From Concept to Clinic: How Our In-house Automated Planning System Augmented the Commercial TPS for Treating Over 10,000 Patients

Masoud Zarepisheh

Department of Medical Physics, Memorial Sloan-Kettering Cancer Center, New York

Memorial Sloan Kettering Cancer Center

Automated Planning

- **1- Knowledge-based planning (Varian Rapid plan)**
  - 1-1 :Extract knowledge from database of treated patients
  - 1-2: Use the knowledge to treat the new patient
- **2- Multiple criteria optimization (RayStation MCO)**
  - 2-1: Pre-generate a set of Pareto plans upfront
  - 2-2: User navigates among the plans
- **3- ECHO (Expedited Constrained Hierarchical Optimization)**
  - 3-1: Solve a series of constrained optimization problems
  - 3-2: Critical clinical criteria defined as hard constraints
  - 3-3: Desirable clinical criteria are optimized in order

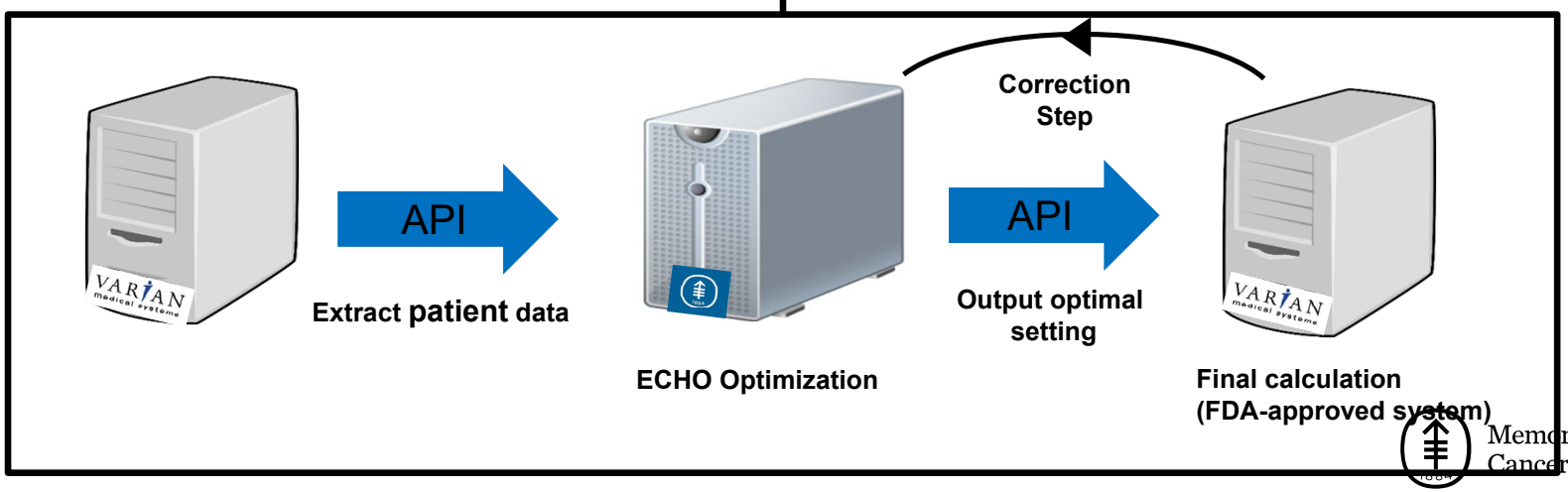
Clinical-Workflow

Planner runs ECHO plug-in

Planner notified, and evaluates the plan

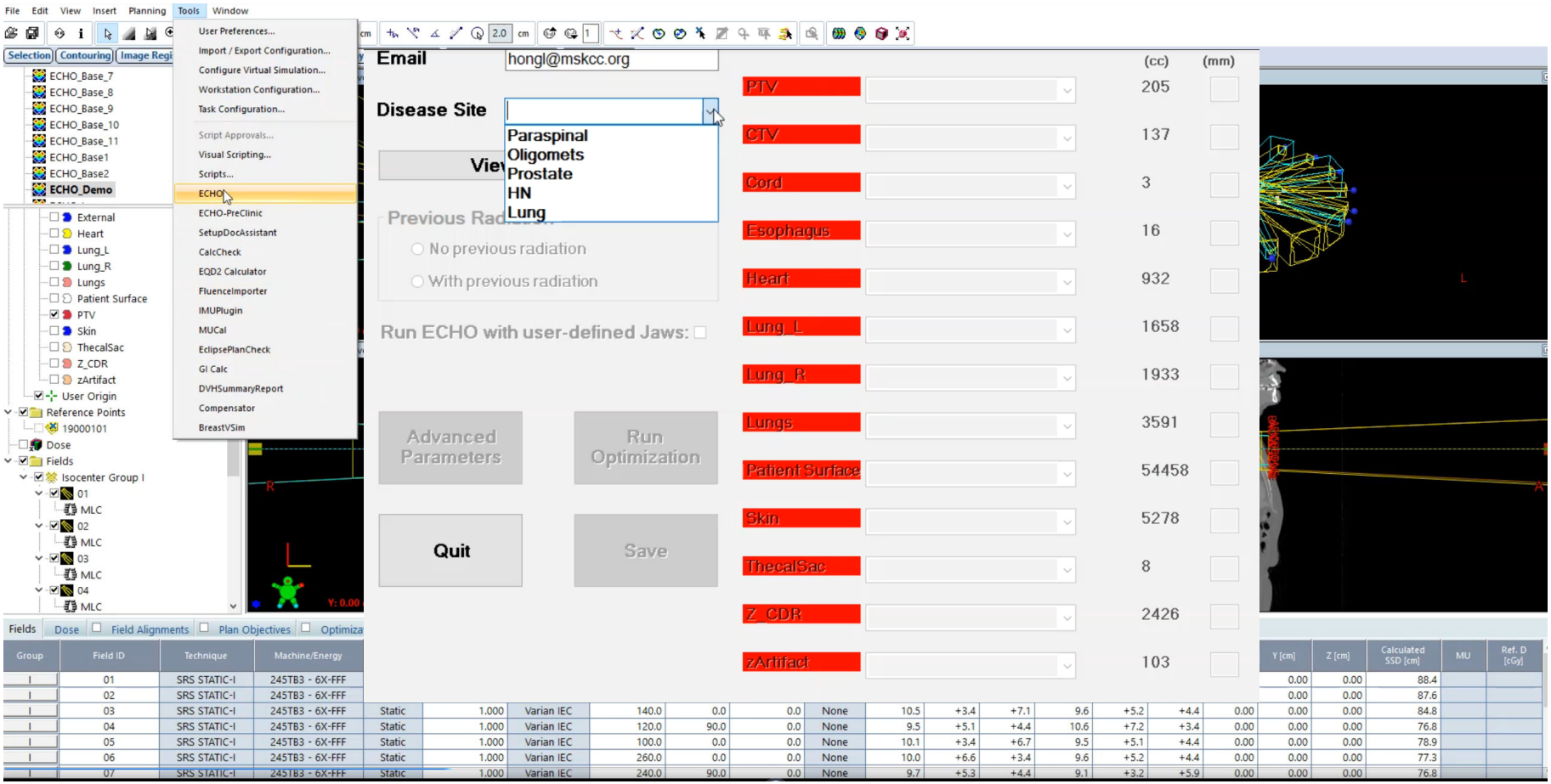
~30 min

MSK ECHO



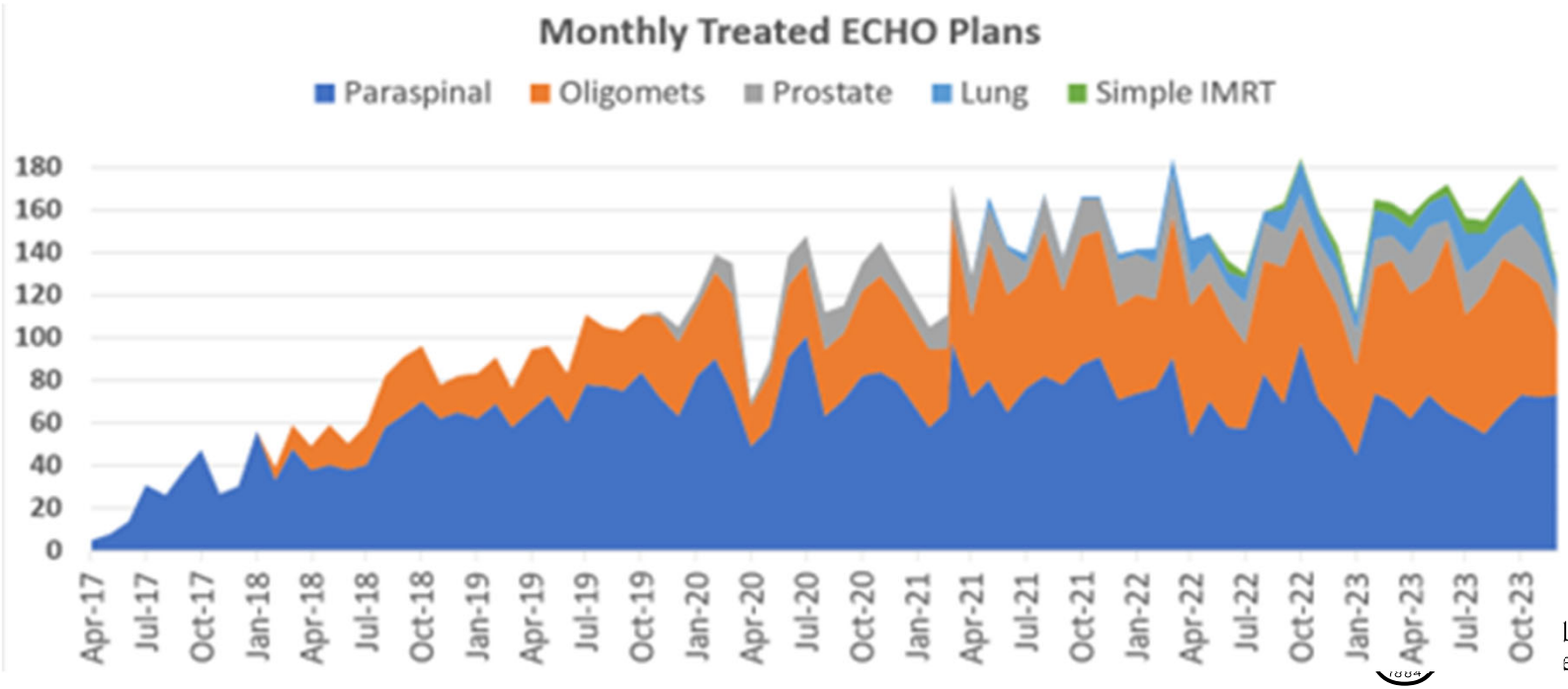
Memorial Sloan Kettering Cancer Center

User Interface



Data

- > 10,000 patients to-date (2017-2024)
- ~ 200 plans per month

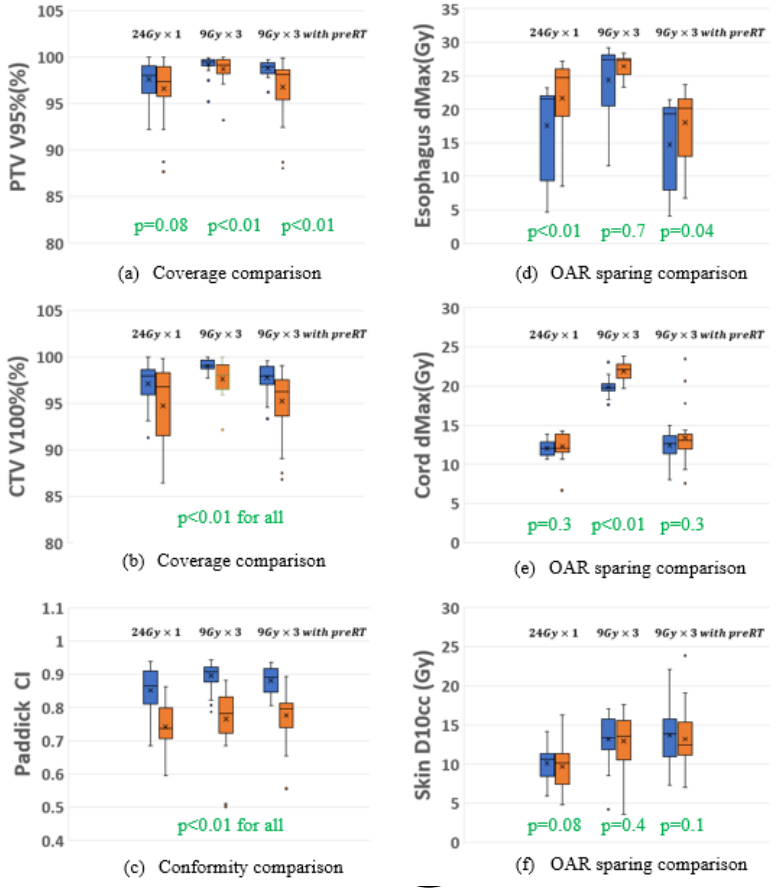


l Sloan Kettering
enter

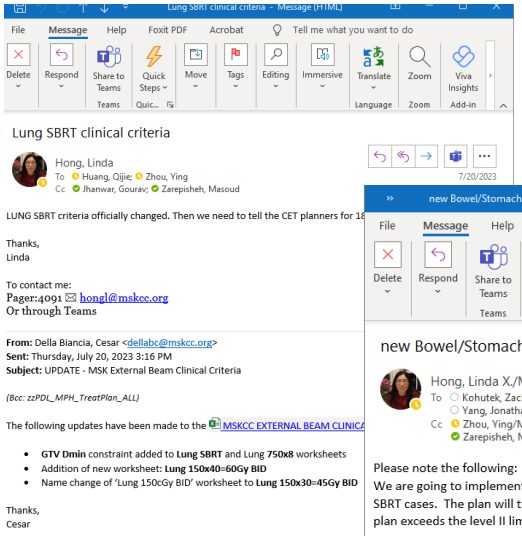
Improved Plan Quality and Consistency

- Pre-clinical validation before adding new site
- Ensuring improved/comparable plan quality compared to the manual plans

ECHO vs. Manual:75 Paraspinal patients



Adaptability to changes in clinic



Lung SBRT clinical criteria

Hong, Linda
To Huang, Qijie; Zhou, Ying
Cc Jhanwar, Gourav; Zarepisheh, Masoud
7/20/2023

LUNG SBRT criteria officially changed. Then we need to tell the CET planners for 18

Thanks,
Linda

To contact me:
Pager:4091 hongl@mskcc.org
Or through Teams

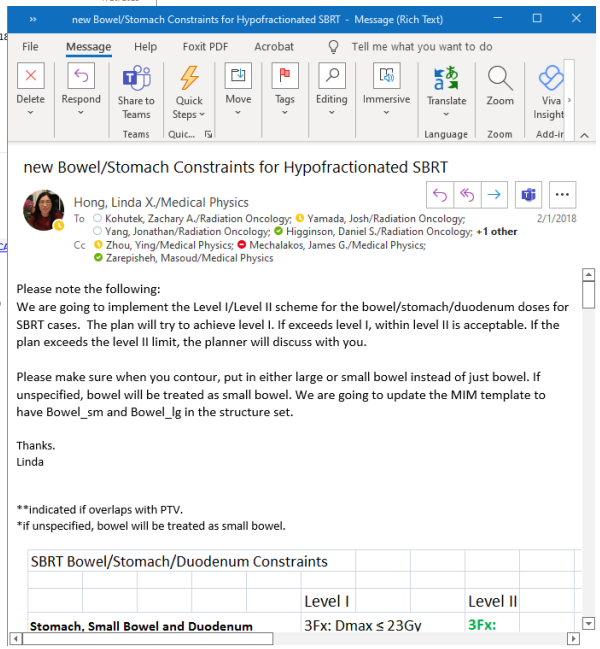
From: Della Biancia, Cesar <dellabc@mskcc.org>
Sent: Thursday, July 20, 2023 3:16 PM
Subject: UPDATE - MSK External Beam Clinical Criteria

(Bcc: zzPDL_MPH_TreatPlan_ALL)

The following updates have been made to the MSKCC EXTERNAL BEAM CLINICA

- **GTV Dmin** constraint added to **Lung SBRT** and Lung **750x8** worksheets
- Addition of new worksheet: **Lung 150x40=60Gy BID**
- Name change of 'Lung 150cGy BID' worksheet to **Lung 150x30=45Gy BID**

Thanks,
Cesar



new Bowel/Stomach Constraints for Hypofractionated SBRT

Hong, Linda X./Medical Physics
To Kohutek, Zachary A./Radiation Oncology; Yamada, Josh/Radiation Oncology; Yang, Jonathan/Radiation Oncology; Higginson, Daniel S./Radiation Oncology; **+1 other**
Cc Zhou, Ying/Medical Physics; Mechalakos, James G./Medical Physics; Zarepisheh, Masoud/Medical Physics
2/1/2018

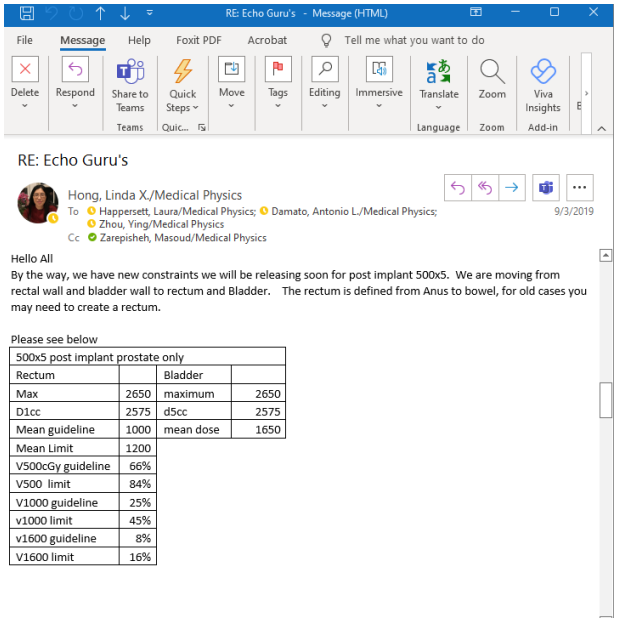
Please note the following:
We are going to implement the Level I/Level II scheme for the bowel/stomach/duodenum doses for SBRT cases. The plan will try to achieve level I. If exceeds level I, within level II is acceptable. If the plan exceeds the level II limit, the planner will discuss with you.

Please make sure when you contour, put in either large or small bowel instead of just bowel. If unspecified, bowel will be treated as small bowel. We are going to update the MIM template to have Bowel_sm and Bowel_lg in the structure set.

Thanks.
Linda

**indicated if overlaps with PTV.
*if unspecified, bowel will be treated as small bowel.

SBRT Bowel/Stomach/Duodenum Constraints		
	Level I	Level II
Stomach, Small Bowel and Duodenum	3Fx: Dmax ≤ 23Gy	**3Fx:**



RE: Echo Guru's

Hong, Linda X./Medical Physics
To Happersett, Laura/Medical Physics; Damato, Antonio L./Medical Physics; Zhou, Ying/Medical Physics
Cc Zarepisheh, Masoud/Medical Physics
9/3/2019

Hello All
By the way, we have new constraints we will be releasing soon for post implant 500x5. We are moving from rectal wall and bladder wall to rectum and Bladder. The rectum is defined from Anus to bowel, for old cases you may need to create a rectum.

Please see below

500x5 post implant prostate only			
Rectum		Bladder	
Max	2650	maximum	2650
D1cc	2575	d5cc	2575
Mean guideline	1000	mean dose	1650
Mean Limit	1200		
V500cGy guideline	66%		
V500 limit	84%		
V1000 guideline	25%		
v1000 limit	45%		
v1600 guideline	8%		
V1600 limit	16%		

Memorial Sloan Kettering Cancer Center

ECHO

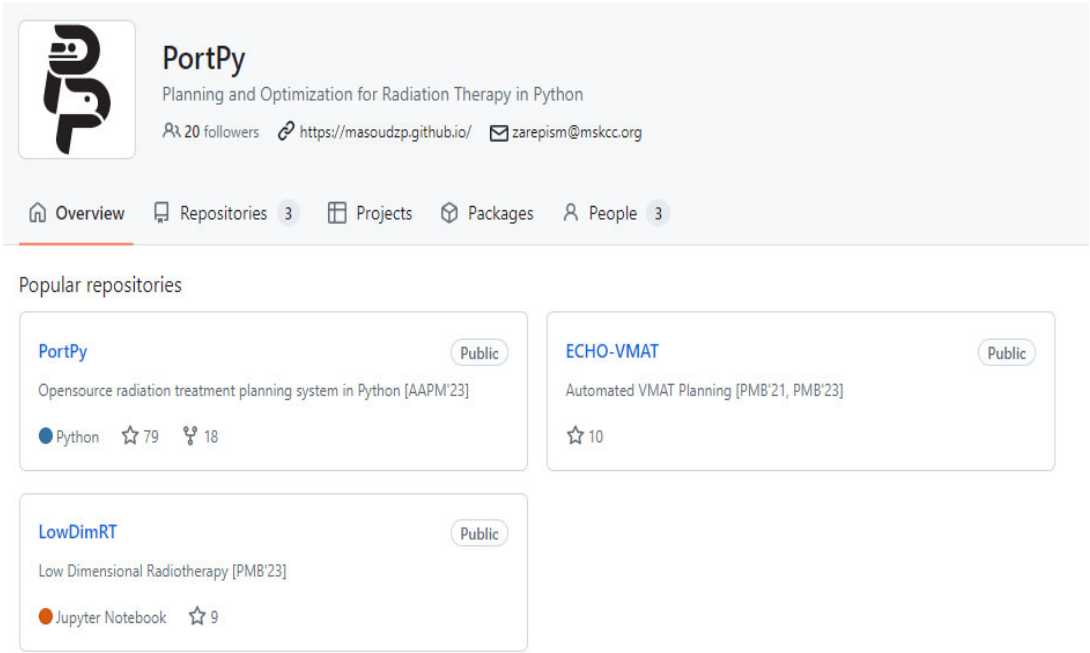
- ❖ 12 Publications (10 in PMB/Medical Physics)
- ❖ 2 Patents

Implementation Status	Challenge	Technique	Publication
Clinically Deployed	Multi-Criteria Challenge	Hierarchical Constrained Nonlinear Optimization	Zarepisheh et al. (2019) *(Medical Physics)* Zarepisheh et al. (2021) *(INFORMS)* Hong et al. (2020) *(Advances in RO)*
	Dose Discrepancy	Lagrangian Methods	Zarepisheh et al. (2019) *(Medical Physics)*
	Hard constrained DVH	Mixed Integer Programming, Convex Relaxation	Mukherjee et al. (2020) *(Medical Physics)*
	Non-convexity in Machine Parameters (VMAT)	Sequential Convex Programming	Dursun et al. (2021) *(PMB)* Dursun et al. (2023) (PMB)
Research & Development	Proton: Beam Angle Selection	Bayesian Optimization	Taasti et al. (2020) *(Medical Physics)*
	Proton: Uncertainty Management	Robust Optimization (P-Norm Function)	Taasti et al. (2020) *(Medical Physics)*
	Multi-Criteria Challenge	Deep Learning Predictions (Moment-Based Loss Functions)	Jhanwar et al. (2022) *(PMB)*
	Proton: Increasing Computational Complexity With Uncertainty Managements	Distributed Optimization (ADMM)	Fu et al. (2022) *(Medical Physics)*
	Reducing IMRT plan complexity	Wavelet-induced smoothness	Tefagh, Zarepisheh (2023) (PMB)

norial Sloan Kettering
cer Center

PortPy Open-source

Planning and Optimization for Radiation Therapy in Python



Quick start and examples

The easiest way to start is through the PorPy following examples.

Example File	Description
1_basic_tutorial.ipynb	Demonstrates the main functionalities of PortPy (e.g., Access data, create an IMRT plan, visualize)
vmat_scp_tutorial.ipynb	Creates a VMAT plan using sequential convex programming
vmat_scp_dose_prediction.ipynb	Predicts 3D dose distribution using deep learning and converts it into a deliverable VMAT plan
3d_slicer_integration.ipynb	Creates an IMRT plan and visualizes it in 3D-Slicer
imrt_tps_import.ipynb	1. Outputs IMRT plan in DICOM RT format and imports it into TPS. 2. Outputs IMRT plan optimal fluence in an Eclipse-compatable format and imports it into Eclipse
vmat_tps_import.ipynb	Outputs VMAT plan in DICOM RT format and imports it into TPS
imrt_dose_prediction.ipynb	Predicts 3D dose distribution using deep learning and converts it into a deliverable IMRT plan
vmat_global_optimal.ipynb	Finds a globally optimal VMAT plan
beam_orientation_global_optimal.ipynb	Finds globally optimal beam angles for IMRT
dvh_constraint_global_optimal.ipynb	Finds a globally optimal plan meeting Dose Volume Histogram (DVH) constraints
structure_operations.ipynb	Creates new structures by expanding/shrinking the existing ones or using boolean operations
inf_matrix_down_sampling.pynb	Down-samples beamlets and/or voxels for computational efficiency
inf_matrix_sparsification.ipynb	Sparsifies (i.e., truncates) the influence matrix for computational efficiency

Summary

- ECHO: Fully automated treatment planning system
- Integrated with commercial TPS using API scripting
- Treated > 10,000 patients
- Open-sourcing our tools using PortPy (Planning and Optimization for Radiation Therapy in Python)

Memorial Sloan Kettering Cancer Center