[0018] A typical operating gas of the drift tubes comprises a non-flammable gas, such as a mixture of argon, carbon dioxide and Tetrafluoromethane (CF_4)

[0019] The drift cells can comprise a set of drift tubes located above the volume and another set of drift tubes located below the volume. Each set of drift tubes can have at least three drift tubes configured in a first direction and another at least three drift tubes configured in a second direction. The first direction can be orthogonal to the second direction.

[0020] A gamma ray or neutron source can be arranged within the system to enable active interrogation of material occupying the volume.

[0021] According to another aspect, a monitoring system has a cosmic ray-produced muon ~~tracker~~tomography system having a plurality of muon detectors in the form drift tubes or cells. The drift tubes can be arranged at least above and below a volume to be scanned both to enable tracking of incoming and outgoing muons and counting of gamma rays. In use, the system can both selectively detect high density shielding of radioactive material occupying the volume from multiple scattering of the muons passing through the volume and detect the radioactive material occupying the volume from gamma rays emitted therefrom.

[0022] The volume to be scanned can be of sufficient size to enable a vehicle or cargo container to occupy the volume. Advantageously, adopting drift tubes as muon detectors enables the system to perform passive scanning of occupied passenger vehicles with short scanning times and no dose radiation above ambient background.

[0023] According to yet another aspect, a method of monitoring comprises arranging a plurality drift tubes or cells on opposite sides of a volume to be scanned; detecting with the drift tubes or cells incoming and outgoing cosmic ray-produced charged particles together with any gamma rays; selectively detecting any material occupying the volume from multiple scattering of the charged particles passing

through the volume; and detecting from the gamma rays any radioactive sources occupying the volume.

[0024] Arranging the plurality of drift cells can comprise arranging a set of at least three planes of drift tubes above the volume and arranging a set of at least three planes of drift tubes below the volume and can further comprise arranging the drift tubes in each plane in two orthogonal coordinates.

[0024a] According to another aspect, there is provided a particle detection system, comprising: a first set of position sensitive charged particle detectors located on a first side of an object holding area to measure positions and directions of incident charged particles towards the object holding area; a second set of position sensitive charged particle detectors located on a second side of the object holding area opposite to the first side to measure positions and directions of outgoing charged particles exiting the object holding area; and a signal processing unit to receive data of measured signals of the incoming charged particles from the first set of position sensitive charged particle detectors and measured signals of the outgoing charged particles from the second set of position sensitive charged particle detectors, wherein the signal processing unit is configured to analyze scattering of the charged particles in the materials within the object holding area based on the measured incoming and outgoing positions and directions of charged particles to obtain a tomographic profile or the spatial distribution of scattering centers within the object holding area, and wherein the position sensitive charged particle detectors are arranged to allow at least three charged particle positional measurements in a first direction and at least three charged particle positional measurements in a second direction different from the first direction.

[0024b] According to yet another aspect, there is provided a method for sensing a presence or absence of a material in a target object, comprising: exposing the target object to incident charged particles; using a first set of position sensitive charged particle detectors located on a first side of the target object to measure positions and directions of incident charged particles towards the target object before reaching the target object; using a second set of position sensitive charged particle detectors located on a second side of the target object opposite to the first side to measure positions and directions of outgoing charged particles exiting the target object; obtaining first detector signals from the first set of position sensitive charged particle detectors containing information of the incoming charged particles and second detector signals from the second set of position sensitive charged particle detectors containing information of the outgoing charged particles; analyzing scattering of the charged particles in the target object based on the positions and directions of the incoming and outgoing charged particles to obtain a tomographic profile or the spatial distribution of scattering centers within the target object; and processing the tomographic profile or the spatial distribution of scattering centers to determine a presence or absence of a material in the target object, wherein the analyzing scattering of the charged particles in the target object includes obtaining angle and momentum information of each charged particle passing through the target object to provide a probability distribution of charged particle scattering; wherein the first set of position sensitive charged particle detectors includes a first double-layer of drift tubes arranged in an X direction and a second double-layer of drift tubes arranged in a Y direction.

[0024c] According to yet another aspect, there is provided a particle detection system, comprising: a first set of position sensitive charged particle detectors located on a first side of an object holding area to measure positions and directions of incident charged particles towards the object holding area; a second set of position sensitive charged particle detectors located on a second side of the object holding area opposite to the first side to measure positions and directions of outgoing charged particles exiting the object holding area; means for processing scattering of the charged particles in the materials within the object holding area based on the measured incoming and outgoing positions and directions of charged particles to obtain a tomographic profile or the spatial distribution of scattering centers within the object holding area; means for reconstructing a trajectory of a charged particle through the object holding area; means for measuring a momentum of an incoming charged particle based on signals from the first set of position sensitive charged particle detectors; means for measuring a momentum of an outgoing charged particle based on signals from the second

set of position sensitive charged particle detectors; means for obtaining a spatial distribution of a scattering density of the object holding area, means for determining spatial distribution of the scattering density of the object holding area to obtain predetermined charged particle tomography data corresponding to scattering angles and estimated momentum of charged particles passing through the object holding area; means for producing a probability distribution of charged particle scattering for use in an expectation maximization algorithm based on a statistical multiple scattering model; and means for determining a substantially maximum likelihood estimate of the scattering density of the object holding area using the expectation maximization algorithm, wherein the first set of position sensitive charged particle detectors includes a first double-layer of drift tubes arranged in an X direction and a second double-layer of drift tubes arranged in a Y direction.