Diamond detector simulations with GEANT4

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GEANT4

- **GEANT4 GEometry ANd Tracking** – Monte-Carlo simulations of radiation transport in matter.

- C++ toolkit which replaced the FORTRAN-based GEANT3.

- Object-oriented design: G4Run, G4Event, G4Track, G4Step...

- Easy access to the information in particle tracks.

- High versatility in design of geometry and physics in simulations.

- Modular approach to the description of the simulated physics.
Photons (I)

• Included in **Standard EM** physics package:

  1. Photoelectric absorption.
  2. Compton scattering.
  3. Pair production.
Photon interaction probability

![Graph showing the probability of photon interaction as a function of gamma energy. The graph includes three curves: blue for photoelectric absorption, red for Compton scattering, and pink for pair production. The x-axis represents gamma energy in eV, and the y-axis represents interaction probability on a log scale.]
X-ray (80 keV)

Compton scattering

Photoelectric absorption

Deposited energy [keV]

a.u.
Gamma (2 MeV)

Compton scattering

Pair production

Deposited energy [MeV]
Photons (II)

- Included in **Standard EM** physics package:
  1. Photoelectric absorption.
  2. Compton scattering.
  3. Pair production.

- Influence of multiple processes in a single event.

- Complexity of the simulated geometry.
Charged particles (I)

• **Standard EM** physics package.

• One of the standard HEP **physics lists** (QGSP, FTFP, etc.)
Stopping power of proton in diamond
Stopping power of proton in diamond

490 eV/μm = 36 eh-pairs/μm

610 eV/μm = 45 eh-pairs/μm
Charged particles (I)

- **Standard EM** physics package.
- One of the standard HEP **physics lists** (QGSP, FTFP, etc.)
- Production of secondaries
Neutrons (I)

• **Standard EM** physics package.

• One of the standard HEP **physics lists** (QGSP, FTFP, etc.)
Thermal neutrons (25 meV)

\[ ^6\text{Li}(n,\alpha)t \]

Counts

\[ \begin{align*}
\text{Counts} &:\ 10^5 \\
&: 10^4 \\
&: 10^3 \\
&: 10^2 \\
&: 10 \\
\end{align*} \]

Energy [MeV]

\[ \begin{align*}
\text{Energy} &: 0 \\
&: 0.5 \\
&: 1 \\
&: 1.5 \\
&: 2 \\
&: 2.5 \\
&: 3 \\
&: 3.5 \\
&: 4 \\
\end{align*} \]

\( \gamma \)-background

\( \alpha \)

\( t \)
DD-neutrons (2.45 MeV)

$^{12}$C(n,el)
Fast neutrons (17 MeV)

\[ ^{12}\text{C}(n,3\alpha) \]
Neutrons (II)

• **Standard EM** physics package.

• One of the standard HEP **physics lists** (QGSP, FTFP, etc.) - ?

• Custom built **physics list**
DT-neutrons (14.3 MeV)
DT-neutrons (14.3 MeV)
DT-neutrons (14.3 MeV)
Neutrons (III)

- **Standard EM** physics package.
- One of the standard HEP **physics lists** (QGSP, FTFP, etc.) - ?
- Custom built **physics list**
- Validation of cross sections
Conclusions

- GEANT4 is a convenient tool for diamond detector simulations.
- Studies of detector efficiency, detector response functions and detailed examination of interaction processes is possible.
- Simulations are in a close agreement with measurements.
- The list of physics models in simulations must be set up with caution.
Thank you!