A Compact Double Bragg Detector for Event-by-Event Study of the Fission Process in Actinide Nuclei

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Contents of this Talk

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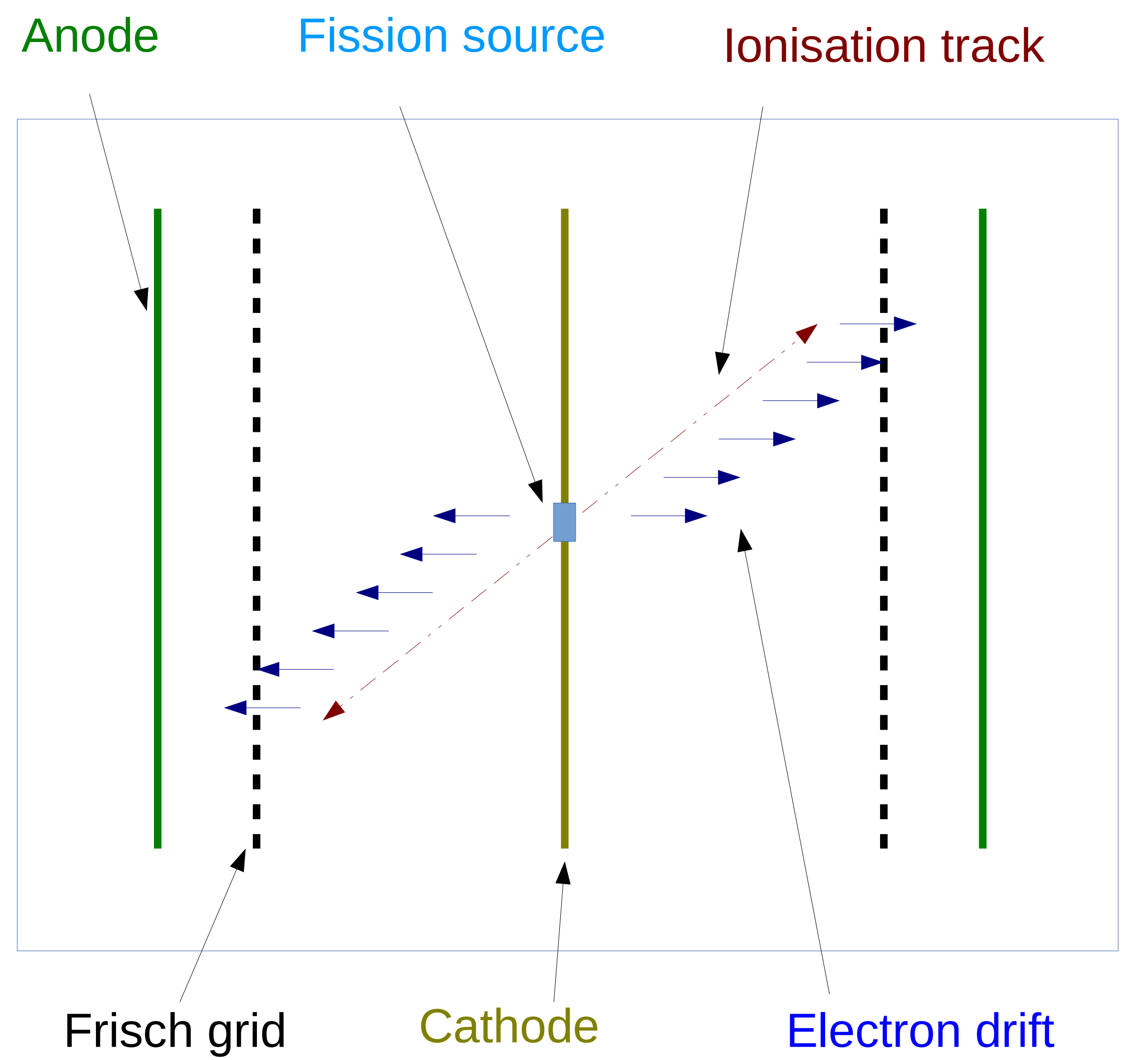
- Principles of Detector Design
  – present and future
- Data Analysis
- Modelling and Experimental Work
- The Future

Project Objectives

- Detection of fission fragments in 4pi
- Measure E and determine A and Z for both fragments
- Identification of ternary fission events
- Obtain angular distributions in 3D
- Adaptable for various methods of inducing fission
- Combine with 4pi neutron/gamma detection arrays

Double Bragg Detector – Principle of Operation

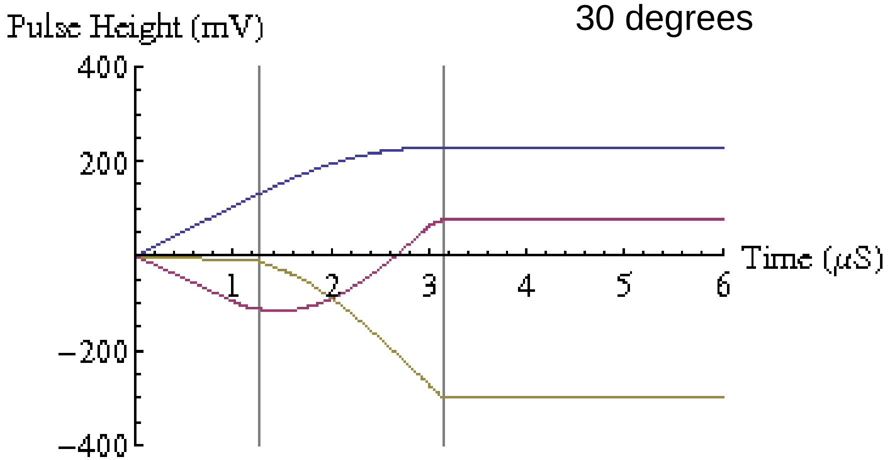
- Source mounted in cathode plane
- Drift region between cathode and grid
- Collection region between grid and anode



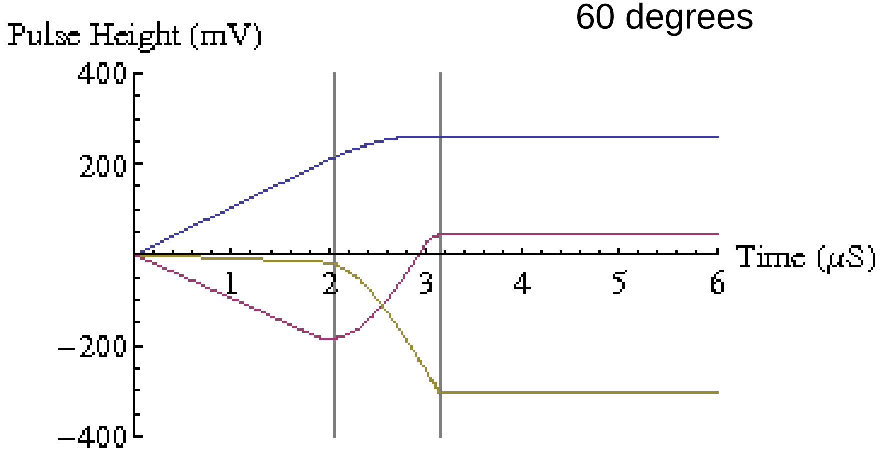
Position sensitivity using charge induced by electron drift

- Cathode signals give positions sensitive information
- BUT... Cathode signal SUM of side1 and side2 – inseparable
- Grid1 + Anode1 = Cathode1
- No information on azimuthal angle available

30 degrees



60 degrees



Position sensitivity using anode segmentation

- Radial anode segmentation
  - Polar angle determination
  - Only two segment required
  - Comparison of signal peak-hight and peaking-time

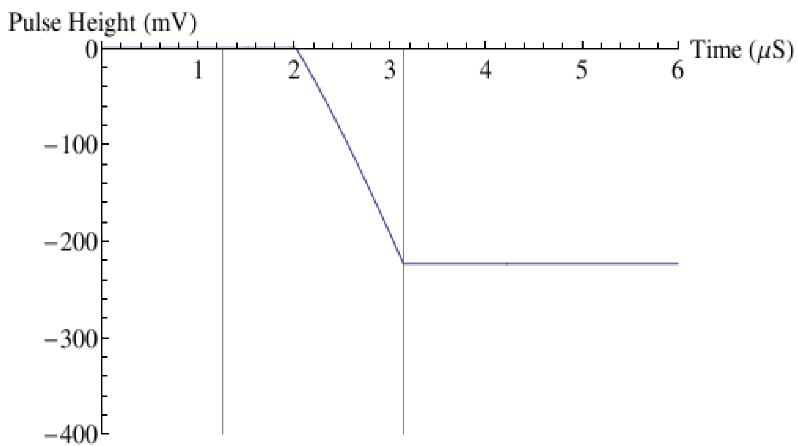
- Transverse anode segmentation
  - Azimuthal angle determination
  - Resolution only as good as degree of segmentation
  - Many channels needed

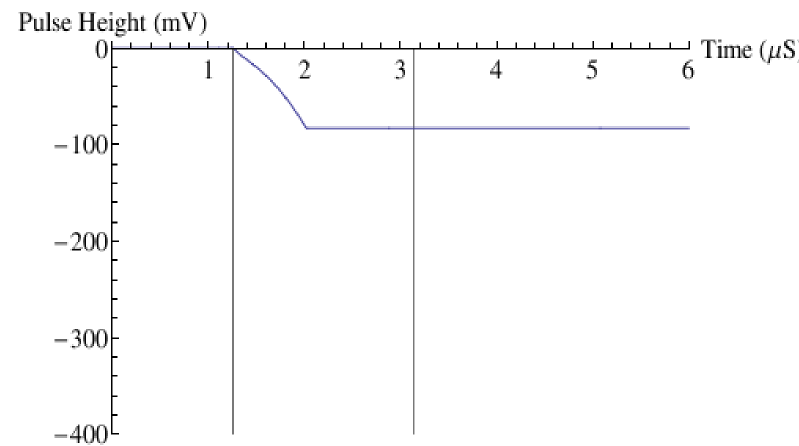
Position sensitivity using electrode segmentation

Central

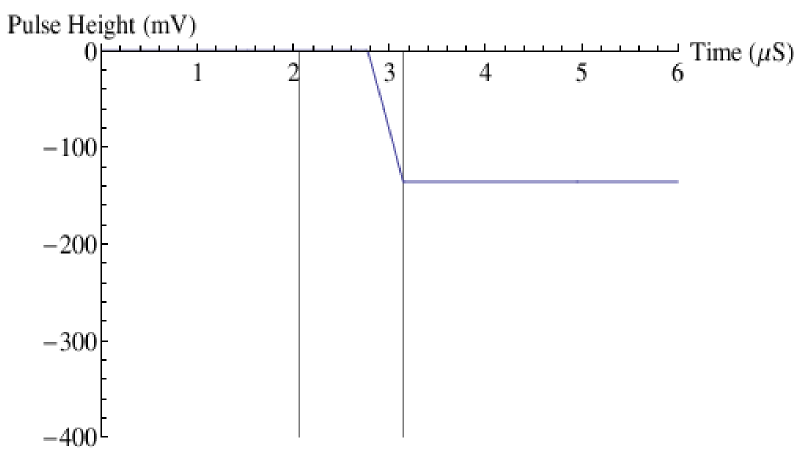
Outer

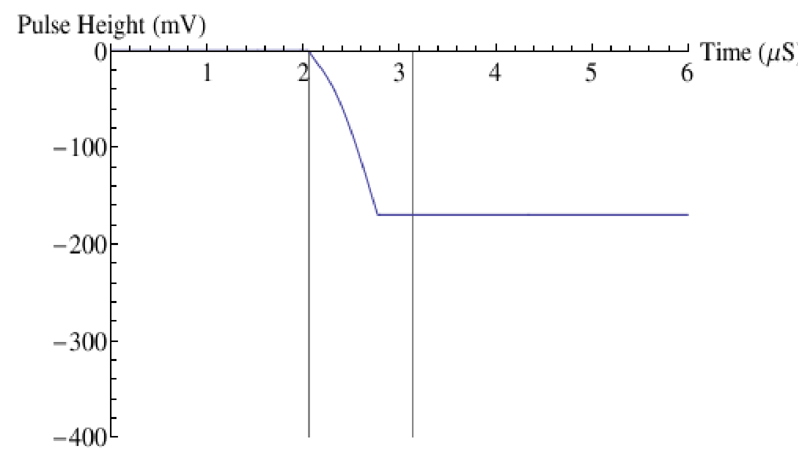
30 degrees



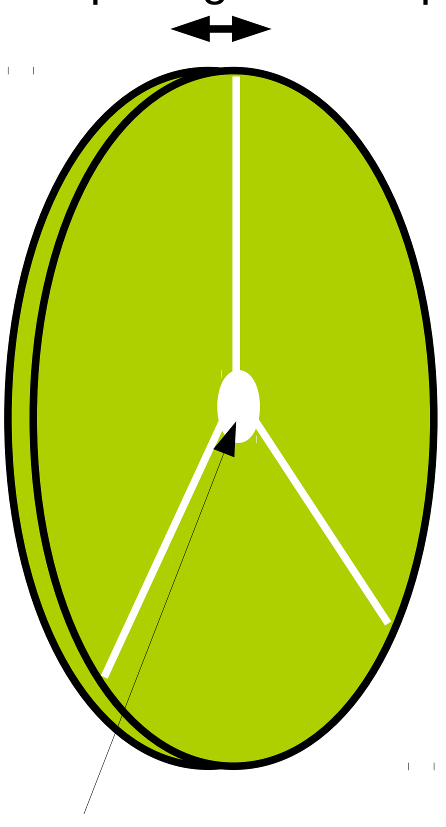


60 degrees



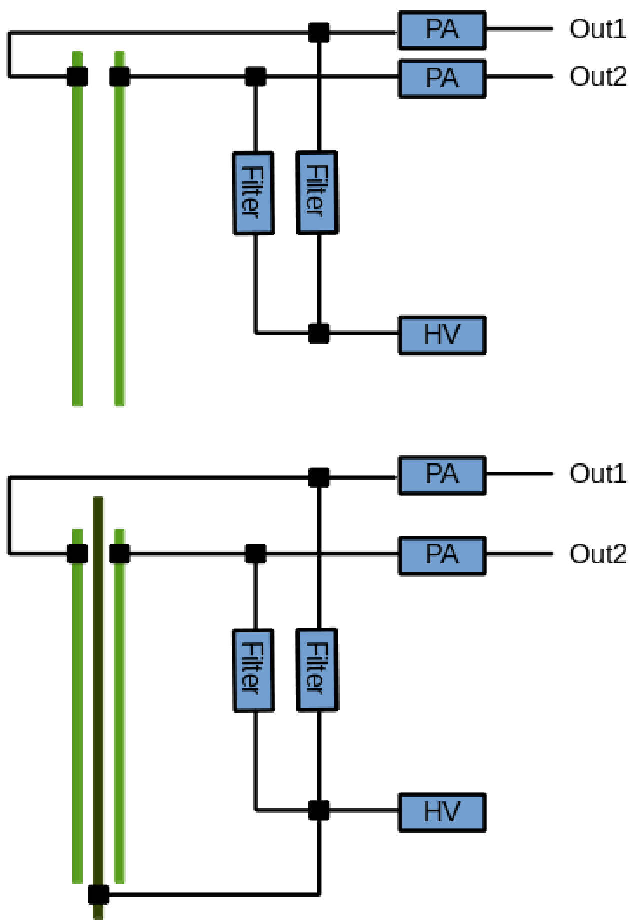


Combined cathode segmentation and electron drift method



- Split cathode to serve each side of the detector independently
- Transversely segmented
- Charge induced by electron drift means only three segments required for azimuthal

Combined cathode segmentation and electron drift method - Issues



- Split cathode will act as a capacitor
- Additional plate must be added and tie to local ground
- Dead region created either side of fission source
- Challenging to manufacture

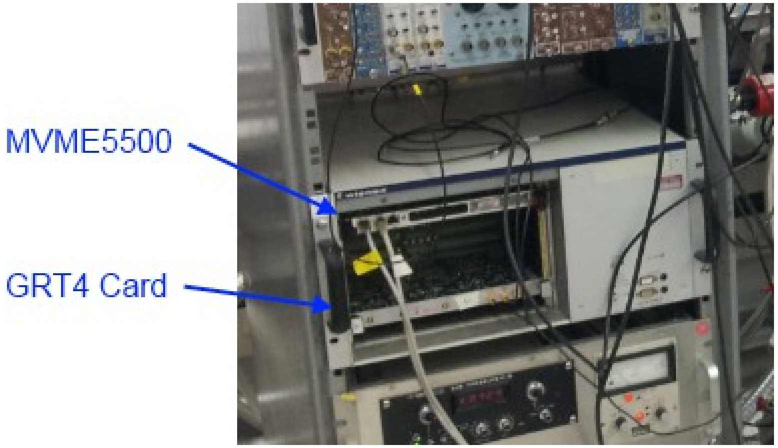
Other Important design considerations

- Electric field linearity
- Grid inefficiency – function of detector and grid geometries,
- Inter electrode capacitances
- Fill gases – fast electron drift with low electric fields, fast neutrons experiments require non-H based gases
- Source design, vapour deposition, self-spluttering

Data Acquisition

- Gamma Ray Tracking 4 Cards
  - 4 channels per card
  - 80MHz ADC's (12.5ns channel width)
  - Event window of ~500 Samples (~5us)
  - Pre-trigger of up to 5us

- MVME5500 single board computer
  - Runs the MIDAS TimeSysLinux firmware
  - Multiple card configuration possible
  - VME bus limit of 4Mbytes/sec

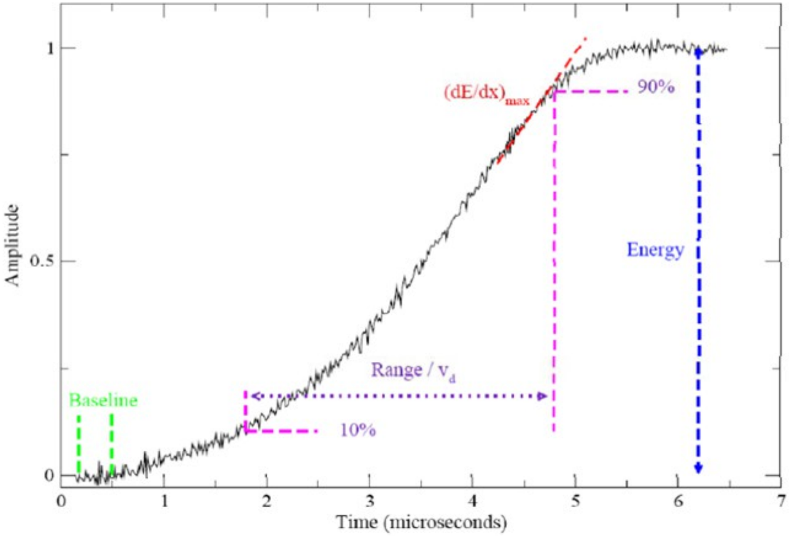


- And PC running:

  - Developed at the Daresbury Laboratory

Data Analysis

- High-pass and low-pass filters
  - Removal of low frequency baseline components
  - Differentiation
- Ballistic deficit correction
  - Resulting from fall time of the amplifiers
- Energy loss in target corrections
  - Gold for 252Cf
  - Mylar for 232Th



- Correction for Frisch grid inefficiency
  - Appears as an early rise of a few % on the pulse traces
- Corrections for energy deposited by neutron-induced charged particle emission (fast neutron experiments only)
- Reconstruction of the segmented anode signals

Data Analysis

- Energy is given by anode pulse hight
- Masses are then given by double E method:

$$m_1 = \frac{E_2 M_{CN}}{E_1 + E_2} \qquad m_2 = \frac{E_1 M_{CN}}{E_1 + E_2}$$

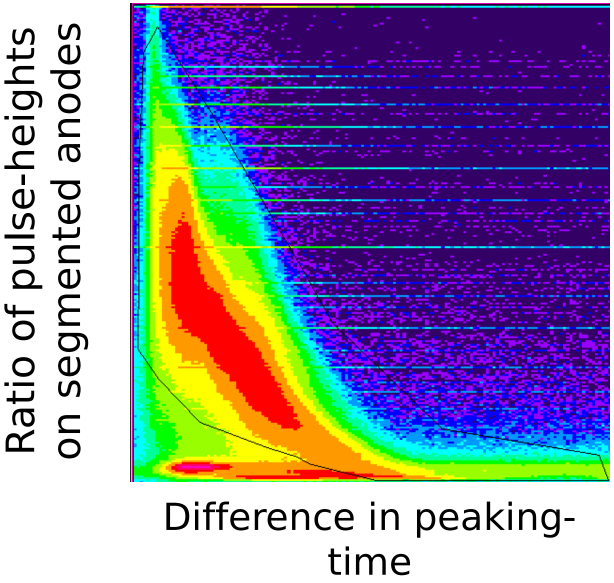
- Angle is determined by methods discussed previously
- Range can be estimated using angle and collection time
- Peak stopping Power can be used to estimate charge

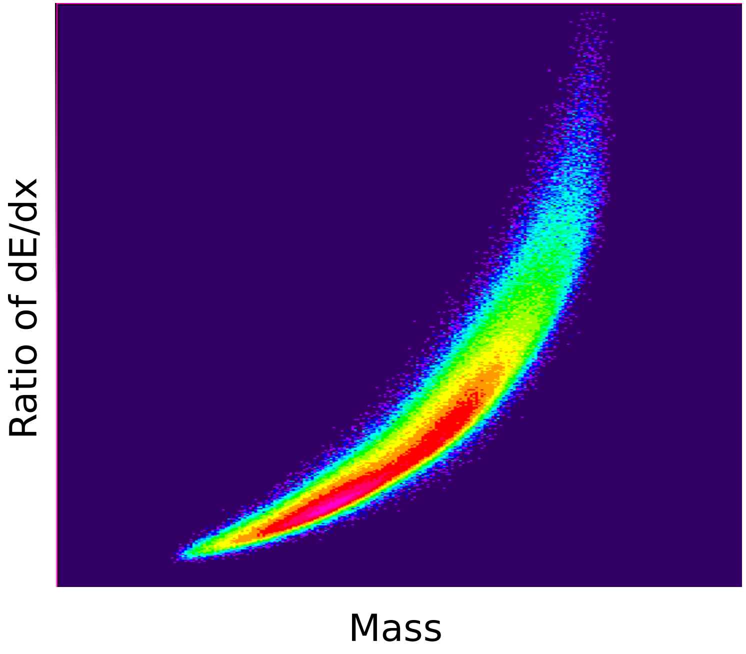
Modelling

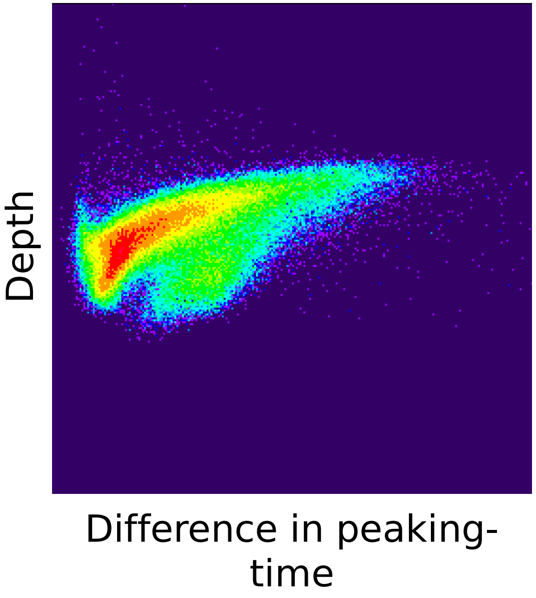
- Neutron transport using MCNP4
- Spice modelling – capacitance effects
- Basic 2D Signal generation using SRIM/Mathematica
- Advanced 3D Signal Generation using SRIM/GMSH/Garfield

252Cf Spontaneous fission at the University of Manchester

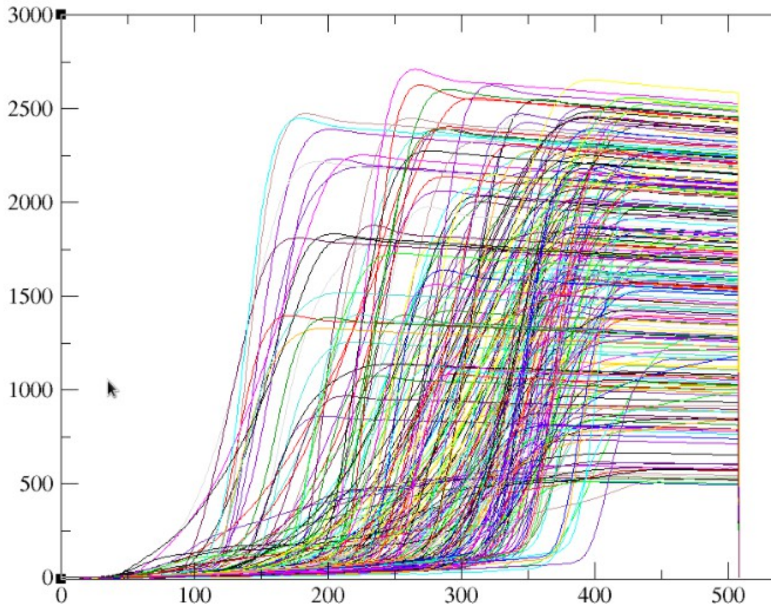
- Large data sets from varying stages of the detectors development.
- Preliminary analysis undertaken on small data subsets
- Results consistent with expectations bar a few anomalies to be investigated



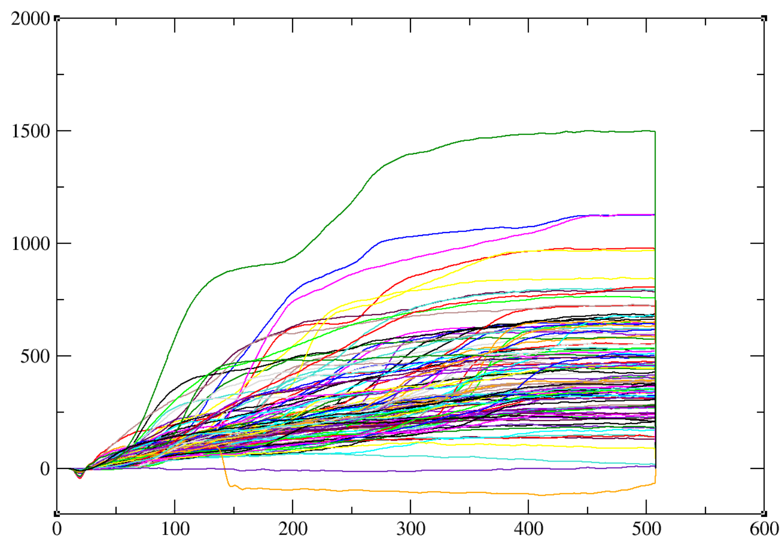




Background test with fast neutrons at the LPSC, Grenoble



- Trace 252Cf in chamber
- Runs conducted at 14MeV
- Evidence of charged particle emission from chamber components
- Cross-sections show events start to become significant above ~6MeV



- Source of emissions confirmed by 2.5MeV
- Al entry window replaced with thin Mylar
- Borated polyethylene collimator

The Future

- ILL, Grenoble - thermal neutrons with 235U target
- nTOF, CERN – white neutron spectrum with energy determined by time-of-flight
- Gammasphere - correlation of prompt gamma emission with fragments from SF source

Sponsors and Collaborators

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