High Purity Germanium Detector Characterisation and Analysis

UNIVERSITY OF LIVERPOOL

Overview

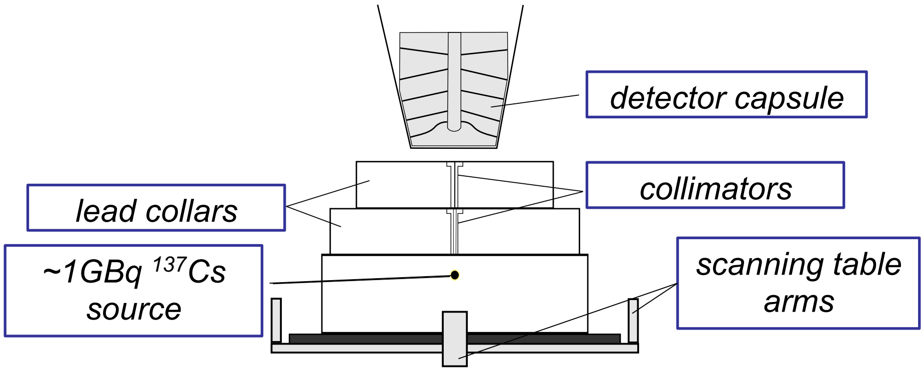
This lecture will cover

- Basics of the Liverpool detector scanning system.
- Features of the AGATA segmented detectors.
- How to open and sort data with the MTSort software package.
- Identify scan output that is important for detector characterisation.

Detector scanning (1)

The **scanning system** consists of:

- Two motorised arms moving in an X-Y grid with millimetre precision.
- An active single photon energy source is used: ^{137}Cs (661.7 keV) or ^{241}Am (59.54 keV), selected for the scan depth within the detector.
- Tungsten collimator are used to form a 1 mm pencil beam.
- The scanning table position is read out to a PC.

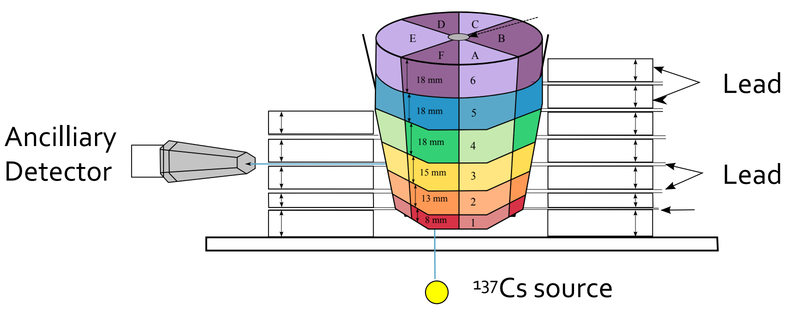


Detector scanning (2)

- Measure the **average detector response** as function of **position**.
- Output:
  1. Full energy in hit segment event traces
  2. Transient signals (segmented detectors)
  3. Moving Window Digital energy
  4. Scanning table position in step x and step y.
- The pulses are read out and gated by the position of the scanning table.
- **Detector Performance** and **Uniformity** can be measured.
- **Charge collection** can be studied through the analysis of detector traces.

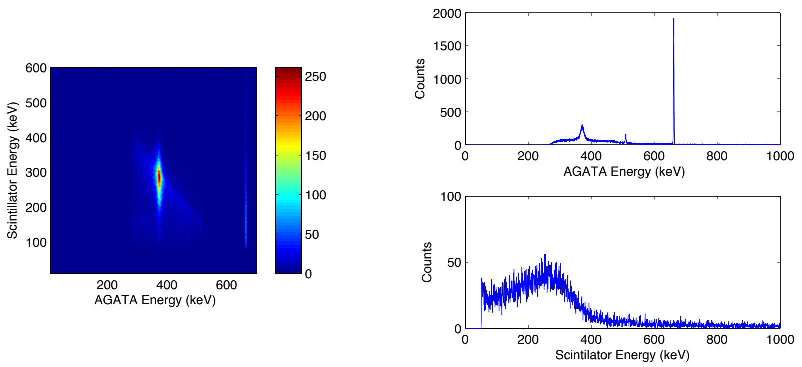
Detector scanning (3): Coincidence

- For full X, Y, Z position information, a **coincidence** scan is performed.
- Secondary lead collimators are placed along the length of a detector.
- The ^{137}Cs collimated beam will scatter at 90 degrees in the HPGe detector.
- The scattered gamma-ray will deposit energy within ancillary detectors.



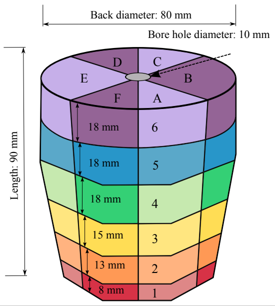
Detector scanning (4): Coincidence

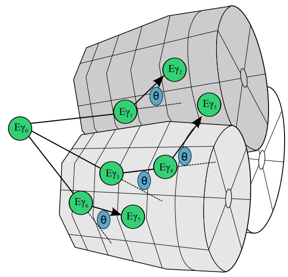
- The energy for a 90 degree **Compton scattering energy** can be gated:
- 374 keV in the scanned detector and 288 keV in the detectors.
- From this information a pulse shape database can be created.



The AGATA Detectors

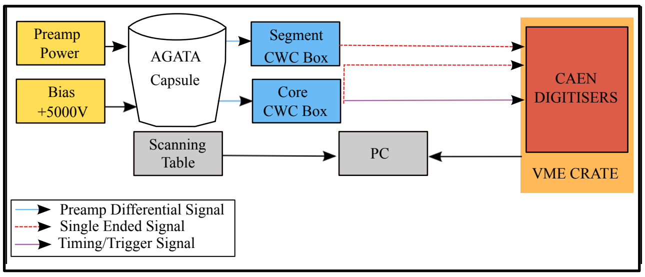
- State of the art segmented High Purity Germanium (**HPGe**) detector encapsulated within aluminum canister.
- The detectors are segmented 36 times, into 6 rings and 6 sectors.
- Both the outer segment electrodes and code will collect charge carriers (holes and electrons) and are highly position sensitive.
- Utilized for *Gamma-ray tracking* within **gamma-ray spectroscopy**.





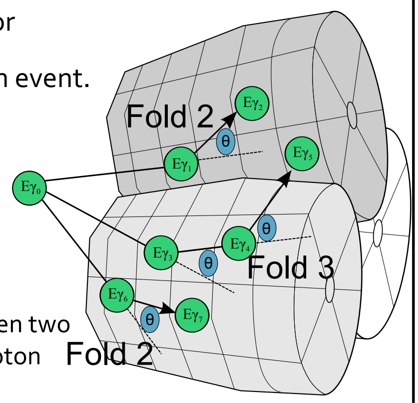
Scan Data Acquisition electronics

- Power is supplied to the preamplifiers (12 V) and to the detector.
- For AGATA data acquisition, 36 segment and 2 core signals (one for energy, one for timing) are read from the detector to the CAEN digitiser.
- The AGATA differential preamplifier signal is converted to a single ended signal within CWC converter boxes.
- The detector traces are read into CAEN digitiser cards which digitise the preamplifier signal and calculate MWD energies.



Data Parameters

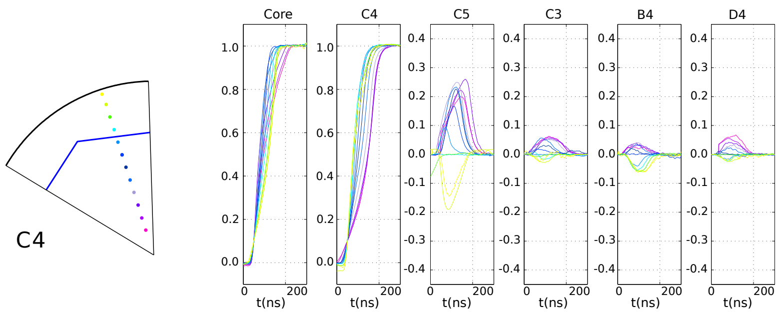
- **Energy:** The energy registered
- **Event:** A count registered in the detector
- **Fold:** How many segments registered an event.
  - Fold 1: Hit in 1 segment
  - Fold 2: Hit in 2 segments
  - Fold 3: Hit in 3 segments



- Events that have Compton scattered between two segments can be **added-back** to the full photon event energy.

Detector Output

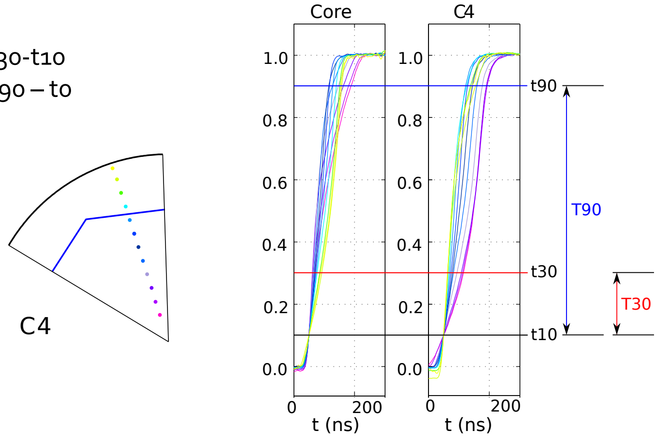
- Real and transient pulses are produced by the AGATA detector.
- An event is registered in the core and in the segment.
- Transient signals are formed in adjacent segments.
- The magnitude of the transient signals is dependant upon the proximity of the even to the adjacent segment -> further position information.



Detector Output (2)

- In order to study detector response, we can quantify the pulse shapes by looking at the risetime.
- The risetime will vary with charge collection position within the detector segment.

- T30: t30-t10
- T90: t90 – t0



AGATA Detector Data to Analyse

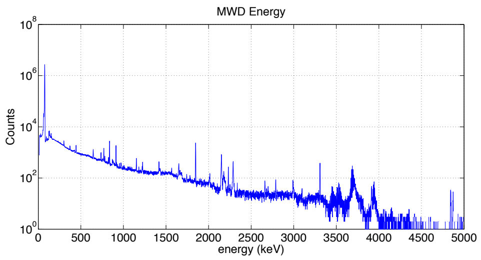
- In your practical you will analyse **2 sets** of AGATA detector data:

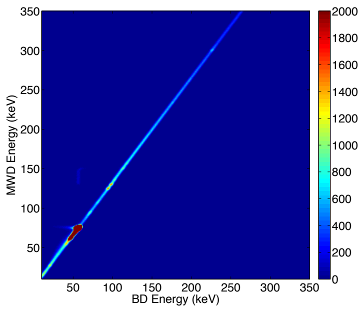
1) Presorted AGATA scan spectra, taken at 60 seconds per scan position. Using these spectra you will analyse the fold counts, event energy, risetime and image charge asymmetry response of the detector.

2) Unsorted AGATA scan data at 1 second per position. You will analyse this data with MTSort using a prewritten analysis code.

MTSort Language

- **MIDAS** is a software package utilised for digital data acquisition.
- **Basic MTSort programming language:**
  - You will be given a "Quickstart" Guide to assist in the software use
  - Used to read in and sort digital data.
  - Simple syntax designed for creating and 1D and 2D spectra:





Sortfile Format

Sections are separated using "Starwords":

- *FORMATS: Identify which experimental parameters you will use, including which kind of digitiser.
- *DATA: Sample lengths, constant variables, and gain matching parameters.
- *SPECTRA: Declare which one dimensional and two dimensional spectra you wish to generate.
- *COMMANDS: Process the pulses, gain match, set gates on energy, fill declared spectra
- *RUNFILES: the run file, listed as DISC /path/run*
- *FINISH: Denotes the end of the sort file.

Running a sort

Opening MTSort: Applications → Start MIDAS Session

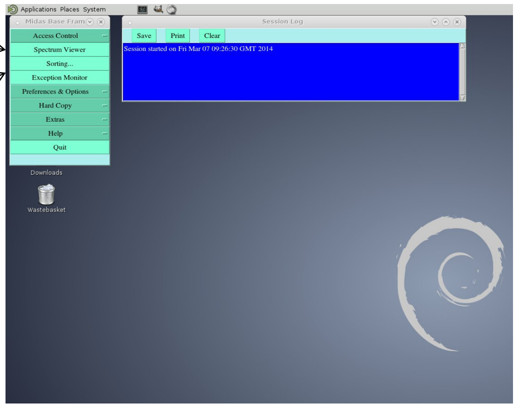
- **Spectrum Viewer:**

Display saved MTSort spectra

- **Sorting…**:

Will allows you to open the

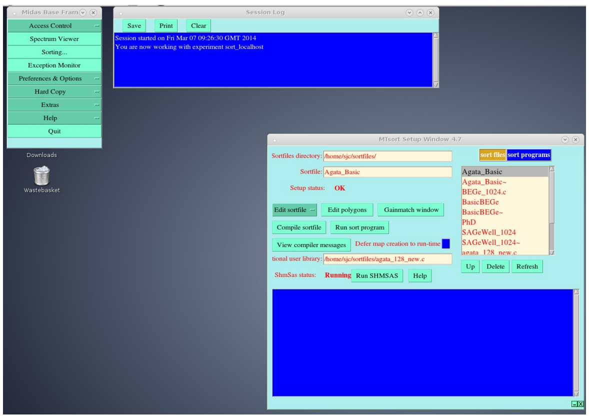
MTSort Control Window.



Running a sort

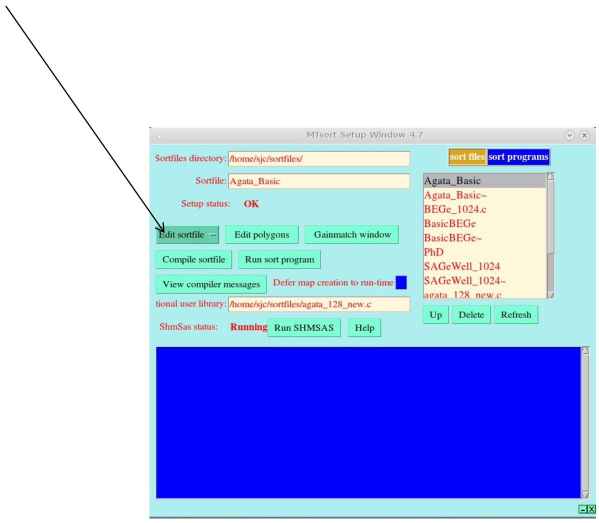
- The **MTSort Setup Window** is now open:

- The MTSort file can be edited.
- An optional C-code for pulse processing can be included.
- The Sort window can be opened.



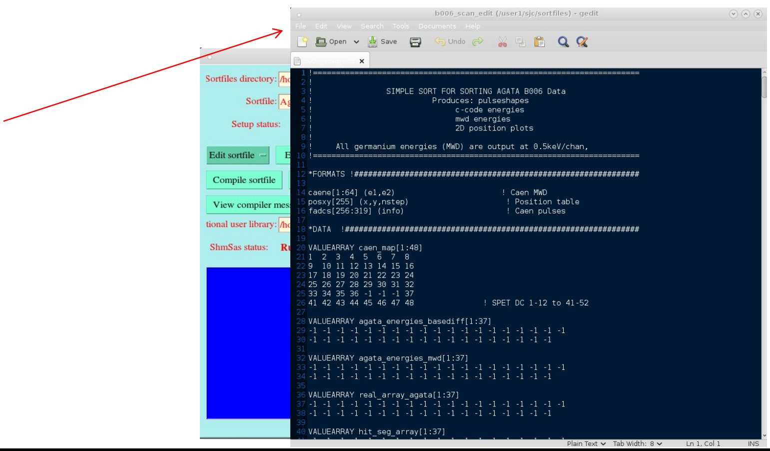
Running a sort

- **Editing the Sortfile**



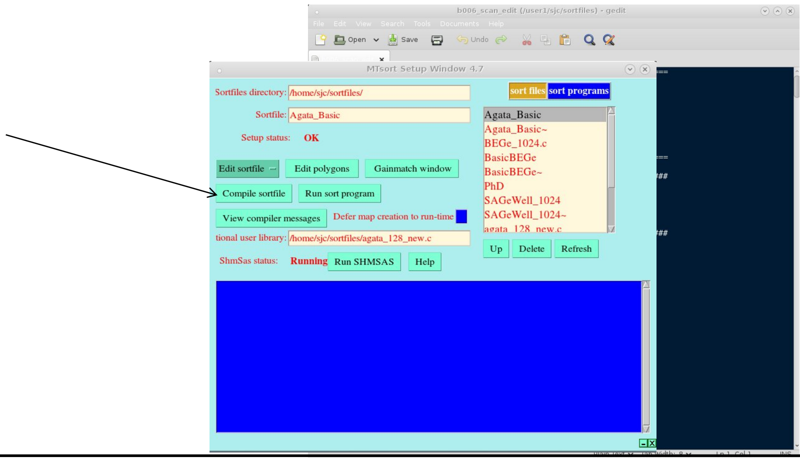
Running a sort

- **Editing the Sortfile:**
- In a text editor (gedit or emacs), the sortfile can be created and edited to include additional arrays, spectra, variables etc, for analysis.



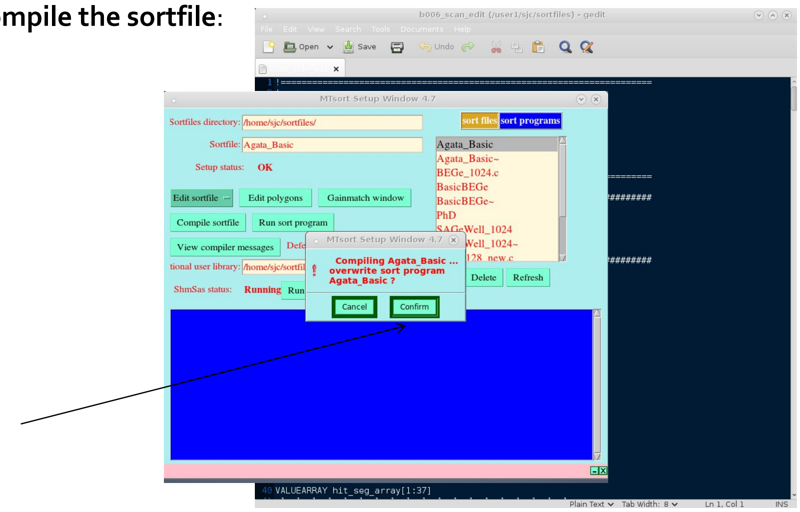
Running a sort

- **Compile the sortfile:**
- The sortfile must be compiled along with the C-code before the sort can be run. If there are any errors in the compilation the sort will **not** run.



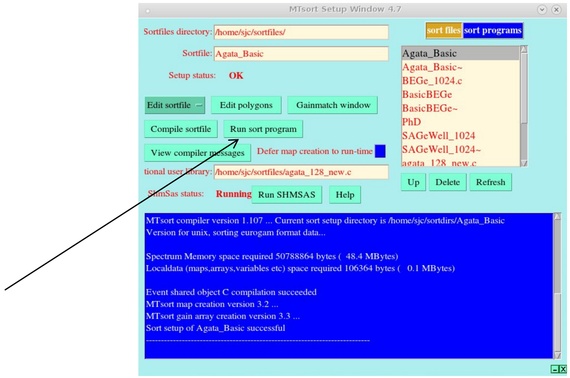
Running a sort

- **Compile the sortfile**:



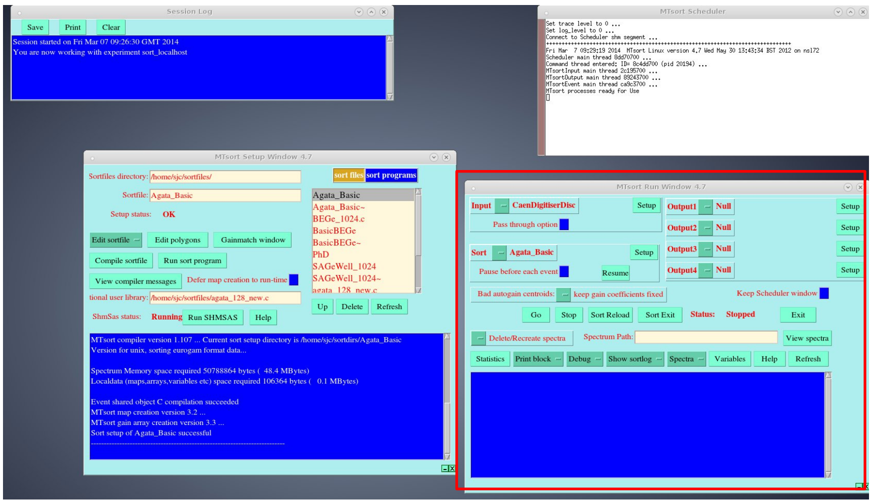
MTSort

- Compiling Successful, now you can **run** the sort program



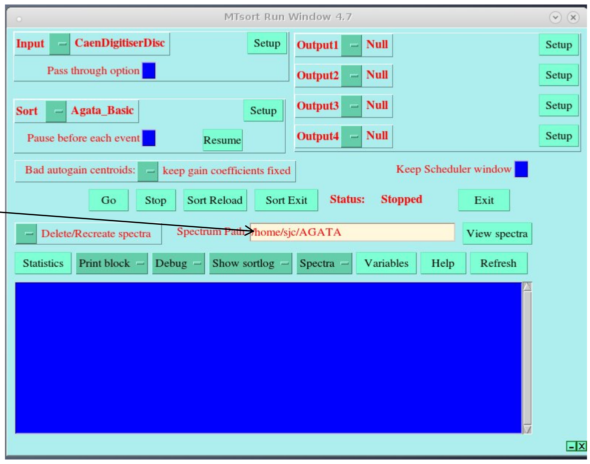
MTSort

- **MTSort Run Window:**



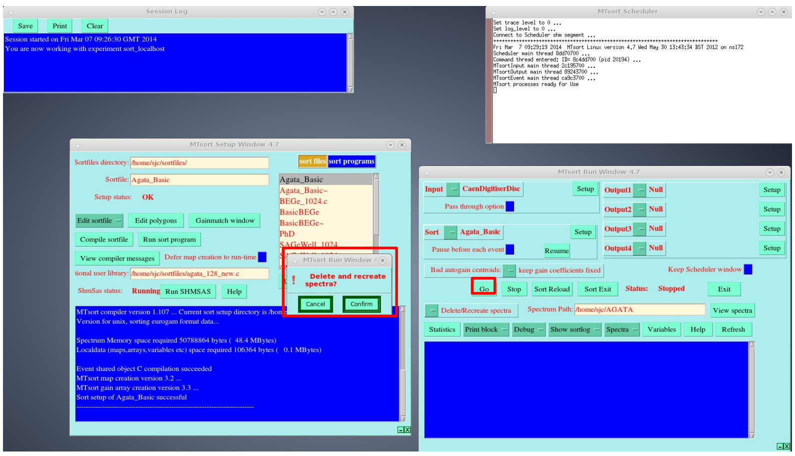
MTSort

- Enter the **spectrum path** for where the spectrum will be saved



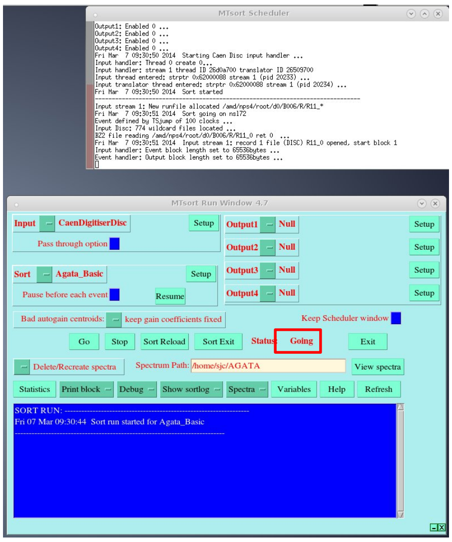
MTSort

- Select **Go**
- **Confirm delete and recreate spectra.**



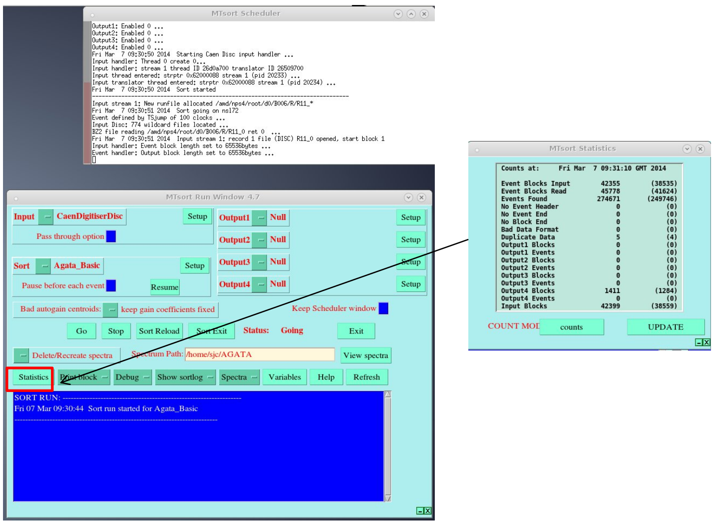
MTSort

- Sort is now **running**



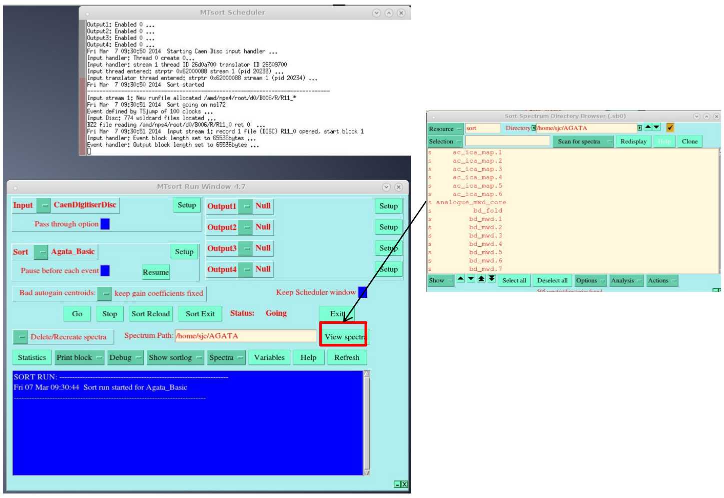
MTSort

Statistics



MTSort

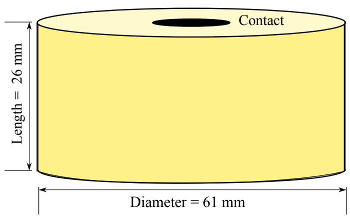
View the spectra you are creating, using **View Spectra**.

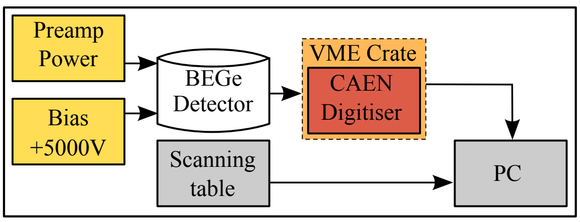


BEGe Detector

A Broad Energy Germanium (BEGe) Detector

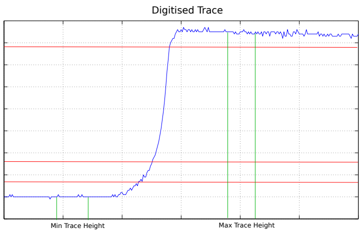
- The BEGedetector has been scanned with a ^{241}Am source.

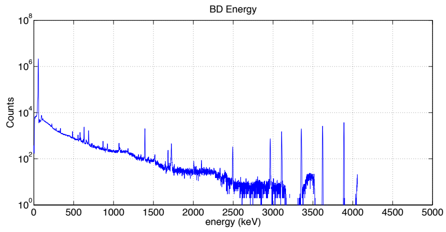




Example: BEGe Scan Data

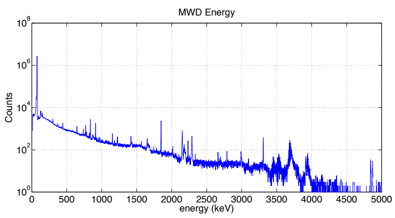
- The CAEN cards will read out the MWD energy and the pulse traces.
- From the traces, the baseline difference (BD) energy is calculated within the C-code in an MTSort sort.
- **BD energy: Difference between trace height before and after the pulse.**
- Less accurate energy calculation than MWD energy.

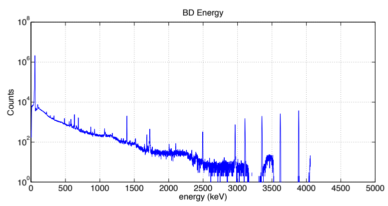


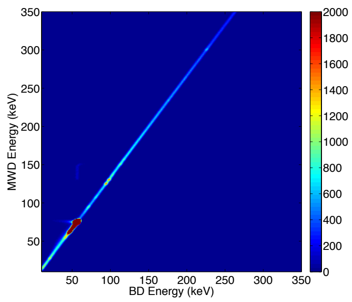


Example: BEGe Scan Data

- The CAEN cards will read out the MWD energy and the pulse traces.
- From the traces, the baseline difference (BD) energy is calculated within the C-code in an MTSort sort.
- The MWD and BD Energy Spectra:

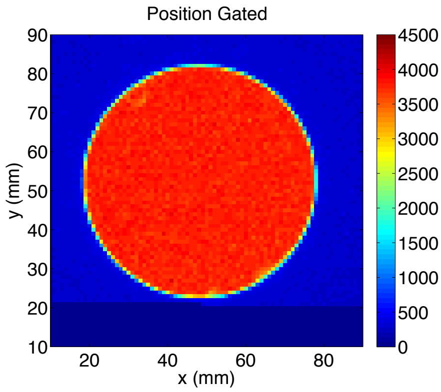






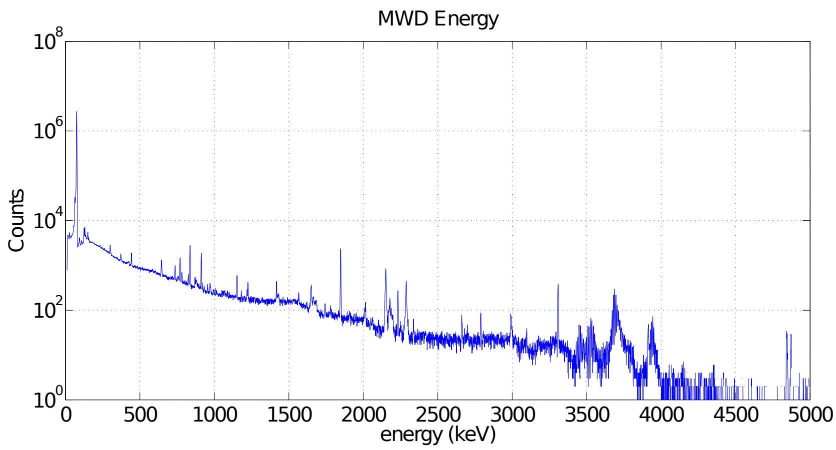
Example:BEGe Scan Data

- Output position x and position y gated Spectra:



Example BEGe Spectra

- Gate on the energy: low_en and high_en gate on the ^{241}Am peak.



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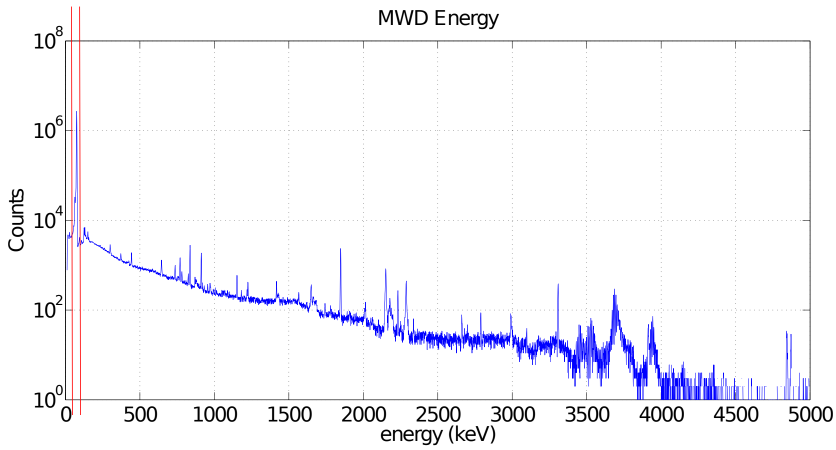
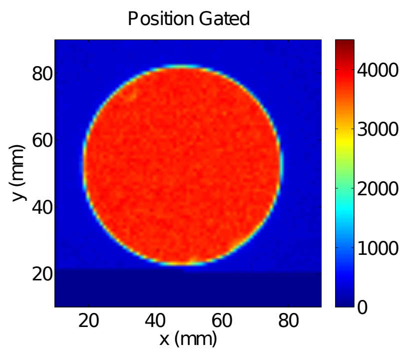
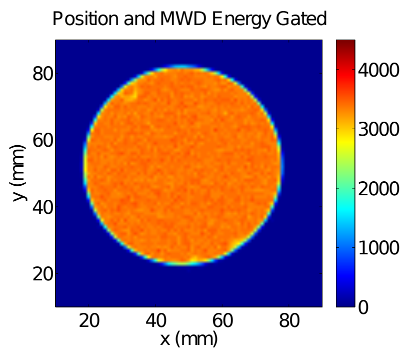


Example BEGe Spectra

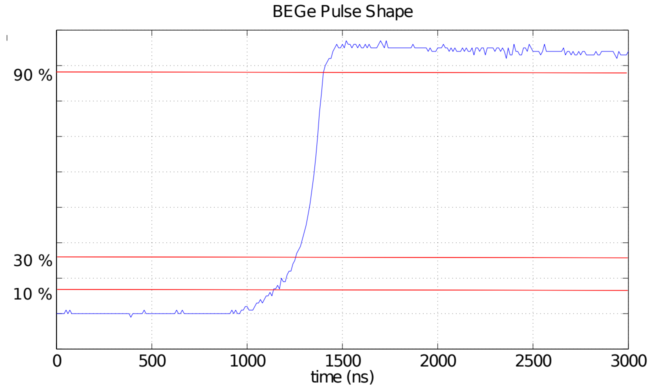
- Generate a position and energy gated spectra:
- This shows the full energy absorption of the 59.54 keV gamma-ray.





Example BEGe Spectra

- **Generate Risetime spectra:**
- Calculate the t10, t30 and t90 values of the digitised traces



Example BEGe Spectra

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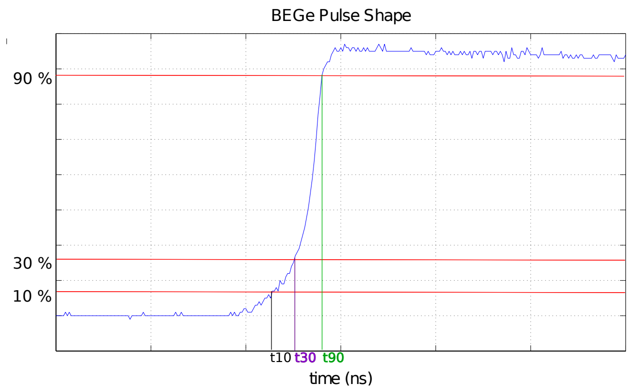
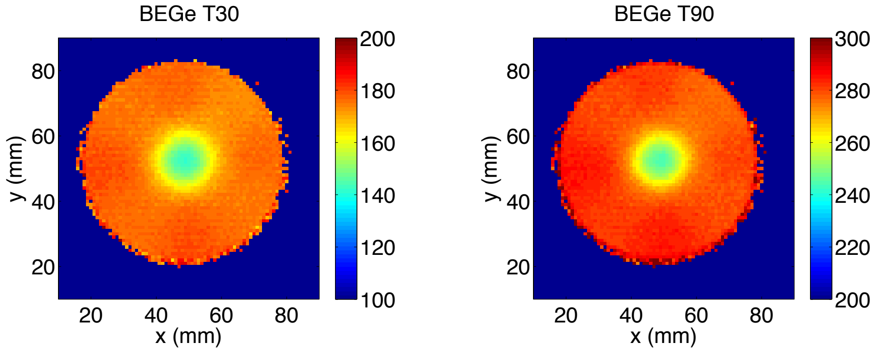


Example BEGe Spectra

- Risetime position spectra



Practical work

After this practical you should be able to:

- Identify the components of a detector scanning system.
- Understand features of the AGATA segmented detectors.
- Sort digital detector data utilising the MTSort package.
- Identify key component of detector characterisation