

# CYCLINAC FOR HADRONTHERAPY Roundtable

Ugo Amaldi

*University of Milano Bicocca and TERA Foundation*

## ***15 years of TERA: 1992-2007***

TERA has proposed and produced 3 designs for the National Centre for carbon ions (and p) to be built on 3 sites: Novara (1993-1995), Milano (1996-2000) and Pavia



**1. CNAO is being completed in Pavia**

TERA has developed (1993-2006) a novel type of accelerator:  
the “cyclinac” for protons and carbon ions



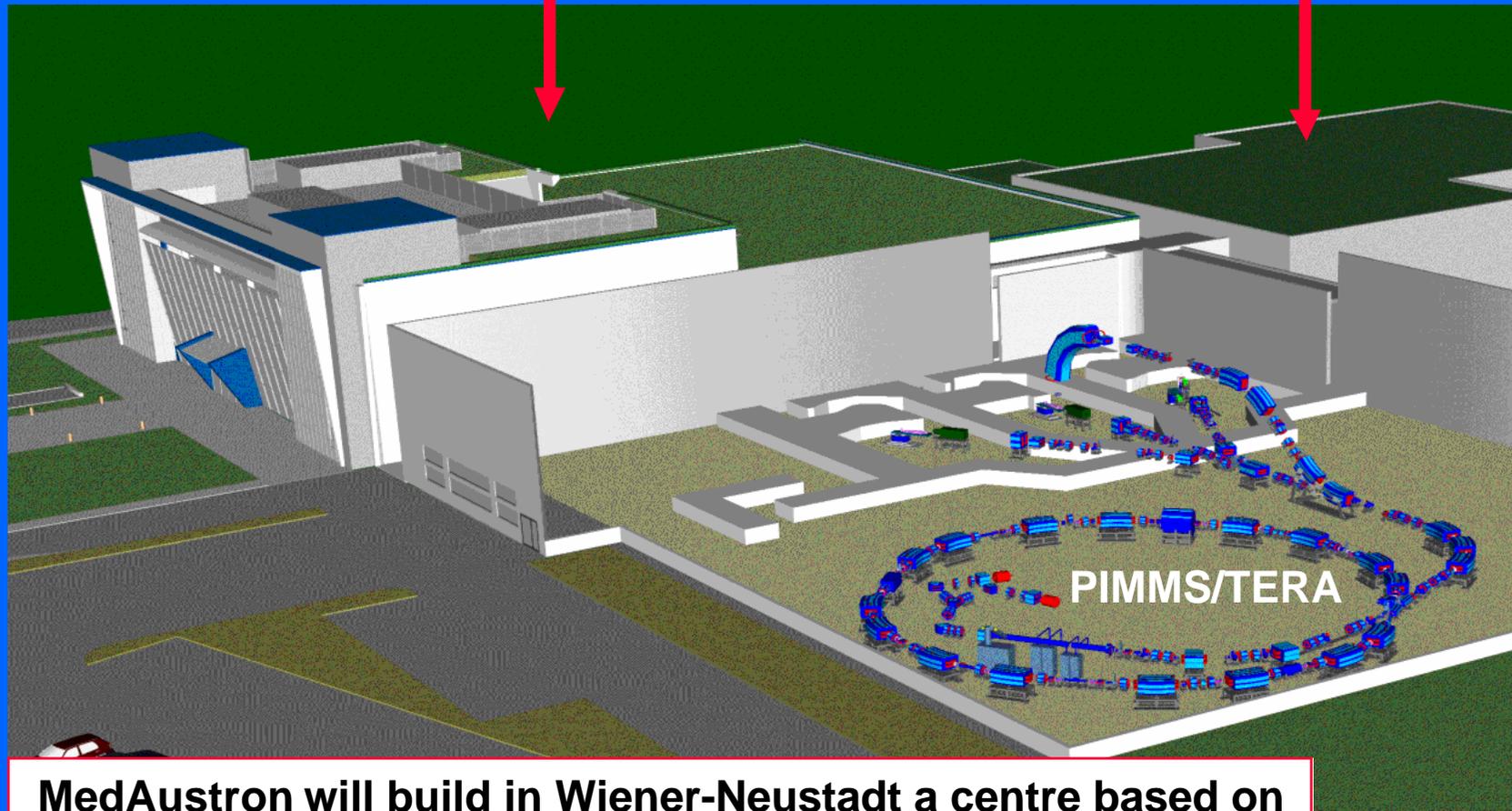
**2. IDRA (2001)**

**3. CABOTO (2005)**

# The CNAO Foundation constructs the Centre designed by TERA

Hospital building

High-tech building



**MedAustron will build in Wiener-Neustadt a centre based on the CNAO construction drawings**

**Medical Director: Roberto Orecchia    Technical Director: Sandro Rossi**

## *CNAO status in September 2007*



**Hospital Building**

## The synchrotron area



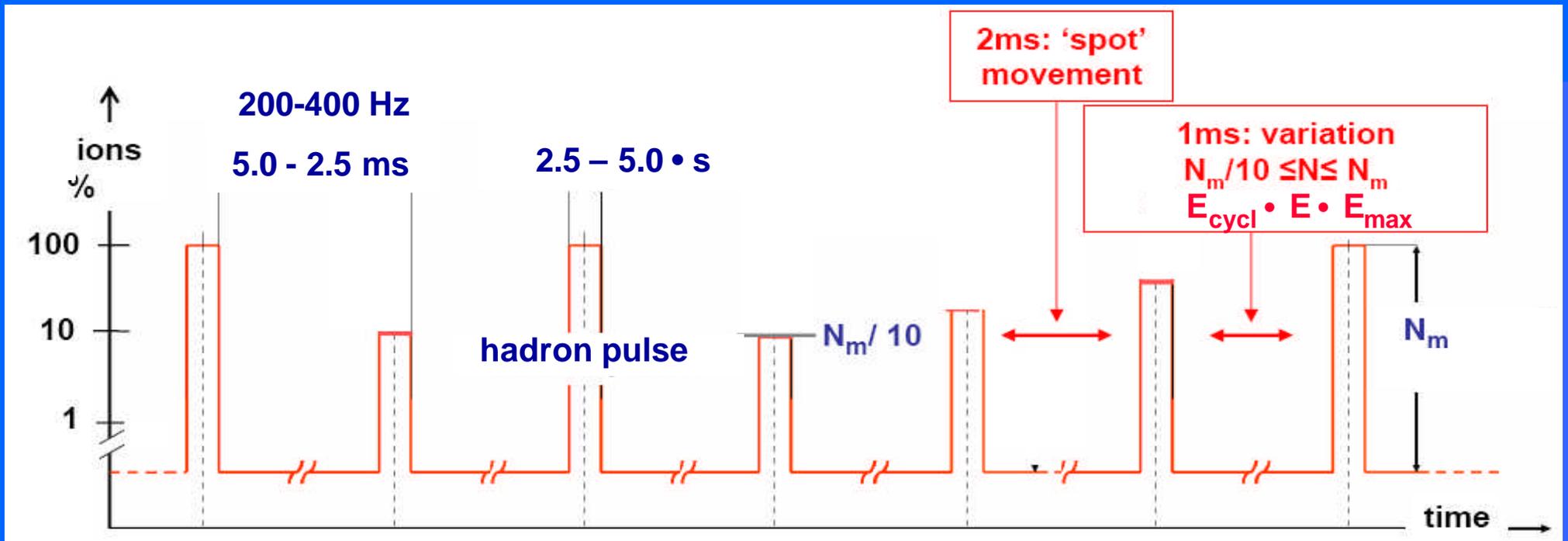
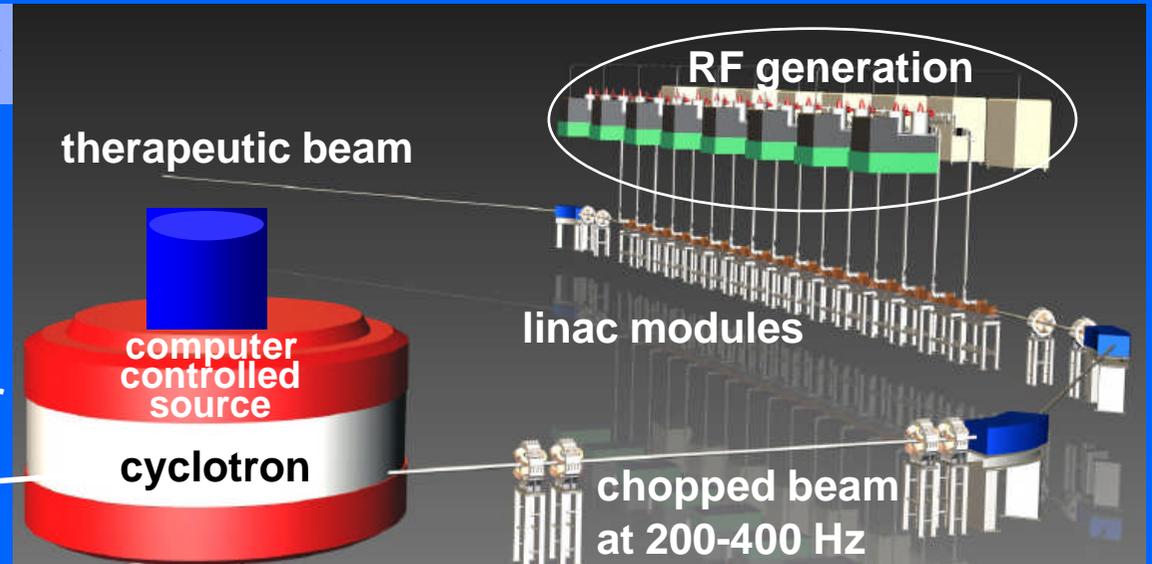
Two sources are working

First beam in summer 2008

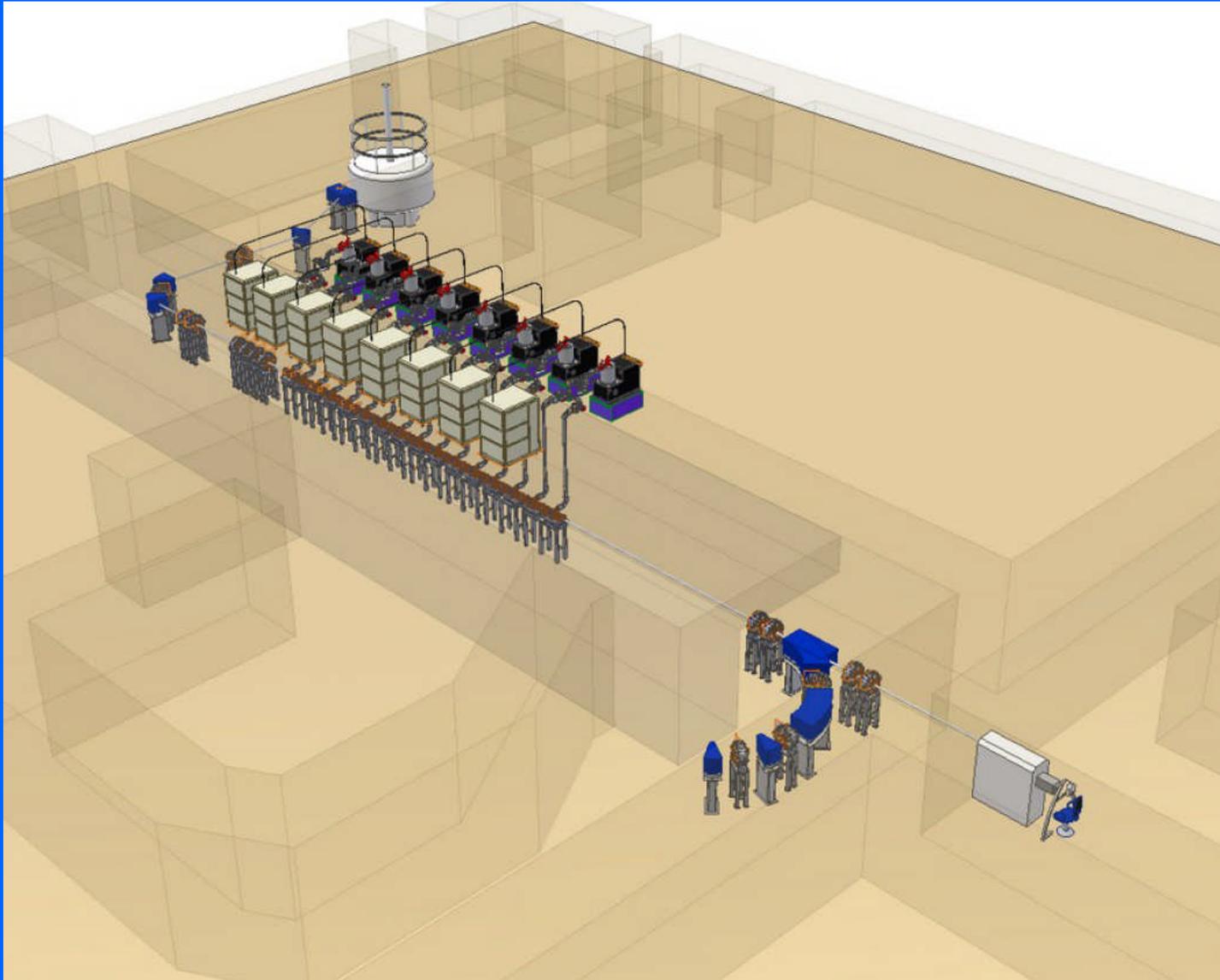
Girders and supports are in place

# Properties of cyclinac beams

beam(s) used for other purposes

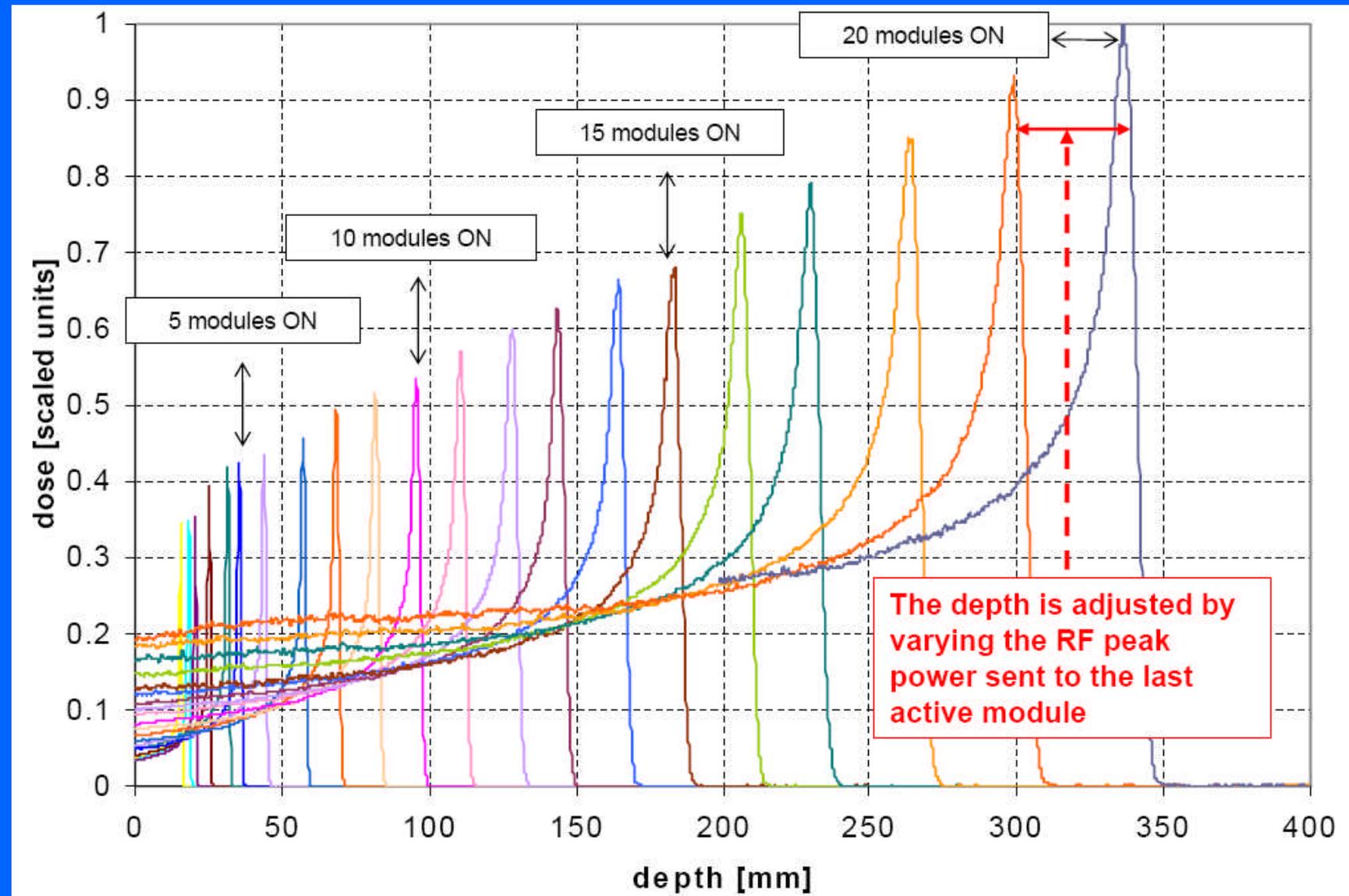


# *IDRA= Institute for Diagnostic and RAdiotherapy*

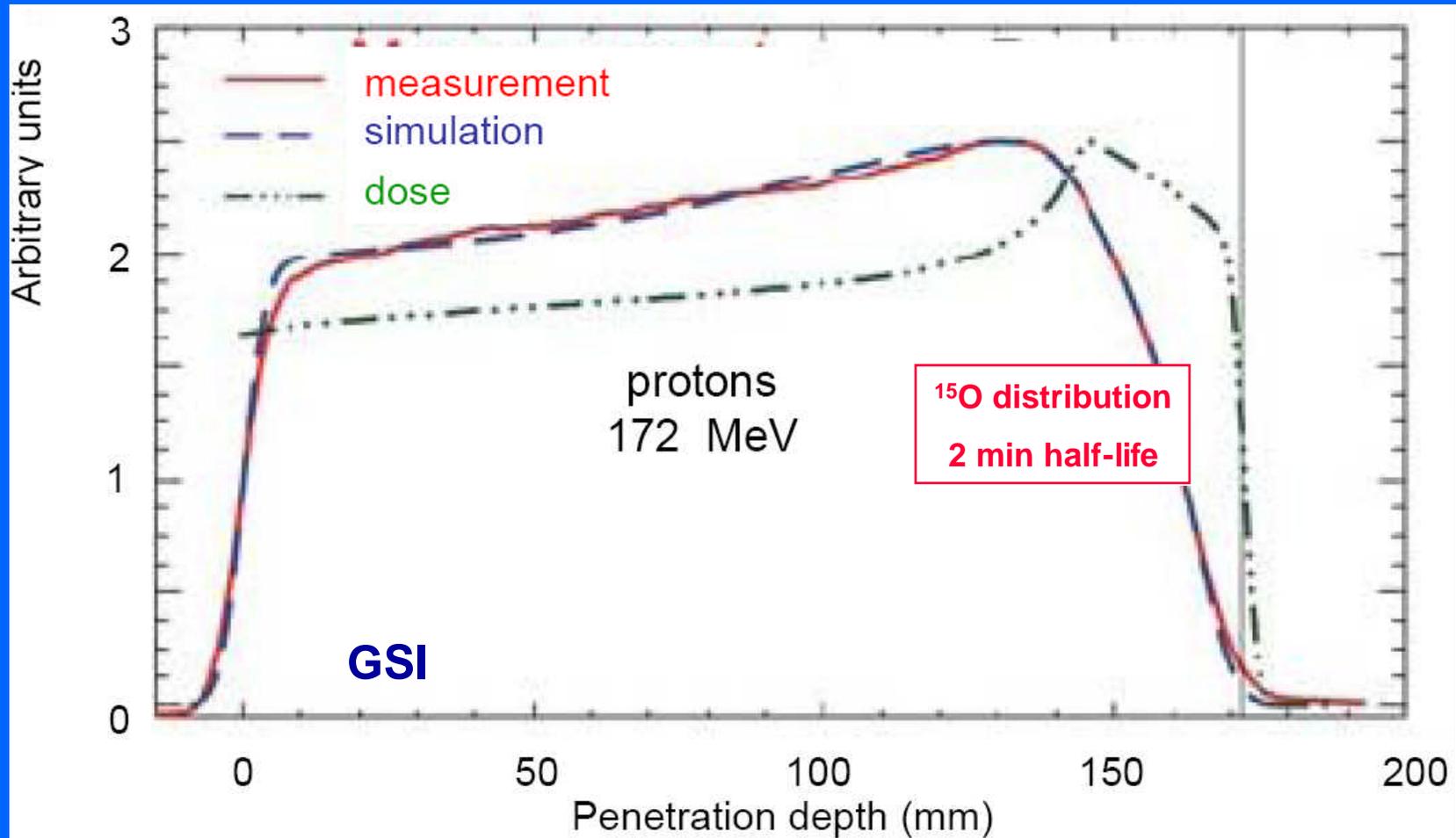


230 MeV protons

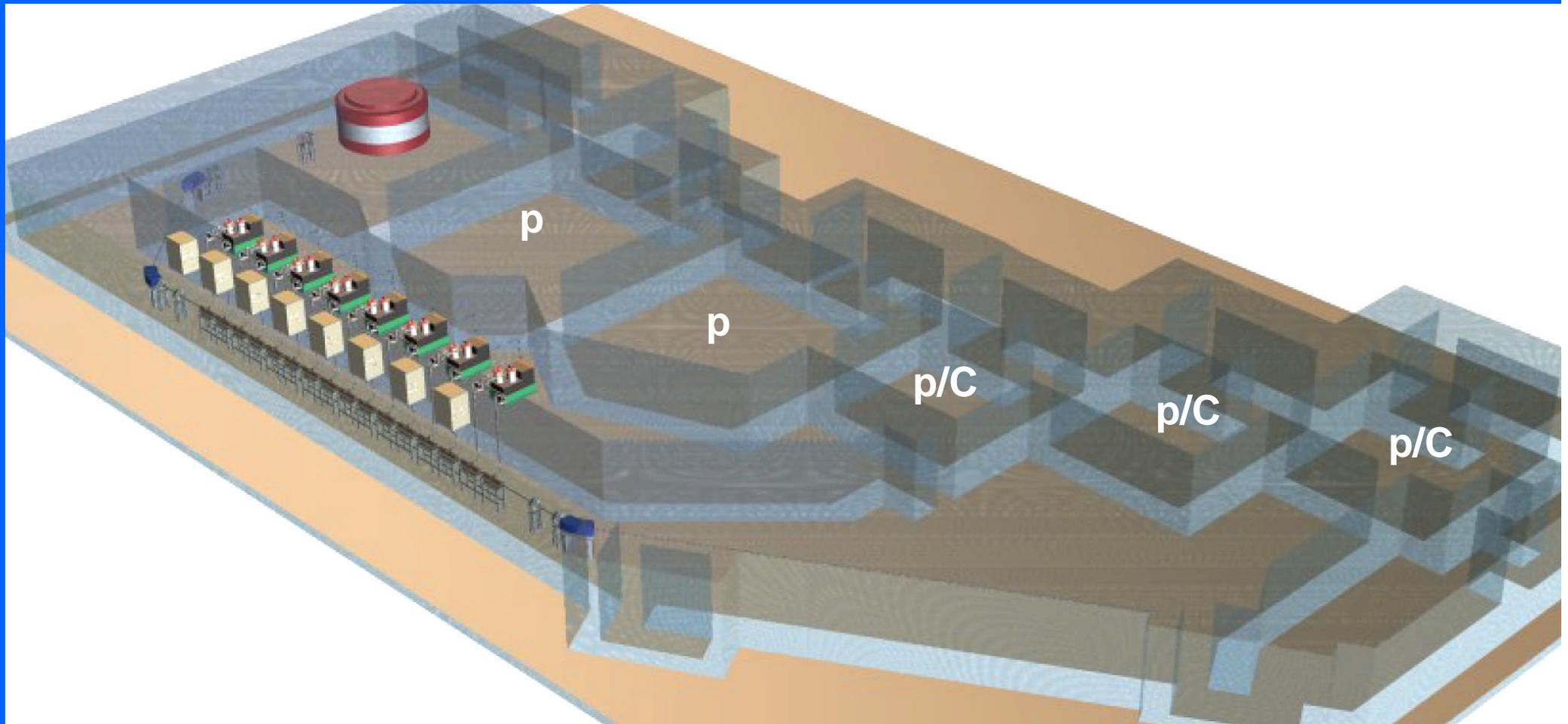
## Depth as a function of the number of active klystrons



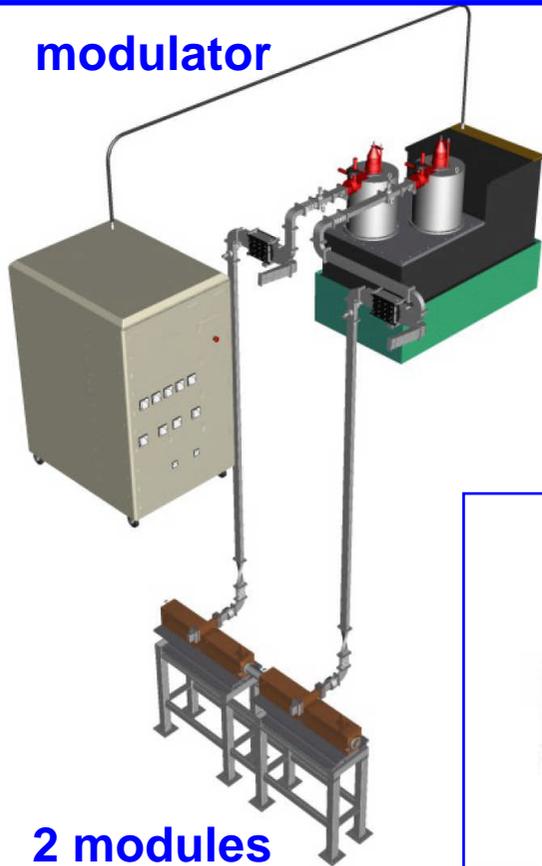
# The cyclinac beam is 99% OFF, suitable for PET-on-beam



# Perspective views of CABOTO

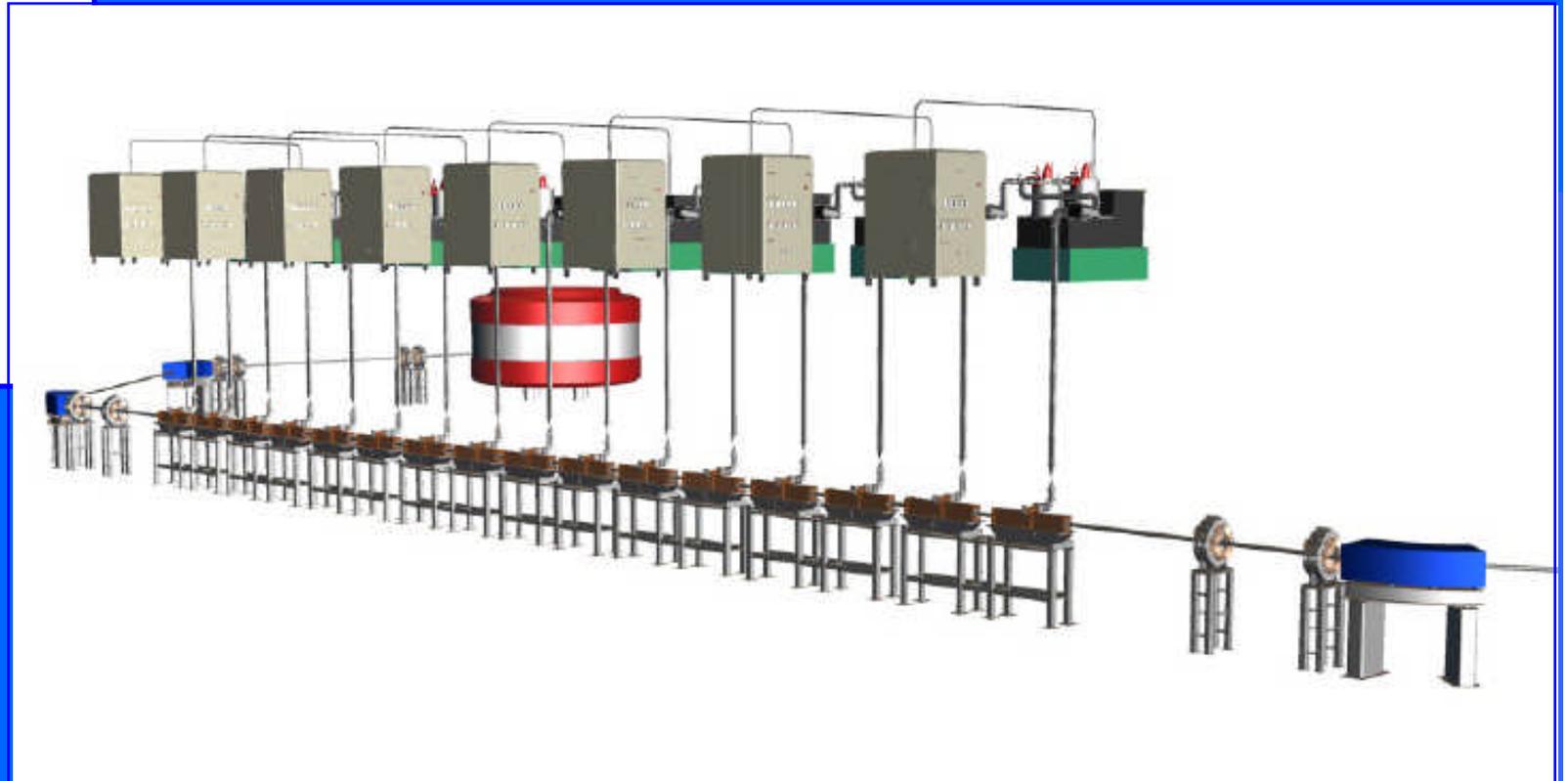


modulator

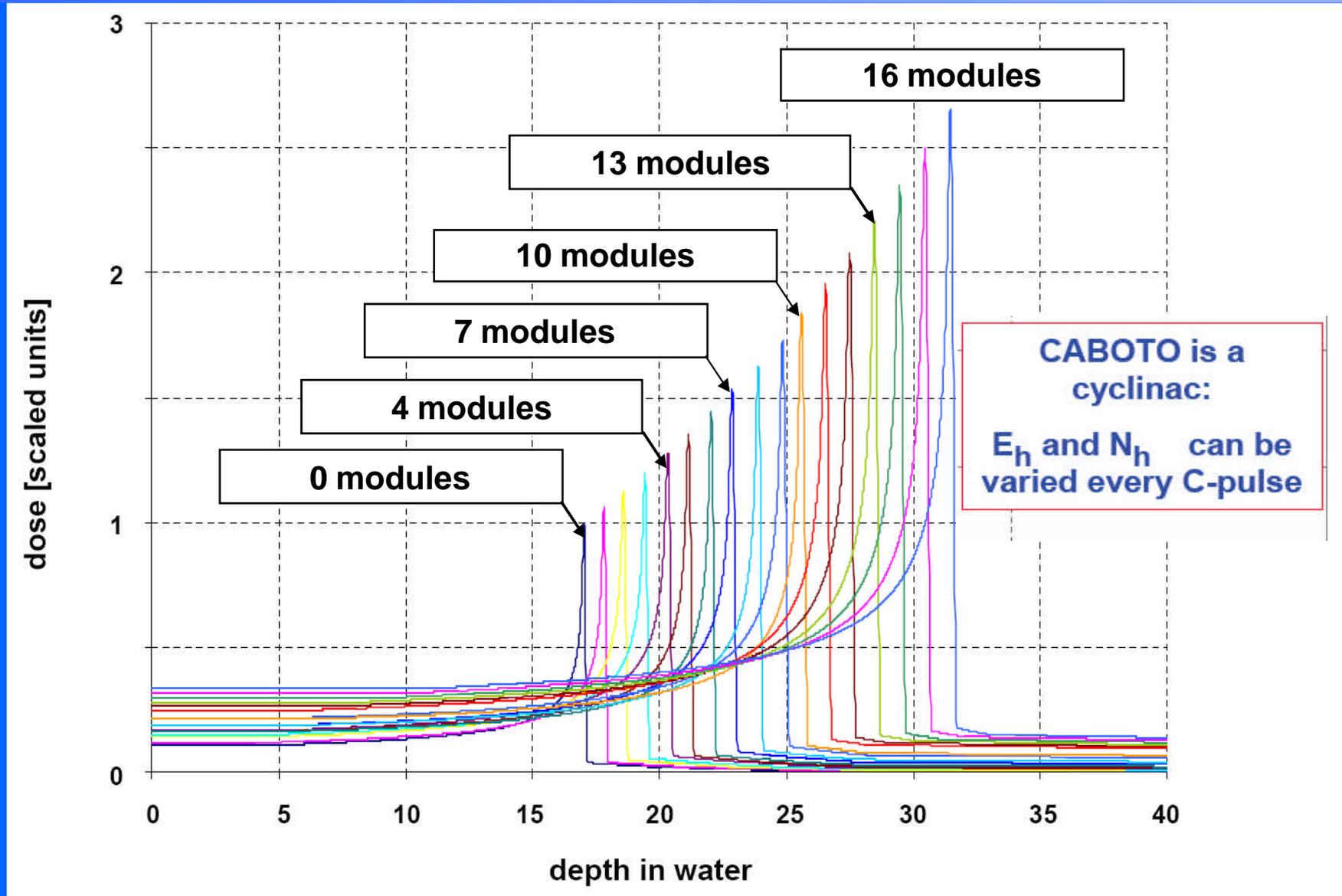


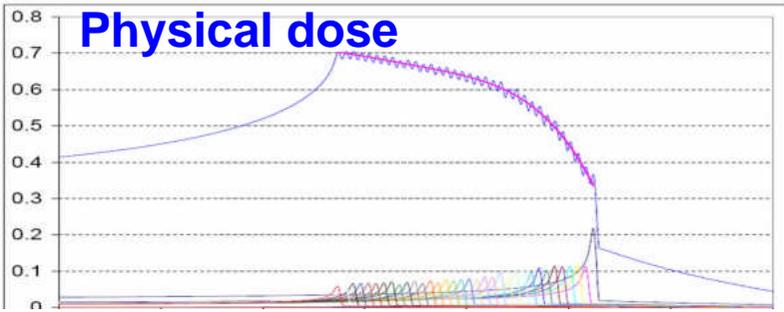
2 modules

*The basic unit of CABOTO has 2 klystrons*



# Ion Bragg curves by adjusting the klystrons: 300-435 MeV/u

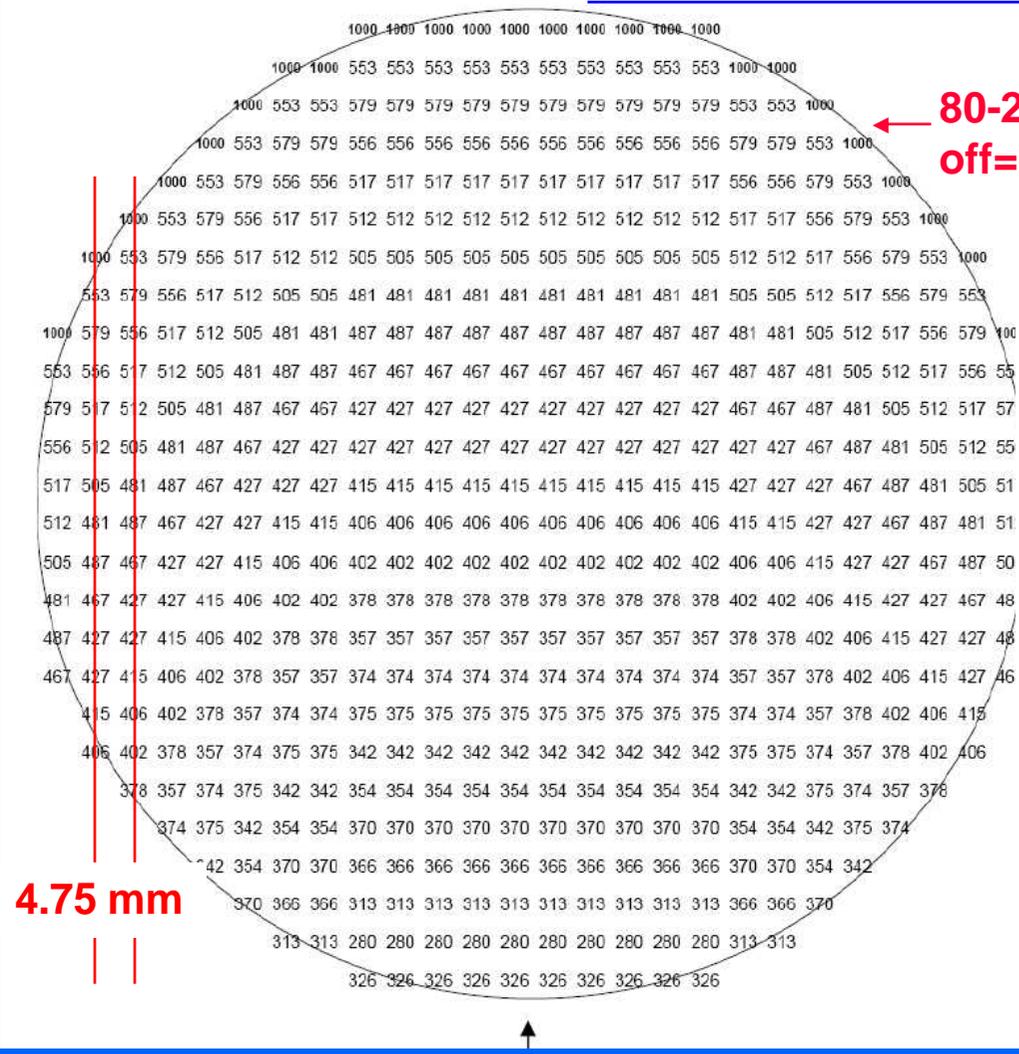




**1 Liter volume with 10 120 voxels**

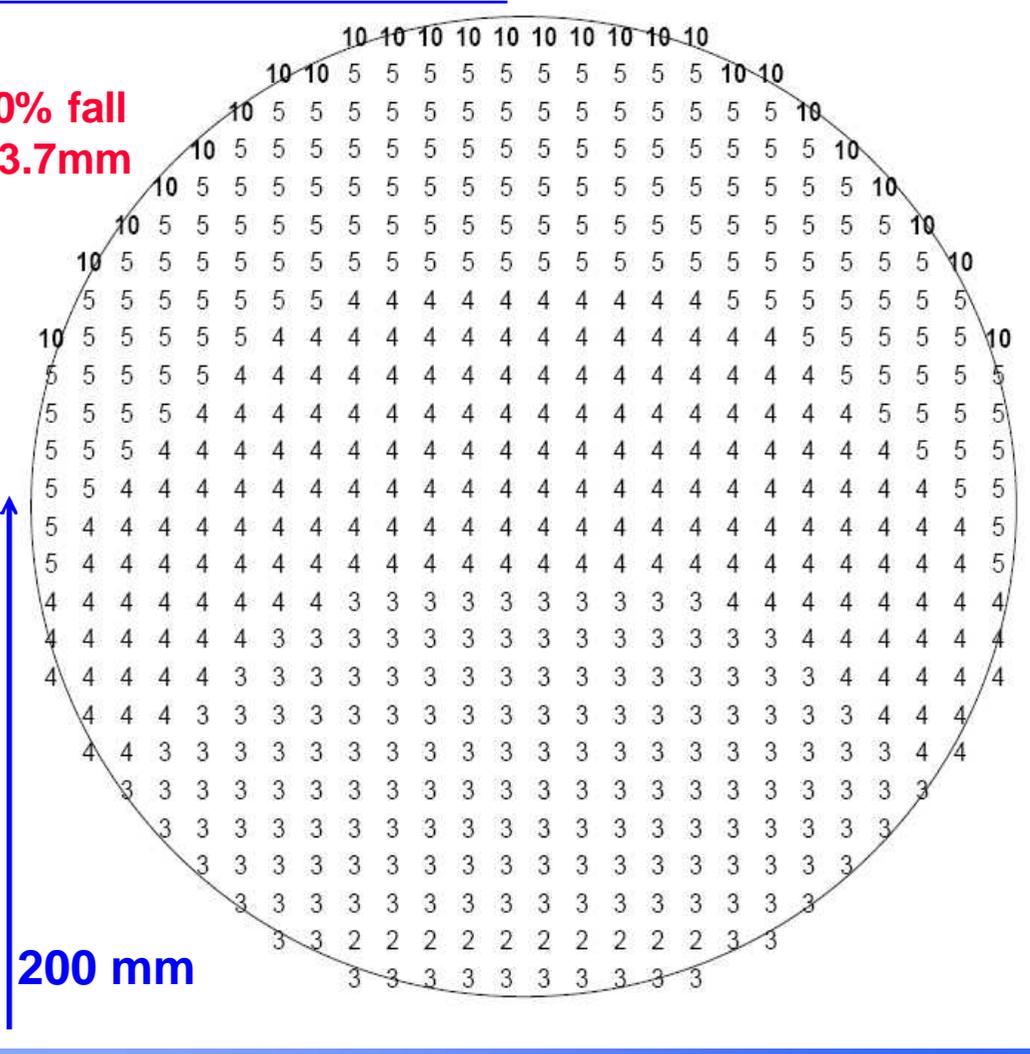
**More that 10 paintings with FWHM = 6.3 mm**

**262 mm**



**80-20% fall off = 3.7mm**

**4.75 mm**



**200 mm**

For 2 Gy/l min corresponding to 5 Gye/l min

4  $10^5$  carbon ions/pulse at 400 Hz

which are obtained with the Dresden EBIS source by DREEBIT GmbH

Power : SCENT + CABOTO 800 + 400 MW

Energy spread FWHM = 0.4 %

Emittance 2 • mm mrad

Weight negligible for the LINAC

Cost of CABOTO about 10 MEuro

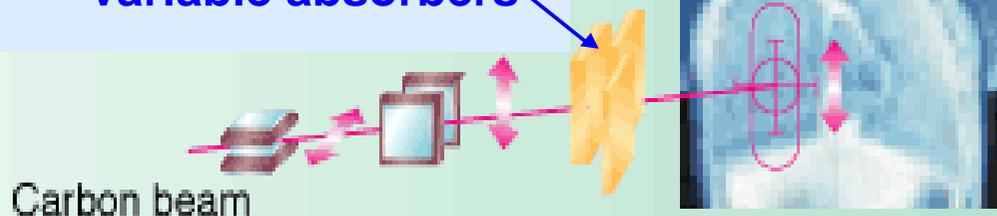
## Properties of the beams of different accelerators

Accelerator	Beam always present during treatments	Energy variation by electronic means	Time needed for varying the energy
Cyclotron	Yes	No	50 ms (*)
Synchrotron	No	Yes	1 second
<b>Cyclinac</b>	<b>Yes</b>	<b>Yes</b>	<b>1 millisecond</b>

The energy is varied by adjusting the RF pulses to the modules

(\*) With advanced movable absorbers

The cyclinac beam is ideal to follow moving tumours in 3D without variable absorbers



Gantry momentum acceptance:  $\pm 1.5\%$   
 Longitudinal displacement:  $\pm 10 \text{ mm}$

### Carbon/proton therapy: A novel gantry design

D. Trbojevic\* and B. Parker

Brookhaven National Laboratory, Upton, New York 11973, USA

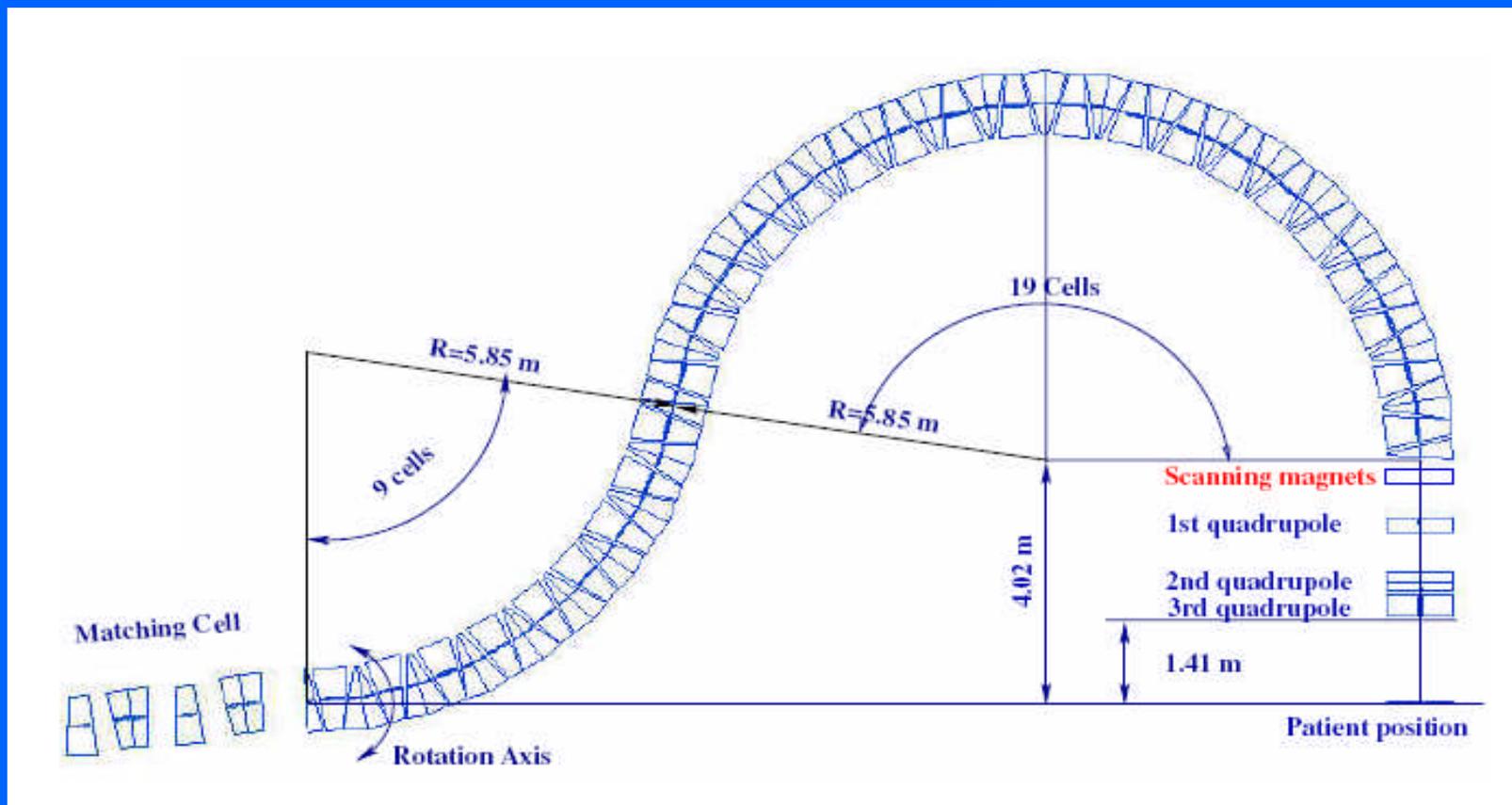
E. Keil

CERN, Geneva, Switzerland

A. M. Sessler

Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA

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***THE END***

