Completion of Treatment Planning

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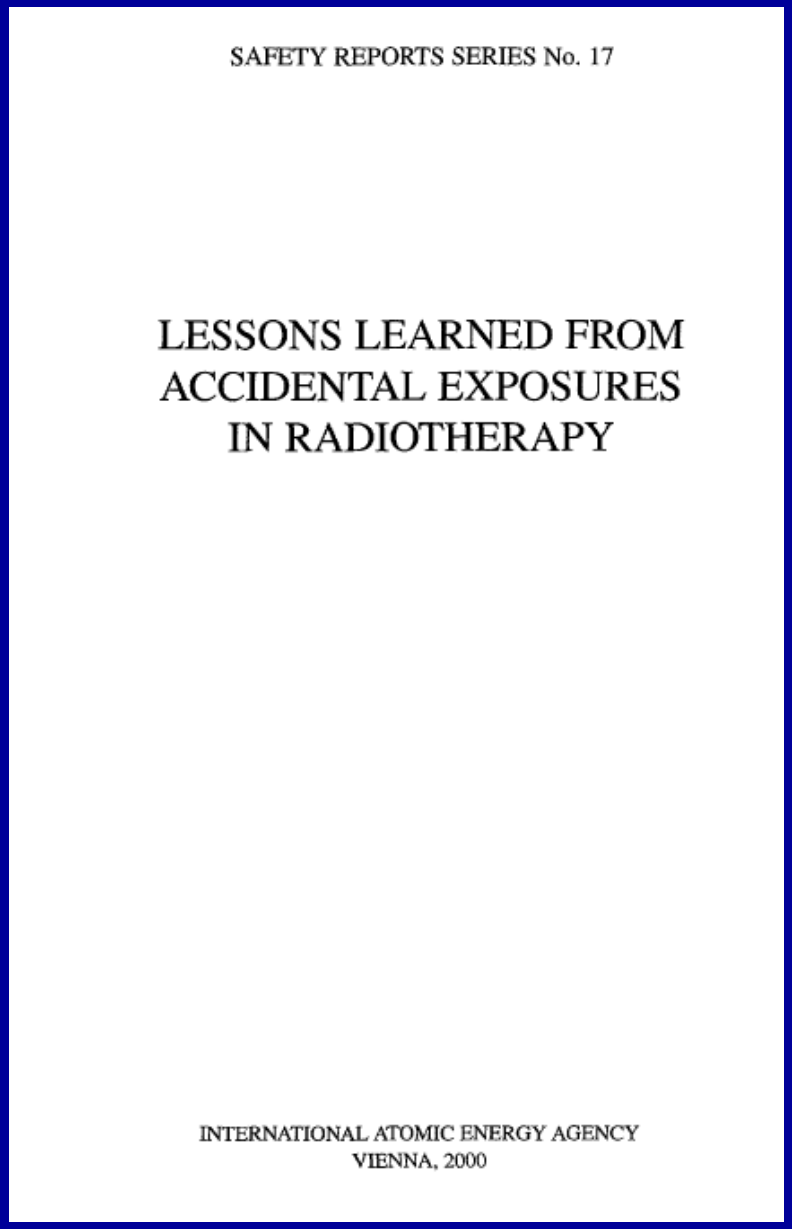
Outline

- Entering Prescription
- Plan Printout
- Print and Transfer DRR
- Segment BEV
- Export to R&V
- Physician approval
- Second check

Why so much Attention?

- Most likely place for mistakes (event in Glasgow)
- Seems obvious but it is not (event in NYC)
- Requires clinical judgment
- Most important stage of planning
- Becomes more difficult if several dosimetrists worked on the same plan

IAEA Reports

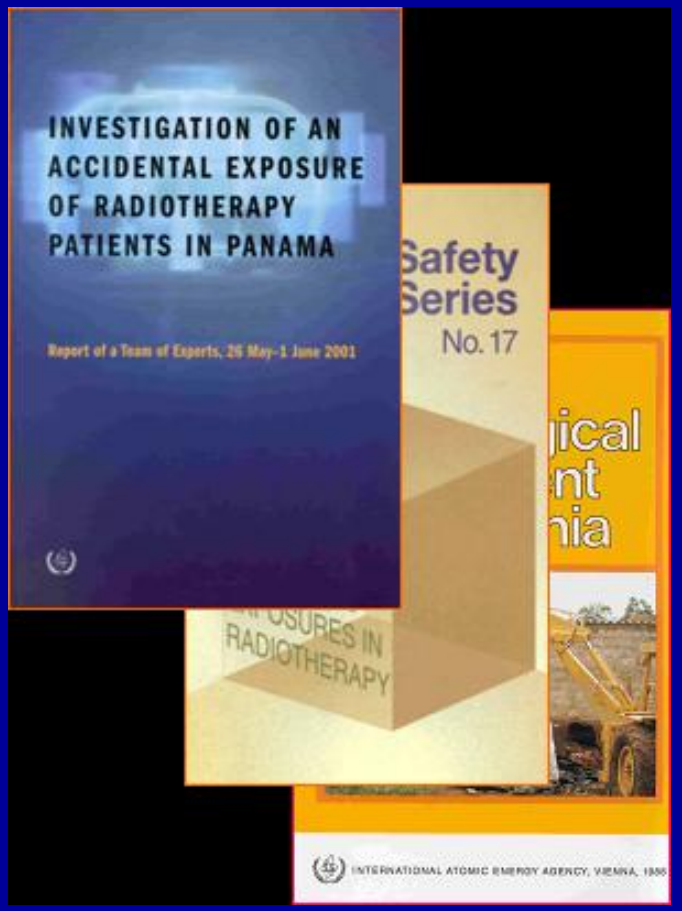


A slide from IAEA website

References

References

- All the main references are on the internet
- File format: Adobe Acrobat (*.pdf)
- Icon (below) indicates that a reference is linked to the IAEA website (http://rpop.iaea.org)



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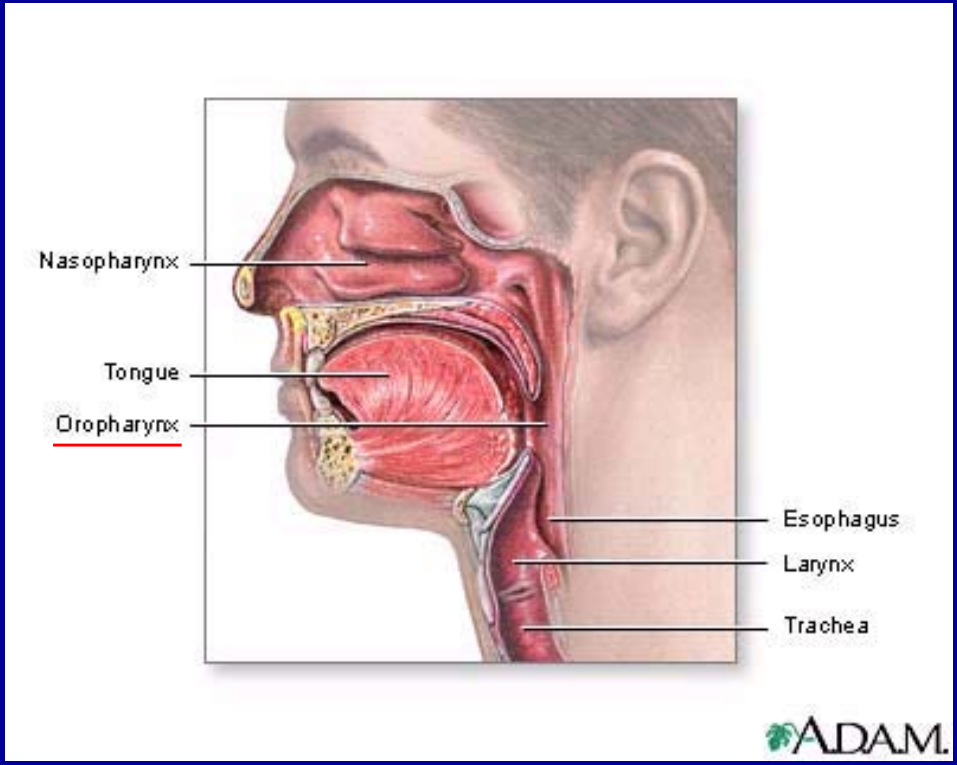
Example of Incorrect IMRT Planning Completion (US)

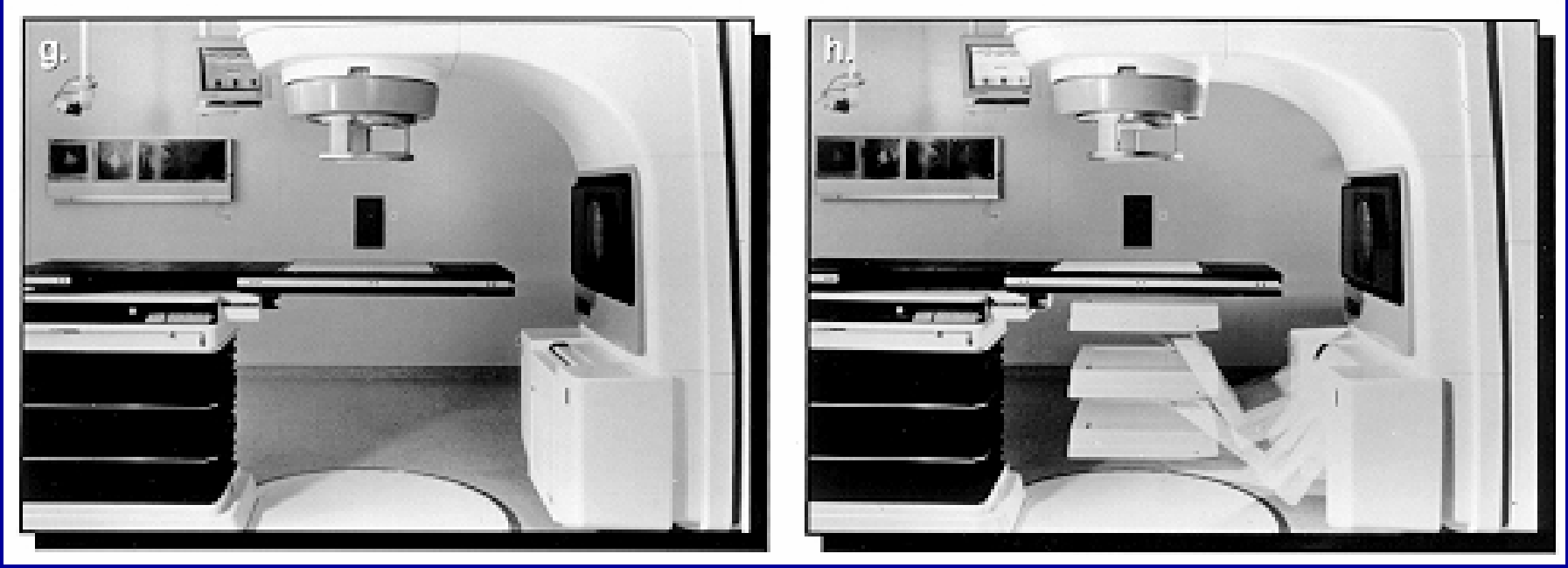
Background

- March 2005, somewhere in the state of New York, USA
  - A patient is due to be treated with IMRT for head and neck cancer (oropharynx)



What happened?

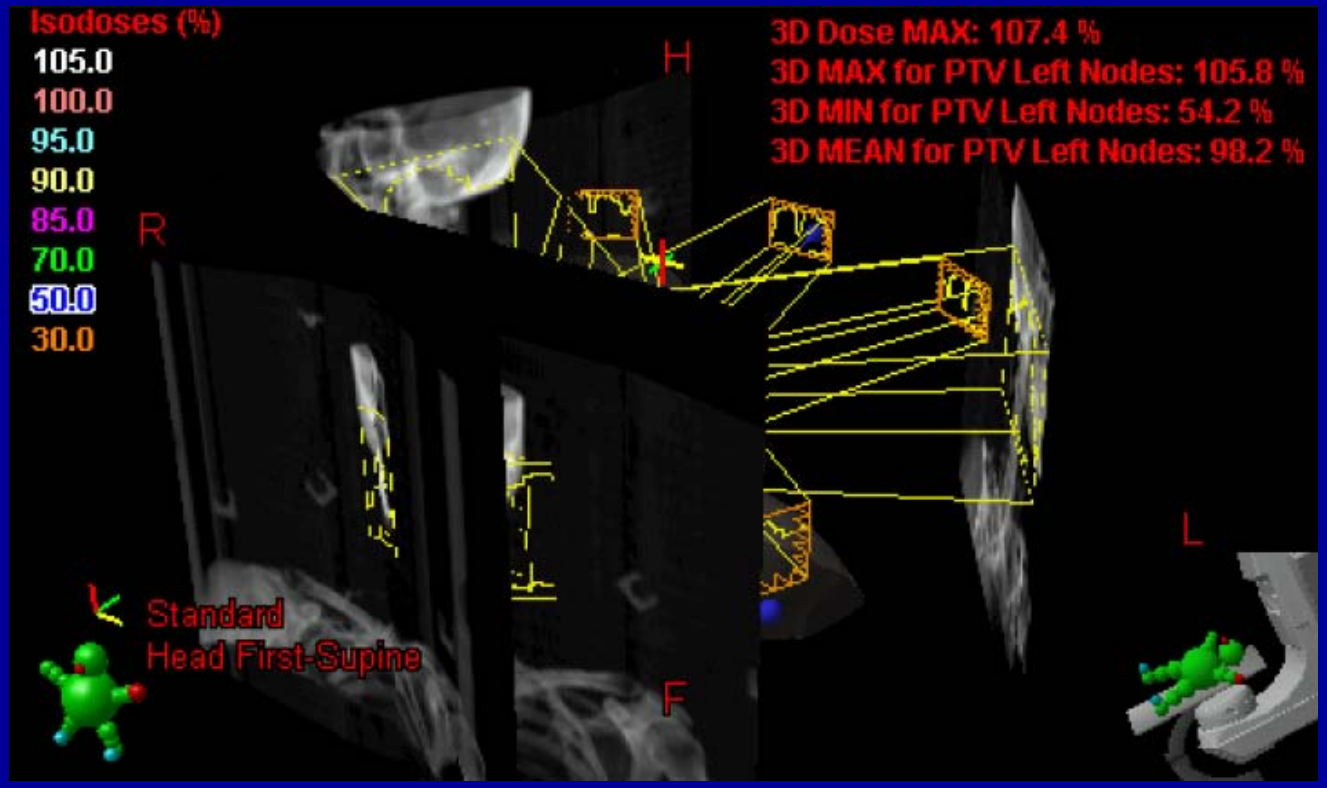
- March 4 – 7, 2005
  - An IMRT plan is prepared: “1 Oropharyn”. A verification plan is created in the TPS and measurements by Portal Dosimetry (with EPID) confirms correctness.



Example of an EPID (Electronic Portal Imaging Device) (Picture: P.Munro)

What happened?

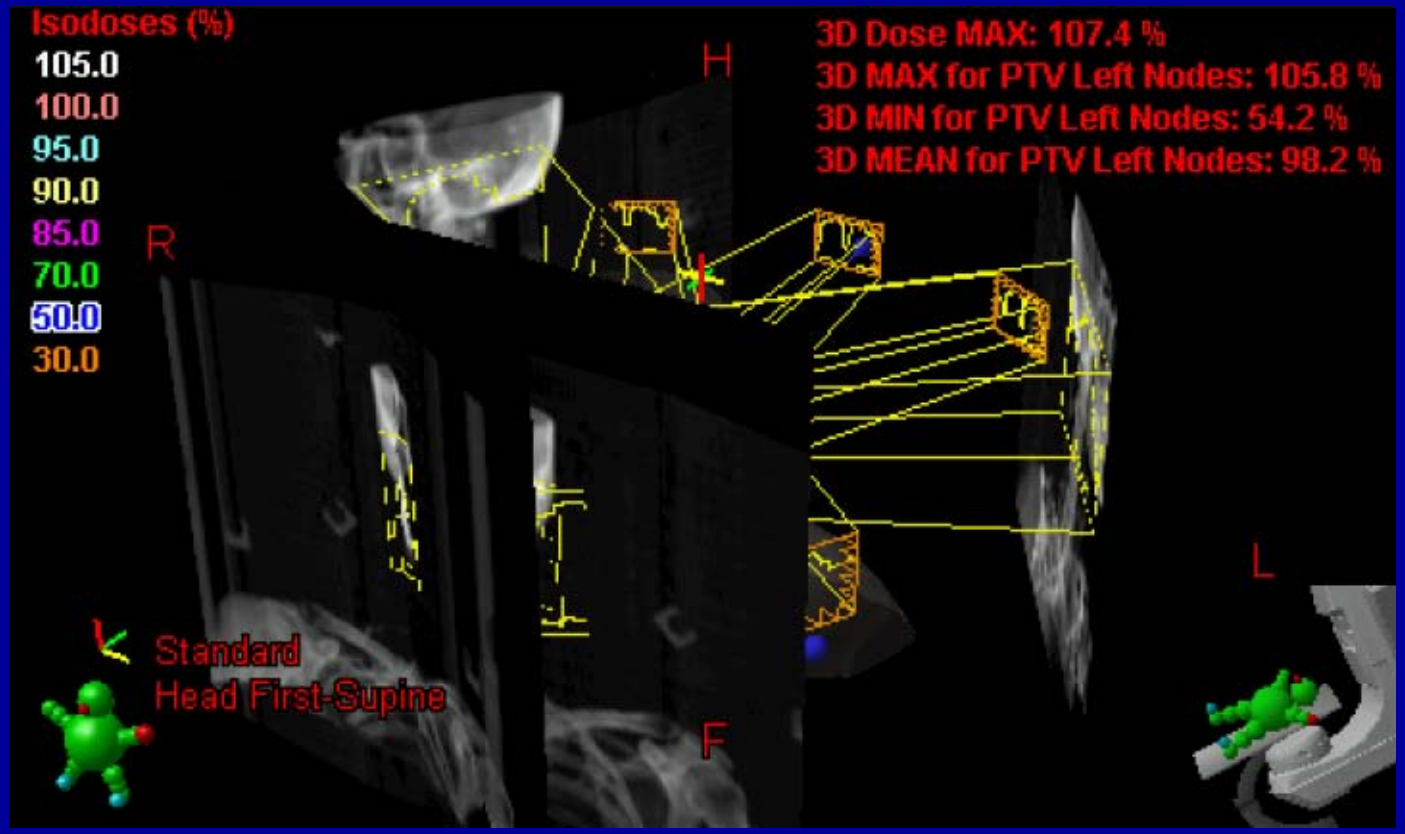
- March 8, 2005
  - The patient begins treatment with the plan “1 Oropharyn”. This treatment is delivered correctly.



“Model view” of treatment plan (Picture: VMS)

What happened?

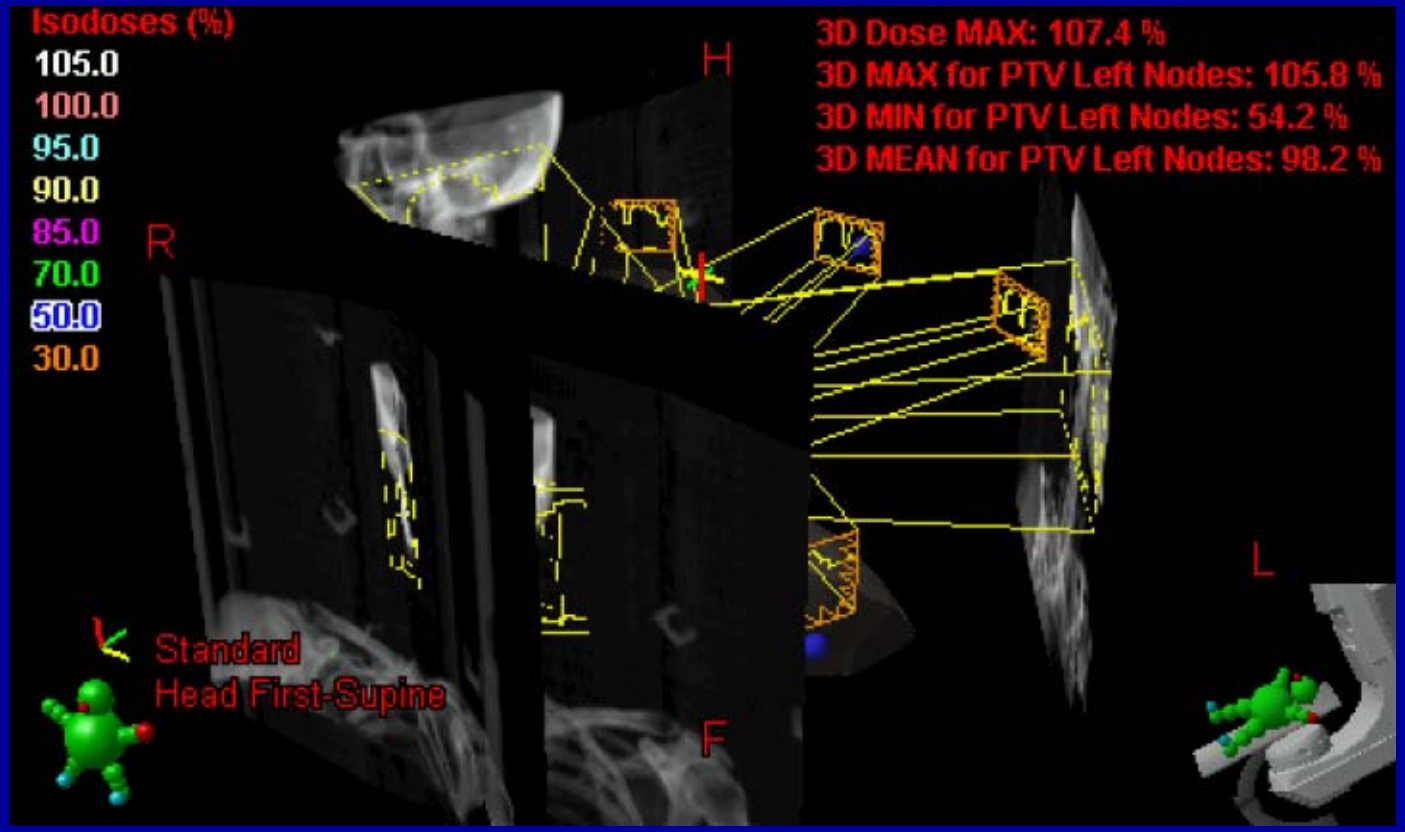
- March 9-11, 2005
  - Fractions #2, 3 and 4 are also delivered correctly. Verification images for the kV imaging system are created and added to the plan, now called “1A Oropharyn”.



“Model view” of treatment plan (Picture: VMS)

What happened?

- March 11, 2005
  - The physician reviews the case and wants a modified dose distribution (reducing dose to teeth) “1A Oropharyn” is copied and saved to the DB as “1B Oropharyn”.



“Model view” of treatment plan (Picture: VMS)

What happened?

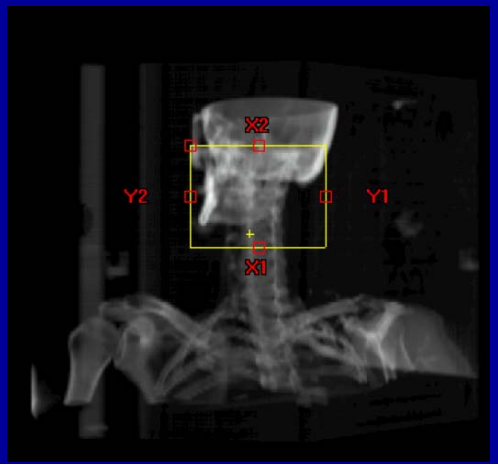
- March 14, 2005
  - Re-optimization work on “1B Oropharyn” starts on workstation 2 (WS2).
  - Fractionation is changed. Existing fluences are deleted and re-optimized. New optimal fluences are saved to DB.
  - Final calculations are started, where MLC motion control points for IMRT are generated. Normal completion.

Multi Leaf Collimator (MLC)

What happened?

- March 14, 2005, 11 a.m.
  - "Save all" is started. All new and modified data should be saved to the DB.
  - In this process, data is sent to a holding area on the server, and not saved permanently until ALL data elements have been received.
  - In this case, data to be saved included: (1) actual fluence data, (2) a DRR and (3) the MLC control points

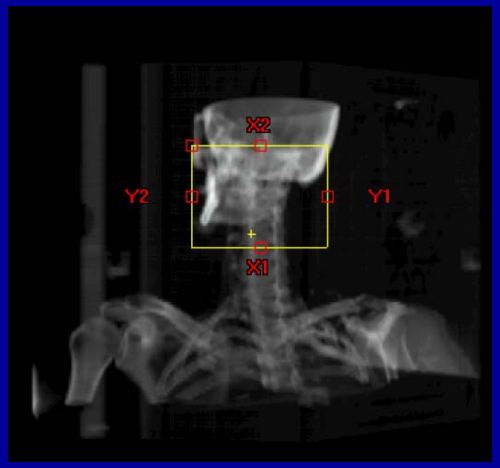
A Digitally Reconstructed Radiograph (DRR) of the patient



What happened?

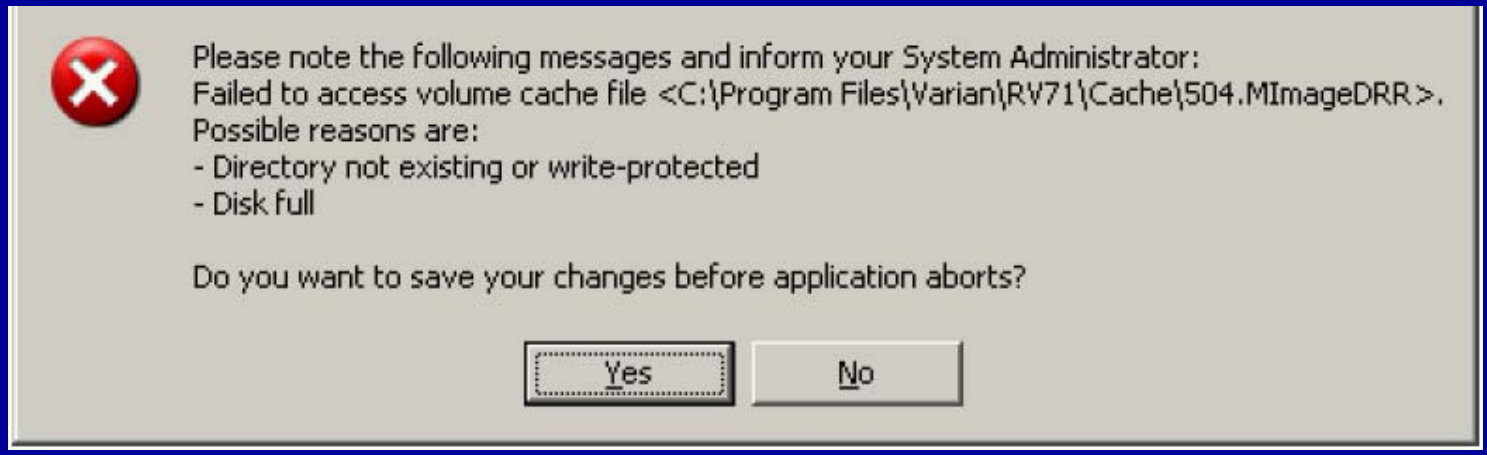
- March 14, 2005, 11 a.m.
- The actual fluence data is saved normally.
  - Next in line is the DRR. The “Save all” process continues with this, but is not completed.
  - Saving of MLC control point data would be after the DRR, but will not start because of the above.

A Digitally Reconstructed Radiograph (DRR) of the patient



What happened?

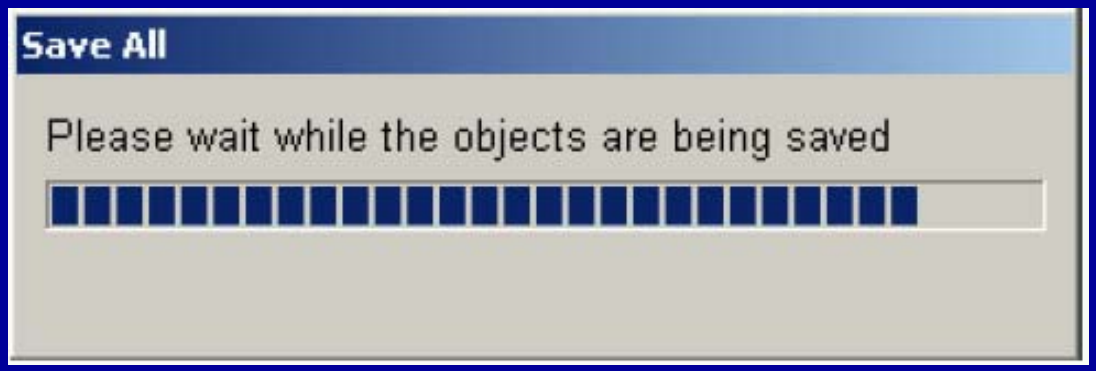
- March 14, 2005, 11 a.m.
  - An error message is displayed.
  - The user presses “Yes”, which begins a second, separate, save transaction.
  - MLC control point data is moved to the holding area.



The transaction error message displayed

What happened?

- March 14, 2005, 11.a.m.
  - The DRR is, however, still locked into the faulty first attempt to save.
  - This means the second save won't be able to complete.
  - The software would have appeared to be frozen.



The frozen state of the second "Save All" progress indication

What happened?

- March 14, 2005, 11.a.m.
  - The user then terminated the TPS software manually, probably with Ctrl-Alt-Del or Windows Task Manager
  - At manual termination, the DB performs a “roll-back” to return the data in the holding area to its last known valid state
  - The treatment plan now contains (1) actual fluence data; (2) not the full DRR; (3) no MLC control point data

Ctrl-Alt-Del

What happened?

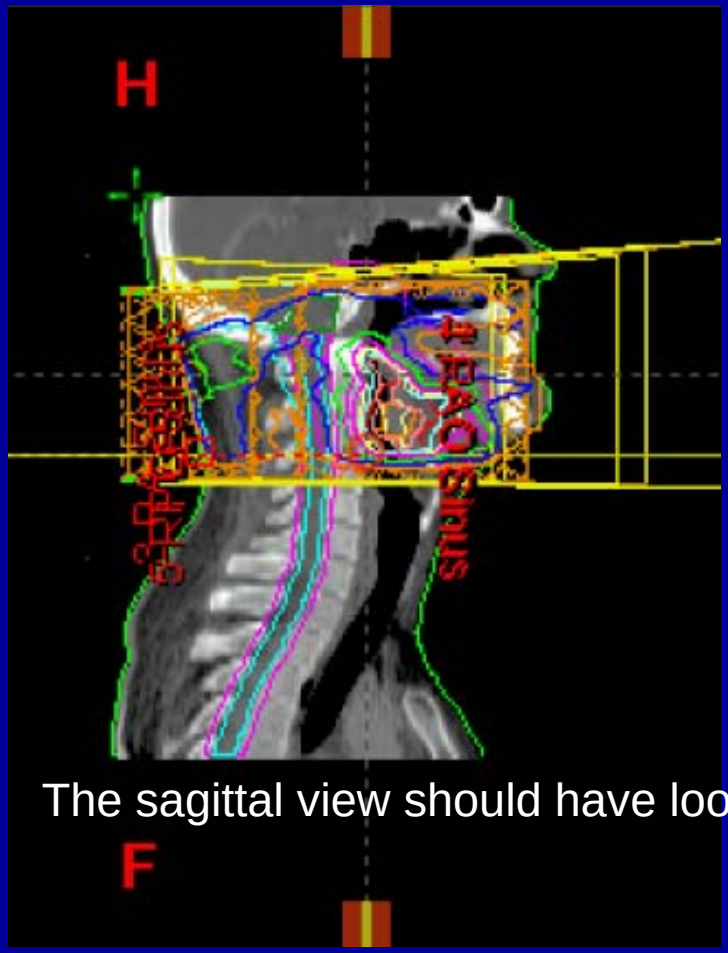
- March 14, 2005, 11.a.m.
  - Within 12 s, another workstation, WS1, is used to open the patients plan. The planner would have seen this:

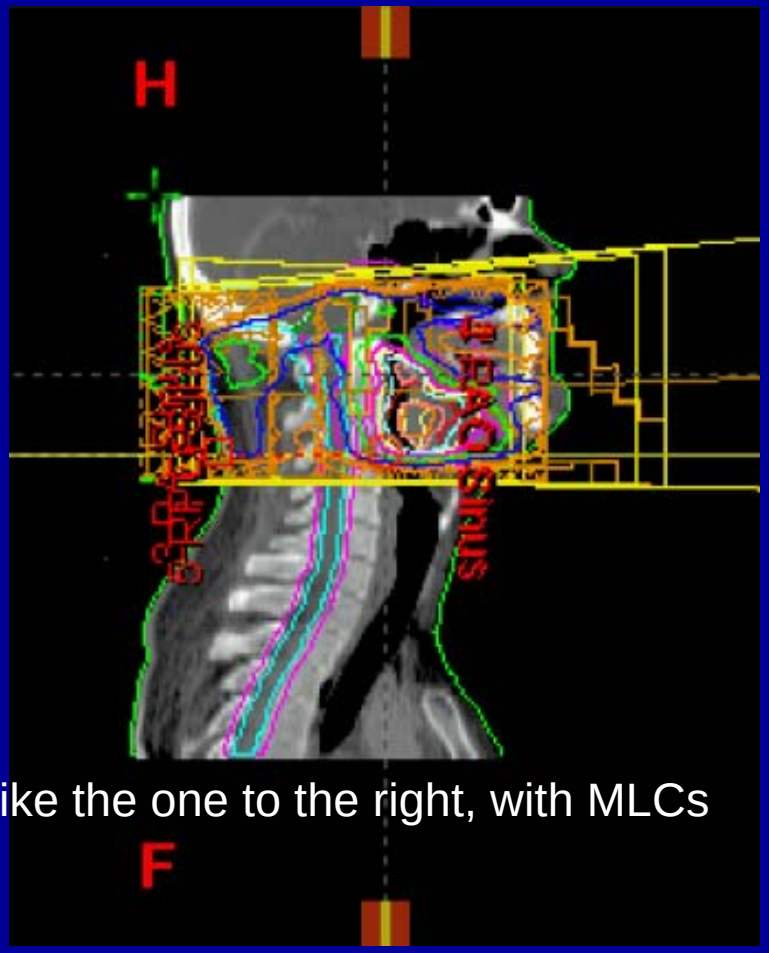
Valid fluences were already saved. Calculation of dose distribution is now done by the planner and saved. MLC control point data is not required for calculation of dose distribution.

Sagittal view of patient, with fields and dose distribution

What happened?

- March 14, 2005, 11.a.m.
  - No control point data is included in the plan.





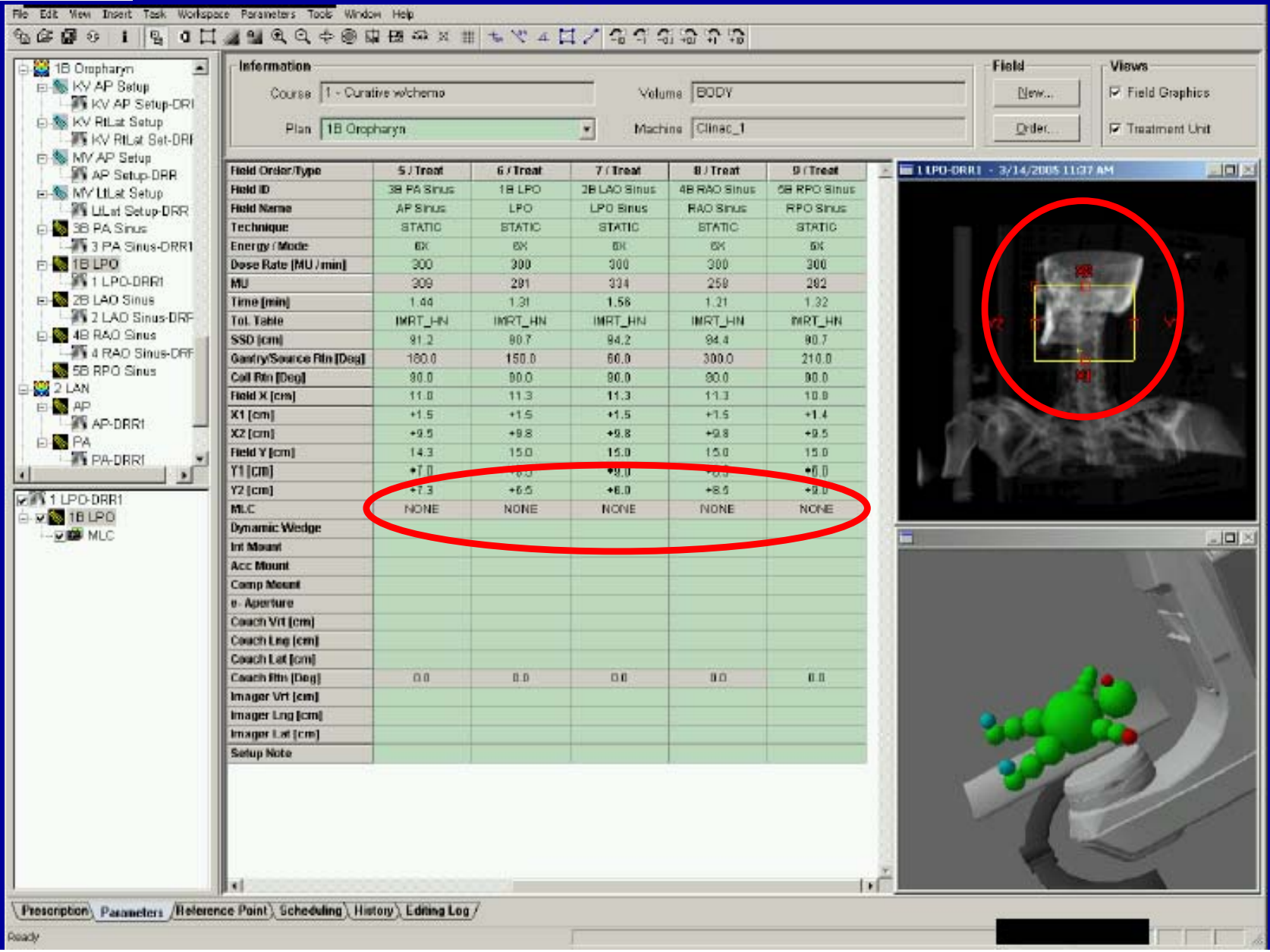
The sagittal view should have looked like the one to the right, with MLCs

What happened?

- March 14, 2005, 11 a.m.
  - No verification plan is generated or used for checking purposes, prior to treatment (should be done according to clinics QA programme)
  - The plan is subsequently prepared for treatment (treatment scheduling, image scheduling, etc) – after several computer crashes.
  - It is also approved by a physician
  - According to QA programme, a second physicist should then have reviewed the plan, including an overview of the irradiated area outline, and the MLC shape used.

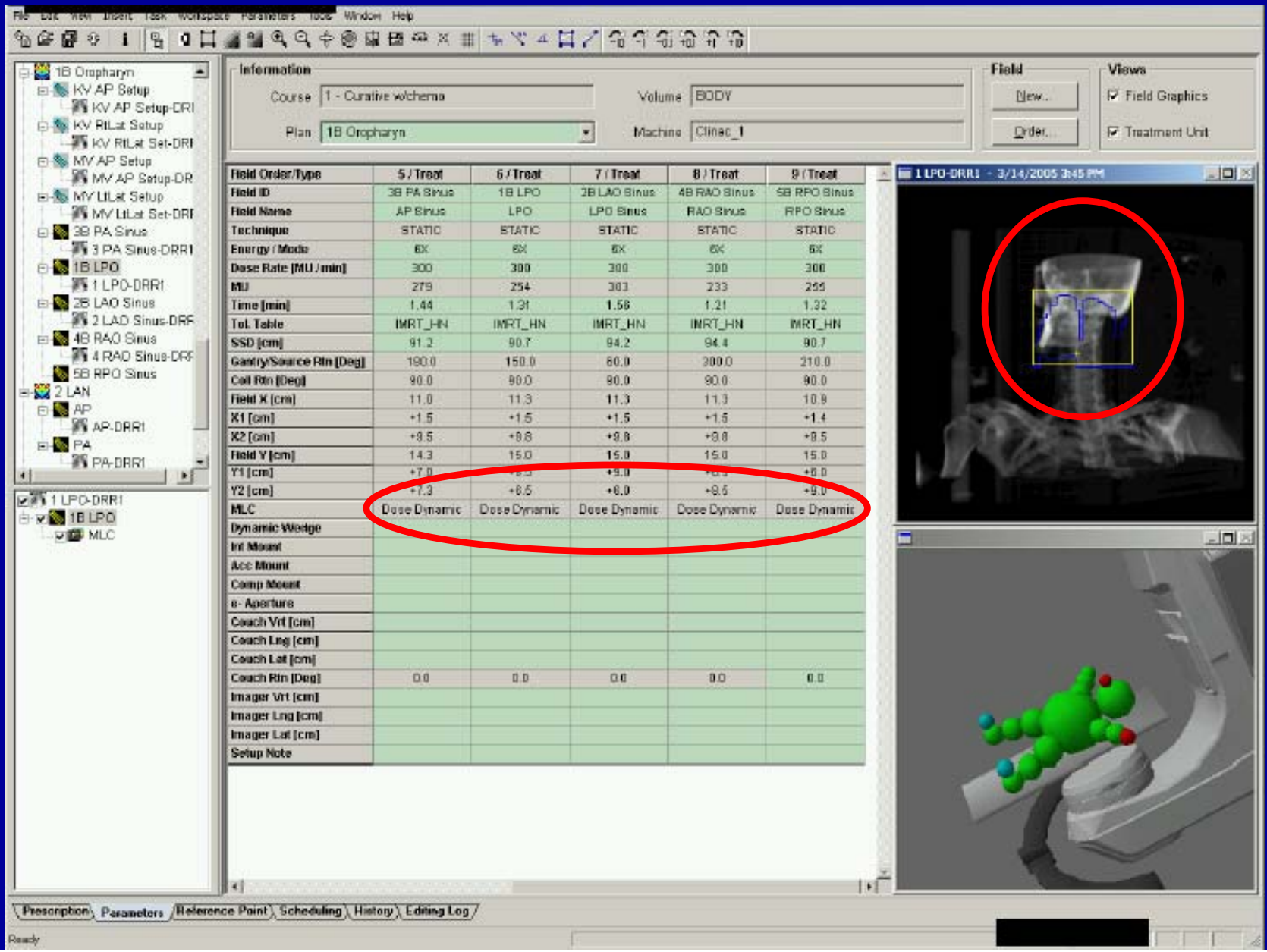
What happened?

- Would have been seen on verification:



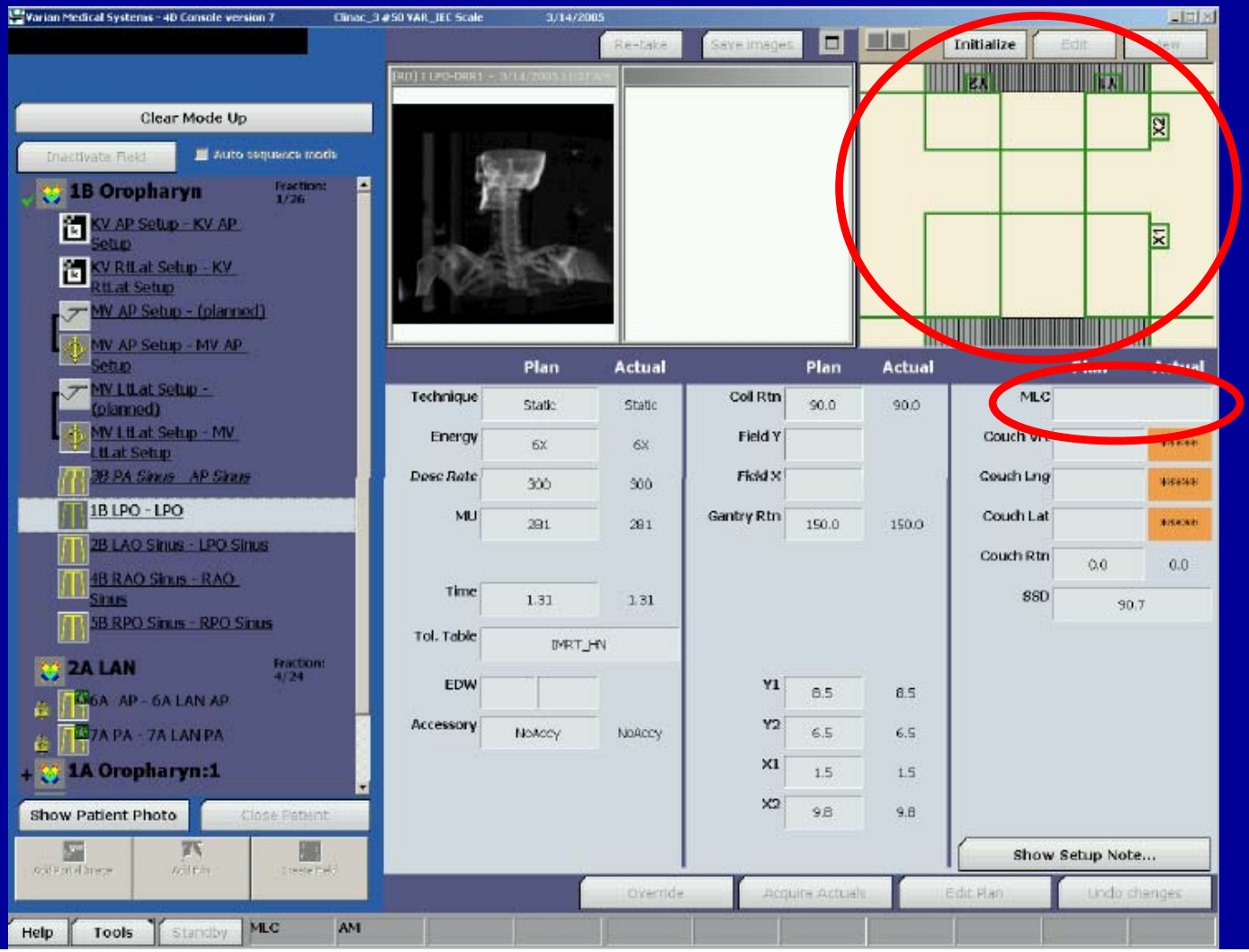
What happened?

- Should have been seen on verification:



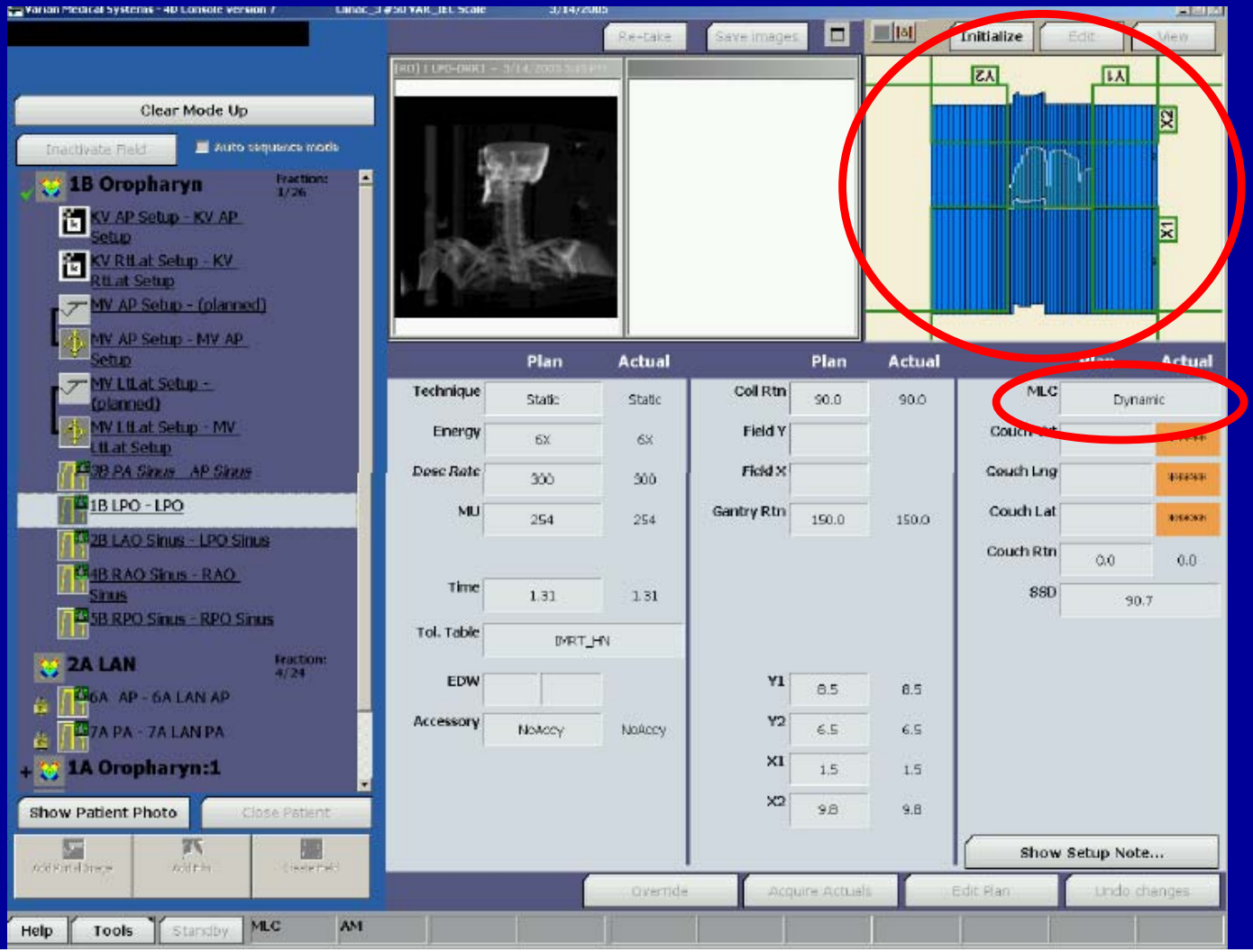
What happened?

- March 14, 2005, 1 p.m.
  - The patient is treated. The console screen would have indicated that MLC is not being used during treatment:



What happened?

- March 14, 2005, 1 p.m.
  - Expected display:



Discovery of accident

- March 15-16, 2005
  - The patient is treated without MLCs for three fractions
  - On March 16, a verification plan is created and run on the treatment machine. The operator notices the absence of MLCs.
  - A second verification plan is created and run with the same result.
  - The patient plan is loaded and run, with the same result.

Impact of accident

- The patient received 13 Gy per fraction for three fractions, i.e. 39 Gy in 3 fractions

Lessons to learn

- Do what you should be doing according to your QA program – the error could have been found through verification plan (normal QA procedure at the facility) or independent review

- Be alert when computer crashes or freezes, when the data worked on is safety critical

- Work with awareness at treatment unit, and keep an eye out for unexpected behaviour of machine

References

- [Treatment Facility] Incident Evaluation Summary, CP-2005-049 VMS. 1-12 (2005)

- ORH Information Notice 2005-01. Office of Radiological Health, NYC Department of Health and Mental Hygien (2005)

Questions

Do you think the accidents have not happened in recent years? ANSWER: NO! If YES, then think again!

Do you think well-developed centres are immune to these accidents? ANSWER: NO! If YES, then think again!

Overdose due to incorrect Rx

Unintended overexposure of patient Lisa Norris during radiotherapy treatment at the Beatson Oncology Centre, Glasgow in January 2006

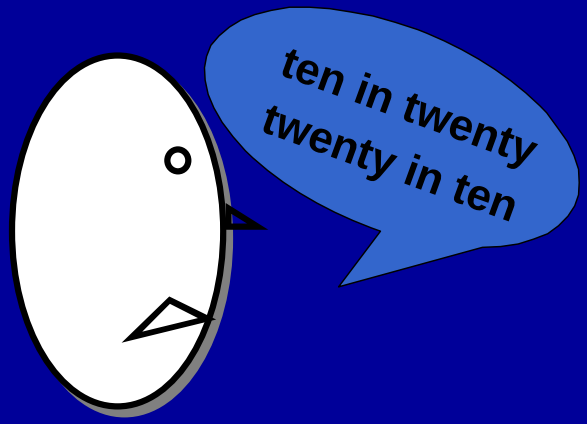
8. Summary of principal findings

8.1 The principal findings arising from investigation of this incident both by staff at the BOC and by the Inspector are summarized in the following paragraphs.

8.2 In May 2005 an upgrade to the existing computer package to the new *Varis 7* system was installed at the Beatson Oncology Centre. This upgrade overcame previous technical and operational obstacles to allow the data calculated by the *Eclipse* treatment planning module within *Varis 7* to be transferred electronically (rather than manually) to the *RTChart* module which verifies these treatment parameters prior to treatment delivery and records those set at delivery. To optimise the benefit of the change to electronic data transfer, the previous practice at the BOC whereby all treatment plans were computed using a standardized dose fraction of 1 Gray (100 centiGrays) was changed so that they were then calculated using the actual prescribed radiation dose per fraction.

Treatment set-up and delivery

13. Misunderstanding of a complex treatment plan given verbally



A patient was prescribed a Cobalt treatment to two different treatment sites. Site One: 2.4 Gy per fraction for 20 fractions. Site Two: 2.5 Gy per fraction for 10 fractions.

The two technologists misunderstood the physician's verbal instructions, in particular in relation to differences in number of treatment fractions.

Therefore, the second site received an additional four days of treatment before the error was detected.

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Many Studies of Errors

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Errors in radiation oncology: A study in pathways and dosimetric impact

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As complexity for treating patients increases, so does the risk of error. Some publications have suggested that record and verify (R&V) systems may contribute in propagating errors. Direct data transfer has the potential to eliminate most, but not

Typical Errors

Table 1. Summary of errors over a 30-month span. New patient starts are for 30-month period. # of R&V were the number of errors felt to be potentially propagated by the R&V system.

Error type: typical # fractions: Method of detection	# of Events (% of starts)	# of R&V	Notes
incorrect treatment coordinate(s): most often 1 fraction: port film	19 (0.48%)	7	*one case R&V not used.* Led to change in process whereby R&V display turned off in treatment room.
wrong gantry angle: most often 1 fraction: port film	15 (0.38%)	8	*one case R&V not used.* Led to change in process whereby R&V display turned off in treatment room.
wrong or omitted cerrobend block: most often 1 fraction: port film	15 (0.38%)	N/A	not part of R&V system
incorrect calculation: 2 to 5 fractions: diode reading or physics chart review	11 (0.28%)	N/A	not part of R&V system
wrong field size: one fraction: port film	9 (0.23%)	8	*one case affected dose p.g. enhanced dynamic wedge factor.* Led to change in process whereby R&V display turned off in treatment room.
incorrect collimator angle: one fraction: port film	8 (0.20%)	3	led to change in process whereby R&V display turned off in treatment room.
missing compensating filter: 2 to 5 fractions: diode of physics chart review	6 (0.15%)	N/A	
incorrect MU: 2 to 5 fractions: diode check	5 (0.13%)	4	*one case without R&V.* Led to change in override rights in MUs for therapists.
wrong photon energy: 2 to 3 fractions: diode check	3 (<0.1%)	3	in-service provided to therapists in reading treatment plans.
missing or incorrect MLC Shape: one fraction: port film	3 (<0.1%)	3	
incorrect wedge direction: 1, 5, or 16 fractions: physics check, later diode check	3 (<0.1%)	3	after second event: (1) diode readings taken off-axis, (2) TP printout with rooms-eye-view placed in setup information.
incorrect number of fractions for given set of fields: 1 to 3 fractions: physics review	3 (<0.1%)	2	
incorrect or rotated compensating filter: 2 or 11 fx fractions: therapist discovery for first case, diode check for second	2 (<0.1%)	N/A	coinciding with wedge direction led action, diodes taken off-axis.
patient treated head to gantry but scanned foot to gantry: one fraction: port film	1 (<0.1%)	N/A	divergent wire built into immobilization system registration device.

Entering Prescription Dose and Number of Fractions

- Entering prescription dose and a number of fractions into treatment planning system.
- Double-check with a written record in the prescription sheet and/or a computer record (in paperless departments).
- Saving the plan

Plan Printout

- Printing the plan
- Double-checking patient’s name and ID (MRN)
- Double-checking prescribed dose and monitor units
- Checking completeness of the printout

Preparation of DRR

- Generate DRR for all fields
- Check the landmarks (bony anatomy and fiducials)
- Adjust window and level for better visualization
- Enter contours of organs visible on beam films (e.g., trachea and bronchi)
- Printout DRRs in one or several of the following ways:
  - On film
  - On paper
  - A soft copy of the image transferred to the linac image workstation as a reference for comparison with subsequent port films
- Check labels (patient name and field names/numbers)

BEV Printout for Each Segment (Step and Shoot Delivery)

- Checking beam segments configuration (avoiding too small segments and too narrow windows). Minimum segment area.
- Partial leaf transmission ignored in some treatment planning systems
- Checking monitor units, use factor, and smoothness of the beam fluence

Treatment data export from TPS to R&V (R&M) system

- Perform export from TPS and import to R&V (R&M) computer
- Check beam parameters: linac, energy, gantry, collimator, and couch angles
- Check the apertures and make sure that all the segments have been transferred correctly
- Entering miscellaneous field settings, such as tolerances, beam film settings, maximum beam time etc.

Radiation Oncologist's Approval

- Initial presentation on computer screen
- Printout upon verbal approval
- Physical signature on the printout, Rx % isodose, and date
- Electronic signature could substitute physical signature and printouts

Plan Second Check by Physics

- Check patient's name, MRN, prescription site, beam energy, linac, and dose.
- Evaluate the dose distribution for coverage, homogeneity, and sparing the critical structures.
- Compare Dose-Volume Histogram (DVH) with the institutional and multi-institutional (RTOG, etc.) guidelines on tumor dosage, fractionation, and dose tolerance for critical structures.
- Independently calculate monitor units (can be substituted with measurement QA for an IMRT plan and also plans with non-standard geometry, such as an unusual electron cutout).
- Sign the plan in the chart
- Approve fields for treatment in R&V (R&M) system

Pre-Tx Chart Check by a Therapist

- Checks completeness of the plan
- Checks treatment parameters in R&V system vs. the treatment plan
- Fills out and signs pre-treatment checklist
- Flags the chart (where applicable)

Initial Chart Check by a Physicist

- Double-checks the plan and chart completeness
- Checks the R&V parameters vs. the plan
- Checks correct fraction and dose tracking by the R&V system

Summary

- Treatment planning completion is a very responsible process which requires maximum attention
- Should be independently checked by the planner, physicist, radiation oncologist and a therapist
- Should not be done in a last minute rush
- Proper communication between team members
- Properly set procedure should prevent propagation of an error by one individual to the treatment: the error should be caught by somebody else