# 24th Geant4 Collaboration Meeting, Jefferson Lab, 23rd-27th Sept 2019.

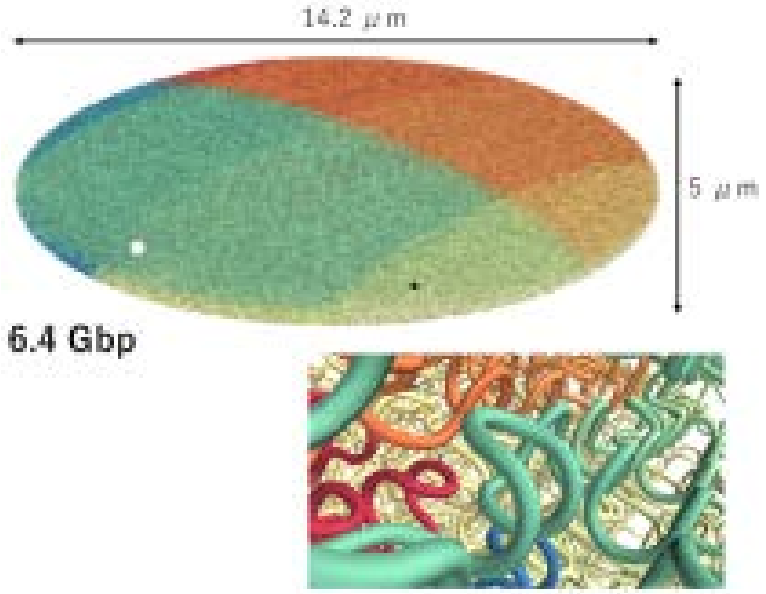
## Parallel session 7B: Geant4 in medicine

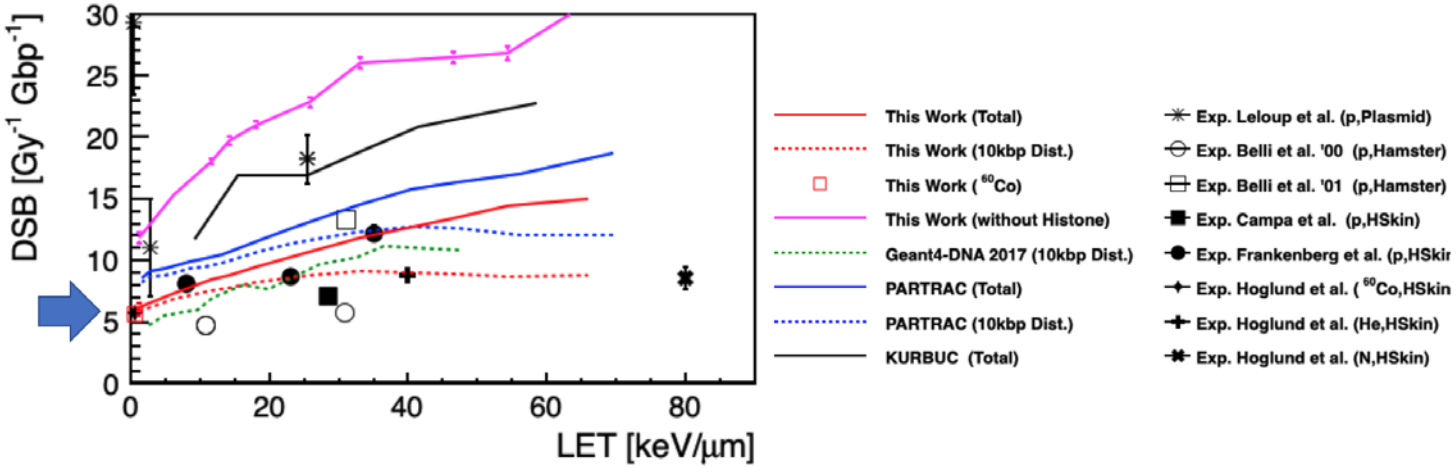
Chairs: B. Faddegon (kindly substituted by J. Ramos Mendez) and S. Guatelli

| | | | |
|---|---|---|---|
| 16:00 | **Evaluation of early radiation DNA damage in a fractal cell nucleus model using Geant4-DNA (remote)** | *Dosatsu Sakata* | |
| | *L102, Jefferson Lab* | | 16:00 - 16:15 |
| | **Current status of IRT for plasmid SSB simulations under the presence of scavengers** | *Jose Asuncion Ramos Mendez* | |
| | *L102, Jefferson Lab* | | 16:15 - 16:30 |
| | **G4MSBG: recent developments** | *Susanna Guatelli* | |
| | *L102, Jefferson Lab* | | 16:30 - 16:45 |
| | **Validation of Geant4 for Microbeam Radiation Therapy** | *Susanna Guatelli* | |
| | *L102, Jefferson Lab* | | 16:45 - 17:00 |
| 17:00 | **Update of Light Ion Bragg Peak test with Li and O data** | *Miguel Antonio Cortes Giraldo* | |
| | *L102, Jefferson Lab* | | 17:00 - 17:15 |
| | **A proposal for a physics list for gamma radiotherapy applications** | *Pedro Arce* | |
| | *L102, Jefferson Lab* | | 17:15 - 17:30 |

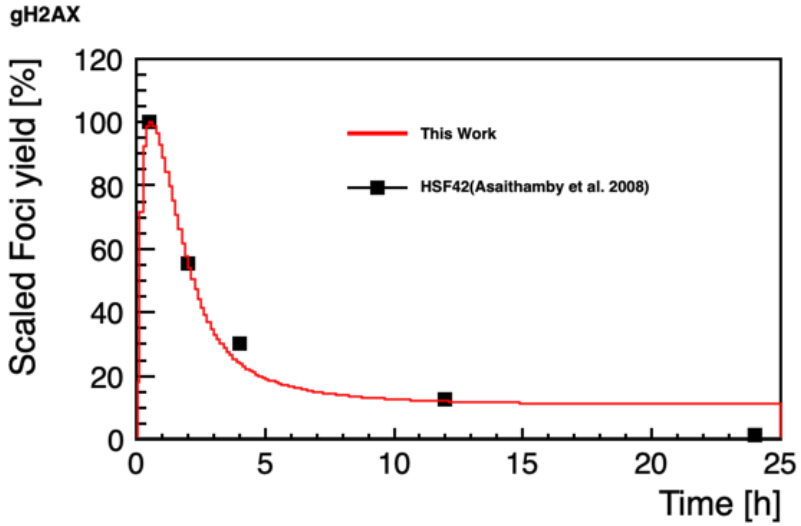
# Evaluation of early radiation DNA damage in a fractal cell nucleus model using Geant4-DNA

**Talk by D. Sakata, NIRS, Japan**




**Simulated SSB/DSB yields are good agreement with Exp. data for both of proton and gamma.**

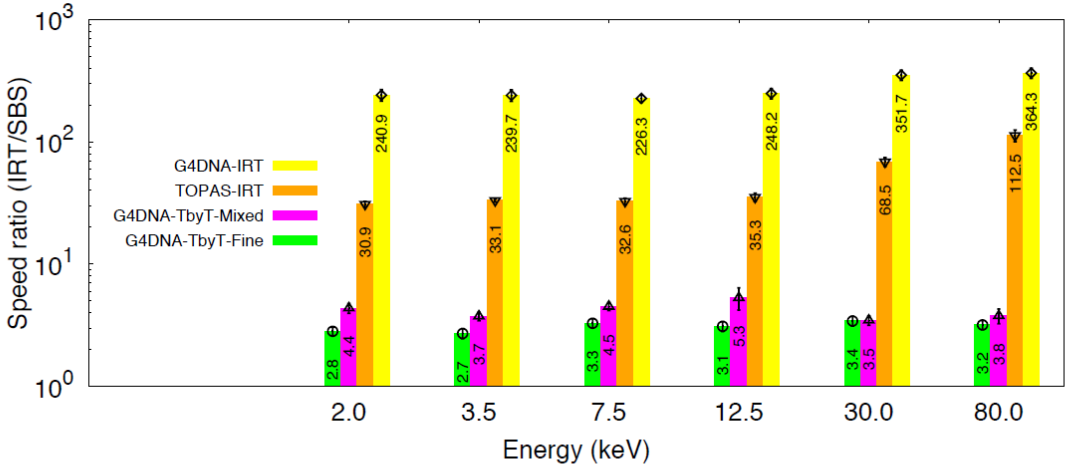


# IRT- Geant4 implementation.

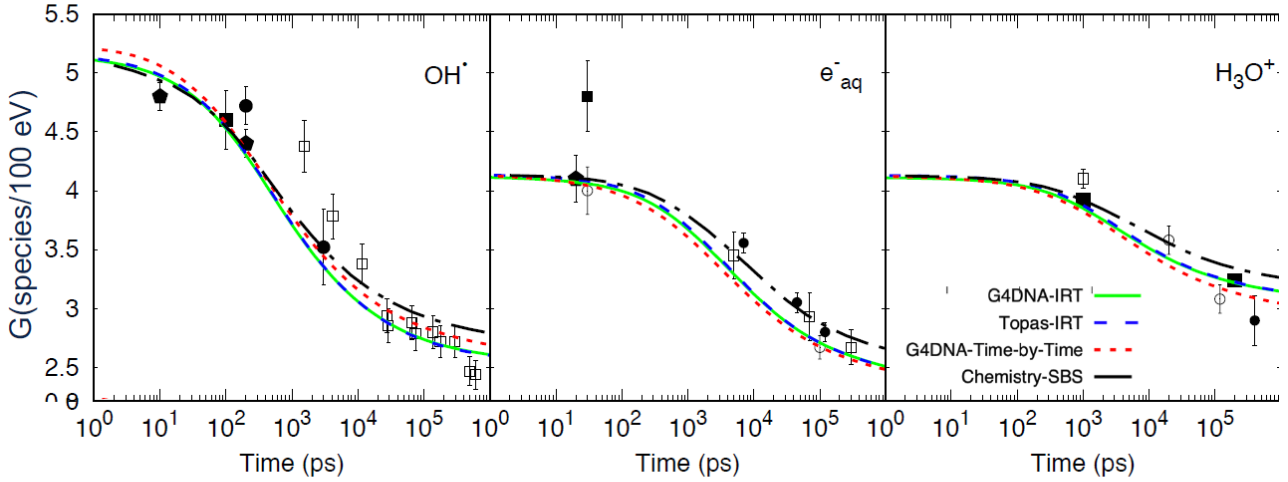
Two IRT approaches are currently being implemented by a dedicated working group within Geant4-DNA collaboration

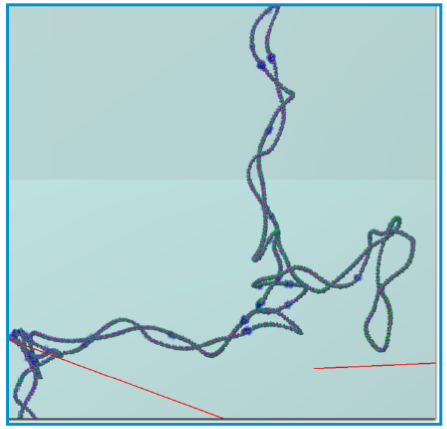
1. One is a faster approach, suitable for comparison with radiochemistry's experimental data: yields, scavengers, etc.
2. The other approach facilitates interaction with geometry boundaries, parallel navigation, magnetic fields, etc.

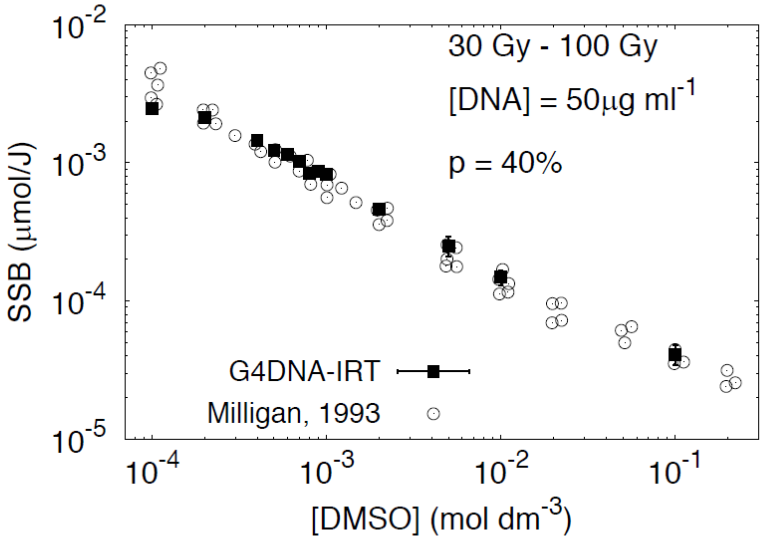
- **The implementation will be compatible with the current chemistry "interface" (basic chemistry functionalities) to facilitate development and maintenance**
- Easy-to-use for the user: swapping between SBS to IRT changing the chemistry list via constructors or UI.




Speed ratio with respect to step-by-step simulations using the dynamic time step resolution. Error bars represent 1 standard deviation. TbyT stands for Time-by-Time.






Tentative release on next year's June-December release.

# G4MSBG (G4-Med): recent developments

P. Arce[1], D. Bolst[2], M-C. Bordage[3], P. Cirrone[4], M.A. Cortes-Giraldo[5], D. Cutajar[2], G. Cuttone[4], L. Desorgher[6], P. Dondero[7], A. Dotti[8], B. Faddegon[9], C. Fedon[10], S. Guatelli[2], S. Incerti[11], V. Ivanchenko[12], D. Konstantinov[13], I. Kyriakou[14], G. Latyshev[13], A. Le[2], C. Mancini-Terracciano[15], A. Mantero[7], M. Maire[16], M. Novak[17], C. Omachi[18], L. Pandola[19], A. Perales[20], Y. Perrot[21], G. Petringa[4], J.M. Quesada[5], J. Ramos-Méndez[9], F. Romano[22], D. Sakata[2], L.G. Sarmiento[23], T. Sasaki[24], I. Sechopoulos[10], E. Simpson[25], T. Toshito[18], D. Wright[26]

[1]CIEMAT, Spain, [2]CMRP, University of Wollongong, Australia, [3]CRCT (INSERM and Paul Sabatier University), France, [4]INFN LNS Catania, Italy, [5]Universidad de Sevilla, Spain, [6]Radiophysics Institute, Switzerland, [7]SWHARD srl, Italy, [8]Former SLAC, USA,[9]University of California San Francisco, USA, [10]Radboud University Medical Center, The Netherlands, [11]CENBG, France, [12]Tomsk State University, Russian Federation, [13]IHEP, Protvino, Russian Federation, [14]Ioannina University, Greece, [15] Roma 1, INFN, Italy, [16]LAPP, IN2P3, France, [17]CERN, Switzerland, [18]Nagoya Proton Therapy Center, Japan, [19]INFN Gran Sasso, Italy, [20]Clínica Universidad de Navarra, Spain, [21]IRSN, France, [22]NPL, UK, [23]Lund University, Sweden, [24]KEK, Japan, [25]ANU, Australia, [26]SLAC, USA

Geant4 Collaboration Meeting, Jefferson Lab, US, 23-27 September 2019

# Summary

- Currently, 18 tests have been included in *G4_Med* to benchmark EM and Hadronic physics capabilities of Geant4 for medical physics applications.
  - Some test  fundamental physical quantities, others include more realistic scenarios.
- ***G4_Med*** is integrated in ***geant-val*** for regular executions on the CERN computing infrastructure.
- Overall, *G4EmStandardPhysics_option4* (**_EMZ**) is recommended for accurate simulations.
- **QGSP_BIC_HP** (_EMZ) physics list provides a good overall description for hadron therapy applications.
- TWiki page:  https://twiki.cern.ch/twiki/bin/view/Geant4/G4MSBG
- Oral presentations
  - M. A. Cortes-Giraldo et al., "G4_Med, a Geant4 benchmarking tool for medical physics applications"; ENSAR2 workshop: Geant4 in nuclear physics; Madrid (Spain), April 24-26, 2019.
  - S. Guatelli et al., "G4_Med, a Geant4 benchmarking tool for medical physics applications"; MCMA 2019, Montreal, Canada, June 19-21, 2019.
- Paper submitted as a Special Report of Medical Physics accepted for publication
  - Revisions to be addressed in the manuscript

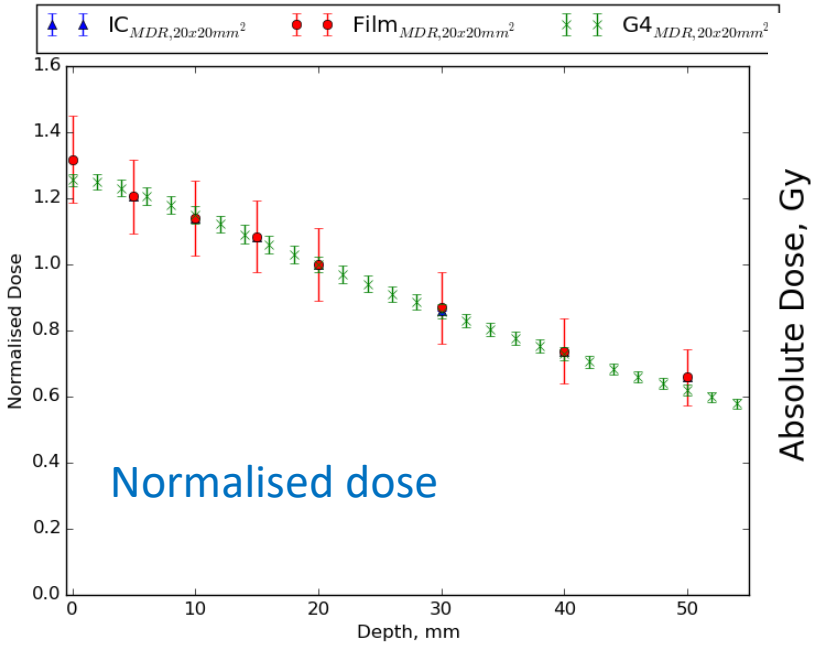
# Next stage

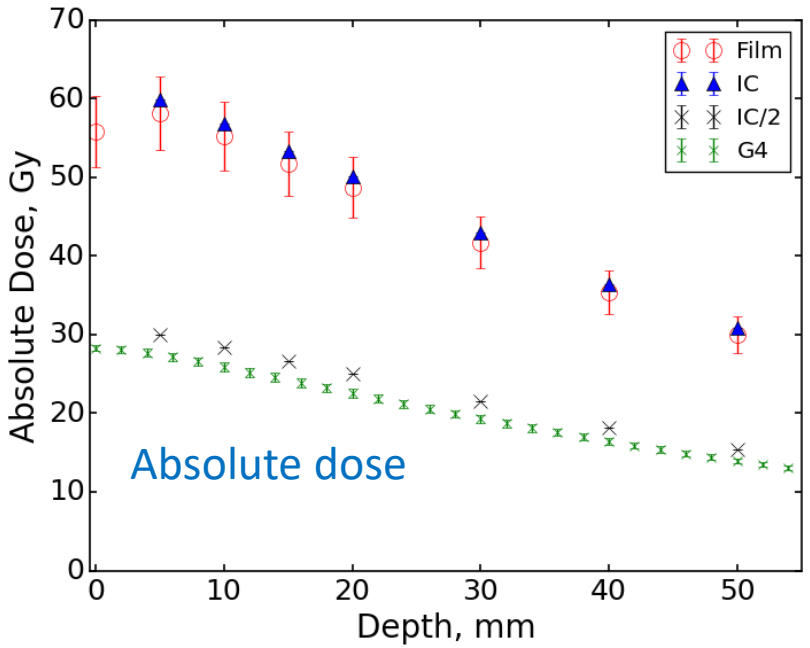
- Introduction of new tests
  - **I-125 source in brachytherapy** - S. Guatelli, D. Cutajar and A. Le
  - **X-ray small field dosimetry** – S. Guatelli and G. Biasi, UOW (within December 2019)
  - **In-vivo PET for carbon ion therapy** – S. Guatelli, A. Chacon and M. Safavi, UOW and ANSTO
  - Donated by the OpenGATE Collaboration, represented by L. Maigne and D. Sarrut.

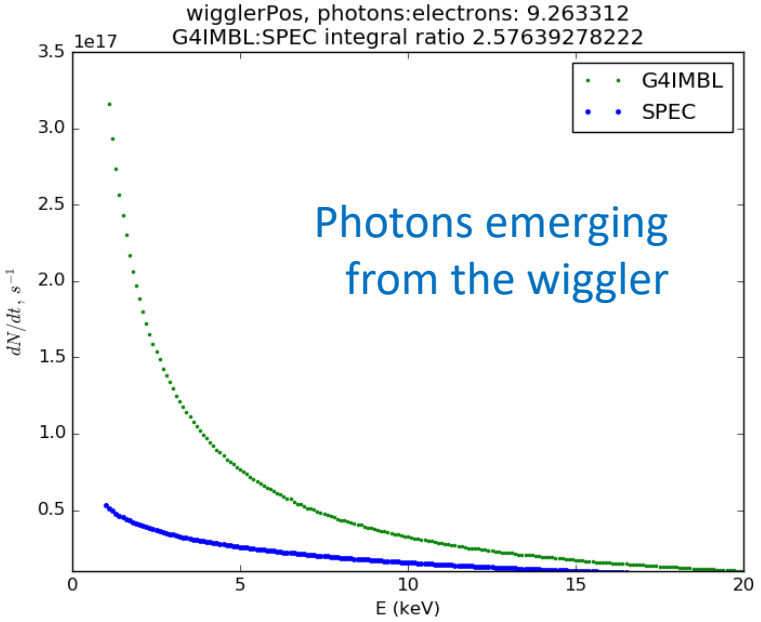
    Geant4 simulations:
    - **Test #1: simplified PET camera**
    - **Test #2: simplified SPECT camera**
  - **Radioactive decay**: L. Desorgher, D. Wright and L. Sarmiento
- Have regression tests
  - we started the systematic benchmarking work with Geant4 10.5
- Improve documentation of Geant4 medical physics pages

# Validation of Geant4 for Microbeam Radiation Therapy

- M. Cameron, A. Dipuglia, I. Cornelius, D. Cutajar, J. Davis, A. Rosenfeld, S. Guatelli, M. Lerch
- Development of a Geant4 simulation for dosimetry
  - Model of the beamline at the Australian Synchrotron
- Excellent agreement in terms of normalised doses, however large differences in absolute terms
  - Cause: the photons generated from G4Synchrotron have  a spectrum with a low energy contribution  higher than expected

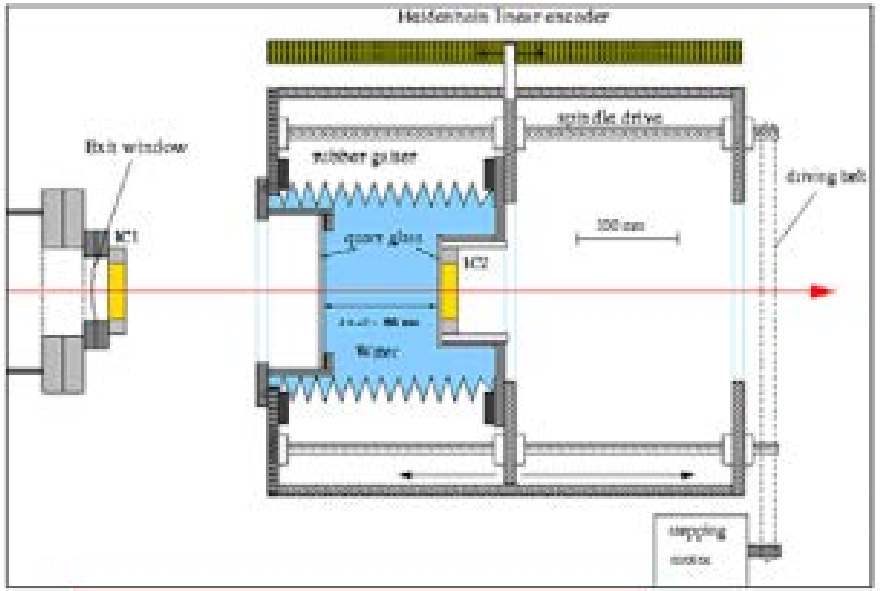


# Update of LightIonBraggPeak test with Li and O data

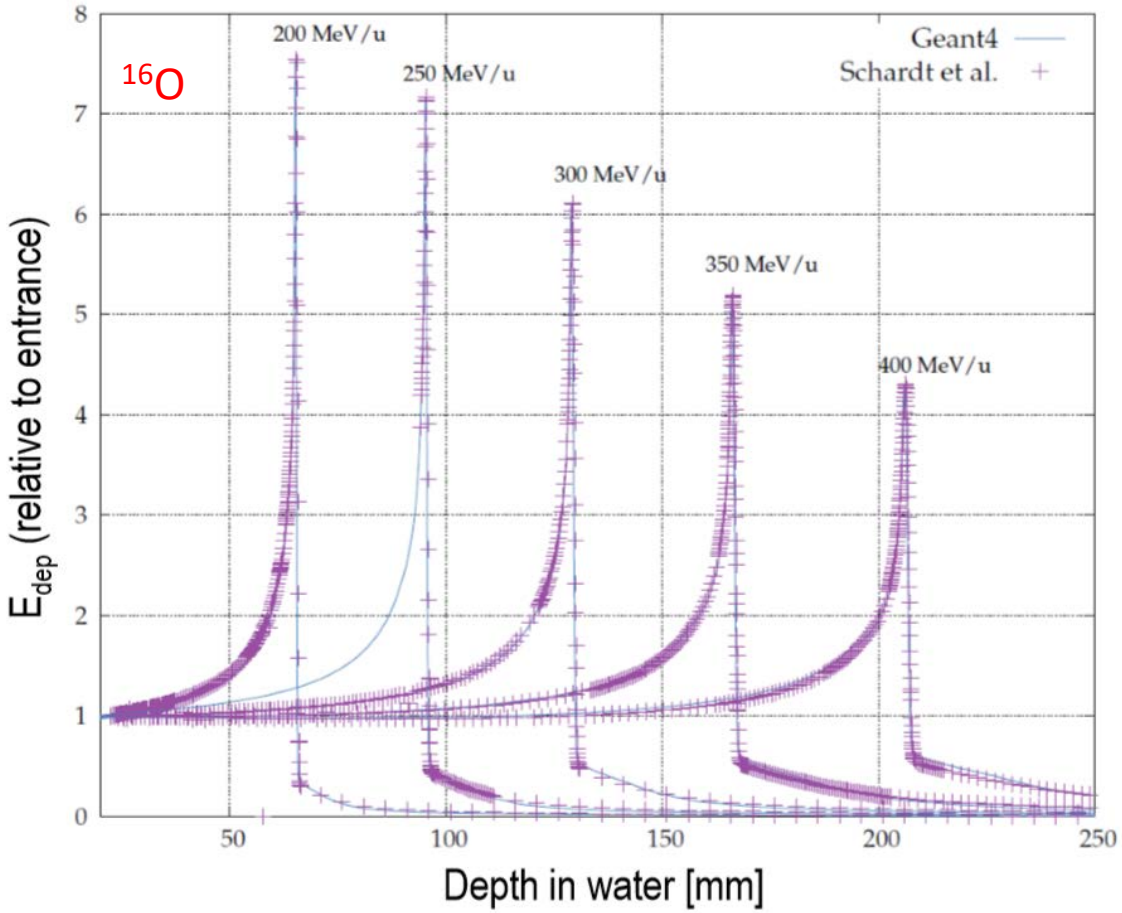
**Authors: M. A. Cortés-Giraldo, J. A. Pavón, A. M. Lallena, D. Schardt, A. Perales, J. M. Quesada**




D. Schardt *et al.*, GSI Scientific Report 2007

**Test integrated in G4-Med, geant-val**

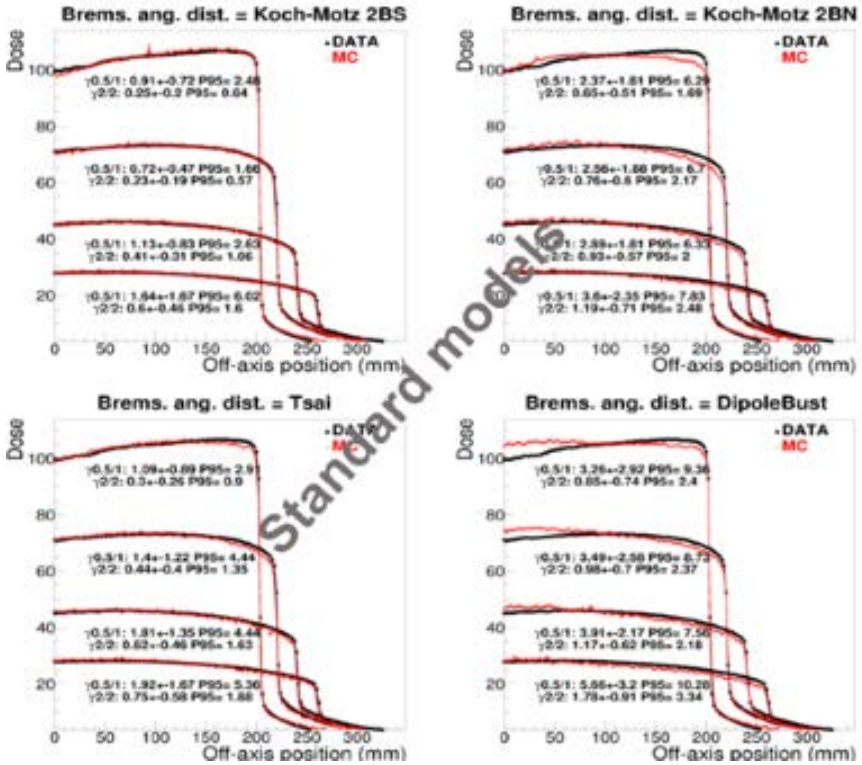
**New incorporated data – incident $^{7}$Li and $^{16}$O**



# An optimized Geant4 physics list for gamma radiotherapy

**Authors: P . Arce, J. I. Lagares, J. D. Azcona, P. B. Aguilar-Redondo**

## Bremsstrahlung angular distribution




**Three setups:**

**VARIAN Clinac 2100 C/D 6 MV**

**ELEKTA Versa HD 6 MV, without flattening filter**

**ELEKTA Versa HD 10 MV, without flattening filter**

## *Proposed physics list for gamma radiotherapy*

- Electromagnetic physics models: **standard**
- Multiple scattering model: **Urban** (DEFAULT)
- Bremsstrahlung angular distribution: **Tsai for small fields** (<20x20 cm), **Koch-Motz 2BS for big fields** (>20x20 cm)

- Multiple scattering step limitation type = **UseSafetyPlus**
- *Msc RangeFactor*: **0.05**
- *Msc GeomFactor*: **2.5**
- *Msc Skin*: **3**
- Eloss StepFunction): **0.2/1** (DEFAULT)
- Eloss & range tables bins per decade of energy for the energy loss and range tables: **20** (DEFAULT)
- *lowKinE*: **1 keV**
- *linLossLimit*: **0.01**

➢ Quite close to G4EmStandard_option3 (factor 1.25 faster)