I VOLUMI DELLA BRACHITERAPIA

M.G. Fabrini
U.O. RADIOTERAPIA PISA

Problematiche tecniche nel planning del carcinoma polmonare non microcitoma
Taranto 21 gennaio 2006

Volumes

The definition of volumes is of utmost importance, both in external-beam planning and in brachytherapy planning, and the process consists of several steps.

The **GTV** and **CTV** are pure oncological concepts and are thus independent of the treatment strategy, discipline or technique.

The definitions of GTV and CTV in brachytherapy are identical to the definitions given for external-beam radiotherapy in *ICRU Report 50 and Supplement to Report 50, ICRU Report 62.*

Gross Tumour Volume (GTV)

The Gross Tumour Volume (GTV) is the gross palpable, visible or demonstrable extent and location of the malignant growth.

The shape, size and location of the GTV may be evaluated by various diagnostic methods : clinical examination i.e., inspection and palpation, endoscopy, and imaging techniques such as radiography, CT, MRI, PET, ultrasound, or other techniques, depending on the location and type of pathology.

GTV IN Bt

In brachytherapy applications, the GTV is mainly the primary tumour, thus **GTV-T.**

Careful identification of the GTV is as important in brachytherapy as in external beam therapy:

(1) accurate description of the GTV is needed for staging (e.g., TNM),

(2)identification of the GTV is necessary to permit recording of tumor response in relation to dose and other relevant factors, which may be used (carefully) as a prognostic factor.

(3) an adequate dose must be delivered to all parts of the GTV to obtain local tumour control in radical treatments.

Clinical Target Volume (CTV)

- The CTV is the volume which contains the „gross“ and „subclinical“ disease.
- Clinically, it thus contains the GTV and a „safety margin” around the GTV (CTV-T) to take into account (probable) subclinical involvement.

The CTV may also include other anatomical areas, e.g., regional lymph nodes (CTV-N) or other tissues with suspected (or proven) subclinical involvement (CTV-M).

The definition of CTV boundaries requires a clinical decision.

In some cases, this decision is based on probability evaluation (when data are available), but it often implies an arbitrary choice (e.g., endovascular brachytherapy)

The final decision rests on the clinical experience and judgement of the radiation oncologist.

Planning Target Volume (PTV)

The Planning Target Volume (PTV) is in general of lower importance in brachytherapy compared to external beam therapy because the radioactive sources and the target volumes are usually fixed to each other and one does not need to deal with the problem of day to day treatment set up variations.

Planning Target Volume (PTV)

- In brachytherapy, the dose distribution to the PTV has to be considered as representative of the dose distribution to the CTV.

Planning Target Volume (PTV)

- The situation is quite different in brachytherapy because the source (or source applicator) is, in general, fixed to the target volume. Therefore, in brachytherapy, the PTV is often considered to be identical to the CTV.
- There are however exceptions. For instance, in ***intraluminal brachytherapy***, a safety margin is added around the CTV to compensate for inaccuracies or uncertainties in the position of the radioactive

Treated Volume

- The treated volume is the volume of tissue which, according to the implant as actually achieved, receives a dose at least equal to the dose selected and specified by the radiation oncologist as being appropriate to achieve the goal of the treatment.

Treated Volume

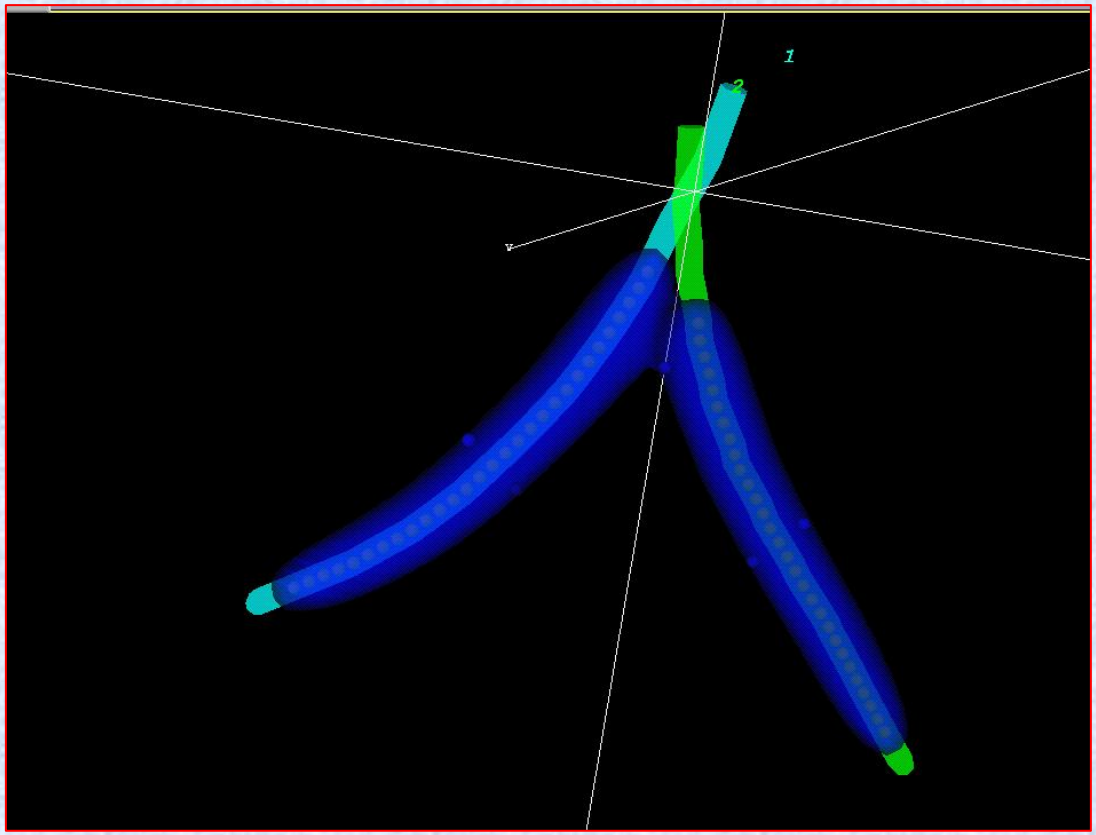
- The Treated Volume is thus encompassed by an isodose surface corresponding to that dose level, which is the *Minimum Target Dose* .This isodose surface should ideally match the PTV as closely as possible, it should entirely encompass the CTV/PTV, but may be larger depending on the available sources and source arrangement. The Treated Volume (and the PTV) thus depends on the irradiation technique.

Irradiated Volume

- The Irradiated Volume is the tissue volume, larger than the Treated Volume, which receives a dose considered to be significant in relation to normal tissue tolerance.

Reference volume

- The reference volume, in intraluminal brachytherapy, is defined as the tissue volume encompassed by the isodose corresponding to 90% of the dose at the reference point.


1
2

Intraluminal Brachytherapy

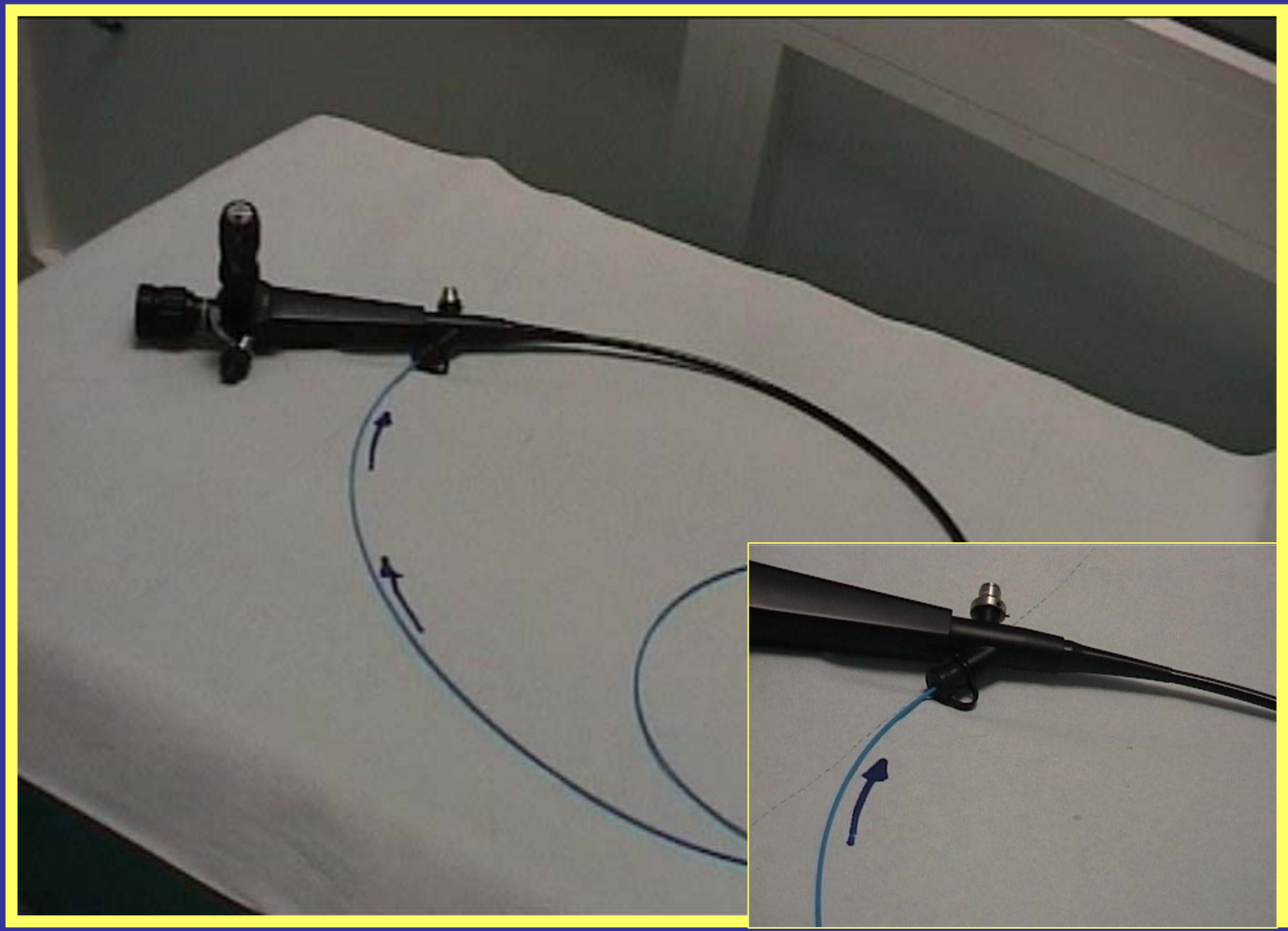
- Intraluminal applications consist of the insertion of one or several linear sources, contained in appropriate applicator devices, in natural cavities (bronchus, esophagus, vagina, biliary duct tumours and endovascular brachytherapy).
- This technique allows delivery of high doses to the CTV, while sparing organs at risk.
- The linear (or quasi linear) sources may be simulated by several point sources (seeds) or a moving source.

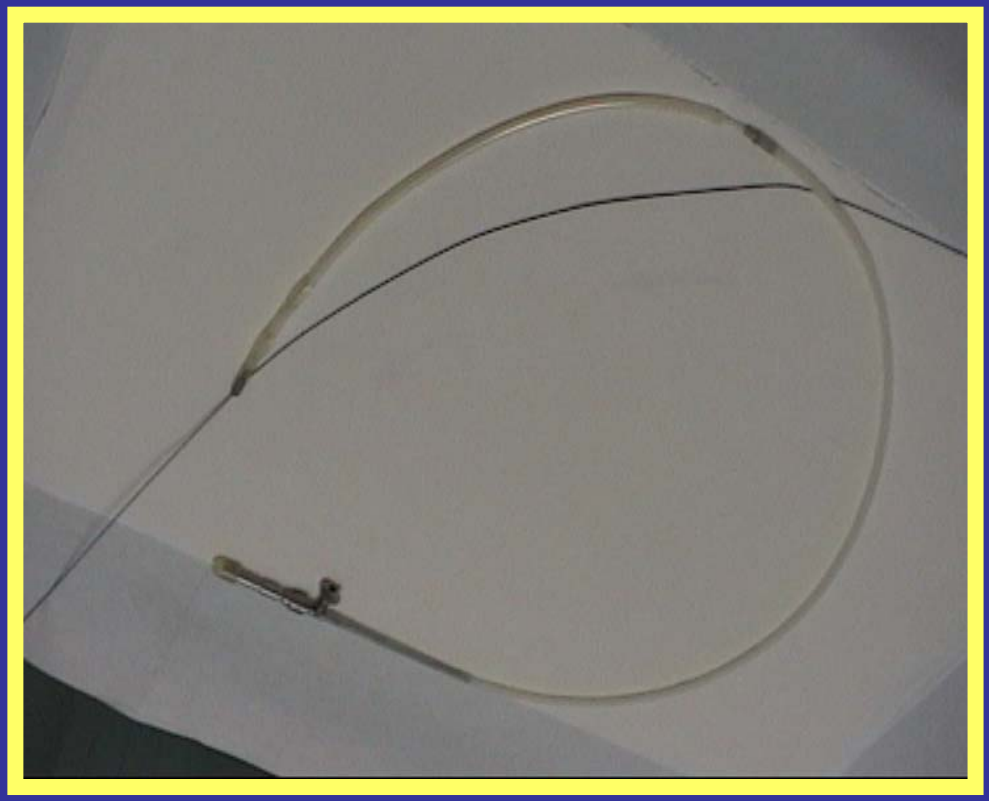
Intraluminal Brachytherapy

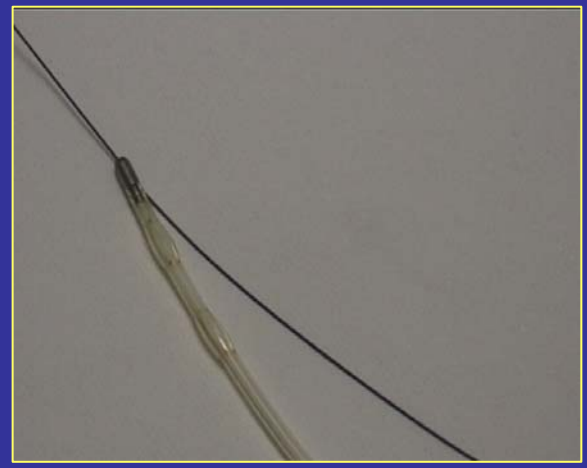
In intraluminal brachytherapy, the radioactive material is inserted in the (anatomical) lumen, limited by the mucosa, the usual site of origin of the tumour.

Due to the (physical) inverse square law :

- (a) the dose is decreasing dramatically as a function of distance to the linear source,
- (b) the dose gradient is steepest close to the source and decreases with distance.







Applicatori endocavitari

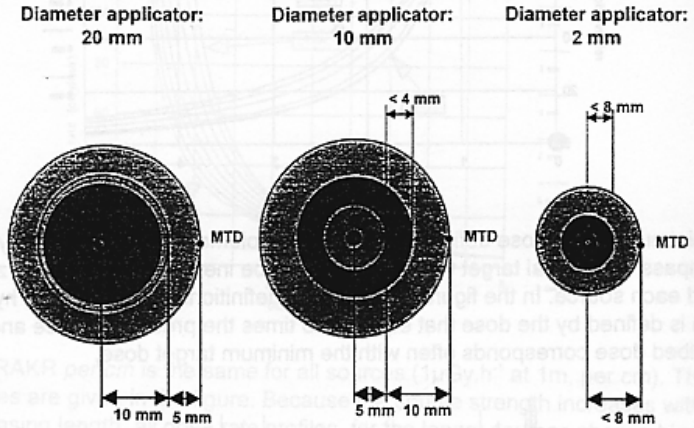
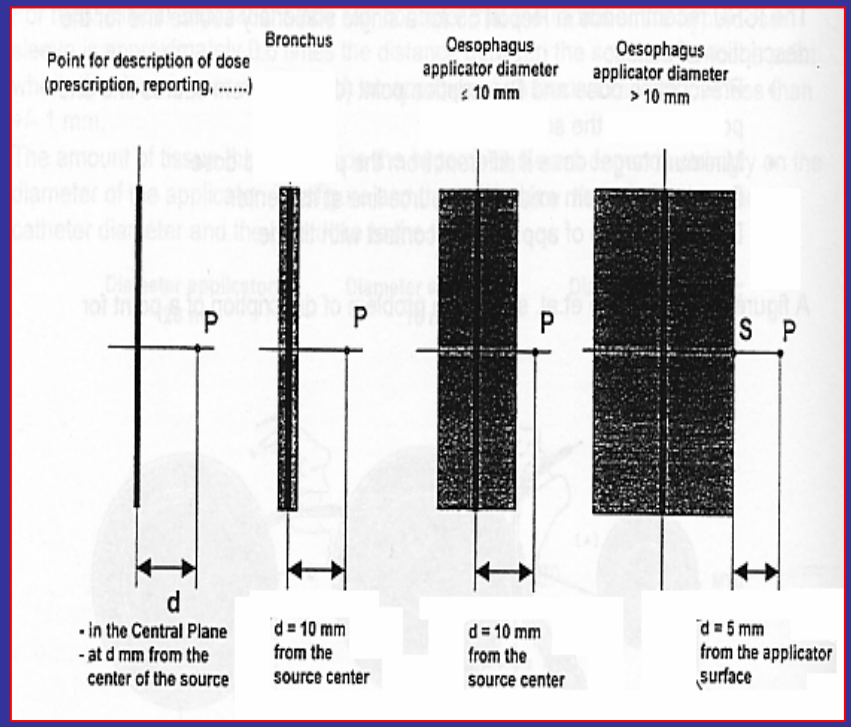


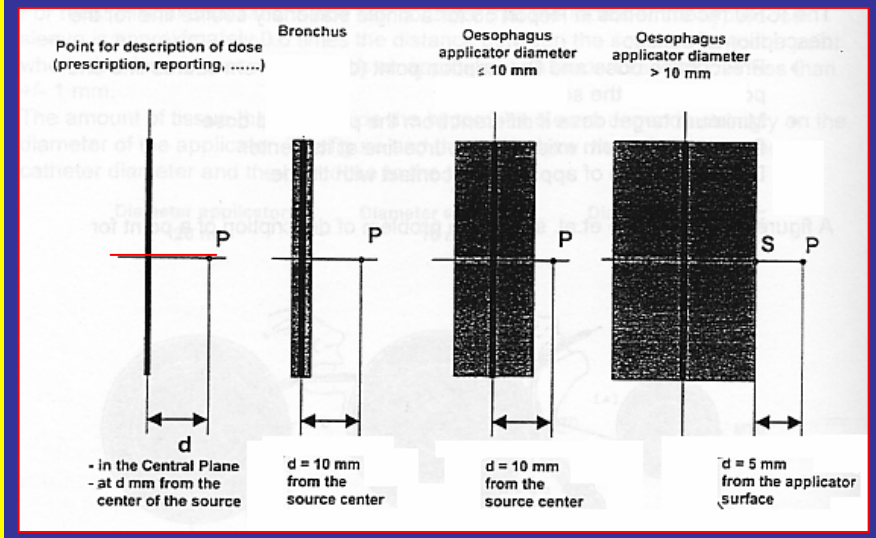
Table Some characteristics of the hyperdose sleeve

diameter applicator (mm)	distance point of dose to surface applicator (mm)	radius hyperdose sleeve (mm)	thickness treated (mm)	Remark
20	5 from the surface of the applicator	0.6x(10+5)=9	5	no tissue exposed to twice the Minimum Target Dosedose or more
10	10 from the surface of the applicator	0.6x(5+10)=9	10	4 mm thickness of tissue included in hyperdose sleeve
very thin	≤ 8	≤ 5	-	Interstitial therapy



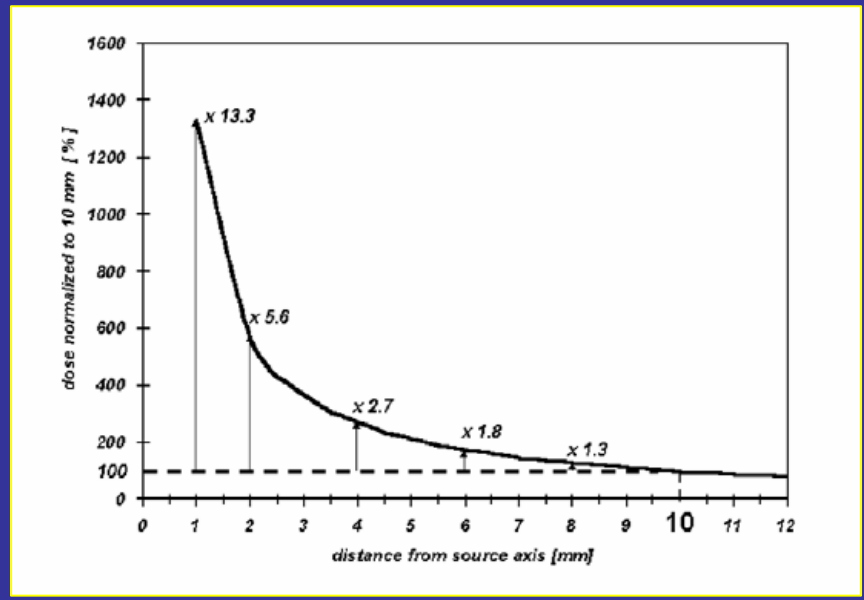
Central plane

- The central plane of an intraluminal application is the plane perpendicular to the axis of the organ lumen, half way between the proximal and distal ends of the PTV.
- The central plane is used for prescribing and reporting.
- The central plane is also used to define the average lumen diameter



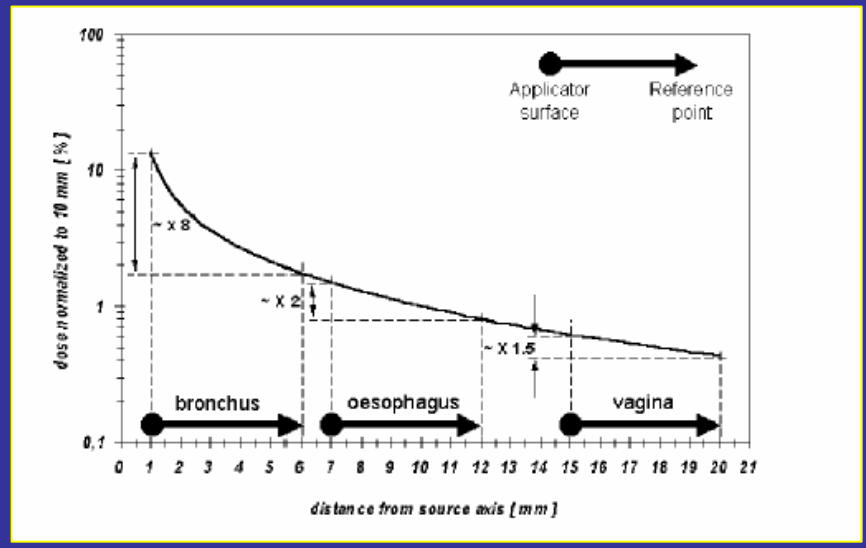
Dose at the luminal surface

- The highest tissue dose is obtained at the level of the luminal surface; it depends on the applicator diameter. The luminal surface dose is critically related to tumour control and the risk of complications.
- In contrast, the highest (physical) dose is within the applicator volume or in the lumen where it isobviously not clinically relevant.



Dose gradient

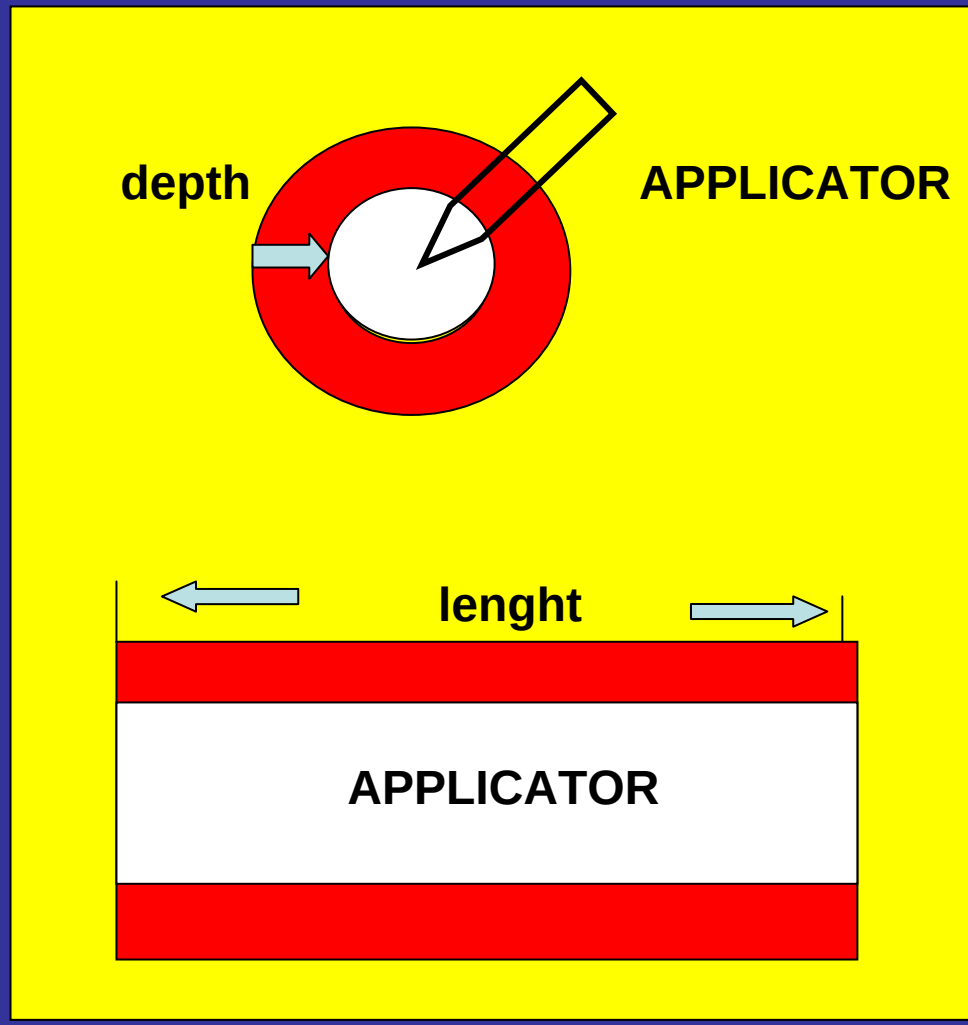
- Dose inhomogeneity in the tissues, over a given radius (e.g., 5 mm), is high close to the source (i.e.,when a small diameter applicator is used); the dose becomes more homogeneous at a distance from the source (i.e., when a large diameter applicator is used).
- Dose homogeneity is better with a large applicator (when clinically

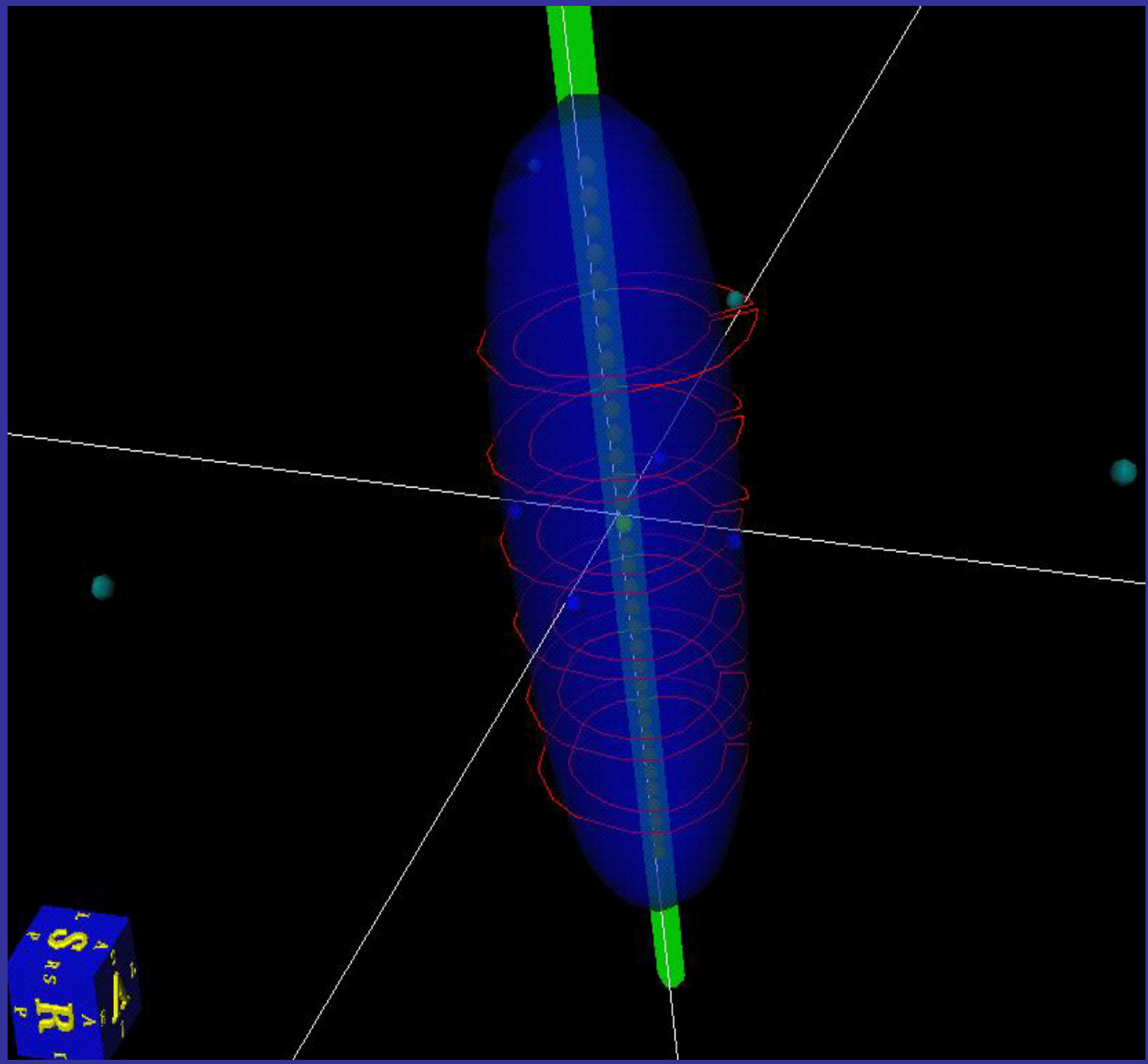


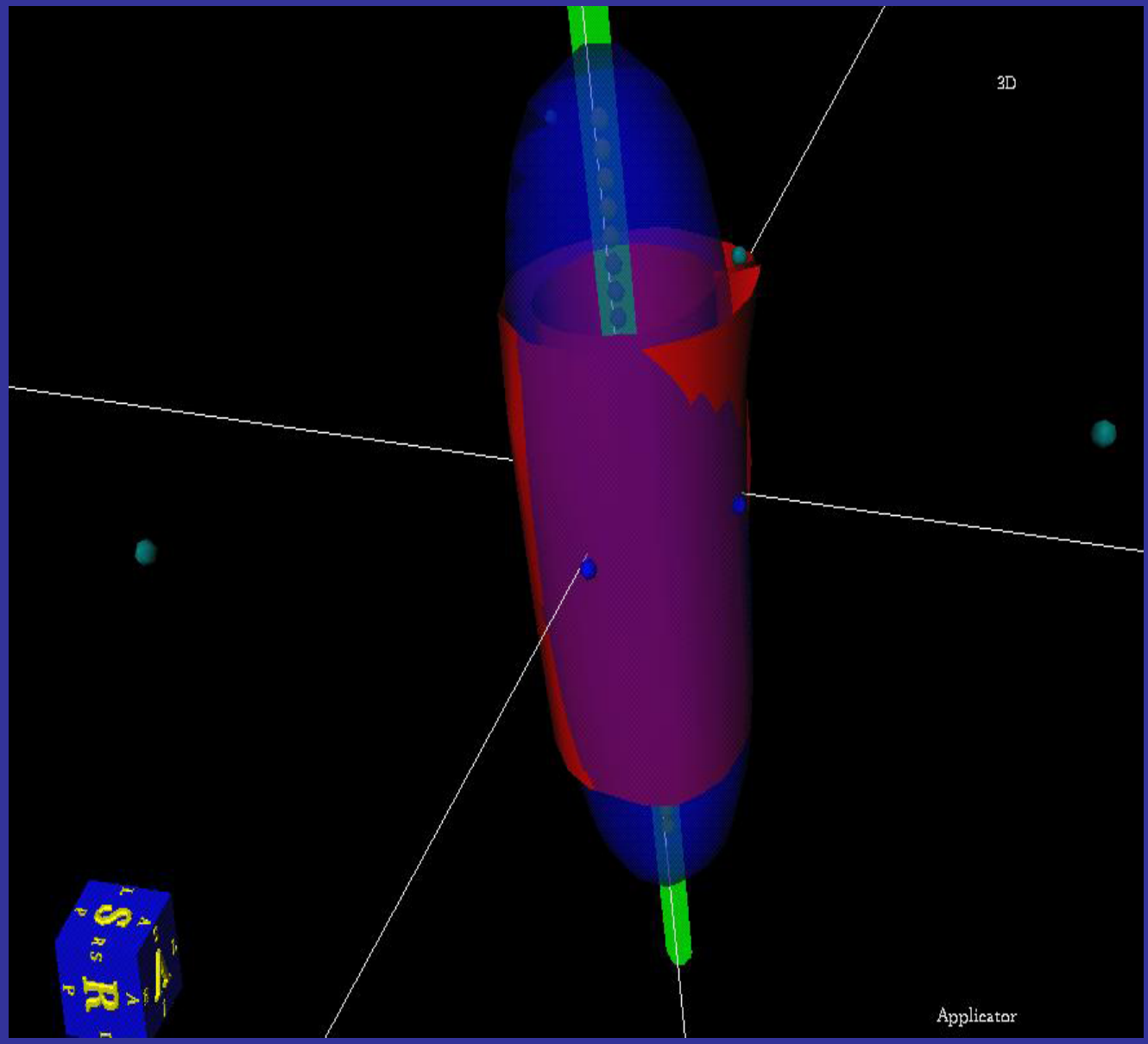
The organs suitable for intraluminal brachytherapy have a central lumen containing the applicator

The dose to the volume occupied by the lumen and the applicator is obviously not relevant.

The main dimensions to evaluate and to report are **the length** and the tissue **depth** (thickness).

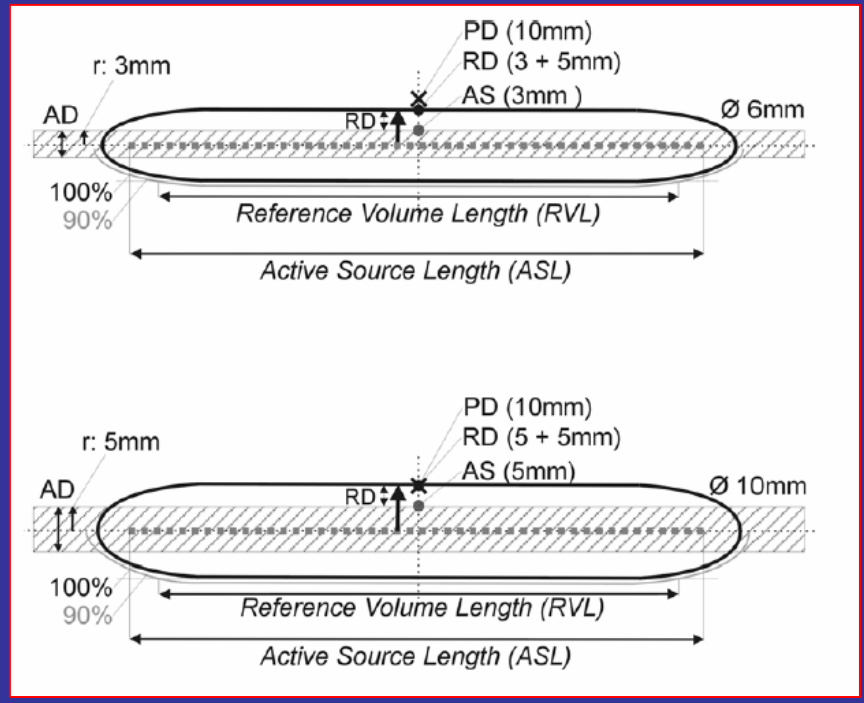



S
R


3D
Applicator

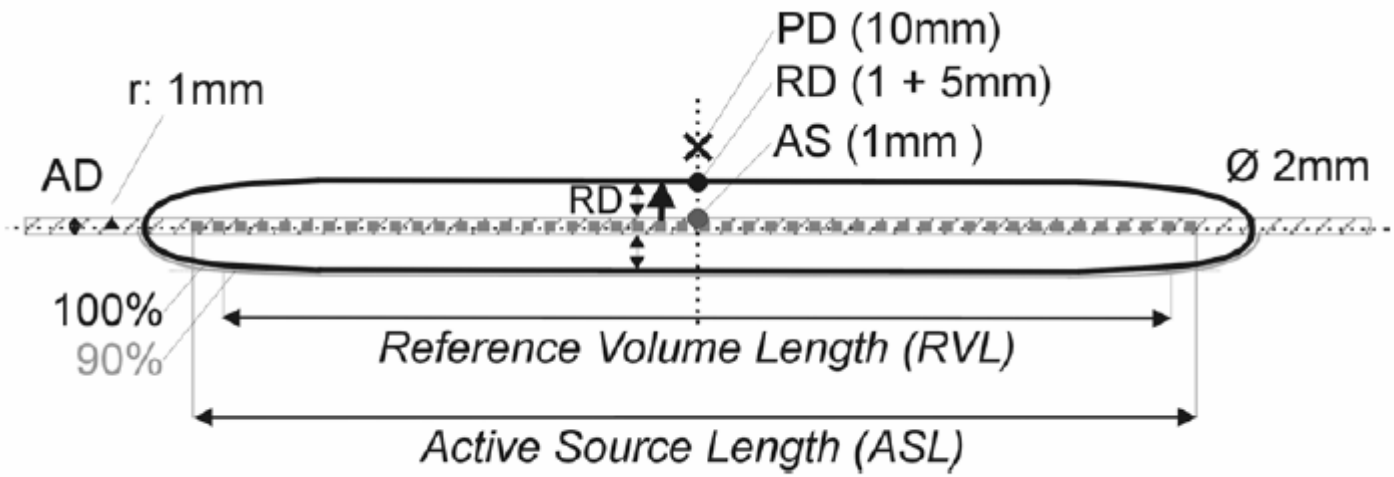
lenght

- The lengths of the GTV, CTV and PTV are defined at the level of the mucosa
- The Length of the Reference Volume (RVL) is defined as the length of the 90%-isodose at the reference depth of 5 mm.



In order to clearly indicate the doses at the reference depth (RD) and at the Lumen Surface (different from the Applicator Surface) the diameter of the (bronchus) lumen has to be reported, which is from ~18mm for the trachea to ~9mm for the tertiary bronchi

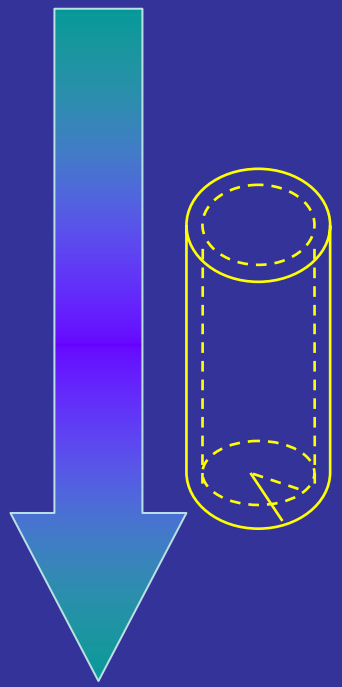
- When a non-centered device is used (e.g. frequent in bronchus and with some systems in endovascular brachytherapy), it is difficult to specify the actual dose at the mucosa
- The best estimation of the maximum and minimum doses should then be reported


PD (10mm)
RD (1 + 5mm)
AS (1mm)
r: 1mm
AD
Ø 2mm
RD
100%
90%
Reference Volume Length (RVL)
Active Source Length (ASL)

BRONCHI PRINCIPALI

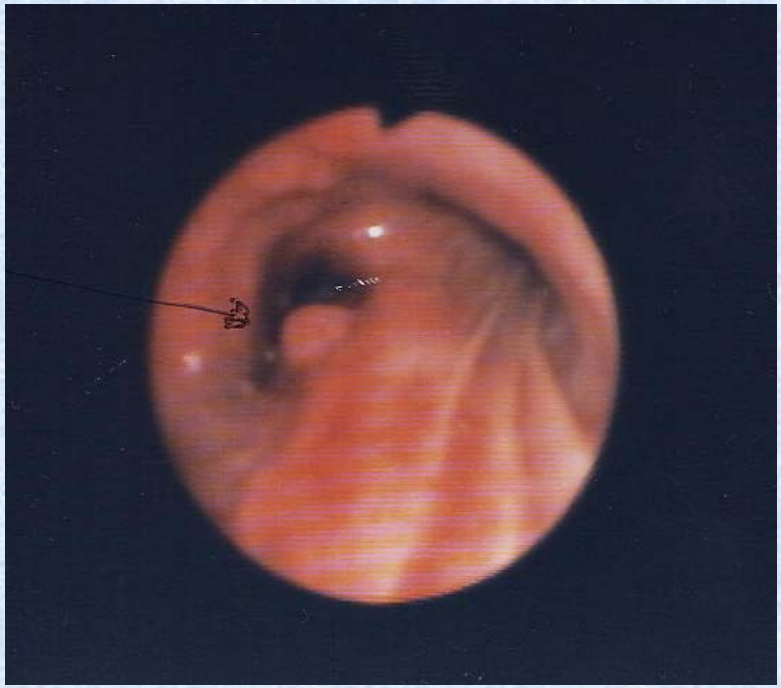
- diametro medio 8mm-10mm
- spessore della parete 3mm
- diametro dell'applicatore 1cm

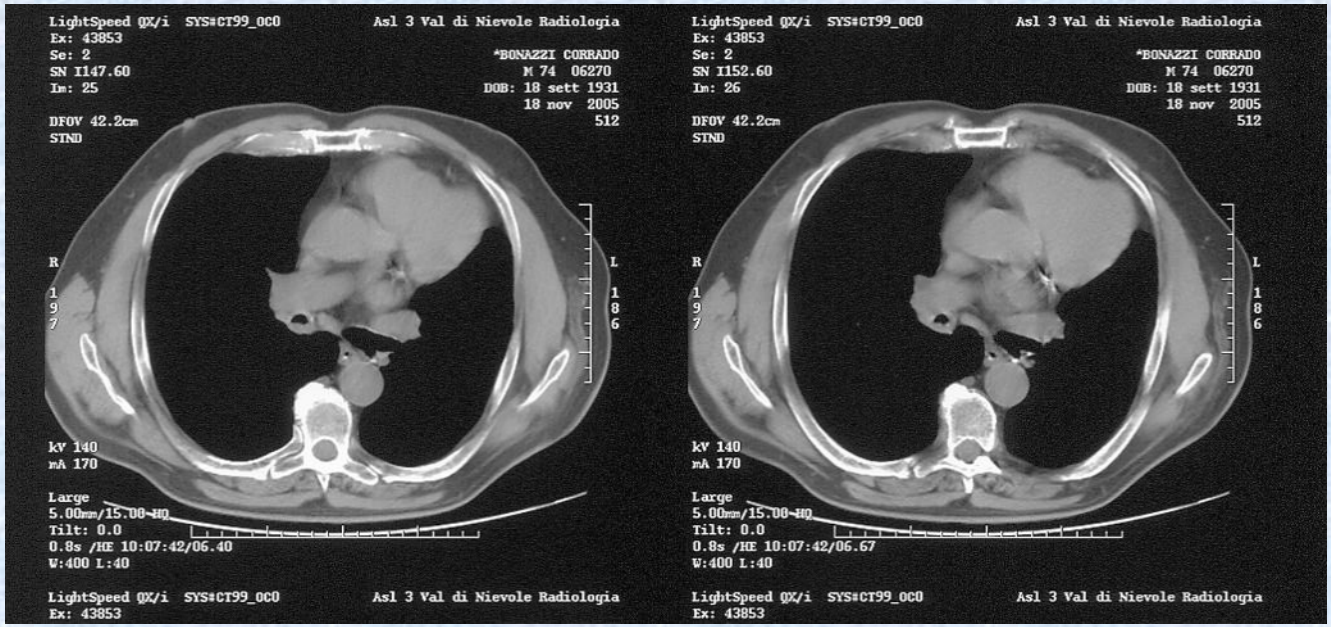
TC SIMULATORE

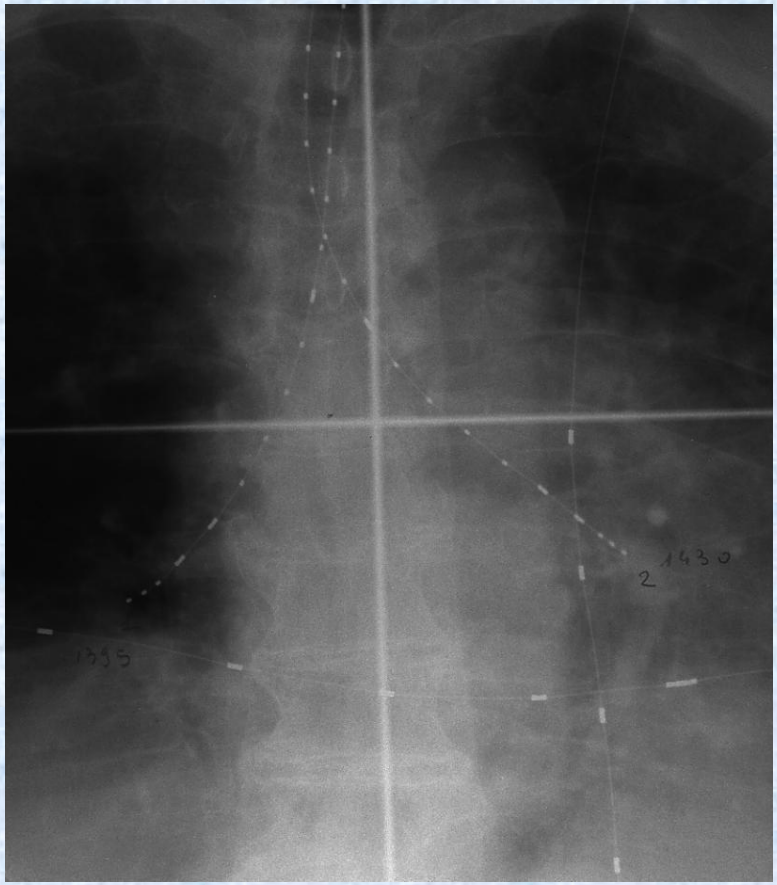


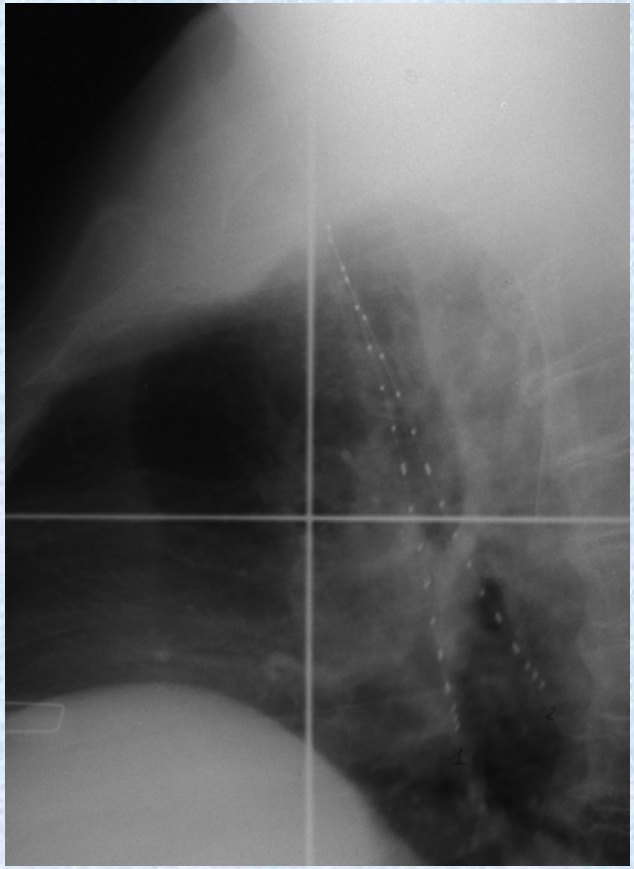
- Il raggio medio del target
- Il raggio medio del lume
- Distanza del catetere dalla estremità più lontana del tumore
- Distanze del catetere dalla mucosa

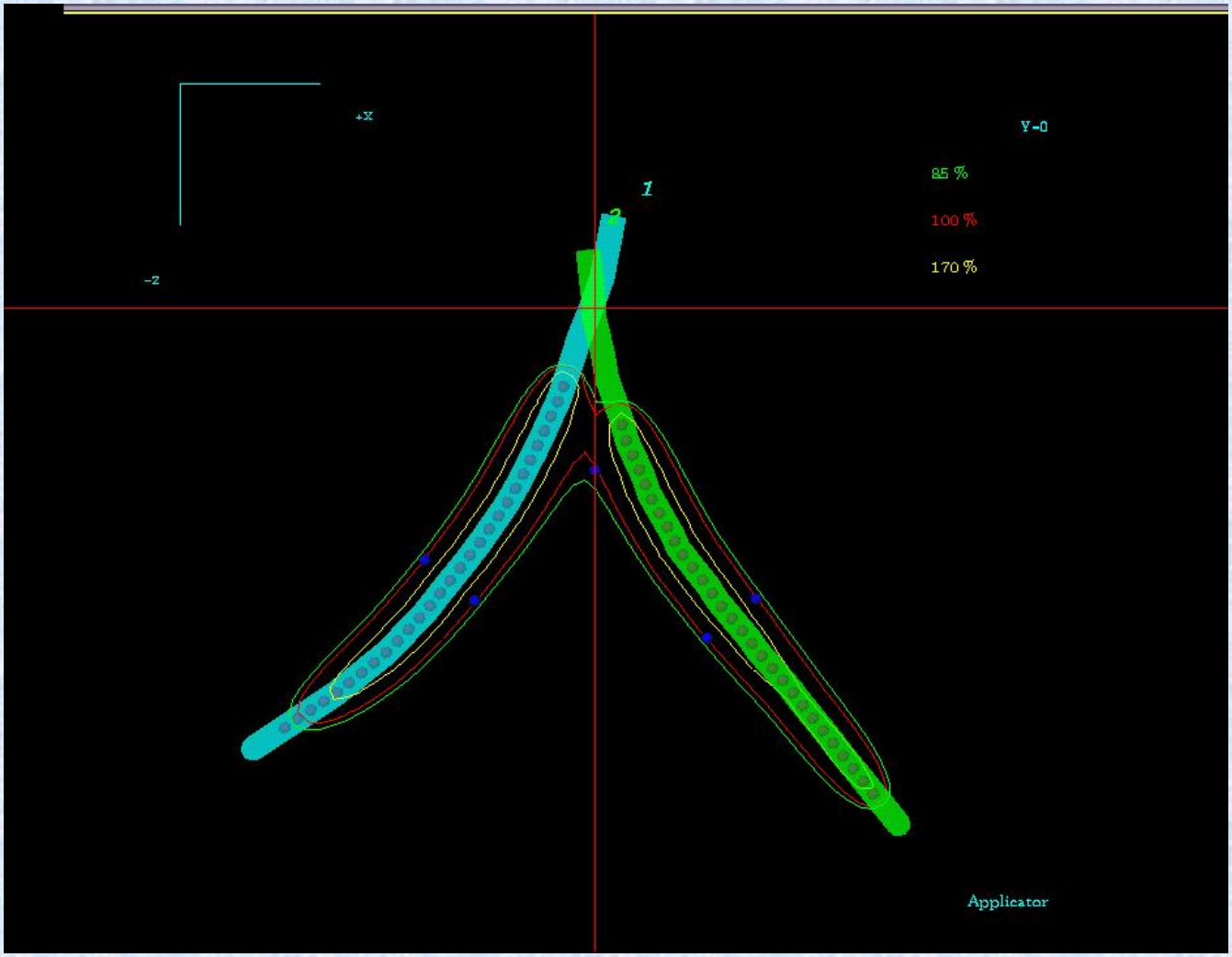
Migliore definizione del target
Istogrammi dose volume
Ottimizzazione del trattamento

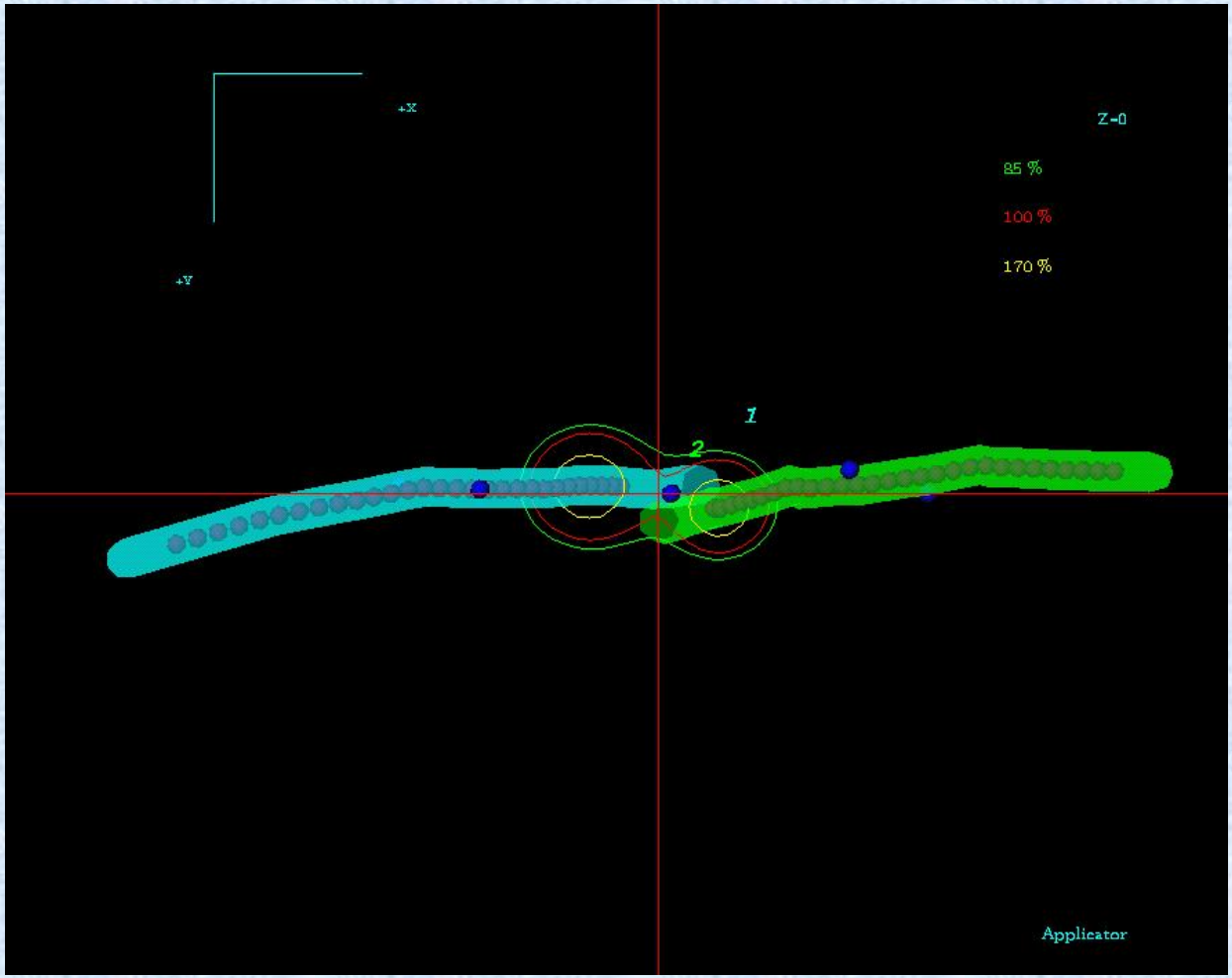


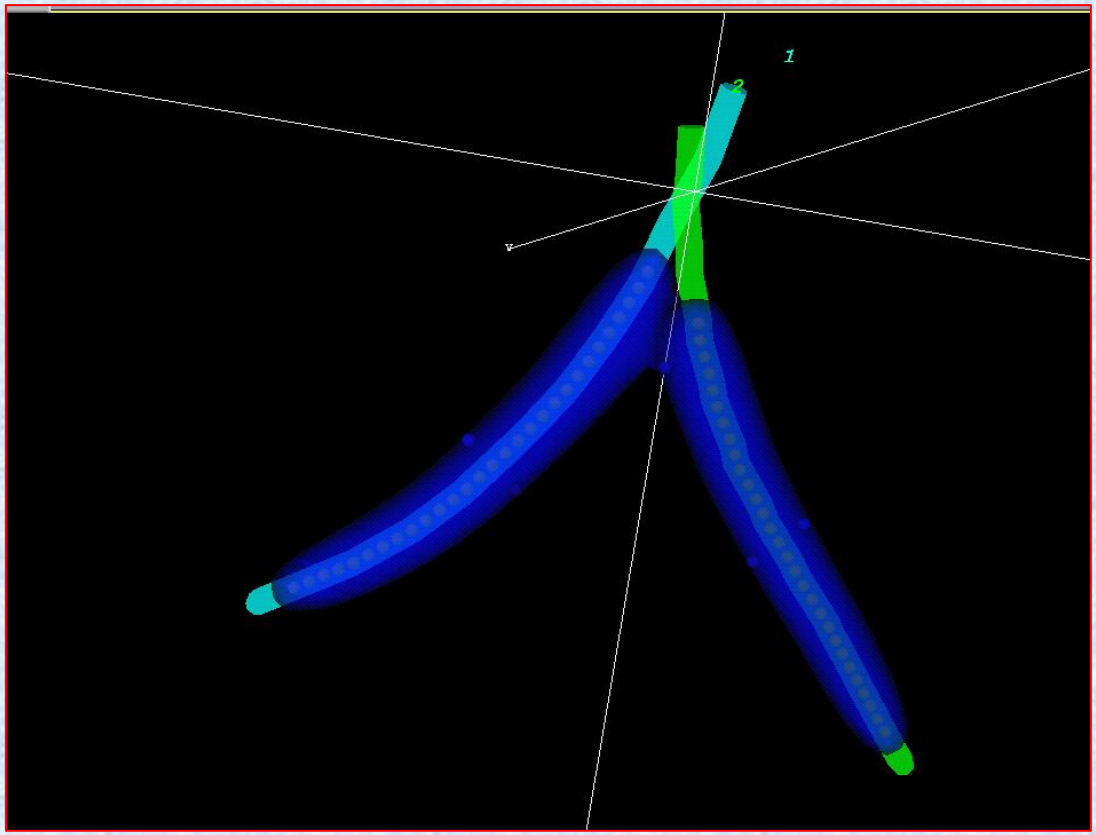

LightSpeed QX/i SYS#CT99_OC0
Asl 3 Val di Nievole Radiologia
Ex: 43853
Se: 2
SN I147.60
Im: 25
*BONAZZI CORRADO
M 74 06270
DOB: 18 sett 1931
18 nov 2005
DFOV 42.2cm
512
STND
R
L
197
186
kV 140
mA 170
Large
5.00mm/15.00-HQ
Tilt: 0.0
0.8s /HE 10:07:42/06.40
W:400 L:40
LightSpeed QX/i SYS#CT99_OC0
Asl 3 Val di Nievole Radiologia
Ex: 43853
LightSpeed QX/i SYS#CT99_OC0
Asl 3 Val di Nievole Radiologia
Ex: 43853
Se: 2
SN I152.60
Im: 26
*BONAZZI CORRADO
M 74 06270
DOB: 18 sett 1931
18 nov 2005
DFOV 42.2cm
512
STND
R
L
197
186
kV 140
mA 170
Large
5.00mm/15.00-HQ
Tilt: 0.0
0.8s /HE 10:07:42/06.67
W:400 L:40
LightSpeed QX/i SYS#CT99_OC0
Asl 3 Val di Nievole Radiologia
Ex: 43853

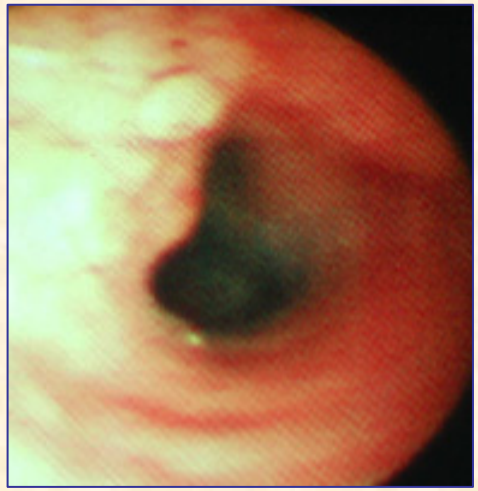

1430
1355

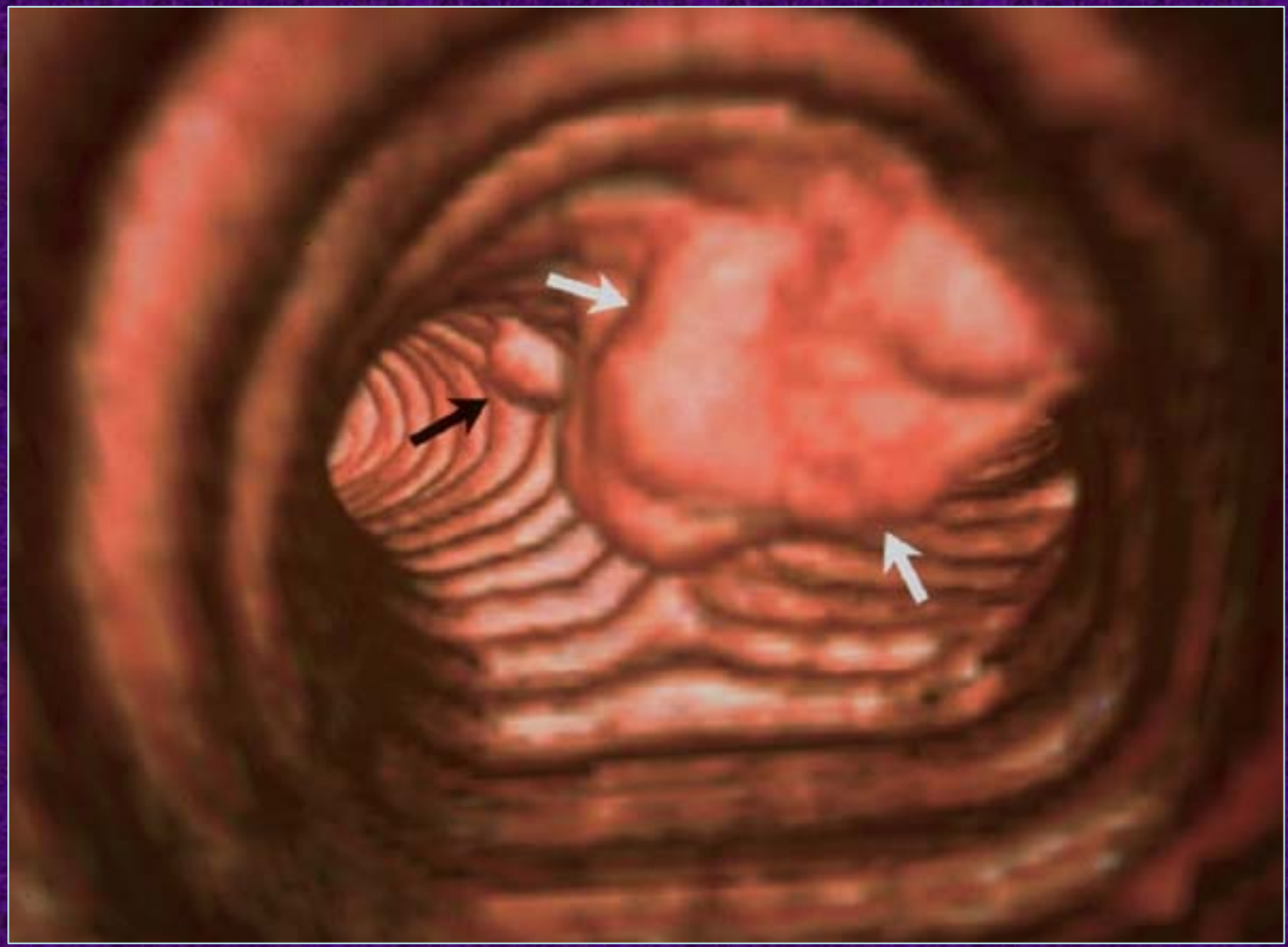


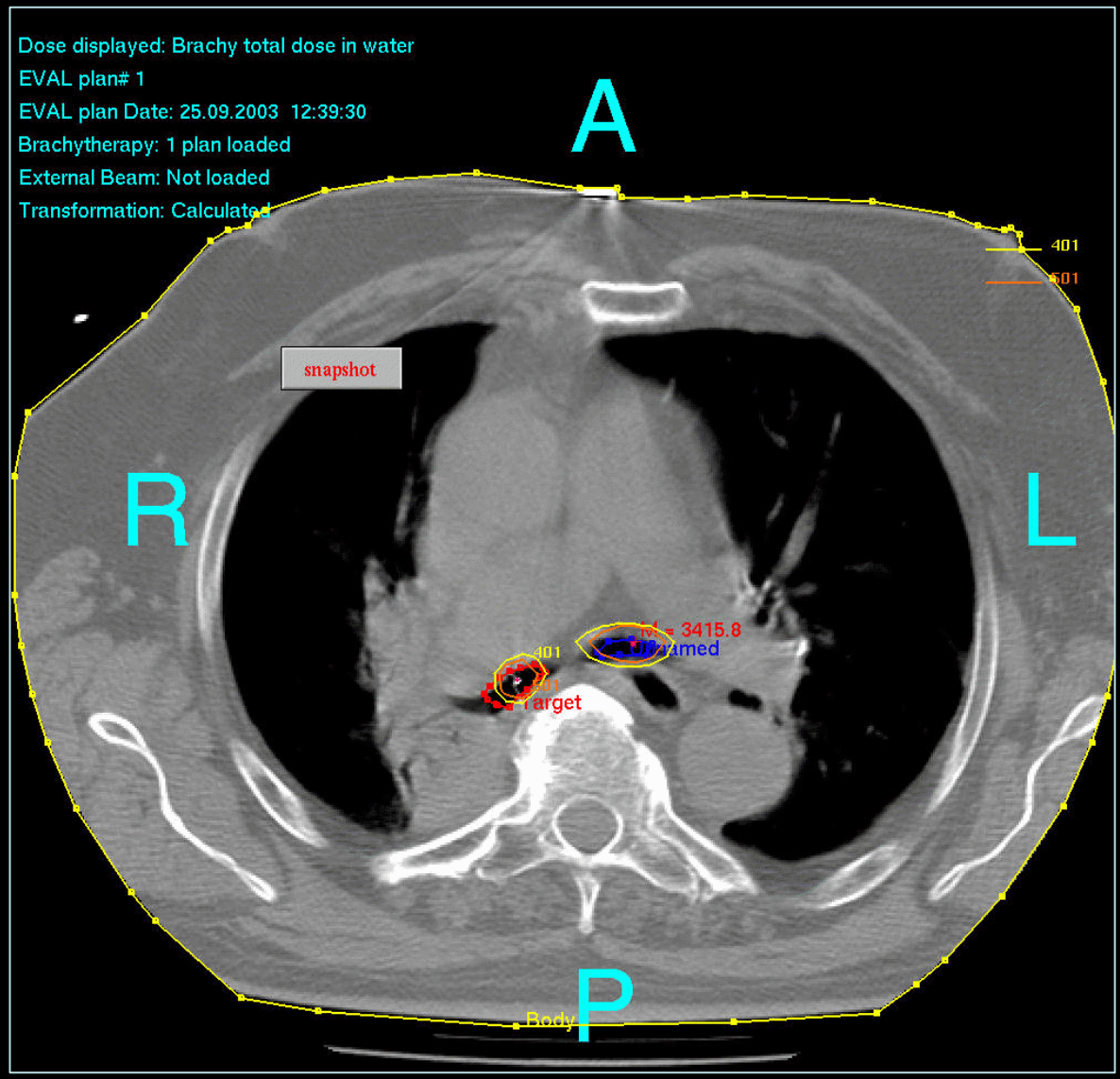

+X
-Z
Y=0
85 %
100 %
170 %
1
2
Applicator

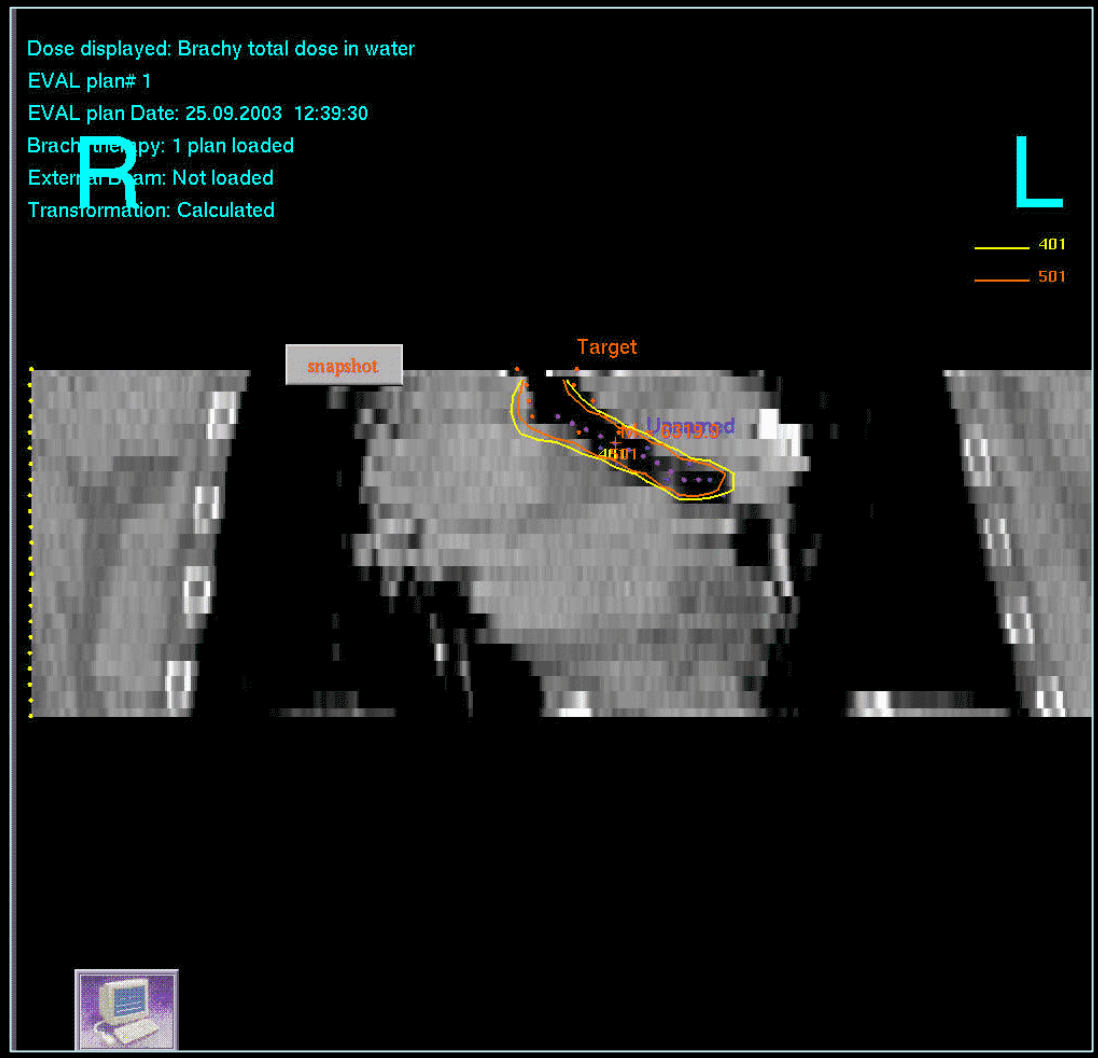

+X
+Y
Z-0
85 %
100 %
170 %
1
2
Applicator

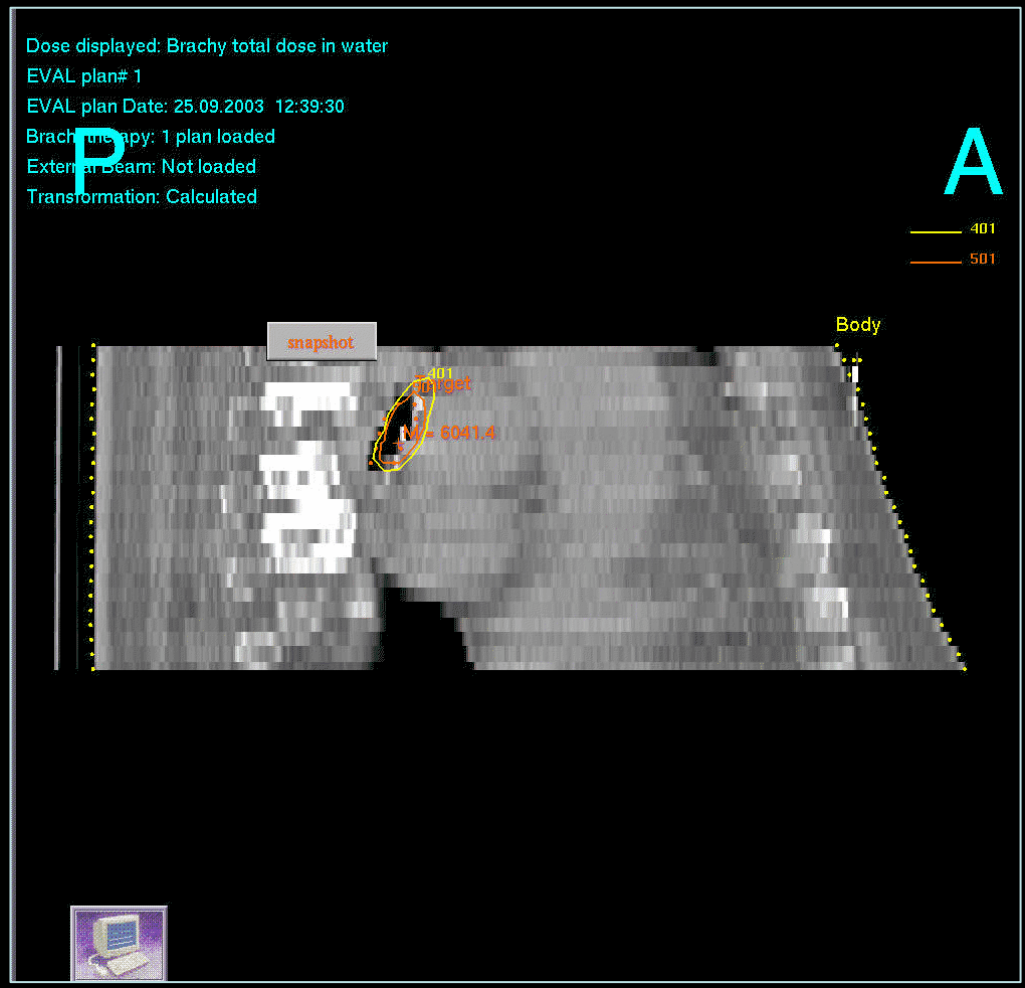

1
2

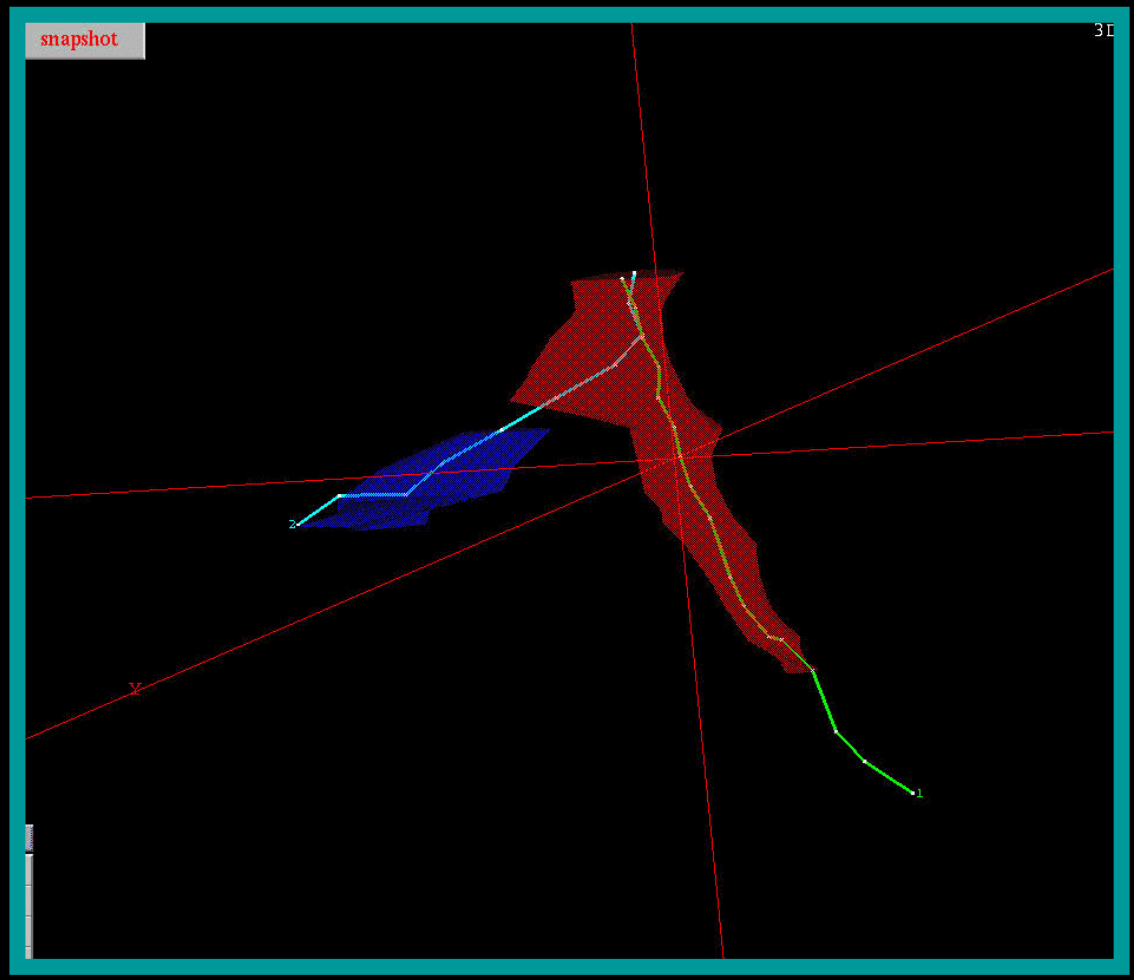





Dose displayed: Brachy total dose in water
EVAL plan# 1
EVAL plan Date: 25.09.2003 12:39:30
Brachytherapy: 1 plan loaded
External Beam: Not loaded
Transformation: Calculated
A
R
L
P
snapshot
401
501
401
Target
Body


Dose displayed: Brachy total dose in water
EVAL plan# 1
EVAL plan Date: 25.09.2003 12:39:30
Brachytherapy: 1 plan loaded
External Beam: Not loaded
Transformation: Calculated
R
L
401
501
snapshot
Target


Dose displayed: Brachy total dose in water
EVAL plan# 1
EVAL plan Date: 25.09.2003 12:39:30
Brachytherapy: 1 plan loaded
External Beam: Not loaded
Transformation: Calculated
P
A
401
501
snapshot
Body
401
Target
6041.4


snapshot
3D
2
1
Y

Reference depth – Reference point

- A Reference depth of 5 mm, from the surface in the organ wall, in the central plane, is recommended for oesophagus, bronchus and vagina
- In endovascular brachytherapy, a reference depth of 1 mm, from the endothelium (surface wall) in the artery, is recommended for reporting dose to the patient, for coronary arteries.
- For peripheral arteries, a depth of 2 mm is recommended.

GRAZIE DELLA CORTESE ATTENZIONE