2016 AAMD / RSS Plan Study
SBRT Prostate

Ben Nelms, Ph.D.
&
Keitt Mobile, M.S., C.M.D.

Outline

1. History
2. Purpose
3. What are we studying? And why?
4. Methods
5. Results & Discussion
6. Tips and Techniques
7. What's Next?

History

2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016

RADIATION
ONCOLOGY
RESOURCES

Goshen Hospital (IN)

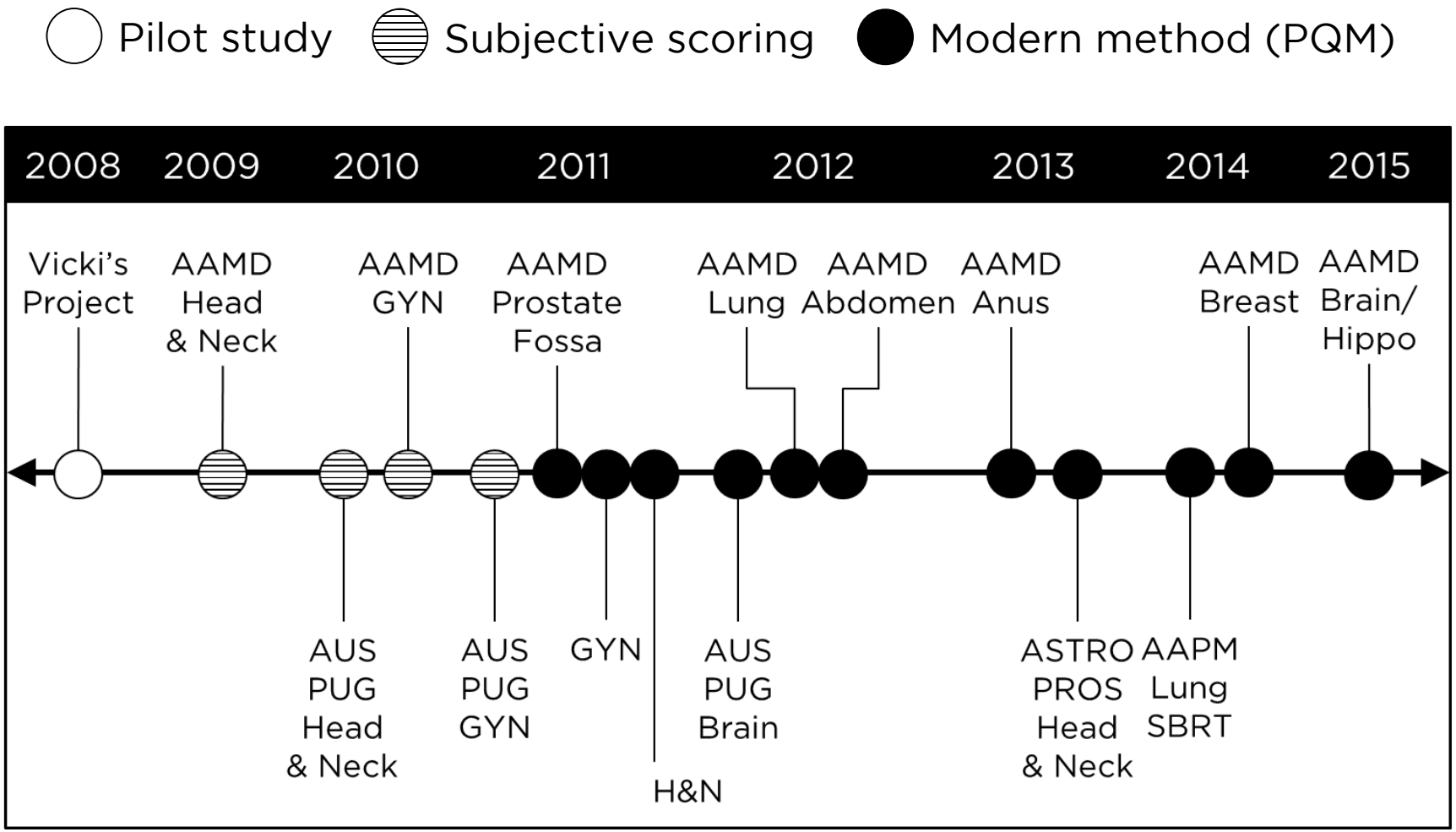
SUN NUCLEAR corporation

Vicki LaCerba, CMD

(pictured here with husband Matt)

Ben Nelms / Canis Lupus LLC

History


Pilot study
Subjective scoring
Modern method (PQM)
2008
2009
2010
2011
2012
2013
2014
2015
Vicki's Project
AAMD Head & Neck
AAMD GYN
AAMD Prostate Fossa
AAMD Lung
AAMD Abdomen
AAMD Anus
AAMD Breast
AAMD Brain/ Hippo
AUS PUG Head & Neck
AUS PUG GYN
GYN
H&N
AUS PUG Brain
ASTRO PROS Head & Neck
AAPM Lung SBRT

History

- Publication of the 2011 AAMD Plan Challenge

practical radiation oncology
pro
www.practicalradonc.org

Variation in external beam treatment plan quality: An inter-institutional study of planners and planning systems

Benjamin E. Nelms PhD[a,b,*], Greg Robinson CMD[c], Jay Markham CMD[c], Kyle Velasco CMD[c], Steve Boyd CMD[c], Sharath Narayan CMD[c], James Wheeler MD, PhD[d], Mark L. Sobczak MD[e]

PURPOSE

- Using rigorous scientific methods,
- compare different systems & modalities in order to:
- identify best practices and high performing individuals and
- share results with the worldwide community.

ULTIMATE GOAL=

Drive out variation and improve plan quality

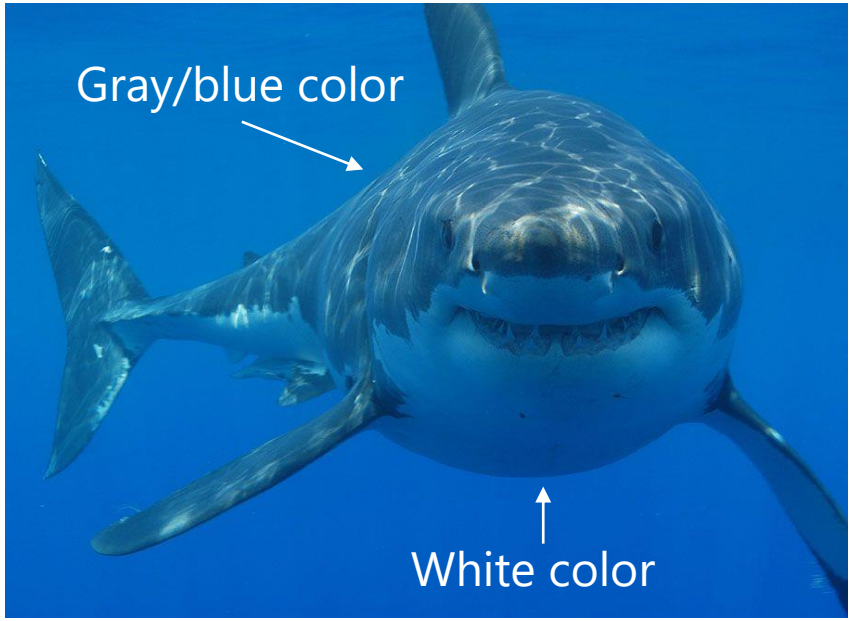
What are we studying? And why?

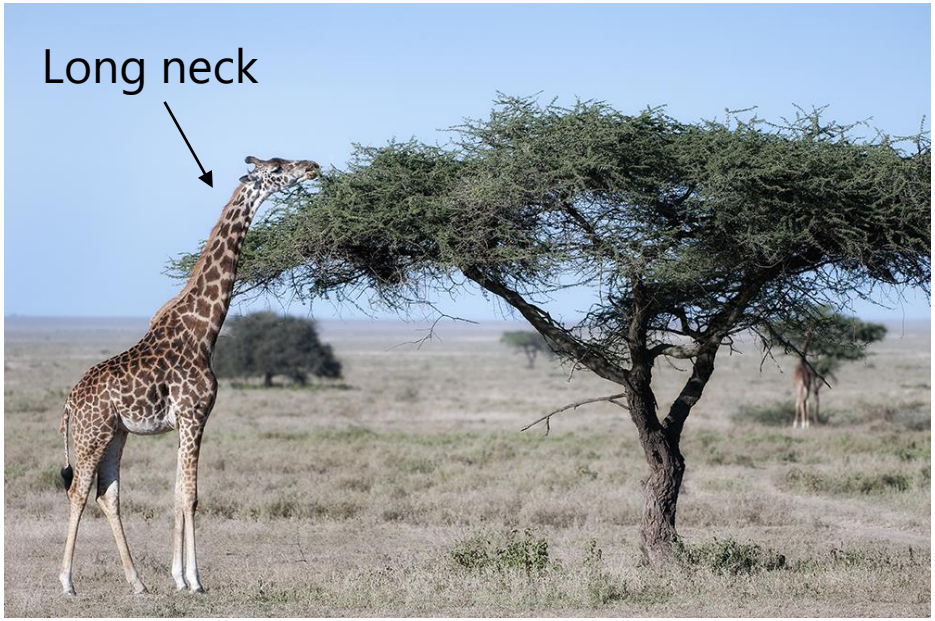
- We are measuring: **plan quality**…
- In order to: **study variation**.

What is so interesting about variation?

Variation: In Biology

- When you first think of variation…
  - Often, our first introduction to variation is in the context of biology and evolution.
  - In this context, variation is good.
  - Genetic variation → variable traits → some traits will be more fit to survive and reproduce through a dynamic environment.





Variation: Manufactured Products

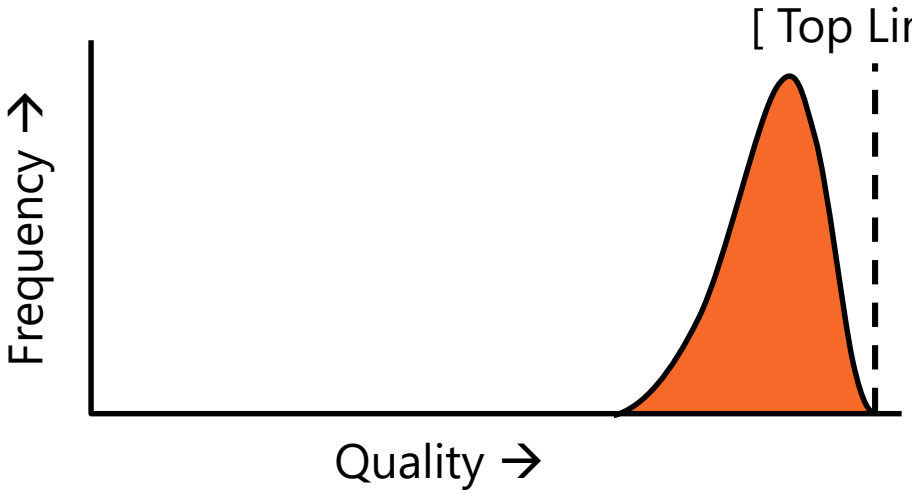
- But concerning manufacturing and quality…
  - In this context, variation is not good.
  - Variation is a by-product of imperfect methods and/or processes.
  - Variation is never good for the "customer."
  - Variation causes waste and risk.

Variation: Manufactured Products

- Variation in manufacturing is bad. (Of course you already know this.)
  - Temperature and flavor of the French Roast from your favorite coffee shop
  - The ingredients and taste of your favorite sub sandwich
  - Location of the pet food at your regular store
  - The composition of the gasoline you put in your car

VARIATION: MEASURED QUALITY

- High variation
- Average quality is low
- Lots of low quality items
- Few high quality items



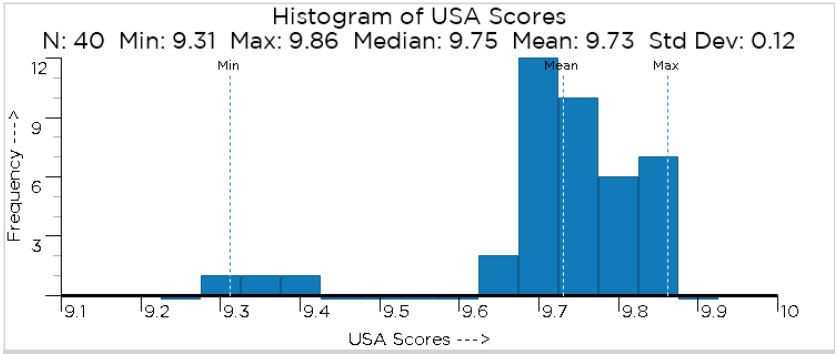
- Lower variation
- Average quality is higher
- Fewer low quality items
- More high quality items

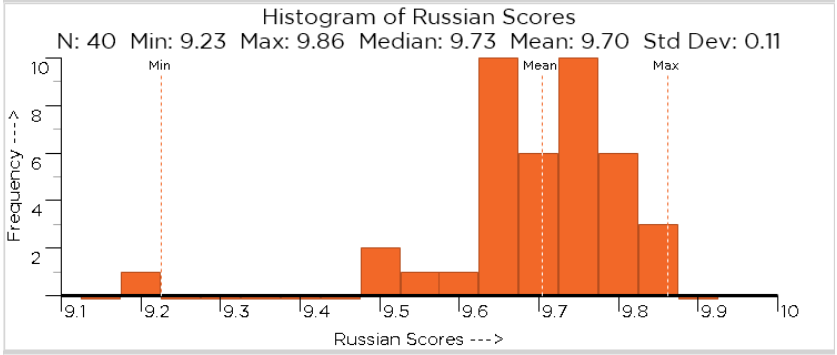
Variation: Measured Quality

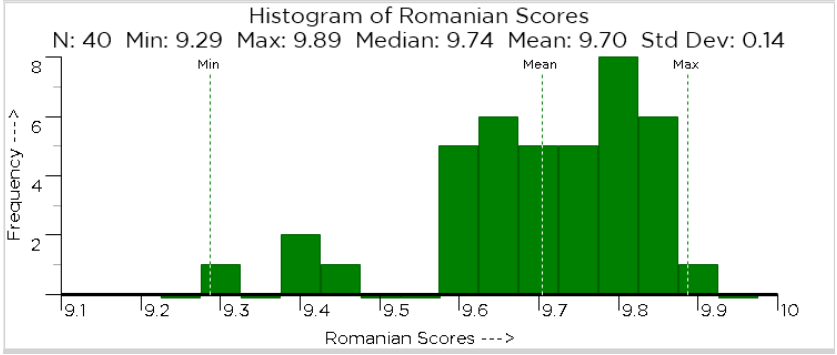
- To study quality, we must be able to objectively measure quality.
- Sports example
  - 2016 marks the 20th anniversary of the USA women's gymnastics team winning the team gold in the Summer Olympics
  - Judges have a well-defined system to score each routine
  - Max score for any routine is 10.0

VARIATION: 1996 TEAM COMPETITION

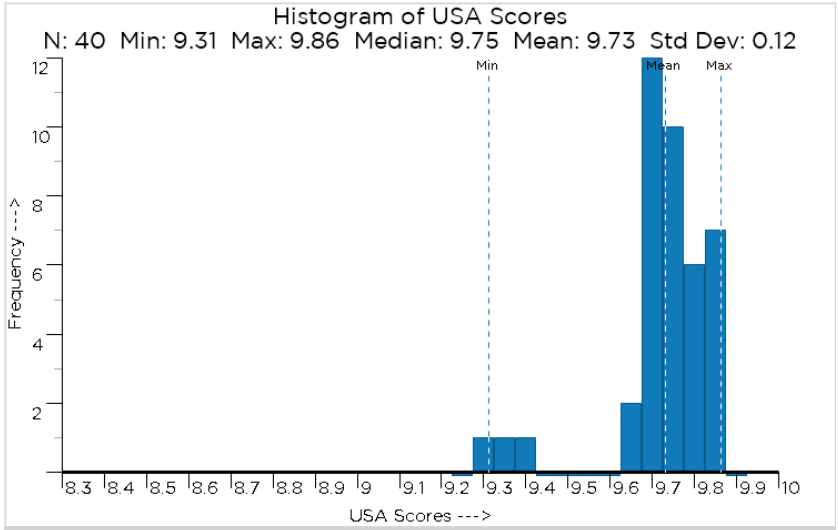
1ST vs. 2ND vs. 3RD

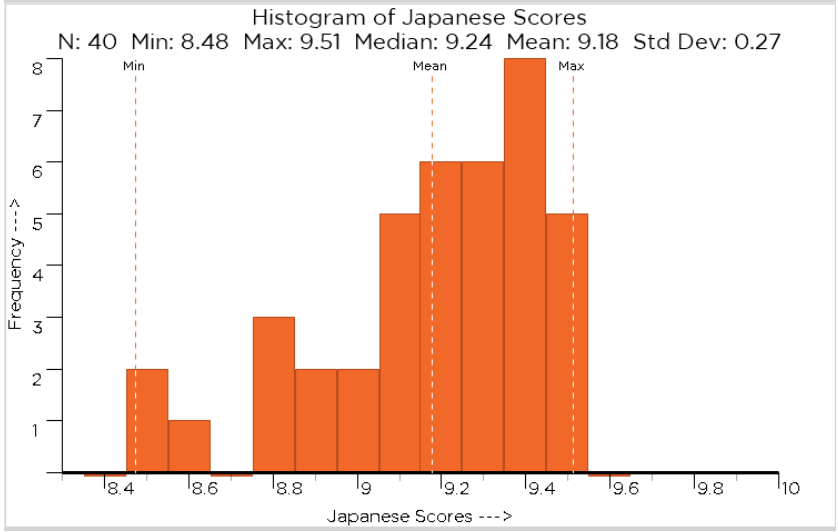






1ST vs. 12TH





Methods

- Scientific Design “101”
  - Control variables
  - Independent variables
  - Dependent variables
  - Try to remove sources of bias
  - Try to remove risks of bad data

METHODS: CONTROL VARIABLES

A control variable is kept the same throughout the experiment. Any change in a control variable in an experiment would invalidate the correlation of dependent variables to the independent variable(s), thus skewing the results.

- Patient model (CT images)
- Patient anatomy (RT Structure Set)
- Planning goals, i.e. plan scoring algorithm
- Scoring software, to eliminate inter-TPS variation in DVH calculation methods [2]

METHODS: CONTROL VARIABLES (CONT.)

- As controlled as we can…
  - Modern dose calculation algorithm (superposition or better)
  - Minimum requirements for dose grid resolution (< 3 mm) and size (covering all scored structures)
  - Practical expenditure of time planning*
  - Practical delivery time**

* We actually captured approx. planning time for this year's study

** We audit this via estimations of "beam on" time from control point data

METHODS: INDEPENDENT VARIABLES

- PLANNER
  - Dosimetrist, physicist, student, etc.
- TREATMENT MODALITY
  - IMRT, VMAT, robotic, proton, etc.
- TREATMENT PLANNING SYSTEM
- ENERGY
- PLANNING TECHNIQUES
- etc.

Methods: Dependent Variables

- COMPOSITE PLAN SCORE
- PER METRIC SCORES
- DELIVERY TIME (estimated)

Methods: Attention to Potential Bias

- Ideally, the population of participants is a microcosm of the real population.
  - Communicate through organizations (AAMD, RSS, etc.)
  - Communicate through all applicable vendors (TPS, delivery, etc.)
  - Look for the right international communication pathways to ensure it's known worldwide.
- We try to remove bias of people not participating due to worries about their experience or scores.
  - Anonymous (except for high performers and peer educators)
  - No real penalty for poor performance
  - Keep plan scoring "open" after the study for participants to try again and measure improvement

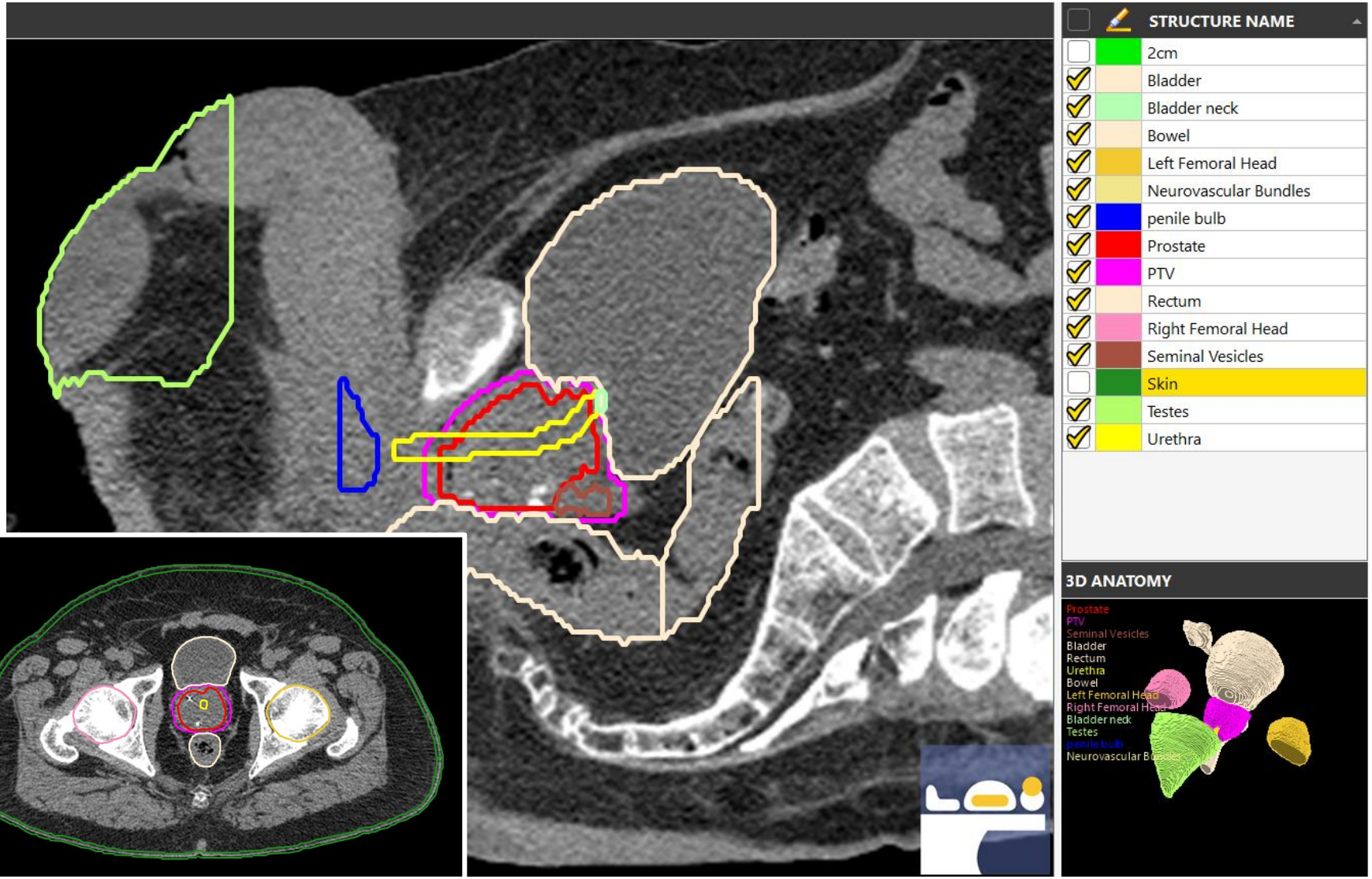
Methods: Try to Minimize Bad Data

- Try to ensure data are "realistic"
  - Monitor delivery time estimates (empirical)
  - Collect treatment planning time estimates (honor system)
  - Requests to "keep it real"…
- Spot checking for bad behavior
  - Yes, there are ways to "cheat" in a plan study.
  - We have strategic spot checks for the most notable tricks.
  - But we cannot analyze every single plan nor can we catch everything, so we rely on the community conscience.
  - Examples…

Methods: Project Planning Team

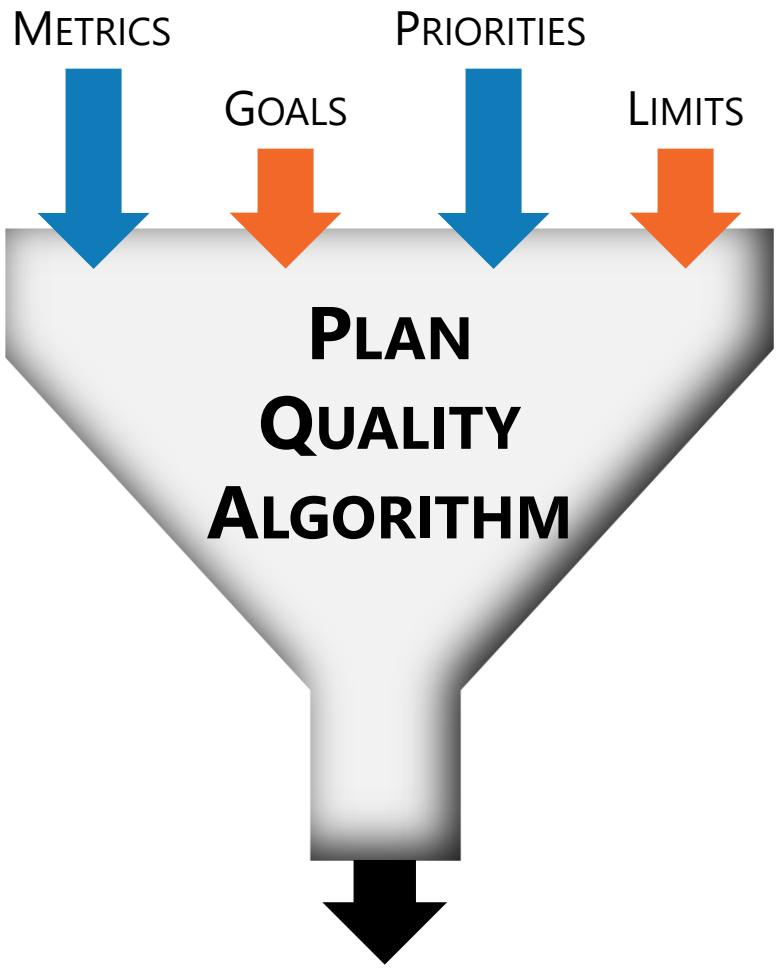
TEAM MEMBER	AFFILIATION
Michael Zelefsky, M.D.	Memorial Sloan-Kettering CC
Robert Meier, M.D.	Swedish Medical Center
Mary Ellen Masterson-McGary, M.A., M.S.	CyberKnife Center, Tampa Bay
Jun Yang, Ph.D. and Jing Feng, M.S.	Philadelphia CyberKnife
Brian Wang, Ph.D.	University of Louisville
Nalani Brown	The Radiosurgery Society
Ben Nelms, Ph.D.	Canis Lupus LLC & ProKnow

METHODS: THE DATASET



Methods: Plan Scoring

- **Identify critical metrics.** Dose, DVH, or formulaic metrics selected from a vast library of options.
- **Define each metric's parameters.** Select applicable structure, dose- or volume- levels, or other input parameters to derive the metric result.
- **Define each metric's scoring.** For each metric, capture what defines success, i.e. specify priority along with: 1) minimally required result, 2) ideal result, and 3) variable scoring in between.



Using **PlanIQ** Scoring Methodology

METHODS: THE PLAN OBJECTIVES

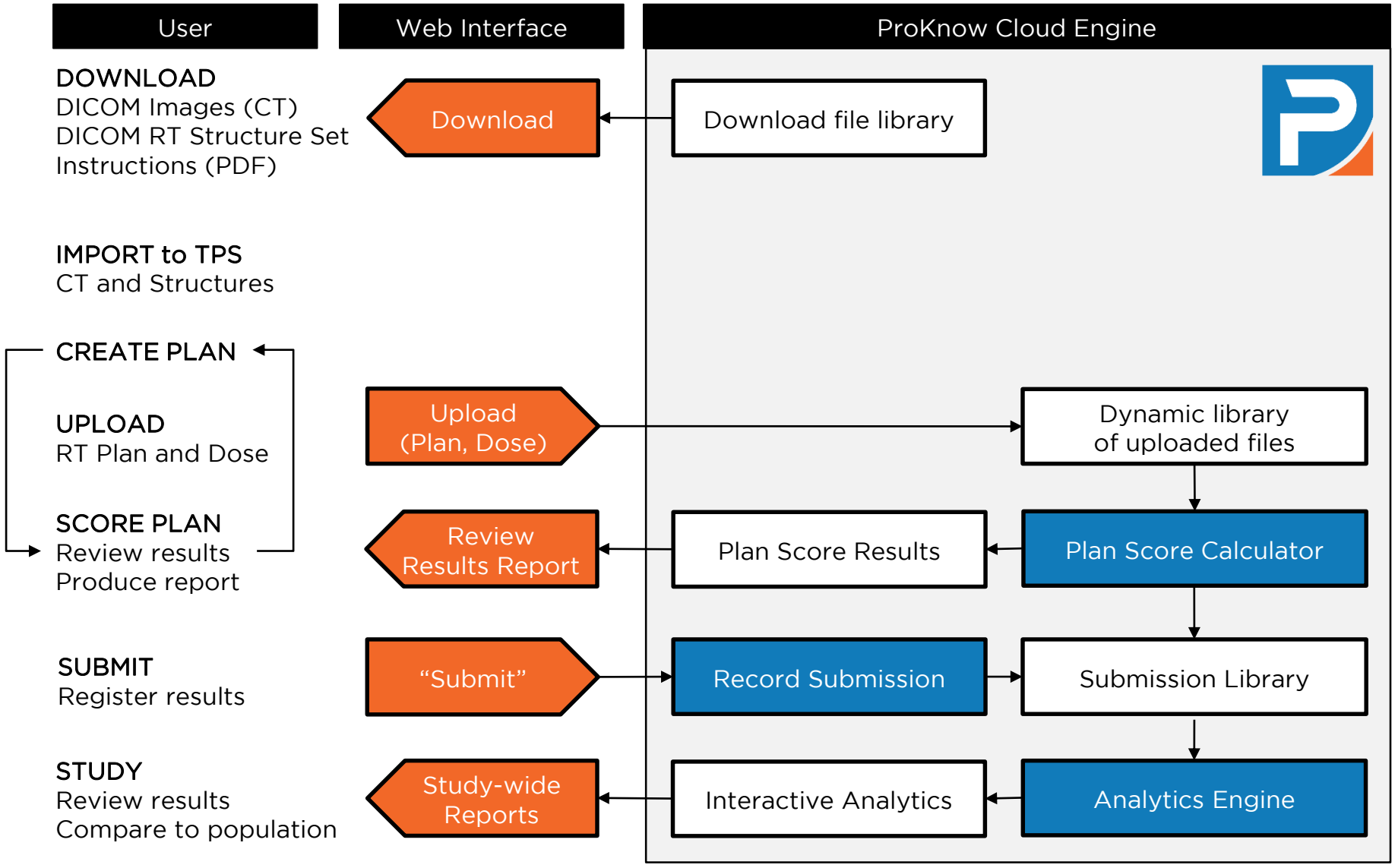
15 Key Metrics Total Points **150**

#	METRIC ID	GOAL (MIN REQ)	GOAL (IDEAL)	WEIGHT (150 Total)
[01]	Volume (%) of the PTV covered by 36.25 (Gy)	90	95	35 points
[02]	Volume (%) of the PROSTATE covered by 40 (Gy)	90	100	20 points
[03]	Dose (Gy) covering whole PTV minus 0.03 (cc)	29	36.25	10 points
[04]	Conformation Number [36.25 (Gy), PTV]	0.6	1	10 points
[05]	Volume (cc) of the RECTUM covered by 36 (Gy)	2	0	15 points
[06]	Volume (cc) of the BLADDER covered by 37 (Gy)	5	0	15 points
[07]	Dose (Gy) covering 40 (%) of the RECTUM	20	10	12 points
[08]	Dose (Gy) covering 20 (%) of the URETHRA	44	40	10 points
[09]	Dose (Gy) covering 1 (cc) of the BOWEL	30	0	5 points
[10]	Dose (Gy) covering 0.1 (cc) of the PENILE BULB	29.5	10	3 points
[11]	Dose (Gy) covering 50 (%) of the NEUROVASCULAR BUNDLES	40	37.5	3 points
[12]	Maximum dose (Gy) inside the RIGHT FEMORAL HEAD	27.5	10	3 points
[13]	Maximum dose (Gy) inside the LEFT FEMORAL HEAD	27.5	10	3 points
[14]	Maximum dose (Gy) inside the SKIN	30	10	3 points
[15]	Maximum dose (Gy) inside the TESTES	2	0	3 points
[16]	Estimated 'beam-on' time, all beams (minutes)	---	---	---

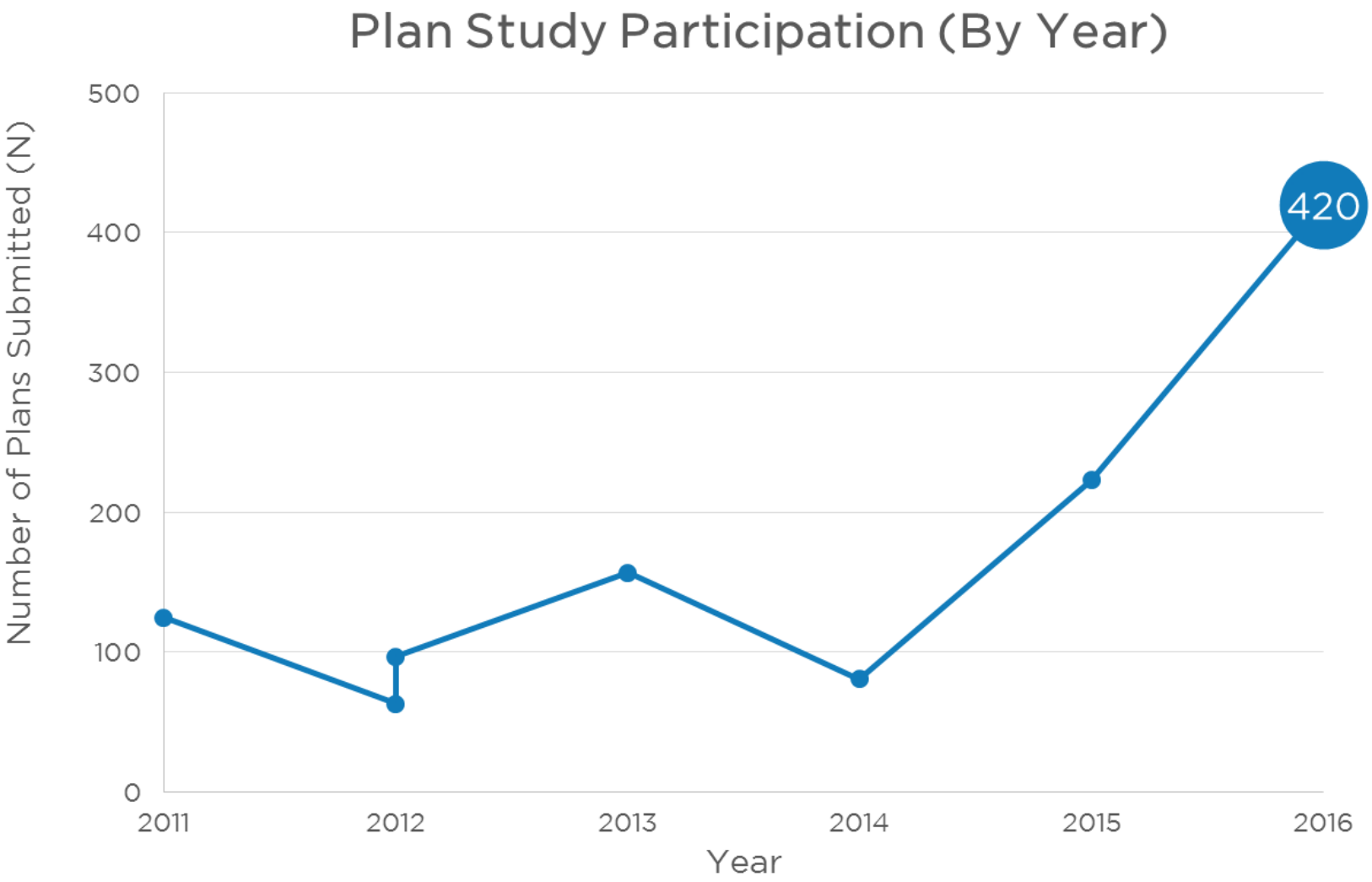
METHODS: EXAMPLE PLAN SCORESHEET

METRIC	RESULT	GOAL (MIN REQ)		GOAL (IDEAL)	POINTS	POINTS (MAX
Volume (%) of the PTV covered by 36.25 (Gy)	98.41	90	*100.0% (*NLS)*	95	35.00	35.00
Volume (%) of the PROSTATE covered by 40 (Gy)	99.72	90	*97.2% (*NLS)*	100	19.89	20.00
Dose (Gy) covering whole PTV minus 0.03 (cc)	31.80	29	*38.6% (*NLS)*	36.25	6.17	10.00
Conformation Number [36.25 (Gy), PTV]	0.85	0.6	*61.7%*	1	6.17	10.00
Volume (cc) of the RECTUM covered by 36 (Gy)	0.00	2	*99.8% (*NLS)*	0	14.99	15.00
Volume (cc) of the BLADDER covered by 37 (Gy)	0.06	5	*98.8% (*NLS)*	0	14.97	15.00
Dose (Gy) covering 40 (%) of the RECTUM	14.01	20	*59.9% (*NLS)*	10	10.40	12.00
Dose (Gy) covering 20 (%) of the URETHRA	41.33	44	*66.9%*	40	6.69	10.00
Dose (Gy) covering 1 (cc) of the BOWEL	1.72	30	*94.3%*	0	4.71	5.00
Dose (Gy) covering 0.1 (cc) of the PENILE BULB	1.94	29.5	*100.0%*	10	3.00	3.00
Dose (Gy) covering 50 (%) of the NEUROVASCULAR BUNDLES	37.30	40	*100.0%*	37.5	3.00	3.00
Maximum dose (Gy) inside the RIGHT FEMORAL HEAD	8.05	27.5	*100.0% (*NLS)*	10	3.00	3.00
Maximum dose (Gy) inside the LEFT FEMORAL HEAD	7.94	27.5	*100.0% (*NLS)*	10	3.00	3.00
Maximum dose (Gy) inside the SKIN	8.66	30	*100.0%*	10	3.00	3.00
Maximum dose (Gy) inside the TESTES	0.31	2	*84.7%*	0	2.54	3.00
Estimated 'beam-on' time, all beams (minutes)	2.26	---	---	---	---	---
TOTALS		15 (of 15)		6 (of 15)	136.53	150.00

METHODS: THE PROKNOW SYSTEM



Results: Participation Level By Year



Results: Participation By Role

Clinical Role	N	%
Dosimetrist	201	47.9
Physicist	172	41.0
Student	22	5.2
Therapist	12	2.9
Other	8	1.9
Physician	5	1.2

Results: Participation By Modality

Modality	N	%
VMAT	335	79.8
IMRT	31	7.4
Robotic	28	6.7
Helical Tomotherapy	20	4.8
Proton	6	1.4

Results: Participation By TPS

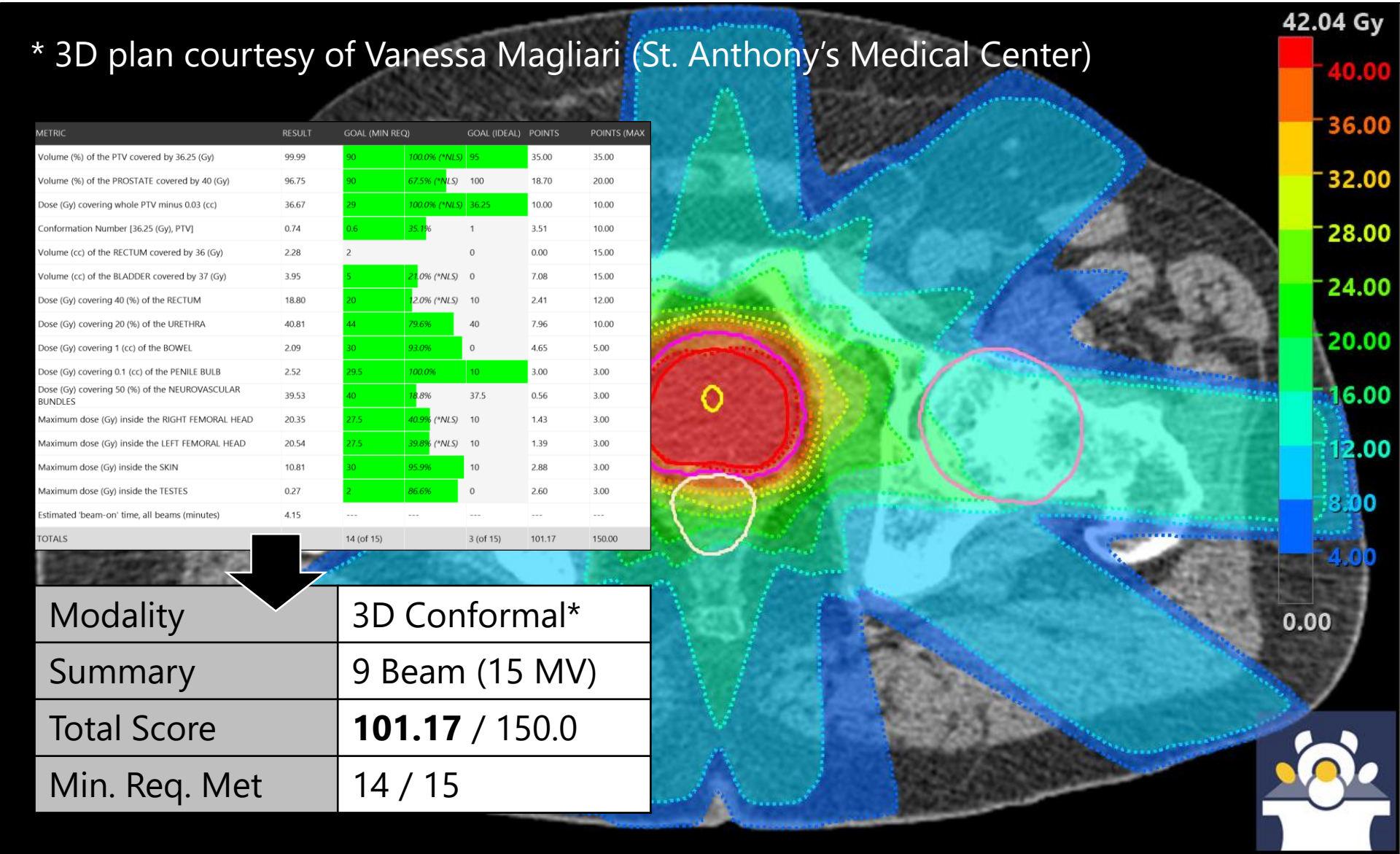
TPS	N	%
Varian Eclipse	199	47.4
Philips Pinnacle	72	17.1
Elekta Monaco	58	13.8
RaySearch RayStation	40	9.5
Accuray CyberKnife (MultiPlan)	28	6.7
Accuray Tomotherapy (Hi Art)	20	4.8
Nucletron Oncentra	2	0.5
BrainLab iPlan	1	0.2

Sanity Check: Simple 3D Conformal

* 3D plan courtesy of Vanessa Magliari (St. Anthony's Medical Center)

METRIC	RESULT	GOAL (MIN REQ)		GOAL (IDEAL)	POINTS	POINTS (MAX
Volume (%) of the PTV covered by 36.25 (Gy)	99.99	90	*100.0% (*NLS)*	95	35.00	35.00
Volume (%) of the PROSTATE covered by 40 (Gy)	96.75	90	*67.5% (*NLS)*	100	18.70	20.00
Dose (Gy) covering whole PTV minus 0.03 (cc)	36.67	29	*100.0% (*NLS)*	36.25	10.00	10.00
Conformation Number [36.25 (Gy), PTV]	0.74	0.6	*35.1%*	1	3.51	10.00
Volume (cc) of the RECTUM covered by 36 (Gy)	2.28	2		0	0.00	15.00
Volume (cc) of the BLADDER covered by 37 (Gy)	3.95	5	*21.0% (*NLS)*	0	7.08	15.00
Dose (Gy) covering 40 (%) of the RECTUM	18.80	20	*12.0% (*NLS)*	10	2.41	12.00
Dose (Gy) covering 20 (%) of the URETHRA	40.81	44	*79.6%*	40	7.96	10.00
Dose (Gy) covering 1 (cc) of the BOWEL	2.09	30	*93.0%*	0	4.65	5.00
Dose (Gy) covering 0.1 (cc) of the PENILE BULB	2.52	29.5	*100.0%*	10	3.00	3.00
Dose (Gy) covering 50 (%) of the NEUROVASCULAR BUNDLES	39.53	40	*18.8%*	37.5	0.56	3.00
Maximum dose (Gy) inside the RIGHT FEMORAL HEAD	20.35	27.5	*40.9% (*NLS)*	10	1.43	3.00
Maximum dose (Gy) inside the LEFT FEMORAL HEAD	20.54	27.5	*39.8% (*NLS)*	10	1.39	3.00
Maximum dose (Gy) inside the SKIN	10.81	30	*95.9%*	10	2.88	3.00
Maximum dose (Gy) inside the TESTES	0.27	2	*86.6%*	0	2.60	3.00
Estimated 'beam-on' time, all beams (minutes)	4.15	---	---	---	---	---
TOTALS		14 (of 15)		3 (of 15)	101.17	150.00

Modality	3D Conformal*
Summary	9 Beam (15 MV)
Total Score	**101.17** / 150.0
Min. Req. Met	14 / 15

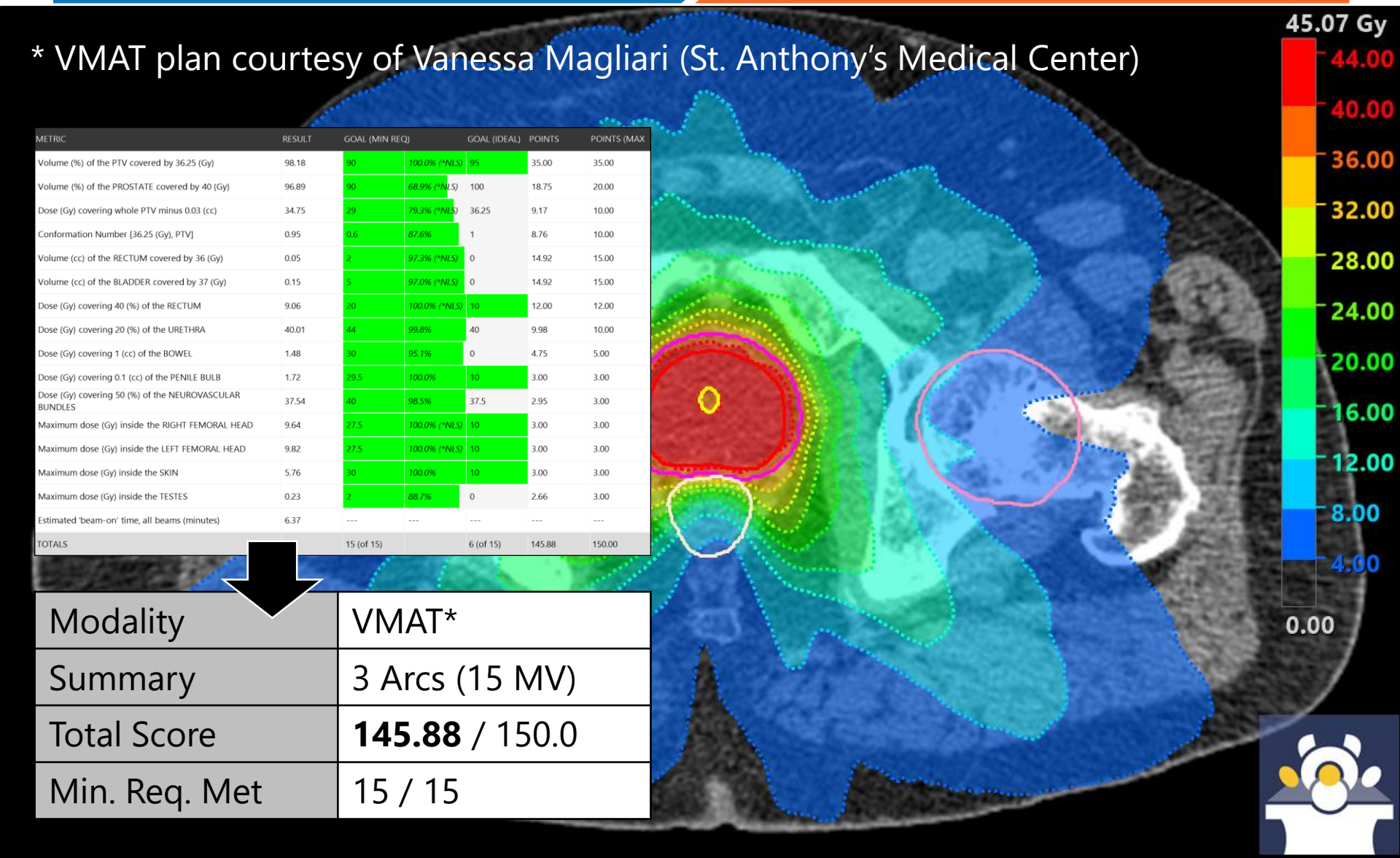


Sanity Check: High Quality VMAT

* VMAT plan courtesy of Vanessa Magliari (St. Anthony's Medical Center)

METRIC	RESULT	GOAL (MIN REQ)		GOAL (IDEAL)	POINTS	POINTS (MAX
Volume (%) of the PTV covered by 36.25 (Gy)	98.18	90	*100.0% (*NLS)*	95	35.00	35.00
Volume (%) of the PROSTATE covered by 40 (Gy)	96.89	90	*68.9% (*NLS)*	100	18.75	20.00
Dose (Gy) covering whole PTV minus 0.03 (cc)	34.75	29	*79.3% (*NLS)*	36.25	9.17	10.00
Conformation Number [36.25 (Gy), PTV]	0.95	0.6	*87.6%*	1	8.76	10.00
Volume (cc) of the RECTUM covered by 36 (Gy)	0.05	2	*97.3% (*NLS)*	0	14.92	15.00
Volume (cc) of the BLADDER covered by 37 (Gy)	0.15	5	*97.0% (*NLS)*	0	14.92	15.00
Dose (Gy) covering 40 (%) of the RECTUM	9.06	20	*100.0% (*NLS)*	10	12.00	12.00
Dose (Gy) covering 20 (%) of the URETHRA	40.01	44	*99.8%*	40	9.98	10.00
Dose (Gy) covering 1 (cc) of the BOWEL	1.48	30	*95.1%*	0	4.75	5.00
Dose (Gy) covering 0.1 (cc) of the PENILE BULB	1.72	29.5	*100.0%*	10	3.00	3.00
Dose (Gy) covering 50 (%) of the NEUROVASCULAR BUNDLES	37.54	40	*98.5%*	37.5	2.95	3.00
Maximum dose (Gy) inside the RIGHT FEMORAL HEAD	9.64	27.5	*100.0% (*NLS)*	10	3.00	3.00
Maximum dose (Gy) inside the LEFT FEMORAL HEAD	9.82	27.5	*100.0% (*NLS)*	10	3.00	3.00
Maximum dose (Gy) inside the SKIN	5.76	30	*100.0%*	10	3.00	3.00
Maximum dose (Gy) inside the TESTES	0.23	2	*88.7%*	0	2.66	3.00
Estimated 'beam-on' time, all beams (minutes)	6.37	---	---	---	---	---
TOTALS		15 (of 15)		6 (of 15)	145.88	150.00

Modality	VMAT*
Summary	3 Arcs (15 MV)
Total Score	**145.88** / 150.0
Min. Req. Met	15 / 15



Simple 3DC vs. High Quality VMAT

METRIC	RESULT	GOAL (MIN REQ)		GOAL (IDEAL)	POINTS	POINTS (MAX
Volume (%) of the PTV covered by 36.25 (Gy)	99.99	90	*100.0% (*NLS)*	95	35.00	35.00
Volume (%) of the PROSTATE covered by 40 (Gy)	96.75	90	*67.5% (*NLS)*	100	18.70	20.00
Dose (Gy) covering whole PTV minus 0.03 (cc)	36.67	29	*100.0% (*NLS)*	36.25	10.00	10.00
Conformation Number [36.25 (Gy), PTV]	0.74	0.6	*35.1%*	1	3.51	10.00
Volume (cc) of the RECTUM covered by 36 (Gy)	2.28	2		0	0.00	15.00
Volume (cc) of the BLADDER covered by 37 (Gy)	3.95	5	*21.0% (*NLS)*	0	7.08	15.00
Dose (Gy) covering 40 (%) of the RECTUM	18.80	20	*12.0% (*NLS)*	10	2.41	12.00
Dose (Gy) covering 20 (%) of the URETHRA	40.81	44	*79.6%*	40	7.96	10.00
Dose (Gy) covering 1 (cc) of the BOWEL	2.09	30	*93.0%*	0	4.65	5.00
Dose (Gy) covering 0.1 (cc) of the PENILE BULB	2.52	29.5	*100.0%*	10	3.00	3.00
Dose (Gy) covering 50 (%) of the NEUROVASCULAR BUNDLES	39.53	40	*18.8%*	37.5	0.56	3.00
Maximum dose (Gy) inside the RIGHT FEMORAL HEAD	20.35	27.5	*40.9% (*NLS)*	10	1.43	3.00
Maximum dose (Gy) inside the LEFT FEMORAL HEAD	20.54	27.5	*39.8% (*NLS)*	10	1.39	3.00
Maximum dose (Gy) inside the SKIN	10.81	30	*95.9%*	10	2.88	3.00
Maximum dose (Gy) inside the TESTES	0.27	2	*86.6%*	0	2.60	3.00
Estimated 'beam-on' time, all beams (minutes)	4.15	---	---	---	---	---
TOTALS		14 (of 15)		3 (of 15)	101.17	150.00

Modality	3D Conformal*
Summary	9 Beam (15 MV)
Total Score	**101.17** / 150.0
Min. Req. Met	14 / 15

METRIC	RESULT	GOAL (MIN REQ)		GOAL (IDEAL)	POINTS	POINTS (MAX
Volume (%) of the PTV covered by 36.25 (Gy)	98.18	90	*100.0% (*NLS)*	95	35.00	35.00
Volume (%) of the PROSTATE covered by 40 (Gy)	96.89	90	*68.9% (*NLS)*	100	18.75	20.00
Dose (Gy) covering whole PTV minus 0.03 (cc)	34.75	29	*79.3% (*NLS)*	36.25	9.17	10.00
Conformation Number [36.25 (Gy), PTV]	0.95	0.6	*87.6%*	1	8.76	10.00
Volume (cc) of the RECTUM covered by 36 (Gy)	0.05	2	*97.3% (*NLS)*	0	14.92	15.00
Volume (cc) of the BLADDER covered by 37 (Gy)	0.15	5	*97.0% (*NLS)*	0	14.92	15.00
Dose (Gy) covering 40 (%) of the RECTUM	9.06	20	*100.0% (*NLS)*	10	12.00	12.00
Dose (Gy) covering 20 (%) of the URETHRA	40.01	44	*99.8%*	40	9.98	10.00
Dose (Gy) covering 1 (cc) of the BOWEL	1.48	30	*95.1%*	0	4.75	5.00
Dose (Gy) covering 0.1 (cc) of the PENILE BULB	1.72	29.5	*100.0%*	10	3.00	3.00
Dose (Gy) covering 50 (%) of the NEUROVASCULAR BUNDLES	37.54	40	*98.5%*	37.5	2.95	3.00
Maximum dose (Gy) inside the RIGHT FEMORAL HEAD	9.64	27.5	*100.0% (*NLS)*	10	3.00	3.00
Maximum dose (Gy) inside the LEFT FEMORAL HEAD	9.82	27.5	*100.0% (*NLS)*	10	3.00	3.00
Maximum dose (Gy) inside the SKIN	5.76	30	*100.0%*	10	3.00	3.00
Maximum dose (Gy) inside the TESTES	0.23	2	*88.7%*	0	2.66	3.00
Estimated 'beam-on' time, all beams (minutes)	6.37	---	---	---	---	---
TOTALS		15 (of 15)		6 (of 15)	145.88	150.00

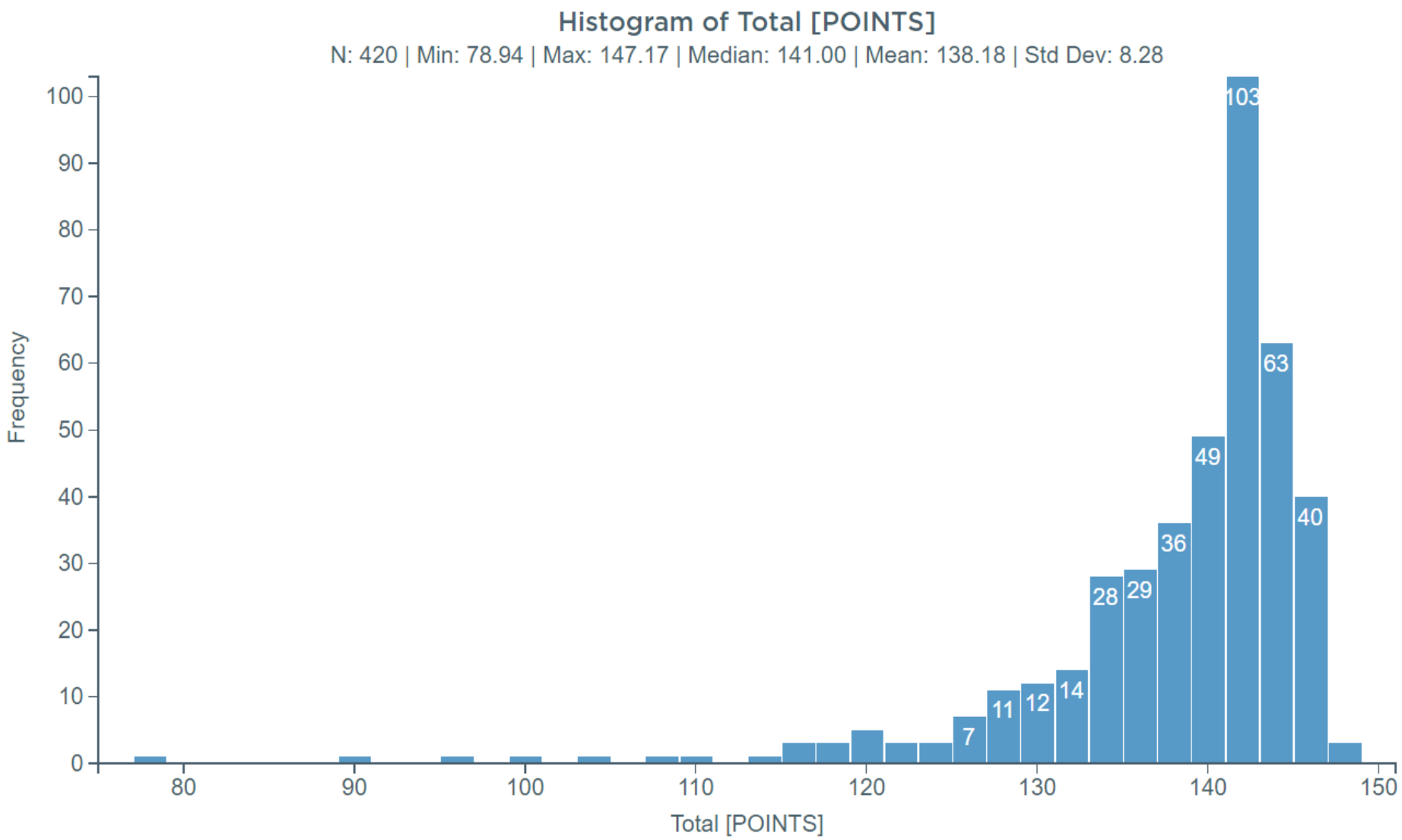
Modality	VMAT*
Summary	3 Arcs (15 MV)
Total Score	**145.88** / 150.0
Min. Req. Met	15 / 15

* Both plans courtesy of Vanessa Magliari (St. Anthony's Medical Center)

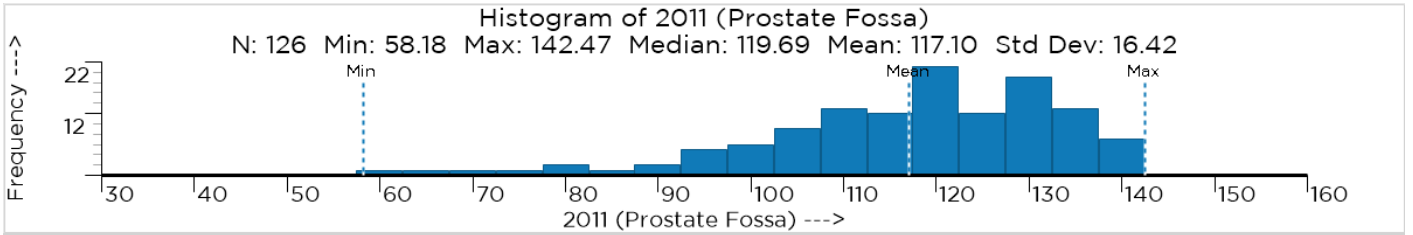
Results: Meeting Min Requirements

# Min Requirements Achieved	N	%
15 (out of 15)	383	91.2
14	30	7.1
13	3	0.7
12	2	0.5
11	1	0.2
10	1	0.2
< 10	0	0.0

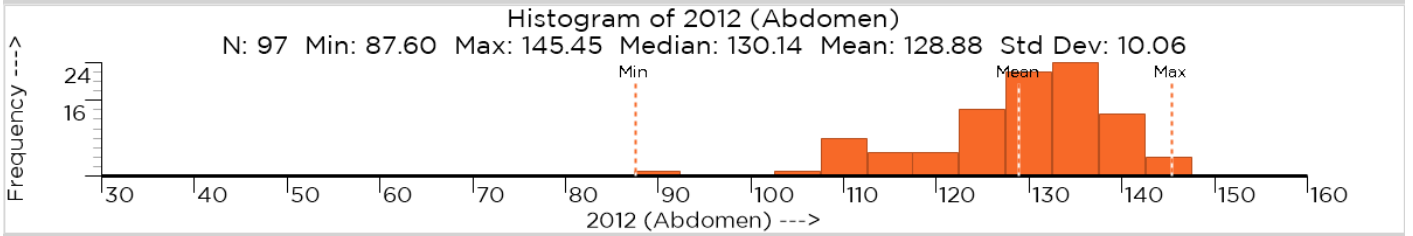
Results: Score Distribution (All)



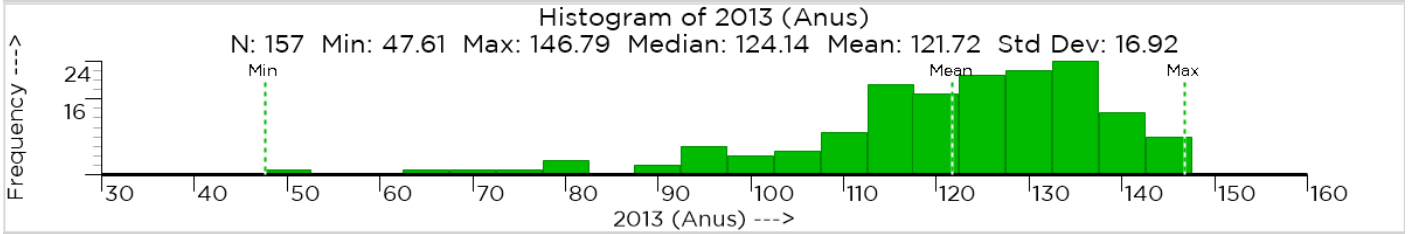
2011



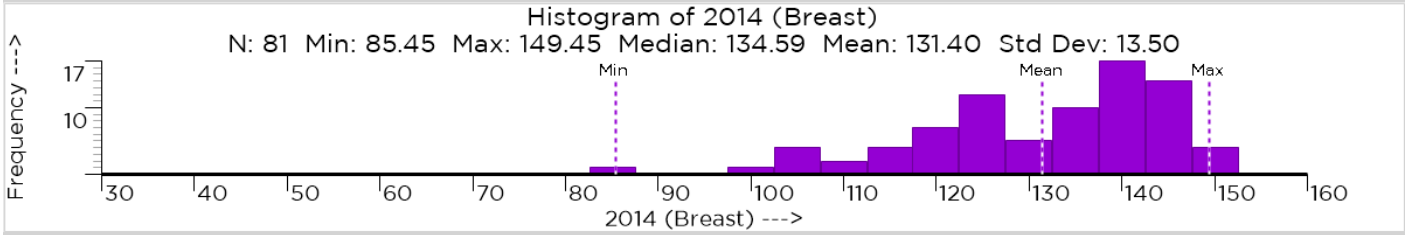
2012



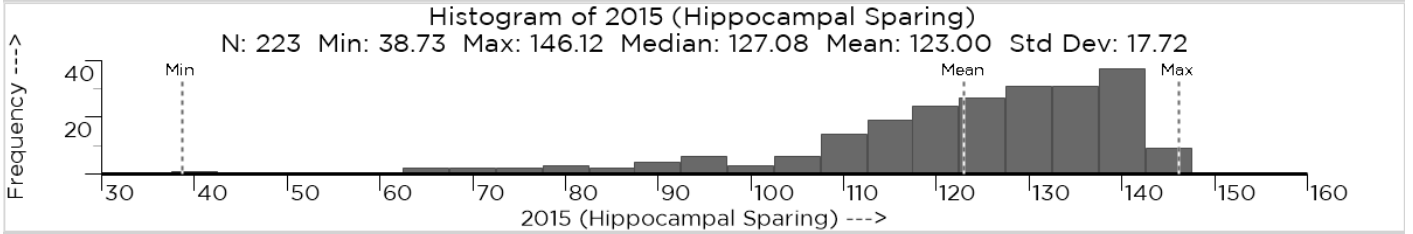
2013



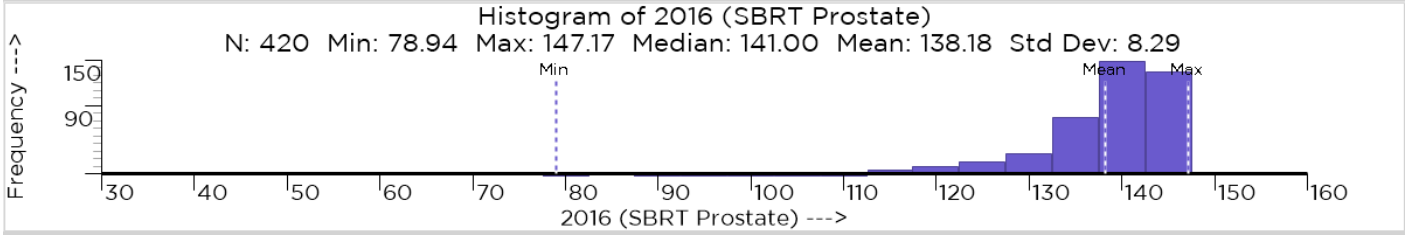
2014



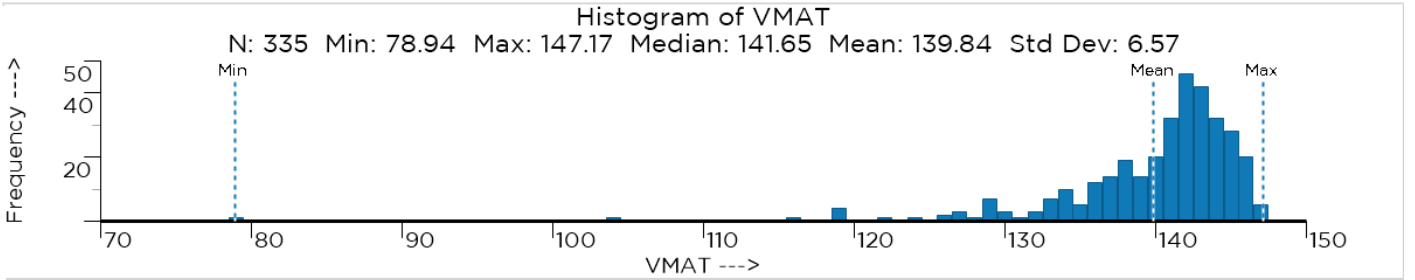
2015



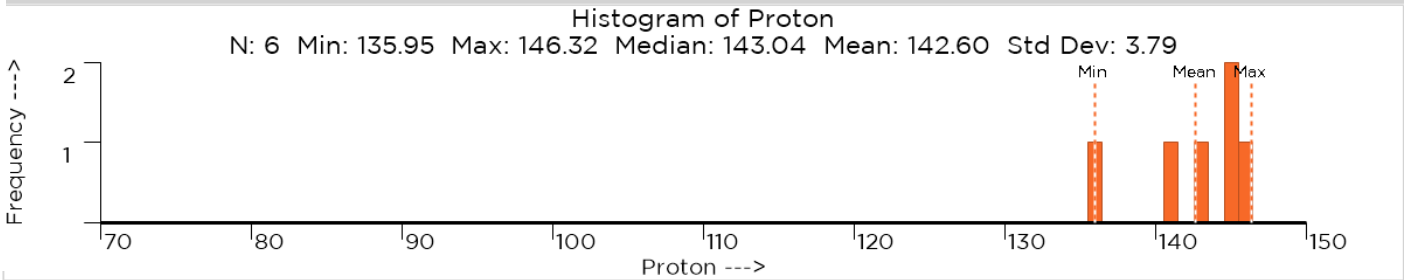
2016



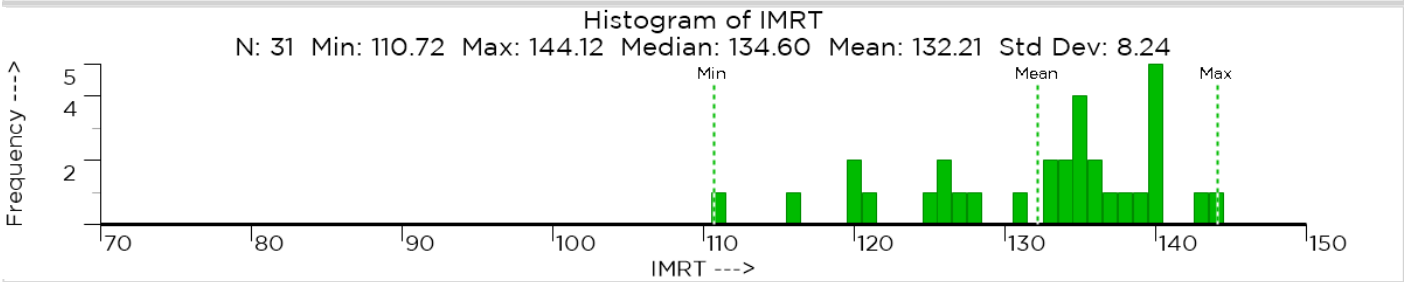
VMAT



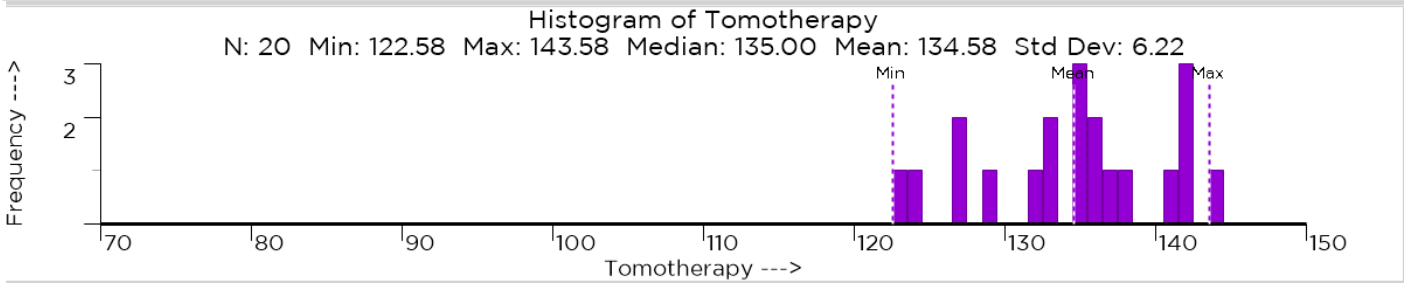
Proton



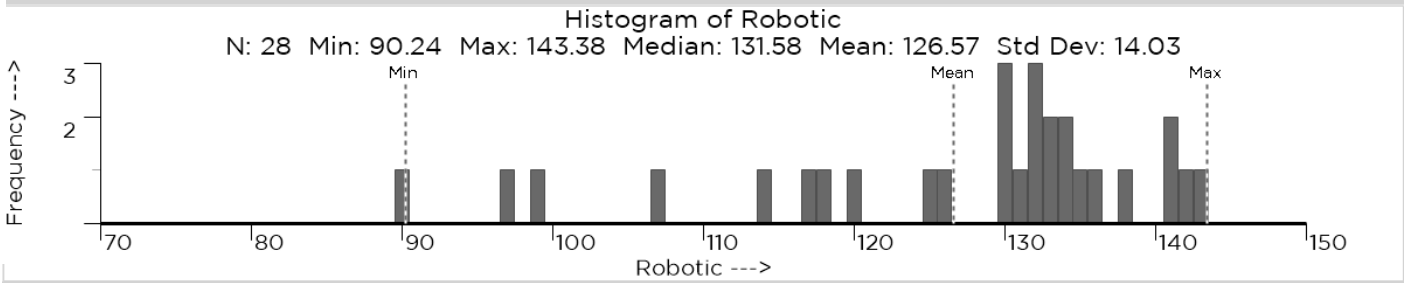
IMRT



Helical Tomotherapy



Robotic



Results: Per Modality

TPS	N	MIN	MEDIAN	MAX	ST DEV
VMAT	335	78.94	141.65	147.17	6.57
Proton	6	135.95	143.04	146.32	3.79
IMRT	31	110.72	134.60	144.12	6.29
Tomotherapy	20	122.58	135.00	143.58	6.22
Robotic	28	90.24	131.58	143.38	14.03

Eclipse

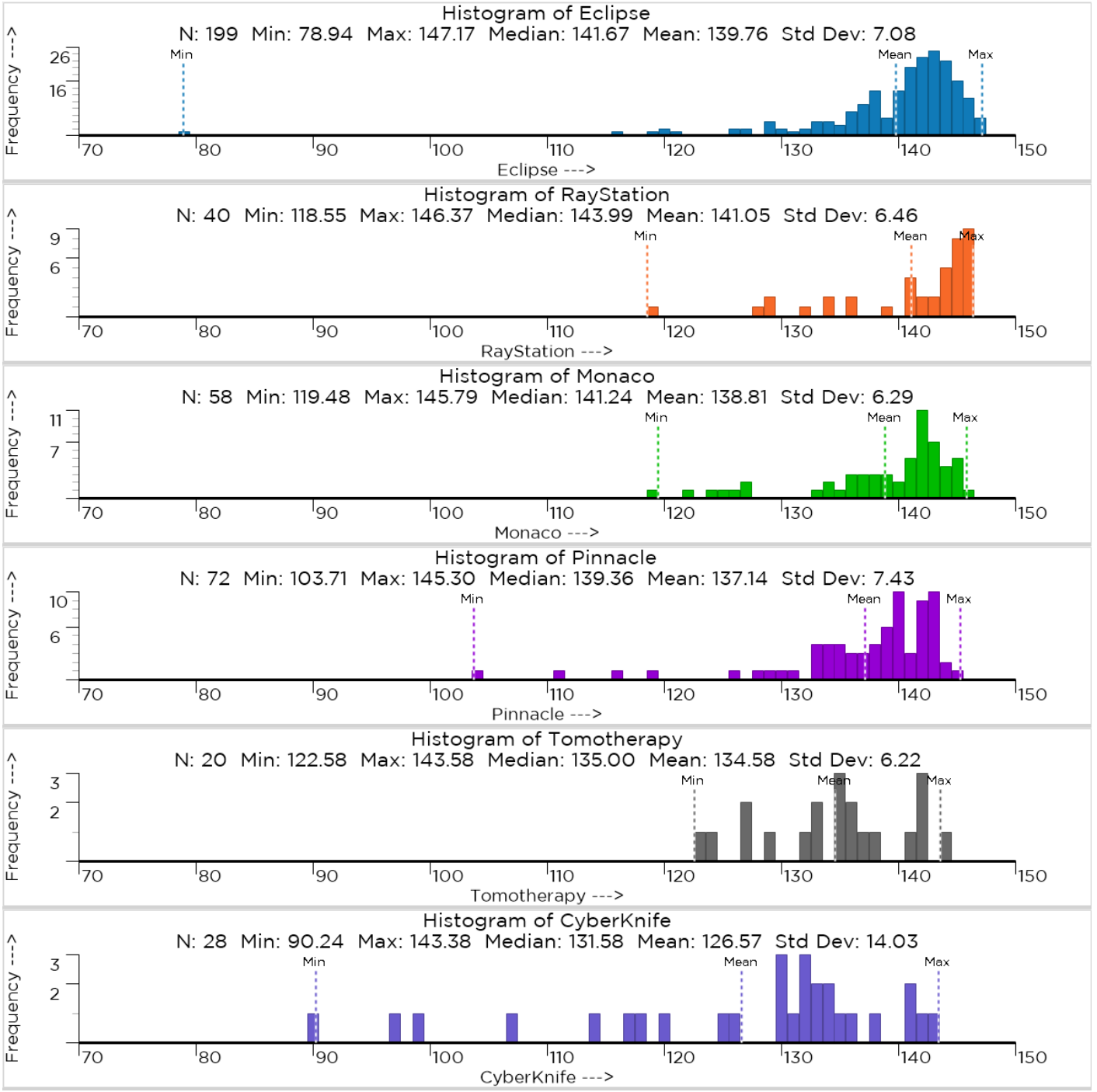
RayStation

Monaco

Pinnacle

Tomotherapy (Hi-Art)

CyberKnife (MultiPlan)

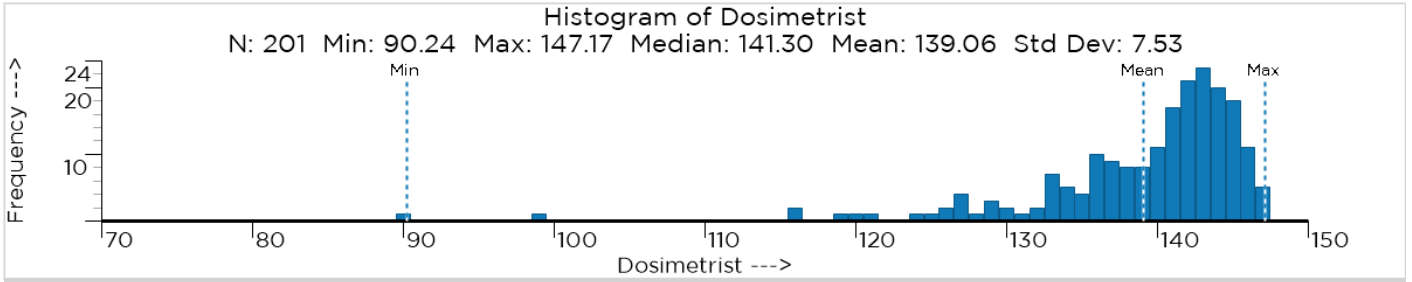


Results: Per TPS

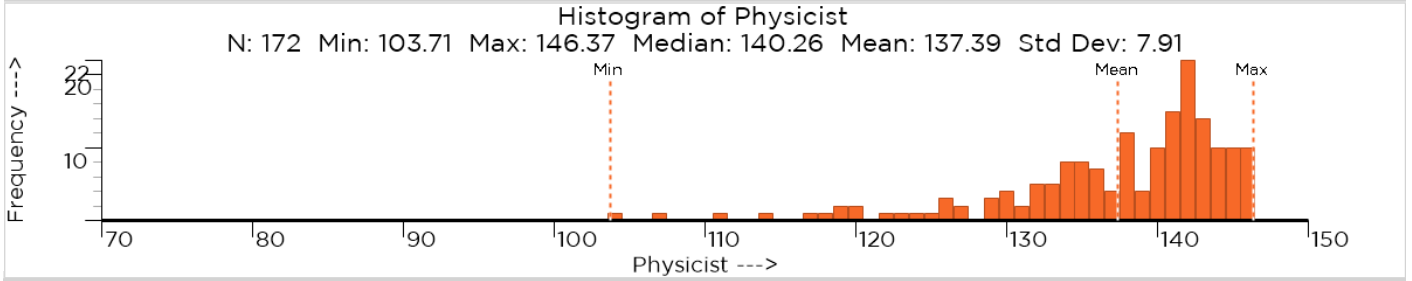
TPS	N (n)	MIN	MEDIAN	MAX	ST DEV
Eclipse	199 (1)	78.94	141.67	147.17	7.08
RayStation	40 (2)	118.55	143.99	146.37	6.46
Monaco	58 (22)	119.48	141.24	145.79	6.29
Pinnacle	72 (3)	103.71	139.36	145.30	7.43
Tomotherapy	20 (3)	122.58	135.00	143.58	6.22
CyberKnife	28 (2)	90.24	131.58	143.38	14.03
Oncentra	2 (0)	141.43	n/a	142.36	n/a
BrainLab	1 (0)	n/a	n/a	135.18	n/a

N = Number of plans per TPS
(n) = Number of plans submitted by the TPS vendor's employees

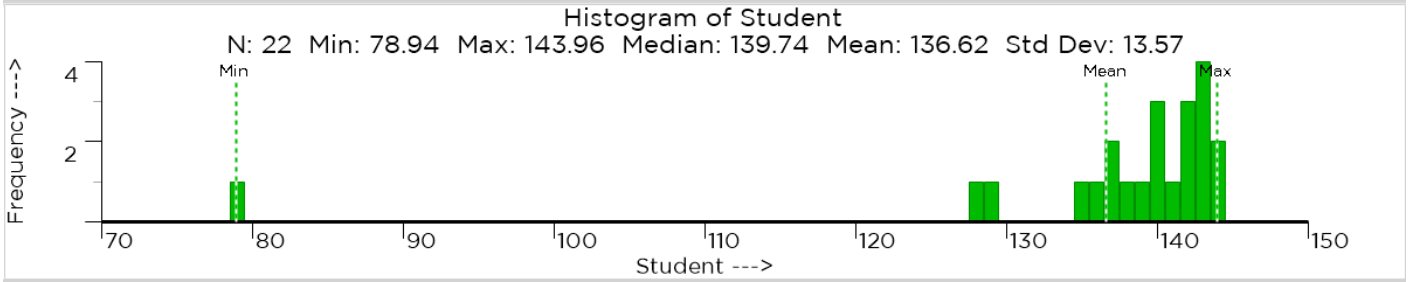
Dosimetrist



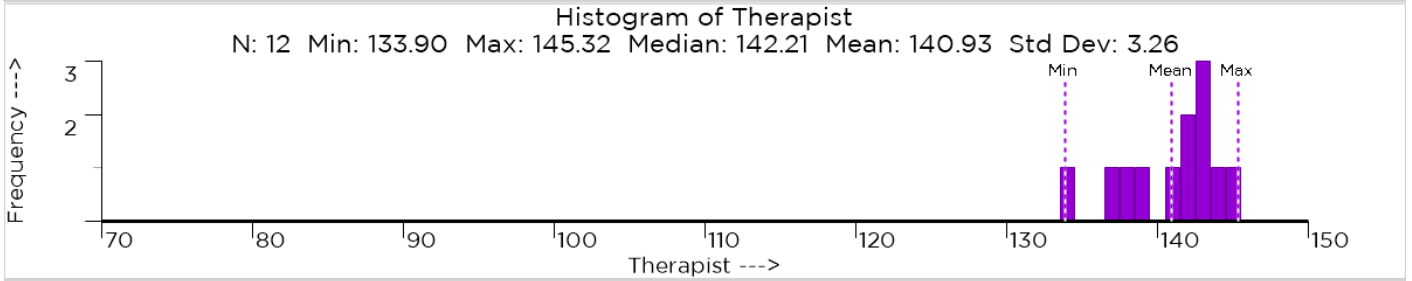
Physicist



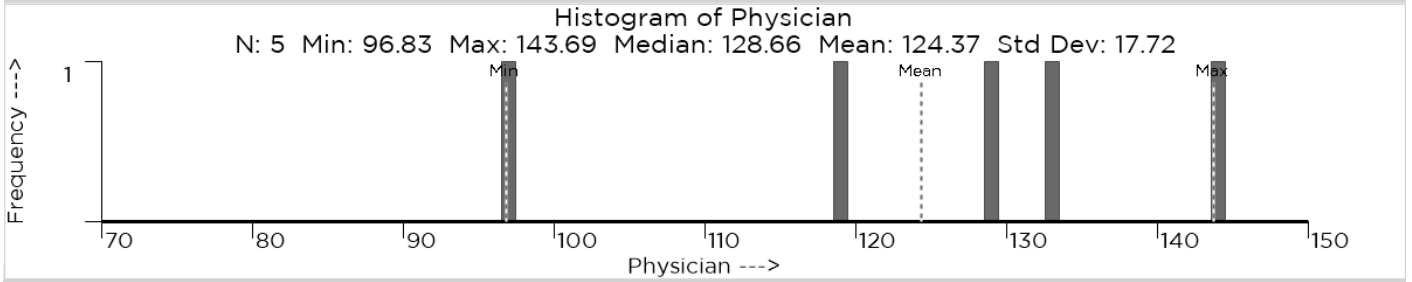
Student

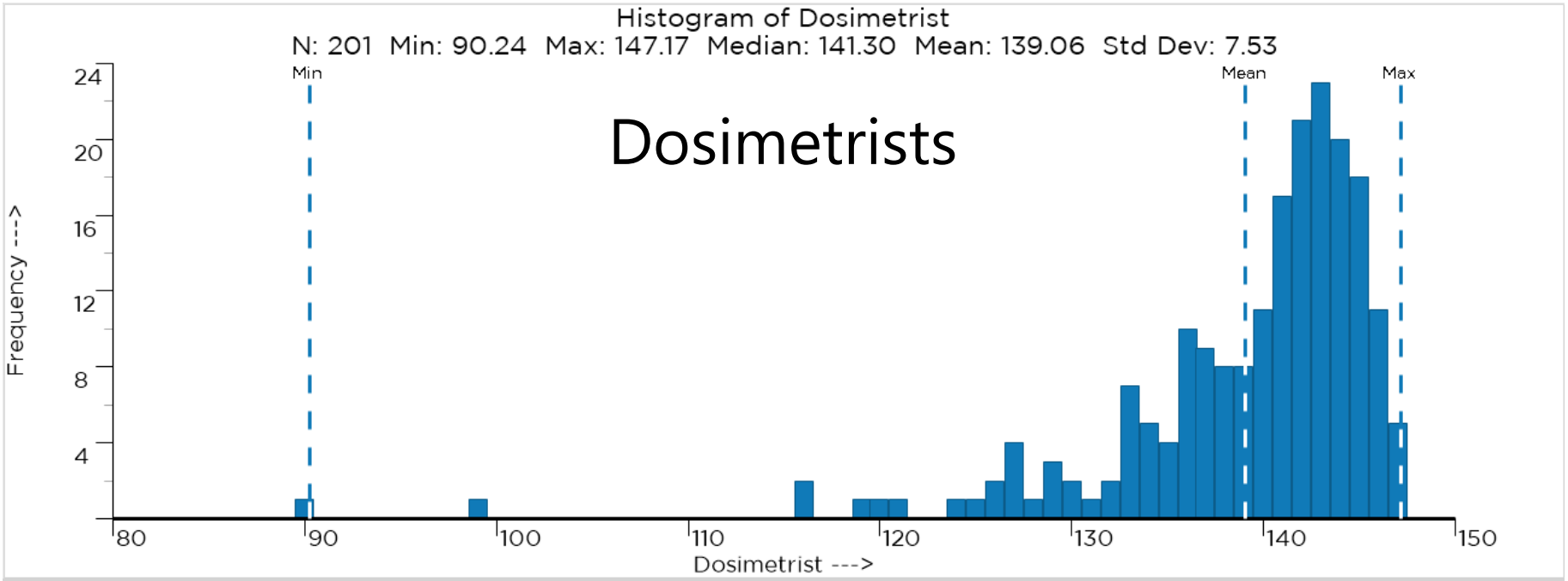


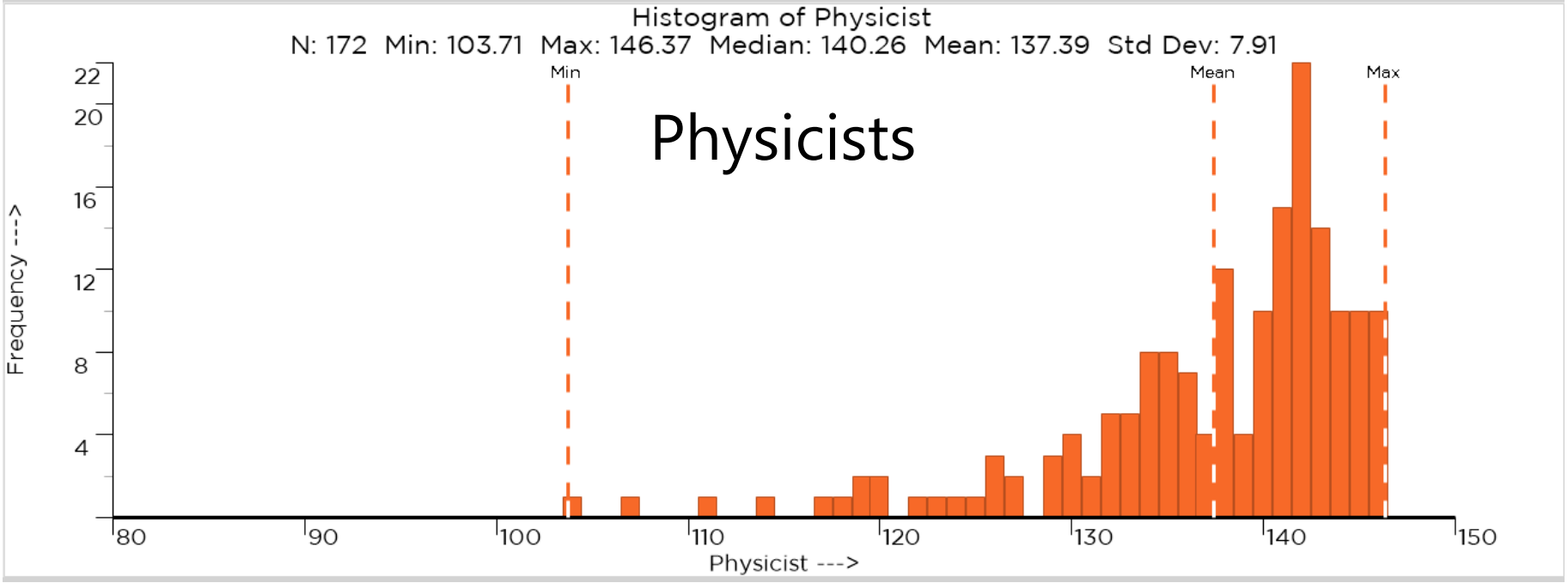
Therapist



Physician

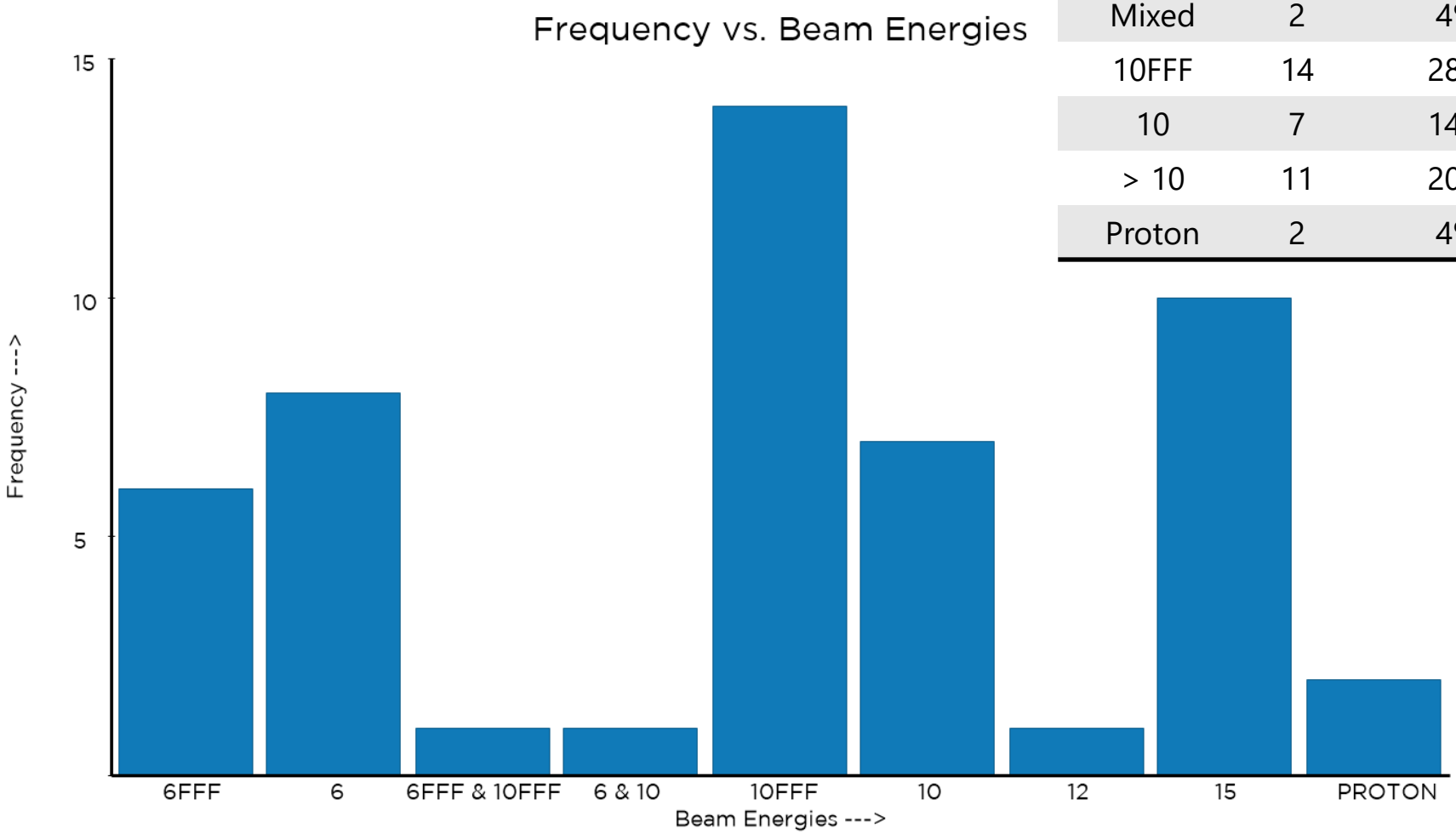



Histogram of Dosimetrist
N: 201 Min: 90.24 Max: 147.17 Median: 141.30 Mean: 139.06 Std Dev: 7.53
Min
Mean
Max
Dosimetrists
Frequency --->
24
20
16
12
8
4
80
90
100
110
120
130
140
150
Dosimetrist --->


Histogram of Physicist
N: 172 Min: 103.71 Max: 146.37 Median: 140.26 Mean: 137.39 Std Dev: 7.91
Min
Mean
Max
Physicists
Frequency --->
22
20
16
12
8
4
80
90
100
110
120
130
140
150
Physicist --->

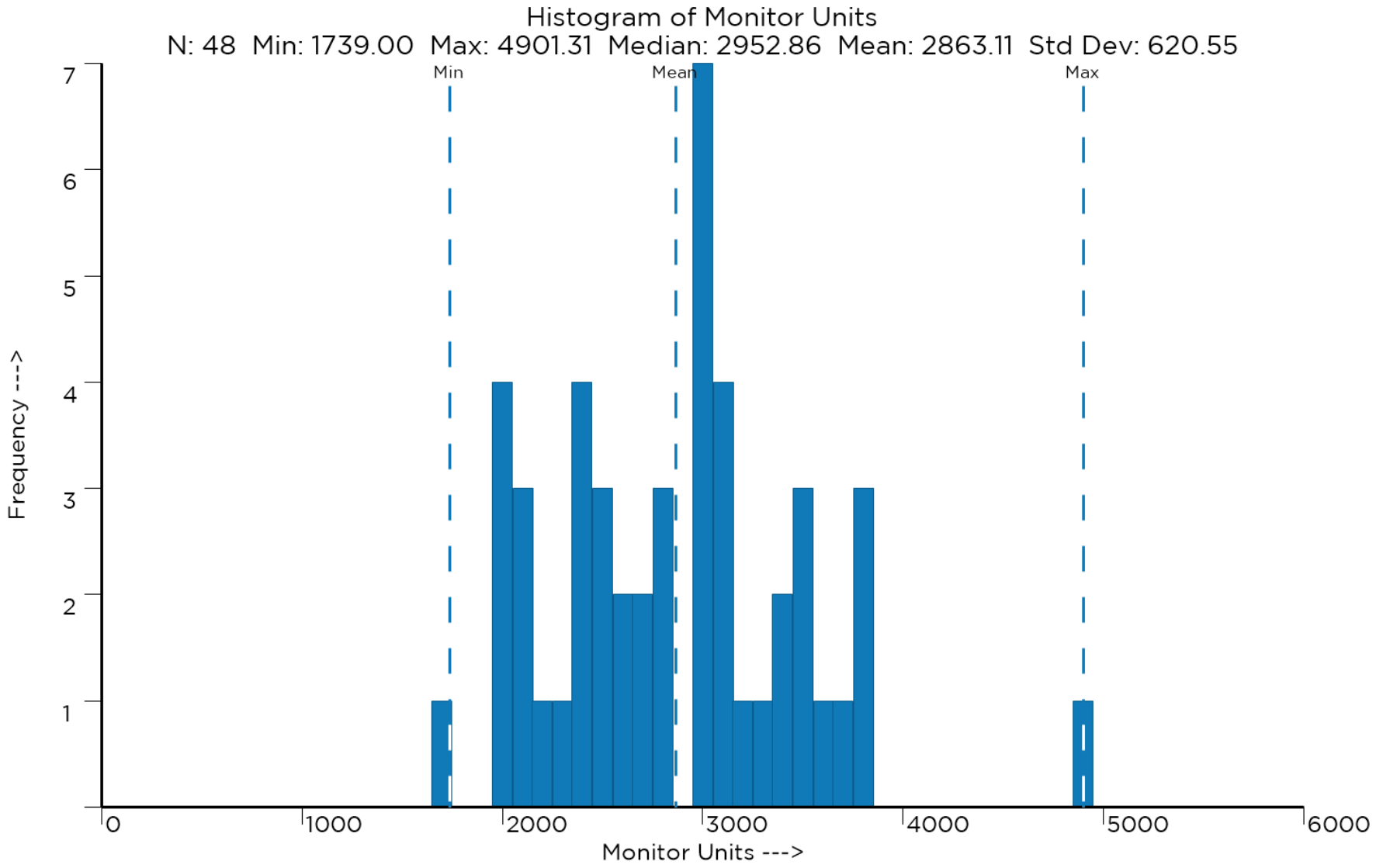
Results: Energies Used in Top 50

Energy	N	% of Top 50
6FFF	6	12%
6	8	16%
Mixed	2	4%
10FFF	14	28%
10	7	14%
> 10	11	20%
Proton	2	4%

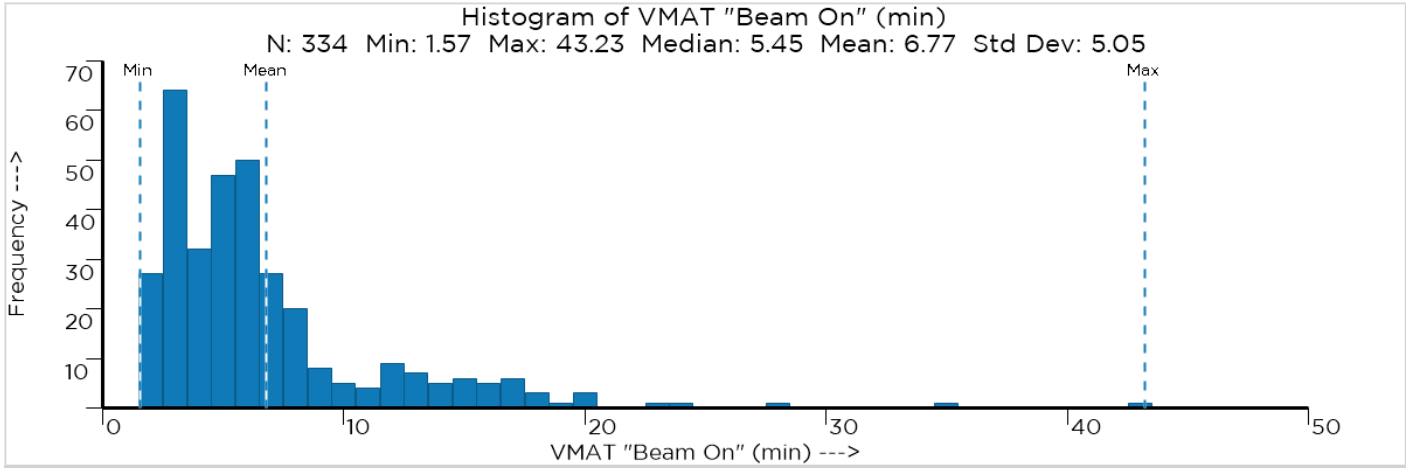


Results: Monitor Units Used, Top 50*

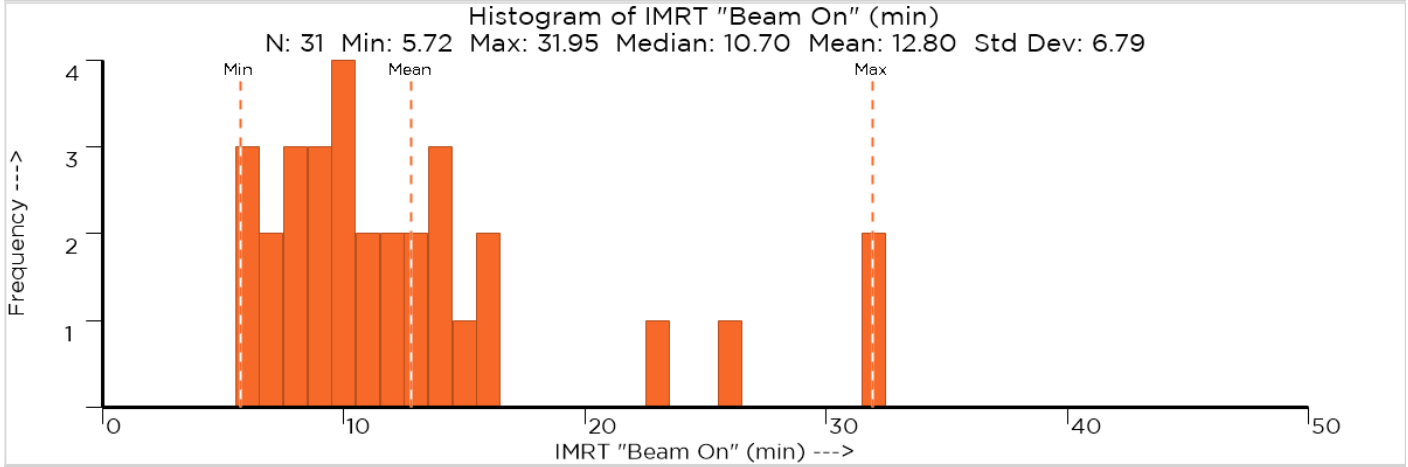
*Omit two proton plans



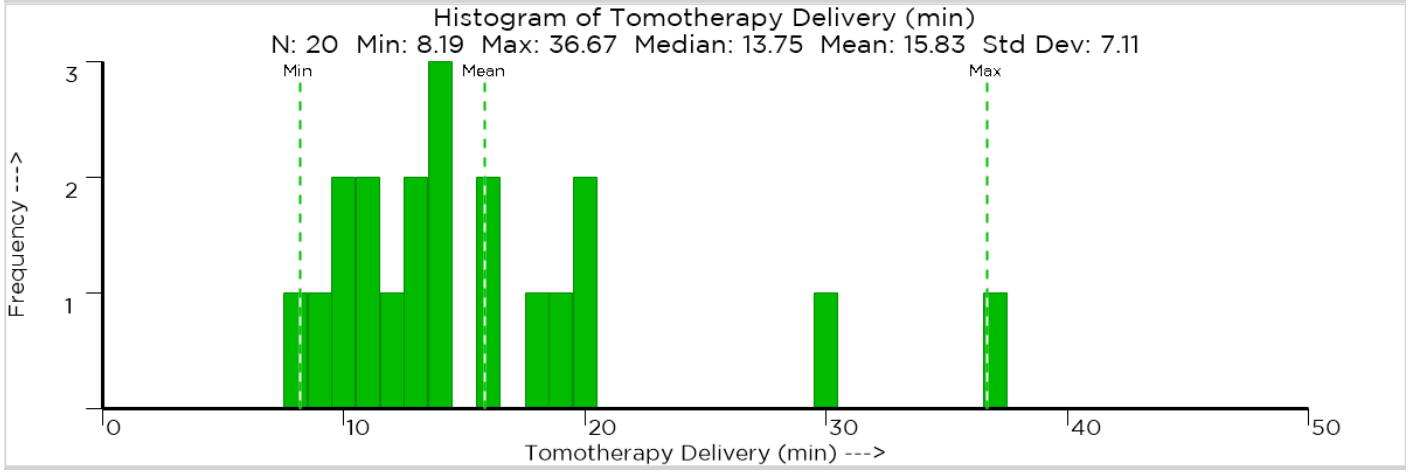
VMAT

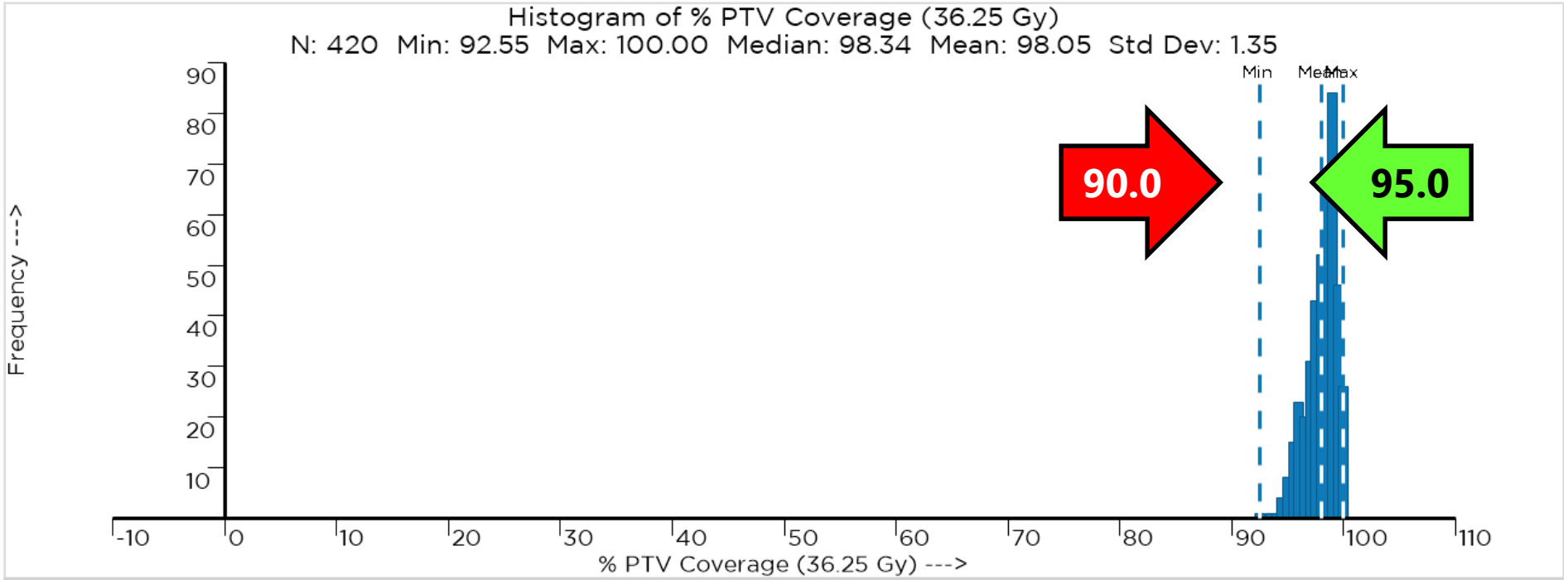


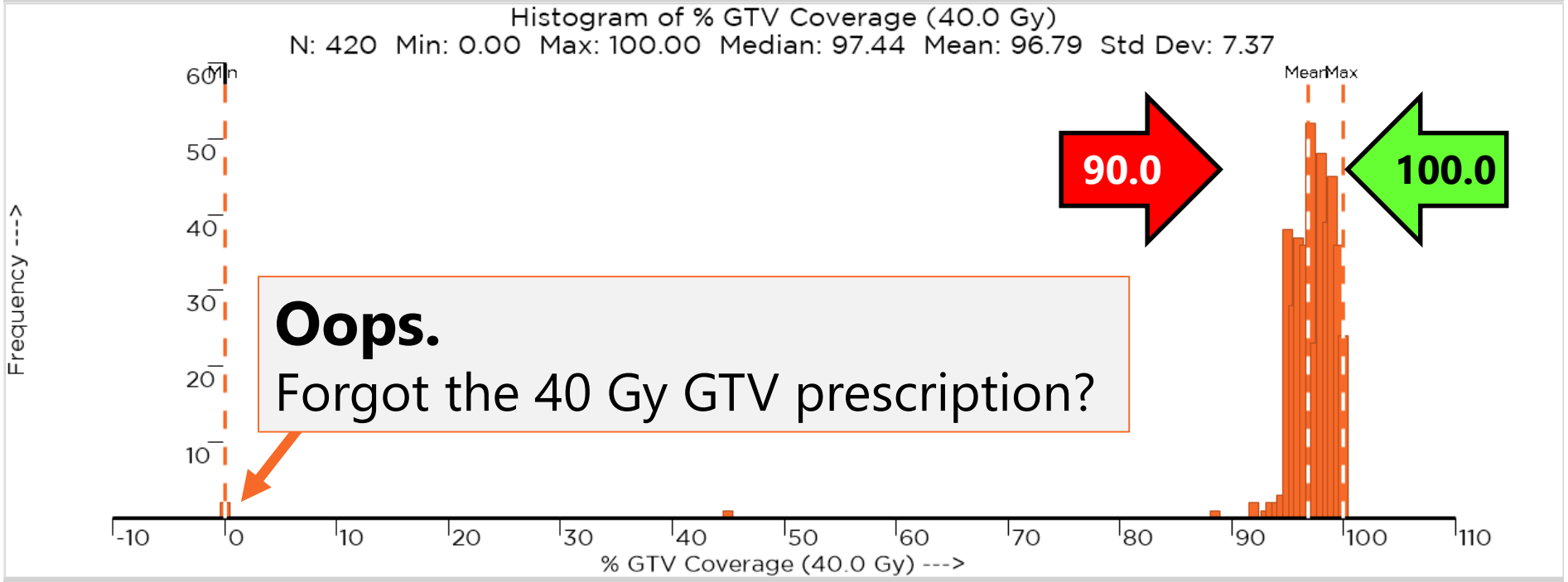
IMRT

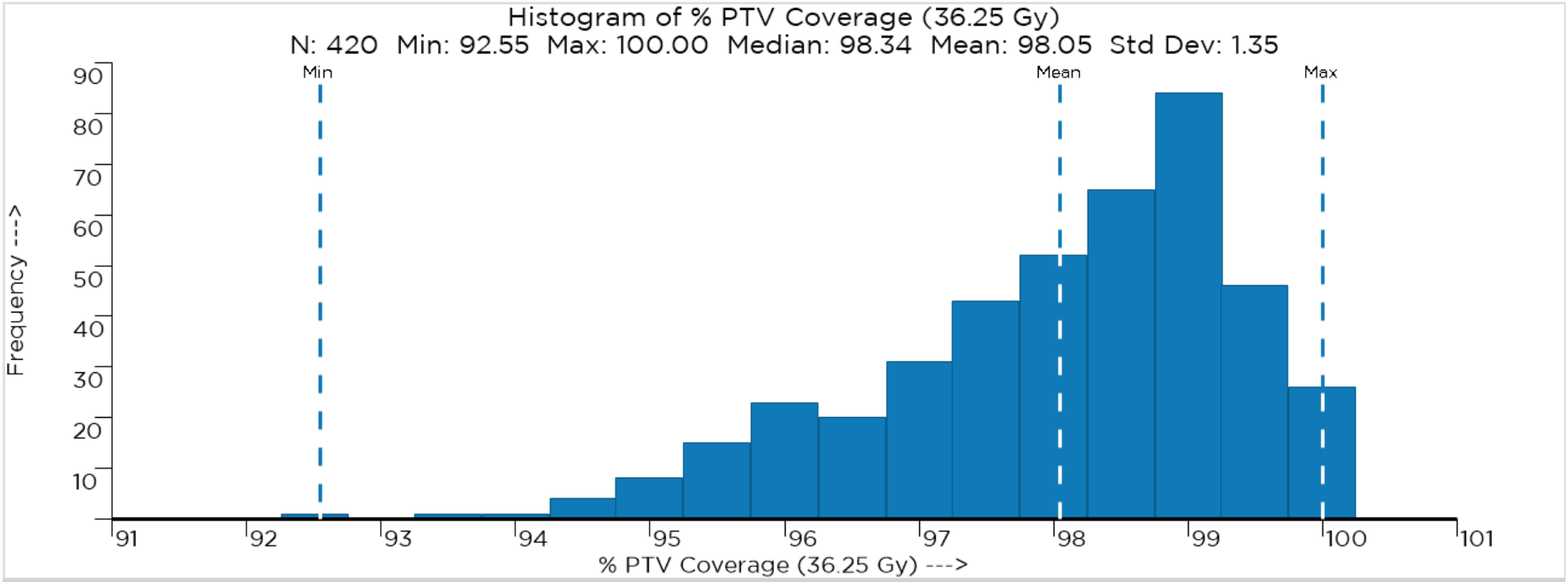


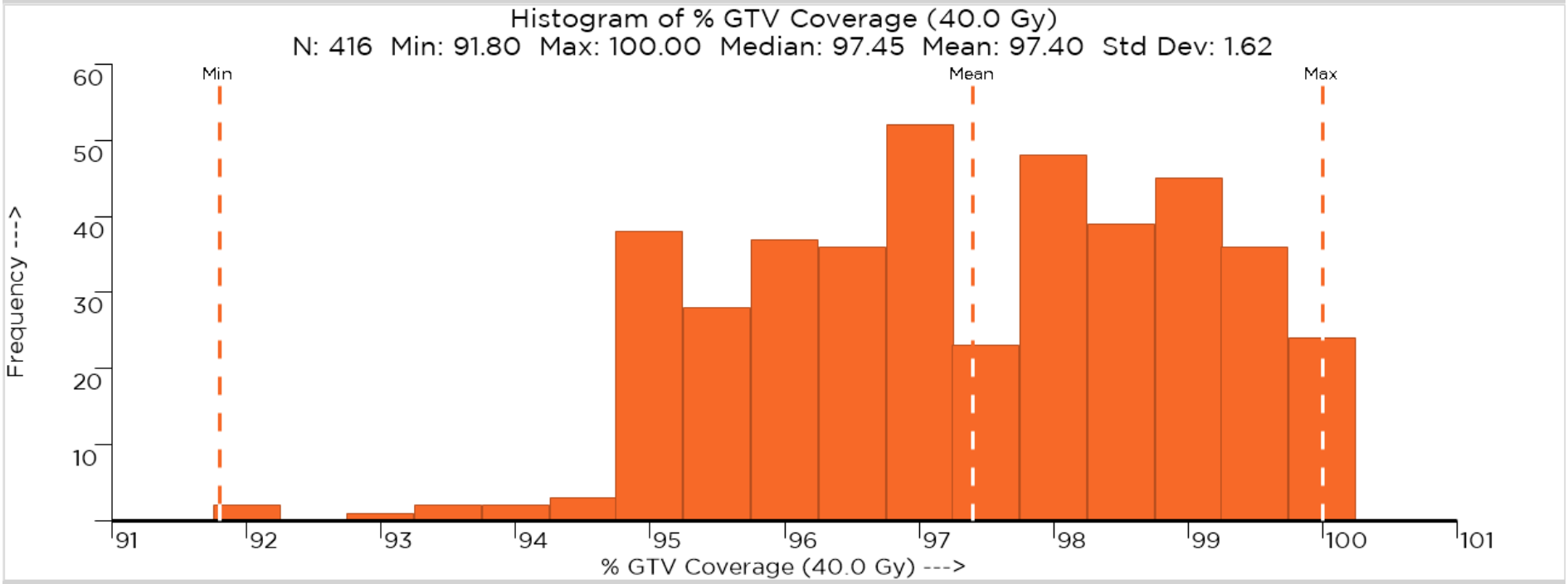
Helical Tomotherapy

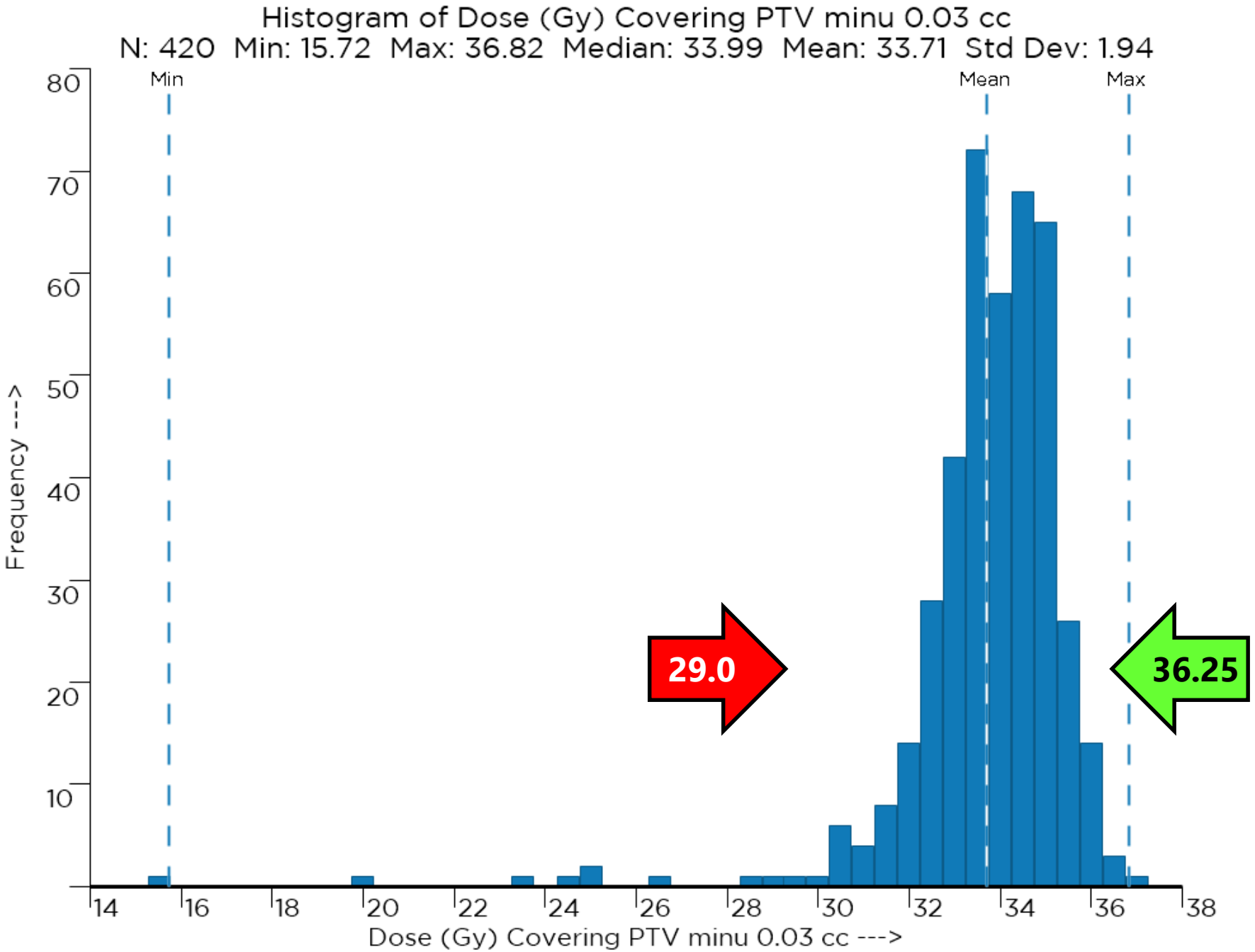


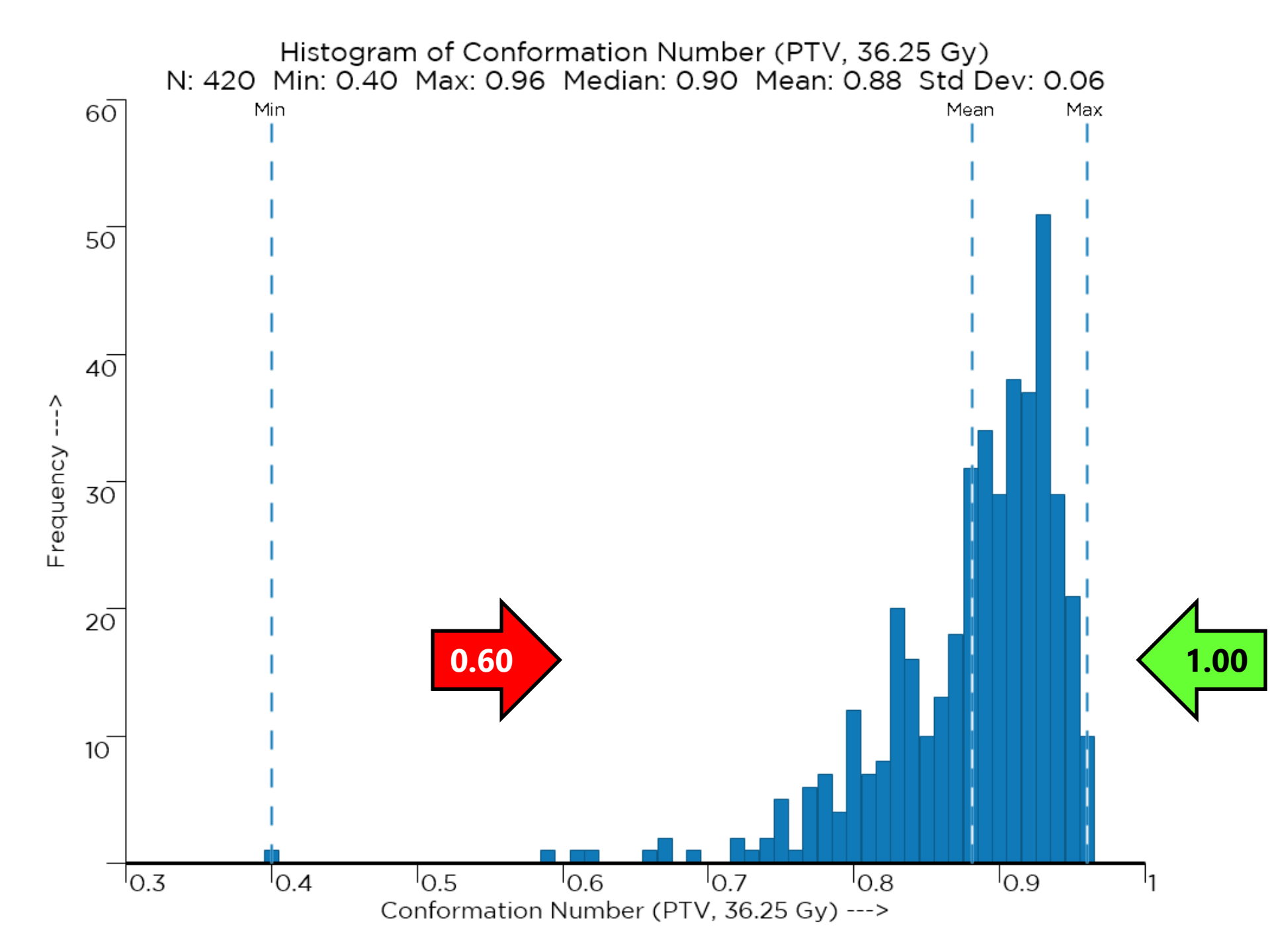

Histogram of % PTV Coverage (36.25 Gy)
N: 420 Min: 92.55 Max: 100.00 Median: 98.34 Mean: 98.05 Std Dev: 1.35
Min
Mean
Max
90.0
95.0
Frequency --->
% PTV Coverage (36.25 Gy) --->

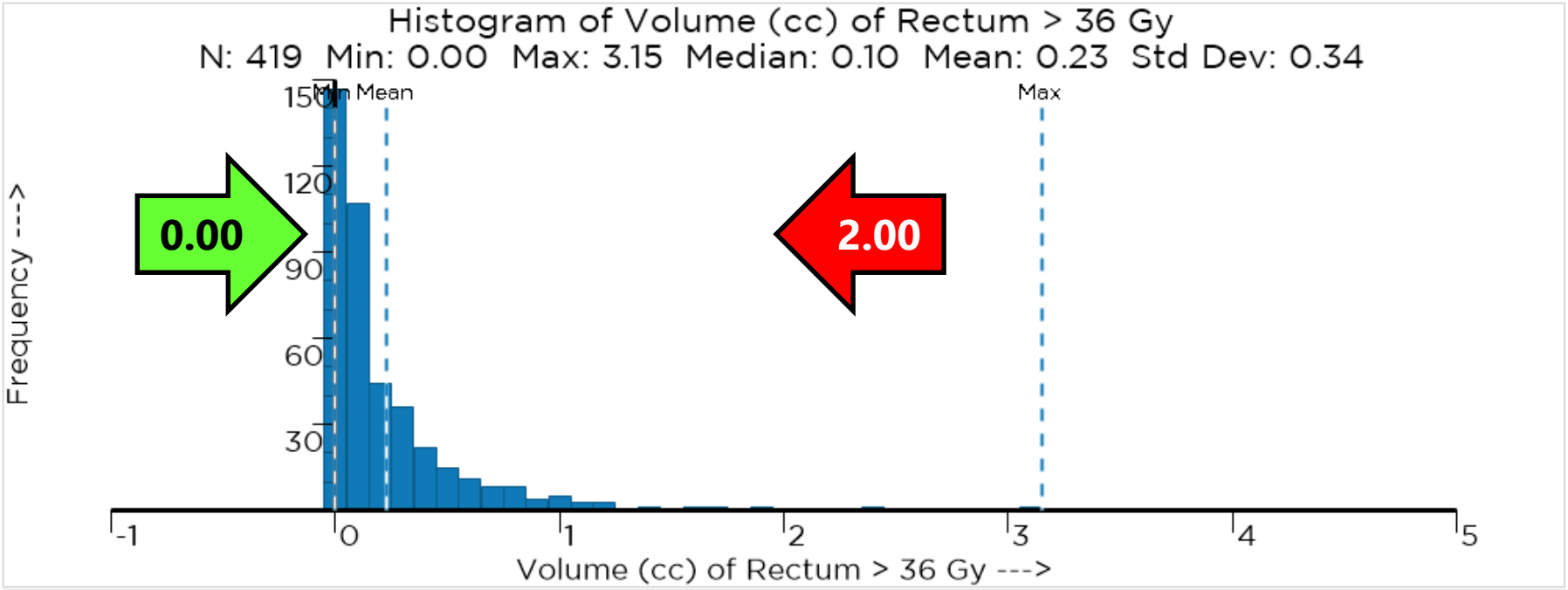

Histogram of % GTV Coverage (40.0 Gy)
N: 420 Min: 0.00 Max: 100.00 Median: 97.44 Mean: 96.79 Std Dev: 7.37
Min
Mean
Max
90.0
100.0
Oops.
Forgot the 40 Gy GTV prescription?
Frequency --->
% GTV Coverage (40.0 Gy) --->

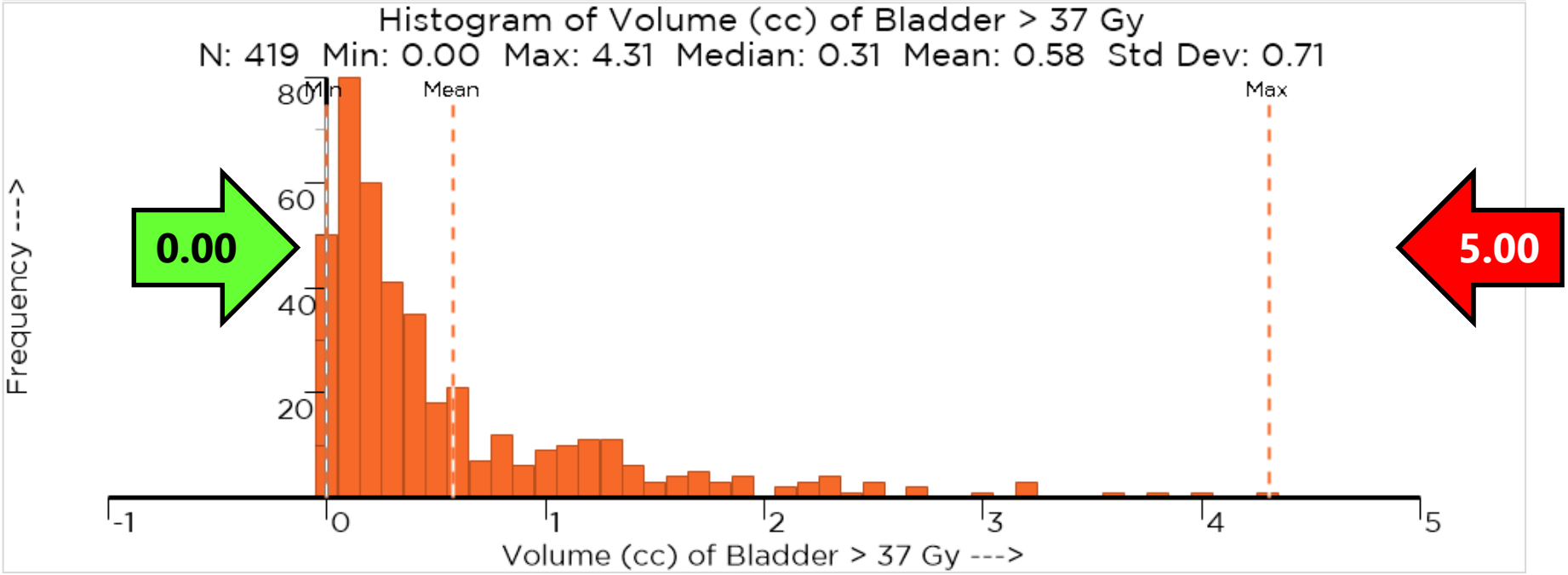

Histogram of % PTV Coverage (36.25 Gy)
N: 420 Min: 92.55 Max: 100.00 Median: 98.34 Mean: 98.05 Std Dev: 1.35
Min
Mean
Max
Frequency --->
% PTV Coverage (36.25 Gy) --->

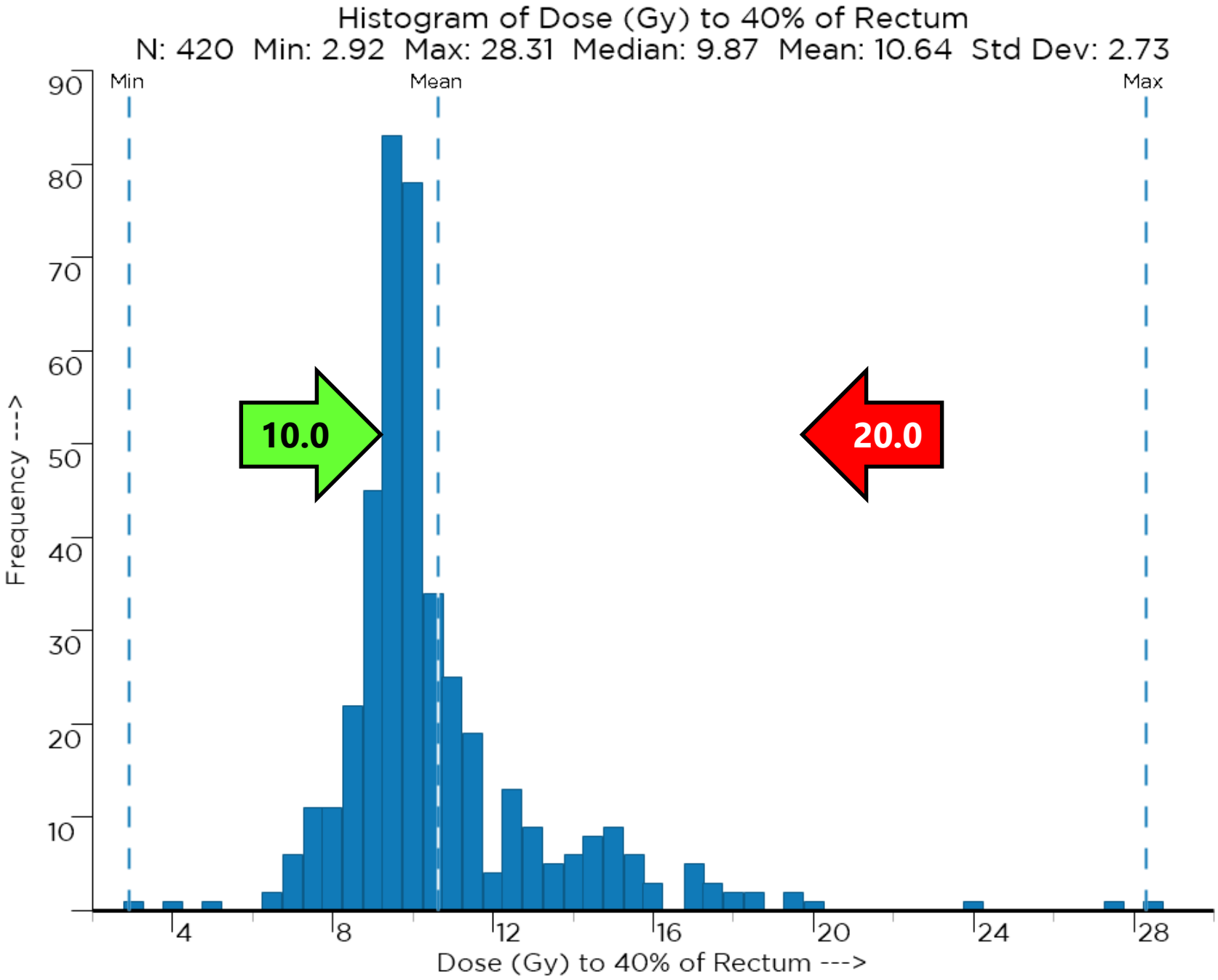

Histogram of % GTV Coverage (40.0 Gy)
N: 416 Min: 91.80 Max: 100.00 Median: 97.45 Mean: 97.40 Std Dev: 1.62
Min
Mean
Max
Frequency --->
% GTV Coverage (40.0 Gy) --->

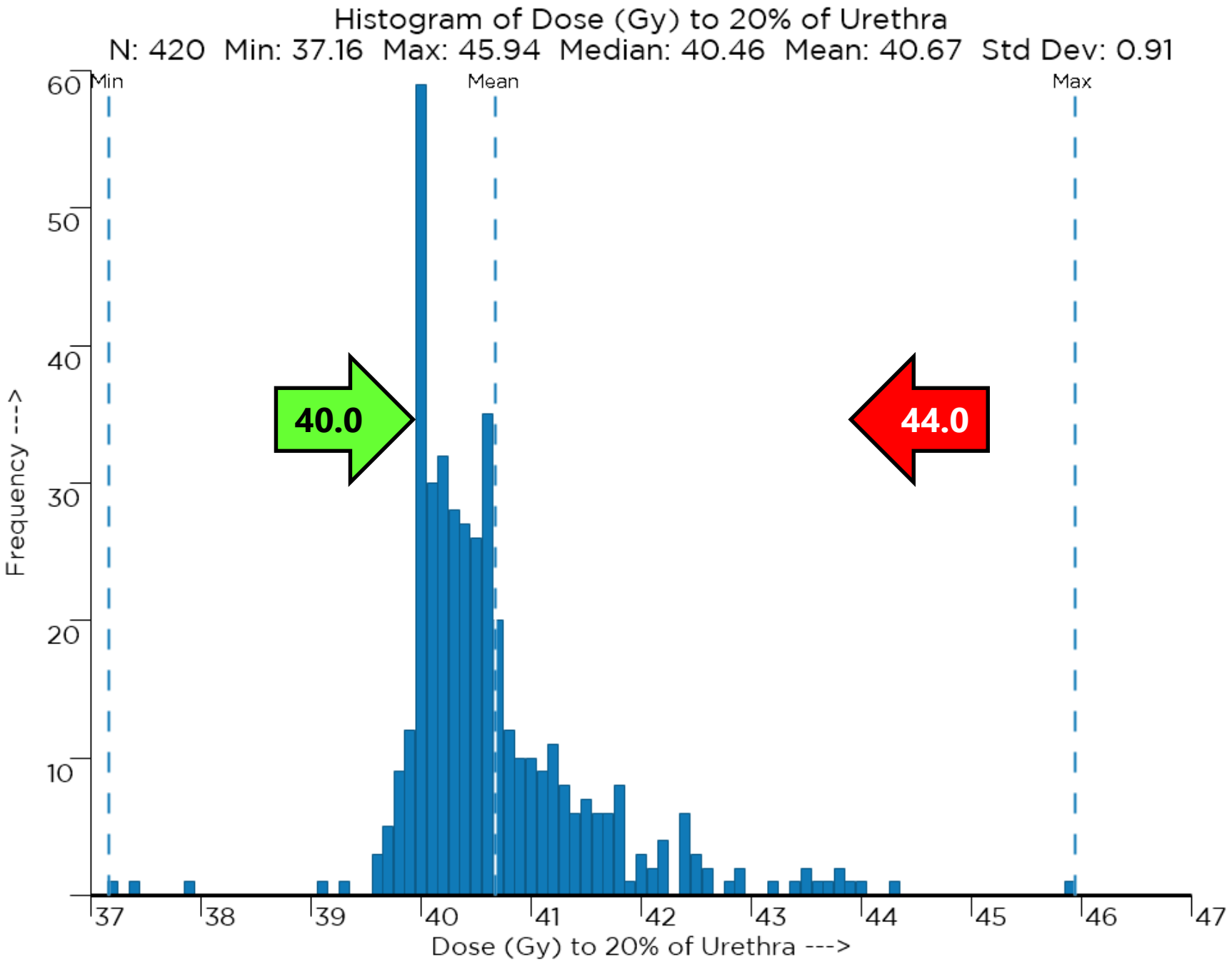

Histogram of Dose (Gy) Covering PTV minu 0.03 cc
N: 420 Min: 15.72 Max: 36.82 Median: 33.99 Mean: 33.71 Std Dev: 1.94
Min
Mean
Max
80
70
60
50
40
30
20
10
Frequency --->
29.0
36.25
14
16
18
20
22
24
26
28
30
32
34
36
38
Dose (Gy) Covering PTV minu 0.03 cc --->

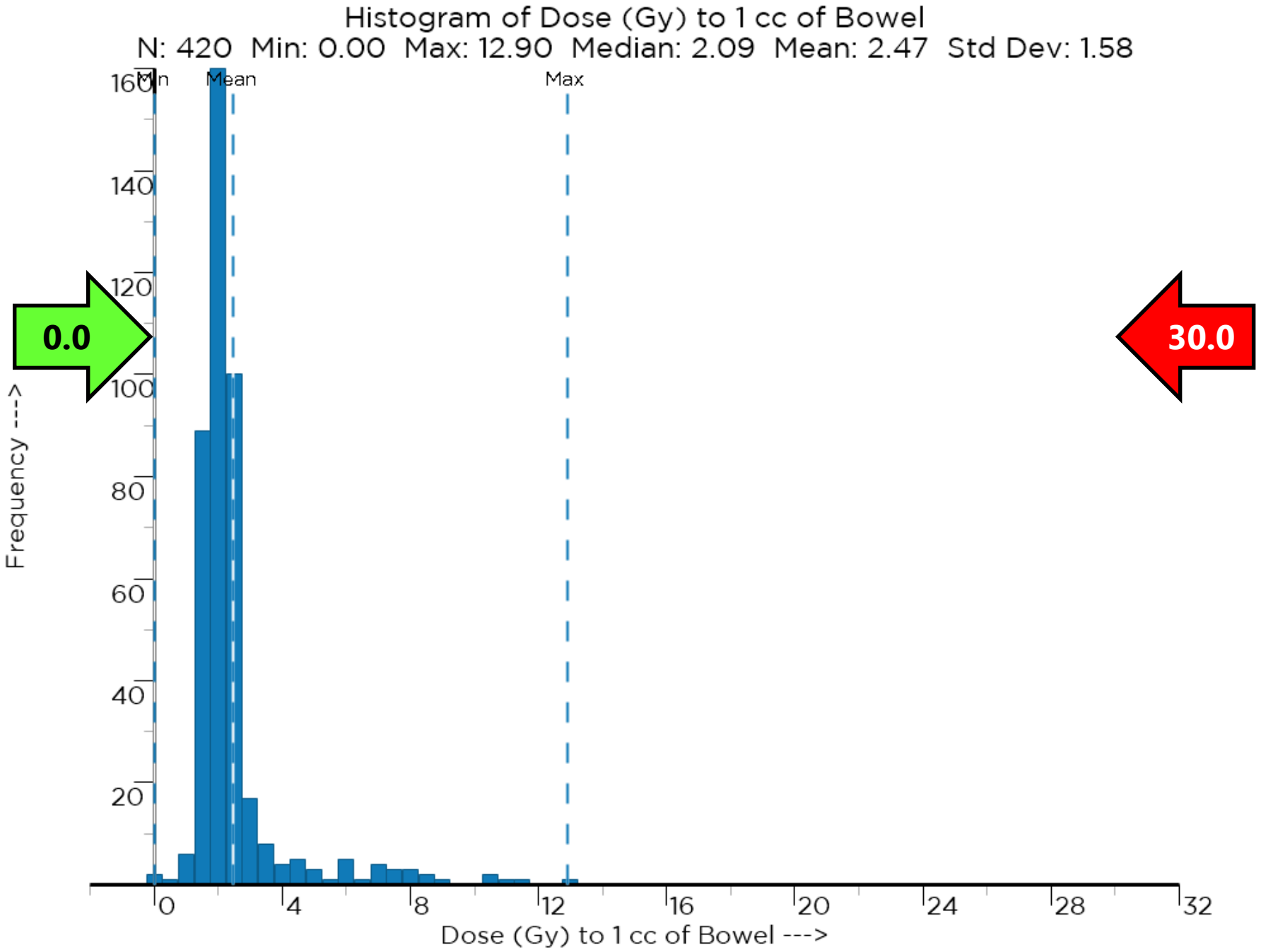

Histogram of Conformation Number (PTV, 36.25 Gy)
N: 420 Min: 0.40 Max: 0.96 Median: 0.90 Mean: 0.88 Std Dev: 0.06
Min
Mean
Max
60
50
40
30
20
10
Frequency --->
0.60
1.00
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Conformation Number (PTV, 36.25 Gy) --->


Histogram of Volume (cc) of Rectum > 36 Gy
N: 419 Min: 0.00 Max: 3.15 Median: 0.10 Mean: 0.23 Std Dev: 0.34
Min
Mean
Max
0.00
2.00
Frequency --->
150
120
90
60
30
-1
0
1
2
3
4
5
Volume (cc) of Rectum > 36 Gy --->


Histogram of Volume (cc) of Bladder > 37 Gy
N: 419 Min: 0.00 Max: 4.31 Median: 0.31 Mean: 0.58 Std Dev: 0.71
Min
Mean
Max
0.00
5.00
Frequency --->
80
60
40
20
-1
0
1
2
3
4
5
Volume (cc) of Bladder > 37 Gy --->


Histogram of Dose (Gy) to 40% of Rectum
N: 420 Min: 2.92 Max: 28.31 Median: 9.87 Mean: 10.64 Std Dev: 2.73
Min
Mean
Max
10.0
20.0
Frequency --->
90
80
70
60
50
40
30
20
10
4
8
12
16
20
24
28
Dose (Gy) to 40% of Rectum --->


Histogram of Dose (Gy) to 20% of Urethra
N: 420 Min: 37.16 Max: 45.94 Median: 40.46 Mean: 40.67 Std Dev: 0.91
Min
Mean
Max
40.0
44.0
Frequency --->
60
50
40
30
20
10
37
38
39
40
41
42
43
44
45
46
47
Dose (Gy) to 20% of Urethra --->


Histogram of Dose (Gy) to 1 cc of Bowel
N: 420 Min: 0.00 Max: 12.90 Median: 2.09 Mean: 2.47 Std Dev: 1.58
Min
Mean
Max
0.0
30.0
Frequency --->
160
140
120
100
80
60
40
20
0
4
8
12
16
20
24
28
32
Dose (Gy) to 1 cc of Bowel --->

RESULTS: SUPERLATIVES

- First, a word about individual recognition.
- **List of high performers**
- **Plan + QA (!)**
- **“Best in Class” mentions**

RESULTS: HIGH PERFORMERS (>142*)

*Some plans were < 142 but in top 20% for particular TPS

David Littlejohn
Thomas Costantino
Bruce Phillips
Jade Griffin
Frank Simac
Mikel Byrne
Anthony Magliari
Mihai Ene
Timothy Burns
Ben Archibald-Heeren
Christopher Peck
Jill Brooks
Adam Cohen
Cameron Ditty
Ross McCall
Rolland Julien
Richard Shores
Vanessa Magliari
Laura Sawicki
Paul Barry
Thomas Kendra
Scott Downs
Fazal Khan
Jonathan Stenbeck
Tom Sullivan
Karen
shaomin zhang
Mikhail Diachenko
Matthew Squires
Dinesh Kumar Mynampati
Bruno Bosco
Ludovic
Abdul Wahab Sharfo
Sarah Ghandour

Gail VanDerbeck
Randy Larson
Amy Longsdon
Angleraud
George
Tomas Prochazka
Zuo Zhang
Chris Huff
Nelly Ju
George Tolekidis
Lisa
Kathleen Broche-Gardner
Jallon
dupas
Mark Arends
Jason Metzger
Mark Addington
clare
Tchong Len
Kayla Brown
Zhiqiang Han
Luke Mackowiak
Thamizhisai Swaminathan
Josh Russell
Carol
Jennifer Back
Rodney Hood
Brandon Van Asten
Jason Edwards
Joakim Nilsson
nguyen Daniel
Yu-Wen Chang
Bridget
anthony rosain

Alex Nevelsky
John Paul Zenone
Hisato Nagano
Mattia Di Martino
Jamie Christ
Lisbet Williams
Andrew Mercurio
Joong-Yeol Woo
Shaun
Dustin Alex Whittington
Rui Silva
Nara Elahidoost
sangjun Son
Fares
Brett
Matt Brennan
Steven Murphy
Jane McNamara
nader
Antonio Ruiz
Daniel Bryant
Qiwei Hu
Boris Zholendz
Brian Doozan
James WARD
Qianyi Xu
Martin PavlÃ¡t
Kyle Riffle
Jeremy mulligan
Peter Treon
Christopher Amaloo
Akos Gulyban
Peter Kovacs
Ray Dalfsen

Megan Tattersall
Brandie
Chavanon Apinoraethkul
Jong Ho
Sneha Cloake
Anthony Huynh
Andrew Lyubinskiy
Albert
Wesley Groves
Elaine C Almeida
Shenpeng Jiang
Kent Powell
Wei Loong
Catherine Vogelesang
Jake Jackson
Stephen Jones
Jason
Perry Hunter
Vanessa Monteiro
Matthew Thomas
Rik Westendorp
Yan Chen
Collin
James Buckley
Jennifer Porosky
Udai Kumar
Teo Yuan Xin
Michael Oliver
sopaul seng
Stuart Williams
Danny
Greg Bartlett
Maryellen Kassab
Valerie Wright

Luke Arentsen
Nadir
Susannah Jansen van Rensburg
Trevor Williams
Jessica Stanley
Leslie Humpal
Danny Tran
Brais Rodriguez
Aneta Kawa-Iwanicka
Justin
Arun Gandhi
Justin Gilles
Timothy Atkins
Mark McGee
LuoShoubang
Stela Paltrinieri Nardi
Kenny Guida
David Ly
Carol McRee
Kevin Burke
Lei Fu
Christina Schipper
Shane Hagler
Jeremy Donaghue
Colin Sims
Michele Wolfe
Santosh Ladsaria
Eric Lobb
Eric Ehler
Oliver Blanck
Christopher Peck
Omar Chibani
Rick Scherer

PLAN + QA (!)

- I contacted the to 50 plan scorers and asked them if they (or their physicists) could run a full pre-treatment QA for their plan.
- Measurement in a 3D phantom was requested. If not available, I still post their normal QA method's results.
- Of those who had access to the linac featured in their plan, I got a **great response**. More than 50% did a comprehensive pretreatment QA for their plan.
  - **15** (of 26) used **3D dosimetry phantom**
  - **2** used **three film planes**
  - **4** used **2D array as a coronal plane** in square phantom
  - **3** used **EPID-based dose recalculation**
  - **2** used **EPID-based portal image** comparisons

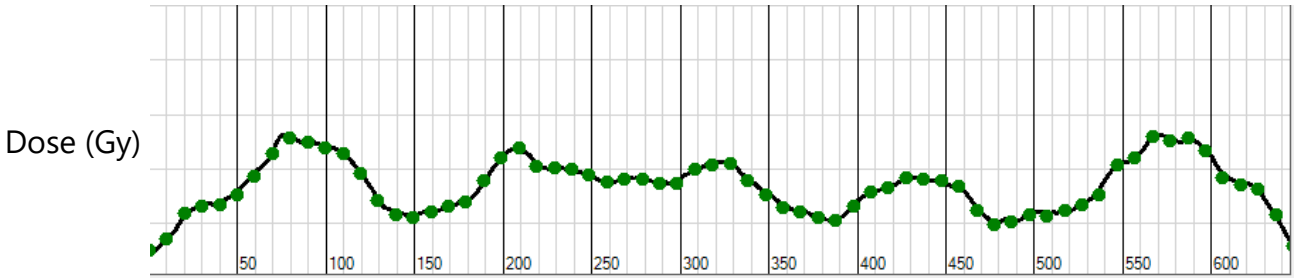
Special Results: Plan + QA

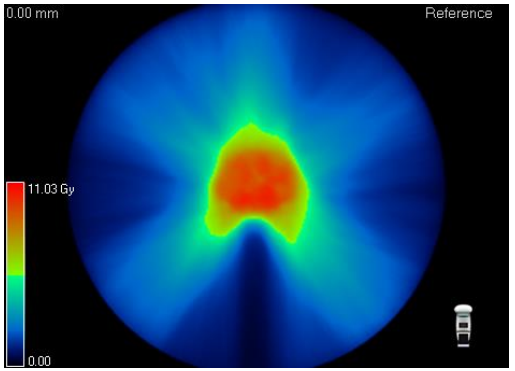
- **Christopher Peck**
- Landauer Medical Physics
- VMAT (3 beam), Eclipse
- Plan Quality Score = **146.24**

Within 1 pt. of Highest

- QA Results
  - ArcCHECK 3D Dosimeter, meas. uncertainty "off" and using 3DVH software
  - **100.0% passing (3% global, 3 mm, 10% lower TH)**
  - **99.2% passing (2% global, 2 mm, 10% lower TH)**
  - **98.0% passing (2% local, 2 mm, 20% lower TH)**

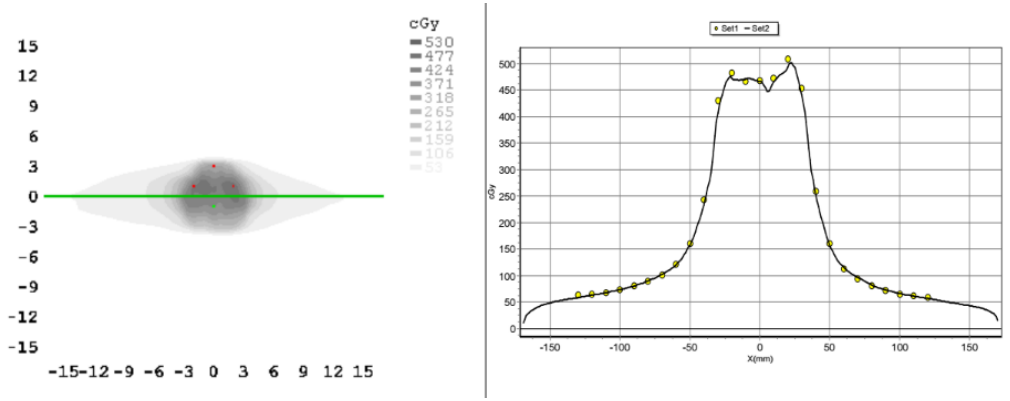
Highest





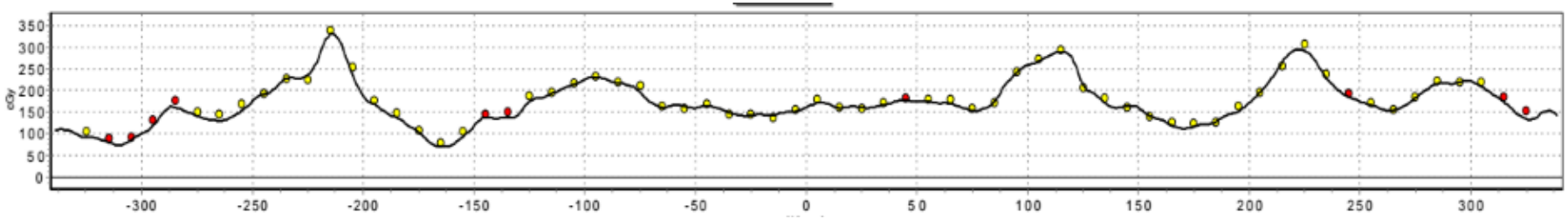
SPECIAL RESULTS: PLAN + QA

- **Tommy Costantino**
- South Florida Radiation Oncology
- VMAT (3 beam), Eclipse
- Plan Quality Score = **147.16**
- QA Results
  - MapCHECK2 as coronal plane in solid water square
  - Meas. Uncertainty “on”
  - ~97% (avg per beam) passing 2% global, 2 mm, 10 TH



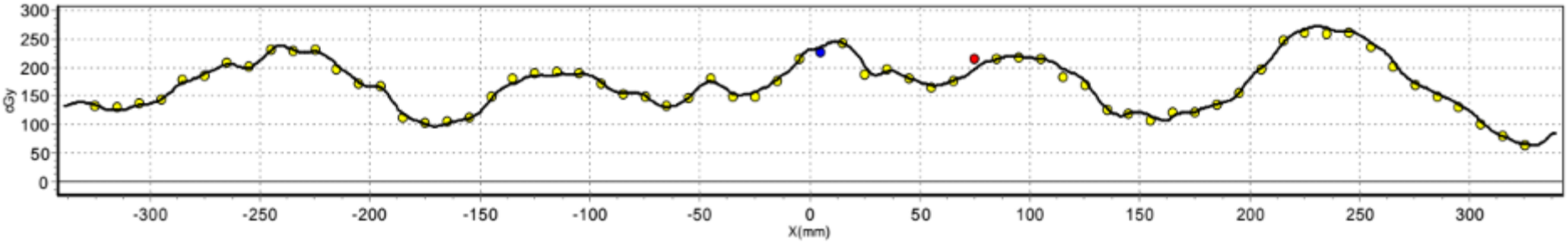
Special Results: Plan + QA

- **Mikel Byrne** and **Ben Archibald-Heeren**
- Radiation Oncology Centres (Wahroonga, AUS)
- VMAT (3 beam), RayStation
- Plan Quality Score = **146.37** and **146.27**
- QA Results
  - ArcCHECK 3D dosimeter, unplugged, meas uncertainty "on"
  - 97.8% passing (3% global, 3 mm, 10% lower TH)
  - ~80% passing (2% global, 2 mm, 20% lower TH)
  - Would *not* have passed their QA but they also have not yet commissioned SBRT, so this was not unexpected.



SPECIAL RESULTS: PLAN + QA

- **Mihai Ene**
- Pacific Cancer Institute of Maui
- VMAT (3 beam), Eclipse
- Plan Quality Score = **146.32**
- QA Results
  - ArcCHECK 3D Dosimeter, Meas. Uncertainty “on”
  - 99.3% passing (3% global, 3 mm, 10% lower TH)
  - 95.6% passing (2% global, 2 mm, 10% lower TH)
  - 92.5% passing (2% local, 2 mm, 10% lower TH)



SPECIAL RESULTS: PLAN + QA

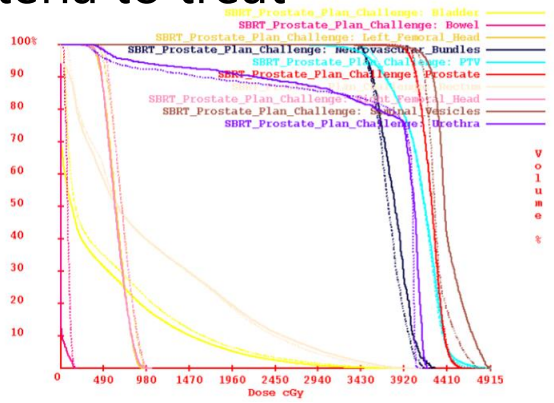
- **Able Shores**
- Greenville Health System
- VMAT (3 beam), Eclipse
- Plan Quality Score = **145.91**
- QA Results
  - ArcCHECK 3D dosimeter, unplugged, meas uncertainty “off”
  - 97.7% passing (3% global, 3 mm, 10% lower TH)
  - ~85% passing (2% local, 2 mm, 20% lower TH)

SPECIAL RESULTS: PLAN + QA

- **Vanessa Magliari**
- St. Anthony's Medical Center
- VMAT (3 beam), Eclipse
- Plan Quality Score = **145.89**
- QA Results
  - No 3D phantom available
  - Audit of delivery done with Portal Dosimetry
  - 99+% passing 3% (global), 3 mm
  - 97+% passing 2% (local), 2 mm

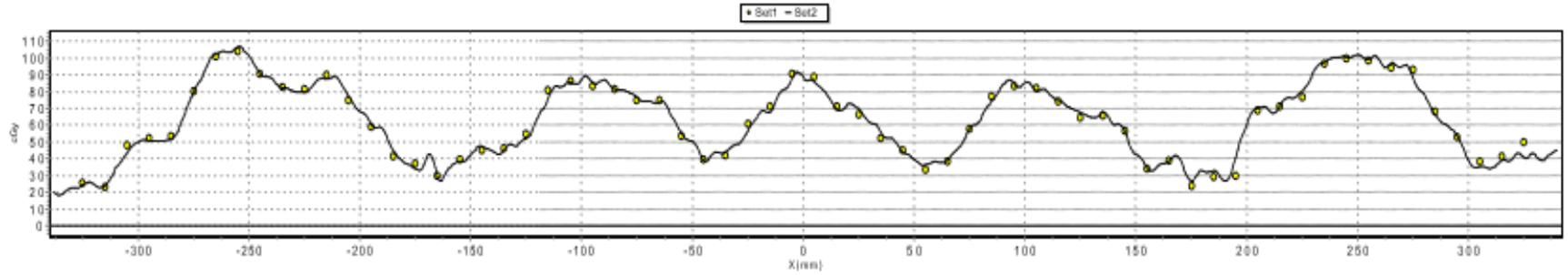
Special Results: Plan + QA

- **Laura Sawicki, Tom Kendra, Scott Downs**
- Ironwood Cancer & Research Center
- VMAT (3 beam), RayStation
- Plan Quality Scores = **145.85, 145.76, 145.73**
- QA Results
  - "Dosimetry Check," EPID-based dose recalc with pencil beam
  - Physics performed by **Tim Paul**
  - All three plans would pass their clinical criteria to treat



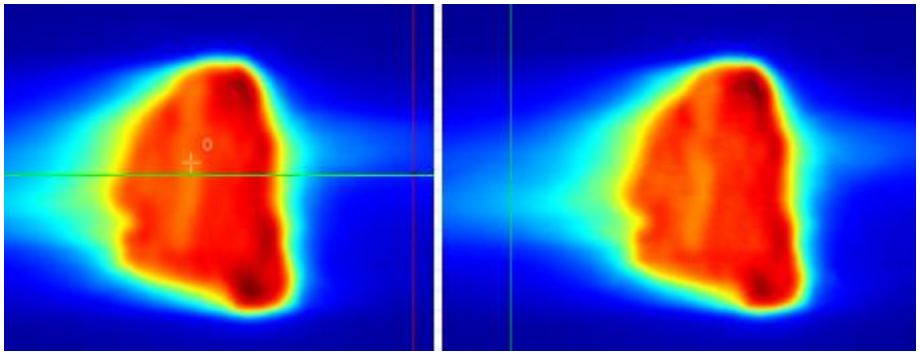
Special Results: Plan + QA

- **Jonathan Stenbeck**
- Greenville Health System
- VMAT (3 beam), Eclipse
- Plan Quality Score = **145.62**
- QA Results
  - ArcCHECK 3D dosimeter, unplugged, meas uncertainty “off”
  - 99.3% passing (3% global, 3 mm, 10% lower TH)
  - 93.1% passing (2% local, 2 mm, 20% lower TH)



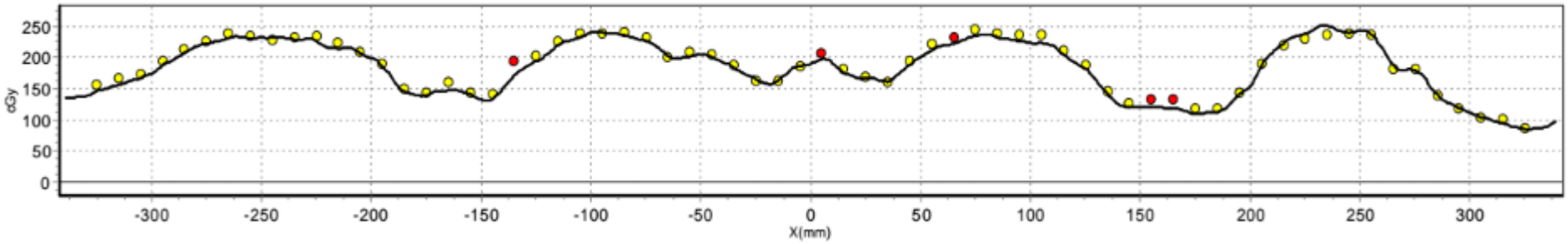
Special Results: Plan + QA

- **Karen Chin Snyder**
- Henry Ford Hospital
- VMAT (2 beam), Eclipse
- Plan Quality Score = **145.60**
- QA Results
  - Three planar films through target region
  - 99+% passing (3% global, 3 mm)
  - 98+% passing (3% global, 2 mm)



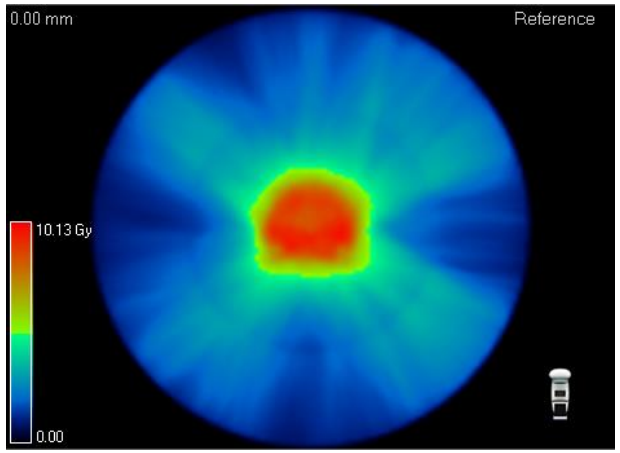
Special Results: Plan + QA

- **Tom Sullivan**
- Pacific Cancer Institute
- VMAT (3 beam), Eclipse
- Plan Quality Score = **145.60**
- QA Results
  - ArcCHECK 3D dosimeter, Meas. Uncertainty "on"
  - Physicist noted the plan was 10FFF, not yet a fully commissioned energy for them
  - 95.8% passing (3% global, 3 mm, 10% lower TH)
  - 82.8% passing (2% global, 2 mm, 10% lower TH)
  - 79.6% passing (2% local, 2 mm, 10% lower TH)



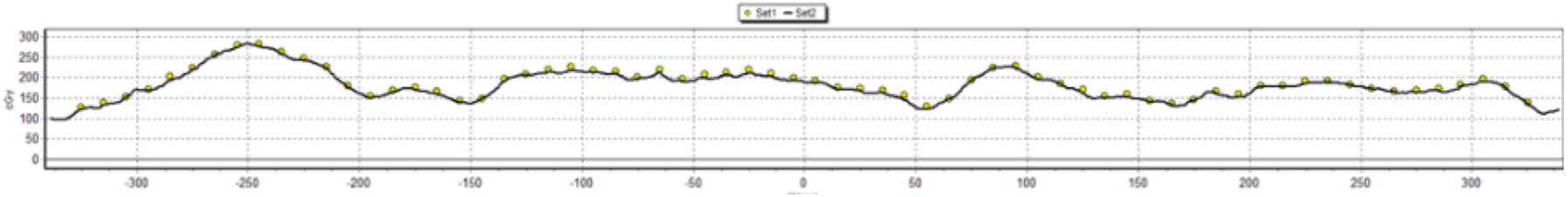
Special Results: Plan + QA

- **Shaomin Zhang**
- Abington Jefferson Health
- VMAT (3 beam), Eclipse
- Plan Quality Score = **145.45**
- QA Results
  - ArcCHECK 3D dosimeter, unplugged, meas. uncertainty "off" evaluated using 3DVH
  - 98.6% passing (3% global, 3 mm, 10% TH)
  - 93.3% passing (3% global, 3 mm, 10% TH)
  - 86.9% passing (2% local, 2 mm, 20% TH)



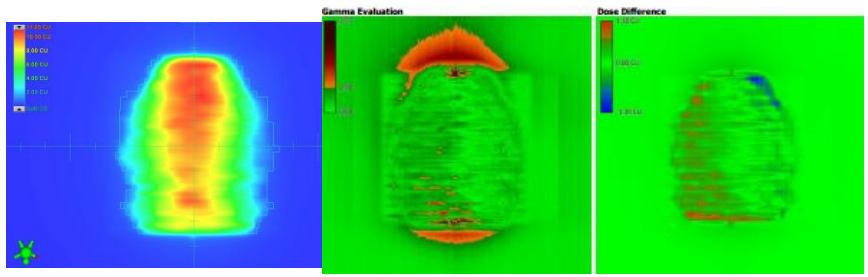
SPECIAL RESULTS: PLAN + QA

- **Mikhail Diachenko**
- JSC "Medicina" (Moscow)
- VMAT (3 beam), Eclipse
- Plan Quality Score = **145.42**
- QA Results
  - ArcCHECK 3D dosimeter, meas. uncertainty "off"
  - 100.0% passing (3% global, 3 mm, 10% lower TH)
  - 98+ passing (2% global, 2 mm, 10% lower TH)
  - 96.5% passing (2% local, 2 mm, 10% lower TH)



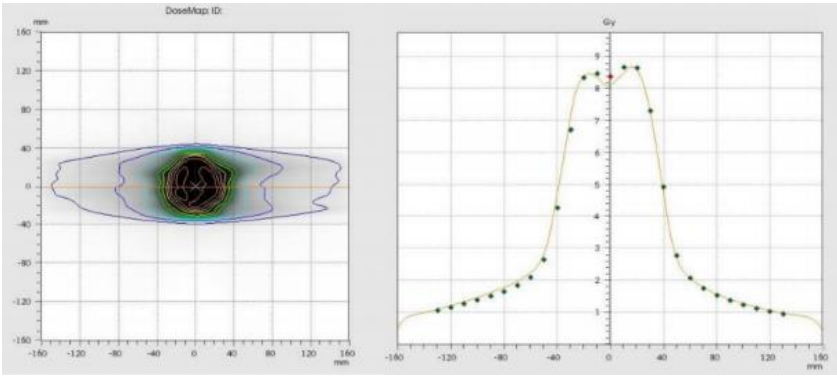
SPECIAL RESULTS: PLAN + QA

- **Dinesh Kumar Mynampati**
- Montefiore Medical Center
- VMAT (2 beam), Eclipse
- Plan Quality Score = **145.33**
- QA Results
  - No 3D phantom available so dose calc accuracy was not audited
  - Audit of delivery done with portal dosimetry
  - ~99% for 3% (global), 3 mm
  - ~94% for 2% (local), 2 mm



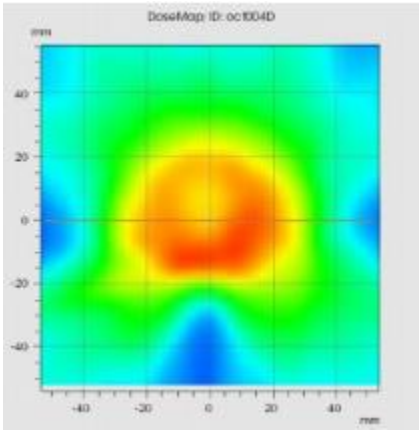
Special Results: Plan + QA

- **Ludovic Michon**
- CRT Versailles (France)
- VMAT (2 beam), Pinnacle
- Plan Quality Score = **145.30**
- QA Results
  - Octavius 729 chamber array treated as coronal plane
  - 100.0% for 3% (global), 3 mm
  - 95.5% for 2% (global), 2 mm
  - 82.1% for 2% (local), 2 mm



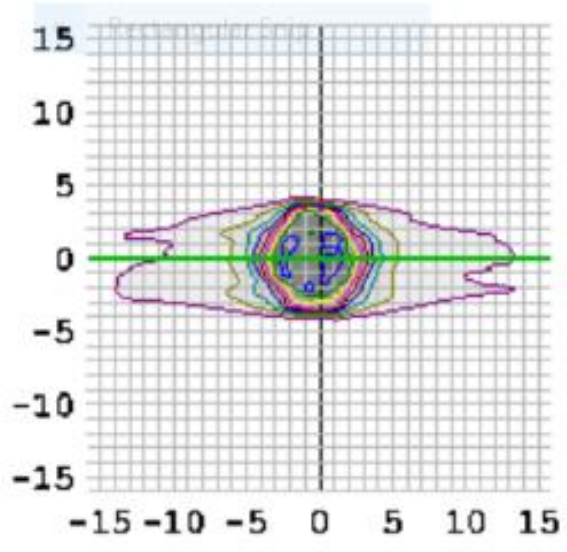
SPECIAL RESULTS: PLAN + QA

- **Sarah Ghandour**
- Hôpital Riviera-Chablais (Switzerland)
- VMAT (2 beam), RayStation
- Plan Quality Score = **145.28**
- QA Results
  - Octavius 4D 1000 SRS
  - 99.0% passing 2% (local), 2 mm (5% lower TH)



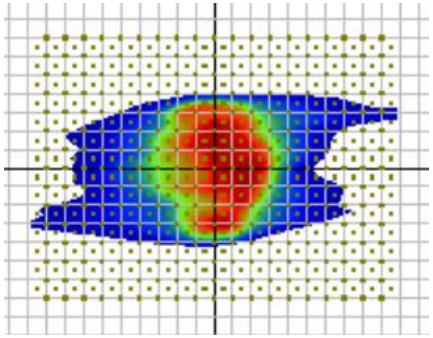
Special Results: Plan + QA

- **Gail Vanderbeck**
- Calloway & Young Cancer Center
- VMAT (3 beam), Eclipse
- Plan Quality Score = **145.27**
- QA Results
  - MapCHECK2 as coronal plane in solid water square
  - Meas. Uncertainty “on”
  - 99.4% passing 3% global, 3 mm, 10 TH
  - 96.7% passing 2% global, 2 mm, 10 TH



Special Results: Plan + QA

- **Amy Longsdon**
- North Star Lodge
- VMAT (3 beams), Eclipse
- Plan Quality Score = **145.18**
- QA Results, care of physicist **Anton Eagle** (NMPC)
  - MapCHECK2 cumulative, coronal plane in square phantom
  - 100.0% passing (3% global, 3 mm, 10% lower TH)
  - 99.6% passing (2% global, 2 mm, 10% lower TH)
  - 95.3% passing (2% local, 2 mm, 10% lower TH)

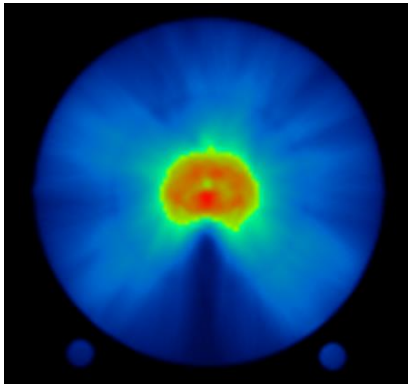


SPECIAL RESULTS: PLAN + QA

- **George Borzov**
- Rambam Medical Centre (Israel)
- VMAT (1 beam, multidirectional), Monaco
- Plan Quality Score = **145.16**
- QA Results
  - Delta4 3D dosimeter
  - 100.0% passing (3% global, 3 mm, 10% lower TH)
  - 97.8% passing (2% global, 2 mm, 10% lower TH)
  - 95.6% passing (2% local, 2 mm, 10% lower TH)

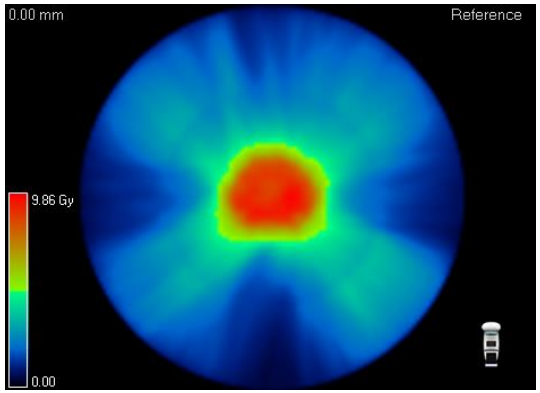
Special Results: Plan + QA

- **Tomáš Procházka**
- Masaryk Memorial Cancer Institute (Czech Republic)
- VMAT (3 beam), Eclipse
- Plan Quality Score = **145.06**
- QA Results
  - ArcCHECK 3D dosimeter, meas. uncertainty “off”
  - 100.0% passing (3% global, 3 mm, 10% lower TH)
  - 99.2% passing (2% global, 2 mm, 10% lower TH)
  - 97.7% passing (2% local, 2 mm, 20% lower TH)



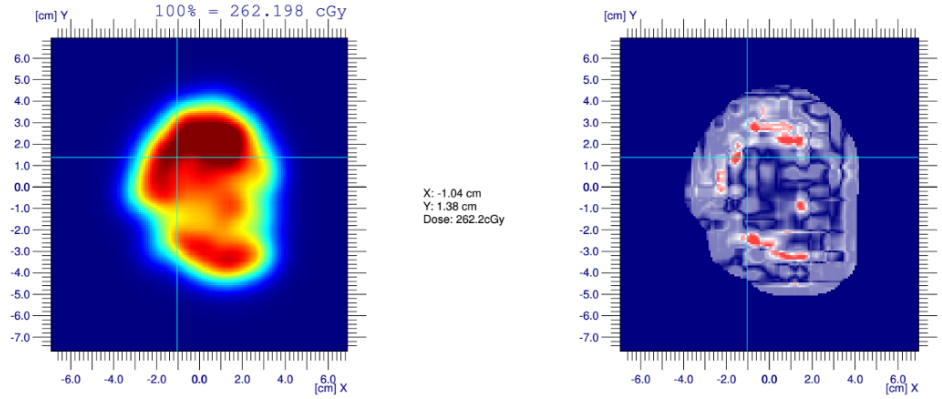
Special Results: Plan + QA

- **Zuo Zhang**
- Phoenixville Hospital
- VMAT (3 beam), Eclipse
- Plan Quality Score = **145.05**
- QA Results
  - ArcCHECK 3D dosimeter, unplugged, meas. uncertainty “off” evaluated using 3DVH
  - 99.7% passing (3% global, 3 mm, 10% TH)
  - 96.0% passing (3% global, 3 mm, 10% TH)
  - 90.4% passing (2% local, 2 mm, 20% TH)



SPECIAL RESULTS: PLAN + QA

- **Nelly Ju**
- ProCure Proton Therapy Center
- 4-Beam Proton Plan with RayStation TPS
- Plan Quality Score = **145.03**
- QA Results (**Chin-Cheng Chen & Scott Luckman**)
  - Matrixx 2D IC array at four (4) different depths through PTV
  - 95 – 99% passing 3% (global), 3 mm
  - 94 – 97% passing 3% (local), 2 mm

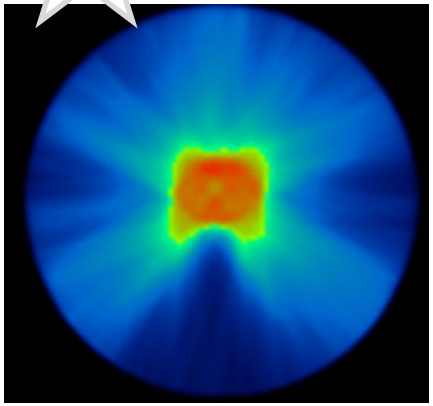
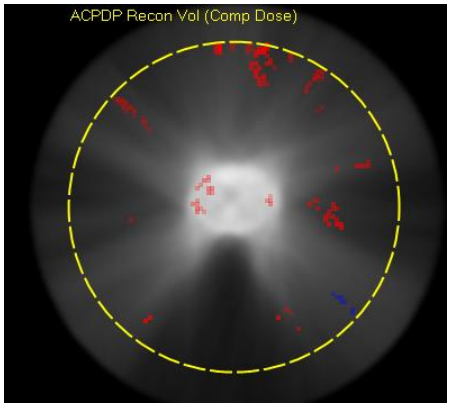


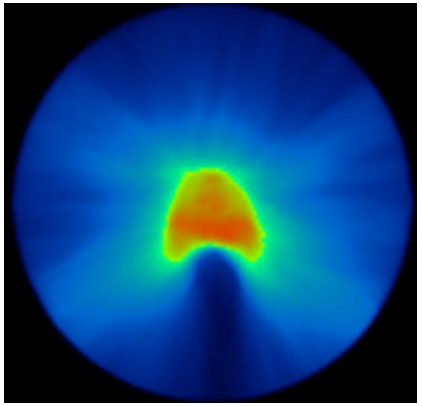
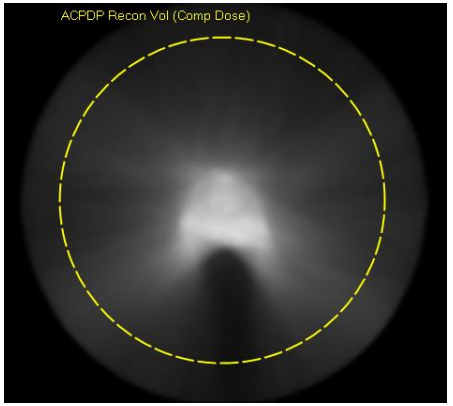
Special Results: Plan + QA

- **Mark Addington**
- Ohio State / Wexner Medical Center
- VMAT (3 beam), Eclipse
- Plan Quality Score = **144.82**
- QA Results
  - ArcCHECK 3D dosimeter
  - Percent Passing 3% global, 3 mm, 10% lower TH: **99.6%**
  - Percent Passing 2% local, 2 mm, 20% lower TH: **92.6%**

SPECIAL RESULTS: PLAN + QA

- **Magadalena Jallon & Aurélie Dupas**
- ICO Paul Papin (France)
- VMAT (3 beam), Eclipse
- Plan Quality Scores = **144.90 & 144.87**
- QA Results
  - ArcCHECK and 3DVH VirtualGel measurement-guided reconstruction
  - Percent Passing 3% global, 3 mm, 10% lower TH: **99.9% & 99.4%**
  - Percent Passing 2% local, 2 mm, 20% lower TH: **94.7% & 96.1%**

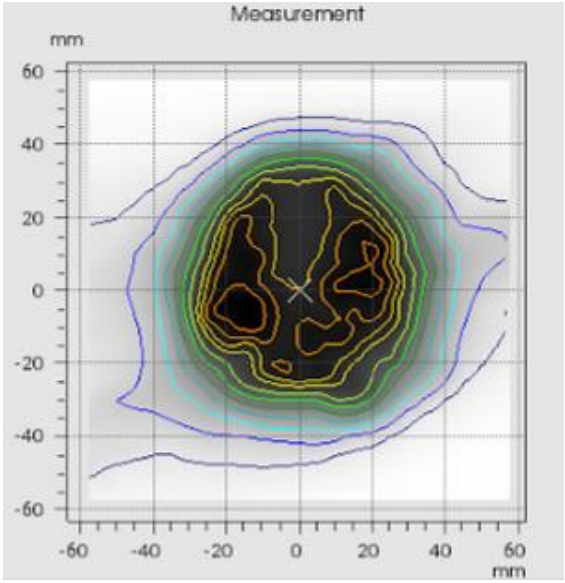



Special Results: Plan + QA

- **Oliver Blanck**
- University Medical Center Schleswig-Holstein
- CyberKnife
- Plan Quality Score = **141.16 (75 min),138 (40 min)**
- QA Results
  - Film analysis (141.16, i.e. 75 min plan)
  - 99.6% passing 3%, 1 mm
  - 97.5% passing 1% (local), 1 mm

Wow.



Results: "Best in VMAT" (1 per TPS)

Category	Name	Site	Score
VMAT (Eclipse)	David Littlejohn (Dosimetrist)	South Florida Radiation (USA)	147.17
VMAT (RayStation)	Mikel Byrne (Physicist)	ROC Wahroonga (NSW, Australia)	146.37
VMAT (Pinnacle)	Ludovic Michon (Physicist)	CRT Versailles (France)	145.30
VMAT (Monaco)	Abdul Wahab Sharfo (Physicist)	Erasmus MC (Rotterdam, Netherlands)	145.28*
Tomotherapy	Luke Arentsen (Physicist)	University of Minnesota (USA)	143.58*
VMAT (Oncentra)	Timothy Atkins (Physicist)	Royal United Hospitals NHS (UK)	142.36

* Denotes there was a higher score in the category, but by a vendor employee

RESULTS: "BEST IN IMRT" (1 PER TPS)

Category	Name	Site	Score
IMRT (Monaco)	Alex Nevelsky (Physicist)	Rambam Medical Center (Haifa, Israel)	144.12
IMRT (Eclipse)	Boris Zholendz (Dosimetrist)	Rochester Regional Health (New York, USA)	143.46
IMRT (Pinnacle)	Vidheesha Arora (Student)	University of Toledo (Ohio, USA)	139.74*

* Denotes there was a higher score in the category, but by a vendor employee

Results: "Best in Proton" (1 per TPS)

Category	Name	Site	Score
Proton (Eclipse)	Anthony Magliari (Dosimetrist)	Varian	146.32
Proton (RayStation)	Nelly Ju (Dosimetrist)	ProCure Proton Therapy (New Jersey, USA)	145.03
Proton (Eclipse)	Chavanon Apinorasethkul (Dosimetrist)	University of Penn (Pennslyvania, USA)	143.04*

* Denotes there was a higher score in the category, but by a vendor employee

Results: "Best in Robot"

Category	Name	Site	Score
CyberKnife	Qianyi Xu (Physicist)	MD Anderson at Cooper (New Jersey, USA)	143.38

Results: "Best in MU Efficiency"

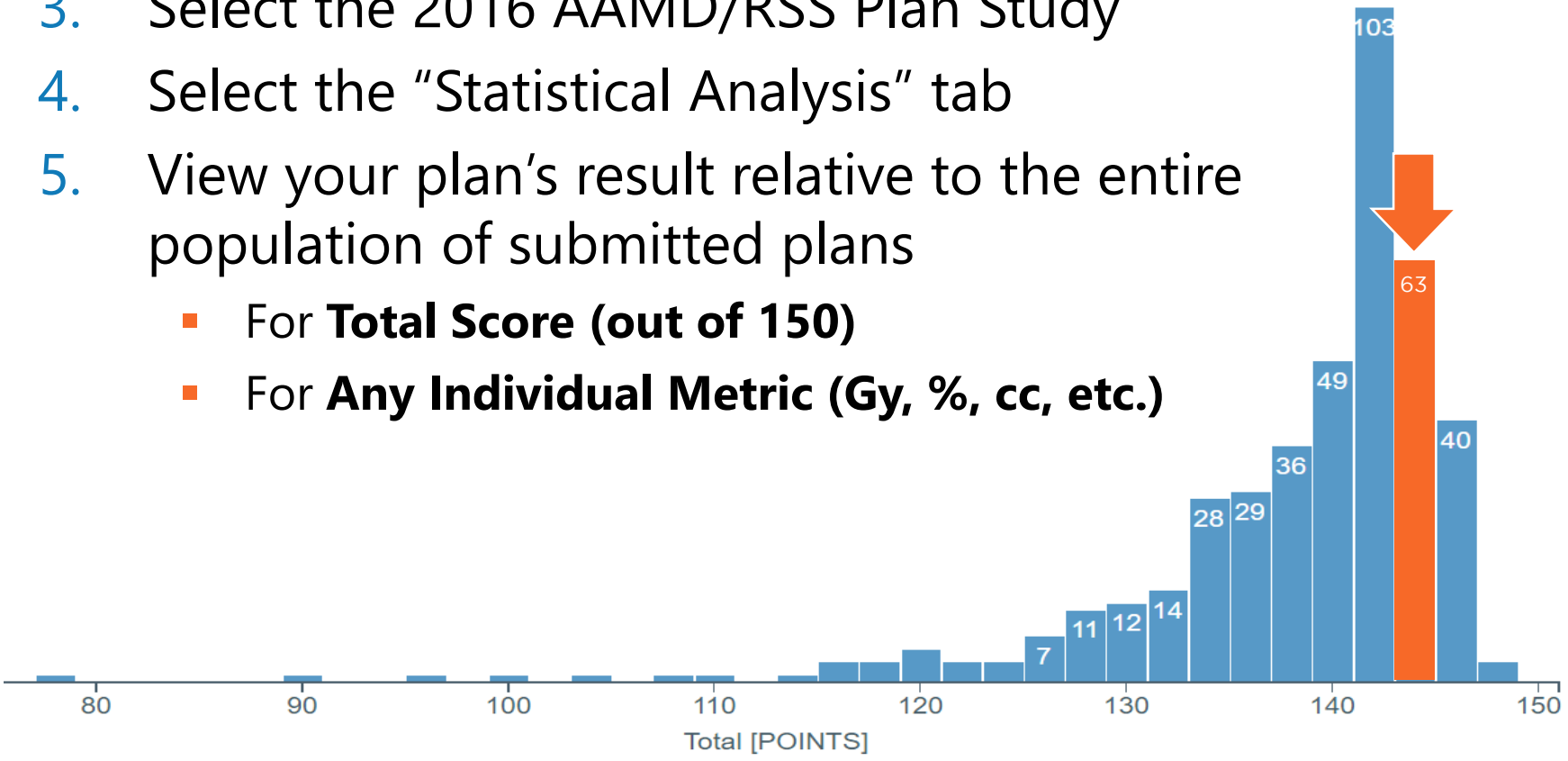
Category	Name	Site	Score
VMAT (RayStation)	Jason Metzger (Dosimetrist)	Eastern Maine Health (USA)	144.84 (1739 MU)

Results: "Top 10 Students"

Name	Program	TPS	Modality	Score
Jamie Christ	SIU Medical Dosimetry Program	Eclipse	VMAT	143.96
Nara Elahidoost	RTU-VT	Eclipse	VMAT	143.78
Jong Ho	UT MD Anderson Cancer Center	Pinnacle	VMAT	143.01
Anthony Huynh	Grand Valley State University	Eclipse	VMAT	143.00
Elaine C Almeida	RTU-VT	Eclipse	VMAT	142.96
Sopaul Seng	UT MD Anderson Cancer Center	Pinnacle	VMAT	142.58
Shane Hagler	UT MD Anderson Cancer Center	Pinnacle	VMAT	142.13
Shelby	The Ohio State University	Eclipse	VMAT	141.67
Stacy Peterson	UT MD Anderson Cancer Center	Pinnacle	VMAT	141.55
Thomas Iverson	University of Cincinnati	Eclipse	VMAT	141.26

Results: Individual Data Analysis

1. Sign in to www.proknowsystems.com
2. Go to "Plan Studies" and set the filter to "All Studies"
3. Select the 2016 AAMD/RSS Plan Study
4. Select the "Statistical Analysis" tab
5. View your plan's result relative to the entire population of submitted plans
   - For **Total Score (out of 150)**
   - For **Any Individual Metric (Gy, %, cc, etc.)**



Tips & Techniques

General Techniques

- Analyze Contours and Prescription
  - Is what you are being asked for achievable?
  - Is there a need to “break up” up OAR’s that intersect with GTV/PTV
  - Do any new structures need creating?
    - Try to minimize dose specific structures

General Techniques

- Do a starting/base plan first
  - Get a “feel” for the plan
  - Keep constraints simple
  - Set realistic objectives
  - Fine tune

General Techniques

- Focus on target coverage first
- Then work on OAR's

General Techiniques

- Don’t forget about your low dose regions
- Don’t overdo table kicks
- Don’t be afraid to try 10X
- Try to keep MU’s to 2x daily dose
  - Helps with modulation

MONACO

- Try to get you best results you can on the first stage
  - Only little tweaks on second stage
- Set calculation grid to 2mm
- Understand how the cost functions work
- Use Quadratic Overdose in Body to create rings

Monaco

- Make sure your constraints are set in the correct order
- Consider manually weighting your Target
- Watch your Iso-constraints and Relative Impacts
  - Compare
    - Will you really gain by your adjustment

CyberKnife

- Forget everything you have learned in every other TPS
- Use shell structures to control
  - Dose conformity
  - Dose fall off
  - Hot spots outside target area

CyberKnife

- Set MU limit
  - 350-600 MU per beam
- Consider using IRIS collimator
  - Gives optimizer more options
  - Reduces treatment time
- Be patient
  - Try again
  - You never know what you may end up with

ECLIPSE

- Need to understand how to use the NTO (Normal Tissue Optimizer) properly
- Otherwise need to utilize rings
- About 50% seem to use both rings and NTO
  - .1 to .5cm around PTV
  - 1 to 1.5cm around PTV
  - .1 to .3cm around urethra and NVB

ECLIPSE

- Pay attention to priorities
- Pause the optimizer often
  - Make tweaks if needed
  - Especially in level one and two
- Collimator angles 10-90 degrees use

PINNACLE

- Watch your optimizer
  - If you don't get your coverage in the first 50 or so iterations re-evaluate your objectives
- Start with small dose grid then expand
- Limit your 50% to 2cm away
  - Good starting point for compact distribution
  - Then work on OAR's

CONCLUSION

- KISS Principle
  - Know how your optimizer works
  - Small adjustments can bring big rewards
  - Don’t over complicate the process
  - Common sense is you best friend

What's Next?

- What is next year's study? ***You decide!***
  - ProKnow allows any group to request and design a plan study.
  - The requirements:
    - The plan have a novel purpose or angle (e.g. challenging case study)
    - The results are presented at a national meeting and/or published in a peer-reviewed journal.
  - Next year, one of YOU is up here giving this talk.

What's Next?

- "Next Level" studies we plan to do…
  - Plan Quality + QA Accuracy
    - Study not only plan quality, but also deliver the plan to a 3D dosimetry phantom and submit your QA scores
    - This is a bit closer to "end-to-end" testing where the TPS dose calculation and dose delivery are also audited
  - Planning Efficiency
    - Time limit imposed
    - Who and what can create the highest quality plans in a restricted amount of time?
  - "John Henry vs. the Steam Engine"
    - TPS auto-planning vs. high performers from previous plan studies

Closing Words

- We have worked very hard to build the new "Plan Study" technology and get it off the ground.
- We know it makes a real-world difference (to clinicians, vendors, and ultimately our patients).

But…

We just make the airplane. You are the pilots.

In other words,
without you, none of this flies.

REFERENCES

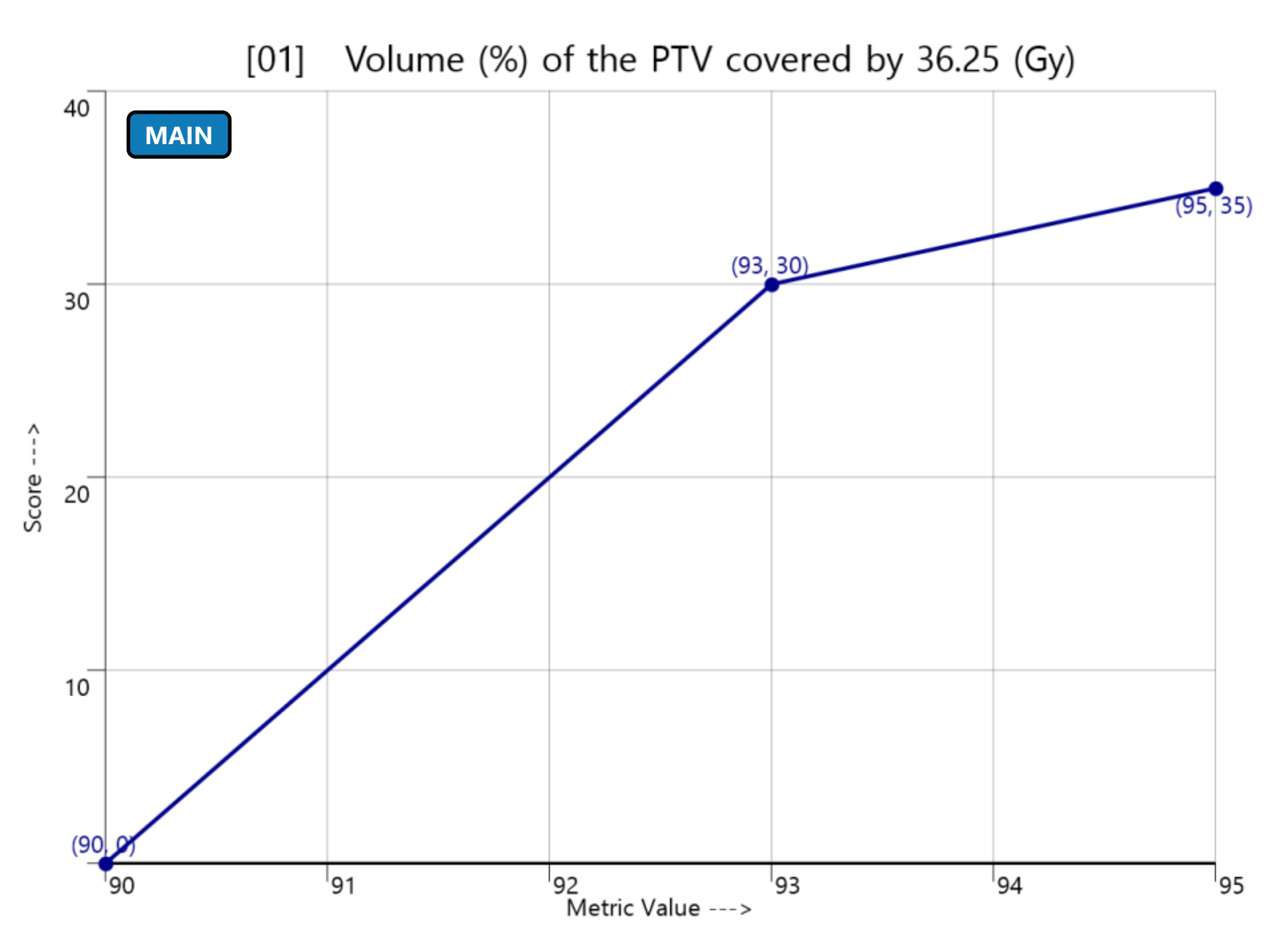
1. Nelms BE, Robinson G, Markham J, Velasco K, Boyd S, Narayan S, Wheeler J, Sobczak M. Variation in external beam treatment plan quality: An inter-institutional study of planners and planning systems. Practical Radiation Oncology 2012 Oct;2(4):296-305.

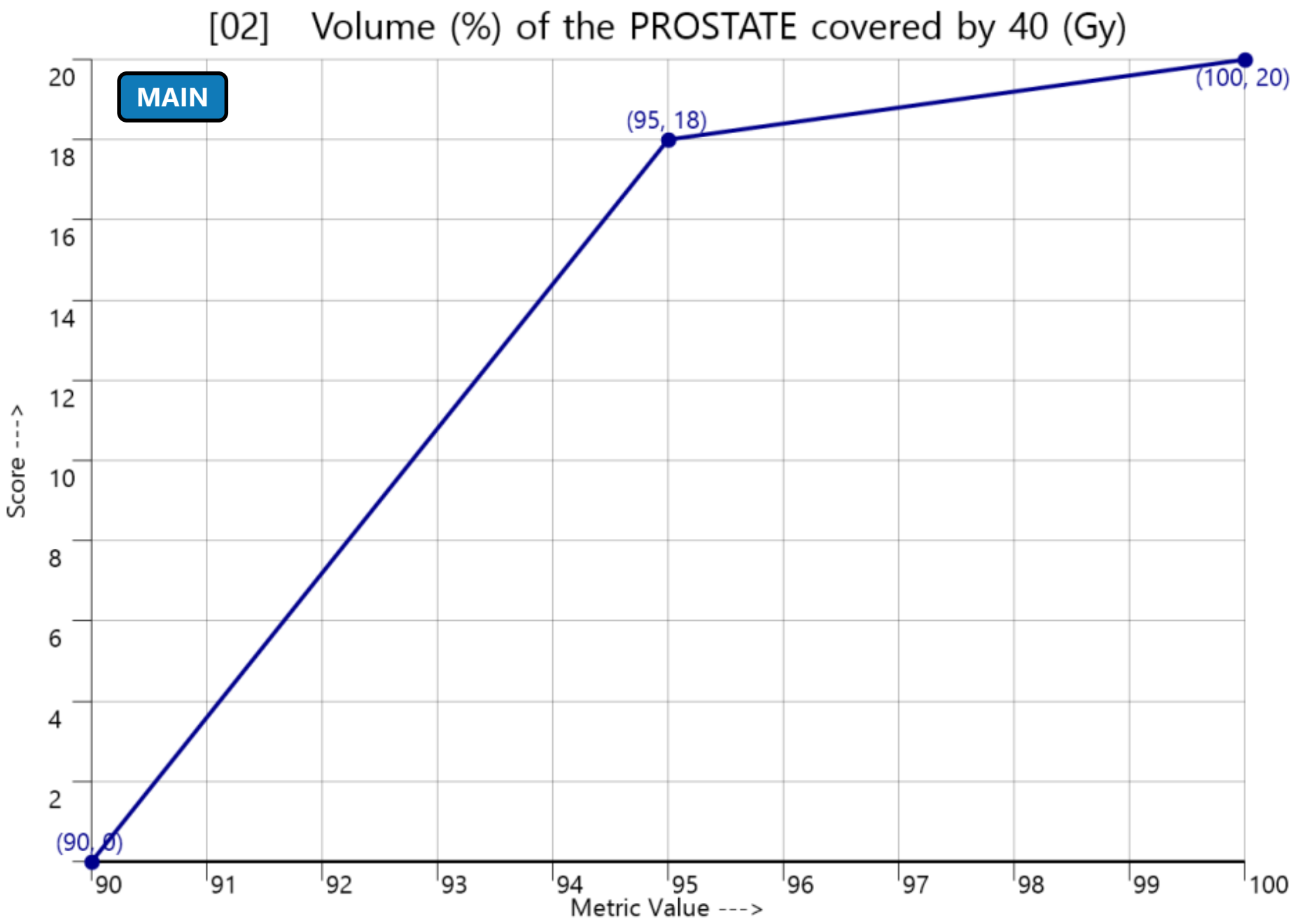
2. Nelms BE, Stambaugh C, Hunt D, Tonner B, Zhang G, and Feygelman V. Methods, software and datasets to verify DVH calculations against analytical values: Twenty Years Late(r). Med Phys. 2015 Aug; 42(8).

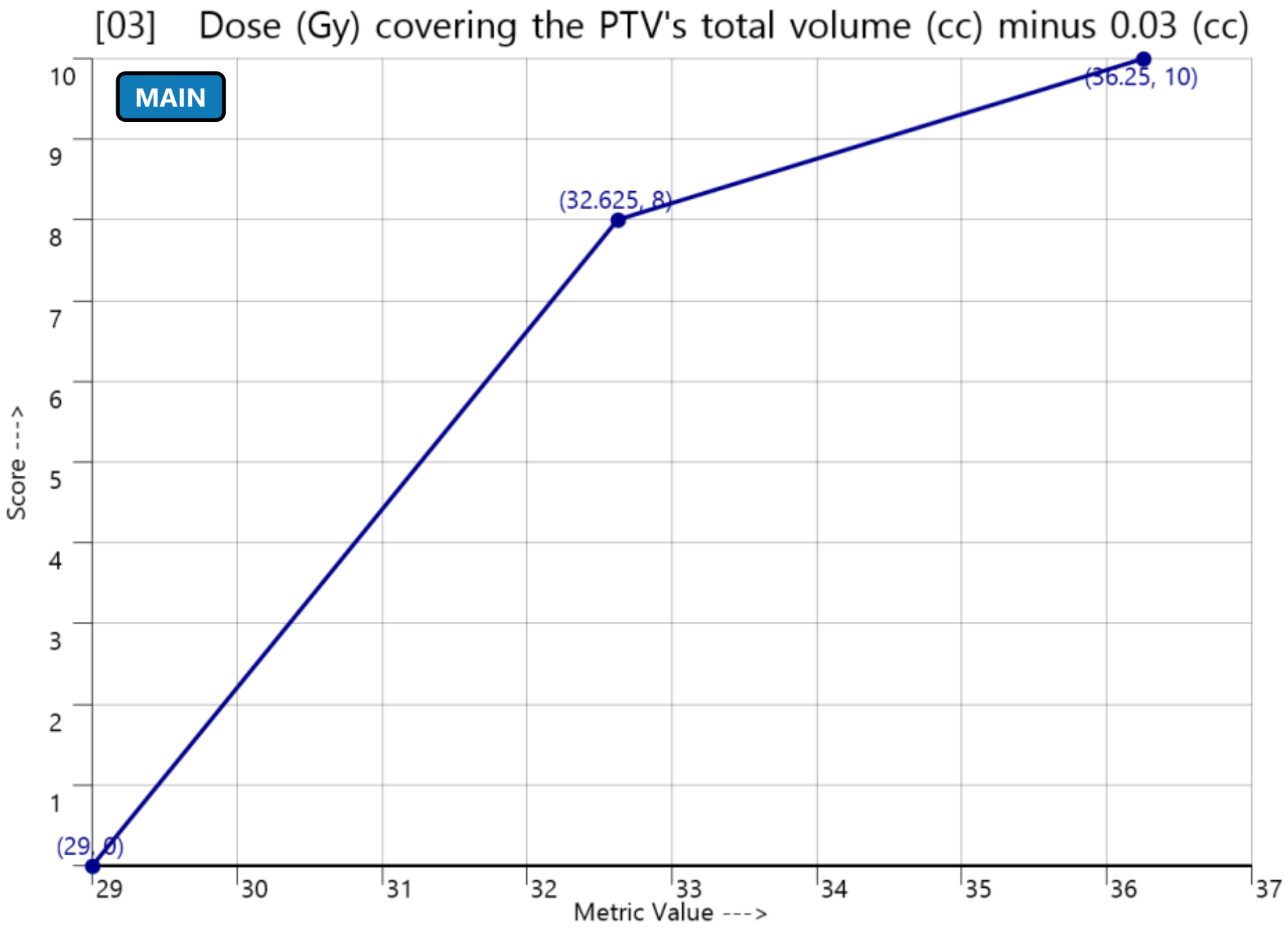
Appendix 1: Plan Metrics

← MAIN

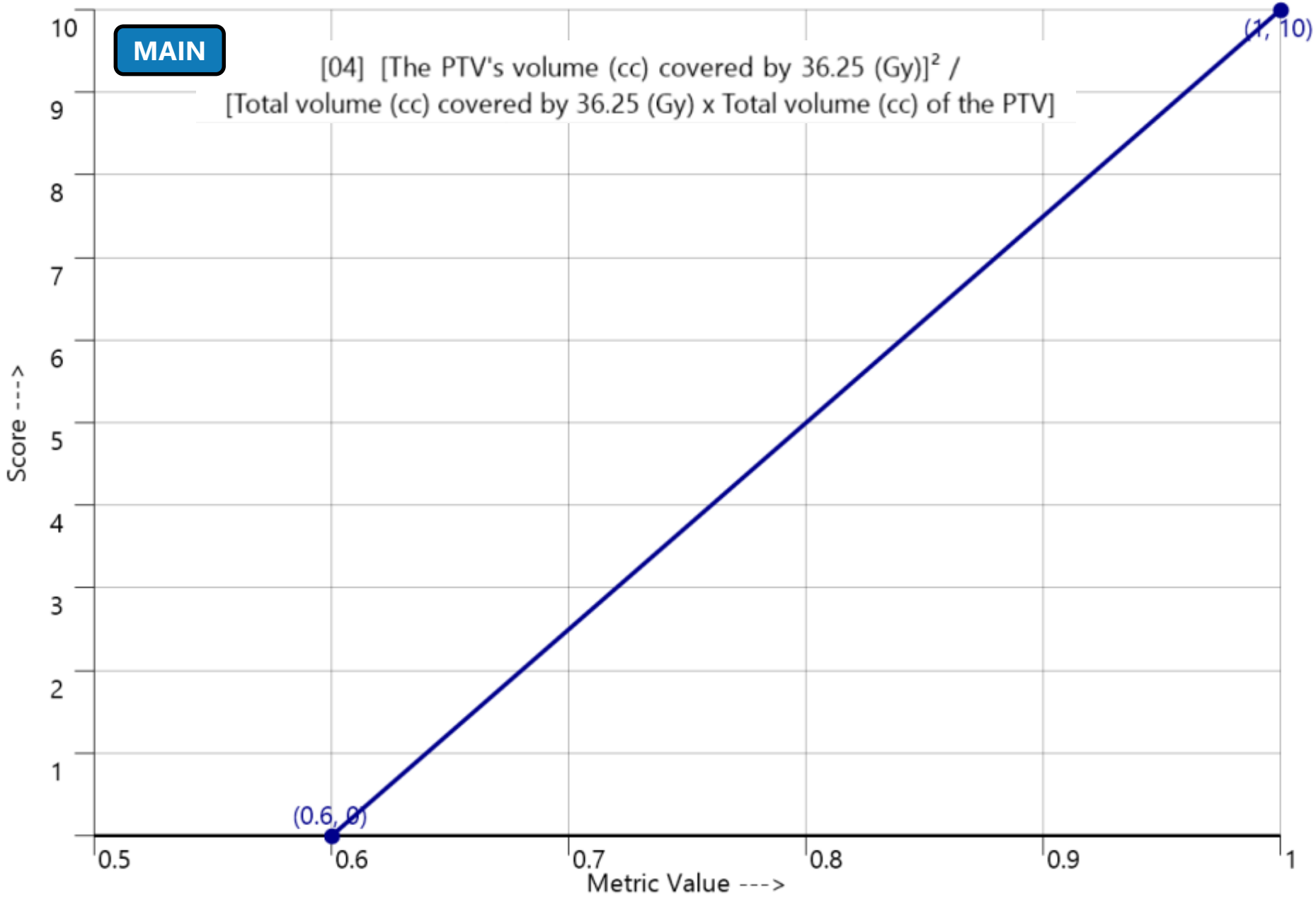
- Each of the 15 metric components and their score functions are listed in the subsequent slides.

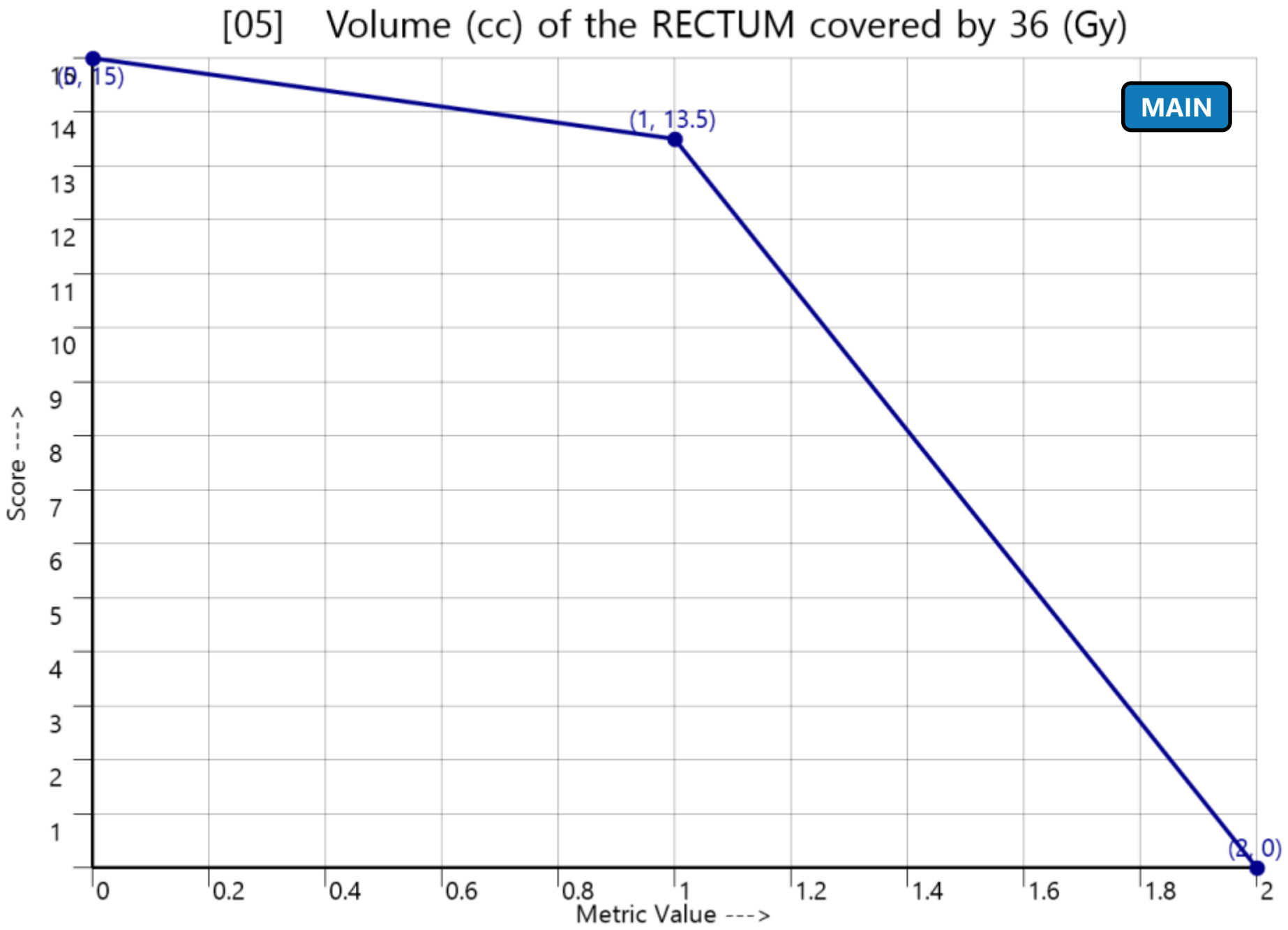

[01] Volume (%) of the PTV covered by 36.25 (Gy)
MAIN
40
30
20
10
Score --->
(90, 0)
(93, 30)
(95, 35)
90
91
92
93
94
95
Metric Value --->

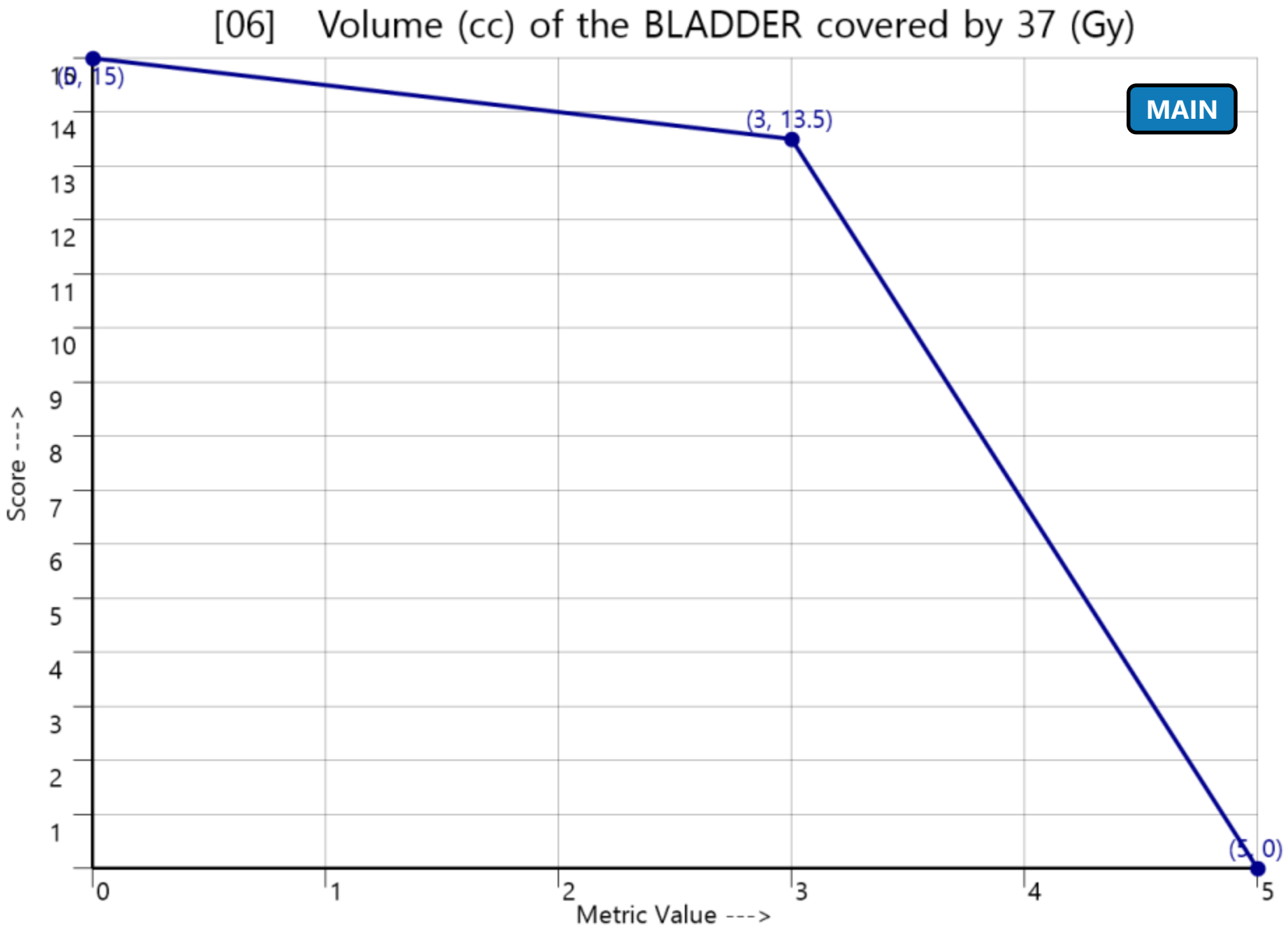

[02] Volume (%) of the PROSTATE covered by 40 (Gy)
MAIN
(90, 0)
(95, 18)
(100, 20)
Score --->
Metric Value --->
20
18
16
14
12
10
8
6
4
2
90
91
92
93
94
95
96
97
98
99
100

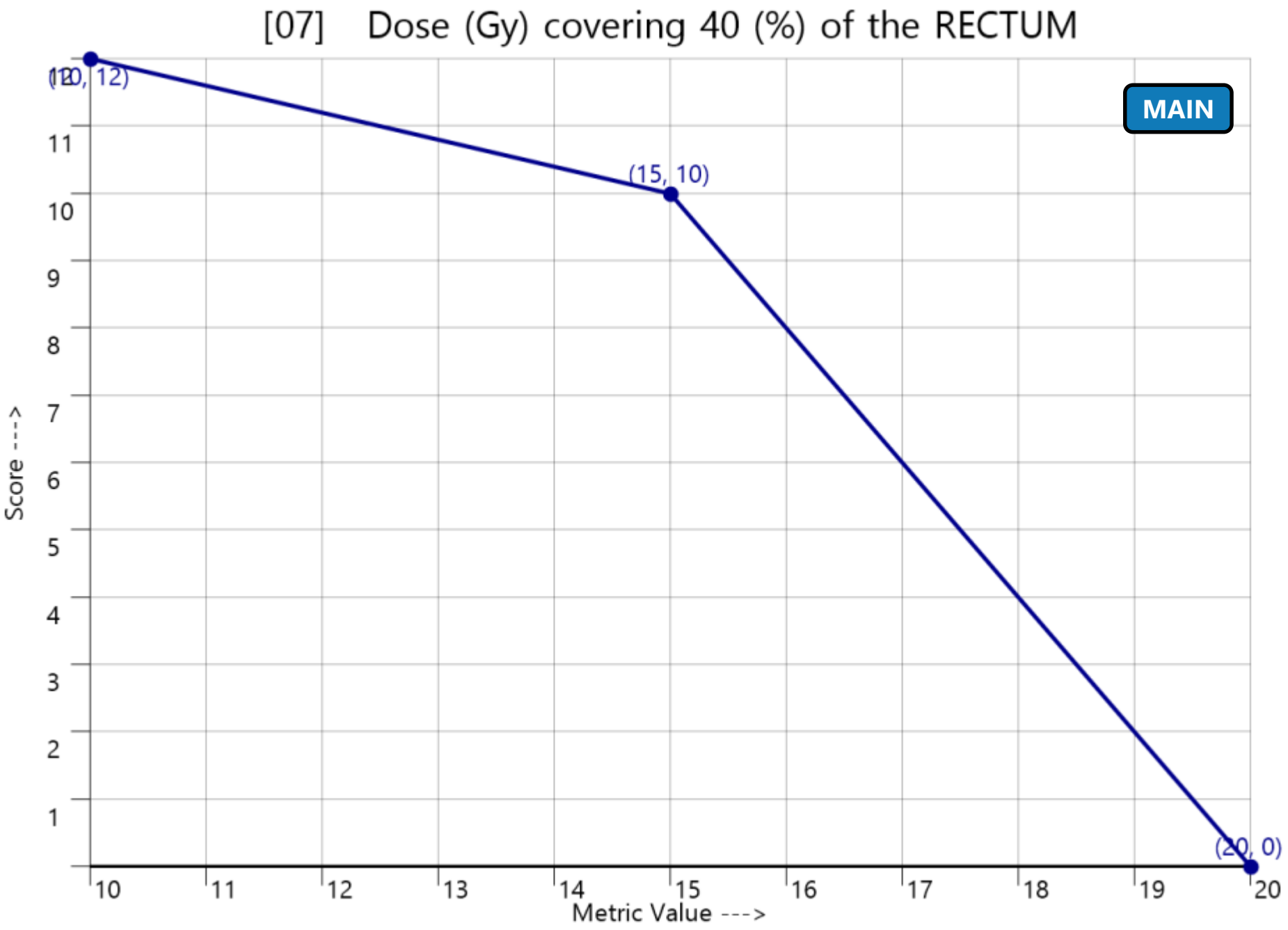

[03] Dose (Gy) covering the PTV's total volume (cc) minus 0.03 (cc)
MAIN
(29, 0)
(32.625, 8)
(36.25, 10)
Score --->
Metric Value --->
10
9
8
7
6
5
4
3
2
1
29
30
31
32
33
34
35
36
37

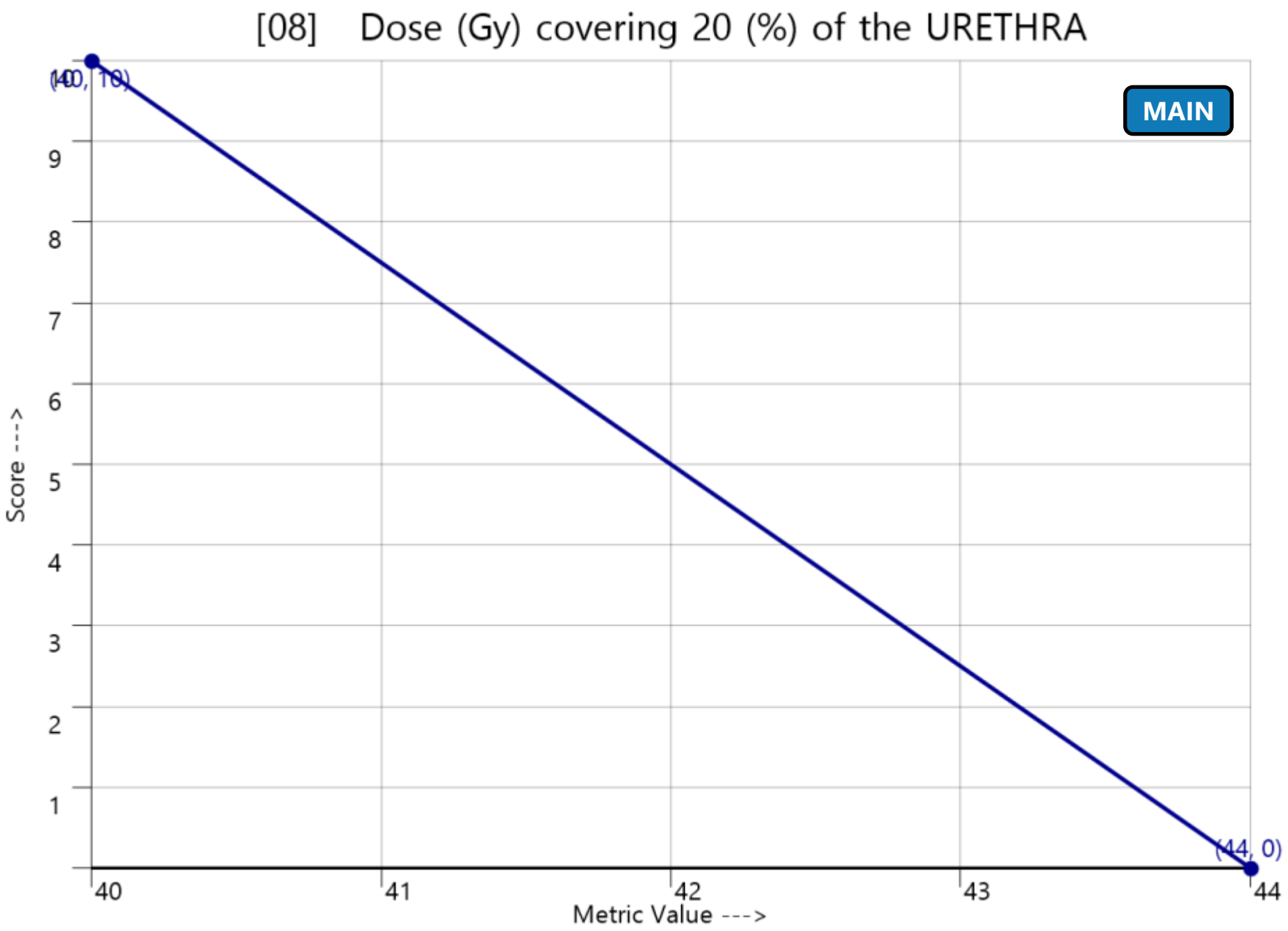
[04] Conformation Number

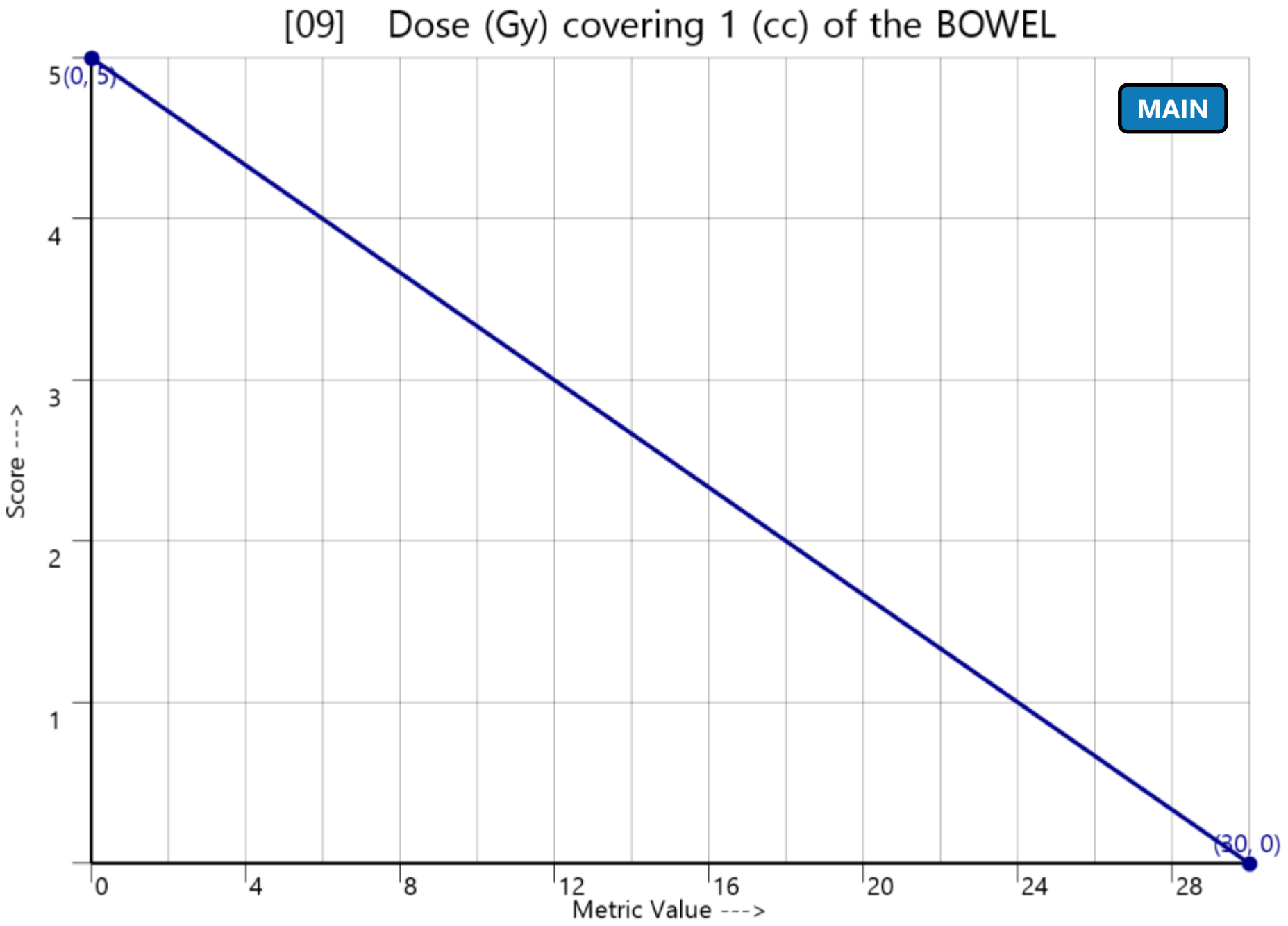


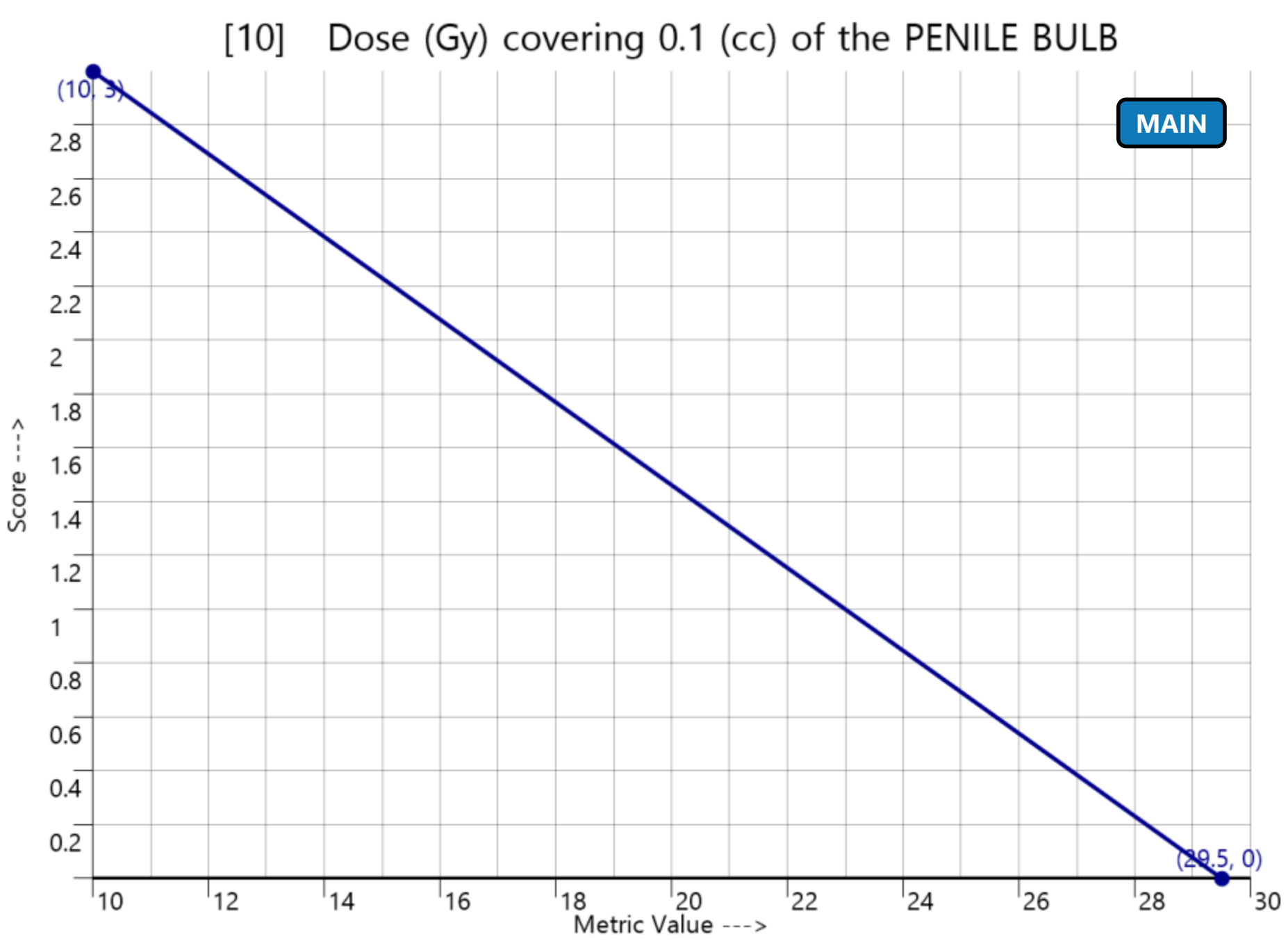

[05] Volume (cc) of the RECTUM covered by 36 (Gy)
MAIN
(0, 15)
(1, 13.5)
(2, 0)
Score --->
Metric Value --->
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2

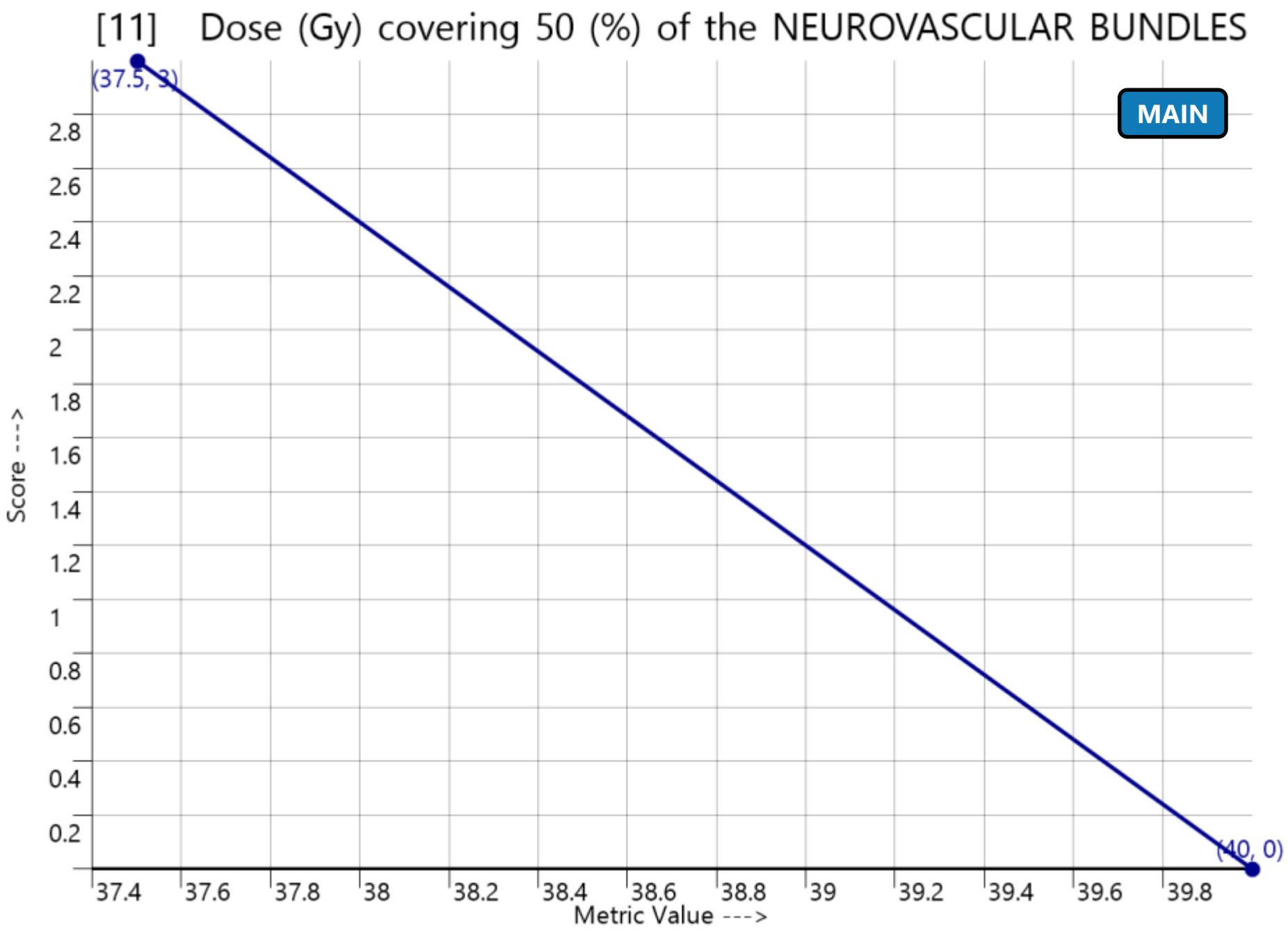

[06] Volume (cc) of the BLADDER covered by 37 (Gy)
MAIN
(0, 15)
(3, 13.5)
(5, 0)
Score --->
Metric Value --->
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5

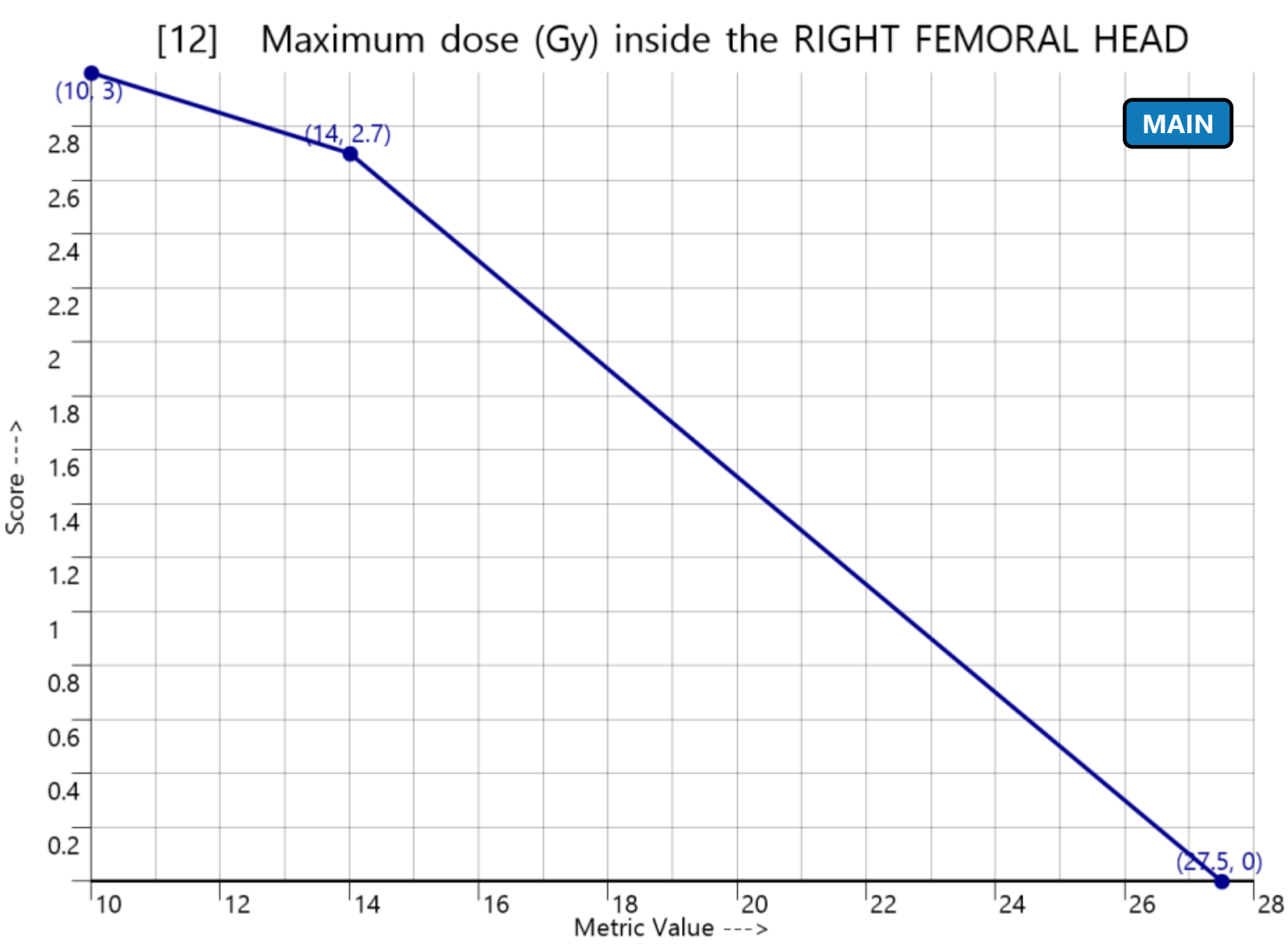

[07] Dose (Gy) covering 40 (%) of the RECTUM
MAIN
(10, 12)
(15, 10)
(20, 0)
Score --->
Metric Value --->
12
11
10
9
8
7
6
5
4
3
2
1
10
11
12
13
14
15
16
17
18
19
20

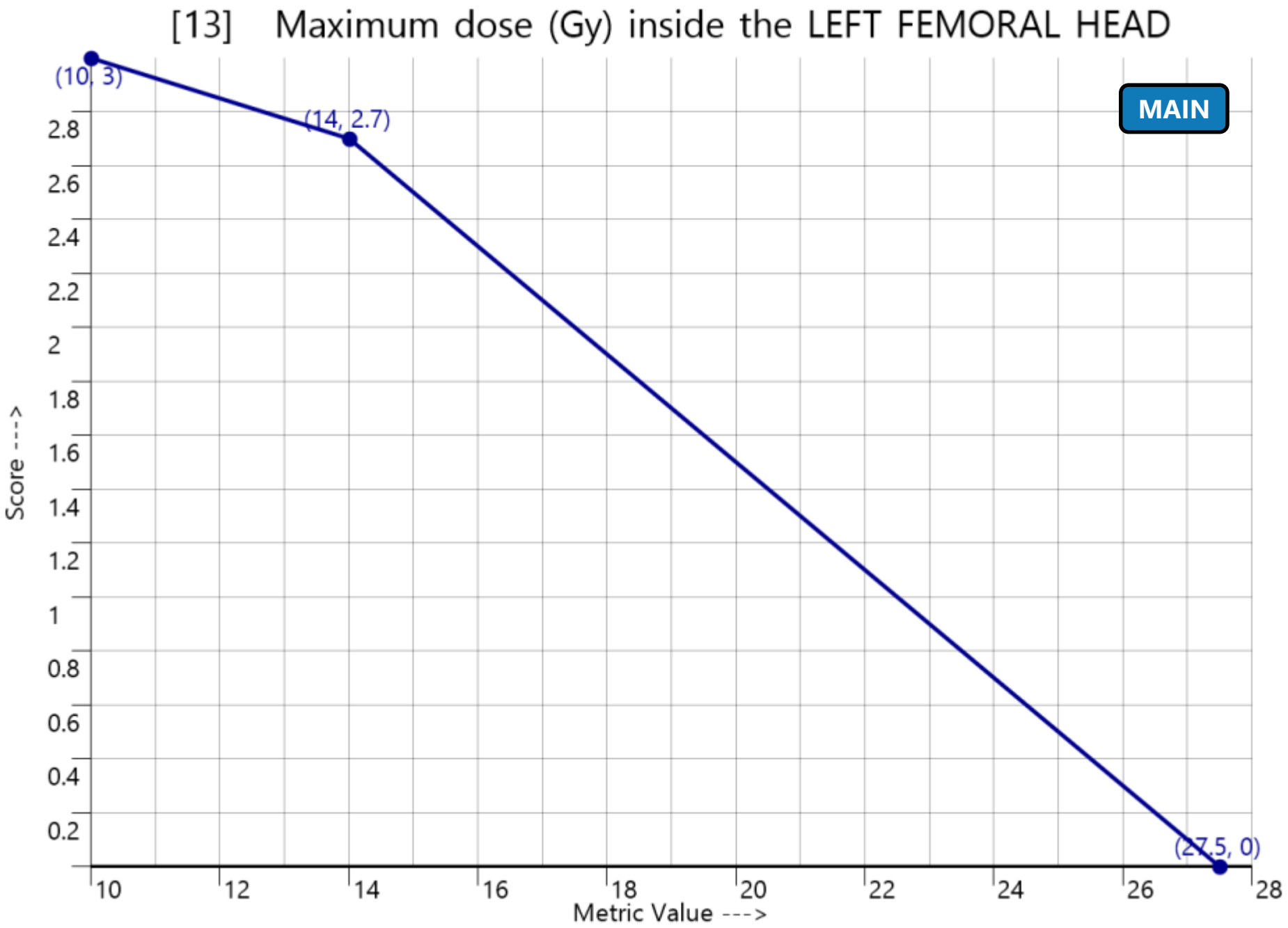

[08] Dose (Gy) covering 20 (%) of the URETHRA
MAIN
(40, 10)
(44, 0)
Score --->
Metric Value --->
1
2
3
4
5
6
7
8
9
40
41
42
43
44

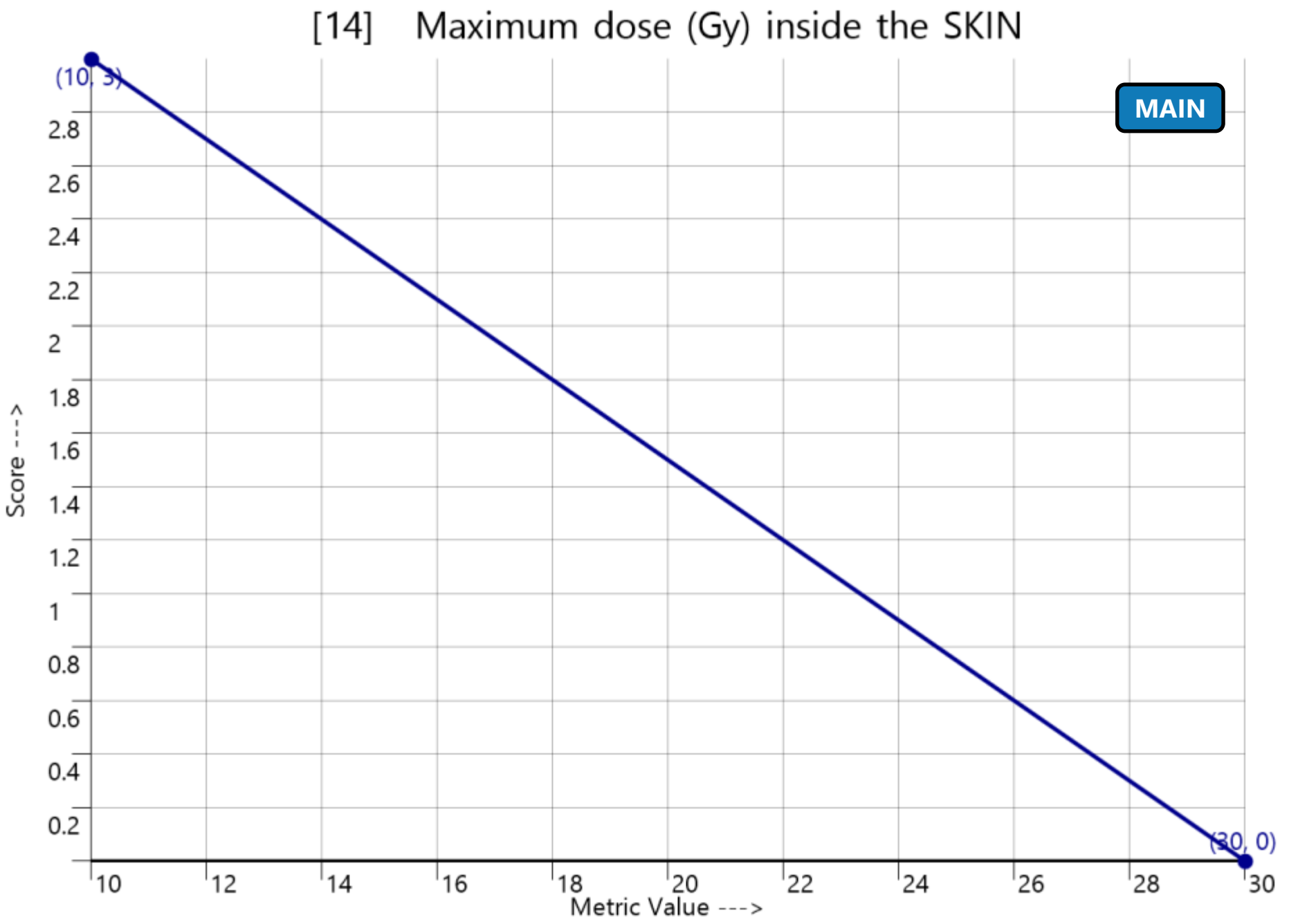

[09] Dose (Gy) covering 1 (cc) of the BOWEL
MAIN
5
4
3
2
1
Score --->
(0, 5)
(30, 0)
0
4
8
12
16
20
24
28
Metric Value --->

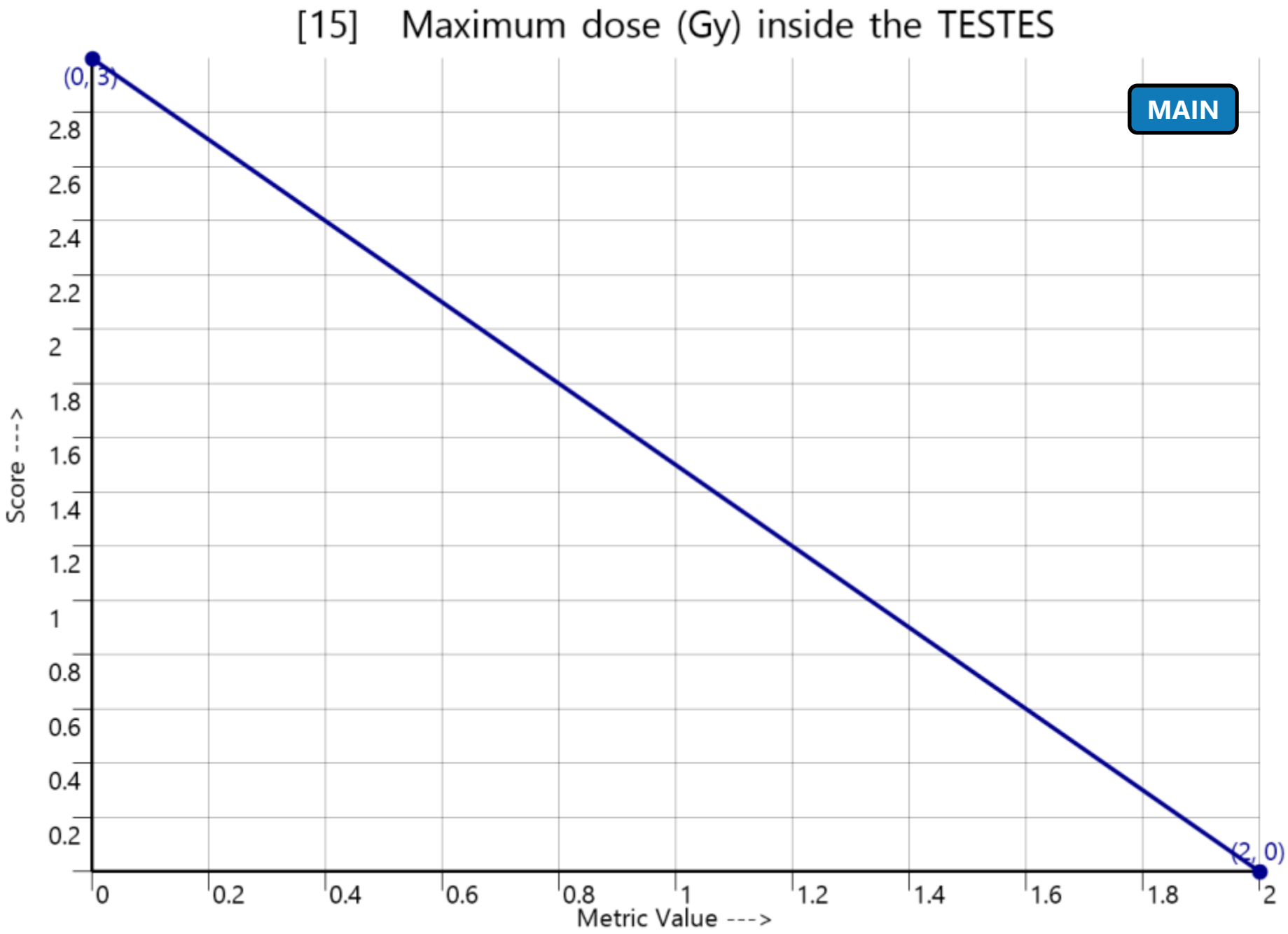

[10] Dose (Gy) covering 0.1 (cc) of the PENILE BULB
MAIN
(10, 3)
(29.5, 0)
Score --->
Metric Value --->
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
10
12
14
16
18
20
22
24
26
28
30


[11] Dose (Gy) covering 50 (%) of the NEUROVASCULAR BUNDLES
MAIN
(37.5, 3)
(40, 0)
Score --->
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
37.4
37.6
37.8
38
38.2
38.4
38.6
38.8
39
39.2
39.4
39.6
39.8
Metric Value --->


[12] Maximum dose (Gy) inside the RIGHT FEMORAL HEAD
MAIN
(10, 3)
(14, 2.7)
(27.5, 0)
Score --->
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
10
12
14
16
18
20
22
24
26
28
Metric Value --->


[13] Maximum dose (Gy) inside the LEFT FEMORAL HEAD
MAIN
(10, 3)
(14, 2.7)
(27.5, 0)
Score --->
Metric Value --->
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
10
12
14
16
18
20
22
24
26
28


[14] Maximum dose (Gy) inside the SKIN
MAIN
(10, 3)
(30, 0)
Score --->
Metric Value --->
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
10
12
14
16
18
20
22
24
26
28
30


[15] Maximum dose (Gy) inside the TESTES
MAIN
(0, 3)
(2, 0)
Score --->
Metric Value --->
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8