HADRONTHERAPY IN EUROPE (p,C, not n)

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- ☞ **Evolution** (from the first to the second generation)
- ☞ **Medical case** (why such an evolution ?)
- ☞ **Examples in Europe** (protons and carbons, just a flavor)
- ☞ **Industry** (Hadrontherapy is a business)
- 🍸 **Summary**

EVOLUTION

Particle therapy facilities in Operation (PTCoG)

1961 p Harvard, Boston, USA 9116
1969 p ITEP, Moscow, Russia 3927
1975 p St.Petersburg, Russia 1320
1979 p Chiba, Japan 145
1983 p PMRC1, Tsukuba, Japan 700
1984 p PSI-1, Villigen, Switzeland 4646
1989 p Dubna, Russia 318
1989 p Uppsala, Sweden 738
1989 p Clatterbridge, England 1584
1990 p Loma Linda, CA, 11414
1991 p Nice, France 3129
1991 p Orsay, France 3766
1993 p iThemba, South Africa 486
1993 p MPRI, IN, USA 220
1994 p UCSF, CA, USA 920
1994 ion HIMAC, Chiba, Japan 2867
1995 p TRIUMF, Canada 111
1996 p PSI-2, Switzerland 262
1997 ion GSI, Germany 316
1998 p HMI, Berlin, Germany 829
1998 p NCC, Kashiwa, Japan 462
2001 p + ion HIBMC,Hyogo, Japan 1099 +131
2001 p PMRC2, Tsukuba, Jp 930
2001 p NPTC, Boston, USA 2080
2002 p INFN-LNS, Catania, Italy 114
2003 p Shizuoka, Japan 410
2002 p Wakasa, Japan 33
2004 p WPTC, Zibo, China 270
2006 p MD Anderson, Houston, USA 114
2006 p FPTI, Jacksonville, FL, USA 15

Remarkable Europe Acceleration

From this table : Europe = 11 North America = 8 Japan + 8 p >> ion

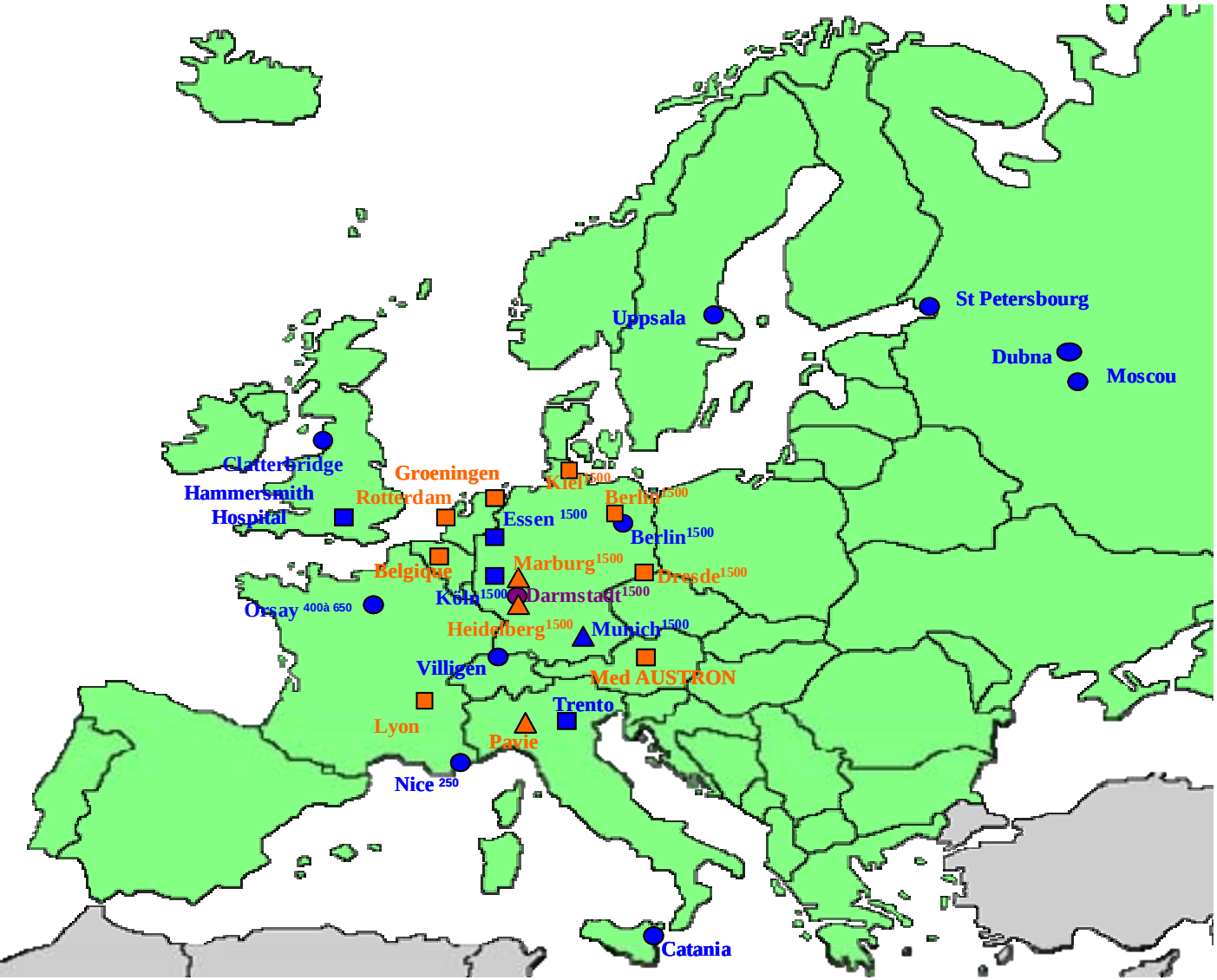
EVOLUTION

Commissioning – under construction - planning stage

2007	p	RPTC, Munich, Germany
2007/08	p	PSI, Villigen, Switzerland (OPTIS2/Gantry2)
2007	p	NCC, Seoul, Korea
2007	p + ion	HIT, Heidelberg, Germany
2007	p + ion	CNAO, Italy
2009	p	UPenn, USA
2009	p	WPE, Essen, Germany
2009 ?	p	iThemba Labs, South Africa
2009 ?	p	RPTC, Koeln, Germany
2010 ?	p	ICPO, Orsay, France
2010 ?	p	Trento, Italy
2011 ?	ion	Gunma Univ, Japan
2011	P	Northern Illinois PT Res. Inst, Chicago, IL, USA
2011	p + ion	PTC, Marburg, Germany
2011	p + ion	ETOILE, Lyon, France
2011 ?	p + ion	Med-AUSTRON, Austria

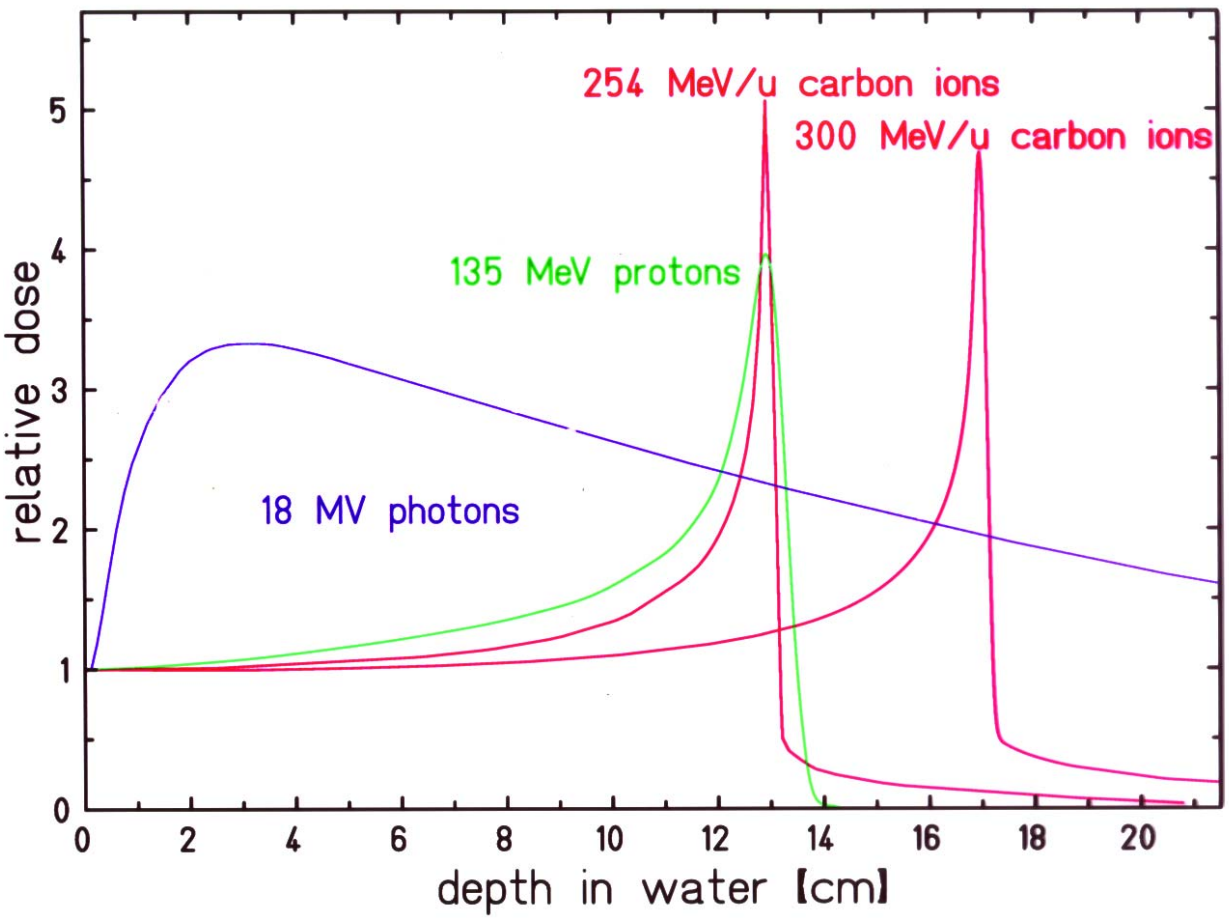
More than 16 centres over 5 years 11 in Europe 5 in Germany Ion

EVOLUTION more comments…



- Switch form the first generation (with parasitic use) to the second generation (dedicated facilities) (like synchrotron radiation sources) Ex : PSI, ICPO
- more and more turnkey constructions by specialized Companies Ex : Rieneker, Marburg, ETOILE

MEDICAL BENEFIT Particles vs Photons



Bragg pic

☞

Better ballistic precision than photons

☞

Better preservation of the healthy tissues and "organ at risk" (?)

Huge progress with IMRT, Cyber-Knifes … & same radiobiological efficiency

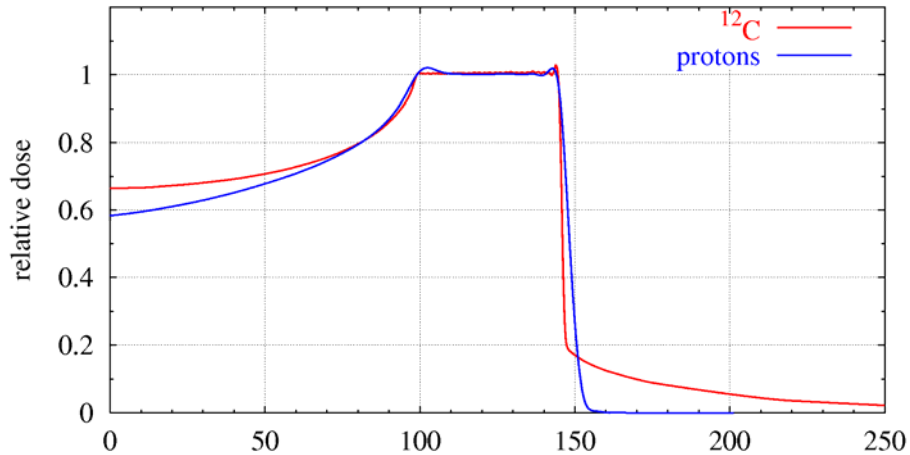
☞ **no clear advantage of protons vs photons**

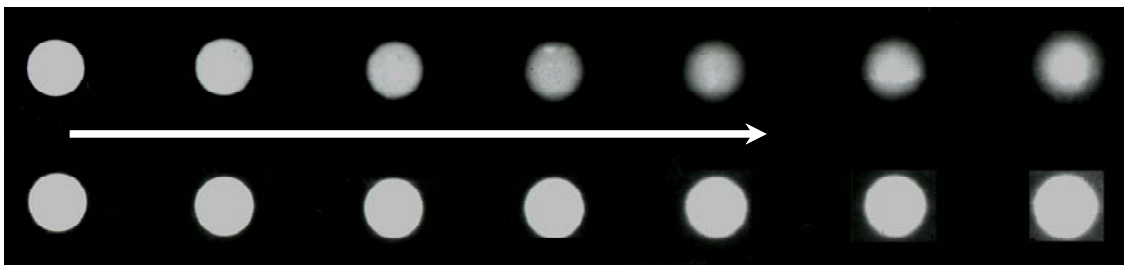
MEDICAL BENEFIT Carbons vs Protons

< Fragmentation of the carbon ions

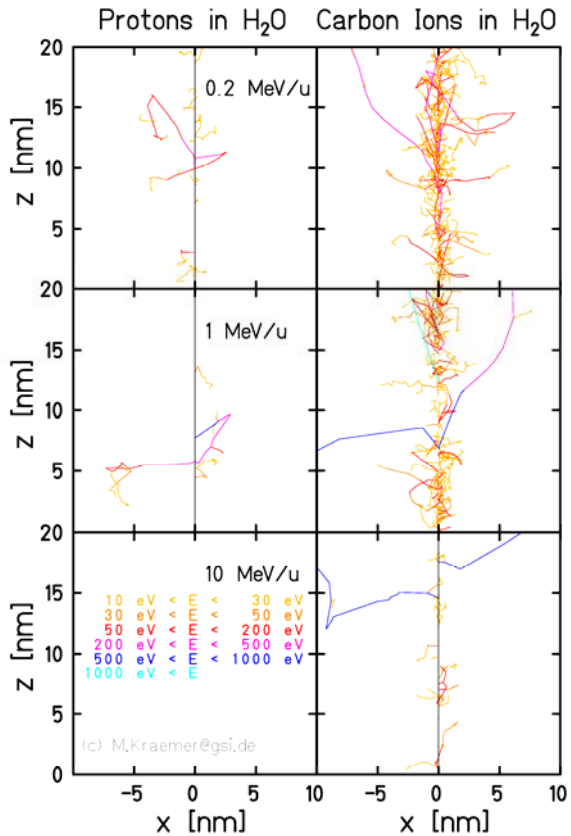
>> Much less beam scattering using carbon

>>> Radiobiological effect of carbons x 3 … 5 … 8 vs photons and protons

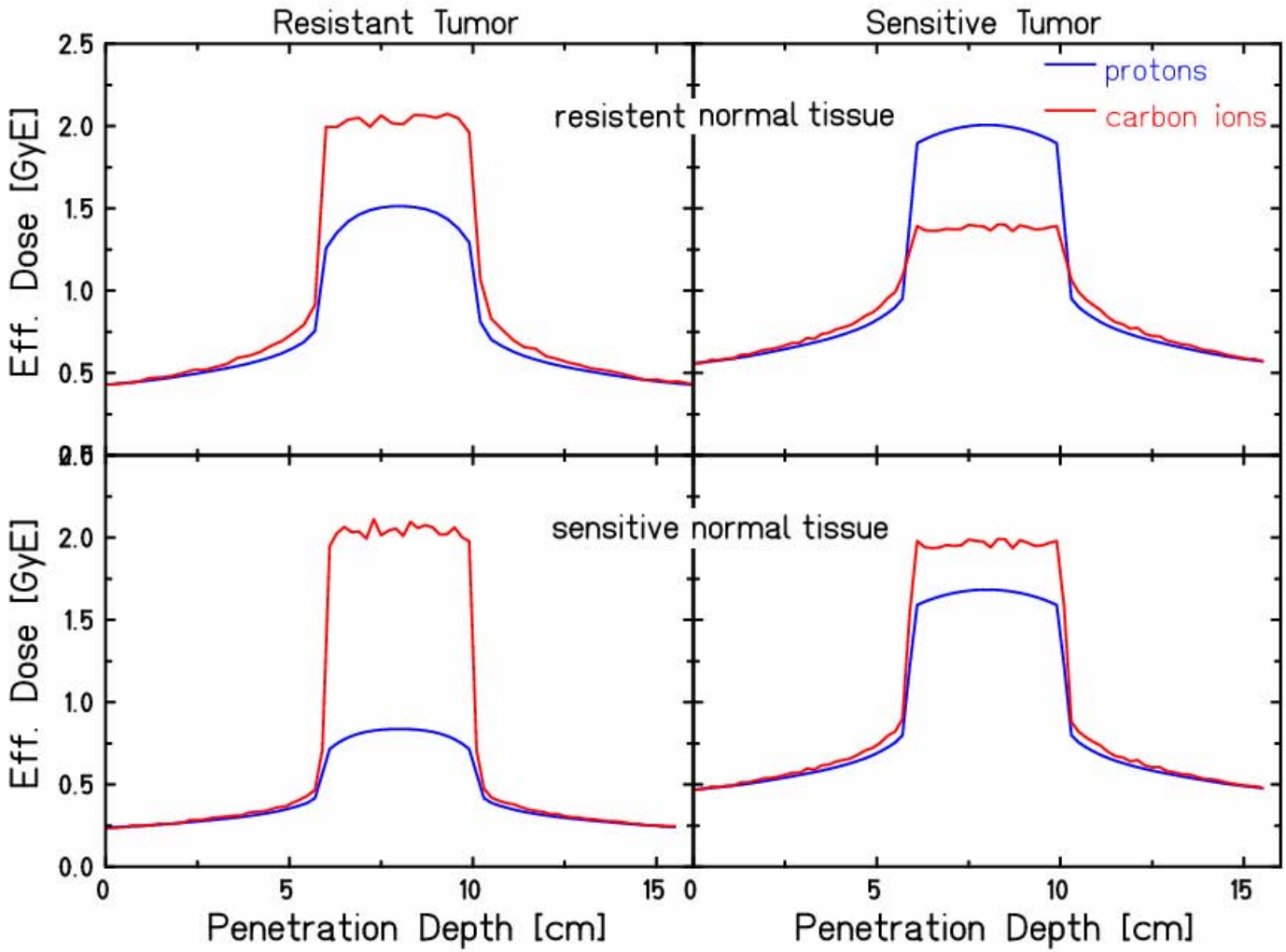




E Blakeley LBL



MEDICAL BENEFIT Photons / Protons / Carbons

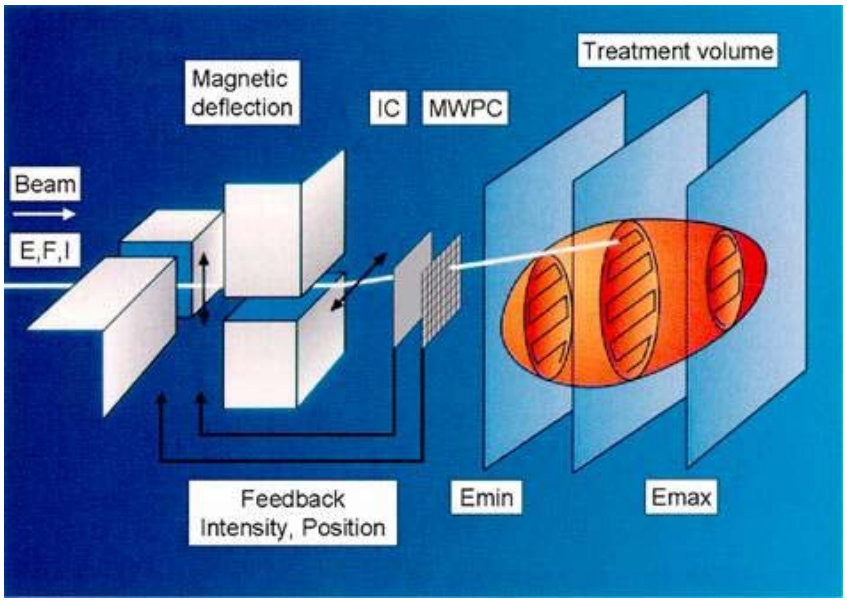


M. Scholz, GSI

Effective dose deposition (GyEquivalent) in and around the tumour

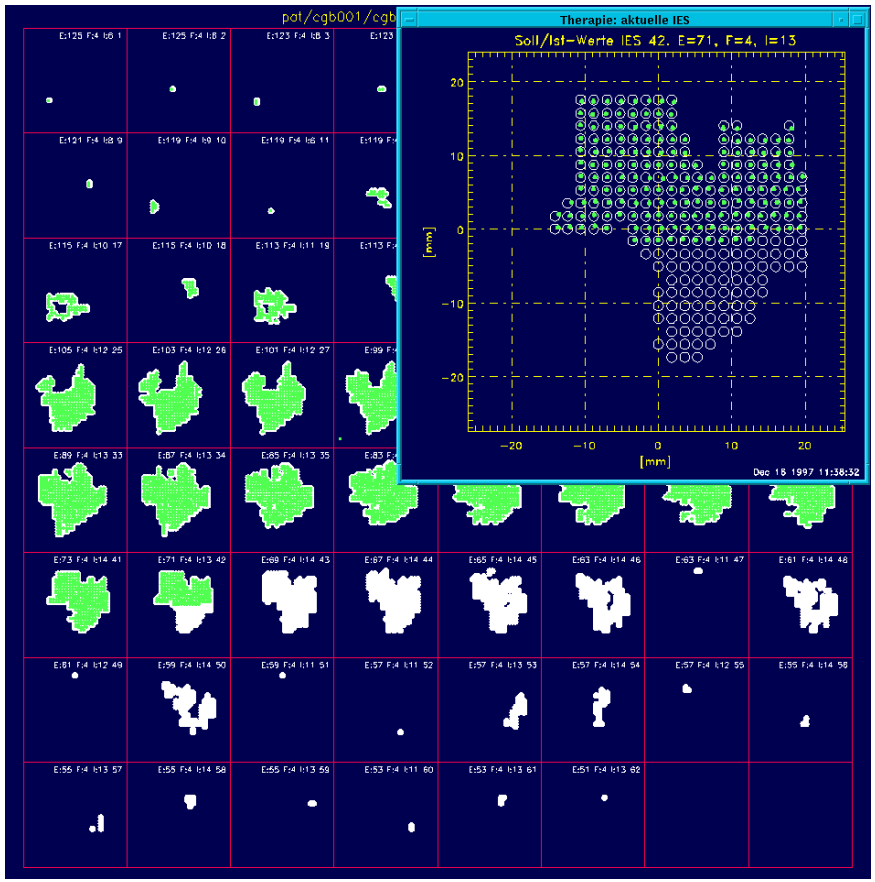
High RBE ☞ Decisive advantage of carbon treatments for radio resistant tumors

GSI Pioneer work (with HIMAC) in carbon-therapy



Conception of the raster scanning (spot-scanning) mm precision p … c

+ Ion radiobiology + Ion TPS



GSI ⏩ HIT HEIDELBERG

November 2004

September 2006

As it is today

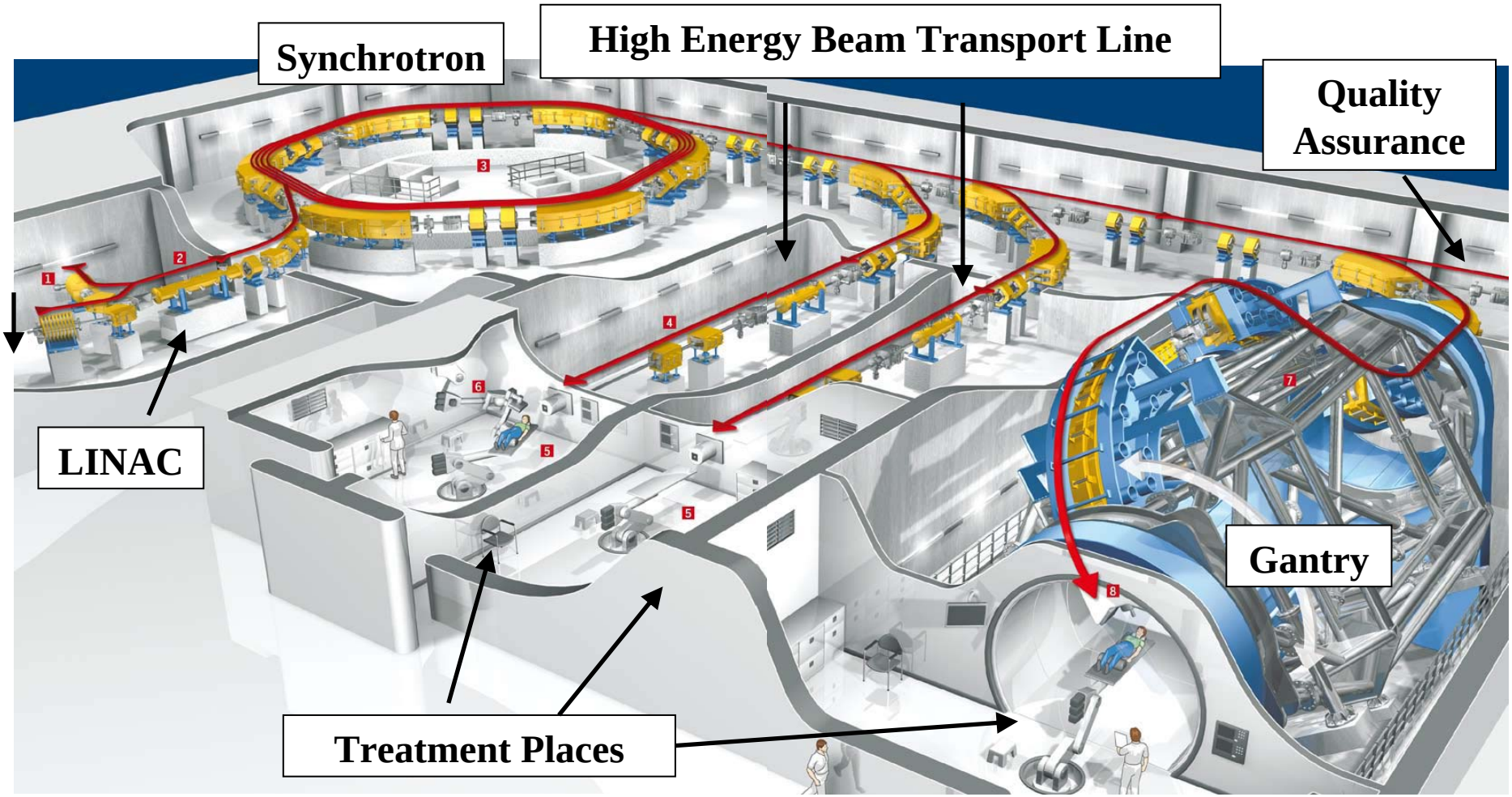
a 4 year story for the construction …

After a long gestation !

BRAVO

Dieter Bohne, Helmuth Heikoff,
Udo Weinrich …

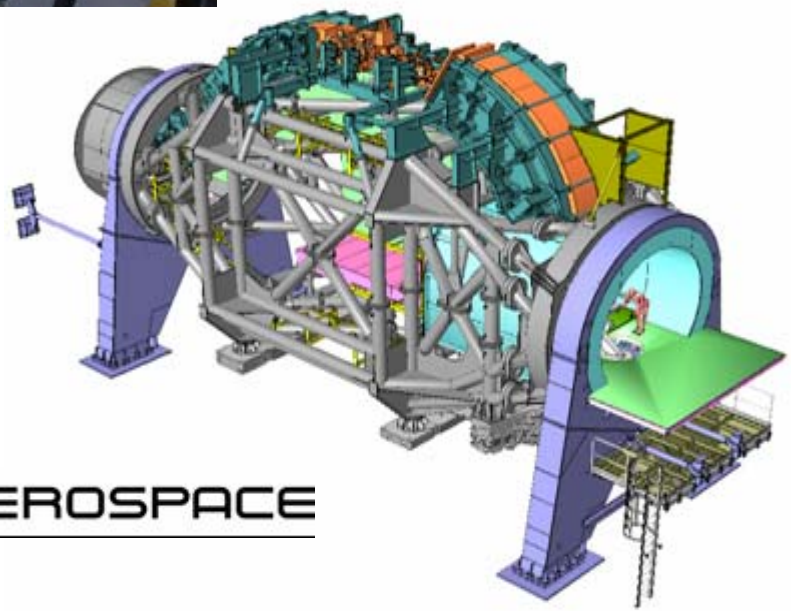
HIT HEIDELBERG



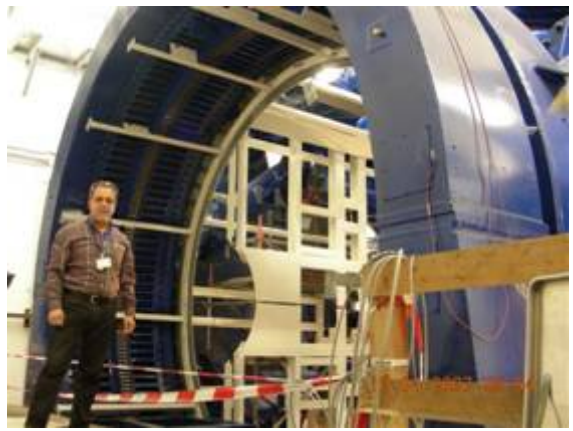
GSI accelerator design **First turn in the synchrotron Febr. 2007**

Commissioning of the facility in progress

HIT HEIDELBERG, Gantry for 430 MeV/u C beams



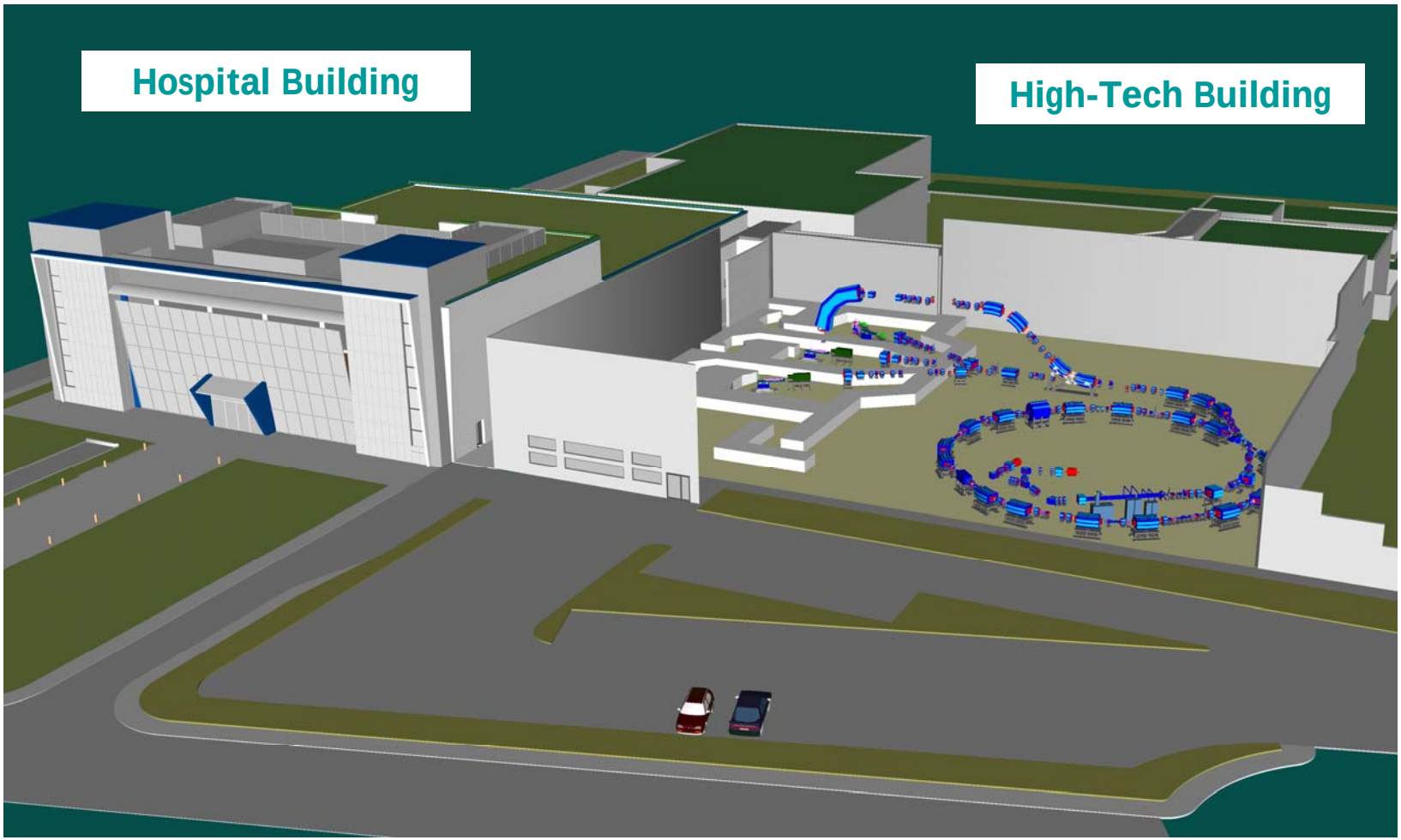
MT AEROSPACE



Total weight = 600 Tons **Normal-conducting magnets**

First rotation April 21, 2007

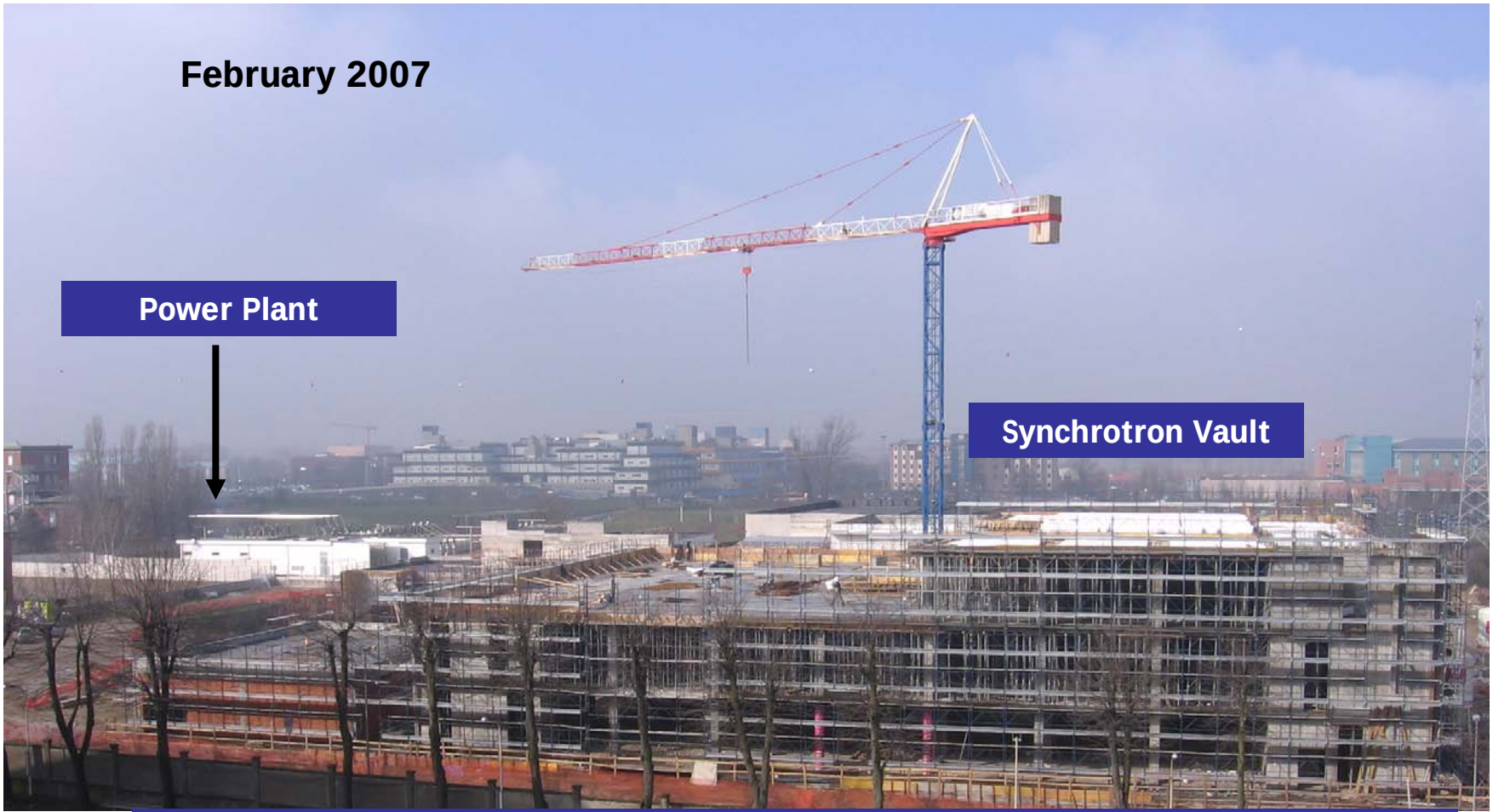
CNAO, Pavia, Carbon Facility



Accelerator based on the PIMMS design (CERN)

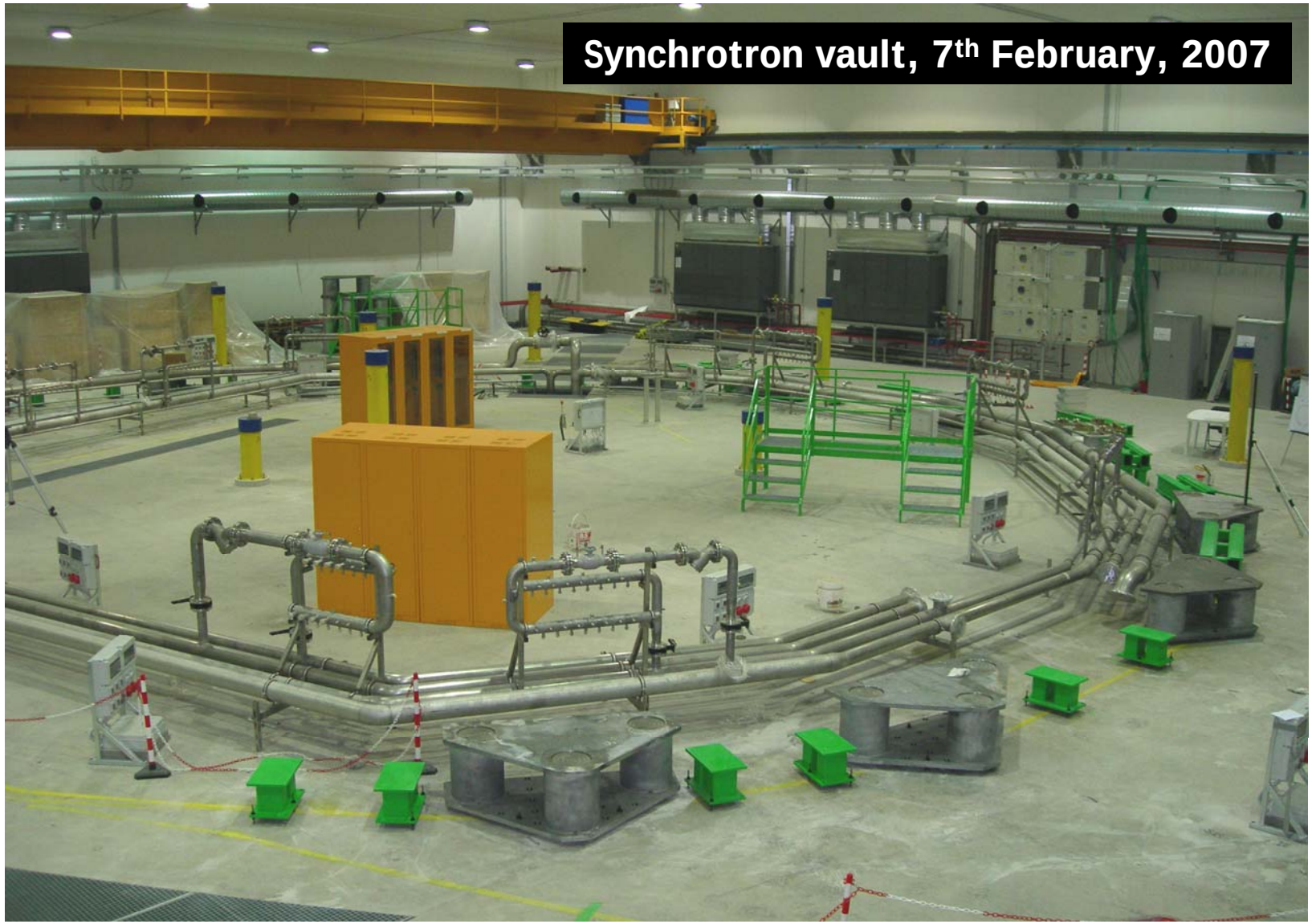
3 treatment rooms : H - H + V - H

CNAO, Pavia, Carbon-Therapy



CNAO is built to treat 3000 patients / year in phase 1

CNAO, Pavia, Carbon-Therapy



ETOILE Carbon-Therapy facility, Lyon, France

ETOILE
National Hadrontherapy Centre

Project approved by the French ministries of health and research in May 2006

Will be built in the framework of a Public – Private Partnership

- The Private Partner will <u>finance and built</u> the facility

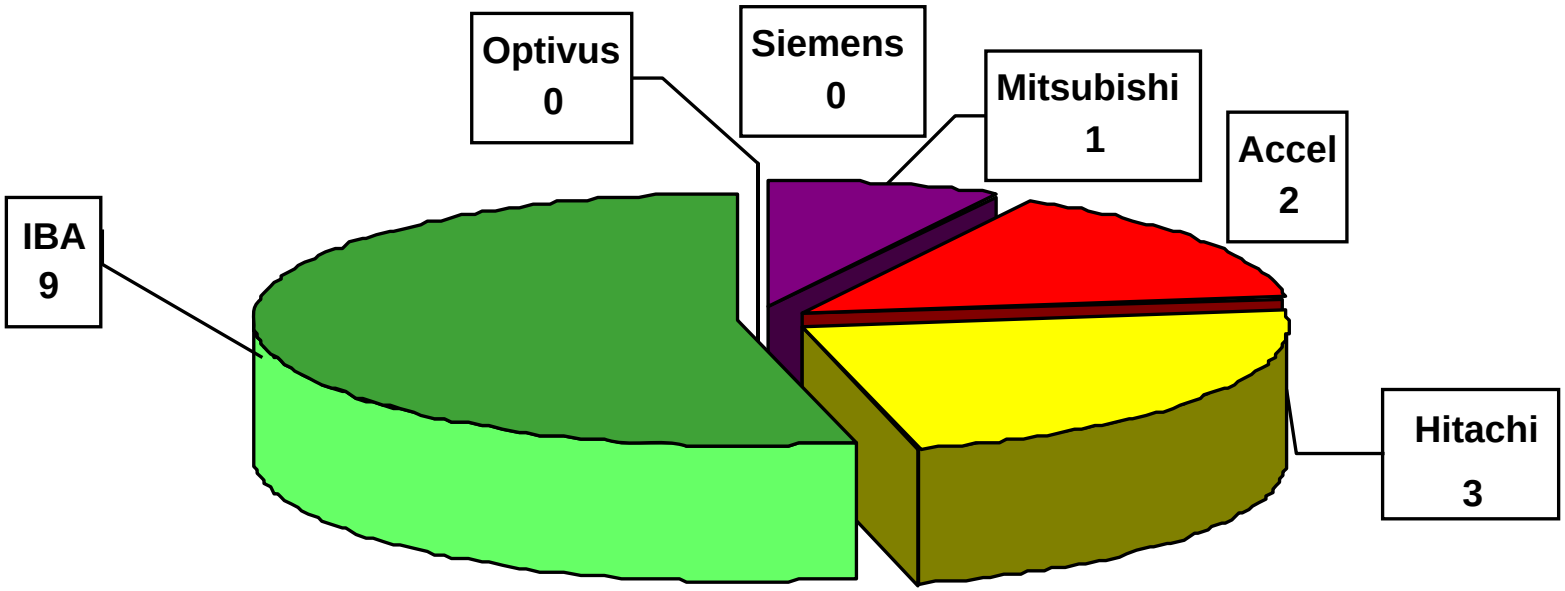
- The facility will be the property of the Private Partner, he will operate and maintain the facility (technical operation)

- The medical team (Public Partner) will rent the beam time

Private Partner selection before end-2008

Hadrontherapy is a business

Like radiotherapy… therapy…

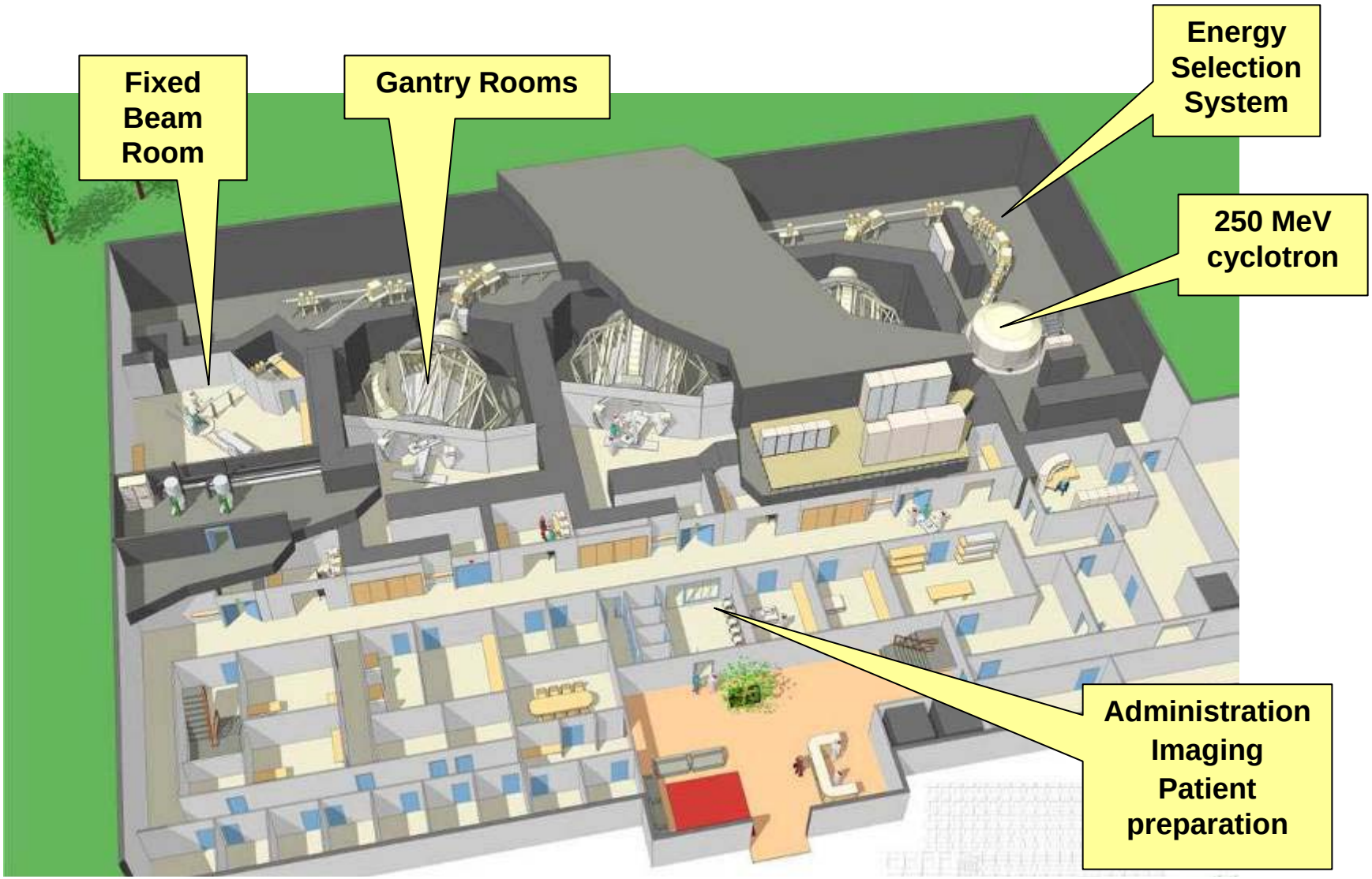


15 “industrial” protontherapy centers running today

11 by EU / 4 by JP companies

The first “industrial” carbon therapy centre (Marburg) is built by Siemens

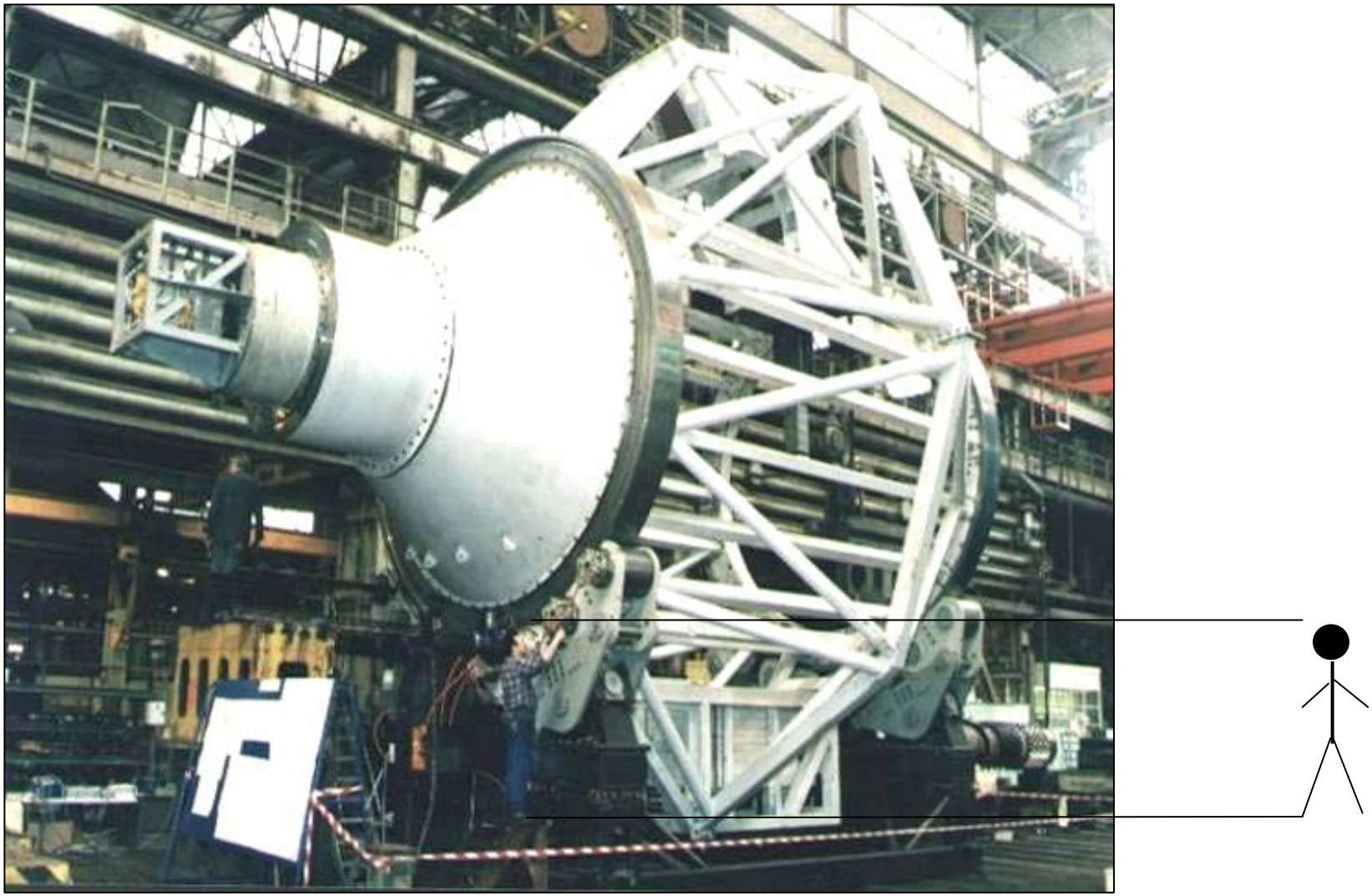
IBA Protontherapy center design



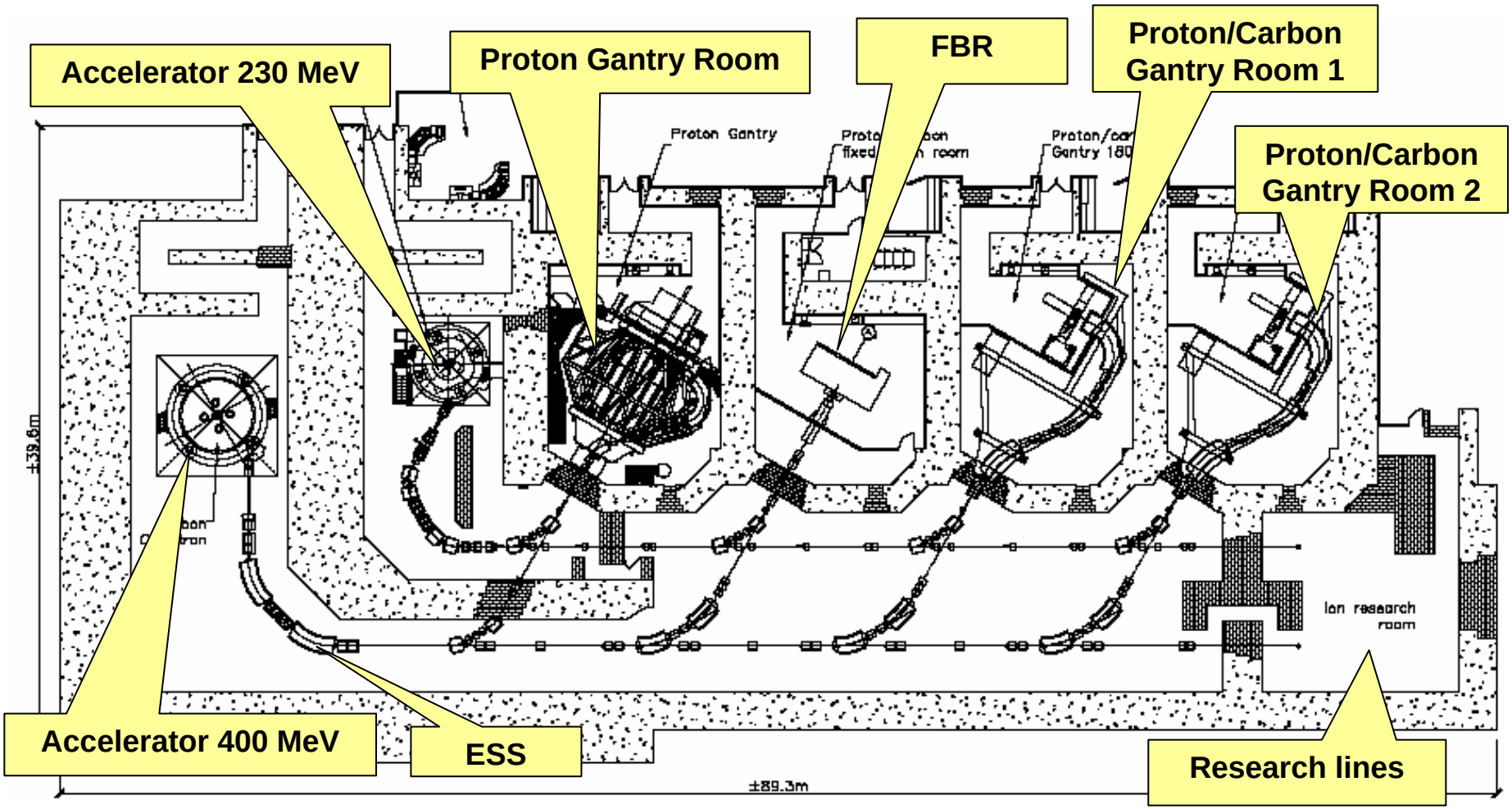
IBA Proteus 235 cyclotron

Simple and compact

IBA Proton gantry



IBA Proton – Carbon facility proposal



Superconducting isochronous cyclotron accelerating Q/M = 1/2 ions to 400 MeV/U

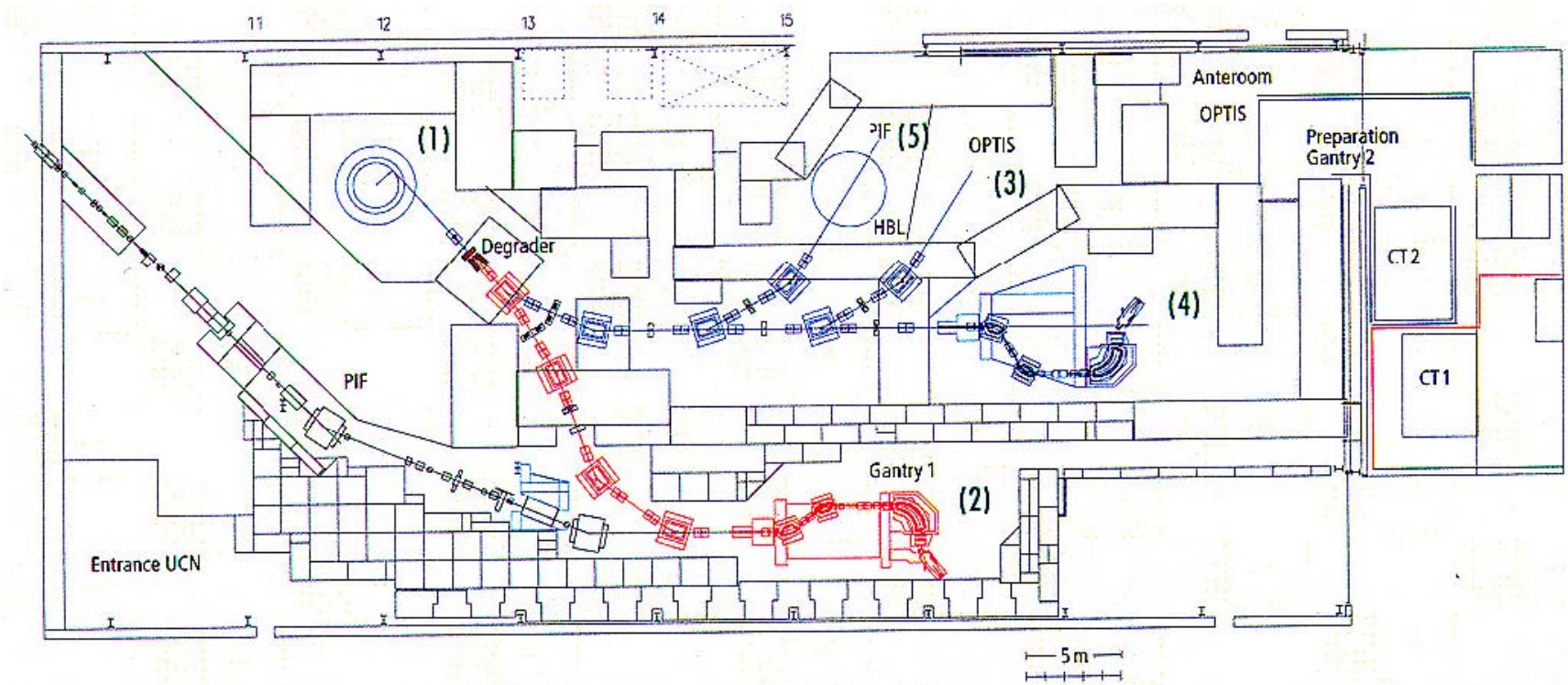
ACCEL for PROSCAN at PSI

One of the very first best place for protontherapy in Europe

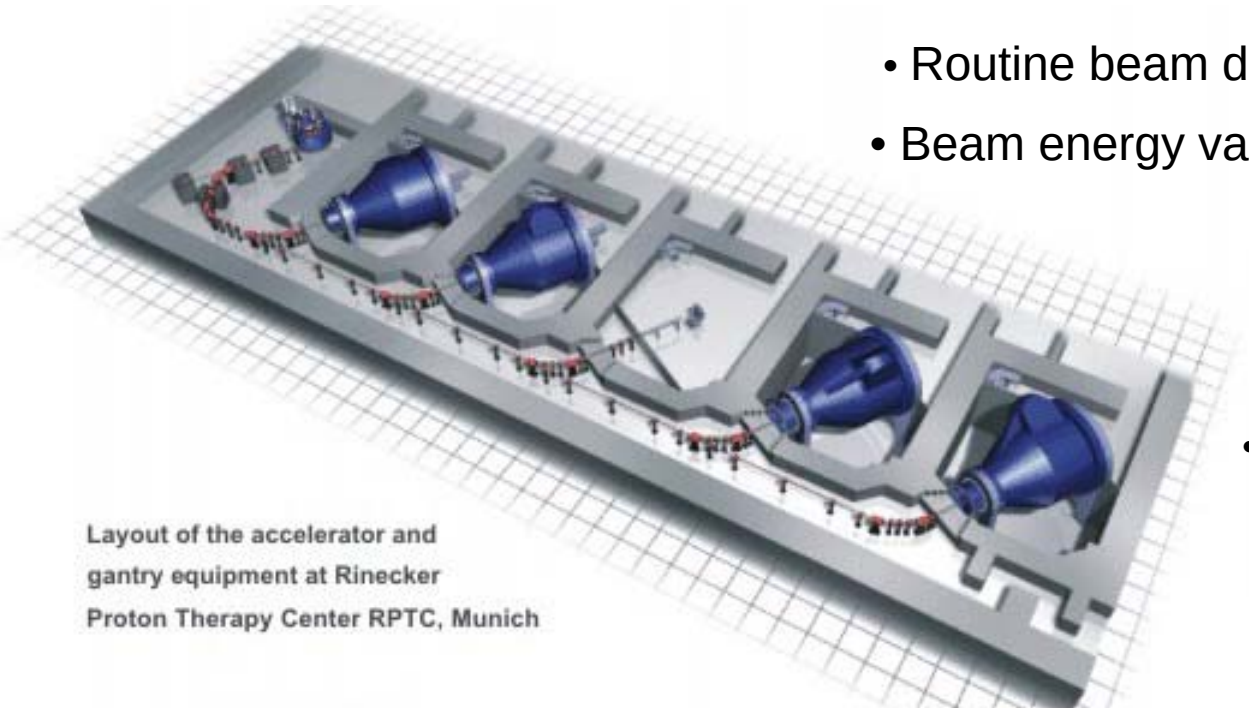
Switch from the first (SIN parasitic use) to the second generation (ACCEL)

VILLIGEN, Switzerland, March 22, 2007

"Clinicians at the Paul Scherrer Institute in Switzerland have begun clinical treatments using the world's first commercial superconducting cyclotron for routine medical use"



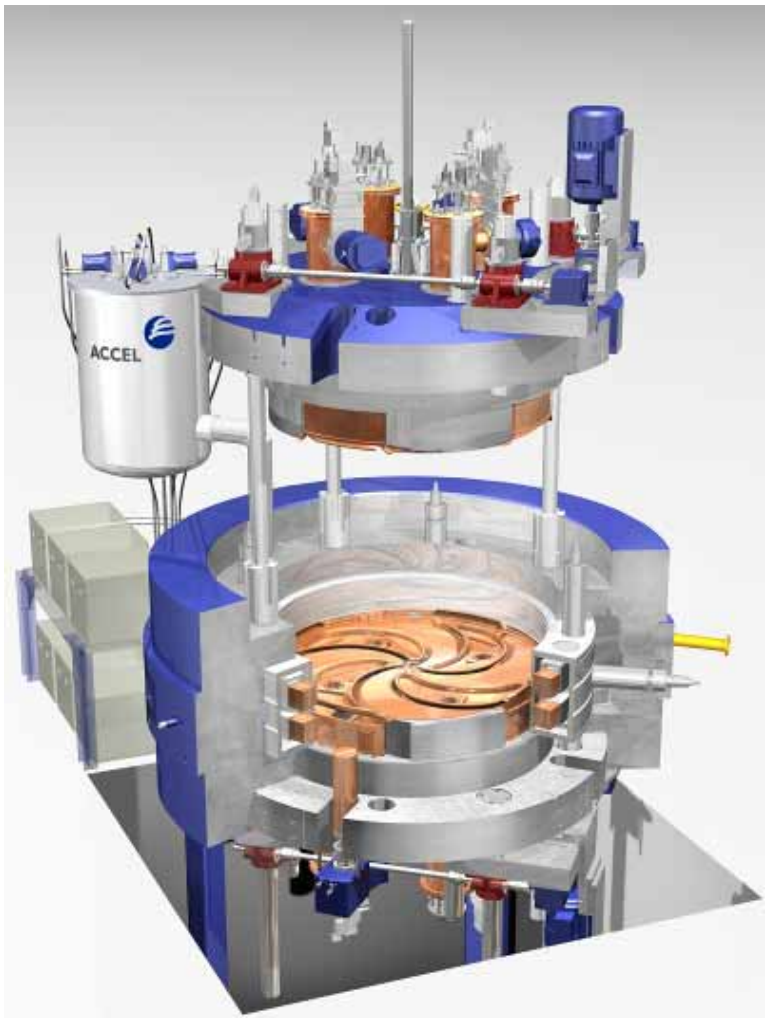
ACCEL RINECKER PROTON THERAPY CENTRE



Layout of the accelerator and gantry equipment at Rinecker Proton Therapy Center RPTC, Munich

- Routine beam delivery to gantry room G1
- Beam energy variable from 70 to 250 MeV
- Extracted beam up to 1µA
- Extraction efficiency of cyclotron > 80 % at PSI, > 70 % at RPTC
- Scanning systems operable (G1)
- Patient positioning / verification accepted by TÜV
- Software tools for Gantry 1 completed incl. therapy planning system
- Successfull test of ~1 % dose conformity by technical expert of approving authority

ACCEL ⏩ VARIAN-ACCEL



Since the begining of this year

Varian Medical Systems' ACCEL group

Varian's expertise in image-guided radiation therapy (IGRT), treatment planning, information systems, clinical workflow, manufacturing, service and distribution

+

ACCEL's proton therapy technology and expertise

☞

Offer of a fully integrated proton treatment system from a single company

SIEMENS Medical Solutions - Carbon facilities

Industrial offer thanks to a Knowledge-transfer & licenses from GSI

- Synchrotron and raster scanning technology (Spot scanning)
- Treatment optimization (biological effects of ions)
- Treatment planning software

Siemens and Danfysik Cooperation Joint development

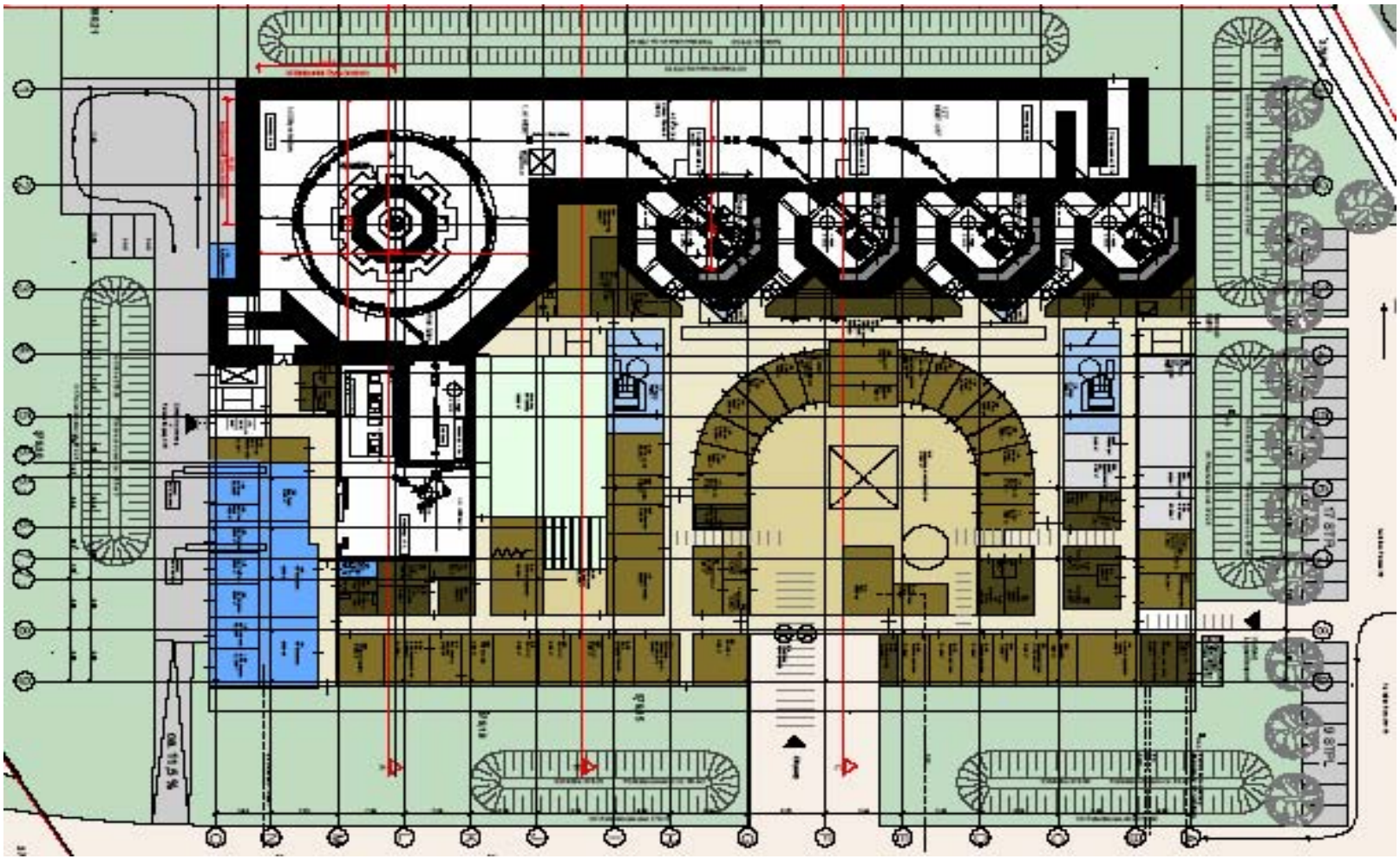
- Standardized solution for Proton and Carbon therapy in one system
- Danfysik is the exclusive supplier of accelerator systems for Siemens
- Accelerator systems including proton and carbon sources, synchrotron accelerators, and beam delivery systems from the synchrotron up to the medical treatment rooms

SIEMENS Medical Solutions - Turn-key carbon facilities

Accelerator and beam lines
are just one component of a Complex System

- Accelerator with beam line
- Scanning and beam monitoring system
- Treatment rooms (gantry, robotic table for patient positioning)
- Patient transport system
- Imaging (diagnostic and position verification)
- Treatment Planning System
- IT (oncology information system, administration, archiving, …)
- Project management
- Technical operation and maintenance

SIEMENS Marburg CarbonTherapy Centre



Surface optimization **Construction phase**

SUMMARY 1/3

Hadrontherapy is born thanks to the developments made in the field of fundamental physics

(Pioneer work at Berkeley, Uppsalla … Fermi for Loma Linda… Chiba, GSI…)

Hadrontherapy benefits less and less of the investments done for fundamental physics

NOW,

€€€€€ $$$$$ HADRONTERAPY IS A BUSINESS $$$$$ €€€€€

👎

Industrial competition

👎

Involvement of Academic Laboratories more and more complex

Even if some groups are still getting some money for fun

Study exotic solutions following a French proverb :

“Why do it simple when we can make it complicated ?”

SUMMARY 2/3

Electron, proton and heavy ion accelerators for radiotherapy and hadrontherapy are now built (and operated) by industry

Several companies have demonstrated that they can built very performing accelerator turnkey facilities with medical assurance quality standards for the best price

A lesson for the construction of accelerator facilities for fundamental research ?

Which future for protontherapy ?

Protontherapy in competition with the new photon technologies (IMRT)

From “some experts” :

Passive p < IMRT

Active p ~ IMRT

?

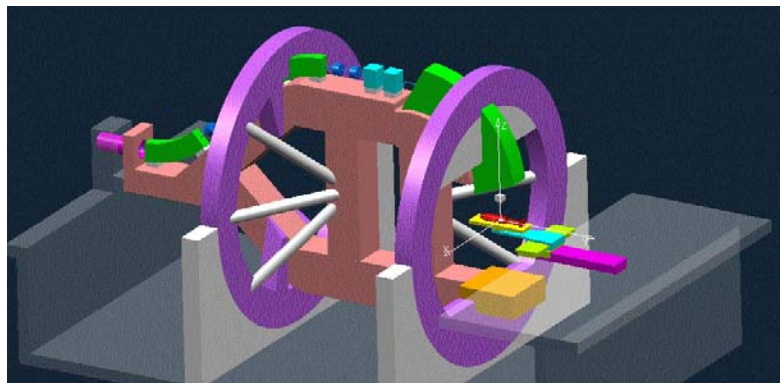
SUMMARY 3/3

The higher ballistic precision and RBE give a medical advantage to carbon for the treatment of radio-resistant tumours

"Market" estimated ~ 10% of radiotherapy ☞ 1 facility for ~15 M inhabitants

Interest for carbon gantries using superconducting magnets

The goal must be to decrease the cost not to decrease weight or size !



The highest R&D priorities are not strictly related to accelerators

☞ Treatment Planning System :

- Error tolerance – Better taking into account of the RBEs – Monte Carlo simulations

☞ Fast and accurate beam monitoring ☞ Patient positioning system

☞ Respiration gating (moving targets) ☞ Dose homogeneity (repainting)

☞ Imaging and online dose monitoring (online PET for QA …)

THANKS

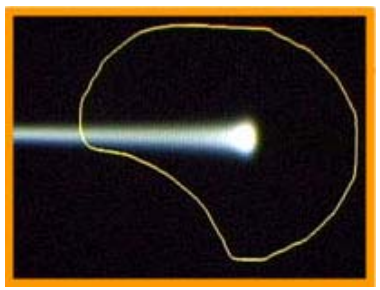
Gerhard Kraft and Wilma Kraft-Weyrather (GSI)

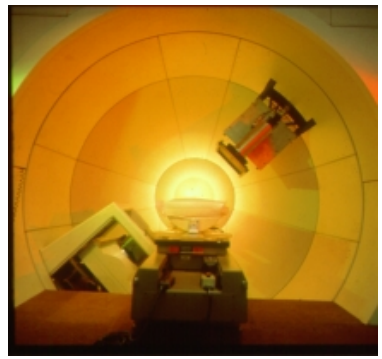
Udo Weinrich (GSI – HIT)

Sandro Rossi (CNAO)

ETOILE and ASCLEPIOS Teams

HIMAC Team





… and a lot of exceptional medical-doctors, medical-physicists and physicists working in this field

Interested to go further in hadontherapy ?
Visit http://ptcog.web.psi.ch/ and attend the PTCOG meetings…