Two-Photon emission from the first excited state of ^{72}Ge

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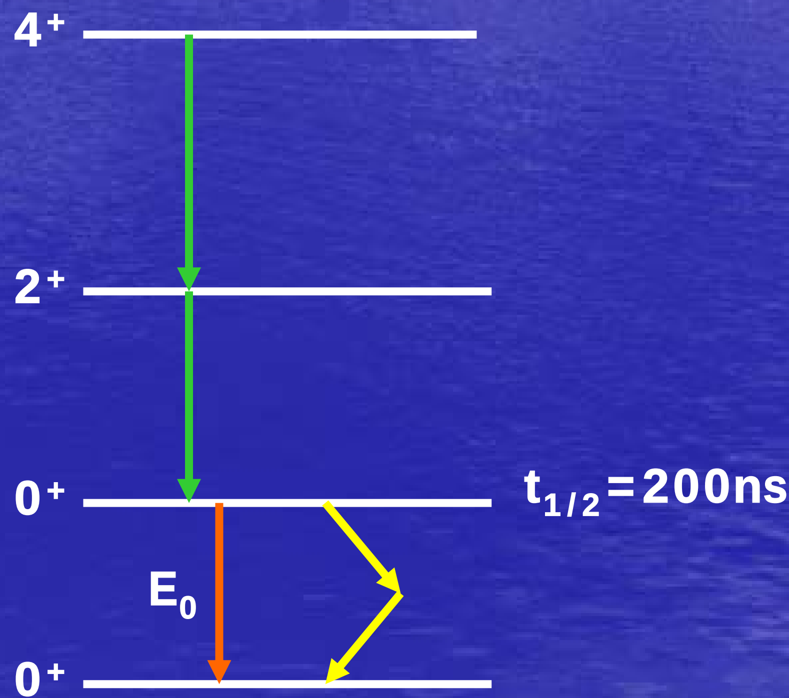
Introduction to two-photon emission

- An excited state decays via the spontaneous emission of two photons
- Competes with all other modes of decay
- High order decay mechanism, hence has a very small branch
- So improbable, it is very hard to measure

How to spot two photon emission

- Impossible to observe in competition with rapid gamma ray emission

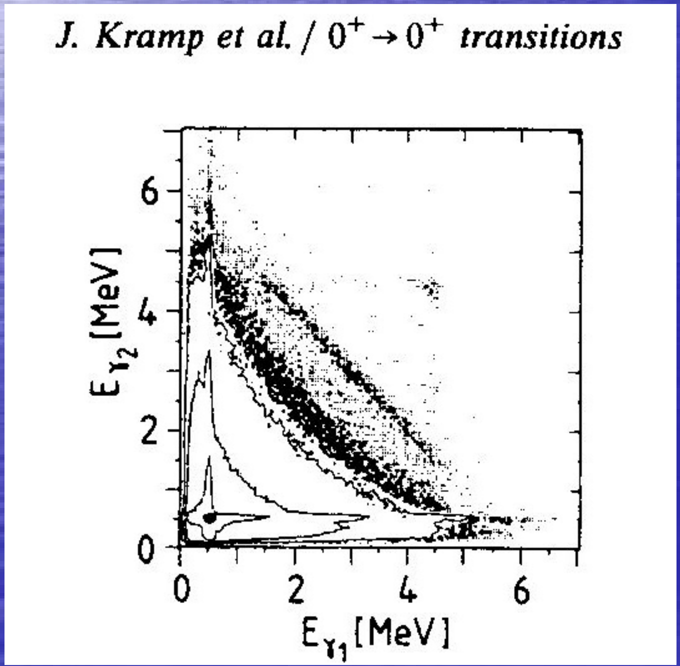
- **Can occur between states of any spin/parity**
- **Selection rules prohibit gamma-ray emission between states of equal spin and parity, owing to the photons intrinsic spin of S=1**



Previous investigations

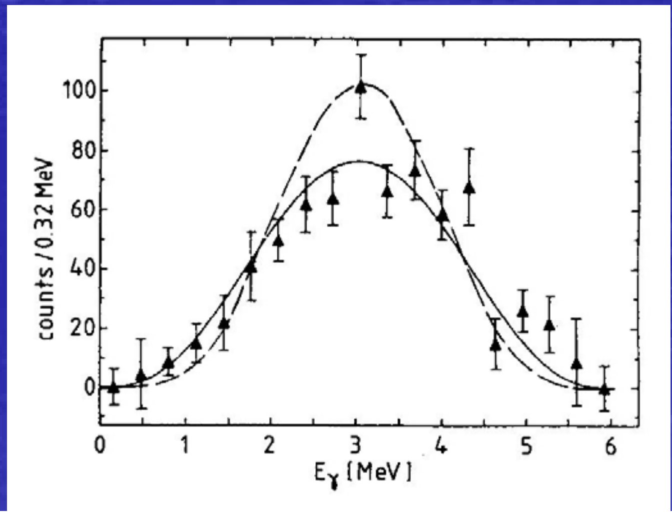
- Experiments have been carried out on ^{16}O, ^{40}Ca, ^{72}Ge and ^{90}Zr which all have $0^+ \rightarrow 0^+$ transitions

Branches vary around 6×10^{-4}



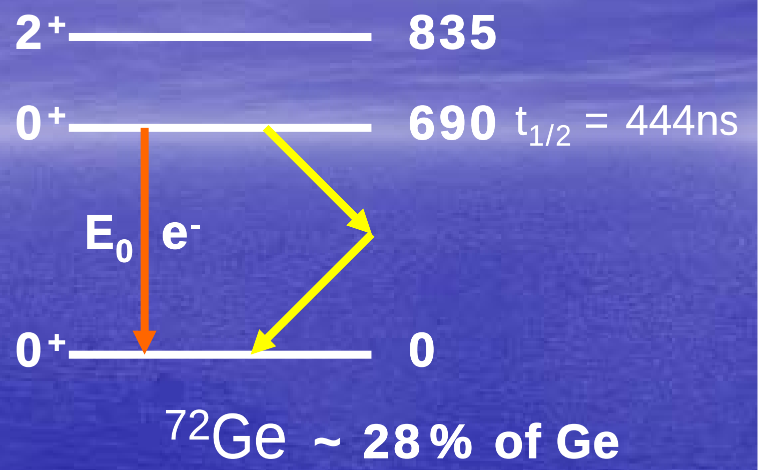
Taken from Nucl. Phys. **A474** 412 (1987)

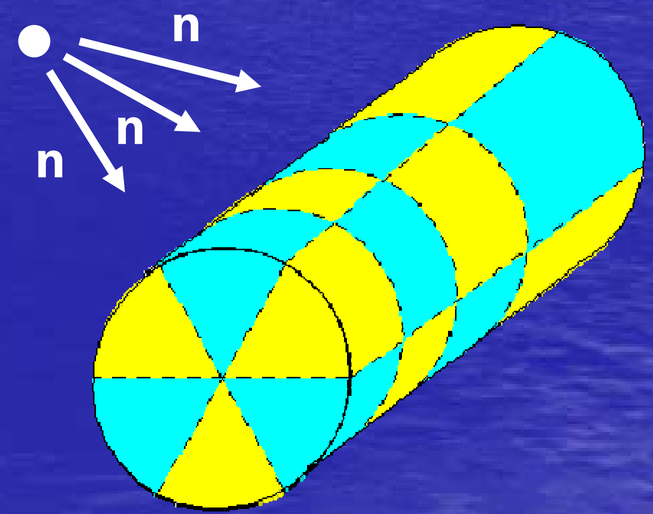
- Best measurements made on ^{16}O where photons were found to be two E1 or M1 transitions with equal probability
- The energies were found to follow a Gaussian distribution



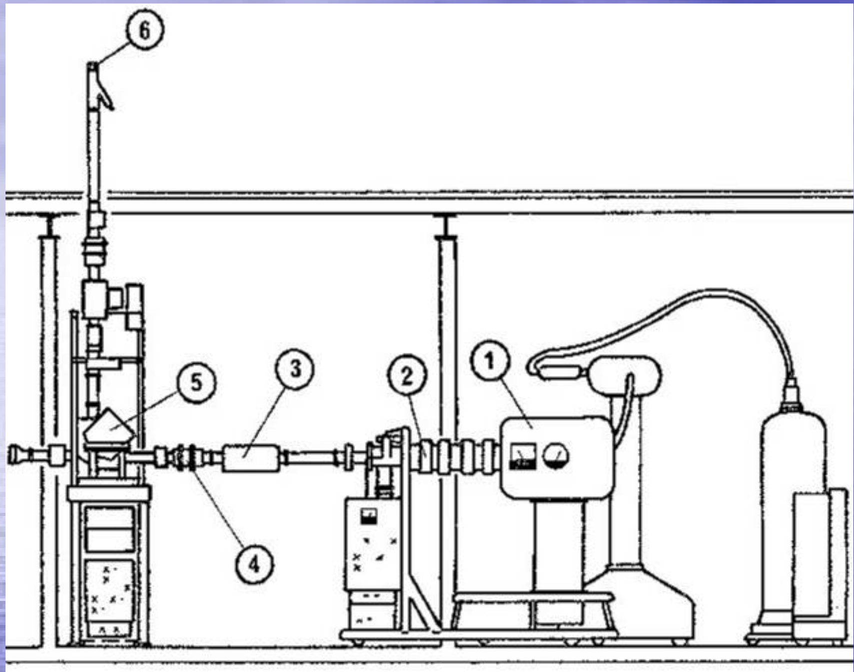
Experiment

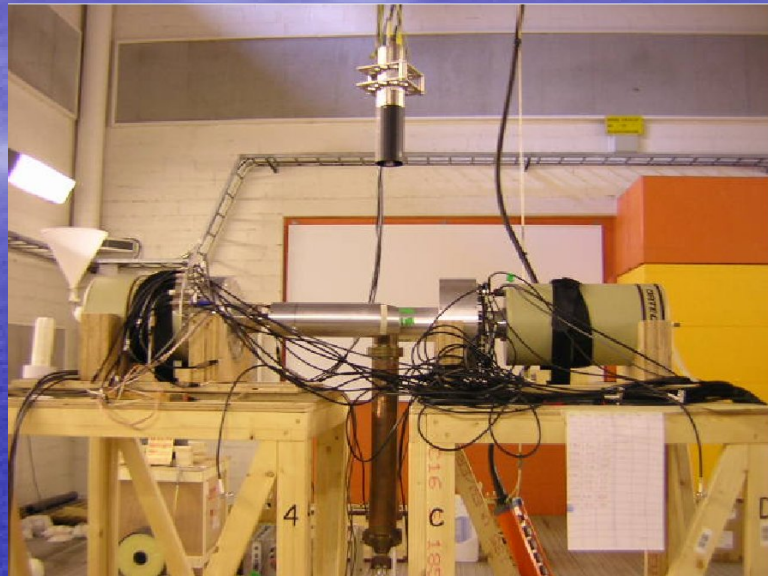
- Uses germanium as target and as detecting medium
- Segmented detector is capable of measuring both photons simultaneously
- Excite the low lying states of germanium nuclei by inelastic scattering of 2.45 MeV
- Make use of the half-life of the first exited 0^+ state



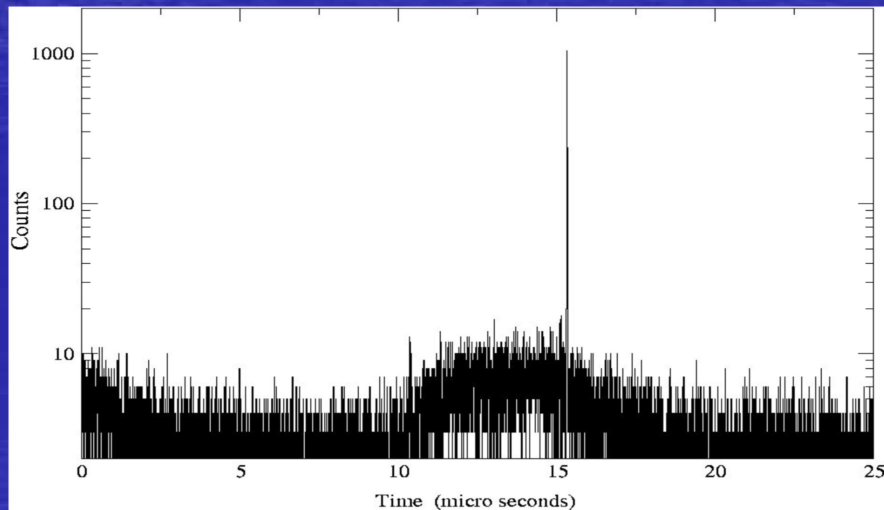


Neutron Generator

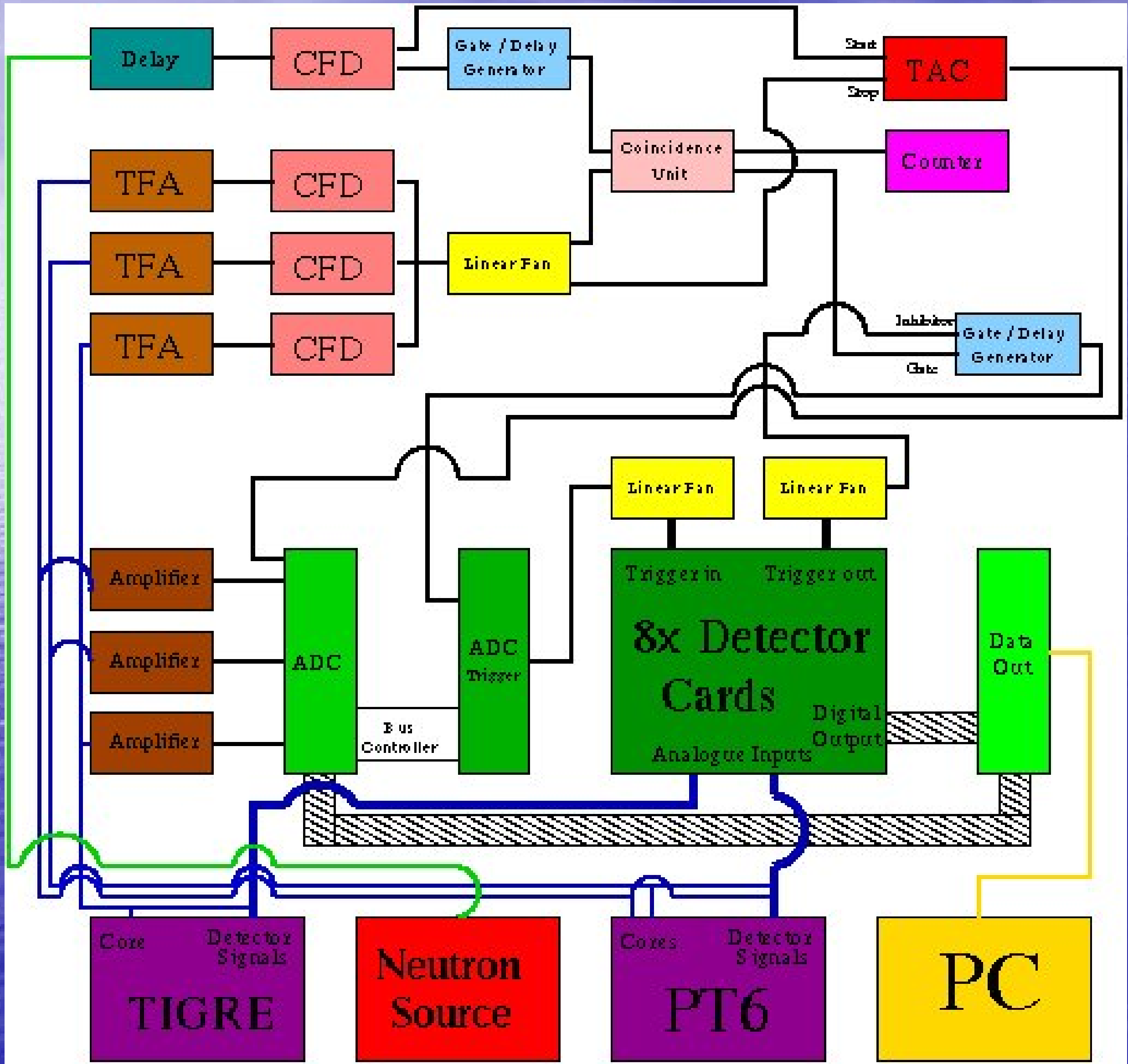




$d + d \longrightarrow {}^{3}He + n$



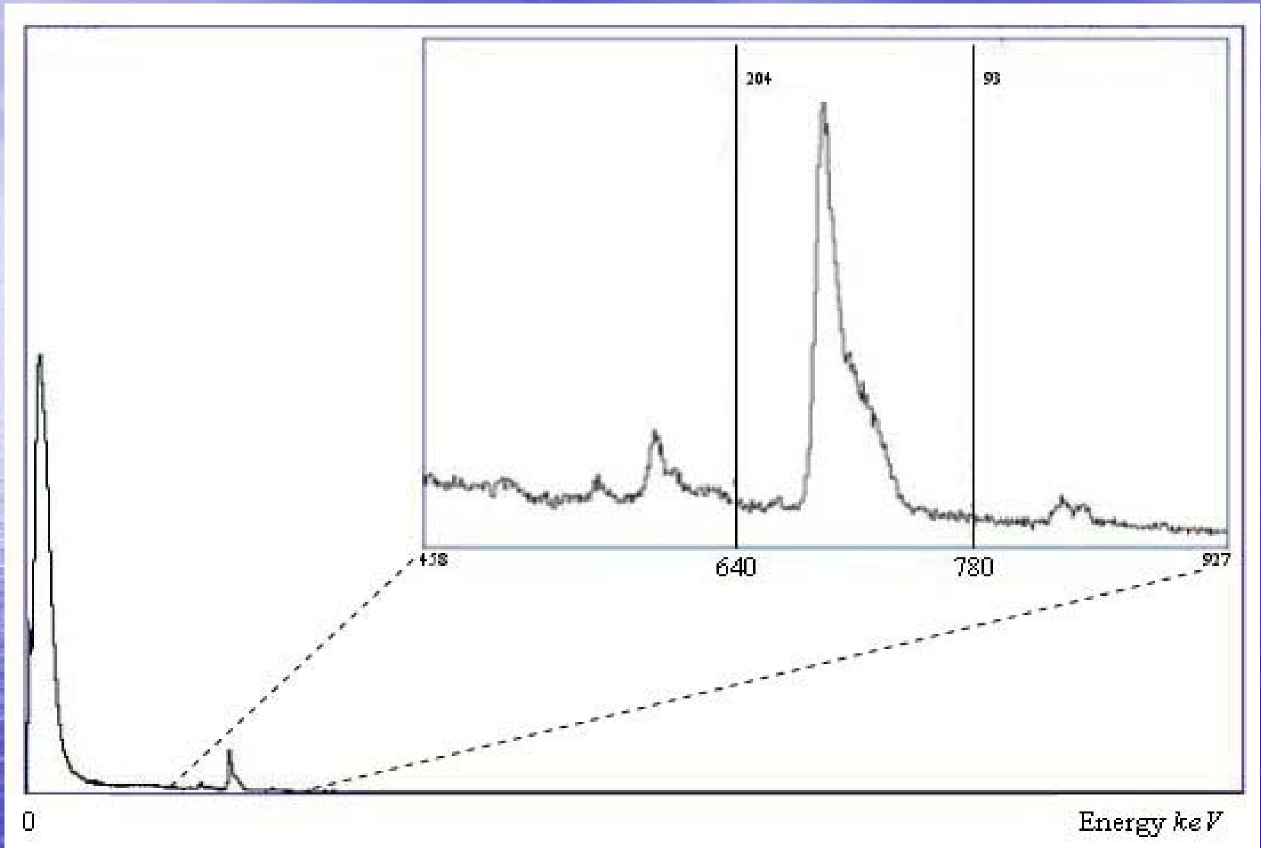
Electronics



Hardware Trigger generated whenever a core signal found in coincidence with a 200ns delayed neutron signal

Fast data cards write out the full pulse shapes for a period 4us before and 2us after the trigger condition is satisfied

Spectra



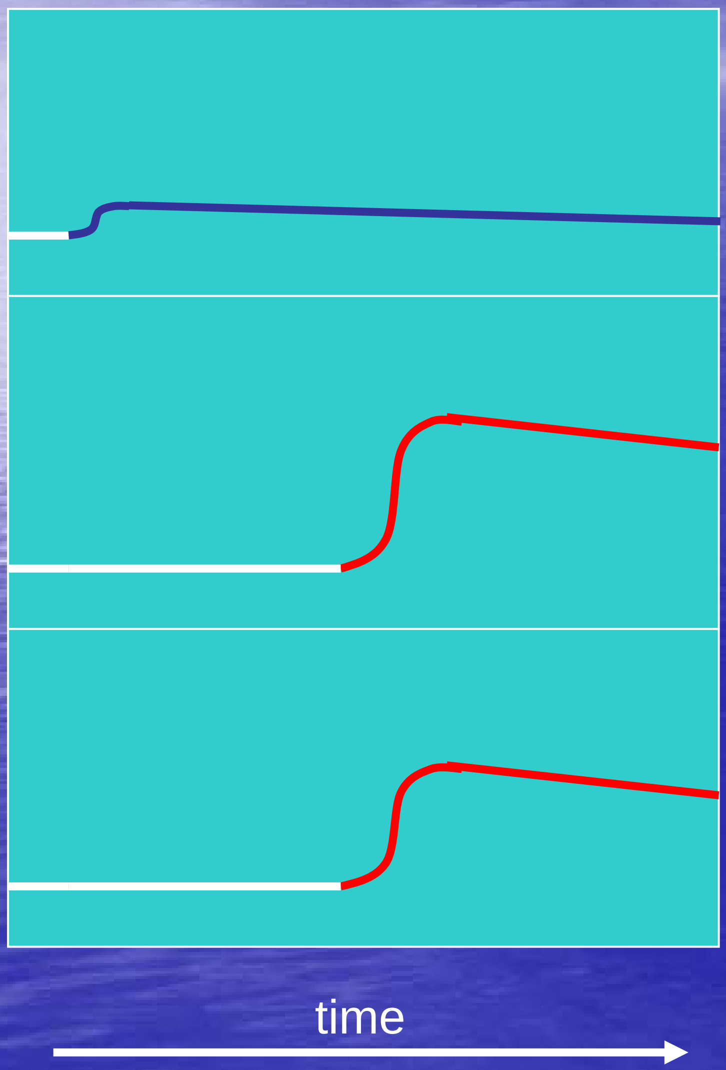
Singles spectrum shows that the experiment successfully probed the transitions from the first excited state

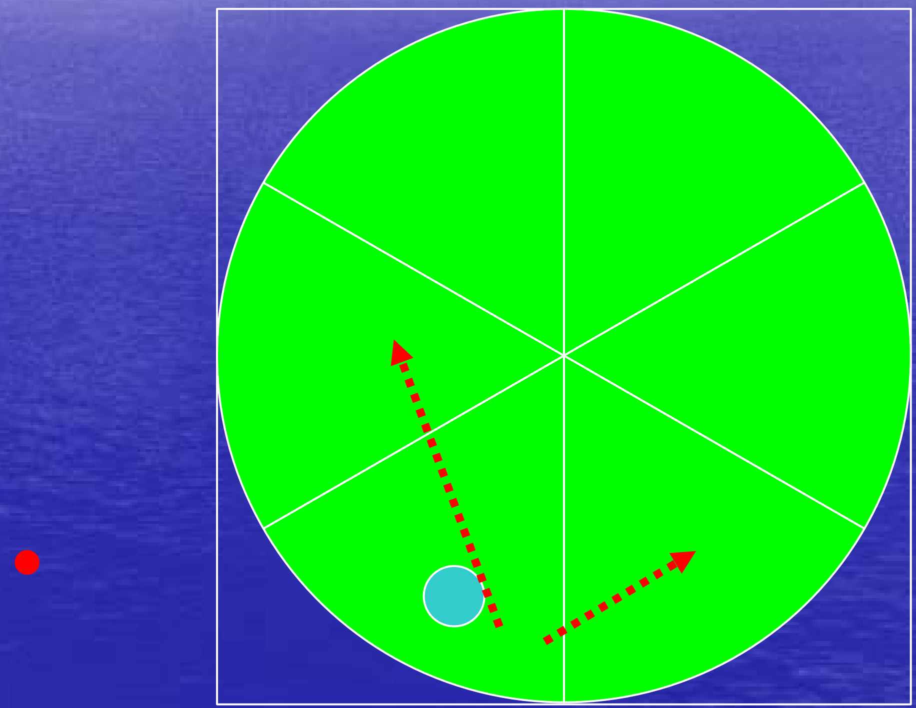
Electron has a small probability of crossing a segment boundary and so the 690-keV peak is much smaller in the 2-fold spectrum

In folds 3 and 4, we see no 690 peak owing to the short range of the electron

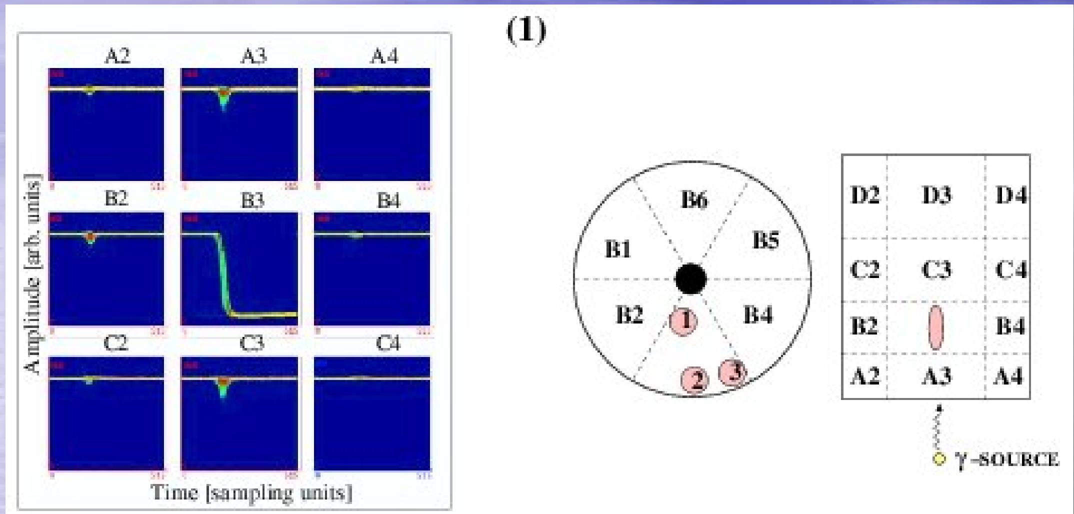
Two-photon events are buried underneath the above spectrum

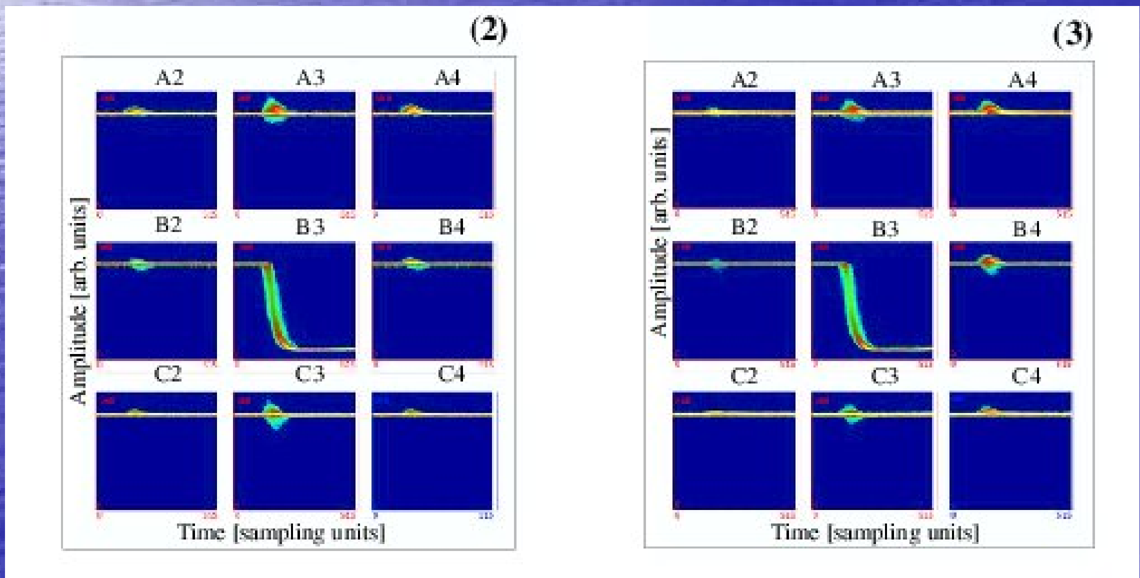
Pulse shape analysis





More pulse shapes

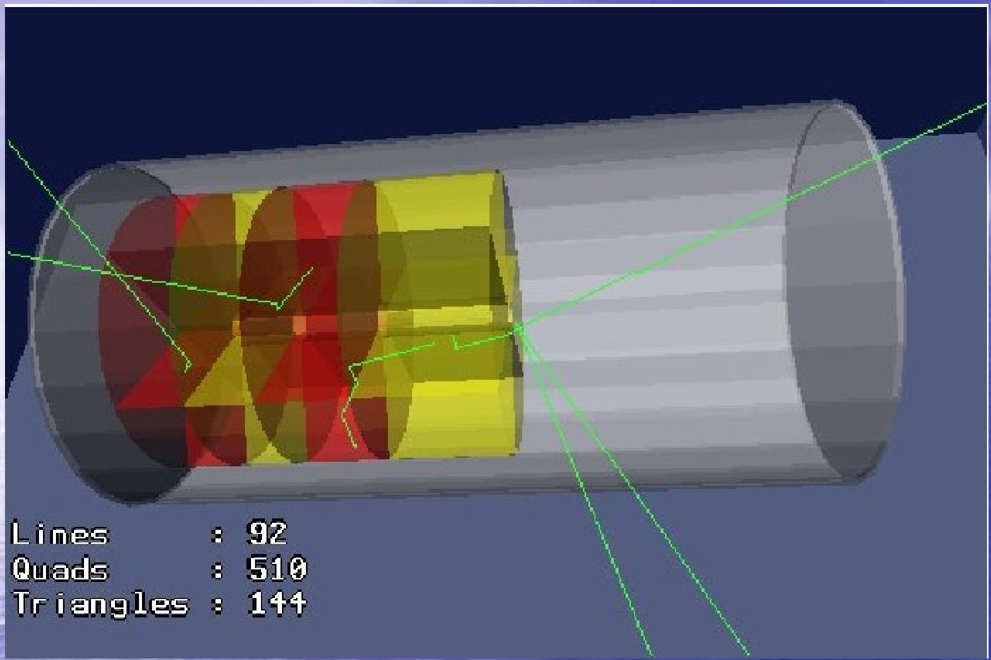


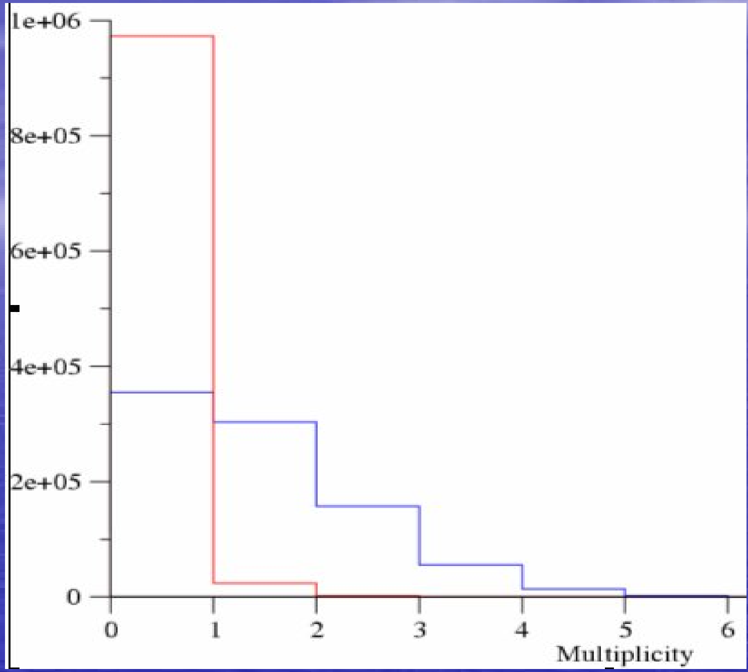


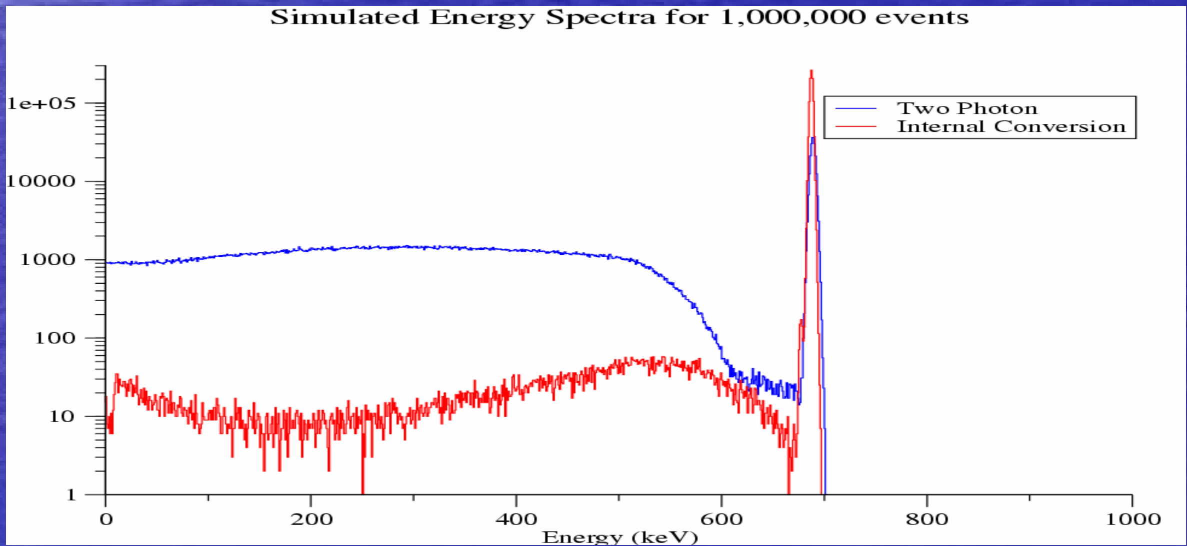
With the smaller amount of events we can carry out a more in depth analysis of the pulse shapes

Able to distinguish between real two-photon events and electrons crossing boundaries

Geant4


Lines : 92
Quads : 510
Triangles : 144


1e+06
8e+05
6e+05
4e+05
2e+05
0
0
1
2
3
4
5
6
Multiplicity


Simulated Energy Spectra for 1,000,000 events
Two Photon
Internal Conversion
1e+05
10000
1000
100
10
1
0
200
400
600
800
1000
Energy (keV)

summary

- Use Pulse-shape analysis to measure number of two-photon events
- Use efficiency from Geant4 to scale up measured number of counts to the real number of two-photon events
- Calculate branching ratio of two-photon emission for the first time in ^{72}Ge

Acknowledgements

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