FDG-PET/CT Imaging Feedback Tumor Response Assessment Treatment Adaptation

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Disclosure: no conflict interest on this talk

Main Subjects

1. Treatment tumor response assessed quantitatively using FDG PET/CT imaging feedback

2. Quantifying treatment objective with using tumor voxel dose response

3. Treatment planning optimization and delivery

FDG-PET/CT Imaging (?) for Tumor Response

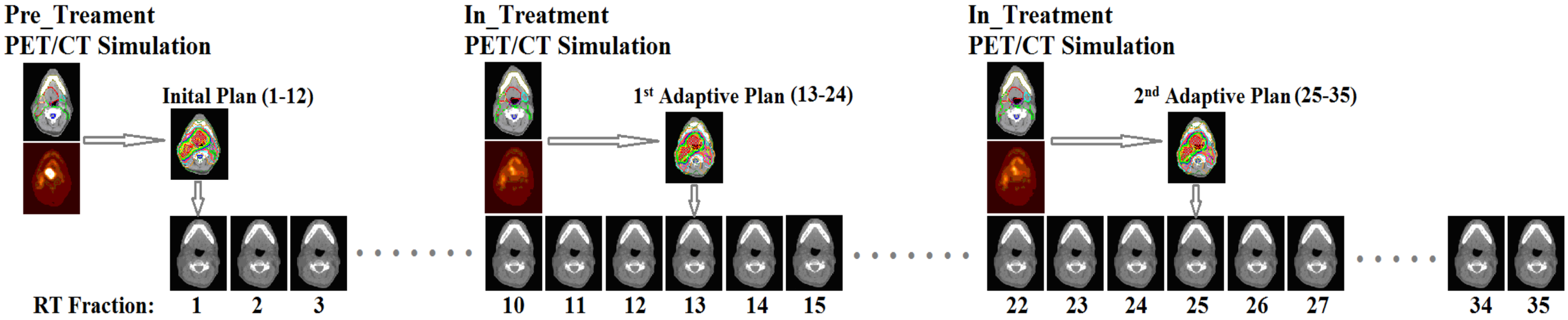
- Tumor Metabolic Activity is most likely correlated to tumor cell Survival/Growth during the radiation treatment

- Therefore, change of metabolic image intensity (due to radiation dose) depends upon the tumor intrinsic radiosensitivities, proliferation, hypoxia, change of micro environment, etc

- **PET**: [^{18}F, ^{11}C] Glucose, Lactate, Glutamine, Glutamate
- **MRI**: Hyperpolarized [1-^{13}C] Pyruvate, Lactate, Glucose; APTw, Glu-CEST

FDG-PET/CT is so far the most mature & popular modality to measure tumor metabolic activity!

Adaptive Treatment Protocol (IRB 2012-100)

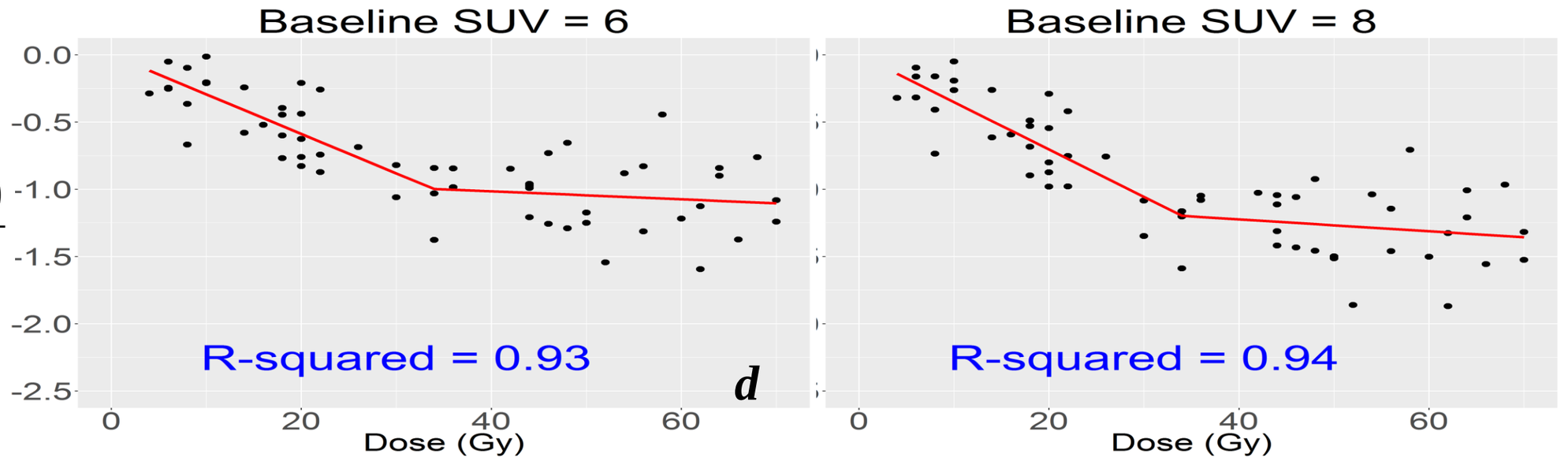


Adaptive Treatment Process:

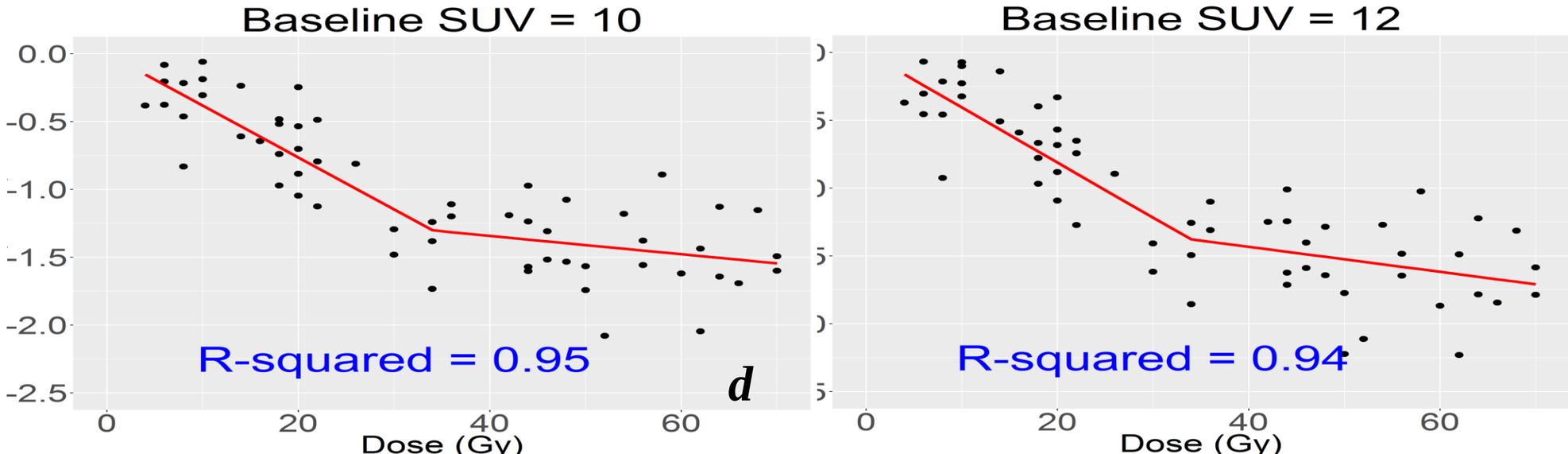
- 2 feedback PET/CT images obtained within the 2nd and 3rd treatment weeks
- Utilizing deformable PET/CT image registration, the change ratios of tumor voxel SUV vs its pre-treatment baseline SUV are obtained and used to quantify tumor voxel response

Tumor Voxel SUV Change Ratio vs Radiation Dose

$$\ln \frac{SUV(d)}{SUV_0}$$



$$\ln \frac{SUV(d)}{SUV_0}$$



Tumor voxel response matrix, ***DRM*** = exp(31.75x**A**), derived to have a similar numerical range as $\mathbf{SF_2}$

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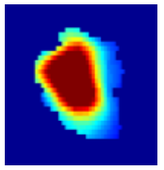
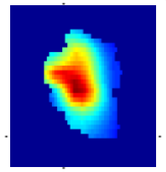


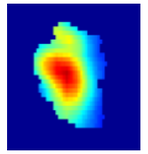
$SUV_0(v)$

$$\ln \frac{SUV(v,d)}{SUV_0(v)}$$

$$A_{(v)} \cdot d + \xi$$



$SUV_{18Gy}(v)$



$SUV_{28Gy}(v)$

- Tumor voxel SUV dynamics can be described using a linear random process with the slop **A**.
- The slop **A** can then be estimated using the feedback images

Distribution of Voxel Dose Response for 17,086 Voxels in 34 HN Tumors

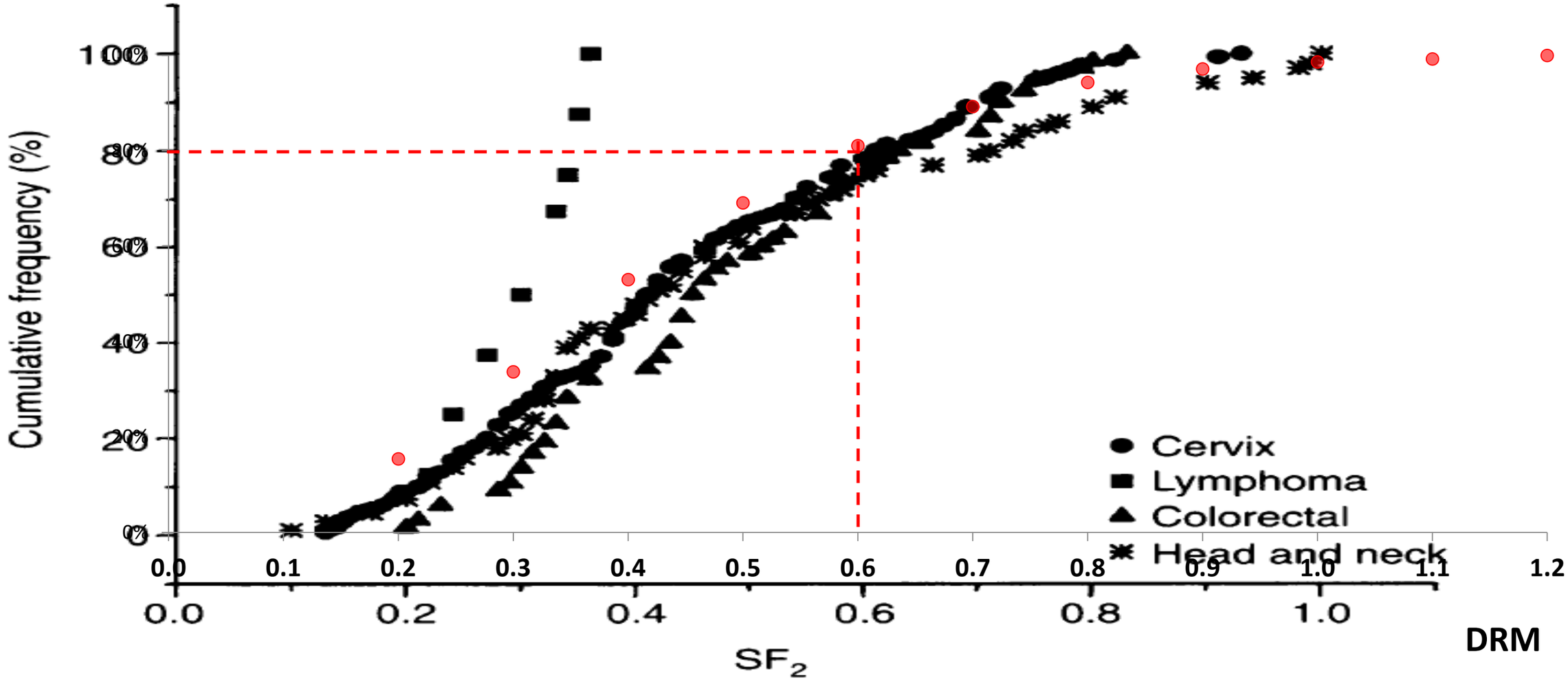
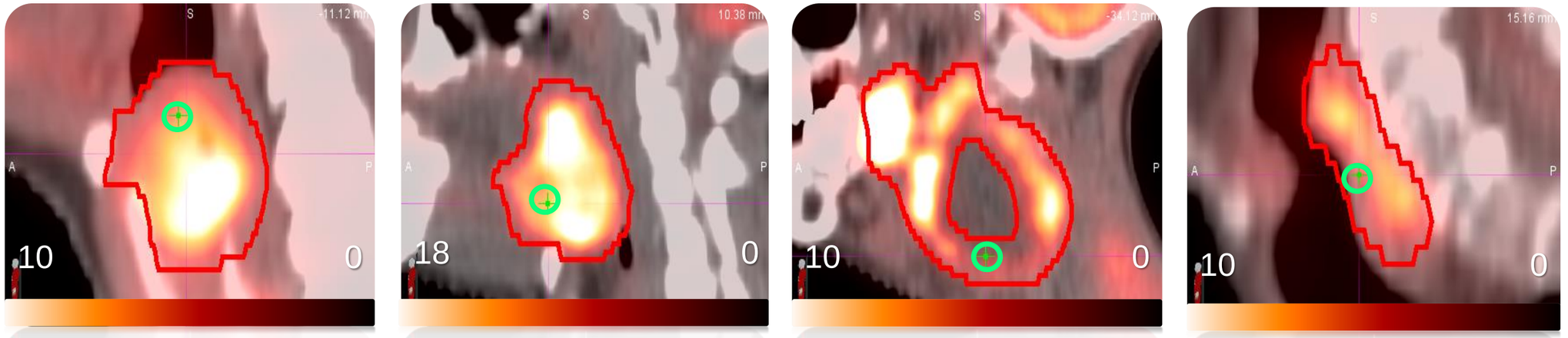


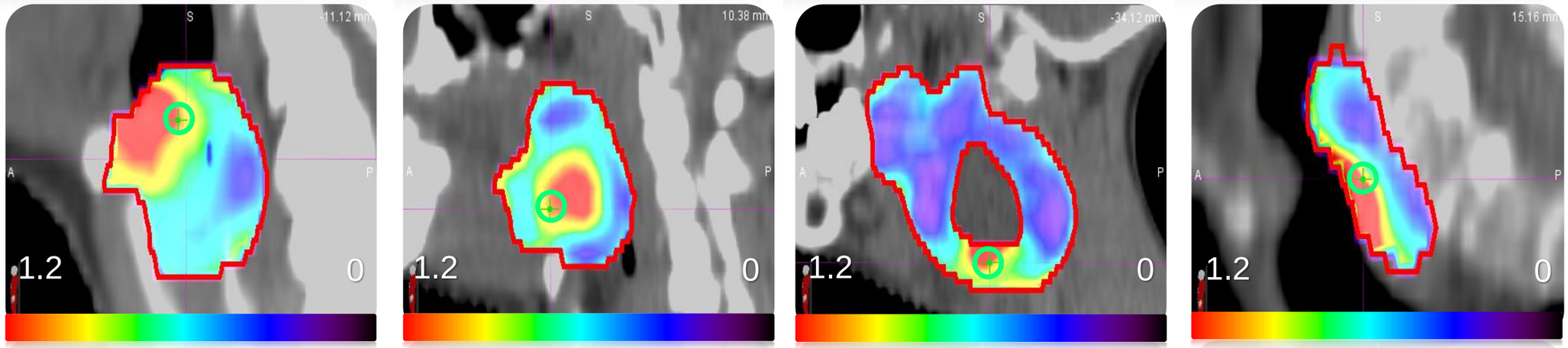
Figure 2 Cumulative frequency distribution of SF_2 values for head and neck tumours ($n = 88$), carcinomas of the cervix ($n = 145$), colorectal cancers ($n = 65$) and lymphomas ($n = 8$)

T Bjork-Eriksson, CML West, etc: "In vitro Radiosensitivity ". BJR 1998, 77:2371-75



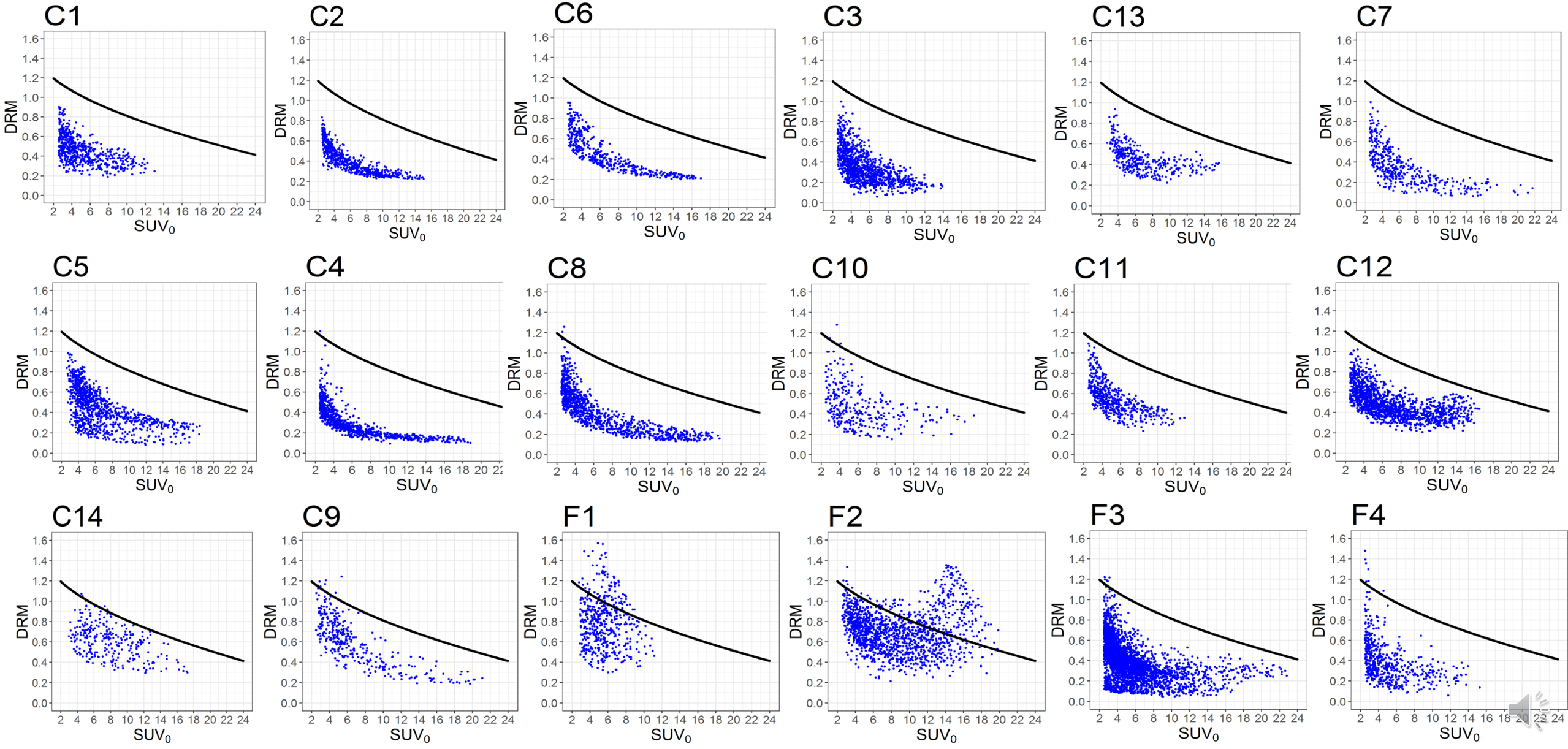
SUV_0

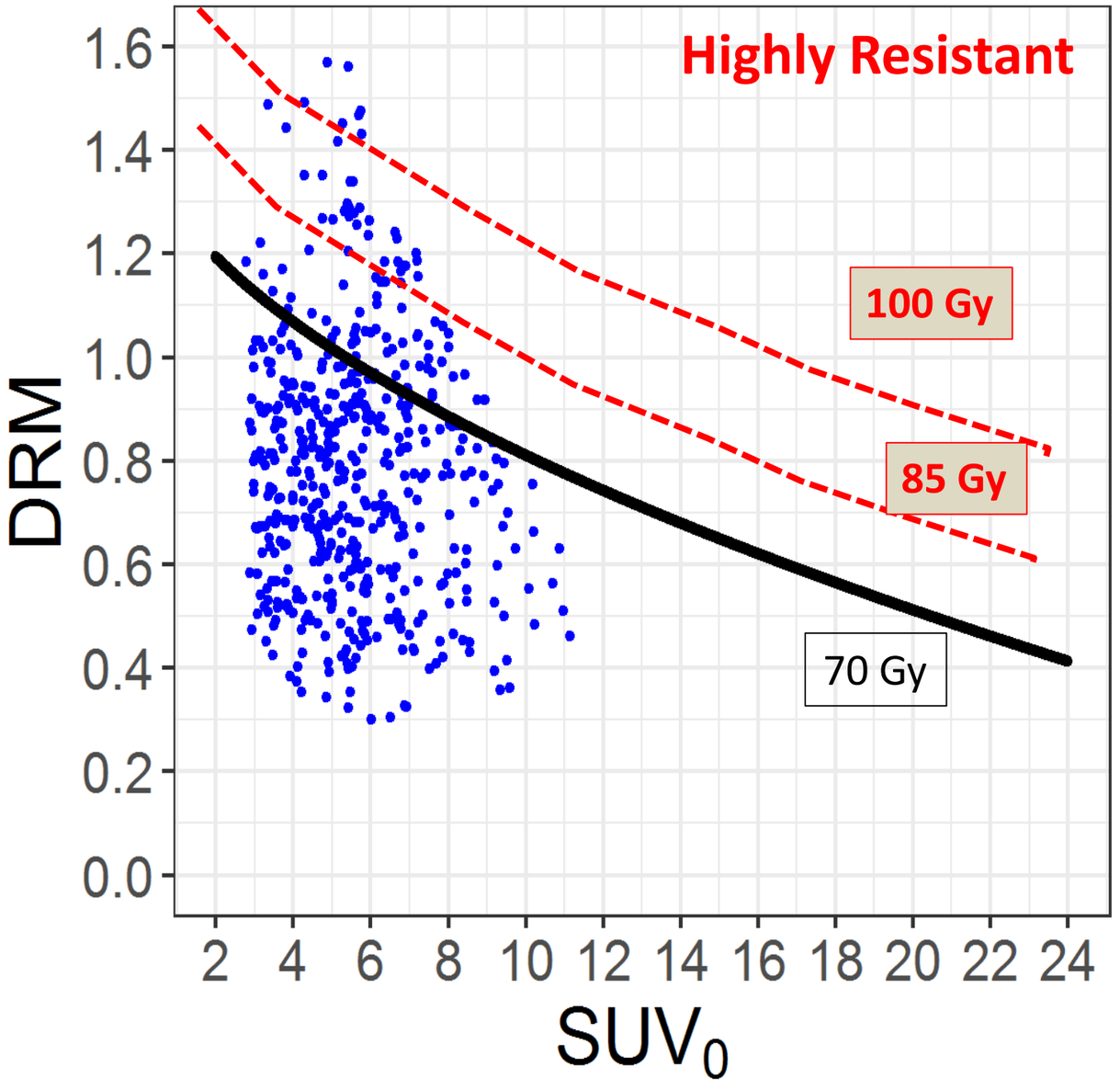
Post-PET

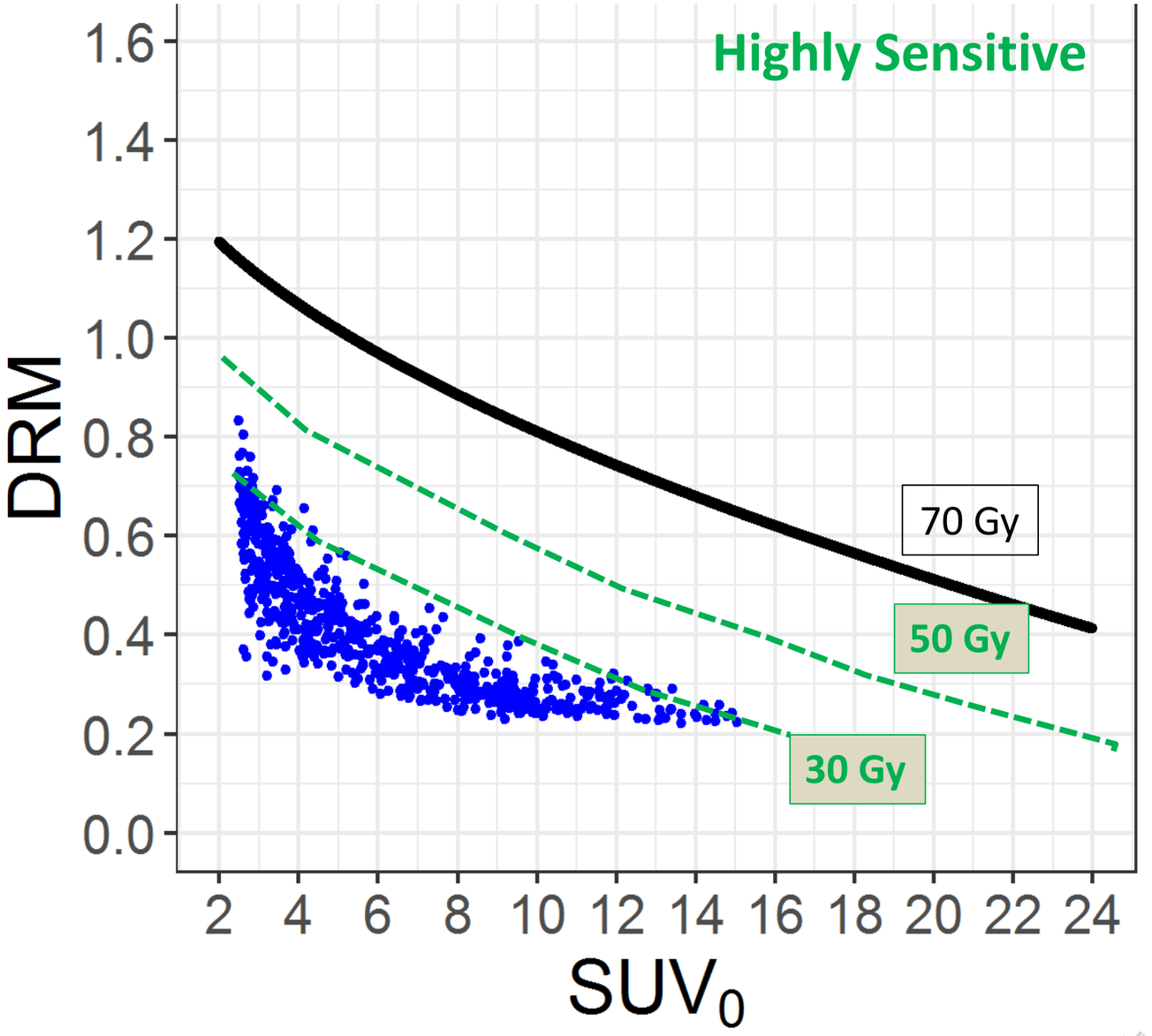


DRM

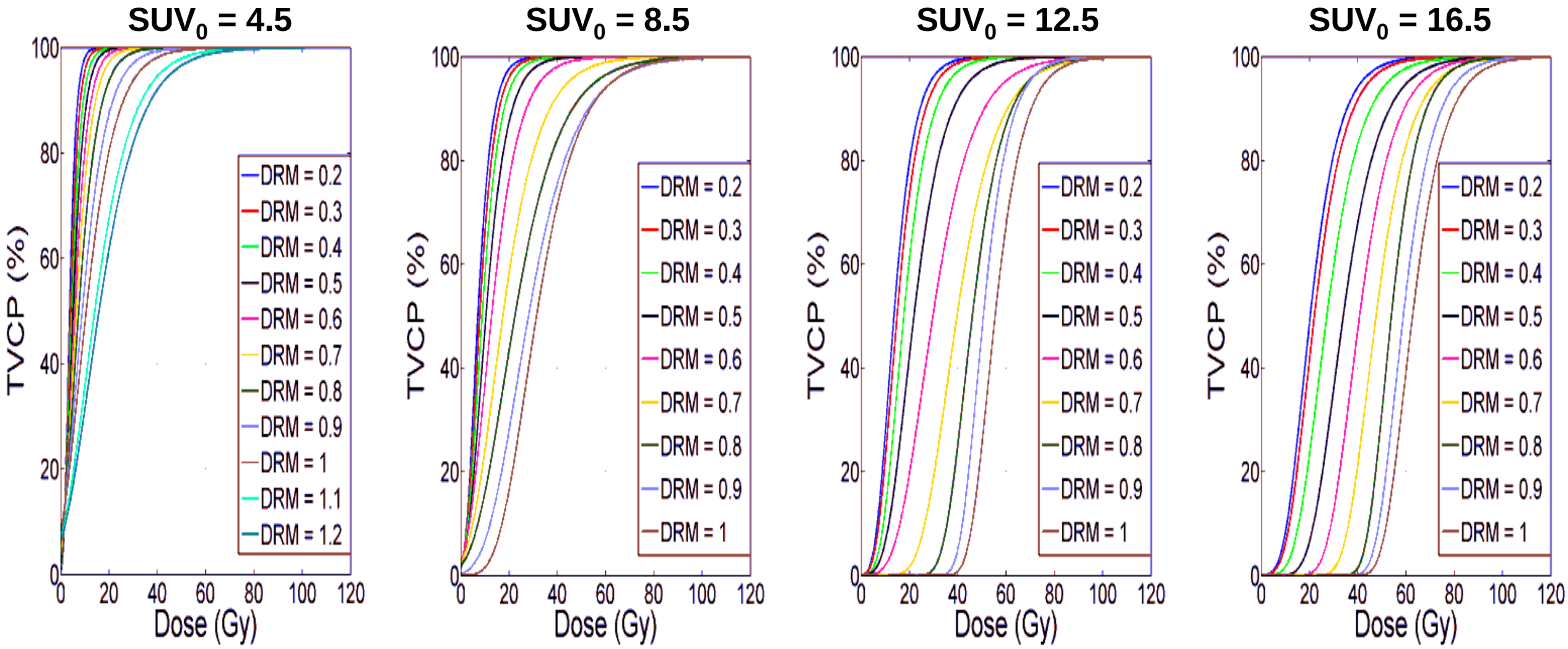
Relationship of Tumor Voxel SUV_0 & DRM vs Tumor Control




Highly Resistant
100 Gy
85 Gy
70 Gy
DRM
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2 4 6 8 10 12 14 16 18 20 22 24
SUV0


Highly Sensitive
70 Gy
50 Gy
30 Gy
DRM
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2 4 6 8 10 12 14 16 18 20 22 24
SUV0

Tumor Voxel Control Probability (TVCP): Lookup Table



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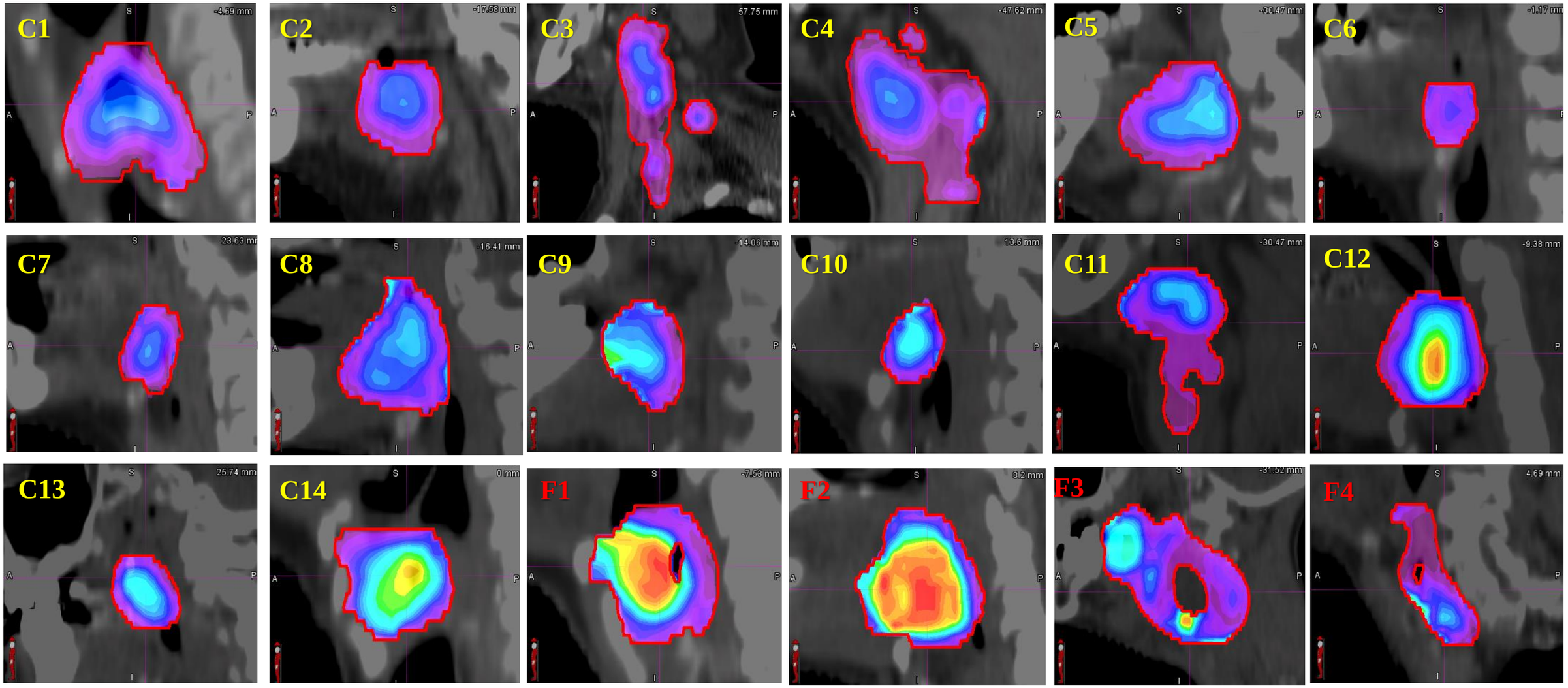
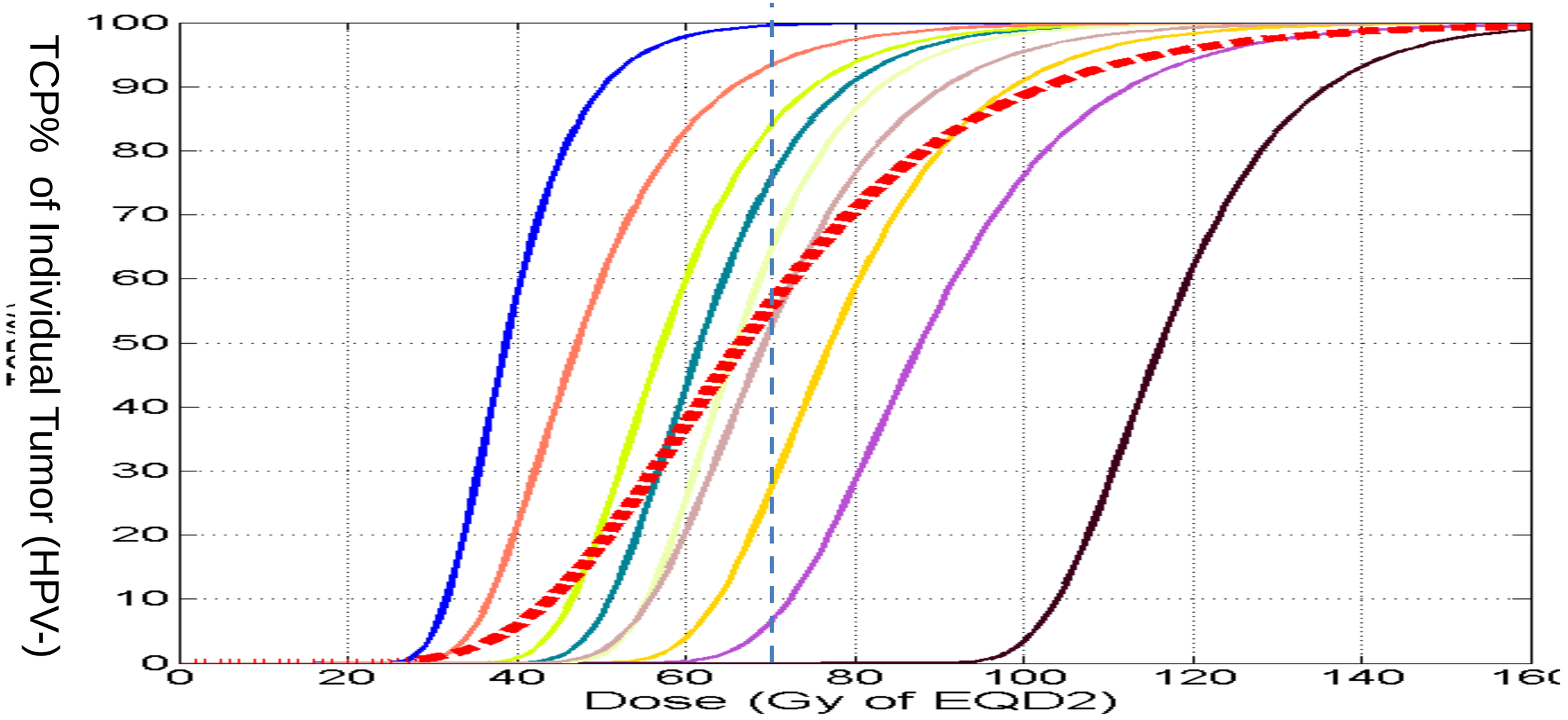
Tumor Dose Prescription Map

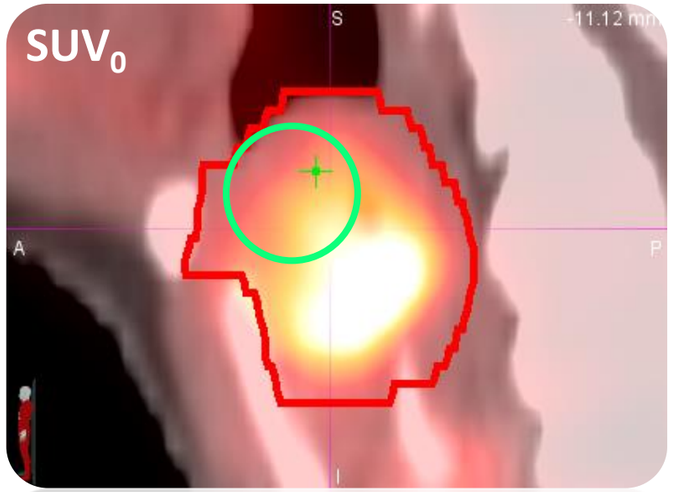


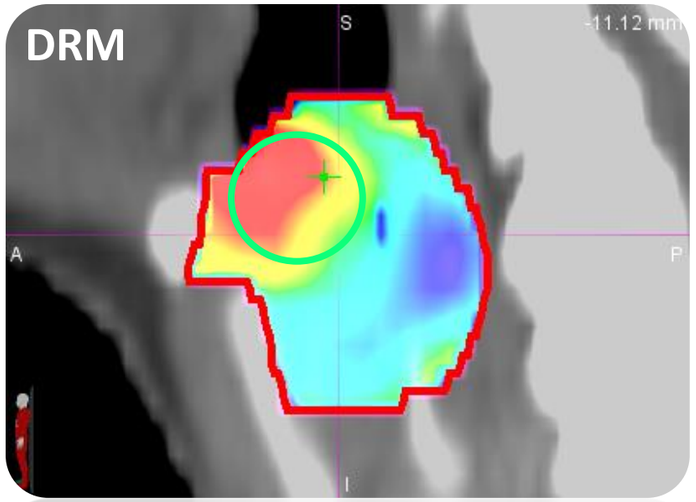
Effect of Dose Response Heterogeneity for Individual Tumors



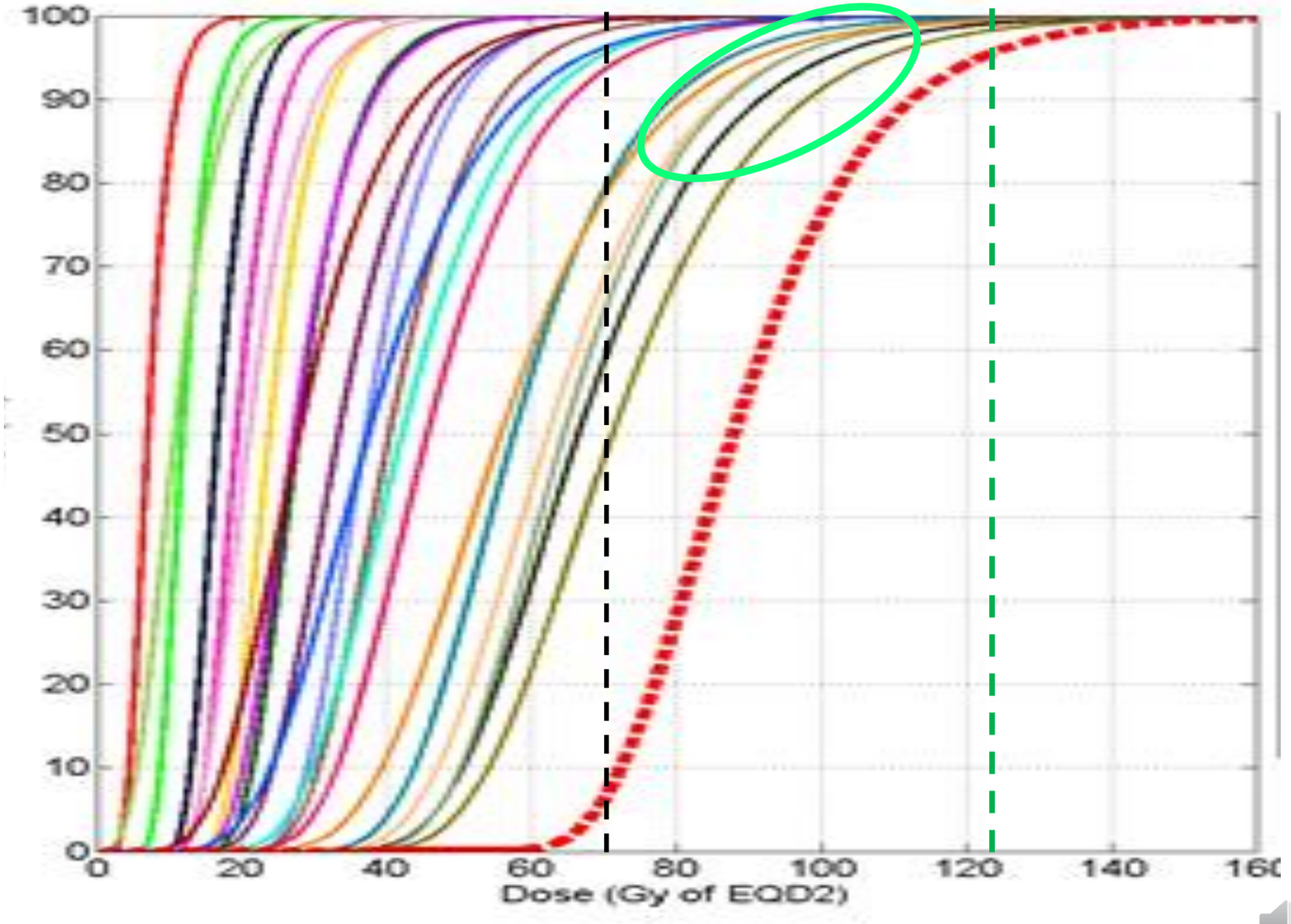
Effect of Heterogeneity in Individual Tumor

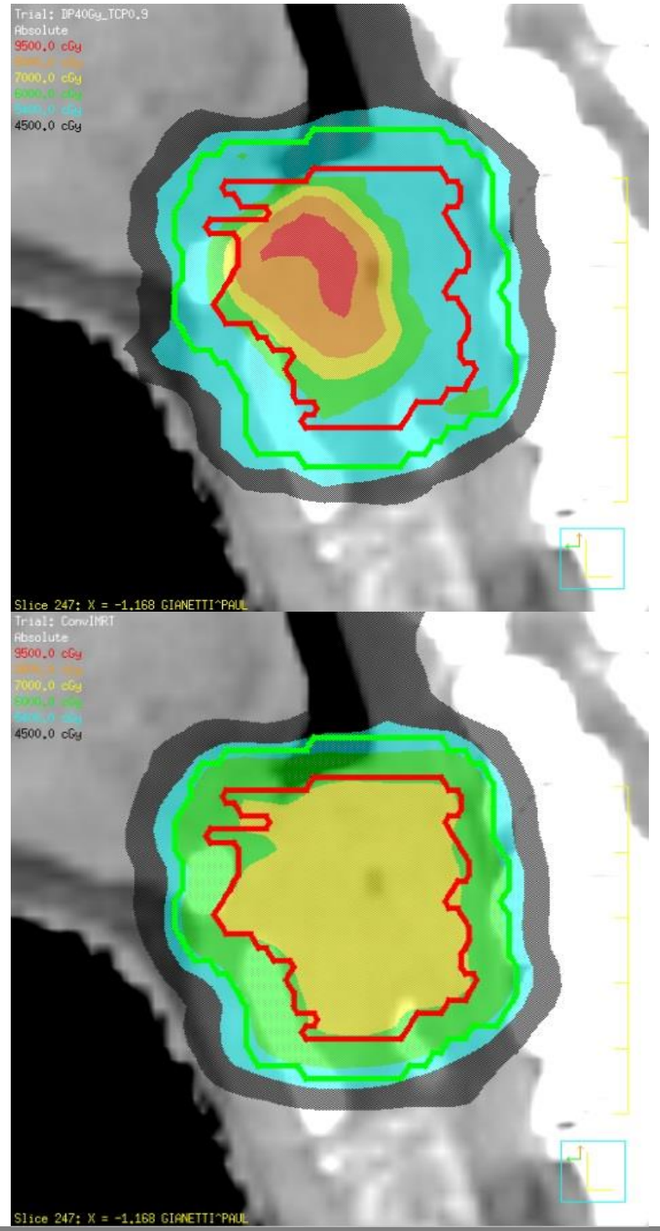
Target The Most Resistant Area



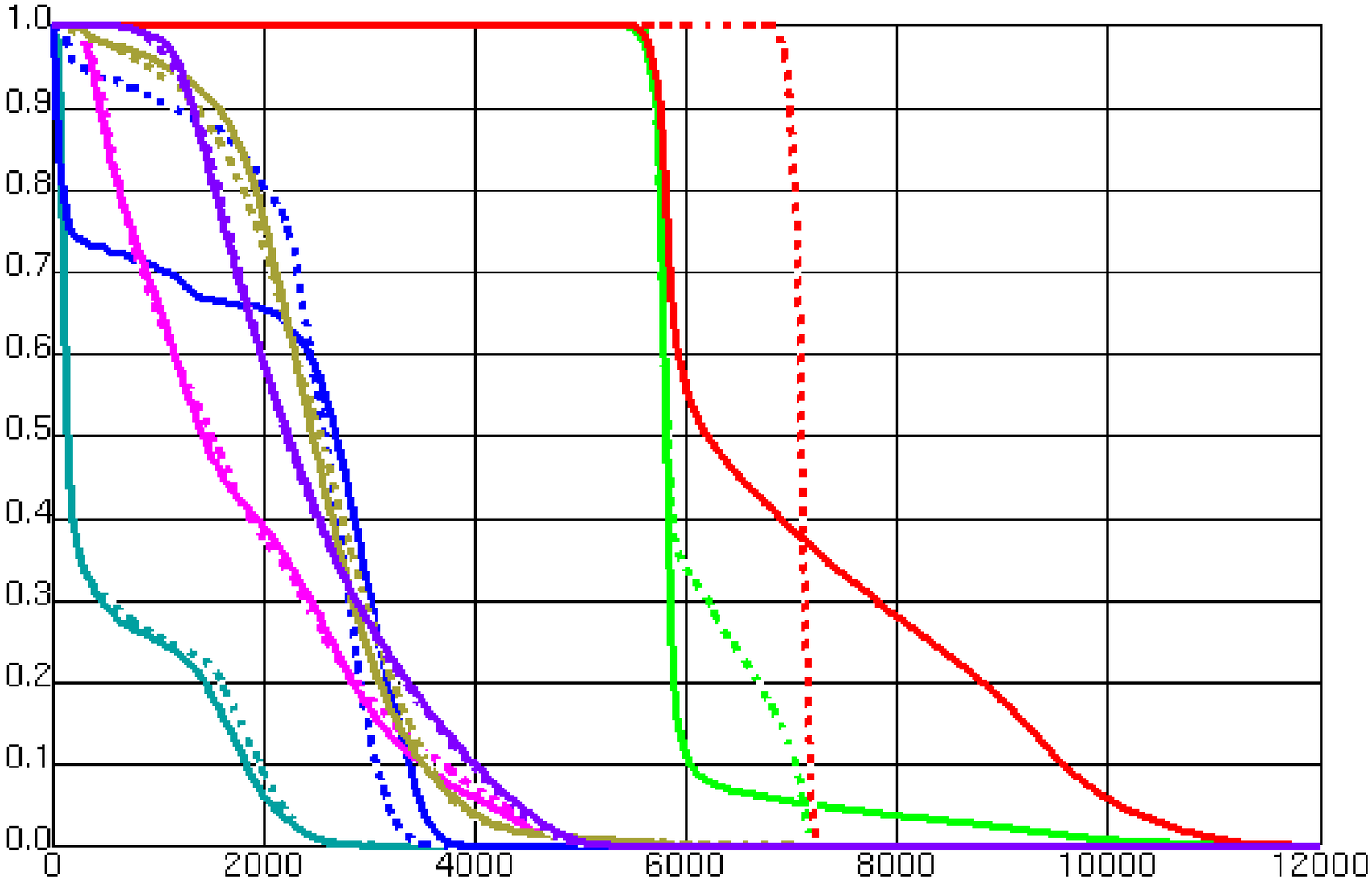


0 1.2





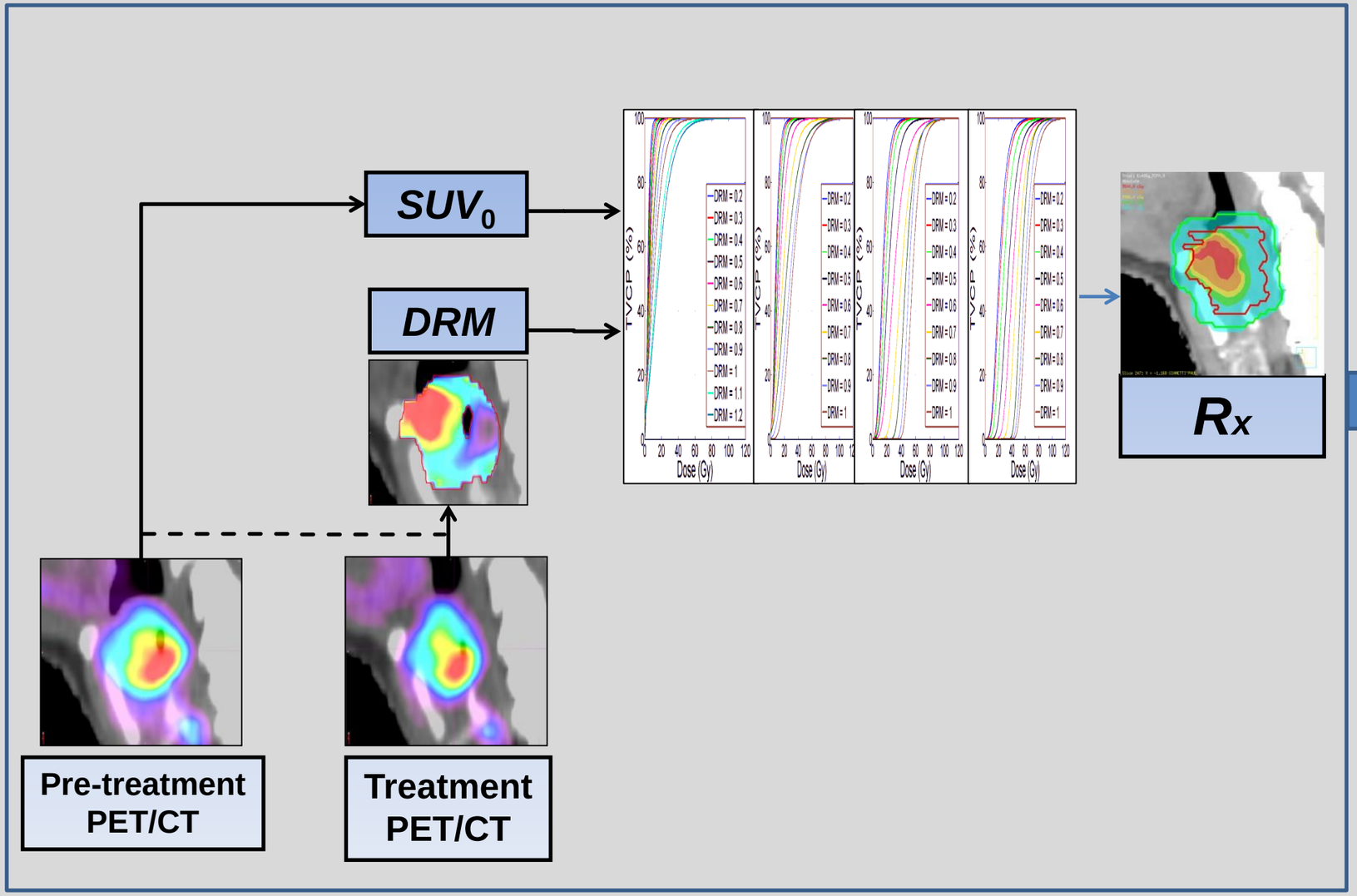
Conv(Dash-line TCP = 0.25) vs DPbN (Solid TCP = 0.9)

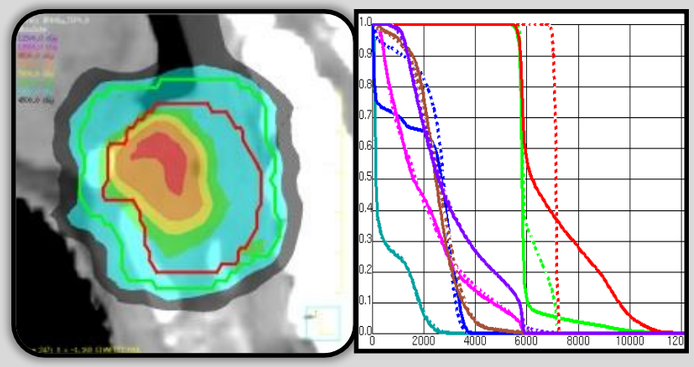


Dose: 115 95 80 70 60 54 Gy

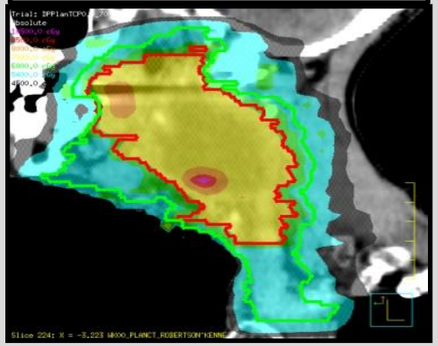
CTV, GTV, R-parotid, L-parotid, Brainstem, Cord, Mandible

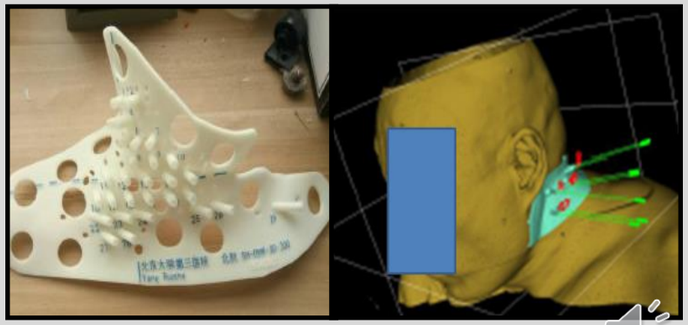
Tumor Response Guided Adaptive Treatment Process





SRS or PRT Boost





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