Evaluation of Geant4 for in-vivo range verification in Heavy Ion Therapy

NIRS
Australian Government
ansto
CENTRE FOR MEDICAL RADIATION PHYSICS
UNIVERSITY OF WOLLONGONG AUSTRALIA

Authors

Presenting author

- [1,2]Andrew Chacon

Contributing Authors

- [2,1]Mitra Safavi-Naeini
- [2]Marie-Claude Gregoire
- [1,3]Susanna Guatelli
- [1,3]Anatoly Rozenfeld

Experiment and PET Imaging Collaborators

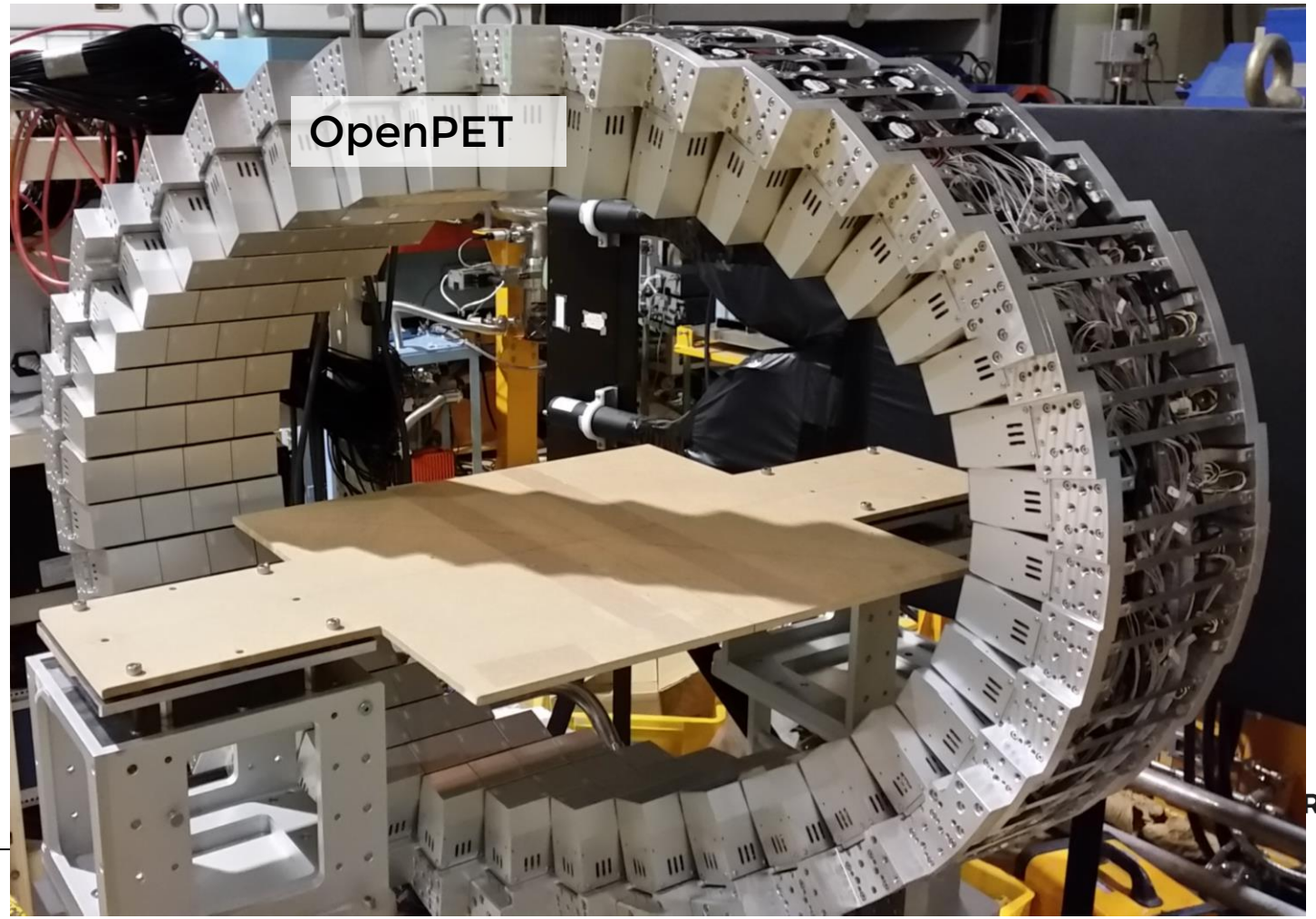
- [4]Akram Mohammadi
- [4]Muneka Nitta
- [4]Fuminiko Nishikido
- [4]Yuma Iwao
- [4]Hideki Tashima
- [4]Eiji Yoshida
- [4]Taiga Yamaya

[1] University of Wollongong, Centre for Medical Radiation Physics, Wollongong, NSW, Australia
[2] Australian Nuclear Science and Technology Organisation, Human Health, Lucas Heights, NSW, Australia
[3] University of Wollongong, Illawarra Health and Medical Research Institute, Wollongong, NSW, Australia
[4] National Institutes for Quantum and Radiological Science and Technology, National Institute of Radiological Sciences (NIRS), Inage-ku, Chiba, Japan

NIRS Australian Government ansto CENTRE FOR MEDICAL RADIATION PHYSICS UNIVERSITY OF WOLLONGONG AUSTRALIA

Vision

- Collaboration with NiRS to improve OpenPET simulation

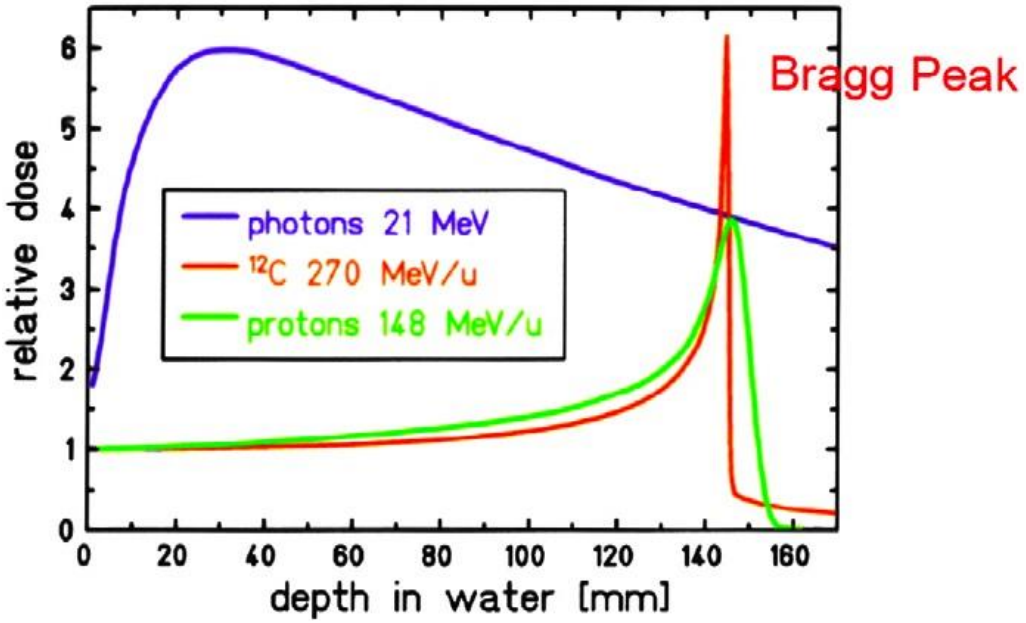


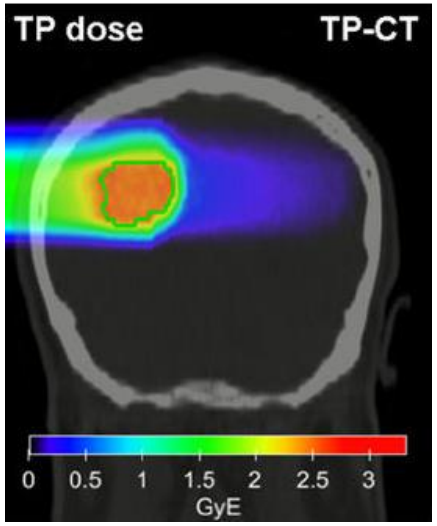
CENTRE FOR MEDICAL RADIATION PHYSICS

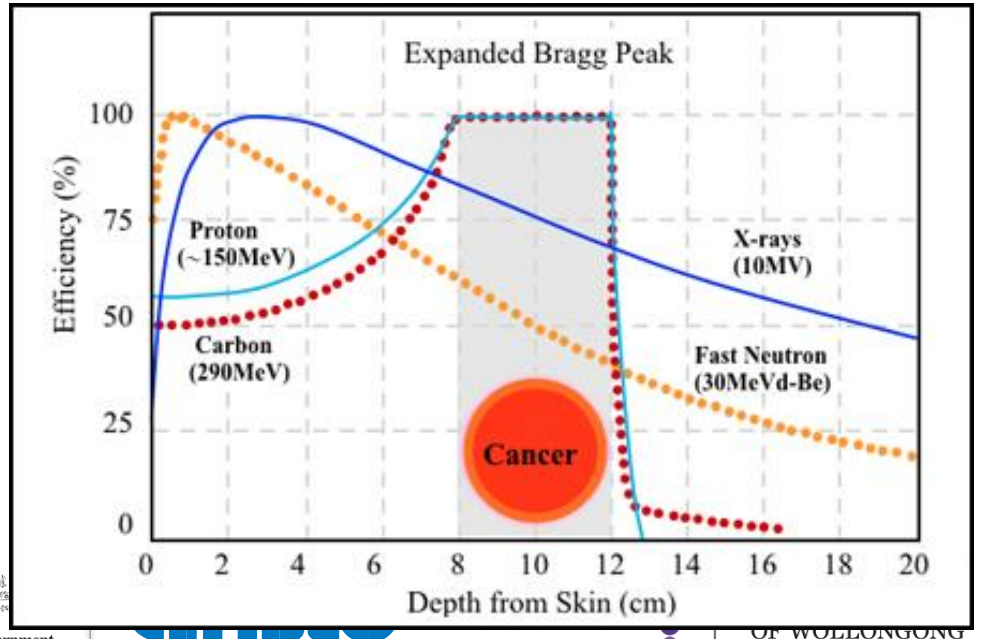
UNIVERSITY OF WOLLONGONG AUSTRALIA

Carbon-12 Therapy

- Presence of the Bragg peak
- Less dose to surrounding healthy tissue
- High radiobiological efficiency
- Less lateral scattering



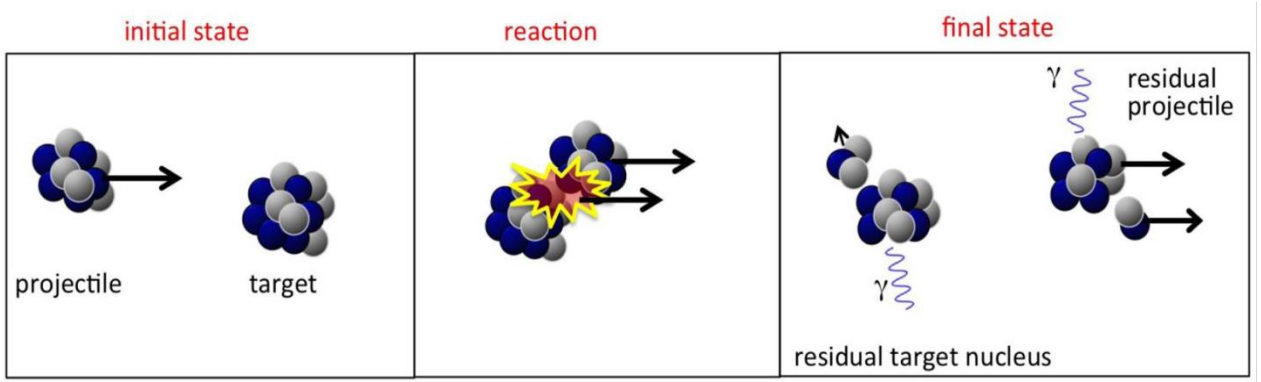




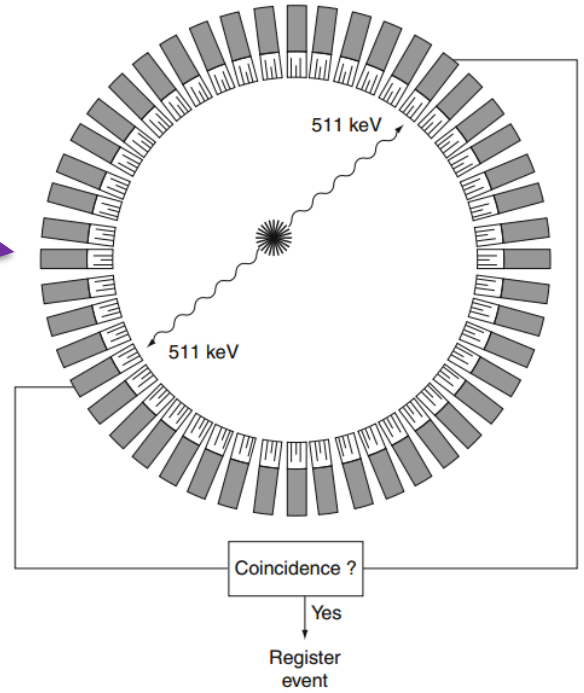
1) Paulo Crespo et al. “On the detector arrangement for in-beam PET for hadron therapy monitoring”. In: *PHYSICS IN MEDICINE AND BIOLOGY* 51 (2006), pp. 2143–2163
2) c/o Laboratory for Chemistry and Life Science, What is BNCT?, Japanese Society of Neutron Capture Therapy, viewed 1 April 2017, http://www.jsnct.jp/e/about_nct/
3) Fokas et al, The Bragg peak for carbon ions, "Ion beam radiobiology and cancer: Time to update ourselves", Biochimica et Biophysica Acta **1796** (2009) 216–229.)

Fragmentation and Beta emitters

- Coulomb interactions
  - Ionisation & excitation of electrons
- Nuclear fragmentation
  - Creation of β+ emitters
- Positron Emission Tomography (PET)
  - Coincidence detection of 511 KeV annihilation photons



Nuclear Fragmentation of a Carbon-12 Atom [1]



[1] Kraan, A. C. (2015). Range Verification Methods in Particle Therapy: Underlying Physics and Monte Carlo Modeling. *Frontiers in Oncology*, *5*, 150. http://doi.org/10.3389/fonc.2015.00150

Aim

- To identify which hadronic ion physics model best describes the production of β^+ emitters for ^{12}C therapy
  - Binary Ion Cascade (BIC)
  - Quantum Molecular Dynamics (QMD)
  - Liege Intranuclear Cascade model (INCL++)

Acknowledgements

- Monash University **M3** cluster for computational resources
- University of Wollongong, High Performance Cluster (**HPC)** cluster for computational resources
- The Australian Government, National Computational Infrastructure (NCI), **Raijin** cluster, for computational resources
- Centre for Medical and Radiation Physics, University of Wollongong **Centaur cluster** for computational resources
- The Australian Nuclear Science and Technology Organisation (ANSTO) **Commodore** for computational resources
- Heavy Ion Medical Accelerator in Chiba (HIMAC), National Institute of Radiological Science (NiRS) for ^{12}C beamline use
- Department of Radiation Measurement, Imaging and Dosimetry, National Institute of Radiological Science (NiRS), Chiba, Japan for the use of OpenPET
- This research has been conducted with the support of the Australian Government Research Training Program Scholarship


Thanks!