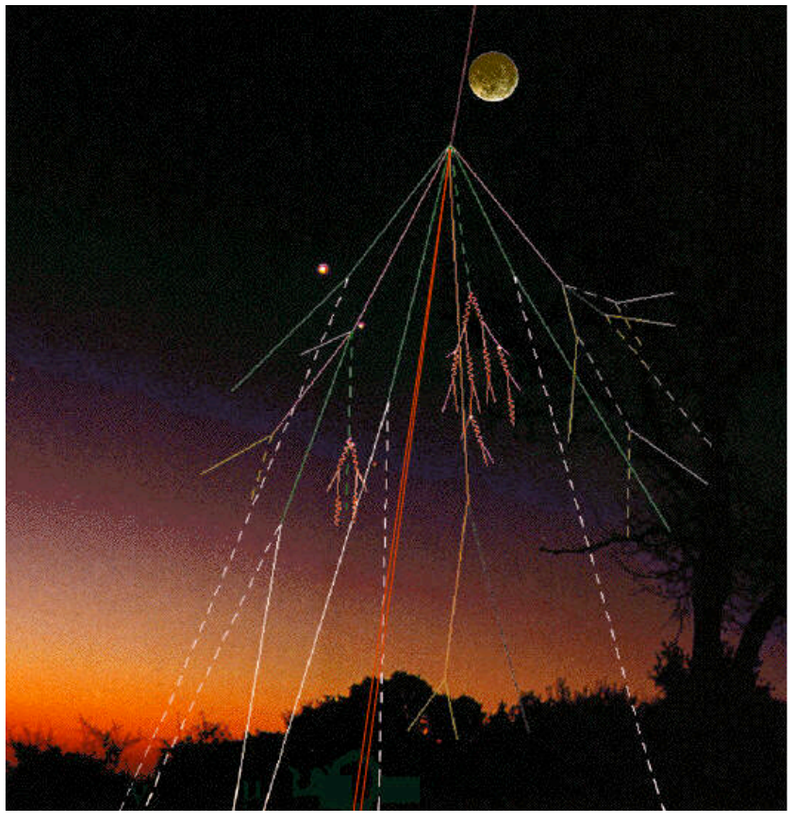
CREAM TEA

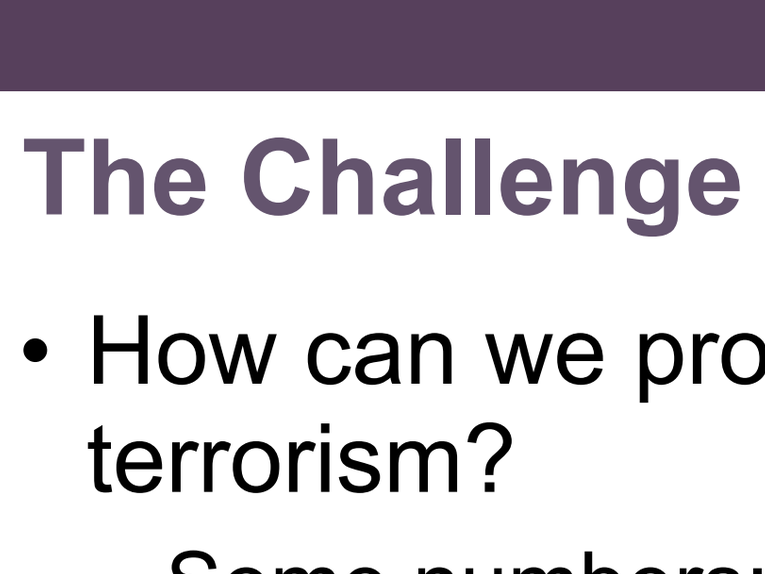
Cosmic Ray Extensive Area Mapping for Terrorism Evasion Application

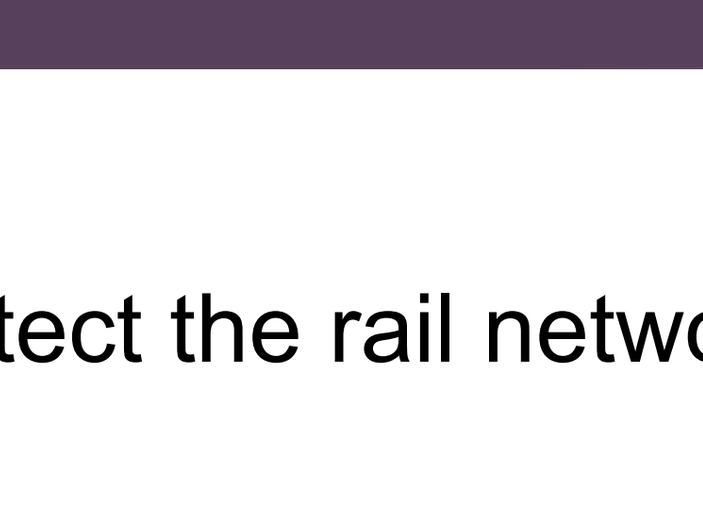
Ryan Nichol



The Challenge

- How can we protect the rail network from the threat of terrorism?
  - Some numbers:
    - Over 1,000,000,000 journeys per year
    - Over 2,500 stations



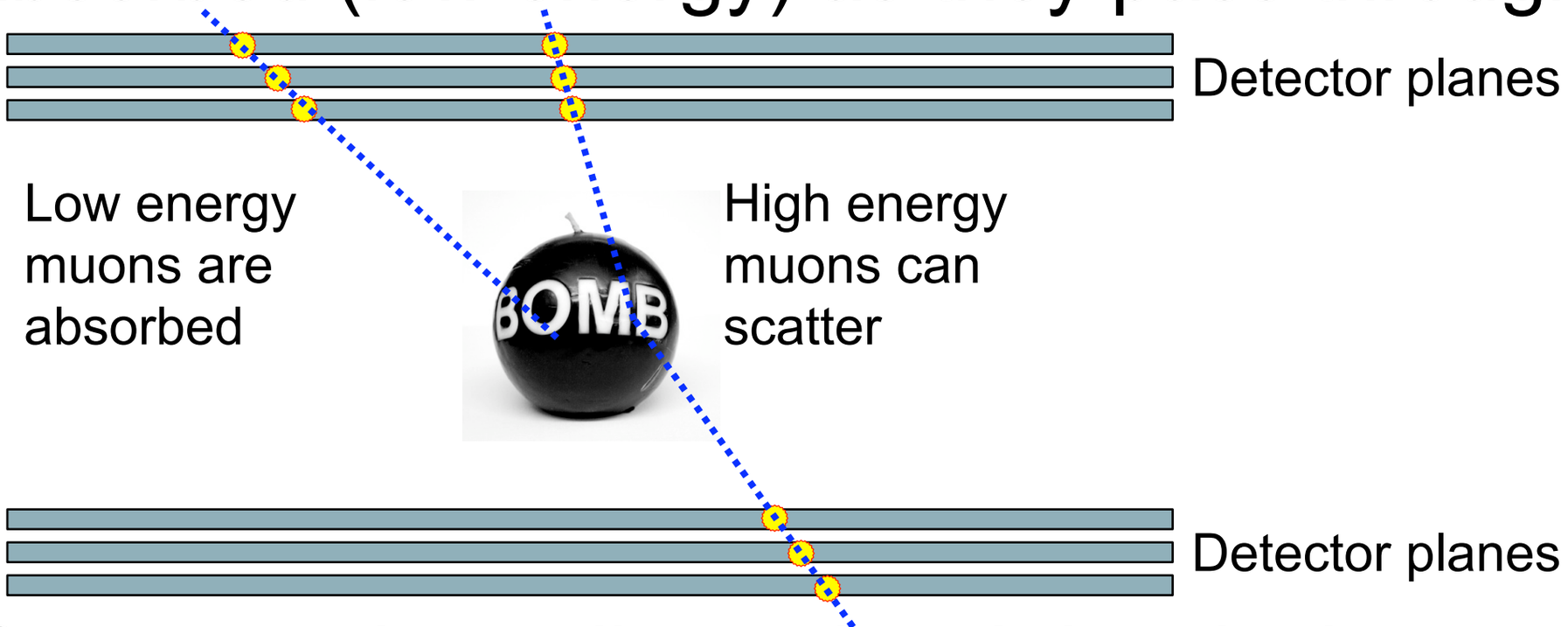


``...given the very large passenger flows and thousands of entry points on the UK rail and underground networks, 100% airport-style screening is currently not feasible"

Tom Harris 2008 (then the rail minister)

The Idea - Cosmic Ray Muon Tomography

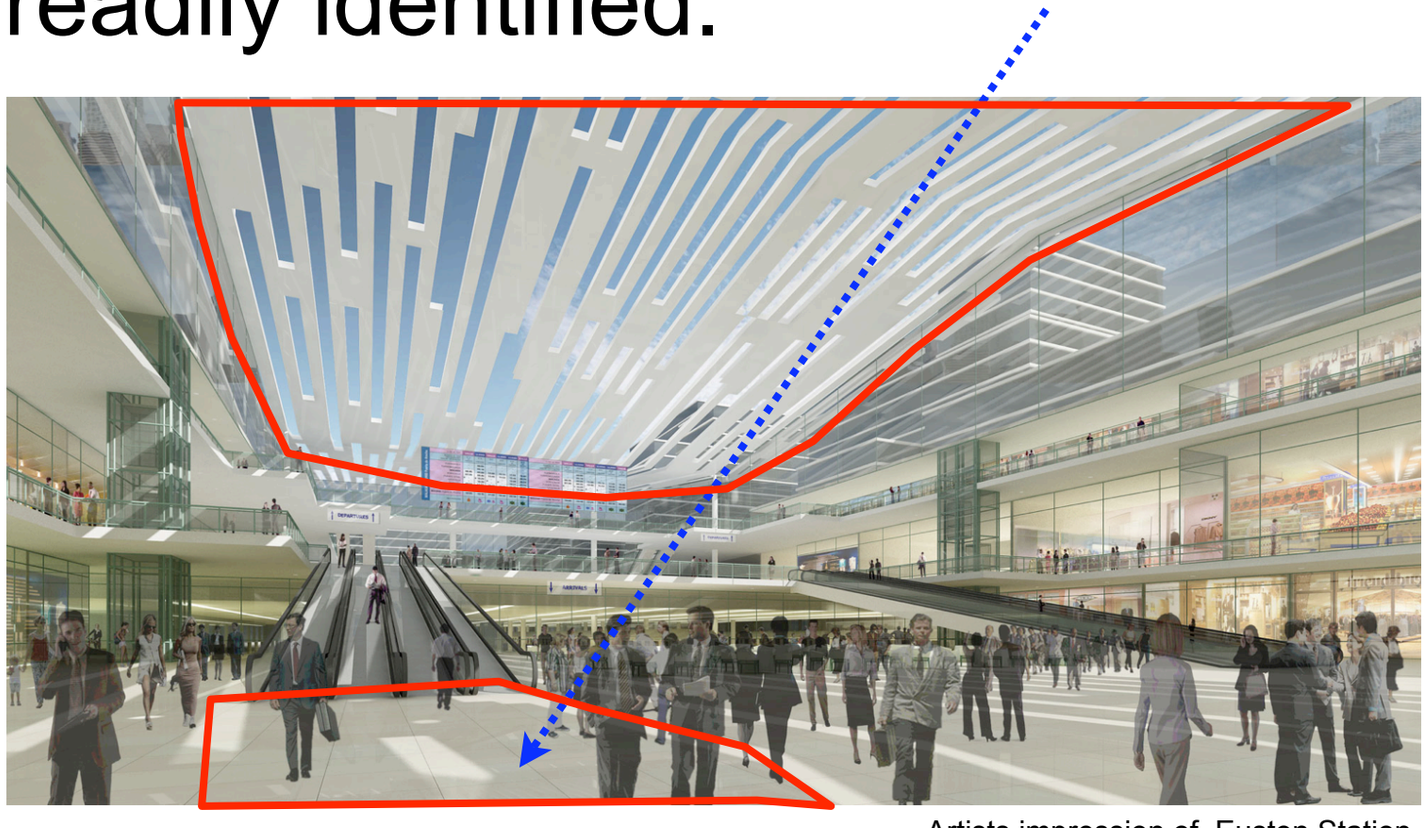
- Over 10,000 cosmic ray muons a minute stream through each square metre of the Earth's surface.
- These particles either scatter (high energy) or are absorbed (low energy) as they pass through matter.



- Creates a three dimensional density image.
  - Cosmic ray imaging is an old idea (1950's) and has been used to image: pyramids, volcanoes, mines, ...

The Solution??

- Equip very large volumes (eg. train stations) with cosmic ray detectors above and below.
- Using background subtraction techniques can produce fast (time scale of minutes) density images.
- High density objects (nail bombs, fissile material, etc.) can be readily identified.



Artists impression of Euston Station

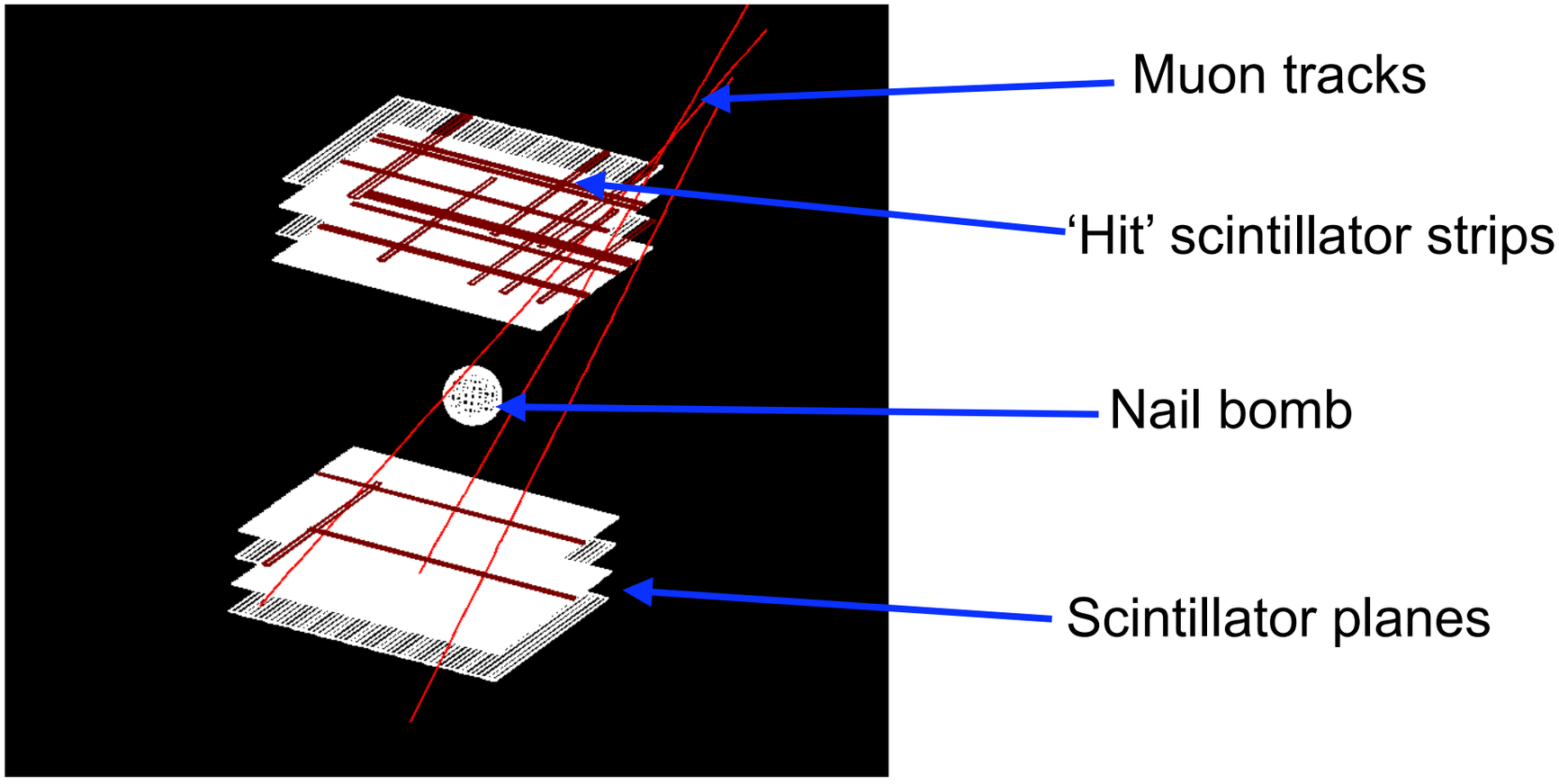
CREAM TEA - Phase I

- Phase I of the project is a 12-month feasibility study with two main strands:
  - Computer simulations (using the high energy physics GEANT Monte Carlo tool) to:
    - Determine the capabilities (and limitations) of the technique for imaging large volumes.
    - Optimise potential detector geometry.
    - Develop image processing tools.
    - Simulate the laboratory test-stand.
  - A laboratory test-stand using plastic scintillator detector modules
    - Validate the simulation results.
    - Perform imaging benchmarking tests.

The Simulation - Current Status

- GEANT4 is the particle physics communities tool of choice for simulation.
  - Contains all known particle interactions with matter.
- We have a rudimentary simulation, used as part of a fourth year undergraduate project.

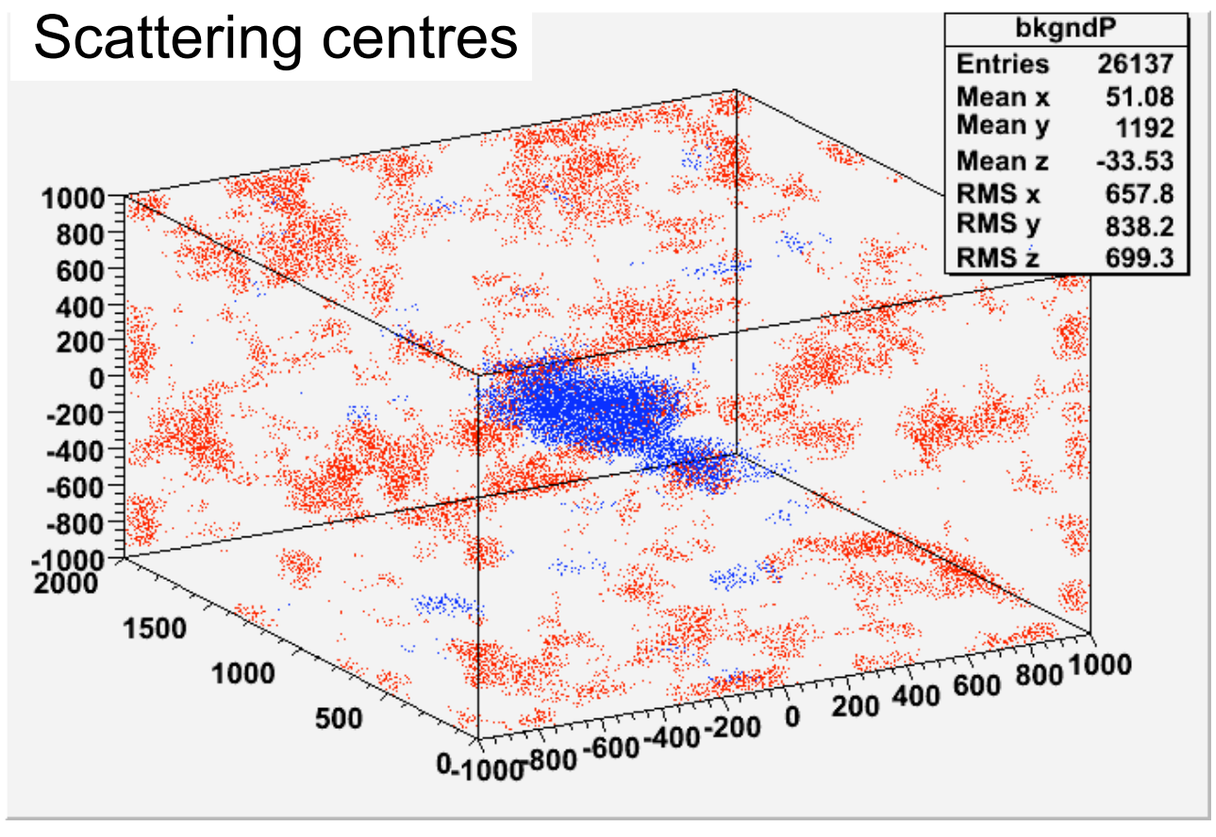
GEANT4 visualisation of CREAM TEA test-stand



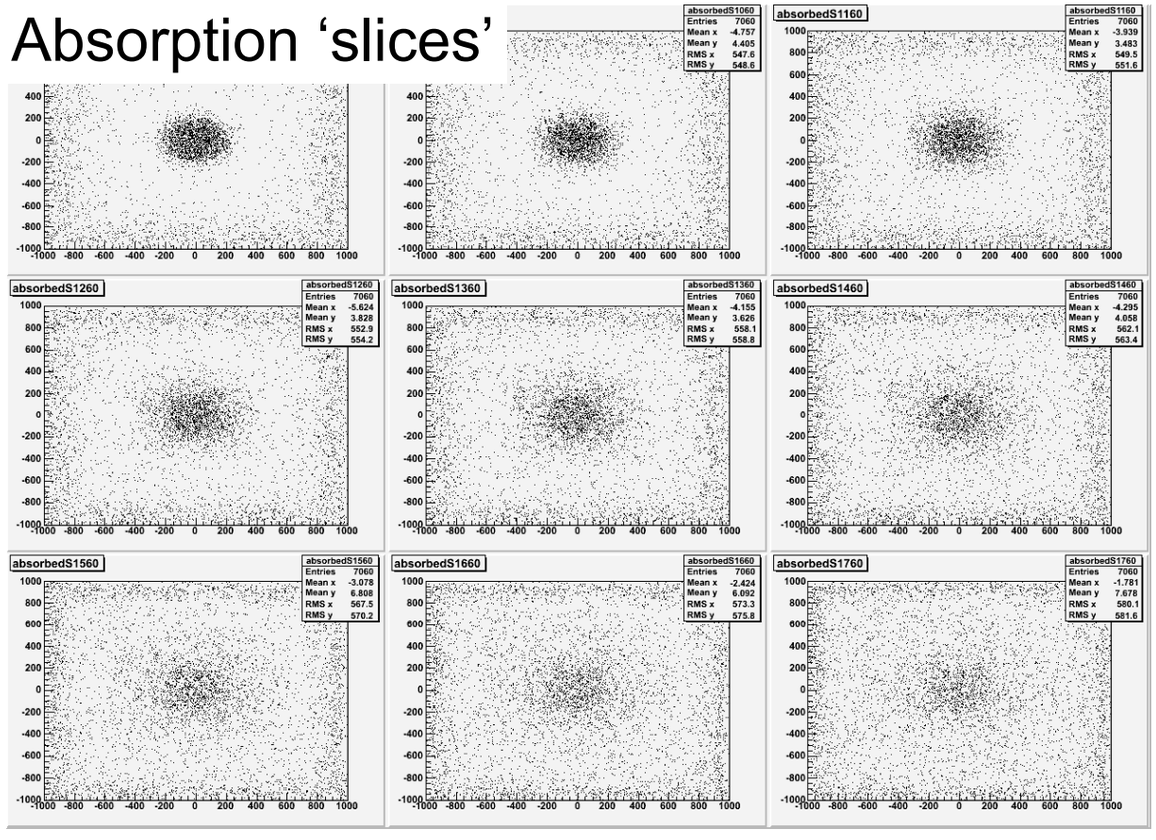
The Simulation - Preliminary Results

- Simulating a 30cm nail bomb between detector planes (see previous slide) exposed for 10 minutes.
  - Left plot shows the background subtracted scattering centres.
  - Right plot shows absorption in vertical slices.

Scattering centres

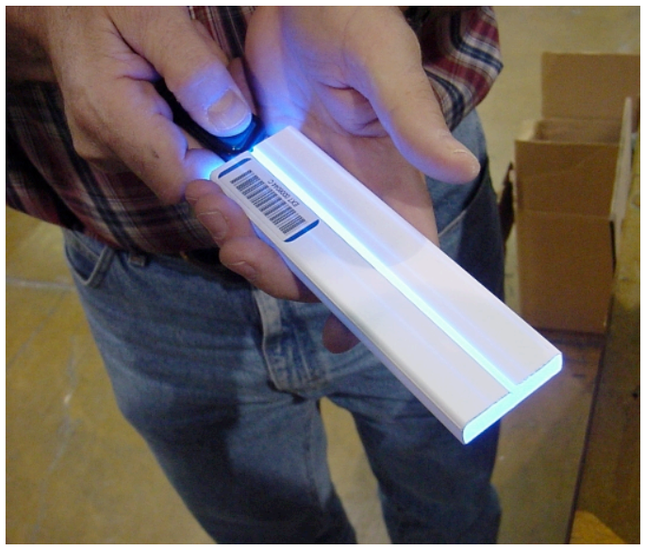


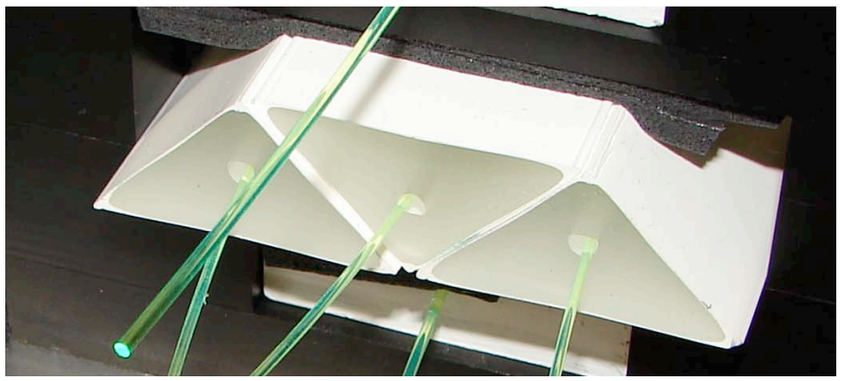
Absorption ‘slices’



The Test-Stand Detector

- Same detector technology as the MINOS and MINERVA detectors.
  - Plastic scintillator is a solid inert material (so none of the safety concerns of liquid or gas based detectors).
  - The MINOS Far Detector has 25,000 m^2 of scintillator.
  - The test-stand modules are $1m^2$ with 24 strips per plane.





  - MINERVA obtains 1.5mm position resolution using 33x17mm triangular ‘strips’ and signal weighting.

The Unanswered Questions

- How good does the detector resolution need to be?
- How thick does each set of detector planes have to be?
- What is the optimum detector segmentation (shape + size) and separation?
- Do the electronics need to record signal strength or just digital hit detection?
- How much detector coverage is necessary (4π is great but so is daylight)?
- How long can the detector strips be before losing efficiency?
- ....

Summary

- Muon tomography is an old idea (with its roots in London at Birkbeck College) seeing new light with 21st computer image processing techniques.
  - Cosmic ray muons may provide one of the tools with which to tackle the threat of terrorism.
    - In addition to securing large enclosed spaces (train stations, etc.) the technology is easily adaptable for other security purposes (eg. cargo screening).
- Support is needed to move forward with the CREAM TEA project

Task	FTE
1) Phase I -- Feasibility Study	
1.1) Initial Simulations	0.2
1.2) Hardware Benchmarking	0.1
1.3) Further Simulations	0.2
1.4) Test-stand validation of simulation	0.2
1.5) Simulate CREAM TEA detector prototype	0.3
2) Demonstrate Feasibility