

# Why protons? Or why protons **now**?

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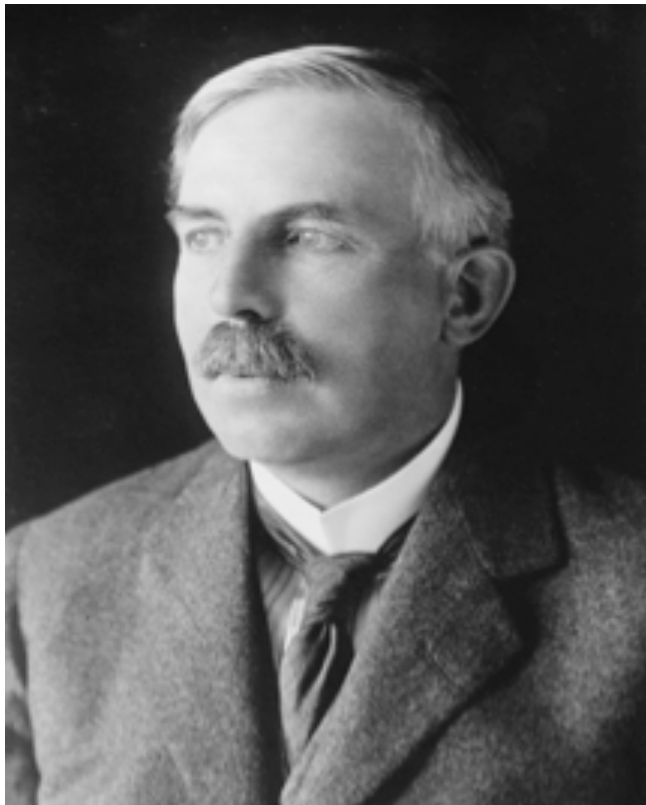
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- **Physical reasons**
- **Medical reasons – or more and more indications**
- **Technical reasons**
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- **Conclusion**

# INTRODUCTION

# **A formerly modern technic**

- **E. Rutherford discovered protons in 1919 (Nobel Prize)**
- **R. Wilson developed the medical guidance in 1946**





# Centres on going and in project



| ☐          | En cours ☐ | Construction ☐ | Projet ☐ | Total ☐ |
|------------|------------|----------------|----------|---------|
| Amérique ☐ | 21 ☐       | 13 ☐           | 3 ☐      | 37 ☐    |
| Asie ☐     | 13 ☐       | 8 ☐            | 5 ☐      | 26 ☐    |
| Europe ☐   | 17 ☐       | 8 ☐            | 8 ☐      | 33 ☐    |
| Afrique ☐  | 1 ☐        | 1 ☐            | 0 ☐      | 2 ☐     |
| Océanie ☐  | 0 ☐        | 0 ☐            | 0 ☐      | 0 ☐     |
| Total ☐    | 52 ☐       | 30 ☐           | 16 ☐     | 98 ☐    |

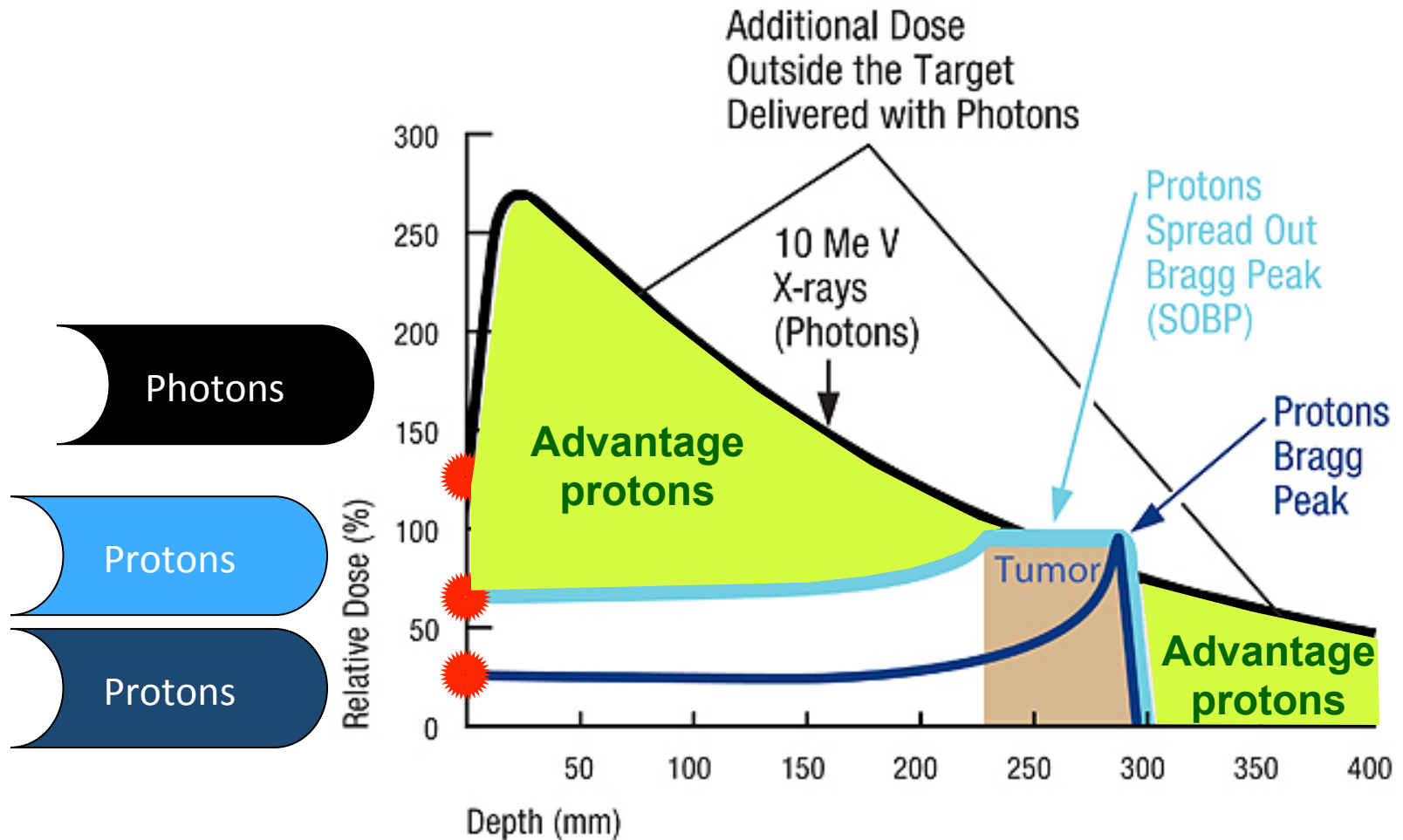
# **Current protontherapy development**

- **Protontherapy develops ineluctably**
  - **Radiation oncologist have always had interest in the new technologies if they are less invasive**
  - **Patients plead to obtain less deleterious treatments**
- **Cure and to be healed are not enough: it is time to add quality of life to quantity of life**

**PHYSICAL REASONS**

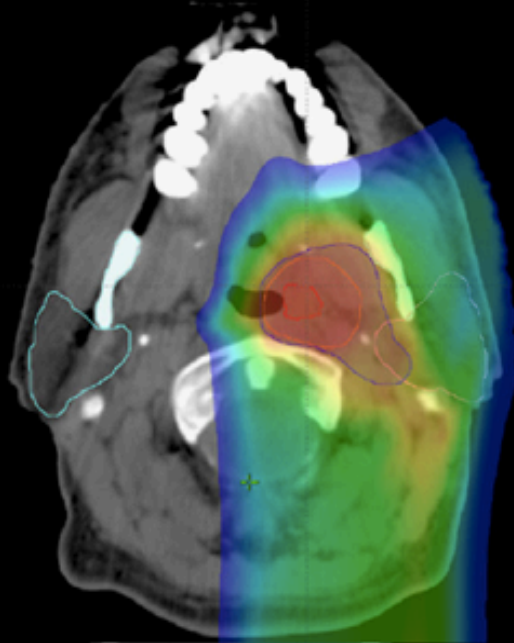
# Protons versus photons

## Superior beam properties

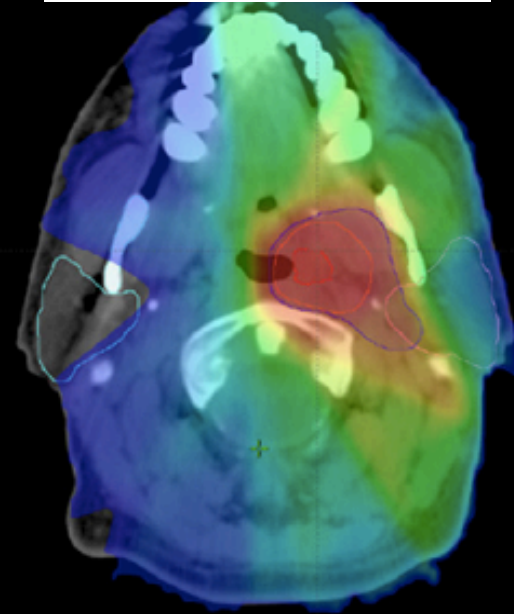


## Protontherapy

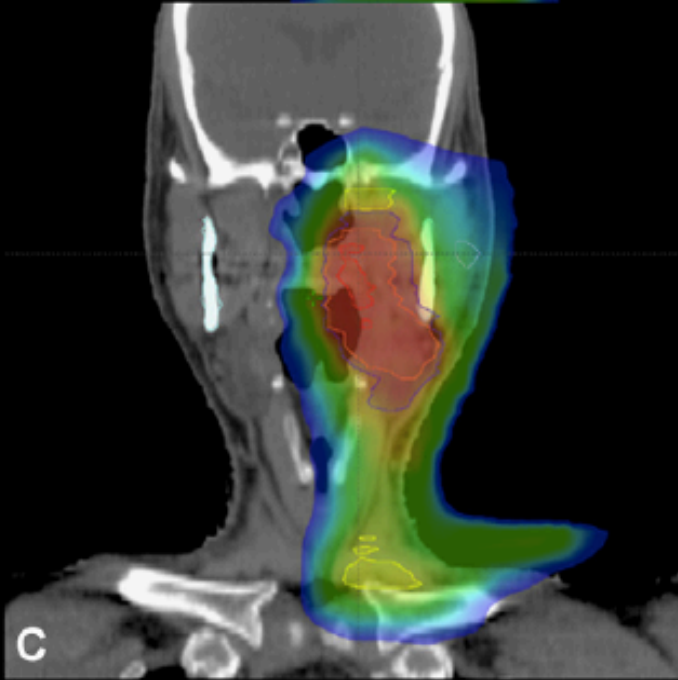
## Intensity Modulated Radiation Therapy



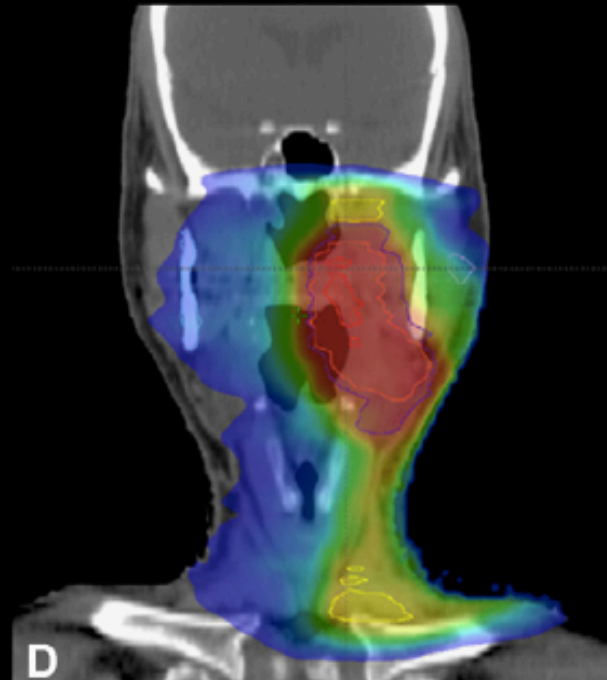
A



B



C



D

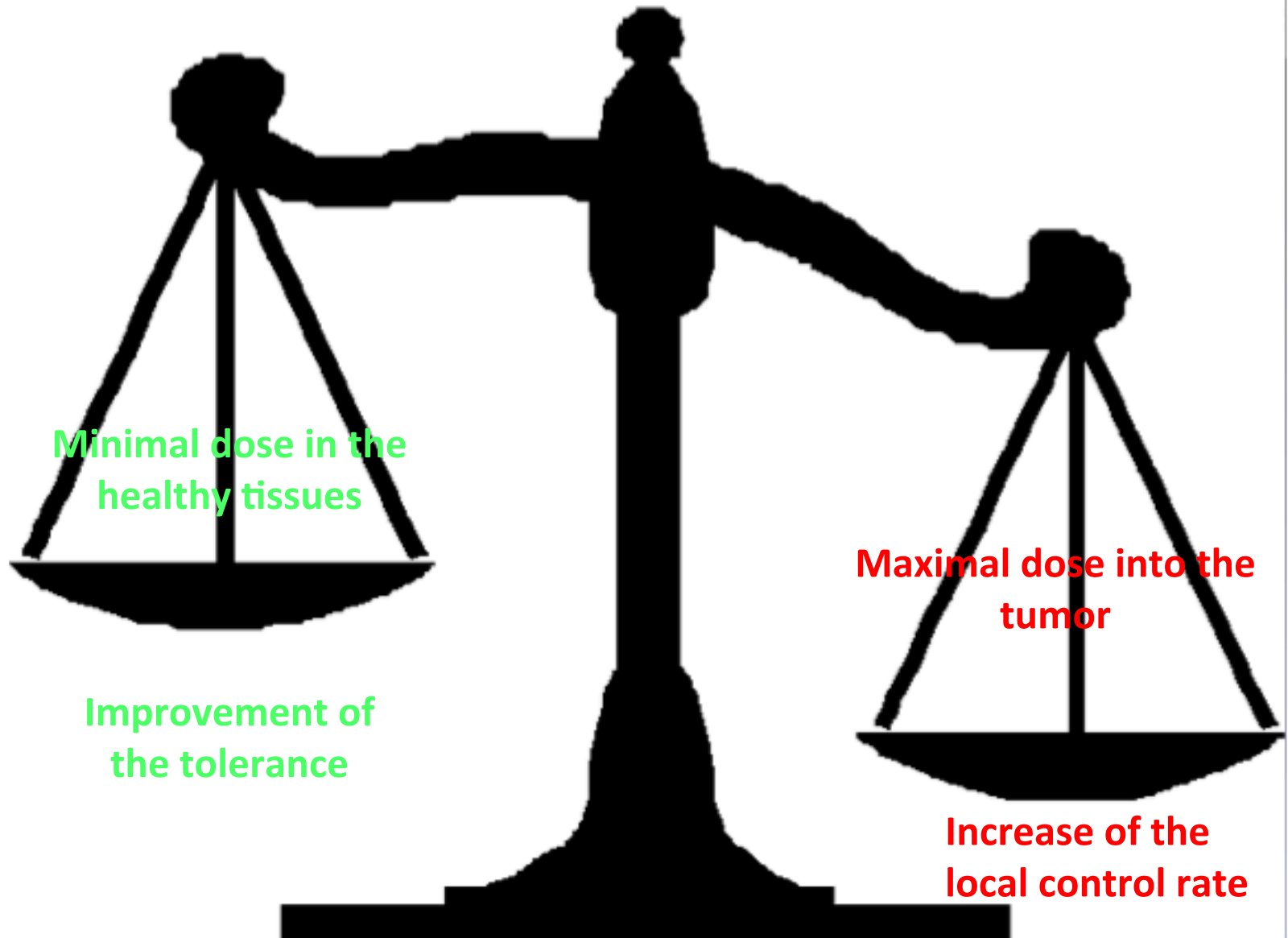
# Consequences

- **Decrease dose deposits in the surrounding tissues of the tumor**
  - **Increase tolerance of the tissues to irradiation**
  - **Decrease acute side-effects: dermatitis, mucositis...**
  - **Decrease the late side-effects: vascular, fibrosis...**
  - **Decrease the DNA breaks which, can lead to secondary tumors or radiation-induced cancers**

# Consequences

- **Keep equivalent dose deposits in the surrounding tissues of the tumor (compared to photons)**
  - **Allows the increase the dose into the tumor or into the cancer**
  - **Increase the local control of the tumor to expect an improvement of the survival**

# Balance of the therapeutic ratio



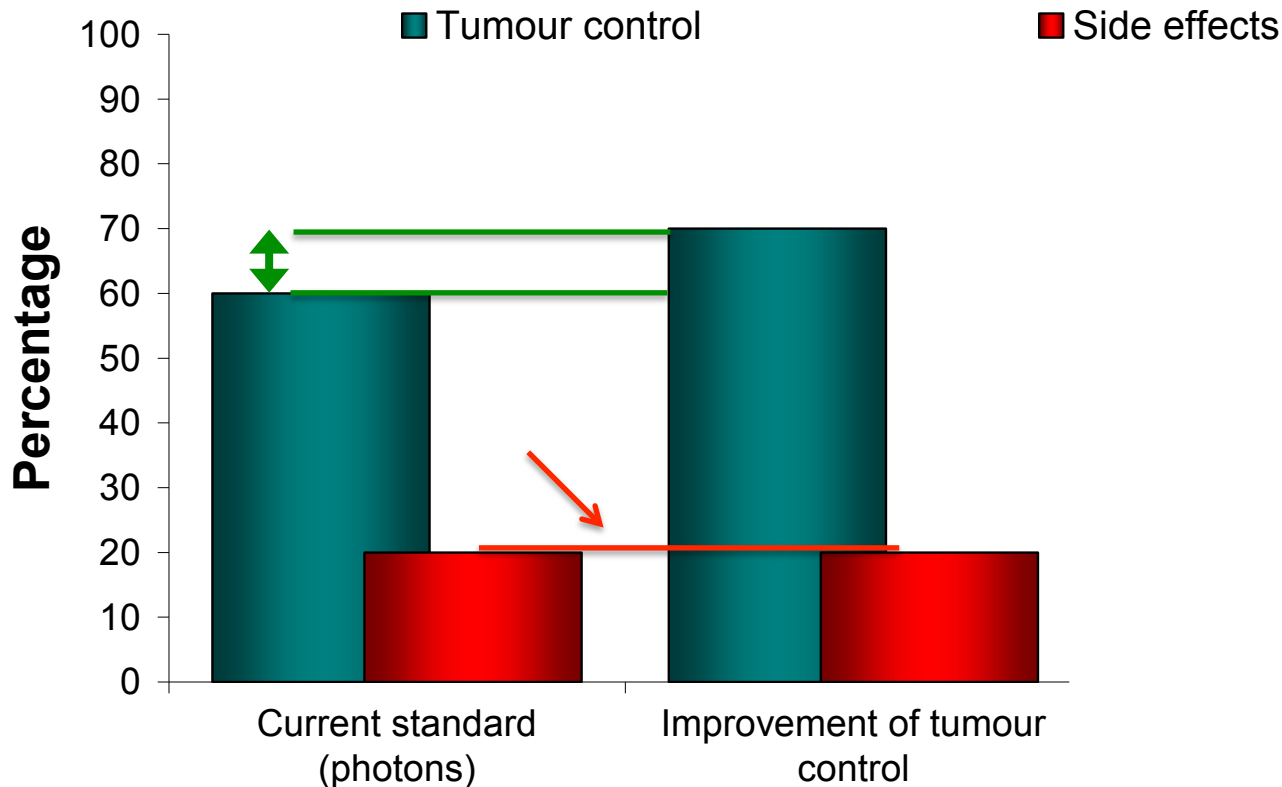


**MEDICAL REASONS – OR MORE AND  
MORE INDICATIONS**

# Superior beam properties

How to translate into clinical benefits?

- Side effects are acceptable but further increase is not acceptable
- Dose escalation is expected to improve local tumour control



Clinical cases :

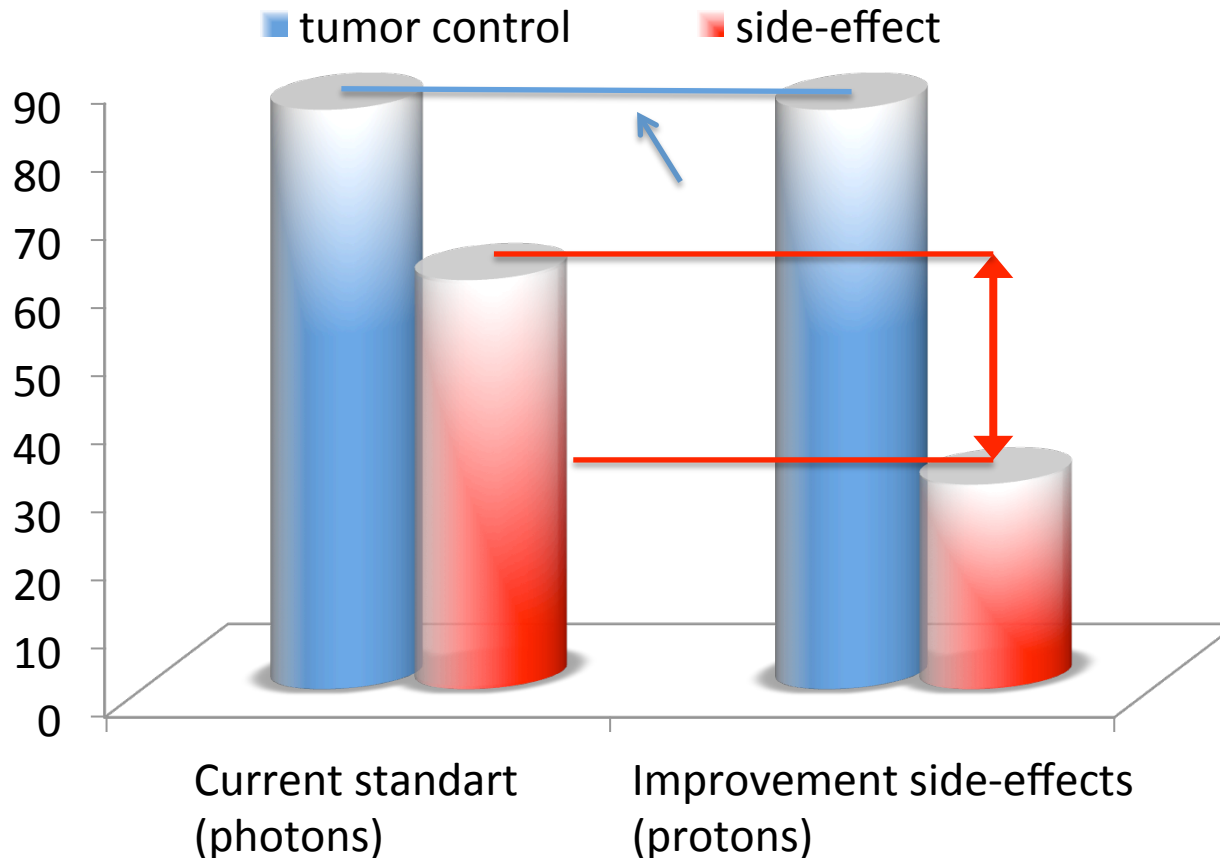
Chordoma  
Melanoma

Lung cancer  
Pancreas

# Superior beam properties

How to translate into clinical benefits?

Side effects are not acceptable and decreasing is expected  
Local control is acceptable and is not degraded with new treatment



Clinical cases :

Pediatric tumor

Hodgkin disease

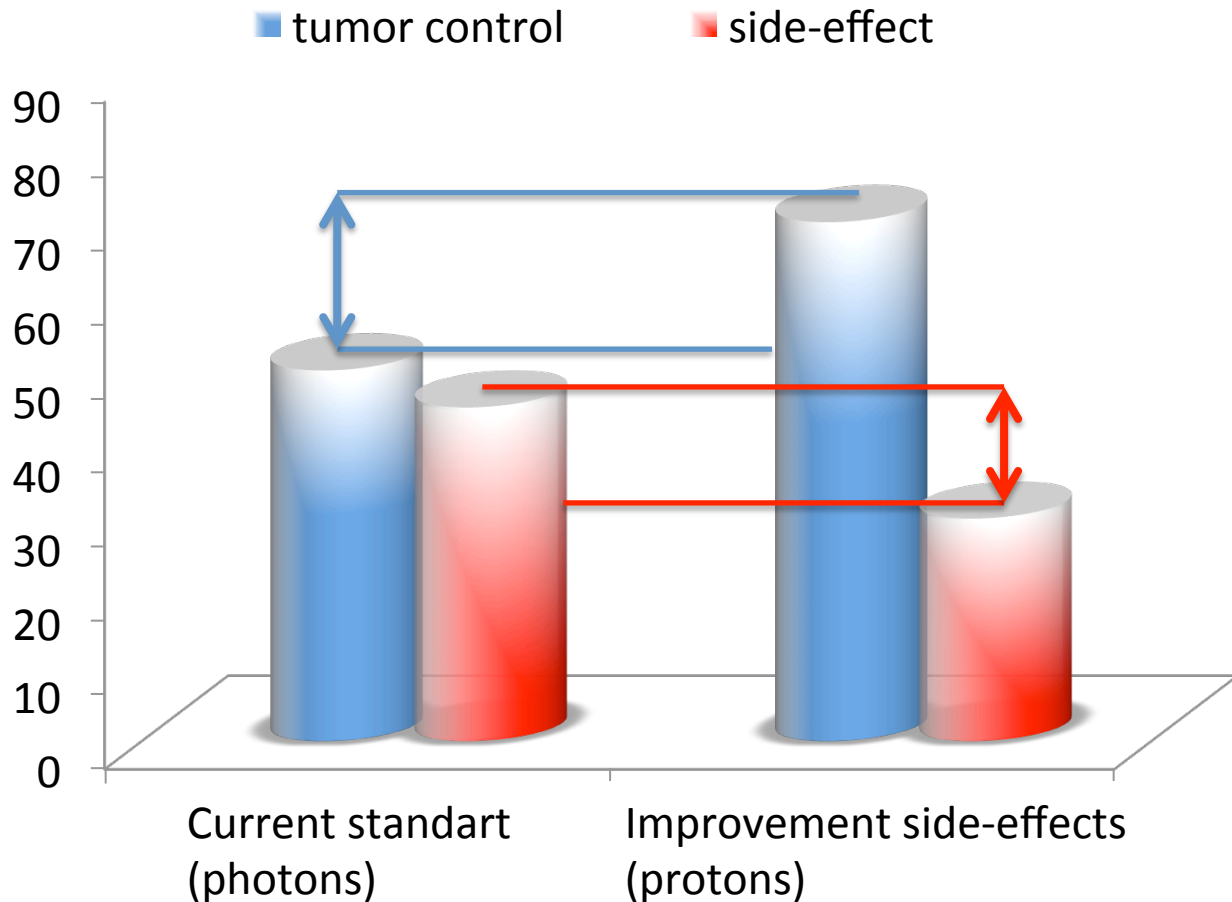
Prostate cancer

Breast cancer

# Superior beam properties

How to translate into clinical benefits?

Side effects are not acceptable and decreasing is expected  
Dose escalation is expected to improve local tumour control



Clinical cases :

Brain tumor

Sarcomas

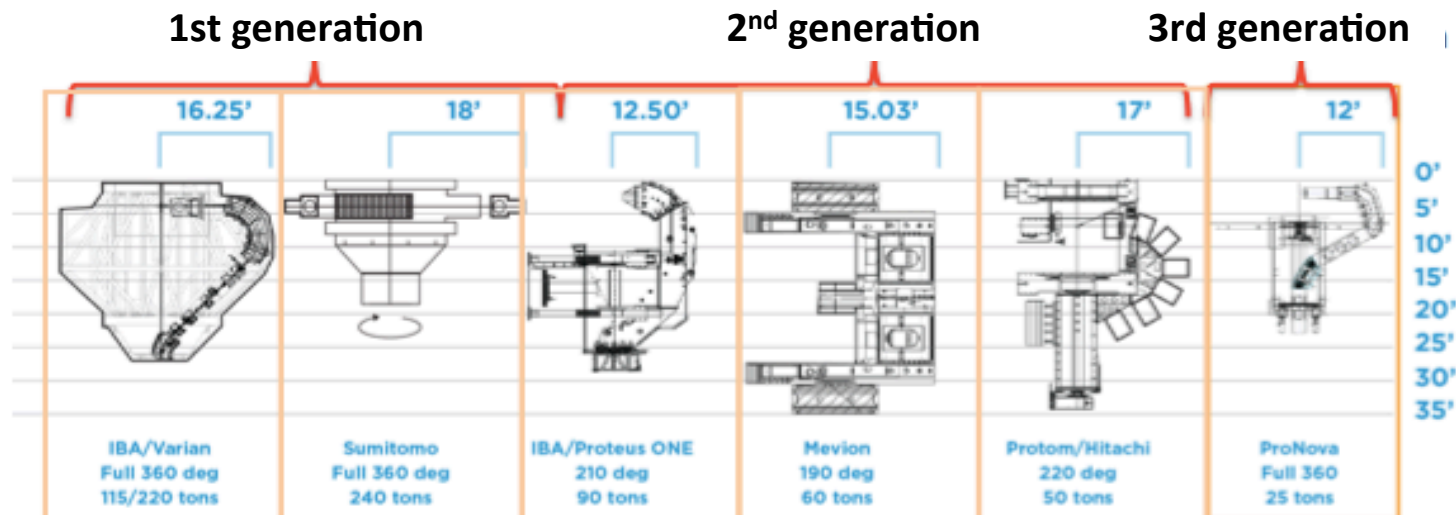
Head and Neck relapse

# Clinical

- **None patient cannot benefit of proton treatment**
  - What is our goal ?
  - What are we expecting ? (everybody and not only physicians)
  - What are our limits of acceptation of the new technology?

**TECHNICAL REASONS**

# Area to install the accelerator



| Kind of gantry         | 360°                        | 360°      | Partiel            | Partiel           | Partiel     | 360°               |
|------------------------|-----------------------------|-----------|--------------------|-------------------|-------------|--------------------|
| accelerator            | Cyclotron                   | Cyclotron | Synchro cyclotron  | Synchro cyclotron | Synchrotron | cyclotron          |
| Total area (m2)        | 1250/<br>902 m <sup>2</sup> | -         | 670 m <sup>2</sup> | 372m <sup>2</sup> | -           | 530 m <sup>2</sup> |
| Heigth of the room (m) | 12/12                       | 12        | 12                 |                   | 12          | 10,3               |
| Depth of wall (m)      | 2,44                        | 2,44      | 2,44               | 2,44              | 2,44        | 1,83               |

# **Improvement of the technic**

- **Decrease of the weight of the machine divided by 8**
- **Room surFace divided by 2.5**
- **Decrease of the room height and depth of wall of 25% and 14% respectively**

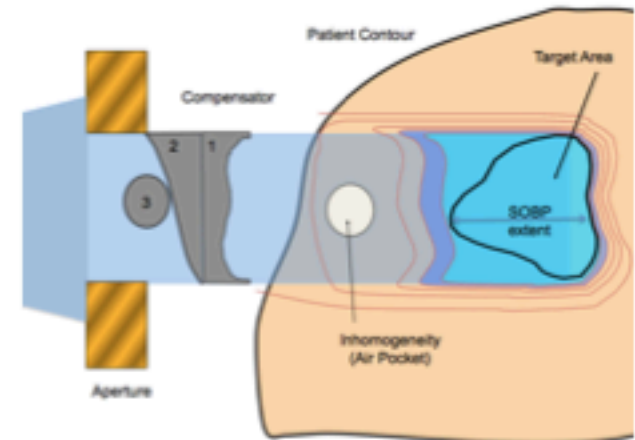
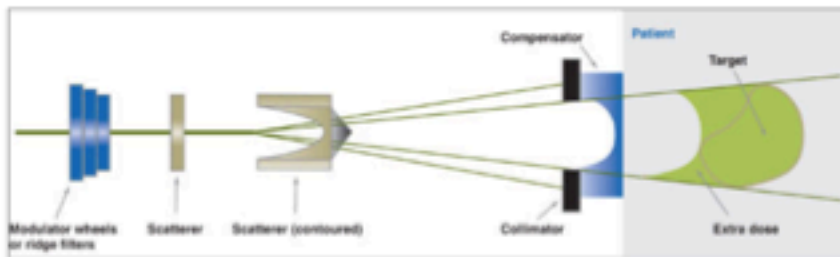


# evolution of the techniques

## From passive scattering to pencil beam

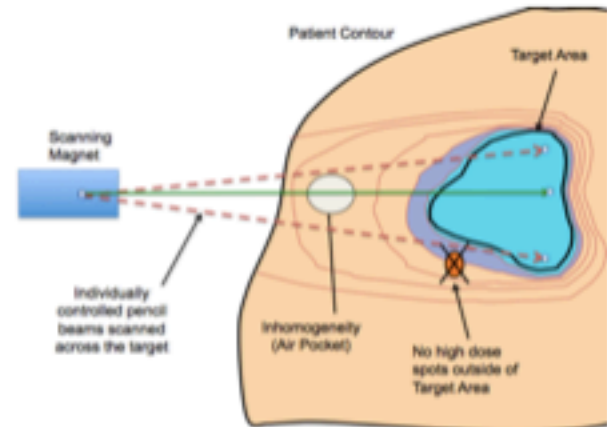
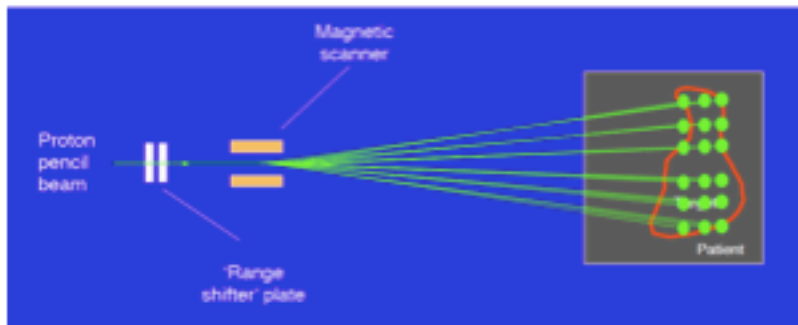
Passive scattering

Numerous components in the nozzle



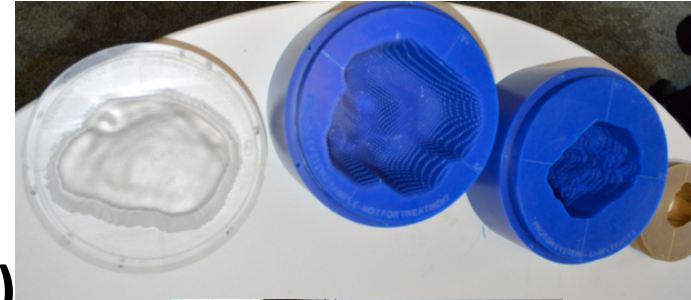
Pencil Beam Scanning

Simplified nozzle

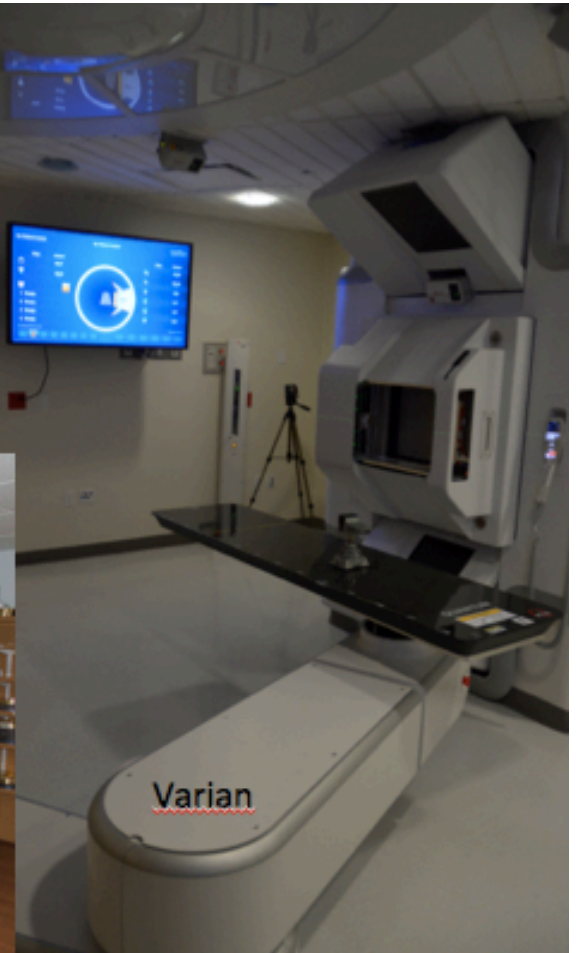
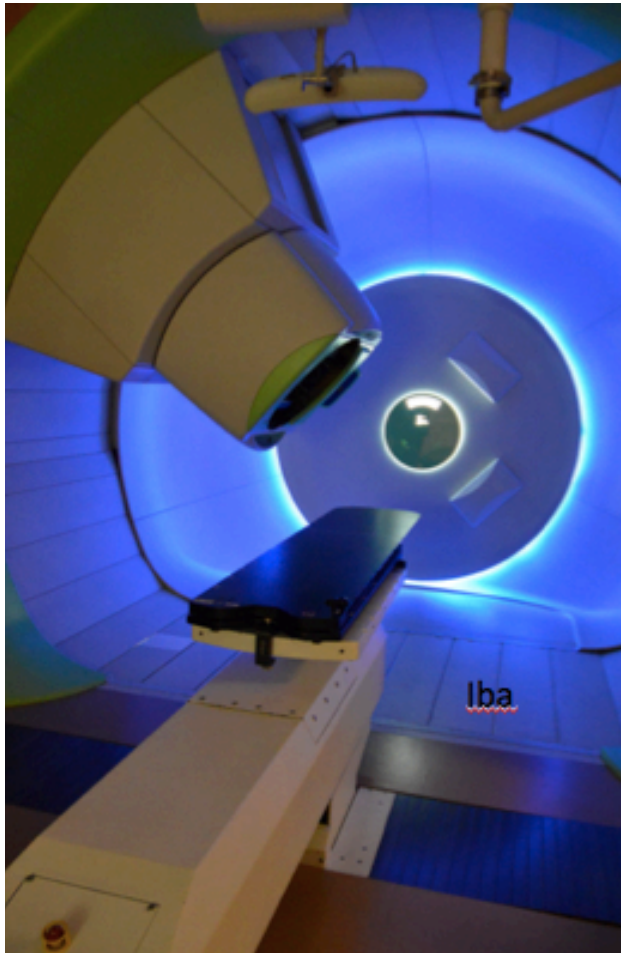


# Change in the delivering of beam

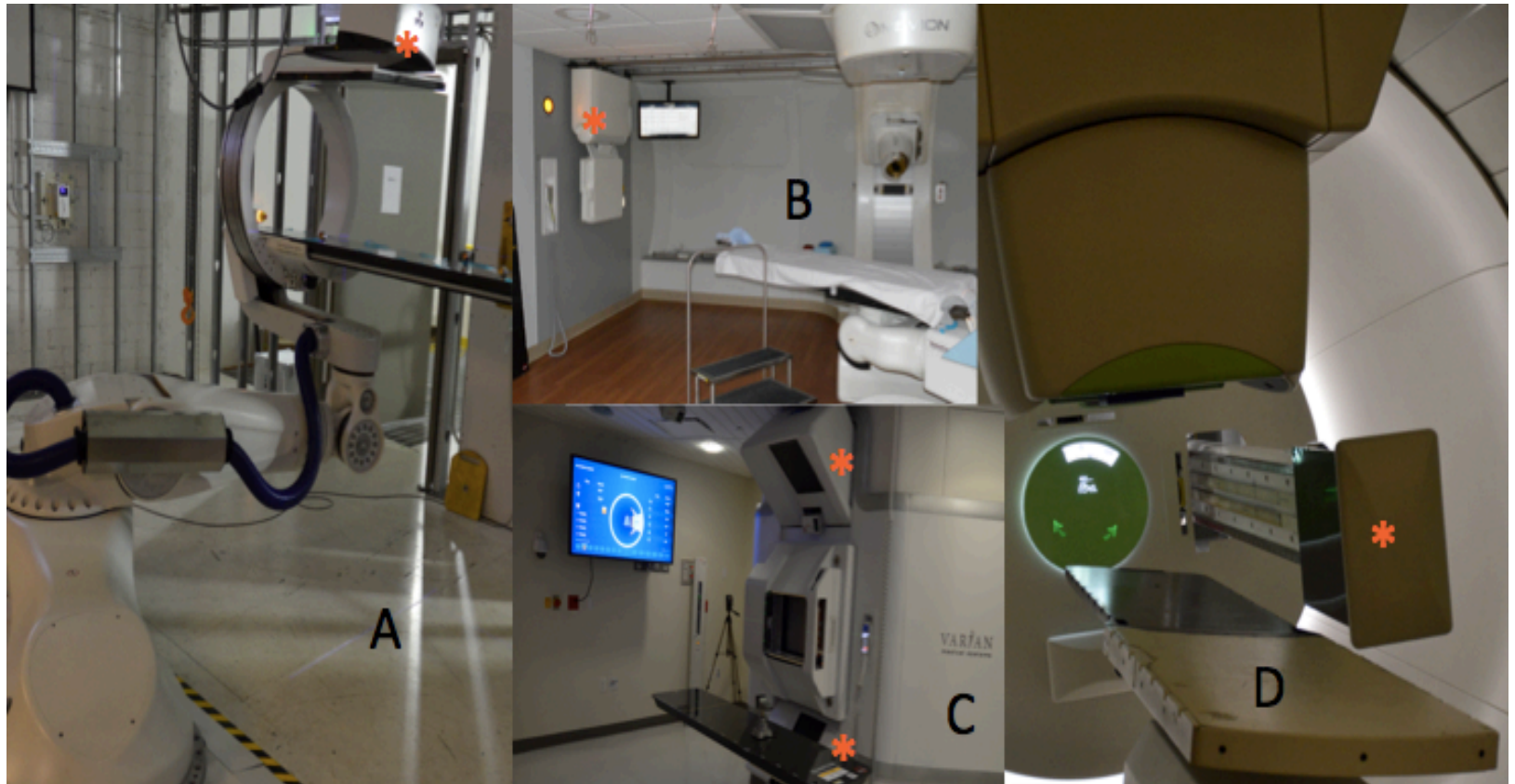
- **Passive scattering**
  - Activated radioactive pieces
    - Compensator (plexiglass or wax)
    - Collimator (brass)
  - Production of neutrons
- **Pencil beam**
  - Simplified nozzle
  - Small beam leading to more conformal field
  - Decrease of neutrons



# 6 degrees of freedom of the couch with robot



# Development of on board imaging



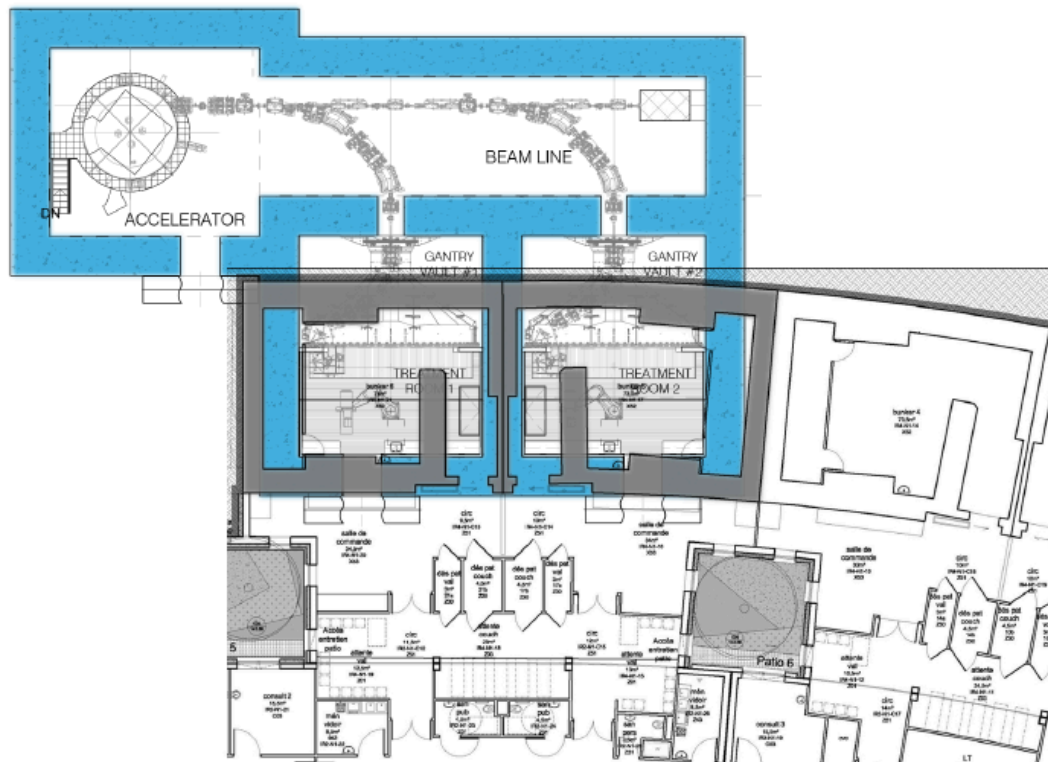
- A:** Provision ring imager (\*), moving the table in the ring, helicoidal images;
- B:** Mevion 2D imager (face profile), RX sensor (\*) for the lateral fields, on rails displaceable;
- C:** Varian imaging with two 45 ° sensors (\*), for fixed beam room;
- D:** 2D imager of Iba, retractable (\*) and obtaining a scanner image by rotation of the isocentric arm



# Protons « photon-like »

Integration of the room in a previously in place building

Proton room as ergonomic as a photon room



**COST REASONS**

# Variable costs

- **Decrease of the machine cost**
  - From 50 to 25 M€
- **Decrease of the bunker cost**
- **Decrease of total treatment cost**
  - Amortization
  - hypofractionation

# **Decrease of the human resources**

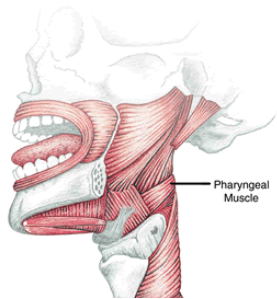
- **No more physicist than for photon**
- **No more technician**
- **No more engineer for the machine**
- **Physician can treat with photons and protons**



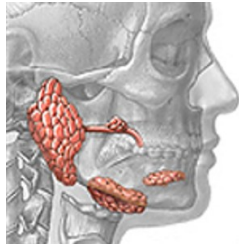
# Cost of treatment

- Today classical treatment in photons
  - 2 Gy per fraction to limit the risk of late side-effects
  - Decreasing the number of fraction for the same tumor efficiency lead to
    - Increase the dose per fraction
    - The risk of late complication
- With protons, **for the same tumoral effect** and less side-effects, **we can use less fractions** with higher dose per fraction
- In France , as a treatment cost depend on the number of fractions, the decreasing of the number of fractions leads to an inferior total treatment cost

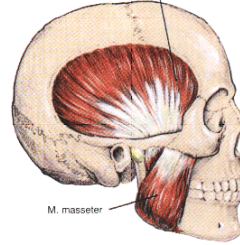
# Decrease of the complication cost ex. H&N tumor



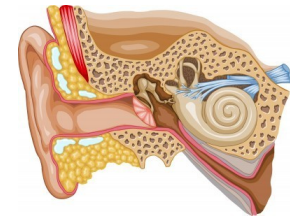
**Swallowing dysfunction**



**Salivary dysfunction**



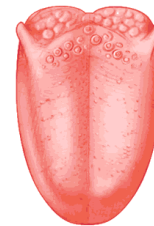
**Trismus**



**Hearing loss**

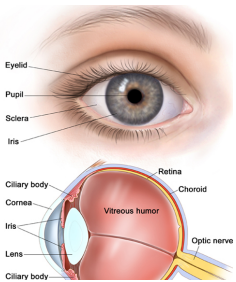


**Hypothyroidism**



**Taste loss**

**TOTAL  
COST  
FUNCTION**



**Visual impairment**

**In France : cost of complications is not known**

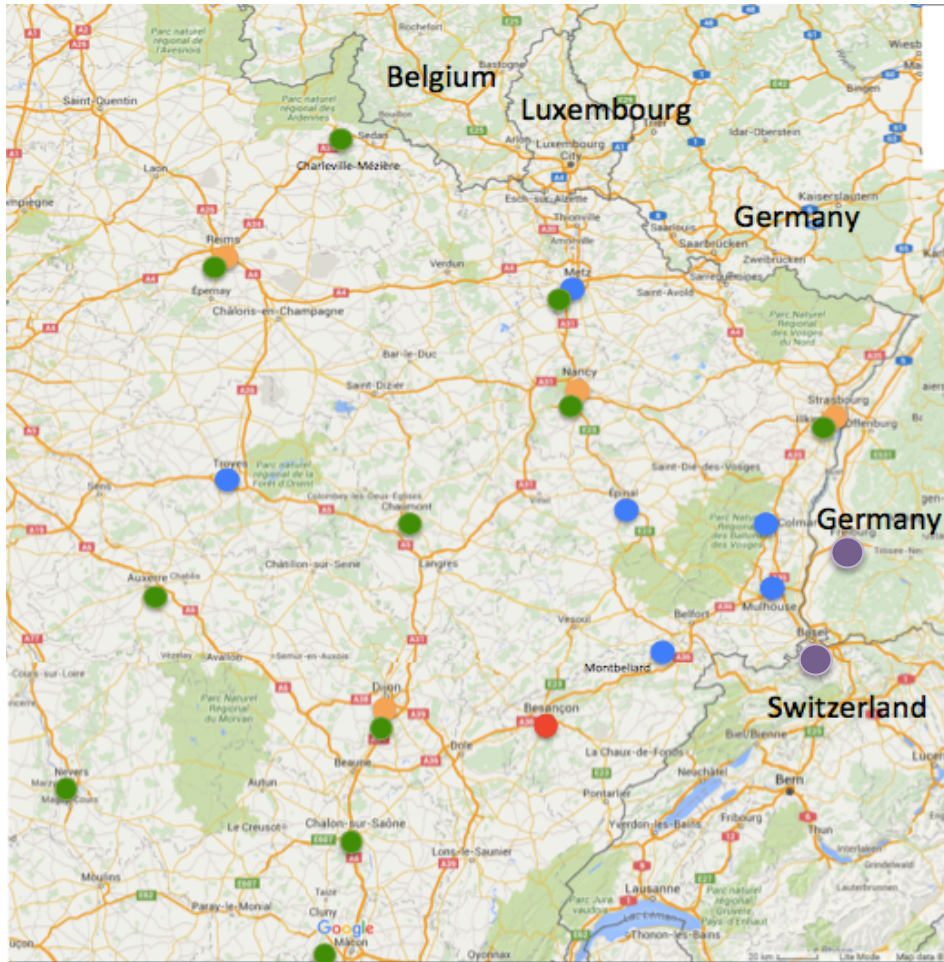
**REGIONAL REASON**

# Population of four potential regions

| Regions                        | Number of inhabitants | % of the French population |
|--------------------------------|-----------------------|----------------------------|
| Bourgogne                      | 1 644 000             | 2.49                       |
| Franche Comté                  | 1 179 000             | 1.79                       |
| <b>Bourgogne-Franche-Comté</b> | <b>8 363 000</b>      | <b>12.67</b>               |
| Alsace                         | 1 861 000             | 2.82                       |
| Champagne Ardenne              | 1 333 000             | 2.02                       |
| Lorraine                       | 2 346 000             | 3.55                       |
| <b>Grand Est</b>               | <b>5 540 000</b>      | <b>8.39</b>                |
|                                |                       | % of the German population |
| <b>Bad Wurtemberg</b>          | <b>10 500 000</b>     | <b>12.7</b>                |
|                                |                       | % of the Swiss population  |
| <b>Bale eurodistrict</b>       | <b>430 000</b>        | <b>5.0</b>                 |

# Why to gather the four regions?

- Because the Lorraine, Alsace and Bourgogne work together since a longtime thanks to a political, administrative and research organization: « the canceropole »
- Because Bad Wurtemberg represent a administrative entity and **scientific university relationship** in place

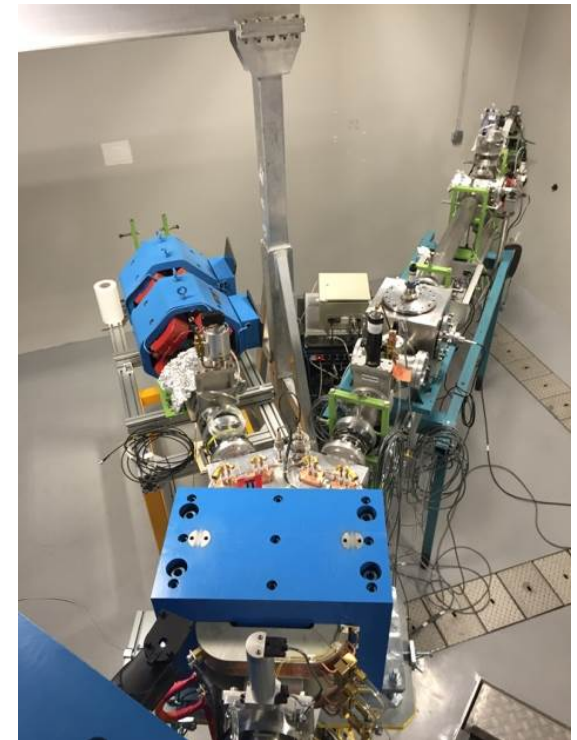






# Main regional reasons

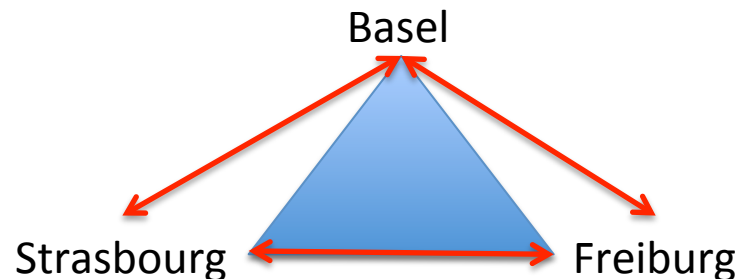
- **Radiobiological reason – translational research**
  - Freiburg – Strasbourg
  - Radiobiological Proton line (CPR)
  - Physic collaboration





# Main regional reasons

- **University educational project**
- **Summer school for radiation education**
  - Every three years Basel / Freiburg / Strasbourg
  - High level lessons
  - Network platform to exchange lessons (e-learning)
  - EUCCOR call (project on going)
- **Resident exchange for 6 months one to one**



# Main regional reasons

- **Retrospective analysis of patient treatments**
  - Comparison
  - Increase the power of analysis
  - Improve publication impact
  - One study on going between Strasbourg and Freiburg and possibly Basel (brain metastasis of melanoma)
- **Prospective studies**
  - Brain tumors
  - Prostate cancer
  - Physic research

# Conclusions

- **Technical, medical, scientific arguments are available to develop now protontherapy**
- **Collaboration between our regions, developed confidence between physicians**
- **This transborder proton center and its organisation is a reachable goal in a near future because we are able to design a real collaboration**
- **We need to discuss with politicians, and that health-care institutions promote a new original approach of development of radiation technic**



**Whatever the means, we know  
that a border is crossing**





**A dream you dream alone is only a dream**



**A dream you dream together is reality**



J. Lennon