CNAO: status and perspectives

Sandro Rossi

Journée d'échange scientifique GDR MI2B - ARCHADE
November 10th, 2020

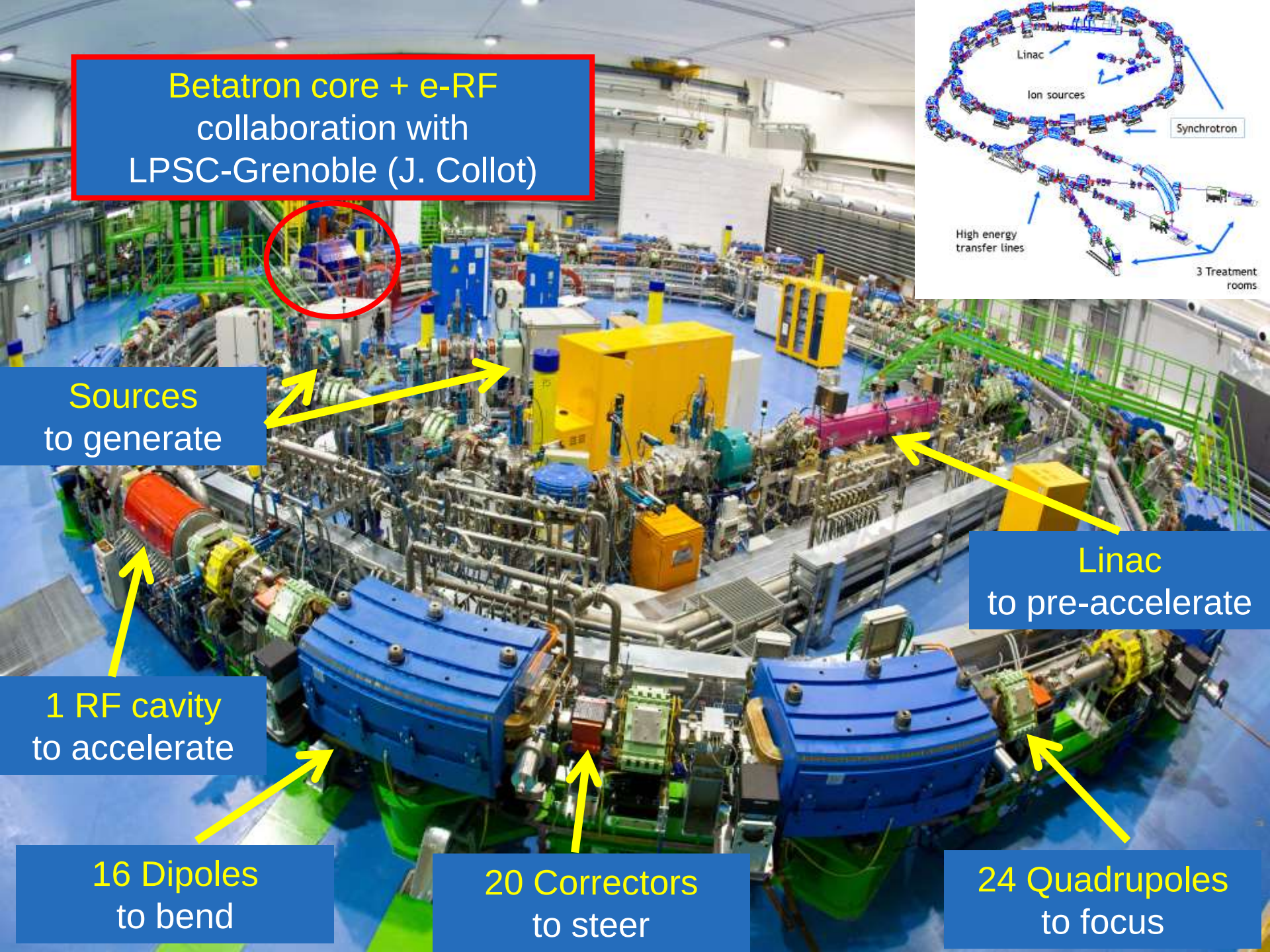
CNAO
Centro Nazionale di Adroterapia Oncologica

Not-for-profit private Foundation

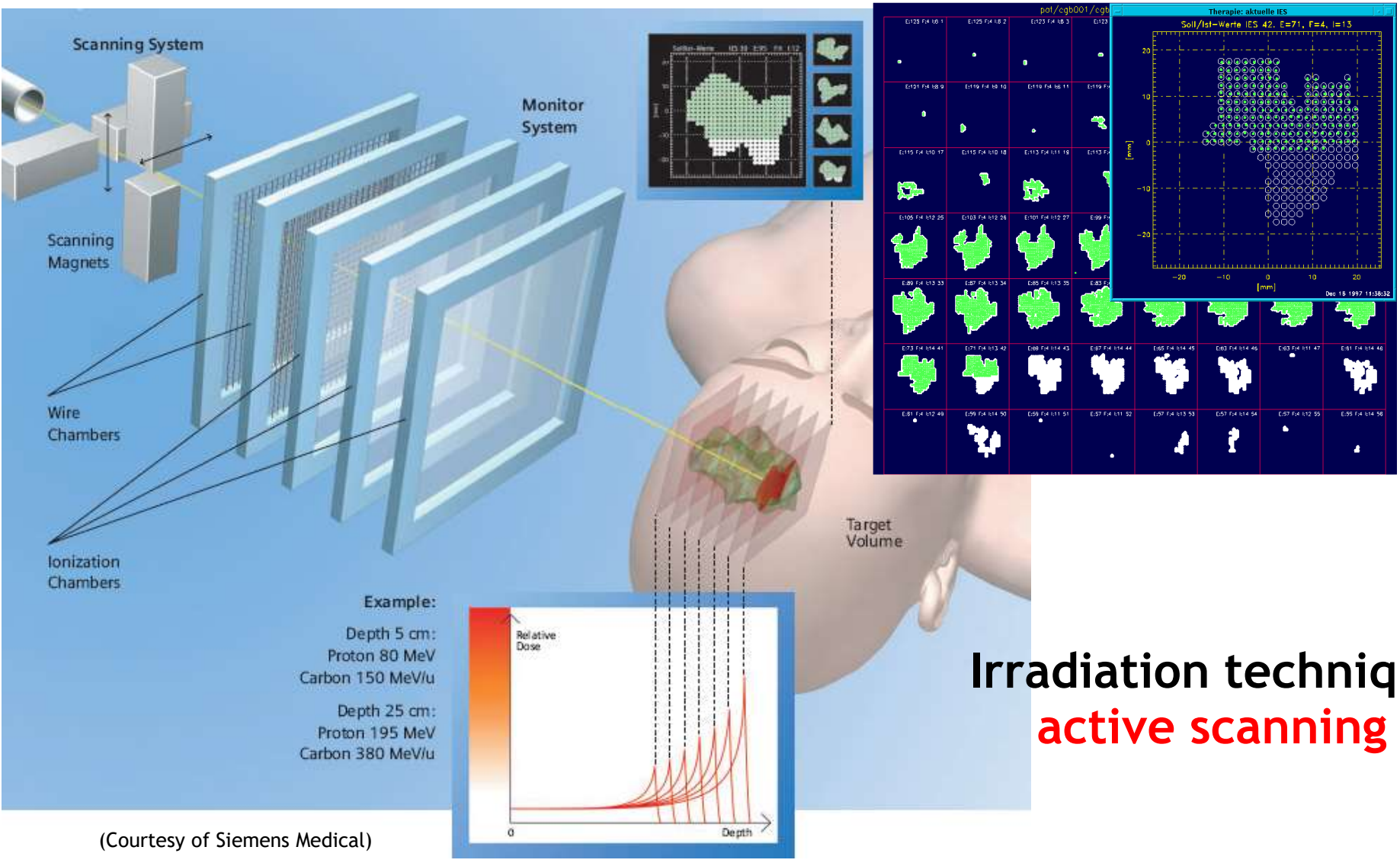
Created by the Italian Ministry of Health in 2001

with the purpose to build and run a hadrontherapy Centre

Only 6 multi-particle centres in the World


Betatron core + e-RF
collaboration with
LPSC-Grenoble (J. Collot)
Linac
Ion sources
Synchrotron
High energy
transfer lines
3 Treatment
rooms
Sources
to generate
Linac
to pre-accelerate
1 RF cavity
to accelerate
16 Dipoles
to bend
20 Correctors
to steer
24 Quadrupoles
to focus

Hadrontherapy to treat ‘difficult’ cases: PRECISION

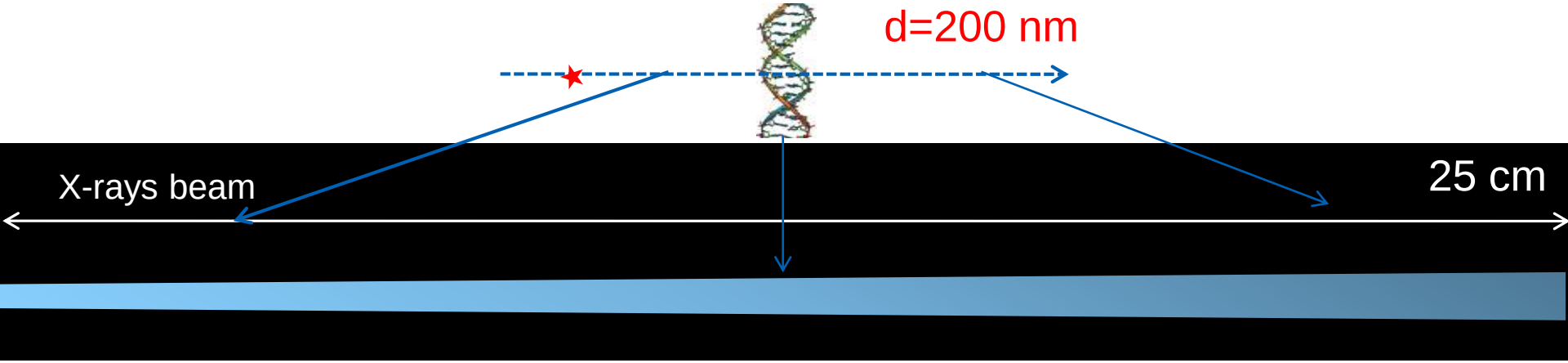


(Courtesy of Siemens Medical)

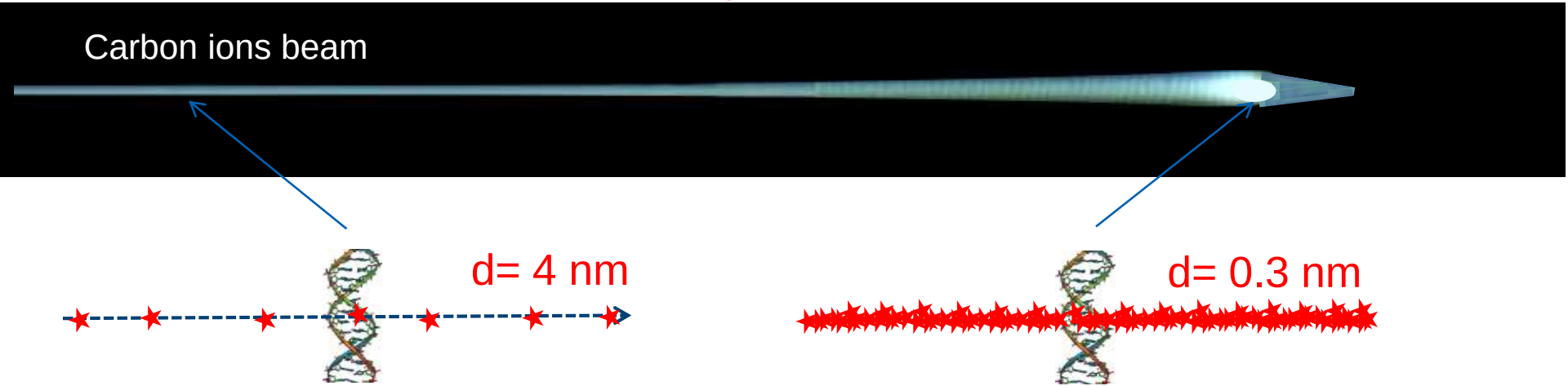
Irradiation technique
active scanning

Hadrontherapy to treat 'difficult' cases: EFFICACY

X-rays: sparse damage and indirect effects

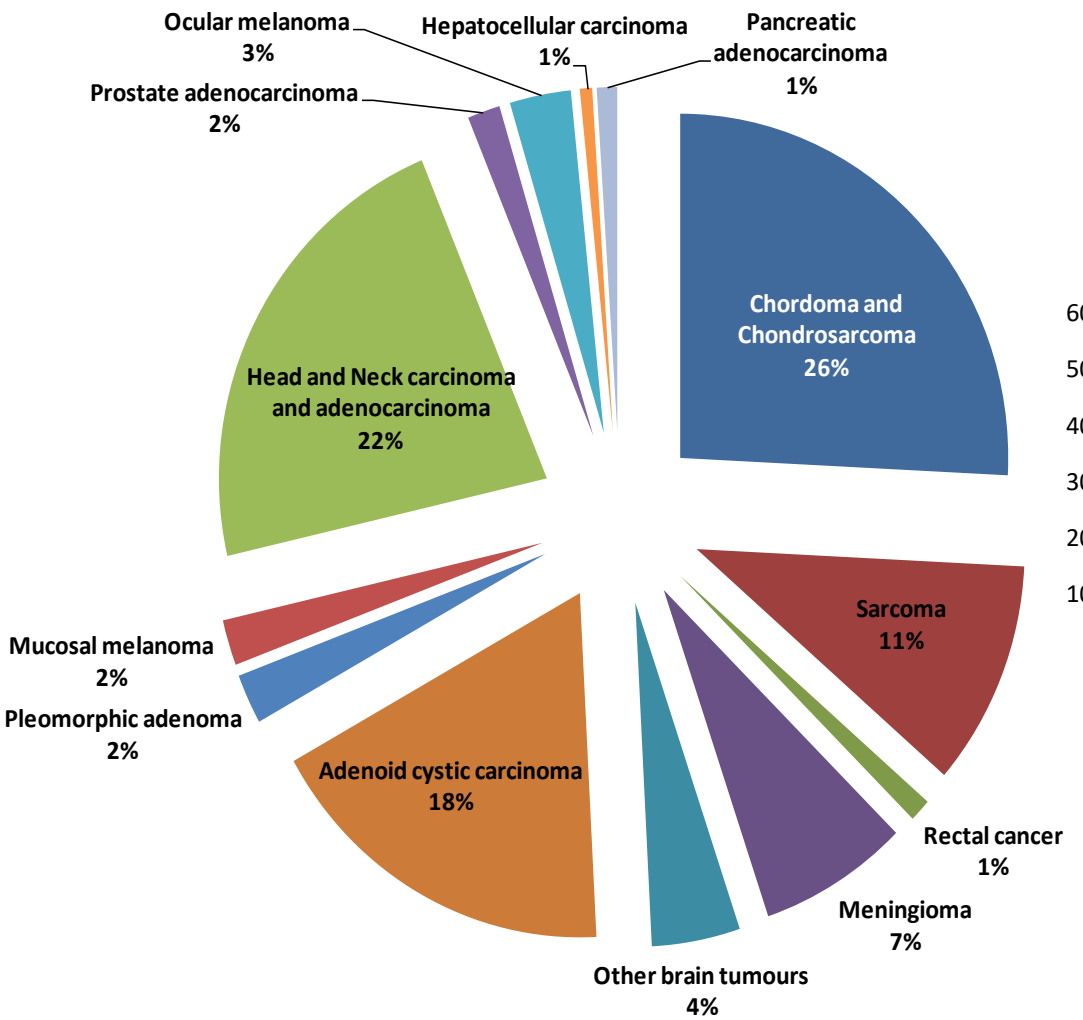


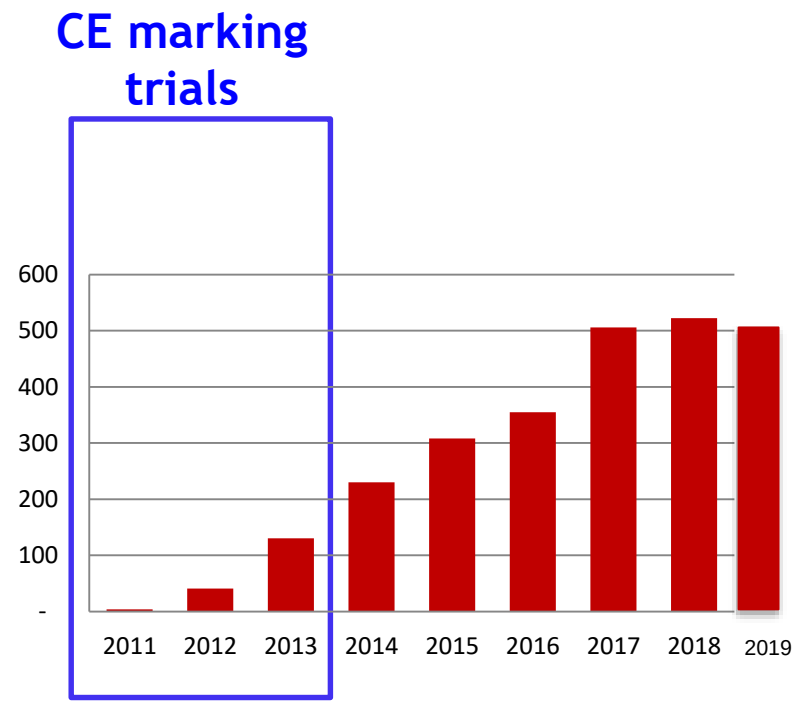
Carbon ions: clustered damage on tumour and direct effect



CNAO: 3100 patients treated

57% carbon ions - 43% protons



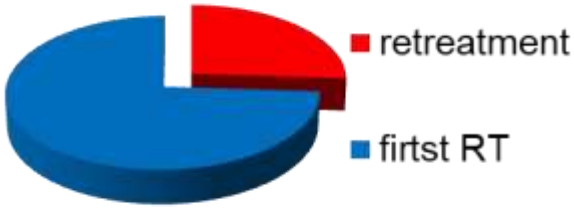


Patients per year

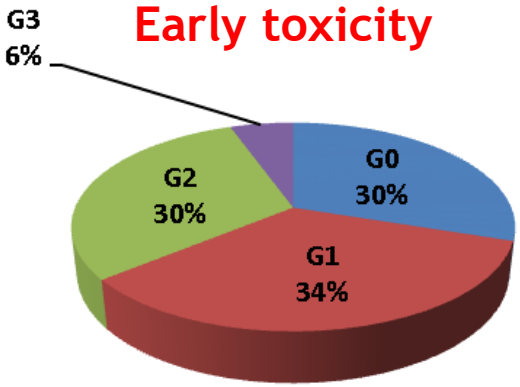
Protocol PHRC Etoile-Ulice (J. Balosso) – Phase III Randomized study comparing the carbon ion with conventional radiation, including proton, therapy for the treatment of radioresistant, inoperable tumours (250 pts, 125+125, 38 pts enrolled)

Treatments: efficay + reduced toxicity

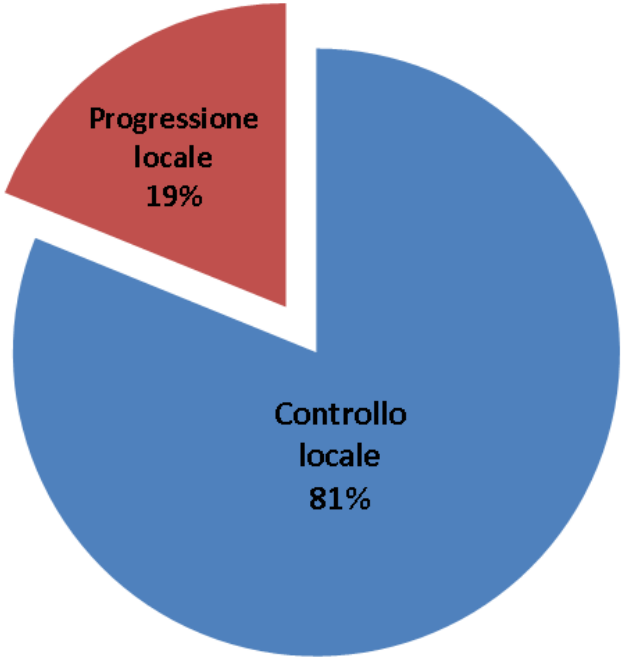
26% re-treatment



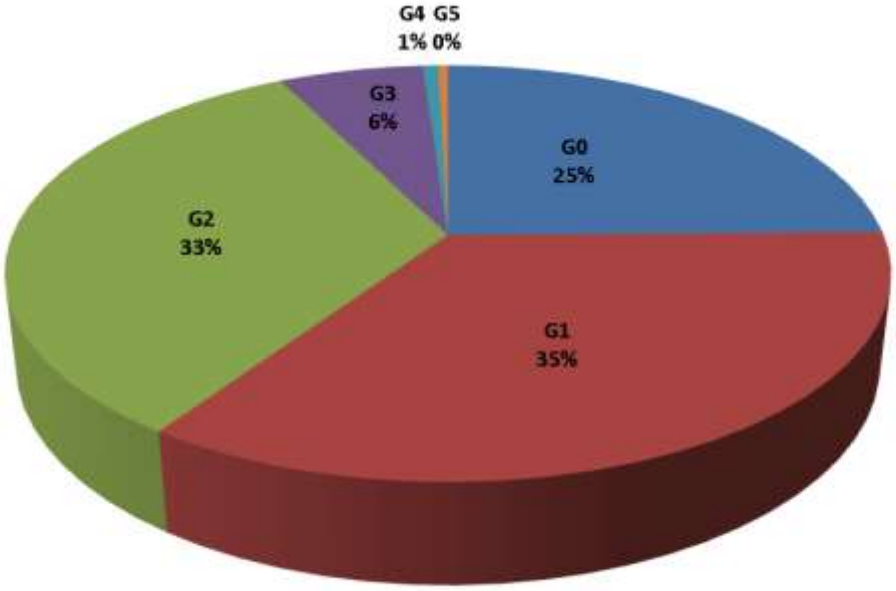
Early toxicity



Undistinguished local control



Late toxicity



Non oncological application: ventricular arrhythmia

In press on:
European Journal of Heart Failure

Non-invasive Proton Radiotherapy for Refractory Ventricular Tachycardia in advanced heart failure: first in-man case.

Veronica Dusi[1,2], MD, PhD; Viviana Vitolo[5], MD; Laura Frigerio[1,3], MD; Rossana Totaro[1,3], MD; Adele Valentini[4], MD; Amelia Barcellini [5],MD; Alfredo Mirandola[5], PhD; Giovanni Battista Perego[6], MD; Michela Coccia [3], MD , Alessandra Greco[3], MD, Stefano Ghio[3] ,MD, Massimiliano Gnecchi [1,2], MD, PhD; Luigi Oltrona Visconti[3] , MD, Roberto Rordorf[1,3]MD.

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[2]Department of Molecular Medicine, Section of Cardiology, University of Pavia, Pavia, Italy
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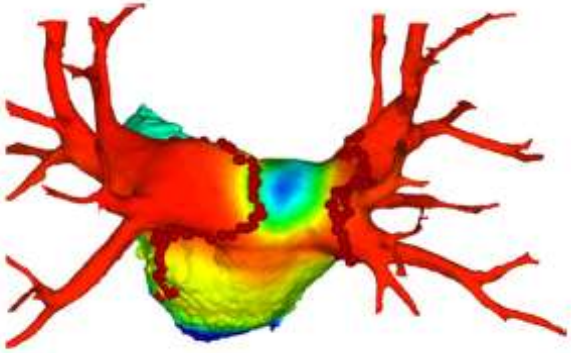
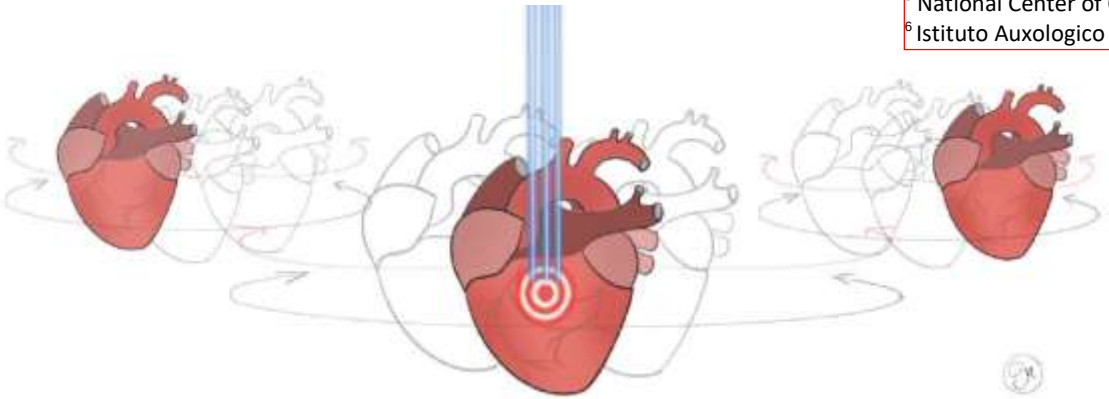
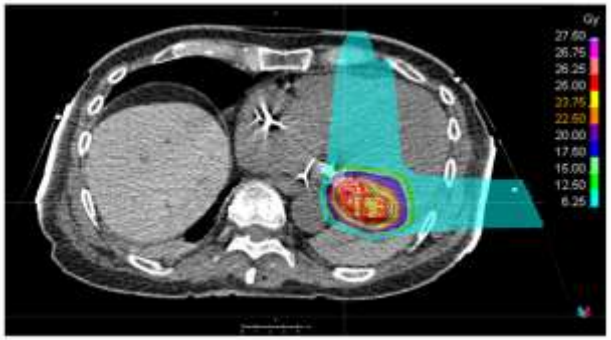
[5] National Center of Oncological Hadrontherapy (Fondazione CNAO), Pavia, Italy.
[6] Istituto Auxologico Italiano, Ospedale San Luca, Milan, Italy.

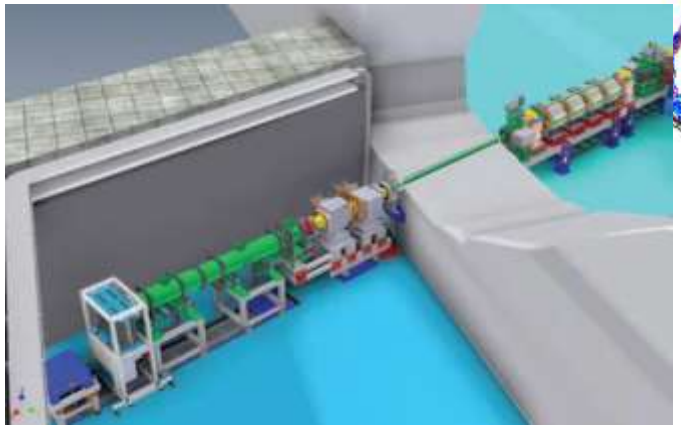


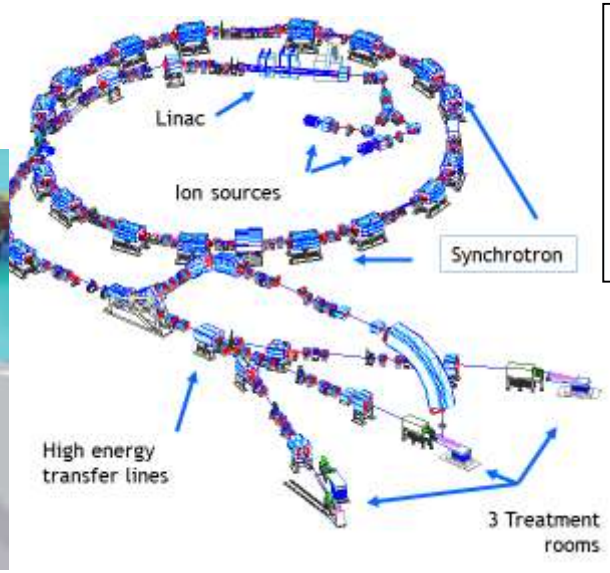




New Research Room

Realized in collaboration with INFN





Animal house and other facilities at Univ. of Pavia (500 m away)

Research Facility@CNAO:

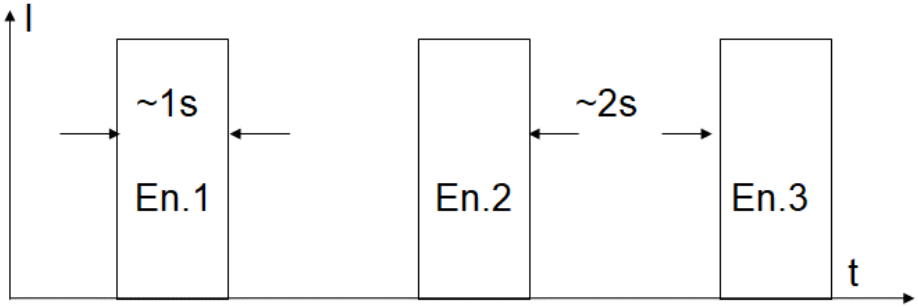
Biomedical research facility available for national and international research groups.

Ready to discuss access strategy and managment

Beam structure

- Protons
- 60-250 MeV
- 10^8 - 10^{10} p/spill

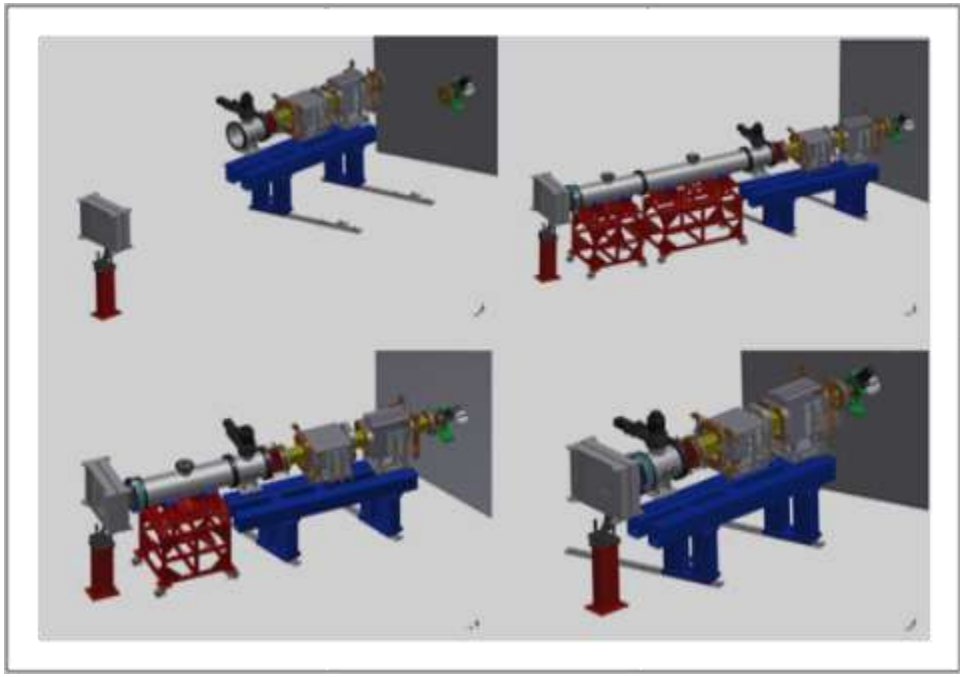
- Carbon
- 120-400 MeV/u
- 4 x 10^6 - 4 x 10^8 C/spill



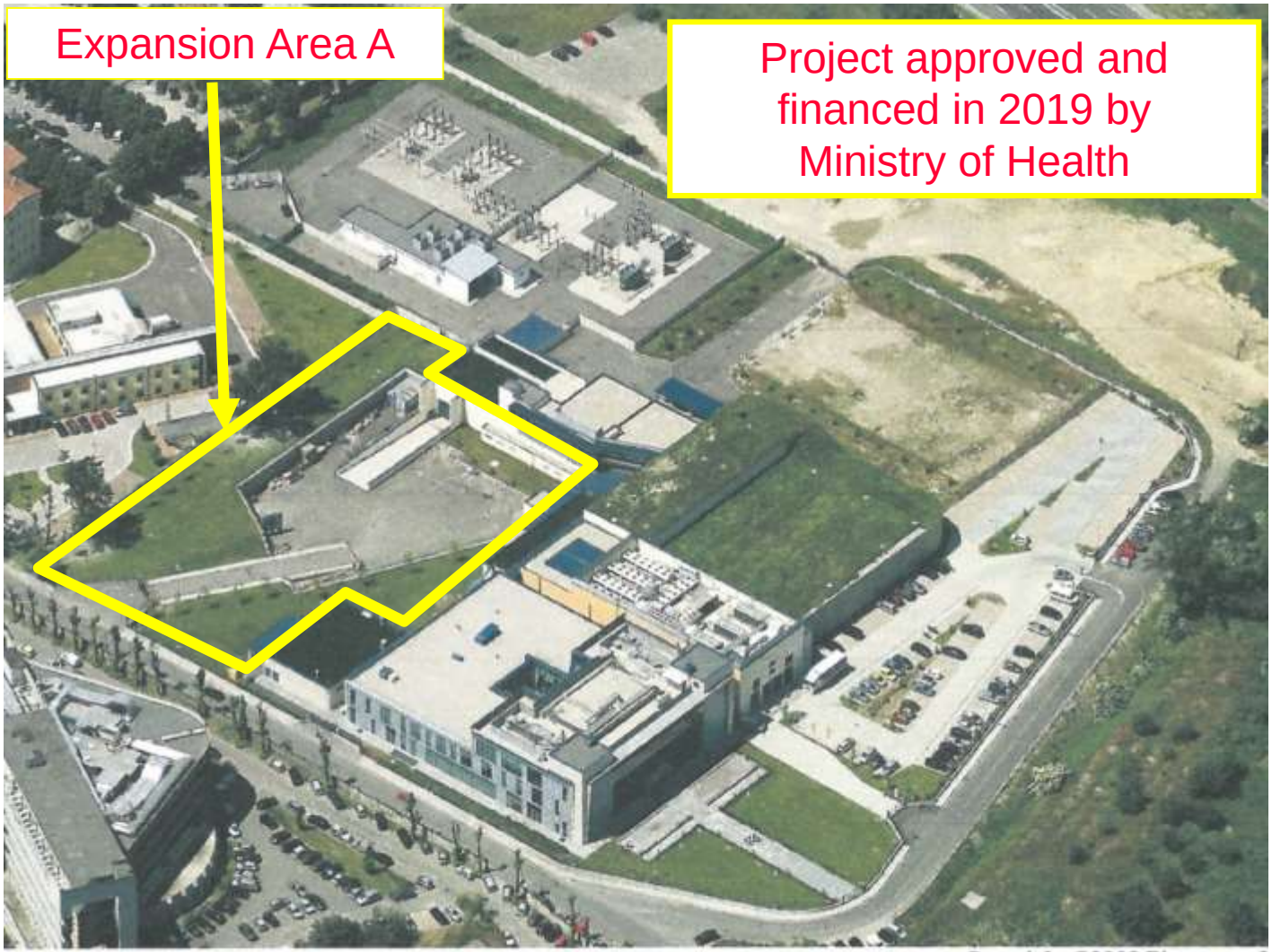
Microstructure at many frequencies (~100 Hz, ~10 kHz, ~1 MHz)

New source coming up

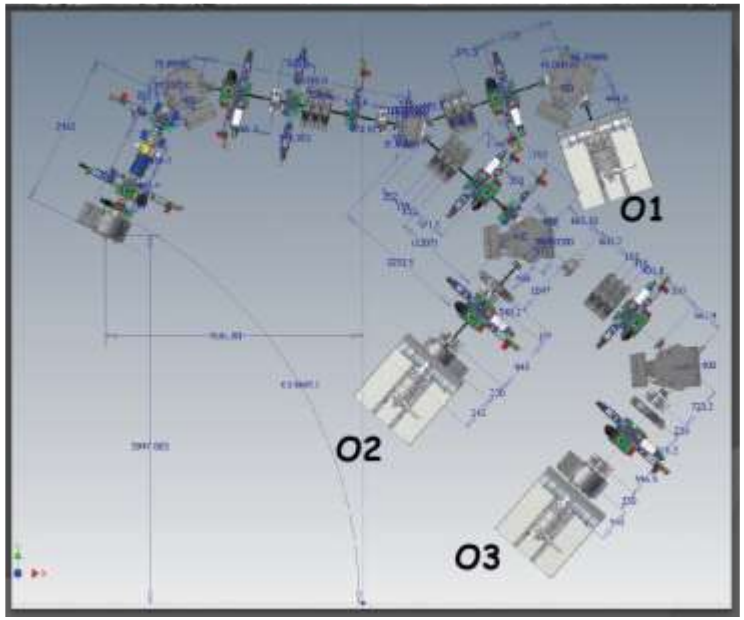
Multiple-isocentres research stations (different field sizes and equipment dimensions)



Expansion project:
to keep CNAO at cutting edge of the technology



Third source: new ion species



Collaboration CNAO-INFN-HiFuture

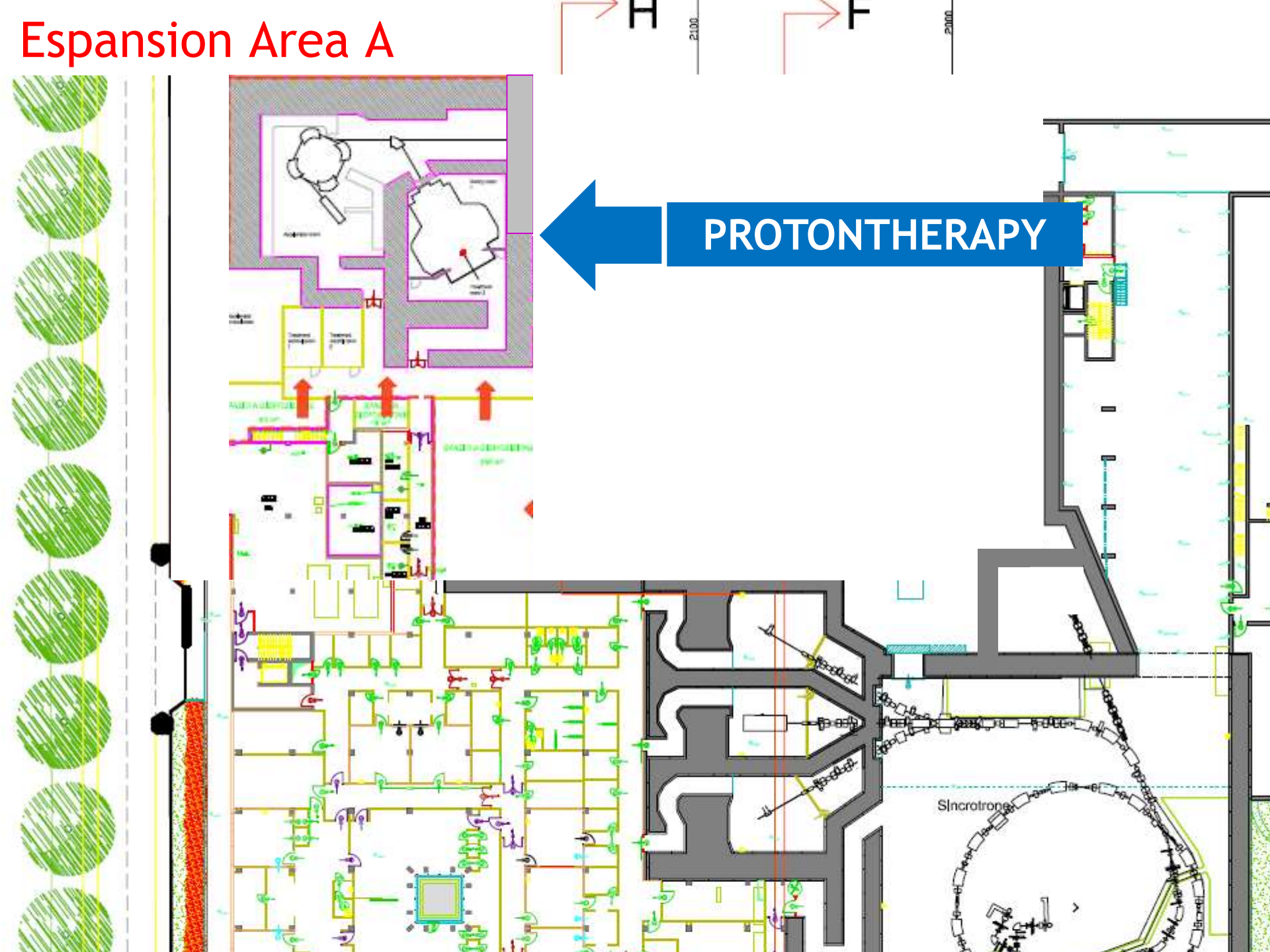
A facility INnovativa di irraggiamento con Sorgente per Ioni per Ricerca e studi di radiation hardness con applicazioni IndusTriali e cliniche INSpIRIT – ID 1161908
Call HUB ricerca e Innovazione – EU/Regional funds

Expected currents

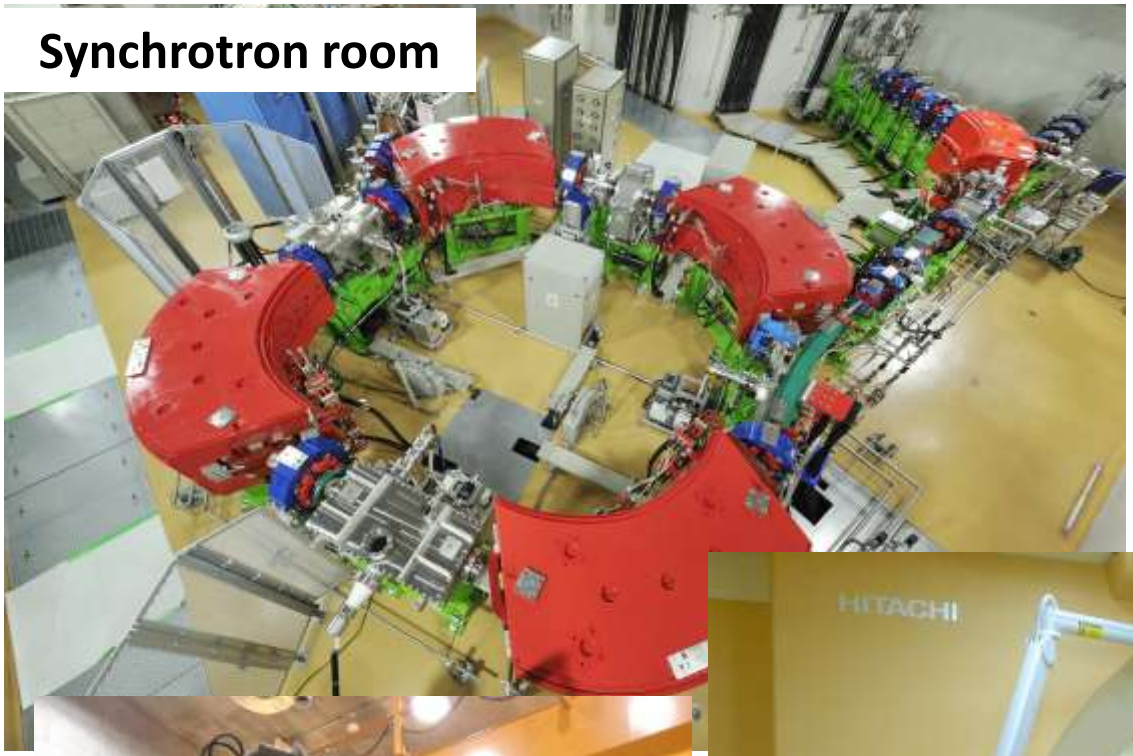
Ion beam production (eμA)

Ion	Supernanogan (14 GHz)	AISHa (18 GHz + TFH)
H^+	2000	4000
H_2^+	1200	2000
H_3^+	1000	1500
$^3He^+$	800	2000
$^{12}C^{4+}$	250	800
$^6Li^{2+}$ - $^7Li^{2+}$	//	800
$^{10}B^{3+}$ - $^{11}B^{3+}$	//	600
$^{18}O^{6+}$	400	1000
$^{21}Ne^{7+}$	120	500
$^{36}Ar^{12+}$	20	150

Espansion Area A

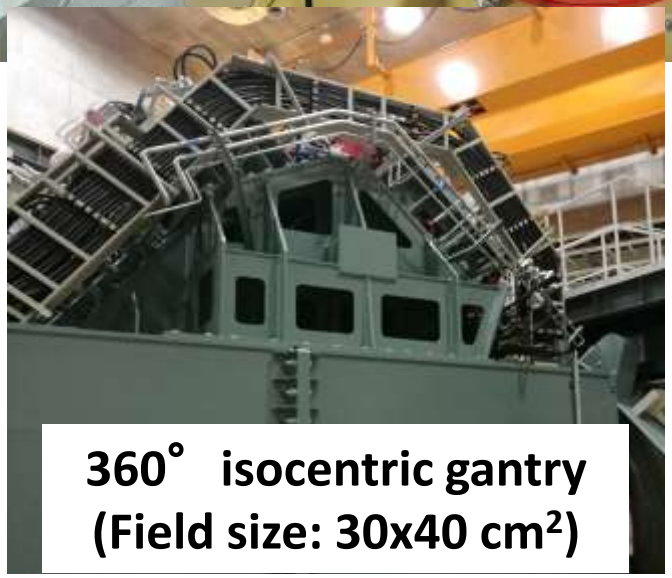


New single-room for protons

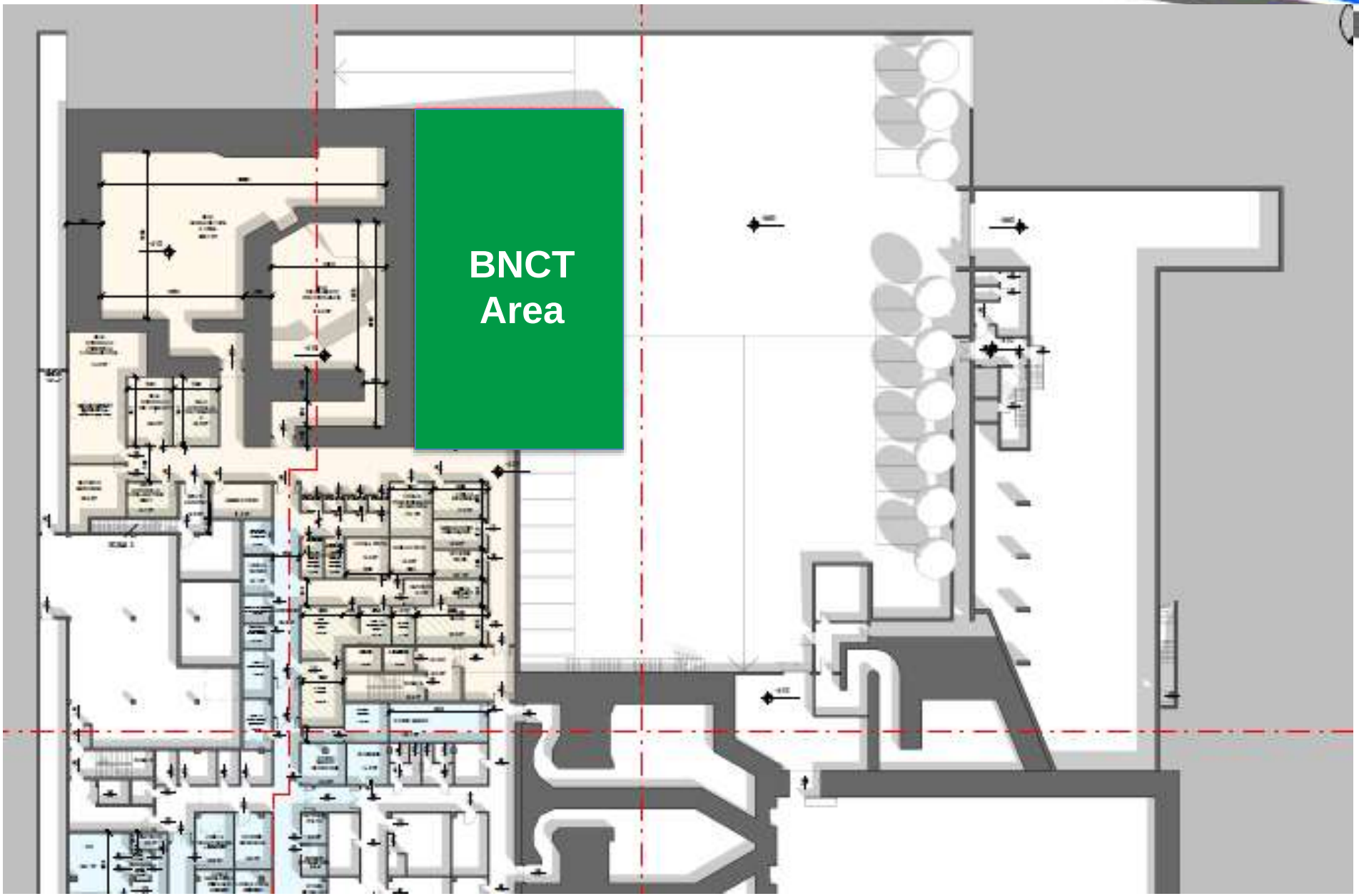


Contract signed with Hitachi:
December 5th, 2019

Operational 2023



Expansion Area A: integrating BNCT

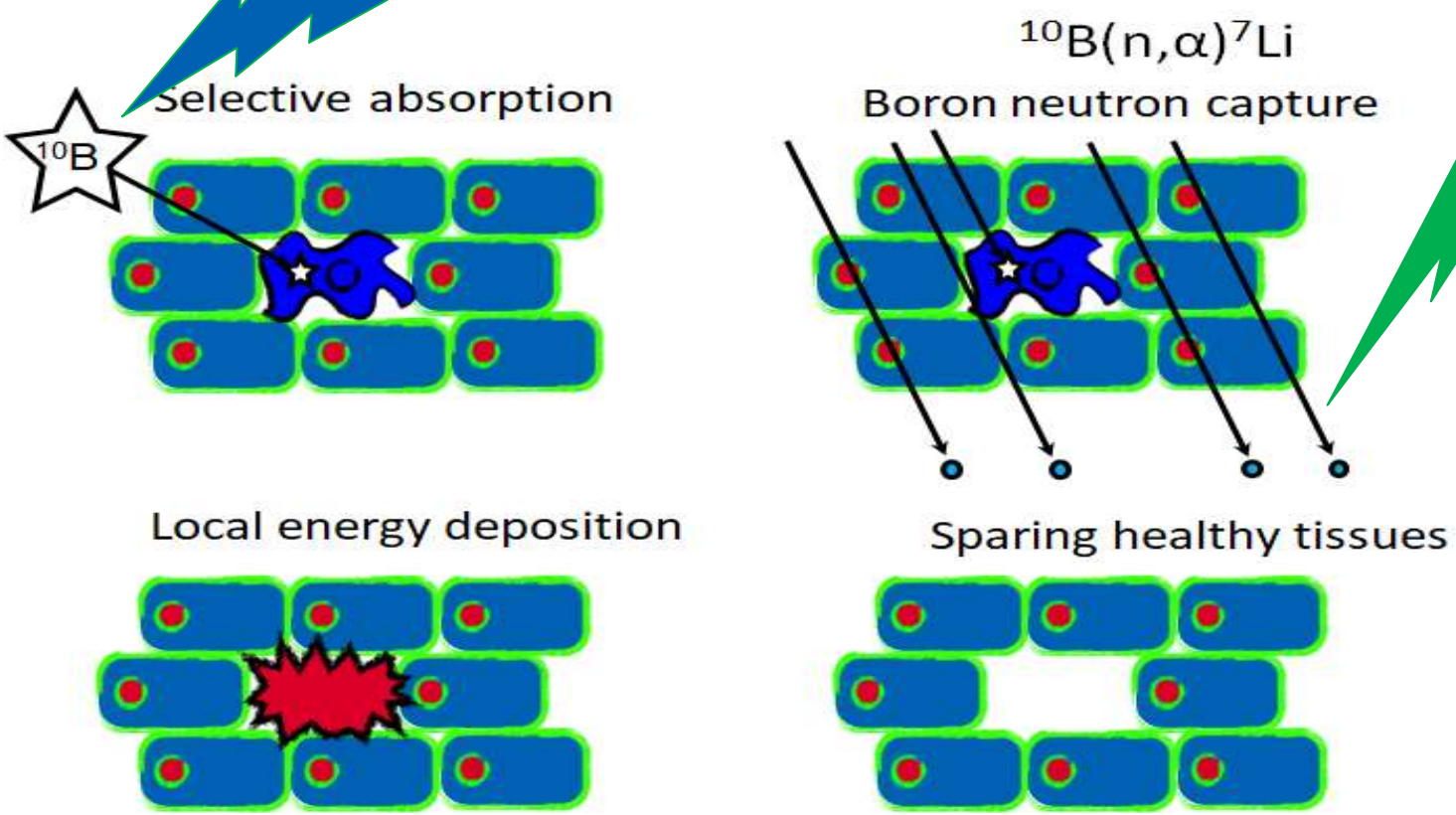


BNCT: Boron Neutron Capture Therapy

2-steps research approach for metastasized tumours

Boronated drug that selectively reaches the tumour cells and avoids the healthy tissues

Accelerator driven neutron production



BNCT: tandem accelerator

Collaboration agreement signed
September 2020

Operational 2023

Proton energy 2.5 MeV
Intensity 10-15 mA
p-Li reaction

alpha beam™

tae LIFE SCIENCES

HITRI*plus*
PARTICIPANTS

22 Institutes
(4 CIRT centres, 10 research institutions, 5 universities, 3 SMEs)

14 European Countries

Participant No *	Participant organisation name	Country
1 (Coordinator)	Fondazione Centro Nazionale di Adroterapia Oncologica (CNAO)	IT
2	Bevatech GmbH (BEVA)	DE
3	Commissariat à l'énergie atomique et aux énergies alternatives (CEA)	FR
4	European Organisation for Nuclear Research (CERN)	IEIO
5	Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT)	ES
6	Cosylab Laboratorij za kontrolne systeme dd (CSL)	SI
7	GSI Helmholtzzentrum für Schwerionenforschung GmbH (GSI)	DE
8	Universitätsklinikum Heidelberg (UKHD/HIT)	DE
9	Istituto Nazionale di Fisica Nucleare (INFN)	IT
10	EBG MedAustron GmbH (MEDA)	AT
11	Marburger Ionenstrahl-Therapie Betreibergesellschaft mbH (MIT)	DE
12	Paul Scherrer Institut (PSI)	CH
13	South East European International Institute for Sustainable Technologies (SEEIIST)	CH
14	Universita ta Malta (UM)	MT
15	Philipps-University Marburg (UMR)	DE
16	Uppsala University (UU)	SE
17	Wigner Research Centre for Physics (Wigner RCP)	HU
18	Riga Technical University (RTU)	LV

Third party participation linked to SEEIIST		
Participant No *	Participant organisation name	Country
19	Ss, Cyril and Methodius University in Skopje, Republic of North Macedonia (UKIM)	MK
20	Clinical Centre of Montenegro (CMSM)	ME
21	Sentronis a.d. (SEN)	RS
22	Jožef Stefan Institute (IJS)	SI

WP1: Management

WP2: Networking and Communication, Dissemination and Outreach

WP3: Clinical networking

WP4: Innovation, technology transfer, industry relation

WP5: Education and Training

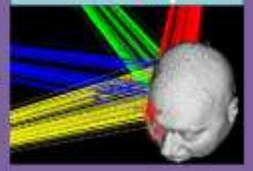
JRA Joint Research Activities

TNA WP6 Transnational Access

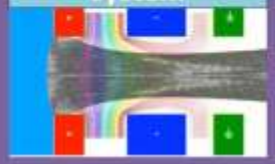
WP7: Advanced accelerator and gantry design

WP8: Superconducting magnets design

WP9: Advanced beam delivery

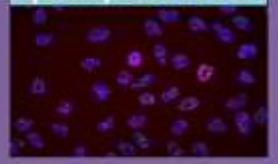


WP10: Multiple energy extraction system



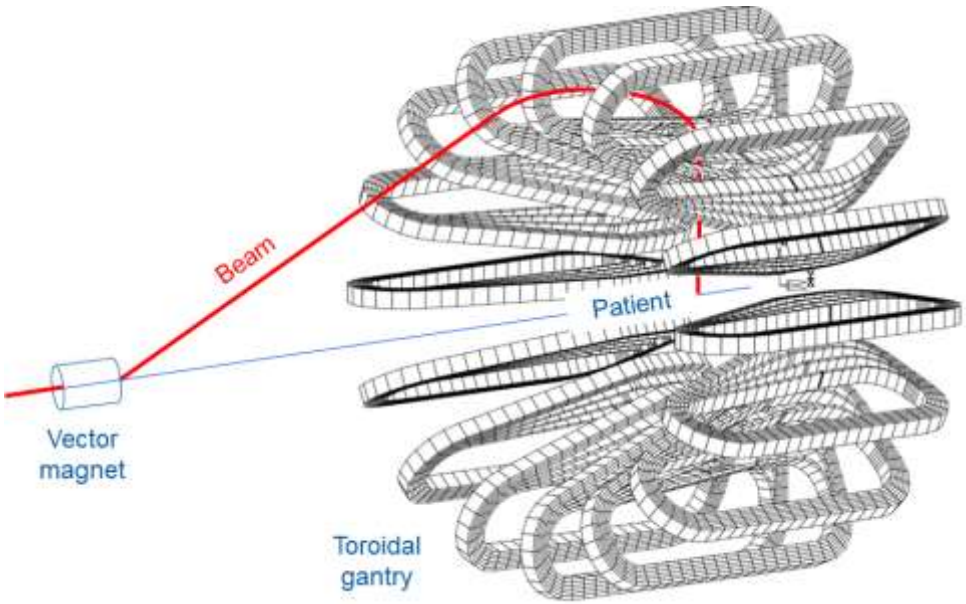
WP11: Controls and safety

WP12: Radiobiology and quality assurance

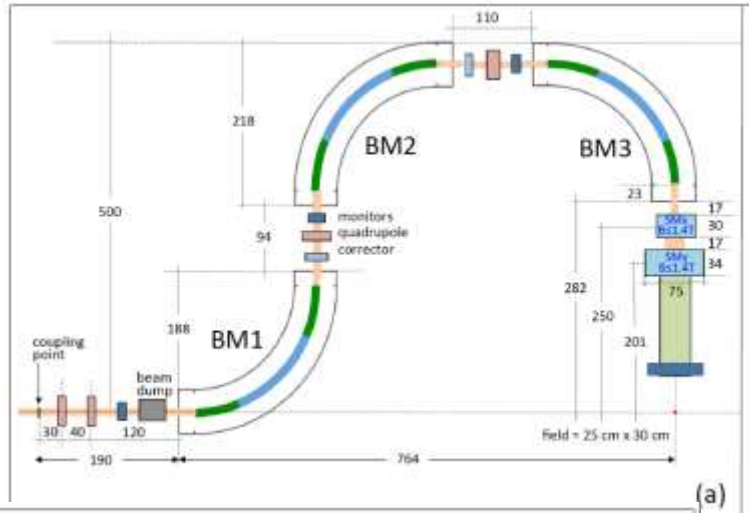


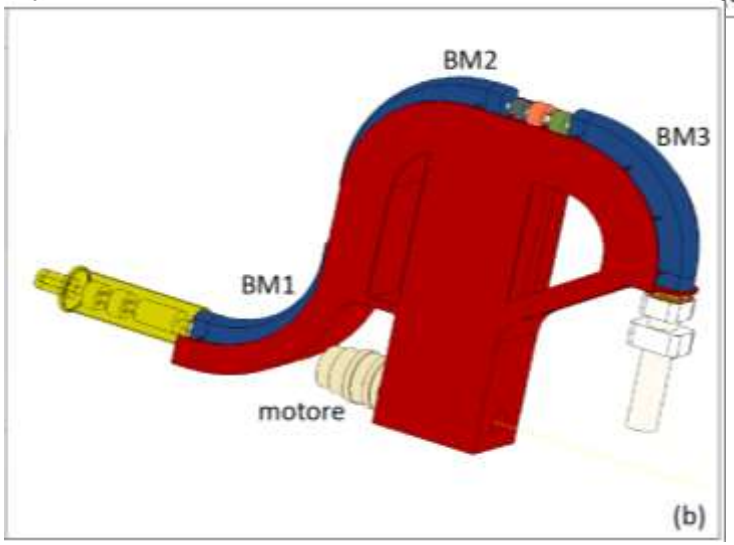
R&D: carbon ions gantry

Collaboration CNAO-INFN-CERN-MedAustron
under discussion: start 2021, 3 years project



Toroidal magnet SC design (L. Bottura/CERN)





TERA-CERN-LBNL (SC canted cosine theta)

Thank you

“Real progress happens only when advantages of a new technology become available to everybody”

H. Ford