Reconstruction of physical and biological dose distributions of carbon-ion beam through deconvolution of longitudinal dosimeter responses

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Purpose

- Ideal QA dosimetry system for carbon-ion RT
 - of highly complex beam fields
 - at high spatial and dose resolutions
 - especially, for Bragg peaks
 - in RBE-weighted (biological) dose
 - to evaluate clinical significance of observed deviations.
- This study aims to propose such a system using existing technologies.

2

Idea of longitudinal dosimetry with radiochromic film (RCF)

3

Methods

- Example carbon-ion beam to test:
 - Biologically uniform SOBP formed by layer stacking of range-shifted elemental beams (beamlets).
 - 32 layers at 2.5 mm range-shift intervals for 8 cm SOBP
- RCF dosimetry simulation
 - RCF response (optical density interpreted as 6MV dose) based on an empirical function of LET.
- Deconvolution of RCF responses
 - to estimate weights of beamlets finely arranged at 0.5 mm range-shift intervals.
- Reconstruction of physical and biological doses
 - using a conventional dose-summation algorithm.

5

Basis beamlet data (the beamlet without range shifting)

6

Results

10

Conclusions

- This simulation study has shown:
 - Physical and biological doses can be measured in longitudinal RCF dosimetry by applying deconvolution algorithm with full beamlet data and RBE model used in treatment planning.
 - Dose errors will approximately correspond to RCF measurement errors.
 - Beam delivery failure will be easily detectable especially in biological-dose distribution.

See also: Kanematsu et al Med Phys (2019) <https://doi.org/10.1002/mp.13360>

11