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Introduction

- **Pancreatic cancer** is the **4th** leading cause of cancer-related **death** in the US.
- **Proton therapy (PT)** poses a **great potential alternative treatment** to photon therapy due to¹:
 - **Dose escalation**
 - **While more organs-at-risk (OARs) Sparing**
- With **2D Image Guidance (IG)**, **5 mm uniform optimization target volume (OTV)** is widely accepted².
- However, **conservative 5 mm OTV compromises plan quality**.
- By introducing **4D IG** with real time gated proton therapy (RGPT), margins can be reduced to allow **more room for dose escalation**.

The Question is:
Can we reduce OTV margins from 5 mm without losing robustness and plan quality?

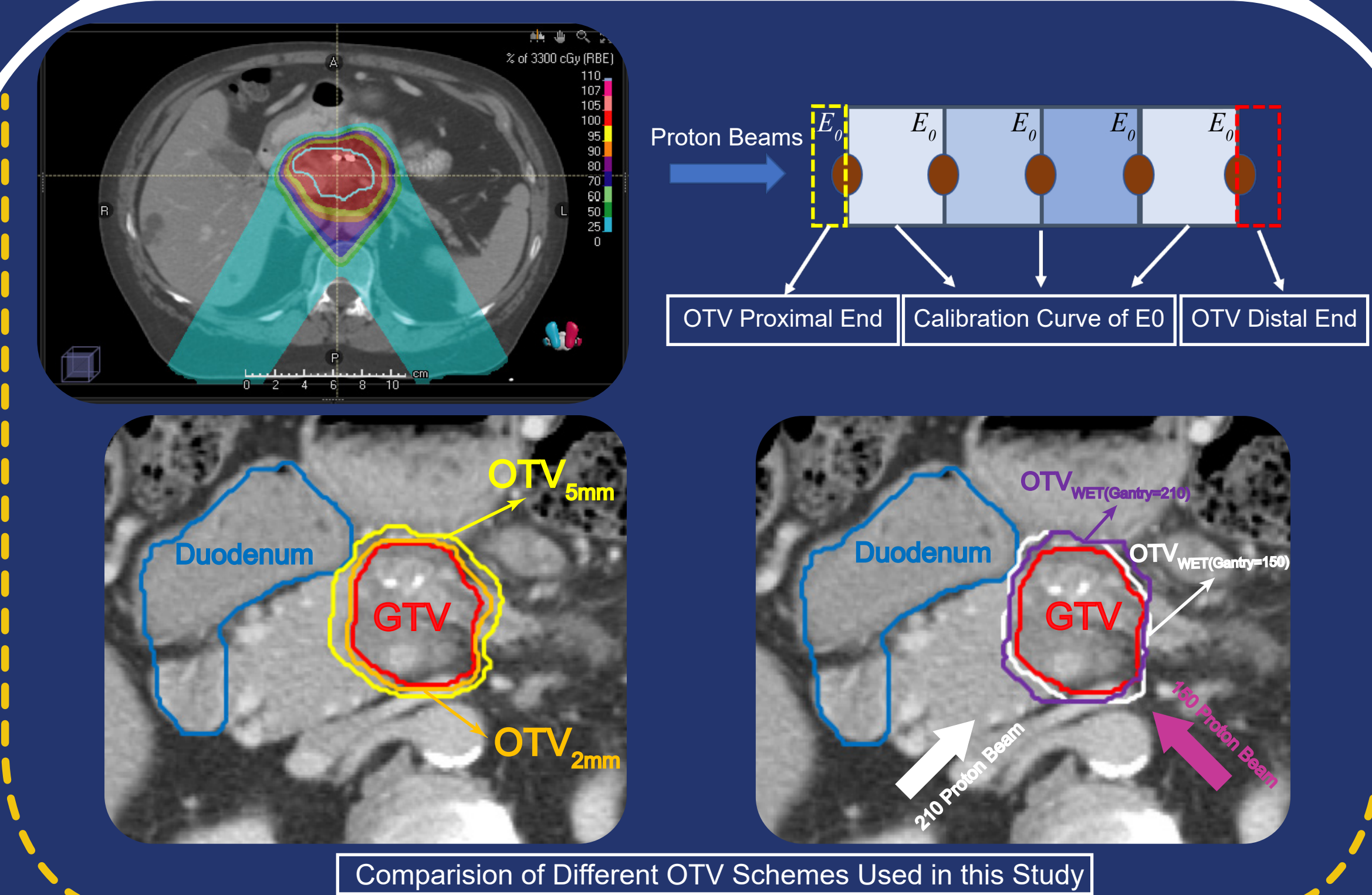
Methods and Results

Dosimetric Materials

- 5 LAPC patients previously treated with SBRT are planned for SBPT with 33 Gy(RBE) in 5 fractions.
- Three OTV expansion schemes are compared:
 - 1) 5mm Uniform Expansion (OTV_{5mm})
 - 2) 2mm Uniform Expansion (OTV_{2mm})
 - 3) Beam Specific Water Equivalent Thickness³ Non-Uniform Expansion (OTV_{WET})

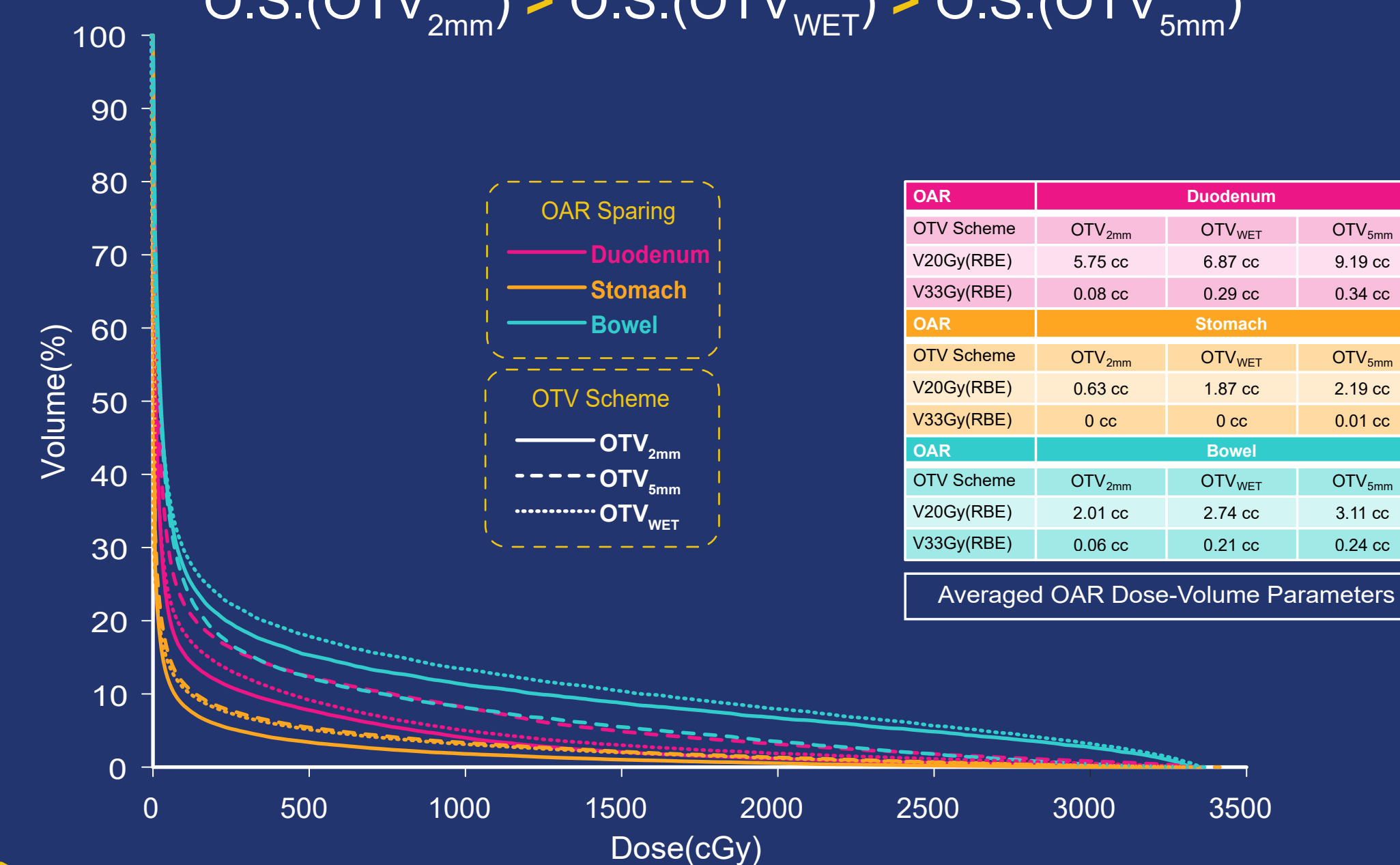
2mm laterally → Setup Uncertainty

- OTV_{WET} = $\text{OTV}_{2mm} + 3.5\% \text{ GTV depth beam direction}$ → Range Uncertainty



Plan Quality Comparison

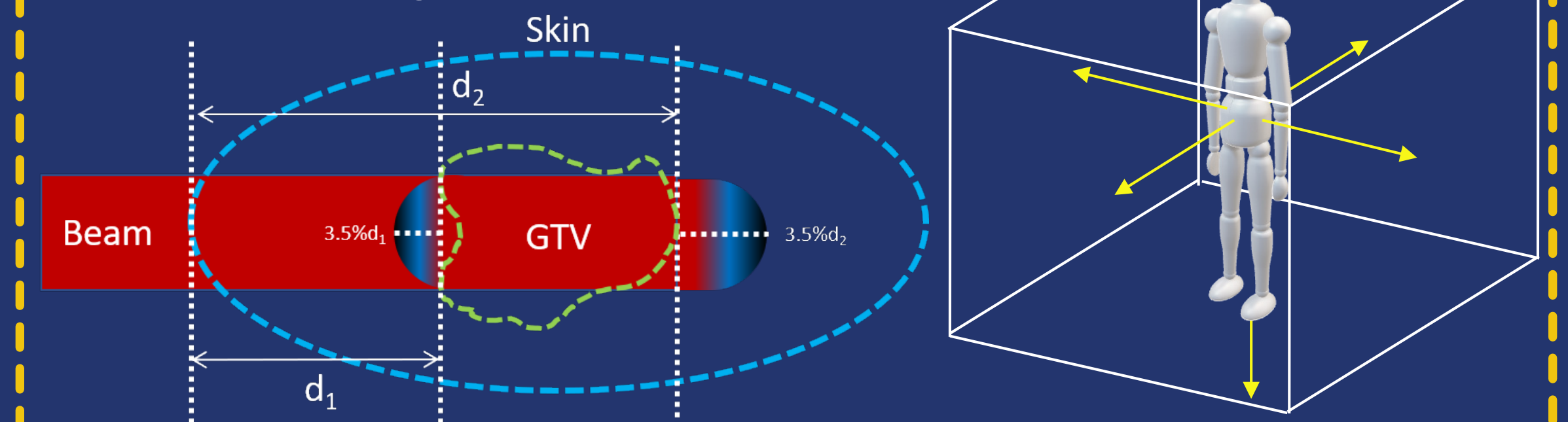
- SBPT plans are compared based on:
 - Target Dose Coverage (T.D.):
D98% = 33 Gy(RBE)
 - OAR Sparing (Duodenum, Stomach, Bowel) (O.S.):
V33Gy(RBE) < 1cc and V20Gy(RBE) < 20cc
- Results:
T.D.(OTV_{2mm}) = T.D.(OTV_{WET}) = T.D.(OTV_{5mm})
O.S.(OTV_{2mm}) > O.S.(OTV_{WET}) > O.S.(OTV_{5mm})



Is OTV_{2mm} the best scheme?!
But, how robust these plans are to uncertainties?

Robustness Evaluation

- SBPT plans are perturbed with:
 - 2mm setup error in all directions
 - 3.5% range error in beam direction



- Robustness Performance (R.O.):
R.O.(OTV_{2mm}) < R.O.(OTV_{5mm}) < R.O.(OTV_{WET})

Conclusion

- OTV_{2mm} shows most promising results if **only OAR-sparing** and **target coverage** are considered.
- However, delivery of SBPT is associated with **setup** and proton beam **range uncertainties**.
- OTV_{WET} shows a **highly robust** performance compared to the other schemes.
- Contrary to what is expected from OTV_{5mm}, it does **not perform well** in **robustness evaluation**.
- The results of our study demonstrate a considerable **improvement** of overall SBPT plan **quality** when **beam specific OTV_{WET}** is used.

References

- 1 T.T. Sio, et al., Spot-scanned pancreatic stereotactic body proton therapy: A dosimetric feasibility and robustness study, Phys. Medica 32(2), 331–342 (2016).
- 2 R.F. Thompson, et al., A dosimetric comparison of proton and photon therapy in unresectable cancers of the head of pancreas, Med. Phys. 41(8), 1–10 (2014).
- 3 P.C. Park, et al., A beam-specific planning target volume (PTV) design for proton therapy to account for setup and range uncertainties, Int. J. Radiat. Oncol. Biol. Phys. 82(2), 329–336 (2012).