



TYPES OF ACCELERATORS PRESENTLY USED FOR PARTICLE **RADIOTHERAPY: CYCLOTRONS**

Isochronous cyclotrons

- Cyclotron frequency (typically 25 MHz) determines the RF frequency of the accelerating cavities (in the typical range 50-100 MHz) Extracted bunches have fixed energy - 230-250 MeV for a proton therapy
- cyclotron
- Depth (energy) control for radiotherapy treatment is achieved by reduction of the extracted beam energy using the Energy Selection System (ESS) from the fixed output energy.
- Absorbers produce substantial losses of protons and concomitant stray radiation as well as a significant lateral spreading of the beam.
- The time needed to vary the beam energy is dictated by the mechanical movement of the absorbers and is at minimum 100 milliseconds.
- Isotopes generated by proton induced reaction on iron and nickel have relatively long half-lives $t_{1/2}$ and high energy E_{σ} , like for instance ${}^{56}\text{Fe} \rightarrow {}^{56}\text{Ms}(t_{1/2} = 312 \text{ adys}, E_{\sigma} = 0.44 \text{ MeV})$ and ${}^{59}\text{Ni} \rightarrow {}^{60}\text{Co}$ ($t_{1/2} = 5.27 \text{ years}, E_{\rho} = 0.44 \text{ NeV}$) and ${}^{59}\text{Ni} \rightarrow {}^{60}\text{Co}$ ($t_{1/2} = 5.27 \text{ years}, E_{\rho} = 1.17$ -1.33 MeV), respectively.



spin-off

Inventor Yves Jongen with the first compact proton therapy cyclotron

TYPES OF ACCELERATORS PRESENTLY USED FOR PARTICLE RADIOTHERAPY: SYNCHRO-CYCLOTRONS

- · Frequency of the accelerating voltage is reduced as protons spiral outward and away from the centre to compensate for the relativistic effect.
- . Proton bunches are extracted in pulses 5-7 microsecond long and at a typical repetition rate in the order of 500 to 1000 Hz. · Superconducting magnets are used resulting in a more compact machine.
- At present, compact synchro-cyclotrons have been produced and are used in $\underline{single-room\ facilities}$ with a footprint typically less than 400m².

















- Linear accelerators (LINACs) accelerate beams in a straight path obviating the need for bending magnets.
- LINAC acceleration is provided by a single pass of the charged particle through a series of radiofrequency (rf) cavities.
- Klystrons produce an axial, linear accelerating gradient.
 Commercially available combinations of S-band rf modulators and klystrons are available providing repetition rates of about 200 Hz.
- klystrons are available providing repetition rates of about 200 Hz.Electron beam LINACs are the most commonly used accelerators in teletherapy but have yet to be adopted in particle therapy.
- teletherapy but have yet to be adopted in particle therapy.Applications of Detectors and Accelerators to Medicine (ADAM SA)
- Applications of Detectors and Accelerators to Medicine (ADAM SA) is now building a full LINAC proton therapy system called LINAC for Image-Guided Hadron Therapy (LIGHT).













LIGHT FEATURES FOR PROTON THERAPY				
Our intention is to de	liver:			
Active energy modulation	ightarrow no absorber and degrader			
Pulsed beam at 200 Hz	→ intensity and energy modulation in 5 ms			
Small beam emittance	→ small magnets aperture			
Almost no losses!	→ reduced shielding			

















	SCANNED PRO	ON MINIBE	AMS
Charge	d Particle Therapy with Mini-	Segmented Beams	
A healthy tissue		Variation d Paramited 1979- 1979- 1979- 1979- 1979- 1970-	$\frac{1}{10000000000000000000000000000000000$
F. Avraham Dil	nanian ^{123°,} John G. Eley ⁴ , Adam Rusek ¹⁴ and Sunil Krishnan		













