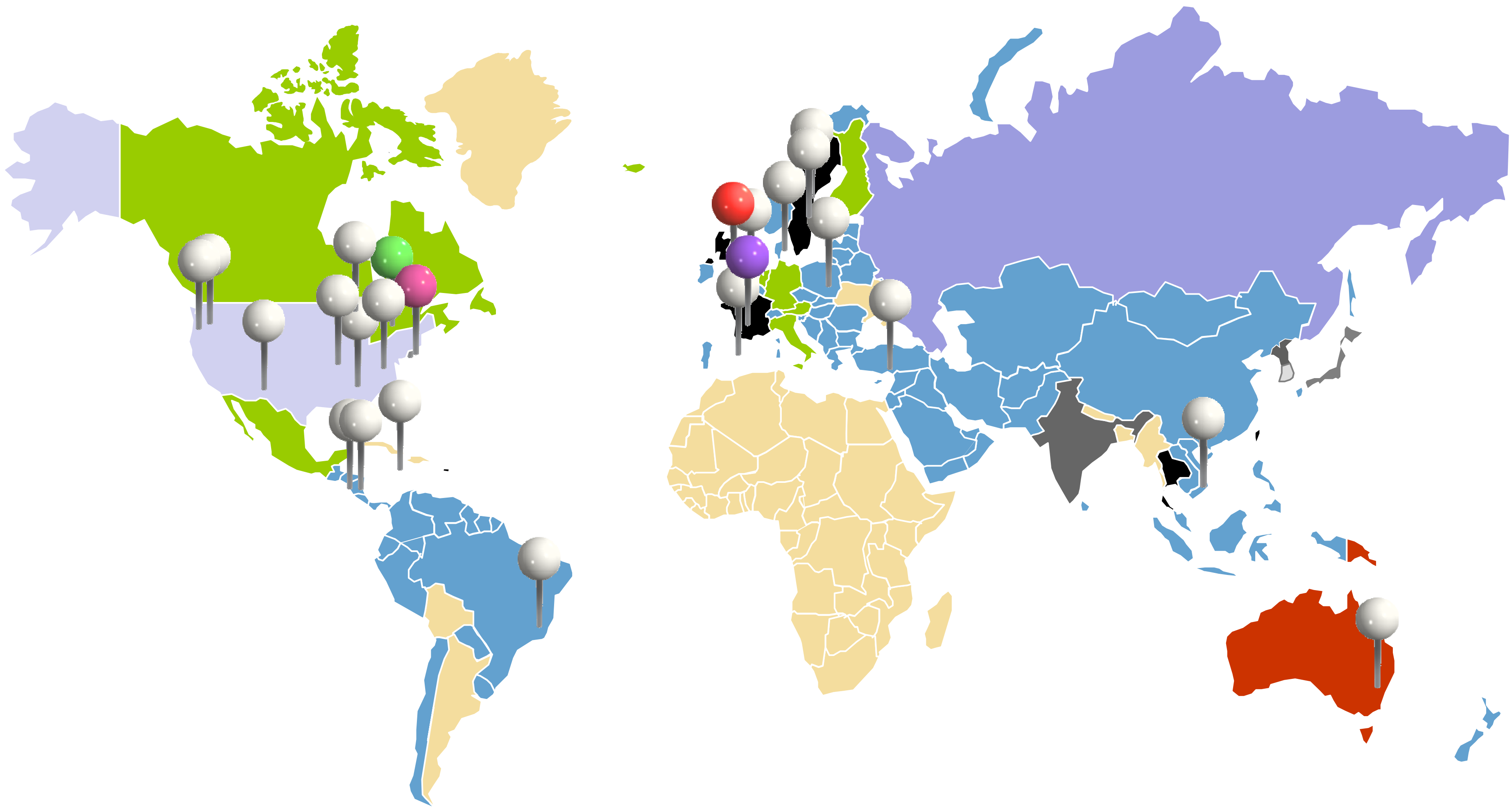
Case histories of radiotherapy accidents & clinical consequences

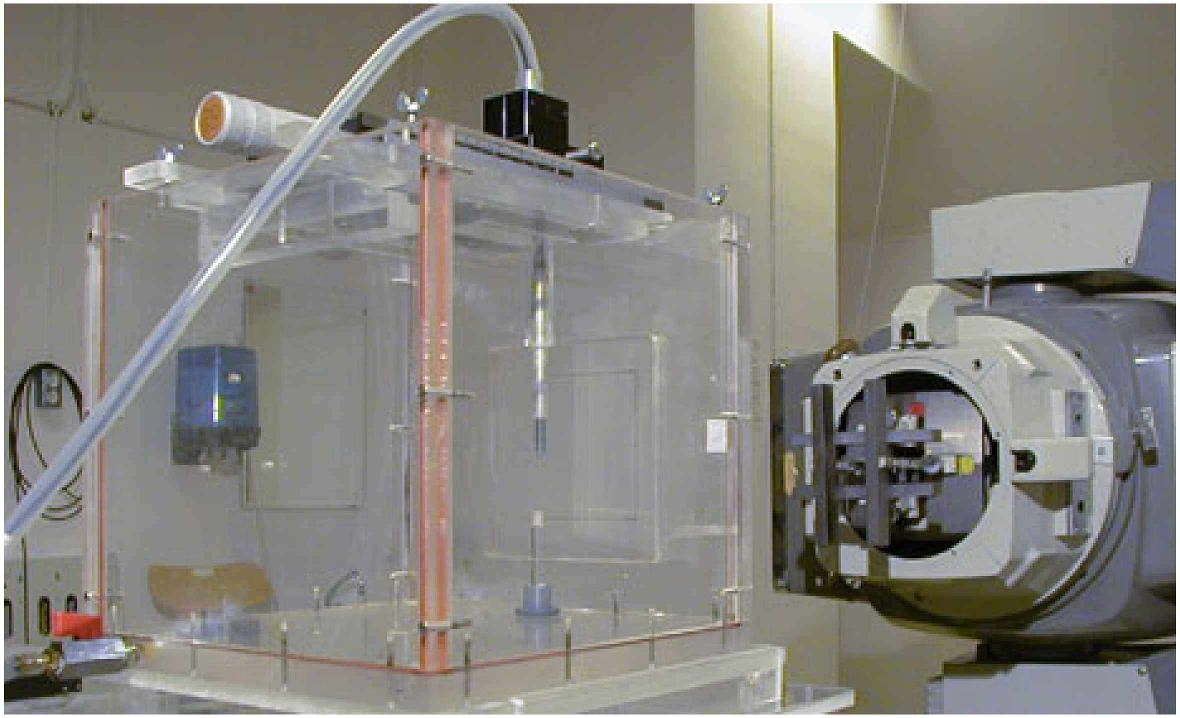
Ben Mijnheer

Accidents happen everywhere…..



Erroneous calibration, Exeter, UK, 1988

- Installation of a new cobalt source



- A physicist calibrated the new source

2/2/88.

O/P calibration of New Source

~~Baldwin~~ Farmer 2570 with probe, in water tank at depth 5.0c

Water tank outside dimensions (perspex): 32 × 32 × ~21 cm to water surf

T = 293   P = 760·3 . SSD = 800 mm, 100 × 100 mm FIELD

Farmer left on for 45 mins before any measurements

Water tank filled and left to come to room temp overnight

Farmer readings (0·8 mins): ~~90·95~~, 90·92, 90·90, 90·90, 90·90 → 90·90₅

" " (0·4 mins) 46·47, 46·40, 46·40, 46·42, 46·42 → 46·42₂

Steady state 0·4 min reading 44·48₃

Steady State Doserate

at 800 mm, 100 × 100 = 2 × $\frac{293\cdot3}{293}$ × $\frac{760}{760\cdot3}$ × 0·947 × $\frac{100}{79\cdot0}$ × 44·48

(absorbed dose Farmer factor; 1.00)

= 106·7 cGy/min.

1/0.4 = 2.5 not 2 !!!
Should have been
133.4 cGy/min

"Dose effective Timer error" = $\frac{90\cdot90_5 - 2 \times 44\cdot48_3}{2 \times 44\cdot48_3}$

= 0·0218 mins

What went wrong and how was it detected?

- The physicist has multiplied by the wrong factor (2.0 instead of 2.5) to achieve an equivalent exposure for one full minute. Tragically, this inaccuracy was then not recognised, possibly because the physicist was working on his own and his data may not have been checked
- Commonly afterwards only relative dose calculations are used to calculate the treatment time for an individual patient
- As a result of this calibration error, 205 patients were significantly overdosed (by about 25%) with increased morbidity and possible deaths as a consequence.
- The Institute of Physical Sciences in Medicine performed a National multicentre dosimetric comparison (external audit) and discovered this error

Lessons

- One clear lesson from this accident is that a calibration of a new cobalt source or linear accelerator must be checked and rechecked (and rechecked…).
- It is certainly possible to cross check a new installation by asking a colleague. It might even be sensible to repeat the calibration of a new source a month after its first use in case of contamination with other isotopes which might have unexpected patterns of decay.
- Participate in an external audit, e.g. the IAEA TLD audit system


Miscalibration
The Ottawa Hospital Cancer Centre
2008
Cancer Centre
Centre de cancérologie

What happened?

- The centre reported a calculation error with one of its radiation machines – an orthovoltage machine (kV-range) – April 2008
- The calculation error took place during re-commissioning after the unit was moved from the General Campus to the Civic Campus – Nov 2004
- Checks of the calibration of the unit showed that measurements and calculations had been performed correctly at that moment – Nov 2007

To make it short!

- The last step of generating output tables should have been to calculate the output for all cones from the absorbed dose to water in water under reference conditions, through the application of ratios of distance corrected in-air charge measurements and ratios of backscatter factors

- The re-commissioning covered only a 10x10 cm^2 field!

To make it short!

- The last step of generating output table [illegible] ve been to calculate the output for all c [illegible] e absorbed dose to water in wate [illegible] ence conditions, through the appl [illegible] os of distance corrected in-air charge m [illegible] s and ratios of backscatter factors
- The re-com [illegible] overed only a 10x10 cm^2 field!

Ratios of backscatter factors were not applied in this final step and this is the error which led to the under-dosing of 326 patients.

Affected Patients

- The treatment charts of all 326 patients affected were reviewed by their respective treating physicians and the patients were contacted for an immediate follow up appointment
- The error did only involve patients with basal cell and squamous cell carcinomas:
  - Patients were treated between November 2004-November 2007
  - Patients were treated at the Civic Campus
  - In some cases, patients received radiation up to 17% less than the prescribed dose
- Patients who received radiation therapy for any other type of cancer were not affected.

External review by experts

- The basis of this review and analysis of the events focused on the following questions:
  - Why were the incorrect output tables prepared during re-commissioning?
  - Why was an independent second check not done prior to release of the output tables?
  - Why was the error not detected for 3 years?

- Root causes
  - Incorrect output tables were released for clinical use
  - Multiple significant tasks were assigned to the physicists
  - A comprehensive, independent second check was not performed

Staffing shortage behind radiation error: probe

Skin cancer patients at Civic given wrong dosages between 2004 and 2007

BY PAULINE TAM

A critical shortage of medical physicists at The Ottawa Hospital played a key role in an error that left 326 skin cancer patients with less than the recommended radiotherapy dosages to destroy their tumours, a provincial investigation into the incident has found.

The staffing crunch, combined with gaps in safety and performance checks, was "a significant contributory factor" behind the improper calibration of a radiation treatment machine that went undetected for three years, the investigation concluded.

The patients were treated at the hospital's Civic campus between November 2004 and November 2007 for basal-cell and squamous-cell carcinomas — slow-growing cancers that typically do not metastasize and are generally responsive to radiation or surgery.

The hospital has since contacted all affected patients to offer them counselling and closer medical monitoring over the next five years. So far, none have shown signs of relapse, and none have filed formal complaints related to the underdosing, said Dr. Jeff Turnbull, the hospital's chief of staff.

While some patients received radiation amounts that were 17-per-cent below what's normally recommended, it's not yet clear whether the lower doses necessarily resulted in less effective treatment, said Dr. Turnbull.

"We have to be vigilant. We're sorry that this happened, but on the other hand, we think that the likelihood that someone is going to be seriously impacted by this is low."

The hospital publicly disclosed the error in April and asked Cancer Care Ontario to launch an independent review. The provincial agency that oversees cancer treatment appointed a panel of Alberta specialists to look into how the mistake happened.

See RADIATION on PAGE A2

Radiation: 'Excessive' work hours

Continued from PAGE A1

The panel found that, of the 11 medical physicists on staff at the time, five were unavailable for duty.

One was being trained for the job, another was a full-time manager and a third was on maternity leave. A fourth was on extended sick leave and a fifth had been reassigned to radiation safety duties, leaving the remaining physicists overworked.

"It appears that all the medical physicists available at the time of the incident had been routinely working an excessive number of hours, up to 60 hours per week, for an extended period," the panel reported.

To complicate matters, the radiation machine was being relocated from the hospital's General campus to the Civic campus, where the lone physicist assigned to reinstall it made the programming error.

Though the machine was routinely tested over the years, it wasn't until November 2007, when a more rigorous testing process was rolled out to cancer hospitals across Canada, that the error was finally detected.

The higher standards forced hospitals to check multiple settings, or field sizes, on their machines to determine whether patients were indeed receiving their prescribed radiation doses.

Previously, hospitals were only required to test one radiation setting on the machines to establish that they had been calibrated properly.

"The difference between what we did then and what we do now is that, at the time, we routinely just checked one field size," said Dr. Brenda Clark, The Ottawa Hospital's head of medical physics. "And now it's ...

Asked whether the physicist responsible for the error has been disciplined, Dr. Turnbull would only indicate that the individual had since retired from the hospital.

"I think it's important to recognize this was a very, very competent individual whom we had a great deal of faith in. He was very diligent. And we've taken the approach ... that, as this gentleman is retired currently, we want to just learn from this mistake and make sure that in the future, we provide the most up-to-date and safe procedures for the patients of Ottawa."

Among the changes recommended by the panel to avoid similar mistakes in the future, the hospital has already implemented some key ones, Dr. Turnbull said.

Chief among them is an increase in the number of medical physicists on staff. Since the incident first came light, the hospital has hired three more people resulting in a total of 14 physicists, Dr. Clark said.

The hospital has also introduced provisions to restrict the number of patients it treats if the number of medical physics staff falls below a certain acceptable threshold, Dr. Turnbull said.

In all, 620 patients received 1,019 radiation treatments from the misprogrammed machine.

Report blames shortages

Staffing shortages among medical physics personnel at the Ottawa Hospital contributed to a calculation error on a radiation machine affecting 326 patients over a three-year period, according to an independent review.

In a report released Thursday on the radiation treatment calculation error affecting patients with basal cell and squamous cell cancers at the Civic campus between November 2004 and November 2007, a three-member panel found staffing shortages of medical physics personnel was "a significant contributory factor" in the miscalculation of radiation output on the relocated treatment unit.

The independent panel, led by Peter Dunscombe, the director of the medical physics department at Calgary's Tom Baker Cancer Centre, also cited "the cultural norm" at the hospital that allowed the scheduling of new treatment programs and equipment without ensuring adequate medical physics staff were available.

While the dosage recalculation error happened in November 2004, the mistake wasn't discovered by hospital staff for three years.

The calculation error on a radiation machine at the Ottawa Hospital resulted in 326 skin cancer patients being underdosed during treatments, according to hospital officials.

— THE CANADIAN PRESS

Ottawa

Short-staffing led to dosage error

TRACEY TONG
tracey.tong@metronews.ca

An Ottawa Hospital department was short-staffed by about half at the time that a calculation error was made that caused hundreds of cancer patients to receive lower than required radiation doses over three years.

A report by Cancer Care Ontario, ordered by the hospital, found the error occurred after an orthovoltage radiation treatment unit was moved from the General campus to the Civic campus of the Ottawa Cancer Centre in November 2004.

It resulted in 326 skin cancer patients receiving up to 17 per cent lower-than-needed doses of radiation.

Hospital staff didn't discover the error for three years. There were no reported overdoses.

At the time of the incident, staffing levels were down due to maternity leave and illnesses, said Dr. Brenda Clark, head of the department of medical physics.

"We were seriously understaffed," she said.

There were up to seven physicists at the time of the incident, compared to 14 now, she said.

The report makes two recommendations — to develop local staffing standards for medical physics support that reflect the complexity of radiation therapy, and to establish a threshold where medical physics staffing falls below that level.

The hospital has acted on both recommendations, said Dr. Jeff Turnbull, the hospital's chief of staff.

"Today, Ottawa Hospital medical physics staffing levels exceed currently accepted standards," Turnbull said.

Patient patients

- Although patients in a few instances were upset about the error, most were forgiving and understanding, said head of radiation and oncology, Dr. Laval Grimard.

The individual who made the error on the machine, whom Turnbull called "very competent," has since retired.

Turnbull doesn't expect any adverse results for patients.

"These are low-grade tumors that grow very slowly," he said.

"We're sorry this happened, but ... the likelihood of anyone being affected is extremely low."

The patients will be seen twice a year for five years, compared to the usual once-a-year consultation.

Cancer error well handled

Report says hospital reacted properly following blunder

JON WILLING
Sun Media

The Ottawa Hospital's response to a glitch in treating skin cancer patients will hopefully bolster its reputation, the hospital's chief of staff said yesterday.

"We don't take any of these events lightly," Dr. Jeff Turnbull said as the hospital released an independent review into an "orthovoltage incident" that wasn't detected for three years.

Reviewers found that between Nov. 2004 and Nov. 2007, hospital staff gave 1,019 treatments to 620 patients using miscalculated radiation outputs.

Of those patients, doctors found 326 with curable forms of cancer who required reviews because of the miscalculation, which resulted in an underdosage of up to 17% of the prescribed levels of radiation. There were no reported overdosages.

The hospital went public about the problem in April.

Doctors believe patients haven't suffered significant health effects because of the miscalculation.

Dr. Laval Grimard, the hospital's head of radiation oncology, said doctors have seen "no alarming increase" in the spread of cancer among the patients since the problem was discovered.

However, it won't be for another two or three years that doctors will be able to assess the impact, if any, on the patients, Grimard said.

SUN VIDEO
Dr. Jeff Turnball discusses steps taken by the hospital, at ottawasun.com/video

Extra visits

Doctors have increased patient visits and the hospital is paying for parking costs for the extra trips.

Grimard said there were only a "few instances" of patients being upset by the mistake.

The review panel found staffing shortages were a "significant contributory factor." At the same time, the panel believes a "cultural norm" at the hospital was to schedule new clinical programs and add equipment without having enough staff.

The hospital has since improved its staffing, with the number of medical physicists now exceeding the accepted standard.

The problem with the piece of radiation therapy equipment started after it was moved to the General campus from the Civic in 2004. A staff physicist recommissioned the unit after installation. An annual quality review of the unit in 2007 uncovered the problem.

'Conscientious'

Dr. Brenda Clark, head of medical physics at the hospital, characterized the incident yesterday as "one mistake by one individual."

That individual, who Turnbull said staff had a "great deal of faith in," has since retired from the hospital.

Dr. Peter Dunscombe, director of medical physics at the Tom Baker Cancer Centre in Calgary, chaired the three-member expert review panel, which is satisfied with the hospital's response.

"Upon discovery of the problem, the Ottawa Hospital responded in an appropriate and conscientious manner," the panel wrote in its report.

Patients treated since Nov. 2007 have received proper doses of radiation.

jon.willing@sunmedia.ca

ANDRE FORGET/SUN MEDIA

Dr. Jeff Turnbull, centre, chief of staff at the Ottawa Hospital, speaks to the media during a press conference yesterday as Dr. Brenda Clark and Dr. Laval Grimard look on. The hospital released an independent review into an "orthovoltage incident" that saw 620 patients receive an underdosage of radiation in their cancer treatments.

From Pierre Scalliet, Brussels

How could these accidents happen?

Lack of a QA program or mismanagement of a QA program

Incorrect manual parameter transfer
Glasgow, Scotland

- Introduced a common data base for linacs, TPS and R/V system in 2005
- Previously all plans were calculated for
  1 Gy as prescribed dose and the number of MUs were scaled to correct the dose manually
- Now all plans were made for the correct prescribed dose

What happened?

- 5th January 2006, Lisa Norris, 15 years old, started her whole CNS treatment at BOC
- The treatment plan was divided into head-fields and lower and upper spine-fields
- This is considered to be a complex treatment plan, performed about six times per year at the BOC

What happened?

- Whole CNS plans still went by the “old system”, where the TPS calculates MUs for 1 Gy with subsequent upscaling for dose per fx
- A “medulla planning form” was used, which is passed to treatment radiographers for final MU calculations

Annex 2: A blank copy of the first page of Medulla Planning FM.14.014 as used for Lisa Norris’s treatment plan

BEATSON ONCOLOGY CENTRE - QA CONTROLLED DOCUMENT

MEDULLA PLANNING FORM **FM.14.014**
TWO SPINE FIELDS

Name:	**Site:**
B.O.C. No:	**Unit:**
Radiotherapist:	**Date:**
Physics:	

Setup	Head fields isocentric; asymmetric jaws; customised shielding trays. Physics to move junction after every .... fractions (see over).			
Site	**Head (a)**		**Upper Spine (b)**	**Lower Spine (c)**
Description	Right Lateral	Left Lateral	Posterior	Post / Sup
Field Size (approx for first .... fractions)				
Jaw Settings	x_1 y_1 x_2 y_2	x_1 y_1 x_2 y_2		
F.S.D.	ISOCENTRIC		100 cm	100 cm
Gantry Angle	90°	270°	0°	.......° (i.e. ...... ° to sup)
Collimators	.......° (i.e. ....° Sup End Post)	.......° (i.e. ......° Sup End Post)	90°	90°
Floor Rotation	0°	0°	270°	270°
Beam Modifier	Shielding block tray code =	Shielding block tray code =	Wax compensator (a). tray code 17	Wax compensator (b). tray code 17

Beam Weight (%)	100% (a)	100% (a)	100% (b)	100% (c)
Output (MU/100cGy)				
Dose Information	T.A.D. mid brain = 100% Normalisation = ... %		spinal cord: ......% max subcut: .....%	spinal cord: ......% max subcut: .....%

File Name: FM14014	**Page Number: 1 of: 1**	**Date: 11.8.98**
Issue Number: 1	**Authorised By:**	**Issued By:**

Output (MU/100cGy)

What happened?

- HOWEVER – “Planner X” let the TPS calculate the MUs for the full dose per fx – not for 1 Gy as intended
- Since the dose per fx to the head was 1.67 Gy, the MUs entered in the form were 67% too high for each of the head-fields

Annex 2: A blank copy of the first page of Medulla Planning FM.14.014 as used for Lisa Norris’s treatment plan

BEATSON ONCOLOGY CENTRE - QA CONTROLLED DOCUMENT

MEDULLA PLANNING FORM FM.14.014
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Description	Right Lateral	Left Lateral	Posterior	Post / Sup
Field Size (approx for first .... fractions				
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F.S.D.	ISOCENTRIC		100 cm	100 cm
Gantry Angle	90°	270°	0°	.......° (i.e. ...... ° to sup)
Collimators	.......° (i.e. ....° Sup End Post)	.......° (i.e. ......° Sup End Post)	90°	90°
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Beam Modifier	Shielding block tray code =	Shielding block tray code =	Wax compensator (a). tray code 17	Wax compensator (b). tray code 17

Beam Weight (%)	100% (a)	100% (a)	100% (b)	100% (c)
Output (MU/100cGy)				
Dose Information	T.A.D. mid brain = 100% Normalisation = ... %		spinal cord: ......% max subcut: .....%	spinal cord: ......% max subcut: .....%

File Name: FM14014	Page Number: 1 of: 1	Date: 11.8.98
Issue Number: 1	Authorised By:	Issued By:

Output
(MU/100cGy)

What happened?

- This error was not found by the more senior planners who checked the plan
- The radiographer on the unit thus multiplied with the dose per fx a second time
- 2.92 Gy per fx to the head

Annex 2: A blank copy of the first page of Medulla Planning FM.14.014 as used for Lisa Norris's treatment plan

BEATSON ONCOLOGY CENTRE - QA CONTROLLED DOCUMENT

MEDULLA PLANNING FORM **FM.14.014**
TWO SPINE FIELDS

Name:	**Site:**
B.O.C. No:	**Unit:**
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Setup	Head fields isocentric; asymmetric jaws; customised shielding trays. Physics to move junction after every .... fractions (see over).			
Site	**Head (a)**		**Upper Spine (b)**	**Lower Spine (c)**
Description	Right Lateral	Left Lateral	Posterior	Post / Sup
Field Size (approx for first .... fractions				
Jaw Settings	x_1 y_1 x_2 y_2	x_1 y_1 x_2 y_2		
F.S.D.	ISOCENTRIC		100 cm	100 cm
Gantry Angle	90°	270°	0°	.......° (i.e. ...... ° to sup)
Collimators	.......° (i.e. ....° Sup End Post)	.......° (i.e. ......° Sup End Post)	90°	90°
Floor Rotation	0°	0°	270°	270°
Beam Modifier	Shielding block tray code =	Shielding block tray code =	Wax compensator (a). tray code 17	Wax compensator (b). tray code 17
Beam Weight (%)	100% (a)	100% (a)	100% (b)	100% (c)
Output (MU/100cGy)				
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File Name: FM14014	**Page Number: 1 of: 1**	**Date: 11.8.98**
Issue Number: 1	**Authorised By:**	**Issued By:**

Output (MU/100cGy)

Discovery of the accident

- “Planner X” calculated another plan of the same kind and made the same mistake
- This time, the error was discovered by a senior checker (1st of Feb ‘’06)
- The same day, the error in the calculations for Lisa Norris was also identified

Impact of the accident

- The total dose to Lisa Norris from the right and left lateral head fields was 55.5 Gy (19 x 2.92 Gy)
- She died nine months after the accident
  - Probably due to recurring disease

Lessons to learn

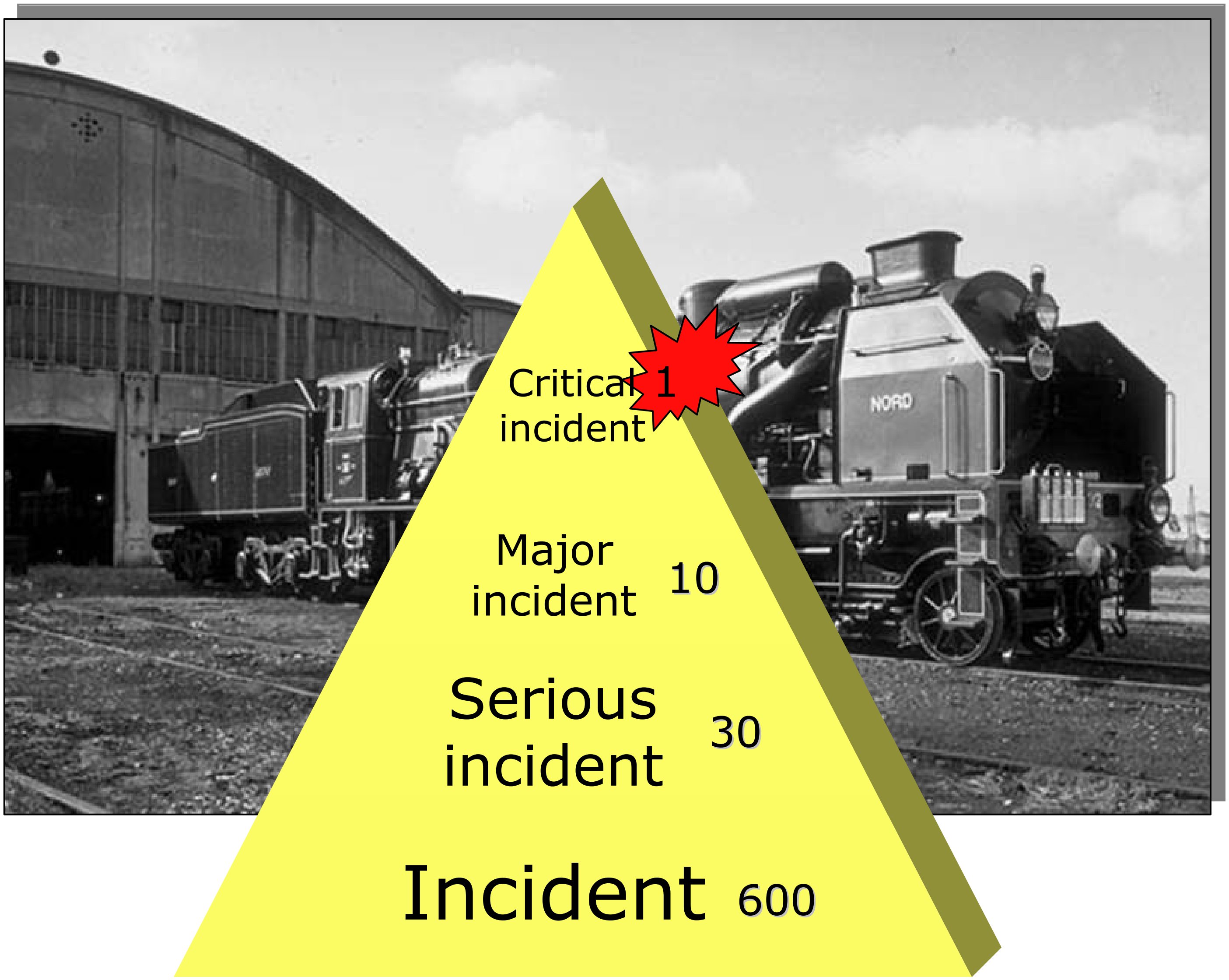
- The experienced planner supervised and checked the plan her-/himself)
- No instructions for putting values into the old form
- Could have been avoided by an independent check of the number of MUs
- *In vivo* dosimetry may have identified the erroneous dose
- Lack of staff (6-7000 patient annually) may have contributed

Lessons to learn

- Ensure that all staff
  - are properly trained in safety of critical procedures
  - are included in training programmes and has supervision as necessary, and that records of training are kept up-to-date
  - understand their responsibilities
- Include in the quality assurance program
  - formal procedures for verifying the risks following the introduction of new technologies and procedures
  - to perform independent MU checking of all treatment plans
- Review staffing levels and competencies

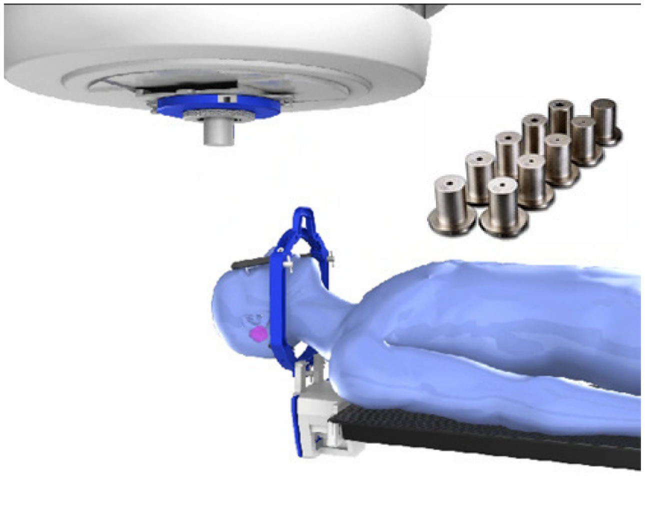
From Pierre Scalliet, Brussels

The incident triangle



Inappropriate beam calibration France 2007

- Reported in 2007 at Hôpital de Rangueil in Toulouse, France
- In April 2006, the physicist in the clinic commissioned the new BrainLAB Novalis stereotactic unit
  - This unit can operate with microMLCs (3 mm leaf-width) or conical standard collimators



Background

- Very small fields can be defined with the microMLCs
  - High dose to a 6 mm x 6 mm field is within capability
  - The TPS requires percent depth doses, beam profiles and relative scatter factors down to this field size
  - Care must be taken when measuring small fields!
- Different measuring devices were used by the physicist
  - A measuring device not suitable for calibrating the smallest microbeams was used
  - "…an ionisation chamber of inappropriate dimensions…" according to Nuclear Safety Authority (ASN) inspectors
- The incorrect data was entered into the TPS
  - All patients treated with micro MLC were planned based on this incorrect data
  - Patients treated with conical collimator were not affected

Discovery of the accident

- The BrainLAB company discovered that the measurement files did not match up with those at other comparable centres, during a worldwide intercomparison study
- It should be noted that the company does not validate or hold any responsibility for local measurements or implementation

Impact of the accident

- Treatment based on the incorrect data went on for a year (Apr´06 – Apr´07)
- All patients treated with microMLCs were affected (145 of 172 stereotactic patients)
- The dosimetric impact was evaluated as small in most cases, with 6 patients identified for whom over 5% of the volume of healthy organs may have been affected by dose exceeding limits

Lessons to learn

- Ensure that staff

  - understands the properties and limitations of the equipment they are using

- Include in the quality assurance programme

  - an intercomparison with other hospitals, in this case an independent check of the output of a new accelerator by an independent group (using their own equipment) before the equipment is clinically used

Incorrect IMRT planning/delivery

USA, NY – 2005

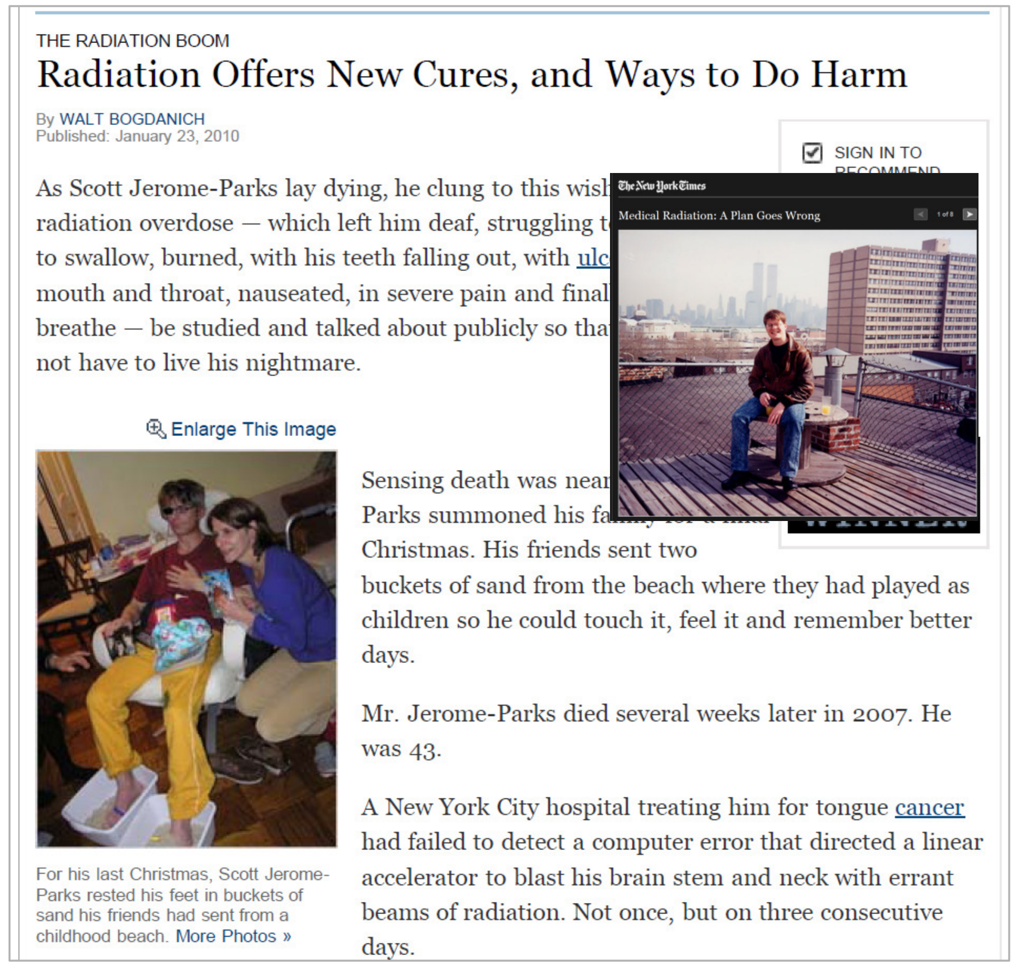
Discussed in

The New York Times

2010

The New York Times January 2010

- Several articles in the NYT early 2010
- Lot's of fuzz in the radiotherapy community
- Hearing in the US Senate
- Many meetings in the US on radiation safety



THE RADIATION BOOM

Radiation Offers New Cures, and Ways to Do Harm

By WALT BOGDANICH
Published: January 23, 2010

SIGN IN TO RECOMMEND

As Scott Jerome-Parks lay dying, he clung to this wish radiation overdose — which left him deaf, struggling t to swallow, burned, with his teeth falling out, with ulc mouth and throat, nauseated, in severe pain and final breathe — be studied and talked about publicly so tha not have to live his nightmare.

The New York Times
Medical Radiation: A Plan Goes Wrong

Enlarge This Image

For his last Christmas, Scott Jerome-Parks rested his feet in buckets of sand his friends had sent from a childhood beach. More Photos »

Sensing death was near Parks summoned his fa Christmas. His friends sent two buckets of sand from the beach where they had played as children so he could touch it, feel it and remember better days.

Mr. Jerome-Parks died several weeks later in 2007. He was 43.

A New York City hospital treating him for tongue cancer had failed to detect a computer error that directed a linear accelerator to blast his brain stem and neck with errant beams of radiation. Not once, but on three consecutive days.

Energy and Commerce - Subcommittee on Health held a hearing entitled "Medical Radiation: An Overview of the Issues" on Friday, February 26, 2010

http://www.youtube.com/watch?v=NcqRgVqeQSg

http://www.youtube.com/watch?v=L_IzTqhghMs

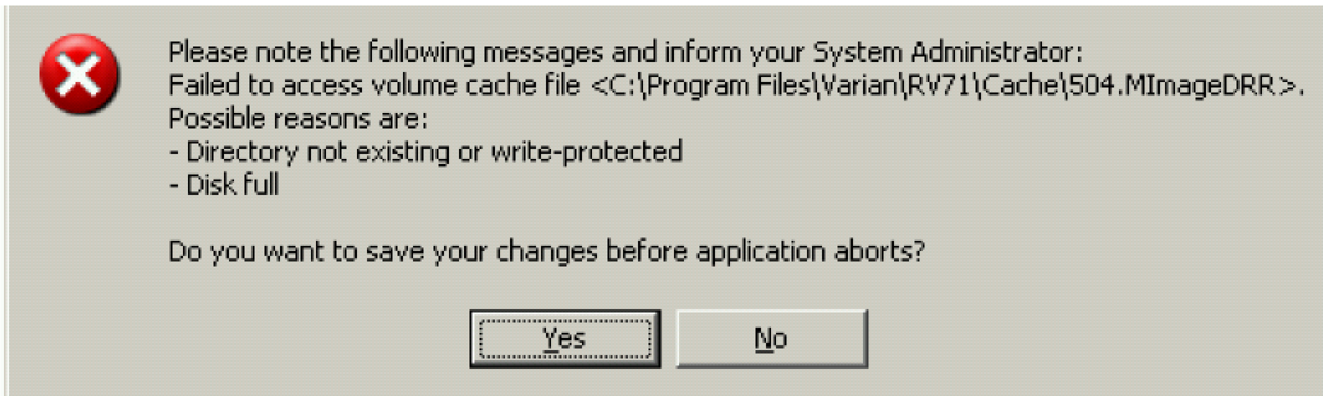
What happened

- Tuesday - March 8, 2005
  - The patient begins an IMRT treatment at St Vincent's Hospital, Manhattan, NY
  - The plan had passed the QC process according to the local protocol
  - The treatment is delivered correctly
- Friday - March 11, 2005
  - The physician reviews the case after 4 fractions
    - Wants a modified dose distribution (reducing dose to teeth)
- Monday - March 14, 2005
  - Re-planning and re-optimization starts
  - Fractionation is changed. Existing fluences are deleted and re-optimized. New optimal fluences are saved
  - Final calculations are started, where MLC motion control points for IMRT are generated

What happened?

- “Save all” is started; all new and modified data should be saved
- In this case, data to be saved included
  - actual fluence data
  - a DRR
  - the MLC control points

What happened?

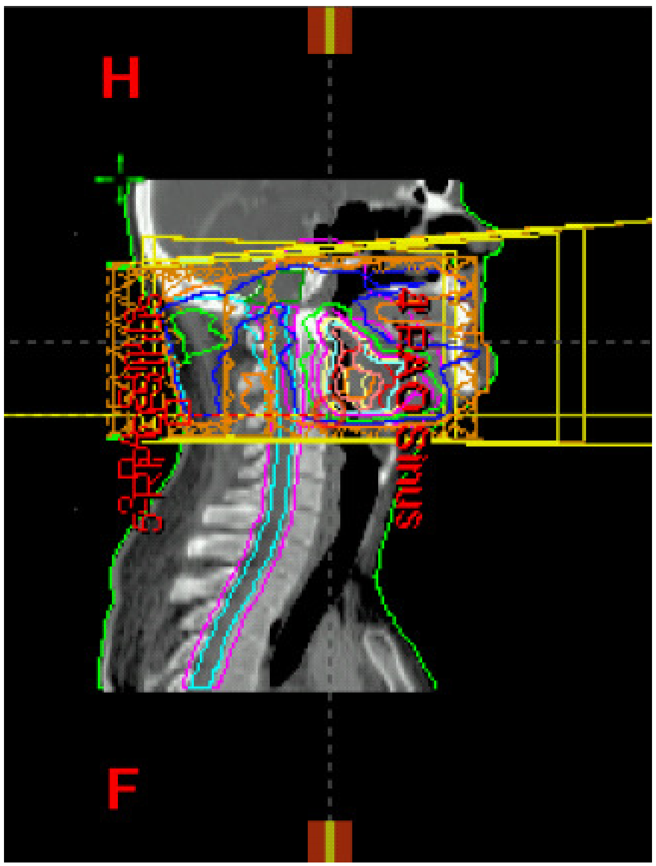


The transaction error message displayed

What happened?

What happened?

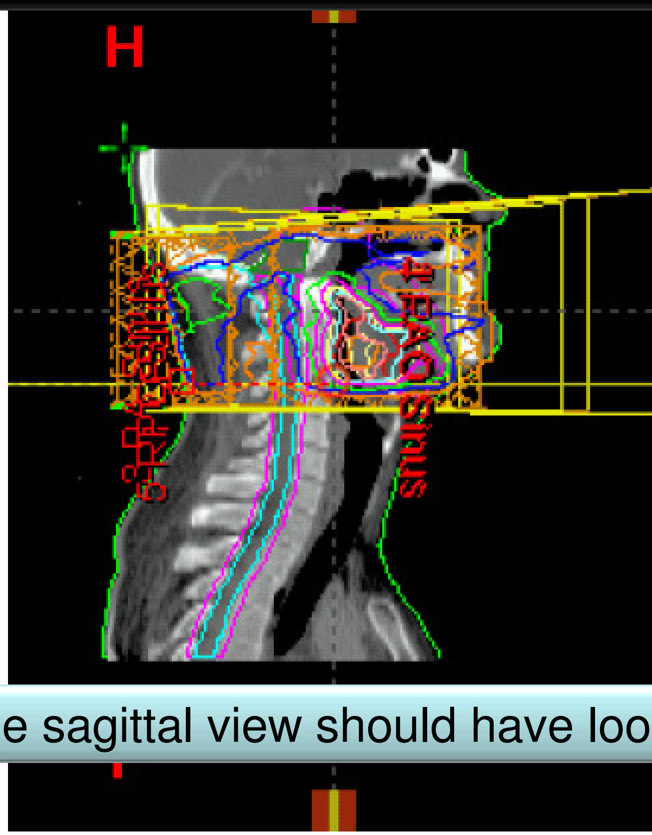
- Monday - March 14, 2005, 11.a.m.
  - Within 12 s, another workstation, WS1, is used to open the patient plan. The planner would have seen this:

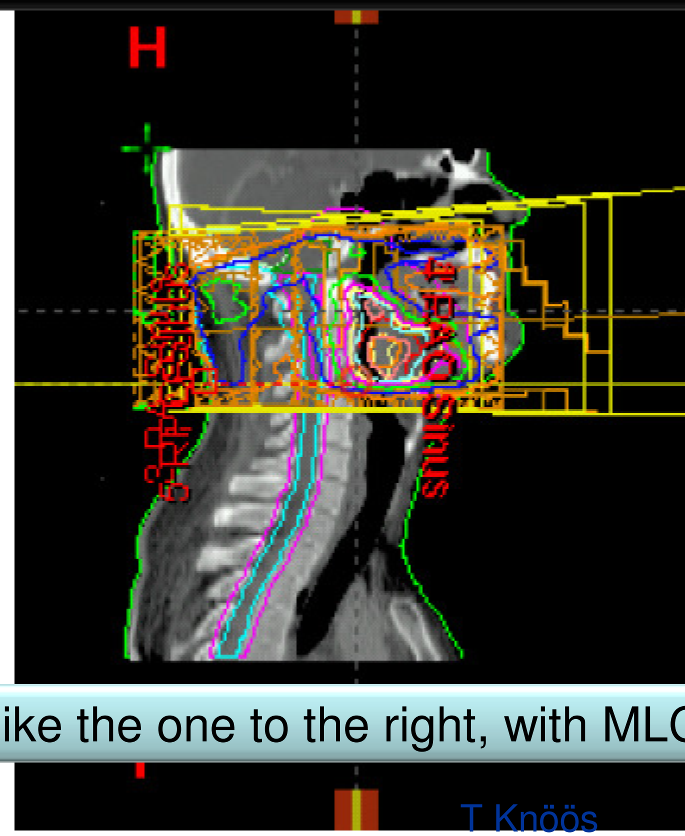


What happened?

- Monday - March 14, 2005, 11.a.m.

No MLC control point data is included in the plan, neither required for dose calculation, display and approval !!!



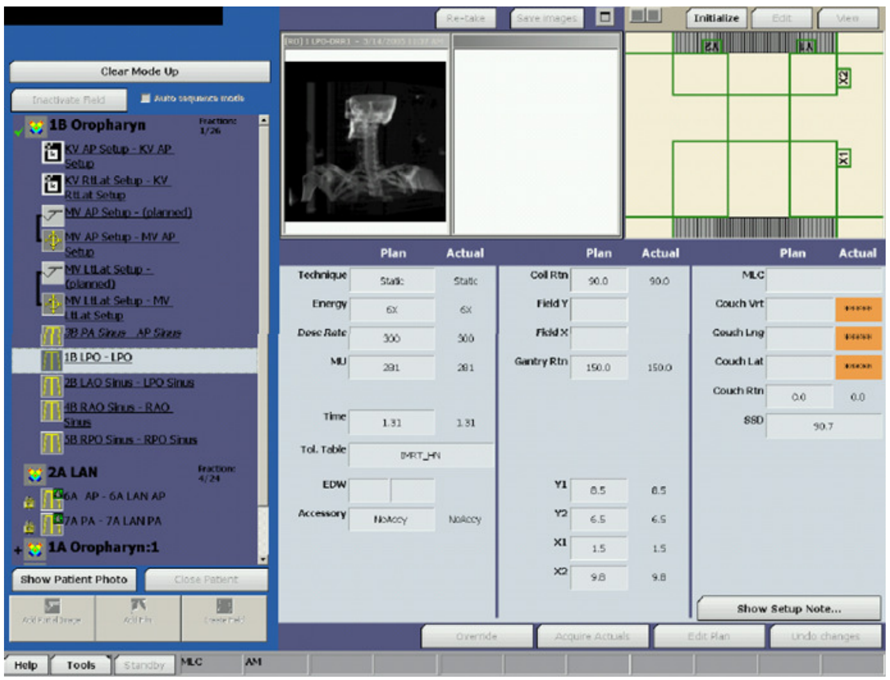


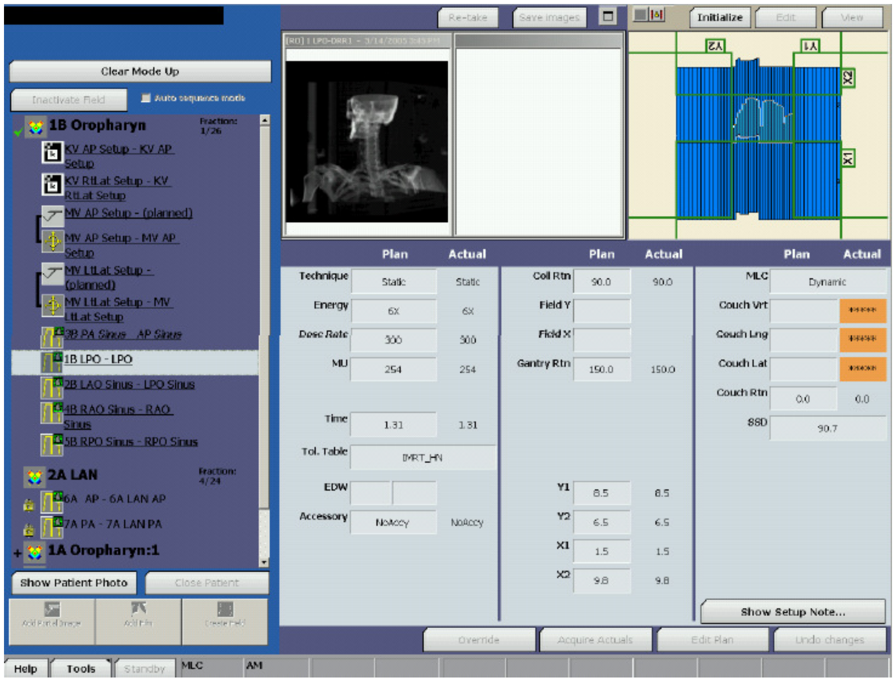
The sagittal view should have looked like the one to the right, with MLCs

T Knöös

What happened?

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





Discovery of accident

- Monday - March 14, 2005, 11 a.m.
  - No verification plan is generated or used - should be done according to local QA program
  - The plan is subsequently prepared for treatment (treatment scheduling, image scheduling, etc
- It is also approved by a physician
- According to local QA program, a second physicist should then have reviewed the plan
  - including an overview of the irradiated area outline
  - MLC shape
  - Etc

- Tuesday/Wednesday - March 15-16, 2005
  - The patient is treated without MLCs for three fractions
- Wednesday - 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 received 13 Gy per fraction for three fractions, i.e. 39 Gy in 3 fractions

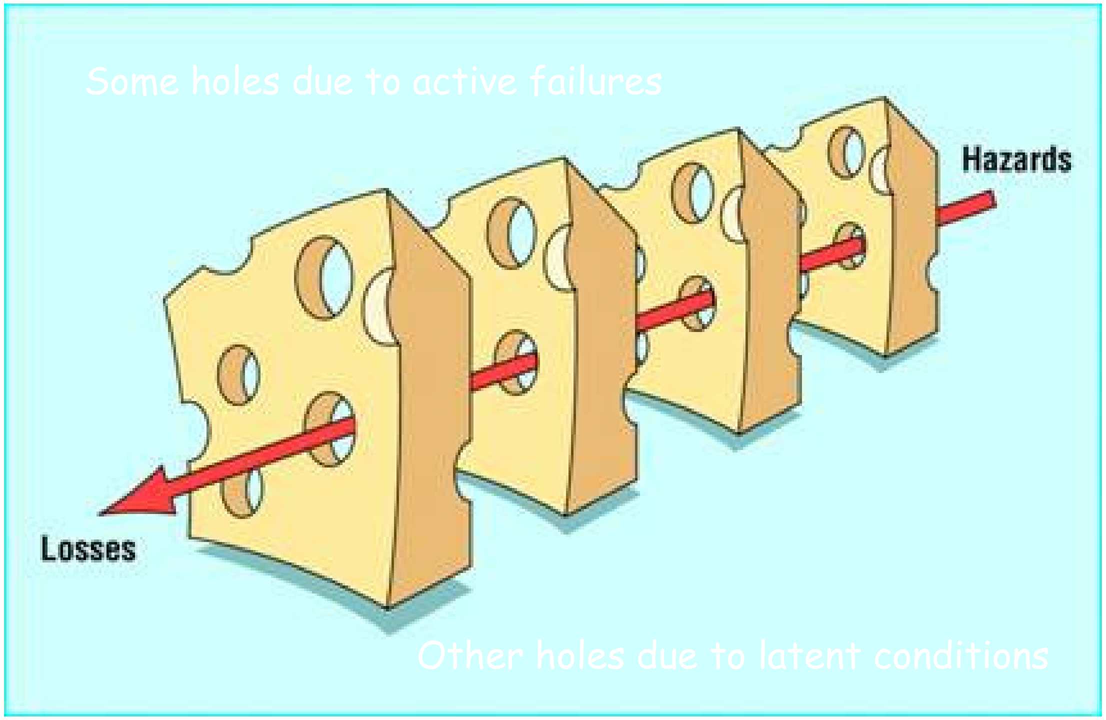
Lessons to learn

- Do what you should be doing according to your QA programme
  - The error could have been found through a verification of the plan (normal QA procedure at the facility) or an independent review
- Be alert when a computer crashes or freezes; check the data before you continue working
- Work with awareness at the treatment unit, and keep an eye out on unexpected behaviour of the machine

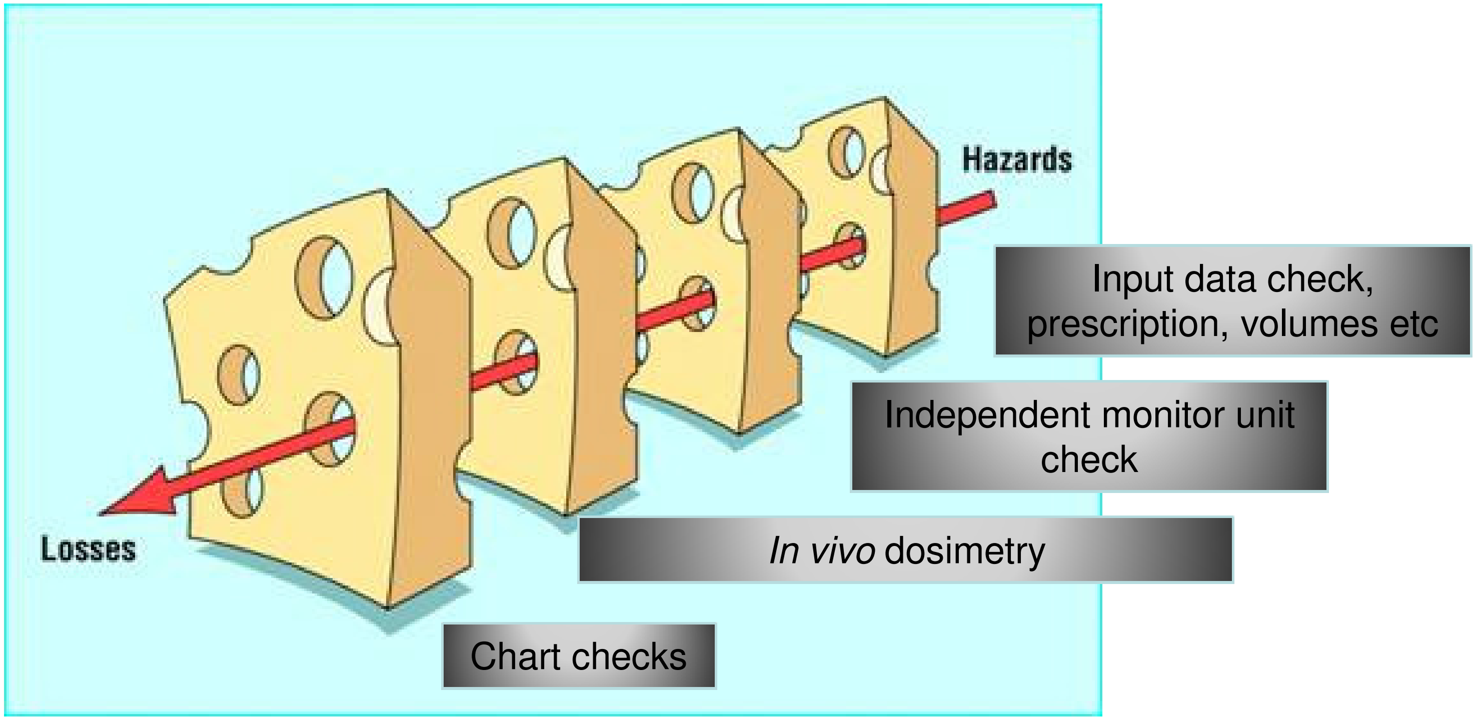
Mr. Jerome-Parks with his wife, Carmen, on the day he received his diagnosis of tongue cancer. For his treatment, he chose St. Vincent's Hospital in Manhattan, which was promoting a new linear accelerator and a treatment called Intensity Modulated Radiation Therapy, which could more precisely shape and modulate the radiation beam. Treatment started March 8, 2005

Sensing that death was near, Mr. Jerome-Parks and his wife summoned his family for a final Christmas together. Friends sent buckets of sand from the beach in Gulfport, Miss., where they had played together, so that he could sink his feet in it and remember happy times. Two month later in Febr. 2007 he died from his injuries.

Swiss cheese model of failure propagation



Radiotherapy safety layers



Summary and lessons to learn

- Work with awareness and alertness
  - Be aware of what you are doing
  - An irradiation can't be undone
- Procedures
  - Think through if procedures are covering everything that might go wrong
- Training and understanding
  - Have a thorough understanding of equipment and the data that is used for patient treatments
- Responsibilities
  - Make sure all responsibilities are allocated and understood
  - All members of staff are educated according to their tasks and kept up-to-date in their training

Thanks for listening

and thanks particularly to Tommy Knöös for using many of his slides in this presentation

And...

To ensure patient safety we need