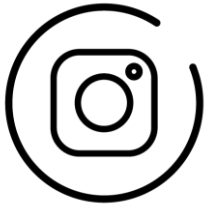
# Note

Please feel free to photograph and share these slides on social media.



Xia Li
Paul Scherrer Institut, ETH Zurich

# Uncertainty-aware MR-based CT synthesis for robust proton therapy planning of skull-based tumour

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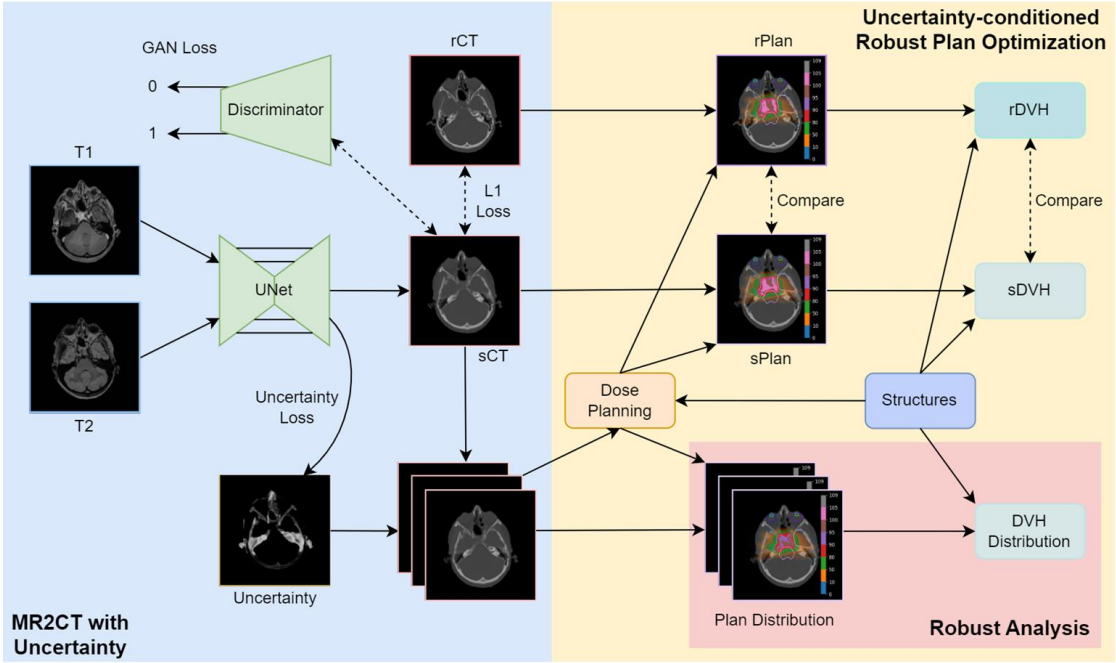
ETH zürich

Strategic Focus Area
Personalized Health
and Related Technologies

InspireProject

# An Uncertainty-aware Framework for Robust MR-based Proton Therapy




## MR2CT with Uncertainty

- Modified conditional GAN network
- Estimates both sCT and voxel-wise uncertainty

## Uncertainty-conditioned Robust Plan optimization

- Conditioned on voxel-wise uncertainty
- Account for network prediction errors

## Robust Analysis

- Maximum-minimum doses
- Over- and Under-shoot cases

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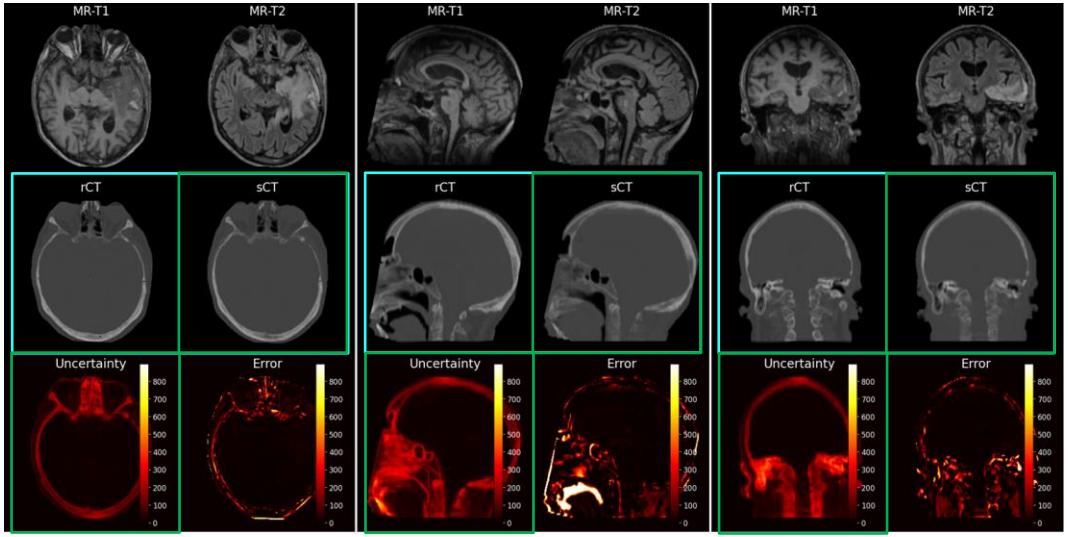
# Generation of Synthetic CT with Uncertainty Map and Image-level Evaluation




| MAE_body | MAE_bone | MAE_tissue | Dice_body | Dice_bone | Dice_tissue |
|---|---|---|---|---|---|
| 80.84±9.84 | 221.88±31.69 | 35.78±6.07 | 90.33±2.43 | 85.53±4.16 | 95.13±0.80 |

- **Dataset**
  - 64 skull-based patients from PSI
  - 8-fold cross validation
- **Network**
  - UNet structure
  - Bayesian Neural Network
    - Per-voxel Laplacian distribution
    - Estimates the parameter [μ, β]
- **Evaluation**
  - MAE and Dice between sCT and rCT
  - Correlation Coefficient between uncertainty and MAE: 0.62±0.01
    - Positively correlated

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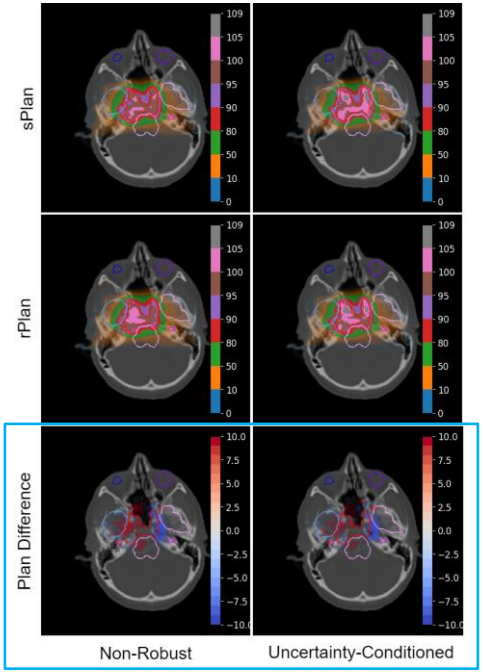
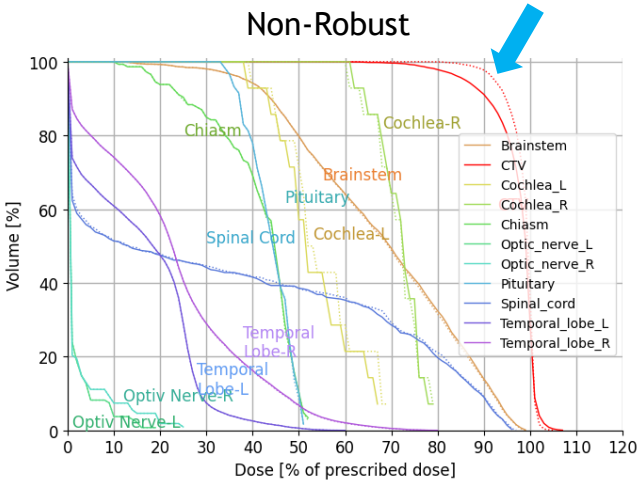
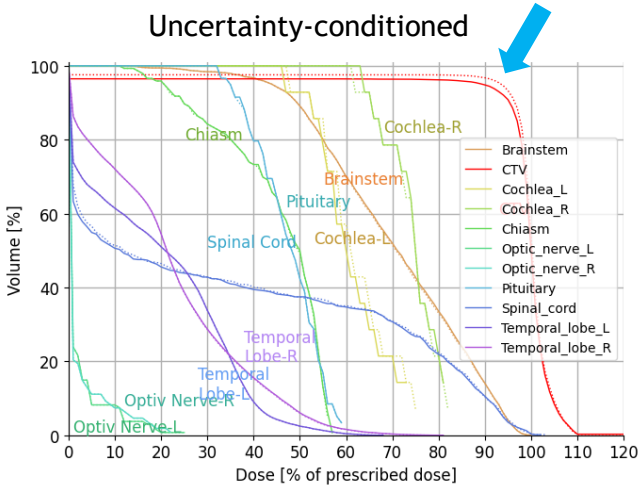
# Uncertainty-aware Robust Optimization and Dosimetric-level Evaluation




Non-Robust




Uncertainty-conditioned




Robustly treatment planning on sCT
- Account for network prediction uncertainty
- Over the per-voxel distribution

Recalculate on sCT --> sPlan
Recalculate on rCT --> rPlan

- Less difference between sPlan and rPlan
- Closer DVH curves between sPlan and rPlan

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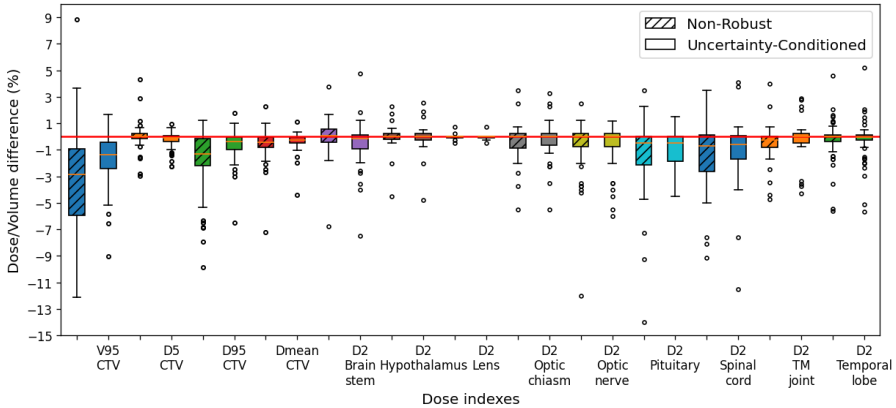
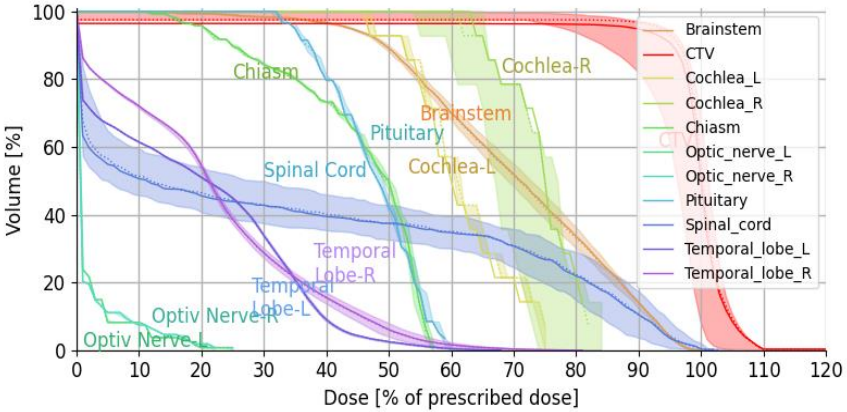
# Robust Analysis and Conclusion




Uncertainty-aware robust plan optimization achieves more conformal sPlan and rPlan




DVH distribution provides tool to analyze the robustness

- High-quality sCT generation from MR images with 3D uncertainty prediction
- Improved plan robustness against network prediction error by uncertainty-aware optimization
- Clinically acceptable accuracy (+/-3%) for proton therapy planning of skull-based tumour
- Powerful tools for determining the clinical usefulness of synthetic CTs for individual patients

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