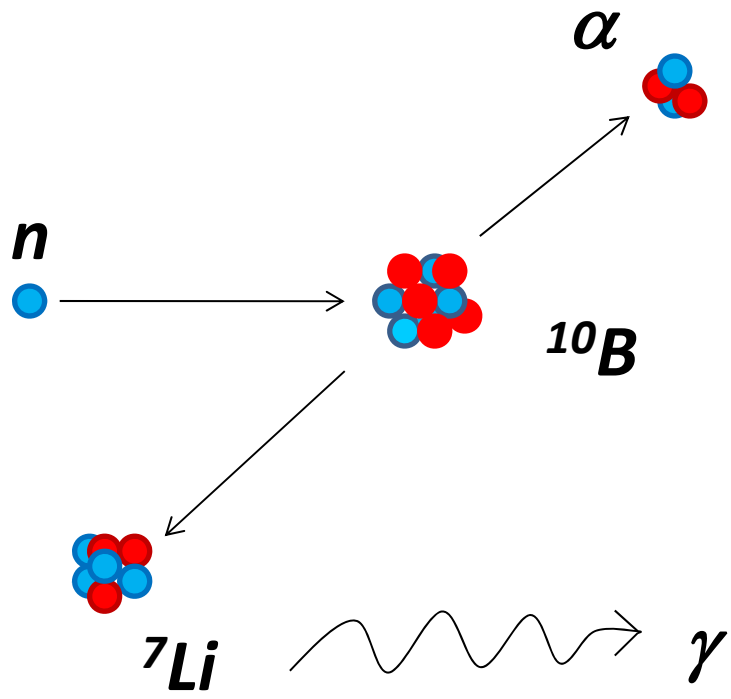


# Radioterapia per Cattura Neutronica e Modellizzazione di Morte Cellulare

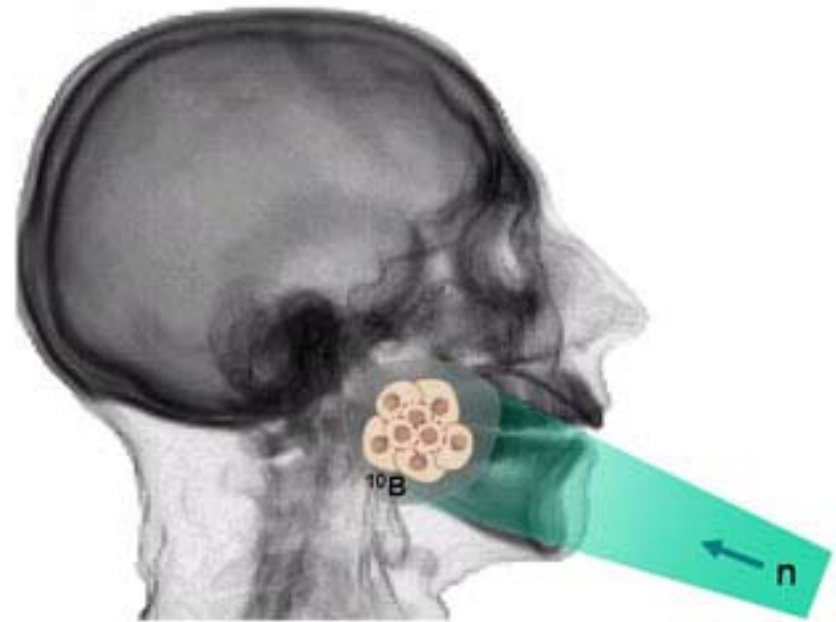


***Saverio Altieri, Silva Bortolussi, Nicoletta Protti,  
Ian Postuma, Setareh Fatemi,  
Francesca Ballarini, Mario Carante***



Radioterapia per  
Cattura Neutronica

*Saverio Altieri, Silva Bortolussi,  
 Nicoletta Protti, Ian Postuma,  
 Setareh Fatemi*

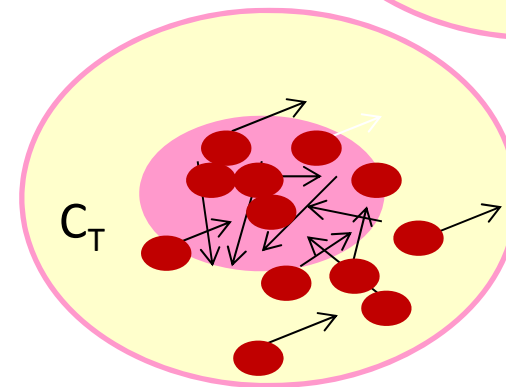
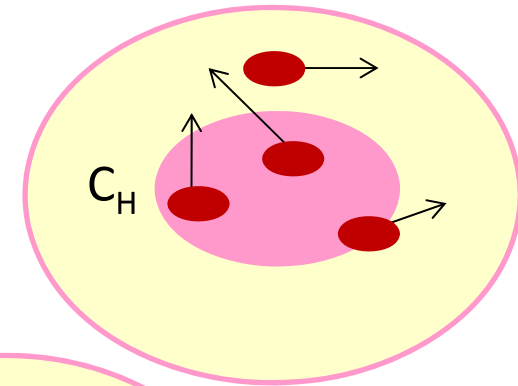


# Boron Neutron Capture Therapy

*Il range delle particelle ad alto LET è più corto di un diametro cellulare, le cellule normali non vengono danneggiate dalle reazioni.*

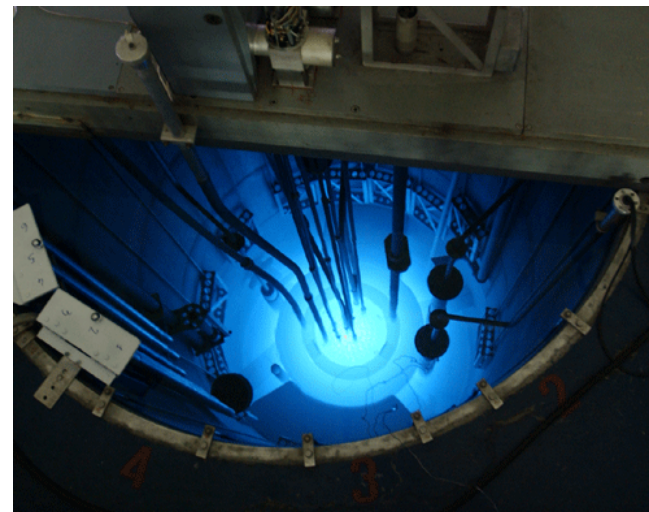
**SELETTIVITA'  
INDIPENDENTE  
DAL FASCIO!**

**Cellula normale  $D_H \propto C_H$**



**$D_T \propto C_T$**

**Cellula Tumore**



***Reattore di ricerca  
TRIGA Mark II  
L.E.N.A. – UniPV  
Unico in Italia***

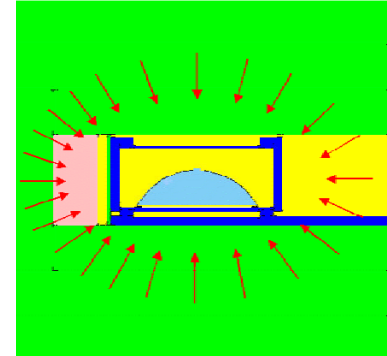


# Applicazioni a Pavia

**TUMORI DIFFUSI NON OPERABILI, QUASI SEMPRE FATALI**

**metastasi epatiche**

→ **Autotrapianto**

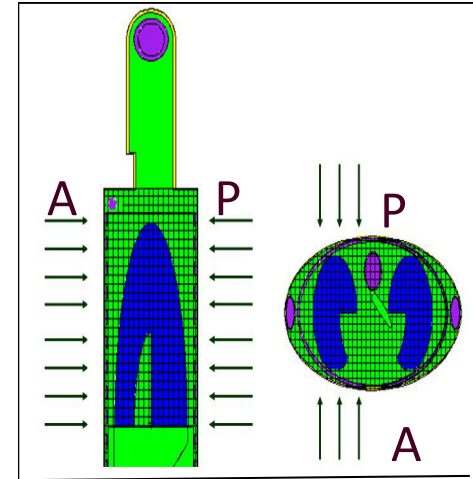


**tumori polmonari**

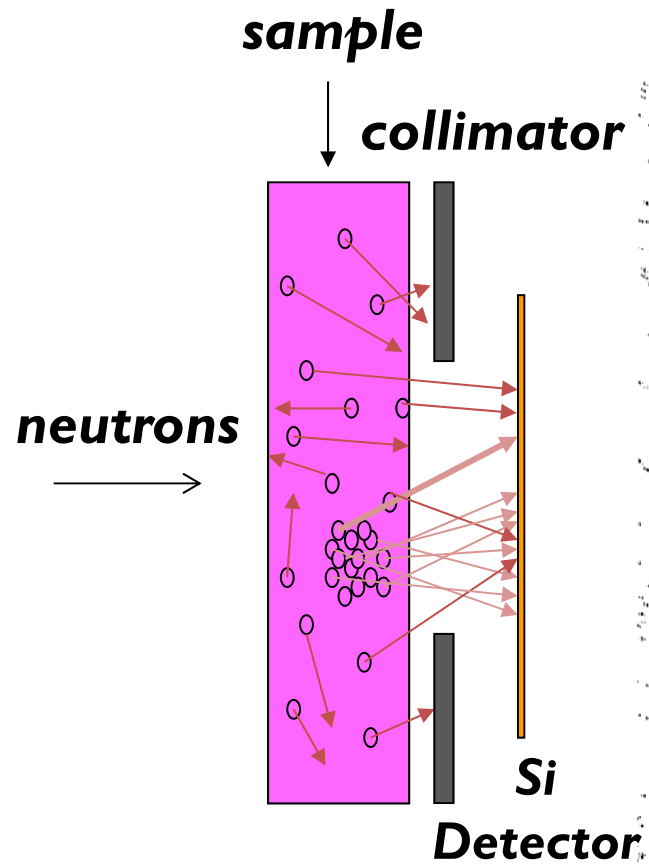
**mesotelioma**

**osteosarcoma**

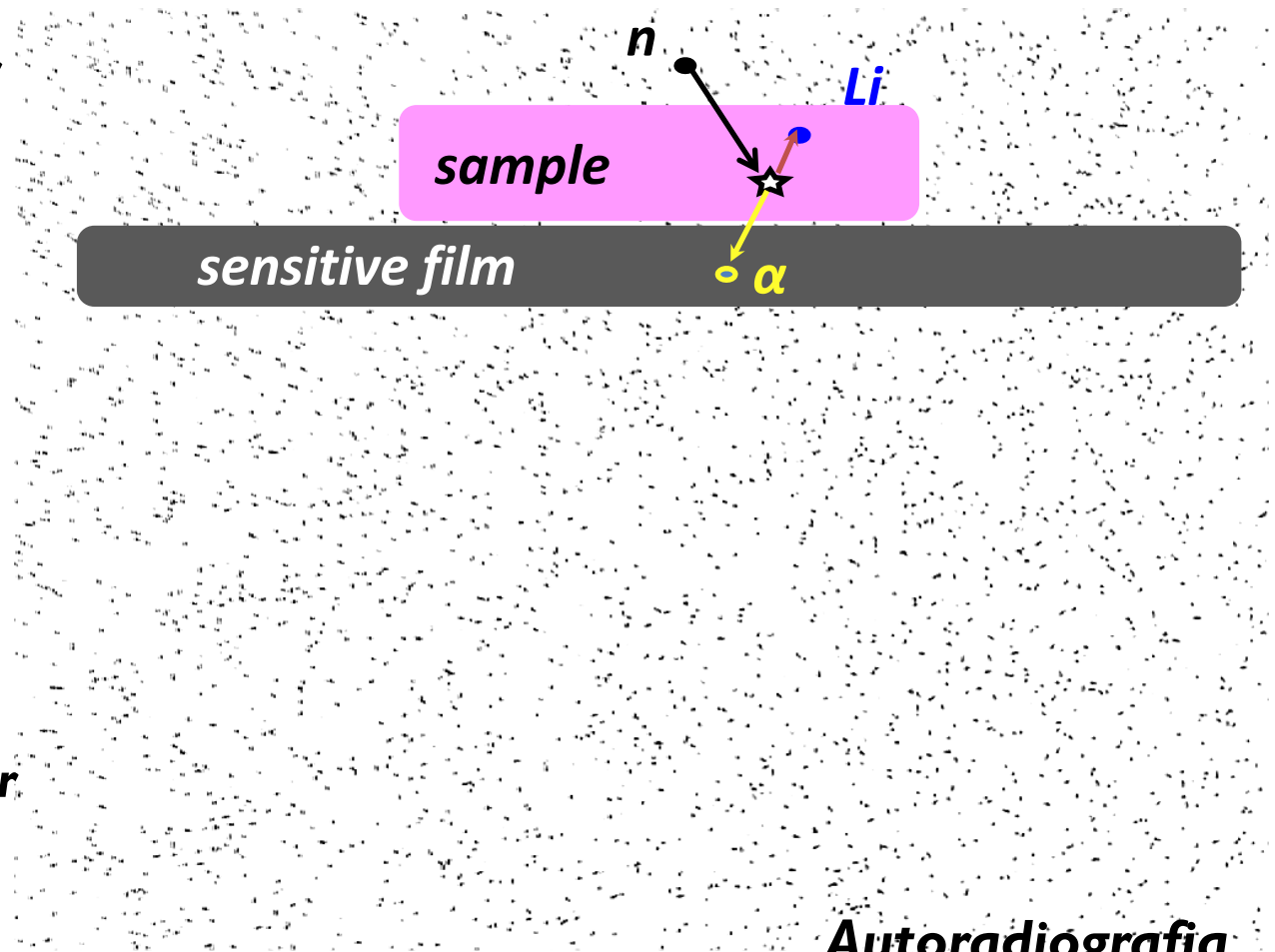
→ **Fasci esterni**



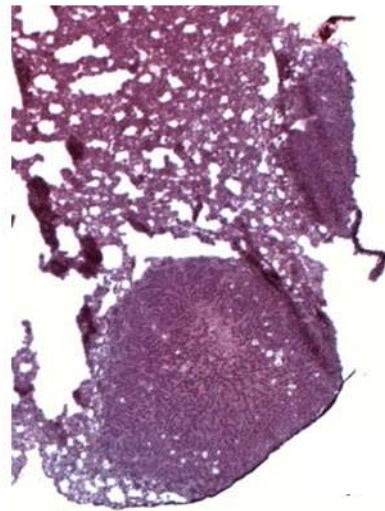
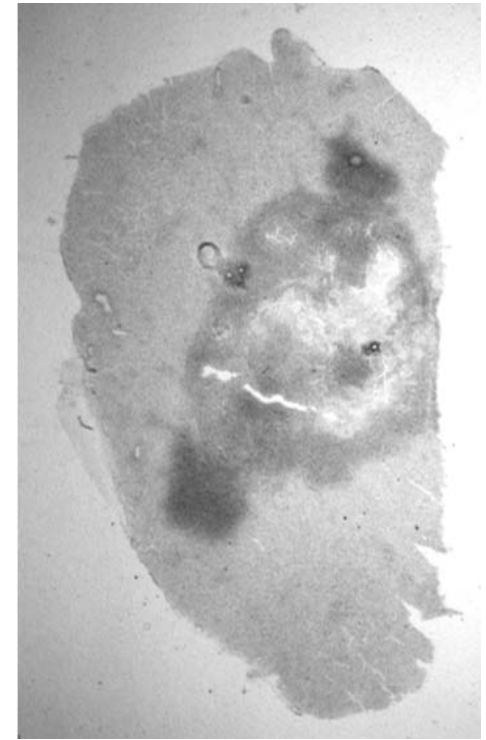
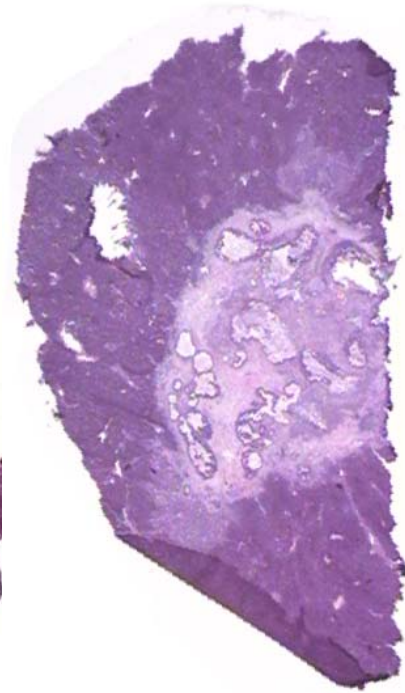
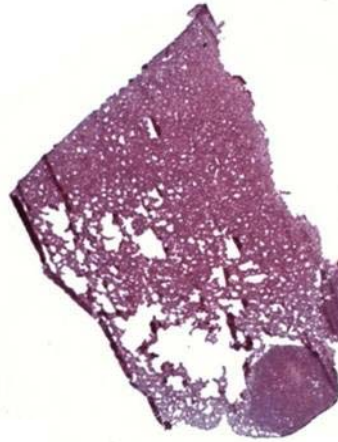
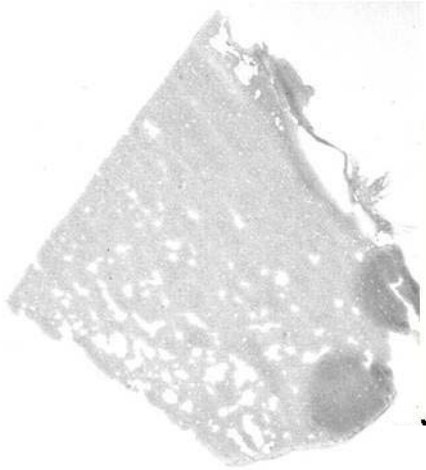
# Misura del boro in tessuti e cellule



**Spettrometria di  
Particelle cariche**



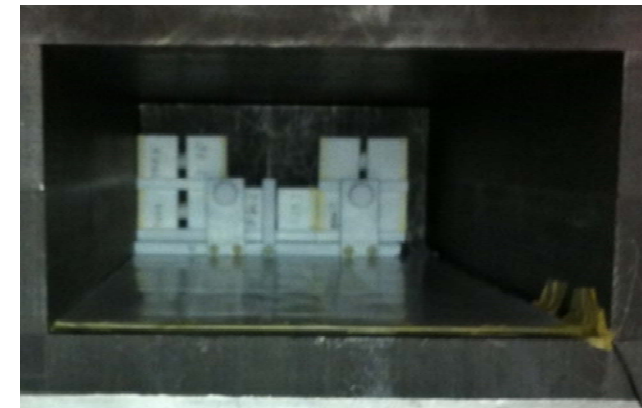
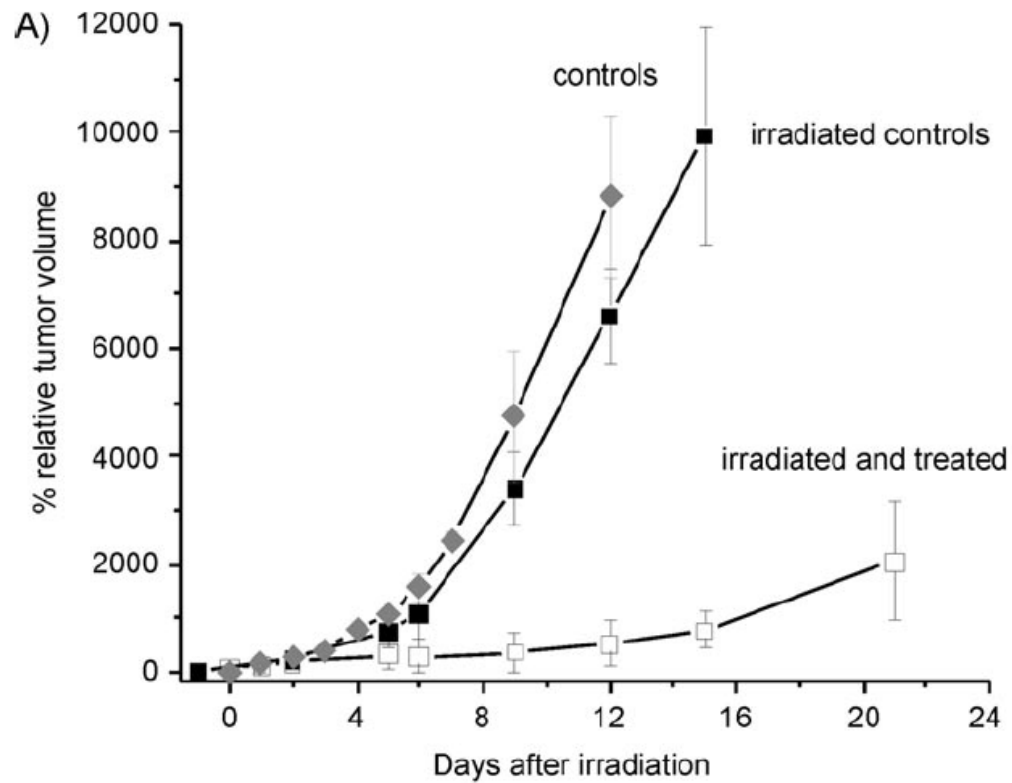
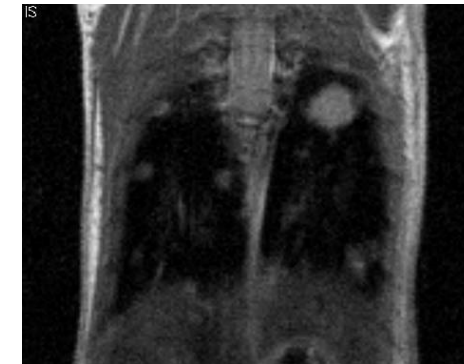
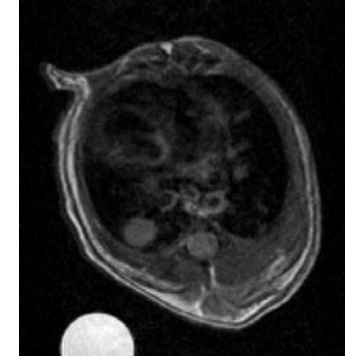
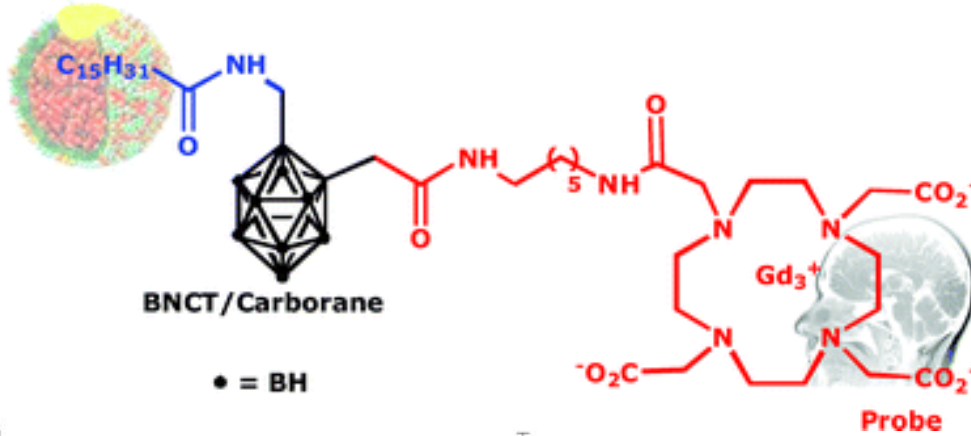
**Autoradiografia  
Neutronica**



*Imaging:  
Analisi qualitativa*

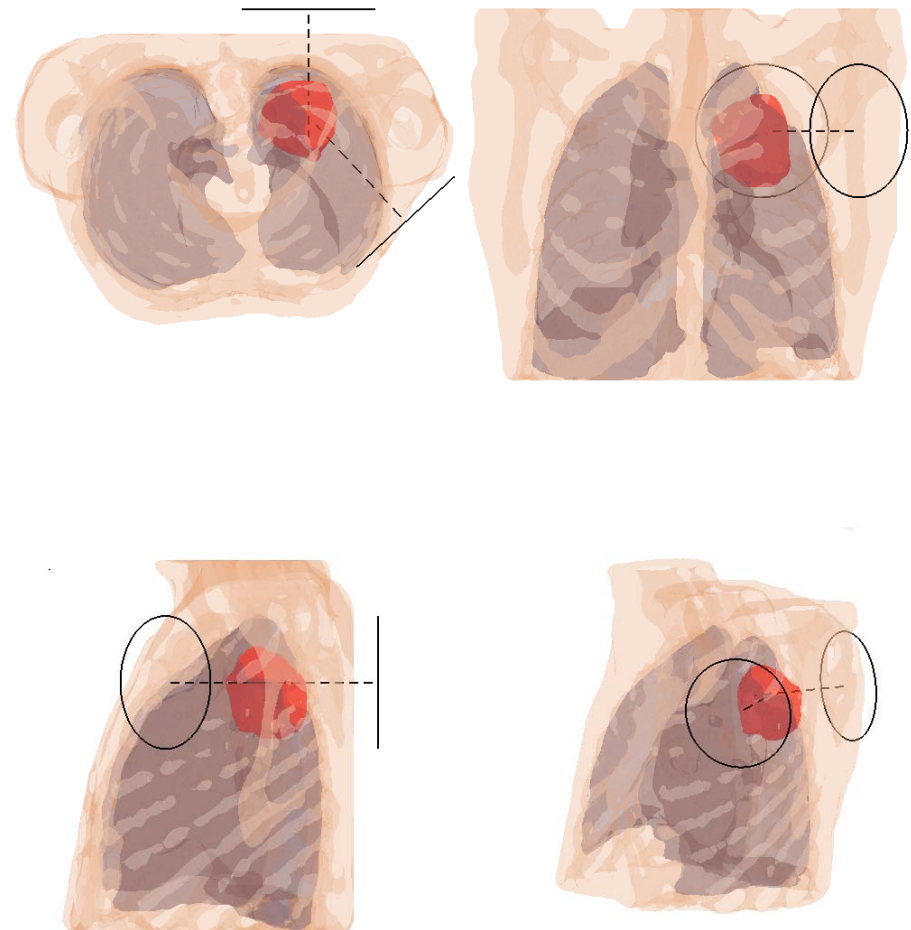
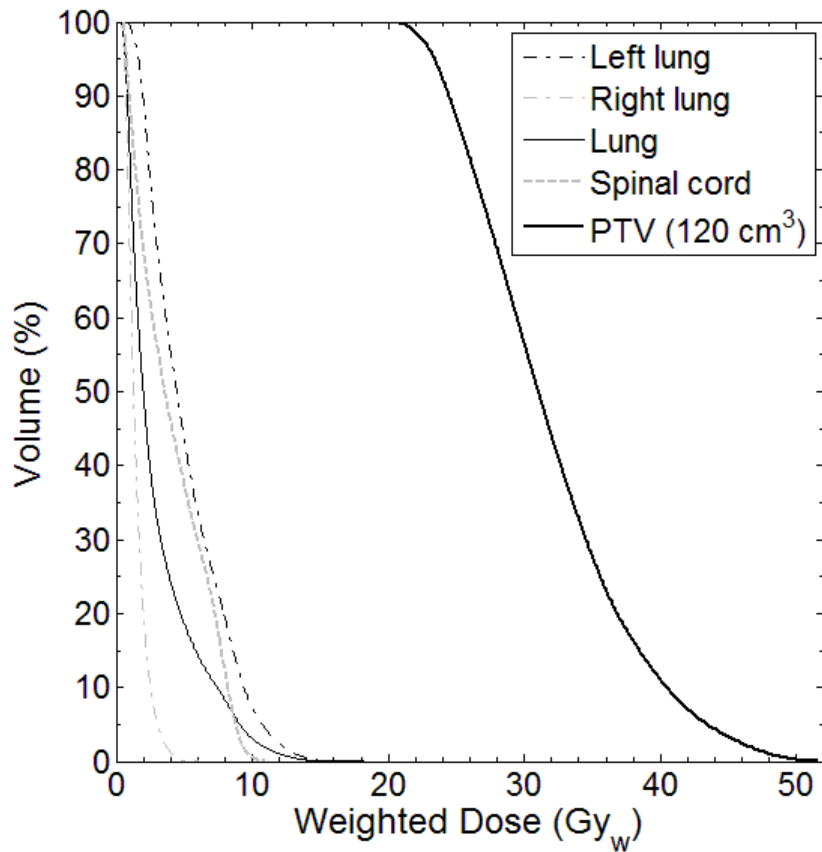
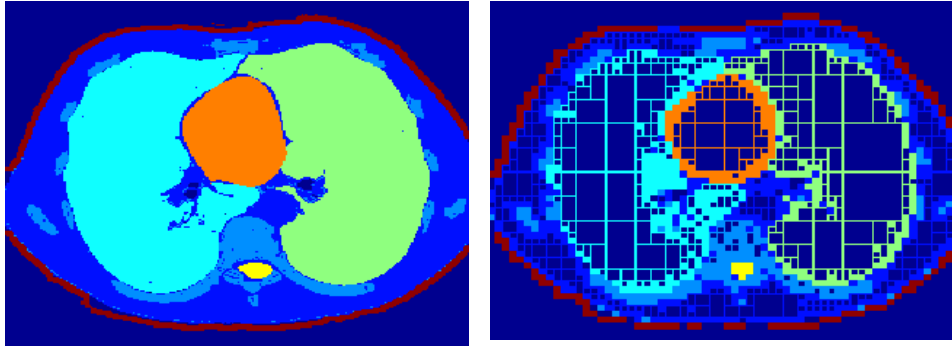
# Test di efficacia in vivo

Biological vector

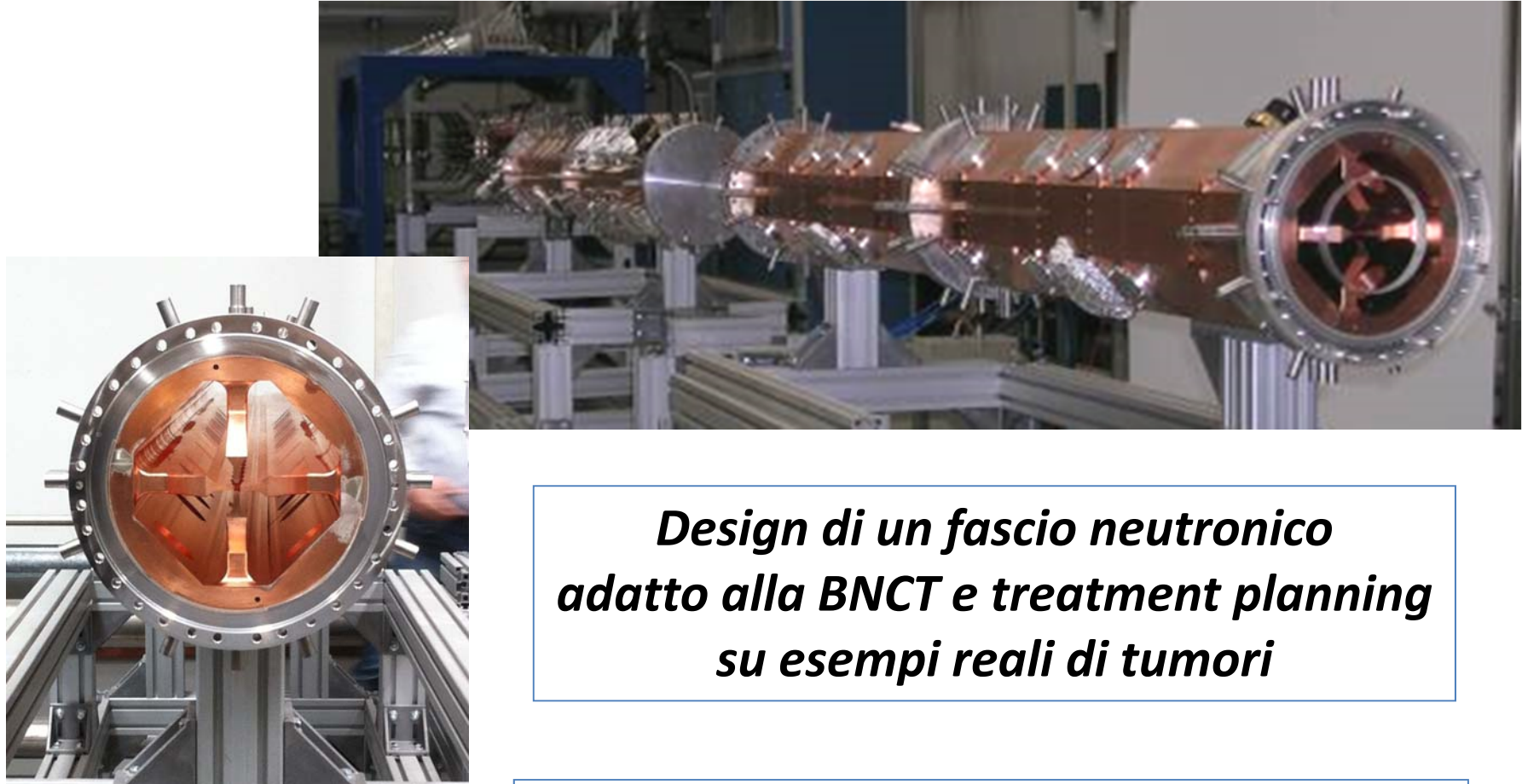




# Treatment Planning

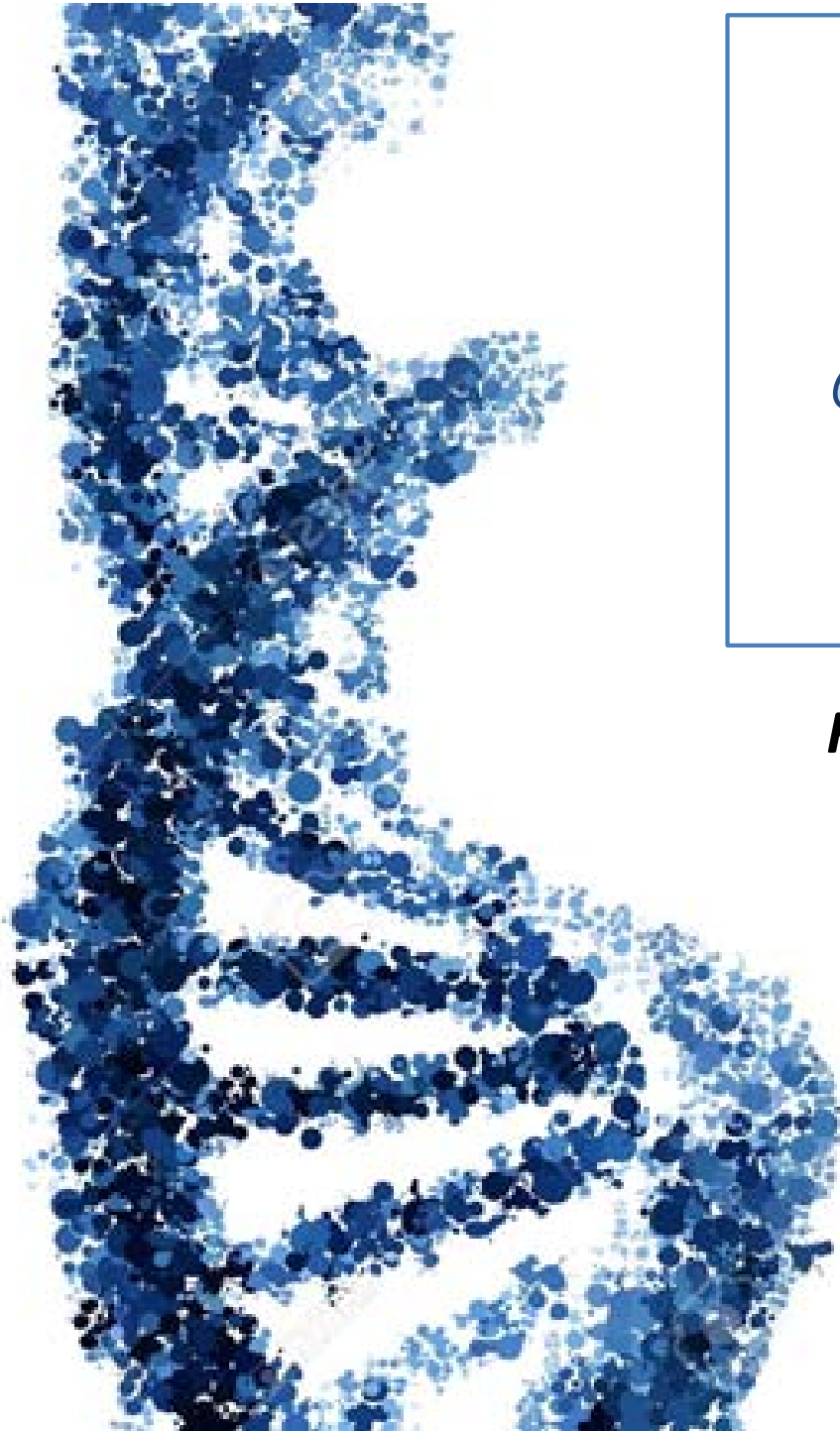


# Acceleratore per BNCT



***Design di un fascio neutronico  
adatto alla BNCT e treatment planning  
su esempi reali di tumori***

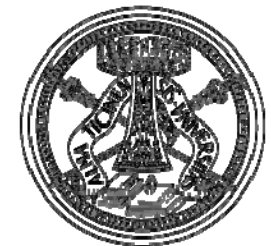
***Progettazione di un Sistema di Imaging  
del gamma di diseccitazione del Li per la  
valutazione della dose on-line***



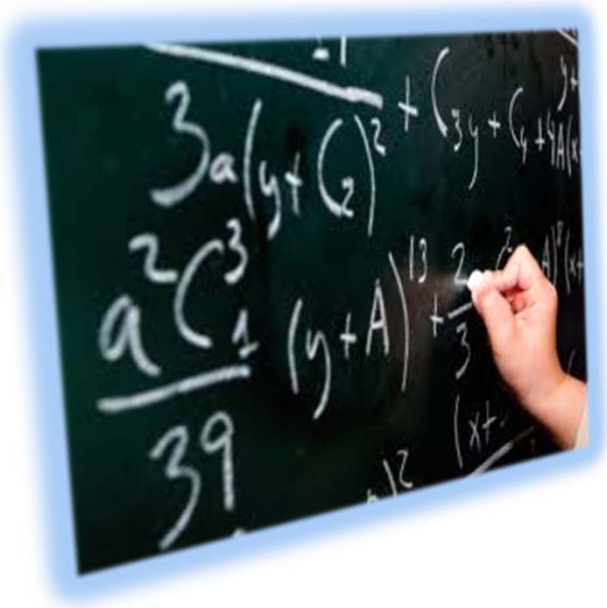
# Modellizzazione di morte cellulare e danno cromosomico radioindotto

***Francesca Ballarini, Mario Carante***

[francesca.ballarini@unipv.it](mailto:francesca.ballarini@unipv.it)  
[mariopietro.carante01@ateneopv.it](mailto:mariopietro.carante01@ateneopv.it)



# Modellizzazione

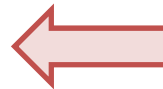


```
23 *****
24 * PARAMETERS, VECTORS AND MATRIXES *
25 *****
26
27
28 * PARAMETERS
29
30
31     PARAMETER (ncro=46)
32
33     PARAMETER (ncub=30)
34     PARAMETER (ncubf=60)
35
36     PARAMETER (ncubh=20)
37     PARAMETER (ncuba=100, ncubb=50)[
38
39     parameter (pi=3.1415)
```

ooo

Comprendere meglio  
i meccanismi

Fare previsioni dove  
non vi sono dati (es.  
basse dosi)

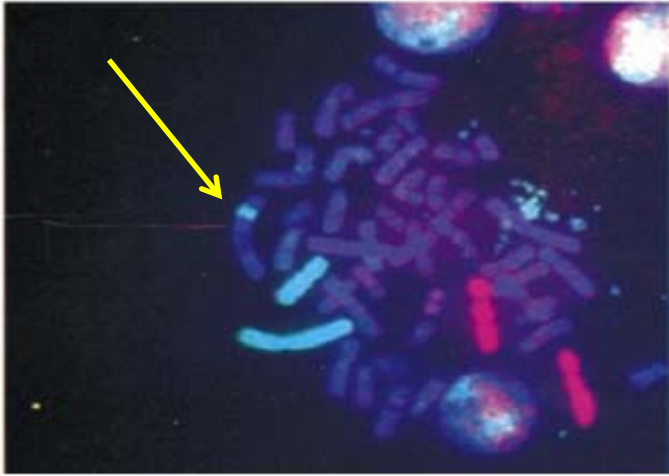


```
9107 * "SCAMBIA"
9108 *****
9109
9110     subroutine scambia(nvettprimo,nvettsecondo)
9111
9112     dimension nvettprimo(100),nvettsecondo(100)
9113
9114     do j = 1,100
9115         ntemp=nvettprimo(j)
9116         nvettprimo(j)=nvettsecondo(j)
9117         nvettsecondo(j)=ntemp
9118     enddo
9119
9120
9121     return
9122     end
9123
```

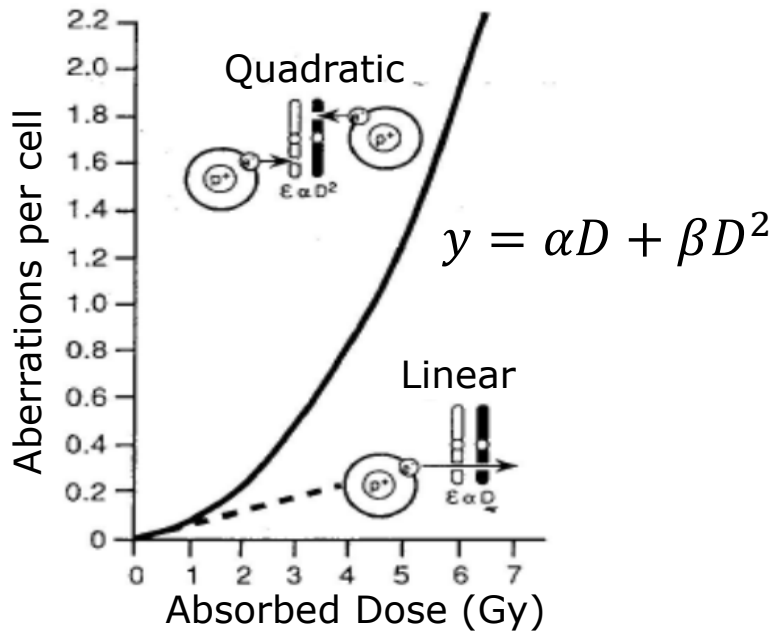


# Effetti

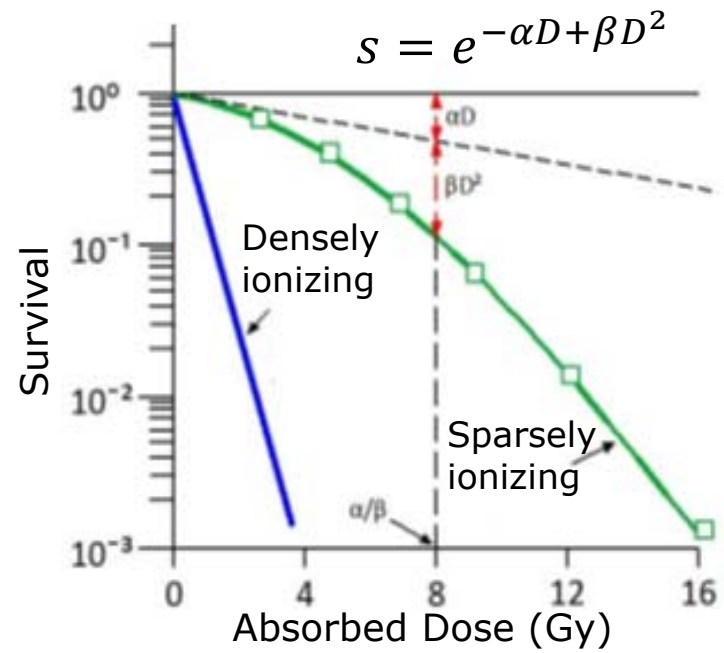
Aberrazioni cromosomiche



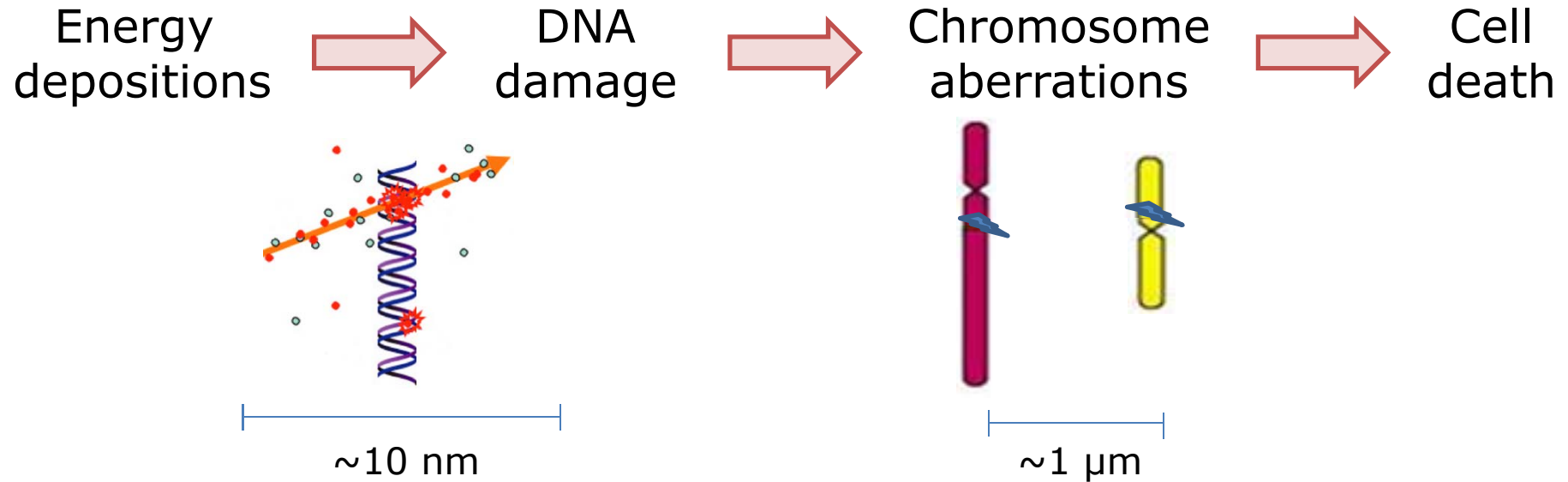
Astronaut cell



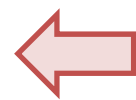
Morte cellulare



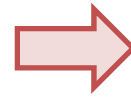
# Il modello e le assunzioni



Parametri fondamentali:  $E$ , dose  $f$ ,  $dE/dx$  ma soprattutto...  
la **distribuzione spaziale** dei danni



$E \approx 280 \text{ J}$

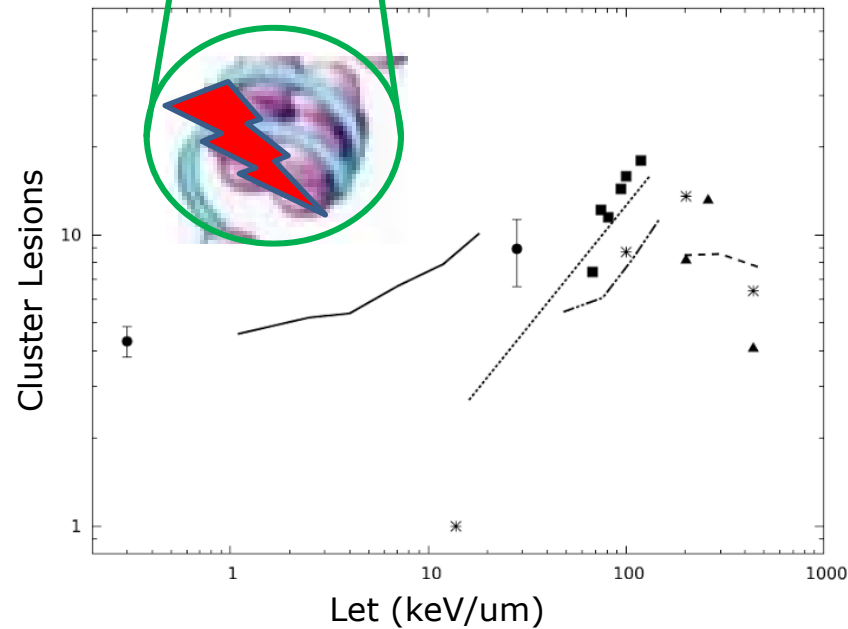
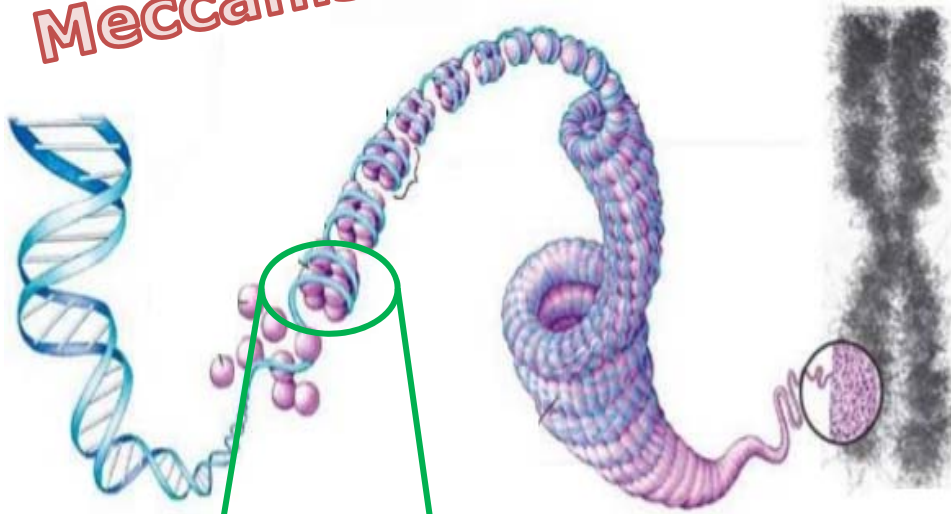


4 Gy x-rays total  
body (70 kg)



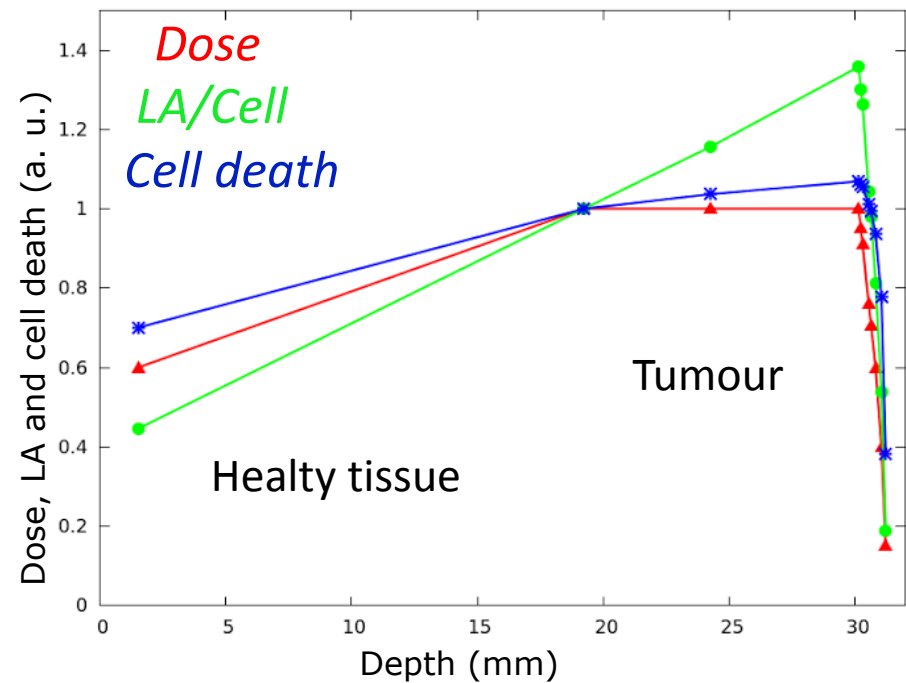
# Risultati

Meccanismi



Applicazioni

Tumori oculari trattati a Catania con protoni



# Attività in corso/future

## Meccanismi

- Includere **apoptosi**, o "suicidio cellulare" (in coll. con ENEA, Roma)
- Includere esplicitamente la radiosensibilità
- ... ..

## Adroterapia

- Aberrazioni **non letali** (danno ai tessuti sani)
- Estendere a cellule tumorali
- Applicazione a fasci terapeutici (in coll. con **CNAO**)
- ... ..

## Terapia con emettitori interni

- Modellizzare emissione alfa isotropa (in coll. con ISS Roma e Università di Napoli, progetto INFN "ETHICS")
- ... ..



# Grazie per l'attenzione!!

***I corsi attinenti a queste attività sono:***

- ***Fisica delle Radiazioni Ionizzanti (Altieri)***
- ***Simulazioni in Campo Biosanitario (Ballarini, Bortolussi)***

***Per INFO:***

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***[mariopietro.carante01@ateneopv.it](mailto:mariopietro.carante01@ateneopv.it)***