# MONOLITHIC ΔE/E DETECTORS SUMMARY

In the last years the study of exotic nuclei, especially those near the neutron and proton driplines[1,2,3,4], required the development of a generation of new detectors[5]. When studying rare decay channels the main challenges to overcome are low statistics and low kinetic energy of the particles. Furthermore, multi particle decays require complex detector arrays in order to faithfully reconstruct the events. These two requirements, low energy thresholds and granularity, are fulfilled by a modular integrated ΔE-E telescope.

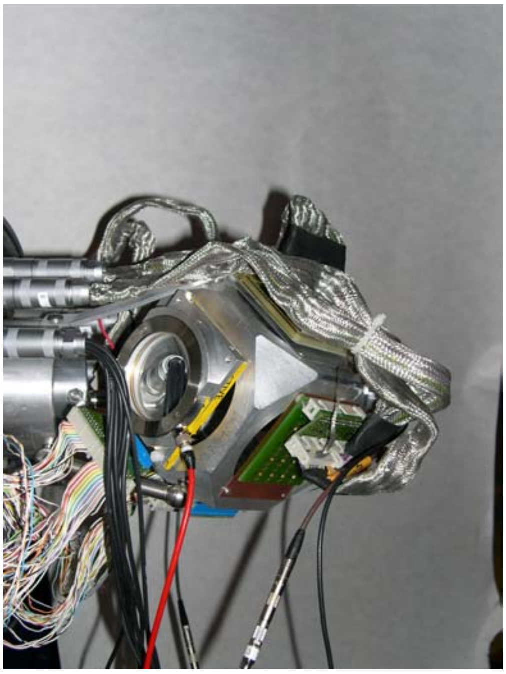

*Fig. 1: Compact cubic set up counted at the IS-417 experiment at ISOLDE. The monolithic array of telescopes has been mounted on the lowest face.*

This test detector consists of 16 independent telescopes placed in an 5x5 $cm^2$ area (fig 1.). Each telescope is made up of two detectors. First there is a detector which measures the energy loss through a thin layer, ΔE. Then there is a thicker detector, E, that stops the particles and measures the total energy of the particle[6]. Thus it is crucial that the particle can actually reach the E part, so the thinner ΔE part, the better. In this new design a solution is achieved by simply integrating the two stages in the same wafer. By doing this way it is possible to avoid one support, since there is only one common anode for the two parts.

The detector performance obtained with standard alpha sources will be discussed in this summary. Data were taken during IS-417 experiment at CERN-ISOLDE. Here we analyse a 7.5h run using a triple alpha (239Pu, 241Am and 244Cm) source placed in front of the detector at XXX cm distance.

1.-Telescope configuration.

The telescope configuration is:

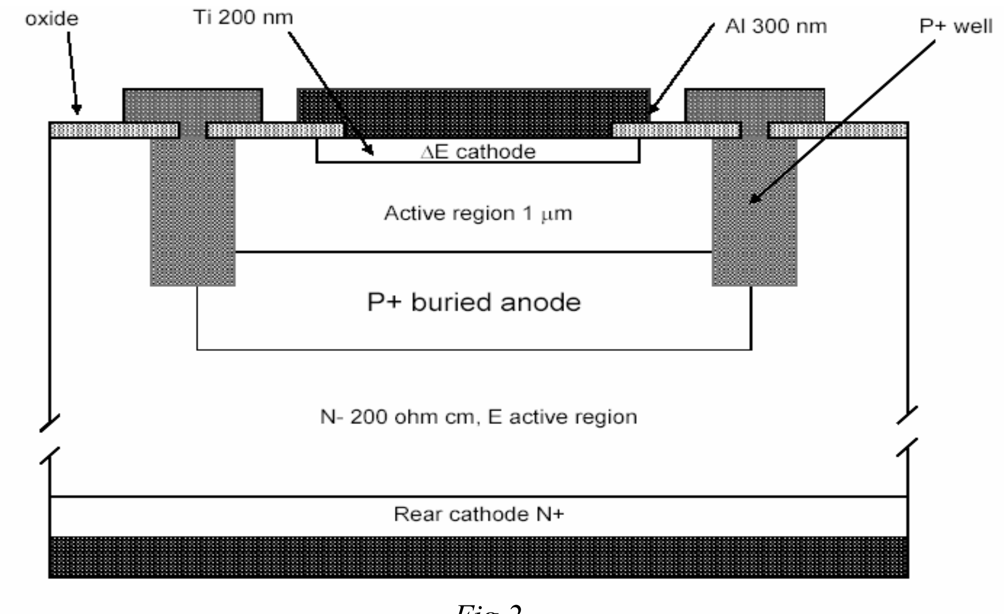


*Fig.2*

-ΔE: 1 μm thick. 8 of the telescopes have a 570 nm deadlayer which consists of a Ti/TiON/Ti doping plus Al/i/Cu contact. The other 8 have an 1700 deadlayer of the same composition.

- Between the ΔE and the E part it is the common anode. It is produced by Boron implantation on the Si.

-E: 400 μm thick Si layer

The ΔE, with the upper dead layers and the anode, acts as a 2 μm dead layer for the E part. It has to be taken into account to properly calibrate de E part.

In order to obtain a reasonable capacitance in the ΔE part its surface cannot be too big, thus as a compromise a surface of 3.5x3.5 $mm^2$ is choose

2-Analysis and results.

Data were obtain in a run of 7.5h. Triple alpha source (239Pu, 241Am and 244Cm) was placed in front of the detector. Raw E histograms were produced in order to have a general overview of the data taken. The Alpha peaks obtained are:

$^{239}Pu$

| Detector number | Channel | Energy (keV) | Intensity | FWHM (keV) |
|---|---|---|---|---|
| 1 | 2048.57 | 5150.78 | 30246 | 56.82 |
| 3 | 1981.02 | 5155.57 | 23194 | 64.98 |
| 6 | 2027.3 | 5153.34 | 31062 | 58.53 |
| 9 | 2022.71 | 5158.49 | 18584 | 67.87 |
| 11 | 2043.01 | 5161.66 | 13566 | 66.87 |
| 12 | 2049.19 | 5164.12 | 6484 | 69.90 |
| 14 | 1948.89 | 5164.02 | 9774 | 66.45 |
| 16 | 1974.86 | 5167.70 | 4034 | 78.66 |

$^{241}Am$

| Detector number | Channel | Energy (keV) | Intensity | FWHM (keV) |
|---|---|---|---|---|
| 1 | 2186.81 | 5479.00 | 30684.00 | 68.95 |
| 3 | 2115.80 | 5480.02 | 23790.00 | 70.11 |
| 6 | 2160.60 | 5479.09 | 31786.00 | 66.13 |
| 9 | 2159.12 | 5479.50 | 19264.00 | 68.18 |
| 11 | 2180.78 | 5479.75 | 13586.00 | 67.19 |
| 12 | 2189.08 | 5479.97 | 6502.00 | 74.77 |
| 14 | 2082.58 | 5478.33 | 9660.00 | 76.33 |
| 16 | 2115.18 | 5484.02 | 4130.00 | 83.55 |

$^{244}Cm$

| Detector number | Channel | Energy (keV) | Intensity | FWHM (keV) |
|---|---|---|---|---|
| 1 | 2318.99 | 5794.06 | 23024.00 | 59.71 |
| 3 | 2244.12 | 5790.71 | 17574.00 | 65.64 |
| 6 | 2287.78 | 5791.50 | 23864.00 | 59.03 |
| 9 | 2289.50 | 5786.43 | 13856.00 | 61.49 |
| 11 | 2311.94 | 5784.65 | 10112.00 | 62.94 |
| 12 | 2321.99 | 5782.81 | 4798.00 | 70.75 |
| 14 | 2208.44 | 5784.16 | 7110.00 | 64.84 |
| 16 | 2246.00 | 5782.40 | 3126.00 | 79.72 |

In the E part spectra apart from the peaks from the alpha source we can clearly see ghost peaks appearing at more or less half of the real peak's energy. Their area at full width half maximum, for selected detectors, is:

| Detector number | Intensity($^{239}$Pu) (ghost/real)% | Intensity($^{241}$Am) (ghost/real)% | Intensity($^{244}$Cm) (ghost/real)% |
|---|---|---|---|
| 1 | 3.40 | 3.13 | 2.79 |
| 3 | 3.99 | 4.08 | 4.11 |
| 6 | 3.28 | 2.44 | 2.68 |
| 9 | 7.62 | 6.10 | 3.18 |
| 11 | 9.54 | 8.35 | 5.77 |
| 12 | 12.24 | 9.26 | 6.42 |
| 14 | 8.88 | 7.17 | 4.89 |
| 16 | 12.22 | 10.43 | 5.14 |

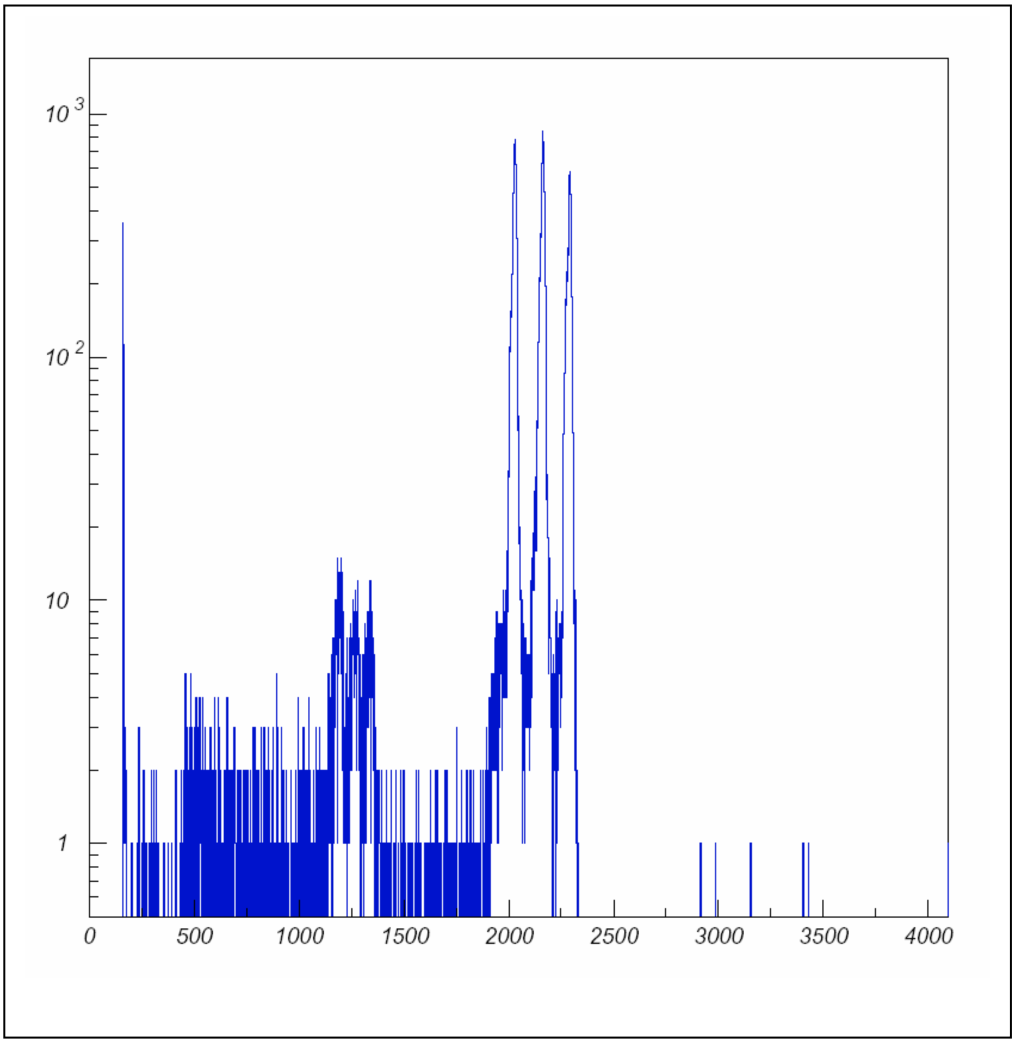


*Fig. 3: E spectra of the 6th telescope*

In the ΔE spectra we can see two bumps. Since the three alpha energies are quite similar, it would be expected to have only one bump. The origin of the low energy bump has to be noise or signal coming from the ghost peaks.

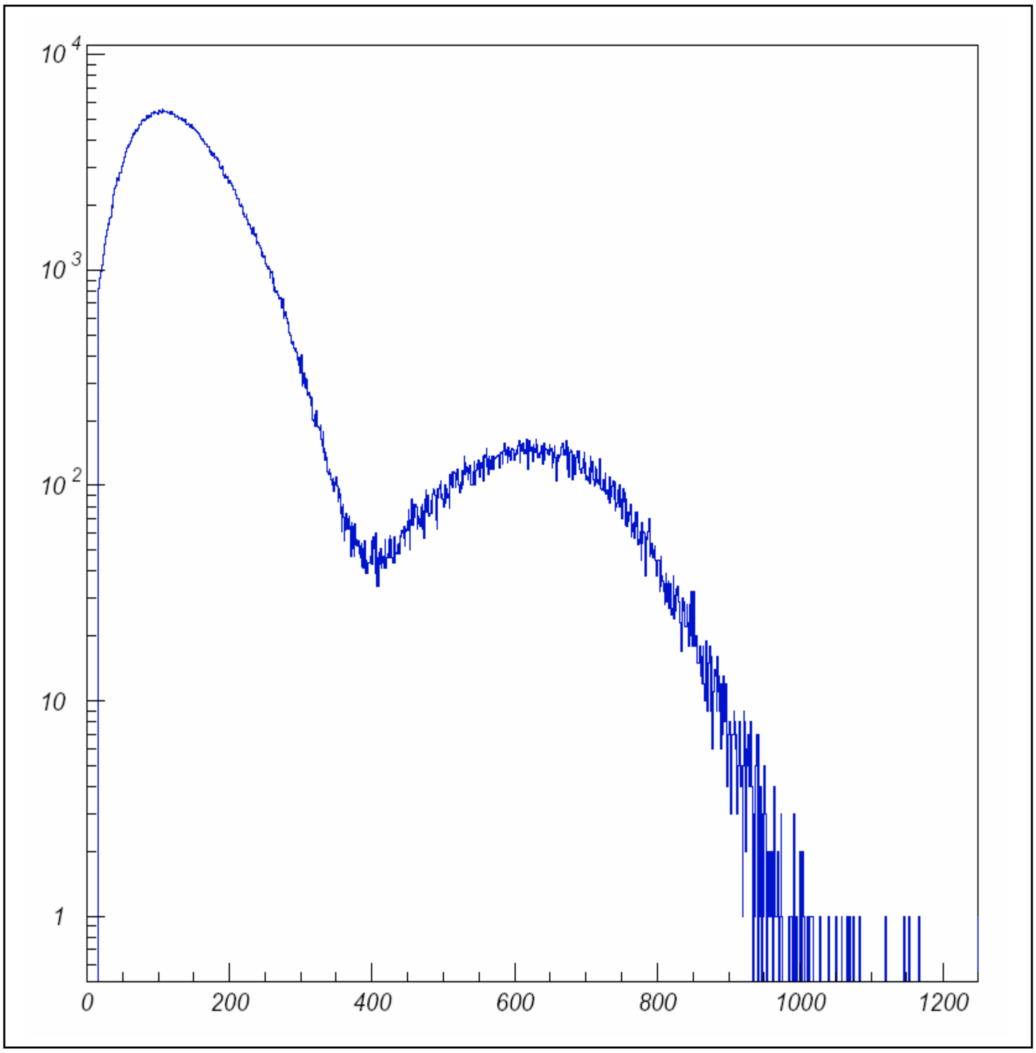


*Fig. 4: ΔE spectra of the 6th telescope*

The first obvious gate in the data is to take only events in which we have signal for the same detector in the E and the ΔE parts. By doing this way we can neglect almost all the noise in the ΔE part without reducing the statistics in the E part histograms [fig. 6]. Unfortunately some hits still remain in the low energy bump.

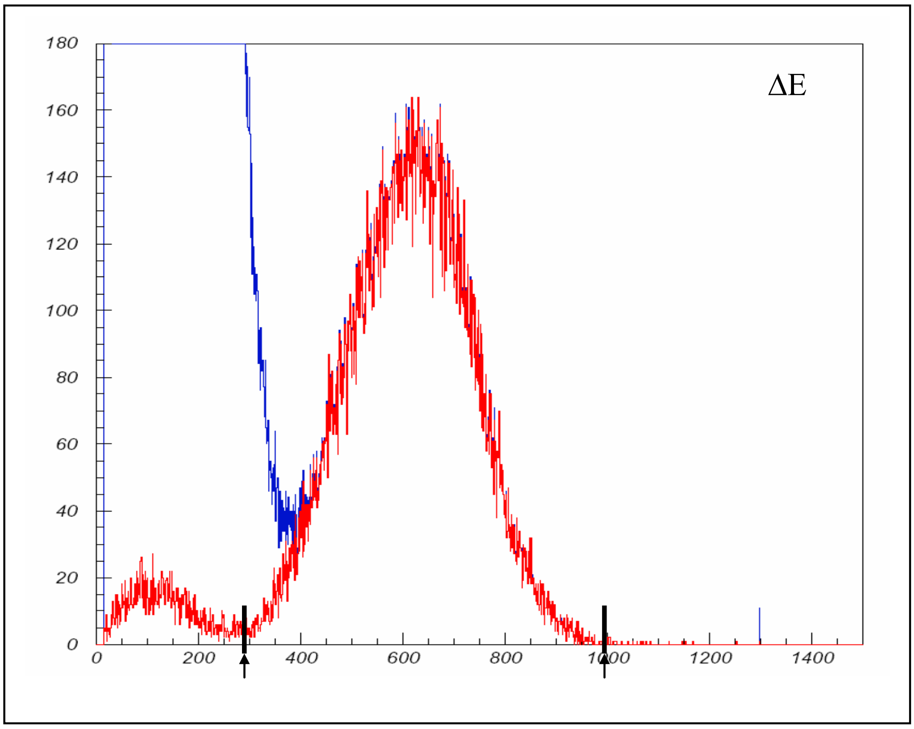


*Fig. 5: Comparison between gated (red-lined) and ungated (blue-lined) ΔE spectra of the 6th telescope*

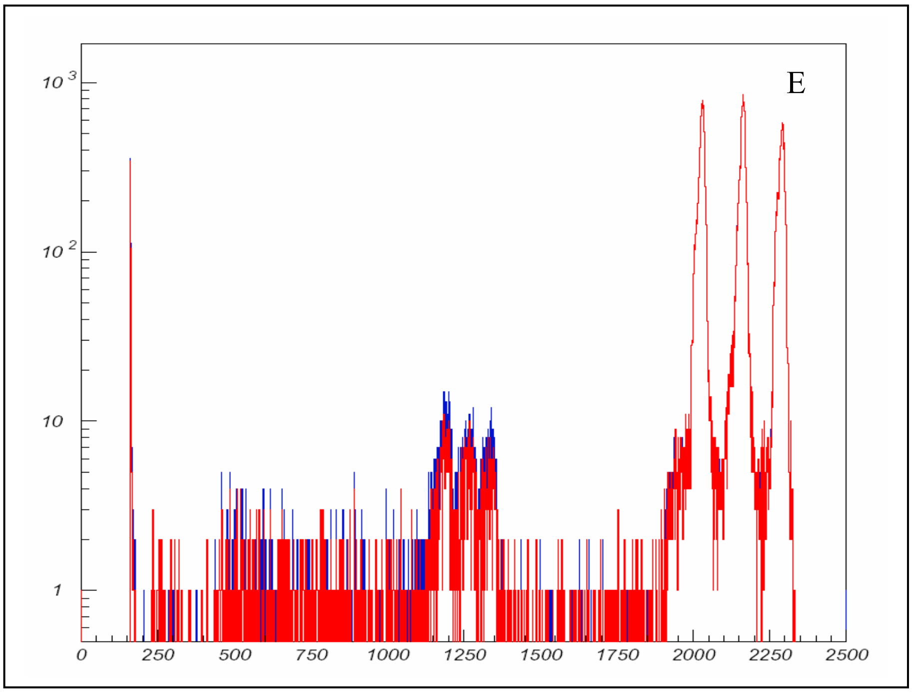


*Fig. 6: Comparison between gated (red-lined) and ungated (blue-lined) E spectra of the 6th telescope*

In order to find the origin of this remaining hits we placed a gate in the true alpha hits, and another gate in the ghost peaks hits. As we can see in the next figure the true alpha events occur in coincidence with the high energy bump in the ΔE part, and the ghost peaks events are correlated with those at low energies in the ΔE detector. Furthermore by using the true alpha gate we have removed almost all the low energy noise in the ΔE part.

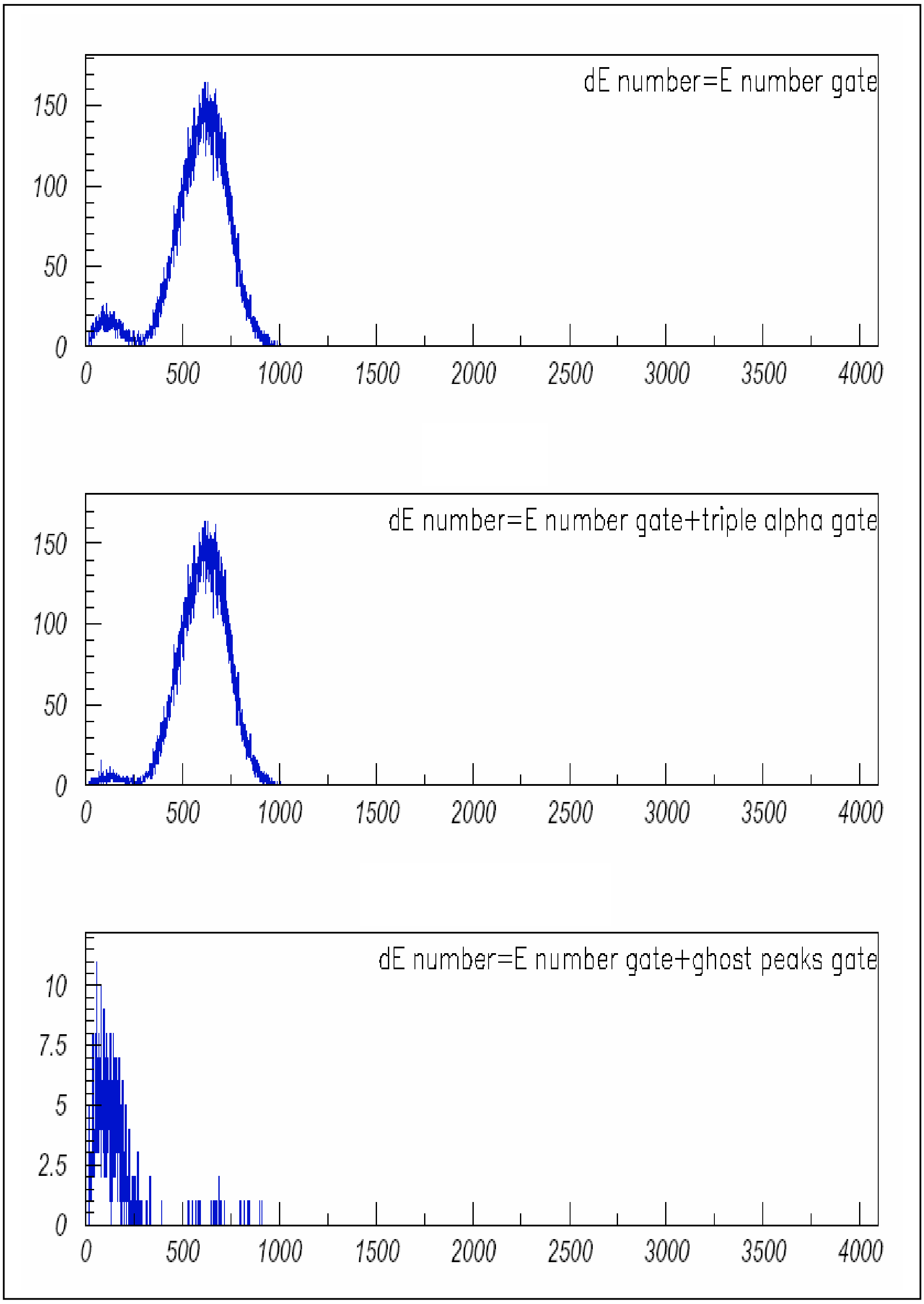


*Fig. 7: Different gates in the E(6) spectrum projecting ΔE .*

We have also calculated the area at full width half maximum of the ghost peaks in the equal-detector gated histograms:

| Detector number | Intensity(239Pu) (ghost/real)% | Intensity(241Am) (ghost/real)% | Intensity(244Cm) (ghost/real)% |
|---|---|---|---|
| 1 | 2.75 | 2.56 | 2.16 |
| 3 | 3.42 | 3.41 | 3.40 |
| 6 | 2.23 | 1.87 | 2.02 |
| 9 | 7.16 | 5.76 | 2.92 |
| 11 | 9.53 | 8.44 | 5.87 |
| 12 | 11.78 | 9.69 | 5.84 |
| 14 | 8.41 | 7.61 | 4.89 |
| 16 | 10.24 | 9.17 | 6.21 |

The simplest solution to avoiding these ghost peaks appears in the previous figure. By putting a gate in the $\Delta E>250$(ch) = XXX keV, the high energy bump(see fig. 5), we select only events in the real peaks in the E detector without losing much intensity.

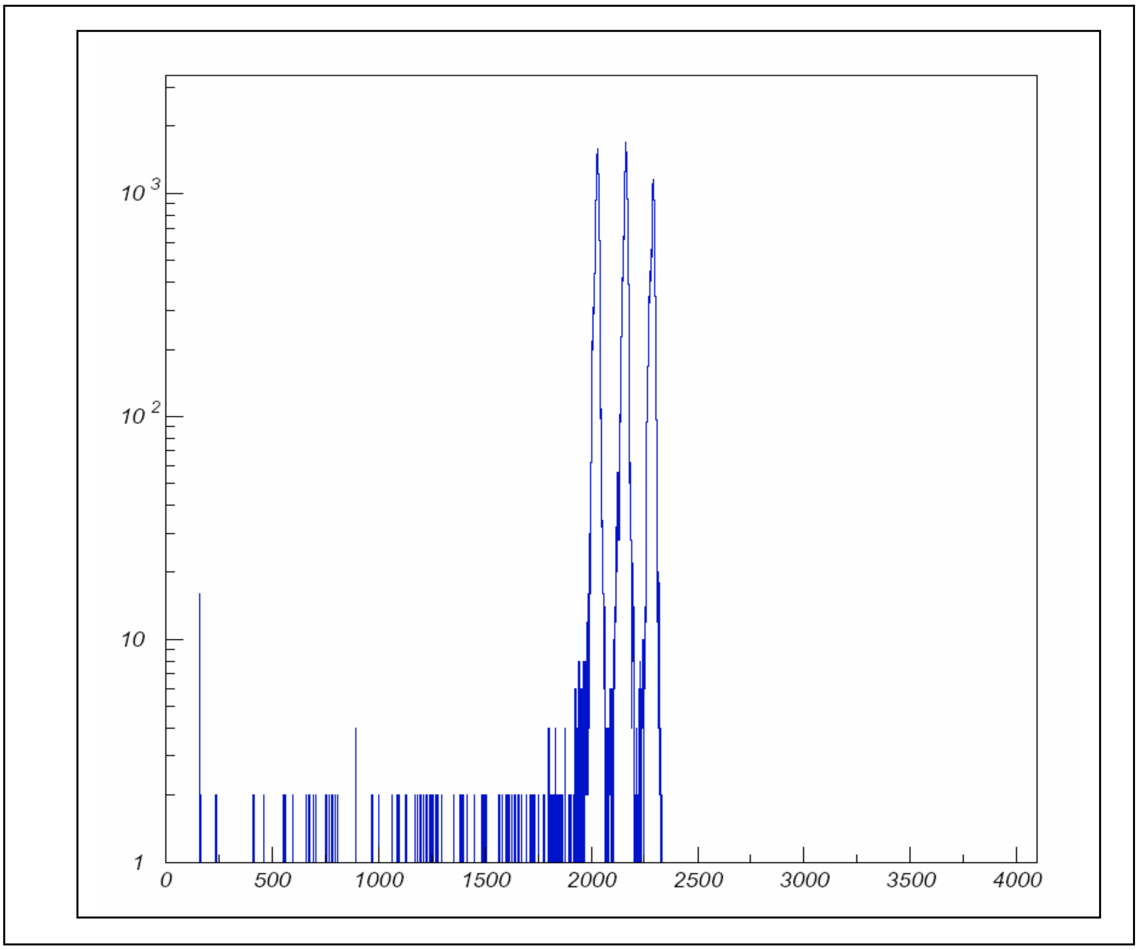


*Fig. 8: A gate placed in $\Delta E>200$(channel) projecting E histogram. The ghost peaks disappear*

## -References:

1. T. Nilsson, G. Nyman, K. Riisager, Hyperfine Interactions (2000) 67
2. B. Jonson, Phys. Rep. 389 (2004) 1
3. N. Bohr, Nature 137 (1936) 344
4. D. Habs et al., Hyperfine Int. 129 (2000) 43
5. O. Tengblad Nucl. Phys. A701 (2002) 222c.
6. S. Tudisco et al., Nucl. Instr. Meth. A426 (1999) 436-445