

Accelerators for Medical Applications:

What is so special?

Marco Schippers

PAUL SCHERRER INSTITUT



Univ. Med. Center Groningen



Many **commercial** systems: **Optimized** for their purpose →

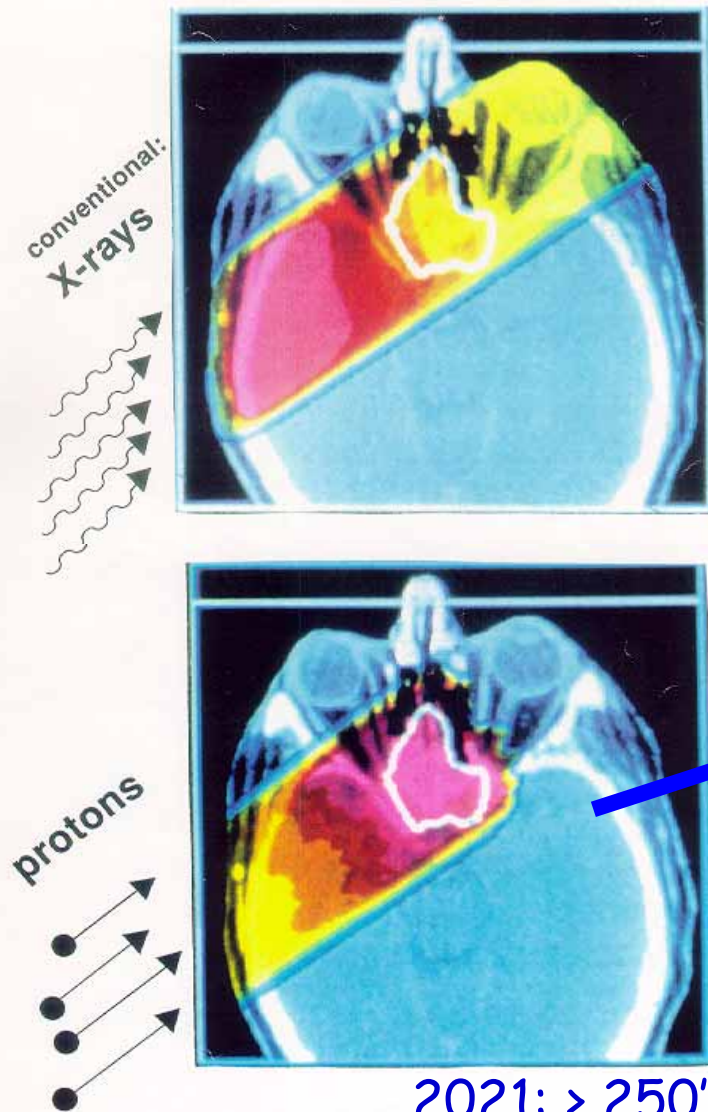
→ **minimum effort** to set system

→ **changes** difficult / impossible

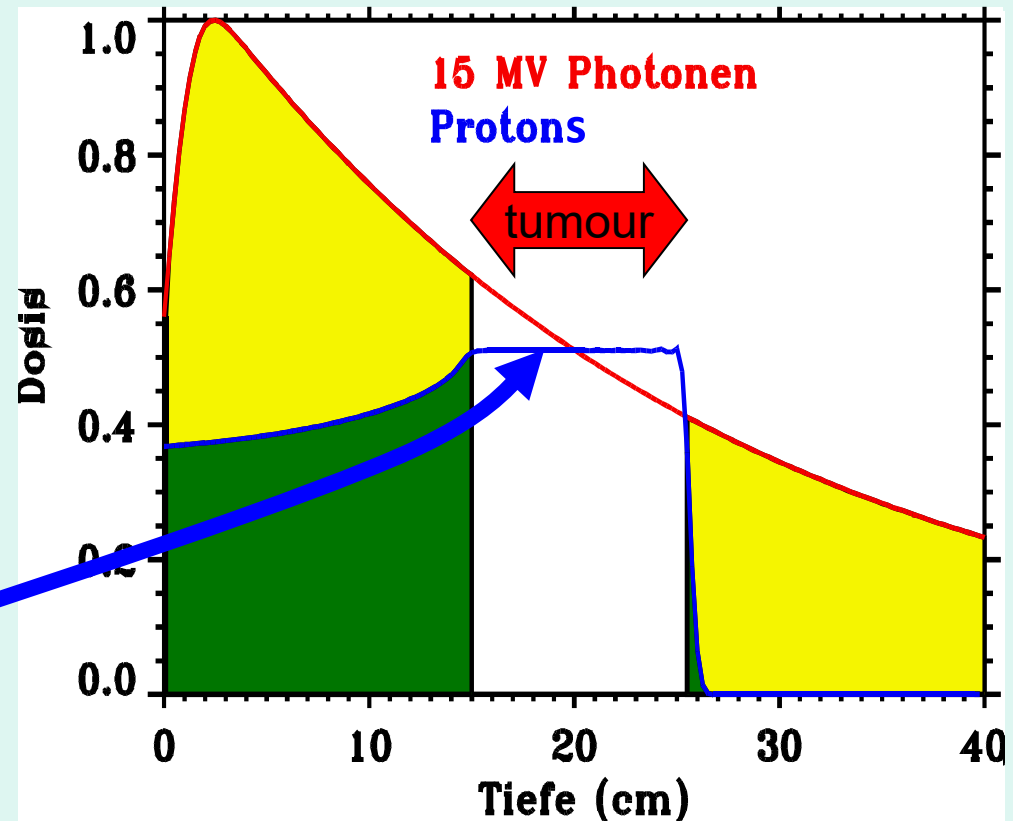
Application discussed here: **Proton Therapy**

Contents:

- Why proton therapy
- Facility
- Operational aspects
- Safety



Depth-dose curve:



2021: > 250'000 patients treated with protons or C-ions



cyclotron



synchrotron

Proton therapy facility

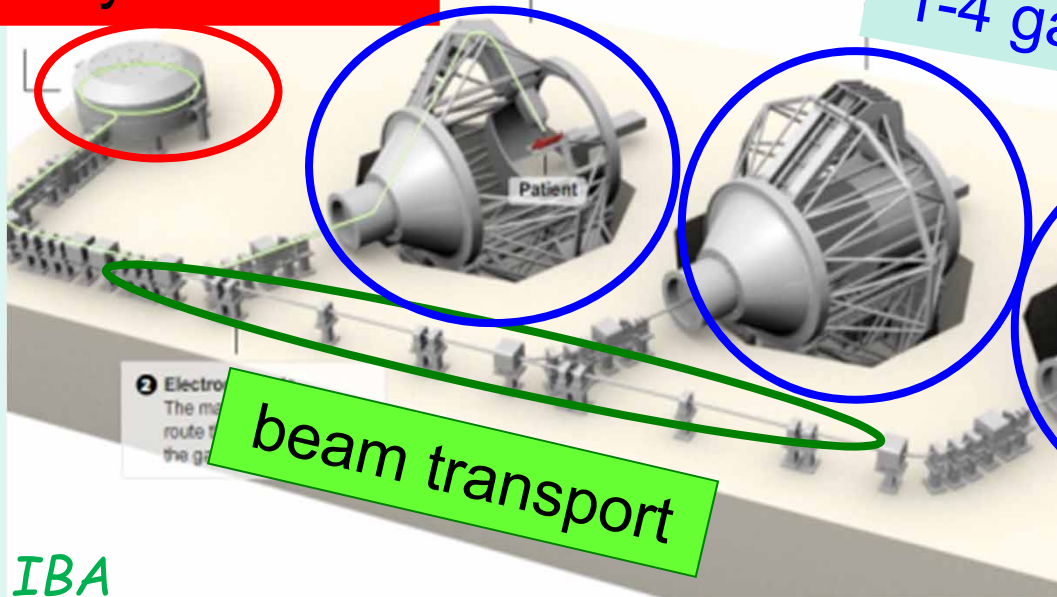
cyclotron
or synchrotron



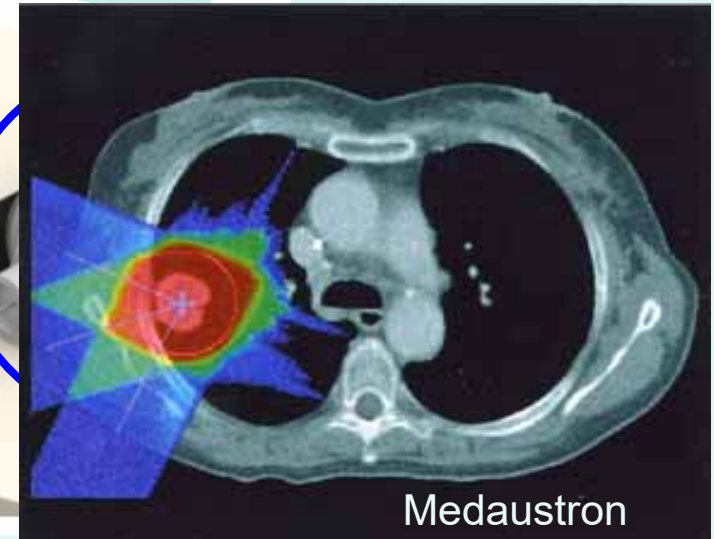
Each of the three gantries
is three-story
weighs 200

1-4 gantries

Gantries aim
proton beams
from different
directions:



IBA



2022: World wide:

>140 p/C working facilities mostly commercially supplied

at patient:

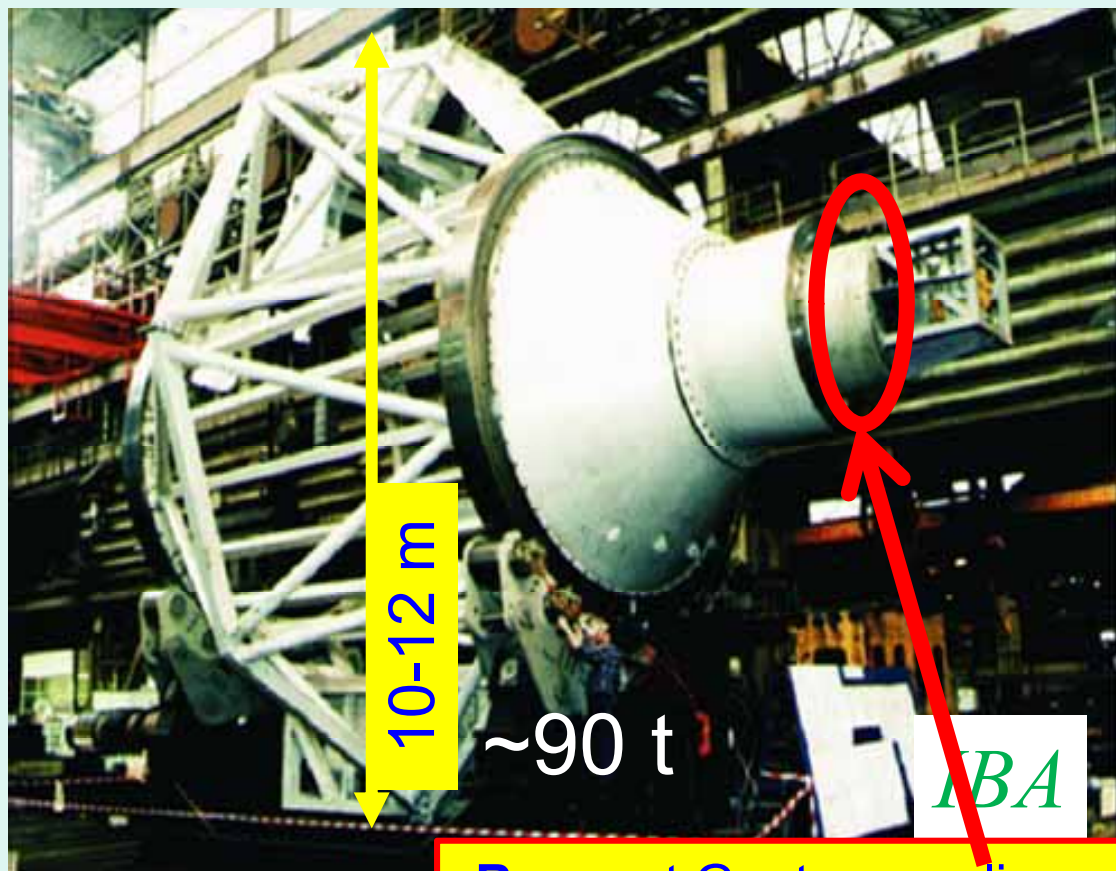
Pencil Beam ($\varnothing$ 5-10 mm)

position, size, intensity, energy



...as seen from patient side

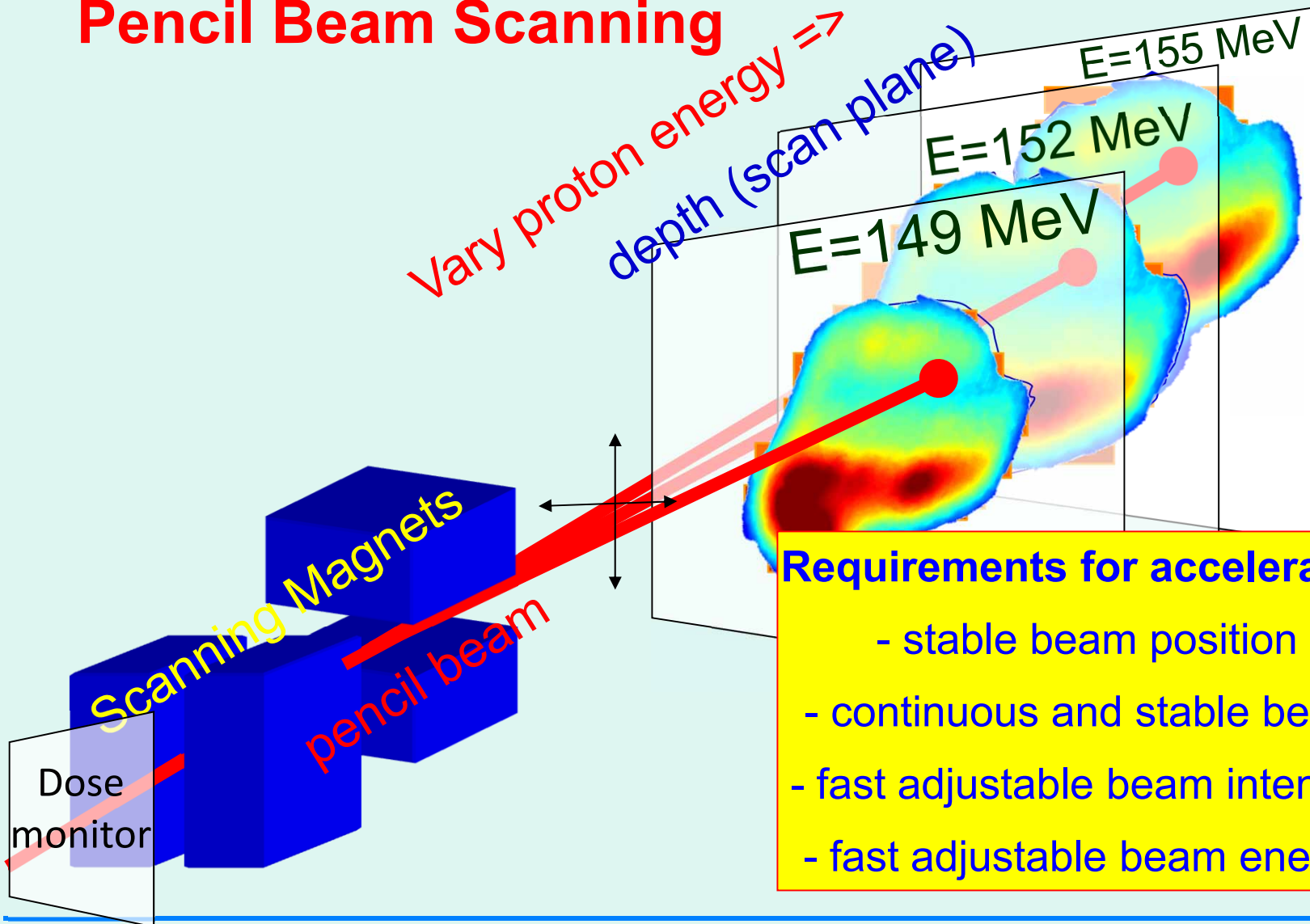
...as seen at machine side



Beam at Gantry coupling:

- Phase space symmetric
- No dispersion

Pencil Beam Scanning

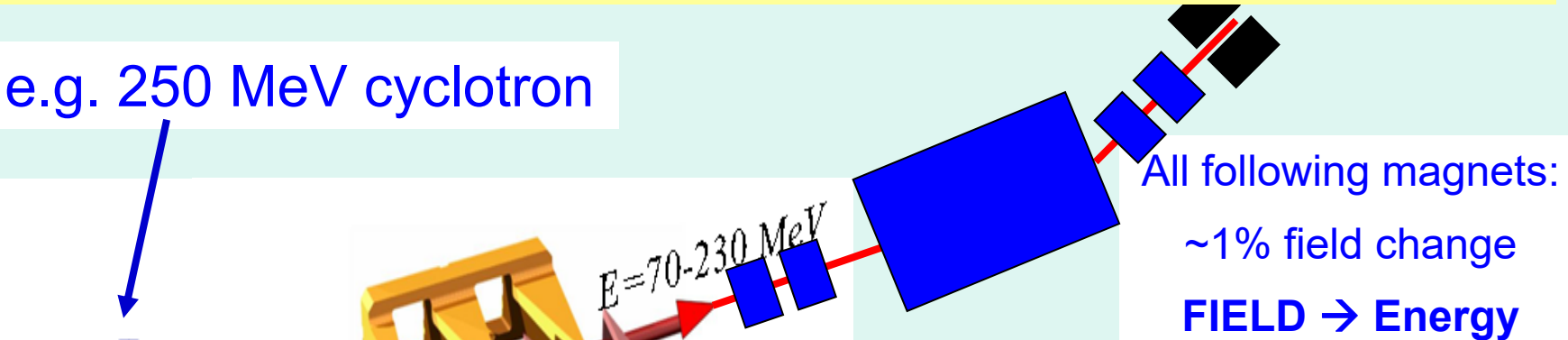


Requirements for accelerator:

- stable beam position
- continuous and stable beam
- fast adjustable beam intensity
- fast adjustable beam energy

Cyclotron has fixed energy => slow down (degrade) to desired energy

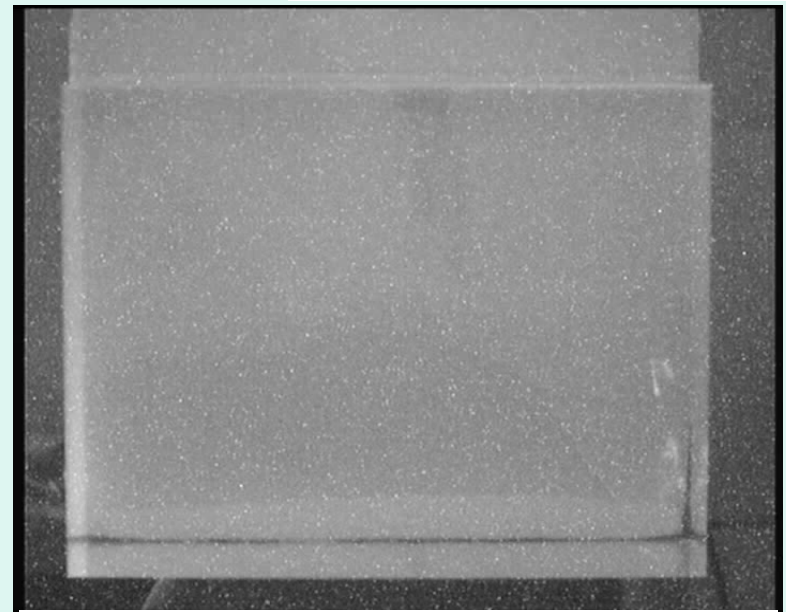
e.g. 250 MeV cyclotron



E-Steps →

$\Delta R \approx 5 \text{ mm in } 100 \text{ ms}$

INSERTION → Energy



PSI Gantry-2: E.Pdroni, D.Meer

- - Typical tumor dose = 70 Gy in daily fractions of 2 Gy
- - 2 Gy dose in tumor of 500 g needs $\sim 10^{11}$ protons
- Beam “on” ~ 1 min. $\rightarrow$ **beam intens. ≈ 0.25 nA**
- **Dose** ($= \text{nr. p} * E_{\text{lost}}$): ABSOLUTE value within **1-2%**
- **Set + check on line:** e.g.: beam **intens.**, **dose** (nr protons), **energy**
 $\rightarrow$ fast, (**abs**) accuracy $\rightarrow$ feed back to Control Sytem
- **Reproducible** and **reliable** operation
- **Devices, operation, QA, service:** limited by **Certifications**
 (e.g. FDA, CE, Med.product.....)

At Psi: **Separate interlock systems:**

More special
for
treatments

Machine interlocks:

all components technically OK

Area access & area dose:

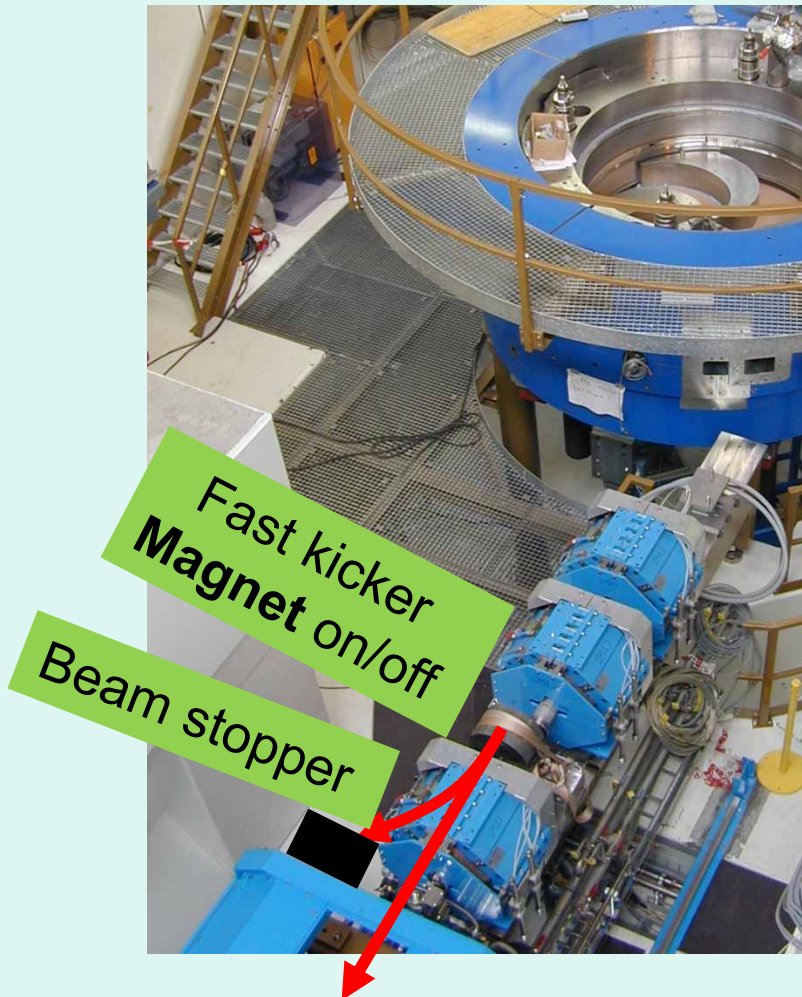
Doors closed, dose rate < $\mu\text{Sv/h}$

Patient safety:

Dose delivery as planned

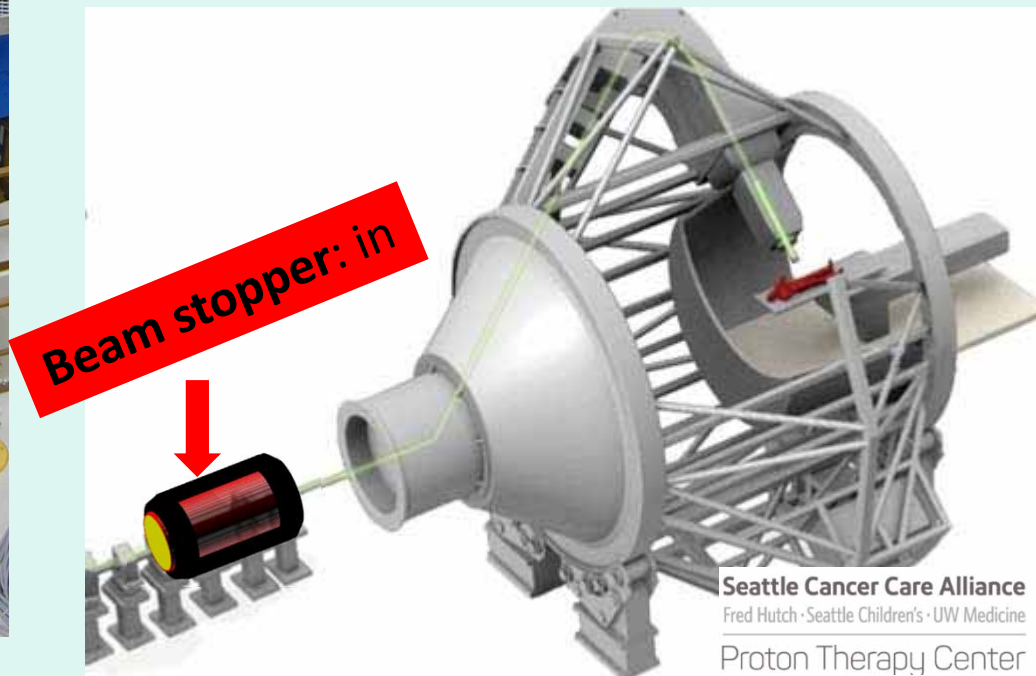
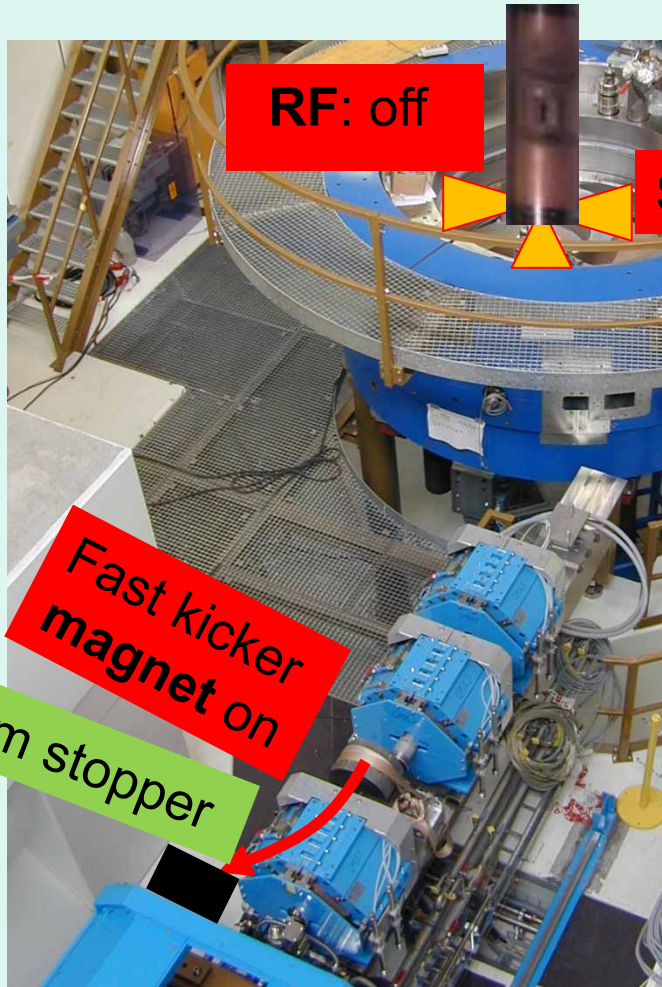
Beam interruption:

- **Normal** in procedure
(e.g. ready or scanning)

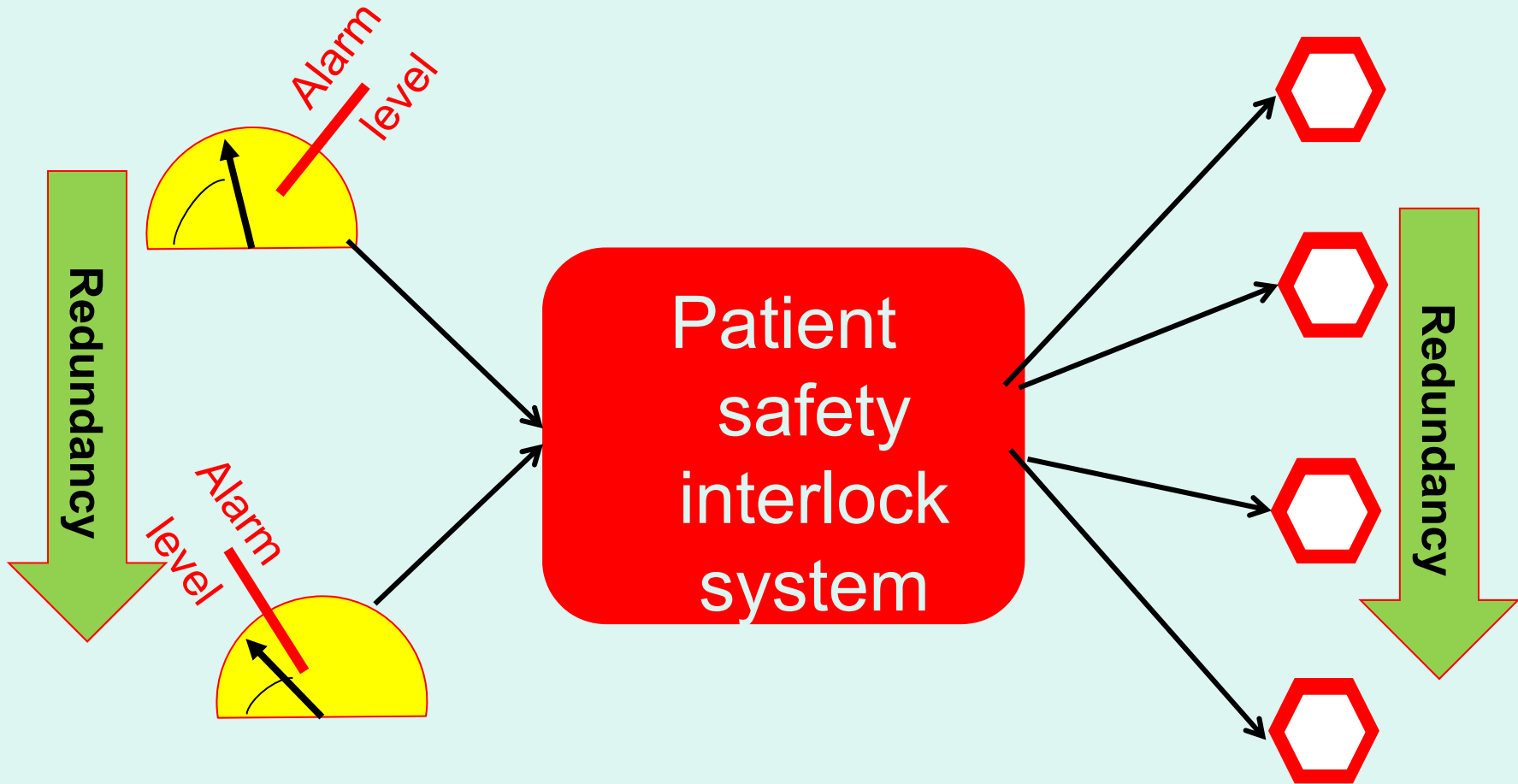


Beam interruption:

- **Normal** in procedure
- **Error** → Interlock



measurement → BEAM off

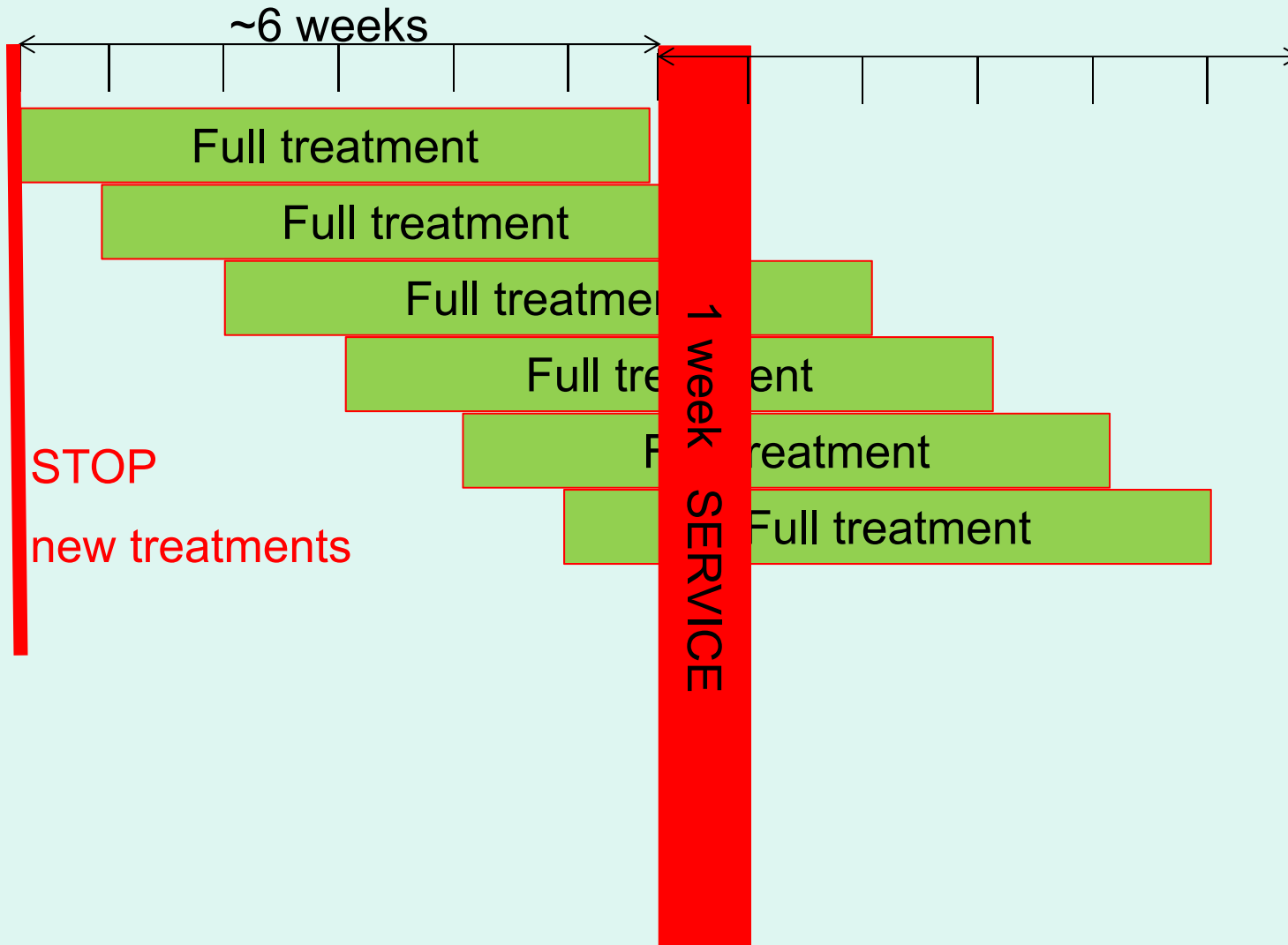


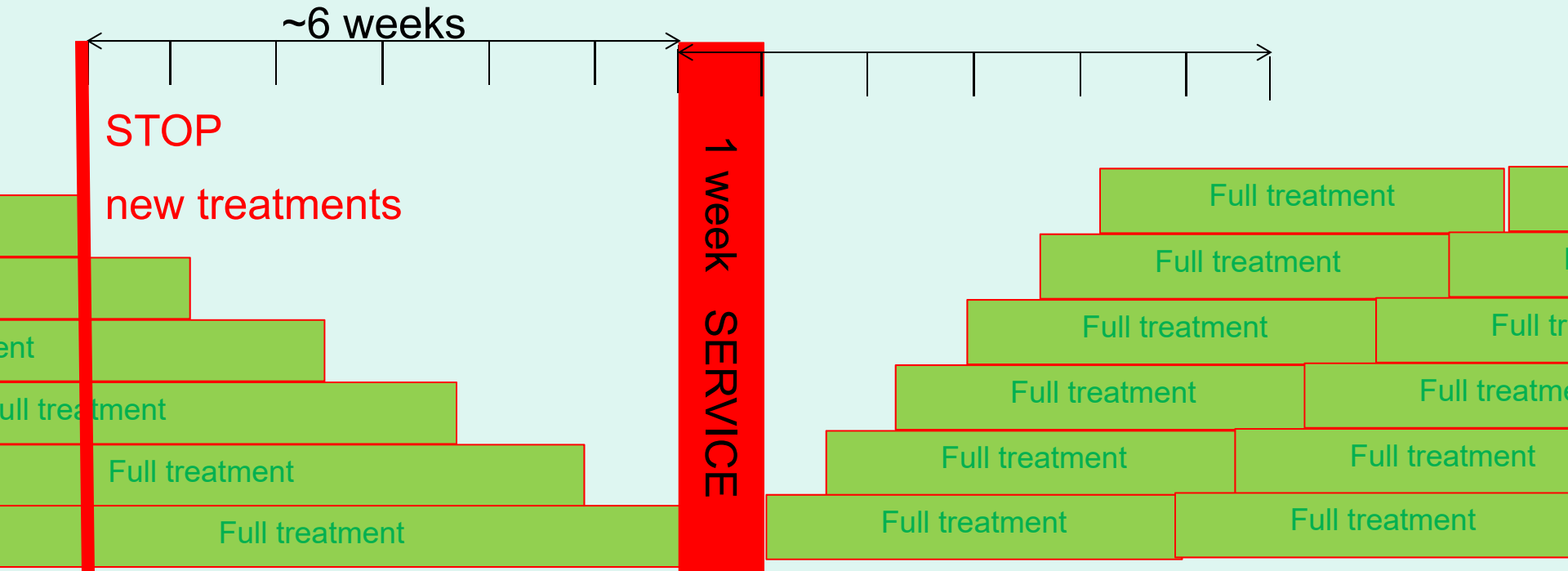


What
happened ?

NO BEAM

Strong need for
ERGONOMIC
display of: **Status**
Instructions





Effectively: 8-10 weeks lost

=> only planned, **short**, well prepared services

Unique Aspects of Accelerators for Medical Applications:

What is **so special**?

- **Technics:** dedicated, but not on the limitbut...
Reliable, Reproducible, Reliable, Reproducible
- **Operation:** by non accelerator experts
strictly according procedures
NO long services
- **Control and **safety**:**
VERY DEDICATED and SPECIAL :
Reliable, redundant, but not too sensitive

first scanning gantry : PSI, 1996

**Thank
you !!**

Gantry: Eros Pedroni

Tumours in kids: Beate Timmermann, Gudrun Goitein