A Look into the Future of External Beam RT: Quality and Science

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And the 2011 AAPM Summer School Faculty!

Canadian Foundation for Innovation, CIHR, OICR

Radiation Therapy Dose

Can’t smell it, touch it, or feel it – need to place it in the human body to within a few mm and to within a few percent.

RT

Quality is the Priority

RT

INFLUENCE OF TECHNOLOGIC ADVANCES ON OUTCOMES IN PATIENTS WITH UNRESECTABLE, LOCALLY ADVANCED NON–SMALL-CELL LUNG CANCER RECEIVING CONCOMITANT CHEMORADIOTHERAPY

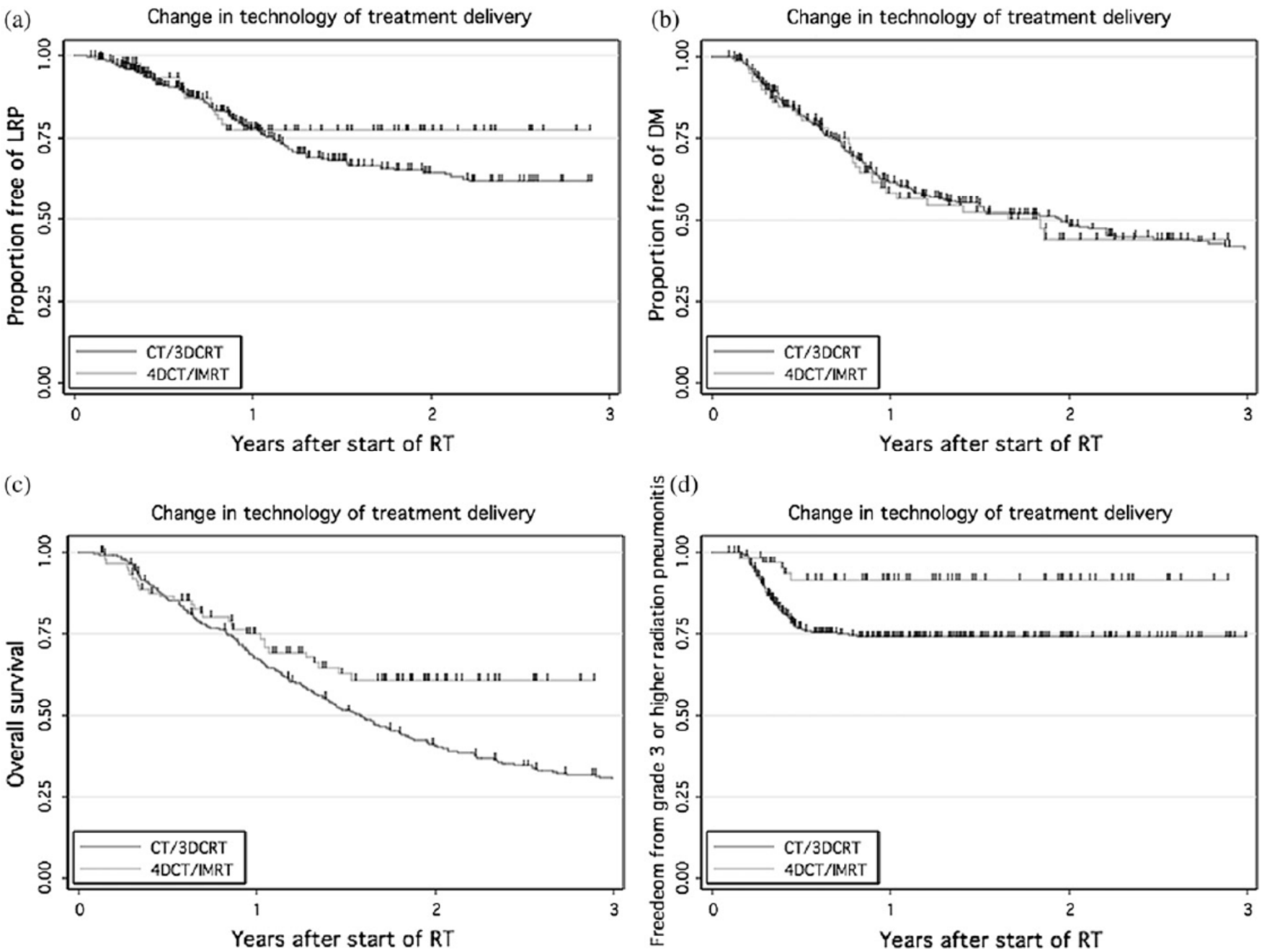
ZHONGXING X. LIAO, M.D.,* RITSUKO R. KOMAKI, M.D.,* HOWARD D. THAMES, JR., PH.D.,§ HELEN H. LIU, PH.D.,† SUSAN L. TUCKER, PH.D.,‡ RADHE MOHAN, PH.D.,† MARY K. MARTEL, PH.D.,† XIONG WEI, M.D.,* KUNYU YANG, M.D.,* EDWARD S. KIM, M.D.,‖ GEORGE BLUMENSCHEIN, M.D.,‖ WAUN KI HONG, M.D.,‖ AND JAMES D. COX, M.D.*

Departments of *Radiation Oncology, †Radiation Physics, ‡Bioinformatics and Computational Biology, §Biostatistics, and ‖Head and Neck/Thoracic Medical Oncology, The University of Texas M. D. Anderson Cancer Center, Houston, TX

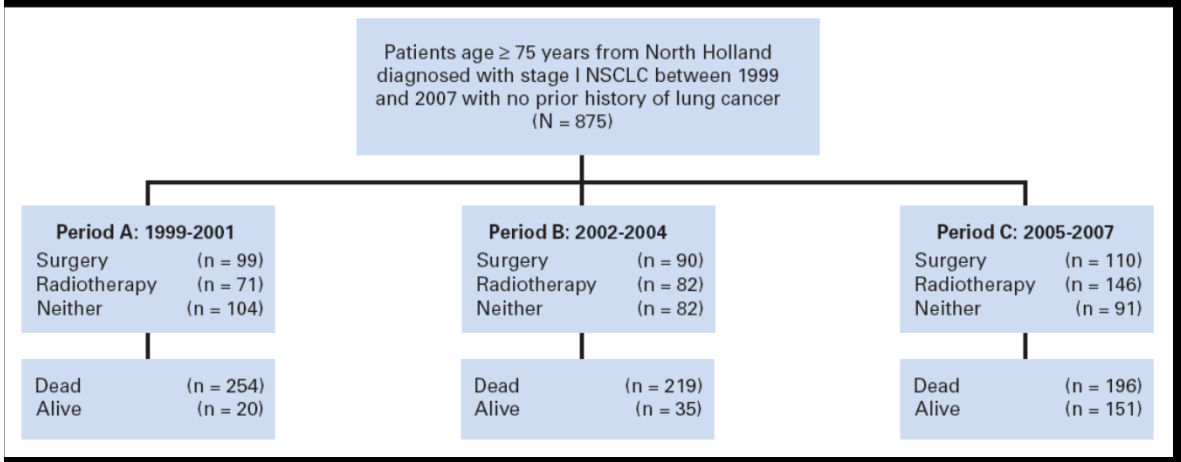
Purpose: In 2004, the institution began using four-dimensional computed tomography (4DCT) simulation and then intensity-modulated radiotherapy (IMRT) (4DCT/IMRT) instead of three-dimensional conformal radiotherapy (3DCRT) for the standard treatment of non–small-cell lung cancer (NSCLC). <u>This retrospective study compares disease outcomes and toxicity in patients treated with concomitant chemotherapy and either 4DCT/IMRT or 3DCRT.</u>

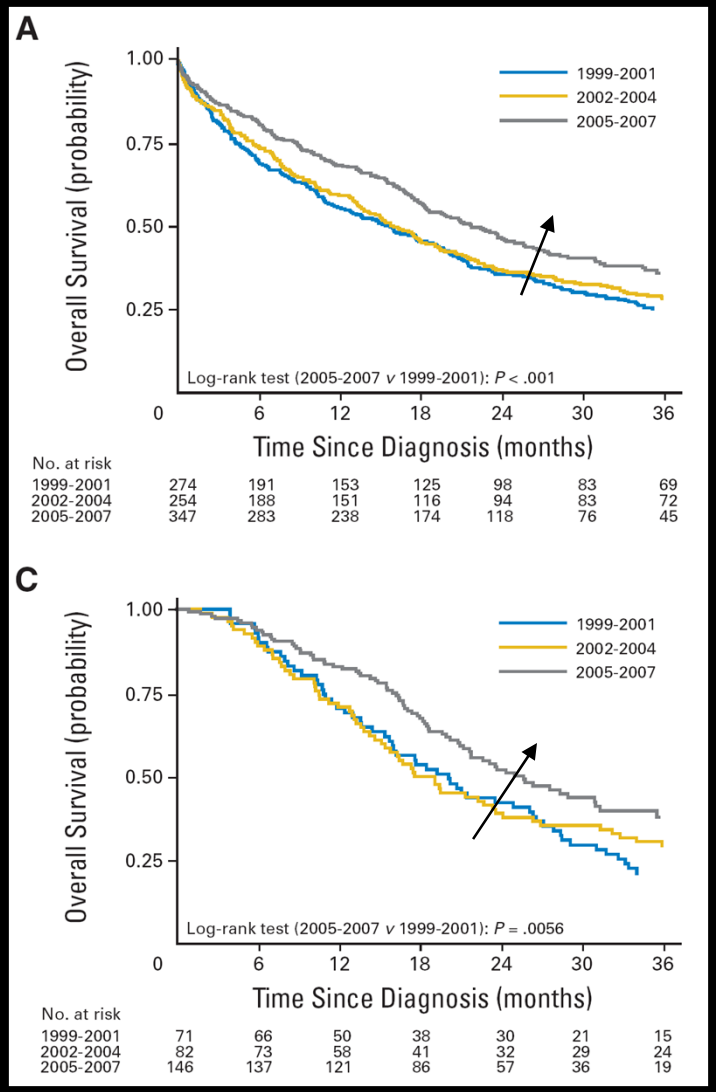
Conclusions: Treatment with 4DCT/IMRT was at least as good as that with 3DCRT in terms of the rates of freedom from Loco-regional Progression and Distant Metastasis. There was a significant reduction in toxicity and a significant improvement in Overall Survival.

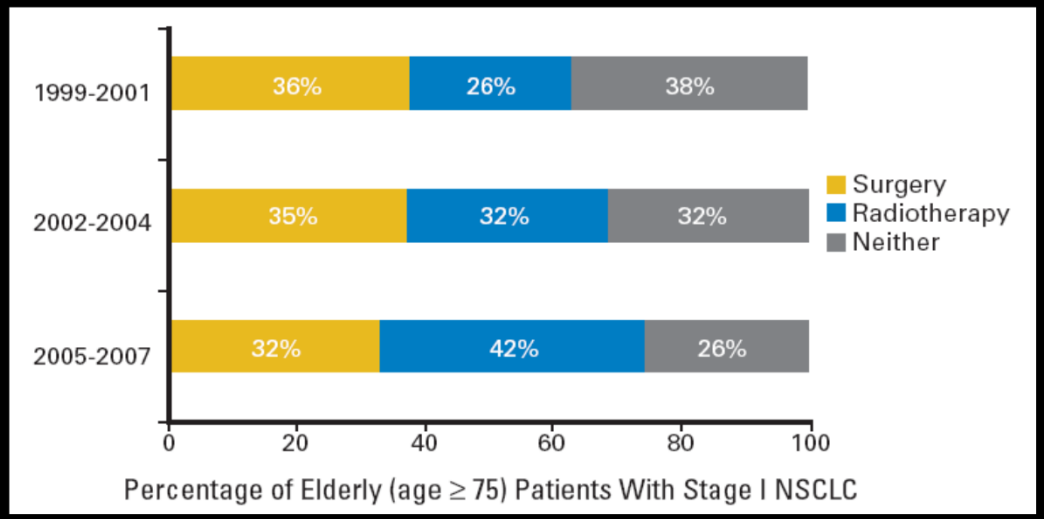
Int. J. Radiation Oncology Biol. Phys., Vol. 76, No. 3, pp. 775–781, 2010


(a)
Change in technology of treatment delivery
Proportion free of LRP
1.00
0.75
0.50
0.25
0.00
CT/3DCRT
4DCT/IMRT
0
1
2
3
Years after start of RT
(b)
Change in technology of treatment delivery
Proportion free of DM
1.00
0.75
0.50
0.25
0.00
CT/3DCRT
4DCT/IMRT
0
1
2
3
Years after start of RT
(c)
Change in technology of treatment delivery
Overall survival
1.00
0.75
0.50
0.25
0.00
CT/3DCRT
4DCT/IMRT
0
1
2
3
Years after start of RT
(d)
Change in technology of treatment delivery
Freedom from grade 3 or higher radiation pneumonitis
1.00
0.75
0.50
0.25
0.00
CT/3DCRT
4DCT/IMRT
0
1
2
3
Years after start of RT

SBRT Lung: Outcome Trends







Palma, D. et al. JCO 28, 5153-5159 (2010).

SBRT Lung: Outcome Trends

JAMA. 2010 March 17; 303(11): 1070–1076. doi:10.1001/jama.2010.261.

Stereotactic Body Radiation Therapy for Inoperable Early Stage Lung Cancer

Robert Timmerman, M.D., **Rebecca Paulus, B.S.**, **James Galvin, Ph.D.**, **Jeffrey Michalski, M.D.**, **William Straube, Ph.D.**, **Jeffrey Bradley, M.D.**, **Achilles Fakiris, M.D.**, **Andrea Bezjak, M.D.**, **Gregory Videtic, M.D.**, **David Johnstone, M.D.**, **Jack Fowler, Ph.D.**, **Elizabeth Gore, M.D.**, and **Hak Choy, M.D.**

Design, Setting, and Patients—Phase 2 North American multicenter study of patients with biopsy-proven peripheral T1-T2, N0, M0 non-small cell tumors less than 5 cm in diameter and medical conditions precluding surgical treatment. The prescription dose was 18 Gy per fraction times 3 fractions (54 Gy total) delivered in 1½-2 weeks. The study opened May 26, 2004, and closed October 13, 2006; data were analyzed through August 31, 2009.

Main Outcome Measures—The primary endpoint was primary tumor control with overall survival, disease free survival, adverse events, involved lobe, regional, and disseminated recurrence as secondary endpoints.

Results—A total of 59 patients accrued, of which 55 were evaluable (44 T1 and 11 T2 tumors) with a median follow-up of 34.4 months (range, 4.8 to 49.9 months). Only 1 patient had a primary tumor failure; the estimated 3-year primary tumor control rate was 97.6% (95% confidence interval [CI], 84.3%, 99.7%). Three patients had recurrence within the involved lobe; the 3-year

SD-IGRT: Metastases

ELSEVIER

Int. J. Radiation Oncology Biol. Phys., Vol. 79, No. 4, pp. 1151–1157, 2011

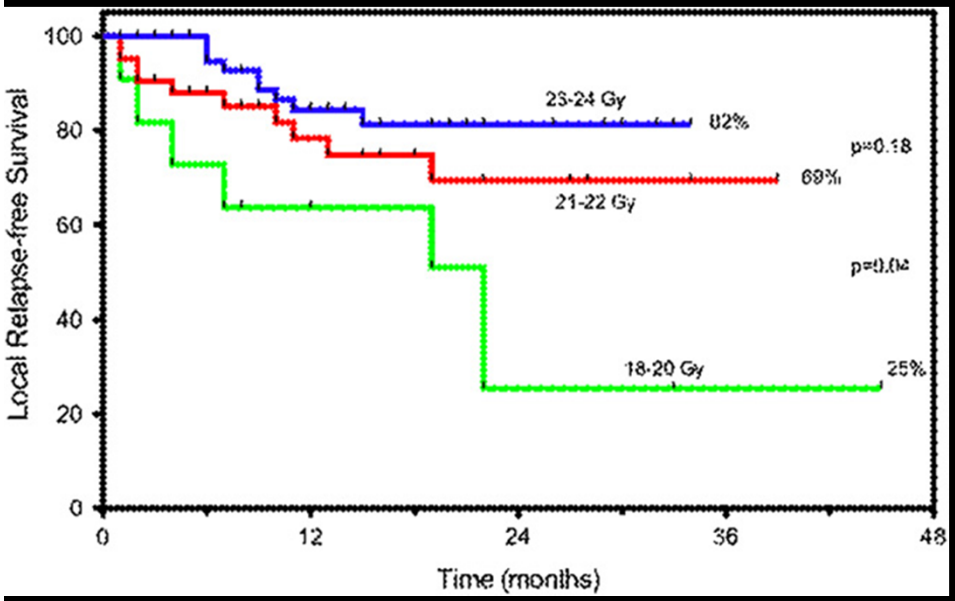
0360-3016/$–see front matter

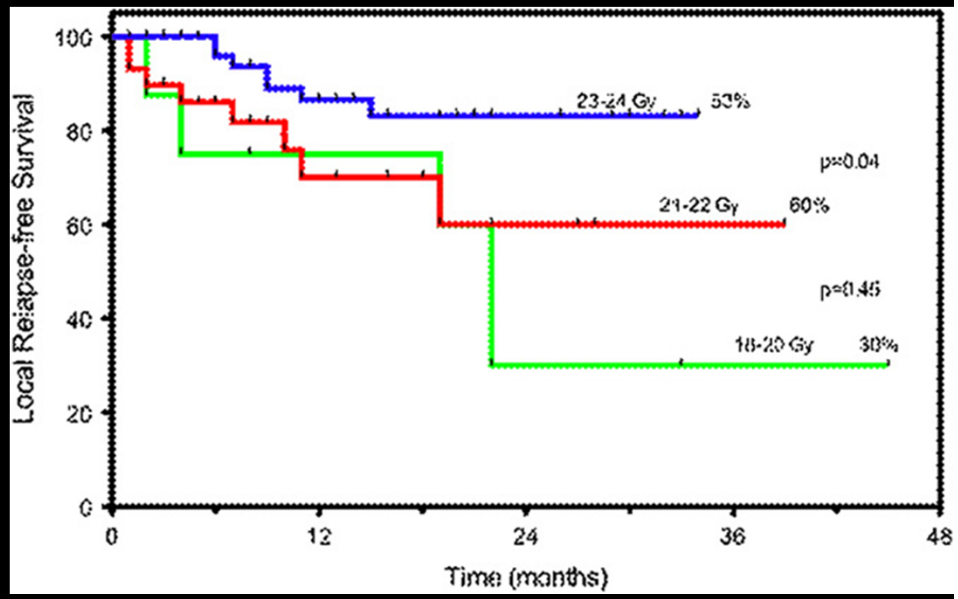
doi:10.1016/j.ijrobp.2009.12.038

CLINICAL INVESTIGATION **Metastasis**

PREDICTORS OF LOCAL CONTROL AFTER SINGLE-DOSE STEREOTACTIC IMAGE-GUIDED INTENSITY-MODULATED RADIOTHERAPY FOR EXTRACRANIAL METASTASES

Carlo Greco, M.D.,* Michael J. Zelefsky, M.D.,* Michael Lovelock, Ph.D.,† Zvi Fuks, M.D.,* Margie Hunt, M.S.,† Kenneth Rosenzweig, M.D.,* Joan Zatcky, B.S., N.P.,* Balem Kim, B.A.,* and Yoshiya Yamada, M.D.*





(all lesions) **(bone only)**

Wow, we are good!

- This radiation therapy stuff really works!
- We can relax, maybe we've probably been overstating the concerns around uncertainty…

INCREASED RISK OF BIOCHEMICAL AND LOCAL FAILURE IN PATIENTS WITH DISTENDED RECTUM ON THE PLANNING CT FOR PROSTATE CANCER RADIOTHERAPY

Renaud de Crevoisier, M.D.,* Susan L. Tucker, Ph.D.,† Lei Dong, Ph.D.,‡
Radhe Mohan, Ph.D.,‡ Rex Cheung, M.D., Ph.D.,* James D. Cox, M.D.,*
and Deborah A. Kuban, M.D.*

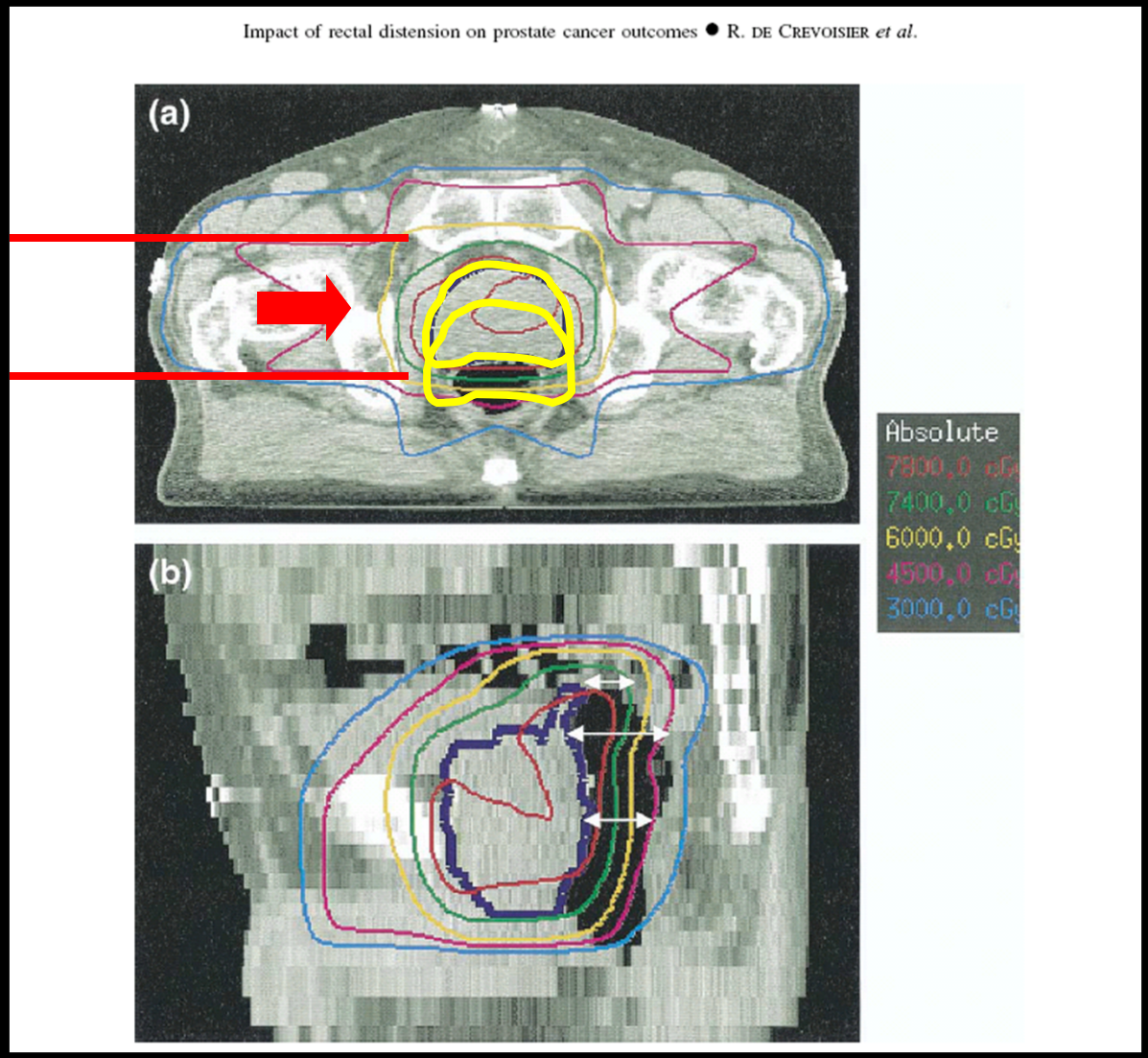
Departments of *Radiation Oncology, †Biostatistics and Applied Mathematics, and ‡Radiation Physics, The University of Texas M. D. Anderson Cancer Center, Houston, TX

<u>Hypothesis</u>: If the rectum is distended on the planning CT, the probability is high that it will be less distended during treatment, and, consequently, the prostate, on average, will be shifted posteriorly during treatment relative to its position at the time of CT simulation.

de Crevoisier et al., Int. J. Radiation Oncology Biol. Phys., Vol. 62, No. 4, pp. 965–973, 2005

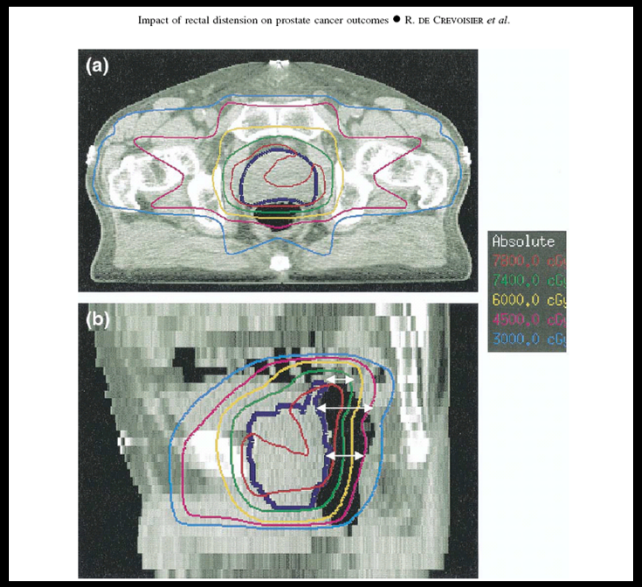
Methods:

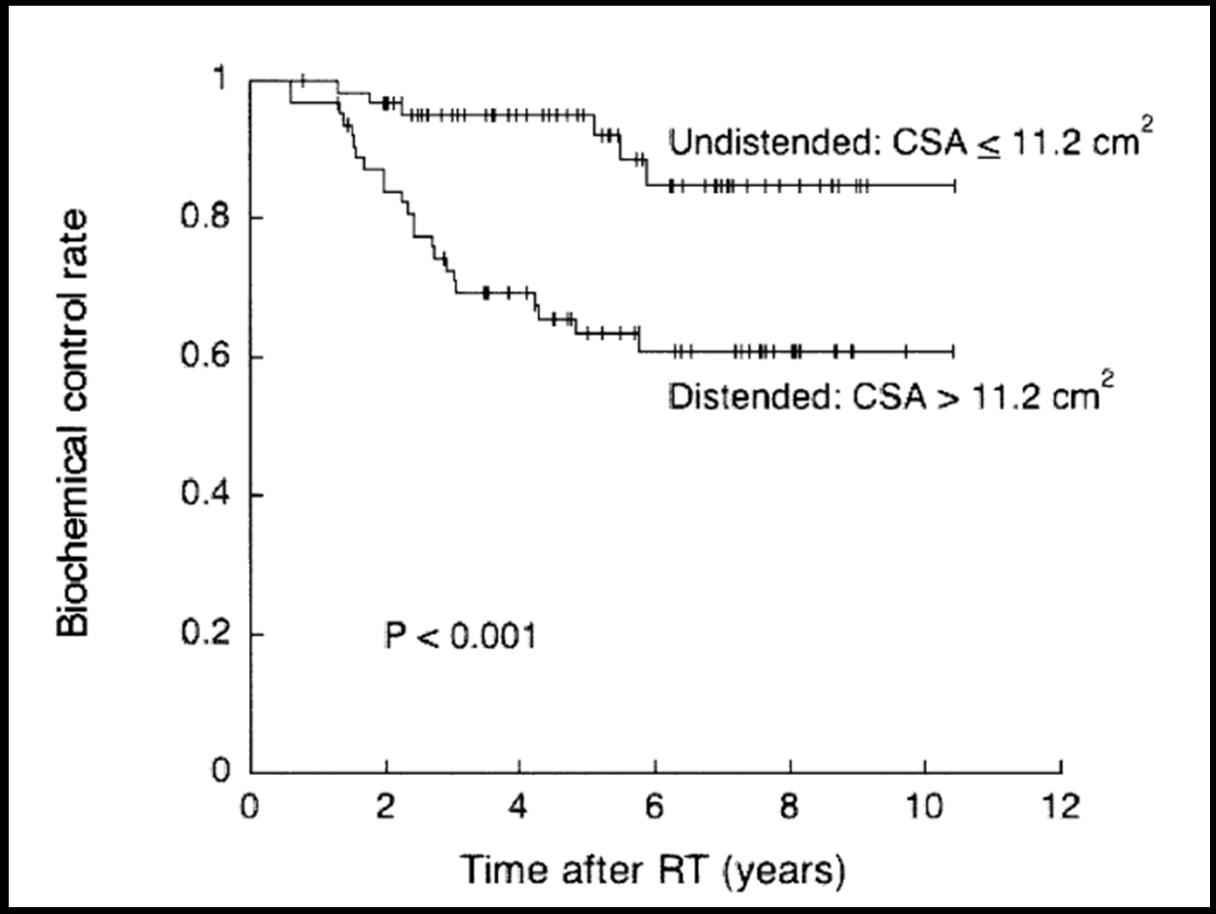
- 127 patients with definitive 3D-CRT for prostate cancer (78 Gy)
- Rectal distension assessed by calculation of the average cross-sectional rectal area (CSA; defined as the rectal volume divided by length) and measuring three rectal diameters on the planning CT.
- Test the impact of rectal distension on biochemical control, 2-year prostate biopsy results, and incidence of Grade 2 or greater late rectal bleeding was assessed.



de Crevoisier et al., Int. J. Radiation Oncology Biol. Phys., Vol. 62, No. 4, pp. 965–973, 2005

Results:





Median Cross-sectional Area (CSA) = 11.2 cm^2

de Crevoisier et al., Int. J. Radiation Oncology Biol. Phys., Vol. 62, No. 4, pp. 965–973, 2005

CLINICAL INVESTIGATION

FAILURE TO ADHERE TO PROTOCOL SPECIFIED RADIATION THERAPY GUIDELINES WAS ASSOCIATED WITH DECREASED SURVIVAL IN RTOG 9704—A PHASE III TRIAL OF ADJUVANT CHEMOTHERAPY AND CHEMORADIOTHERAPY FOR PATIENTS WITH RESECTED ADENOCARCINOMA OF THE PANCREAS

Ross A. Abrams, M.D.,* Kathryn A. Winter, M.S.,† William F. Regine, M.D.,‡
Howard Safran, M.D.,§ John P. Hoffman, M.D.,‖ Robert Lustig, M.D.,† Andre A. Konski, M.D.,¶
Al B. Benson, M.D.,** John S. Macdonald, M.D.,†† Tyvin A. Rich, M.D.,‡‡
and Christopher G. Willett, M.D.§§

In Radiation Therapy Oncology Group 9704, as previously published, patients with resected pancreatic adenocarcinoma received continuous infusion 5-FU and concurrent radiotherapy (5FU-RT). 5FU-RT treatment was preceded and followed by randomly assigned chemotherapy, either 5-FU or gemcitabine. This analysis explored whether failure to adhere to specified RT guidelines influenced survival and/or toxicity.

Abrams IJORBP 2011

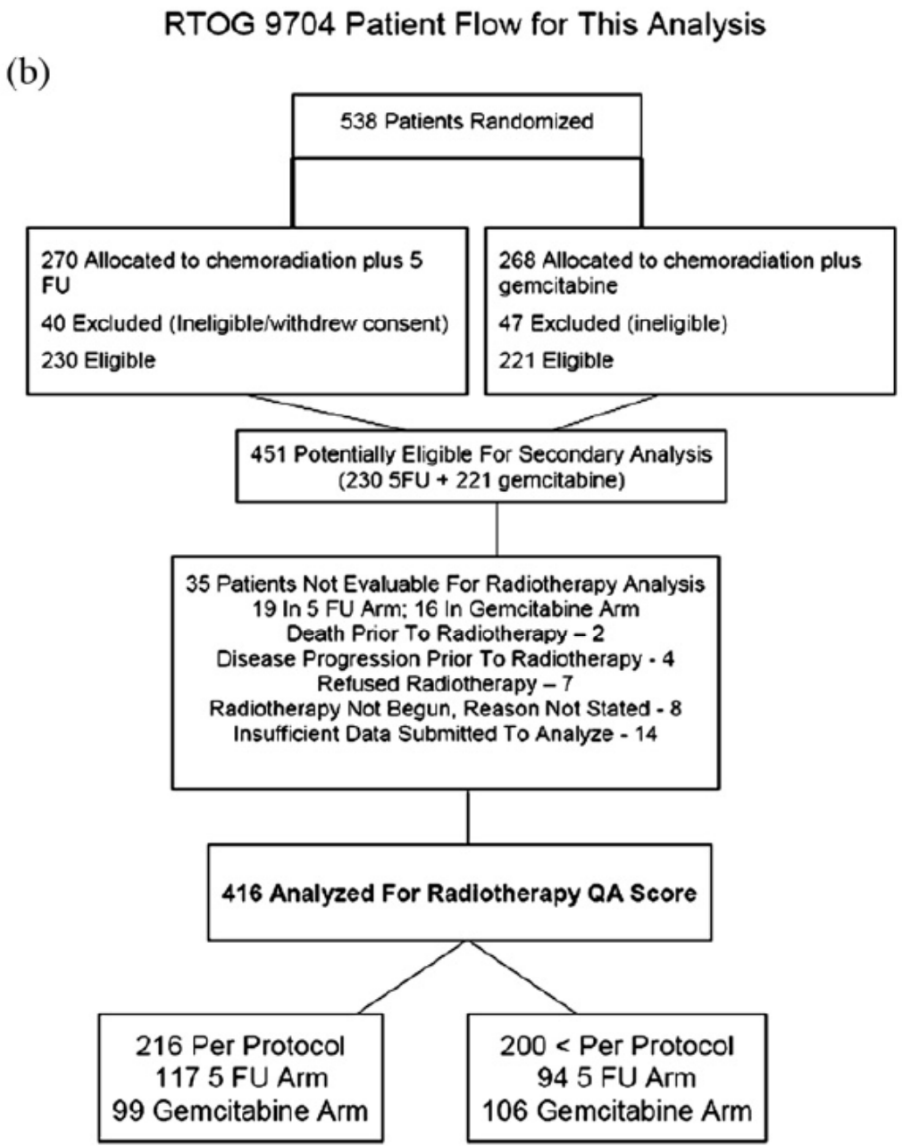


Figure 1. (A) Treatment schema for RTOG Protocol 9704. (B) Consort diagram.

Table 2. Variations and their frequency in the 200 patients with <per protocol radiotherapy (total variations are more than 200 as some patients had more than one variation)

Variation	Initial treatment or boost treatment	Frequency
Field placement or size	Initial	140
Dose administered	Initial	14
Dose per fraction	Initial	6
Elapsed treatment time	Initial	26
Field placement or size	Boost	127
Dose administered	Boost	12
Dose per fraction	Boost	3
Elapsed treatment time	Boost	14

Table 5. Multivariate analysis for overall survival (continued): head of pancreas patients only ($n = 359$)

Adjustment variables	Comparison	Adjusted HR	p value†
Treatment	Gemcitabine vs. 5-FU	0.79 (0.62–0.99)	0.043
Nodal involvement	No vs. yes	1.47 (1.13–1.91)	0.0036
Tumor diameter	<3 vs. ≥3 cm	1.25 (0.98–1.59)	0.070
Surgical margin status	Negative	Reference level	—
	Positive	1.07 (0.82–1.40)	0.64
	Unknown	0.94 (0.69–1.27)	0.68
RT QA score	<PP vs. PP	0.75 (0.60–0.95)	0.016

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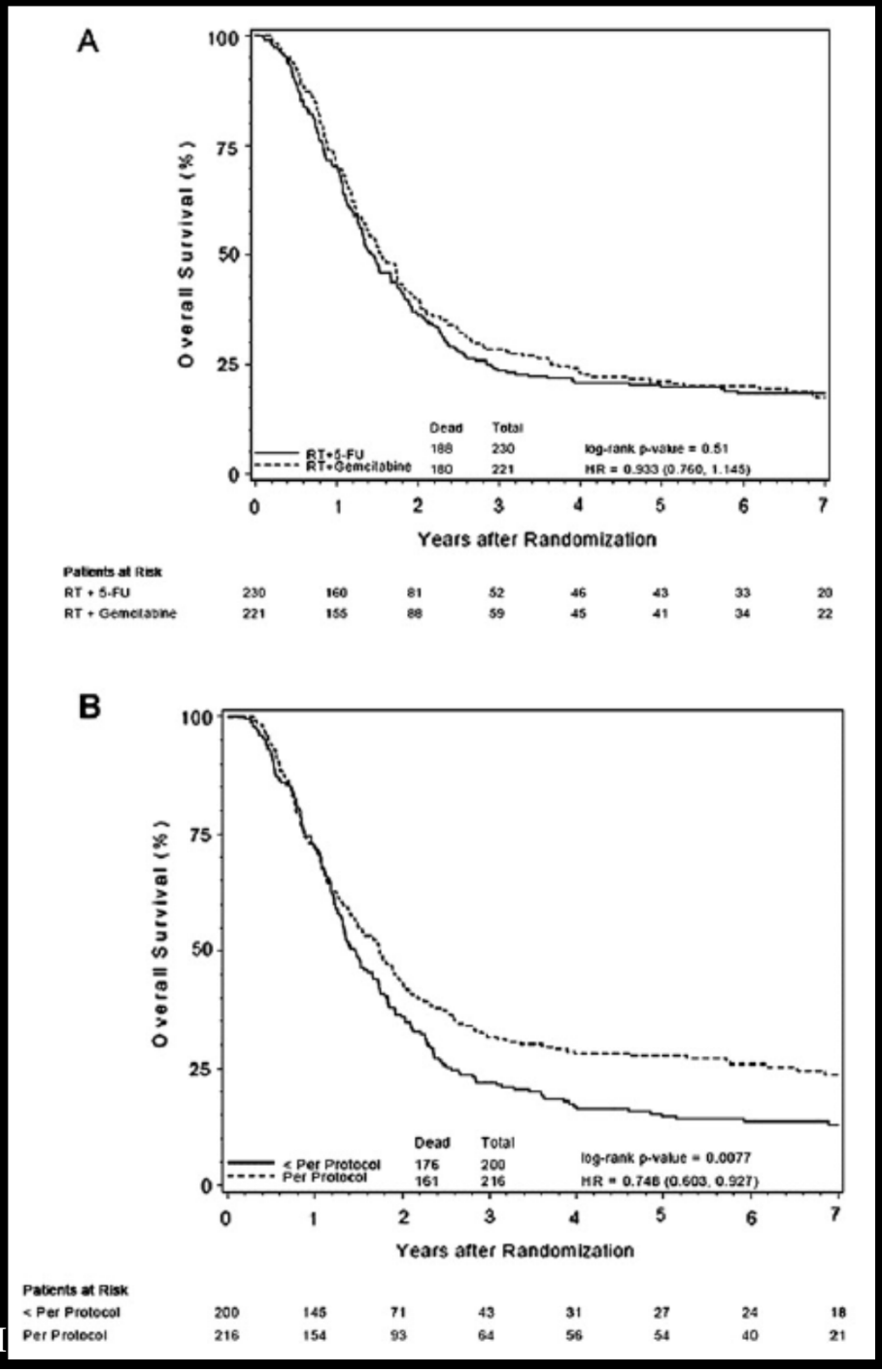

Figure 2. (A) Survival results. Survival results by randomization between treatment arms. There is no significant difference in survival between the two treatment arms. Median survivals: 5FU arm = 1.43 years; gemcitabine arm = 1.55 years (p = 0.51).
(B) Survival results by radiotherapy quality (RTQA) score as per protocol (PP) or <PP. Patients with RTQA score of PP had significantly better survival; 1.74 years vs. 1.46 years (p = 0.0077).

Abrams IJORBP 2011

VOLUME 28 · NUMBER 18 · JUNE 20 2010

JOURNAL OF CLINICAL ONCOLOGY

ORIGINAL REPORT

Critical Impact of Radiotherapy Protocol Compliance and Quality in the Treatment of Advanced Head and Neck Cancer: Results From TROG 02.02

Lester J. Peters, Brian O'Sullivan, Jordi Giralt, Thomas J. Fitzgerald, Andy Trotti, Jacques Bernier, Jean Bourhis, Kally Yuen, Richard Fisher, and Danny Rischin

To report the impact of radiotherapy quality on outcome in a large international phase III trial evaluating radiotherapy with concurrent cisplatin plus tirapazamine for advanced head and neck cancer.

Peters et al. JCO 2010

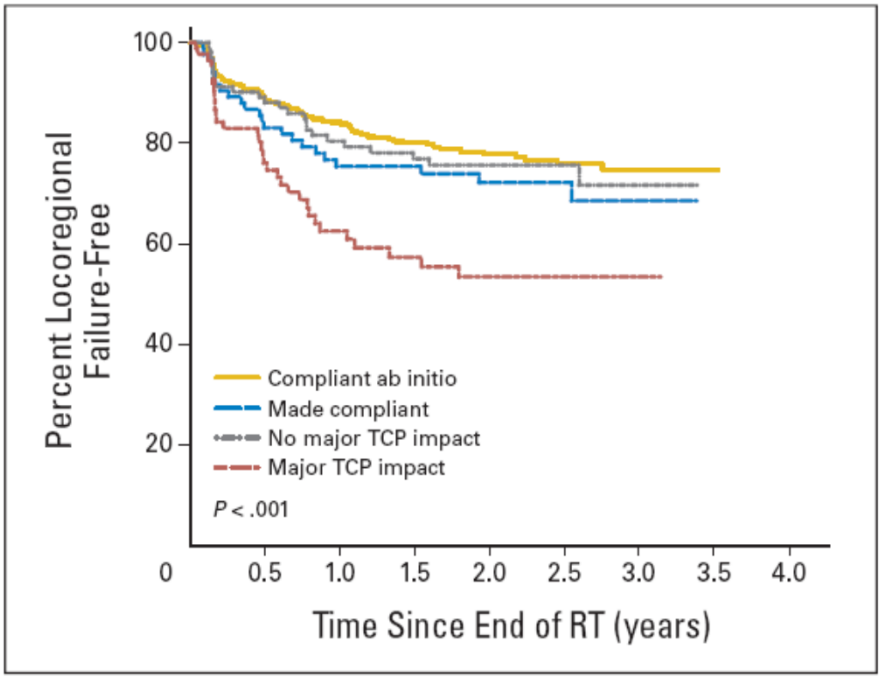

Fig 3. Time to locoregional failure by deviation status. The four cohorts are (1) compliant from the outset (n = 502), (2) made compliant following a review by the Quality Assurance Review Center (n = 86), (3) noncompliant but without predicted major adverse impact on tumor control (n = 105), and (4) noncompliant with predicted major adverse impact on tumor control (n = 87). Overall $P < .001$. Pair-wise tests were not statistically significant except for cohort 1 versus cohort 4 ($P < .001$), cohort 2 versus cohort 4 ($P = .004$), and cohort 3 versus cohort 4 ($P = .006$). TCP, tumor control probability; RT, radiotherapy.

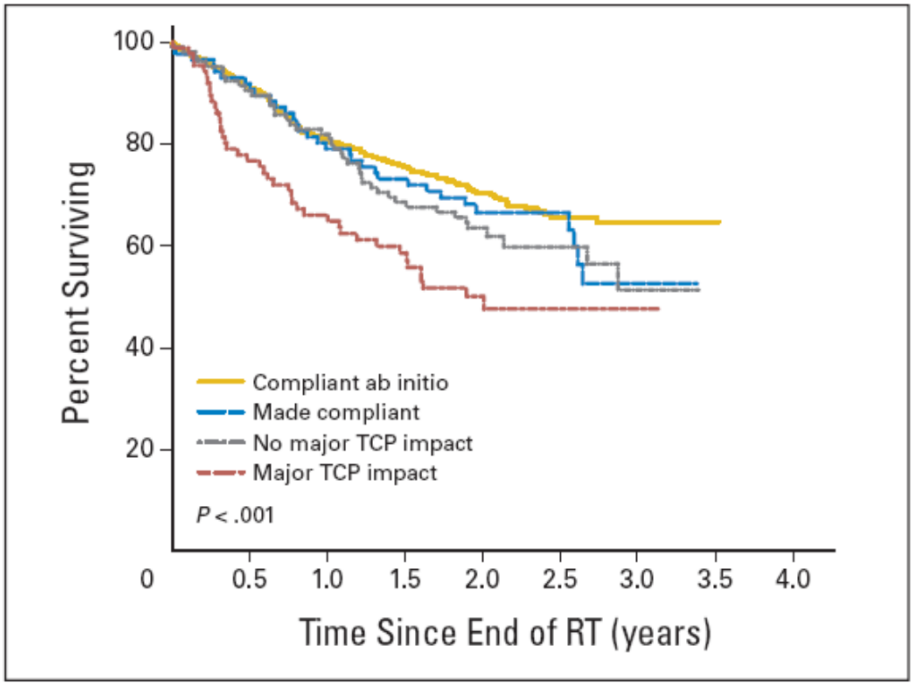

Fig 2. Overall survival by deviation status: (1) compliant from the outset (n = 502), (2) made compliant following a review by the Quality Assurance Review Center (n = 86), (3) noncompliant but without predicted major adverse impact on tumor control (n = 105), and (4) noncompliant with predicted major adverse impact on tumor control (n = 87). Overall $P < .001$. Pair-wise tests: not statistically significant except for cohort 1 versus cohort 4 ($P < .001$), cohort 2 versus cohort 4 ($P = .041$), and cohort 3 versus cohort 4 ($P = .006$). TCP, tumor control probability; RT, radiotherapy.

In the overall context of head and neck cancer treatment in the community, these results strongly reinforce the importance of doing well what we already know. It is sobering to note that the value of good radiotherapy is substantially greater than the incremental gains that have been achieved with new drugs and/or biologicals.

Peters et al. JCO 2010

Overdose cancer girl dies

Your views (2)

Thursday, October 19, 2006

A teenage cancer patient who was given a massive overdose of radiation has died.

Lisa Norris, 16, was given 17 overdoses of radiation therapy during her treatment for a brain tumour at the Beatson Oncology Centre in Glasgow in January.

It was reported she died yesterday at her home in Ayrshire surrounded by her family.

LE FIGARO·fr

• Accueil • France • Politique • International • Sports • Madame
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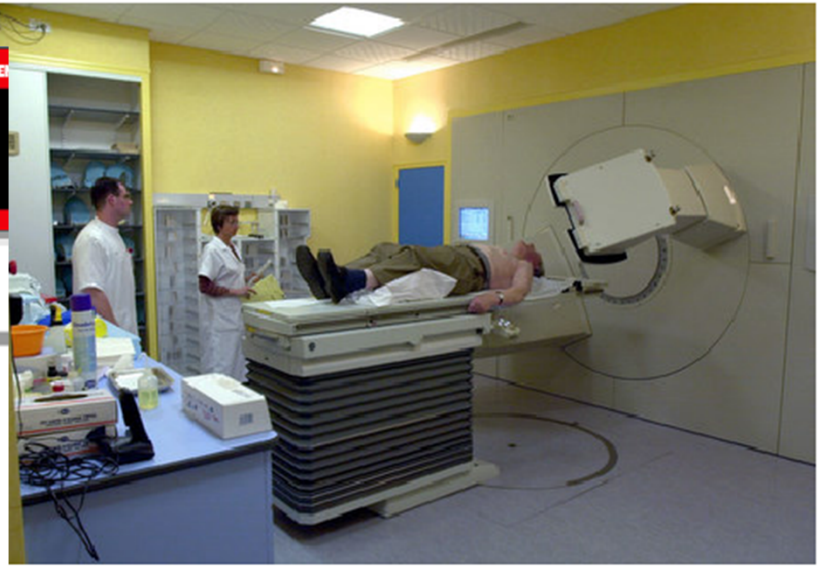
Radiothérapie : "l'affaire d'Épinal plus grave que prévu"



séance de radiothérapie au centre régional de lutte contre le cancer de Caen.
dits photo : Daniau/AFP

lon la ministre de la Santé, 300 nouveaux cas de patients irradiés joutent aux quelque 400 cas déjà recensés. Et d'autres pourraient bientôt se faire connaître grâce à un numéro vert mis en place vendredi. «L'affaire d'Epinal est plus grave que prévu», prévient, la ministre de la

OTTAWA SUN

24 hours

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Sens vs. Thrashers ... full coverage in your Thursday Sun and online

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News Ottawa & Region

Thu, October 30, 2008

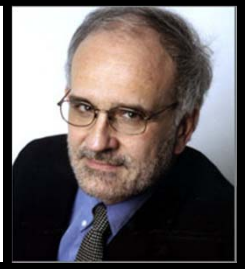
Staff shortage led to radiation error: report

Wrong dosage given to 326 Civic Hospital cancer patients

By DONNA CASEY, Sun Media

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.

The New York Times



Bogdanich - 3 Times Pulitzer Prizes Winner

THE RADIATION BOOM

Radiation Offers New Cures, and Ways to Do Harm

By WALT BOGDANICH
Published: January 23, 2010

As Scott Jerome-Parks lay dying, he clung to this wish: that his fatal radiation overdose — which left him deaf, struggling to see, unable to swallow, burned, with his teeth falling out, with ulcers in his mouth and throat, nauseated, in severe pain and finally unable to breathe — be studied and talked about publicly so that others might not have to live his nightmare.

Error rates are very low, but not low enough.

Are we really missing things?

Catching errors with *in vivo* EPID dosimetry

A. Mans,[a] M. Wendling,[b] L. N. McDermott,[c] J.-J. Sonke, R. Tielenburg, R. Vijlbrief, B. Mijnheer, M. van Herk, and J. C. Stroom
Department of Radiation Oncology, The Netherlands Cancer Institute—Antoni van Leeuwenhoek Hospital, Plesmanlaan 121, 1066 CX Amsterdam, The Netherlands

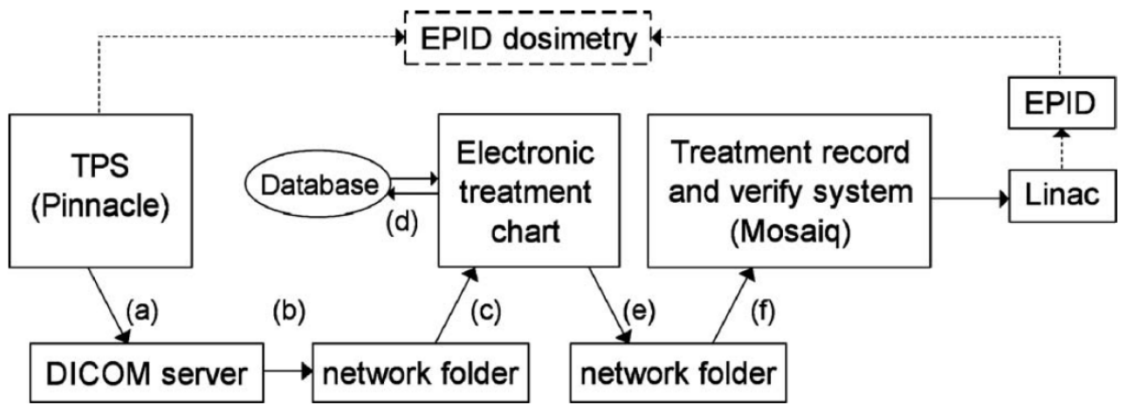


FIG. 1. Schematic overview data flow in our department. Solid lines indicate the route that the treatment plans follow (plan transfer steps are indicated with letters). Dashed lines indicate EPID dosimetry information transfer.

EPID analysis tools to analyze the images we can already collect.

"Since the clinical introduction of the method in January 2005 until August 2009, treatment plans of **4337 patients** have been verified. Among these plans, **17 serious errors** were detected that led to intervention. Due to their origin, nine of these errors would not have been detected with pretreatment verification."

Med. Phys. 37 (6) June 2010

Wow! Quality Matters!

- It matters for our patients.
- It matters for our field.
- It matters for our science.
- It matters for our future patients.

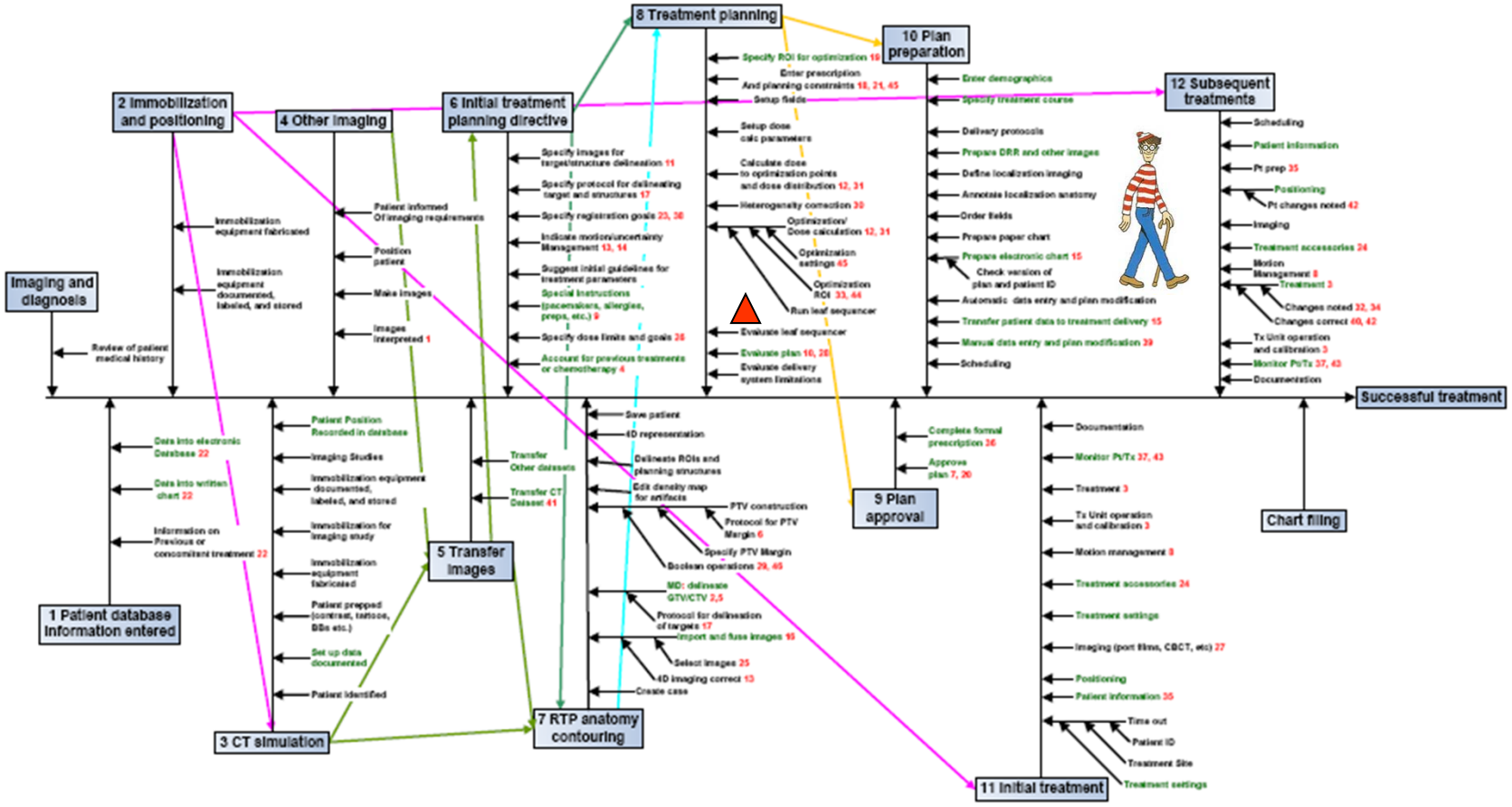
Quality is the Priority

Growing Technological Complexity

RT

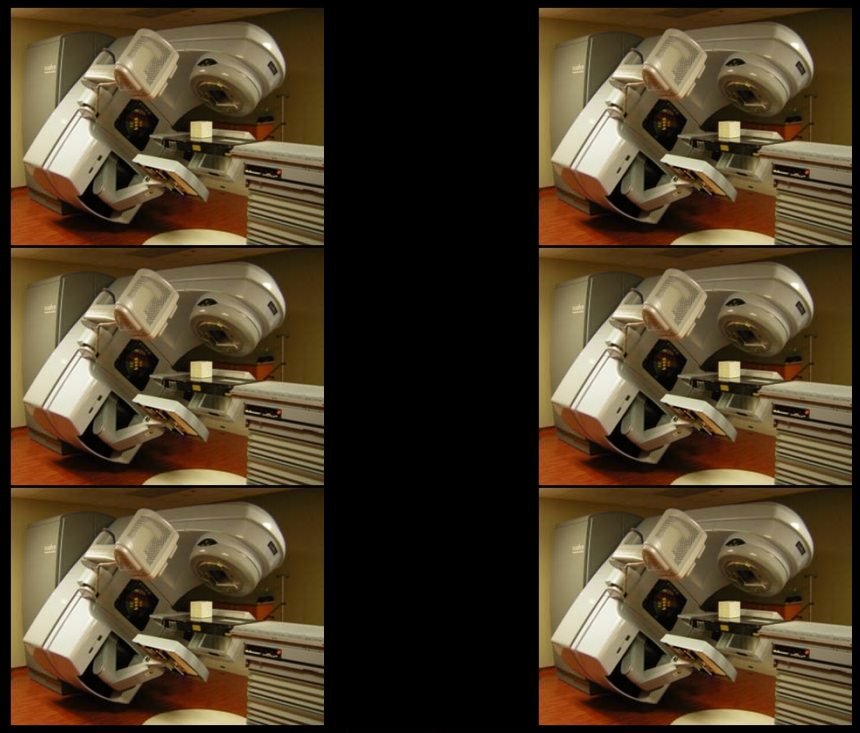
Process tree (map)

I wouldn't try to read it…will hurt your eyes



You are here.

Supervised Robotic Intensity-modulated, Image-guided Radiation Therapy

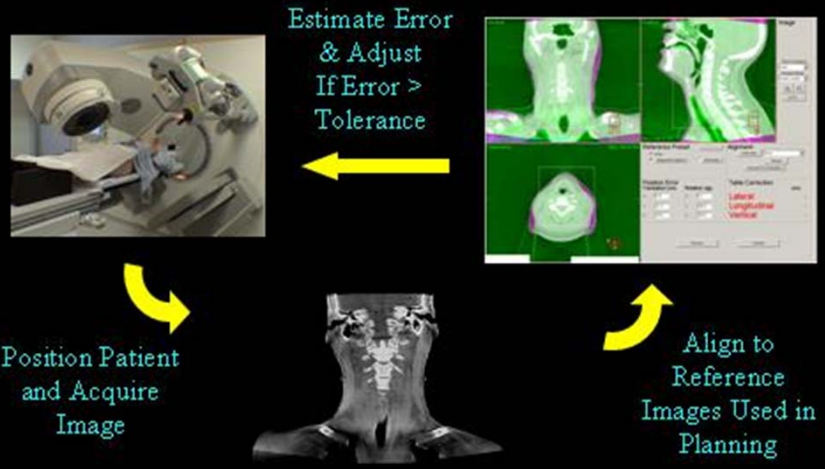


In a period of 10 years, Radiation Therapy has evolved from employing:

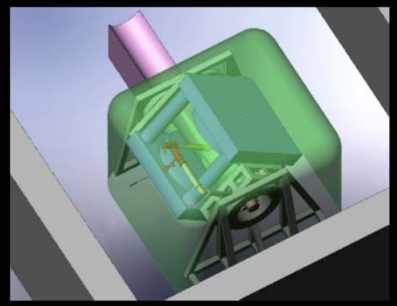
10 Mb to 1000 Mb of Data (100X)

10 to 1000 Digital Treatment Parameters (Robotic Control)

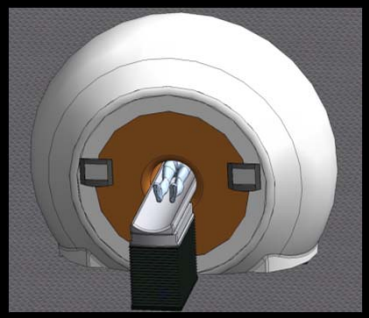
Supervised, Image-guided Operation



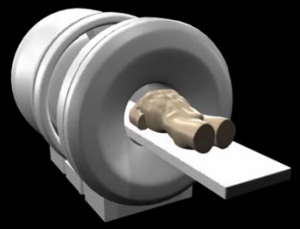
Next Up: MR-Guided RT Platforms



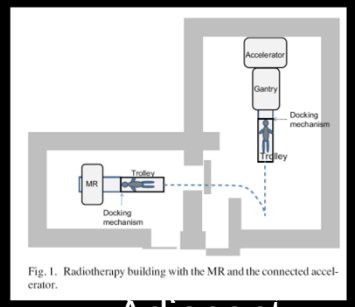
Edmonton Solution



Utrecht Solution



Viewray Solution



Adjacent Systems

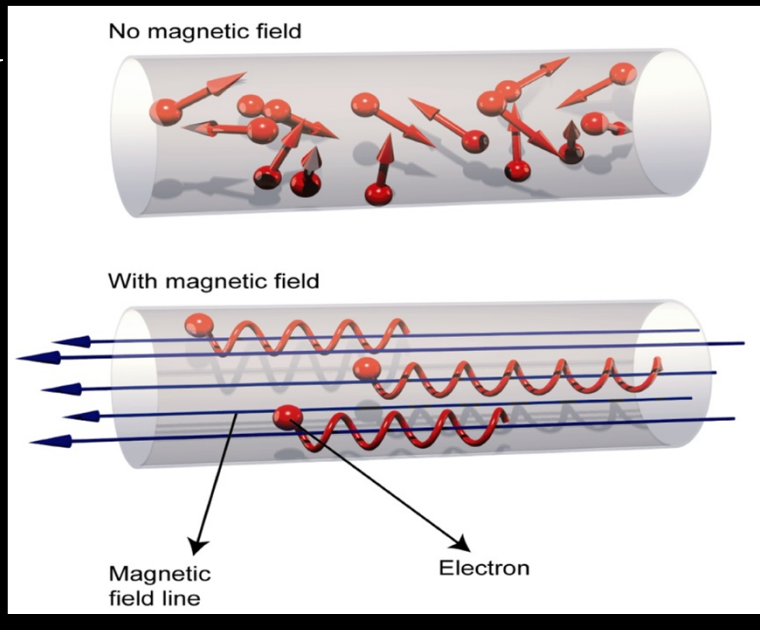
•"Lots of times you can't really see what you are trying to see" – E. Soisson

MR-Guided RT

Fast imaging, higher CNR, more responsive in delivery.

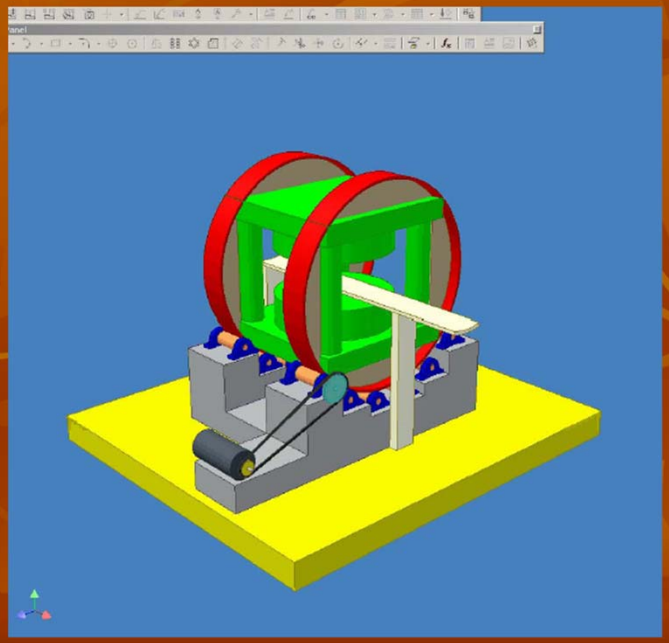
Why Pursue MR-guided RT?

- Pros
  - Intrinsic Contrast of Target and Normal Tissue
  - No Significant Toxicities
  - Physiological Measurement Capabilities
- Cons
  - Geometric Distortions/Accuracy
  - Influence on Dose Deposition
    - Electron Return Effect (ERE)
  - Safety/Screening/Repairs
  - Cost



SMALL BORE (28 cm) Linac-MRI

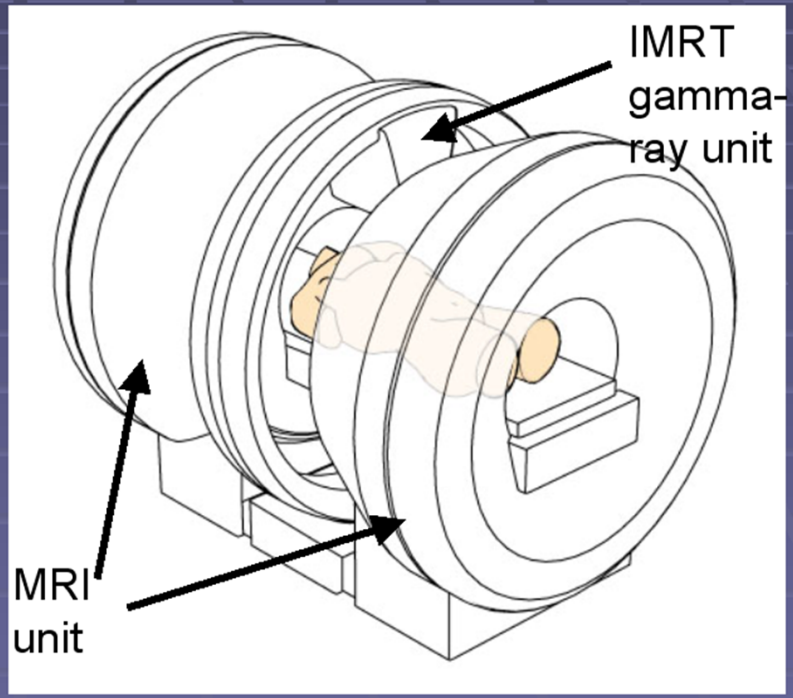
- Arrival of bi-planar MRI: on transit
  - Excellent linearity (no distortion)
  - Parallel imaging (improved image quality & speed)
- 2 linacs already on site
- Medical Physics Development "from scratch"
- Plans for a Body Human System are developed



Courtesy of G. Fallone, Cross Cancer Institute, Edmonton, Canada

Prototype of the Renaissance™ Device

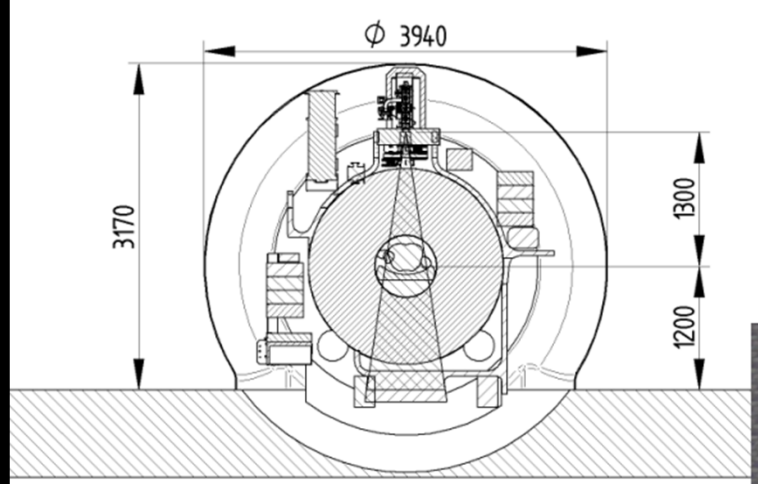
- Co-registered and gantry mounted
  - Open split solenoid MRI
  - MLC-Based cone beam IMRT unit with axial patient access
  - Multiple sources…
- Imaging during beam-on
- Daily optimization
- Daily recording of delivered dose

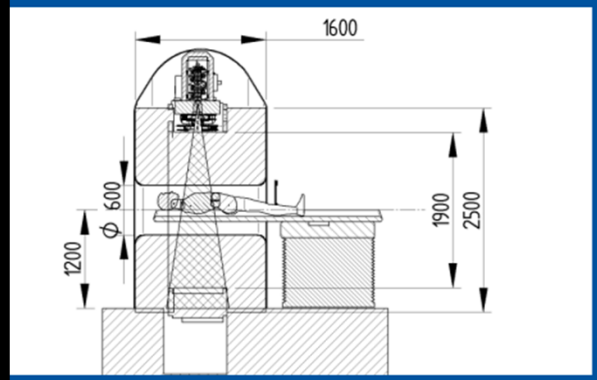


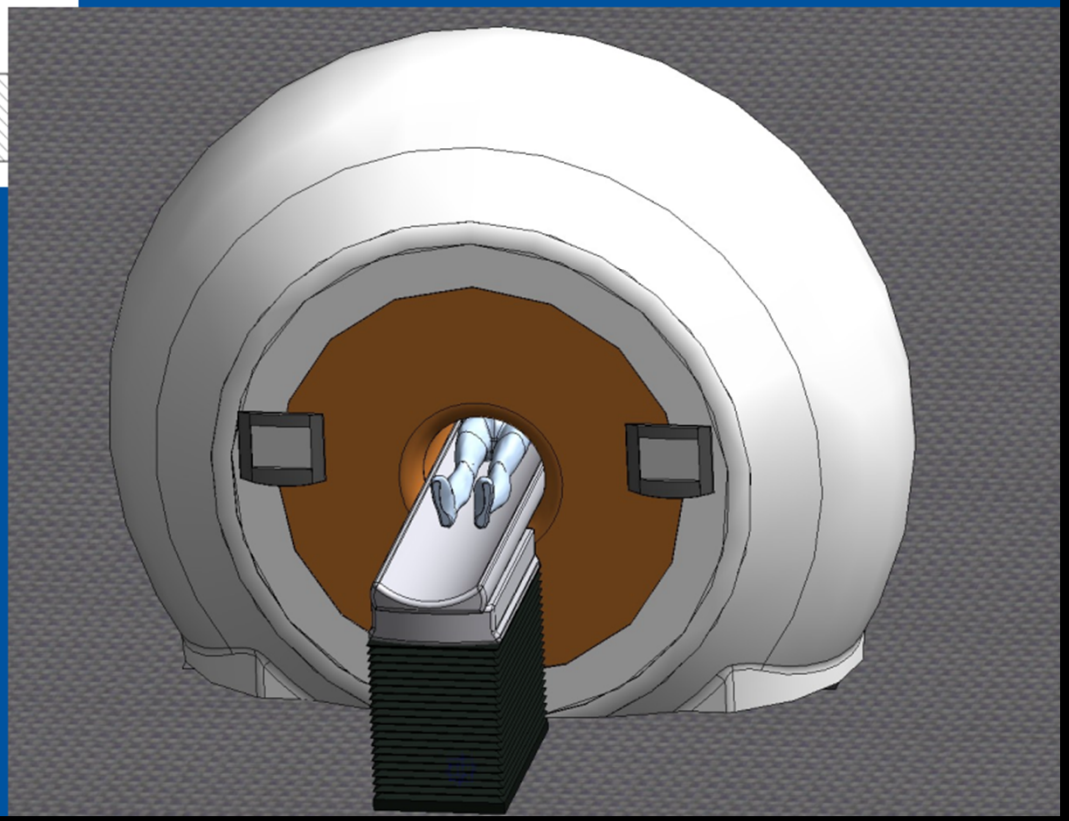
Courtesy of J. Dempsey, Viewray Inc.

Image guided Radiotherapy: MRI accelerator combination

Universitair Medisch Centrum Utrecht

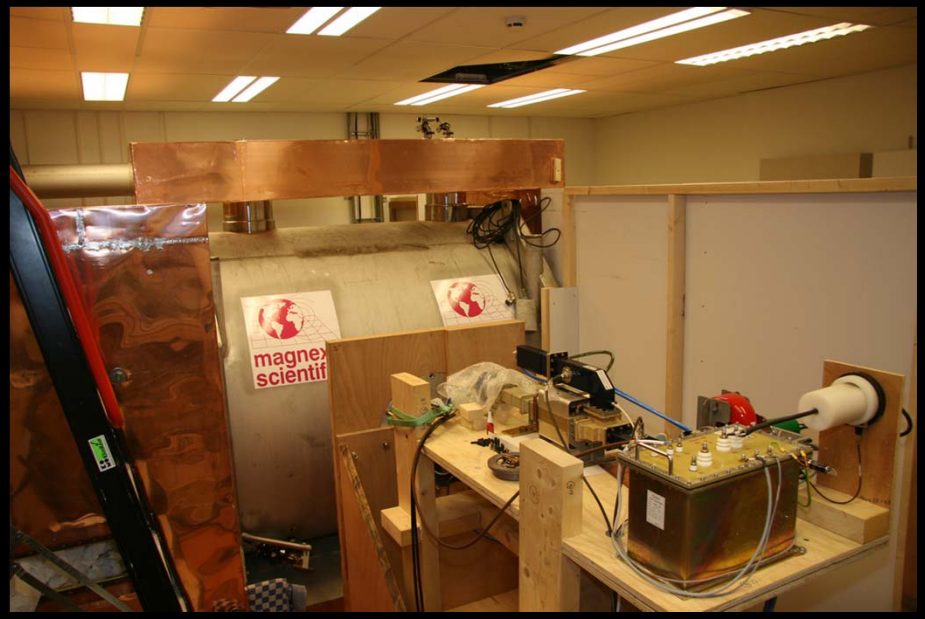




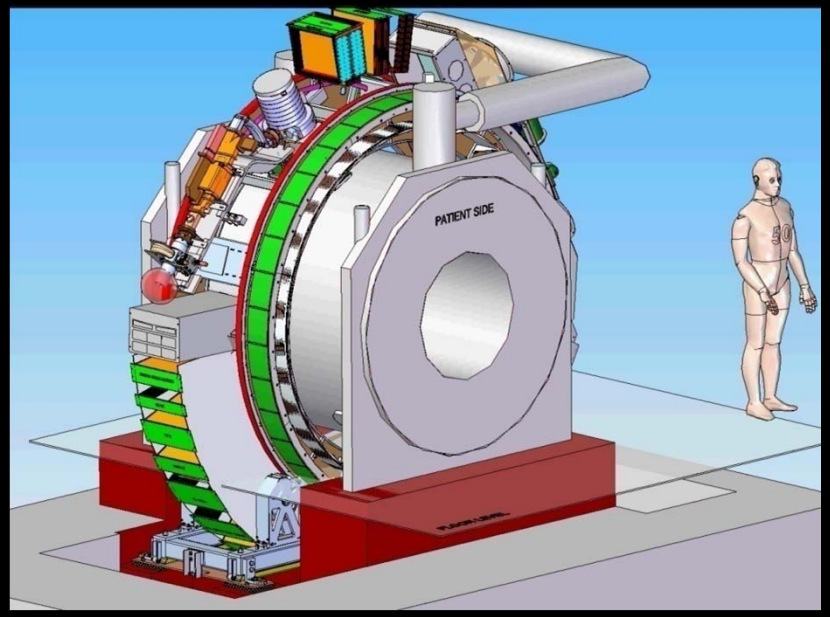


Courtesy of J. Lagendijk, Utrecht, Netherlands

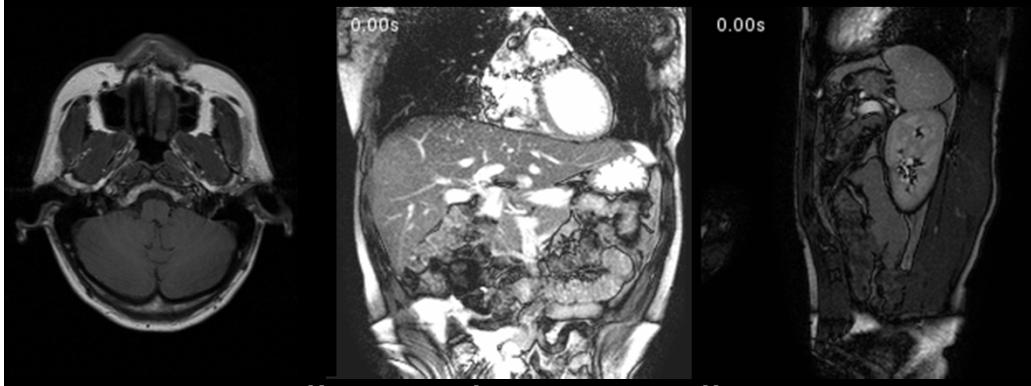
UMC Utrecht MRI linac system
6 MV linac and 1.5 T MRI



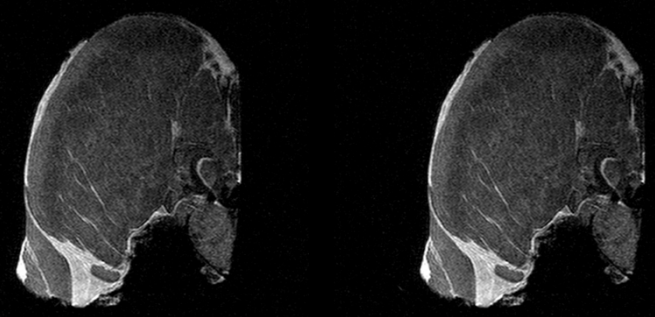
Prototype MRI accelerator



Dynamic prototype under construction

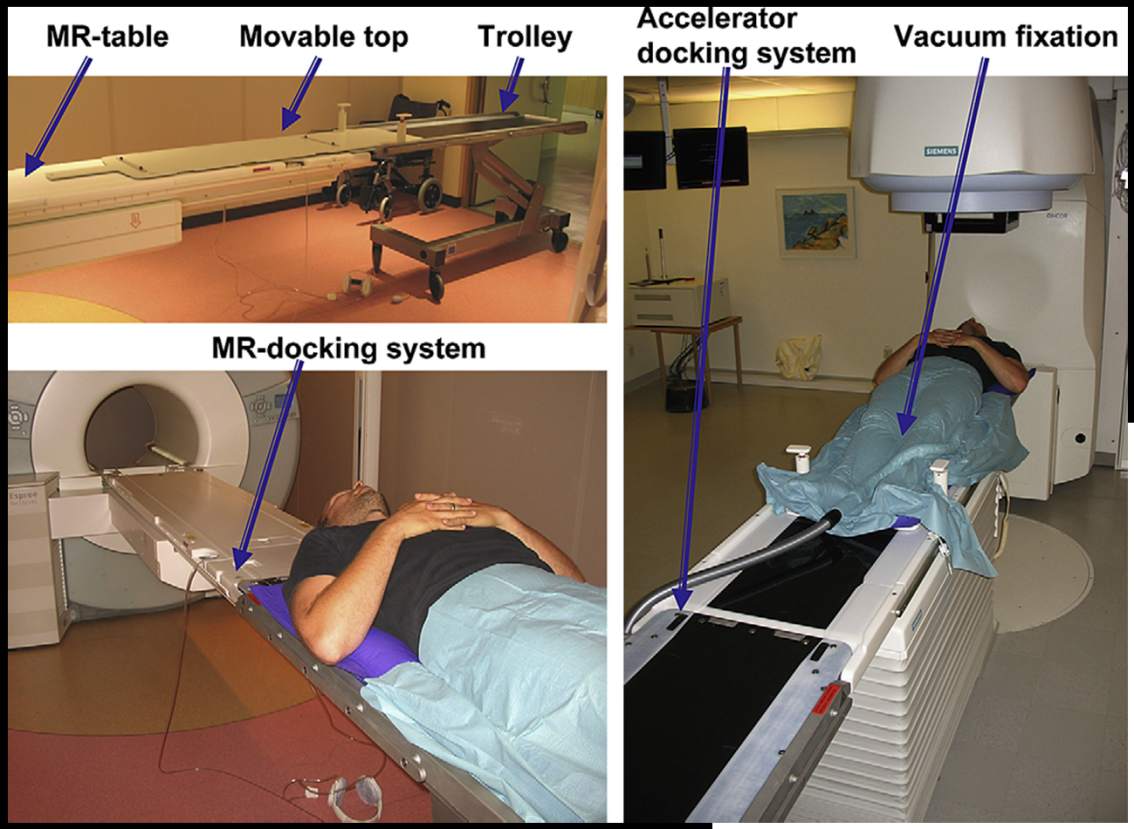


1.5 T diagnostic MRI quality



No impact of beam on MRI

Raaymakers et al. Phys. Med. Biol. 2009



Karlsson et al. Int. J. Radiation Oncology Biol. Phys., Vol. 74, No. 2, pp. 644–651, 2009

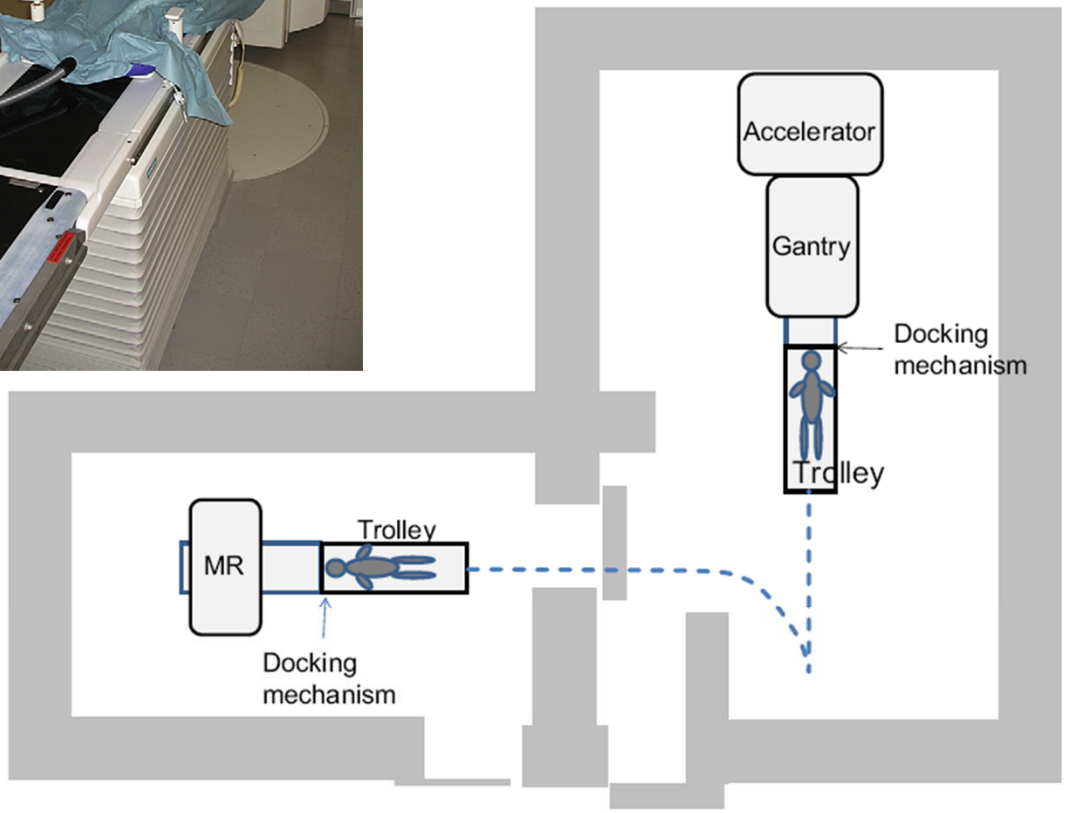
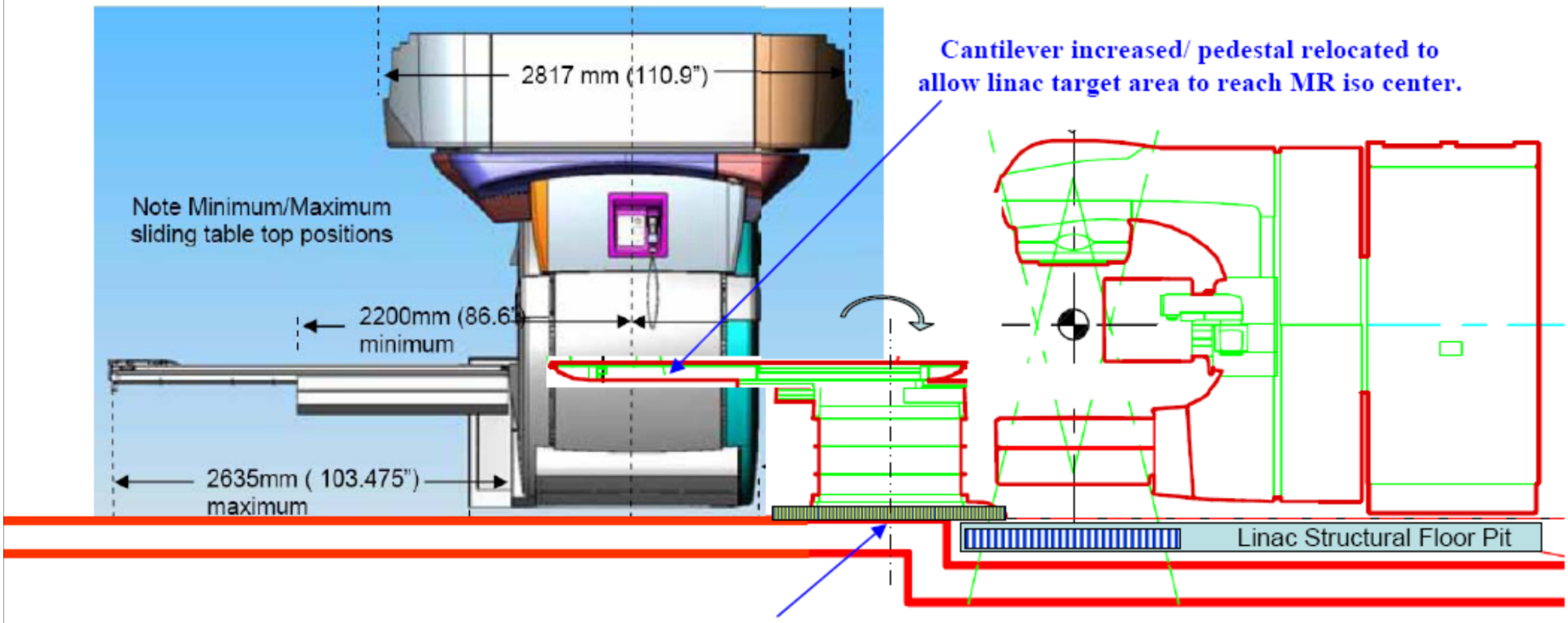


Fig. 1. Radiotherapy building with the MR and the connected accelerator.

The Princess MRgRT Facility

Under construction: Estimated time to completion: 18 Months

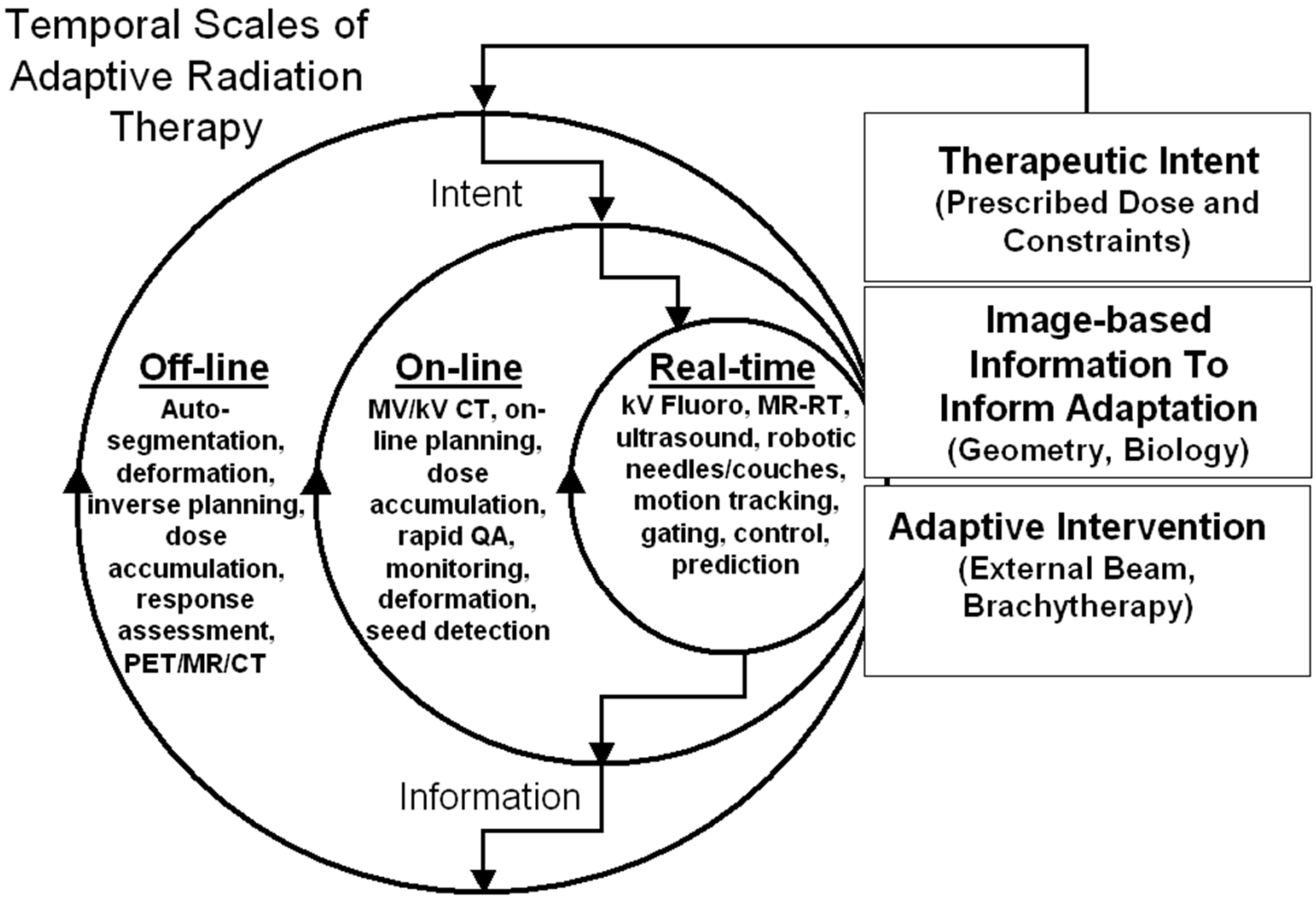
The Princess MRgRT Facility



Specifications:

MR imaging to RT in <90 seconds
Diagnostic Performance
Linac and Brachytherapy operate indep. of MR

Complex Machinery of Adaptive



Quality is the Priority

Growing Complexity

RT

New Science

Where's the Evidence?

20 Years of Advancing Radiation Therapy: 'Testing the 3D Hypothesis'

- Transition from 'technique-based' approach to employing the 3D information in the creation of the intervention.
  - Information largely derived from imaging
- Move from 'patterning' to 'deriving' the RT intervention.
- Data driven process that operates on imaging, dose computation, and population-based knowledge of radiation response.
- Enabling dose escalation without corresponding increases in toxicity.

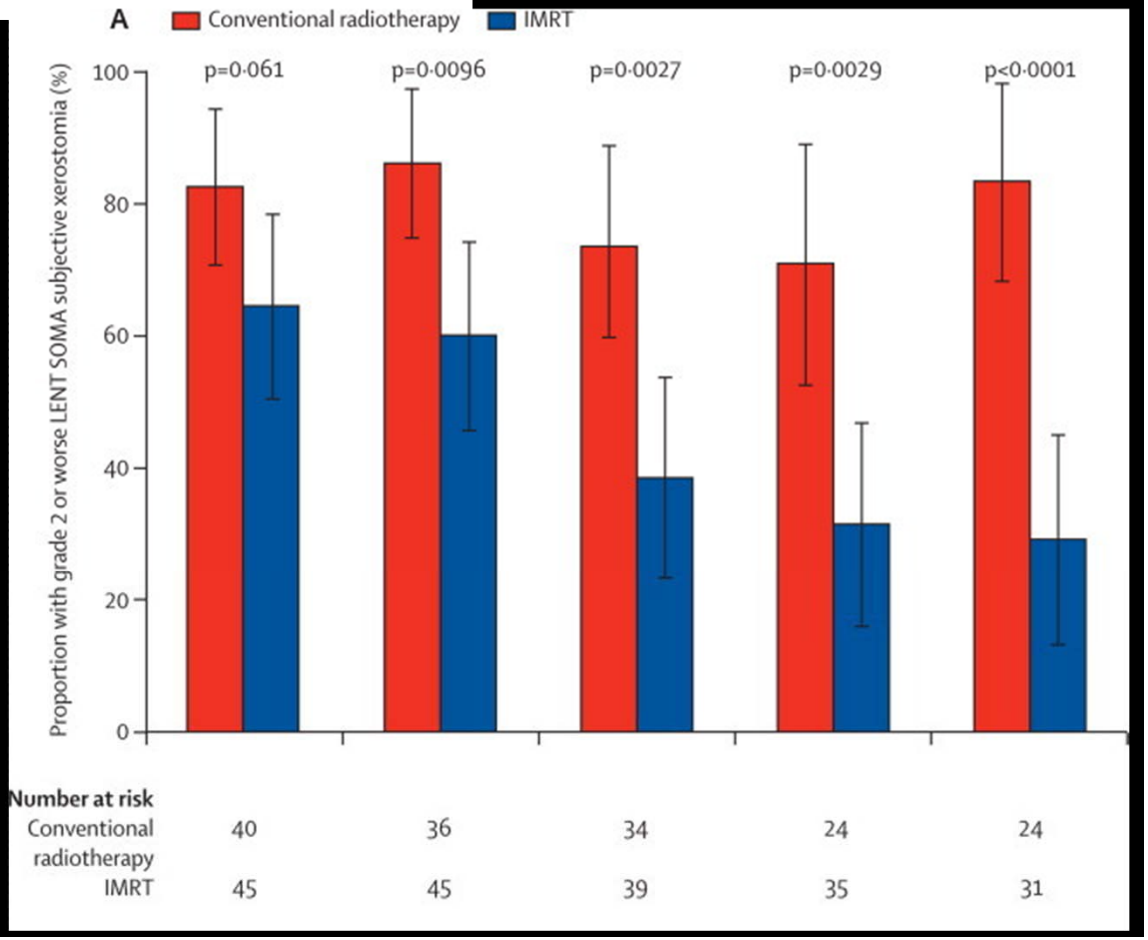
Published as: *Lancet Oncol.* 2011 February ; 12(2): 127–136.

Parotid-sparing intensity modulated versus conventional radiotherapy in head and neck cancer (PARSPORT): a phase 3 multicentre randomised controlled trial

Christopher M Nutting[a,b,*], James P Morden[b], Kevin J Harrington[a,b], Teresa Guerrero Urbano[c], Shreerang A Bhide[a], Catharine Clark[d], Elizabeth A Miles[e], Aisha B Miah[a], Kate Newbold[a], MaryAnne Tanay[a], Fawzi Adab[f], Sarah J Jefferies[g], Christopher Scrase[h], Beng K Yap[i], Roger P A'Hern[b], Mark A Sydenham[b], Marie Emson[b], Emma Hall[b], and on behalf of the PARSPORT trial management group[†]

At 24 months, no significant differences were seen between randomised groups in non-xerostomia late toxicities, locoregional control, or overall survival.

47 patients were assigned to each treatment arm. Median follow-up was 44·0 months (IQR 30·0–59·7). At 12 months xerostomia side-effects were reported in 73 of 82 alive patients; grade 2 or worse xerostomia at 12 months was significantly lower in the IMRT group than in the conventional radiotherapy group.



From the ‘3D Hypothesis’ to the ‘4D Hypothesis’

Fundamentally enabled by minimally-invasive methods of characterizing the disease state in the context of intervention

“Probably every patient needs to be monitored, some will benefit from adaptation.” – K. Langen

COMPUTED MEDICAL IMAGING

Nobel Lecture, 8 December, 1979

BY
GODFREY N. HOUNSFIELD
The Medical Systems Department of Central Research Laboratories EMI, London, England

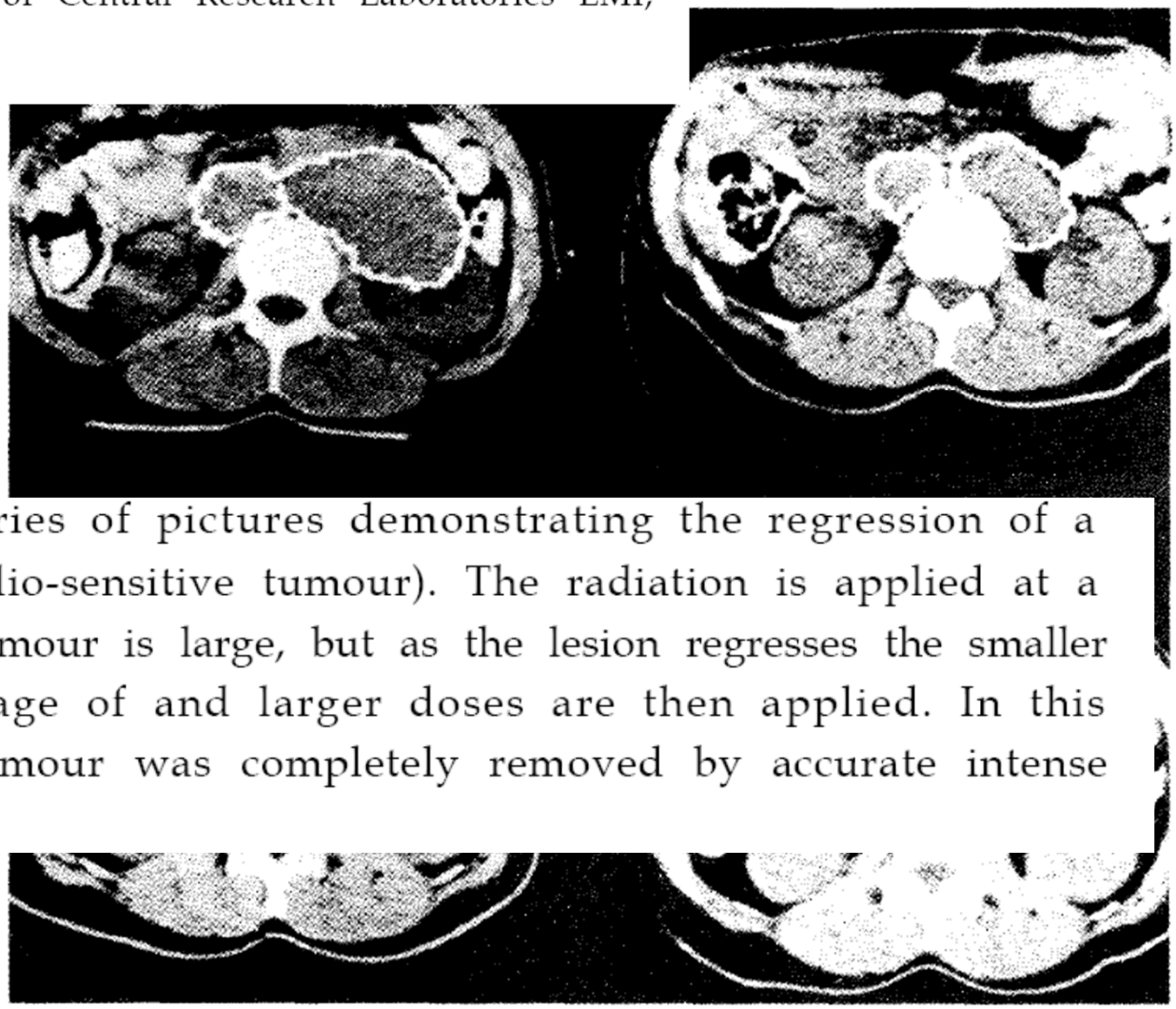


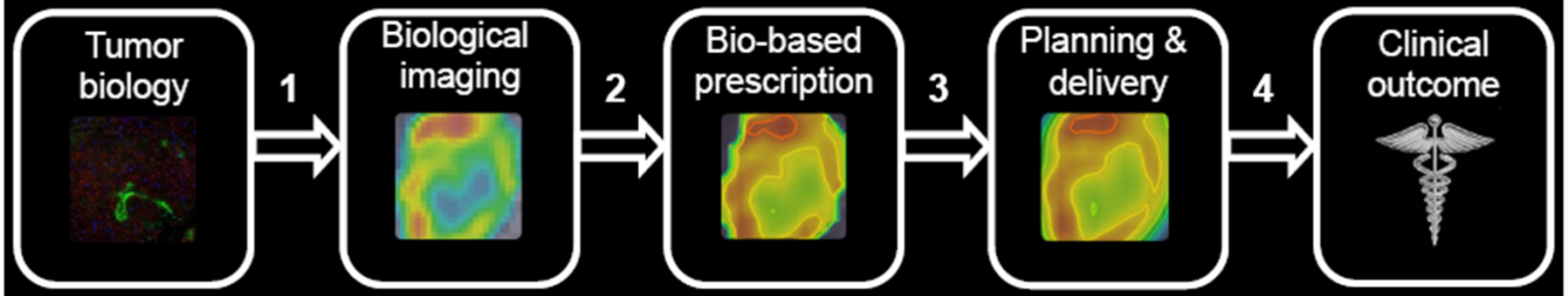
Fig. 13 shows a series of pictures demonstrating the regression of a seminoma (a very radio-sensitive tumour). The radiation is applied at a low level while the tumour is large, but as the lesion regresses the smaller area is taken advantage of and larger doses are then applied. In this particular case the tumour was completely removed by accurate intense radiation.

Fig. 13. Demonstrating the regression of a seminoma after four stages of therapy treatment.

Setting Out to Test the 4D Hypothesis: Many Challenges

- Quantification: Without accuracy and precision, there is nothing.
- Integration: imaging and intervention
  - Spatial and temporal proximity to intervention
- Interpretation: Automated methods of deriving intervention from frequent measurement
- Memory: A system to hold the context of the intervention
- Cost: Methods of managing the cost of measurement and adjustment
- Validation and Feedback: Was it all worth it?

Clinical outcome correlation



R. Jeraj - Friday

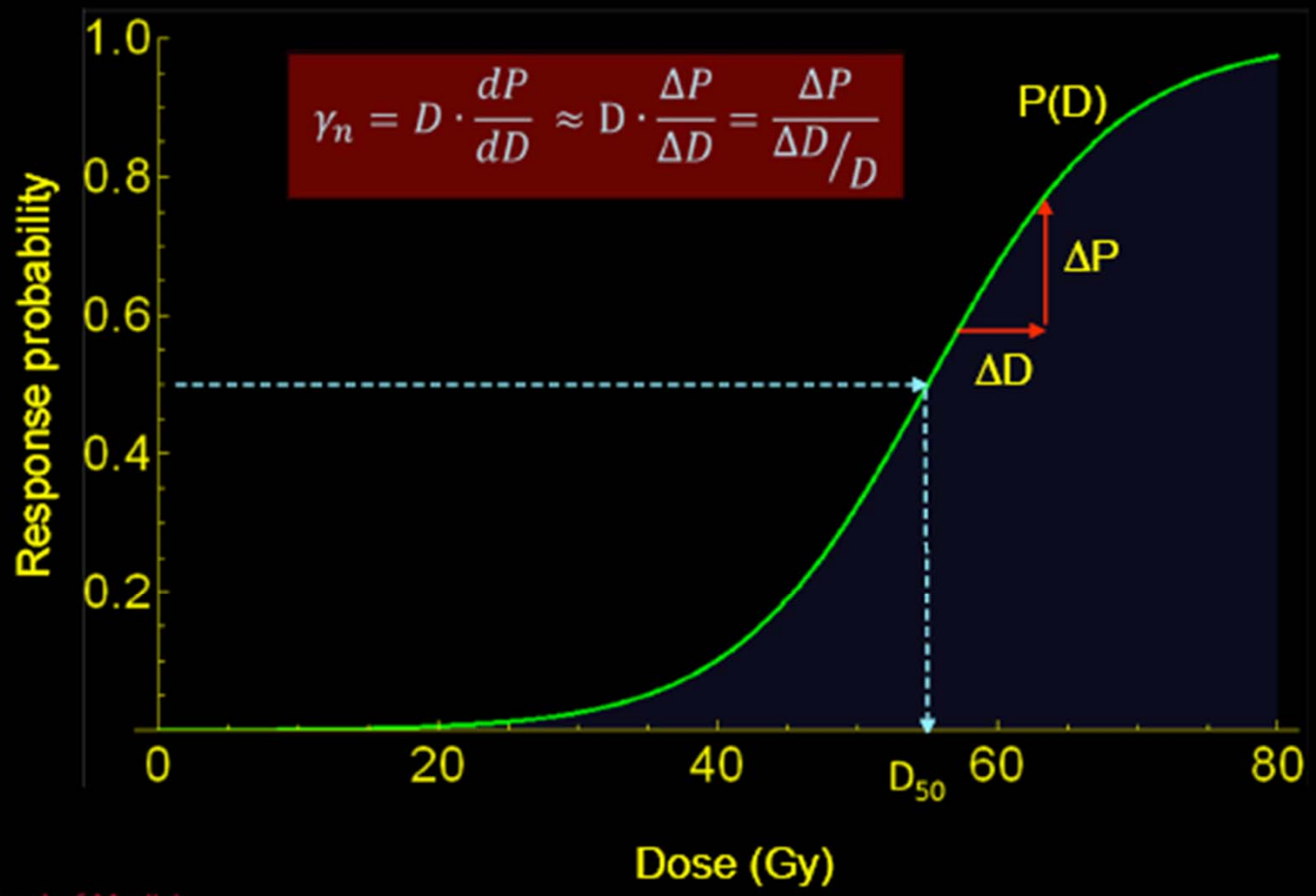
"We are dependent on imaging systems, we will be more dependent on imaging systems in the future." – J. Balter

Personalized Cancer Medicine

"The right treatment for the right patient at the right time"

- Increased effort in the management of a patient
  - Measurement costs, data handling costs, image analysis costs, complexity costs
- Risk of error by exposing the patient to multiple decisions
  - "Uncertainty Exposure" – Measurement/Model
  - "Error Exposure" – Decision Making

The normalized dose-response gradient

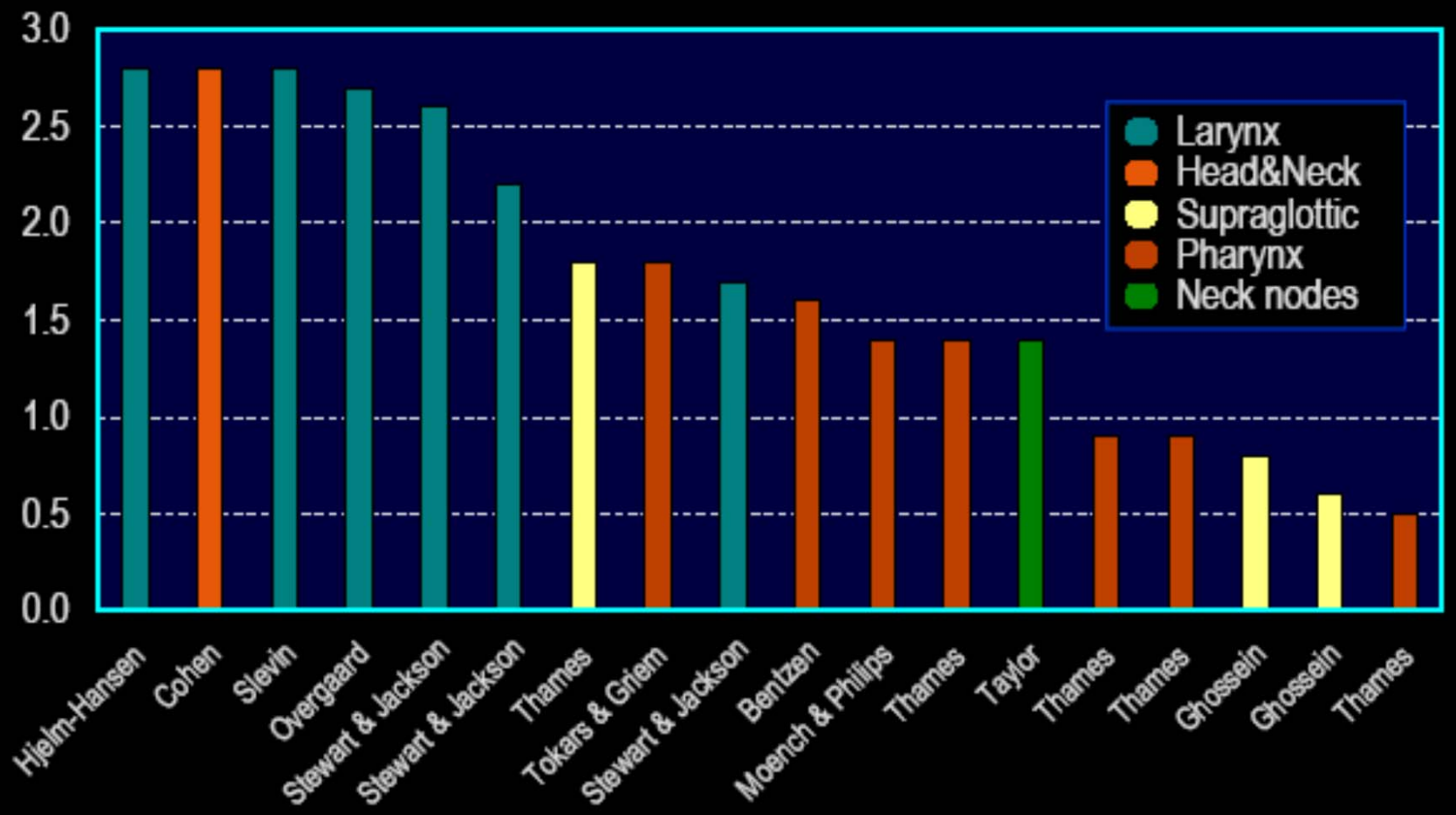


School of Medicine and Public Health
UNIVERSITY OF WISCONSIN-MADISON

/SMB 09/11

S. Bentzen – Last Friday

Steepness of DR curves for HNSCC



School of Medicine and Public Health
UNIVERSITY OF WISCONSIN-MADISON

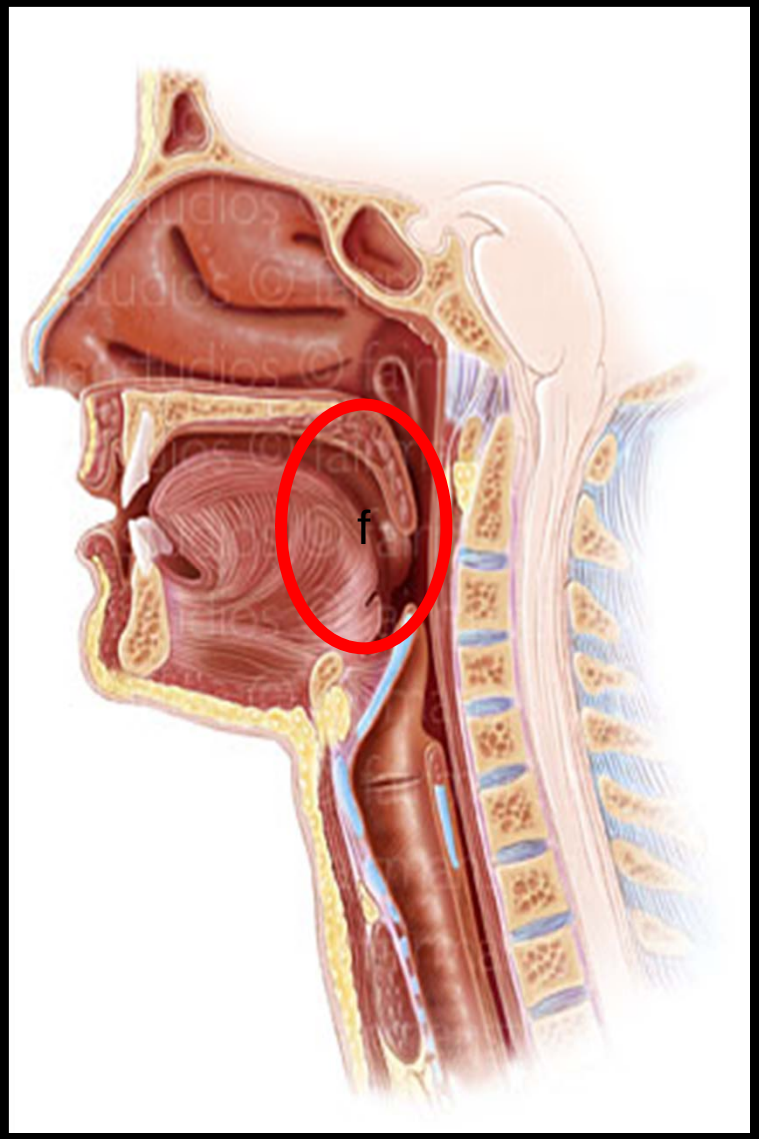
Bentzen *R&O* 32: 1 (1994)

/SMB

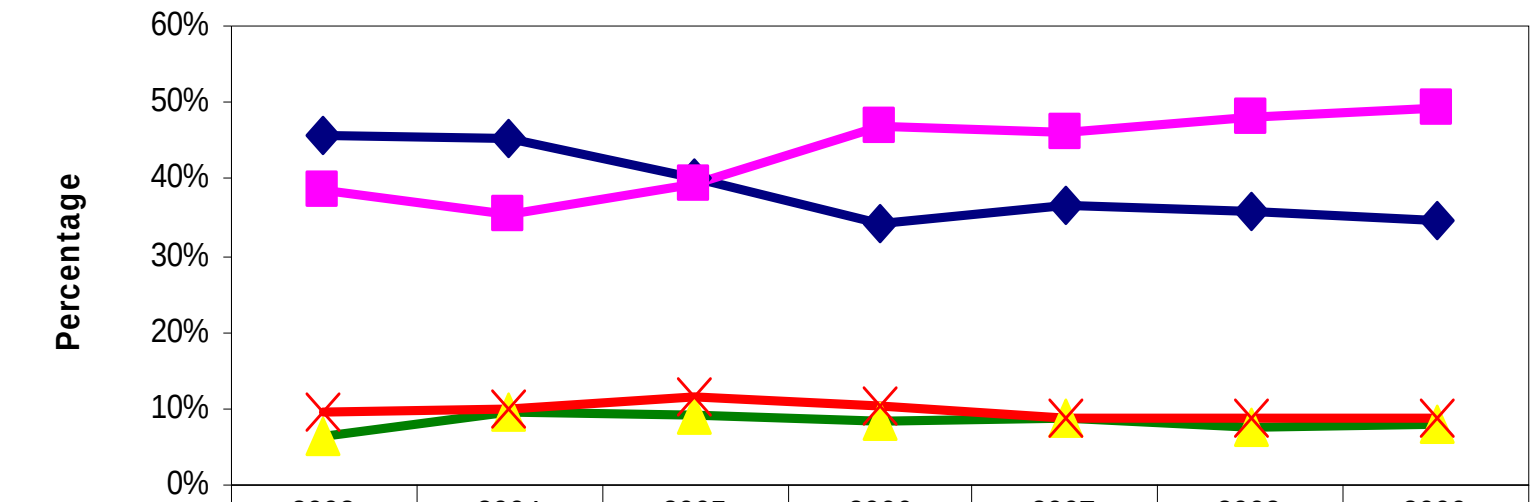
S. Bentzen – Last Friday

HNC – Oropharynx: Two Populations?

- Traditional risk factors for head & neck cancers (HNC) are cigarette smoking, and EtOH consumption
- Epidemiology has <u>changed</u> in recent decades
- HPV-related Disease versus Classical Disease



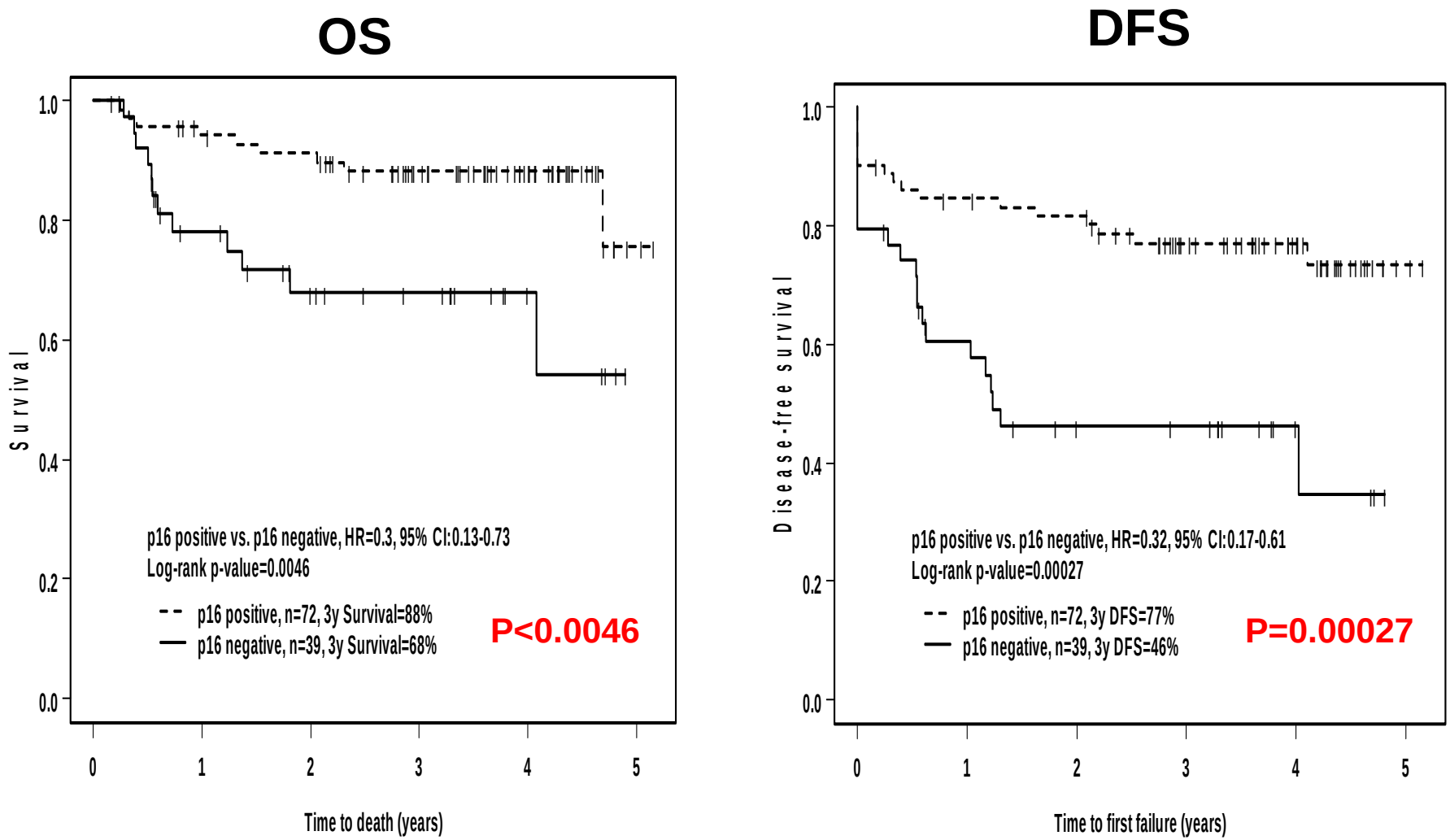
Dynamics of Disease in the Population



	2003	2004	2005	2006	2007	2008	2009
Larynx	46%	45%	40%	34%	36%	36%	34%
Oroph	38%	35%	39%	47%	46%	48%	49%
Hypoph	6%	9%	9%	8%	9%	7%	8%
Unknown	10%	10%	11%	10%	9%	9%	9%

All patients with locally-advanced OPC are offered concurrent chemo-radiation

Separation of Patients by p16 Expression



Shi *et al*; *JCO* 27:6213, 2009

"If what I said is extremely clear, then you misunderstood." – S. Bentzen

More Science to Do: Delineation Rational Margin Design vs Irrational PTV Constraint

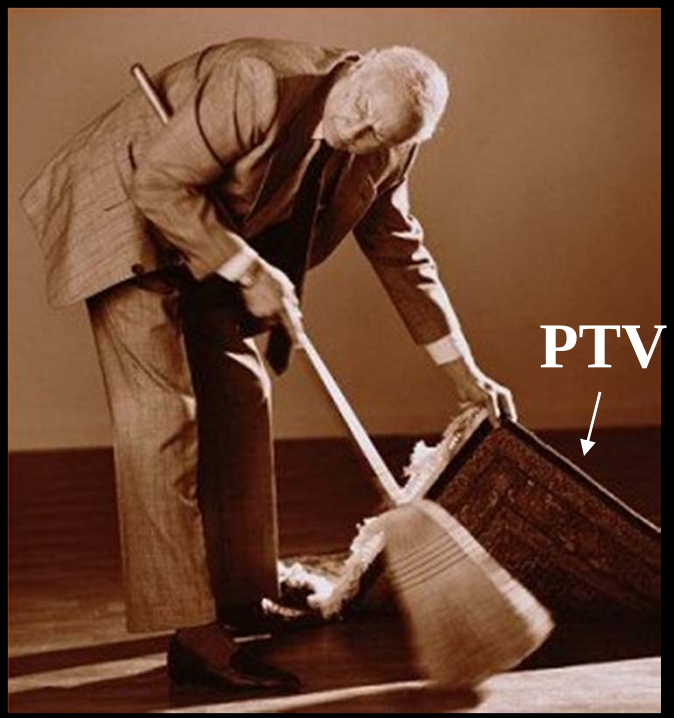
Acta Oncologica, 2008; 47: 1186–1187

EDITORIAL

Will IGRT live up to its promise?

MARCEL VAN HERK

The Netherlands Cancer Institute/Antoni van Leeuwenhoek Hospital, Amsterdam, the Netherlands



Need new, robust information about the extent of disease.

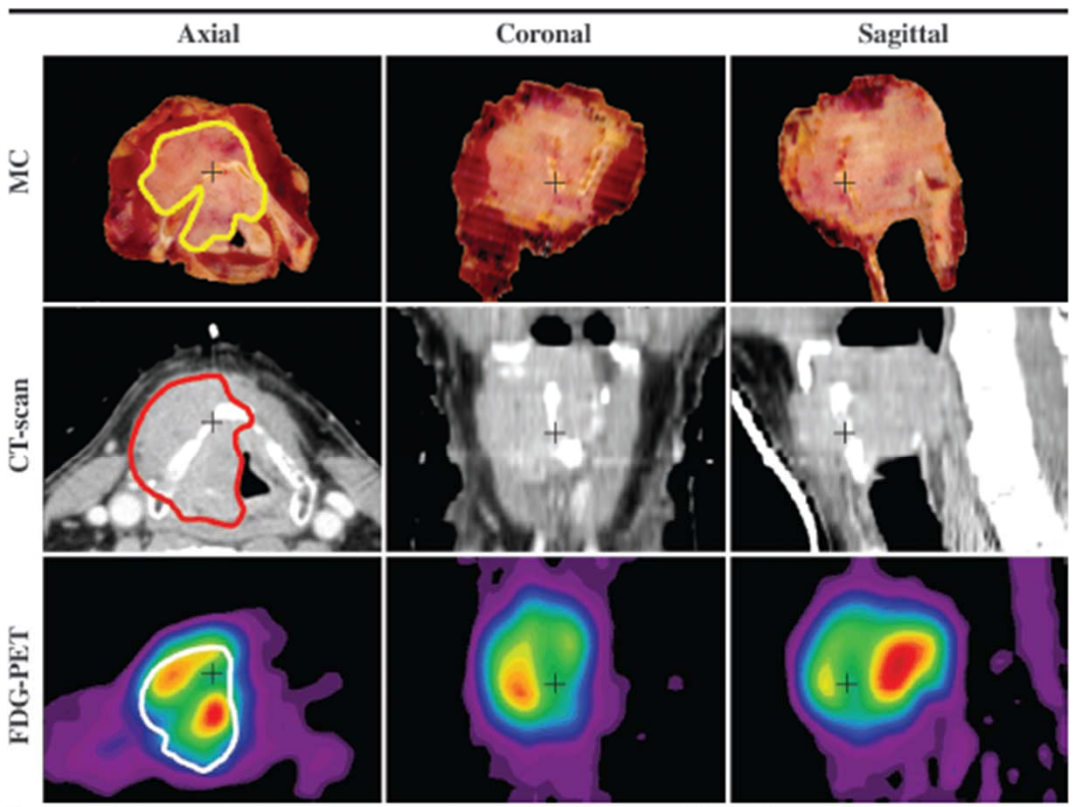


Figure 1. Coregistration between the macroscopic specimen *(MC)*, CT, and FDG PET images. Volumes are displayed on transverse, coronal, and sagittal planes. The outline shows the GTV delineated with each modality, and the small cross represents the same point in space for each of the modalities. Infiltration of the parathyroid muscles on the left side is clearly visible on the macroscopic images.

94 Radiology October 2004 Daisne et al

TABLE 2
Average Mismatch of Oropharyngeal GTVs between Imaging Modalities

Pair	Mismatched Volume (%)
CT	
To MR imaging	42 (11.9/27.9)
To FDG PET	73 (14.7/20.3)
MR imaging	
To CT	28 (8.9/32.0)
To FDG PET	64 (12.9/20.3)
FDG PET	
To CT	14 (4.5/32.0)
To MR imaging	20 (5.7/27.9)

Note.—Data in parentheses are the average mismatched volumes in cubic centimeters.

Need to engage pathology more in target characterization.

One of a few papers that have attempted this problem.

From 3D to BTV: It's a long road.

I. J. Radiation Oncology ● Biology ● Physics Volume 47, Number 3, 2000

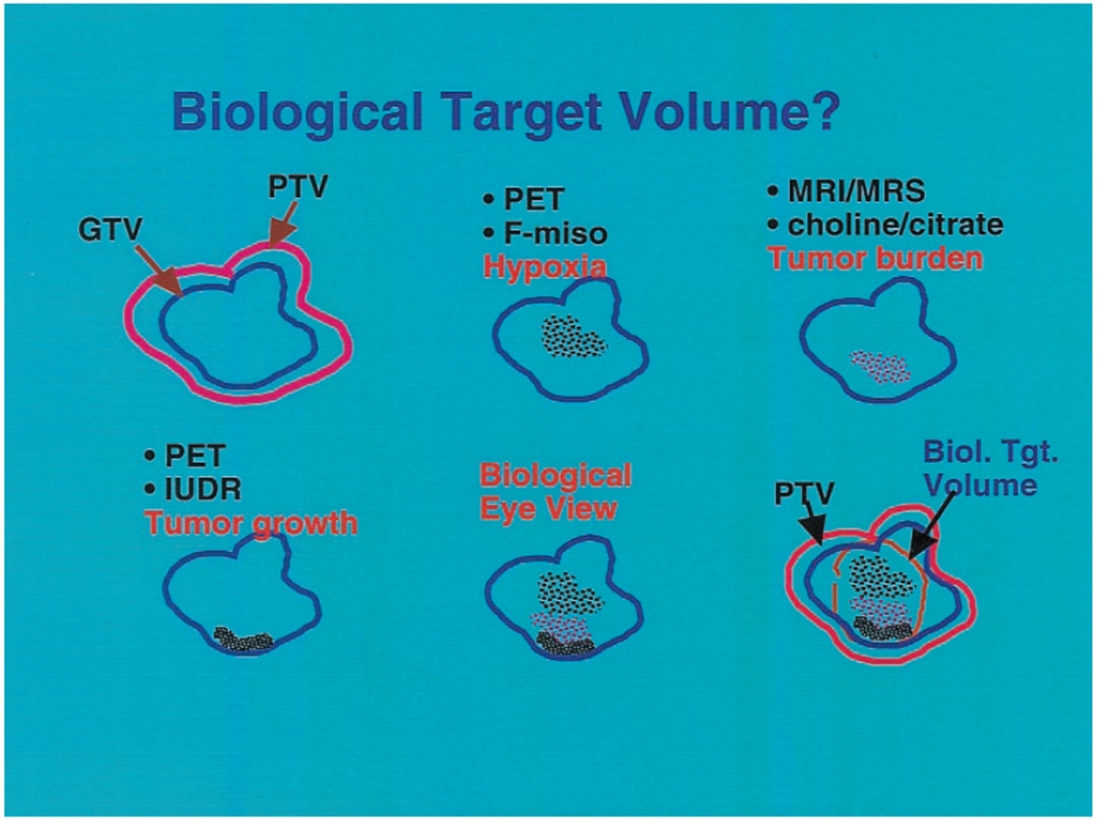


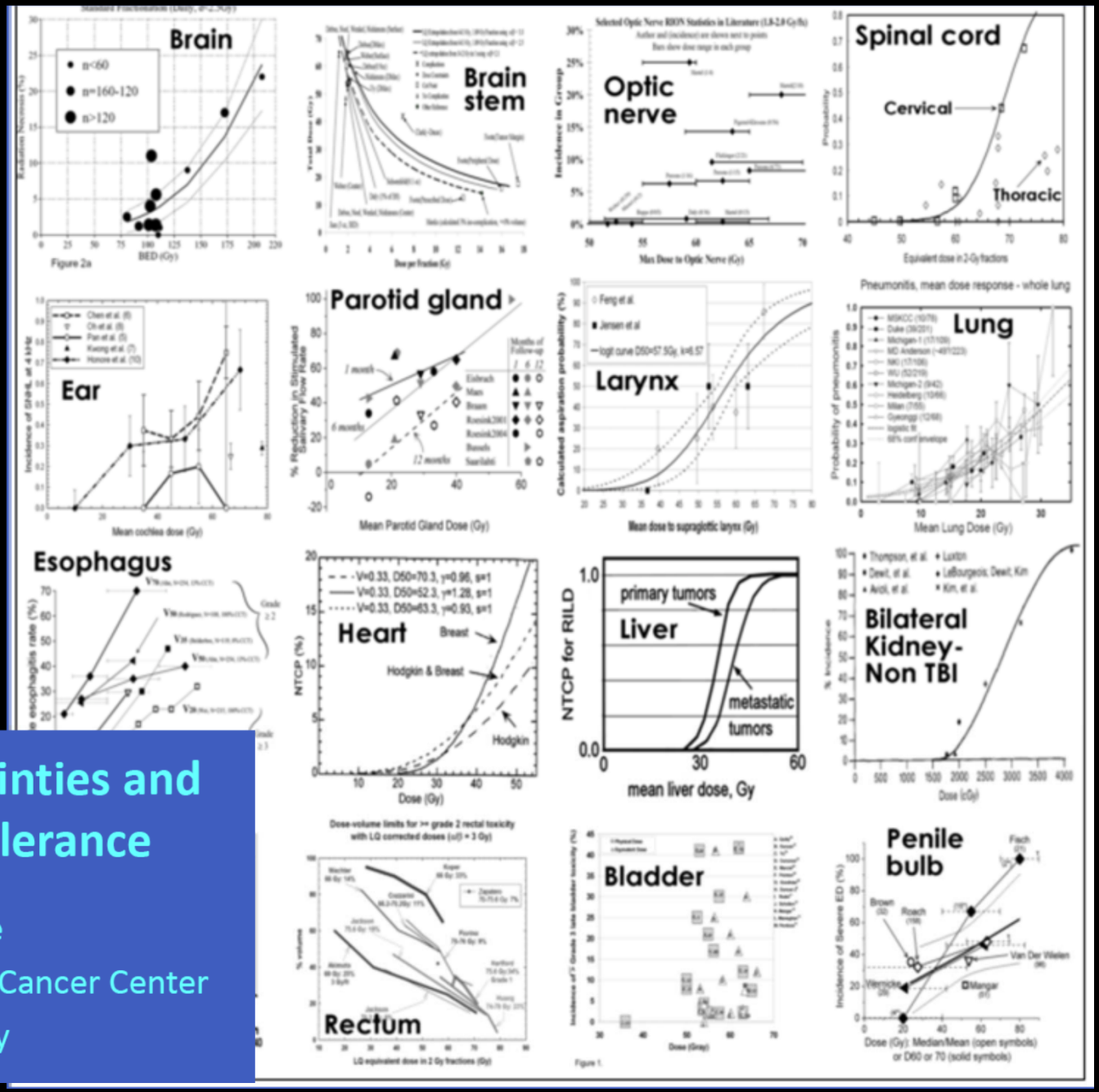
Fig. 2. An idealized schematic illustrating the concept of biological target volume (BTV). Whereas at present the target volume is characterized by the concepts of GTV, CTV, and PTV, biological images as depicted in Fig. 2 may provide information for defining the BTV to improve dose targeting to certain regions of the target volume. For example, regions of low pO_2 level may be derived from PET-^{18}F-misonidazole study, high tumor burden from MRI/MRS data of choline/citrate ratio, and high proliferation from PET-^{124}IUdR measurement.

"Incremental to the concept of gross, clinical, and planning target volumes (GTV, CTV, and PTV), we propose the concept of "biological target volume" (BTV) and hypothesize that BTV can be derived from biological images and that their use may incrementally improve target delineation and dose delivery." - Ling et al.

 Ling et al., Int. J. Radiation Oncology Biol. Phys., Vol. 47, No. 3, pp. 551–560, 2000

“…one more example…” – F-F. Yin

Populating our Models (Quantec Initiative)



Dosimetric Uncertainties and Normal Tissue Tolerance

Ellen D Yorke

Memorial Sloan-Kettering Cancer Center

New York City

Quality is the Priority

Growing Complexity

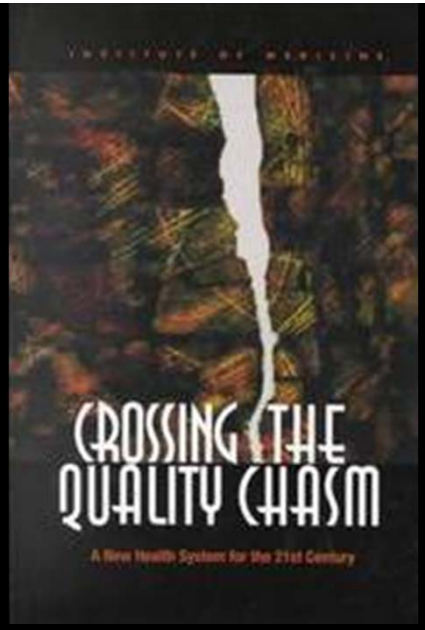
RT

New Science

Where's the Evidence?

Health care today is characterized by more to know, more to manage, more to watch, more to do, and more people involved in doing it than at any time […]. Our current methods of organizing and delivering care are unable to meet the expectations of patients and their families because the science and technologies involved in health care—the knowledge, skills, care interventions, devices, and drugs—have advanced more rapidly than our ability to deliver them safely, effectively, and efficiently.

(The Robert Wood Johnson Foundation, 1996)



ISBN 0-309-07280-8

Dave's Assertion

1. The lack of quality and efficiency in current medical practice will prevent us from testing the personalized medicine hypothesis.
2. The personalized medicine agenda has been and will be accelerated by medical physics engagement <u>because</u> we contemplate uncertainty.

If you

then

Physicists and their machines.

- Maybe we just need to expand our definition of the treatment machine…
- Expand it to include the <u>system</u>.

Herring DF, Compton DMJ: "The degree of precision required in the radiation dose delivered in cancer radiotherapy"

Brit J Radiol 5:1112-1118, 1970*

- Recommends that the dose delivered over the course of treatment be known to within ± 5%.
- Achieving this level of accuracy and precision requires that each step of the treatment process performs at a dosimetric precision much better than 5%.
- This places stiff tolerances on both (i) the precision of the clinical dosimetry and (ii) the geometric precision in delivery and planning.
- To achieve and maintain the desired level of precision, it is recommended that a *system* of treatment delivery be constructed considering dosimetric and geometric factors.

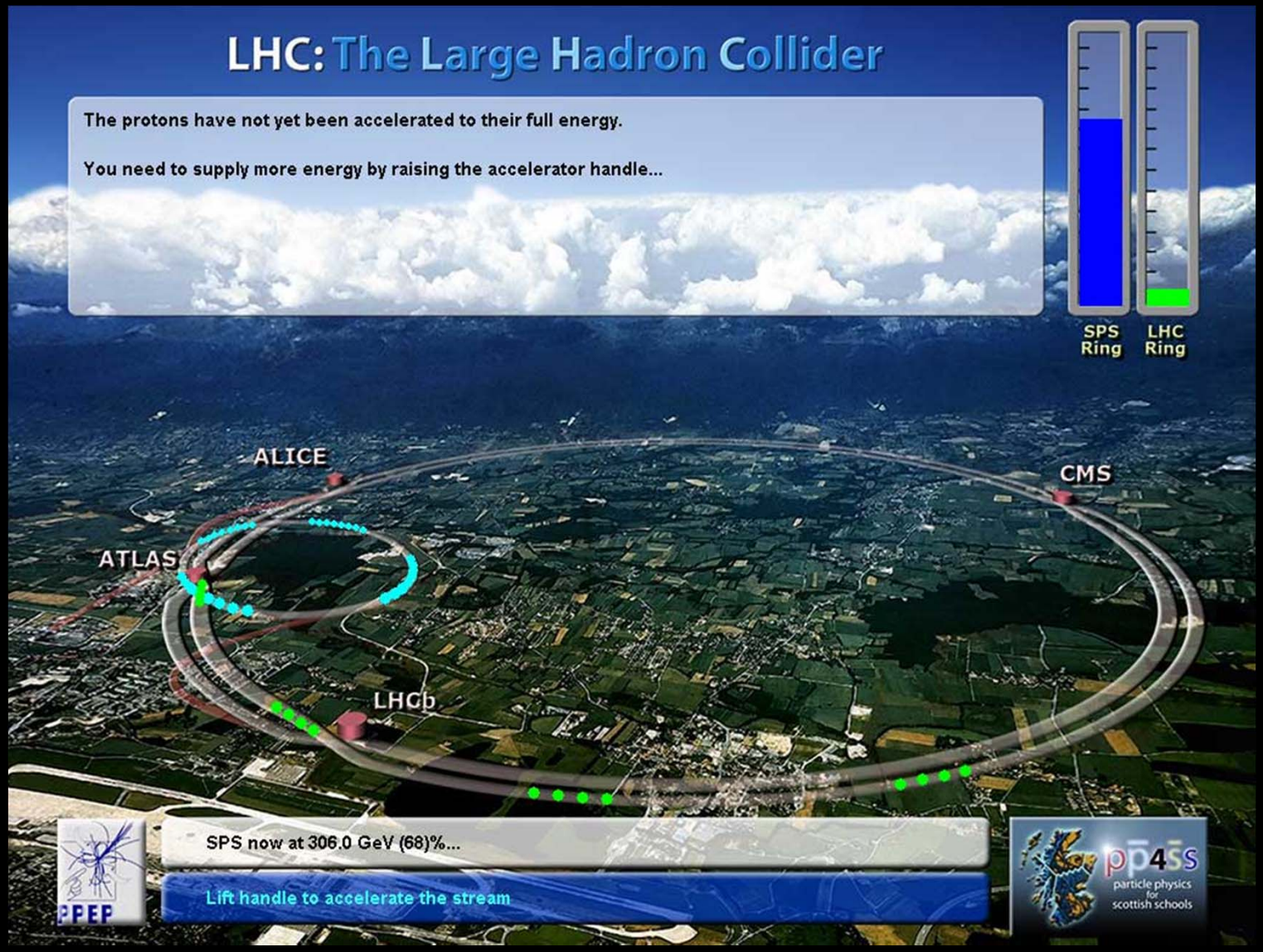
***41 Years Ago**

A story about Instrumentation and Discovery

…cloth merchant in Amsterdam - magnifying glasses mounted on a small stand used by textile merchants, capable of magnifying to a power of 3.
Improved lens to 300-500X and exposed the field of micro-biology.

Business,
Technology,
Discovery Science
(in that order)

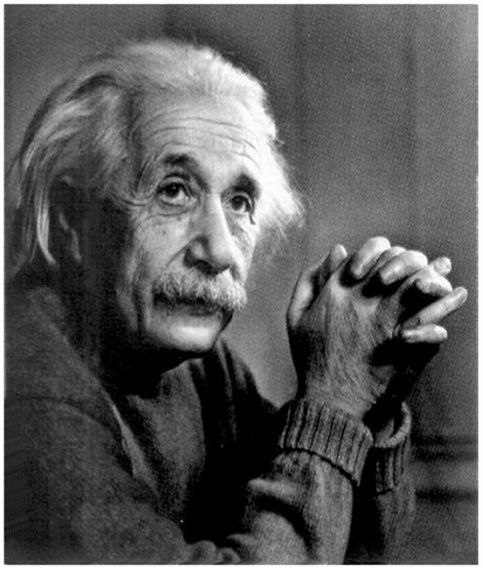
Ant ek



Could radiotherapy become model another well-known large-scale science project?

What would a such an ‘instrument’ for medical discovery look like?

- Precise
  - Measurement
  - Terminology
- Accurate
- Efficient
- Simple
  - As possible



Things should be made as simple as possible, but not simpler.

Albert Einstein

An ‘Optimistic’ Perspective

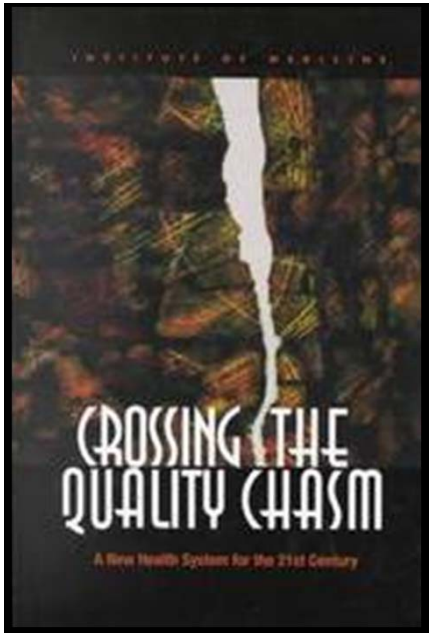
- Continued advances in technology and development of new knowledge will improve the performance of cancer intervention.
  - It will not necessarily be simple.
  - It will not necessarily be elegant.
  - It may be <u>very complex</u>.
  - It will likely be multi-modal.
  - It will be intolerant to errors.
- It will have to be very well-organized.

An ‘Optimistic’ Perspective

- I think we can build this…
- In fact, if we don’t we will be out of a job…
- BTW, the jobs we currently have could be better done by intelligent systems.
- Wouldn’t you rather do some science?

Why am I optimistic?

Do I have any preliminary data?



The Strengthening of the Quality Agenda

Identify four key issues affecting quality in health care delivery:

(1) the growing complexity of science and technology,

(2) the increase in chronic conditions,

(3) a poorly organized delivery system, and,

(4) constraints on exploiting the revolution in information technology.

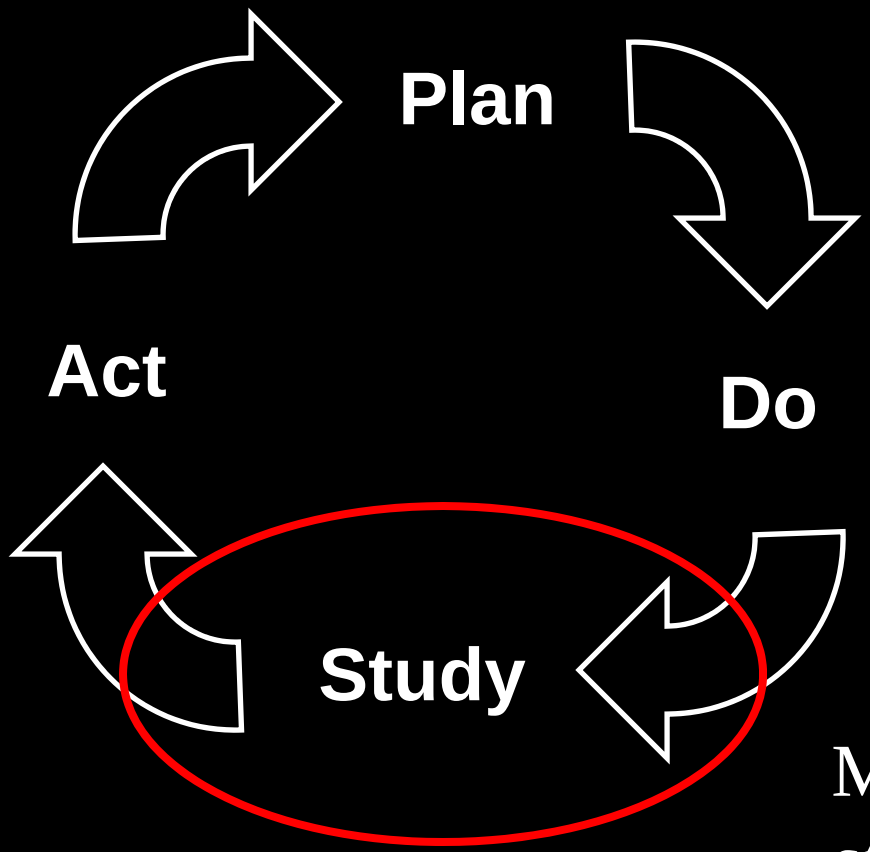
ISBN 0-309-07280-8

QUALITY

THE RACE FOR QUALITY HAS NO FINISH LINE-
SO TECHNICALLY IT'S MORE LIKE A DEATH MARCH.

www.despair.com

Driving Quality: The Deming Cycle



Measurement and study is central to The Deming Cycle

William Edwards Deming (October 14, 1900 – December 20, 1993)

SYSTEMS THINKING

for Health Systems

World Health

BOX 1.2 FOUR REVOLUTIONS THAT WILL TRANSFORM HEALTH AND HEALTH SYSTEMS

There are four revolutions currently underway that will transform health and health systems. These are the revolutions in: a) life sciences; b) information and communications technology; c) social justice and equity; and d) ***systems thinking to transcend complexity***.

Source: *Frenk J. "Acknowledging the Past, Committing to the Future". Delivered September 5, 2008. Available at: http://www.hsph.harvard.edu/multimedia/JulioFrenk/FrenkRemarks.pdf*
Italics added for emphasis.

ed.: Don de Savigny and Taghreed Adam (2009).

SYSTEMS THINKING

for Health Systems Strengthening

Table 2.1 Skills of systems thinking

Usual approach	Systems thinking approach
Static thinking	**Dynamic thinking**
Focusing on particular events	Framing a problem in terms of a pattern of behaviour over time
Systems-as-effect thinking	**System-as-cause thinking**
Viewing behaviour generated by a system as driven by external forces	Placing responsibility for a behaviour on internal actors who manage the policies and "plumbing" of the system
Tree-by-tree thinking	**Forest thinking**
Believing that really knowing something means focusing on the details	Believing that to know something requires understanding the context of relationships
Factors thinking	**Operational thinking**
Listing factors that influence or correlate with some result	Concentrating on causality and understanding how a behaviour is generated
Straight-line thinking	**Loop thinking**
Viewing causality as running in one direction, ignoring (either deliberately or not) the interdependence and interaction between and among the causes	Viewing causality as an on-going process, not a one-time event, with effect feeding back to influence the causes and the causes affecting each other

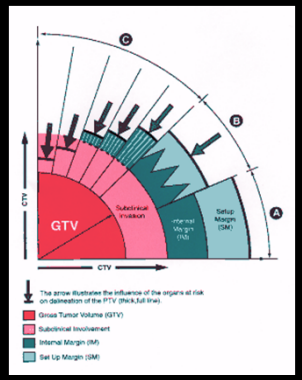
Modified from Richmond, 2000 (28).

World Health Organization

ed.: Don de Savigny and Taghreed Adam (2009).

RT Towards ‘Systems Thinking’

- Safety and Quality as Priorities
  - Variance Tracking, Measurement
- Advancing a Nomenclature for RT
  - ICRU 50, 62, 83
- Standardization in Treatment Methods
  - Delineation Standards
- Measuring Outcomes
  - Pay for Performance, Expertise Growth
- Engineering Principles
  - FMEA, Control Charts, Measure and Correct Strategy



Are Quality and Innovation Competitive?

Fresh Thinking on Innovation and Quality

An ASQ
White Paper

The idea that innovation must embrace both the blue sky and the practical is neither new nor radical, yet we cling to our fascination with the home run.

It makes sense to manage innovation activities with the same management tools and approaches that are used in other major sectors of the business.

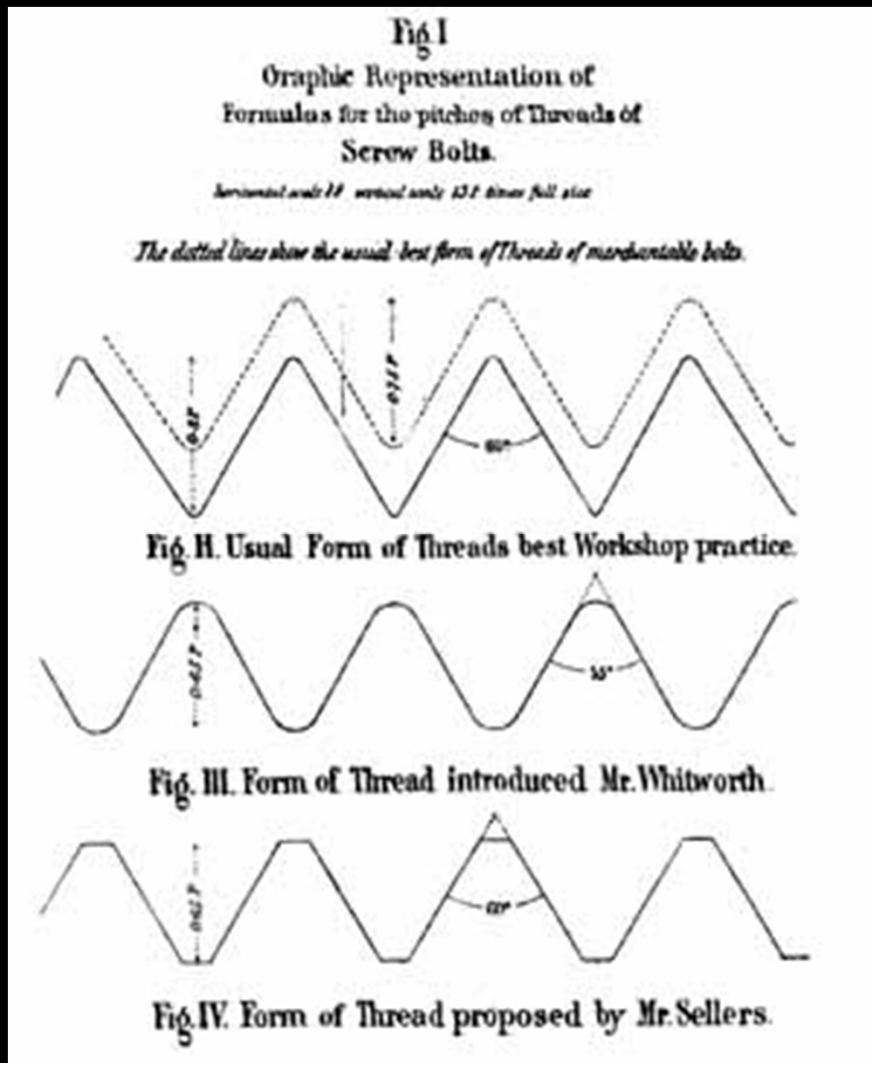
ASQ (American Society for Quality) is the world's leading authority on quality and sole administrator of the Malcolm Baldridge National Quality Award.

ASQ 2010

Standardization and Innovation: A Paradoxical Association?

Not at all.

- DICOM-RT
- TCP-IP
- The kilogram
- The standardized bolt thread



Henry Maudslay (~1800) - the modern screw-cutting lathe made interchangeable screws a practical commodity.

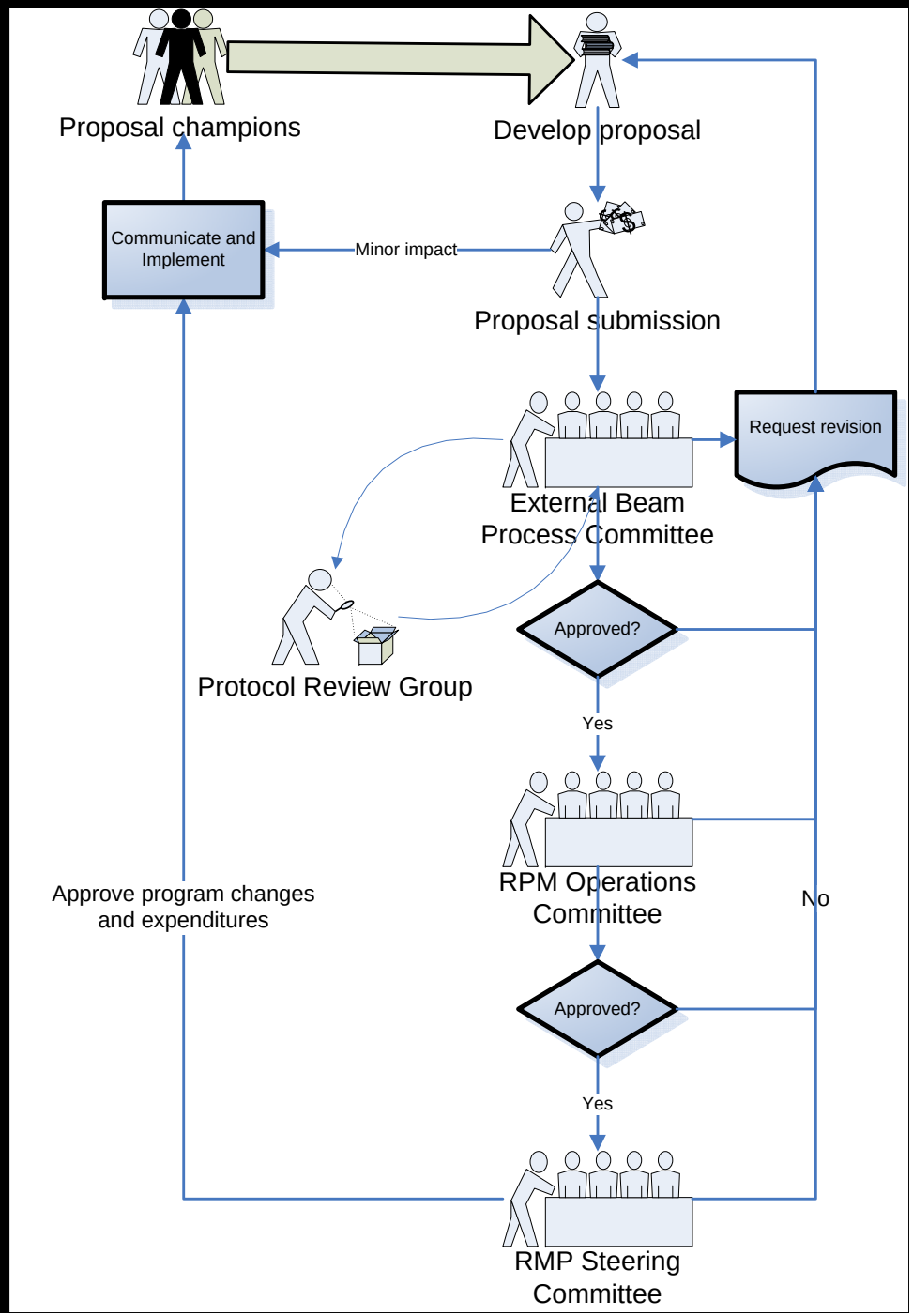
Innovating with Confidence: A Reaction to IMRT/IGRT Deployment

- To address the freedom enabled by the new technologies, needed to revise the infrastructure to support quality and error elimination activities:
  - Change Management:
    - External Beam Process Committee
  - Investigation:
    - QUINCy
  - Analysis, Synthesis, Reporting:
    - Quality Assurance Monitoring Committee is
  - Sharing/Knowledge Transfer:
    - Program-wide QA Conference
  - Peer-review:
    - Site-specific Rounds

‘External Beam Process Committee’

- Change management system for our External Beam treatment practices.
- …innovation not (seen) as a series of unrelated eureka moments, but rather as a process—a change process that can be managed with familiar change management and quality management methods.

ASQ, 2010



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SBRT LUNG SCANNING PROTOCOL

SITE

LUN

Equi

Patie

RADIATION MEDICINE PROGRAM TREATMENT PLANNING PROTOCOL

SITE – SBRT LUNG

TECHNI

PRESCR

Nominal

6000 cGy

5400 cGy

4800 cGy

6000 cGy

RESEAR

DATA IM

RADIATION MEDICINE PROGRAM TREATMENT DELIVERY PROTOCOL

SITE- STEREOTACTIC BODY RADIOTHERAPY (SBRT) LUNG

TECHNIQUE: SBRT / VMAT

PRESCRI

6000 cGy/

5400 cGy/

4800 cGy/

6000 cGy/

RESEARC

SBRT Lung XVI Imaging Protocol

Setup patient as per Tx Setup notes

Acquire CBCT scan "T2_SBRT_Lung_Acquire"

1a. Automatic Bone (spine) Matching
1b. Use "Automatic Grey Value" match in "Green-Purple View"
1c. Assess rotation: Zero out if ≤ 3 degrees

2a. Manual Tumor Matching "Localization View"
2b. Match ITV contour to tumor
2c. PTV should encompass full volume

3a. Verify applicable OAR Contours (Spinal Canal for all patients).
3b. Verify applicable isodose lines

NOTE:
2 Step Matching Process with Verification of OARs and Isodose lines

TRIAL SET-UP:
1. All patients have Trial Set-Up
2. Fellow or DRO to be present
3. Acquire CBCT Scan
4. Check for Clearance
5. Document: Shifts/OAR/Any Matching Issues

Organs At Risk (OAR)

- Spinal Canal (Verify for ALL Pts)
- Heart, Trachea
- Bronchus, Esophagus

Discuss & Document OAR and Isodose line contours with planner/DRO during pre-workup.

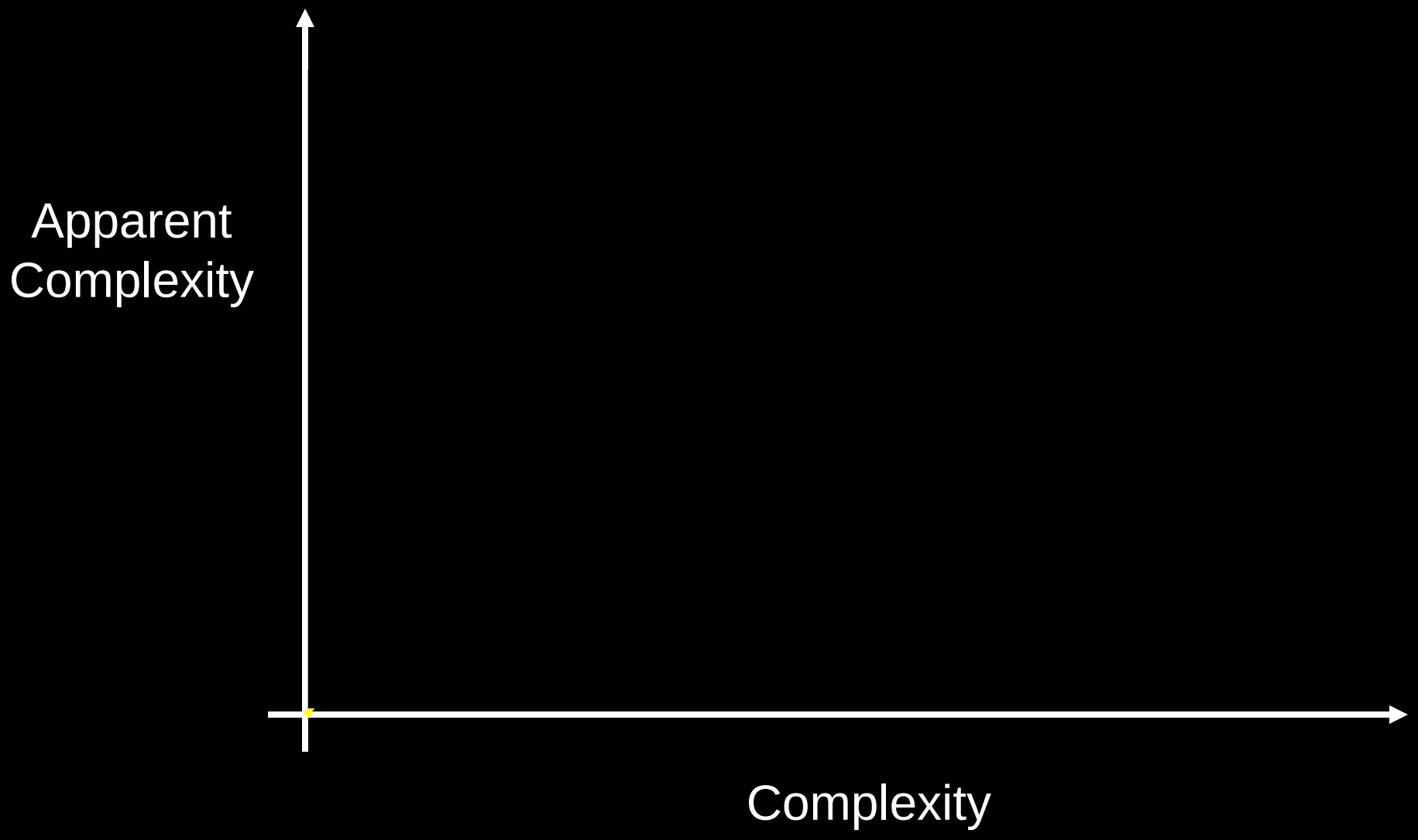
It is getting altogether too complex.

We are at the complexity limit!

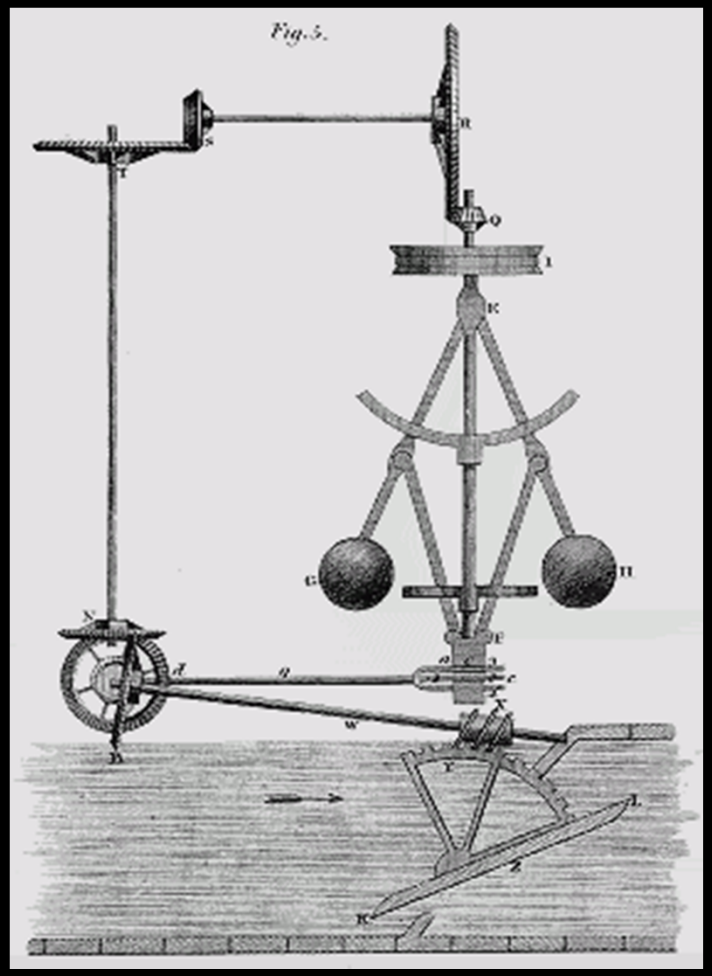
We can’t do it, will is not enough.


Re: More Photos From Our Trip
Q W E R T Y U I O P
A S D F G H J K L return
Z X C V B N M
.?123
.?123

Dave's Theory of Complexity Reciprocity



Automation: Complexity ‘Hide Thy Self’



Mr. Watt believed that throttling a steam valve by a human being was not the best way to maintain a constant speed of the steam engine.

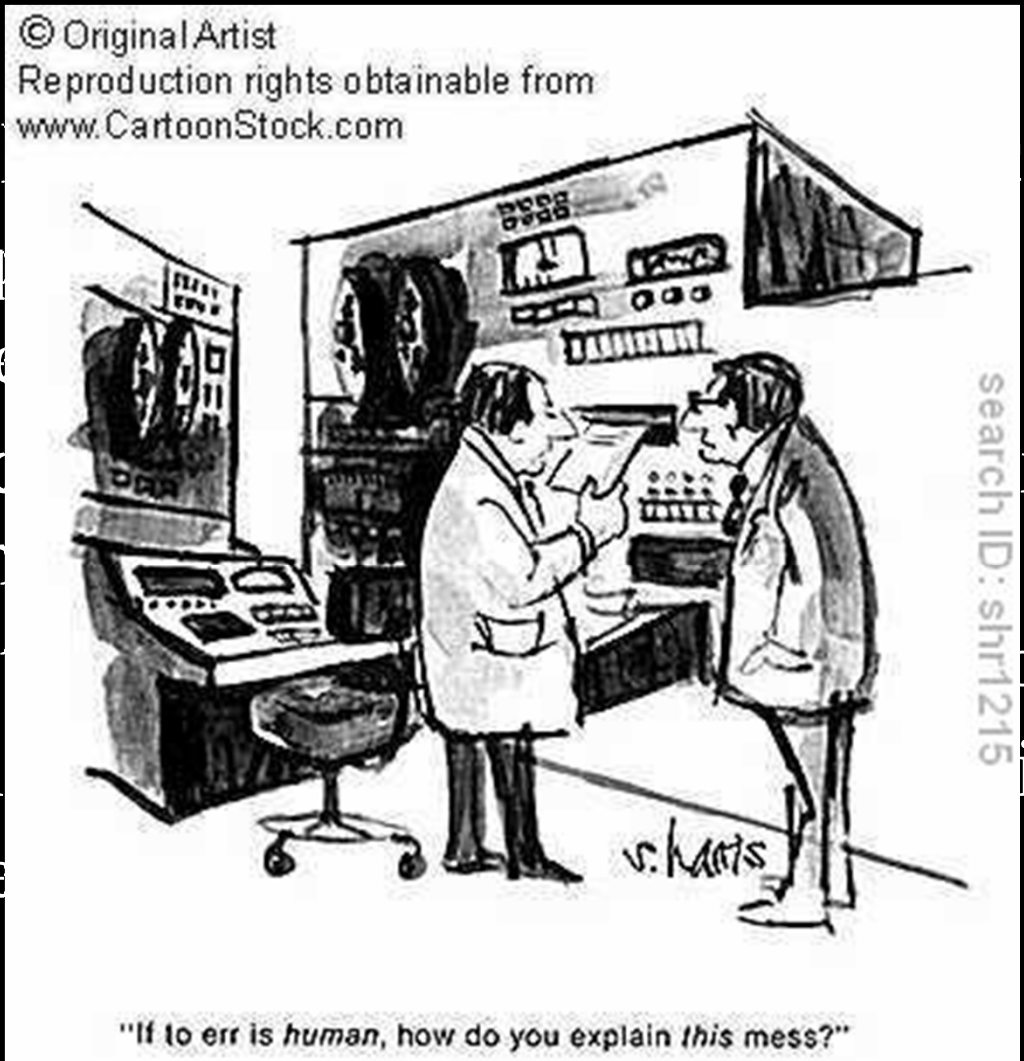
The beginning of modern automatic control began, when James Watt in 1788 developed a mechanical device the flyball governor.

The flyball governor maintained the speed of the steam engine automatically by controlling the opening and closing of the steam valve.

Vintage AAPM Summer School – Colorado Springs - 2003

Automation is Powerful Stuff

- Enab lature
  - Rep
  - Inte
- Rapid initial organ
  - Au omation
- Redu ion)
  - See



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ELSEVIER

Int. J. Radiation Oncology Biol. Phys., Vol. ■, No. ■, pp. 1–9, 2011

0360-3016/$ - see front matter

doi:10.1016/j.ijrobp.2010.11.016

PHYSICS CONTRIBUTION

AUTOMATED PLANNING OF TANGENTIAL BREAST INTENSITY-MODULATED RADIOTHERAPY USING HEURISTIC OPTIMIZATION

THOMAS G. PURDIE, PH.D.,*† ROBERT E. DINNIWELL, M.D.,*† DANIEL LETOURNEAU, PH.D.,*† CHRISTINE HILL, B.SC.,* AND MICHAEL B. SHARPE, PH.D.*†

*Radiation Medicine Program, Princess Margaret Hospital, University Health Network, Toronto, ON, Canada; and †Department of Radiation Oncology, University of Toronto, Toronto, ON, Canada

Purpose: To present an automated technique for two-field tangential breast intensity-modulated radiotherapy (IMRT) treatment planning.

Method and Materials: A total of 158 planned patients with Stage 0, I, and II breast cancer treated using whole-breast IMRT were retrospectively replanned using automated treatment planning tools. The tools developed are integrated into the existing clinical treatment planning system (Pinnacle[3]) and are designed to perform the manual volume delineation, beam placement, and IMRT treatment planning steps carried out by the treatment planning radiation therapist. The automated algorithm, using only the radio-opaque markers placed at CT simulation as inputs, optimizes the tangential beam parameters to geometrically minimize the amount of lung and heart treated while covering the whole-breast volume. The IMRT parameters are optimized according to the automatically delineated whole-breast volume.

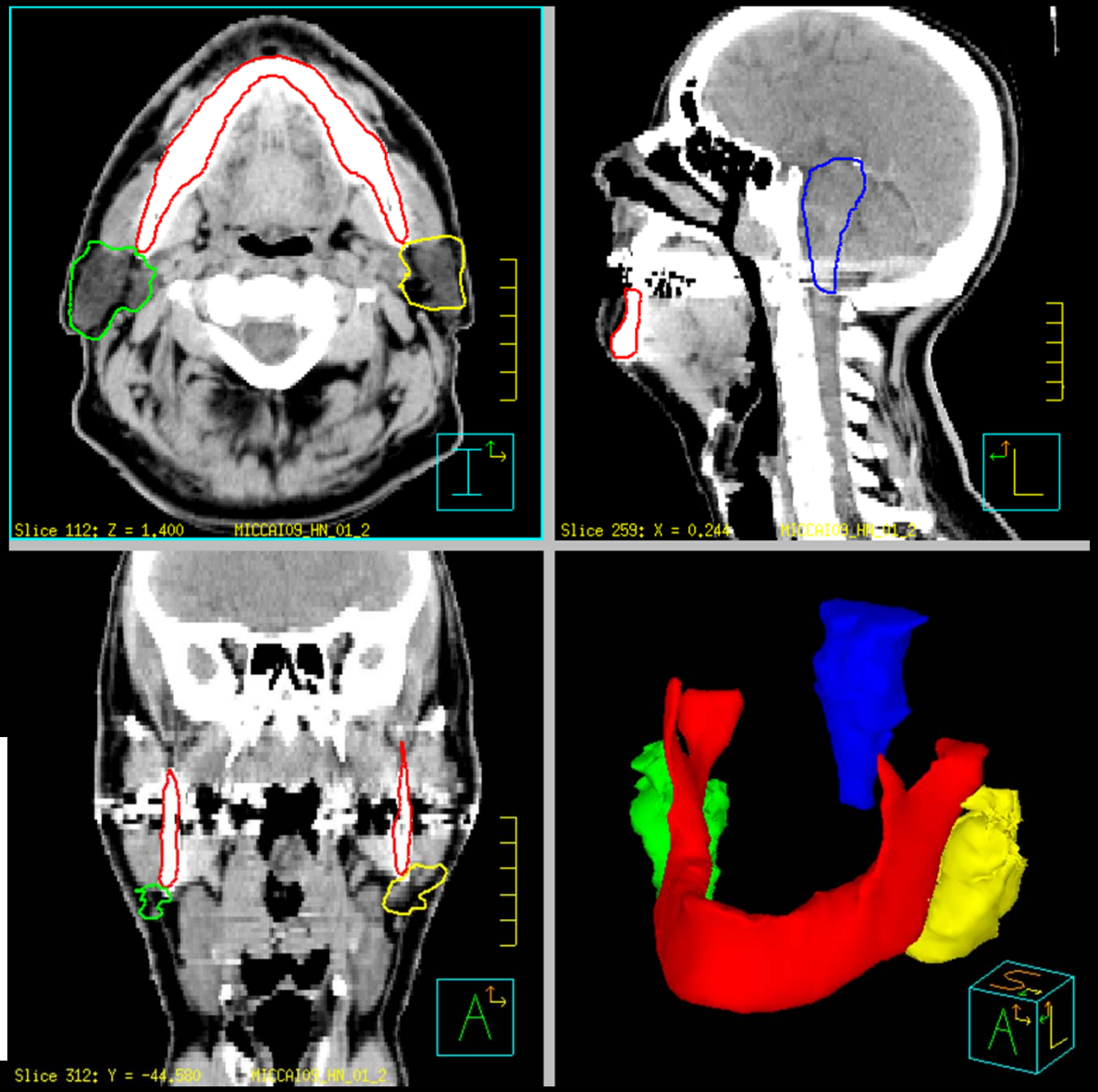
Results: The mean time to generate a complete treatment plan was 6 min, 50 s ± 1 min 12 s. For the automated plans, 157 of 158 plans (99%) were deemed clinically acceptable, and 138 of 158 plans (87%) were deemed clinically improved or equal to the corresponding clinical plan when reviewed in a randomized, double-blinded study by one experienced breast radiation oncologist. In addition, overall the automated plans were dosimetrically equivalent to the clinical plans when scored for target coverage and lung and heart doses.

Conclusion: We have developed robust and efficient automated tools for fully inversed planned tangential breast IMRT planning that can be readily integrated into clinical practice. The tools produce clinically acceptable plans using only the common anatomic landmarks from the CT simulation process as an input. We anticipate the tools will improve patient access to high-quality IMRT treatment by simplifying the planning process and will reduce the effort and cost of incorporating more advanced planning into clinical practice. © 2011 Elsevier Inc.

Breast cancer, Intensity-modulated radiotherapy, Tangential, Automation.

Purdie et al. - Int J Radiat Oncol Biol Phys. 2011 Jan 13.

Automated Contouring: Model-based Segmentation



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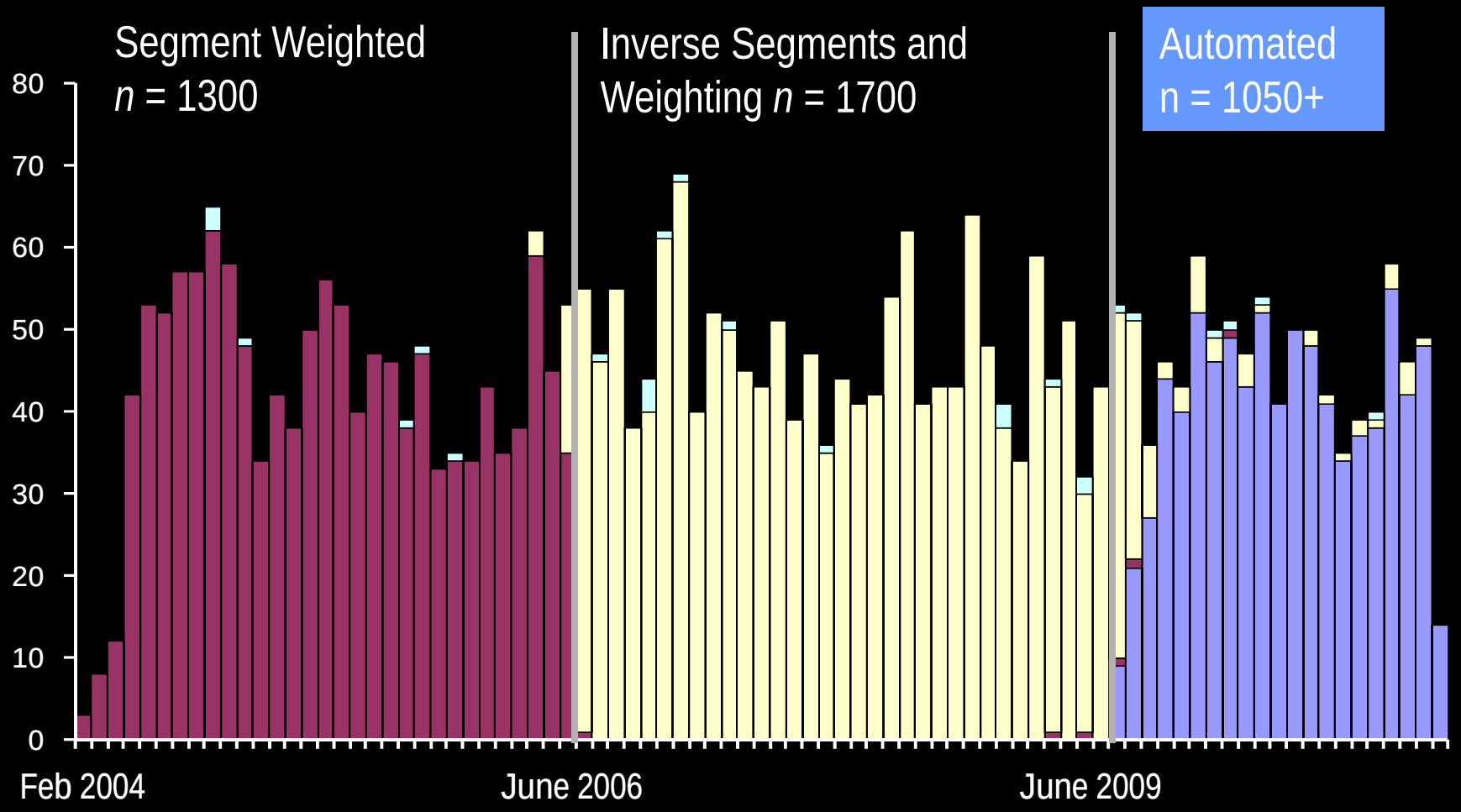
PHILIPS

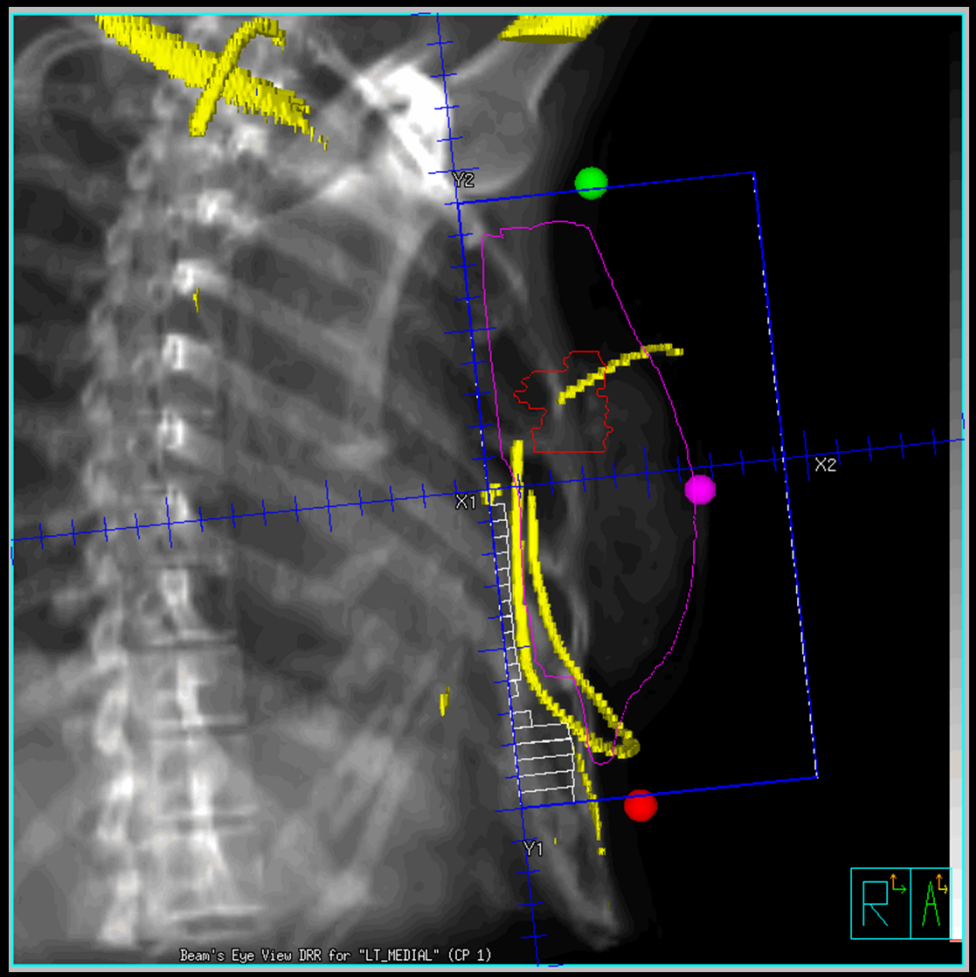
S. Allaire, V. Pekar et al.

Tangential Breast IMRT at PMH



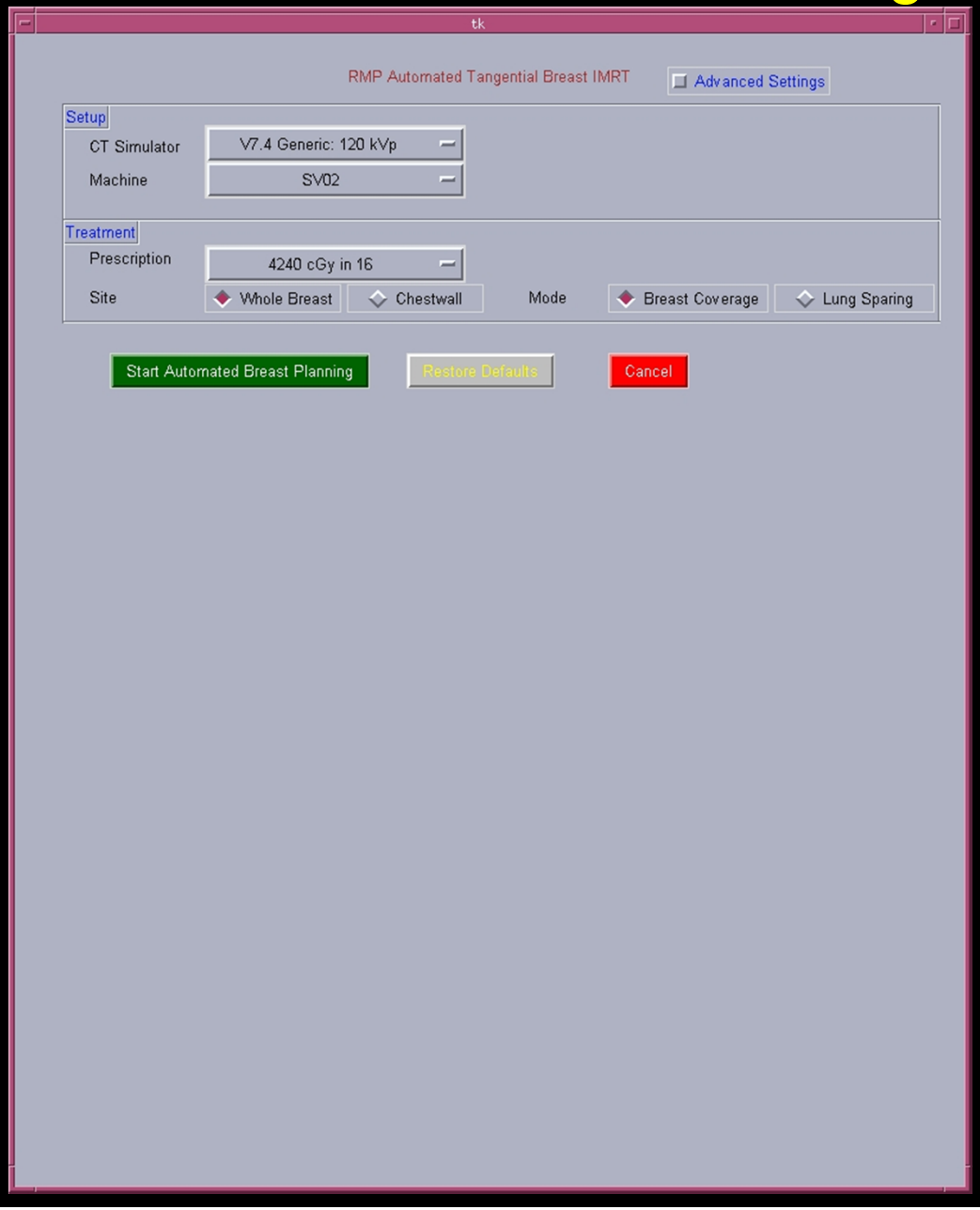
Since June 2009, 1050+ patients planned using automated planning tools

Objectives of Automated Planning Process



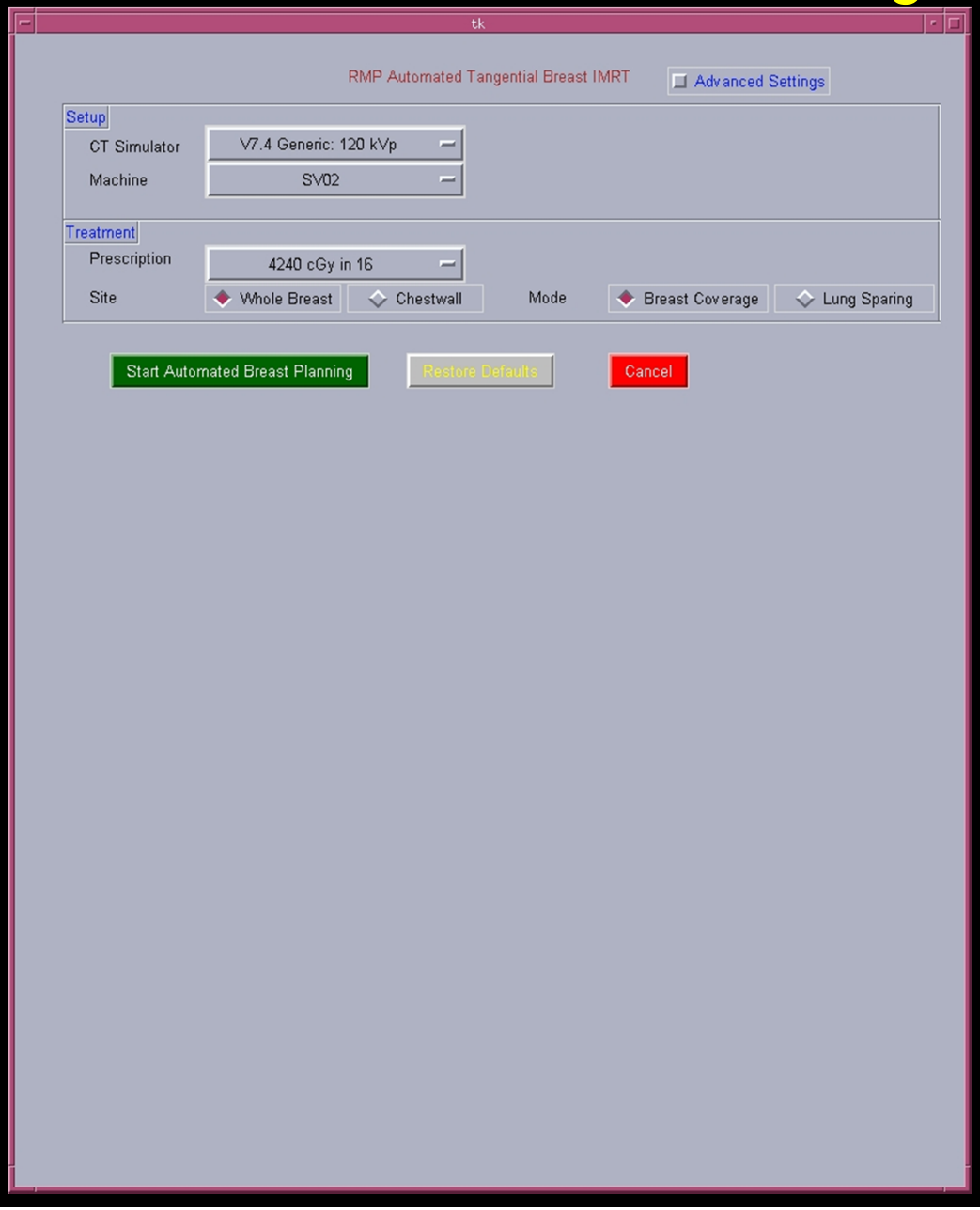
- Algorithm has learned to set beam gantry and collimator angles, isocenter etc based on 100s of previously treated patients using marks placed at sim for initialization.
- Goal is to spare heart, lung etc and cover whole breast volume using initi
- Beam optimization will include post-surgery cavity and wire placed on patient at time of sim (if present)
- Advanced options can be used to tweak any of the default settings

Automated Breast Planning Launcher



Defaults

Automated Breast Planning Launcher



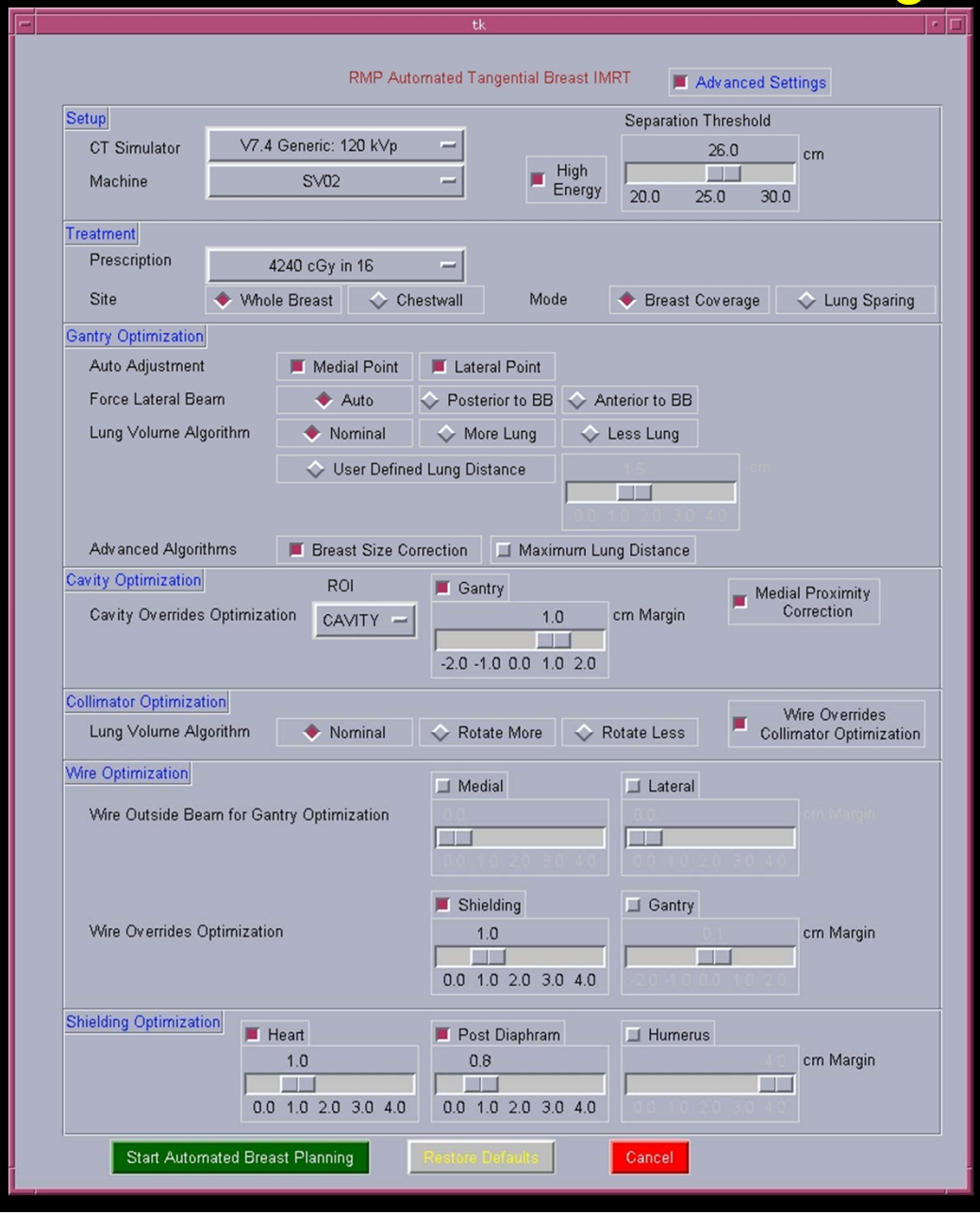
Defaults

Push

Green Button

Get a Treatment Plan

Automated Breast Planning Launcher



Beam Energy

Gantry

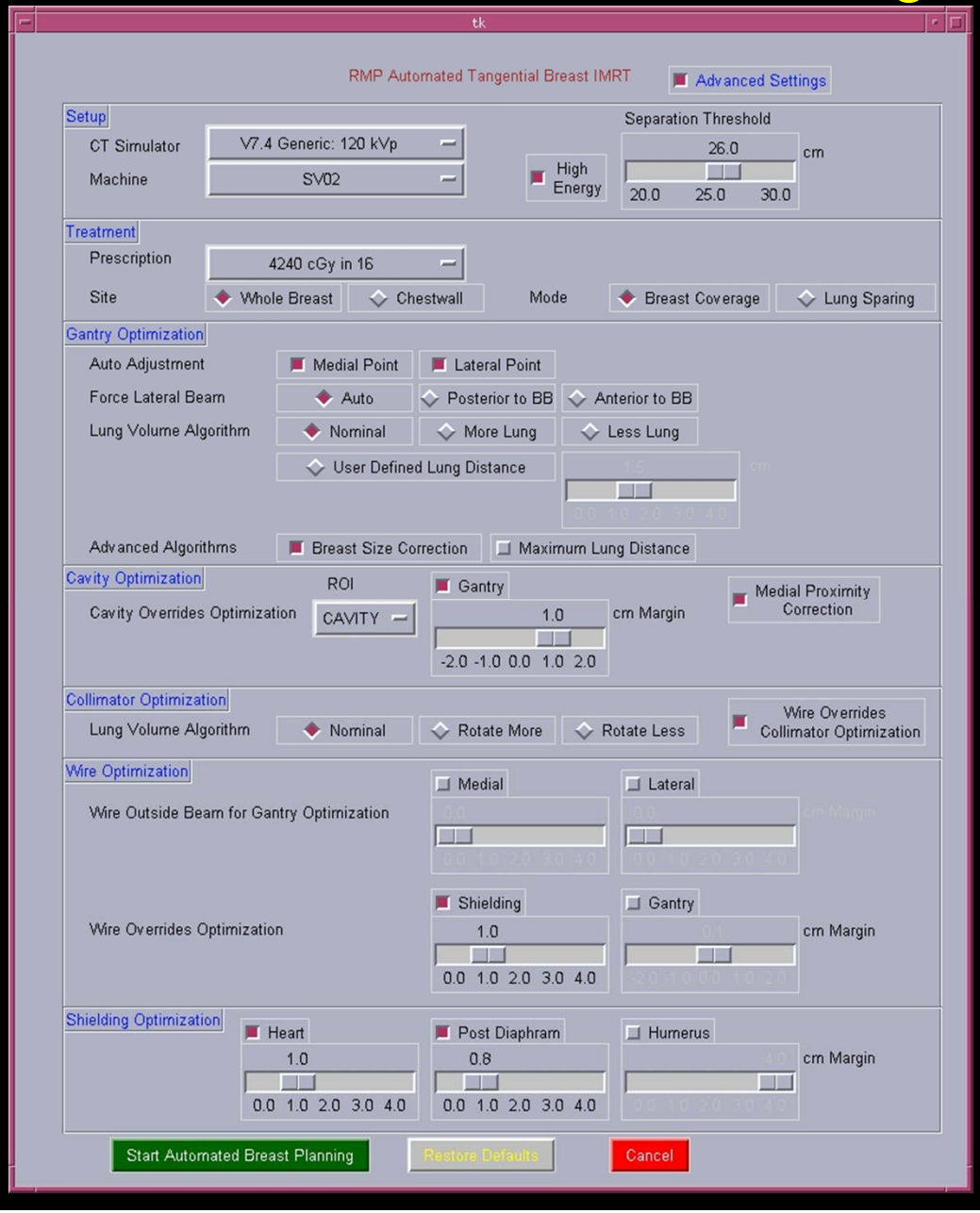
Cavity

Collimator

Wire

Shielding

Automated Breast Planning Launcher

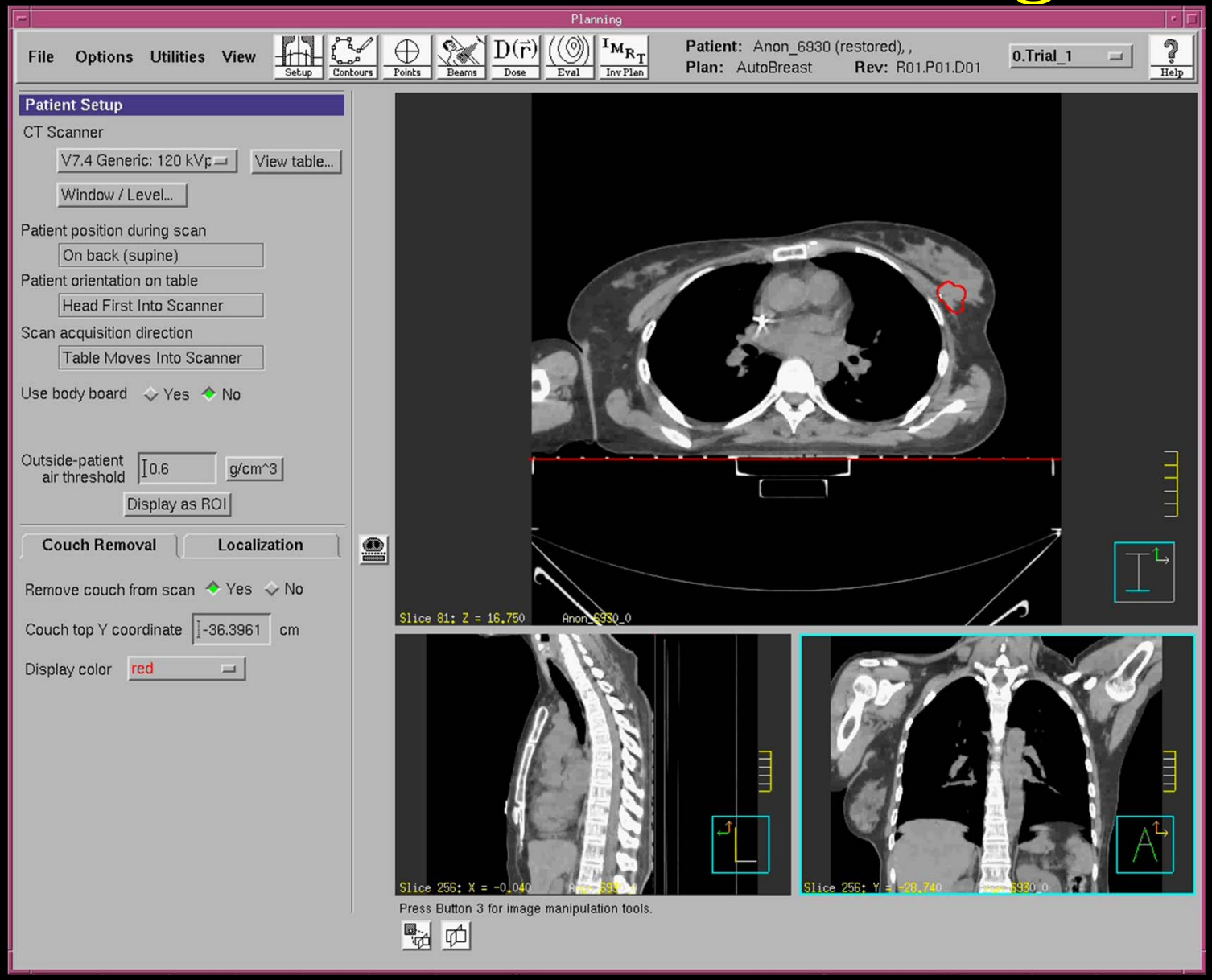


Push

Green Button

Get a Treatment Plan

Automated Breast Planning



Purdie et al. - Int J Radiat Oncol Biol Phys. 2011 Jan 13.

Automated Reporting – Plan Summary

```
Automated Pinnacle QA Report - Automated Tangential Breast

Patient ID:      3000001
Patient Name:    Anon_6930 (restored),
Plan Name:       AutoBreast
Revision:        R01.P01.D01
Trial Name:      0.AutoTangentDMP0
Institution:     Automated Breast Planning
Published By:    purdie
Published On:    2009-07-16 15:04:39
---------------------------------
General Summary (Flags:  1)
---------------------------------
Mean Lung Area:          1.8 cm2 (2.0 cm2) .......... ok
Max Lung Distance:       2.4 cm  (2.0 cm ) >>>>>>> noted
CAVITY Margin:           1.1 cm  (1.0 cm ) .......... ok
Couch Removed Y:       -36.2 cm
---------------------------------
Beam Summary (Flags:  0)
---------------------------------
                  MU  Limit                 Weight  Limit
Medial
--- CP1 Open  140.0 (139.1) .......... ok  88.6% (75.0%) .......... ok
--- CP2        14.0  (20.0) .......... ok   8.9% (10.0%) .......... ok
--- CP3         4.0  (20.0) .......... ok   2.5% (10.0%) .......... ok
--- Total     158.0

Lateral
--- CP1 Open  144.0 (139.1) .......... ok  76.6% (75.0%) .......... ok
--- CP2         6.5  (20.0) .......... ok   3.5% (10.0%) .......... ok
--- CP3         7.6  (20.0) .......... ok   4.0% (10.0%) .......... ok
--- CP4        15.6  (20.0) .......... ok   8.3% (10.0%) .......... ok
--- CP5        14.3  (20.0) .......... ok   7.6% (10.0%) .......... ok
--- Total     188.0
---------------------------------
Setup Summary
---------------------------------
Lateral TTH from Chestboard:                7.0 cm
Set Depth at Medial Centre Tattoo:          6.3 cm
Then Shift:                                 9.4 cm LEFT
Ant @ Isocentre Depth:                      7.1 cm

Medial (Gantry=304°)(Coll=  6°)   Depth:  11.5 cm
Medial Field from Medial Tattoo:            --- cm  ON

Lateral (Gantry=124°)(Coll=354°)  Depth:   8.0 cm
Lateral Field from Lateral Tattoo:          0.2 cm POST


--------------
Page 1 of 2
```

Automated Reporting – Dose Summary

```
Automated Pinnacle QA Report - Automated Tangential Breast

Patient ID:      3000001
Patient Name:    Anon_6930 (restored),
Plan Name:       AutoBreast
Revision:        R01.P01.D01
Trial Name:      0.AutoTangentDMPO
Institution:     Automated Breast Planning
Published By:    purdie
Published On:    2009-07-16 15:04:45
-----------------------------------------------------------------
Dose Summary for 4240 in 16 fractions (Flags:  1)
-----------------------------------------------------------------
                            Volume        Dose      Variation      Limit
aCTV (510.0 cc)
------ Max Dose              (2.0 cc)     4480 cGy (105.7%)       (<108%) .......... ok
------ Min Dose            (504.9 cc)     4030 cGy  (95.0%)        (>92%) .......... ok
------ Mean Dose                          4242 cGy (100.1%)     (97-103%) .......... ok

aTreated Volume (1220.5 cc)
------ Max Dose              (2.0 cc)     4484 cGy (105.8%)       (<108%) .......... ok

modCAVITY (9.9 cc)
------ Min Dose              (9.9 cc)     4076 cGy  (96.1%)
------ Coverage              (9.8 cc)     4132 cGy  (97.5%)        (>95%) .......... ok

DEVcavity (64.9 cc)
------ Min Dose             (64.9 cc)     3898 cGy  (91.9%)
------ Coverage             (64.2 cc)     4106 cGy  (96.8%)        (>95%) .......... ok

aLTLUNG (1038.5 cc)
------ Max Dose             (45.0 cc)     3870 cGy  (91.3%)        (<90%) >>>>>>> noted
------ Max Dose            (145.0 cc)     2042 cGy  (48.2%)        (<50%) .......... ok

aHEART (550.5 cc)
------ Max Dose             (10.0 cc)     3556 cGy  (83.9%)        (<90%) .......... ok
------ Max Dose             (25.0 cc)     1894 cGy  (44.7%)        (<50%) .......... ok


--------------
Page 2 of 2
```

Automated Breast Plans

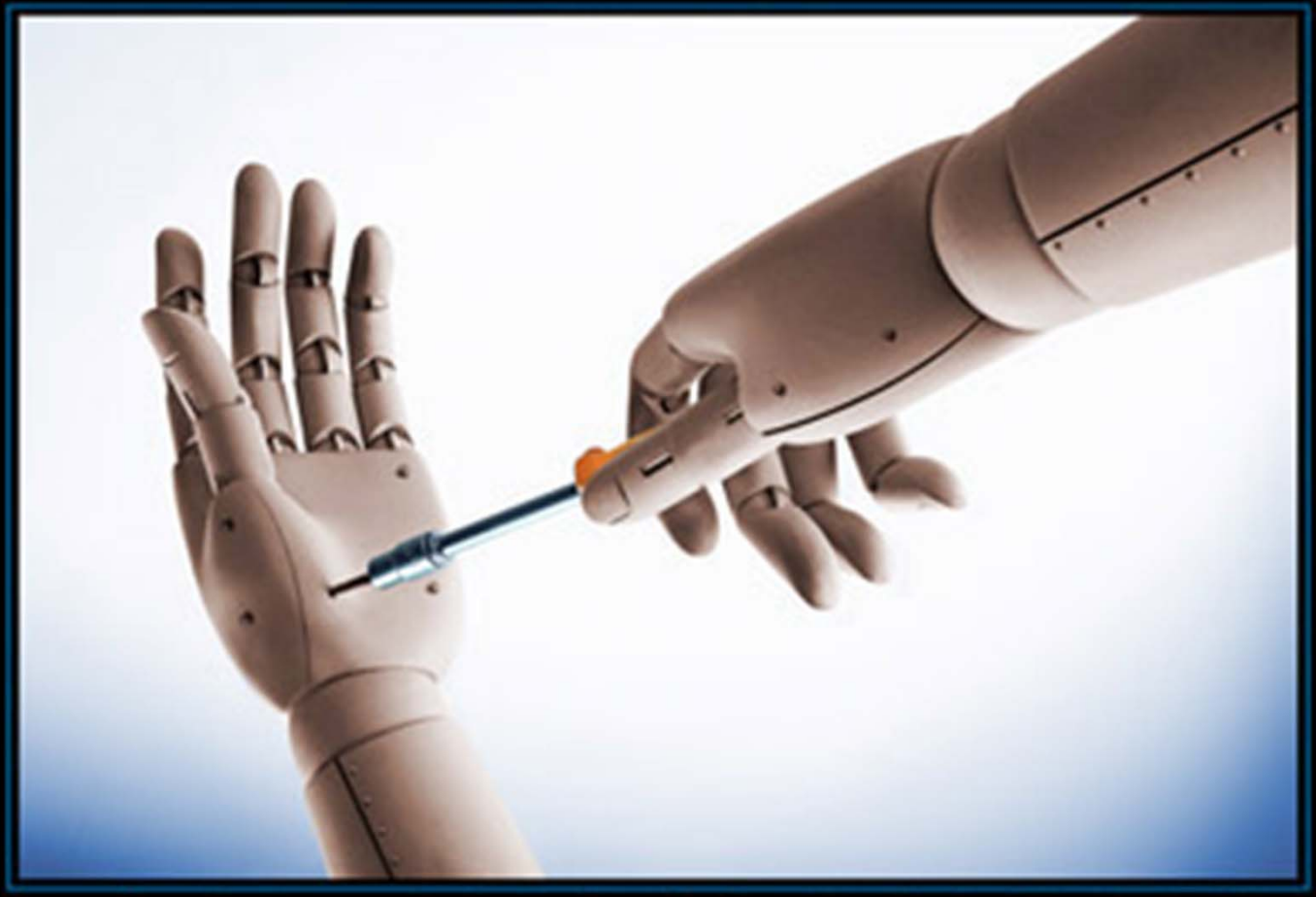
Date: June 11, 2009 – now

Published Plans:

- 1050+ approved plans for treatment
- All plans reviewed in multi-disciplinary weekly QA rounds
- Average time for complete plan and documentation in clinical environment:

  8:55 ± 1:23 minutes with standard 810 boxes

  Now: 4-6 minutes with PCM
- ~97% of tangential treatments planned with automated tools
- Exceptions which will be handled in the future:
  - bolus
  - tattoos placed for breast and supraclav treatment for which tangents only treated
  - lung shielding required i.e. wide tangents to include cavity



ADAPTATION

THE BAD NEWS IS ROBOTS CAN DO YOUR JOB NOW. THE GOOD NEWS IS WE'RE NOW HIRING ROBOT REPAIR TECHNICIANS. THE WORSE NEWS IS WE'RE WORKING ON ROBOT-FIXING ROBOTS- AND WE DO NOT ANTICIPATE ANY FURTHER GOOD NEWS.

QA Revolt??

TG-40 + TG-142 + TG-100 + TG-XXX

Task Group 142 report: Quality assurance of medical accelerators[a)]

Eric E. Klein[b)]
Washington University, St. Louis, Missouri

TABLE VI. Imaging.

Procedure	Application-type tolerance: non-SRS/SBRT	Application-type tolerance: SRS/SBRT
Daily[a]		
Planar kV and MV (EPID) imaging		
Collision interlocks	Functional	Functional
Positioning/repositioning	≤2 mm	≤1 mm
Imaging and treatment coordinate coincidence (single gantry angle)	≤2 mm	≤1 mm
Cone-beam CT (kV and MV)		
Collision interlocks	Functional	Functional

"Physicists would need to have the machine for 8 hours a day just to do all the tests that the new TG-40 would recommend." – J. Palta

Time for a 'QA Spring' in RT QA

Drivers of Change

Complexity of RT Systems
Transparency in QA
Intolerance to Errors
Manpower Costs
Systems Thinking

Enablers of Change

Detector Technology
Computerization/IT
Standardized Terminology
Systems Thinking

Star-shots
Monthly Dosimetry
Audits (RPC etc.)
Multiple Dosimetry Systems
Daily Flat./Sym.
Patient-Specific QC
Manual Oversight
Labor Intensive
IGRT Performance

Inferred Dose-Geometry Performance

Explicit Dose-Geometry Performance

Integrated, Imageable Dosimetry Systems
Defined Methodologies for Analysis/Action
Self-Audits
Semi-automatic Monitoring
Inexpensive Measurement
Dual-purpose Patient-Specific QC

Current State

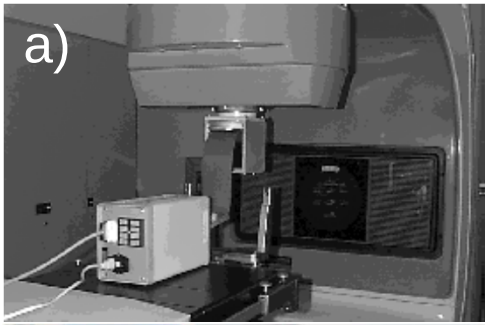
Future State

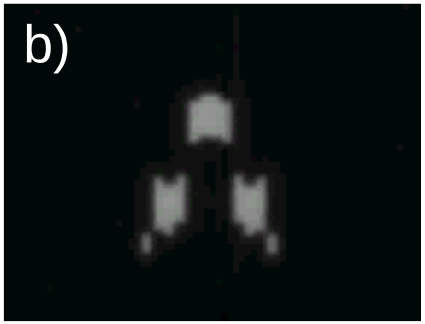
A-SI:H Array- T. Solberg

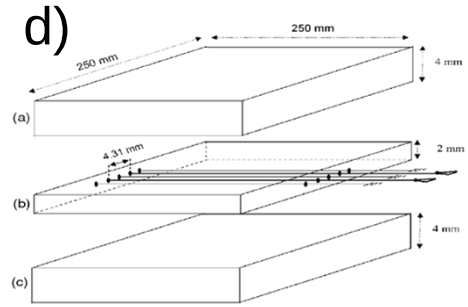
David™ multi-wire system - PTW

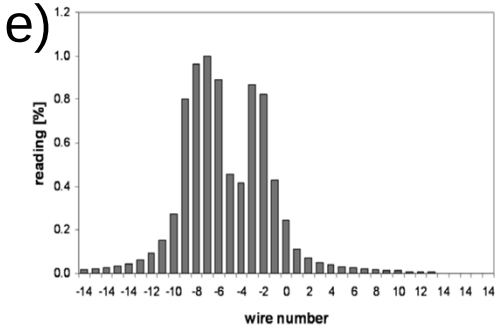
Compass™ Ion Array - IBA

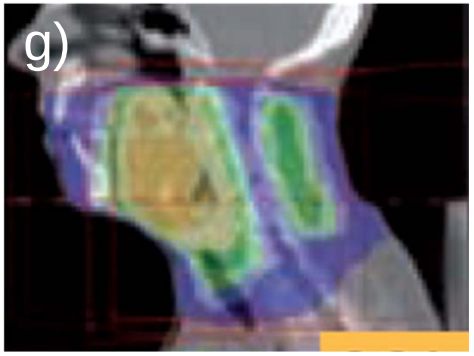
Gradient Chamber – Islam et al.

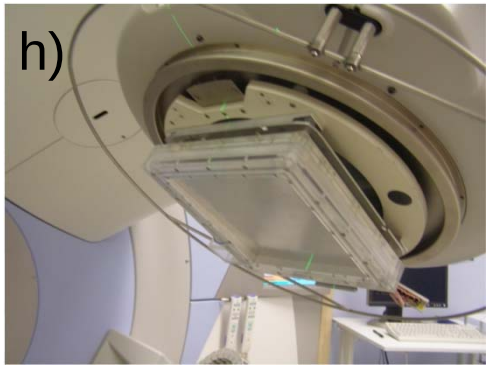


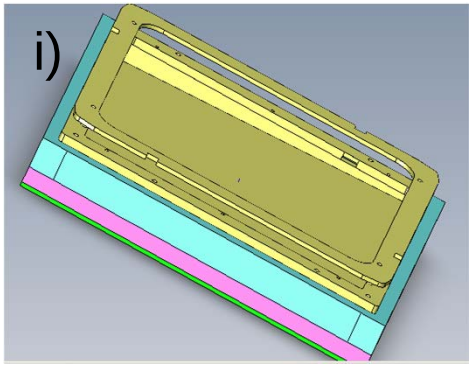


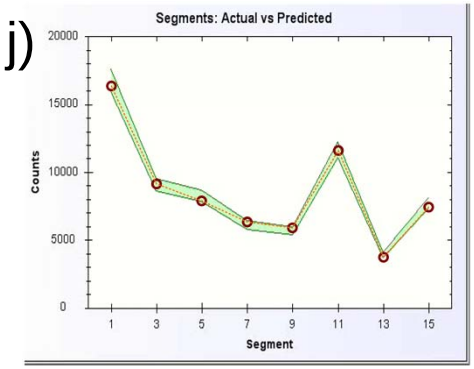








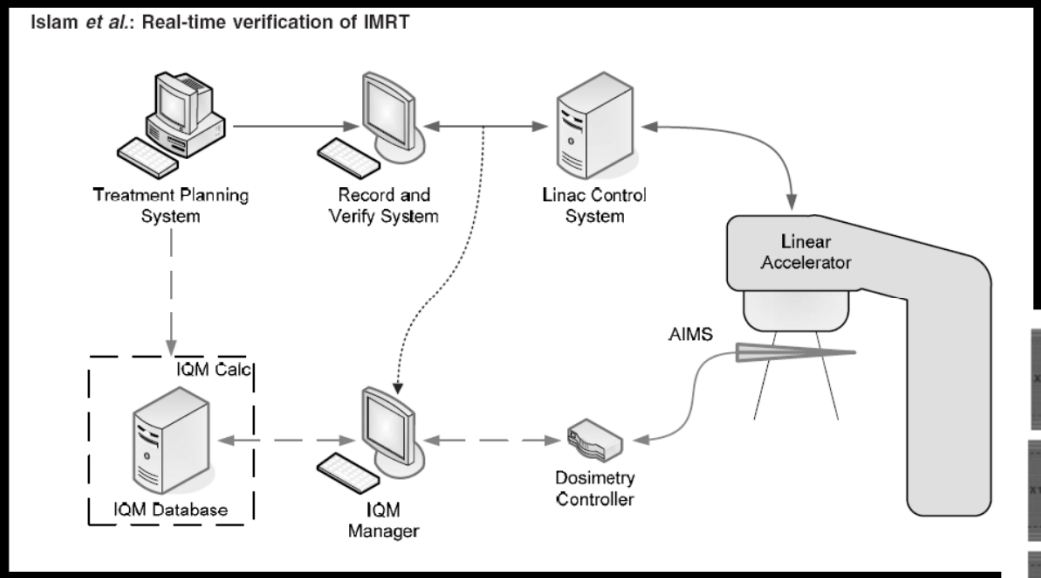




Lowering the Cost of Measurement

An integral quality monitoring system for real-time verification of intensity modulated radiation therapy

Mohammad K. Islam[a)]
Department of Radiation Physics, Radiation Medicine Program, Princess Margaret Hospital, Toronto, Ontario M5G 2M9, Canada; Department of Radiation Oncology, University of Toronto, Toronto, Ontario M5G 2M9, Canada; and Institute of Biomaterials and Biomedical Engineering, University of Toronto, Toronto, Ontario M5S 2Z9, Canada



Independent real-time monitoring of machine fluence pattern…

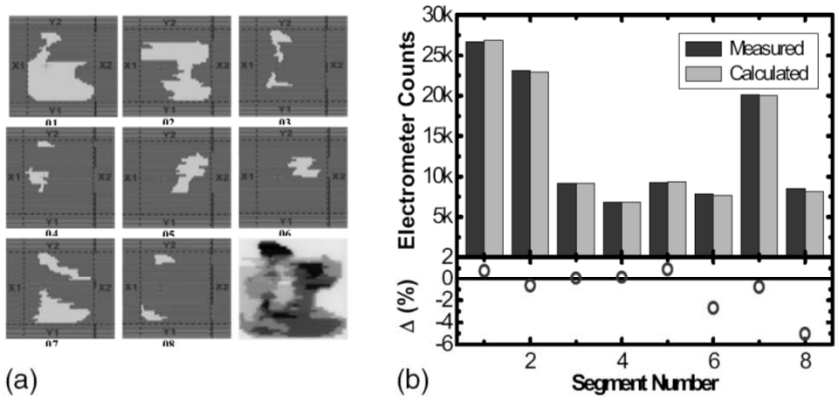
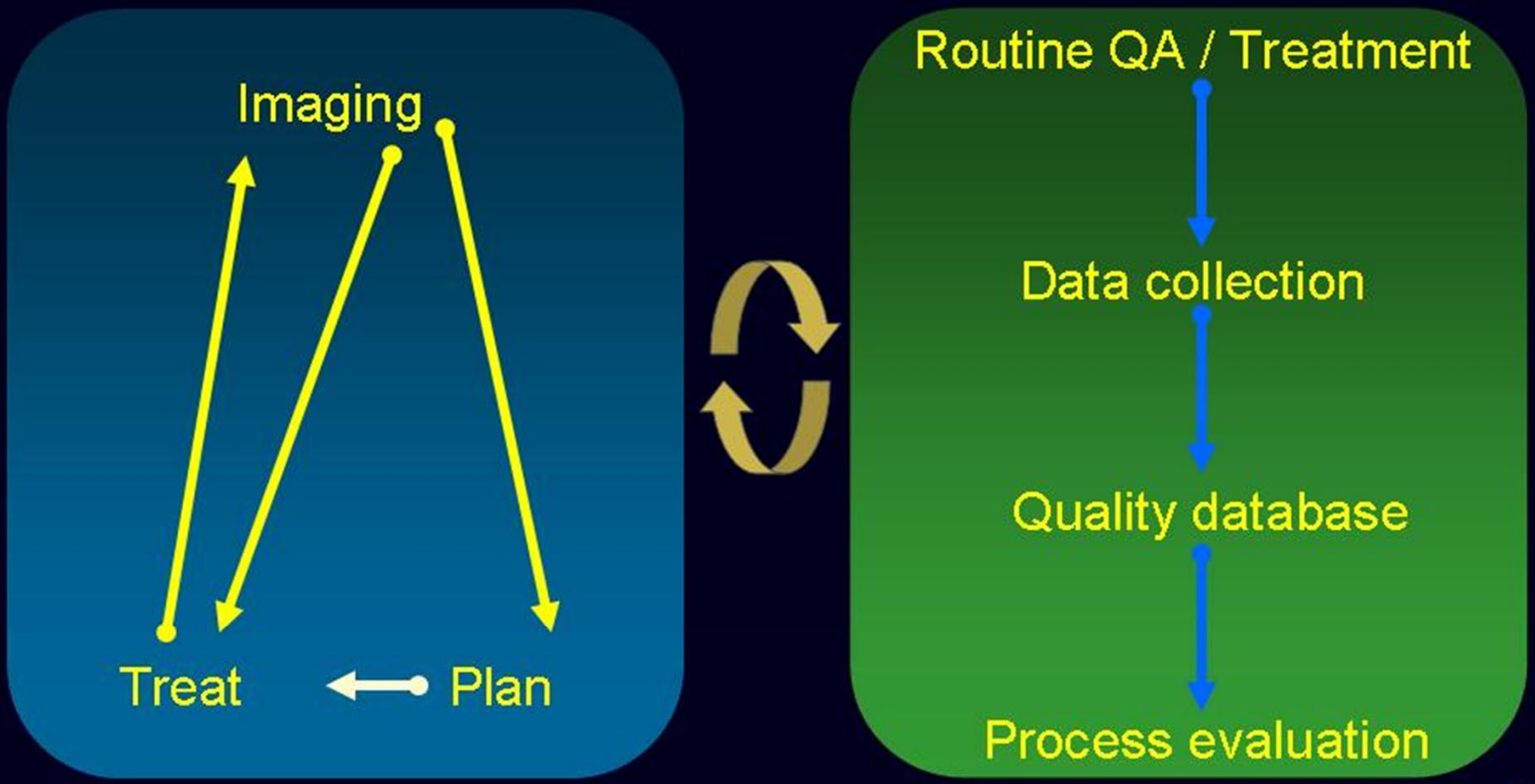


FIG. 8. Sample results for a step-and-shoot head and neck IMRT field. (a) The figure on the left shows the MLC apertures for each segment and the composited fluence map. (b) The results of IQM calculation, measured values, and corresponding percent differences.

Med. Phys. 36 (12), December 2009

Aligning Practice, QC, and On-going Commissioning

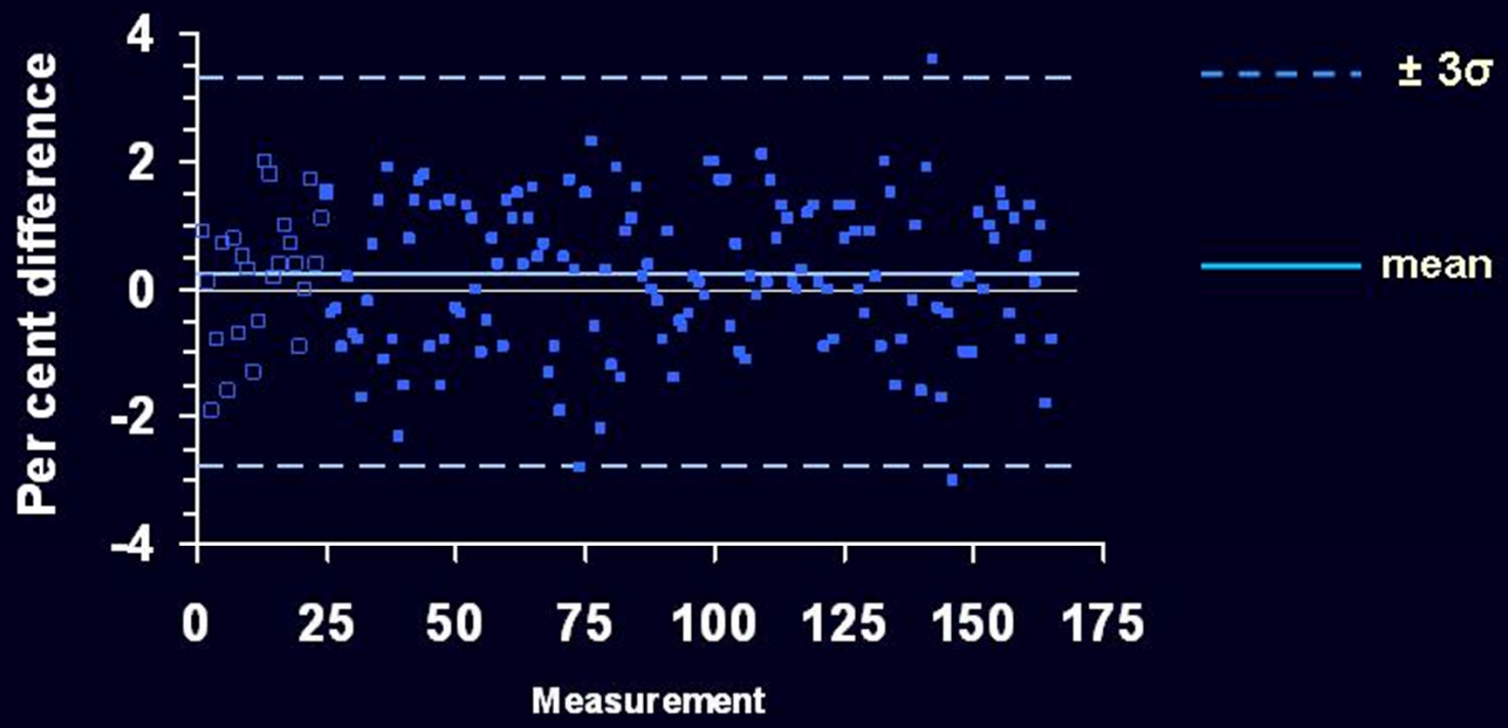


With thanks to Tim Craig

Radiation Oncology
UNIVERSITY OF TORONTO
Princess Margaret Hospital
University Health Network

IMRT Process Monitoring

165 high-dose measurements
Head and neck IMRT
Pinnacle 7.6c (Sept – Dec, 2005)



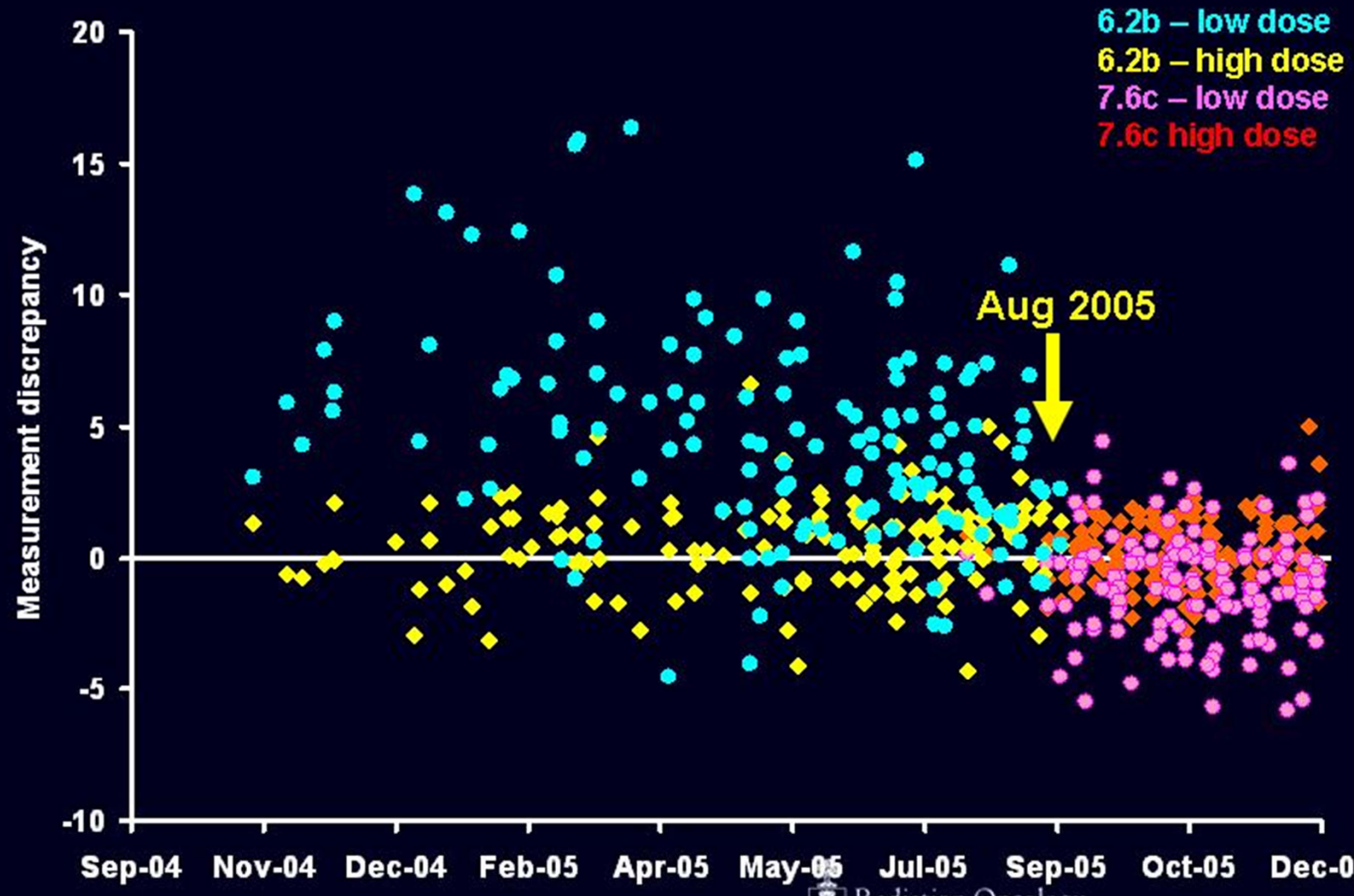
Breen SL, Moseley DJ, Zhang B, Sharpe MB. Med Phys 35:4417-4425 (2008)

Radiation Oncology
UNIVERSITY OF TORONTO Princess Margaret Hospital
University Health Network

IMRT Verification Measurements

Head & Neck Cancers

Breen *et al*, Med. Phys. Oct 2008



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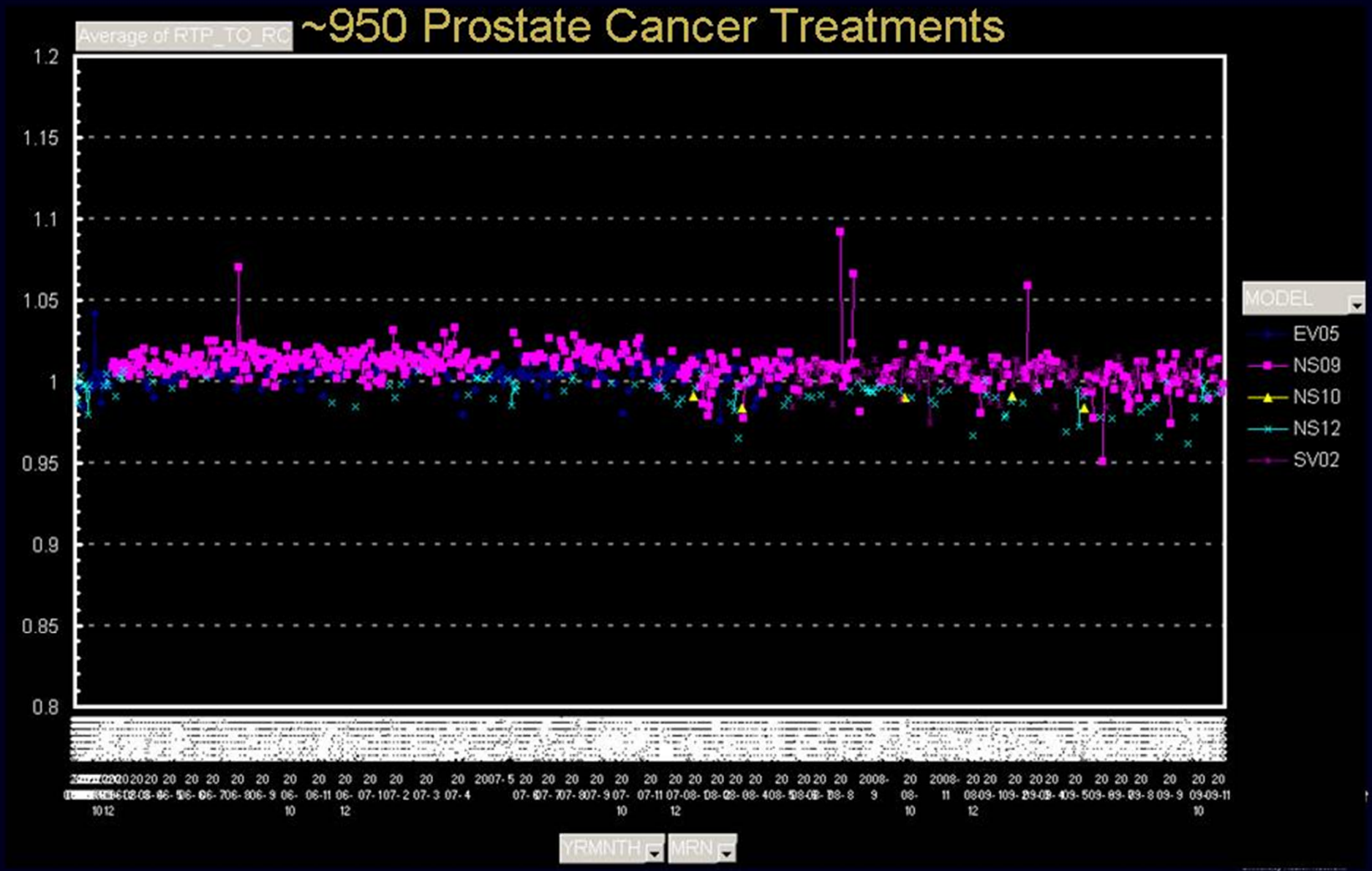
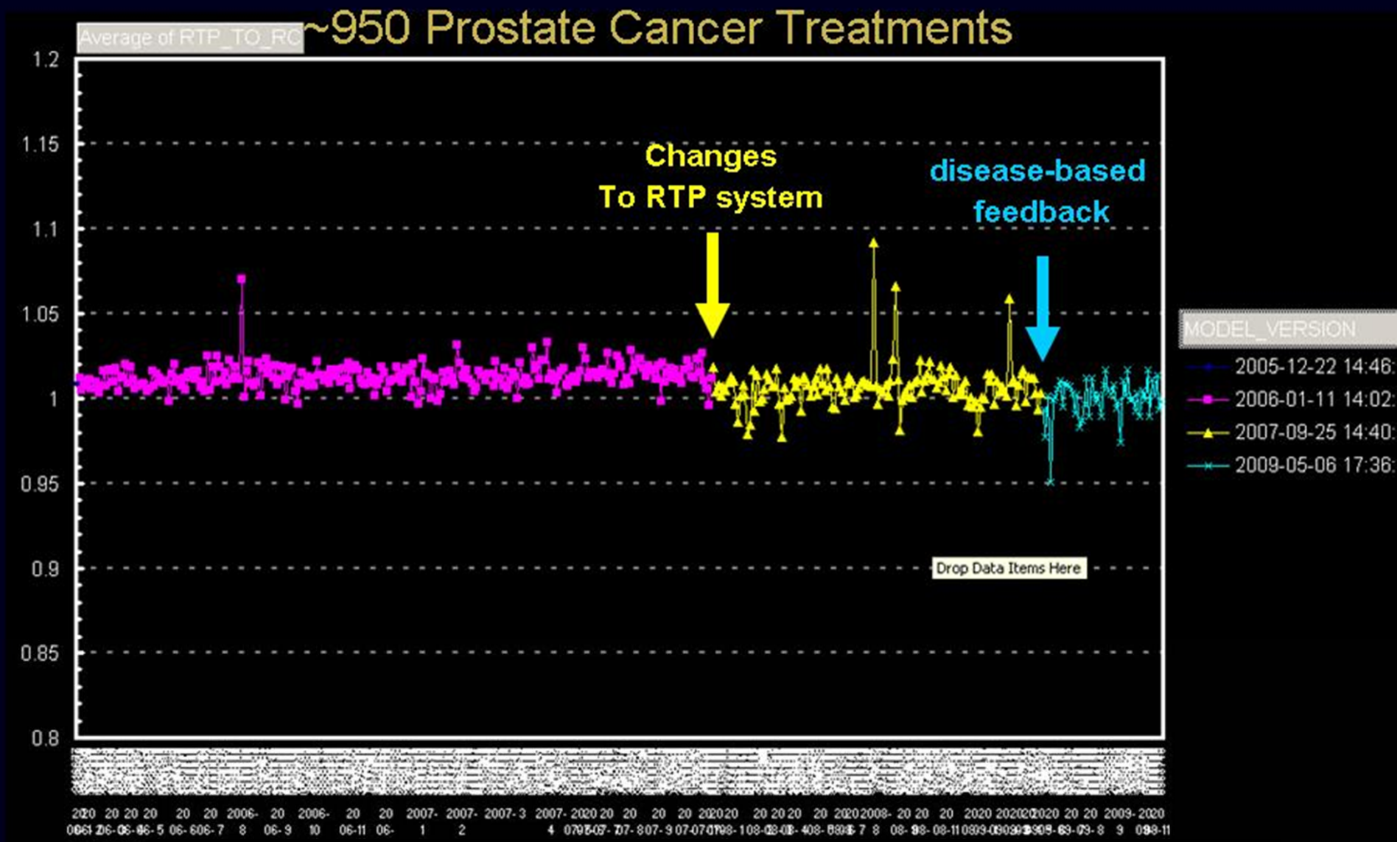
University Health Network

P3 vs 2nd Calculation, By Machine Model



P3 vs 2nd Calculation, Synergy S Models



"Did I mention commissioning is important?" – J. Siebers

Automated beam model optimization

Daniel Létourneau[a)] and Michael B. Sharpe
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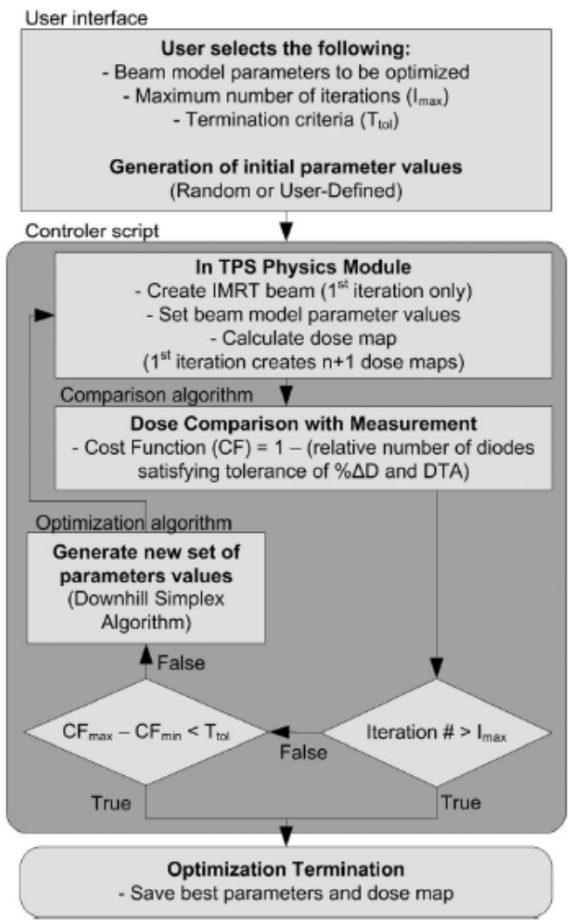
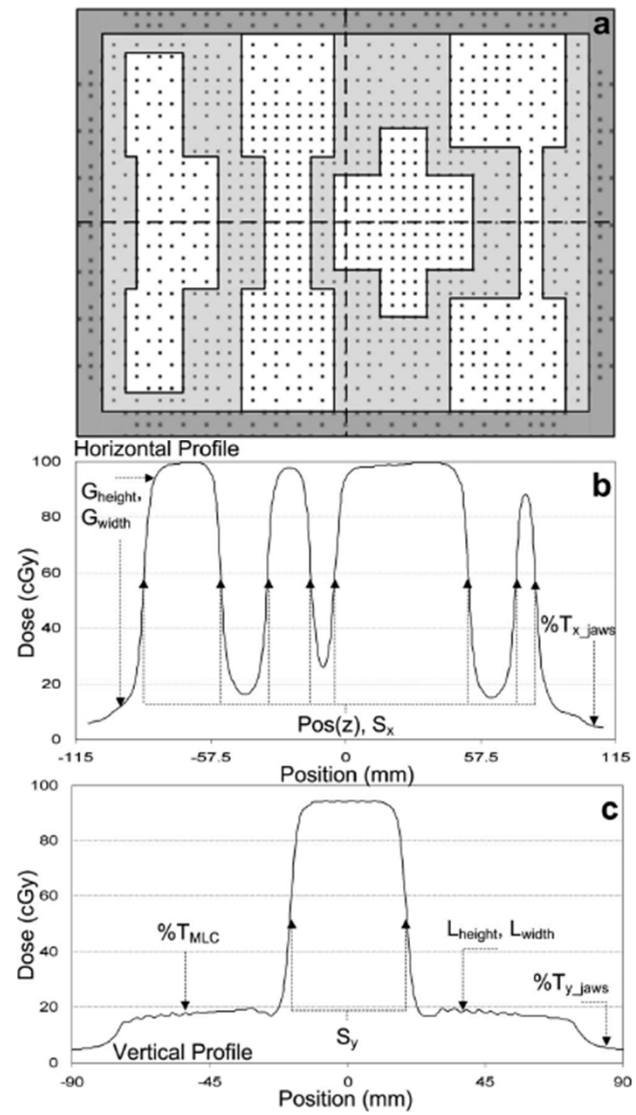




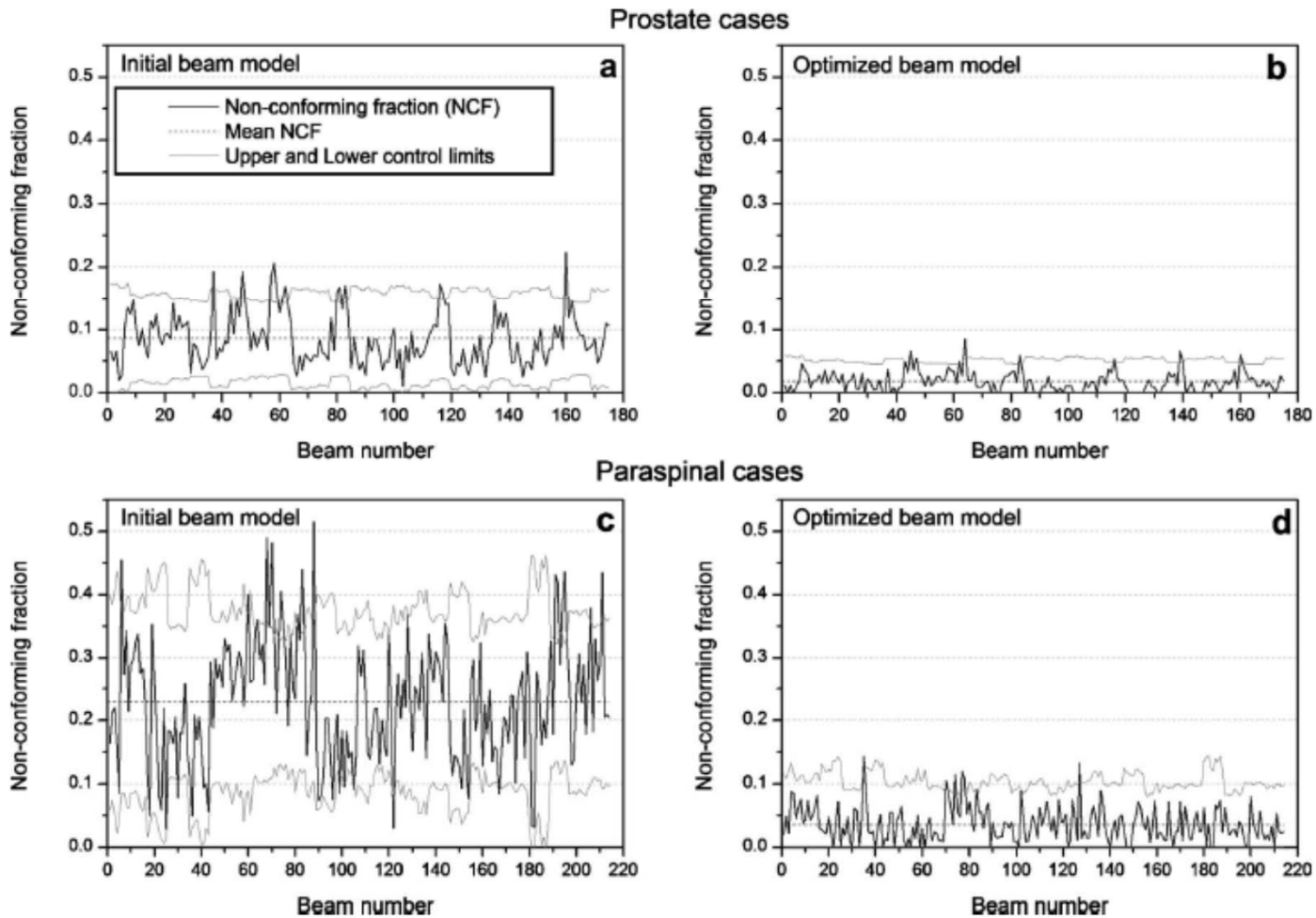


FIG. 4. The non-conforming fraction of diodes is shown as function of the beam number for the [(a) and (b)] 25 prostate and [(c) and (d)] paraspinal cases. The measured and calculated dose maps were compared for both the initial and the optimized beam models using the following tolerances: 3% of dose difference (%ΔD) or 2 mm of distance to agreement (DTA) and an inclusion threshold (%Th) of 10%.

Need for Integrated Database for System Quality/Safety

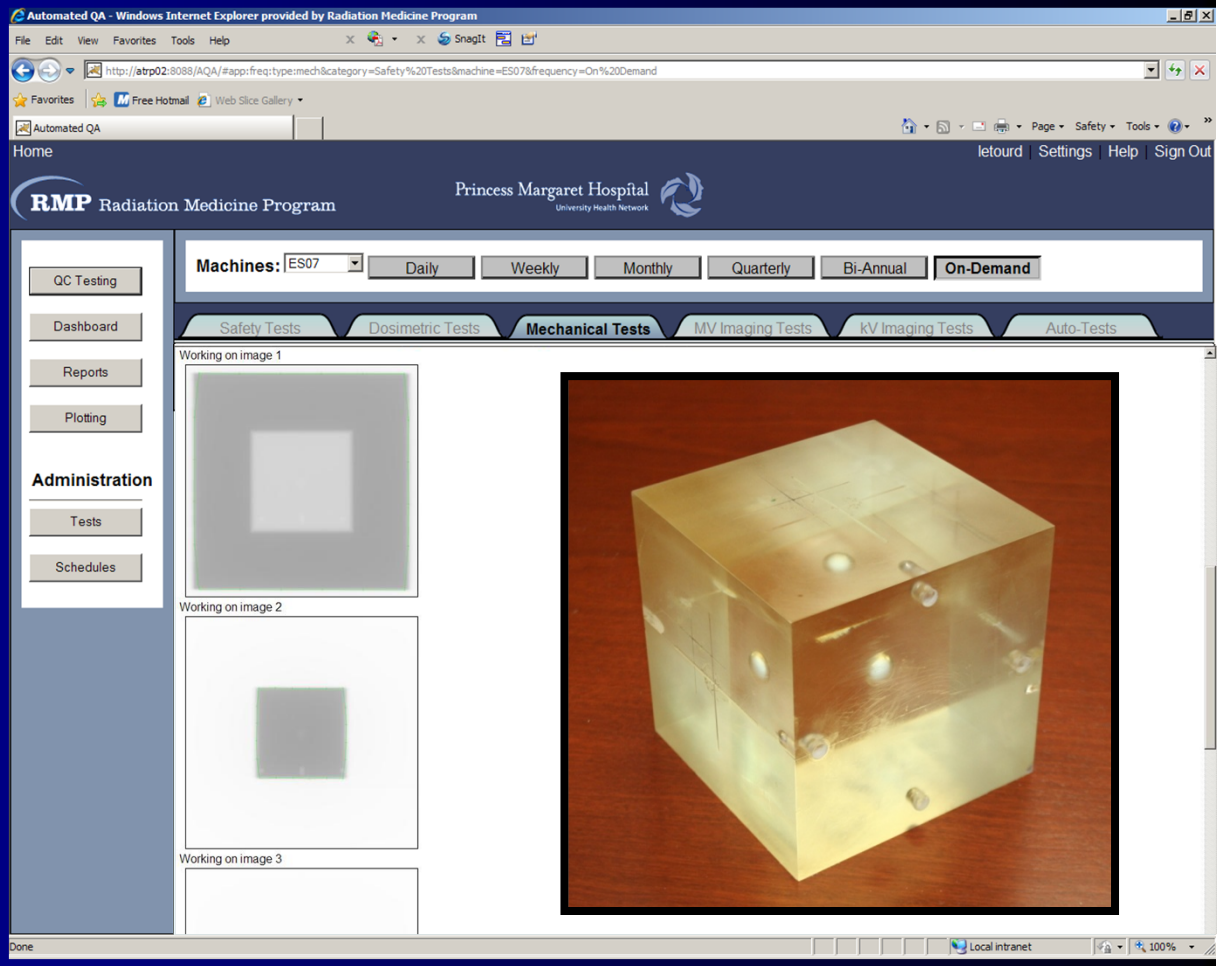
- Multiple, fragmented software systems that do not communicate
- No centralized QA database for entire RT department
- No efficient reporting mechanism for compliance and performance assessment

As a result, many clinics rely on in-house and inefficient means to perform QA, collect QC data, analyze and manage QC results.

Comprehensive Semi-Automated QA

Semi-Automated QC Tests:

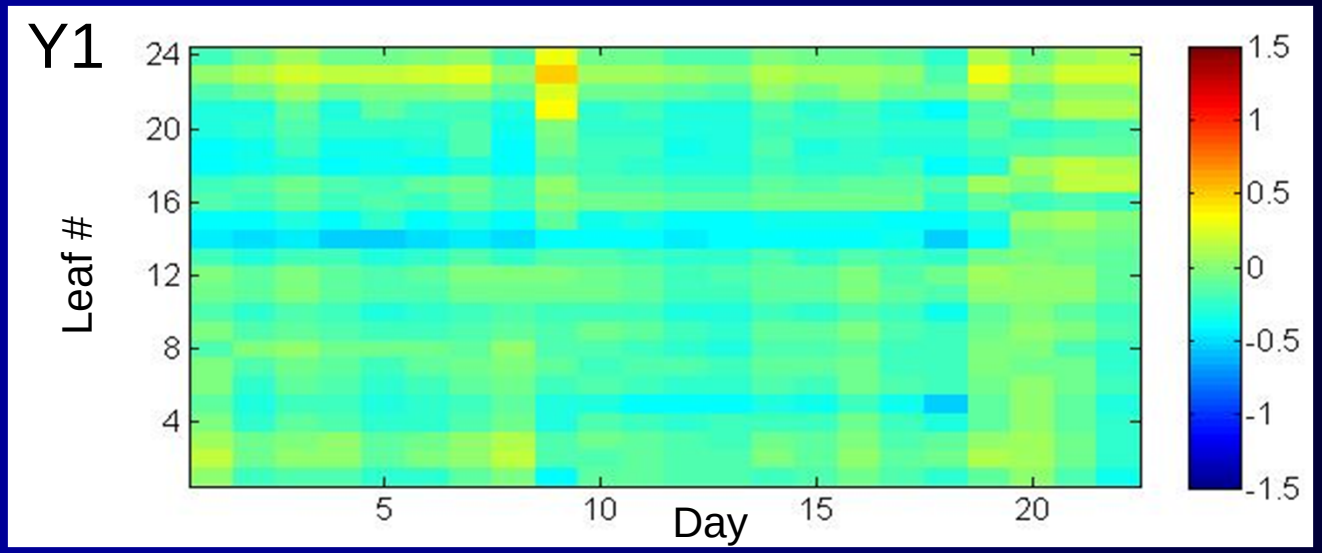
- MLC and Jaw Position
- Isocenter Motion
  - Collimator
  - Gantry
  - Couch
- Collimator and gantry readouts
- IG Accuracy
- Dosimetry
  (Matrix and MV flat panel)



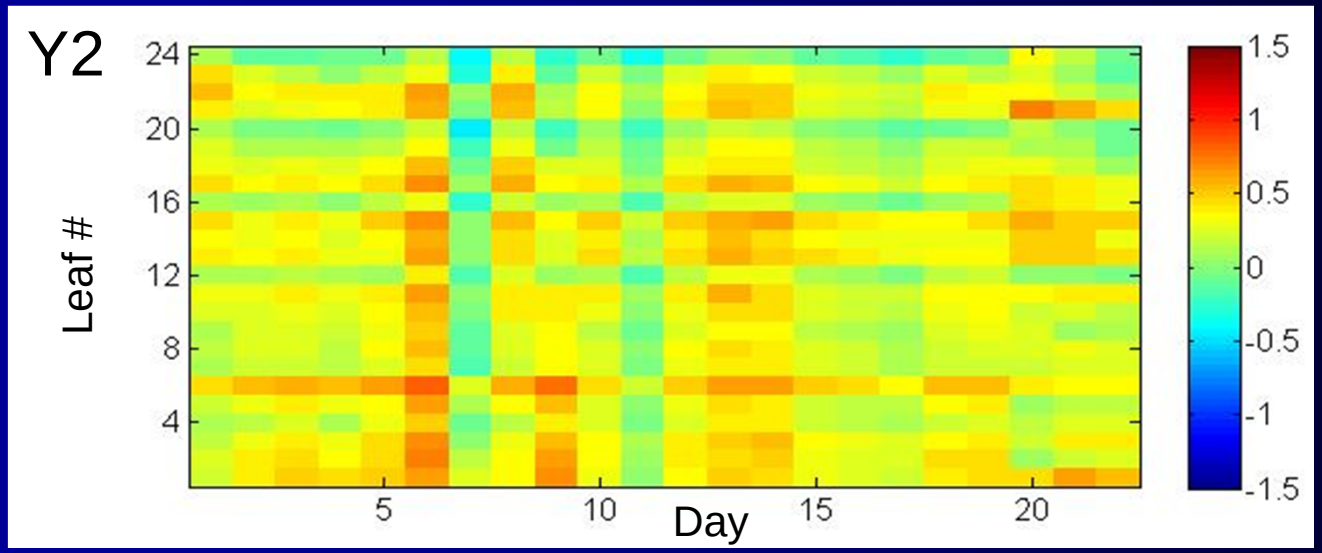
Daniel Létourneau - PMH

Comprehensive Semi-Automated QA

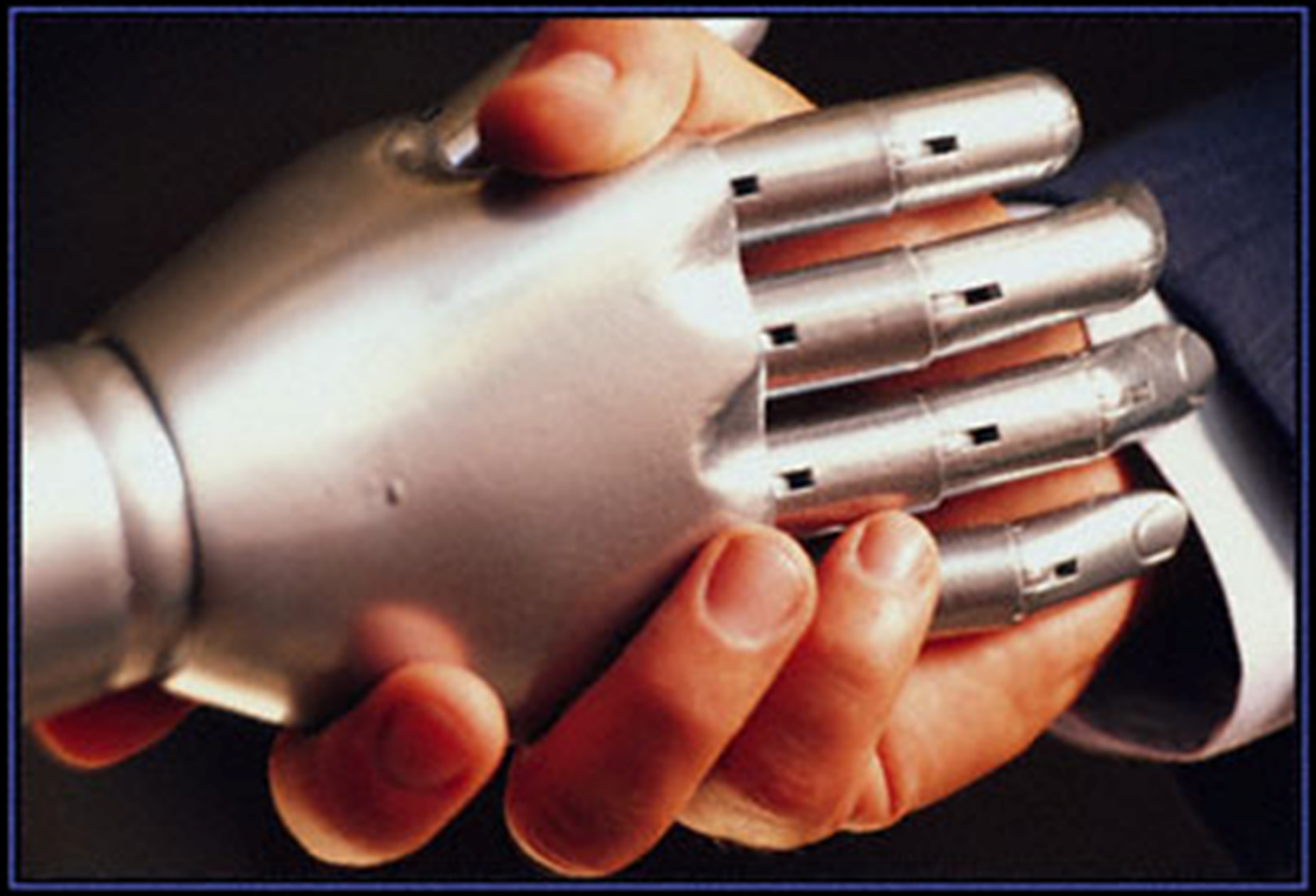
MLC Positioning error (mm): Nominal = 100 mm



Mean error: -0.2 mm



Mean error: +0.3 mm



INNOVATION

IF IT CAN MAKE YOUR JOB EASIER, IT CAN PROBABLY MAKE IT IRRELEVANT.

Collaborative Approach

The Quantitative Imaging Network (QIN)

- PAR-11-150; a U01 mechanism issued originally in August 2008, and reissued in March 2011.
  - No set-aside funds and no limit to the number of awards
- Submission dates:
  - February 5, June 5, and October 5
  - Electronic submissions through grants.gov
- Reviewed by Special Emphasis Panel (SEP) from NCI

QIBA

- Mission: Improve the value and practicality of quantitative biomarkers by reducing variability across devices, patients, and time
- Current committees:
  - DCE MRI
  - fMRI
  - FDG-PET
  - Volumetric CT
  - COPD-Asthma

Quantitative Imaging Biomarkers Alliance

RSNA

From a Through-Away Society to Learning Organizations

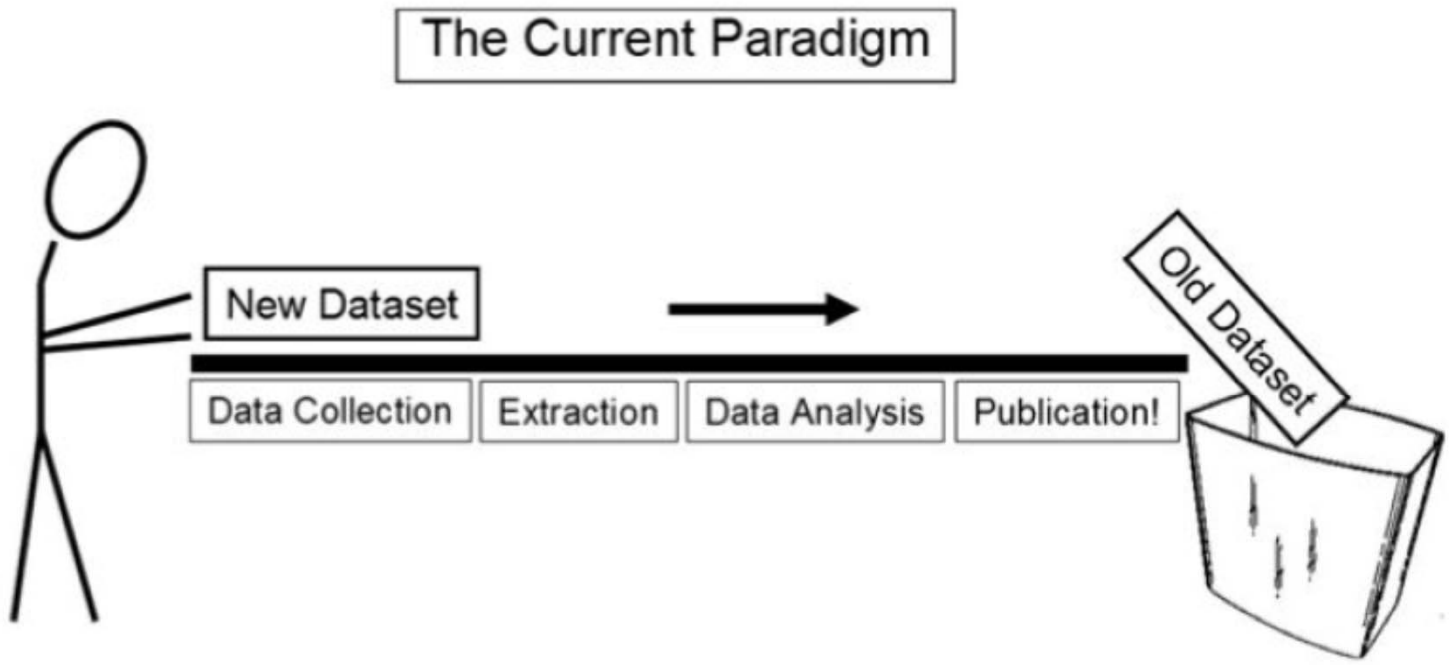


Fig. 2.
"The current (data-loss) paradigm." Data are effectively lost to the wider scientific community after publication. Capturing key datasets in query-able data repositories would accelerate the discovery of causative factors and increase the accuracy of parameter estimates.

Deasy et al. - Int J Radiat Oncol Biol Phys. 2010 March 1; 76

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IMRT Quality Assurance Program

- Develop and implement an IMRT Quality Assurance Testing Program for Ontario

- CCO ⇒ CAPCA ⇒ RPC (yearly) ☑
- CCO ⇒ External IMRT QA ⇒ End to End testing ☐
  - Once a year on a case that represents their IMRT practice
- Our Goal:
  - ICPs will develop their own IMRT QA procedures and policies as part of their ramp up of IMRT capabilities
  - This program will provide external validation, time limited as part of the roll-out of IMRT

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IMRT Quality Assurance Program

Numerous centers expressed interest in sharing beam models

After running for a few years, it is reasonable to assume we would have >100 accelerators running the best beam model. Why wouldn't we?

Needs Assessment

Some Results:

- All 13 Centers agreed to participate
- Centers expressed a strong interest :
  - Independent measurements and analysis of dose delivery (13/13)
  - Help define planning and QA goals (10/13)
  - Assess setup accuracy (11/13)
  - Identifying areas for improvements for planning and machine performance (11/13)


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COLLABORATION
WHEN A MOTIVATED GROUP OF PEOPLE JOIN TOGETHER,
THEY CAN TURN PROBLEMS INTO OPPORTUNITIES. ESPECIALLY DRINKING PROBLEMS.

Proficiency Matters!

- It matters for our patients.
- It matters for our field.
- It matters for our science.
- It matters for our future patients.
- It will determine whether we are able to exploit new technologies.
- It will allow us to engage in the science of advancing medicine.

Efficiency Matters!

Efficiency means not re-inventing the wheel.

Summary

- Technological advances allow greater precision and accuracy in radiation therapy and will allow us to measure what we do.
- While traditional approaches to practice have brought the field a long way, our methods and practices are becoming a burden.
- The promising discoveries in clinical science require a level of organization and efficiency that remains elusive.
- Encouragingly, there is a ground swell of ‘Systems Thinking’ that if properly harnessed can transform these concepts into reality.

Thank You

"Medicine is a science of uncertainty and an art of probability".

"He who studies medicine without books sails an uncharted sea, but he who studies medicine without patients does not go to sea at all".

"The best preparation for tomorrow is to do today's work superbly well".

Sir William Osler (1849-1919)
A Canadian Physician,
The Father of Modern Medicine

Courtesy of J. Palta