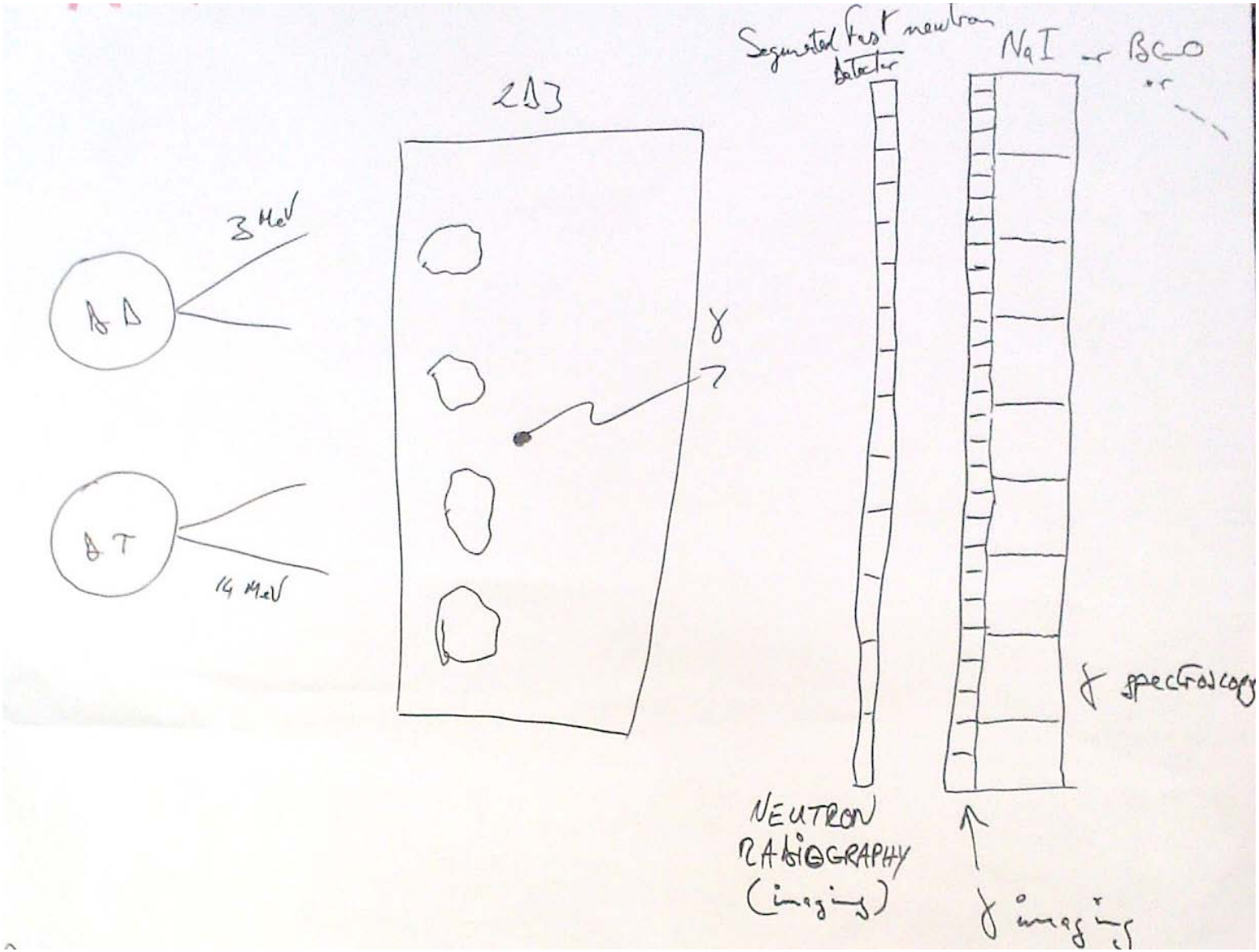
The University Of Sheffield.

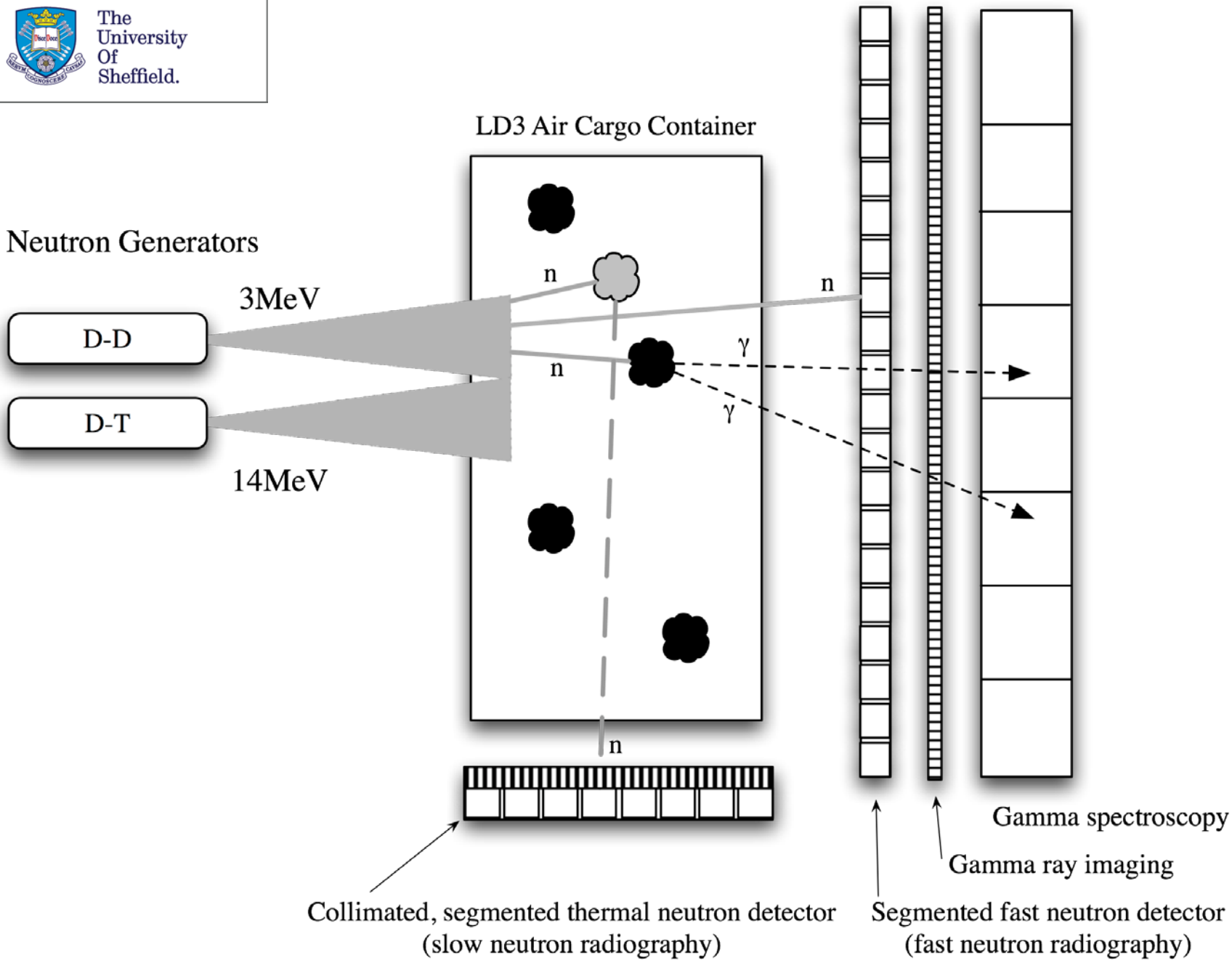
Pulsed Fast Neutron Activation Imaging

John McMillan, The University of Sheffield
Val O'Shea, University of Glasgow

The University Of Sheffield.



The University Of Sheffield.



The University Of Sheffield.

Thermal neutron analysis (TNGA)

Fast neutrons slow to thermal energies within the interrogated object. The thermal neutrons react with nuclides in the object and the prompt capture gamma-rays are detected. Nitrogen and hydrogen can be detected by capture gamma-rays, giving the density distribution of nitrogen and hydrogen within the object.

The University Of Sheffield.

Fast neutron analysis (FNA) and Pulsed fast neutron analysis (PFNA)

The de-excitation gamma-rays released from nuclei activated in fast neutron inelastic scattering events are detected. Specific elements present are identified through the de-convolution of the measured gamma-ray spectra. By pulsing the incident neutrons and making use of neutron time-of-flight, the location of the interacting nuclide may be determined, thereby facilitating three-dimensional elemental imaging. By using two different neutron energies, 2.5 and 14.1MeV, differences in the interaction cross-sections will give further information about the ratios of elements present.

The University Of Sheffield.

Pulsed fast neutron transmission spectroscopy (PFNTS)

This is essentially neutron radiography. Pulsed beams of neutrons are directed through the object under interrogation and the transmitted neutrons are detected in a bank of fast neutron detectors. Knowledge of the total cross-sections for H, C, N, O, and other critical elements, allows the measured transmission spectra to be unfolded to provide densities of elements present in the object.

The University Of Sheffield.

Pulsed fast-thermal neutron analysis (PFTNA)

In the period after the fast neutron pulse has ended, some of the fast neutrons remaining within the object thermalize and are captured by elements such as H, N, Cl and Fe. The prompt capture gamma-rays are detected by the same detectors and the events stored separately from the inelastic scattering spectrum. By combining fast inelastic neutron scattering, thermal neutron capture and delayed activation analysis, a large number of elements contained in an object can be measured.

The University Of Sheffield.

Fast neutron scattering analysis (FNSA)

Fast neutron scattering analysis (FNSA) is an alternative approach in which neutrons scattered out of the interrogated material are detected. The type, amount and positions of the nuclides responsible for the scattering are determined from measurements of the dependence of scattered neutron intensity and energy on scattering angle and the incident neutron energy.

The University Of Sheffield.

Delayed fission analysis (DFA)

After all neutrons in the pulsed beam have thermalised and been absorbed, the continued emission of neutrons and gamma-rays by the interrogated object are a signature of the presence of fissile material. This is clear indicator for special nuclear materials, in particular weapons grade uranium, which is difficult to detect by other methods.

The University Of Sheffield.

i) Gamma-Rays From Fast Neutron Inelastic Scattering

ii) Prompt Neutrons From Fast Fission

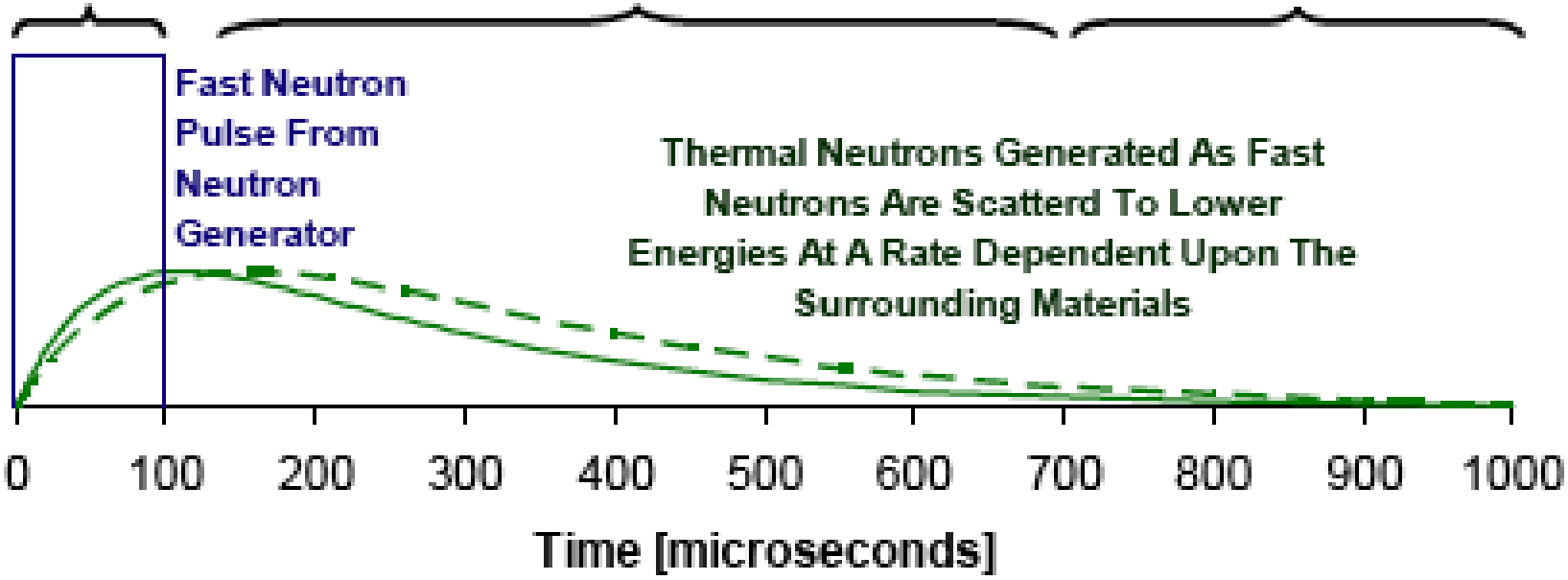
i) Thermal Neutron Capture Gamma-Rays

ii) Prompt Neutrons From Thermal Fission

iii) Thermal Neutron Die-Away

i) Gamma-Rays From the Decay of Activation Products

ii) Delayed Fission Neutrons



The University Of Sheffield.

Best technique?

Determine by modelling, experimentally or fusion of more than one technique?

The University Of Sheffield.

Modelling and Simulation

MCNPX chosen as main simulation platform

- industry standard for low energy neutrons and coupled gamma problems

Some simulations obtained from Euritrack

The University Of Sheffield.

Facility

The University Of Sheffield.

Neutron generator

Three manufacturers shortlisted

VNIIA -Russia

NSD-Fusion - Germany

Thermo-electron -USA

Temporary machine available from Liverpool

The University Of Sheffield.

Detectors

In the initial stages detectors are needed to monitor the generator - neutrons and gamma

Fast neutron detectors

BC-501 (NE-213); pulse shape discrimination liquid

and EJ-410 (NE-451, BC-720); acrylic plus ZnS

Currently testing with AmBe neutron source

The University Of Sheffield.

Data Acquisition

MIDAS - A versatile Data Acquisition System
for medium scale physics experiments.
https://midas.psi.ch/

Data collection from local and/or remote hardware sources.
Data recording to common storage media.
Full data flow control.
Event-by-event analysis through PAW or Root based application.
GUI histogram visualizer application.
Range of hardware supported.
Open source, GPL licence.

Experiments being undertaken on slow control and simple acquisition