CLAIMS

1. A method of analyzing material in a plurality of voxels of a target, the method comprising:

(a) illuminating the said plurality of voxels with a photon beam, such that the said beam enters and exits a first voxel selected from said plurality of voxels, and upon exiting said first voxel enters and exits remaining voxels selected from said plurality of voxels in a predetermined sequence;

(b) measuring at least one energy spectrum of photons scattered from each of the said selected voxels;

(c) determining, using the said at least one measured energy spectrum, an average atomic number in each of the said selected voxels;

(d) determining a flux of photons incident on the first selected voxel;

(e) for the first selected voxel, using the determined photon flux, the determined average atomic number, the measured at least one energy spectrum, and predetermined values of a scattering kernel, estimating an average mass in the said first selected voxel;

(e) for each of said selected remaining voxels, in the predetermined sequence in which the beam transits them,

(i) determining a flux of photons incident on the selected remaining voxel, based upon the photon flux incident on a prior voxel in the predetermined sequence, the determined average atomic number in the prior voxel, the estimated average mass in the prior voxel, and predetermined values of a scattering kernel; and

(ii) estimating an average mass in the said selected remaining voxel, using the incident flux into the selected remaining voxel, the average atomic number for the selected remaining voxel, the at least one energy spectrum for the said selected remaining voxel, and predetermined values of a scattering kernel;

(e) estimating a flux of photons exiting from a final selected voxel, based upon the photon flux incident on the said voxel, the determined average atomic number in the said voxel, the estimated average mass in the said voxel, and predetermined values of a scattering kernel;

(f) measuring a measured exit flux exiting the target;

(g) computing a difference between the estimated exit flux and the measured exit flux;

(h) computing a corrected estimated average mass in each selected voxel based upon the computed difference between the estimated exit flux and the measured exit flux; and

(i) generating a signal based upon the corrected estimated average mass computed.

2. The method of claim 1, wherein computing a corrected estimated average mass in each selected voxel further comprises assigning, for each said voxel, a contribution to the computed difference between the estimated exit flux and the measured exit flux in proportion to the estimated average mass in that voxel.

3. The method of claim 1, wherein computing a corrected estimated average mass in each selected voxel further comprises using a minimization procedure to adjust the estimated average mass in each said voxel so that the computed difference between the estimated exit flux and the measured exit flux is minimized.

4. The method of claim 1 wherein computing a corrected estimated average mass in each selected voxel further comprises adjusting the determined average atomic number in each said voxel so that the computed difference between the estimated exit flux and the measured exit flux is minimized.

5. A system for analyzing material in a voxel of a target, the system comprising:

a device for generating a photon beam;

a means for determining a photon flux incident on the voxel;

a detector configured to view the target and equipped to detect an energy spectrum of photons scattered from the voxel; and

a processor; wherein

the processor is configured to determine, using the energy spectrum, the average atomic number in the voxel; and

the processor is further configured to determine a mass in the target voxel using the incident flux, the average atomic number, the energy spectrum, and predetermined values of a scattering kernel.

6. A method of analyzing material in a voxel of a target, the method comprising:

illuminating the voxel with a photon beam;

determining an incident flux upon the voxel;

measuring an energy spectrum of photons scattered from the voxel;

determining a first number of photons contributing to the energy spectrum in a first energy range;

determining a second number of photons contributing to the energy spectrum in a second energy range;

computing a ratio of the first number of photons to the second number of photons;

determining a number of photons contributing to the energy spectrum in an energy range including 511 keV;

using a correlation between the computed ratio and the number of photons in the energy range including 511 keV to determine a probable average atomic number in the voxel; and

generating a signal based upon the probable average atomic number determined.

7. The method of claim 6, wherein one of the first energy range and the second energy range includes 511 keV.

8. A method of scanning a target for potential threats, the method comprising:

(a) selecting a plurality of voxels in the target such that each selected voxel has a surface on an exterior of the target,

(b) for each such selected voxel,

(i) illuminating the voxel with a photon beam;

(ii) determining an incident flux upon the voxel;

(iii) measuring at least one energy spectrum of photons scattered from the voxel;

(iv) determining, using the at least one energy spectrum, an average atomic number in the voxel; and

(v) determining a mass in the voxel using the incident flux, the average atomic number in the voxel, the at least one energy spectrum, and predetermined values of a scattering kernel corresponding to the voxel; and

(vi) determining if the photon beam upon leaving the said voxel enters a downstream voxel prior to leaving the target, and, if so, repeating steps (ii) to (vi) for the downstream voxel which the beam enters, until the photon beam leaves the target; and

(c) determining whether to trigger further action using the determined masses and determined average atomic numbers; and, if so

(d) generating a signal to trigger further action based upon the masses and the average atomic numbers determined.

9. The method of claim 8, further comprising displaying a spatial distribution of the masses on an output device.

10. The method of claim 8, wherein further action comprises scanning a portion of the target by nuclear resonance fluorescence.

11. The method of claim 8, wherein further action comprises notifying an operator that suspicious material may be present.