RAYSEARCH WORKSHOP
25 MAYIS 2019, ANKARA

Yiğit Çeçen

RaySearch Laboratories

ONCOTECH
MEDİKAL SİSTEMLER | MEDICAL SYSTEMS

Raysearch

Dedicated to radiation therapy software

Founded in 2000
Spin off from Karolinska Institutet

2001
First IMRT module released

Delivering software modules for

PHILIPS

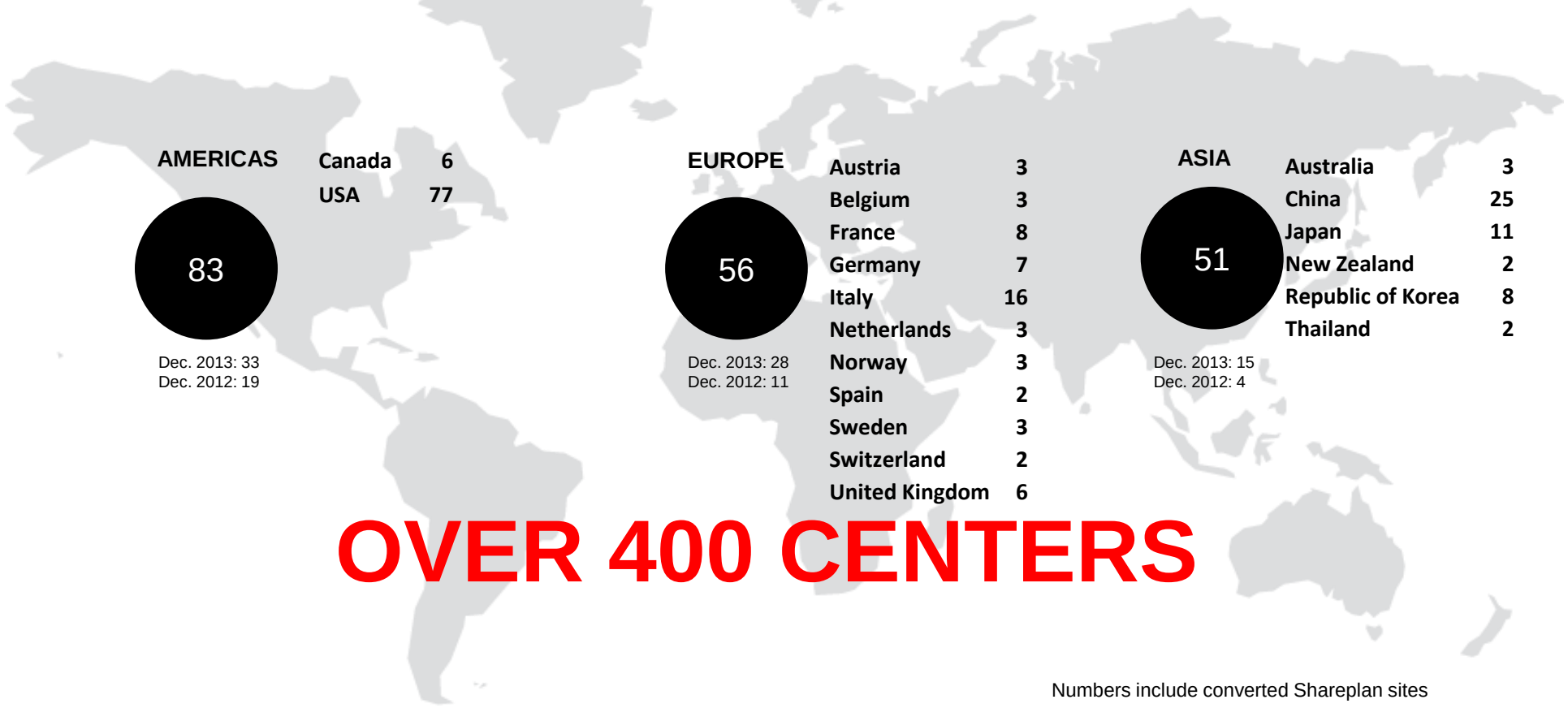
VARIAN
medical systems

Nucletron
AN ELEKTA COMPANY

iba
Dosimetry

Over 2600 installations in more than 65 countries

RAYSTATION CENTERS –
190 CENTERS IN 19 COUNTRIES February 2015



AMERICAS

83

Dec. 2013: 33
Dec. 2012: 19

Canada	6
USA	77

EUROPE

56

Dec. 2013: 28
Dec. 2012: 11

Austria	3
Belgium	3
France	8
Germany	7
Italy	16
Netherlands	3
Norway	3
Spain	2
Sweden	3
Switzerland	2
United Kingdom	6

ASIA

51

Dec. 2013: 15
Dec. 2012: 4

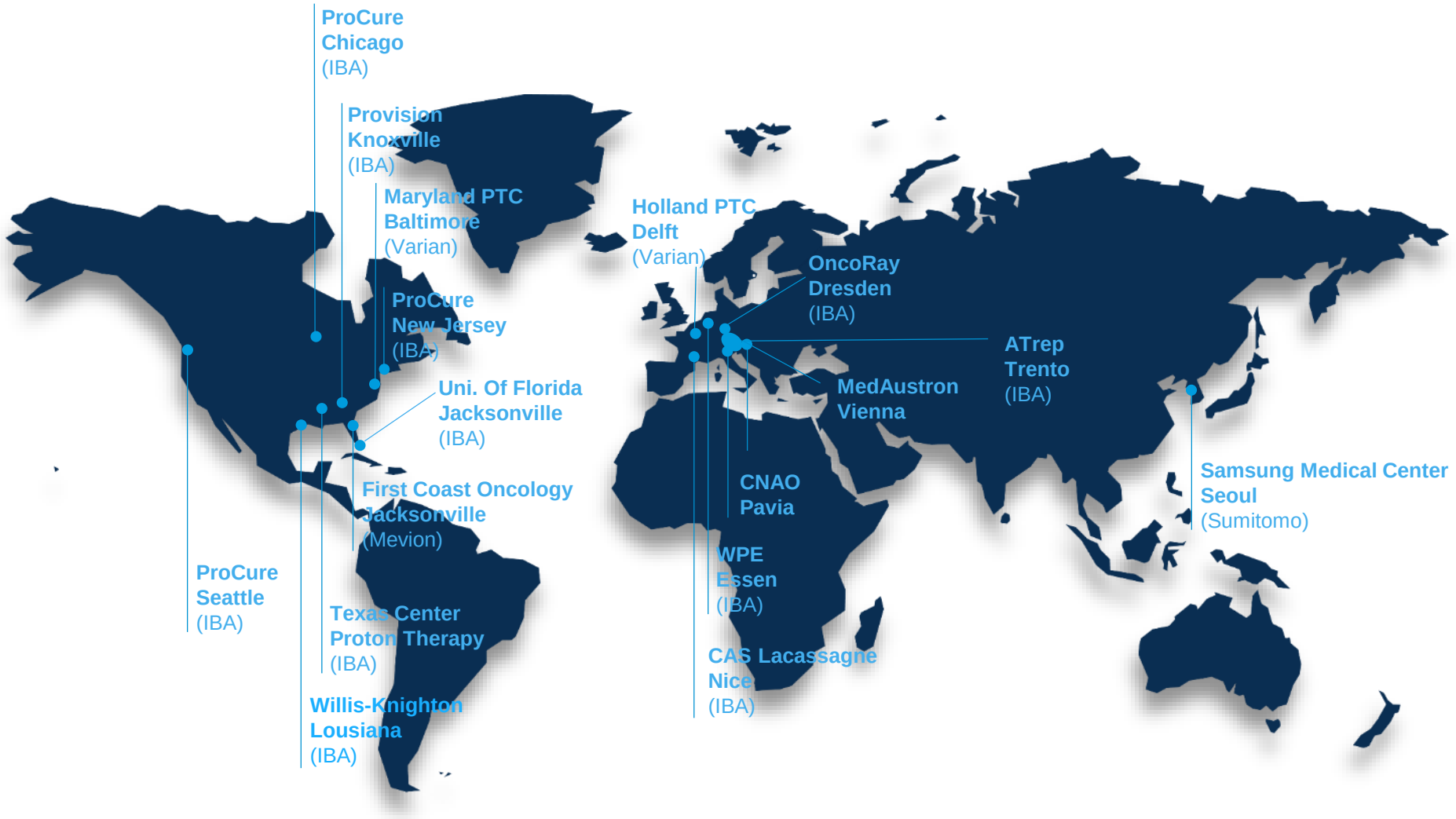
Australia	3
China	25
Japan	11
New Zealand	2
Republic of Korea	8
Thailand	2

OVER 400 CENTERS

Numbers include converted Shareplan sites

Raystation proton centers

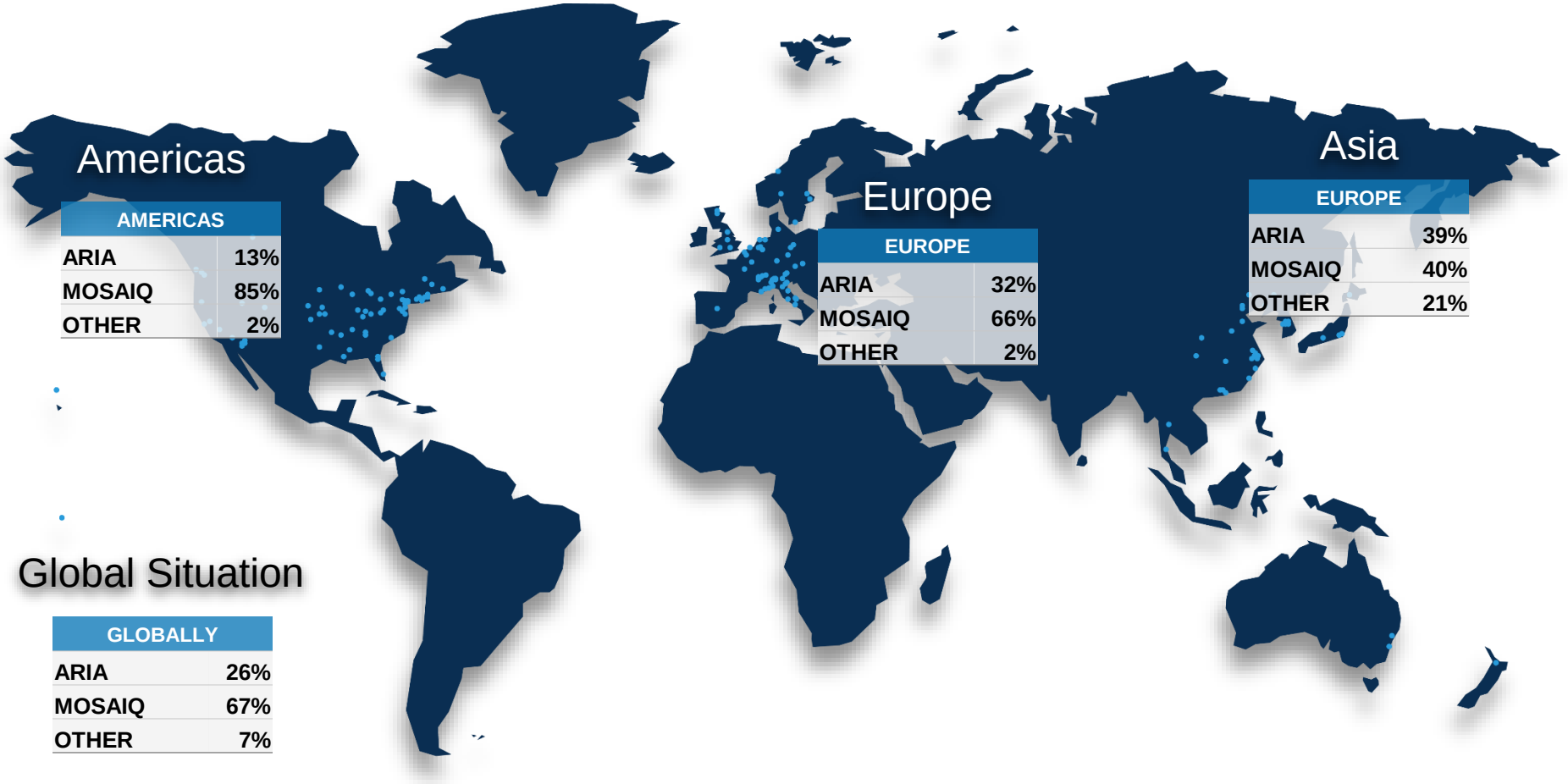
May 2016



Updated 15.2.2016

Which Ois is used together with raystation?

September 2015



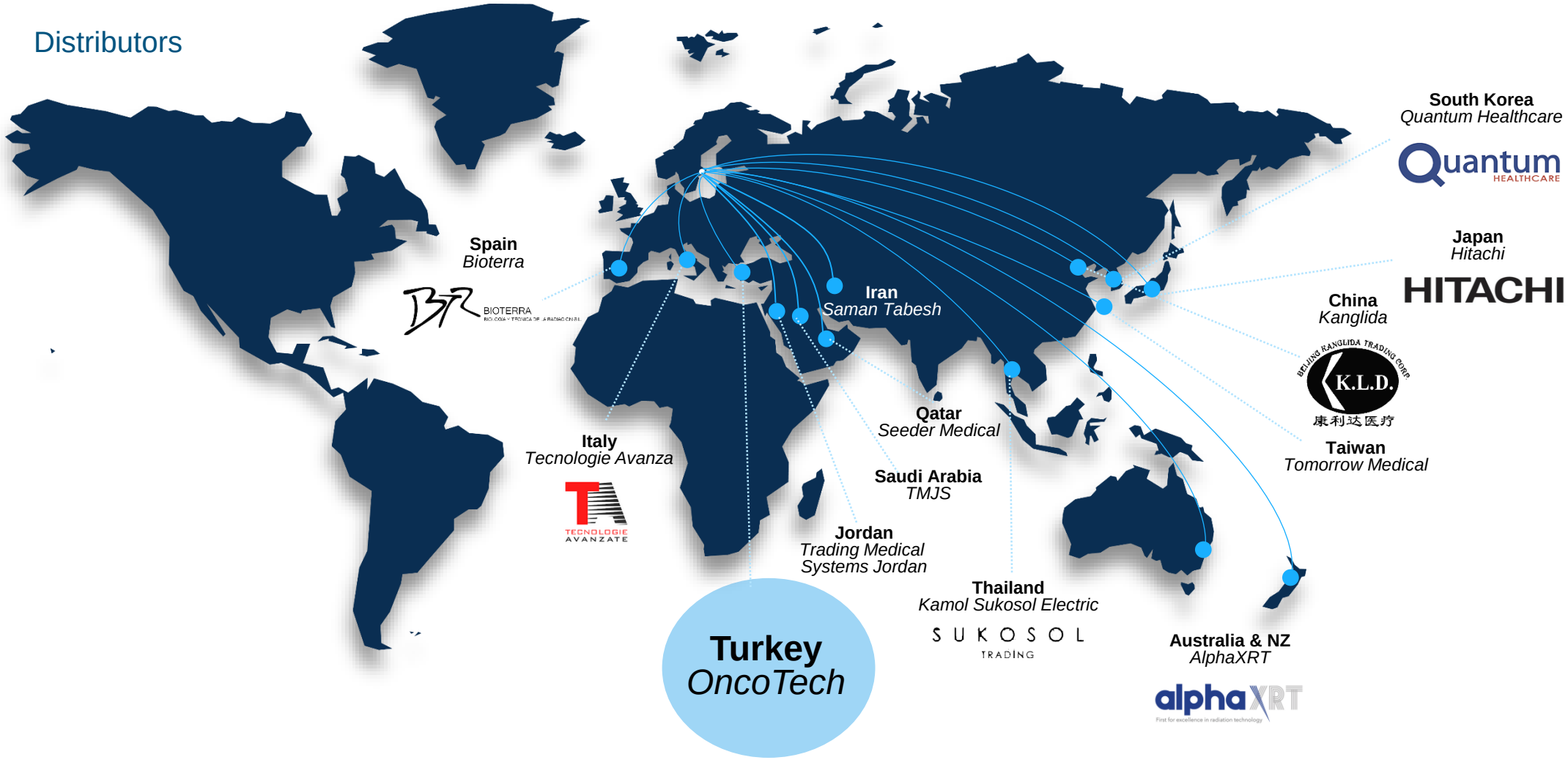
Global Situation

GLOBALLY	
ARIA	26%
MOSAIQ	67%
OTHER	7%

Some missing data - Updated 9.9.2015

RAYSEARCH INTERNATIONAL PRESENCE

Distributors



RAYSEARCH partner products

Over 2600 installations in more than 65 countries

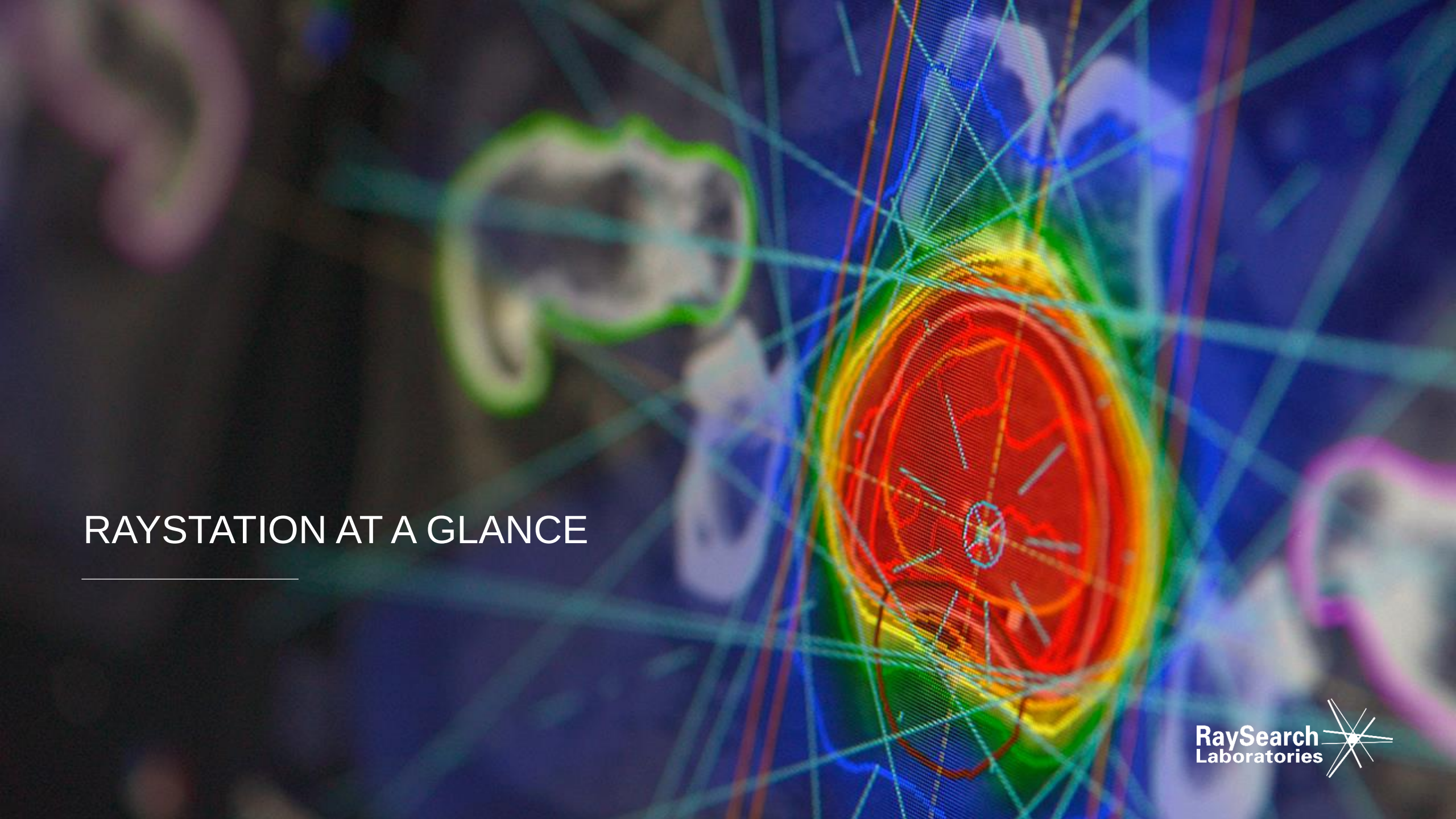
PHILIPS BrainLAB iba Nucletron ACCURAY VARIAN medical systems

RaySearch partner products

Ongoing relationships, first partner in 2001

Partner product	Philips	Nucletron	IBA Dosimetry	Varian	Accuray*	Brainlab
3D-CRT				■		
IMRT	■	■				
VMAT	■	■				■
Biology	■			■		
Automated Planning					■	
Dose Calculation			■			
Quality Assurance			■			
Model Based Segmentation		■				
Vero						■
InverseArc						■

* RaySearch and Accuray ended the partnership in 2013 and the functionality provided to Accuray customers is now available as an integrated module in RayStation (rayFallback).



RAYSTATION AT A GLANCE

RaySearch Laboratories

RayStation

AUTOMATED PLANNING
Fallback Planning - **rayFallback**
Automatic Breast Planning - **rayAutoBreast**
Scripting - **IronPython**

PROTON PLANNING
IMPT Optimization (PBS) - **rayPencilScanning**
Uniform Scanning - **rayUniformScanning**
Double Scattering - **rayPassiveScattering**

PLANNING
3D-CRT - **rayConformal**
IMRT - **rayIntensity**
VMAT - **rayArc**
Electron - **rayElectronPlanning**

ADVANCED OPTIMIZATION TOOLS
Multi-Criteria Optimization - **rayNavigator**
Radiobiological Optimization and Evaluation - **rayBiology**

ADAPTIVE PLANNING
Deformable Registration - **rayDeformable**
Dose Tracking - **rayTracker**
Adaptive re-Planning - **rayAdaptive**

PATIENT MODELLING
rayAnatomy

PLAN EVALUATION
rayEvaluation

A WORLD OF ENDLESS POSSIBILITIES IN TREATMENT PLANNING

RaySearch Laboratories

www.raysearchlabs.com

Cihazlar Arası Direkt Bağlantı

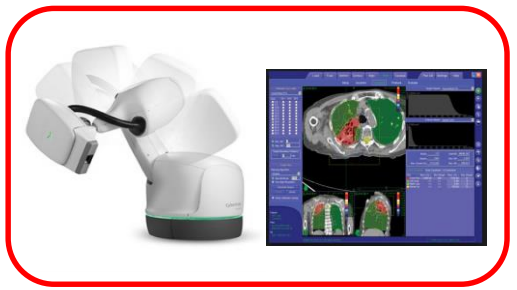
Neden Raystation

Varian/Eclipse

Elekta/Monaco

Birbiri ile Konuşamazlar

Tomoterapi/VoloPlan



Cyberknife/Multiplan

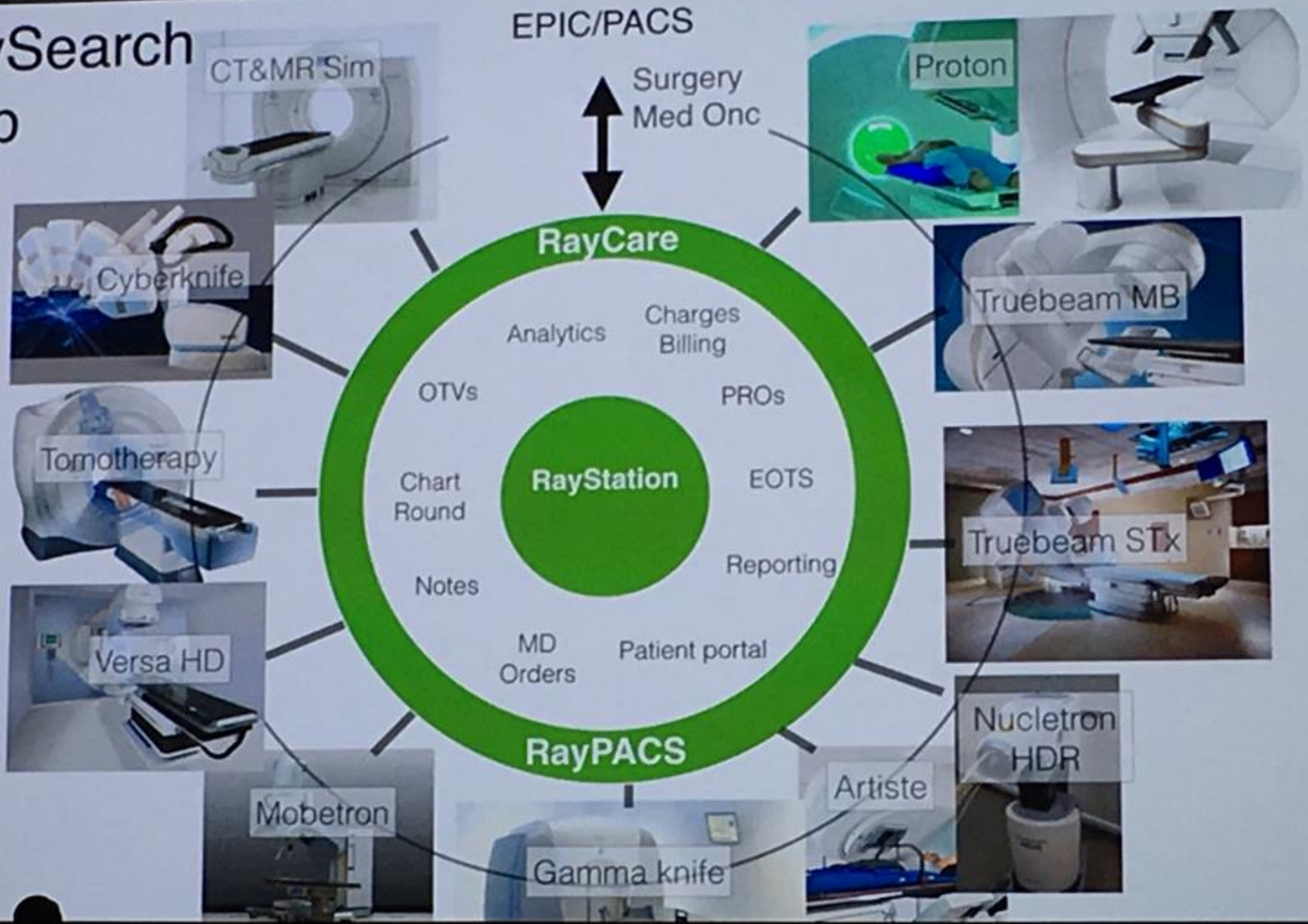
Neden Raystation

Treatment planning the way it should be

- **TEK PLATFORM TUM CIHAZLAR CALISAN TEK SISTEM**
- TUM TEDAVI TEKNIKLERINE PLAN SAGLAYAN TEK SISTEM
  - **3D-CRT, IMRT, VMAT, HELICAL AND ELECTRONS (BRAKI HARIC)**

RayStation

UCSF-RaySearch Partnership Vision

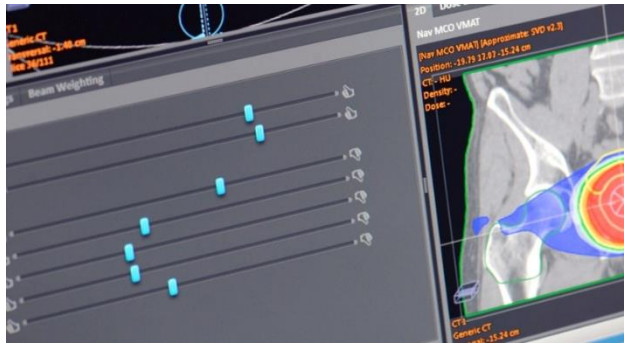


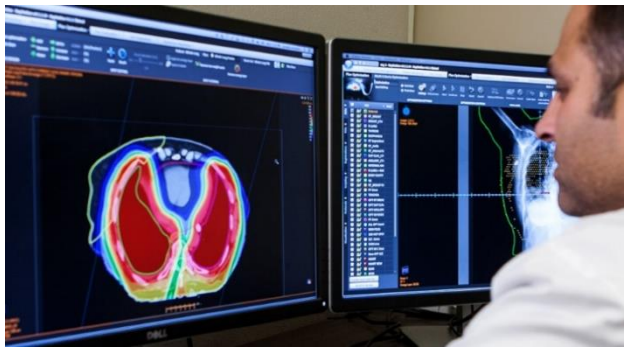
raystation

Advancing cancer treatment

- **Compatibility** with most linacs, OIS and third-party QA
- **Workflow-driven design**, user experience is an integral part of our product development
- **Extraordinary speed and accuracy** that make planning easier and more effective
- **Robust optimization** for all treatment techniques
- **Real-time evaluation** of clinical trade-offs with multi- criteria optimization

RayStation



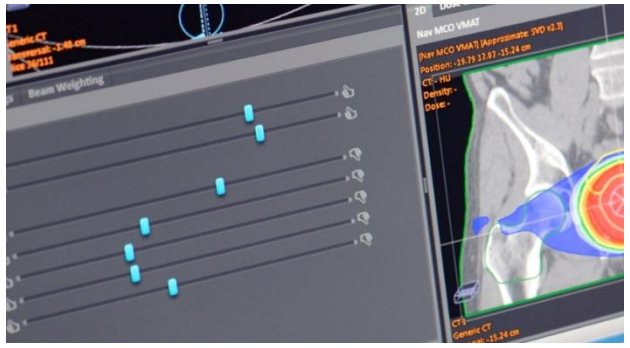


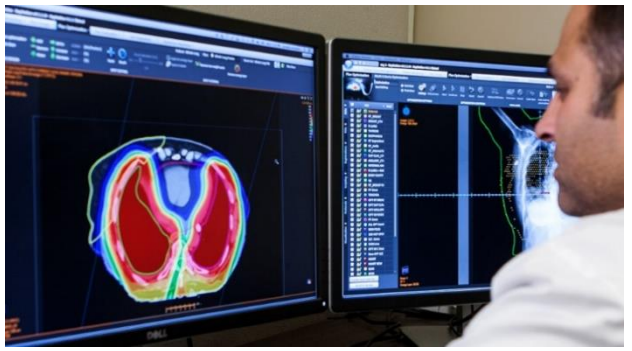
raystation

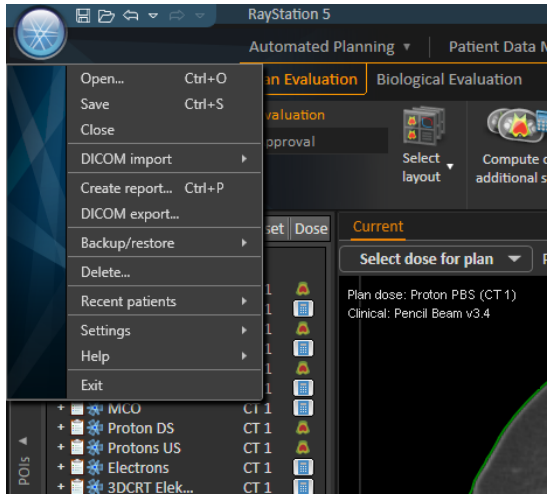
Advancing cancer treatment

- **Automatic creation of Fallback Plans** for all your machines
- **Flexibility** beyond the standard user interface aided by scripting, templates and protocols
- **Advanced particle therapy expertise**, RayStation is in use at several proton sites worldwide
- **Adaptive therapy** and **automatic planning** available today
- **Emphasis on partnership**, focused on scientific collaboration and training and support of our customers.

RayStation

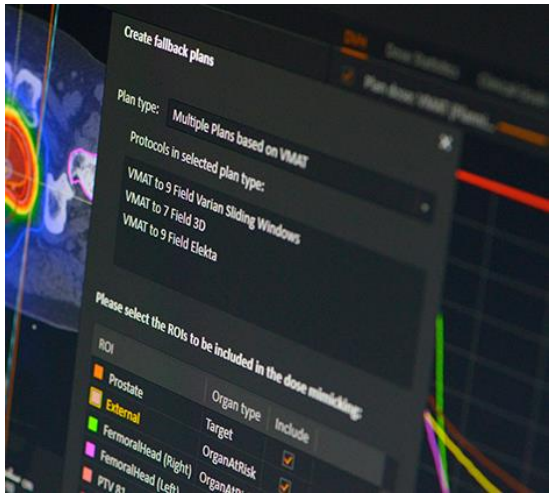






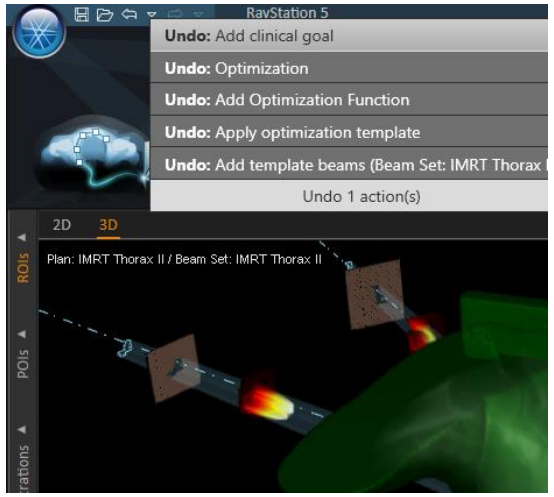
No confusion

RayStation runs on Windows and appears as any other modern application.



Flexible and Efficient

Easy accessible, clinic-tailored protocols and templates help to automate customized workflows.

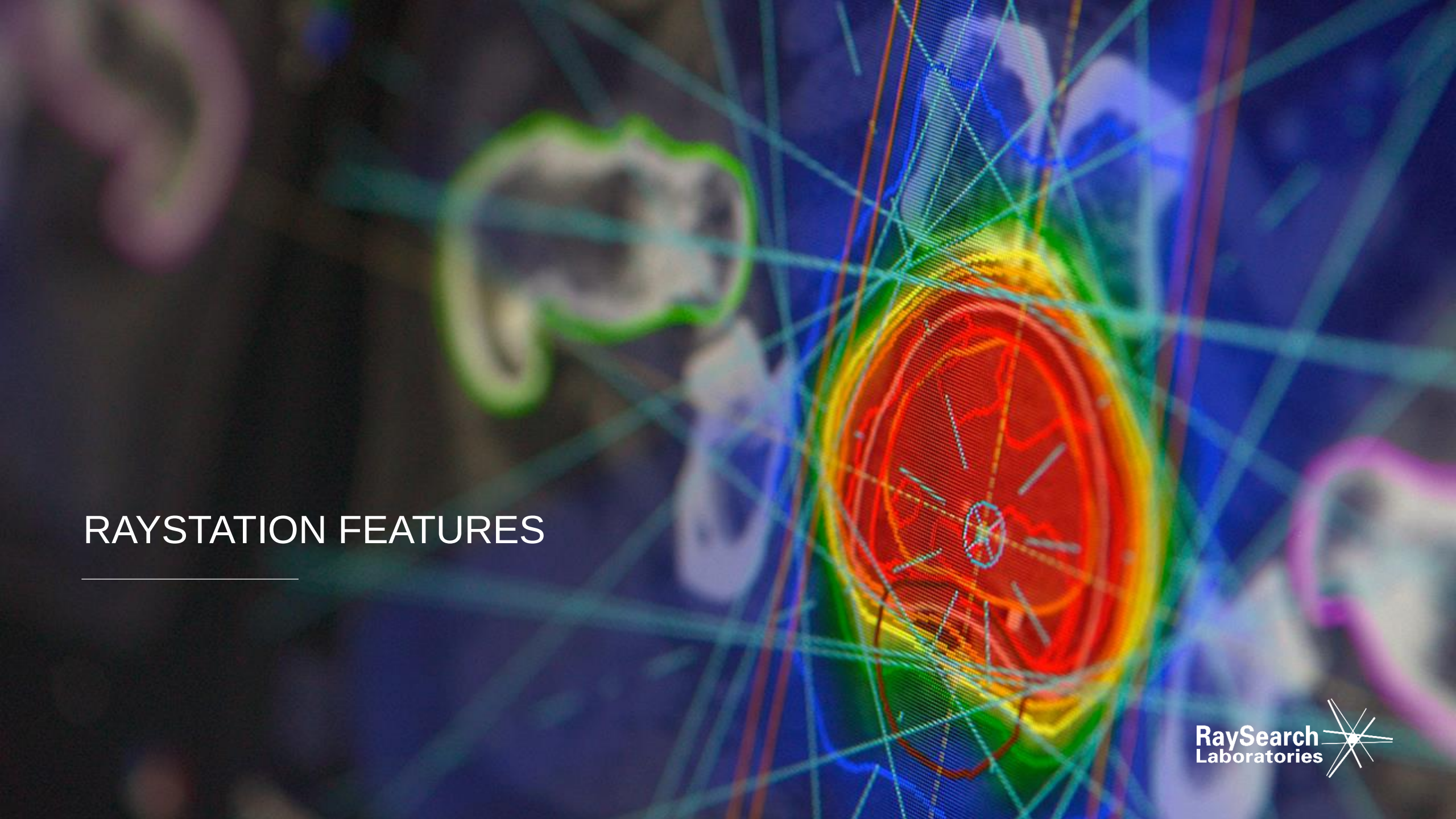


Smart Undo Redo

RayStation supports complete undo and redo. It works on any action and on any number of actions.

Help when needed

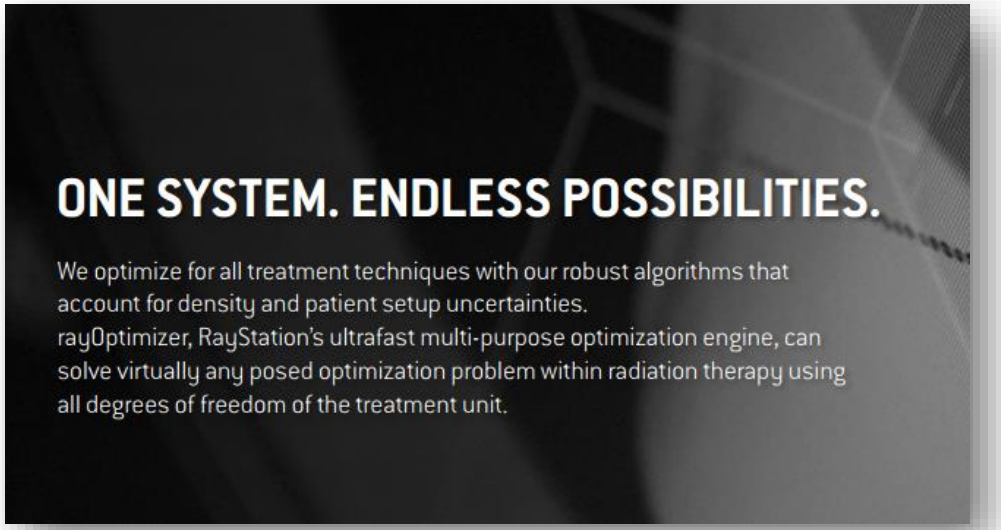
The RayStation user manual tells it all. Lots of images and to the point descriptions make it easy to understand all functions and algorithms.



RAYSTATION FEATURES

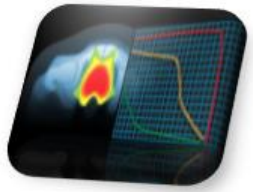
RaySearch Laboratories

Diğer Sistemledeki ÜSTÜN Özellikler Raysearch'de Standard



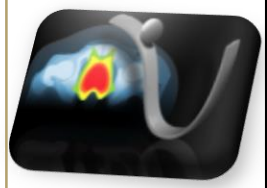
1. Patient modelling & evaluation

rayAnatomy
Patient Modeling



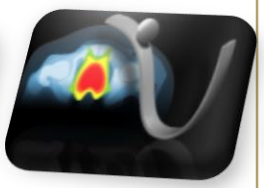
rayEvaluation
Plan Evaluation

2. Photon planning



rayPhotonPhysics
Photon Dose Calculation

rayConformal
3DCRT planning



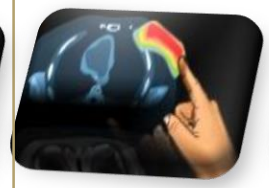
rayIntensity
IMRT Optimization

rayArc
VMAT Optimization

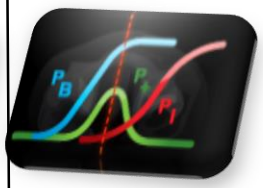
Raysearch’de ÜSTÜN ve MUADİLİ OLMAYAN Özellikler

3. Additional optimization tools and electron planning

rayNavigator
Multi-Criteria Optimization



rayElectron-Planning
Electron Planning



rayBiology
Radiobiological Optimization and Evaluation

5. Adaptive

rayDeformable
Deformable Registration

rayTracker
Dose Tracking

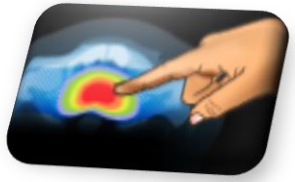
rayAdaptive
Adaptive re-Planning

4. Automated planning

rayFallback
Fallback Planning

rayAutoBreast
Automatic Breast Planning

6. Proton planning



rayProtonPhysics
Proton Dose Calculation

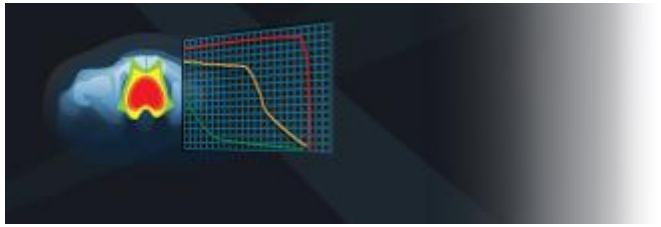
rayPencilScanning
IMPT Optimization (PBS)

rayPassive Scattering & rayUniform Scanning
Conformal Proton Planning

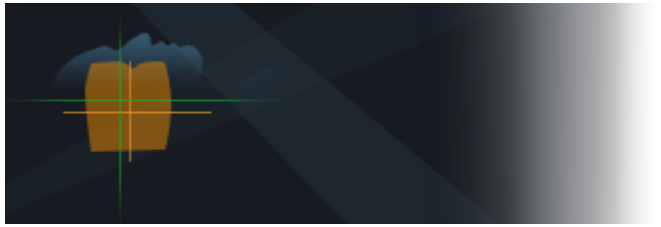
Raystation features

Patient modeling, virtual simulation and plan evaluation

- rayAnatomy – Patient modeling
  - Manual and semi-automatic organ and target delineation tools
  - Model and atlas based segmentation
  - Rigid image registrations and fusion tools



- rayEvaluation – Plan evaluation
  - Dose statistics and clinical goal lists
  - Plan evaluation tools
  - Perturbed dose computations (isocenter shifts and density errors)



- raySimulation – Manual planning
  - Dedicated workspace for virtual simulation
  - One click creation of plan with orthogonal beam pair
  - Isocenter placement using DRR pair
  - Export to patient marking systems

Raystation features

Dose calculation

- rayPhotonPhysics – Photon dose calculation
  - Collapsed cone photon dose calculation engine
  - Beam commissioning workspace with automodelling

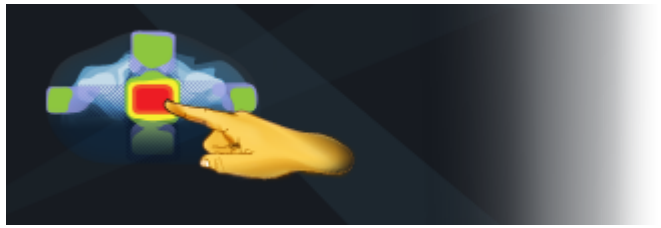
- rayCarbon – Carbon dose calculation
  - Carbon dose computation using pencil beam dose engine (Support for GPU and CPU)
  - RBE dose computation using Local Effect Model (LEM)
  - Low dose approximation for non-clinical dose and classic algorithm for clinical dose

- rayProtonPhysics – Proton dose calculation
  - Pencil beam - highly optimized algorithm with 19-fold multi tracing per spot and separate handling of the nuclear halo effect.

- rayElectronPhysics – Electron dose calculation
  - Dose calculation engine using Monte Carlo

Raystation features

Linac photon planning tools



- rayConformal – 3DCRT planning
  - Support for multiple, high quality DRRs and DCRs
  - Direct optimization of 3D-CRT treatment parameters, (leaf positions, beam weights, wedge fractions, wedge- collimator-, gantry-couch angle)

- rayArc – VMAT planning
  - Direct optimization of leaf positions and arc segment weights
  - Creation of single or multiple arcs
  - VMAT with constant gantry angle speed and dose rate for non-upgraded LINACs

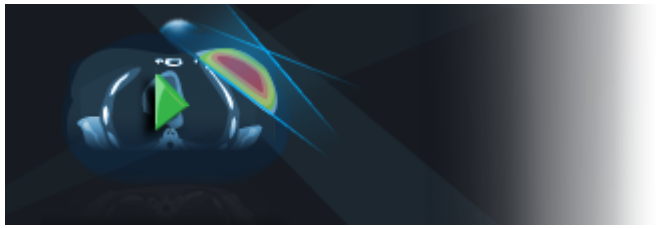
- rayIntensity – IMRT planning
  - Direct optimization of step-and-shoot segment shapes, and segment weights
  - Support for Sliding Window IMRT (dynamic MLC)

- rayElectron – Electron planning
  - Forward electron treatment planning tools for electron applicators and inserts

Raystation features

Automated planning tools

- rayExplorer – Plan Exploration
  - Automatic generation of plans for different treatment techniques and beam arrangements (e.g. 20-100) based on prioritized clinical goals
  - Plan exploration using filters based on clinical goals, treatment techniques and machines
  - Plan selection with side-by-side comparison

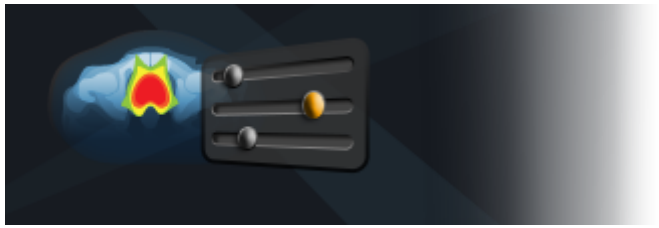


- rayAutoBreast – Automated breast planning
  - Fully automatic planning (segmentation of OARs and plan optimization)
  - Licensed from Princess Margaret Hospital (PMH), Toronto, Canada

- rayFallback – Fallback planning
  - Automatically create alternative plans for other machines and techniques using dose mimicking
  - Visual tools for comparing alternative plans with different techniques

Raystation features

Additional optimization tools



- rayNavigator – Multi- criteria optimization
  - Navigation tool for selecting the best clinical trade-off between target coverage and sparing of surrounding tissue
  - Automatic tool for generating a deliverable treatment plan from this selection

- rayBiology – Radiobiological Optimization
  - Evaluate treatment plans based on radiobiological indices (NTCP and TCP)
  - Evaluate effects of different fractionation schedules
  - Optimize directly on the biological indices

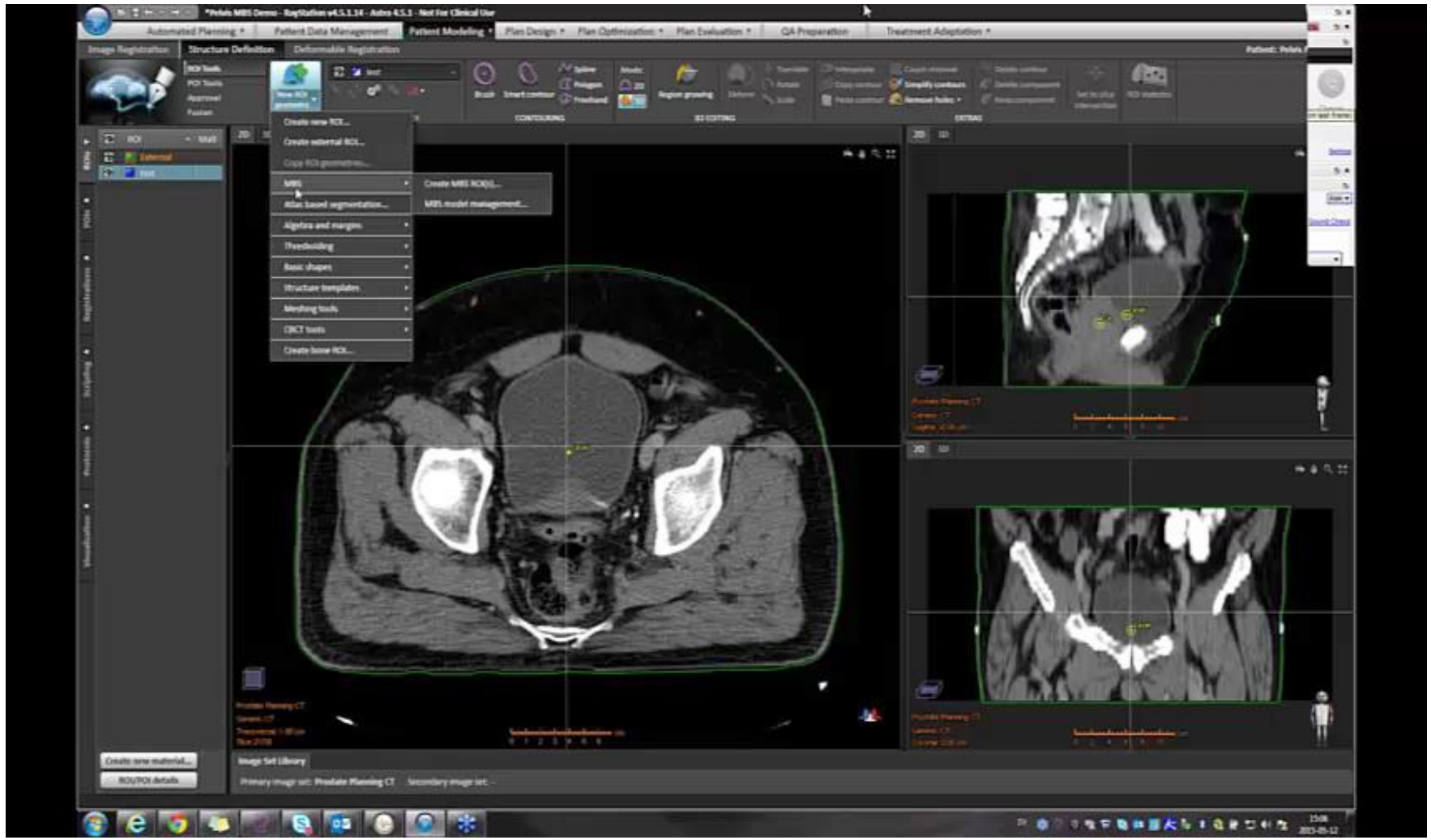
Raystation features

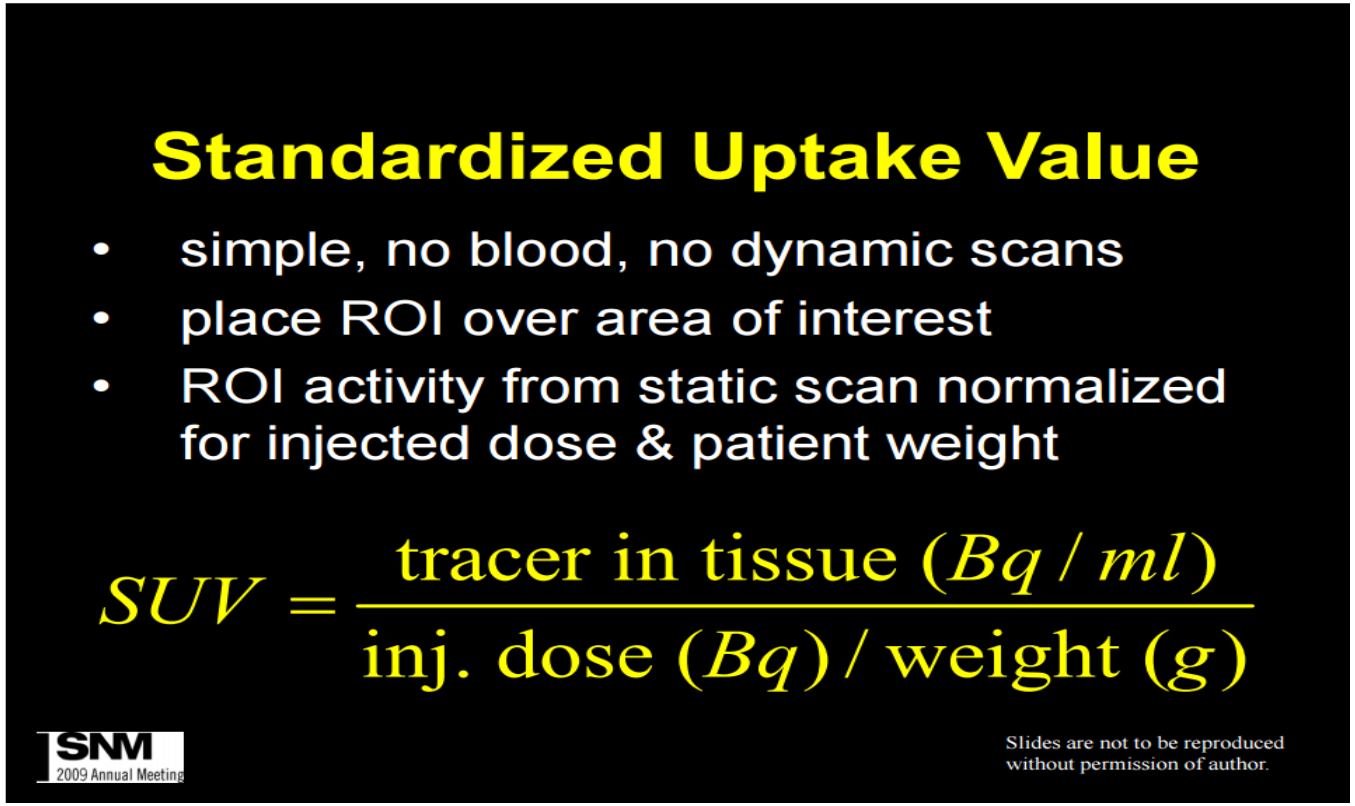
Adaptive radiation therapy

- rayDeformable – Deformable registration
  - Deformable registration tools to map CT or CBCT to planning CT
  - Mapping and accumulation of dose between the CT-datasets

- rayTracker – Dose tracking
  - Recalculate, deform and accumulate doses from different fractions in a common geometry
  - Computing the dose delivered to the patient anatomy

- rayAdaptive – Adaptive re- planning
  - Re-optimizing and adapting the plan, taking the accumulated dose into account

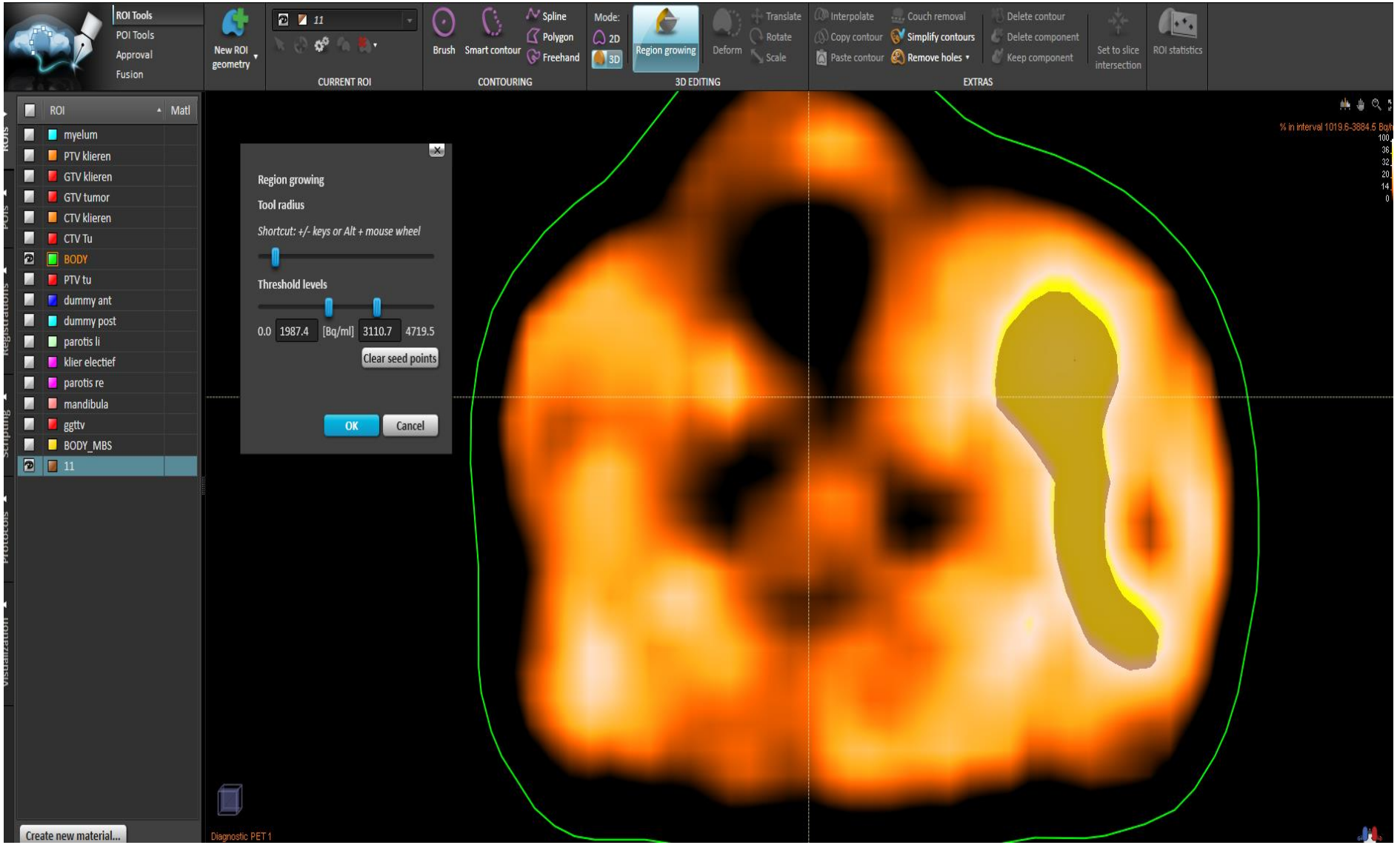

Automated Planning
Patient Data Management
Patient Modeling
Plan Design
Plan Optimization
Plan Evaluation
QA Preparation
Treatment Adaptation
Image Registration
Structure Definition
Deformable Registration
Create new ROI...
Create external ROI...
Copy ROI geometries...
MBS
Create MBS ROI(s)...
MBS model management...
Atlas based segmentation...
Algebra and margins
Thresholding
Basic shapes
Structure templates
Meshing tools
CBCT tools
Create bone ROI...
Image Set Library
Primary image set: Prostate Planning CT



Örneğin: Hastalara 9-15 mCi (333-555 MBq) F-18 FDG intravenöz yolla verilsin, ortalama 444 MBq' dir. 80 kg (80000 g) olan bir hastada SUVmax ≥ 2.5 sağlamak için;

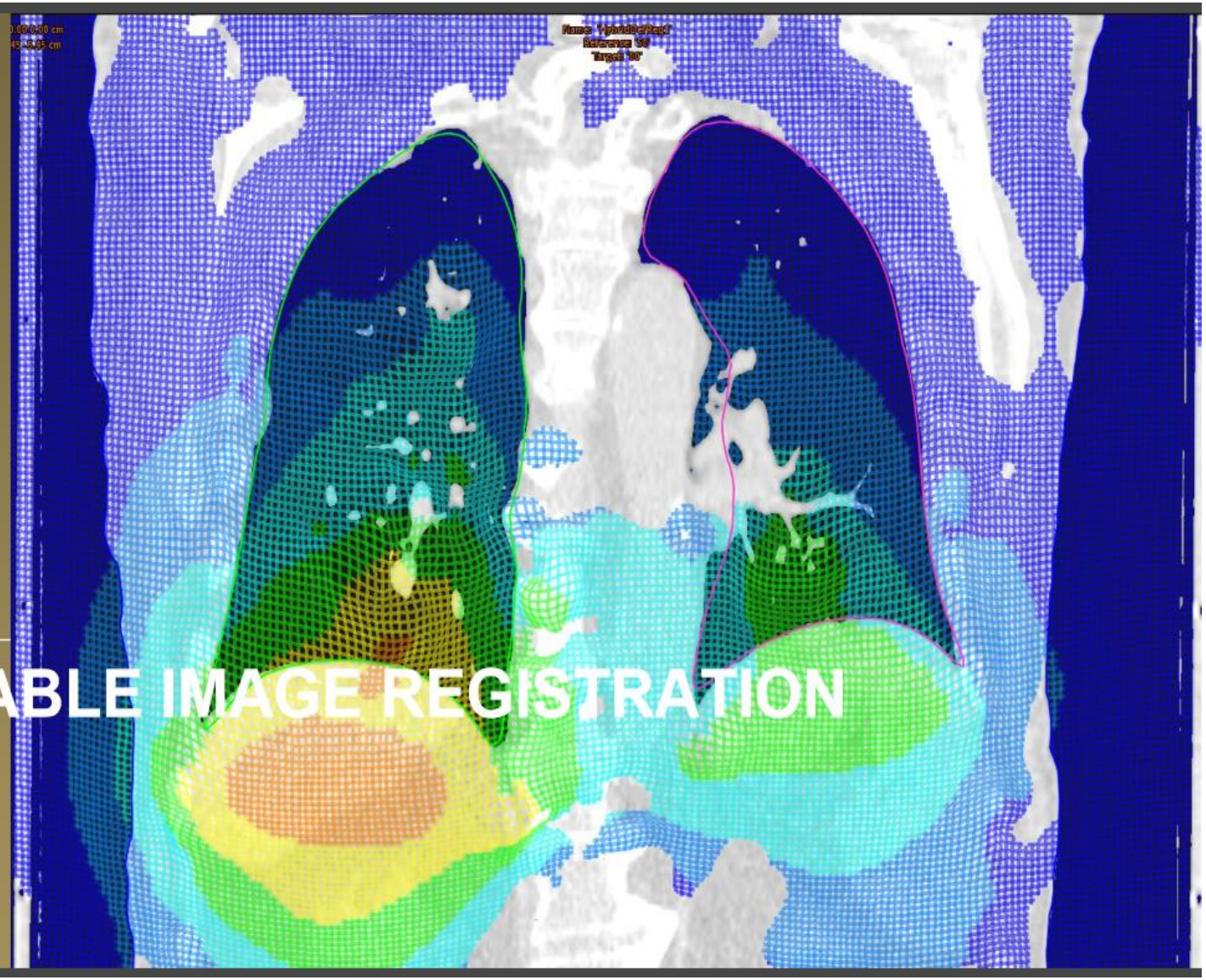
- 2.5 = (Bq/ml) / (444000000 Bq / 80000 g) = (Bq/ml) / 555

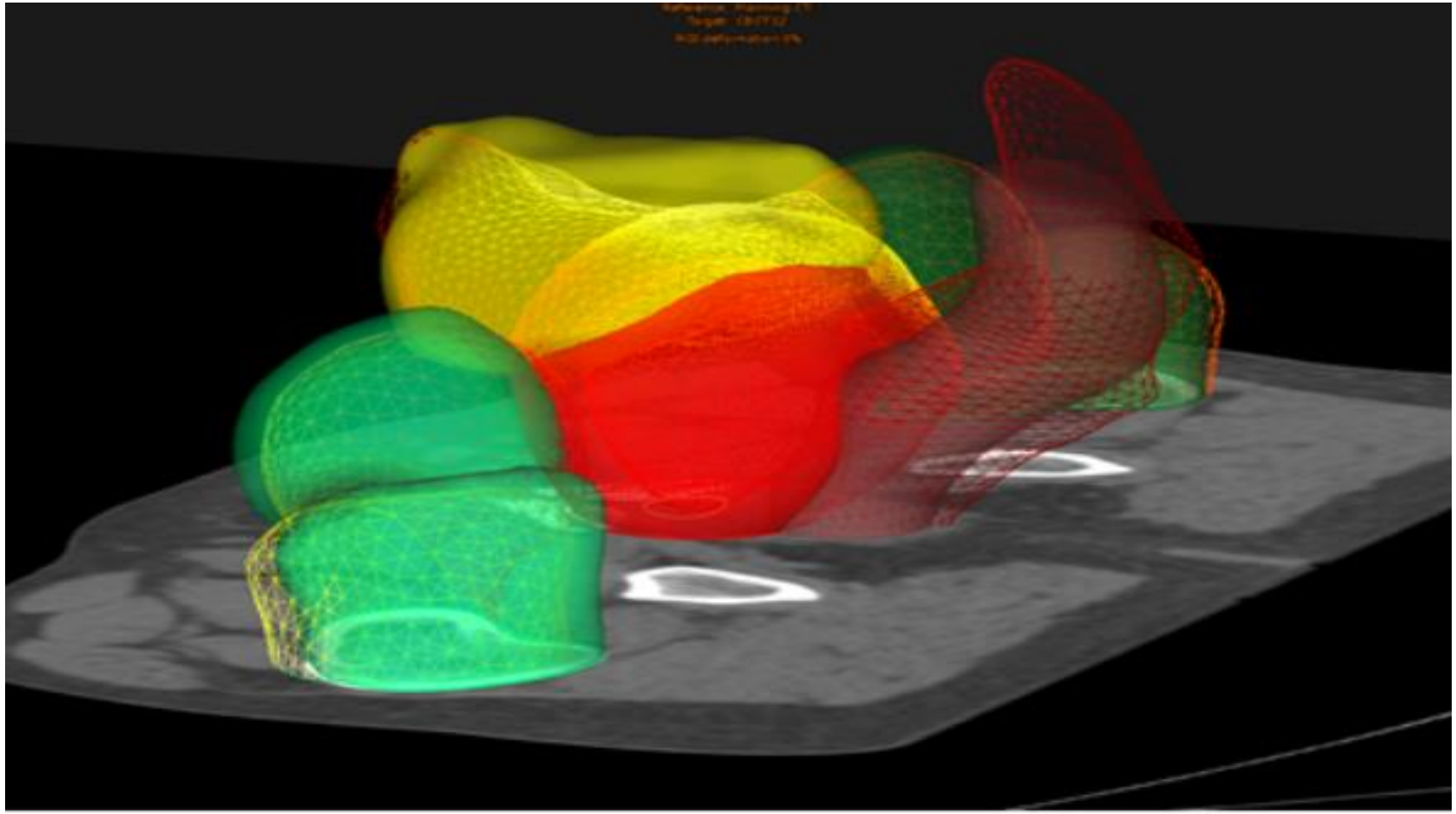
- Yani SUVmax ≥ 2.5 için planlamada en az 1387.5 Bq/ml değerini çizmeliyiz.



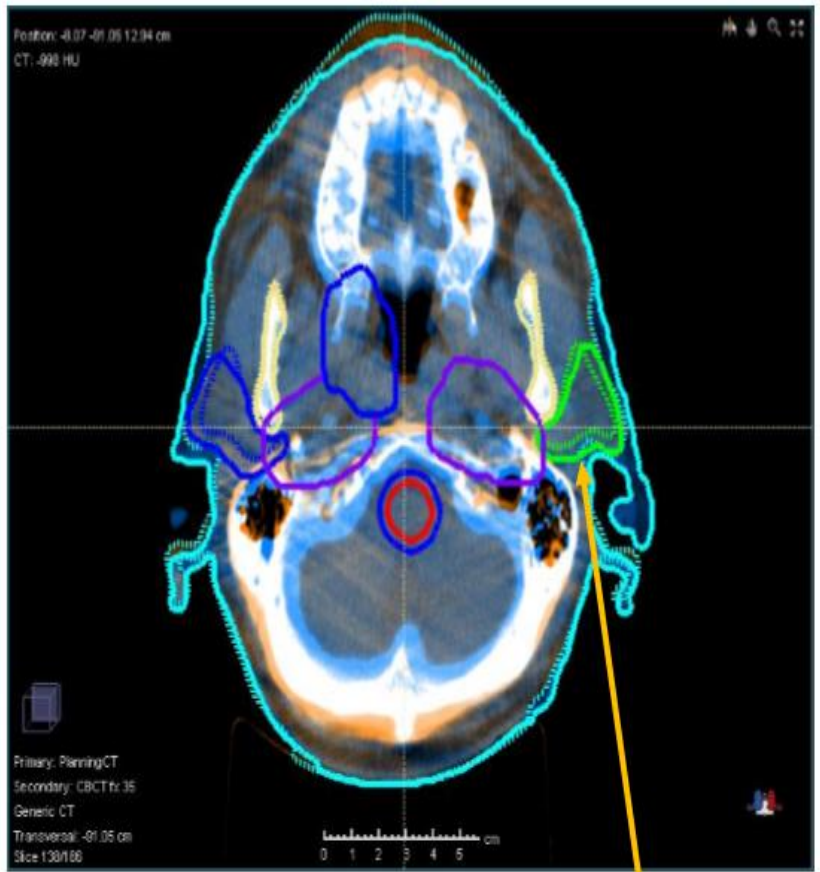
- Örnek hasta için SUVmax ≥ 2.5 1387.5 Bq/ml ile sağlanabilir.

DEFORMABLE IMAGE REGISTRATION





View showing the reference ROIs and the deformed ROIs so that the user can assess more cleanly what happened between data sets.

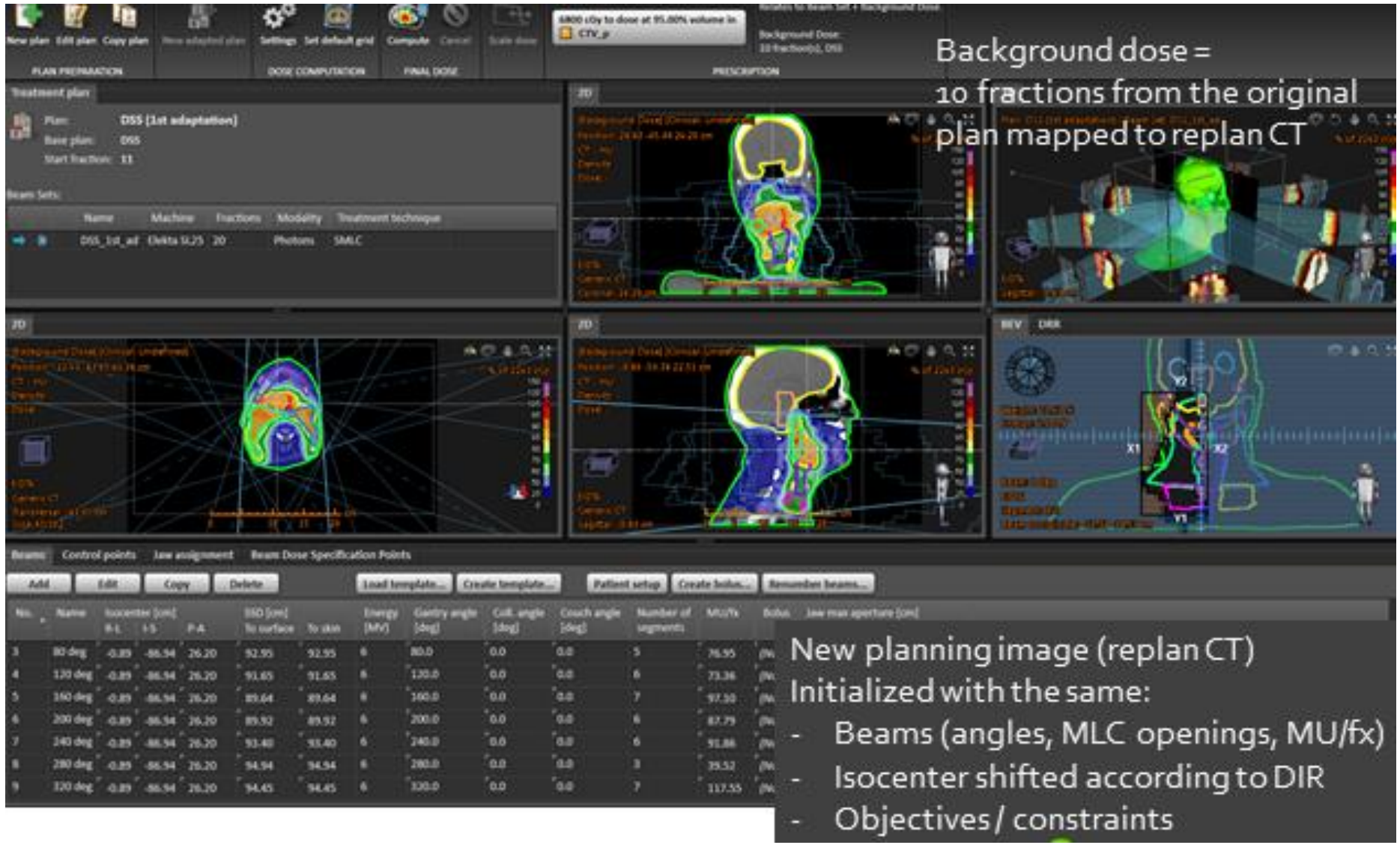


Rigid registration

Deformable registration

Shrinkage of parotid can imply modifications to the treatment are recommended

RaySearch Laboratories


Background dose =
10 fractions from the original plan mapped to replan CT
New planning image (replan CT)
Initialized with the same:
- Beams (angles, MLC openings, MU/fx)
- Isocenter shifted according to DIR
- Objectives / constraints


External
Larynx
CTV_p
PTV primary
PTV_left_neck
PTV_right_neck
PTV_lower_left
PTV_lower_right
Brain
Brainstem
Eye (Left)
Eye (Right)
Mandible
ParotidGland (Left)
ParotidGland (Right)
SpinalCord
Right parotid on plan CT
Right parotid on replan CT

MR-Tabanli Planlama

- CT Goruntusune Ihtiyac Duymadan direk MR goruntusu uzerinden Planlama

- **MR_ATLAS** tabanli otomatik konturlama

Doz Hesaplama; Model-Based method

Collapsed Cone Algorithm

- Fogliatta A., et al. Phys Med Biol. 2007
- 7 algorithms compared
  - Included Pinnacle and Eclipse
- Monte Carlo simulations used as benchmark
- 6 and 15 MV beams
- Various tissue densities (lung – bone)

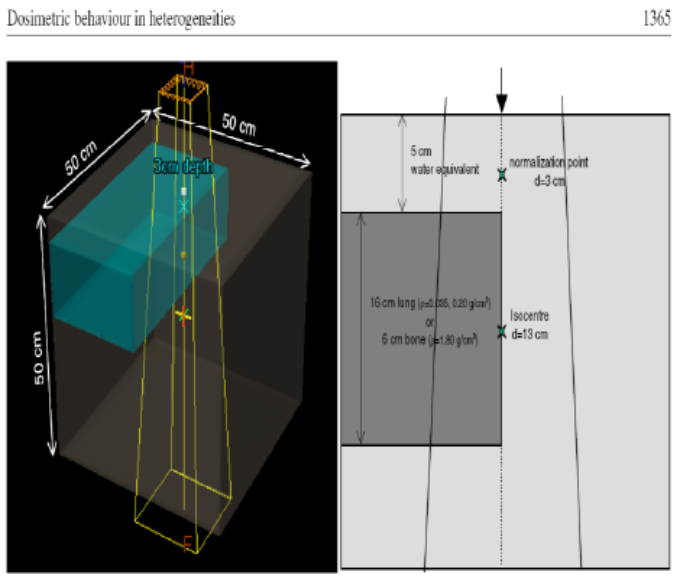


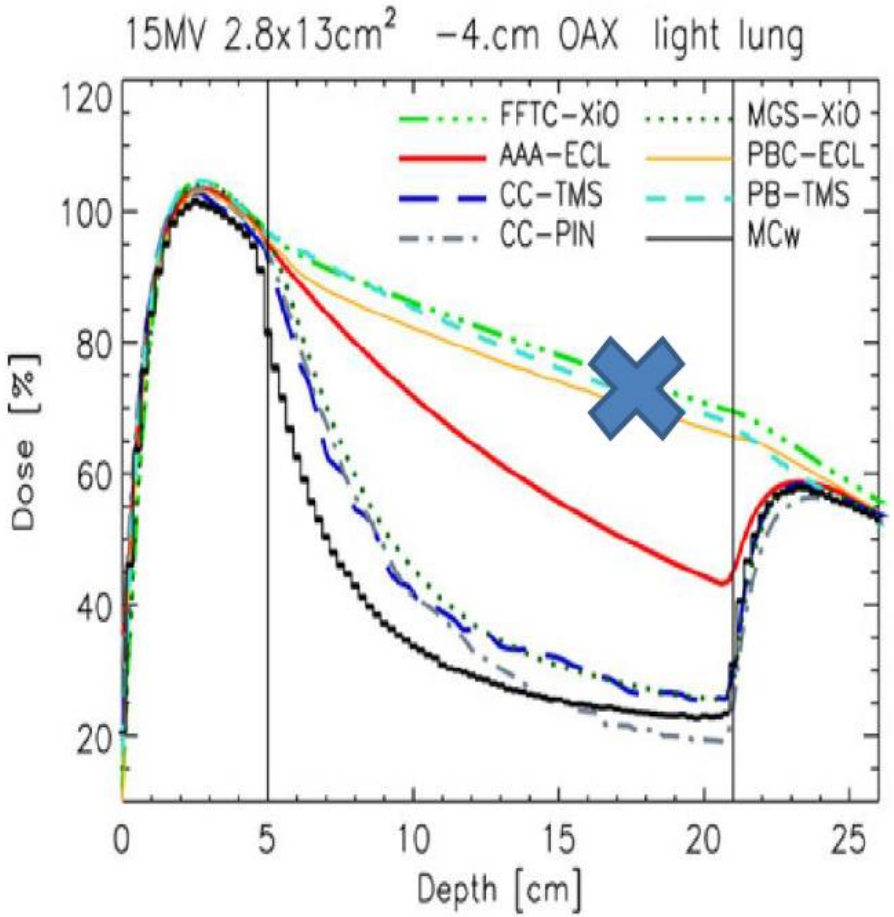
Figure 1. Geometrical layout of the phantom.

Type A: Electron (energy) transport not modeled

Type B: Electron transport accounted for (Pinnacle CC and Eclipse AAA).

Doz Hesaplama; Model-Based method

Collapsed Cone Algorithm



Type A algorithms inadequate inside heterogeneous media, esp. for small fields type B algorithms preferable.

Prostate/Pelvis planning: A or B sufficient

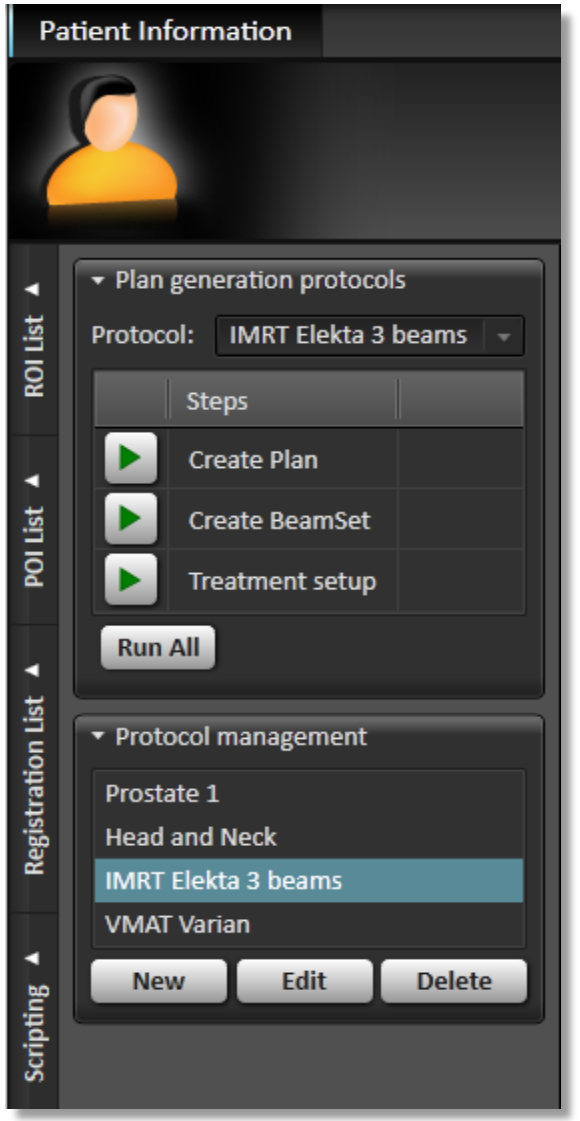
Thoracic/Head & Neck – type B recommended

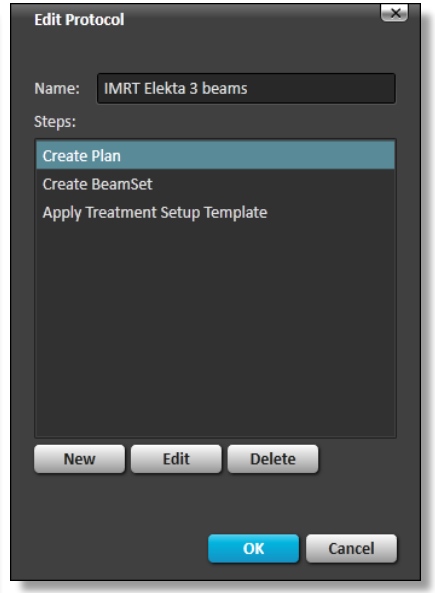
Type B generally more accurate in the absence of electronic equilibrium

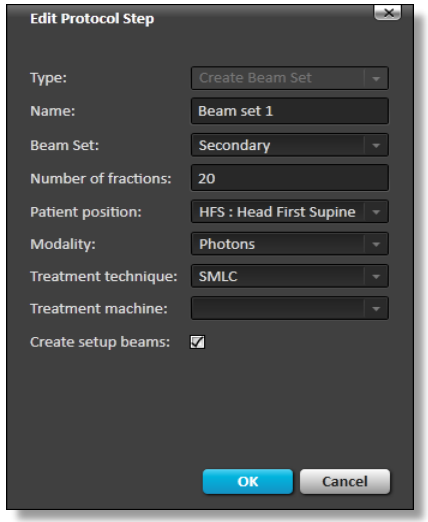
PLAN GENERATION PROTOCOLS

Reduces planning time and enforces standardization

- A protocol is a list of plan generation steps which can be applied automatically
  - Examples of plan generation steps include
  - Atlas based segmentation
  - Plan creation
  - Set dose grid resolution
  - Add beams, optimization functions and settings
  - Dose computation
- When a protocol is run it will automatically create a plan using the included steps
- Eliminates repetitive work
- Reduces planning time and human error
- Enforces name conventions and standardization







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THE EFFECT OF PLANNING SPEED ON VMAT PLAN QUALITY - RAYSEARCH STUDY

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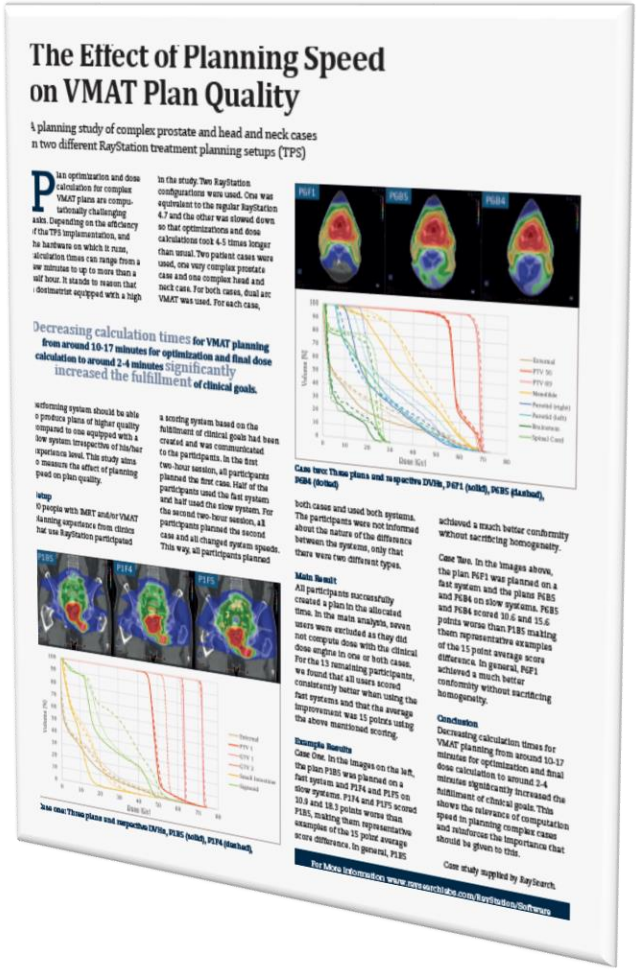
REVOLUTIONIZING COMPUTATION SPEED

One of the main priorities for RaySearch

- Optimization and dose calculation speed is one of the main priorities for RaySearch
  - Greater efficiency
  - Improved patient care
  - Pre- requisite for implementing automated planning

- Recent RayStation study could show that by **decreasing** calculation times for VMAT planning from 10 – 17 minutes to 2 – 4 minutes the fulfillment of clinical goals **significantly increased**



The Effect of Planning Speed on VMAT Plan Quality

A planning study of complex prostate and head and neck cases in two different RayStation treatment planning setups (TPS)

Decreasing calculation times for VMAT planning from around 10-17 minutes for optimization and final dose calculation to around 2-4 minutes significantly increased the fulfillment of clinical goals.

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Saniyelerle yarışıyoruz

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RAYSEARCH WORKSHOP
GENERAL OPERATIONS
HANDS-ON PLANNING

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MULTI- CRITERIA OPTIMIZATION

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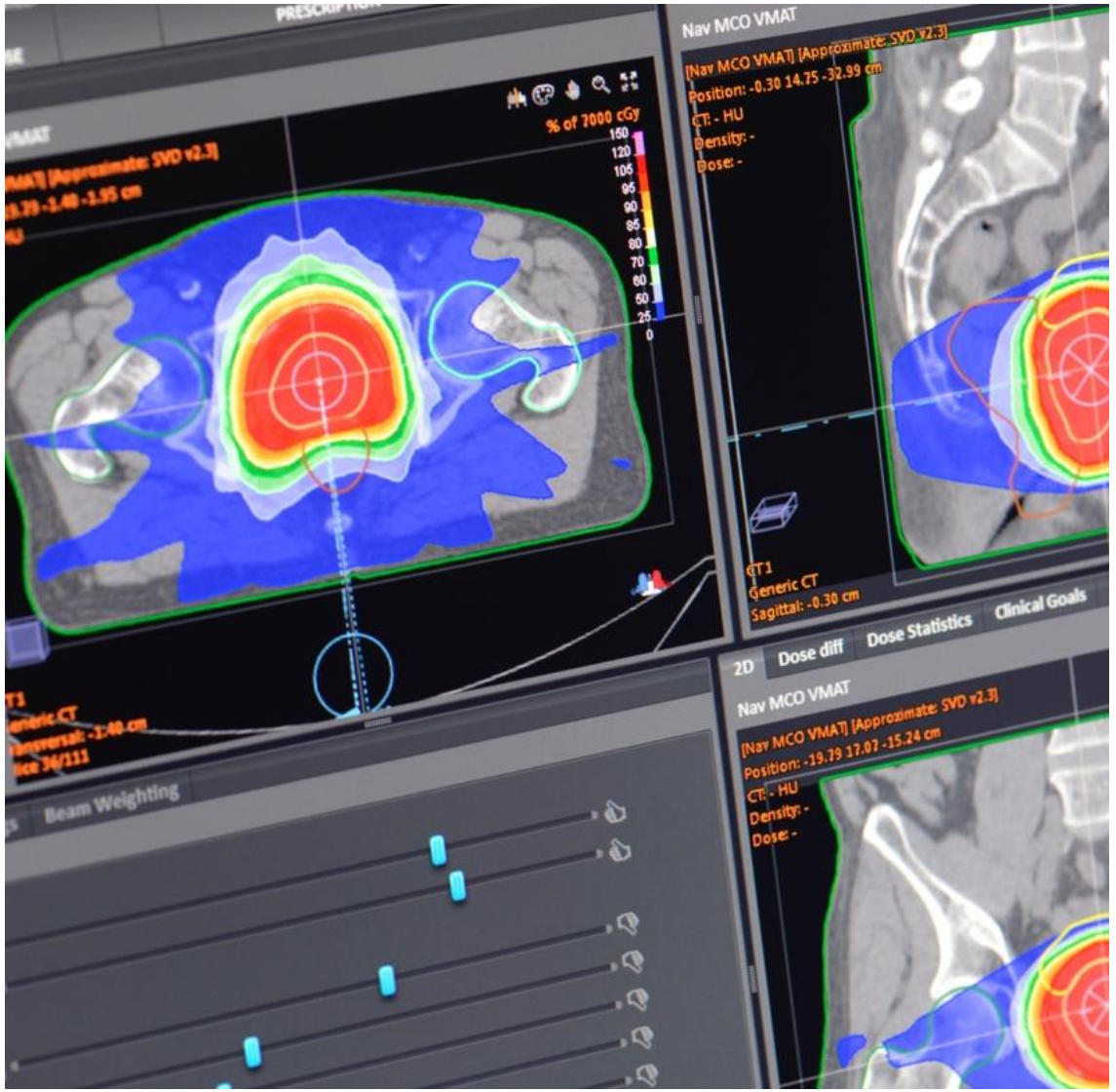
MULTI-CRITERIA OPTIMIZATION

Explore conflicting objectives in real time

- **Pre-computation** of all relevant plans that are Pareto optimal*
- Navigate plans in real time to **explore conflicting objectives**
- Select best **clinical trade-off** with real time interactive navigation tool
- What is the price I have to pay to get a even lower dose to..?



* A plan is Pareto optimal if it fulfills all the constraints and can not be improved in one objective without negatively affecting something else.

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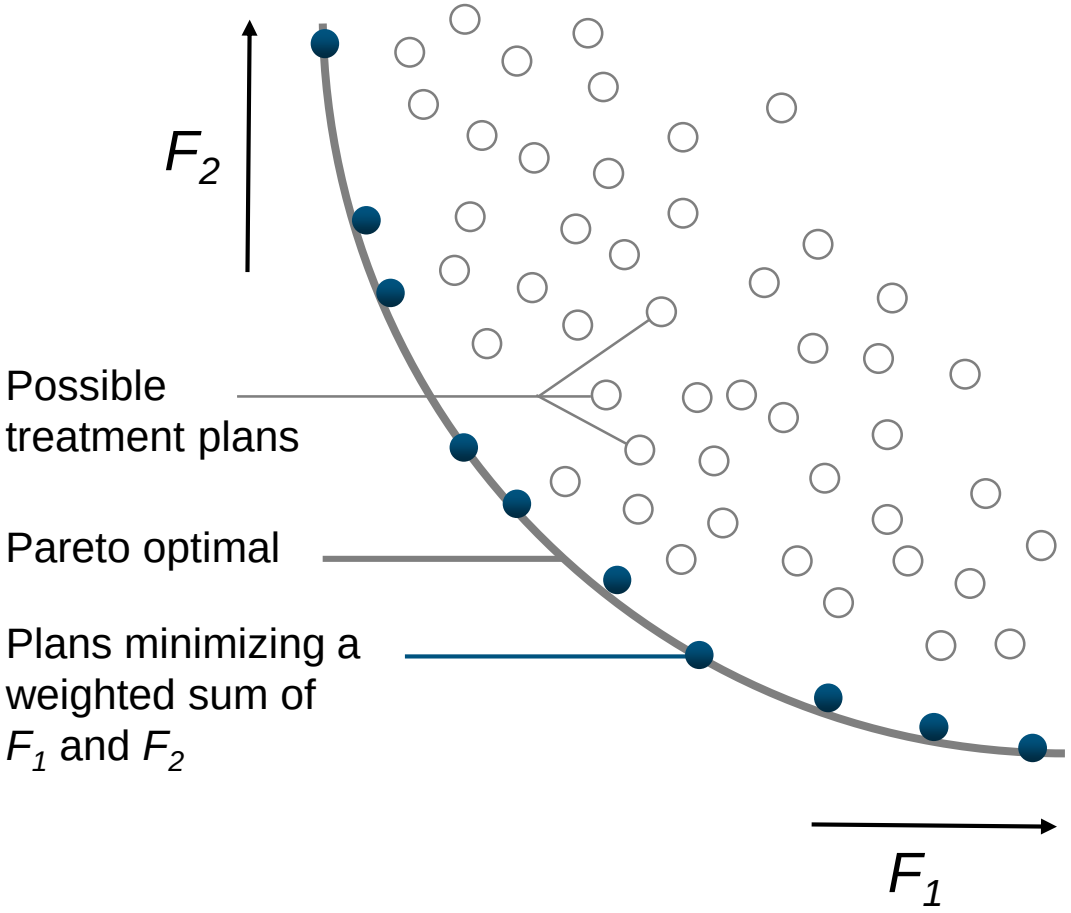
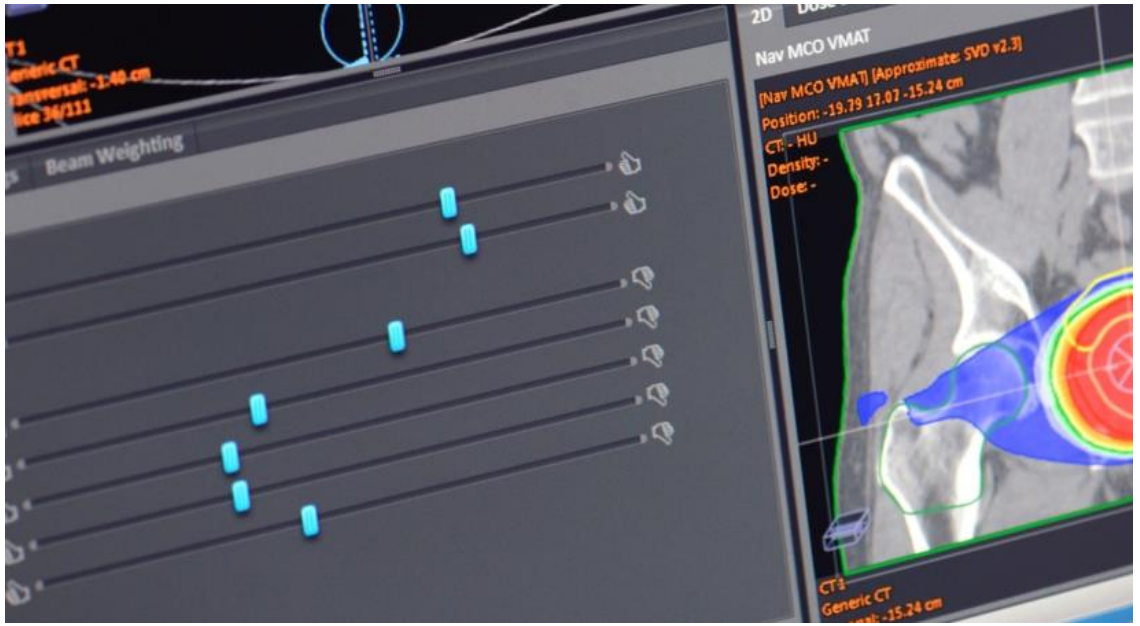
MULTI- CRITERIA OPTIMIZATION



- Goal: minimize F_1 and F_2
- Navigate Pareto line in real time in MCO interface



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MULTI- CRITERIA OPTIMIZATION

Explore conflicting objectives in real time

- **Interactive navigation tool**, in real time, for selecting the best clinical trade-off between conflicting objectives such as target coverage versus normal tissue sparing
- The optimizer **pre-computes** a representation of **all relevant plans** that are Pareto optimal with respect to the specified trade-off objectives and constraints
- A plan is **Pareto optimal** if it fulfills all the constraints and can not be improved in one objective without worsen something else
- Navigate in real time to **explore conflicting objectives** and in a continuous fashion see how the dose distribution and the DVHs changes

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MULTI- CRITERIA OPTIMIZATION

Impact on the treatment planning workflow

- The planner **uses MCO to prepare a navigated solution**, taking the clinical goals defined by the physician into account
- The planner and the physician can together in a **single session explore different solutions** and the physician can directly influence the plan
- **No need for an iterative process** either for the planner in producing the plan or between the planner and the physician for review and approval

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MULTI- CRITERIA OPTIMIZATION

Clinical findings

- Planners and physicians can find **solutions they didn't know existed**
- When physicians perform the navigation they select **plans with higher OAR** sparing at the expense of slightly target under dosing because they can see exactly where it happens
- The total **treatment planning time** is significantly reduced without compromising plan quality
- Planners with **limited experience** and knowledge can produce **clinically acceptable plans**

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RayStation

FALLBACK PLANNING

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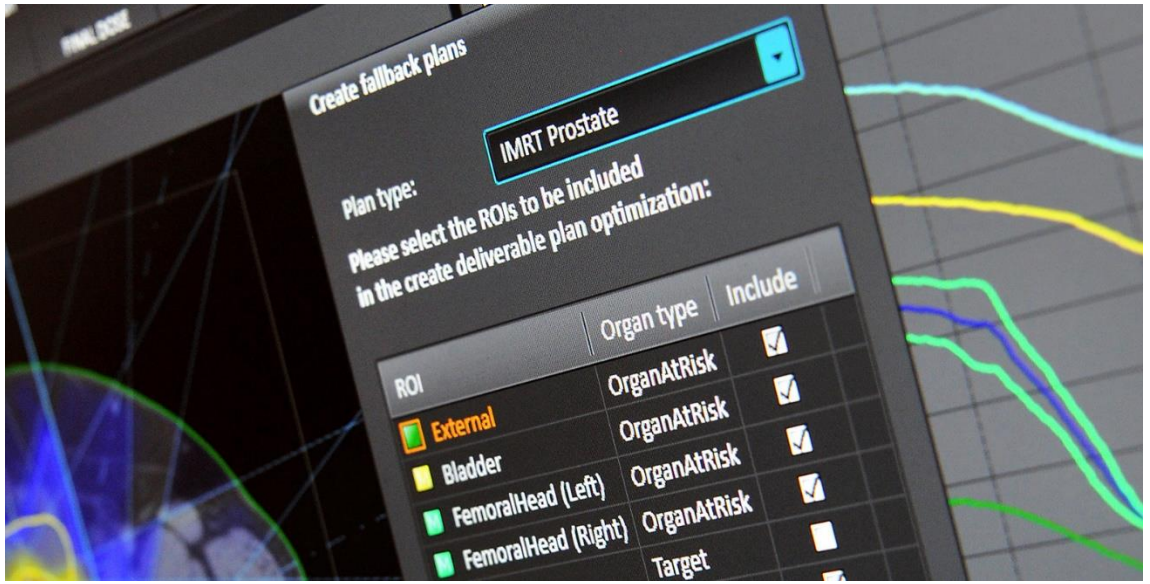
FALLBACK PLANNING

Automatically create additional plans

- Key step towards automated planning
- Tool for creating additional plans
- In a contingency situation enabling a patient to be treated on another machine, with a different modality and/or treatment technique, in case the original machine is unavailable
- Evaluate if improved results can be achieved with a different treatment technique
- Plans of any modality can be converted



- **3DCRT plan**
- **IMRT plan**
- **VMAT plan**
- **Proton plan**
- **Tomotherapy plan**

Dose mimicking

- **3DCRT plan**
- **IMRT plan**
- **VMAT plan**

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FALLBACK PLANNING

Automatically create additional plans

- No user interaction is needed, rayFallback is using a dose mimicking function to replicate and try to improve the DVH of the original plan but with a different machine or treatment modality
- Clear overview whether the clinical goals are achieved for the additional plans and if needed the plan can be further improved and re–optimized
- With summation tools the fallback plan and the original plan can be combined using their delivered fractions so that actual dose can be visualized on the patient data set

- **Reduce planning time**
- **Avoid treatment interruption**
- **Reduce stress on staff**
- **Explore other treatment techniques**

Dose Statistics | Dose Difference | Clinical Goals

Add physical... | Add biological... | Edit... | Copy | Delete | Load template... | Create template...

Dose	ROI/POI	Clinical goal	Value	Result	% outside grid
Fallback plan dose: VMAT to 6 fld 3D-CRT Varian (CT 1)	Penile Bulb	At most 11.00 Gy dose at 25.00 % volume	10.46 Gy	✓	0 %
Fallback plan dose: VMAT to 9 fld IMRT Elekta (CT 1)	Penile Bulb	At most 11.00 Gy dose at 25.00 % volume	10.58 Gy	✓	0 %
Fallback plan dose: VMAT to 9 fld IMRT Varian (CT 1)	Penile Bulb	At most 11.00 Gy dose at 25.00 % volume	9.84 Gy	✓	0 %
Fallback plan dose: VMAT to VMAT Elekta (CT 1)	Penile Bulb	At most 11.00 Gy dose at 25.00 % volume	10.03 Gy	✓	0 %
Plan dose: VMAT (CT 1)	Penile Bulb	At most 11.00 Gy dose at 25.00 % volume	8.97 Gy	✓	0 %
Fallback plan dose: VMAT to 6 fld 3D-CRT Varian (CT 1)	PTV 81	At least 80.50 Gy dose at 95.00 % volume	80.14 Gy	!	0 %
Fallback plan dose: VMAT to 6 fld 3D-CRT Varian (CT 1)	PTV 81	At most 85.00 Gy dose at 2.0 cm³ volume	84.10 Gy	✓	0 %
Fallback plan dose: VMAT to 9 fld IMRT Elekta (CT 1)	PTV 81	At least 80.50 Gy dose at 95.00 % volume	80.43 Gy	!	0 %
Fallback plan dose: VMAT to 9 fld IMRT Elekta (CT 1)	PTV 81	At most 85.00 Gy dose at 2.0 cm³ volume	84.12 Gy	✓	0 %
Fallback plan dose: VMAT to 9 fld IMRT Varian (CT 1)	PTV 81	At least 80.50 Gy dose at 95.00 % volume	80.59 Gy	✓	0 %
Fallback plan dose: VMAT to 9 fld IMRT Varian (CT 1)	PTV 81	At most 85.00 Gy dose at 2.0 cm³ volume	84.21 Gy	✓	0 %
Fallback plan dose: VMAT to VMAT Elekta (CT 1)	PTV 81	At least 80.50 Gy dose at 95.00 % volume	81.43 Gy	✓	0 %
Fallback plan dose: VMAT to VMAT Elekta (CT 1)	PTV 81	At most 85.00 Gy dose at 2.0 cm³ volume	88.77 Gy	!	0 %
Plan dose: VMAT (CT 1)	PTV 81	At least 80.50 Gy dose at 95.00 % volume	81.00 Gy	✓	0 %
Plan dose: VMAT (CT 1)	PTV 81	At most 85.00 Gy dose at 2.0 cm³ volume	83.99 Gy	✓	0 %
Fallback plan dose: VMAT to 6 fld 3D-CRT Varian (CT 1)	Rectum	At most 80.00 Gy dose at 10.00 % volume	74.32 Gy	✓	0 %
Fallback plan dose: VMAT to 9 fld IMRT Elekta (CT 1)	Rectum	At most 80.00 Gy dose at 10.00 % volume	73.43 Gy	✓	0 %
Fallback plan dose: VMAT to 9 fld IMRT Varian (CT 1)	Rectum	At most 80.00 Gy dose at 10.00 % volume	74.11 Gy	✓	0 %
Fallback plan dose: VMAT to VMAT Elekta (CT 1)	Rectum	At most 80.00 Gy dose at 10.00 % volume	74.71 Gy	✓	0 %
Plan dose: VMAT (CT 1)	Rectum	At most 80.00 Gy dose at 10.00 % volume	73.72 Gy	✓	0 %

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SCRIPTING

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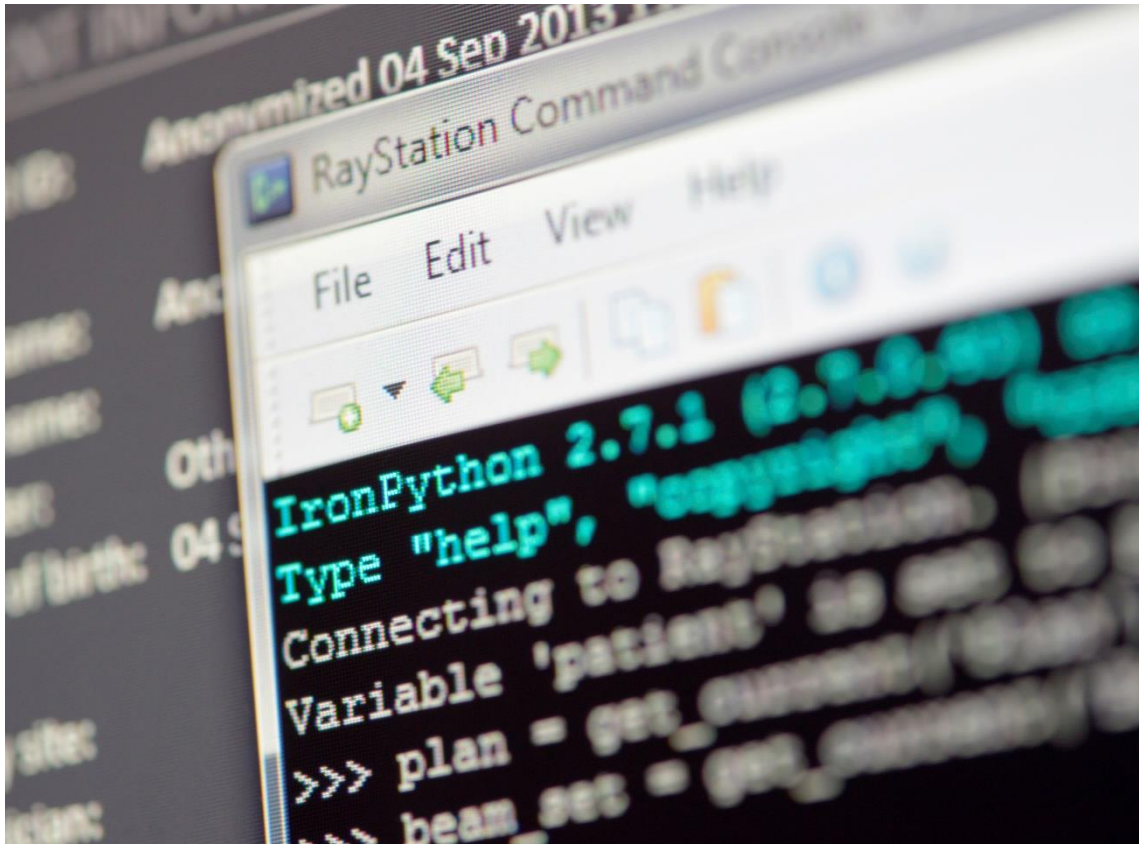
SCRIPTING IN RAYSTATION

Create new capabilities in an easy and powerful way

- Scripts can **be recorded or programmed**
- Scripting language **Iron Python**, allows access to **Microsoft.NET**
- Read and write **all data** in RayStation
- Create and display windows, create pdf reports and **interface directly** with other applications such as **Matlab or Excel**
- A number of **general scripts are included in RayStation** and more example scripts are available on *github.com/raysearchlabs/scripting* or the scripting forum in RayStation Community



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SCRIPTING IN RAYSTATION

Examples of clinical applications

- **Automation** of clinic specific procedures
- **Customize** the interaction between RayStation and other software components where DICOM is not sufficient
- **Execute over multiple plans** and patients and create own Graphical User Interface

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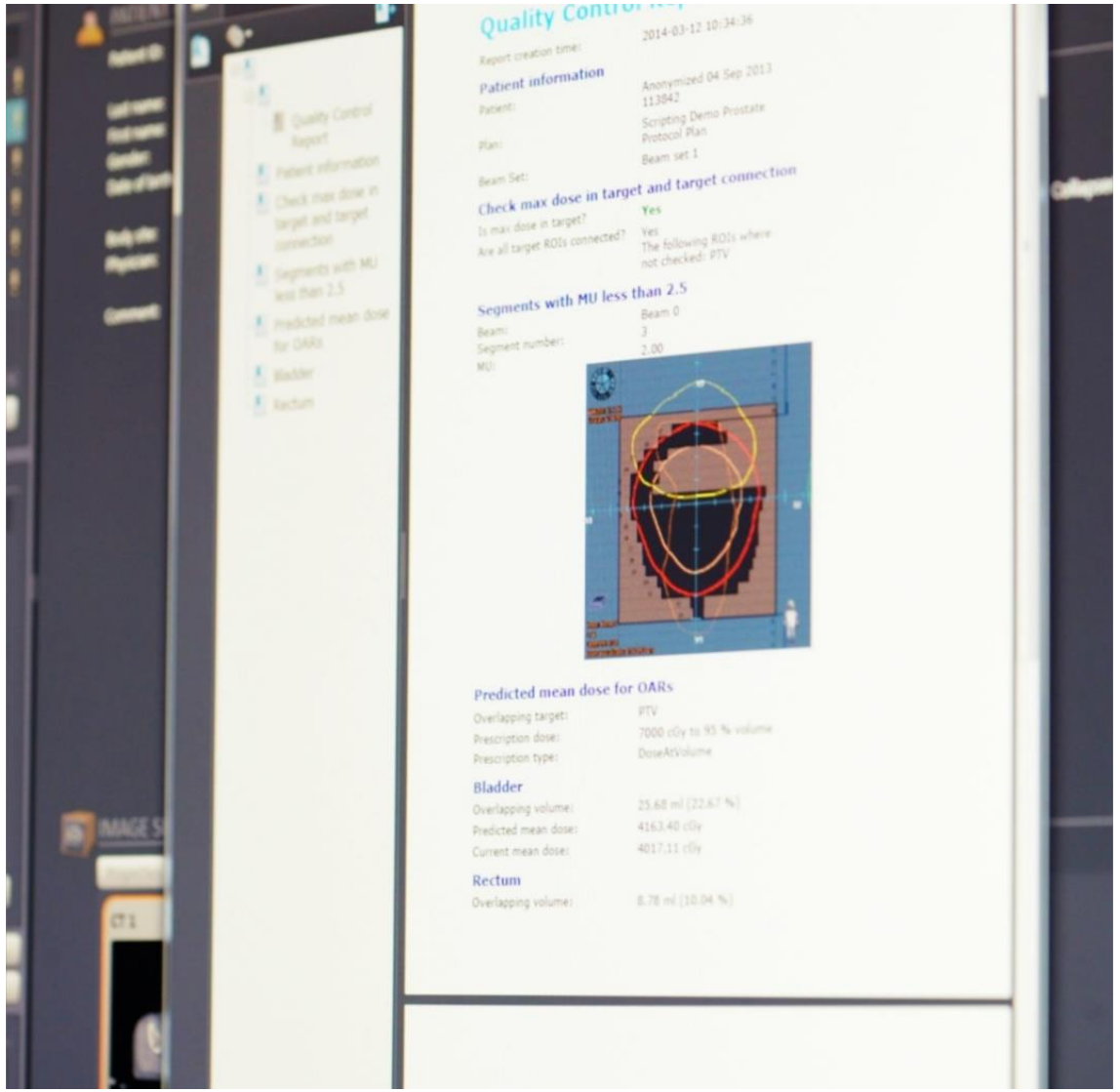
SCRIPTING IN RAYSTATION

Examples of clinical applications

Quality control check list

- User is prompt to select certain quality control features that should be checked for the plan
- All checks are automatically performed and displayed in a pdf report



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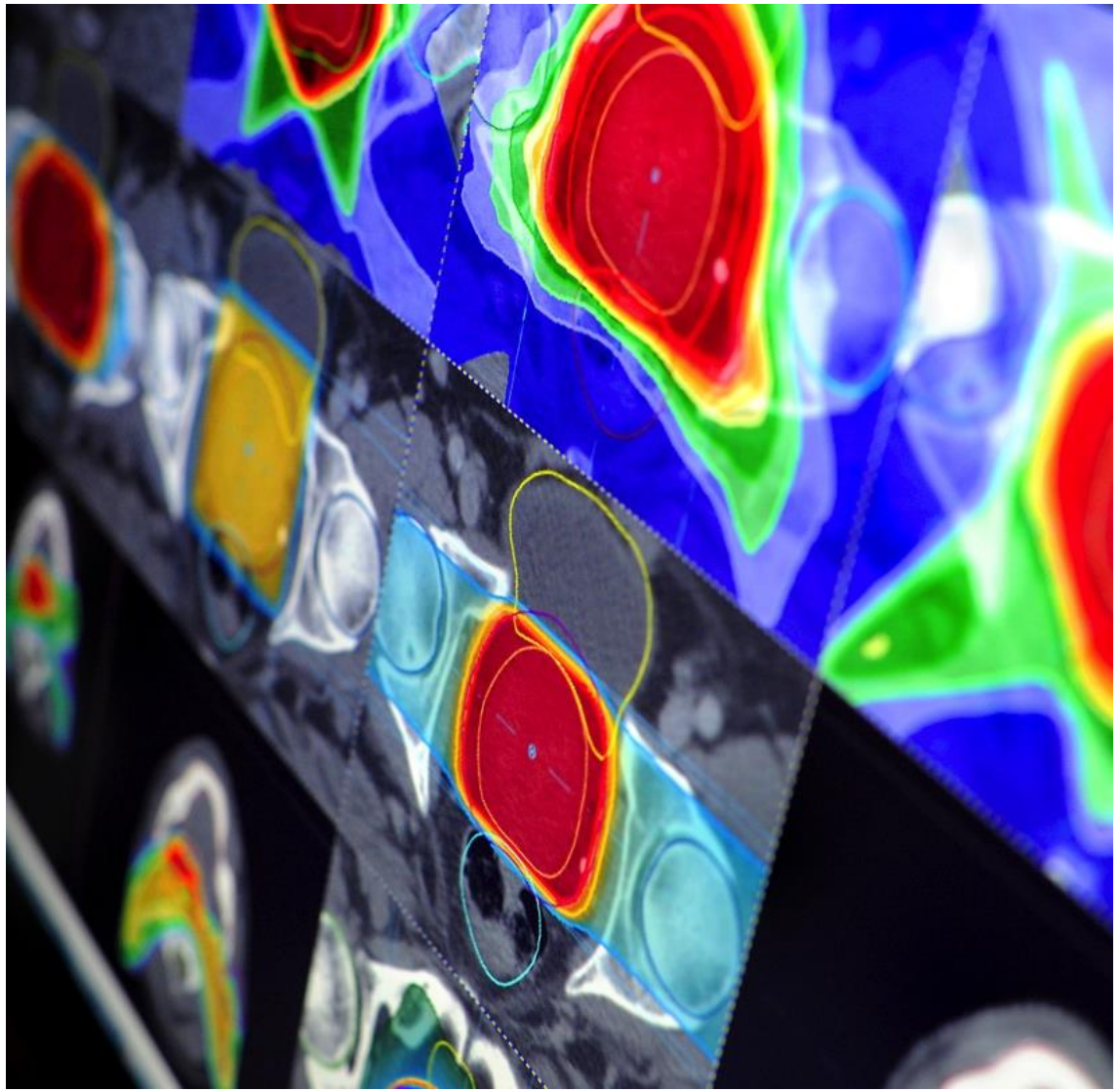
SCRIPTING IN RAYSTATION

Examples of clinical applications

Cohort review

- Select different cases
- Retrieve the dose images from the database
- Display in a cohort review and scroll through them in all directions



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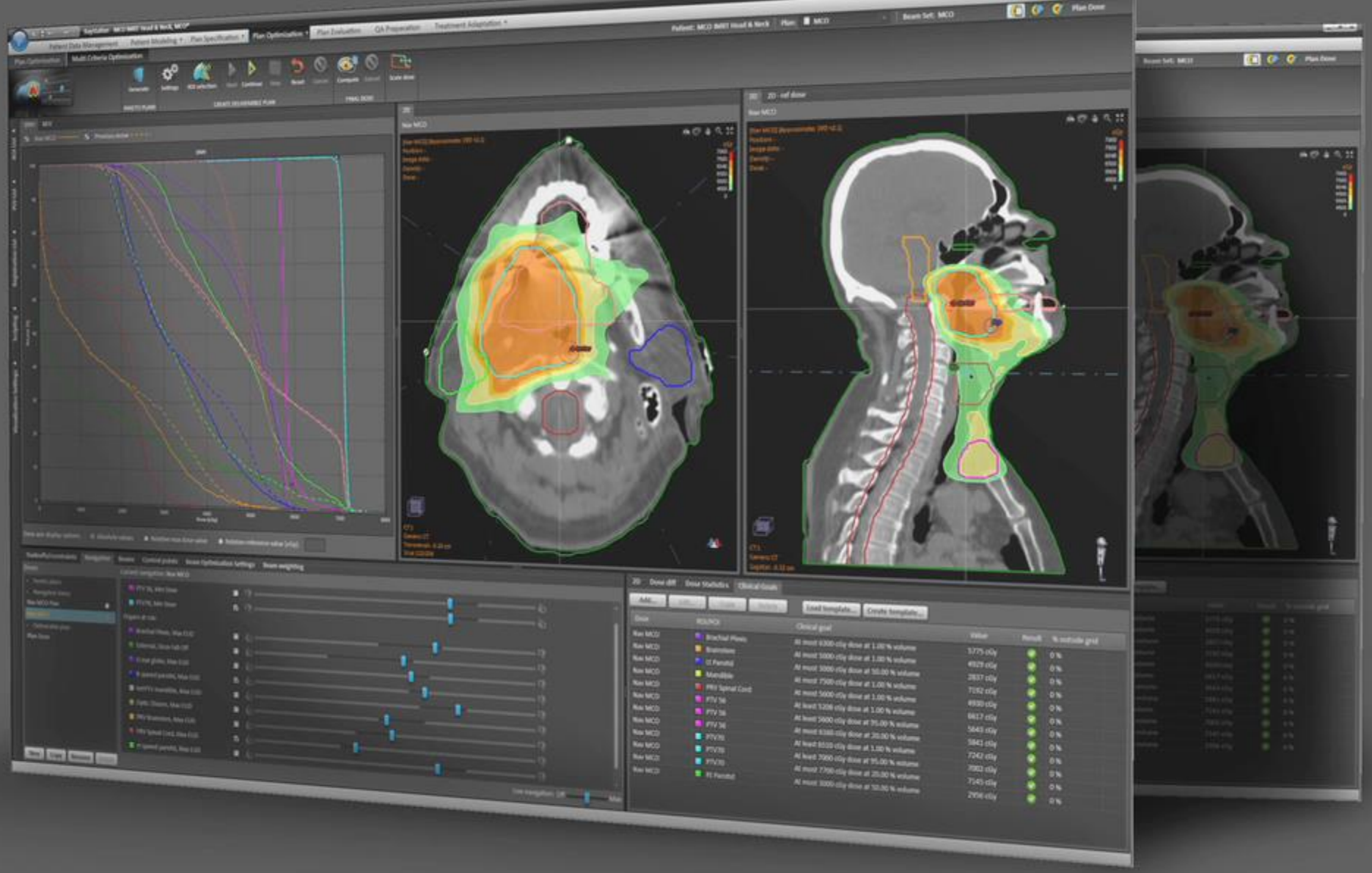


raysearchlabs.com

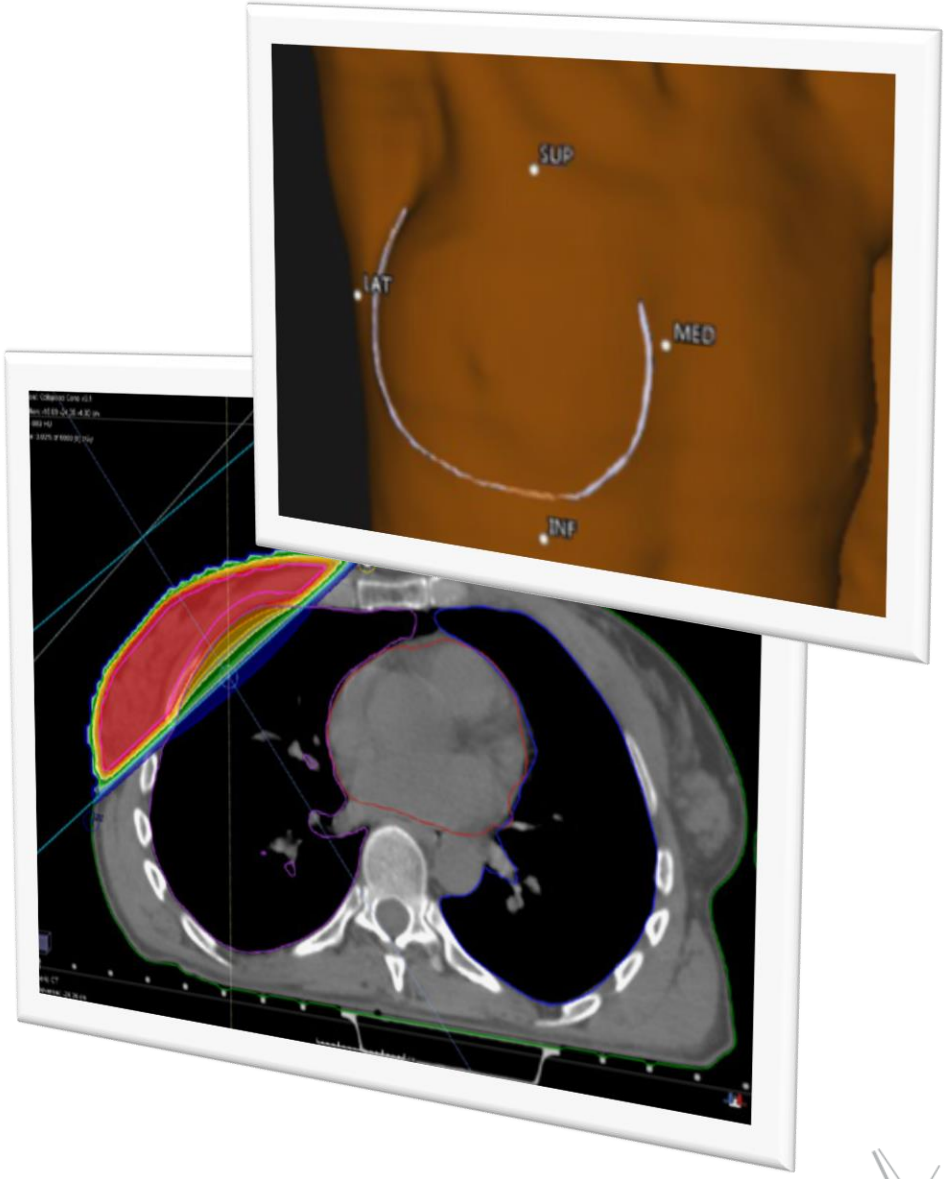
AUTOMATED BREAST PLANNING

RaySearch Laboratories

AUTOMATED BREAST PLANNING

Tangential breast IMRT planning – one click solution

- Applicable for most early stage breast cancer patients suitable for tangential breast IMRT
- A wire is placed around the breast tissue or along the chest wall together with four markers denoting the superior, inferior, lateral and medial margins
- Automatic contouring of all the relevant target and risk organs
- Automatic setup of beams, including heuristic optimization of gantry and collimator angles
- Automatic creation of objective functions, optimization and segmentation settings and clinical goals
- With scripting this procedure can be done for a large number of cases at once



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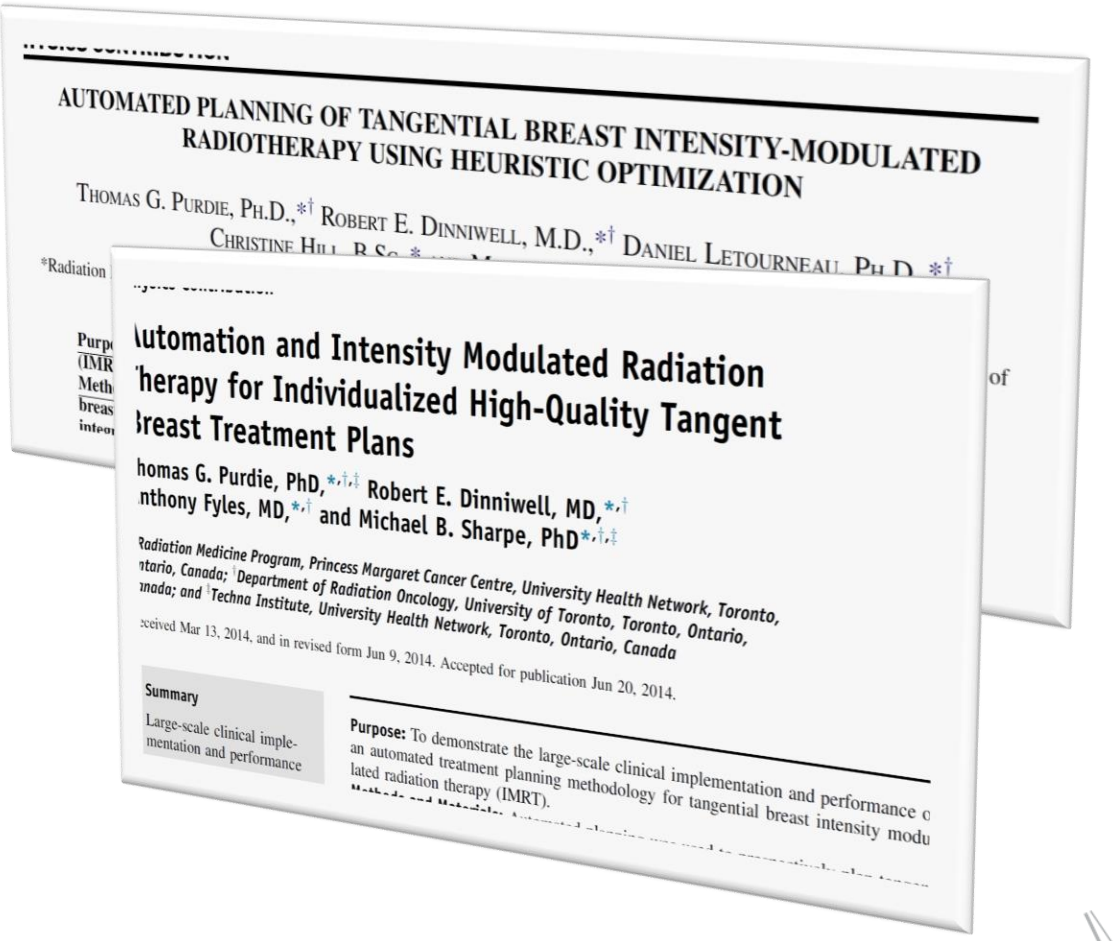
AUTOMATED BREAST PLANNING

Licensed from Princess Margaret Cancer Center, Toronto, Canada – Clinical findings

- Used at the Princess Margaret Cancer Centre, Toronto, Canada since June 2009, with more than 3,000 patients receiving treatment
- 6-7 minutes for a complete treatment plan
- 97 % of all tangential breast IMRT planned with automated tools
- Decreases in the number of overall plans rejected and number of plan rejections due to planning errors
- Adds efficiency, standardization and quality to the treatment planning process


AUTOMATED PLANNING OF TANGENTIAL BREAST INTENSITY-MODULATED RADIOTHERAPY USING HEURISTIC OPTIMIZATION

THOMAS G. PURDIE, PH.D.,*† ROBERT E. DINNIWELL, M.D.,*† DANIEL LETOURNEAU, PH.D.,*†

utomation and Intensity Modulated Radiation
herapy for Individualized High-Quality Tangent
reast Treatment Plans

homas G. Purdie, PhD,*,†,‡ Robert E. Dinniwell, MD,*,†
nthony Fyles, MD,*,† and Michael B. Sharpe, PhD*,†,‡

Summary

Large-scale clinical implementation and performance

Purpose: To demonstrate the large-scale clinical implementation and performance
an automated treatment planning methodology for tangential breast intensity modu
lated radiation therapy (IMRT).

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PLAN EXPLORER

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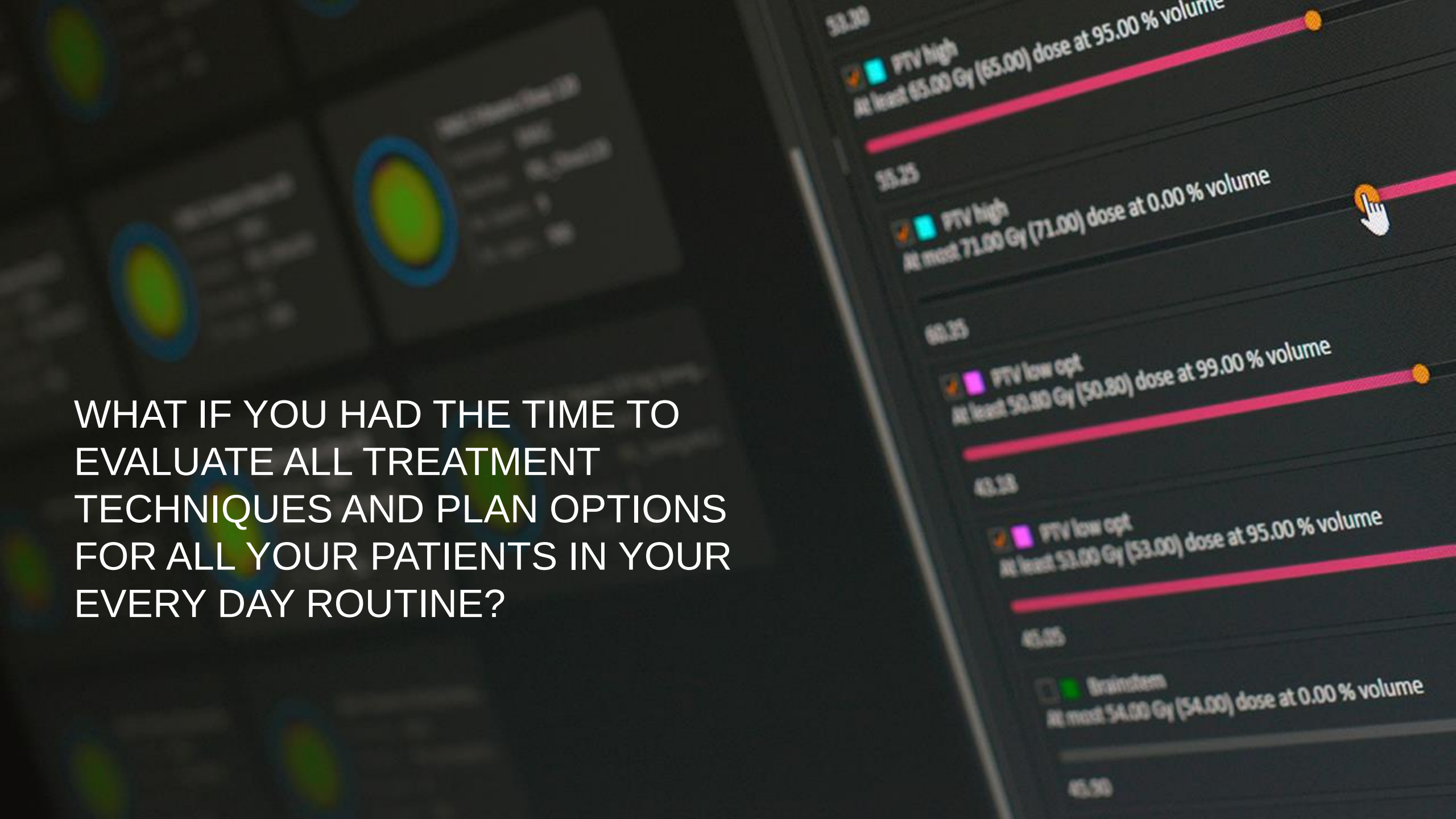

WHAT IF YOU HAD THE TIME TO EVALUATE ALL TREATMENT TECHNIQUES AND PLAN OPTIONS FOR ALL YOUR PATIENTS IN YOUR EVERY DAY ROUTINE?

PLAN EXPLORER

Treatment planning will never be the same

- Automatic generation, based on given clinical objectives, of multiple plans for the different treatment techniques and beam settings available at the clinic.
- Choose plans instead of designing them

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PLAN EXPLORER

Potential clinical benefits

- Explore different treatment techniques that would have been too time consuming to consider in the everyday routine
  - The best treatment setup (machine, #beams, #segments) is not known beforehand
  - Same, or better plan quality can be achieved with a different treatment setup (time, MU, #segments)
- Optimize the use of your current treatment delivery machines
- Get more time to evaluate the plans

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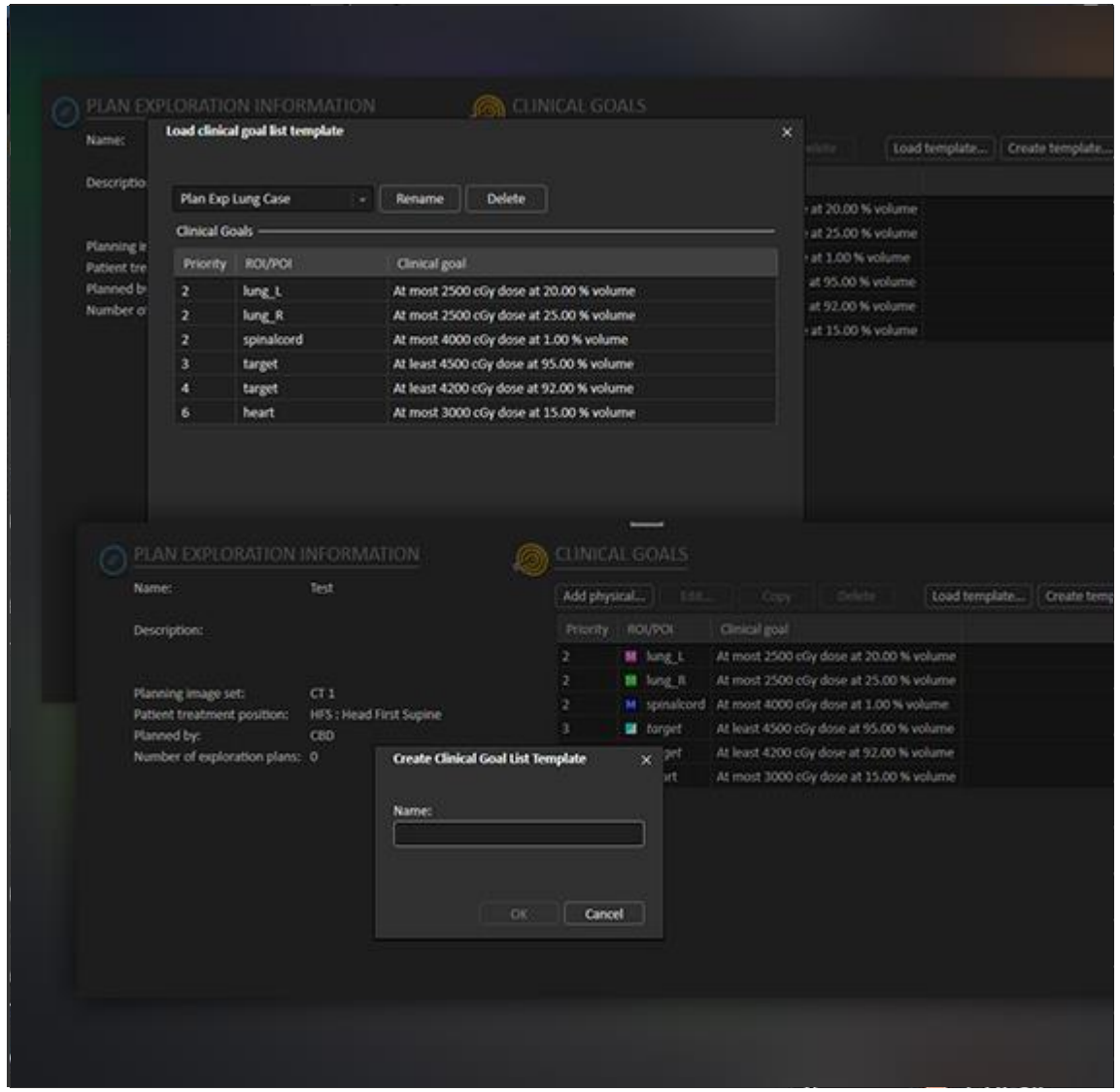
PLAN EXPLORER

Explore, filter and select

1. Start by establishing your clinical goals and priorities.
2. Load your exploration templates with different machine, beam and segment settings
3. Click start and let RayStation do the work
4. It creates multiple plans for the templates you have uploaded
5. Get a rapid overview of which plans best fulfill your goals with the intuitive “radar chart” visualization
6. Filter plans easily by machine, by number of beams, segments or MU, or for each clinical goal
   - You can for example uncheck machine X and remove all related plans
   - You can adjust dose to a specific organ
7. Once you have selected some plans you want to further work with, you click on compare to evaluate plans side by side
8. You can then choose the plan you find most suitable



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RAYSTATION PARTICLE THERAPY
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RAYSTATION PROTON SOLUTIONS

Experice the full potential of particle therapy

- Strong focus on in the area of particle therapy
- The first RayStation customer was Westdeutsche Protonentherapiezentrum in Essen
- First patient treated in May 2014 at Provision Proton Center, Knoxville, Tennessee, USA
- RayStation has been the vendor of choice for the majority of the Proton centers world wide in recent years

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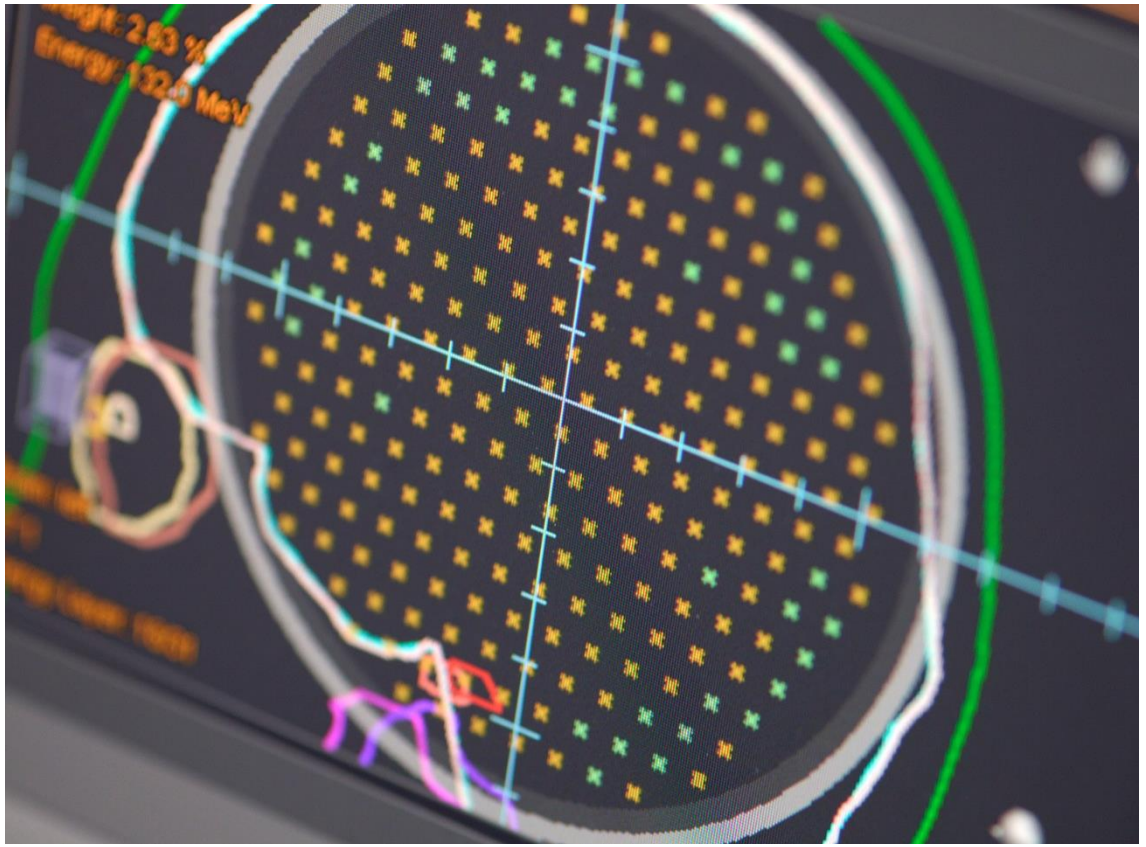
RAYSTATION PROTON SOLUTIONS

Support for a variety of treatment techniques

- Support for a variety of treatment techniques
  - Pencil Beam Scanning (PBS)
  - Double scattering
  - Uniform scanning
  - Wobbling techniques
- Multi- Criteria optimization (MCO) for PBS plans
- Spot weights limitation accounted for in the optimization – no post processing steps needed
- With Raystation fallback planning a proton plan can automatically be converted into a photon plan ensuring no interruption in the treatment and a valuable tool for plan comparison



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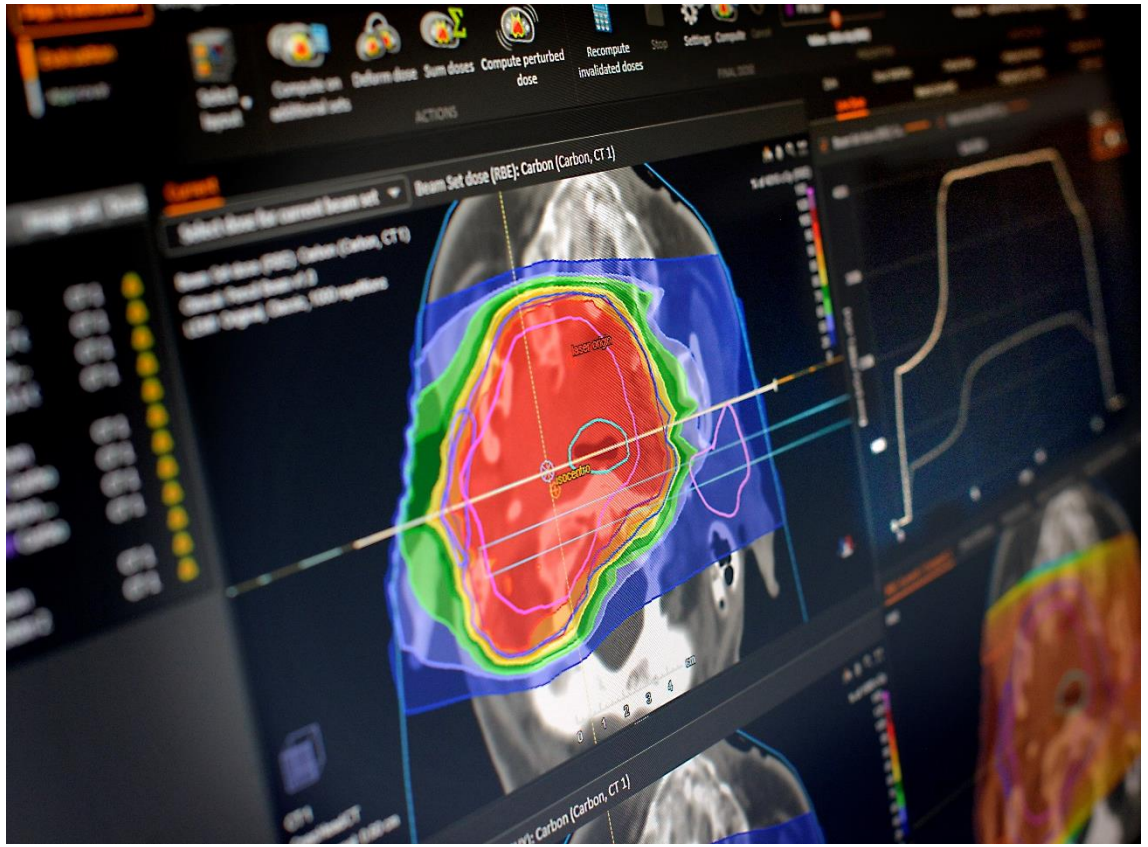
RAYSTATION CARBON ION SOLUTIONS

The only commercially available system that provides support for carbon ion

- First delivered to MedAustron (Austria) and CNAO (Italy)
- Pencil beam dose engine to compute physical dose and RBE weighted dose according to the Local Effect Model (LEM)
  - RayBiology - new workspace for handling Relative Biological Effectiveness (RBE) models
  - MKM model under development for future releases
- Optimization of carbon Pencil Beam Scanning (PBS) plans
  - Equivalent functionality as for proton PBS (i.e., spot selection, filtering and sorting, manual editing etc.)
  - Possibility to add objectives and constraints on both physical and RBE weighted dose
- Plan directly deliverable on synchrotrons after optimization
  - Minimum spot weight and other synchtron specific machine constraints taken into account in the optimization



RaySearch Laboratories

PRESS RELEASE

STOCKHOLM 2 OCTOBER 2015

RAYSTATION® WILL BE EXTENDED TO INCLUDE TREATMENT PLANNING FOR THE TOMOTHERAPY® AND CYBERKNIFE® SYSTEMS

RaySearch Laboratories AB (publ) (NASDAQ OMX Stockholm: RAY B) and Accuray Incorporated (Nasdaq: ARAY) announced today that they have expanded on their existing relationship with the signing of a new long-term collaboration agreement, which will lead to the integration of treatment planning support for the TomoTherapy® and CyberKnife® Systems in the RayStation® treatment planning system (TPS). RayStation is one of the most advanced independent treatment planning systems available and will provide an ideal complement to the unique Accuray treatment delivery systems, enabling customers to choose the delivery technology that will best meet their needs. Accuray and RaySearch previously announced a long-term collaboration regarding the RayCare® oncology information system.

"This agreement marks an important progression in our partnership with RaySearch. We believe the integration of their industry-leading TPS along with our innovative treatment delivery systems will enable clinicians to further optimize their experience and use of Accuray technology long-term," said Joshua H. Levine, president and chief executive officer of Accuray. "Our goal is to maximize the clinical effectiveness of our Systems and enhance the ease with which they integrate within the radiation oncology department. We are pursuing multiple paths to achieve this result, including this agreement with RaySearch, which will provide both flexibility and enhanced options for our customers."

Under the contract, Accuray will have the opportunity to offer RayStation to clinicians who use the TomoTherapy and CyberKnife System product portfolios. Current RayStation users report that the software provides multiple benefits including advanced treatment planning tools, leading workflow support and an excellent user experience, all of which enhance treatment delivery flexibility within a radiation oncology department.

Accuray has an installed base of more than 500 TomoTherapy Systems and more than 300 CyberKnife Systems worldwide. Treatment planning support for TomoTherapy Systems in RayStation is targeted for release during 2016 and support for CyberKnife Systems for release during 2017.

"This agreement with Accuray enables us to expand our relationship with a like-minded company committed to improving the way radiation therapy is delivered," said Johan Löf, president and chief executive officer of RaySearch Laboratories AB (publ). "For the first time ever, treatment planning for both of the Accuray systems as well as conventional linear accelerators will be available in one integrated treatment planning system. This integration alone will entail significant gains in efficiency for clinics that have several machine types. Additionally, we see that many of RayStation's unique strengths are exceptionally well suited to the Accuray systems. In summary, we think that this collaboration will strengthen both RayStation's and the Accuray systems' competitiveness."

RaySearch Laboratories

PRESS RELEASE

STOCKHOLM, 3 NOVEMBER, 2016

HACETTEPE UNIVERSITY HOSPITALS, TURKEY, SELECTS RAYSTATION

Hacettepe University Hospitals, a leading Turkish academic hospital group, has chosen RayStation® as its treatment planning system. The Department of Radiation Oncology at Hacettepe is one of the most technologically advanced centers in the Euro-Asia region, with equipment including Varian and Elekta linacs, CyberKnife, brachytherapy and 4D-CT imaging.

The order was placed through Oncotech Medical Systems, RaySearch's distribution partner in Turkey, with installation scheduled to take place during fall 2016. Functionality will include 3D-CRT, VMAT, IMRT, fallback planning, deformable registration and multi-criteria optimization.

Hacettepe University Hospitals aims to create an integrated radiation therapy center that will lead the way in providing advanced cancer treatment. An important step in achieving this is to unify its broad range of treatment technology under a single treatment planning system. RayStation makes this possible through outstanding flexibility and support for all the latest treatment techniques and machines.

Professor Gokhan Ozyigit, Chairman of the Department of Radiation Oncology at Hacettepe University Hospitals, says: "The radiation therapy community tends to focus on treatment machines rather than software. I believe we must change that focus for the well being of our patients. RayStation will be our backbone platform for various types of radiation therapy machines. The unique and advanced features of this powerful tool will enable a machine-independent environment and give us a new approach and direction for the future of radiation therapy."

Mecit Canbolat, General Manager of Oncotech Medical Systems, says: "Hacettepe University Hospitals is one of the best-known such facilities in Turkey and a leading innovator in radiation therapy. RayStation is the perfect match for a department that needs to consolidate such a wide range of machines. This cooperation will help improve treatment quality for patients and should inspire other clinics."

Johan Löf, CEO of RaySearch, says: "We have designed RayStation to meet the needs of leading-edge clinics like Hacettepe University Hospitals, which work with advanced techniques and often have systems from different providers. Software is driving innovation in radiation therapy today, and RayStation is at the forefront of the transformation. It helps to unify technology, opens up new treatment possibilities and provides the best possible user experience for clinicians."

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GAZİANTEP ÜNİVERSİTESİ

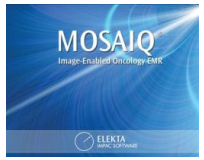
Elekta

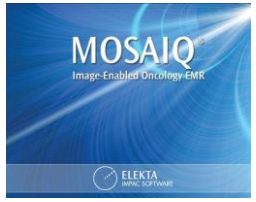
Step&Shoot IMRT

Elekta

3D-CRT

Electron





RayStation®
Tedavi Planlama Sistemi

RaySearch Laboratories

HACETTEPE ÜNİVERSİTESİ

Elekta

Step&Shoot IMRT

VMAT

Brainlab

DMLC IMRT

VMAT

Varian DHX

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