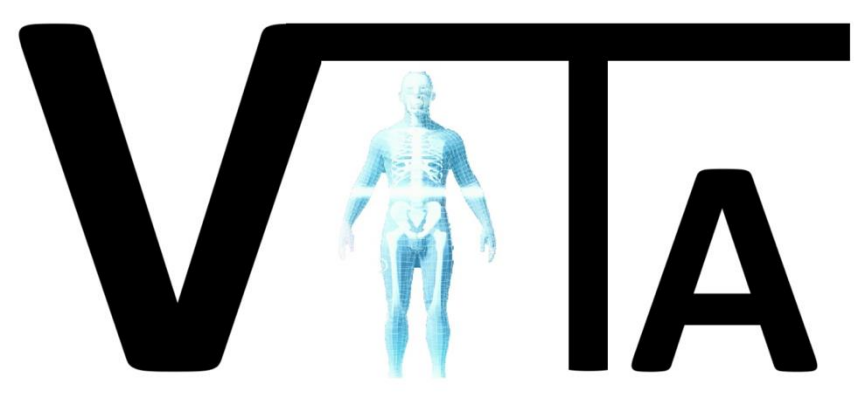




Virtual Imaging TriAls in Medicine

a frontier project of interdisciplinary & technological research of INFN CSN5

Responsabile Nazionale
Giovanni Mettivier

Sezioni Coinvolte
Napoli, Roma1, Padova, Torino, Catania, CNAF, TIFPA, Firenze

40 Ricercatori coinvolti



Clinical Imaging Trials

Evaluation of any new medical imaging technique or device is done via Clinical Imaging Trials.



Image acquisition from human subjects



Lack of ground truth knowledge.



limited by ethical constraints



Time consuming



Difficulty in requiring enough diverse subjects



Expensive



We need **more rapid and objective assessment** of new medical imaging technologies.

A practical solution is to perform **in silico trials of medical imaging technologies** using a computational model of the patient, the imaging device, and the physician.



Cost effective



Time effective



No ethical concerns
(no dose delivered to patients)



Ground truth is
known



Higher statistical power

Real trial

Real population



Real acquisition



Radiologist interpretation

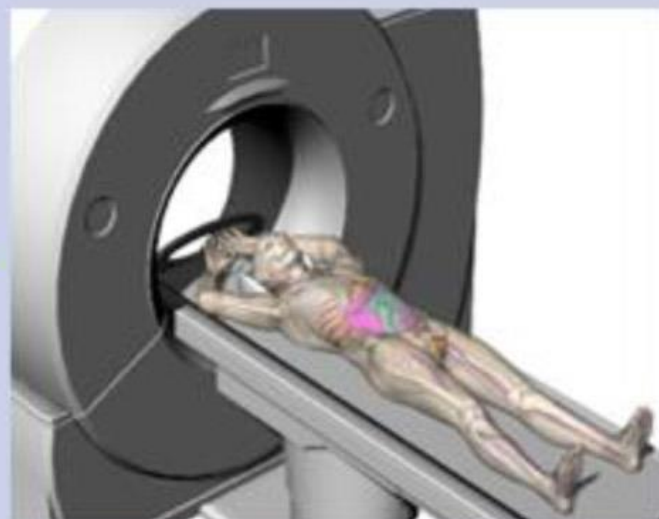


Virtual trial

Virtual population



Virtual acquisition



Virtual interpretation



Virtual patient (digital twin)

Computational anthropomorphic phantoms that model the patient anatomy and physiology.

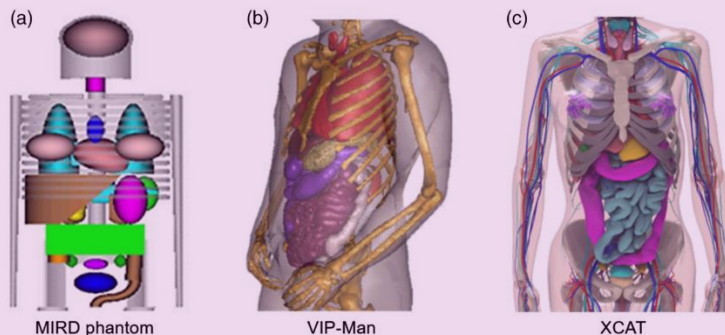
Provide ground truth for virtual imaging.

Phantom types

(a) Mathematical

(b) Voxelized

(c) Boundary Representation (BREP)



Virtual scanner (digital twin)

Techniques to replicate the scanner

1. Monte Carlo techniques (X-ray imaging, SPECT, PET)
2. Efficient equation solvers (MRI)
3. Finite-element analysis (Ultrasound)



Virtual reader

Mechanism to retrieve a judgement and interpretation about a virtual imaging case.

AI models to decide whether the lesion is present or not or to localize it (computer-aided detection algorithms)



Virtual patient

(digital twin)

Computational anthropomorphic phantoms that model the patient anatomy and physiology.

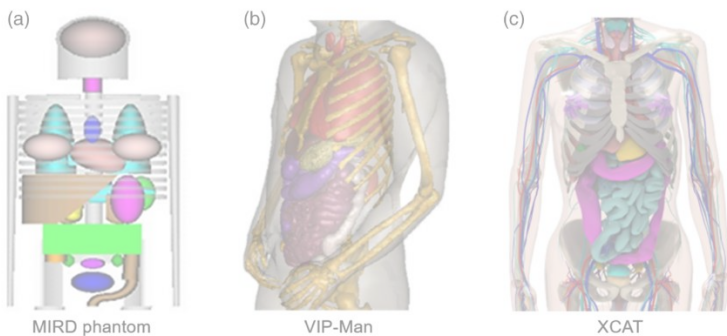
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(digital twin)

Techniques to replicate the scanner

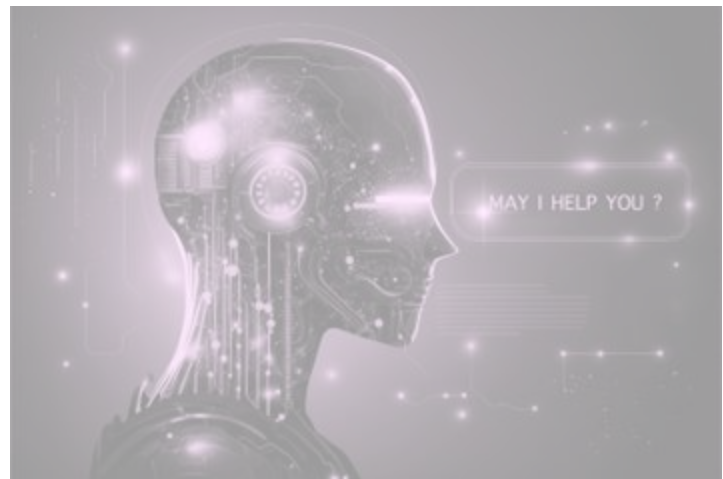
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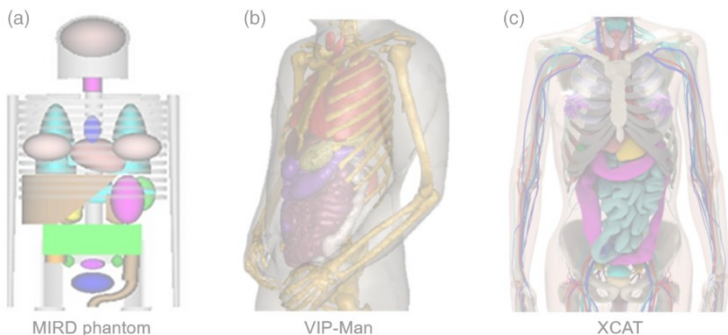
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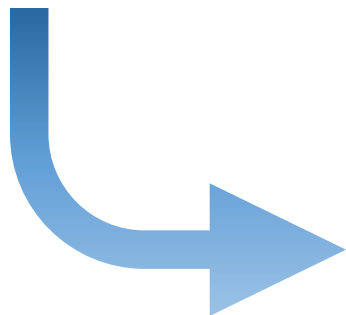
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AI models to decide whether the lesion is present or not or to localize it (computer-aided detection algorithms)



Realizzare un Centro Nazionale per i VIT



Realizzazione, tramite una stretta collaborazione tra i maggiori enti di ricerca del campo, di un archivio che comprenda sia risorse computazionali, hardware e software, che database (dati generati e dati raccolti da diversi centri) accessibile a livello nazionale.





- Istituzione di un gruppo di lavoro nazionale.
- CRO Aviano - Piani di cura in silico con utilizzo di AI.
- Città della Salute Torino: ottimizzazione tecniche di imaging radiologico utilizzando fantocci antropomorfi e metodi virtuali.
- Azienda Ospedaliera Trento: TANGO correzione aneurismi aortici addominali, neurochirurgia tumori cerebrali.
- Azienda Ospedaliera Verona: Modelli AI-based per segmentazioni immagini RM mammella



- Spoke 8 In Silico Medicine and Omics Data nel progetto PNNR ICSC Centro Nazionale HPC, Big Data e Quantum Computing, per offrire elevate capacità di calcolo e storage per soluzioni biomediche. Inoltre, l'INFN, sta creando, attraverso i finanziamenti del PNRR, le basi per un futuro Centro Nazionale di Calcolo con una particolare attenzione alle applicazioni di natura medica come i processi di Virtual Imaging Trials.
- VCT-Breast e VIT-OSTEO (INFN Napoli)



- Tecniche Monte Carlo/AI per applicazioni mediche

Infrastruttura di calcolo

- Con i ricercatori dell'INFN si individueranno ed implementeranno le migliori soluzioni per la realizzazione di una infrastruttura capace di fornire uno storage condiviso per i fantocci ed i codici messi a disposizione dai diversi partner, all'uso di questi codici ed alle politiche di accesso a queste risorse

Virtual Patients

- Libreria di fantocci che modellano una vasta gamma di anatomie includendo aspetti patologici in tessuti e organi con caratteristiche note
- Libreria di immagini generate di volta in volta «su misura» tramite IA (GAN)

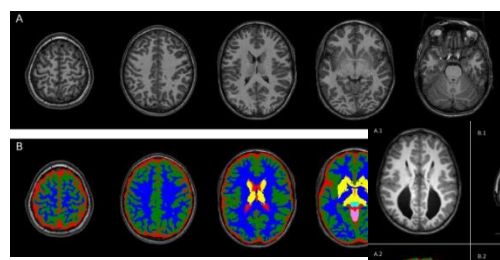
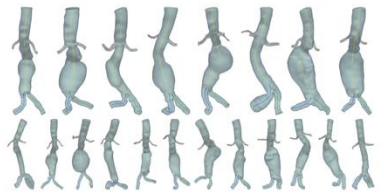
Virtual Scanner

- Ottimizzazione di due piattaforme di simulazione, una per la Breast CT e una per la brachiterapia oculare già precedentemente sviluppate dall'unità di Napoli e dall'ISS

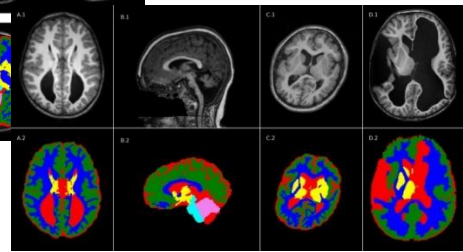
Virtual Readers

- In clinica, le immagini mediche vengono interpretate dai radiologi La creazione di un equivalente computazionale sotto forma di lettori virtuali che abbracciano tre categorie: modelli di osservatori, radiomica e reti neurali è un ambito di ricerca molto interessante ed attivo.

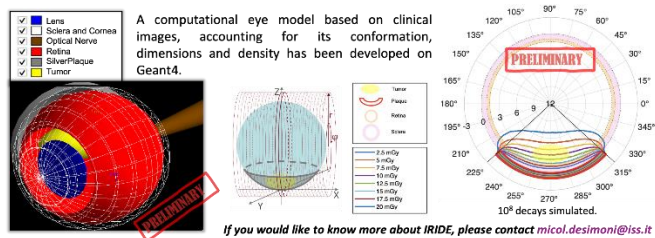
Abdominal aortic aneurysm



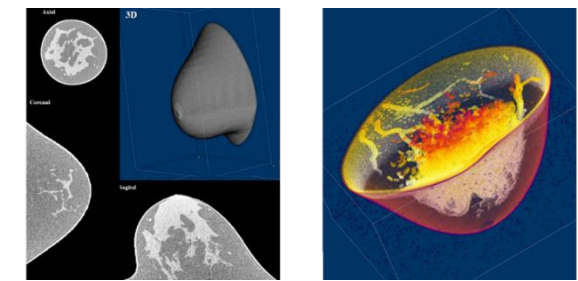
Brain tissue segmentation



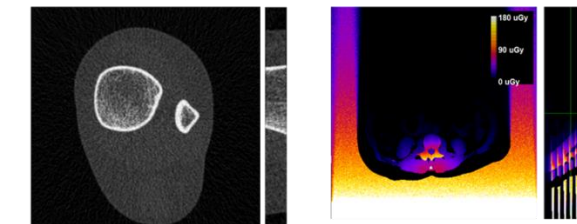
Pediatric retinoblastoma treatments



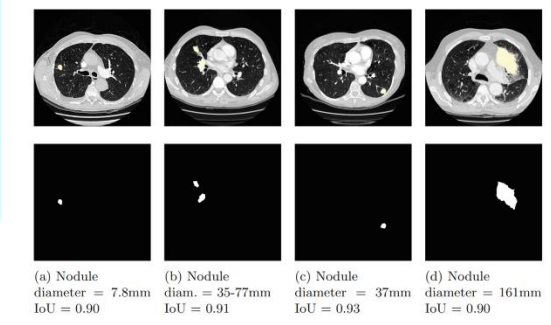
Breast Imaging and dosimetry



Bone densitometry

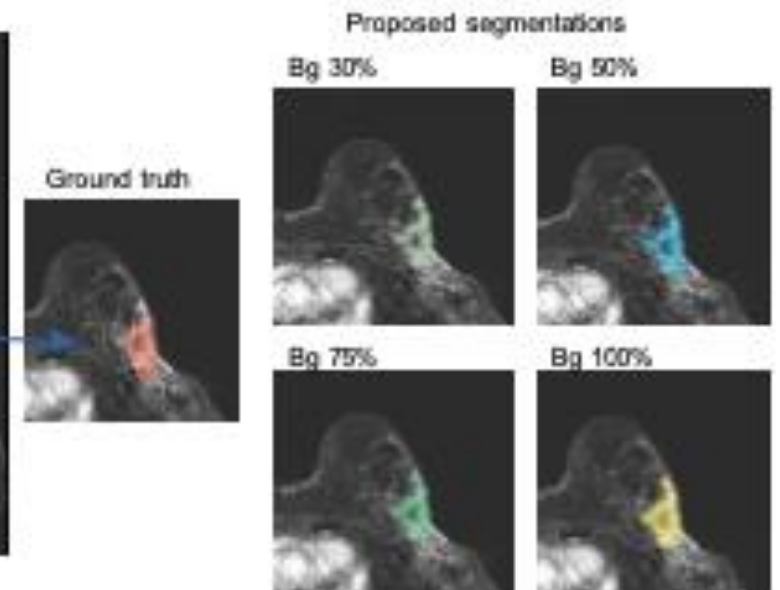
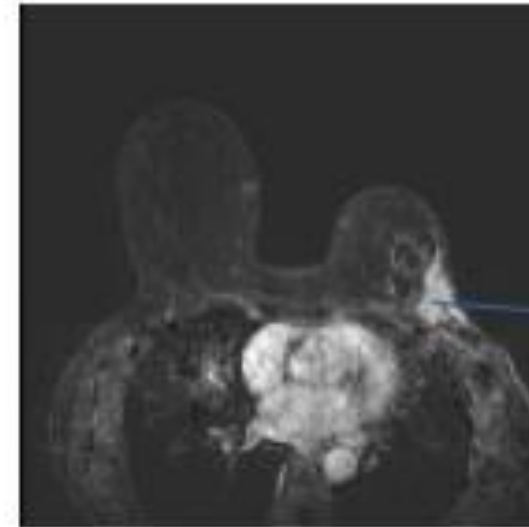
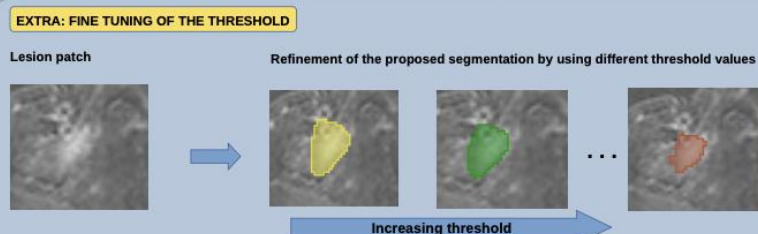
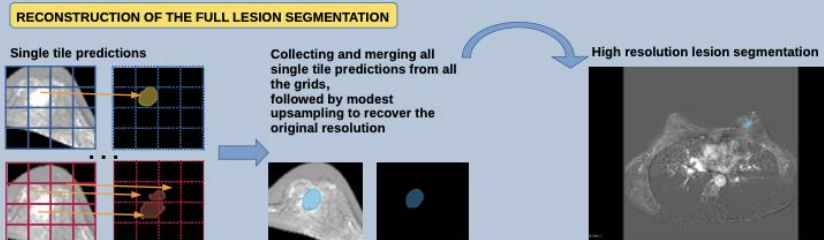
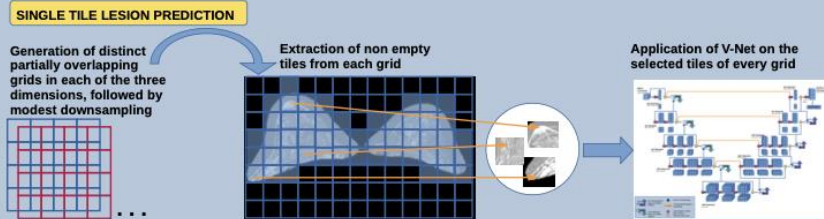
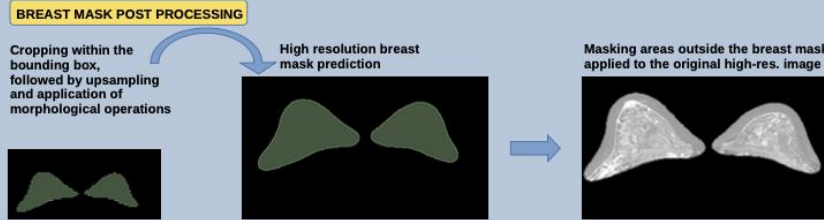
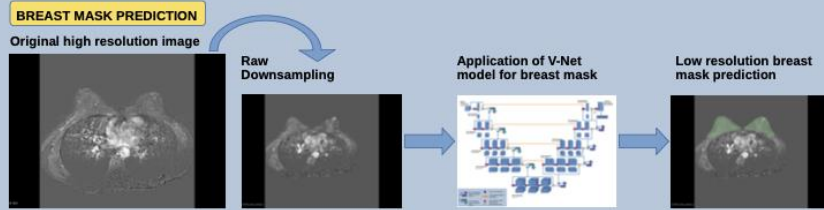


CT Imaging



V-Net deep learning segmentation of breast lesions on DCE-MR Images

Altabella L., Fedon Vocaturo M, Esposito P. G., Cavedon C.



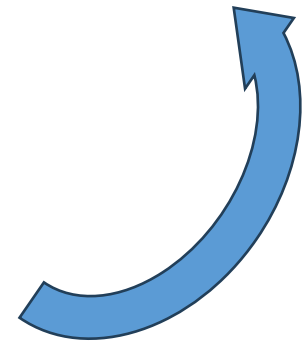
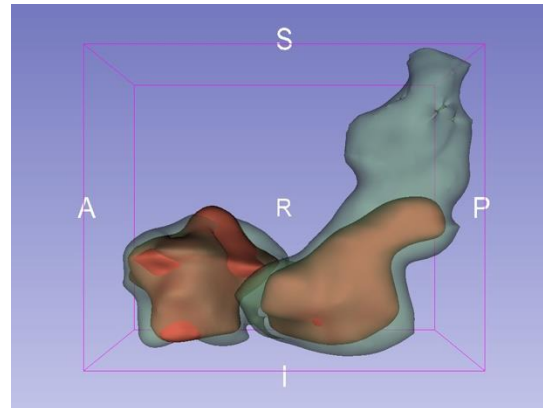
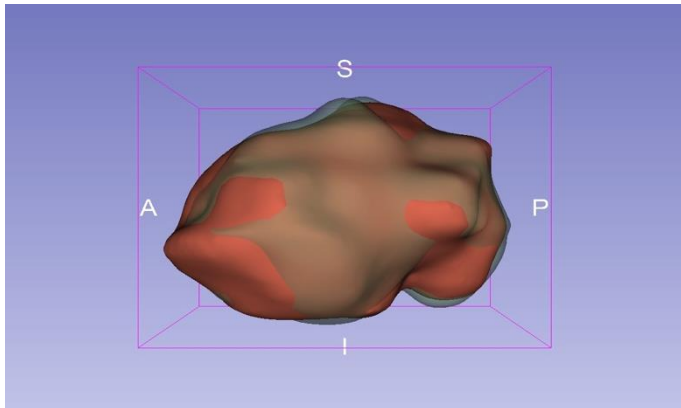
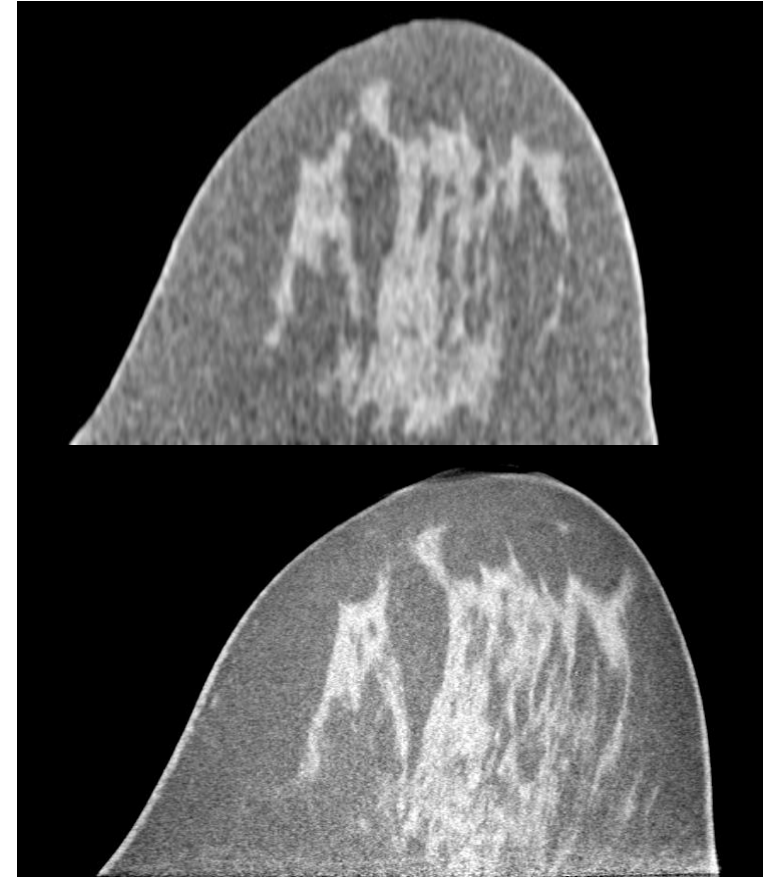
	median	IQR
DSC	0.71	0.52-0.82
RSD	0.003	-0.276-0.300
accuracy	0.9998	0.9998-0.9999
specificity	0.9999	0.9999-1.0000
precision	0.74	0.64-0.85
sensitivity	0.81	0.53-0.92



Further perspectives (for 2026):

- Validation on lesion free patients;
- Validation on external DB
- Publication

Development of lesion masks of real breast patient tumors available for Virtual Phantom (i.e CT breast images)



Richiesta budget 2025

- ✓ Fondi pubblicazione → No
- ✓ Missioni → partecipazione incontro ISS a Novembre (2pp)
- ✓ Consumabili → Hard disk 5 TB per storage dati



Virtual Clinical Trial: stato dell'arte in Italia e prospettive

data da definire

organizzato da

ISTITUTO SUPERIORE DI SANITÀ

Centro nazionale per la protezione dalle radiazioni e fisica computazionale

In collaborazione con

ISTITUTO NAZIONALE DI FISICA NUCLEARE

e

ASSOCIAZIONE ITALIANA di FISICA MEDICA e SANITARIA



Richiesta budget 2026

- ✓ Fondi pubblicazione → 3000 euro
- ✓ Missioni → 5000 euro
- ✓ Consumabili → 2000 euro

FTE

Padova		1
Carlo Cavedon	0.4	
Luisa Altabella	0.3	
Pier Giorgio Esposito	0.3	



Progetto Iniziale

2026



Carlo Cavedon	0.3	1
Luisa Altabella	0.3	
Pier Giorgio Esposito	0.2	
Marina Fedon Vocaturo	0.2	