Hadrontherapy Monitoring via Integral Prompt Gamma Detection

Jochen Krimmer¹, Loup Balleyguier¹, Denis Dauvergne², Joel Hérault³, Jean Michel Létang⁴, Marco Pinto⁵, Etienne Testa¹, Yannick Zoccarato¹

¹IPNL Lyon, ²LPSC Grenoble, ³CAL Nice, ⁴CREATIS INSA Lyon, ⁵LMU Munich

Journée industrielle de Labex Primes Lyon 13/09/2017



Introduction

• Aims

- Online monitoring during hadrontherapy
- Detect deviations from prescribed treatment
- information independent from monitoring devices of the beamline
- Methods
 - Detection of prompt gamma-rays produced in the target (patient)
 - use TOF to discriminate events created in the target from events created in the nozzle
 - Integral of TOF spectra depends on absorbed energy (range) as well as on target material

Prompt Gamma Peak Integral: PGPI

Creation of secondary radiation



- Production rate of secondary radiation correlated with dose fall-off
- Detection of secondary radiation (charged particles and prompt γ-rays)
 - -> online monitoring
- Various approaches for prompt γ-detection (collimated & uncollimated)

[J.K., D. Dauvergne, J.M. Létang, E. Testa NIM A 2017]

PGPI: Test Measurements





- protons 65 MeV at CAL Nice
- Passive beam delivery modulator wheel
- Scintillation detectors
- Clinical intensities



- TOF spectra corresponding to different angles of the wheel
- Identify events from the target

Relative count rates



- Integration of background subtracted TOF spectra
- Relative count rate as a function of wheel angle
- Diminution by more than a factor five: two effects:
 - Reduction of proton path inside the target
 - Scattering in modulator -> less protons passing collimator
- Simulation of collimator transmission

Simulation studies



- 8 detectors symmetrically around target
- Spherical target
- displacement



- Combine detector information
- Geometric (arithmetic) mean
 -> independent on target position
- Ratios: detection of target misplacement possible

[J.K. et al. Appl. Phys. Lett. 110, 154102 (2017)]

Summary and outlook

- Uncollimated prompt γ-ray detection
- Sensitive to deviations on the per-cent level for reasonable detector sizes and a statistics corresponding to 1 spot in PBS
- Multiple detectors: combine information to either
 - Get precise information on generated prompt γ-rays (independent on position) or
 - Detect a possible misplacement
- Next steps:
 - Measurements with more realistic phantoms
 - Improve precision of the predictions / simulations
 - improve data base for prompt γ -ray production