Medical Physics at a Proton Source

- Proton Therapy
- Fast Neutron Therapy
- Isotope Production
- Basic Research

Proton Therapy Requirements

- **Average current 10-20 nA**
  - ***Higher current leads to safety issues***
- **Energy Range 70-300 MeV**
  - ***Allows for proton radiography***
- **Continuously variable energy**
  - ***Accommodates varying tumor depth***
- **Voxel Scanning**
  - ***Minimizes healthy tissue dose***

Proton Therapy Using a Linac

- **Average current 10-20 nA**
  - ***Much lower than typical linac current (>40 μA)***
  - ***Solution for proton therapy at SSC linac***
- **Energy Range 70-300 MeV**
  - ***Easy with a linac***
- **Continuously variable energy**
  - ***Can be done with energy degraders***
- **Voxel Scanning**
  - ***Not practical with degraders***

Proton Therapy with a Synchrotron

- Average current 10-20 nA
  - *Easy with a synchrotron*
- Energy Range 70-300 MeV
  - *Easy with a synchrotron*
- Continuously variable energy
  - *Easy with a synchrotron*
- Voxel Scanning
  - *Easy with a synchrotron, especially a rapid cycling synchrotron*

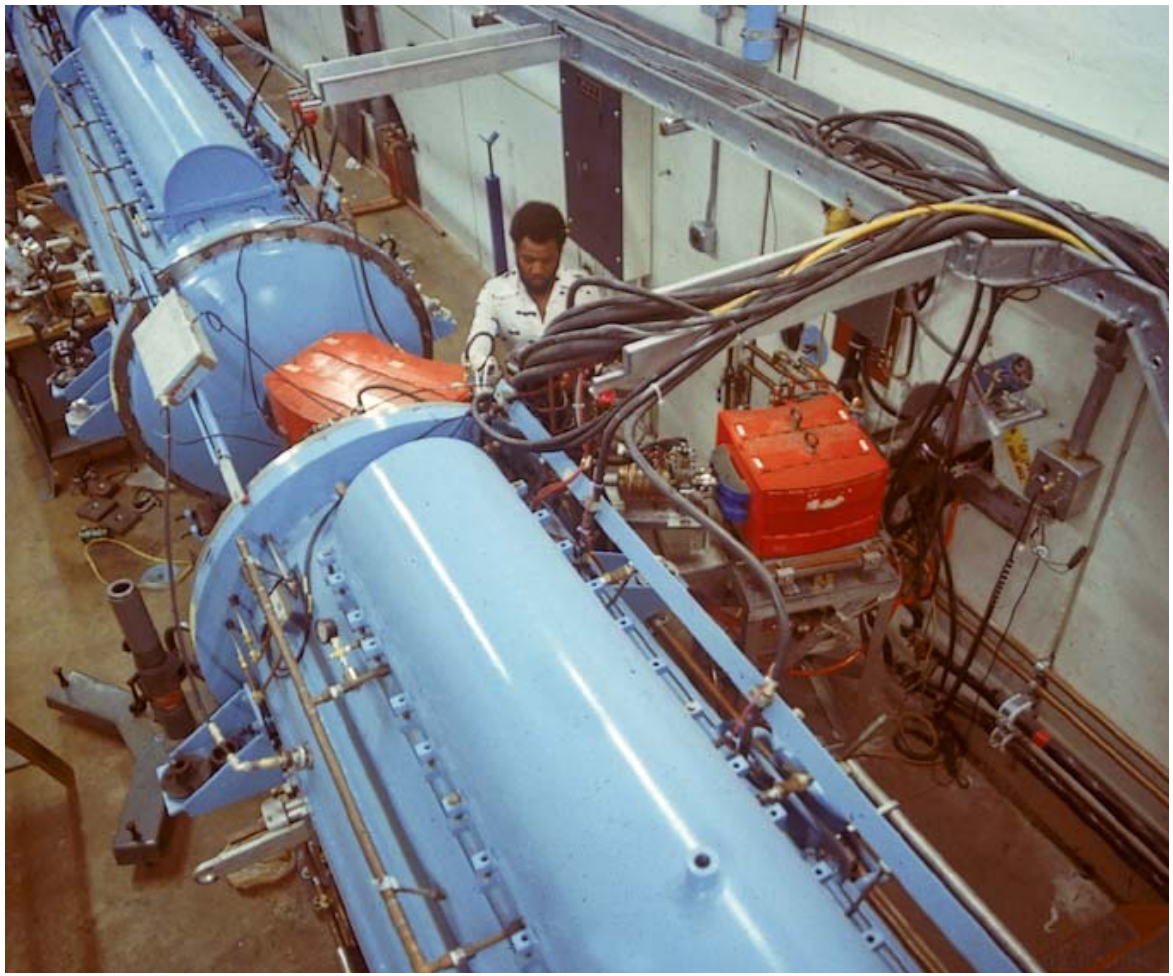
Synchrotrons are well matched to proton therapy!

Fast Neutron Therapy Requirements

- Average Proton Current 45 - 200 μA
- Energy Range 70 - 100 MeV
- Fixed energy OK
- No scanning requirements

Linacs are well matched to neutron therapy!

Fast Neutron Therapy Requirements



Must be able to extract between 70 and 100 MeV

Isotope Production Requirements

- Average Proton Current 45 μA - 1 mA
- Energy Range 45 - 100 MeV
- Fixed energy OK, but extraction at two energies would be helpful
- No scanning requirements

Linacs are well matched to isotope production!

Isotopes Produced by 70 MeV Protons

Mausner et al - Brookhaven

Nuclide	Half-life	Nuclide	Half-life	Nuclide	Half-life
7Be	53.3 d	**77Br**	2.37 d	**122Xe**	20.1 h
22Na	2.6 y	**81Kr-m**	13.1 s	**127Xe**	**36.4 d**
28Mg	21 h	**82Sr**	**25.4 d**	**128Ba**	2.43 d
48V	16 d	**88Y**	106.6 d	**139Ce**	137.6 d
52Fe	**8.3 h**	**89Zr**	3.27 d	**179Ta**	1.8 y
55Fe	2.73 y	**95Tc-m**	61 d	**178W**	21.6 d
55Co	17.5 h	**96Tc**	3.4 d	**195Pt-m**	4.02 d
57Co	271 d	**97Ru**	2.89 d	**195Hg-m**	1.67 d
61Cu	3.35 h	**103Pd**	**17.0 d**	**203Pb**	2.2 d
64Cu	12.7 h	**109Cd**	462 d	**205Bi**	15.3 d
67Cu	2.58 d	**111In**	**2.8 d**	**206Bi**	6.2 d
68Ge	**272 d**	**117Sn-m**	14.0 d	**211At**	7.2 h
73As	80.3 d	**123I**	**13.3 h**	**237Pu**	
74As	17.8 d	**124I**	4.2 d		

*** Medically Useful**

Radiobiology Research Requirements

- Average Proton Current >45 μA
- Energy Range 45 - 300 MeV for protons
- Energy Range 70 - 100 MeV for neutrons
- Fixed energy OK

Linacs are well matched to radiobiology research!

Possible Research Areas

Radiation effects in outer space -NASA

Cell survival studies

Particle Therapy Calibration Equipment

Benchmark simulation software

Health Physics Applications - e.g.muon dosimetry

References

"Current Status and Future Directions of Production of Radioisotopes with High Energy Accelerators" by Mausner and Srivastava, in *Proceedings of the Third International Topical Meeting on Nuclear Applications of Accelerator Technology*, Long Beach CA, Nov 14-18, 1999, pp 13-19.

Proceedings of the 400-MeV Beam International Conference, Fermilab,Edited by Carol Johnstone, Oct 24-27, 1993.