Cosmic-ray tomography

Musing on muons

How to detect smuggled uranium and plutonium using muons

AMERICANS may no longer fret about being showered with nuclear-tipped ballistic missiles, but the idea that an atom bomb might enter their country in a shipping container or on the back of a lorry is still one that keeps the security services awake at night. They may sleep more easily, though, if an idea being developed by Michael Staib of the Florida Institute of Technology, in Melbourne, and his colleagues comes to fruition.

Dr Staib is using naturally generated subatomic particles called muons to look inside places where such bombs, or the nuclear explosives needed to make them, may have been hidden by smugglers. At first sight this seems crazy. The muons in question drizzle down from the atmosphere at the rate of only one per square centimetre a minute. But, as Mr Staib told a meeting in Atlanta of the American Physical Society on April 2nd, this is enough for a practical muon scanner.

Muons are like electrons, though heavier and unstable. They are produced when cosmic rays (fast-moving atomic nuclei from space) hit the atmosphere. The reason they might be useful for detecting nuclear explosives is that they are scattered more by heavy atomic nuclei, such as those of uranium and plutonium, than by lighter ones—even including relatively heavy elements such as lead. Clever electronics can tell the difference. Someone wanting to smuggle uranium or plutonium might shield their contraband from detection by a Geiger counter using lead. But that would be no shield against detection by muons.

The original idea, dreamed up in 2003 at the Los Alamos National Laboratory in New Mexico, was to use detectors called drift tubes to track muons through a cargo. Decision Sciences, a company spun out of that effort in 2005, has been refining this approach since then. It says it will install a container-size demonstration unit in a port in the Bahamas this summer, though it will not reveal any technical details.

Drift tubes, however, are unwieldy. They may also be unable to pick out smaller lumps of contraband. Mr Staib and his colleagues think they can do better. They have been working with another type of detector, called a gas electron multiplier (GEM). GEMS are a tenth of the size of drift tubes, and consist of perforated foil embedded in a thin plate filled with gas. As a muon passes through, it dislodges electrons from the gas, leaving a trail which the ▸▸

▸ electronics can discern.

Mr Staib's prototype can see a piece of uranium 4cm across hidden in a parcel 30cm on each side—too small, still, to be of serious use, but a hundredfold improvement on an initial effort two years ago. On top of that, it has detectors on the sides as well as above and below. This means it can locate a suspicious item precisely within a given volume of space.

The next step is to build a cubic-metre-sized system. Marcus Hohlmann, Mr Staib's boss, expects this to take less than three years and to cost about $300,000. Scaling up beyond that is just a matter of building bigger detectors and tweaking the software to cope with more muons. The team at Los Alamos originally put the cost of scanning all the lorries coming into the United States at $1 billion a year. That sounds a lot. But it would be only 0.14% of America's defence budget. ■

Some corrections and clarifications on this article:

- Contrary to the statement at the beginning of the second paragraph, Mike hasn't quite earned his Ph.D., yet. At the time of the writing of this article, he is preparing his M.S. thesis on muon tomography.
- Our group does not and has never claimed that we originally "developed muon tomography." That credit for the originally invention of this intriguing technique clearly belongs to the group of researchers at Los Alamos National Laboratory led by Dr. Chris Morris. In all our publications on the subject in the scientific literature we make it very clear that Los Alamos deserves that credit by citing their work first and as the original idea. Mike actually even briefly discussed these original developments at Los Alamos, and similar work at INFN and DSIC explicitly in his presentation at the APS meeting before discussing our own recent work to give the appropriate credit and background information. The slides from that public presentation were made available to the author of this article as a reference for his research on the subject. Unfortunately, these issues are represented in a somewhat misleading fashion in the article. I also find the choice of wording ("dreamed up in 2003 at the Los Alamos National Laboratory") where the article does address LANL's rightful claim to the invention of MT a bit inappropriate. Obviously, we do not have control over how journalists write their articles.
- What we DO claim is that we bring different, more miniaturized detection technology (GEMs) to muon tomography. It is a fact that a GEM detector with two-dimensional readout is about ten times thinner than two crossed drift tube detectors. Our tracking stations are about 10cm thick while the LANL and DSIC stations are more on the order of 100cm thick as can be seen in publicly available images of those stations. Having a smaller detector with better spatial resolution allows us to put the detectors closer together.

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