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Clinical and physical aspects of precise radiotherapy for medical physicists

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Role of medical physicists in radiotherapy

Everything we do medical physicists is for the benefit of the patient!

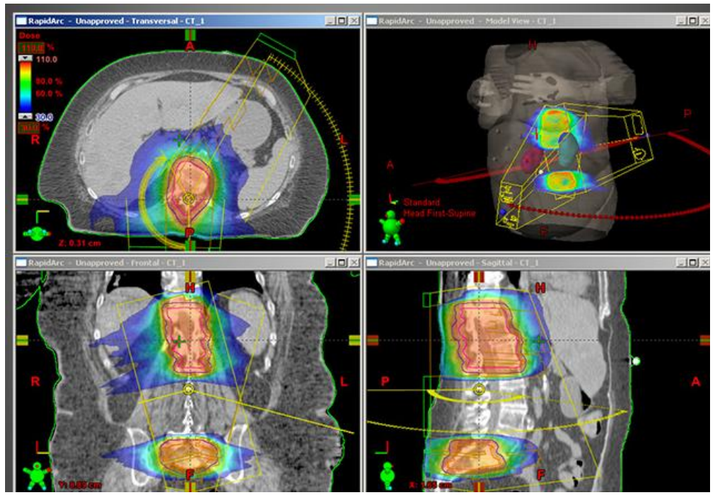
From quantitative point of view

our efforts are directed at delivering

the prescribed dose to the Clinical Target

Volume while minimising the dose given

to the critical organs.



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What is the most important?

physical aspects

Absolute and relative dosimetry

Regularly repeated quality control

The treatment planning system should be of particular concern to us, but we have no influence on the system itself

we have physicists influenece on data preparation and on the model adjustment

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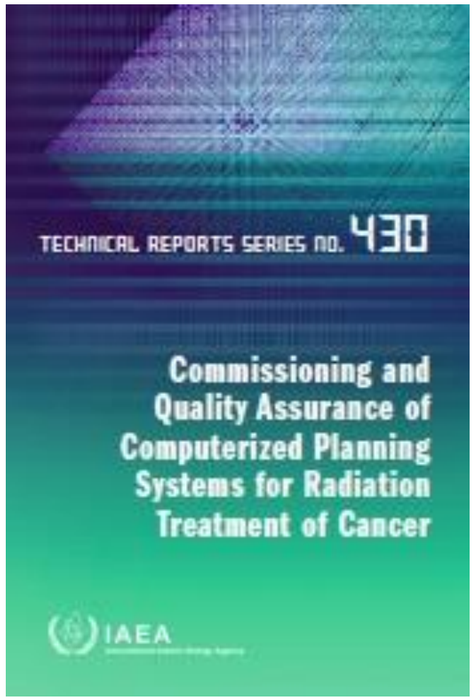
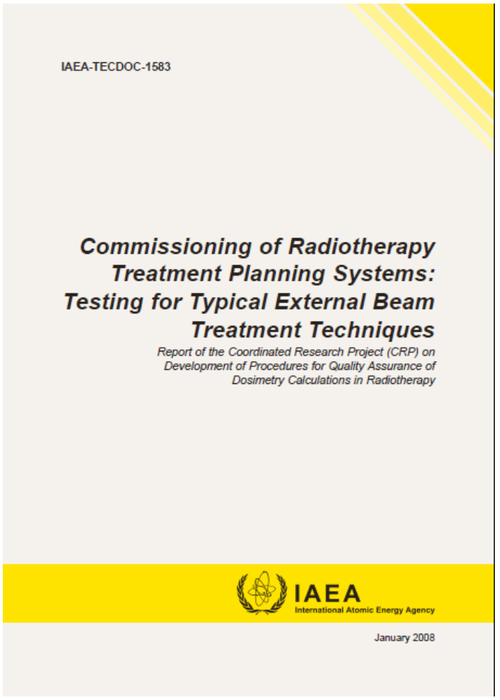
Treatment Planning System commissioning





I would like to make a few comments about the commissionig.

Comissioning of TPS
before you start

However it meets requirements, BUT…

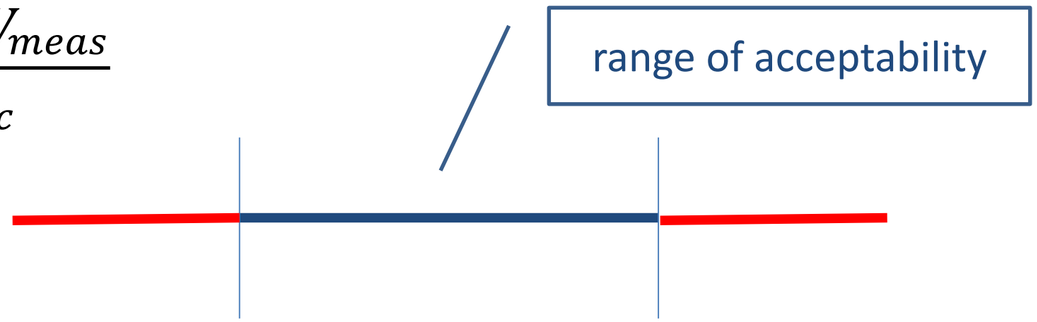
Quantitative tests

- tolerances should be defined

Tolerance is strictly defined as

- the range of acceptability beyond which corrective action is required

$$\delta = 100 \times \frac{V_{calc} - V_{meas}}{V_{calc}}$$



VENSELAAR, J., WELLEWEERD, H., MIJNHEER, B., Tolerances for the accuracy of photon beam dose calculations of treatment planning systems, Radiother. Oncol. **60 (2001) 191–201**

Comparison in terms of relative values or absolute values

The best is to compare the calculated and measured data

in terms od absolute values.

The best way is to express data in terms of reference dose, which is the

Output Factor for 10x10 cm^2 at reference point (value from TPS)

- it is not easy
  - some programming is needed.

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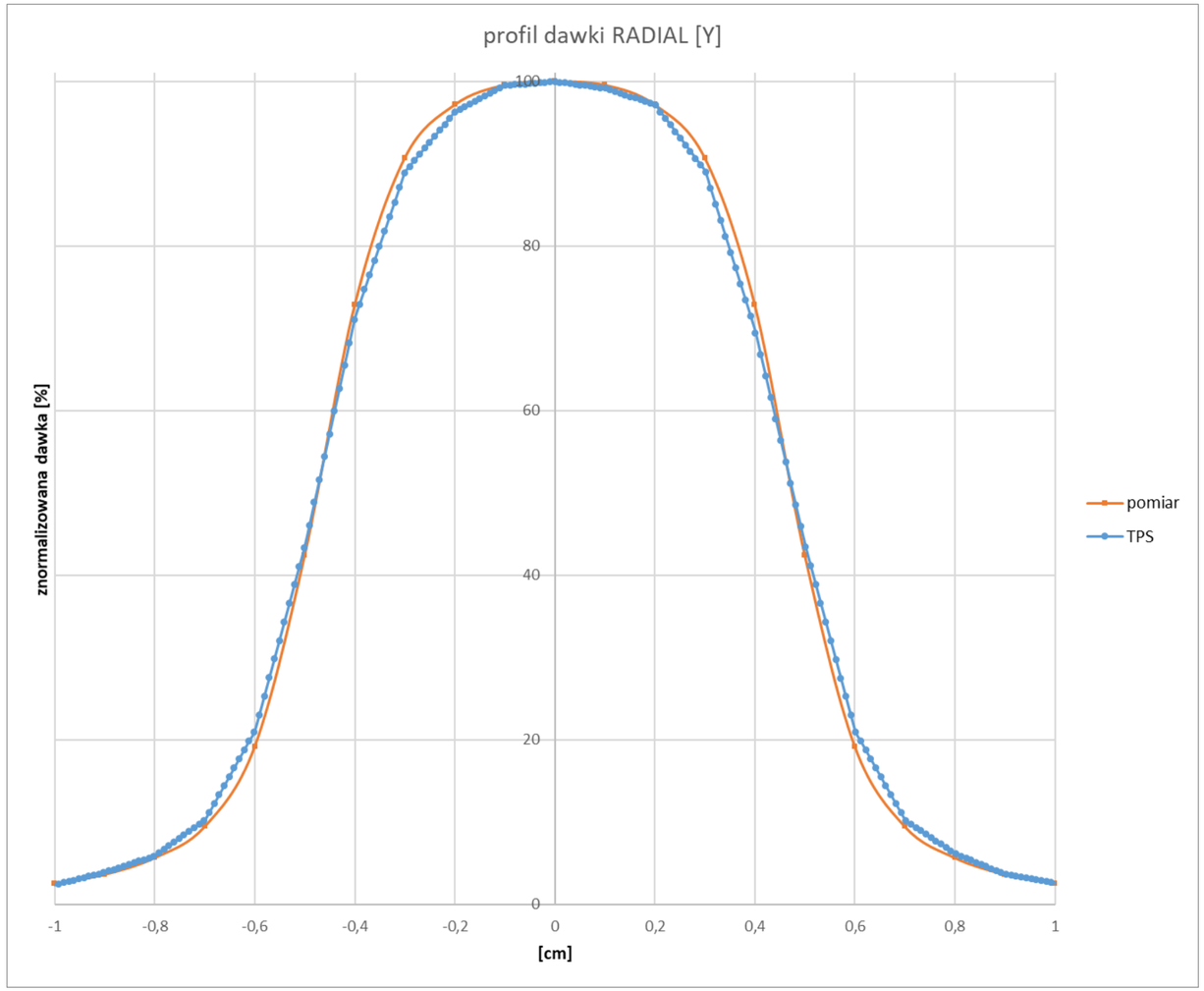
Relative comparison



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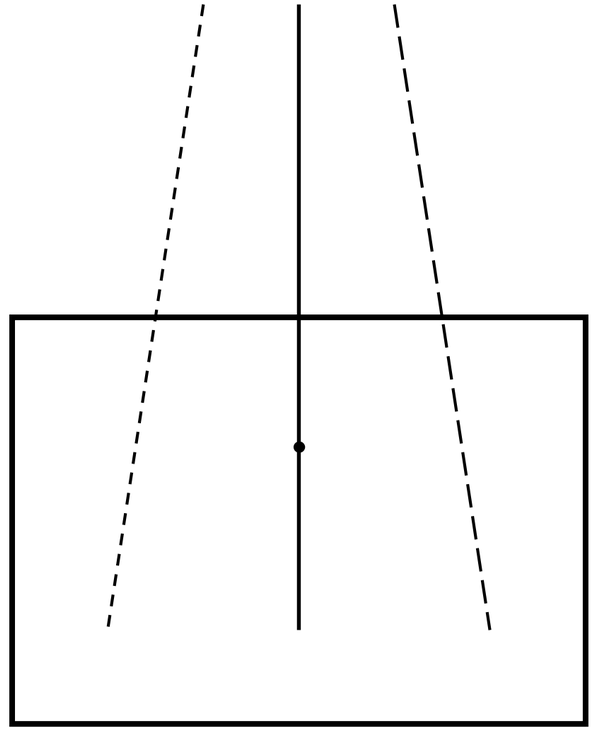
What we should keep in mind?

Absolute measurements - correction with present values

$$\left(D_{meas}\right)_{corr} = D_{meas} \cdot \frac{OF_{TPS}}{OF_{Act}}$$

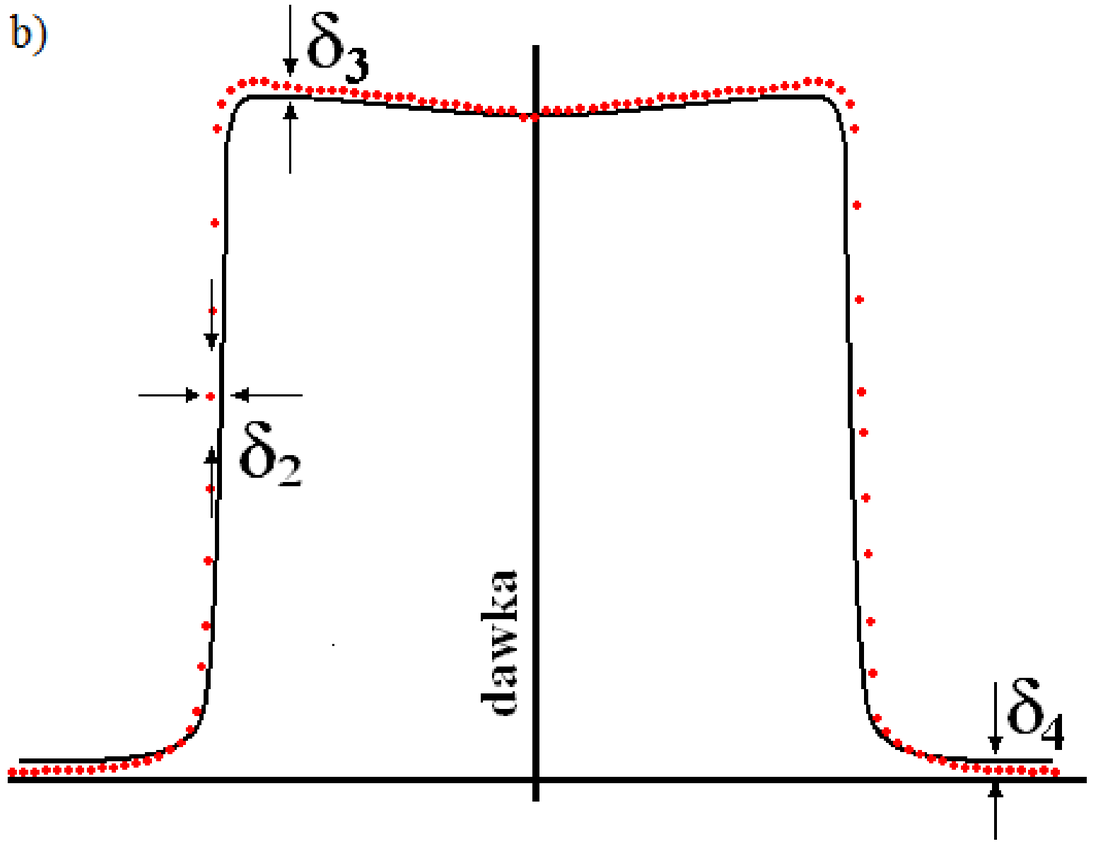
$$\delta = 100 \times \frac{D_{calc} - \left(D_{meas}\right)_{corr}}{D_{calc}}$$



Tolerances

Can be expressed in terms of

- dose (low gradient)
  - at least two values
- distances (high gradient)



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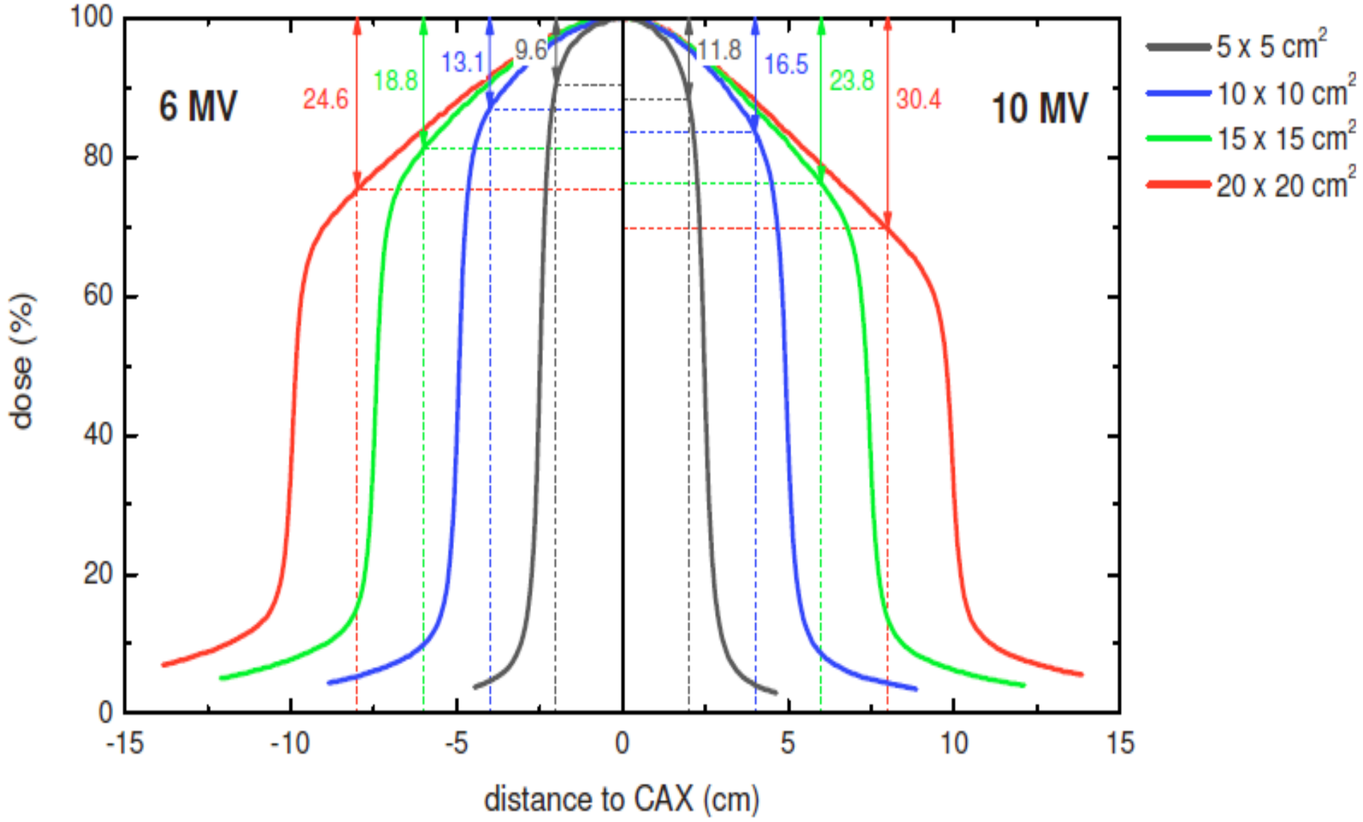
Data preparation
consistency of data

Visual verification of the data is obligatory

- profiles



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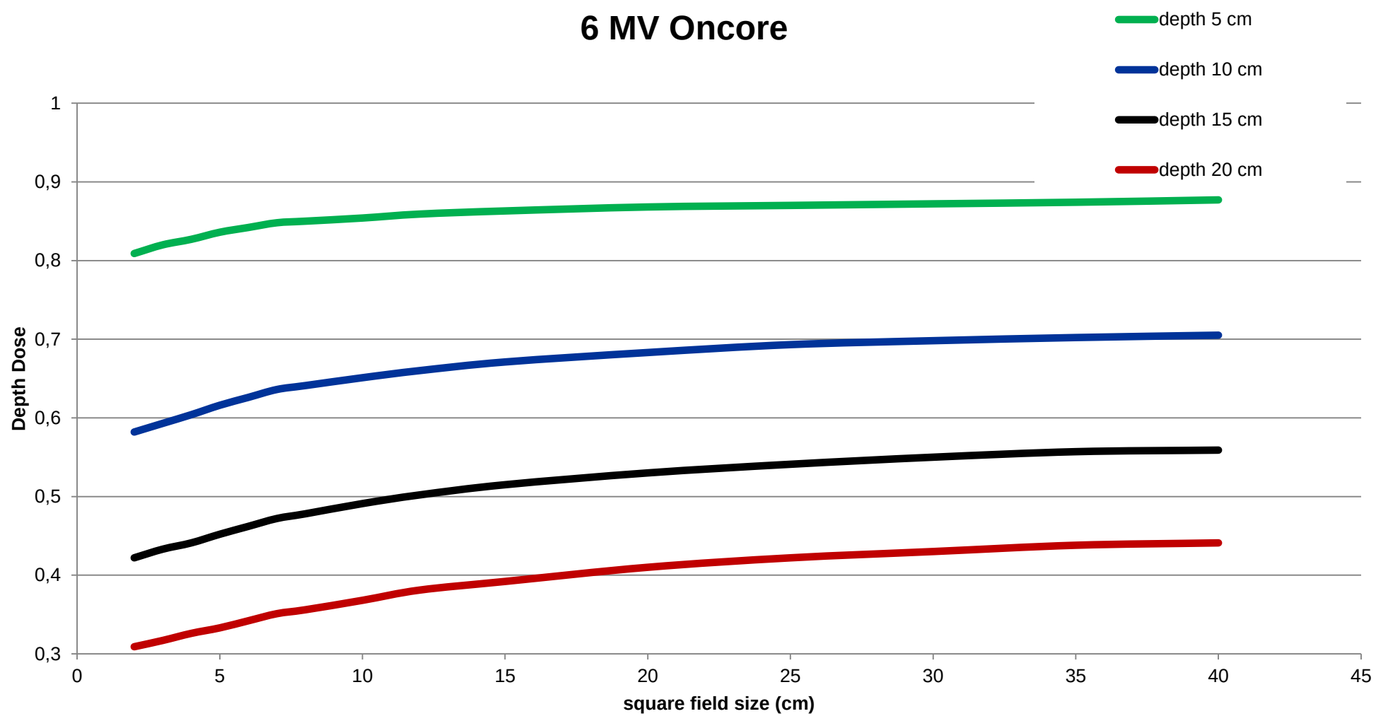
Data preparation
consistency of data

Visual verification of the data is obligatory

- depth doses versus field size



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Data preparation
consistency of data

Output factors - graphs should be prepared and carefully analyzed

Output factors (cGy/MU) Y

X	2	3	4	5	6	8	10	12	15	20	30	40
2	0,64	0,671	0,681	0,688	0,694	0,702	0,707	0,71	0,714	0,718	0,723	0,724
3	0,658	0,693	0,707	0,717	0,724	0,737	0,743	0,75	0,755	0,761	0,766	0,768
4	0,665	0,704	0,721	0,733	0,742	0,757	0,767	0,774	0,779	0,788	0,794	0,797
5	0,67	0,712	0,731	0,744	0,757	0,774	0,786	0,794	0,802	0,811	0,818	0,822
6	0,675	0,718	0,739	0,756	0,768	0,787	0,801	0,811	0,82	0,829	0,839	0,843
8	0,685	0,729	0,752	0,769	0,784	0,808	0,823	0,834	0,846	0,858	0,868	0,873
10	0,689	0,736	0,76	0,779	0,797	0,821	0,84	0,853	0,867	0,881	0,893	0,898
12	0,694	0,739	0,765	0,785	0,803	0,829	0,85	0,864	0,879	0,894	0,909	0,916
15	0,696	0,742	0,771	0,791	0,809	0,838	0,86	0,875	0,891	0,91	0,927	0,935
20	0,699	0,746	0,775	0,797	0,815	0,847	0,869	0,887	0,907	0,927	0,948	0,956
30	0,7	0,749	0,777	0,801	0,822	0,853	0,879	0,898	0,919	0,944	0,966	0,977
40	0,702	0,752	0,78	0,805	0,826	0,859	0,885	0,903	0,927	0,952	0,978	0,987

Last but not least

Functional tests - the right interpretation of the treatment plan parameters

Here are some of them

- conventions concerning angles
- coordinats systems used by the system
- naming of collimator jaws
- naming and orientation of wedges

0 1

Treatment planning

How much time do you spend on preparing the treatment plan?

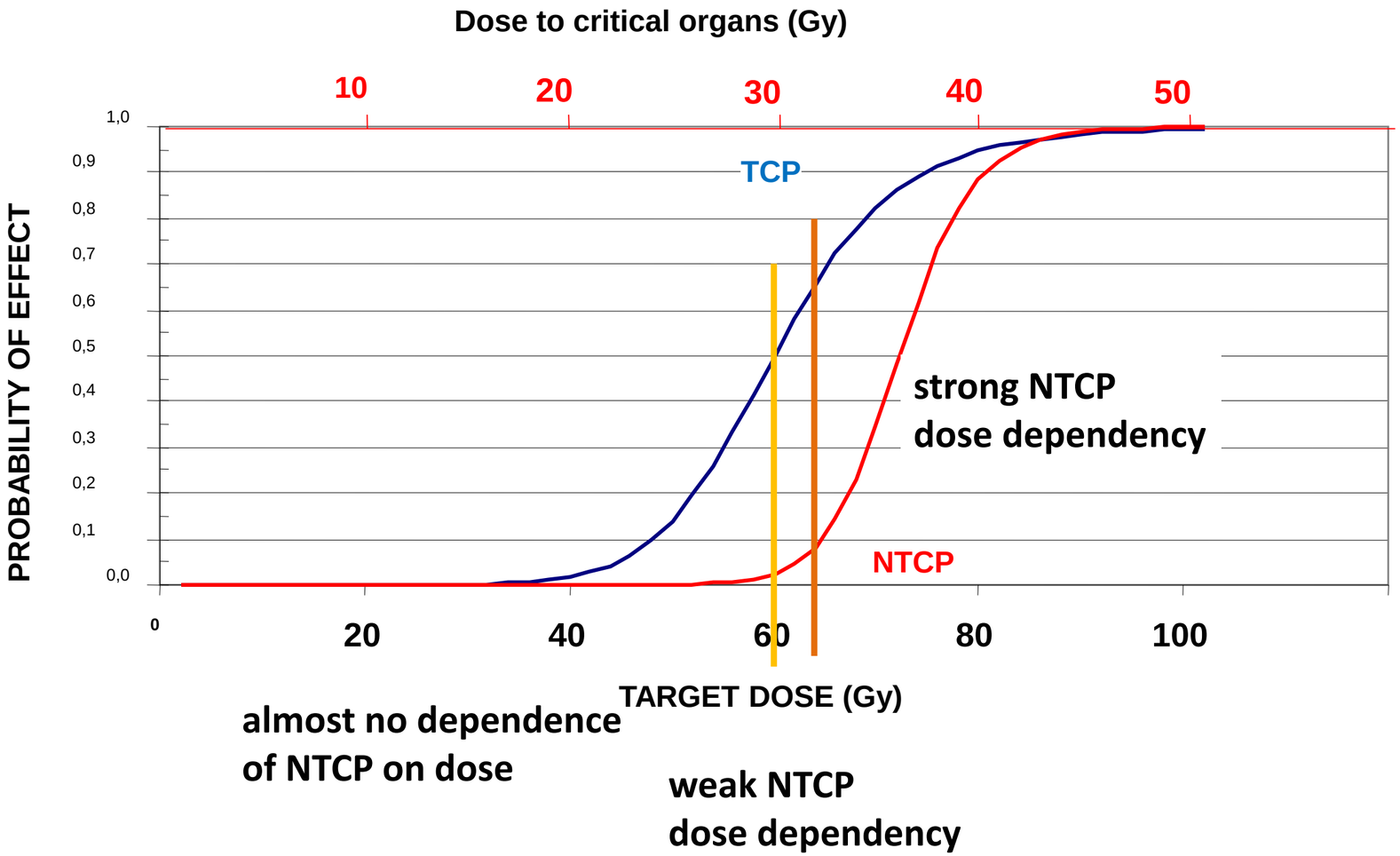
When do you complete the planning?

Until the **internal protocol** requirements are met.

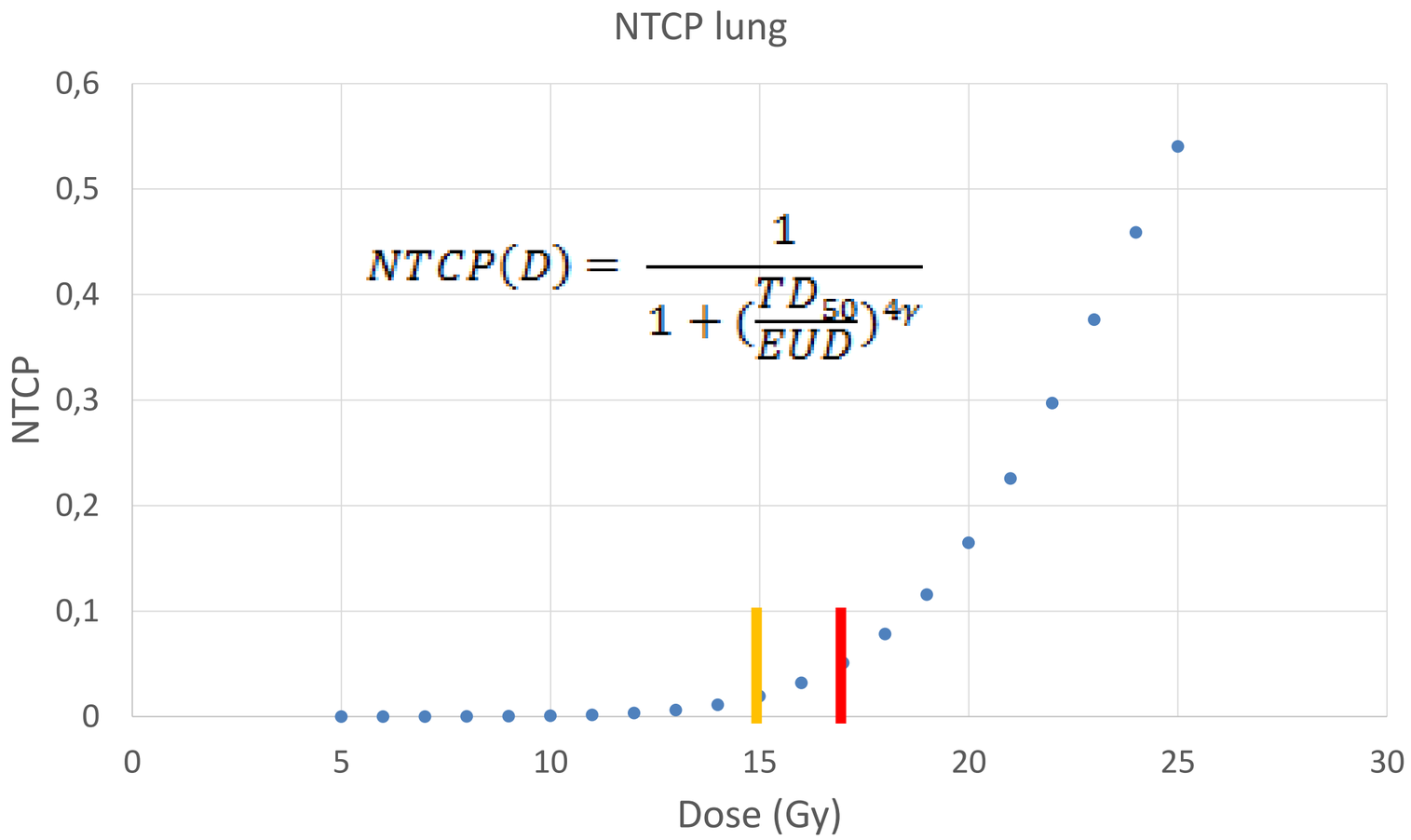
Until the doctors are satisfied.

Until I am satisfied.

What we should be aware of ?



Lung NTCP



TD50 =24.5 Gy

γ= 2

Major sources of uncertainty in dose delivery

1. Absolute and relative dosimetry

2. Quality control

3. Treatment planning - preparation of TPS

4. Preparation and irradiation

    1. Accuracy of patient positioning (?)

    2. Changes of patient anatomy – adaptive radiotherapy (?)

    3. Organisation of work

tasks of medical physicists

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Tasks of medical physicists

clinical part

Especially in radiotherapy departments with not long history

a very important task of physicts is to promote and implement all solutions that make radiotherapy more effective!!!

I call it the clinical aspect of a medical physicist's work.

Conditions under which we operate

You will tell me:

It doesn’t depend on me, medical doctors make a decision.

you probably don't have access to financing.

What you can and you want to do with a very limited money.

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You have money!

One day a sponsor appears

who wants to develop radiotherapy

in your country.

What are your proposals?

Technology (?)

Knowledge - skills

Organisation

Spirit of work

Knowledge

This is what you are doing now and here!

- reading, reading, reading!
  - reading manulas of the equipment
- undertaking (even) simple research projects
  - writing a paper

programming

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Manuals

Have you used all the functionalities of your devices?

What are these functionalities?

If not implemented why?

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Knowledge – training – cooperation

I don’t want to tell that medical doctors are not important!

Radiotherapy is a team activity,

- from the physicist’s point of view, good cooperation with radiation technologiests is of special importance

Medical physicists should be familiar with the work of RTTs,

- physicists are usually a source of knowledge for technicians.

All clinical aspects of physicists' work should be determined in collaboration with RTTs.

Simple research projects

Who has ever collected and analysed data from patient positioning?

- very simple and very fruitful project

< 1 fraction in 35 fractions

30 patients

Effectiveness of the No action level protocol for head & neck patients
Time considerations

Pawel Kukolowicz[a,*], Monika Mietelska[b], Dorota Kiprian[c]

Results: The number of setup errors in the posterior-anterior, inferior-superior, and right–left directions ≥3 mm and ≥4 mm were 98, 79, and 91 sessions and 44, 38 and 30 sessions out of 884 sessions. After NAL protocol the number of errors ≥3 mm and ≥4 mm decreased to 84, 57, and 39 sessions and 31, 15 and 10 sessions, respectively. The average time needed for one set-up control was 5.1 min. NAL protocol allows saving 4049 min for the whole group.

37 patients instead of 30

Don't start a project without at least a brief description.

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Optimisation of CBCT protocols

Optimisation of CBCT based on

- patient size
- location

Tube potential (kVp)	Tube current (mA)	Tube current-time product (mAs)	Gantry rotation trajectory	Gantry speed (Deg/s)	Number of projections

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Auto Beam Hold

Varian TrueBeam

Comprehensive imaging protocol to get planned dose distribution

- with fiducials
  - CTV-PTV margin
- without fiducials
  - CTV-PTV margin

Triggered imaging for hypofractionated prostate treatment on Varian TrueBeam linear accelerator

Jelizaveta Ter-Minasjan, Margit Marjamäe
North Estonia Medical Centre, Oncology Clinic, Radiotherapy department

https://www.postersessiononline.eu/173580348_eu/congresos/ESTRO37/aula/-EP_2383_ESTRO37.pdf

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Protocols

Today the world operates according to protocols

this has both good and bad points.

I will try to show you the good points first.

Pessimist: it could not be worse. Optimist: maybe, maybe.

Protocols - tips

We can only return to the saved document

- speaking is relatively simple but often vague,
- good communication should end with a written protocol that is accepted by all (almost all - consensus).

Simple protocols (complicated ones do not) make things easier

- should be written after accumulating some experience; experience should be gathered in a formalised manner
  - preliminary protocols are helpfull.

Example of the protocol
further improved in our hospital

How to ensure continuity of radiotherapy - interruptions in treatment.

Protocol: Interruption in radiotherapy.

What is interruption? (1,2, 3… days),

- the moment of interruption.

What are reasons for interruption? Predictable and unpredictable interruptions.

TWINS MACHINES!!!

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Example of the protocol
further improved in our hospital

Who is informed about interruption?

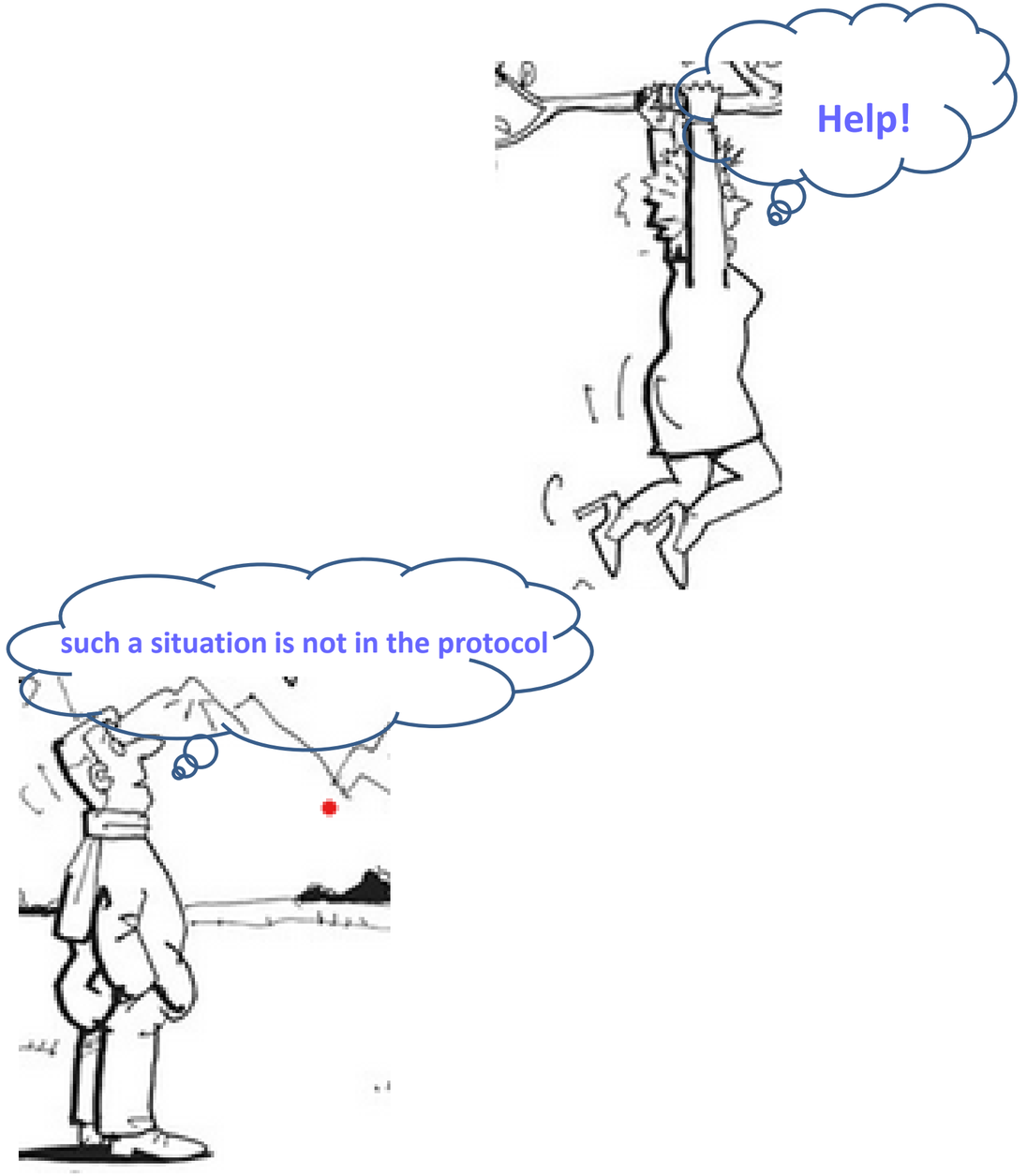
- patient itself,
- medical doctor,
- physicsts' staff

What has to be done to continue irradiation

- new plan (we have one Edge machine, and one tomotherapy),
  - if new plan the plan itself and verification of the plan.

Protocols - risks

An extremely formalised world switches off thinking!



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Mould room

very important!!!

Staff

- a team familiar with the entire radiotherapy pathway,
- full of empathy,
- prepared for difficult conversations,
- with manual skills,
- …

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And finally

And … a minute for my pride

I try to remember that pride comes before a fall

New developments we have introduced in our hospital last few years

Patient preparation for radiotherapy

- preparation room

What is interested for patients

- does radiotherapy hurt,
- does radiation endanger my family,
- …

Our task it to explaine all steps of preparation and perfoming radiotherapy

- What are tattoos and why are they made,
- how important is reproducibility,
- …

Radiotherapy and ionizing radiation is a terrible monster!

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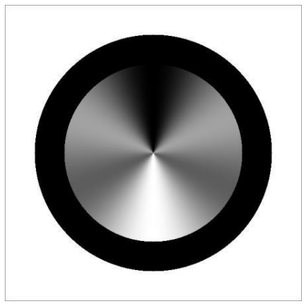
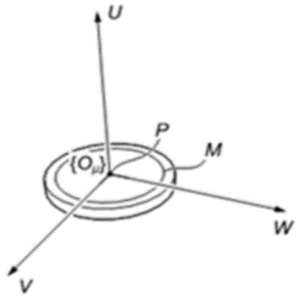
Positioning preparation for DIBH

MaRian Optical System





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Training for DIBH

Training for DIBH

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Before

After

Measurement of mechanical isocenter

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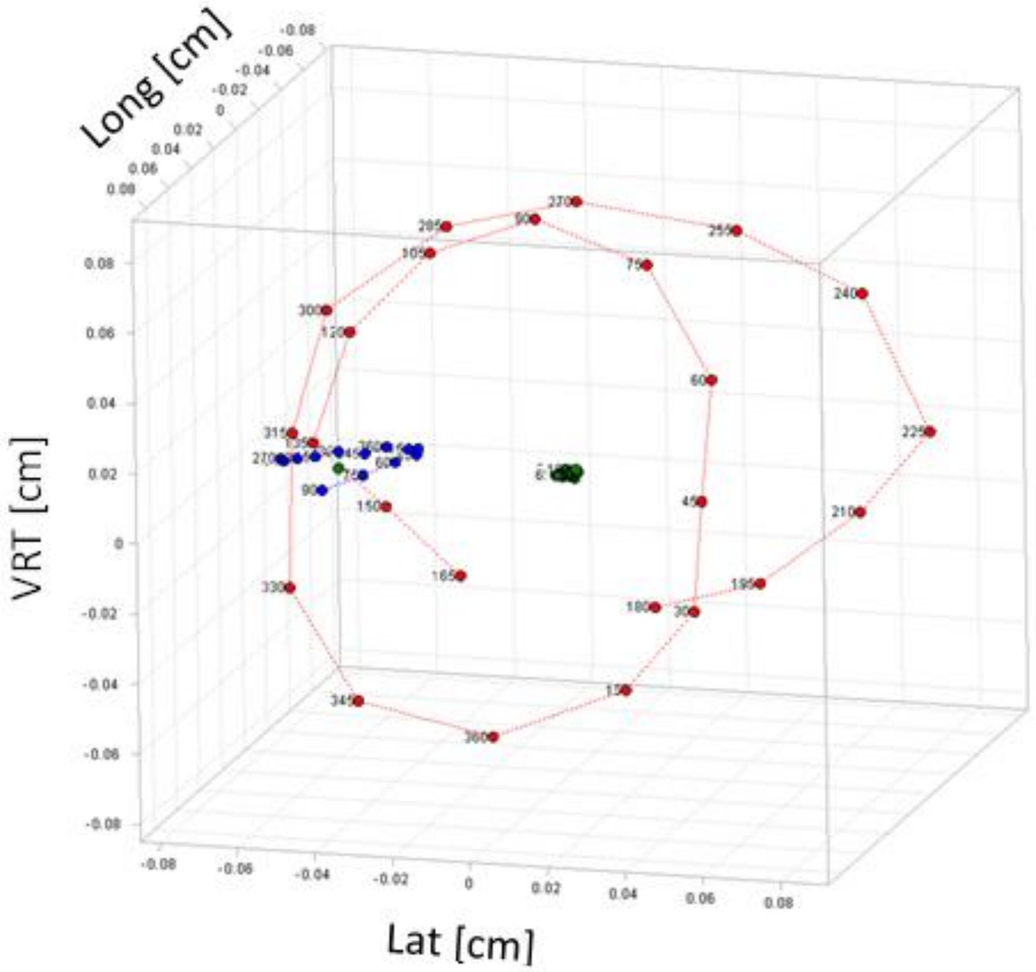
NaviRation optical system

Target

Measurement of mechanical isocenter

Results of measurements in 3D
Red curve – gantry
Blue curve – table
Green curve collimator



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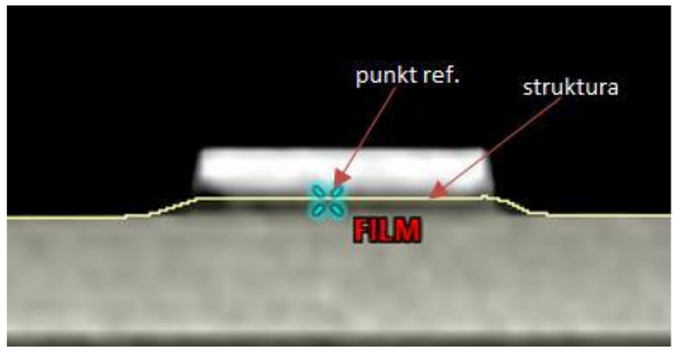
In-vivo detector for VMAT



Program for reading the dose from TPS

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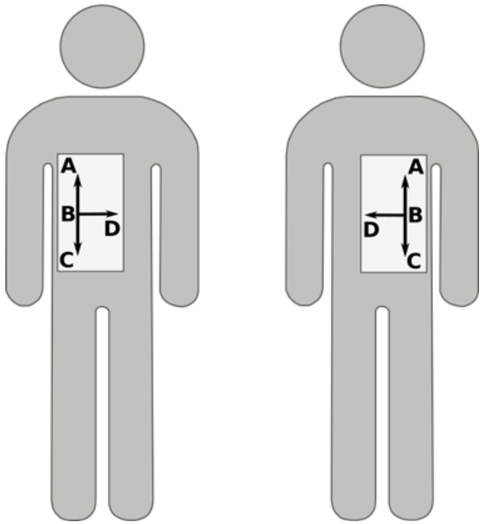
Sarcoma patients treated with VMAT results

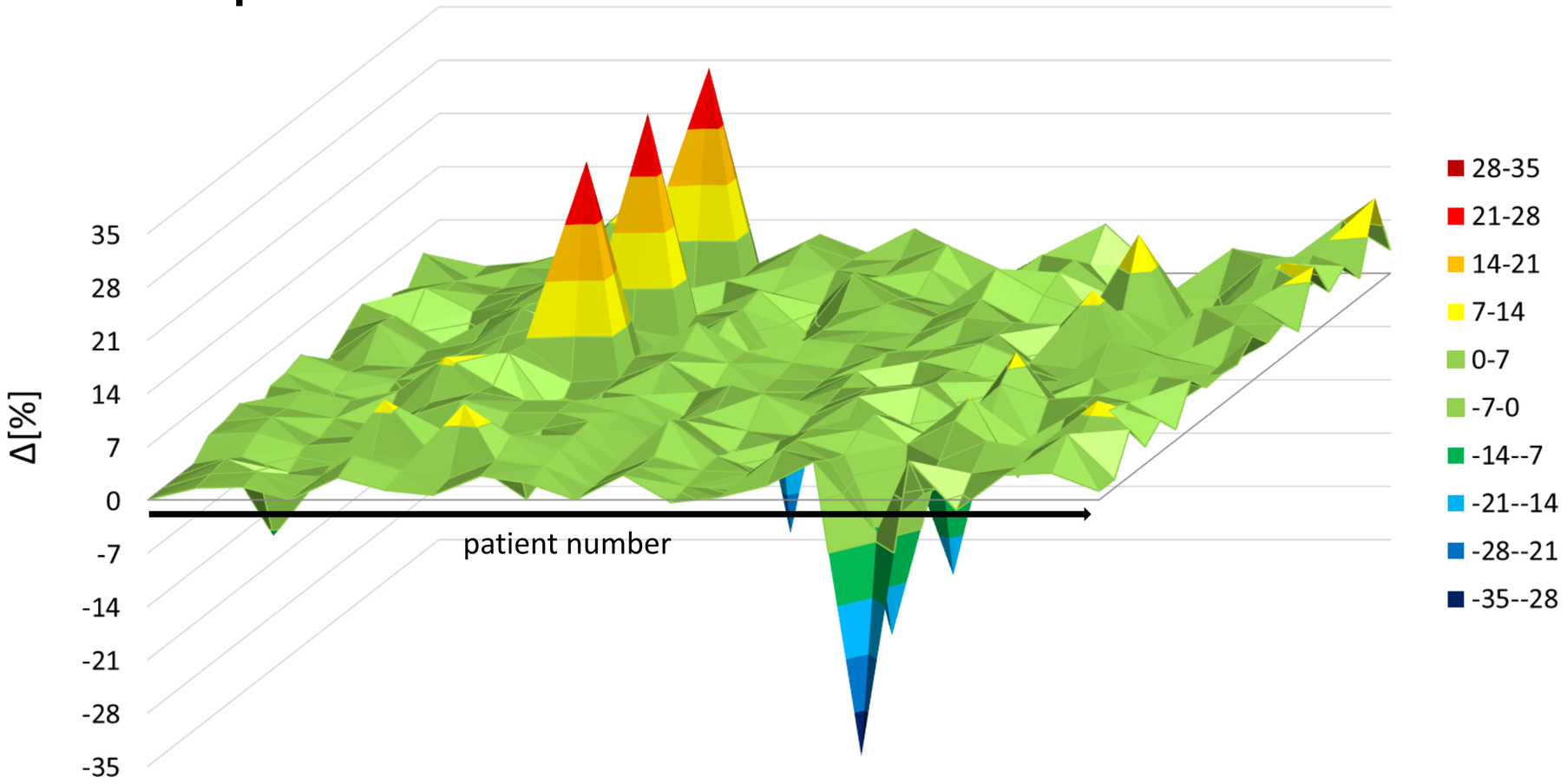
21 patients 98 treatment session

< 7% accepted

in 95,5% of cases $|\Delta_N^{I,J}| < 7\%$

in 85% of cases $\Delta_N^{I,J} > 0$





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Physics is fascinating!

From a human point of view, the environment is no less important !

Thank you for your attention!

autumn is coming