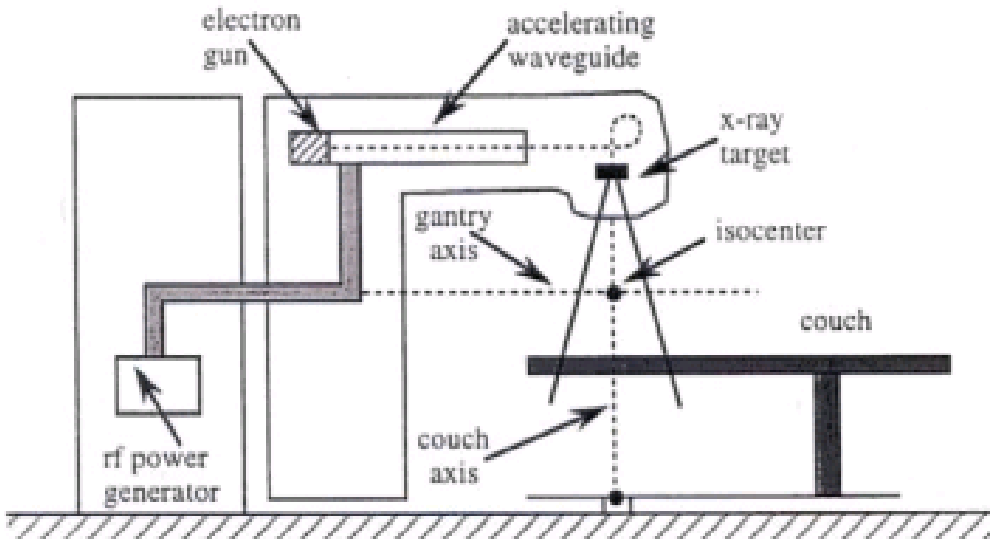
What are the two types of waveguides are used in linacs, and what do they do?



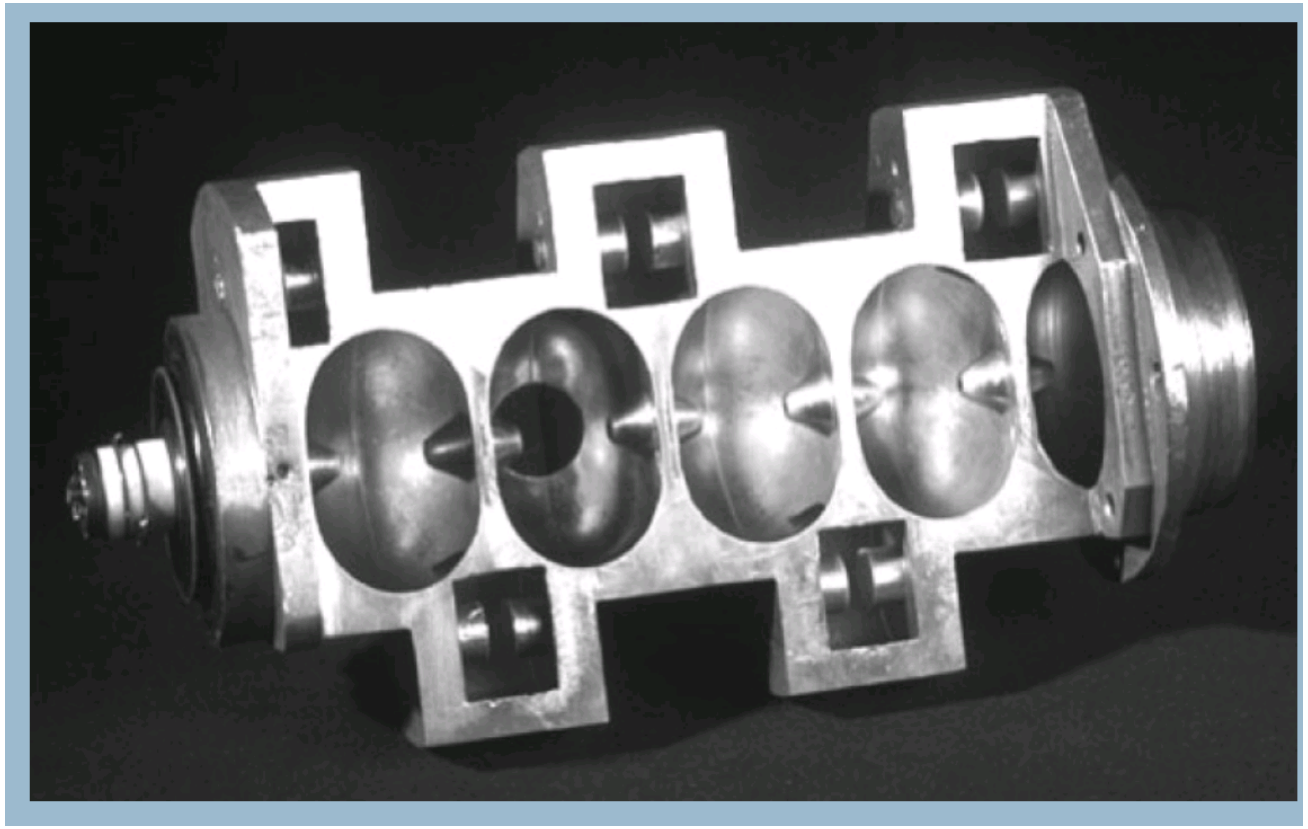
1. RF power transmission waveguides
2. Accelerating waveguides

1. The power transmission waveguides transmit the RF power from the power source to the accelerating waveguide in which the electrons are accelerated
2. Accelerates electrons to high energy

1. What is the gas/pressure inside the accelerating waveguide?
2. What is the gas/pressure inside the connecting waveguide?

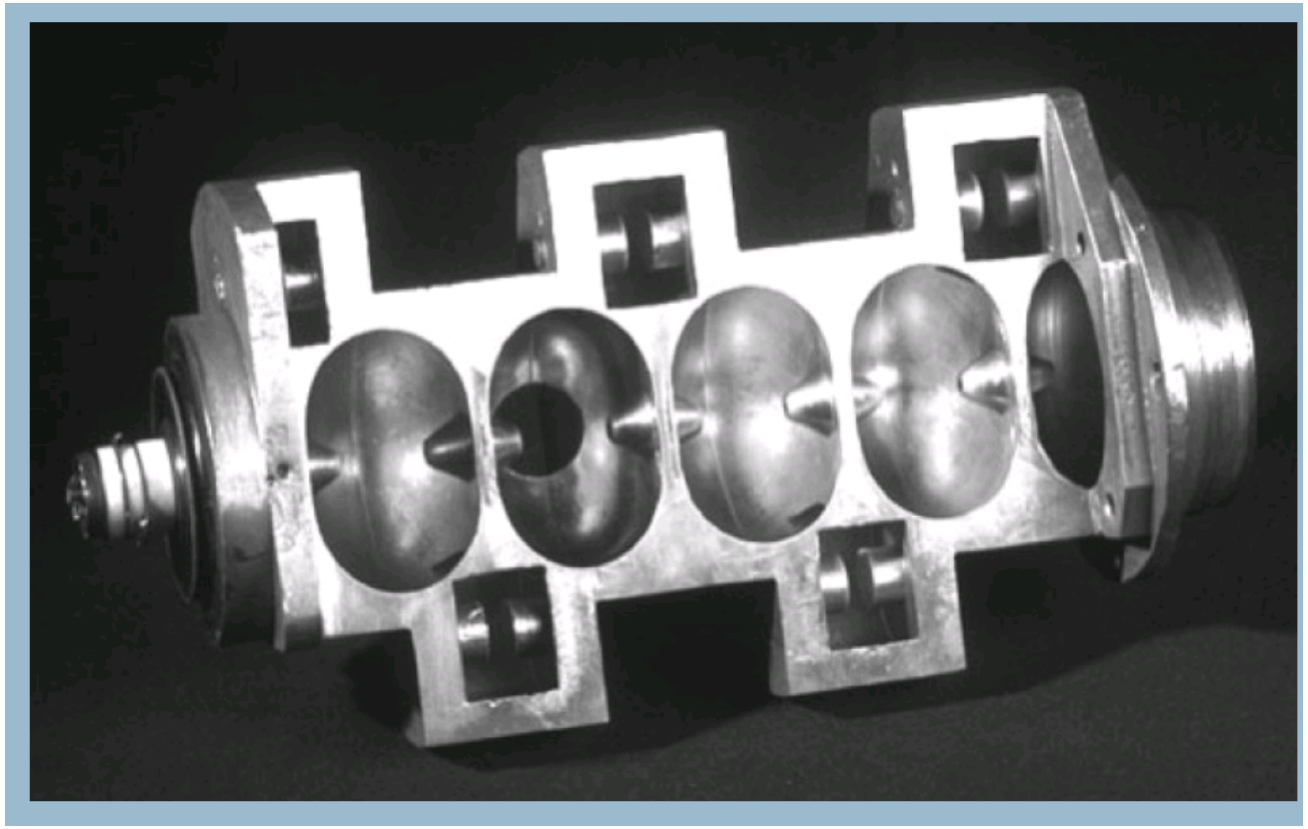
The microwave power produced by the *RF* generator is carried to the accelerating waveguide through rectangular uniform S-band waveguides which are either evacuated or, more commonly, pressurized with a dielectric gas (freon or sulfur hexafluoride, SF_6) to twice the atmospheric pressure.

An important component, which must be inserted into the *RF* power transmission circuit between the *RF* generator and the accelerating waveguide, is a circulator (sometimes referred to as an isolator) which transmits the *RF* power from the *RF* generator to the accelerating waveguide but is impervious to reflected radiation moving in the opposite direction, thereby protecting the RF source from the reflected power.



1. What is this structure?
2. What is it for?
3. How does it work?

1. Standing wave accelerating waveguide for 6X linac.
2. Accelerates electrons to high energy (6 MV for this waveguide).
3. The structure is designed to “resonate” at specific frequency. For most linacs, the frequency is in the S band, 3 GHz. The acceleration the electron receives in each cavity increases with the microwave power fed into the waveguide.

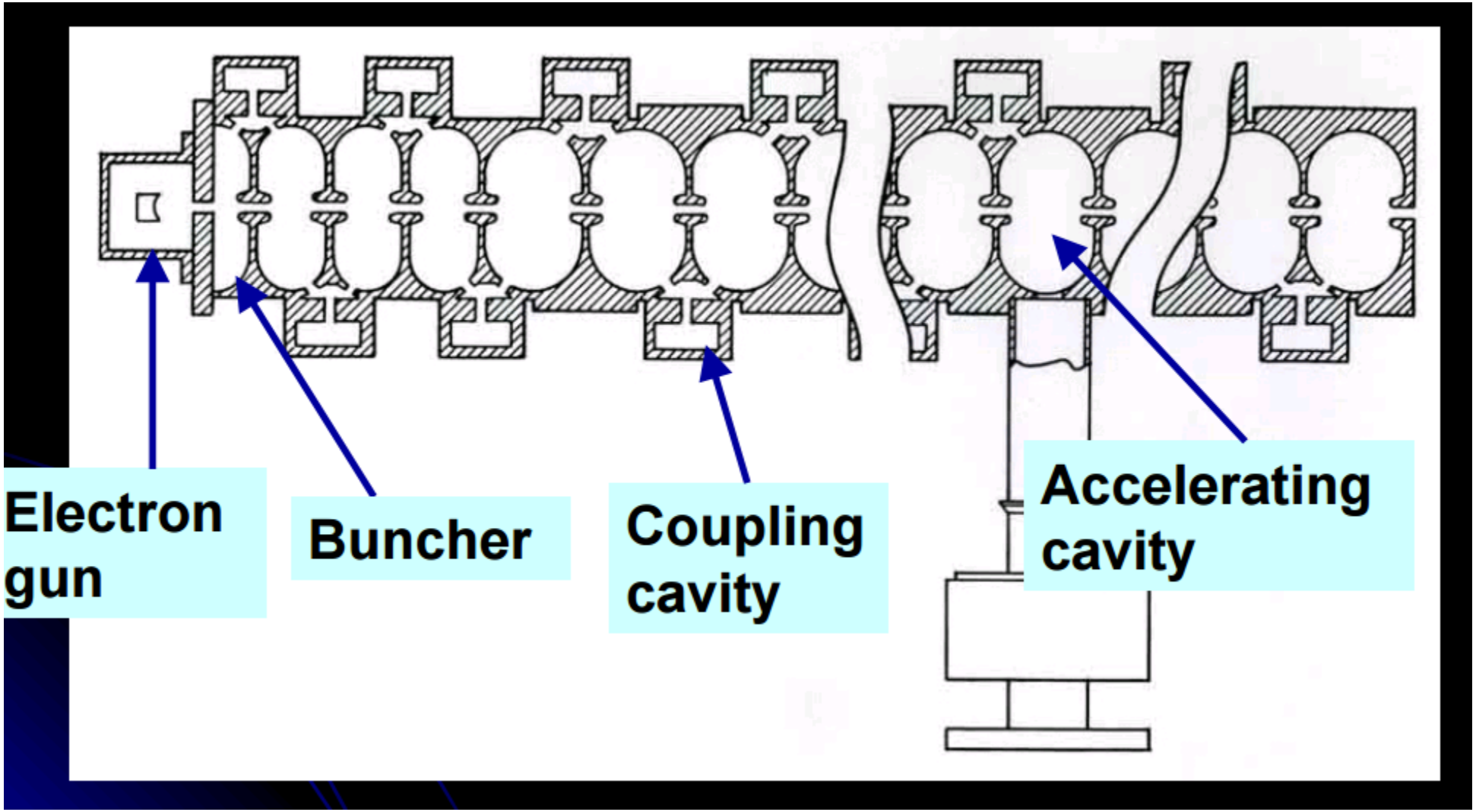


Follow Up:

1. What is the dimension of each cavity?
2. Can you design a smaller waveguide?

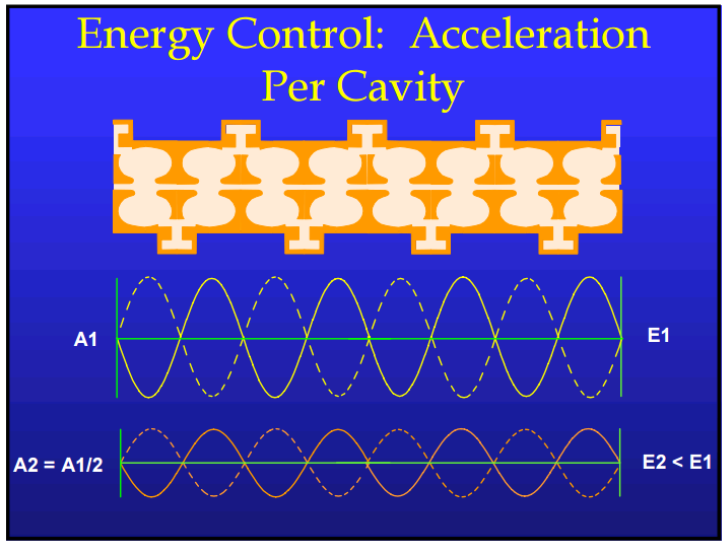
1. Each cavity is ½ wavelength
   For S band, f = 3 GHz -> This gives λ = c/f = 10 cm. -> cavity = 5cm.

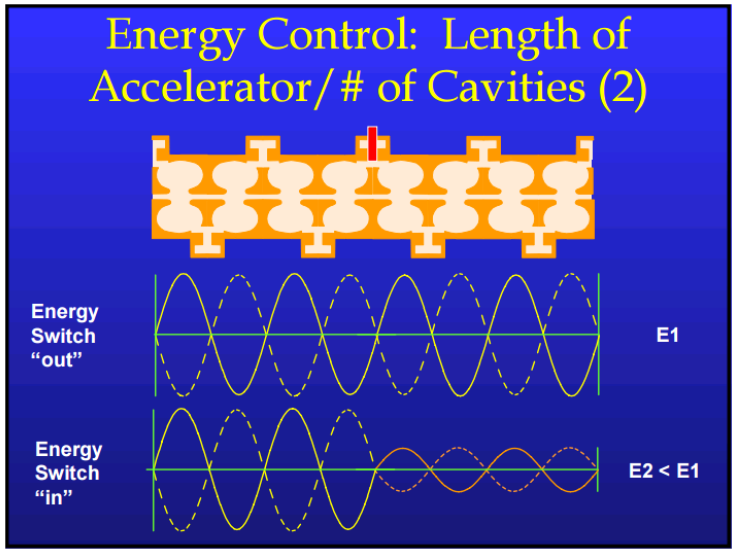
2. You could use higher frequency (9 GHz in the X band). Cavity is 1/3 shorter in the X band; eg CyberKnife cavity = 3.33 cm.

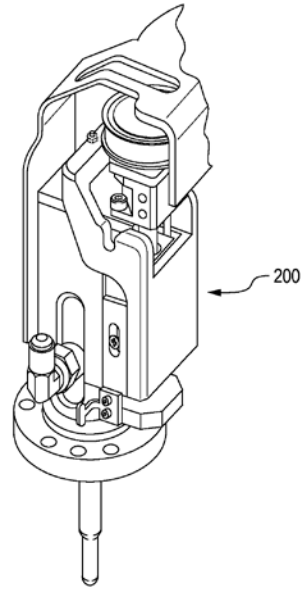

Electron gun
Buncher
Coupling cavity
Accelerating cavity

- How does a Linac vary the energy of electron beams? (4 possible answers)

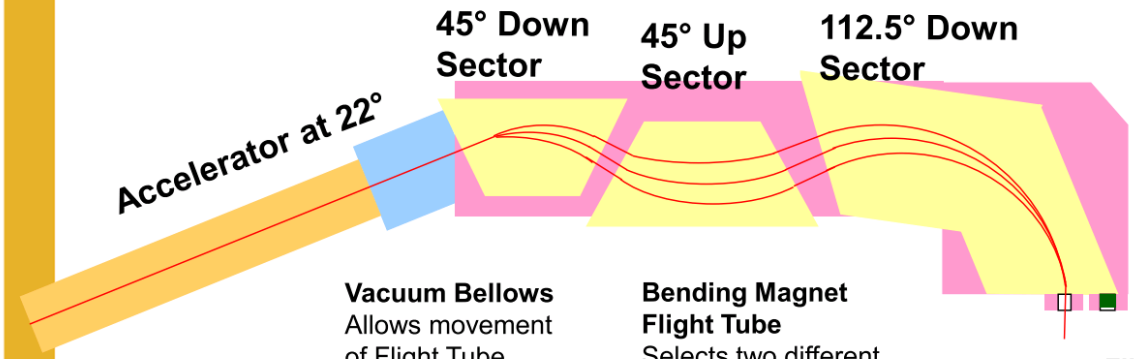
1. Vary the RF power into the accelerator.
2. Vary the injection beam current or “beam loading”. (TW)
3. Detune the RF source frequency and/or part of accelerating cavities. (TW)
4. Separate the accelerating cavities into two portions. For a low energy mode the second section has a lower net average RF electric field. (SW)



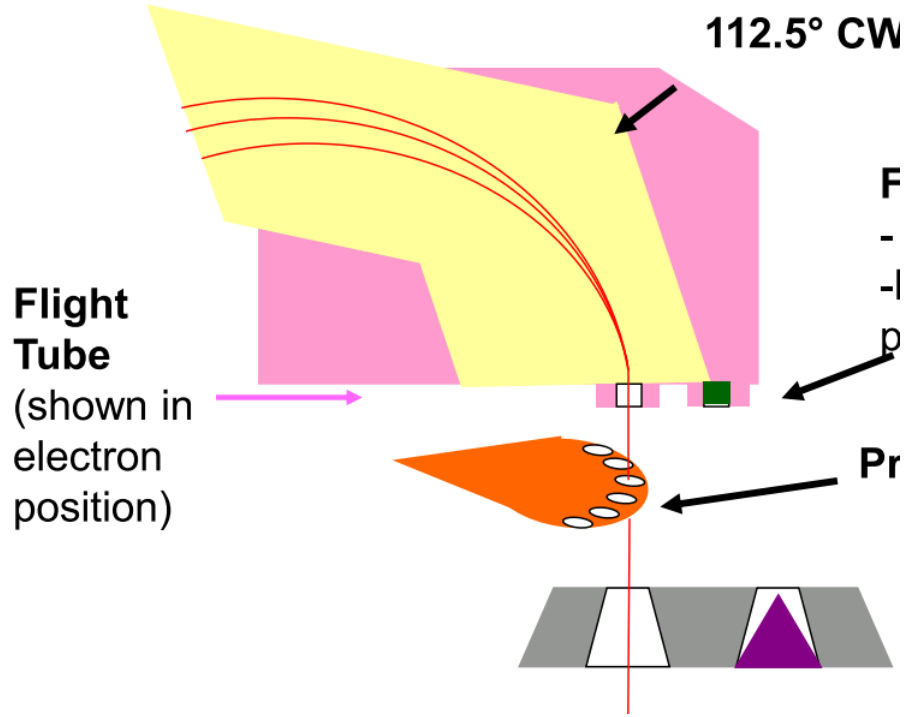




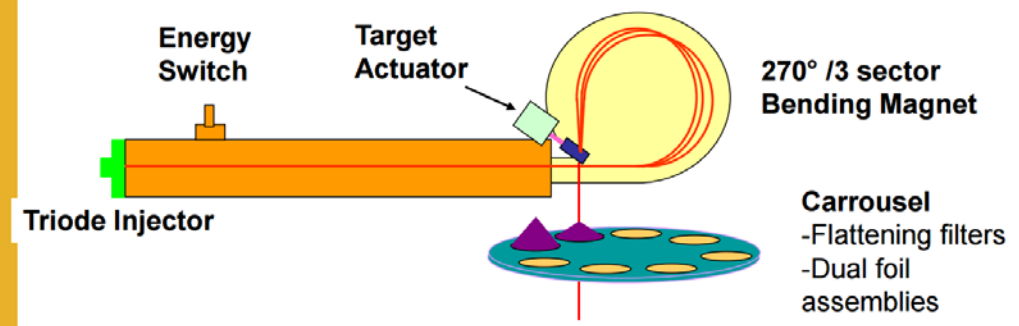
Elekta Mode Selection/Control -Energy



- Intrinsic beam energy spectrum is a function of microwave power, frequency.
- Final energy spectrum is selected by bending magnet
- Energy is servoed by adjusting injection current to produce different beam “loading”.
- Energy is monitored by ion chamber -inplane symmetry.



Varian Clinac Mode Selection/Control



- Standing-Wave Accelerator, intrinsic energy a function of RF power level in accelerator.
- Energy switch eliminates propagation of RF in distal 2/3 of accelerator, allowing high RF power/beam current at low energy for low-X.

Truebeam:
Redesigned - Continuously variable energy switch