3.4
Geometry Corrections
Monte Carlo codes

Intercomparison of Monte Carlo codes used in gamma-ray spectrometry.

Applied Radiation and Isotopes 66 (2008) 764-768

T. Vidmar[1], I. Aubineau-Laniece[2],
M. J. Anagnostakis[3], D. Arnold[4],
R. Brettner-Messler[5], D. Budjas[6],
M. Capogni[7], M. S. Dias[8], L-E. De Geer[9],
A. Fazio[7], J. Gasparro[10], M. Hult[10],
S. Hurtado[11], M. Jurado Vargas[12],
M. Laubenstein[13], K. B. Lee[14], Y-K. Lee[2],
M-C. Lepy[2], F-J. Maringer[5],
V. Medina Peyres[15],
M. Mille[16], M. Moralles[8], S. Nour[16],
R. Plenteda[9], M. P. Rubio Montero[17],
O. Sima[18], C. Tomei[13], G. Vidmar[19]

1 *Jozef Stefan Institute, Jamova cesta 39, SI-1000 Ljubljana, Slovenia*
2 *CEA Saclay, 91191 Gif-sur-Yvette Cedex, France*
3 *National Technical University of Athens, Athens, Greece*
4 *Physikalisch-Technische Bundesanstalt, Bundsallee 100, Braunschweig, Germany*
5 *Bundesamt fuer Eich- und Vermessungswesen, Arltgasse 35, 1160 Vienna, Austria*
6 *Max-Planck-Institut fuer Kernphysik, D-69117 Heidelberg, Germany*
7 *ENEA, INMRI, I-00123 Rome, Italy*
8 *IPEN-CNEN, Av. Prof. Lineu Prestes, 2242, Sao Paulo, Brazil*
9 *Preparatory Comission for the CTBTO, P.O. Box 1200, 1400 Vienna, Austria*
10 *EC-JRC-IRMM, Retisweg 111, B-2440 Geel, Belgium*
11 *Universidad de Sevilla, Reina Mercedes s/n, 41012 Sevilla, Spain*
12 *Universidad de Extremadura, Badajoz, Spain*
13 *INFN, LNGS, Assergi L'Aquila, Italy*
14 *Korea Research Institute of Standards and Science, Daejeon, South Korea*
15 *CIEMAT, Madrid, Spain*
16 *NIST, 100 Bureau Dr., Gaithersburg, MD 20874, USA*
17 *Universidad de Extremadura, Merida, Spain*
18 *Physics Department, Bucharest University, Bucharest-Magurele, Romania*
19 *IBMI, Faculty of Medicine, University of Ljubljana, Slovenia*

Monte Carlo simulations can be of significant help in the process of efficiency determination and their use has been gaining in popularity over the years.

Sophisticated packages exist for this purpose, but a study of the intrinsic differences they possess has not been conducted yet.

The results of efficiency calculations with the most important and popular Monte Carlo codes used in gamma-ray spectrometry today were compared amongst themselves, without any reference to the experimental data.

Three different sample-detector arrangements were considered, in increasing order of complexity:

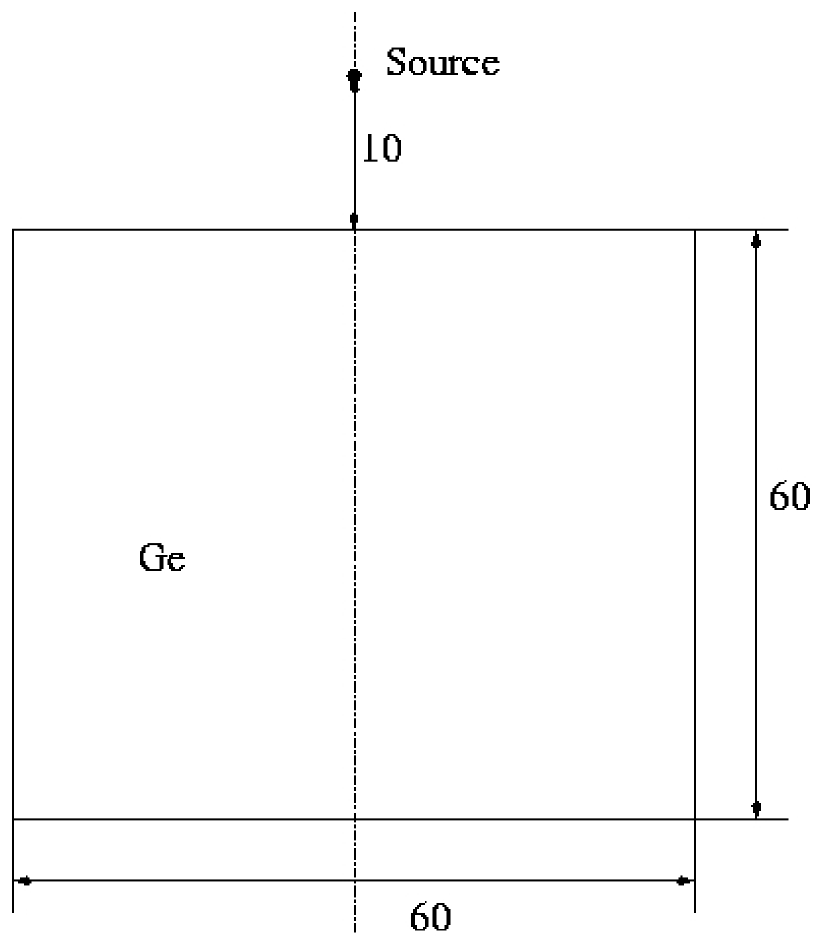
- bare crystal with a point source;
- p-type detector with a point source;
- p-type detector with an extended source.

Full-energy-peak and total efficiencies were calculated for

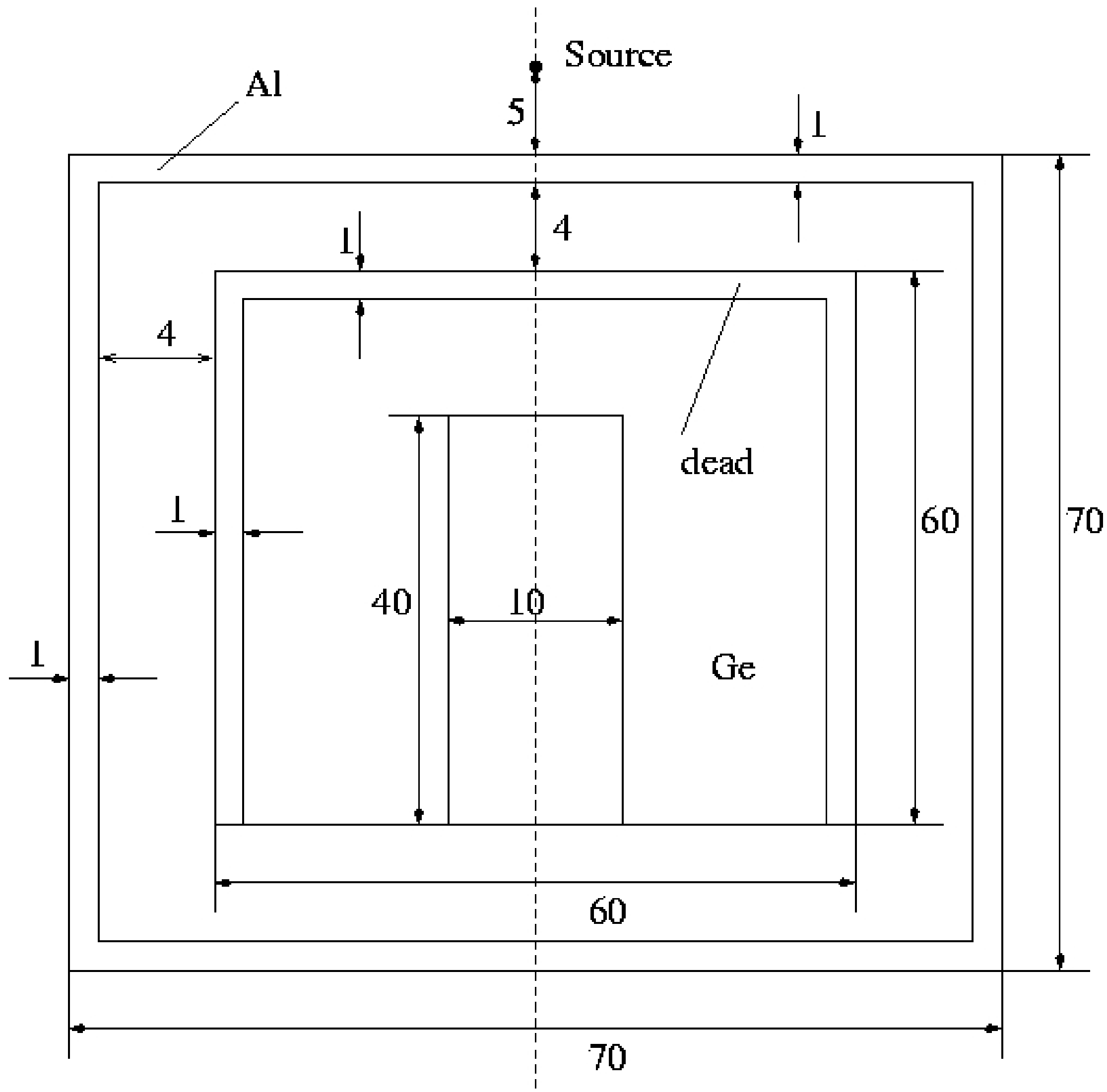
45, 60, 80, 100, 120, 140, 160, 300, 500, 1000, 2000 and 3000 keV.

Relative statistical uncertainty lower than 0.1% required.

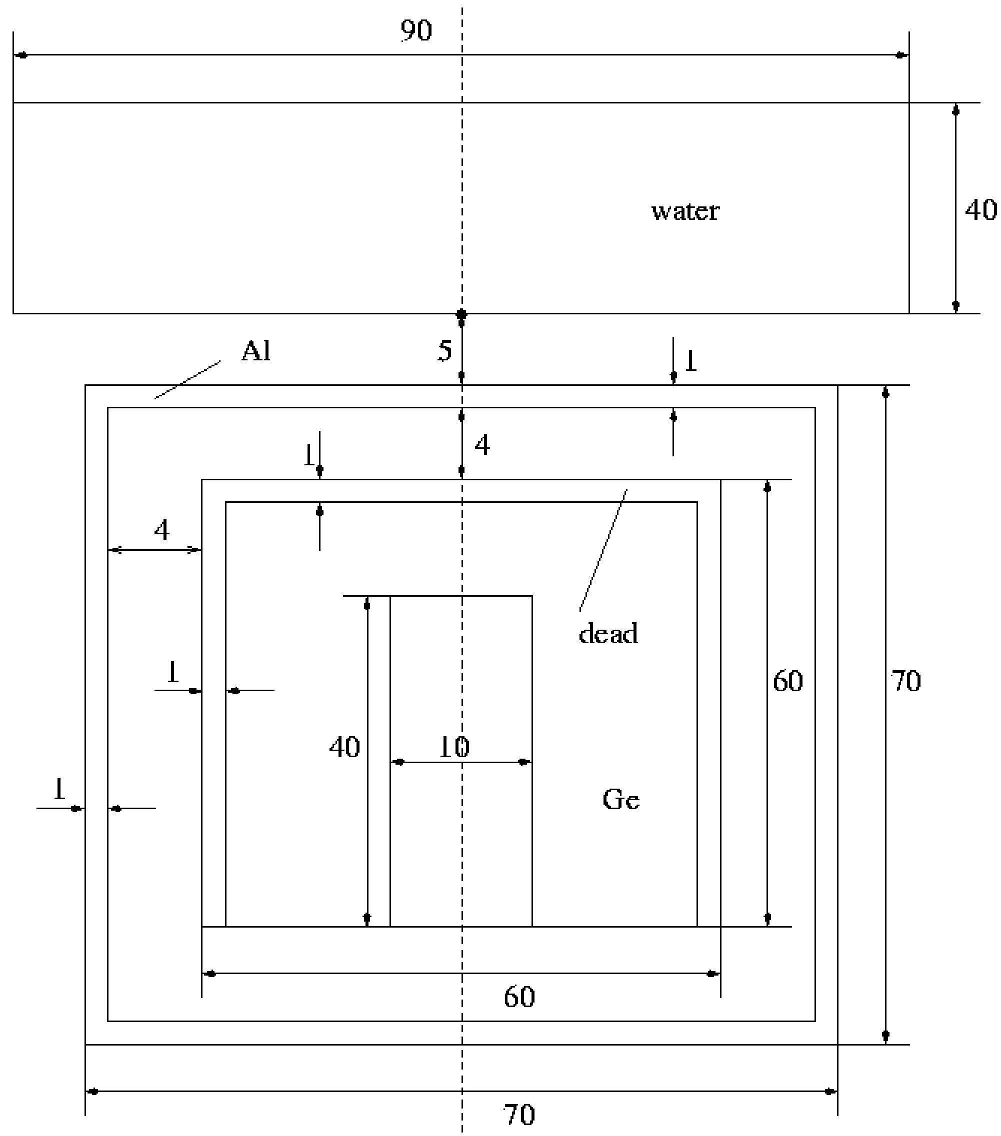
Geometry# 1



Geometry #2



Geometry #3



Geometry #4

Defined as the ratio of efficiencies for Geometries #2 and #3 --

-- suitable for efficiency transfer calculations.

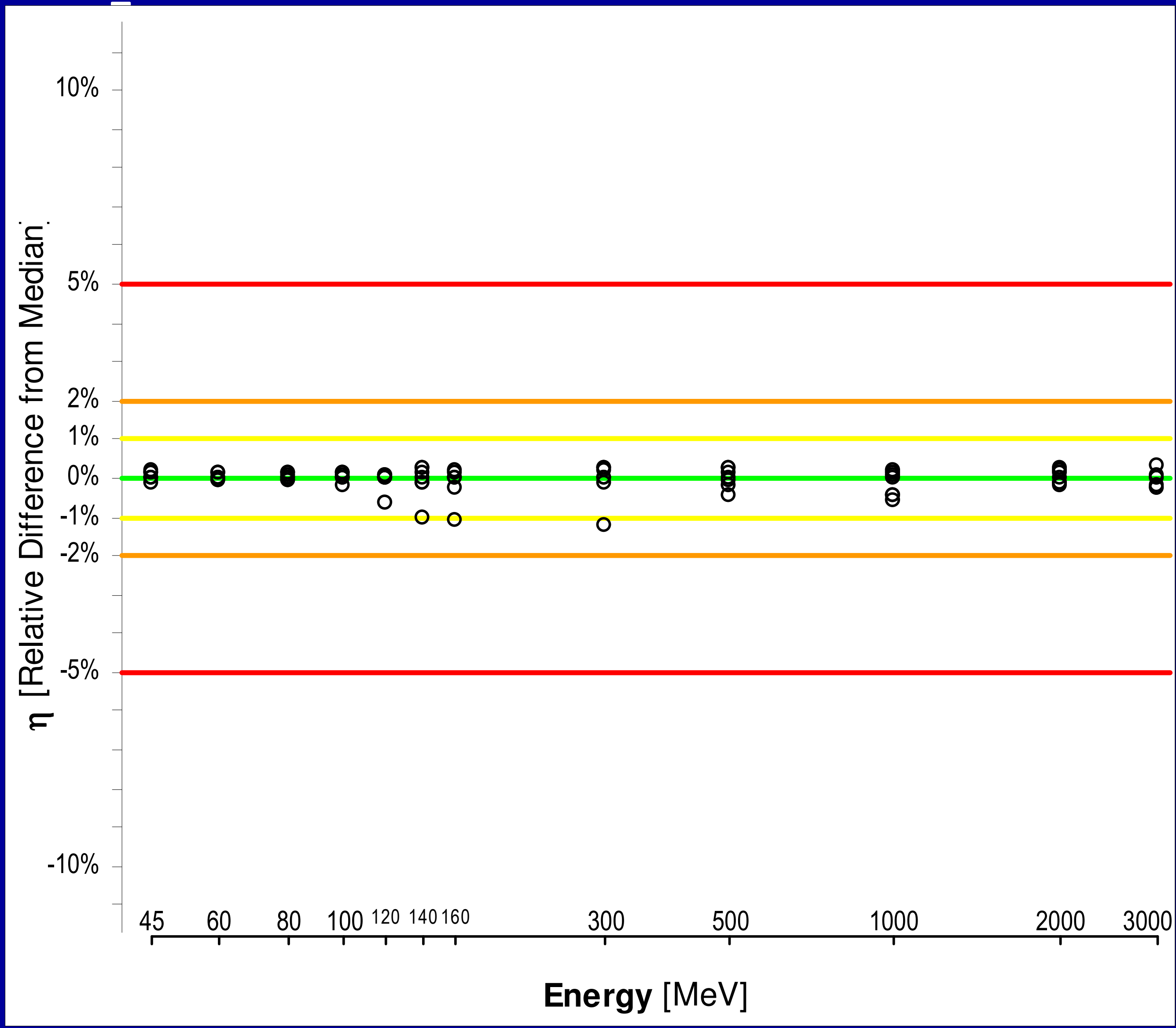
Seven different general Monte Carlo codes were used:

- GEANT3 – 3 users,
- GEANT4 – 5 users,
- EGS – 2 users,
- MCNP – 3 users,
- PENELOPE – 7 users,
- GESPECOR – 1 user,
- TRIPOLI-4 – 1 user.

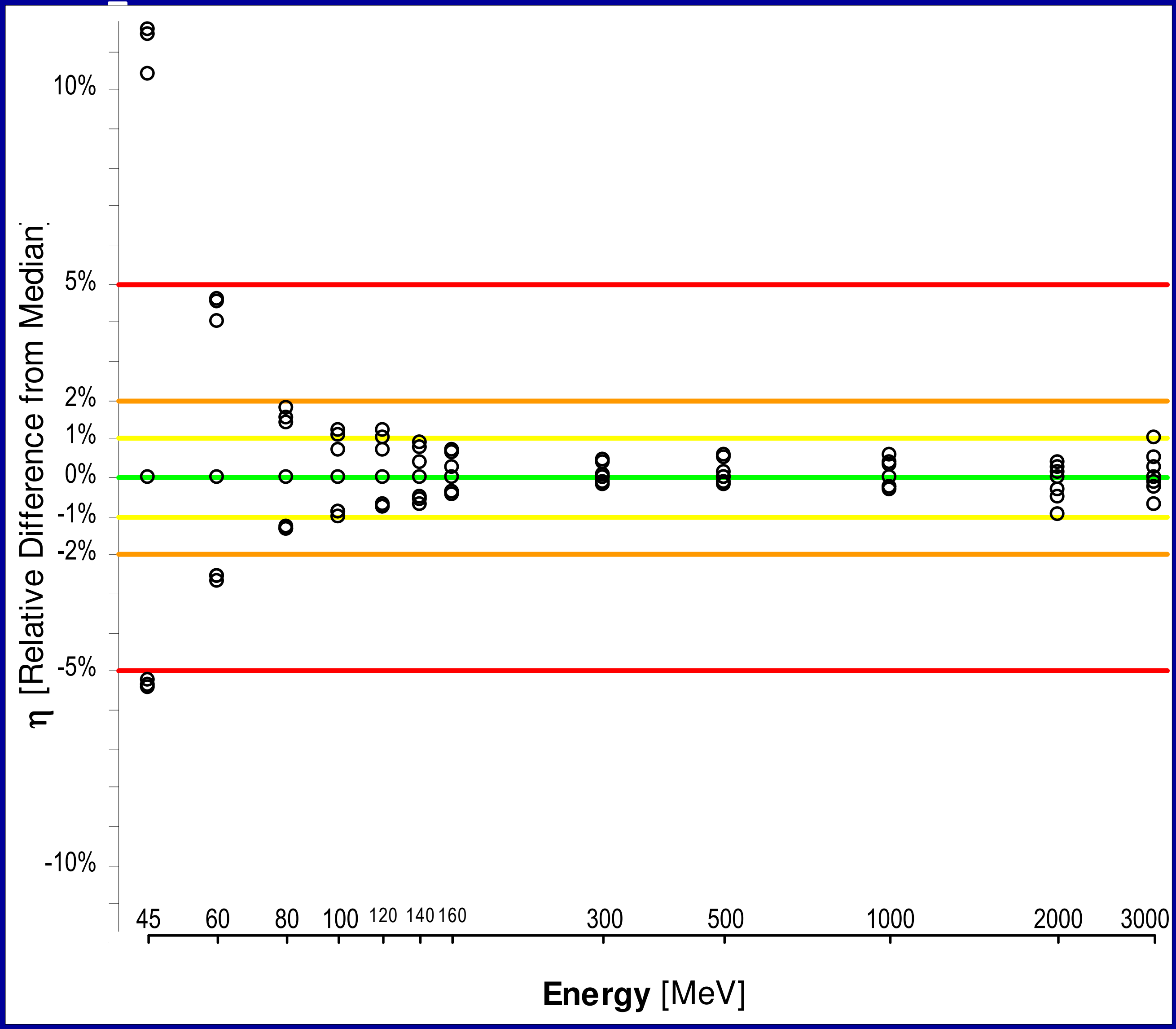
All codes except TRIPOLI featured both photon and electron tracking.

Different versions of each of the codes were employed.

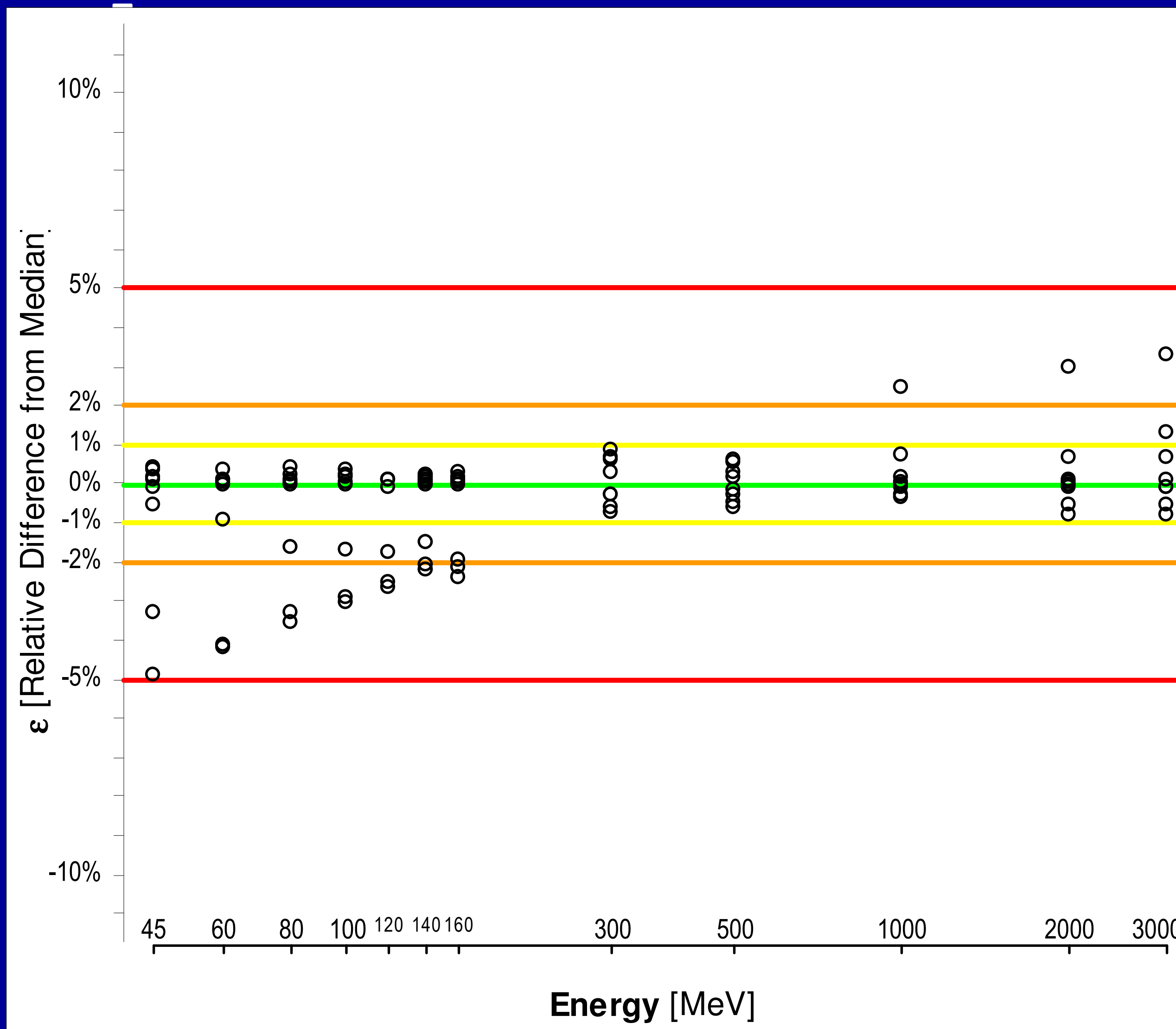
GEANT, Geometry #1, η



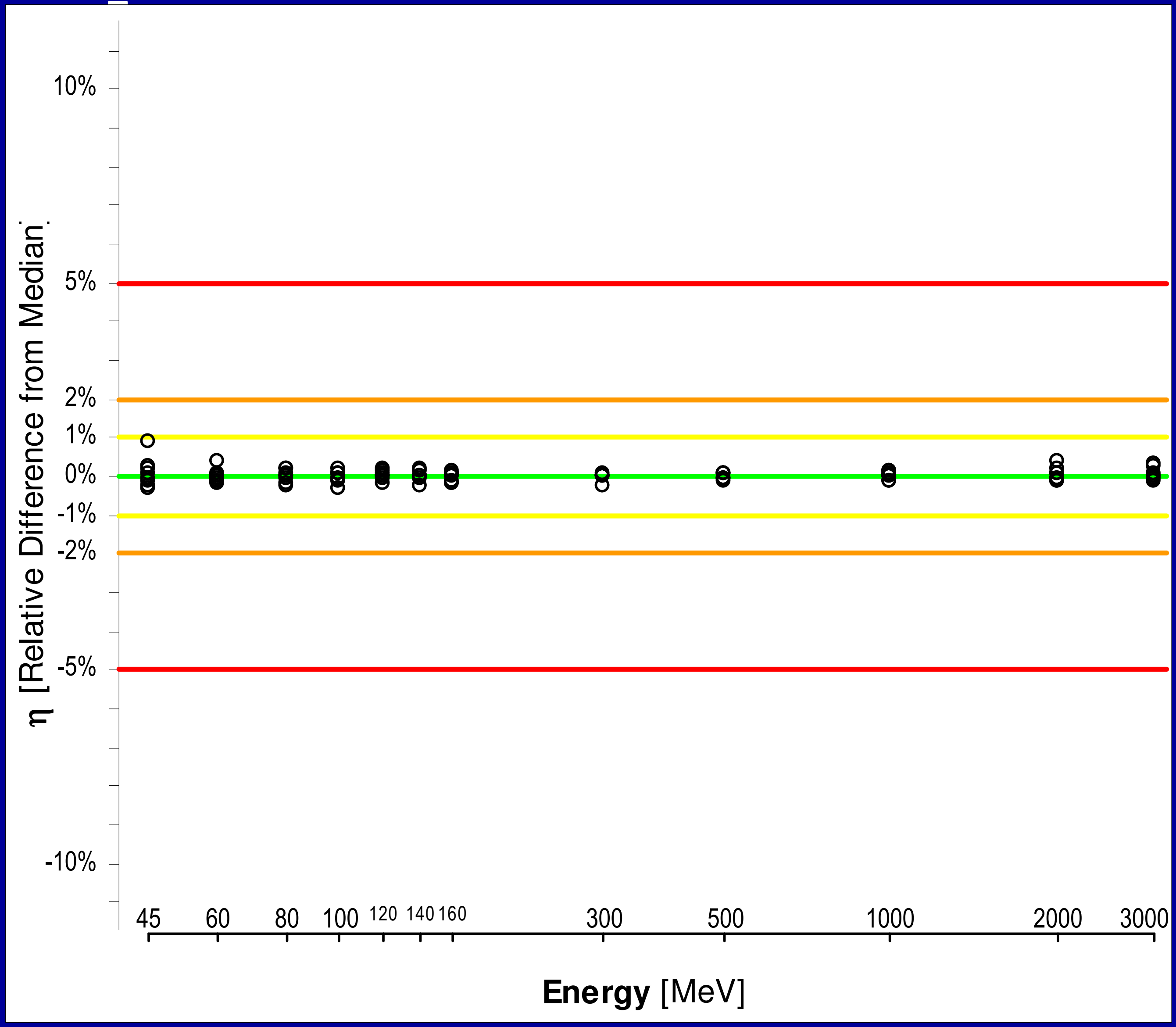
GEANT, Geometry #2, η



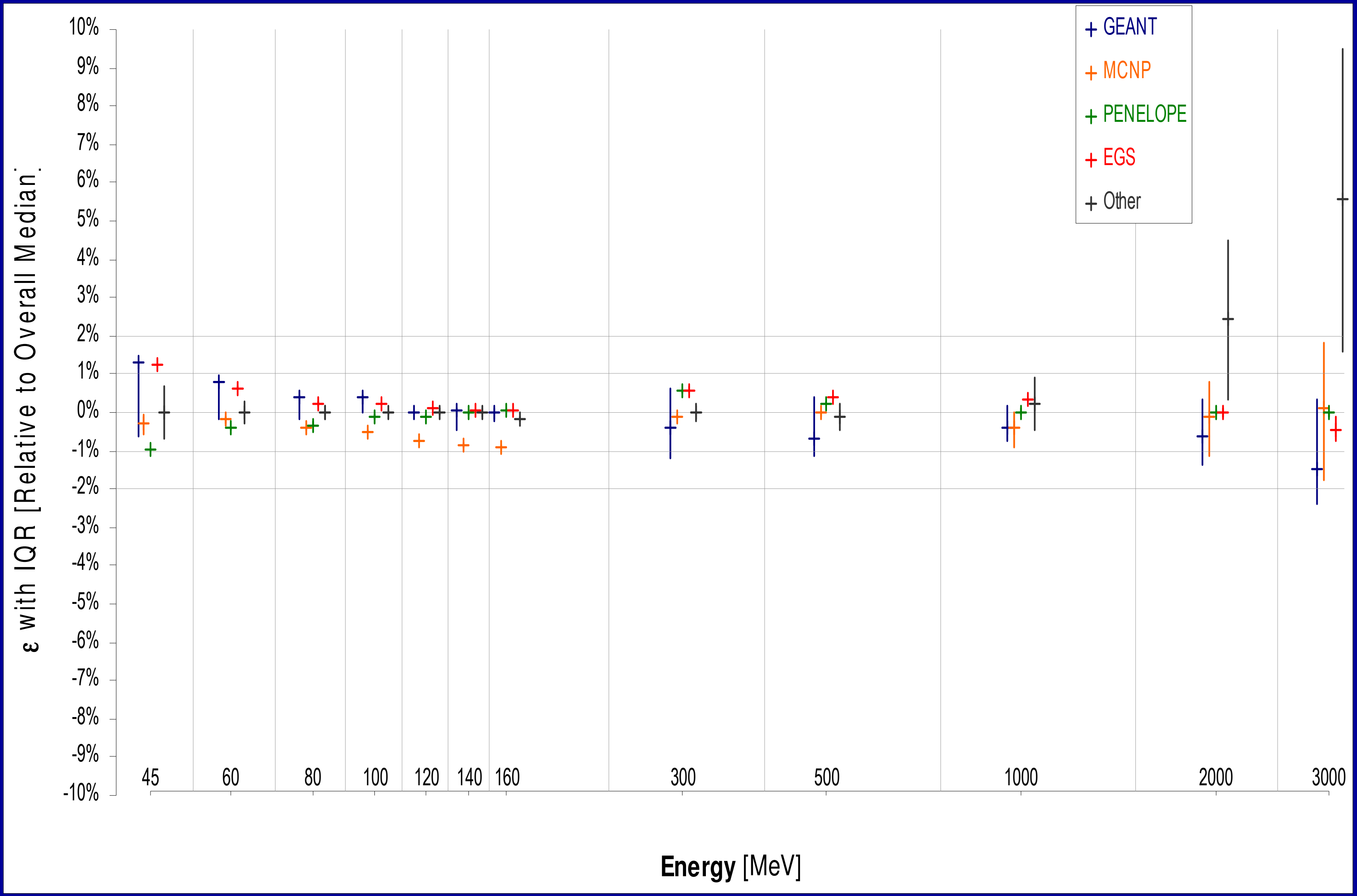
PENELOPE, Geometry #3, ε



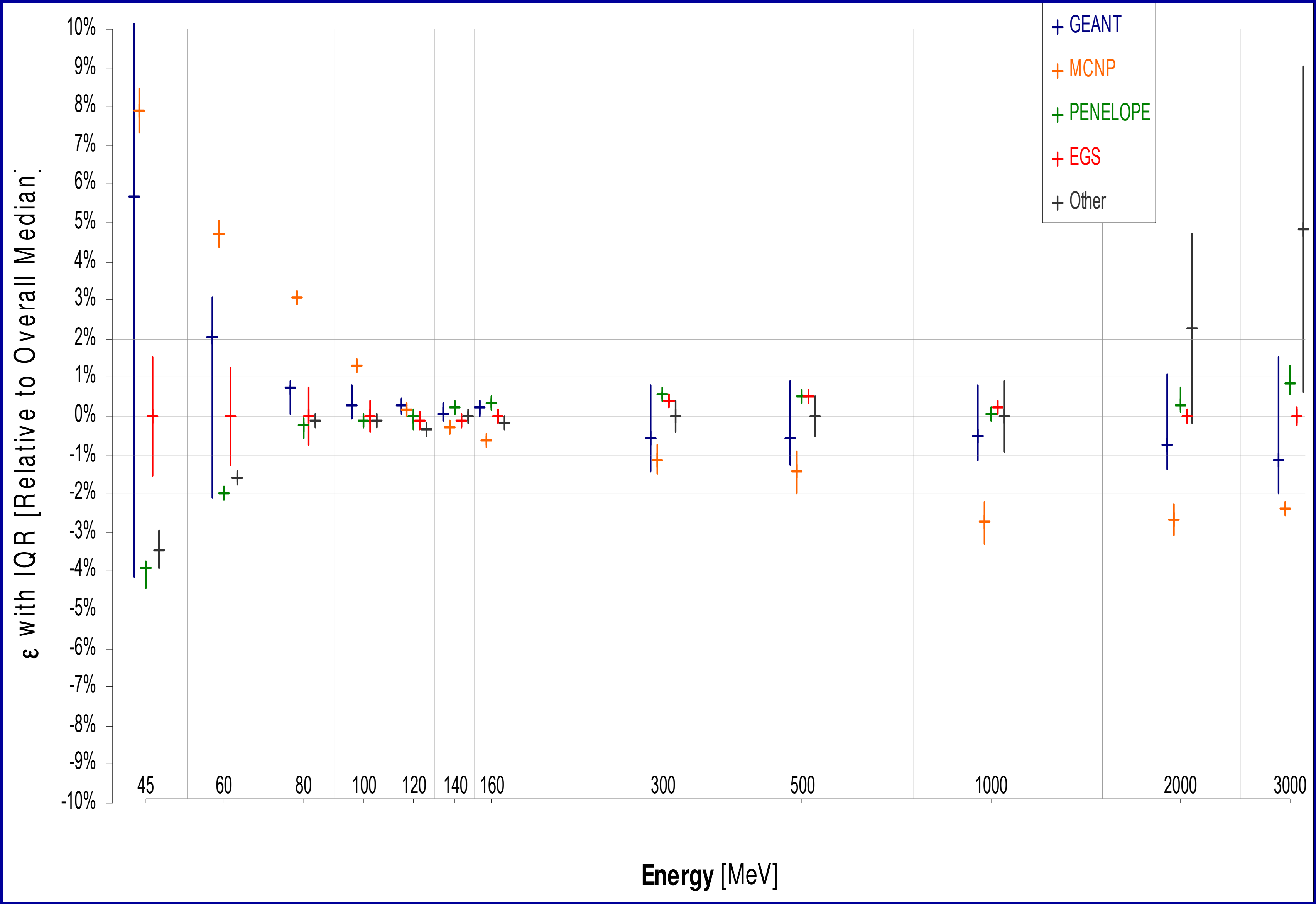
PENELOPE, Geometry #3, η



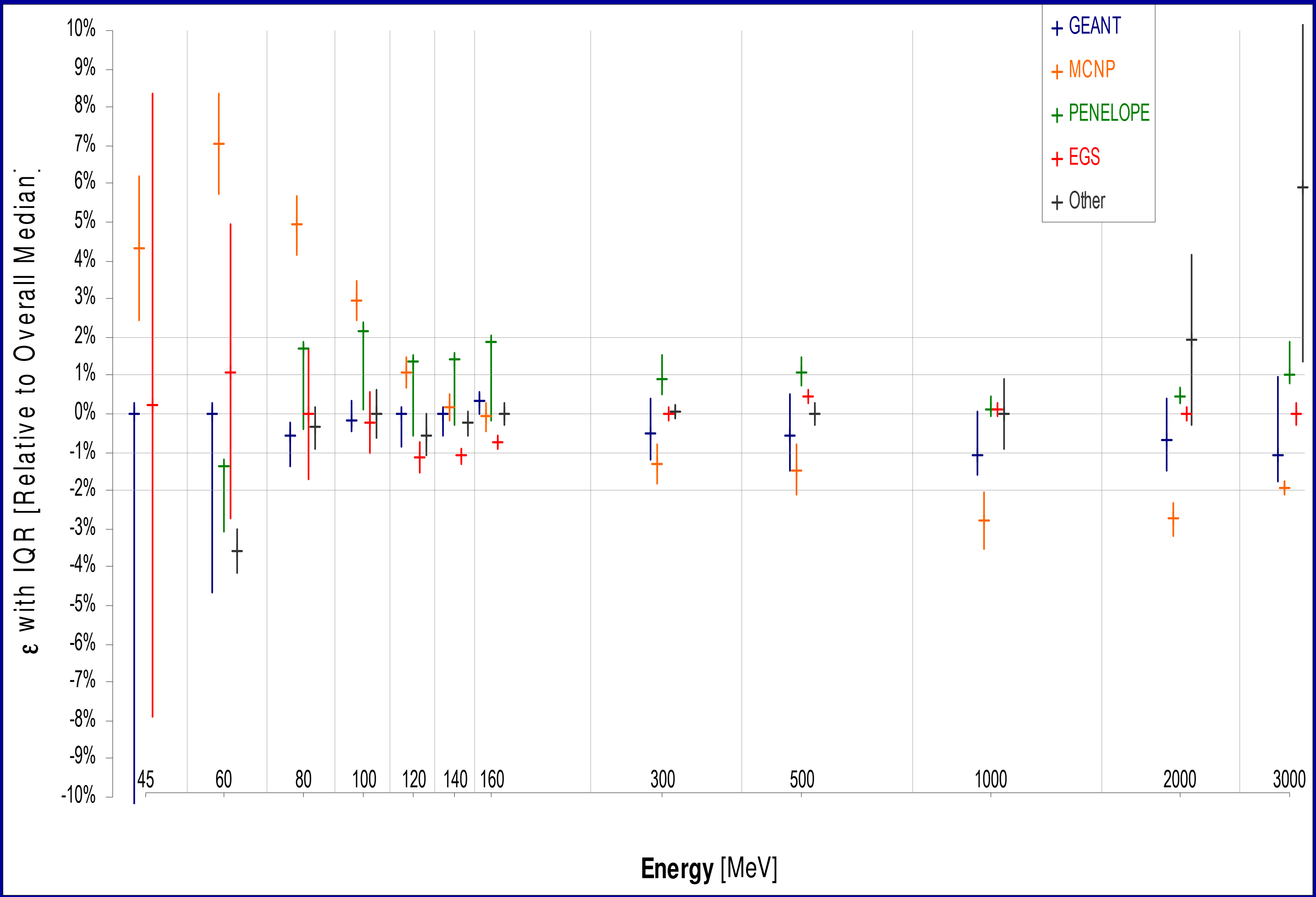
All codes, Geometry #1, ε



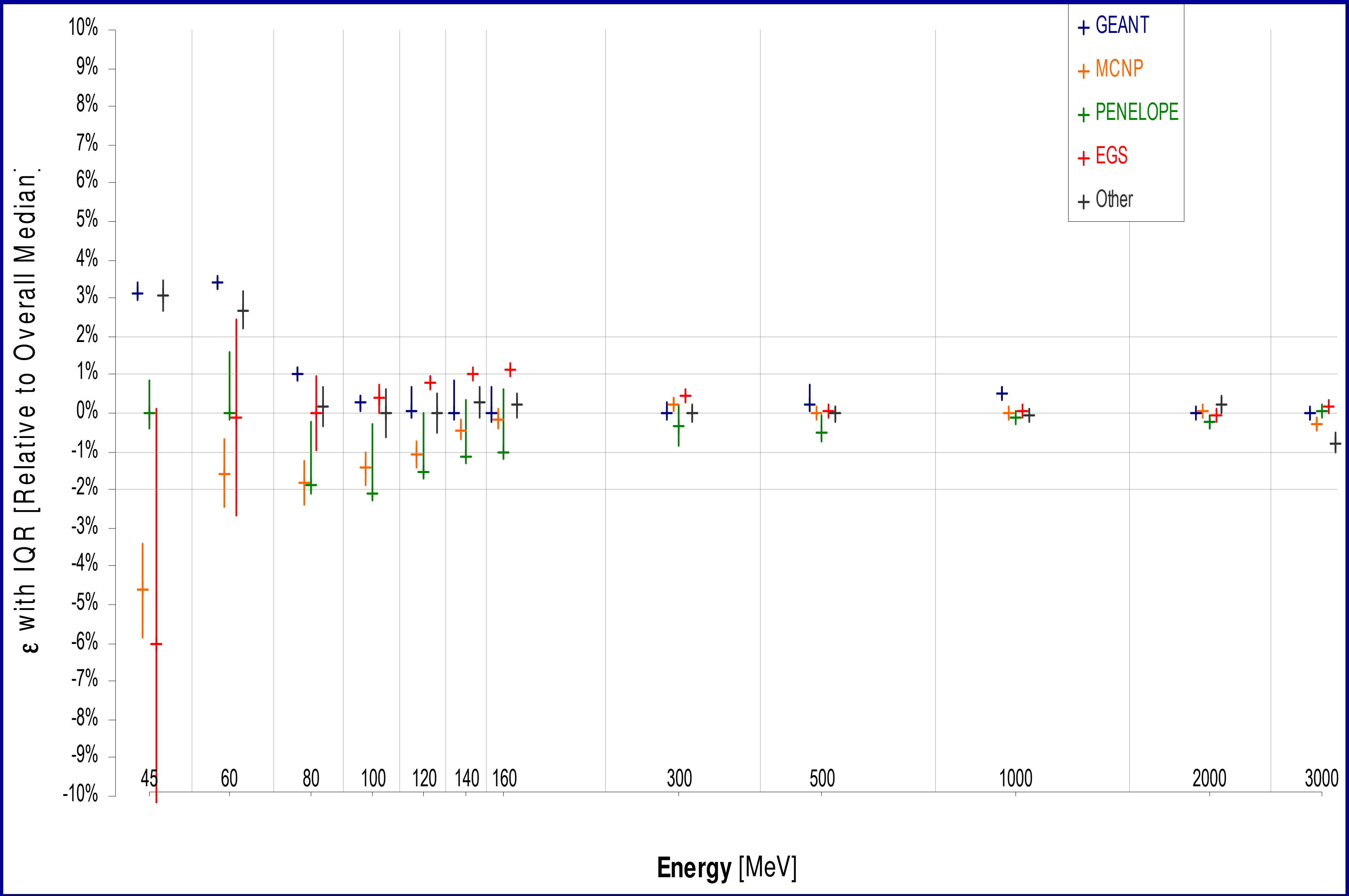
All codes, Geometry #2, ε



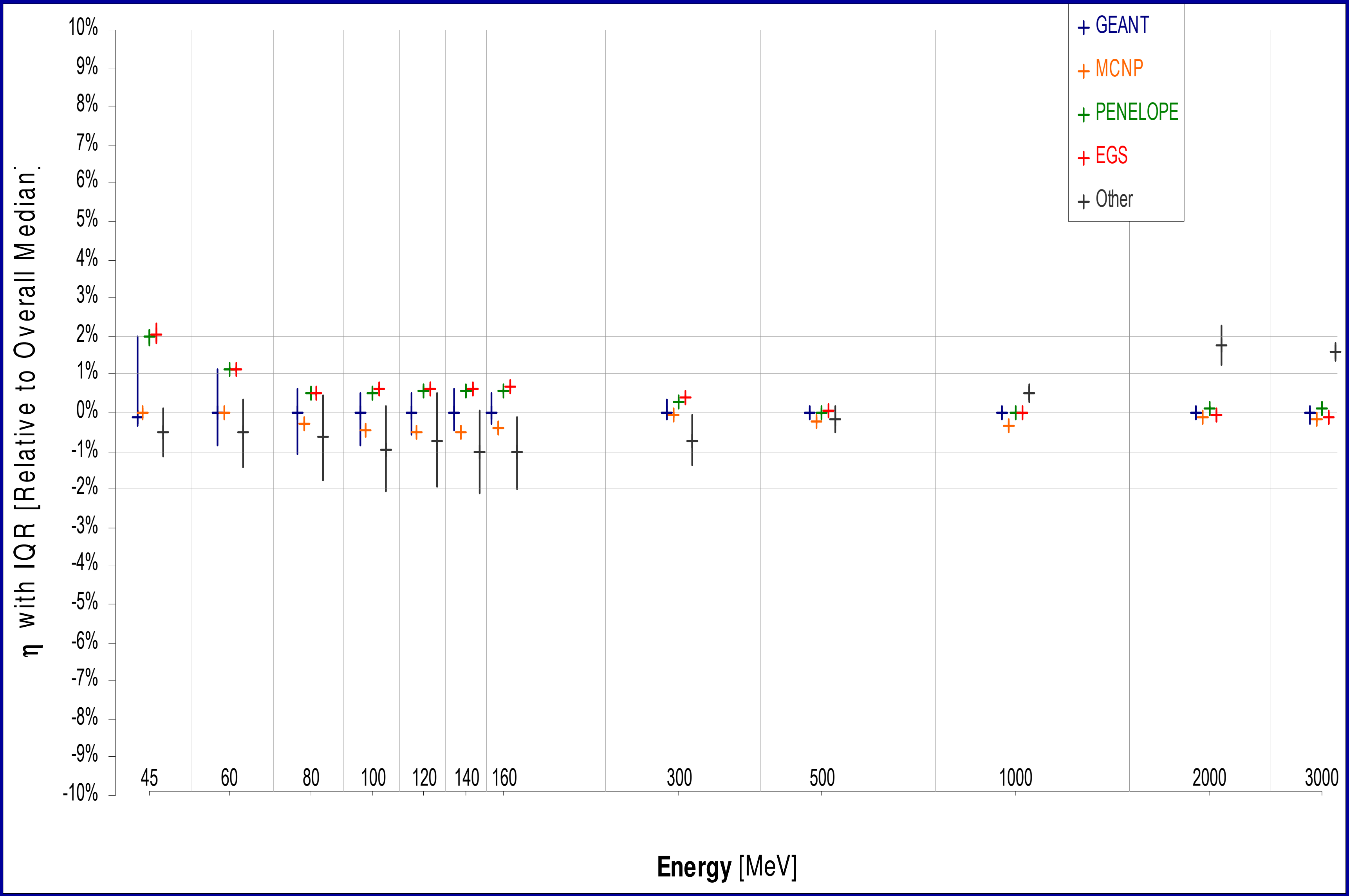
All codes, Geometry #3, ε



All codes, Geometry #4, ε



All codes, Geometry #4, η



Observations

• The differences within a single code were large, much larger than initially expected → errors in geometry input?

• Better results for total efficiencies → the problem of peak-area definition?

• The differences between the codes significant, except for Geometry #1.

• Second round required.

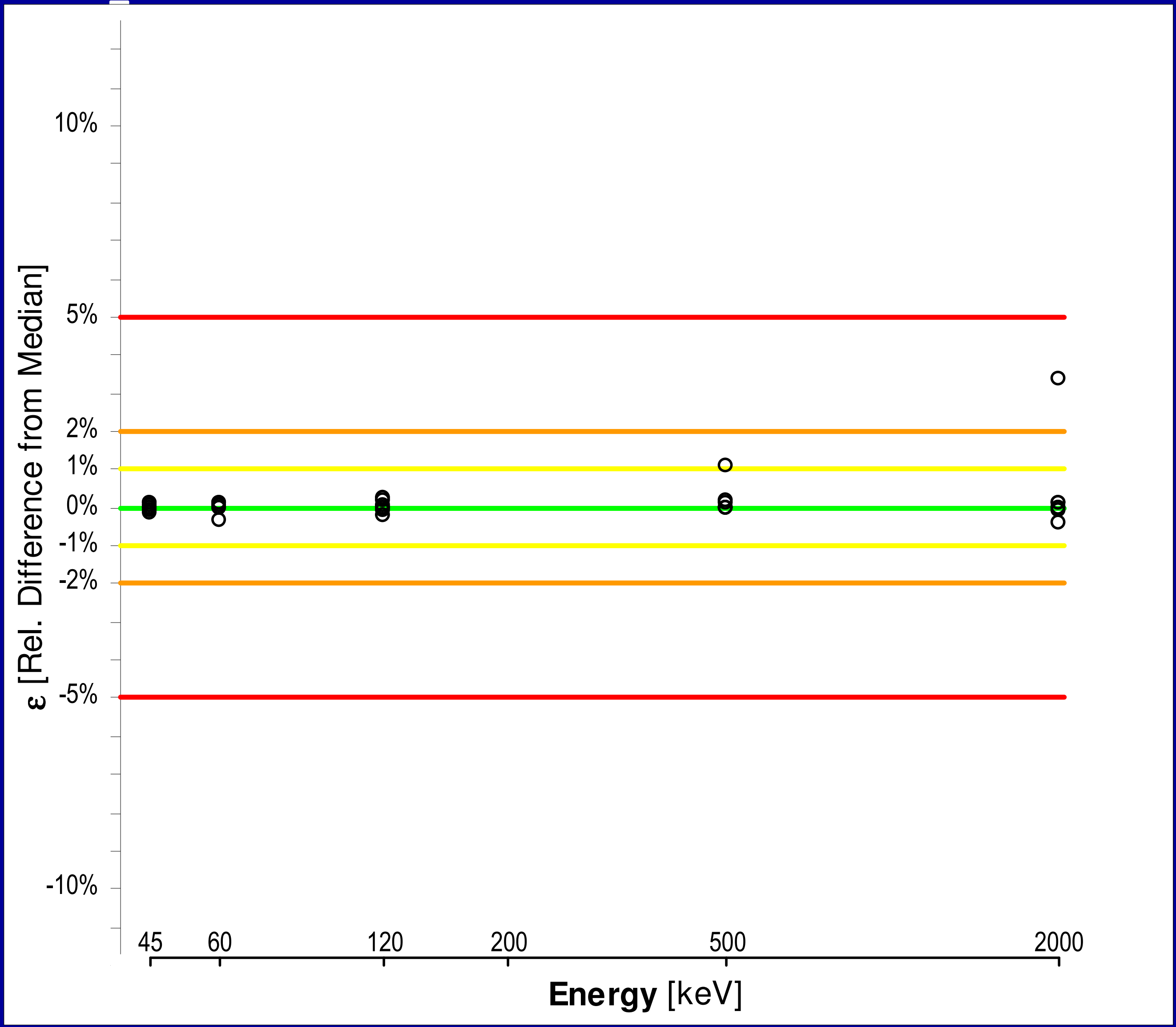
Second round:

- Geometries #2, #3, and #4;
- Energies 45, 60, 120, 200, 500 and 2000 keV;
- Relative statistical uncertainty lower than 0.3% required;
- Code Groups A and B defined.

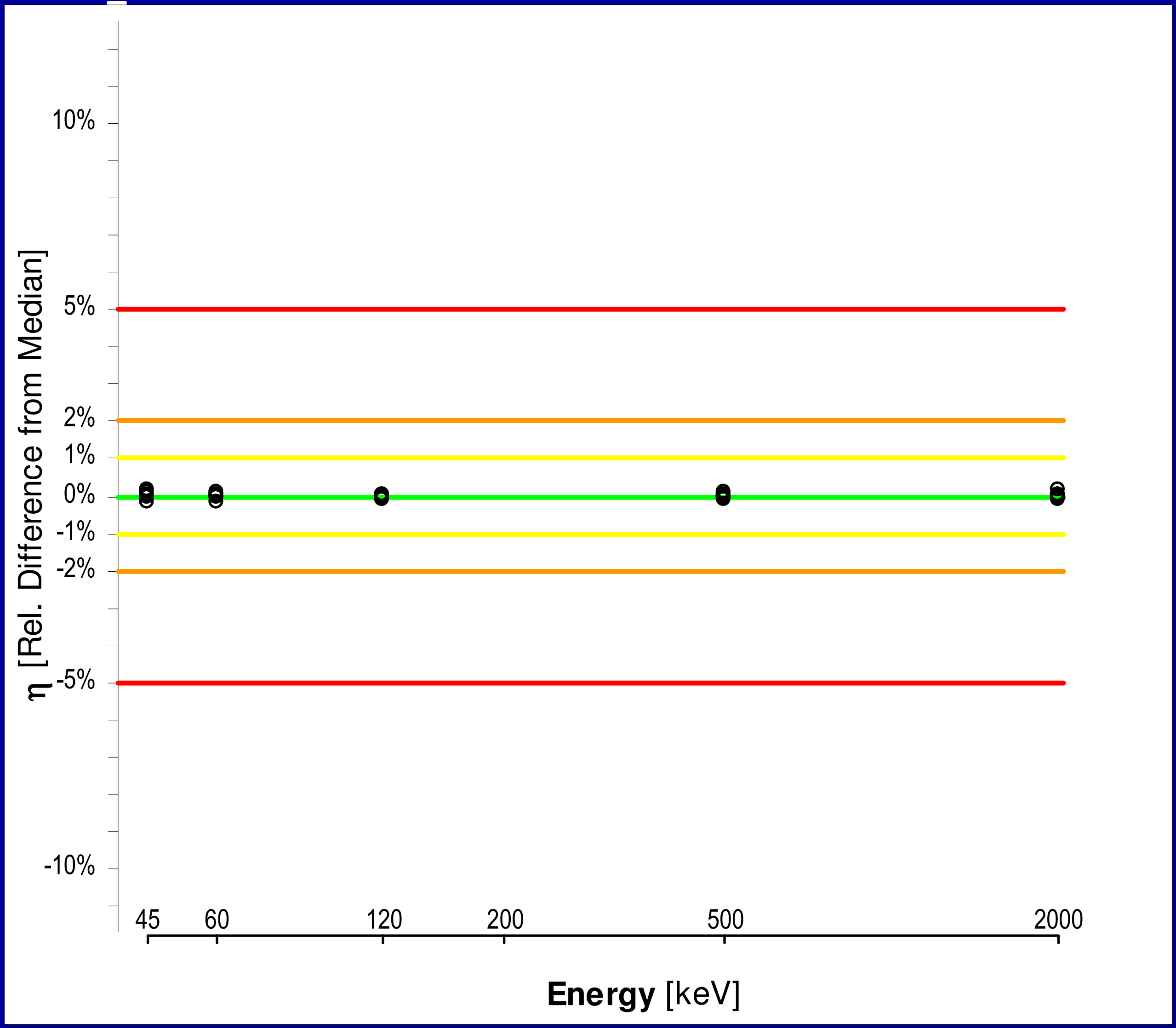
Measures taken:

- No variance reduction techniques allowed;
- A unified set of control parameters for the individual code;
- An energy cutoff of 1 keV adopted for the tracking;
- A unified definition of the full-energy-peak adopted
- Working groups established;
- Separate treatment of GEANT3 and GEANT4.

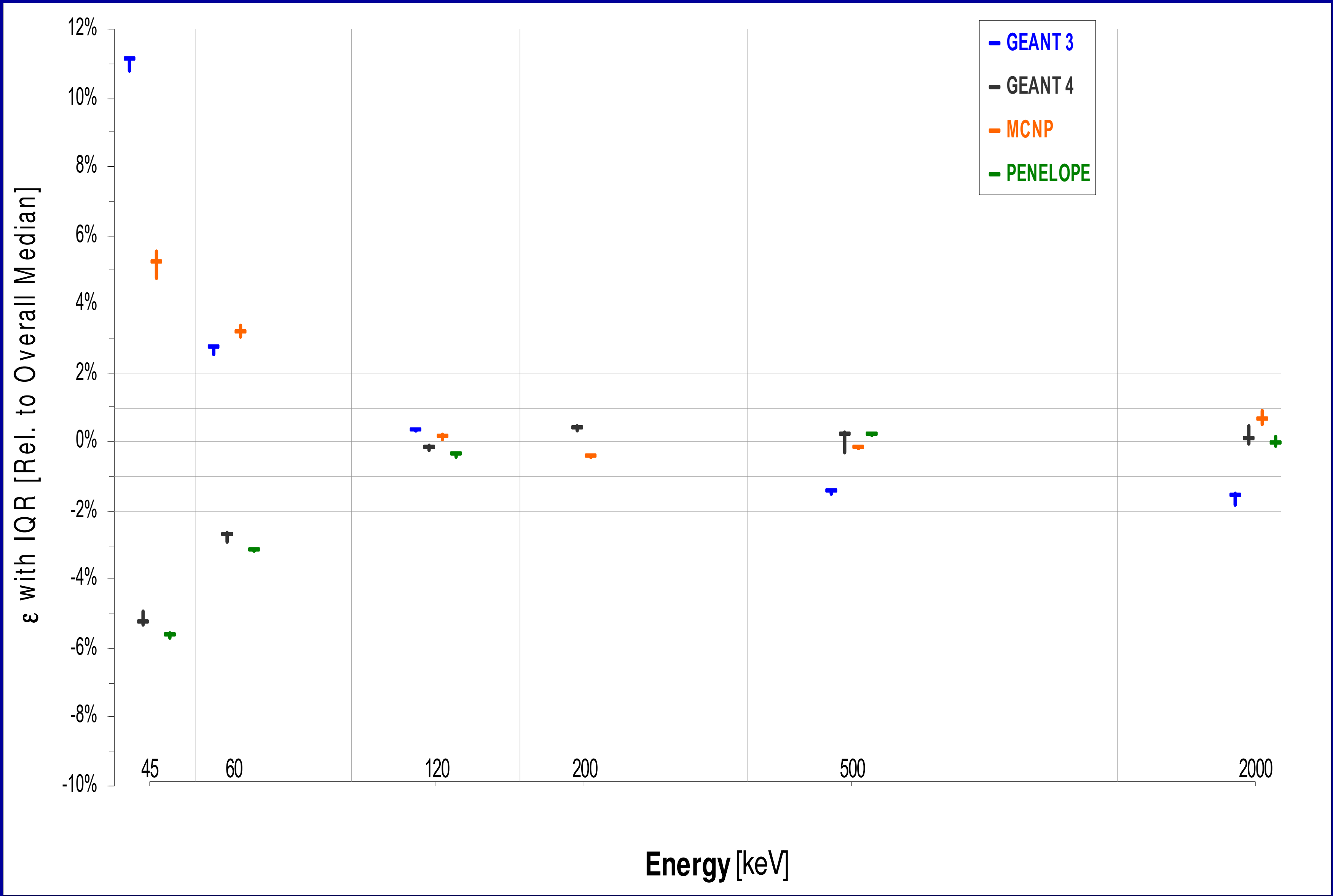
PENELOPE, Geometry #3, ε



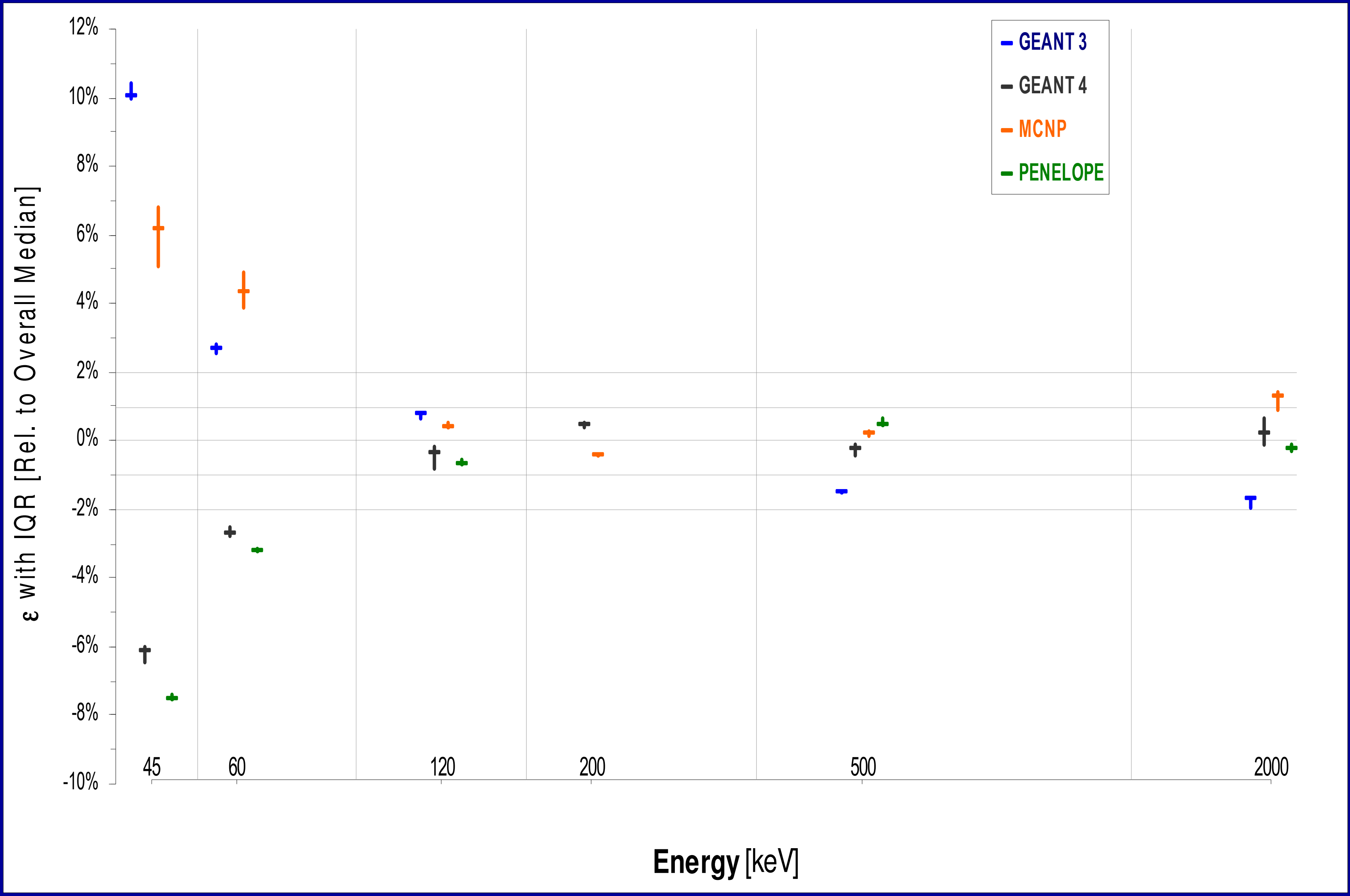
PENELOPE, Geometry #4



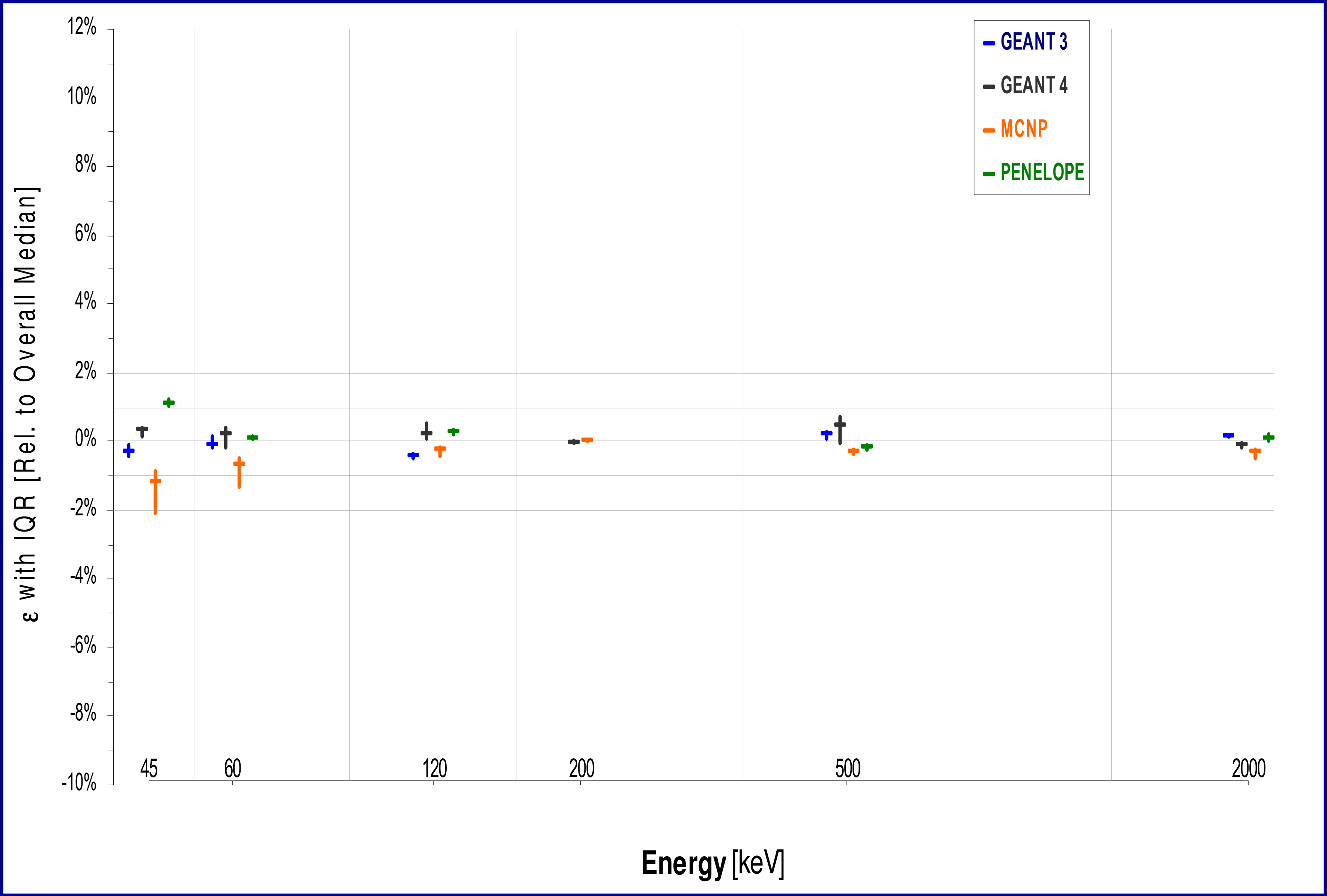
Group A, Geometry #2, ε



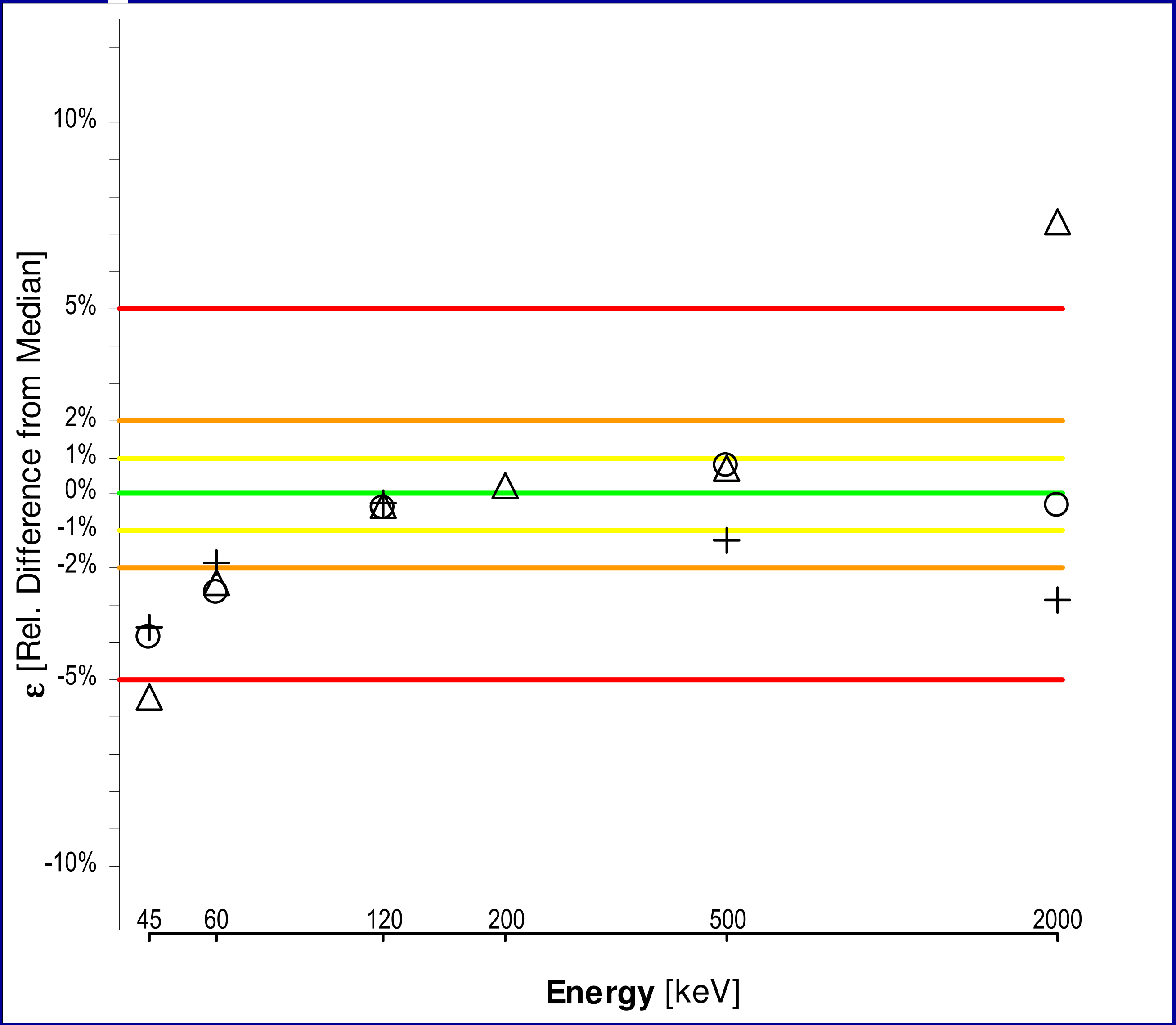
Group A, Geometry #3, ε



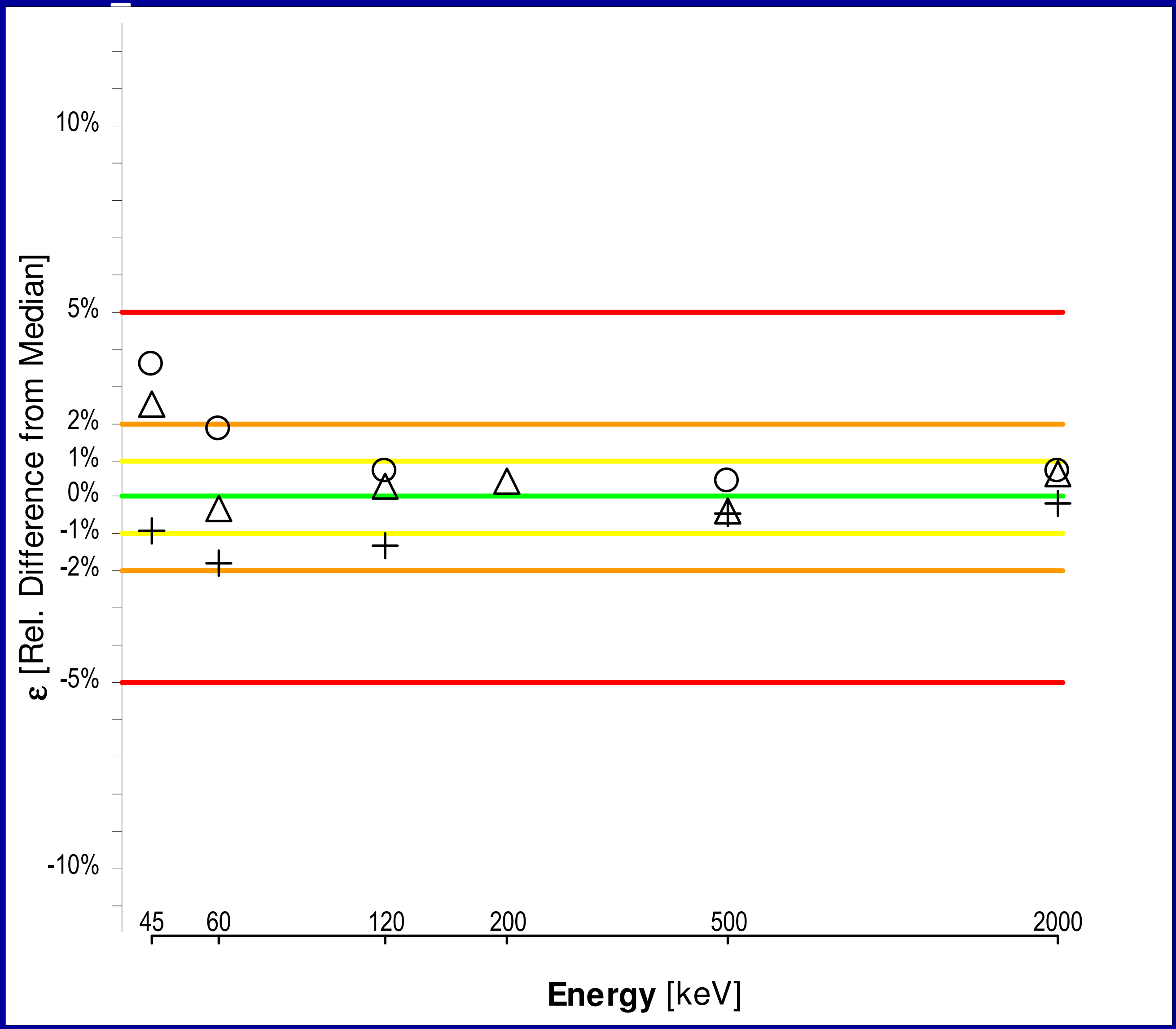
Group A, Geometry #4, ε



Group B, Geometry #3, ε



Group B, Geometry #4, ε



Summary:

- Importance of full energy peak definition;
- Unification of results between different users of the same code achieved;
- Surprising differences between the codes, especially at lower energies;
- Higher energies more satisfactory;
- The reasons remain to be established;
- Efficiency transfer mode "safest".