THE TROG 2018 PLAN CHALLENGE

5-met single fraction SRS

- TRW Committee and planning challenge sub-group:
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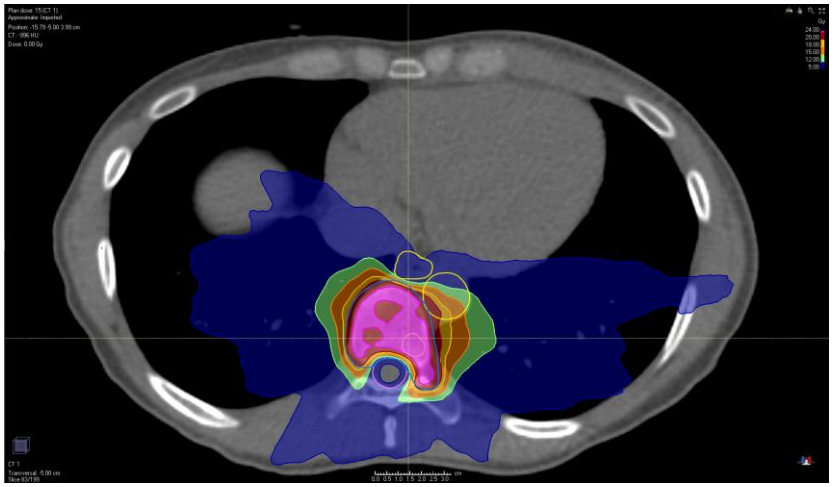
  - Laura O'Connor
  - John Shakeshaft
  - Annette Haworth
  - Olivia Cook
  - Monica Harris
- ProKnow
  - Ben Nelms

Background of the plan challenge

- In 2017, TROG held their first planning challenge, a single fraction spine SABR based on the NIVORAD protocol



- 149 plans from 26 countries were represented

Background of the plan challenge

- The ProKnow Systems team agreed to host a second public plan study for TROG
  - Open from 4 December 2017 – 2 February 2018
  - Open for participation around the world
  - Plan Quality Metrics use for scoring
  - Presentation at the TRW, TROG ASM, March 19th 2018

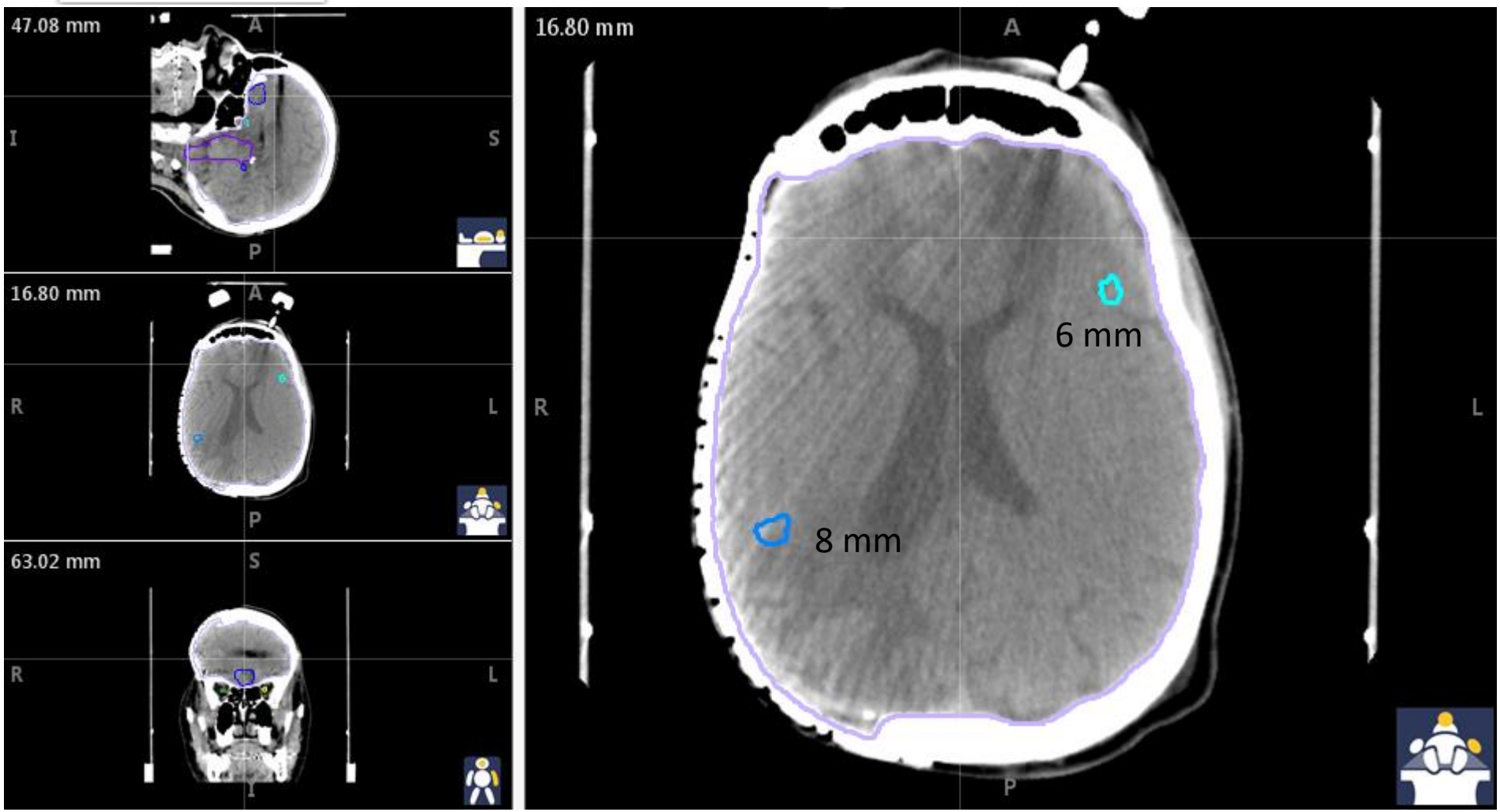
We cannot thank Ben and the ProKnow team enough for helping us again!!!

ProKnow

Building **profound knowledge** to improve patient care

This year's case inspired by Local HER-O

This year's case: Local HER-O

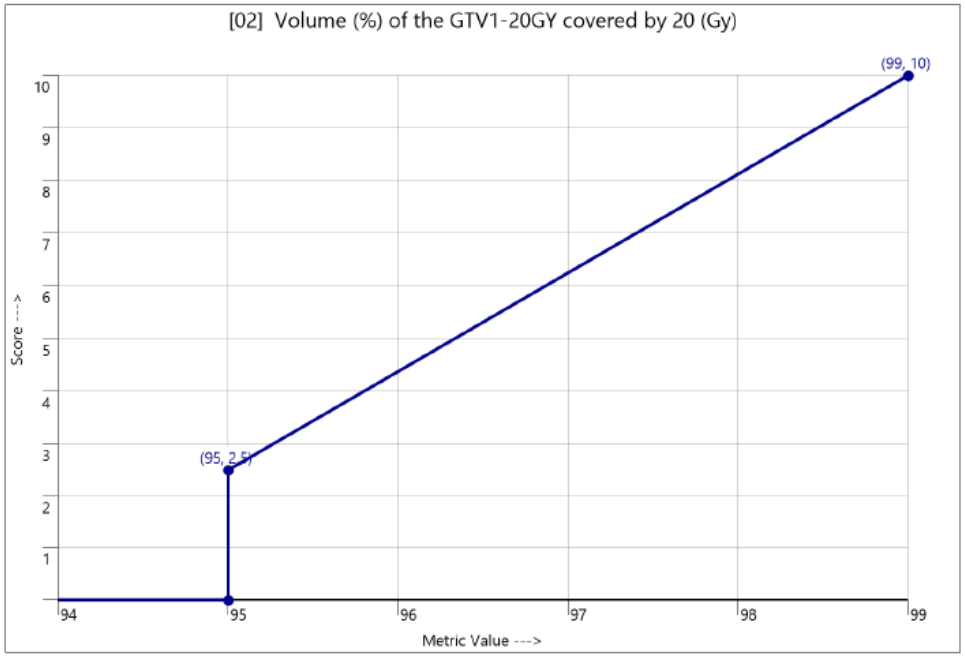


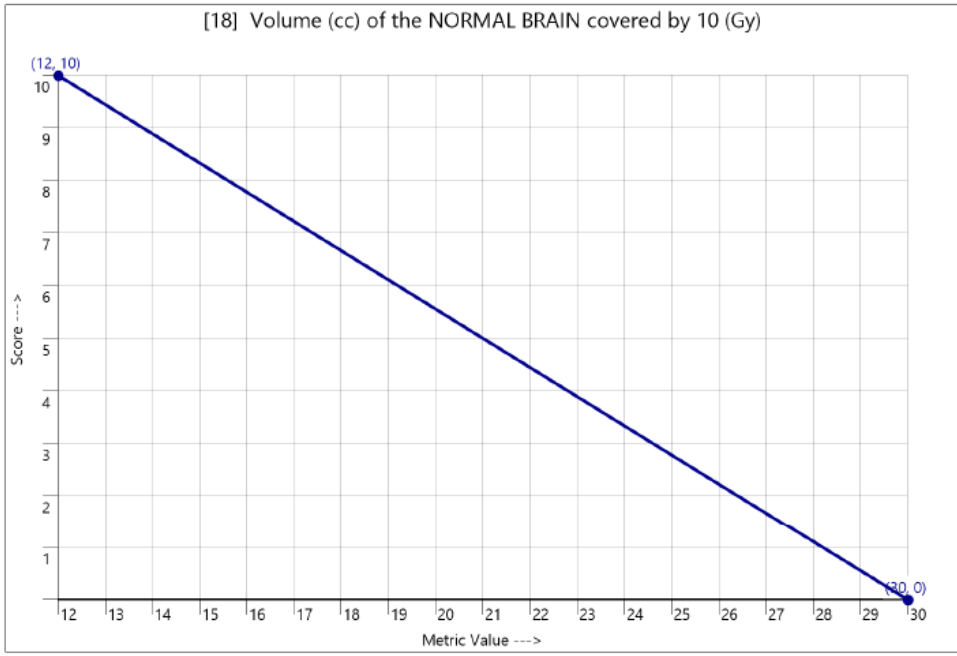
#	METRIC	WEIGHT
1	Structure(s) not fully covered by dose grid	---
2	Volume (%) of the GTV1-20GY covered by 20 (Gy)	10
3	Volume (%) of the GTV2-20GY covered by 20 (Gy)	10
4	Volume (%) of the GTV3-20GY covered by 20 (Gy)	10
5	Volume (%) of the GTV4-20GY covered by 20 (Gy)	10
6	Volume (%) of the GTV5-20GY covered by 20 (Gy)	10
7	Conformation Number [20 (Gy), GTV-TOTAL]	10
8	Conformality Index [20 (Gy), GTV-TOTAL]	2.5
9	Conformality Index [10 (Gy), GTV-TOTAL]	7.5
10	Maximum dose (Gy) to the GTV1-20GY	---
11	Maximum dose (Gy) to the GTV2-20GY	---
12	Maximum dose (Gy) to the GTV3-20GY	---
13	Maximum dose (Gy) to the GTV4-20GY	---
14	Maximum dose (Gy) to the GTV5-20GY	---
15	Maximum dose (Gy) to the BODY	2
16	Structure(s) containing the global max dose point	10
17	Dose (Gy) covering 0.3 (cc) of the BRAINSTEM	10
18	Volume (cc) of the NORMAL BRAIN covered by 10 (Gy)	10
19	Volume (cc) of the NORMAL BRAIN covered by 12 (Gy)	10
20	Volume (cc) of the OPTIC CHIASM covered by 8 (Gy)	5
21	Maximum dose (Gy) to the OPTIC CHIASM	5
22	Volume (cc) of the OPTICNERVE_L covered by 8 (Gy)	5
23	Volume (cc) of the OPTICNERVE_R covered by 8 (Gy)	5
24	Mean dose (Gy) to the HIPPOCAMPUS_L	5
25	Mean dose (Gy) to the HIPPOCAMPUS_R	5
26	Maximum dose (Gy) to the LENS_L	2
27	Maximum dose (Gy) to the LENS_R	2
28	Maximum dose (Gy) to the EYE_L	2
29	Maximum dose (Gy) to the EYE_R	2
30	Number of treatment beams	---
31	Number of unique isocenters	---
32	Number of unique couch angles	---
33	Cumulative meterset over all treatment beams	---
34	Estimated 'beam-on' time, all beams (minutes)	---

72 points for target structures

78 points for target structures

The scoring matrix





Further instructions

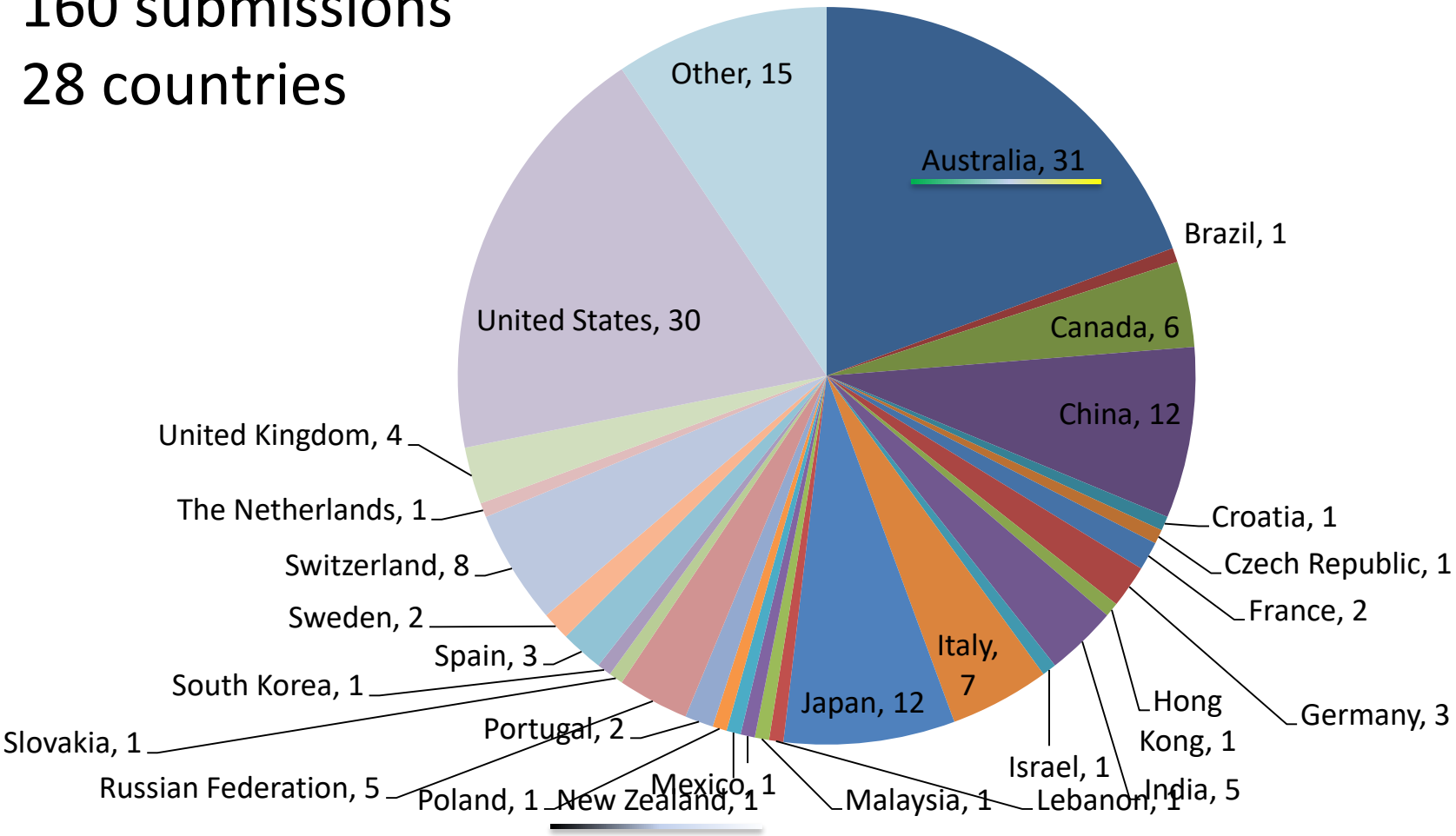
Additional Rules Specific to This Plan Study

1. This is an SRS Brain case with five (5) GTVs, each of which should be treated to 20 Gy in one (1) fraction.
2. This is SRS with small lesions and relatively small overall treated volume, so we require a dose calculation grid of approximately 1 mm x 1 mm x 1 mm spacing.
3. Refer to plan metric appendix for complete rules about plan scoring both overall (composite sum) and per metric.
4. IMPORTANT! The plans you create and submit must be deliverable, i.e., a plan that you would actually consider for patient treatment. For conventional linacs, we anticipate the total treatment monitor units (MU) will be less than ~25. And, of course, the gantry must not collide with the patient. For GammaKnife (with new sources) and CyberKnife, we anticipate treatment times will be less than 120 minutes. You may submit any plan you would treat clinically, but if you get one of the high scores, you may be asked to defend an unusually high MU or number of treatment beams. Ideally, plan study participants will deliver the treatment plan and record the treatment time from first beam on to last beam off.

Zero GTV-PTV margin were used – difference between GK and remaining techniques

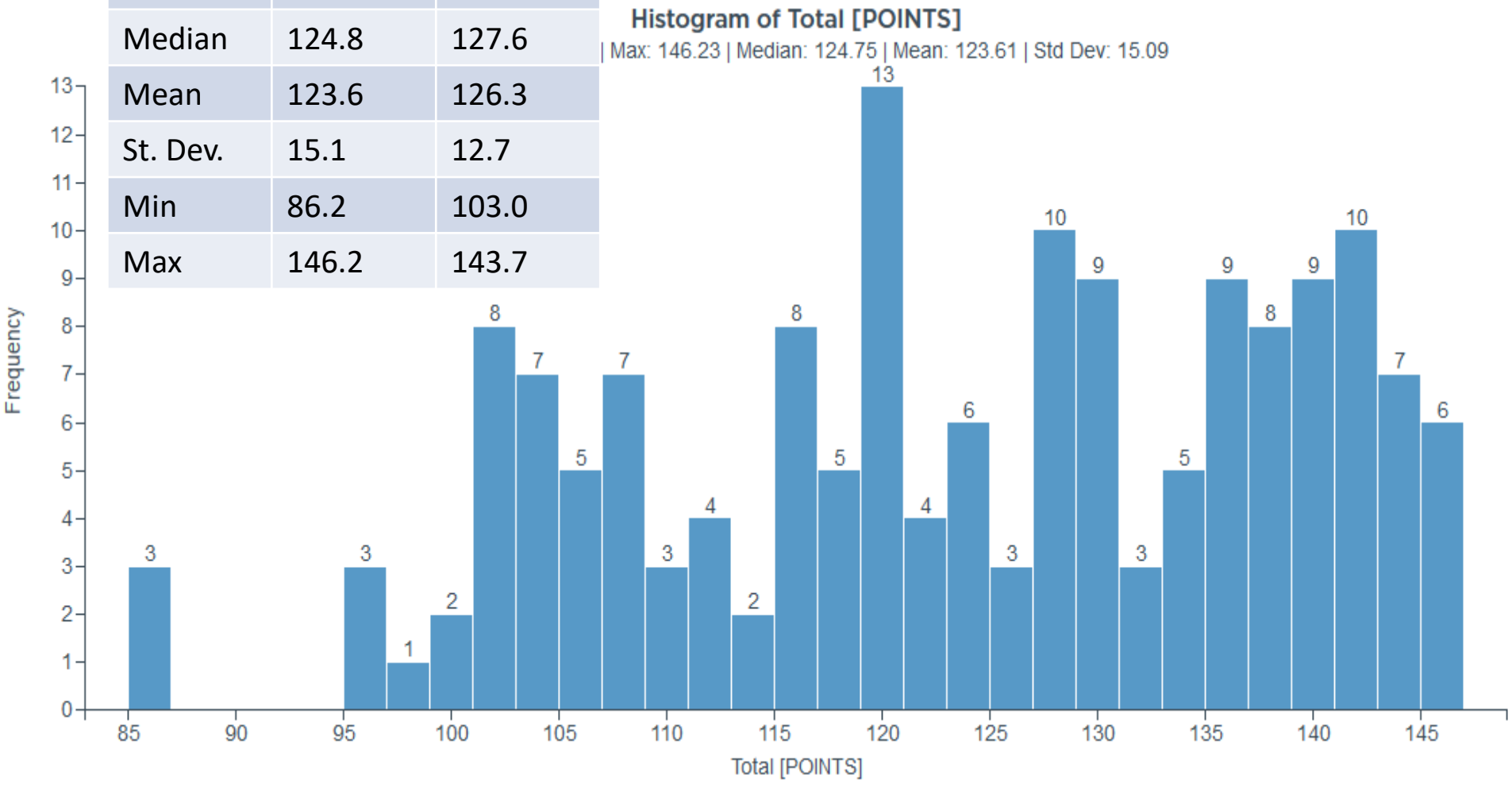
Participation

160 submissions
28 countries



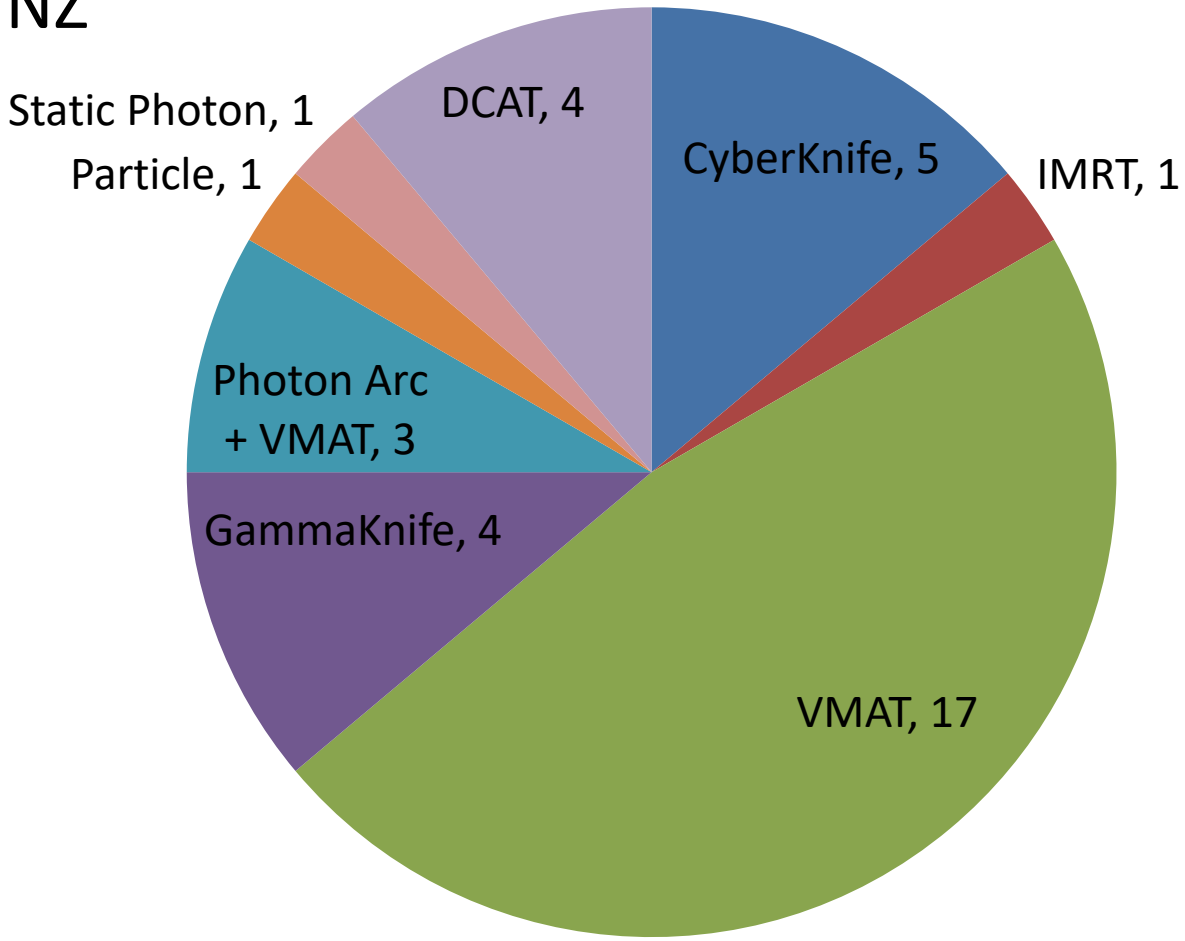
Results: Total score histogram

	Gobal	Au/NZ
N	160	32
Median	124.8	127.6
Mean	123.6	126.3
St. Dev.	15.1	12.7
Min	86.2	103.0
Max	146.2	143.7



Techniques used

Australia/NZ

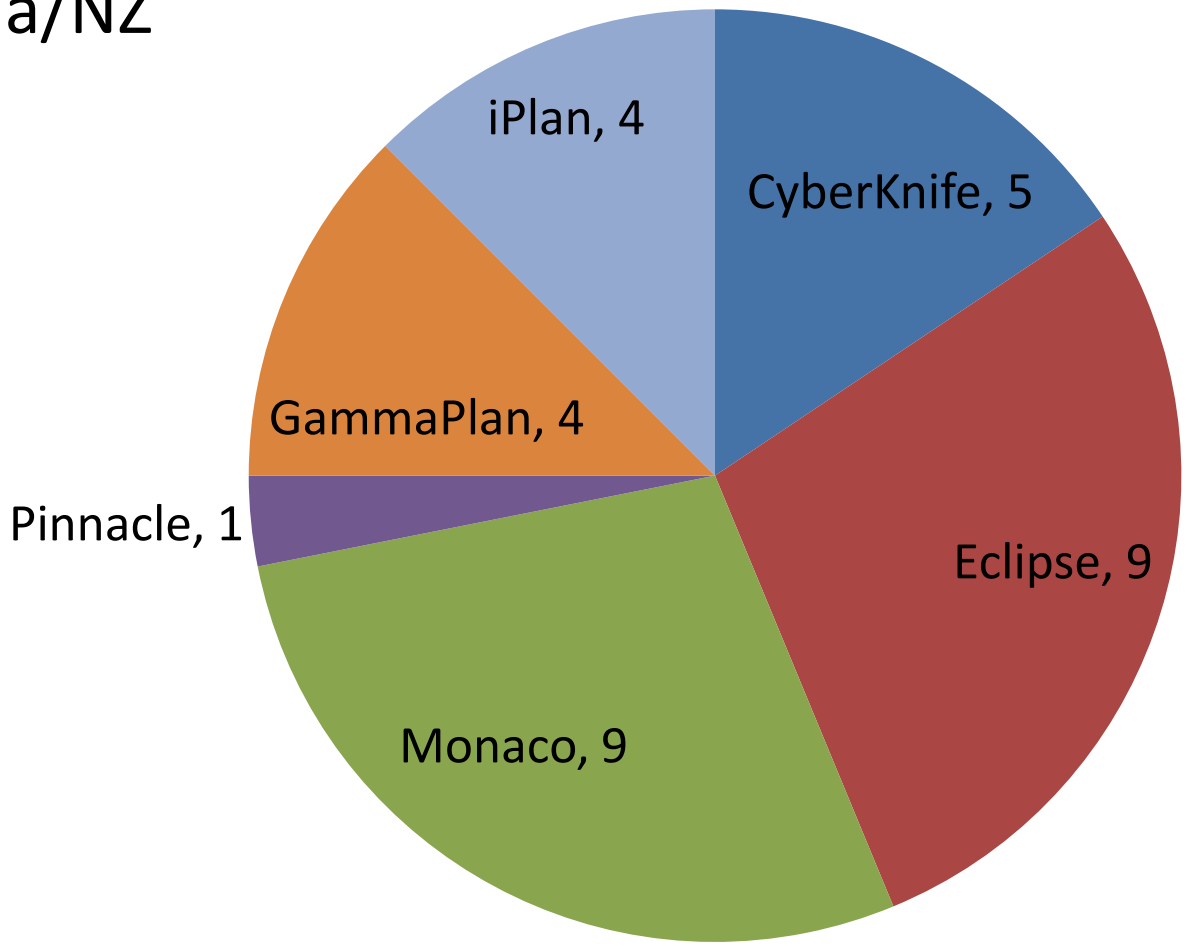


DCAT = Dynamic Conformal Arc Therapy

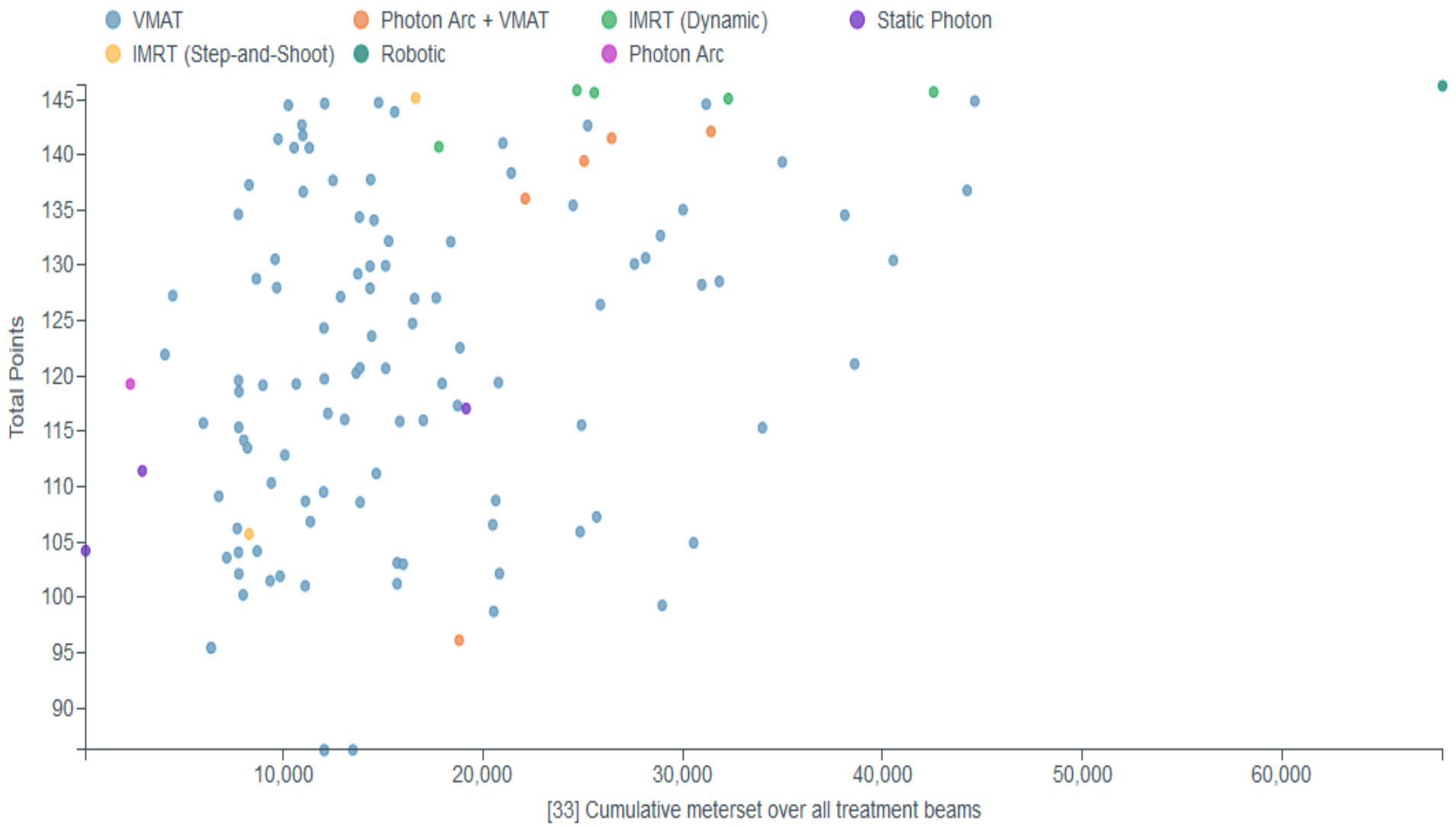
Photon arc = cones

Treatment planning systems

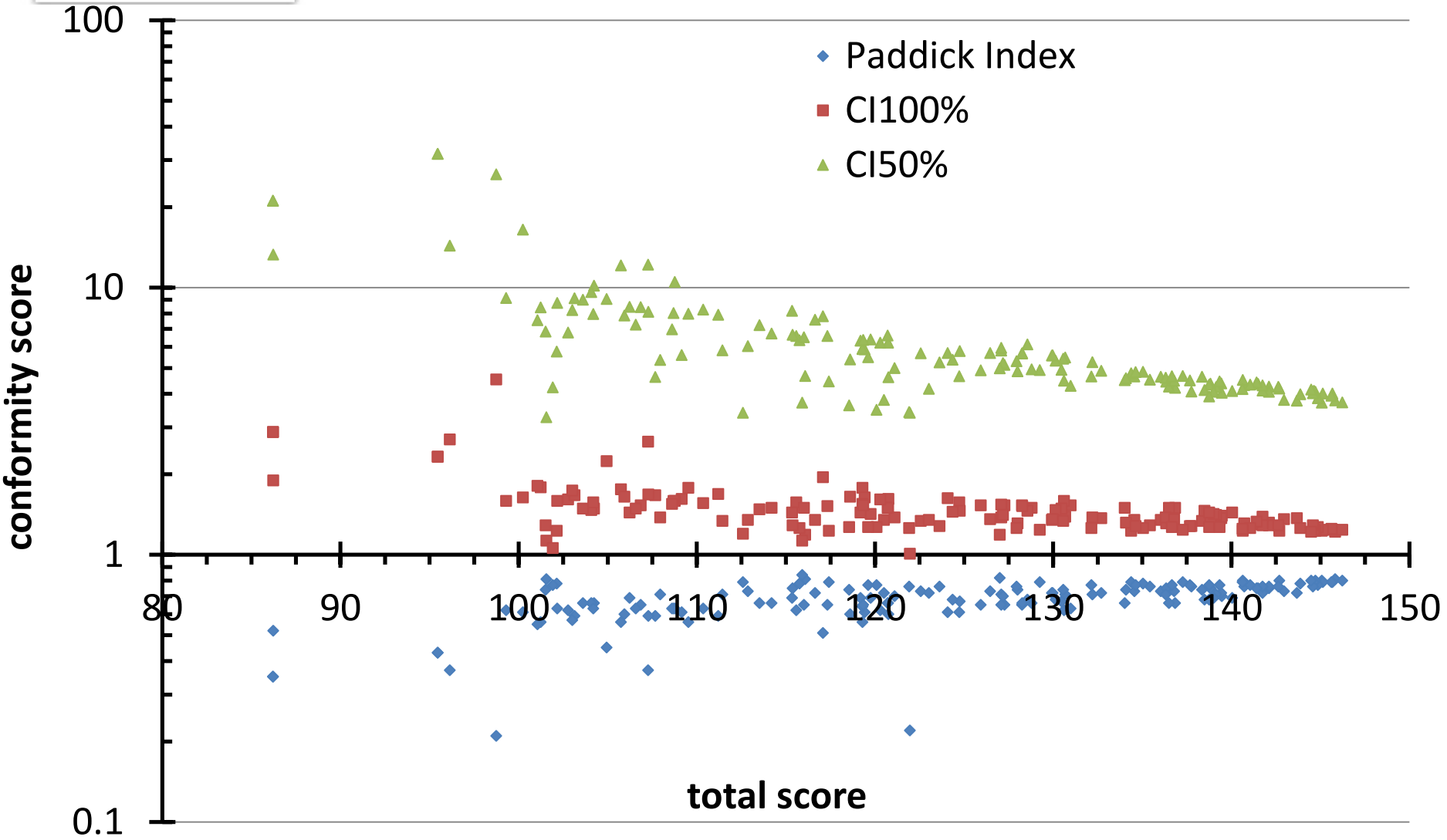
Australia/NZ



Plan score vs Monitor Units

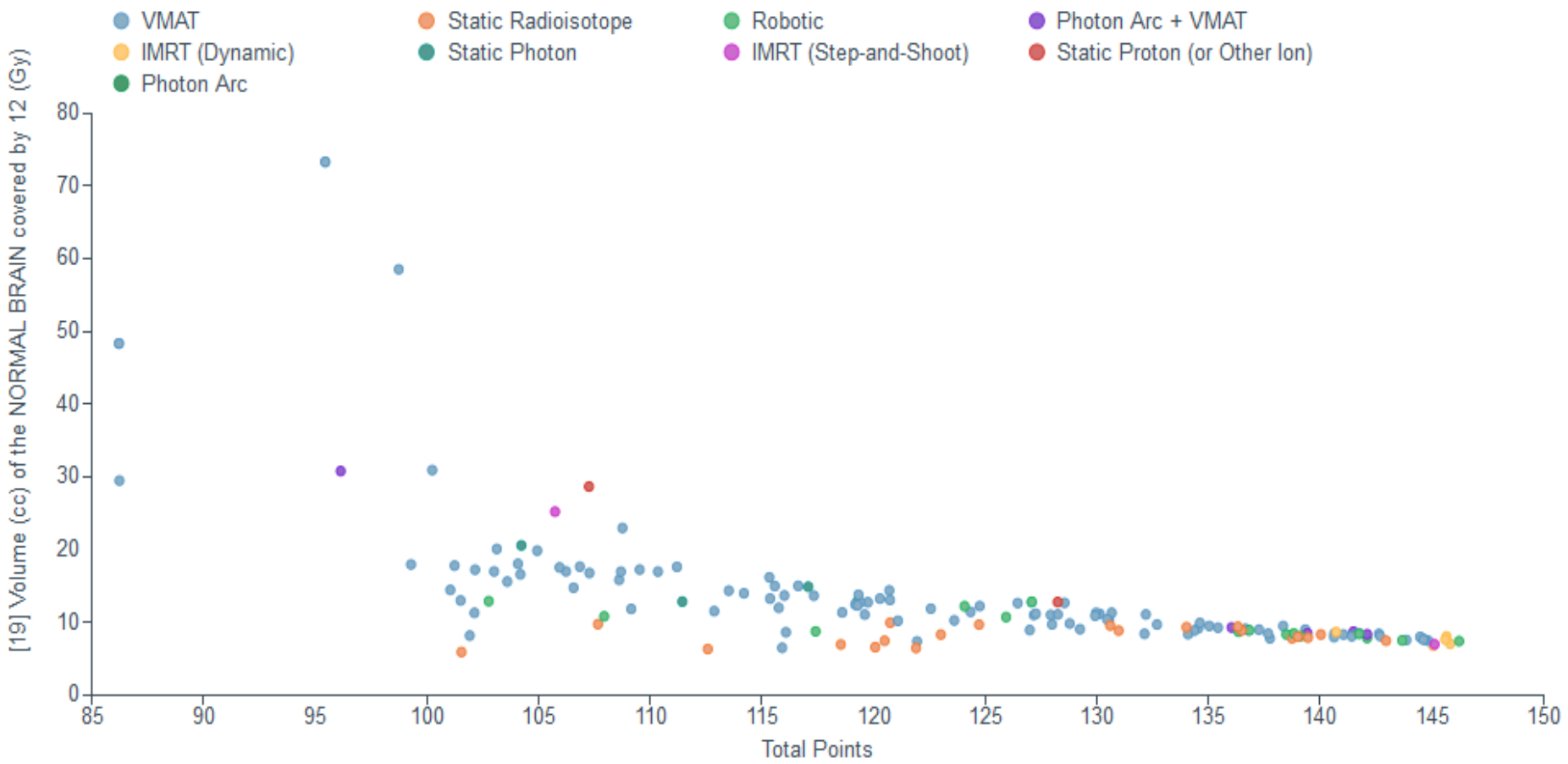


Conformity

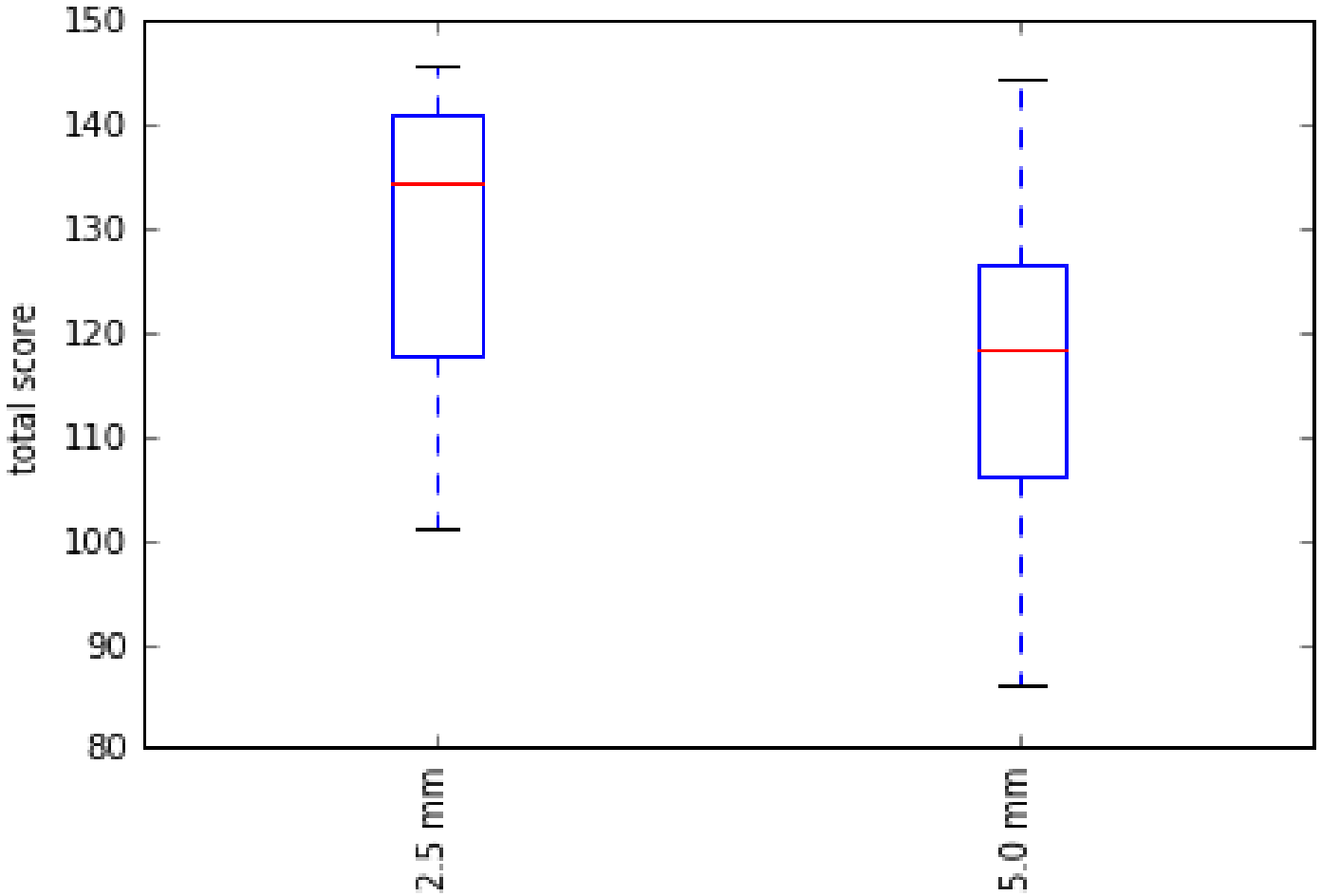

100
10
1
0.1
conformity score
80
90
100
110
120
130
140
150
total score
Paddick Index
CI100%
CI50%

Total score vs Max Dose

Brain V12 Gy vs Total points

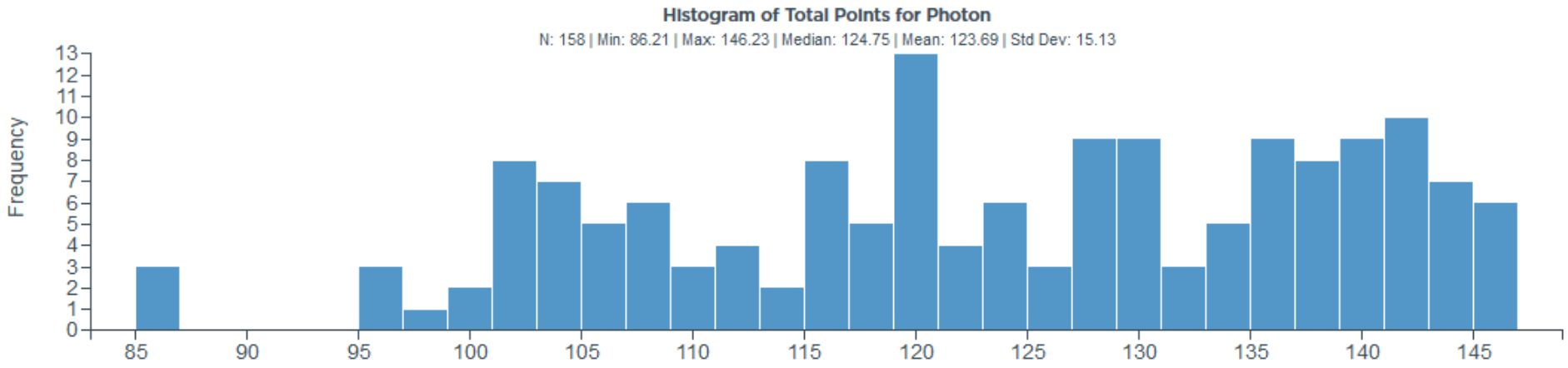


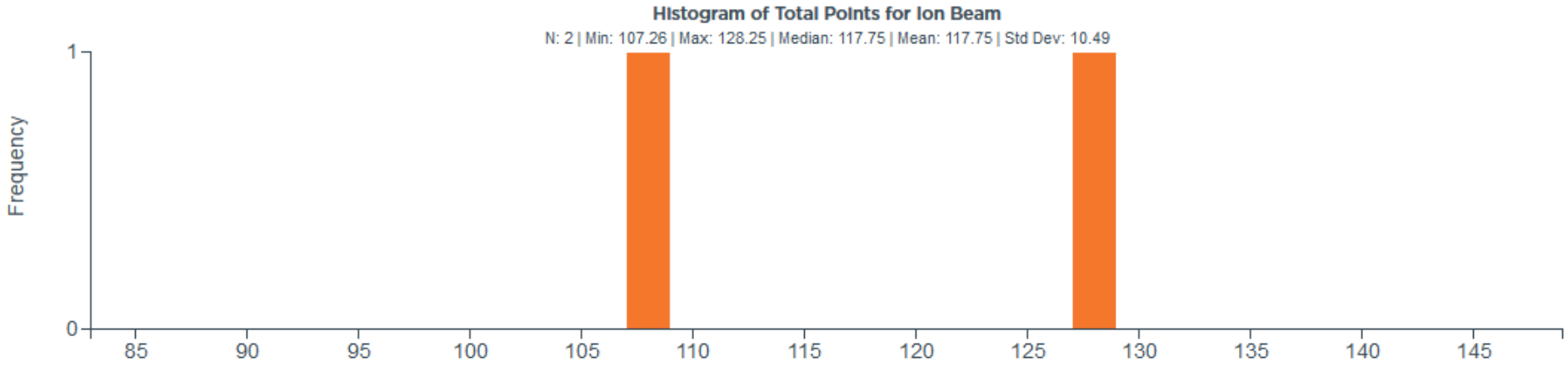
MLC Size: 2.5 mm vs 5.0 mm (all linac plans)



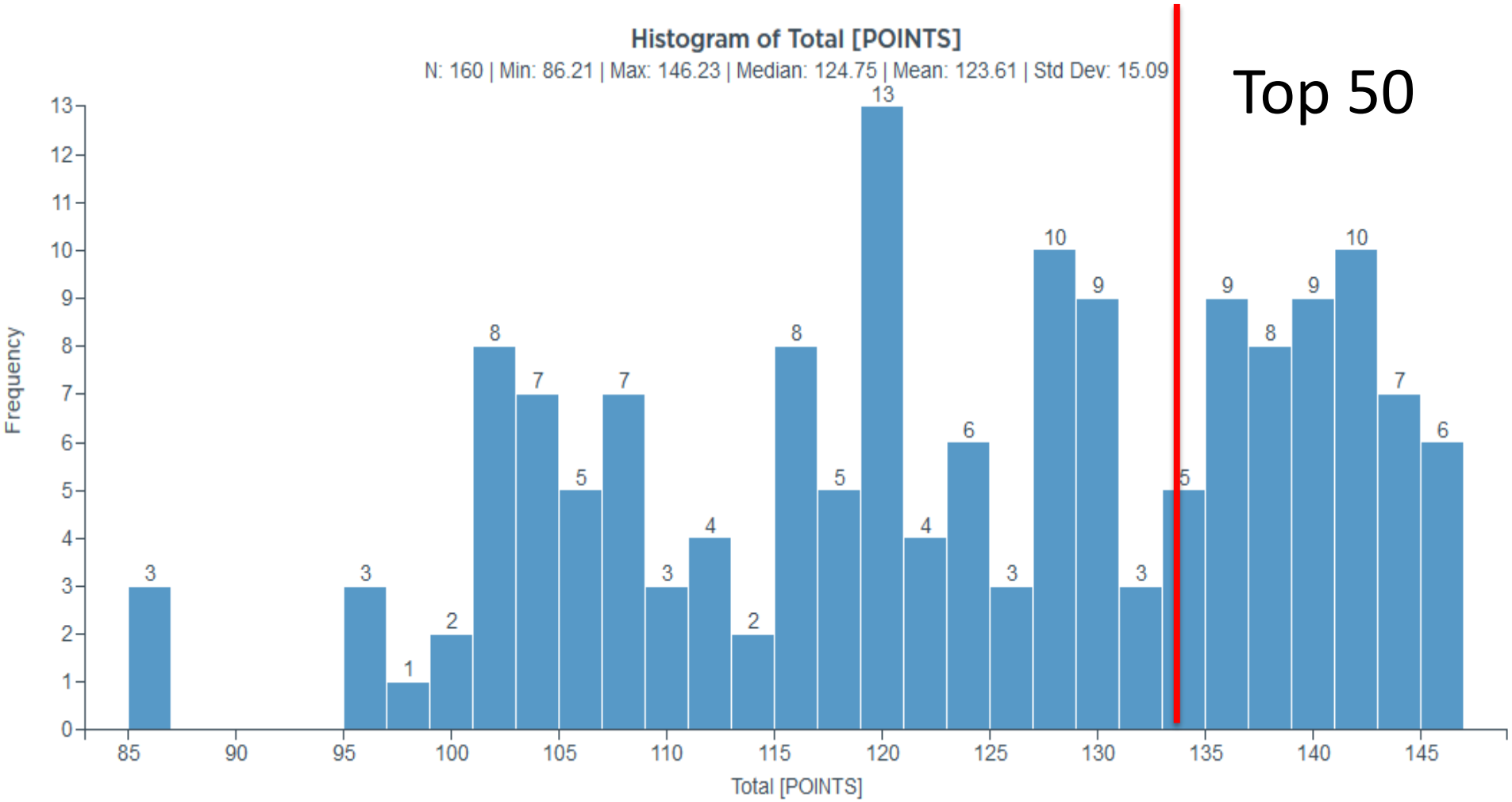
28/33 linac plans in top 50 were 2.5 mm MLC

Photon vs Proton



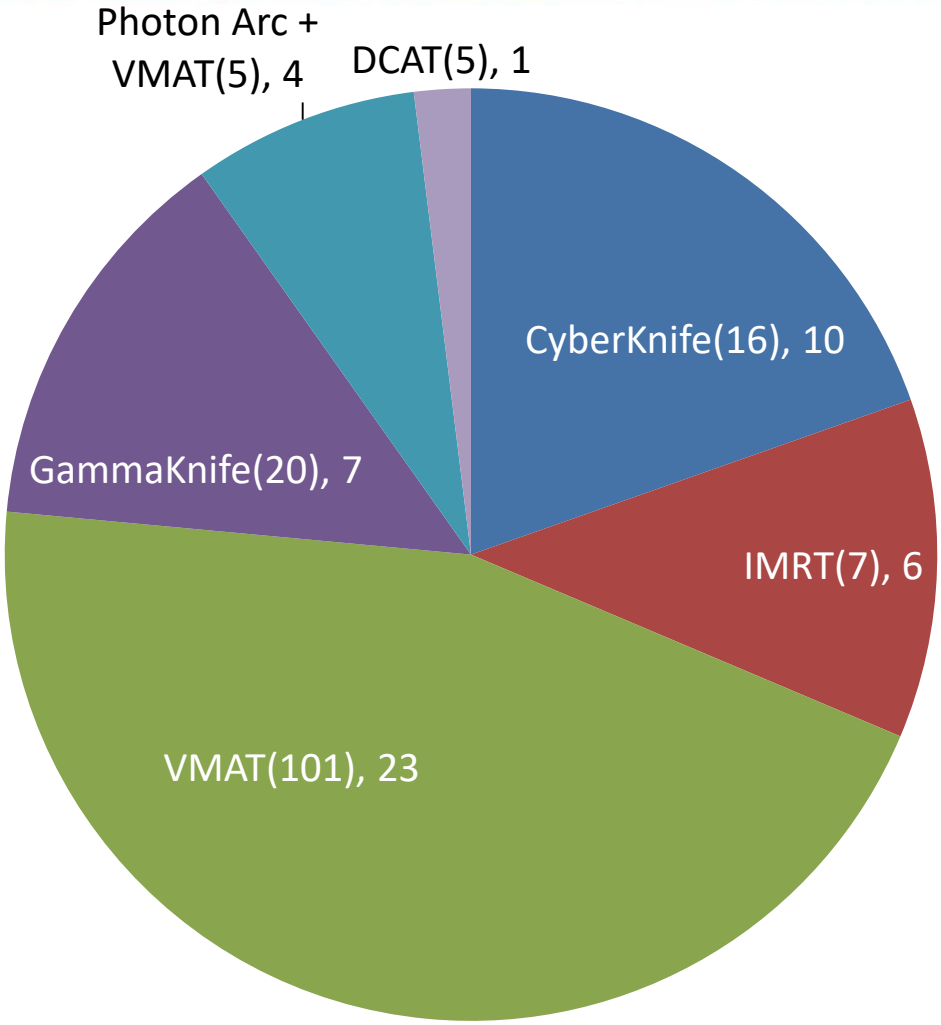


The Top 50

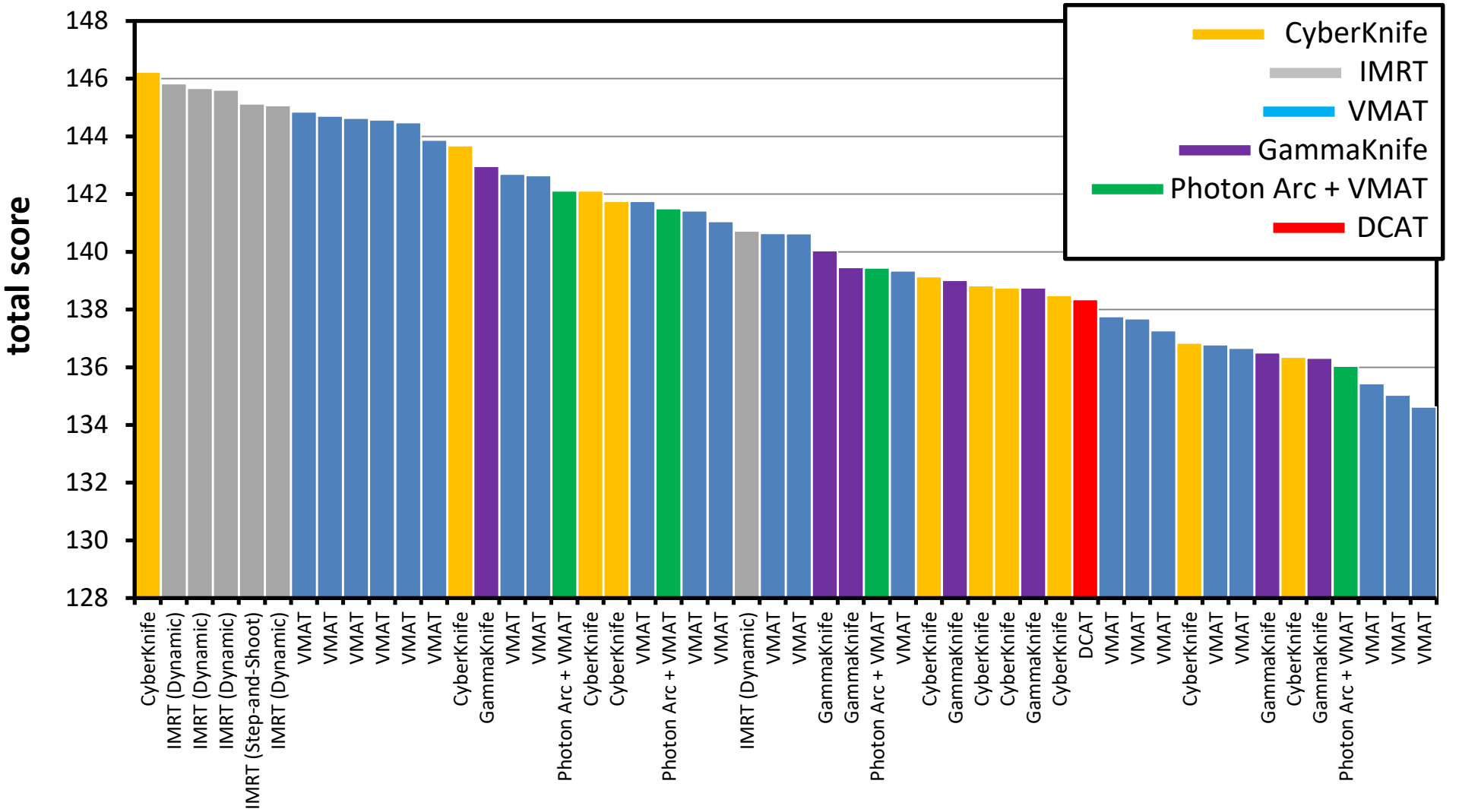

Histogram of Total [POINTS]
N: 160 | Min: 86.21 | Max: 146.23 | Median: 124.75 | Mean: 123.61 | Std Dev: 15.09
Top 50
Frequency
Total [POINTS]
0
1
2
3
4
5
6
7
8
9
10
11
12
13
85
90
95
100
105
110
115
120
125
130
135
140
145
3
3
1
2
8
7
5
7
3
4
2
8
5
13
4
6
3
10
9
3
5
9
8
9
10
7
6

Top 50 by technique

Number in brackets is number of total submissions



Top 50: By technique



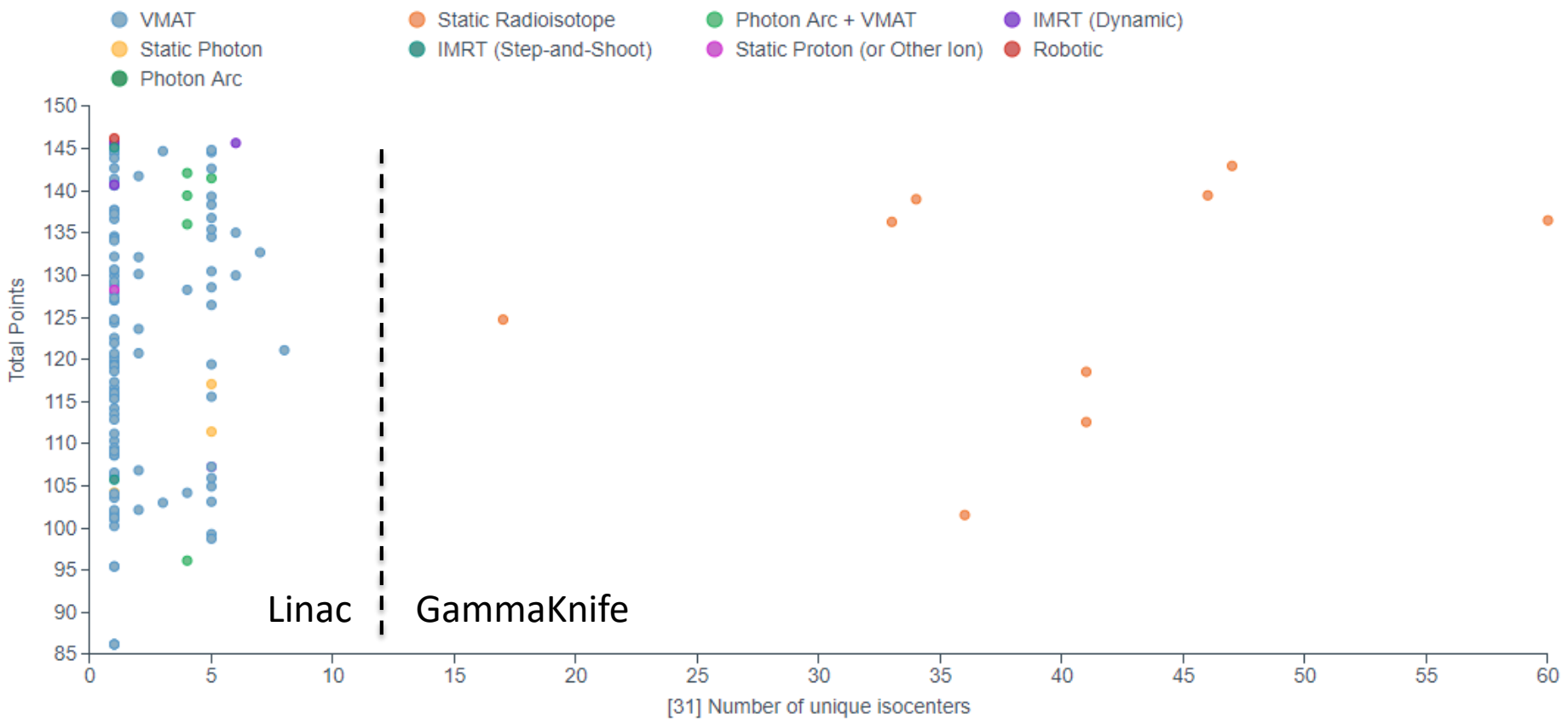
Top 50 Linac: # Isocentres (linac)

Compare

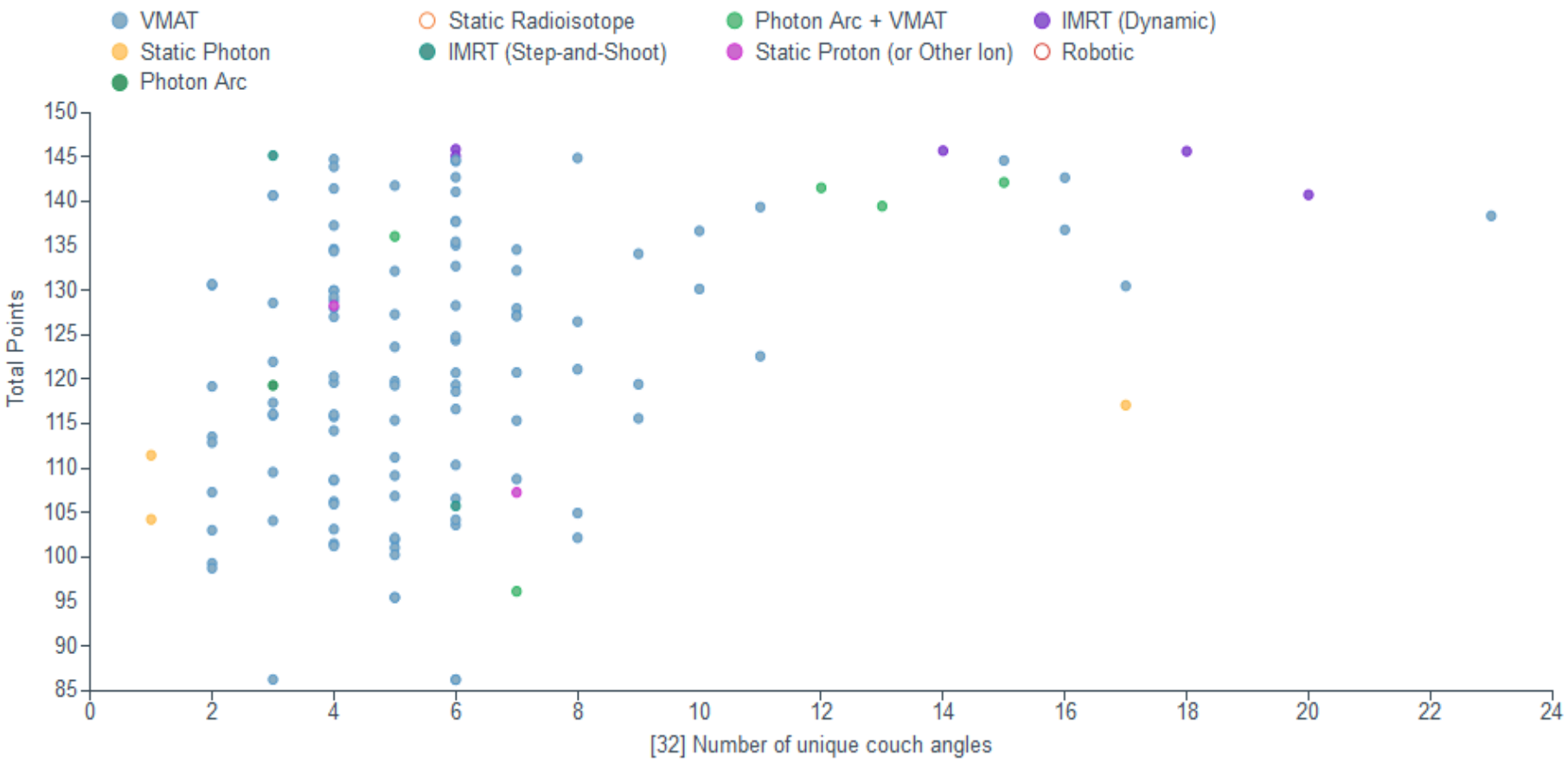
Group By: Delivery Type(s)

X: [31] Number of unique isocenters

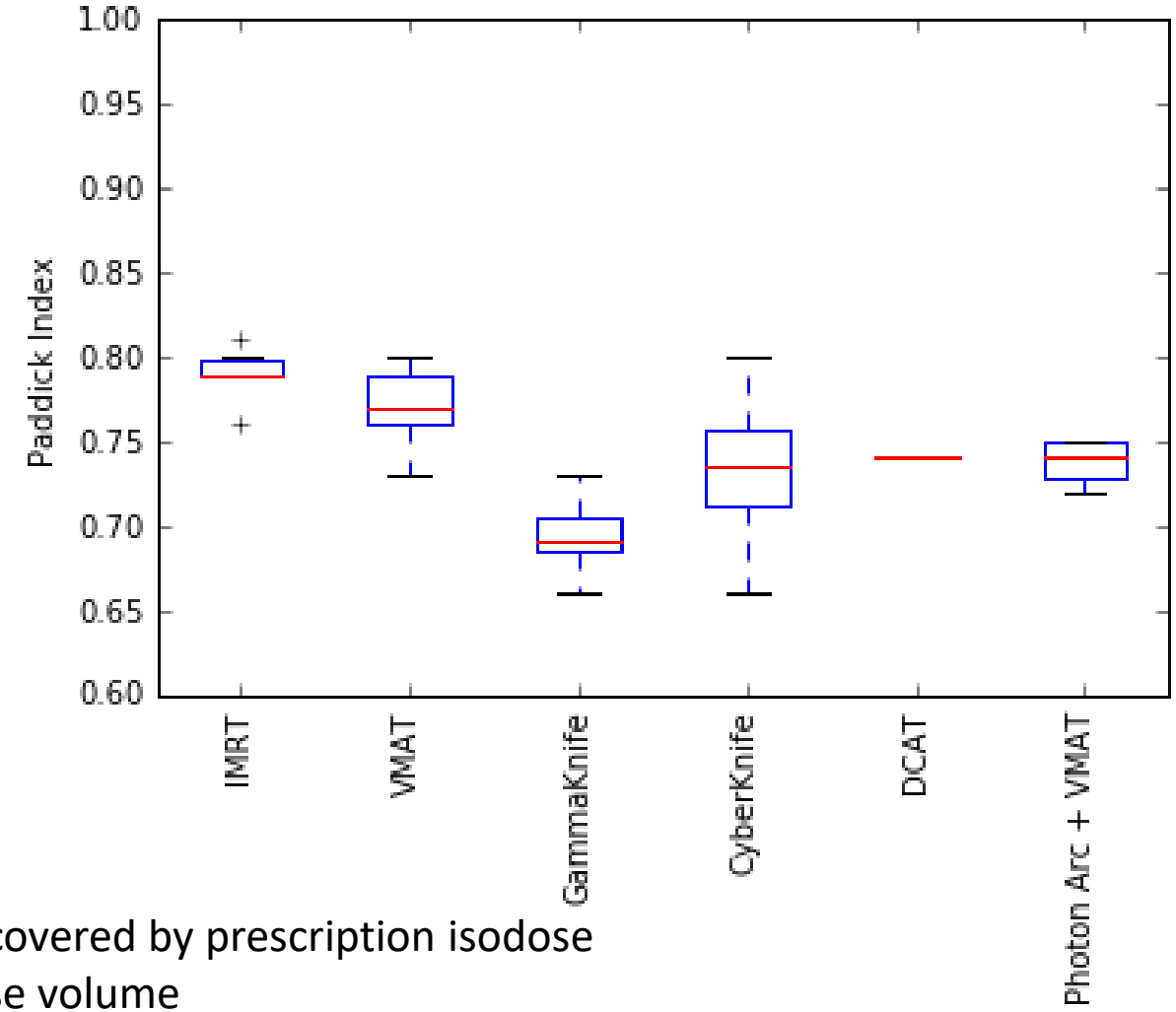
Y: Total Points



Top 50: Couch angles (linac)



Top 50: Paddick Score (larger is better)



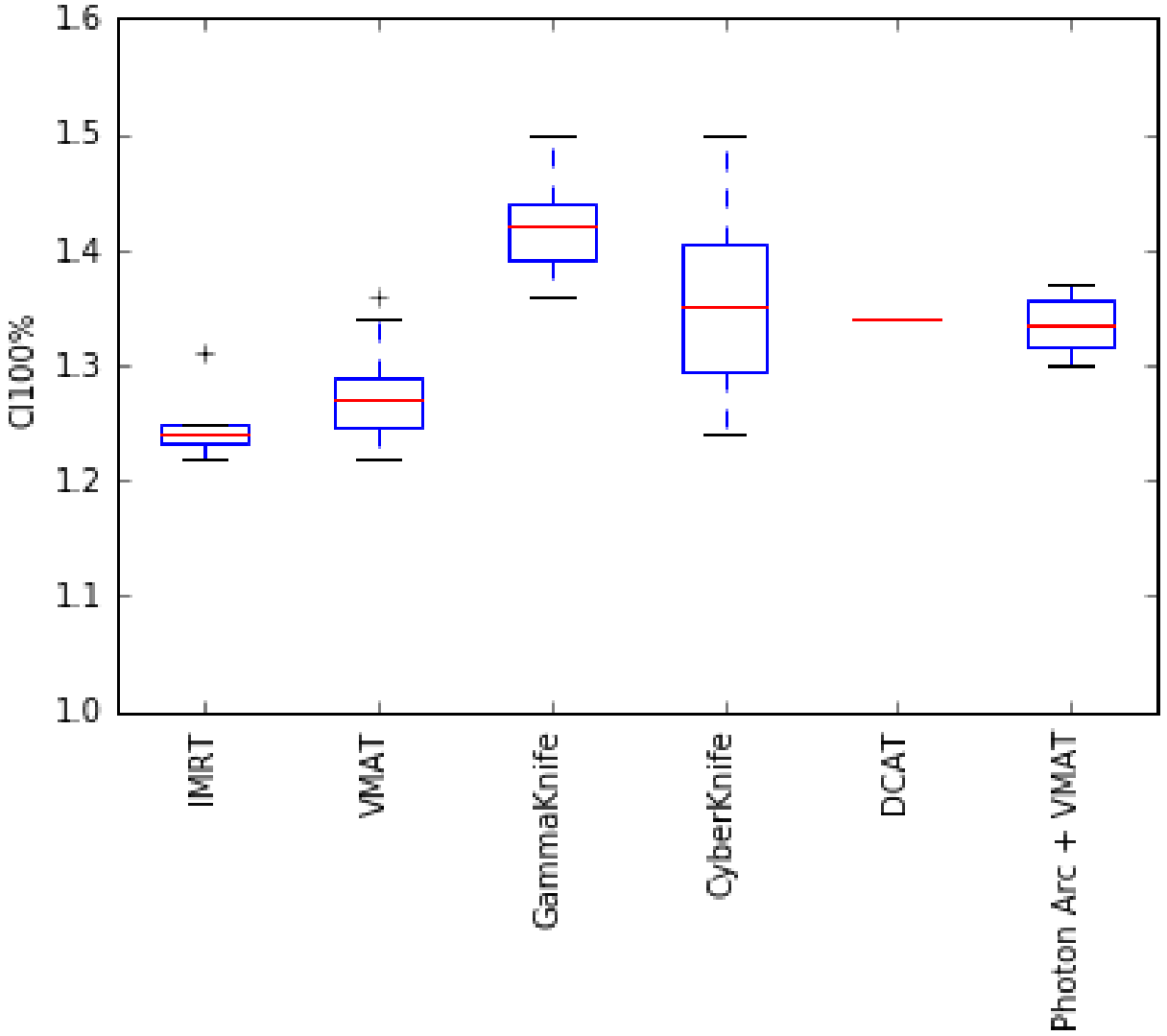
$TVPIV^2/[PVxTV]$

TVPIV = Target volume covered by prescription isodose

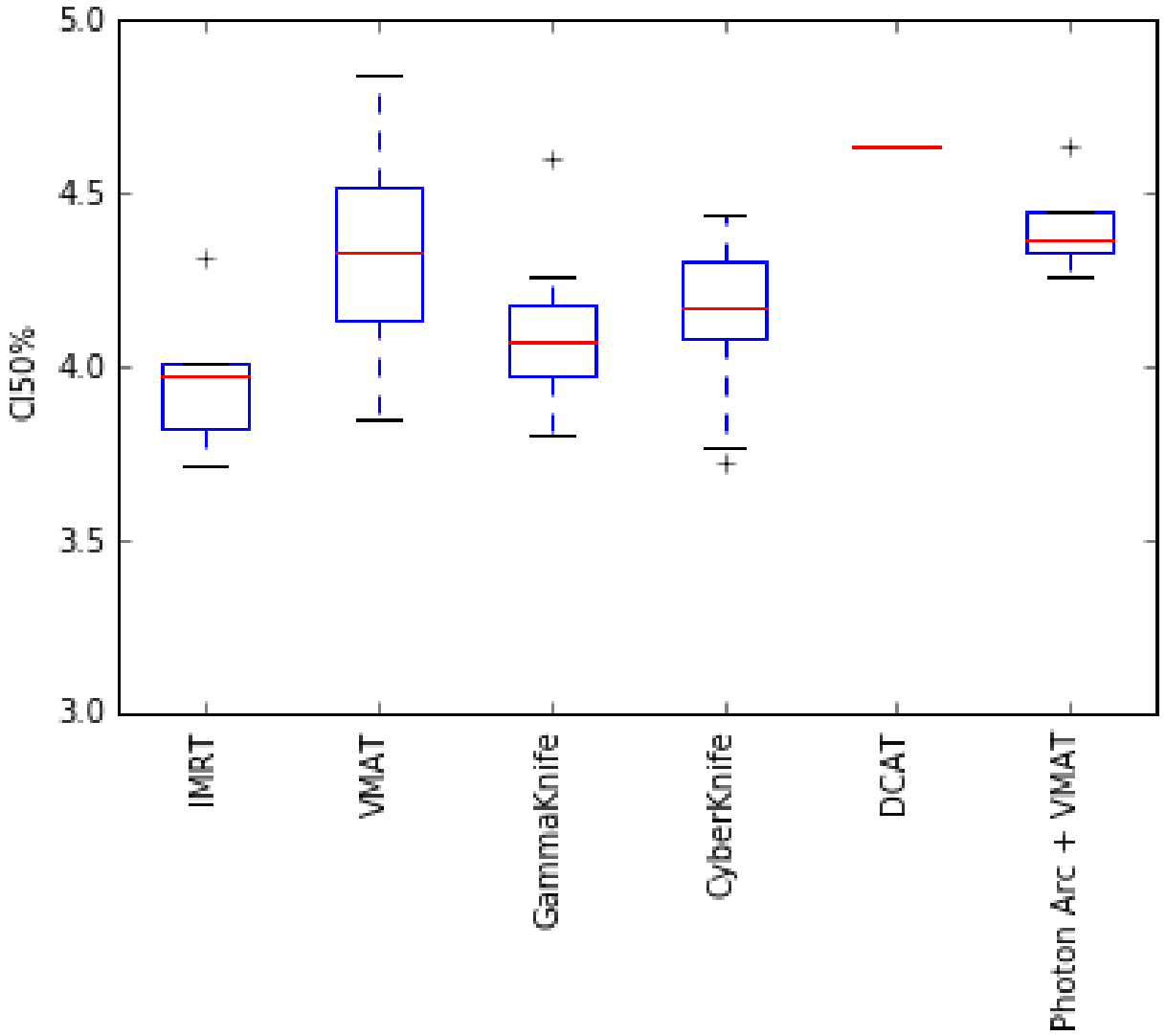
PV = Prescription isodose volume

TV = Target volume

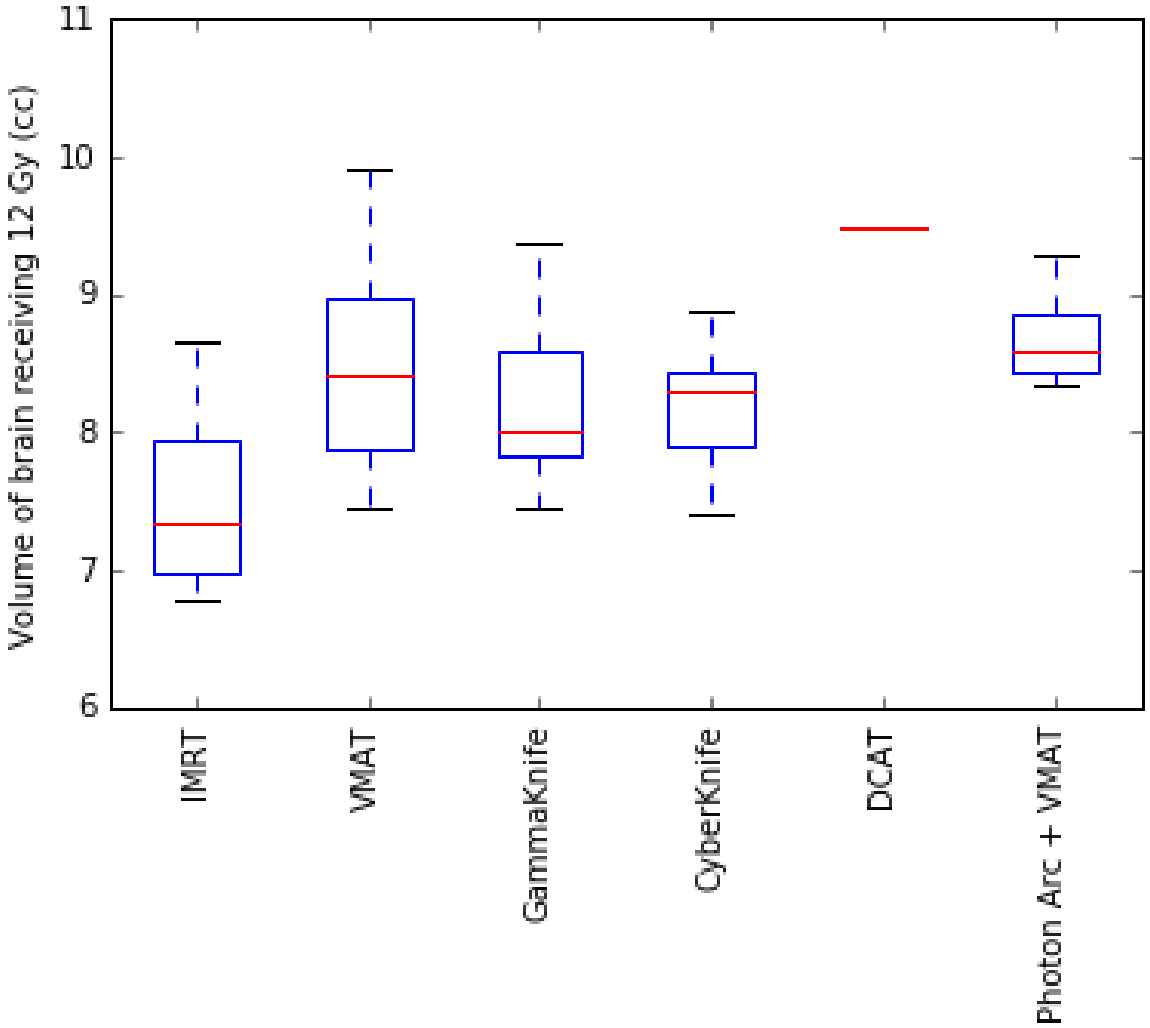
Top 50: CI100% (smaller is better)



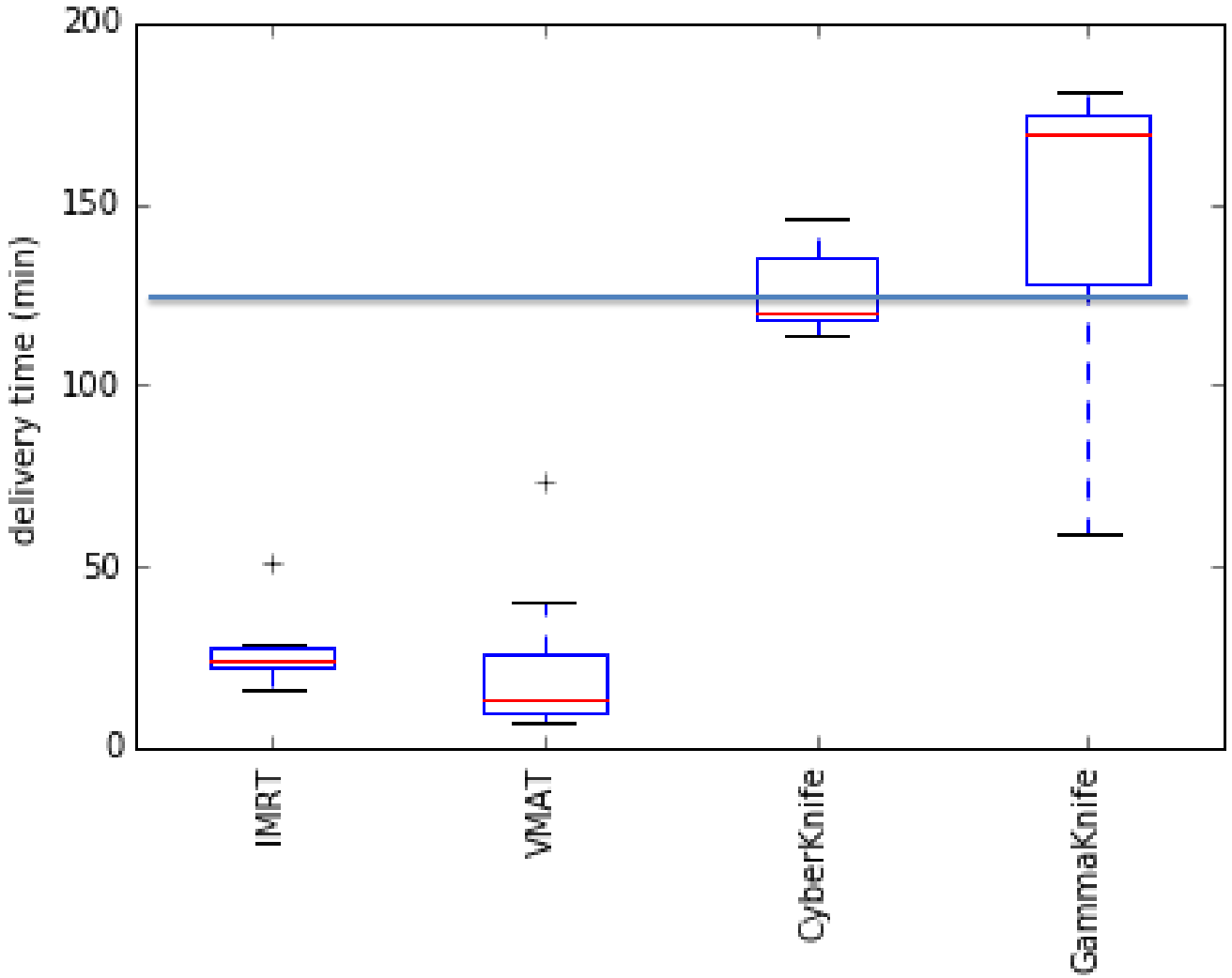
Top 50: CI50% (smaller is better)



Top 50: Normal brain receiving 12 Gy

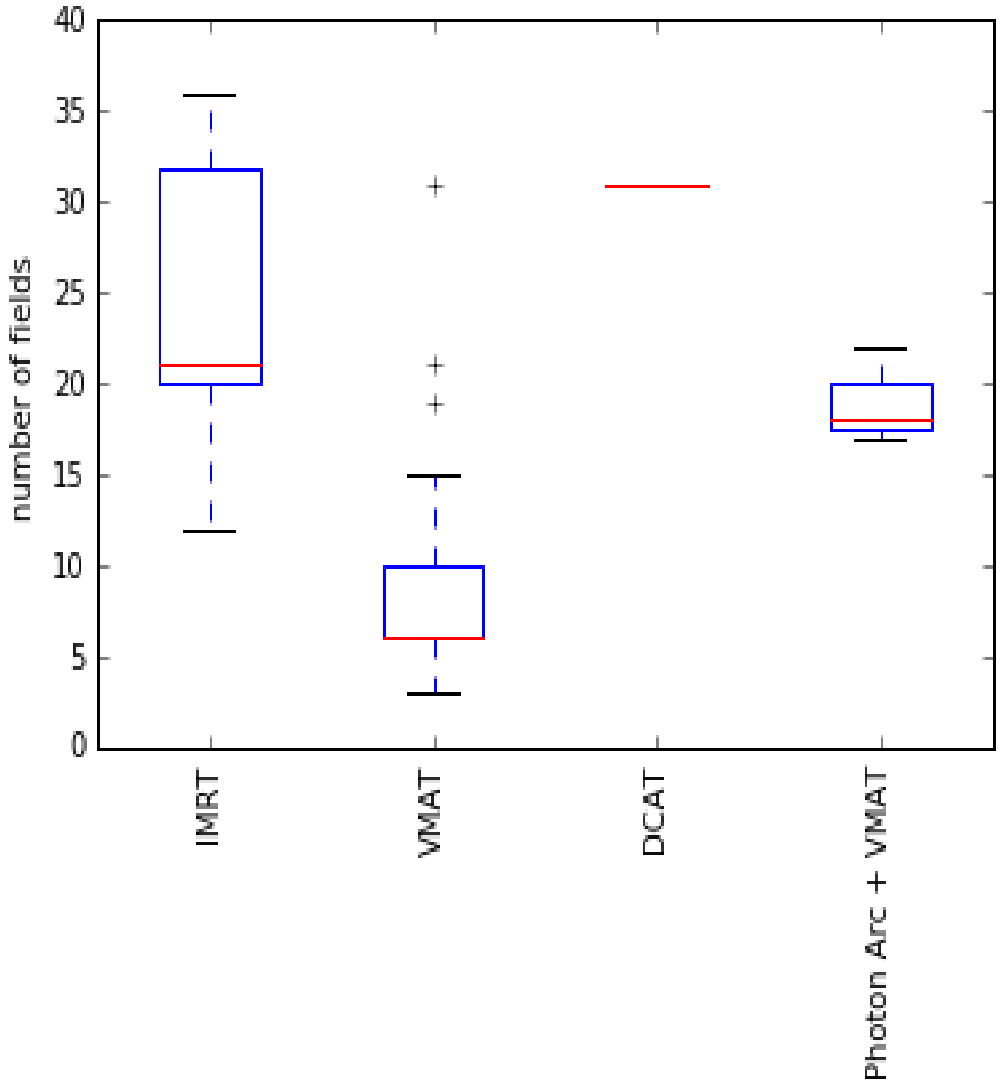


Top 50: Treatment Time

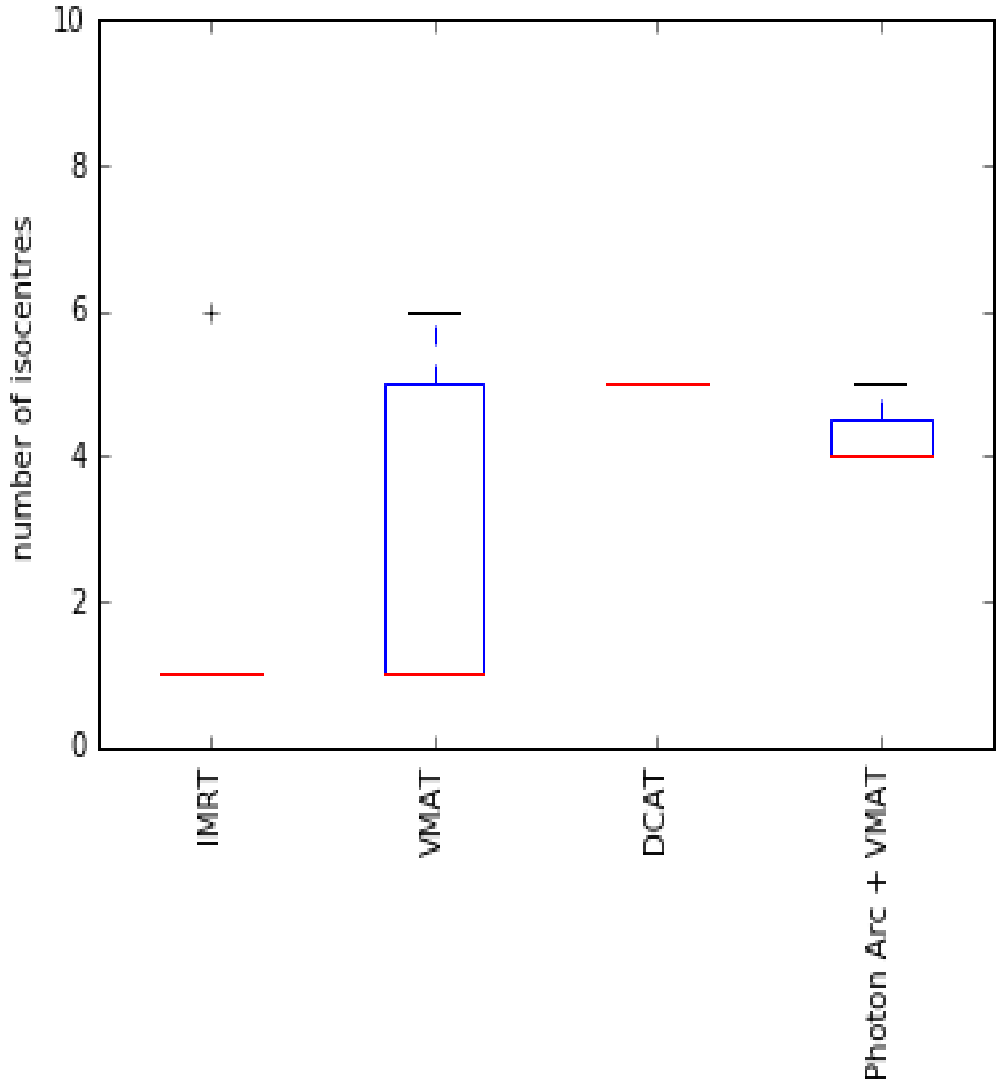


2 hours

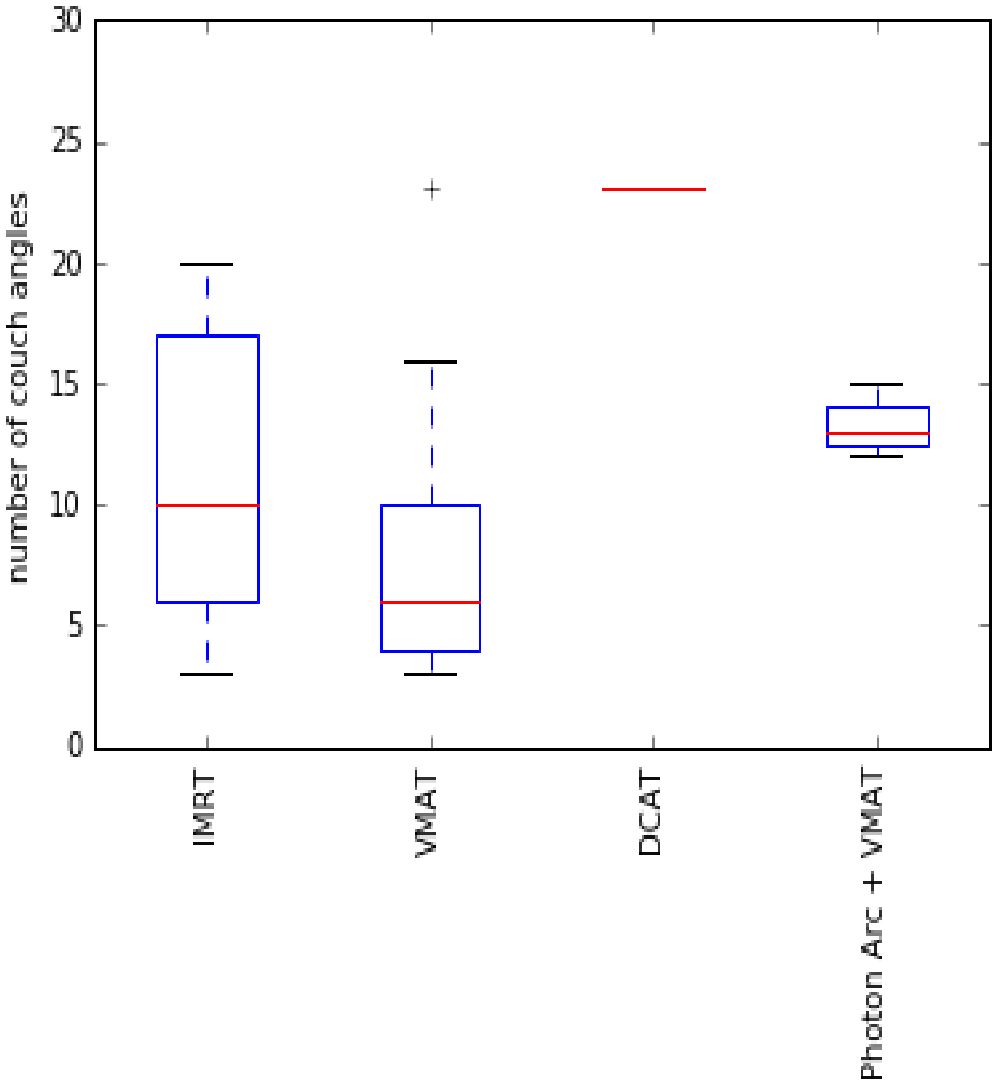
Top 50: Number of fields (linac)



Top 50: Number of isocentres (linac)



Top 50: Number of couch angles (linac)



Top Performers: Australia/NZ

Alphabetical order!

Alan Brown	Sir Charles Gairdner Hospital	CyberKnife
Andrew Le	Royal North Shore Hospital	VMAT
Ben BH YAP	Sir Charles Gairdner Hospital	CyberKnife
Clare Porteous	Elekta	Photon Arc + VMAT
Daniel Papworth	Genesis Cancer Care	VMAT
David Stewart	Prince of Wales Hospital	Photon Arc + VMAT
Elsebe Kirkness	Sir Charles Gairdner Hospital	CyberKnife
James O'Toole	Royal North Shore Hospital	VMAT
Julius Ambat	NSW Health	Photon Arc + VMAT
Michael Jenkins	Princess Alexandra Hospital	Static Radioisotope
Peter Devlin	Sir Charles Gairdner Hospital	CyberKnife
Shaun Graydon	Varian	VMAT

Practical Feedback

Feedback from the

Top 5 ANZ highest scorers …

1. What special preparation did you have to carry out to the anatomy?

e.g. add, or edit the supplied contours? Create special contours for optimisation?

Response 1 Linac: No additional contours were used for the final plan. Initially tried creating surrounding volumes to improve dose conformity but that was done just as well without the extra contours.

Response 2 CyberKnife: There were a couple of structures I had to create. Firstly, as we only use a thermoplastic mask for our brain patients on the CyberKnife I contoured everything outside of the body and assigned that density of zero so it didn't affect the plan. The other structures I created were "shells", in the multiplan system shells can be auto-generated from the target volumes and can be used to achieve a desirable dose drop off. One shell was created 2mm outside the PTVs and this is assigned the prescription dose, 20Gy, and a further shell was created at 10mm and assigned a smaller dose to try and force the dose to drop off quite rapidly.

Response 3 Linac: Body minus 10Gy structure used for optimisation: I created a 10Gy dose structure from a high scoring plan and then removed this structure from the Body. Using this as an optimisation structure with upper objectives helped to tighten the 10Gy spread of dose even further on subsequent plans.

Response 4 CyberKife: The total of GTVs were added together to create a sumGTV tune volume.

Response 5 GammaKnife: No

3. What was your approximate score on your first plan attempt?

Response 1 Linac: First score was around 100.

Response 2 CyberKnife: My first score was approximately 136

Response 3 Linac: 110

Response 4 CyberKife: Can't remember...

Response 5 GammaKnife: 139 from memory

4. Approximately how much time did you spend to get your final plan? Roughly how many iterations of scoring on ProKnow?

Response 1 Linac: I'd say it was about 10 submissions of entirely different plans. Each plan took about 1 hour but that was in between waiting for the TPS to optimise and my normal clinical load. The TPS was regularly left overnight to optimise.

Response 2 CyberKnife: I spent approximately 2 days all up planning and uploaded about 5 plans

Response 3 Linac: 15 - 20 hours - 1mm dose calc grid with our calculation speeds slowed the process down significantly. Probably 20-30 iterations of scoring on Proknow.

Response 4 CyberKife: Can't remember. Maybe a week. Can't remember how many iterations. Many

Response 5 GammaKnife: ~ 1 hr 20 mins before I loaded my first plan and then ~ 2.5 hrs more fine tuning my score. So ~ 4 hrs Total & ~ 8 iterations

5. What techniques did you use to improve your score from your first attempt to your final submission?

Response 1 Linac: I spent a bit of time on refining the cone sizes I used. The majority of the improvements were made in really pushing the VMAT plans and assessing where the TPS was finding conflicts and adjusting to work around them.

Response 2 CyberKnife: In order to improve my score I changed my avoidance structures, with brains we generally tell the system not to give any dose through the mouth or the eyes. However, as the one of the lesions is sitting behind the eye I used the lenses as the avoidance structure allowing a few extra beams to go through the eyes which gave better coverage and the dos to the eyes remained well under tolerance. I also allowed a higher maximum to be delivered to the PTVs, leading to a higher max dose within the PTV and a very sharp fall off outside it.

Response 3 Linac: Tuning Rings, Norming individual mets, NTO

Response 4 CyberKife: N/A

Response 5 GammaKnife: For those familiar with Gamma knife: Repositioning & adjusting weights on individual shots. Two of the targets I adjusted the Gamma Angle. This is particularly useful for reducing dose to the optics. It can also be useful for reducing dose between targets. Selecting individual shots to block a sector or sectors to either reduce dose to an OAR or for shaping purposes. This is a little time consuming but an experienced planner will more often than not produce a superior result to the inverse planning option. Ie when fine tuning the quality of your plan.

6. Any other relevant information/words of wisdom about this plan you may like to share with your peers?

Response 1 Linac: Really study the geometry closely before starting planning, take your time to figure out the beams that will and won't work for you. Don't be afraid to start over from a clean slate if you don't feel like you are making improvements on each iteration.

Response 2 CyberKnife: The CyberKnife allows for a wide variety of positions for the dose to be delivered, the treatment times can be long but it allows for very conformal plans and very rapid dose drop off. Keeping things simple for the system allows it to create a very good plan, I only add in specific organ at risk dose constraints when required after reviewing the initial optimisation.

Response 3 Linac: MU suppression was used to keep MU's down There is a limit of ten arcs for Eclipse VMAT optimisation. This meant that mets had to be optimised in different plans and then used as base plans in the overall plan.

Response 4 CyberKife: N/A

Response 5 GammaKnife: I could have reduced the overall treatment time by replacing a few smaller shots with larger shots without really compromising the plan. As I said above: Changing the Gamma angle is certainly worth considering to reduce dose to OARs and when lesions are adjacent as you can reduce dose to the health brain tissue between the lesions.

Plans to review

- #1:146.23: Top CK and Top Overall
- #2:145.83: Single iso, 6 floor, 24,000 MU IMRT
- #12:144.48: 6 field, 1 iso, 6 floor, 10,200 MU VMAT
- #15:142.96: Top GK

The Winners: Australia/NZ

1	Peter Devlin	Sir Charles Gairdner Hospital	CyberKnife	143.68
2	Michael Jenkins	Princess Alexandra Hospital Radiation Oncology	GammaKnife	142.96
3	James O'Toole	Royal North Shore Hospital	Linac	142.64