SCANNING OF HPGe SURFACES

Serena Riccetto
University of Perugia – INFN Perugia

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Research outlines

Project: Characterization of an AGATA detector and study of its main features by means of low-energy radiation scans with a ^{241}Am collimated source

Study of two particular aspects:

- radiation attenuation zones in each detector segment
- satellite peak in the ^{241}Am energy spectra

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Experimental set-up

- HPGe AGATA detector, 36-fold segmented crystal, closed-end coaxial type, with hexaconical shape
- ^{241}Am collimated source

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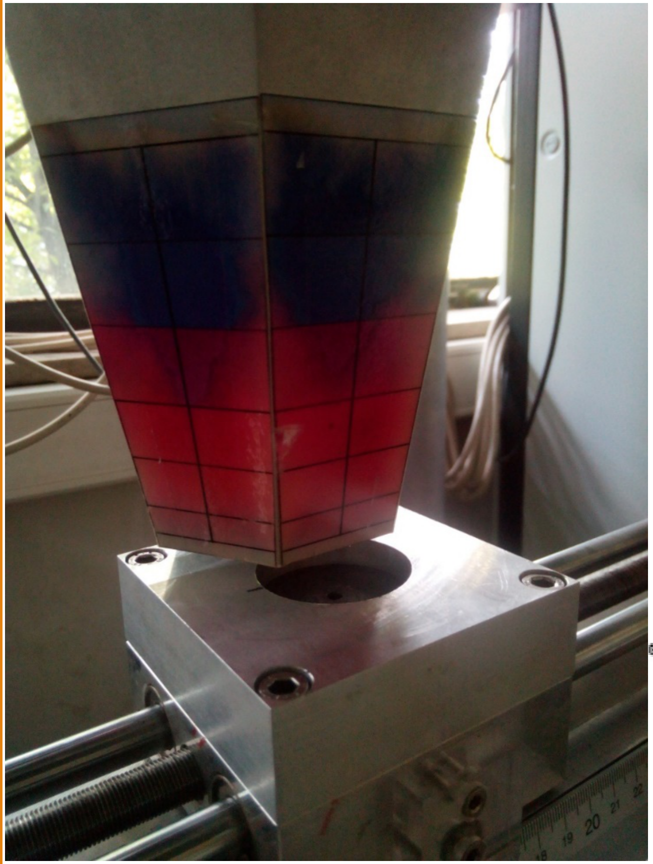
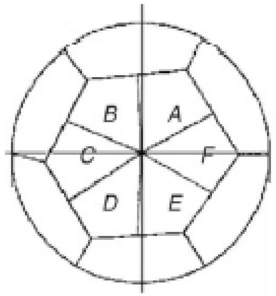
- collimated source

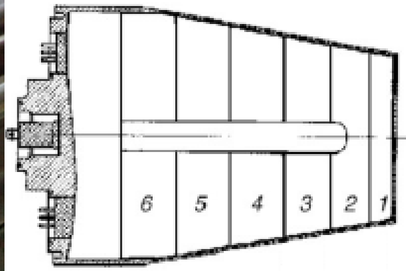
Two different kinds of measurements:

- irradiating from below the detector
- irradiating from the side of the crystal

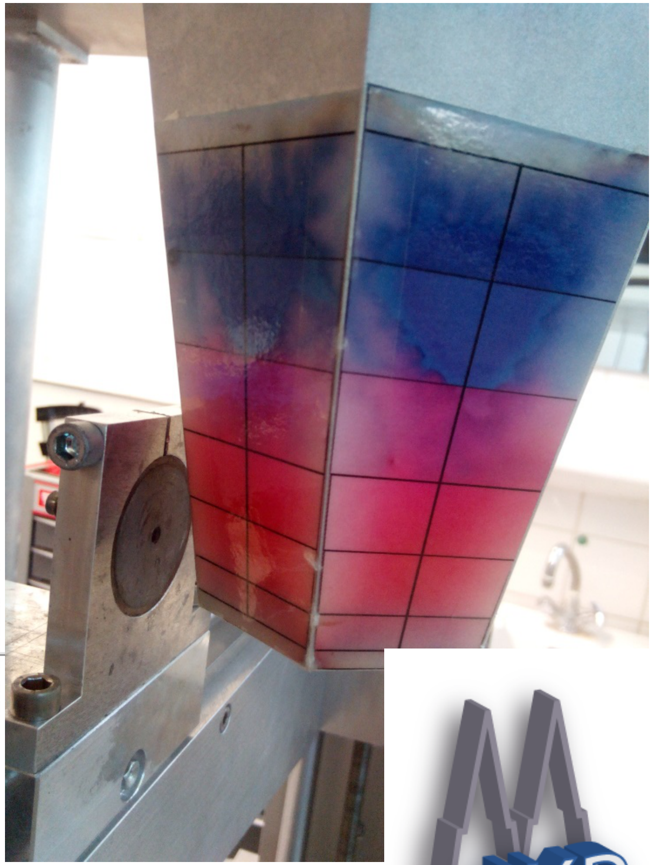




from below



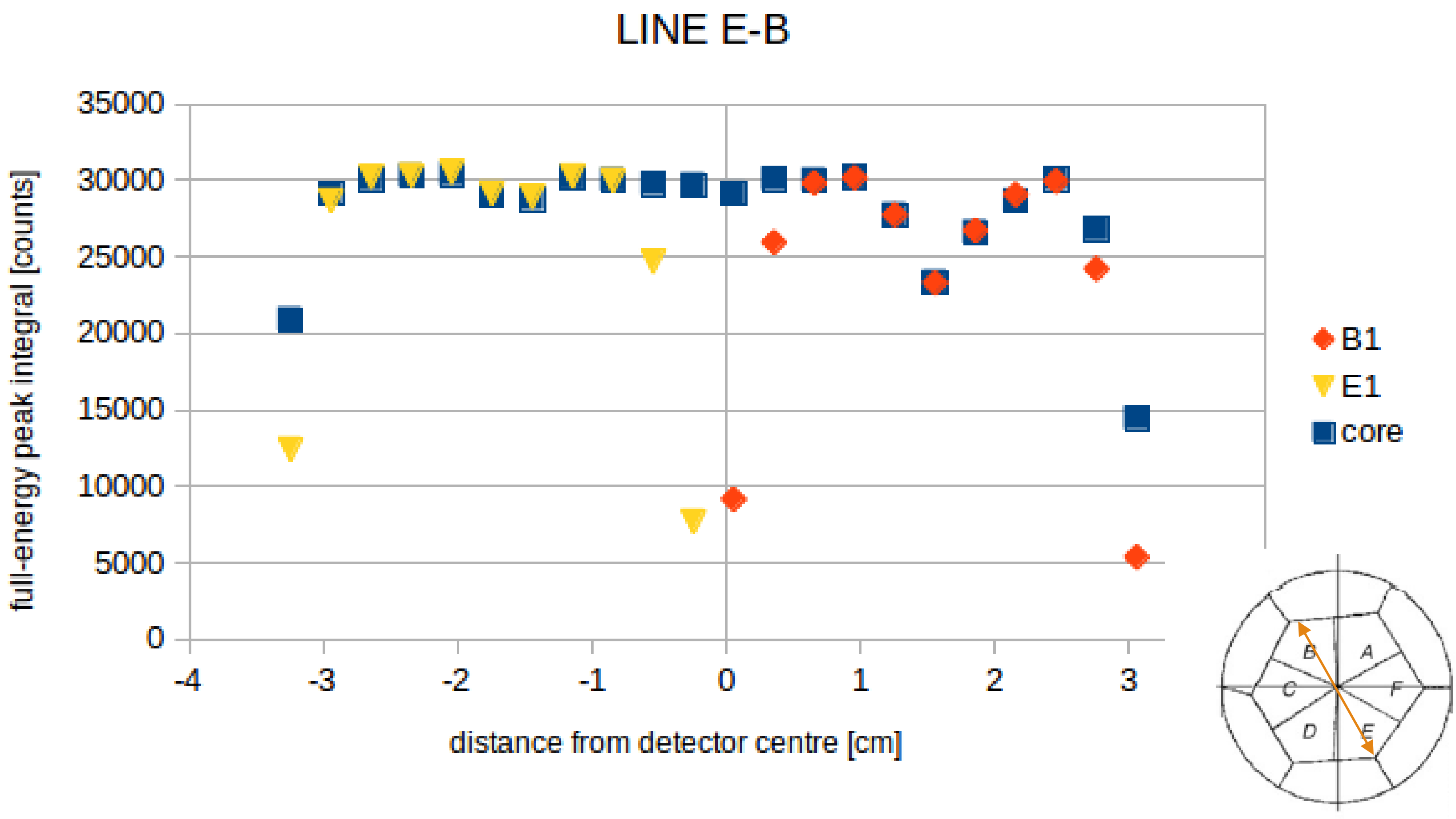
from the side



Moving between two opposite corners

- We observed attenuation zones in the middle of each segment

- collimated source, in front of the detector
- Integrals of the full-energy peak at 59.54 keV, from the core and the segment spectra



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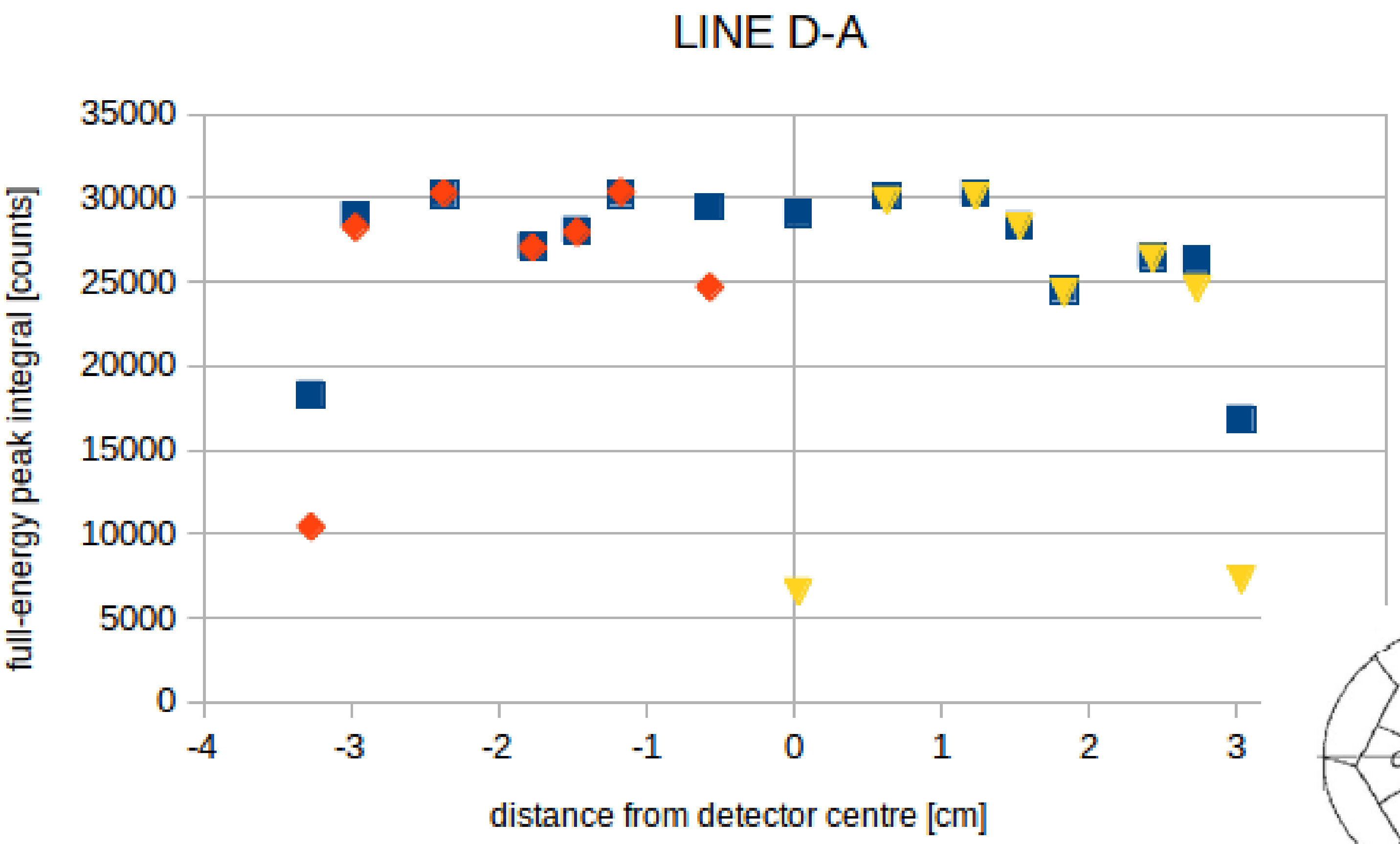

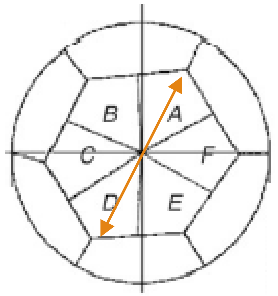

from below

Moving between two opposite corners

- We observed attenuation zones in the middle of each segment
- Not always at the same angle or distance from the centre
- Always the same absorbing materials
- It is not a ring, but single

- collimated source, in front of the detector
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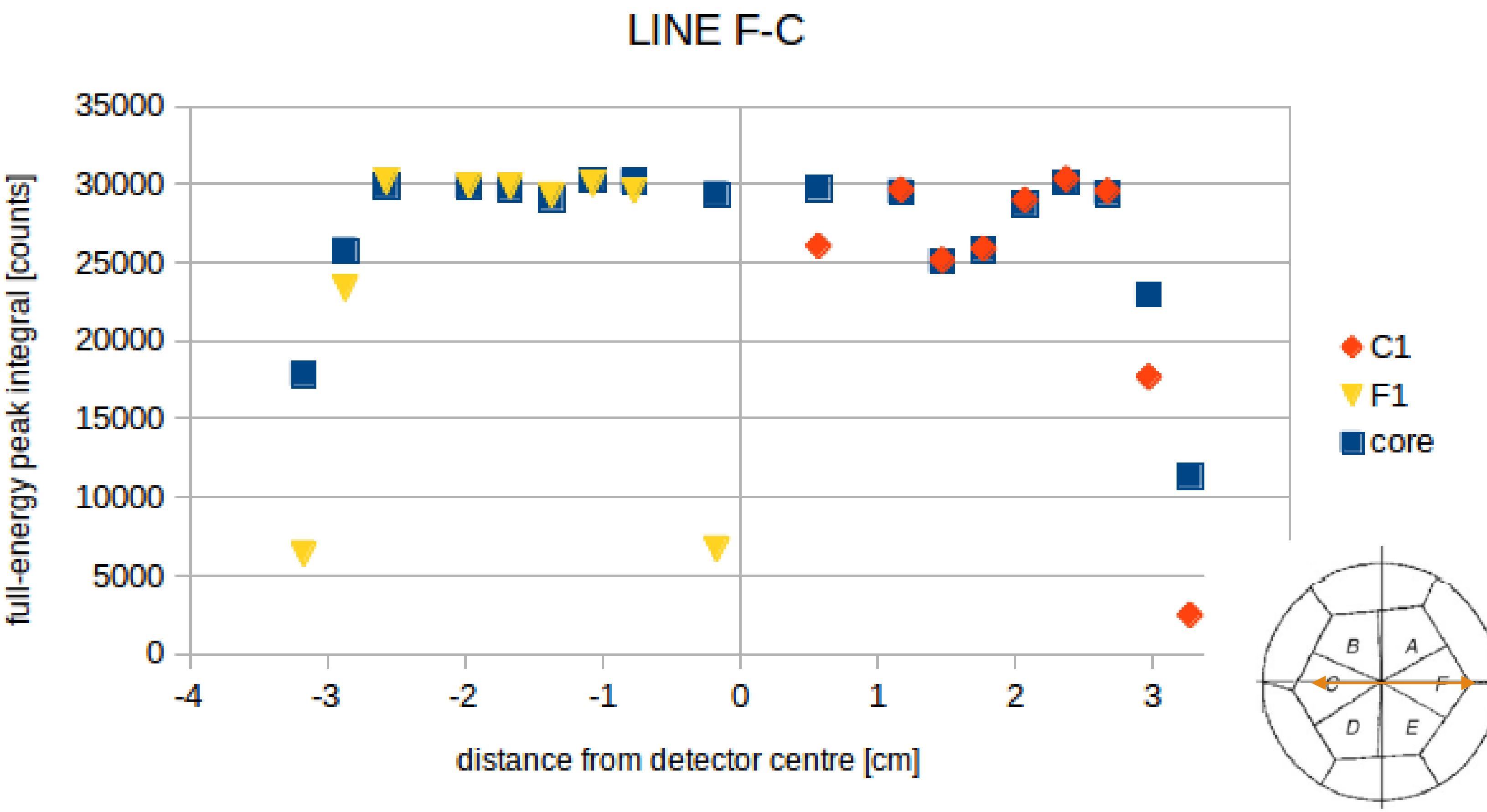
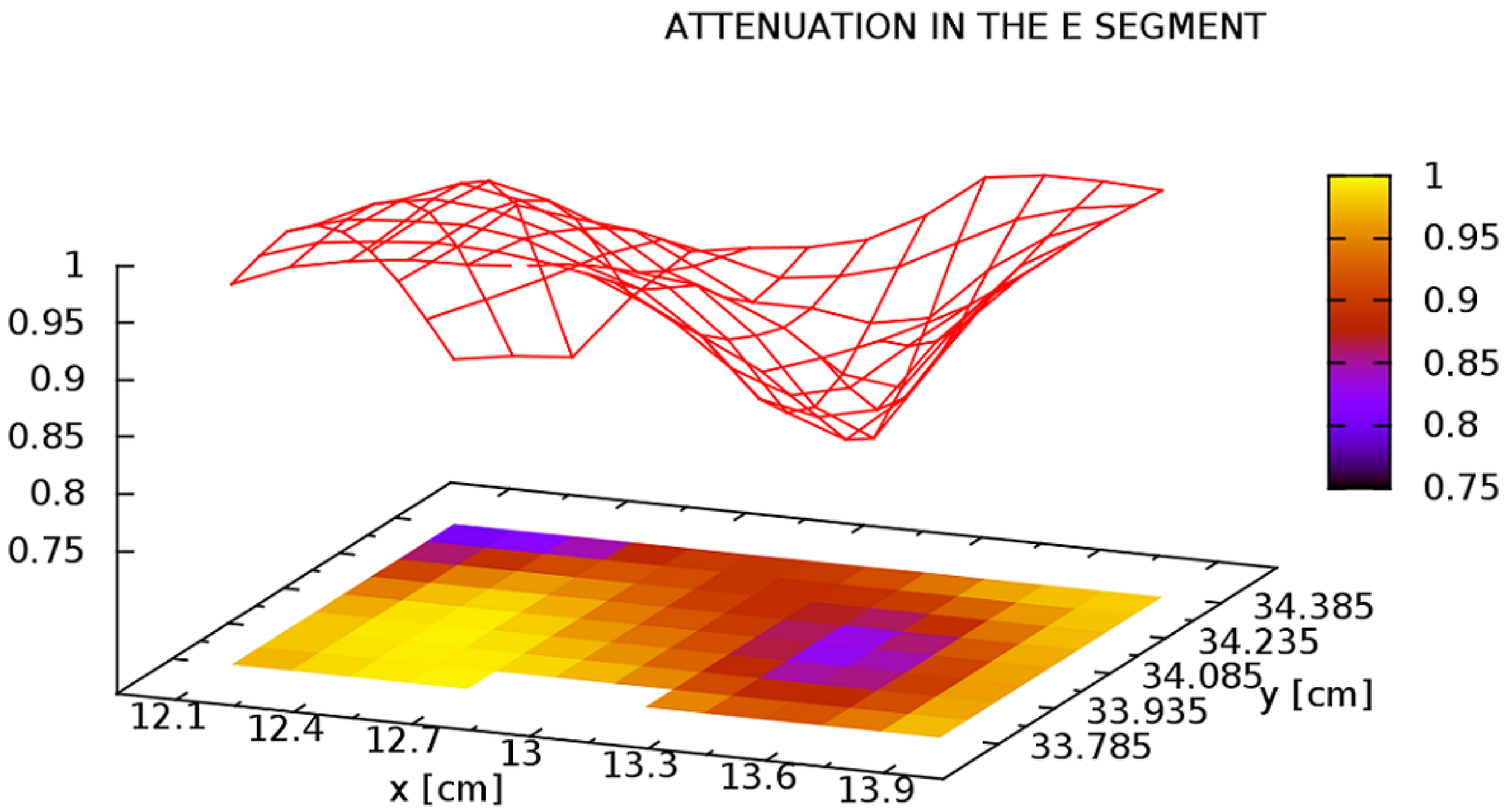


from below

Moving around the attenuation zone in the E segment

- collimated source, in front of the detector
- Integrals of the full-energy peak at 59.54 keV from the core spectra, normalized to the maximum value



Moving around the attenuation zone in the E segment

- Dimensions of the order of 1.5 – 2 mm, but we don't know its shape
- Maximum attenuation about 20%

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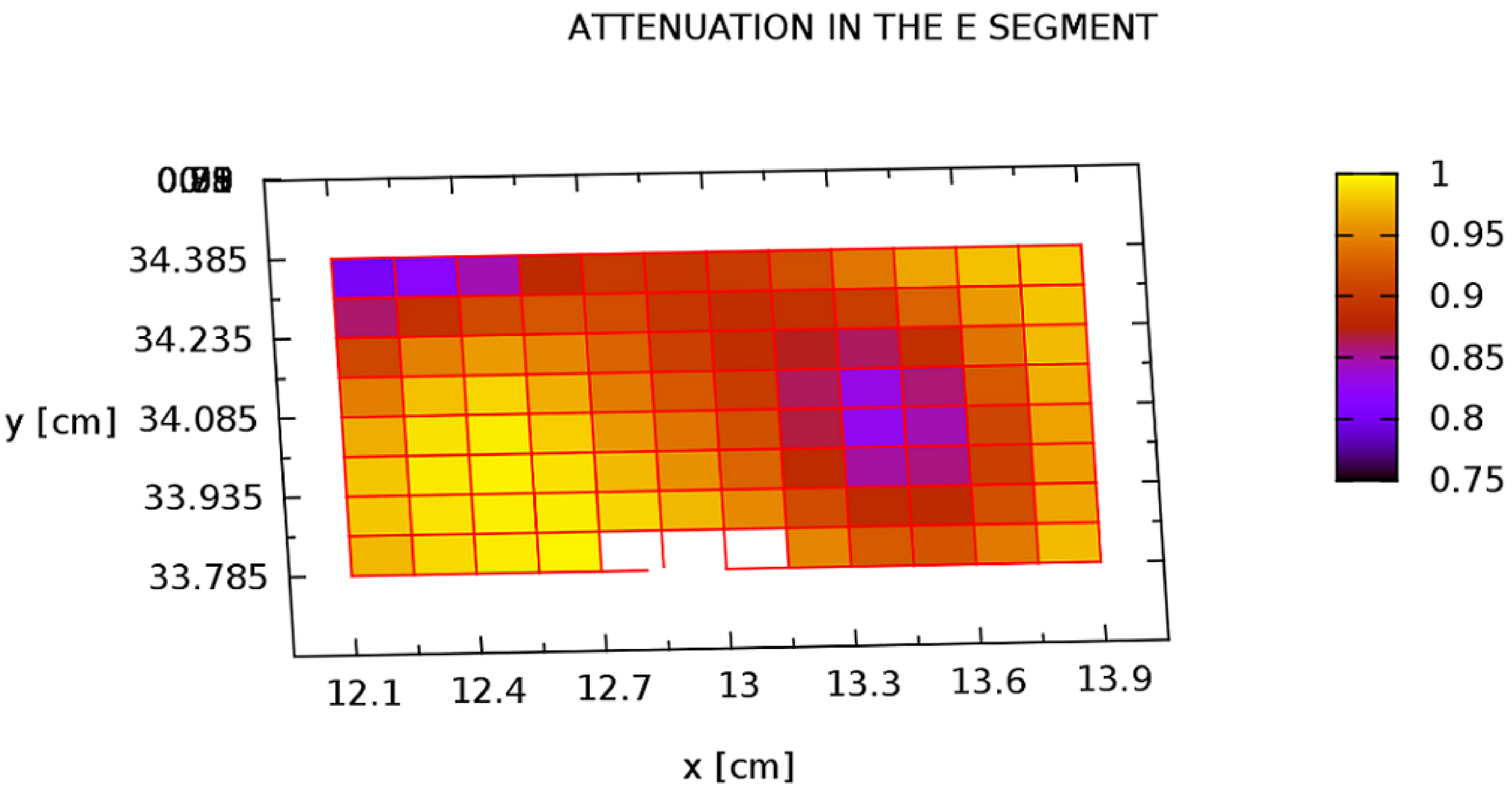


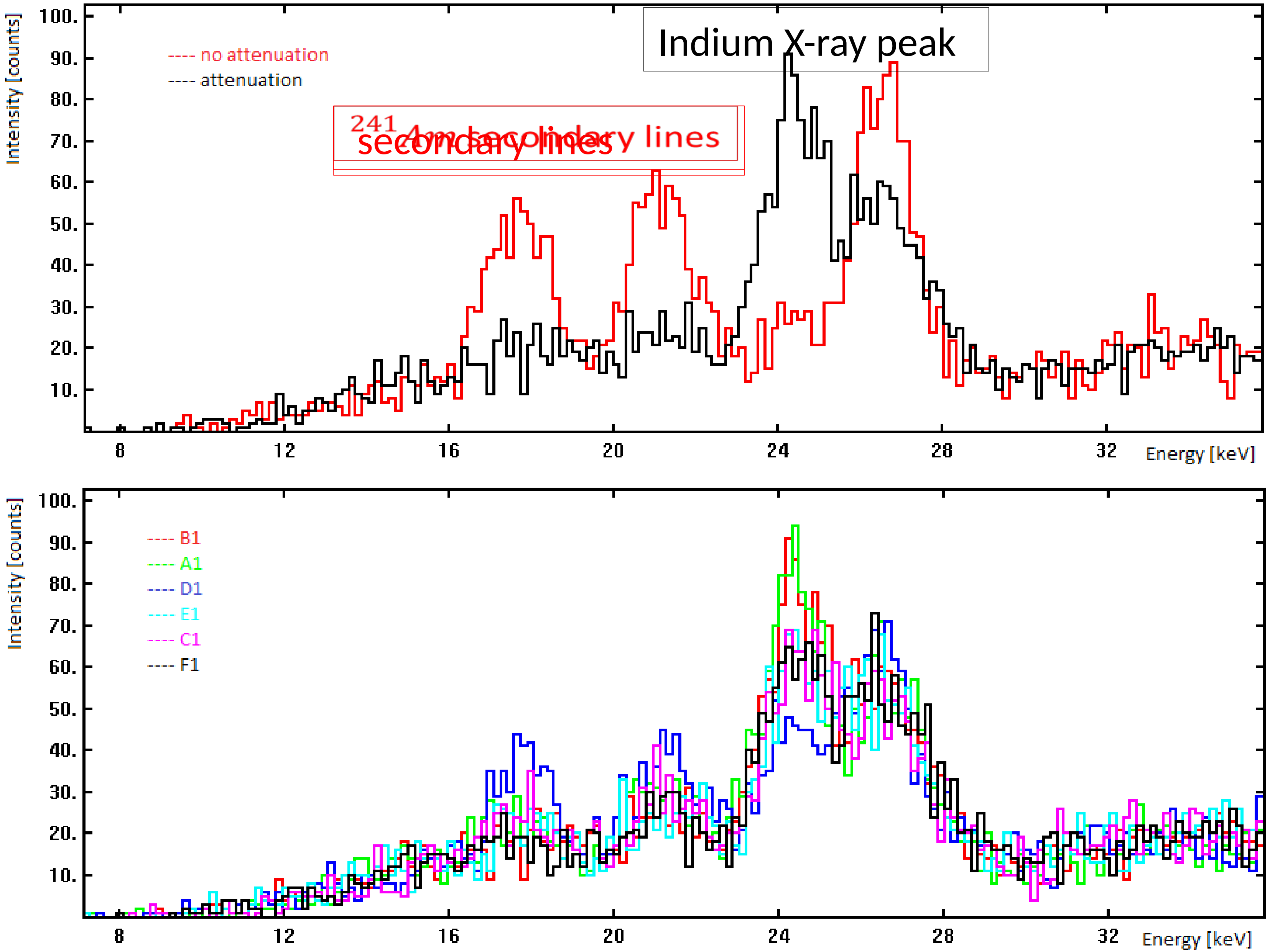
Material

From the attenuation rate it can be derived:

- Not only Teflon
- Some heavier materials

➢ Indium X-ray peak

➢ Probably these spots are the electrical contacts

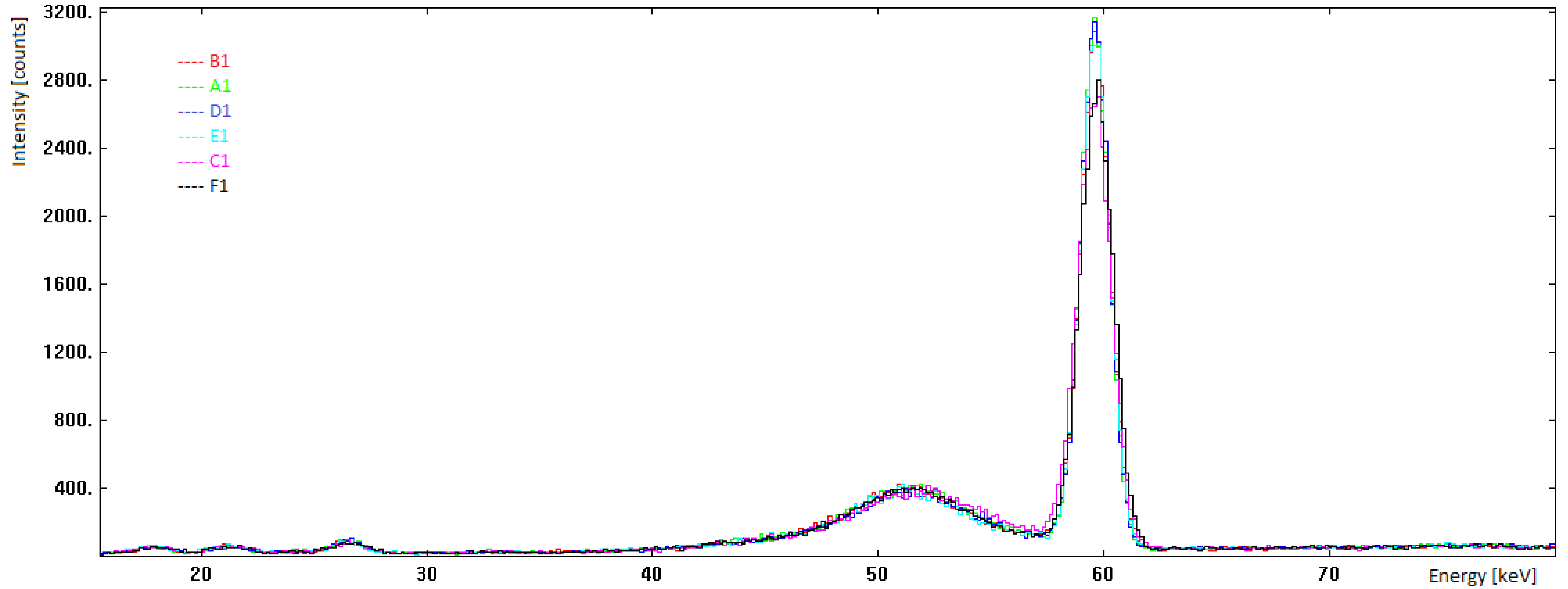


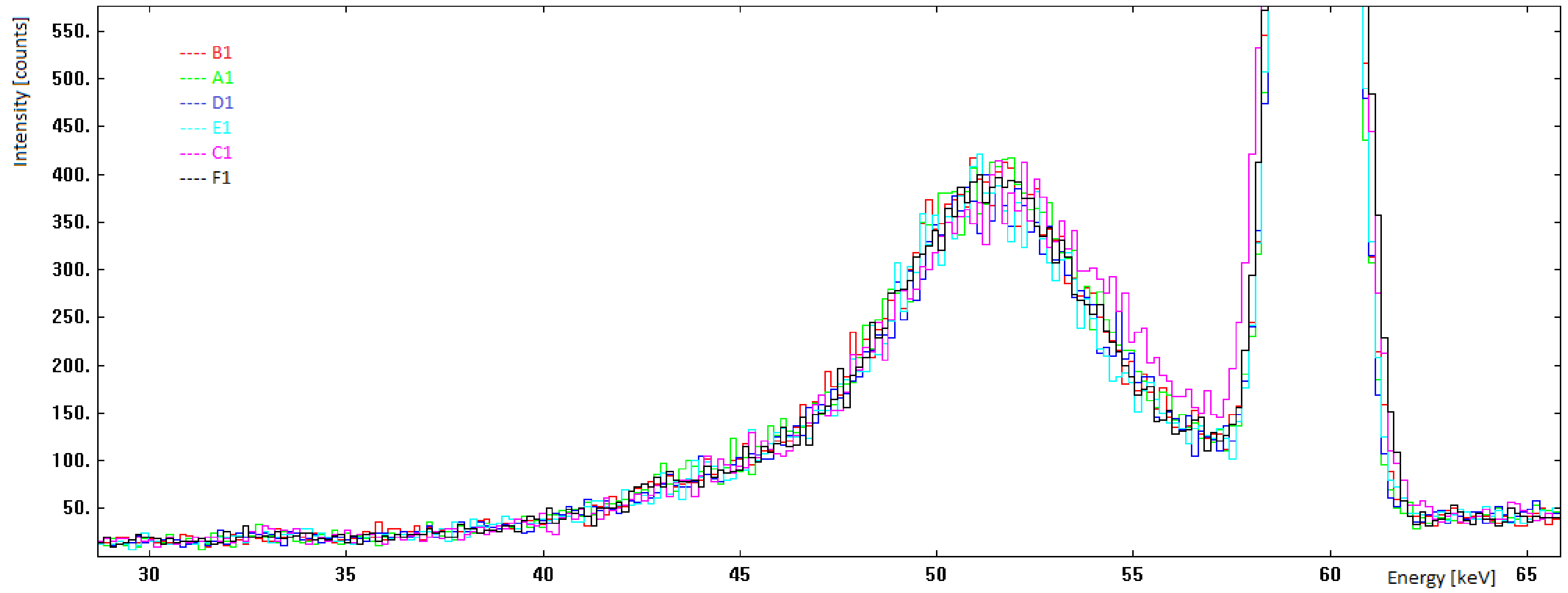
Satellite peak in the ^{241}Am spectra

- This peak is present in each spectrum, in every segment

Both backscattering and X-ray escape are included in its energy range:

- Backscattering range: 180° -> 48.3 keV, 90° -> 53.3 keV
- Ge X-ray escape peaks: k_{α_1} 49.61 keV, k_{α_2} 48.52 keV

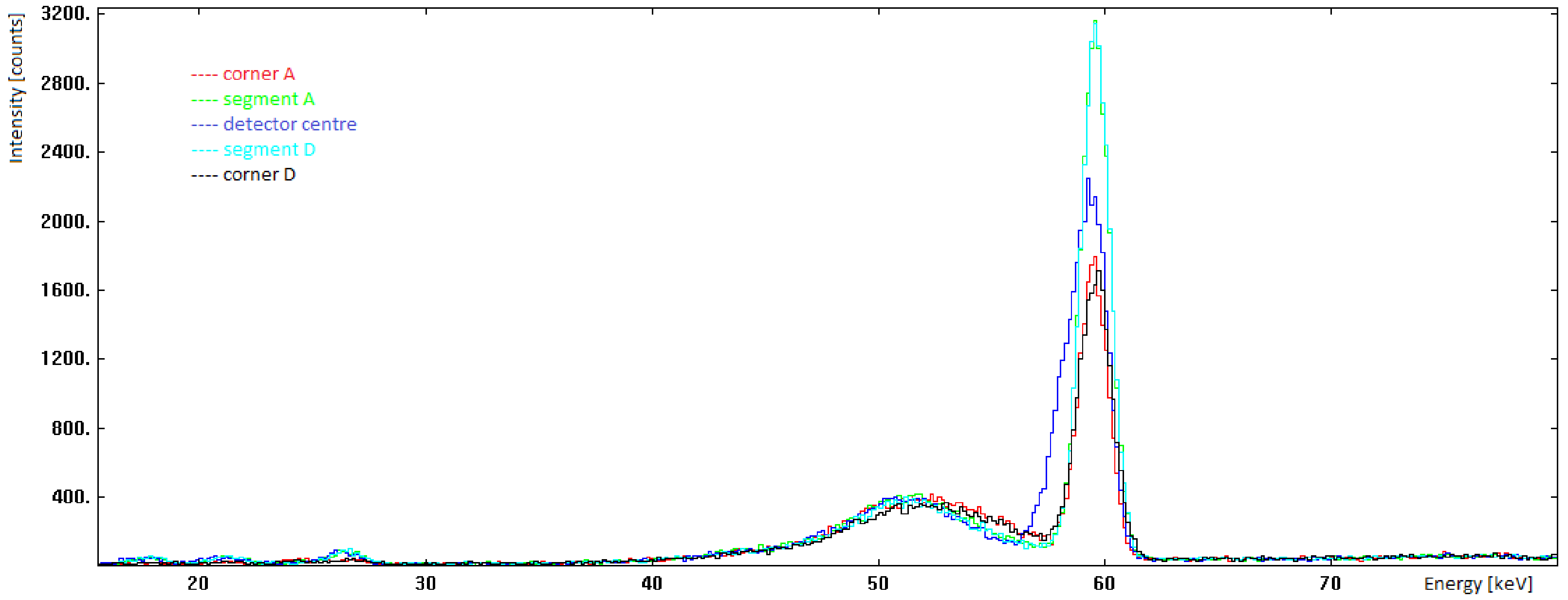


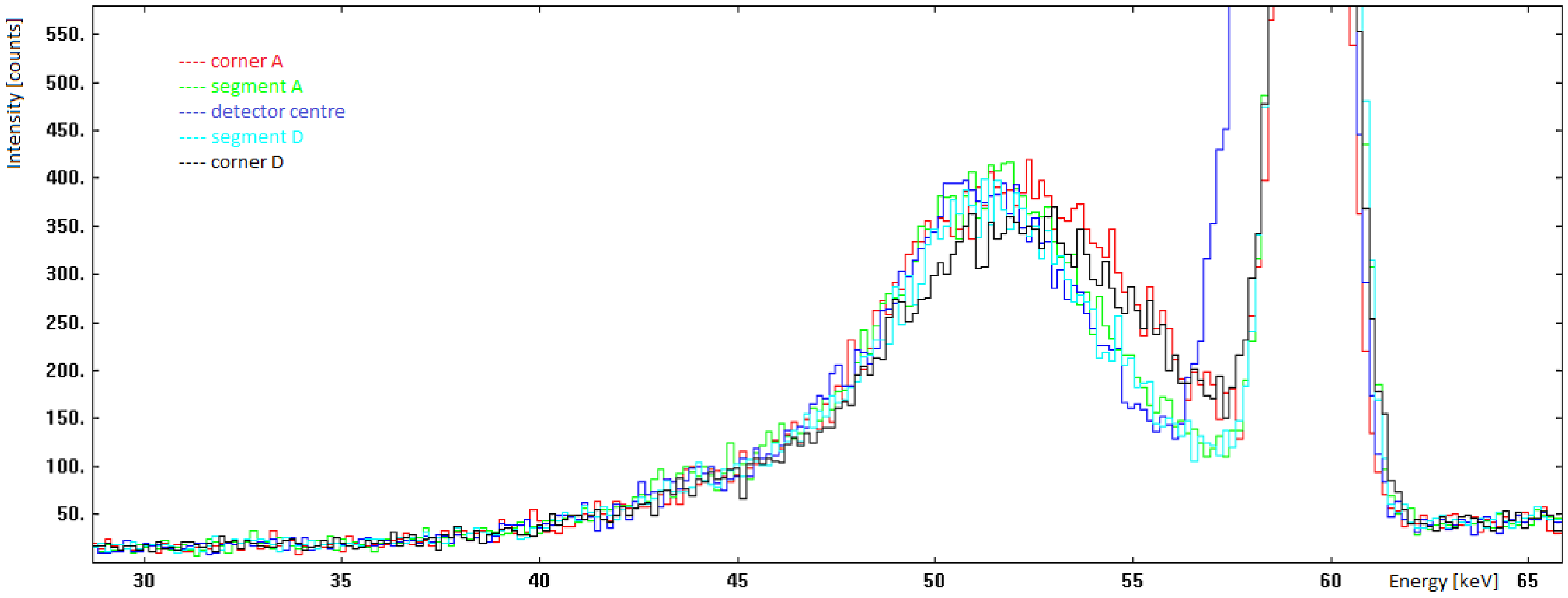


Satellite peak in the spectra from the AGATA detector scan from below

Satellite peak in the ^{241}Am spectra from the AGATA detector scan from below

- In each spectrum, in every segment
- Increasing of the area near the detector borders
- Not always the same centroid position (from 51.2 to 52.5 keV)





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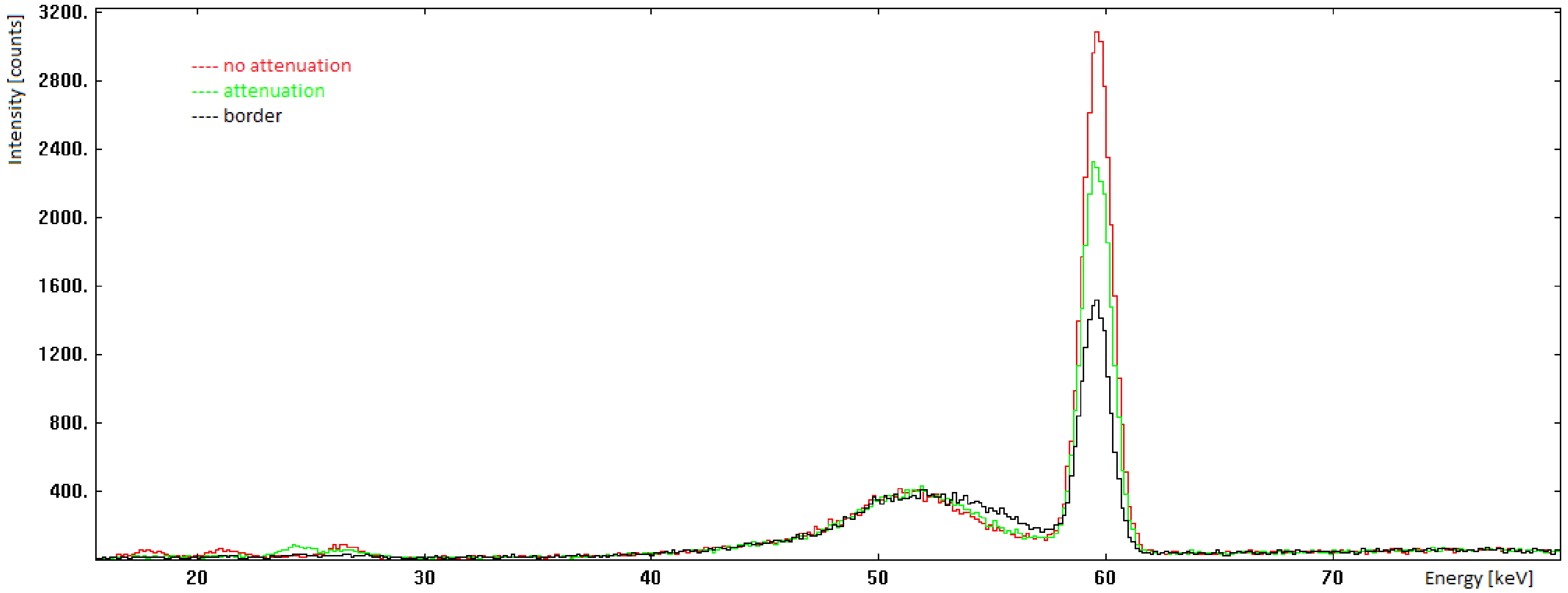

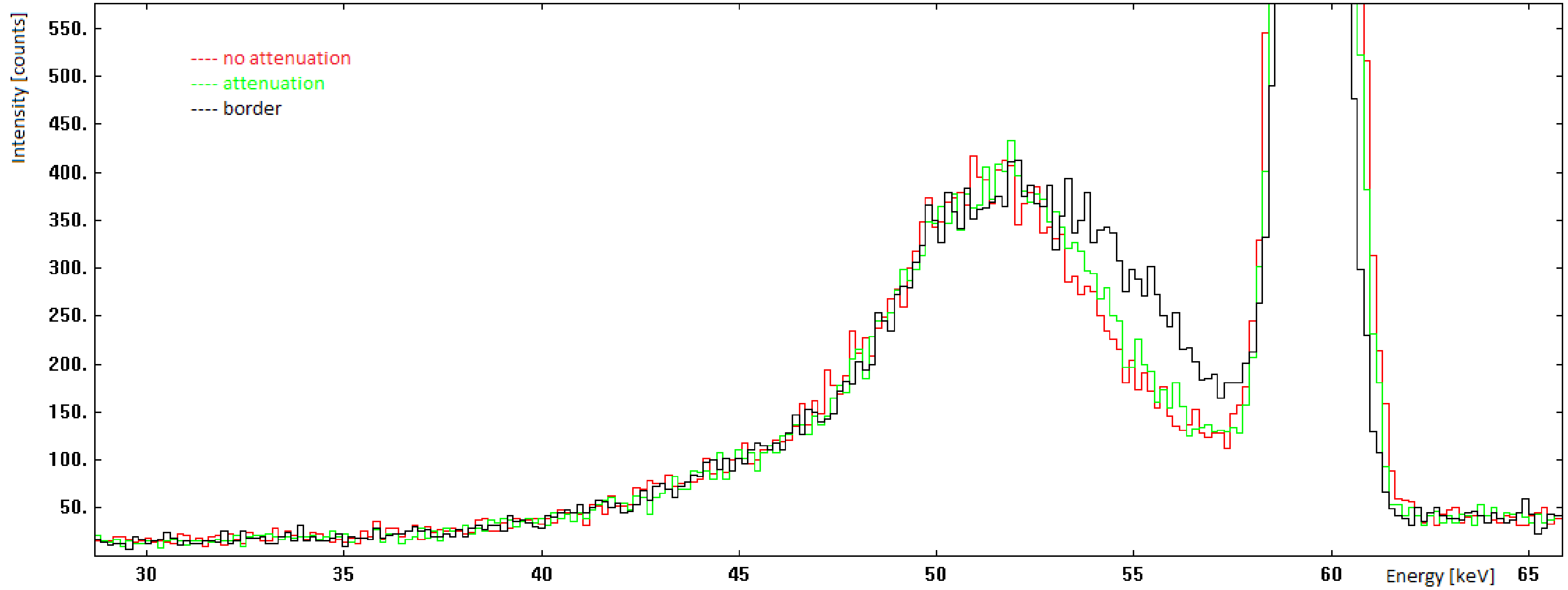

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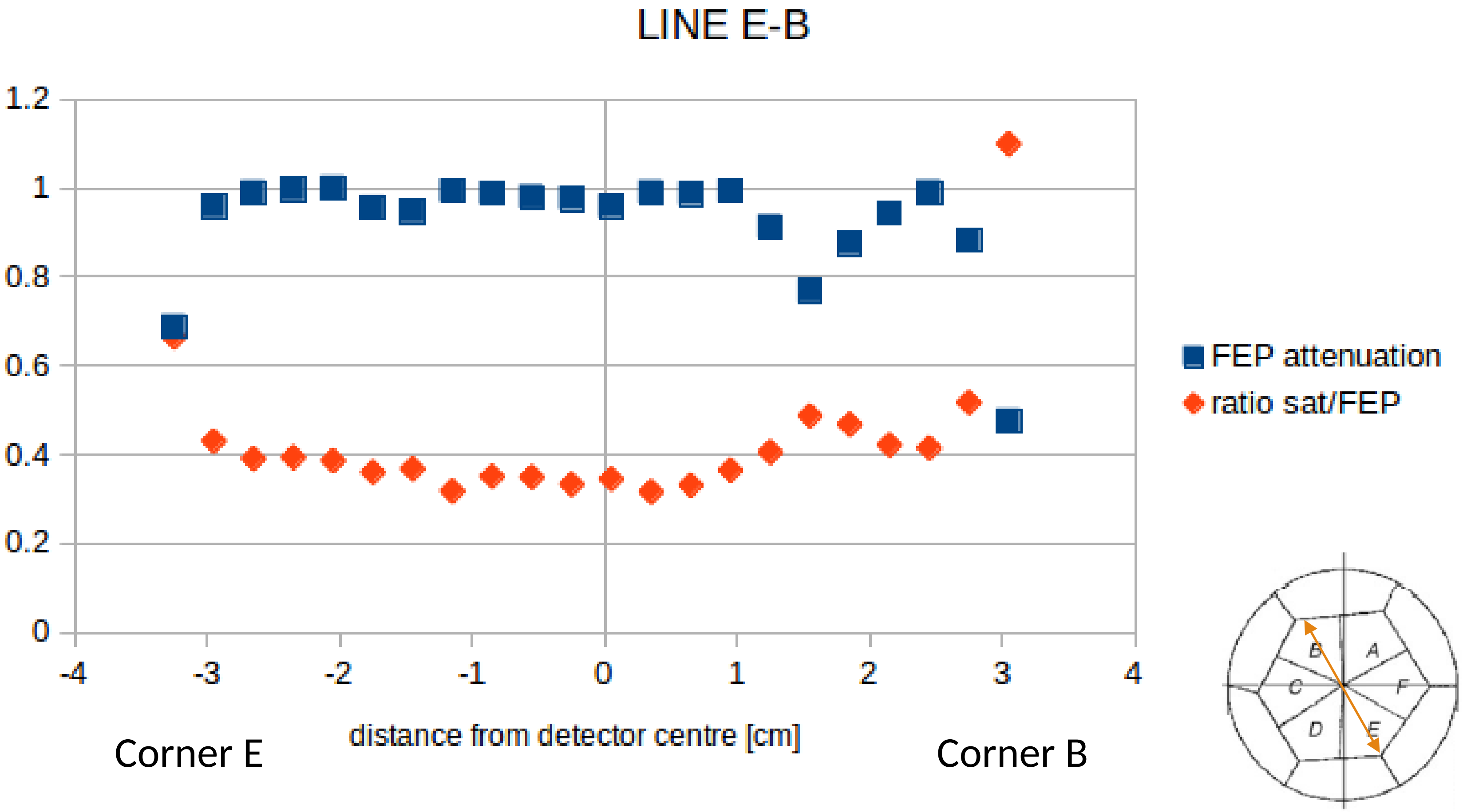
- Same area in the attenuation zones
- Ratio 30 – 40% in the

- ^{241}Am collimated source, in front of the detector
- Integrals of the full-energy peak (FEP) at 59.54 keV and of the satellite peak, from the core spectra



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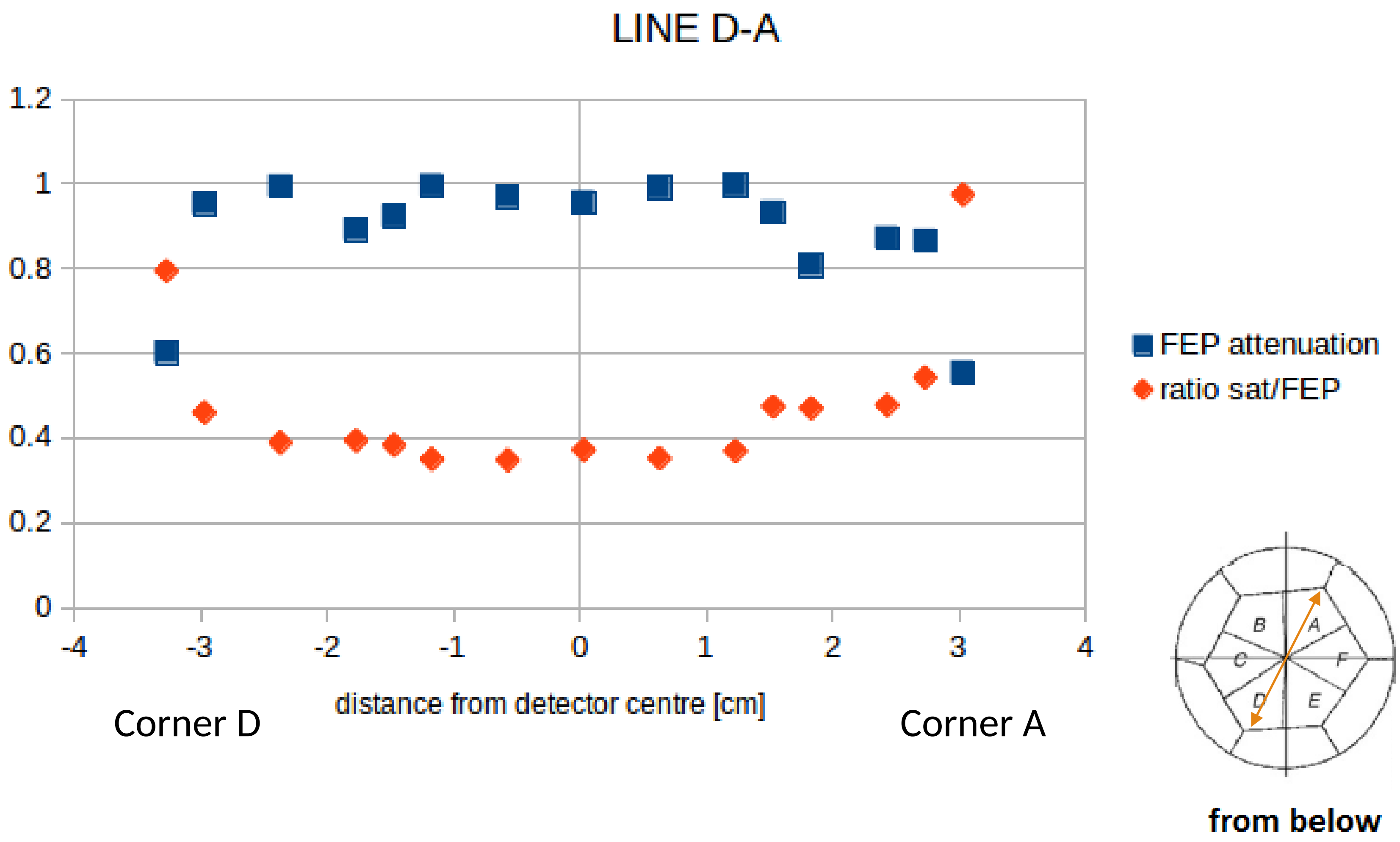

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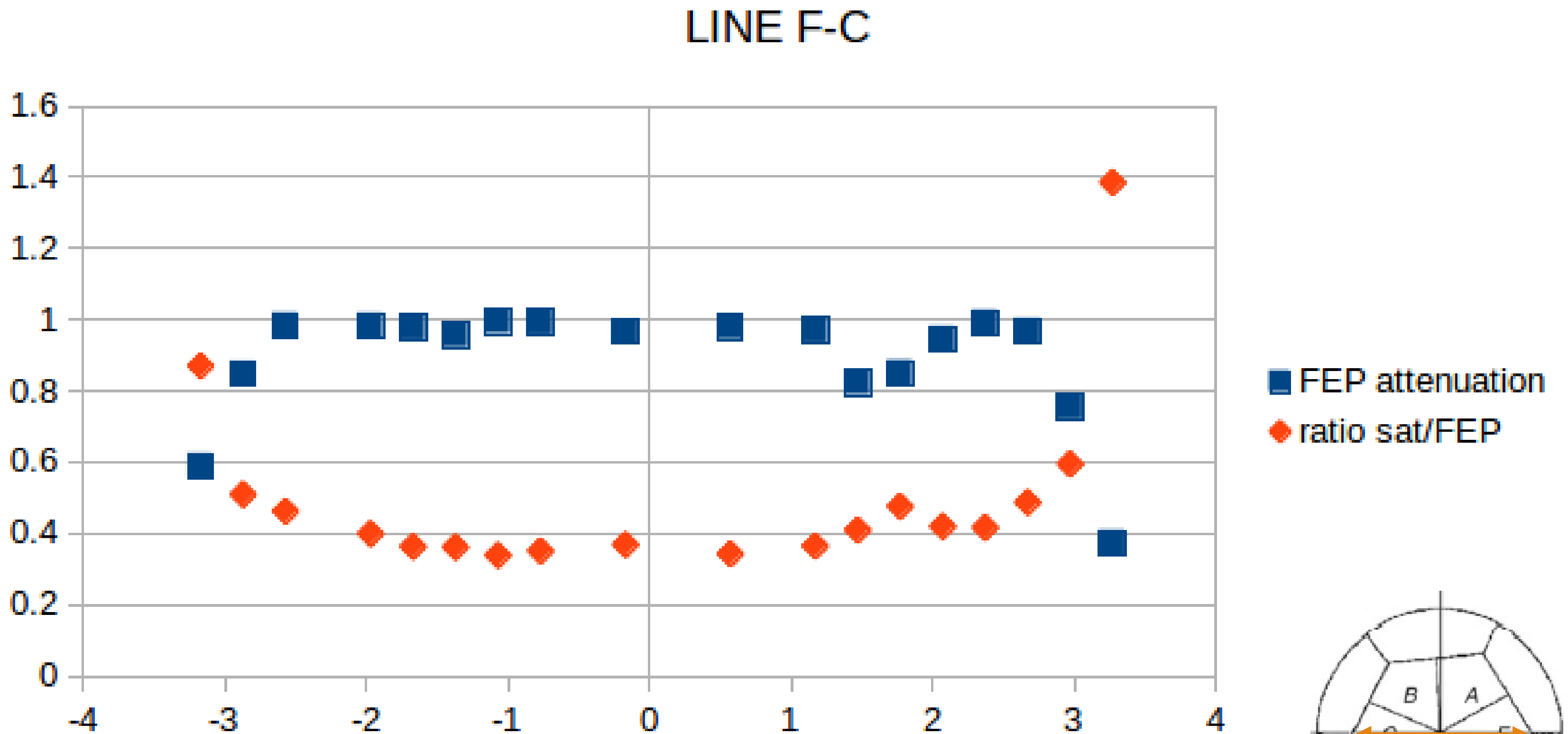
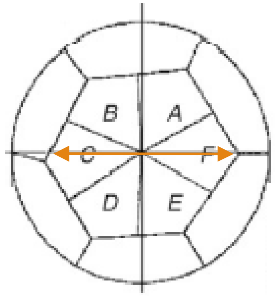


Corner F

Corner C



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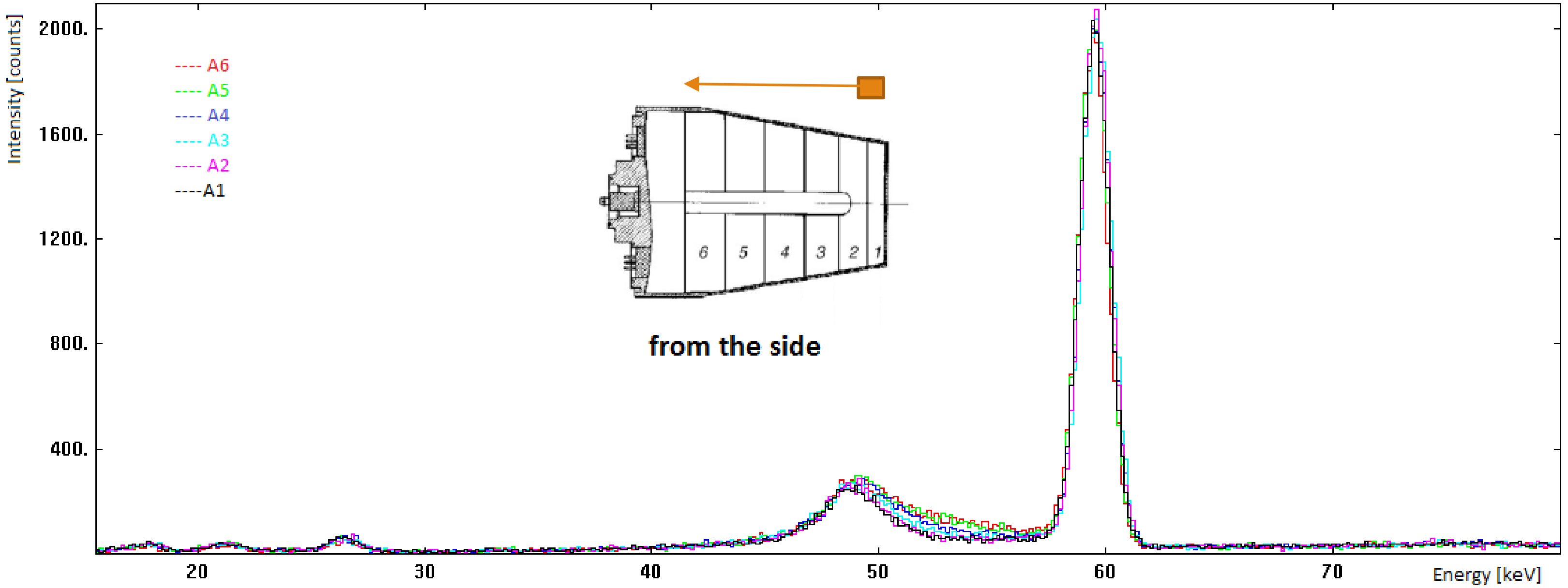
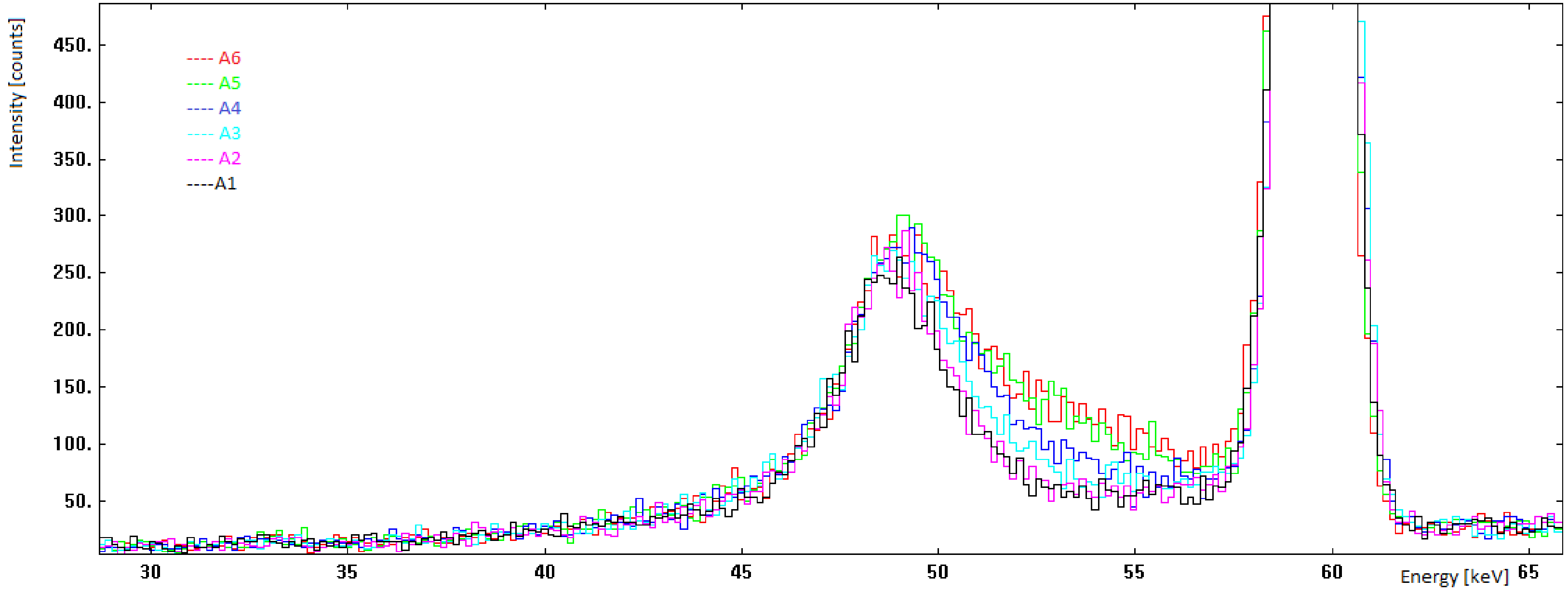
Satellite peak in the spectra from the AGATA detector lateral scan

Satellite peak in the ^{241}Am spectra from the AGATA detector lateral scan

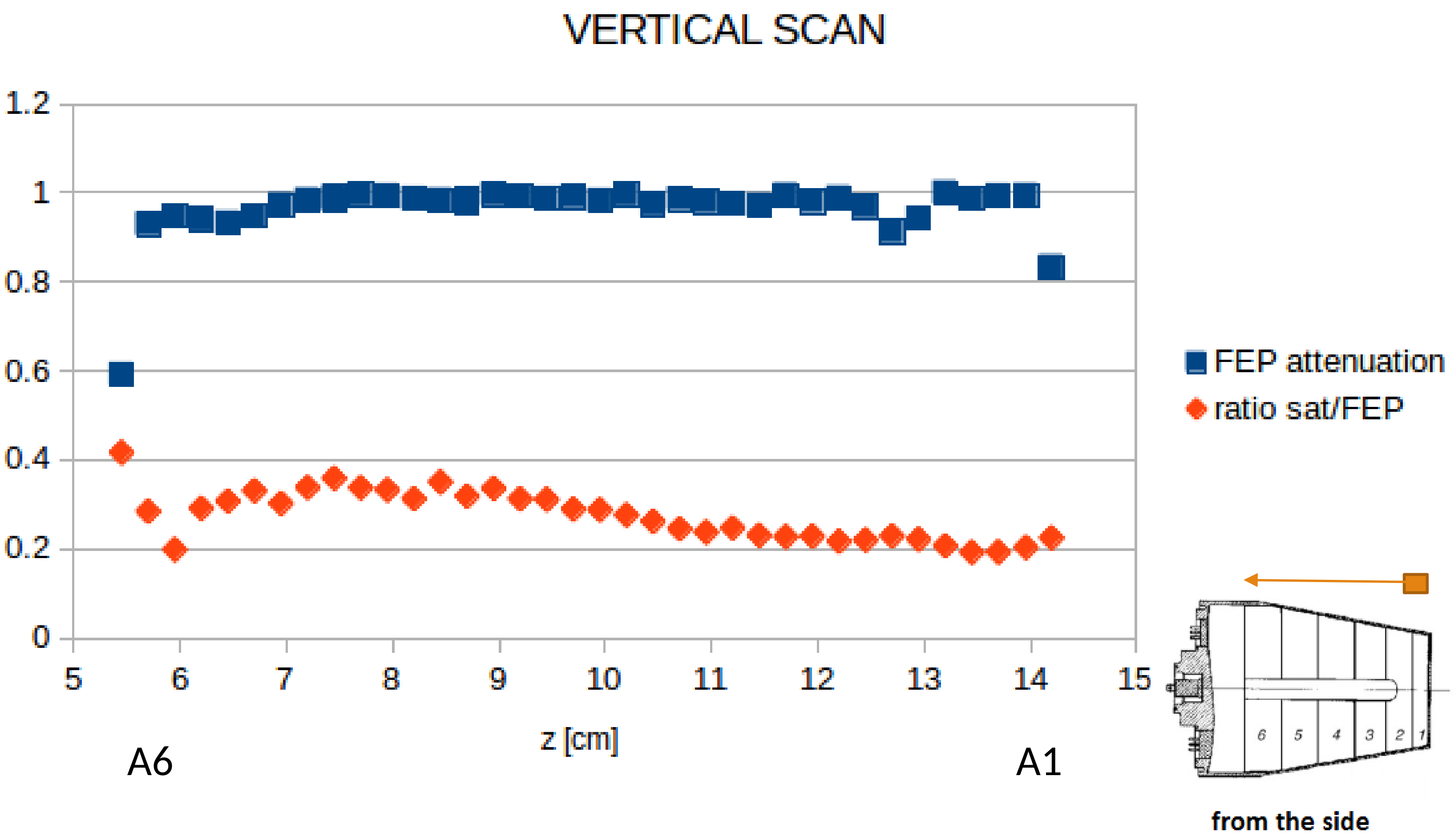
- In each spectrum, in every segment
- Different shape and centroid position (from 48.8 to 49.4 keV) irradiating from the side
- Increasing of area and centroid position, getting closer to the detector





Satellite peak in the ^{241}Am spectra from the AGATA detector lateral scan

- ^{241}Am collimated source, from the side of the detector
- Integrals of the full-energy peak at 59.54 keV and of the satellite peak, from the core spectra



- In each spectrum, in every segment
- Different shape and centroid position (48.8 – 49.4 keV) irradiating from the side
- Increasing of area and centroid position, getting closer to the detector
- Ratio from 19% to 41%

Then…

- It can't be forward scattering inside the lead collimator hole:

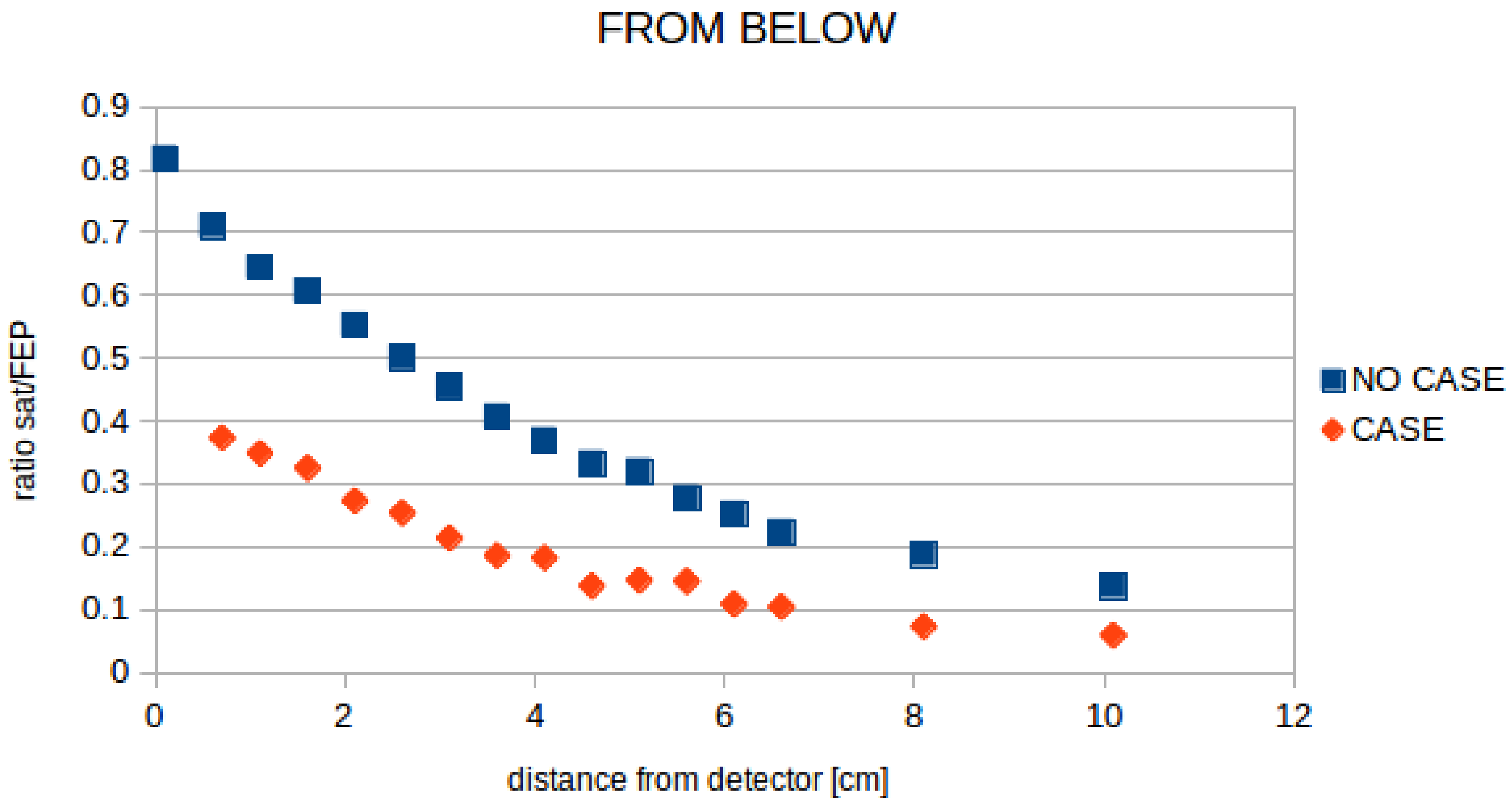
- The photons can't undergo scattering of angles ~180°, so it should be given by multiple scatterings at smaller angles, but this enlarges the probability the photons are absorbed by the lead.
- The satellite peak area doesn't change in the attenuation zones: if these low-energy photons come from the collimator, they should be absorbed even more than the FEP photons; at the end, the sat/FEP ratio should decrease
- Strong dependence on position: this phenomenon isn't given only by the source and the collimator

- BACKSCATTERING from the surroundings & Ge X-ray escape

Satellite peak in the ^{241}Am spectra from the AGATA detector scan from below

Satellite peak in the spectra from the AGATA detector scan from below

- ^{241}Am collimated source, with and without the Al case, in front of the detector
- Integrals of the full-energy peak (FEP) at 59.54 keV and of the satellite peak, from the core spectra

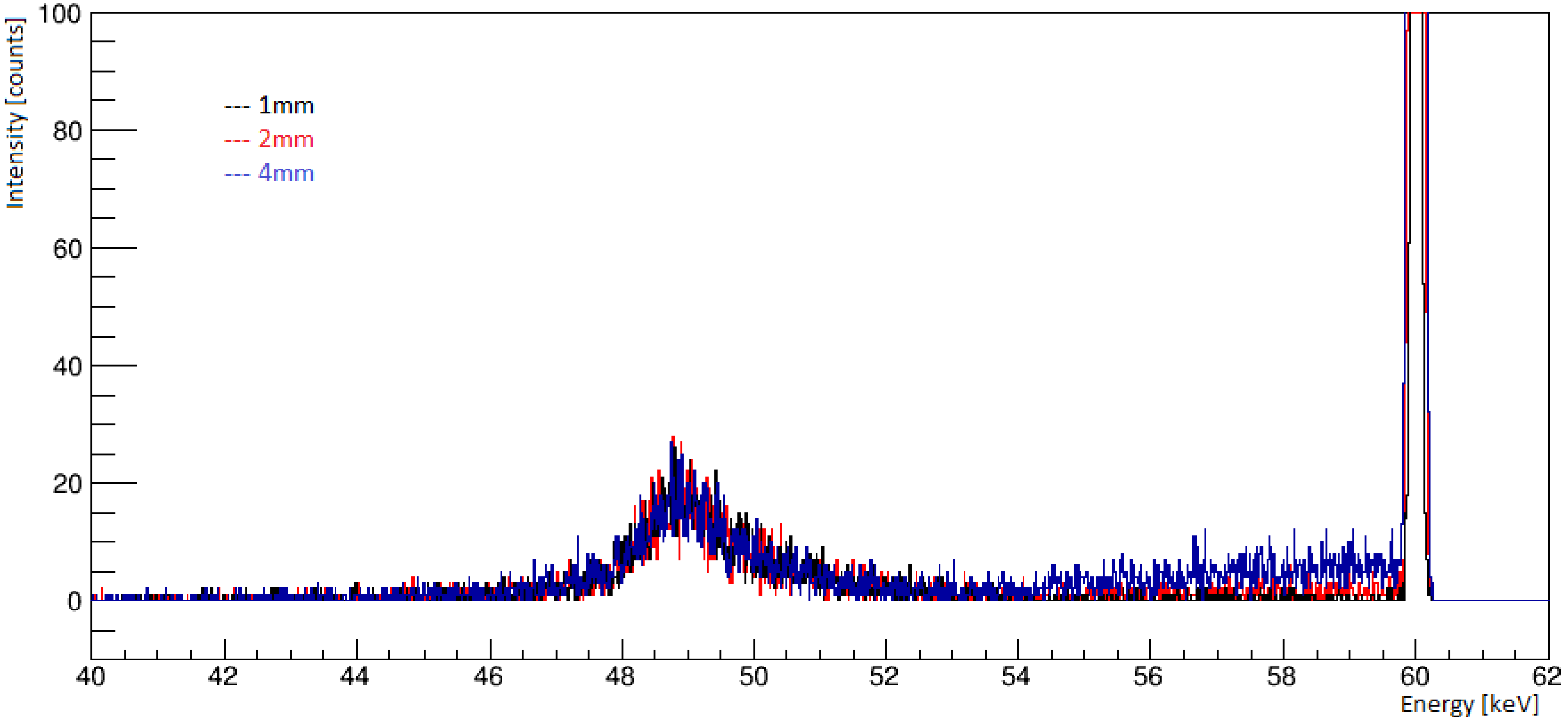


- Satellite peak area decreases with the distance from the detector
- Also decreases if Al case around source and collimator is present
- Backscattering from the surroundings is attenuated when the Al case stops the photons escaping laterally

Satellite peak in the spectra in GEANT4 simulations

Satellite peak in the ^{241}Am spectra in GEANT4 simulations

- GEANT4 SIMULATIONS by Dawid Rosiak (IKP): 60 keV collimated source, in front of the detector



- There are no variations of the peak area when changing the diameter of the collimator hole (while the ratio sat/FEP increases decreasing the diameter)

- There is no dependence on the collimator hole diameter

Satellite peak in the spectra in GEANT4 simulations

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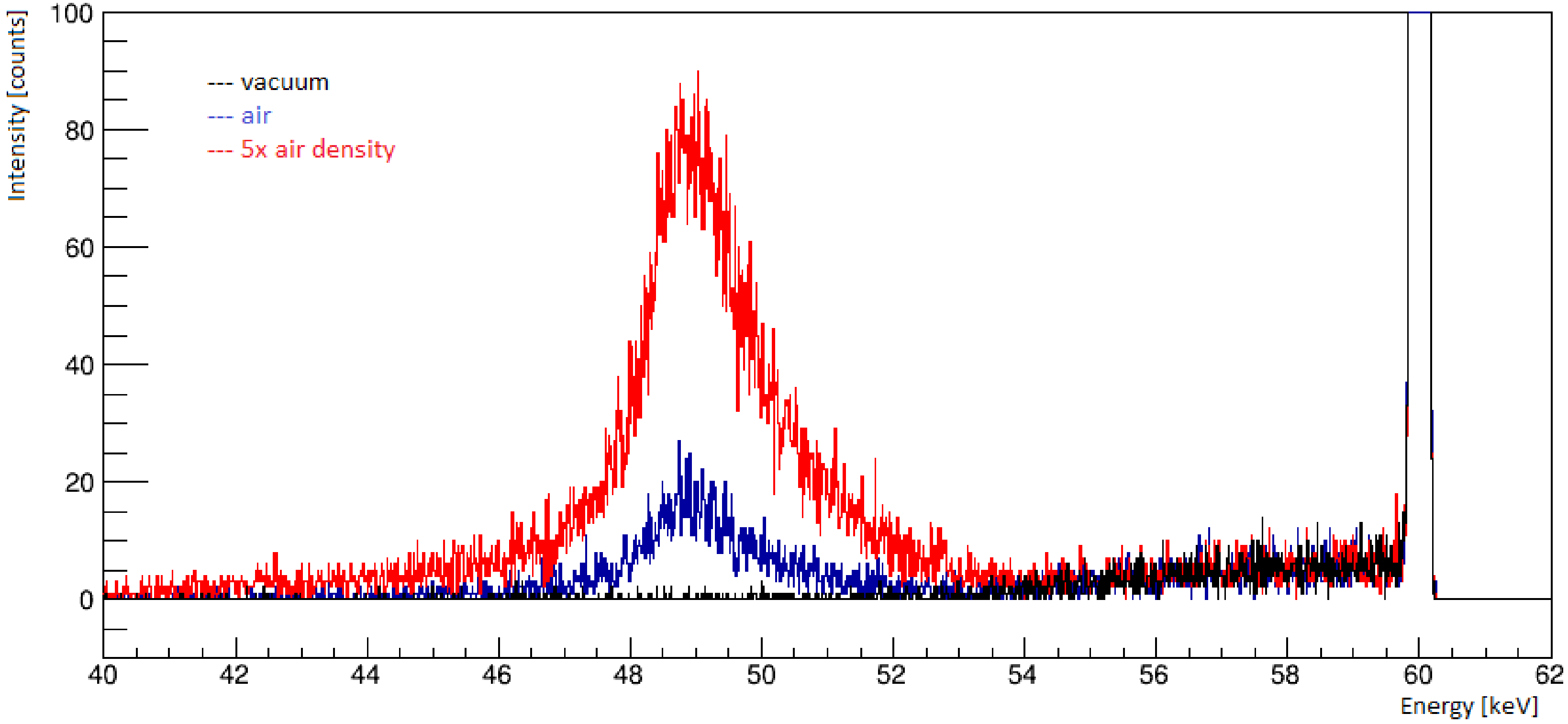


- Increasing of the peak area with the air density (the ratio sat/FEP increases). It disappears in vacuum.

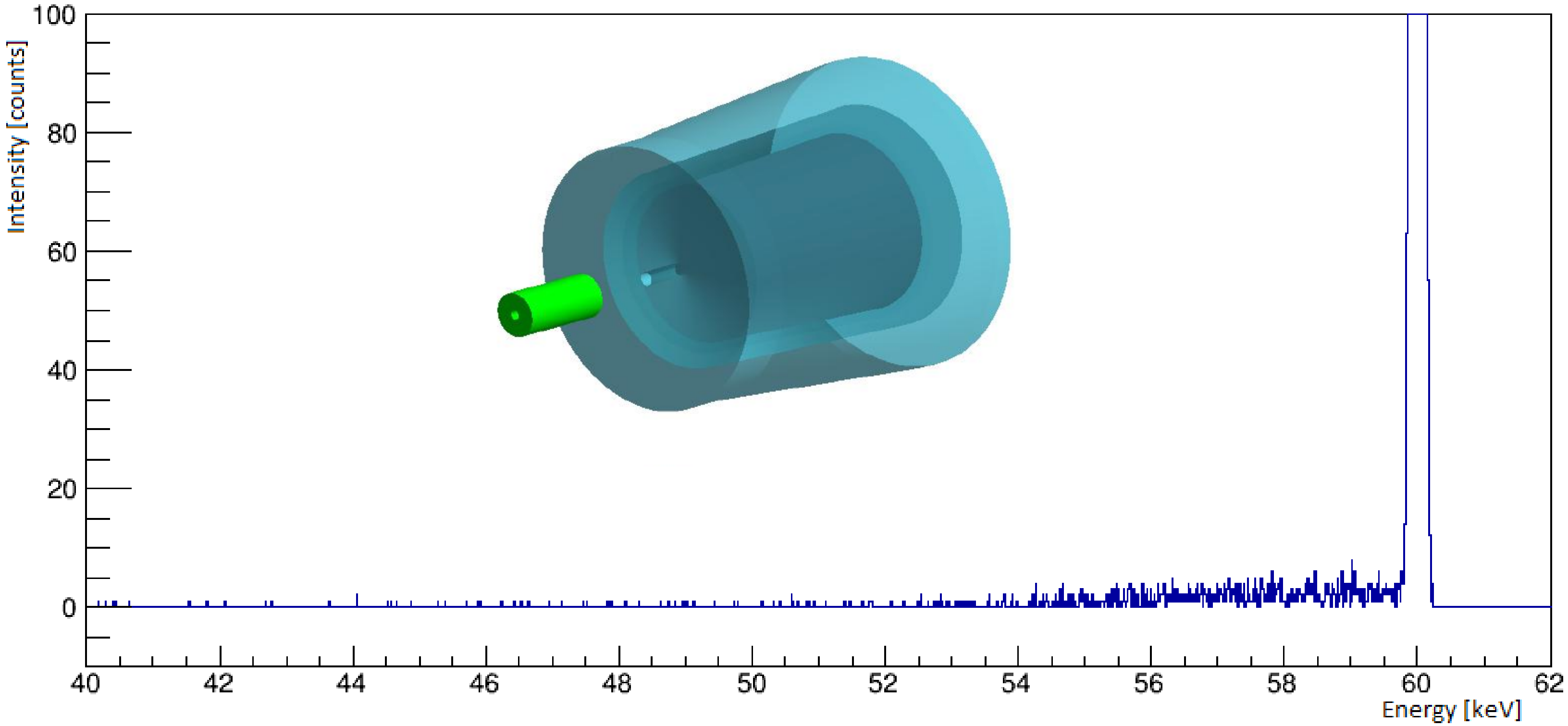
- Backscattering from the surroundings and from the air

Satellite peak in the spectra in GEANT4 simulations

Satellite peak in the ^{241}Am spectra in GEANT4 simulations

- ➢ No satellite peak if we put a shield around the detector, leaving only an opening in front of the collimator hole
- ➢ It means that those photons are not coming from the collimator hole
- ➢ Moreover it seems that Ge X-ray escape are not included in these first

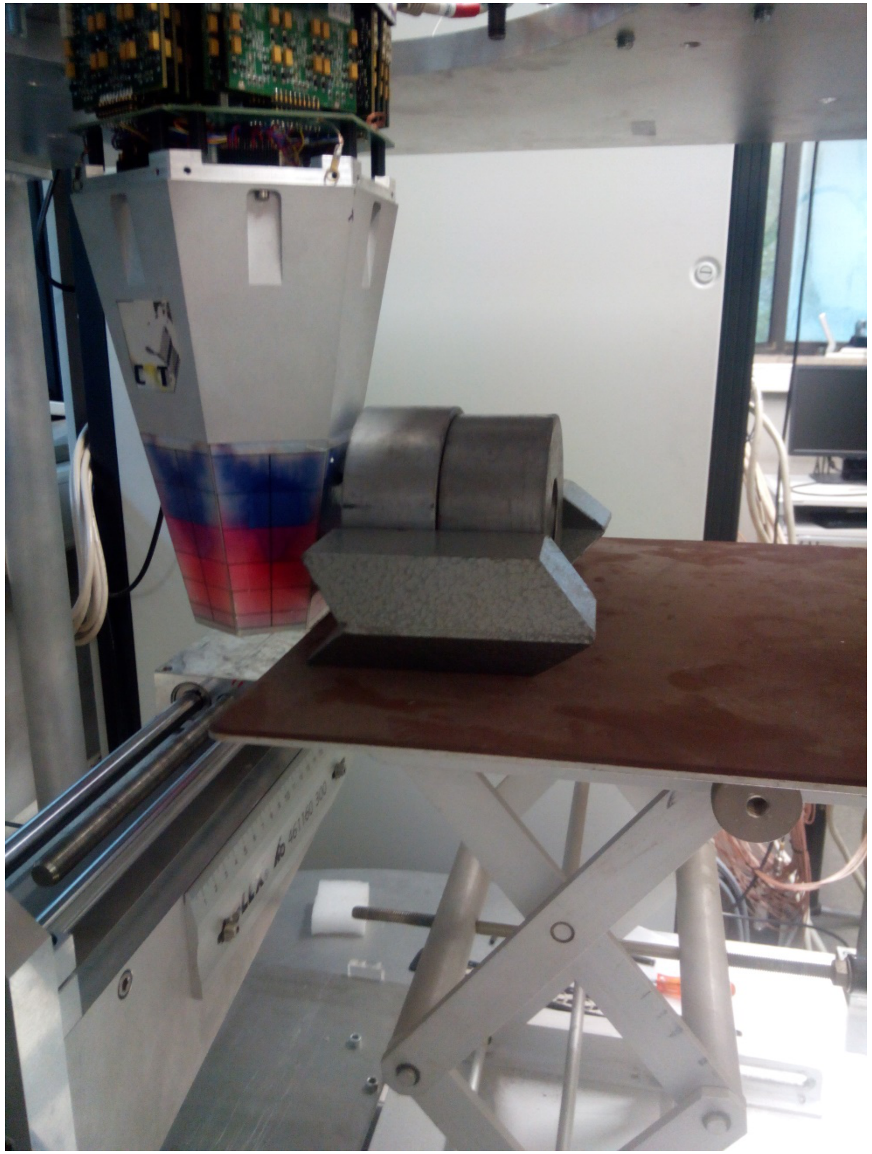
- GEANT4 SIMULATIONS by Dawid Rosiak (IKP): 60 keV collimated source, in front of the detector with a shield around it

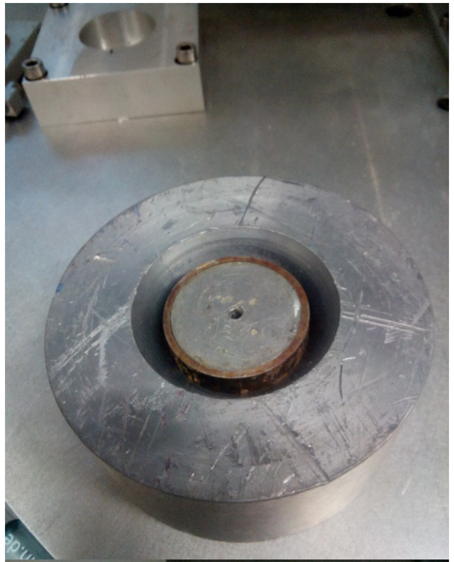


Modified experimental set-up

- More Pb blocks are added around the collimated source in order to reduce the lateral scattering with the surroundings
- The conical shape and the opening behind the source should avoid the photons to scatter at angles ~180° and then to come back through the collimator hole

- collimated source, with more Pb blocks around it, in front and on the side of the detector
- ^{241}Am collimated source, with more Pb blocks around it, in front and on the side of the detector



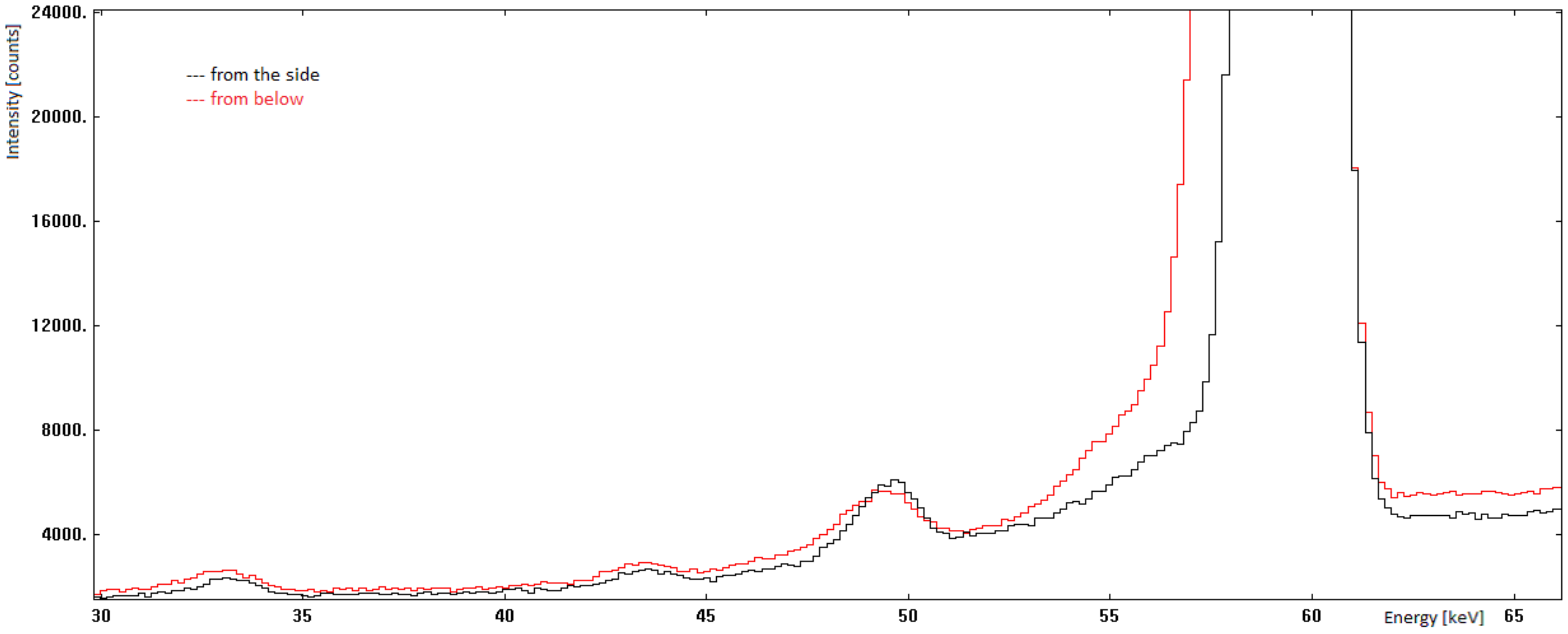


Satellite peak in the ^{241}Am spectra with the new set-up

Satellite peak in the spectra with the new set-up

- ^{241}Am collimated source, with more Pb blocks around it, in front and on the side of the detector

- collimated source, with more Pb blocks around it, in front and on the side of the detector



- Satellite/FEP ratio around 0.7%
- Now that the ratio sat/FEP is close to the literature value, we can look for Ge X-ray escape peaks

Satellite peak in the ^{241}Am spectra: Ge X-ray escape peaks

Satellite peak in the spectra: Ge X-ray escape peaks

- From the side, with analog system

From the side, with analog system

Ge X-ray escape peaks	Position [keV]	FWHM [keV]
k_{α_1}	49.606	1.059
k_{α_2}	48.518	1.058

- Ratio $k_{\alpha_2}/k_{\alpha_1}$ about 30%, instead of 13%. This should be due to the contribution of the remaining backscattering from the surroundings

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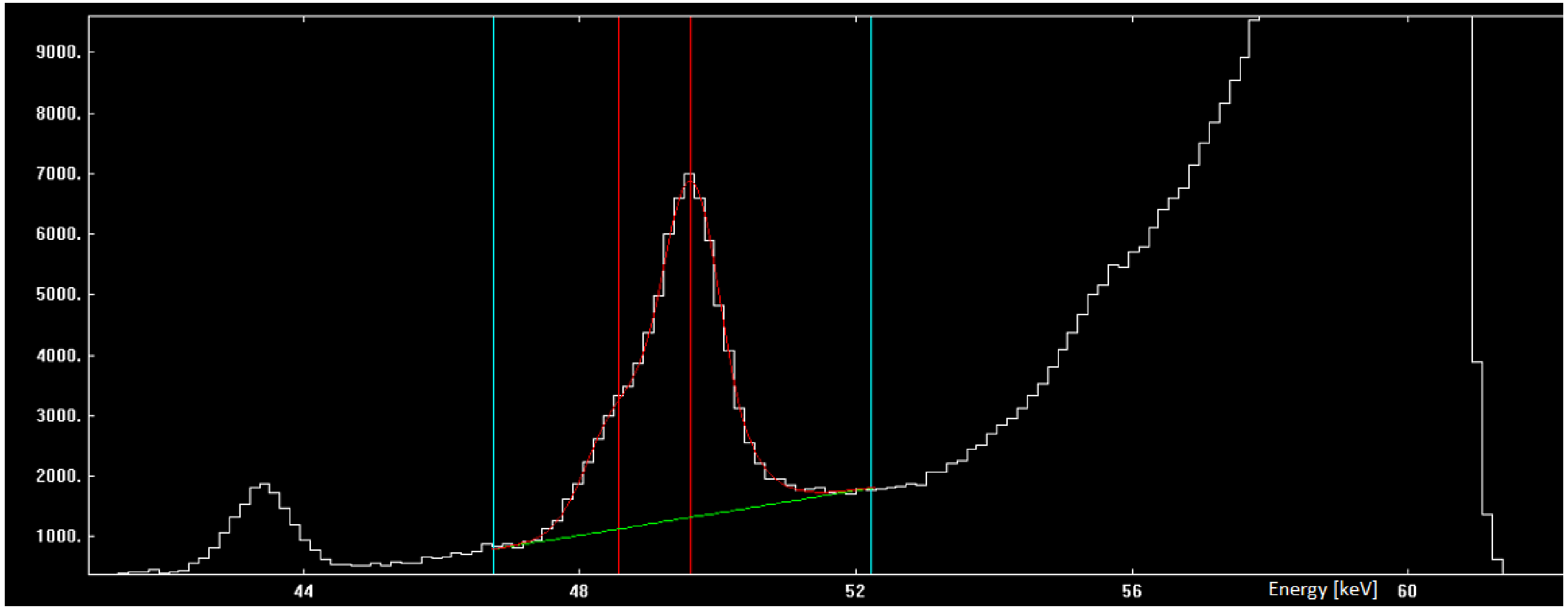

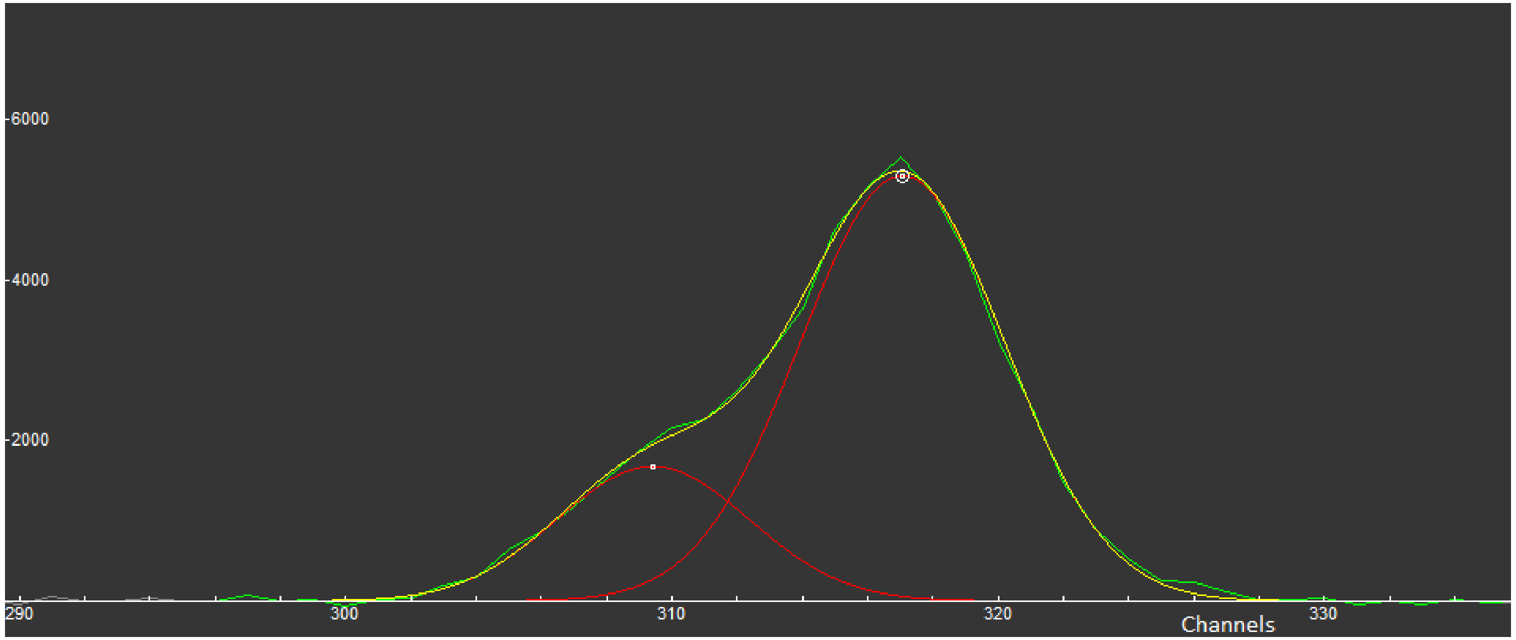

Results

- Identification of the electrical contacts in each detector segment
- Determination of the main contributions behind the satellite peak in the ^{241}Am energy spectra

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- Determination of the main contributions behind the satellite peak in the energy spectra

THANK YOU FOR THE ATTENTION