Erasmus MC
Universitair Medisch Centrum Rotterdam

Cancer Institute

HollandPTC
Particle Therapy Centre

Near real-time automated dose restoration in IMPT to compensate for daily density variations

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Poster Presentation ENLIGHT

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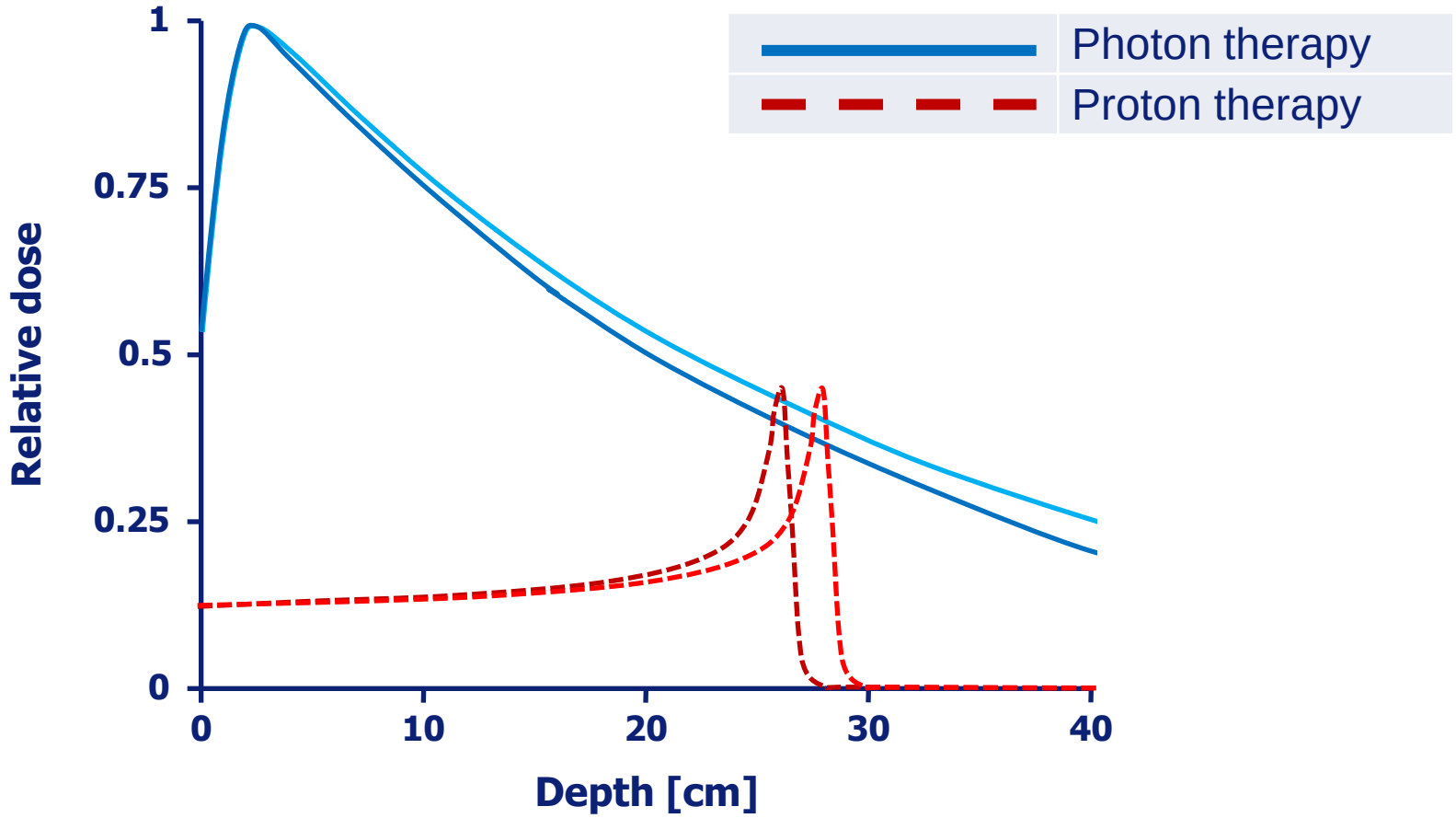
ENLIGHT

Proton therapy is very sensitive to uncertainties



- **Range** uncertainties
- **Motion-based** uncertainties

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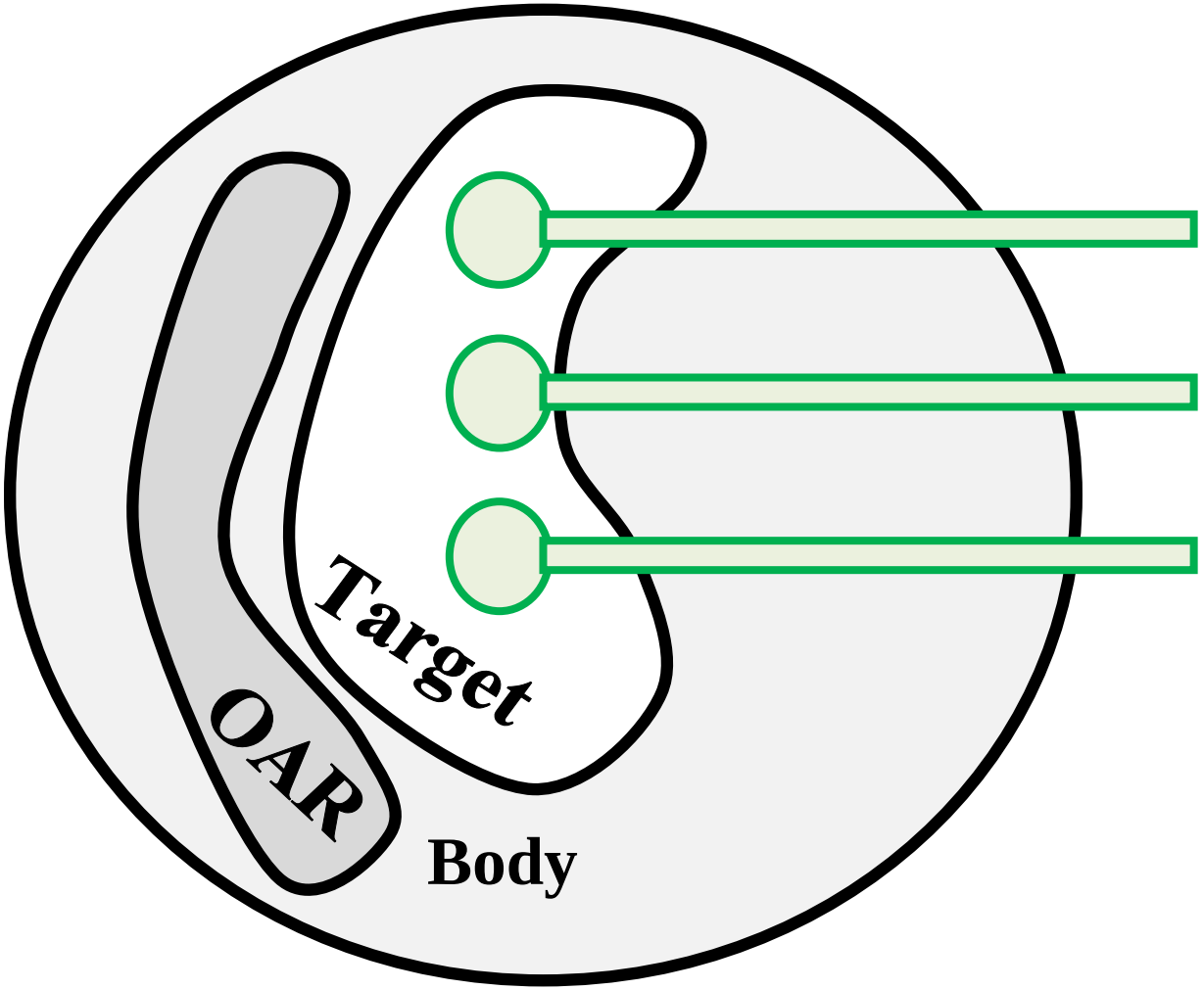
We make a treatment plan



Intended

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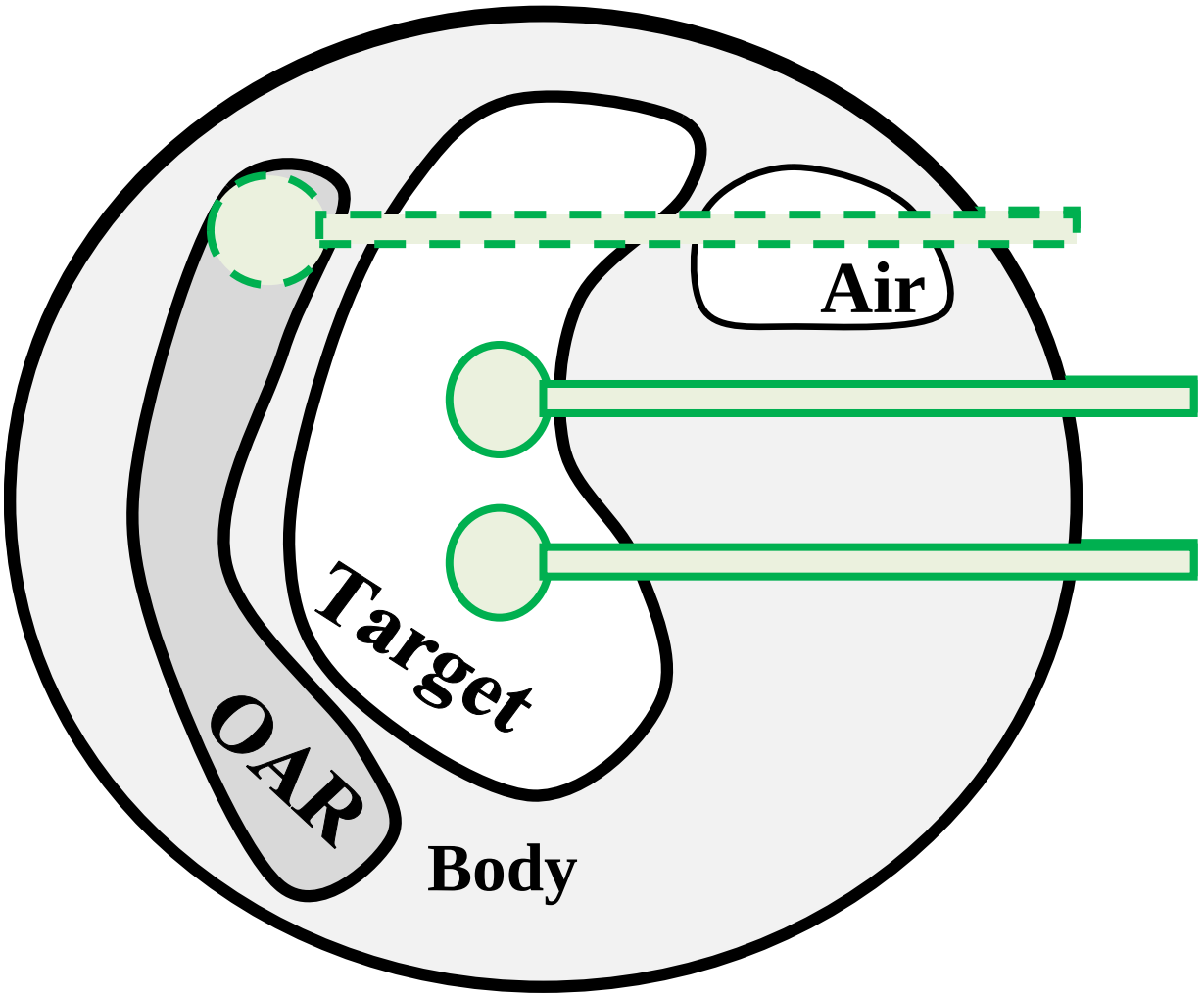
But a density change in the repeat CT scan disturbs the plan



Distorted

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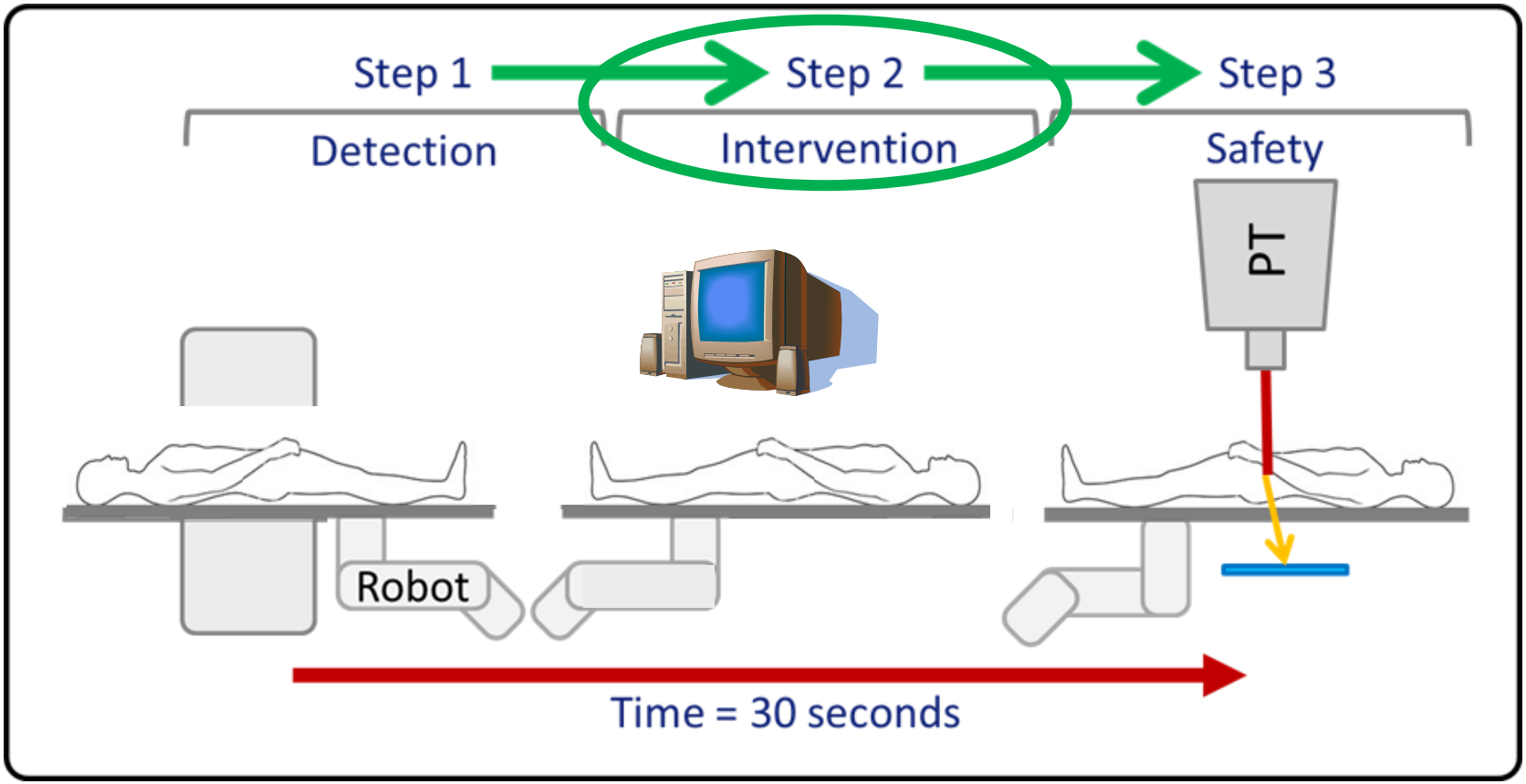
Detect and adapt for these changes at HollandPTC



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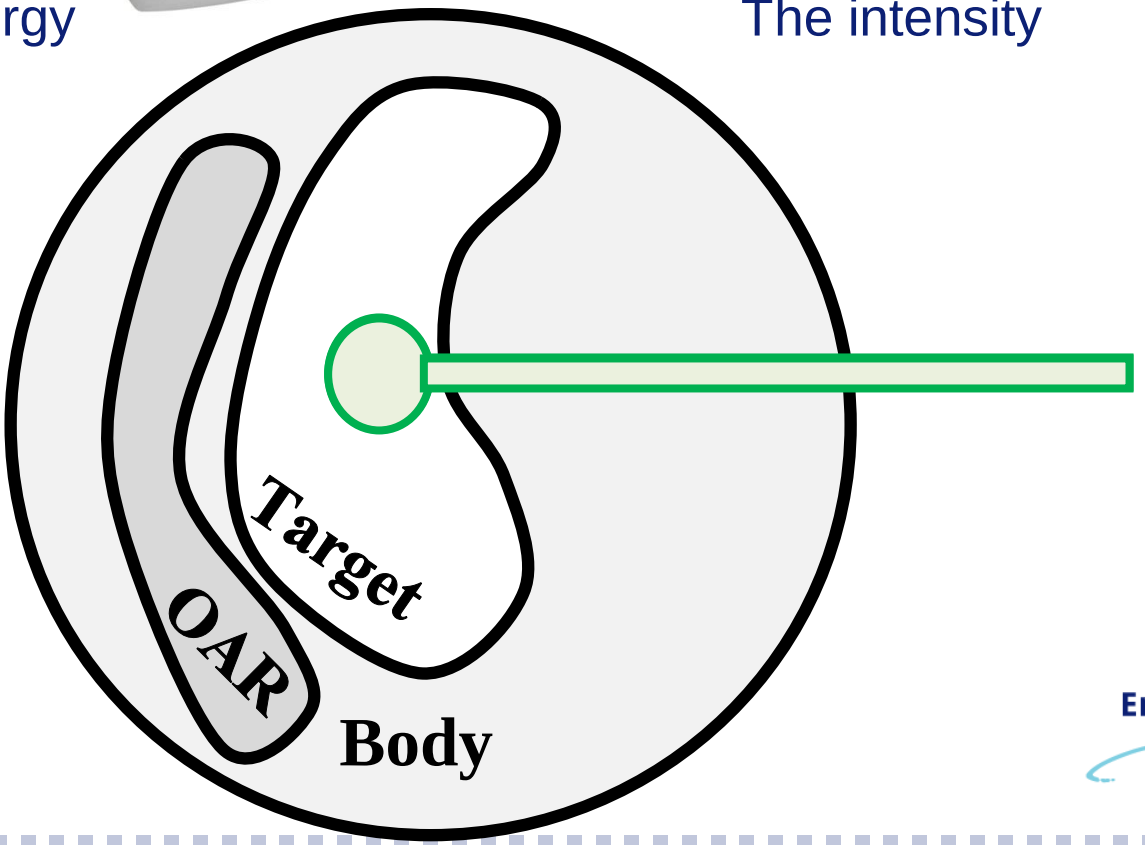
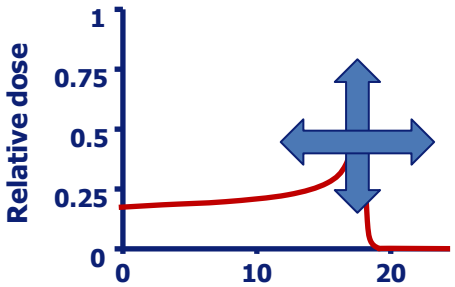
We can control two things

The energy

The intensity





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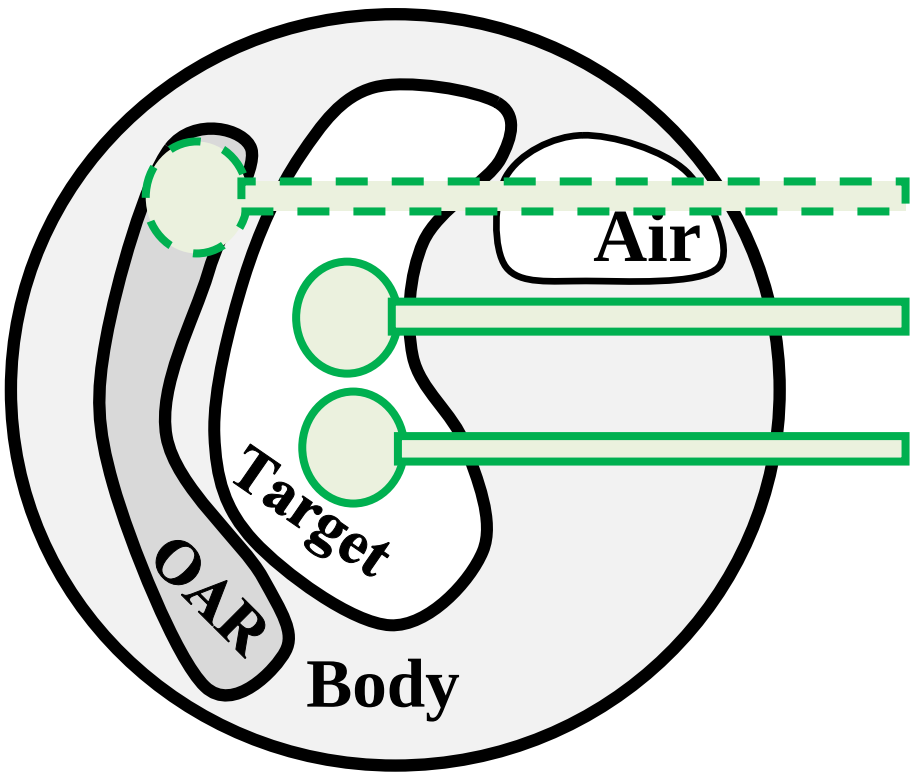
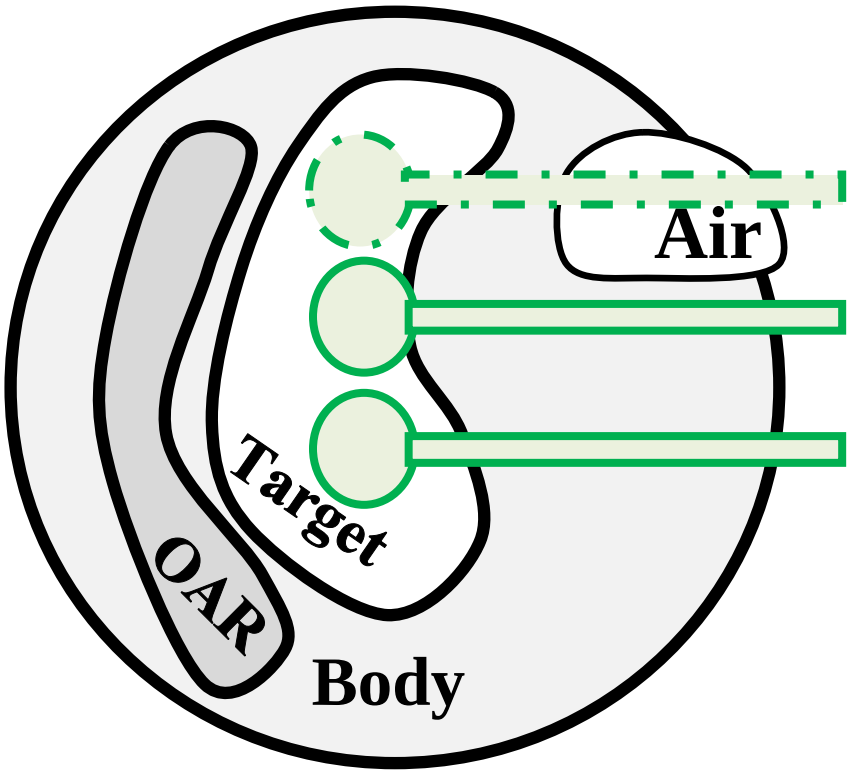
To restore the dose, we start by adapting the energy



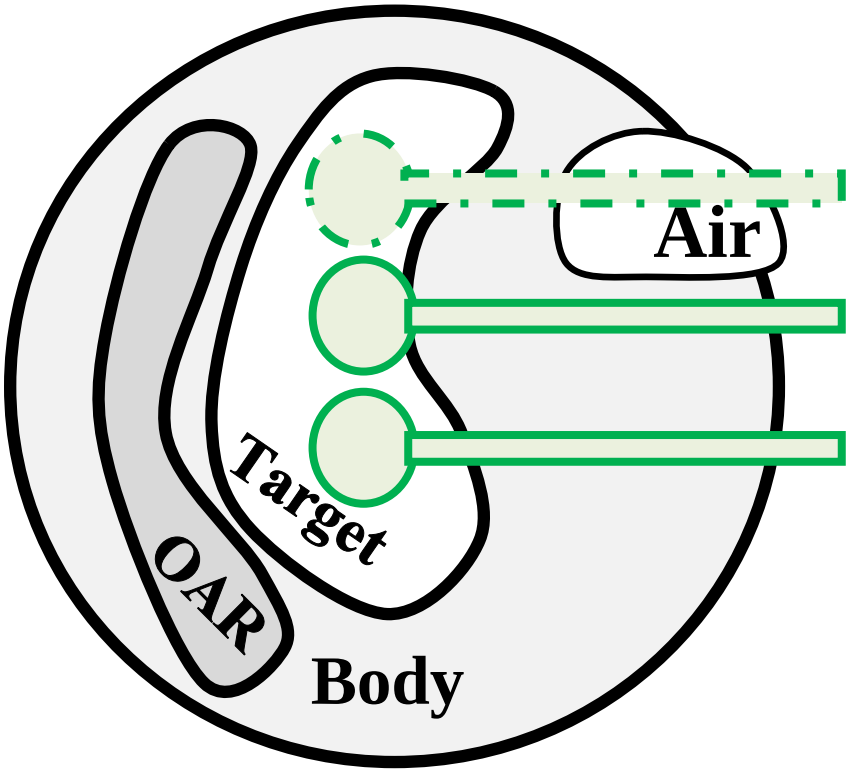
Distorted



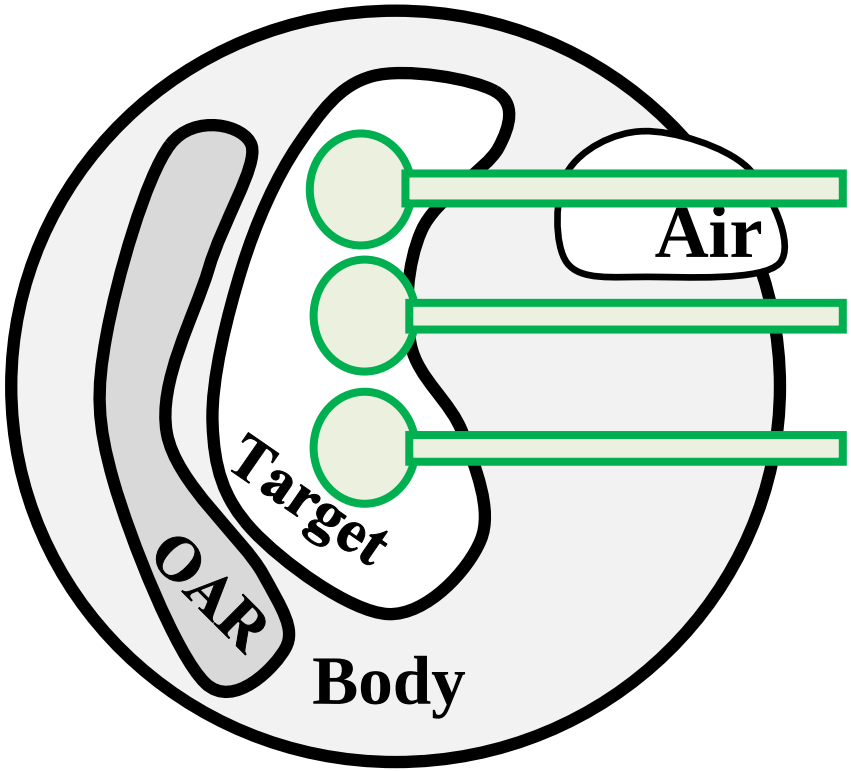
Energy-restored

But then the delivered dose is different…

…So we have to do a re-optimization

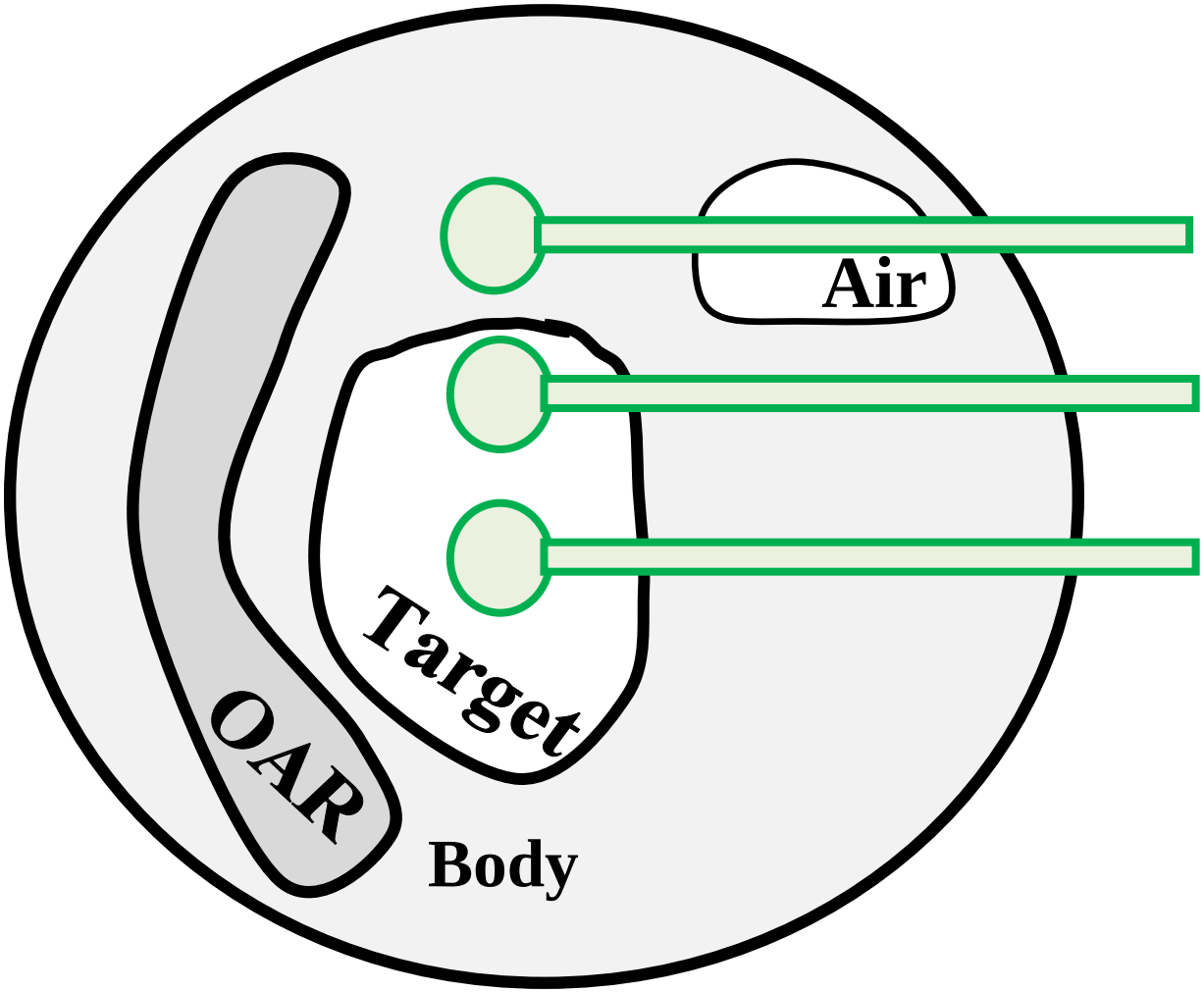


Energy-restored



Re-optimized

This only works for density changes!



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A focused weight re-optimization

Minimize the difference between the intended and energy-restored dose.

4 approaches were tried:

- Method A: No focus
- Method B: Focus on targets
- Method C: Focus on targets and OARs
- Method D: Focus on structure with biggest distortion

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10 prostate cancer patients

- **8-10 repeat CT scans for every patient**
- **1 repeat CT scan used for planning**
- **80 repeat CT scans in total**

- **Targets:**
  - Prostate ($V_{95\%}$, $V_{107\%}$) — 74 Gy prescribed
  - Lymph nodes ($V_{95\%}$, $V_{107\%}$) — 55 Gy prescribed
  - Seminal vesicles ($V_{95\%}$, $V_{107\%}$) — 55 Gy prescribed

- **OARs:**
  - Rectum (D_{mean}, V_{45Gy}, V_{60Gy}, V_{75Gy})
  - Bladder (D_{mean}, V_{45Gy}, V_{65Gy})

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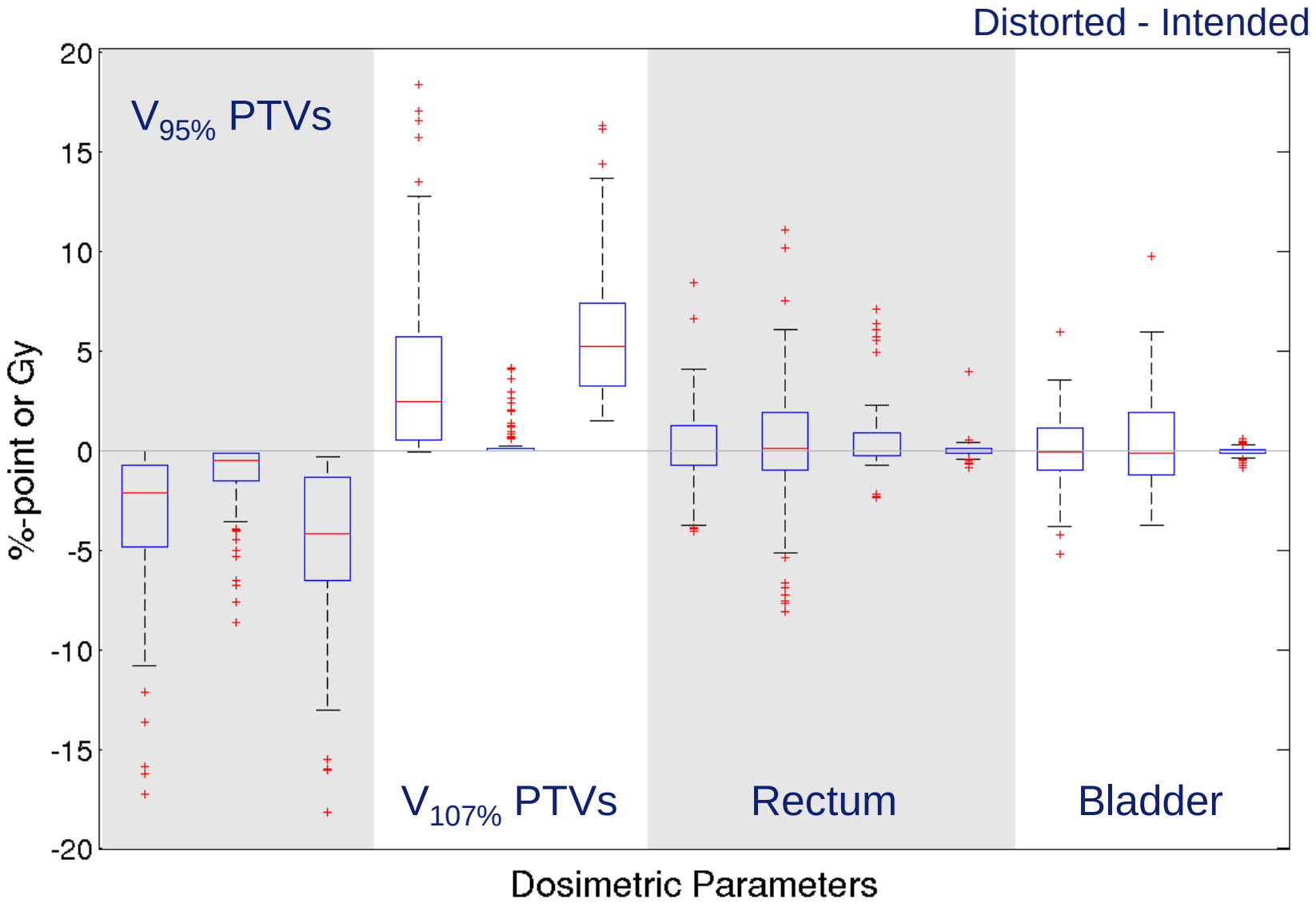
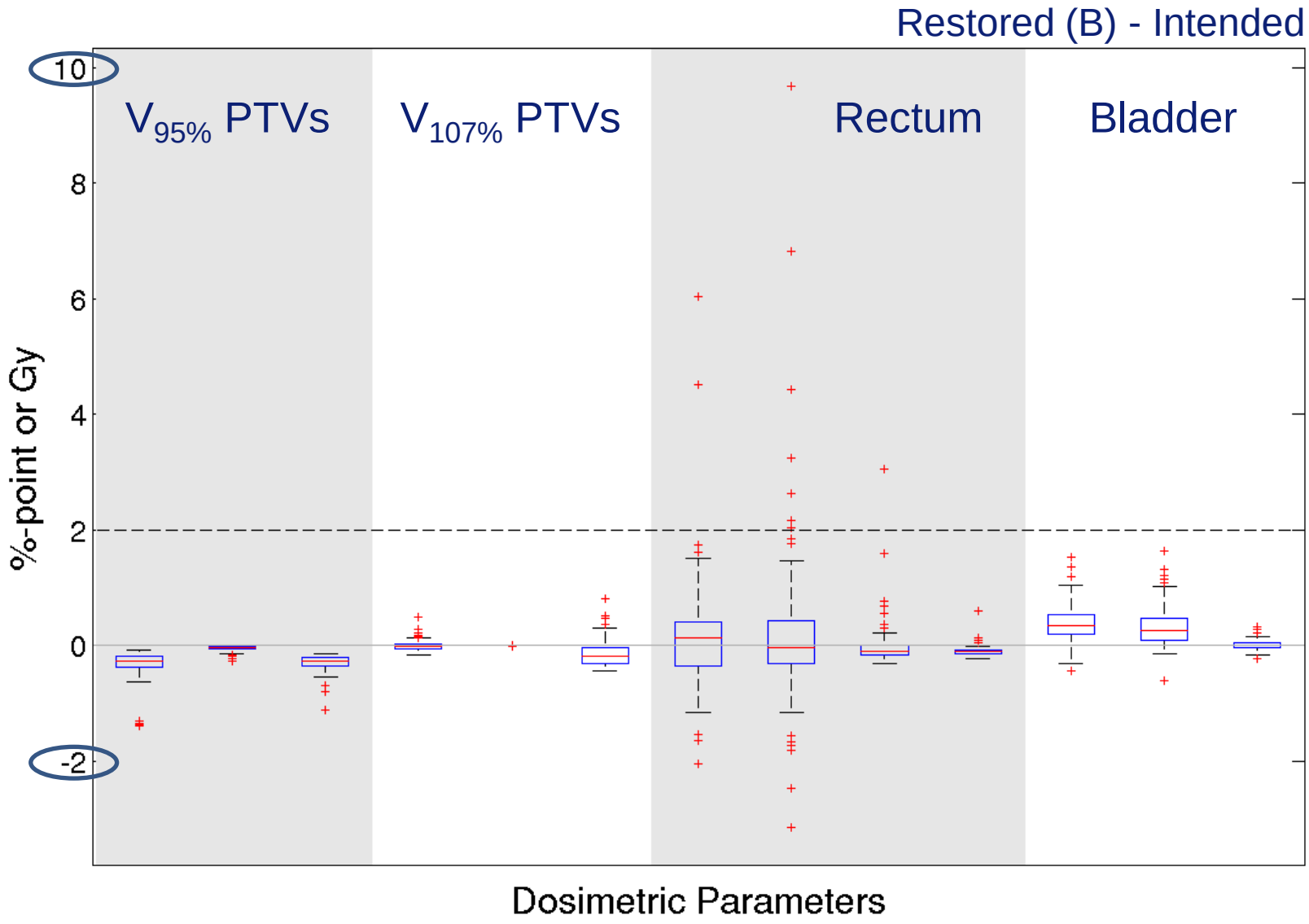
The distortion for the 80 repeat scans



Best results obtained with focus on targets (B)



On average restoration in less than 10 seconds

Energy Adaptation:
5.4
seconds

Re-optimization:
3.8
seconds

Between the two steps:
calculate the dose distribution matrix A.
Mean 4.3 **minutes** (2.4 – 9.6).

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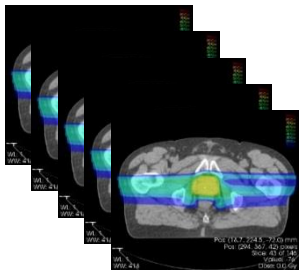
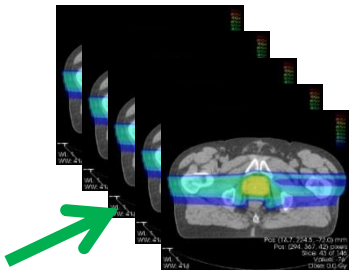
Future work: The ADAPTNOW project

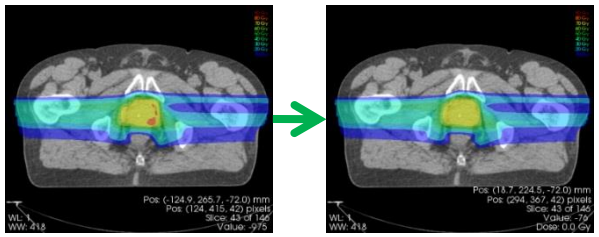
Create a plan library

Dose warping and re-optimization

Dose warping and re-optimization







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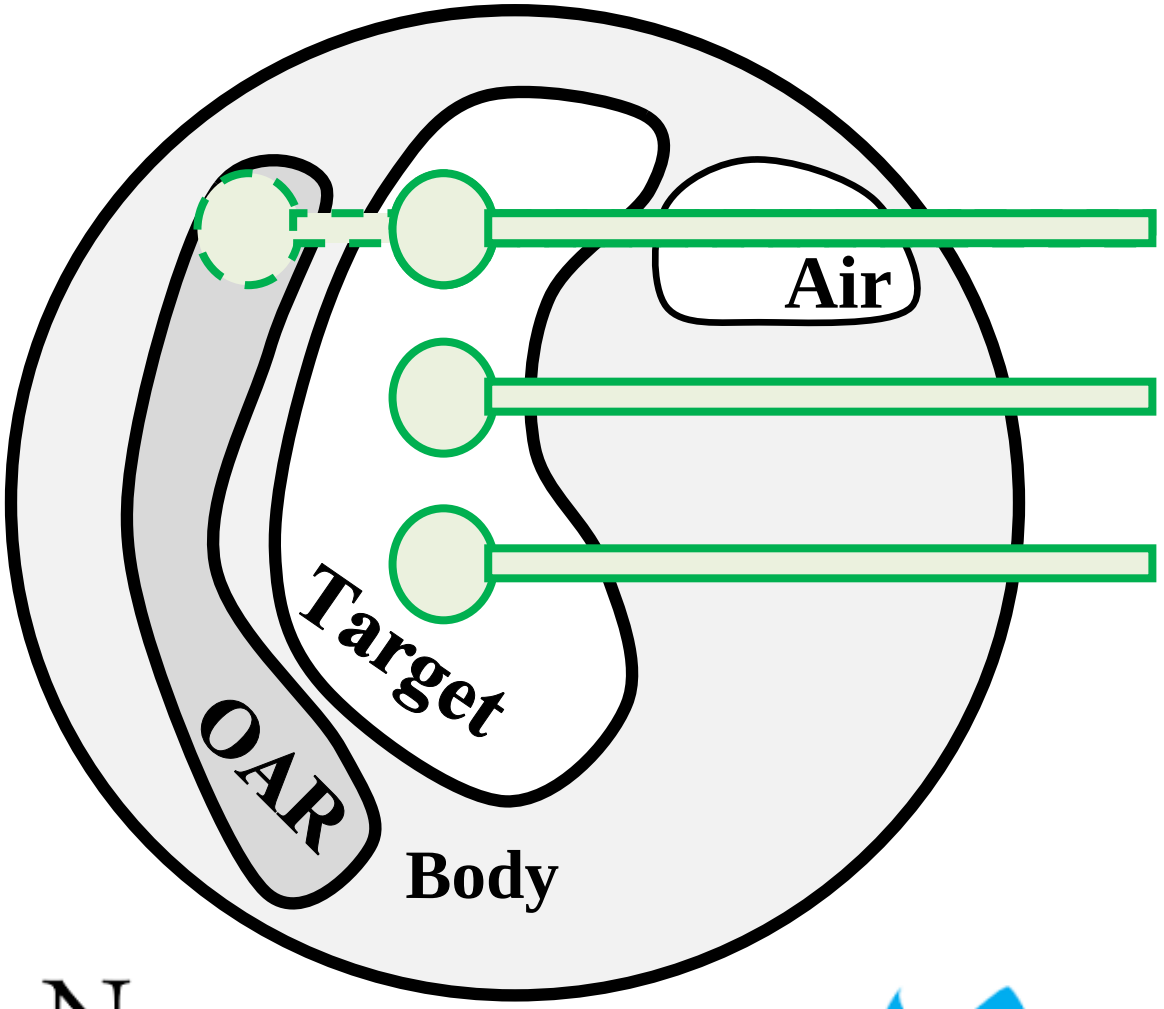
We can do it! Energy adaptation + Re-optimization < 10 seconds



VARIAN
medical systems

ZonMw