Clinical validation of Fred Monte Carlo code in Krakow proton beam therapy centre

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FRED MC
First FRED validation with standard MC codes...

- „FRED” : MC code working on GPU cards.
- Depth-dose profiles obtained with MC FRED are in agreement on level 1–2% (in Bragg peak region) with standard MC codes.

Source : Schiavi et al. (2017)

FRED MC
... and first clinical validation @CNAO

Source: Schiavi et al. (2017)
Validation procedures
applied at CCB Krakow

- Comparing profiles of dose distribution from simulation with TPS
- Gamma index (GI) analysis
- Measurements (work in progress)
Profiles
Single beams

Proton beam with energy 150 MeV

(1) Emittance model – beam envelope defined by measurements of the beam size in air
(2) Paraxial beam – assumed constant beam size based on measurements in water
Profiles

Dose cubes

Range 25 cm, modulation 5 cm

(1) Emittance model – beam envelope defined by measurements of the beam size in air

(2) Paraxial beam – assumed constant beam size based on measurements in water

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Gamma index analysis

The standard method for dose verification which is based on dose difference (DD) and distance to agreement (DTA) criteria to evaluate the agreement between two dose distribution.

Gamma index analysis

Dose cubes

FRED vs TPS
3D 1 :  95.3%

FRED vs TPS
3D 1 :  95.6%

FRED vs TPS
3D 1 :  96.2%

FRED vs TPS
3D 1 :  92.8%

FRED vs TPS
3D 1 :  74.1%
Gamma index analysis

Patient data

2%/2mm passing criteria

Depth in water ranges

Gamma index, [%]

38 cases
41 cases
38 cases

TPS vs. MatriXX measurement
FRED vs. MatriXX measurement
Measurements
Spot size in RW3 slab phantom

Courtesy of Natalia Mojżeszek
Measurements

Spot size in RW3 slab phantom

![Graph showing spot size measurements with markers for FRED and measured spot sizes at different depths.]

Courtesy of Jan Gajewski
Conclusions

- Implemented beam model was validated with dosimetric and clinical cases.
- Over 95% passing rate score for most of 3D dose distribution of dose cubes and over 90% for all patient cases considering 2D images.
- Measured data confirmed a high precision of FRED MC dose recalculation.
Next validation steps

- Include calibration curve from CCB Krakow.
- Perform simulations on patient CT images.
Other future plans

- Perform simulation in RW3 material.
- Experimental beam characterization (1st and 2nd Gaussian profile).
- Include measurements for dosimetric calibration.
- Development of treatment plan optimization methods for FRED MC code.
Research partners

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