Is KBP Part of The Solution to Reducing Variation?

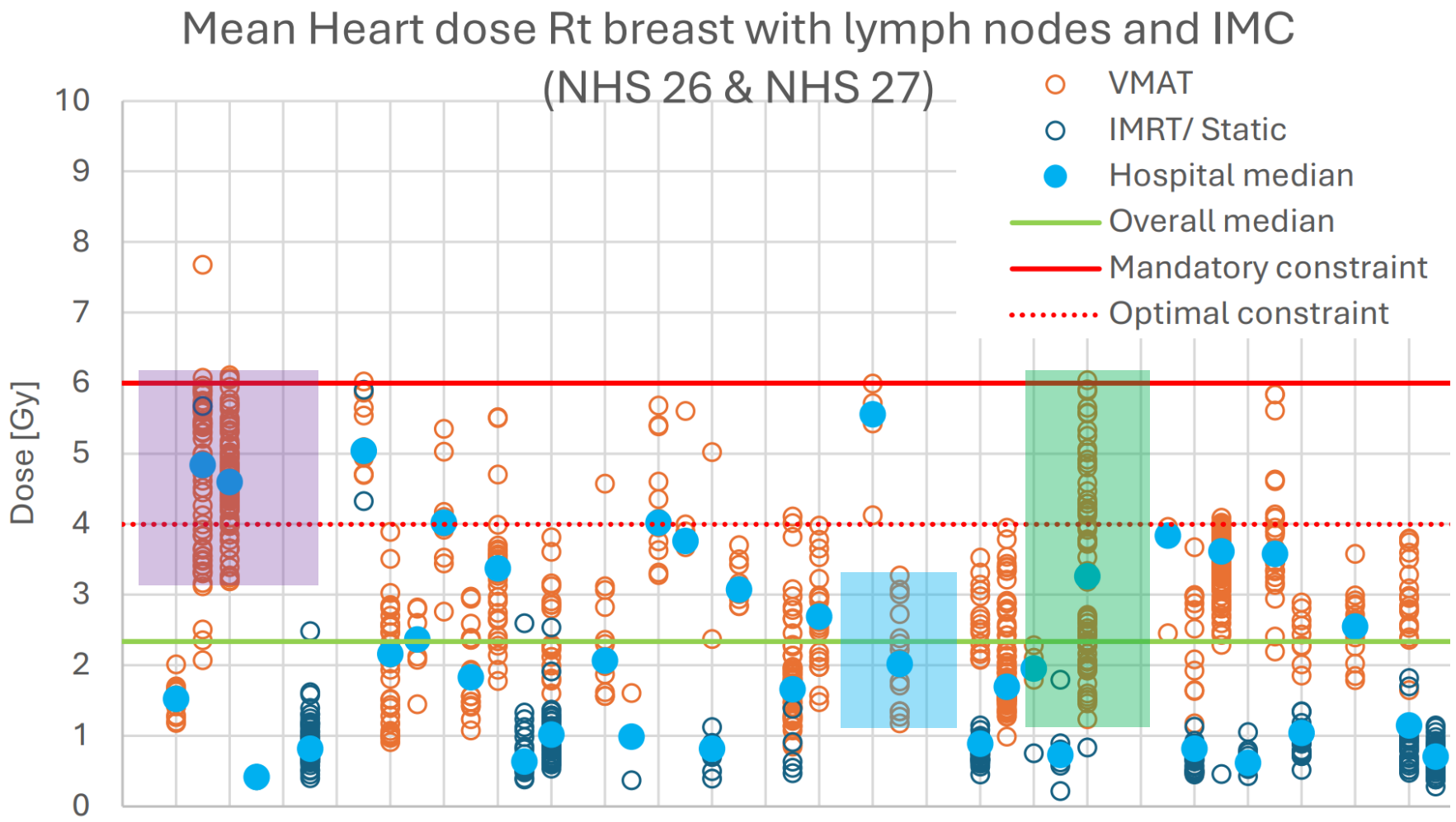
Andrew Bird (Planning Physicist / MPE)

Worcestershire Acute Hospitals Trust

Contents

- Do we see variation in Breast Planning? What approach to KBP did we use?
- How KBP was/is developed into Worcester’s Clinical work.
- KBP in IMC (in Worcester)
- Early Results (IMC in KBP in Worcester)
- Conclusions

Variation does exist



If we search for the best practice within our own box, we might not find the wider best practice.

Establishing and adopting wider best practice will likely involve adapting some decisions that are already made.

Some variation could be driven by different intention.

- Different priority MHD Vs PTV? Different Priority MHD Vs OAR?
- Different treatment machines?
- Different IGRT + Margins?
- And others.

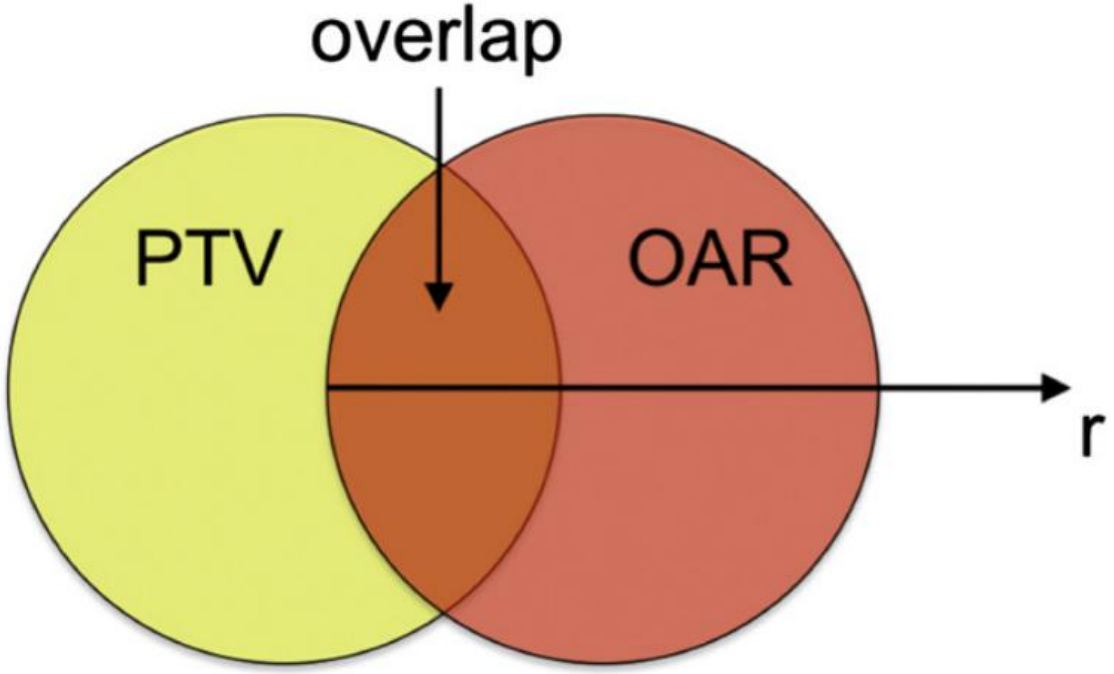
We can't keep those differences and get the same OAR doses / remove variation.

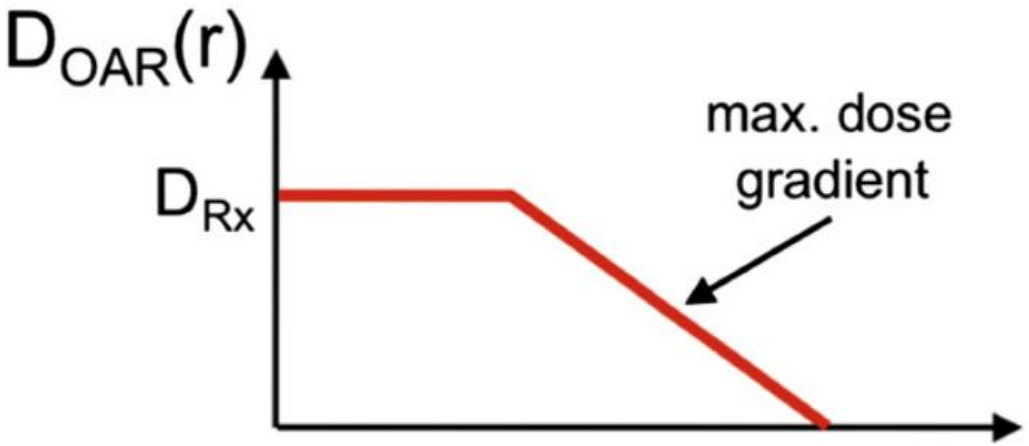
Legal need for plan quality.

- IRMER provides a legal requirement for optimisation.
- Cases vary, and realistically optimisation must be patient specific.
- Clinical Goals are not typically patient specific.
- Therefore Clinical Goals do not indicate an optimised plan; we should continue decreasing risk below clinical goals where possible.

- That leaves a gap – *What is the patient specific "measure" that can represent optimised plan quality per Organ at Risk*?
  - Can one be provided ?
  - Would / Does it help ?

Worcester's KBP Approach





- Significantly not ours! Moore et al's

In a given:

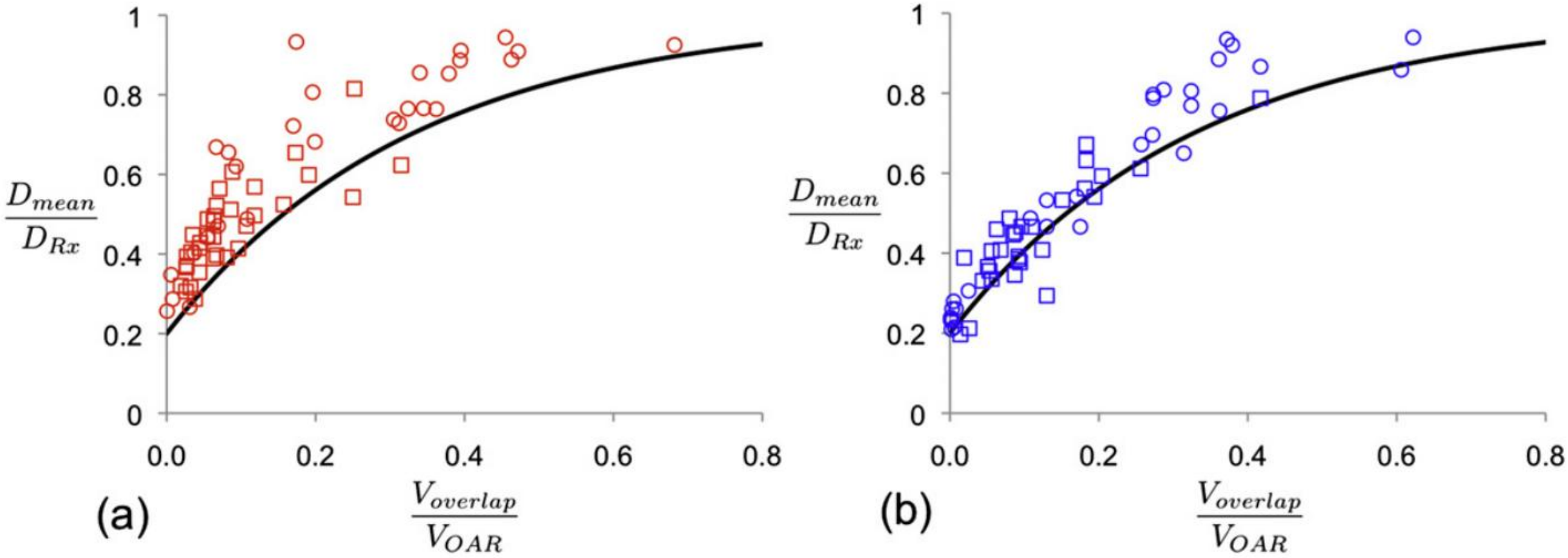
1. planning technique
2. Clinical Site
3. Consistent geometry
4. Consistent priorities

- there is a characteristic max dose fall off into priority OARs.

  In these cases, the mean OAR dose can be predicted given the relative volume of overlap.

I. J. Radiation Oncology ● Biology ● Physics Volume 81, Number 2, 2011

Results – before and after. Rectum and Parotid



Reduced Variation – less vertical difference for given x – positions on the blue data.

I. J. Radiation Oncology ● Biology ● Physics Volume 81, Number 2, 2011

Moore et al reported user experience.

- Staff used the script:
  - 90% strongly agreed or agreed that they chose to use the tool.
- Staff felt the tool improved their planning:
  - 80% strongly agreed or agreed that their planning improved.
- Staff felt the tool improved efficiently:
  - 60% strongly agreed or agreed that they planned faster with the tool.

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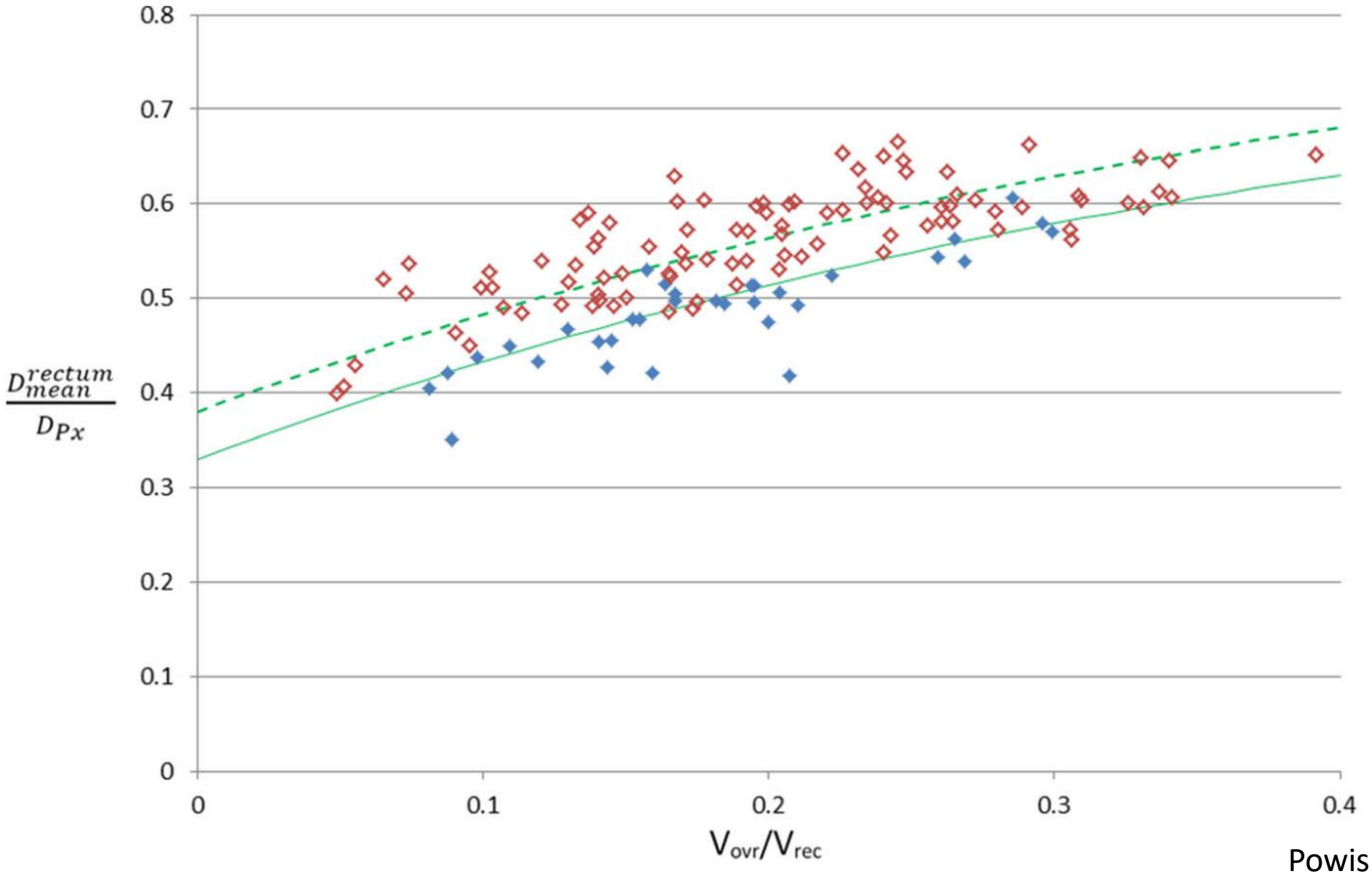
Local KBP Experience – Prostate (2017)



Red – pre KBP
Blue – KBP

Note:
Less variation:
Before: mean δ was 0.11
After: mean δ was −0.03

Lower Doses:
Average 5.6 Gy lower rectum average dose.

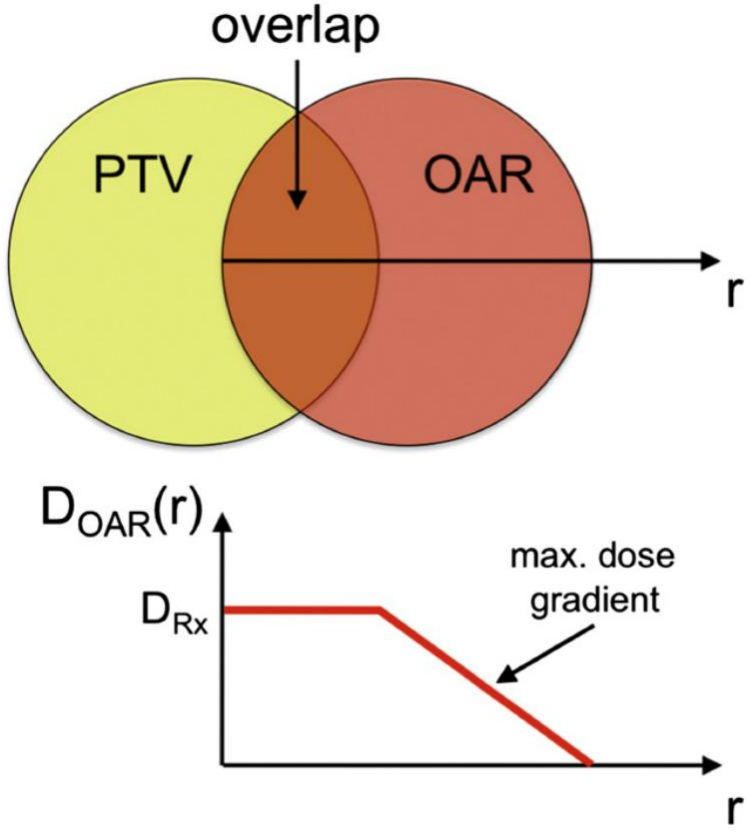
Can derive new curves from updated data and improve further.

Powis et al. Radiation Oncology (2017)

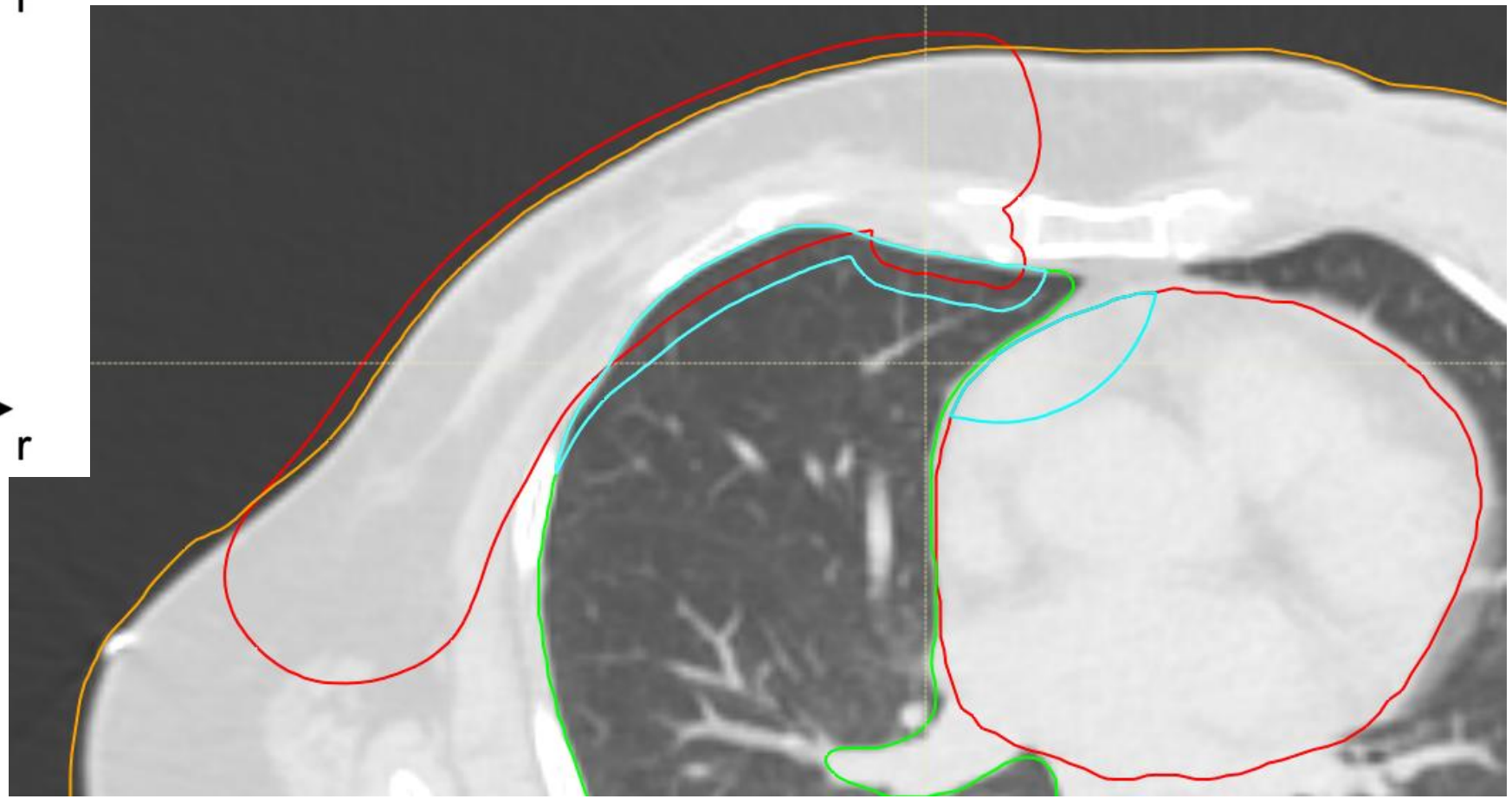
Worcester KBP Timeline

- Prostate: 2017
- Head and Neck 2018
- Gynae 2023
- Prostate and Nodes 2024
- IMC late 2025

Site Specific Overlap Approach



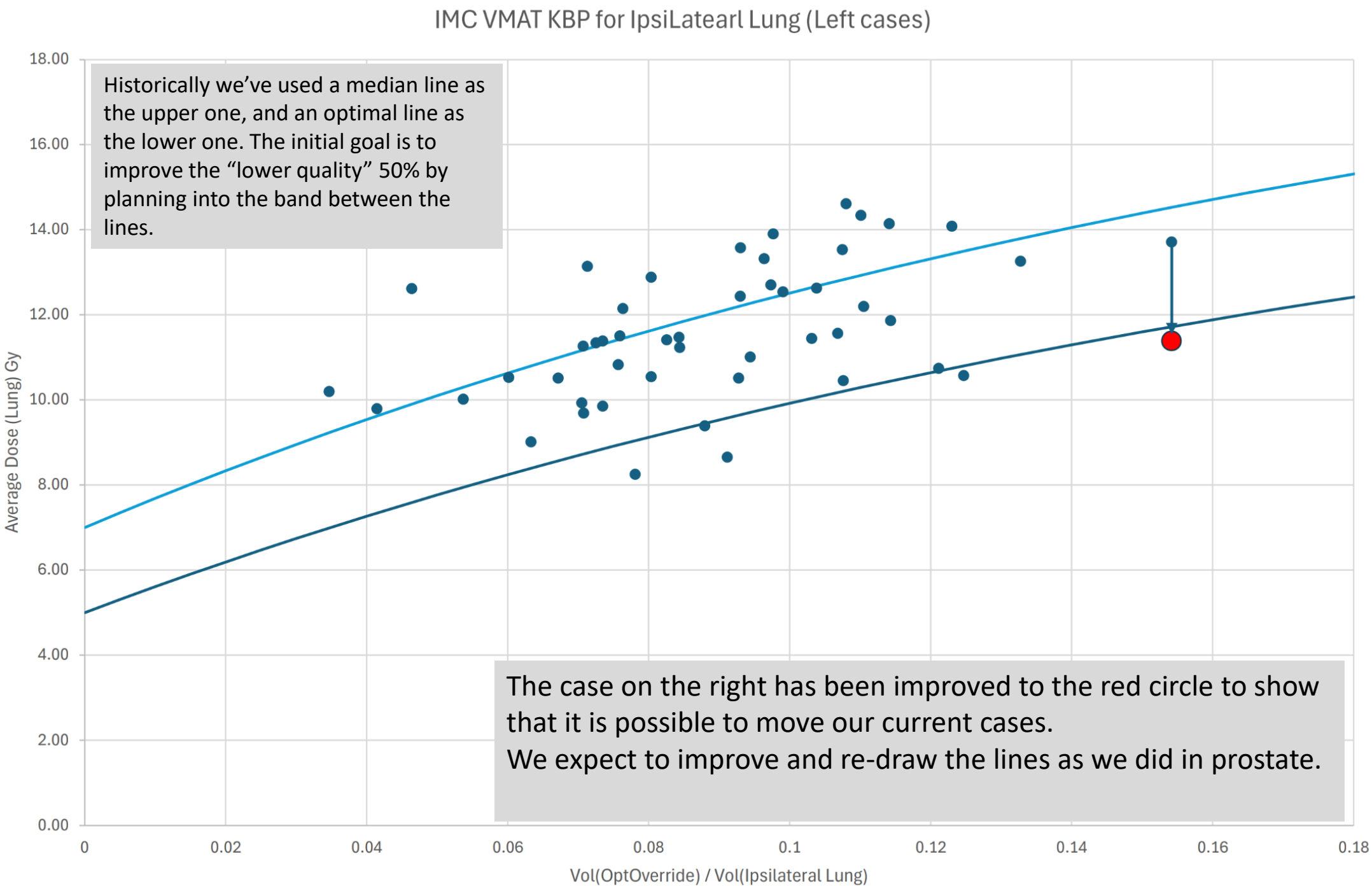
In most of our KBP sites we use OAR overlapped with PTV.
In IMC we have used an expansion of the PTV
Allows use where there is no overlap, e.g. heart below.
Seems to give better correlation to OAR doses for IMC cases.

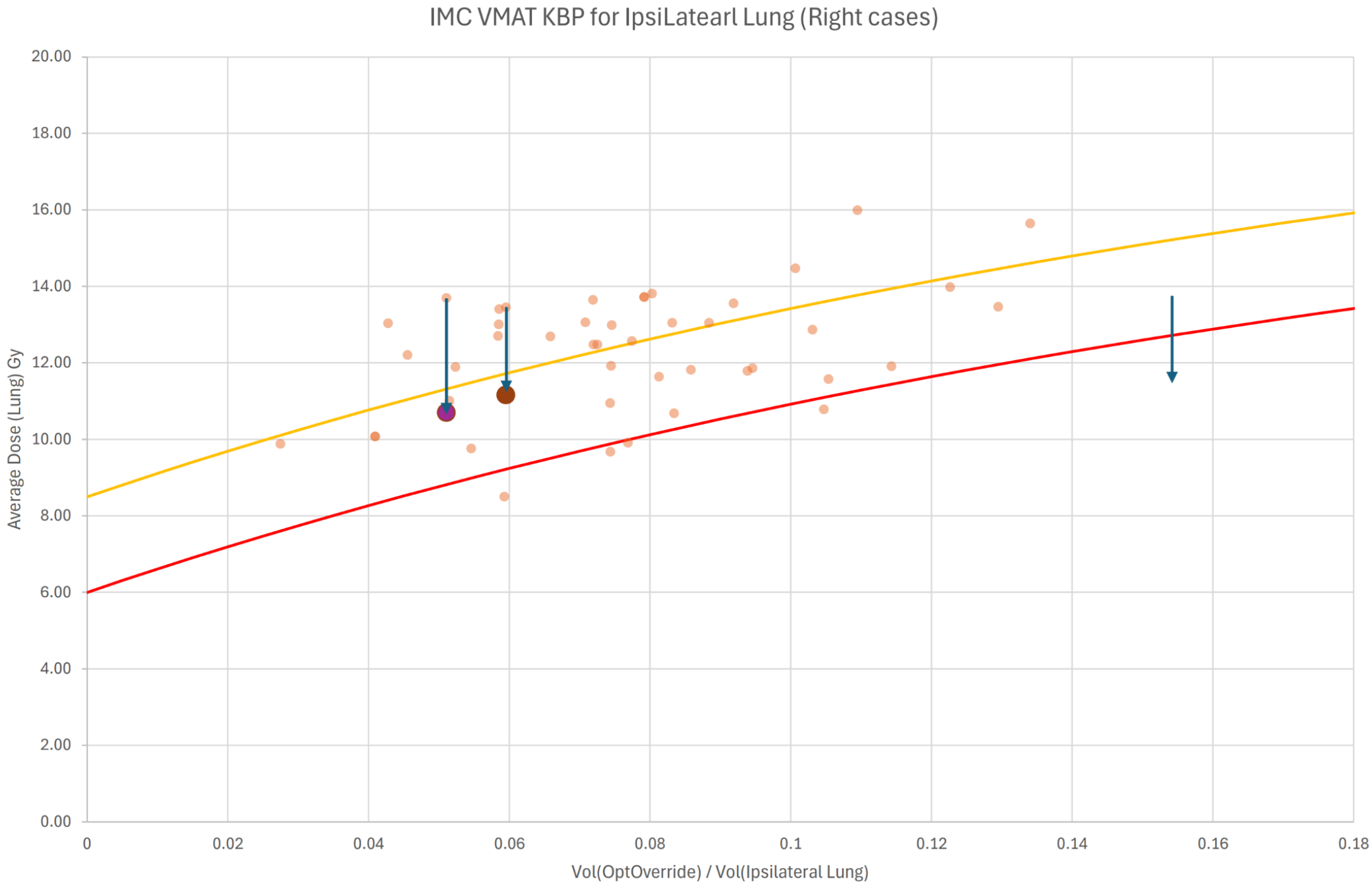


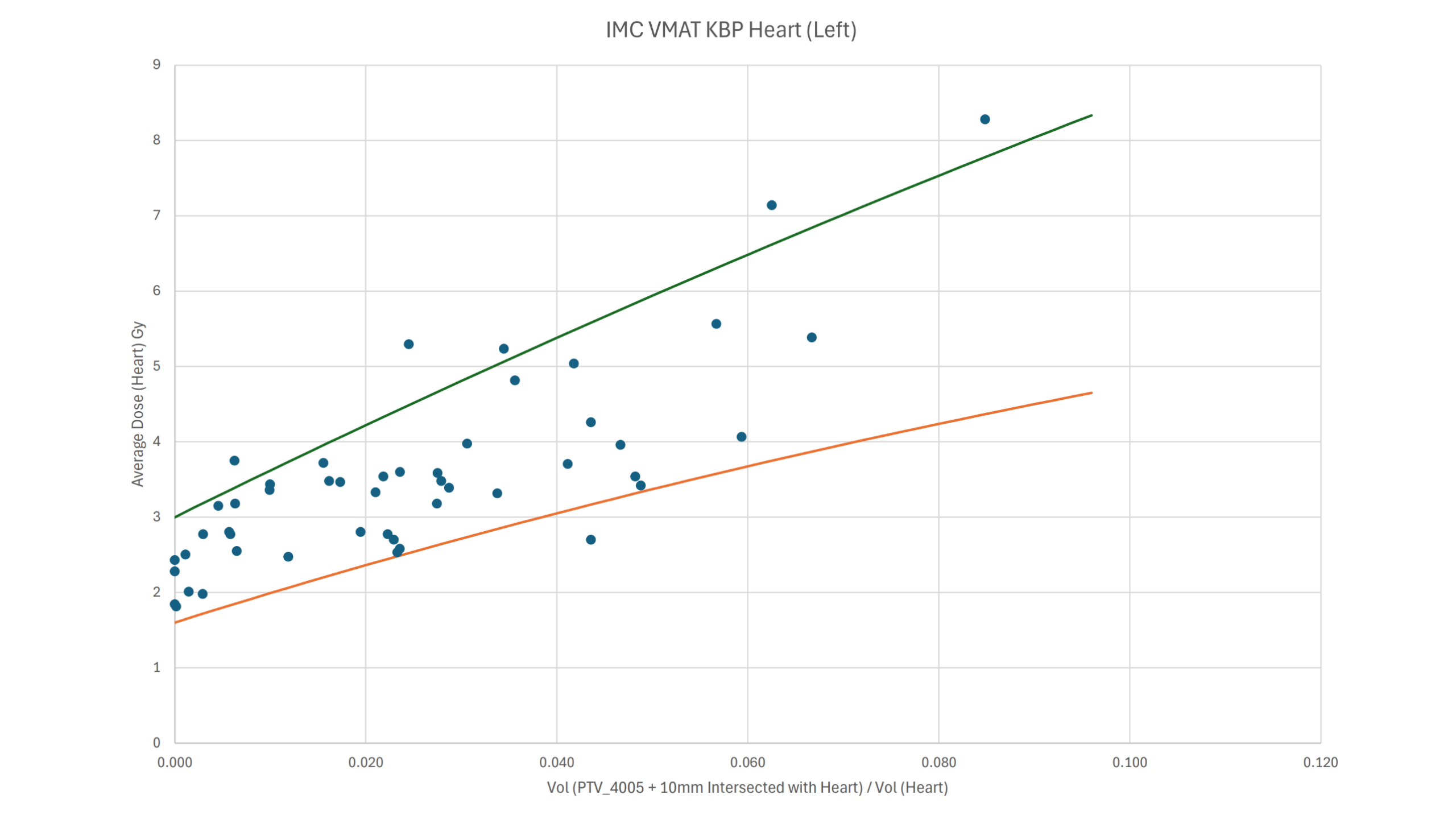
IMC VMAT Breast

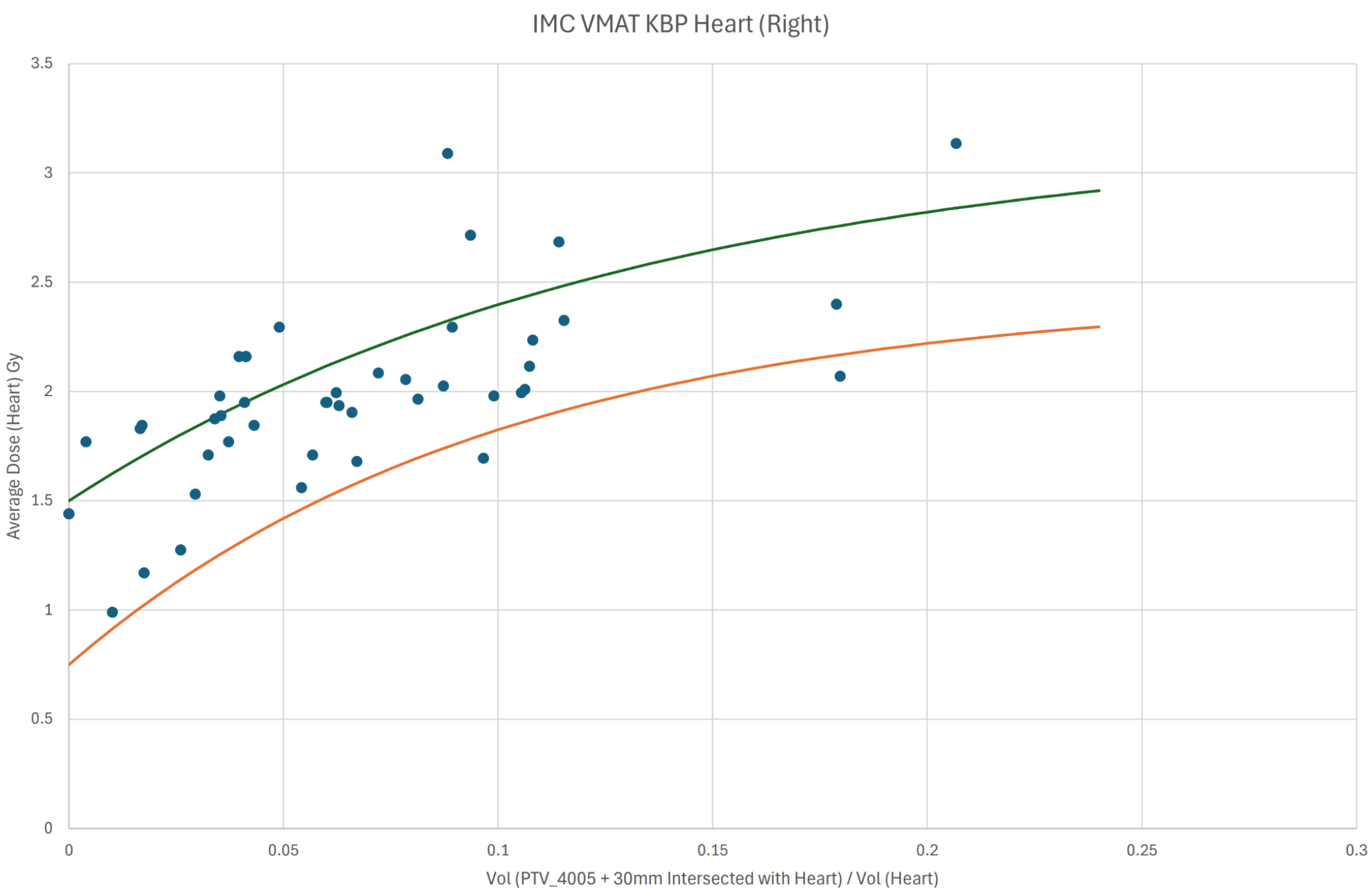
- Rt Cases (40Gy /15) – no SIB in data
  - Rt Lung – Guides on MLD given PTV+5mm overlap with Lung.
  - Heart – Guides on MLD given PTV+5mm overlap with Lung.
- Lt Cases (40Gy /15) – no SIB in data
  - Lt Lung
  - Heart

- Valid for our technique (and others??? we don't know).
  - Dual Partial Arc.
  - Priority on Coverage V38Gy>95%.
  - C/L breast to 3.5Gy.
  - Robustly planned to CTV V38Gy>95%.


IMC VMAT KBP for IpsiLatearl Lung (Left cases)
Historically we've used a median line as the upper one, and an optimal line as the lower one. The initial goal is to improve the "lower quality" 50% by planning into the band between the lines.
The case on the right has been improved to the red circle to show that it is possible to move our current cases.
We expect to improve and re-draw the lines as we did in prostate.
Average Dose (Lung) Gy
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
Vol(OptOverride) / Vol(Ipsilateral Lung)


IMC VMAT KBP for IpsiLatearl Lung (Right cases)
Average Dose (Lung) Gy
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
Vol(OptOverride) / Vol(Ipsilateral Lung)

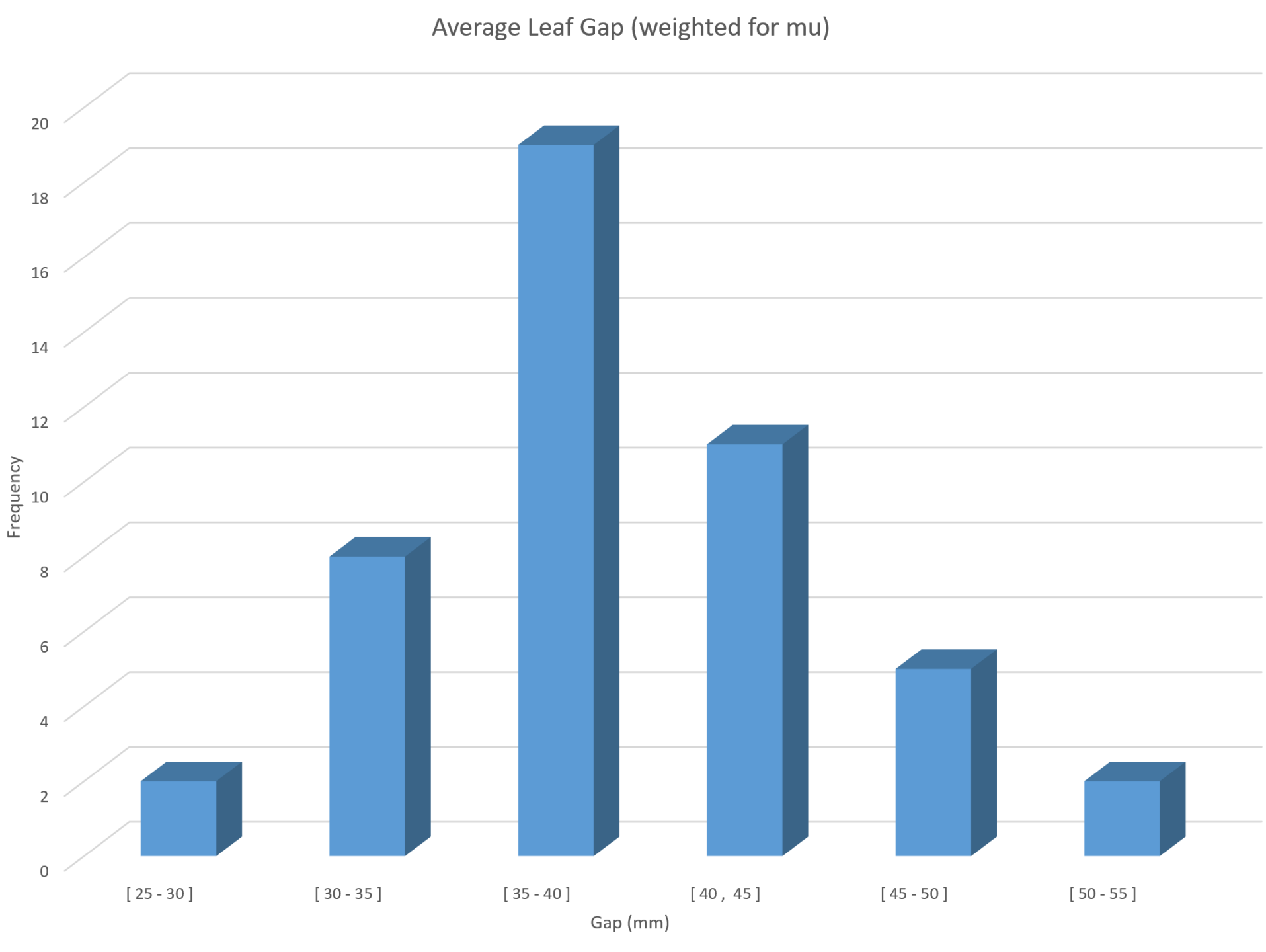

IMC VMAT KBP Heart (Left)
Average Dose (Heart) Gy
0
1
2
3
4
5
6
7
8
9
0.000
0.020
0.040
0.060
0.080
0.100
0.120
Vol (PTV_4005 + 10mm Intersected with Heart) / Vol (Heart)

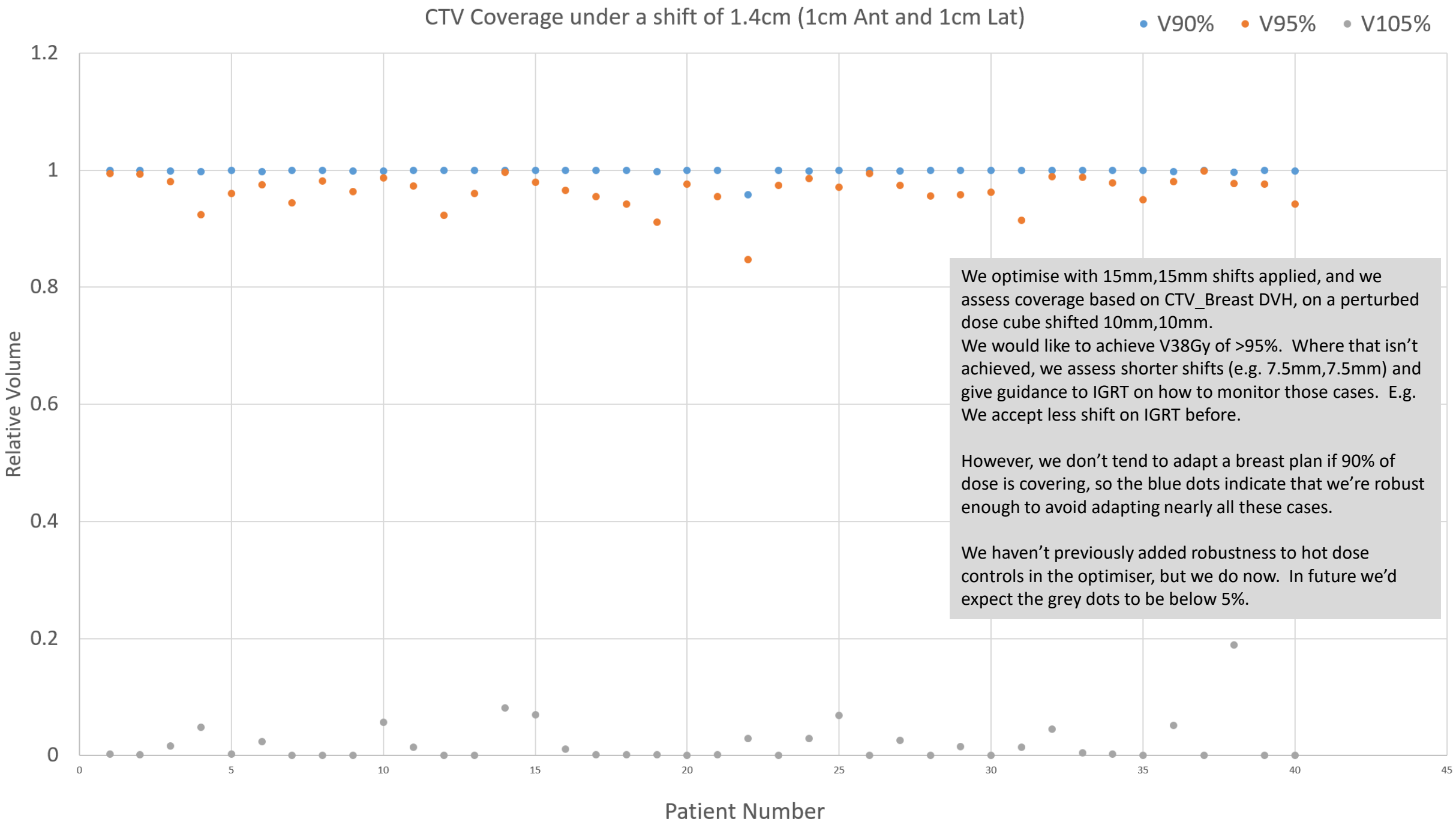

IMC VMAT KBP Heart (Right)
Average Dose (Heart) Gy
3.5
3
2.5
2
1.5
1
0.5
0
0
0.05
0.1
0.15
0.2
0.25
0.3
Vol (PTV_4005 + 30mm Intersected with Heart) / Vol (Heart)

Monitor for variation everywhere else.

- Does the modulation change?
- Does the PTV coverage suffer?
- Do other OARs suffer – is that the correct risk?
  - There is a direct dose payoff between the C/L breast and Ipsi Lung in our technique.

- One method is to rely on good Plan Checking case by case, informed by the specific risks identified as part of the KBP implementation.
- and Audit.


Average Leaf Gap (weighted for mu)
Frequency
0
2
4
6
8
10
12
14
16
18
20
[25 - 30]
[30 - 35]
[35 - 40]
[40 , 45]
[45 - 50]
[50 - 55]
Gap (mm)


CTV Coverage under a shift of 1.4cm (1cm Ant and 1cm Lat)
V90%
V95%
V105%
Relative Volume
Patient Number
1.2
1
0.8
0.6
0.4
0.2
0
0
5
10
15
20
25
30
35
40
45
We optimise with 15mm,15mm shifts applied, and we assess coverage based on CTV_Breast DVH, on a perturbed dose cube shifted 10mm,10mm.
We would like to achieve V38Gy of >95%. Where that isn't achieved, we assess shorter shifts (e.g. 7.5mm,7.5mm) and give guidance to IGRT on how to monitor those cases. E.g. We accept less shift on IGRT before.
However, we don't tend to adapt a breast plan if 90% of dose is covering, so the blue dots indicate that we're robust enough to avoid adapting nearly all these cases.
We haven't previously added robustness to hot dose controls in the optimiser, but we do now. In future we'd expect the grey dots to be below 5%.

Initial Results

Very few cases per cohort since implementing

Measure of “delta” – the difference between the plan and the optimal line in Gy.

Model	Pre KBP	Post KBP
Left Cases | Heart	2.2 Gy	1 Gy
Left Cases | Lung	1.0 Gy	0.7 Gy [1.3 Gy]
Right Cases | Heart	0.5 Gy	0.1 Gy
Right Cases | Lung	2.2 Gy	1.9 Gy

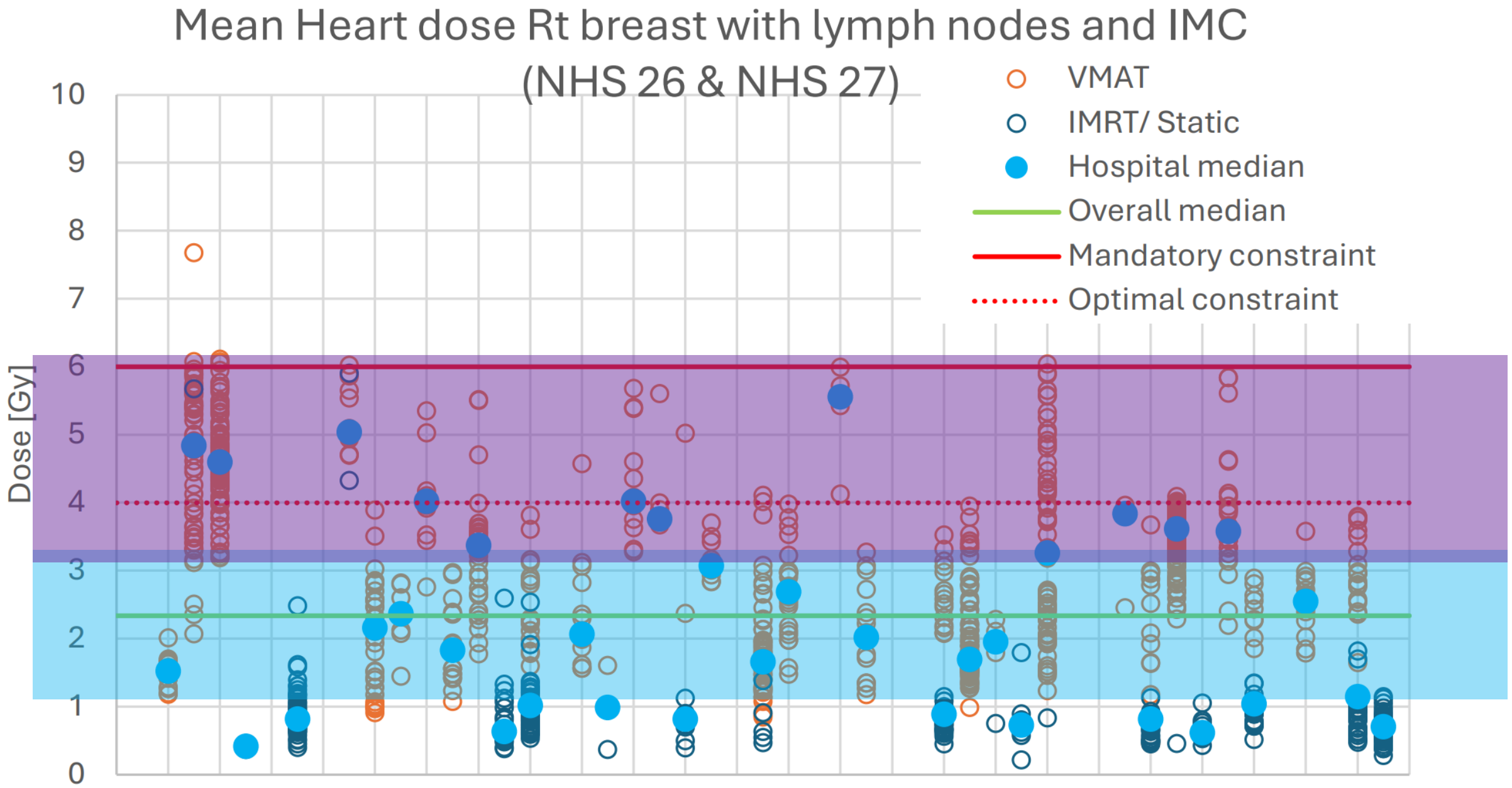
Conclusions

- 2011 – Techniques Described in Literature
  - Reported objective improvement in OAR dose (multiple clinical sites)
  - Reported improvement from users including Plan Quality and Efficiency.

- 2016-17 Techniques Clinically implemented in Region (Prostate)
  - Reported 5.6 Gy average dose reduction to mean Rectum dose.
  - Reduced Delta distribution – less variation across cohort.

- 2018-25 Extended to other VMAT planned clinical Sites within Region.
  - Similar results.

- 2025 Implemented for VMAT IMC (40/15 no SIB)
  - Initial results positive
  - No reason to believe previously observed impact wont be replicated.

- Yes! These KBP models are part of the solution to variation.
- The general methodology is immediately useful to everyone. Find your curve and apply to optimisation.
- There’s scope to use the tools across teams to find best practice / compare decision making…..

Models are not Independent of Planning Methods