North Estonia
Medical Centre

# The Role of Medical Physicists in Modern Radiotherapy

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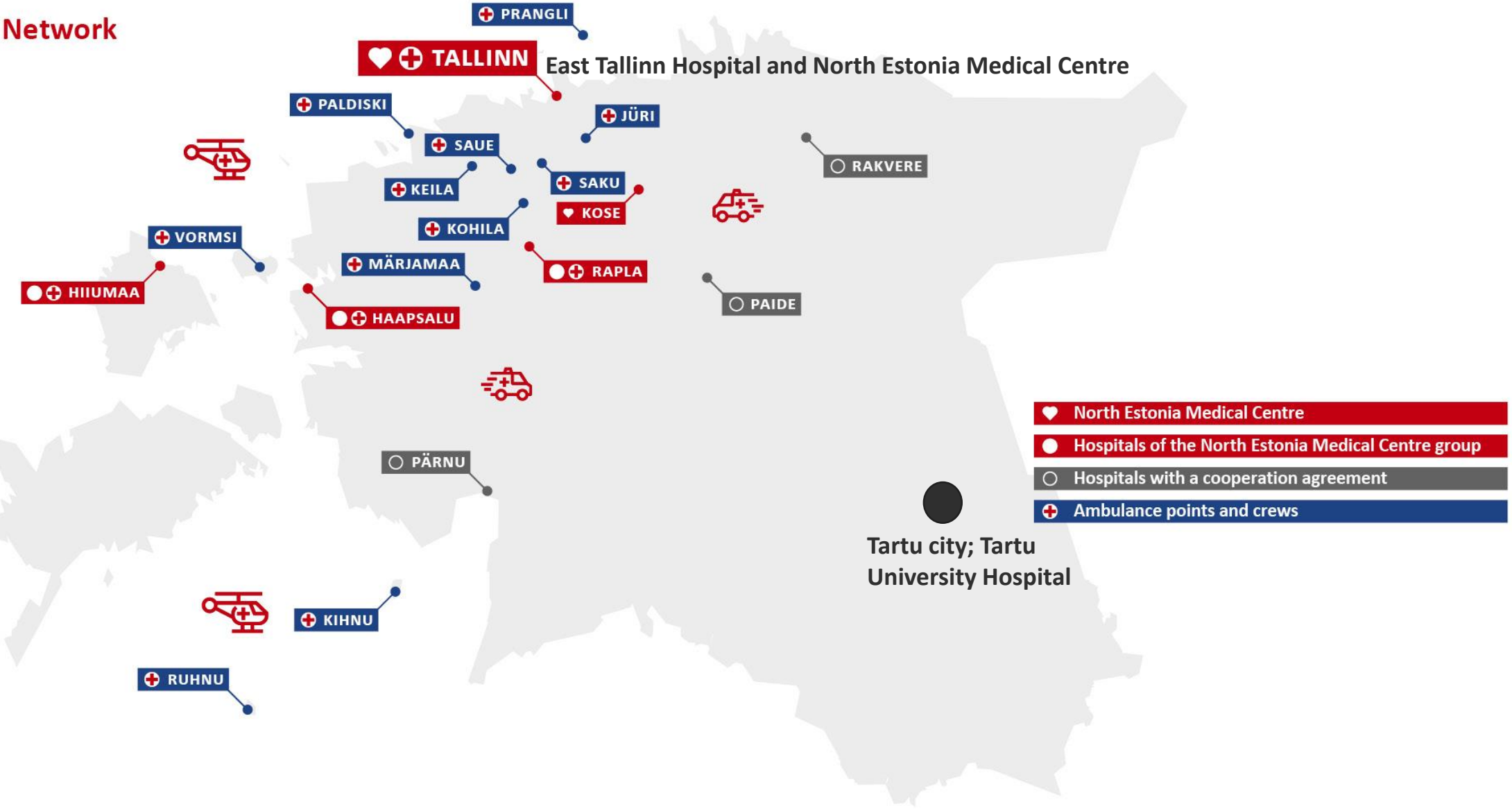
# Healthcare Network



# Medical physicist – (MP)

- MP is a healthcare professional who applies principles of physics to medicine, particularly in the diagnosis and treatment of diseases. They ensure safe and effective use of radiation and other physical agents in medical procedures.
- **Radiation Therapy** - Design and implement treatment plans for cancer patients using radiation. Ensure the accurate delivery of radiation doses. Monitor and maintain radiation equipment.
- **Diagnostic Imaging** - Optimize the performance of imaging equipment such as X-ray, MRI, CT, and ultrasound. Develop and maintain protocols to minimize radiation exposure while ensuring high-quality images. Calibrate and test imaging devices.
- **Nuclear Medicine** - Oversee the use of radioactive materials for diagnosis and treatment. Ensure proper handling and disposal of radioactive substances. Develop protocols for imaging and therapeutic procedures involving radiopharmaceuticals.
- **Responsibilities:** Quality Assurance, Safety, Research and Development, Clinical and Technical Support, Education and Training

# Education of MP-s

- TalTech curricula Biomedical Engineering and Medical Physics (very wide spectra trained together)
- Certification by the professional union Eesti Biomeditsiinitehnika ja Meditsiinifüüsika Ühing (EBMÜ)
- **No clinical residency available for MP-s in Estonia – people trained abroad (personal and hospital funds)**
- **Currently in Estonia we have 11 MP-s in diagnostic and nuclear medicine; 9 MP-s in radiotherapy (clinical MP-s)**

**Level 7 (engineer, MP)**

- MSc + 2 years of work experience (clinical residency)
- Working as a juunior physicist under level 8 MP

**Level 8 (engineer, MP)**

- Level 7 certification + 4 years of work experience + 80 training points
- Recertification every 5 years

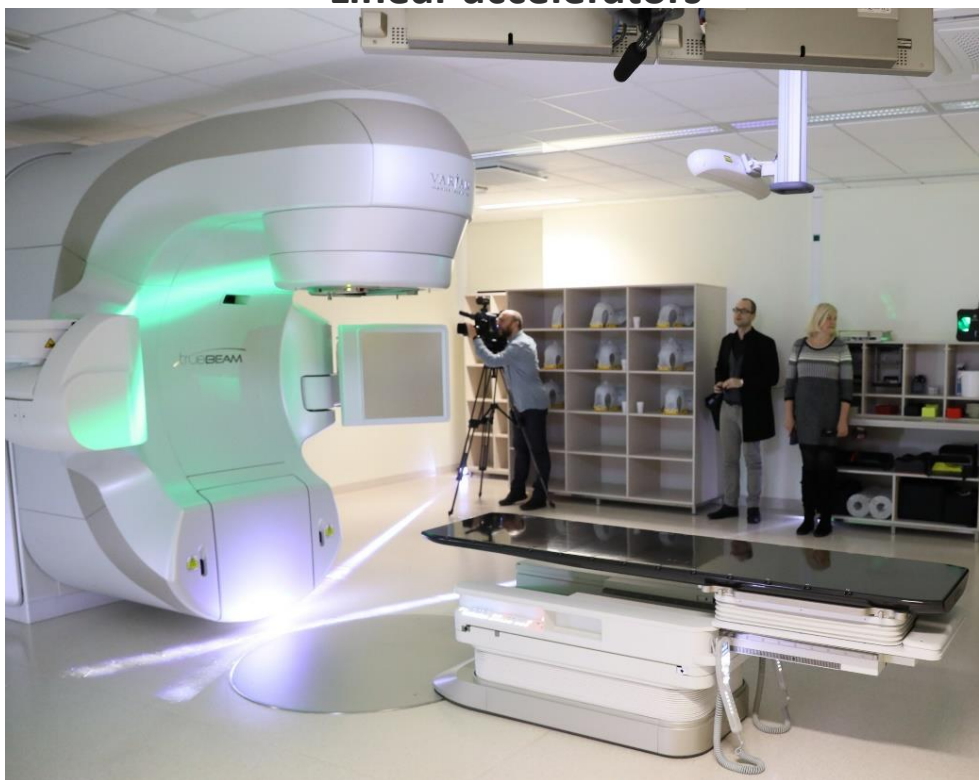
# MP in Radiotherapy team

- Radiation oncologist
- Other doctors (consultants)
- Nurses
- Radiotherapy technicians
- MP-s and dosimetrist
- Engineers
- Secretarys

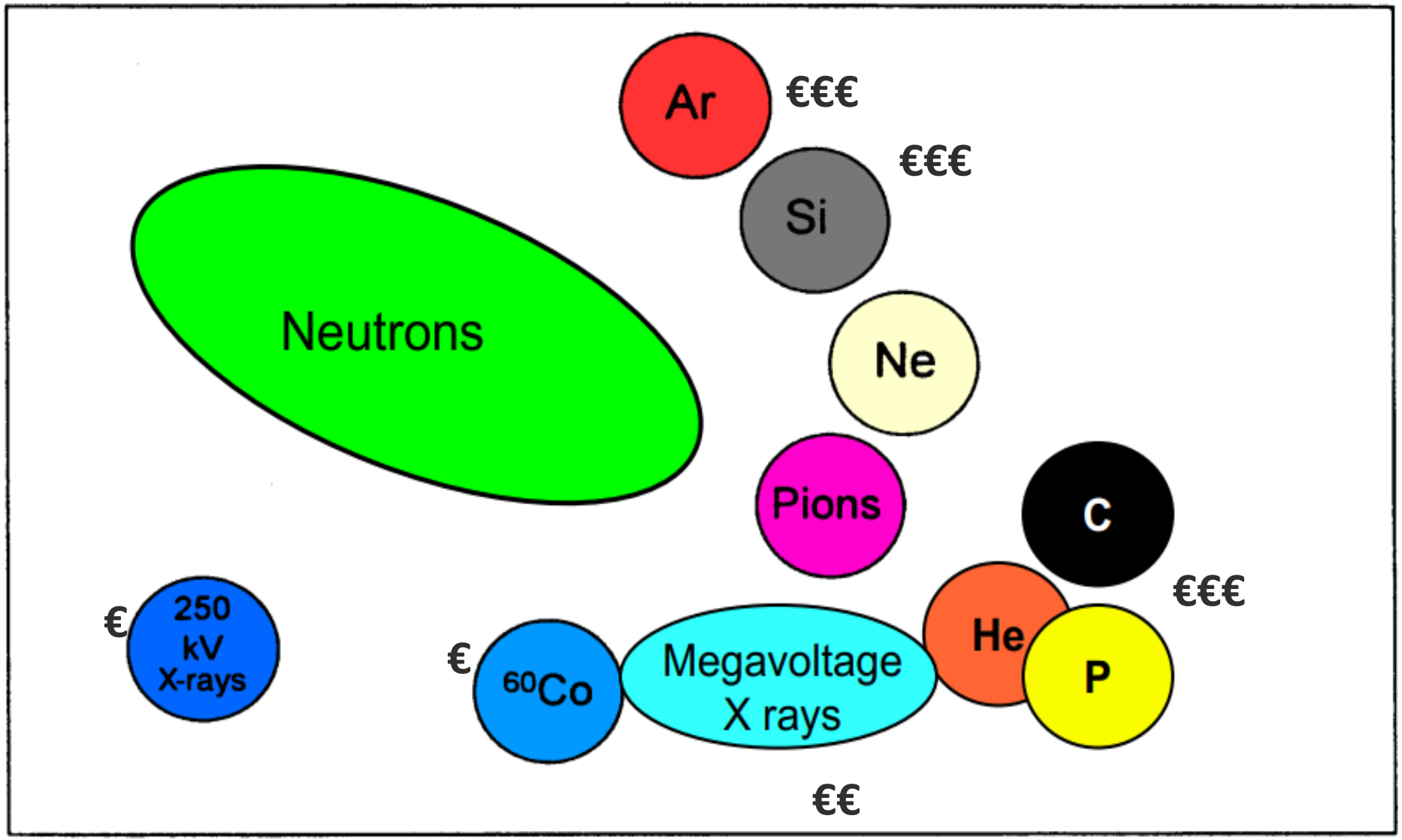
# Modern radiotherapy

- Aim maximum tumor control & minimal side effects
- High doses (30-150 Gy) used to kill cancer cells
- External beam radiotherapy (EBRT) – radiation is directed to patient from outer source, nowadays mainly electrical sources (linacs), used to be Co-60 sources
- Stereotactic radiosurgery (SRT, ablative radiation doses)
- Brachytherapy with radioactive sources
  - HDR (*high dose rate*) – source is used on multiple patients
  - LDR (*low dose rate*) – sources will be permanent in human body
- Medical imaging – computed tomography (CT); magnetic resonance imaging (MRI); positron emission tomography (PET) to see the tumor and normal tissue around it

**Linear accelerators**



# Particles in radiotherapy



# NEMC radiotherapy department

- Ca 1900 external beam cases treated annually; 120-170 fractions per day
- 300 HDR brachytherapy procedures annually
- 76 beds for outpatients – 30 level II (chemoradiation, located in premises), 46 level III (nursing department, located 15 min away)

- CT and MRI (only) based planning (both located in radiotherapy department, GE, Spectronic)
- 4 linear accelerators (2 x Varian Clinac, 2 x Varian Truebeam with SRT capability, 1 with SGRT capability), 1 HDR Unit (Elekta Flexitron) **– 2 oldest are being renewed 2024-2025**
- 2-3 new rooms/bunkers in planning

- Many different planning systems and IT and AI solutions

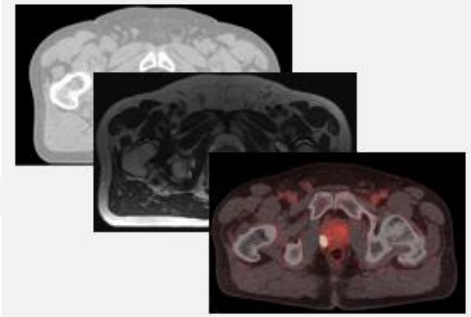

Video: Kiiritusravi on Vimeo
korrus

Konsiilium, raviotsus

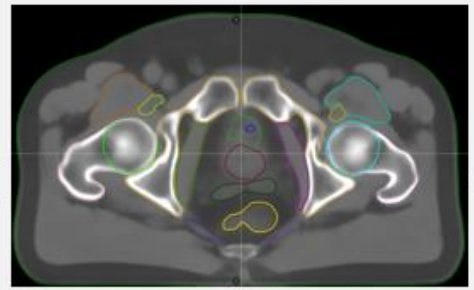
Suhtlus patsiendiga

Kiiritusravi planeerimise KT

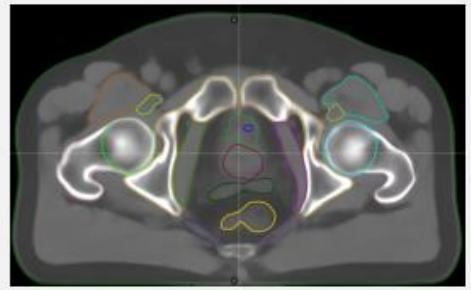
Lisakuvamine PET-KT / MRT



Kujutiste registreerimine



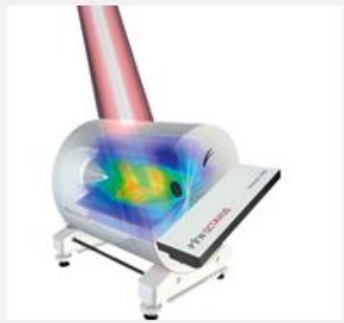
(Auto)kontureerimine



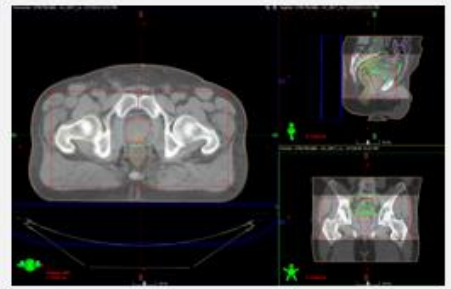
Sihtmaht, preskriptsioon

*Peer review*

Doosi planeerimine



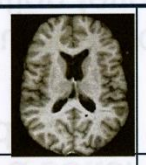
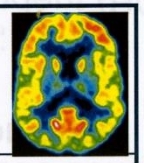
Raviplaani kinnitamine ja QC

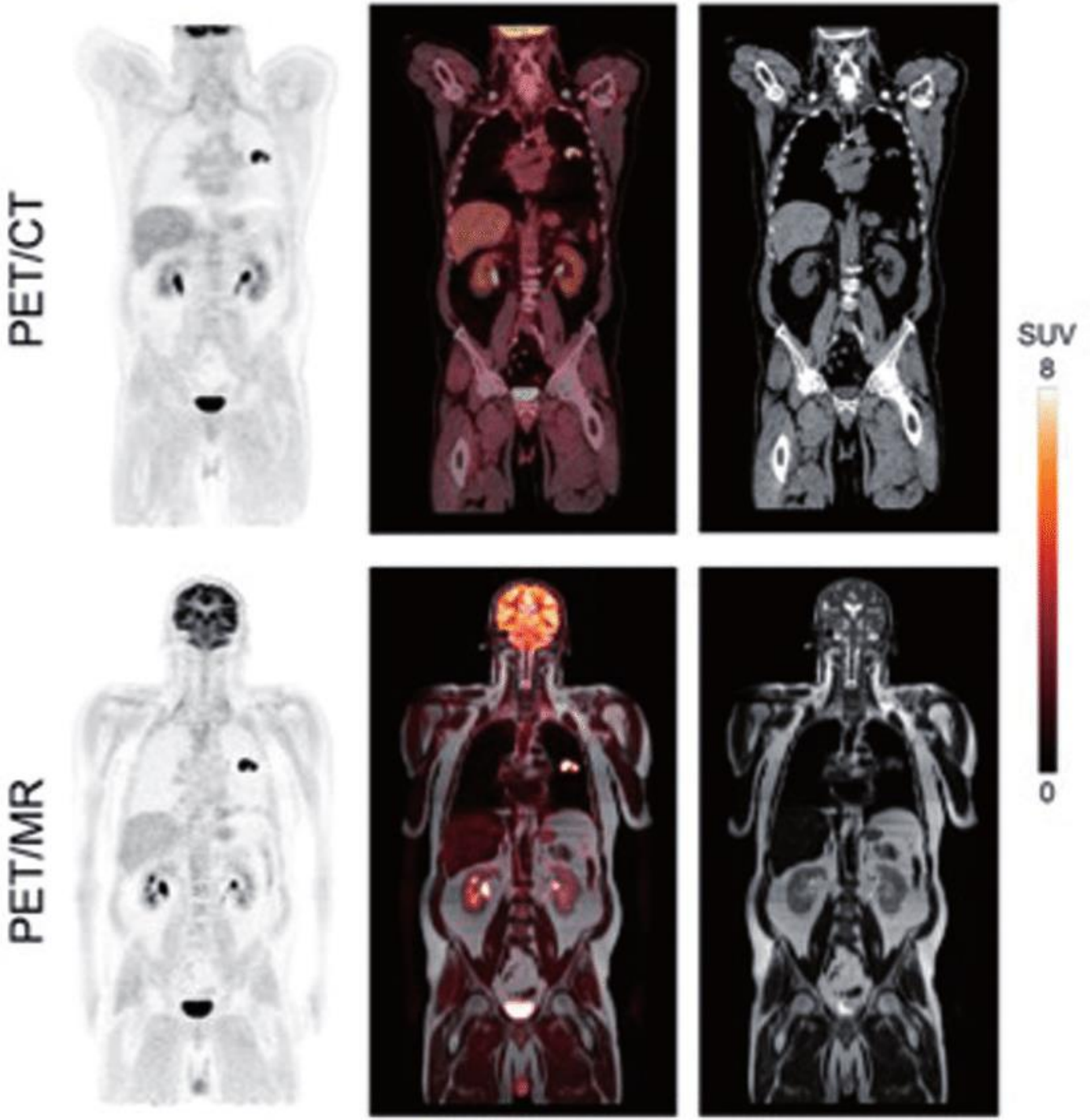


Patsiendi ettevalmistus ja kontroll kiirendil (IGRT)

Ravi kiirendil

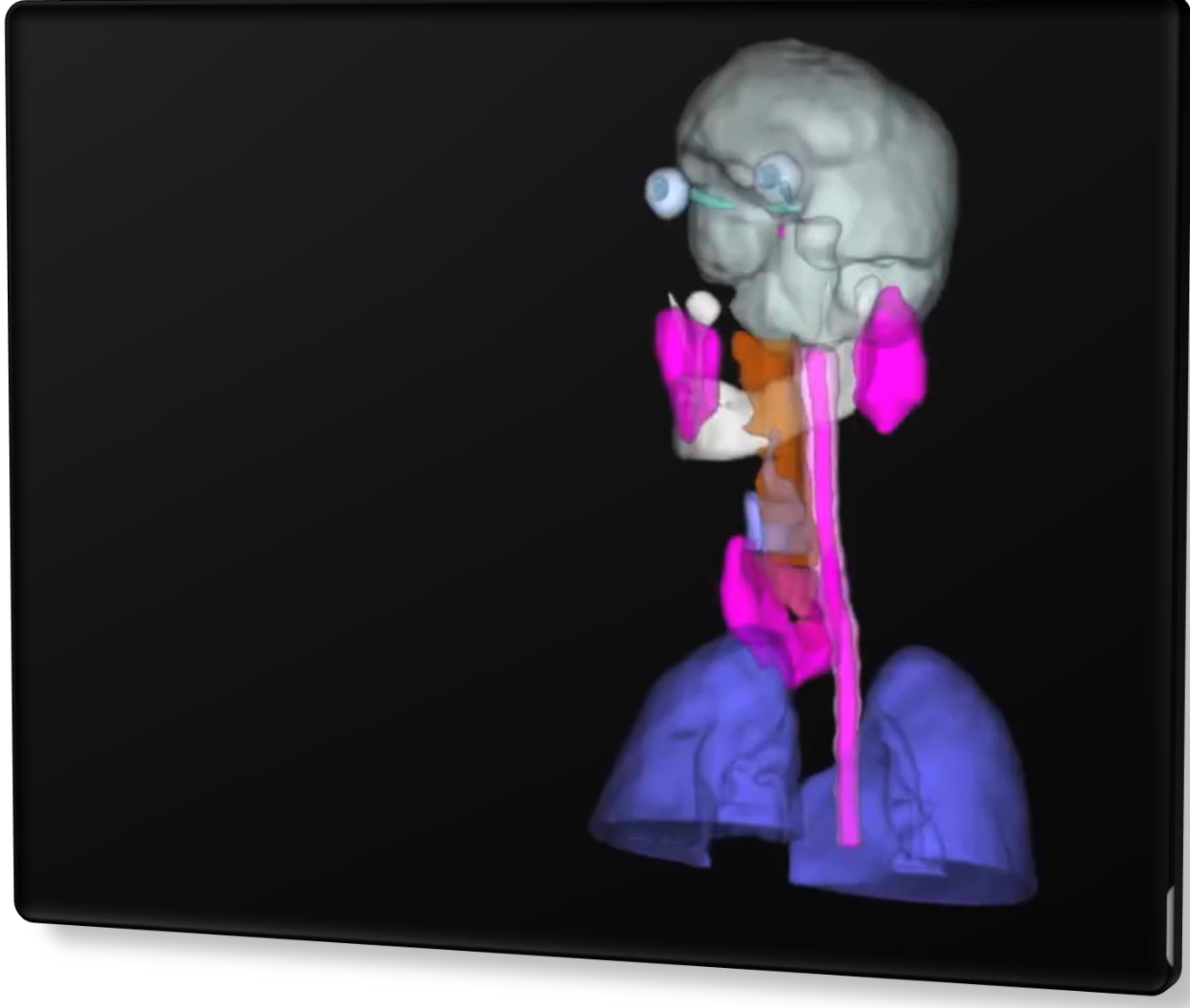
# Medical imaging

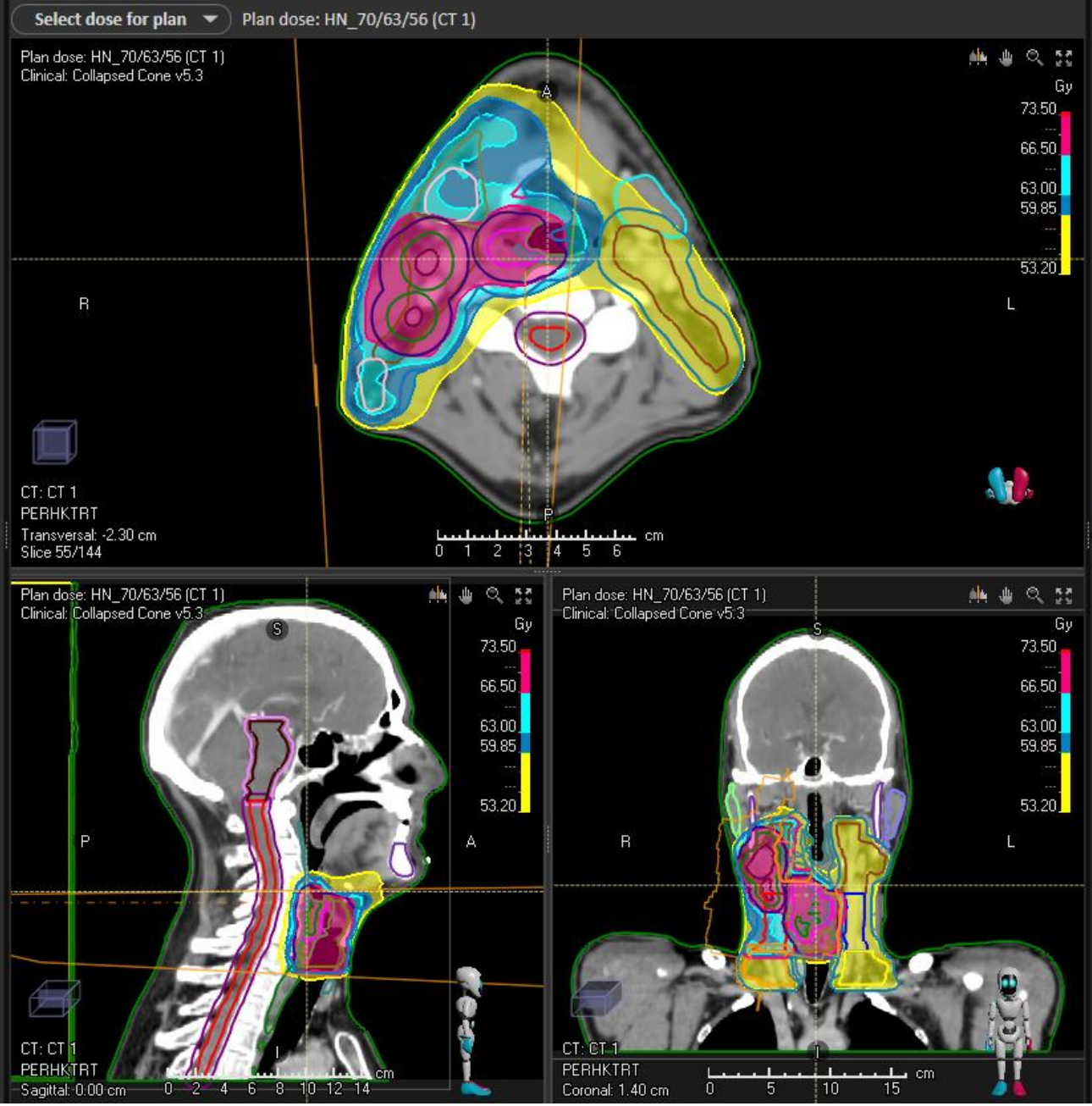

| Parameter | MRI  | PET  |
|---|---|---|
| Anatomical Detail | Excellent | Poor |
| Spatial Resolution | Excellent | Compromised |
| Clinical Penetration | Excellent | Limited |
| Sensitivity | Poor | Excellent |

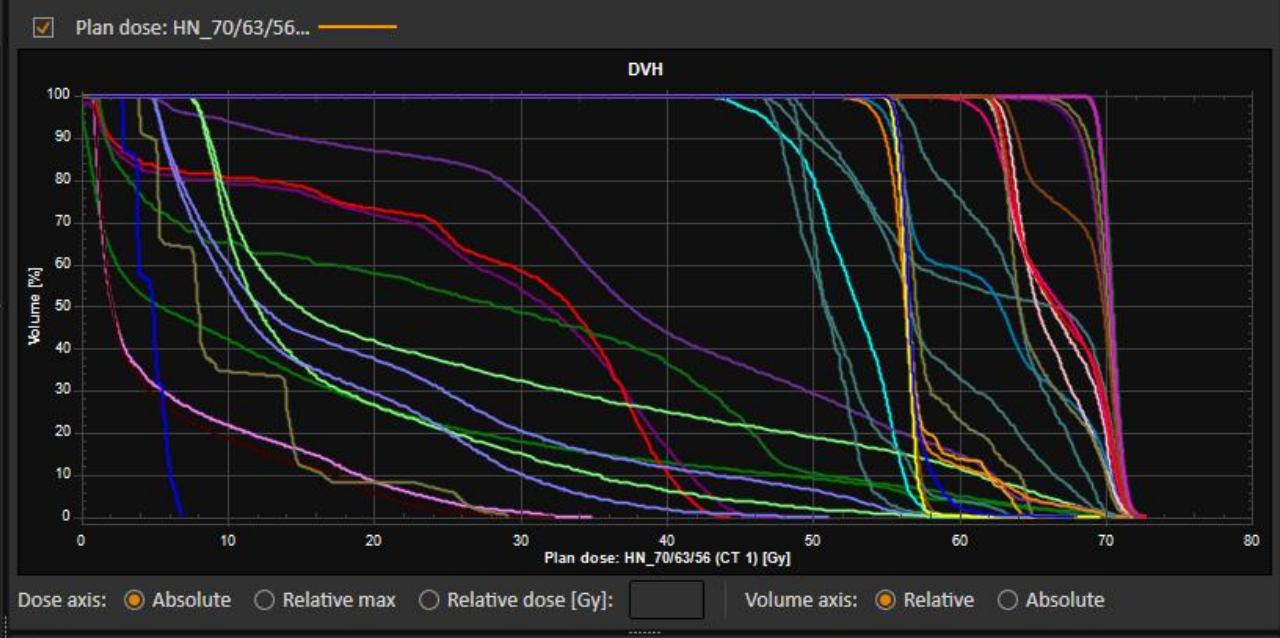


# Artificial intelligence in RT

- Assist humans and speed up the process
- Models developed by tech companies and MP-s together
- Autosegmentation
- Autoplanning
- Automated QA
- Automation of repetative tasks
- Currently research collaboration contracts with GE, Raysearch





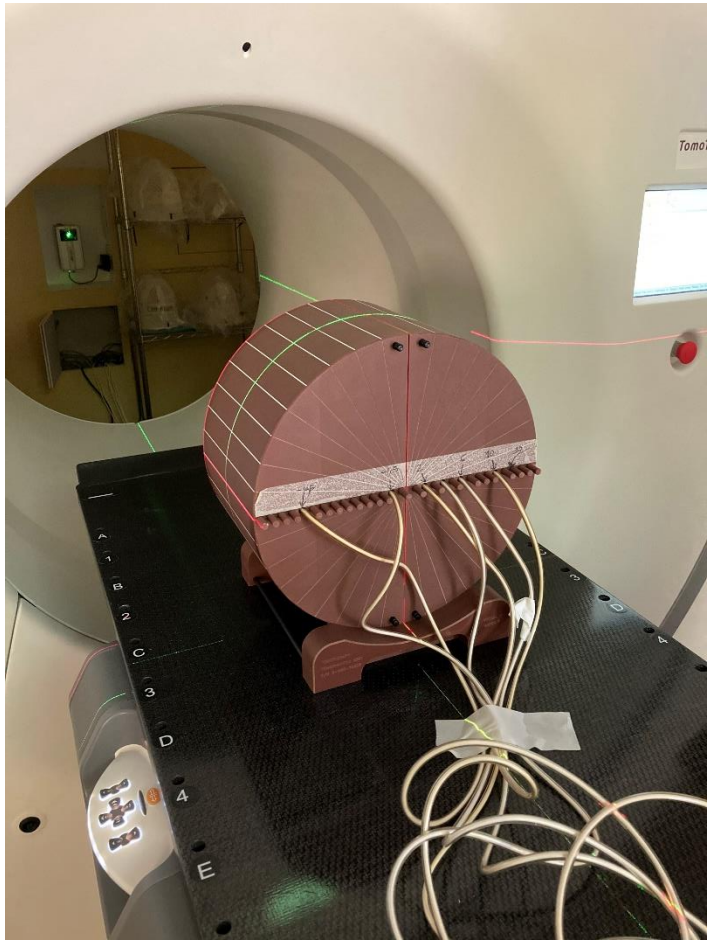

Dose axis: Absolute | Relative max | Relative dose [Gy]: | Volume axis: Relative | Absolute

Beams (Current) | Control points (Current) | BEV (Current)

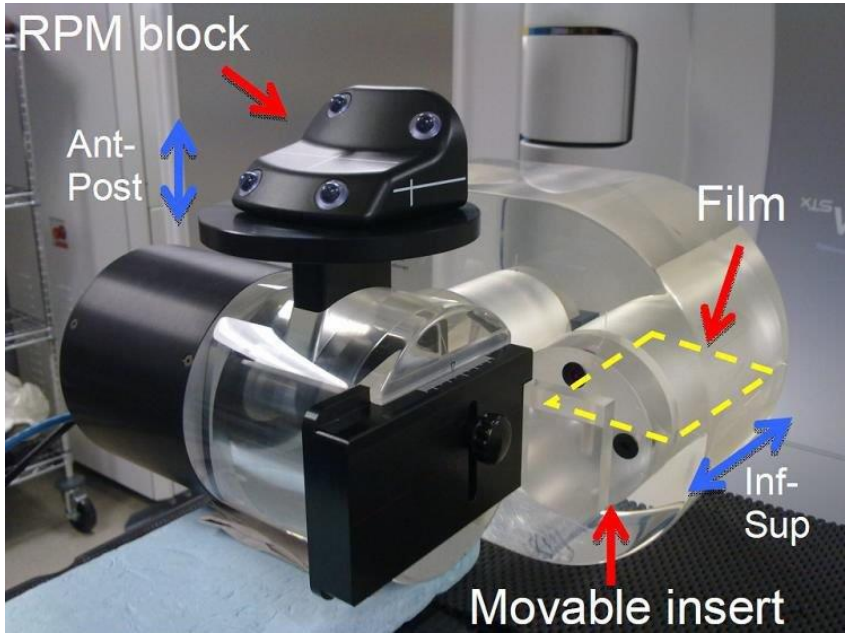
Dose statistics | Clinical goals | Biological response | Plan fraction schedule

ROI statistics | POI statistics

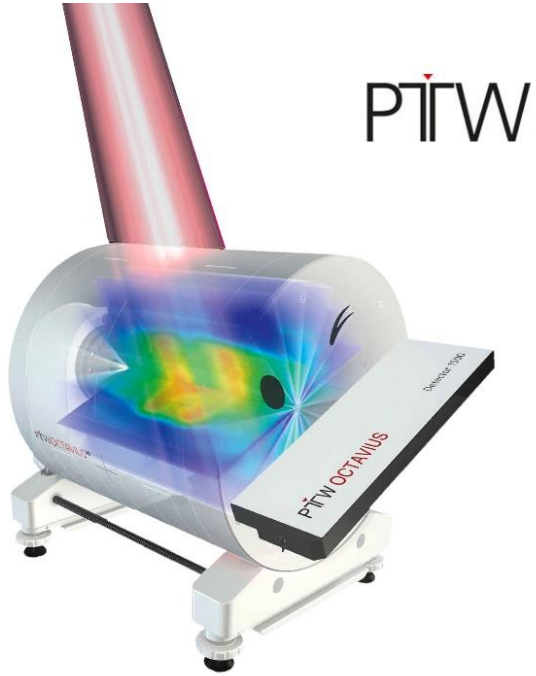
| Dose | ROI | ROI vol. [cm³] | Dose [Gy] D99 | D98 | D95 | Average | D50 | D2 | D1 | % ou |
|---|---|---|---|---|---|---|---|---|---|---|
| Plan dose: HN_70/63/... | 1b dex | 26.48 | 62.12 | 62.33 | 62.60 | 65.43 | 64.10 | 70.81 | 71.10 | 0 % |
| Plan dose: HN_70/63/... | Brainstem | 23.92 | 0.94 | 0.96 | 1.01 | 5.39 | 2.13 | 23.80 | 26.20 | 0 % |
| Plan dose: HN_70/63/... | Brainstem_PRV | 42.92 | 0.87 | 0.90 | 0.94 | 6.09 | 2.15 | 27.74 | 30.60 | 0 % |
| Plan dose: HN_70/63/... | Cochlea_L | 0.15 | 2.82 | 2.83 | 2.84 | 4.69 | 4.90 | 6.72 | 6.83 | 0 % |
| Plan dose: HN_70/63/... | Cochlea_R | 0.15 | 3.96 | 3.97 | 4.03 | 10.12 | 7.99 | 26.92 | 28.21 | 0 % |
| Plan dose: HN_70/63/... | CTV kõri | 29.57 | 68.89 | 69.06 | 69.35 | 70.39 | 70.40 | 71.70 | 71.86 | 0 % |
| Plan dose: HN_70/63/... | CTV1_ alaneel | 15.98 | 69.03 | 69.14 | 69.36 | 70.41 | 70.39 | 71.82 | 72.01 | 0 % |
| Plan dose: HN_70/63/... | CTV1_n | 38.09 | 68.98 | 69.15 | 69.36 | 70.48 | 70.50 | 71.78 | 71.96 | 0 % |
| Plan dose: HN_70/63/... | CTV2_alaneel | 34.91 | 66.73 | 67.33 | 68.10 | 70.03 | 70.17 | 71.65 | 71.87 | 0 % |
| Plan dose: HN_70/63/... | CTV2_n | 83.65 | 65.88 | 66.66 | 67.57 | 69.80 | 70.01 | 71.56 | 71.77 | 0 % |
| Plan dose: HN_70/63/... | *CTVn1* | | | | | | | | | |
| Plan dose: HN_70/63/... | *CTVn2* | | | | | | | | | |



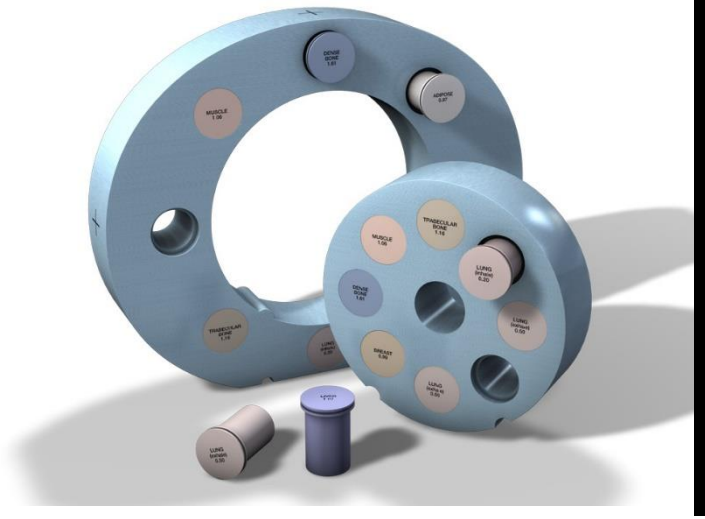
Treatment plan check in tomotherapy

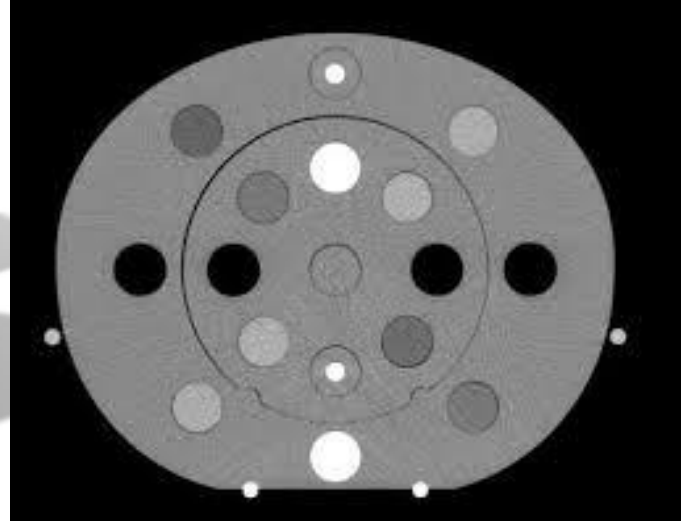



Treatment plan check for moving tumors (breast, lung, liver, pancreas etc)

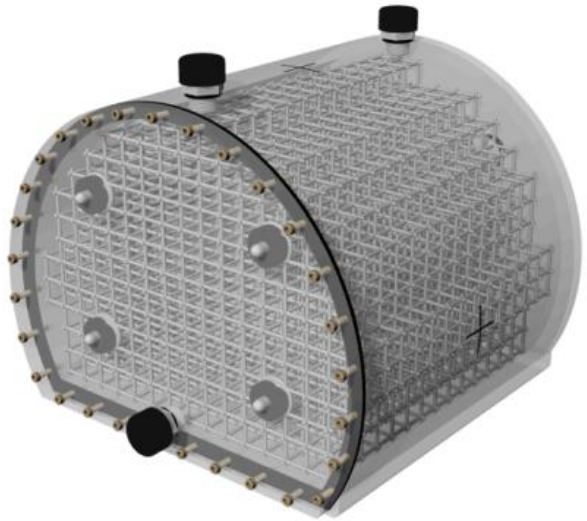


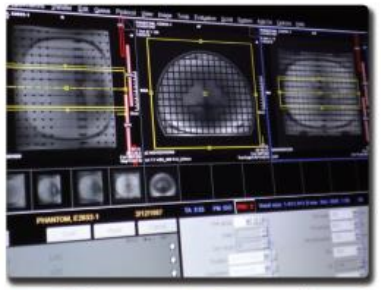

Treatment plan check with plate detector (>1000 mini ion chambers) under linac





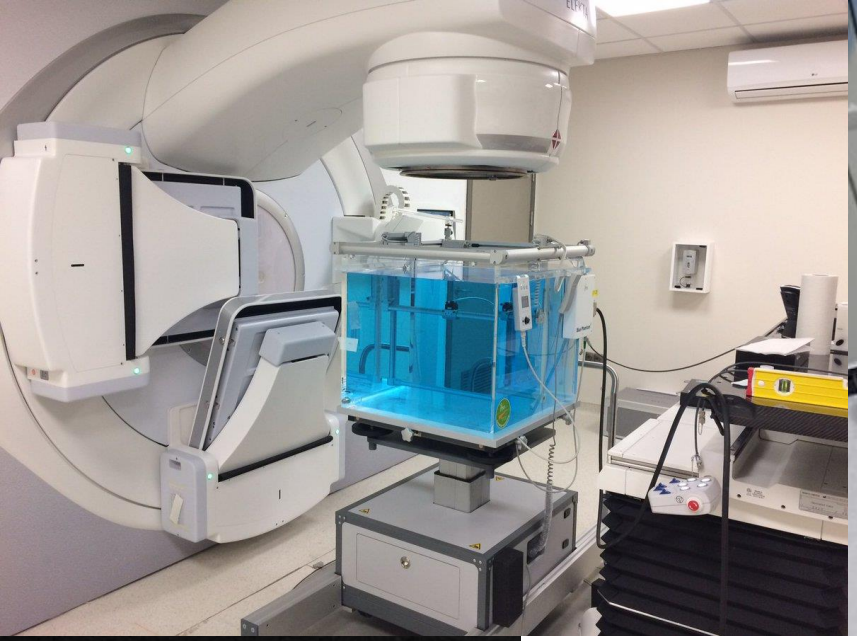
Electron density check – crucial test in dose planning (CT testing)



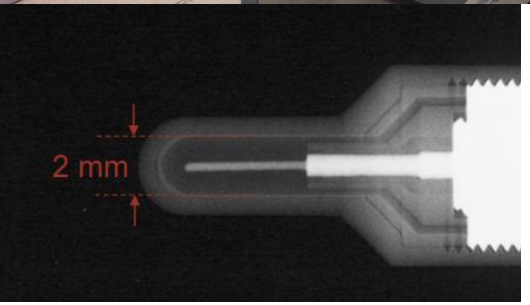


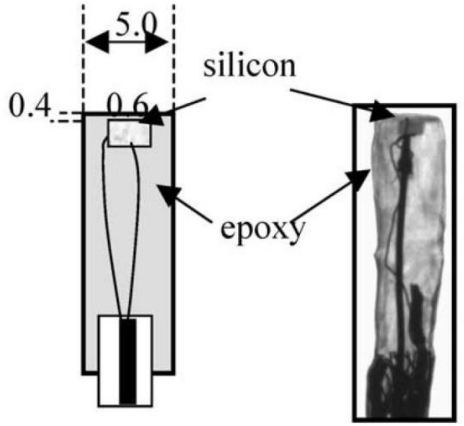
MRI testing – main aspect –geometric distrortion

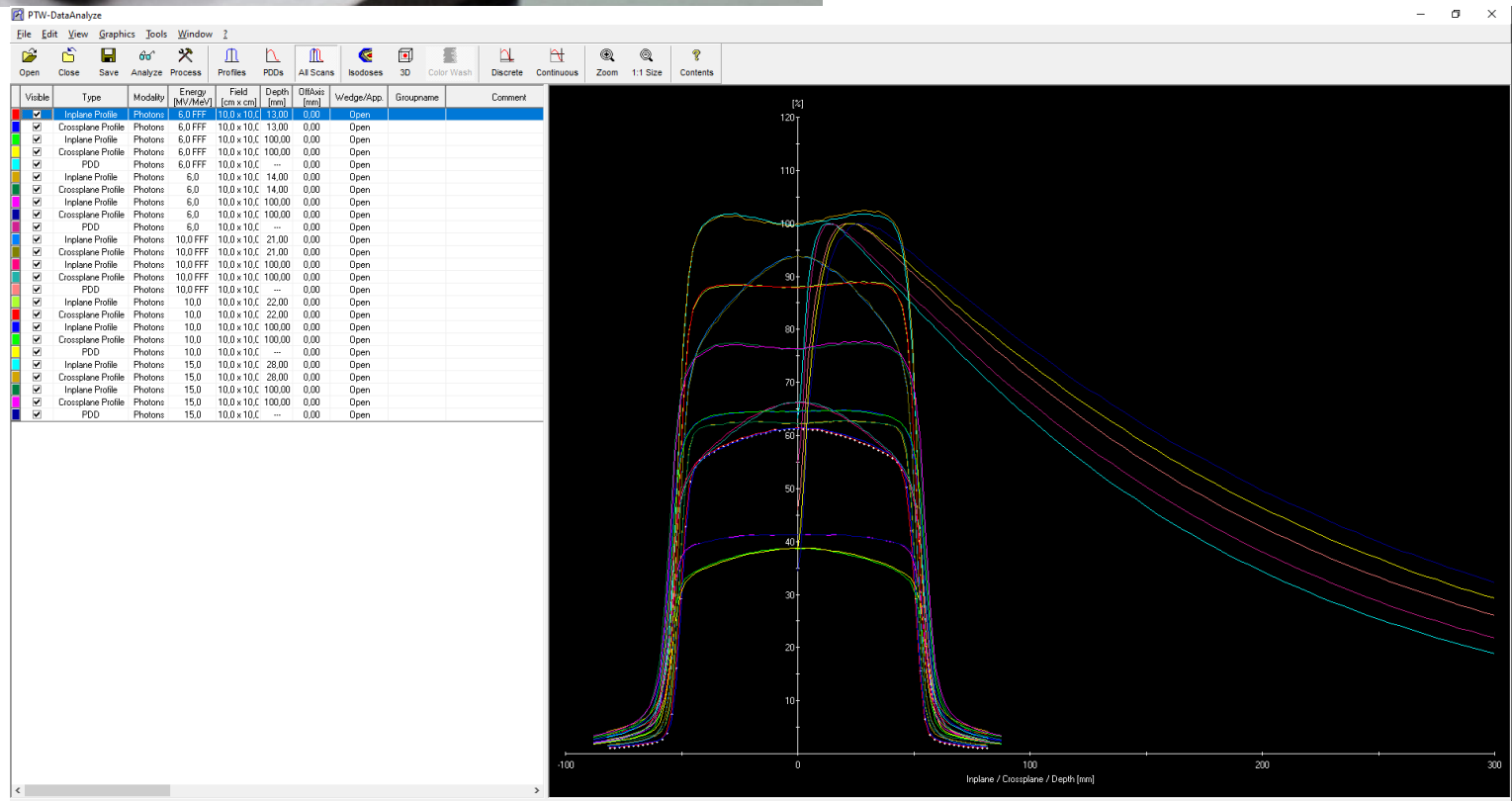
Tests on linac to ensure 1 mm accuracy




Linac dosimetry – measure, calibrate and model ionizing radiation. Data will be used in treatment planning and conducting treatments.



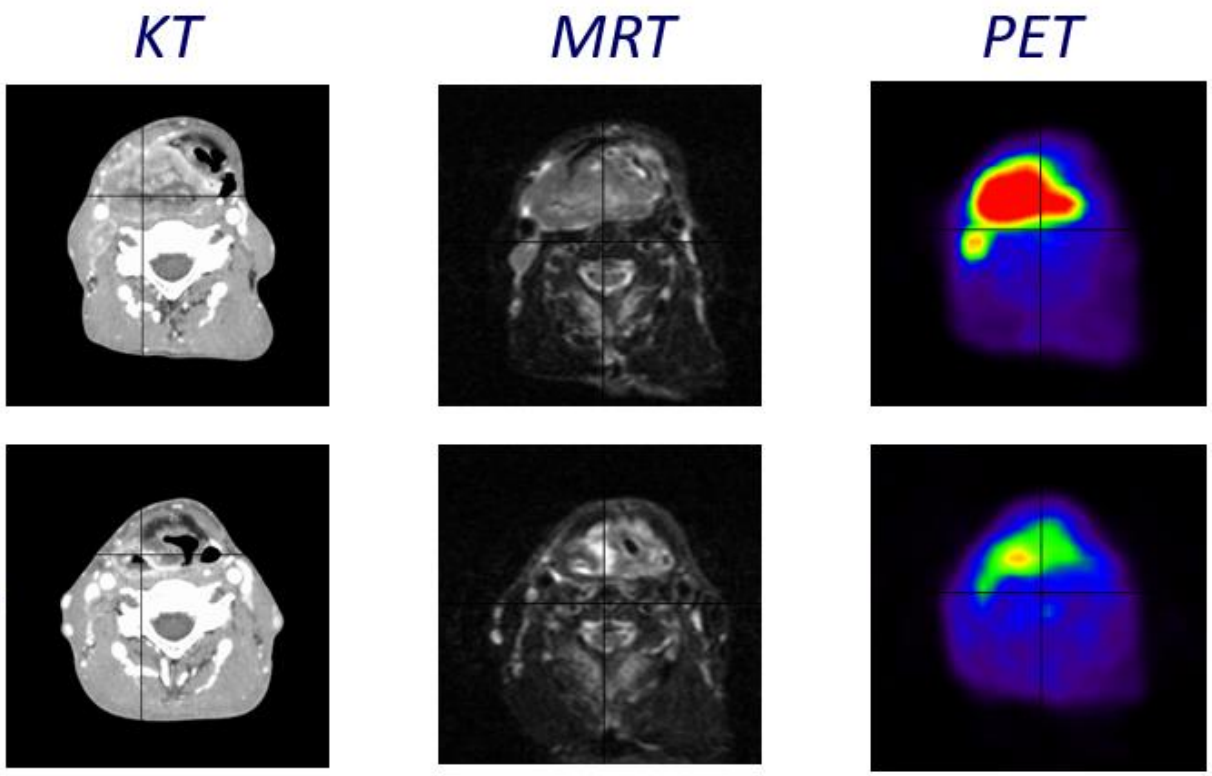




Many different detectors and ionization chambers to use – choice of physicist. Wrong detector = wrong dose measurements

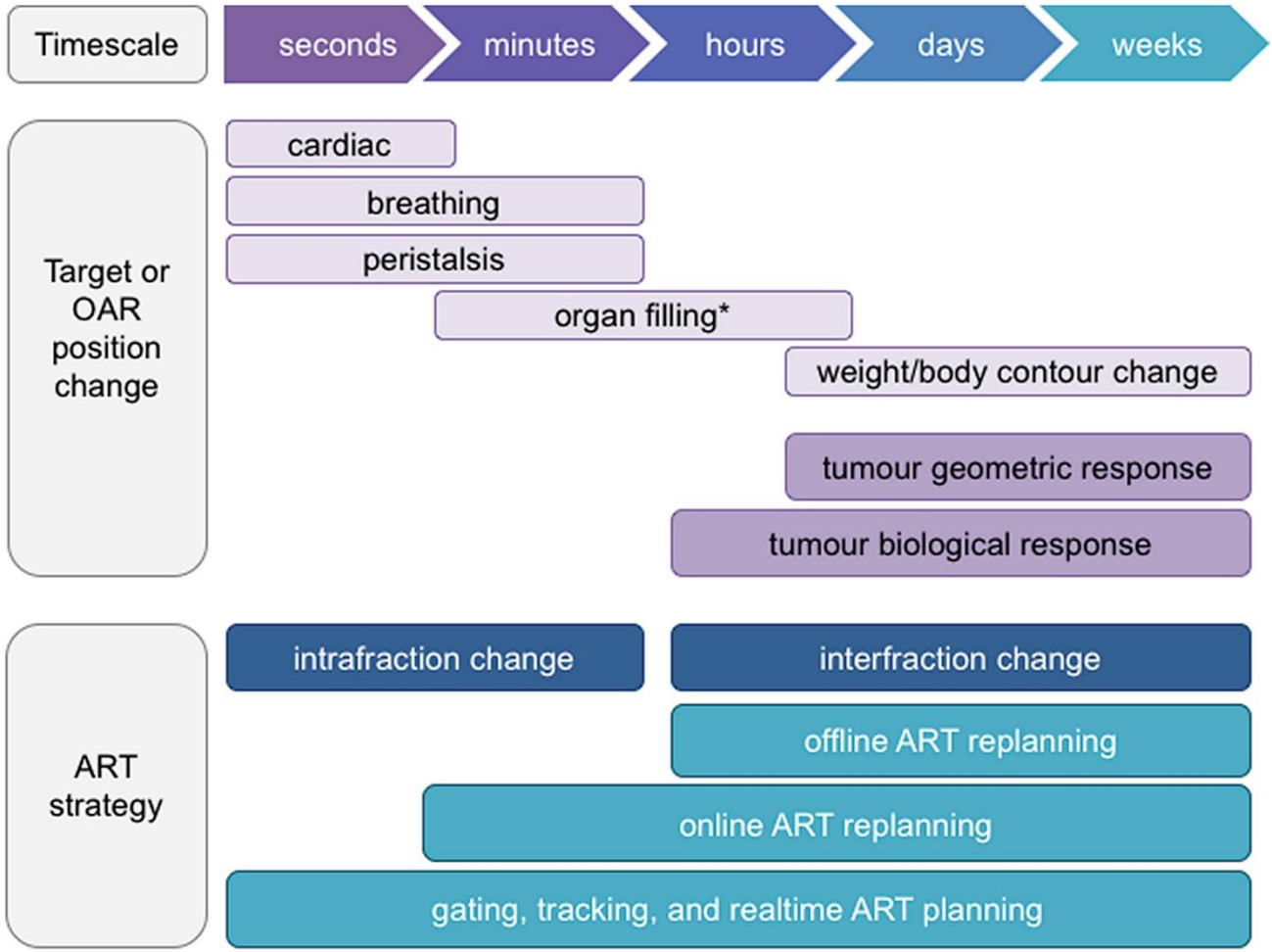
# Future goals - adaptive radiotherapy

- Tumour, lymph nodes, organ at risk (OAR) will change in time (seconds, hours, days, weeks etc) – we need to adapt to reach better outcomes (better tumor control & less side effects)

*Planning vs treatment week 5*




*Pic E. Gerškevitš*




* Organs subject to filling and deformation including bladder, rectum, cervix, and stomach etc


Target Out 0.5 %
Target In
R
Image 20
Position -0.49 cm
W 528
L 268


R

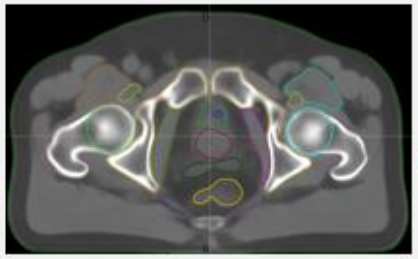
# We are moving towards adaptive, personalized RT – a lot of work to do and a lot of educated people needed

Adaptive personalized radiotherapy – new treatment plan every day

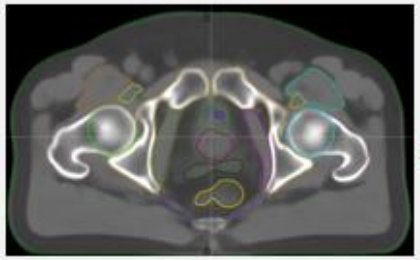
Konsiilium, raviotsus

Suhtlus patsiendiga

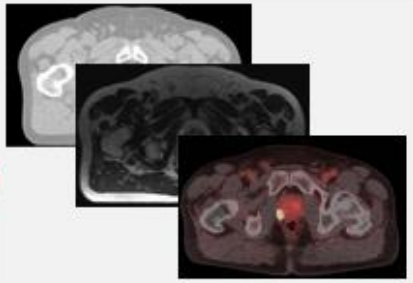
*Peer review*



Sihtmaht, preskriptsioon

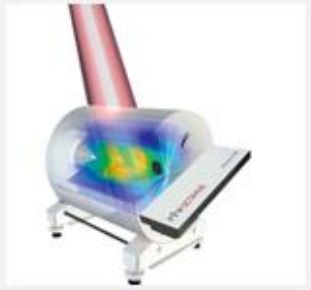


(Auto)kontureerimine

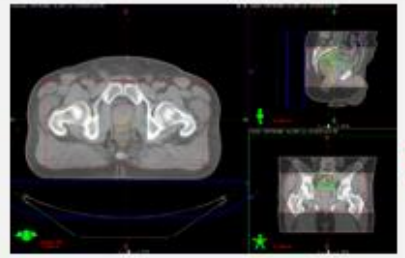


Kujutiste registreerimine

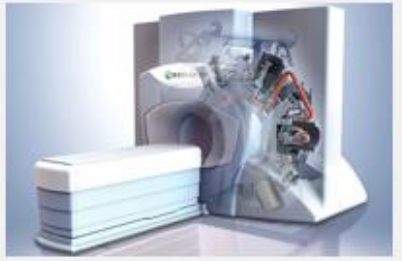
Doosi planeerimine



Raviplaani kinnitamine ja QC



Patsiendi ettevalmistus ja kontroll kiirendil (IGRT)



Ravi kiirendil

# Thank you!

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