THE UNIVERSITY OF TEXAS
MD Anderson Cancer Center
Making Cancer History®

Identifying Treatment Planning System errors through IROC-H Head & Neck phantom irradiations

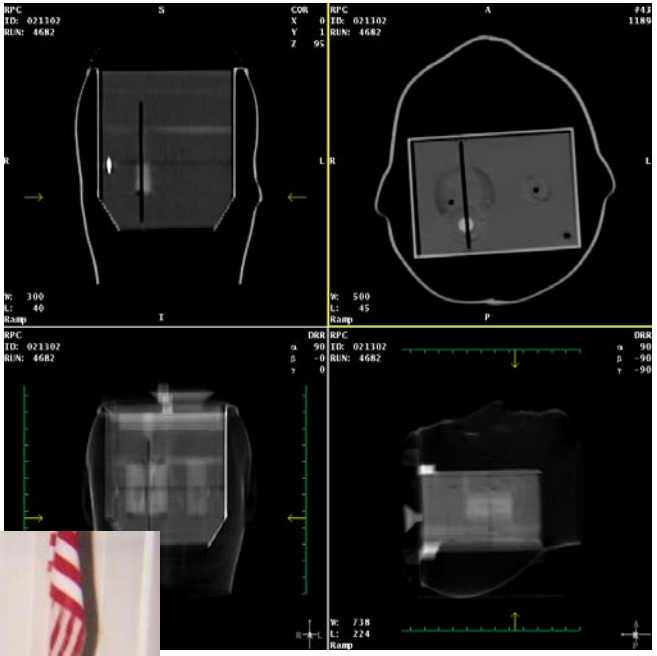
J. Kerns, D. Followill, R. Howell, A. Melancon, F. Stingo, S. Kry

UT MD Anderson Cancer Center

AAPM 2016

IROC-H & Phantoms

- IROC-H dosimetry reviews:
  - **On-site visits**
    - IROC-H physicist, institution's machine
  - **Phantom irradiations**
    - DICOM, TLDs



Problem & Objective

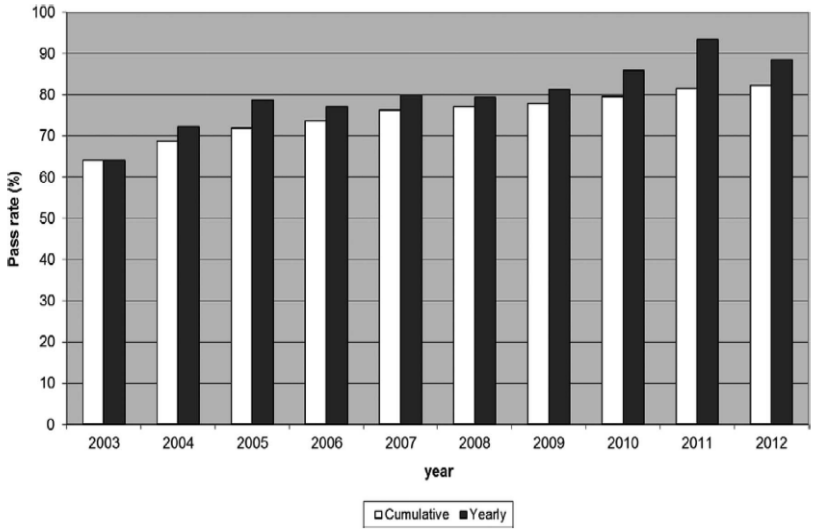
• IROC phantoms fail a lot, even with wide criteria (Ibbott, *et al*. 2008; Molineu, *et al*. 2013)

• IROC-H currently can't definitively diagnose failures; similar to an IMRT QA failure, end-to-end test

•Pre-Tx QA does not accurately predict IROC-H failures (Kry, *et al*. 2014)

• Failures can occur due to:
- •Output
- •Setup
- •Delivery
- •**TPS modelling**

• **Can we definitively determine if an institution has a TPS modelling issue via IROC-H phantom?**



Molineu, *et al*, 2013

JK6

Methods & Approach

- Solution: An accurate, independent recalculation system to compare against
  - 2nd Check TVS; Mobius3D
  - Accurate, representative measurement data
    - On-site dosimetry data
  - Recalculate ~200 H&N phantoms (2012-2015)
- 3 sources: TLD, TPS, TVS; intercomparison identifies TPS error

Slide 4

JK6 An independent calc provides a comparison eval against TLDs. Disagreement indicates a problem with TPS model.

James Kerns, 3/30/2016

"Standard" Data

- On-site dosimetry data
  - Point data: PDD, Output Factors, Off-axis, MLC output factors
    - Accurate (same equipment/people)
    - 2000-present
    - ~500 machines
    - 30+ models

- Goal: Combine dosimetrically equivalent models into "classes" using statistical & clinical criteria

- These data became the reference datasets for the TVS

	Class	Represented Models/Beams
6 MV	Base	21EX (D), 23EX, 21iX, 23iX, Trilogy
	TB	TrueBeam
	TB-FFF	TrueBeam FFF
	Trilogy SRS	Trilogy SRS
	2300	2300 (C) (CD)
	2100	2100 (C) (CD)
	600	600 (C) (CD)
	6EX	6EX

Published as: ***Technical Report: Reference photon dosimetry data for Varian accelerators based on IROC-Houston Site Visit Data***, Kerns *et al*, 2016 *Medical Physics.*

Matching the Standard Data

- Mobius3D has default model, but it's tunable

- Created 3 common beam models in our TVS & recalculated site visit fields:
  - Varian Base
  - Varian TrueBeam
  - Elekta Agility

cm/cm²/cm²/cm	PDD 10x10	Jaw Output	IMRT output	SBRT output	Off-Axis
5/6x6/2x2/5	-0.12%	0.94%	-0.74%	2.06%	-0.58%
10/15x15/3x3/10	-0.15%	-0.29%	-0.23%	1.71%	-0.19%
15/20x20/4x4/15	0.60%	-0.19%	-0.34%	1.29%	-0.38%
20/30x30/6x6	-0.26%	-0.28%	0.43%	0.98%	

M3D Default Varian 6 MV Base Class Model:
11.8

	PDD 10x10	Jaw Output	IMRT output	SBRT output	Off-Axis
5/6x6/2x2	-0.12%	0.21%	-0.94%	-0.51%	-0.10%
10/15x15/3x3	-0.15%	0.00%	-0.72%	-0.12%	0.00%
15/20x20/4x4	0.20%	0.00%	-0.59%	-0.12%	0.00%
20/30x30/6x6	-0.52%	-0.09%	0.21%	0.00%	

M3D Optimized Varian 6 MV Base Class Model:
5.0

Recalculations

- Chose H&N phantom irradiations
- Institution DICOM dataset was linked to the representative model (21EX -> Base)
- Recalculated dose using the TVS
- Pulled out the TLD calculated doses for each phantom

JK17

TPS Error

•TPS Error:

$$\mathrm{E} = \frac{1}{6}\sum_{n=1}^{6}\left(\left|1-\frac{TPS_n}{TLD_n}\right| - \left|1-\frac{TVS_n}{TLD_n}\right|\right) * 100$$

•Two criteria for "considerable" TPS error:

- •Clinical: 2% average TVS improvement **or** 3% single TLD TVS improvement

  and

- •Statistical: Error value distribution was statistically significant

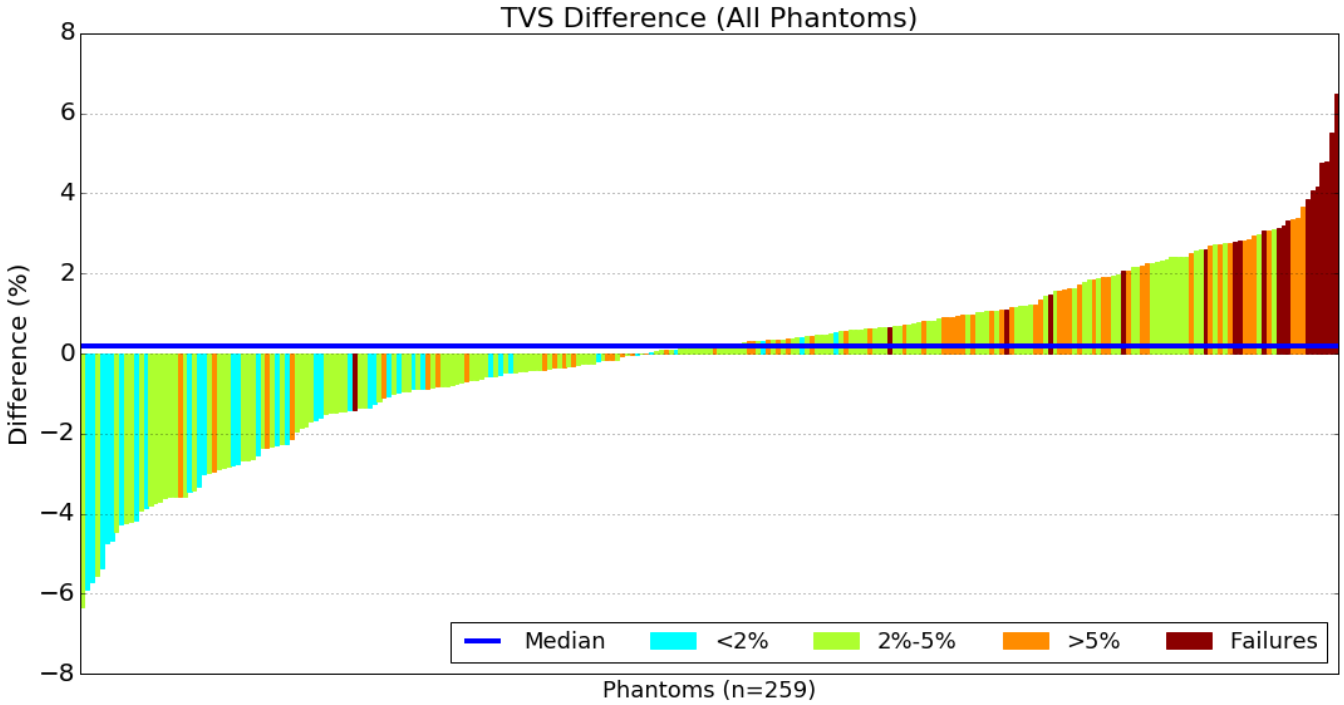
•Examined 2 subsets of phantoms: all and failures

Slide 8

JK17 This was a conservative approach using these metrics
James Kerns, 3/30/2016

JK14

Results: All Phantoms



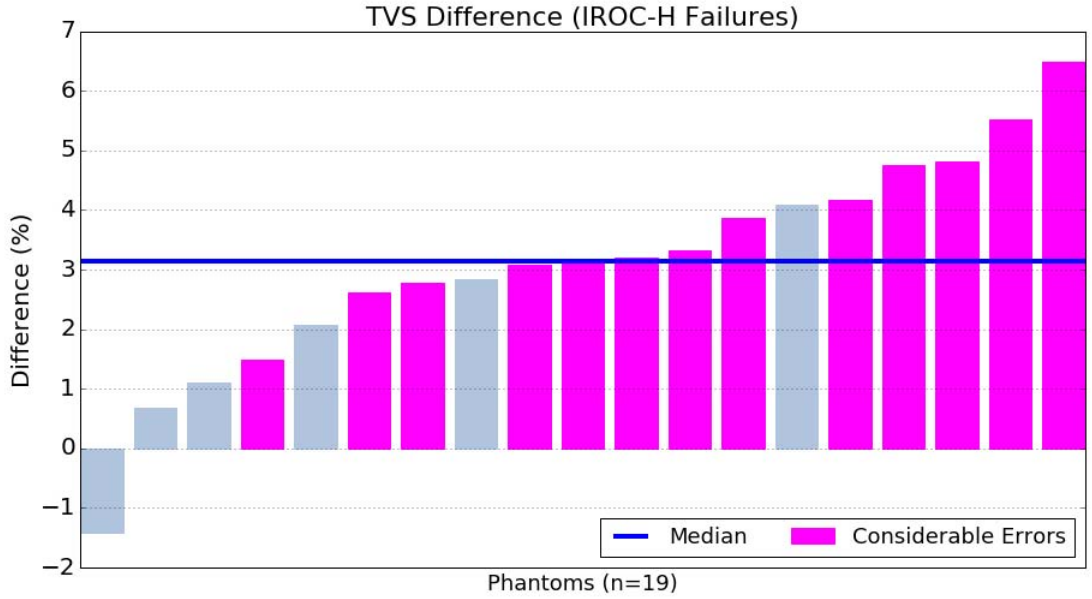
- Median improvement: +0.20%
- 17% of all phantoms had a TPS error

Slide 9

JK14 Maybe make 3 "regions", explaining negatives, noise/middle, positive calcs
James Kerns, 3/30/2016

JK16

Results: Failing Phantoms



- Median improvement: +3.08%
- 68% of failing phantoms had a TPS error

Slide 10

JK16 drop 2nd plot

James Kerns, 3/30/2016

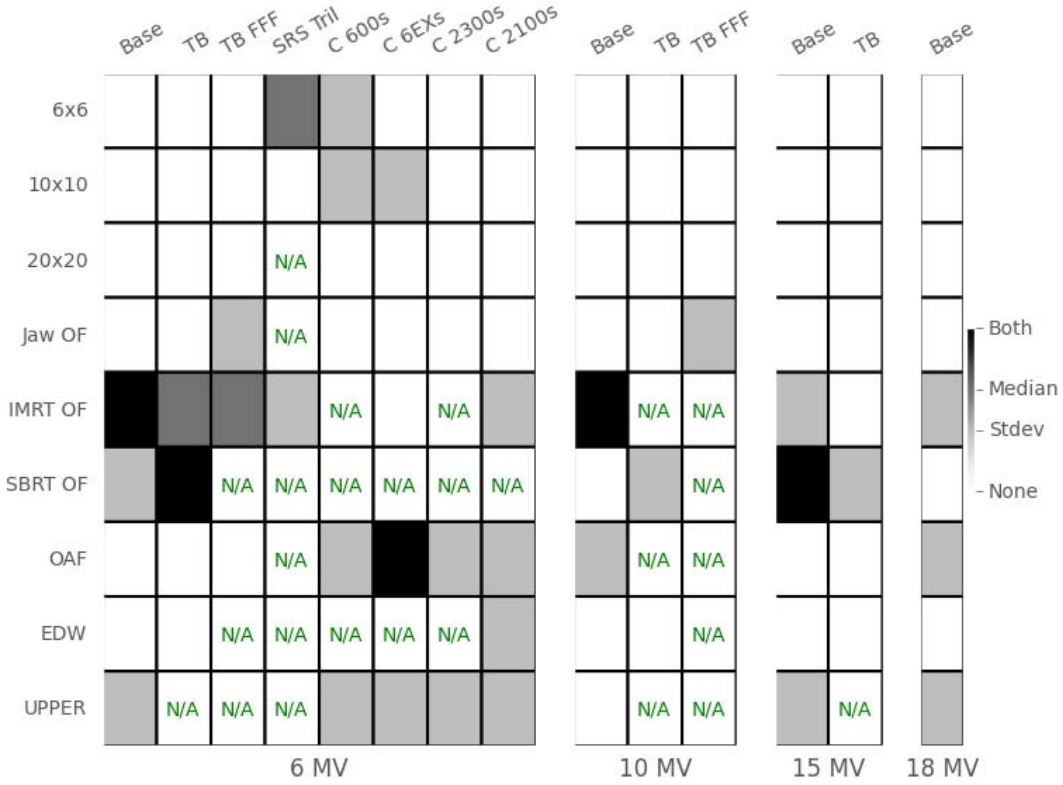
Conclusions

- **IROC-H can now definitively determine if a phantom failed due to TPS modelling errors:**
  - 17% of all phantom irradiations have considerable TPS error
  - 68% of failing irradiations
  - This methodology will be added to IROC-H workflow

- TPS error detection can be passed to the institution to guide a solution

Thank you! Questions?

Bonus


Base
TB
TB FFF
SRS Tril
C 600s
C 6EXs
C 2300s
C 2100s
Base
TB
TB FFF
Base
TB
Base
6x6
10x10
20x20
Jaw OF
IMRT OF
SBRT OF
OAF
EDW
UPPER
N/A
Both
Median
Stdev
None
6 MV
10 MV
15 MV
18 MV

Bonus

- Which linac parameters most often disagree with the TPS?
  - In press: ***Agreement between institutional measurements and treatment planning system calculations for basic dosimetric parameters as measured by IROC-Houston***, Kerns et al, 2016. *International Journal of Radiation Oncology • Biology • Physics*