# SNS COLLEGE OF ALLIED HEALTH SCIENCES

SNS Kalvi Nagar, Coimbatore-35

Affiliated to The Dr.M.G.R Medical University, Chennai

## DEPARTMENT OF RADIOGRAPHY AND IMAGING TECHNOLOGY

## III YEAR

## COURSE NAME : EQUIPMENTS OF ADVANCED IMAGING MODALITIES

## TOPIC : RADIONUCLIDE DOSE CALIBRATOR &

## THYROID UPTAKE PROBE

# INTRODUCTION

- Radionuclide dose calibrator (activity meter) is an instrument for measuring radionuclides and radiopharmaceuticals in nuclear medicine.

- These instruments are basically well type ionization chambers which are sealed after filling the air under pressure.

- The air is filled under pressure in the chamber and sealed.

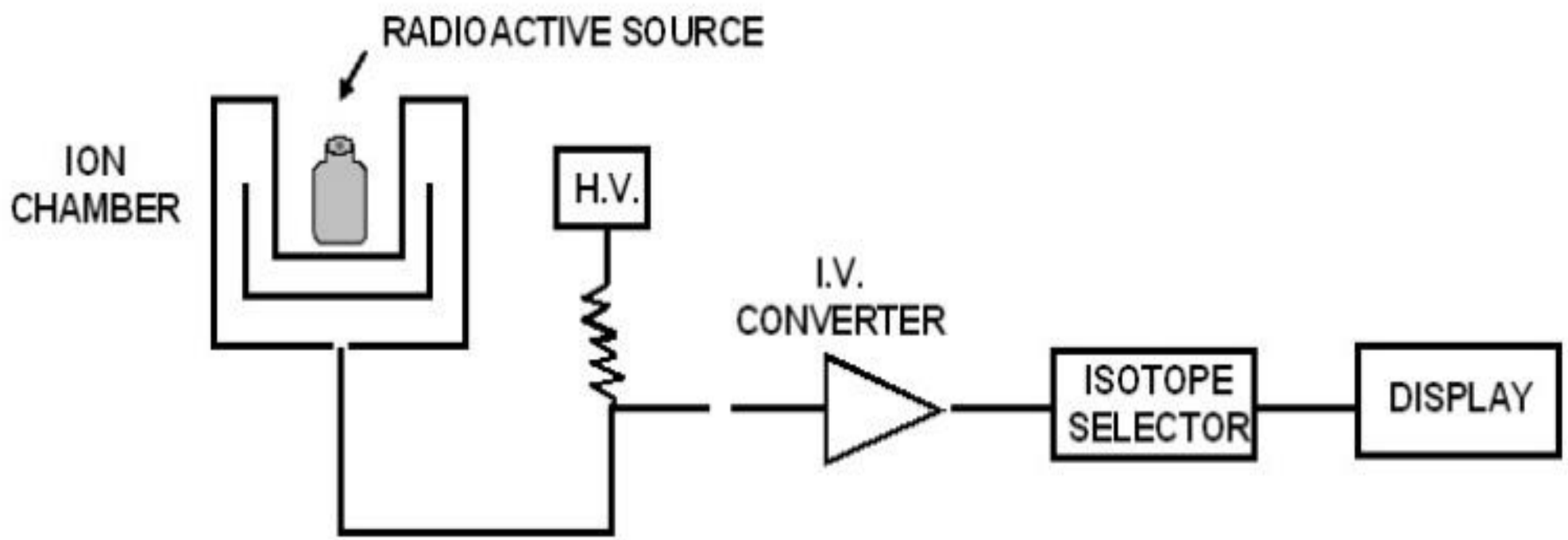
# CONSTRUCTION OF DOSE CALIBRATOR

- It has two co-axial cylindrical electrodes maintained at a given potential difference.

- The ionization produced inside the sealed chamber by radiation emitted from a given radionuclide, placed in the well, is collected by the electrodes as ionization current.

- This ion current is converted into a voltage signal that is processed and displayed in digital form either in Becquerels (Bq) or Curies (Ci) or both.

# LAY OUT DIAGRAM OF DOSE CALIBRATOR



## Cont.,

- The ionization current hence the voltage signal produced by the chamber is directly related to the amount of activity present in the well but will be different for different radionuclides due to the difference in type, energy and branching fraction for the emitted radiation.

- There are various sources of error while measuring activity in a dose calibrator.

- They may be related to sample position or volume, non-linearity over a wide range of activity (very small to very high), accuracy and precision etc., that need proper consideration and testing.

# Cont.,

- To get rid of the geometrical variation along the well, plastic holders for vials and syringes are made available by the manufacturers so that the activity is measured always at the same and appropriate location.

- This particular area of the ion chamber at a given depth normally shows stability in measurement.

- The well is surrounded by a lead lining to provide shielding for the operator and also reduces the effect of radiation coming from outside.

- To eliminate the background radiation completely, its reading has to be subtracted from the measured value

# CONCLUSION

- In modern dose calibrators there is provision for auto zero corrections.
- When the lead lining is not provided by the supplier or additional shielding is added by the users on their own then the instrument needs to be recalibrated and all the performance parameters should be evaluated due to change in back scatter value.
- It is necessary to maintain the dose calibrators always at their optimum performance for which routine quality control tests are essential.

# THYROID UPTAKE PROBE

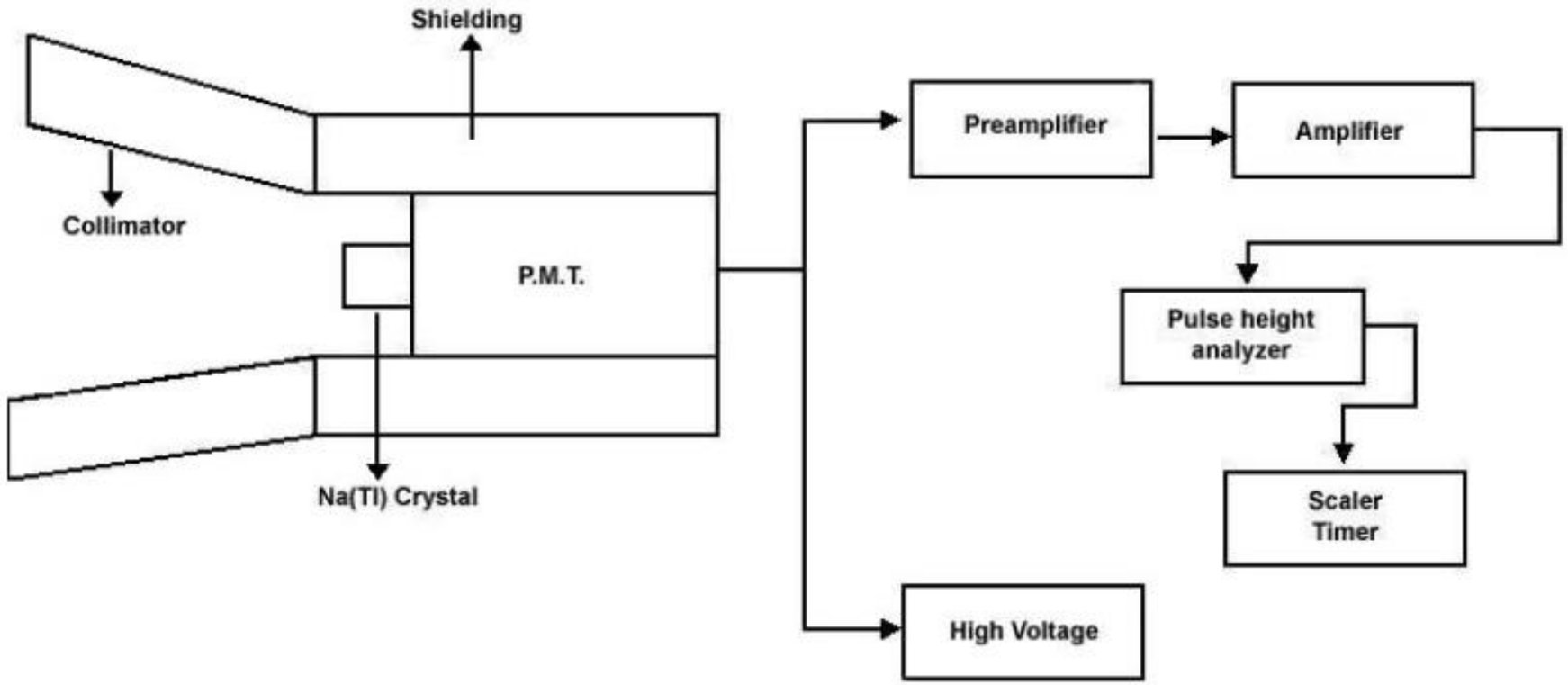
- The thyroid uptake probe is a counting device that is used to measure the percentage uptake of 131I in the thyroid gland after oral administration of 131I.

- The gamma rays produce scintillations in NaI(Tl) crystal, which are converted into an electrical pulses by the photomultiplier tube (PMT) to which the crystal is optically coupled.

- The intensity of light produced is proportional to the energy of the gamma ray absorbed.

- The associated electronic components in the circuit such as preamplifier, amplifier, pulse height analyzer and the counter/scalar.

# BLOCK DIAGRAM OF THYROID UPTAKE PROBE



# COMPONENTS OF THYROID PROBE SYSTEM

- ❑ Crystal
- ❑ Shielding
- ❑ Collimator
- ❑ Associated electronics

# COMPONENTS OF THYROID PROBE SYSTEM

## CRYSTAL :

- For medium energies a NaI(T1) crystal of 50 mm diameter and 25 mm thick is normally used in a thyroid probe.

- About 70% of the incident gamma rays from 131I are absorbed by 25 mm of NaI(Tl) crystal.

- Thicker crystal improve the sensitivity.

# Cont.,

**SHIELDING :**

- Lead Shielding is provided around the detector to reduce its response to the environmental radiation.
- Shielding is extended to the back of the detector.
- About 12.5 mm lead thickness is used for the shielding.

# Cont.,

## COLLIMATOR :

- A simple lead collimator cylindrical in shape but with a given solid angle is mounted in front of the crystal to allow photons to strike the detector emitted from a given mass/volume of tissue.

- The collimator is said to be a flat field collimator as its response is more or less uniform (± 10%) at or beyond a specified distance from the detector.

- The field of view at the working distance of 15-20 cm should be preferably between 12 cm to 15 cm in diameter. The shielded and collimated detector is called probe.

- The probe is usually mounted in a support that is adjustable at various positioning of the neck for counting measurements.

Cont.,

## ASSOCIATED ELECTRONICS :

- In modern systems, the associated electronics in an in-vivo counting system for gamma-radiation measurement provide digital display of acquired counts.

# APPLICATION OF THYROID PROBE

- Thyroid probe is mainly used to measure the uptake of a radioiodine (131I) by thyroid gland.
- It is routinely used in a nuclear medicine facility to estimate the radioiodine uptake by thyroid.
- The required activity is administered to the patient and exactly same amount of activity (by volume) is placed in a neck phantom.
- The phantom is positioned at a working distance (about 15-20 cm) from the detector and counts with and without (background counts) standard activity for a preset time are acquired.

## Cont.,

- The counts are measured normally at 2 h, 24 h, and 48 h or at any other time as suggested by the physician. In the same way, patient's neck counts and background counts at thigh level are counted under similar geometry and orientation.

- While taking thigh counts for background, it should be ensured that the bladder is voided which otherwise adds undesirable counts in the measurement.

- The background counts are subtracted from the measurements to get net counts. The percent uptake can be calculated using following equation:

- $$\text{Percentage uptake} = \frac{\text{Net neck counts of the patient}}{\text{Net standard counts}} \times 100$$

# QUALITY CONTROL TESTS FOR THYROID PROBE

## ACCEPTANCE AND REFERENCE TESTS :

- The instrument should first be physically inspected before commissioning for all expected components in good condition.

- It should then be subjected to the quality acceptance testing.

- The tests like energy calibration, energy resolution, detector efficiency, precision, linearity of energy response, linearity of activity response are performed in the same manner as for a spectrometer.

## RADIATION LEAKAGE FROM THE LEAD SHIELDING :

- The detector shielding should be checked for a leakage of radiation from a commonly used radionuclide.
- It can be accomplished by keeping radionuclide source near but outside the detector shielding.
- The count rate is recorded at different locations.

## FLAT FIELD RESPONSE OF THE COLLIMATOR

- A point source of 131I is used to check the response of the collimator at different distances.
- The counts are acquired with the point source at various positions across the field of view and an iso-response curve is plotted.
- From the iso-response curve, the working distance and field of view for routine and specific clinical conditions can be established.

# ROUTINE CHECKS

- Following are the routine checks, which need to be carried out on daily basis before the instrument is put to use:

- Check for the mechanical safety of collimator and probe mounting.

- Check the photopeak for a standard source of 137 Cesium by pacing it at a given and fixed location. This may be used for efficiency test also.

- Repeat step 2 for 131I.

- Check for background count rate under operating conditions for the radionuclide in use.

# REFERENCE


- Basic Physics and Radiation Safety in Nuclear Medicine by G.S.Pant.