



# CNAO – challenges and perspectives

Sandro Rossi

*OMA School on Medical Accelerators  
Pavia – June 5-9, 2017*

# OUTLINE

SR – Intro

Mario Ciocca – Medical Physics (15')

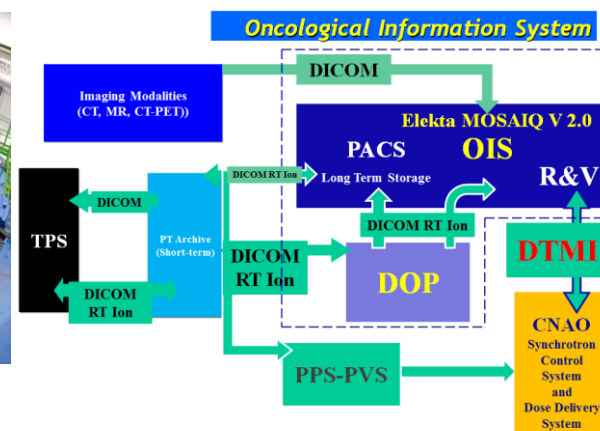
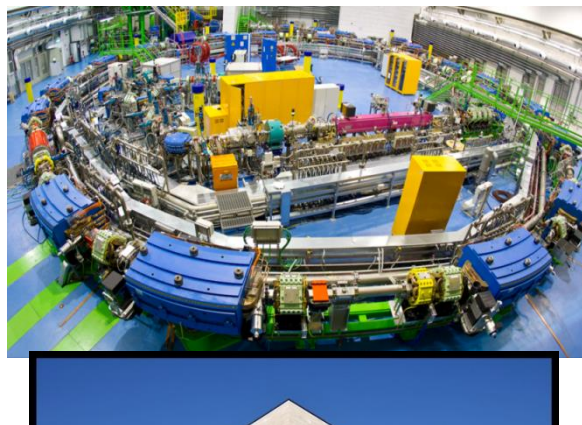
Angelica Facoetti – Radiobiology (15')

Michele Ferrarini – Radioprotection (15')

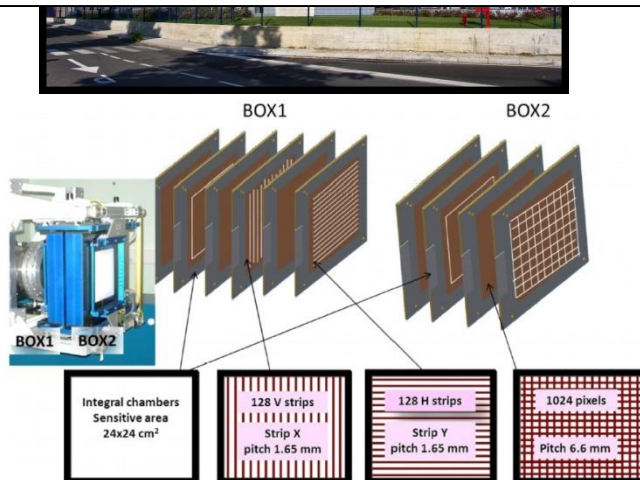
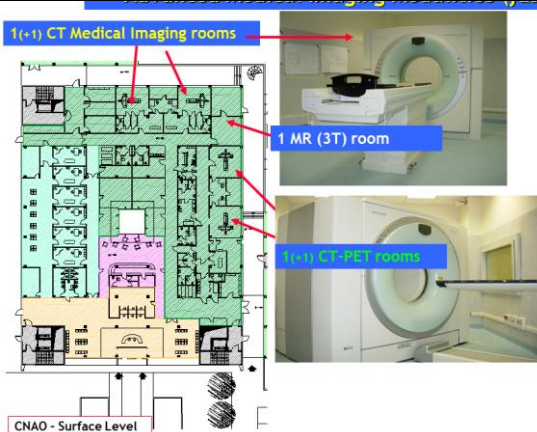
SR - Conclusions

# “LEGO Model”: integrated technical and medical solutions

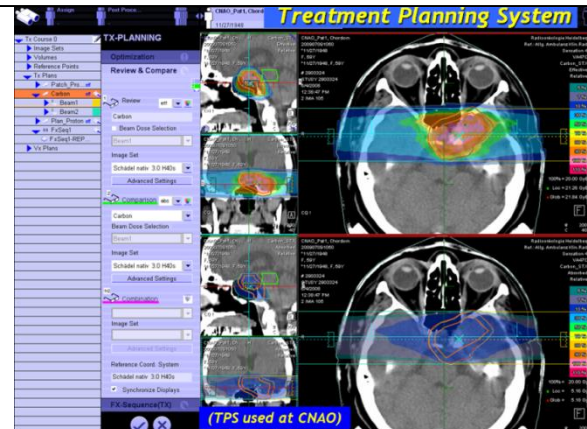
High precision devices for patient positioning



The real challenge:  
**make ALL systems running together**  
 safely, efficiently, reliably and easily maintainable.



Strip and Pixel sensitive area 21x21 cm²



(TPS used at CNAO)

# Performance CNAO from Nov. 2011 to Dec. 2016

- 1768 running days
- 1285 treatment days
- 104 days preventive maintenance
- 36 days of downtime
- **System availability: 94%**
- **System reliability (days): 97%**
- **System reliability (sessions)**



## Year 2016

- 343 gg
- 243 gg
- 20 gg
- 3 gg
- **94%**
- **99%**
- **96% (275 vs 7058)**



# CNAO is Manufacturer of Medical Device (directive 93/42/EEC)

CNAO obtained the CE label after clinical experimentation

 <b>Istituto Superiore di Sanità</b> Organismo Notificato n° 0373 Sez. presso il Dipartimento di Tecnologie e Salute <small>Notified Body n° 0373 - One relating to Department Technology and Health</small>		Mod. 2/2010 - ISS Roma, 13 DIC 2013 <small>VIALE REGINA ELENA, 299          00161 ROMA          TELEGRAMMI: ISTISAN, ROMA          TELEFONO: 06 498011          TELEFAX: 06 4981118          HTTP://WWW.ISS.IT</small>
<b>CERTIFICAZIONE CE</b> Secondo l'allegato III della Direttiva Europea 93/42/CEE e successive modifiche Attuale con DLgs. 37 del 25.01.2010 <b>EC CERTIFICATION</b> According to Annex III of Directive 93/42/EEC and subsequent modifications Transposed by DLgs. 37 of 25.01.2010		
<b>Certificato n° 20131213 036 3303 CT</b> <small>Certificate n°</small>		
<p>L'Istituto Superiore di Sanità, Organismo Notificato n° 0373, certifica che il prodotto sotto menzionato soddisfa i requisiti essenziali di cui all'allegato I della Direttiva 93/42/CEE e successive modifiche verificati in accordo all'allegato III della stessa Direttiva.</p> <p>The Italian National Institute of Health, as Notified Body n° 0373, certifies that the product hereinbelow described satisfies the essential requirements set out in Annex I and verified in compliance with Annex III of Directive 93/42/EEC and subsequent modifications.</p>		
<b>Tipo e modello:</b> <small>Type and model:</small>	Acceleratore per adroterapia <small>Accelerator for hadrontherapy</small>	
<b>Descrizione:</b> <small>Description:</small>	[ 34469 ] ACCELERATORE DI PARTICELLE, RADIOTERAPIA [ 34469 ] PARTICLE ACCELERATOR, RADIOTHERAPY	
<b>Destinazione d'uso:</b> <small>Intended use:</small>	Vedi allegato di 3 pagine <small>See annex of 3 pages</small>	
<b>Numero di serie:</b> <small>Serial number:</small>	0001/2012	
<b>Fabbricante:</b> <small>Manufacturer:</small>	<b>Fondazione CNAO (Centro Nazionale Adroterapia Oncologica)</b> Sede Legale: Via Caminadella,16 – 20133 Milano Sede Operativa: Strada Campeggi, 53 – 27100 Pavia	
<b>Rapporto di conformità n°</b> <small>Conformity report n°</small>	2013 003 33 003	del 13/12/2013 <small>of dd/mm/yyyy</small>
<b>Il presente certificato è valido dal</b> <small>This certificate is valid from</small>	13/12/2013 <small>dd/mm/yyyy</small>	al 08/07/2018 <small>until dd/mm/yyyy</small>
Il Direttore del Dipartimento Tecnologie e Salute F.F. The Acting Director of Department Technology and Health (Ing. Pietro Bartolini) 		



CE label is a good starting point to obtain FDA clearance

# Perspectives: R&D projects



# HORIZON 2020 – Marie Skłodowska-Curie actions Research networks (ITN): support for Innovative Training Networks

## Two running projects at CNAO

- ❑ MARIE SKŁODOWSKA-CURIE ACTIONS  
Innovative Training Networks (ITN) Call: H2020-MSCA-ITN-2014  
**“MEDICIS-PROMED”**
- ❑ MARIE SKŁODOWSKA-CURIE ACTIONS  
Innovative Training Networks (ITN) Call: H2020-MSCA-ITN-2015  
**“OMA”**

# MEDICIS - PROMED

**Project acronym: MEDICIS-PROMED**

**Project full title: *MEDICIS-produced radioisotope beams for medicine***

**Grant agreement no.: 642889 - *MEDICIS-PROMED***

**Duration:** 4 years; start date: 15<sup>th</sup> April 2015

**Project leader:** CERN (European Organization for Nuclear Research)

**CNAO Dept:** Medical Physics

**ESR Supervisor:** A. Mairani

An Early Stage Researcher (ESR) has been recruited at CNAO.

A Korean physicist (KyungDon Choi) has been selected and he is being trained since November 2015 on the following topic: *Personalized  $^{11}\text{C}$  PET aided hadrontherapy*. He is included in the Physics PhD School of the University of Pavia.

CNAO is leading the Work Package 2, *PET aided  $^{11}\text{C}$  Carbon hadrontherapy*, and will organize and host the Summer School foreseen in 2017.



# OMA

**Project acronym: OMA**

**Project full title: *Optimization of Medical Accelerators***

**Grant agreement no.: 675265 - OMA**

**Duration:** 4 years; start date: 1 February 2016

**Project leader:** University of Liverpool

**CNAO Dept:** Bioengineering Unit and Control Systems Unit

**ESR Supervisors:** G. Baroni; L. Casalegno

Two Early Research Stage students have been recruited at CNAO for 3 years, starting from 1<sup>st</sup> October 2016, being trained in the following topics:

- *Light ion therapy software for data exchange (Carlos Afonso)*
- *Tumor tracking in particle therapy (Hanen Ziri)*

The two ESRs are enrolled in the PhD Program in Bioengineering and Bioinformatics at the University of Pavia

**March 2016 – Application**  
**December 2016 – Funded**  
**Project start: March 2017**

- Application to the National Project «*Linea R&S per Aggregazioni<sup>#</sup>*».  
**Title:** Innovative timing for hadrontherapy treatments and dose delivery systems (OTERO)  
**Duration:** 20 months  
**Consortium:** CNAO (leader), 3 Italian SME, National Institute of Nuclear Physics (INFN)  
**CNAO Dept:** Control Systems Unit (S. Toncelli, L. Casalegno, S. Foglio, S. Gioia)

*#: Regione Lombardia, Programma Operativo Regionale 2014-2020; Asse Prioritario I*

## January 2017 (answer after summer 2017)

### - *Application to H2020-MSCA-ITN-2017*

**Title:** Innovative research and training Network for Optimization of Hadron therapy Safety and Efficiency

**Duration:** 4 years

**Consortium:** CEA (leader), FORTH, GSI, UNIPV, UMCG, NIRS, UNICAEN, KVI-CART, PARTHENOPE, MUW, CNAO

**CNAO Dept:** Medical Physics (M. Ciocca)

## January 2017 (answer after summer 2017)

### - *Application to H2020-FET-OPEN-2016-2017*

**Title:** Non-invasive monitoring of precision radiotherapy within the patient

**Duration:** 4 years

**Consortium:** DKFZ Heidelberg (leader), CERN, ADVACAM, CNAO

**CNAO Dept:** Medical Physics (A. Mairani)

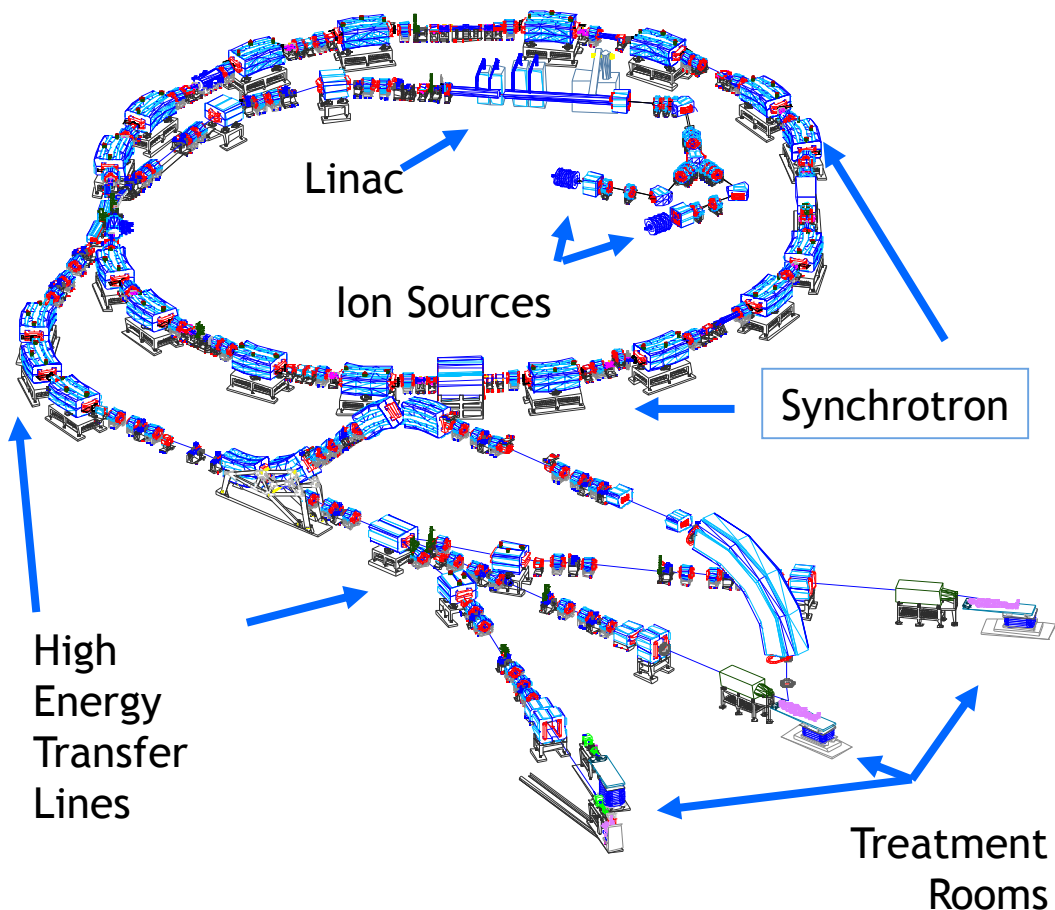
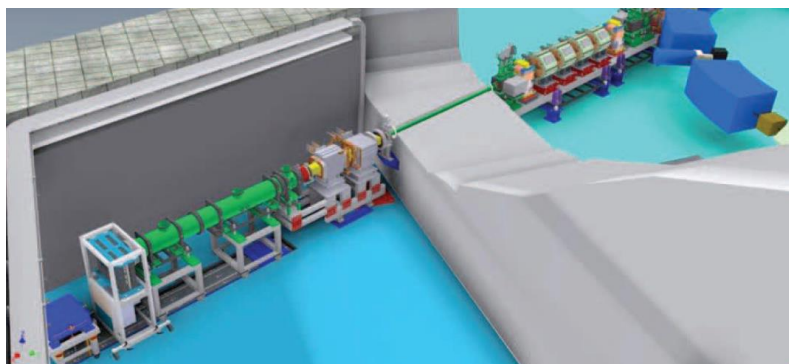
# Perspectives: **expansion programmes**





# Flexible hightech design: compact solution

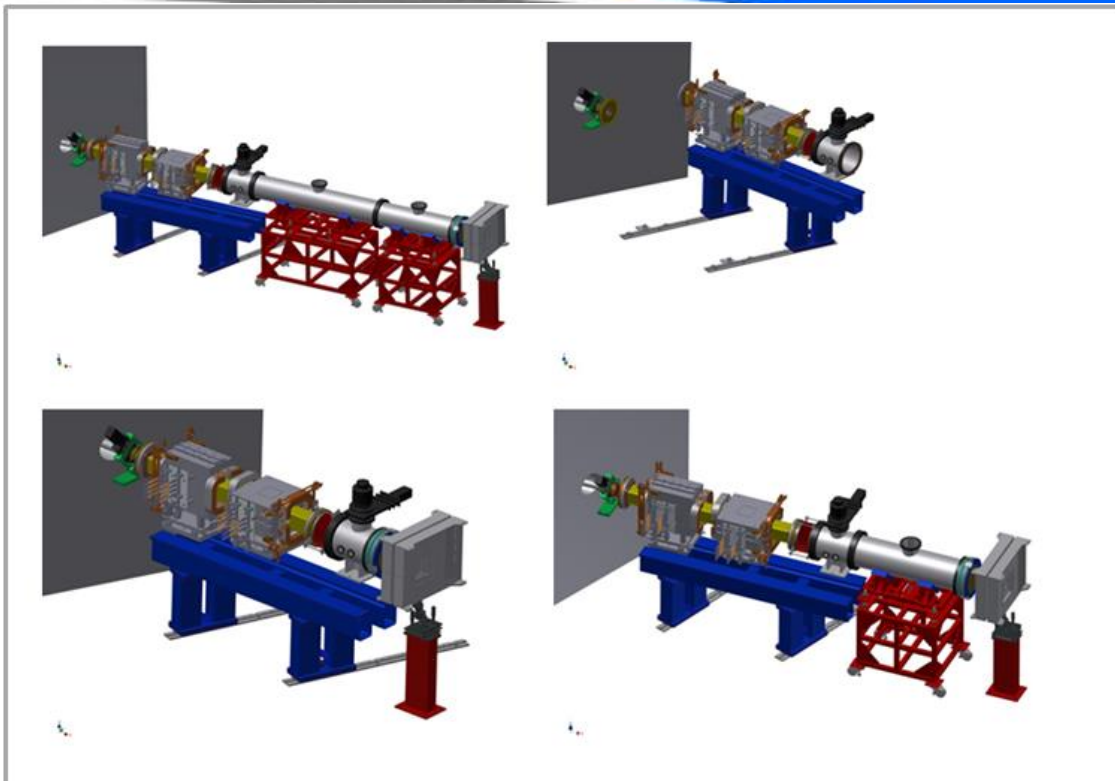
Coming up in 2018  
New experimental room  
(in collaboration with INFN)



Hospital based:  
safety, efficiency, reliability, maintainability

# Research beamline

Multi-isocentre  
configuration



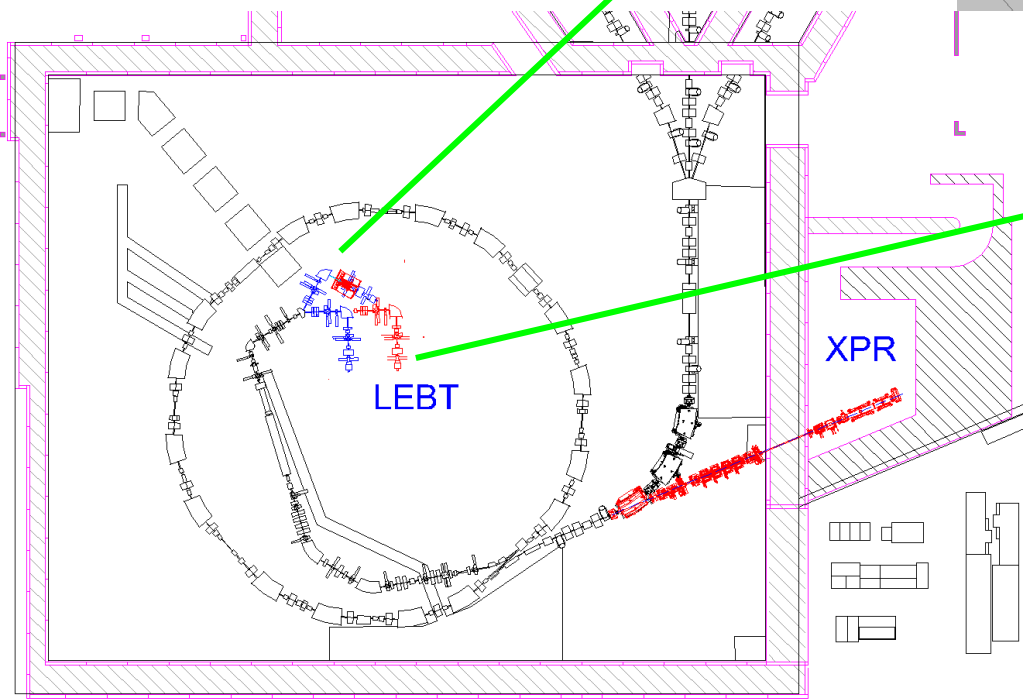
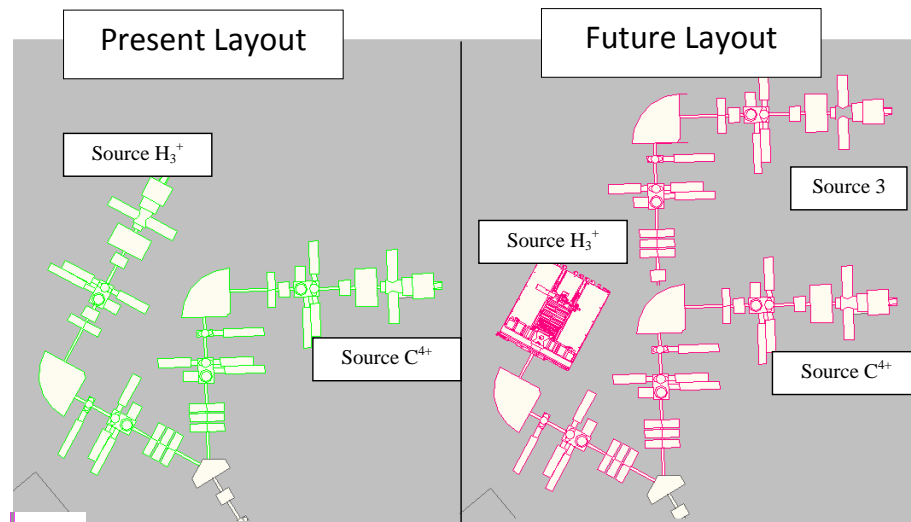
Ready end 2017

In collaboration with INFN

# Research beamline: phase 2

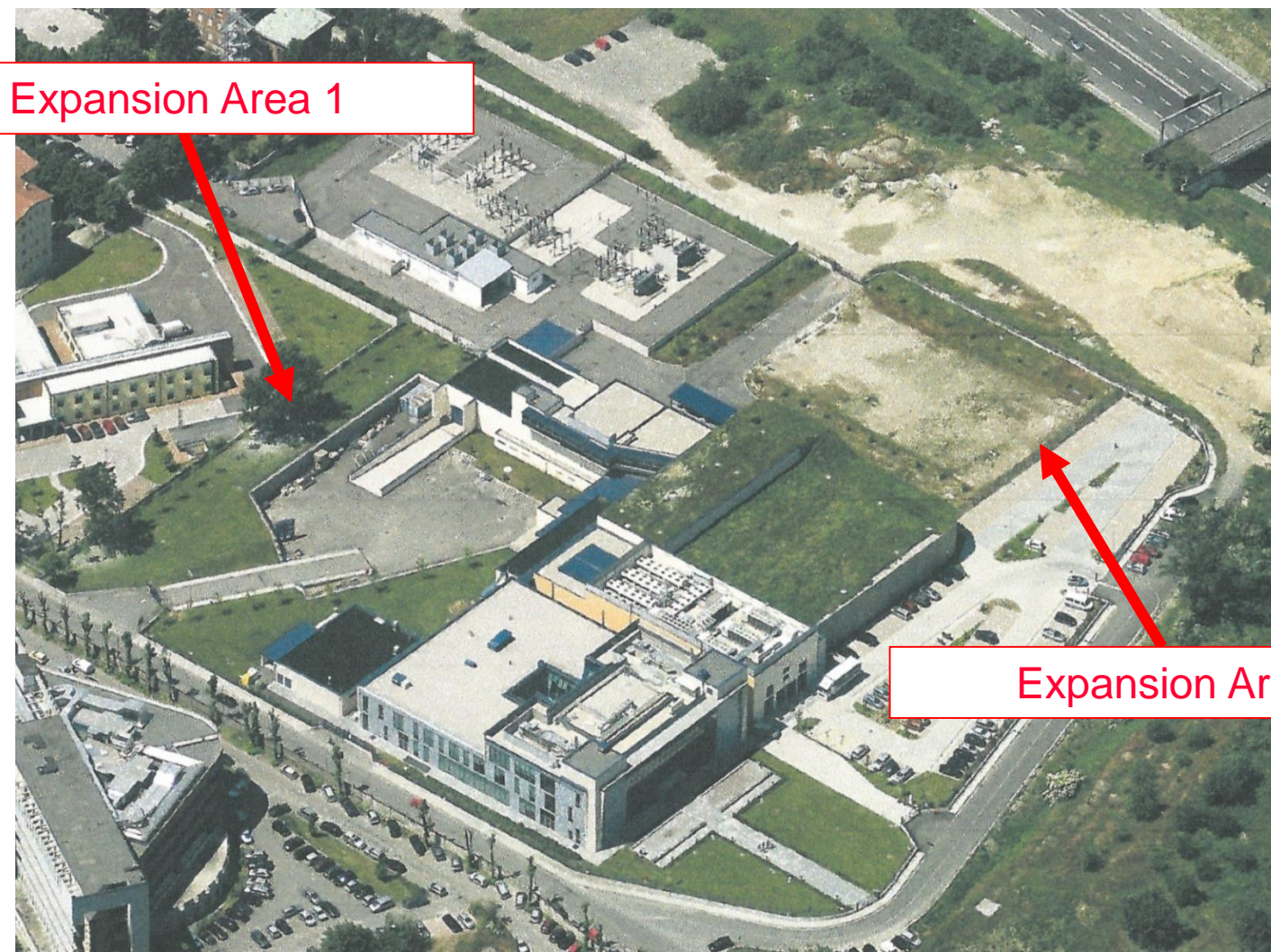
Addition of a 3rd ion source

From He to Ar





# View of the site



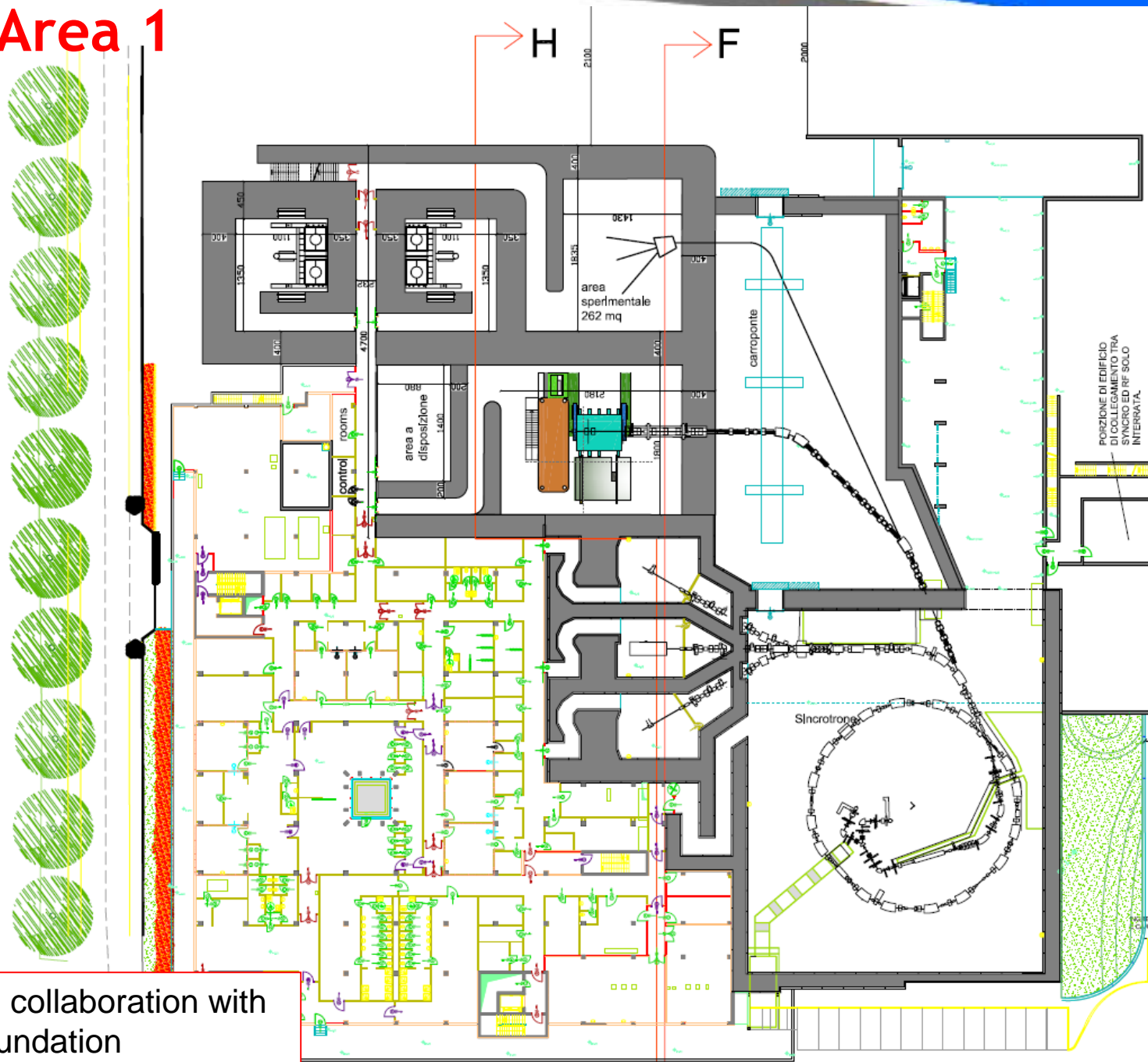
Expansion Area 1

Expansion Area 2

Copyright ©2008 Pictometry I



# Expansion Area 1



Work in progress in collaboration with TERA Foundation

# Protontherapy: 2 single room facilities

fondazione **CNAO**  
Centro Nazionale di Adroterapia Oncologica

## AVVISO PUBBLICO

concernente l'invito a presentare proposte finalizzate alla progettazione e realizzazione di due impianti a sala unica per l'adroterapia con protoni presso la Fondazione CNAO – Centro Nazionale di Adroterapia Oncologica di Pavia

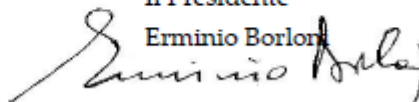
### 6) Modalità e termine di presentazione della manifestazione di interesse

La manifestazione di interesse, unitamente alla documentazione di seguito indicata, dovrà pervenire entro e non oltre le ore 17:00 del giorno 11 maggio 2017

Pavia, 6 febbraio 2017

Il Presidente

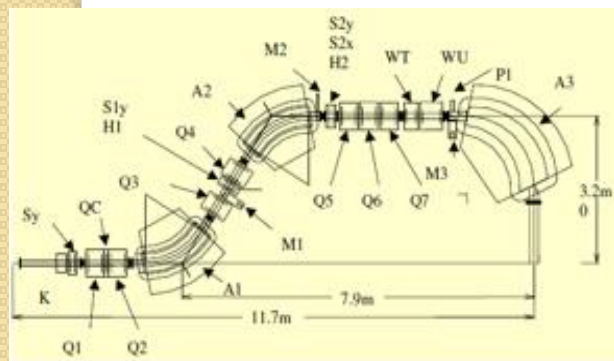
Erminio Borloni





# Gantry: comparison of dimensions

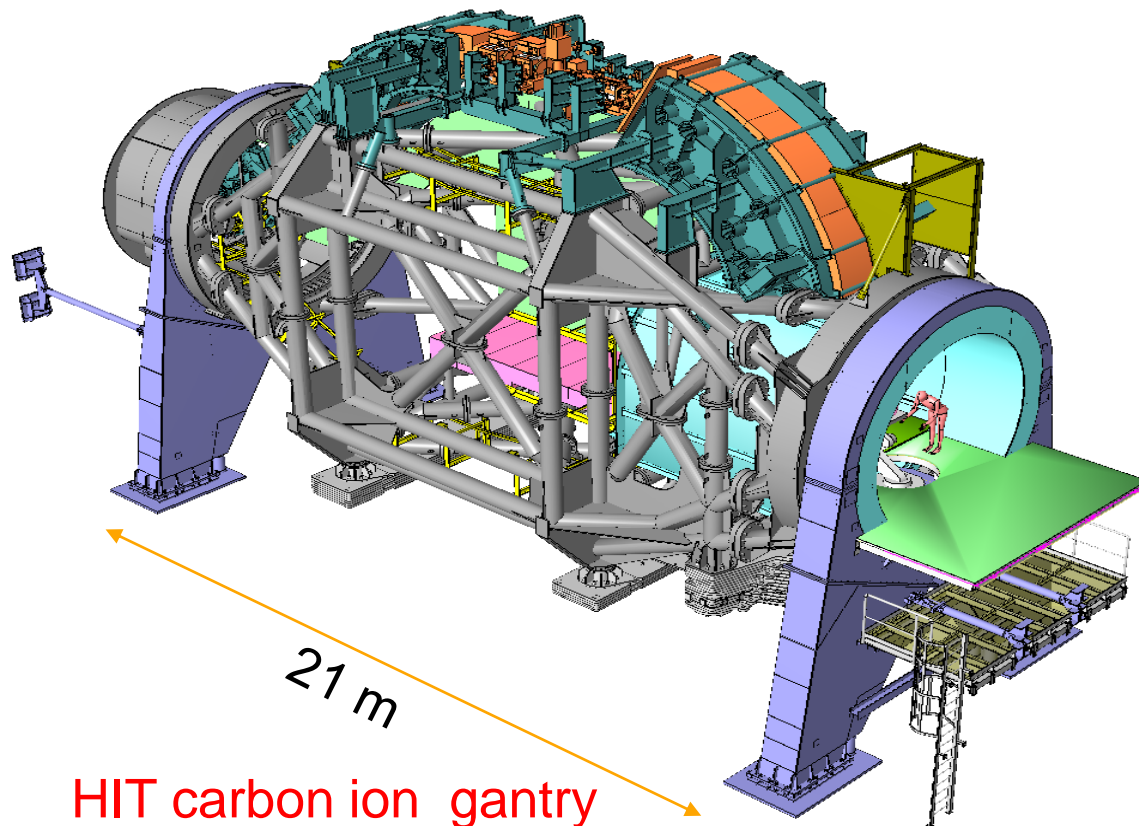
Conventional RT



Proton Gantry  
Br < 2.4 Tm

(Courtesy M. Pullia)

Carbon Ion Gantry  
Br < 6.4 Tm



HIT carbon ion gantry





# On-site Production of radioisotopes for imaging

CNAO: collaboration with UniPv and Pavia hospitals

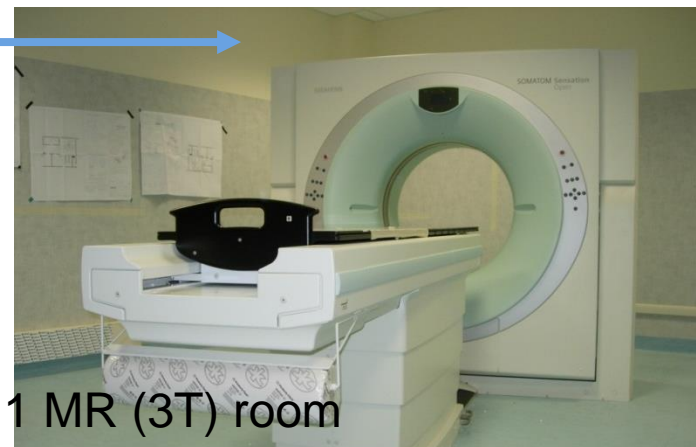
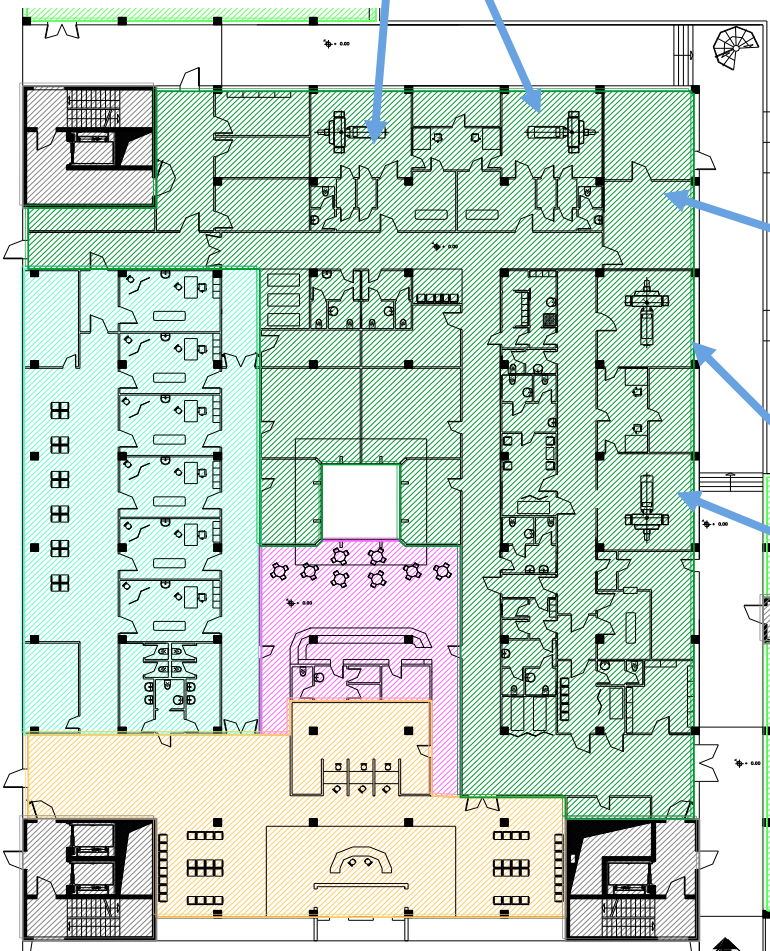


Cyclotron already installed at LENA could be re-used in a clinical&research environment for radioisotopes production to improve imaging capabilities.

Radiofarmacy and drugs development (chemistry) - MULTIDISCIPLINARITY

# Advanced Medical Imaging Modalities (fusion sw)

1(+1) CT Medical Imaging rooms



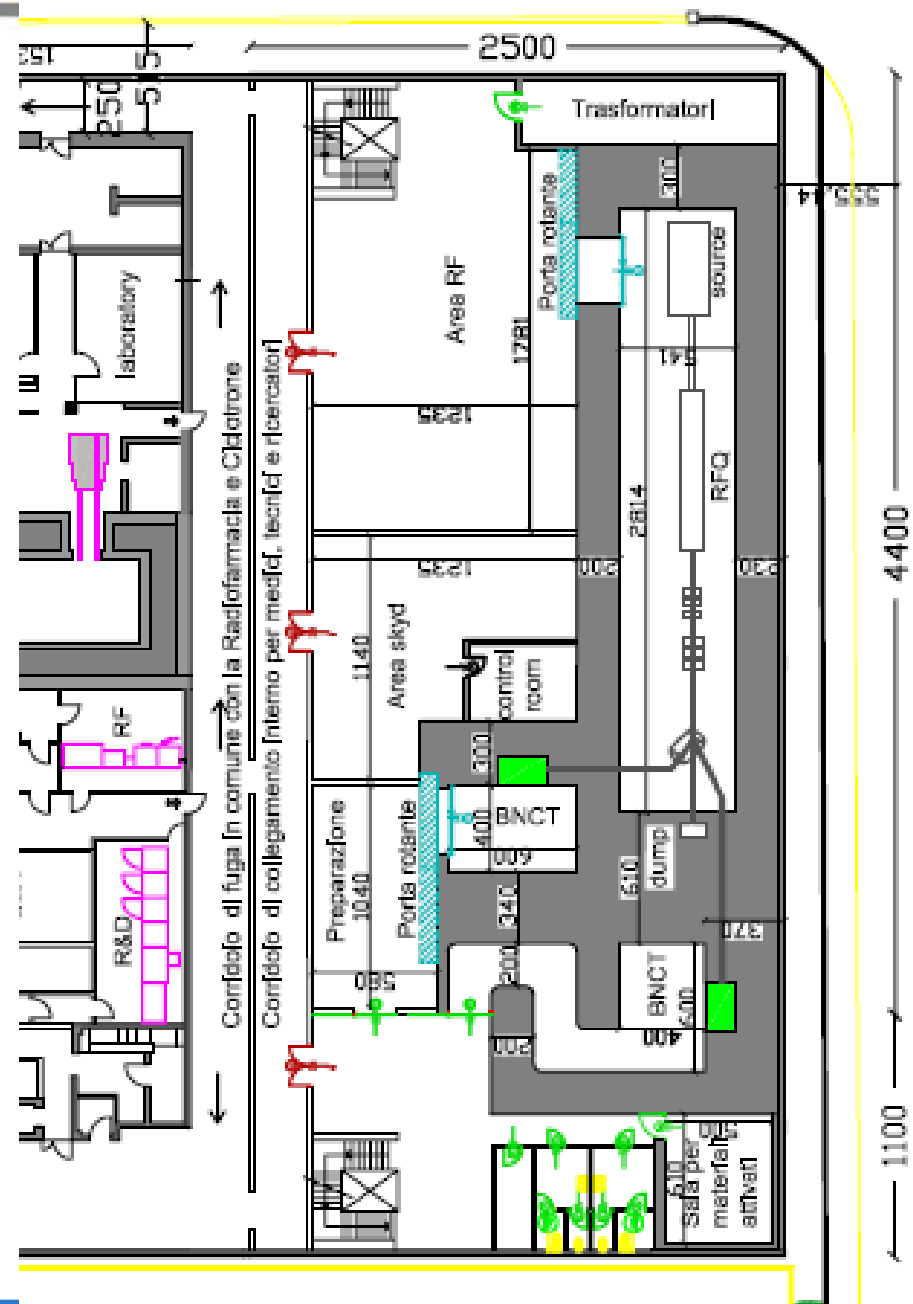
1 MR (3T) room



1(+1) CT-PET rooms

Advanced 3D molecular imaging modalities  
→ tumour molecular profiling  
→ dose painting with different LET ions  
(→ sources and accelerators choices)

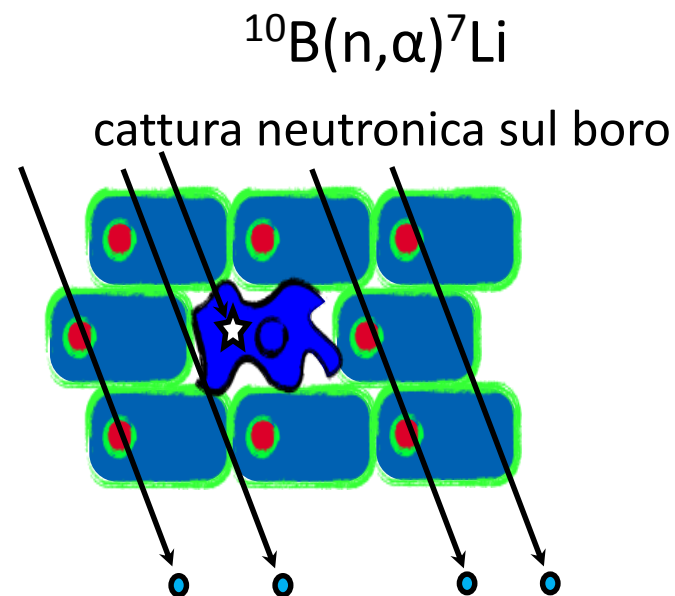
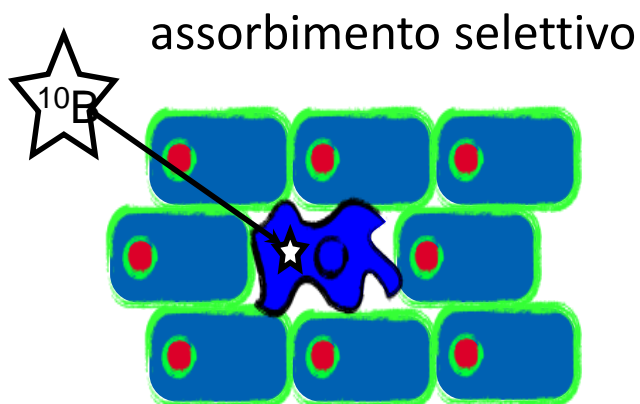
# Expansion Area 2 BNCT



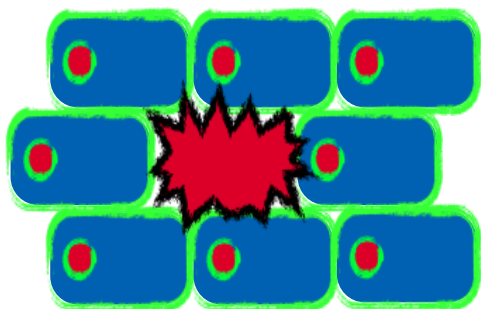
In collaboration with TERA Foundation



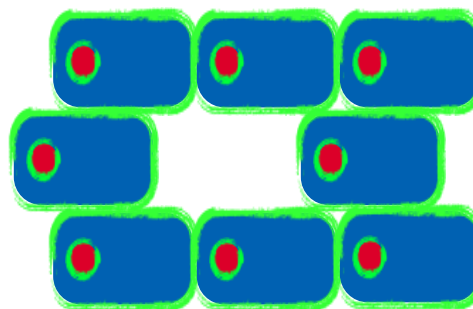
# L'effetto della BNCT



cellula danneggiata muore



tessuto sano conservato

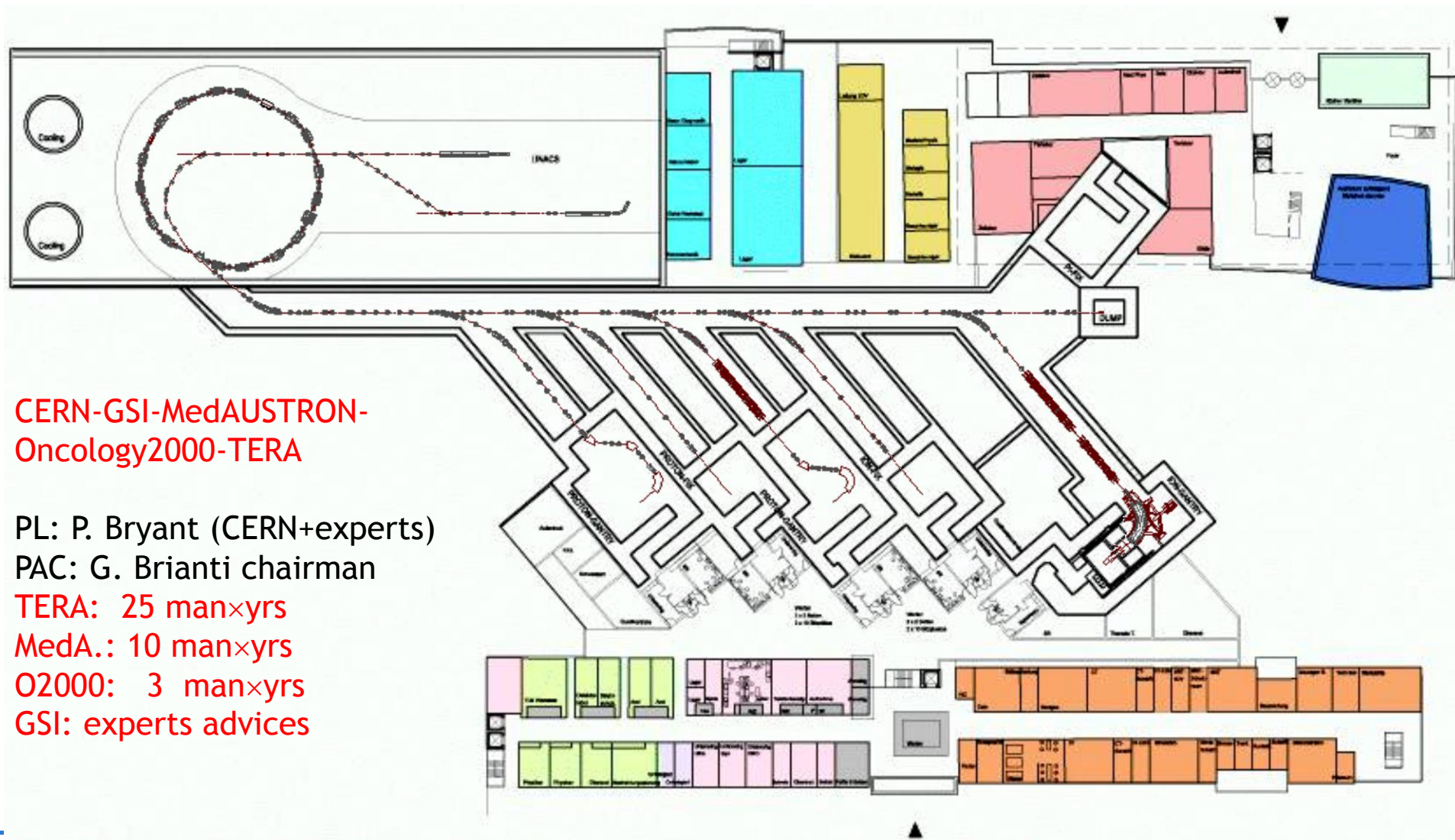


# Perspectives: **new centres in the world ?**



*From 1996 to 1999 at CERN*

## PIMMS (Proton-Ions Medical Machine Study)



**CERN-GSI-MedAUSTRON-  
Oncology2000-TERA**

PL: P. Bryant (CERN+experts)

PAC: G. Brianti chairman

TERA: 25 man×yrs

MedA.: 10 man×yrs

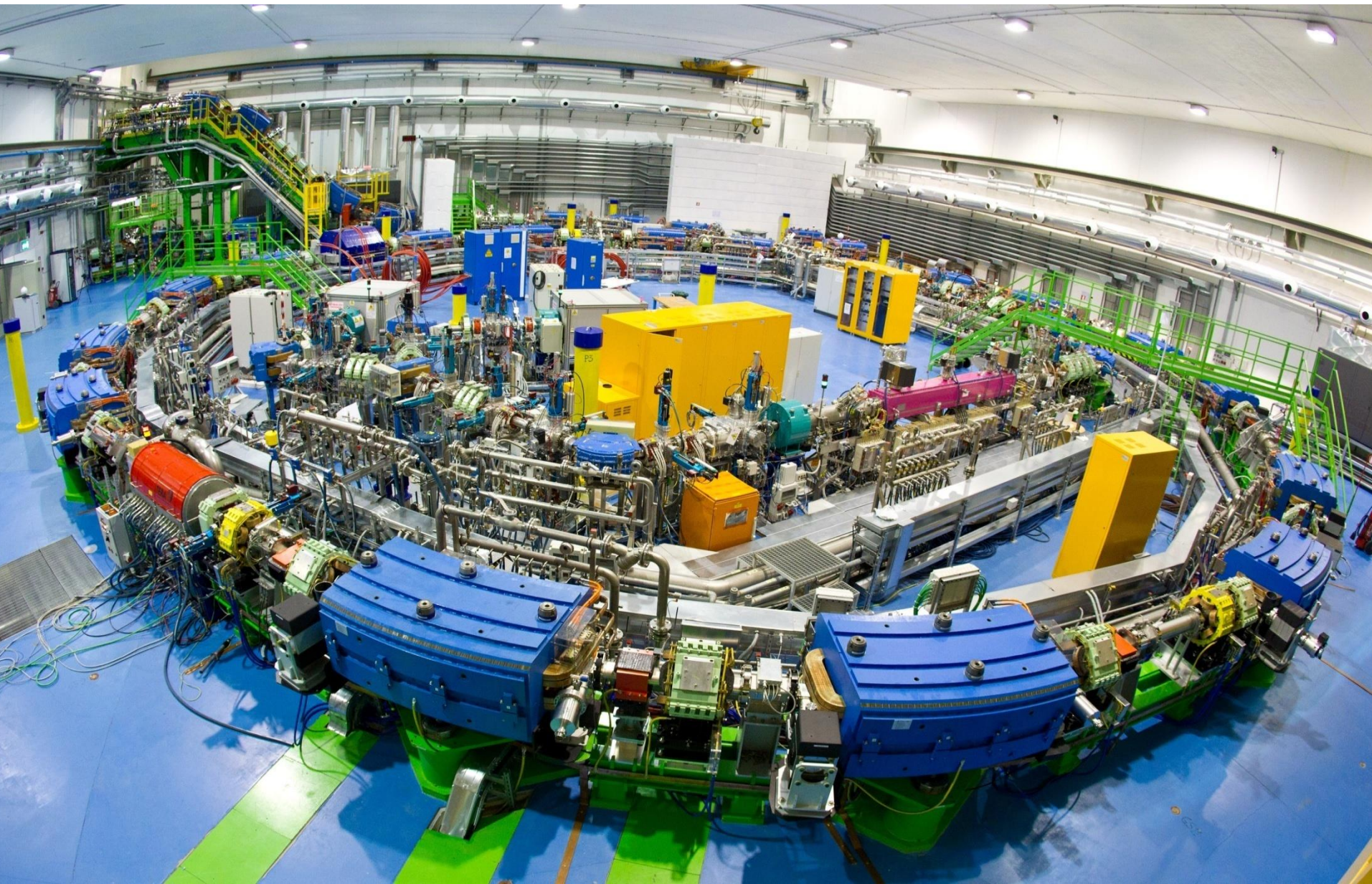
O2000: 3 man×yrs

GSI: experts advices

**Objective: define the optimal hadrontherapy centre without constraints**

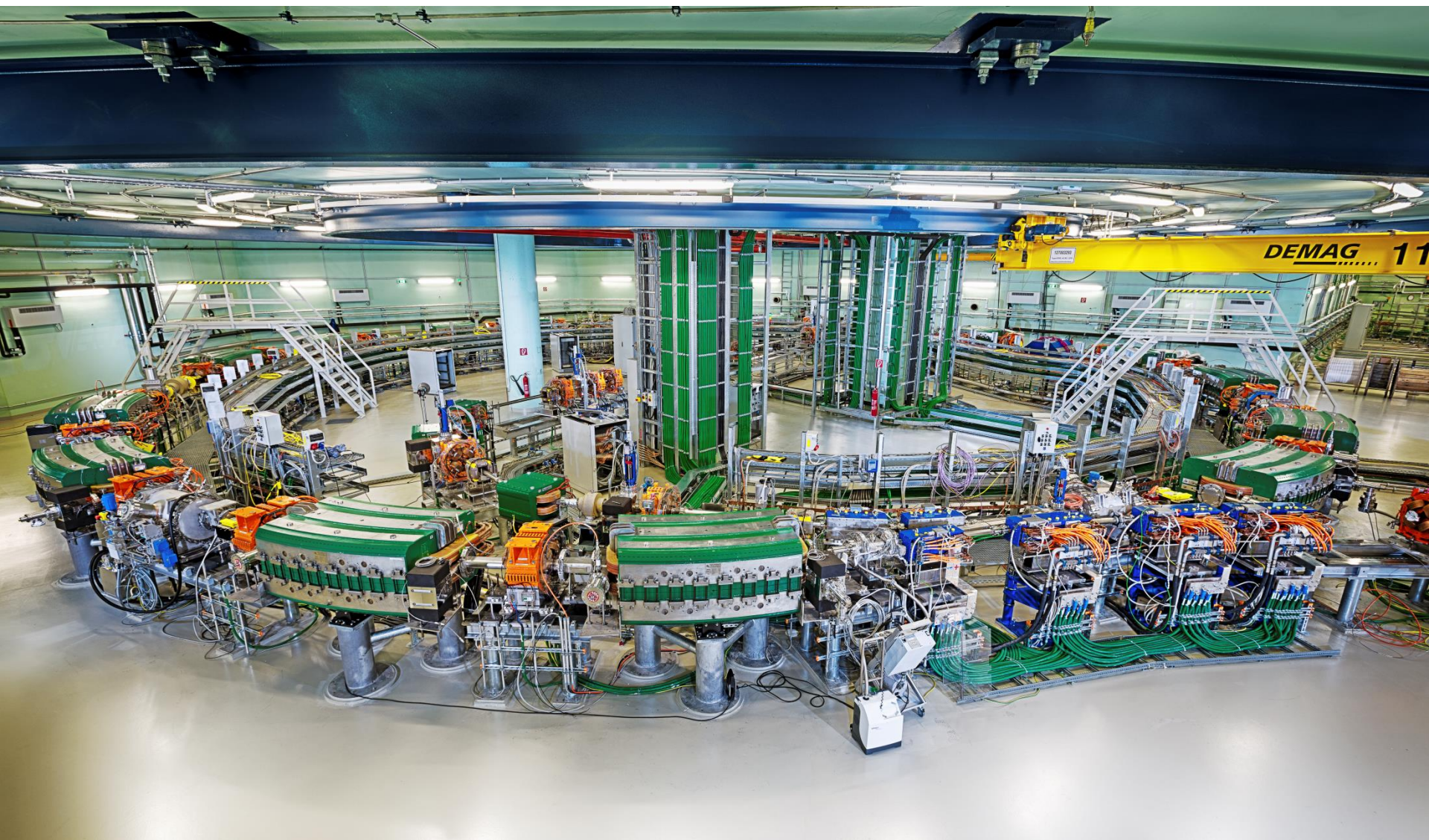


# The high-tech for protons and carbon ions: **CNAOMed1.0**





# The high-tech for protons and carbon ions: **CNAOMed2.0**



*(Courtesy of Peter Urschütz - MedAustron)*



# CNAOMed3.0

A MULTI-ION SOLUTION  
THE LATEST ADVANCED THERAPY  
TO FIGHT CANCER

# CNAO-INFN realizzazione centro in Georgia

DATE: 10.03.2017

CNAO FOUNDATION – CENTRO  
NAZIONALE DI ADROTERAPIA  
ONCOLOGICA

And

TECHNOLOGICAL INSTITUTE  
OF GEORGIA

For CNAO

SIGNED by legal representative

Erminio Borloni

Pavia,

Signature



The image shows a blue circular stamp with the text "FONDAZIONE CENTRO NAZIONALE DI ADROTERAPIA ONCOLOGICA" around the perimeter. Overlaid on the stamp is a handwritten signature in black ink that reads "Erminio Borloni".

For TIG

SIGNED by Acting Executive Director

Teimuraz Lomidze

Tbilisi,

Signature



The image shows a blue circular stamp with the text "TECHNOLOGICAL INSTITUTE OF GEORGIA" around the perimeter. Overlaid on the stamp is a handwritten signature in black ink that reads "Teimuraz Lomidze" and the date "10.03.2017".





# Thank you

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