Hadrontherapy with hElium and protons as Advanced Radiotherapy Treatment for BrEAst Tumors

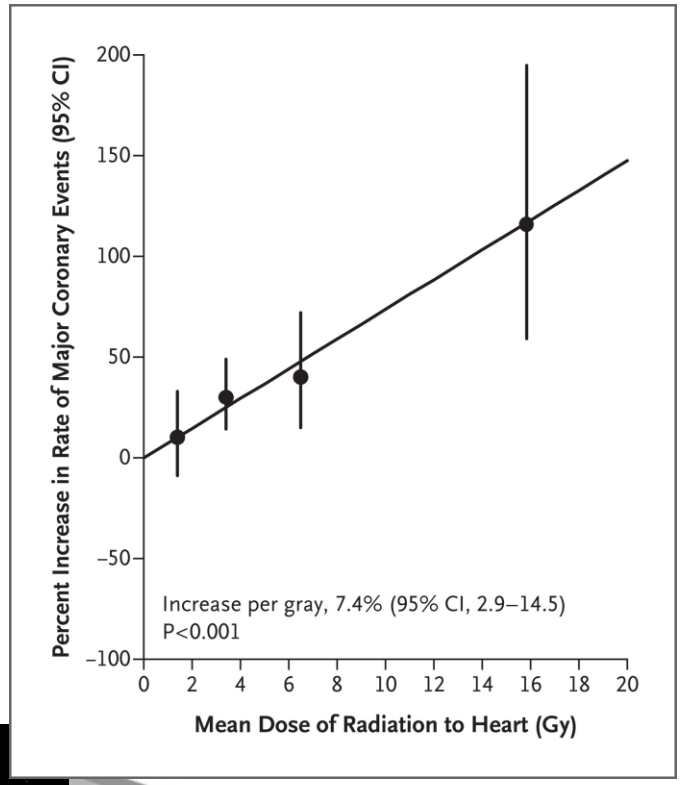
Proposta di nuovo esperimento

INFN-CSN5

2026-28

Rationale

- Breast Cancer (BC) has a deep impact on society
- It can be effectively controlled by photon-based Conventional RadioTherapy (CRT)
- However, late CRT-induced cardiovascular disease (CVD) has emerged as an important complication



Darby et al., Risk of ischemic heart disease in women after radiotherapy for breast cancer, N Engl J Med. 2013

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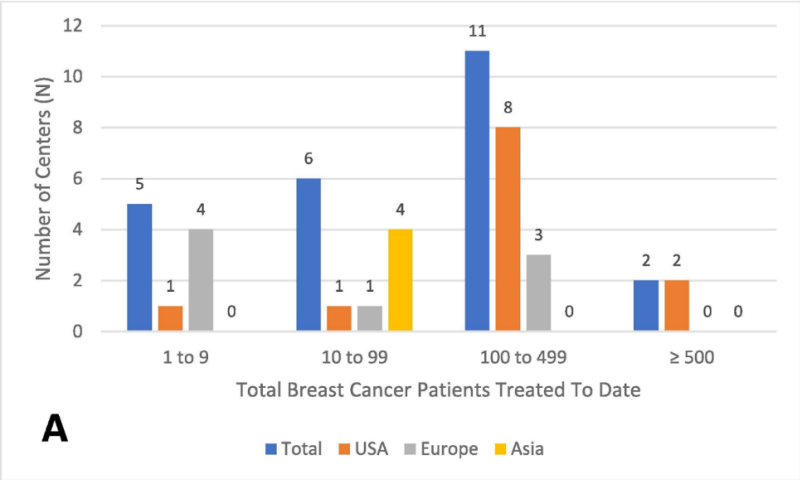
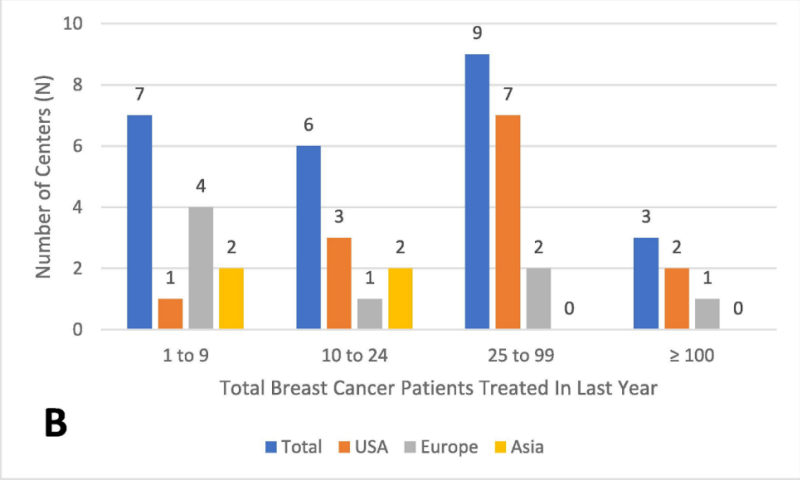
HEARTBEAT will study the possibility to treat BC with protons, given their higher precision in dose conformality to the tumour target, in line with several clinical trials current underway





Choi JI et al., PTCOG international survey of practice patterns and trends in utilization of proton therapy for breast cancer. Clin Transl Radiat Oncol. 48, 100847 (2024).

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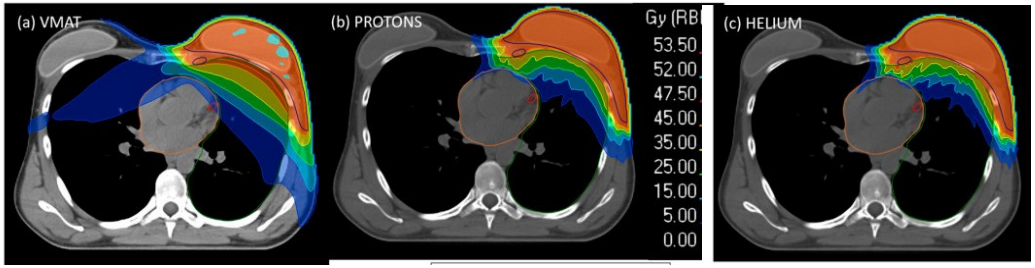
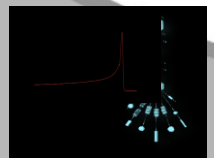
- HEARTBEAT will also study ^{4}He beams, as they promise greater sharp ness in dose penumbra, hence sparing further cardiac tissue



Bonaccorsi SG et al., Exploring Helium Ions' Potential for Post-Mastectomy Left-Sided Breast Cancer Radiotherapy. Cancers (Basel). 16, 410 (2024)

- Irradiations will be performed at CNAO
- Three tasks: Radiobiology, Modelling and Microdosimetry



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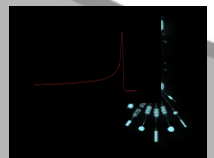
Attività PV

Modelling:

- extension of the BIANCA model to predict cell death in breast cancer cells and chromosome damage in healthy cells (same cells, same particle type and same doses us ed in the experiments)
- comparison of model predictions with the experimental data, and with analogous predictions made by RM3

Experiments (CNAO):

- technical support to the irradiations by all partners
- characterization of breast cancer cell migration/invasive-ness



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Milestones

Task	Month	Milestone
Radiobiology	18	**M1:** Radiobiological characterization of cell death, DNA repair of DNA damage and anti-migratory behavior in BC MCF-7 and MDA-MB231 cells following clinical proton irradiation
	18	**M2***:* Radiobiological characterization of damage to cardiac endothelial and breast epithelial cells by measurement of endpoints related to cardiac injury and secondary cancers in BC patients treated with protontherapy
	36	**M3:** Characterization of the effects of a clinical 4He beam on BC and normal cells: comparison with proton data
Modelling	12	**M4**: Definition of the irradiation setup ensuring matched SOBP and LET for proton and ^{4}He beams to study biological effects under equivalent conditions
	24	**M5:** Prediction of biological damage using BIANCA and Survival models and comparison with experimental results on tumor and normal cell lines
	36	**M6:** Application of validated models to simulate breast cancer treatment plans with protons and ^{4}He
Microdosimetry	24	**M7:**Microdosimetric characterization of the clinical proton beam using all involved detectors. The characterization includes both in-field regions, corresponding to depths within the SOBP overlapping with the tumor volume, and out-of-field regions, to assess the impact on surrounding healthy tissue
	36	**M8:** Microdosimetric characterization of the clinical ^{4}He beam using all involved detectors. The characterization includes both in-field regions, corresponding to depths within the SOBP overlapping with the tumor volume, and out-of-field regions, to assess the impact on surrounding healthy tissues.

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FTE 2026

PV (1.5 FTE), NA (6.1 FTE), LNL (1 FTE), LNS (2.9 FTE), RM2 (1.1 FTE), RM3 (1.3 FTE)
totale: 13.9 FTE

Francesca Ballarini (RL)	PA Unipv	60%
Mario Carante	RTT Unipv	30%
Ricardo Ramos	RTT Unipv	20%
Angelica Facoetti	CNAO	10%
Marco Pullia	CNAO	10%
Federica Carnevale	CNAO	10%
Alexandra Charalampopoulpo	CNAO-Dottoranda IUSS	10%

Richieste 2026

PV: 10 k€ (consumo per esperimenti radiobiologia)
NA: 25.5 k€ (7.5 missioni + 18 consumo)
LNL: 4 k€ (2 missioni + 2 consumo)
LNS: 6 k€ (4 missioni + 2 consumo)
RM2: 4 k€ (2 missioni + 2 consumo)
RM3: 19.5 k€ (7.5 missioni + 12 consumo)
totale 2026: 69 k€