Dose Distribution Comparisons

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Why is this important?

- Quantitation required in dose comparisons
- Doses contain steep gradients
- Many times: one or both distributions are measured = spatial uncertainty/error
- Direct dose comparisons (difference, ratio) are very sensitive to spatial uncertainties/errors in steep dose gradient regions

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Comparison Tests

- Dose Difference
- Distance to Agreement
- γ

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What is γ?

- γ is the rescaled Euclidean distance between an evaluated distribution and each point in a reference distribution
- Each spatial and dose axis is normalized by a criterion
- Renormalized "distance" defaults to distance to agreement and dose difference in shallow and steep dose gradient regions, respectively.

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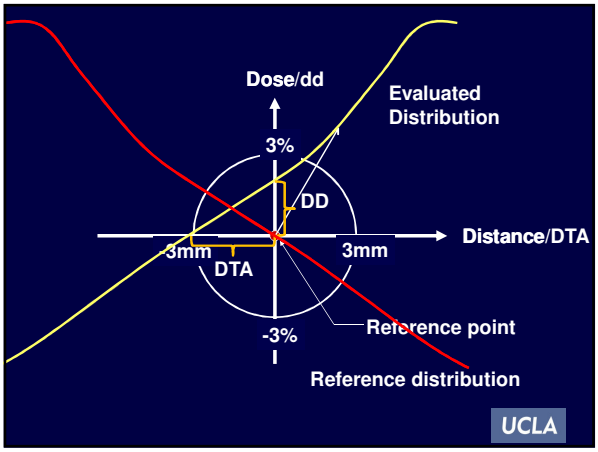

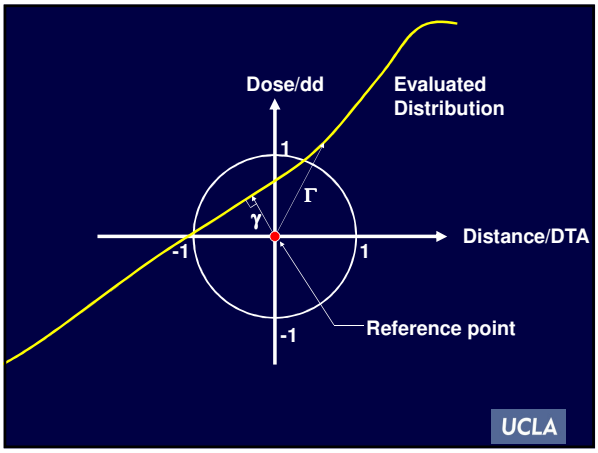

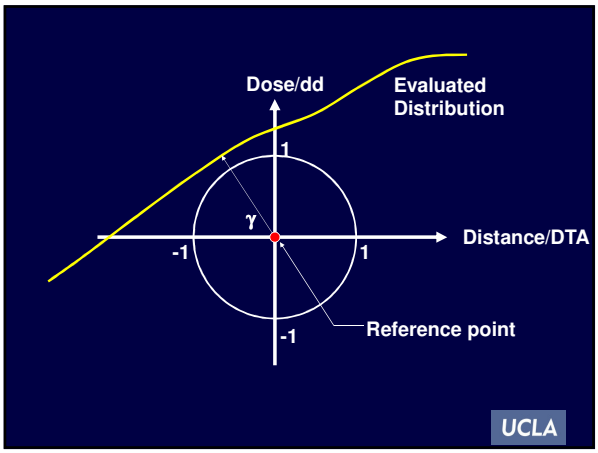
Dose/dd
Evaluated Distribution
1
γ
-1
1
Distance/DTA
-1
Reference point
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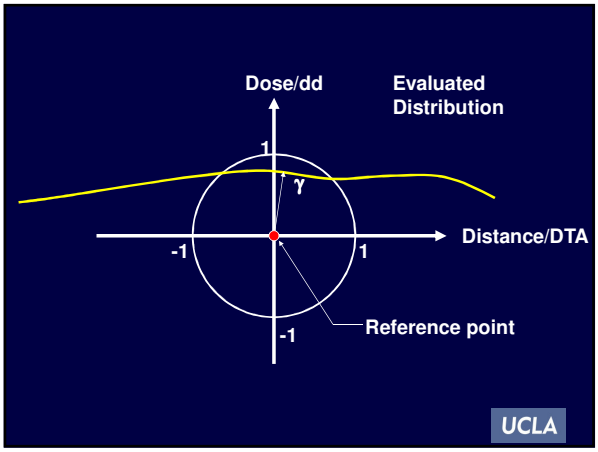
Dose/dd
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1
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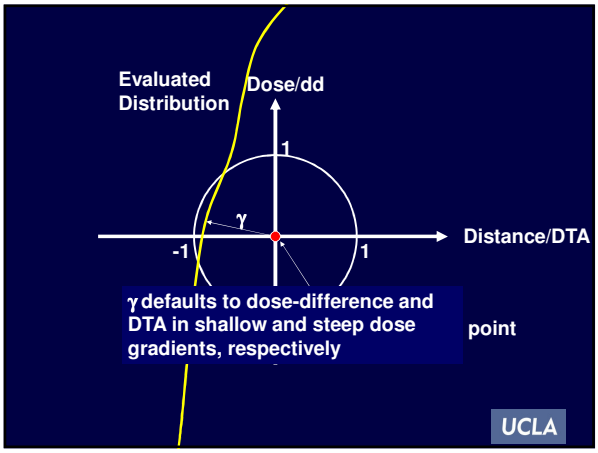
Evaluated Distribution
Dose/dd
1
γ
-1
1
Distance/DTA
γ defaults to dose-difference and DTA in shallow and steep dose gradients, respectively
point
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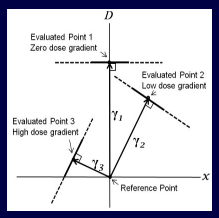
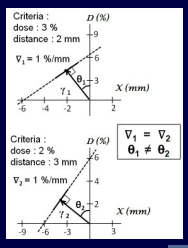
Dose Gradients

- How steep is steep?





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Look at Actual Dose Distributions

- Head and Neck, Prostate, Lung
- Approx 50 patients each
- 2% 3mm, 3% 3mm, 3% 2mm
- Angle θ
- Sine squared θ (surrogate for DTA projection)

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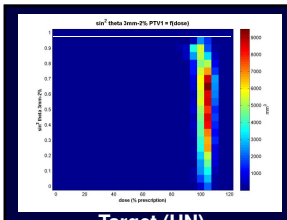
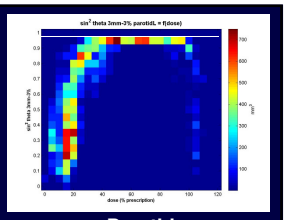
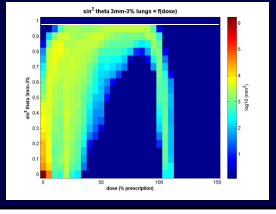


Target (HN)



Parotid



Lung

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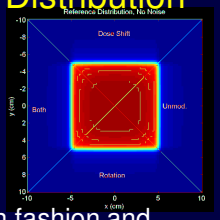
Example Dose Distribution

- Two 10 x 10 fields
- 6 MV
- Coronal
- 3%, 3mm criteria
- Skew one in a smooth fashion and compare doses



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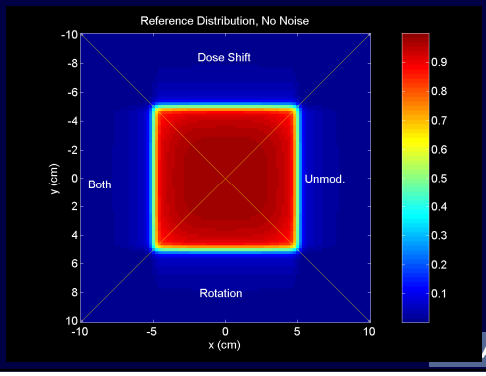
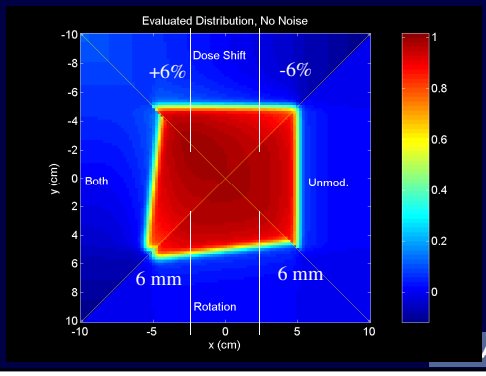
Reference Distribution (10x10 cm^2)



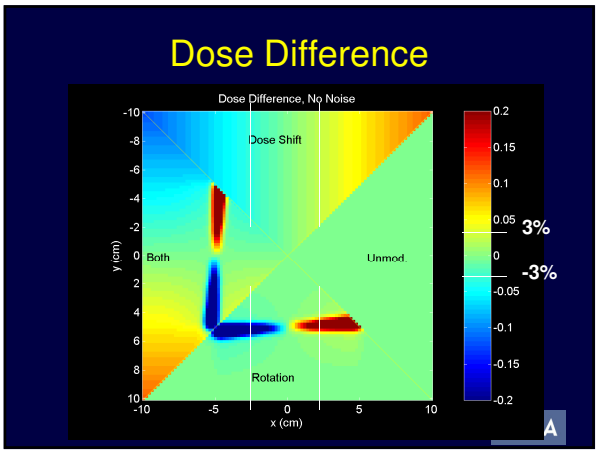
A

Evaluated Distribution

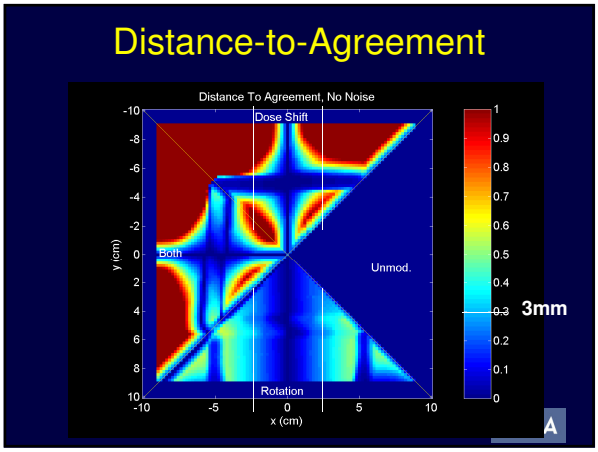


A

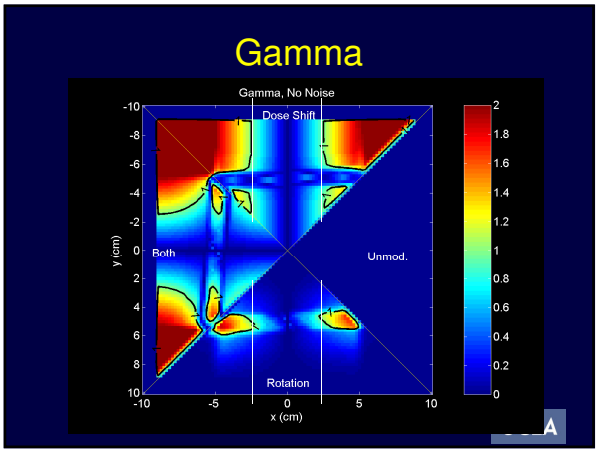
Dose Difference



Distance-to-Agreement



Gamma



Spatial Resolution

- γ is calculated independently for each reference point
- Reference distribution can be a single point
- Evaluated distribution 1D-3D
- Resolution challenge

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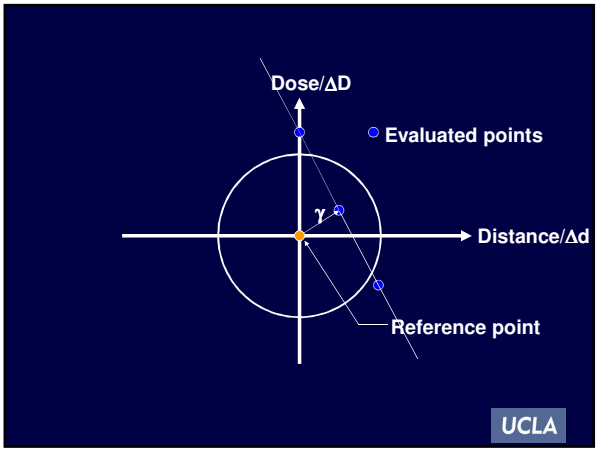

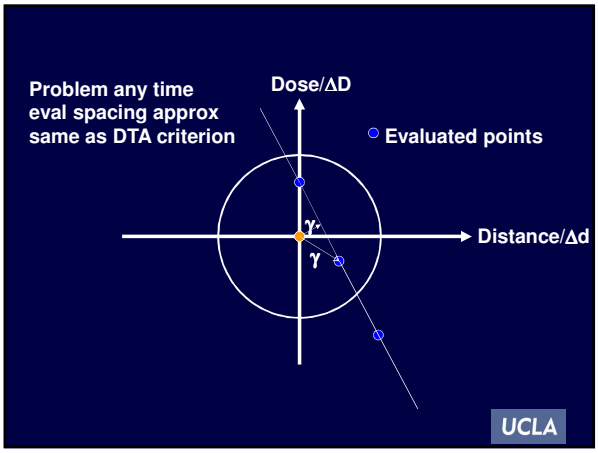

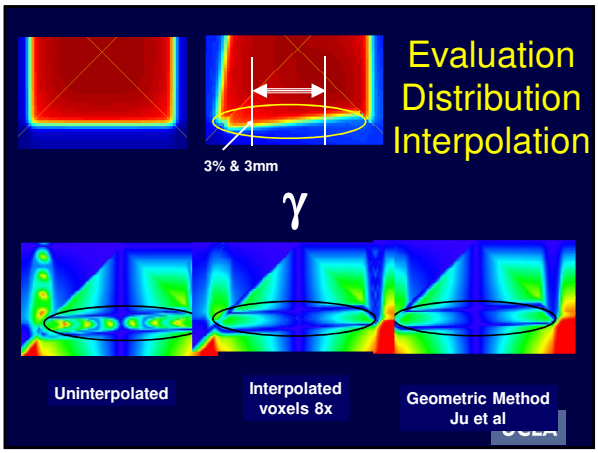

Clinical Issues

- Spatial resolution in evaluated distribution is important unless some type of interpolation is used
- Dose difference criterion is intuitive
- DTA criterion
  - Spatial uncertainty (measurements)
  - Spatial allowance (margins)
- How do we interpret γ failures?

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γ failures

- 100% passing would be nice!
- Not practical
- Caution: γ tool should be used as an indicator of problems, not as a single indicator of plan quality
- Passing Rate (Nelms): passing rate poorly correlated with clinically relevant errors

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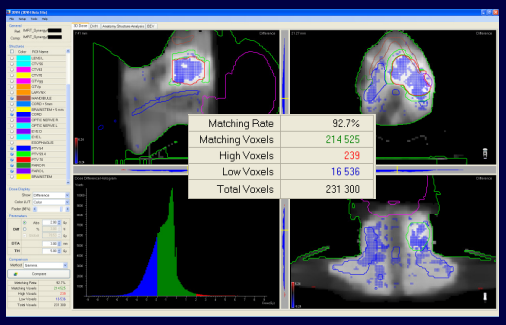

Thanks to Geneviève Jarry, HMR, Montreal

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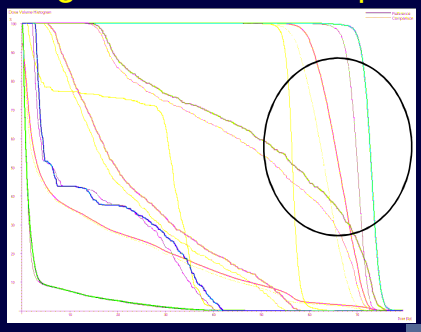
Target Volume Cold Spots



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Conclusions

- γ distribution is a powerful tool that aids in the evaluation of complex dose distributions
- Dose gradients are sufficiently steep so that DTA is sampled
- Interpolation is required to get accurate results
- γ statistics alone are insufficient to determine clinical acceptability

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