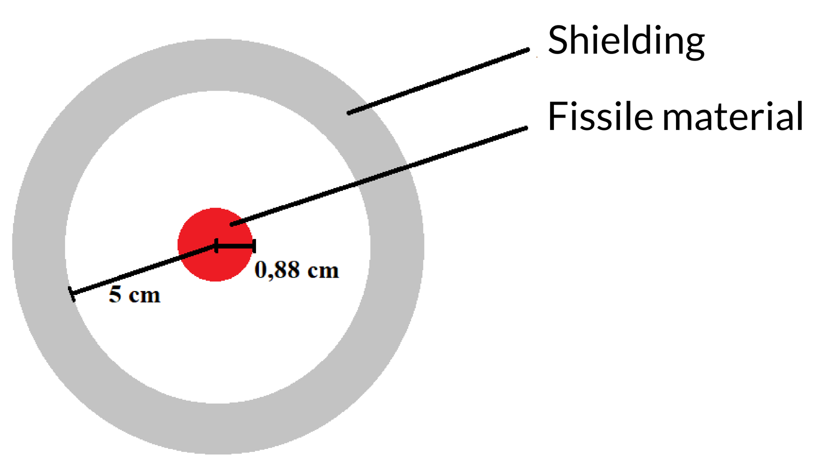
Examining the effects of different shielding configurations on the sensitivity of neutron and gamma based verification techniques.

Yannick Fischer, Patrick Schuck, Simon Hebel, Gerald Kirchner

Universität Hamburg
Carl Friedrich von Weizsäcker-Centre for Science and Peace Research, Hamburg, Germany

INTRO

One major challenge in nuclear disarmament verification is the detection of small masses of plutonium and highly enriched uranium for excluding any diversion of fissile material. A possible procedure is the detection of gamma and/or neutron radiation. This task becomes especially hard when considering deliberately chosen shielding materials.



METHOD

Neutron and gamma flux densities were evaluated with the Geant4 code. The simulation consisted of a 50 gram sphere of plutonium, shielded by different kinds of materials and geometries.

RESULTS

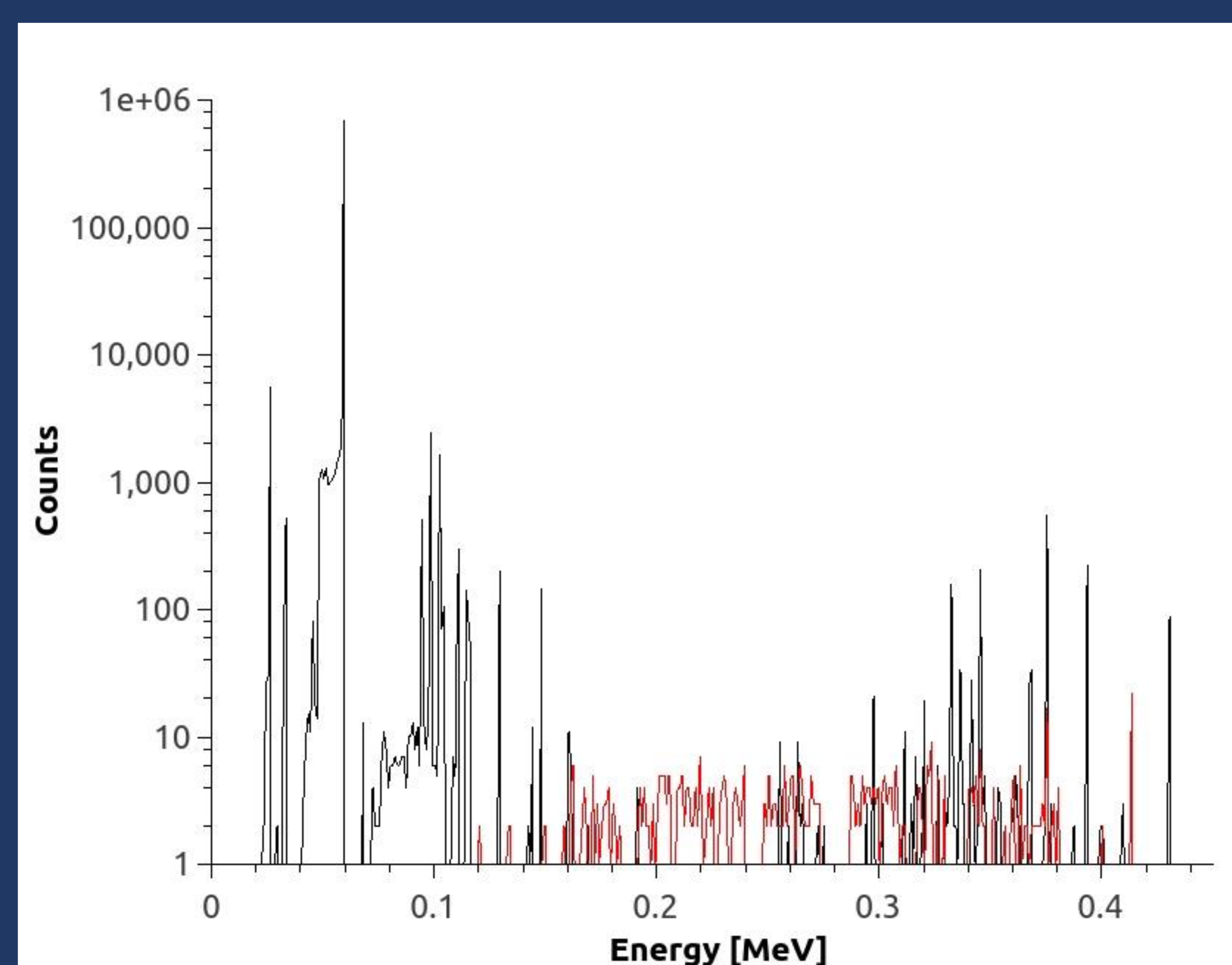
- Neutron radiation from plutonium can be effectively shielded by 20 cm of a polyethylene-boron compound.
- Gamma radiation is shielded by a few cm of lead or iron. The characteristic gamma peaks become unidentifiable behind approximately 5 cm of lead or 10 cm of iron.
- Shielding materials for gamma and neutron radiation are mostly ineffective against the respective other radiation type.

DISCUSSION

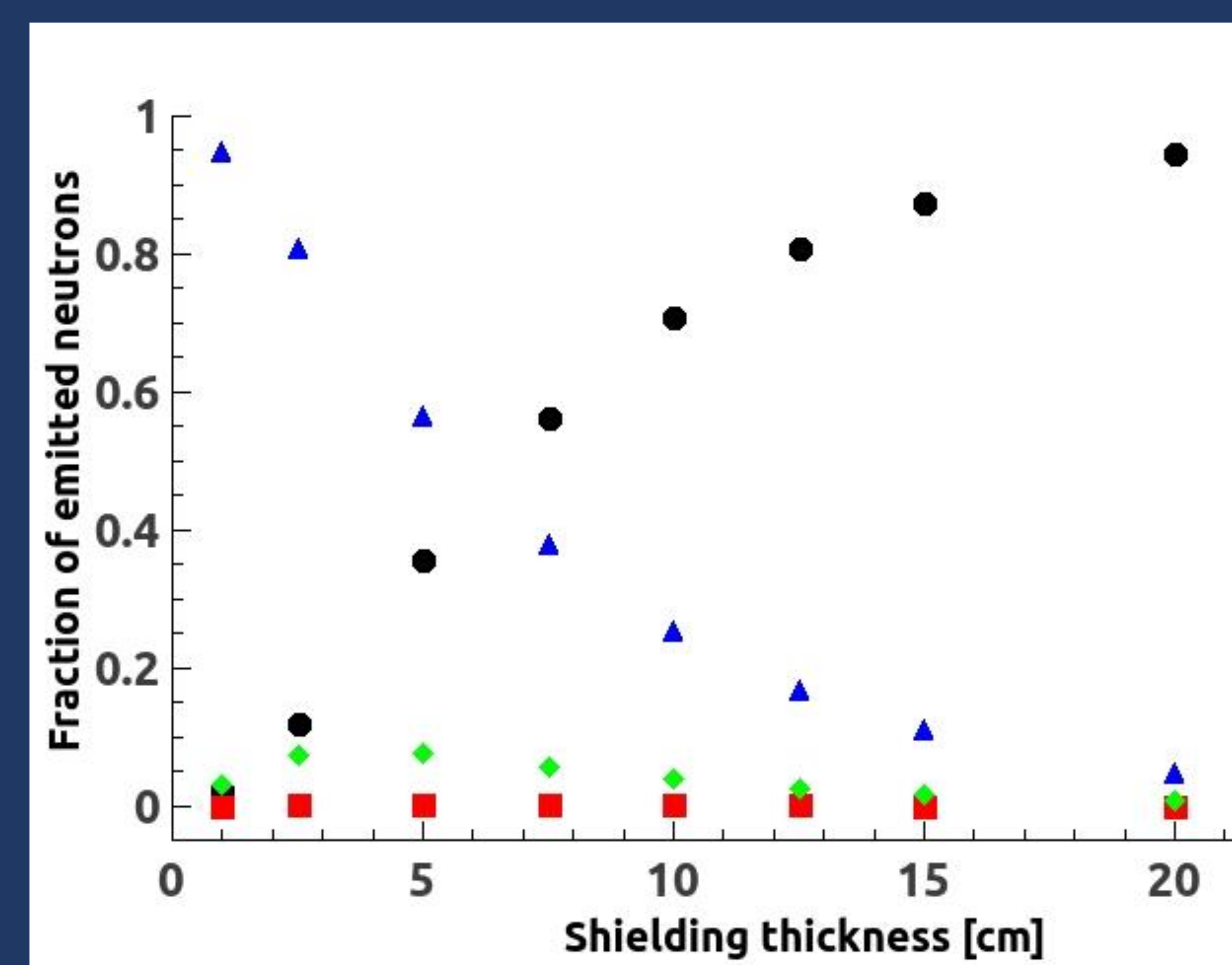
- The Gamma radiation of 50 grams of Plutonium can be shielded easily by iron, which will be present in any case. Verification techniques based solely on passive measurements are easy to manipulate.
- Shielding of neutron radiation is harder and requires more specific materials. But again a manipulation of a neutron measurement on its own is relatively simple.
- A higher level of safety is provided by a combination of both procedures.

The passive **measurement** of **gamma** and **neutron radiation** can be **shielded** easily.

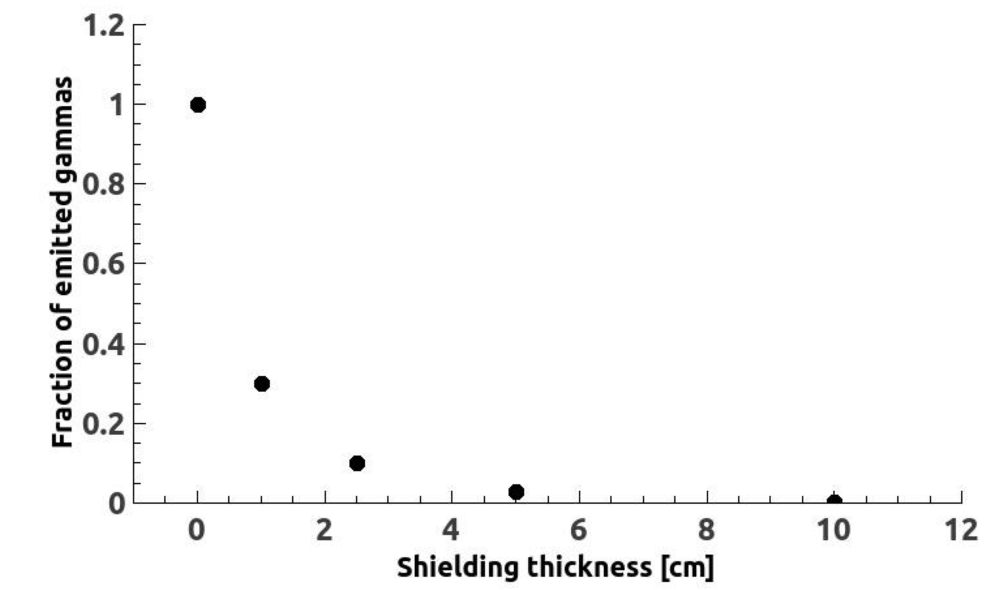
Combined measurements may provide more **safety.**



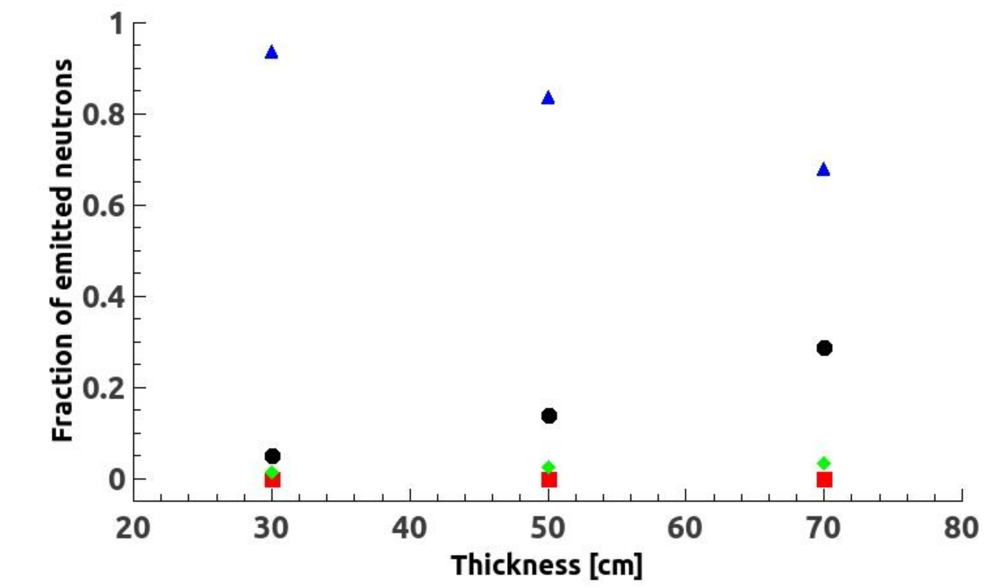
Gamma spectrum of a plutonium probe behind a 10 cm shielding of iron (red) compared with the unshielded spectrum (black).



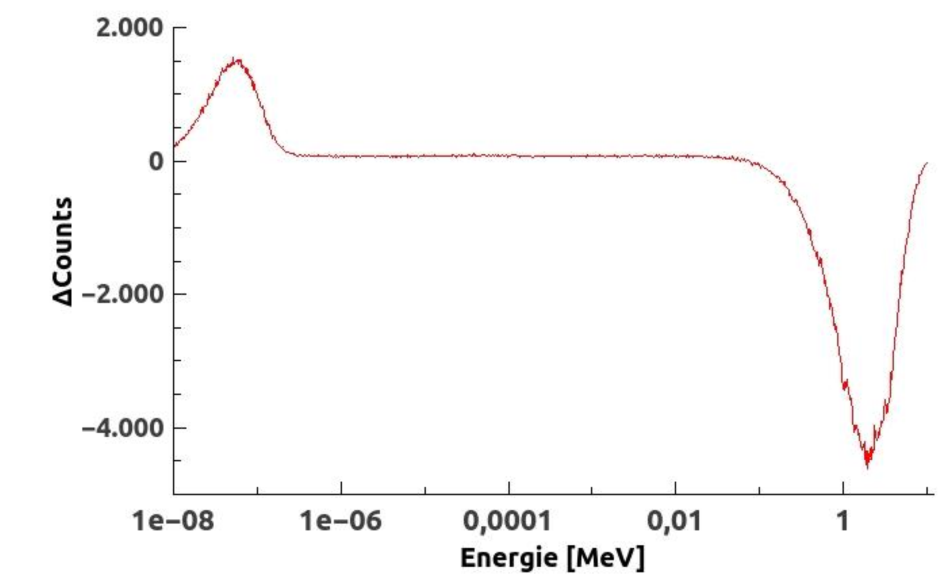
Fraction of the emitted neutrons that are fast (blue triangle), thermal (green rhombus), epithermal (red square) or absorbed (black circle) for different polyethylene shielding diameters.



Gamma absorption in iron



Fraction of the emitted neutrons that are fast (blue triangle), thermal (green rhombus), epithermal (red square) or absorbed (black circle) for different iron shielding diameters.



Difference spectrum between unshielded neutrons and neutrons behind 10 cm of polyethylene

GEANT4

- Geometry and Tracking
- Monte-Carlo-based simulation program developed and used at the CERN
- Used Database: ENDF/B VIII

OUTLOOK

- Simulation of n-gamma- reactions to detect high explosives and/or shielding material
- Evaluation of compound materials which could potentially shield both neutron and gamma radiation
- Extension of the simulation for HEU
- Examination of the effects of a neutron source