CNAO
Centro Nazionale di Adroterapia Oncologica

Advancements in cancer treatments

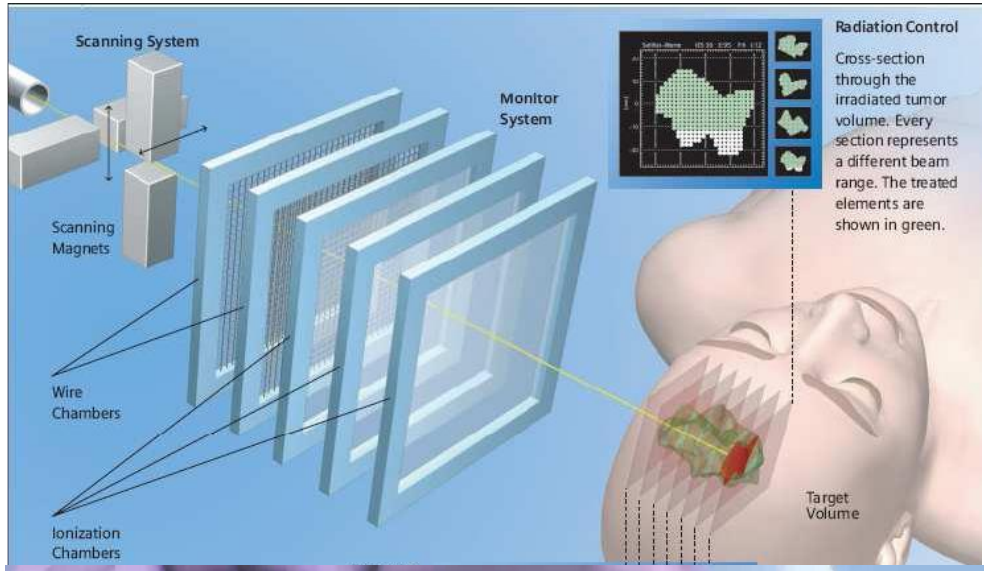
Hadrontherapy: exploring new challanges against cancer

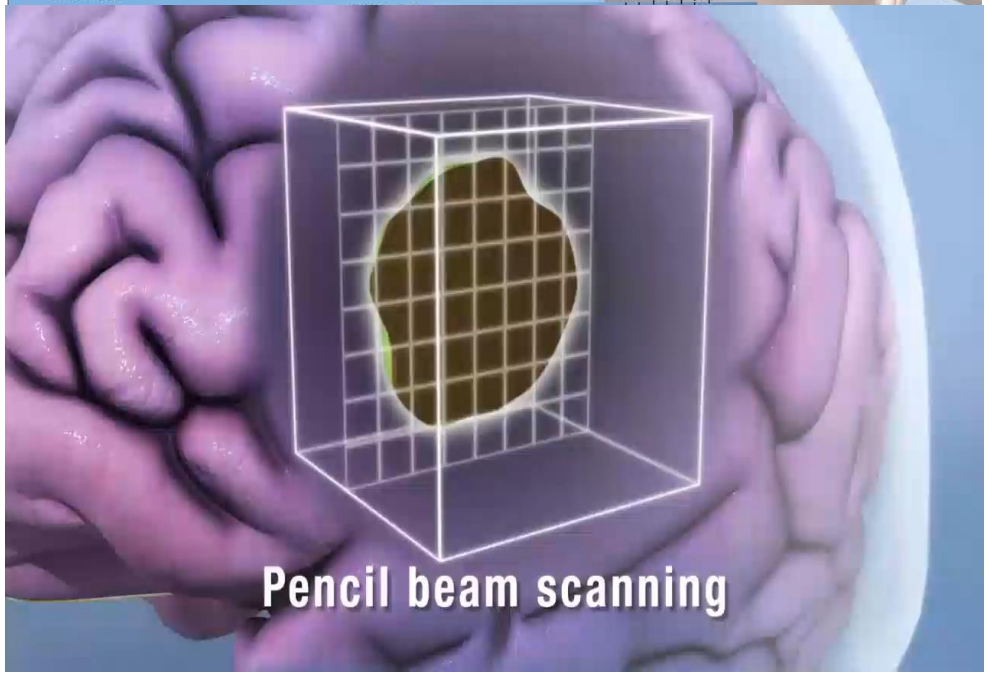
Sandro Rossi

CNAO Foundation

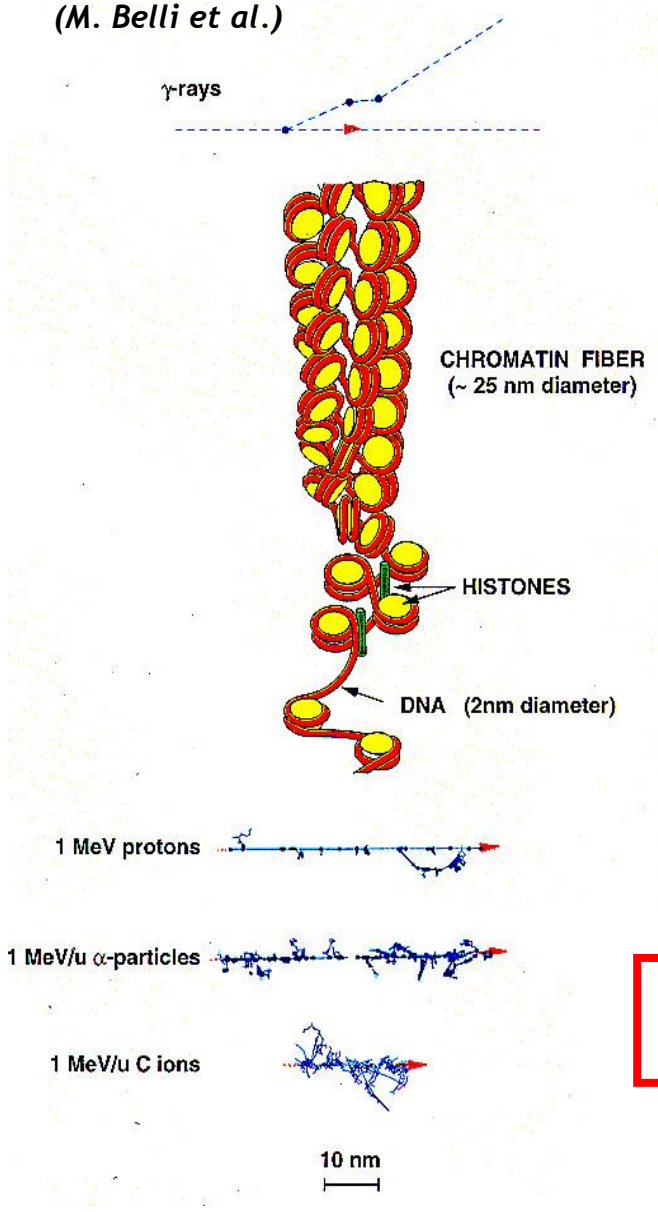
Slovenian Business & Research Association
Rue Joseph II 14, Brussels
November 21st, 2024

RATIONALE of hadrontherapy: precision + efficacy (for Carbon)

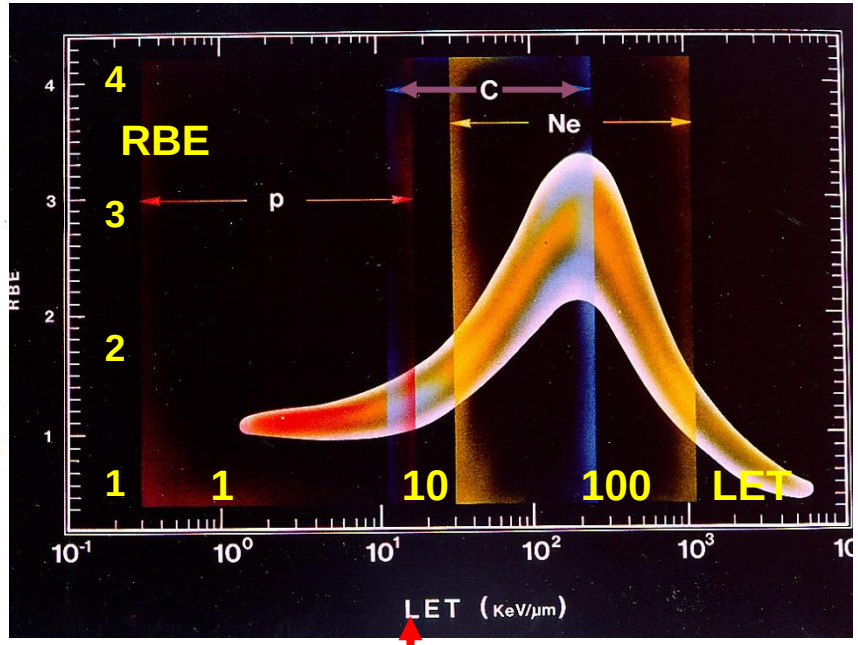




(M. Belli et al.)



RBE = Relative Biological Effectiveness



10 – 20 keV/μm = 100 – 200 MeV/cm
= 20 – 40 eV/(2 nm)

HADRONTHERAPY IN THE WORLD

107 centres with protontherapy (+40 in construction)

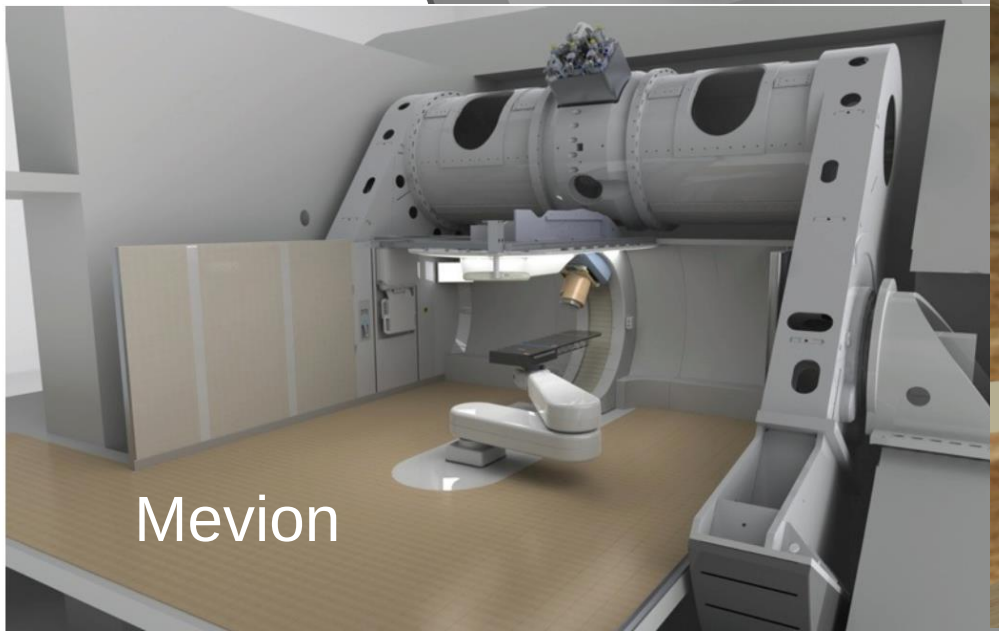
350.000 patients treated (+40.000/year)

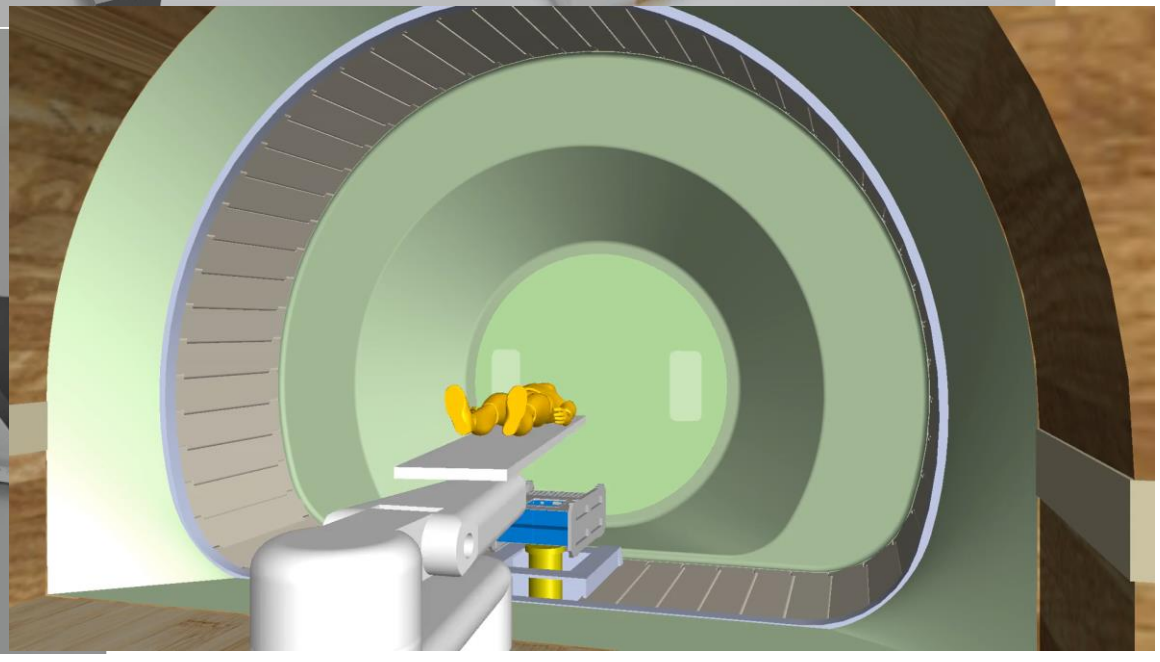
IAEA DIRAC Directory of RAdiotherapy Centres

Particle Therapy Co-Operative Group

Protons…

- ***Hitachi***
- *Varian Medical Systems*
- ***IBA***
- *Protom*
- ***Mevion***
- *Pronova*
- *Toshiba*
- *Sumitomo*
- *Mitsubishi*
- *LinearBeam*
- *Bdot medical*
- *Optivus*





HADRONTHERAPY IN THE WORLD

3 centres in China

6 centres in Japan

CNAO – Pavia (I)

MedAustron – Wien (A)

13 carbon ions centres
(+5 in construction)
6 of them multi-particle

50.000 patients treated
(+5.000/year)

Particle Therapy Co-Operative Group

CNAO = National Centre for Oncological Hadrontherapy

Not-for-profit private foundation

Created by the Italian Ministry of Health in 2001

With the purpose to introduce hadrontherapy in clinics, pursue research and formation

The Board is formed by 14 Institutions:

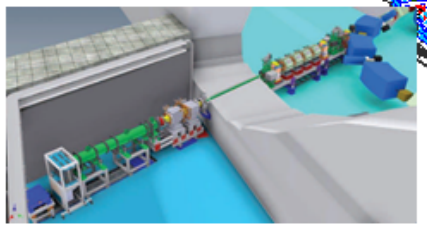
- 5 hospitals
- 3 universities
- 2 research institutes
- 2 public entities (Ministry of Health and Town of Pavia)
- 2 bank foundations

THE CNAO SYSTEM originated from PIMMS at CERN

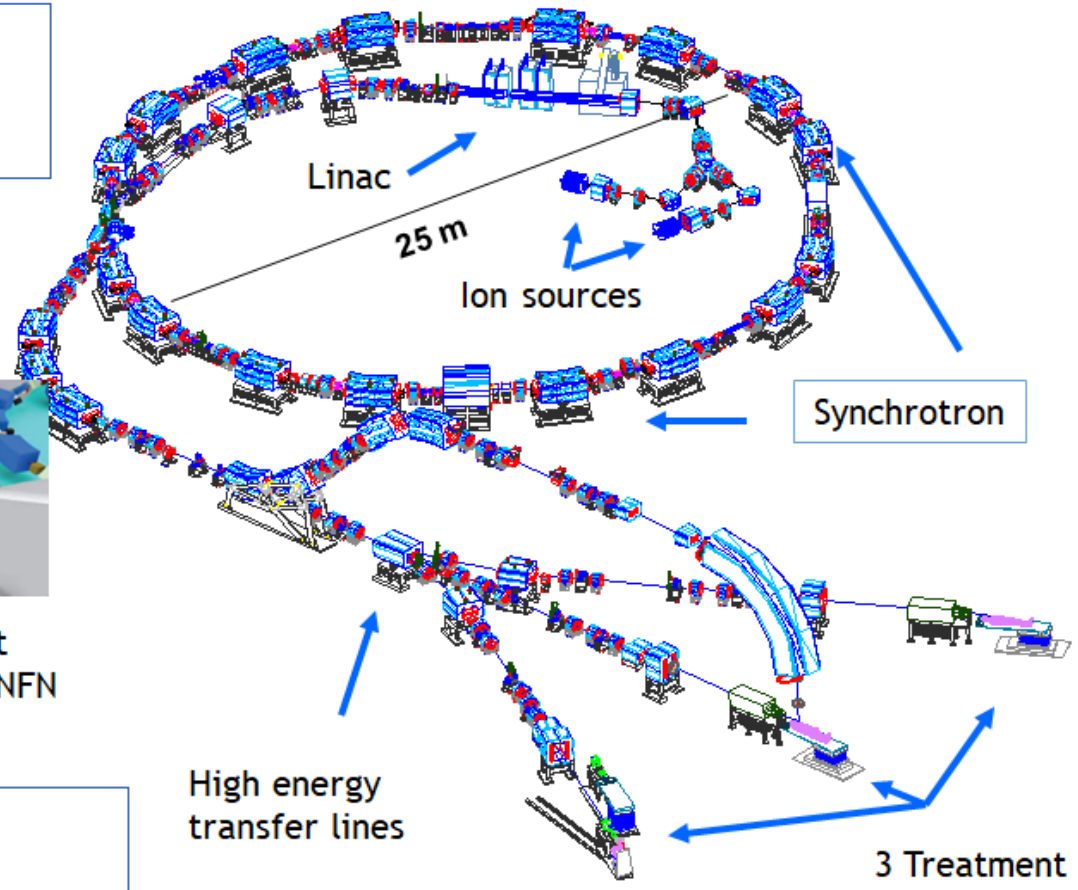
IP shared by CNAO, INFN, CERN

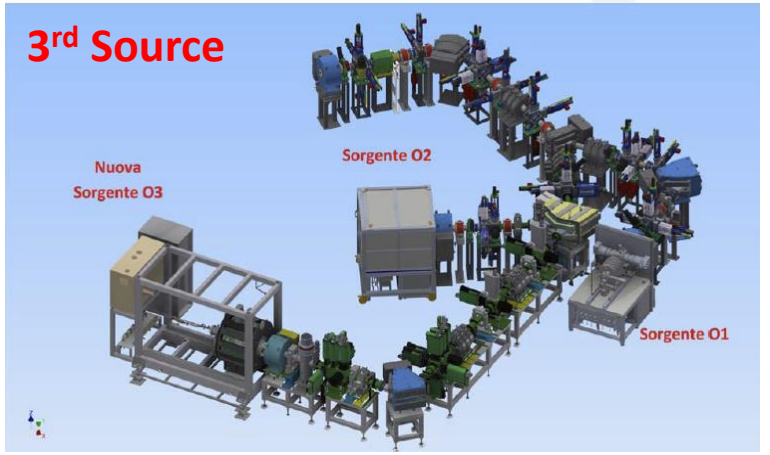
Accelerated ion	p, C, He …
Energy range (MeV/u)	60-225 (p) (30-320mm)
	120-400 (C) (30-270mm)

Extraction	Slow - scanning
Dose uniformity	± 2.5%
Average dose rate	2 Gy/min/liter



Research room built
in collaboration with INFN





Field size (mm×mm)	200×200
Beam size (FWHM) (mm)	4-10
Beam position precision (mm)	0.1

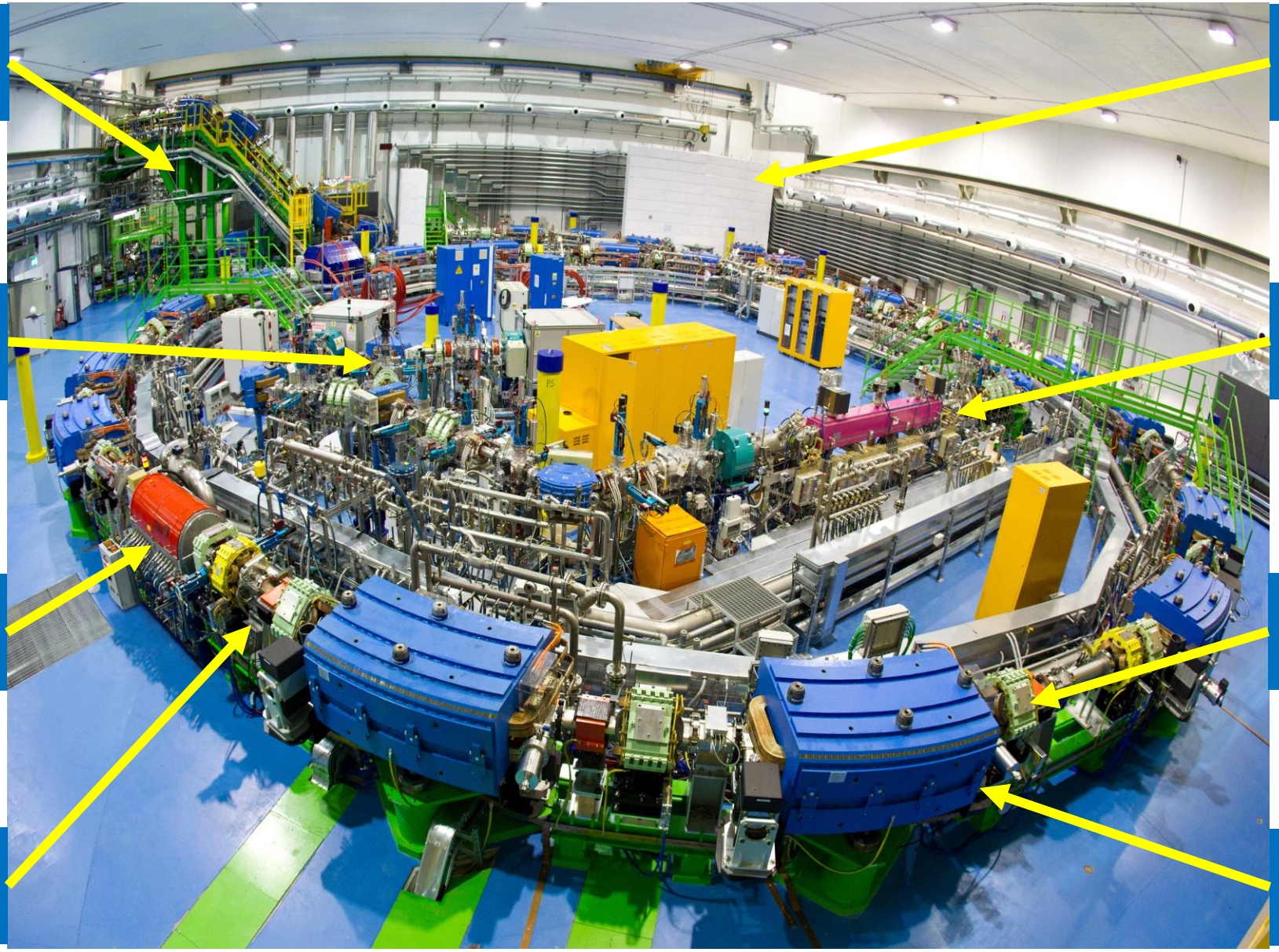
THE HEARTH OF CNAO: THE SYNCHROTRON

Trasfer-lines
tow. patients

Sources
to generate

1 RF cavity
to accelerate

20 Correctors
to steer



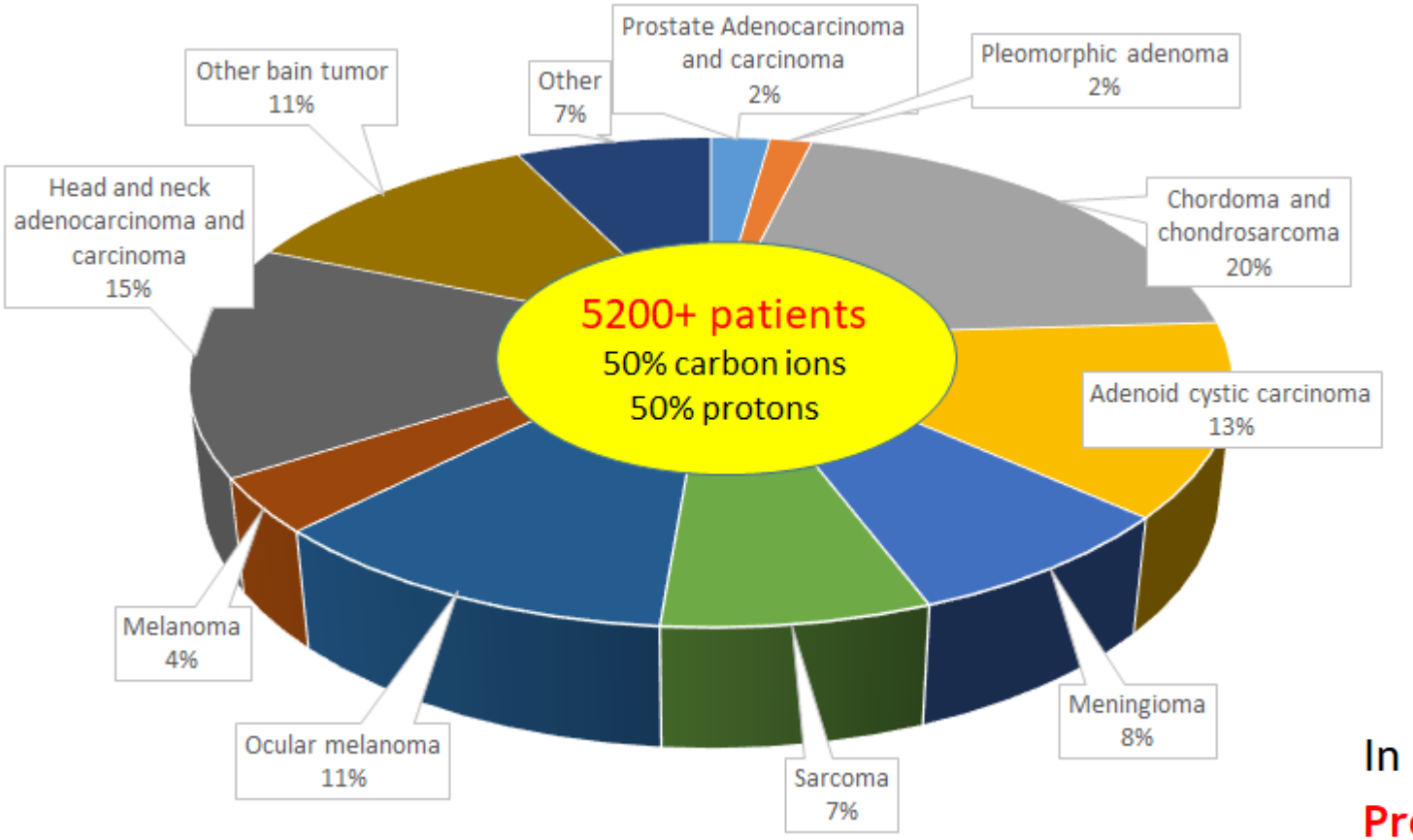
Power supplies
room

Linac
to pre-accelerate

24 Quadrupoles
to focus

16 Dipoles
to bend

CLINICAL Activities at CNAO



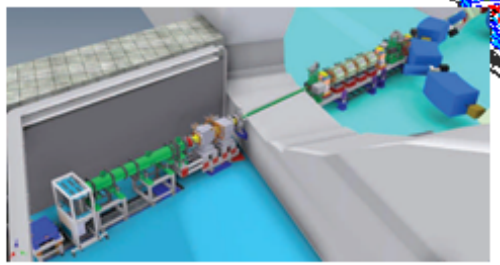
1. **Chordoma & chondrosarcoma base/spine**
2. **Meningiomas**
3. **Brain tumors (trunk)**
4. **ACC Salivary Glands**
5. **Orbit tumors including eye melanoma**
6. **Sinonasal carcinoma**
7. **Soft Tissue & bone Sarcoma (every sites)**
8. **Recurrent tumors (retreatment)**
9. **Patients with immulogical desorders**
10. **Pediatric solid tumors**

In Italy (60 million inhabitants) estimated cases 1-10:

Protons: about 5.000 patients/year

Carbons: about 1.000 patients/year

BEAMTIME AND LABS FOR RESEARCH



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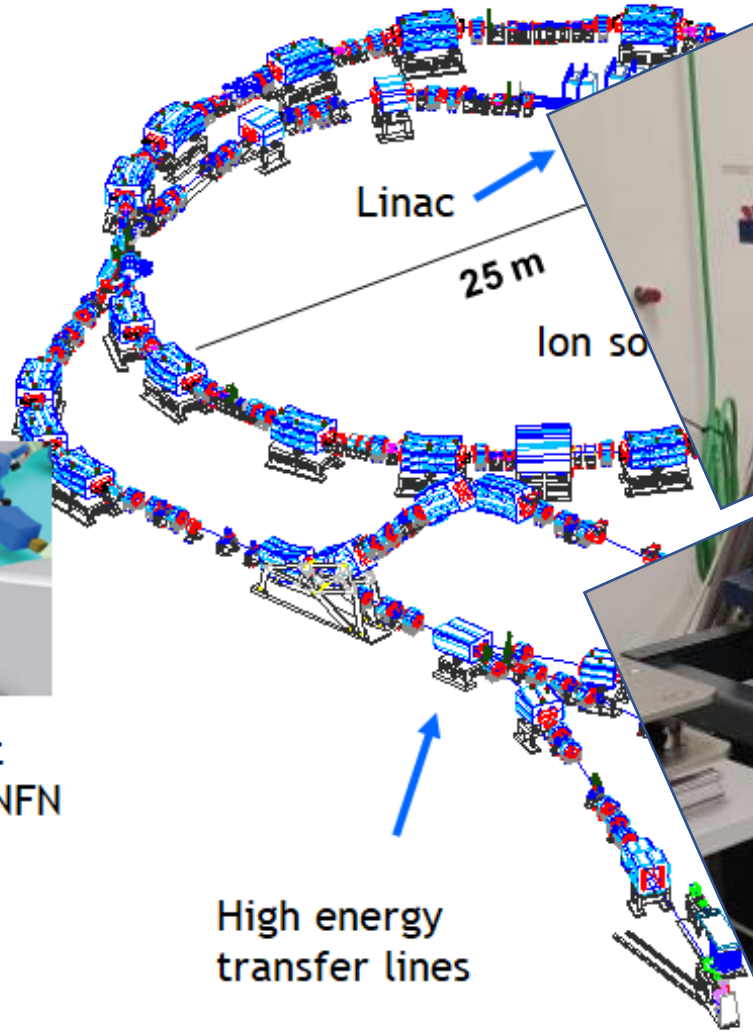
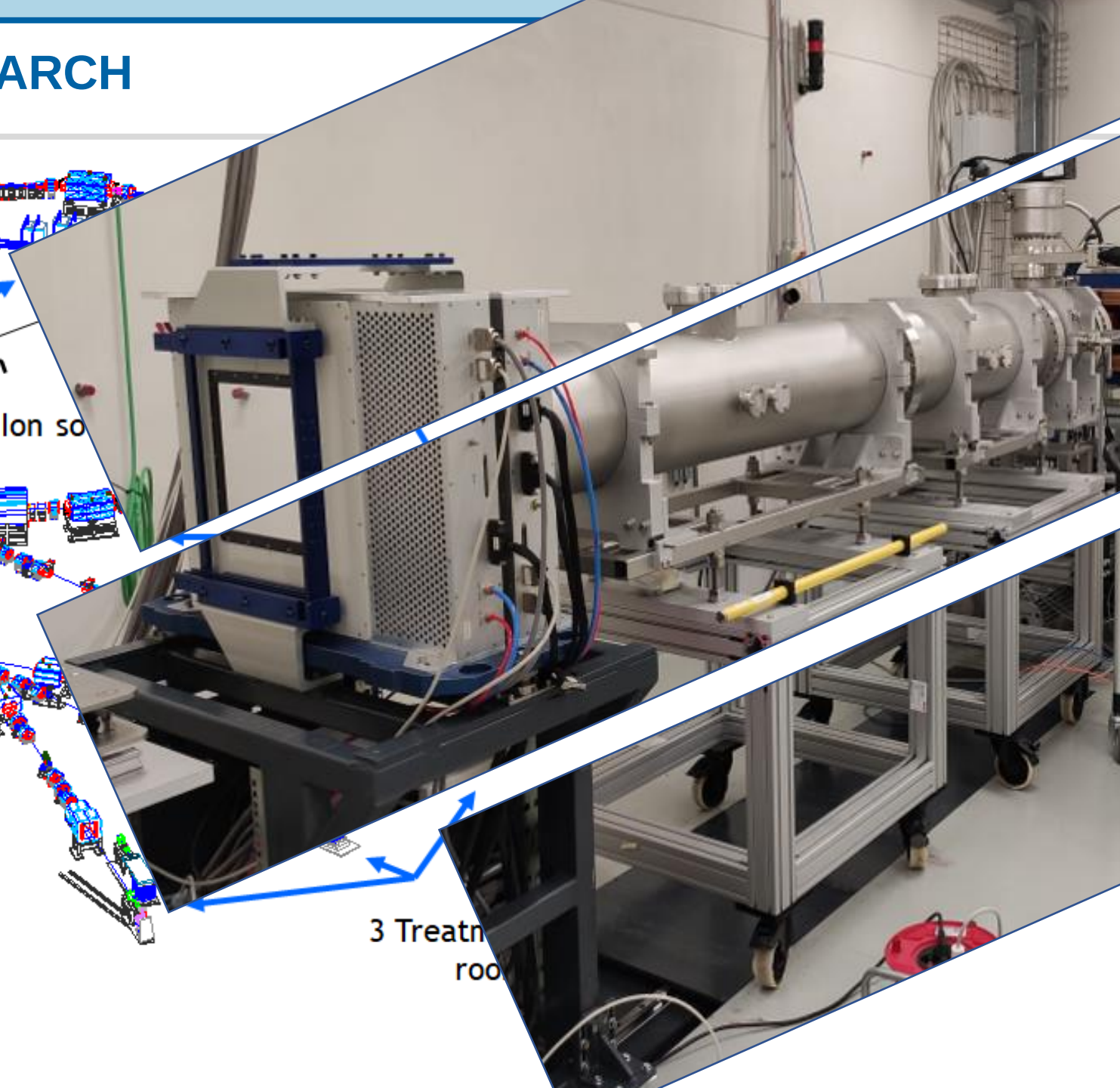
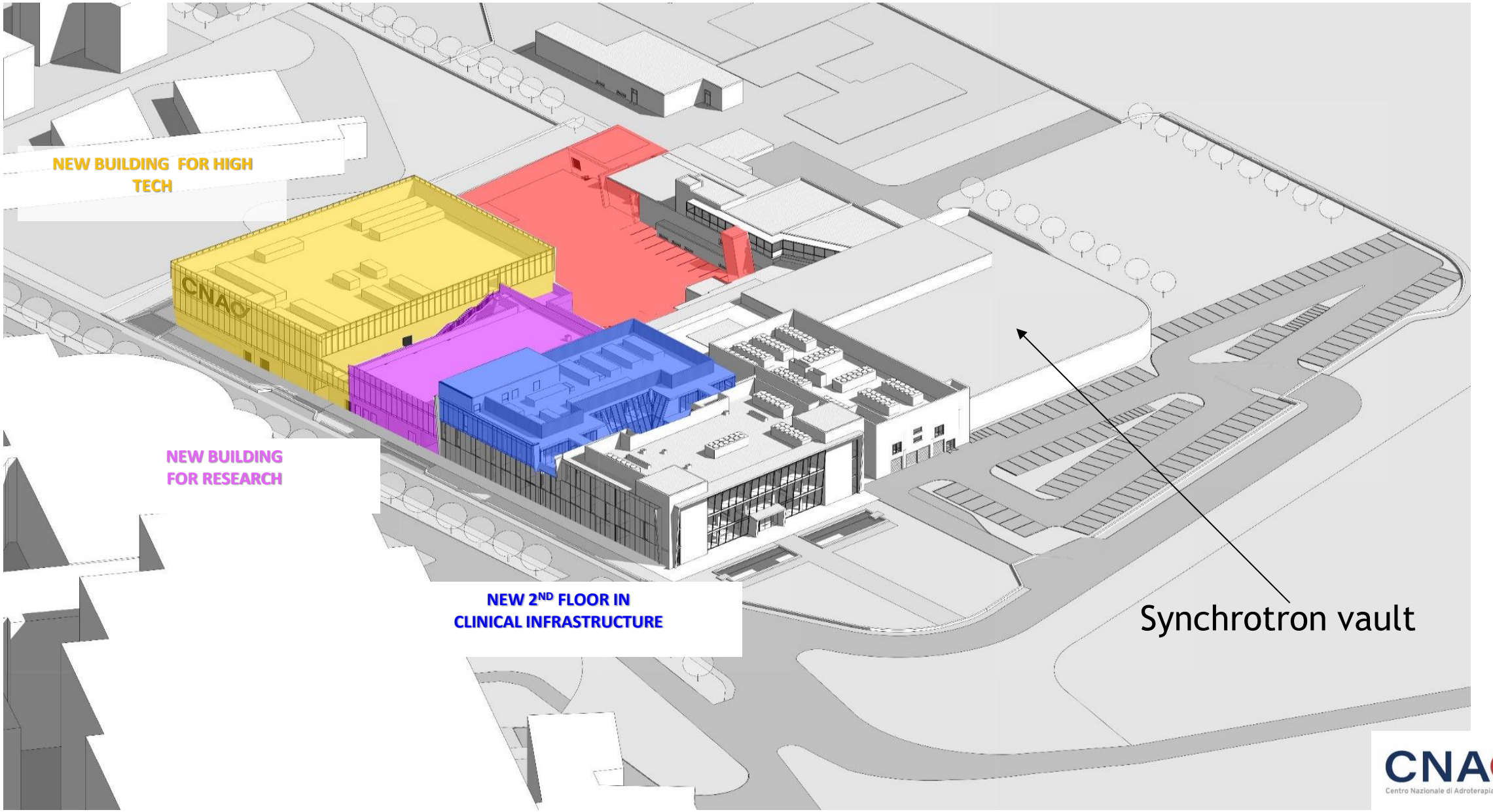




In 2023 more than 500+ hours of beam time to external groups

CNAO Expansion Project: layout end 2024



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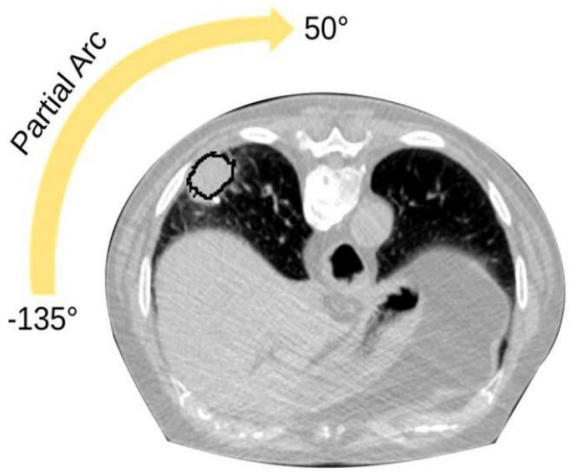
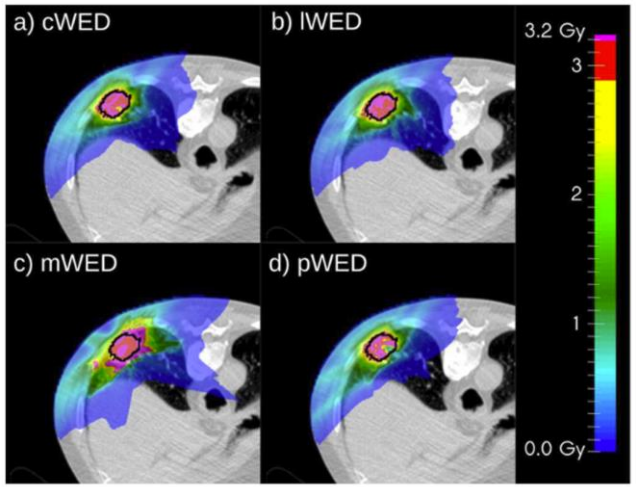
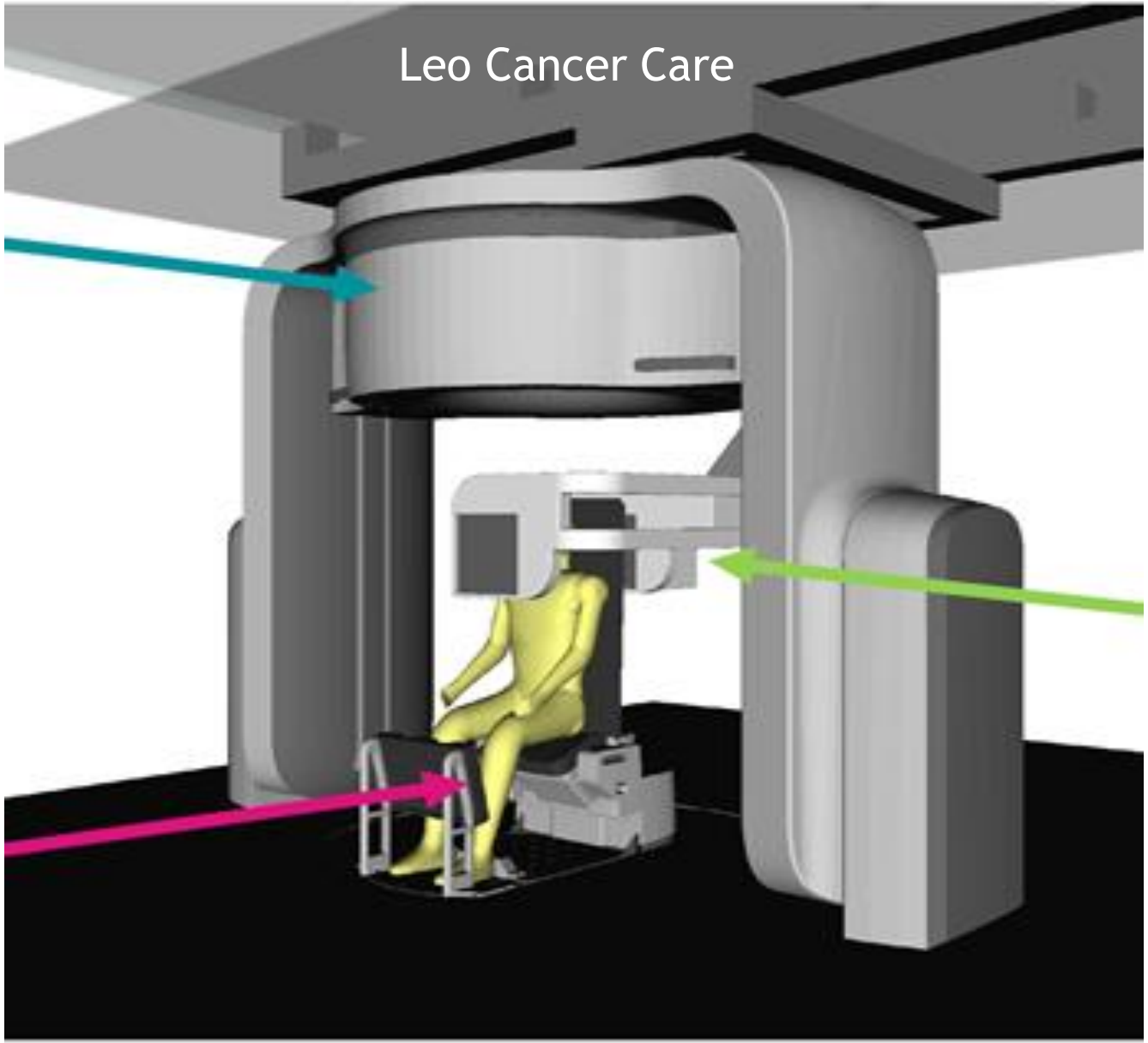
New patient positioning in room #3



Arc therapy

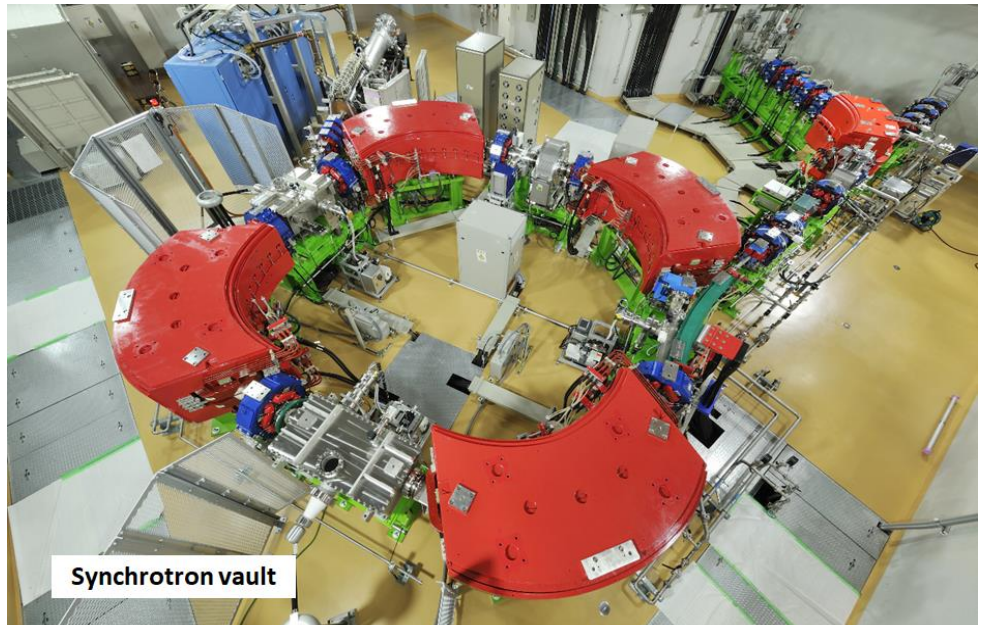


(Collaboration with GSI)

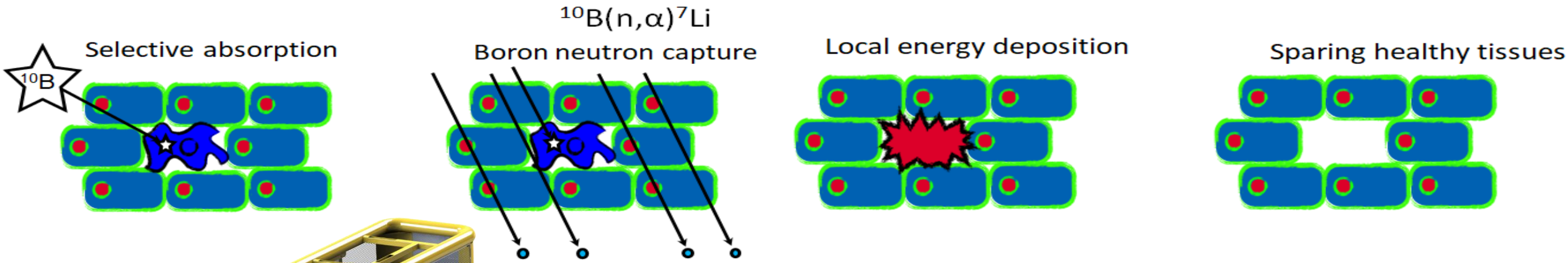


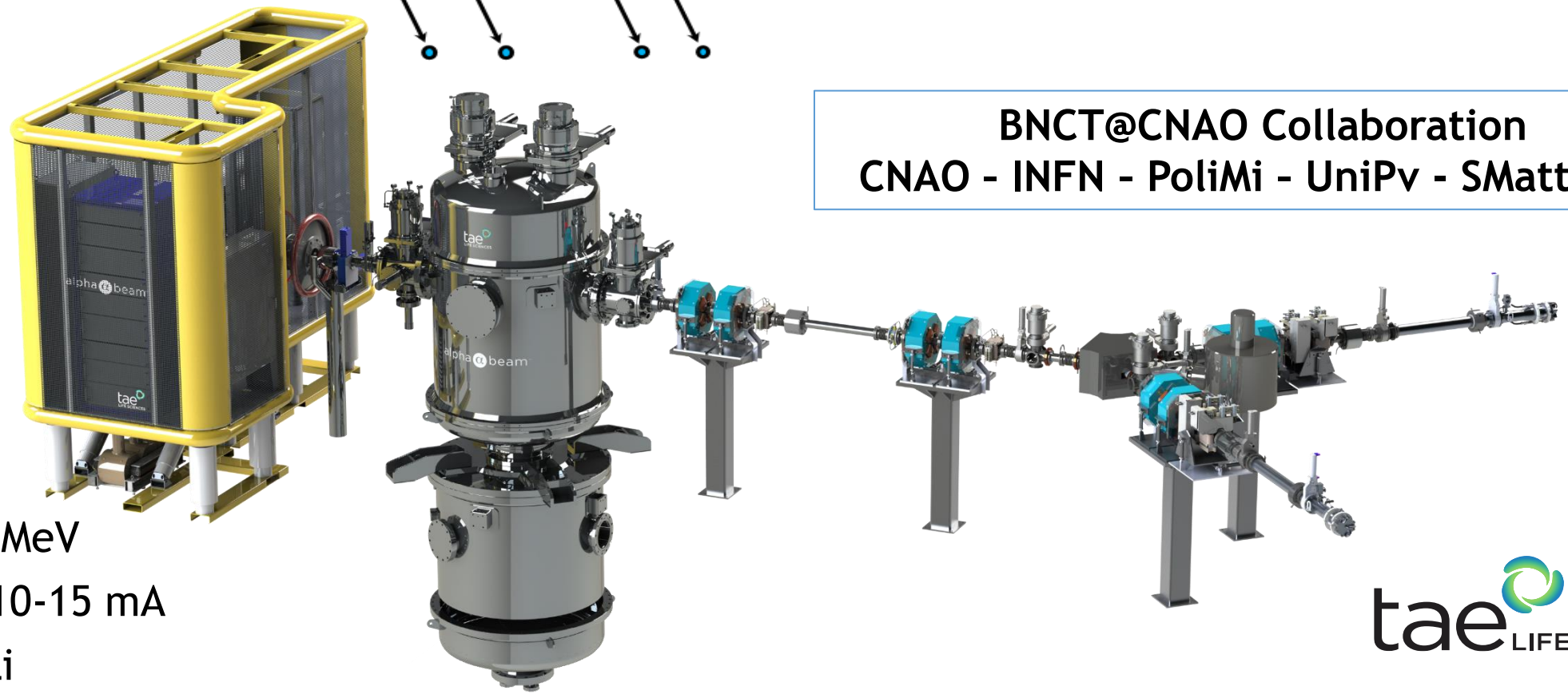
PROTON MACHINE + GANTRY: PAEDIATRICS AND MULTIFIELDS

Start installation
Middle 2024



New clinical research partnership on BNCT: academia - industry





BNCT@CNAO Collaboration
CNAO - INFN - PoliMi - UniPv - SMatteoPv

E_{proton} 2.5 MeV

Intensity 10-15 mA

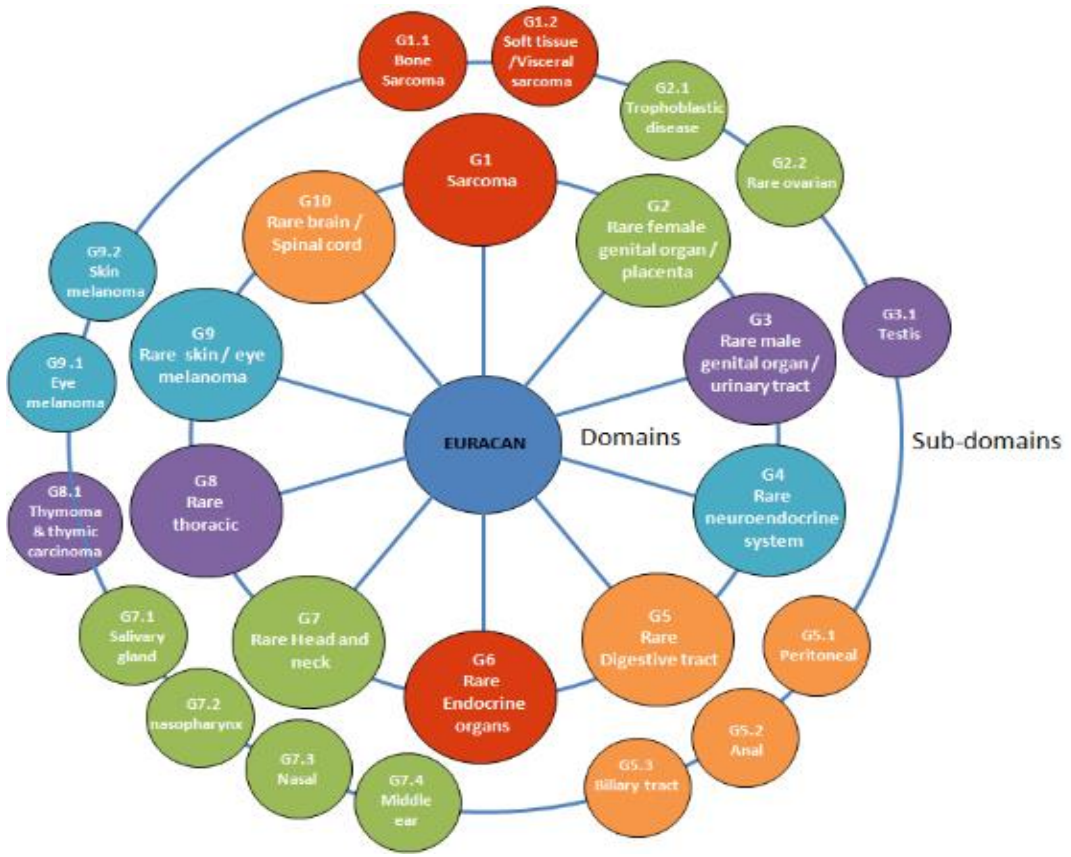
Target p-Li

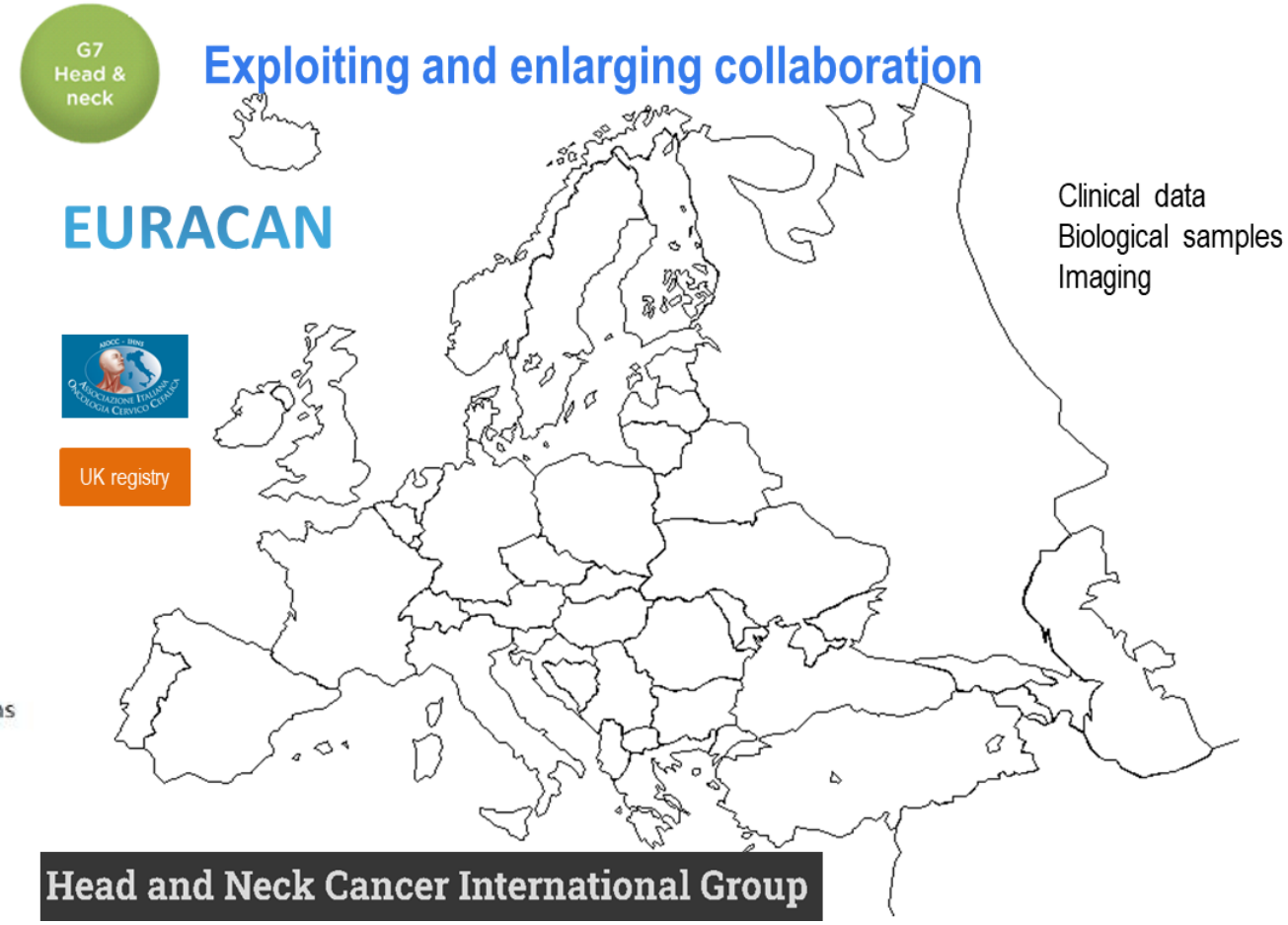
tae LIFE SCIENCES

NETWORKING for a multidisciplinar approach and to facilitate patient recruitment

STARTER

STarting an Adult Rare Tumour European Registry





JANE PROJECT - Joint Action on Networks of Expertise

ACC – Alleanza Contro il Cancro

ROL – Rete Oncologica Lombarda

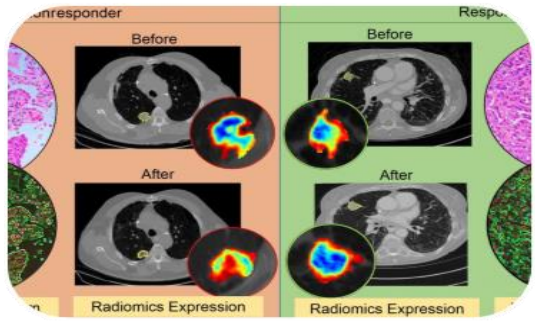
Joint Actions are collaborative projects involving several EU and associated countries with the objective to address key EU health policy priorities

CNAO has been chosen as the Leader of the Innovative Radiotherapies Domain, co-leading with the Center Leon Berard.

Innovative Radiotherapies domain includes representatives from 22 countries, with over 150 participants

1. Nuclear Medicine

2. Radiomics



3. Innovative Radiotherapies

4. Innovative Surgery

5. Physical Methods of Ablation

6. Cell Therapies

7. Ex-vivo Testing of Agents

The HITRI*plus* project
Heavy Ion Therapy Research Integration *plus*

23 Institutes

(4 CIRT centres, 11 research institutions, 5 universities, 3 SMEs)

14 European Countries

4.5 years Project

(1st April 2021 – 30th September 2025)

Total budget: 5 MEuro

New Entries

iba

NHa NORMANDY HADRONTHERAPY

Tera-Care

Grant Agreement number: 101008548 – HITRIplus

H2020-INFRAIA-2018-2020

Trans National Access

	Research [h]	Clinical [h]	Total
CNAO	80	12	92
GSI	296	-	296
UKHD/HIT	72	10	82
MEDA	-	12	12
MIT	-	16	16
	448	50	498

Clinical Research Access to clinicians/medical physicists/technicians

Free travel and accommodation for a 3 days full immersion in hadrontherapy clinics to discuss and examine real research clinical cases

Research Access to perform research activities with carbon ion beams

Free beam-time, travel and accommodation reimbursement

For more information and to apply:
https://www.hitriplus.eu/transnational-access- what-is-ta/

Courtesy Dr. Sanja Damjanovic, GSI, Darmstadt, Germany

Beating Cancer with SEEIIST while shaping Science in South-East Europe

SEEIIST

South East European International Institute for Sustainable Technologies
https://seeiist.eu

A Declaration of Intent was signed on **25 October 2017 by the** Republic of Albania, Bosnia and Herzegovina, Republic of Bulgaria, Kosovo*, Montenegro, Republic of North Macedonia, Republic of Serbia and Republic of Slovenia at a Ministerial meeting held at CERN. Croatia and Greece took an observer status.

NIMMS, HITRI*plus*, SEEIIST, TERA new optimization design (Courtesy M. Vretenar - CERN)

Design to be presented in a CERN Yellow Report in preparation

A. Innovative SEEIIST features:

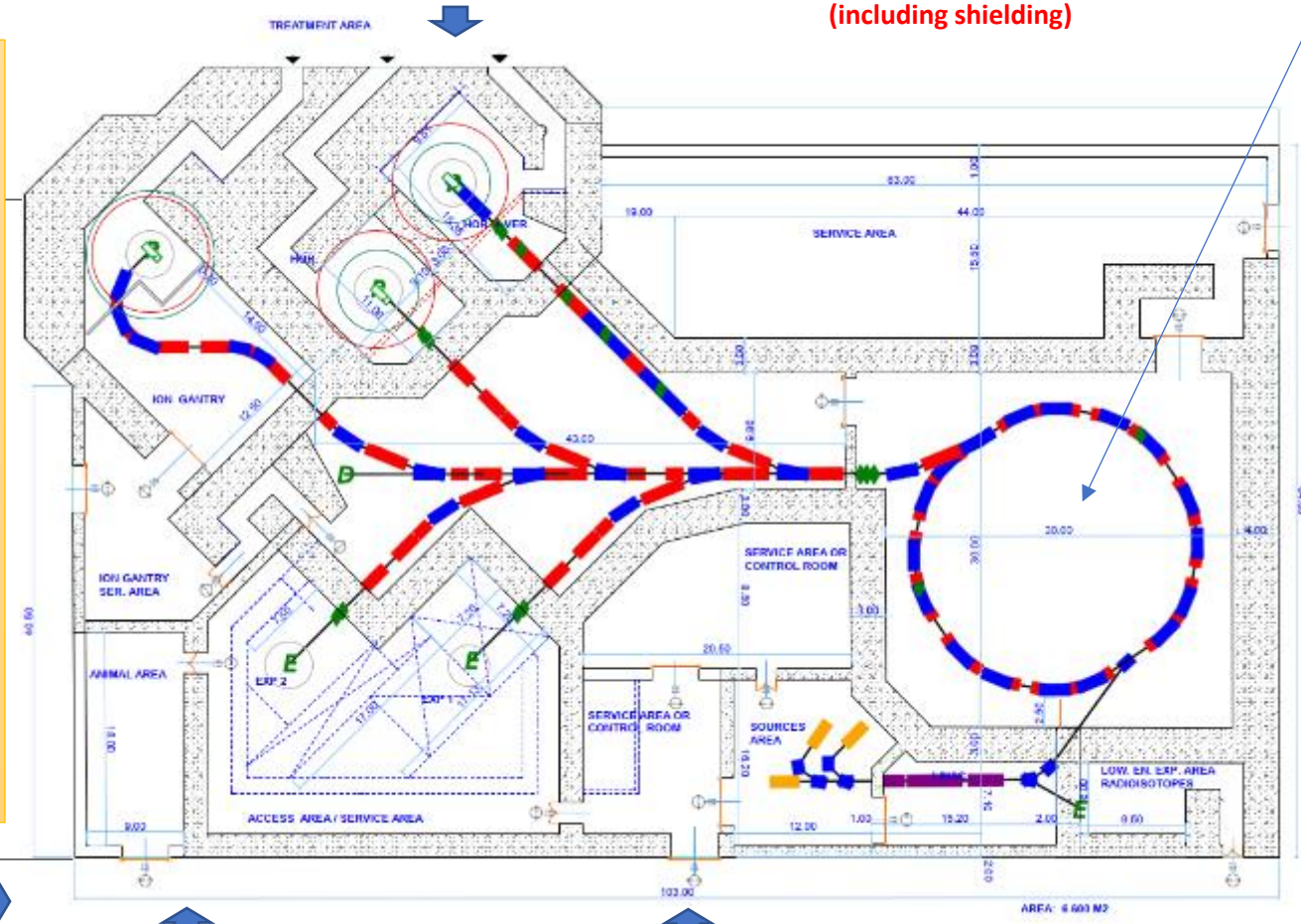
1. Optimised for 50% research and 50% patient treatment (~400 patients/year);
2. Providing 20 times higher beam intensity for carbon ions than present facilities;
3. Equipped with flexible extraction for operation in FLASH mode;
4. Equipped with dual mode linear injector capable of producing radioisotopes for cancer imaging and therapy.

Access for therapy

Total 5,400 m²
(including shielding)

The synchrotron can be replaced by an SC version if R&D successful

Equipment room and access to synchrotron



B. Advanced SEEIIST features (common to other advanced facilities):

1. Operation with multiple ions: protons, Helium, Carbon, Oxygen, Argon;
2. Multiple energy extraction (multiple flat-tops) for faster treatment;
3. Equipped with a compact superconducting gantry of novel design.

Access for animal testing

Reconfigurable experimental room

Access to experimental room and linac

Target for isotope production

HUMAN CAPITAL: vital for knowledge creation and transfer

Total number: 168

Women: 90

Men: 78

Mean age: 40

Graduates: 77% (40% PhD + Master)

Positions: 28

Disciplines: 19

CNAO
Centro Nazionale di Adroterapia Oncologica

November 2024	#
Director General and Services	21
Scientific Directorate and Clinical Trial Centre	4
Clinical Department	76
Administration and Finance Department	17
Technical Department	42
R&D Department	8
Total	**168**

CNAO Collaborations

National

- ✓ TERA Foundation: final design and high tech specifications
- ✓ INFN: technical issues, radiobiology, research, formation
- ✓ University of Milan: medical coordination and formation
- ✓ University of Pavia: technical issues, radiobiology, formation
- ✓ University of Catania: medical physics
- ✓ University of Turin: interface beam-patient, TPS
- ✓ Polytechnic of Milan: patient positioning, radioprotection, authorisations
- ✓ European Institute of Oncology: medical activities.
- ✓ San Matteo Foundation: medical activities, logistics
- ✓ Town of Pavia: land and authorisations
- ✓ Province of Pavia: logistics and authorisation

International

- ✓ CERN (Geneva): technical tasks, PIMMS
- ✓ GSI (Darmstadt): linac and special components
- ✓ IN2P3 (France): research activities
- ✓ Med-Austron (Wien): technical and clinical collaboration
- ✓ NIRS (China): medical activities, radiobiology, formation
- ✓ HIT (Heidelberg): research issues
- ✓ IFJ PAN (Krakow - Poland): medical activities
- ✓ Uni Essen (Germany): medical activities
- ✓ Sykehuspartner (Norway): medical activities
- ✓ TAE LIFE SCIENCES: BNCT technology

THANK YOU!

www.cnao.it

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