University of Glasgow

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Neutron Screening for Airborne Cargo

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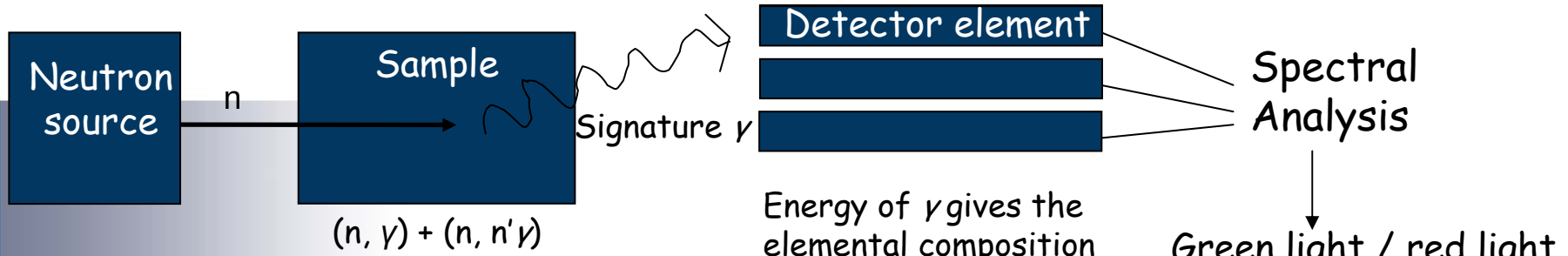
Outline

- Neutron Activation Analysis
  - Pulsed Neutron
  - Associated Particle
- MCNP simulation set-up
- MCAM design set-up
- Future work

IEEE NSS 2009

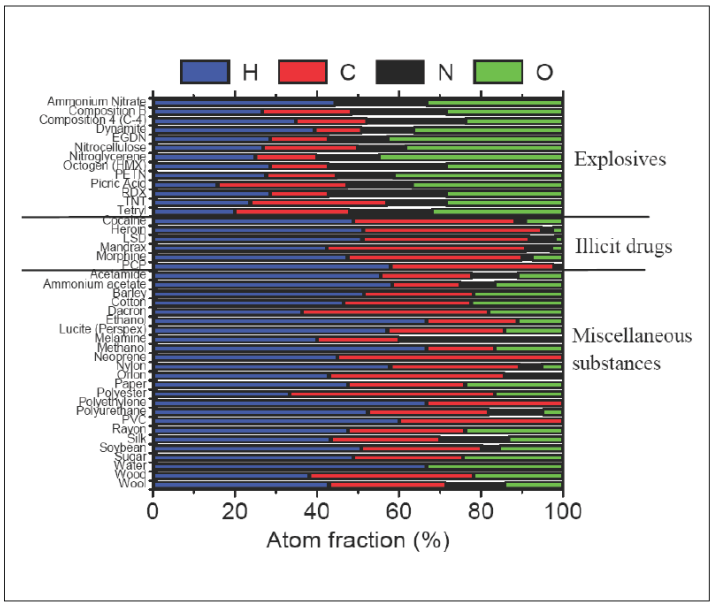
– Homeland Security
- *50+ Posters*
- *20 presentations (1 plenary)*
- *1 workshop – nuclear forensics*
- *1 Short Course - Nuclear Science for Security Applications*

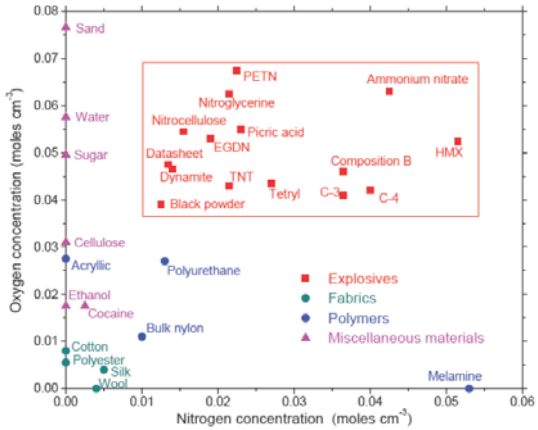
Neutron Activation Analysis

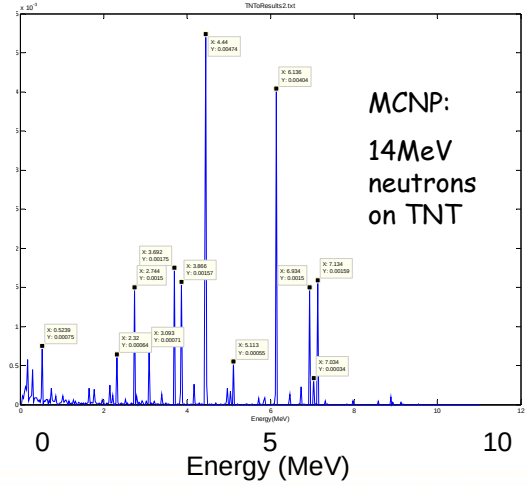


Energy of γ gives the elemental composition and the time information gives the position

Green light / red light system for secure or threatening cargo eliminates human interpretation of results

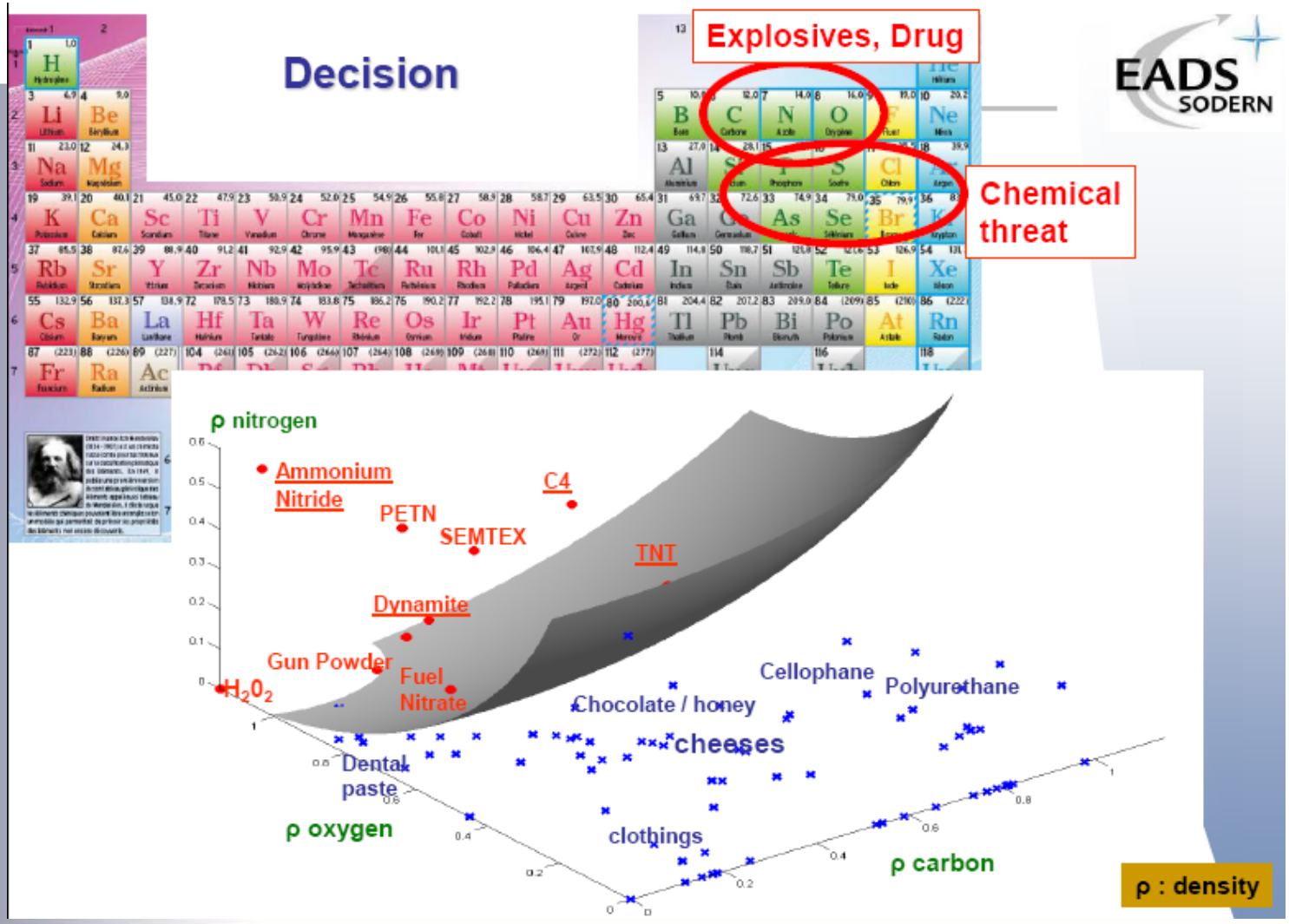






Ratio of C/H/N/O elemental density indicates explosives/drugs, high concentration of chlorine indicates possible region containing cocaine.

Neutron Activation Analysis



3D Elemental Maps of Cargo – γ-ray time

Pulsed Neutrons

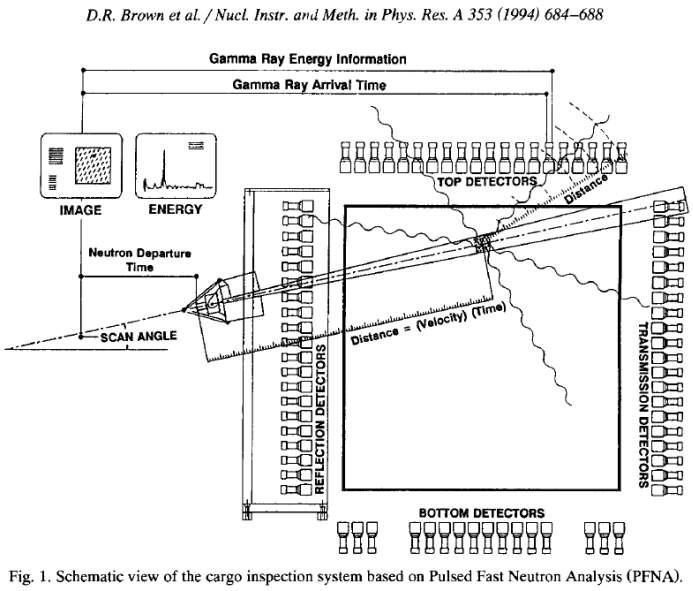
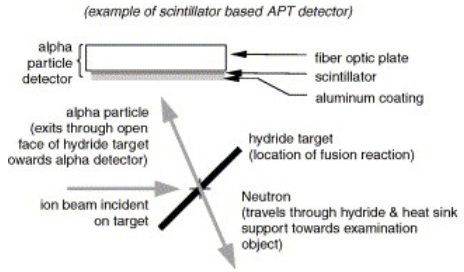


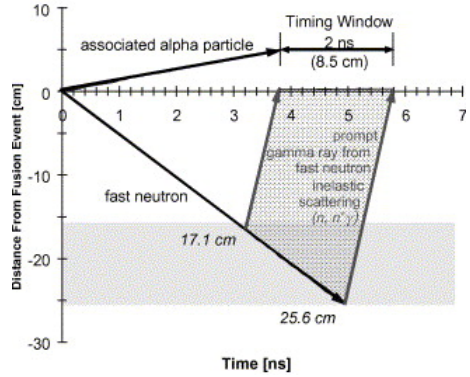
Fig. 1. Schematic view of the cargo inspection system based on Pulsed Fast Neutron Analysis (PFNA).

2 methods for time resolving γ-ray spectra

Associated Particles



Nuclear Instruments and Methods in Physics Research B 241 (2005) 753–758, D.L. Chichester et al.

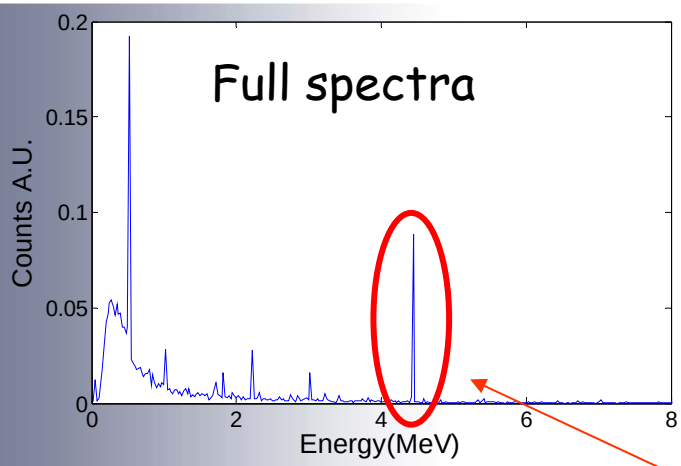


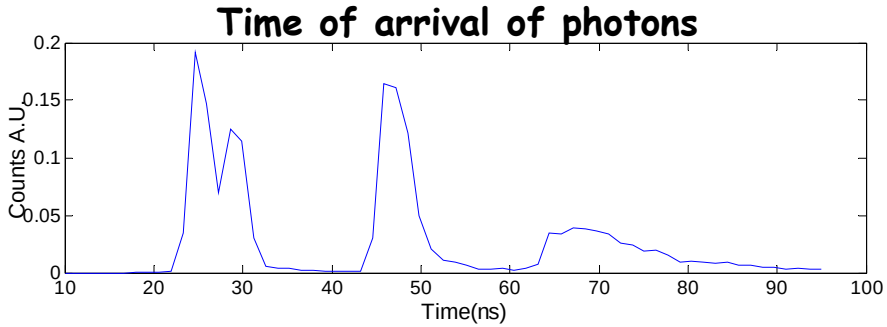
- Pulse width defines voxel length
- Collimated beam gives voxel width
- Scanning of beam or sample creates 3D elemental map of sample
- Pulse width for portable generators in the μs region, 14MeV neutrons travel at 5cm/ns, 0.3μs pulse width = 1.5m voxel length
- Can use high neutron yield = shorter scanning times

- Position and timing of associated helium ion from D-D or D-T fusion reactions allows gives a voxel position for gamma creation
- ns timing resolution gives voxel lengths ~ 10cm, however low flux must be used which increases scanning times

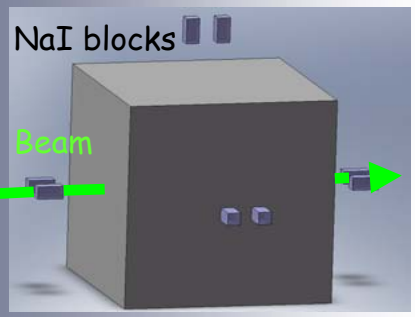
MCNP Time Resolving Spectra

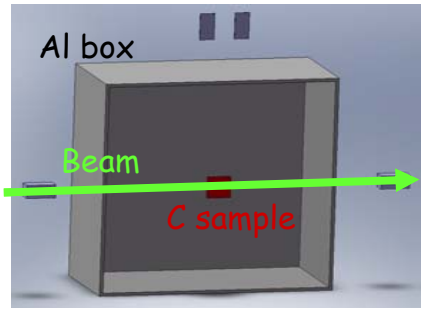
- MCNP F4 used – Flux tallies over detector cells separated into many fine bins multiplied by the cross sections for Compton Scattering and Pair Production (F8- pulse height tally cannot be used with neutron transport problems)
- C++ code written to read MCNP output files and collect time and energy data from many bins and collect to a simple file which can be read into Matlab program for plotting and analysis

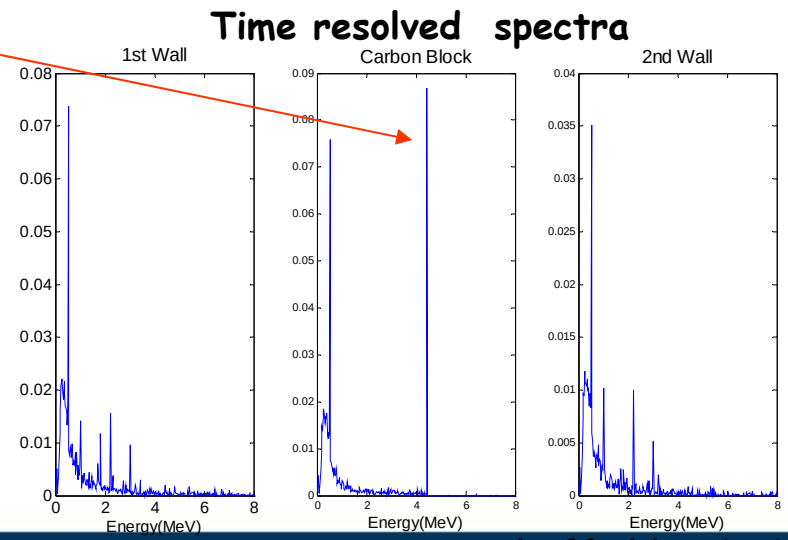




Carbon peak 4.4Mev



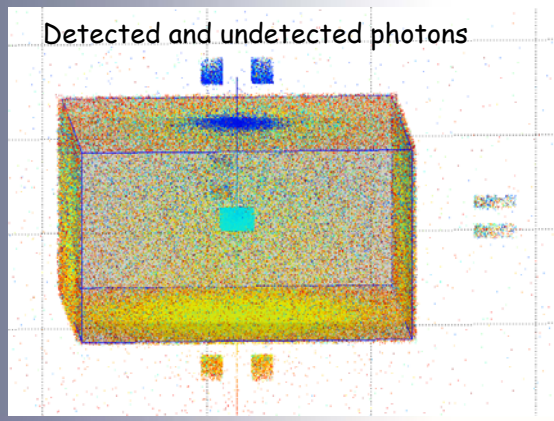




MCNP Simulations: Towards Signal to Noise

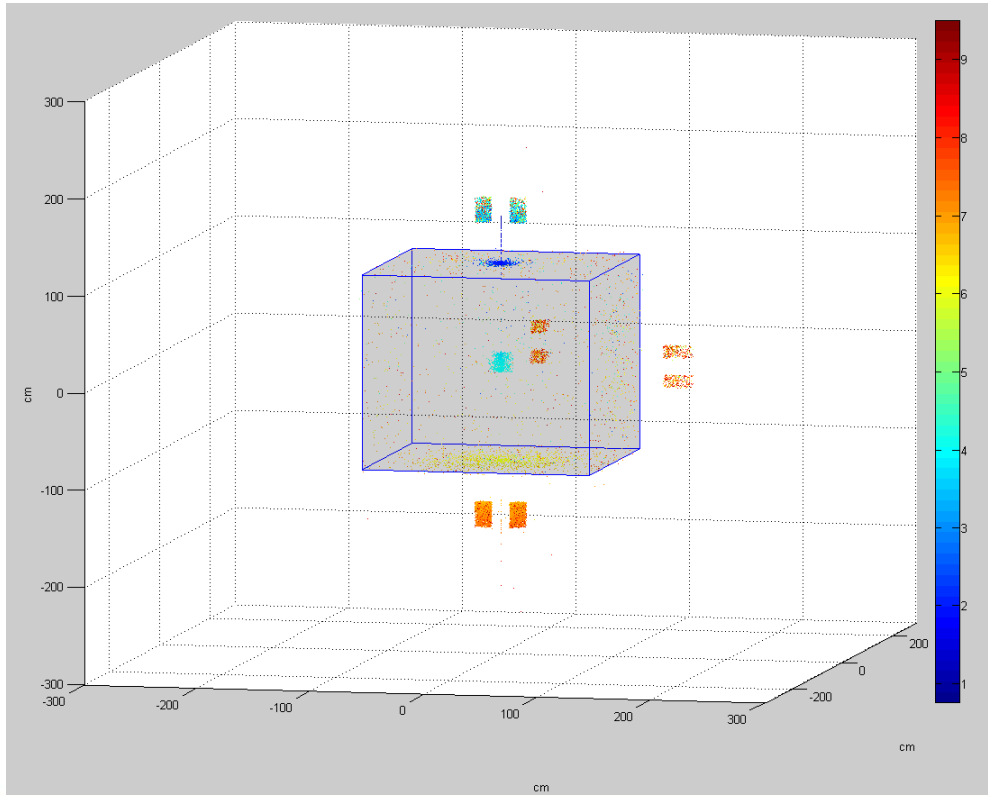
- PTRAC file: an optional output from MCNP which gives the history of all the particles (Gigabytes for each simulation)
- C++ program written to find position, time and the event of each created photon
- Can be used to find the signal-to-noise in each detector when looking at individual samples at different TOF positions
- Also used for the optimisation of the shielding of the source and the detectors

Detected and undetected photons

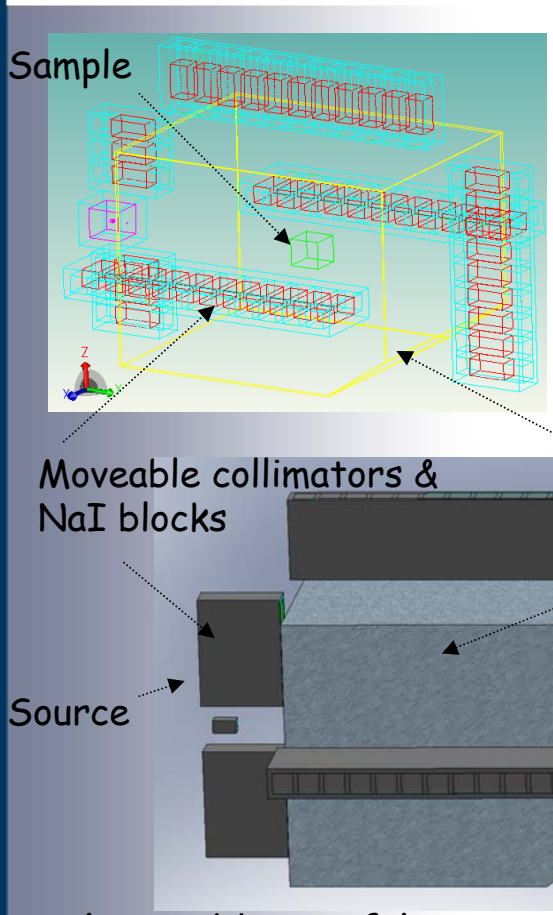


Positions of creation of detected photons

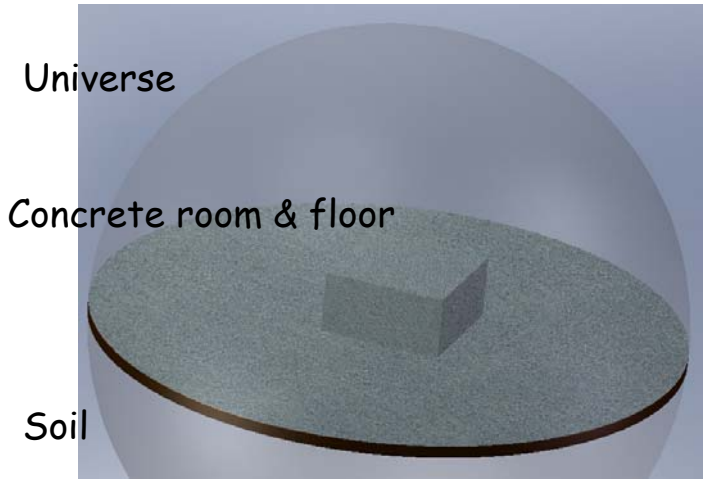
Their time of creation in shown in colourbar



MCAM (Monte Carlo Automatic Modell



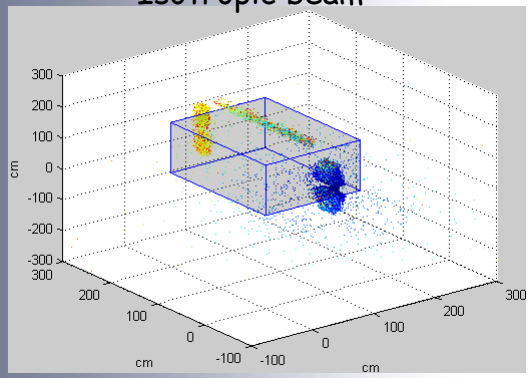
- MCAM has been developed as an integrated interface program between commercial CAD software such as Solidworks and MC codes
- Can create complicated experimental set-ups quickly and transfer to MCNP, good for problem visualisations and code checking



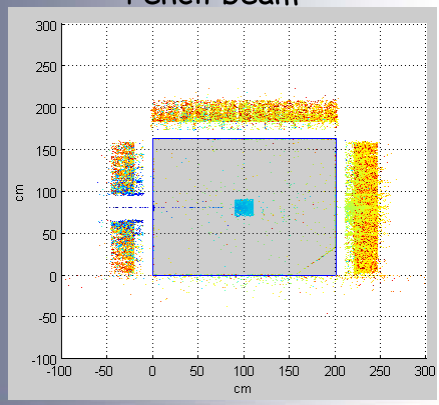
http://www.fds.org.cn/english/mcam/overview.html

Future Work

Isotropic beam

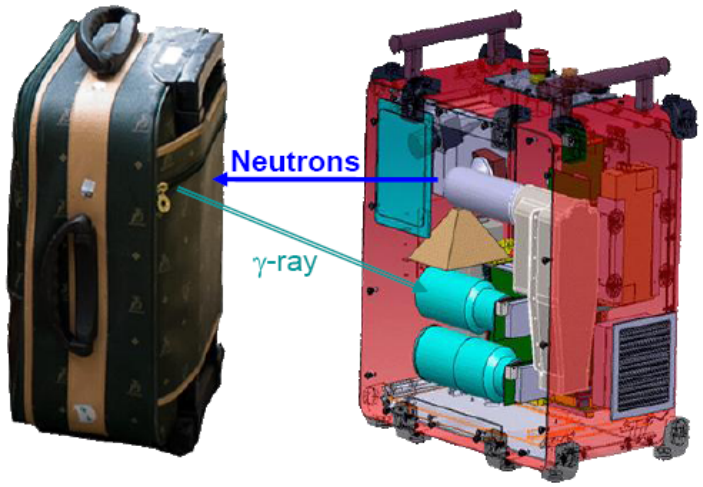


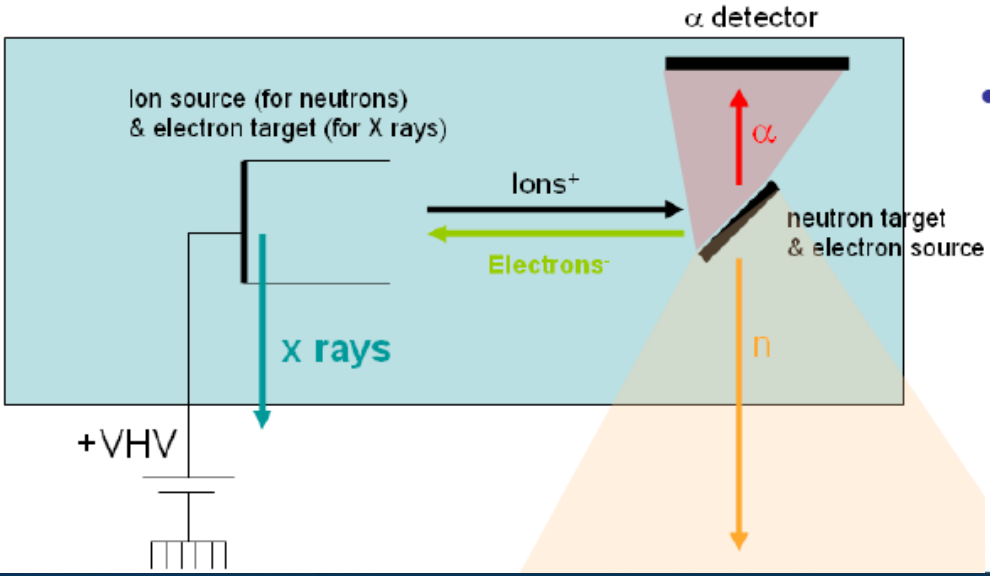
Pencil beam



- Will use
  - analysis programs written for time resolving spectra
  - analysis programs written for SNR
  - MCAM experimental model built
  - MCNP experience to improve on current models / 2-stage simulation
- To investigate
  - Continuous, pulsed and API neutron sources
  - Different detector materials
  - Different collimation procedures
- To compare
  - Time taken to find various samples
  - At a certain SNR (high probability of detection with low probability for false alarms)

The Competition





EADS Sodern at NSS Florida

- Fully integrated and self-sufficient device
- Fitting in a 30kg suitcase
- Capable of detecting
  - ✓ Radionuclide,
  - ✓ Explosive,
  - ✓ Drugs,
  - ✓ Chemical threats
- Could also be used for mine detection

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