IMRT a iné konformálne techniky v praxy

NOÚ, Oddelenie radiačnej onkológie
Marek Paluga
Pavol Bíreš

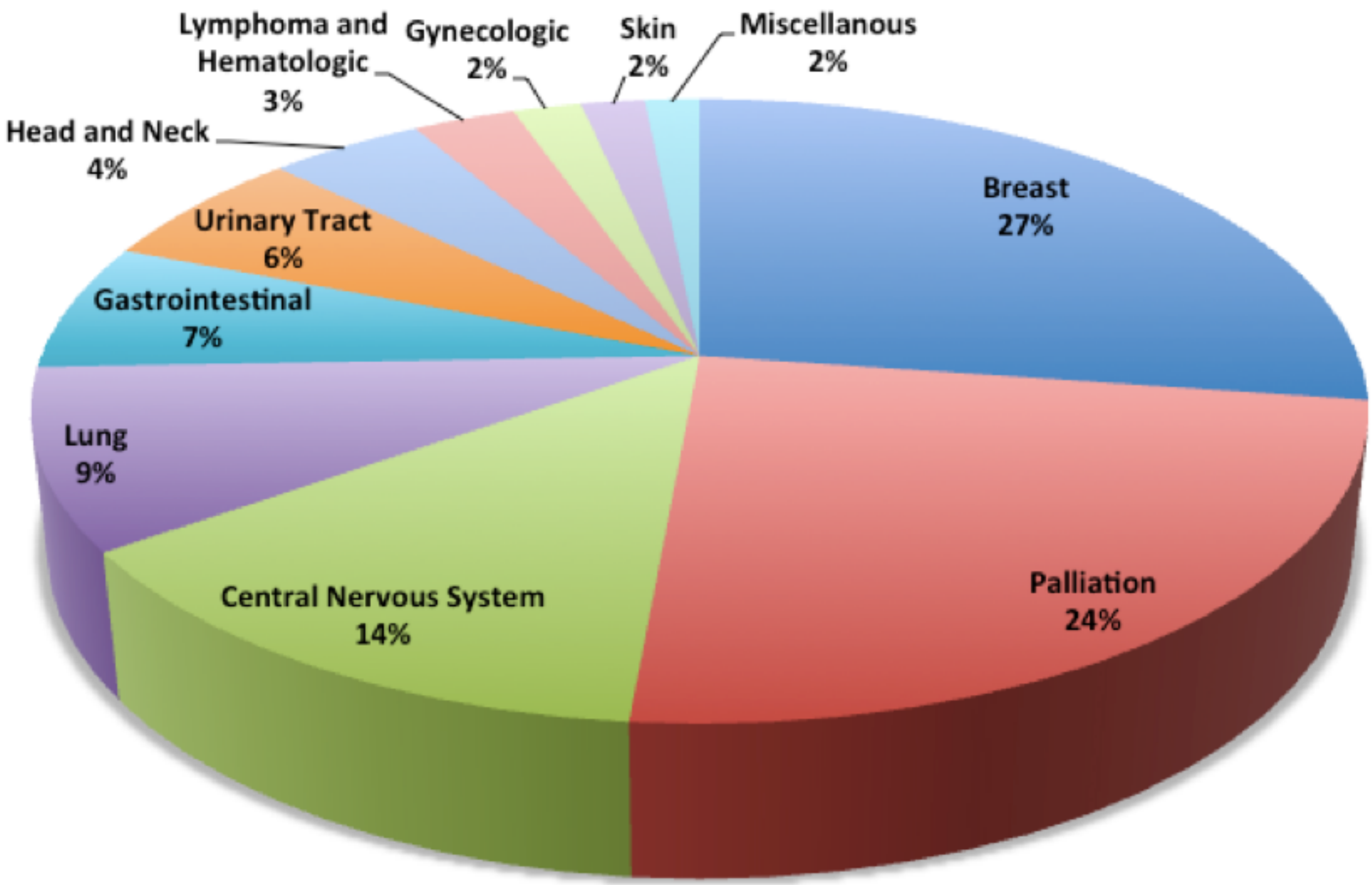
Belgium : country of surrealism

UZ Brussel

Universitair
Ziekenhuis
Brussel

Vrije
Universiteit
Brussel

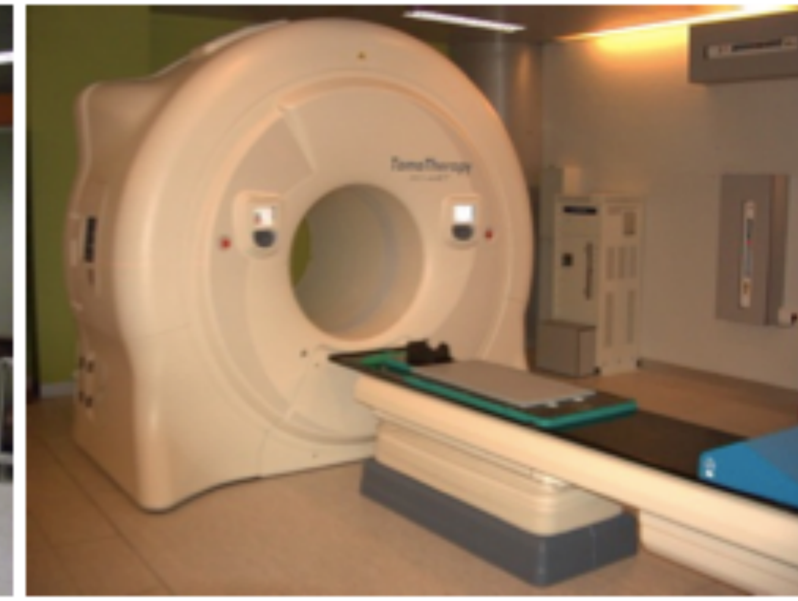
1600 patients/year



exkurzia

- Tomoterapia: absolútna dozimetria
- Tomoterapia: QA plánu autentického pacienta
- VERO real time tumor tracking
- plánovanie, plánovacie systémy, plánovací priestor

Jette (Brussels)



- 12 Radiation oncologists (3 in training)
- 7 physicists/2 dosimetrists
- 5 engineers for linac maintenance
- 25 nurses/therapists
- 1 logistics

Multi-vendor environment

- 2 Elekta
- 1 Varian
- 2 tomotherapy
- 1 Mitsubishi/brainlab
- Brainscan/iPlan/Xio/Monaco/Tomo/*Eclipse/Raysearch*
- Vero RV/Aria/Mosaiq
- SN/IBA/PTW/Ashland
- MIM

Lektori

- **Frank Lohr** (lekár) University of Heidelberg, Mannheim, Germany
- **Matthias Söhn** (fyzik) University Hospital Grosshadern LMU Munich, Germany
- **Marco Schwarz** (fyzik) Centro di Protonterapia Trento, Italy
- **Koen Tournel** (fyzik) Radiotherapy department UZ Brussel, Belgium
- **Andrea Riccardo Filippi** (lekár) Department for Oncology University of Torino, Italy
- **Giovanna Gagliardi** (fyzička) Dept. Medical Physics Karolinska University Hospital, Stockholm, Sweden

Frank Lohr

- IMRT pohľad lekára
- IGRT pre IMRT
- Prsník
- Hlava a krk
- Prostata

Drivers of IMRT

Thing's weren't perfect prior to IMRT

Need to avoid Toxicity

Conveniece / Economical Factors / Simplification of established paradigms

Evolution of Technology / IGRT / Online Adaptation

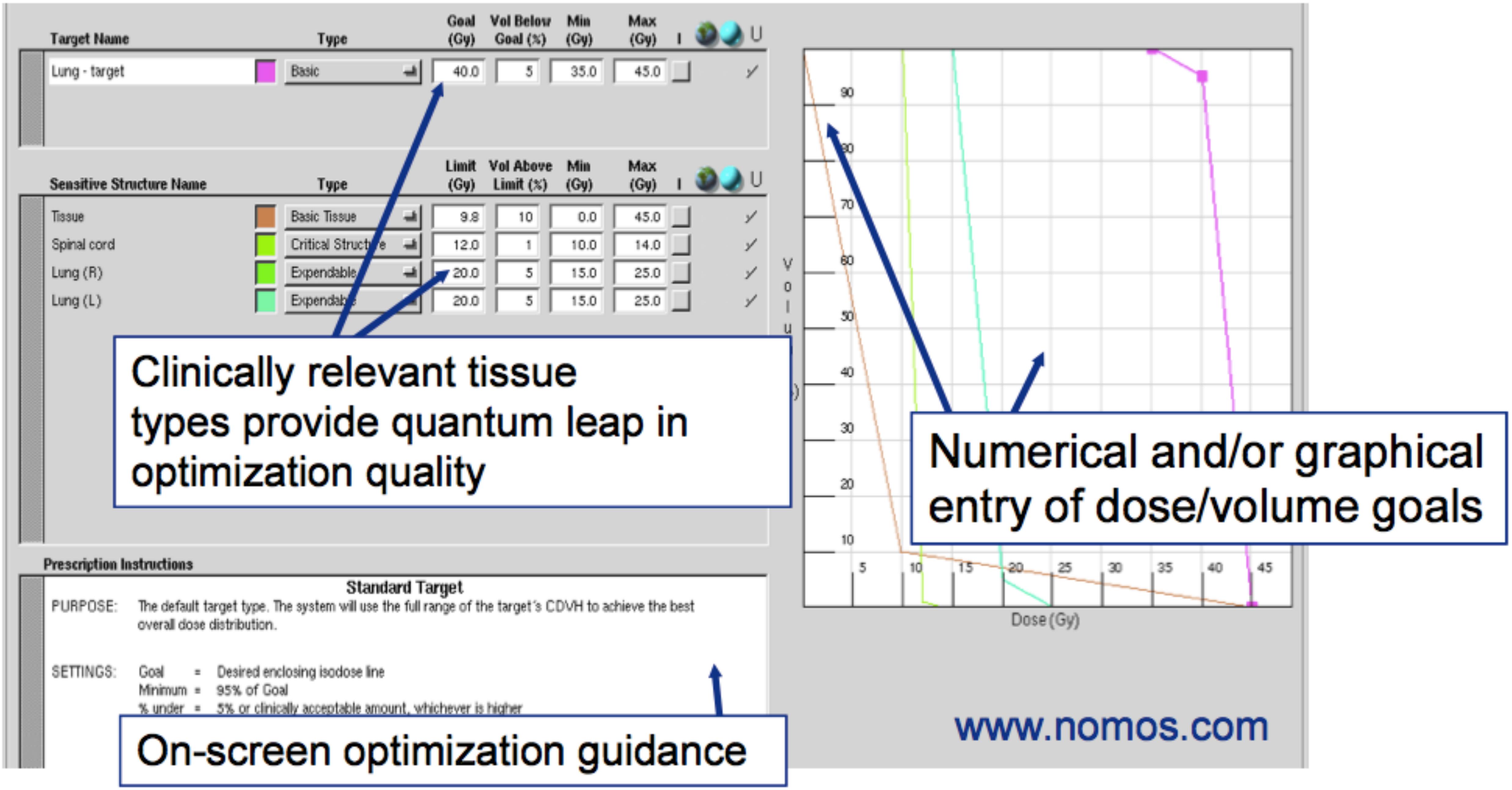
Chronification of Disease/Oligometastases

Expanding Indications for SBRT (e.g. Prostate with the need for dose shaping)

Potentially a new Paradigm in Combination with Immunotherapy

Prescription

The Key to Inverse Planning is a prescription tool that easily and efficiently captures the physician's most critical clinical judgements



Most important indications and treatment philosophy

1. **Head and Neck Cancer**

   CNS

   Paranasal Sinus Tumors / Integrated Boost
   (Better Tumor coverage and shortening of overall treatment time)

   NPC and other ENT Tumors
   (Parotid sparing when possible, better tumor coverage for NPC)

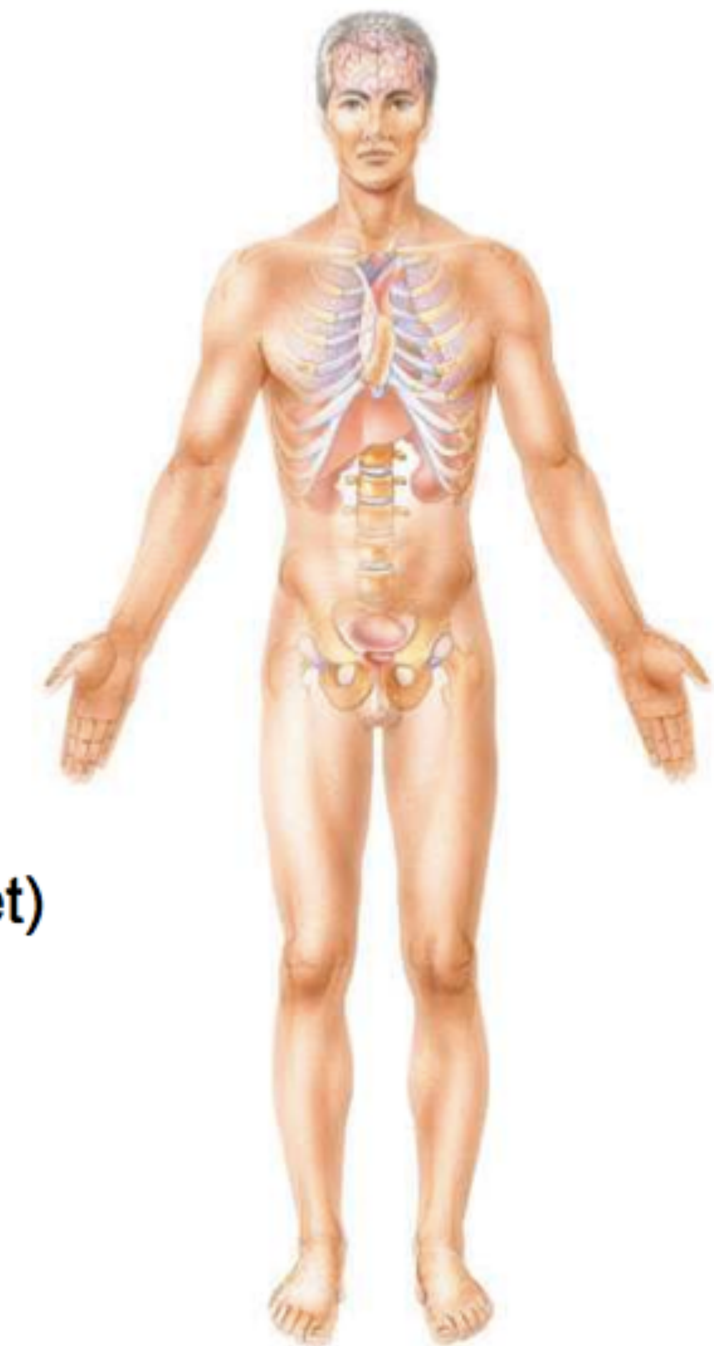
2. **Prostate / Integrated boost**
   (Potentially hypofractionation)

3. **Gastric cancer**
   (Better kidney sparing while treating the whole of the target)

4. **Breast Cancer**

5. **Lung Cancer**

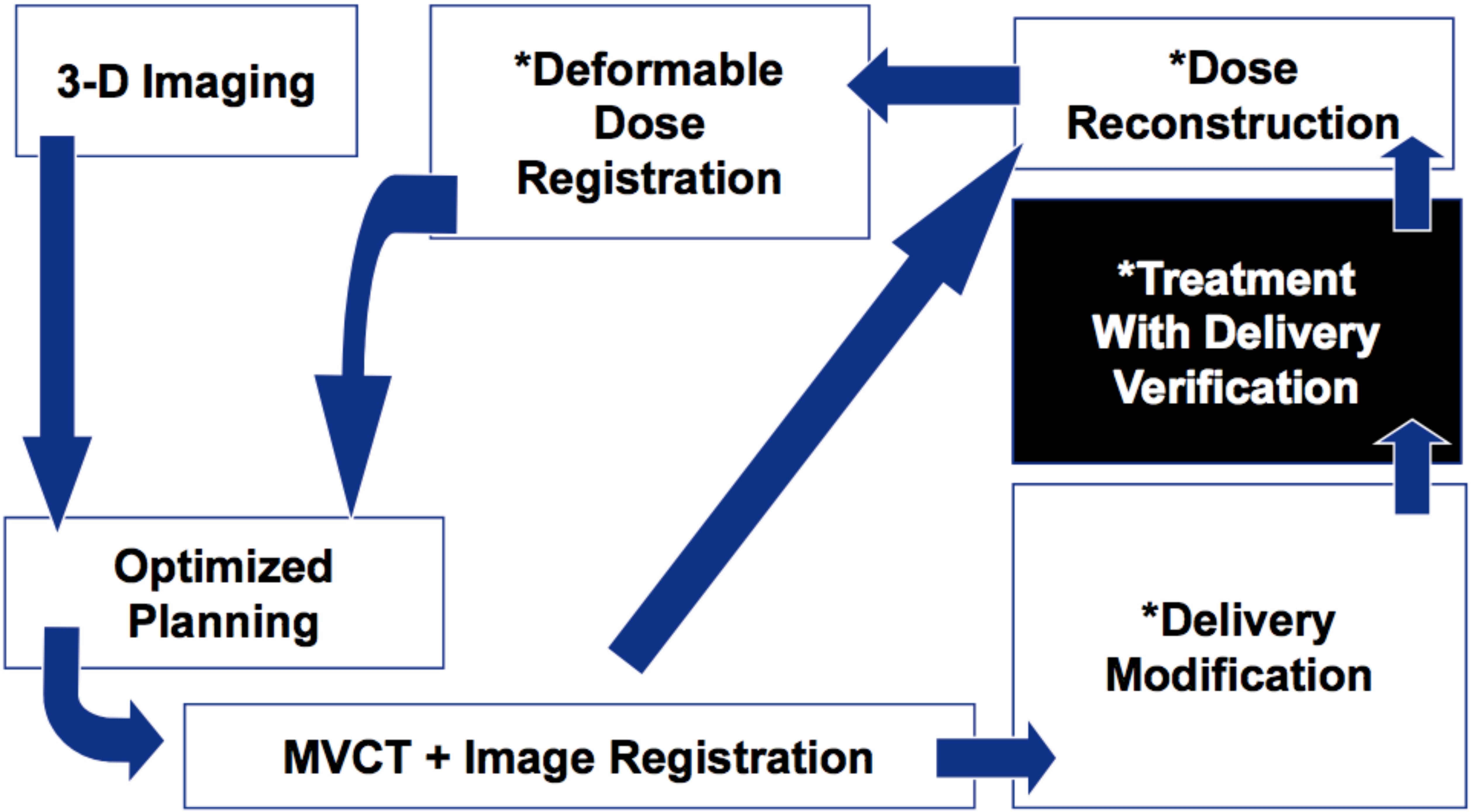
6. **Metastases**



Adaptive Radiotherapy

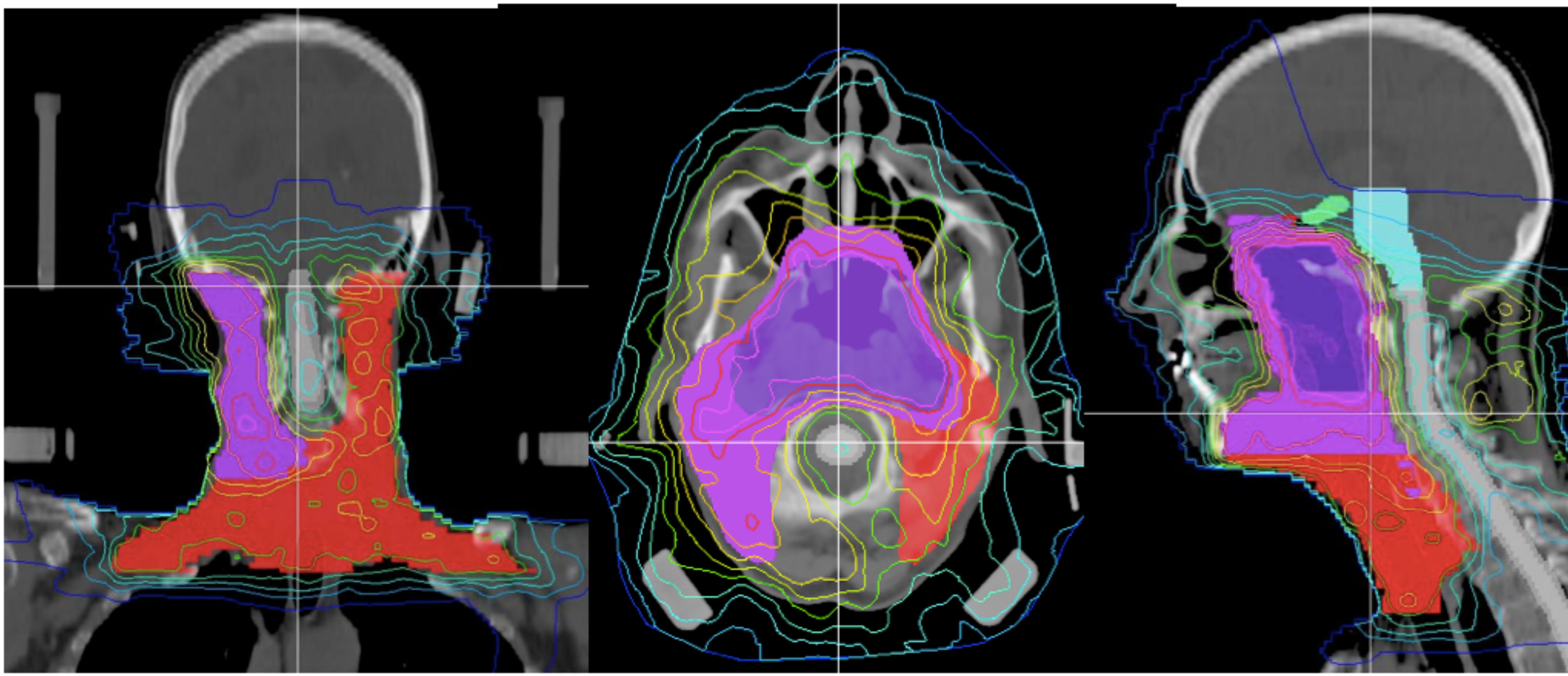
www.tomotherapy.com

This is where we want to go



(*These concepts are work in progress – product not available for sale.)

Nasopharynx
Integrated Boost



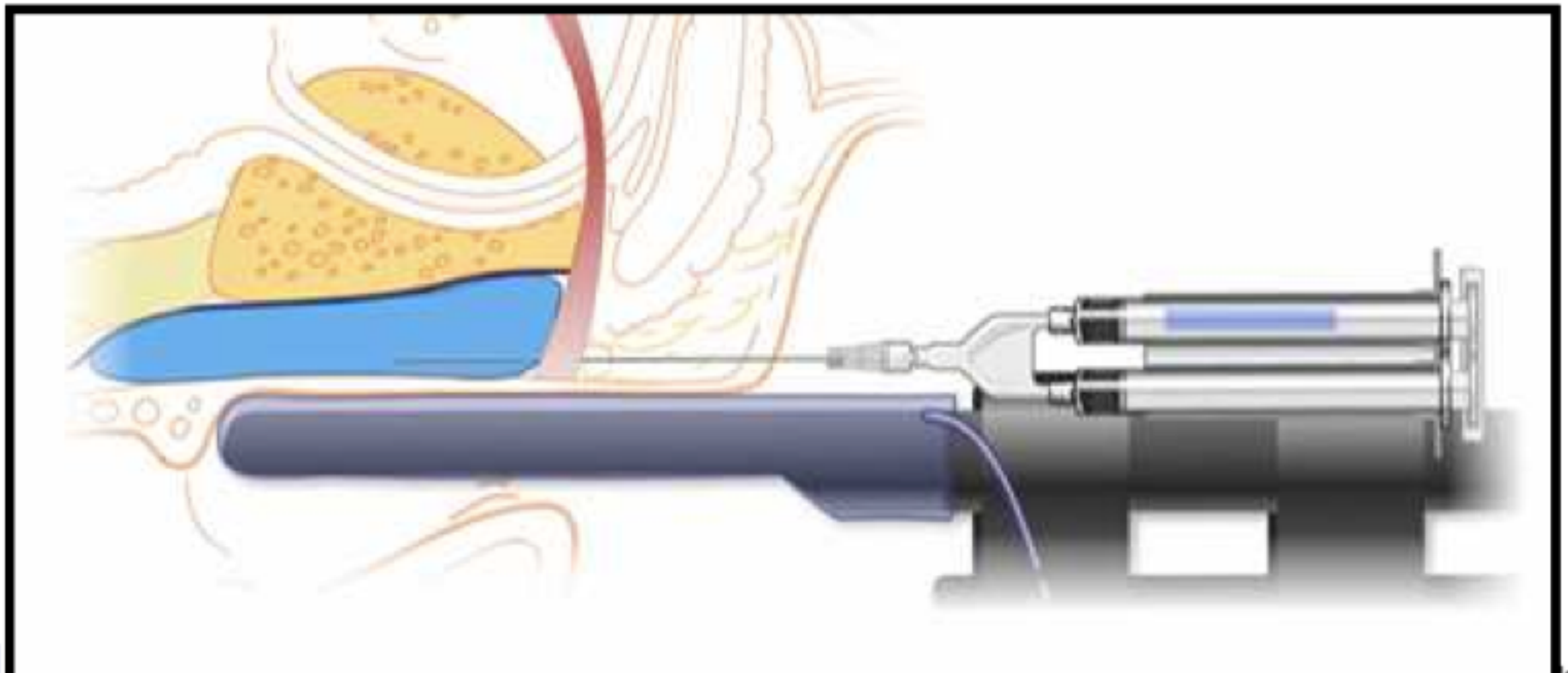
Principles of using Integrated Boost

1. If working with several dose levels, try not to move too far away from single doses with which there is clinical experience (e.g. 1.6 to 2.5 Gy)

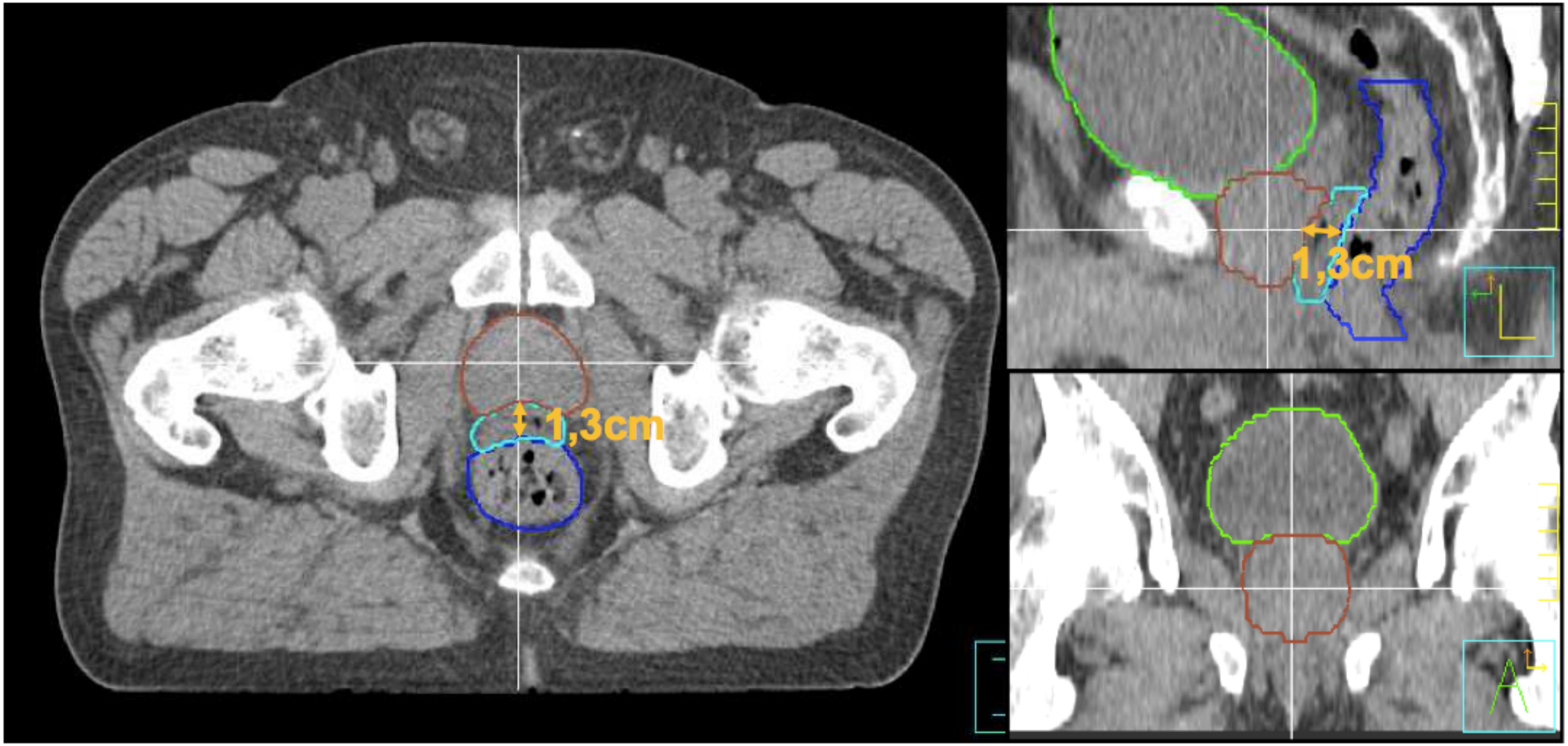
2. Keep the high-total-dose / high-single-dose volume small and away from (especially serial) critical structures

3. Start with IMRT as early as possible in the course of a patient's treatment to keep the single dose spread as low as possible

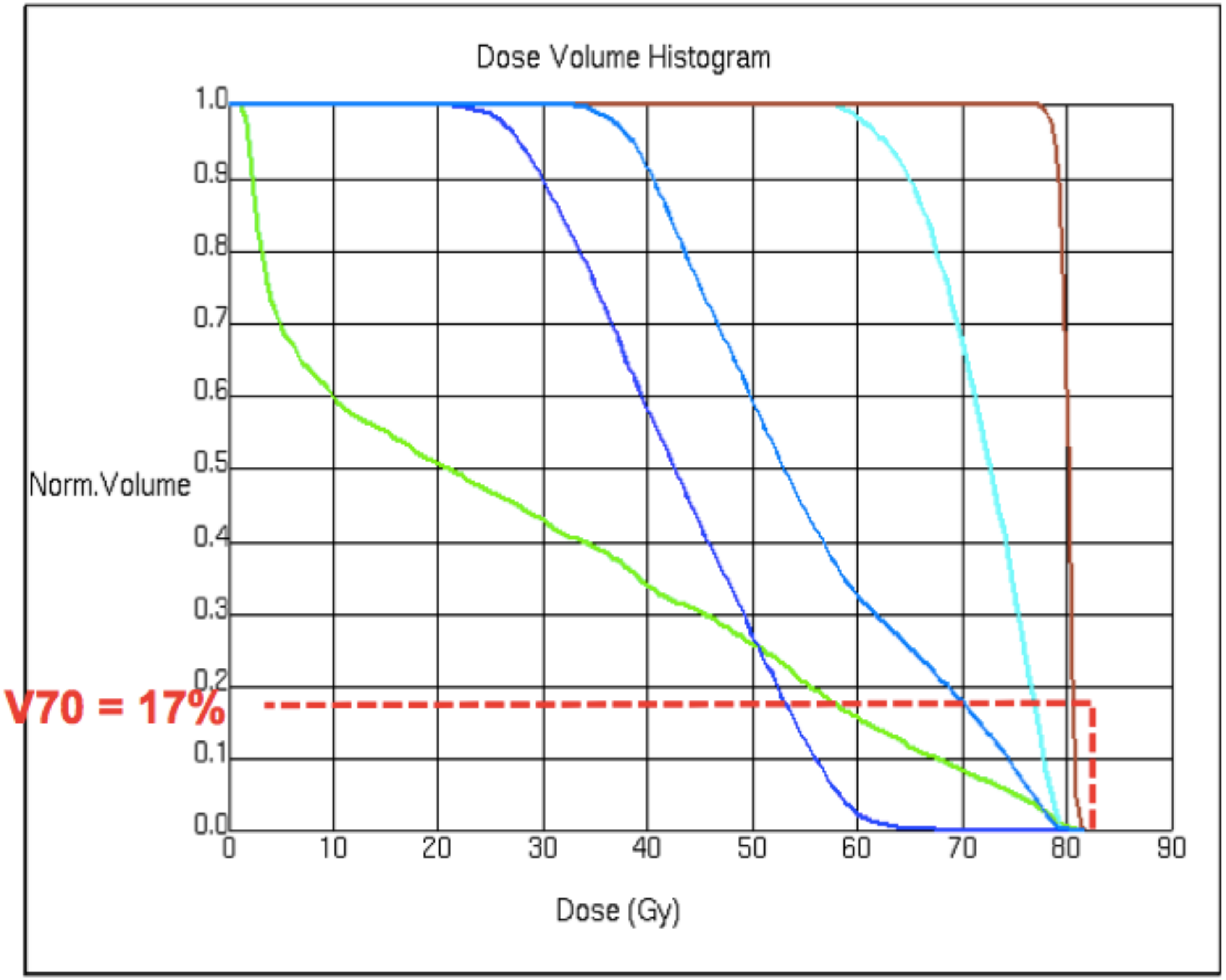
Courtesy: Bernd Gagel, Weiden

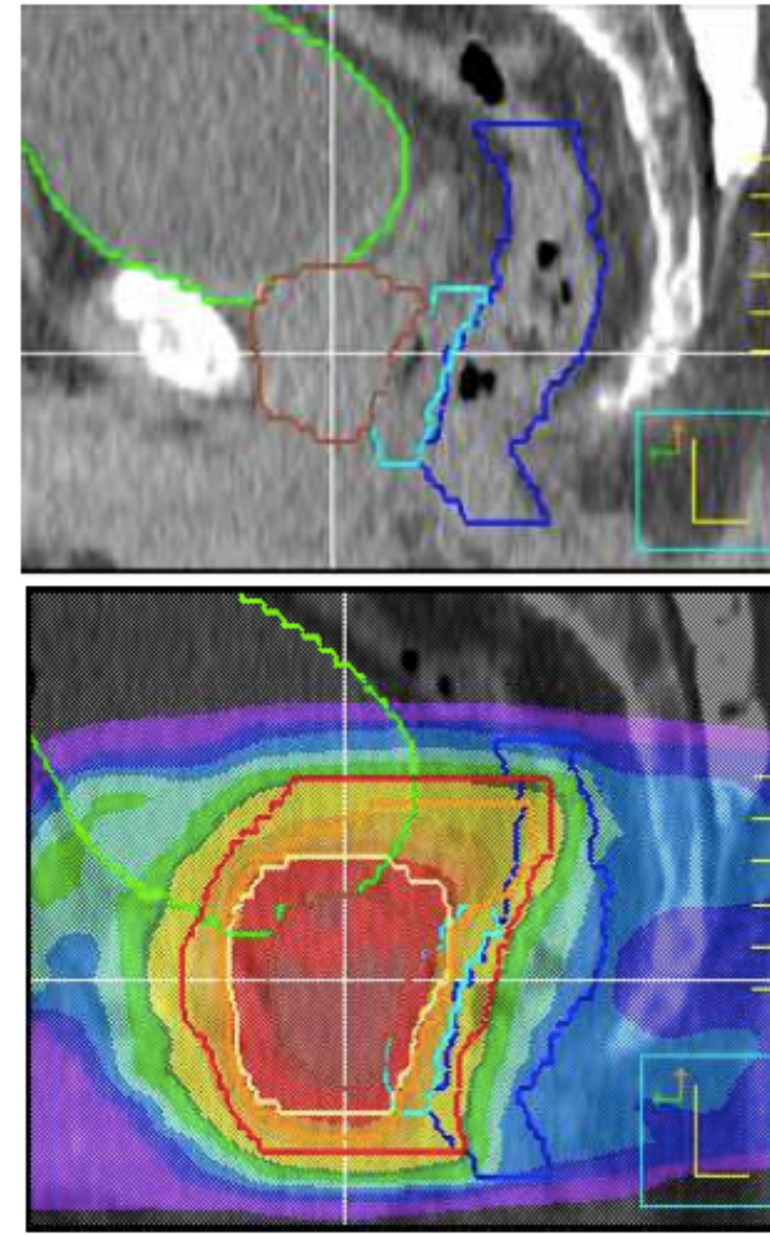


Prostata- / Gel-Volume



Results of treatment planning





Mean rectal dose = 36,6Gy (29,9 – 49,4Gy) Reduction 20%

Mean V70 = 1,5% (0-8%) Reduction 90%

Matthias Söhn

- IMRT optimalizacia a hodnotiace funkcie
- Adaptive RT
- Výpočet dávky

Summary & Conclusions

- IMRT treatment planning means *exploring the limits of physics* for each patient:
  - the 'physics in the patient': Is the desired dose distribution possible? (steepness and placement of gradients,...)
  - Applicability by MLC hardware

- numerous different and partly conflicting target and normal tissue goals need to be balanced — IMRT *optimization algorithms* are tools to 'navigate' through the solution space

- *'navigation'*: using weight factors, constraints, or a library of precalculated plans

- different approaches to arrive at applicable, segmented plans: *two-stage optimization vs. direct aperture optimization*

Summary & Conclusions [2]

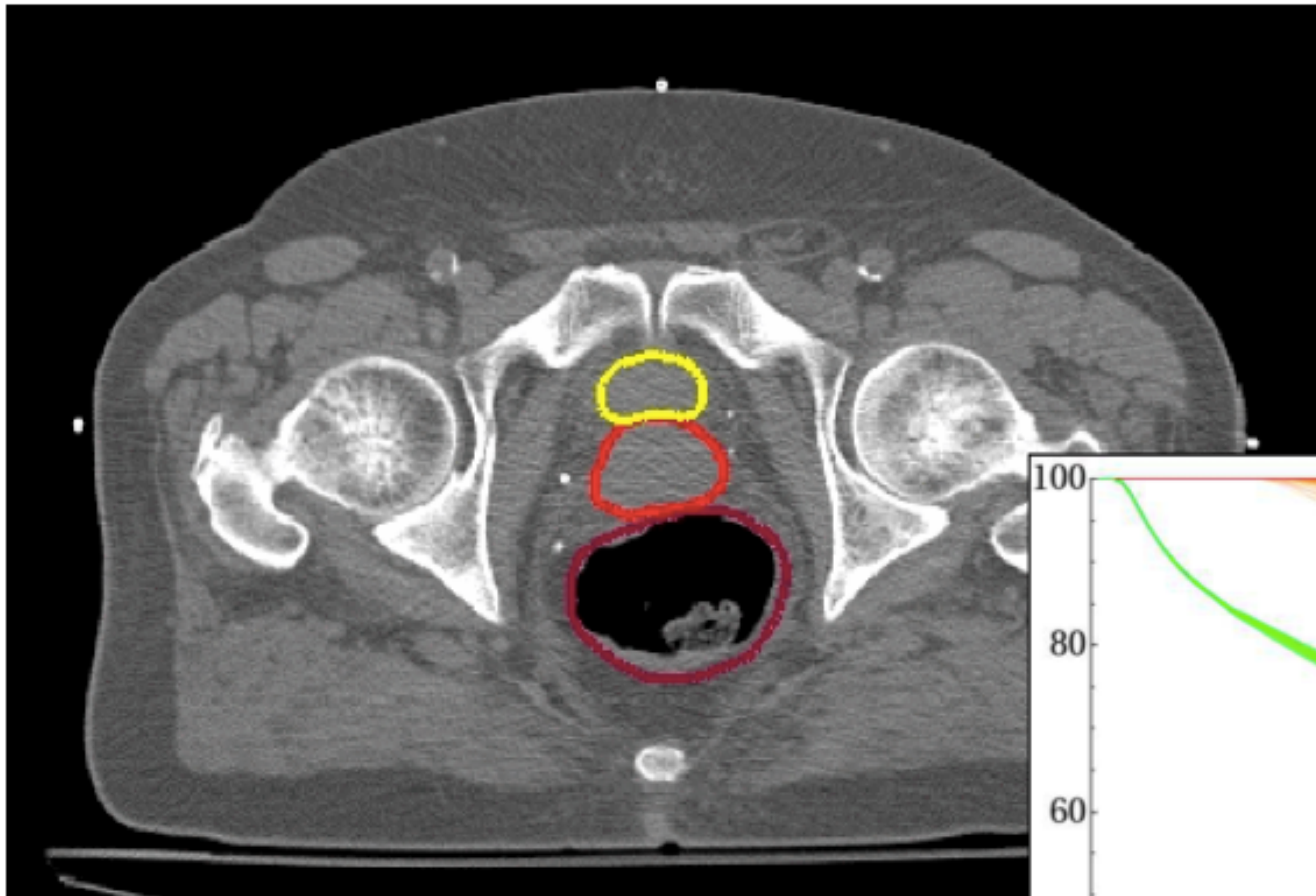
- Cost functions define numerical rules for the IMRT optimizer, which features of a dose distribution should be rewarded and which ones penalized.
  CFs are essential, because the *ideal* dose distribution does usually not exist

- The dose distribution in a volume results from a complex interplay of the cost functions defined in this volume, and all other cost functions.
  It is therefore extremely important to understand which features of the dose distribution are controlled by a cost function and which are uncontrolled and thus random.

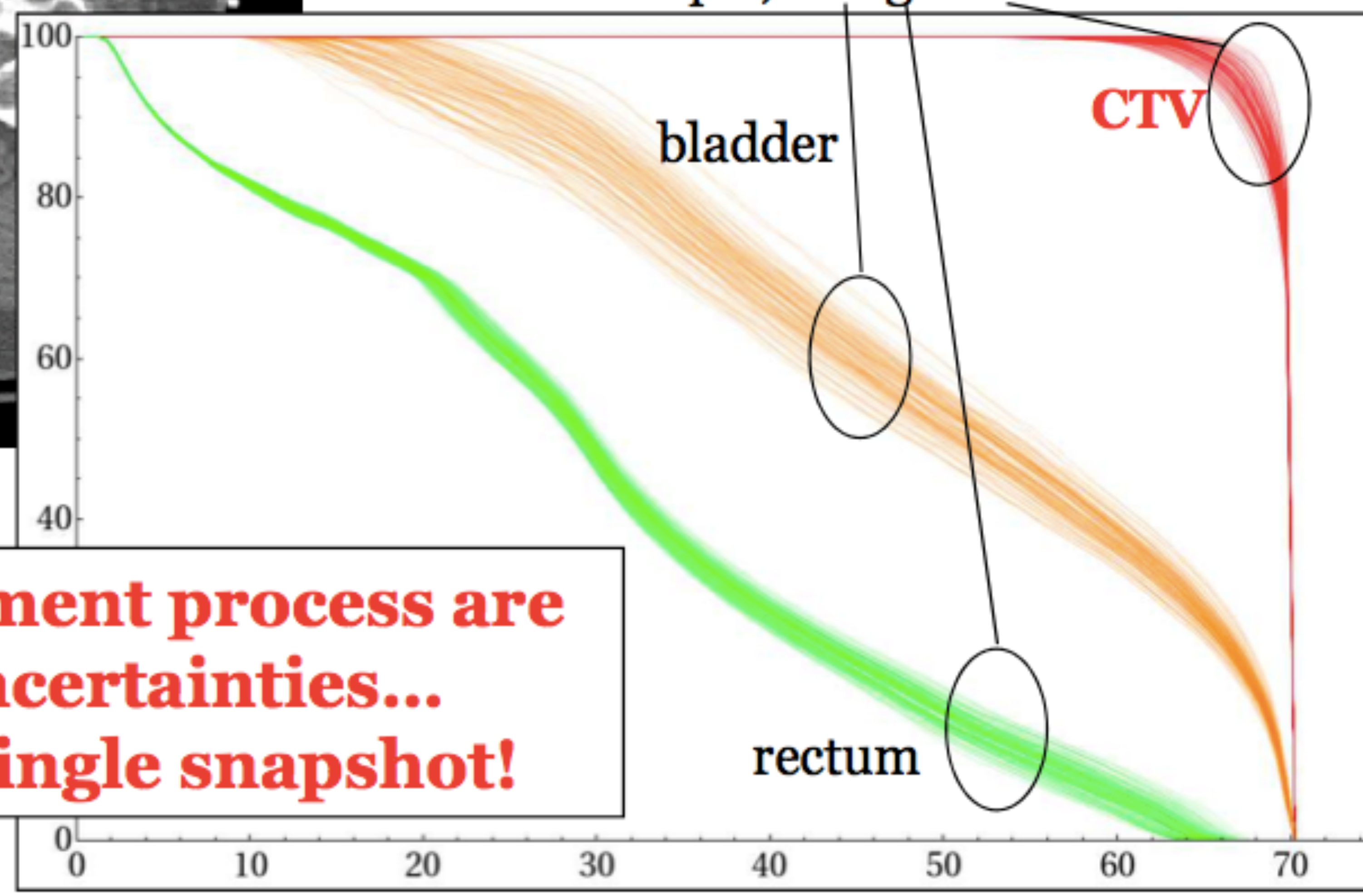
- The ideal dose distribution cannot be arrived at by the perfect set of cost functions, but only in an interactive process of exploring physically possible trade-offs between different treatment goals.

⇒ IMRT optimization is about as much art as it is science
⇒ BUT: experience helps!
⇒ ...as does a good TPS: should make the effects of all actions on the dose distribution transparent to the user in order to reduce trial-and-error

This is what actually happens!



Uncertainties depend on patient, treatment technique, margin size...



Reason: Patient and treatment process are not a *static*, all kinds of uncertainties... The planning CT is just a single snapshot!

The 'Toolbox' of Adaptive RT

- IGRT – imaging!
- prediction methods/models
- evaluation approaches: prospective studies on real (and realistic!) patient data of a study cohort, treatment course simulations, motion models
- deformable registration, dose warping, dose accumulation
- probabilistic and robust planning approaches

Summary and Conclusions

- As clinical **users**, we don't have to know all details of dose calculation algorithms

The few things you should know and be aware of:

- Major effects happen in the accelerator head already
  – importance of a good head model!
- Pencil beam algorithms are very fast, but have major problems with accuracy in regions of the body with large density inhomogenieties (lung/thorax!, head-and-neck)
- thus, the final dose calculation should be done with Collapsed Cone algorithms, Linear Boltzmann Transport Equation Solvers or Monte Carlo algorithms
- be aware: There is not "THE" Pencil Beam or "THE" Collapsed Cone algorithm
  – accuracy and performance depend on vendor-specific implementational details
- finally, and most importantly: *Always keep a critical eye on what is calculated!* (Appendix)

Marco Schwarz

- Technike aspekty imrt
- TPS commisioning
- QA pacienta
- Practical Treatment Planning and biological optimization

General references

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Journal of the ICRU

ICRU REPORT 83

Prescribing, Recording, and Reporting Photon-Beam Intensity-Modulated Radiation Therapy (IMRT)

The use and QA of biologically related models for treatment planning: Short report of the TG-166 of the therapy physics committee of the AAPM[a)]

X. Allen Li[b)]
Radiation Oncology, Medical College of Wisconsin, Milwaukee, Wisconsin 53226

Med Phys 2012

Conclusions

Class solutions ± 'forward planning' might facilitate a gradual transition to IMRT

Appropriate cost function and VOI definition are critical in 'steering' the optimisation in the desired direction.

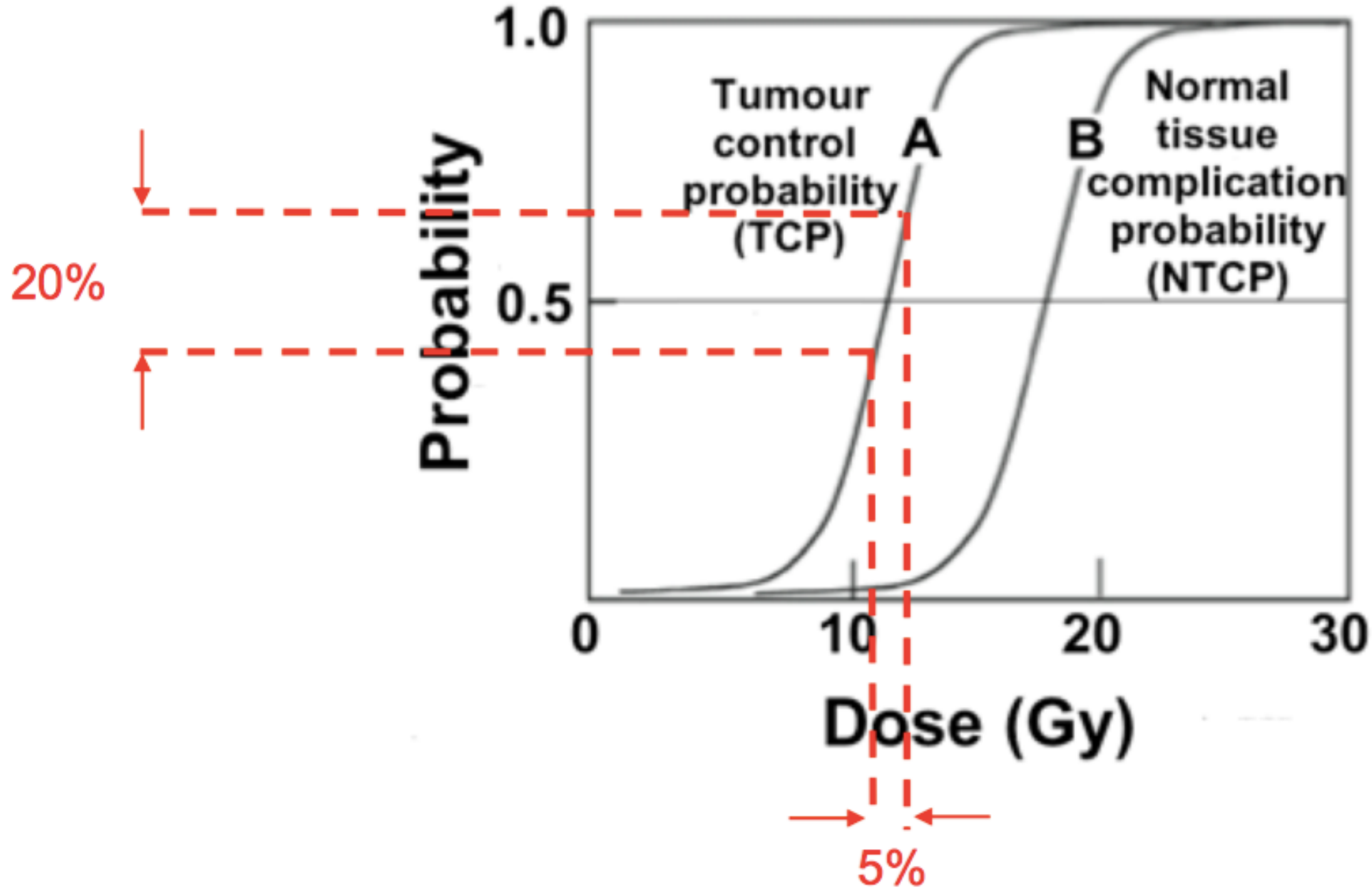
'Biological' planning can be incorporated in everyday practice

Automatic planning is coming. Fast.

Koen Tournel

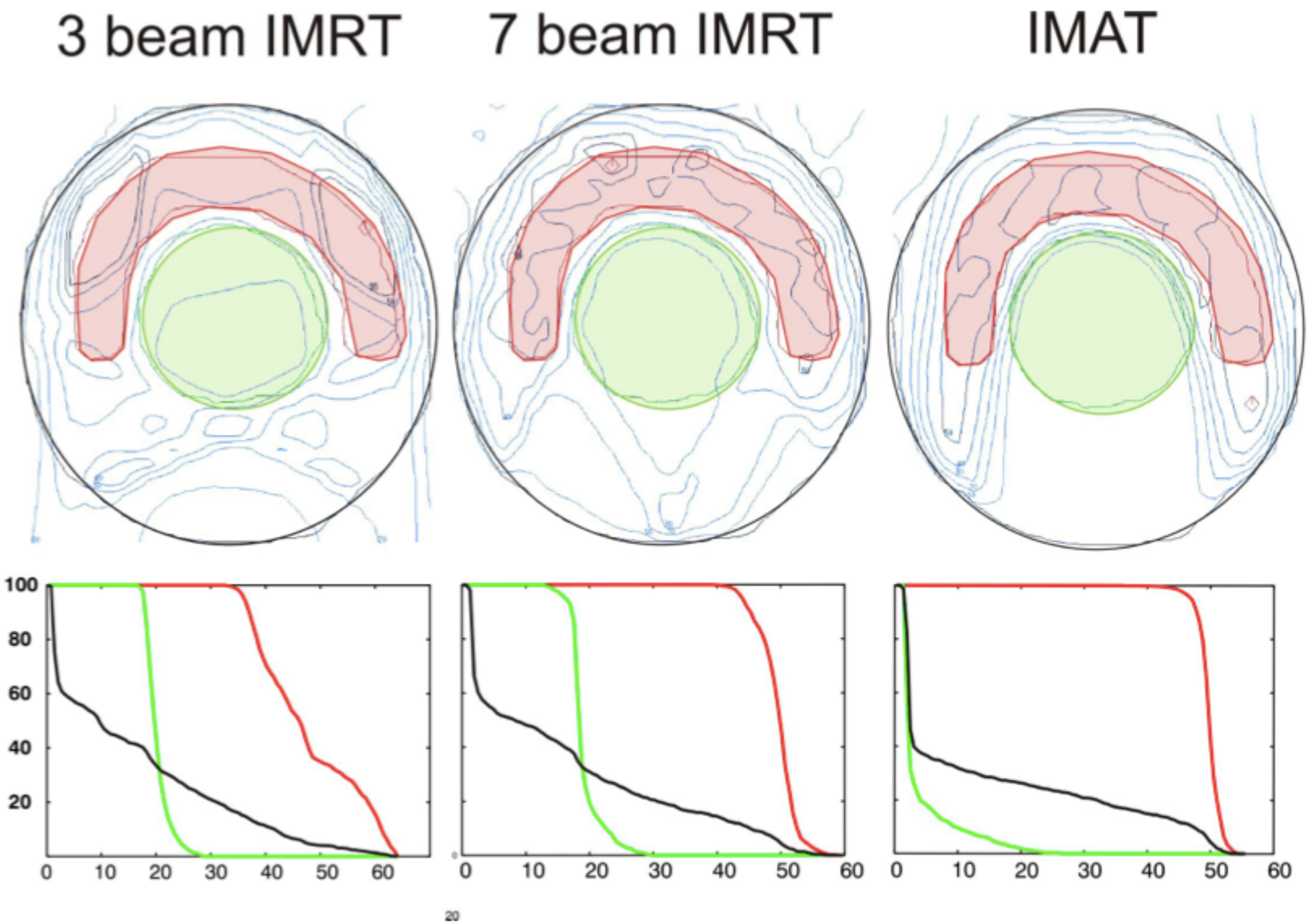
- Úloha dozimetrie
- Geometrické nepresnosti
- Rotačné terapie

The Big Picture



A 5% dose error can lead to a 20% difference in NTCP/TCP

Gent experience…



De meerleer et al

Final conclusions

- Rotational therapy has gone mainstream.
- This has not made it the answer to life the universe and everything
- This has not made it any easier to implement, plan or QA
- In hospital economics, this time and effort should also be incorporated
- In planning:
  - Know your machine’s limitations
  - Know and understand your optimizer and dose calculation
  - Don’t treat it like a coffee machine
- Don’t be afraid, be vigilant

Andrea Riccardo Filippi

- Hodgkinov lymfón
- Skoré štádium rakoviny pľúc
- Pokročilé štádium rakoviny pľúc

Giovanna Gagliardi

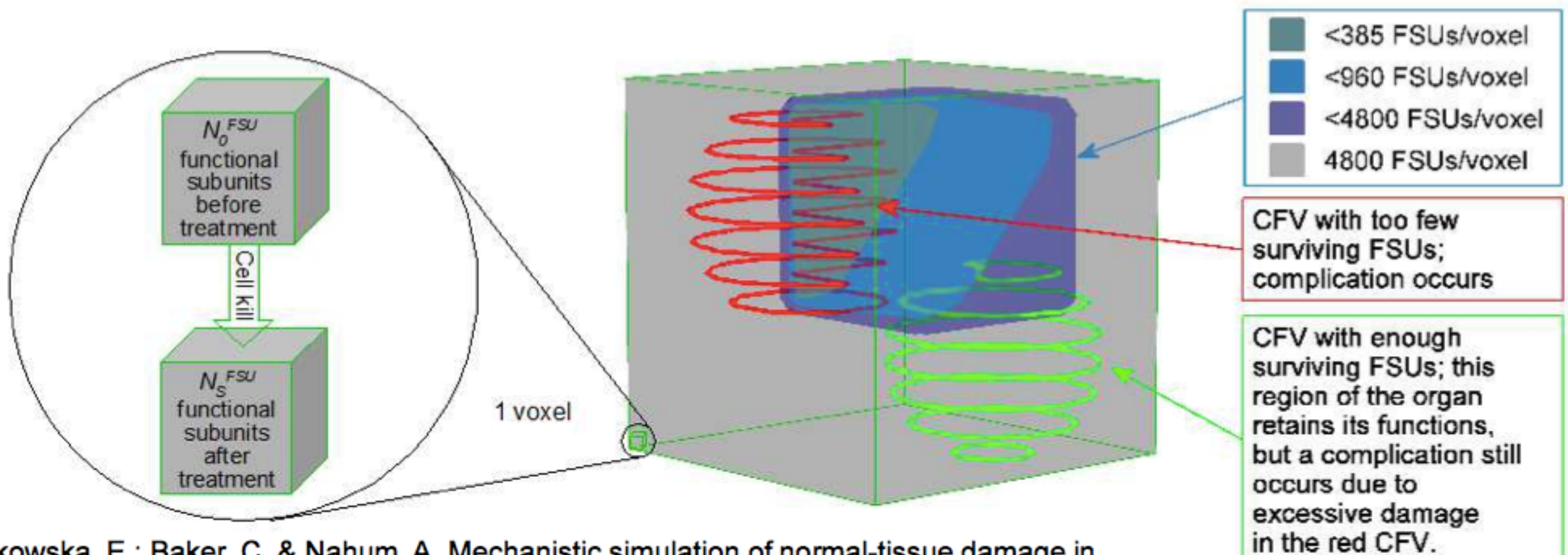
- Matematicko biofyzikálne modelovanie
- HK lokalita
- MP lokalita

Matematicko biofyzikálne modelovanie

- využitie NTCP modelov pre:
  - vyhodnotenie 3D dávkovej distribúcie
  - Kvantitatívne porovnanie plánov
  - zhodnodnotenie clinického potneciálu nových techník

3D organ model

- Models normal-tissue effects from cell death to tissue damage to loss of organ function
- Functional subunit (FSU) inactivation per voxel given by dose distribution, LQ model and Poisson statistics
- Organ response depends on the <u>critical functioning volume</u> (CFV), representing the volume effect.



Rutkowska, E.; Baker, C. & Nahum, A. Mechanistic simulation of normal-tissue damage in radiotherapy - implications for dose-volume analyses. Phys Med Biol, 2010, 55, 2121-2136

Summary: HN dose-volume relationships - Xerostomia

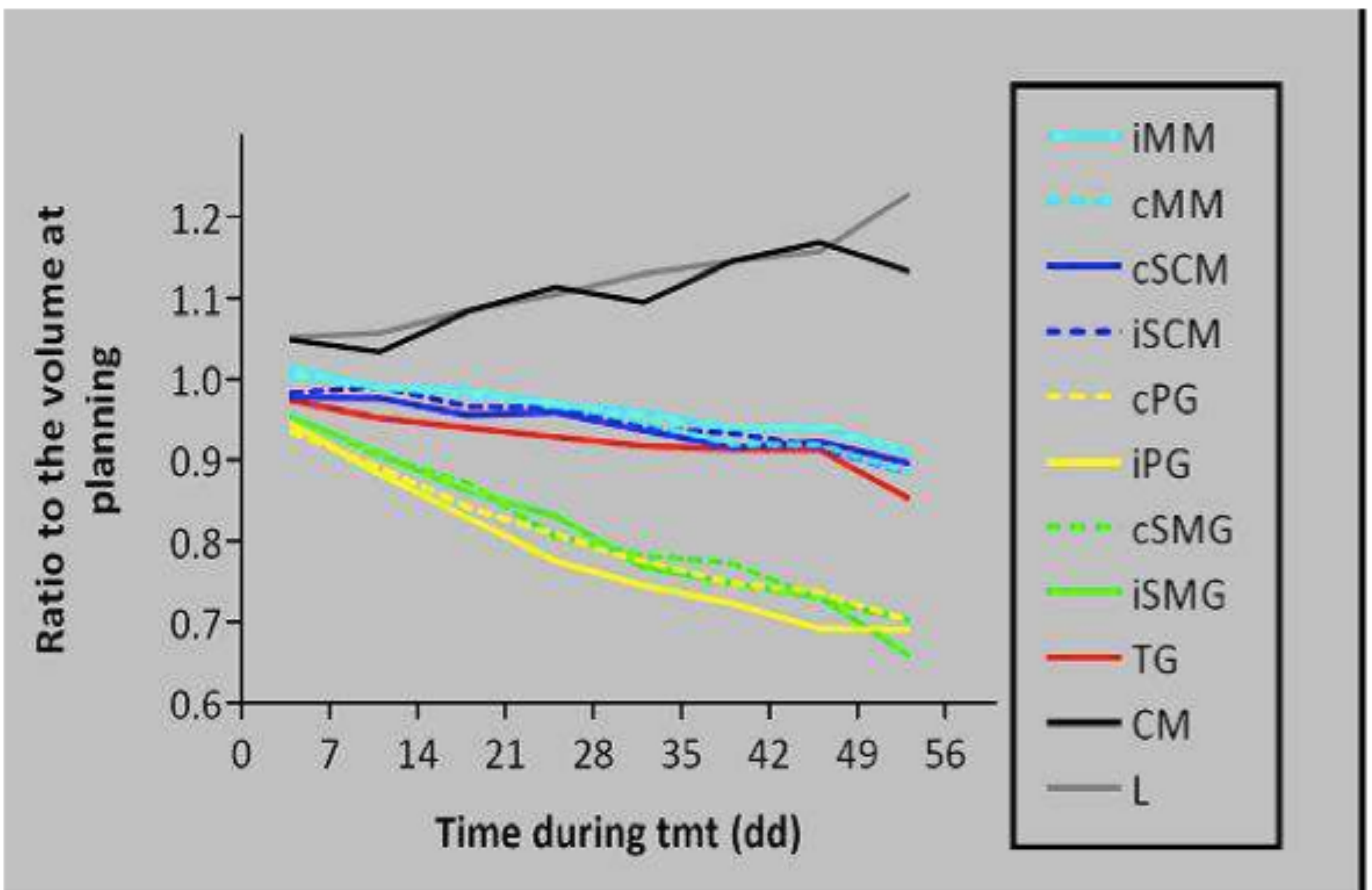
- Consensus : parotid as a parallel organ
- Mean dose, V20-40 best predictors
- Faster recovery of the damage with IMRT
- Different Mean dose vs xerostomia curves between 3DCRT and IMRT pts: spatial effects (?)
- Image-based assessment of early reactions (volumes, density, ….): high potential for better scoring and understanding radiation-induced parotid changes

Summary: HN dose-volume relationships – Disphagia, Larynx edema

- Increasing evidence of dose-volume effects for dysphagia (especially sup. constrictor, larynx)
- Dose-volume effect for Oral mucosa and constrictors in predicting PEG risk/swallowing problems
- Impact of CHT
- NTCP model available for laryngeal edema
- Conformal avoidance approach with IMRT may reduce toxicities (even without quantitative dose-volume relationship)

Volume changes during RT imaged by IGRT to assess normal tissue effects

- Volume variation of parotids and other organs during IMRT for HN cancer



PG: parotid glands
SMG: submandibular glands
TG: thyroid gland
CM: constrictor muscles
SCM:sternocleidomastoid muscles
MM: masticatory muscles
L: larynx
i=ipsi, c=contro

Courtesy C. Fiorino

Ricchetti et al. IJROBP 2011

Záver

- 20 rokov praxe s IMRT je významné obdobie pre zhodnotenie terapeutických výsledkov
- veľa podnetov pre hladanie vlastných limitov a rozširovanie poznania s