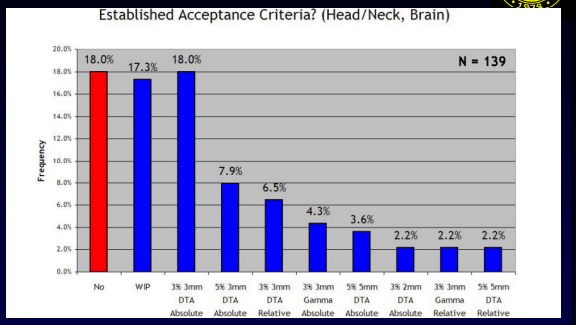
Tolerances and Action Levels for IMRT QA Verification Measurements

Moyed Miften, PhD
University of Colorado

IMRT QA Survey

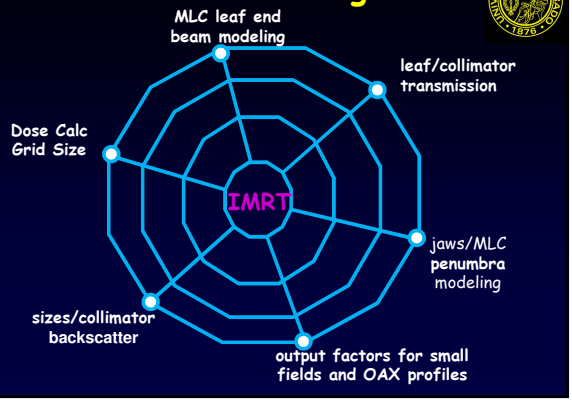


Nelms and Simon, JACMP 8, 1-15 (2007)

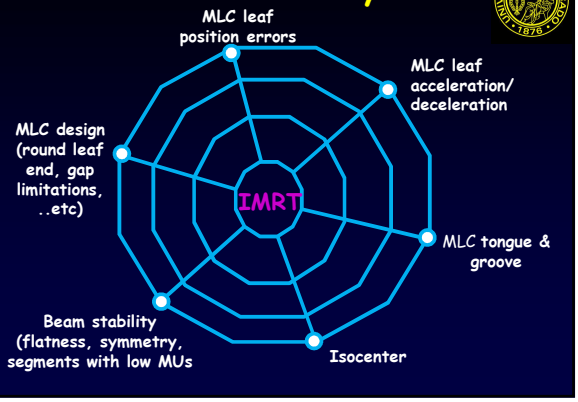
Questions?

- What should be the delivery method for IMRT QA?
- What should be the criteria used … composite %diff/DTA or Gamma?
- How many of the points should pass this criteria … 90%, 95%, 98%?
- What should be the tolerance levels and action limits … 3%/3mm, 3%/5mm?

Uncertainties- Planning



Uncertainties- Delivery



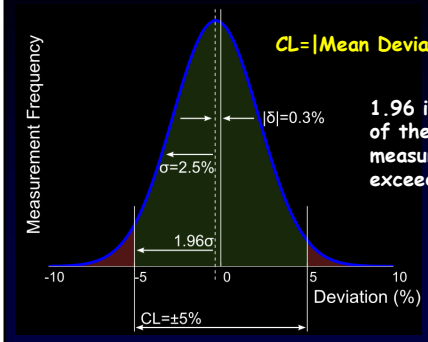
Action Limits (ALs)

- Quality measures (QMs) → set a requirement for the performance of IMRT QA
- Action Limits
  - → degree to which the quality measures are allowed to vary
  - → thresholds for when an action is required
  - → based on clinical judgment
    - acceptability of a certain level of deviation from a QM

Tolerance Limits (TLs)

- TLs → boundary within which a process is considered to be operating normally
- Measurements outside of a TL provide a warning that a system is deviating
  - investigate to see if an issue can be identified and fixed
- Intent → fix issues before they become a clinical problem (i.e. data outside of ALs)

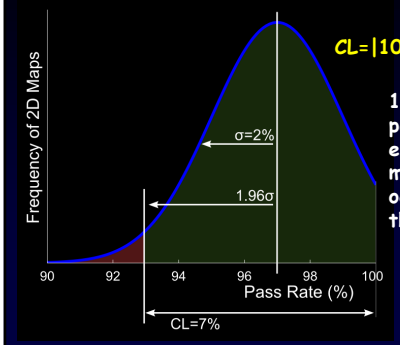
Measurement Confidence Limit



CL=|Mean Deviation|+1.96σ

1.96 implies that 5% of the individual measurements may exceed the limit

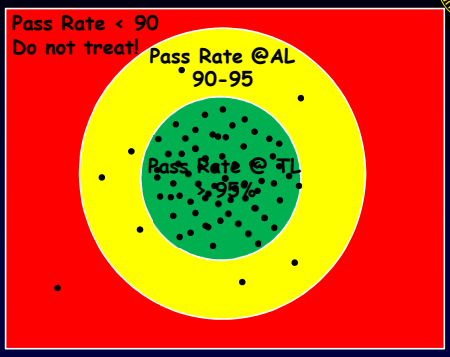
Pass Rate Confidence Limit



CL=|100-Mean|+1.96σ

1.96 implies that passing rates in excess of 100 minus the CL may occur about 5% of the time

What Should We Expect?



Proposed Values by Palta et al

Table 2. Proposed Values of the Confidence Limits and Action Levels for IMRT Planning

Region	Confidence Limit* (P=0.05)	Action level
δ_1 (high dose, small dose gradient)	±3%	±5%
δ_2 (high dose, large dose gradient)	10% or 2 mm DTA®	15% or 3 mm DTA®
δ_3 (low dose, small dose gradient)	4%	7%
$\delta_{90-50\%}$ (dose fall off)	2 mm DTA	3 mm DTA

* Mean deviation used in the calculation of confidence limit for all regions is expressed as a percentage of the prescribed does according to the formula,
$\delta_i = 100\% \text{ X } (D_{calc.} - D_{meas.}/D_{prescribed})$

Confidence Limit: $\Delta = |\text{Mean Deviation}| + 1.96\sigma$

Palta et al, AAPM Summer School 593-612 (2003)

ESTRO Booklet #9

- "Guidelines for the Verification of IMRT"
- Summarized the experience of a number European institutions
- Recommended for chamber measurements
  - 3% TLs
  - 5% ALs

TG119 CLs and Passing Rates

- High Dose Point in the PTV
  - CL of ±4.5%
- Per Field Measurements (3%/3mm)
  - CL of ±7%
  - %passing $\gamma > 93\%$ ~95% of the time
  - 94% of tests fell within CL
- Composite Measurements (3%/3mm)
  - CL of ±12%
  - %passing $\gamma > 88\%$ ~95% of the time
  - 93% of tests fell within CL

Ezzell et al, Med Phys 36, 5359 - 5373 (2009)

Suggestions

- IMRT QA plan delivery
  - True composite OR Beam-by-Beam
  - Beam-by-beam composite is NOT recommended
- Global normalization
  - Norm point in high dose small gradient
- 10% low dose threshold
- Absolute dose analysis

%Diff/DTA Analysis

- Pass → ≥ 95% of the points within 3%/3mm (TLs) AND 100% of the points within 5%/3mm (ALs)
- Fail → 90% of the points within 3%/3mm (TLs) OR any points outside of 5%/3mm (ALs)
- Eval → 90-95% of the points within 3%/3mm

γ Analysis Using 3%/3mm

- Pass → ≥ 95% of the points with $\gamma < 1$ AND no point exceeding a max γ of 2.3 (max dose diff of 7%)
- Fail → < 90% of the points with $\gamma < 1$ OR any point exceeding a max γ of 2.3
- Eval: 90-95% of the points with $\gamma < 1$

Steps to Check Marginal/Failed IMRT QA

- Phantom setup
- Location of the global normalization point
- QA plan generation and data transfer
- Sensitivity and calibration of detector
- Beam flatness, symmetry, and output
- Beam stability when delivering low MU segs

MLC and TPS

- Leaf tolerances (speed, position,…etc)
- TG effects and DLG for rounded-leaf ends
- Leaf transmission
- Tracking jaw positions
- Total # of small segments in the plan
- Calc grid size or the MC variance setting
- Complexity of the intensity patterns

Final Thoughts…

- IMRT passing TLs & ALs may be refined
  - To include clinical site uncertainties
  - To include tolerances
  - To account for the design and age of the accelerator and equipment
- Centers not able to meet suggested limits
  - Analyze distributions from a large # of cases
  - Derive limits to ensure > 95% of the time cases pass within the TLs
- TG218 report is being drafted-- stay tuned

Thank You

CU Anschutz Medical Campus