

Progress in the Application of Hadron Therapy (protons or ions)

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The boost in particle therapy



Particle therapy group: until 2015 > 150.000 patients treated www.ptcog.ch



Contents

- Introduction: particle therapy
- Accelerators
 - Synchrotron
 - Cyclotron
- Treatment facilities
- What is so special?



X-ray dose

X-ray beams (IMRT) from 7 directions



Dose profile of protons





X-rays vs. Protons

X-ray beams (IMRT) from 7 directions

Proton beams from 3 directions



pictures: Medaustron

Biological effect of Carbon ions



RBE>1: Less dose for same cell killing

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electron track (or energy) density at nm scale effects RBE (this means: RBE≠ 1)

Pencil beam scanning





Present accelerator choice

e.g: Boston Florida Seoul Wanjie PSI München Orsay





Houston

Tsukuba

	cyclotron	synchrotron
Protons	in use, Ø3.5-5 m	in use, Ø8-10 m
Carbon ions	in design, Ø6 m	in use, Ø25 m



Synchrotron

Protons only:

(Ø ~8 m)

synchrotron

Proton source + injector



Extracted beam









230 MeV (IBA, SHI,1996) iam. 5 m, 200 tons



250 MeV (ACCEL/Varian,2005) SC coils: diam 3.5 m, 100 tons

250 MeV cyclotron

E=250 Me

E-adjustment with cyclotron

At PSI: Graphite degrader 238-70 MeV All following magnets: 1% field change in 50-80 ms

E=70-230 MeV



Small cyclotron





8-10 T 250 MeV Synchro-cyclotron on a gantry





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Accelerator status (protons)



Time until useable ——





Gantries



PSI Gantry-2: fast 3D scanning



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Gantry for carbon-therapy



NEW: SC gantries





Pronova, Knoxville, USA



- Degrader mounted on the gantry
- Momentum acceptance of approx. ± 12.5 %
 - Treatment of the small tumors without change of the SC magnet field

$\begin{array}{c} \begin{array}{c} \text{PAUL SCHERRER INSTITUT} \\ \hline \end{array} \\ \begin{array}{c} \text{Acc.Lab} \leftrightarrow \text{Hospital} \\ \hline \end{array} \\ \hline \end{array} \\ \hline \end{array} \\ \hline \end{array} \\ \begin{array}{c} \text{What is so special?} \\ \hline \end{array} \\ \hline \end{array} \\ \hline \end{array}$





Operators

Technicians Experienced workshops More improvised actions Radiologist operates CE/FDA-certification: PROCEDURES Local technicians:only small repairs Service by equipment company



Safety ↔ Availability

Separate interlock systems e.g. :

Machine interlocks:

all components technically OK

Area access & area dose:

Doors closed, dose rate < µSv/h

Patient safety:

Dose delivery as planned



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Redundancy







What is so special?

• **Technics**: dedicated, but not on the limit of technologybut...

Reliable, Reproducible, Reliable, Reproducible

• **Operation**: by non-accelerator experts

strictly according procedures

Control and safety:

VERY DEDICATED and **SPECIAL** :

Reliable & Redundant, but not too sensitive



SUMMARY

- Dose:
 - finite range
 - maximum dose at end of track
- Apply the dose by Pencil Beam Scanning
- Accelerators for Medical Application:
 - Cyclotron
 - Synchrotron
- Medical applications: VERY Special Operation
- Facilities: Gantry aims the beam from all directions
- Recent development: SC magnets





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