



# Research Activities at IBA

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**Frédéric Stichelbaut, Ph.D.**



**Domain Expert, IBA Fellow**

**[Frederic.Stichelbaut@iba-group.com](mailto:Frederic.Stichelbaut@iba-group.com)**



# Outline



## □ IBA Activities in short:

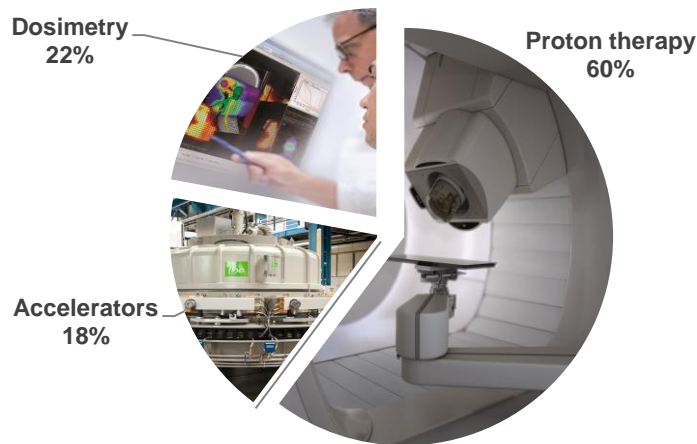
- RadioPharma solutions
- Industrial accelerators
- Dosimetry products
- Proton therapy

## □ Current research activities:

- Health Physics
- Accelerator Physics
- Medical Physics

# IBA in short

- Company formed in 1986 as spin-off of UCL and based in Louvain-La-Neuve (LLN), Belgium
- Employs ~ 1,000 people worldwide, ~500 based at LLN headquarters.
- Number one provider of integrated proton therapy solutions
  - More compact and targeted radiotherapy applications
- Synergistic businesses in dosimetry, medical and industrial accelerators





## QUALITY ASSURANCE & GMP



$^{18}\text{F}$ -  
+ other  
radioisotopes



$^{18}\text{F}$ FDG  
+ other  
compounds



Quality  
control &  
sterility  
tests



MRI/PET  
OR PET/CT



Injection &  
Diagnostic

# IBA CYCLOTRONS FAMILY : GLOBAL COVERAGE



3 MeV

11 MeV

18MeV

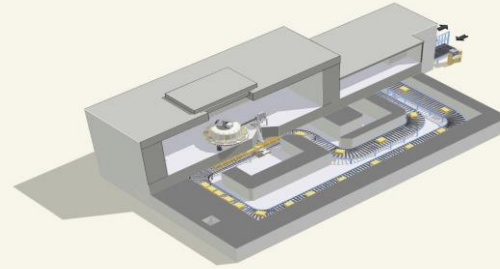
30MeV

70MeV



# IBA Industrial Accelerators (1)

- Electron beams 3 to 10 MeV
- Beam power 35 kW to 700 kW (7 MeV/100 mA)
- E-beam or X-ray treatment modes
- Applications:
  - Medical device sterilization
  - Food pasteurization
  - Advanced material manufacturing (cables, tires, ...)
- Installed base > 200 units



# IBA Industrial Accelerators (2)

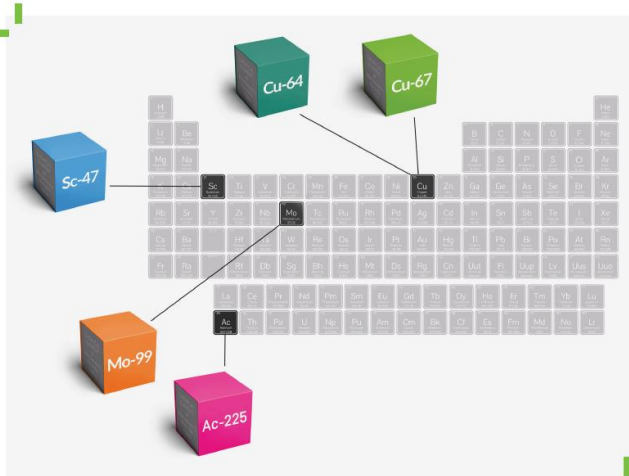
- New Rhodotron able to deliver 40 MeV/125 kW electrons beams.
- Production of medical isotopes via photonuclear reactions such as  $^{100}\text{Mo}(\gamma, n)^{99}\text{Mo} \rightarrow ^{99\text{m}}\text{Tc}$  production.

#### MEDICAL APPLICATIONS

- Diagnostic/Imaging
- Therapeutic

#### SCIENTIFIC APPLICATIONS

- High energy physics
- Photofission

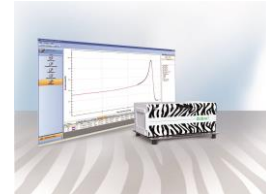
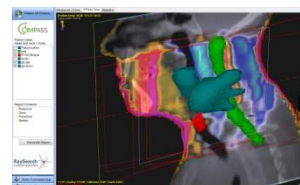


**Rhodotron® TT300-HE**  
High Energy Electron Generator

# IBA DOSIMETRY PRODUCTS

## Radiation Therapy

**Linac commissioning and quality assurance of machine and patient plan, for safer patient treatments.**



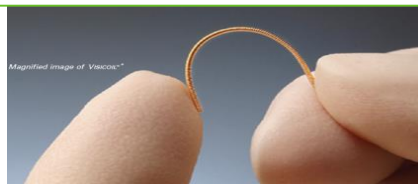
## Medical Imaging

**Full solution provider in quality control in diagnostics imaging, for better diagnosis.**



## Image Markers

**Clear tumor localization, for higher targeting accuracy.**





# Proton Therapy

Next generation in targeted cancer treatment

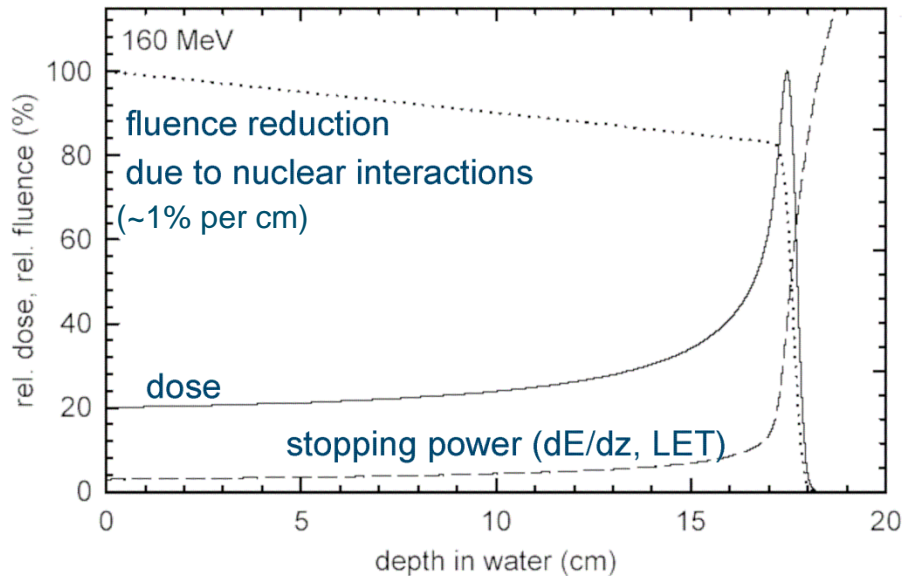


# Proton Depth-Dose Curve



Bragg peak:  
stopping power

$$\frac{dE}{dz} = -4\pi n \frac{Z_{\text{eff}}^2 e^4}{m_e v^2} \left\{ \ln \frac{2m_e v^2}{I(1-(v/c)^2)} - (v/c)^2 \right\}$$



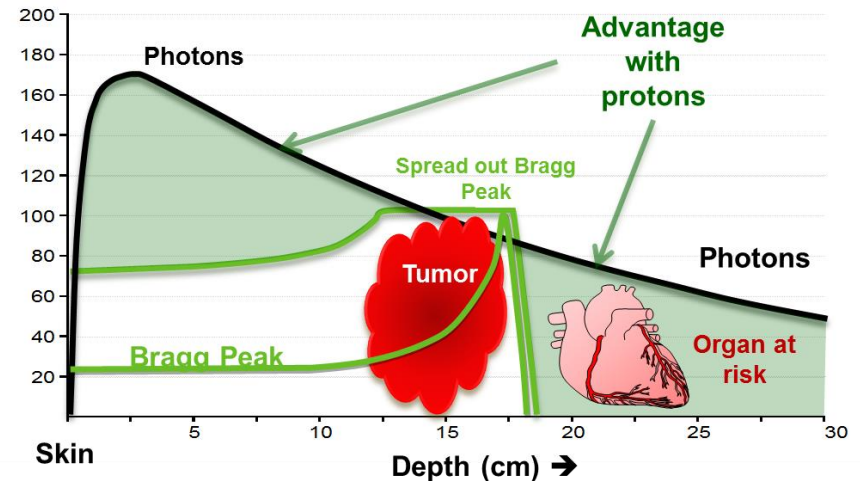
# Proton therapy vs. conventional radiotherapy

Case studies for efficacy and toxicity

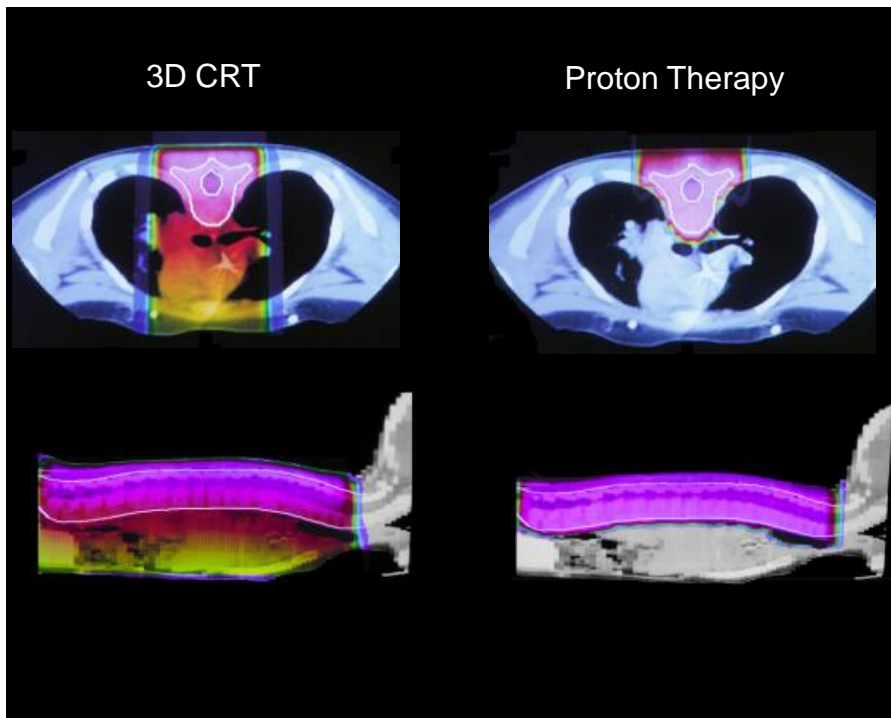
## Protons have a superior dose distribution

- Protons:
  - Deliver their maximum energy within a precisely controlled range
  - Deposit a high and conformal dose
  - Deposit very little entry dose
  - Deposit no exit dose
- Up to 50% reduced risk of radiation-induced secondary cancer
- Much lower risks of adverse effects (toxicity, side effects, abnormal growth)

➔ Better quality of life during and after treatment



# Clinical examples : pediatric medulloblastoma



Side Effects	Photons	Protons
Restrictive Lung Disease	60%	0%
Reduced exercise capability	75%	0%
Abnormal EKGs	31%	0%
Growth abnormality	100%	20%
IQ drop of 10 points at 6 yrs	28.5%	1.6%
Risk of IQ score < 90	25%	15%

“Proton beam therapy has become a standard of care for pediatric cancers...”

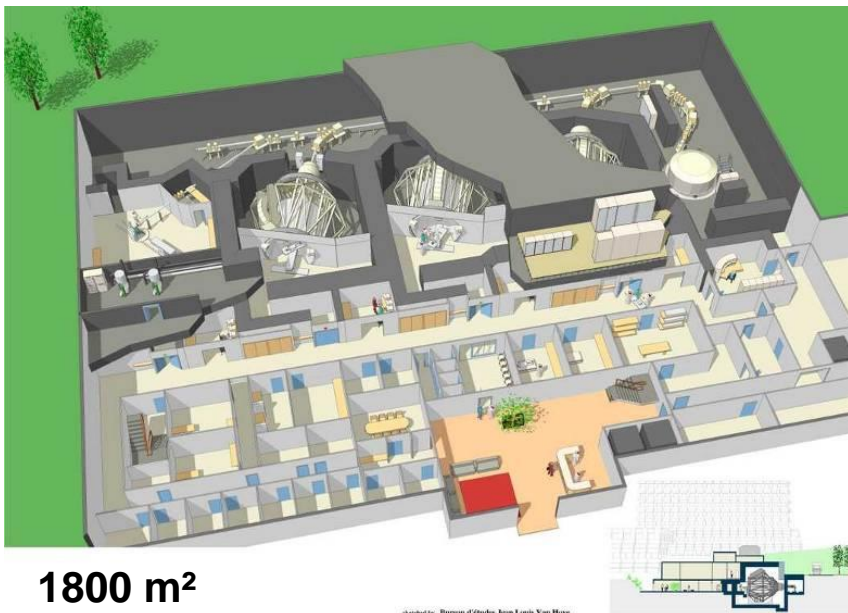
(\*)

(\*) Presentation Dr. Jay S. Loeffler, NPTC/MGH, ASTRO 2001

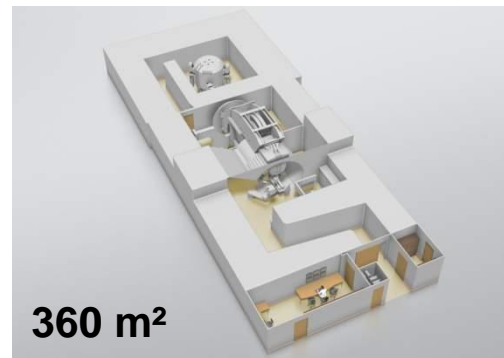
# Clinical outcome and affordable

Multi-room to single-room solutions

## Proteus®PLUS



## Proteus®ONE\*



**\*Proteus®ONE features PBS, Cone Beam CT and Compact gantry.**

# Global adoption of IBA Proton Therapy

26 IBA reference centers - 25,000 patients treated



## NORTH AMERICA NETWORK

4  
score



**CDH PROTON THERAPY CENTER, A PROCURE CENTER**  
Warrenville, IL, USA  
Treating since 2010

5  
score



**UNIVERSITY OF PENNSYLVANIA HEALTH SYSTEM ROBERTS PROTON THERAPY CENTER**  
Philadelphia, PA, USA  
Treating since 2009

5  
score



**HAMPTON UNIVERSITY PROTON THERAPY INSTITUTE**  
Hampton, VA, USA  
Treating since 2010

3  
score



**THE PROTON THERAPY CENTER LLC (TPIC) PROVISION HEALTHCARE**  
Knoxville, TN, USA  
Opening in 2014

1  
score



**WILLIS-KNIGHTON CANCER CENTER**  
Shreveport, LA, USA  
Opening in 2014

4  
score



**PROCORE PROTON THERAPY CENTER IN OKLAHOMA CITY**  
Oklahoma City, OK, USA  
Treating since 2009

3  
score



**MASSACHUSETTS GENERAL HOSPITAL BURR PROTON THERAPY CENTER**  
Boston, MA, USA  
Treating since 2001

4  
score



**SCCA PROTON THERAPY A PROCURE CENTER**  
Seattle, WA, USA  
Opening in 2013

4  
score



**PROCORE PROTON THERAPY CENTER**  
Somerset, NJ, USA  
Treating since 2012

4  
score



**UNIVERSITY OF FLORIDA PROTON THERAPY INSTITUTE**  
Jacksonville, FL, USA  
Treating since 2006

3  
score



**TEXAS CENTER FOR PROTON THERAPY**  
Dallas, TX, USA  
Opening in 2015

2  
score



**INDIANA UNIVERSITY HEALTH PROTON THERAPY CENTER**  
Bloomington, IN, USA  
Treating since 2004



## EUROPE NETWORK

4  
score



**WESTDEUTSCHES PROTONENTHERAPIEZENTRUM ESSEN (WPE)**  
Essen, Germany  
Treating since 2013

2  
score



**AGENZIA PROVINCIALE PER LA PROTONTERAPIA (ATREP)**  
Trento, Italy  
Opening in 2013

1  
score



**CENTRE ANTOINE LACASSAGNE**  
Nice, France  
Opening in 2014

2  
score



**BRONOWICE CYCLOTRON CENTER**  
Kraków, Poland  
Opening in 2013

4  
score



**FEDERAL HIGH-TECH MEDICAL CENTER**  
Dimitrovgrad, Russia, Europe  
Opening in 2013

4  
score



**PROTON THERAPY CENTER CZECH S.R.O.**  
Prague, Czech Republic  
Treating since 2012

2  
score



**CENTRE DE PROTONTHÉRAPIE DE L'INSTITUT CURIE**  
Paris (Orsay), France  
Treating since 2009

2  
score



**SKANDIONKLINIKEN**  
Uppsala, Sweden  
Opening in 2013

1  
score



**UNIVERSITÄTSKLINIKUM CARL GUSTAV CARUS**  
Dresden, Germany  
Opening in 2014



## ASIA NETWORK

1  
score



**NATIONAL CANCER CENTER**  
Ilsan, Korea  
Treating since 2007

3  
score



**APOLLO PROTON THERAPY CENTER**  
Chennai, India  
Opening in 2015

2  
score



**WANJIE PROTON THERAPY CENTER**  
Zibo, China  
Treating since 2004

1  
score



**CHC TAIPEI PROTON THERAPY CENTER**  
Taipei, Taiwan  
Opening in 2015

3  
score



**NATIONAL CANCER CENTER**  
Kashiwa, Japan  
Treating since 1998



● Proteus®PLUS

● Proteus®ONE

THIS MAP HAS BEEN LAST UPDATED IN AUGUST 2013.





# Monte Carlo Simulations at IBA (1)



- **IBA core business deals with the use of particle accelerators for medical and industrial applications → MC transport codes are essential tools in many activities**
  - Radiation protection studies:
    - Shielding design around accelerators and patients/targets;
    - Activation studies for the equipment and the environment (concrete, ground, air, cooling water);
    - Code benchmarking and experimental validations using neutron detectors.
  - Accelerator physics (beam losses, beam transport line modeling);
  - Evaluation of radiation damages to electronic devices;
  - Medical physics:
    - On-line monitoring of proton beam range inside patient (Prompt gamma, PET emission)
    - Study of secondary neutron doses delivered to patient during treatment

# Monte Carlo Simulations at IBA (2)



## □ Major used codes:

### ▪ MCNPX (Monte Carlo N-Particle eXtended) / MCNP6

- Developed by Los Alamos National Lab. for Nuclear Physics
- Transport of  $e^-$ ,  $\gamma$ , n, h, light ions, heavy ions,  $\mu$ , baryons, mesons ( $\pi$ , K, D).

### ▪ PHITS (Particle and Heavy Ion Transport code System)

- Developed by JAEA, RIKEN for accelerator design, medical physics and cosmic-ray research
- Transport of  $e^-$ ,  $\gamma$ , neutrons, protons, light ions, heavy ions

### ▪ GEANT4 (TOPAS)

- Developed by CERN, SLAC and other HEP Labs.
- Transport of particles for energies from 250 eV to 1 TeV.

# Example Project (1)



- **Radioprotection studies around the newly developed Rhodotron High-Energy (40 MeV electrons):**
  - Benchmarking of photonuclear physics implemented in MC codes MCNPX and PHITS;
  - Characterization of radiation fields produced by 40 MeV electrons on various targets ( $^{100}\text{Mo}$ , steel, copper, ...)
    - ➔ X-rays and neutrons produced by photonuclear reactions;
  - Design of a suitable shielding around the accelerator and the targets;
  - Study of equipment/target activation due to secondary X-ray and neutron fields.
  - Optimization of a  $^{100}\text{Mo}$  target station for high-yield uniform  $^{99}\text{Mo}$  production.

# Example Project (2)



□ Study of secondary radiation fields produced by PET isotopes generated during patient treatment with proton beams

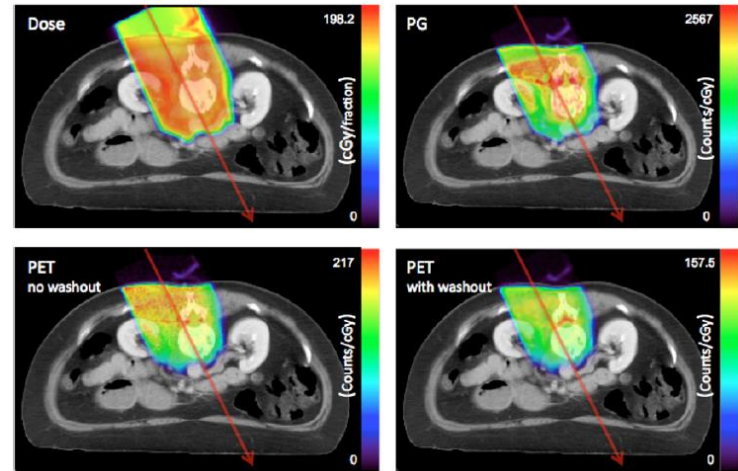
□ Production of PET isotopes in patient:

- $^{11}\text{C}$  ( $T_{1/2} = 20.39$  min)
- $^{15}\text{O}$  ( $T_{1/2} = 2.03$  min)
- $^{13}\text{N}$  ( $T_{1/2} = 9.97$  min)
- $^{30}\text{P}$  ( $T_{1/2} = 2.50$  min)
- $^{38}\text{K}$  ( $T_{1/2} = 7.63$  min)

□ These PET isotopes will decay into 511 keV  $\gamma$  rays some time after treatment

→ Evaluation of total doses delivered to surrounding organs and evaluation of the risk of secondary cancers induced by those doses.

→ Simulation of the external dose rates produced by the patient after treatment.





# Thank You



**Frédéric Stichelbaut, Ph.D.**



**Domain Expert, IBA Fellow**



**Frederic.Stichelbaut@iba-group.com**



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