The Radiological Physics Center
A QA Resource in Radiation Therapy

AAPM Refresher Course
Seattle, July 28, 2005
Geoffrey S. Ibbott, Ph.D.

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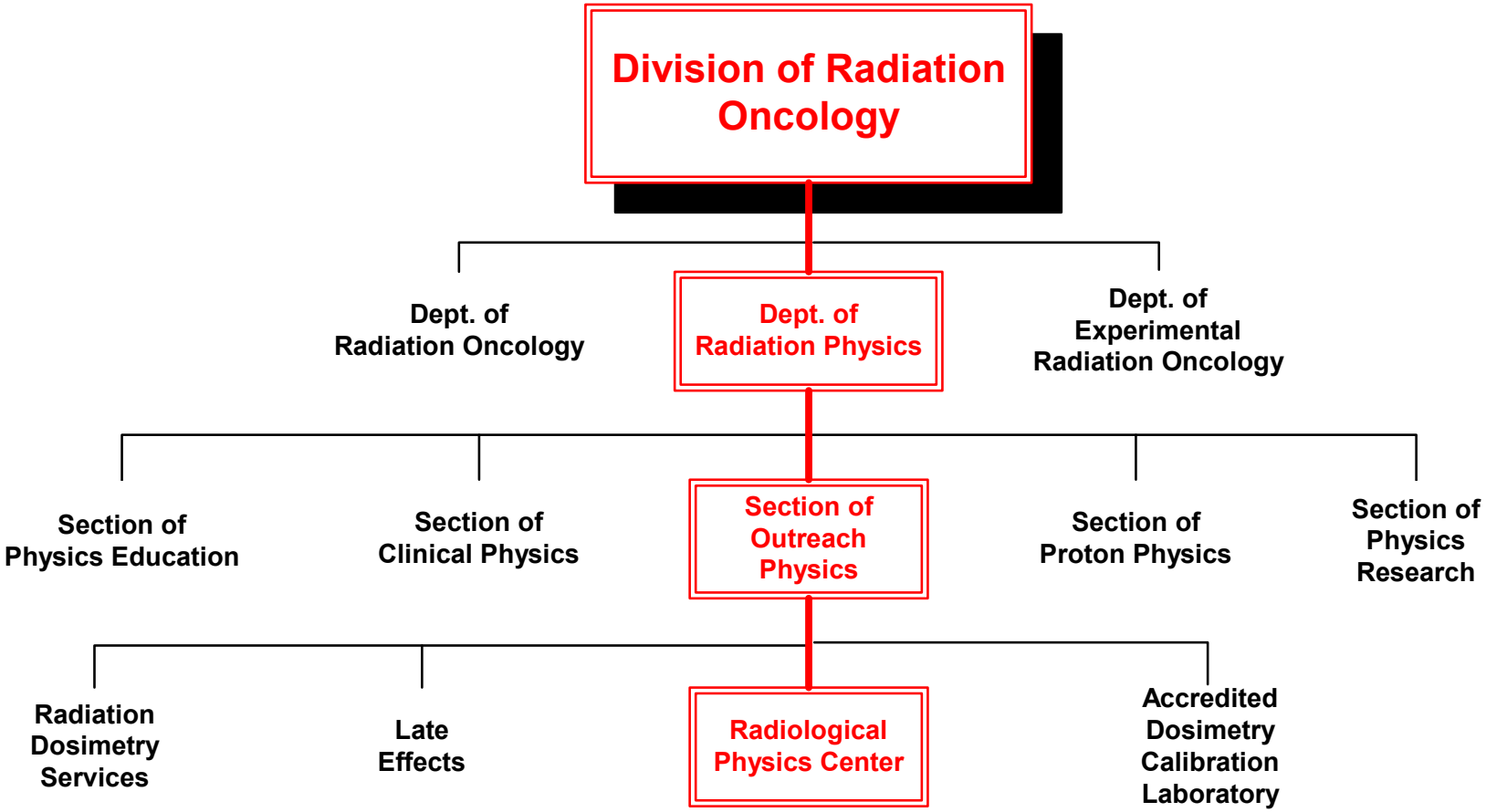
RPC:

Houston



RPC Radiological Physics Center
Excellence through Quality Assurance

Brief Background

- Originated through agreement between AAPM and CRTS
- Founded in 1968 to monitor institution participation in clinical trials
- Funded continuously by NCI as structure of cooperative group programs have changed
- Now 36 years of experience of monitoring institutions and reporting findings to study groups and community

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Mission

The mission of the Radiological Physics Center is to assure NCI and the Cooperative Groups that institutions participating in clinical trials deliver prescribed radiation doses that are clinically comparable and consistent. We do this by assessing the institution's radiotherapy programs, helping the institutions implement remedial actions, assisting the study groups in developing protocols and QA procedures, and informing the community of our findings.

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RPC Activities

- Remote Reviews
- Patient Dosimetry
- On-site Reviews
- Support of Study Groups
- Research/Outreach

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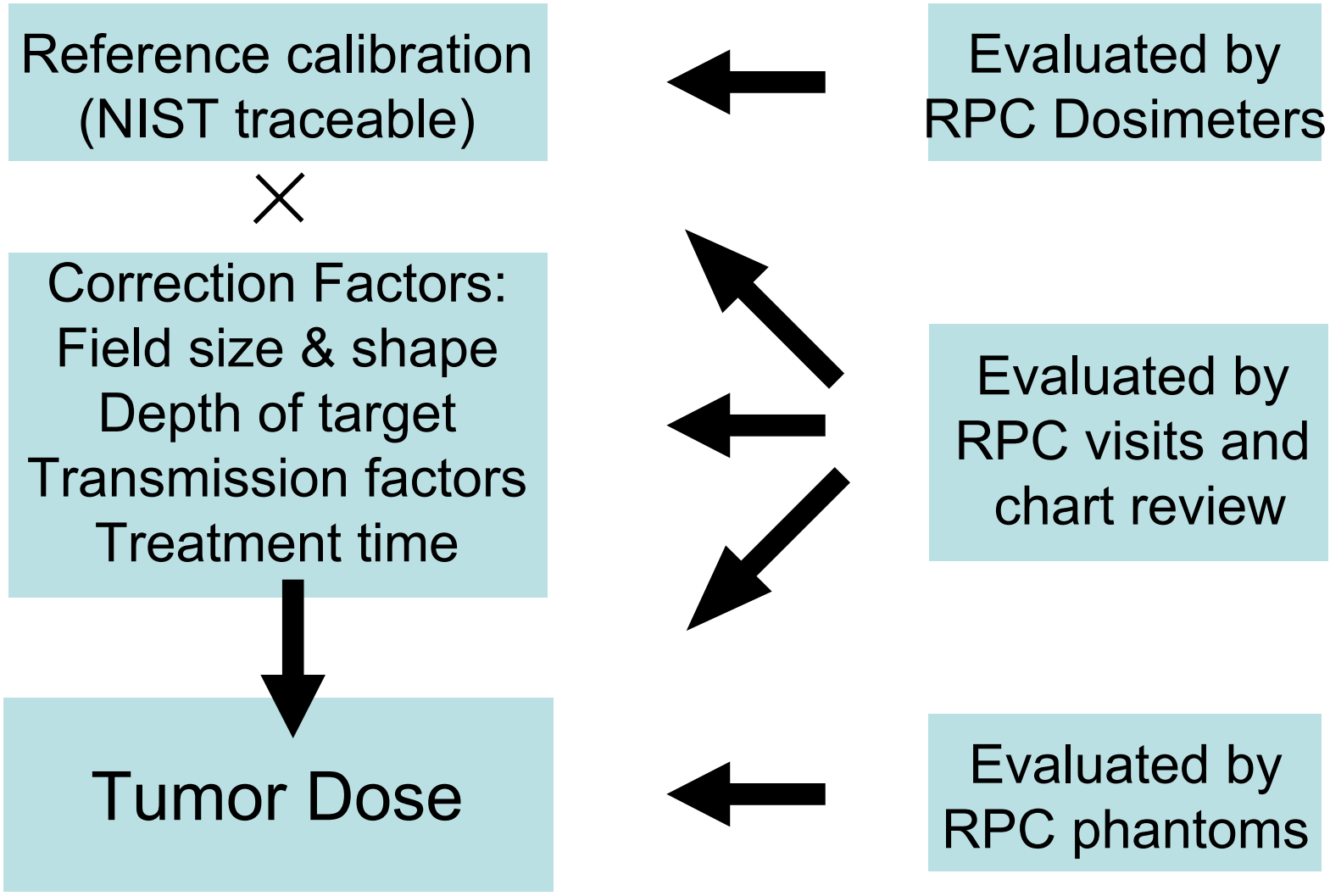
RPC Verification of Institutions' Delivery of Tumor Dose



Remote Audit Tools: The Thermoluminescent Dosimetry (TLD) Program

TLD as a Remote Tool

- Verify dose outputs and energy on radiotherapy units.
- Verify doses at points of interest in anthropomorphic phantoms
- Measure consistency of institutions based on TLD history
- Provide data for patient chart review

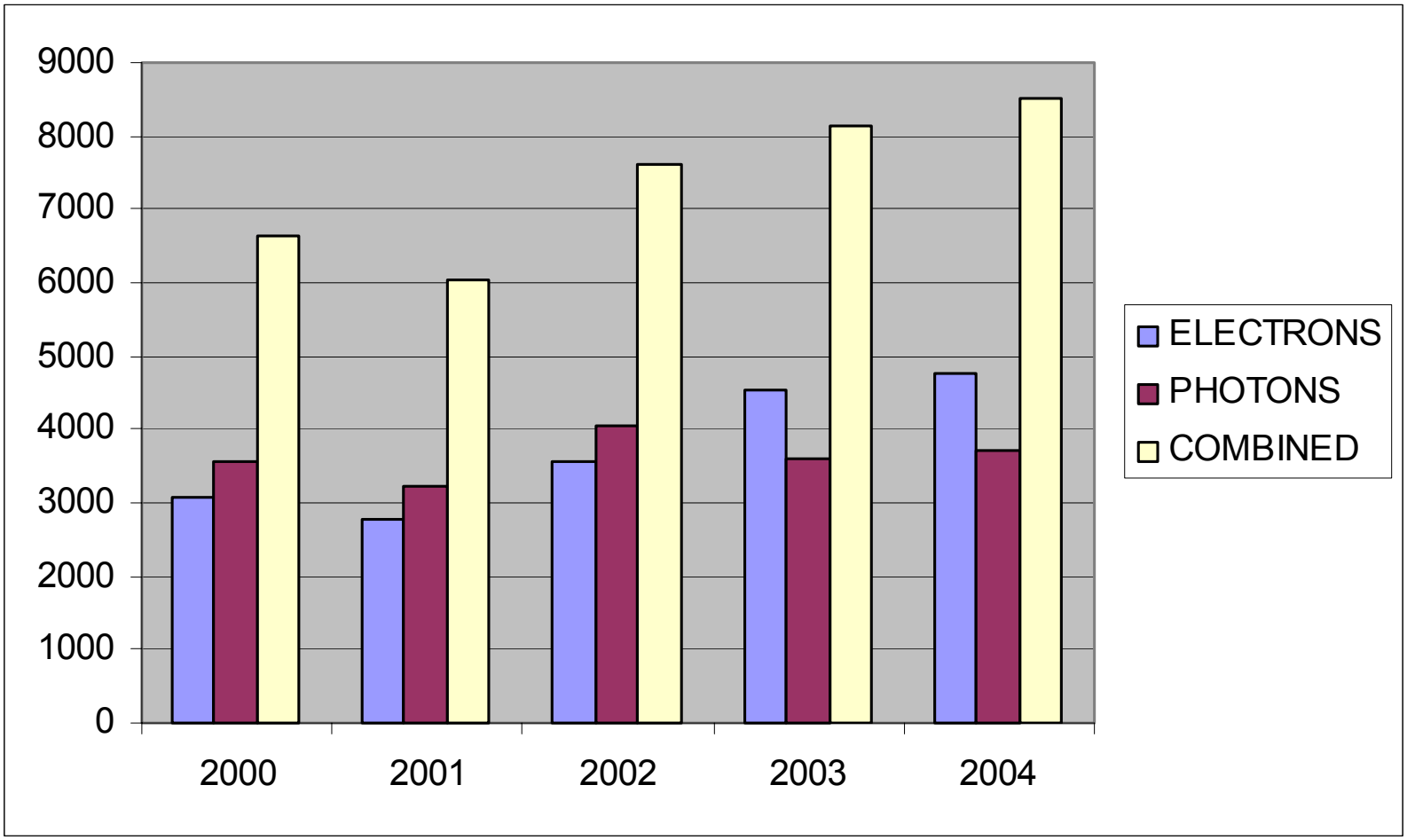
Additional Benefits

- Changes in equipment
- Changes in personnel
- Satisfies requirement for an independent quality assurance audit
- Promotes alertness

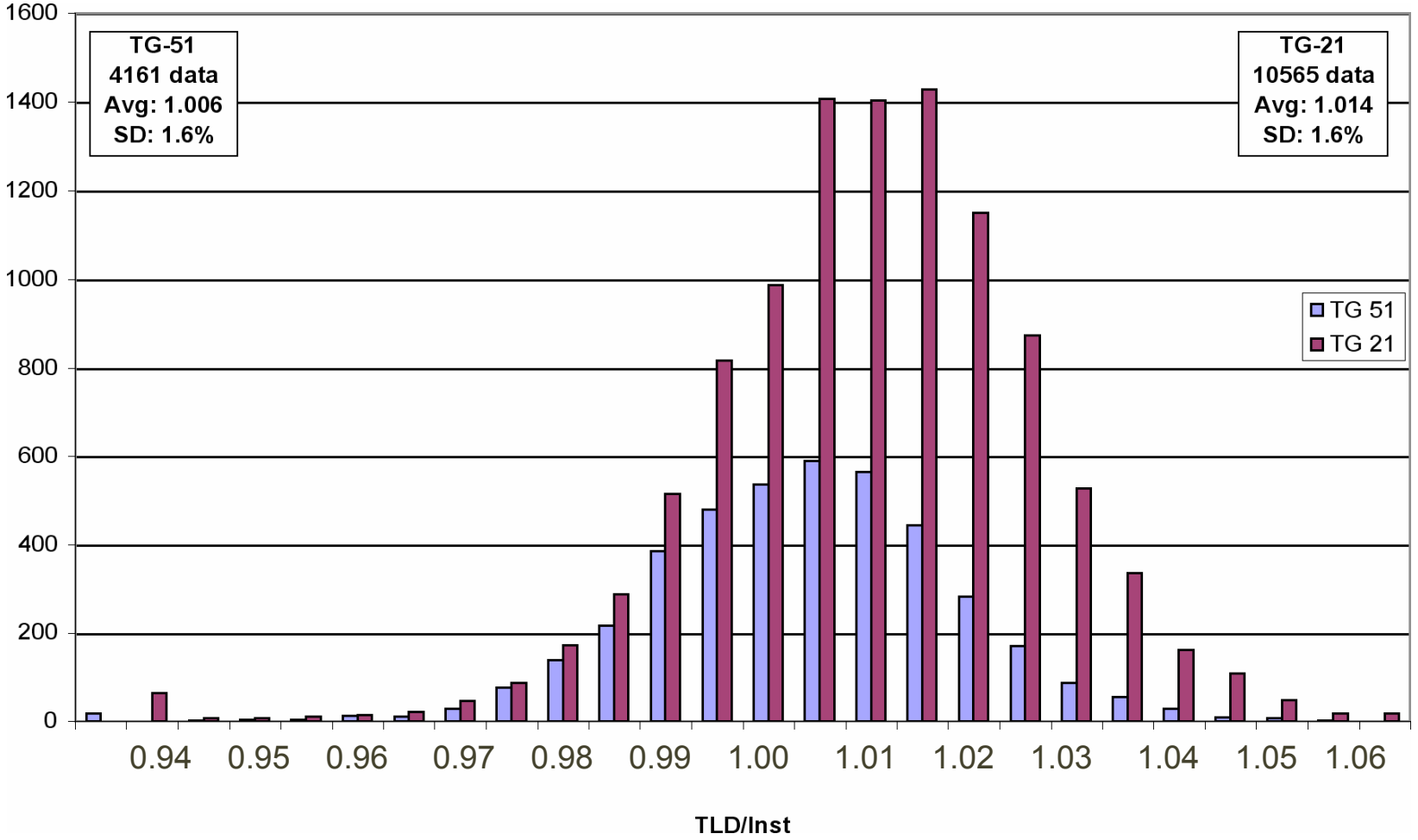
Characteristics of the Program

- 28 years in operation
- Monitoring 1,387 megavoltage therapy sites (80% of US centers)
- Last year, ~8,800 radiation beams monitored with TLD
- Largest of its kind
- Other programs (IAEA, ESTRO, RDS)

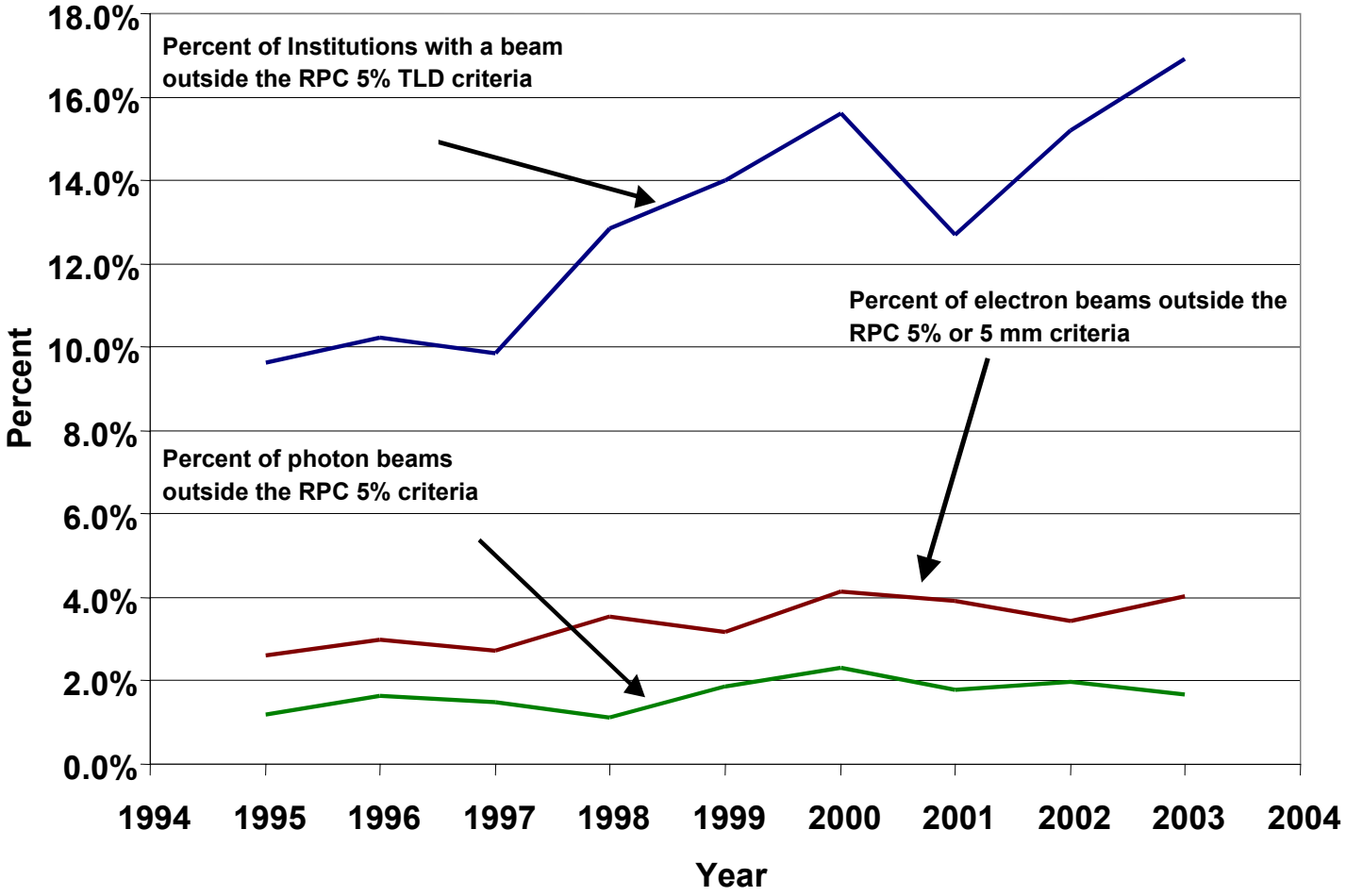
RPC TLD Activities



Comparison of TLD Results Photons



TLD Discrepancies



13 (of 69) institutions visited in last 2 yrs to resolve TLD problems

Benefits of the TLD Program

- Verifies calibrations periodically thus helping institutions to keep vigilant of their quality assurance program
- Problems found contribute to determine priorities for site visits
- Identifies problems that have direct impact on every patient treated
- It is a model for other remote programs

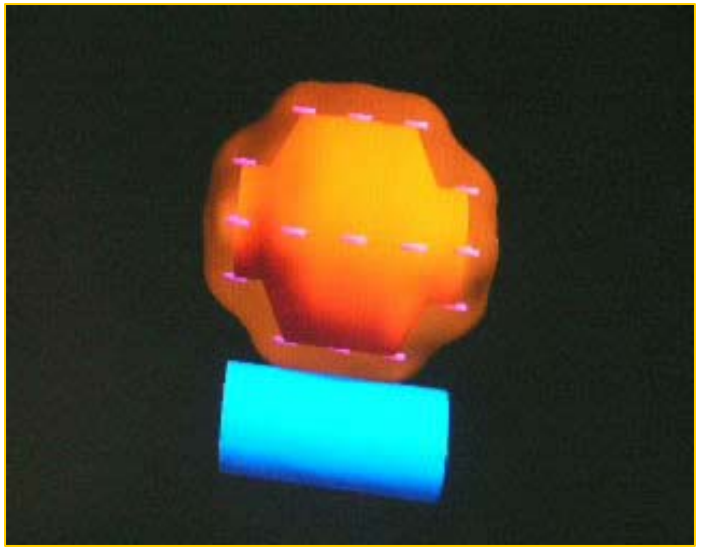
Institutions Monitored by the RPC

As of…	Active Institutions	Active - no XRT	CTSU (Pending)	Total Institutions
7/1/2004	1,306	71	5	1,382
1/1/2005	1,329	71	9	1,409
7/1/2005	1,387	94	12	1,493

Time Span	New machines added	New beams added
2003 - 2004	260	1,659
2004 - 2005	236	1,349

Credentialing Techniques

- **Phantoms** **Benchmarks**



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Purpose of Credentialing

- Education
- Evaluate ability to deliver dose
- Improve understanding of protocol

Reduce deviation rate

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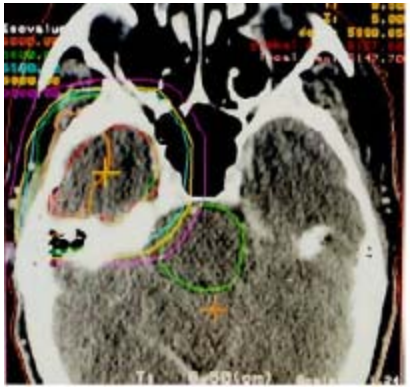
General Credentialing Process

- Previous patients treated with technique
- Facility Questionnaire
- Knowledge Assessment Questionnaire
- Benchmark case
- Electronic data submission
- RPC QA & dosimetry review
- Clinical review by radiation oncologist

Feedback to Institution



Credentialing

3D Conformal Radiation Therapy (3D CRT)

- Innovative high-technology radiation technique where multiple beams are shaped to treat only the tumor
- Evaluate 3D treatment planning process and ability to provide documentation
- North Central Cancer Treatment Group (NCCTG) – October 1, 2004
- 42 institutions credentialed to date

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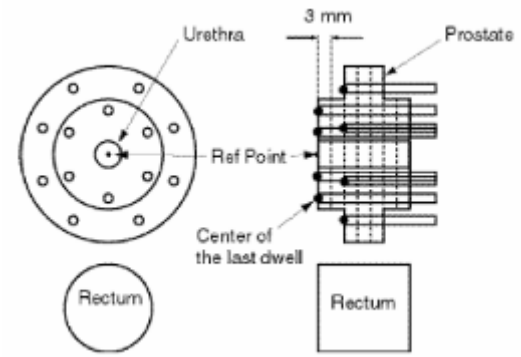
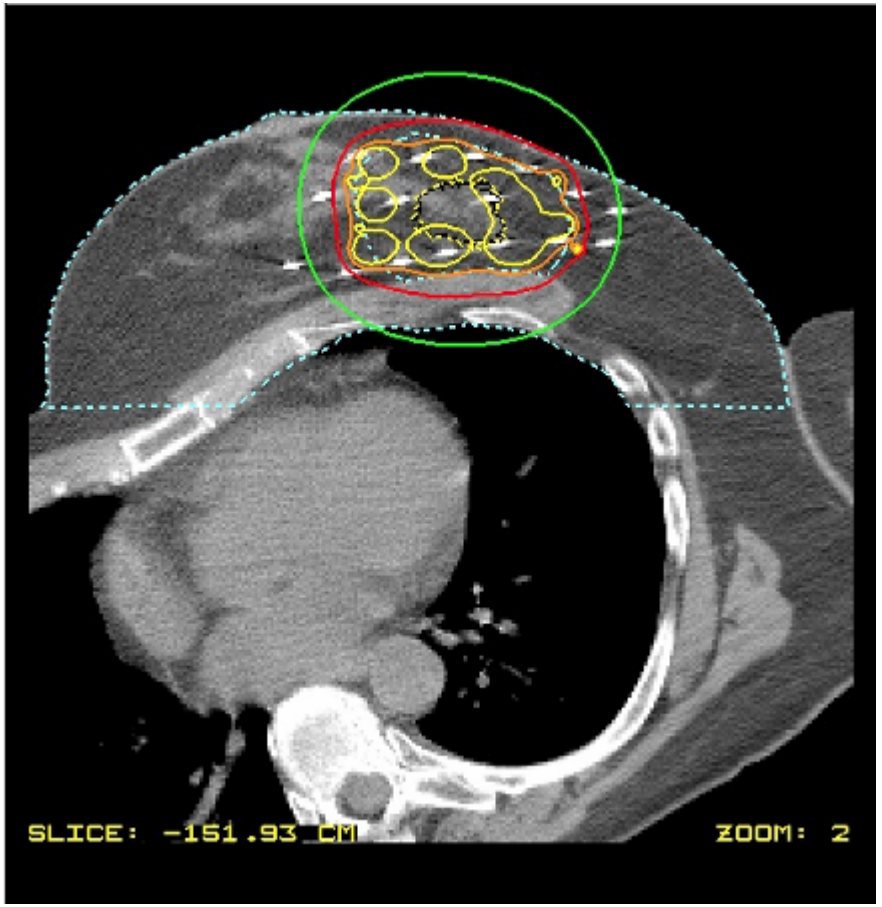
Credentialing
LDR and HDR Brachytherapy

- Evaluate
  - Implant technique
  - Dosimetry
  - Documentation
  - Protocol compliance





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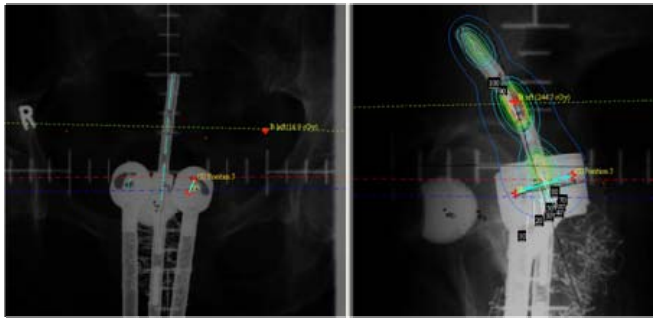
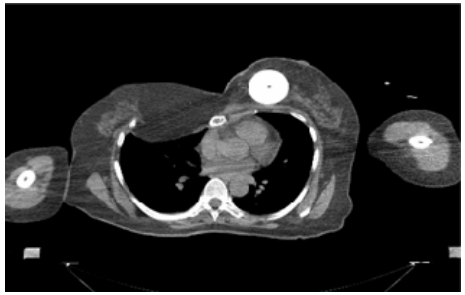
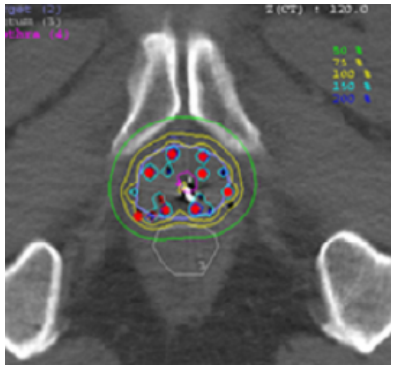
Brachytherapy Studies Requiring Credentialing

- Cervix
  - GOG **165**, **191**
  - RTOG **0116**, **0128**
- Breast
  - RTOG **95-17**
  - RTOG **0413** / NSABP **B-39**
- Prostate
  - NCCTG **N-0052**
  - RTOG **98-05**, **0019**, **0232**, **0321**







Credentials Awarded (based on benchmarks)

	Credentials	Institutions
Prostate LDR (0232)	66	59
Prostate HDR (0321)	11	7
Breast 3D CRT (0413)	158	77
Breast Mammosite®	71	53
Breast Multicatheter	31	13
Other 3D CRT (NCCTG)	42	42
Cervix (GOG)	55	46
TOTAL	434	297

Results of Credentialing
(closed studies)

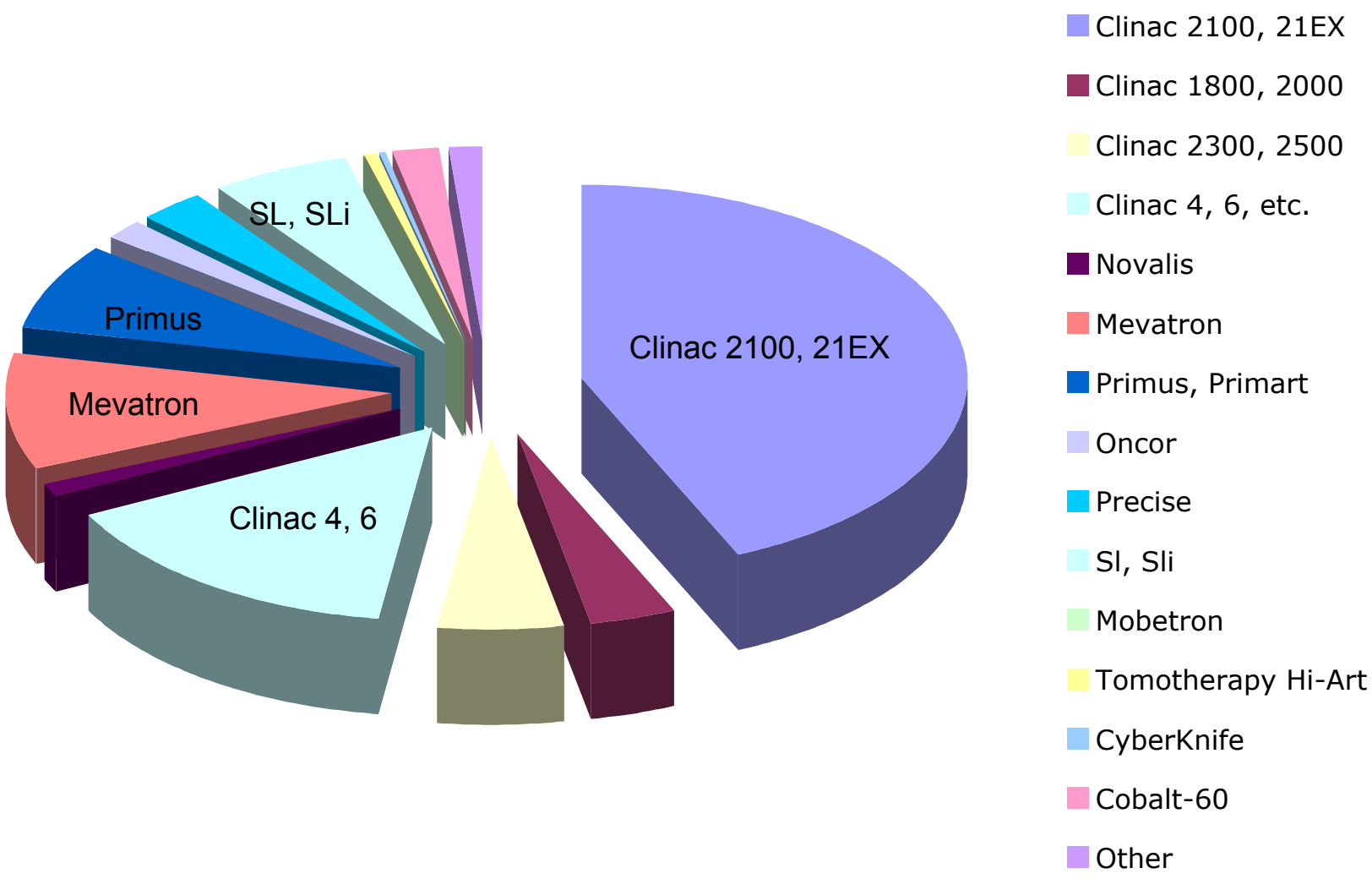
Study	Major Deviations	Minor Deviations	Number of Patients
GOG 165 HDR Cervix Credentialed inst	0	15	70
RTOG 95-17 HDR & LDR Breast (all)	0	4	100
RTOG 0019 LDR Prostate (values for dose only)	0	6	117 reviewed (total 129 eligible)

Results of Credentialing

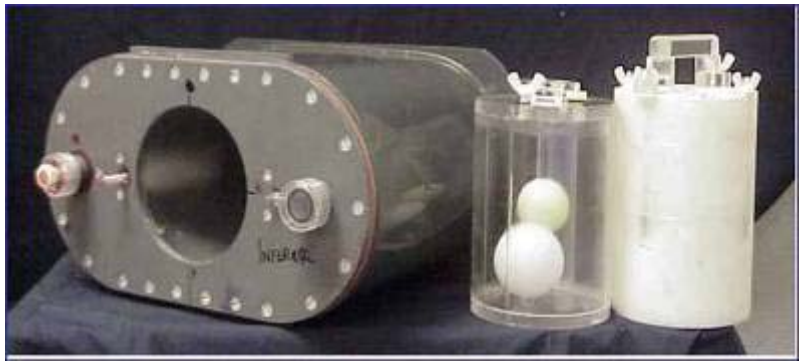
(closed studies)

Study	Major Deviations	Minor Deviations	Number of Patients
GOG 165 HDR Cervix Credentialed inst	0	15	70
Non-credentialed	57	87	275
RTOG 95-17 HDR & LDR Breast (all)	0	4	100
RTOG 0019 LDR Prostate (values for dose only)	0	6	117 reviewed (total 129 eligible)

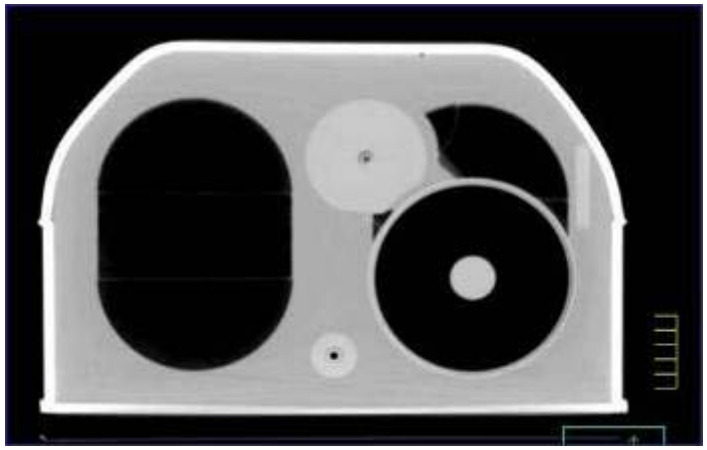
3,040 Treatment Machines Monitored by the RPC



RPC Phantoms



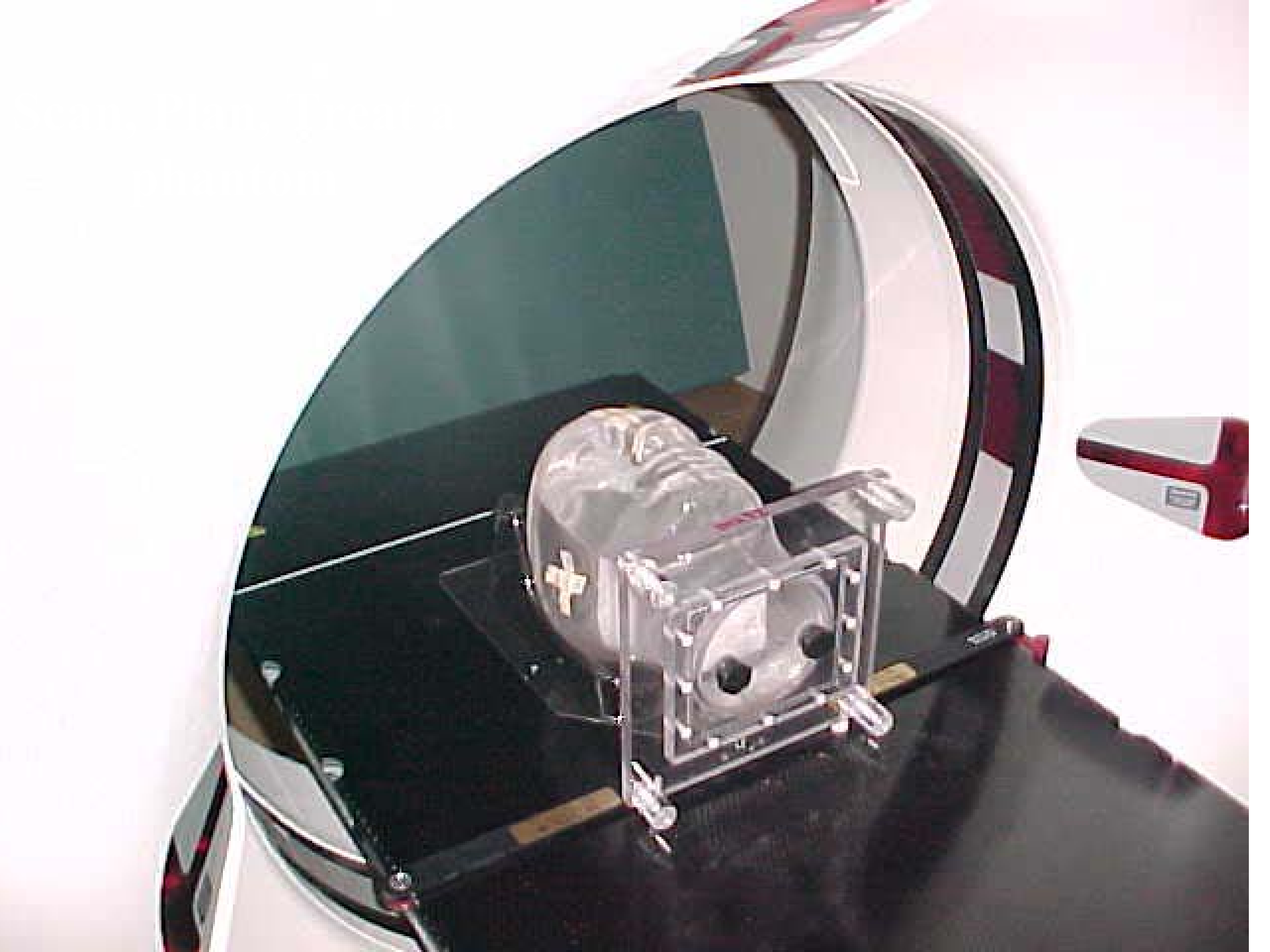
prostate RTOG 0126 (IMRT)

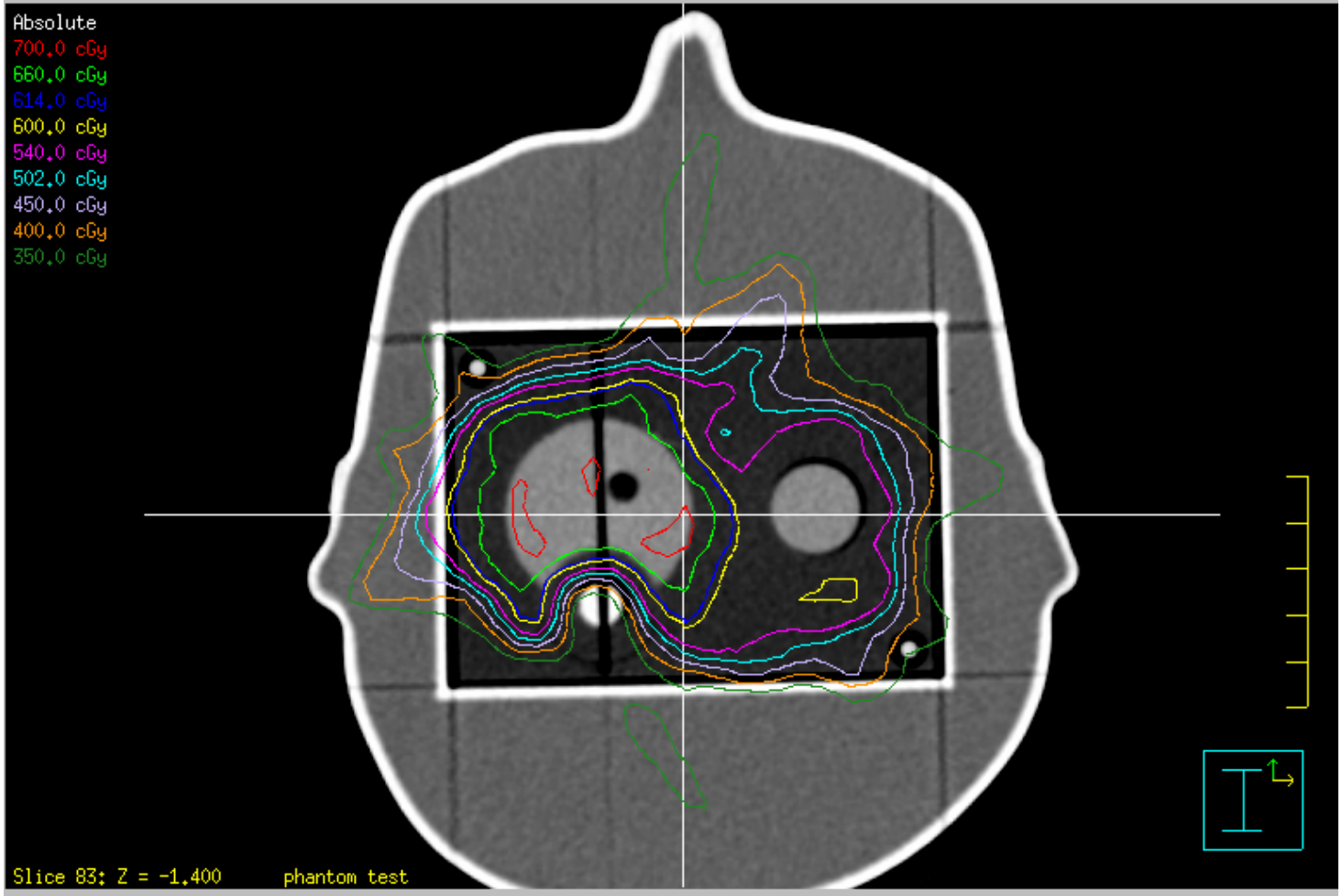


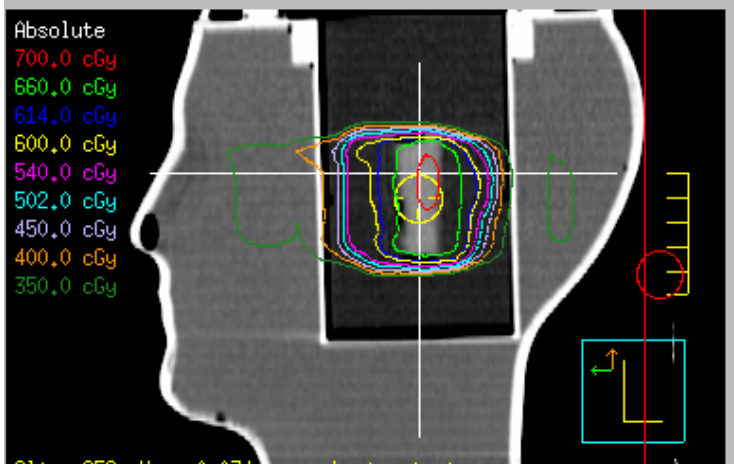
thorax RTOG 0236 (SBRT)

H&N IMRT
RTOG 0225, 0126;
COG ACNS0331

liver RTOG 0438




Absolute
700.0 cGy
660.0 cGy
614.0 cGy
600.0 cGy
540.0 cGy
502.0 cGy
450.0 cGy
400.0 cGy
350.0 cGy
Slice 83: Z = -1.400
phantom test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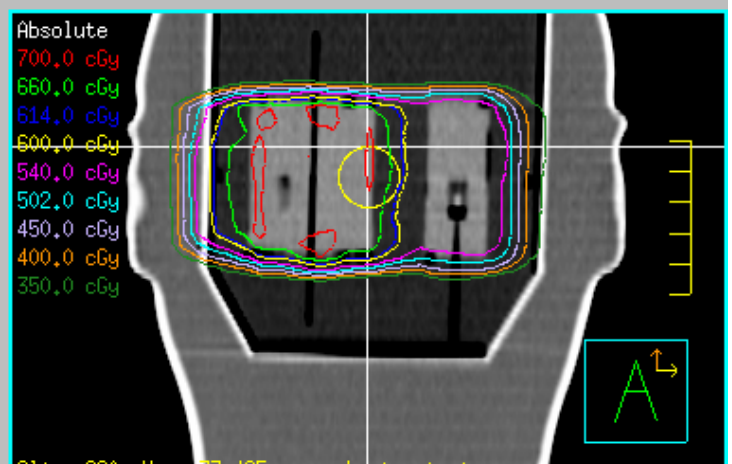
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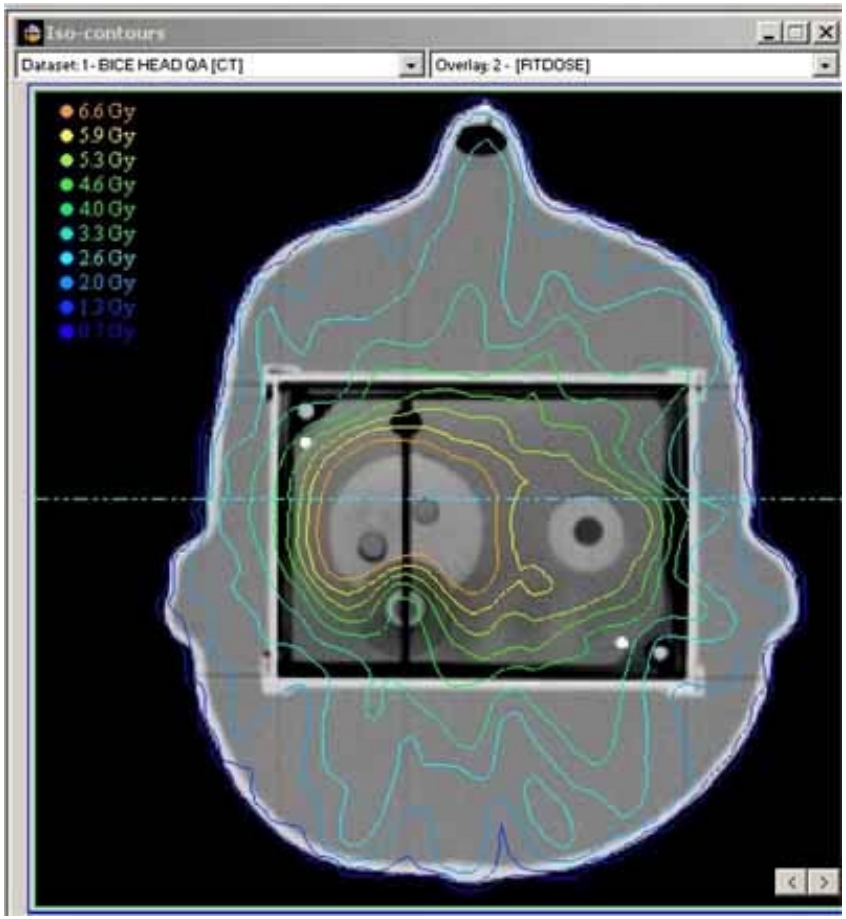
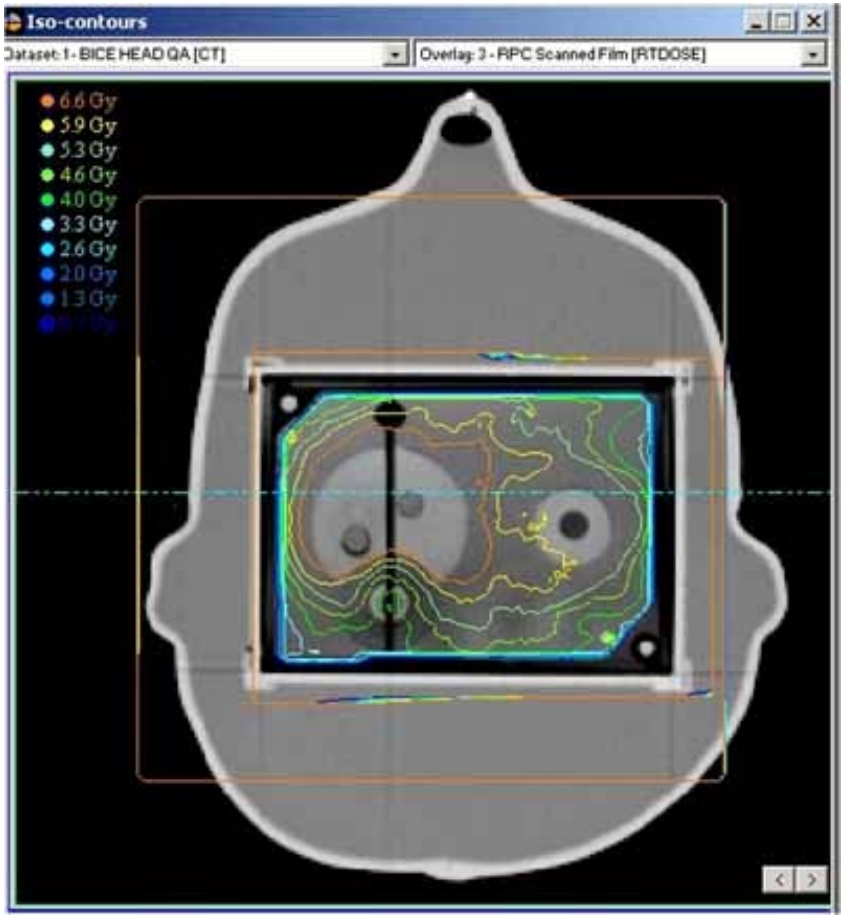
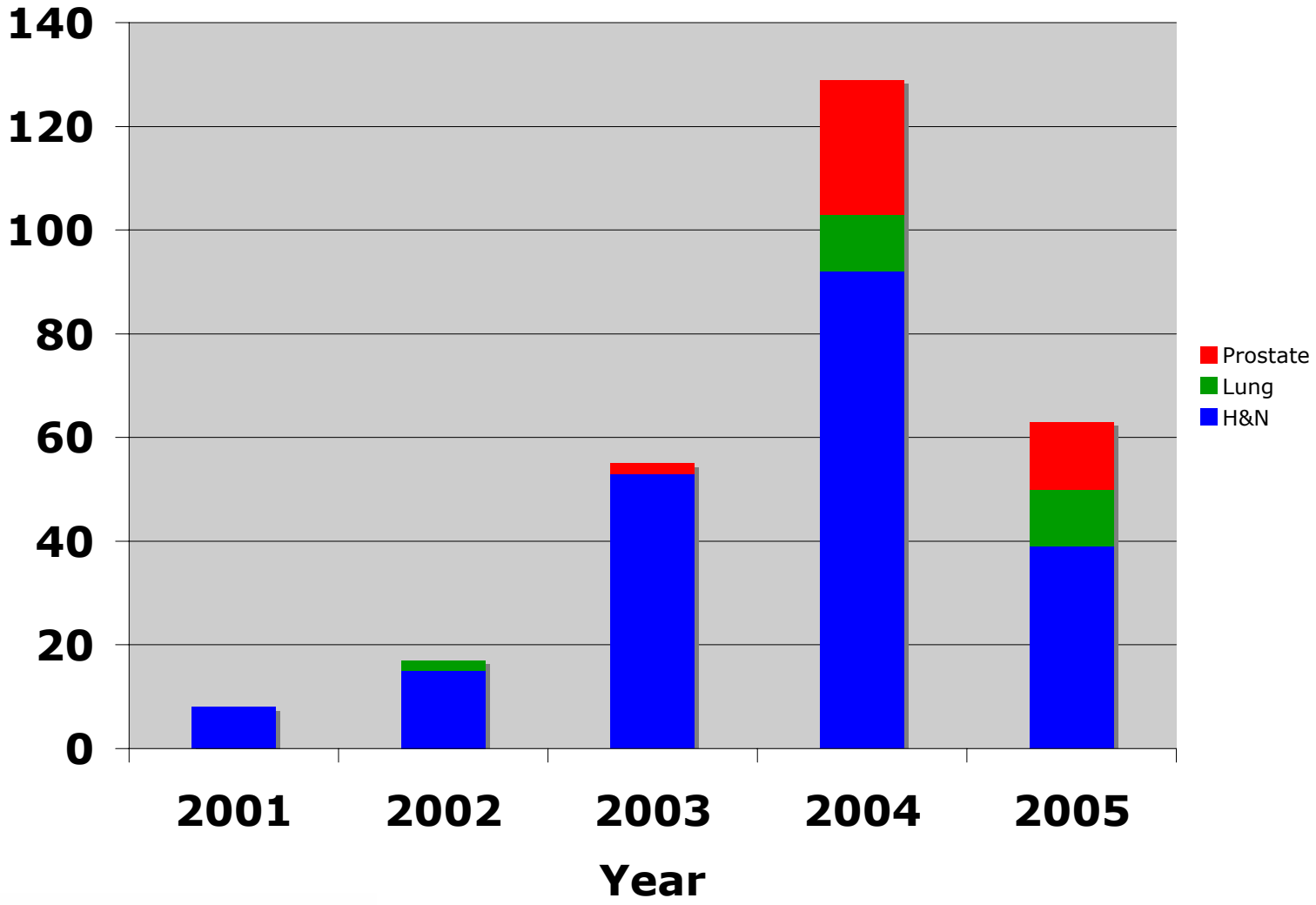
Plan vs. Treatment





Number of Phantom Mailings



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Phantom Results

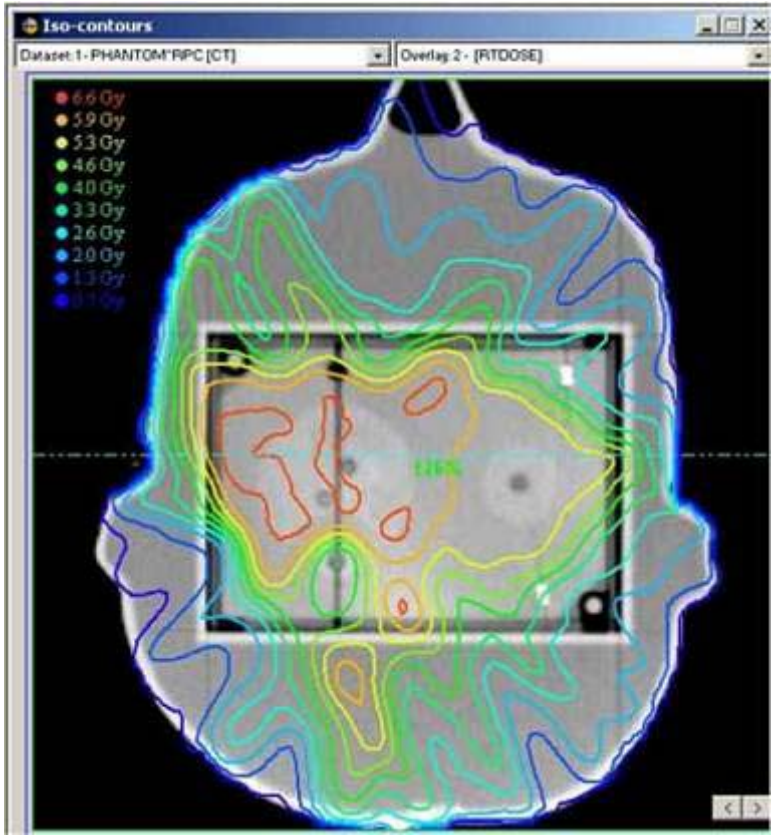
Phantom	H&N	Prostate	Thorax	Liver
Irradiations	157	27	17	-
Pass	109*	24	15	-
Fail	48	3	2	-
Under analysis or at institution	10	3	5	2
Year introduced	2001	Spring 2004	Spring 2004	Spring 2005

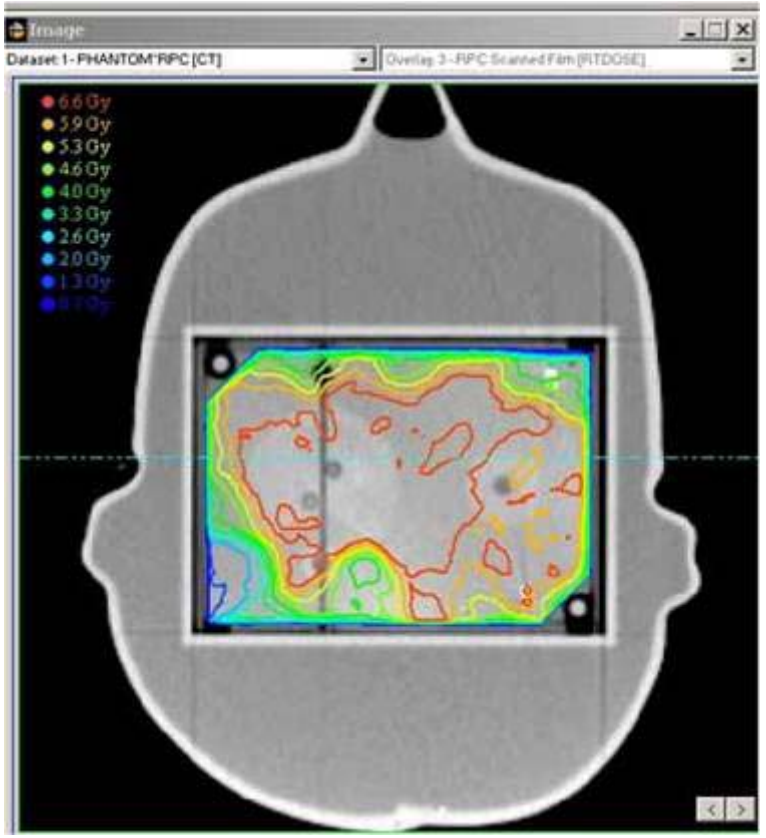
*** 33% of institutions failed H&N phantom on the first attempt**

Explanations for Failures

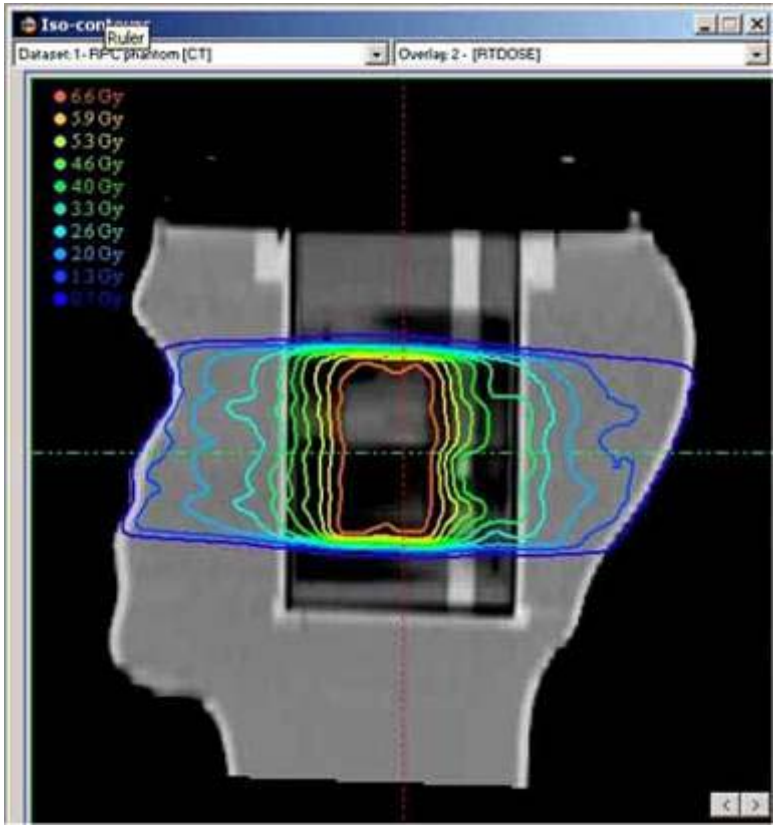
- Incorrect data in planning system
- Output factors, %dd
- Inadequacies in beam modeling (Cadman, et al; PMB 2002)
- Not adjusting irradiation time according to measurements
- Errors in indexing Peacock system
- Setup errors

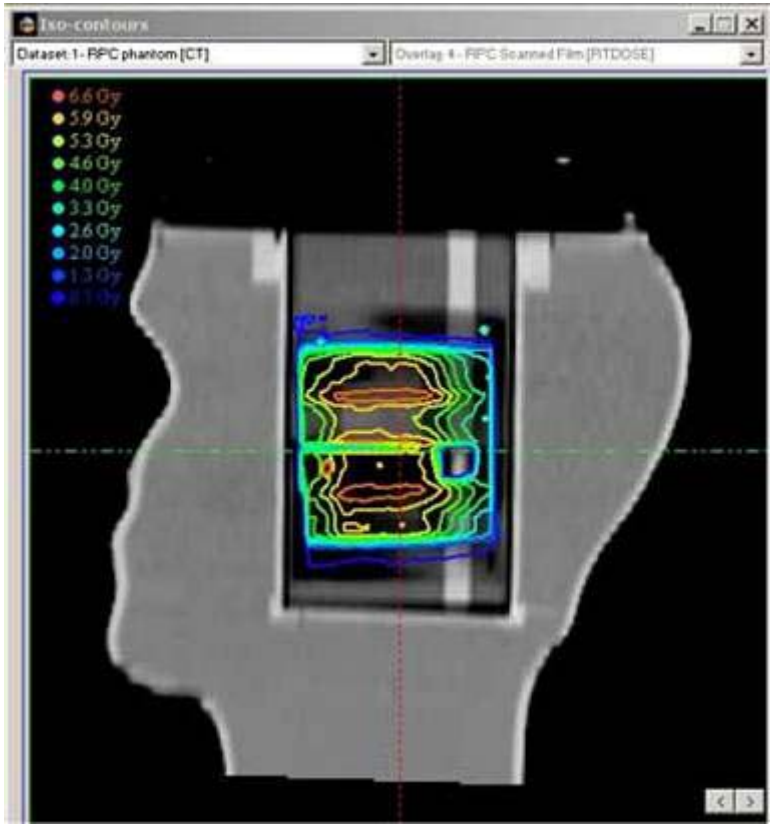
Examples of Failures



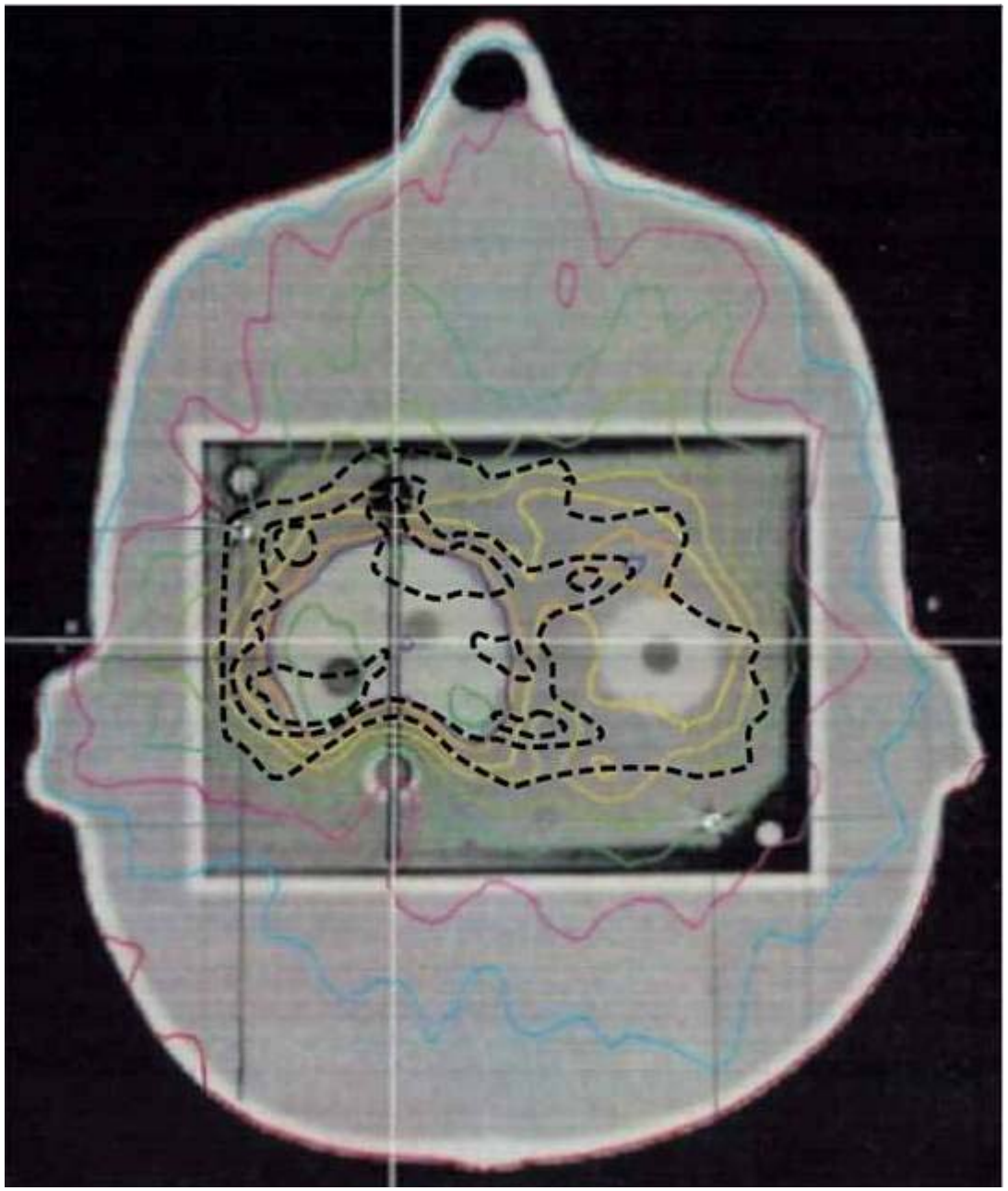


Peacock Indexing Error

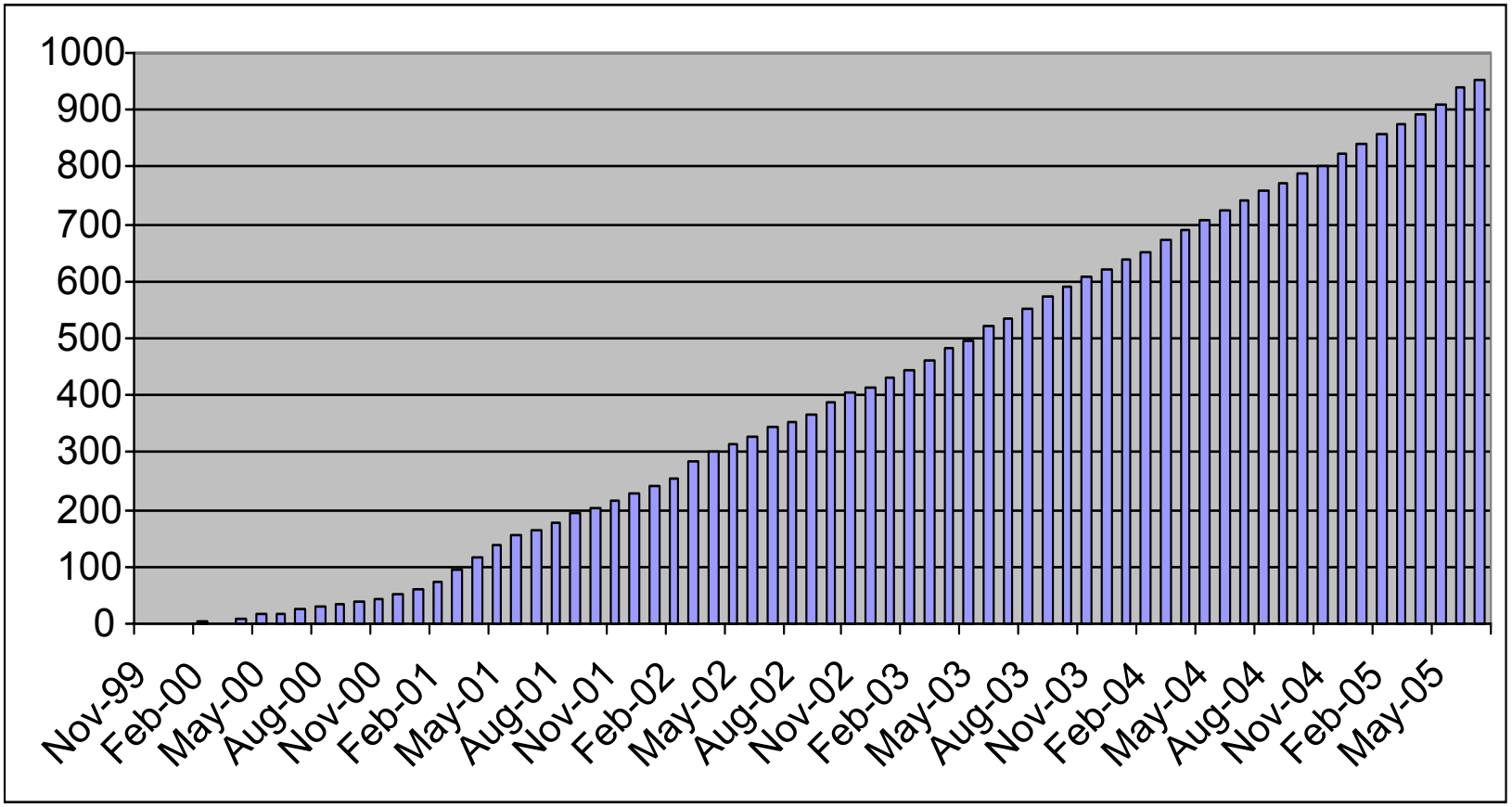




Comparison: Planned vs. Delivered Distribution



Number of Institutions Converting to TG-51



Protocol Patient Review

Purpose of Chart Review

- Correct errors in patient treatments
- Provide correct and comparable data
- Improve quality of care for all RT patients
- Reviewed charts from 1003 institutions
- Only the RPC and RTOG HQ Dosimetry Group confirm doses for external beam
- Only QAO confirming implant doses

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Study Groups Relying on RPC Chart Review

- **GOG** Gynecologic Oncology Group
- **NCCTG** North Central Cancer Treatment Group
- **NSABP** National Surgical Adjuvant Breast and Bowel Project
- **RTOG** Radiation Therapy Oncology Group

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Chart Review Process

- Radiotherapy records, calculations & films received from study group

Independent dose recalculation (±5%)

Resolve errors with institution

Discuss results with Group and Study Chair

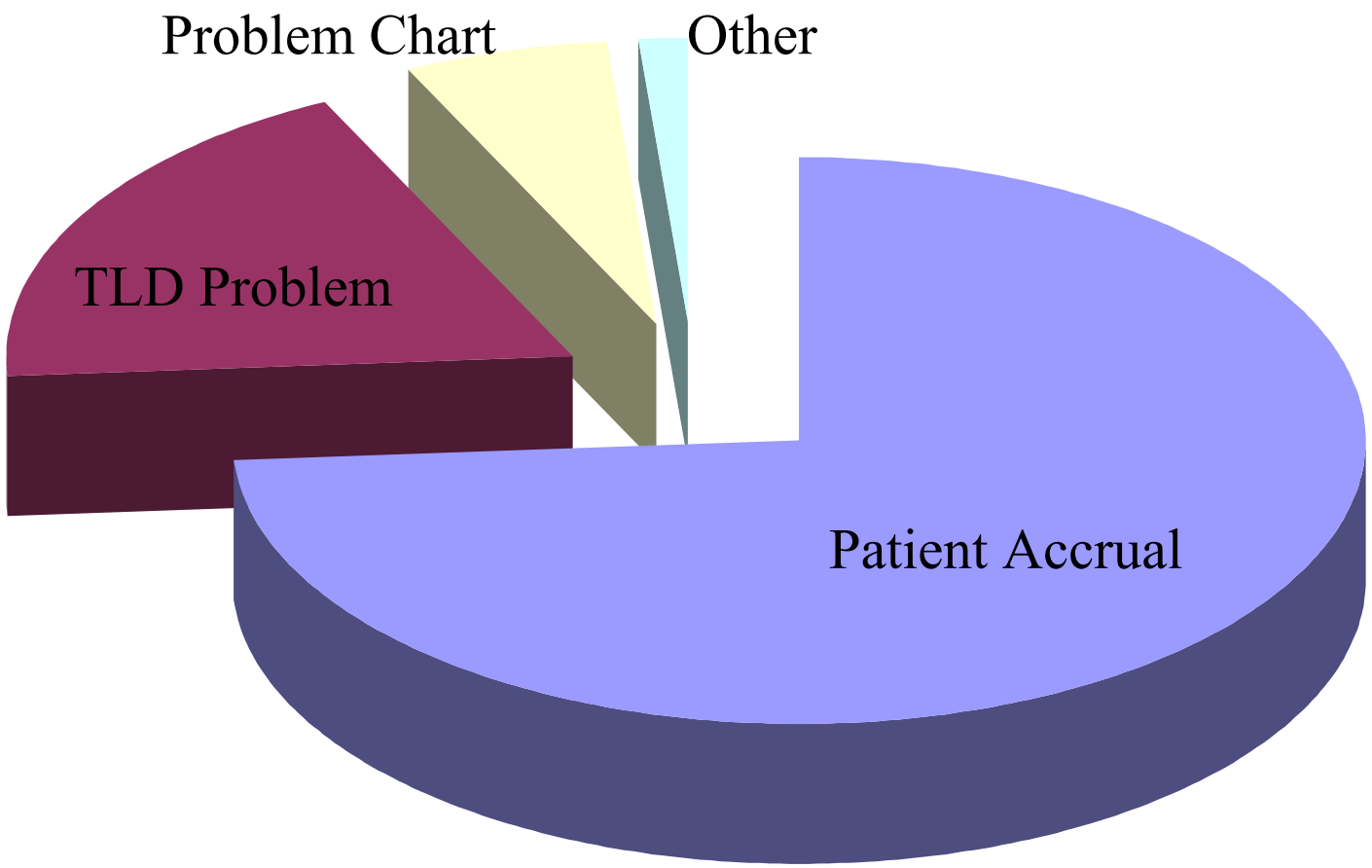
Facilitate clinical review at meetings, RPC, HQ

Results of Chart Review

- 1% Systematic errors
  - Potential to impact every patient treated by institution
- 10% Individual errors
  - Impacts study groups and institution
- 25% Reporting errors
  - Impacts study group and institution

Without RPC review 36% of the doses used by the study group would be incorrect

Priority for Visits



On-Site Dosimetry Review Visit

- **The only completely independent comprehensive radiotherapy quality audit in the USA and Canada**
  - Identify errors in dosimetry and QA program and suggest methods of improvements.
  - Collect and verify dosimetry data needed to review patient charts.
  - Improve quality of patient care for all patients.

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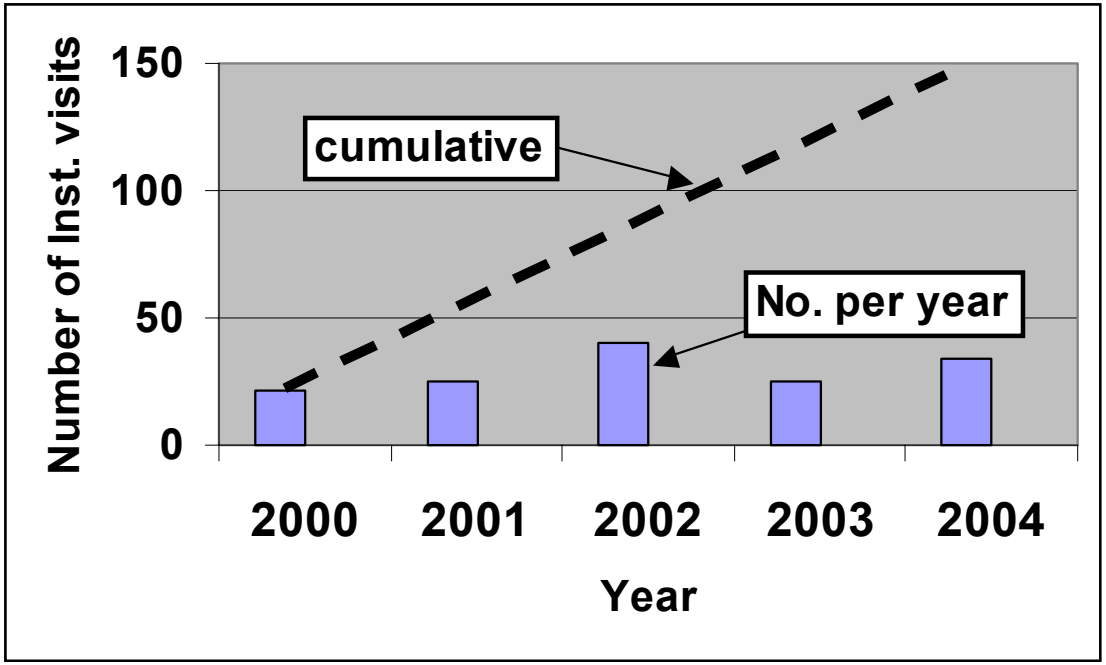
On-Site Dosimetry Review Visit

~1387 institutions participating in clinical trials

	visited	not visited yet
Institutions:	715	672
Patient accrual:	20,130	1,095
	(95%)	(5%)



On-Site Dosimetry Review Visit

~1387 institutions participating in clinical trials

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Institutions:	715	672
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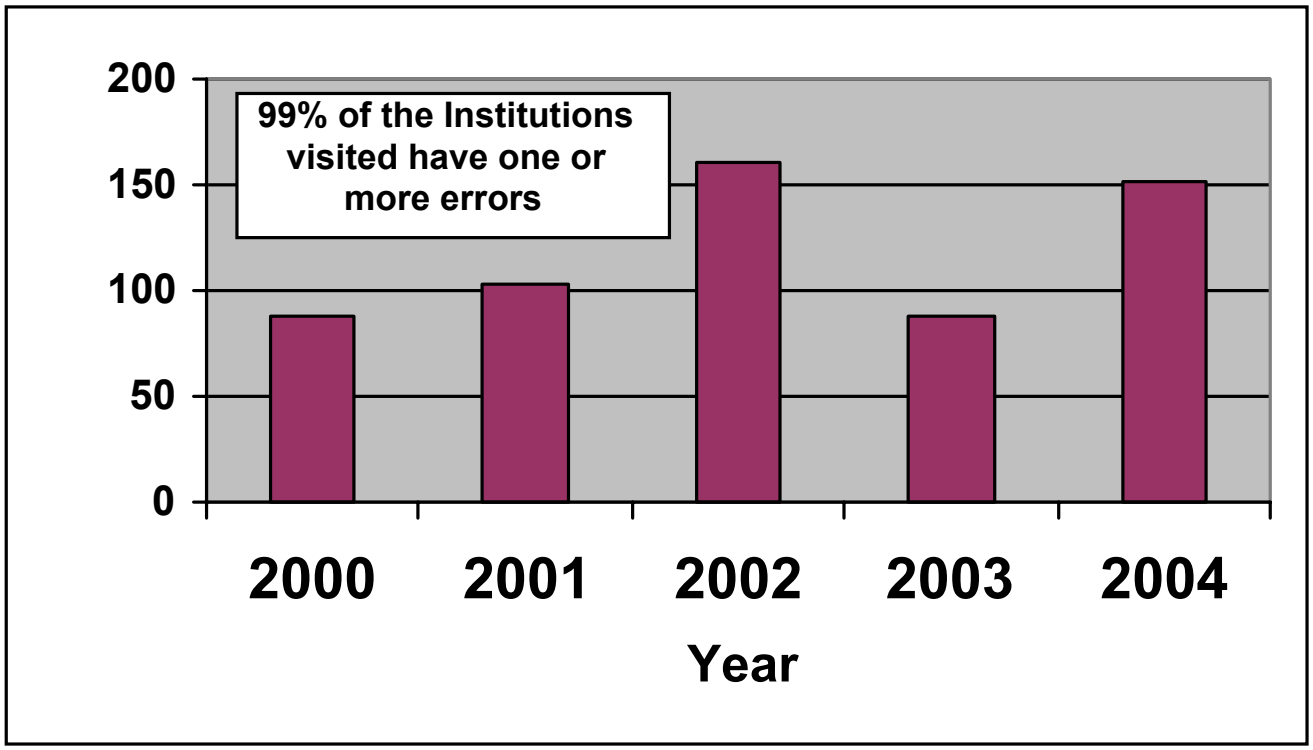
On-Site Dosimetry Review Visit Errors



On-Site Dosimetry Review Visit Errors

Over 500 errors and 85 lapses in QA programs were identified at institutions visited by the RPC during the past 5 years.

These errors potentially impacted on all patients treated at these institutions.

On-Site Dosimetry Review Visits

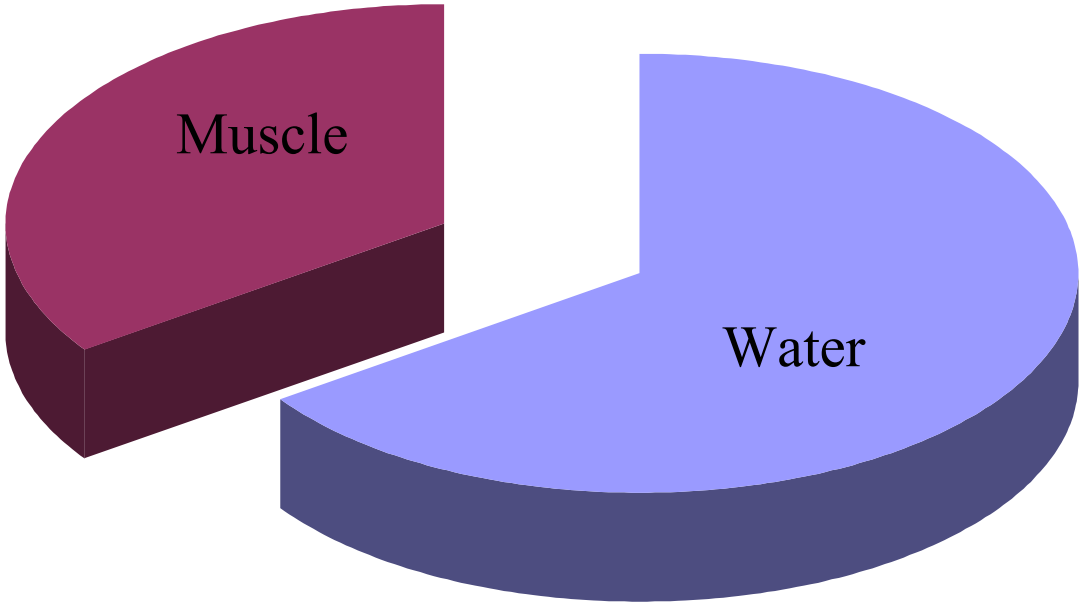
Selected discrepancies discovered during 2004

Errors Regarding:	Percent of Institutions
Review QA Program	(84%)
*Photon Depth Dose	(30%)
Switch to TG-51	(24%)
*Wedge Transmission	(24%)
*Photon Calibration & FSD	(24%)
*Electron Calibration	(22%)
*Off-axis Factors	(16%)

*70% of institutions received at least one of the significant dosimetry recommendations.

Calibration Procedures (1)

Reference calibration adjusted to dose in:



Review of Institutions Dosimetry Program Remotely

How can we evaluate institutions and find errors for the nearly 700 institutions that have a low priority for a visit?

Use the RPC standard data.

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RPC Remote Data Review

What are the RPC Standard Data?

- Compilation of RPC measured **average** data
  1. 2350 photon beams
  2. 81 accelerator model/ energy combinations
- Specific to make/model/energy
- ≥ 5 sets of RPC measured data

Analyses of these data indicate that machines of same make/model/energy have same radiation characteristics.

RPC Remote Data Review

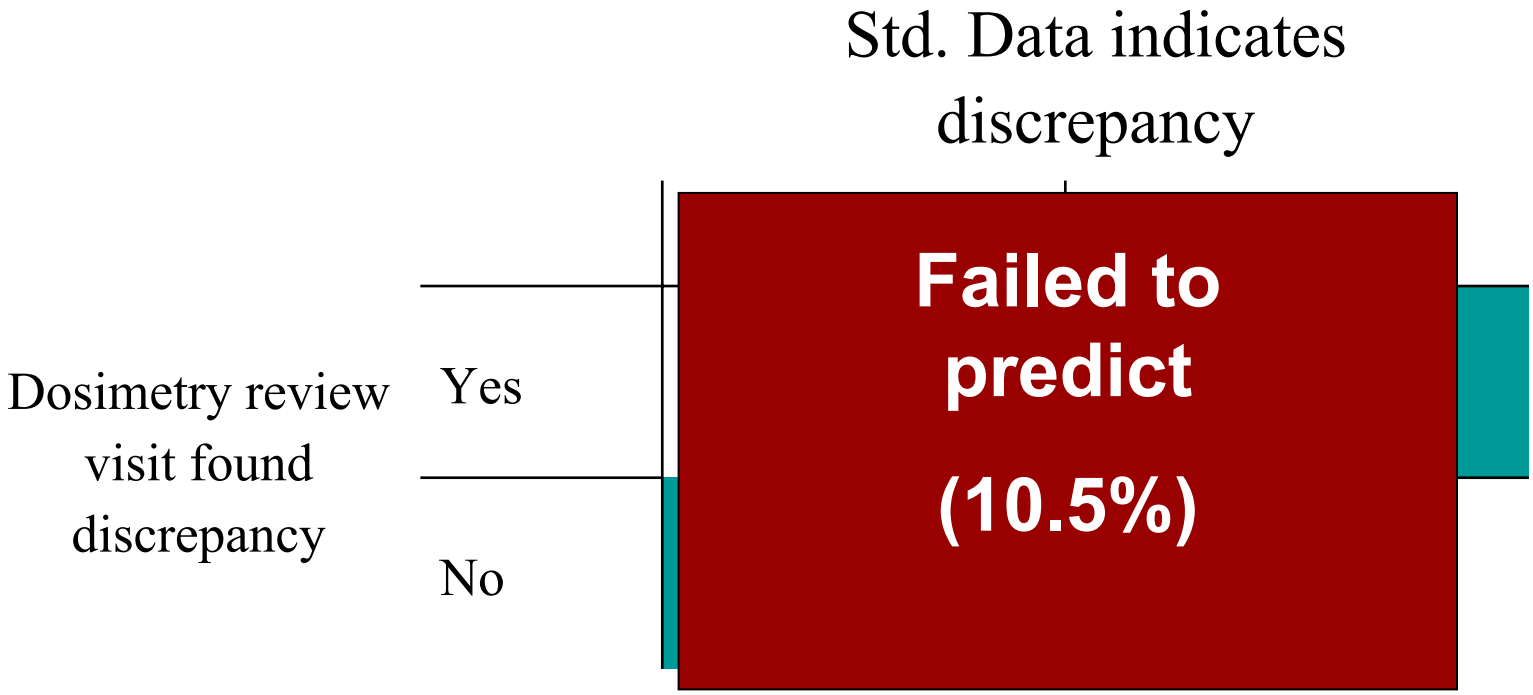
Can standard data discover errors?

(analysis of 7,864 data points from 150 institutions)

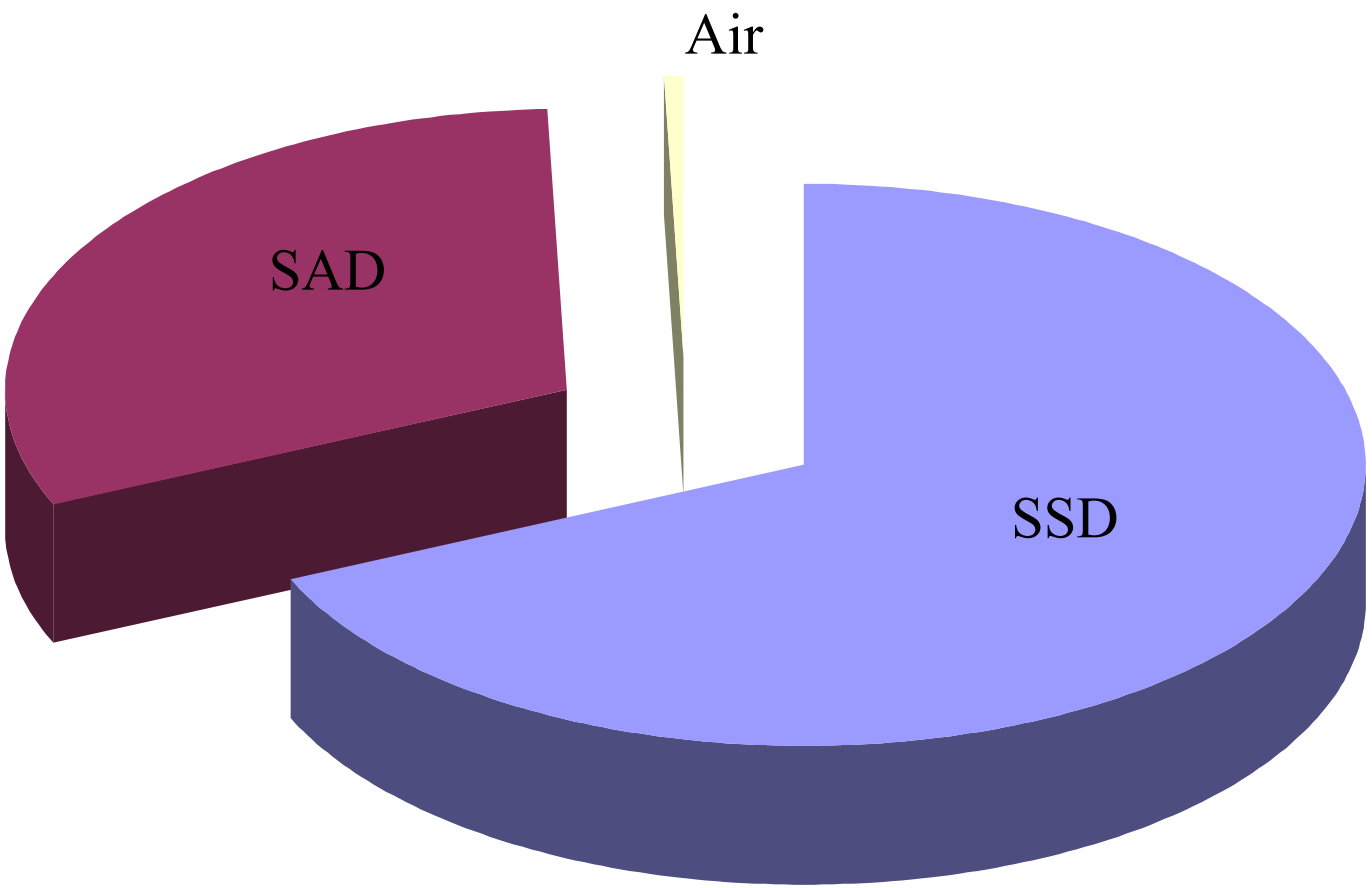
		Std. Data indicates discrepancy: Yes	Std. Data indicates discrepancy: No
Dosimetry review visit found discrepancy	Yes	6890 (87.7%)	**450 (5.7%)**
	No	**378 (4.8%)**	146 (1.9%)

RPC Remote Data Review

Can standard data discover errors?
(analysis of 7,864 data points from 150 institutions)



Calibration Procedures (2)



Communications and Support of the Radiation Oncology Community

(RPC: National Resource)

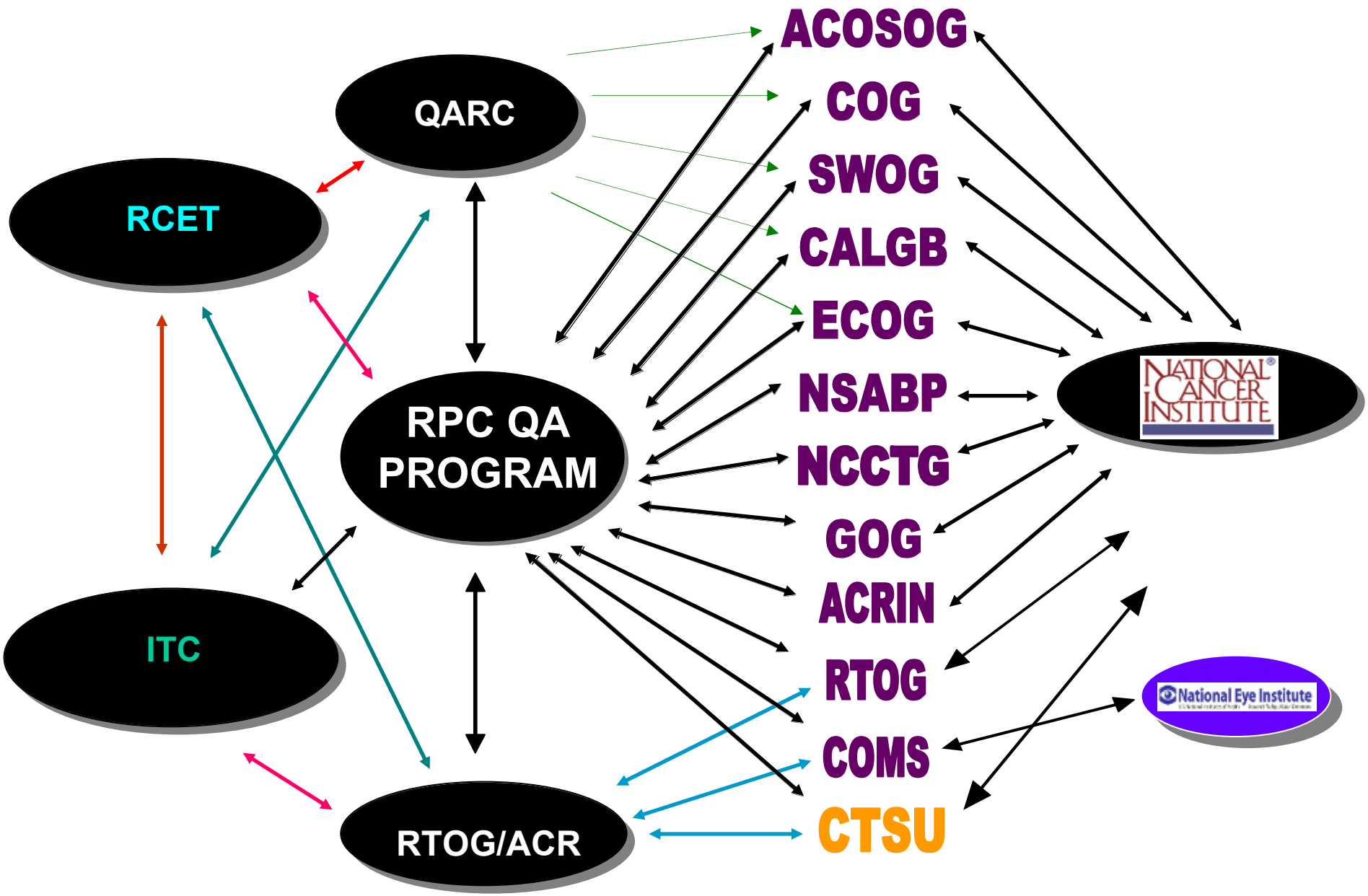
Only QA group within USA and Canada that interacts with oncologists, medical physicists, dosimetrists and other medical staff at 1,400 institutions, regardless of their affiliation or location.

Strongest Interaction is with the Physics Community in Support of Clinical Trials

American Association of Physicists in Medicine (AAPM)

- **Therapy Physics Committee**
- **Brachytherapy dosimetry in clinical trials**
- **Implementation of new calibration protocol**

Only QA Office with relationships with all study groups



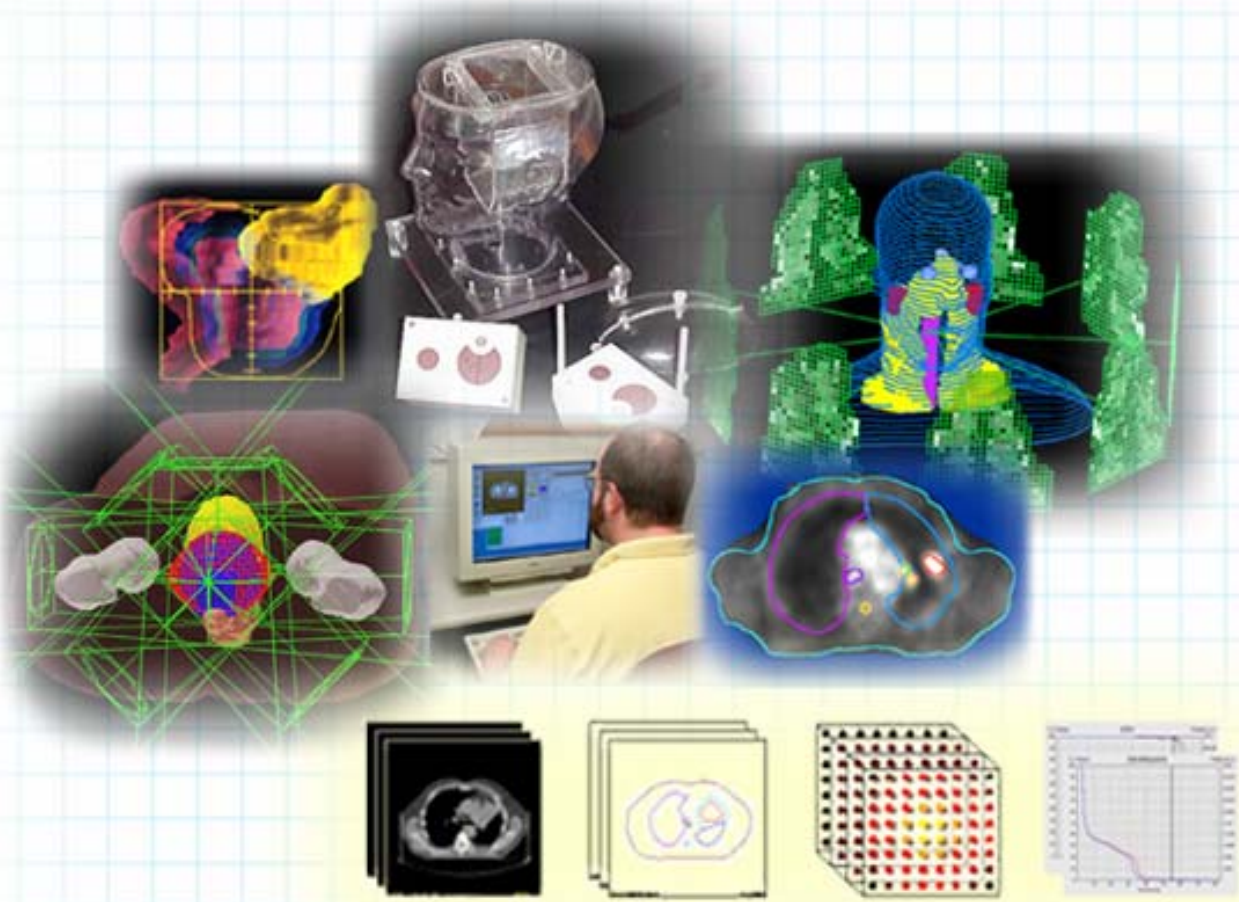
ATC AdvancedTechnologyConsortium

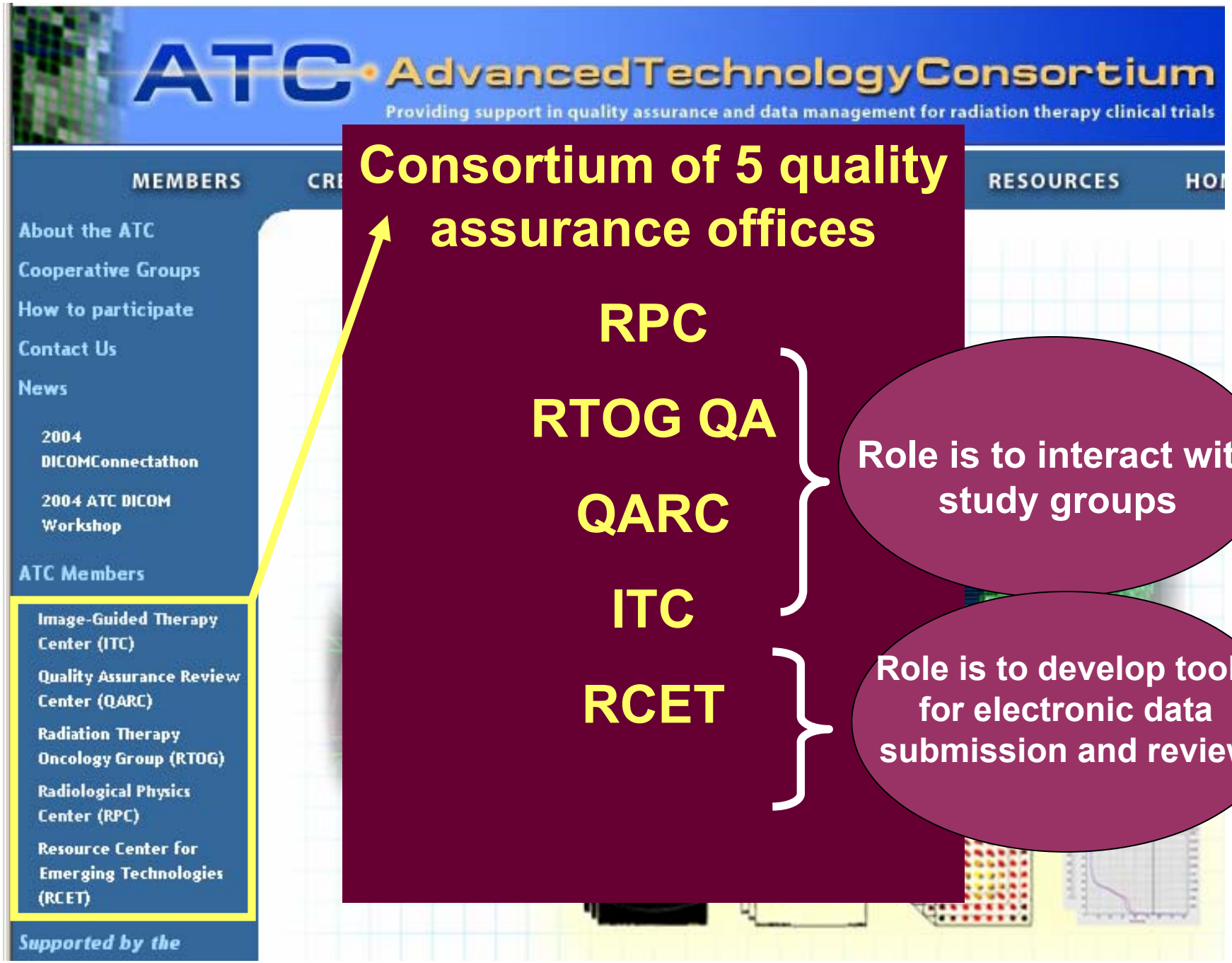
Providing support in quality assurance and data management for radiation therapy clinical trials

MEMBERS | CREDENTIALING | PROTOCOLS | PUBLICATIONS | RESOURCES | HOM

- About the ATC
- Cooperative Groups
- How to participate
- Contact Us
- News
  - 2004 DICOMConnectathon
  - 2004 ATC DICOM Workshop
- ATC Members
  - Image-Guided Therapy Center (ITC)
  - Quality Assurance Review Center (QARC)
  - Radiation Therapy Oncology Group (RTOG)
  - Radiological Physics Center (RPC)
  - Resource Center for Emerging Technologies (RCET)

Supported by the




ATC AdvancedTechnologyConsortium
Providing support in quality assurance and data management for radiation therapy clinical trials
MEMBERS
RESOURCES
About the ATC
Cooperative Groups
How to participate
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2004 DICOMConnectathon
2004 ATC DICOM Workshop
ATC Members
Image-Guided Therapy Center (ITC)
Quality Assurance Review Center (QARC)
Radiation Therapy Oncology Group (RTOG)
Radiological Physics Center (RPC)
Resource Center for Emerging Technologies (RCET)
Supported by the
Consortium of 5 quality assurance offices
RPC
RTOG QA
QARC
ITC
RCET
Role is to interact with study groups
Role is to develop tools for electronic data submission and review

Ongoing Communications with Community

THE UNIVERSITY OF TEXAS
MD ANDERSON CANCER CENTER
Making Cancer History™

AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE

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RECENT POSTINGS	SERVICES	RESEARCH/TG-51	ABOUT RPC	FAQ
CREDENTIALING	INSTITUTIONS MONITORED BY RPC		RPC LINKS	RPC NEWS
PHOTON ALGORITHM VERIFICATION	BRACHY SEEDS		EYE PLAQUE DOSIMETRY	

Welcome to the Radiological Physics Center (RPC). Our Website was created to provide information regarding our research driven quality assurance services, educational services and our history.
For over three decades our nationally and internationally recognized team has provided quality assurance to the National Cancer Institute sponsored cooperative clinical trial groups.

Welcome

NCI IMRT Guidelines Letter

NEW RPC NEWS

Ongoing Communications with Community

RPC WEBPAGE NEWSLETTER

Volume 3, Issue 1 March 2004

Water or muscle - does it matter?

The RPC has received a number of comments about the question on our TLD forms that asks if the institution calibrates to water or muscle. Several callers were concerned that they needed to report their calibration in the same medium as is used by the RPC to report dose. Others asked for the converse; for the RPC to report dose in the same medium as used by their institution for calibration.

The medium used for reporting dose is not necessarily the same as the medium in which the beam output is measured. TG-51 requires that beam output be measured in water, and many institutions report the calibration that way. In other words, they describe the output as 1.00 cGy to water per MU under reference conditions. However, quite a few institutions apply a 1% correction at the time of calibration, and adjust the treatment unit output to 1.00 cGy to muscle per MU under reference conditions. The RPC database indicates that 35% of the institutions report their calibration to muscle and the remaining 65% to water.

We would like institutions to indicate on the TLD forms how their beams are calibrated, not how patient doses are described. If a 1% correction is applied at the time of beam calibration, you should check the box for "muscle". Otherwise you should check "water", even if you apply the 1% correction when calculating MU settings for patient treatments.

Institutions participating in monitoring program

Univ of Pretoria	2099	Private Bag X 169	PRETORIA, 0001, RS	RSA
Univ of Rochester Med. Center	2613	601 Elmwood Ave Box 647	Rochester	NY
Univ of South Alabama Cancer Ctr.	2614	307 University Blvd. - CC/CB 135	Mobile	AL
Univ of Southern California	1674	1200 N State St	Los Angeles	CA
Univ of Tennessee - Chattanooga	1406	975 E Third St	Chattanooga	TN
Univ of Tennessee Medical Center	2616	1924 Alcoa Highway	Knoxville	TN
Univ of Tennessee Medical Ctr.	2616	1924 Alcoa Highway	Knoxville	TN
Univ of Tennessee Memorial Hosp.	2616	1924 Alcoa Highway	Knoxville	TN
Univ of Texas - S.W. Medical	2569	5323 Harry Hines Blvd.	Dallas	TX
Univ of Texas Medical Branch	2618	301 Univ. Blvd; 1.400 K McCullough Bldg	Galveston	TX
Univ of Utah Hospitals and Clinics	2619	AB25 MC	Salt Lake City	UT
Univ of Utah Medical Center	2619	AB25 MC	Salt Lake City	UT
Univ of Vermont	1427	111 Colchester Ave.	Burlington	VT
Univ of Virginia Hospital	2620	Jefferson Pk. Ave. West, Rm.2691	Charlottesville	VA
Univ of Washington Medical Center	2621	1959 N.E. Pacific St., (Box 356043)	Seattle	WA
Univ of West Virginia Med. Ctr.	2723	P.O. Box 8150 Medical Center Drive	Morgantown	WV
Univ of Western Ontario	1714	790 Commissioners Rd E	LONDON	ONTARIO
Univ of Wisconsin Med. Center	2622	600 Highland Ave K4/B100-0600	Madison	WI
Univ. of Texas South West - Moncrief	1749	911 Foster Lane	Weatherford	TX

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Ongoing Communications with Community

1. Via the web site and email burst

2. AAPM newsletter

3. Workshops/ posters/
   oral presentations/ publications

4. Phone!

Ongoing Communications

AAPM NEWSLETTER MAY/JUNE 2004

Clinical Trials Update

Report from the Subcommittee on QA of Clinical Trials
The COG ACNS0331 Protocol

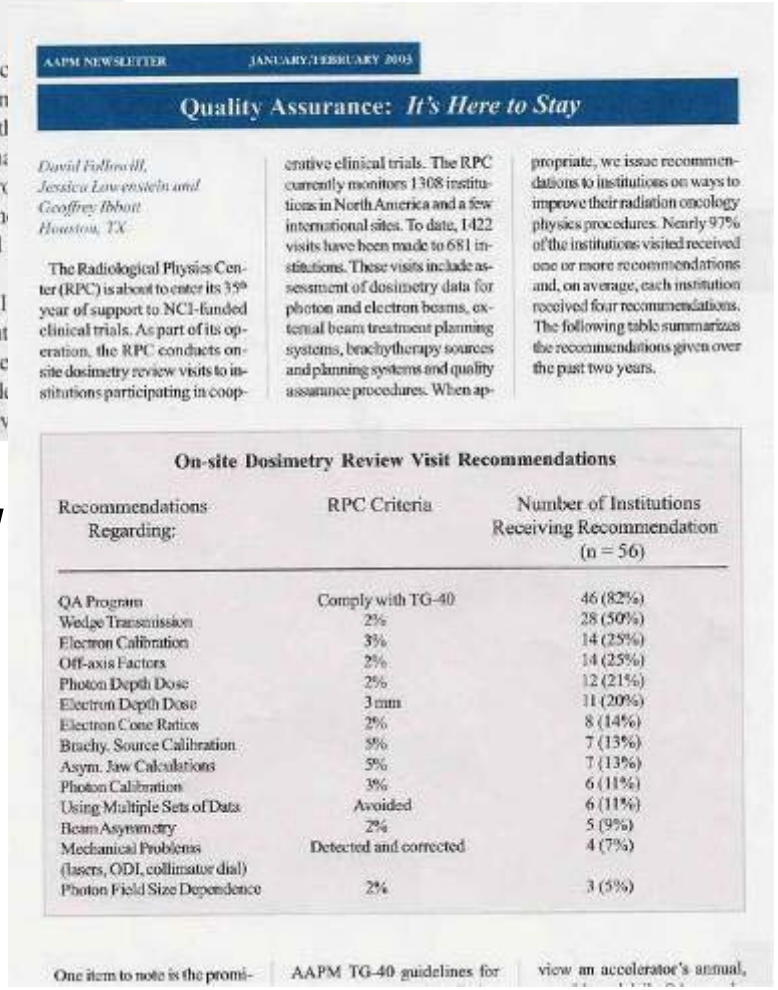
Geoffrey S. Ibbott, Ph.D.
Subcommittee Chair

This is the fourth in a series of articles that describes clinical trials conducted by cooperative study groups that may be of particular interest to medical physicists. Previous newsletter articles have described three RTOG protocols, H-0022, P-0232, and P-0126. This article sets a new trend by discussing a protocol pub-

ume smaller than the whole posterior fossa to 54 Gy without reducing the survival rate, which is currently over 75%. Because

ning and delivery tec
IMRT and proton bean
are allowed provided t
priate benchmarks ha
submitted and are appr
use of proton beam th
quires prior approval
study chair.

Institutions that will
ventional 3D treatment
must submit the 3D be
treatment plan availabl
Quality Assurance Rev



AAPM NEWSLETTER JANUARY/FEBRUARY 2003

Quality Assurance: *It's Here to Stay*

David Followill,
Jessica Lowenstein and
Geoffrey Ibbott
Houston, TX

The Radiological Physics Center (RPC) is about to enter its 35th year of support to NCI-funded clinical trials. As part of its operation, the RPC conducts on-site dosimetry review visits to institutions participating in cooperative clinical trials. The RPC currently monitors 1308 institutions in North America and a few international sites. To date, 1422 visits have been made to 681 institutions. These visits include assessment of dosimetry data for photon and electron beams, external beam treatment planning systems, brachytherapy sources and planning systems and quality assurance procedures. When appropriate, we issue recommendations to institutions on ways to improve their radiation oncology physics procedures. Nearly 97% of the institutions visited received one or more recommendations and, on average, each institution received four recommendations. The following table summarizes the recommendations given over the past two years.

On-site Dosimetry Review Visit Recommendations

Recommendations Regarding:	RPC Criteria	Number of Institutions Receiving Recommendation (n = 56)
QA Program	Comply with TG-40	46 (82%)
Wedge Transmission	2%	28 (50%)
Electron Calibration	3%	14 (25%)
Off-axis Factors	2%	14 (25%)
Photon Depth Dose	2%	12 (21%)
Electron Depth Dose	3 mm	11 (20%)
Electron Cone Ratios	2%	8 (14%)
Brachy. Source Calibration	5%	7 (13%)
Asym. Jaw Calculations	5%	7 (13%)
Photon Calibration	3%	6 (11%)
Using Multiple Sets of Data	Avoided	6 (11%)
Beam Asymmetry	2%	5 (9%)
Mechanical Problems (lasers, ODI, collimator dial)	Detected and corrected	4 (7%)
Photon Field Size Dependence	2%	3 (5%)

One item to note is the promi- AAPM TG-40 guidelines for view an accelerator's annual,

3. Workshops/ poster/ oral presentations/

4. Phone!

Ongoing Communications with Community

1. Via the web site and email burst
2. AAPM newsletter
3. Workshops/ posters/ oral presentations/ publications
4. Phone!

Ongoing Communications with Community

Since 2000

- **> 69 oral presentations/ posters**
- **39 scientific publications**
- **10 workshops**

Ongoing Communications with Community

1. Via the web site and email burst
2. AAPM newsletter
3. Workshops/ posters/
   oral presentations/ publications

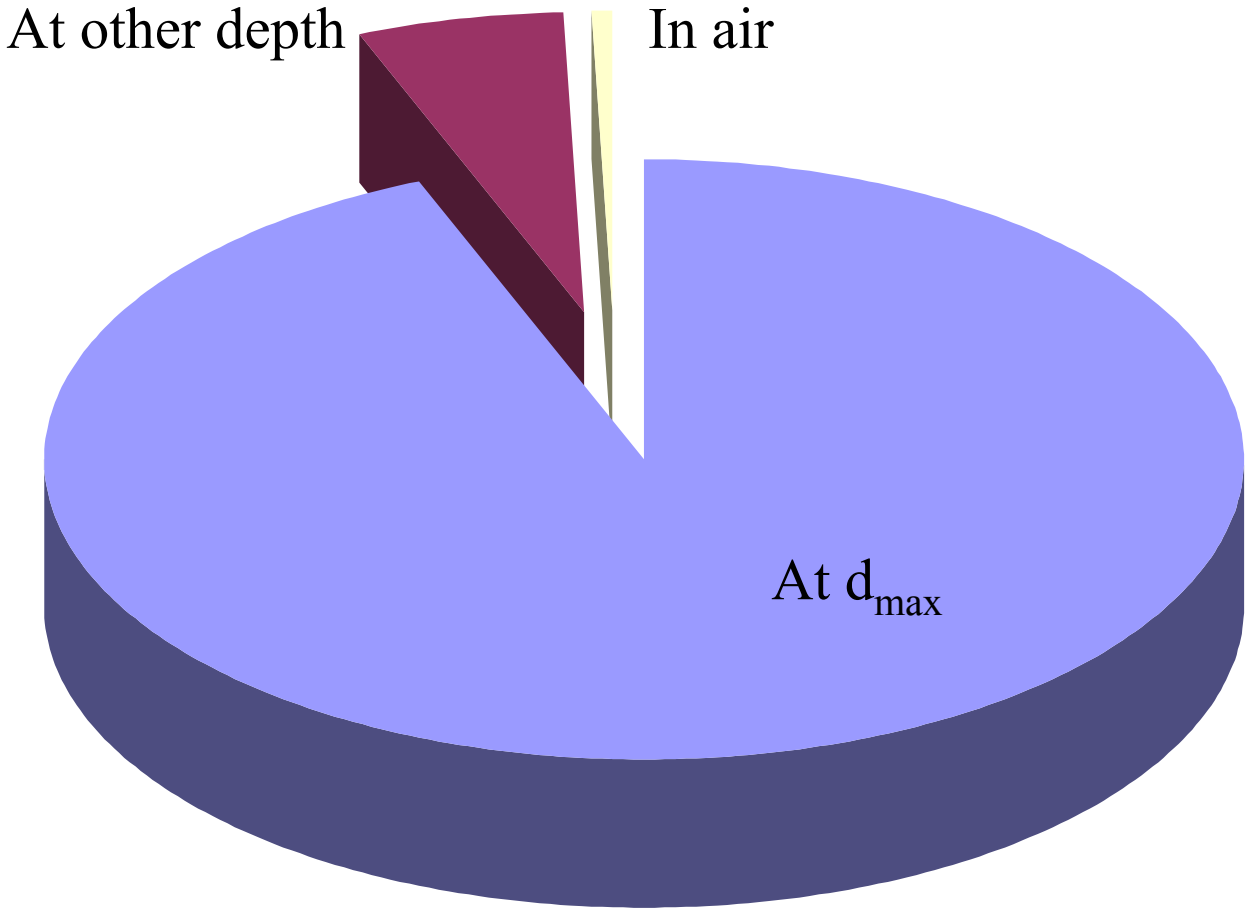
4.Phone/ email !

Ongoing Communications with Community

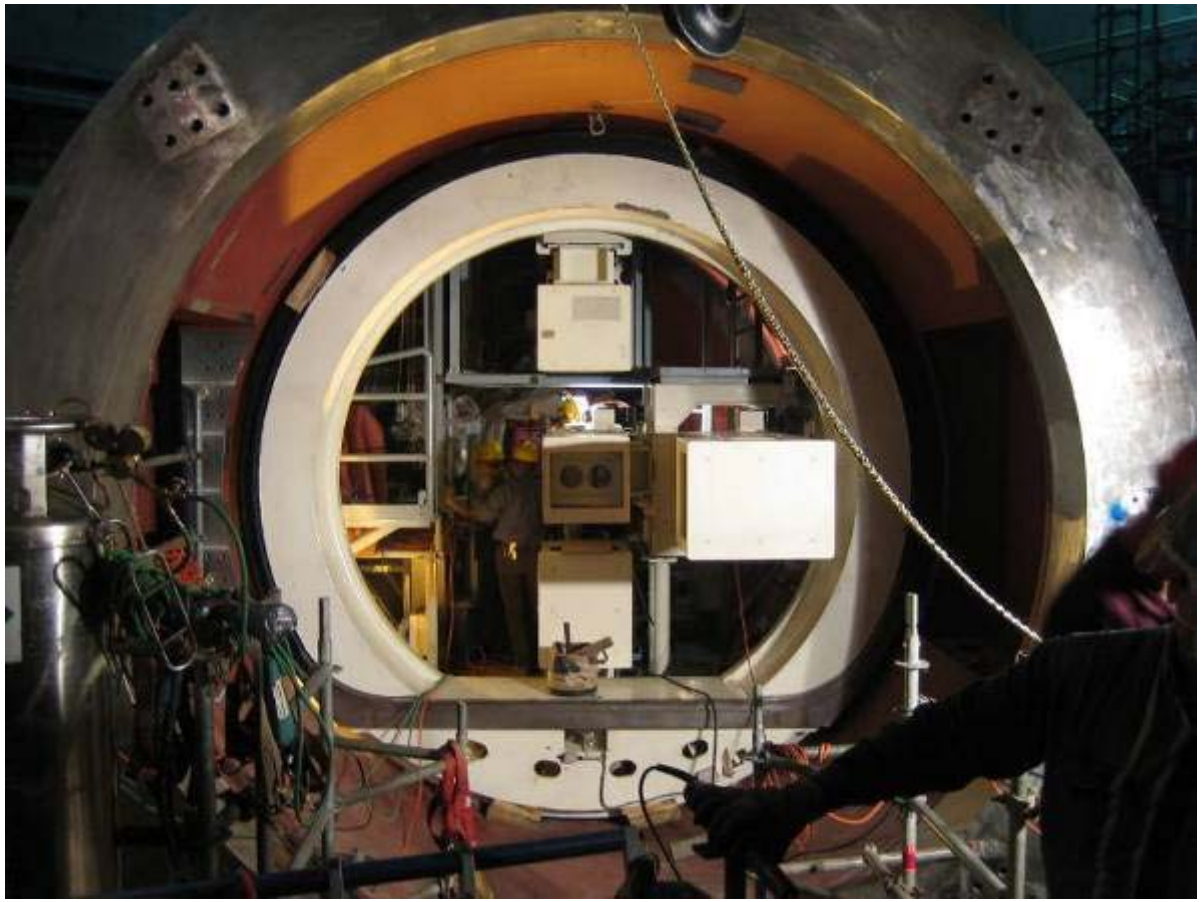
The RPC interacts with the Radiation Oncology community over

100 times per week

Calibration Procedures (3)

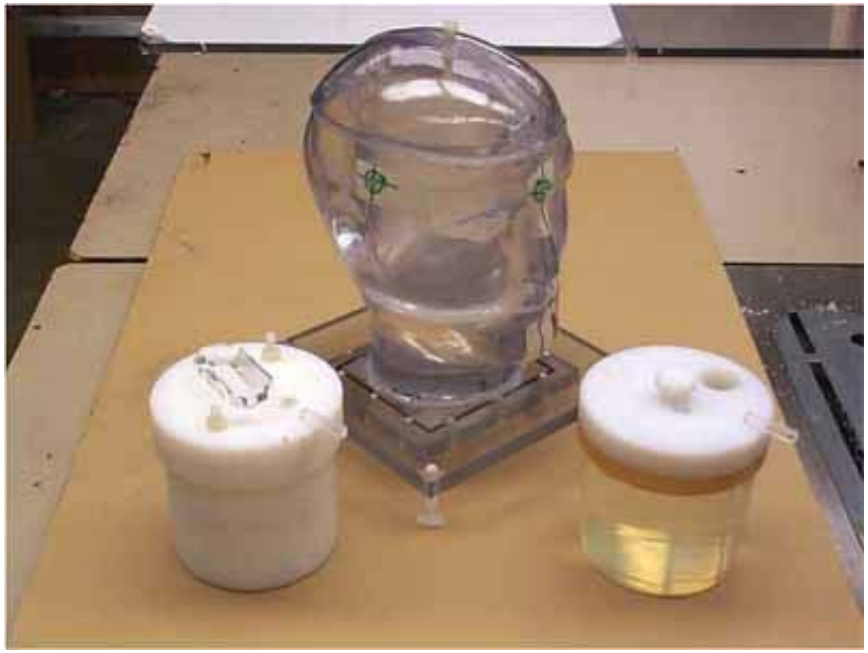


Research and Development Programs

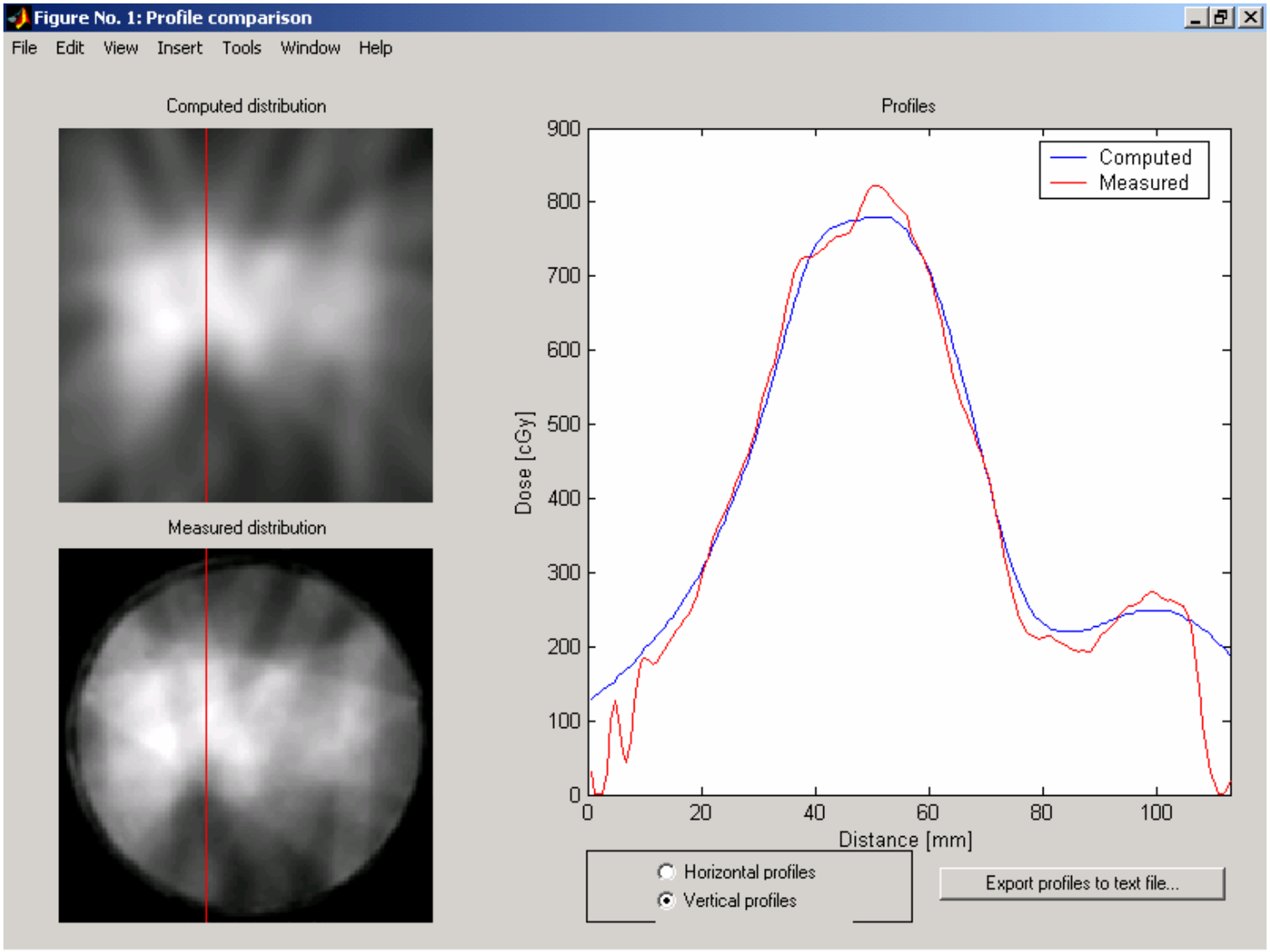


Gel Dosimetry

- Expanded use of gels, adapt to additional phantoms
- Investigation of new gel/solid dosimeters

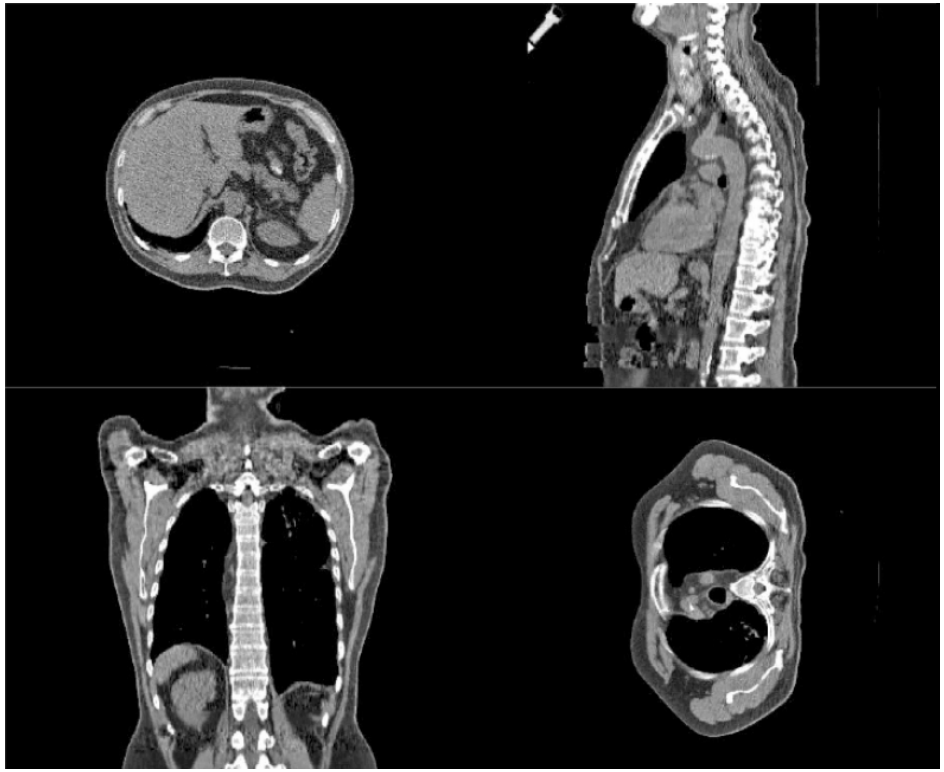


Relative Evaluation



Phantom Development

- Design of “liver” phantom, with simulated respiratory motion, for RTOG 0438
- STTR proposed: Dynamic phantom for gated & adaptive therapy



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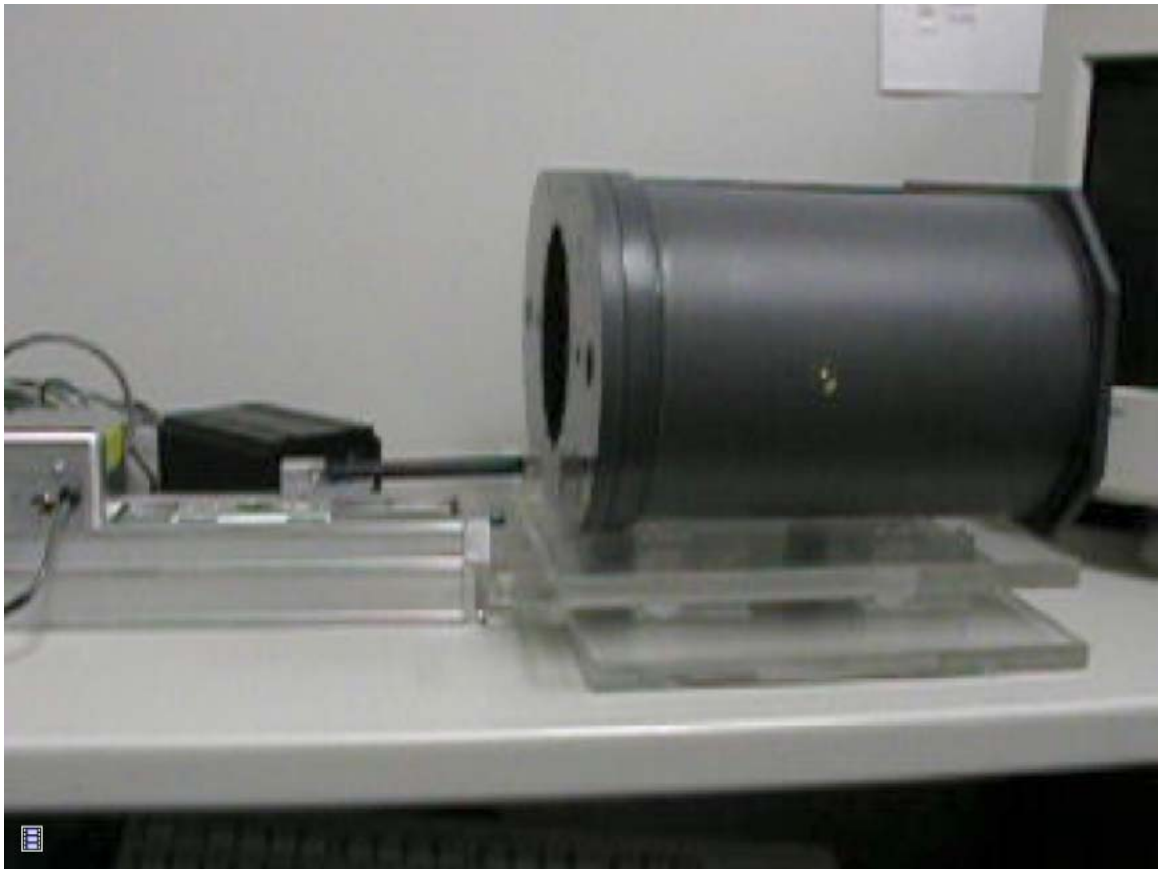
Simulation of Respiratory Motion



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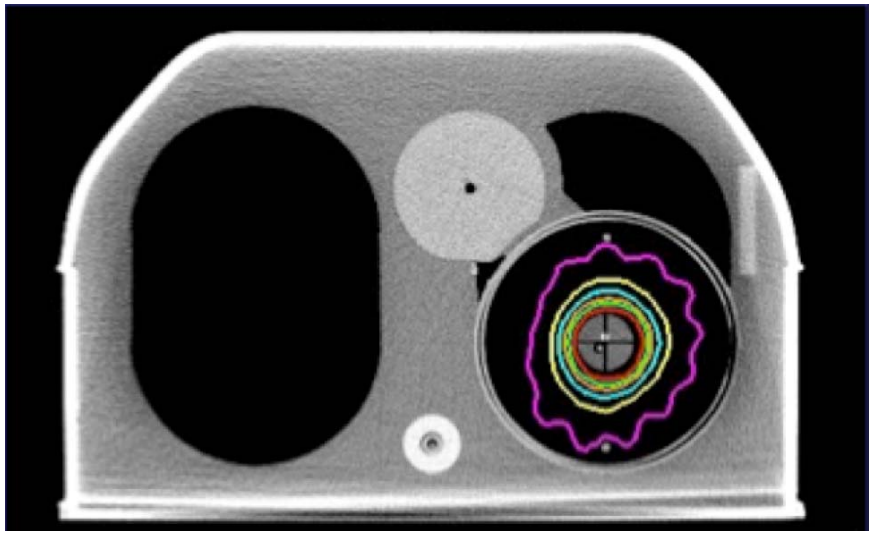
0438 - Liver primary or mets

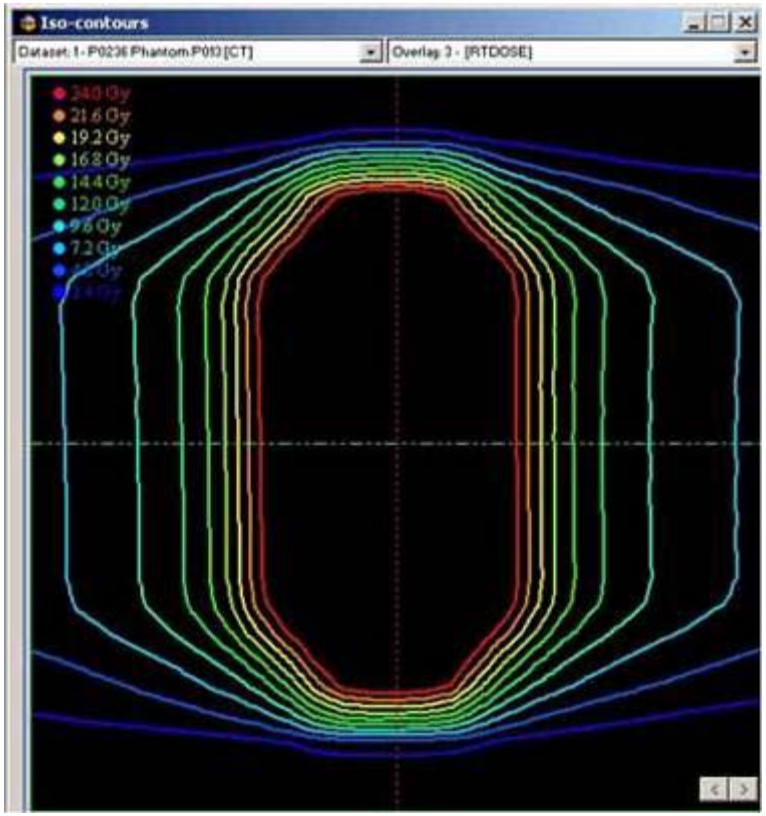
- Questionnaires
- Liver phantom on reciprocating table
- Digital submission

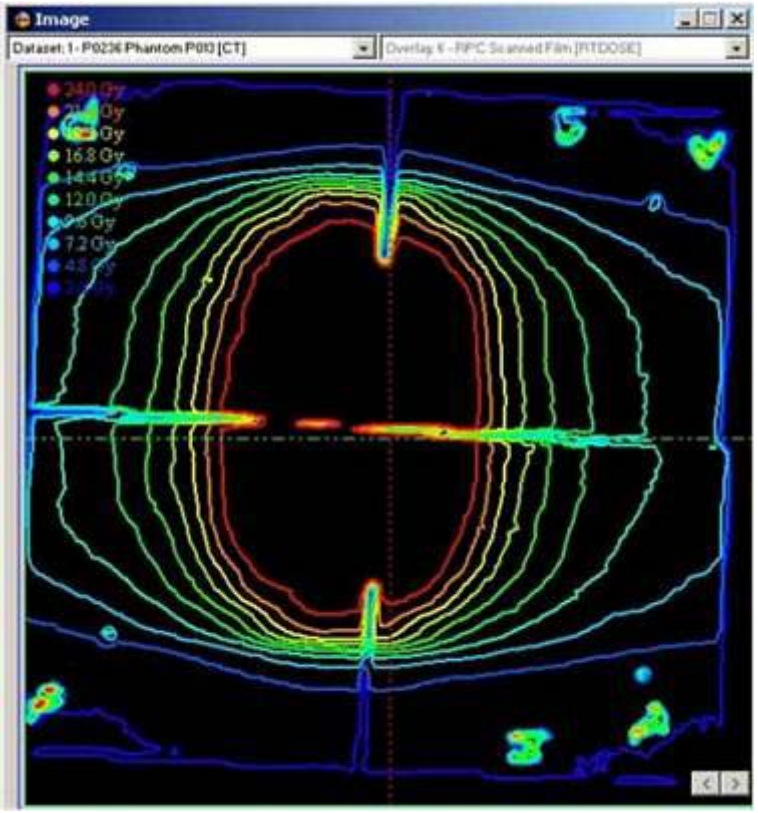
Influence of Lung Tissue on Tumor Dose

- RPC phantom contains lung-equivalent regions
- Comparison of calculations with measurements

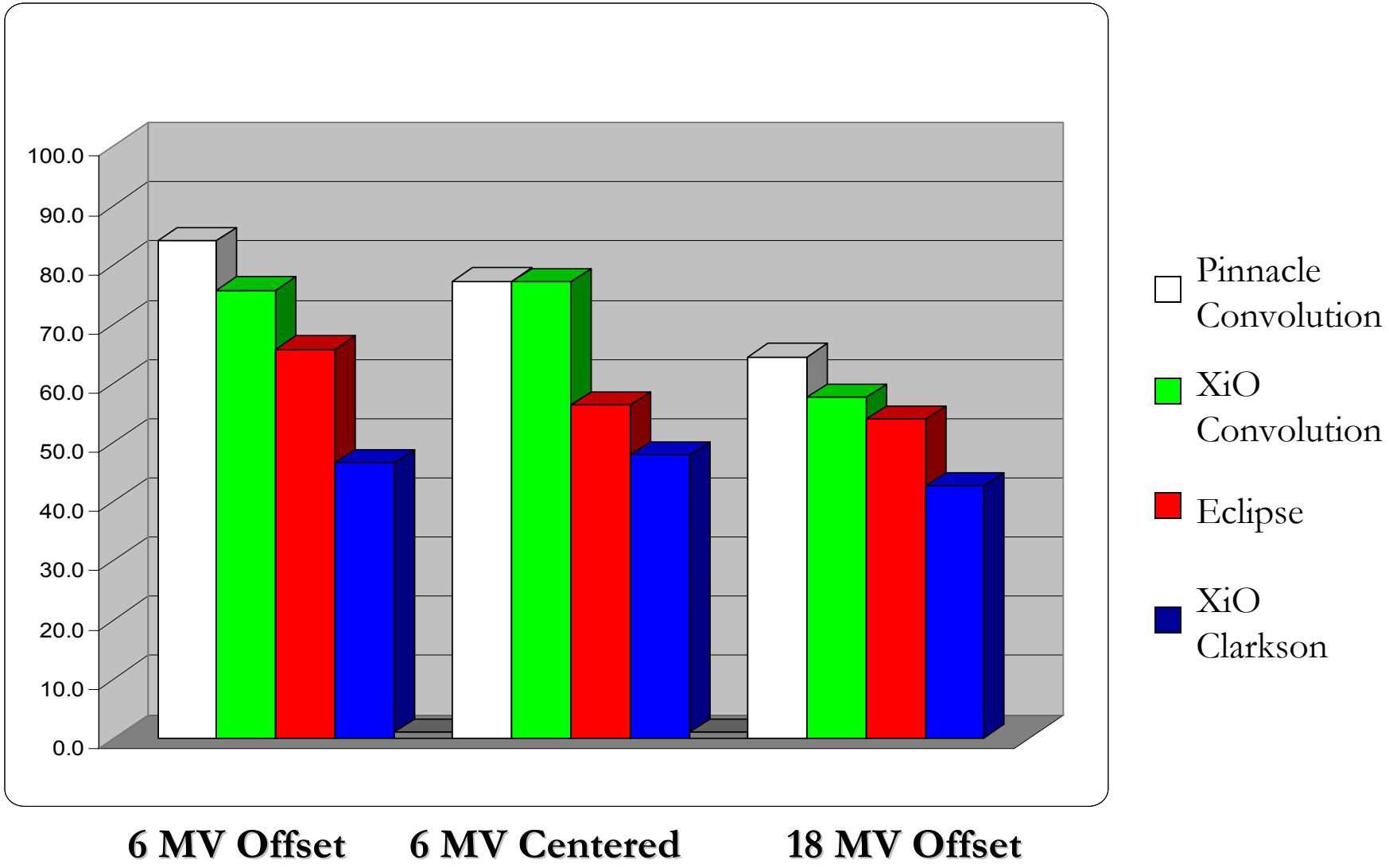


Lung Phantom Comparison

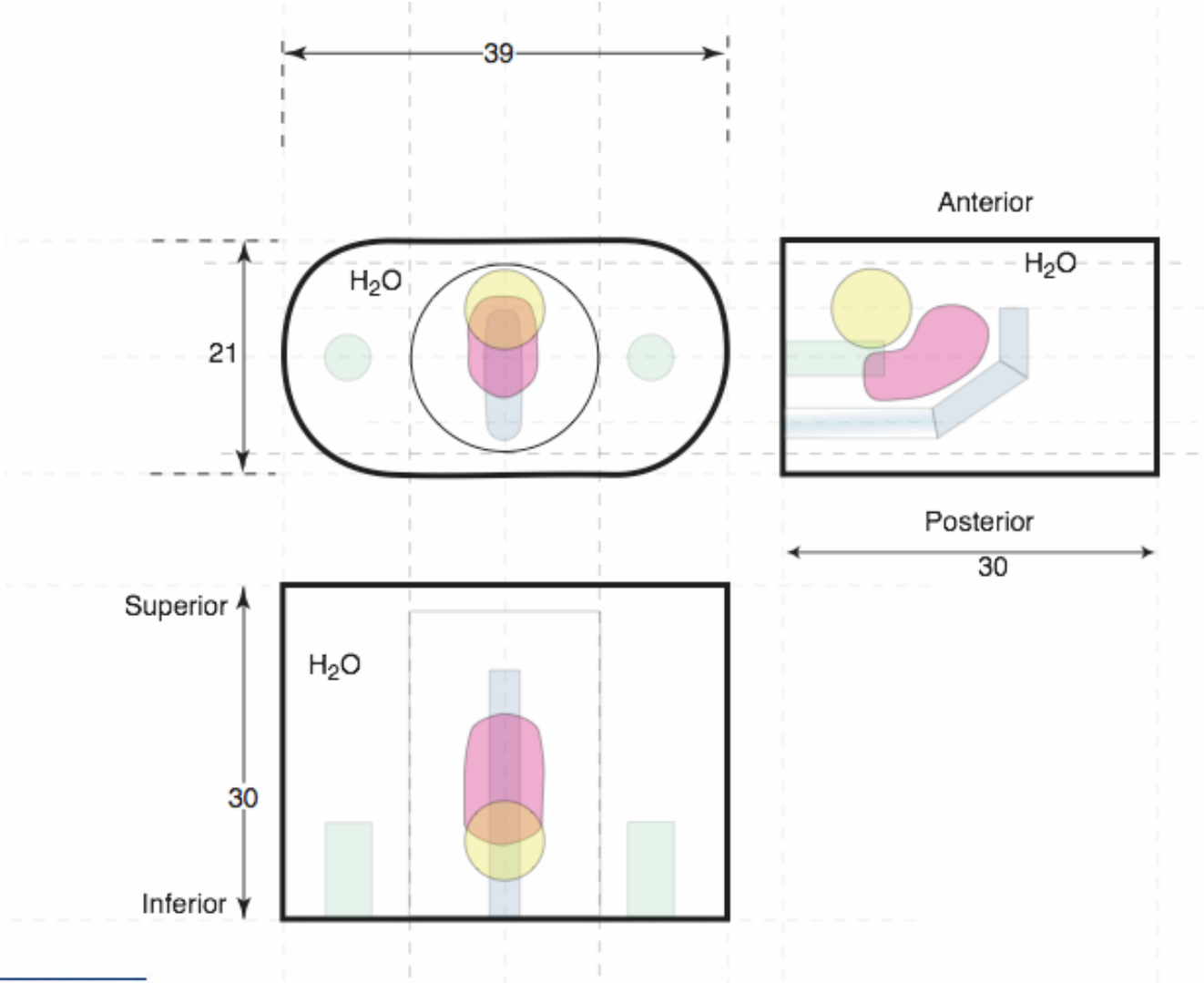




Summary of Gamma-Index Comparison



Gynecological Insert for Pelvic Phantom



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Improvements to Remote Audits

- Alternatives to Lithium Fluoride, automatic TLD readers
- Elimination of %DD measurements
- Expanded audits: non-reference dosimetry, other detectors
- Introduction of Monte Carlo-calculations
  - Supplement “Standard Data”
  - Facilitate validation of complex treatments

Proton Beam Clinical Trials

- Project to investigate radiochromic film
- Anticipate additional projects
  - Other dosimeters
  - Phantoms
  - Visits
- Coordinating with MDACC

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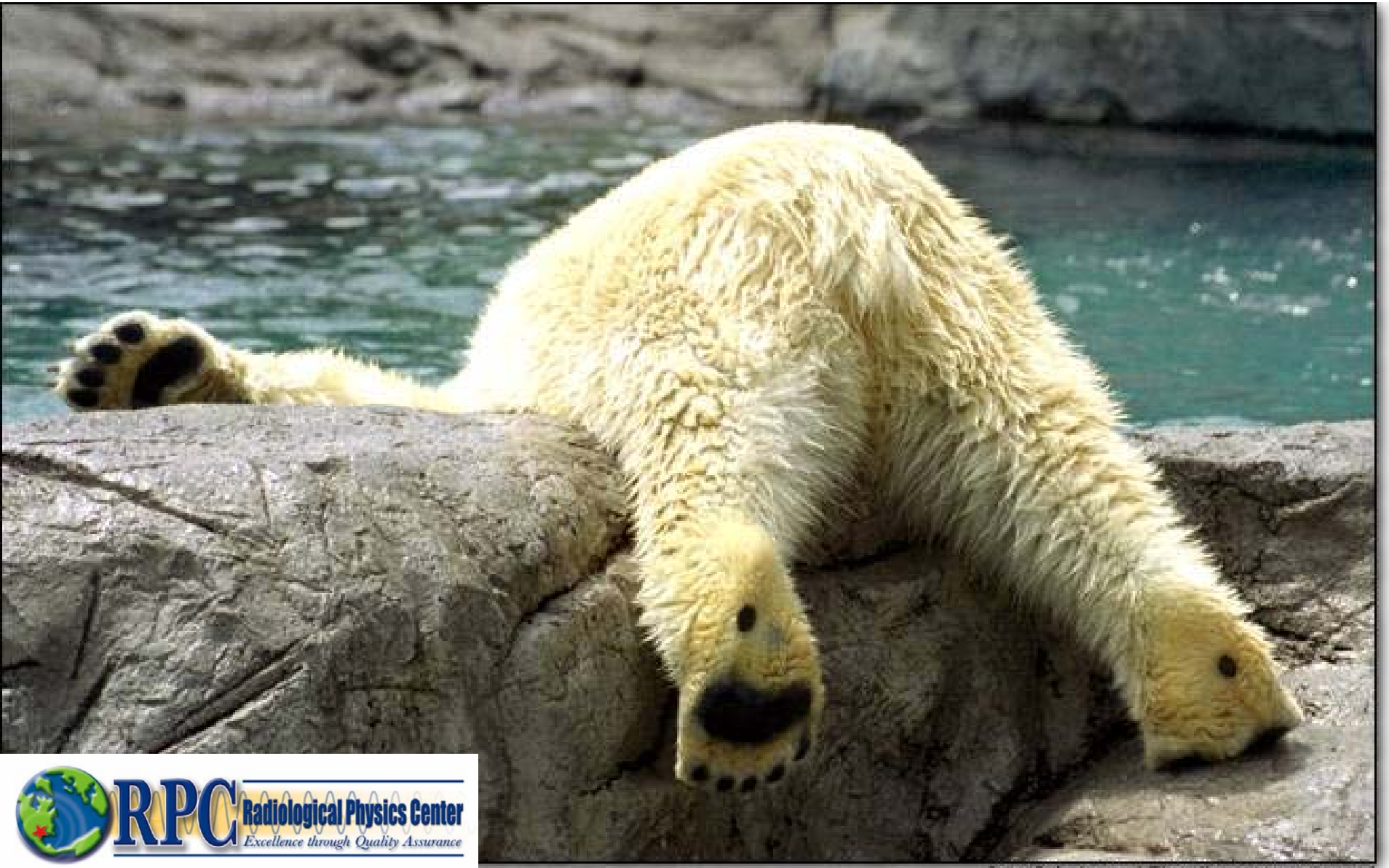
Other Aspects …

- Continue efforts to improve efficiency and service
- Further implement electronic data exchange
- Remain vigilant to needs of study groups and community

The End



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