Planning of Intraluminal Brachytherapy

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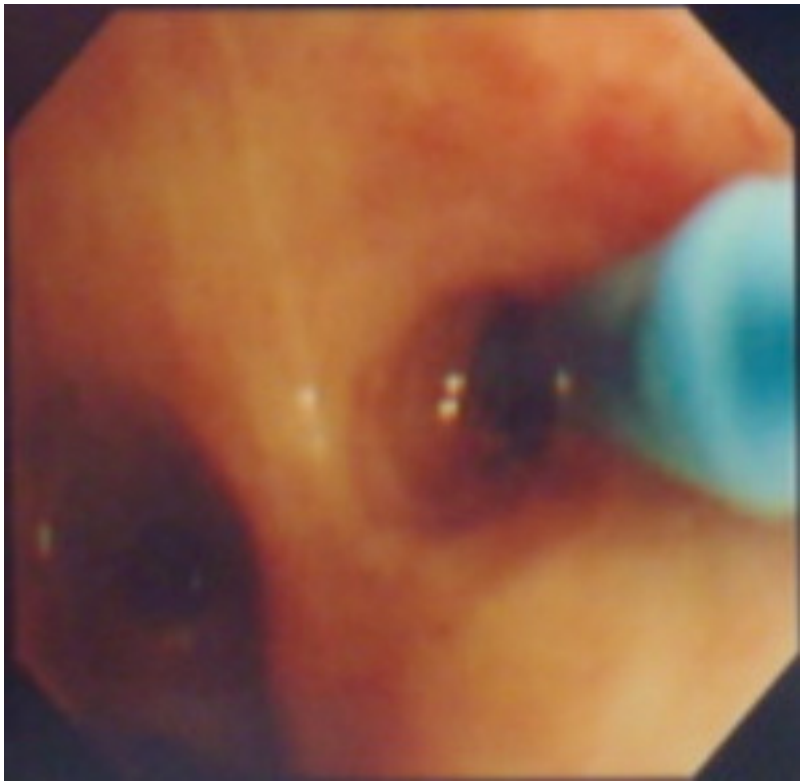
Intraluminal brachytherapy (ILBT)

- Insertion of one or several linear sources, contained in appropriate applicator devices, in natural cavities (lumina).
- Linear or quasi linear sources may be simulated by several point sources seeds (eg Cs-137 in Selectron LDR) or a moving source (Ir-192 in HDR).



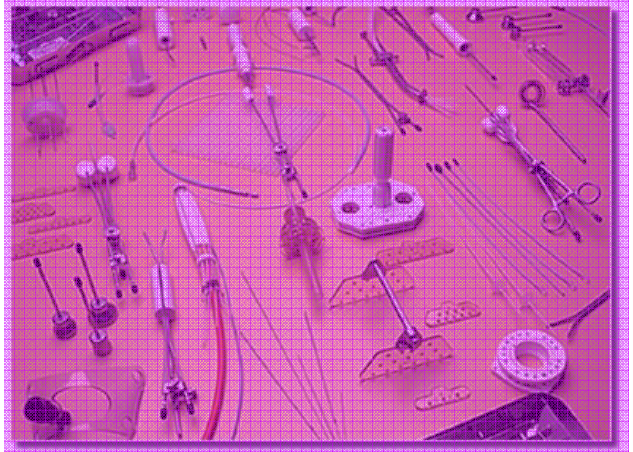
ILBT application & requirements

Applications of ILBT

- esophagus
- bronchus,
- vagina,
- biliary duct
- endovascular brachytherapy

Requirements

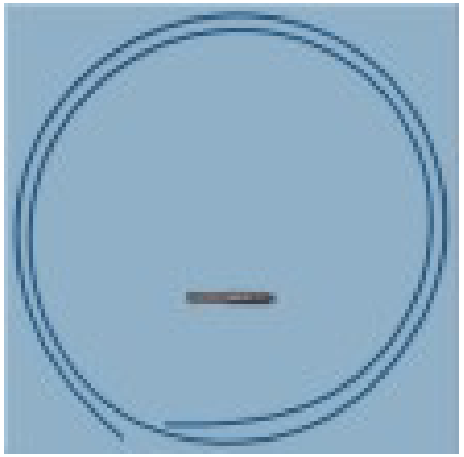
- Various applicators

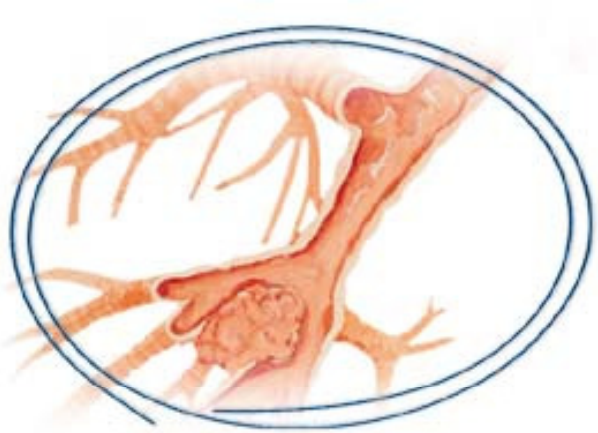


Requirements

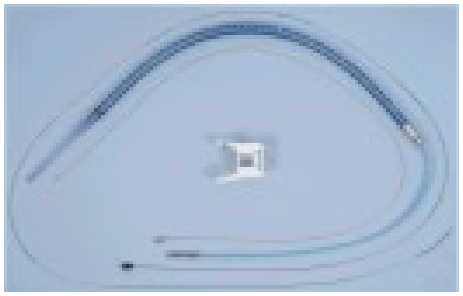
- Treatment machine

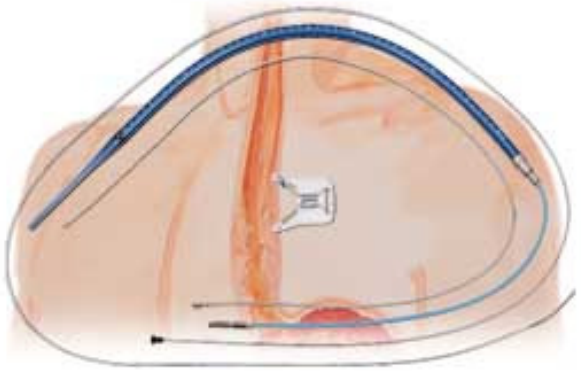
Intraluminal Applicator





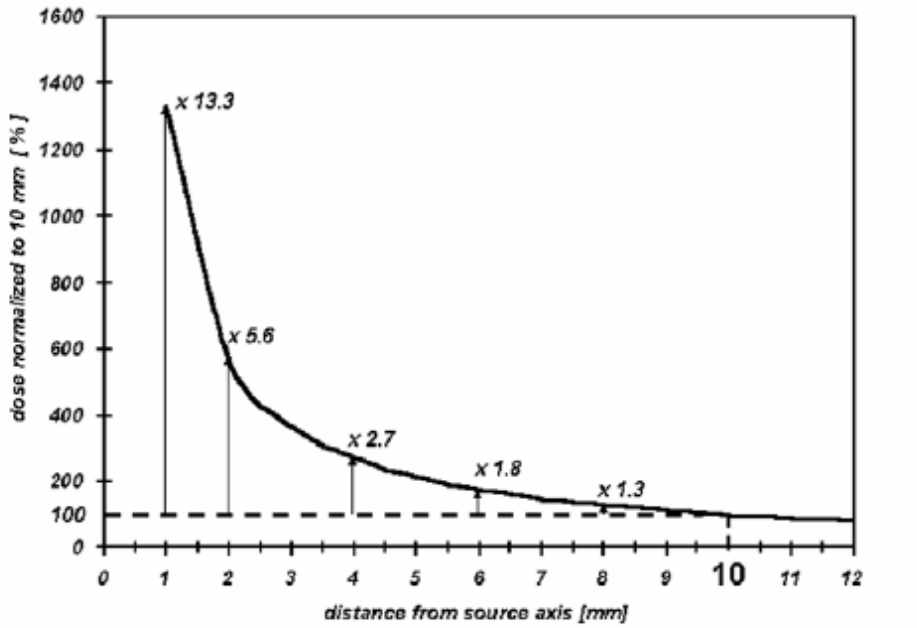
Lumencath Bronchial Applicator Set





Esophageal Applicator Set

Dose gradient in ILBT

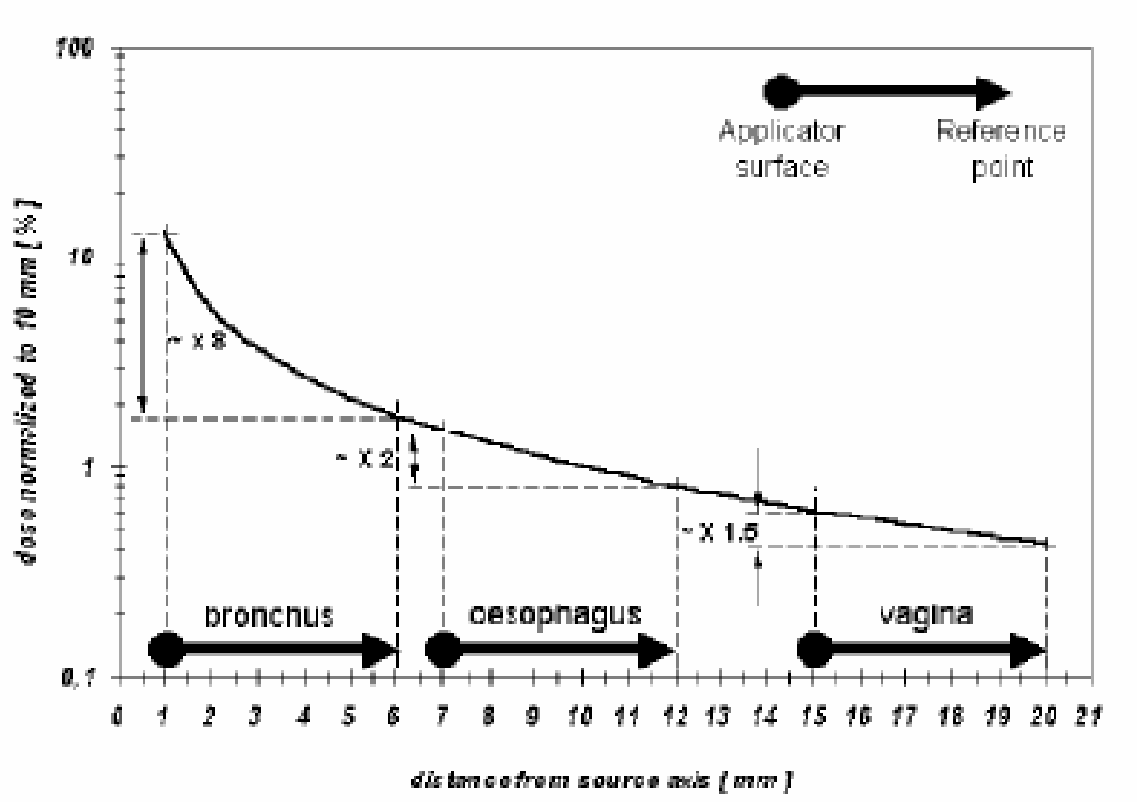


Due to the (physical) inverse square law :

(a) dose decreases dramatically as a function of distance to the linear source

(a) dose gradient is steepest close to the source and decreases with distance

Influence of applicator diameter on the dose variation



Dose variation between the applicator surface and at 5 mm depth in the tissue is indicated.

Steps of ILBT planning

Step 1:
- Source localization with dummies inserted
  - X-ray or CTI/MRI

Step 2:
- Reconstruction of source localization
  - Catheter describing
  - tracking the dummies

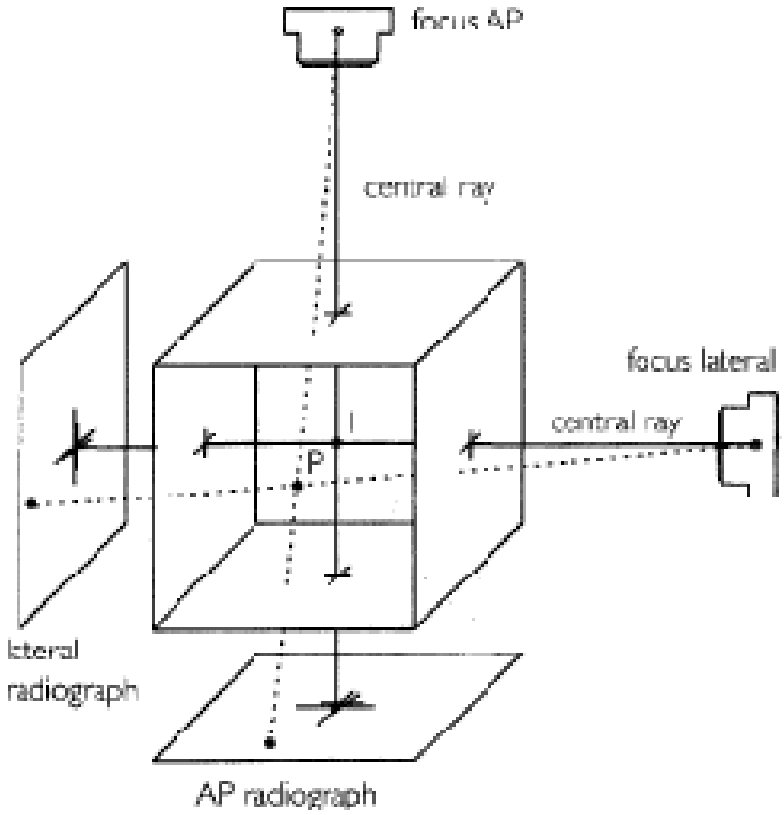
Step 3:
- Source loading based on the length of lumen to be treated
- Dose prescription & normalization
- Plan evaluation based on the dose distribution
- Optimization of dose distribution if needed

Step 4:
- Export of approved treatment plan parameters to treatment machine
- Validation of plan parameters on the machine
- Treatment preparation
- Pretreatment QA
- Treatment Execution

Step 5:
- Reporting

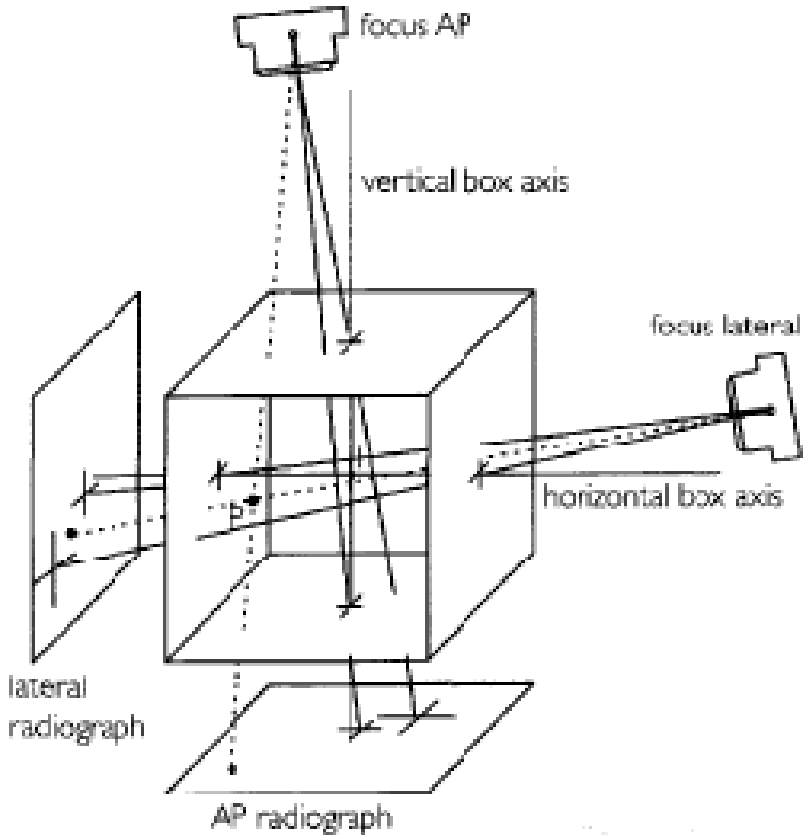
Source localization: Planar X-ray image

- **Orthogonal reconstruction method**
  - Diagnostic X-ray machine/C-arm with localization box/jig
  - Radiotherapy simulator
- X-ray images of opposing cross-wires coincide
- Beam set-up
  - localization of the AP and lateral X-ray foci from the cross-wire images on the radiographs
- Advantage
  - Image easily interpretable
- Disadvantage
  - Difficult to distinguish X-ray markers in Lat radiograph for thick patients



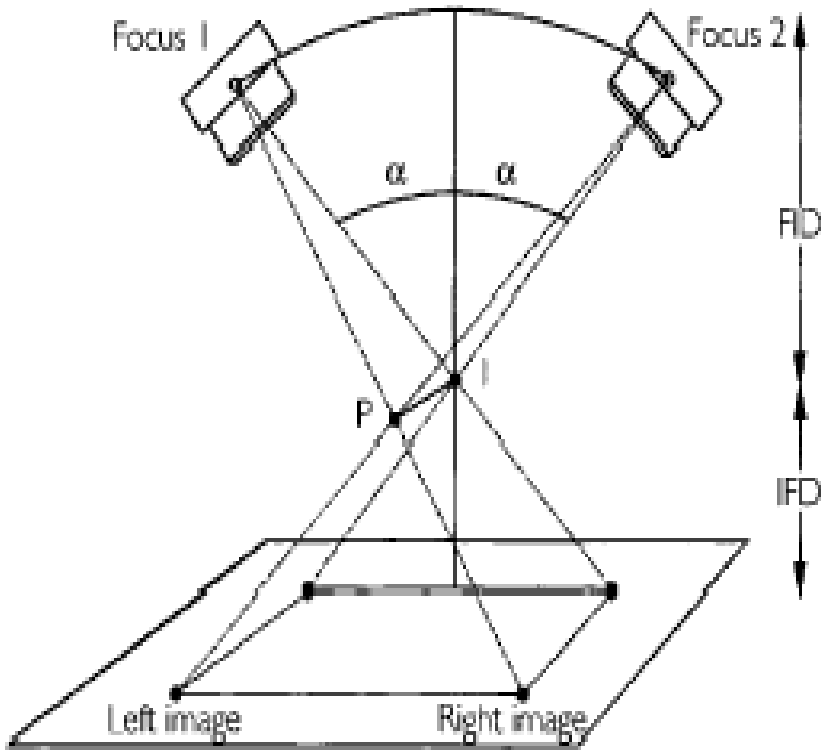
Source localization: Planar X-ray image

- **Semi-orthogonal reconstruction method**
  - Diagnostic X-ray machine/C-arm with localization box/jig
- Not necessary for true orthogonal images
- Beam set-up
  - size and the relative distances of the cross-wire lead marker images on each of the two films.
- Advantage
  - HDR endobronchial applications using portable X-ray machine



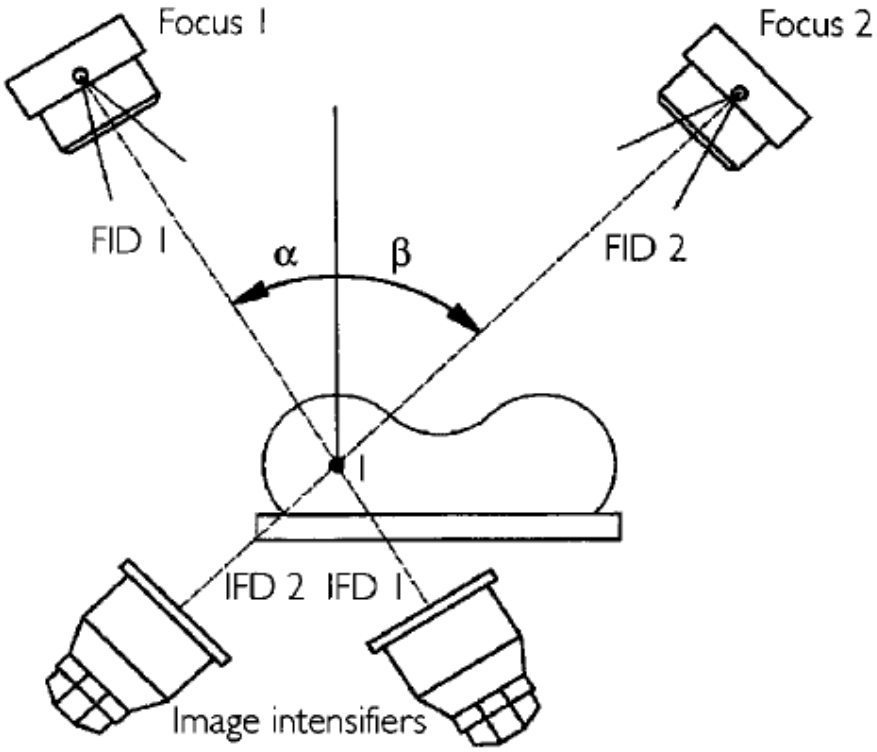
Source localization: Planar X-ray image

- **Isocentric reconstruction method**
  - Isocentric Radiotherapy simulator with large film
- Not necessarily orthogonal
- Beam set-up
  - rotating the gantry over an angle of +α and –α (15°-30°).
- Advantage
  - Interstitial implant

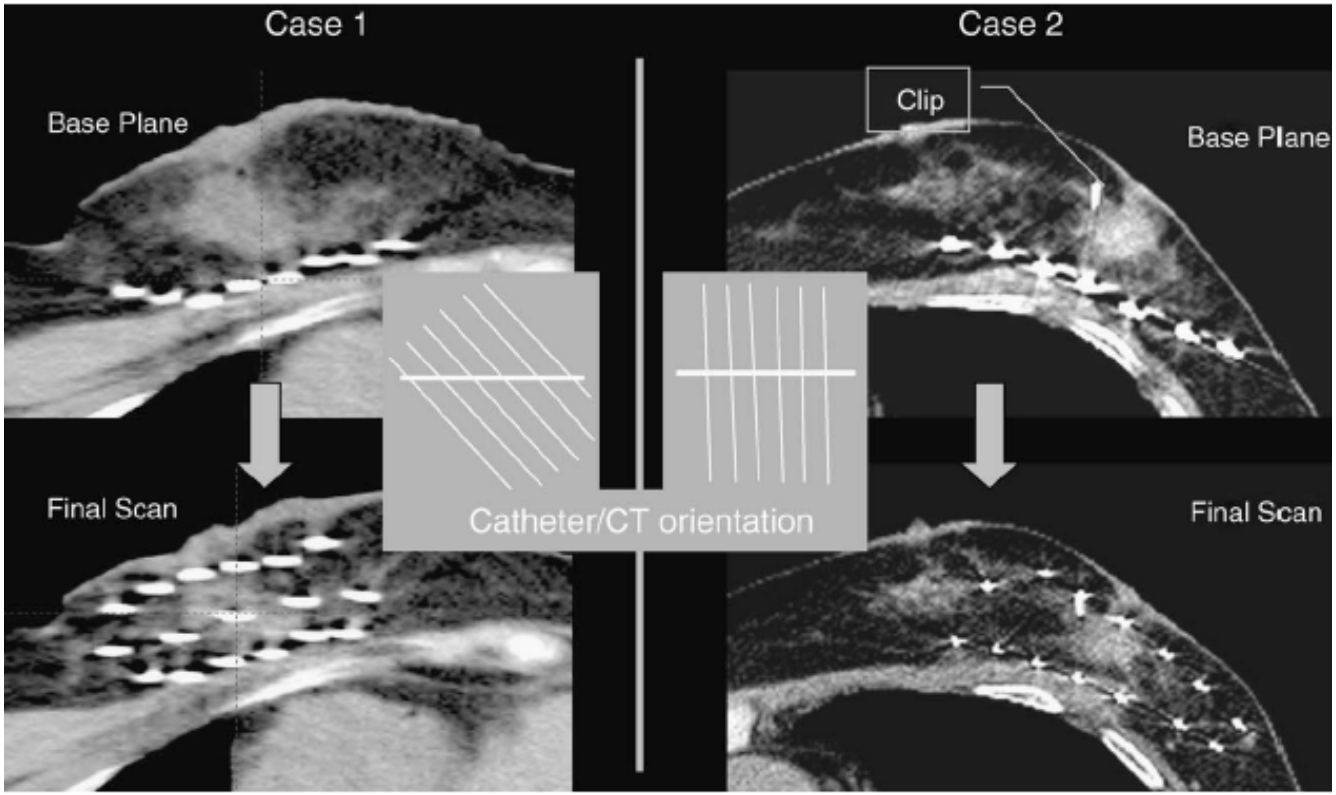


Source localization: Planar X-ray image

- **Variable angle reconstruction method**
  - Isocentric Radiotherapy simulator
- Not necessarily orthogonal
- Beam set-up
  - *Select α and β to give best clearity of catheters on the image intensifier.*
  - Range of *α + β : 60°-120°*
- Advantage
  - Visualization of Implant geometry from different angle through fluoroscopy
- Disadvantage
  - central axes of the projecting beams are not coinciding or opposing



Source localization: CT/MRI



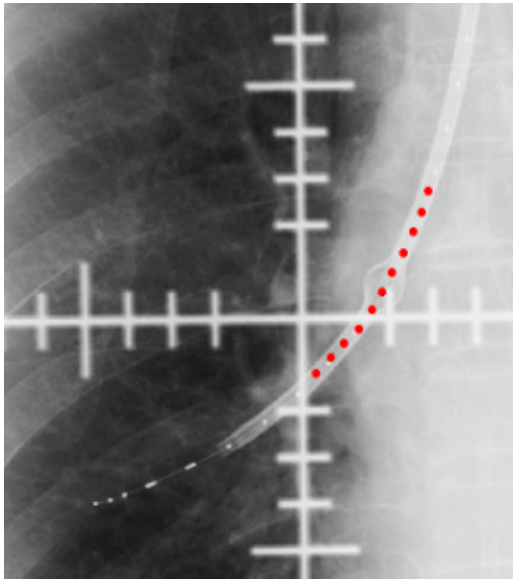
Robust reconstruction algorithm
MPR needed

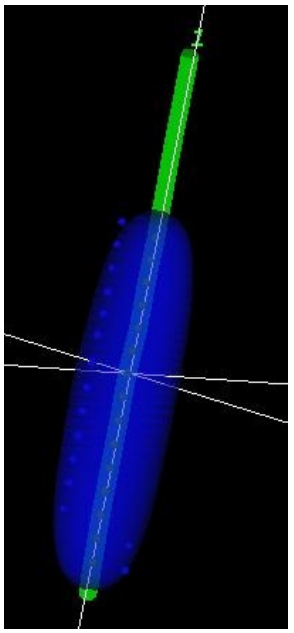
Reconstruction of source localization: Planar X-ray image/CT/MRI

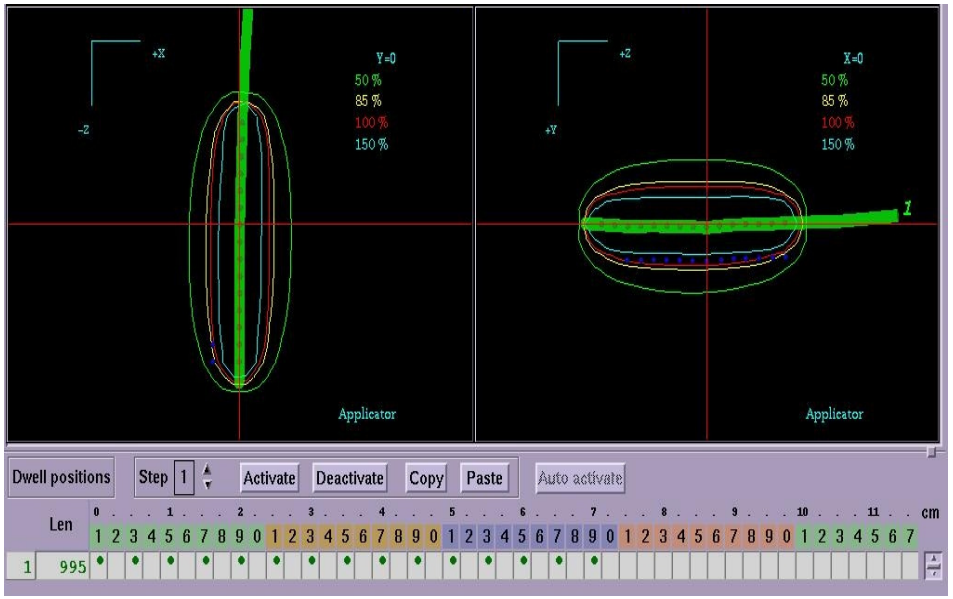
- Catheter Describing
- Catheter tracking

ILRT: Esophagus/Bronchus

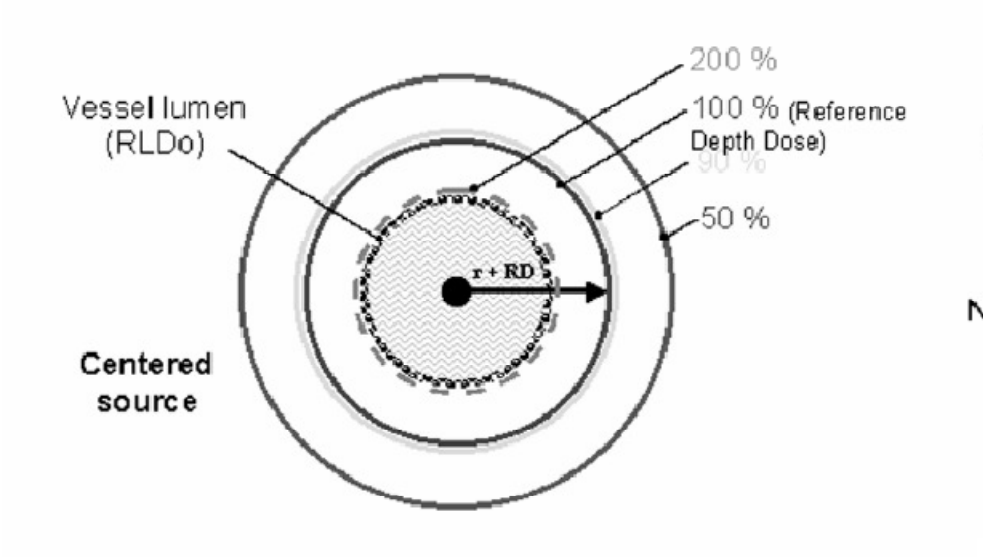
- Reconstruction from 2 sets of planar radiograph
- Source loading based on the length of lumen to be treated (6-7cm)
- Dose prescription at 1 cm from the source axis (0.5 cm from applicator surface)
- Evaluation of prescription isodose envelop

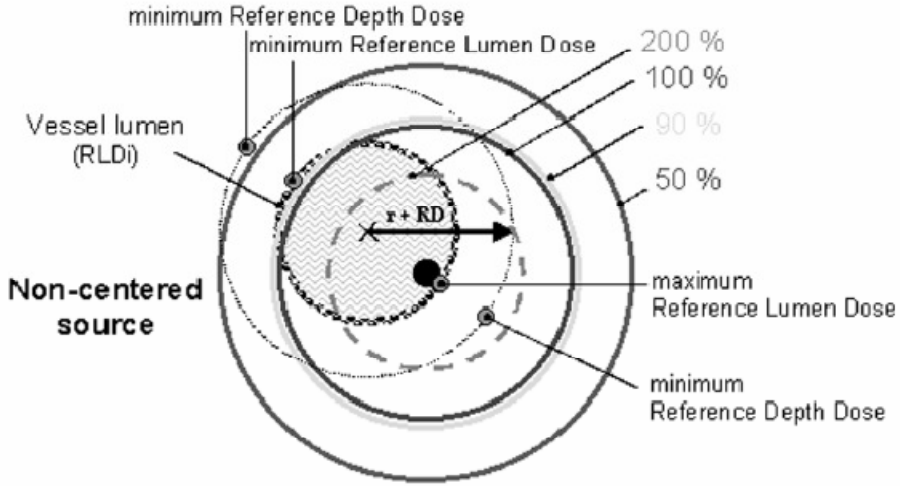






Influence of centering on dose distribution





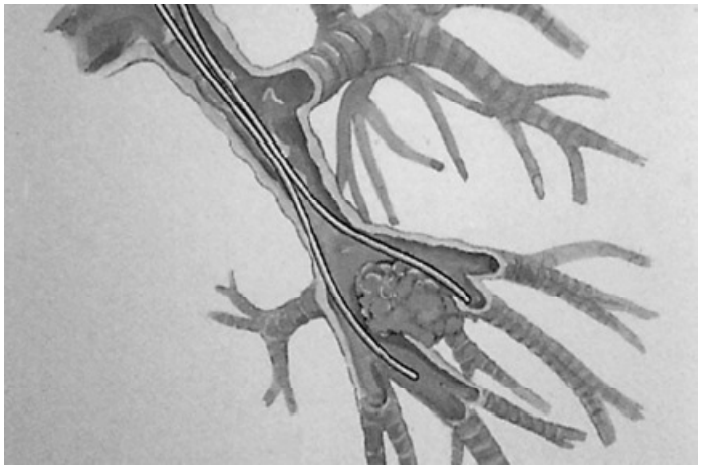
Centered source with a Symmetrical radial dose distribution

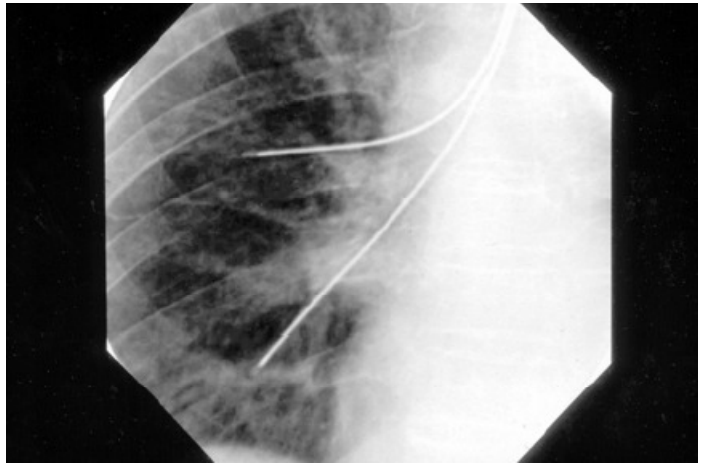
Non-centered source and its influence on the dose at the lumen surface and at the reference depth

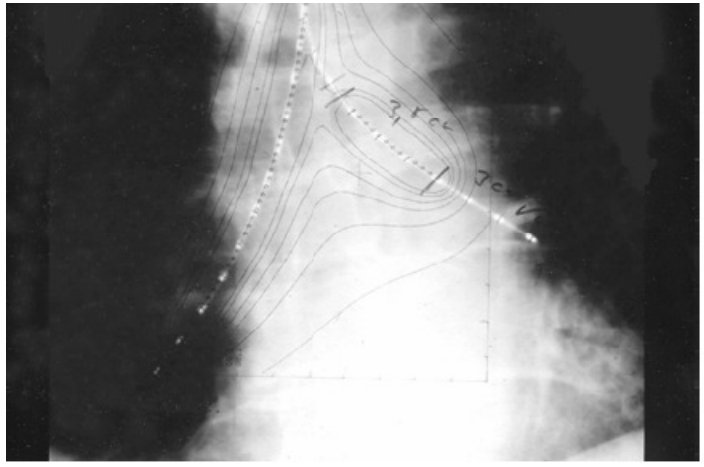
Reference points for reporting ILBT

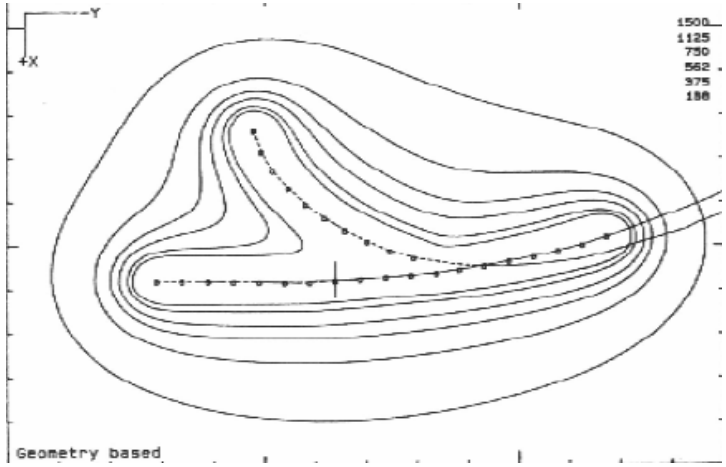
- surface (mucosa) itself
- Minimum Target Dose
- a reference depth of 5 mm in the tissues, from the surface (mucosa)

Intraluminal technique with two tubes in bronchus brachytherapy



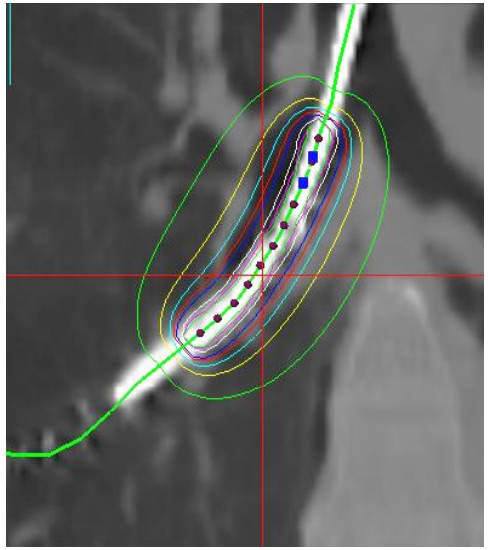


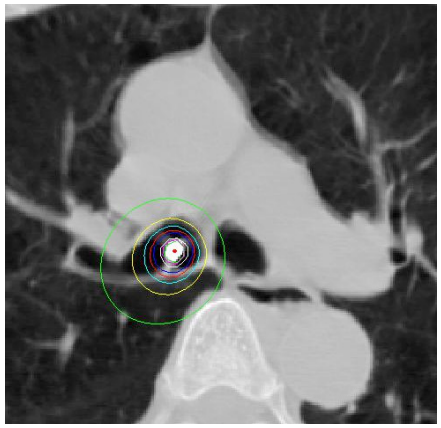


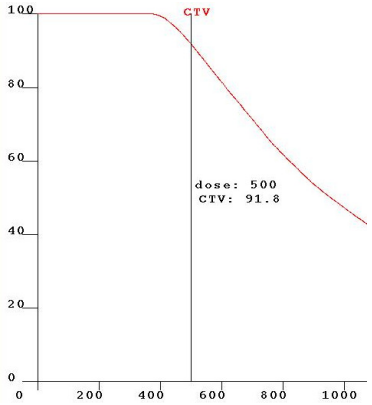


CT based ILBT planning of Endobronchial carcinoma

- Steps of planning
  - Acquisition of axial CT scan with dummy inserted in the applicator
  - Reconstruction of applicator by tracking the dummies using MPR
  - Source loading based on the length of lumen to be treated
  - Dose prescription & normalization at 5mm from the surface of applicator
  - Plan evaluation based on dose distribution on CT images and quantitative evaluation using DVH



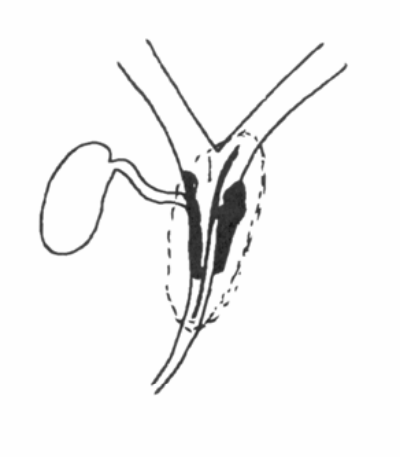


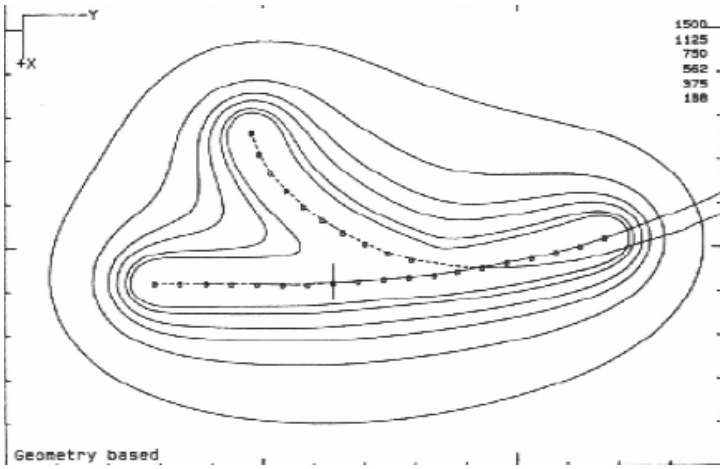


Advantage of CT based planning

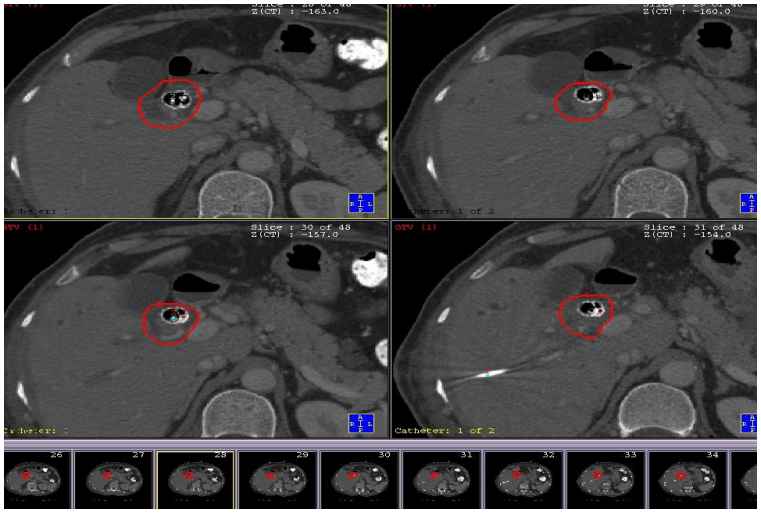
- Allow better delineation of target and applicator
- 3D dose distribution on patient anatomy
- Optimization of dose distribution based on target shape and volume
- quantitative evaluation
- Clinically realistic evaluation of ILBT procedure

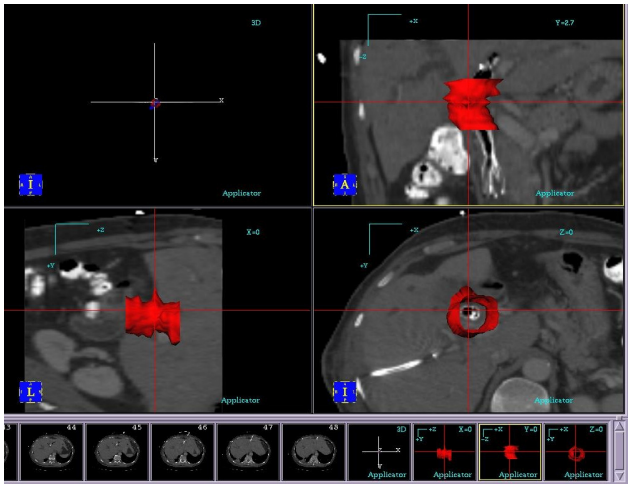
Bile Duct tumor

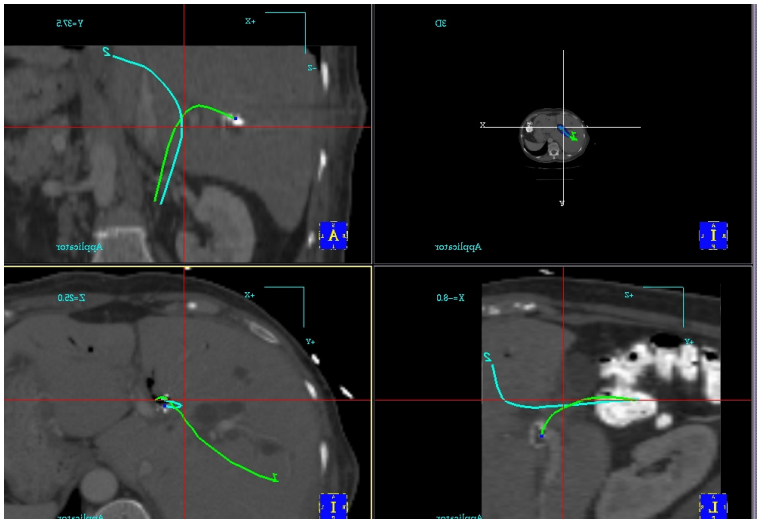


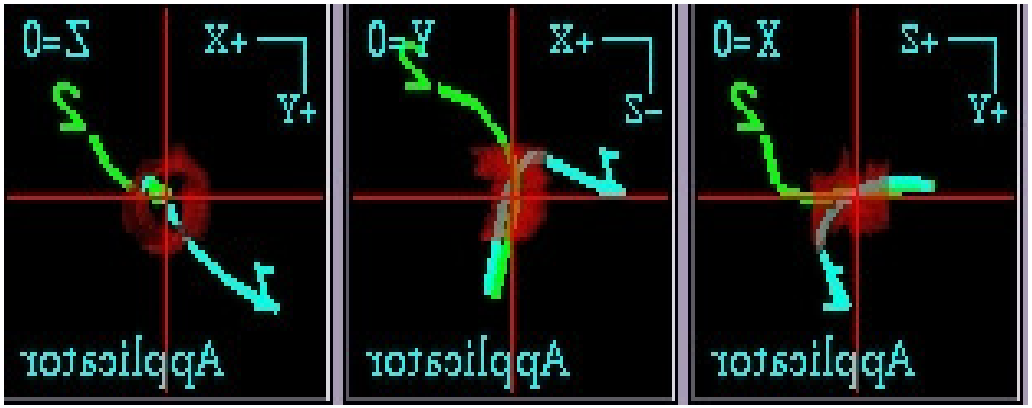


Bile Duct tumor

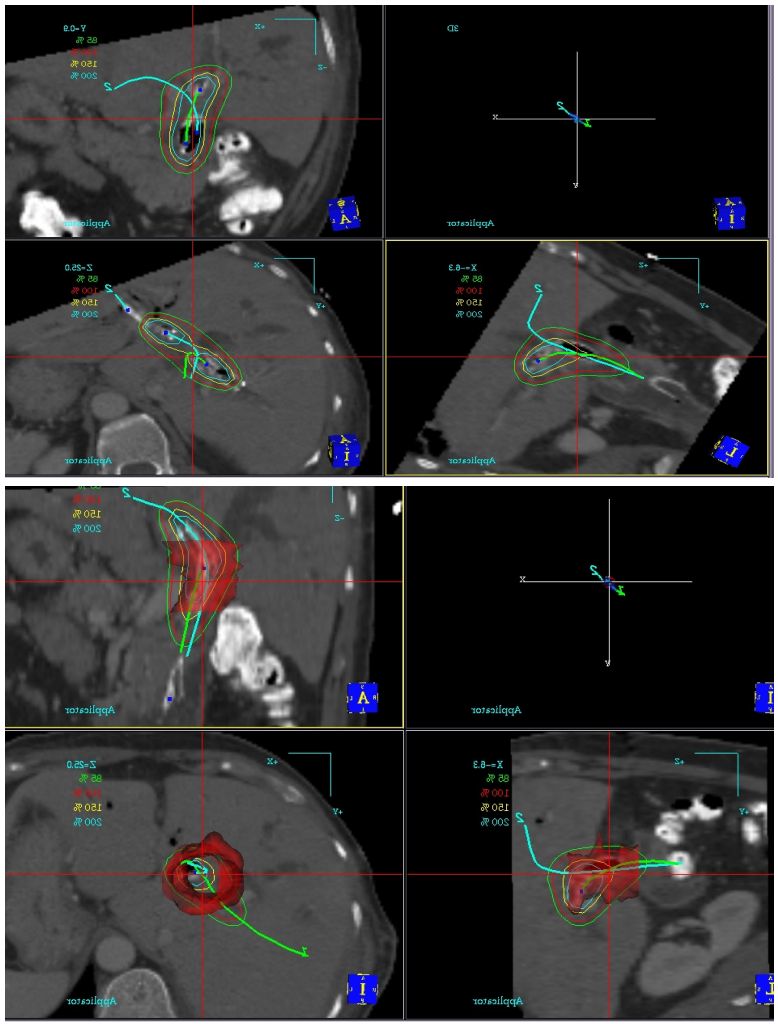


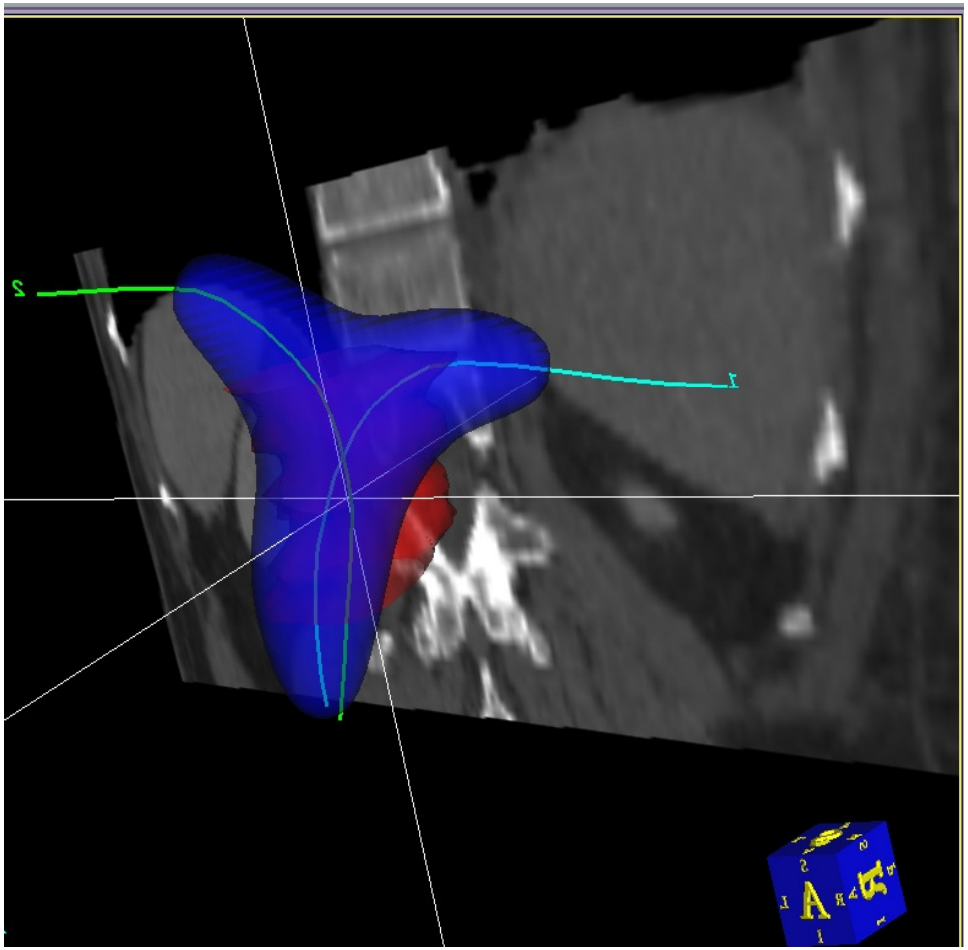






Bile Duct tumor





- Esophagus bougie, 8mm-14 mm diameter,
- Tube catheter, 3.2mm diameter

Dose

- Esophagus
  - 6 Gy in 3Frs
  - Bilary duct
    - 5-4-4-5
    - Bronchous
    - 6Gy in 2 frs