Planning of Interstitial Brachytherapy

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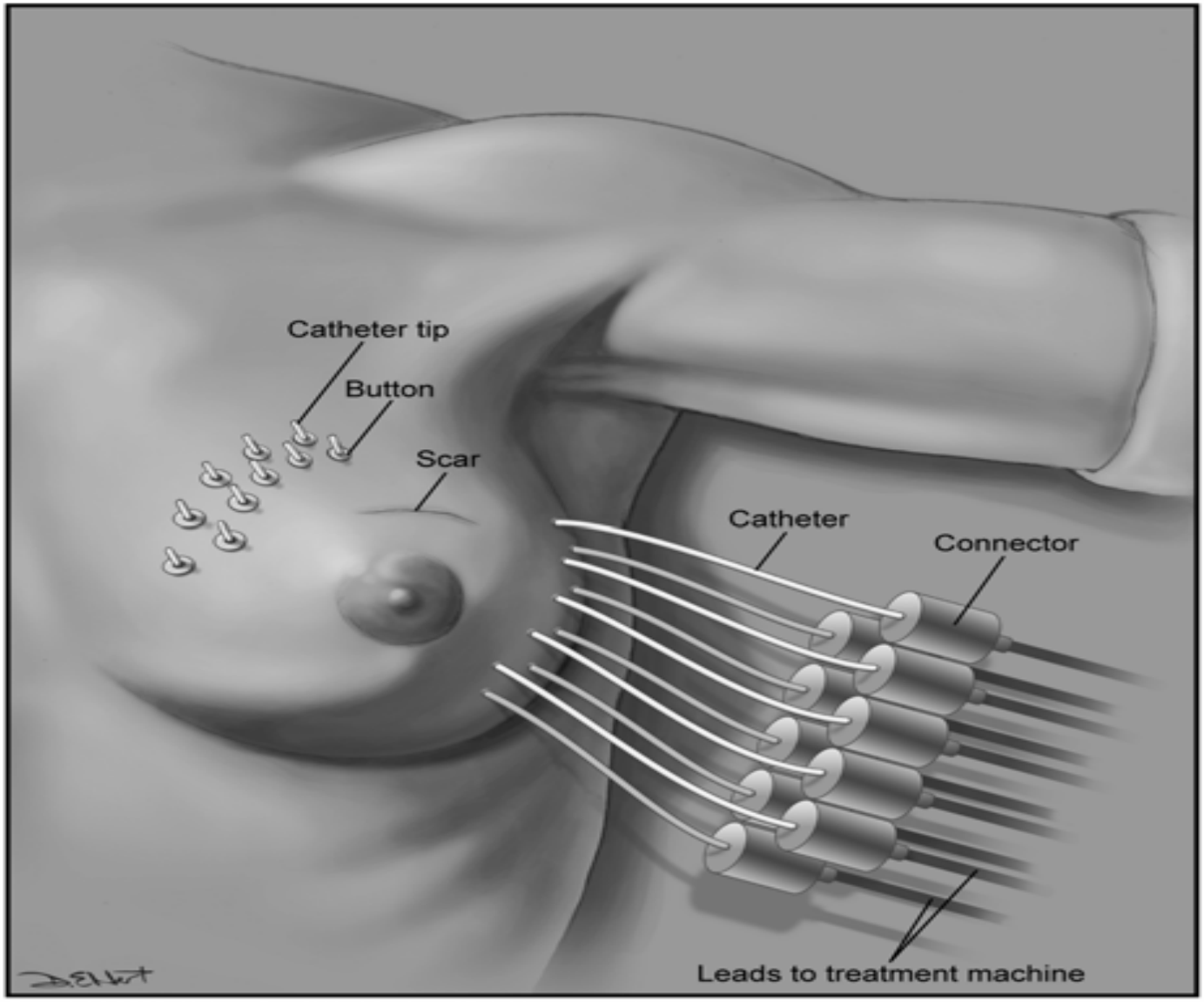
What is brachytherapy?

- **The word "brachy" comes from the Greek word for short or close.**
- **Brachytherapy -- radioactive substance close to the area to be treated.**
- **The dose of radiation can be delivered to a highly localized area, avoiding surrounding normal tissues.**
- **Interstitial breast brachytherapy is the sole treatment after lumpectomy.**

Interstitial brachytherapy

- **Interstitial brachytherapy is an outpatient treatment.**
- **It involves the placement of a radioactive source directly into the region of the tumor.**
- **Temporary plastic tubes, called catheters, are placed into the breast around and through the lumpectomy cavity.**
- **They are connected to a machine during treatment that sends a radioactive seed through the catheters to the treatment area.**
- **After the last treatment the catheters are removed.**



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Radiograph based planning

Using set of Radiograph

Steps

1. **Localization**
2. **Treatment Planning**
3. **Plan Evaluation**

Localization:

- Done on simulator or X-ray Machine
- Patient positioning
- Identification of implant tubes
- Insertion of X-ray markers (dummies)
- Acquisition of set of radiographs
- Measurement of tube length

Patient positioning:

- **Supine, Arm above the head**

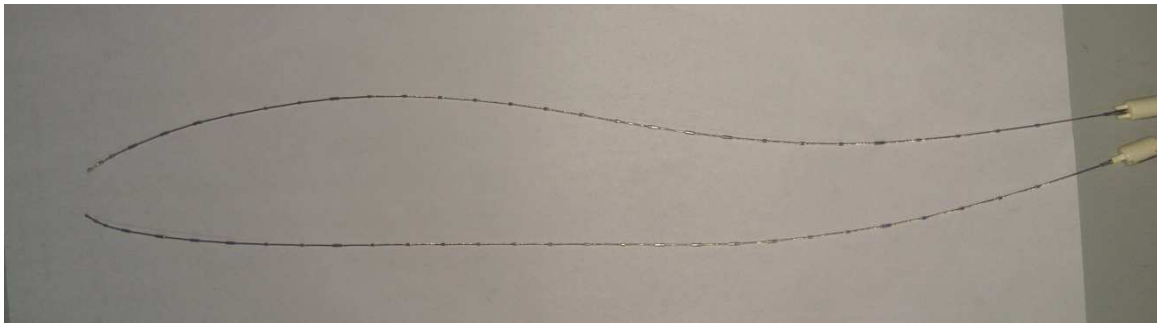
- **Try to orient patient in such a way that implant plane becomes nearly perpendicular to beam axis to make implant tubes more distinguishable on radiographs**

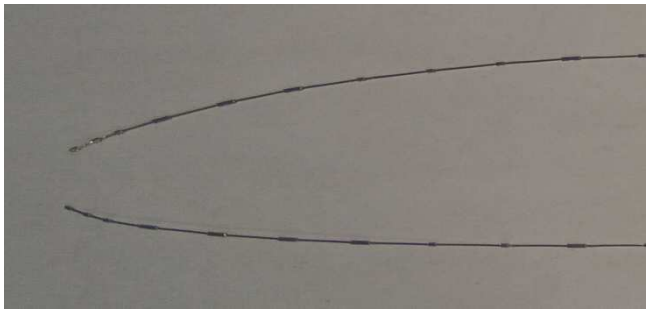
Identification of implant tubes:

- **Identification of implant planes**
- **Numbering of catheters in each plane**
- **Immobilization of tubes from open end (flags)**

Insertion of X-ray markers (Dummies):

- Dummies provided by manufacturer
- Binary coded numbering
- Dummy should reach to the tip end of the implant tube





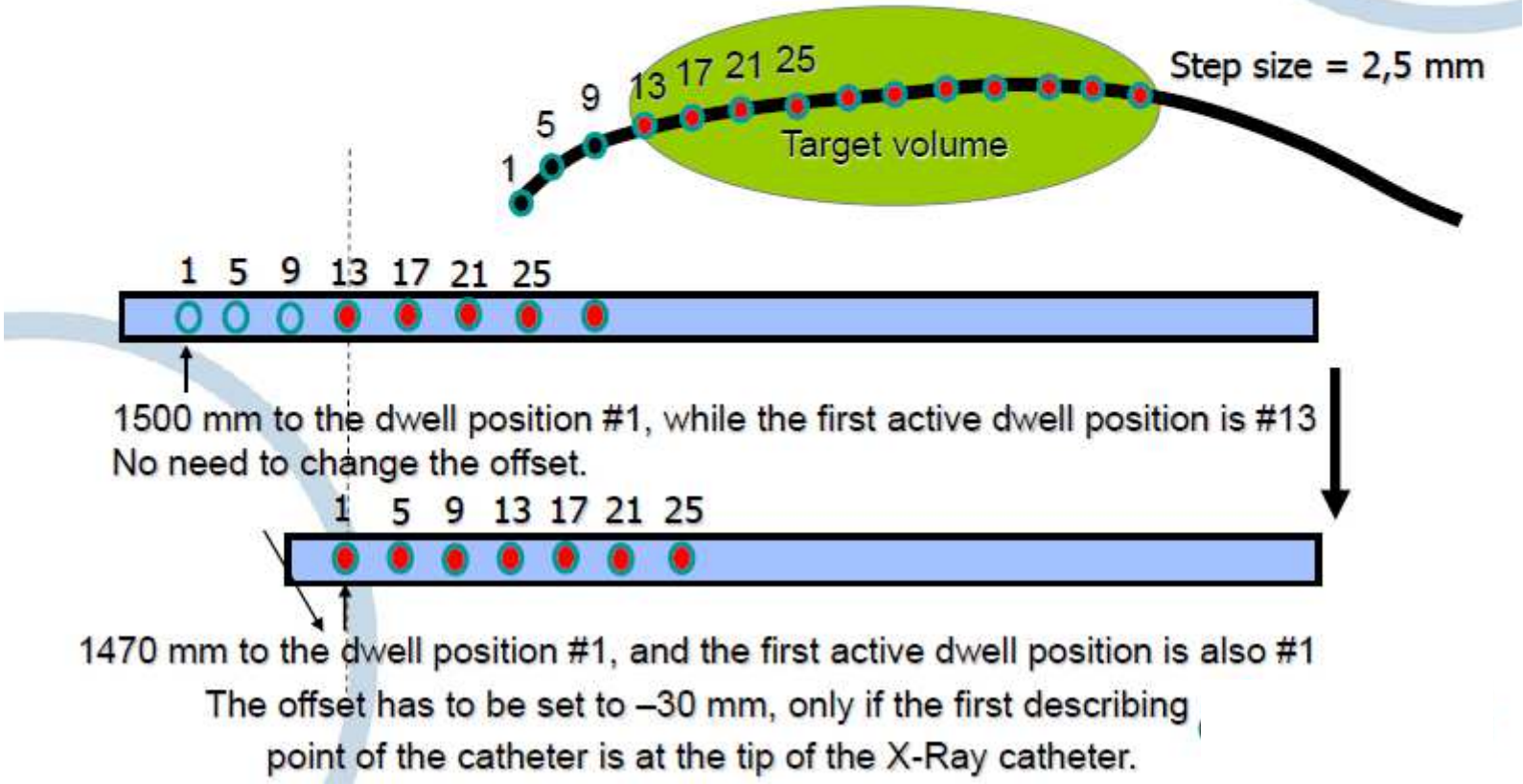
Indexer Length

In case of Breast Implant default (maximum) indexer length needs to be modified for catheters due to the following reasons:

1. The target area may not in direct proximity of the catheter tip(s).
2. The use of needles with different lengths in combination with standard transfer tubes, or flexible catheters (cut at the required non-standard length) for interstitial brachytherapy.

Indexer Length

1. Indexer Length and Offset values have to be changed from the default values. This is a typical situation when the target area is not in the direct proximity of the catheter tips.



Only the 'Indexer Length' has to be changed from the default value and the Offset value remains the same. This can happen in the following cases:

-Needles for interstitial brachytherapy can have different lengths. That will lead to the differences in the Indexer Length in combination with standard transfer tubes.

-Flexible catheters can be cut at any length, so the Indexer Length is almost never standard.

Measurement of tube length:

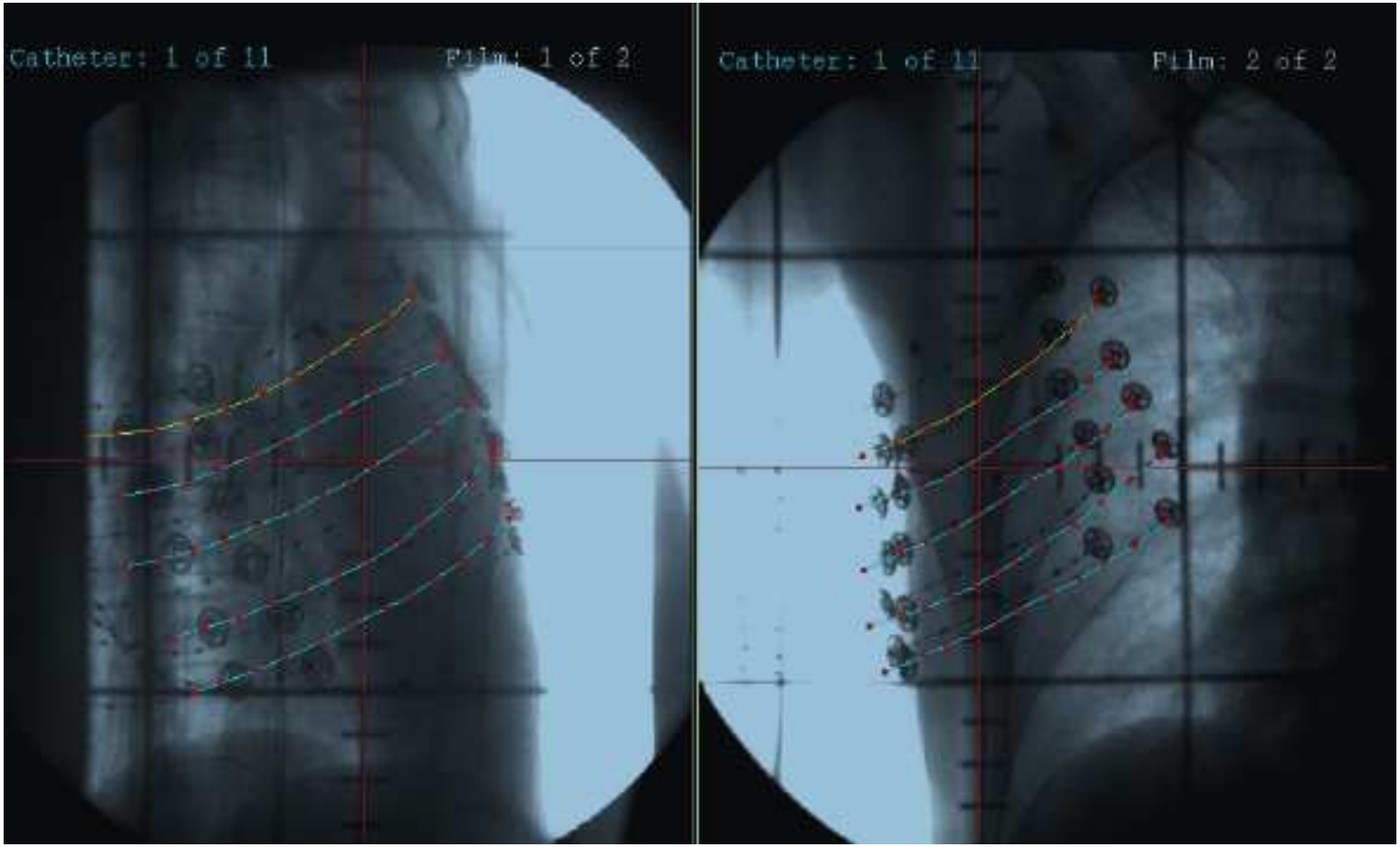
- **To determine Indexer Length:**

"The distance travel by source to reach first dwell position from a reference point in machine"

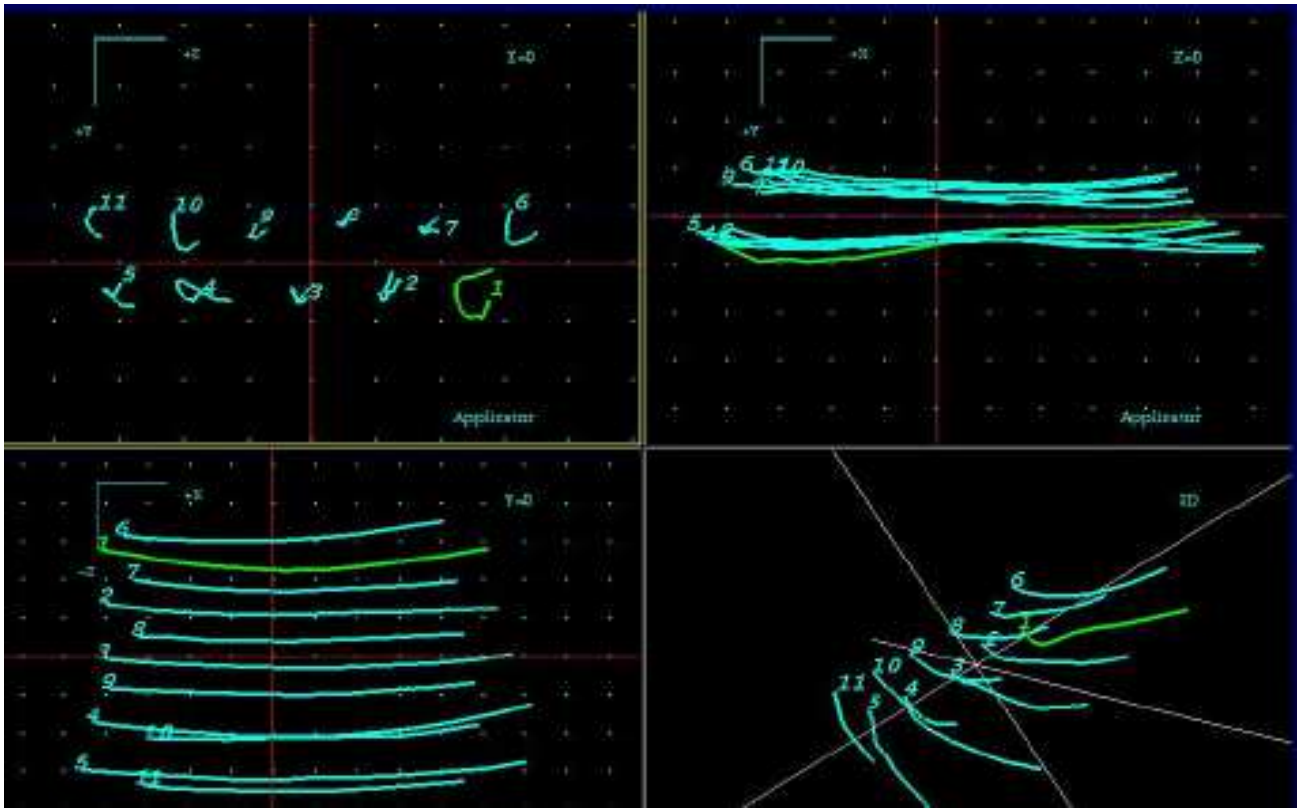
'Source Position Simulator' must be used for determination of the correct Indexer Length value.

Source position Simulator

Reconstruction of implant tubes:



Reconstructed images



Dose points can be calculated based on:

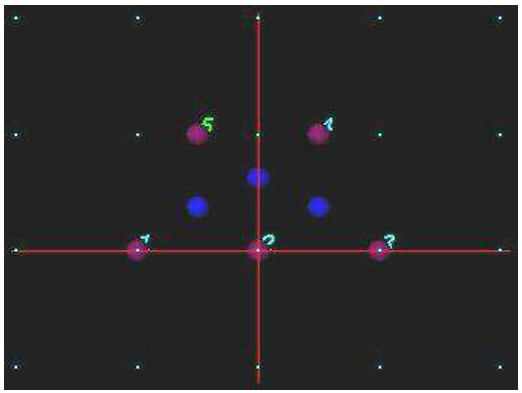
- **The *axis of the applicator co-ordinate system*.**
- **The shape of the *catheter*.**
- **The shape of the *target*.**
- **The Paris system: *basal dose points*.**
- **The *distance at lowest dose*.**
- **Dose points can be created in space around an applicator in a way that they will represent the shape of the target volume, even if the target volume can not be defined directly (on transversal images).**

- **•If normalization / prescription is done to the dose points, the average dose in all the dose points will be equal to the prescribed dose.**

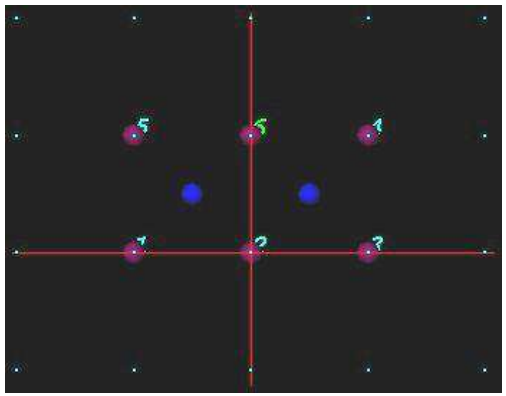
Basal dose points

- **Points at local dose minima**
- **At geometric centre of triangle or square formed by neighboring tubes at the mid of transverse plane of implant**

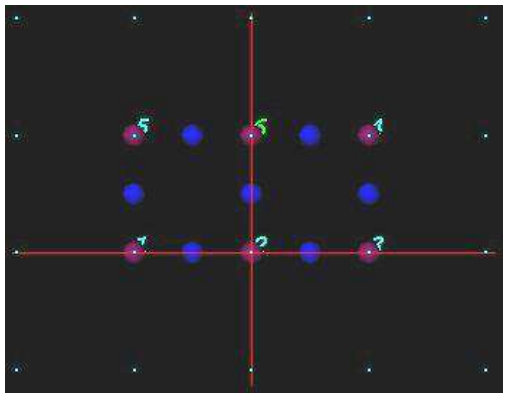
Geometrical methods of the Paris dosimetry system



Triangles

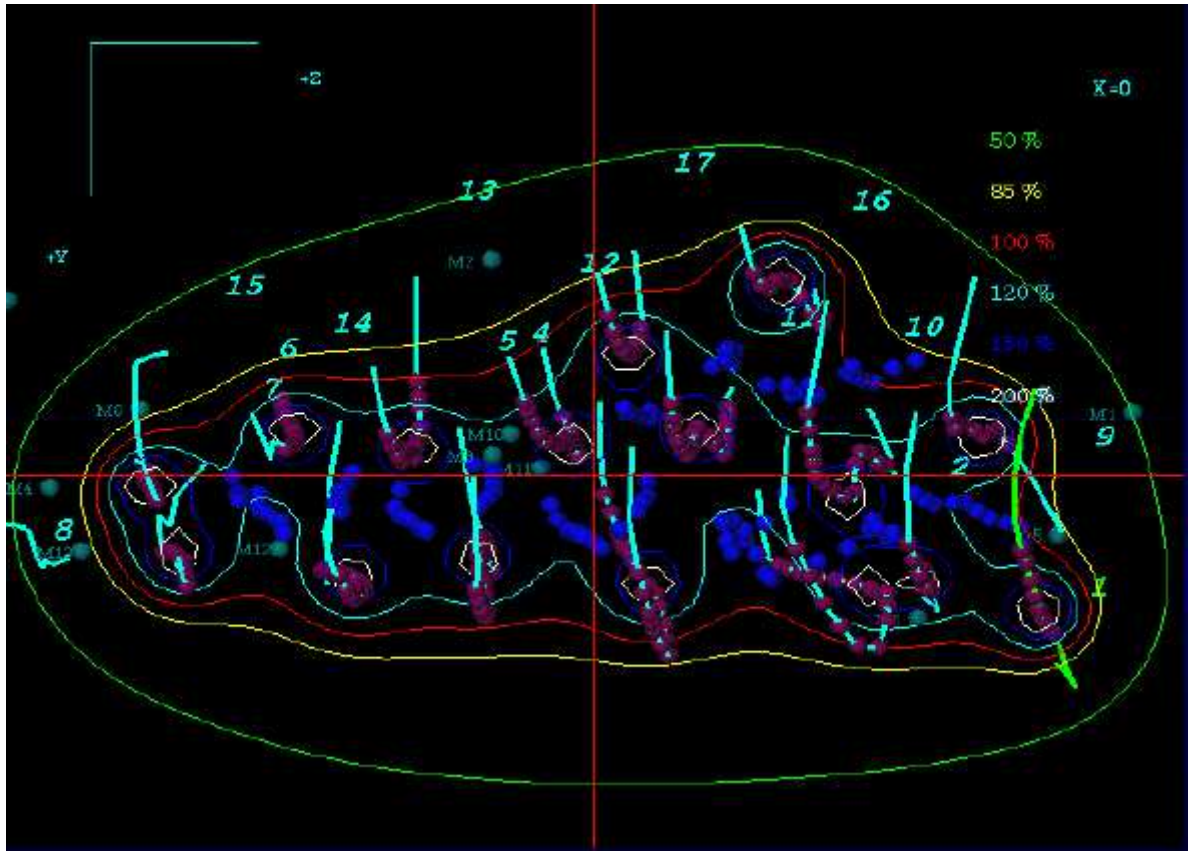


Squares



Lines

Isodose Distribution



Optimization

- **Geometrical Optimization adjust the dwell time of stepping source in each dwell position to increases homogeneity and isodose coverage**

Plan Evaluation

Using Cumulative DVH of Implant

Dose Homogeneity Index

DHI = (V100% - V150%) / V100%

- **DHI > 0.75**
- **V150% < 70 cc**
- **V200% < 20cc**

RTOG 0413

CT based 3D Brachytherapy planning

CT image acquisition

- Patient position: supine

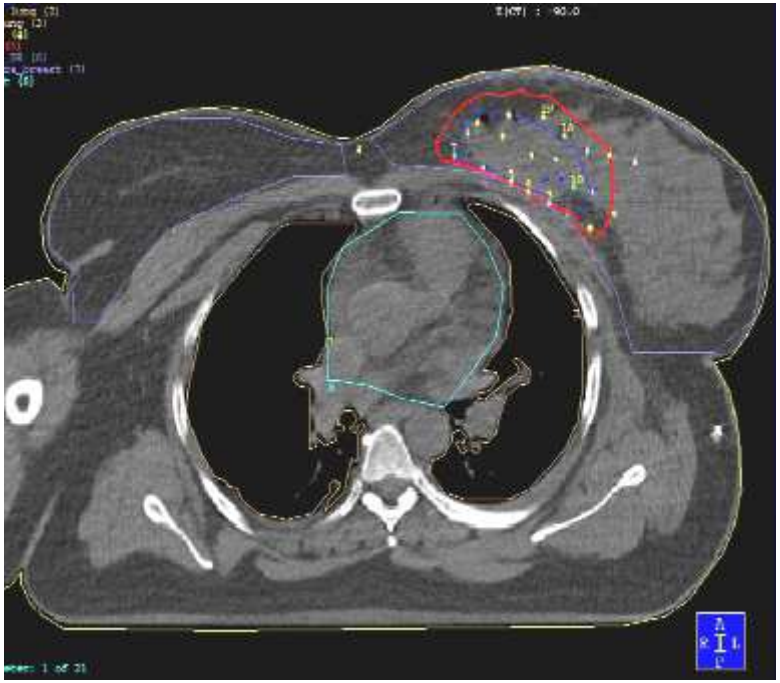
  Both arms above the head.
- Thin copper wires (0.2mm) CT image acquisition inserted inside the tubes for reconstruction of the catheter.
- 3 mm CT cuts from the level of mandible to several centimeters below the inframammary fold
- Entire body contour should be taken in the field of view

Contouring

- Lumpectomy cavity
- Target (CTV)
- For Brachytherapy

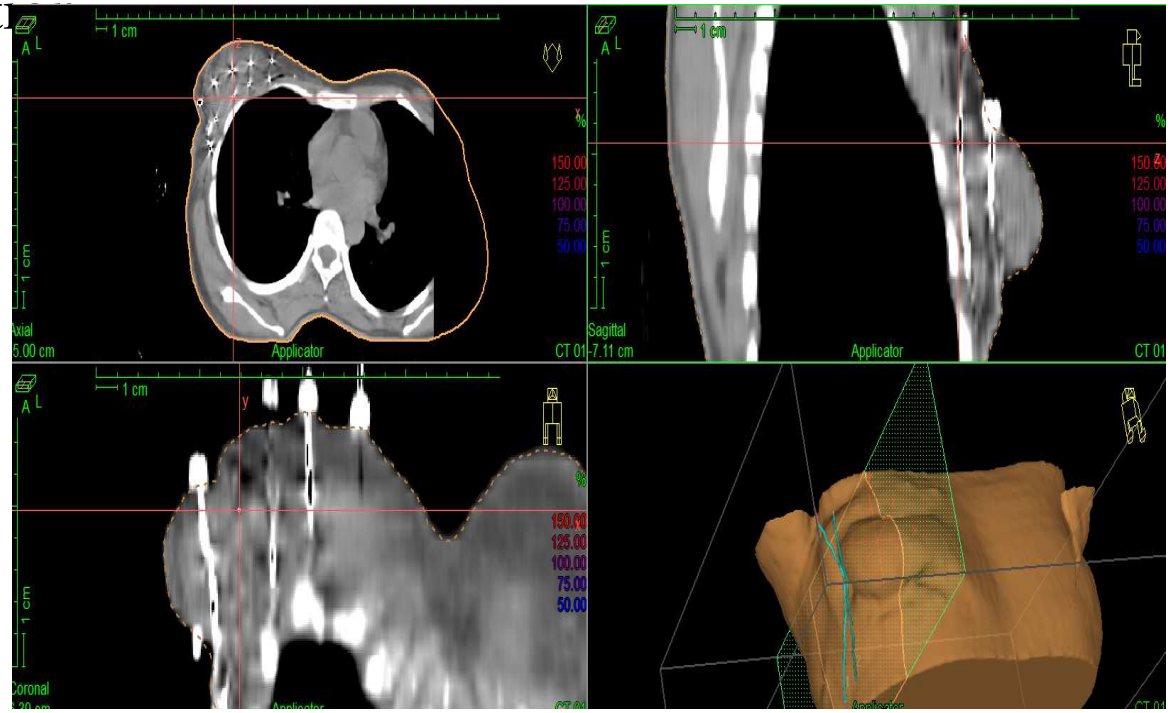
PTV = CTV

- Normal breast
- Heart
- Lung

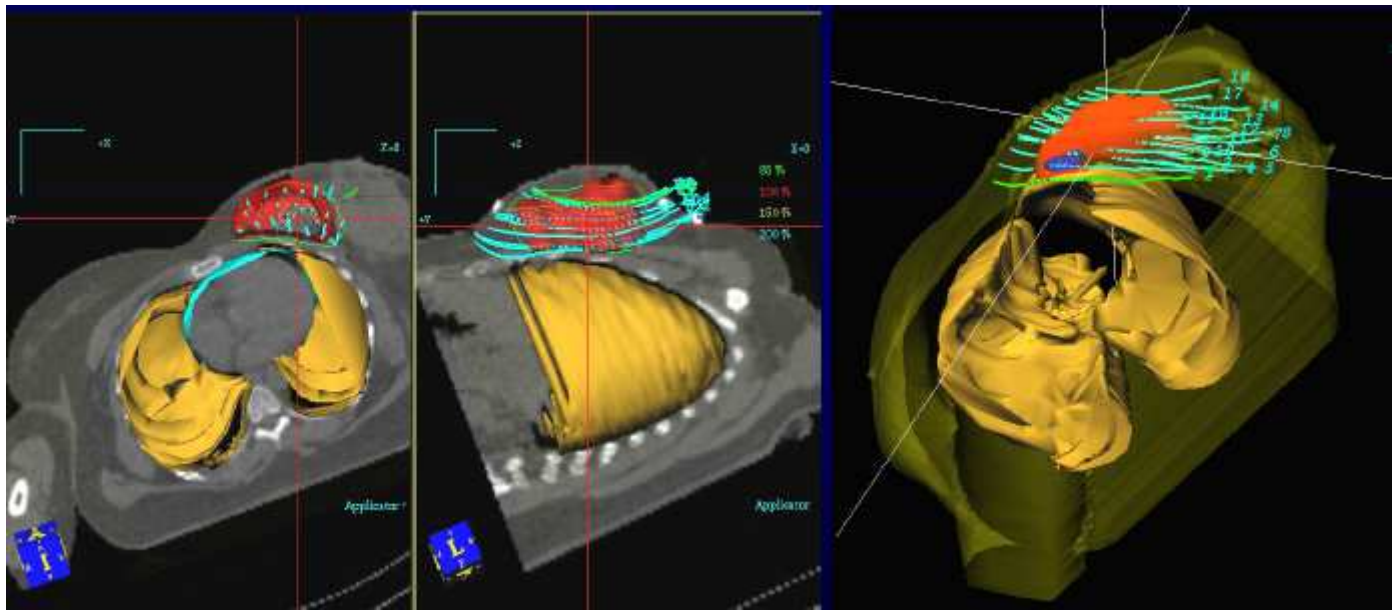


Catheter reconstruction

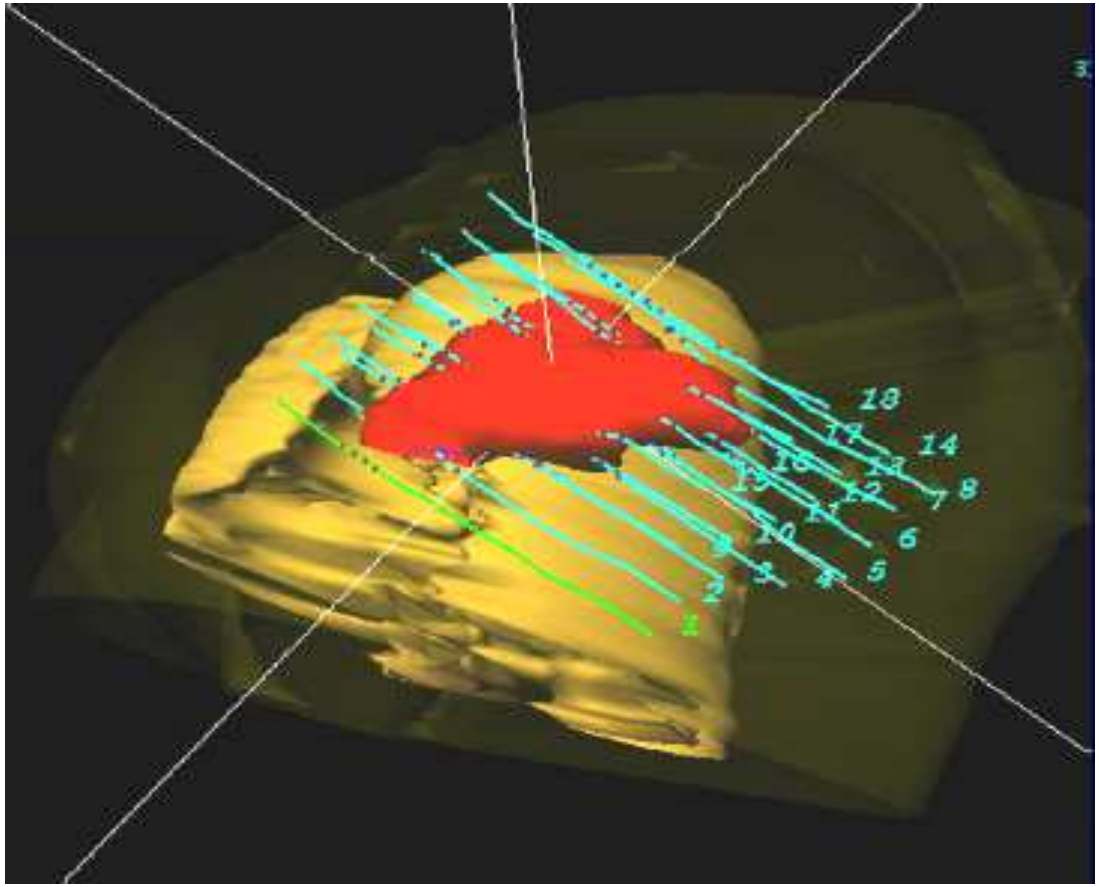
- Transverse CT cuts
  Catheter reconstructi
- Multi planer
  reconstruction



Axial **Sagittal** **3D**



Determination of source loadings



Optimization

- **Graphical Optimization**

It's a kind of manual optimization which allows to optimize dose distribution interactively on multiple planes by dragging the isodose lines.

- To achieve dose distribution more conformal around the target
- To spare the dose to critical structure in acceptable limits

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To achieve dose distribution more conformal around the target

To spare the dose to critical structure in acceptable limits

3D brachytherapy plan evaluation

- DVH of implant geometry
- Dose Homogeneity Index = (V100% - V150%)/ V100%
- DHI > 0.75
- V150 < 70 cc
- V 200 < 20cc
- Dose to marker points
- Target coverage: > 90% of the PTV is covered by 90% of the prescribed isodose line <60% of the whole breast reference volume should receive >50% of the prescribed dose.

Comparison

- CT based 3D brachytherapy is superior over conventional planning
- 3D brachytherapy plan provides more conformal distribution
- Dose reduction to normal breast
- Clinical realistic evaluation of implant dosimetry by DVH analysis