Interfractional movement of the uterus.
Adequate margins in EBRT of cervical cancer

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EBRT
CTV-PTV margins of the uterus

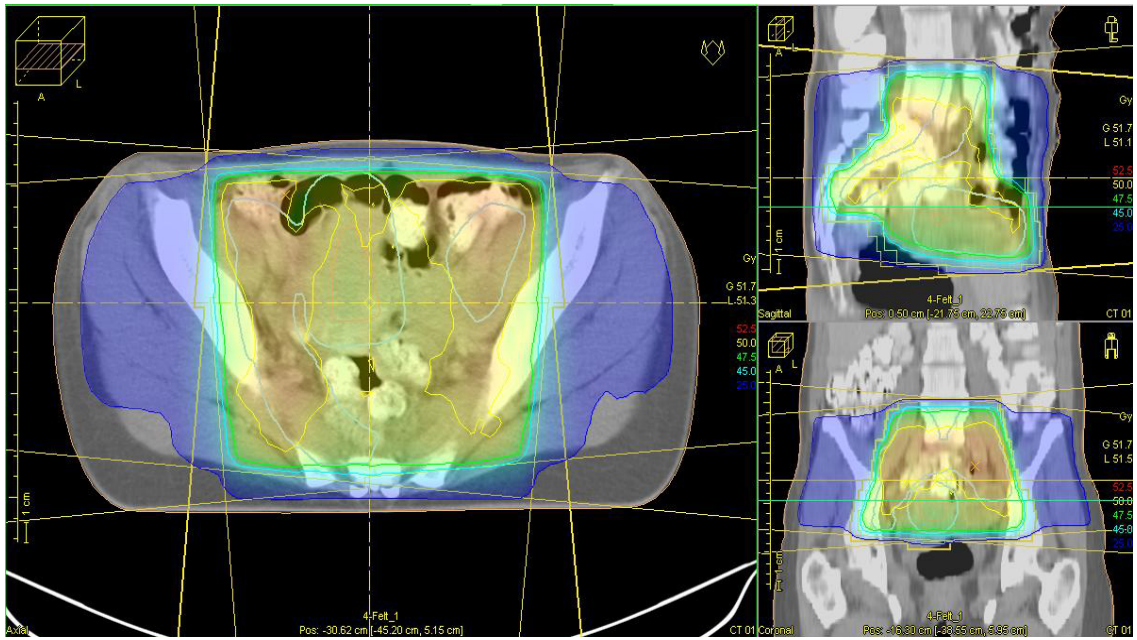
Embrace:

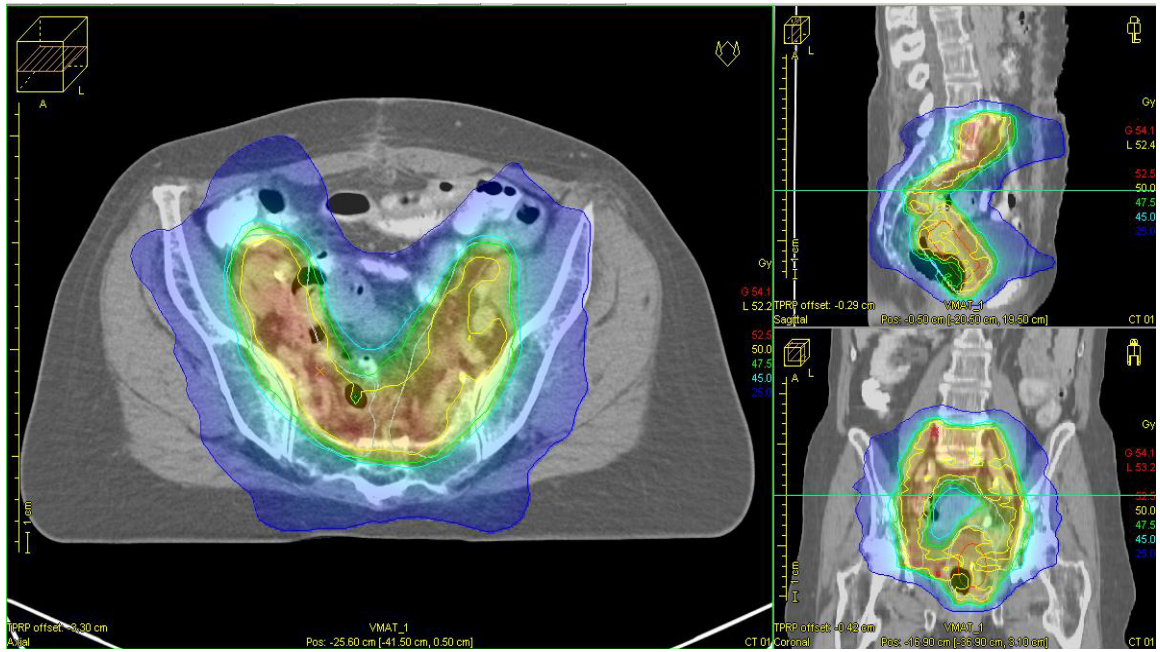
- The whole uterus should be included in the CTV-E
- CTV-PTV margin approximately 10 mm (not generally defined)

Uterus (especially the upper part) is a rather mobile organ;

The CTV-PTV margins used must be sufficient to ensure adequate dose coverage, especially when using conformal techniques (**IMRT and VMAT**).

Movement of uterus - dose coverage





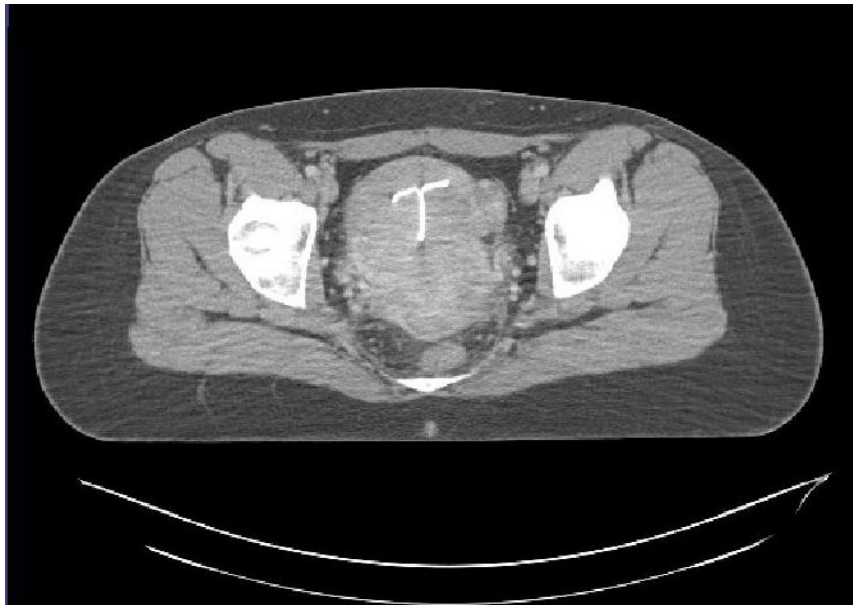
Dependent on

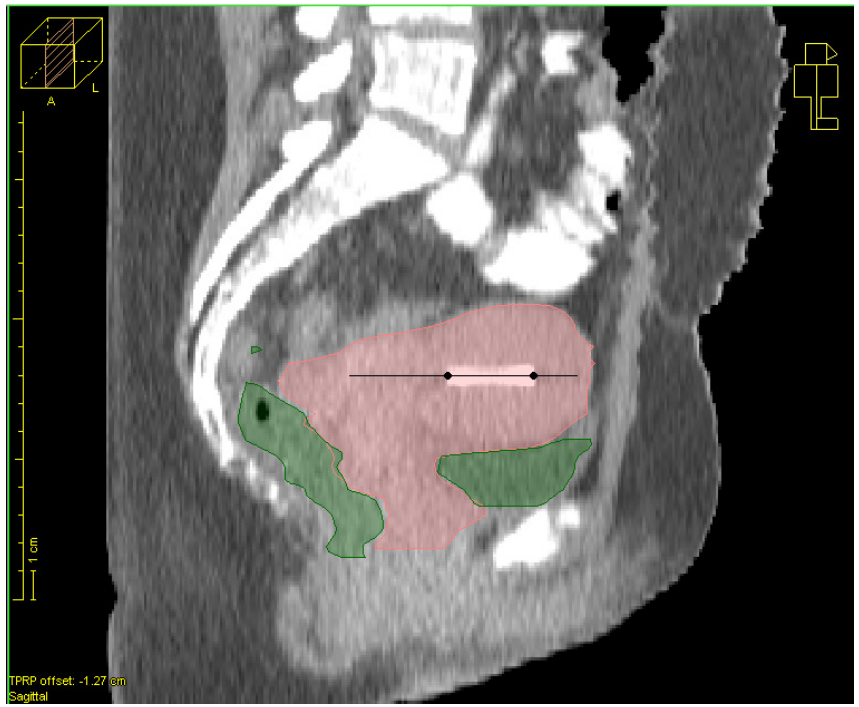
- treatment technique
- direction and size of the movement

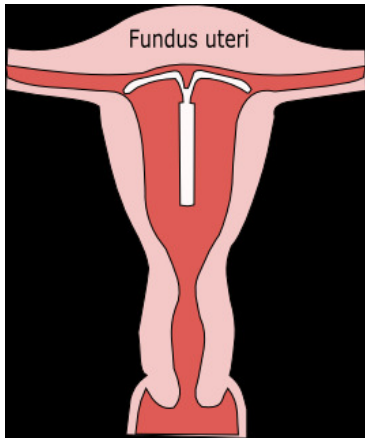
Intrauterine device (IUD)

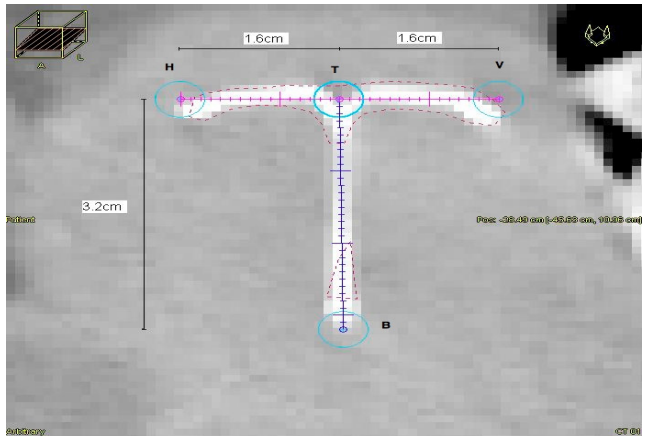
as a geometrical marker:

- Defines the uterine axis
- Used to map the movement of the upper part of the uterus







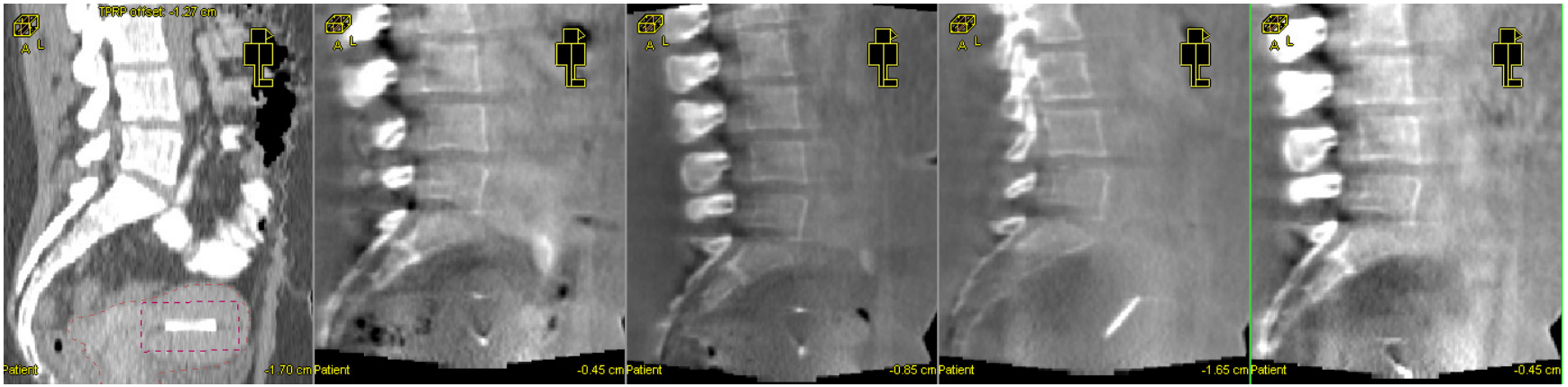


Interfractional movement of the uterus

5 patients recorded:

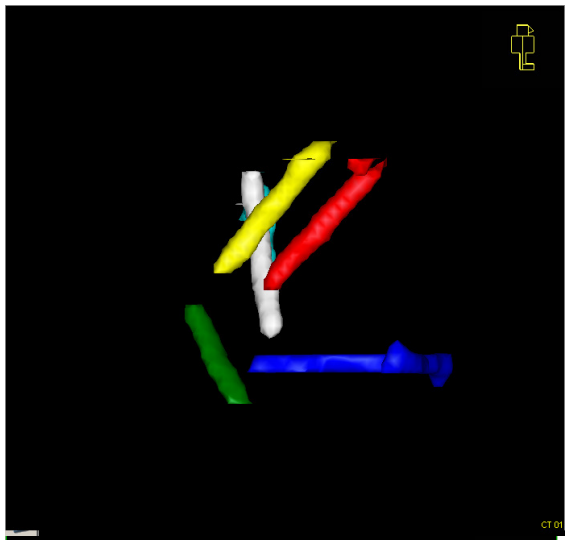
Large differences in interfractional movement of the uterus

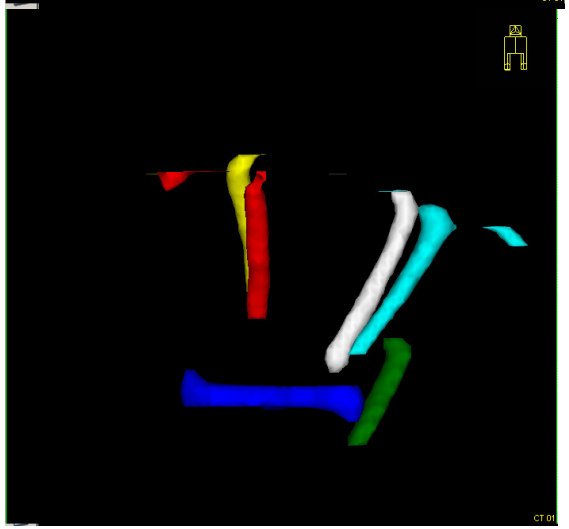
Example: patient with large interfractional movement of the uterus



Day: 0 Day:9 Day:10 Day:13 Day:16

3D- reconstruction of the IUD





Interfractional movements of the IUD

Examples from 2 patients

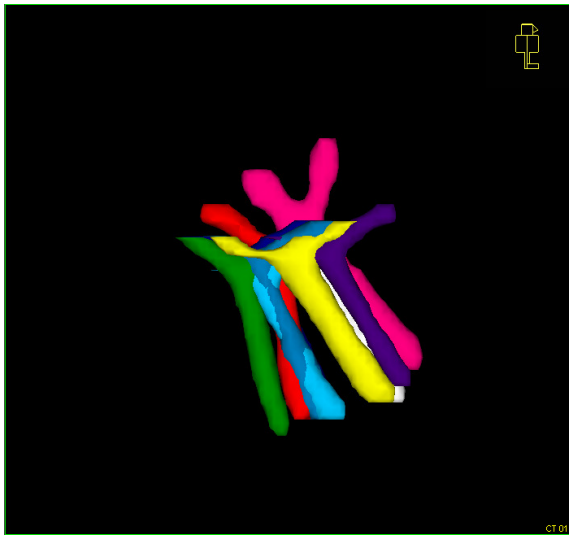
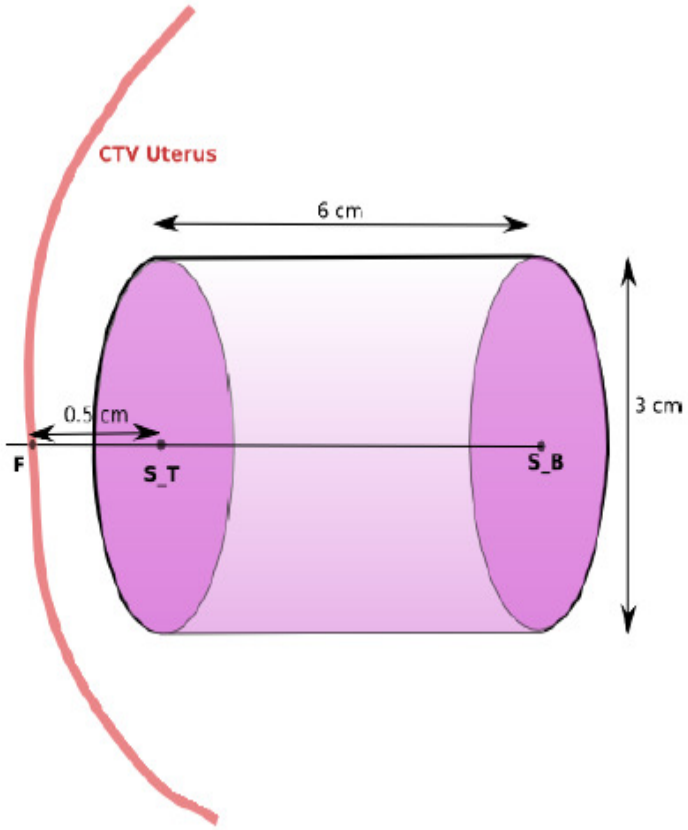
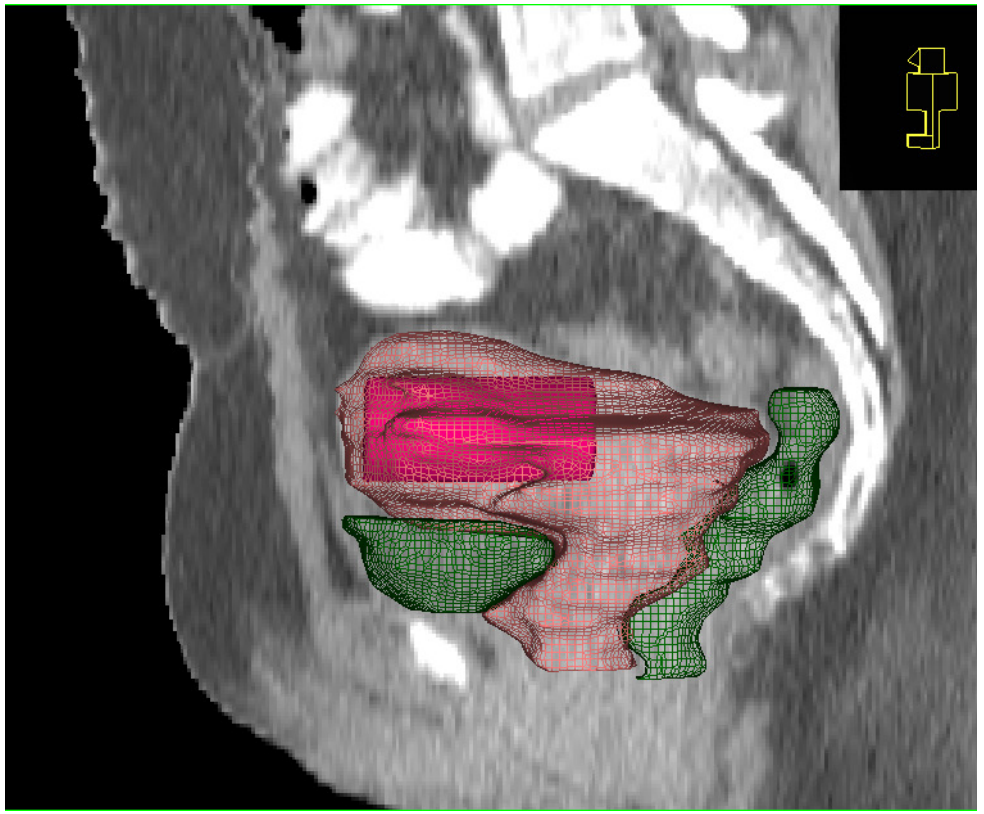


Image registrations based on bone structures

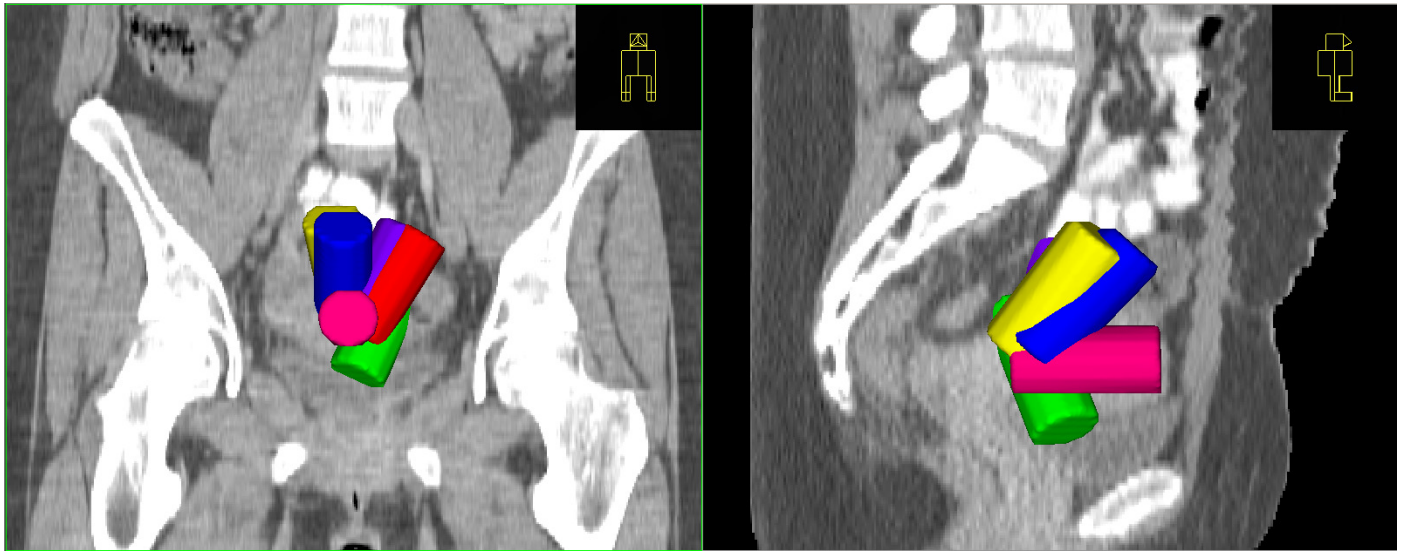
The cylinder model placement in uterus





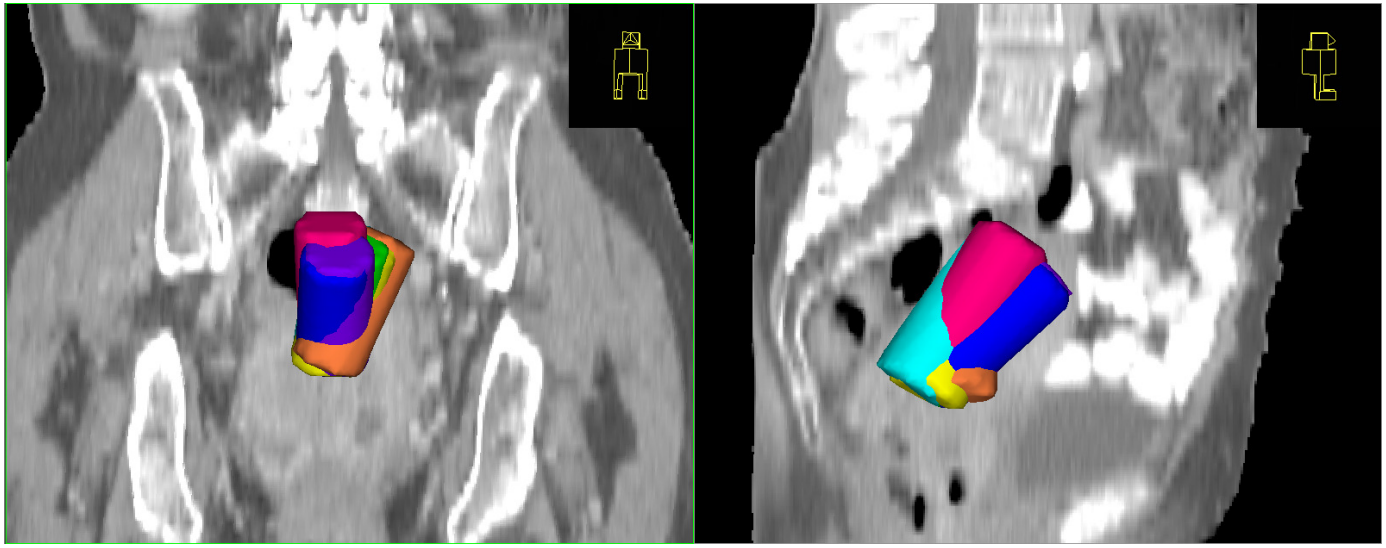
Patient 2

Planning CT(pink)
5 XVI

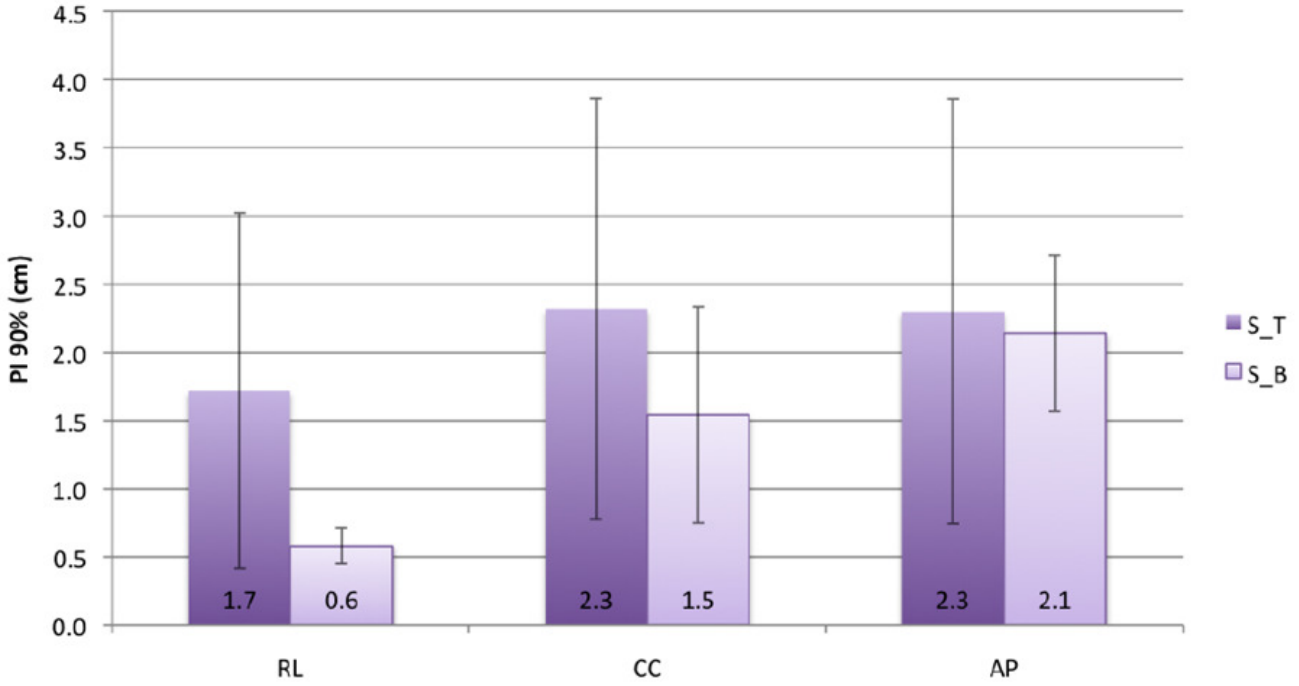


Patient 3

Planning CT (pink)
8 XVI



Movement of the cylinder



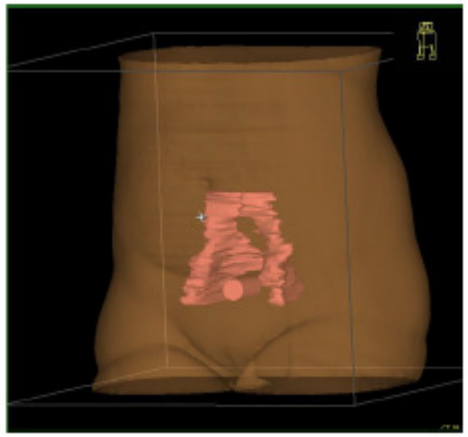
Mean of 90% prediction intervals in RL, CC and AP directions for the points S_T and S_B

Treatment plans

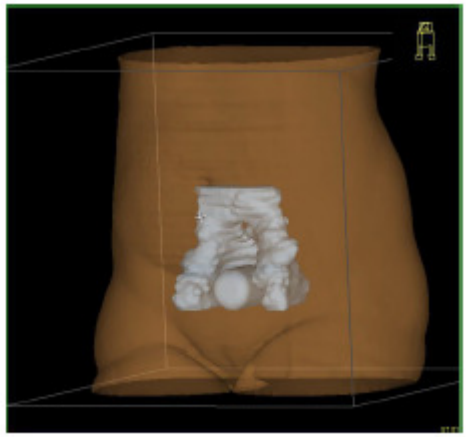
Theoretical PVT volumes:

- Cylinder model (the central upper part of the uterus)
  - PTV-CTV margins 10 – 12 mm
- Lymph node stations with subclinical decease
  - PTV-CTV margins 7 mm

4 field box technique
VMAT

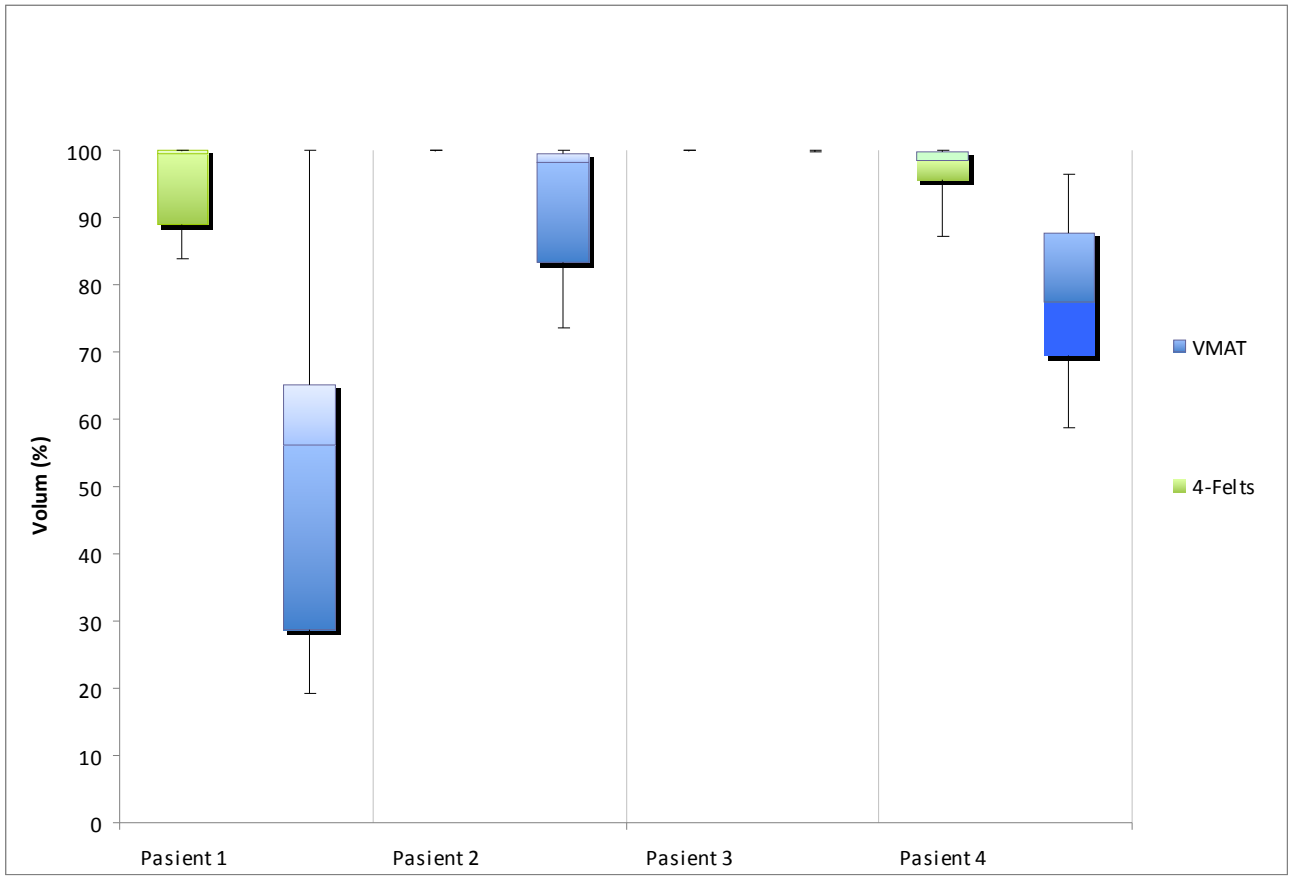


(a) CTV



(b) PTV

Dose coverage of the theortical PTV volumes



V95% for each observation in the cylinder model for VMAT plans and 4-field box technique

CTV-PTV margins

- The CTV-PTV margins of 12 mm are not large enough to account for interfractional movement of the fundus uteri in all patients.
  - Conventional treatment technique:
    - The dose coverage was sufficient
  - VMAT
    - suboptimal dose coverage in some patients.
- Large variations among patients, making it hard to obtain a standardized set of margins.

What margins shall be used?

- Other EMBRACE participants use 15 mm margin (Aarhus).
- Different margins for different treatment techniques?
  - larger margins for VMAT/IMRT (especially in the AP direction)?
- Smaller margins acceptable when using daily image guidance and daily plan selection? (resource demanding)
- Despite that the dose coverage is not sufficient (V95 % > 95 %), our experience is that the treatment effects generally are good.