Simplified IMRT Plans Can Be Delivered with Conventional Jaws

Ping Xia, Ph.D.

University of California
San Francisco

Premise of IMRT

- IMRT plans are too complicated, not intuitive, requiring a lot of extra resources-software, hardware, and human.
- IMRT plans use too many small segments and small MUs, overly stretching the limitation of Linac stability, and the initial design of MLCs.

Premise of IMRT

- IMRT plans are delivered with a prolonged time, resulting in biological disadvantages for tumor control.
- IMRT plans requires a lot more MUs than the conventional CRT plans, increasing the total body dose and the requirement of room shielding.

Are Complicated IMRT Plans Necessary?

- Complicated IMRT plans are due to the use of two-step optimization.
- It first optimizes ideal beam profiles, without considering delivery constraints.
- Then it converts the optimized profiles into deliverable MLC shapes (segments).

How Simply They Can Be?

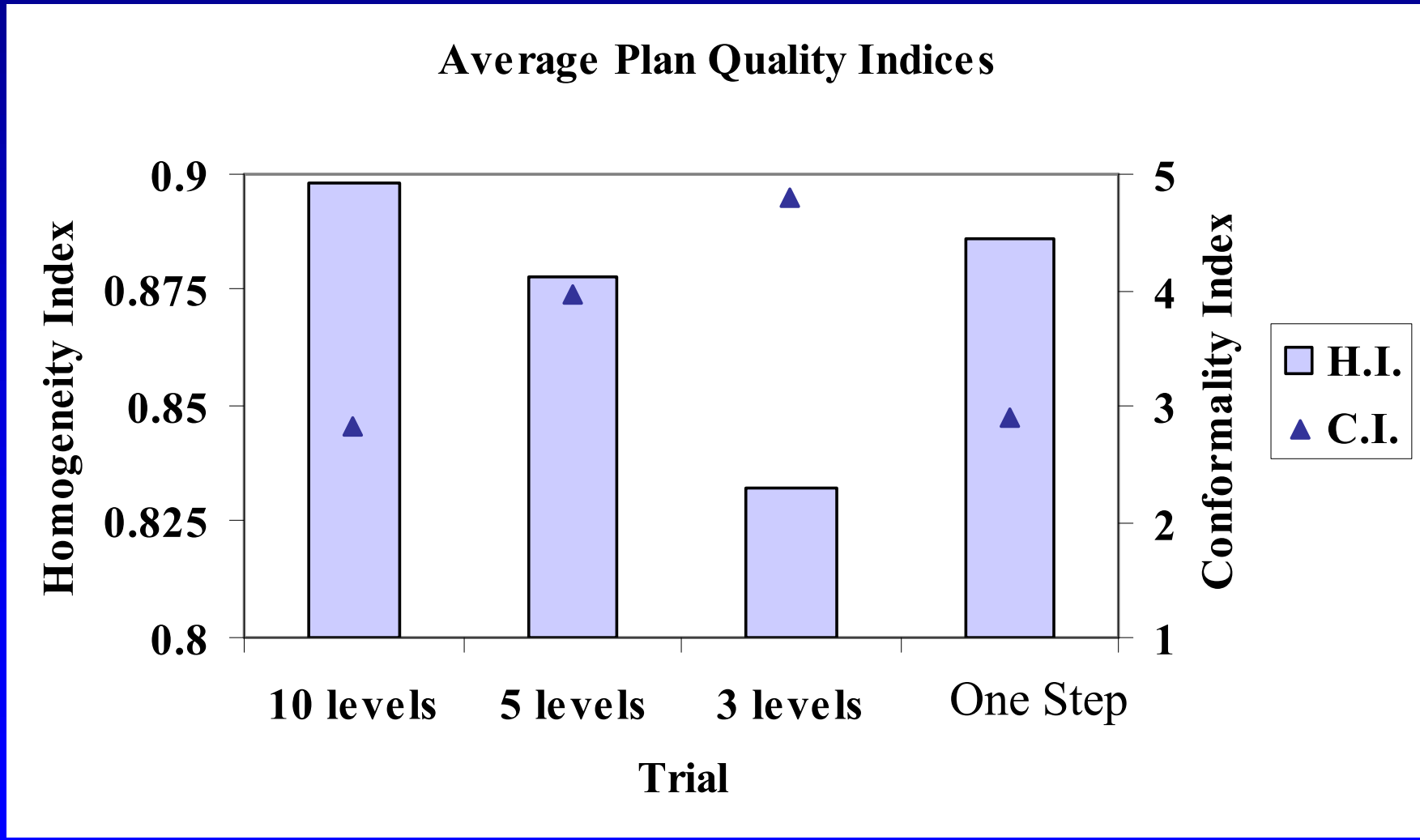
- For typical H&N plans, the number of segments can be reduced from 140-120 segment to 50-60 segments.
- For typical prostate + pelvic lymph node plans, the number of segments can be reduced from 80 segments to 40 segments.

One Step Optimization

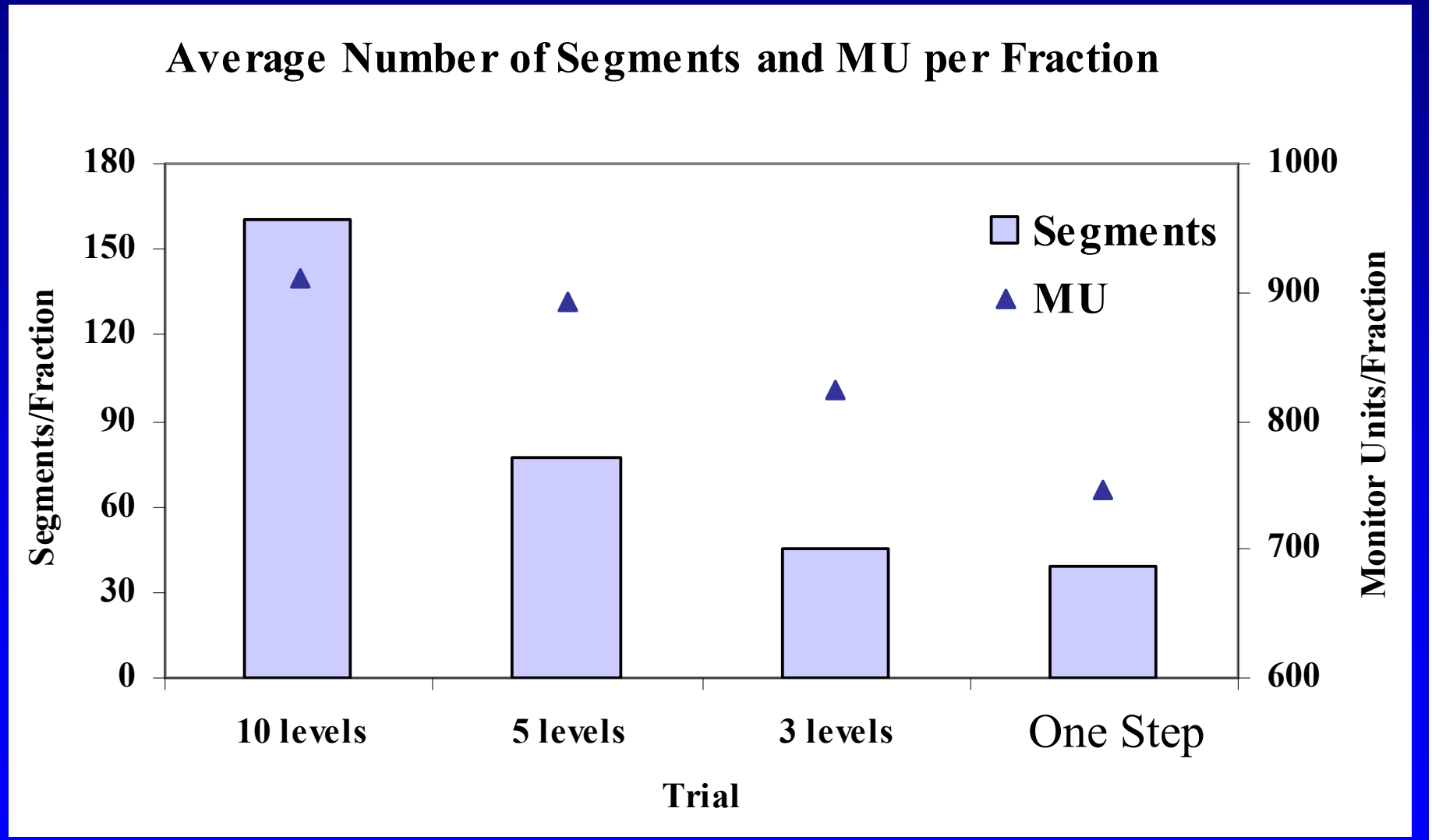
- Directly optimize the shapes and weightings for a given number of segments,
- This method is often referred to as Direct Aperture Optimization (DAO).
- DAO was first proposed by Cedric Yu's group
- This method has been first implemented in Prowess Planning System.
- A similar method also has been implemented in ADAC planning system, referred to as DMPO.

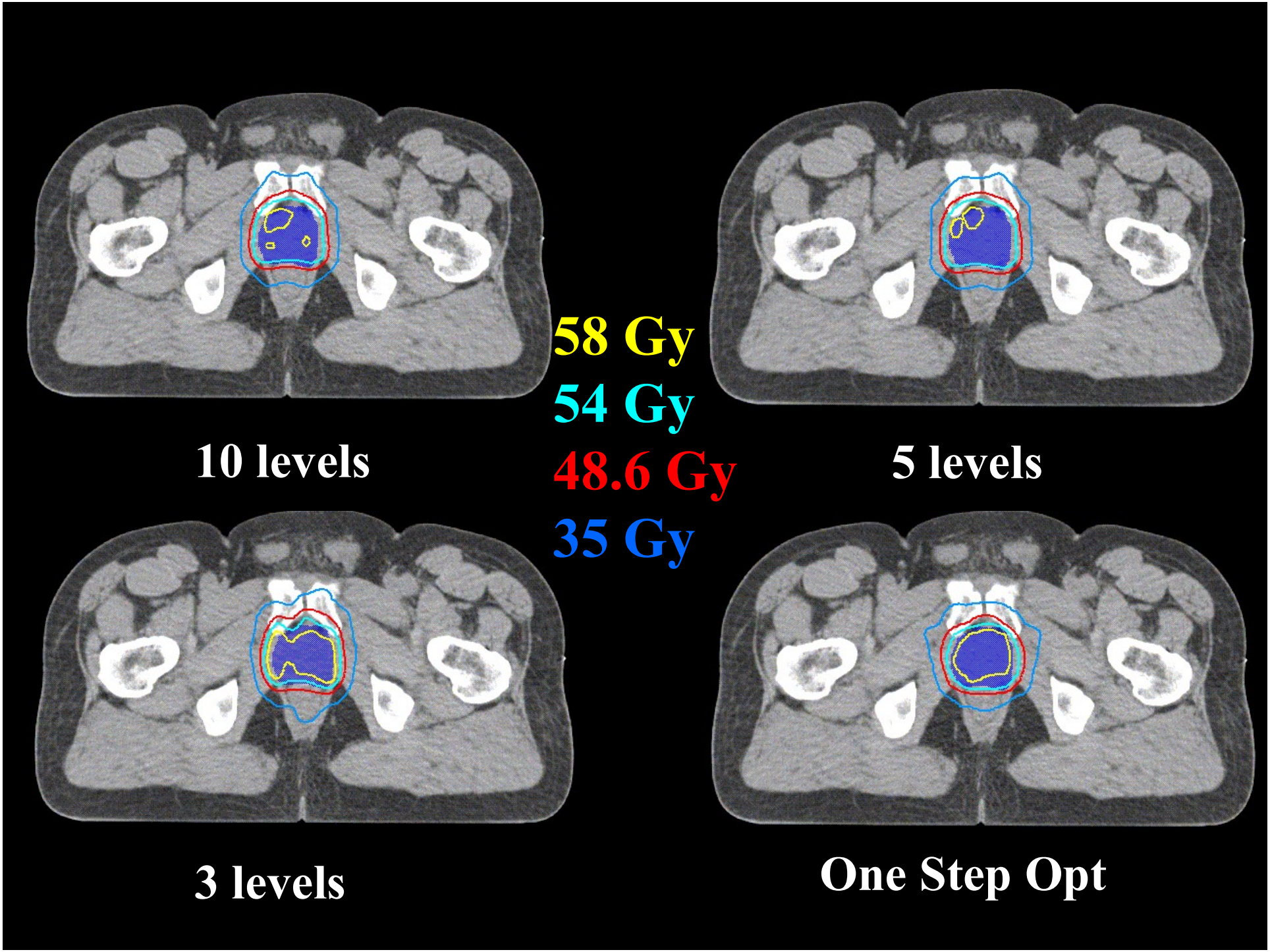
Med. Phys. 29 1001-1018 (2002)

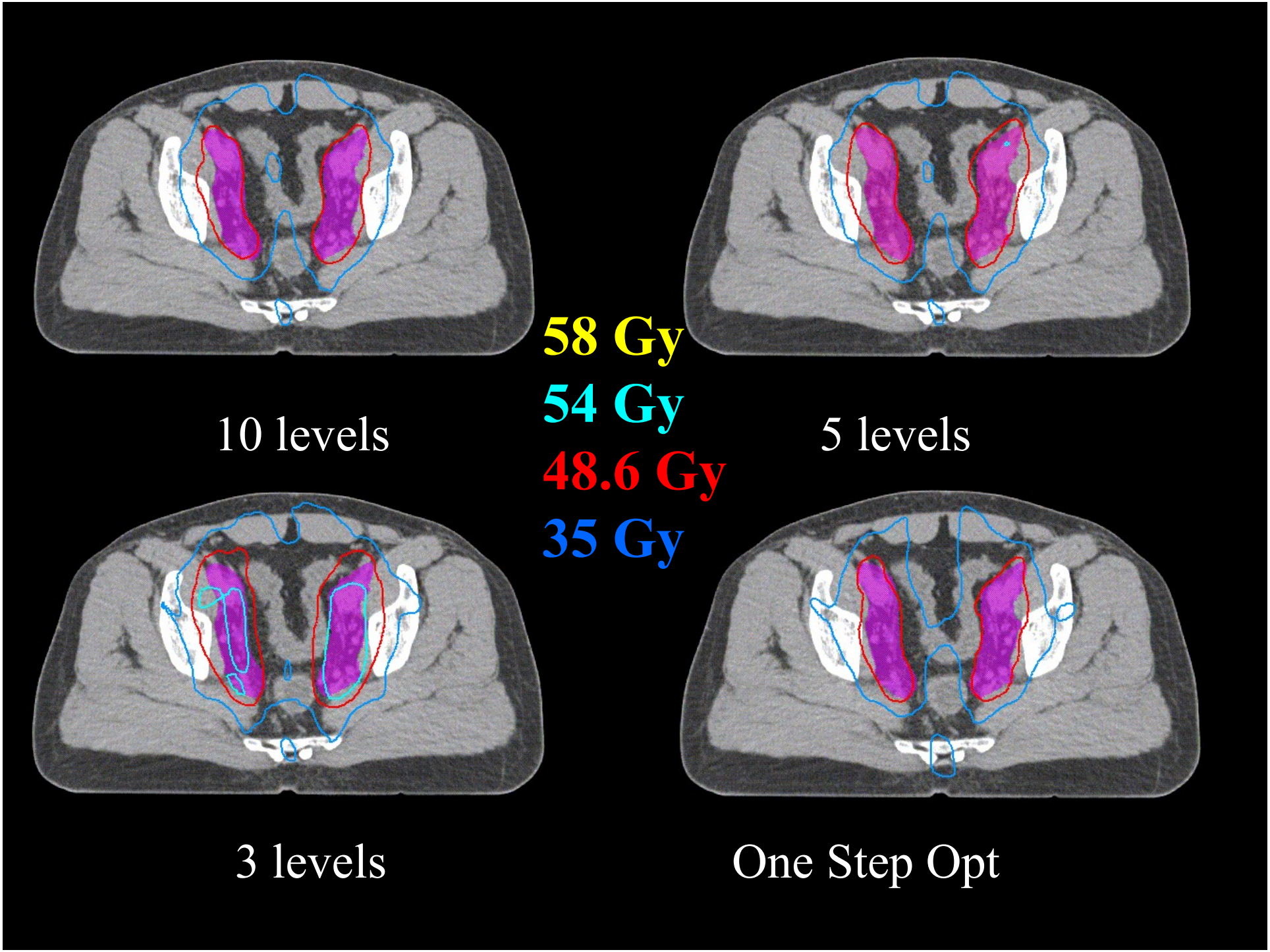
Prostate + Pelvic Lymph Nodes



Prostate + Pelvic Lymph Nodes




58 Gy
54 Gy
48.6 Gy
35 Gy
10 levels
5 levels
3 levels
One Step Opt

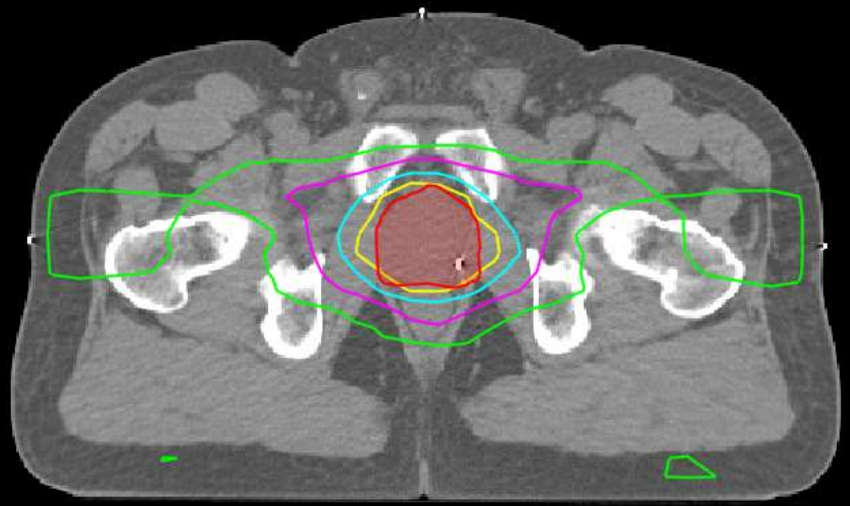

58 Gy
54 Gy
48.6 Gy
35 Gy
10 levels
5 levels
3 levels
One Step Opt

Jaws Only Delivery

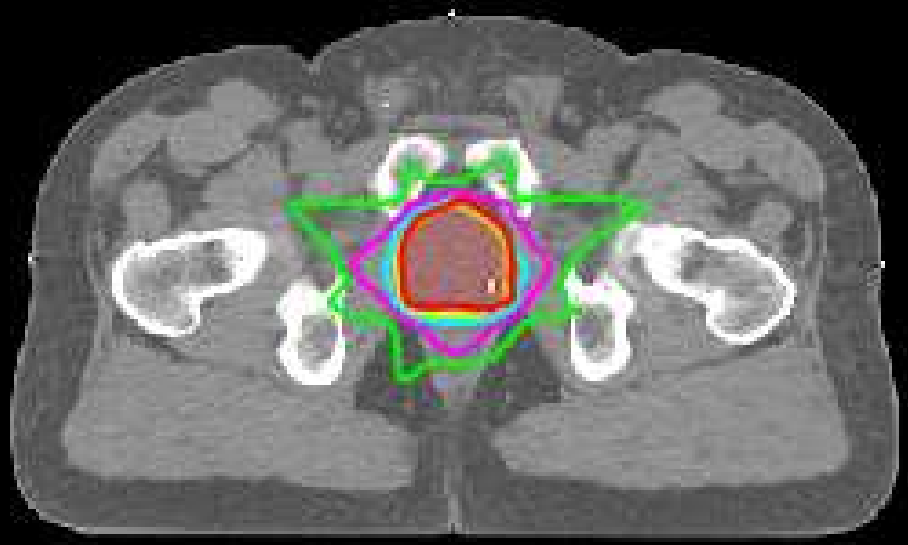
- The algorithm of using conventional Jaws to deliver IMRT fields was first proposed by Dai and Hu's group.
- The algorithm attempted to convert intensity profiles obtained by the conventional two-step optimization using jaws only method
- For a typical prostate and a NPC case, they found that the total number of segments was 147, 426 with jaw only vs 40, 69 with MLC delivery, respectively.

Medical Physics, Vol. 26, (1999)

3D Plan



Jaw Only Plan (28 segs)

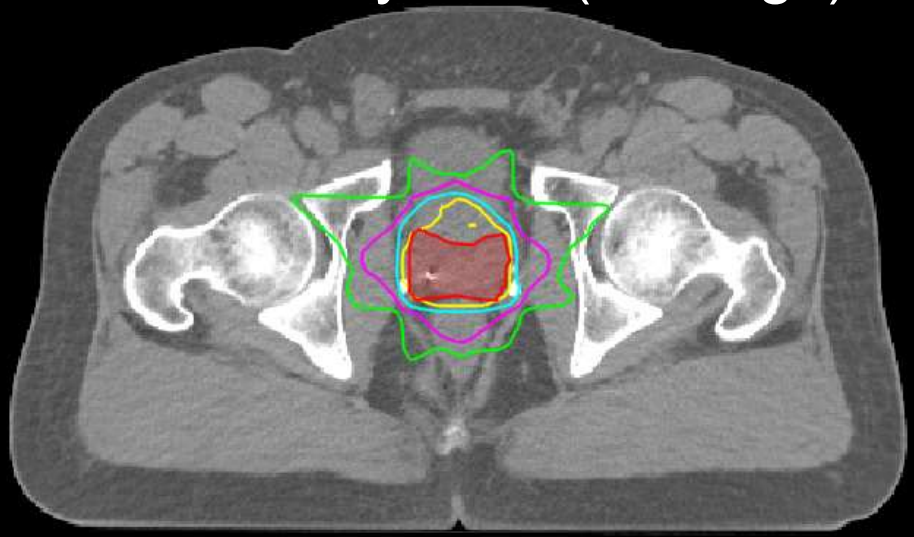


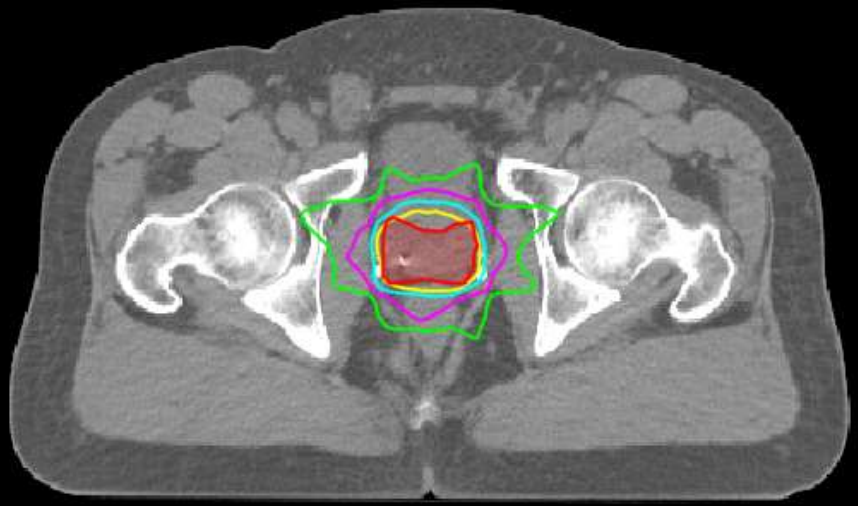
MLC Plan (21 segs)

78 Gy,
72 Gy,
65 Gy,
50 Gy
35 Gy

3D Plan

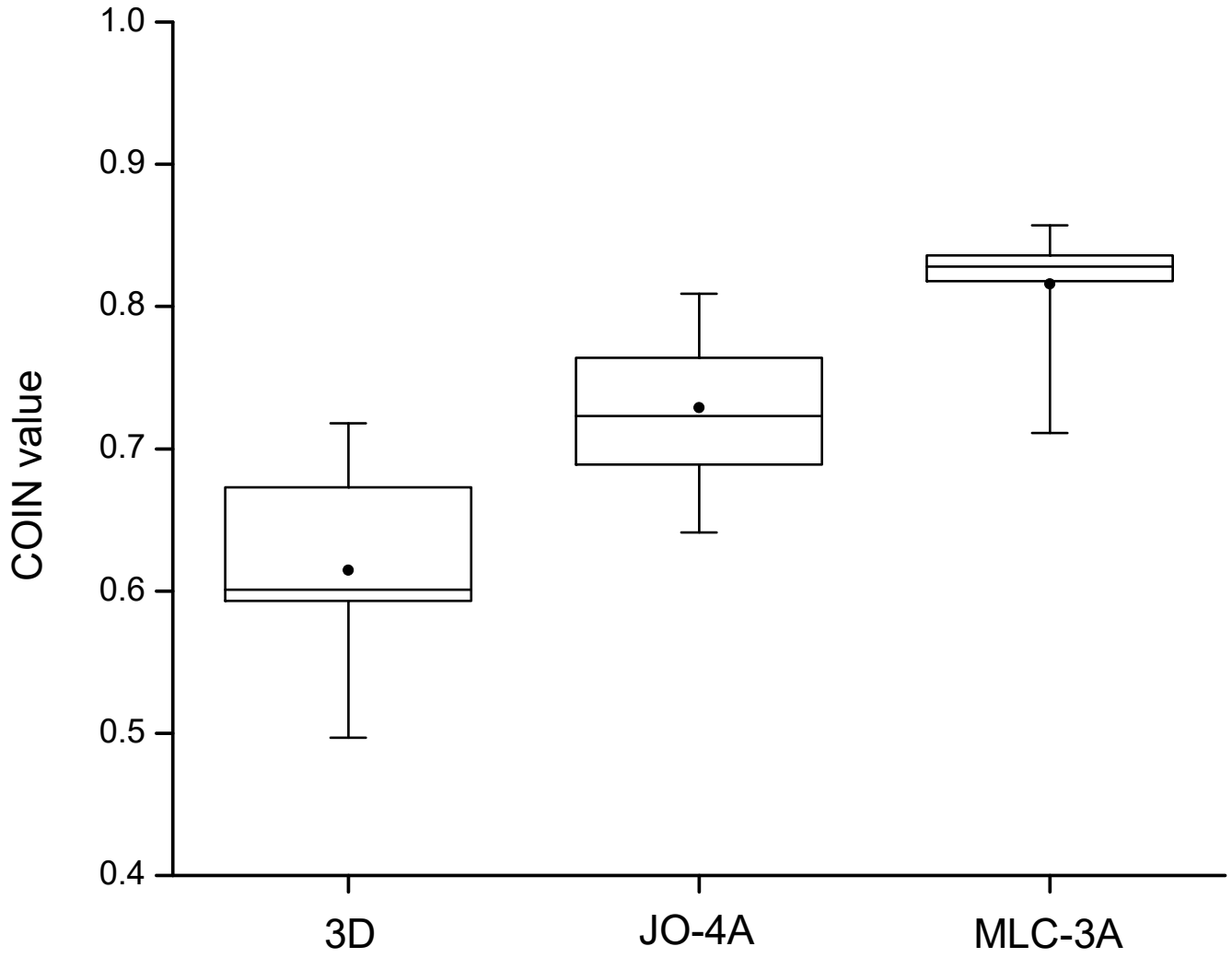
Jaw Only Plan (28 Segs)



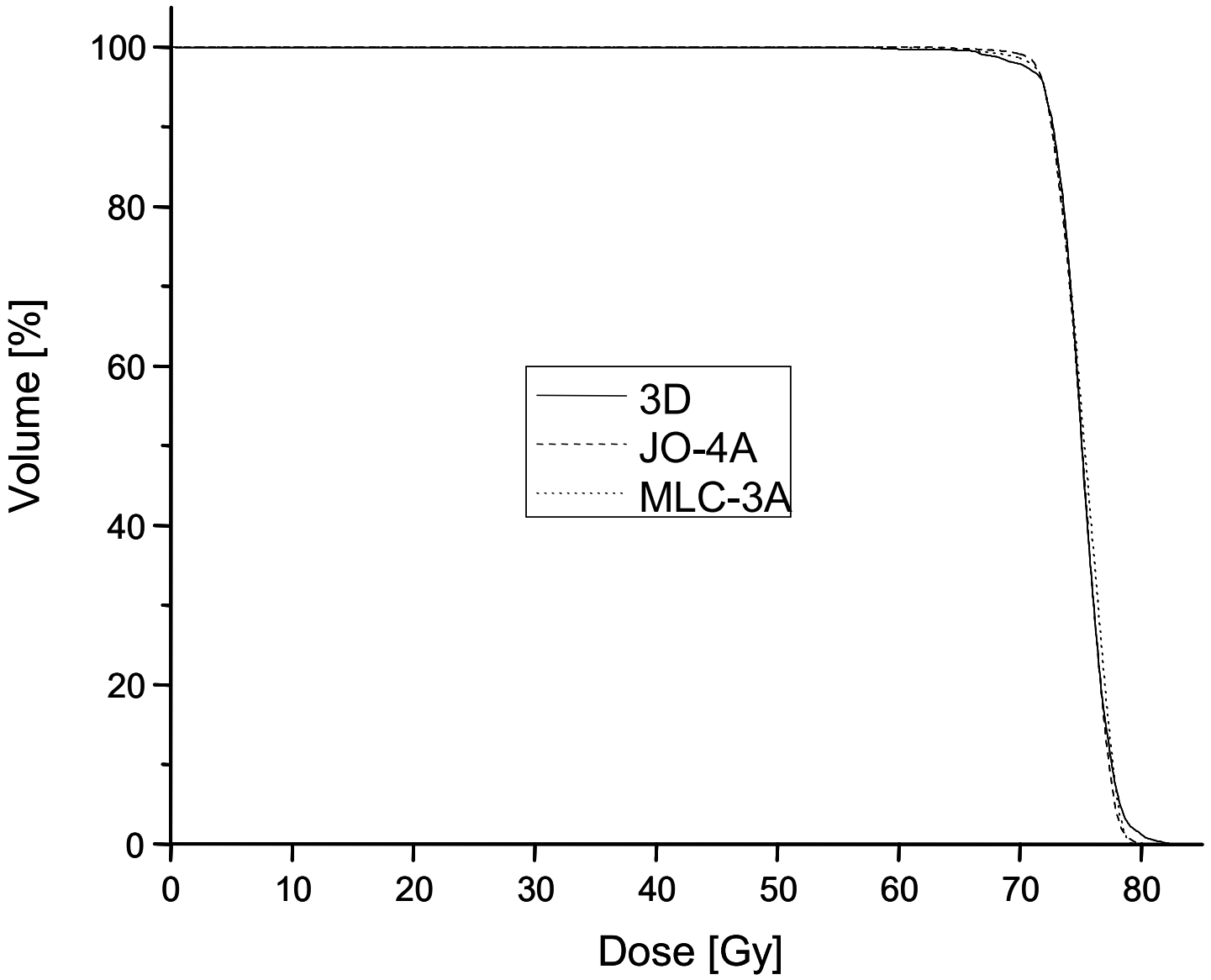


MLC Plan (21 segments)

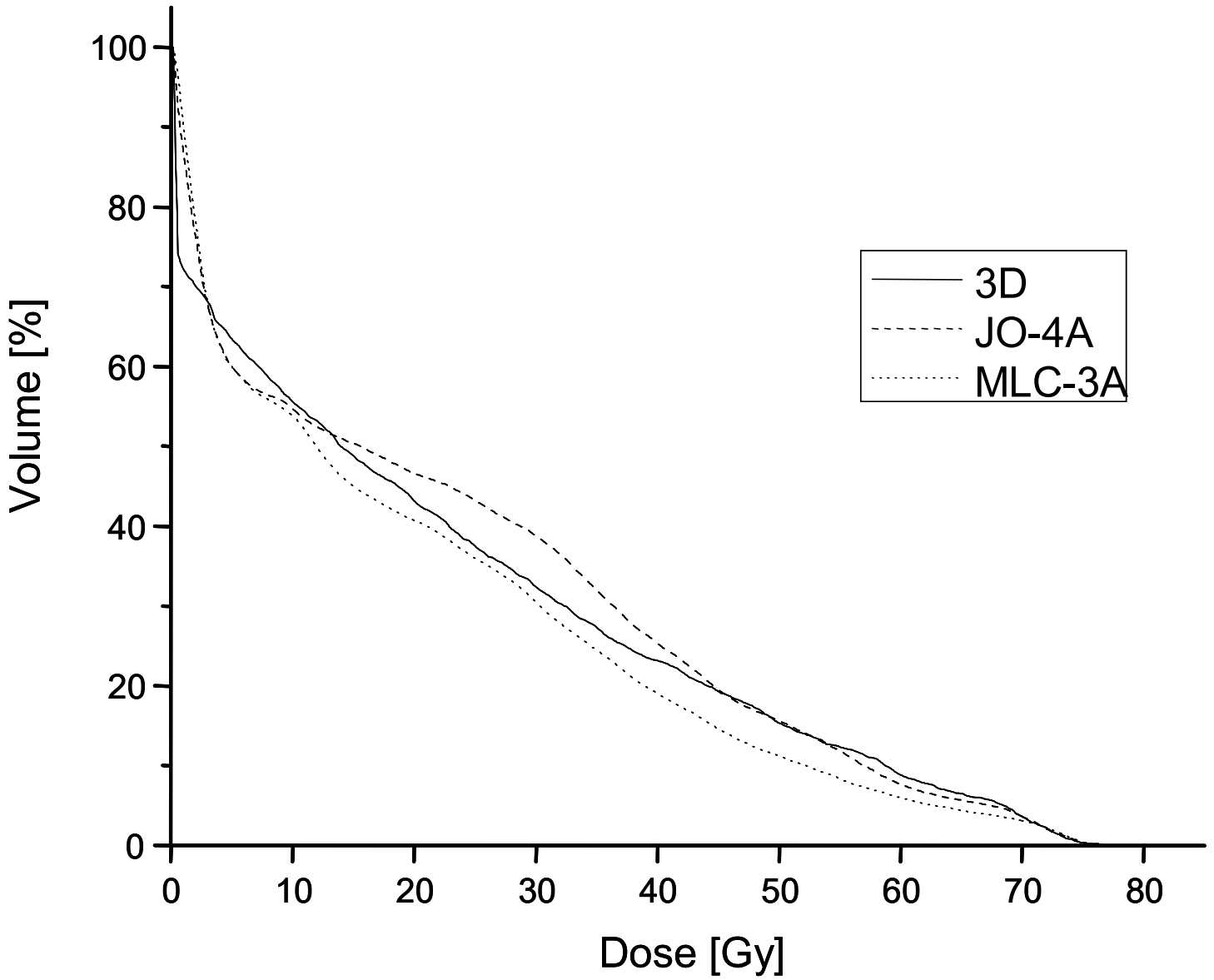
78 Gy,
72 Gy,
65 Gy,
50 Gy
35 Gy



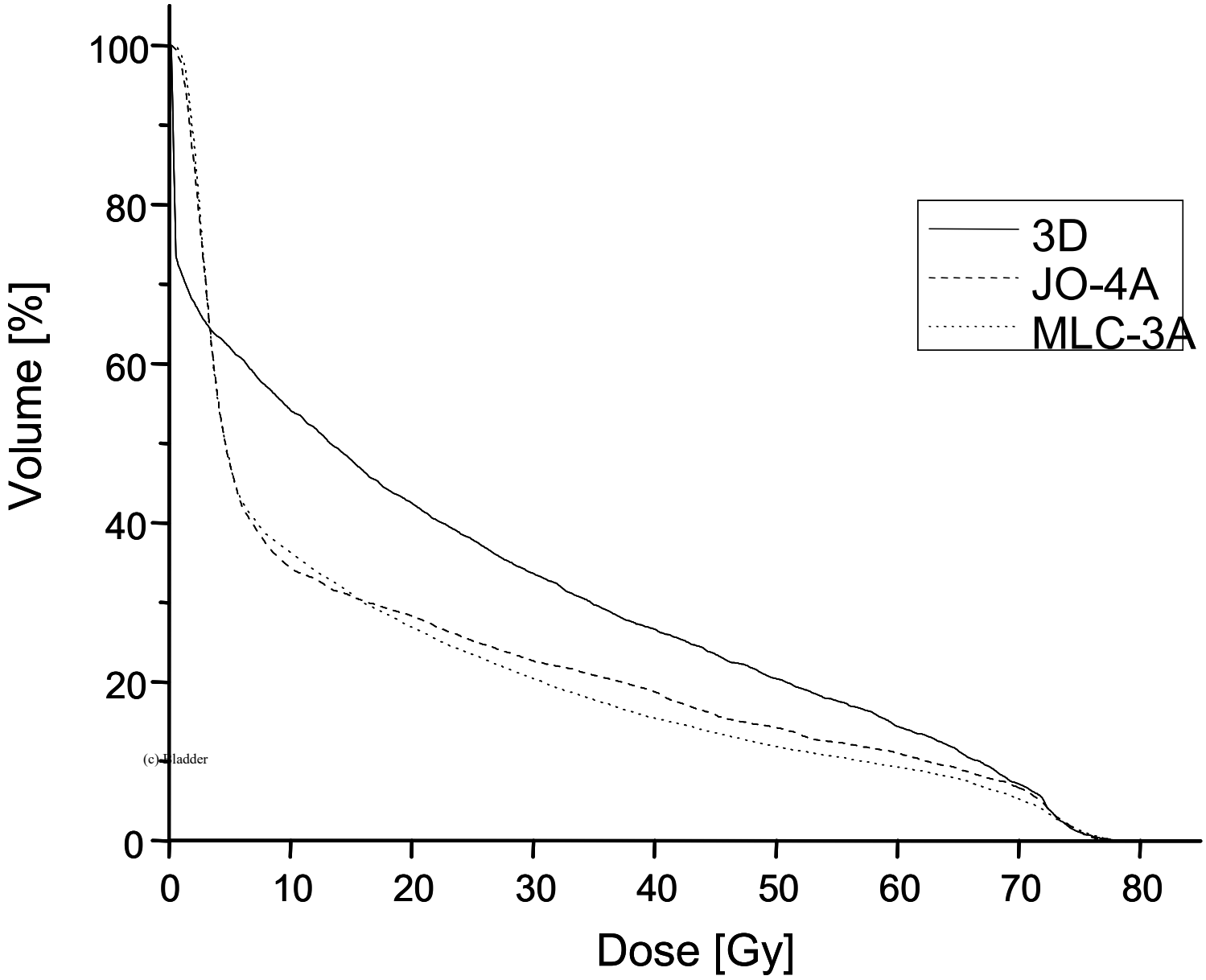
(b) COIN


100
80
60
40
20
0
Volume [%]
0
10
20
30
40
50
60
70
80
Dose [Gy]
3D
JO-4A
MLC-3A

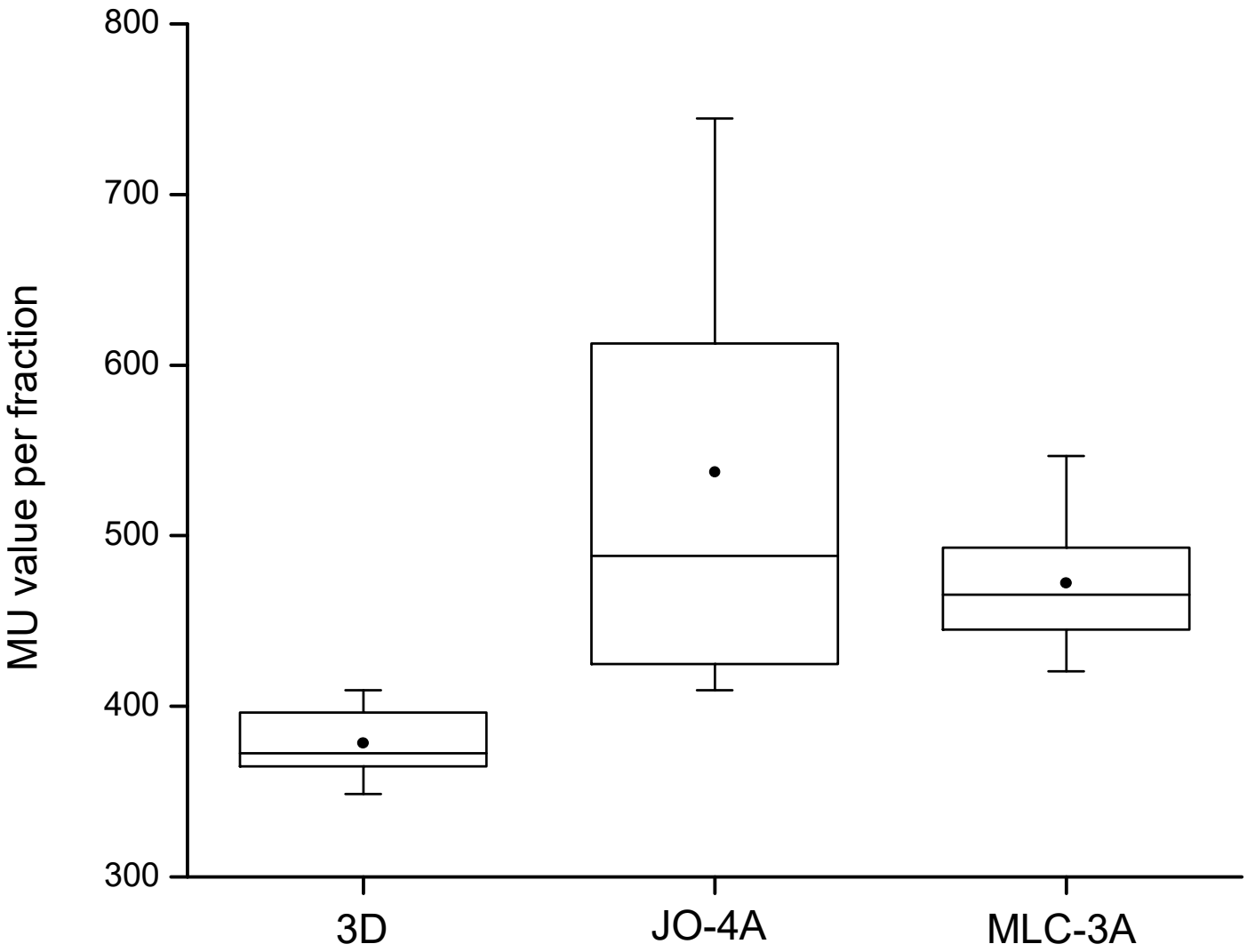
(a) PTV


100
80
60
40
20
0
Volume [%]
0
10
20
30
40
50
60
70
80
Dose [Gy]
3D
JO-4A
MLC-3A

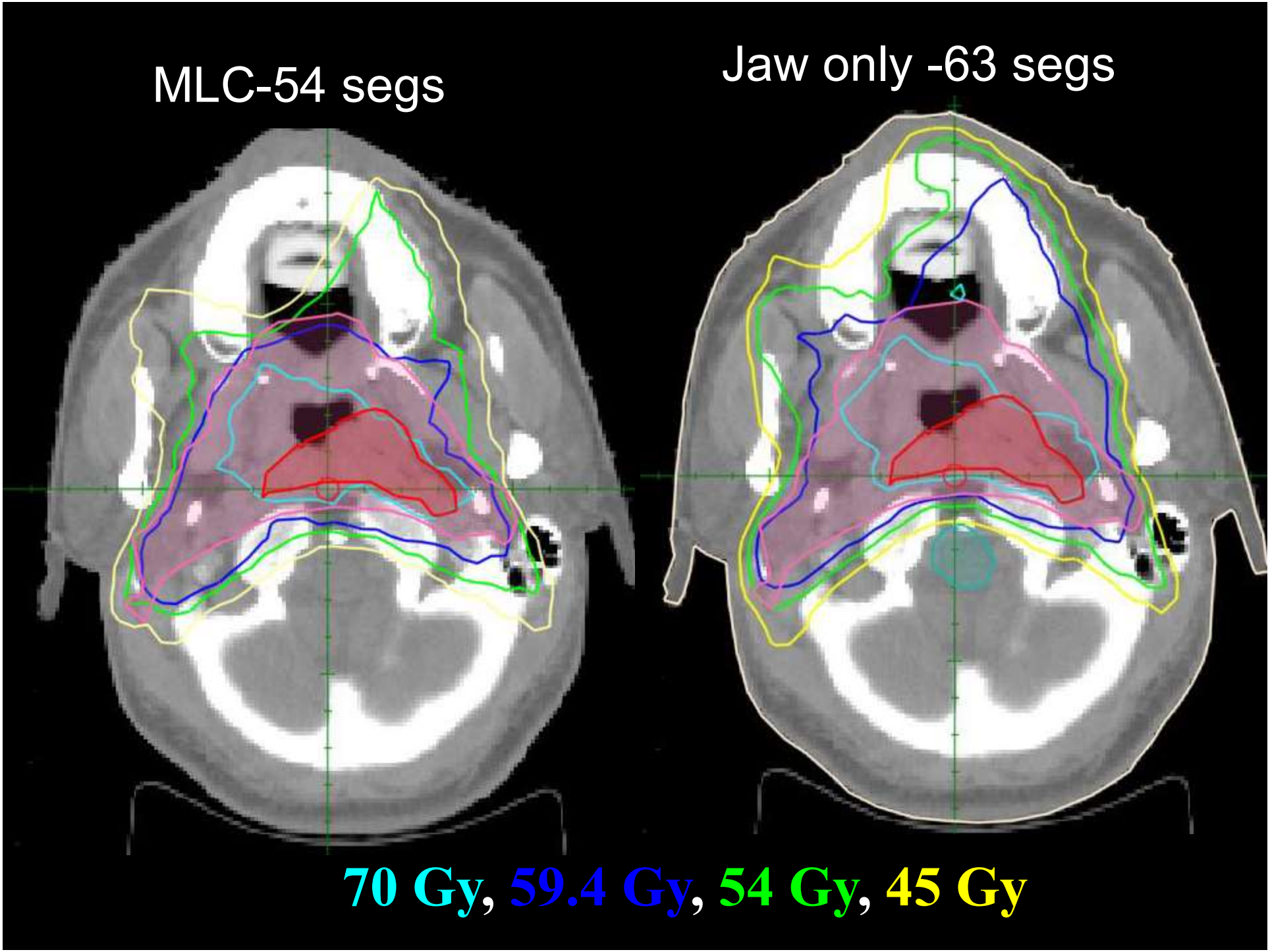
(b) Rectum


100
80
60
40
20
0
Volume [%]
(c) Bladder
0
10
20
30
40
50
60
70
80
Dose [Gy]
3D
JO-4A
MLC-3A

(c) Bladder

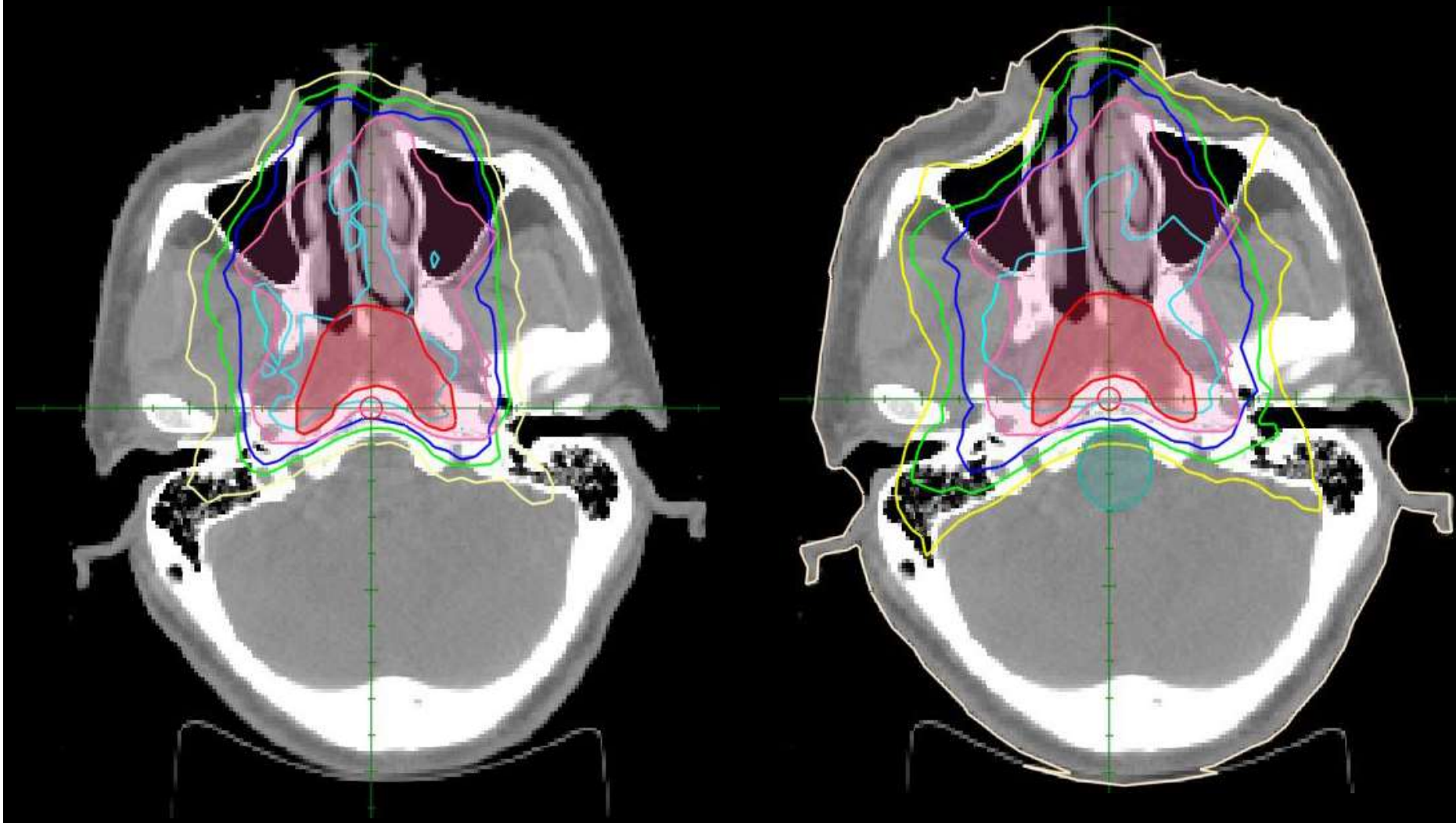


(a) MU


MLC-54 segs
Jaw only -63 segs
70 Gy, 59.4 Gy, 54 Gy, 45 Gy

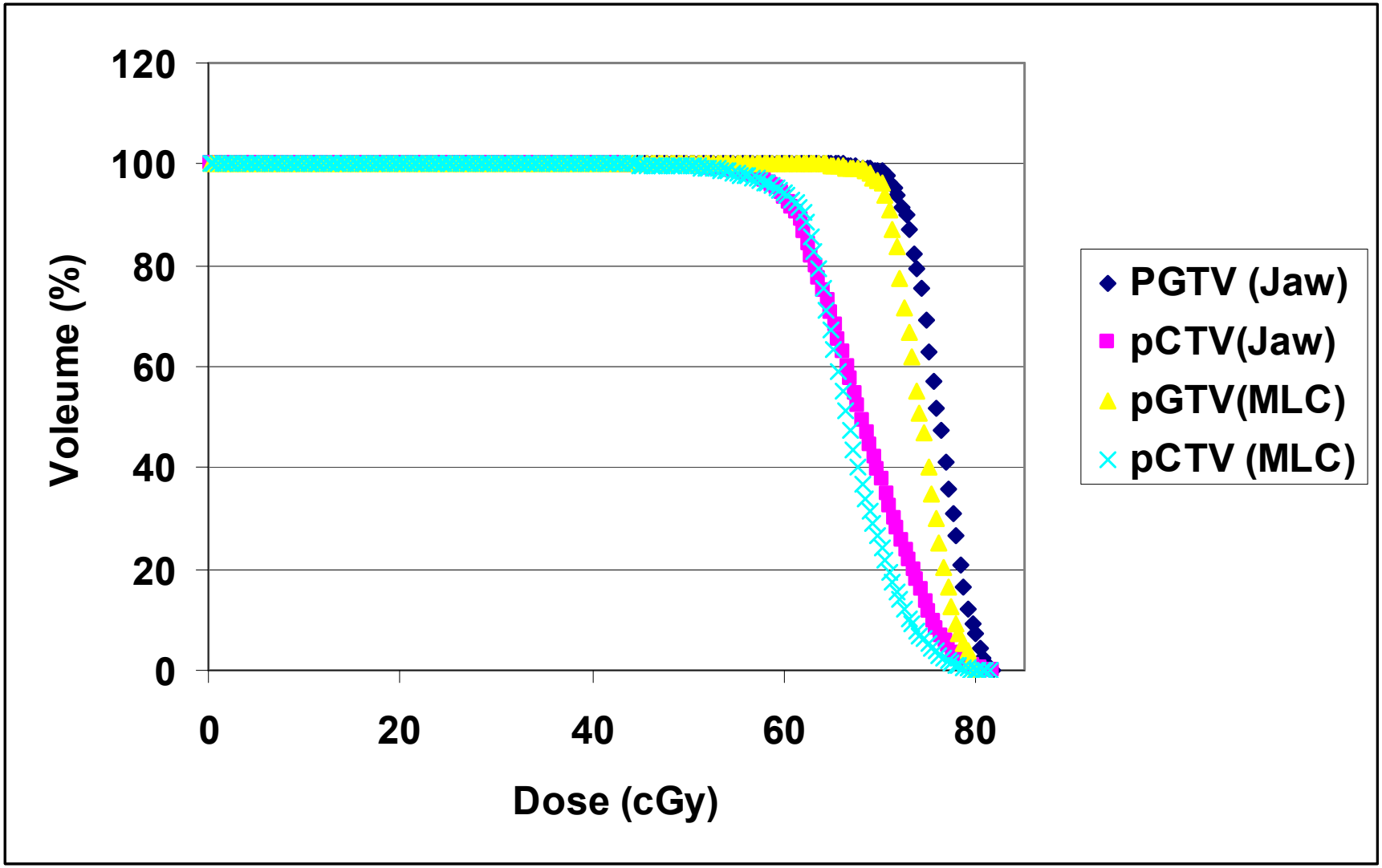
MLC-54 segs

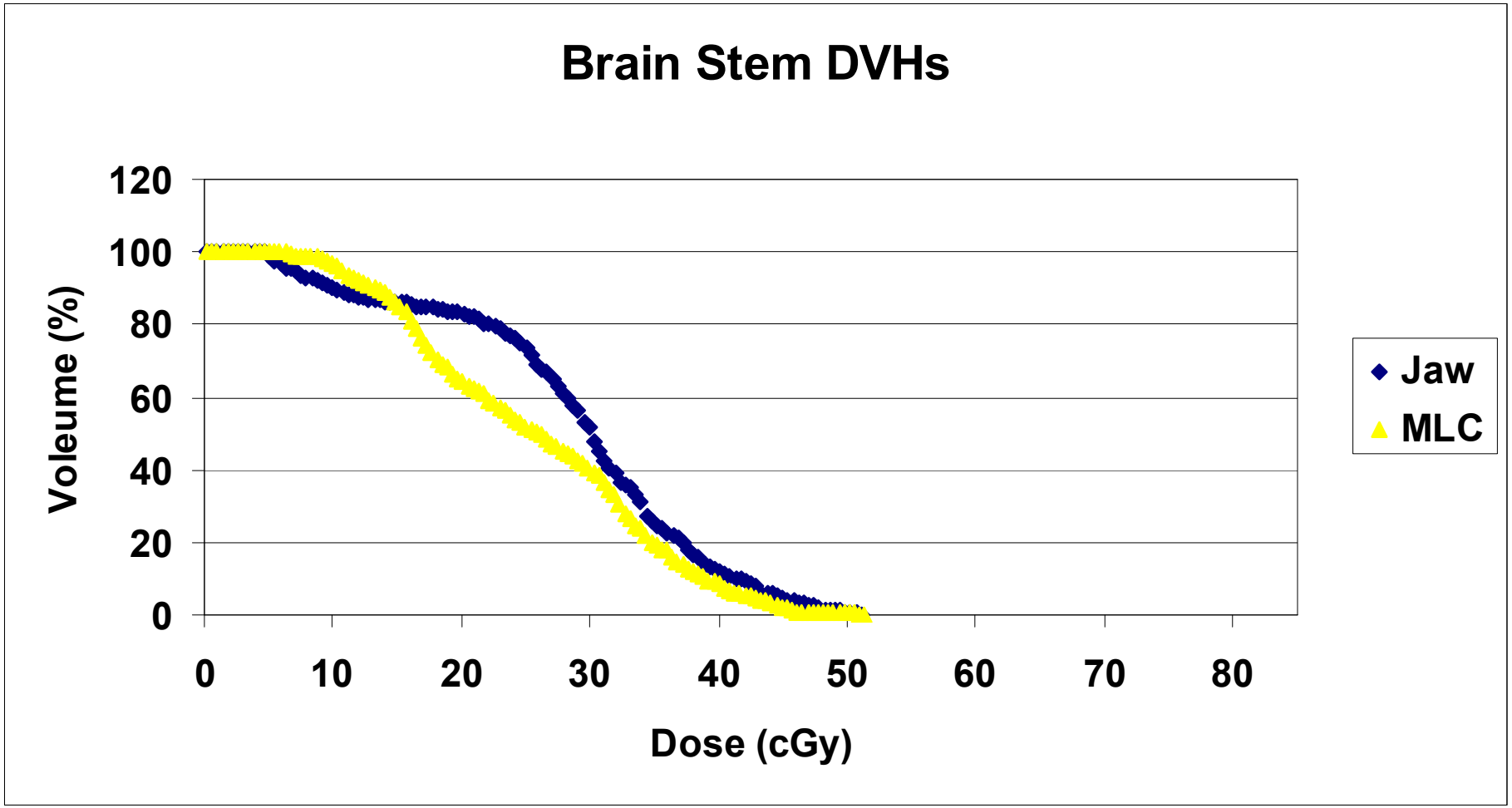
Jaw only -63 segs

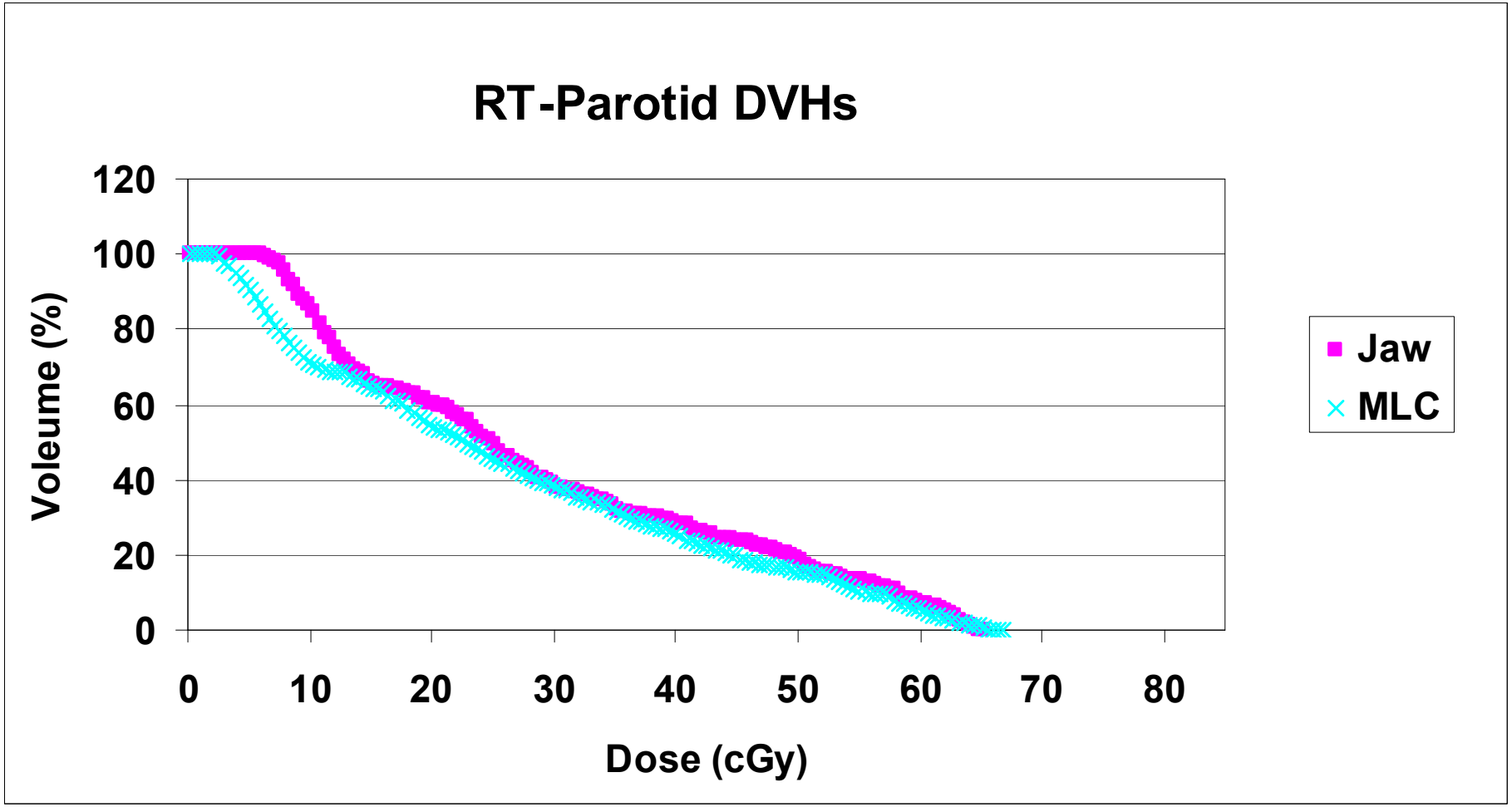


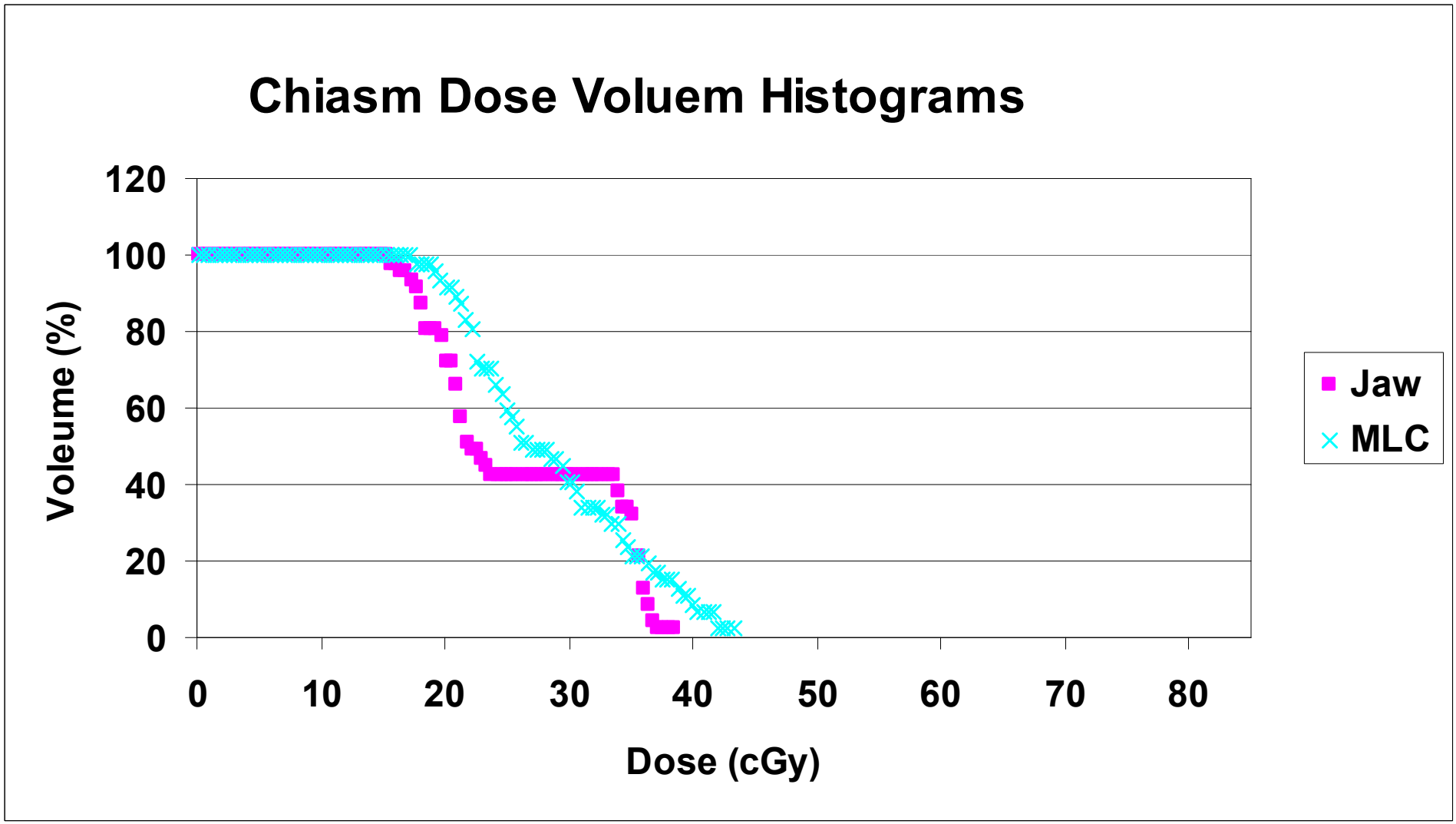
70 Gy, 59.4 Gy, 54 Gy, 45 Gy

Tumor Target Dose Volume Histograms




Brain Stem DVHs
Voleume (%)
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
Dose (cGy)
Jaw
MLC


RT-Parotid DVHs
120
100
80
60
40
20
0
Voleume (%)
0
10
20
30
40
50
60
70
80
Dose (cGy)
Jaw
MLC


Chiasm Dose Voluem Histograms
Voleume (%)
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
Dose (cGy)
Jaw
MLC

Conclusion (1)

- For complicated cases, inverse planning is simpler than 3D-CRT planning.
- It is possible to simply IMRT plans while keeping the same plan quality and improving delivery efficiency.
- The key to simply IMRT plans is to use one step optimization method.

Conclusion (2)

- Using one step optimization method, the conventional jaws can be used for IMRT delivery while keeping the delivery time within 15-20 minutes.
- Inverse planned Jaw only IMRT plans are better than 3D CRT plans.
- Jaw only IMRT plans are clinical achievable without significantly increasing hardware resource.

Acknowledgement

Yongbok Kim, Ph.D.
Guangwei Mu, Ph.D
Erica Ludlum, M.S.

Prowess Inc.
Siemens Medical Solutions