TARGET VOLUME DELINEATION IN RECTAL CANCER

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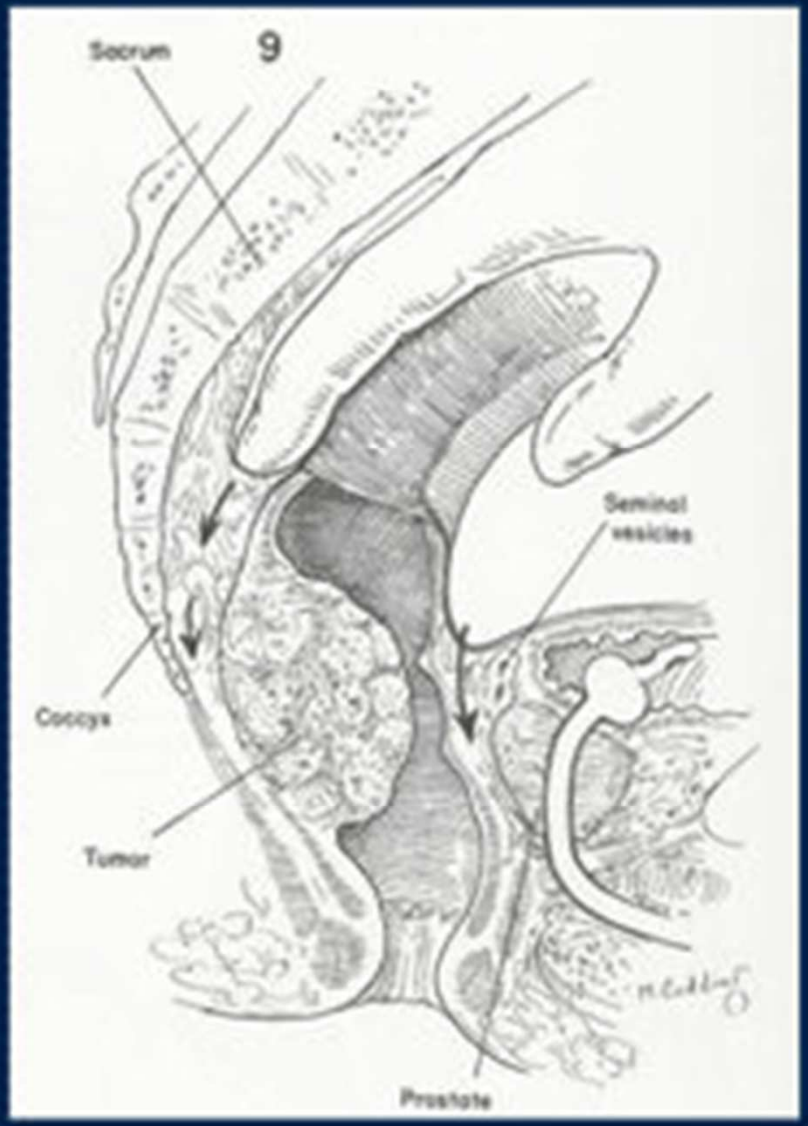
KIMS PINNACLE
COMPREHENSIVE CANCER CENTER

Surgery for Rectal Cancer



Technical Failure Results in Local Recurrence

Zollinger RM Jr, Zollinger RM. *Atlas of Surgical Operations*. 7th ed. New York, NY: McGraw-Hill; 1993.

Circumferential Resection Margin

- In curative resected patients:
  - 23% overall local recurrence rate
    - 66% CRM involved
    - 8% CRM not involved
- Effect of CRM involvement on 5-year survival:
  - 62% overall survival
    - 24% CRM involved
    - 74% CRM not involved
    - $p<0.001$

Adam U, et al. *Lancet*. 1994;344:707-711.

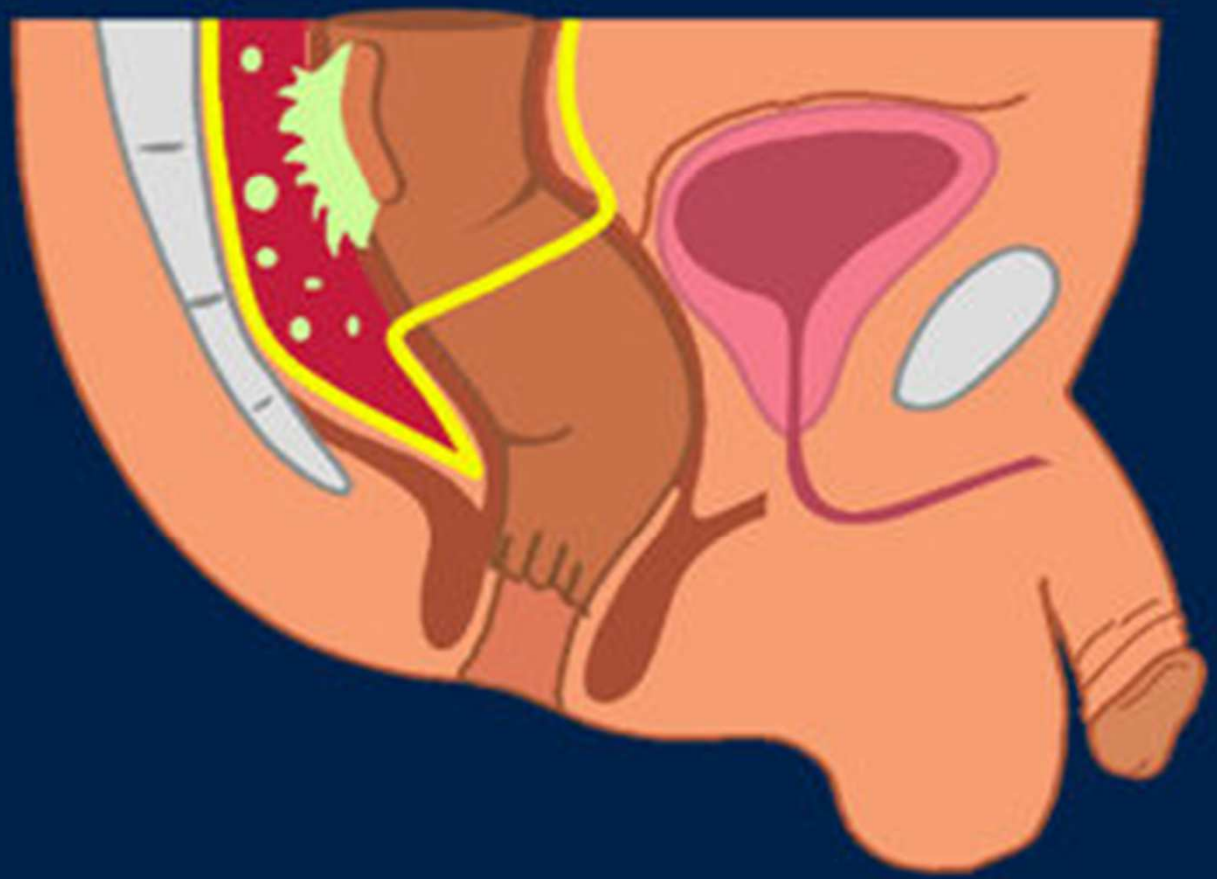
Radial Margin

- The radial margin is defined as involved or positive when the shortest distance between the site of deepest tumor infiltration and the surgical resection margin was less than 1mm
- Sources of circumferential margin involvement:
  - Primary tumor penetration
  - Lymphatic mesorectal spread
  - Mesorectal tumor deposits

Adam U, et al. *Lancet*. 1994;344:707-711.

TME for Rectal Cancer

- Remove rectum en bloc with mesorectum



Study	*n*	Treatment	Tumor downstaging* [% of patients]	pCR [% of patients]	5-year local recurrence rate [% of patients]	5-year OS [% of patients]
Swedish Rectal Cancer Trial (1997)[37]	1,168	Preoperative short-course RT surgery (TME not mandated)	NR NR	NR NR	11.0 27.0	58.0 48.0
German Rectal Cancer Study Group (2004)[8]	421	Preoperative 5-FU + RT Postoperative 5-FU + RT	NR NR	8.0 0	6.0 13.0	76.0 74.0
EORTC 22921 (2005, 2006)[3,43]	1,011	Preoperative RT Preoperative RT + postoperative 5-FU Preoperative 5-FU + RT Preoperative 5-FU + RT + postoperative 5-FU	42.4‡ 42.4‡ 57.1§ 57.1§	5.3‡ 5.3‡ 13.7§ 13.7§	17.1 9.6 8.7 7.6	64.8‡ 64.8‡ 65.8§ 65.8§
FFCD 9203 (2006)[44]	733	Preoperative RT Preoperative 5-FU + RT	NR NR	3.6 11.4	16.5 8.1	67.9 67.4
Dutch Rectal Cancer Study (2007)[35]	1,861	Preoperative short-course RT + TME only	NR NR	NR NR	5.6 10.9	64.2 63.5

*Defined as T0–T2. ‡Combined data from patients receiving preoperative RT with or without postoperative 5-FU. §Combined data from patients receiving preoperative 5-FU + RT with or without postoperative 5-FU. Abbreviations: 5-FU, 5-fluorouracil; LARC, locally advanced rectal cancer; NR, not reported; OS, overall survival; pCR, pathologic complete response; RT, radiotherapy.

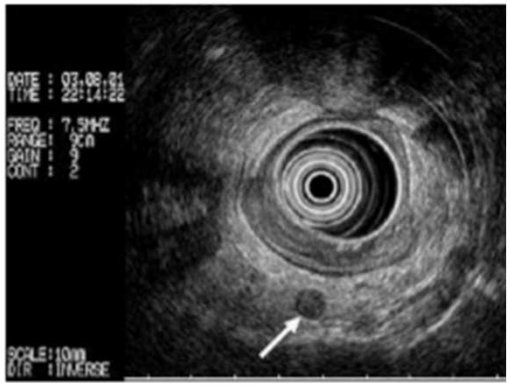
Pre-treatment evaluation

- Digital rectal examination
- Rigid Proctoscopy
- Endoscopic rectal uss
- MRI pelvis
- PET CT

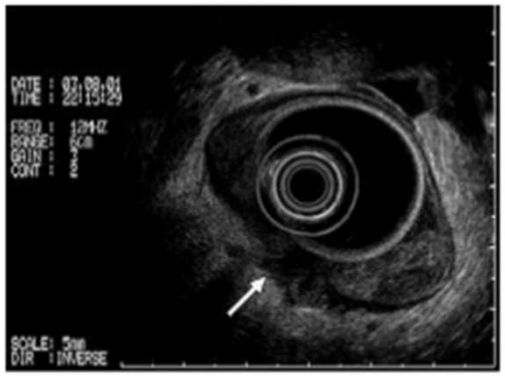
Multidisciplinary Tumour Board

Transrectal Endoscopic Ultrasound (TEUS)

T2



Nodes



T3

MRI

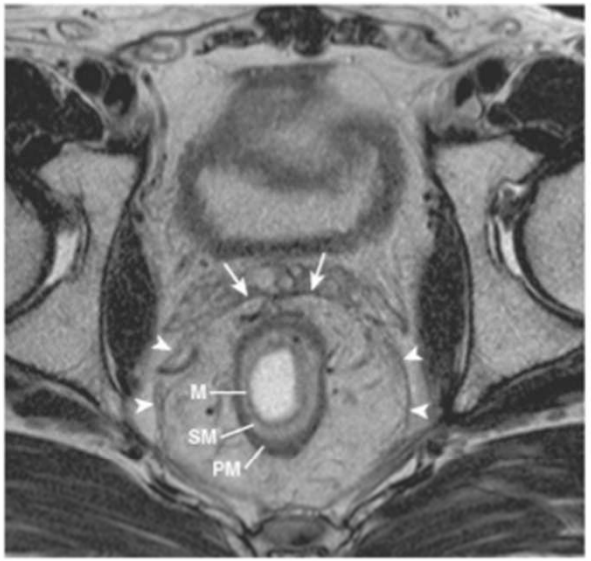


Figure: Normal rectal and perirectal anatomy on high-resolution T2-weighted MRI. Rectal mucosa (M), submucosa (SM), and muscularis propria (PM) are well discriminated. Mesorectal fascia appears as a thin, low-signal-intensity structure *(arrowheads)* and fuses with the remnant of urogenital septum making Denonvilliers fascia *(arrows)*.

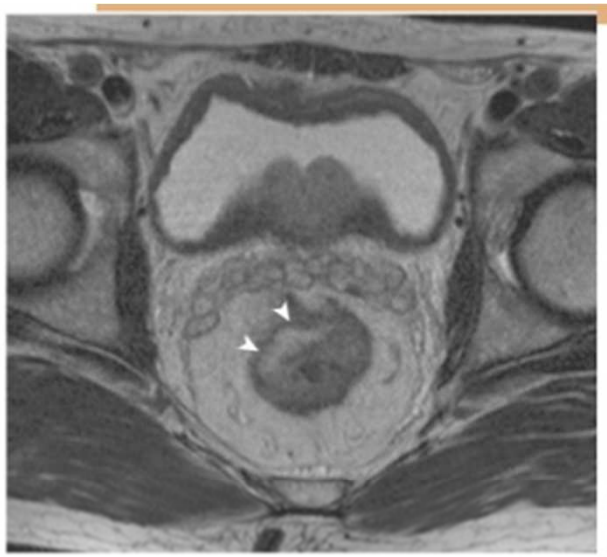
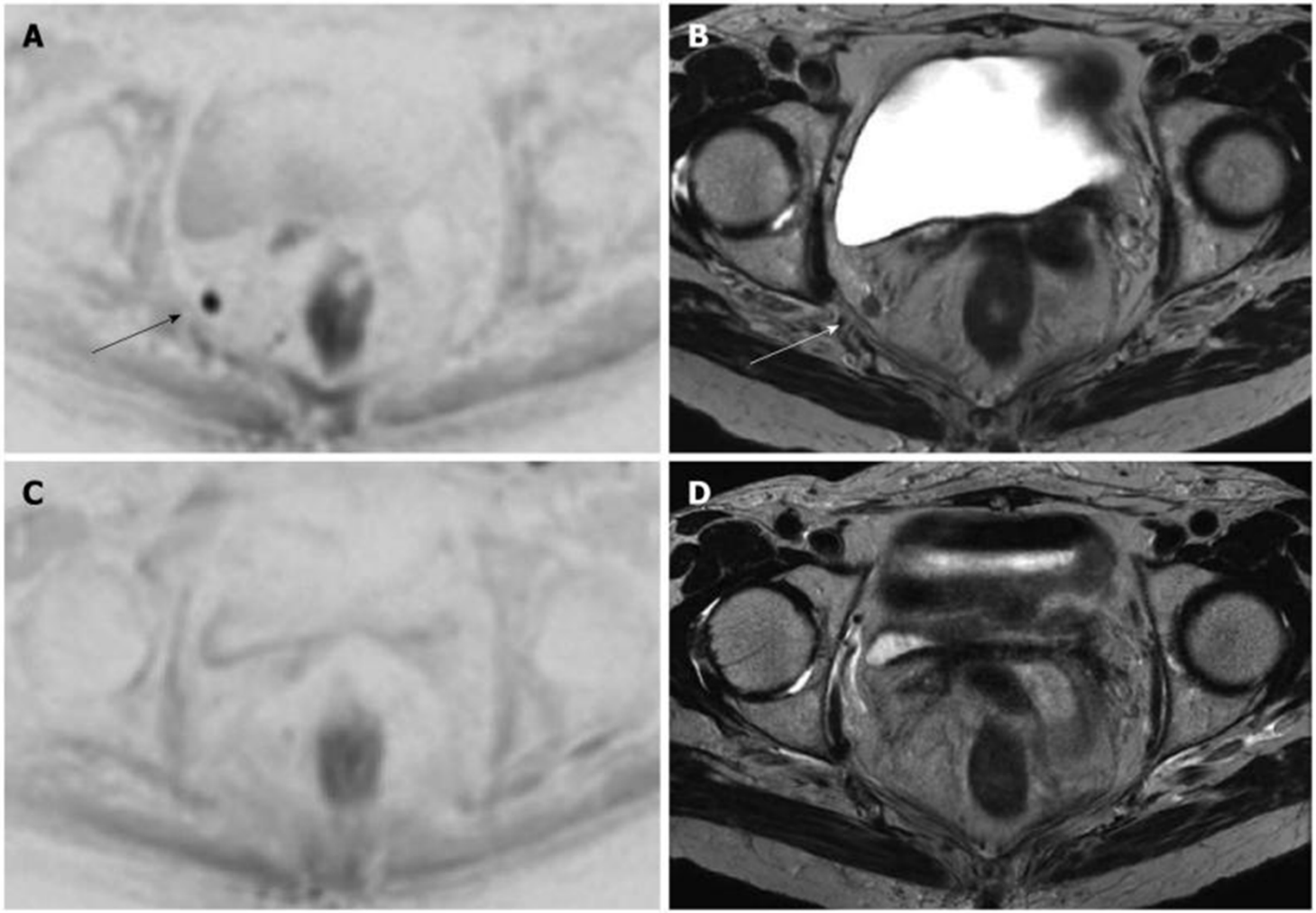


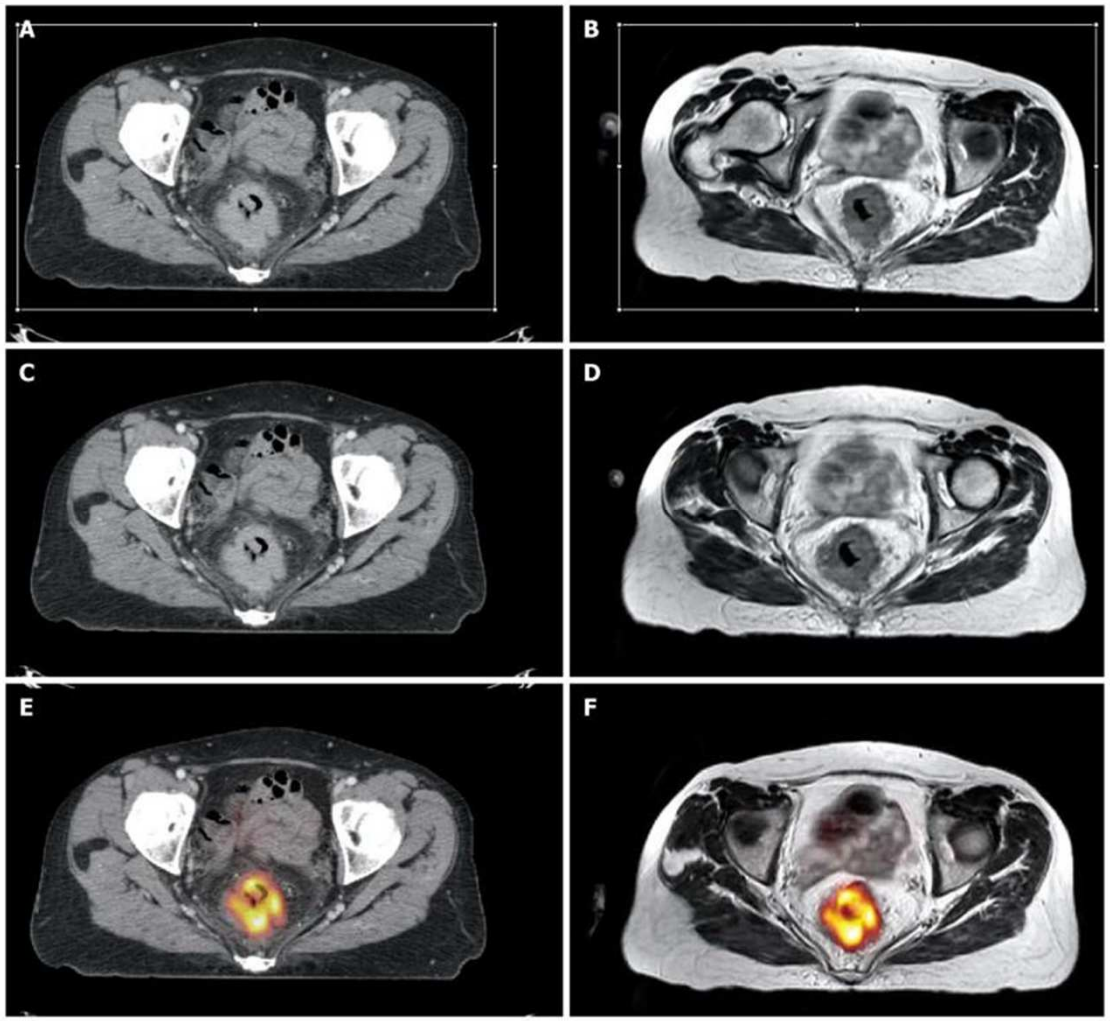
Figure: Mucinous adenocarcinoma of the rectum. T2-weighted MRI shows high signal intensity *(arrowheads)* of the cancer lesion in right anterolateral side of the rectal wall.

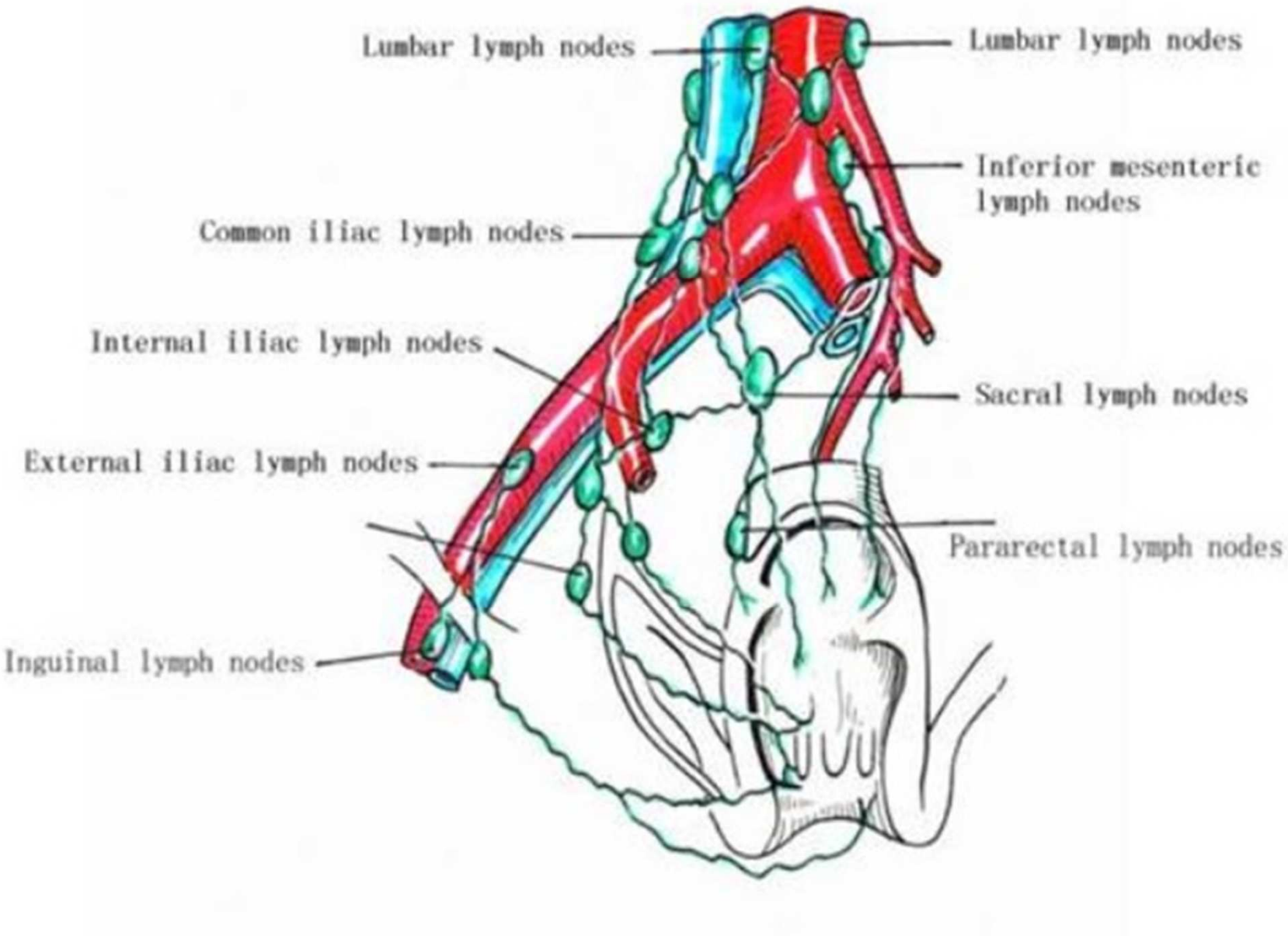
Assess the depth of invasion

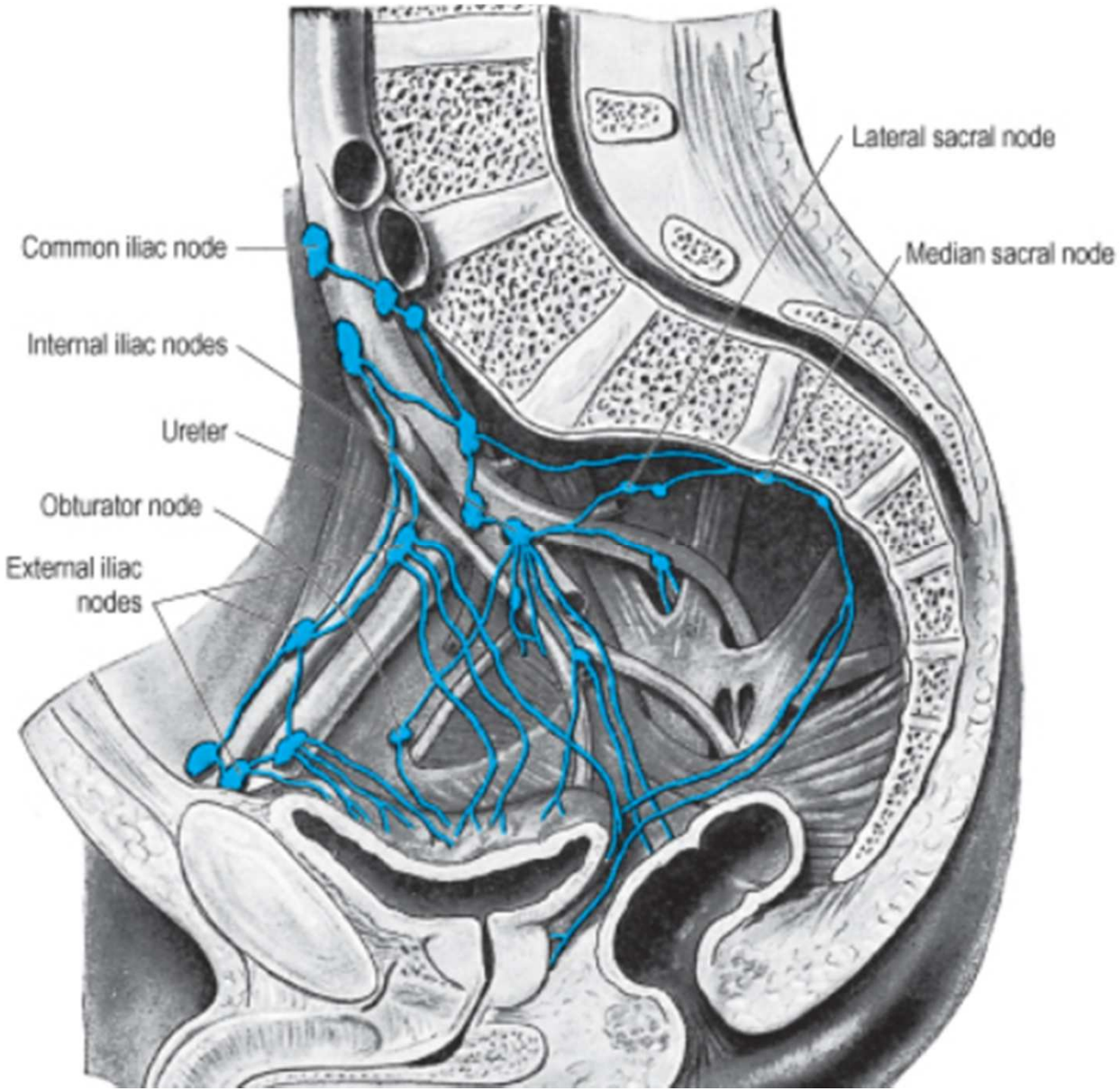
MRI



PET- CT images fused with MRI

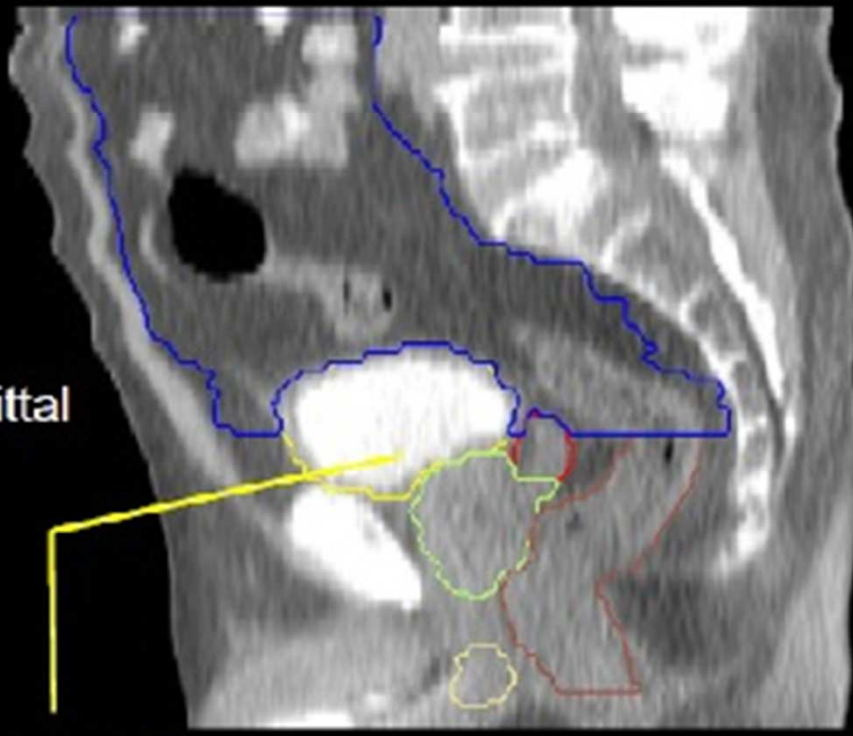



Lumbar lymph nodes
Lumbar lymph nodes
Inferior mesenteric lymph nodes
Common iliac lymph nodes
Internal iliac lymph nodes
Sacral lymph nodes
External iliac lymph nodes
Pararectal lymph nodes
Inguinal lymph nodes


Lateral sacral node
Median sacral node
Common iliac node
Internal iliac nodes
Ureter
Obturator node
External iliac nodes

Contour BowelBag, Colon and SmallBowel the suggested cm above PTV, not necessarily this high

Sagittal

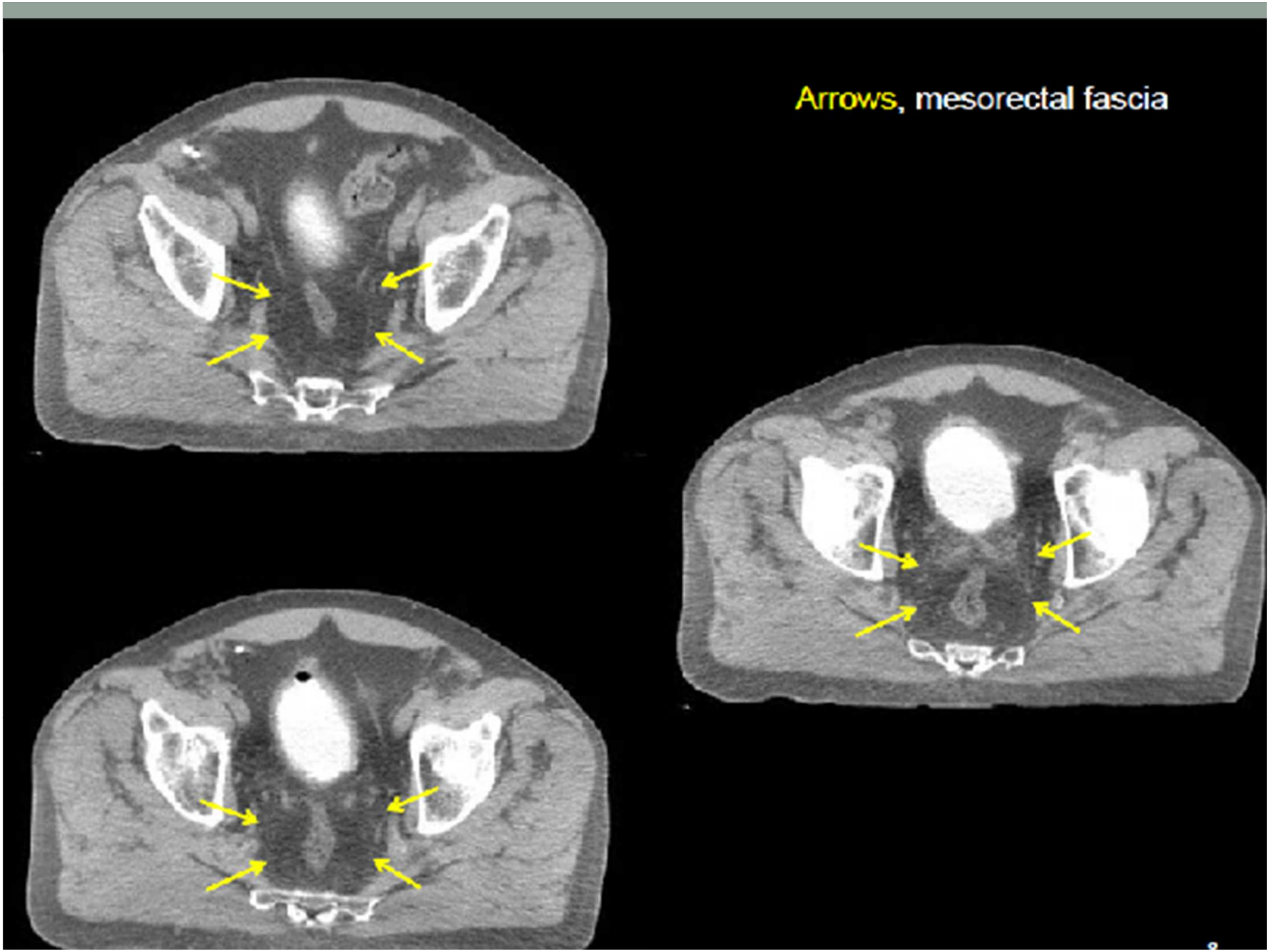


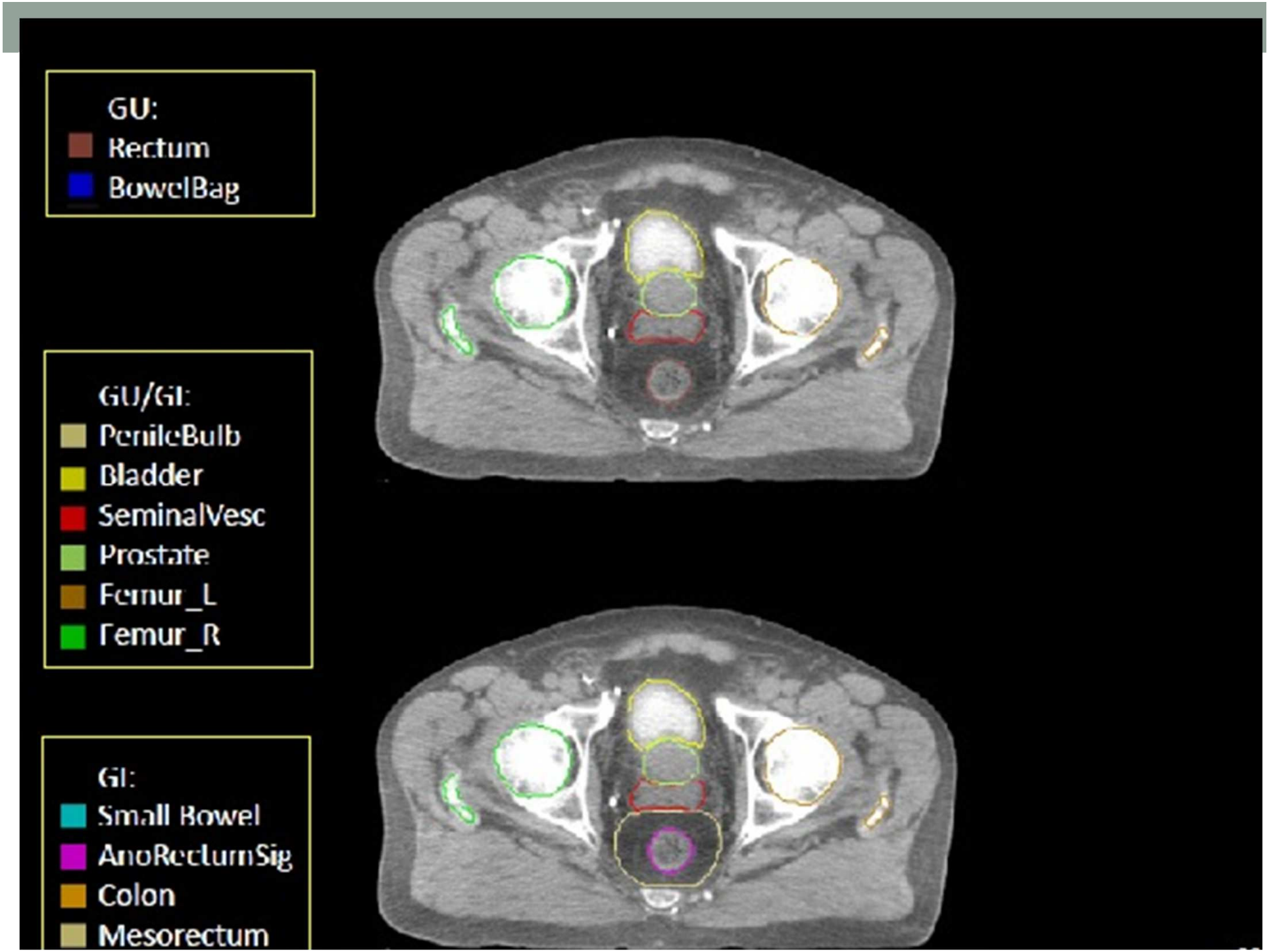
PenileBulb has a rounded shape

- PenileBulb
- SmallBowel
- Bladder
- SeminalVesc
- Prostate
- AnoRectumSig
- Colon

subtract any overlapping non-GI normal structures from BowelBag

- PenileBulb
- Bladder
- SeminalVesc
- Prostate
- Rectum
- BowelBag


Arrows, mesorectal fascia


GU:
Rectum
BowelBag
GU/GI:
PenileBulb
Bladder
SeminalVesc
Prostate
Femur_L
Femur_R
GI:
Small Bowel
AnoRectumSig
Colon
Mesorectum

Design and delivery of pelvic radiation

Anatomic location of the tumour

Pathways lymphatic spread

Patterns local relapse

Pre operative or post operative

Definitive chemo radiation

Pelvic radiation

preoperative

- Better anatomic delineation
- Bowel adhesions less
- Better oxygenated and biologically more effective

Post operative

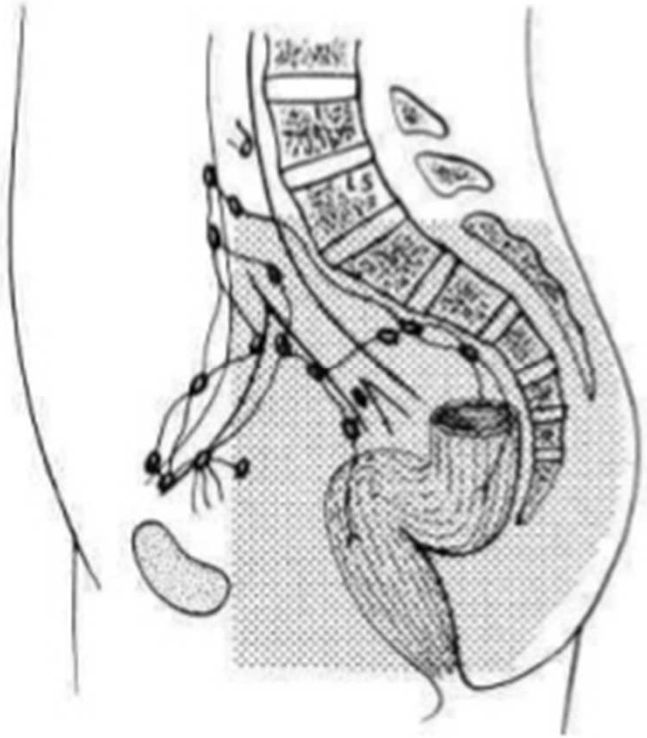
- Target volume is determined by operative findings and extent of surgery
- Bowel adhesions and small bowel radiations more
- less oxygenated and biologically less effective

Position

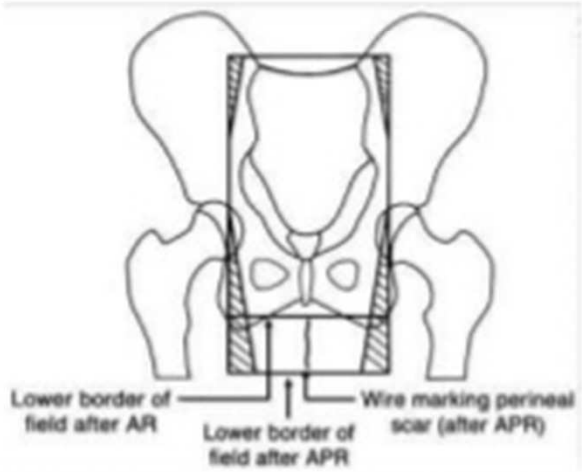
- Prone with belly board
- supine

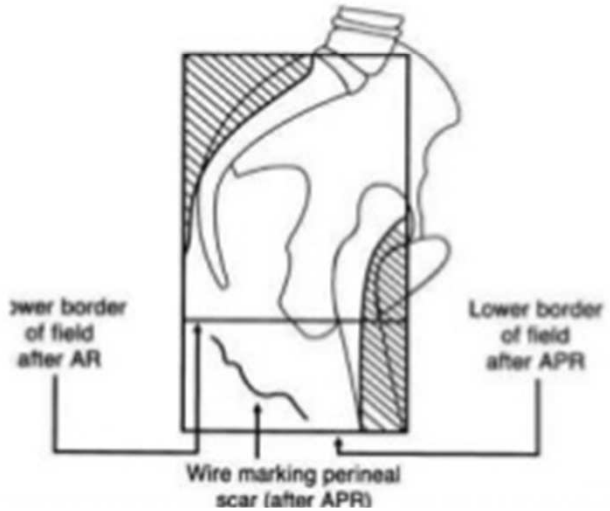
Target volume conventional technique

- Lower limit – 2cm below the lower extent or pelvic floor which ever is lower
- Upper limit sacral promontory or some times L4-5 junction
- laterally 1.5 cm lateral to medial pelvic rim
- Anteriorly just behind the pubic symphysis unless there is extension ant structures or anal canal involvement
- Posteriorly entire sacrum is included



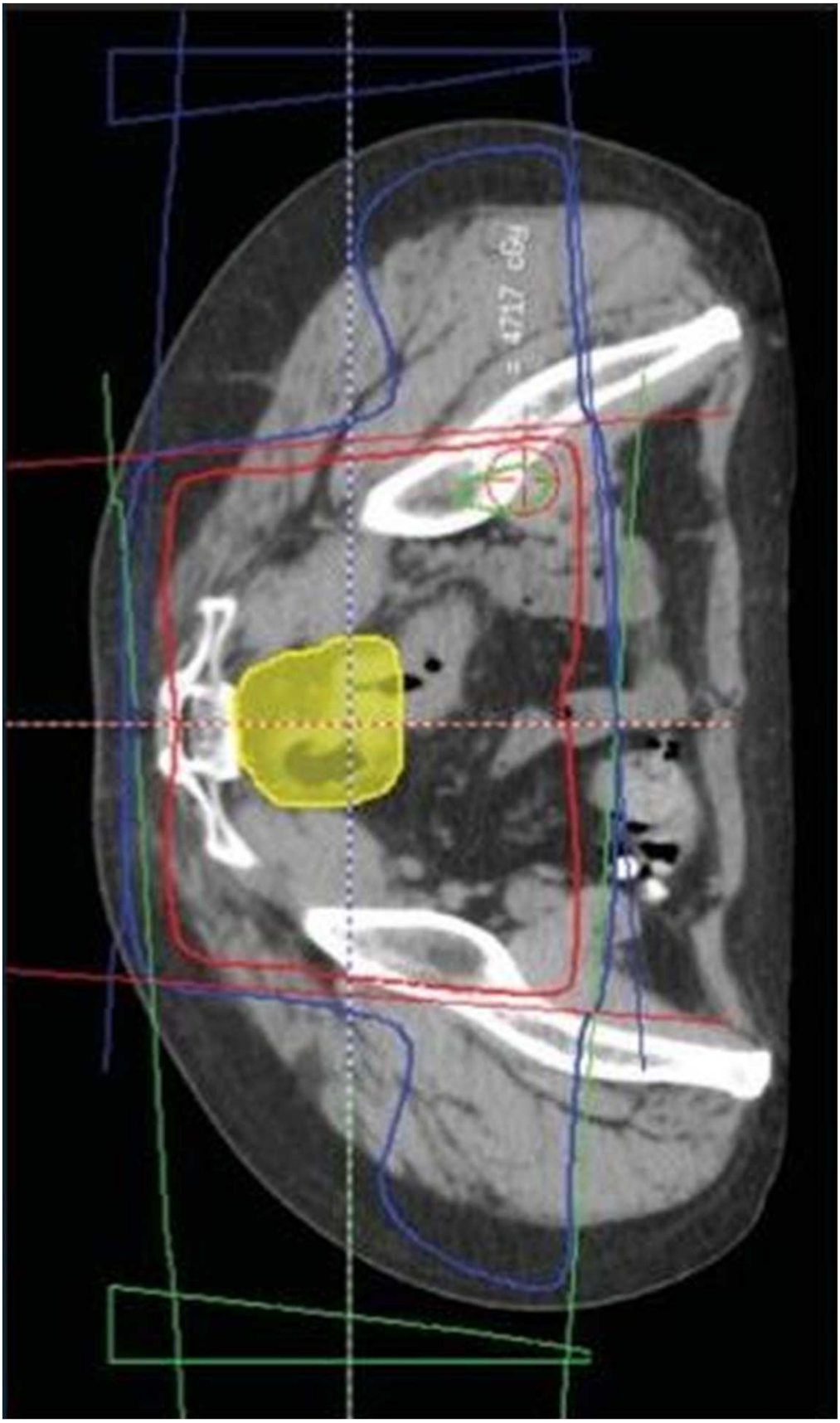
Radiation Targets or Fields





Techniques of radiations

- Conventional - 3field technique with wedges or four field box technique
- Conformal
- 3D planning gives better and uniform target coverage than 2D and should be used
- Prefers 6Mv or more

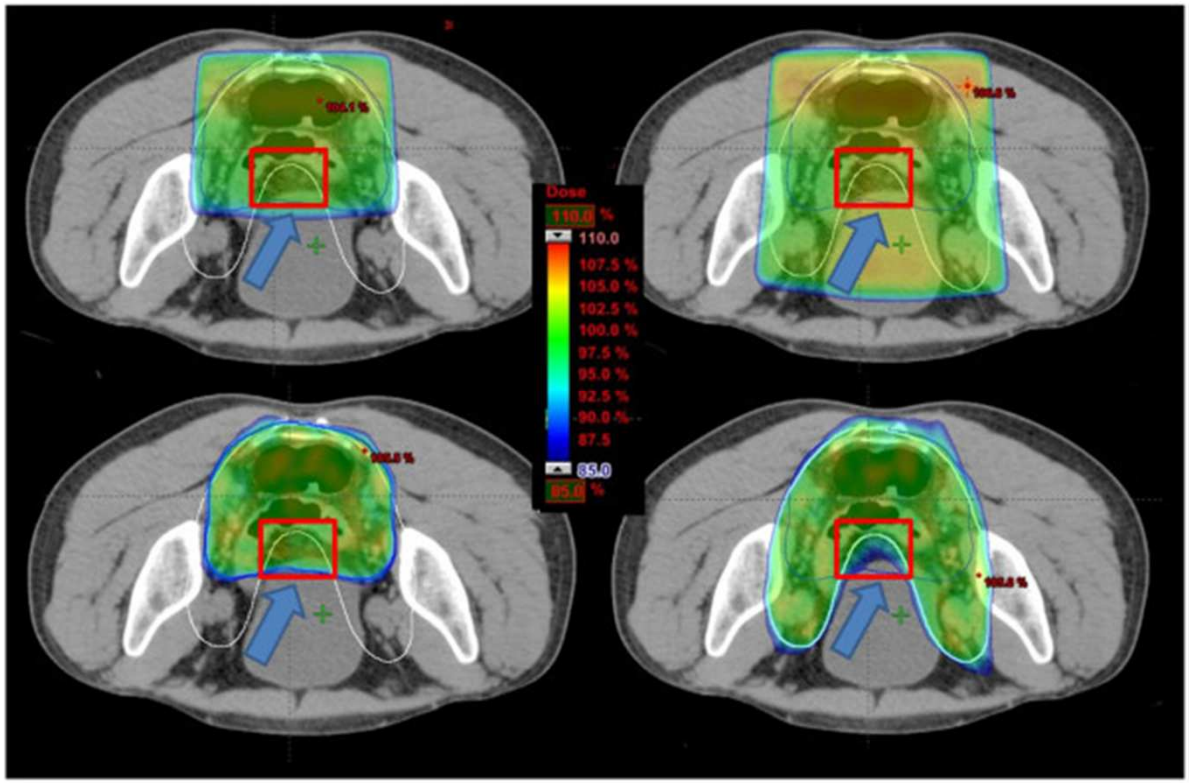

4717 cGy

Techniques of radiation

- IMRT or VMAT using image guided therapy

  highly conformal radiation with better homogeniety

  spare the healthy normal tissue and OAR



RTOG – IMRT

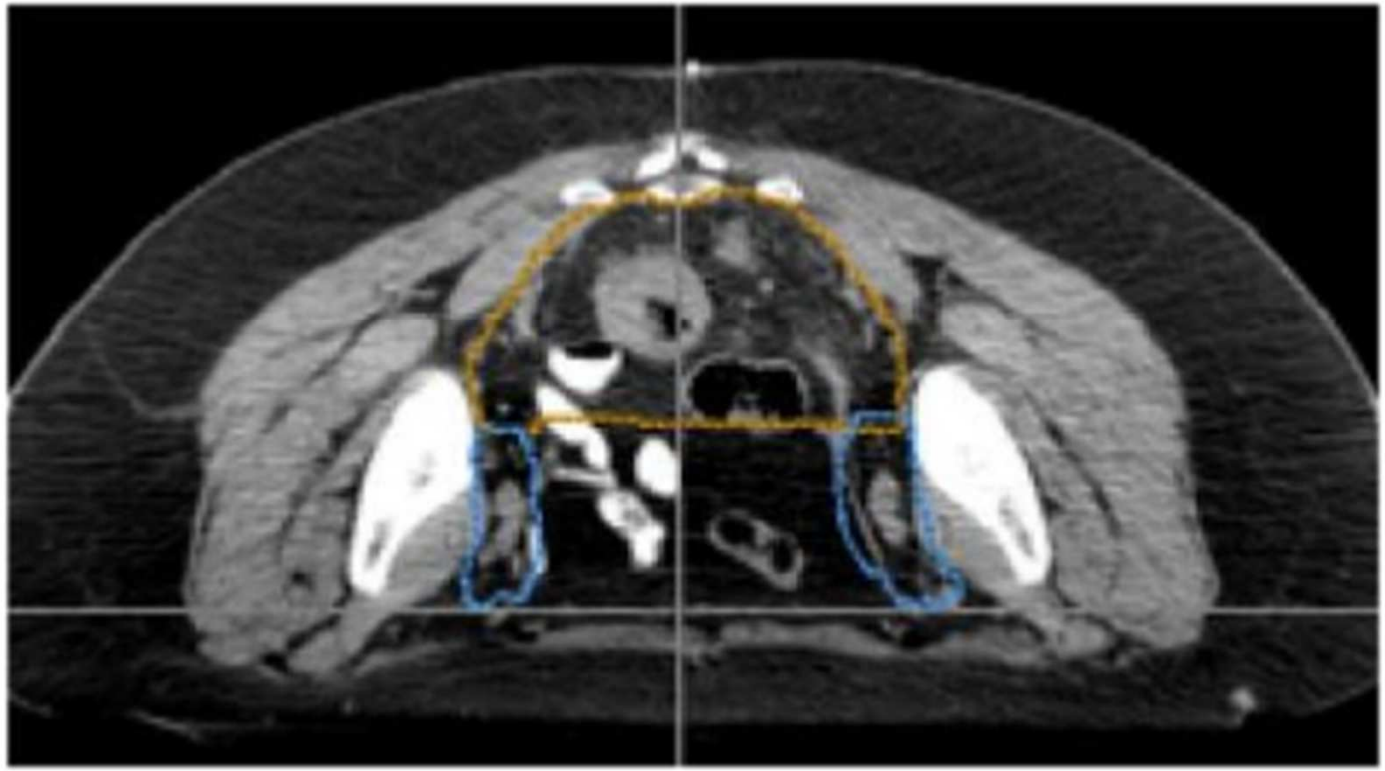
- CTV A – ALWAYS TREATED
  - Rectum and mesorectum (perirectal area)
  - Internal iliac nodes
  - Presacral area
- CTV B
  - External iliac nodal region
- CTV C
  - Inguinal nodal region

RTOG®
RADIATION THERAPY ONCOLOGY GROUP

Core Lab > Contouring Atlases > Anorectal

Anorectal Contouring Guidelines

Group consensus contours: Brown = CTVA (peri-rectal, pre-sacral, internal iliac), Blue = CTVB (external iliac).



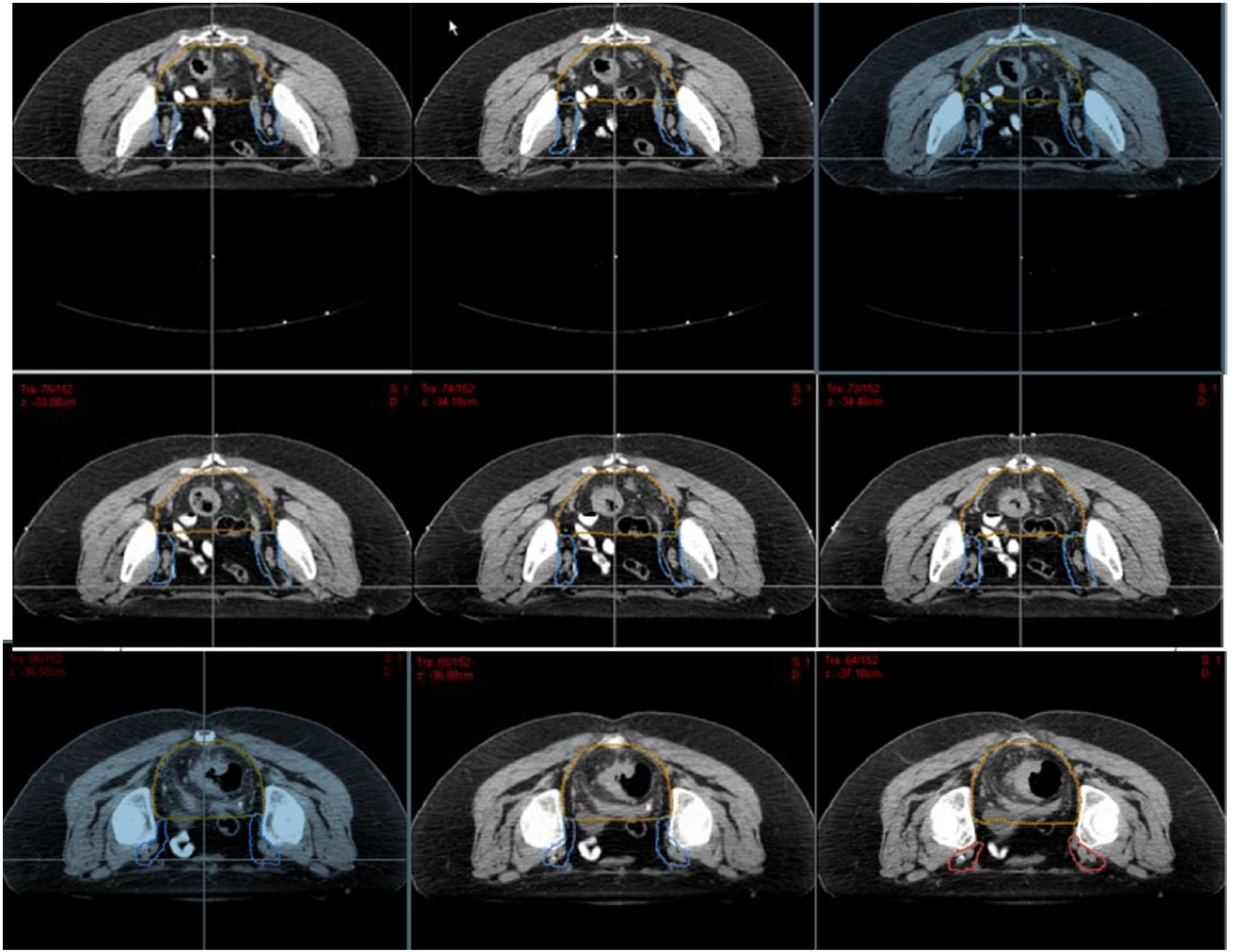
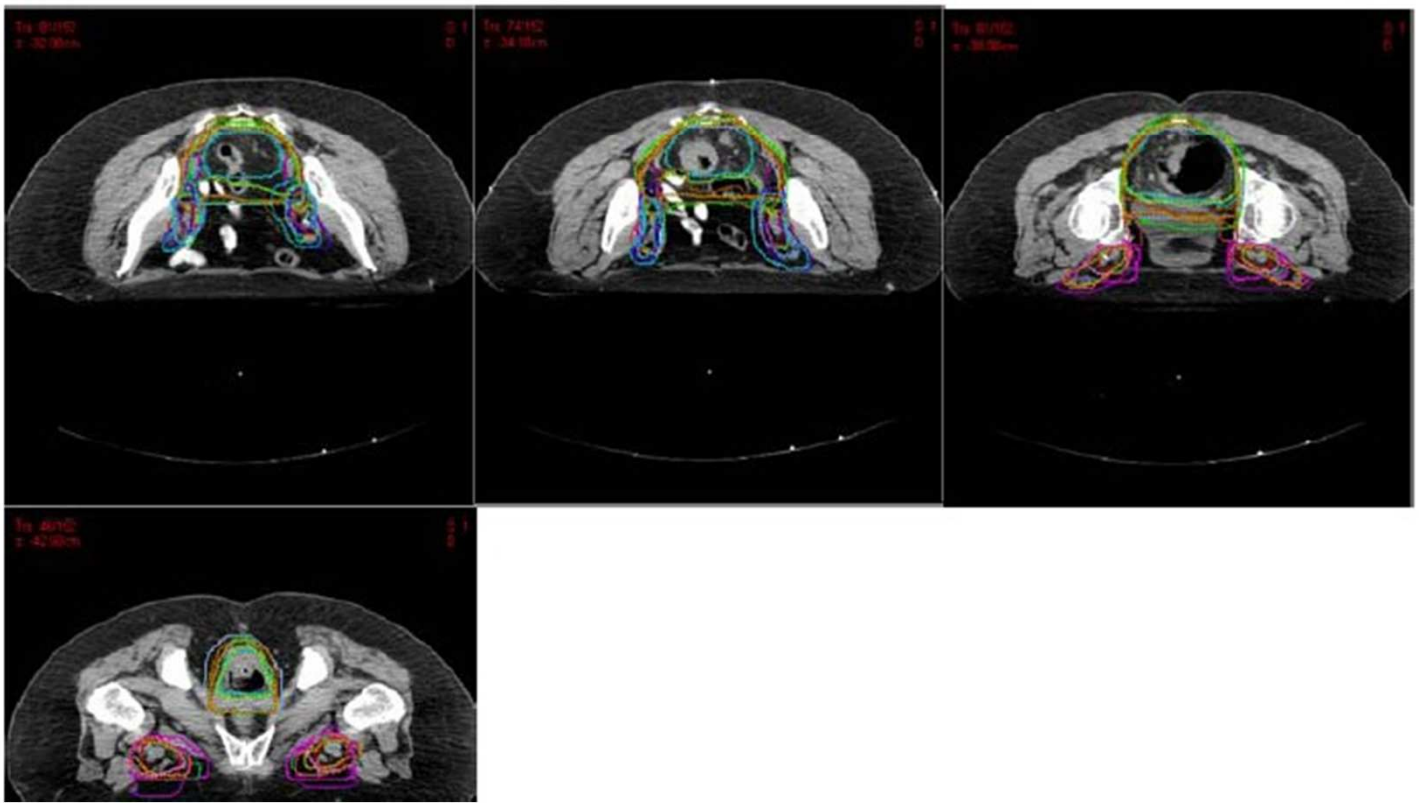
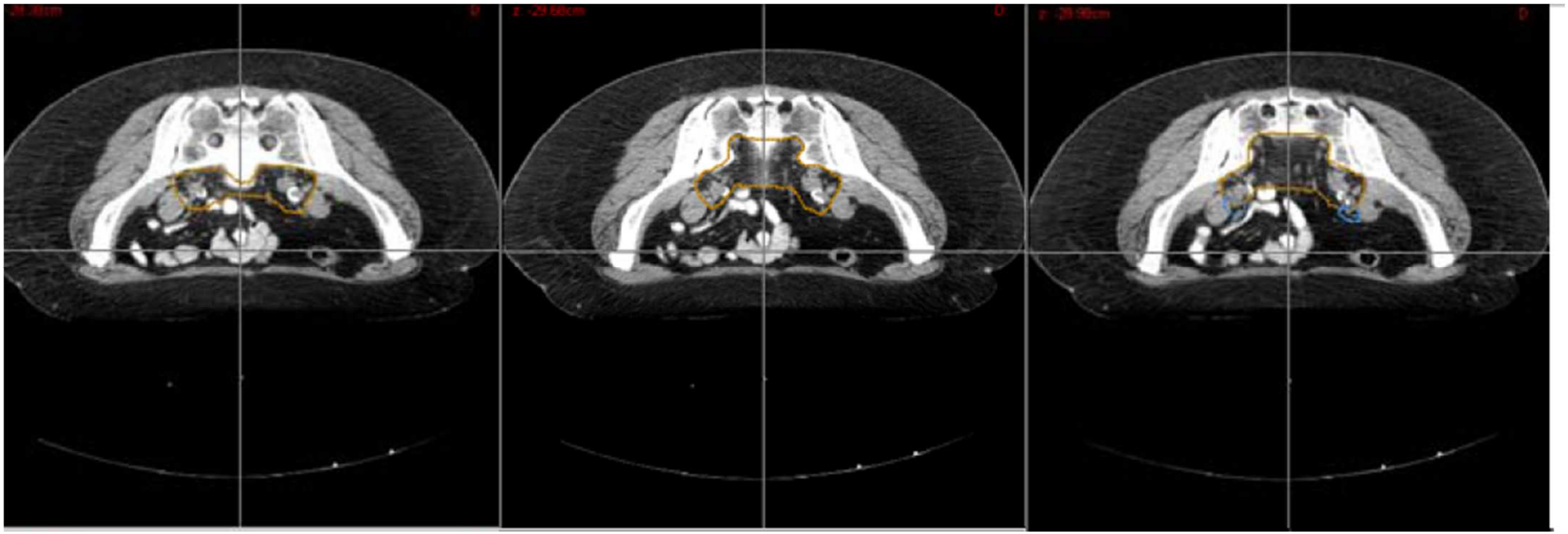


FIGURE 1. Superposition of individual investigator's contours of clinical target volumes. Each contourer was assigned a different color. These are best viewed with a zoom of 200%

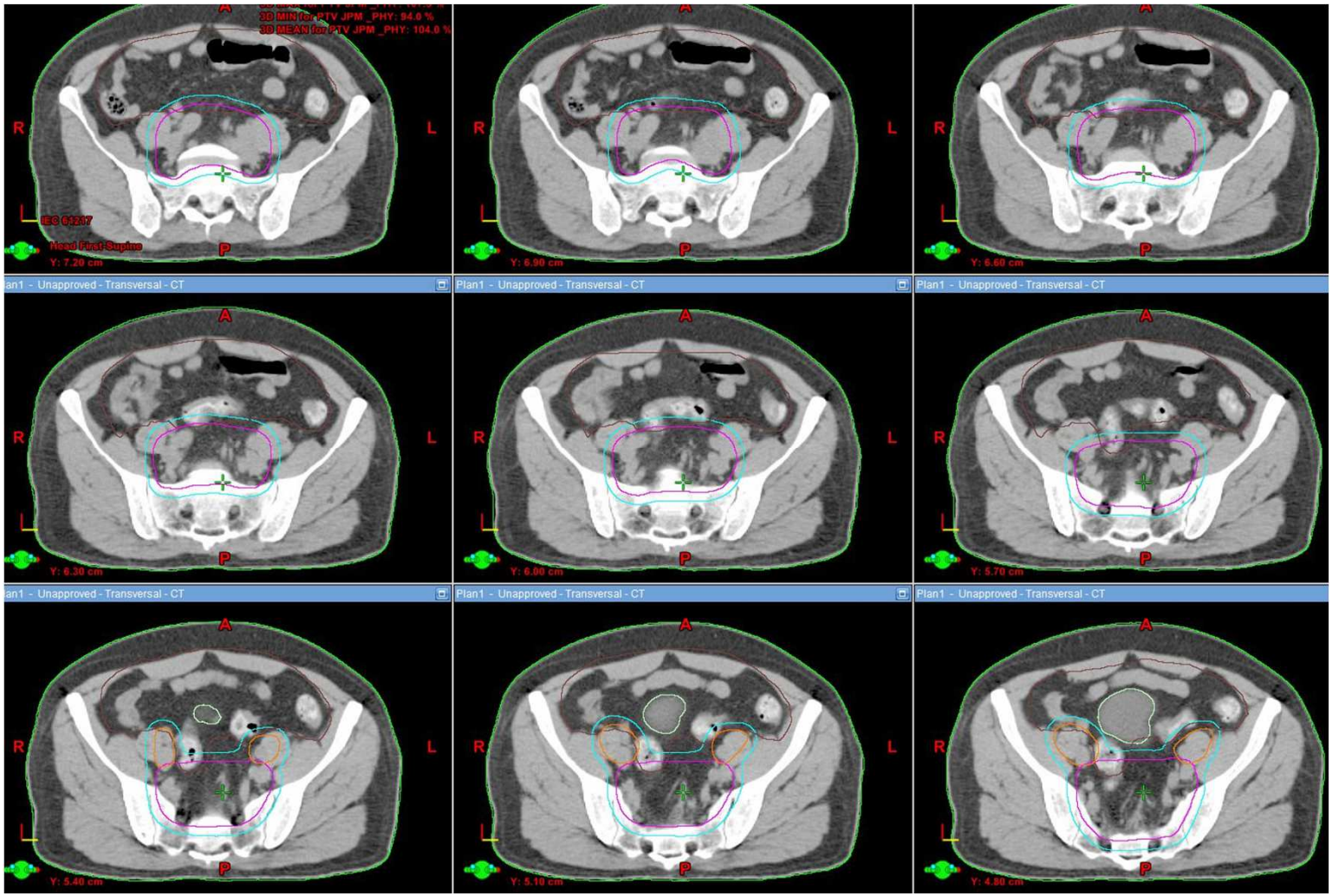


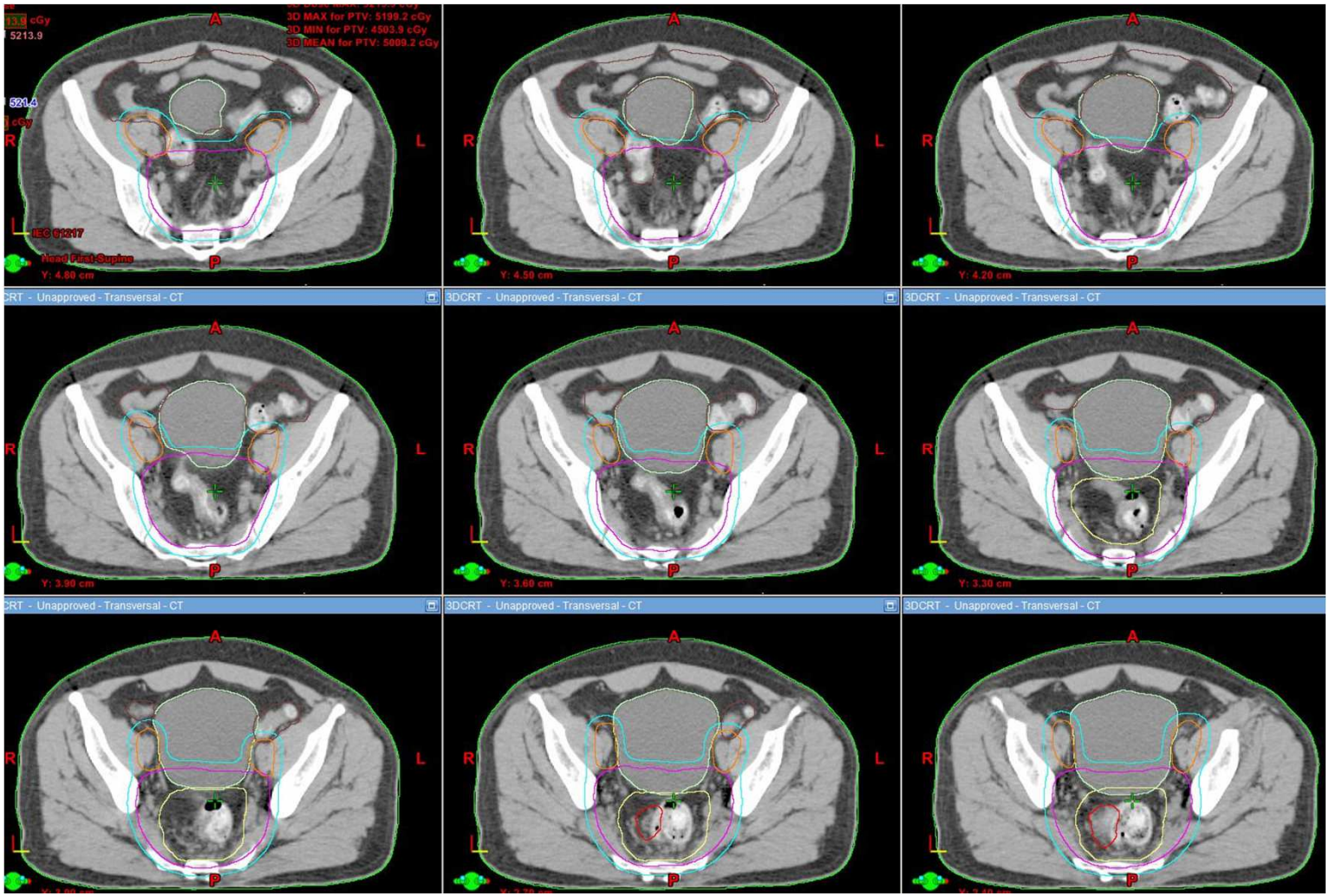


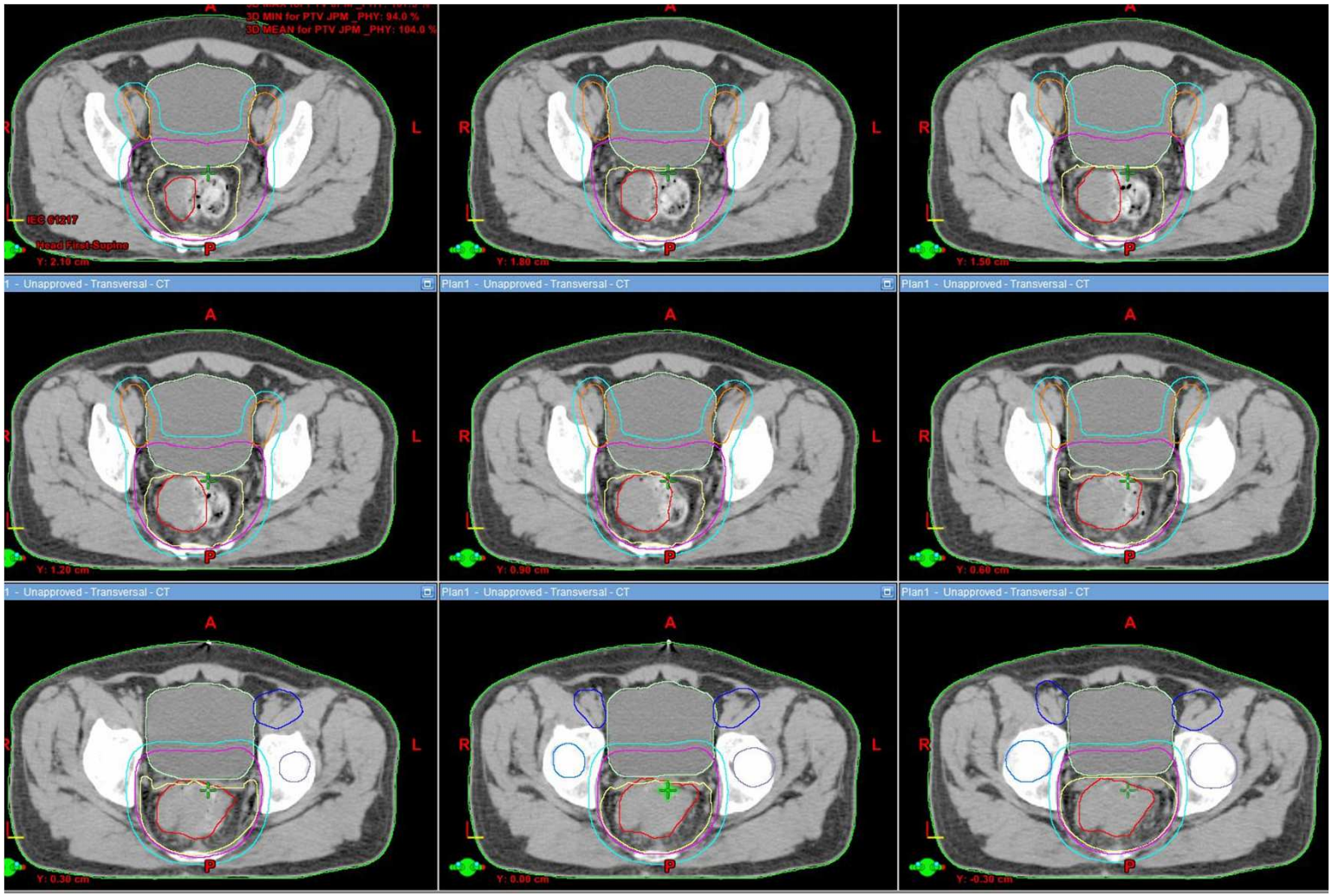
Margin around blood vessels – 7-10mm
PTV margin -7mm-10mm

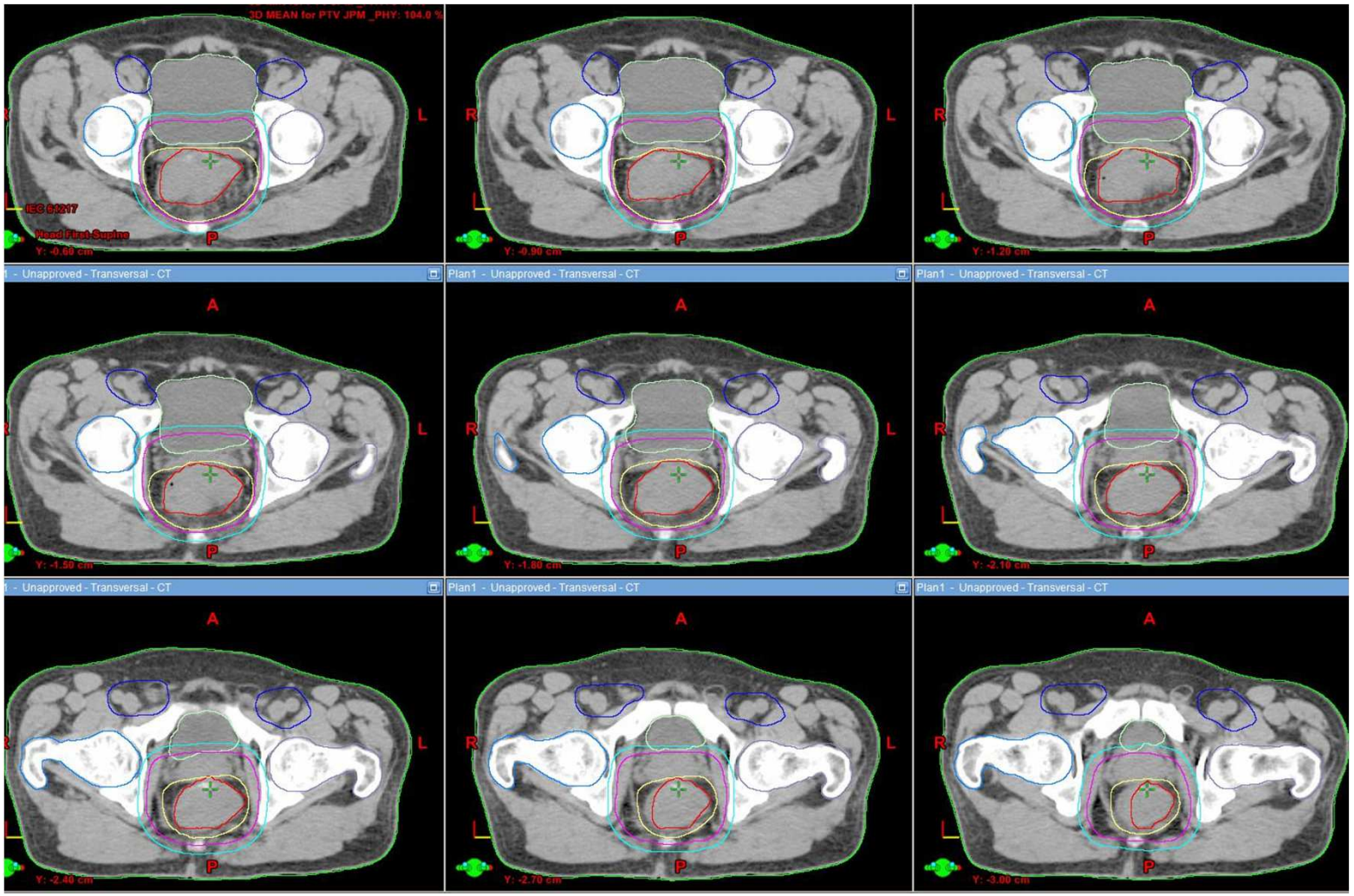
Boost volume

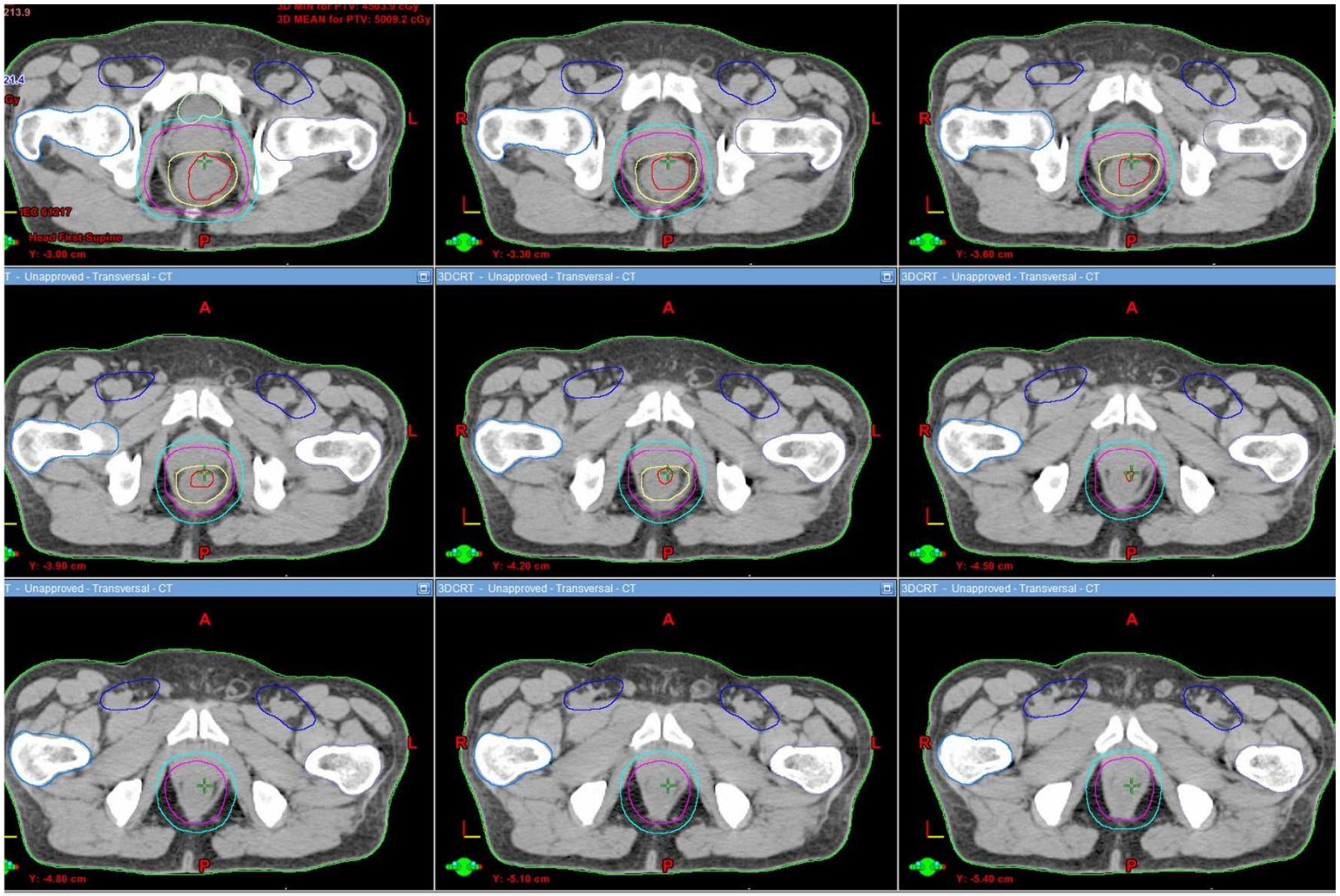
- 2cm margin

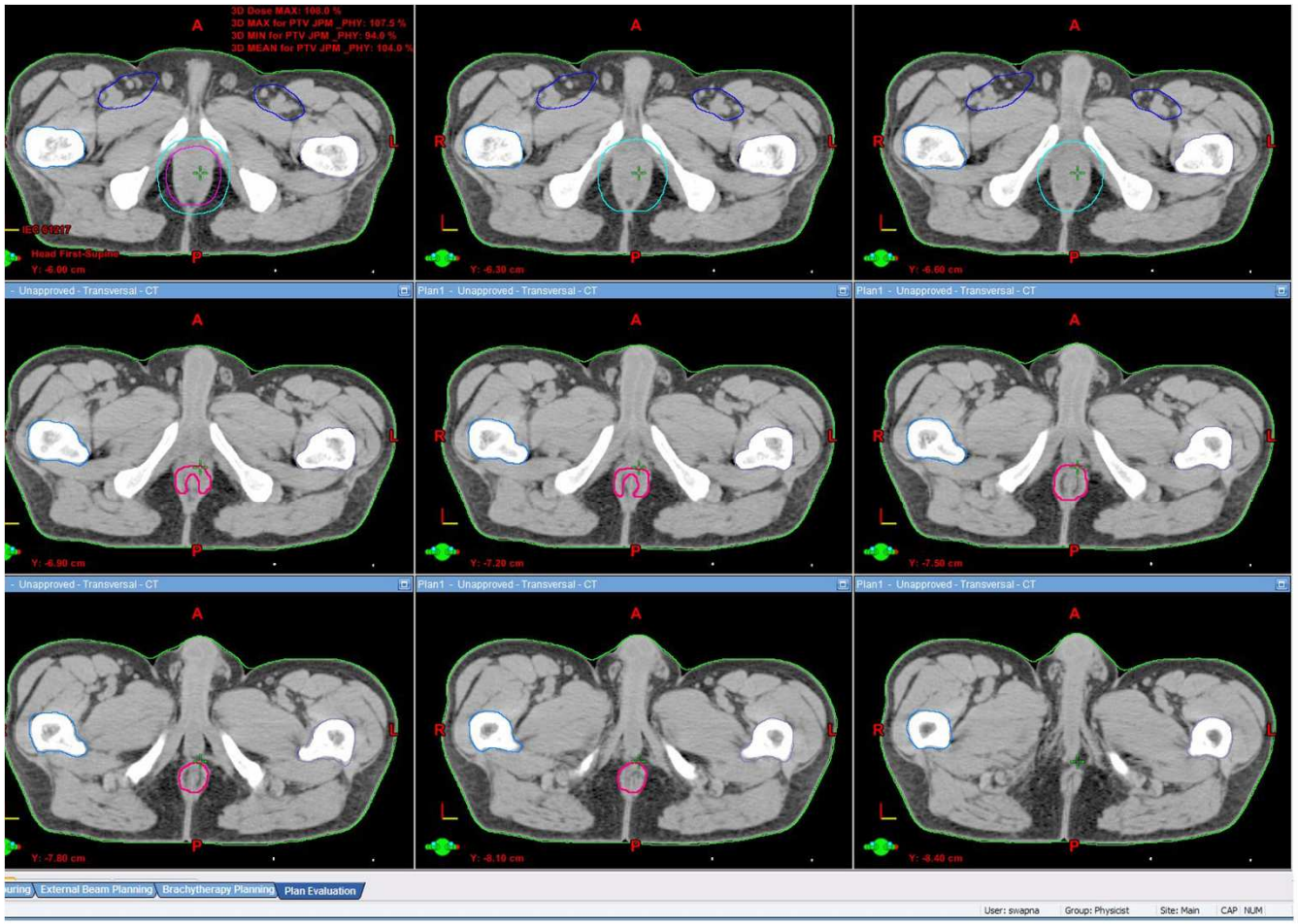

3D MIN for PTV JPM _PHY: 94.0 %
3D MEAN for PTV JPM _PHY: 104.0 %
EC 01217
Head First Supine
Y: 7.20 cm
Y: 6.90 cm
Y: 6.60 cm
Plan1 - Unapproved - Transversal - CT
Y: 6.30 cm
Y: 6.00 cm
Y: 5.70 cm
Y: 5.40 cm
Y: 5.10 cm
Y: 4.80 cm
A
P
R
L

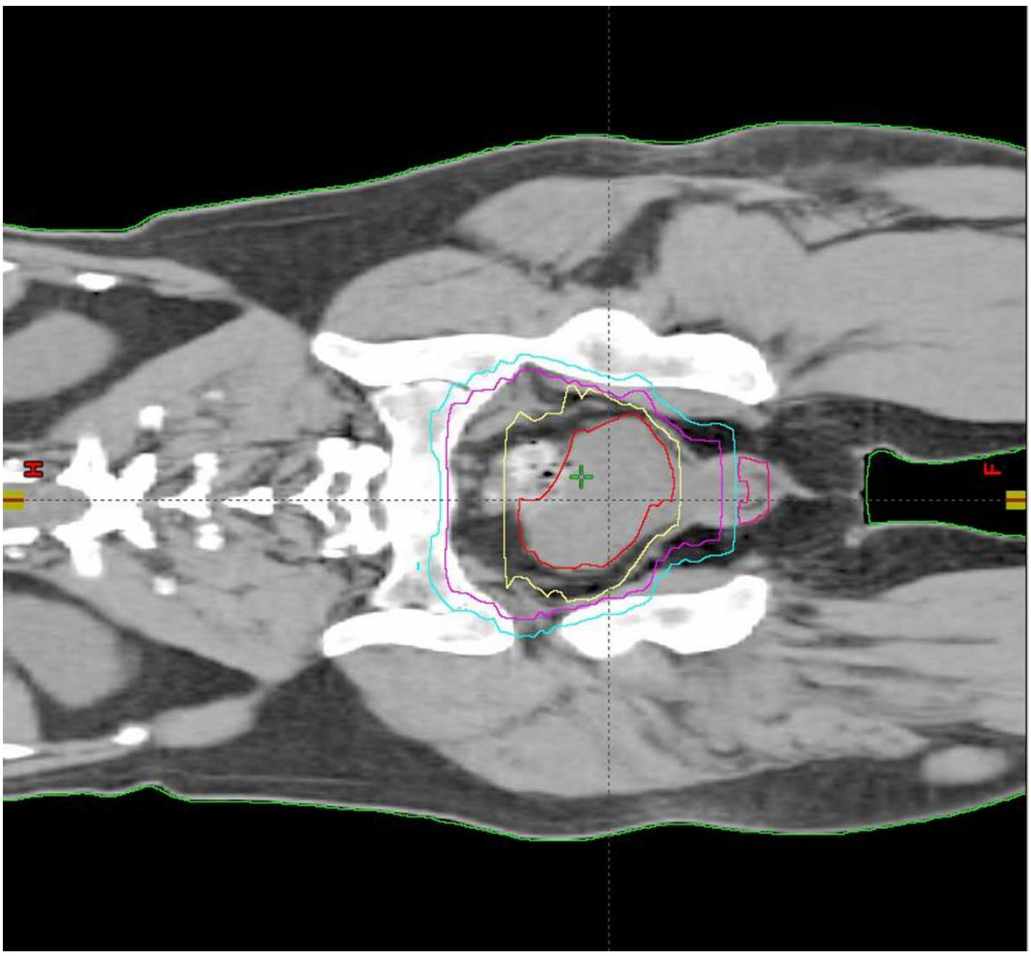

3D MAX for PTV: 5199.2 cGy
3D MIN for PTV: 4503.9 cGy
3D MEAN for PTV: 5009.2 cGy
IEC 61217
Head First-Supine
Y: 4.80 cm
Y: 4.50 cm
Y: 4.20 cm
3DCRT - Unapproved - Transversal - CT
Y: 3.90 cm
Y: 3.60 cm
Y: 3.30 cm
A
P
R
L


3D MIN for PTV JPM _PHY: 94.0 %
3D MEAN for PTV JPM _PHY: 104.0 %
IEC 61217
Head First-Supine
Y: 2.10 cm
Y: 1.80 cm
Y: 1.50 cm
1 - Unapproved - Transversal - CT
Plan1 - Unapproved - Transversal - CT
Plan1 - Unapproved - Transversal - CT
Y: 1.20 cm
Y: 0.90 cm
Y: 0.60 cm
1 - Unapproved - Transversal - CT
Plan1 - Unapproved - Transversal - CT
Plan1 - Unapproved - Transversal - CT
Y: 0.30 cm
Y: 0.00 cm
Y: -0.30 cm

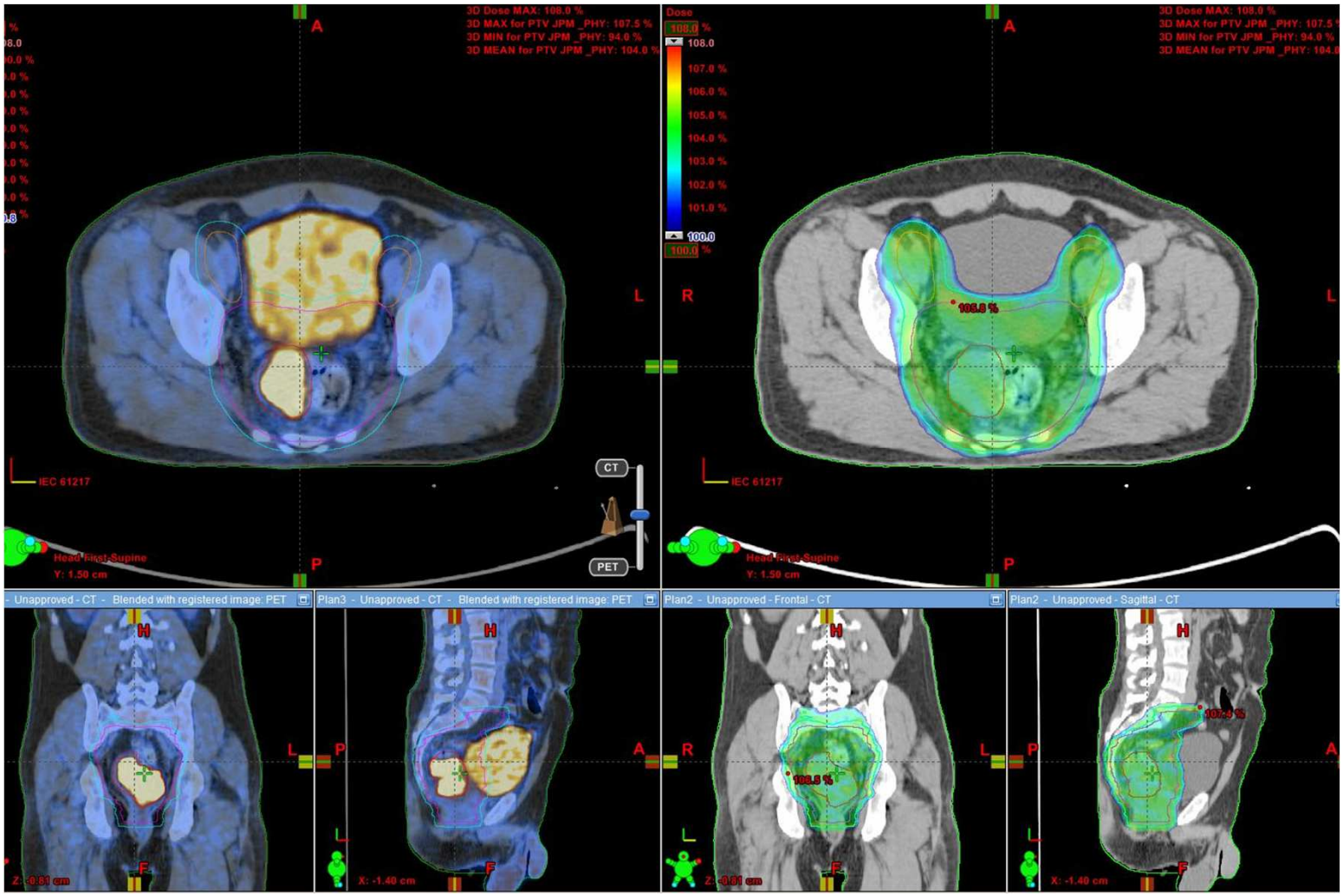

3D MEAN for PTV JPM _PHY: 104.0 %
IEC 61217
Head First Supine
Y: -0.60 cm
Y: -0.90 cm
Y: -1.20 cm
Plan1 - Unapproved - Transversal - CT
Y: -1.50 cm
Y: -1.80 cm
Y: -2.10 cm
Y: -2.40 cm
Y: -2.70 cm
Y: -3.00 cm
A
P
R
L

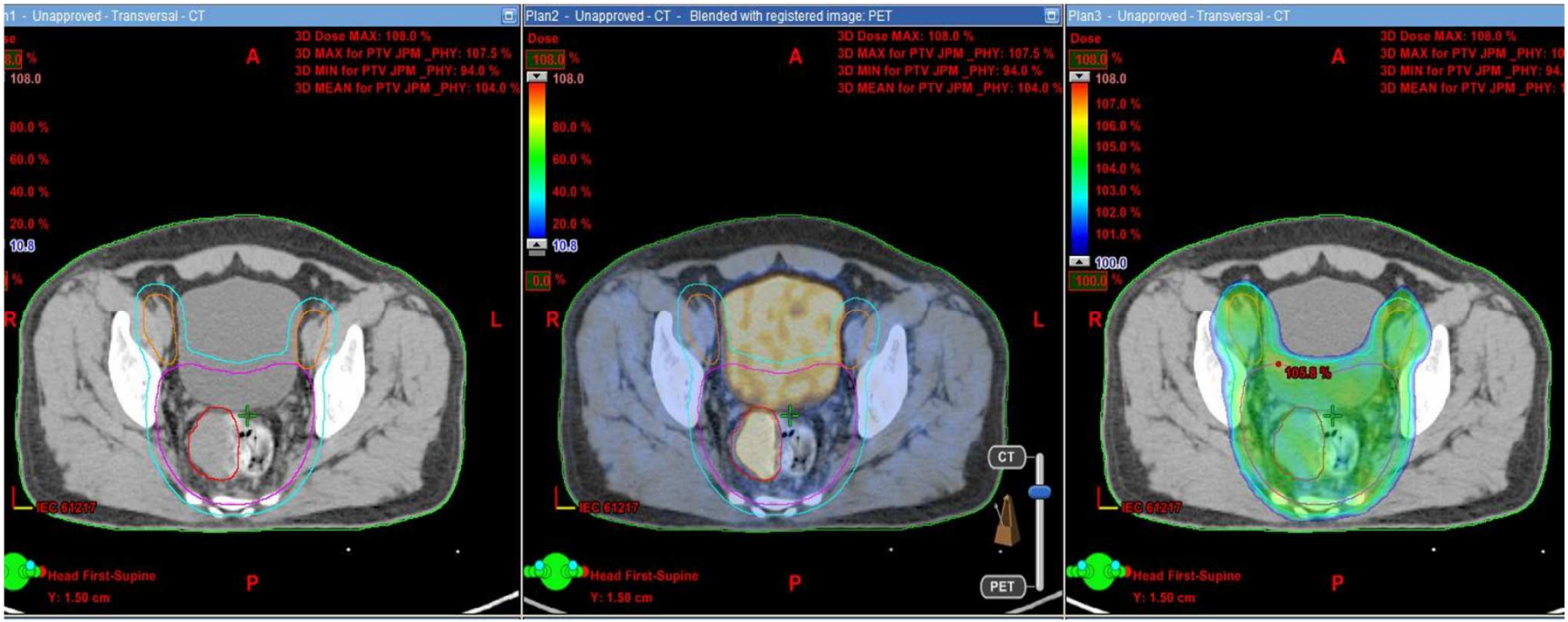

3D MEAN for PTV: 5009.2 cGy
IEC 61217
Head First-Supine
Y: -3.00 cm
Y: -3.30 cm
Y: -3.60 cm
3DCRT - Unapproved - Transversal - CT
Y: -3.90 cm
Y: -4.20 cm
Y: -4.50 cm
Y: -4.80 cm
Y: -5.10 cm
Y: -5.40 cm

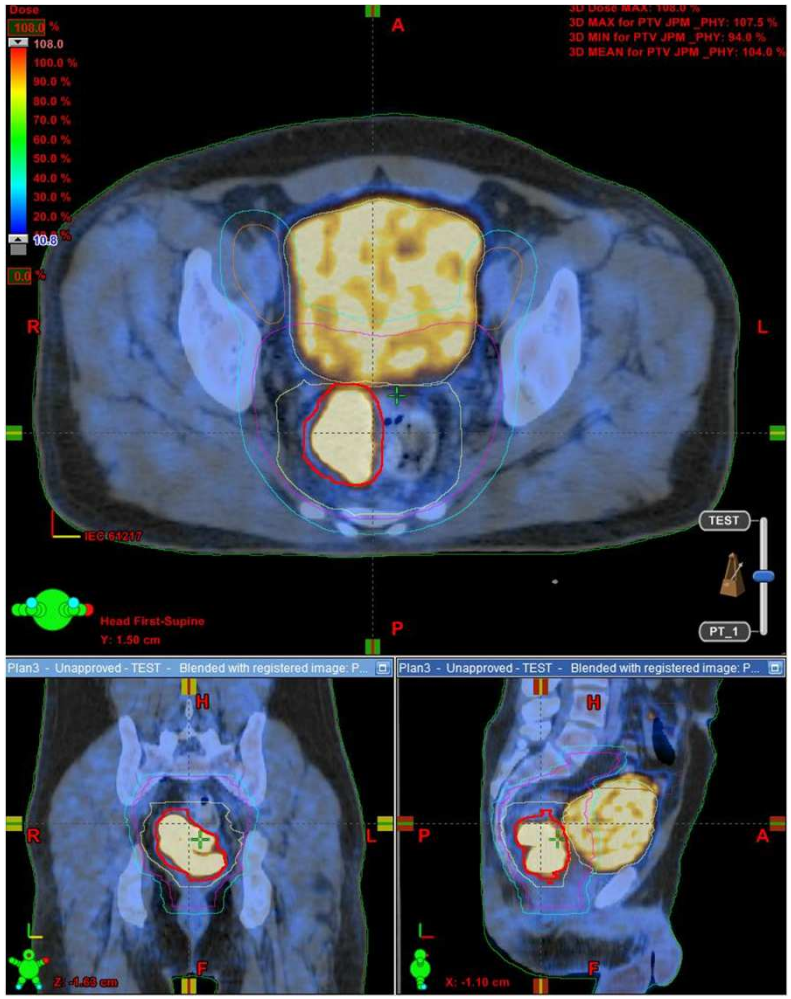

3D Dose MAX: 108.0 %
3D MAX for PTV JPM _PHY: 107.5 %
3D MIN for PTV JPM _PHY: 94.0 %
3D MEAN for PTV JPM _PHY: 104.0 %
Head First-Supine
Y: -6.00 cm
Y: -6.30 cm
Y: -6.60 cm
Plan1 - Unapproved - Transversal - CT
Y: -6.90 cm
Y: -7.20 cm
Y: -7.50 cm
Y: -7.80 cm
Y: -8.10 cm
Y: -8.40 cm
External Beam Planning
Brachytherapy Planning
Plan Evaluation
User: swapna
Group: Physicist
Site: Main
CAP
NUM


H
F

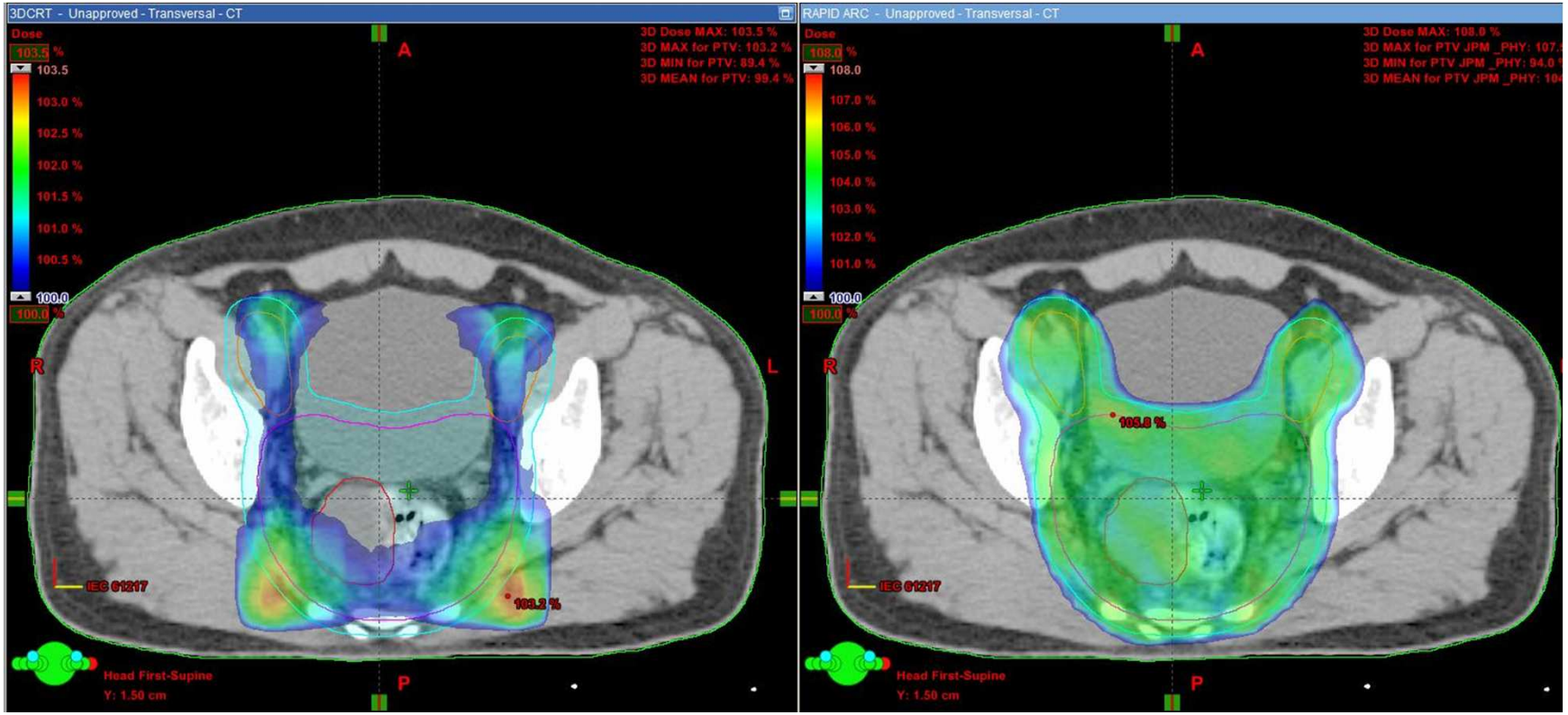

H
F

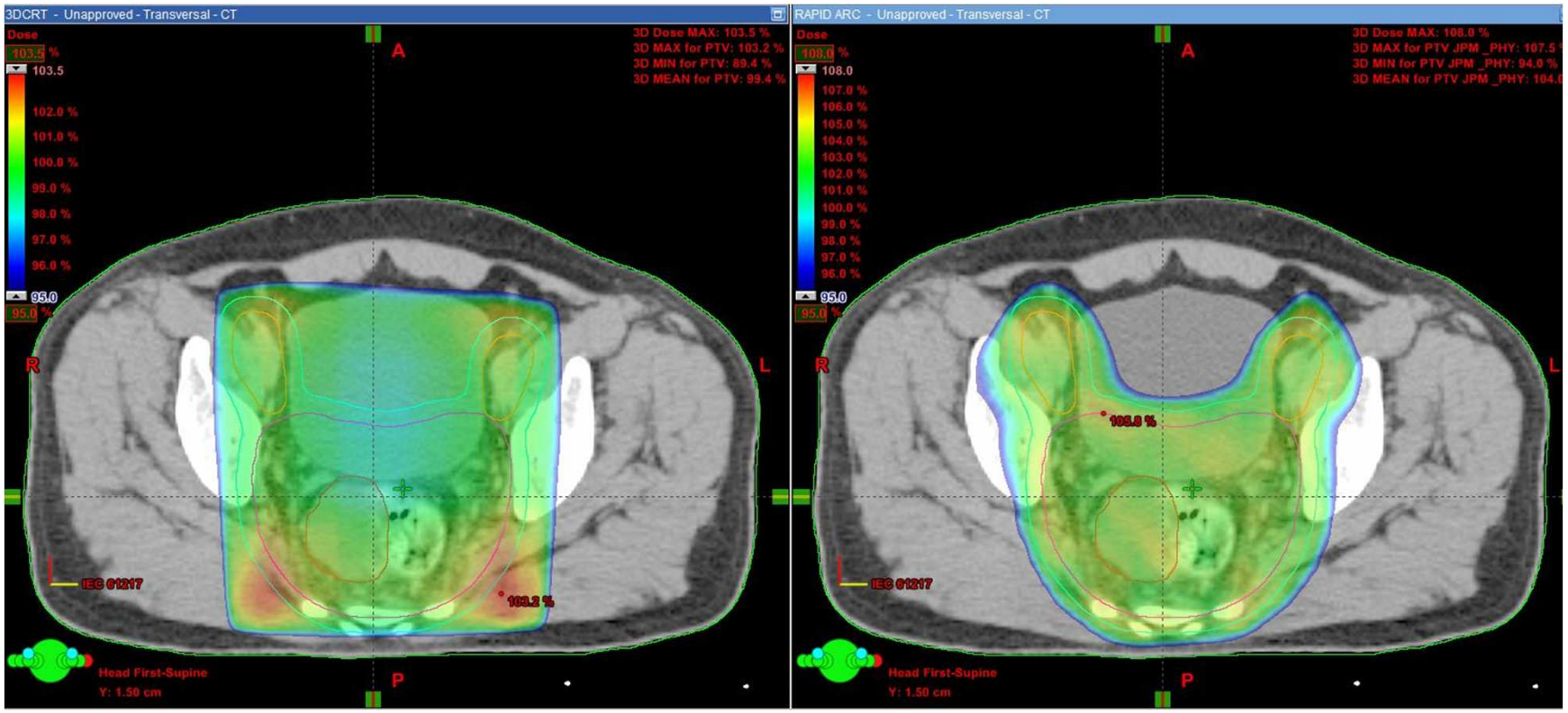

3D Dose MAX: 108.0 %
3D MAX for PTV JPM _PHY: 107.5 %
3D MIN for PTV JPM _PHY: 94.0 %
3D MEAN for PTV JPM _PHY: 104.0 %
Dose
108.0 %
108.0
107.0 %
106.0 %
105.0 %
104.0 %
103.0 %
102.0 %
101.0 %
100.0
100.0 %
108.0 %
IEC 61217
Head First-Supine
Y: 1.50 cm
CT
PET
- Unapproved - CT - Blended with registered image: PET
Plan3 - Unapproved - CT - Blended with registered image: PET
Plan2 - Unapproved - Frontal - CT
Plan2 - Unapproved - Sagittal - CT
X: -1.40 cm


n1 - Unapproved - Transversal - CT
3D Dose MAX: 108.0 %
3D MAX for PTV JPM _PHY: 107.5 %
3D MIN for PTV JPM _PHY: 94.0 %
3D MEAN for PTV JPM _PHY: 104.0 %
108.0
80.0 %
60.0 %
40.0 %
20.0 %
10.8
A
R
L
P
IEC 61217
Head First-Supine
Y: 1.50 cm
Plan2 - Unapproved - CT - Blended with registered image: PET
Dose
108.0 %
0.0 %
CT
PET
Plan3 - Unapproved - Transversal - CT
107.0 %
106.0 %
105.0 %
104.0 %
103.0 %
102.0 %
101.0 %
100.0
105.8 %

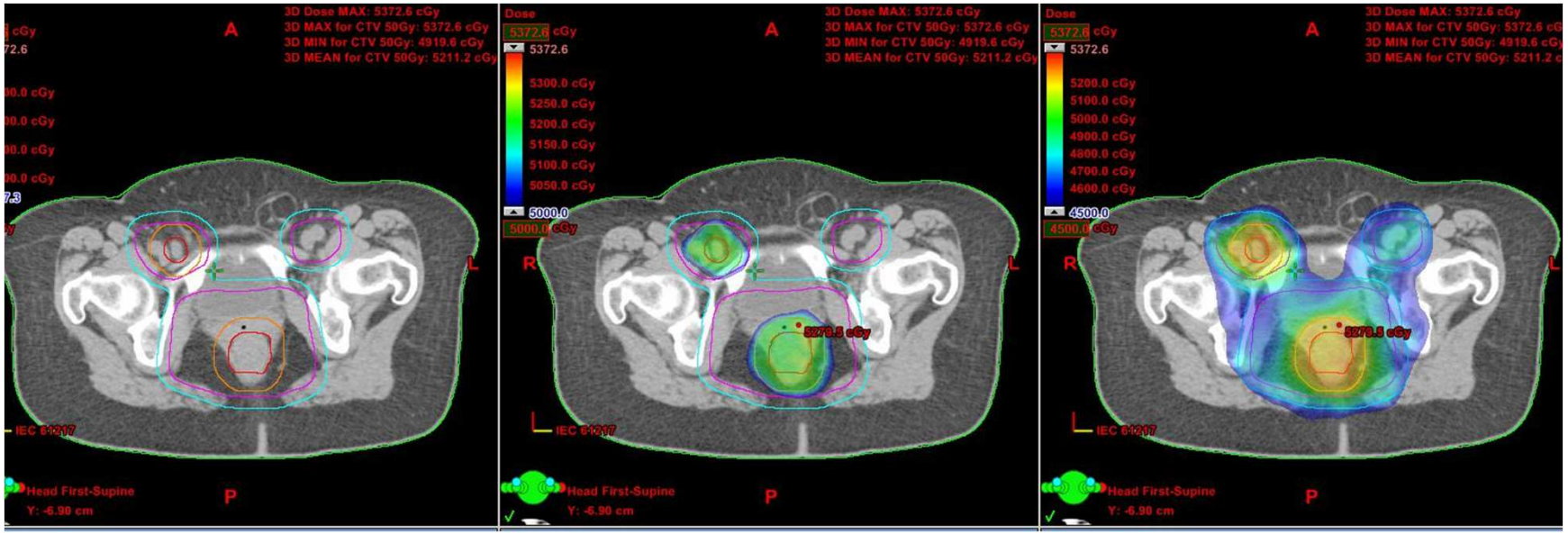

Dose
108.0 %
108.0
100.0 %
90.0 %
80.0 %
70.0 %
60.0 %
50.0 %
40.0 %
30.0 %
20.0 %
10.8 %
0.0 %
3D MAX for PTV JPM _PHY: 107.5 %
3D MIN for PTV JPM _PHY: 94.0 %
3D MEAN for PTV JPM _PHY: 104.0 %
A
R
L
P
IEC 61217
Head First-Supine
Y: 1.50 cm
TEST
PT_1
Plan3 - Unapproved - TEST - Blended with registered image: P...
H
F
Z: -1.65 cm
X: -1.10 cm

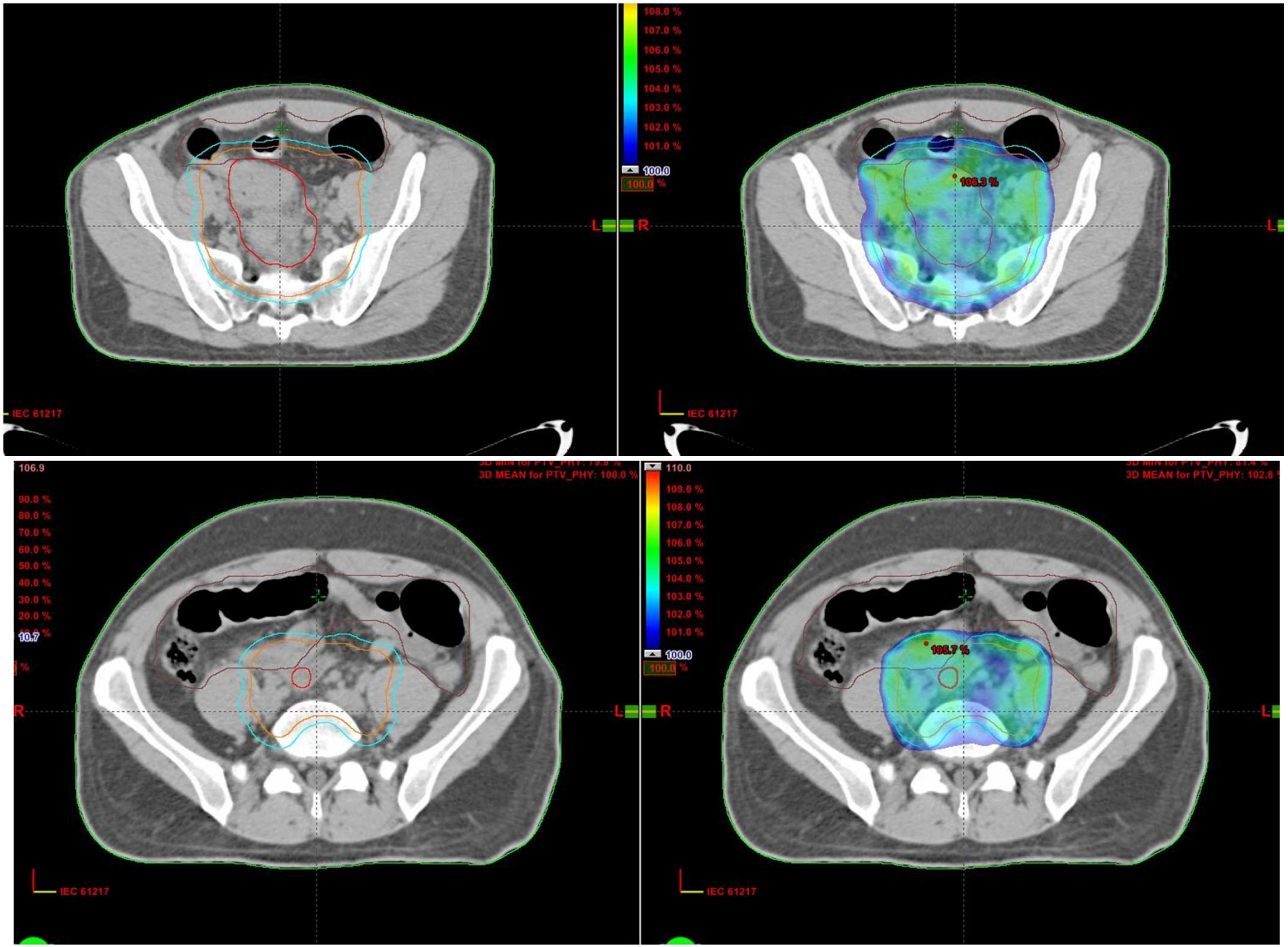

Dose
108.0 %
108.0
100.0 %
90.0 %
80.0 %
70.0 %
60.0 %
50.0 %
40.0 %
30.0 %
20.0 %
10.8 %
0.0 %
3D Dose MAX: 108.0 %
3D MAX for PTV JPM _PHY: 107.5 %
3D MIN for PTV JPM _PHY: 94.0 %
3D MEAN for PTV JPM _PHY: 104.0 %
A
R
L
P
IEC 61217
Head First-Supine
Y: 0.60 cm
TEST
PT_1
Plan3 - Unapproved - TEST - Blended with registered image: P...
H
F
Z: -0.81 cm
X: -1.40 cm


3DCRT - Unapproved - Transversal - CT
Dose
103.5 %
103.5
103.0 %
102.5 %
102.0 %
101.5 %
101.0 %
100.5 %
100.0
100.0 %
3D Dose MAX: 103.5 %
3D MAX for PTV: 103.2 %
3D MIN for PTV: 89.4 %
3D MEAN for PTV: 99.4 %
A
R
L
P
IEC 61217
103.2 %
Head First-Supine
Y: 1.50 cm
RAPID ARC - Unapproved - Transversal - CT
Dose
108.0 %
108.0
107.0 %
106.0 %
105.0 %
104.0 %
103.0 %
102.0 %
101.0 %
100.0
100.0 %
3D Dose MAX: 108.0 %
3D MAX for PTV JPM _PHY: 107.
3D MIN for PTV JPM _PHY: 94.0
3D MEAN for PTV JPM _PHY: 10
A
R
P
106.8 %
IEC 61217
Head First-Supine
Y: 1.50 cm

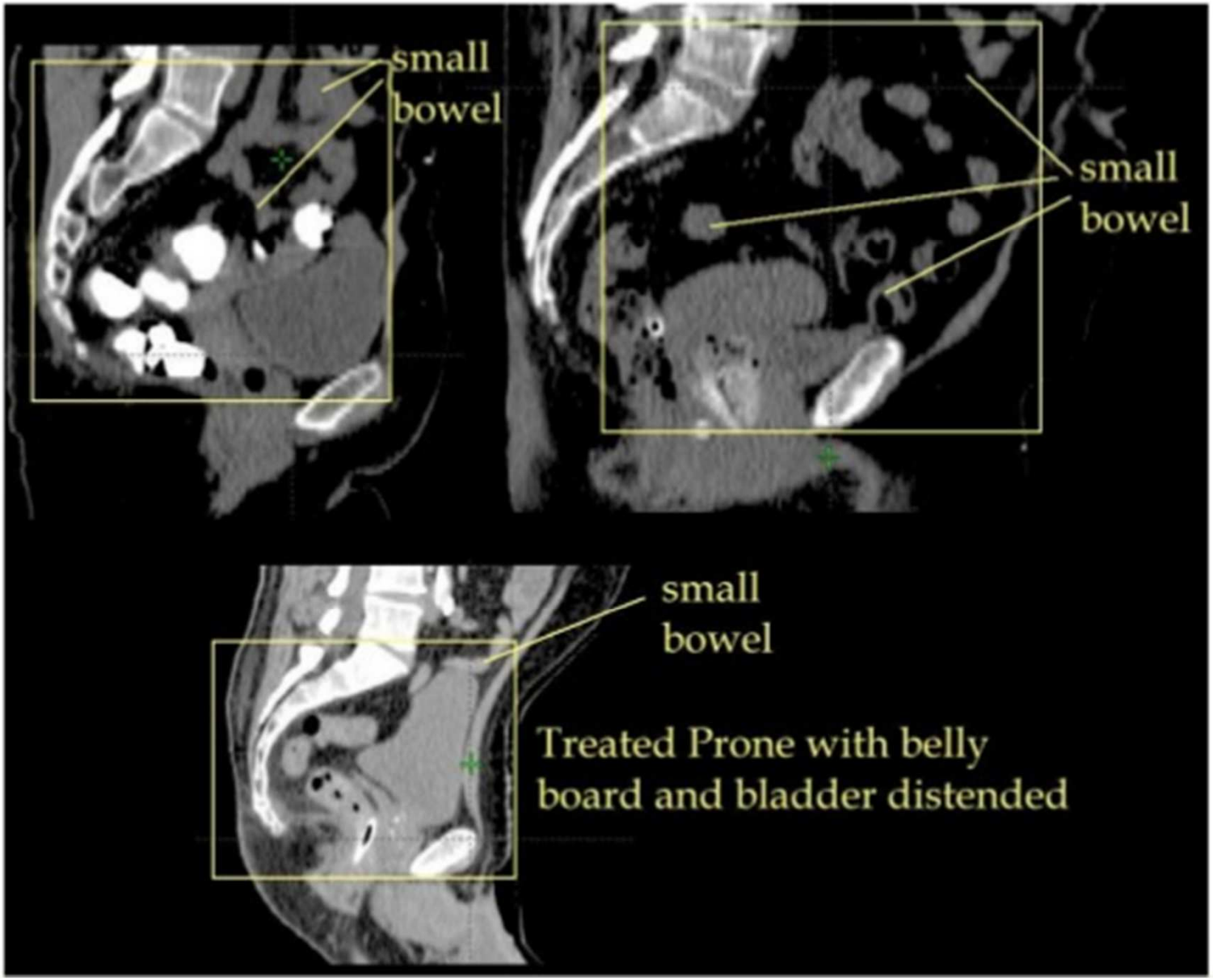

3DCRT - Unapproved - Transversal - CT
Dose
103.5 %
103.5
102.0 %
101.0 %
100.0 %
99.0 %
98.0 %
97.0 %
96.0 %
95.0
95.0 %
3D Dose MAX: 103.5 %
3D MAX for PTV: 103.2 %
3D MIN for PTV: 89.4 %
3D MEAN for PTV: 99.4 %
A
R
L
P
IEC 61217
103.2 %
Head First-Supine
Y: 1.50 cm
RAPID ARC - Unapproved - Transversal - CT
Dose
108.0 %
108.0
107.0 %
106.0 %
105.0 %
104.0 %
103.0 %
102.0 %
101.0 %
100.0 %
99.0 %
98.0 %
97.0 %
96.0 %
95.0
95.0 %
3D Dose MAX: 108.0 %
3D MAX for PTV JPM _PHY: 107.5
3D MIN for PTV JPM _PHY: 94.0 %
3D MEAN for PTV JPM _PHY: 104.
A
R
L
P
IEC 61217
105.8 %
Head First-Supine
Y: 1.50 cm


3D Dose MAX: 5372.6 cGy
3D MAX for CTV 50Gy: 5372.6 cGy
3D MIN for CTV 50Gy: 4919.6 cGy
3D MEAN for CTV 50Gy: 5211.2 cGy
A
Dose
5372.6 cGy
5372.6
5300.0 cGy
5250.0 cGy
5200.0 cGy
5150.0 cGy
5100.0 cGy
5050.0 cGy
5000.0
5000.0 cGy
5200.0 cGy
5100.0 cGy
5000.0 cGy
4900.0 cGy
4800.0 cGy
4700.0 cGy
4600.0 cGy
4500.0
4500.0 cGy
R
L
P
IEC 61217
Head First-Supine
Y: -4.50 cm

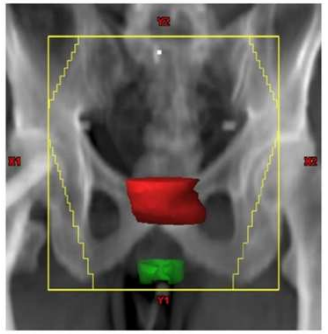

3D Dose MAX: 5372.6 cGy
3D MAX for CTV 50Gy: 5372.6 cGy
3D MIN for CTV 50Gy: 4919.6 cGy
3D MEAN for CTV 50Gy: 5211.2 cGy
A
R
L
P
IEC 61217
Head First-Supine
Y: -6.90 cm
Dose
5372.6 cGy
5372.6
5300.0 cGy
5250.0 cGy
5200.0 cGy
5150.0 cGy
5100.0 cGy
5050.0 cGy
5000.0
5000.0 cGy
5279.5 cGy
5200.0 cGy
5100.0 cGy
5000.0 cGy
4900.0 cGy
4800.0 cGy
4700.0 cGy
4600.0 cGy
4500.0
4500.0 cGy


108.0 %
107.0 %
106.0 %
105.0 %
104.0 %
103.0 %
102.0 %
101.0 %
100.0
100.0 %
108.3 %
IEC 61217
106.9
3D MEAN for PTV_PHY: 100.0 %
90.0 %
80.0 %
70.0 %
60.0 %
50.0 %
40.0 %
30.0 %
20.0 %
10.7
110.0
109.0 %
108.0 %
107.0 %
106.0 %
105.0 %
104.0 %
103.0 %
102.0 %
101.0 %
100.0
100.0 %
106.7 %
3D MEAN for PTV_PHY: 102.8

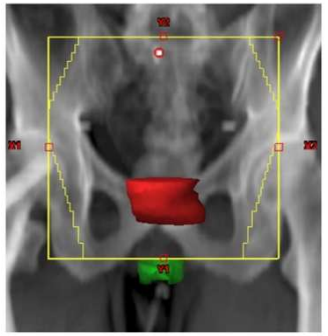
Techniques to minimize radiation side effects



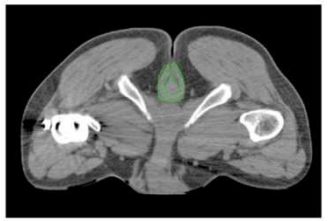
Anal sphincter sparing



(a)



(b)



(c)

(d)

conclusion

- Each centre should have protocol for imaging and integration of various imaging to assess the tumour in a multidisciplinary tumour board
- MRI pelvis should be a standard imaging to assess mesorectal involvement and lymph node metastasis
- Accurate knowledge of anatomy and spread pattern of the tumour improves target delineation
- IMRT and online imaging verification improves dose conformity and homogeneity and spares normal tissue and organ at risk.