How is the dose-rate modulated within the linac(s) at your facility?

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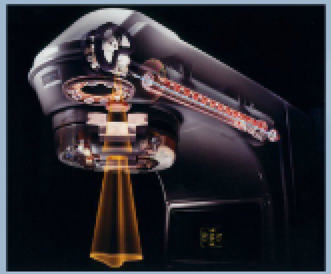

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- Varian linacs have a fixed pulse rate (energized accelerating cavity).
- Dose rate modulation is accomplished by varying how many of the pulses coincide with electron-loading of the accelerating cavity by the gridded gun.

What is this structure? What is it for? How does it work?

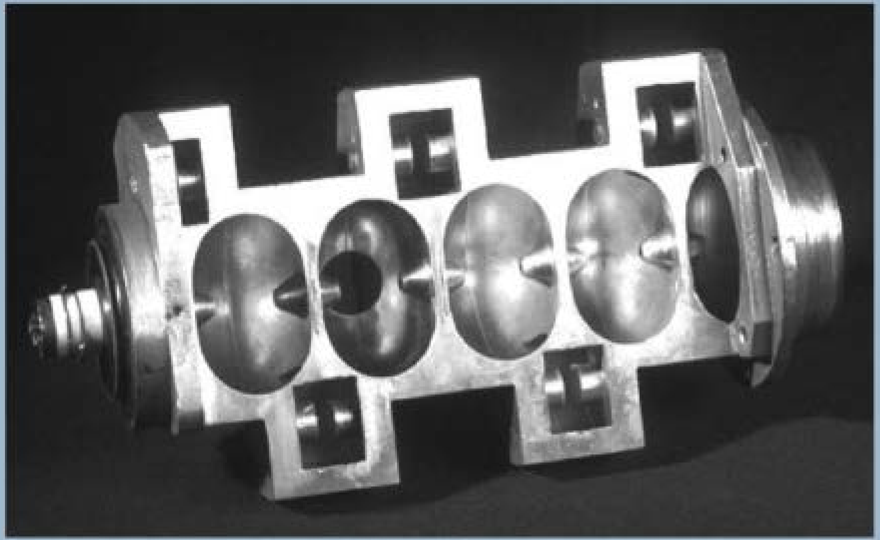
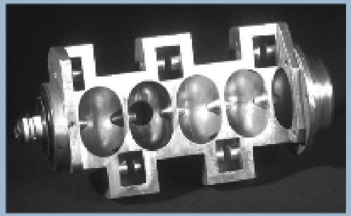


Image from Podgorsak, Radiation Oncology Physics Handbook, IAEA 2005, used with permission



What is this?

- This is a cutaway view of a standing wave accelerating waveguide for 6X linac.
- The electron gun is on the left, target on right
- The side cavities tell you it is a standing wave
- This is the component of a linac that accelerates electrons to high energy (6 MV for this waveguide).
- 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. Controlling input power is one way to change the output energy.

List some of the major annual QA tests performed on your linear accelerator.

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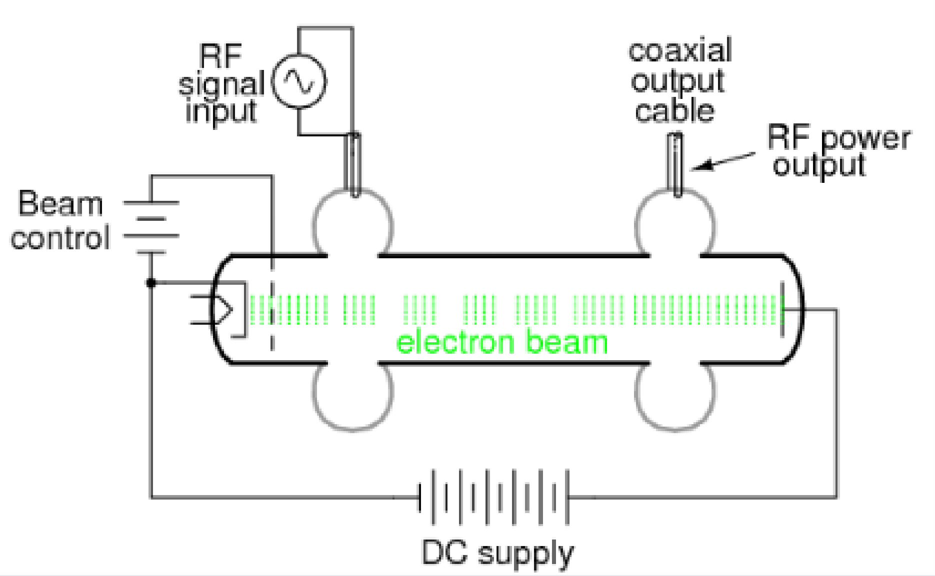
- Safety – emergency off buttons, interlocks, warning lights, area rad. detector, video/audio
- Mechanicals – mech. isocenter and readout accuracy
- Visual – ODI, lasers, light field
- Film – spoke shots, rad. Vs. light (jaws and MLC)
- Scanner – PDD, flatness, symmetry
- Chamber – output, wedge/tray factors, linearity with MU, dose rate, gantry angle, absolute dosimetry calibration

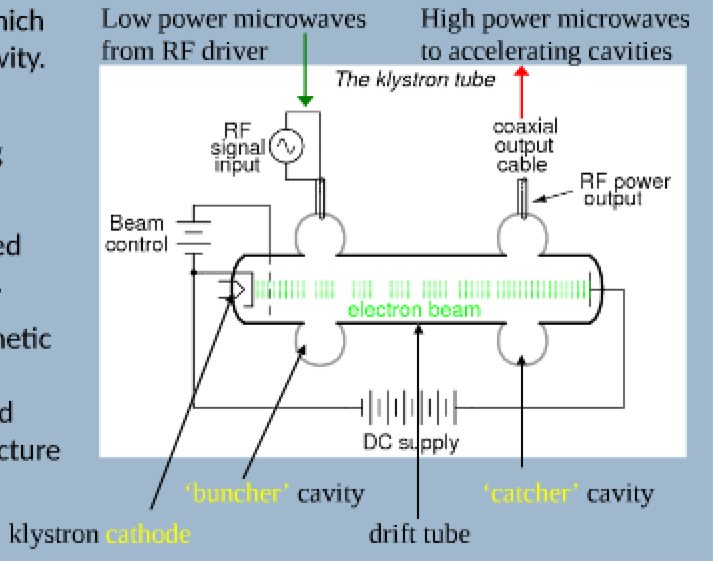
Describe what this schematic represents and how it works?



Describe what this schematic represents and how it works?

This is a klystron tube. It is used in linear accelerators to amplify the microwave signals used to energize accelerating cavities.

1. Klystron cathode emits electrons which are accelerated into the buncher cavity.
2. Low power microwaves entering buncher cavity set up an alternating electric field.
3. The klystron electrons are modulated into bunches through the drift tube.
4. The 'bunched' klystron electrons kinetic energy is converted to high power microwaves in the catcher cavity and transmitted to the accelerating structure through the wave guide.



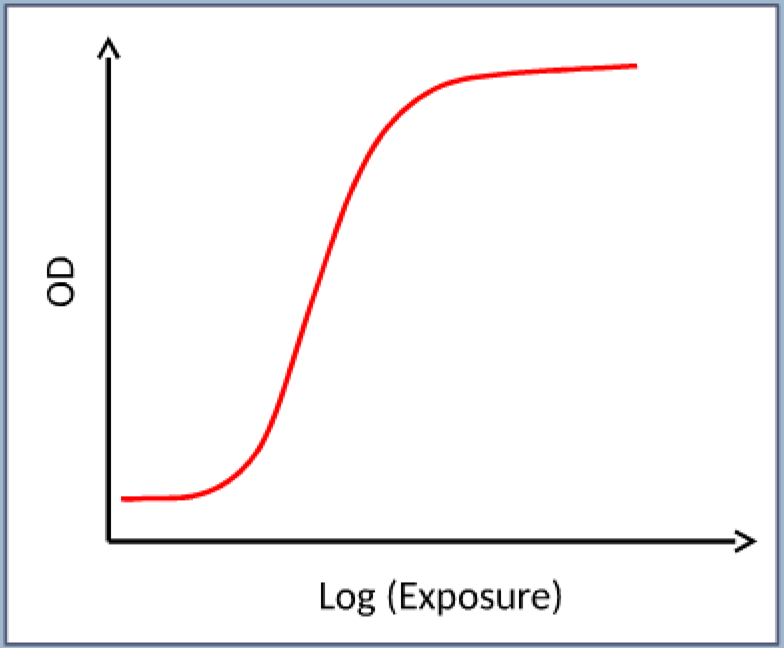
What kind of phantom is this? What is it for?

Image from CIRS

Ultrasound Summary

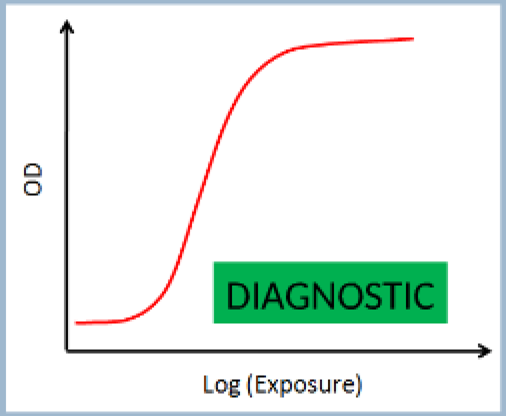
- Diagnostic ultrasound usually uses a frequency of 3-10 MHz
- Speed of sound in soft tissue ≈ 1540 m/s
- Speed of sound in air ≈ 330 m/s
- Attenuation in tissue ≈ 0.5 dB/cm/MHz
- Attenuation at 3 MHz = 1.5 dB/cm ≈ 20% signal loss / cm
- Attenuation at 10 MHz = 5 dB/cm ≈ 70% signal loss / cm
- Higher frequency = higher attenuation, but it gives you better resolution, so user needs to make compromise
- Transrectal ultrasound probes usually have 2 sets of transducers:
  - Transverse array to produce axial images
  - Longitudinal array to produce sagittal (base-apex) images
- Ultrasound is low maintenance. TG-128 only requires its tests to be done annually. But it also cautions that if the unit is frequently transported, the QC needs to be done more often.

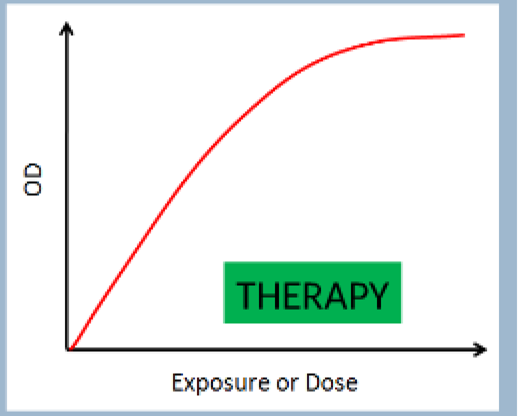
What is this curve called? Discuss the characteristics of this curve, provide typical scale for the curve, and discuss its use in radiation therapy.



What is this curve called? Discuss its characteristics.

- This is called the HD curve (for Hurter and Driffield). Sometimes also called the characteristic or sensitometric curve.
- For diagnostic imaging, the abscissa is the LOG of exposure. This gives the well-known S-like curve. Diagnostic people cares about finding exposure level that gives the optimal contrast
- For therapy or dosimetric purposes, the abscissa is the dose itself (not the LOG). Therapy cares about using film for dosimetry





Explain why the readings from an unsealed ion chamber must be corrected for temperature and pressure conditions?

- Does TG-51 address the use of <u>sealed</u> ion chambers and if so, what does it say?

- Why are the ion chambers in most commercially available medical linear accelerators sealed?

Explain why the readings from an unsealed ion chamber must be corrected for temperature and pressure conditions?

  - For the purposes of dosimetry we are interested in ionization based on a known mass of air.
  - The number of atoms in a volume (atomic density) changes as a function of temperature, thus must be normalized by including corrections to account for non-standard environmental conditions.

Does TG-51 address the use of <u>sealed</u> ion chambers and if so, what does it say?

- There is not a statement in TG-51 that precludes the use of sealed ion chambers, however the inclusion of the temp/pressure correction factor in the protocol indicates that use of unsealed chambers are expected.
- Sealed chambers for absolute calibration purposes are troublesome because a leaky chamber would produce incorrect results and may be difficult to detect.

Describe the requirements for the calibration of radiation survey meters?

Describe the requirements for the calibration of radiation survey meters?

- Calibrated annually and following repair
- 2 reading per scale to establish linearity
- Actual readings within +/-20% of expected
- Check source should be present
- Calibration sticker should include date of last calibration and when due, check source identified with setup instructions and expected readings

Describe the purpose and design of a medical linear accelerator flattening filter.

Describe how the beam profiles change with depth in water.

Describe the purpose and design of a medical linear accelerator flattening filter.

- The purpose of a flattening filter is to spread out a peaked photon beam to provide a more uniform and symmetric beam profile.
- Flattening filters are typically made of lead, aluminum, steel or brass and are thick along the central axis of the photon beam but taper off away from the center.

Describe how the beam profiles change with depth in water.

- Due to the substantial attenuation of the photon beam along the central axis (thickest part of the filter) the profile may show a dip in the center at shallow depths.
- As the depth increases, in-scatter preferentially increases dose at the center of the profile to produce a flatter, and eventually somewhat peaked profile as depth increases.

Describe the steps to perform a CT Sim end to end test.

- *Why purchase an external laser system when the CT already has lasers?*
- *What routine QA is performed on your external laser system?*
- *What sort of QA test are recommended for the CT scanner table?*

Describe the steps to perform a CT Sim end to end test.

Stereotactic Dose Verification Phantom from Standard Imaging, Inc.

1) Scan phantom with fiducial marker.
2) Transfer data to workstation and check orientation.
3) Outline external contour and calculate volume & area.
4) Align isocenter to fiducial marker, move CT couch to iso.
5) Mark phantom insuring lasers match fiducial marker
6) Set field, send to RTP system (check orientation & field)
7) Check CT numbers if phantom is heterogeneous
8) Send data to treatment machine
9) Print DRRs and setup documentation
10) Setup and verify phantom treatment

- *Positioning lasers integrated into the CT scanner lack the precision and accuracy required for patient marking for radiation therapy and are not easily accessible for adjustment.*
- *External laser marking systems are convenient in that the overhead and side lasers are motorized and may be directed to isocenter or other significant coordinates on the patient.*
- *Only longitudinal couch movements are necessary to mark the patient.*

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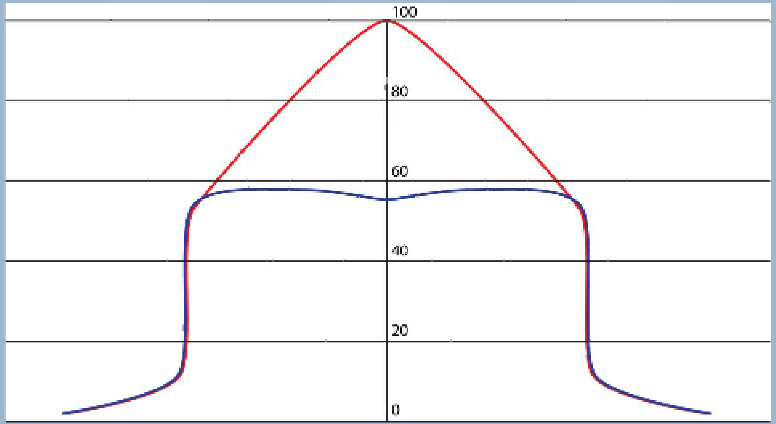
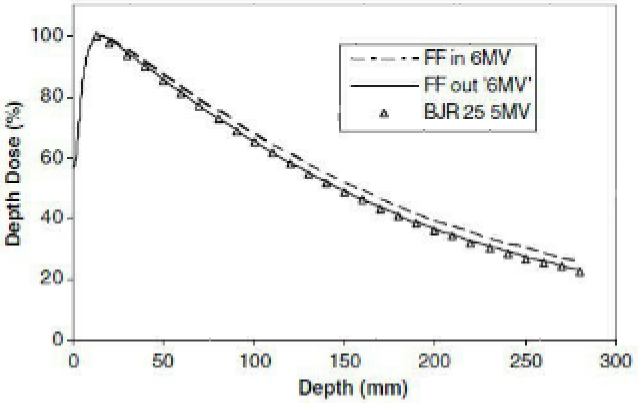
Discuss the following two beam profiles



- Why are flattening filters used?
- What are some differences between flat and flattening filter free (FFF) beams?
- What kinds of treatments are FFF beams useful for?
- With modern dose calculation algorithms, is the dose calculation made easier or more difficult by removing the flattening filter?
- How does switching to a FFF beam affect portal imaging and portal dosimetry?

Why use flat beams? (1)

- Because the bremsstrahlung distribution of photons at clinically relevant energies is strongly forward peaked, flattening filters were traditionally used to make beam profiles flat a given depth. This was done using a conical attenuator made out of a high-z material. A flattened beam makes dose calculation for simple algorithms easier.
- Radiation treatments have been done for a long time without flattening filters. Cyberknife and Tomotherapy machines both do not have them. Another example is the 50 MeV Scanditronix racetrack microtron from the 1980s which relied on a scanning electron beam.



Why use flat beams? (2)

- With advanced dose calculation algorithms now widely available, the reasons for using flattened beams are becoming more limited.
- FFF beams are most useful for small field techniques (eg. SBRT and IMRT), but they can also be used for 3D conformal treatments. However, the number of fields and MU needed can be significantly increased compared to flat beams, which reduces some of the advantages of FFF.

- FFF beams, compared to flat beams, have:
  - A softer energy spectrum
  - A higher photon energy fluence and therefore higher dose per pulse
  - Significantly reduced electron contamination (other sources: monitor unit chamber, irradiated air column)
  - Significantly reduced head scatter. Head scatter from the flattening filter in a flattened beam contributes 3-10% of the total photon fluence
  - Minimal collimator exchange effect
  - Higher dose rates, increasing with energy, which can decrease treatment time