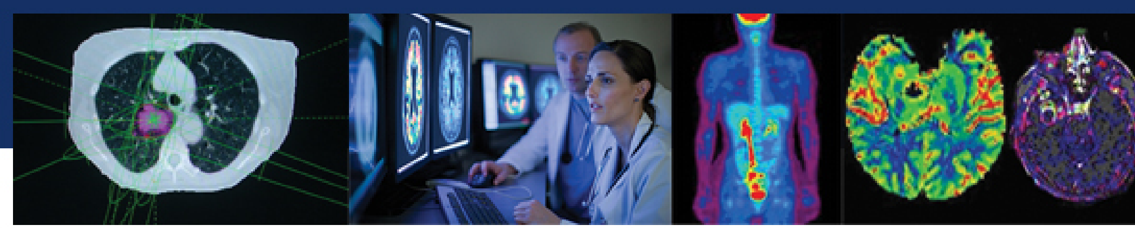
Proton Therapy National Ion Chamber Intercomparison



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IMAGING AND
RADIATION ONCOLOGY CORE
Global Leaders in Clinical Trial Quality Assurance

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IROC's Mission

Provide integrated radiation oncology and diagnostic imaging quality control programs in support of the NCI's NCTN Network thereby assuring high quality data for clinical trials designed to improve the clinical outcomes for cancer patients worldwide

IROC Proton Activities

- Proton facility questionnaire
- Annual remote output checks
- Proton phantom audits
- On-site dosimetry review
- Clinical trial knowledge assessments
- IGRT credentialing

Proton Calibration Protocol History

- 1998: ICRU 59 Protocol
  1) air kerma (N_x) calibration -or-
  2) absolute dose to water ($N_{D,w}$) calibration
  – Most early institutions used air kerma calibration
- 2000: IAEA TRS 398 Protocol
  – Absolute dose to water calibration
- 2007: ICRU 78
  – Endorsed use of TRS 398

Experimental Goals

NIST, IROC (then the RPC), and NCI organized ion chamber round robin with goals to:

- Compare individual users' calibrations with a standard calculation
- Compare different proton calibration protocol results
- Derive consensus k_Q values for new calibration ion chambers

Experimental Design

- 9 proton institutions participated, as well as NIST and IROC
- 22 ion chambers (11 thimble and 11 parallel plate) used

Experimental Design

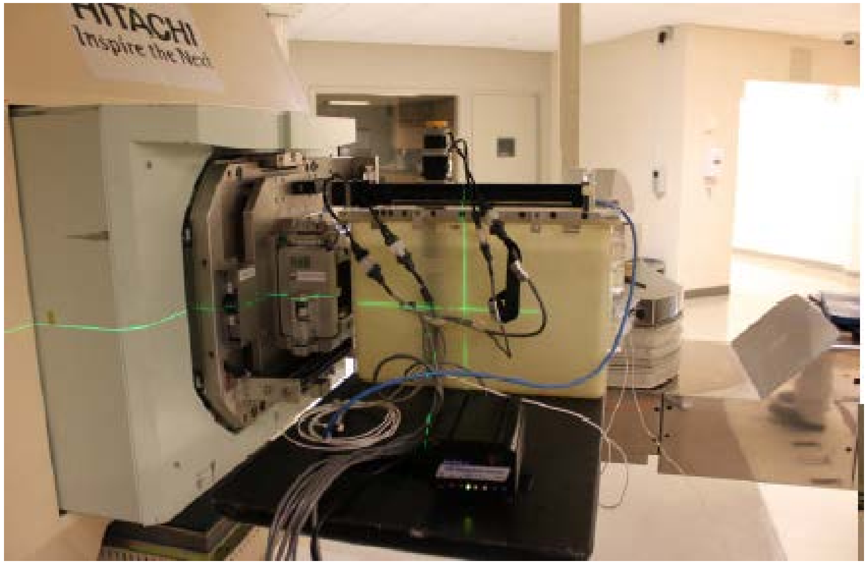
THE UNIVERSITY OF TEXAS
MD Anderson
~~Cancer~~ Center

Accredited Dosimetry Calibration Laboratory
Schedule of Charges for Calibration Services

- Each chamber freshly calibrated at MD Anderson Accredited Dosimetry Calibration Laboratory (ADCL)
- Received in-air (N_x) and in-water ($N_{D,w}$) calibration factors

Experimental Design

- 2 “clinical” scattered proton beam configurations used: brain and prostate
- Measurements performed in water
- Each user measured dose per monitor unit



Experimental Design

Simulated Treatment Site	Prostate	Brain
Energy	250 MeV	120 MeV
Scatterer size	medium	medium
Applicator size	small	medium
R_{90}	260 mm H_2O	60 mm H_2O
R_{10}	270mm H_2O	63 mm H_2O
$M_{95\text{-}90}$	96 mm H_2O	34 mm H_2O
Aperture size	96 mm x 96 mm	46 mm x 46 mm
Aperture-to-surface distance	70 mm	85 mm
Chamber position	at isocenter	at isocenter
Chamber depth	212 mm H_2O	45 mm H_2O
Residual range	58 mm H_2O	18 mm H_2O

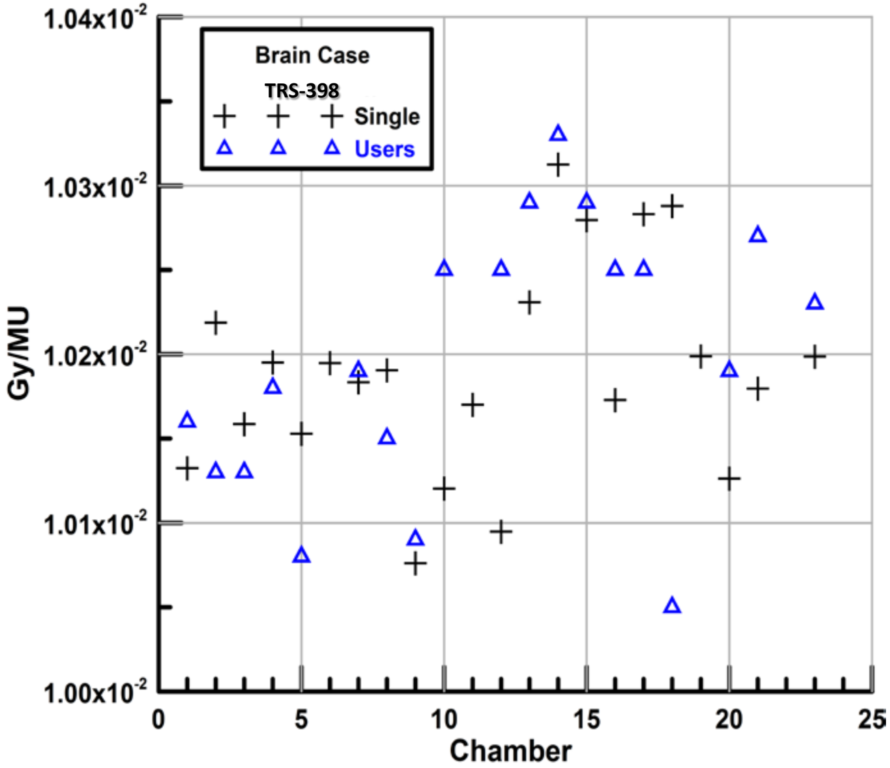
Experimental Design

- D/MU calculated by each user using the TRS 398 $N_{D,w}$ method with fresh chamber factors
- D/MU calculated by a single user using the TRS 398 $N_{D,w}$ method with fresh chamber factors
- D/MU calculated by a single user using the ICRU 59 N_x method with fresh chamber factors
- D/MU calculated by a single user using the ICRU 59 $N_{D,w}$ method with fresh chamber factors

Preliminary Findings

- None of the clinical users were still using ICRU 59 – all had transitioned to TRS 398
- We'll focus on variations in D/MU determined by multiple users as compared to single user

Results: Brain Field



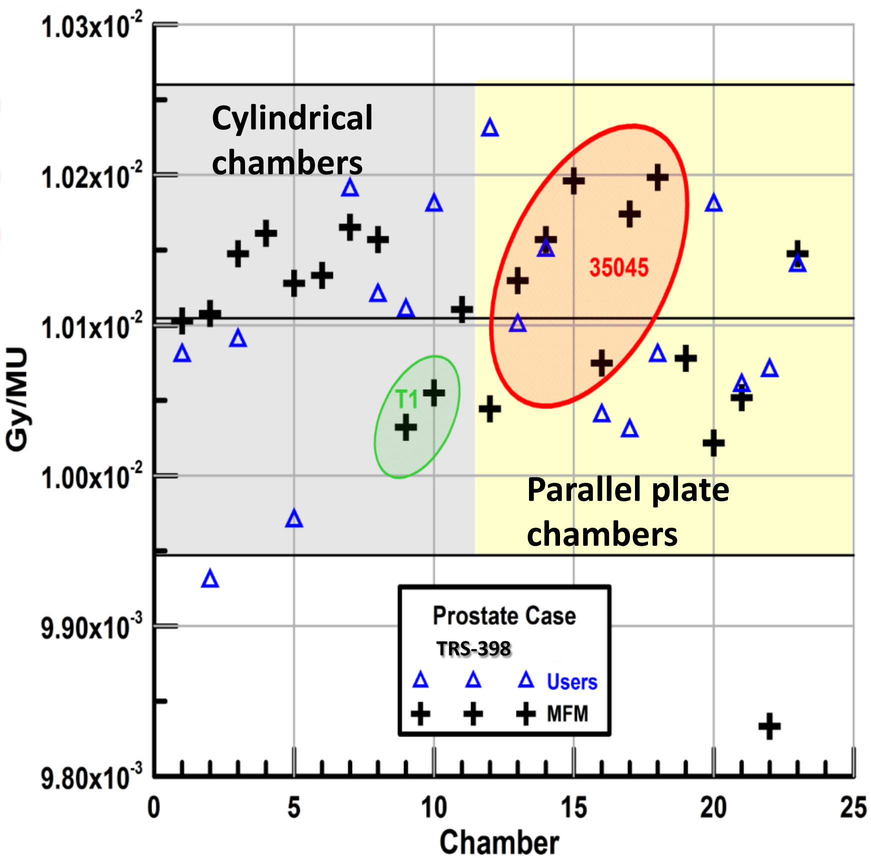
Multi-user

- max-to-min = 2.75%
- 2 SD = ± 1.54%
- Difference between thimble chamber and parallel plate results

Single user

- max-to-min = 2.32%
- 2 SD = ± 1.22%
- Slightly smaller spread than for multi-user determinations
- Smaller difference between thimble and parallel plate than multi-user results

Results: Prostate Field



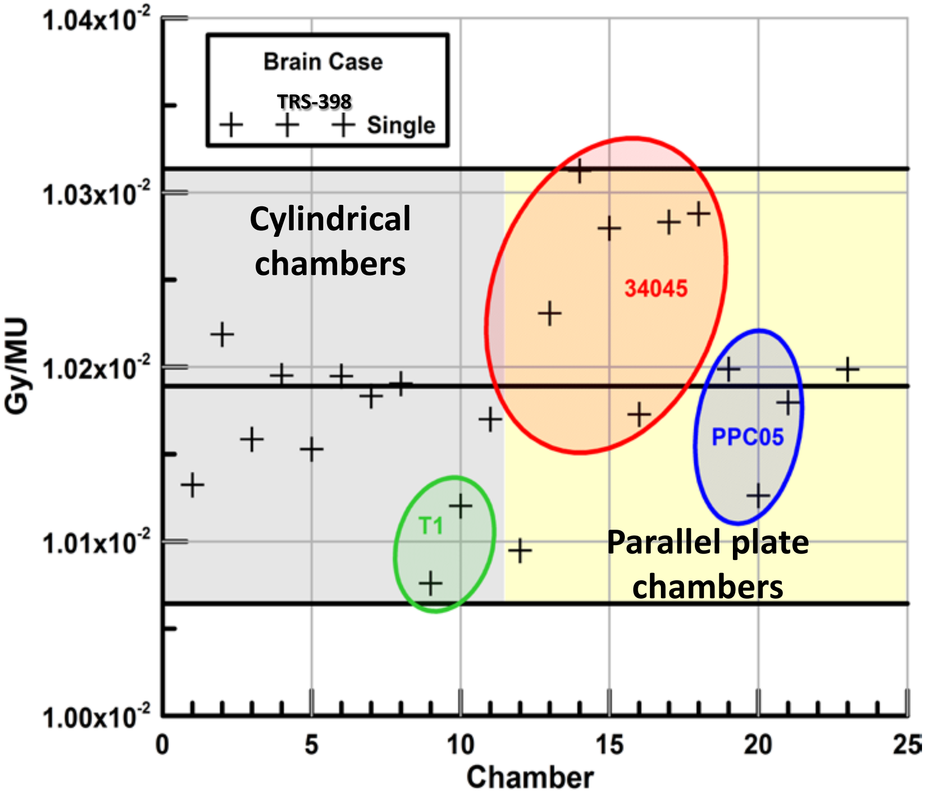
Multi-user

- max-to-min = 2.97%
- 2 SD = ± 1.62%
- Similar spreads to that demonstrated with ICRU 59 N_x method in 1998 intercomparison (Vatnitsky)

Single user

- max-to-min = 1.75%
- 2 SD = ± 1.05%
- Significantly smaller spread than for multi-user determinations

Results: New k_Q Values



Results suggest better consistency could be obtained using new k_Q values for R_{res} between 18 - 50 mm

- T1v2, T1v3: 1.014
  - T1v1 value = 1.006
- Markus 23343: 1.010
  - old value = 1.003
- Markus 34045: 0.997
  - no previous value
- PPC05: 1.007
  - no previous value

Takeaways

- The spread of D/MU values using the TRS 398 $N_{D,w}$ method and different detectors is similar to results of previous intercomparisons, slightly larger than using ICRU 59 N_x method, and smaller than the spread of values using ICRU 59 $N_{D,w}$ method
- Use of the TRS 398 $N_{D,w}$ method by multiple institutions can provide sufficiently consistent results for use in inter-institutional protocols

Future Calibration Protocol Development

$$k_s = a_0 + a_1\left(\frac{M_1}{M_2}\right) + a_2\left(\frac{M_1}{M_2}\right)^2$$

- High instantaneous dose rate requires adjustment of k_s measurements
  - Users switch to higher calibration bias (e.g. 400 V instead of 300 V), or use continuous equation instead of pulsed/pulsed-scanned
  - TRS 398 working on update, has solicited feedback

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Thank you.
Questions?