50000 traiettorie

La mappa del trattamento

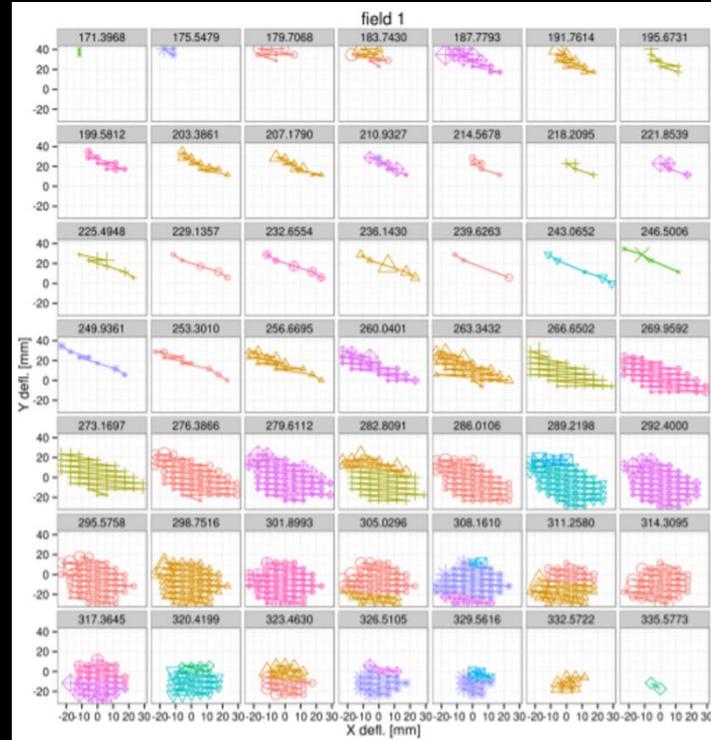


Monitoraggio



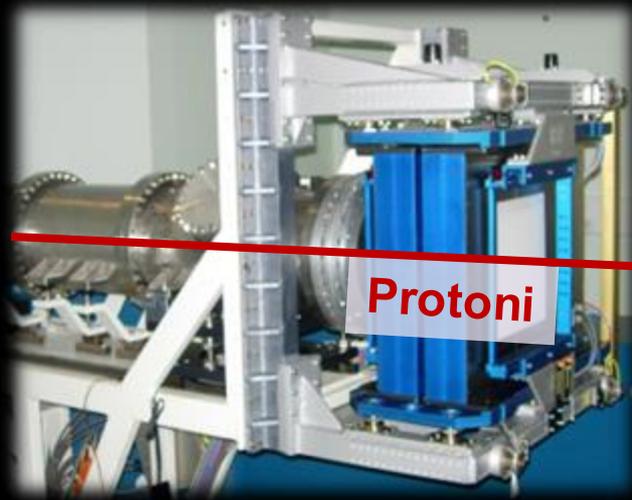
le mappe dell'adroterapia

Il controllo in 2D

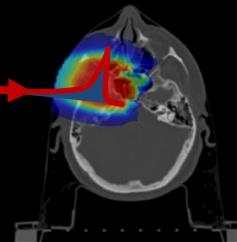




Il controllo in 2D



Protoni

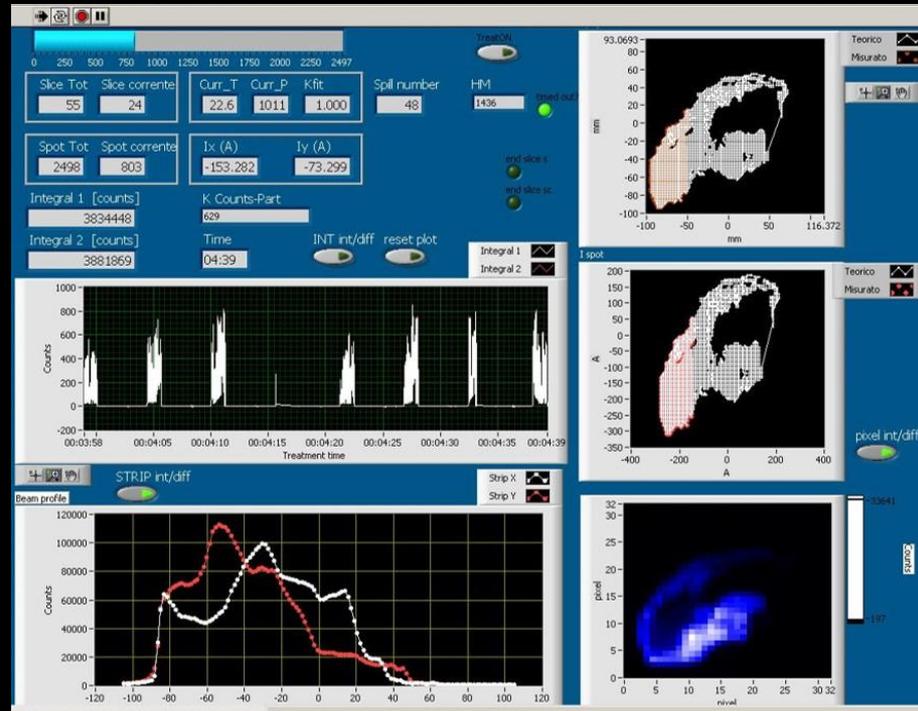


Il controllo in 2D

forma di una fetta di tumore
che si sta irraggiando

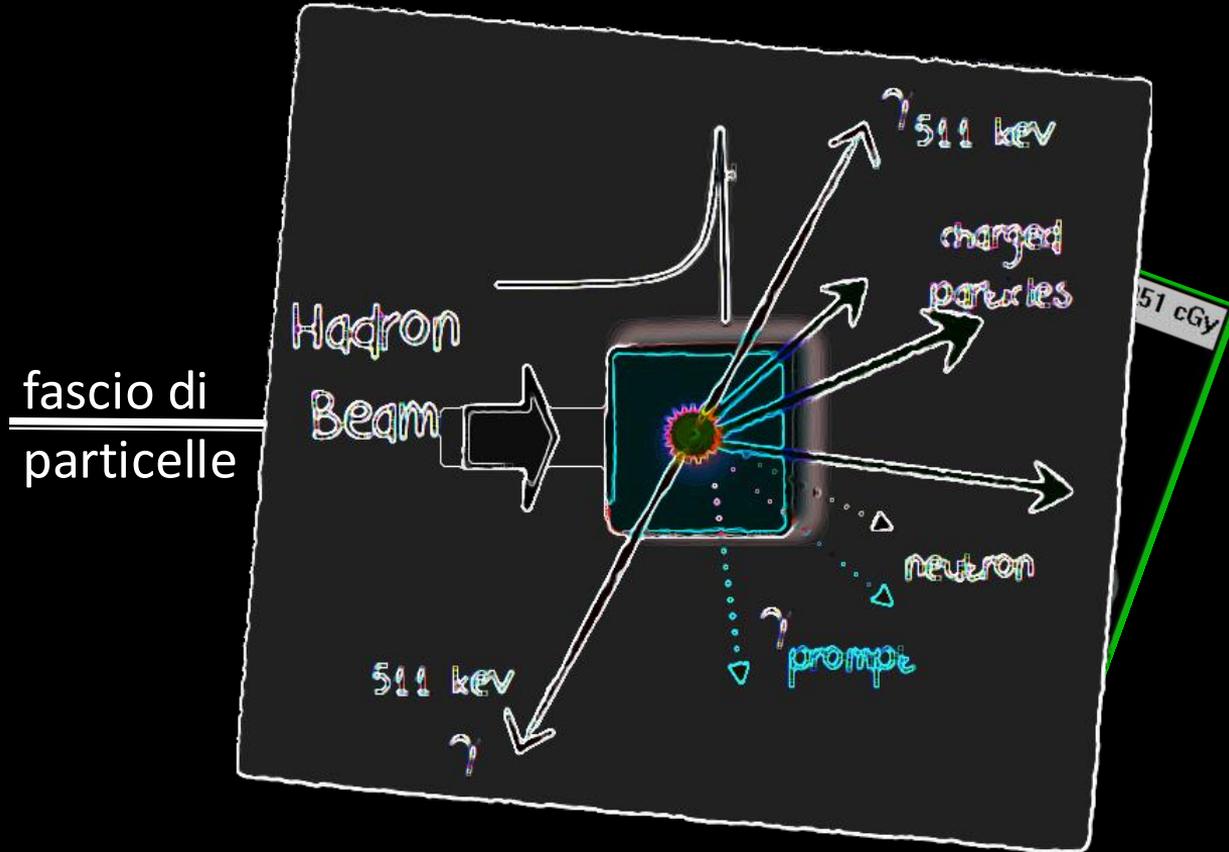
Intensità
del fascio

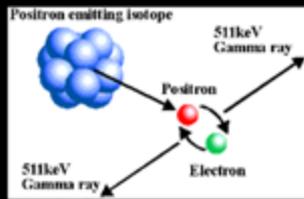
Profili
di dose



Misura
di dose 2D

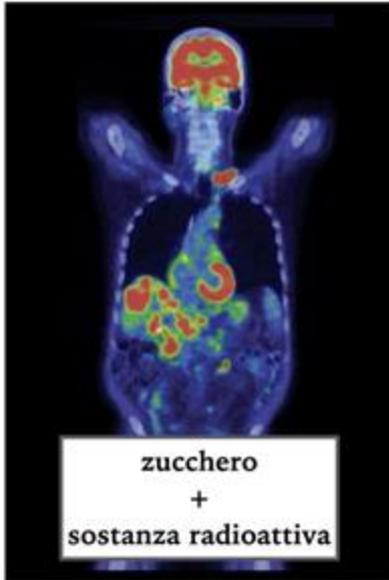
Il controllo in 3D



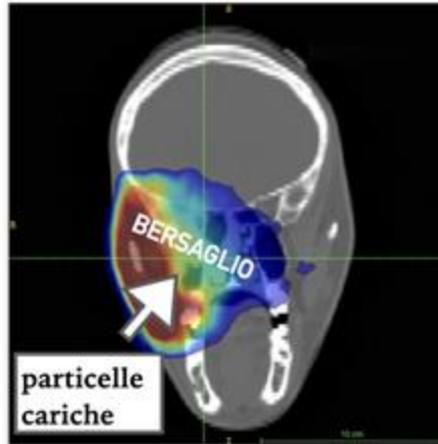


La PET, di nuovo...

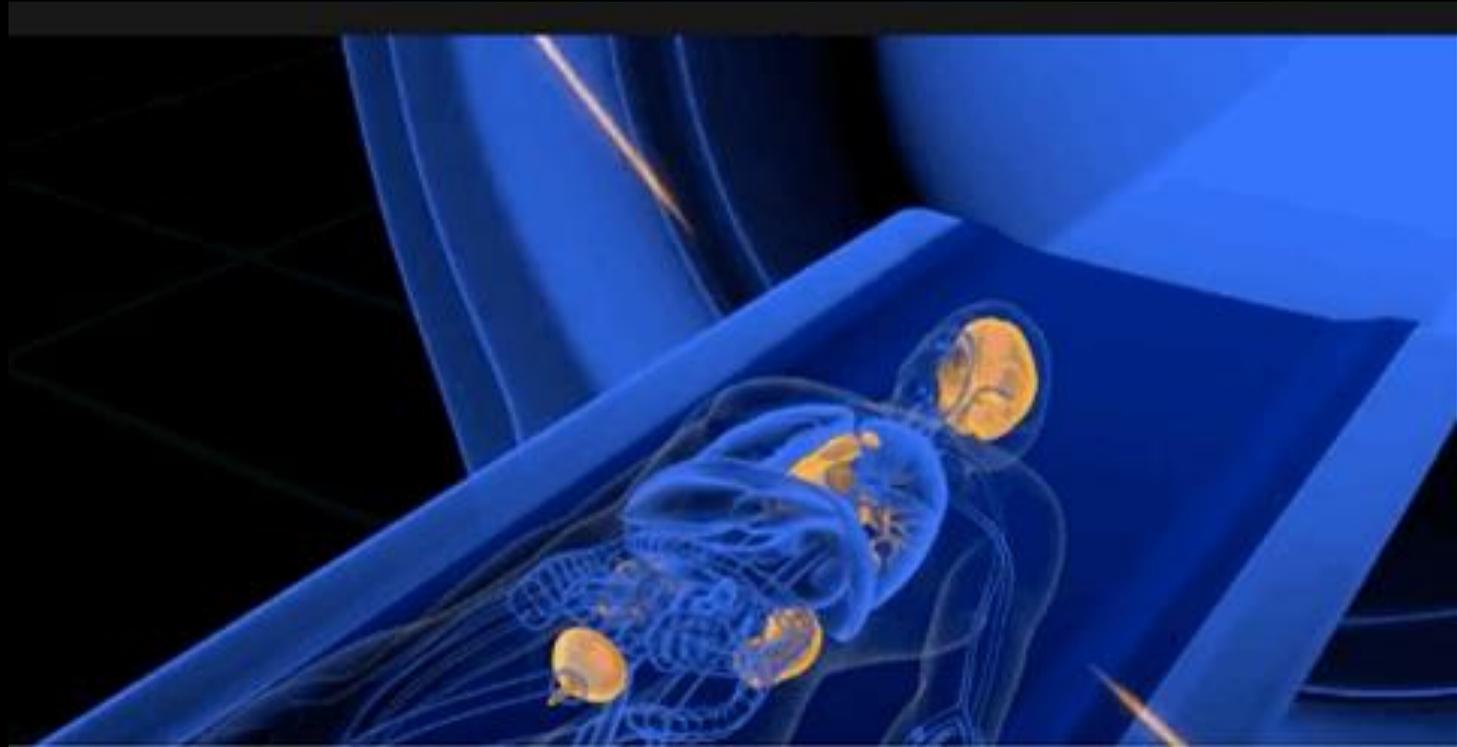
PET CLINICA



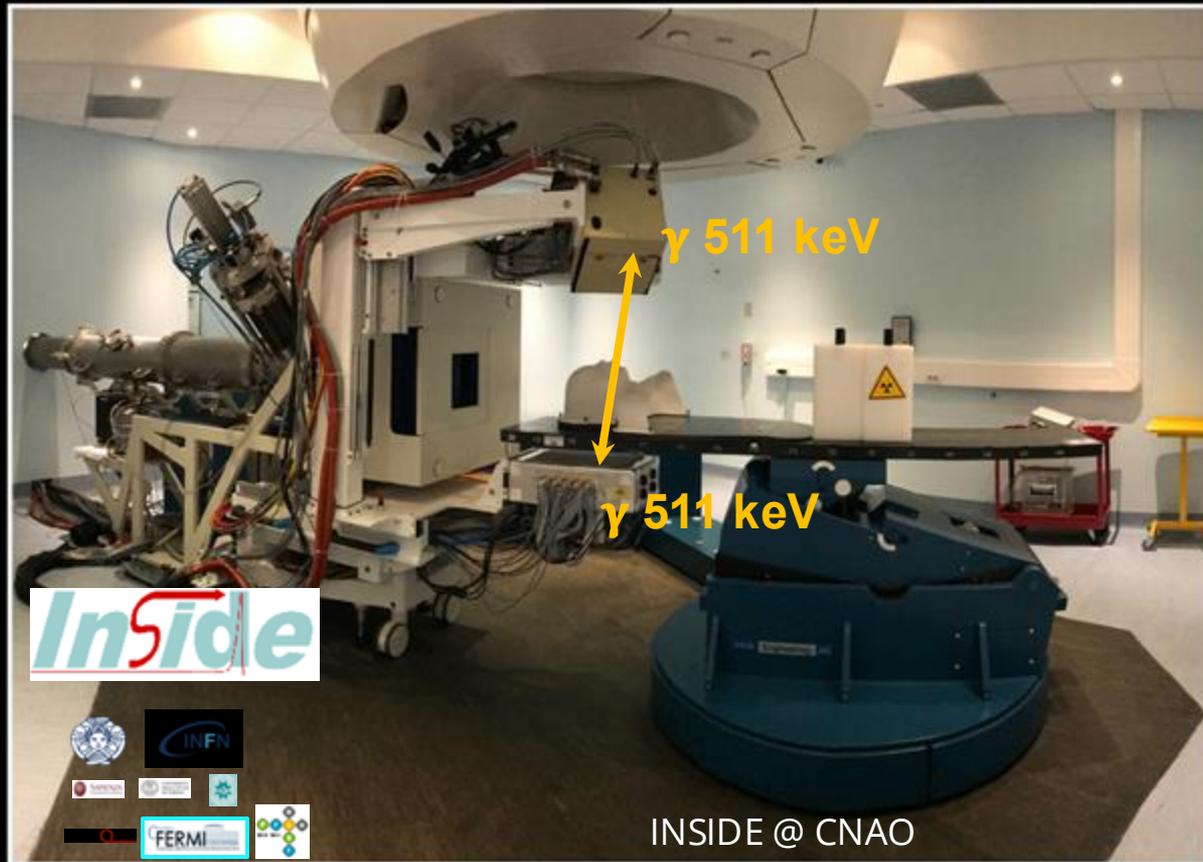
PET PER LA RICERCA



PET



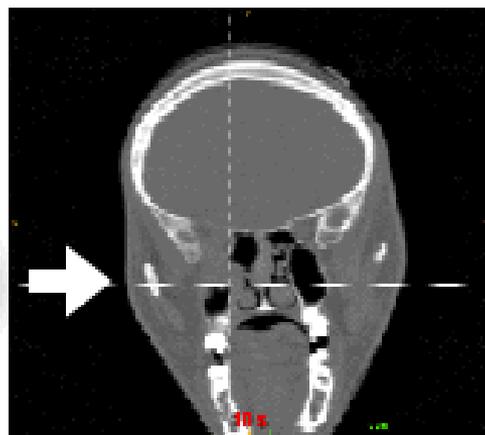
PET per la ricerca



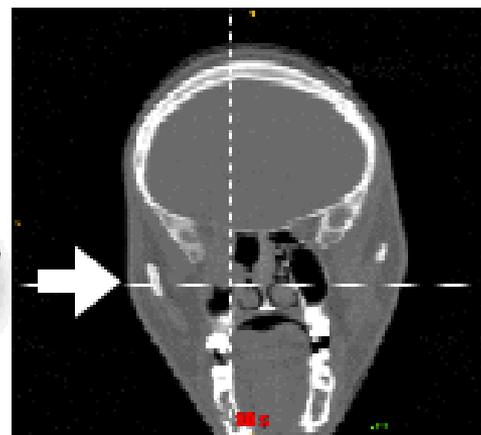
PET per la ricerca

MONITORAGGIO CON PET INSIDE

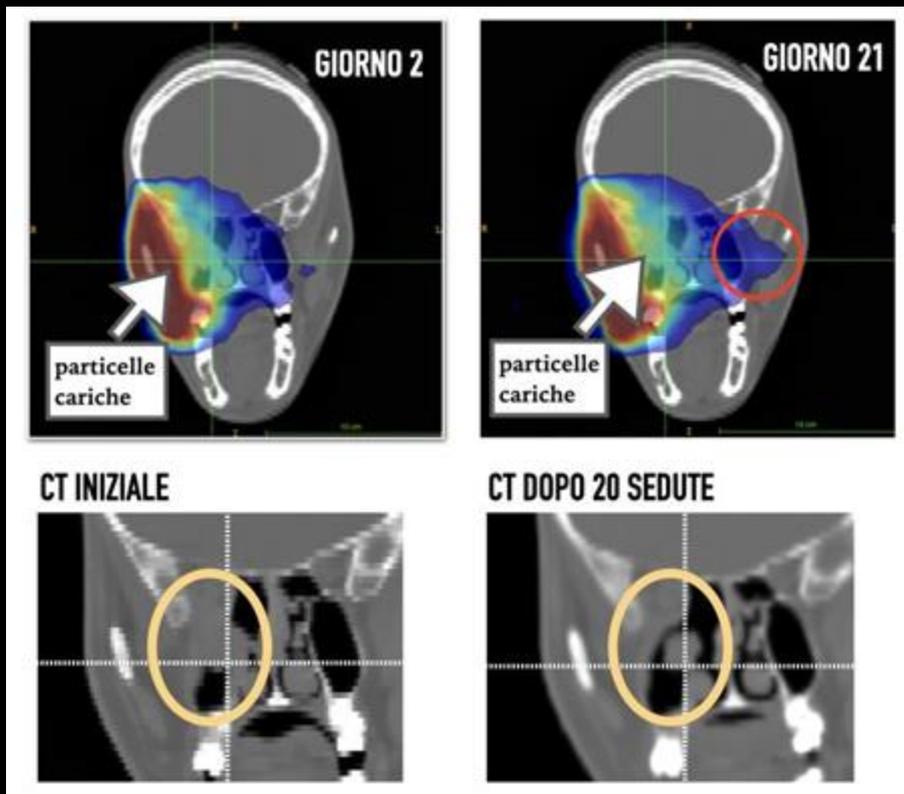
GIORNO 2



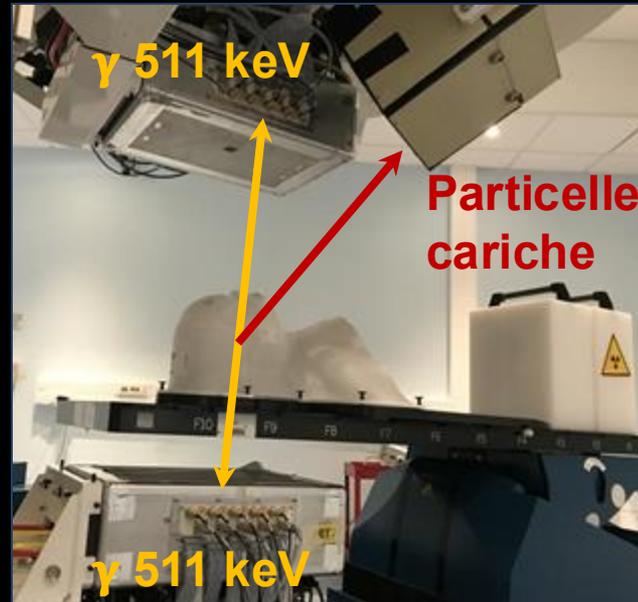
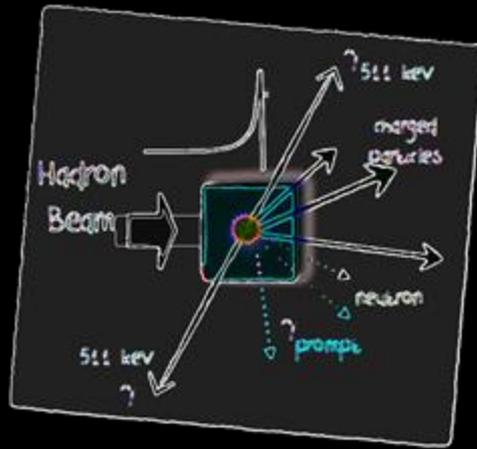
GIORNO 21



PET per la ricerca

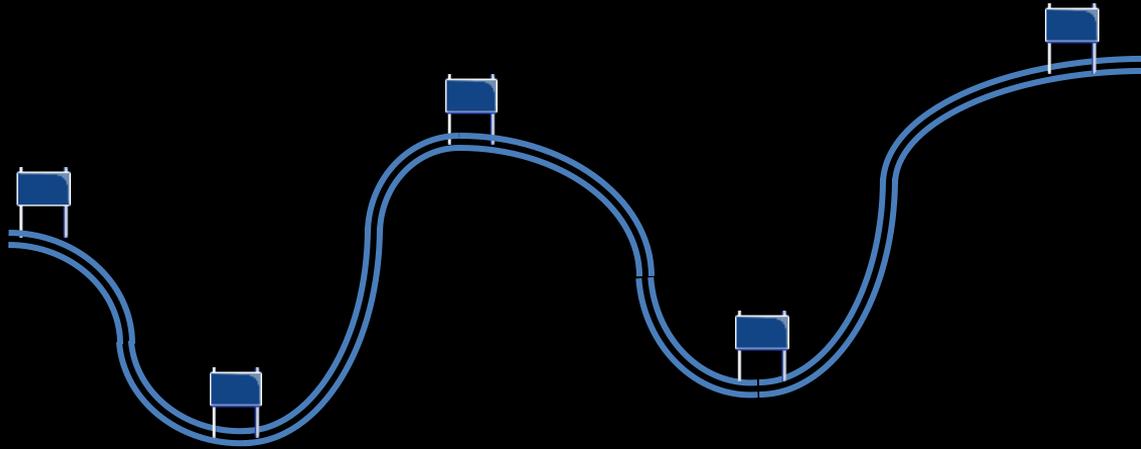


PET, ma non solo...



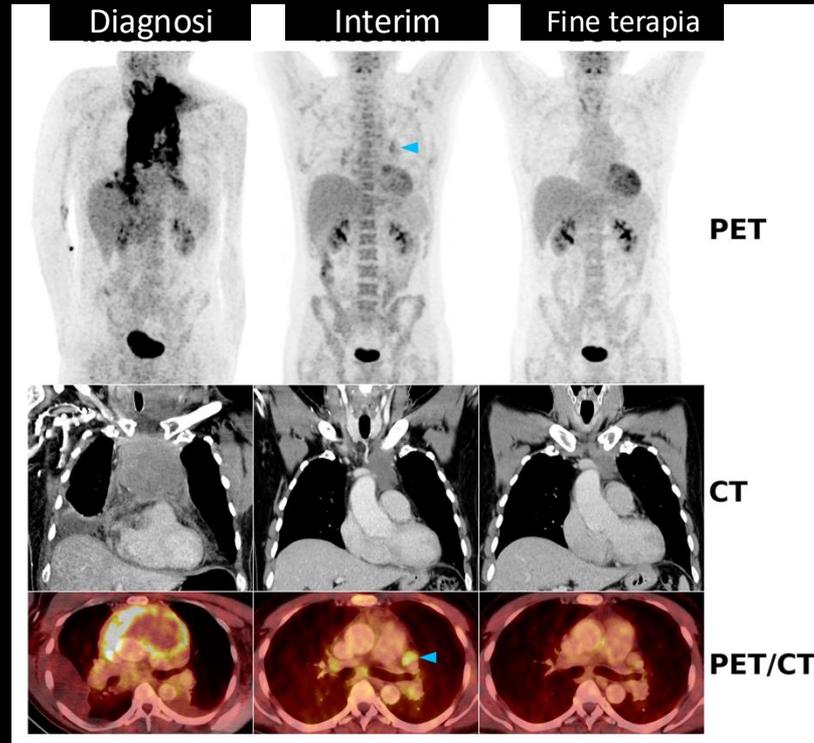
fotoni singoli

Follow-up



le mappe dell'adroterapia

... ritorniamo alle mappe diagnostiche



D. Berzacy et al., RECL Versus Lugano for Treatment Response Assessment in FDG-Avid Non-Hodgkin Lymphomas:

Art & Science

