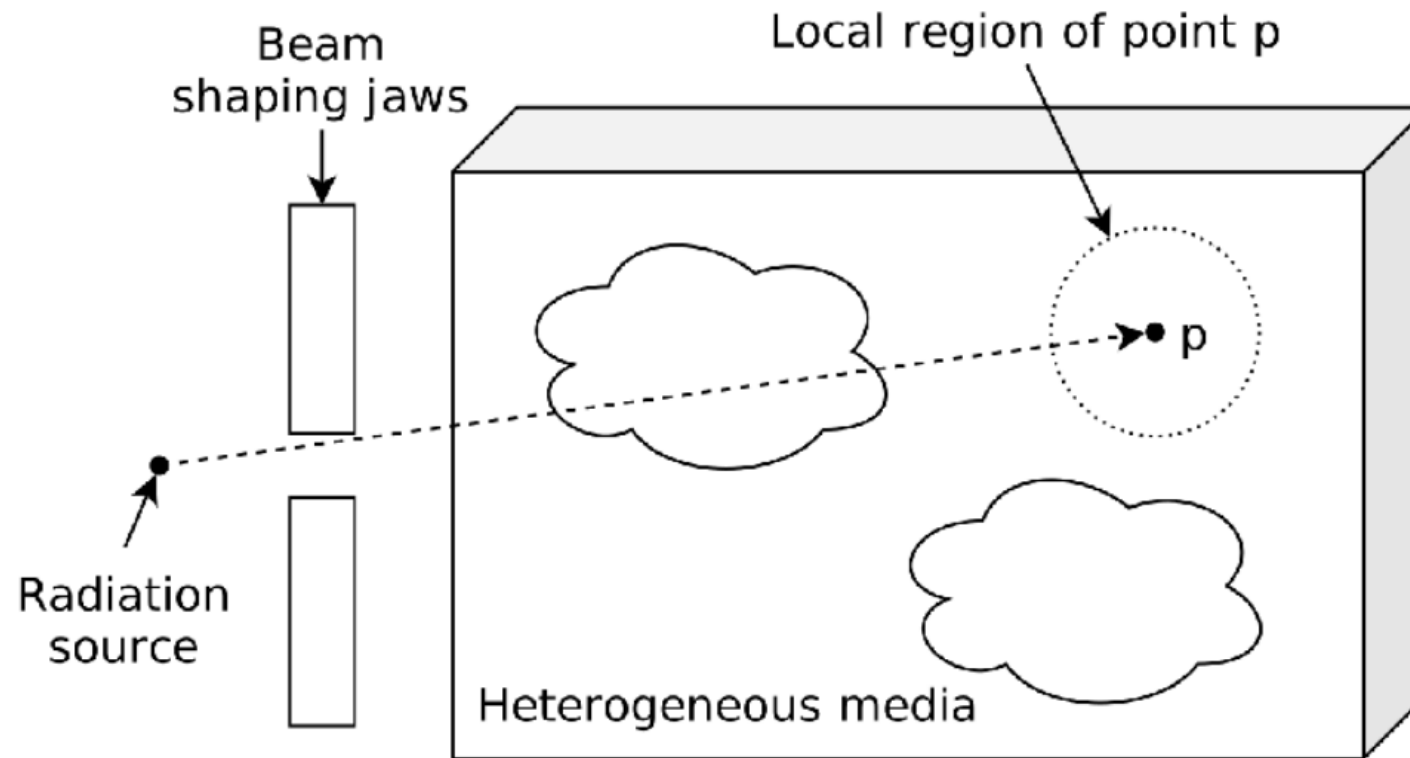


James Keal¹, Alexandre Santos^{1,2},
Scott Penfold^{1,2}, & Michael Douglass^{1,2}

Simplex noise as training data for learned 3D dose calculation

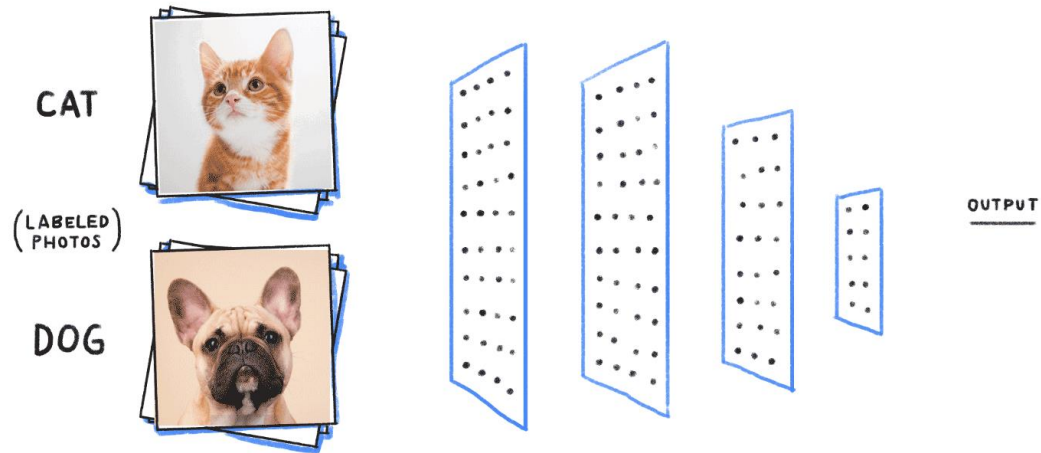
Dose Calculation



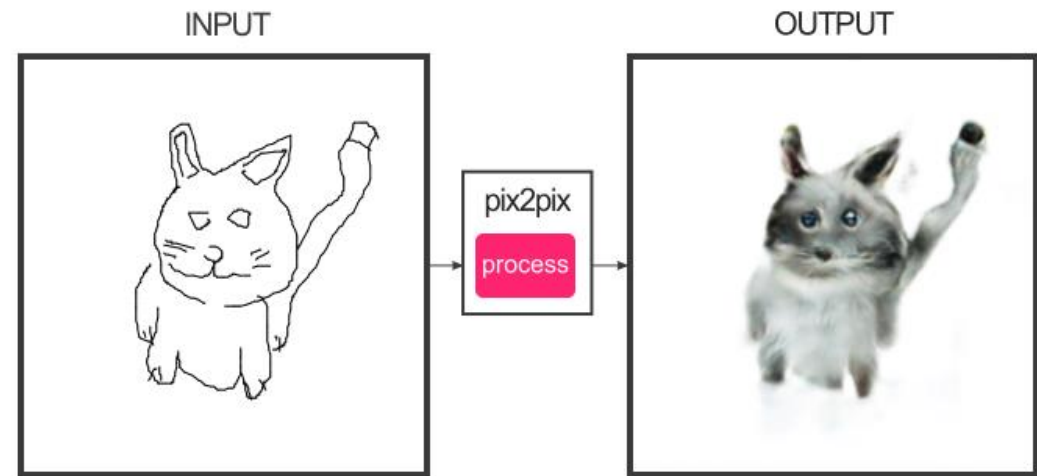
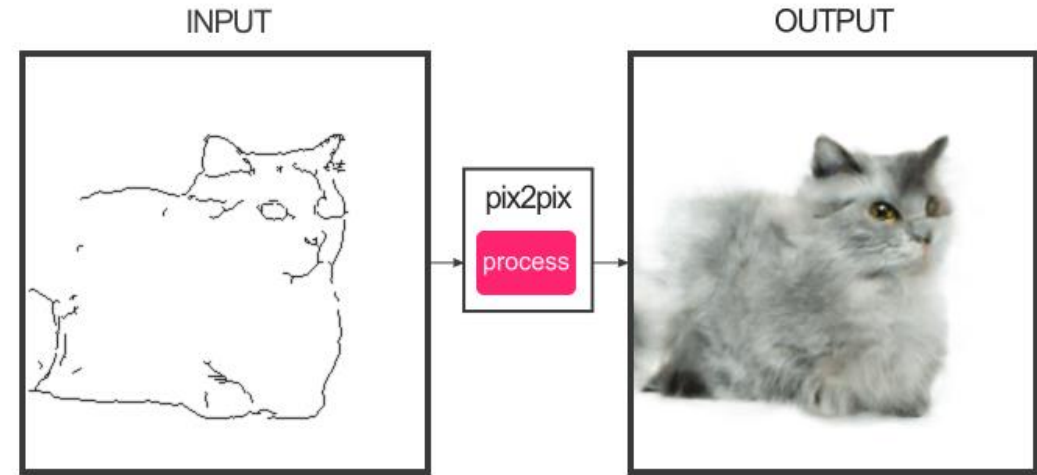
Machine Learning

$f(\text{dog photo}) \rightarrow \text{dog}$

$f(\text{cat photo}) \rightarrow \text{cat}$



Source: becominghuman.ai



Source: affinelayer.com/pixsrv/

Machine Learning for Dose Calculation

GET DATA

- Create Monte Carlo simulation
- Use MC dose as accurate training data

TRAIN

- Develop a model architecture
- Training takes a while

DEPLOY

- Very fast

THE PROBLEM

Machine learning requires data

TRAINING DATA

QUANTITY AND QUALITY

**DATA
BIASES**

ETHICS

COMPREHENSIVE

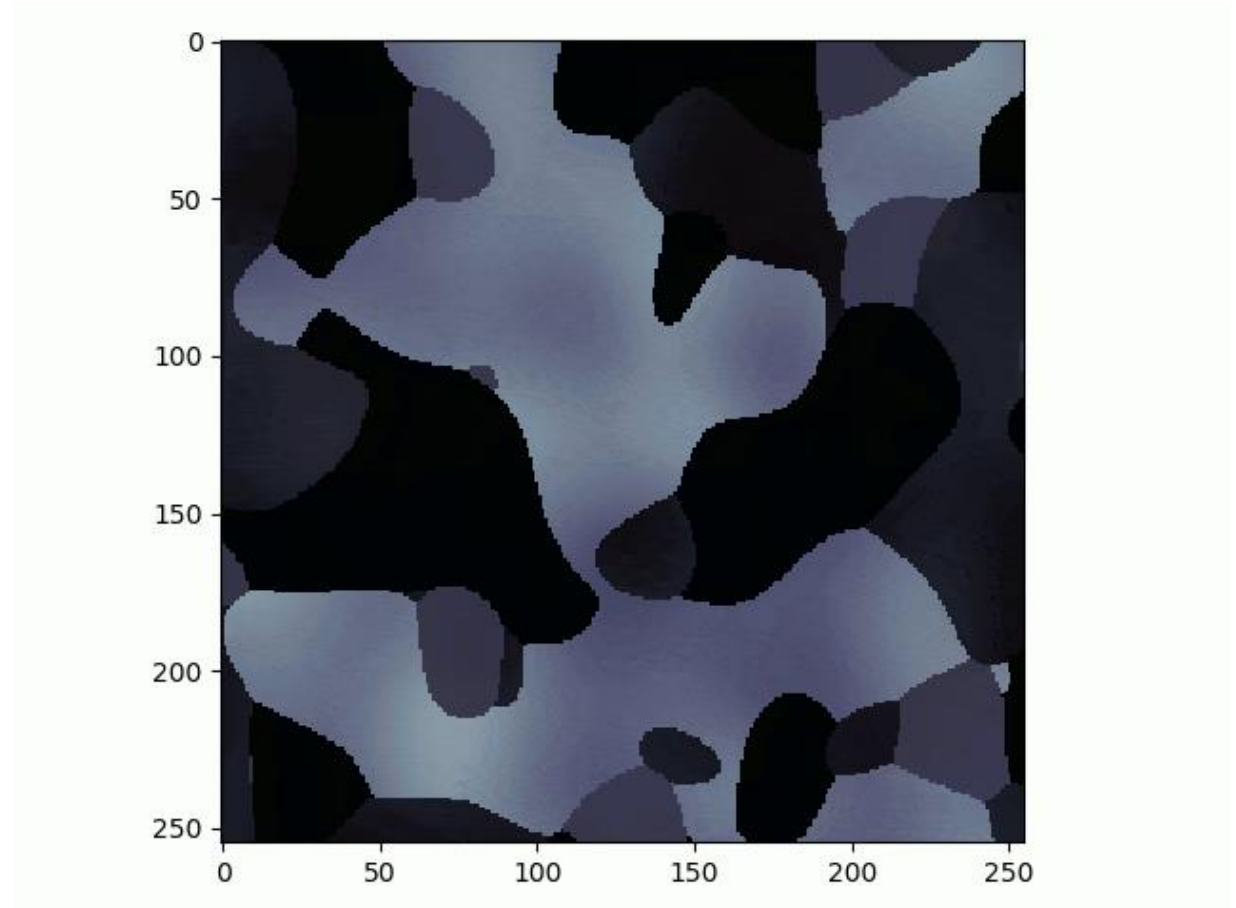
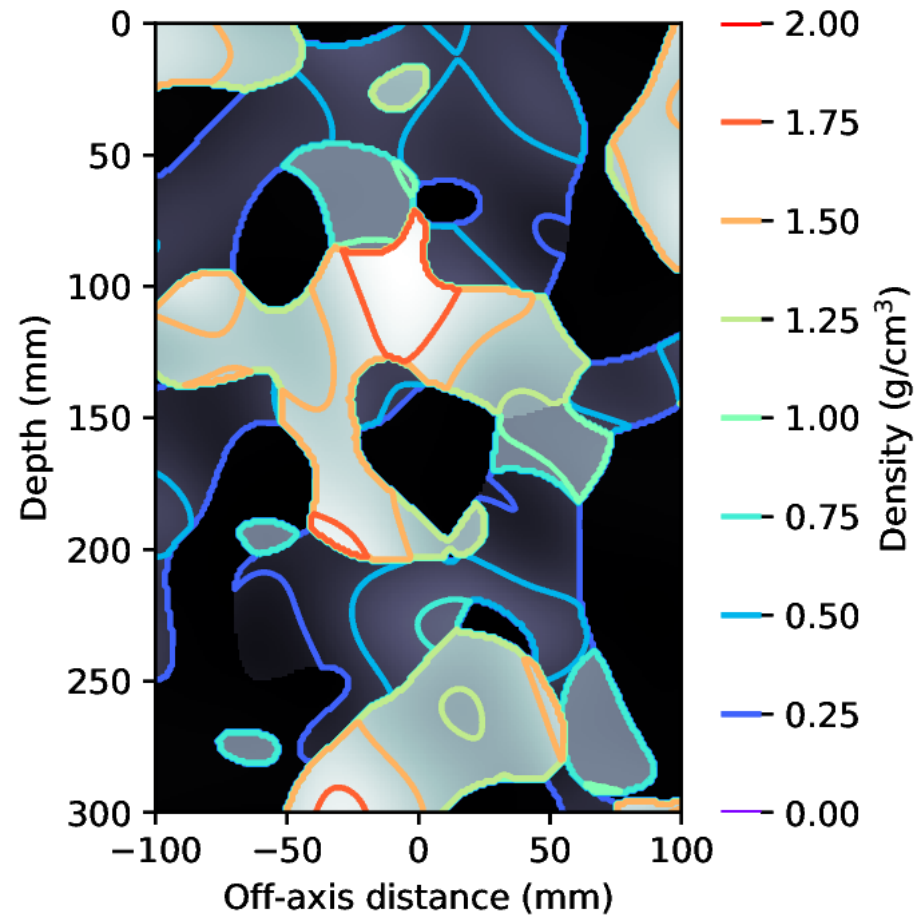
**RESEARCHER
ACCESS**

CONSISTENT

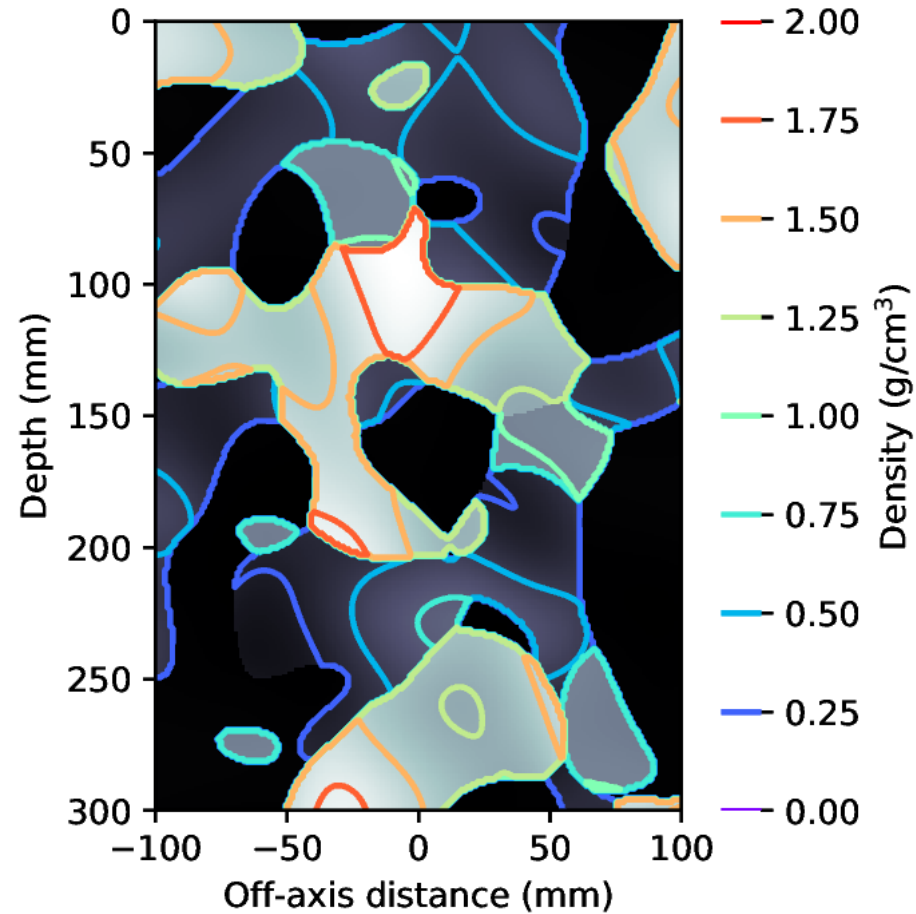
A POTENTIAL SOLUTION

Simplex noise as training data

Simplex Noise



Simplex Noise



ALGORITHM

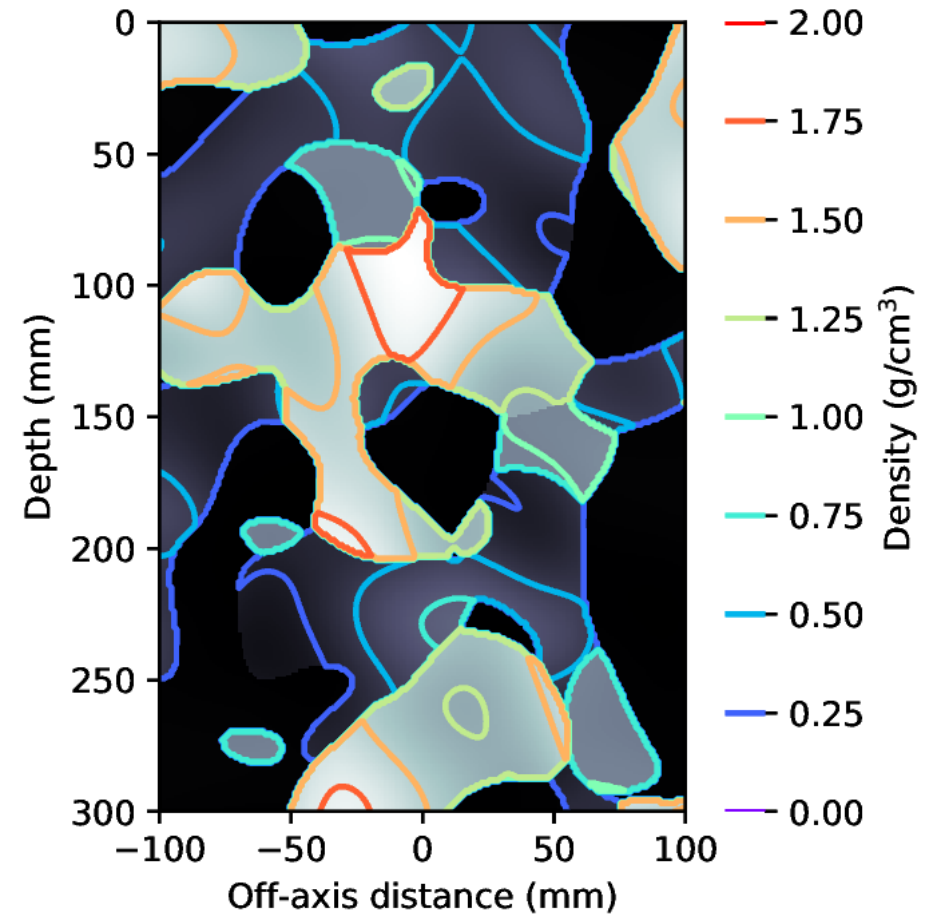
- Generate one noise volume per material
- Rescale each noise volumes to material density
- Generate another noise volume per material
- Sample n^{th} scaled noise volume where n^{th} unscaled noise volume is minimal

EVALUATION

Simplex noise

Encoding Fields

DENSITY CHANNEL

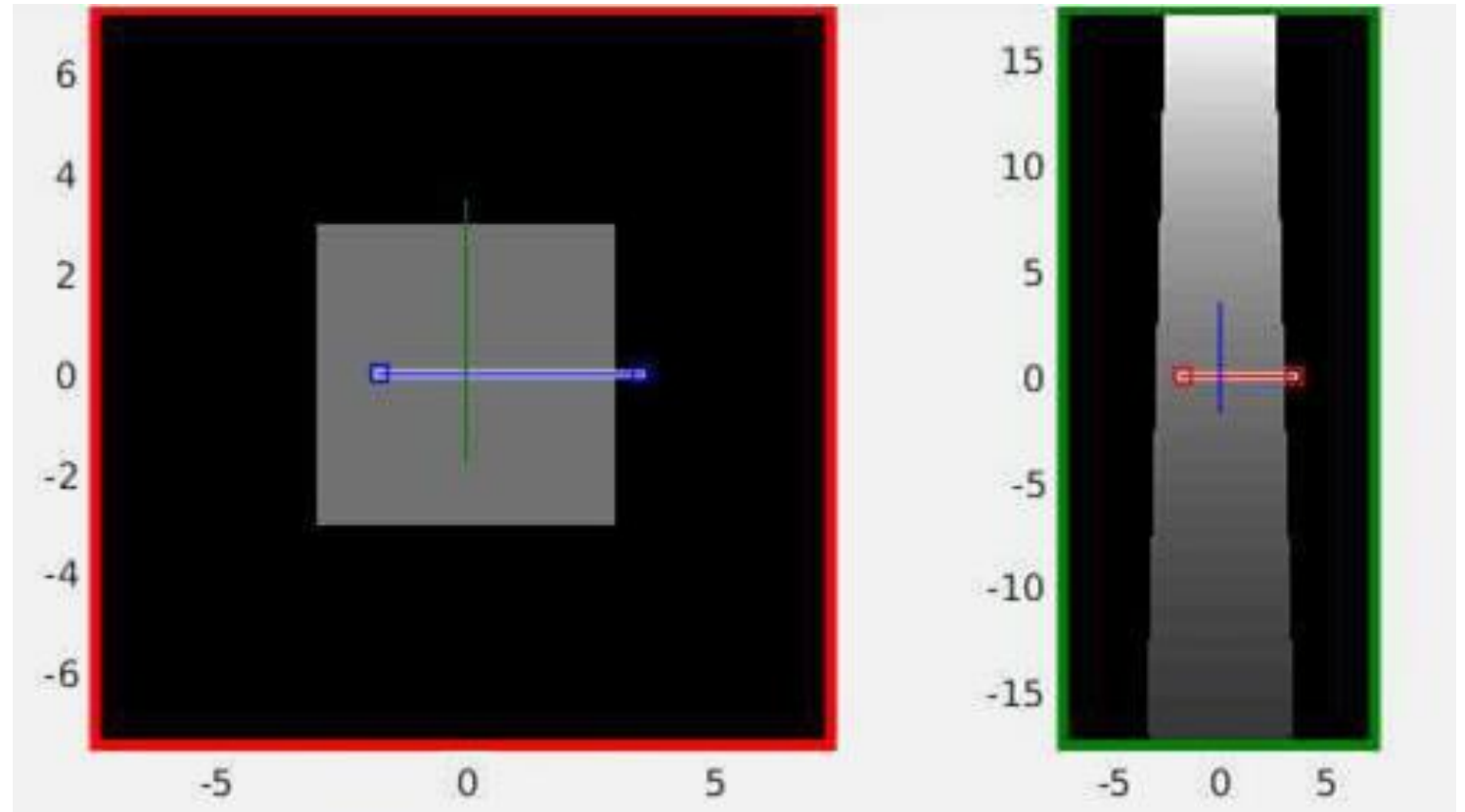


Encoding Fields

$$\Psi_0(\mathbf{r}, E) = \frac{e^{-\tau(\mathbf{r}_0 \rightarrow \mathbf{r}, E)} Q_A(\mathbf{r}_0, E)}{|\mathbf{r} - \mathbf{r}_0|^2}$$

DENSITY CHANNEL

FLUENCE CHANNEL

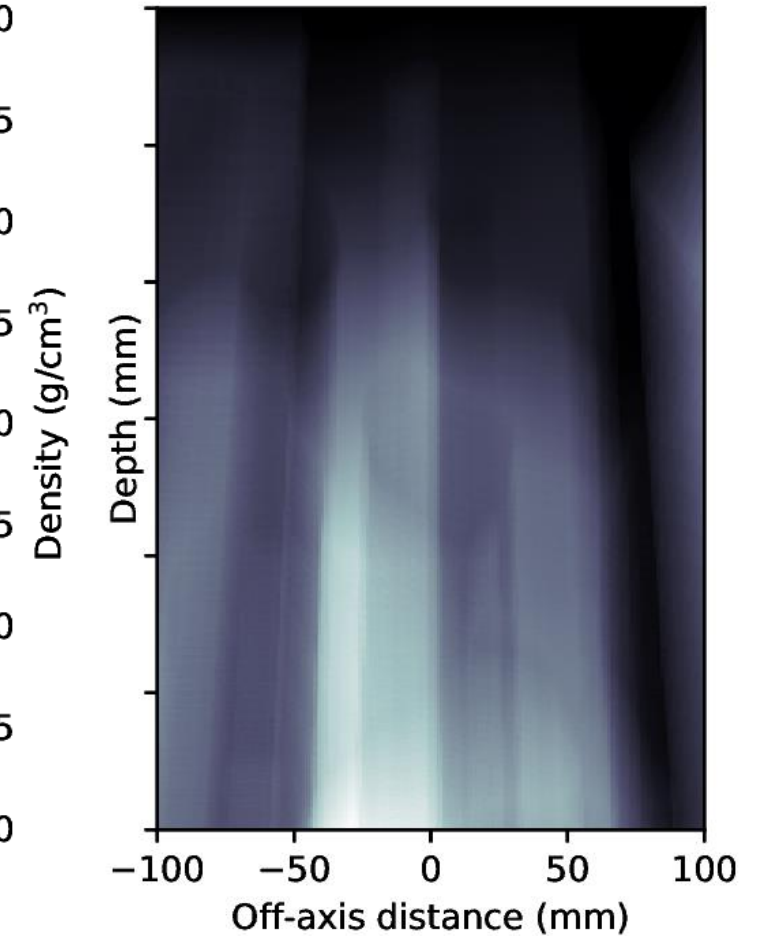
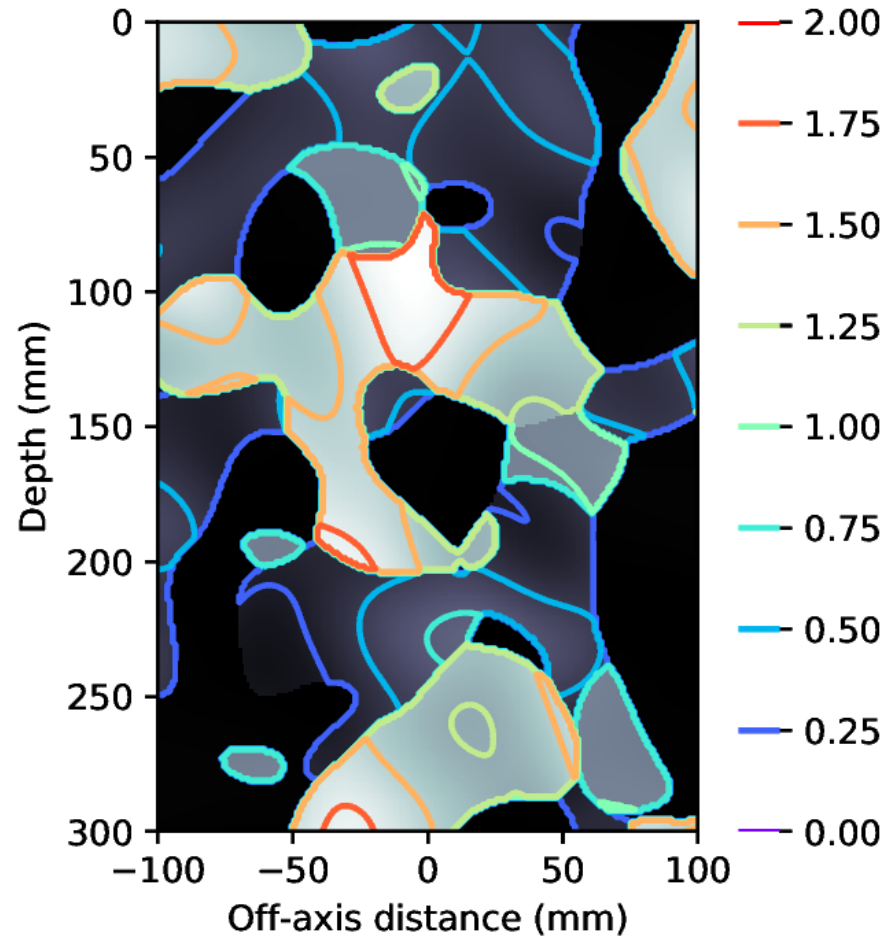


Encoding Fields

DENSITY CHANNEL

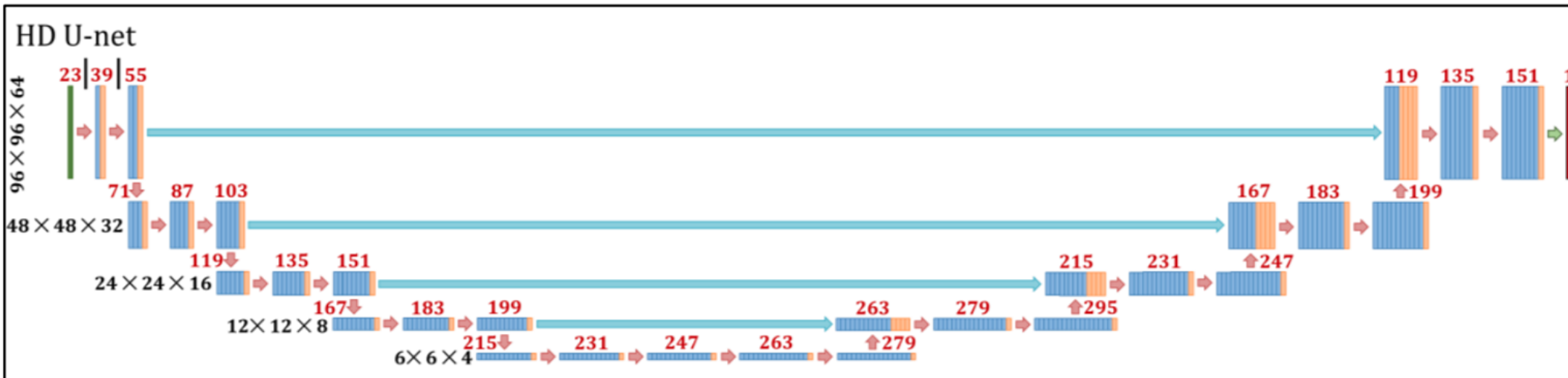
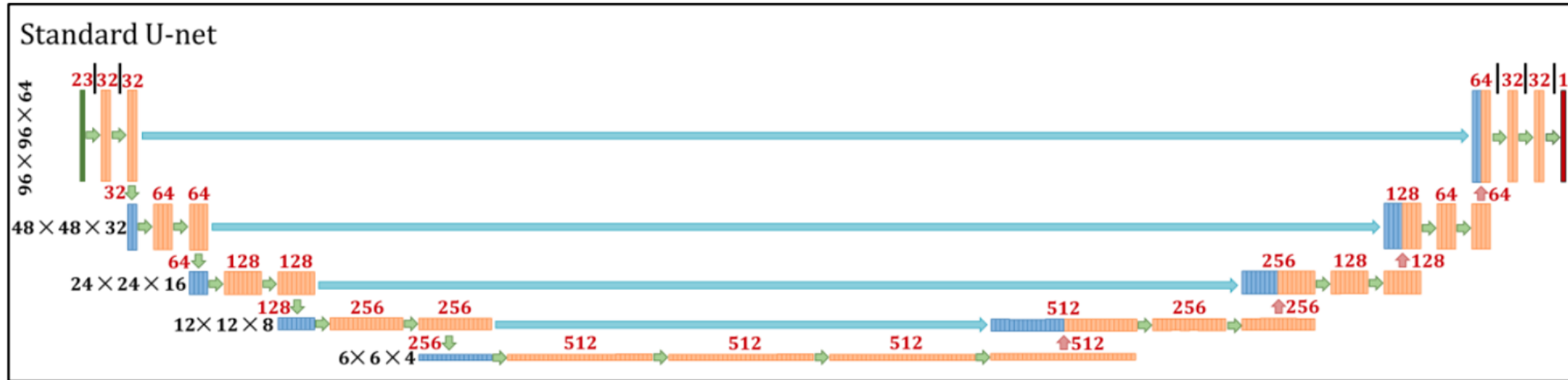
FLUENCE CHANNEL

**RADIOLOGICAL
PATH LENGTH
CHANNEL**



HD U-NET

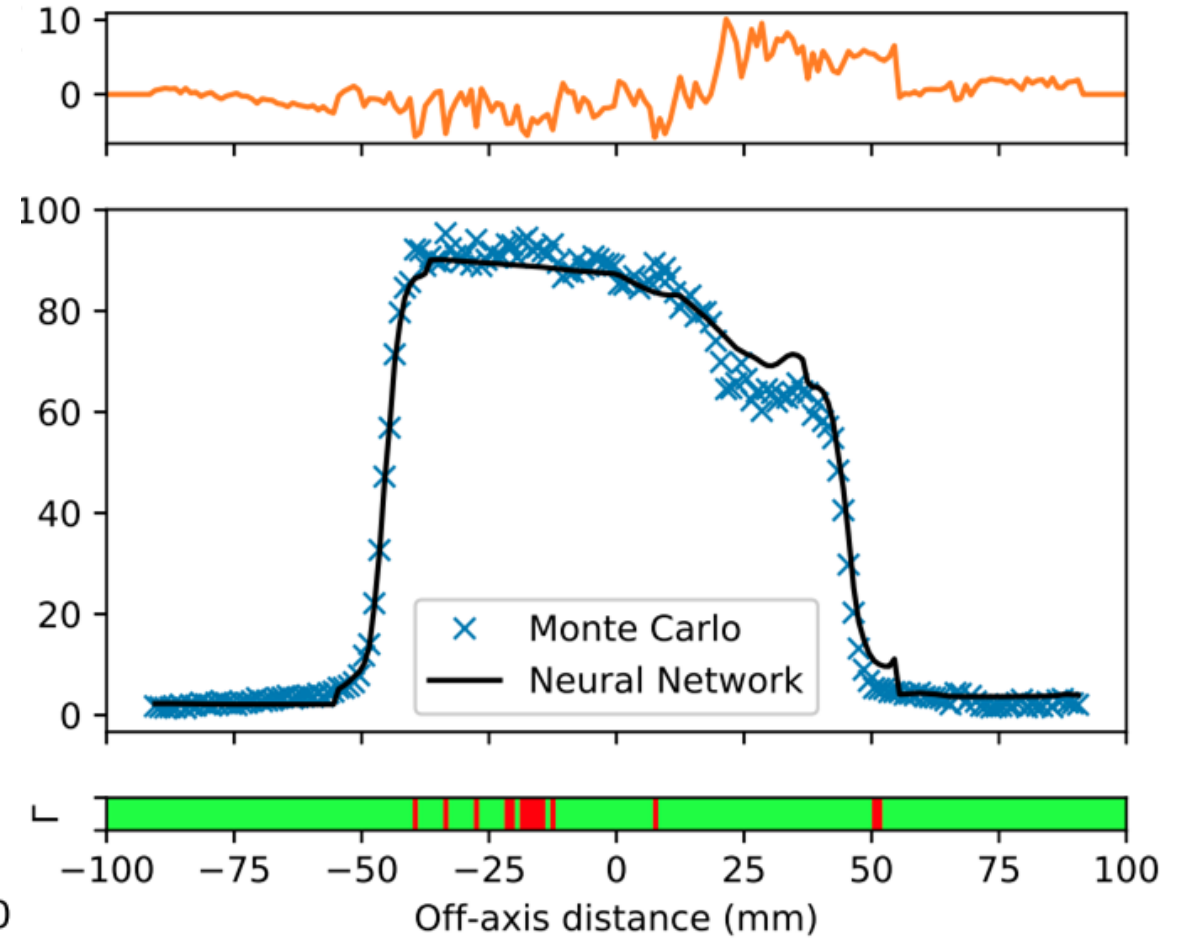
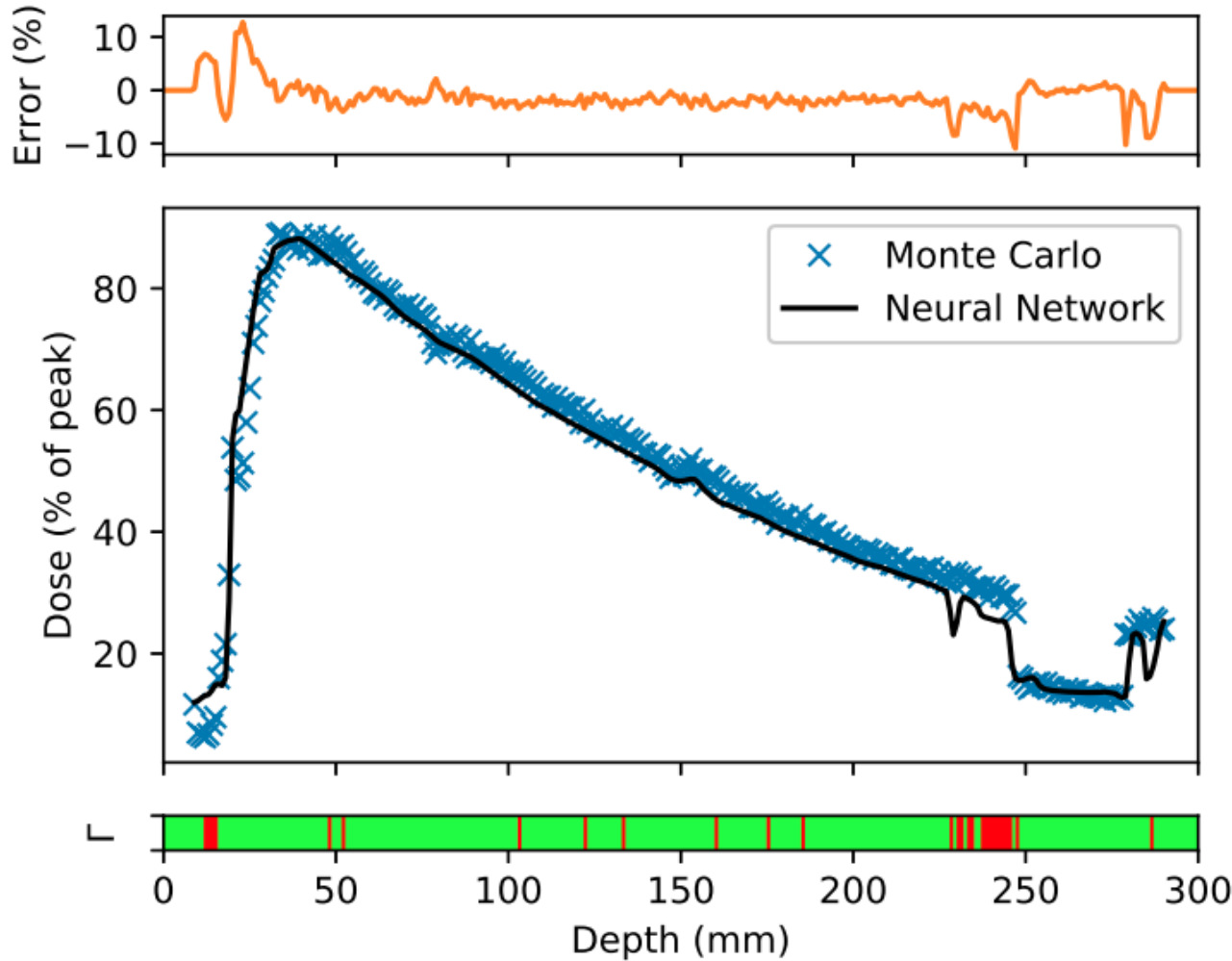
Source: Nguyen et. al. 2019



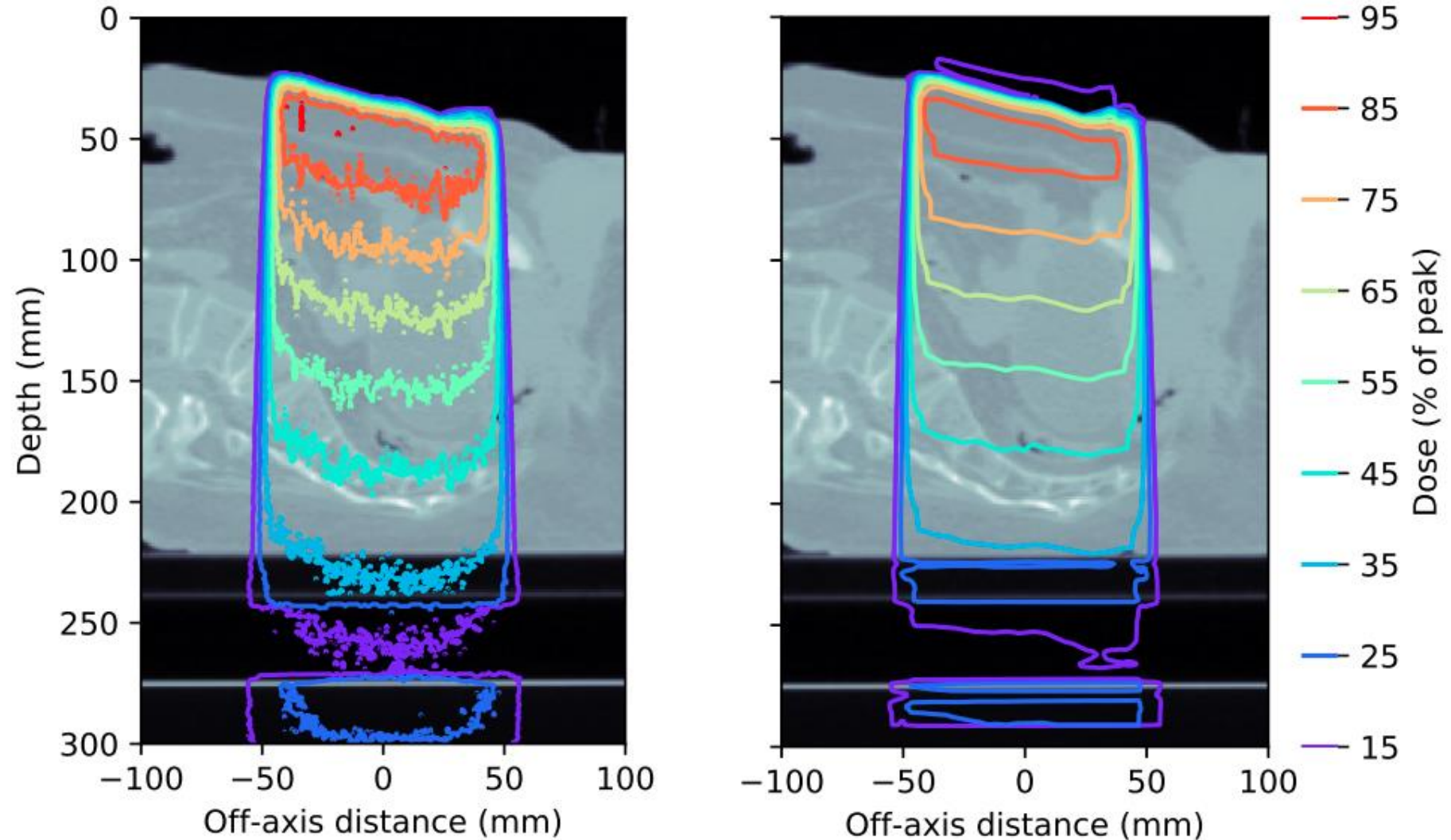
RESULTS

Simplex noise

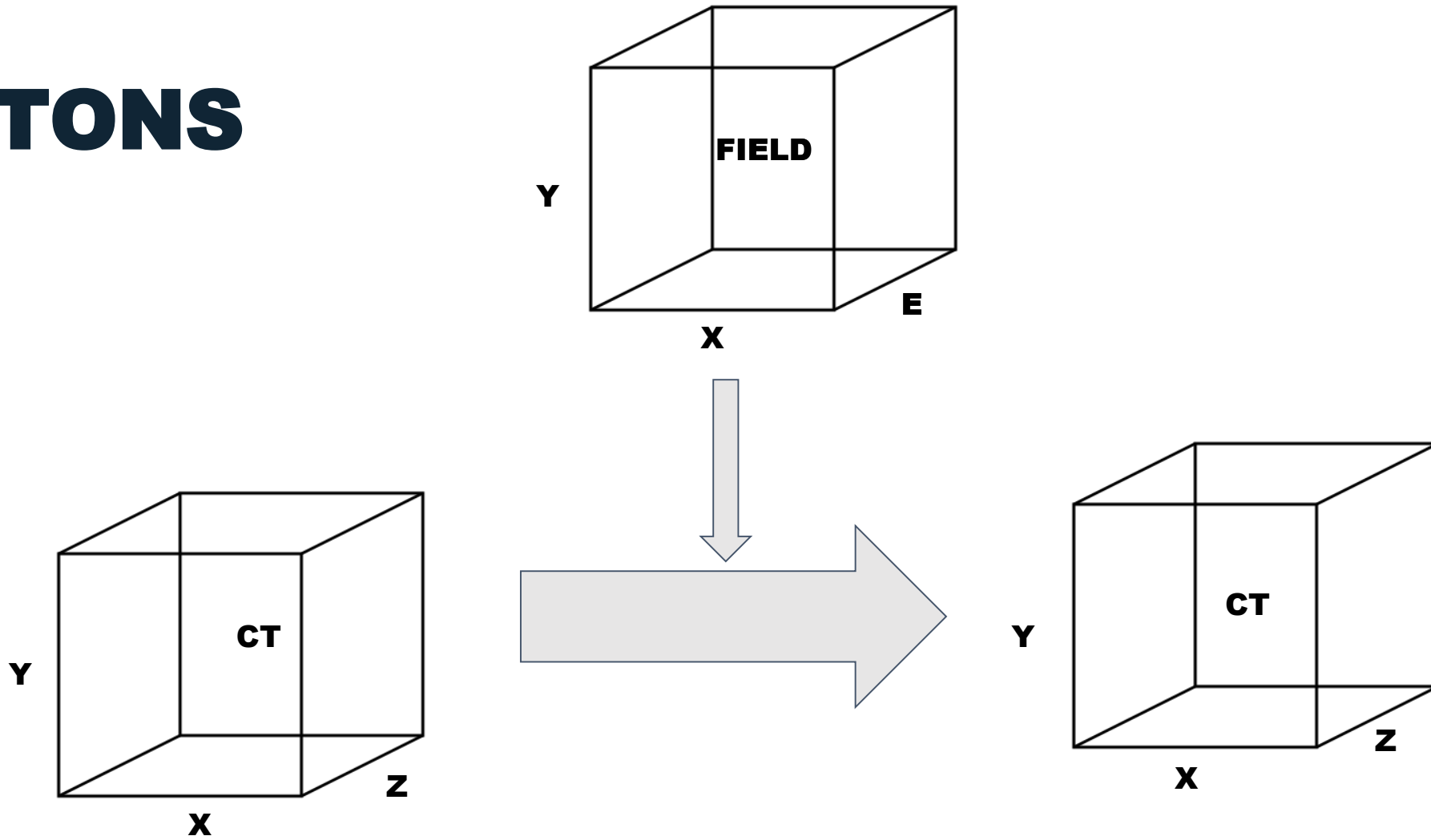
MEGAVOLTAGE X-RAYS



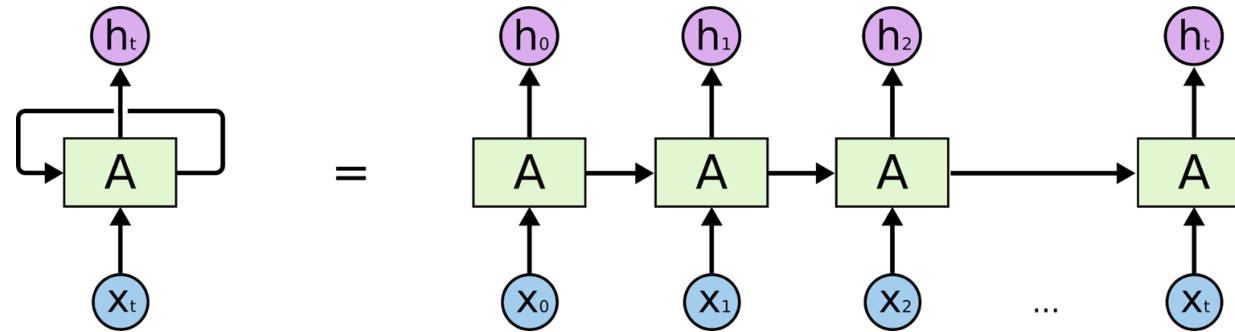
MEGAVOLTAGE X-RAYS



PROTONS

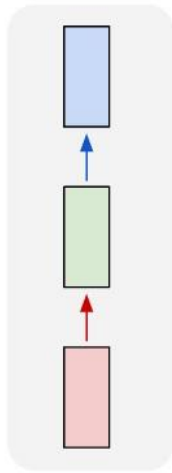


RNN

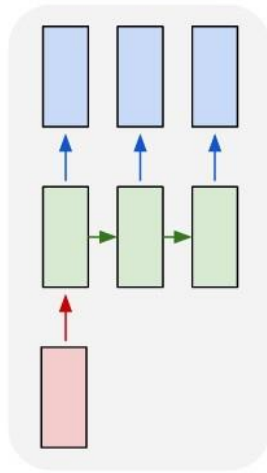


Source: Nguyen et. al. 2019

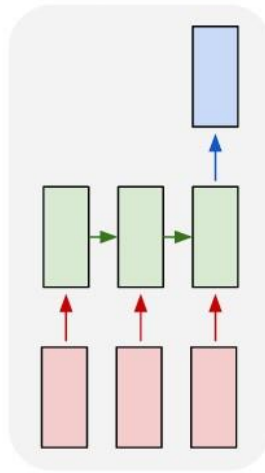
one to one



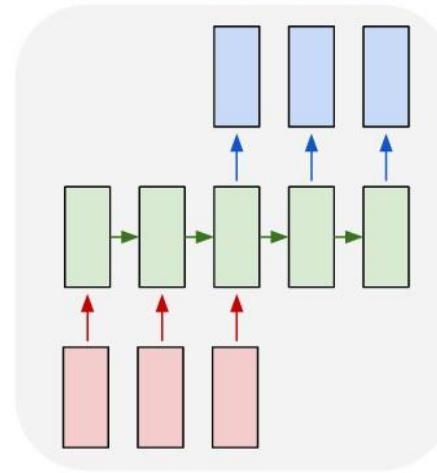
one to many



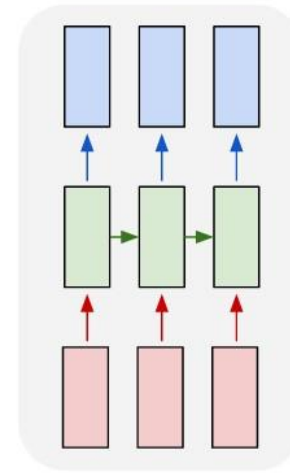
many to one



many to many



many to many



CONCLUSIONS

Simplex noise is a viable source of high quantity, high quality training data for dose calculation using machine learning.

A model trained using the proposed framework may be fast enough to use in inverse optimisation algorithms/as a secondary MU calculation.

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