Simulation of cosmic rays in highly segmented AGATA HPGe detectors

Bundesministerium
für Bildung
und Forschung

David Schneiders, Benedikt Birkenbach, Peter Reiter, Dawid Rosiak, Andreas Vogt

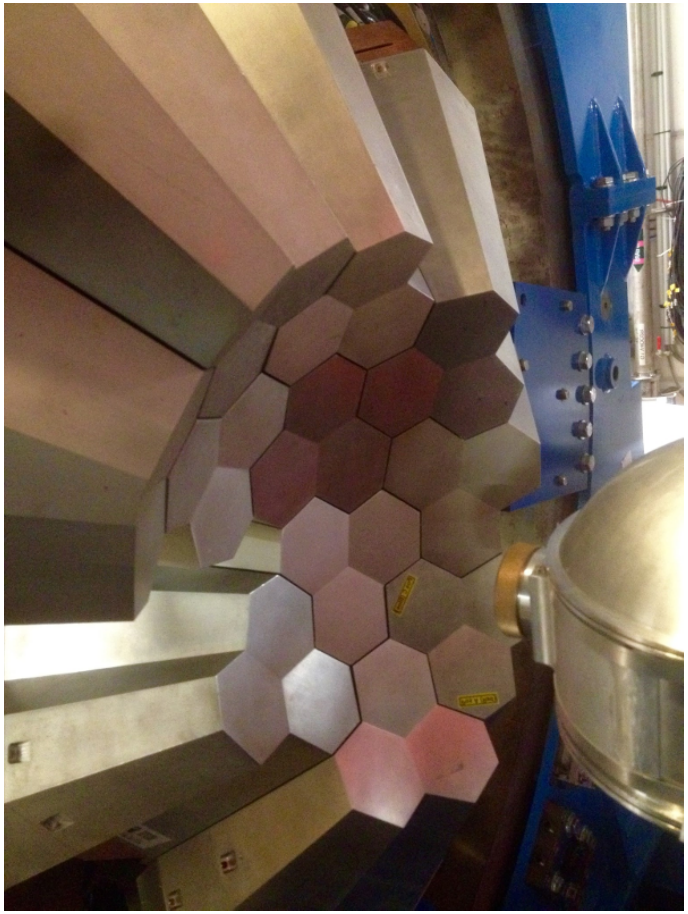
Institut für Kernphysik, Universität zu Köln

Funded by BMBF & GSI

Simulation of cosmic rays in highly segmented AGATA HPGe detectors

- **Motivation**
- **Experimental Setup: AGATA detector**
- **Simulation Setup: GEANT4 & CRY library**
- **Simulation Results & Comparison**
- **Outlook & Summary**

Motivation



AGATA @ GANIL

AGATA @ FAIR - NUSTAR - HISPEC
fragmentation reactions
→ high-energy secondary particles expected

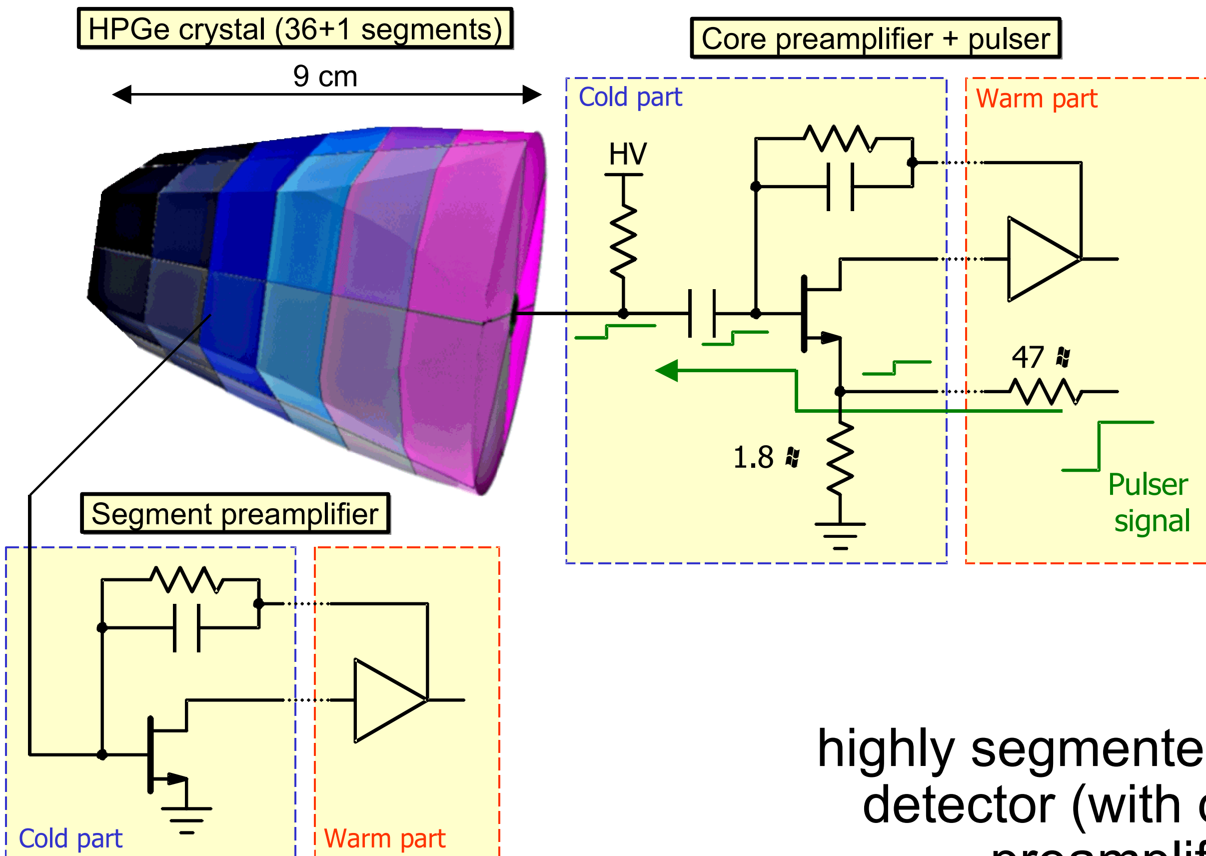
Energy depositions up to 180 MeV directly measureable in single HPGe crystal

Study of background in PreSPEC 2014[1]: high rate of events with saturated detectors

Simulations necessary to validate calibration and estimate secondary particle flux

1: GSI Scientific Report 2014, Guastalla et al.

Experimental Setup



Output:

2x 2 Core (Energy & INH)

36x Segment (Energy)

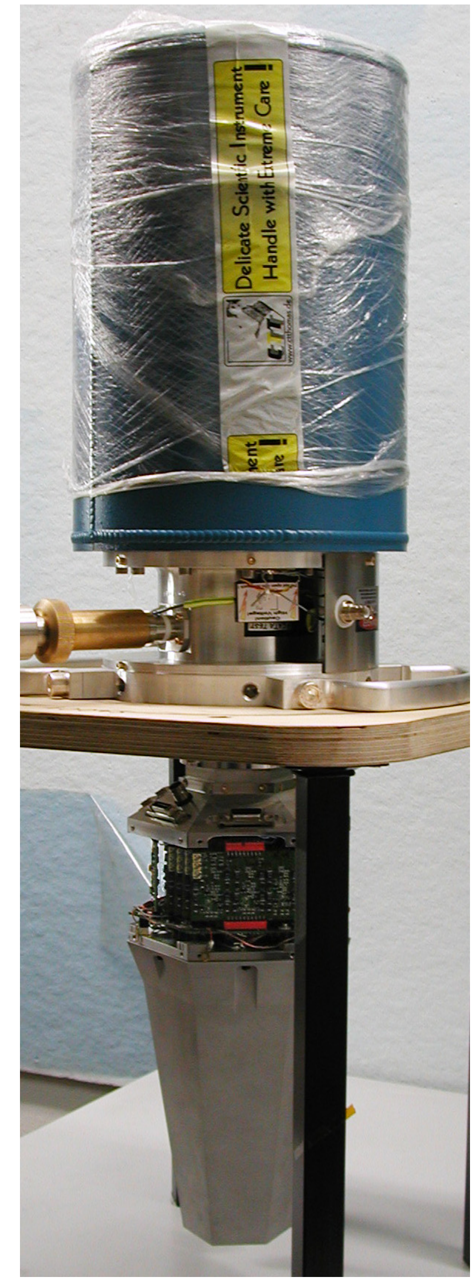
Trigger: High Gain Core
(min. 10 MeV energy deposition)

highly segmented HPGe detector (with dual gain preamplifier)

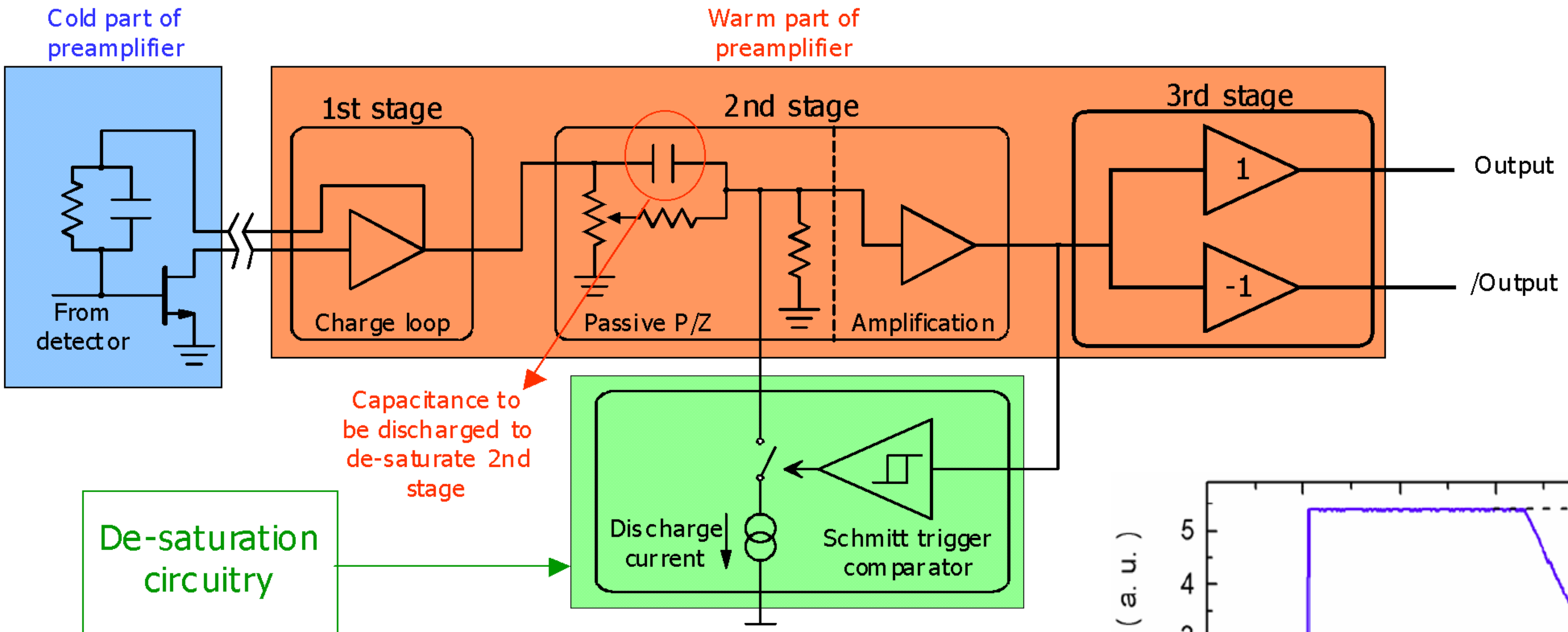
converter boxes (diff to single)

'DGF Pixie-4' modules

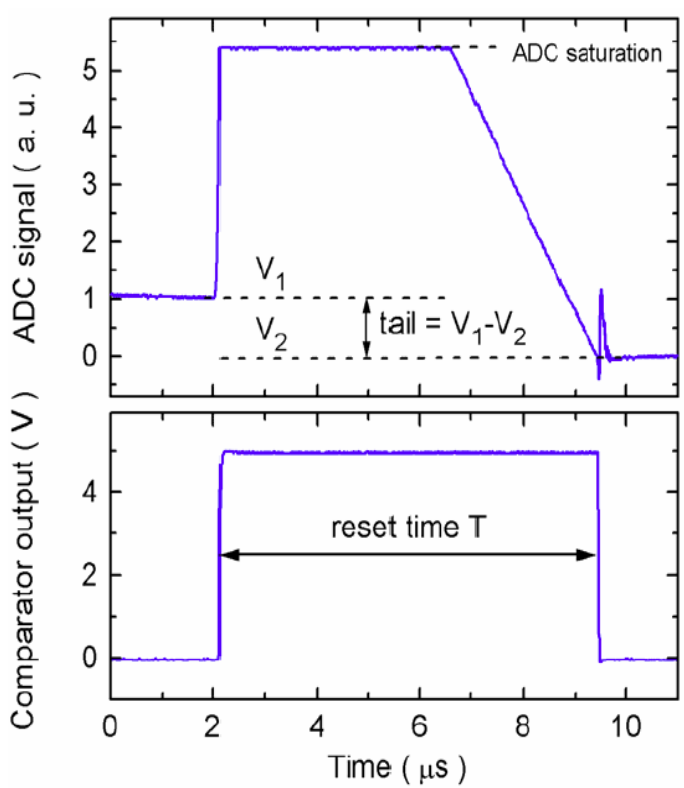
DAQ computer



Detection technique



A. Pullia et al., „Active Reset of Digitized Preamplifiers for Ionizing-Radiation Sensors", IEEE Trans. Nucl. Sci., 51(3), 2004

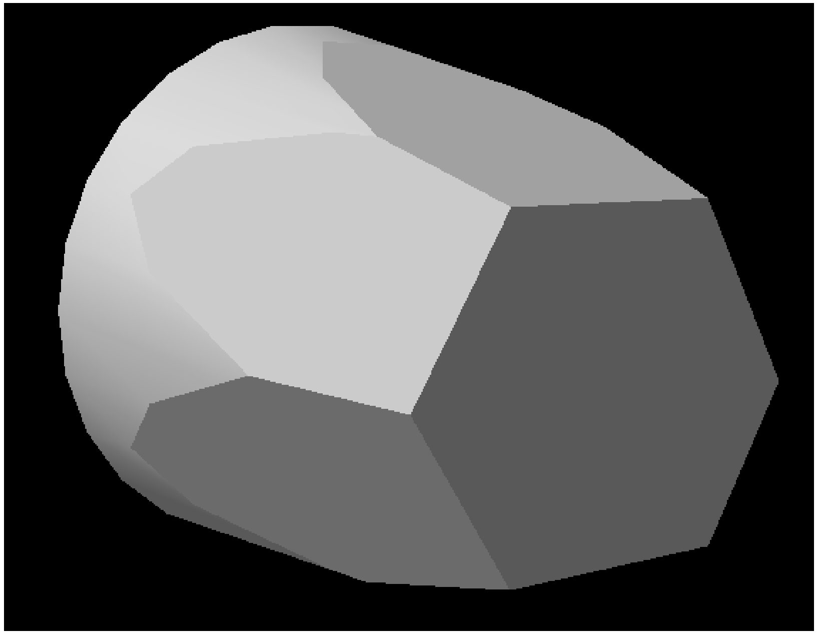


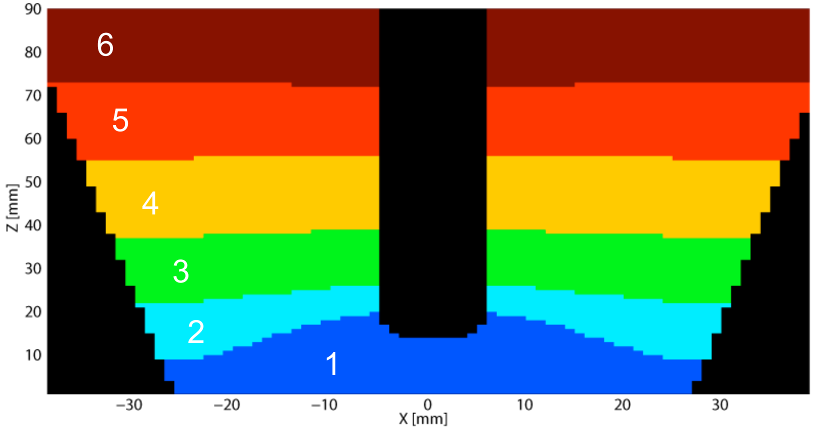
Time-over-Threshold method (ToT)

Energy of the signal directly dependent on length of inhibit signal

$$E = b_1T + b_2T^2 - (V_1 - V_2)/G + E_0$$

Simulation Setup





M. Schlarb: Simulation and real-time analysis of pulse shapes from segmented hpge-detectors, PhD thesis, LMU Munich, 2009

GEANT4 simulation with CRY library:

C. Hagmann et al., „Cosmic-ray Shower Library (CRY)“, LLNL UCRL-TM-229453

generates cosmic showers in a planar field ($3x3m^2$) above the upright cryostate

room surroundings do not influence spectra

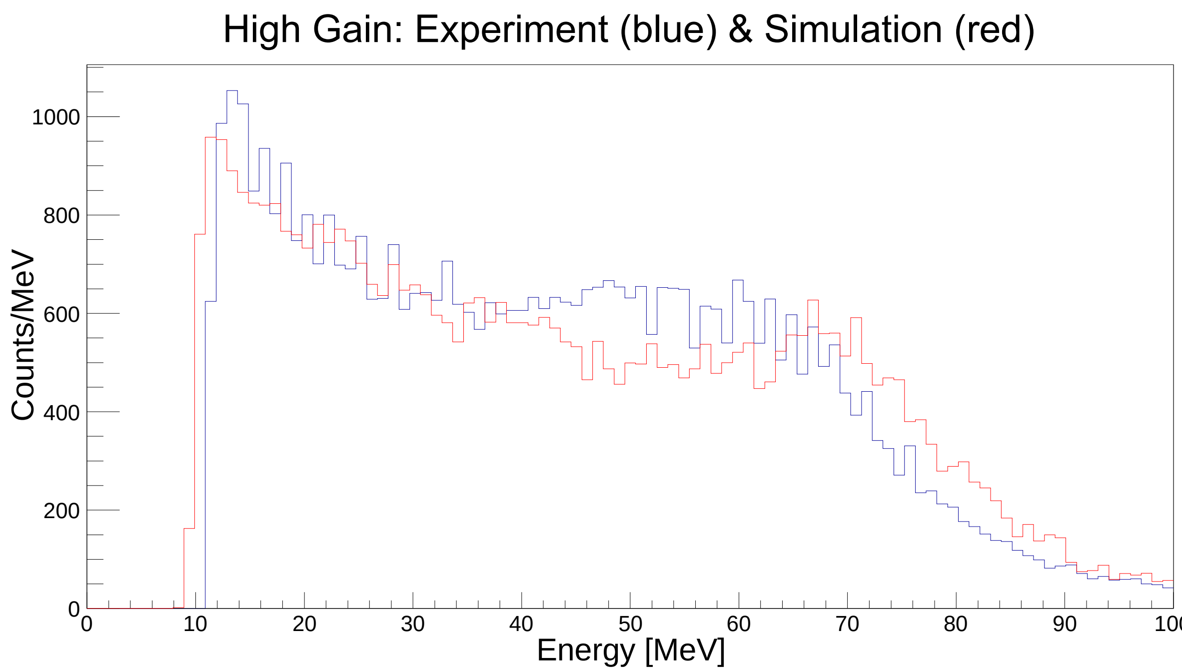
→ left out for calculation time

→ only muons and gammas simulated

two simulation modes:

complete crystal (core), horizontal rings

Results – Core spectrum

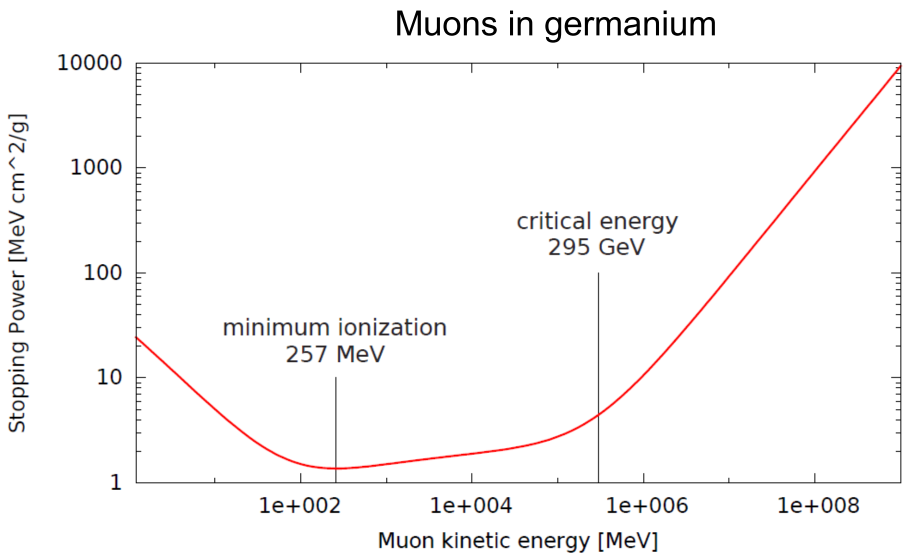


energy loss of muons around minimum ionization almost linear

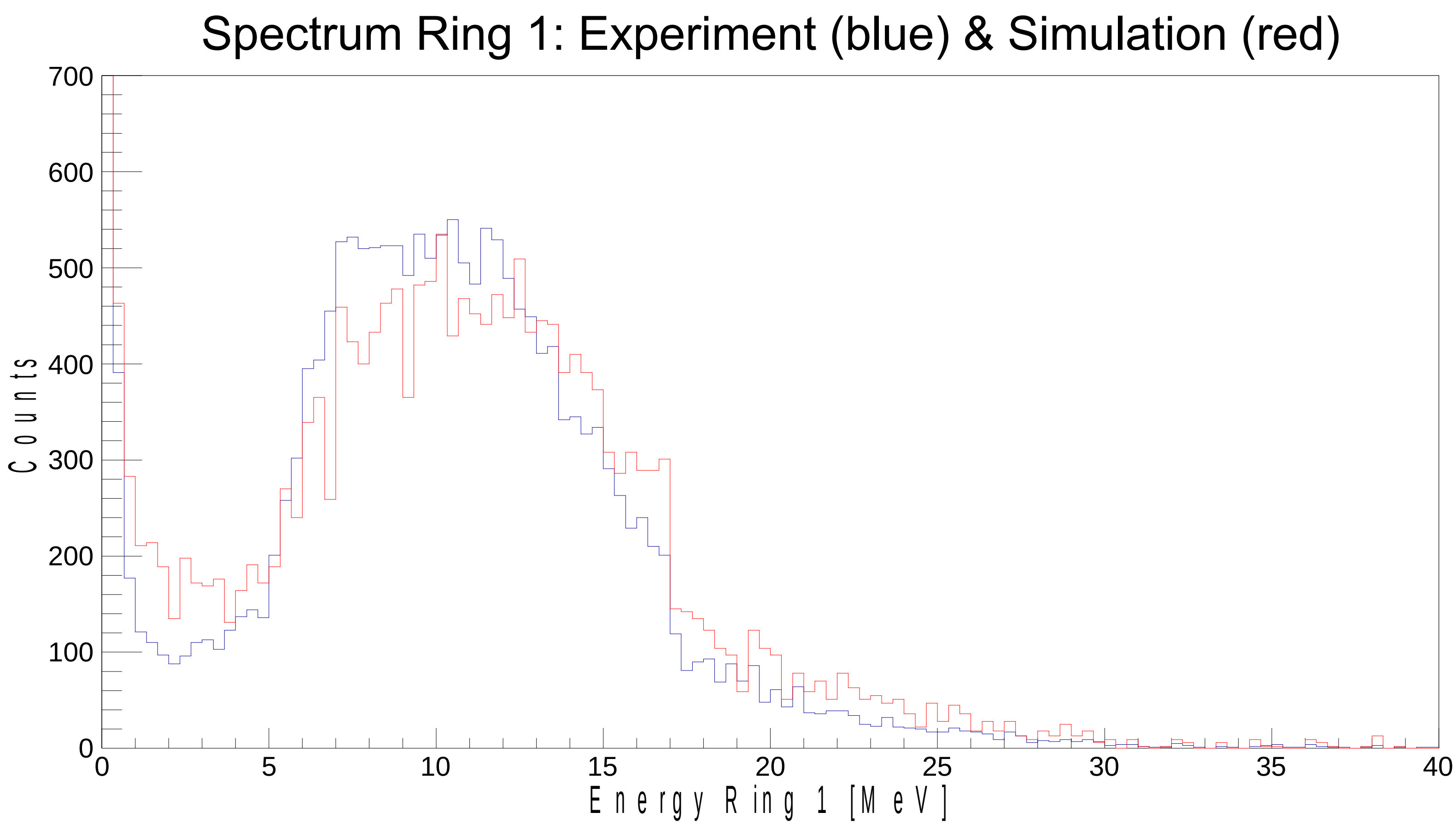
→ 'knee' in spectrum corresponds to longest path through crystal

little deviations due to geometrical differences

→ energy depositions in the passivation layer



Results – Ring spectra

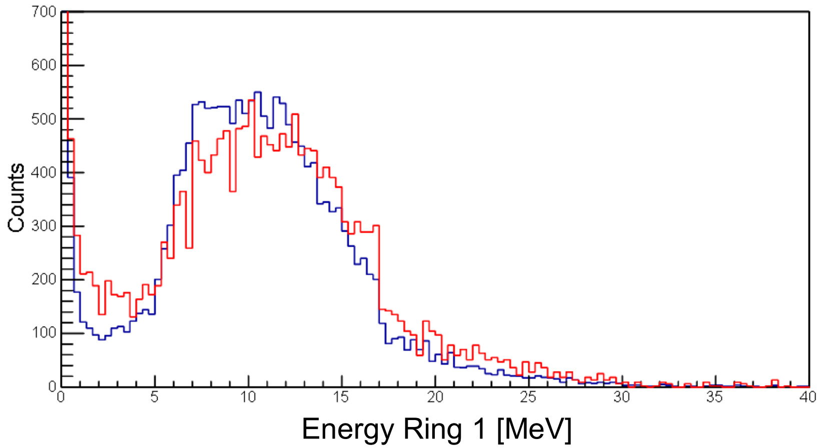


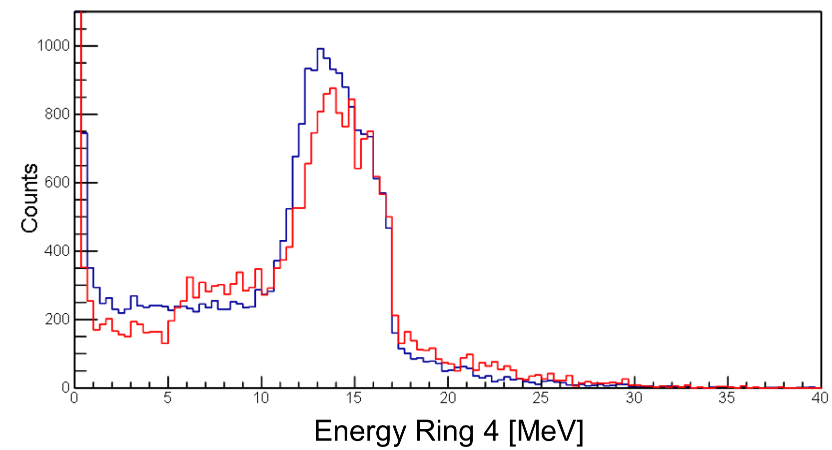
new conditions for simulation code:

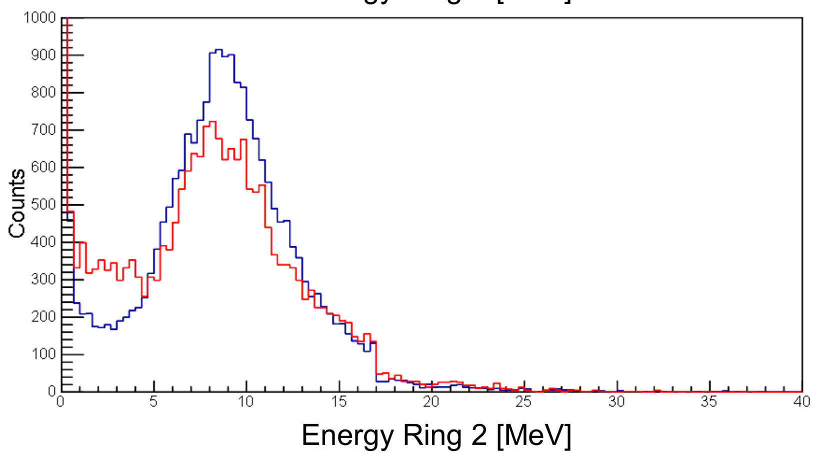
min. 10 MeV energy deposition in whole crystal

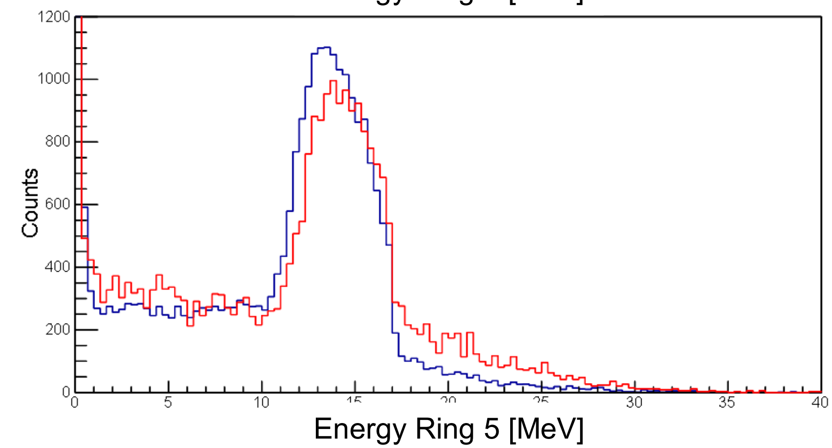
max. 17 MeV energy deposition per event and segment

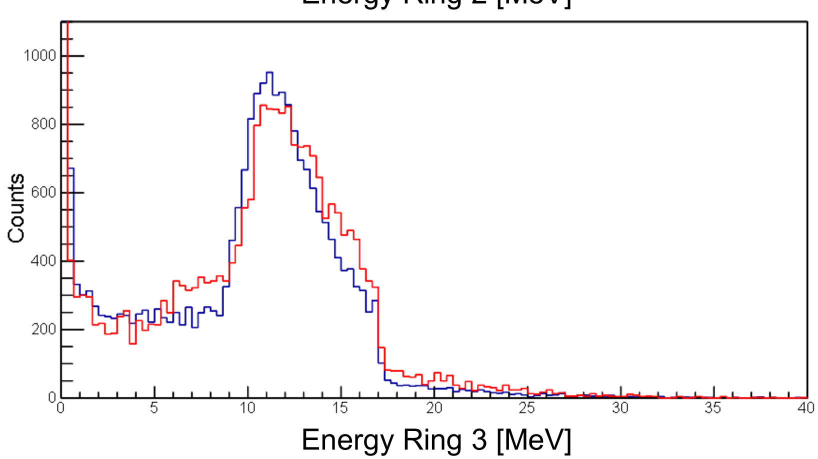
Results – Ring spectra

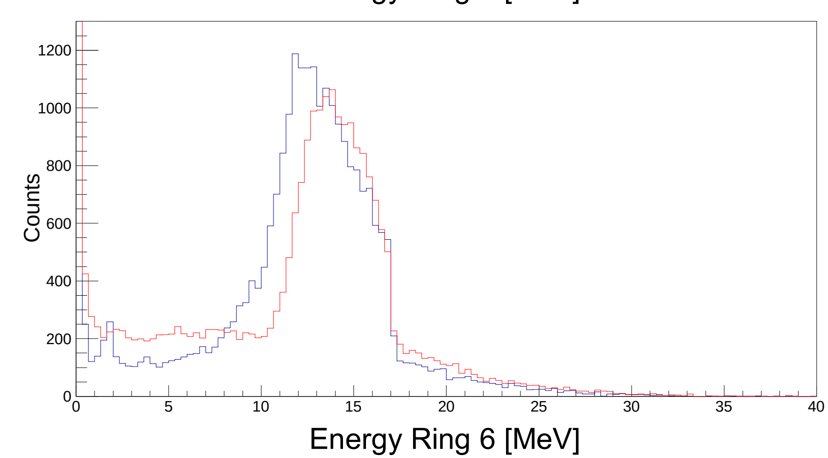




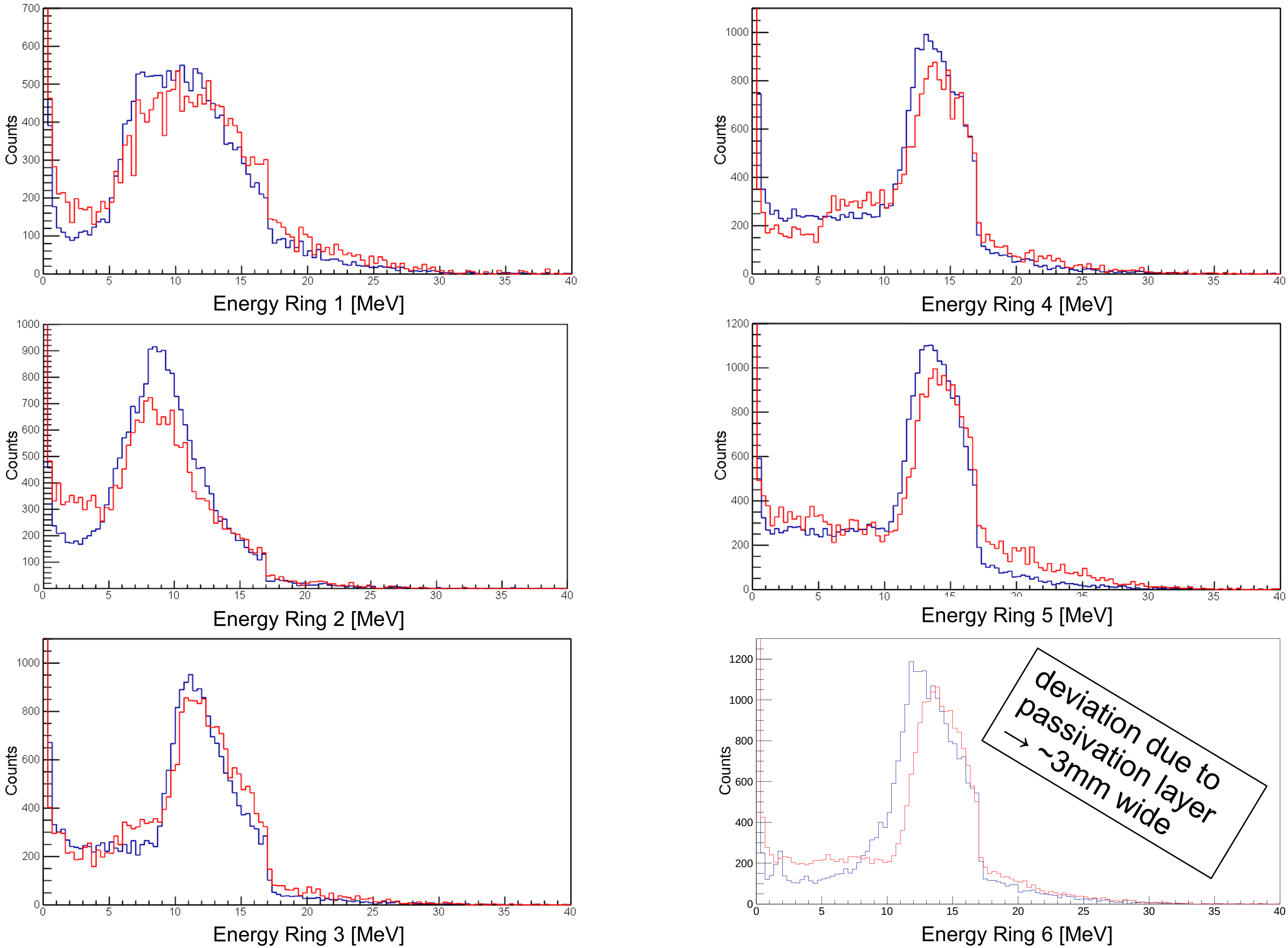




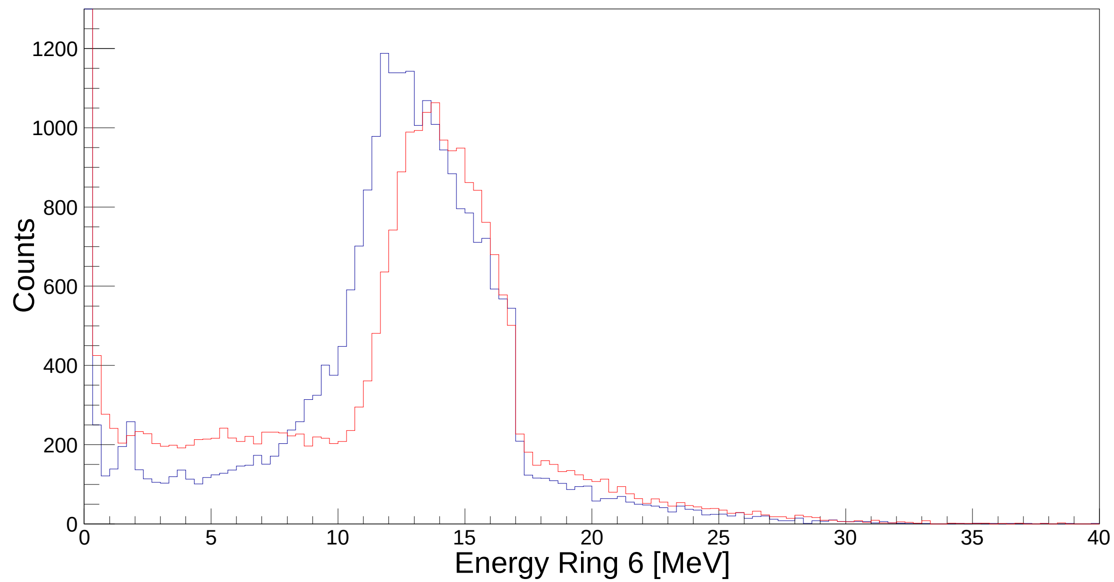




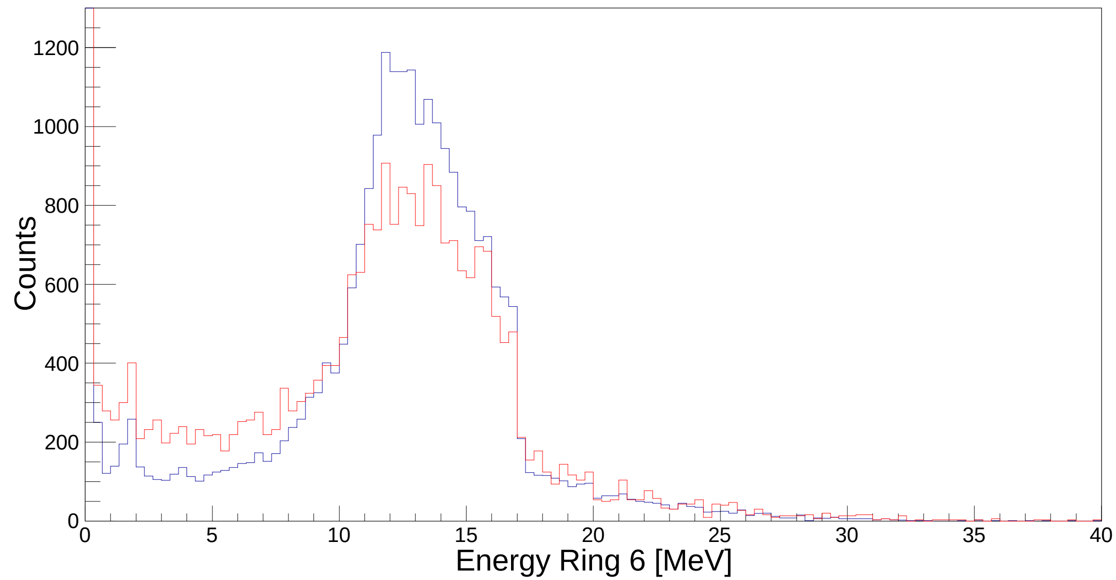
Results – Ring spectra



Results – Ring spectra



without passivation layer



with passivation layer, 3 mm wide

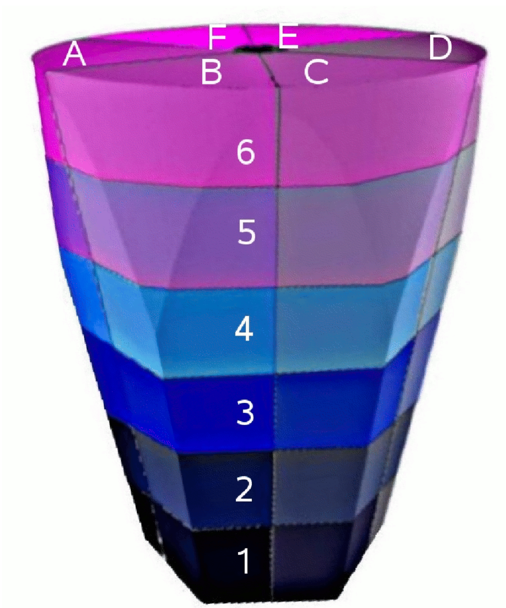
conclusion: quantitative and qualitative agreement

Outlook

fragmentation reactions with AGATA (at RIB facilities)

↓

many secondary particles (pions, muons, electrons...) expected



secondary particles differ significantly in energy deposition

-----

→ radiation length of pions in germanium: ~ 2 cm

→ muons show linear paths through detector

→ electromagnetic showers have short range and a broadening distribution

↓

simulation of full 36-fold segmentation allows prediction of particle identification (from beam experiments)

Summary

GEANT4 simulation code supports experiments with new preamplifier technique

Simulation allows estimation of thickness of passivation layers at upper detector part

Implementation of full segmentation will enable particle tracking and identification

Estimation of detector degradation in RIB experiments due to secondary particles possible

Funded by BMBF (05P12PKFNE TP4) & GSI

Thank you for your attention!