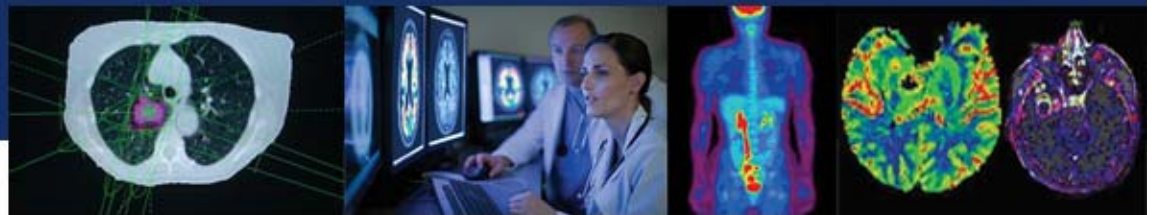




IROC Houston's Proton Beam Validation for Clinical Trials



IROC[™]
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RADIATION ONCOLOGY CORE
Global Leaders in Clinical Trial Quality Assurance

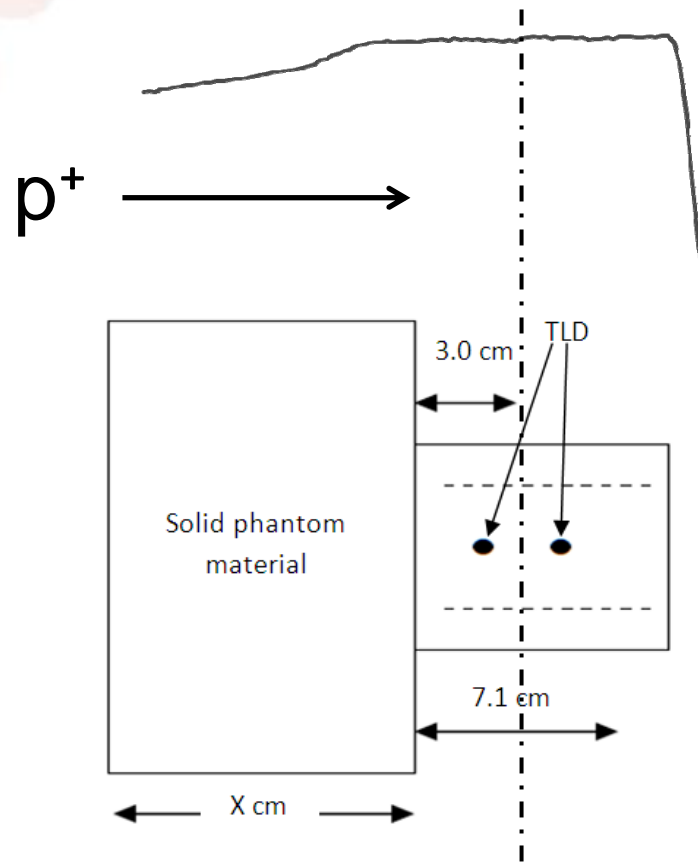
ACR
AMERICAN COLLEGE OF
RADIOLOGY

Paige Taylor, M.S.
AAPM Annual Meeting
July 14, 2015

Proton QA Audit Components

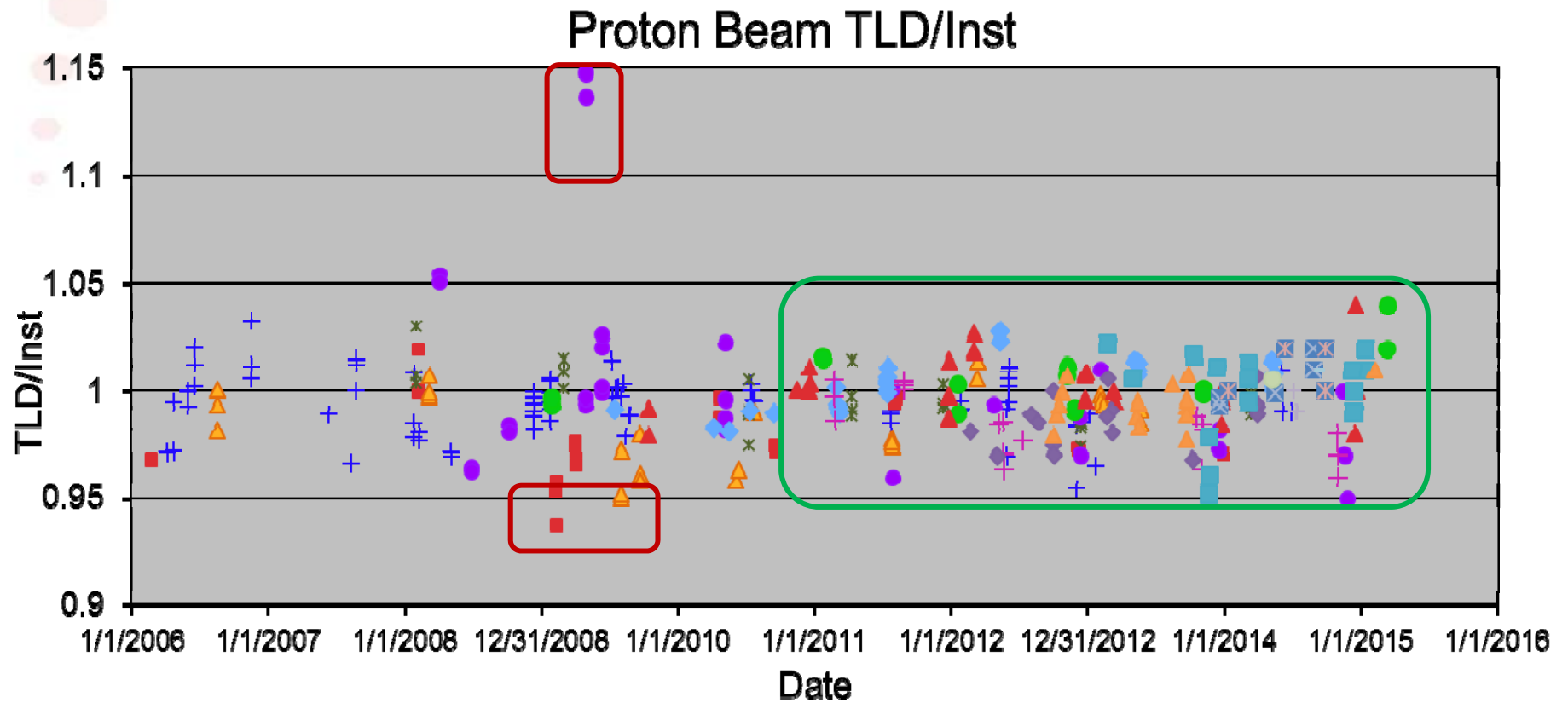
- Goal: ensure proton centers deliver consistent, comparable dose for clinical trials & follow NCI/AAPM recommendations
- Remote
 - Annual TLD audit of beam calibrations
 - Anthropomorphic proton phantom audits
- On-site
 - Dosimetry review site-visit

Output Audits



- TLD used to monitor beam output annually – verification of TRS 398 protocol
- TLD placed in acrylic blocks, institutions provide own water-equivalent buildup
- OSLD also investigated
- Characterizable response at center of modulation

TLD Output Audits



Which calibration protocol is recommended for proton beams?

- 20% 1. AAPM TG 21
- 20% 2. AAPM TG 43
- 20% 3. AAPM TG 51
- 20% 4. IAEA TRS 277
- 20% 5. IAEA TRS 398

Correct Answer:

- 5: IAEA TRS 398

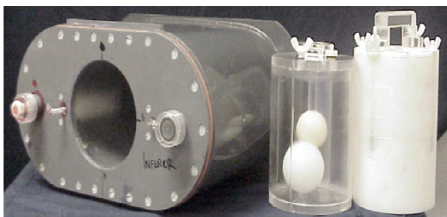
Per recommendations by NCI and AAPM Ad-hoc advisory group in 2012

Ref: NCI. **Guidelines for the Use of Proton Radiation Therapy in NCI-Sponsored Cooperative Group Clinical Trials**: RPC; 2012.

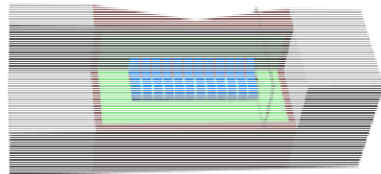
Ref: IAEA, P. Andreo, D. T. Burns, K. Hohlfeld, M. S. Huq, T. Kanai, F. Laitano, V. G. Smyth, and S. Vynckier. 2000. **Code of Practice for Proton Beams. In Absorbed Dose Determination in External Beam Radiotherapy: An International Code of Practice for Dosimetry Based on Standards of Absorbed Dose to Water**. IAEA, Vienna. 181.

Phantom Irradiation Audits

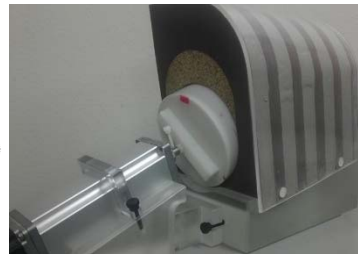
- 5 proton phantoms: prostate, spine, lung, head, liver
 - Prostate, head: simple, spherical target geometry
 - Spine: field matching
 - Lung, liver: motion included
 - Liver: 2 targets



Prostate/pelvis



Spine



Lung/thorax



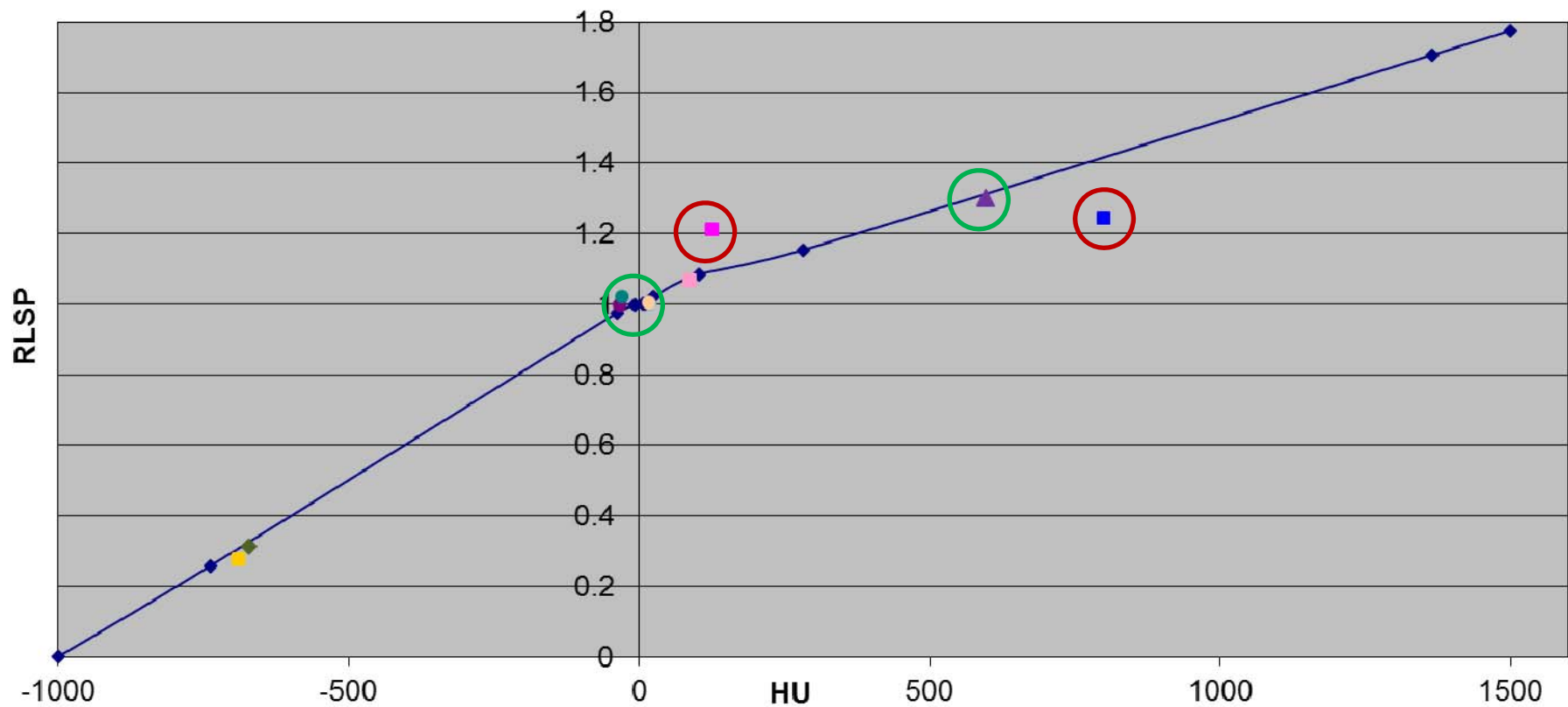
Head



Liver

Phantom Irradiation Audits

- Phantoms made from proton-equivalent plastics



—◆— Tissue Curve ■ Acrylic ● Polyethylene ● HI Polystyrene ■ PVC ● Water
● Blue Water ● Solid Water ◆ Balsa ● Cork ▲ Techtron HPV

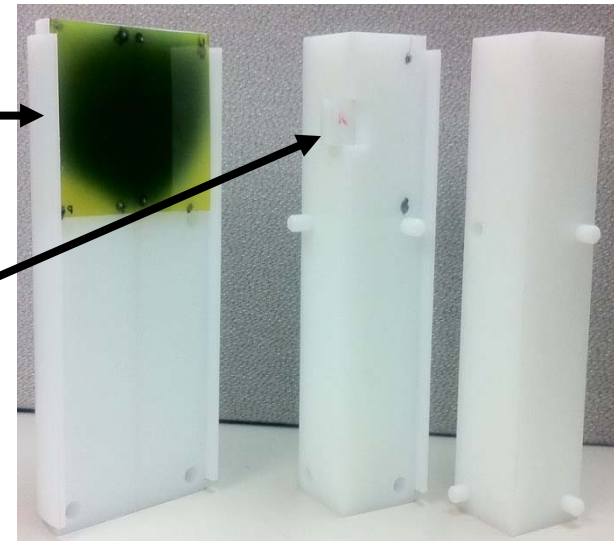
Phantom Irradiation Audits

- Phantoms contain TLD and radiochromic film – used for absolute and relative dose comparison with treatment plan



Liver phantom insert

Film →
TLD holder →
Targets →



Head phantom insert

Phantom Irradiation Audits

- 91 proton phantoms irradiated, analyzed

	Prostate	Spine	Lung	Head	Liver	TOTAL
Total Irradiations	35	16	20	16	4	91
# Passed	25	13	15	16	2	71
Pass Rate	71%	81%	75%	100%	50%	78%

Why are different plastics required for proton phantoms relative to photon phantoms?

20% 1. Photon plastics are too heavy

20% 2. To match tissue HU-RLSP curve

20% 3. Proton plastics are cheaper

20% 4. Different dosimeters are used

20% 5. Proton plastics are deformable

Correct Answer:

- 2: To match tissue HU-RLSP curve

Many plastics used for our photon phantoms do not fall on the tissue-equivalent conversion curve for proton therapy

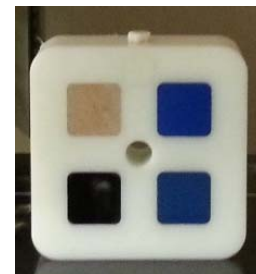
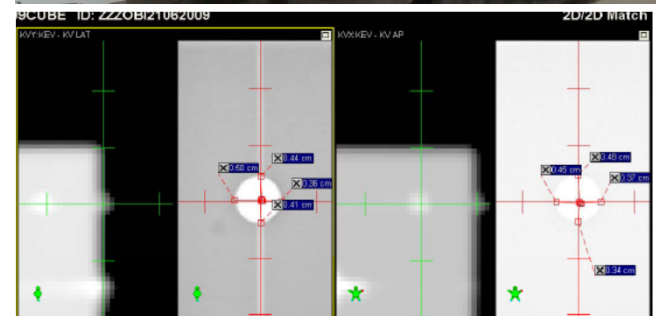
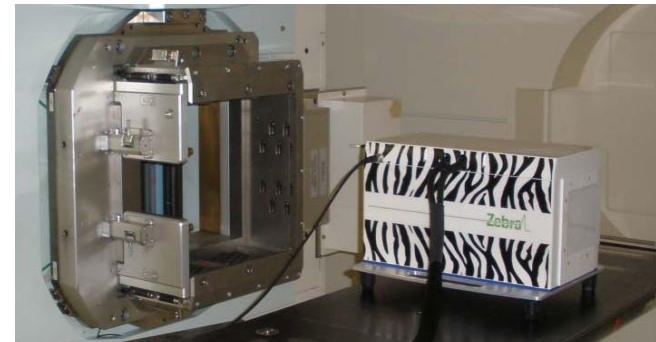
Ref: Grant, et al. **Relative stopping power measurements to aid in the design of anthropomorphic phantoms for proton therapy.** [JACMP](#). 2014; 15(2): 121-126.

On-site Proton Dosimetry Audits

- Institutions visited after routinely treating patients for 6 months, no fewer than 3 disease sites
- Each delivery modality has separate audit requirement – must *each* be reviewed
 - Scattering
 - Uniform Scanning
 - Spot Scanning/PBS

On-site Proton Dosimetry Audits

- Review:
 - Absolute calibration
 - Ion chamber in water
 - Dosimetry for reference and patient fields
 - 2D ion chamber array, MLIC
 - IGRT
 - Film on cube
 - CT-RLSP
 - Tissue-equivalent phantom
 - Treatment planning procedures
 - Machine & patient-specific QA



On-site Proton Audit Results

- Common site visit recommendations:
 - QA (66 rec's)
 - Expected to improve when AAPM Task Group 224 (proton machine QA) is published
 - CT Number/RLSP conversion (11 rec's)
 - Most discrepancies observed at high CT #s, a few at low CT #s
 - Very few recommendations for beam output, delivery

Summary

- TLD
 - Output measurements within $\pm 5\%$ over past several years
 - Will transition to OSLD in the near future
- Phantoms
 - Phantom pass rates improving
 - Motion, OARS, multiple targets prove challenging
- On-site Dosimetry Review
 - Very few dosimetry recommendations
 - Many QA recommendations

Questions?

