The Status of Ion Beam Therapy

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Early Years - US

- Bevalac
  - 1975 – 1993
  - 1200 patients (majority with neon)
  - Treatment program funding was secure
  - But operating funds for Bevalac itself were discontinued due to startup of RHIC and CEBAF
HIMAC - Japan

• Celebrated 20 years this January
• World leader in carbon ion therapy
• Has moved beyond development
  – 5 carbon ion centers
Other ion therapy sites

• Heidelberg – Germany
• CERN/Enlight
  – CNAO – Italy
  – MedAustron – Austria
  – France
• China
  – Lanzhou
  – Shanghai
22m x 13m
600 tons
Similar size as synchrotron
MedAustron

NCR, P,C, P,C, P only
Issues for ion therapy vs protons

- Charge/mass twice that of protons
  - Doubles magnetic field or radius of magnets
  - Requires switching if doing proton CT with ion therapy
- Desired range requires higher MeV/nucleon
  - 240 MeV – proton
  - 300 MeV/nucleon – ions
- Multiple ion sources
- More complex radiobiology
  - More complex treatment planning
  - Iso-killing power vs isodose
What are the issues for this group?

- Can we make an order of magnitude reduction in size/cost?
- Is it really an accelerator issue?
  - How important is size/cost?
  - Any lessons from Kirby, Beltran, Pankuch?
  - Will it become a control/complexity issue?
Recent US efforts

• DOE/NCI Workshop on Ion Beam Therapy
  – Jan. 2013

• Nov, 2012 – Feb, 2013
  – Multi-Lab working group for a proton/ion center at Walter Reed Hospital
  – 0’th order cost estimate effort spread across 6 national labs
    • FNAL
    • SLAC
    • LBNL
    • BNL
    • JLAB
    • ANL
Recent US efforts

- DOE LAB 14-1142
  - Accelerator Stewardship Topical Areas
    - Particle Therapy Beam Delivery Improvements
      - Lawrence Berkeley National Laboratory, The Paul Scherrer Institute, and Varian Particle Therapy, Inc.
        - develop light weight superconducting magnet technology that will reduce the size and weight of particle beam delivery systems by nearly a factor of 10.
      - Massachusetts Institute of Technology and ProNova Solutions, LLC
        - Develop an innovative design for an ironless superconducting cyclotron

- DOE LAB 16-1438
  - Proposals due this month
• NCI PAR-13-371
  – Planning for a National Center for Particle Beam Radiation Therapy Research (P20)
    • The Center must be planned to operate as a research center adjunct to an independently created and funded, sustainable clinical facility for PBRT.
  – 2 Awards
    • National Particle Therapy Research Center
      – Specifications for research line
      – Monte Carlo Dose Engine
      – Management/infrastructure development
    • NAPTA: Optimizing clinical trial design & delivery of particle therapy for cancer
      – Integration of existing research
      – Range uncertainty/radiobiology
      – Management/infrastructure development
The Center must be planned to operate as a research center adjunct to an ... 

...an independently created and funded, sustainable clinical facility
• **Other interests**
  - **Mayo Clinic**
    - Joint Symposium on Carbon Ion Therapy – May, 2013
  - **Walter Reed National Military Medical Center – 2012/2013**
    - Effort involving 6 national labs to develop cost estimate and white paper for ion therapy center
    - Looked at synchrotron, cyclotron, and cyclinac options
22m x 13m
600 tons
Similar size as synchrotron
Figure 5 The rotating gantry installed at the Heidelberg Ion Therapy Center facility

Superconducting rotating-gantry

Ion kind: $^{12}$C
Irradiation method: 3D Scanning
Beam energy: 430 MeV/n
Maximum range: 30 cm in water
Scan size: $200 \times 200$ mm$^2$
Beam orbit radius: 5.45 m
Length: 13 m

The size and weight are considerably reduced

Weight: order of 300 tons
Conclusion

• Medical applications straddle too many boundaries to get much traction in the US
• The National Cancer Institute does not build hardware
• The Department of Energy does not perform medical research
• As can be seen in the history of proton therapy, the US model leaves late stage development and commercialization to industry
• While there are significant accelerator technology challenges yet to be faced, the larger issue for wide-scale utilization of ion beam therapy will be the economic integration of all the necessary functions – imaging, guidance, control, patient management, immobilization, etc.
So what do we need from an accelerator?

- Conform dose
- Change energy rapidly
- Range of ions ?
- Spot scanning
- Number of beams - gantry
- Compact
- Cheap
- Looks like photon treatment
What do we need from an accelerator?

- Maximum dose to tumour
- Minimise effects to normal tissue
- Conform dose to tumour
- Hypo-fractionation – dose escalation?
- Spot scanning
- Multiple beams – Gantry design
- Range of ions
- Compact
- Cheap
- Easy to operate
- Faster throughput
- Reliable