Introduction

Beam line is a series of discrete magnetic element(dipoles, quadrupoles) that determine the beam’s position, direction and shape and others (steering beam profile monitors, beam stops, collimator and degrader...)

The beam line of SC200 can transform the 70-200MeV proton beam after degrader to the different treatment room and meet the different therapy need. It can also quickly stop proton beam to ensure the safe in the therapy. 

The beam line of SC200 consist of energy selection section (45-degree horizontal asymmetry achromatic bending sections), matching section, period matching section, 45 horizontally symmetrical achromatic bending section, the fixed beam room match section and Gantry section.

The optical calculation design of the SC200 beam transport line is based on the Charged particle beam transmission principle. The design process is guided by the following principles:

1. The beam line is divided into several functional sections. It simplifies complex issues avoiding different requirements for interaction.
2. It is necessary to consider the magnet and the vacuum tube and improving the stability of the beam to make the envelope of beam not change dramatically or too large as far as possible. At the same time, both dispersion and its derivatives should be set as zero to avoid its effects on the beam.
3. In general, it is more convenient to describe beam transport line using the envelope of beam. There are several program based on the beam envelope and the transfer matrix method for the optical design of beam such as TRANSPORT, TRACE3D and MADX. And here the TRANSPORT code was used for the optics calculations.

Energy selection section + The Fixed beam room

Energy selection section:
- The first 45° dipole give the beam a large horizontal dispersion
- 1 quad H focusing + 2 quad H defocusing + Max H beam size
- Horizontal Silt to Select the required energy
- All above elements are aimed at finally achieving a achromatic system system (D=0, D'=0)

Periodic matching section:
- Deflection of the beam from the matching point towards a treatment room
- Forming a achromatic system (D=0, D'=0)
- Vertical size (y direction)
All treatment rooms are connected by a series of period matching section.

Achromat section and Fixed beamroom section:
- The beam has circular shape at isocenter (FWHM=4-10mm),
- Forming a achromatic system (D=0, D'=0)
- FWHM=4-10mm at the isocenter
- The beam has circular shape at the isocenter

Gantry section

- Layout type: isocentric, 4+155° rotation, 50°-40°-90° dipoles, achromatic
- Beam delivery type: Downstream PBS
- Quadrupole (quantity and effective length): 7/6.25m
- Dipole magnet (radius and Edge): 3.6m, 58°
- Maximum beam envelope: 27mm
- Beam range: 8-200 MeV
- Beam FWHM at P in vacuum: 0.1mm

The radius of Gantry: 4.65m
The length of Gantry: 9.6m

Conclusion & Reference

we designed two beam line base on the 70MeV proton beam which have the maximum emittance (16 mm.mrad both in the x and y direction). And then we can calculate the magnet filed of dipole and the magnetic filed gradient of quadrupole for the 70-200MeV proton beam. The maximum beam envelope is 27.24mm and the maximum beam momentum acceptance is equal to 1%. The fixed beam room can achieve the FWHM of beam varying from 4 to 10mm(in vacuum)

GANTRY dose delivery systems are now acknowledged as a necessary part of a medical hadron therapy facility. Since GANTRY is a most expensive part of such a facility, it’s parameters should be carefully chosen and optimized. Because the gantry rotates, it mixes the horizontal and vertical planes.it is thus required that both planes have exactly the same characteristics at the entrance point of the rotating system. For similar reason of plane mixing, the beam characteristics at the isocenter must fulfill the same conditions. This ensures that the same beam is delivered irrespective of the gantry angle. Here TRANSPORT computer code was used for optics calculations. We present a new optical scheme of isocentric GANTRY, First we assumed the initial emittance is e=16mm.mrad and the beam has circular shape at isocenter (FWHM=4-10MM), and the beam line of beam line inversion (BLI) will be applied here. (The beam is set with the beam profile monitors, beam stops, collimator and degrader). And finally we get that the maximum momentum spread of gantry is 0.8%,the coupling point matching parameter is a=0, β=1,γ=1, the radius of gantry is 4.65m, the length of Gantry is 9.6m, the FWHM at isocenter is 4-10mm and it can transfer 70-200MeV proton beam to the isocenter.

Reference

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