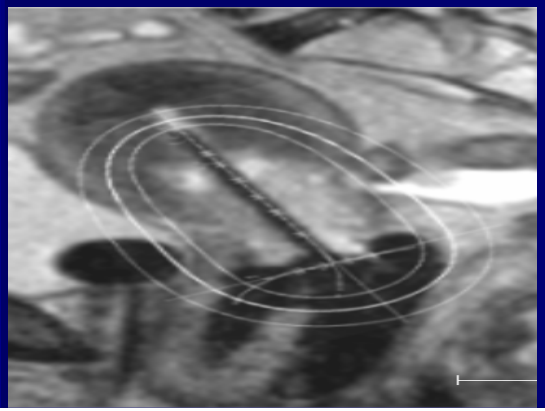
# Principles and pre-requisites for brachytherapy



- Chaitali

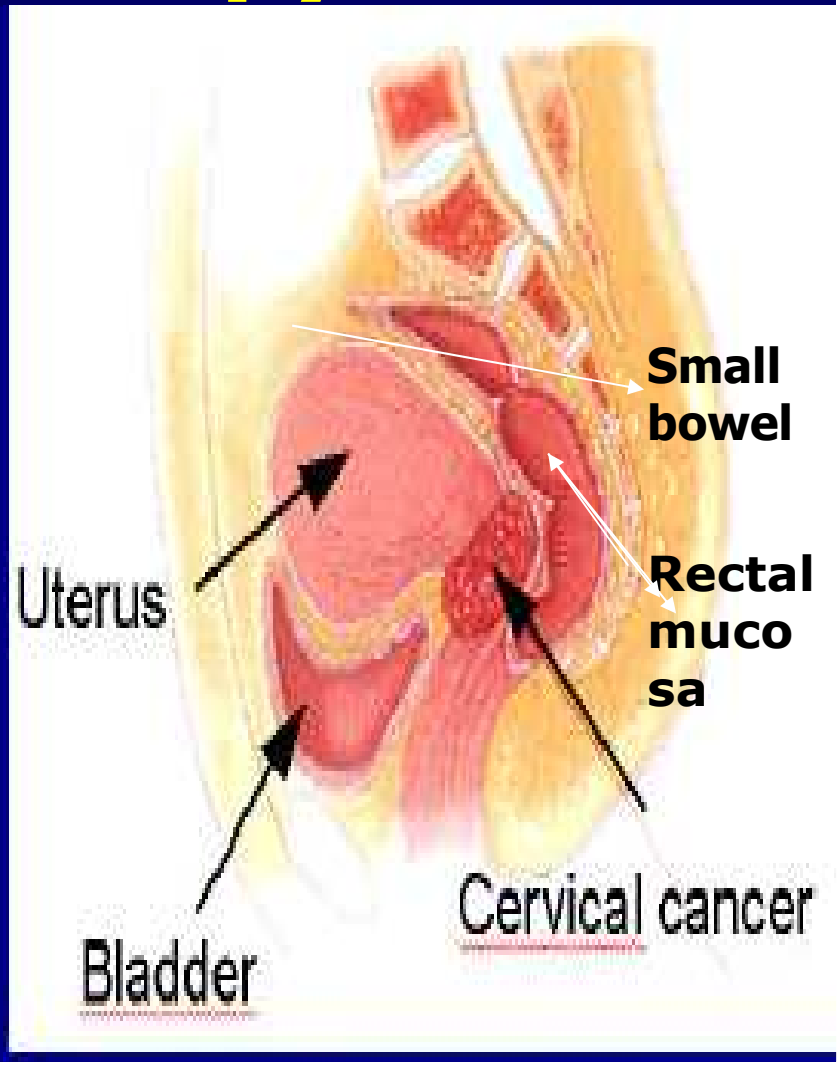
**Principles of ICRT**

**Principles of ISRT**

**Pre-requisites**

# Need of brachytherapy

- tolerance of target organ
- limitations of EBRT
- produce ideal dose distribution in volume of interest
- shorter treatment time



# Indication

Radical

Boost

Palliative

# Contraindication

**Residual disease upto lateral pelvic wall.**

**Disease infiltrating rectovaginal septum and / or posterior bladder wall at the time of brachytherapy.**

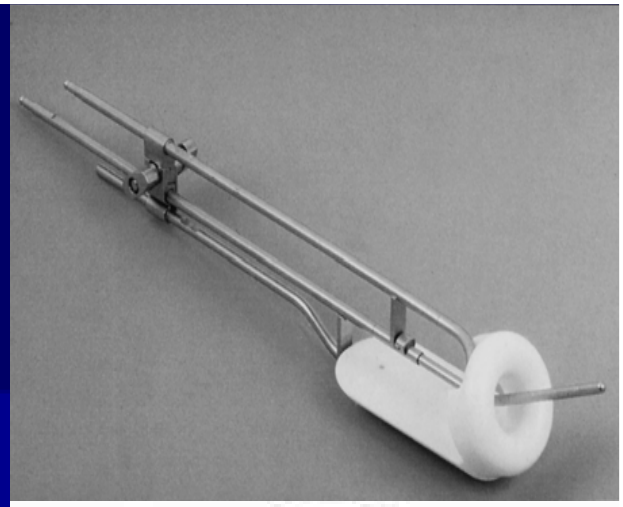
- **Intracavitary** – tandem based
  - vaginal cylinder

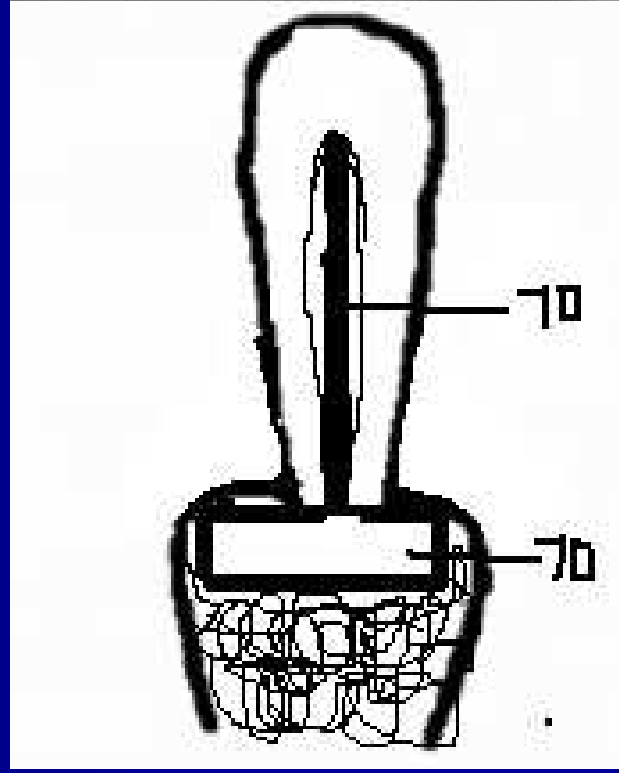
- **Interstitial** – different templates –
  MUPIT,
  Syed Neblett,
  Vienna app,
  Hamersmith Hedge Hog app,
  Queen Merry Hospital app

# Intracavitary Radiation Therapy

# Stockholm System

- Forsell and Heymen (1914)
- preloaded uterine tube & vaginal silver box
- applicators not fixed
- 2-3 insertions, 3 weekly, each 20-30 hr
- 6500-7100 mg-hrs,
  4500 mg-hrs in vagina.



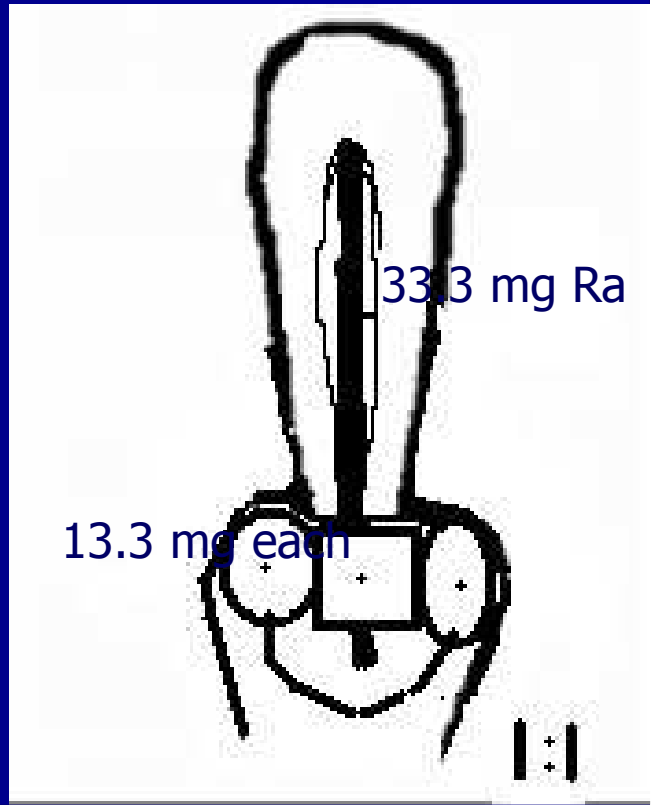



**Fractionated treatment**

# Paris system

- **Regaud (1926)**
- **Cork applicator**
  **- preloaded uterine tube**
  **- three vaginal corks**
- **Single application**
- **5 days to deliver 7200-8000 mg-hrs.**

**Applicator design**



# Need of New System

- Limited use of EBRT.
- Dose prescription in terms of mg-hr; ignored anatomical targets and organs at risk.
- When intracavitary therapy specified in terms of mg-hr used in combination with EBRT prescribed in terms of absorbed dose, overall radiation treatment can not be adequately defined.

# Manchester System

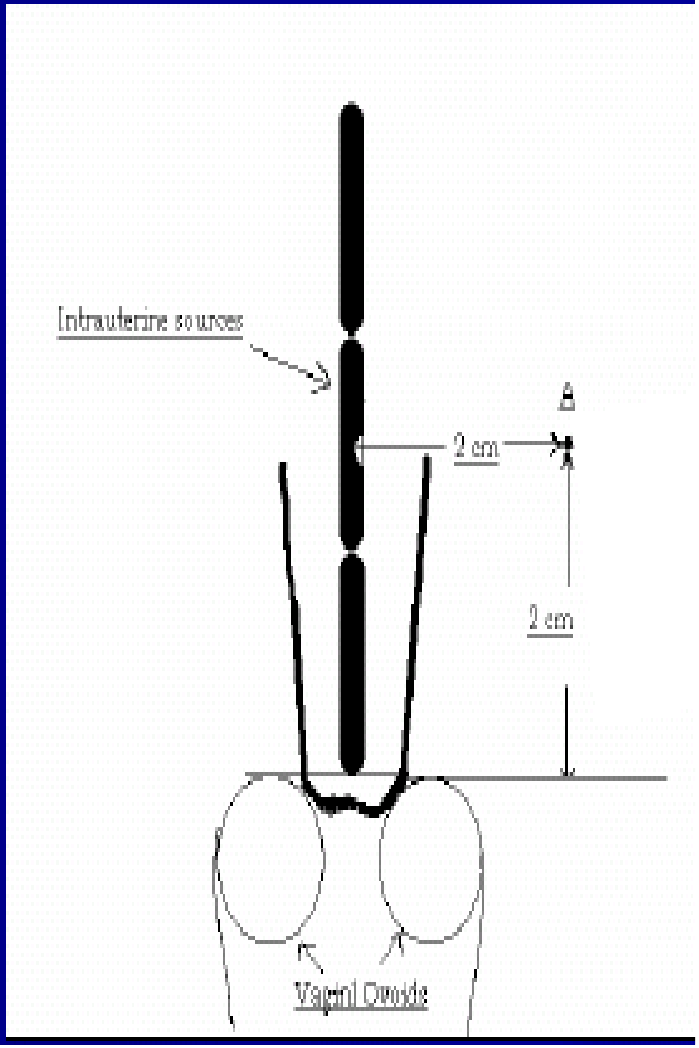
- **Todd and Meredith (1930).**
- **Modification : the Paris system (source loading) and Stockholm system (fractionated delivery of dose ).**
- **Calculate dose in Roentgen to various points in pelvic region where dose variation was not rapid and at which exposure dose should be stated and measured.**

# 4 steps -

1. Define point
2. Applicator design
3. Loading and dose specification
4. Procedure

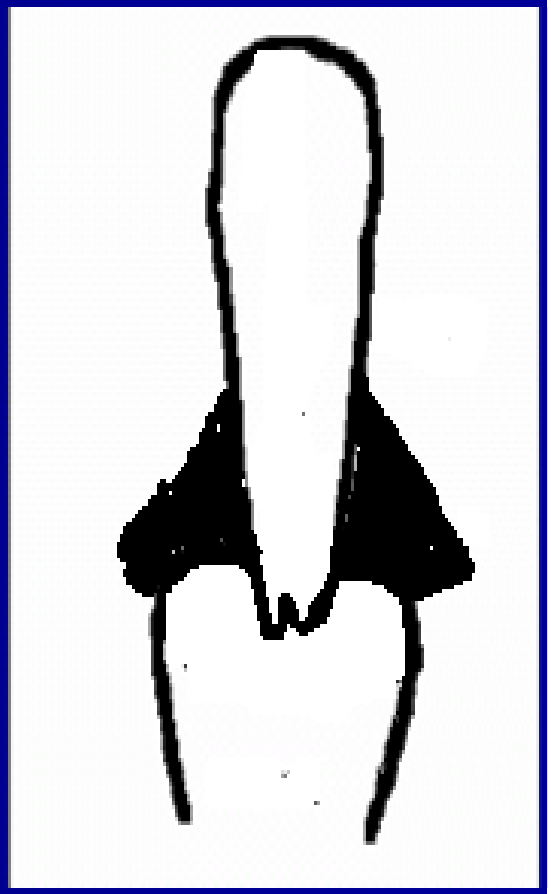
# First step

- To define treatment in terms of dose to a point representative of target, more or less reproducible from patient to patient.
- Original point A - 2 cm lateral to uterine canal and 2 cm from mucous membrane of lateral fornix of vagina in the plane of uterus.



# Why point A?

- Paracervical Triangle , pyramid shaped area - medial edge of broad ligament where uterine vessels cross the ureter. radiation necrosis
- Tolerance of this is the main limiting factor in irradiation of uterine cervix.
- Dose rate at this point is not too sensitive to small variations in applicator position.



# Second step

## Applicator design

- To fit range of vaginal and uterine size met in practice.

- Thin rubber or plastic tubes/ ovoids.

# Intra uterine tubes

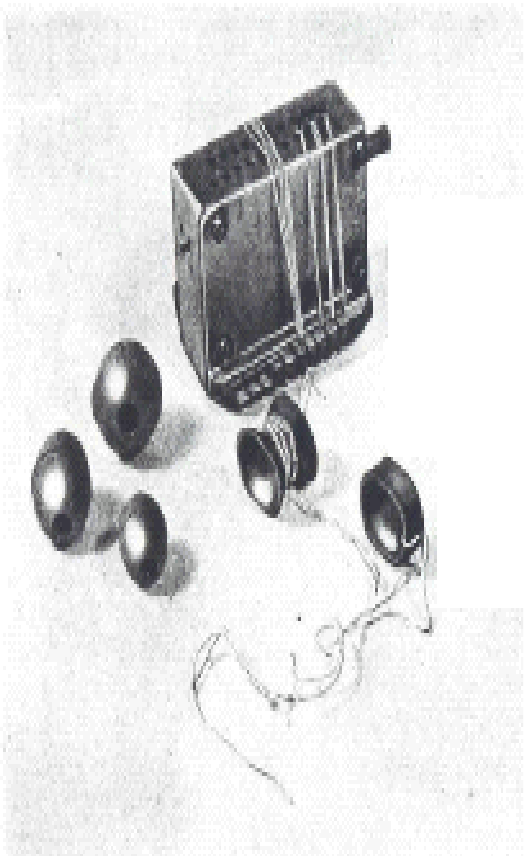
- Closed at one end and have flange at another end for aiding fixation.
- Available in three lengths,2 cm, 4 cm and 6 cm, meant for one, two and three radium tubes resp.

# Vaginal ovoids

- **Shape** is based on isodose curves around a radium tube of 1.5 cm active length.
- Diameter ….2, 2.5, 3 cm.
- Used in pairs.
- Inserted in vagina, one in each lateral fornix at level of cervix .
- Locked in position

….Either by **SPACER** ….which fixes them 1 cm apart.

….Or by **WASHER** ….which allows them to lie almost in contact.



# Third step

- To devise loading to enable same exposure rate to be attained, at point A, regardless of which applicators are used.
- Dose specification.

# Exposure and absorbed dose

- **Absorbed dose in rad =**

  **exposure in roentgen x f**

**f = 0.957, for soft tissue and radium gamma rays or for gamma rays from any other sources likely to be used.**

# Radium sources and their loading

- **1 Unit of radium was defined as 2.5 mg of radium with 1 mm platinum filtration.**
- **All loadings in intrauterine tubes and vaginal ovoids were made integral multiples of this unit.**

## Manchester System cont ……

| Intrauterine applicators | Loading in terms of units Cx to fundus | | Vaginal ovoids | Loading in terms of units (In each) |
|---|---|---|---|---|
| Large 6 cm | 4-4-6 (10-10-15 mg) | | Large 3 cm | 9 (22.5 mg |
| Medium 4 cm | 4-6 (10-15 mg) | | Medium 2.5 cm | 8 (20 mg) |
| Short 2 cm | 8 /10 (20mg) | | Short 2 cm | 7 (17.5 mg |

# Dose specification

- Optimal total dose to point A: 8000R (4000 Rx2) (72.8Gy)
- 1-2 sessions
- Each of 72 hr duration
- ~ 1 week (4-7days) apart.
- Dose rate 55.5 R per hour.
- Not more than 1/3rd of total exposure rate at point A should be delivered from vaginal radium.

# Fourth step -

- Method of application

Step 4 cont…….

## Manchester System cont ……

- **Pre-op investigations and preparation of patient.**
- **Knee-chest position on operating table.**
- **IV anaesthesia.**
- **C & D.**
- **Sim's speculum inserted….posterior vaginal wall pulled up.**
- **Cx canal searched for & slightly dilated & uterine length measured.**

Step 4 cont…….

- **Estimate size of paired ovoids.**
- **Load uterine tube with correct no. of units & insert with flange at os.**
- **1st ovoid ⟹ L-shaped retractor ⟹ Spacer / washer ⟹ 2nd ovoid.**
- **Ovoids rest on anterior vaginal wall.**
- **Posterior vaginal packing with radio-opaque gauze.**
- **Patient catheterised …. Bladder drill.**

Step 4 cont…….

- **Rectal probe with scintillation counter**

  ⟹ **max reading on rectal mucosa obtained**

  ⟹ **if excess, Radium removed and repacked.**
- **Procedure 15 min.**
- **Anteroposterior and lateral *X-rays***

  ⟹ **position of radium tubes is checked.**

# Treatment schedule :

- Radium alone *Stage I & II*

  4000 R at pt A in 3 days – rest 4 – 7 days- 4000 R at pt A in 3 days

- Ra X-ray R *stage III*

  3500/3750 R in 3 days- Xray 2500rad 3 wk kV/Xray 3000R 3 wk MV-3500 R in 2-3 days/Ra 3750 R in 3 days

- X-ray Ra Ra *stage III*

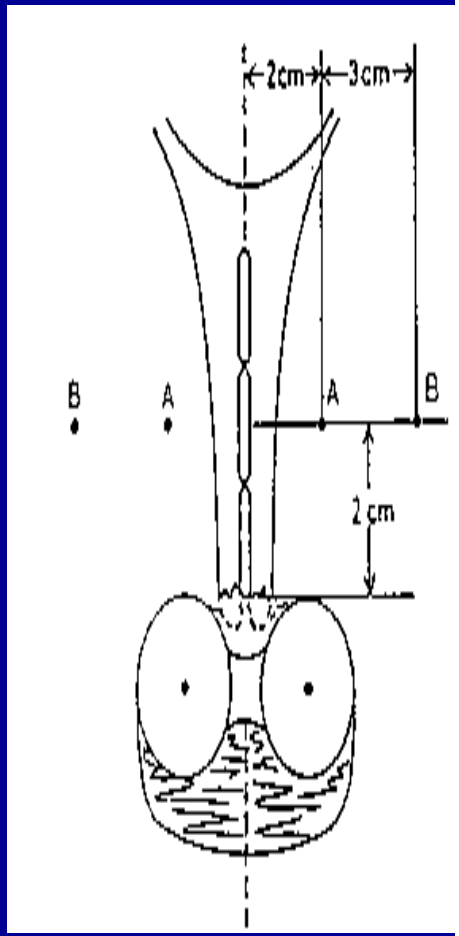
  Xray 25000(kV)/3000(MV) rad 3 wk

  ICRT…..3250 R 2-3 days - 4 days rest- 3250 R 2-3 days

# Dose at other points:

## Point B

- Is at same level as point A, but 5 cm from the midline.
- Is in proximity to obturator nodes.
- Indicates rate of fall-off of dosage laterally.
- Dose to point B is ~ 20-25% of dose at point A.
- Depends upon total amount of radium used



# Rectovaginal septum at level of cervix

- Dose there should not exceed that at point A .
- At least 1.5 cm of well packed gauze should be between ovoids and septum.

# Maximum permissible dose

- Point A : 8000 R.
- Vaginal mucosa : 2000-2500 R.
- Rectovaginal septum : ~ 6750 R.

# Remember

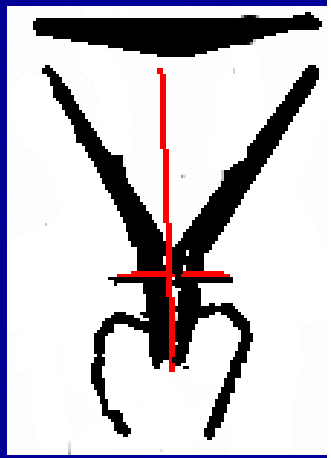
- Increase colpostat diameter……..
  Decrease vaginal surface dose.
- Increase tandem length ……..
  Increased point B contribution.
- As size of ICA applicator increases, penetration or lateral throw off of dose distribution increases.
- Always, use longest tandem and largest colpostat that patient's anatomy can accommodate.

# Drawbacks of point A

- It relates to **position of sources** and not to specific anatomic structure.
- It is very sensitive to **position of ovoid sources** relative to tandem sources which should not be determining factor in deciding on implant duration.
- Depending on **size of cervix**

  point A may be inside or

  outside of tumor.

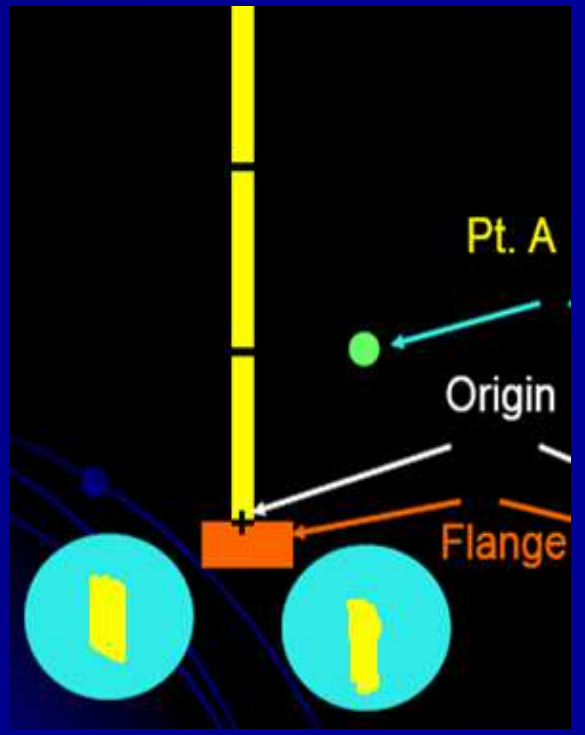


# Manchester system : most acceptable

- concept of specification of dose to a single point.
- Source loading rules were defined in a way that point A receives same dose rate no matter which ovoid and intrauterine combination is used.
- In place of 226Ra,radium substitutes can be used with appropriate correction factors applied.

# Revised point A

- Although point A was defined in terms of important anatomical structures, these can not be revealed on a radiograph.
- So point A definition was modified in 1953.
- "2 cm superior from lower end of central radium tube and 2 cm lateral from uterine canal in radiograph of radium insertion."



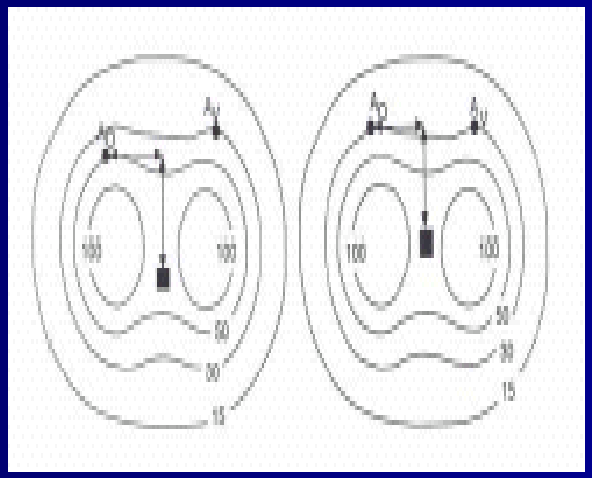

Tod et al(1953)Br J Radiol,26,25

# Other dose specification points as variation of point A

- **Point Av :**

  'v' for vagina

  Potish 1987

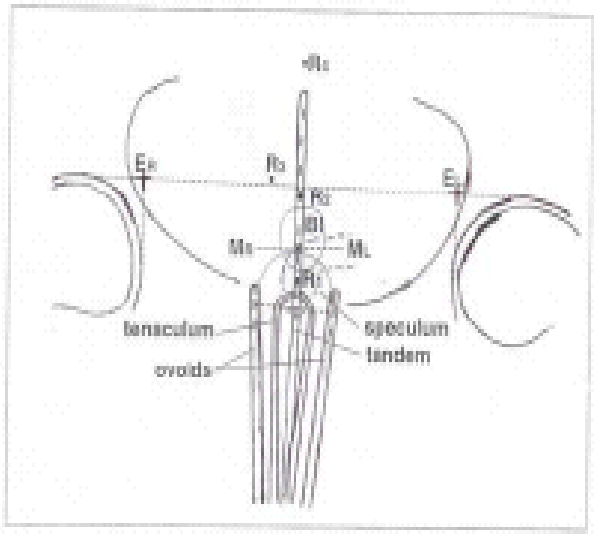


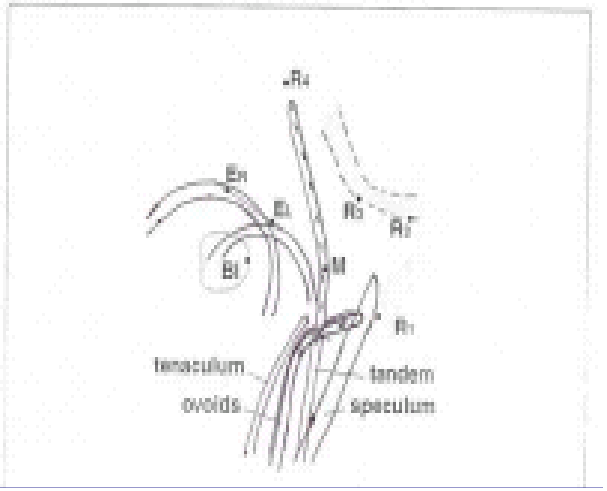
- **Point M:**

  Madison system

  lower small bowel dose

  judith a stitt, i j r o b p, 1992,24(2)



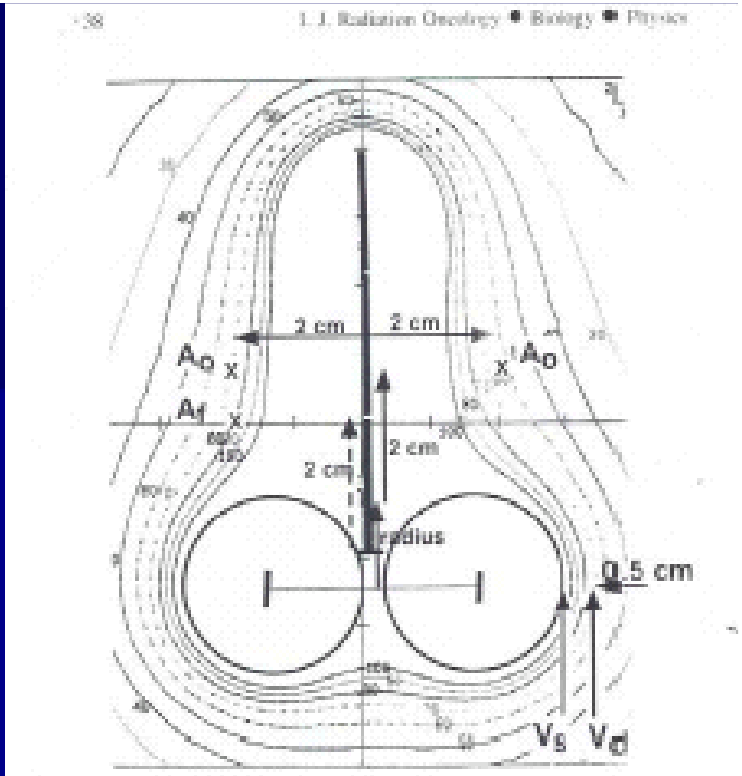



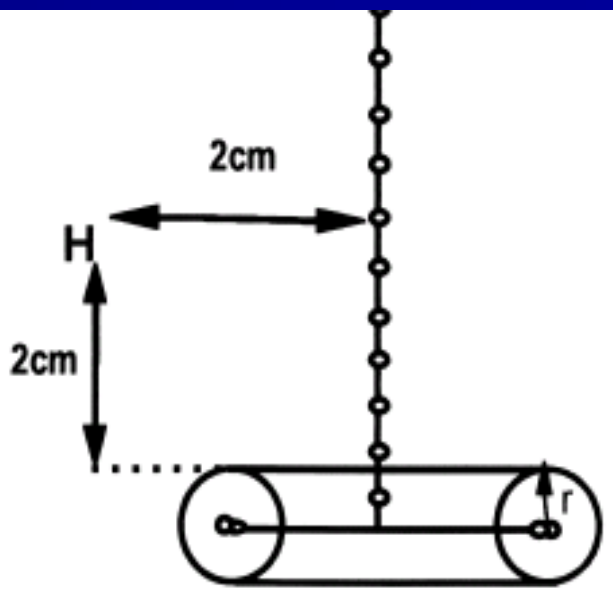
# ABS point A

- Draw a line connecting middle of sources in vaginal ovoids on A-P radiograph and move 2 cm plus the radius of ovoid superiorly along the tandem from intersection of this line with intrauterine source line and then 2 cm lateral on either side of the tandem.

..... **POINT H**

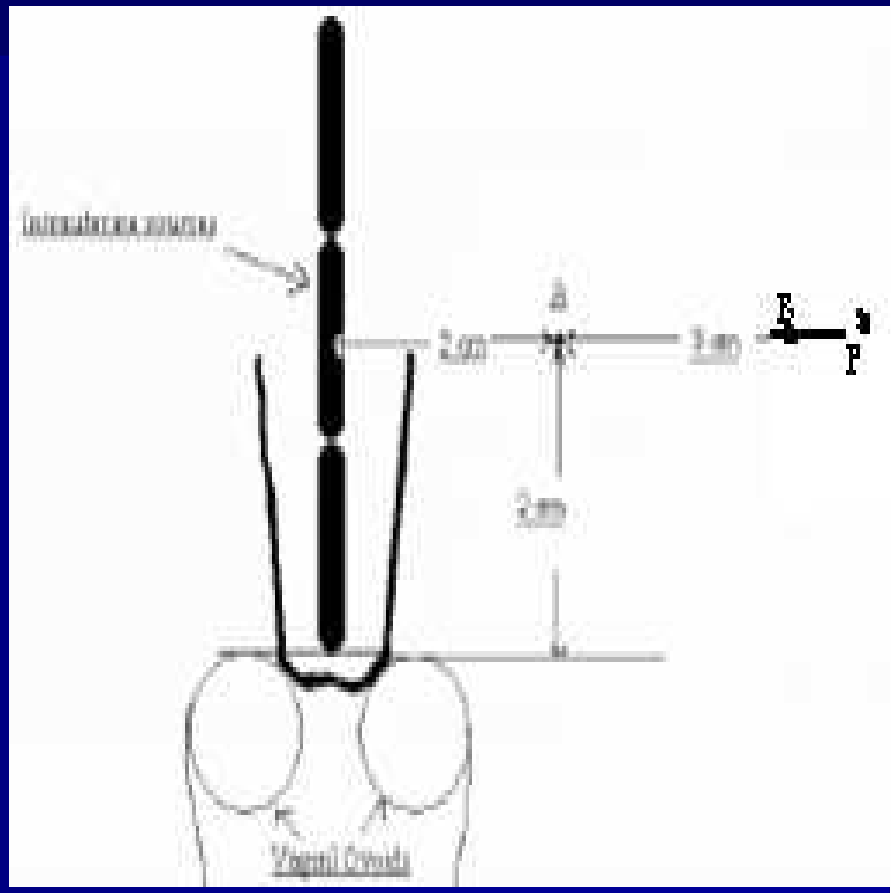
IJROBP.48(1),201-11,2000



# Point P

- is used by **Mallinckrodt Institute of Radiology System** to specify minimum dose to **pelvic lymph nodes.**
- It is 6 cm to Rt and Lt of patient midline in same plane as of classical point A.



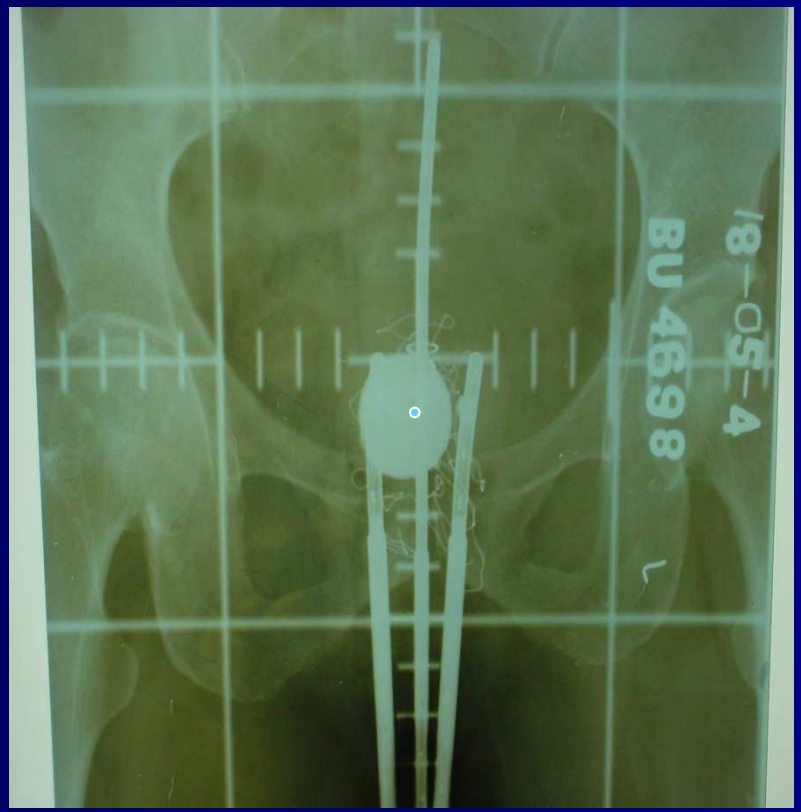
# Radiographic localization

- Foleys bulb in trigone of **bladder** with 7cc (2+5) dilute contrast medium: this location does not represent hottest part of bladder.
- **Rectum** : localization with

| | |
|---|---|
| Radio-opaque qauze | Dilute barium |
| Rectal marker | ICRU rectal point |
| Detector to measure rectal dose | |

- Non of these localizes small bowel, organ at very much risk
- Intracavitory brachytherapy source localization with radiograph is **easy, clear and accurate**. For this radiograph is unmatched.

# Orthogonal X-rays



# Ideal insertion

- **AP view –**

**Tandem midline, unrotated**

**Tandem midway between coplpostats**

**Flange in close proximity to markers placed**

**Colpostats high in fornices along cervix, ideally ~ 1/3$^{rd}$ above flange**

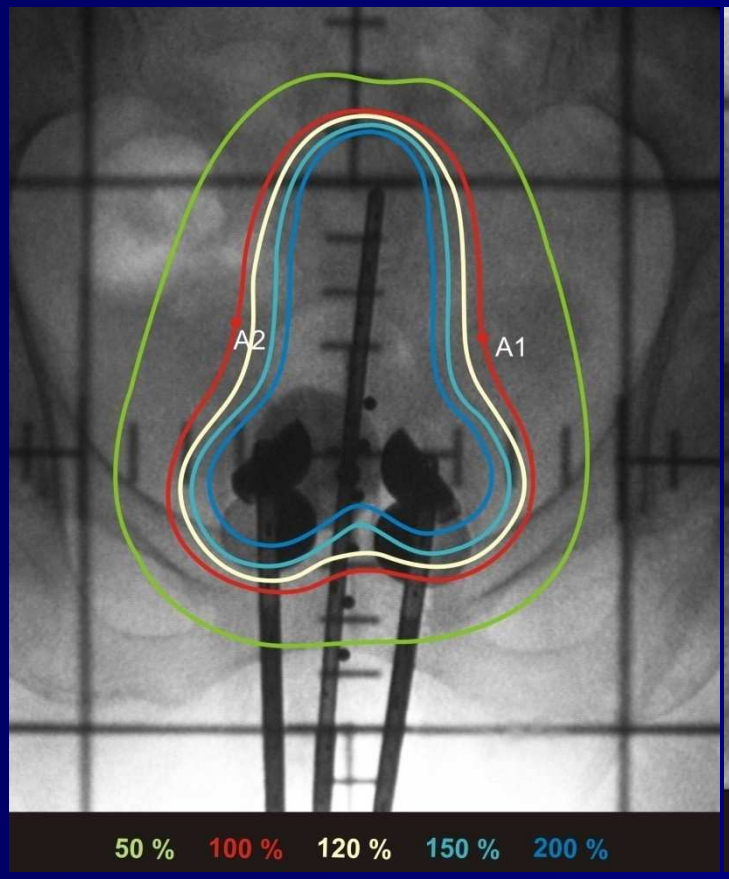
- **Lateral view**

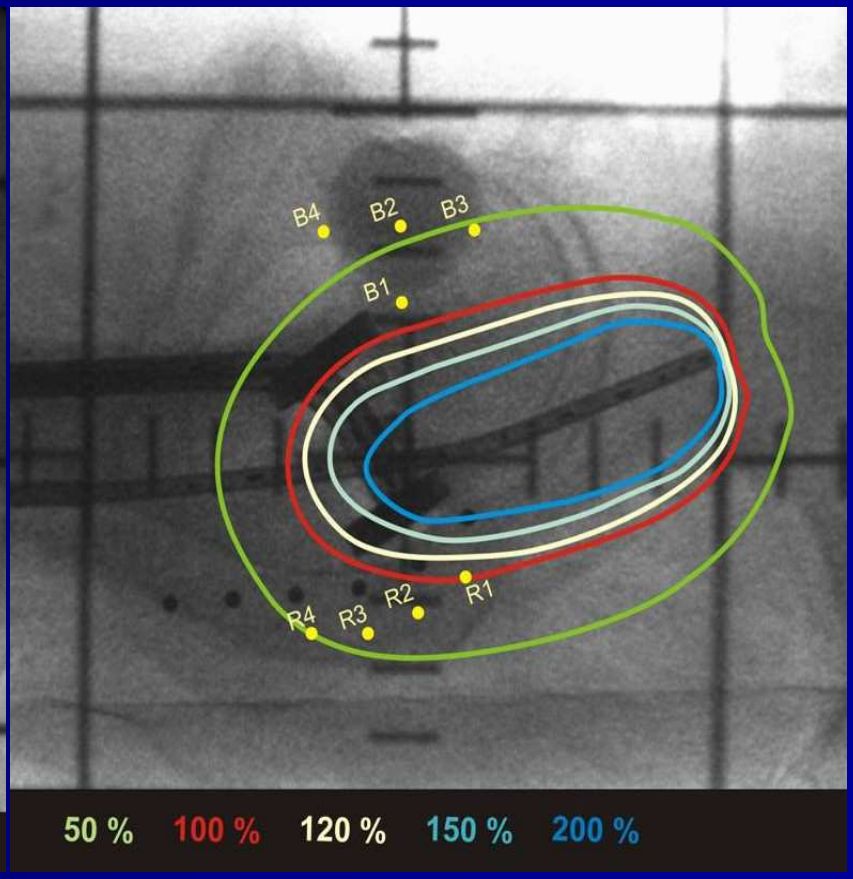
**Tandem bisects the colpostats**

**Sufficient anterior and posterior packing**

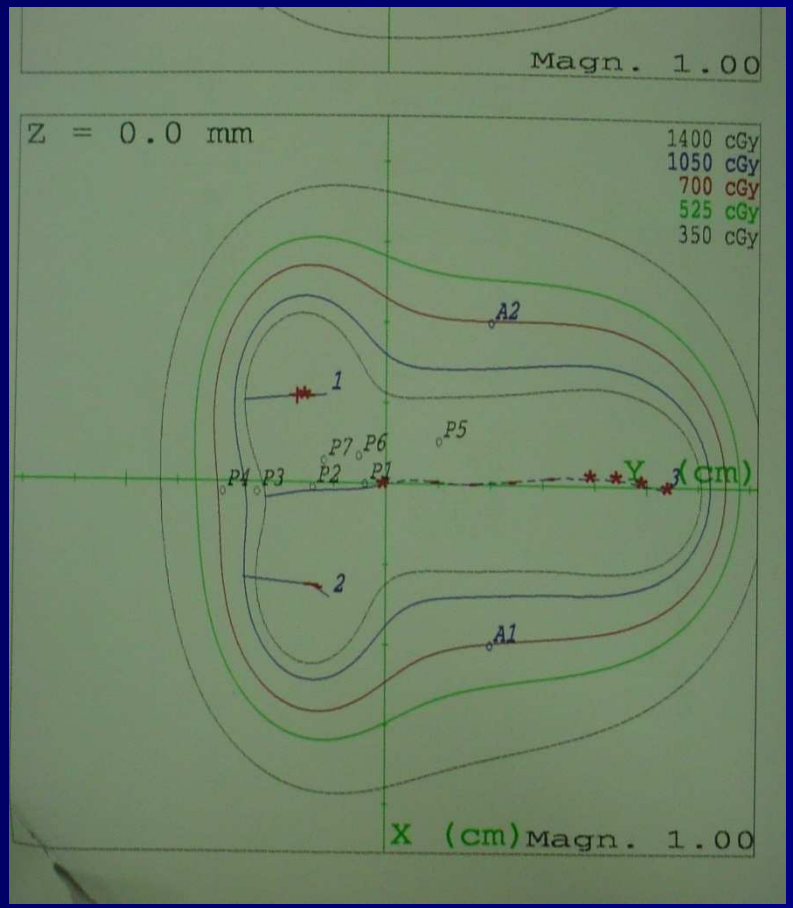
**Foley balloon firmly tugged down.**

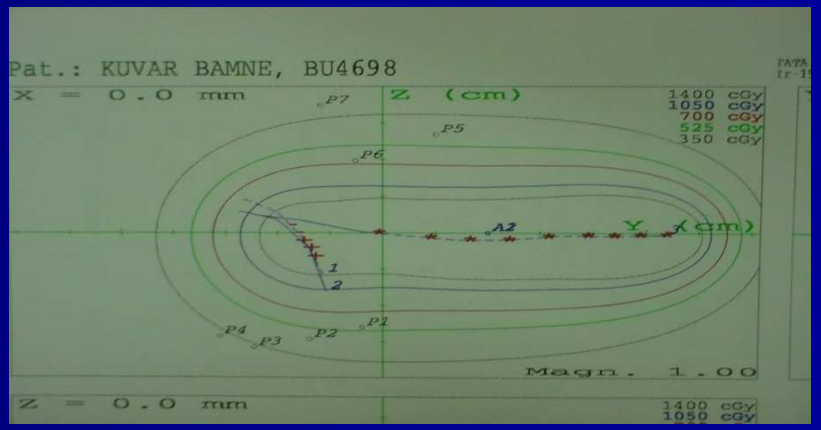
# Orthogonal Xrays with isodose curves

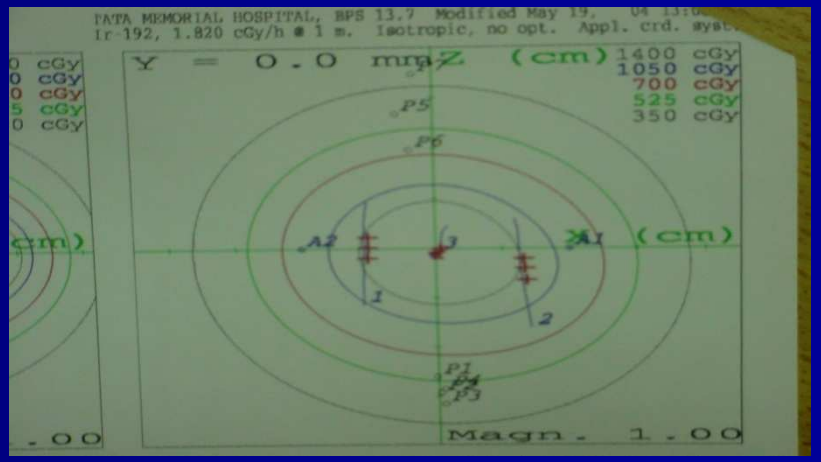


# Isodose curves



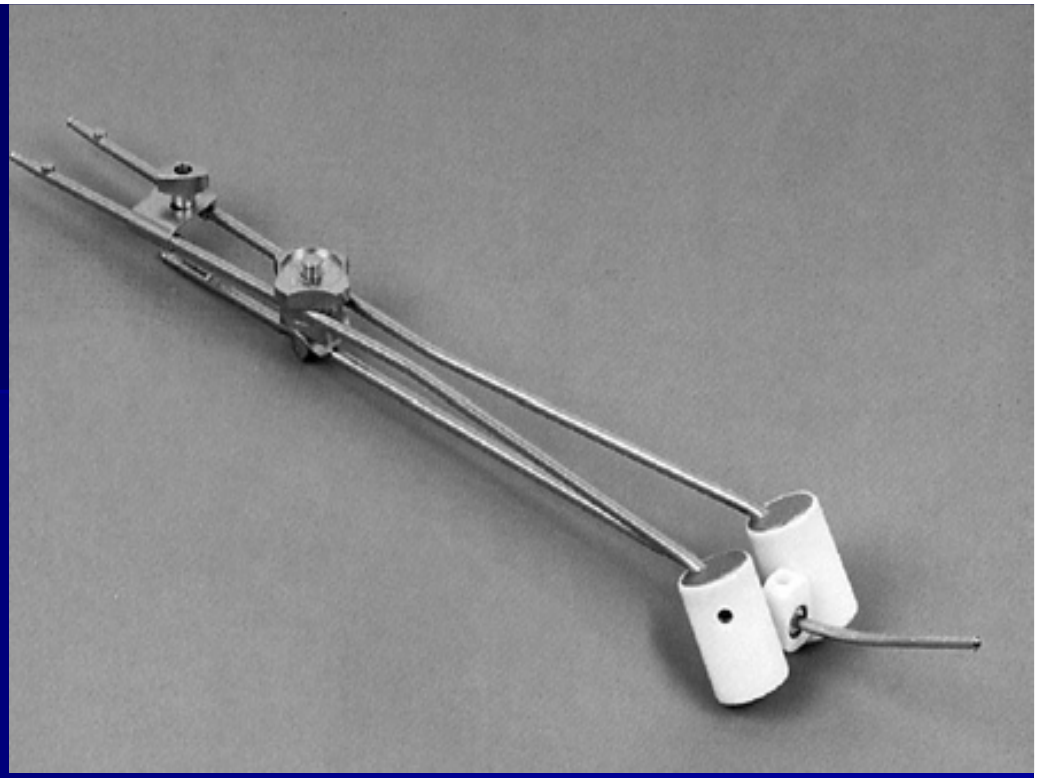



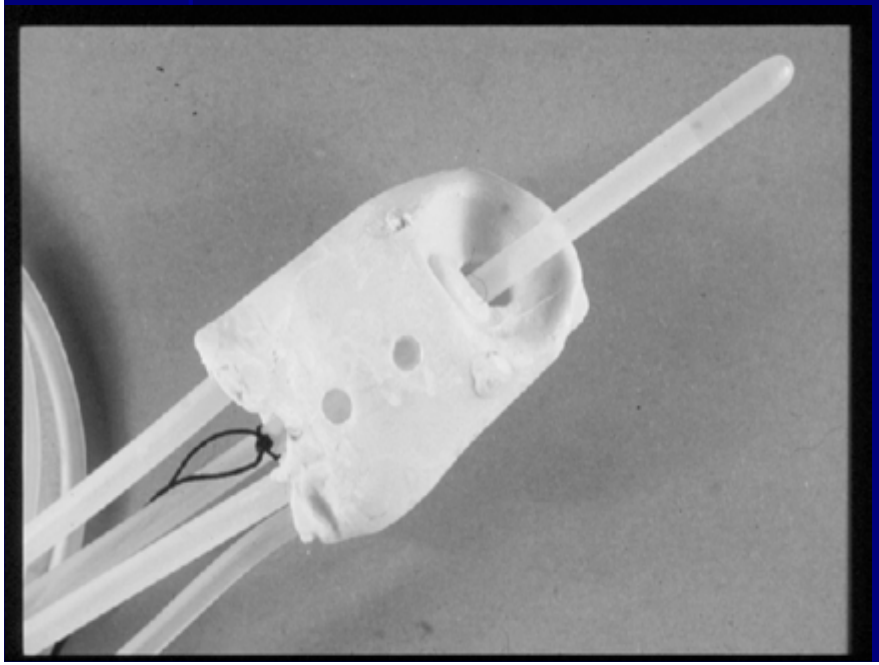
# Data needed for reporting intracavitary therapy in gynecology according to ICRU 38 :

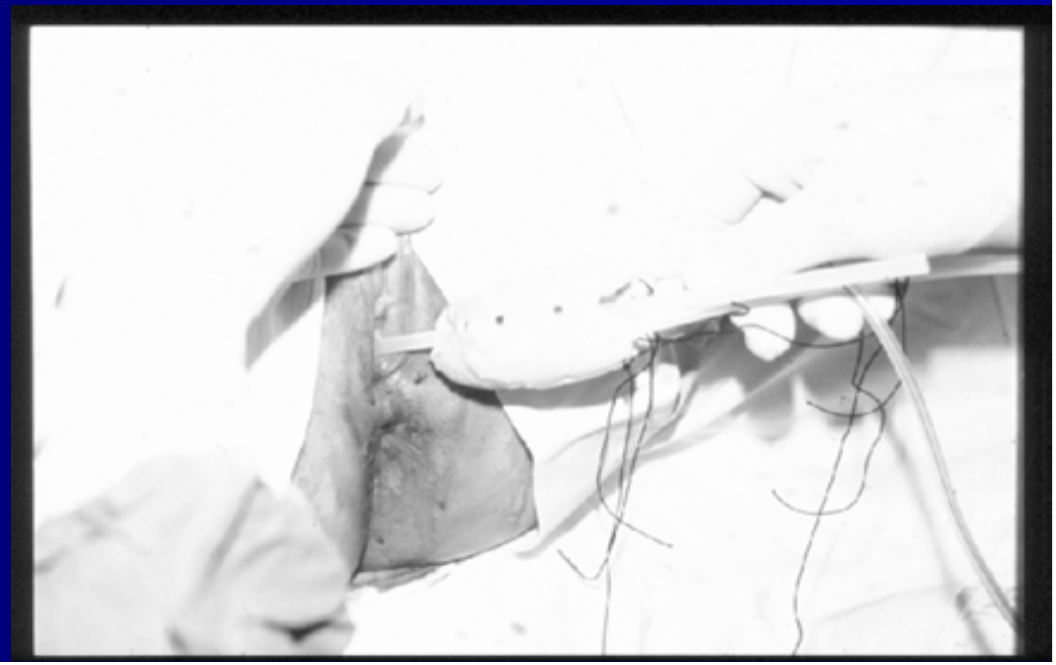
- Description of the technique used
- Total reference air kerma TRAK(cGy at 1 m )
- Description of dose reference volume
  - dose level if not 60 Gy
  - dimensions of reference volume
- Absorbed dose at reference points
  - Bladder reference point
  - Rectal reference point
  - Lymphatic trapezoid
  - Pelvic wall reference point
- Time –dose pattern

# *Fletcher based Technique*



# *Moulded Applicator (Moulage)*





# Non standard insertions:

- **Single short intrauterine tube**

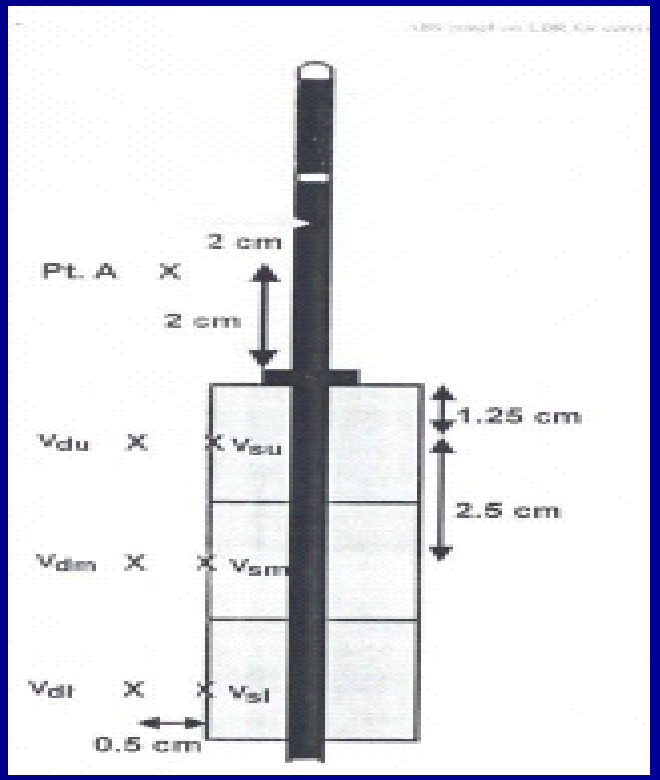
  **E g -uterine canal not found and applicator in cavity lined by tumor. Uterine tube underloaded with 8 units. Reduced exposure rate to point A is accepted.**

- **Narrow vagina –**

  **ovoids are placed one below the other in vagina with upper ovoid having its centre at level of intrauterine tube and are oriented so that radium tubes are parallel to vaginal axis.**

- **tandem and vaginal cylinder** ……point A : from the flange of the tandem move 2 cm superiorly along the tandem and then laterally 2 cm perpendicular to the tandem on both sides on A-P radiograph.

ABS recommendation

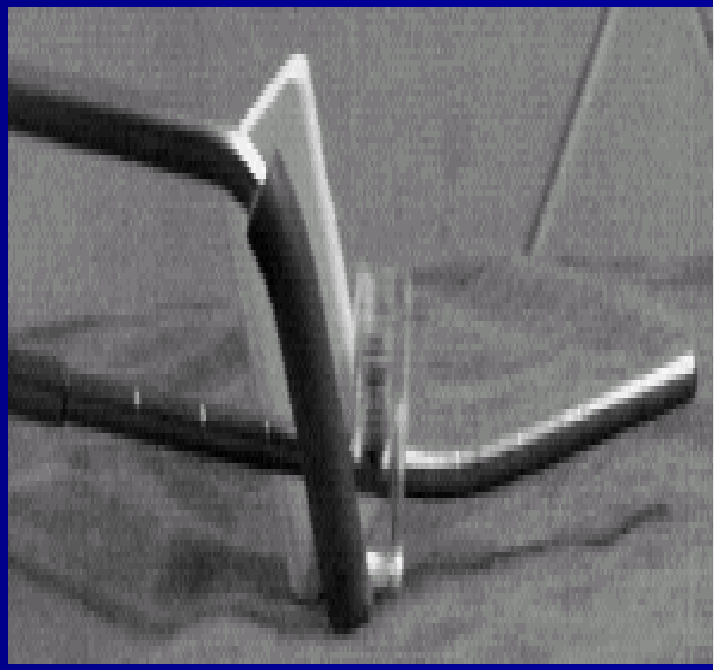


- **NARROW VAGINA**
  **…single ovoid**

  **Vaginal capacity at level of external os less than 3.7 cm….**

  **Use single ovoid.**

  **i e modified HDR intracavitary technique.**



**Brachytherapy (2) 2003,246-48 Vinay S, Umesh M**

# ABS HDR

- Point A dose- 80-85% early stage, 85-90% late stage – LDR equivalent
- Rectum < 75 Gy, Bladder <80 GY – LDR equivalent
- Treatment time < 8wk

Brachytherapy 2012;11(1):47-52

# Drawbacks of 2D planning

- Limitations of point A based dosimetry
- Target volume assessment
- Delineation of OAR

# Image based 3-D treatment planning

- Goals of imaging : to determine relation between source position, target, organ at risk.

- Imaging modalities used for Image Based ICRT planning :

  USG

  CT scan

  MRI

  PET scan

- **In this new post Radium, afterloading era MANCHESTER SYSTEM is still the best guide for intracavitary radiotherapy in carcinoma cervix.**

# Interstitial brachytherapy

- Edith Quimby- Quimby System
- R Paterson and H M Parker – Manchester system
- B Perquin and A Dutreix – Paris system

# Indications

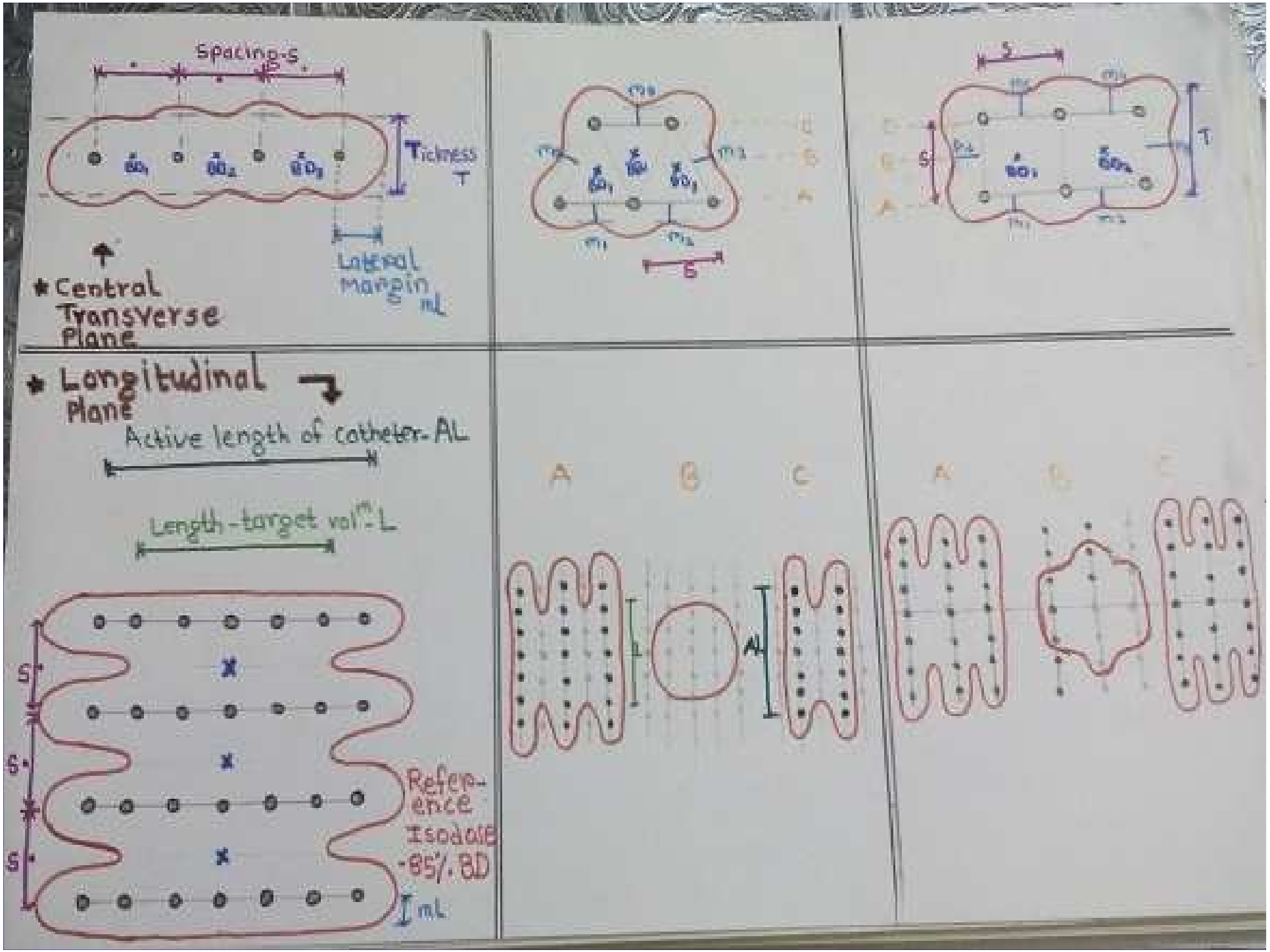
- Extensive parametrial disease
- Narrow and distorted vagina
- Post-hystrectomy recurrence
- Distal vaginal involvement
- Persistent disease after radical RT

# Paris dosimetry system

- LDR
- Wires of equal linear activity (Ir 192)or regularly spaced pellets (Cs 137) of equal linear activity
- Parallel catheters in single or double plane.
- Specifies the spacing between active lengths in the catheters.

# PDS rules

- S- 8-15 for short implant (AL</=4cm) , 15-22mm long implant
- T</=12mm- single plane implant – S~T/0.6, ml~0.35xS
- T>/=12mm-double plane- ▲ S~T/1.3, ms~0.2xS
  ■ S~T/1.57, ms~0.27xS
- AL = L/0.7 Ir wires  L/0.8 Ir pellets
- AL outside target to correct bending of reference isodose in between the catheter ends.
- Basal dose points are defined in the central transverse plane through the implant and are located midway between the catheters where the dose rate is lowest. BD is the mean dose at these dose points.
- Reference Dose is 85% of BD and it defines an isodose surface extending 0.5cm from the outer catheters


Spacing-S
Thickness T
Lateral margin mL
* Central Transverse Plane
* Longitudinal Plane
Active length of catheter-AL
Length-target vol-L
S
S
S
Refer-ence Isodose -65%. 8D
mL
A
B
C
A
B
C

# Stepping source dosimetry system (SSDS)

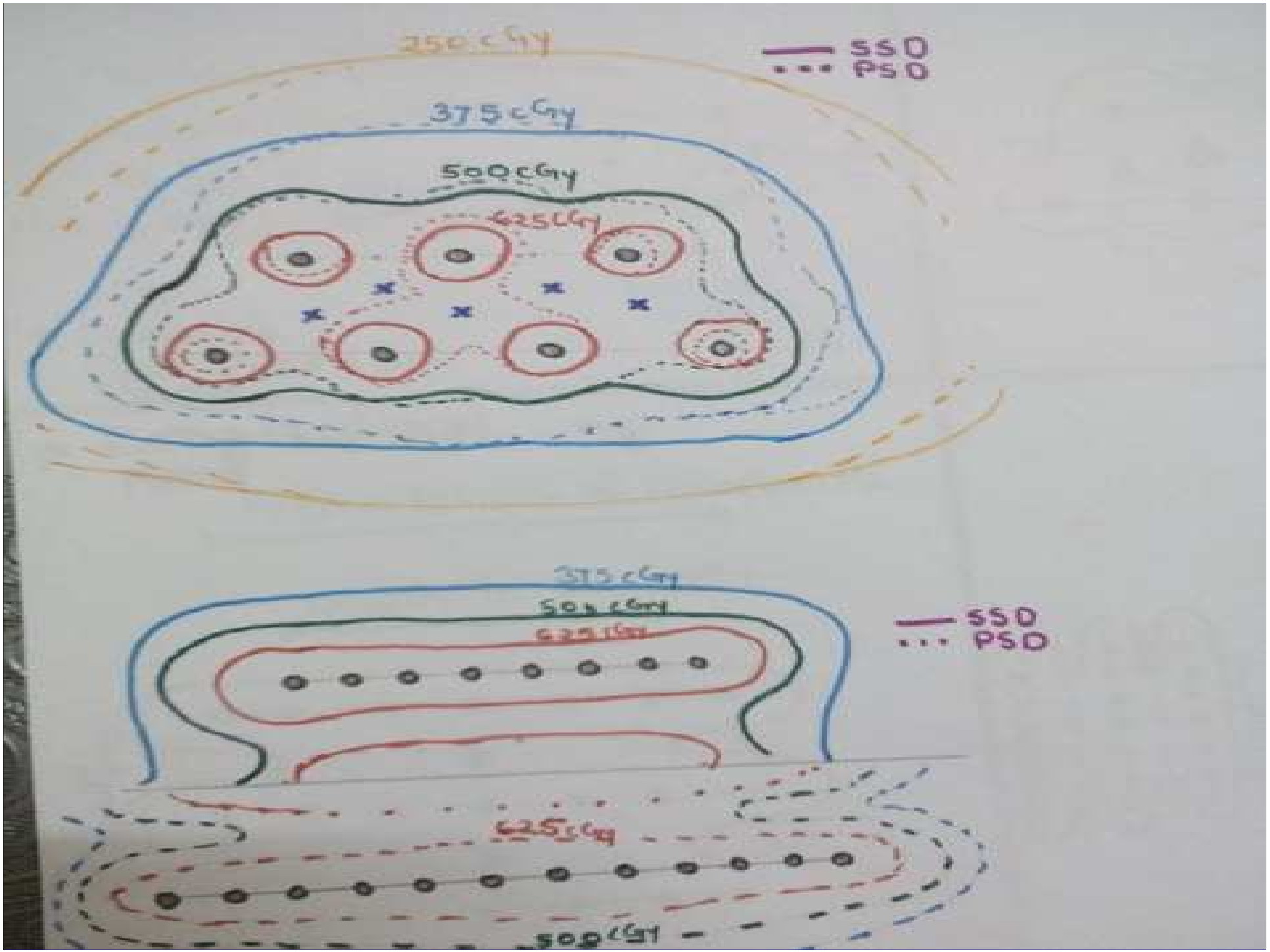
- a system to optimise implants with needles or flexible catheters with an HDR source stepping through them.
- Developed as an extension to PDS.
- PDS can be adapted to HDR by applying equidistant dwell positions with equal dwell times.
- DIFFERENCE – use of increased dwell time at the longitudinal ends of the implant to keep the active dwell positions inside the target volume. It also reduces the dwell time in the central part of the implant to increase the dose homogeneity across the taget.

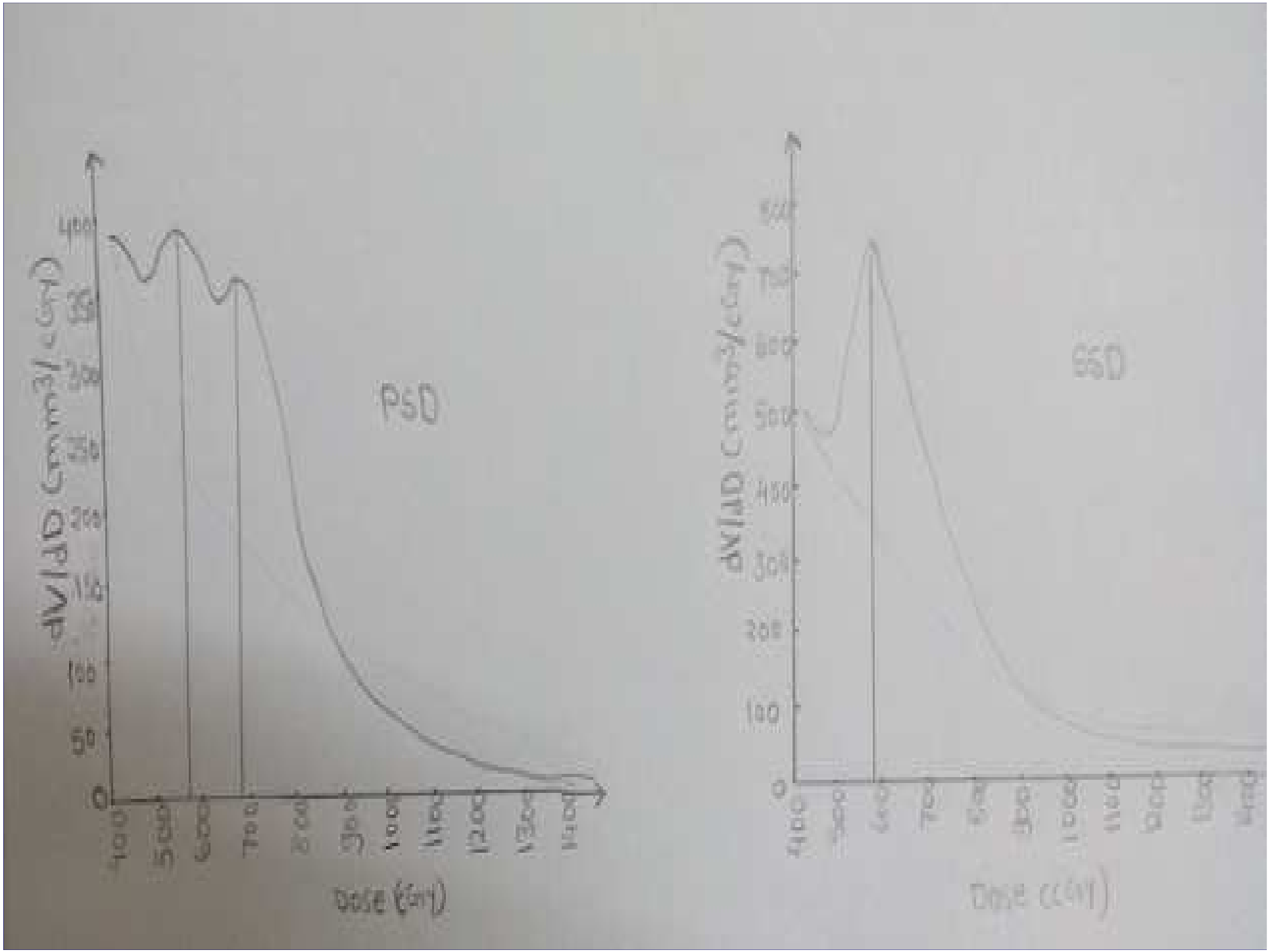
# SSDS

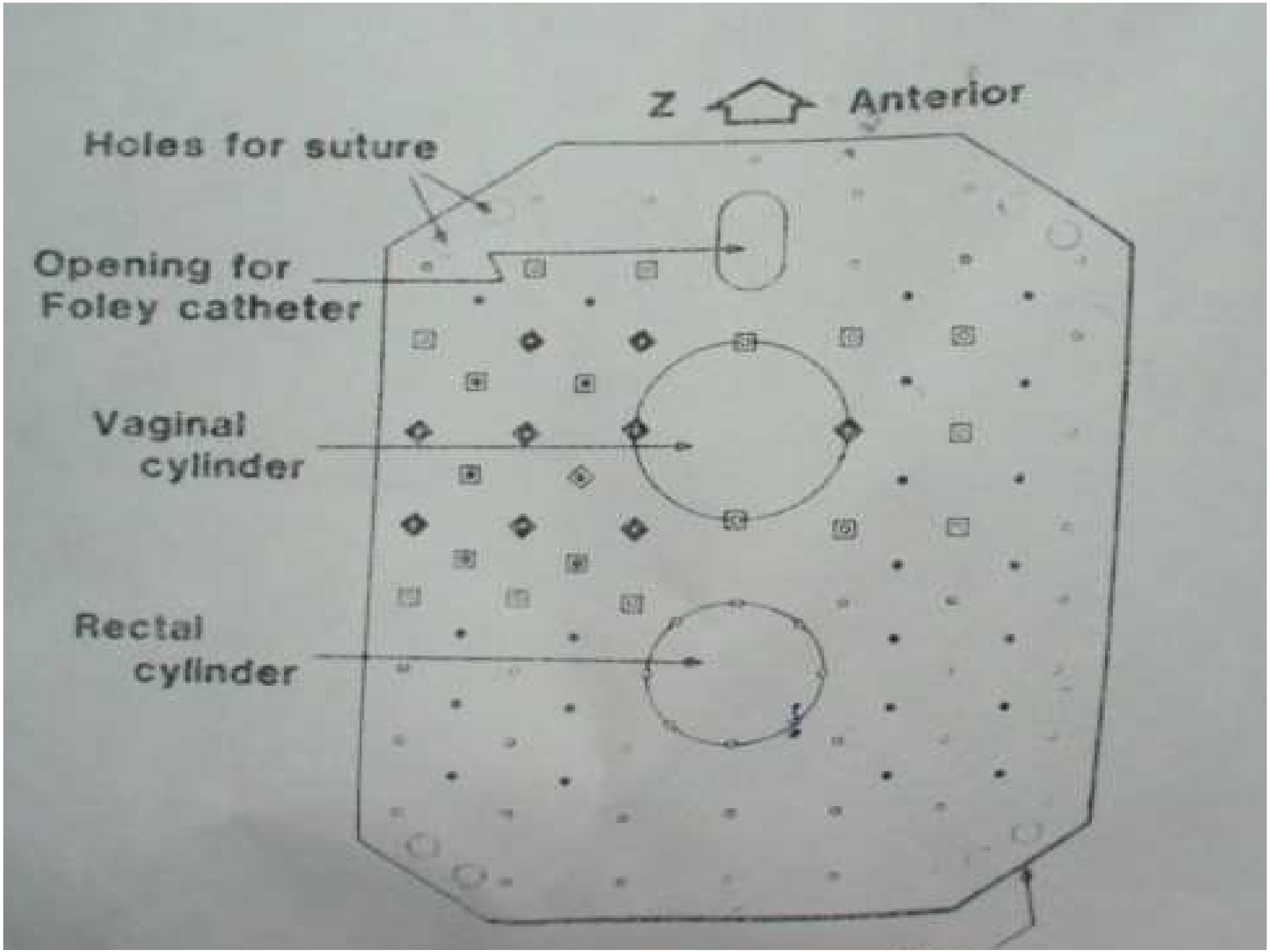
- Uses same rules as PDS except – AL ~ L*1cm
- Equidistant dwell positions.
- Optimised dwell time
- RD is 85% of mean dose in all dose points.

# Difference - SSDS and PDS

- Active length in catheters - 0.5cm vs 1.5cm
- Target volume and treated volume
- Dose homogeneity over the target volume.
- Reference dose
- Dose distrinution

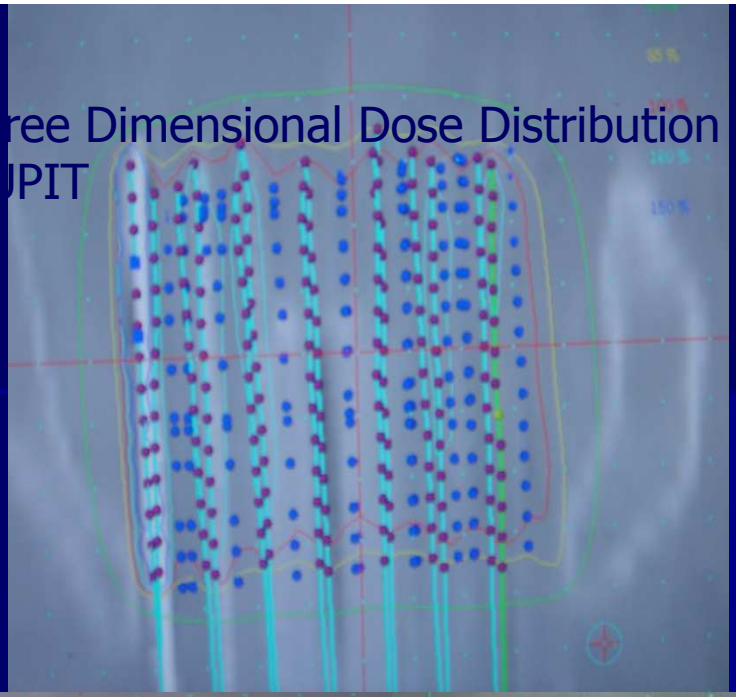

250 cGy
375 cGy
500 cGy
625 cGy
SSD
PSD
375 cGy
500 cGy
625 cGy
SSD
PSD
625 cGy
500 cGy

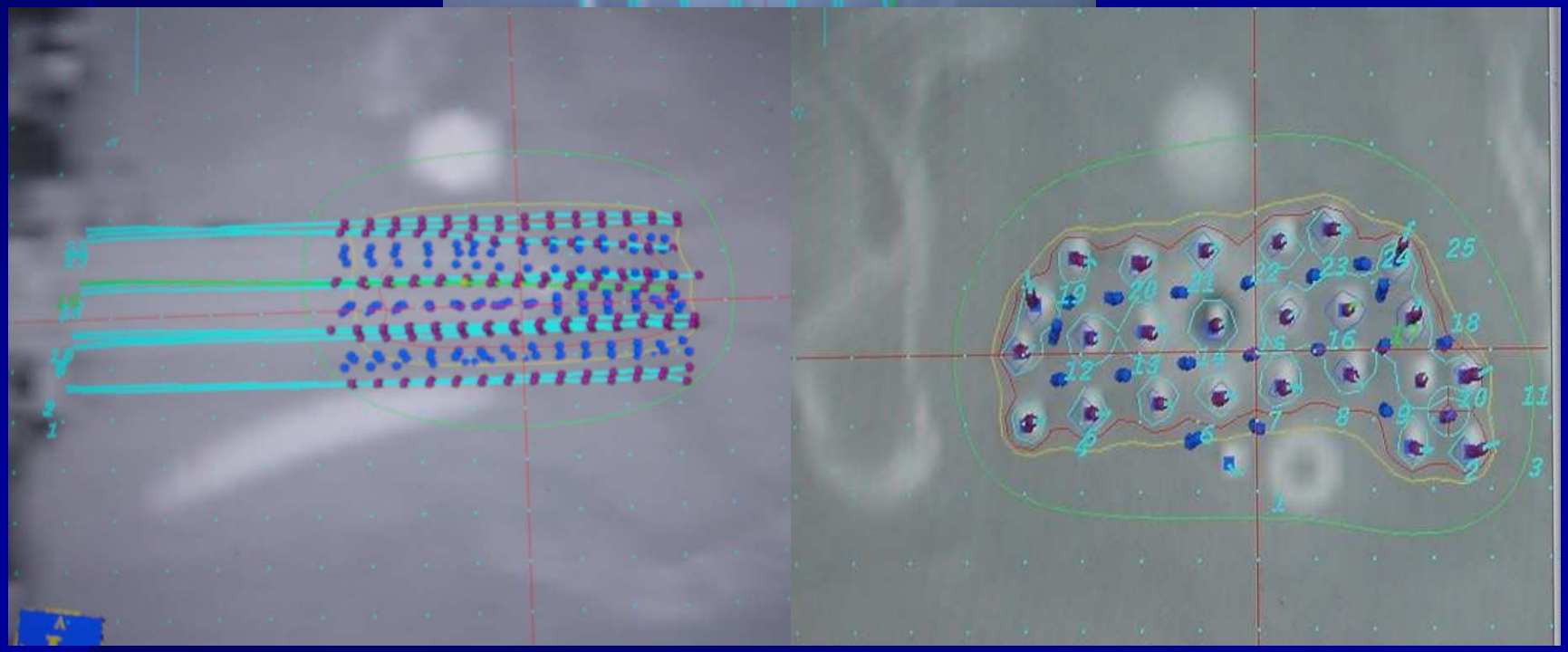

PSD
dV/dD (cm³/cGy)
Dose (cGy)
GSD
dV/dD (cm³/cGy)
Dose (cGy)


Z
Anterior
Holes for suture
Opening for
Foley catheter
Vaginal
cylinder
Rectal
cylinder

- Load the sources as per the planned volume to be implanted.
- Sources can be made active either in the step size of 2.5,5 ,10 mm.
- For smaller implants upto 10 cm in length step size of 2.5 mm may be used ( Source is allowed 40 stepping positions).
- However if the length is more than 10 cm a larger step size has to be employed
- Template holes at 11,12,1,5,6 clock should not be loaded to avoid hot spots in bladder and rectum.

# ree Dimensional Dose Distribution
UPIT





# Dose Evaluation in interstitial implant: ICRU 58

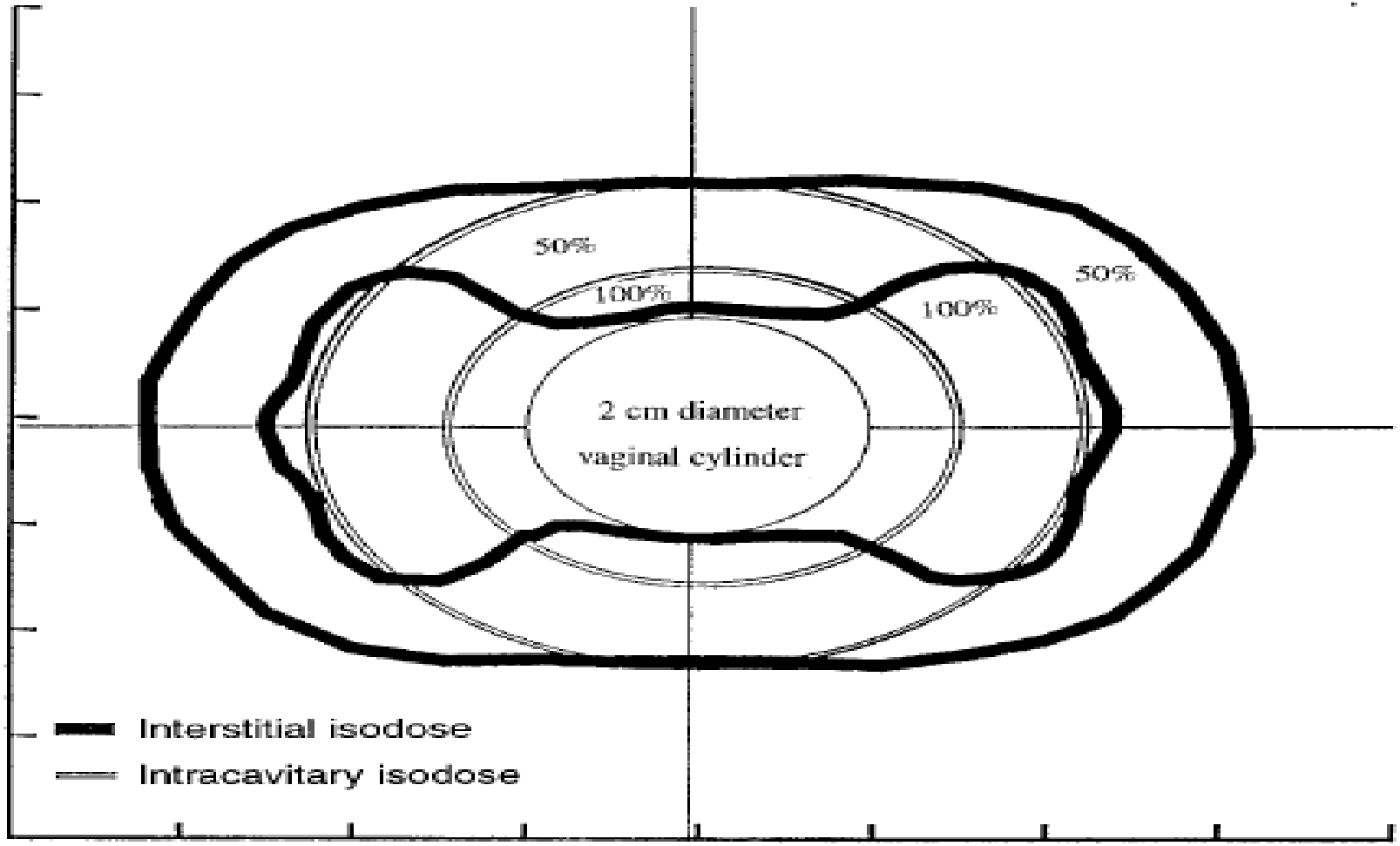
- Prescription Dose
- Mean Central Dose (MCD)
- Minimum Target Dose(MTD)
- High Dose Volume
- Low dose Volume
- Dose Homogeneity Index

# Qualitative assessment of Implants: ICRU 58

- Dose Homogeneity Index (ICRU 58)
- Dose Non Uniformity Ratio
- Coverage Index
- External Volume index
- Overdose Volume Index

# Reporting Interstitial Brachytherapy: ICRU 58

- Description of Volumes: GTV/CTV
- Description of sources:
- Radio nuclide, Type of source, Length, Reference air kerma
- Description of technique and source pattern.
- Description of time dose patterns
- Description of Prescribed dose, MCD,MTD, High dose, Low dose, dose uniformity data.


50%
100%
50%
100%
2 cm diameter
vaginal cylinder
Interstitial isodose
Intracavitary isodose

# Vaginal cuff brachytherapy

- ICRT /ISRT – depends on depth of vaginal wall invasion, distribution of disease

- Treatmet length

Upper ½ or upper 3/4$^{th}$

Papillary , serous and clear cell or extensive LVI – whole length of vagina

# Pre-requisites

- Knowledge of ca cervix biology and patterns of spread
- Basic knowledge of RT (EBRT + ICRT)
- Basic of ICBT/ISRT procedure and planning

# Conclusion :

- Brachytherapy is an integral part of treatment of gynecological malignancy.
- Manchester system is followed for ICRT.
- Paris system is followed for ISRT.
- Basic knowledge of disease biology, natural history of disease, brachytherapy planning and procedure is necessary for successful treatment outcome.


THANK YOU