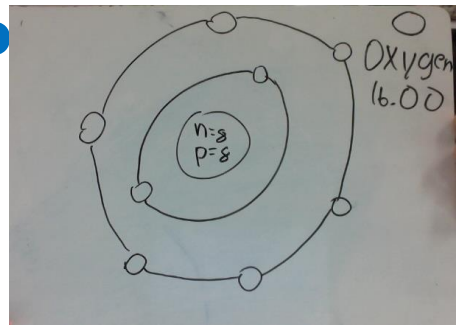
BIOphysical characterization of Helium and Oxygen ion beams for hadronTherapy

BIO HOT!

Proposta di nuovo esperimento

INFN-CSNV

2023-25



Unità partecipanti

- **PV:** F. Ballarini, M. Carante, A. Facoetti, M. Pullia, A. Maira ni *(da associare)*
- **NA**: L Manti *et al.* (RN)
- **Roma3:** A. Antoccia, F. Berardinelli, V. Dini

- Partners:
  - CNAO (Centro Nazionale di Adroterapia Oncologica)
  - HIT (Heidelberg Ion-beam Therapy centre)
  - Queen's University, Belfast, UK

Anagrafica PV

Francesca Ballarini (PA) 0.5

Mario Pietro Carante (RTDa) 0.2

Angelica Facoetti (CNAO) 0.5

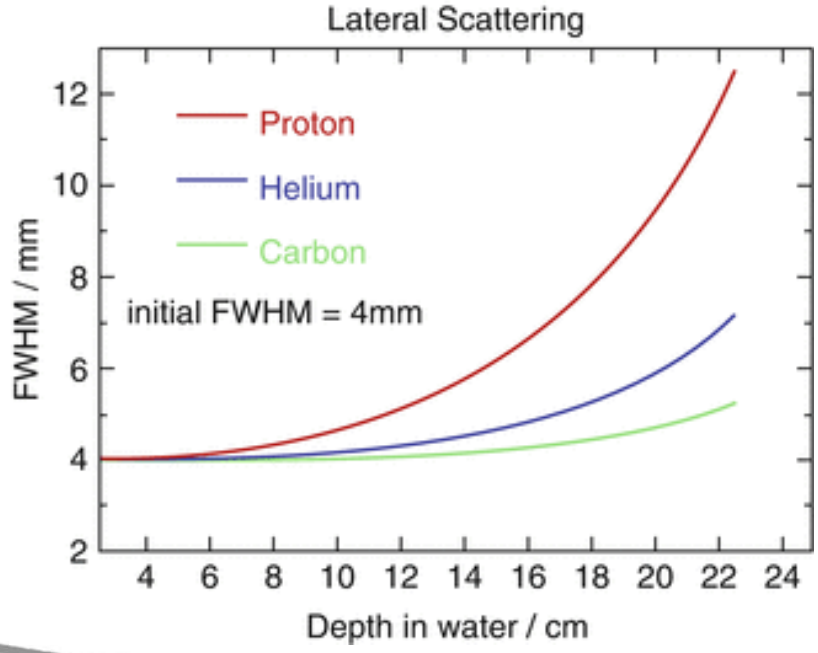
Marco Pullia (CNAO) 0.2

Andrea Mairani (HIT, *da associare*) 0.2

FTE Pavia 2023: **1.6**

Motivation for He ions

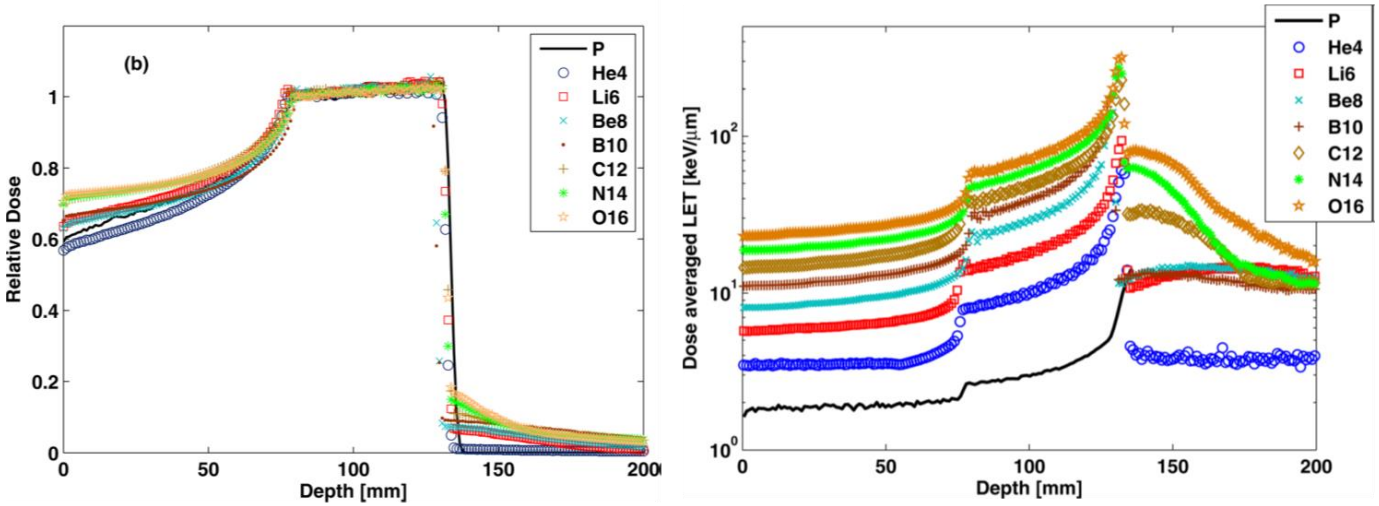
- with respect to protons, ^{4}He has less lateral scattering and range straggling, and higher LET ➡
  - *higher dose conformity to tumour with higher RBE*
  - *reduced dose to surrounding healthy tissues*
  - *indications for paediatric and/or close-to-OAR radioresistant tumours*
- at HIT, a patient has already been treated with ^{4}He
- CNAO will have a new source accelerating ^{4}He by 2023



Motivation for O ions

- ^{16}O is more effective than ^{12}C ions ⇒
  - *potential benefit against radioresistant tumours*
  - *greater insensitivity to cell-cycle variations*
  - *enhanced anti-angiogenic and anti-metastatic properties*

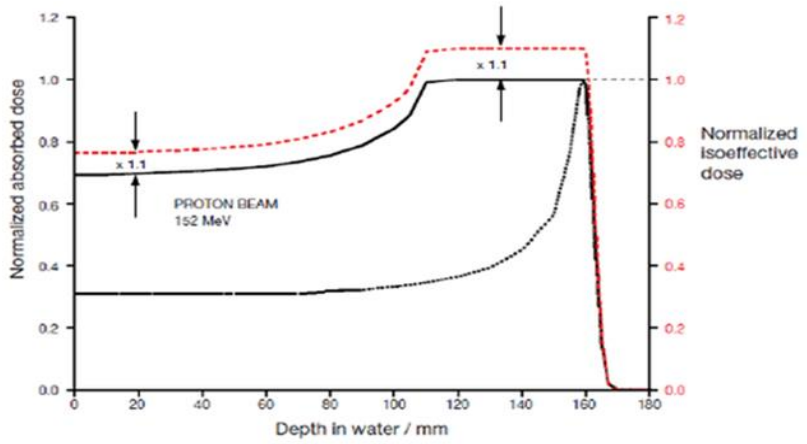
- both HIT and CNAO are also considering to use ^{16}O beams

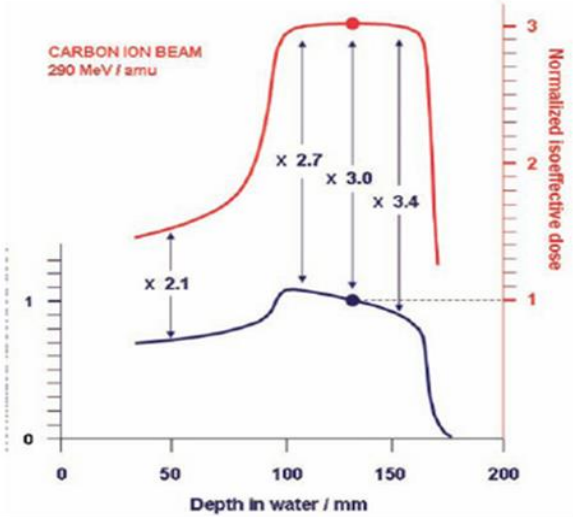


Relative dose (left)and dose-averaged LET (right) distributions for various ions.
He offers the best peak-to-plateau ratio, O the best trade-off between high LET and fragment tail
Kantemiris et al., Medical Physics, 2011

Motivation of the project

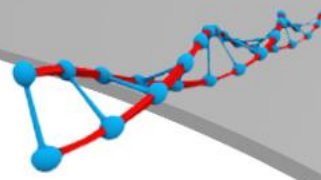
- for protons, a constant RBE (= 1.1) is assumed in clinics, but f or heavier ions (Z>1) the RBE needs to be known precisely in every position of the SOBP *(mm resolution)*
- the RBE can be evaluated, basing both on *in vitro* (and *in vivo*) experimental data and on biophysical models
- while for C-ions many data and models are already available, for He- and O-ions more data and modelling studies are nece ssary





Technical Reports Series n.461 (IAEA 2008).

Main objectives



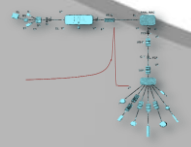
· need of *in vitro* and *in silico* pre-clinical data for ^{4}He and ^{16}O

⇒main project aim:

Biophysical characterization of these new beams, by means of:

- radiobiology experiments, to evaluate the response of both tumoral and healthy (=non-tumoral) cells
- modeling/simulations of the same endpoints, for interpreting the ex perimental results and making predictions where there are no data
- microdosimetric measurements

- This will prove essential also for facility intercomparison between HIT and CNAO



Pavia activity
1. Computational radiobiology

- the simulation activities will be based on the BIANCA biophysical model, developed in Pavia
- BIANCA can simulate cell death and chromosome aberrations by different radiation qualities (=different ions and energies) and for different cell lines
- BIANCA can be interfaced to a radiation transport code or a TPS to predict the biological effects along therapeutic ion beams
- BIANCA has been already validated for C-ions (and protons)
- in BIOHOT, BIANCA will be extended to He- and O-ions, for the same cell lines used in the experiments

Pavia activity
1. Computational radiobiology- *continued*

In particular, the simulation outcomes will be compared with th e following data obtained by the experimental partners:

- cell survival curves for a (pancreas) tumour cell line ⇒ evaluation of the RBE for tumour control

- chromosome aberration dose-response curves for two normal (=non tumoral) cell lines ⇒ evaluation of healthy tissue damage

- DNA damage 'foci', which will be compared with the BIANCA param eter representing DNA 'critical lesions' ⇒ insights into the mechanis ms of radiation-induced damage

Pavia activity
2. Radiobiology experiments

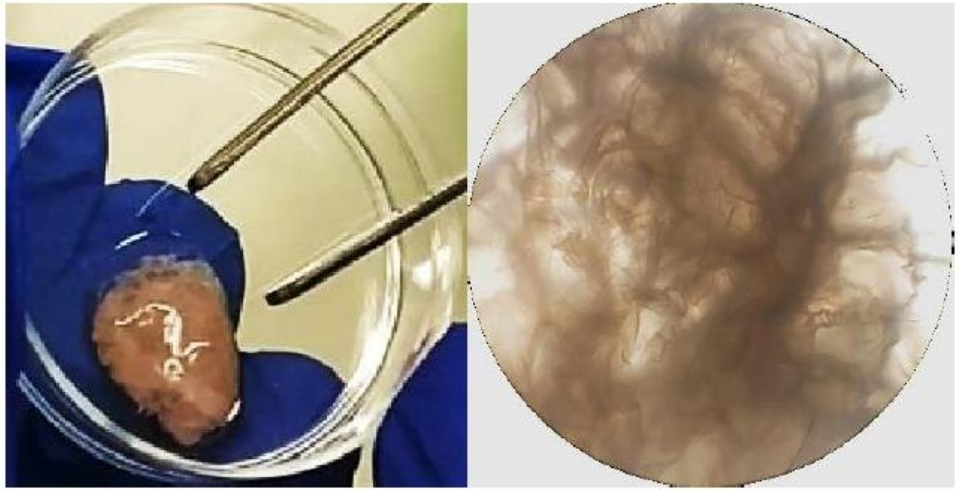
The experimental activities will be carried out based on the exp ertise of the CNAO radiobiology group on biological scaffolds:

- biological scaffolds are biological structures derived from real tissues/organs deprived of their cellular component, but preserving the structural and functional molecular units of the remaining extracellular matrix (ECM)
- they mimic the *in vivo* environment, promoting cell viability, proliferation, diffusion of oxygen and nutrients, etc.
- they have already been used by the CNAO research group, which for the first time ever used this system for radiobiological studies with photons and charged particles

Pavia activity

2. Radiobiology experiments -*continued*

Hepatic scaffolds will be used:



- the scaffolds will be populated through the seeding of normal and/ or tumour cells
- they will be then irradiated by He- and O-ions, and photons for co mparison

Spese PV-2023

MISSIONI: 2 k€ (turni di misura a HIT-Heidelberg)

CONSUMO: 15 k€ per esperimenti radiobiologia *(reagenti per pr eparazione scaffolds, plastica e reagenti per coltura cellule, kit is tochimica, kit immunoistochimica)*

INVENTARIABILE: 1.5 k€ per PC portatile da utilizzare per acqu isizione dati durante i turni di misura presso CNAO e/o HIT

- BUDGET INTERO PROGETTO: ~30 k€ per Unit per year ⇒ **~90 k€ for 2023**