IFMP WORKSHOP IN IONIAN UNIVERSITY, CORFU, GREECE
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RADIATION PROTECTION IN A TREATMENT CENTRE

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AcibademSistina Clinical Center, Skopje, MK

Abstract: Radiation protection as a term and essentially constitutes a devised program that prescribes rules of conduct for people who for some reason are located in the ionization zone and are exposed to ionizing radiation.
Substances that produce ionizing radiation (radioactive substances) are part of the environment that surrounds us, cosmic radiation also touches the world in which we live - that means that every individual on the Earth is more or less exposed to ionizing radiation. Additionally, the modern way of life involves the use of ionizing radiation sources in almost all spheres: industry, medicine, service activities. Natural exposure can not be affected, but exposure originates from man-made radiation sources can be controlled, optimized and minimized. As positive effects of ionizing radiation on biological objects are not known, international standards relating to radiation protection (BSS – Basic Safety Standards) prescribe dose limits for different tissues depending on the type of ionizing radiation they are exposed to.
The main physical quantities used in safety standards are the activity and the absorbed dose. To be able to quantify biological effects of radiation upon tissues the special radiation protection quantities should be introduced: organ dose, defined as the mean dose in a specified tissue or organ of the human body; equivalent dose that defines radiation type effect on the organ dose; effective dose, as the summation of different tissue equivalent doses, each multiplied by particular tissue factor. The ICRU has defined a set of measurable operational quantities for radiation protection purposes: Ambient dose equivalent (for area monitoring) and Personal dose equivalent (for personnel monitoring).

In a medical institution, in a department that uses ionizing radiation sources (radiology, nuclear medicine and radiotherapy) one person can be found as an employee, as a patient or his companion, or a person accidentally present for a completely non-medical reason. According to this, radiation exposures are divided into three categories:
.-1- Occupational exposure - defined as all exposures of workers incurred in the course of their work.
.-2-Medical exposure - defined as the exposure incurred by patients as part of their medical diagnosis or treatment (also by volunteers involved in a program of research or helping in the support and comfort of patients)
.-3 Public exposure - defined as exposure incurred by members of the public. In order to ensure that the embryo or fetus is afforded the same broad level of protection as required for members of the public, pregnant workers are in this category.

In accordance with international recommendations, the country's regulatory body sets the national framework, and the radiation safety officer (RPO) in each medical center provides conditions for how these recommendations would be applicable.
An average radiation therapy center is equipped with machines-linear accelerators that produce high energy (MeV) beams of electron photons or protons. Therefore, in order to implement good radiation protection practice, several preconditions must be done. First, the shielding design of the treatment room should be optimized, taking into account primary and secondary radiation, leakage and scattering. The ambient dose measured in the working area later, after installation of the equipment must be in the frame of the standards. That will ensure that workplace is safe for the workers that perform the treatment.
Further, the acceptance and commissioning tests, as well as the regular quality control of the treatment machine and the treatment planning software (mechanic and dosimetry checks, beam calibration) provide an optimal dose distribution in the body of the treated patient. Means, the basic radiotherapy principle is achieved - high accuracy of the delivered dose in the volume of interest and maximum protection of surrounding healthy tissue in the same time.

As a conclusion, even the risks associated with radiation exposure cannot be eliminated, by following the established radiation protection rules and reaching ALARA (As Low As Reasonable Achievable) principle for minimizing radiation dose, the radiation exposure can be controlled and restricted.

Sonja: Petkovska: Radiation Protection in a Treatment Centre

RADIATION PROTECTION
in
radiotherapy practice

Sonja Petkovska
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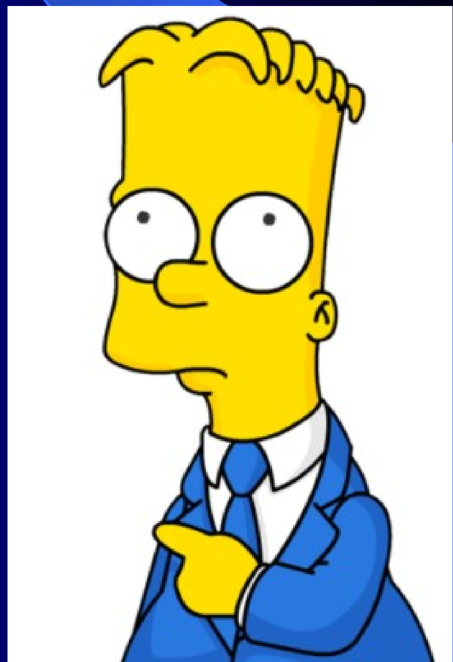
Corfu 2017

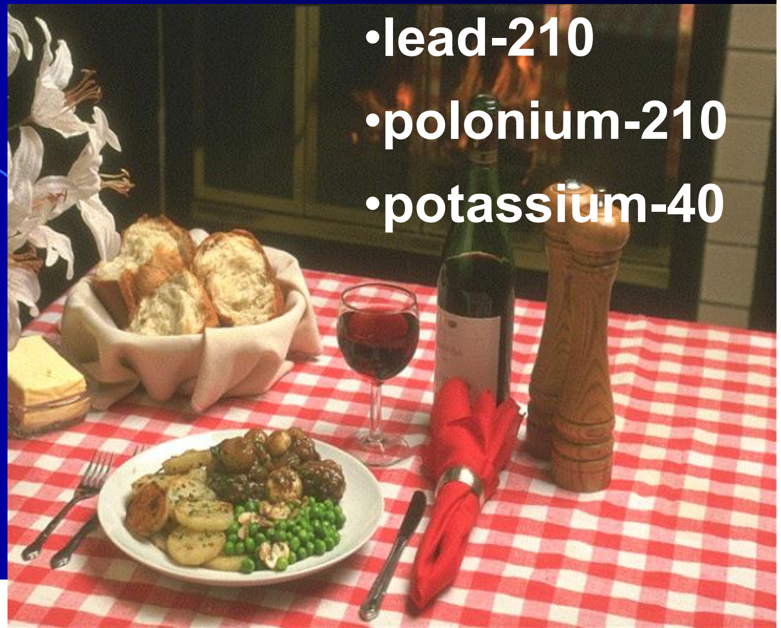
Introduction RADIATION PROTECTION

- as a term and essentially it constitutes a devised program that prescribes rules of conduct for people who for some reason are located in the ionization zone and are exposed to ionizing radiation

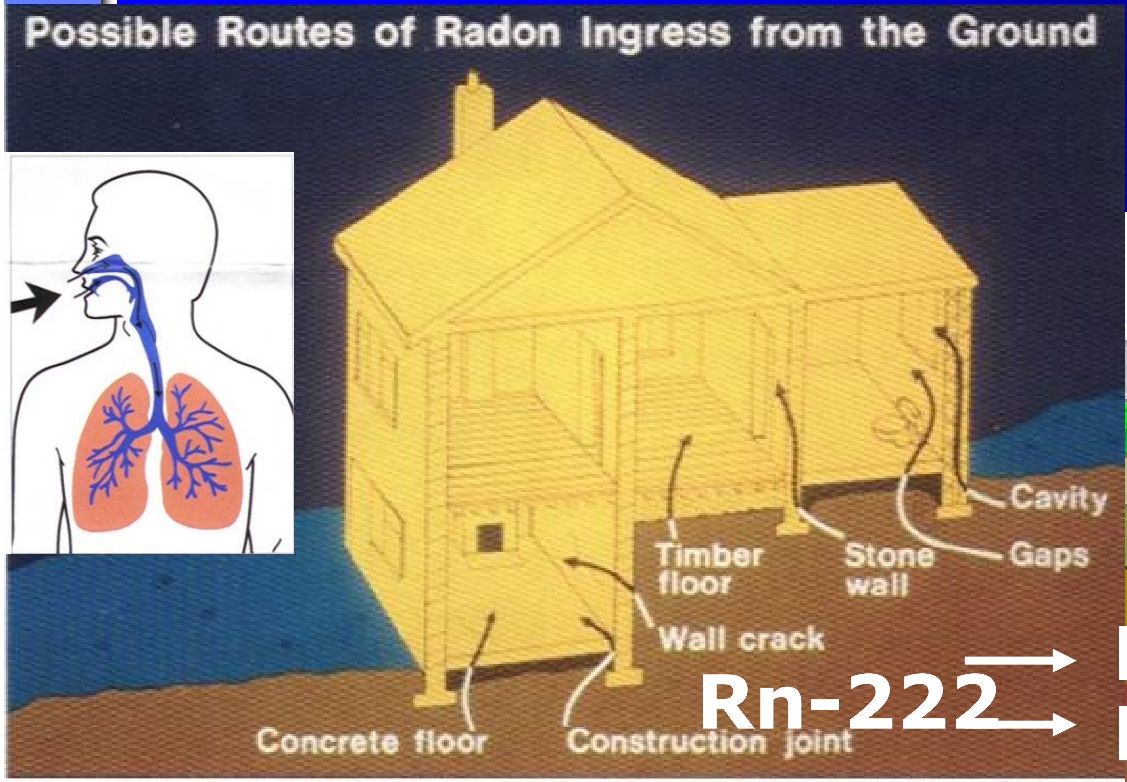


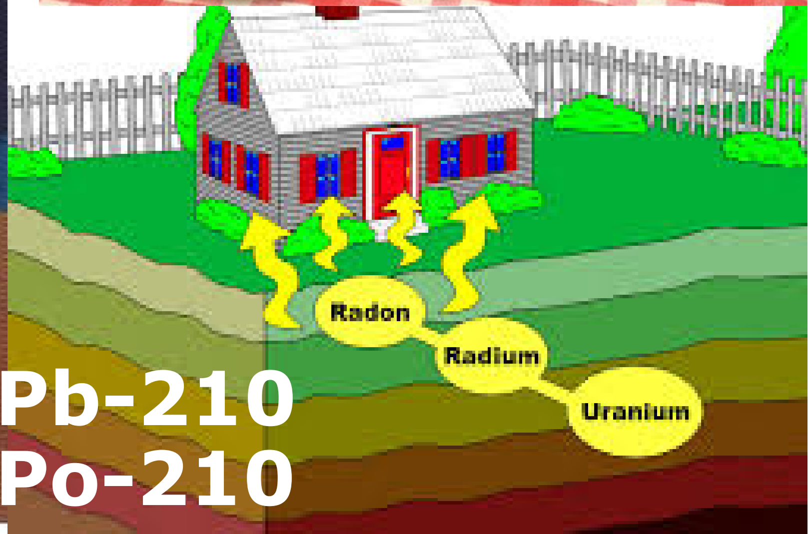
Introduction IONIZING RADIATION

- Substances that produce ionizing radiation (radioactive substances) are part of the environment that surrounds us



- lead-210
- polonium-210
- potassium-40



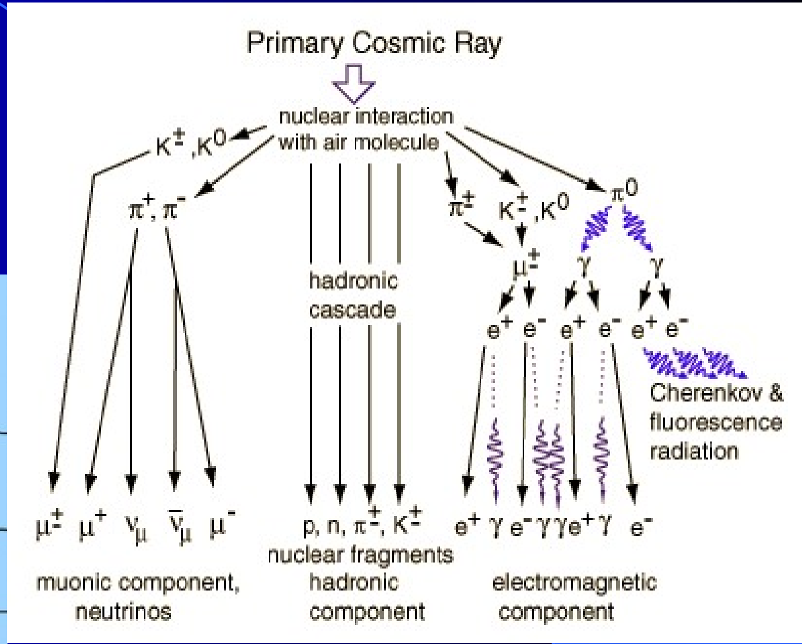


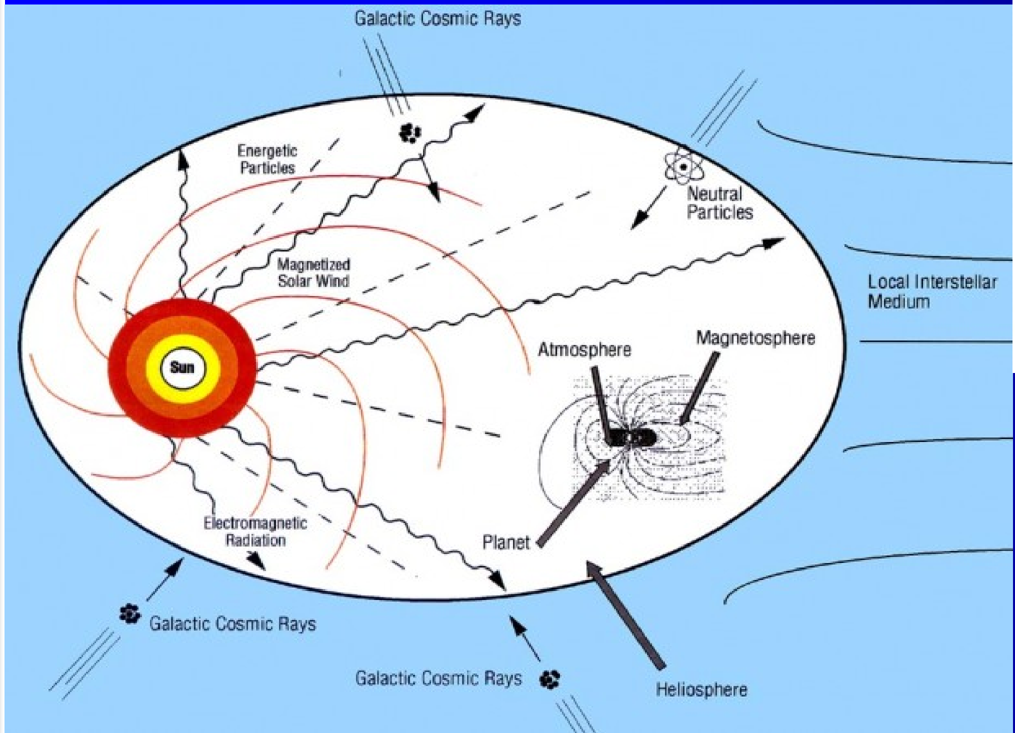
Rn-222 → Pb-210

Rn-222 → Po-210

Introduction IONIZING RADIATION

- Cosmic radiation also touches the world in which we live





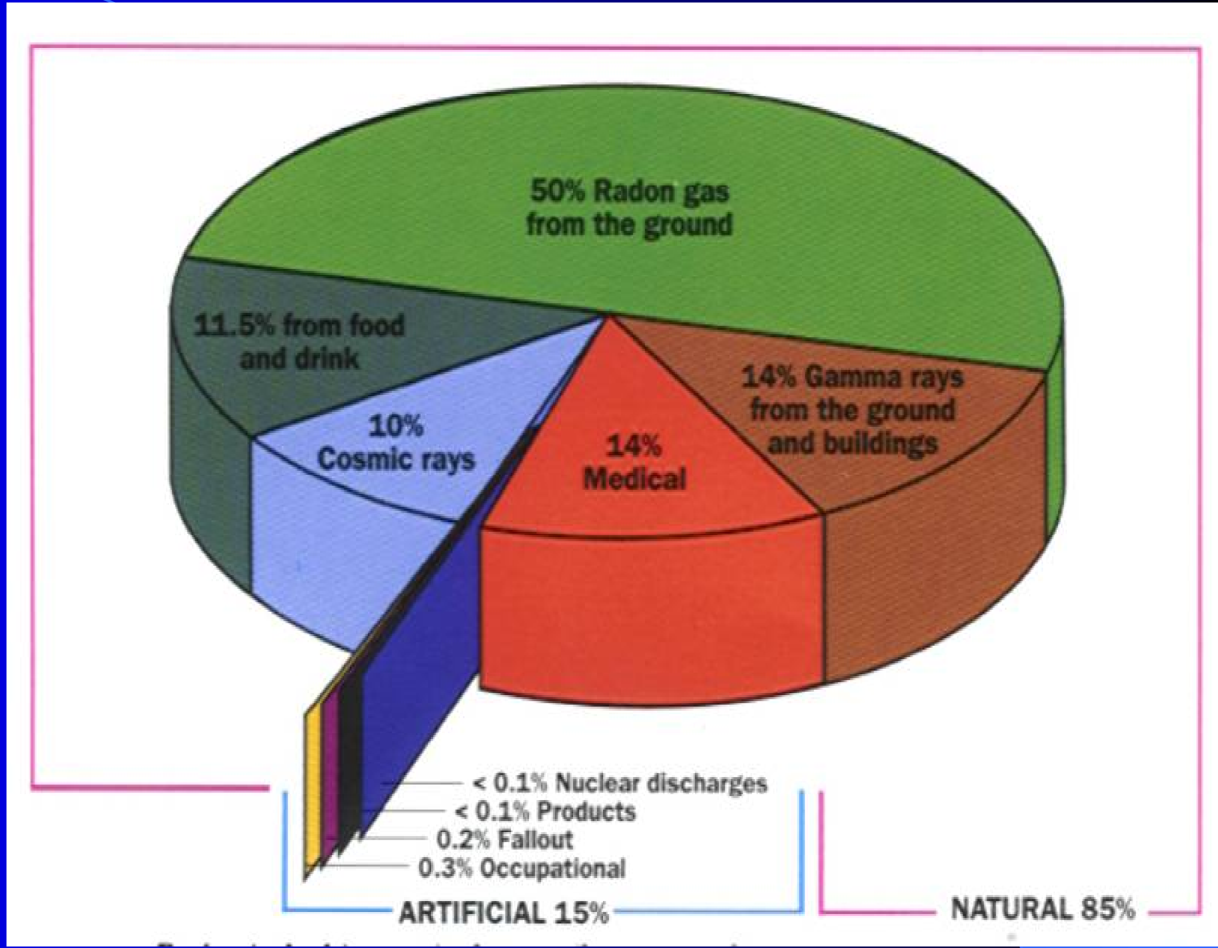
Introduction IONIZING RADIATION

- Additionally, the modern way of life involves the use of ionizing radiation sources in almost all spheres:

  - industry
  - medicine
  - service activities
  - research…

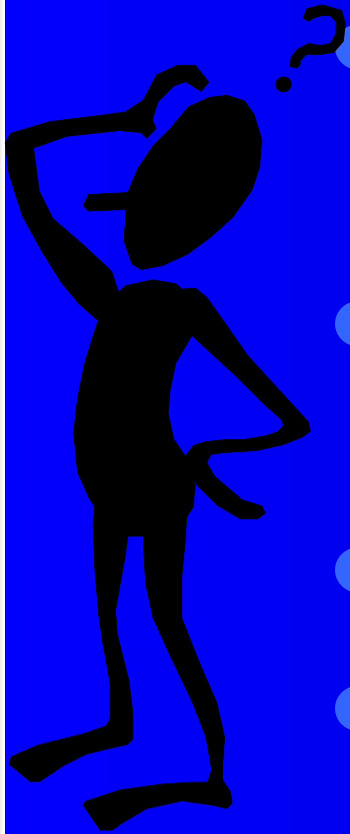
Introduction IONIZING RADIATION

- MEANS



every individual on the Earth is more or less exposed to ionizing radiation.

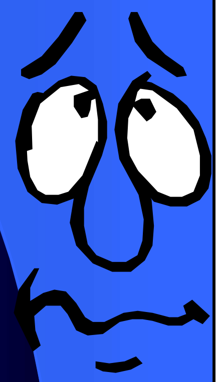
Why RADIATION PROTECTION is needed



- Diagnostic Radiology
  - CT, MRI, mammography, rtg, echography
- Interventional Radiology
  - angiography, coronagraphy…
- Nuclear Medicine
- Radiotherapy

BIOLOGICAL EFFECTS

- Positive effects of ionizing radiation on biological objects are not known
- The effects (damage) could be
  - Deterministic (threshold of the dose)
  - Stochastic (probability increases with the dose increasing)



RADIATION PROTECTION QUANTITIES

- The main physical quantities used in safety standards are the activity and the absorbed dose.
- To be able to quantify biological effects of radiation upon tissues the special radiation protection quantities should be introduced:
  - equivalent dose that defines radiation type effect on the organ dose;
  - effective dose, as the summation of different tissue equivalent doses, each multiplied by particular tissue factor (risk related to radiation exposure to the whole body)

RADIATION PROTECTION QUANTITIES

- The ICRU has defined a set of measurable operational quantities for radiation protection purposes: Ambient dose equivalent (for area monitoring) and Personal dose equivalent (for personnel monitoring).

RADIATION EXPOSURE

- In a medical institution, in a department that uses ionizing radiation sources (radiology, nuclear medicine and radiotherapy) one person can be found as an employee, as a patient or his companion, or a person accidentally present for a completely non-medical reason. According to this, radiation exposures are divided into three categories:

RADIATION EXPOSURE

- Occupational exposure - defined as all exposures of workers incurred in the course of their work
- Medical exposure - defined as the exposure incurred by patients as part of their medical diagnosis or treatment (also by volunteers involved in a program of research or helping in the support and comfort of patients)
- Public exposure - defined as exposure incurred by members of the public.
- In order to ensure that the embryo or fetus is afforded the same broad level of protection as required for members of the public, pregnant workers are in this category

RADIATION PROTECTION

- In accordance with international recommendations, the country's regulatory body sets the national framework, and the radiation safety officer (RPO) in each medical center provides conditions for how these recommendations would be applicable.
- How it can be achieved?

QA Management system

- QA protocols, establishing and following

RADIATION PROTECTION

- in order to implement good radiation protection practice, several preconditions must be done
  - Proper shielding design
  - Accelerator QA
  - Whole equipment QA (TPS; dosimetry tools…)
  - Individual patientQA

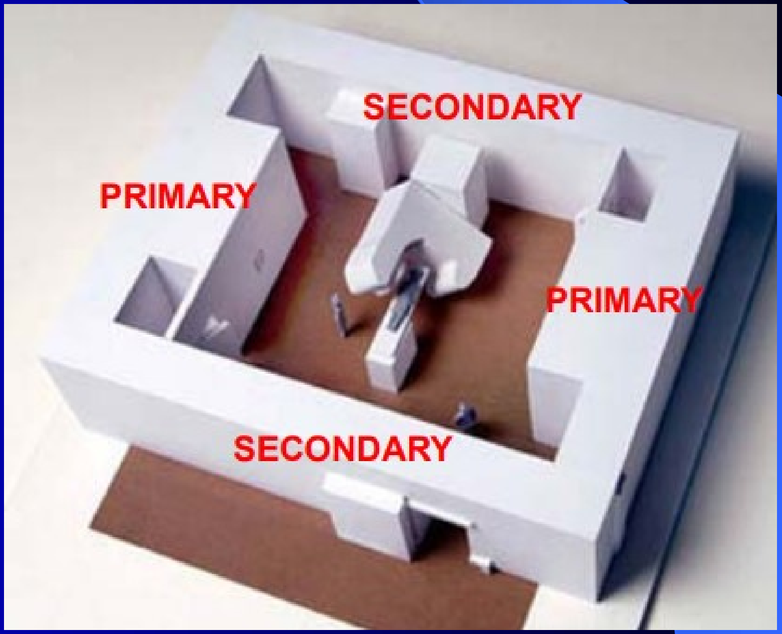
RADIATION PROTECTION

- An average radiation therapy center is equipped with machines-linear accelerators that produce high energy (MeV) beams of electron, photons or protons

SHIELDING design

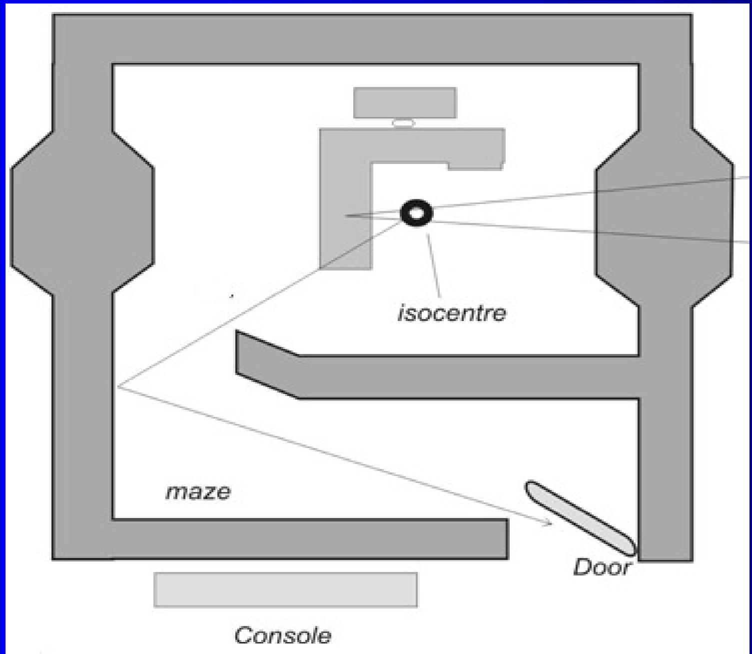
- First, the shielding design of the treatment room should be optimized, taking into account primary and secondary radiation, leakage and scattering.

- The purpose is to reduce the outside point dose to the level determined by the regulations



SHIELDING design

- Plan of the bunker (dimension, position of the machine in the room, min. distance of the isocenter to the wals roof and floor…)
- Machine specification (isocenter position, max. energy)
- Plan of the surrounded areas in each direction



SHIELDING design

- P - design goal

  = 5 mSv/year for controlled area

  = 1 mSv/year for public area

- T - occupancy factor

Location	(T)
Full occupancy areas (areas occupied full-time by an individual), e.g., administrative or clerical offices; treatment planning areas, treatment control rooms, nurse stations, receptionist areas, attended waiting rooms, occupied space in nearby buildings	1
Adjacent treatment room, patient examination room adjacent to shielded vault	1/2
Corridors, employee lounges, staff rest rooms	1/5
Treatment vault doors	1/8
Public toilets, unattended vending rooms, storage areas, outdoor areas with seating, unattended waiting rooms, patient holding areas, attics, janitor’s closets	1/20
Outdoor areas with only transient pedestrian or vehicular traffic, unattended parking lots, vehicular drop off areas (unattended), stairways, unattended elevators	1/40

data from NCRP #151

SHIELDING design

- U - use factor is fraction of a primary beam workload directed toward primary barrier
- W- workload is average dose in Gy delivered per week
- TVL - Tenth Value Layer (for particular shielding material)

Primary TVL (cm)

E (MeV)	**4**	**6**	**10**	**15**	**18**	**20**
concrete	35 (30)	37 (33)	41 (37)	44 (41)	45 (43)	46 (44)
steel	9.9	10	11	11	11	11
lead	5.7	5.7	5.7	5.7	5.7	5.7

data from NCRP #151

SHIELDING design

$$B_p = \frac{Pd^2}{WUT}$$

$$B_s = \frac{P}{aWT} d^2_{sec} d^2_{sca} \frac{400}{F}$$

$$B_l = \frac{1000 * Pd_l^2}{WT}$$

- **B** is barrier transmision factor
- **n** is number of TVL required to reduce the dose to P value

$$n = -\log_{10}(B)$$

$$T =_{p,l} TVL_1 + (n-1)_{p,l} TVL_e$$

data from NCRP #151

SHIELDING design

- The ambient dose measured in the working and public areas later, after installation of the equipment must be in the frame of the stan

- The shielding design must provide that occupational and public exposure is under the limits.

PATIENT RADIATION PROTECTION

- Optimal shielding design directly effect radiation protection of the workers (mainly technologists and physicist that spend a lot of time into control room

- What about patient radiation protection? Is that exists in radiotherapy?

PATIENT RA

Accidents

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Fatal Radiation

Software problems and poor quality control at St. Vincent's Hospital cause a fatal overdose. Related Article »

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March 16, 2005
Mr. Jerome-Parks's medical physicist ran a series of tests on the equipment. All of them showed that the collimator was wide o and the hospital reali a serious overdose o radiation had been administered.

HOWLIFEWORKS.COM

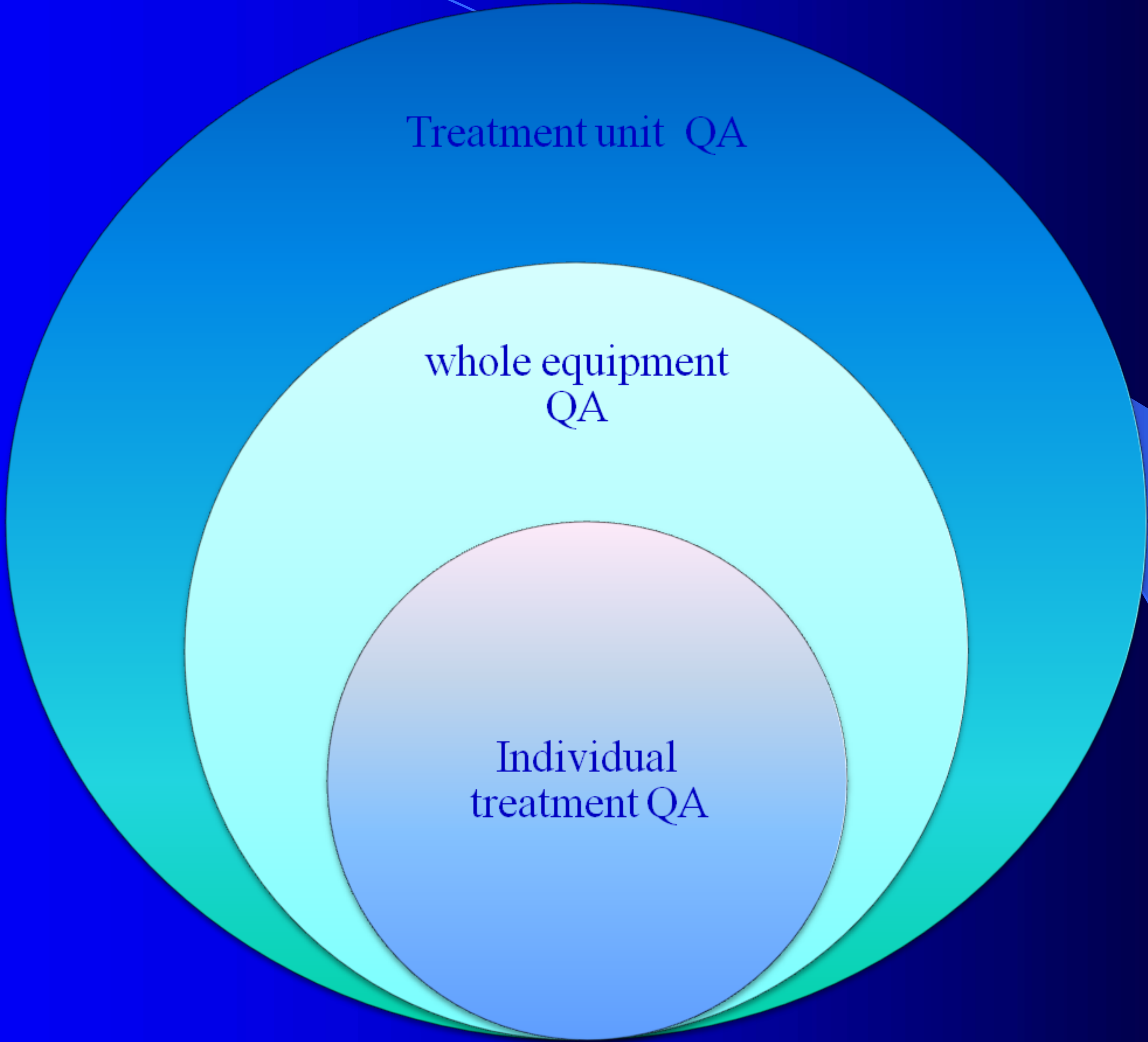
lth today announced that it has discovered that 76 pat specific type of treatment for brain tumors and other difficult-to-treat stereotactic radiation therapy system, were accidentally exposed to rad d the intended, therapeutic dose. The average variation of all the treatm ed the prescribed dose by approximately 50 percent. A variation on the delivered dose of up to 10 percent is not significantly different than the prescribed dose and is considered no more risky than the prescribed treatment.

IA

The BrainLAB stereotactic system utilizes a high dose of precisely targeted radiation to be delivered to smaller areas within the brain and other organs in the body, minimizing damage to surrounding tissues. This treatment is called stereotactic radiation therapy.

who would take care of your family?

Radiotherapy QA program

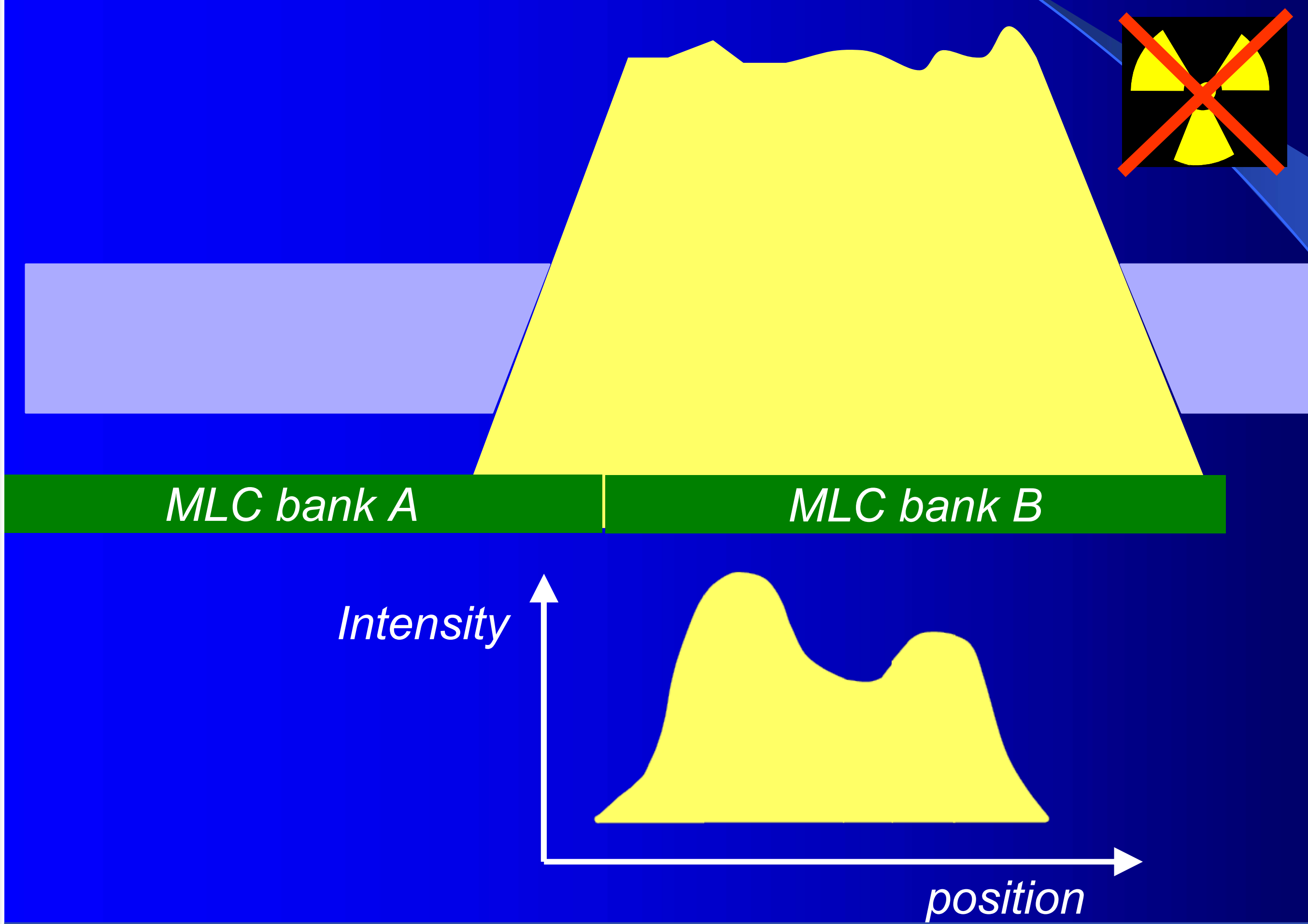


Commissioning

Prepare the unit for clinical use:
- measure necessary parameters
- use them as reference values for calculation

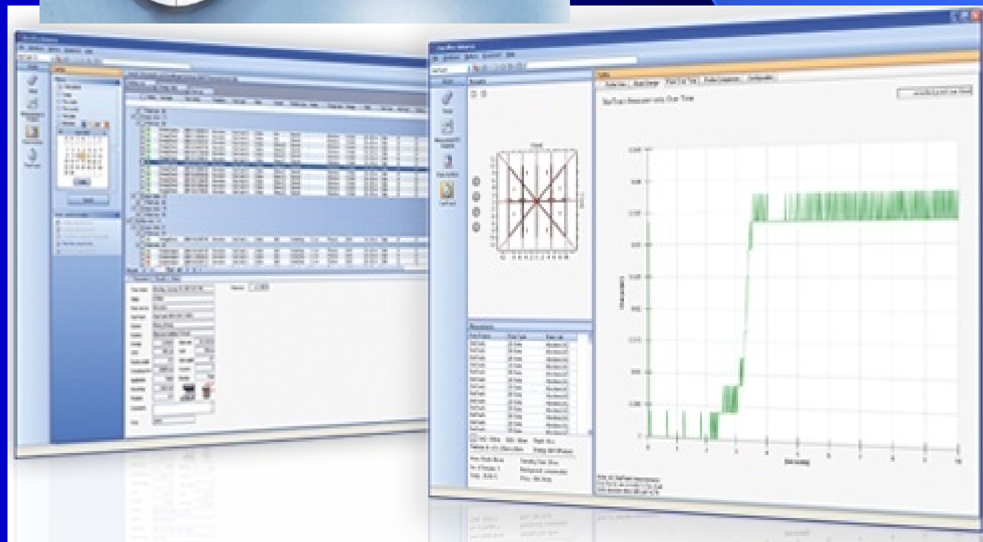
Calibration and Dosimetry checks

Periodically measurements of these parameters, comparing with the reference values and calibrate them if necessary


MLC bank A
MLC bank B
Intensity
position

Calibration in Radiotherapy

water phantom, ionizing chambers, electrometers, software for data collecting and analyzing… should also be calibrated



Calibration in Radiotherapy

Calibrate the unit on the way to have:

- minimal geometrical uncertainties
- dose received to the tumor as it was prescribed
- dose delivered into health tissue being as predicted

How we are sure that the delivered dose is the same as the predicted one?

Delivered dose accuracy depends on:

-machine functionality,
-beam calibration errors
-calculation algorithm uncertainty

How we are sure that the dose is delivered at the right place?

Delivered dose accuracy depends on:

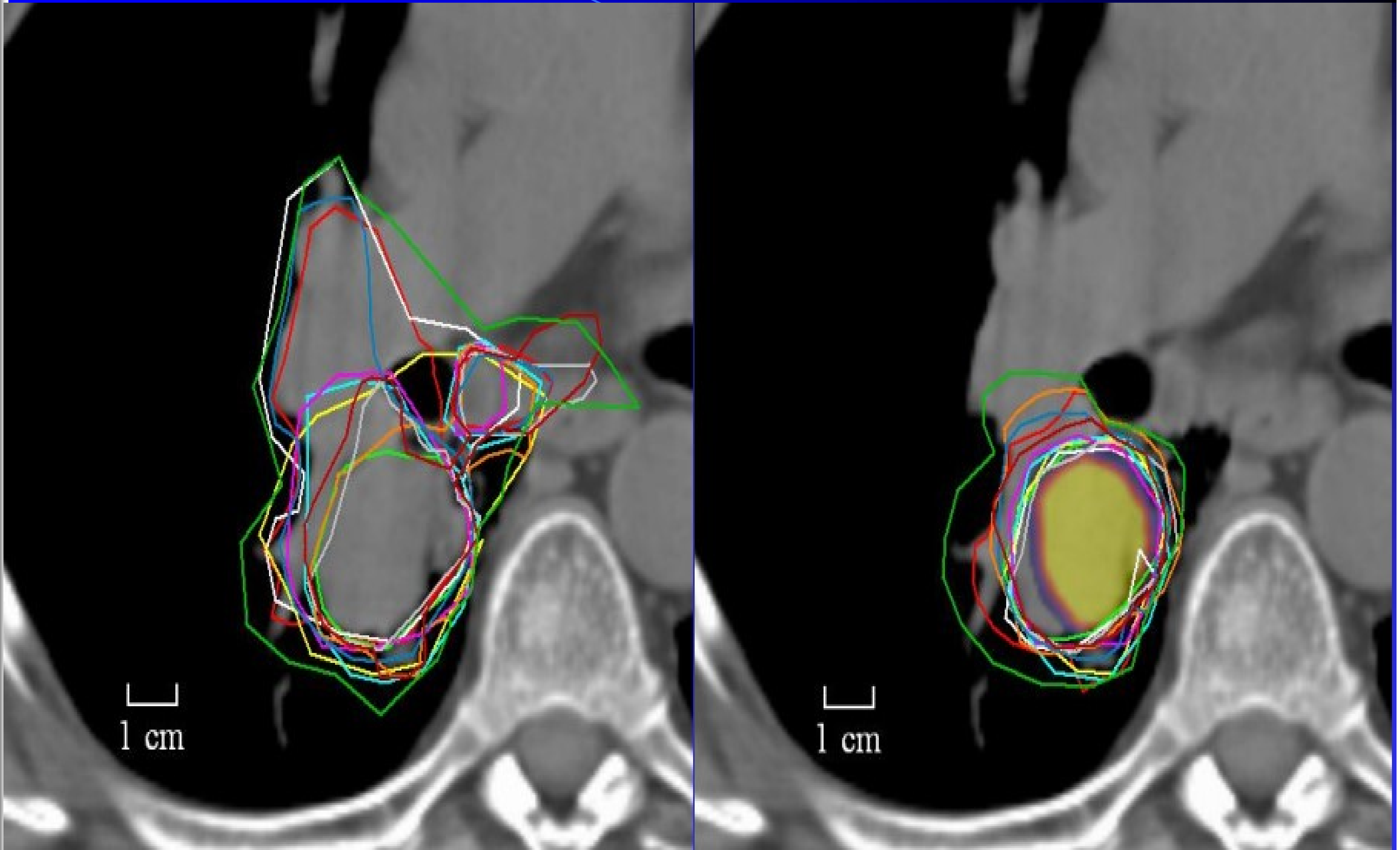
-patient position errors
- volume of interest delineation precision

How we are sure that the delineation is correct?

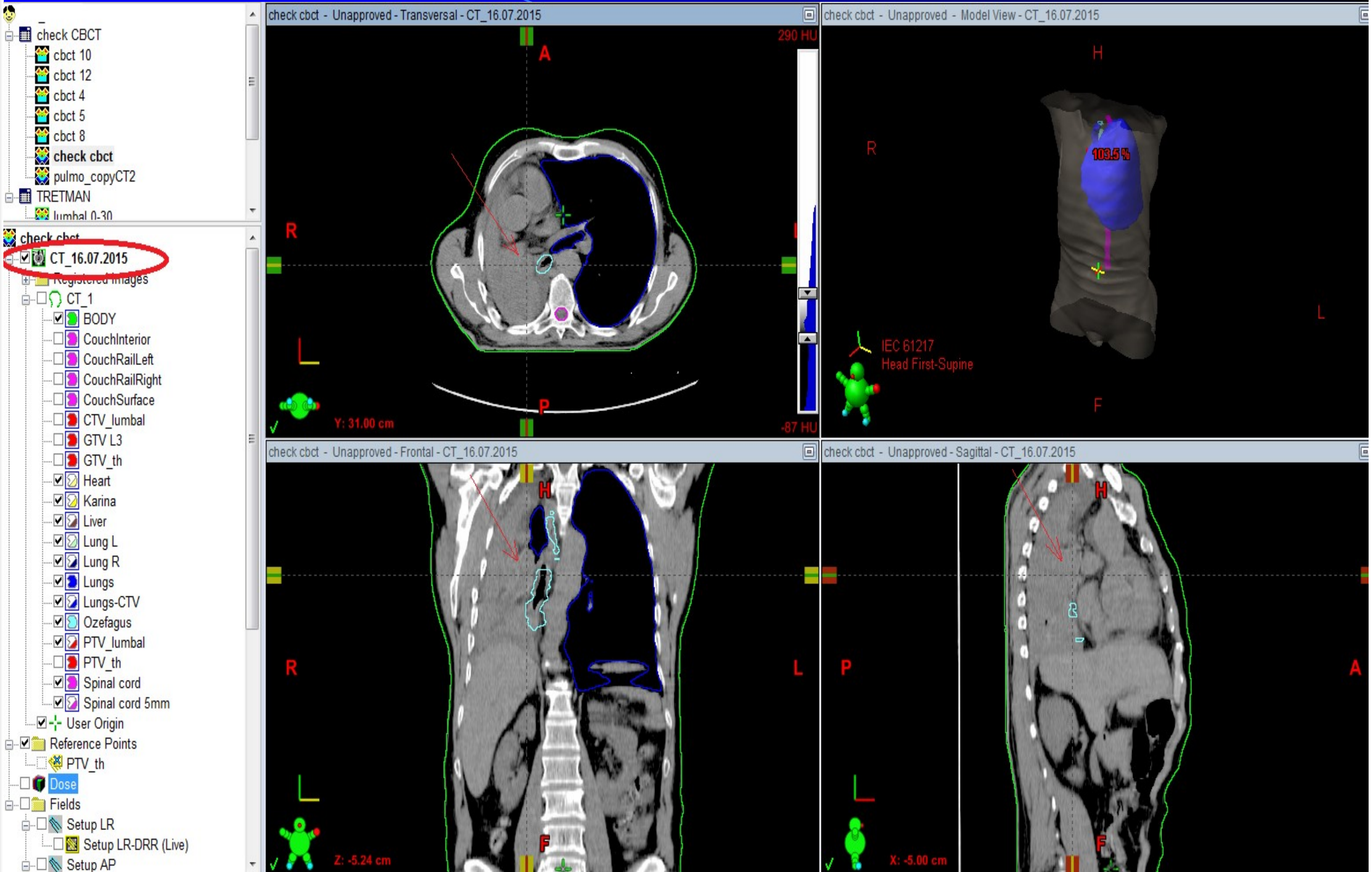
Delineation accuracy depends on:

- tumor tissue visibility
- radiation oncologist experience

CONTURING



TREATMENT PLANING



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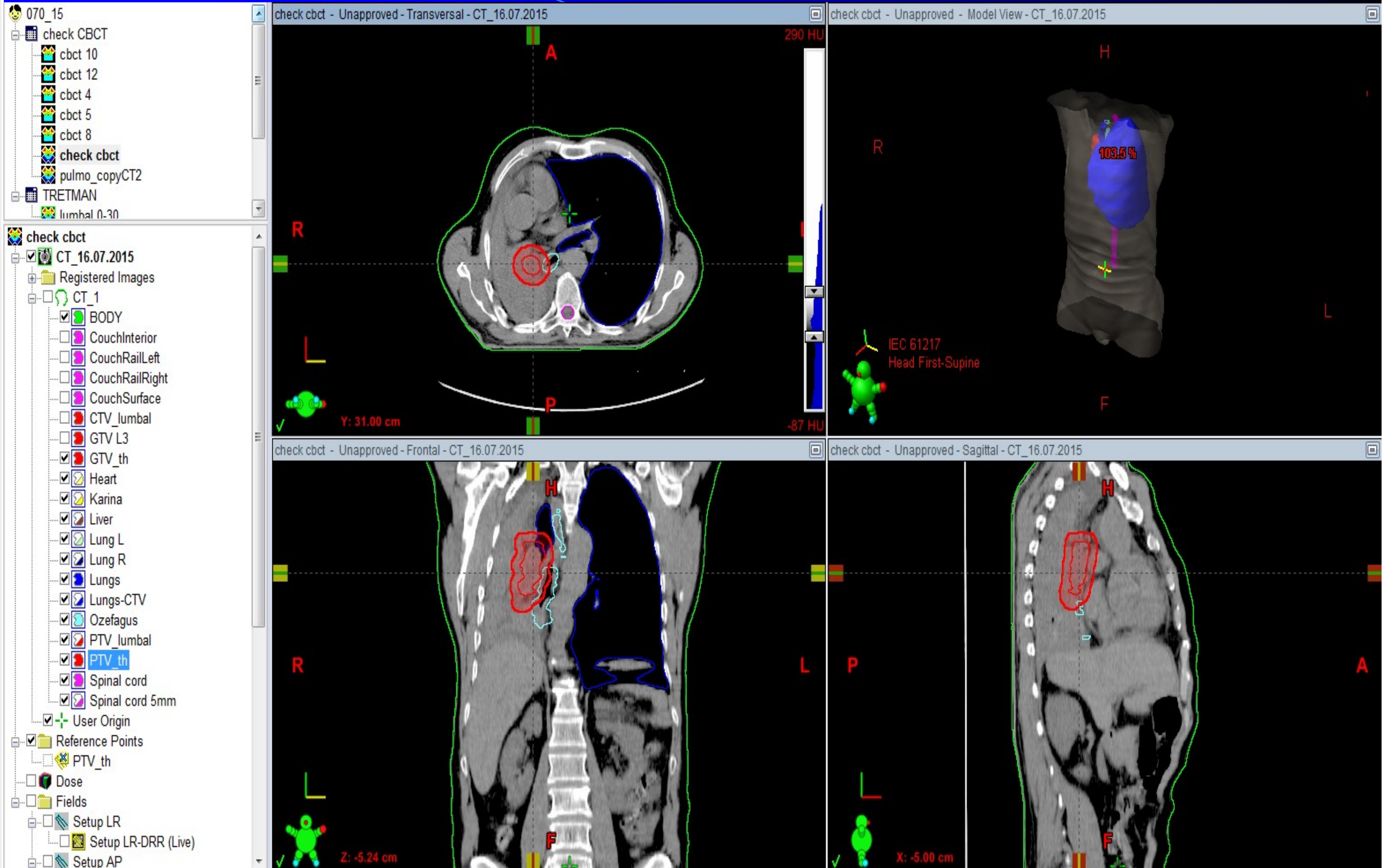

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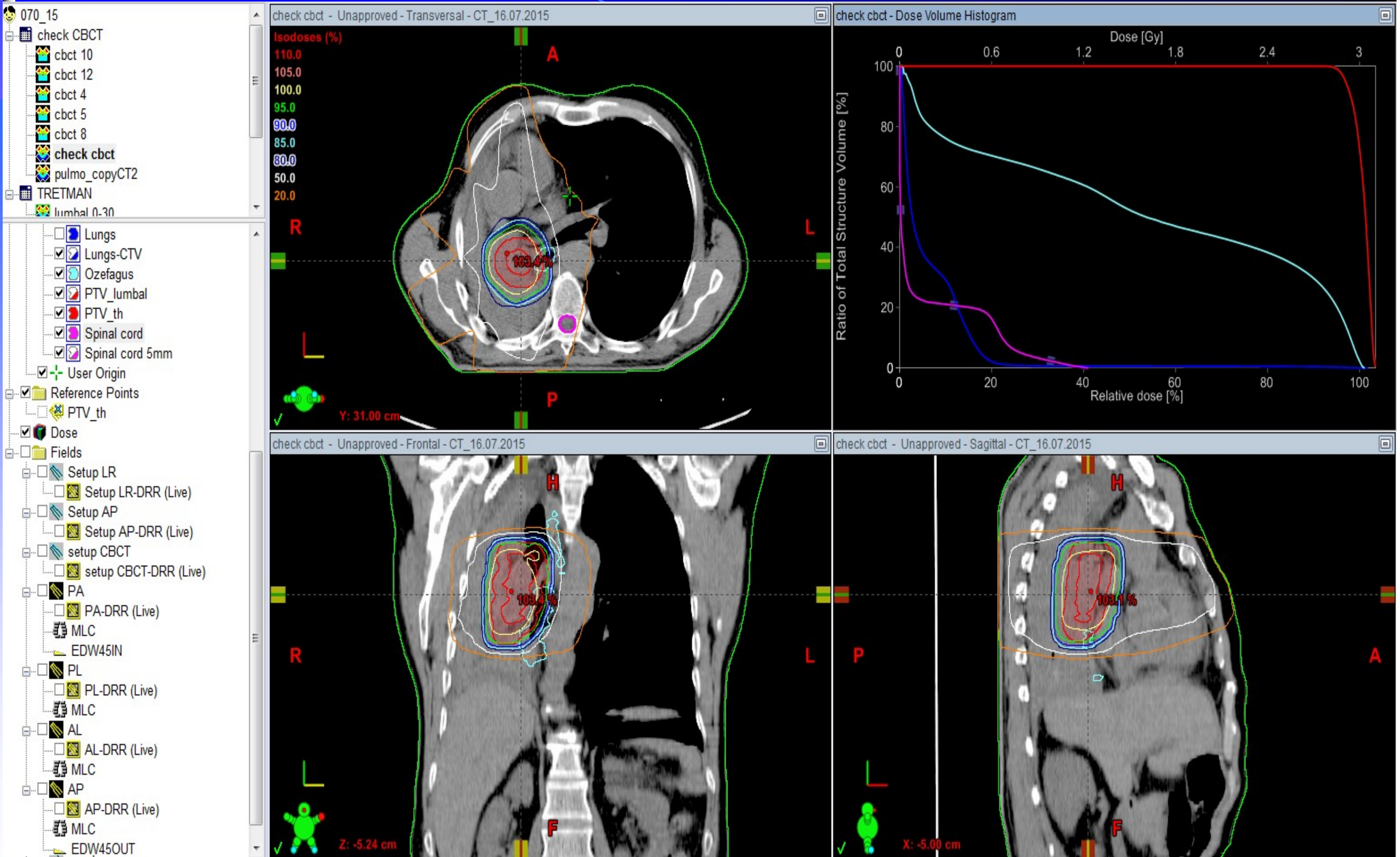

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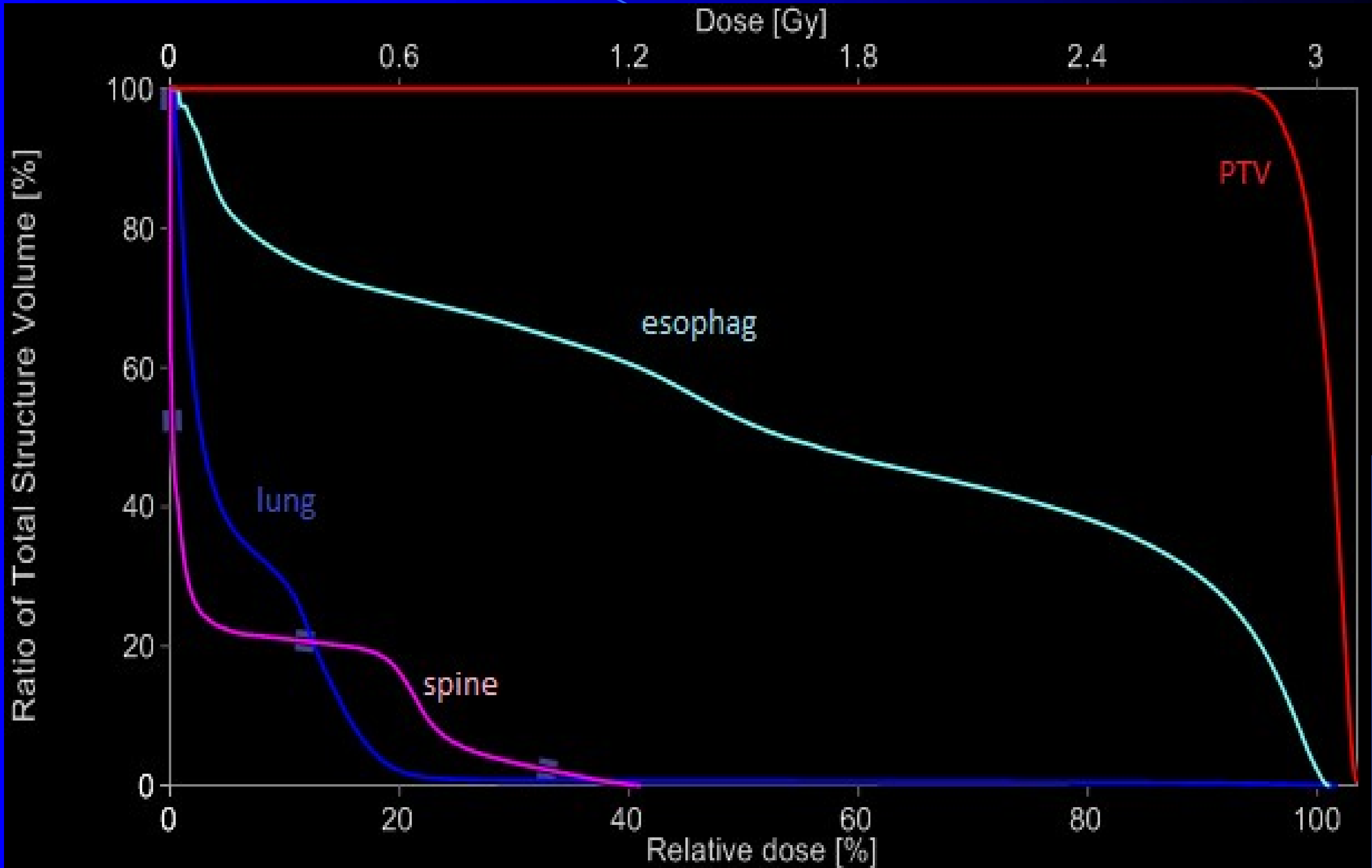
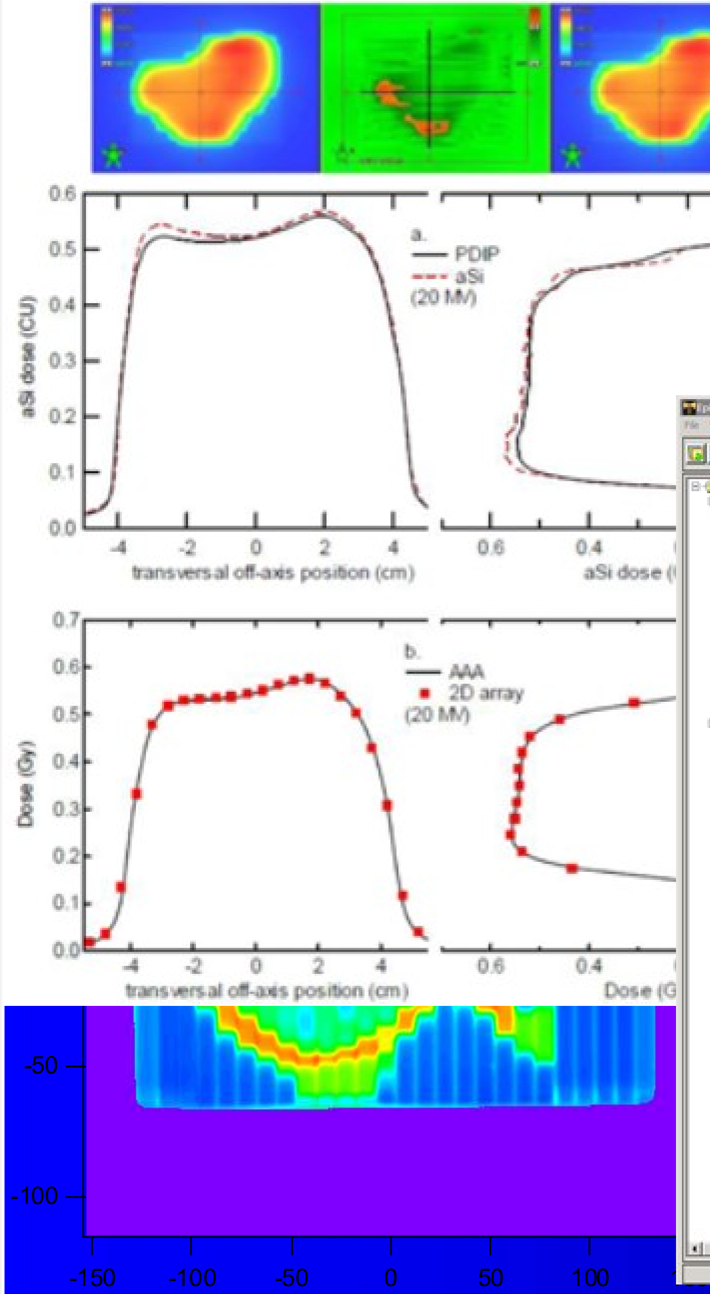
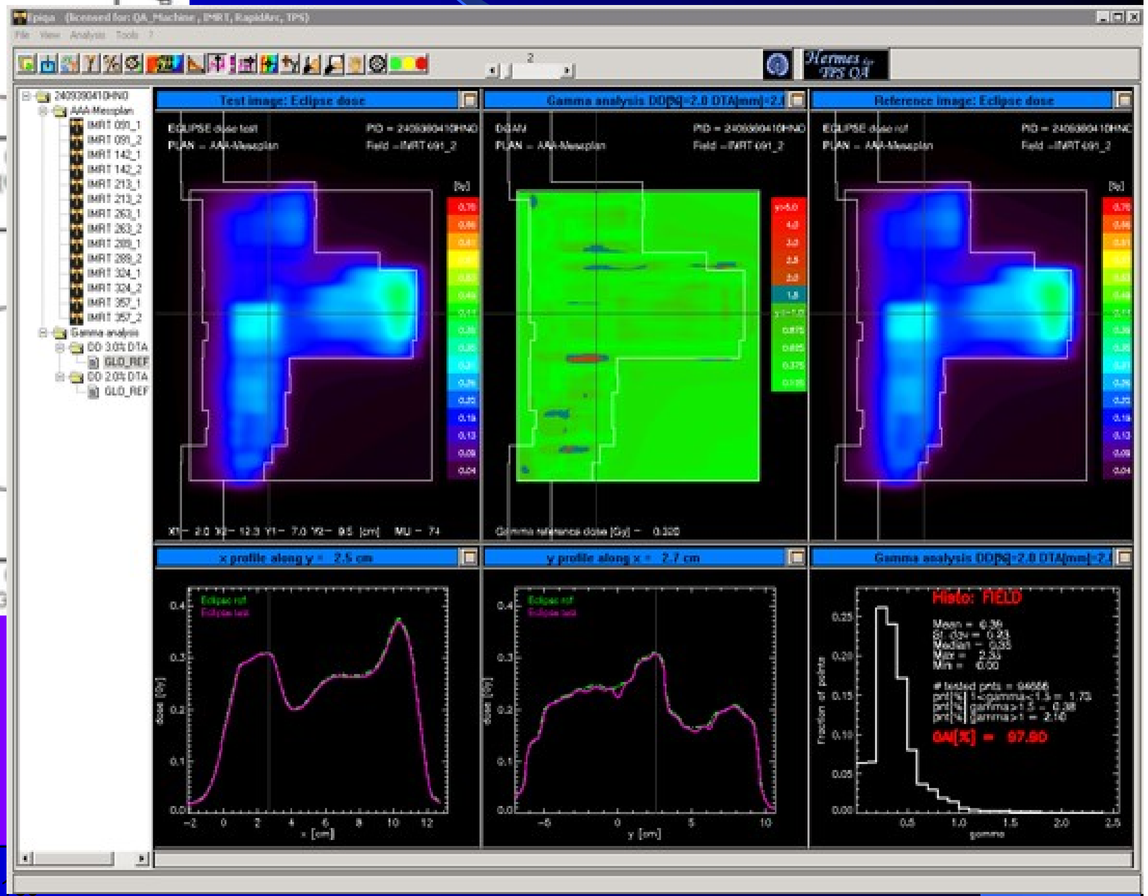


PLAN VERIFICATION





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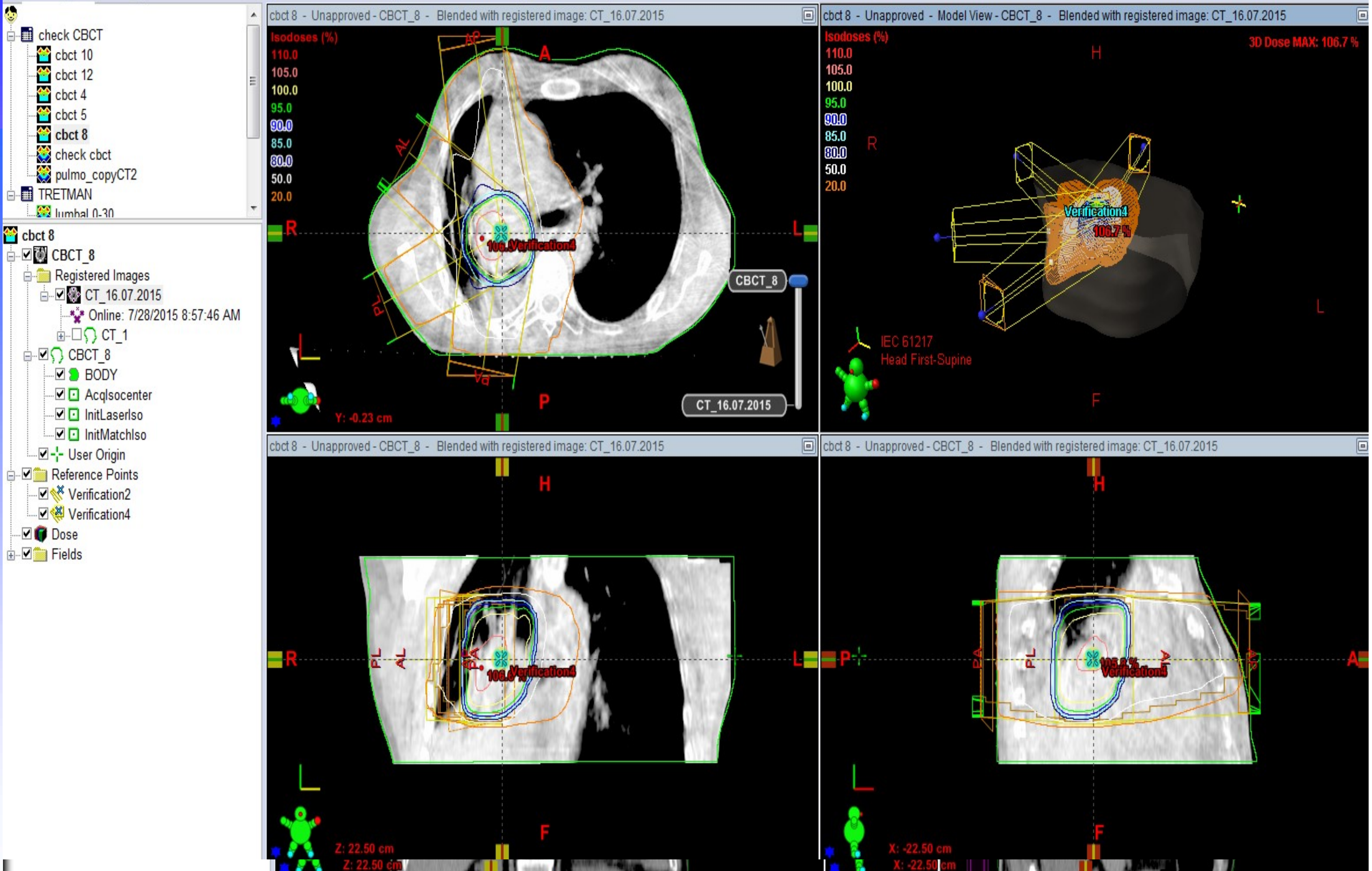

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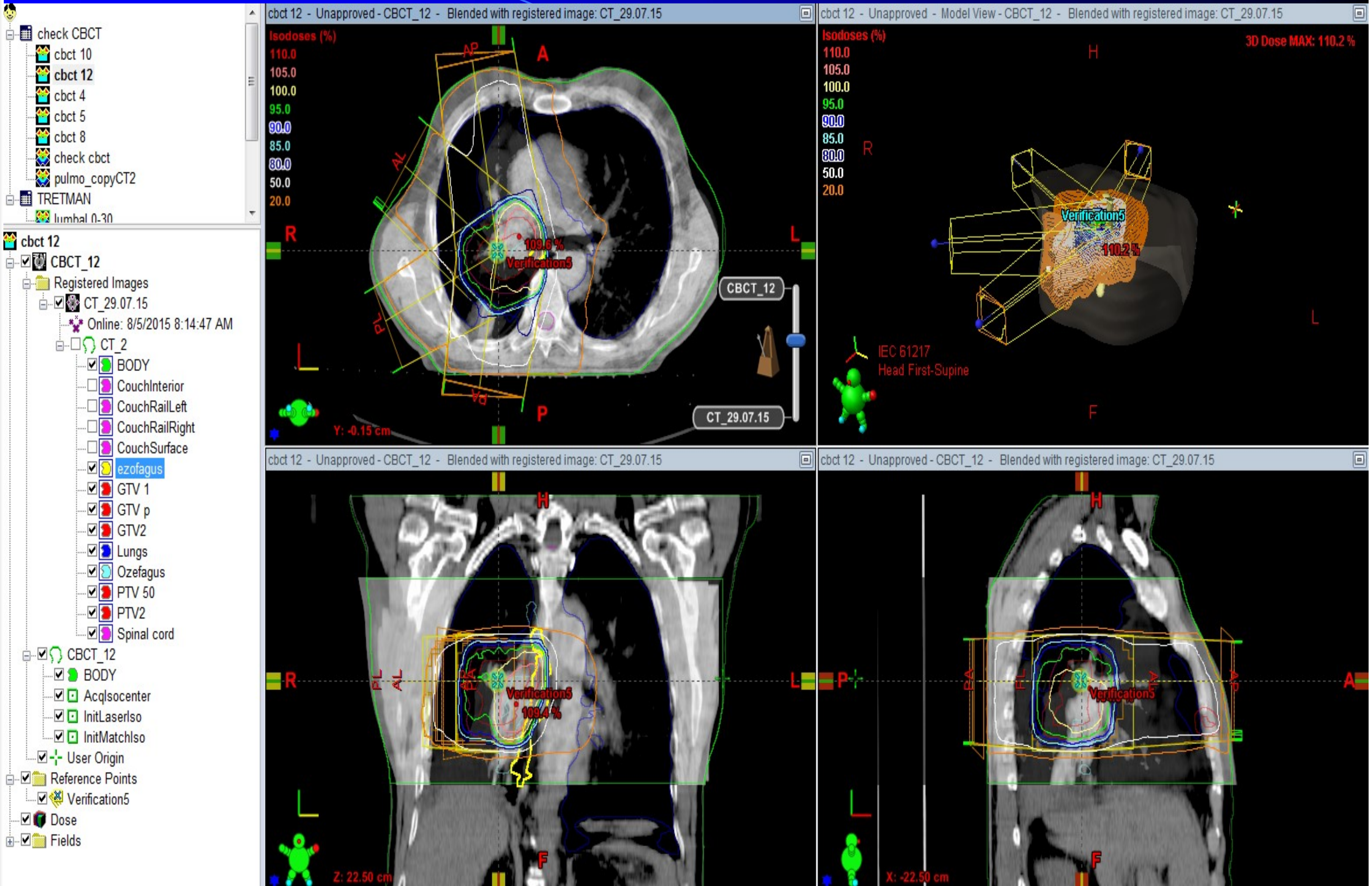

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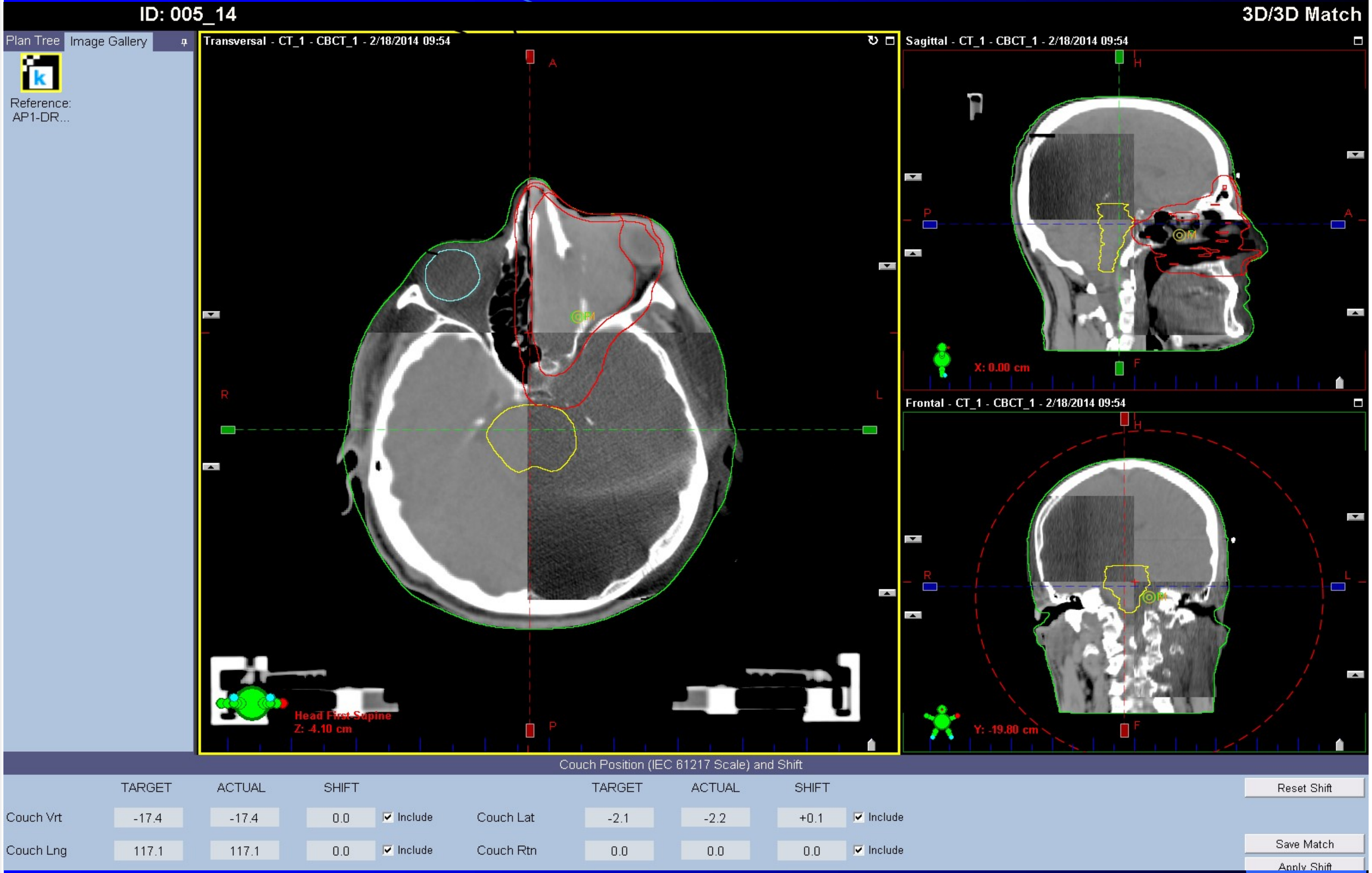
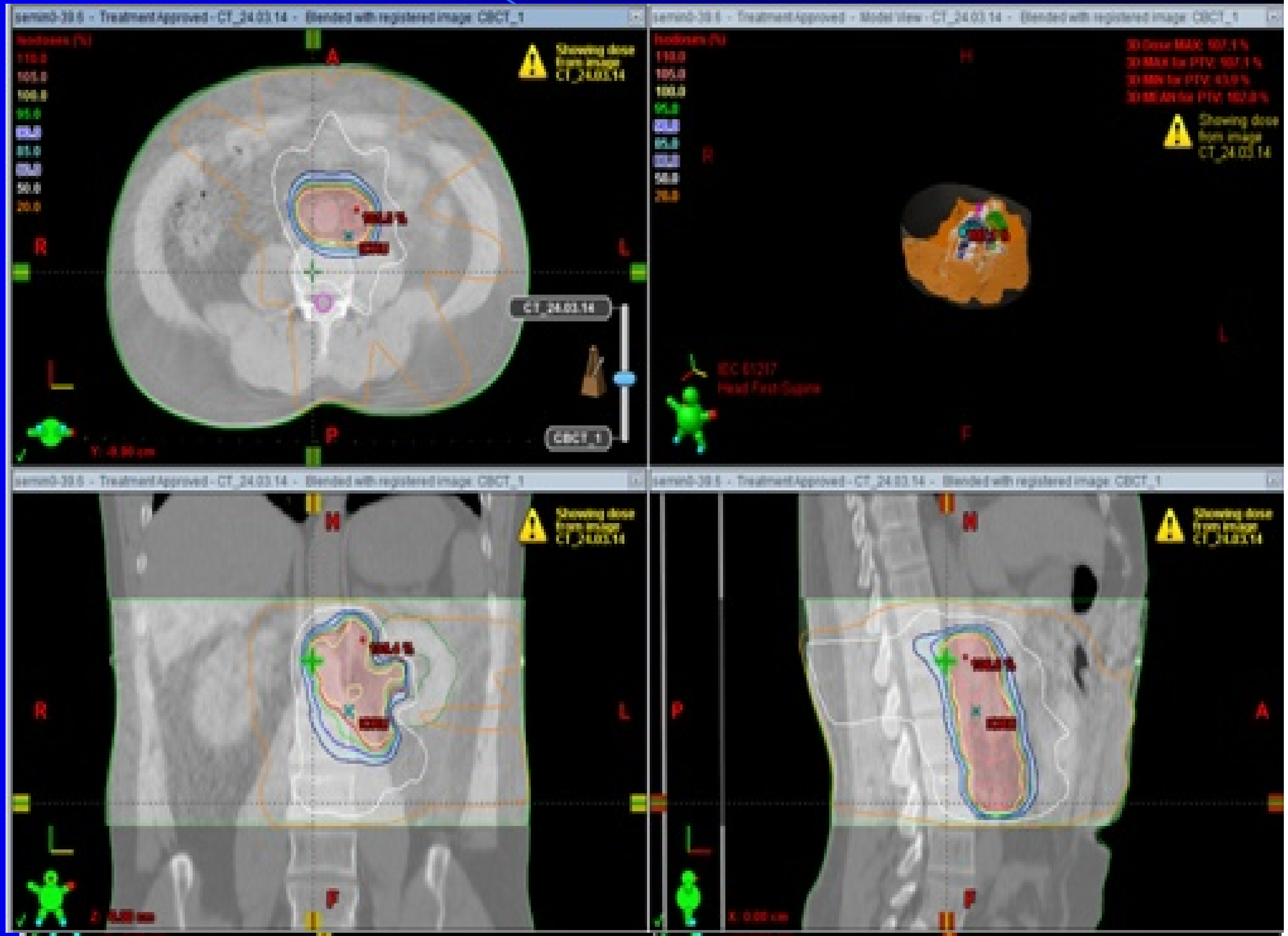


TREATMENT EVALUATING



CONCLUSION

- even the risks associated with radiation exposure cannot be eliminated, by following the established radiation protection rules and reaching ALARA (As Low As Reasonable Achievable) principle for minimizing radiation dose, the radiation exposure can be controlled and restricted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