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<sup>b</sup>  
UNIVERSITÄT  
BERN

Nov. 2003 – Dec. 2006:

**The IDRA cyc-linac  
and the PRASSI project**

Saverio Braccini

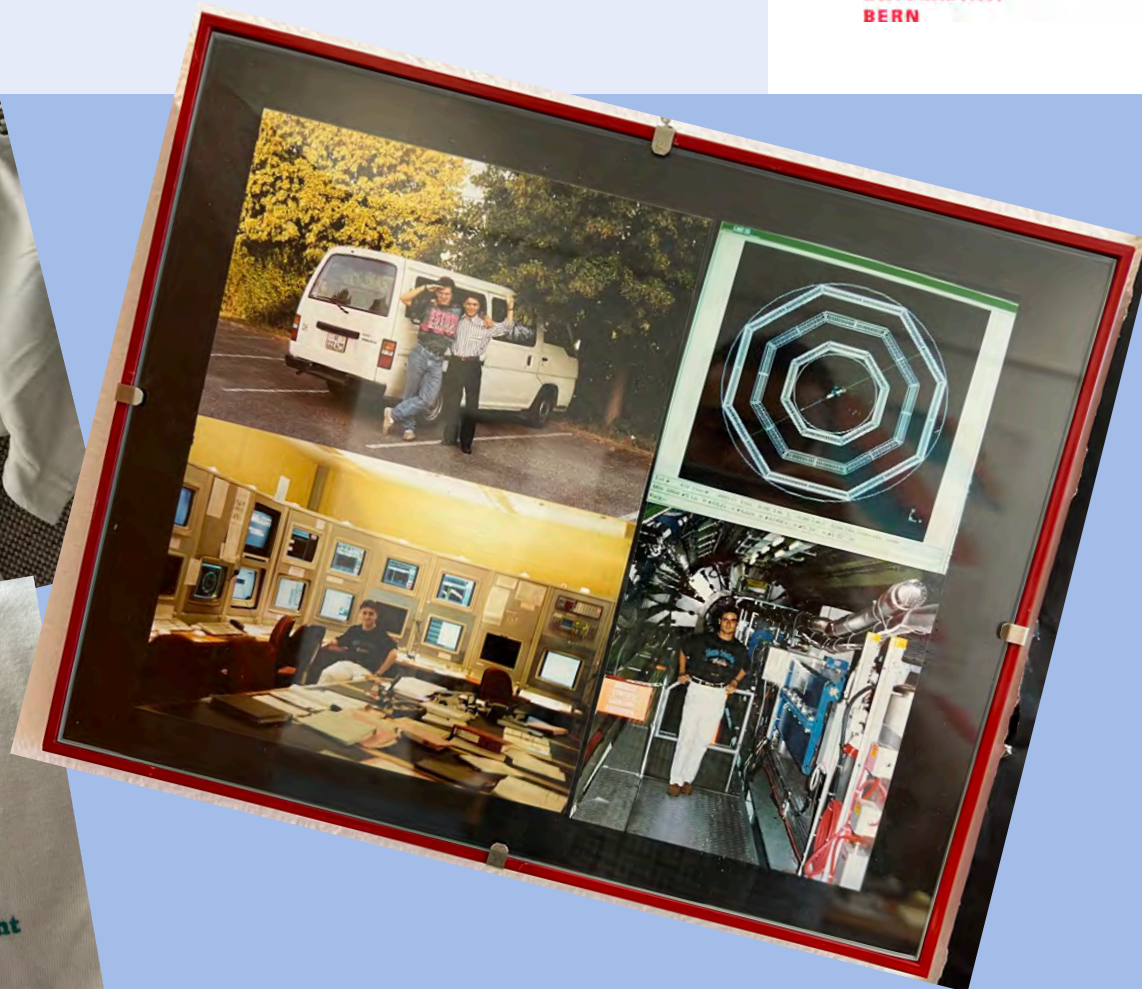
Albert Einstein Center for Fundamental Physics (AEC)  
Laboratory for High Energy Physics (LHEP)  
University of Bern, Switzerland

# 1992: a year that changed my life



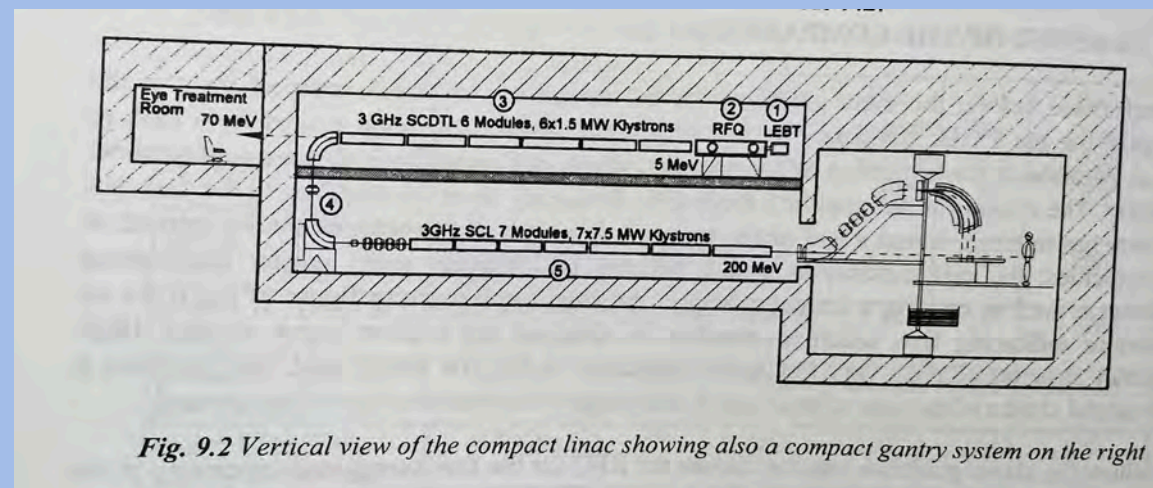
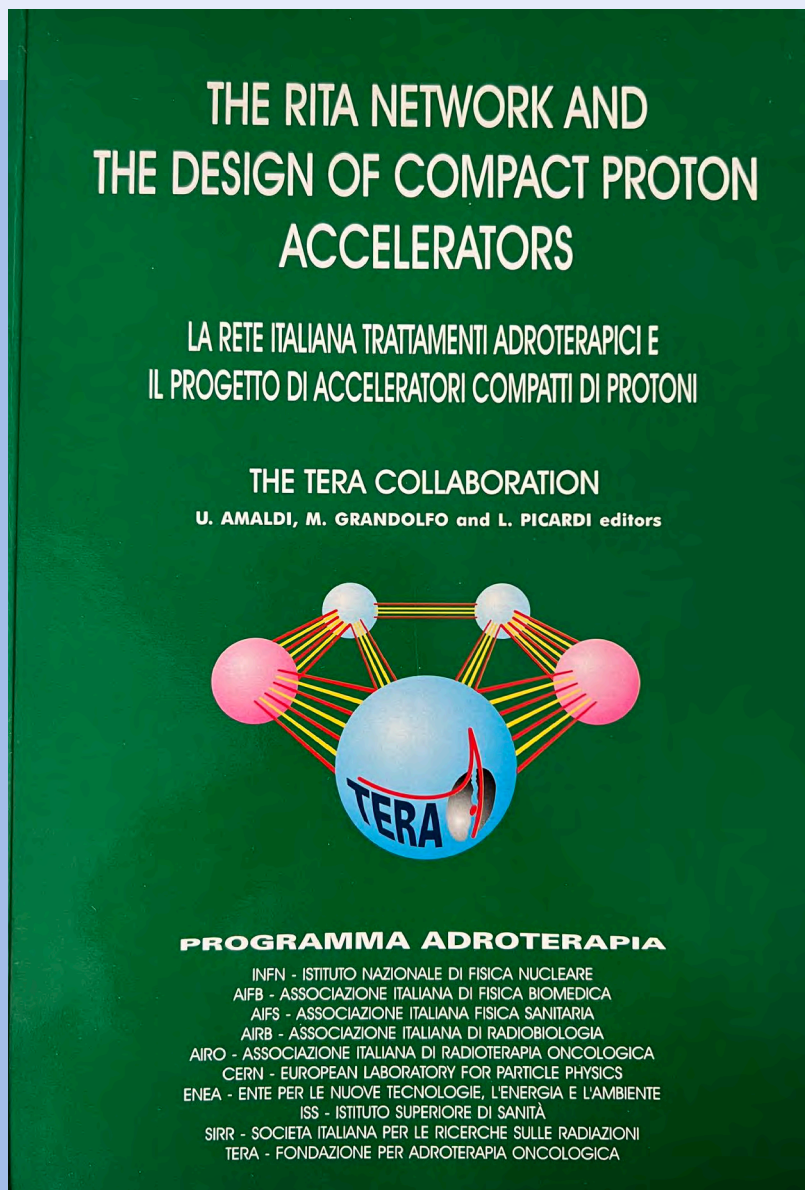
Arcetri, Florence, 1992

# 1992: a year that changed my life



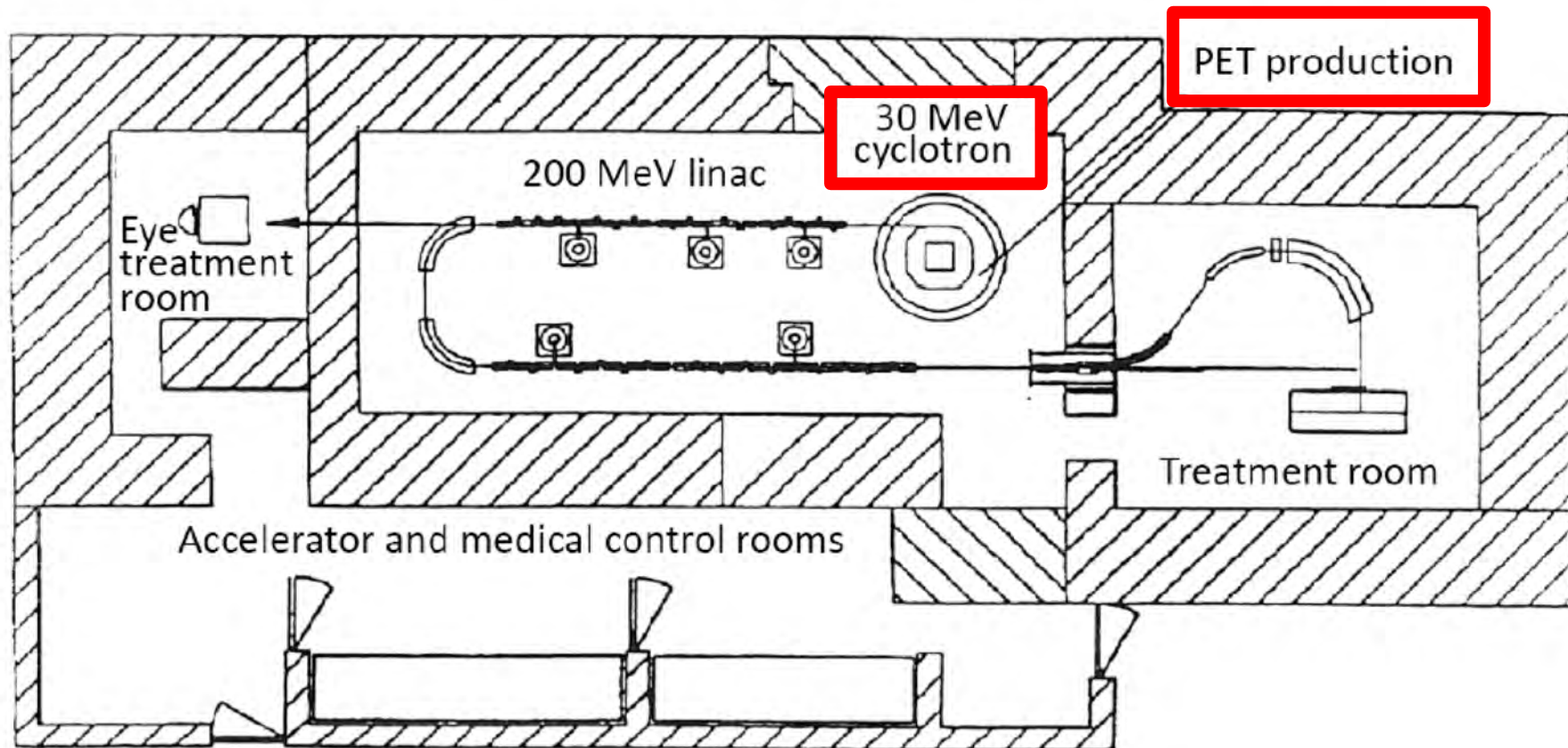
CERN Summer Student, 1992  
L3 Collaboration at LEP

# The green book (1996)



## Chapter 9 – High frequency proton linac “Compact Accelerator project”

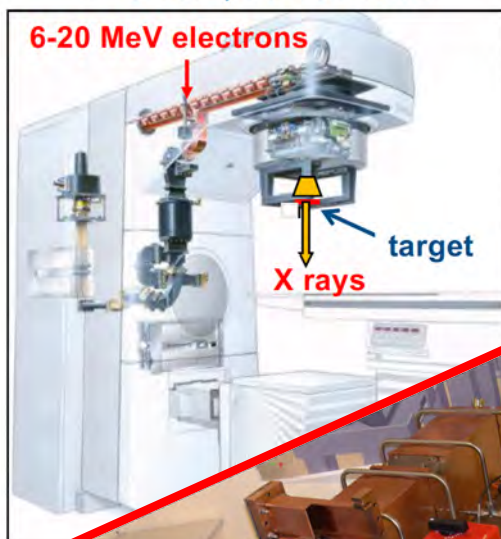
# Cyc-linac: the first idea of accelerator complex for theranostics



U. Amaldi and G. Tosi, The hadron therapy project three years later,  
TERA 94/13, GEN 11.

# First cyc-linac (2001): SC cyclotron of INFN + LIBO

Standard electron linac  
f = 3 GHz, 10-15 MV/m



Laboratori Nazionali del Sud  
Catania



62 MeV  
74 MeV  
**LIBO**  
f = 3 Ghz, 16 MV/m

U. Amaldi et al., LIBO - a linac-booster for protontherapy:  
construction and tests of a prototype, NIM A 521 (2004) 512-529.

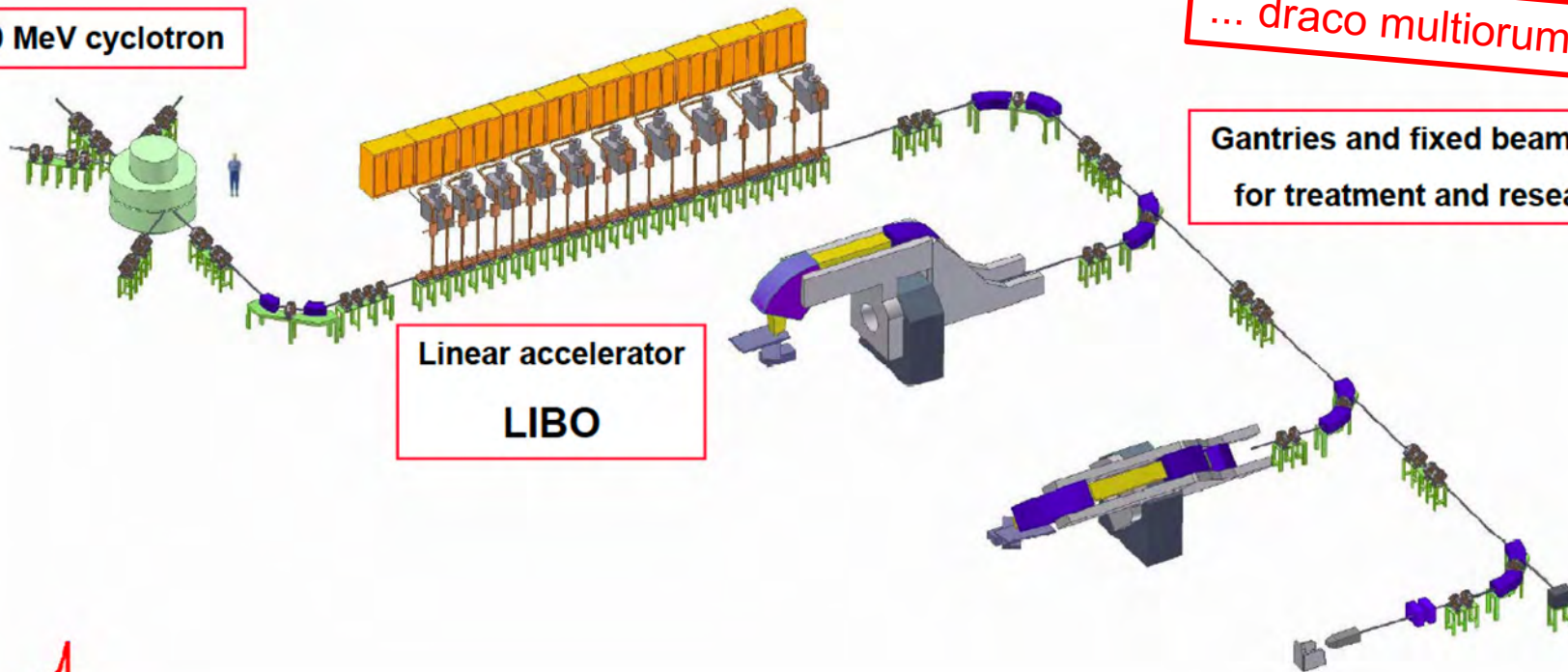
# IDRA (2004): Radioisotopes, proton therapy and research

## IDRA

Institute for **D**iagnostics and **RA**diotherapy



30 MeV cyclotron

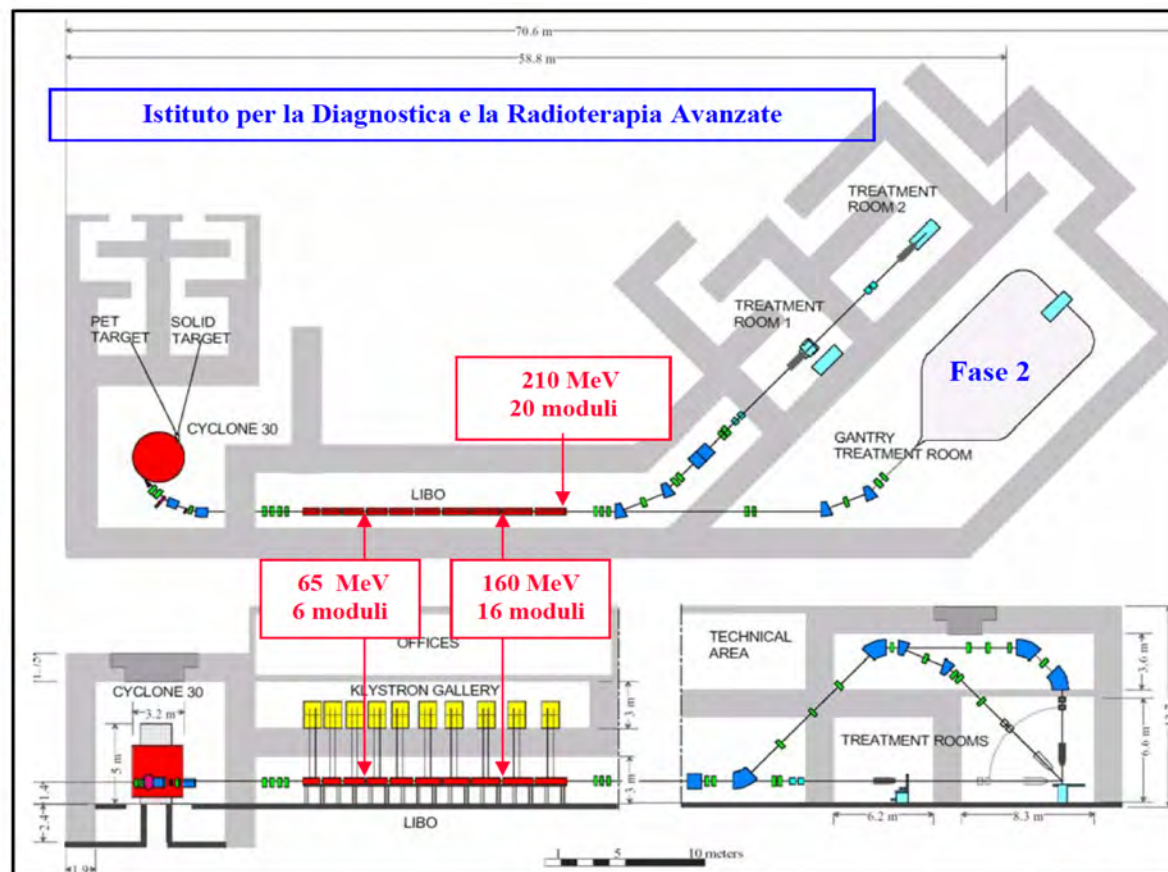


Linear accelerator  
**LIBO**

Gantries and fixed beam lines  
for treatment and research

# IDRA at Biella (2005): First project with 30 MeV cyclotron

Two 30 MeV cyclotrons



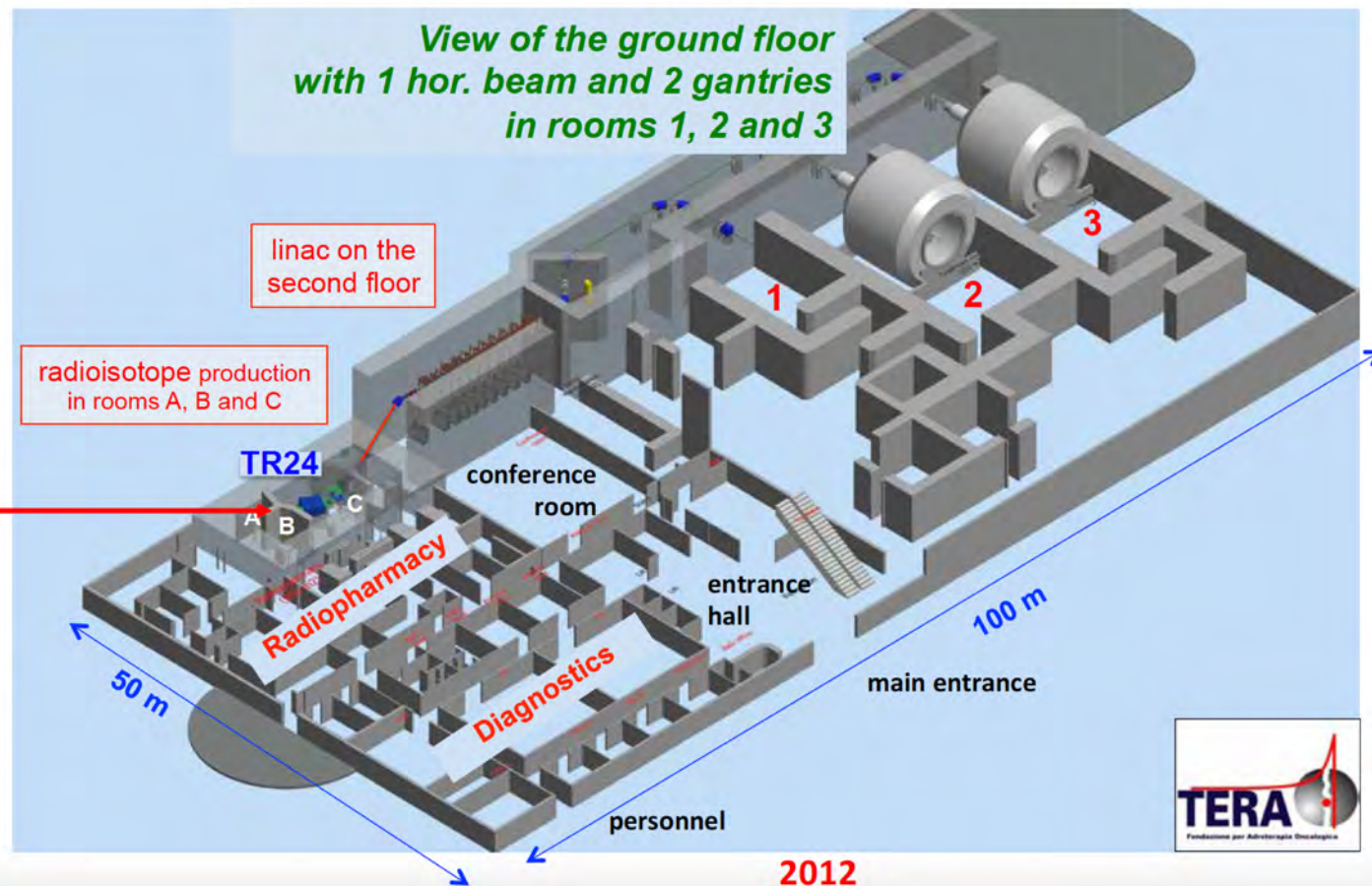


# IDRA at Biella: Final project with 24 MeV cyclotron

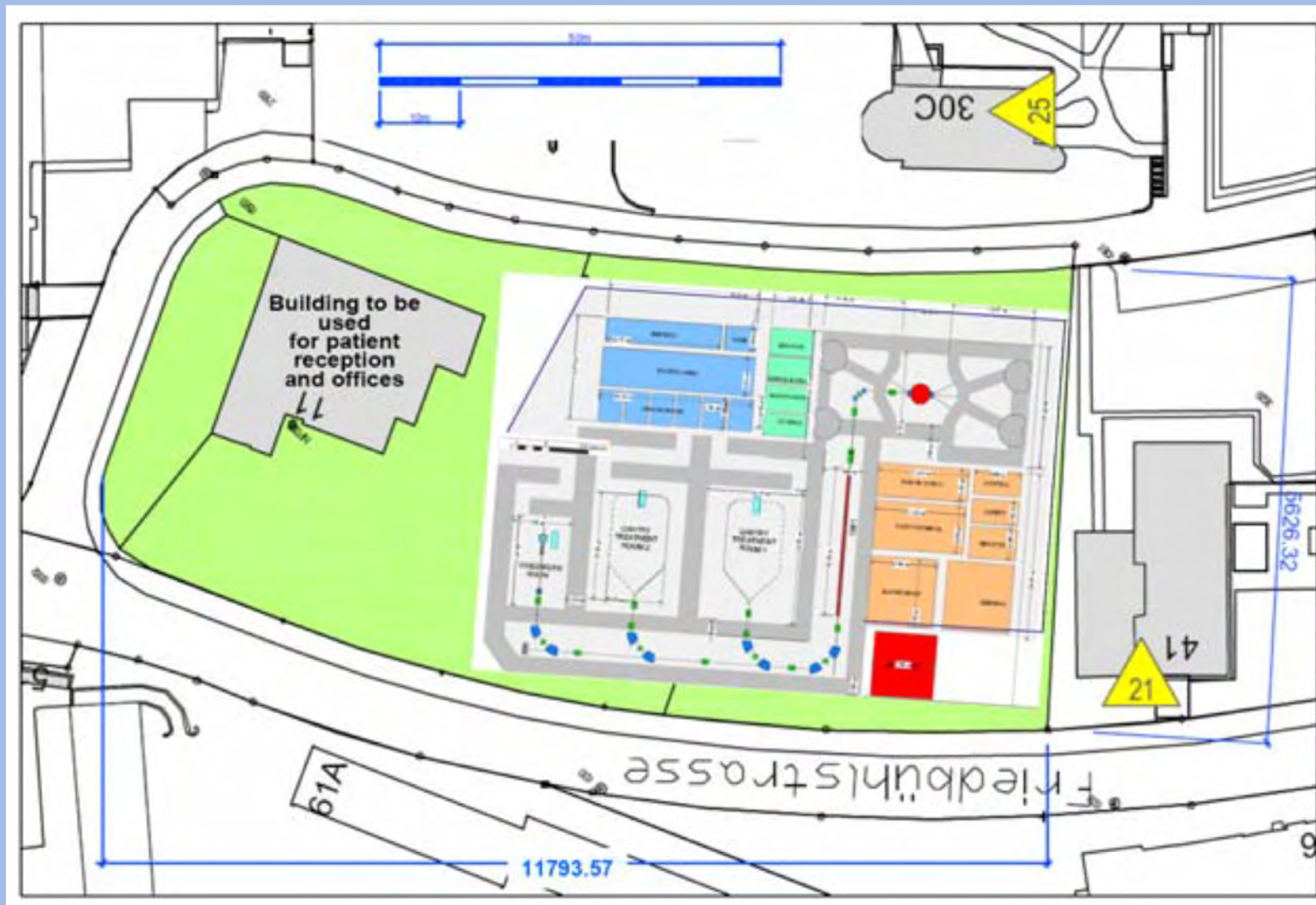
## IDRA by TERA Institute for Diagnostics and RAdiotherapy



24 MeV cyclotron by  
Advanced Cyclotron Systems Inc

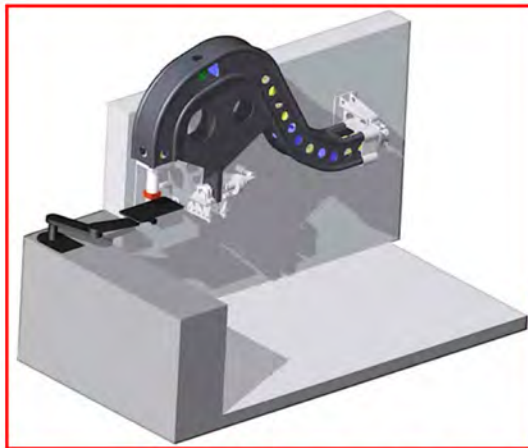


# IDRA at the Inselspital in Bern (2006-2007)

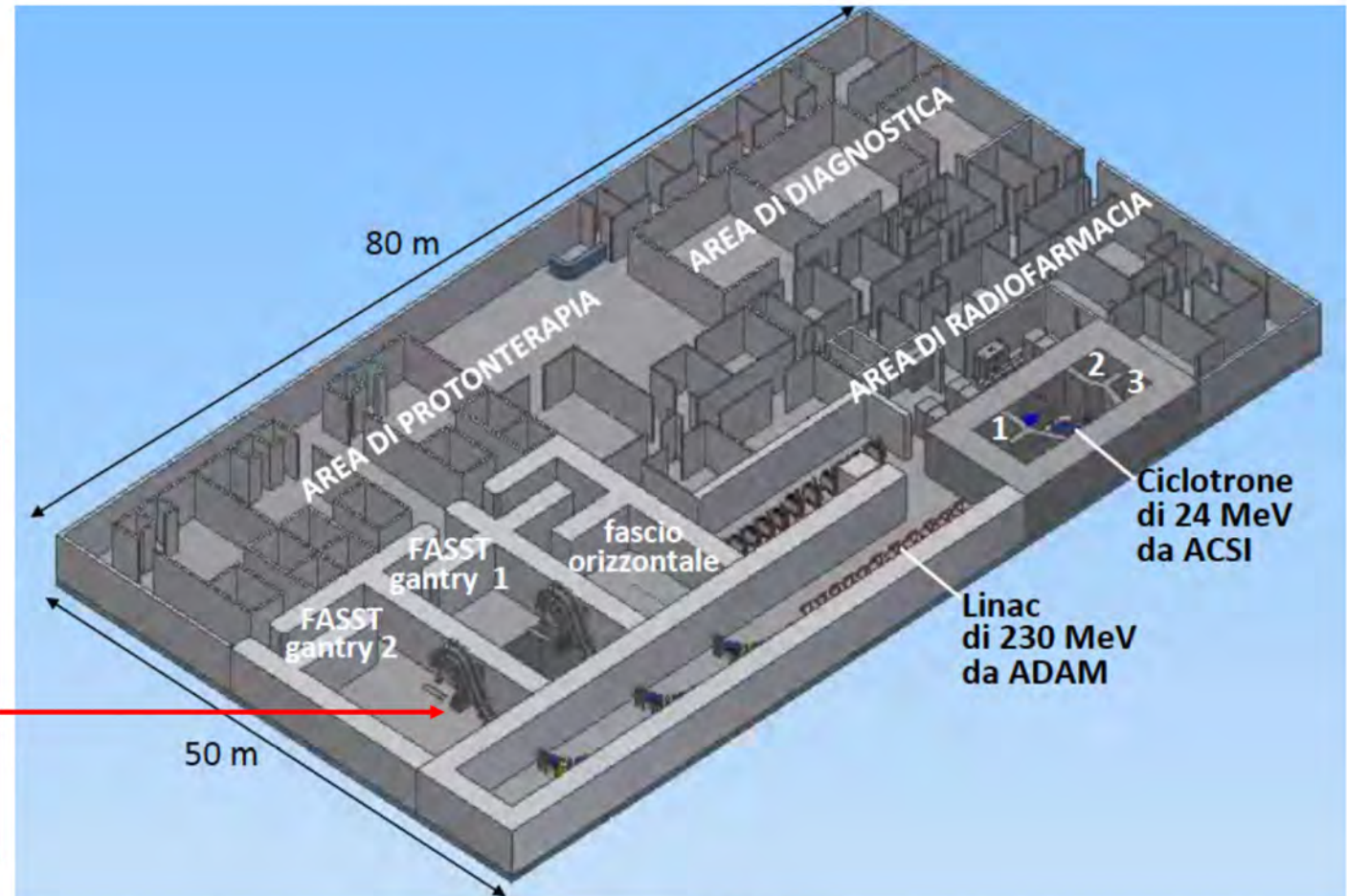


# Paediatric IDRA for Stella Maris Foundation – Calambrone (Pisa)

**Stella Maris Foundation**  
specialized in the treatment  
of children tumours

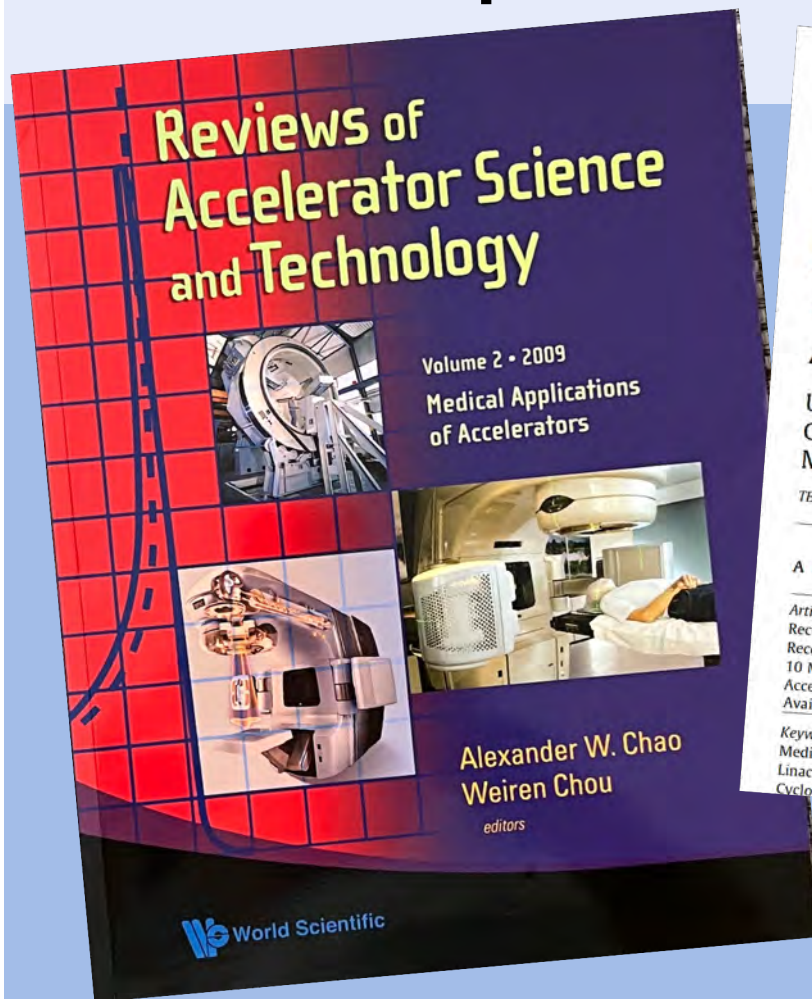


**TERA FASST gantry**  
(P. Riboni mechanics)

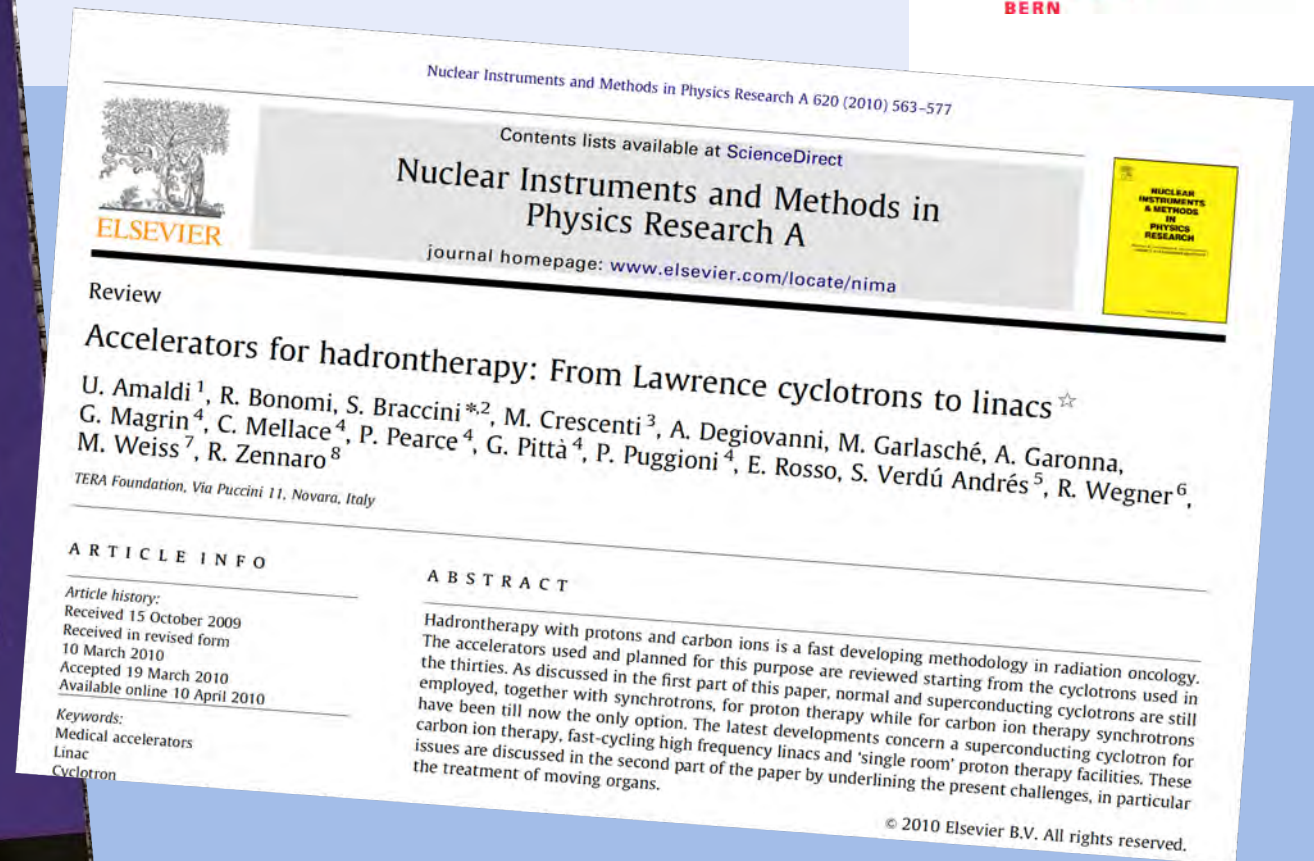


**2015**

# The IDRA publications and notes



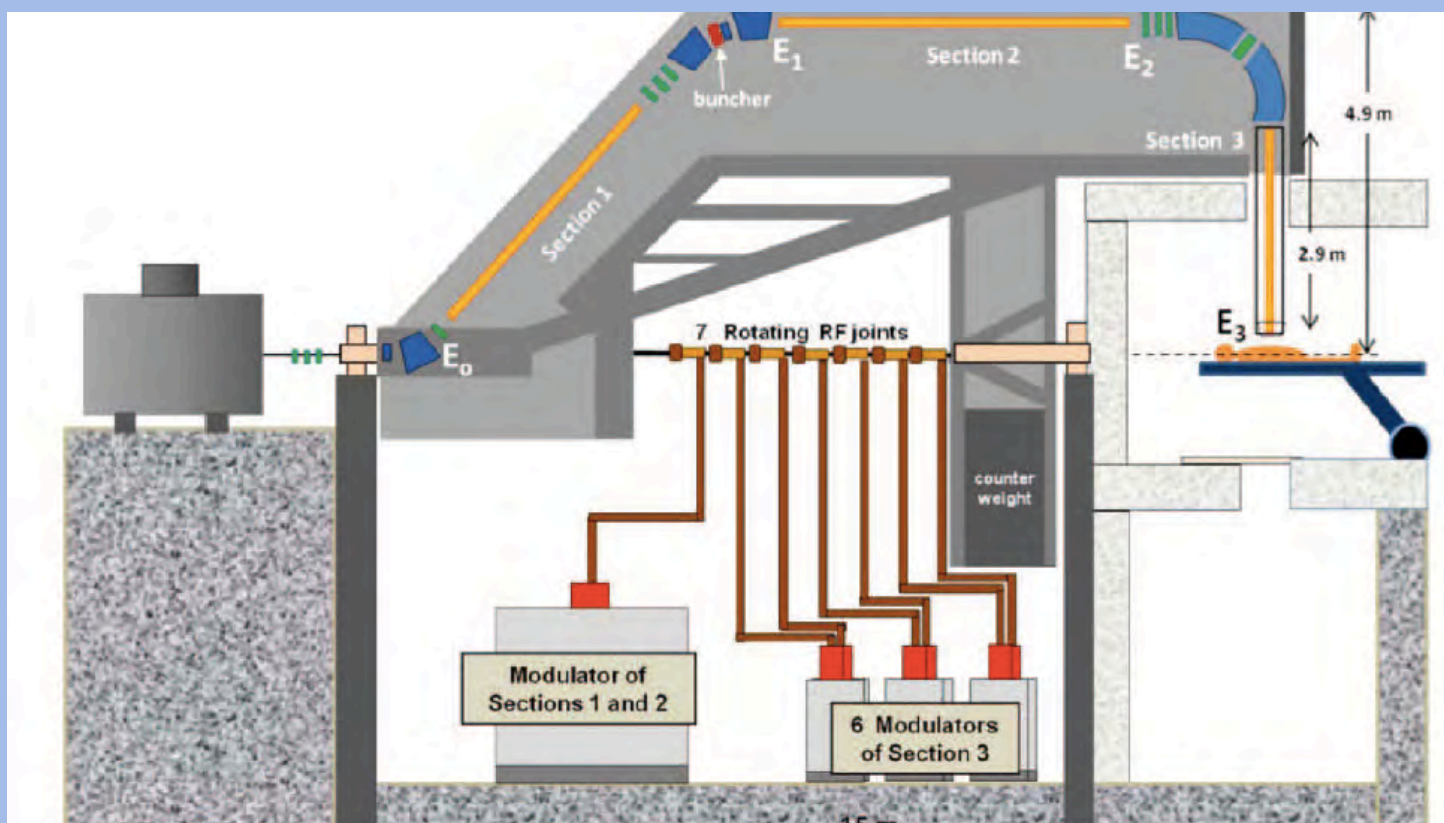
U. Amaldi, S. Braccini, P. Puggioni,  
 High Frequency Linacs for Hadrontherapy,  
 Reviews of Accelerator Science and Technology  
 Vol. 2 (2009) 111–131



## + 16 IDRA Notes

Other scientific contributors (2003-2006): S. Allegretti, P. Ciampanelli, A. Citterio, M. Domnietto, G. Fagnola, A. Giuliacci, G. Pittà, S. Toncelli, C. Tronci

# First cyc-linac design of TULIP: TU<sup>r</sup>ning LI<sup>n</sup>ac for P<sup>r</sup>oton-therapy (2006)

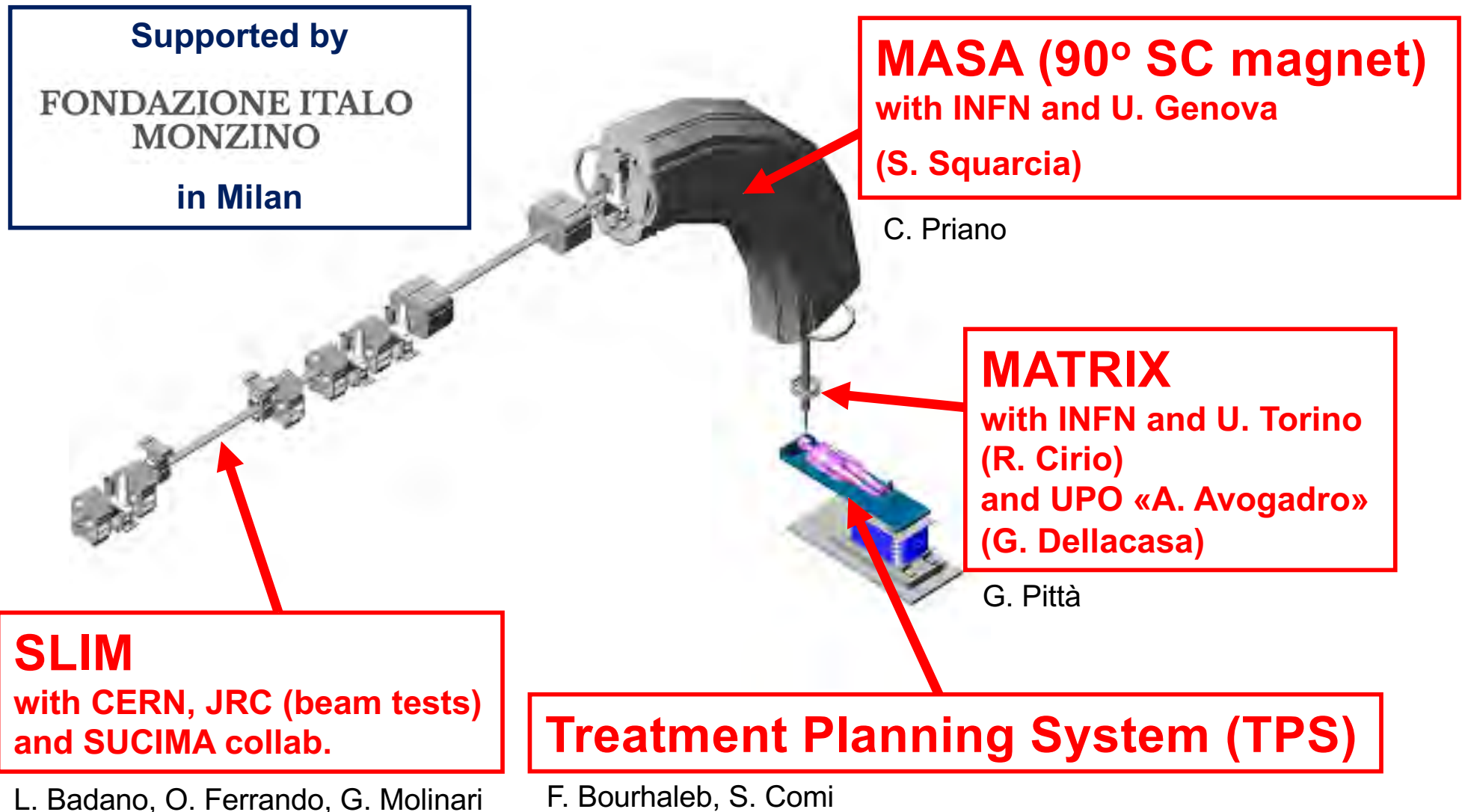


- 24 MeV cyclotron: injector + radioisotope production
- Advanced spot scanning (moving organ tacking)
- On-line proton radiography

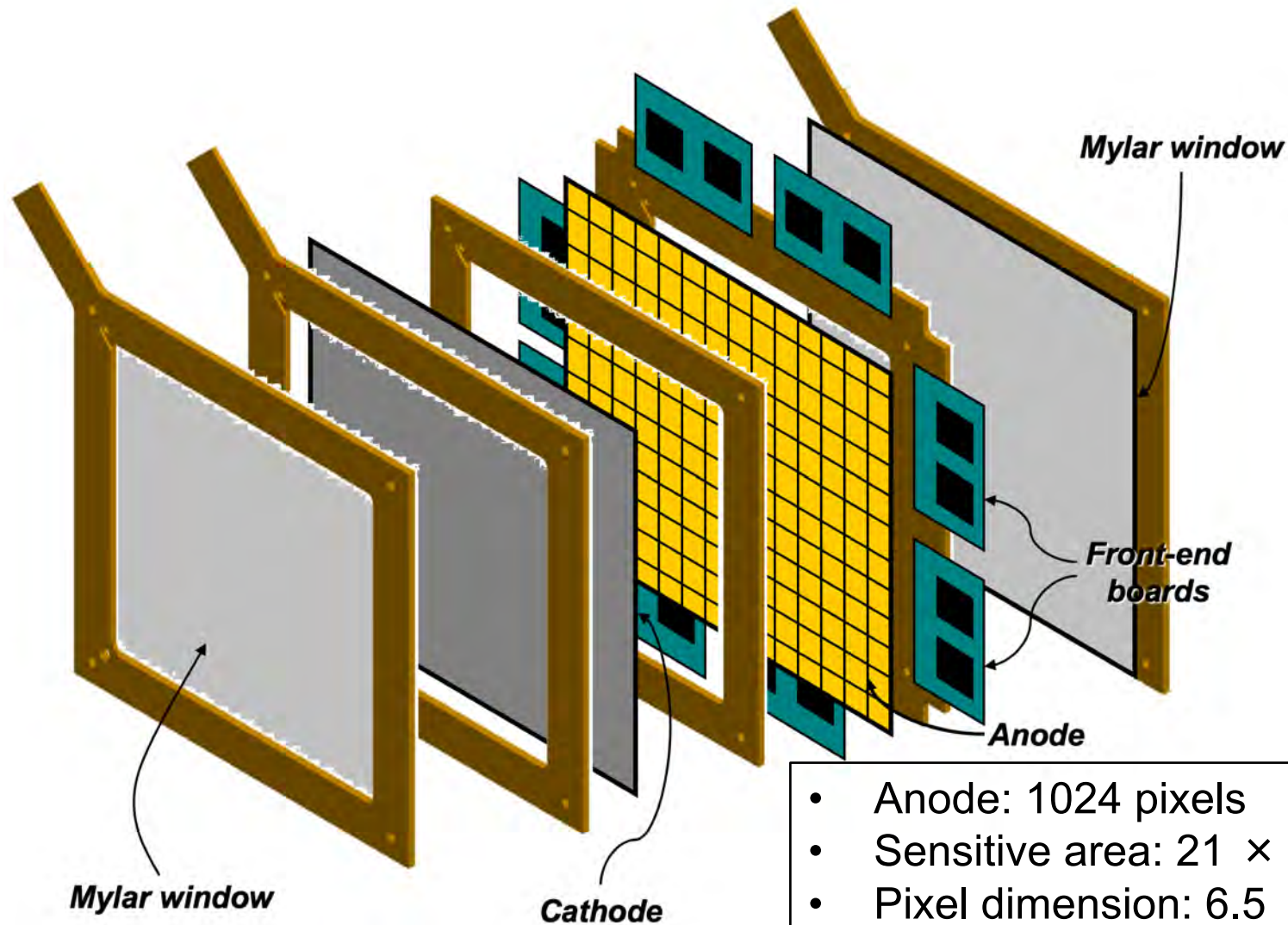
Patent US8405056 B2 and EP2106678 B1

# The PRASSI project (2003-2006)

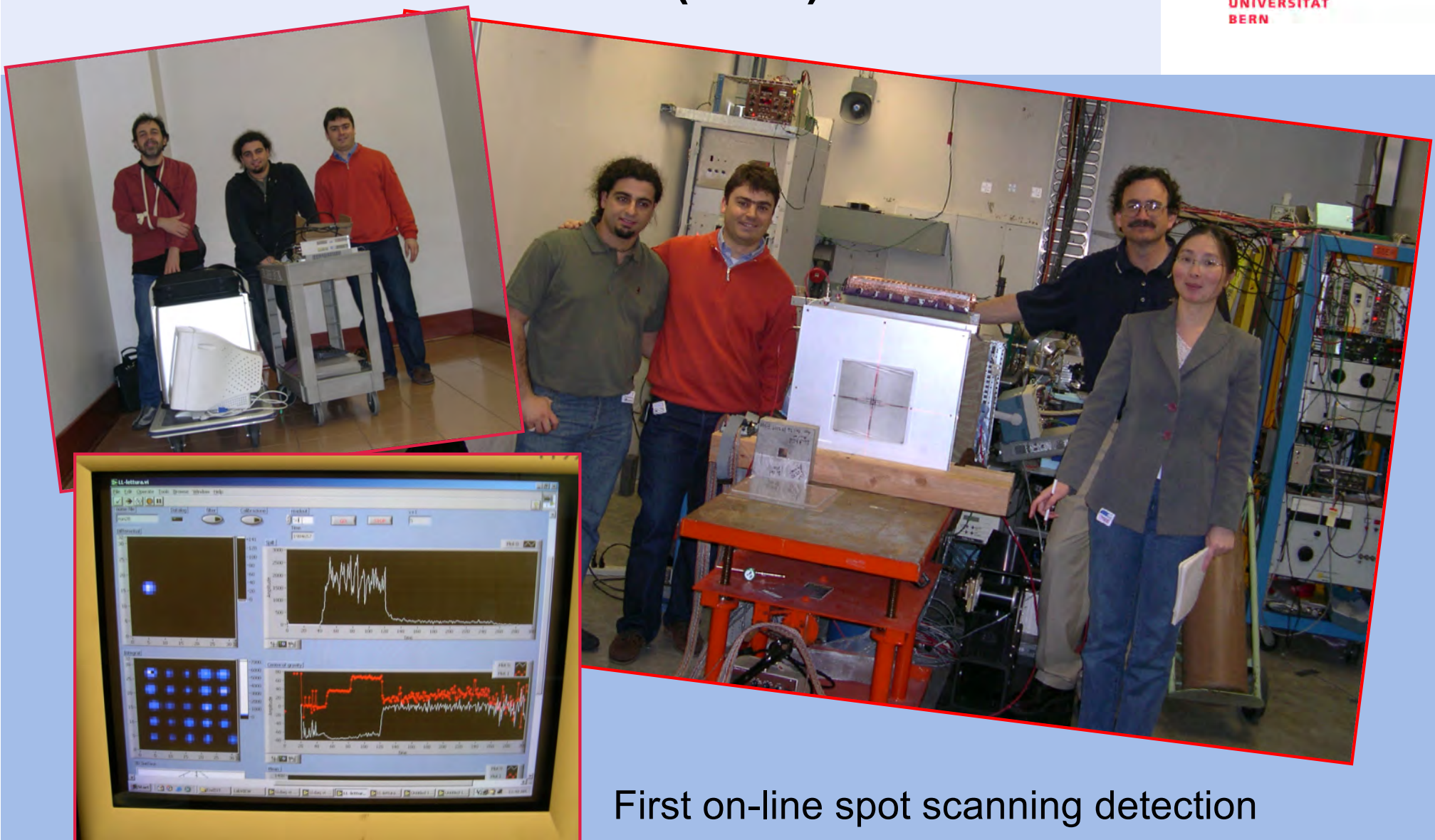
Piani di Radioterapia con Adroni e Sistema di Scansione Integrati



# MATRIX



# MATRIX at Loma Linda (2005)



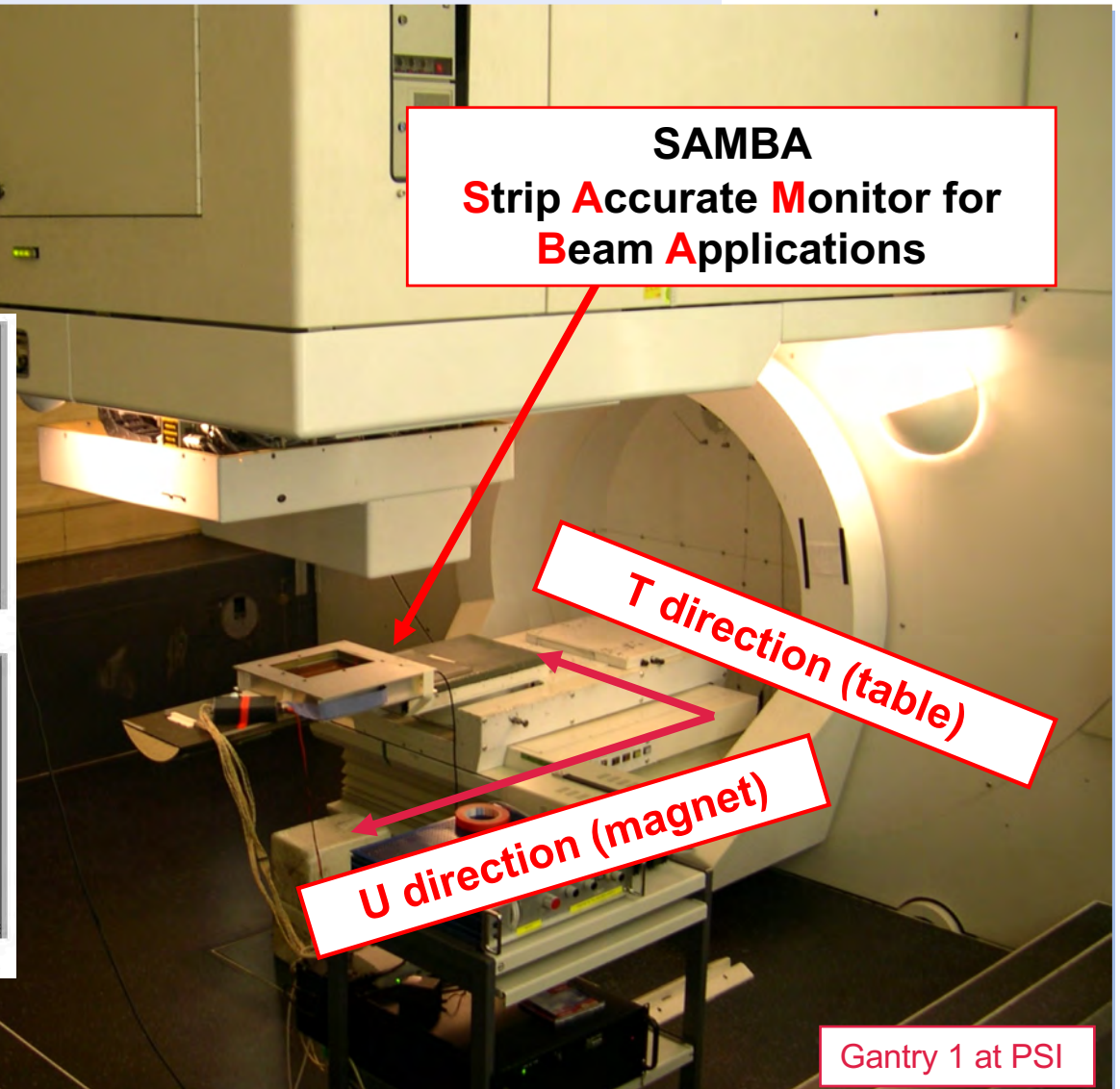
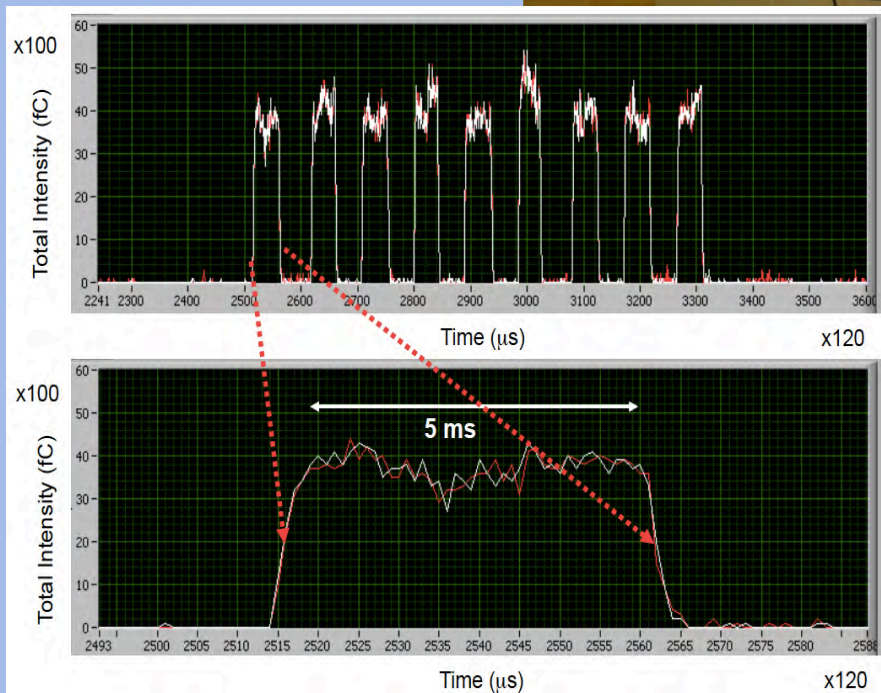
First on-line spot scanning detection



# SAMBA (2006): a strip chamber still in use at the Gantry 2 at PSI

**On-line monitoring spot-by-spot**  
**Precision 90  $\mu\text{m}$**

**SAMBA**  
**Strip Accurate Monitor for**  
**Beam Applications**



Gantry 1 at PSI

# PRASSI: collaborations, scientific results, spin-off company



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Vol. 30, No. 17 (2015) 1540026 (15 pages)  
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DOI: 10.1142/S021773231540026X

**World Scientific**  
www.worldscientific.com

## Segmented ionization chambers for beam monitoring in hadrontherapy

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Laboratory for High Energy Physics (LHEP),  
University of Bern, Sidlerstrasse 5, CH-3012 Bern, Switzerland  
Saverio.Braccini@lhep.unibe.ch*

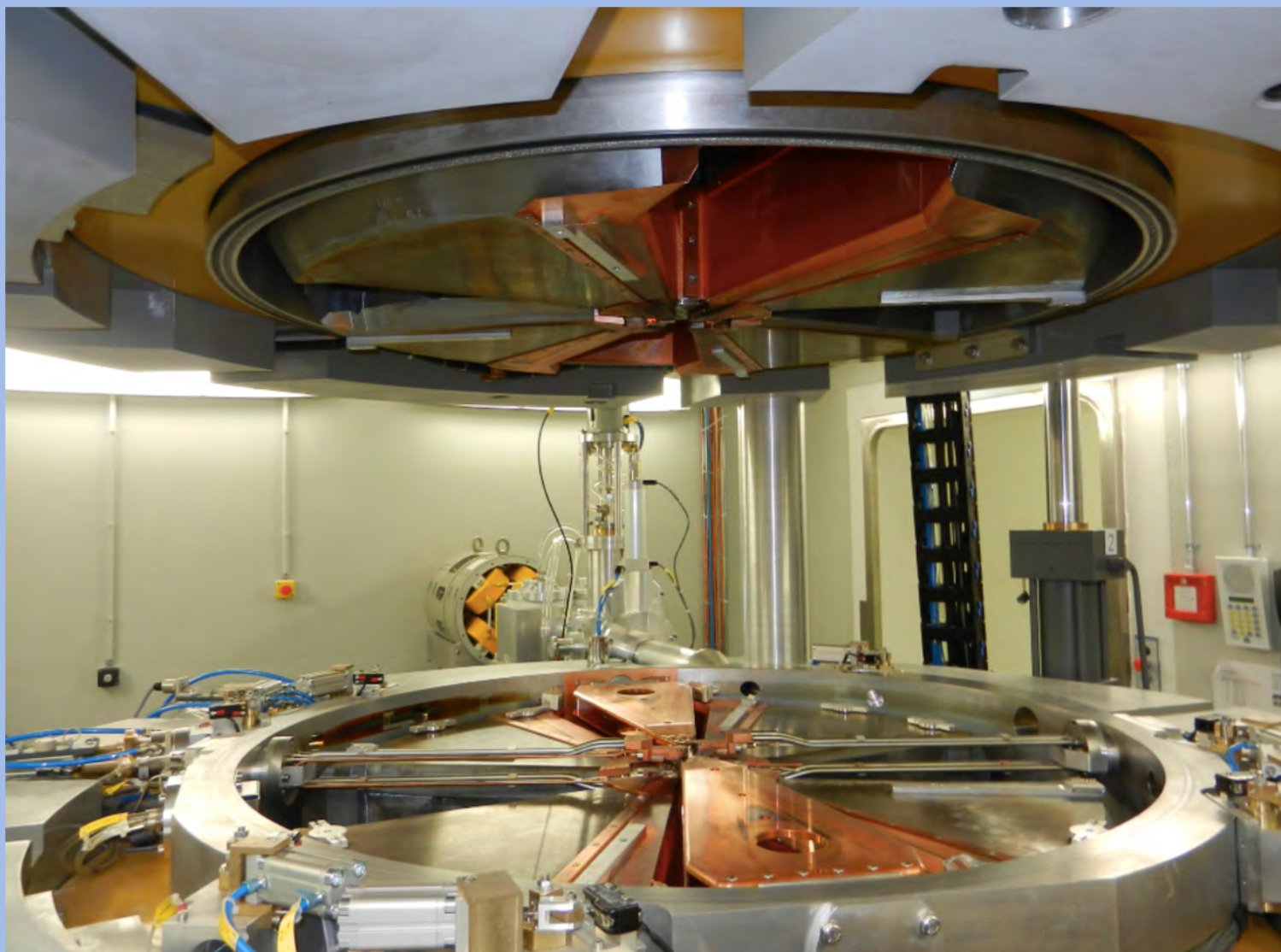
Roberto Cirio<sup>\*†</sup>, Marco Donetti<sup>†,‡,§</sup> and Flavio Marchetto<sup>†</sup>

*\*Physics Department, University of Torino, Via Giuria 1, Torino 10125, Italy  
†Istituto Nazionale di Fisica Nucleare, Section of Torino, Via Giuria 1, Torino 10125, Italy  
‡Centro Nazionale Adroterapia Oncologica, Strada Campeggi 53, Pavia 27100, Italy*

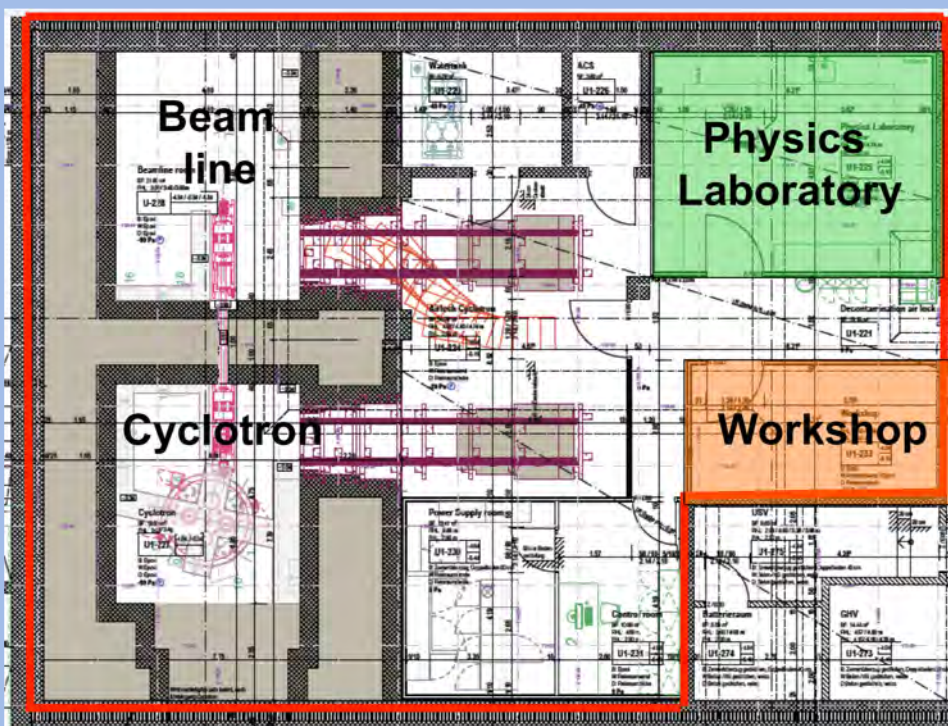
Giuseppe Pittà<sup>§</sup>, Marco Lavagno and Vanessa La Rosa  
*DE.TEC.TOR. Devices and Technologies Torino srl, via Livorno 60, Torino 10144, Italy*

**DETECTOR**  
DEVICES AND TECHNOLOGIES TORINO

# The Bern 18 MeV medical cyclotron

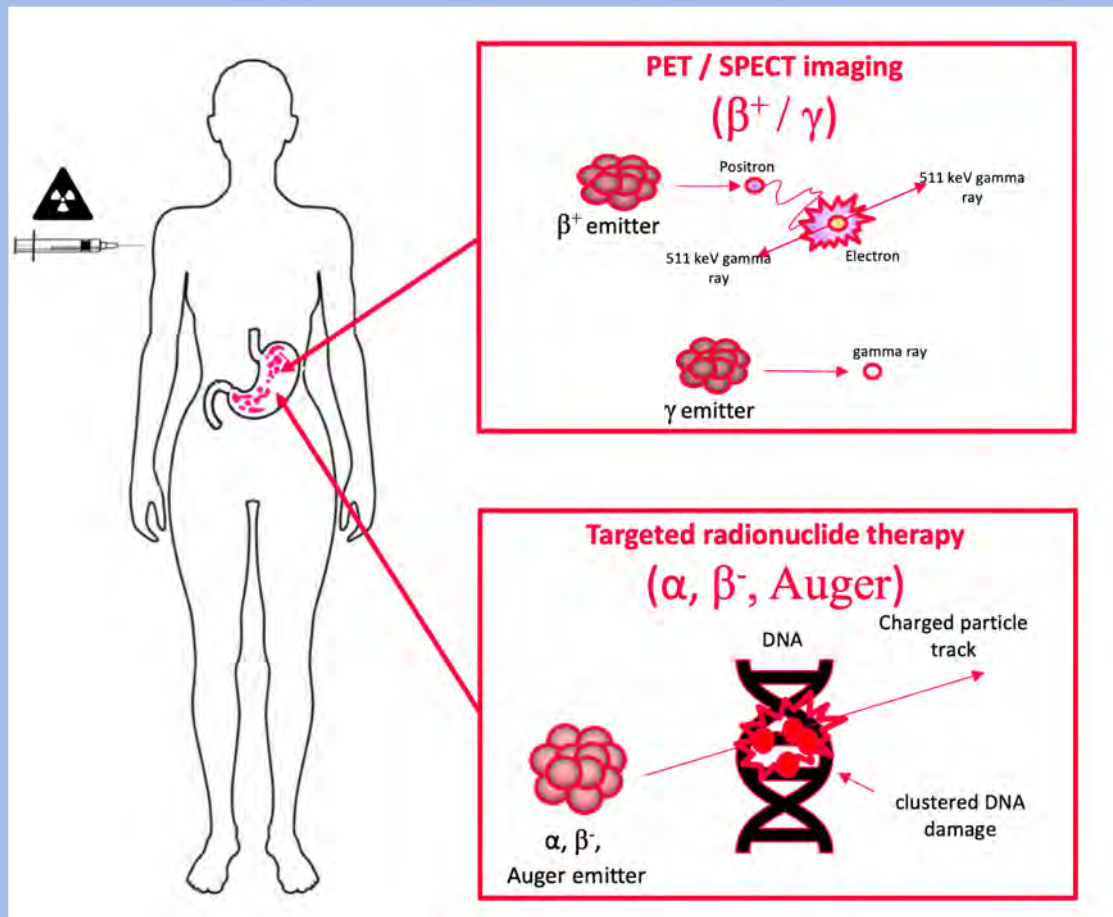


# Production + multi-disciplinary research (as in IDRA)



- > GMP production of radiopharmaceuticals
- > Research with External Beam Transfer Line (BTL) line in a separate bunker

# Radionuclides for theranostics in nuclear medicine



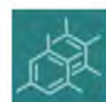
## > Promising pairs:

- >  $^{68}\text{Ga}/^{177}\text{Lu}$  and  $^{68}\text{Ga}/^{225}\text{Ac}$
- >  $^{43}\text{Sc}/^{47}\text{Sc}$  and  $^{44}\text{Sc}/^{47}\text{Sc}$
- >  $^{61}\text{Cu}/^{67}\text{Cu}$  and  $^{64}\text{Cu}/^{67}\text{Cu}$
- >  $^{155}\text{Tb}/^{149}\text{Tb}$  and  $^{155}\text{Tb}/^{161}\text{Tb}$

## > Radiometals

- > Solid targets

# Sc was highlighted in one IDRA note ... ... it is now ready for clinical applications!



molecules

Molecules 2020, 25(20), 4706



Article

## Developments toward the Implementation of <sup>44</sup>Sc Production at a Medical Cyclotron

Nicholas P. van der Meulen <sup>1,2,\*</sup>, Roger Hasler <sup>2</sup>, Zeynep Talip <sup>2</sup>, Pascal V. Grundler <sup>2</sup>, Chiara Favaretto <sup>2</sup>, Christoph A. Umbricht <sup>2</sup>, Cristina Müller <sup>2</sup>, Gaia Dellepiane <sup>3</sup>, Tommaso S. Carzaniga <sup>3</sup> and Saverio Braccini <sup>3</sup>

<sup>1</sup> Laboratory of Radiochemistry, Paul Scherrer Institute, 5232 Villigen-PSI, Switzerland

<sup>2</sup> Center of Radiopharmaceutical Sciences ETH-PSI-USZ, Paul Scherrer Institute, 5232 Villigen-PSI, Switzerland; rogerhasler26@gmail.com (R.H.); zeynep.talip@psi.ch (Z.T.); pascal.grundler@psi.ch (P.V.G.); chiara.favaretto@psi.ch (C.F.); christoph.umbricht@gmail.com (C. Umbricht); cristina.mueller@psi.ch (C.M.)

<sup>3</sup> Albert Einstein Center for Fundamental Physics, Laboratory of High Energy Physics, University of Bern, 3012 Bern, Switzerland; gaia.dellepiane@lhep.unibe.ch (G.D.); tommaso.carzaniga@lhep.unibe.ch (T.S.C.); saverio.braccini@lhep.unibe.ch (S.B.)

In collaboration with PSI

IBA Award 2020



Thank you **TERA**  for this great adventure!

August 2003

