

# Irradiations, recherche sur la radiothérapie/radiobiologie

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*CNRS - LPSC Grenoble*



*Journée thématique sur les irradiations et analyses*

# Introduction: Radiobiology

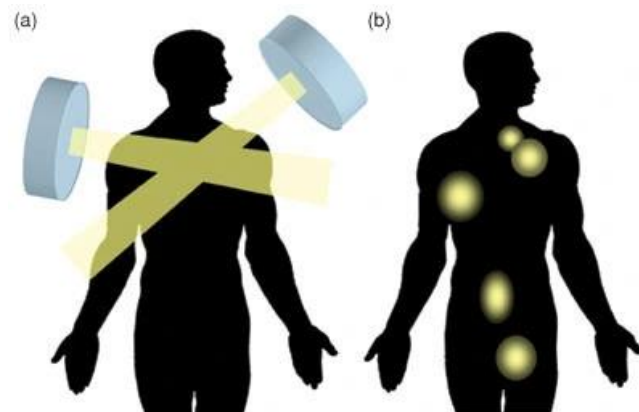
## Radiation Therapy and Diagnosis



## Radioprotection



## Space Radioprotection



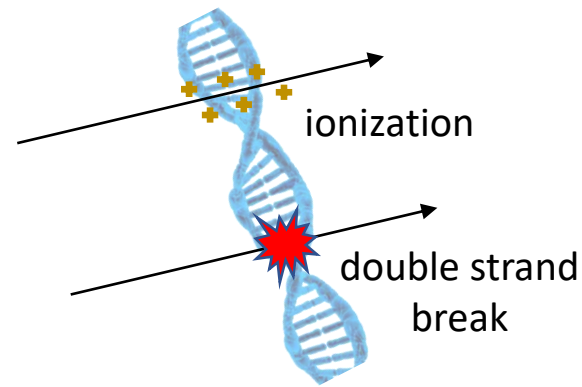
ZONES RÉGLEMENTÉES				
ZONES SPÉCIALEMENT RÉGLEMENTÉES				
<b>ZONE SURVEILLÉE</b>	<b>ZONE CONTRÔLÉE</b>	<b>ZONE CONTRÔLÉE</b>	<b>ZONE CONTRÔLÉE</b>	<b>ZONE INTERDITE</b>
Accès Réglementé	ACCÈS RÉGLEMENTÉ	ACCÈS SPÉCIALEMENT RÉGLEMENTÉ	ACCÈS SPÉCIALEMENT RÉGLEMENTÉ	ACCÈS SPÉCIALEMENT RÉGLEMENTÉ
<small>Ordonnance 2000-206 du 21 mars 2001 Article 40 10 mai 2000</small>				



# Introduction: Interaction of radiation and tissues

- **Indirect damage:** Water radiolysis leads to chemical species that may induce cell damage (e.g. oxidative stress)

- **Direct damage:** induced along ion track (e.g. DNA double strand break )

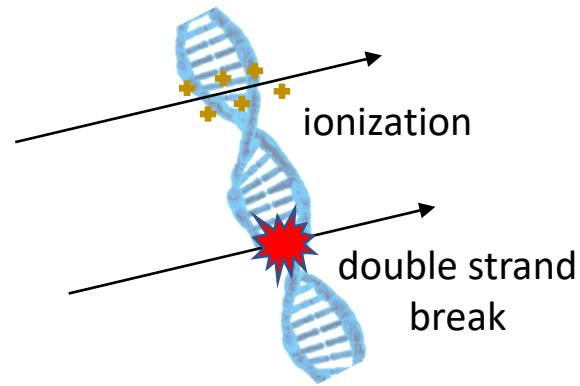


It depends on the particle

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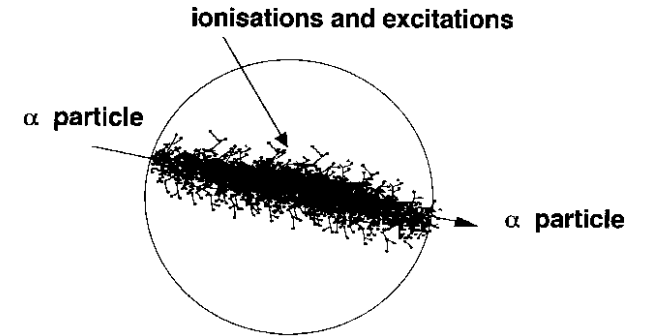
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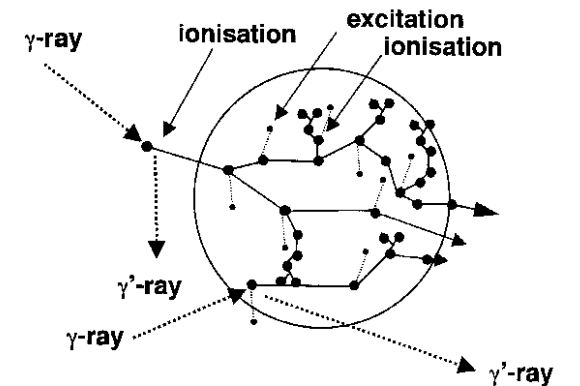


It depends on the particle

**High-LET:**



**Low-LET:**

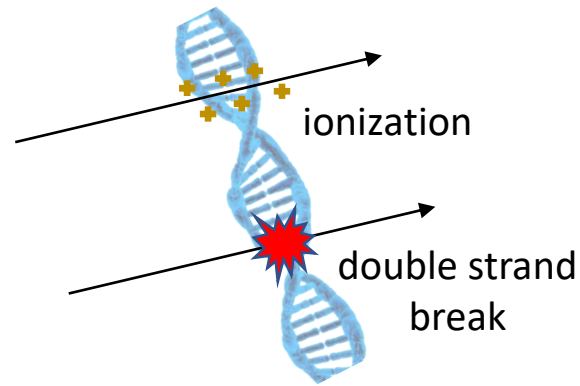


LET (linear energy transfer)

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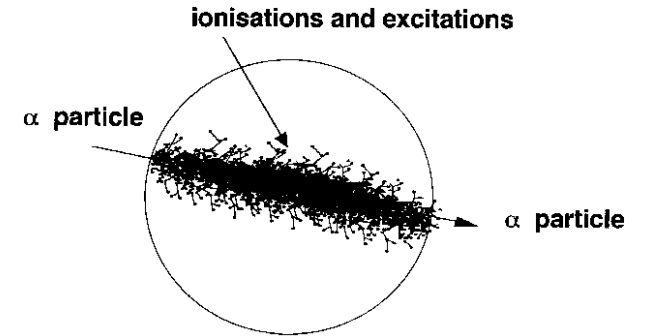
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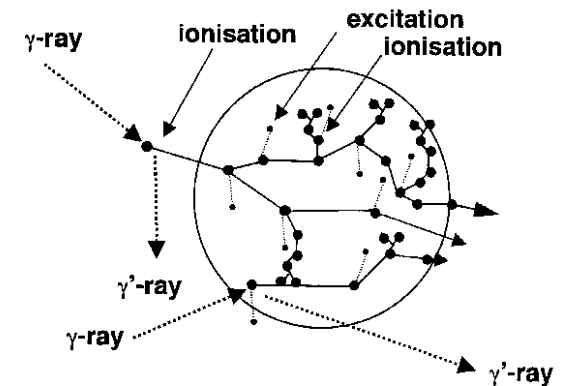


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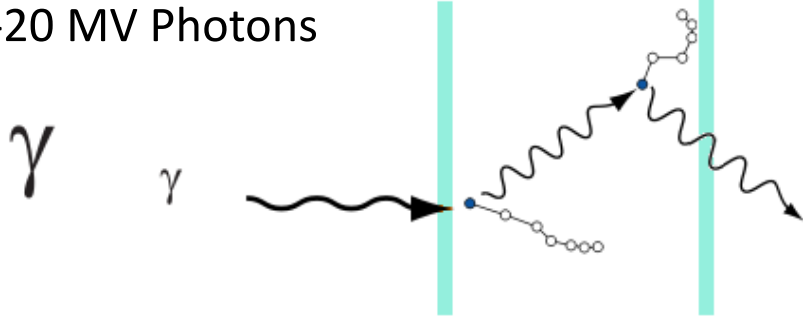


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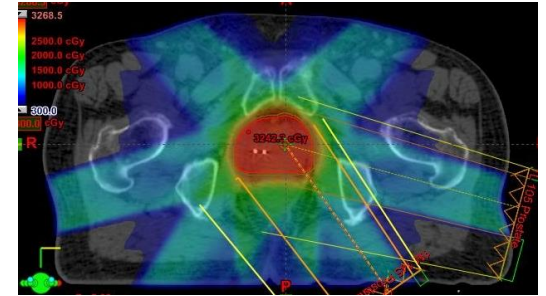
**Main idea of radiotherapies: Damage the tumour while keeping as safe as possible the healthy tissue**

# Radiotherapies: Conventional radiotherapy

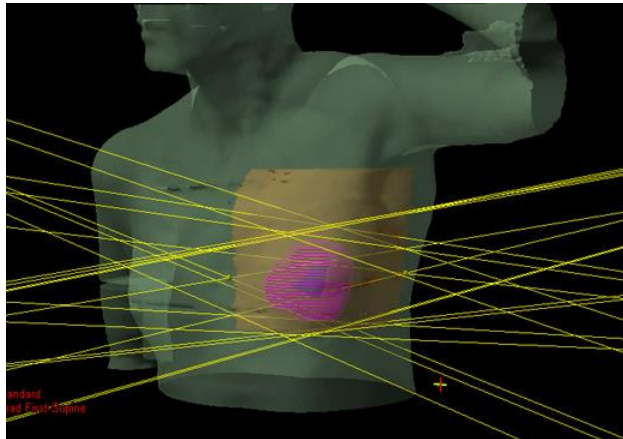
6-20 MV Photons



Mostly indirect damage all along their path



- > 95% of radiotherapy treatments
- External irradiation
- Geometry is key
- Healthy tissue is also damaged.

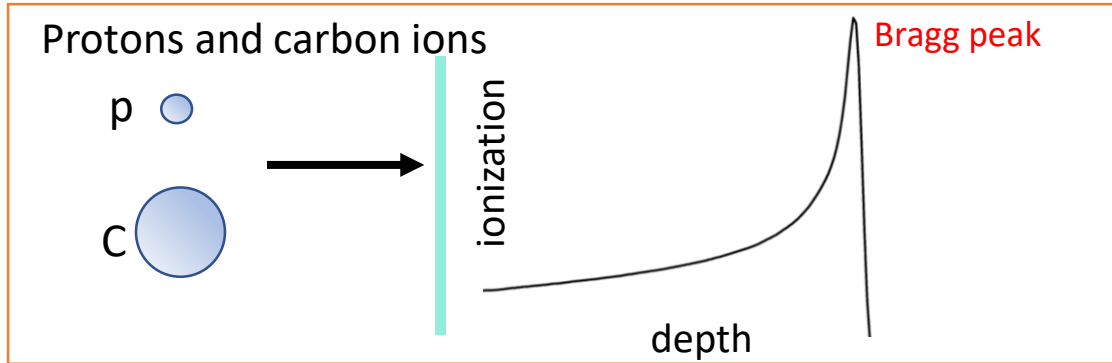


**No curative solutions for very radioresistant, bulky and diffuse cancers (glioblastomas), or non-localized tumors (multiple metastasis)**



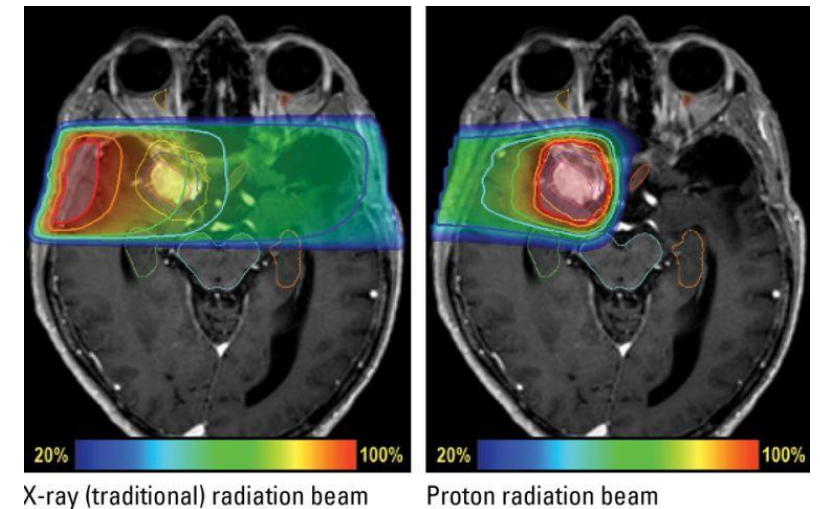
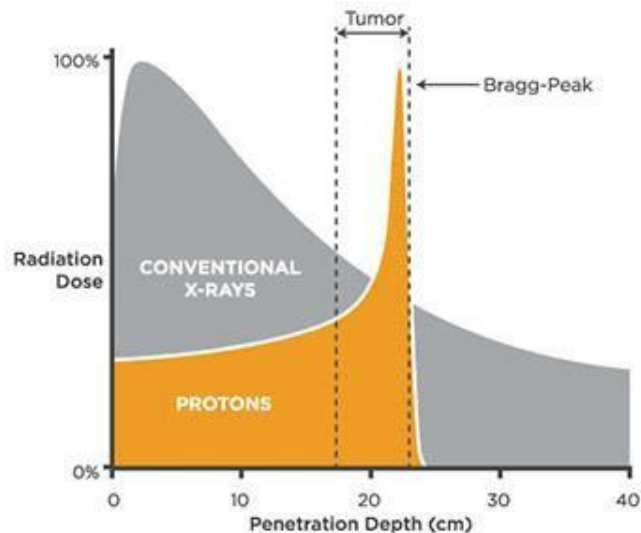
# Radiotherapies: Ions therapies, Hadrontherapy

Protons and carbon ions



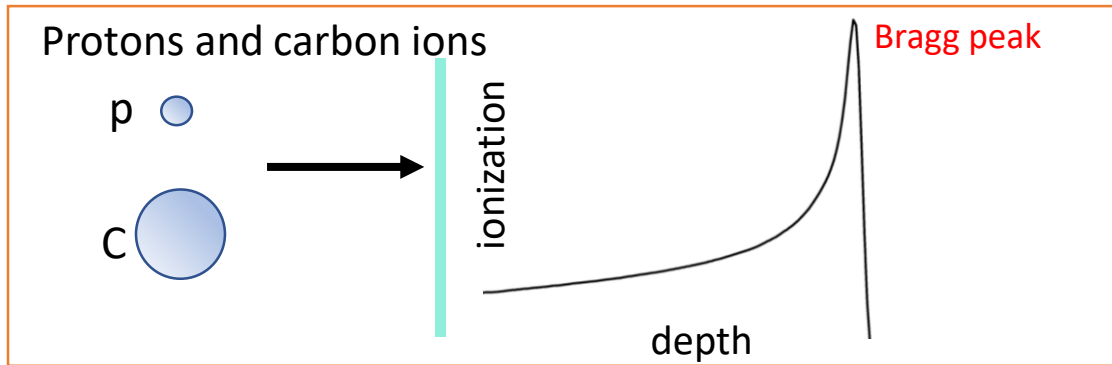
Energy lost following the bragg peak.  
Highest biological damages at a controlled deep.

- Extreme precision
- Induce a more efficient tumoral irradiation
- Preserve the healthy tissues
- Possibility to treat radio-resistant tumors



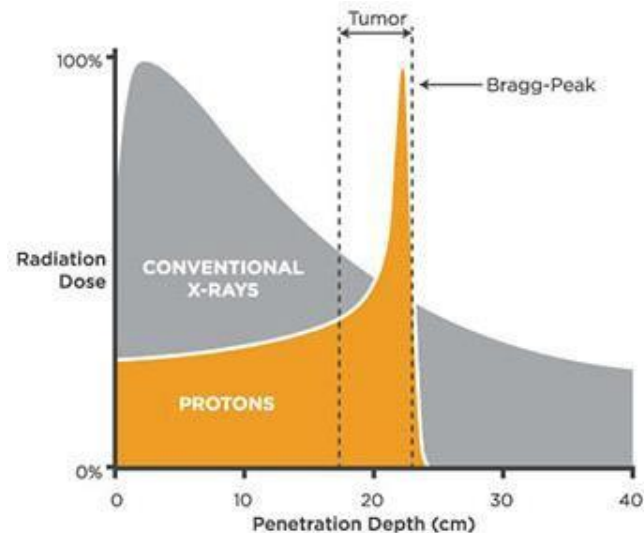
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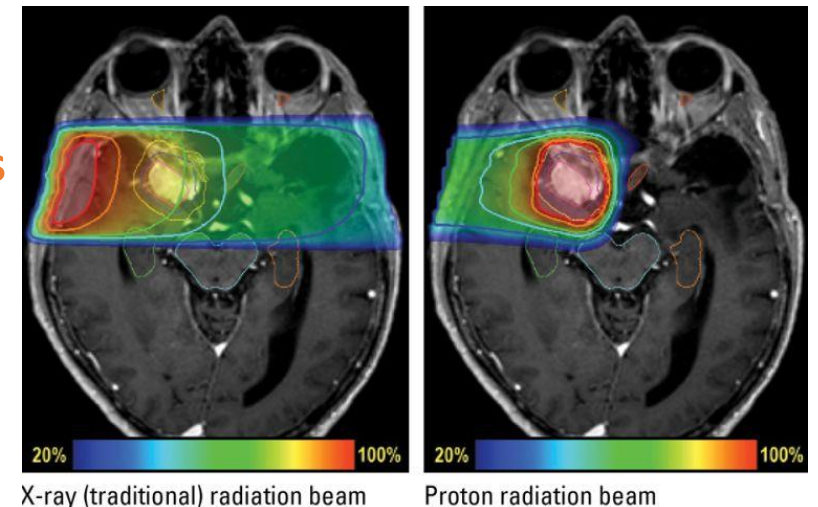
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**Treat radio-resistant tumors and tumors in particularly difficult locations**

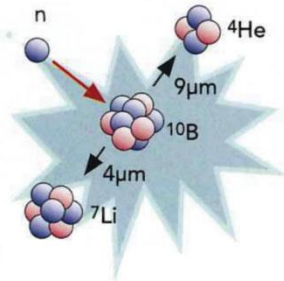
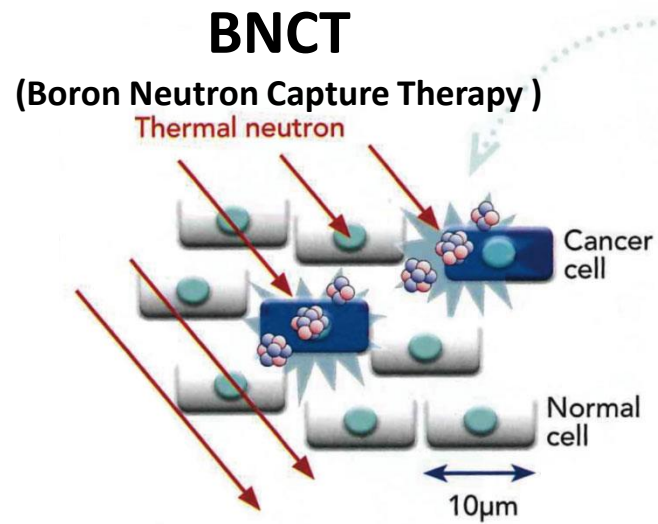
**Still No curative solutions for diffuse cancers (glioblastomas) or non-localized tumors (multiple metastasis)**



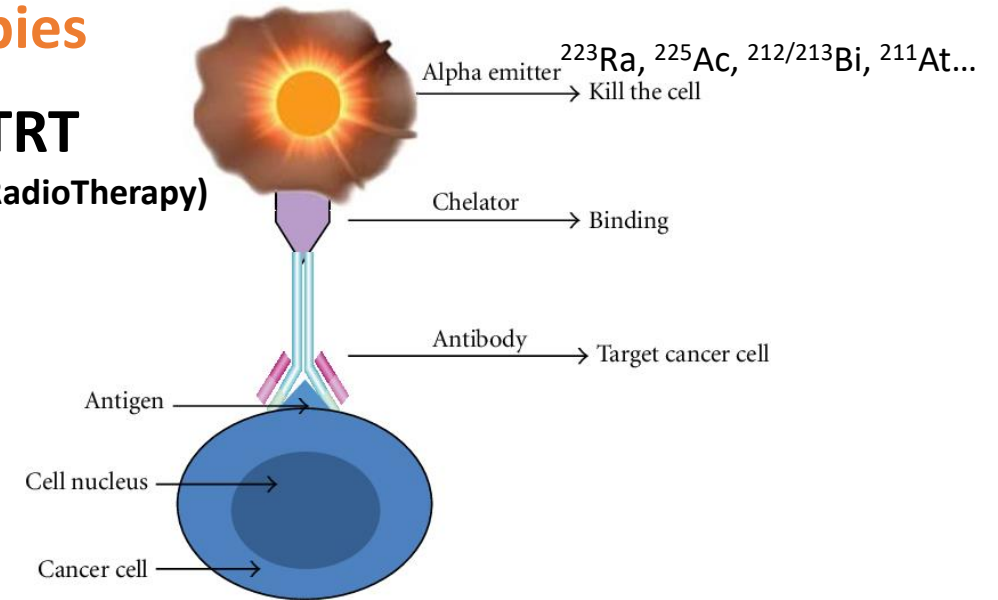


# Radiotherapies: Ion therapies, new therapies

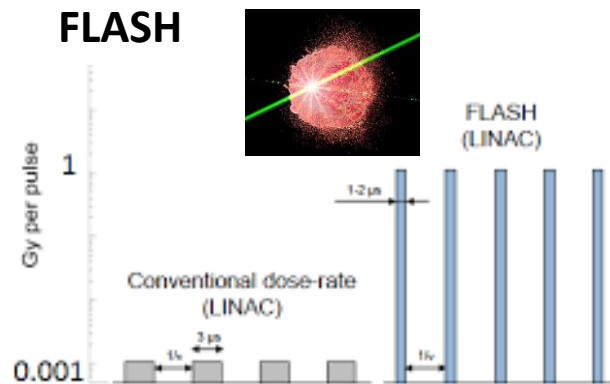
## Targeted radiotherapies



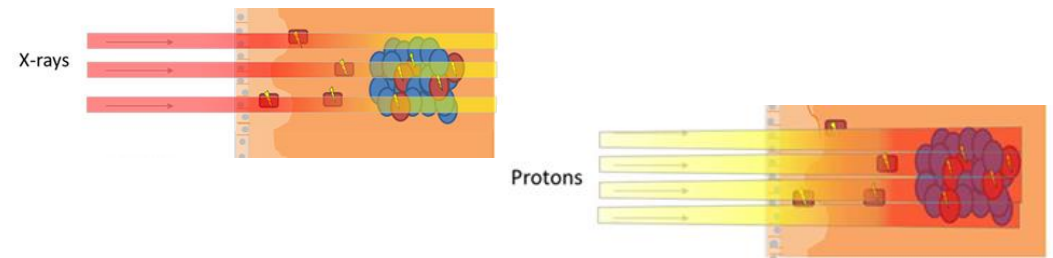
## $\alpha$ -TRT ( $\alpha$ -Targeted RadioTherapy)



## New dose delivery mode



## MRT (Microbeam RadioTherapy)




# Radiotherapies: Treatment Planification

- Absorbed Dose: Energy deposited in matter by ionizing radiation per unit mass
- Grays:  $1\text{Gy}=\text{J}\cdot\text{kg}^{-1}$
- The absorbed dose estimation in the patient and treatment design are done with treatment planning systems adapted for each radiotherapy




It is necessary a robust model that describes good the energy deposition and the biological consequences to plan correctly the treatments

# Radiotherapies: Biological Dose

Absorbed dose  Biological dose

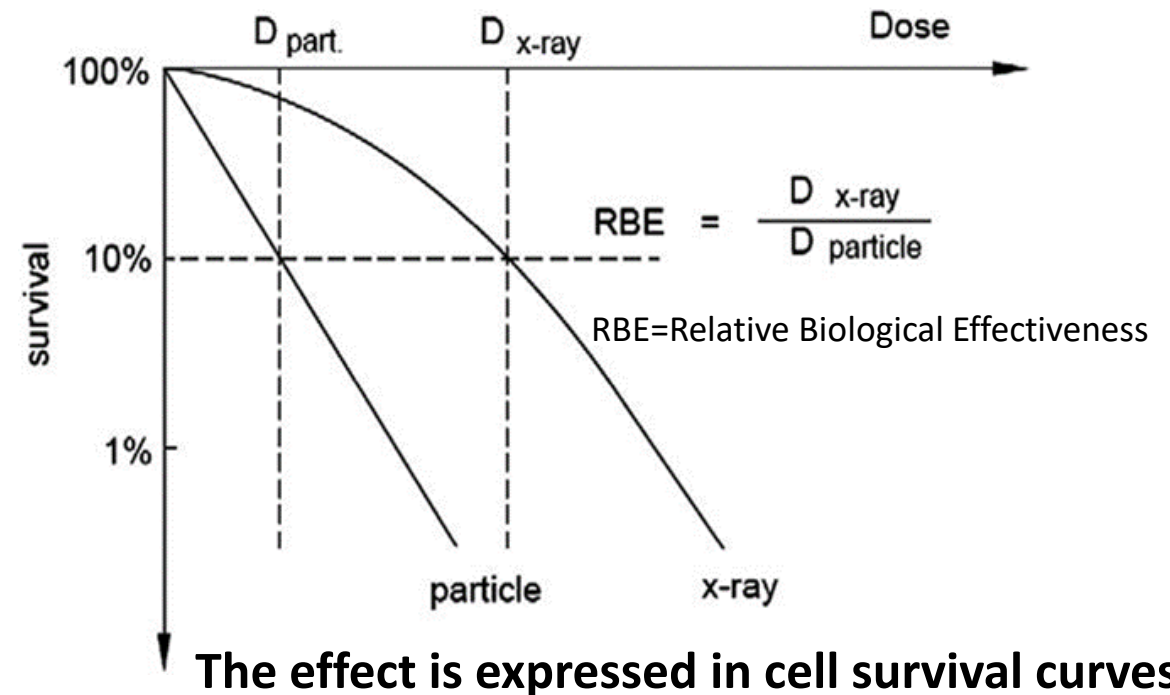


# Radiotherapies: Biological Dose


Absorbed dose  Biological dose



1. Weight each dose with a factor (**RBE**)
2. Compare with a known effect (**Reference photon Dose**)



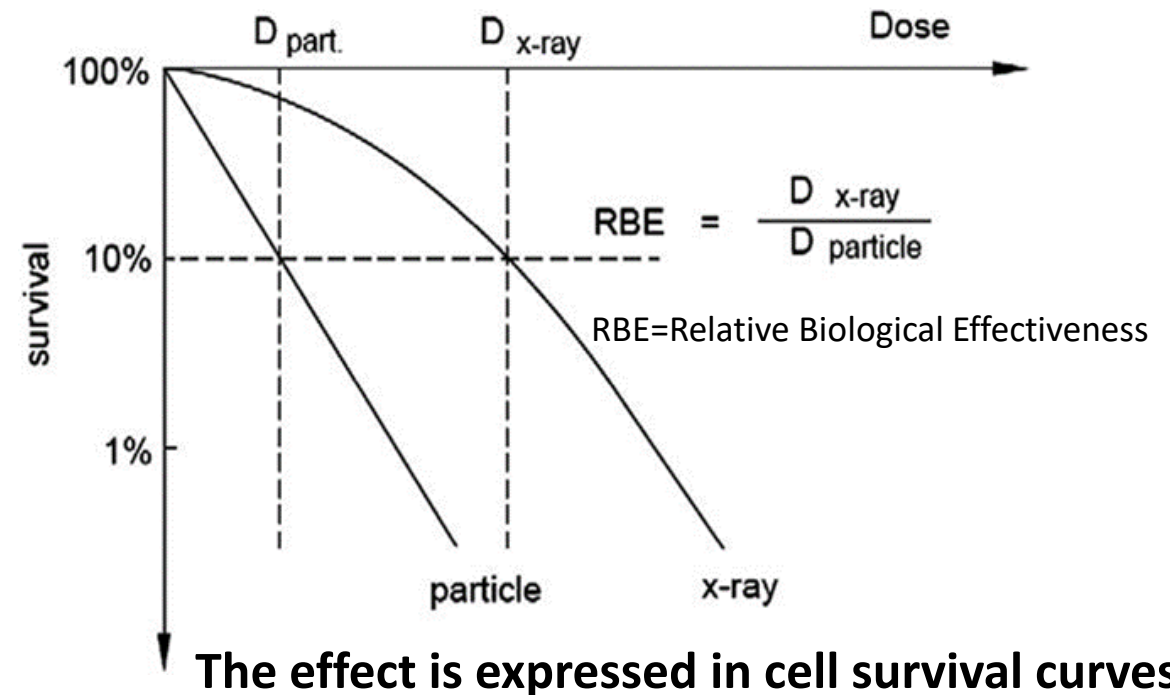
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Absorbed dose  Biological dose



**RBE** depends on:  
Particle type, energy and LET, Cell type, Dose, dose per fraction...

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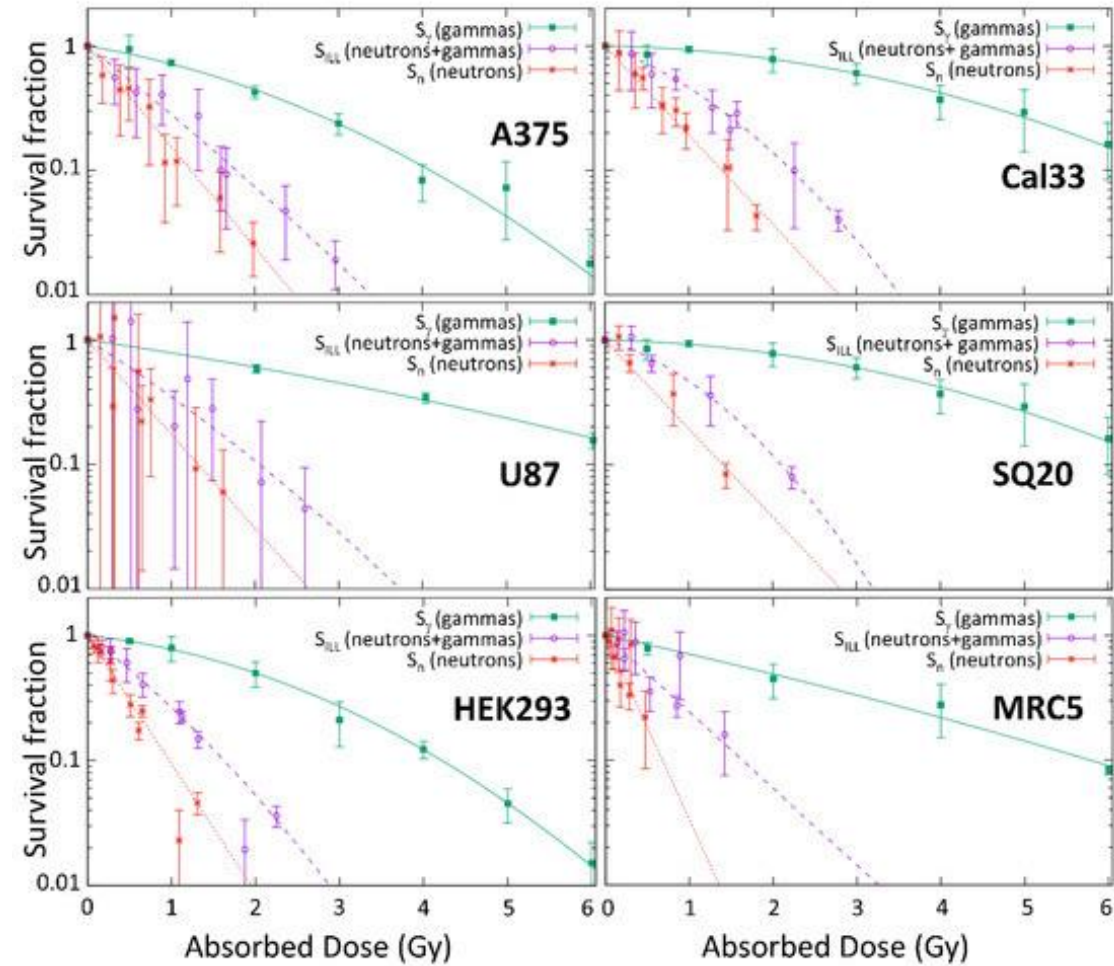


# Radiotherapies: Biological Dose

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**There is a clear necessity of a lot and variable data for accurate RBE values for each case**

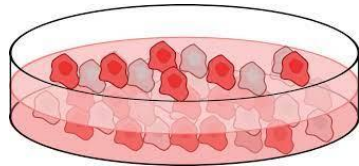
# HOW?

# Experiments: Irradiations

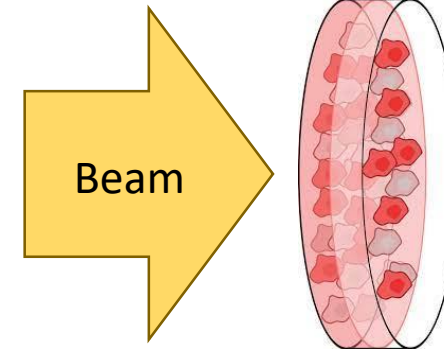
*In vivo*



*In vitro*



Irradiations



All cells must receive the same very well known dose

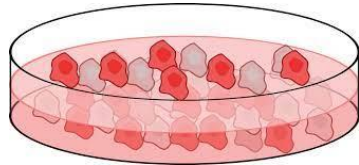


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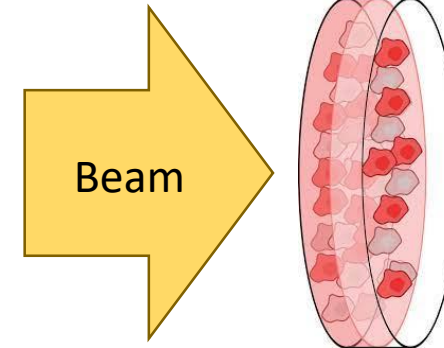
*In vivo*



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Irradiations



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## Dosimetry tools

Monte Carlo simulations



Set-up (beam, geometry, Dose rate...)



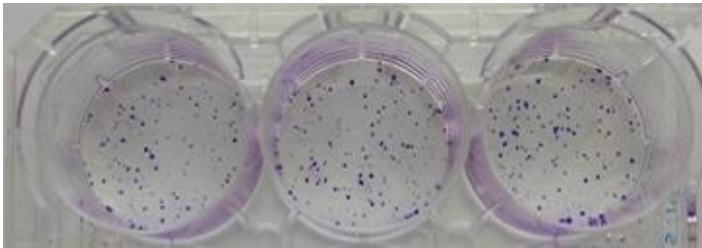
Detectors



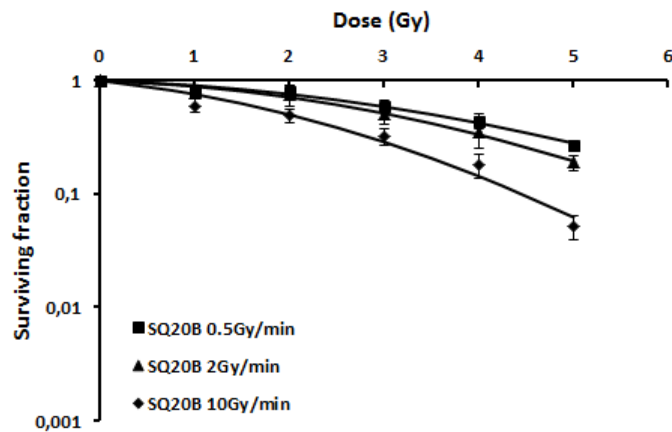
# Experiments: In vitro, cell analysis

Endpoint -> what do we look at after the irradiation

Survival (Clonogenic assays)



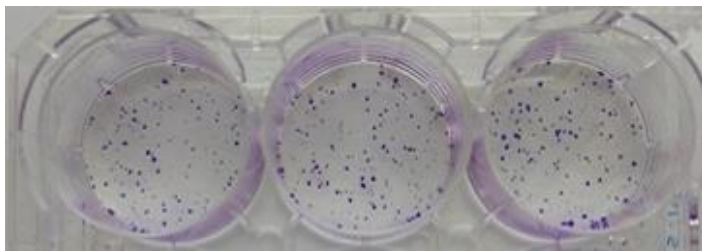
Survival curves



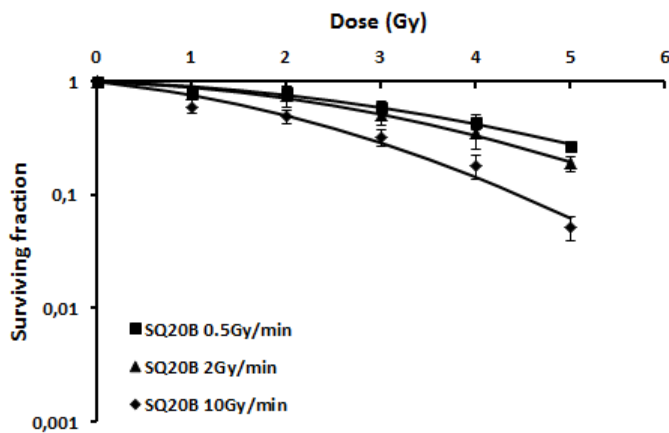
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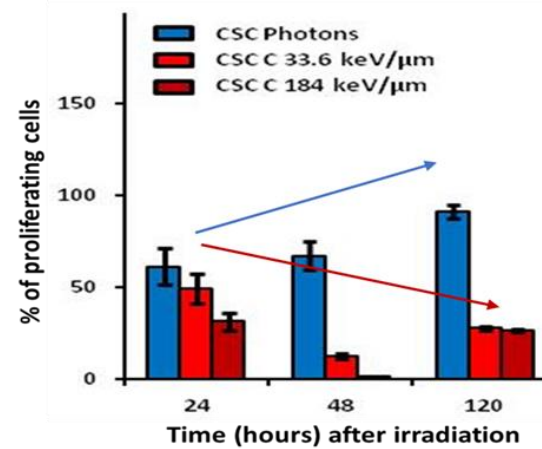
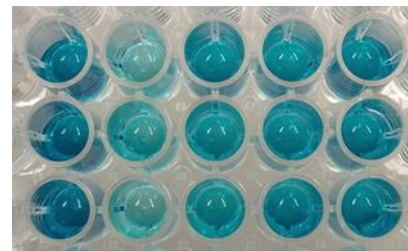
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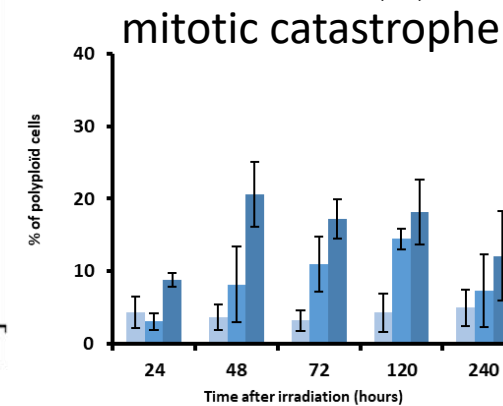
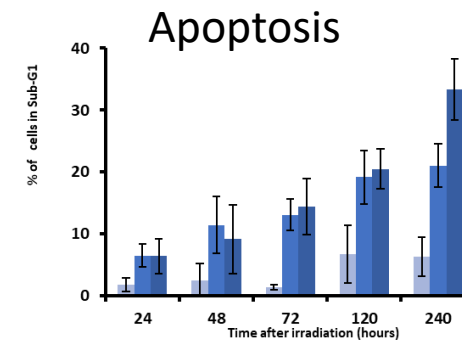
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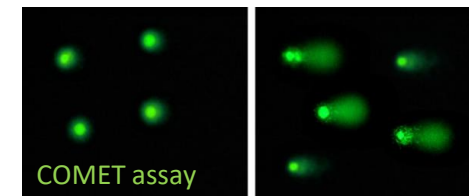
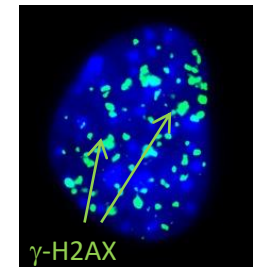
Proliferation



Cell death



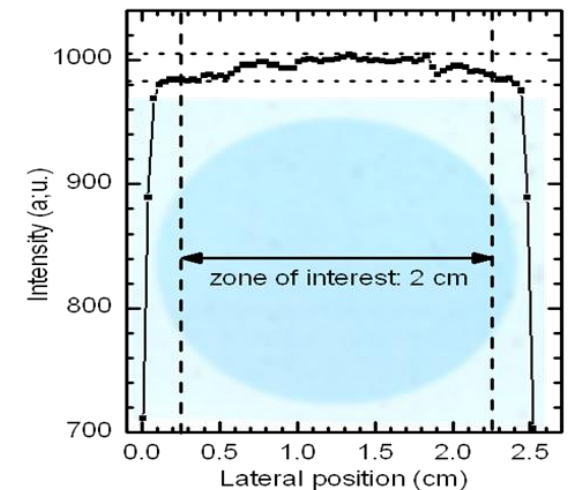
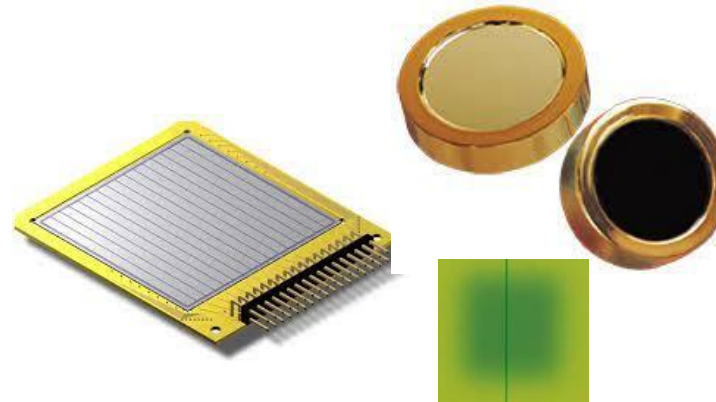
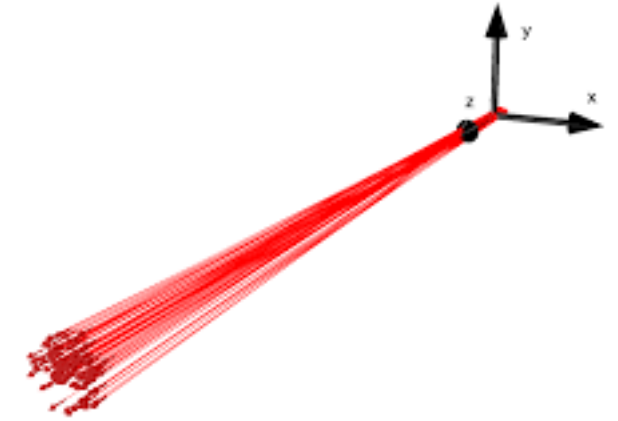
DNA Lesions



Necessity of triplicates samples

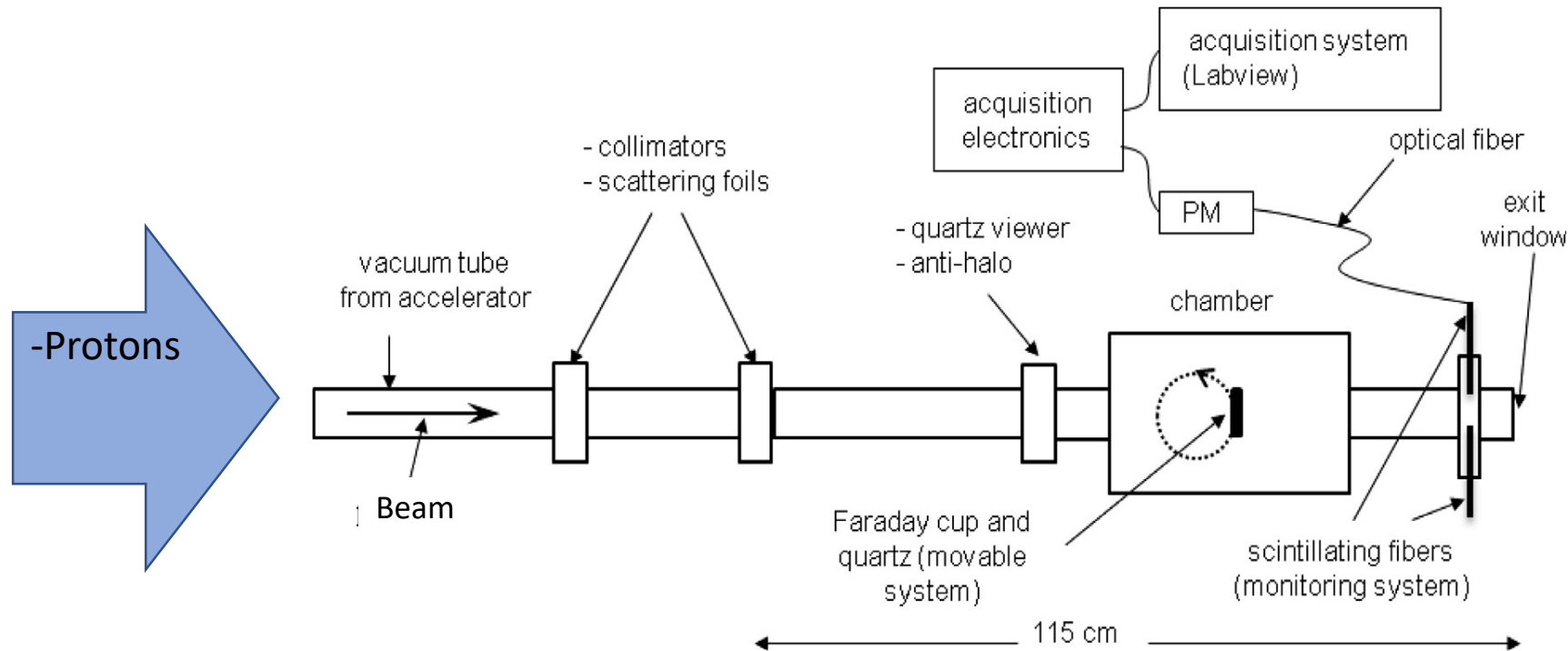
# Requirements for radiobiological experiments

- Biological lab
- Beam of the particles which effect wants to be studied
- Very well-known beam for precise dose estimation
- Detectors for beam monitoring for dose checking
- Beam stability and homogeneity for reproducibility of the results



# Example: A radiobiological experiment at ALTO

# Example: A Radiobiological line at ALTO, Radiograaff



## 3 MeV protons

Penetration: 150  $\mu\text{m}$  in water

Zone: 2 cm diameter disk

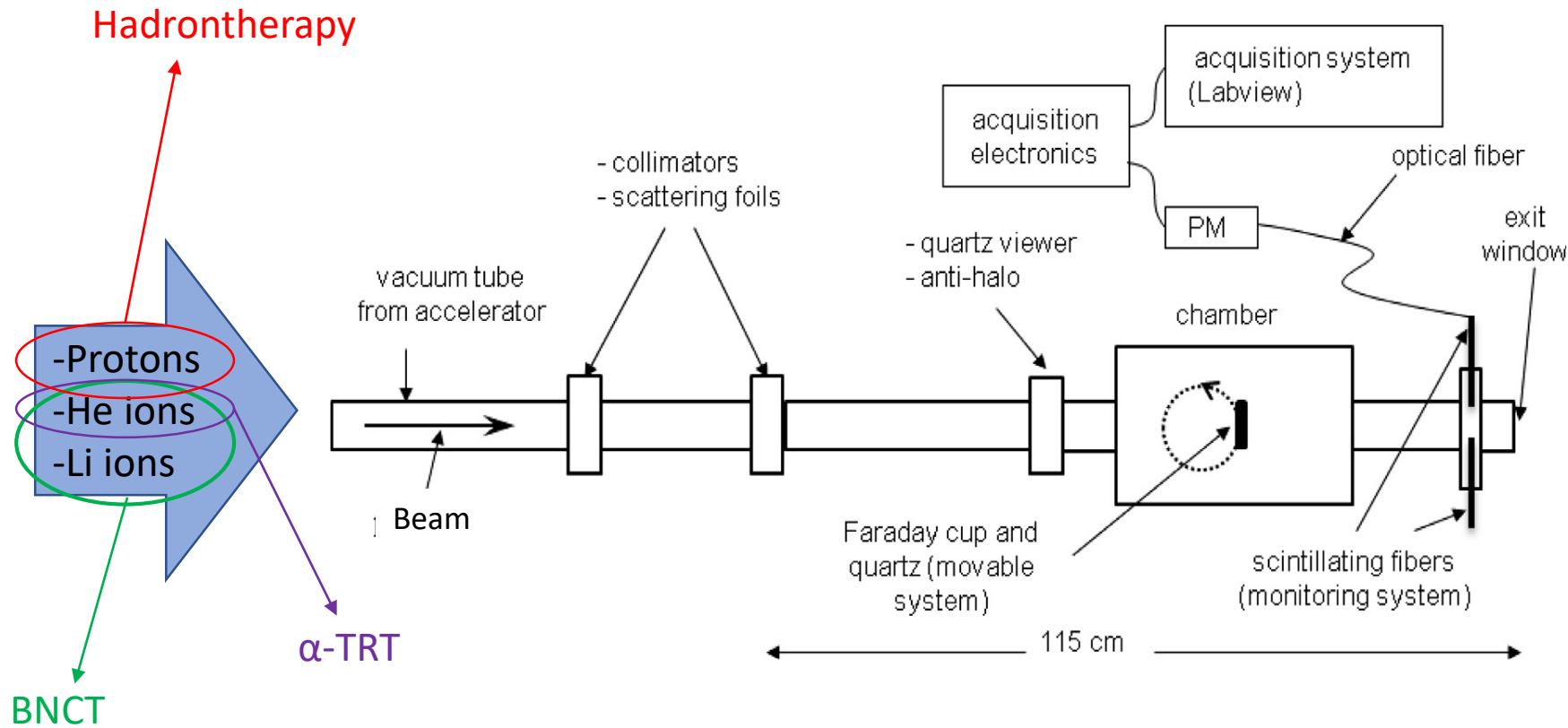
Energy: fixed at  $\pm 2\%$ .

Uniform dose:  $\Delta D/D \pm 2\%$ .

Fluence:  $\Delta F/F \pm 4\%$  Dose rate

Dose rate: 0.1 Gy/min to 10 Gy/min

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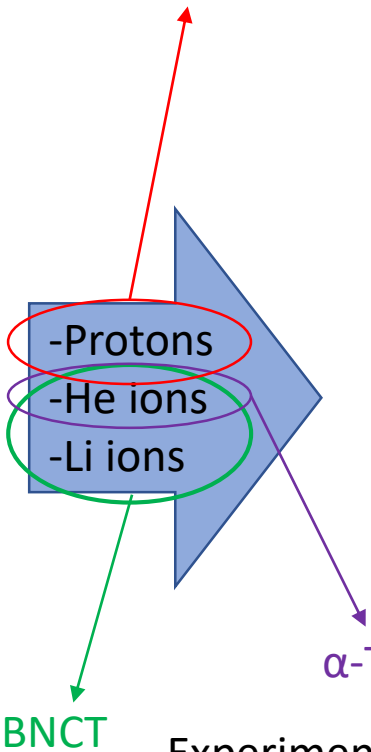
**Lithium**

**>3 MeV protons**

Feasibility study

# Example: A Radiobiological line at ALTO, Radiograaff

Hadrontherapy



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**Helium**

**Lithium**

**>3 MeV protons**

Feasibility study

Experiments for setting up the beamline started on June 2021.

Silicon detector counting and gafchromic films measurements were done

**Once the beamline study and installation is complete, it will open the door for other groups for future radiobiology irradiations.**



Thank you for your attention!  
Merci!  
Gracias!



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