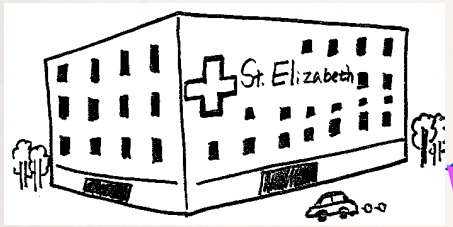
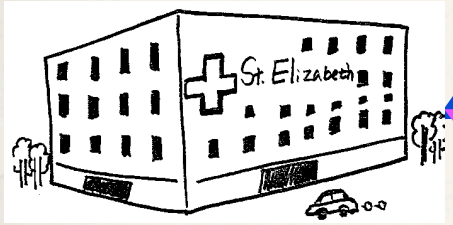
The RPC's Evaluation of Advanced Technologies

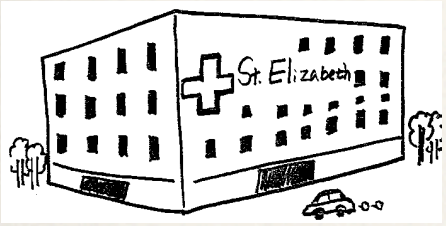
Geoffrey S. Ibbott, Ph.D.
and RPC Staff

QA Infrastructure for Clinical Trials

Participating Institutions







Cooperative Groups
ACRIN

Funding Agency

NATIONAL CANCER INSTITUTE

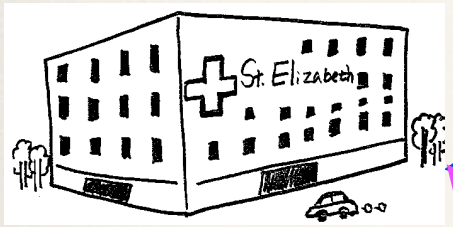
RPC QA Office

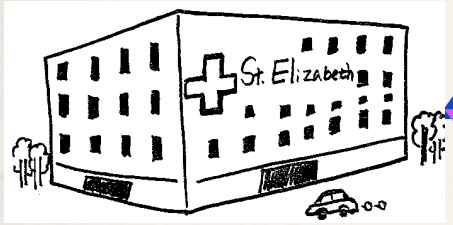
RPC Radiological Physics Center

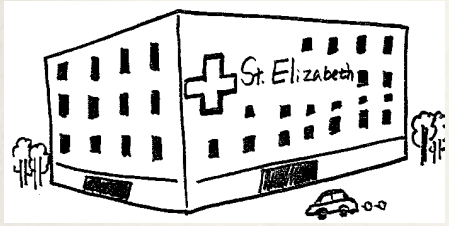
AAPM July 27, 2009

QA Infrastructure for Clinical Trials

Participating Institutions







Cooperative Groups

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AAPM July 27, 2009

Radiological Physics Center

- Formed when AAPM received funding from NCI and announced competition
- Founded in 1968 to monitor institution participation in clinical trials
- Funded continuously by NCI as structure of cooperative group programs have changed
- Now 40 years of experience of monitoring institutions and reporting findings to study groups and community

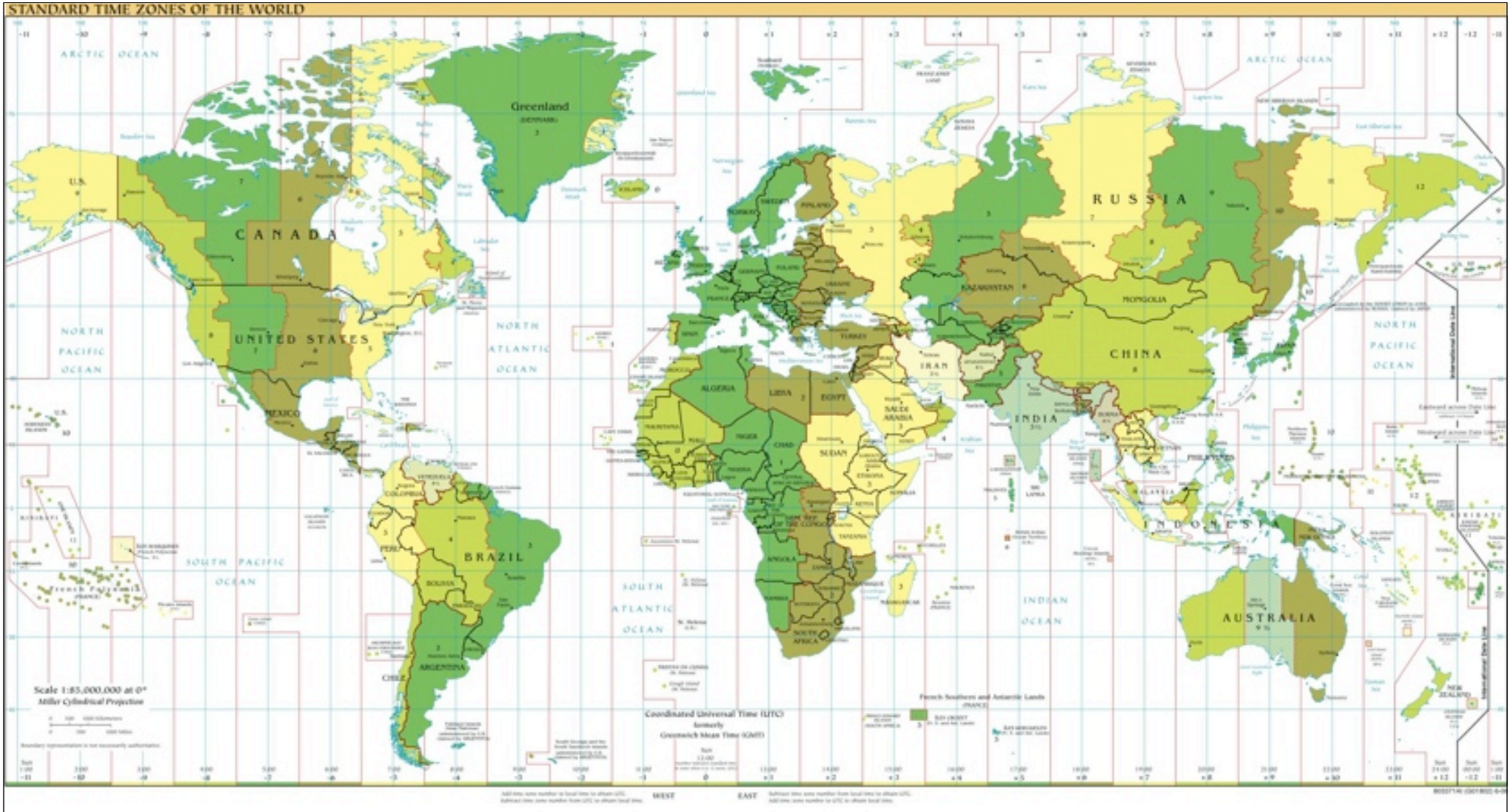
Mission

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 summarizing our findings for the radiation therapy community.

Mandate from the Cancer Trials Evaluation Program (CTEP)

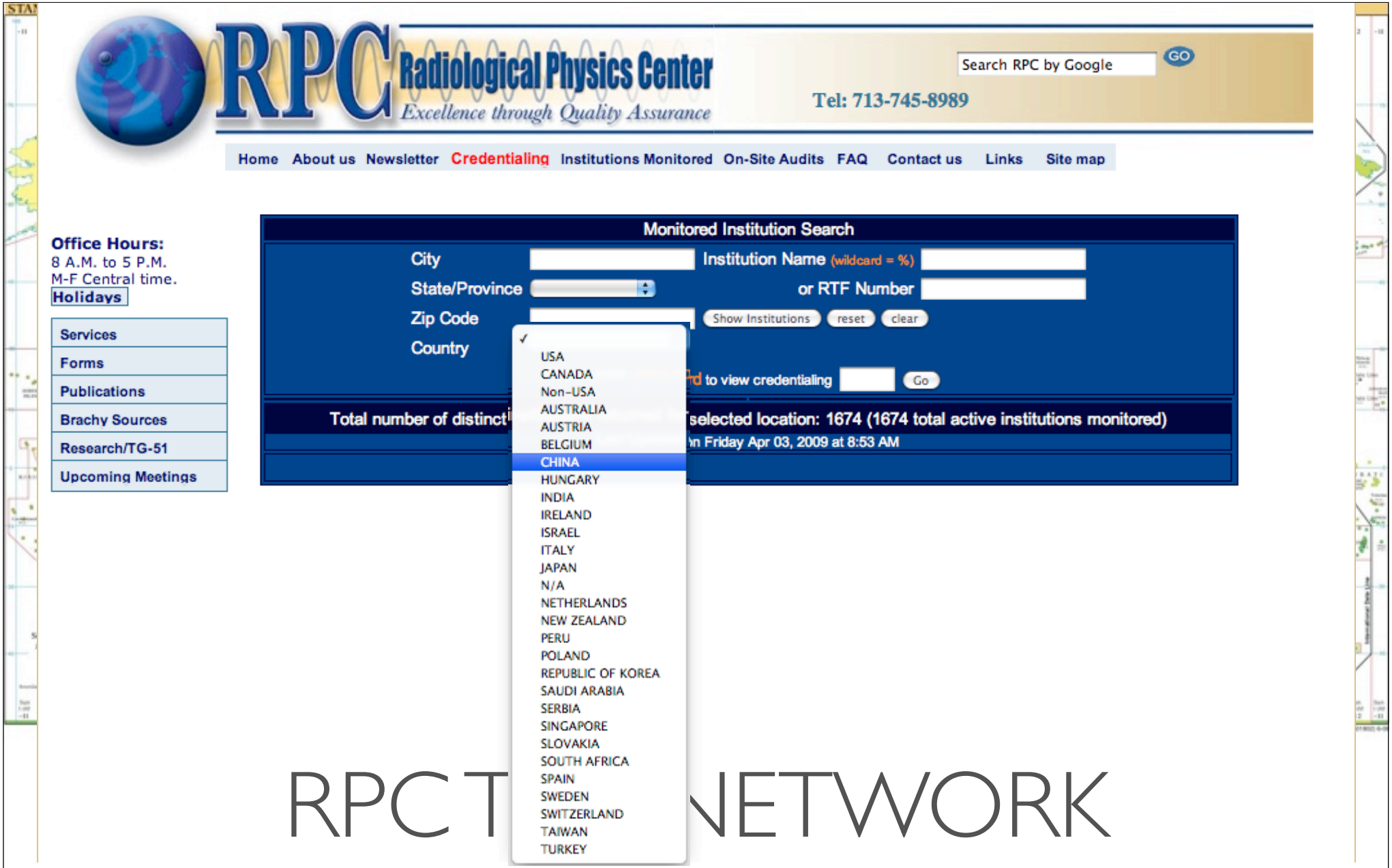
Components of a QA Program

- Remote audits of machine output
  - 1,674 institutions, 14,188 beams measured with TLD (2008)
- Treatment record reviews
  - Review for GOG, NSABP, NCCTG, RTOG (brachy)
- Independent recalculation of patient dose
  - Continue to find errors
- On-site dosimetry reviews
  - 50 institutions visited (~150 accelerators measured)
- Credentialing
  - Phantoms, benchmarks, questionnaires, rapid reviews



RPC TLD NETWORK

1,674 RT facilities in 27 countries throughout the world, including 58 EORTC members



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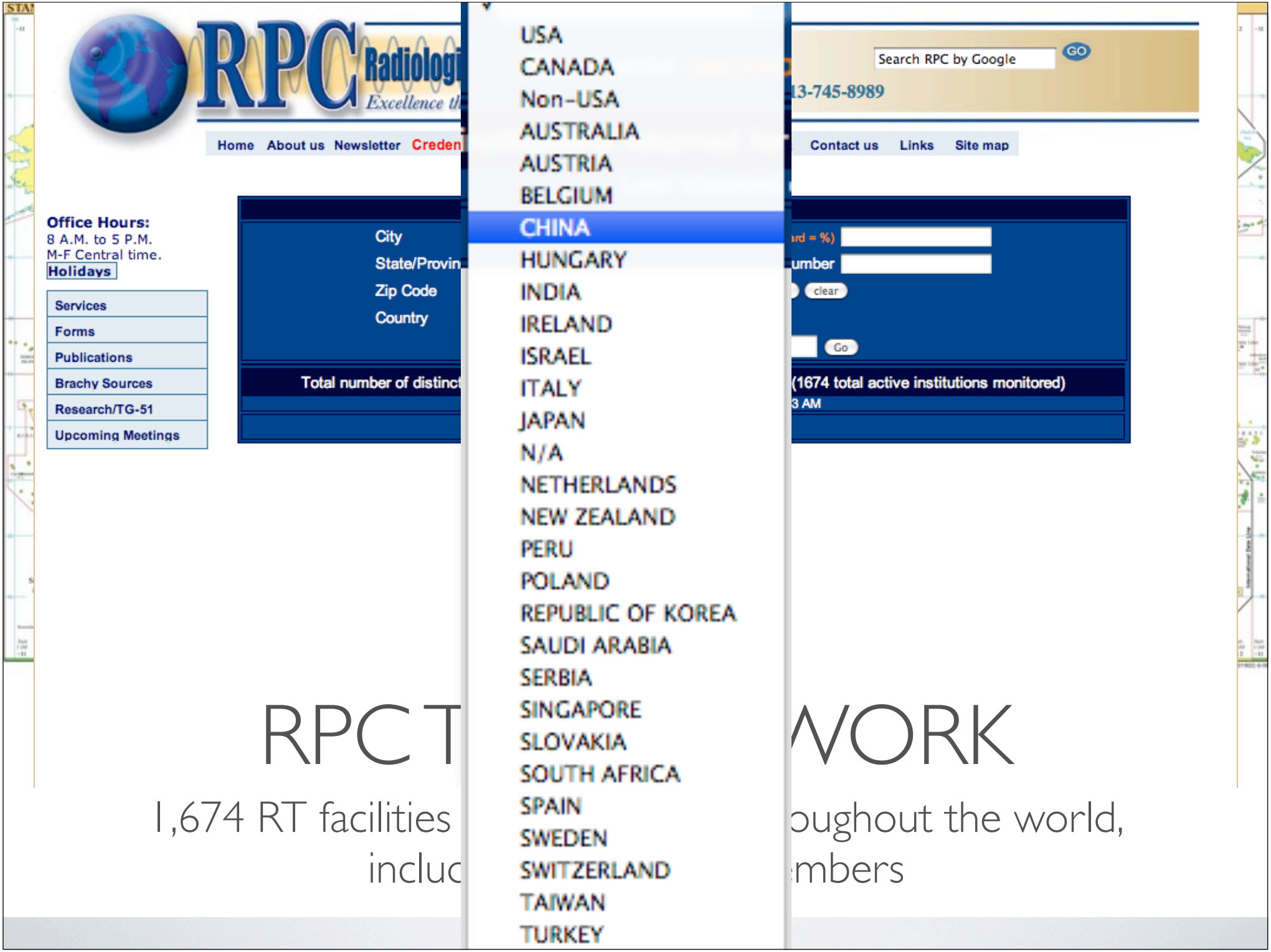


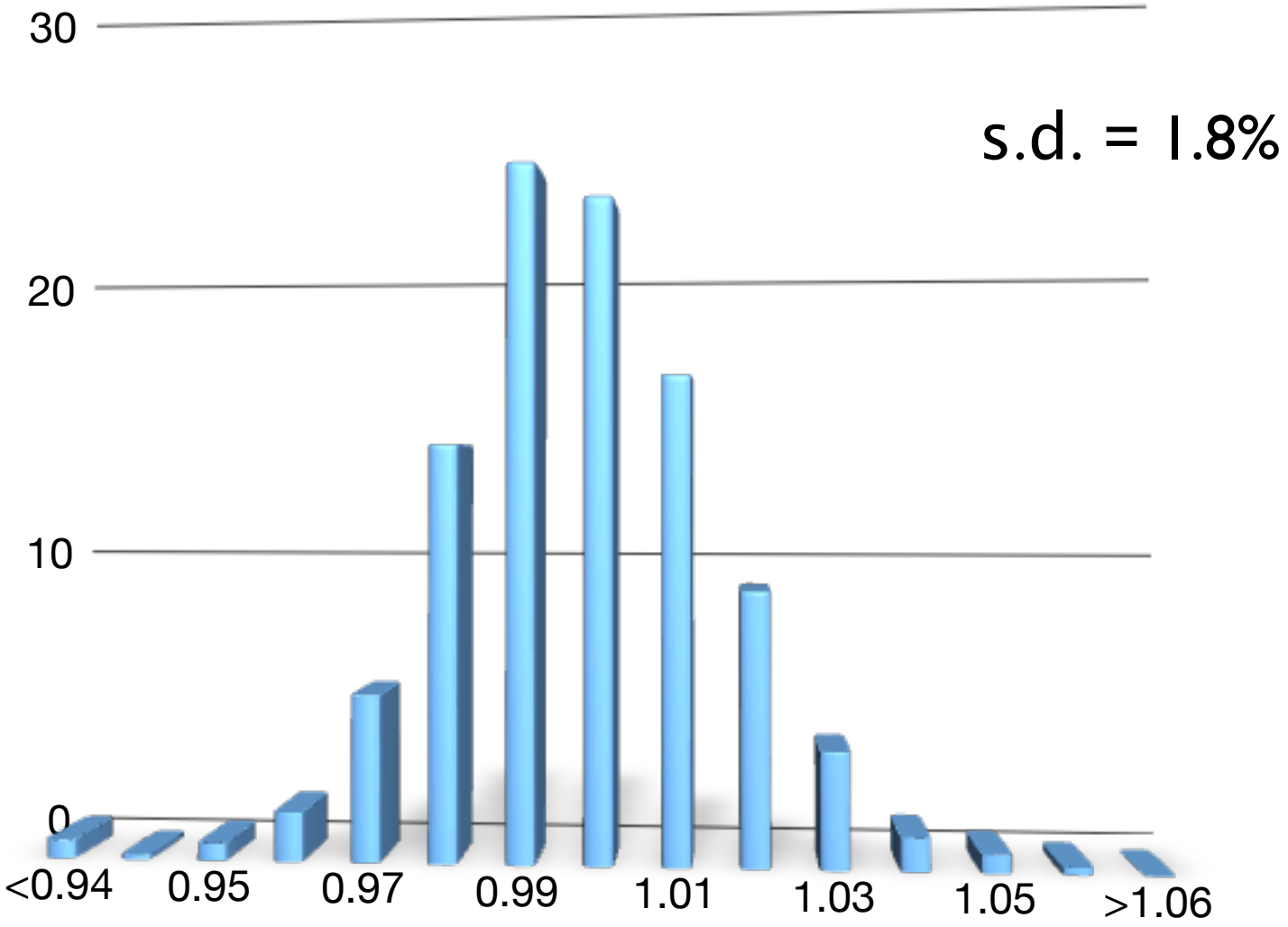
RPC T WORK

1,674 RT facilities oughout the world, inclu mbers

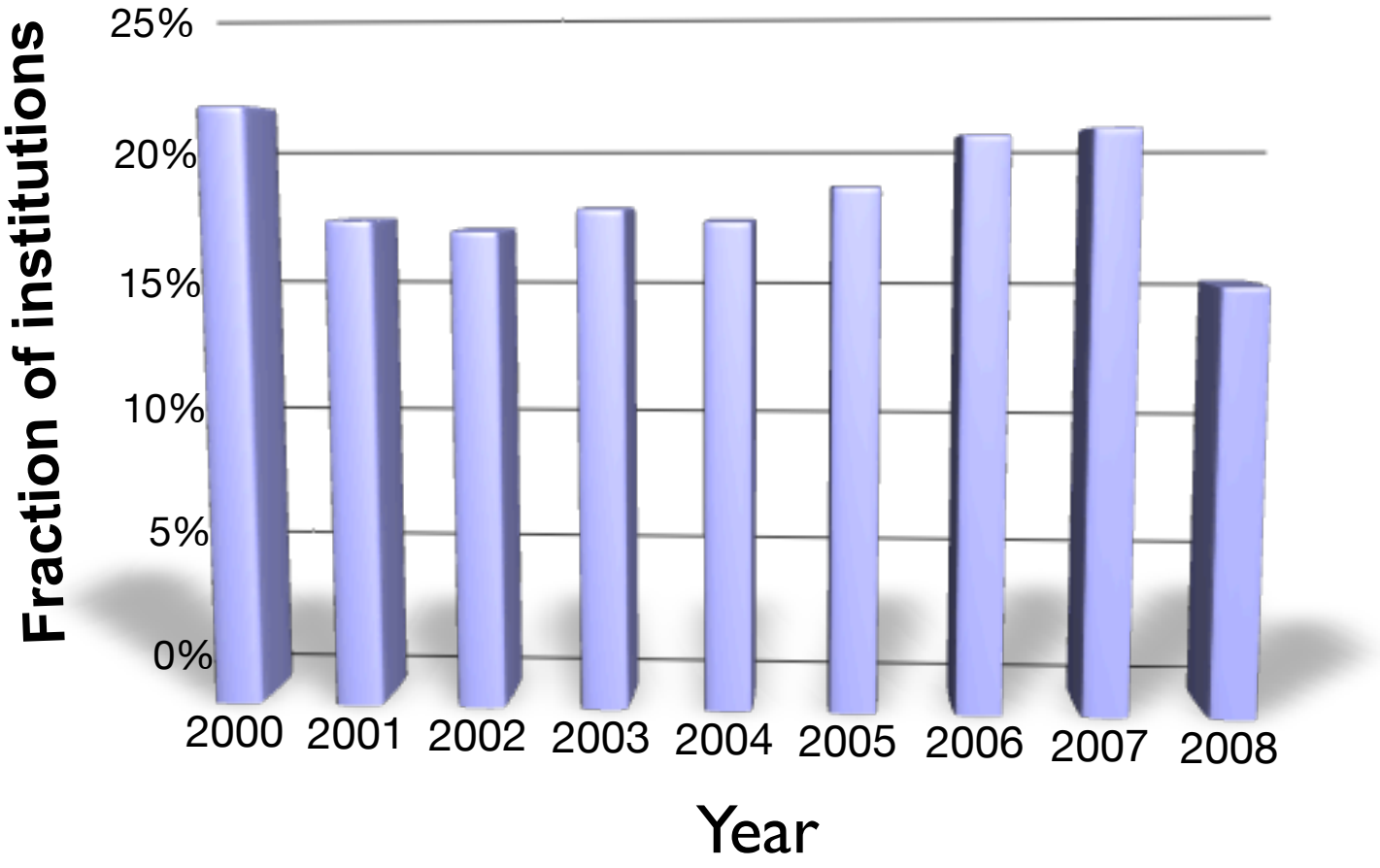
TLD IRRADIATION

Institutions receive acrylic block containing dosimeters

Distribution of Photon Beam TLD Measurements



Institutions with One or More Unacceptable TLD Measurements



Benefits of the TLD Program

- Helps institutions stay vigilant
- Problems contribute to priorities for visits
- May satisfy state/local requirements for independent review
- Identifies problems that have direct impact on every patient treated
- It is a model for other remote programs

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Followill Poster SU-FF-T-320

Components of a QA Program

- Annual checks of machine output
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RPC Patient Dose Review

- Independent calculation of tumor dose
- Agree within 5% (15% for implants)
- Verify dose, time, fractionation per protocol
- Notify institution if major deviation seen during review to prevent further deviations

RPC Patient Dose Review

- Independent calculati… dose
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Lowenstein Poster SU-FF-T-25

Components of a QA Program

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  - Continue to find errors
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  - 50 institutions visited (~150 accelerators measured)
- Credentialing
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On-Site Dosimetry Review Visit

- **The <u>only</u> completely independent comprehensive radiotherapy quality audit in the USA and Canada**
  - Identify errors in dosimetry and QA and suggest improvements.
  - Collect and verify dosimetry data for chart review.
  - Improve quality of patient care.

On-Site Dosimetry Review

Selected discrepancies discovered 2004 – 2008

Errors Regarding	Number of Institutions (%)
Review QA Program	127 (77%)
*Wedge Transmission	53 (32%)
*Photon FSD (small fields)	46 (28%)
Off-Axis, Beam Symmetry	42 (25%)
*Photon Depth Dose	34 (21%)
*Electron Calibration	25 (15%)
*Photon Calibration	22 (13%)
*Electron Depth Dose	19 (12%)

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

Components of a QA Program

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Credentialing

Why?

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

Reduce deviation rate

General Credentialing Process

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

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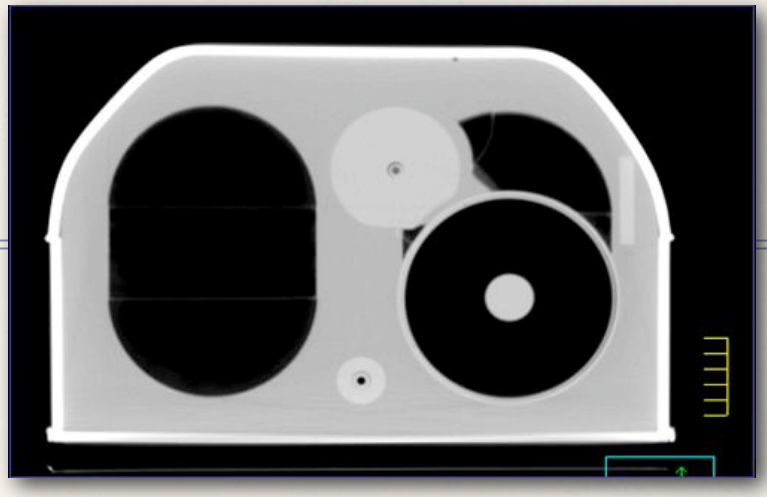
RPC Phantoms

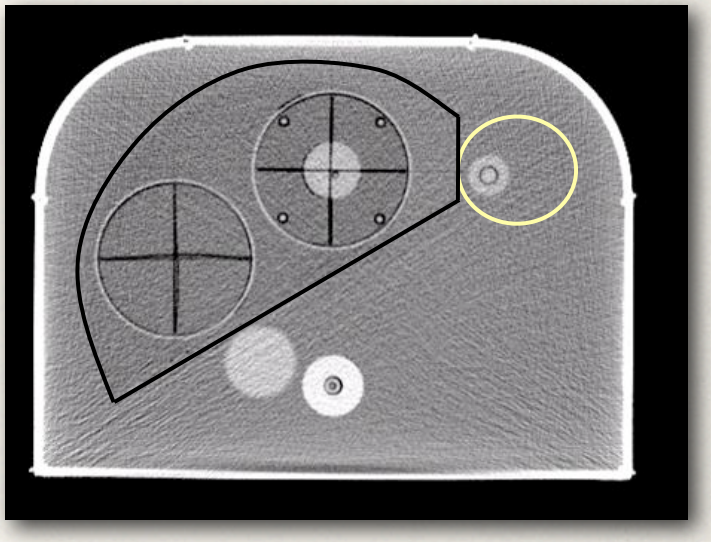
Pelvis (10)



Thorax (13)

H&N (31)

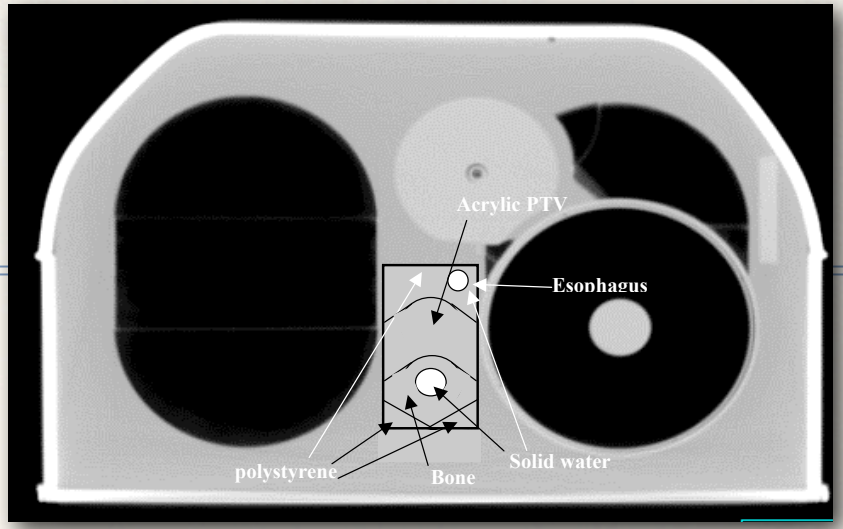
SRS Head (4)



Liver (2)

RPC Phantoms

Pelvis (10)



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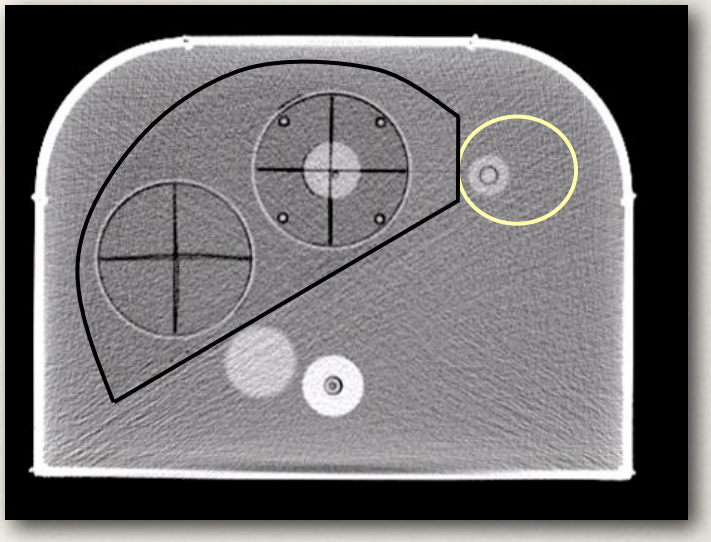
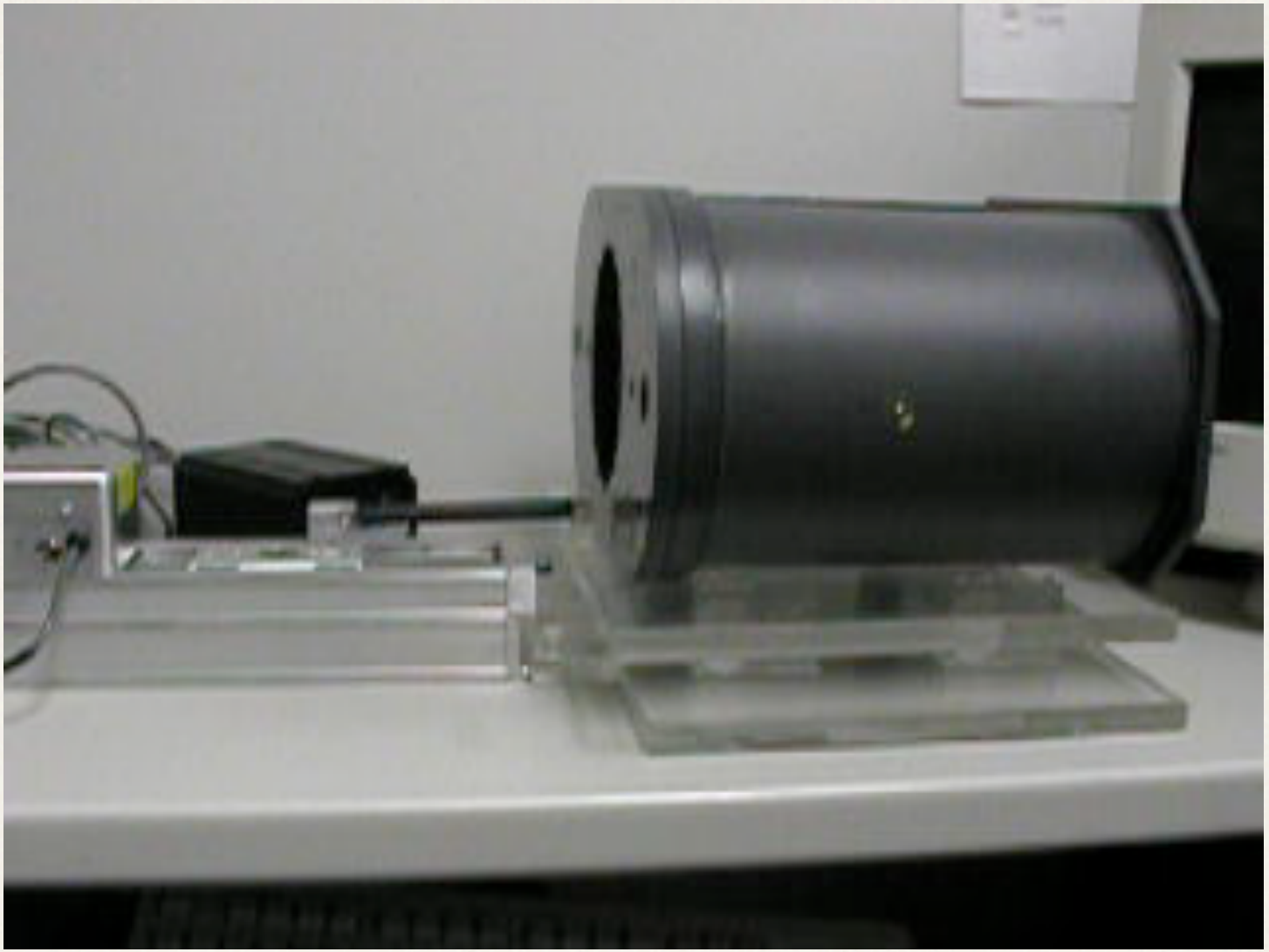


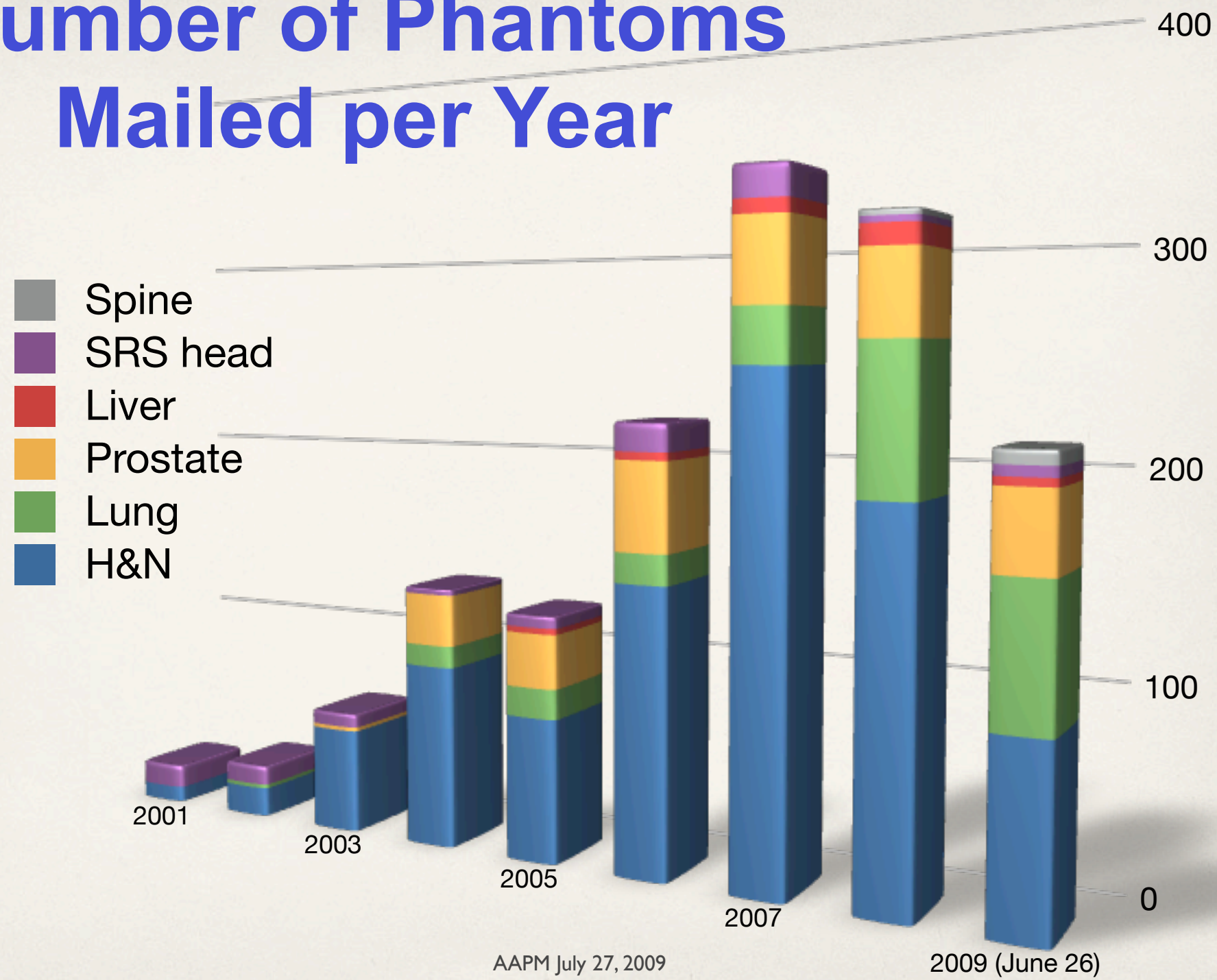
Liver (2)

Lung Phantom and Moving Platform



AAPM July 27, 2009

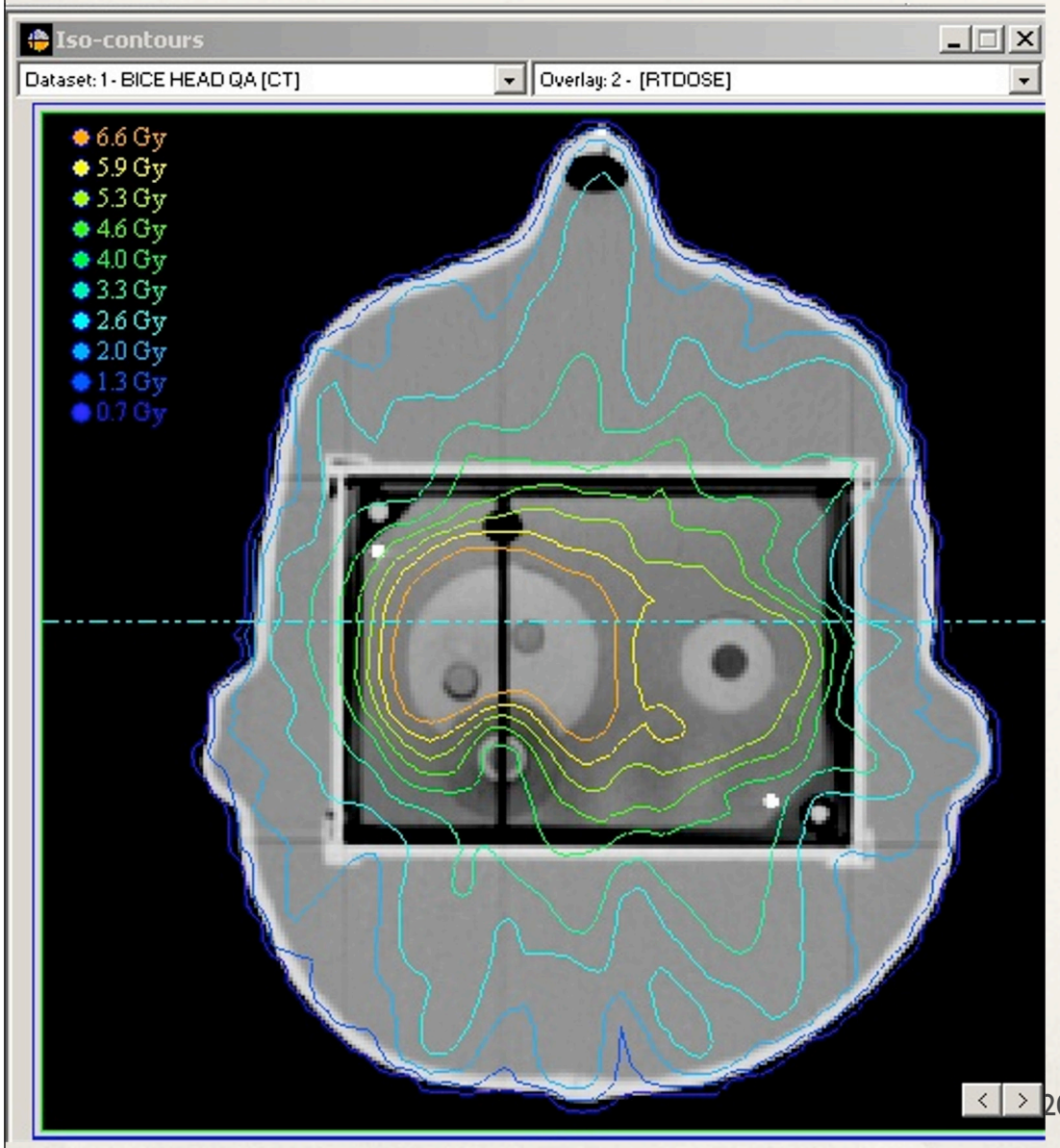
Number of Phantoms Mailed per Year



Treat phantom as if it were a patient

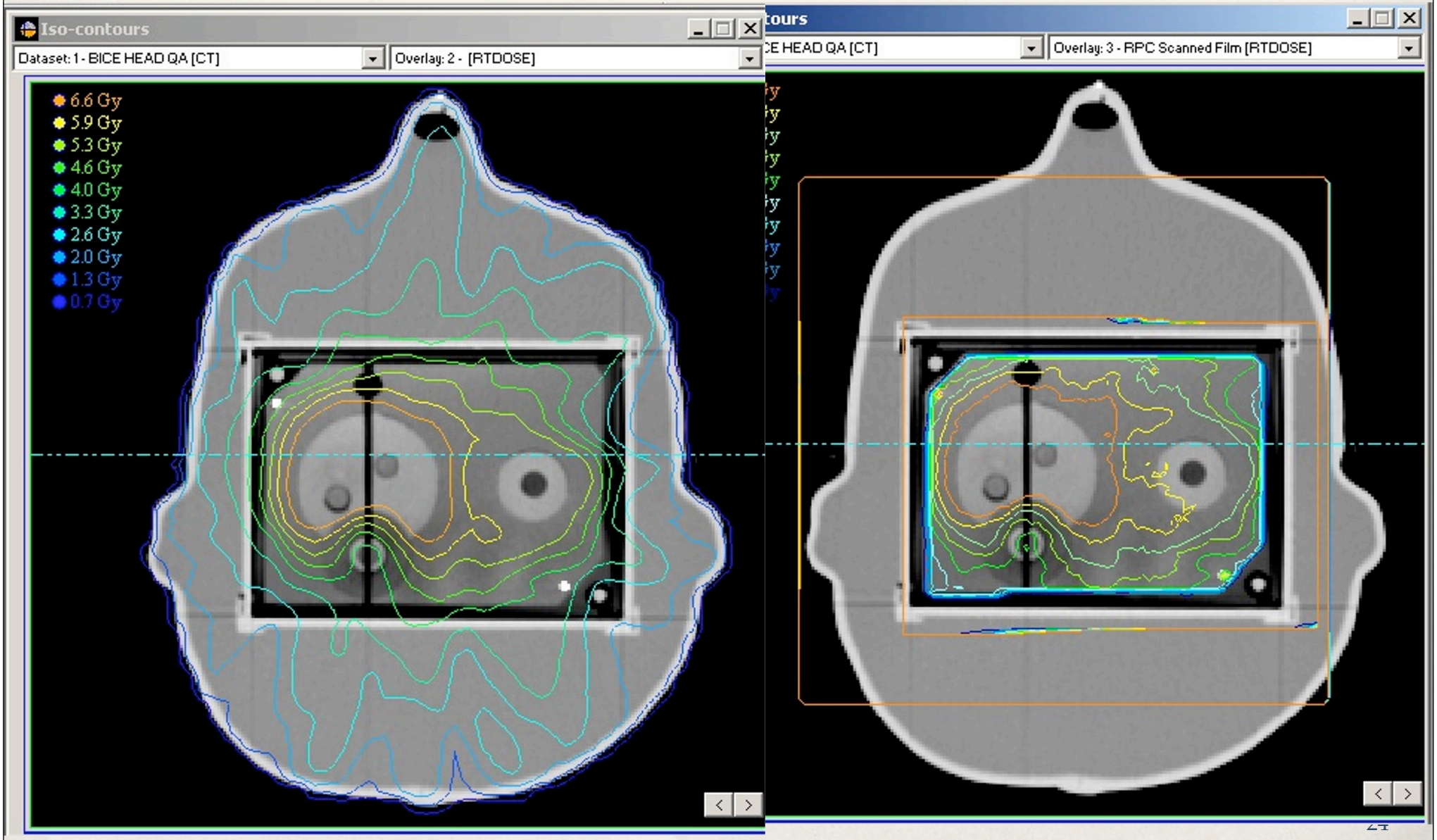
Deliver treatment

RPC Compares Treated Distribution with Plan



2009

RPC Compares Treated Distribution with Plan



Phantom Results

Comparison between institution's plan and delivered dose.

Criteria for agreement: 7% or 4 mm DTA (5%/5mm for lung)

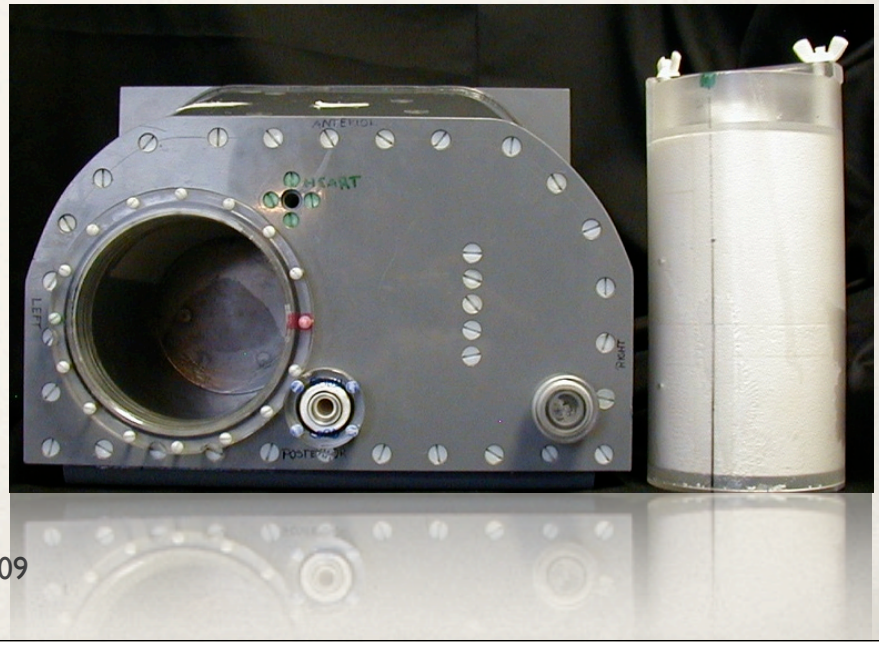
Site	Institutions	Irradia-tions	Pass
H&N	472	631	75%
Pelvis	108	130	82%
Lung	67	77	71%
Liver	15	18	50%

Explanations for Failures

Explanation	Minimum # of occurrences
incorrect output factors in TPS	1
incorrect PDD in TPS	1
IMRT Technique	3
Software error	1
inadequacies in beam modeling at leaf ends (Cadman, et al; PMB 2002)	14
QA procedures	3
errors in couch indexing with Peacock system	3
equipment performance	2
setup errors	7

Questions raised regarding RPC Credentialing Programs

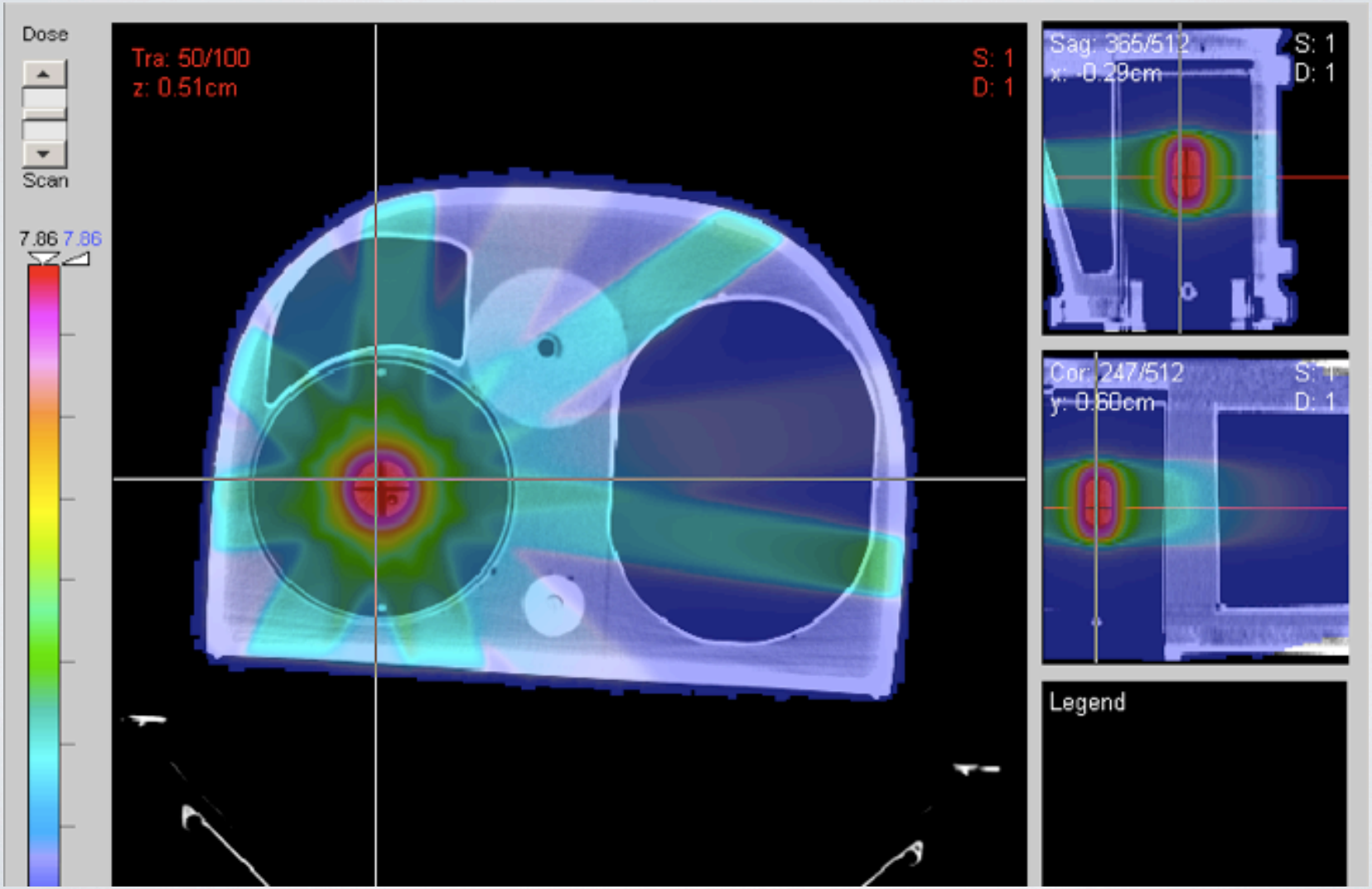
- Credentialing process for lung protocols criticized in AAPM poster
- RTOG protocols (e.g., 0618, 0813) require RPC lung phantom
- ALL phantoms are commissioned, manufacturing verified, film registration confirmed, TLD dosimetry checked.
- Lung phantom was irradiated ≥ 50 times to assure reproducibility and accuracy



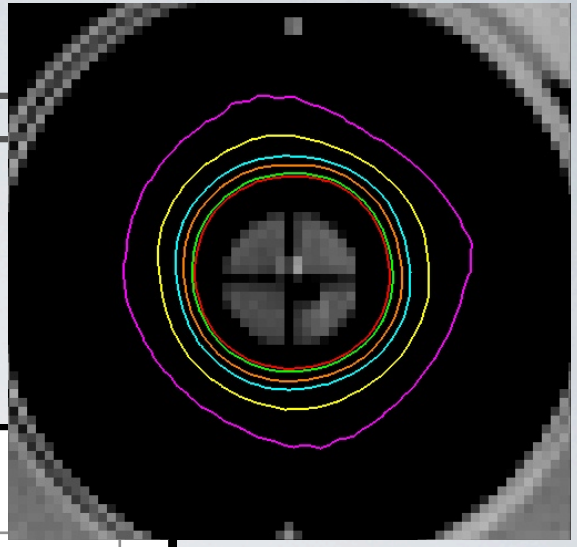
Criticisms of RPC Lung Phantom

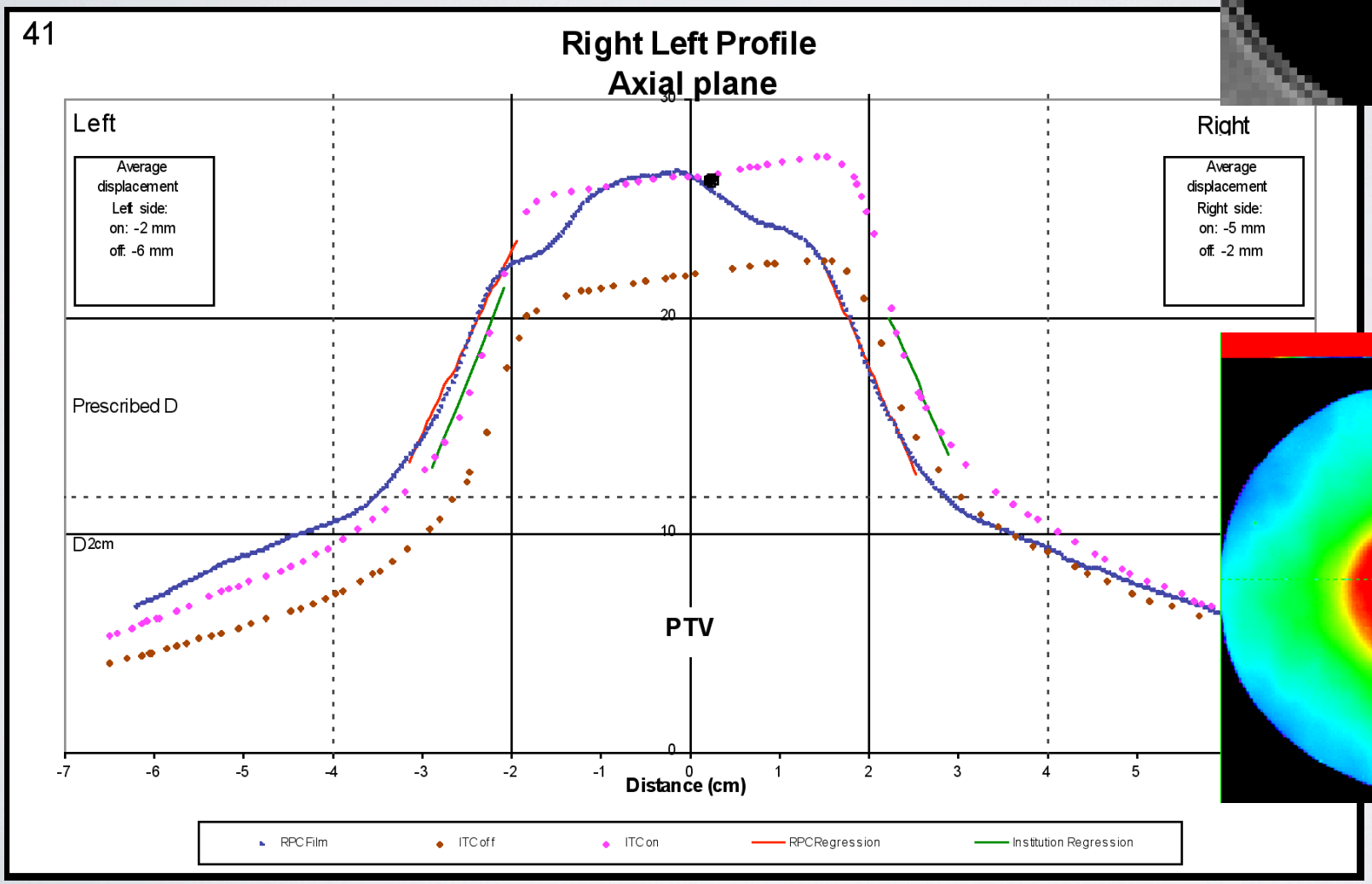
- Procedure required homogeneous calculation, then correction turned on
  - Was a requirement of older protocol (institution began process >2 years ago
  - Current protocols (and phantom procedures) require heterogeneous calculation
- Suggestion that this increased dose gradients
  - No evidence; data demonstrate uniform distribution

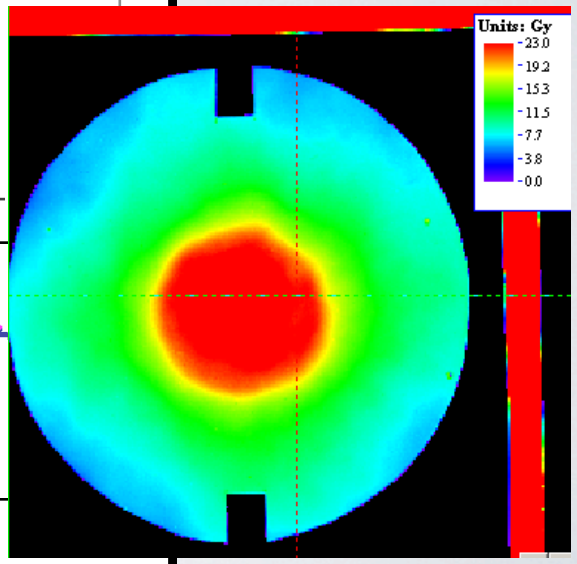
INSTITUTION'S PLAN



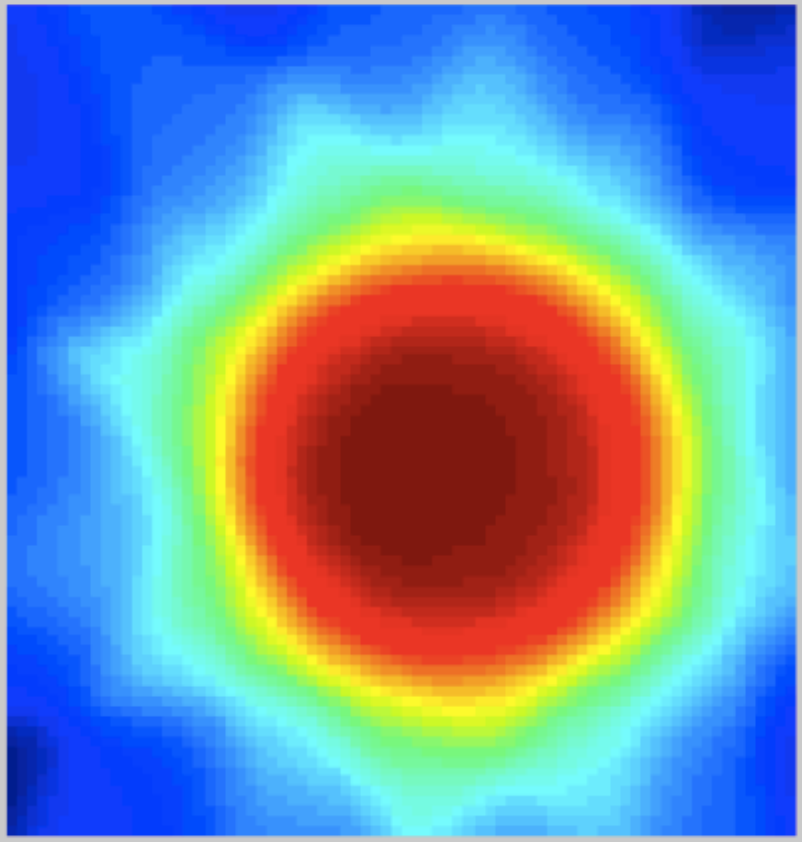
PENCIL-BEAM PROF

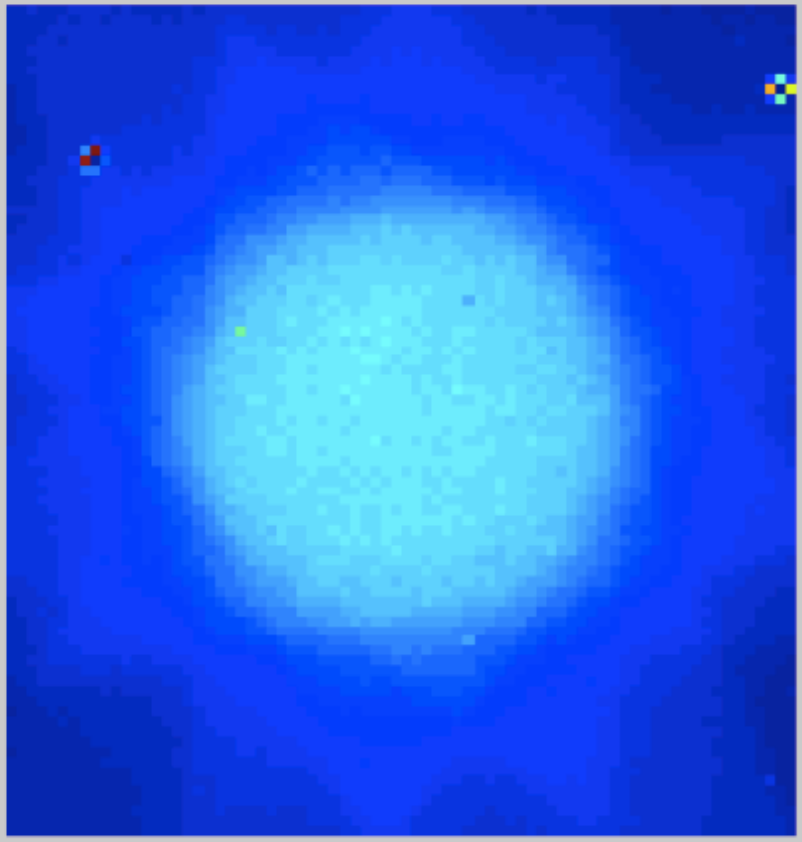






2D GAMMA INDEX EVALUATION CONVOLUTION ALGORITHM





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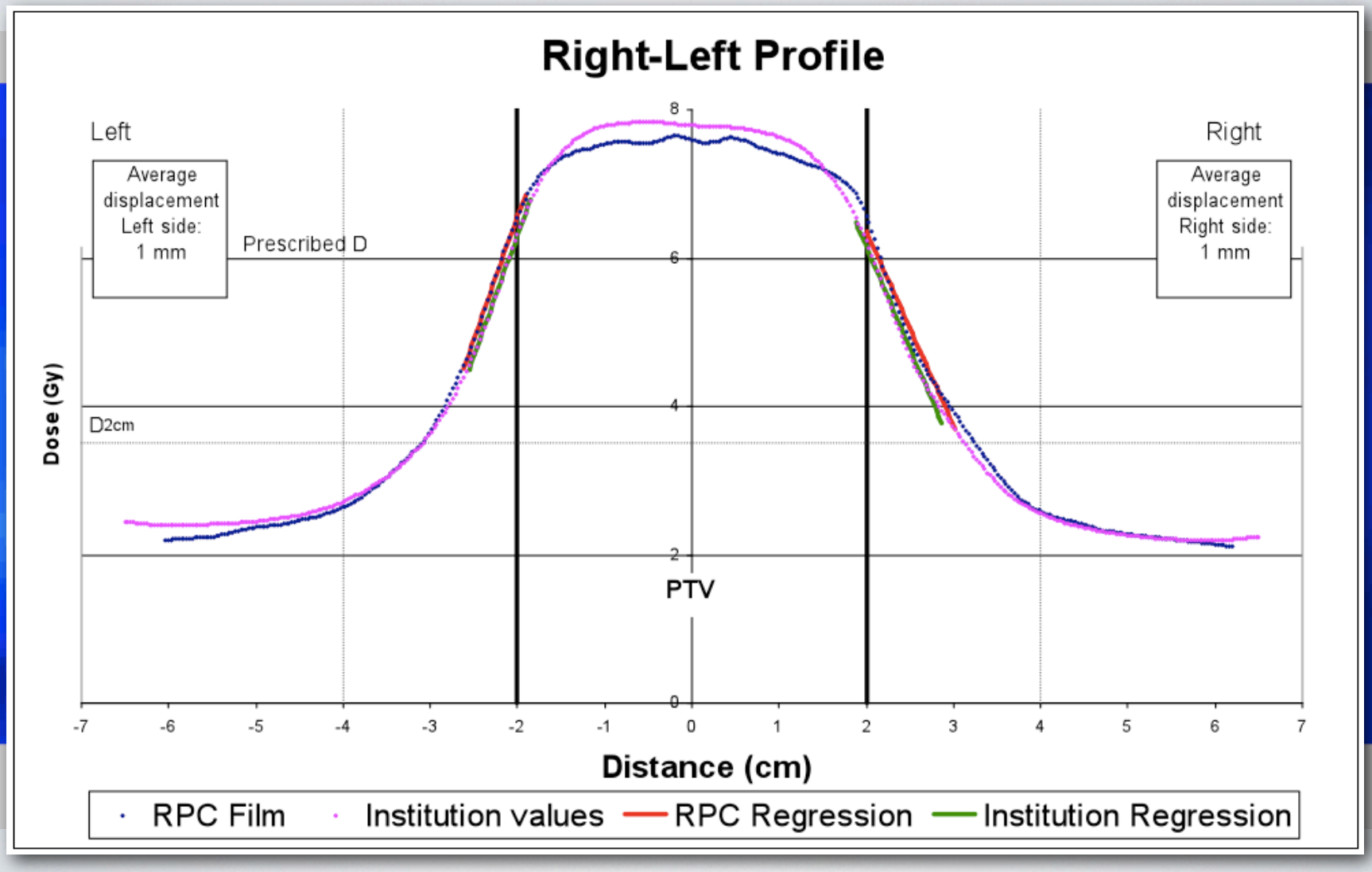

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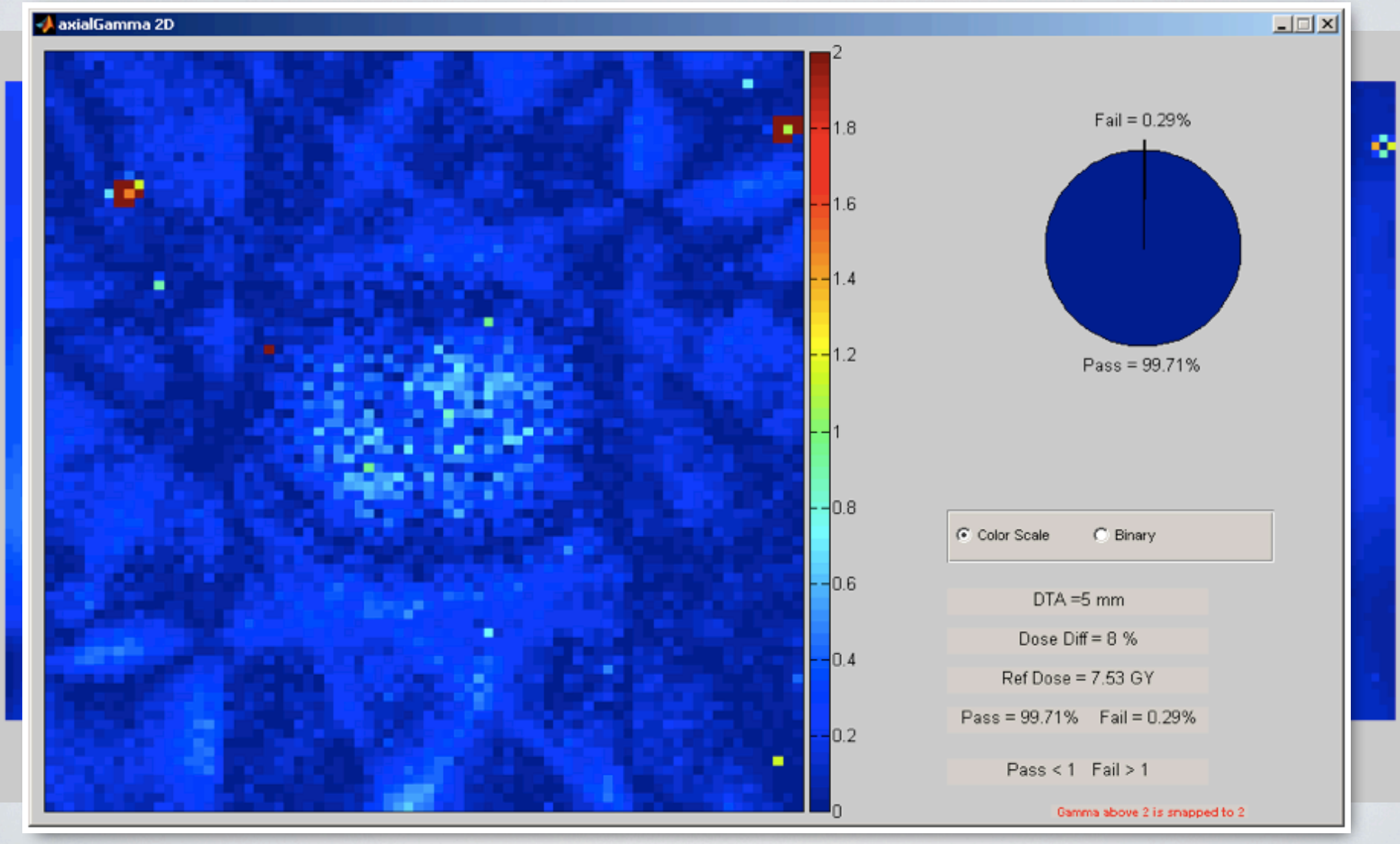

Criticism of RPC TLD System

- Volume of TLD too large
- Measurements with 0.6 cc ion chamber presented for comparison

Criticism of RPC TLD System

- Volume of
- Measurem parison

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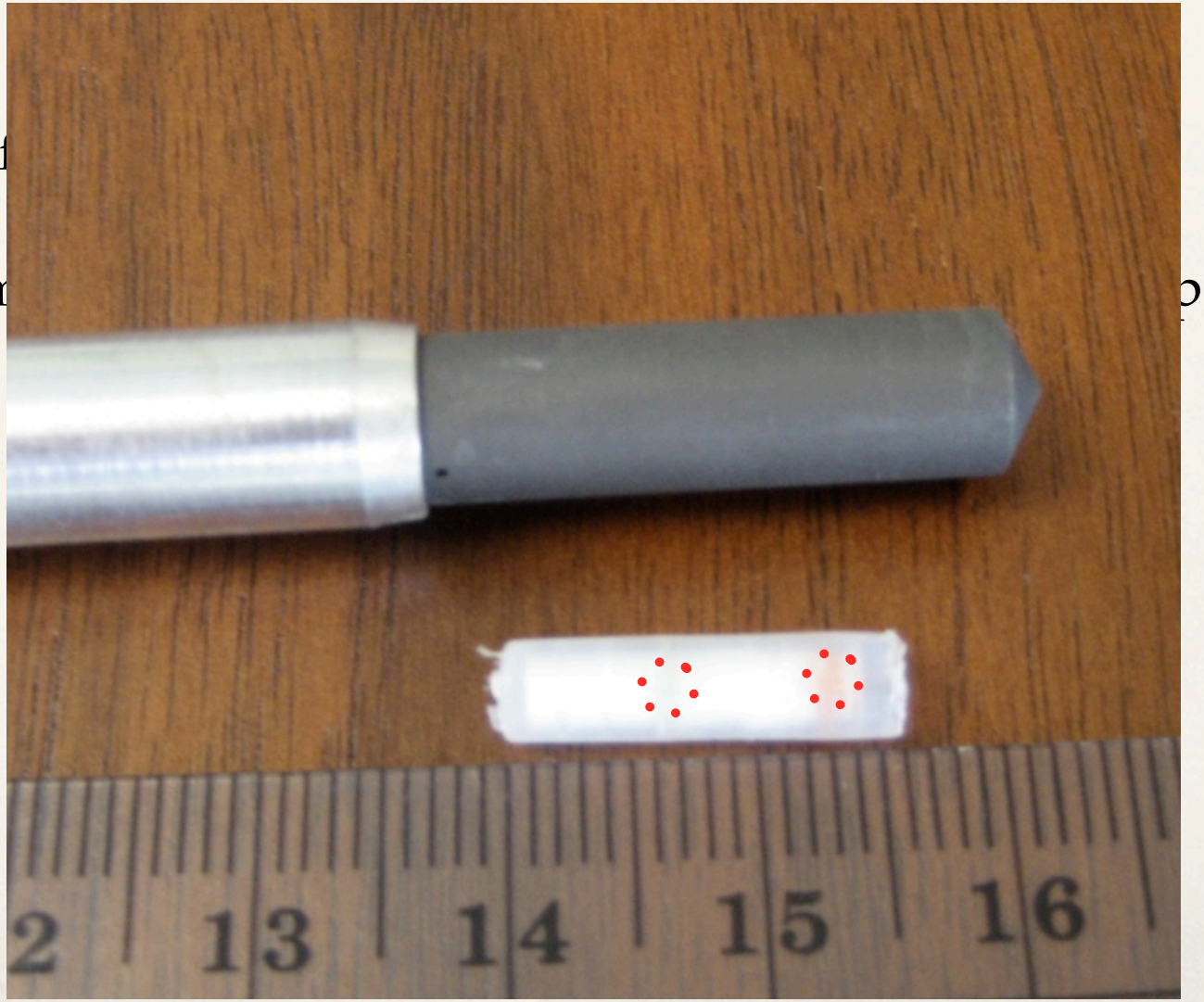

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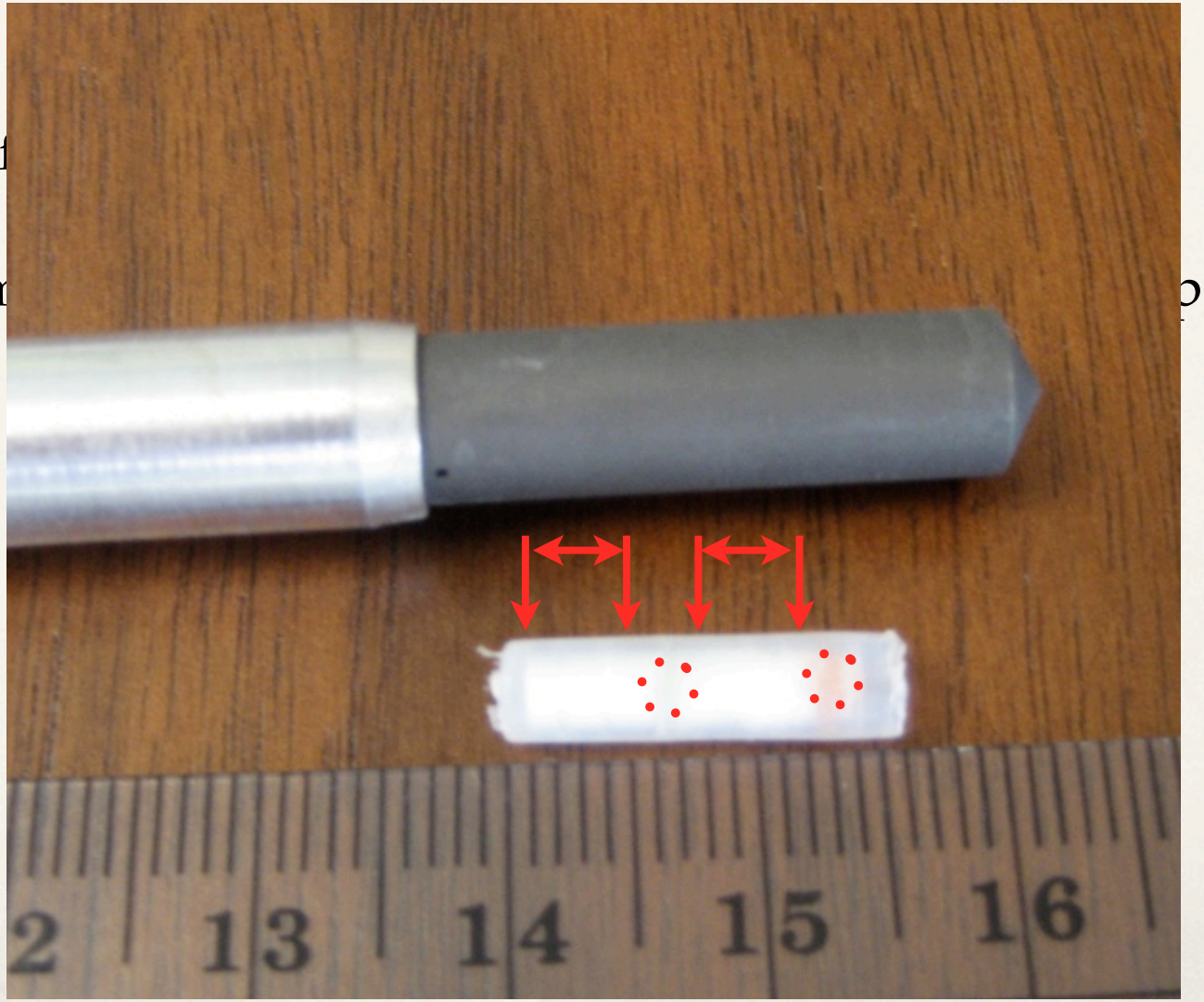

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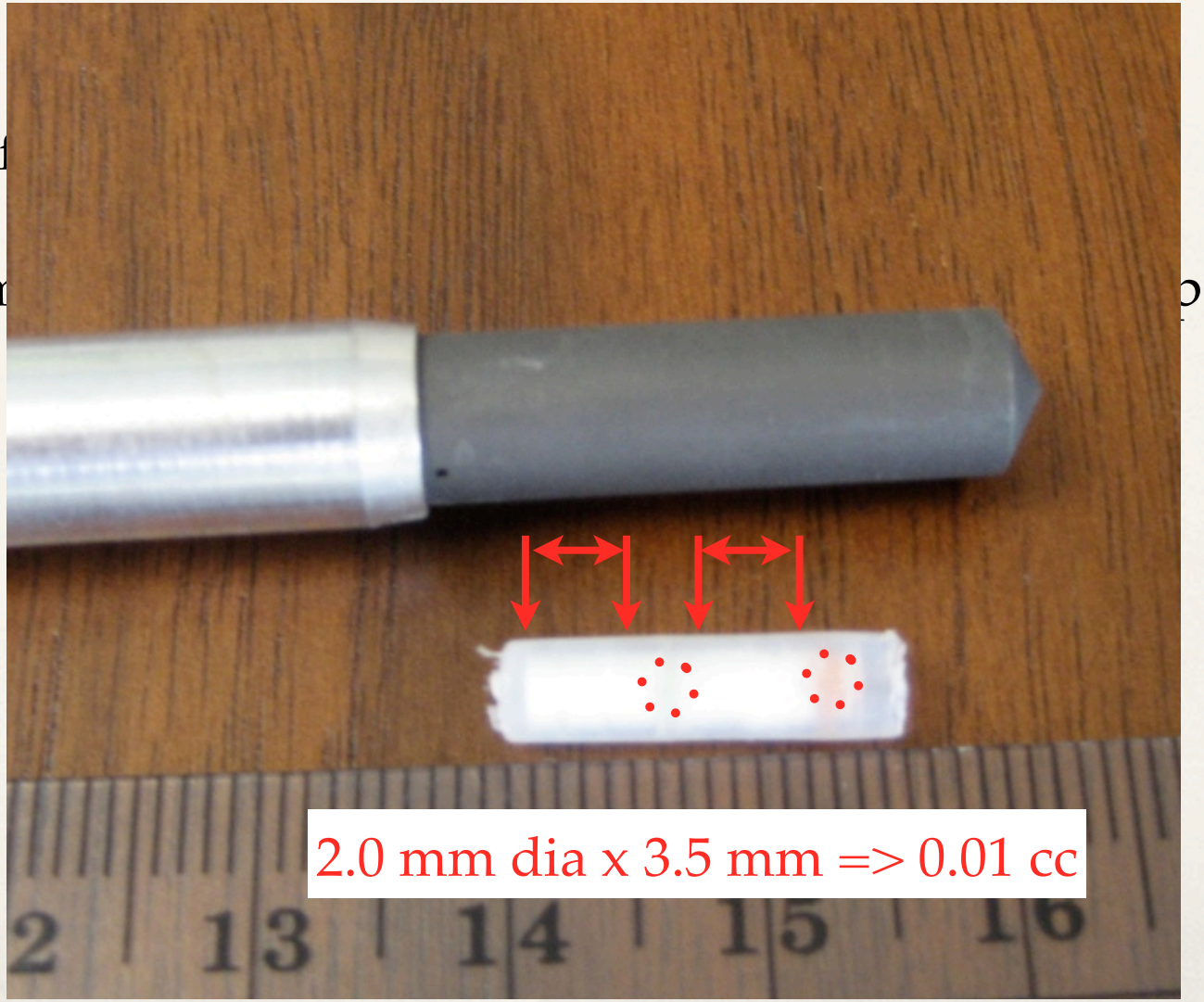
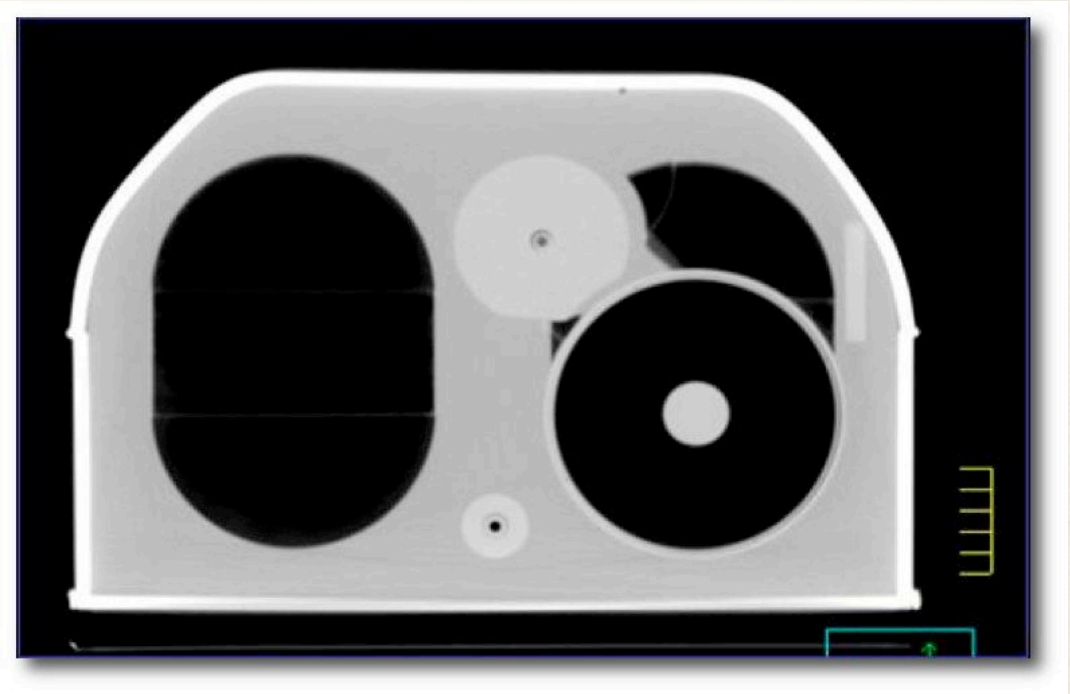


TLD Capsule vs. 0.6 cc Chamber [2]

- RPC measurements are in 1 g/cc "tumor"
- Institution put ion chamber in low density "lung"
- Raises questions about electronic equilibrium



Recent New Programs

- Adopt OSL in place of TLD program
- Ongoing evaluation of gel dosimetry
- RPC audits of Proton treatment centers
- Implementation of Monte Carlo planning
- International collaboration and harmonization

Optically Stimulated Luminescence (OSL) Dosimeters

- Detector material of aluminum oxide crystals (Al_2O_3:C)
- Landauer's InLight™ NanoDot™ dosimeters and microStar™ Reader

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- Landauer's InLight™ Nano[illegible]simeters and microStar™ Rea[illegible]

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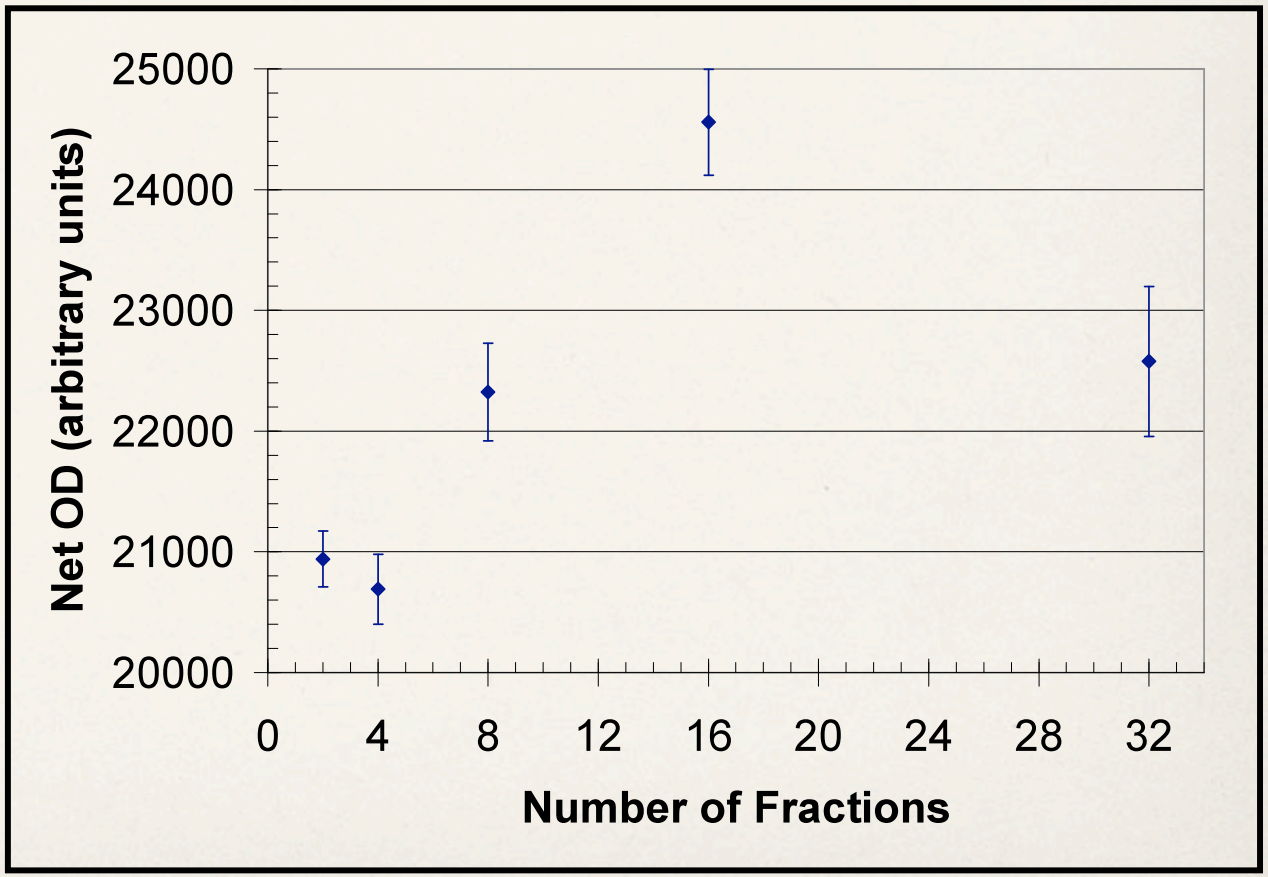
Evaluations of Gel Dosimetry

- Comparison of PAGAT gel response to fractionated radiation (e.g., IMRT)



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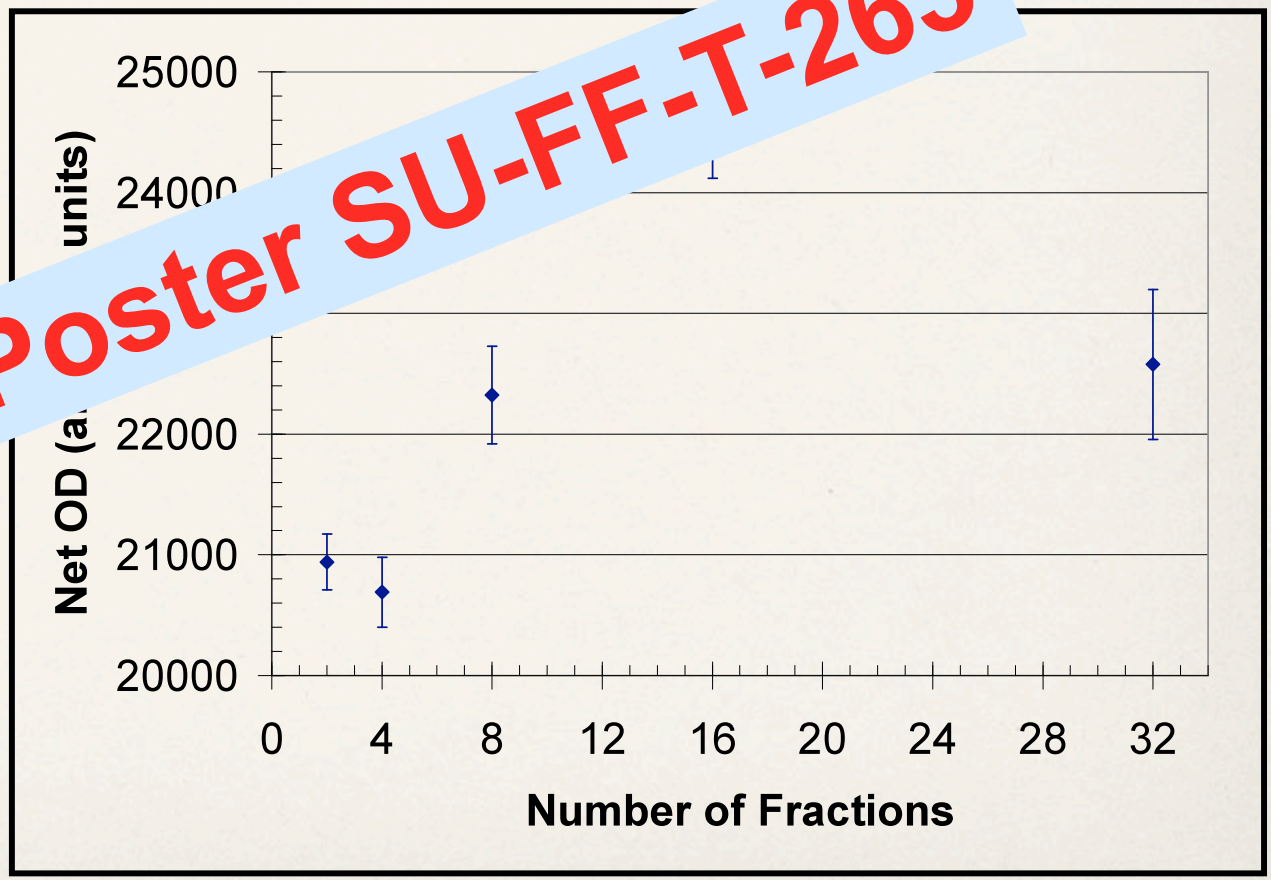


Heard Poster SU-FF-T-263

International Participation

- RPC has audited international institutions that are members of US study groups, as part of routine audits
- In 2007, RPC was approached by EORTC to consider offering TLD audits to EORTC members, at cost
- Following agreement among RPC, EORTC and NCI, EORTC began recommending RPC's TLD service to their members
- Subsequent meetings between RPC, EORTC, and other groups have been held to discuss expanding auditing procedures
- RPC now auditing 100 non North-American institutions
  - Including 58 EORTC members

International Study Groups

- RPC has developed relationships with several international clinical trials QA offices, leading to reciprocal visits and collaborations:
  - TROG – Trans-Tasman Radiation Oncology Group
  - EORTC – European Organization for Research and Treatment of Cancer
  - Japanese National Cancer Center: Outreach Radiation Oncology and Physics

G. Ibbott meeting with staff of Japanese center and viewing calibration facilities

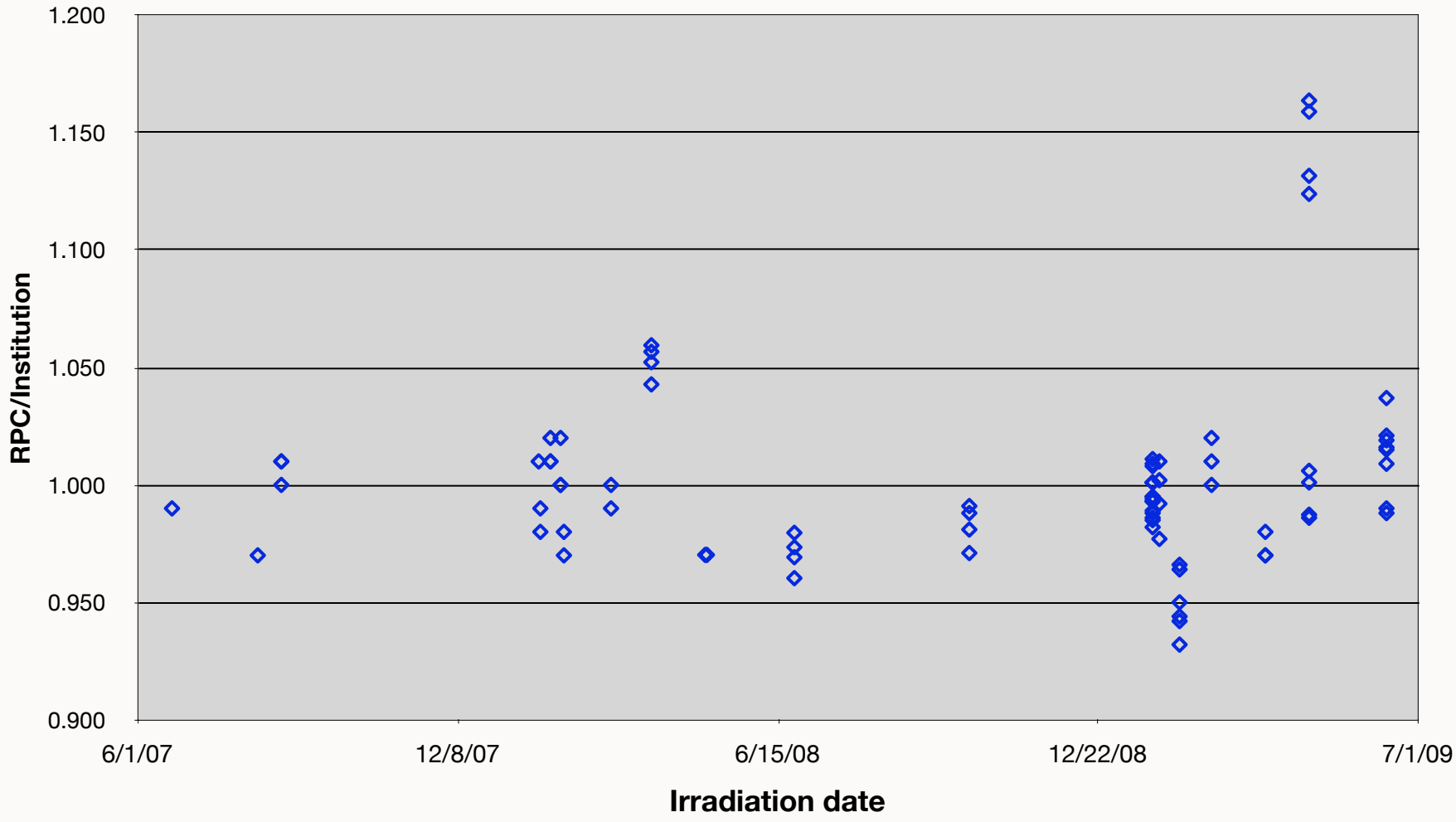
Irradiation of RPC Phantoms

- Through various arrangements, 18 international institutions have already irradiated RPC phantoms
- Arrangements are being discussed for providing phantoms to additional institutions in Europe, the Middle East, Australasia and Latin America
- Through agreement with the RTOG and NCI, international non-member institutions participating in RTOG trials will meet the same QA requirements as member institutions

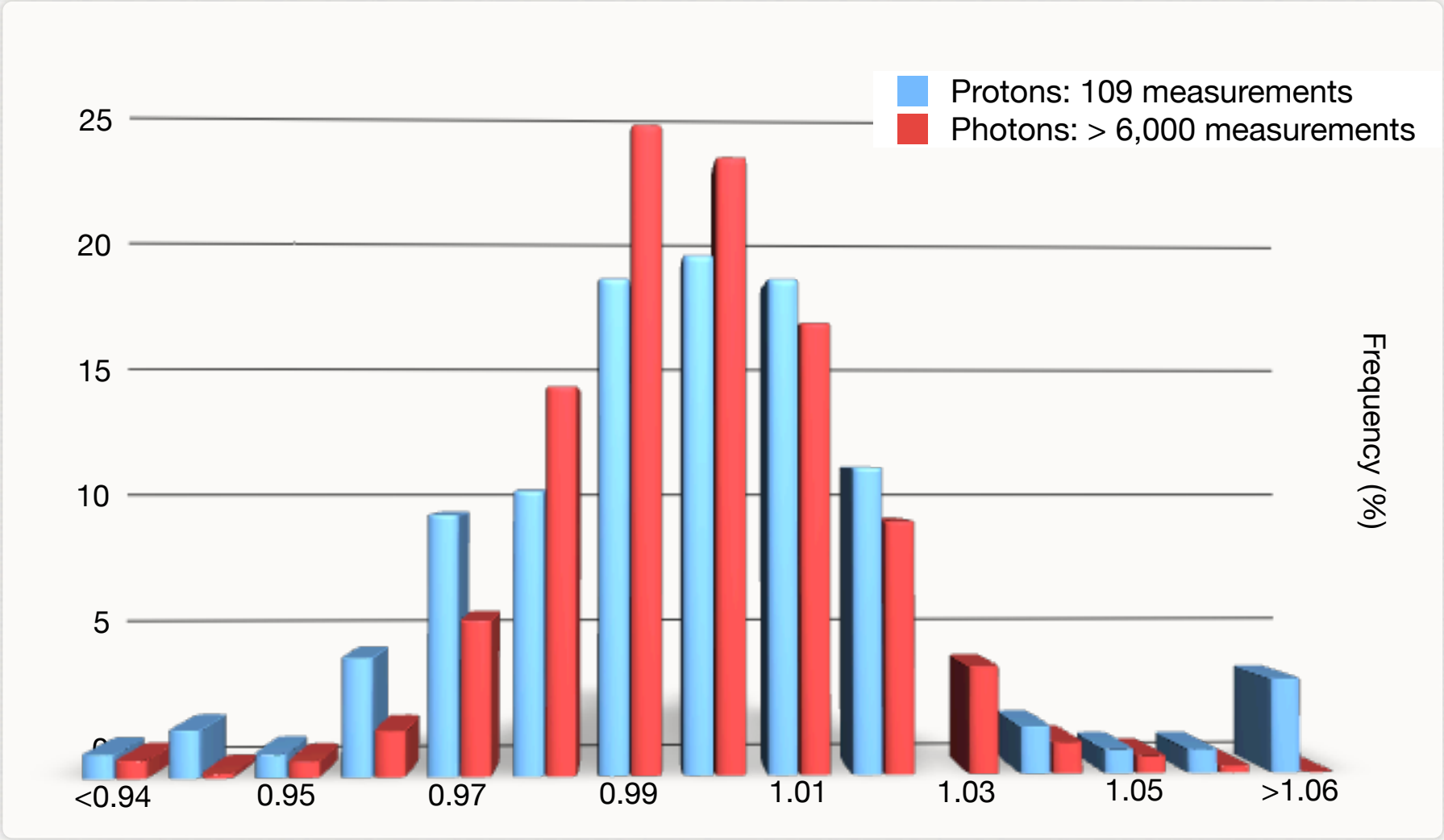
PROTON FACILITY CREDENTIALING

- NCI Guidelines mandate –
  - Questionnaire - sent to facilities by QARC
    - Completed by 4 of 5 centers
  - TLD monitoring
    - Mailed to all 5 US centers + 1 Japanese center
  - On-site dosimetry review visits
    - 1st visit completed
  - Anthropomorphic phantom
    - Modified existing pelvis phantom

PROTON BEAM MONITORING



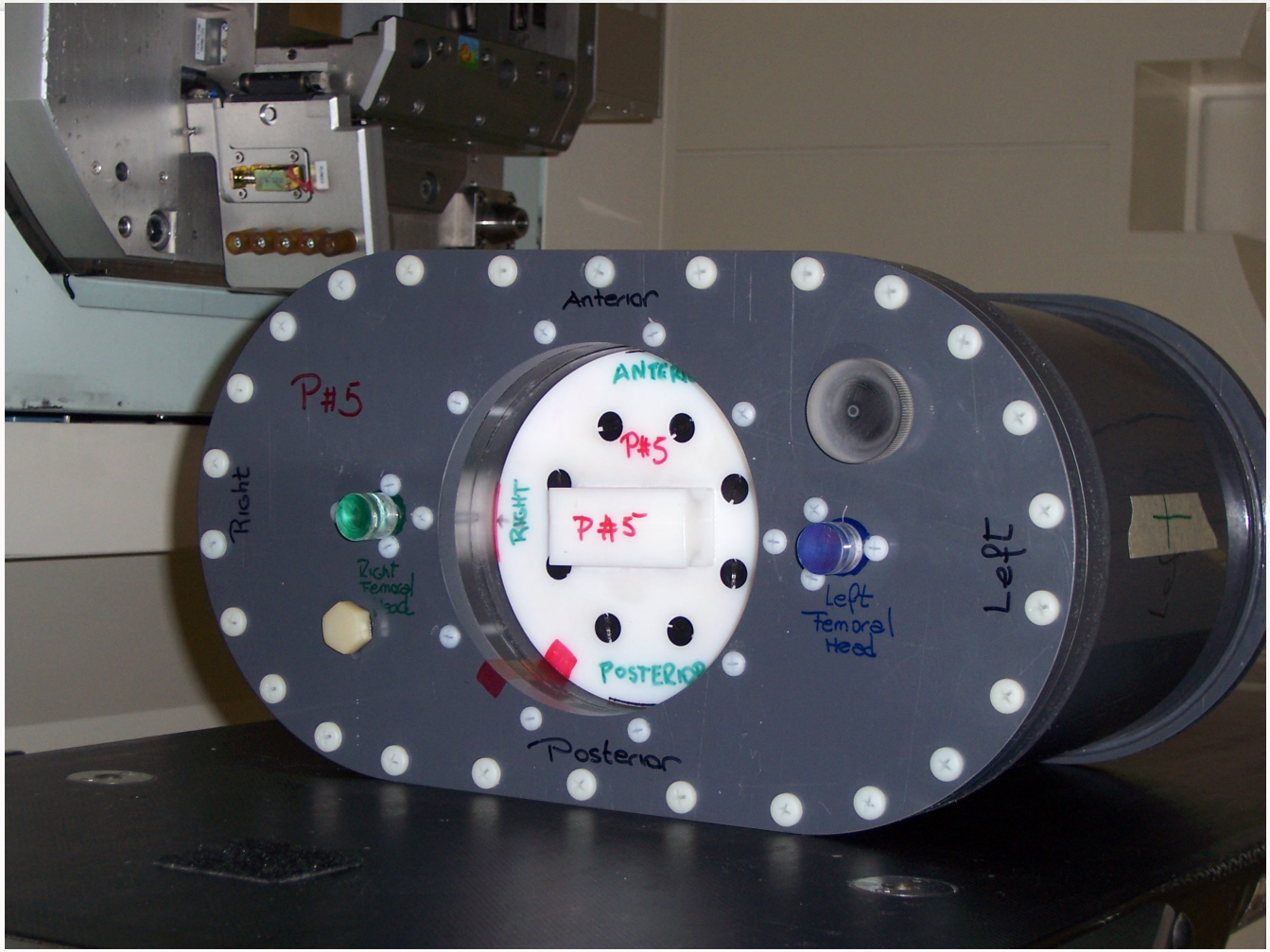
PROTON BEAM MONITORING



PHANTOMS

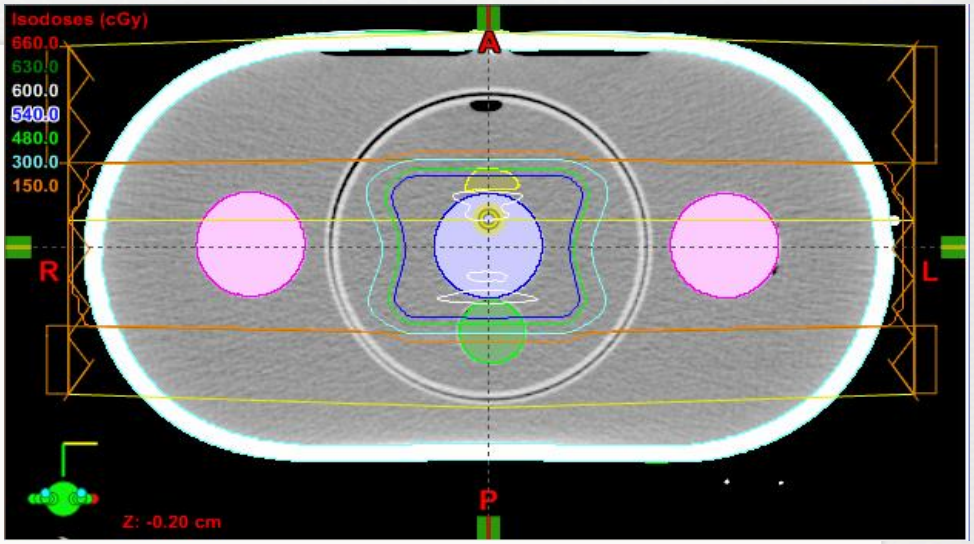
- Pelvis phantom has been developed
  - Evaluation is under way, will be completed this summer
- Lung phantom evaluation will begin this fall
  - Evaluation of materials will be considerably more complex
  - Likely to extend into next grant cycle

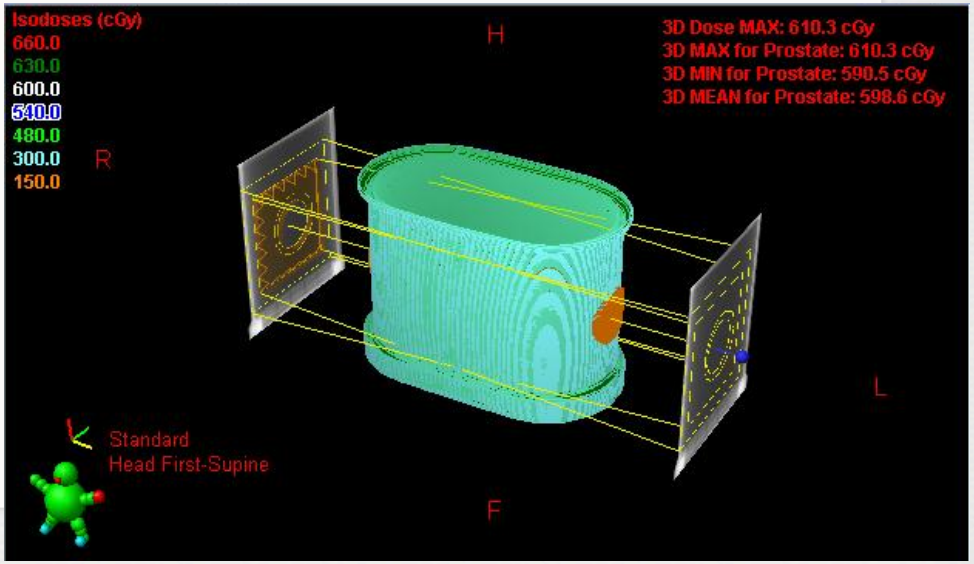
PROTON PELVIS PHANTOM



PHANTOM TREATMENT

- Treatment plan created with a prescription of 6 Gy to the prostate
- Plan delivered 3 times with film and TLD inserted in phantom
- Plan accounting for difference in patient and material SP to be delivered in near future



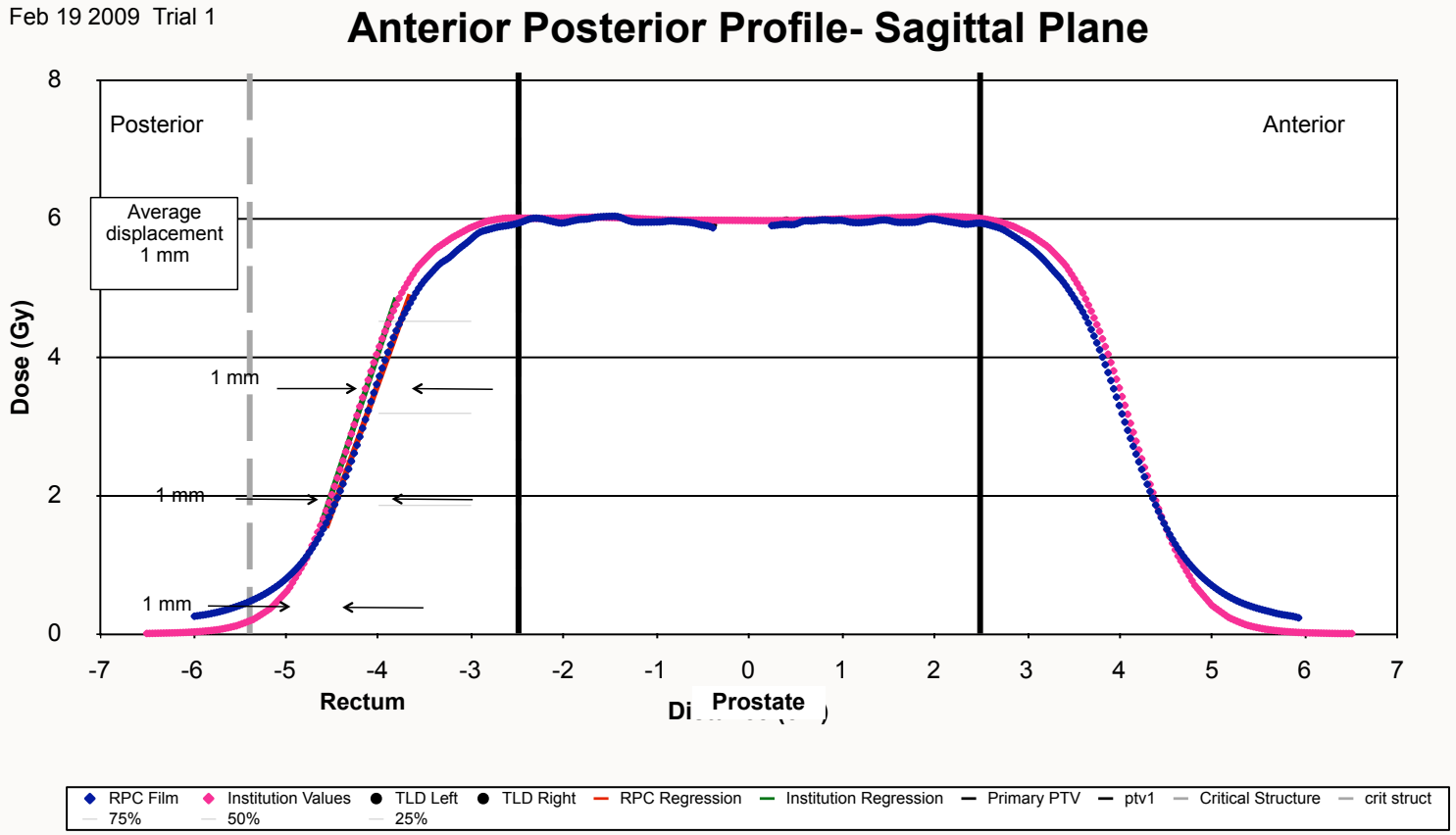


TLD RESULTS

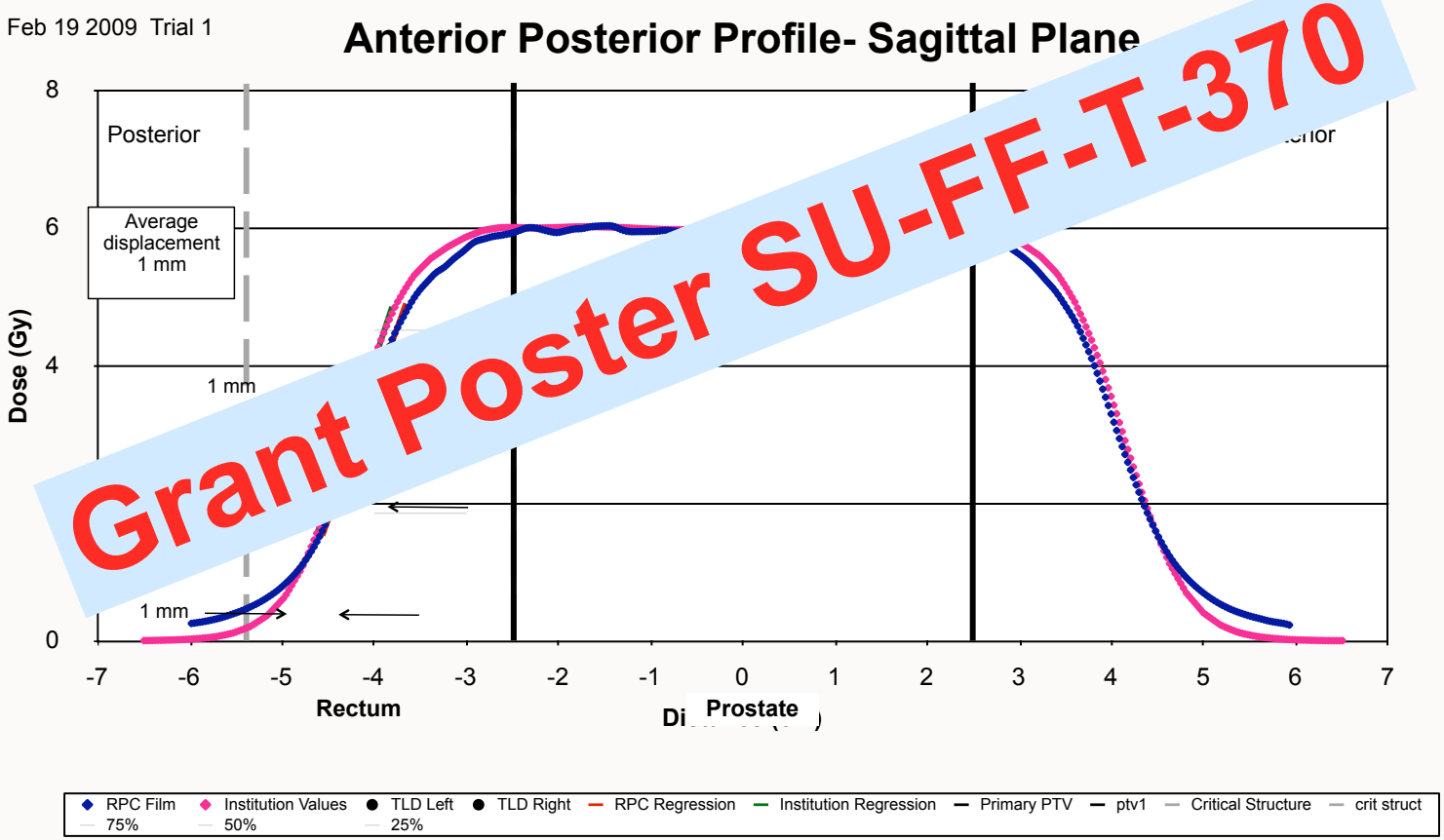
	PTV Right	PTV Left	Femur Right	Femur Left
Institution Predicted Dose (cGy)	600.2	600.2	247.3	243.8
TLD Measured Dose (cGy)	589.8	595.1	242.1	240.4
Measured / Predicted Dose	**0.983**	**0.992**	**0.979**	**0.986**

- PTV within 1.7% of predicted value
- Femur within 2.1% of predicted value

FILM RESULTS



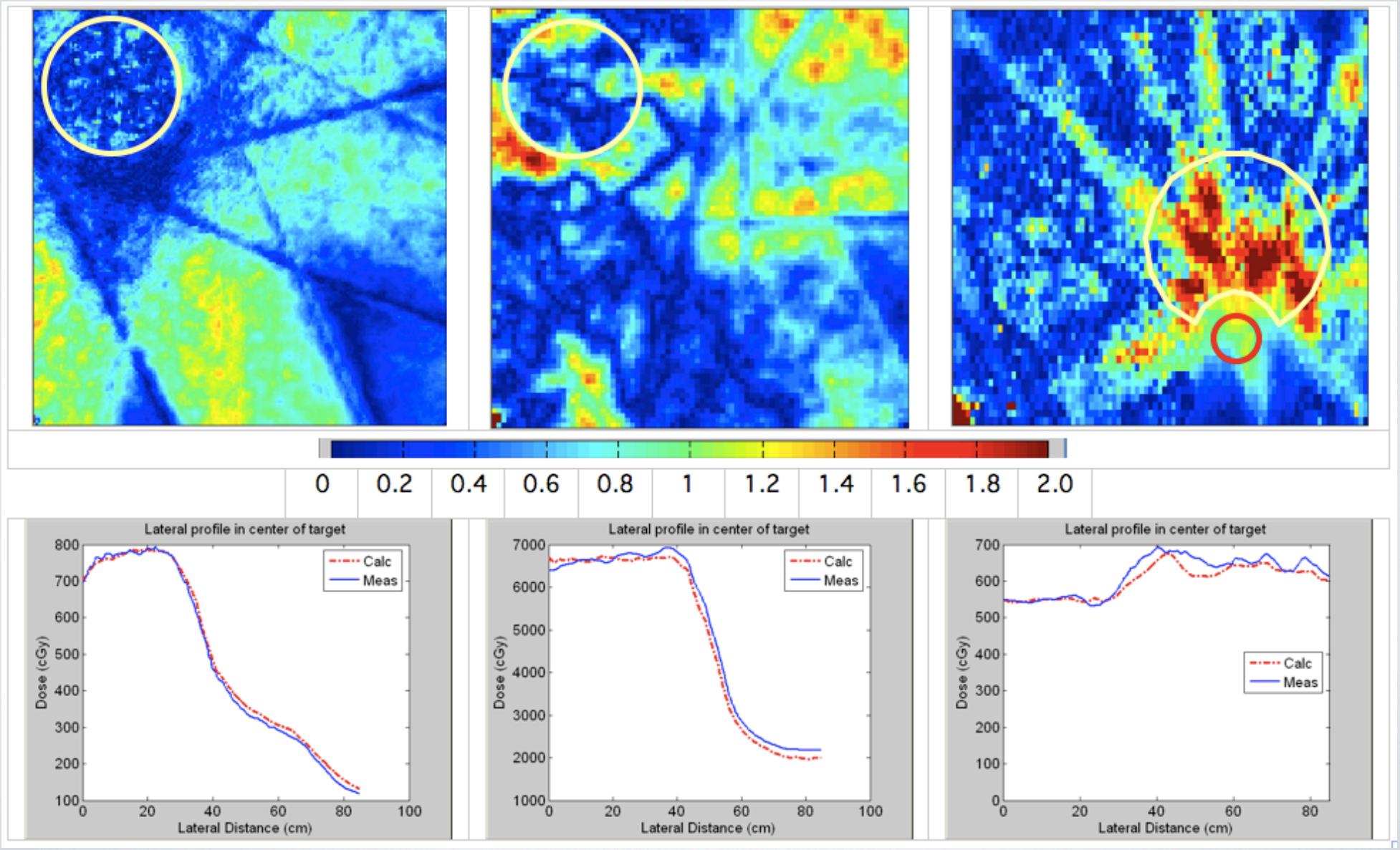
FILM RESULTS



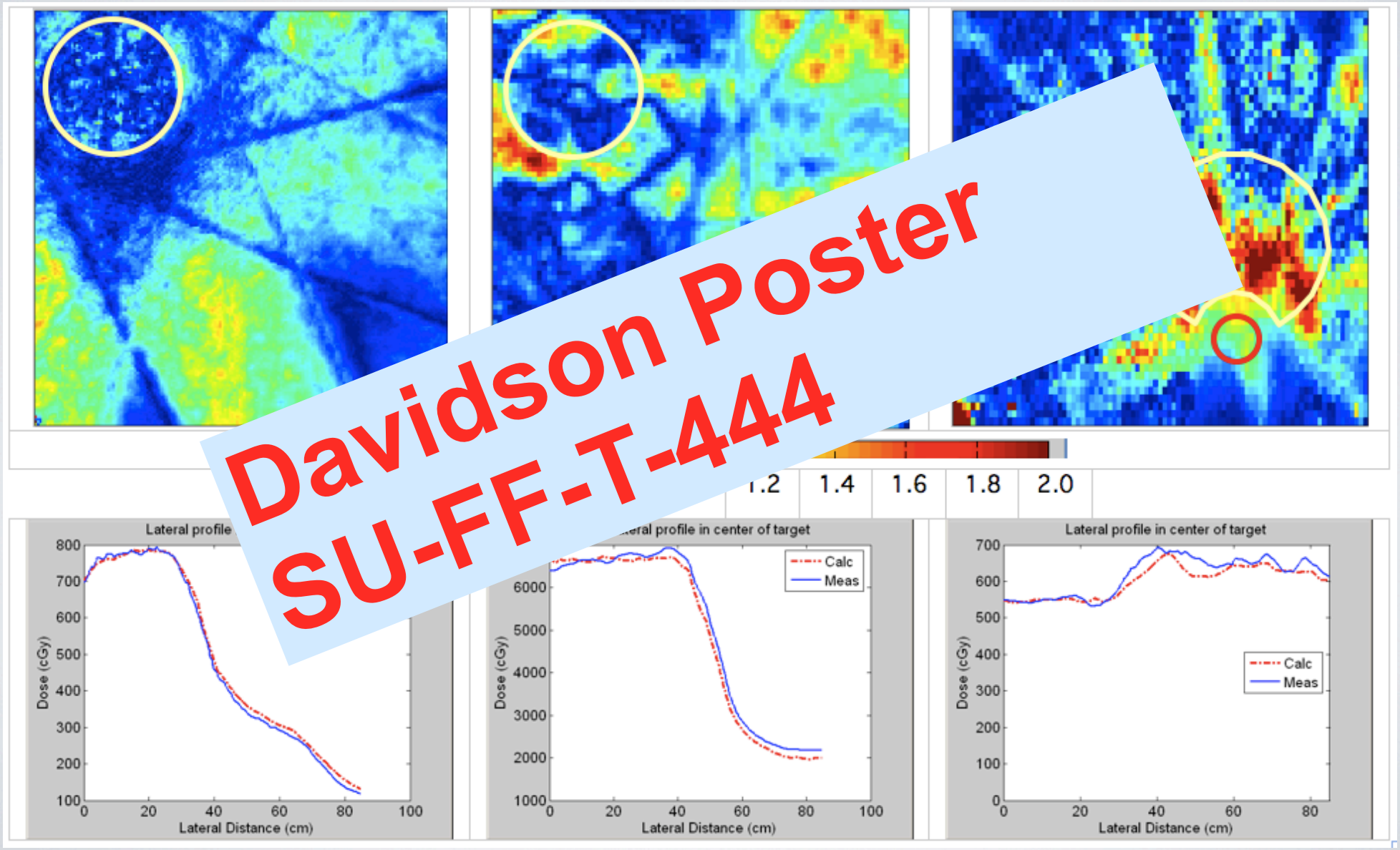
VISITS

- Visit procedures have been developed at PTC-H
- First full visit conducted weeks of April 20 & June 8
  - F. H. Burr Proton Therapy Center @ MGH
  - Final report is in review
- Measurements made:
  - Mechanical tests, x-ray imaging/patient alignment
  - Output, depth dose, range (for variety of beam energies, modulation, field size, etc.)
  - Review of treatment planning procedures

MONTE CARLO CALCULATIONS



MONTE CARLO CALCULATIONS



Optically Stimulated Luminescence (OSL) Dosimeters

- Detector material of aluminum oxide crystals (Al_2O_3:C)
- Landauer's InLight™ NanoDot™ dosimeters and microStar™ Reader

Reproducibility - NanoDots

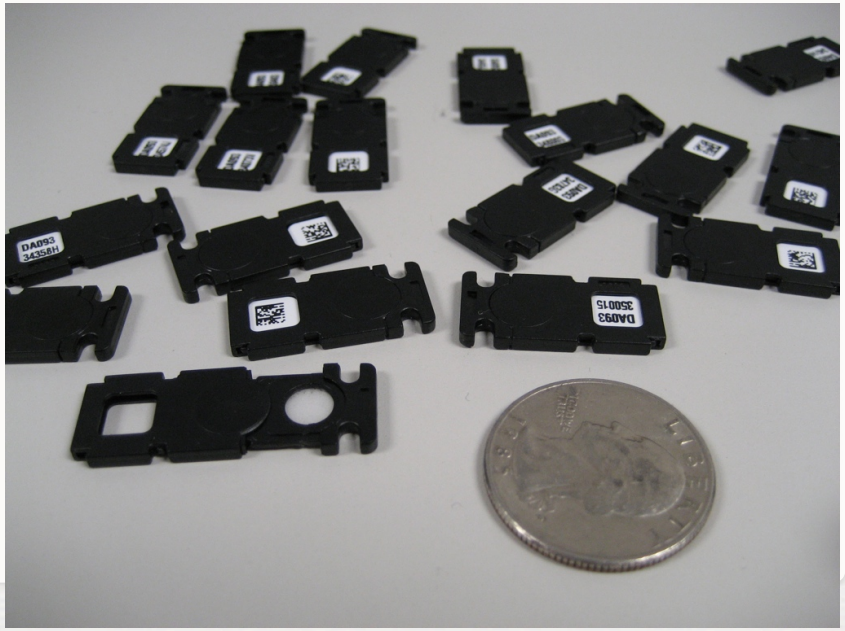
Dosimeter ID	AVG ECF	STDEV
DN09305639P	1.035	0.34%
DN09307843U	0.950	0.50%
DN09307865O	0.989	0.83%
DN09307916P	0.974	0.85%
DN09308972Q	1.045	1.34%
DN093090941	0.997	0.24%
DN09309159T	1.010	0.60%
DN09309249S	1.030	0.48%
DN09309355X	1.012	0.39%
DN09309697J	0.989	0.96%

Reproducibility - NanoDots

Dosimeter ID	AVG ECF	STDEV
DN09305639P	1.035	0.34%
DN09307843U	0.950	
DN09307865O		.83%
DN0930791	4	0.85%
DN0	1.045	1.34%
090941	0.997	0.24%
DN09309159T	1.010	0.60%
DN09309249S	1.030	0.48%
DN09309355X	1.012	0.39%
DN09309697J	0.989	0.96%

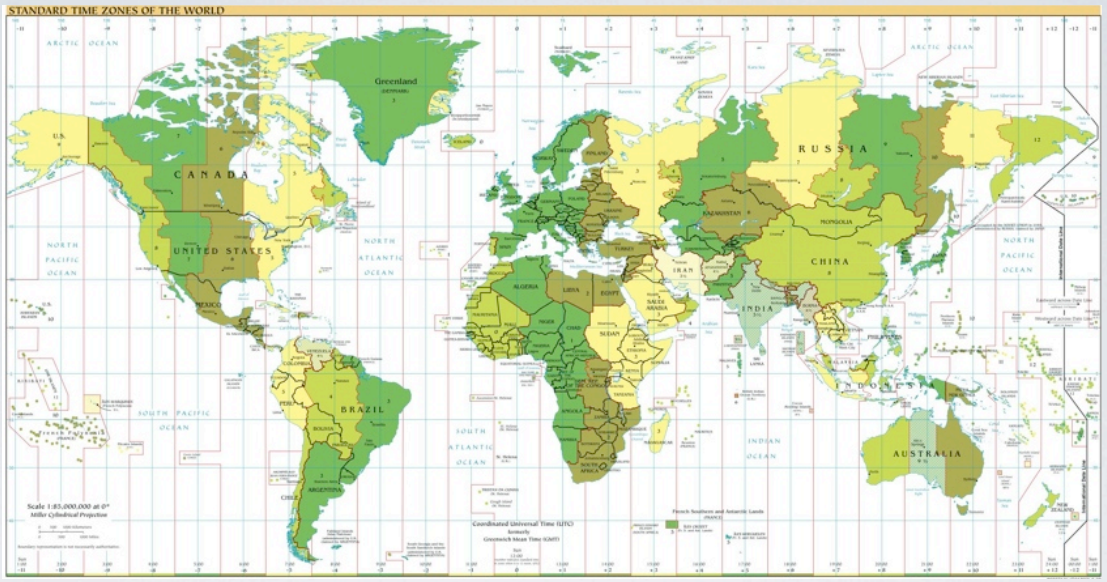
AUDITS

- Evaluation of OSL for audits of proton beams will begin this summer
- Program of evaluation likely to extend into next grant cycle



International Participation

- RPC has audited international institutions that are members of US study groups, as part of routine audits
- In 2007, RPC was approached by EORTC to consider offering TLD audits to EORTC members, at cost
- Following agreement among RPC, EORTC and NCI, EORTC began recommending RPC's TLD service to their members
- Subsequent meetings between RPC, EORTC, and other groups have been held to discuss expanding auditing procedures
- RPC now auditing 100 non North-American institutions
  - Including 58 EORTC members



RPC TLD Network

1,674 RT facilities in 27 countries throughout the world

Including:

100 non-North American facilities

58 EORTC members

International Clinical Trials

- RTOG (and several other study groups*) are expanding trials to international participation
- Through agreements with EORTC, RPC will likely make phantoms available to international participants in NCI-sponsored clinical trials
  - Funding source yet to be determined

*NCCTG and GOG, among others

International Study Groups

- RPC has developed relationships with several international clinical trials QA offices, leading to reciprocal visits and collaborations:
  - TROG – Trans-Tasman Radiation Oncology Group
  - EORTC – European Organization for Research and Treatment of Cancer
  - Japanese National Cancer Center: Outreach Radiation Oncology and Physics

G. Ibbott meeting with staff of Japanese center and viewing calibration facilities

Irradiation of RPC Phantoms

- Through various arrangements, 18 international institutions have already irradiated RPC phantoms
- Arrangements are being discussed for providing phantoms to additional institutions in Europe, the Middle East, Australasia and Latin America
- Through agreement with the RTOG and NCI, international non-member institutions participating in RTOG trials will meet the same QA requirements as member institutions

http://rpc.mdanderson.org

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