Parallel 3A: Basic, Extended and Advanced Examples

I. Hrivnacova[1)]

S. Guatelli[2)]

[1)] IJCLab Orsay (CNRS/IN2P3)

[2)] University of Wollongong, Australia

hadronic/ParticleFluence	*Alberto Ribon*	
TD1	14:00 - 14:07	
dna/moleculardna - Hoang Tran	*Hoang Tran*	
TD1	14:07 - 14:14	
Parameterisations/Par04	*Anna Zaborowska*	
TD1	14:14 - 14:21	
runAndEvent/RE07	*Jonas Hahnfeld*	
TD1	14:21 - 14:28	
Update on the basic and extended examples	*Ivana Hrivnacova*	
TD1	14:30 - 14:45	
Update on the advanced examples	*Susanna Guatelli*	
TD1	14:45 - 14:55	
Fast drawing in the "ICRP HumanPhantoms"	*John Allison*	
TD1	14:55 - 15:05	
An advanced example for 3D imaging of microscopic samples by proton tomography	*Zhuxin Li et al.*	
TD1	15:05 - 15:20	
Update on the advanced example Radioprotection	*Jacopo Magini et al.*	
TD1	15:20 - 15:30	

New Extended Hadronic Example :

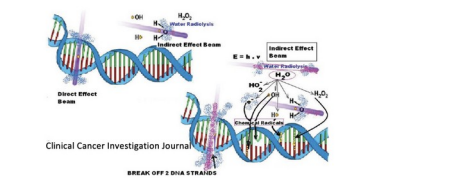
ParticleFluence

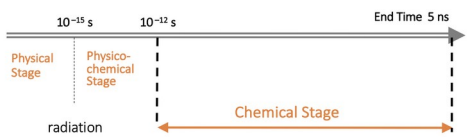
Alberto Ribon
(CERN EP-SFT)

Geant4 Collaboration meeting, Rennes, 27 September 2022

- Motivated by recent ATLAS has report of significant changes in particle fluence between Geant4 10.1 and 10.6
- Dedicated test for particle fluence in four setups: Layer, Sphere, ConcentricSpheres and Calo (cylindrical colorimeter)
- For regression testing – comparing Geant4 versions

MolecularDNA: can simulate early DNA damage using only Geant4 macro commands - No C++ skills needed





Simulation of physics, physico-chemistry and chemistry processes in DNA geometries.

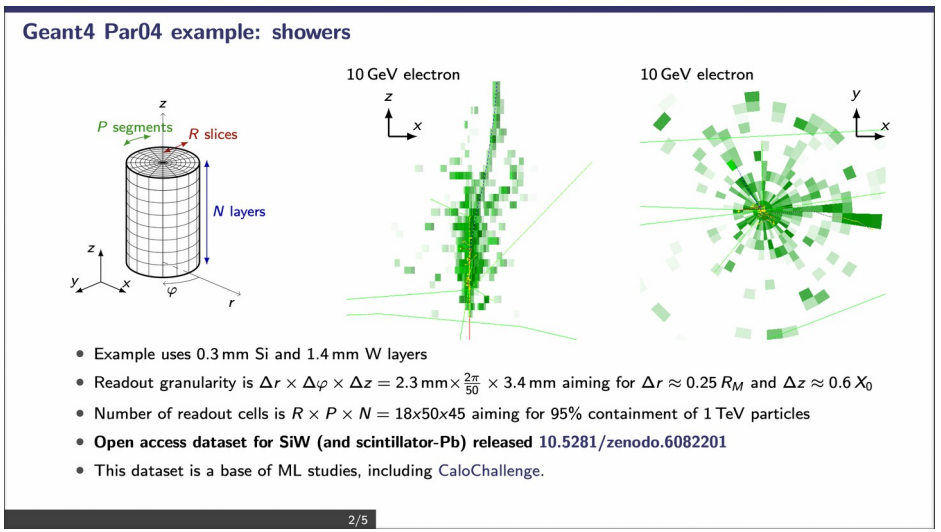
```
/world/worldSize 10200 nm
/cell/radiusSize 3 3 3 um

/dnageom/setSmartVoxels 1
/dnageom/checkOverlaps false

/dnageom/radicalKillDistance 9 nm
/dnageom/interactionDirectRange 7 angstrom

/dnageom/placementSize 30 30 180 nm
/dnageom/fractalScaling 1 1 1 nm
/dnageom/definitionFile geometries/prisms200k_r3000.txt
/dnageom/placementVolume prism geometries/straight-216-0.txt

# Damage Model
/dnadamage/directDamageLower 17.5 eV
/dnadamage/directDamageUpper 17.5 eV

/dnadamage/indirectOHBaseChance 1.0
/dnadamage/indirectOHStrandChance 0.65
/dnadamage/inductionOHChance 0.0

/dnadamage/indirectHBaseChance 1.0
/dnadamage/indirectHStrandChance 0.65
/dnadamage/inductionHChance 0.00

/gps/particle e-
/gps/ang/type iso
/gps/energy 4.5 keV
/gps/pos/type Volume
/gps/pos/shape Sphere
/gps/pos/radius 500 nm
/gps/pos/centre 0 0 0 nm
/run/beamOn 1000
```

Geometry info

Damage model

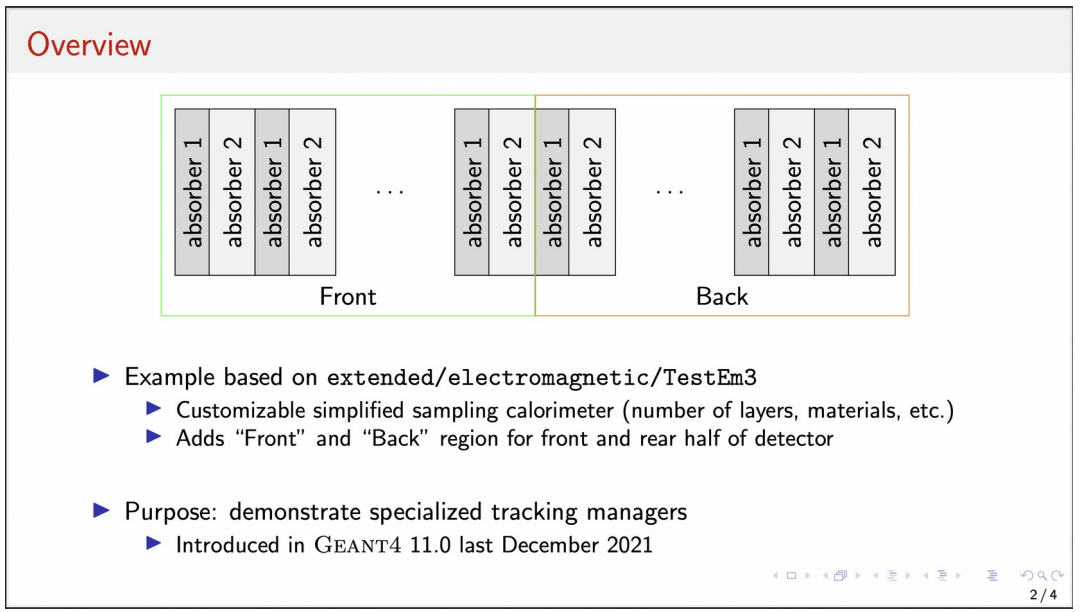
Particle source

- « molecularDNA » example
- Hoang Tran
- Physics, physico-chemistry and chemistry processes in DNA geometries
- Modular geometry model allowing to define complex geometries in an easy way
- https://geant4-dna.github.io/molecular-docs/
- Contributors:
- *J.M.C. Brown, K. Chatzipapas, M. Dordevic, S. Incerti, M. Karamitros, N. Lampe, D. Sakata, W.G. Shin*



- parameterisations/Par04 example
- Dalila Salamani, **Anna Zaborowska**

- Demonstrates how to use the Machine Learning (ML) inference to create energy deposits as a fast simulation model using ONNX runtime and LWTNN libraries.
- The model used in this example was trained externally (in Python) on data from this examples' full simulation and can be applied to perform fast simulation.
- The python scripts are available in the training folder



- examples/extended/runAndEvent/RE07
- Demonstration of Specialized Tracking Managers
- Jonas Hahnfeld

- RE07 has three modes (/setMode UI command):
  - 1. processes: use G4EmStandardPhysics (opt0), the default mode
  - 2. tracking: specialized tracking manager for e± and γ (same physics as opt0)
  - 3. specialized: an assortment of possible use cases:

Common Ongoing Tasks

- Followed at the WG wiki:
  - https://twiki.cern.ch/twiki/bin/view/Geant4/NoviceExtendedExamples
- Coding Guidelines
  - Updated in 2021 - **Version 2.1** (at the new Geant4 web site)
- Macro and UI Commands Review
  - Progressing slowly, the biasing examples commands/macros reviewed for 11.1 release
- Clang tools configuration

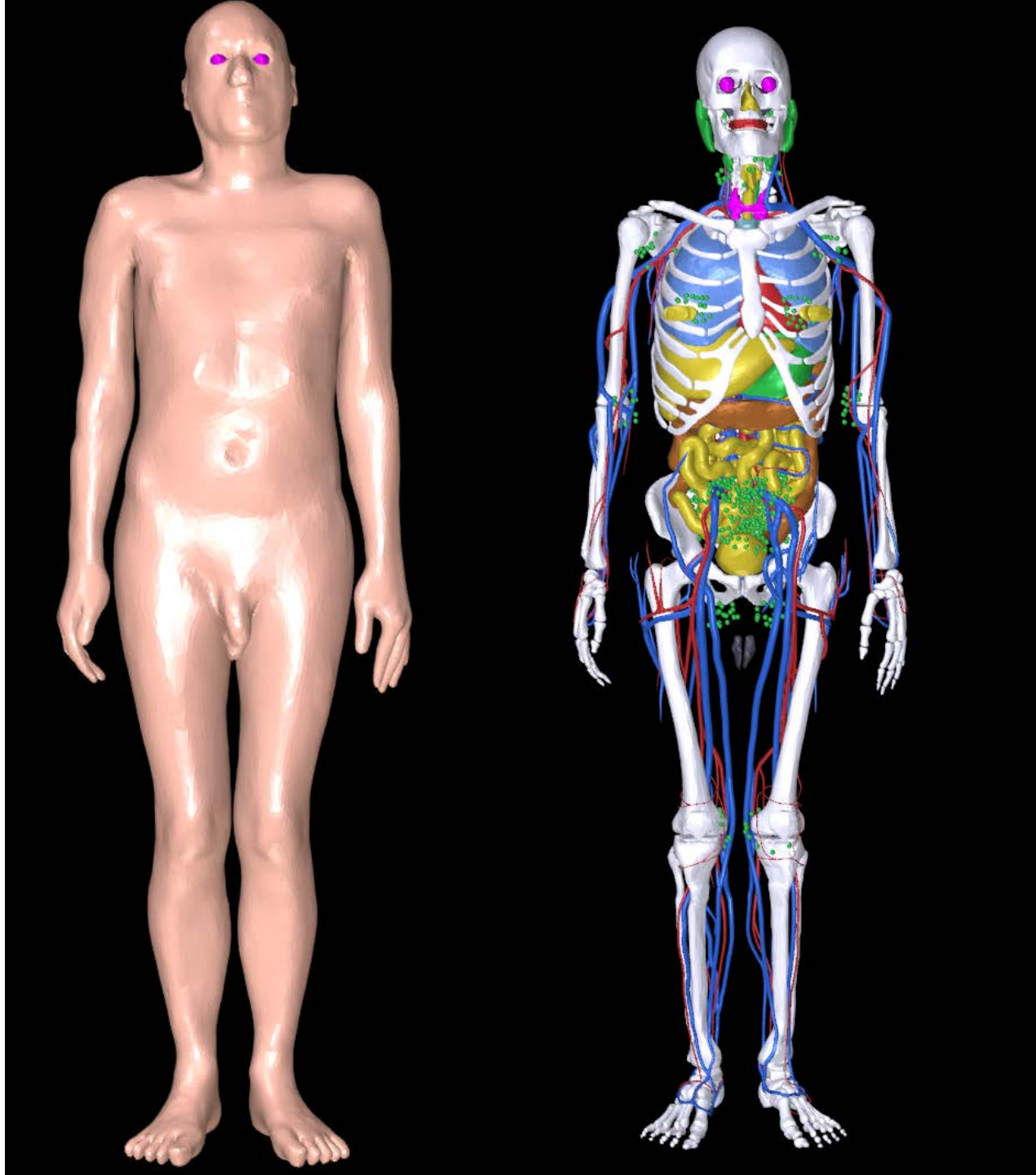
Update on the Advanced Examples

27th Geant4 Collaboration Meeting
26th-30th September 2022, Rennes, France

S. Guatelli and F. Romano
On behalf of the Geant4 Advanced Examples Working Group

New Advanced example in Geant4 11.p01: ICRP145Phantom

- ICRP Publication 145 on Adult Mesh-type Reference Computational Phantoms
  - Ann ICRP . 2020 Oct;49(3):13-201. doi: 10.1177/0146645319893605.
- Use of the General Particle Source
- Calculation of the **dose in the organs of the phantoms**
- To be released in Geant4 v.11.01, with the permission of the ICRP, in agreement with the original developers of the models/Geant4 simulation (available on the web):
  - **Principal developer**: Haeginh Han / Hanyang University, Republic of Korea
  - Min Cheol Han / Yonsei University Health System, Republic of Korea
  - Banho Shin / Hanyang University, Republic of Korea
  - Chansoo Choi / University of Florida, USA
  - Yeon Soo Yeom / Yonsei University, Republic of Korea
  - Jonghwi Jeong / National Cancer Center, Republic of Korea
  - Chan Hyeong Kim / Hanyang University, Republic of Korea
- Code review done



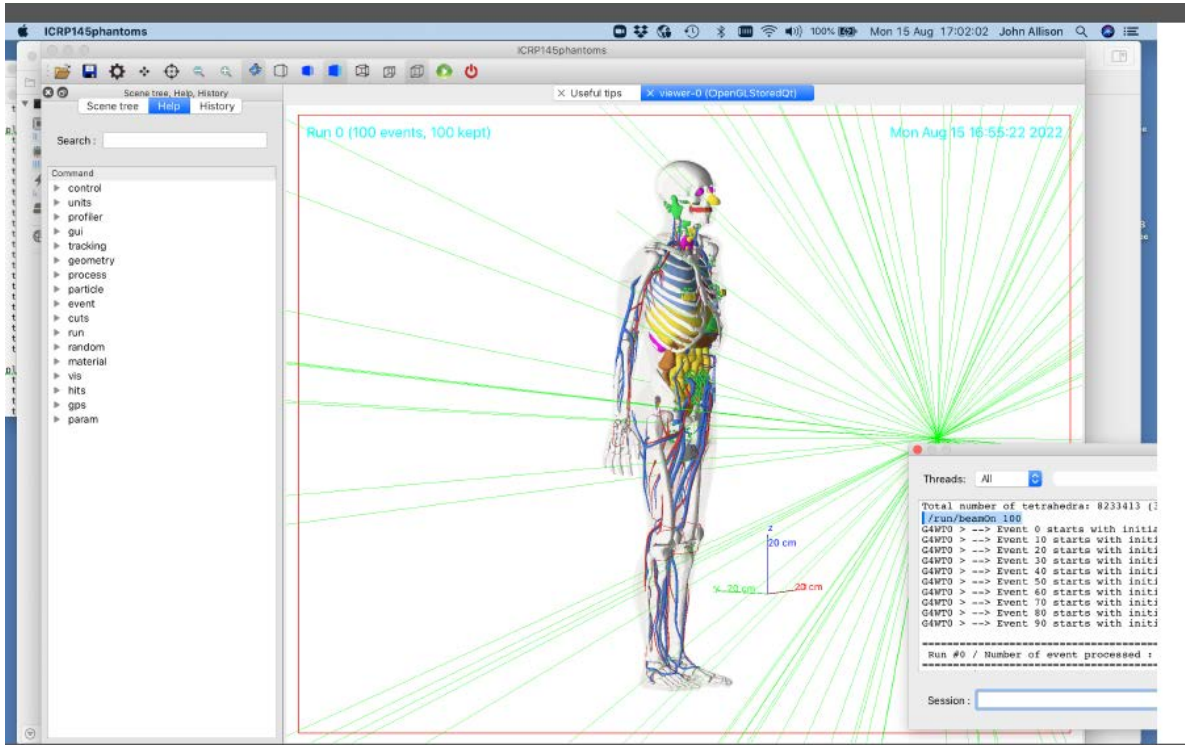
Fast drawing in the ICRP Human Phantoms examples series

- Modified to take advantage of developments in **graphics_reps** (Evgueni Tcherniaev) and in **visualization** (John Allison)
    - "Special Mesh Rendering": presented in the vis session by J. Allison and E. Tchaerniev
- The human phantom and beam trajectories can be visualised in a performant way
- Total number of tetrahedra: **8,233,413** (32,933,652 faces) are reduced to **4,807,770** facets (14%) for visualisation (tracking is not affected):

/vis/viewer/set/specialMeshRendering

/vis/viewer/set/specialMeshRenderingOption surfaces

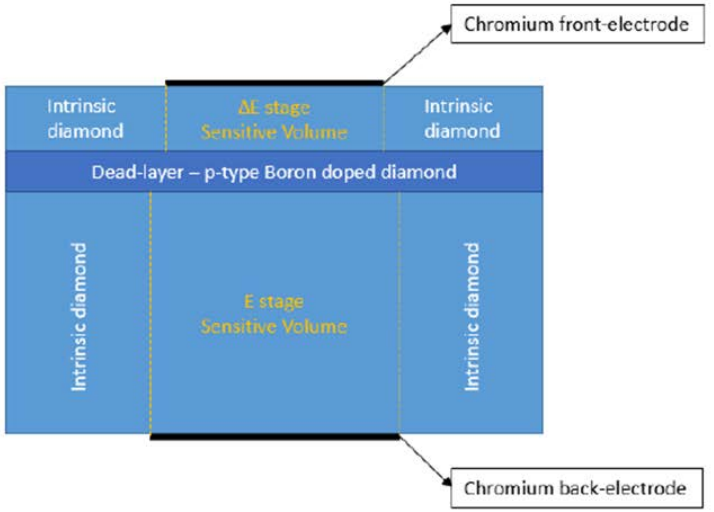
/vis/drawVolume



Slide from the talk by J. Allison in parallel session 3A

Radioprotection advanced example

- Example that shows how to use Geant4 for characterisation of solid state detectors for space radiation protection
  - microdosimetry
- Collaboration between:
  - J. Magini, G. Parisi, G. Schettino (University of Surrey),
  - F. Romano (INFN)
  - S. Guatelli, D. Bolst (CMRP, UOW)
- New developments for 2023
  - Extend the applicability of the example to the development of detectors for particle therapy Quality Assurance
  - Improvement of UI commands to allow to non C++ experts to customise the simulation
    - E.g. detector design
  - Include a two-stage diamond detector



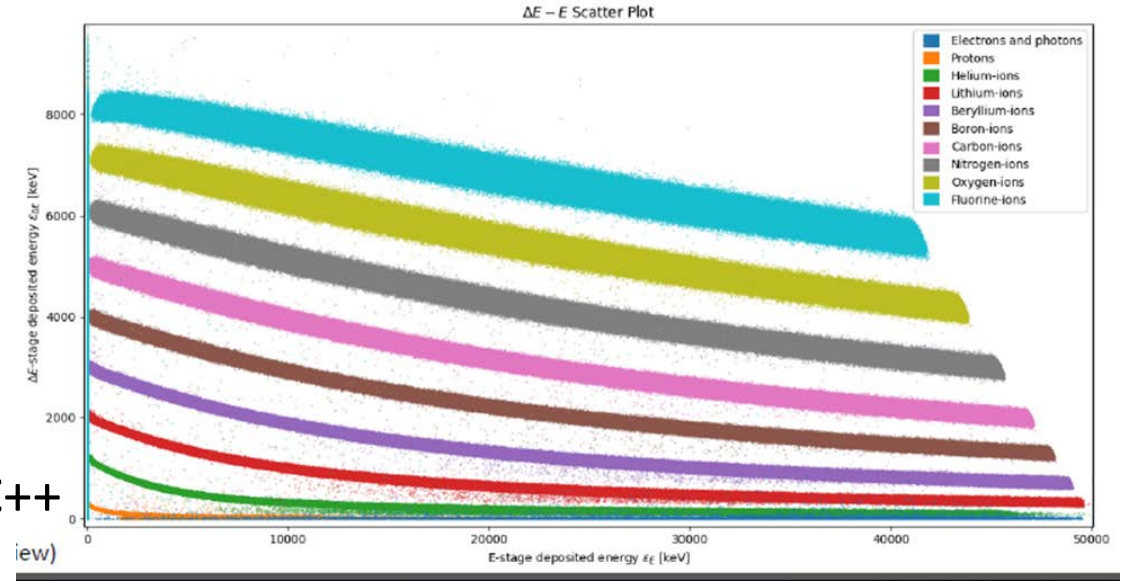


Figure from the talk by J. Magini in Parallel Session 3 A

New example in the pipeline

Proton imaging on biological micro-organism like Caenorhabditis elegans (C. elegans)

By Z. Li, C. Michelet and S. Incerti

Slide from the talk by Z. Li in parallel session 3A

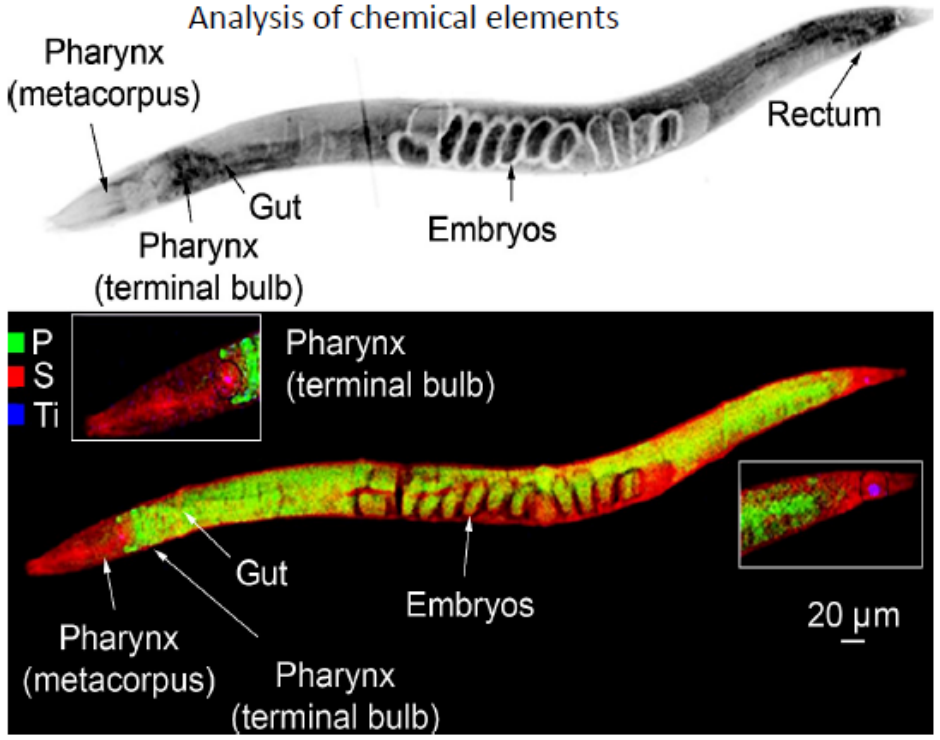
Objective:

Understand the biological effects of contaminants, such as TiO2 nanoparticles, widely used in cosmetics, the food industry, paints, etc.

Methods:

STIM and PIXE tomography experiments

Analysis of chemical elements



Non-destructive techniques, do not require marking, coloring…

- Spatial resolution ~300 nanometers in vaccum
- Detection limit ~1 ppm

STIM-T: Scanning Transmission Ion Microscopy tomography

Measurement of the residual energy of the protons after passing through the sample

→ Material thickness (g/cm²)

→ Visualization of the internal structure

Density Contrast Imaging ≈ Proton "Radiography"

PIXE-T: Particle Induced X-ray Emission tomography

Measurement of the energy of emitted X-rays

→ Location of chemical elements

→ Quantification

Minerals, trace metals, exogenous elements (here the nanoparticles of TiO_2)…

Other items of the Work Plan 2022

- Release of a new example showing how to import in Geant4 simulations IAEA Phase Space Files (2)[*] (M. Cortes Giraldo): postponed to next year
- Development of a SPring-8 synchrotron x-ray polarimetry example for testing low energy polarised gamma-ray physics (1,2) (J. Brown): postponed to next year
- Microelec advanced example: to include new Geant4-DNA cross sections for solid state materials beyond silicon (see talk in 5A by C. Inguimbert)
- Measurements and statistical analysis of size, McCabe, Halstead, Chidamber and Kemerer software metrics over at least 50% of the advanced examples; explication of the results in relation to ISO/IEC 9126 and ISO/IEC 25000 (1,2) (M. G. Pia): In progress
- Migration and improvement of the webpage (1,2) (S. Guatelli) – Done (**thanks to Dmitri, Anna and Alex!)**
- Maintenance and code review in selected examples (1,2)
  - Technical meeting done with Ben Morgan; migration to C++11/14/17 done in brachytherapy, eRosita, human_phantom, ICRP110Phantom, ICRP145Phantom
  - In-depth code review in the human_phantom
  - Make sure that all the examples use pre-built physics lists (where appropriate)

Other developments: to be done in 2023

- Code review in **`iort_therapy`**
  - Adaptation to FLASH electron radiotherapy
  - By G. Miluzzo, J. Pensavalle & F. Roman
- Code review in **`medical_linac`**:
  - Revision of the example
  - Inclusion of comparison to experimental data documented inEURADOS Report 2020-05
  - By B. Caccia, S. Pozzi, C. Mancini, et al
- Other matters
  - Give appropriate acknowledgment to external contributors to the Geant4 Collaboration
    - Delicate matter, especially for students
    - So far, we acknowledge the contribution in the README file and in the webpage
    - Can we do more?
    - E.g. certificate of contribution?
    - Other ideas?