Validation of Geant4 Electron Pair Production by Photons

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Pair production:
- occurs when a photon interacts with the field of the atomic nucleus or with an electron from the atom (triplet production)
- important issue in various experimental domains
- Bethe and Heitler (1934) => theoretical model for multiple scattering induced radiation assuming the scatterings are independent (valid for energies below TeV)
- above TeV => Landau, Pomeranchuk and Migdal, the so-called LPM effect.

Photon conversion models are implemented in all general-purpose Monte Carlo systems:
- MCNP(X)
- PENELope
- ITS
- FLUKA
- ETRAN
- EGS(nrc)
- Geant4

EGS5
EGSrone
CORSIKA – delegates pair-production to EGS

Triplet production
LPM effect

EGS5, EGsrone
users may choose among the libraries by Storm and Israeli, EPDL, XCOM, or add a “personal” library

Comparison between experimental data near threshold and EPDL, Geant4-Standard and XCOM

Experimental data:
- Collected from the literature:
  - Experimental cross sections
- Materials: Al, Fe, Ni, Cu, Ge, Se, Zr, Mo, Rh, Cd, Sn, Ce, Ta, W, Pt, Au, Pb, Bi, U

Evaluation of experimental data:
- Systematic effects: identified whenever possible
- Outliers

Data Analysis:
- Quantitative appraisal of capabilities and differences:
  - Goodness-of-fit test
  - Chi² test

Ongoing work:
Pair production is important in all energy ranges.
The first phase of the project is focused on the validation of total cross sections, validation of angular distributions will follow.
The preliminary results shown below concern the low energy range close to the threshold.

Preliminary comparison between experimental data near threshold and EPDL, Geant4-Standard and XCOM

Preprocessing

Pair production cross sections

Preliminary
- EPDL => compatible with experimental data starting from approximately 100 keV above the threshold (p-value of the χ² test > 0.05)

Geant4 standard
NIST XCOM
Penelope (based on XCOM)