TITLE: FAST RADIATION DETECTOR FOR HOMELAND SECURITY

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SUMMARY

Sub-second radiation detection is needed for Homeland Security. We describe a small device for radiation detection with moving sources (e.g., mail/packages) and/or moving detectors (e.g., plane/ship/car). The device can easily be combined with X-ray scanners or metal detectors. This device is ideal for 'Responders' because it can mount on headgear and detect radiation quickly with eyes-free/hands-free head turning. It detects radiation thru rubble holes, from buried objects and with imperfect shielding. It shows the radiation source direction. No new personnel, no contact, no development, and no training is needed. Testing is complete. A US Patent on homeland security applications for scintillating fiber dosimeters is pending.

OVERVIEW OF THE DEVICE

Radiation is a threat to security, commerce, and health. It is not 'seen' by X-ray or Metal Detection.

Flaws in current detection methods are i) slow detection, ii) unsafe detection, & iii) impossible detection.

We describe a device to remove these flaws:

The device can detect 'below-health-threatening' radiation in less than 1 millisecond.

The device can use 'audio' radiation detection, leaving eyes and hands free for other tasks.

The device can mount on headgear, giving radiation detection with 'head-turning'.

The device shows radiation direction, and allows shallow-buried-earth searching.

The device can be easily combined with X-ray & metal detection, giving added security without delay.

The device has 'simplicity'. It is a 'no-training', 'no-change', 'no-contact', 'add-on' detection device.

The device is 'passive'. No health risk or interference with electronic devices is possible.

The device reduces the effectiveness of radiation shielding.

The device uses reliable, existing, technology. No new research, testing, or development is needed.

The device is small, portable, and has only modest cost.

THE DEVICE BASIS: High energy X and gamma-rays can penetrate the body deeply via the skin. 'Skin penetrating' and 'ionizing' radiation is a threat to human health and to national security. Many current radiation detection methods will not provide radiation identification or detection as expected. Our device provides faster and better detection of penetrating, ionizing, threatening, radiations.

Possible radio-nuclides for terrorist use include Cesium-137 and Cobalt-60 because of their (respective) penetrating radiation quantum energy (0.7 & 1.3 MeV gamma rays), long radiation half-life (30 & 5 years), and known technology for high activity radiation production (e.g., for medical use). 'Shielding' can not hide radiation threat since 'shielding' is more easily detected than the radio-nuclide.

Radiation detection thru 'holes' in rubble/cargo, with fast 'fly/drive/walking', and in other applications may require measurement times as short as 1 millisecond. To provide health protection, and to add simplicity in survey use, we omit radiation energy analysis, and concentrate on detecting health-threatening dose_rate. Our device uses a Scintillating Fiber and Photo-Multiplier tube (SF/PMT). Radiation detection with small, fast moving sources & detectors is thus possible. Many new applications related to health, national security, and other uses, are possible. As examples of these new applications:

Our SF/PMT can do FAST radiation testing of people/bags/packages/vehicles/cargo/.....

Our SF/PMT can be added to x-ray units, metal detectors & mail sorters for FAST radiation detection.

Our SF/PMT can do FAST clothing/shoes radiation testing of Responders and other 'exposed' people.

Our SF/PMT can do FAST determinations of location and angular widths of radiation sources.

Our SF/PMT can do 'audio-radiation-detection' for simple, quantitative, 'eyes/hands-free' operation.

Our SF/PMT can do FAST detection of radiation from 'buried' emission sources or absorption objects.

Our SF/PMT can be readily used at all worldwide departure and entrance points to the US.

Our SF/PMT can be operation tested and calibrated, using only a small, safe, ‘exempt’ source radiation.

Successful high energy and low energy radio-nuclide tests of our SF/PMT are completed.

A US patent is pending for scintillating fiber dosimeters for homeland security applications. A 510k FDA Pre-Market Clearance, and US Patent 6,713,765 have been obtained for our SF/PMT used in Low Dose Rate medical radiation dosimetry.

METHODS OF MEASURING RADIATION FOR HOMELAND SECURITY

Radiation can be measured ‘instantaneously’ (dose_rate), or ‘after-the-fact’ (dose). Because of its much greater speed (we seek measurement times ~ milliseconds), we consider only ‘dose_rate’ measurements. (For a discussion of radiation detection, and the limitation of simple but slow Geiger ‘counters’, see ‘Radiation Detection and Measurement’, 3rd Edition, Glenn F. Knoll, Chapter 7, John Wiley, 2000.)

In detecting radiation for Homeland Security, preventing ‘health harm’ must be the prime objective. With ‘Dirty’ bombs, spectroscopy for energy/nuclide-identification is of little use because there will generally be an unpredictable energy loss due to the unknown scattering and absorption in the radiation path. For all Homeland Security detection, it is best to quickly separate ‘threatening’ cases from ‘no-harm’ cases.

We note that X-ray scanners and metal detectors cannot detect radiation.

The need for speedy detection with negligible ‘false-positives’ discourages the use of gaseous ‘counters’.

Only sufficiently sensitive, high speed, radiation detection can offer protection from ‘health harm’. Our new SF/PMT radiation detector overcomes these shortcomings. It is housed in a small, light package. By way of example, the 2" SF/PMT radiation detector weighs ~ 5 ounces (batteries excluded).

An example of fast radiation detection (using solar radiation ‘spikes’) with our SF/PMT was found. This signal would be seen with a fast moving detector passing a stationary radiation shield, or ‘rubble’, with small cracks or holes. It is the simplest demonstration of the SF/PMT speed.

DESCRIPTION OF THE SCINTILLATING FIBER/PHOTO-MULTIPLIER (SF/PMT) DEVICE

Our device consists of a single, fast-responding, Scintillating Fiber (SF), a Photo-Multiplier Tube (PMT), and, for final indication, a voltage-to-audio frequency converter, or a multimeter, or a LED.

Detailed descriptions of the SF/PMT device, its performance, and its advantages, are now presented.

ADVANTAGES AND REQUIREMENTS USING SCINTILLATING FIBERS (SFs)

The advantages of SFs for radiation detection are very fast response speed, contact tolerance, and one- dimensional thinness/flexibility.

SFs convert radiation into visible light in nanoseconds. The visible (scintillation) light is detected by a PMT. The SF/PMT output signal scales linearly with the SF radiation dose_rate and the SF length (with a small attenuation correction). Our device uses a polymer SF. An important property of a polymer SF is that of having a density and chemical composition more similar to the human body than other (e.g., gaseous) 'detection' materials. This similarity is essential for the fast, simple, and reliable detection of 'health-threatening' radiation.

However, SFs also 'respond' to ambient light. To prevent ambient light from providing a 'False-Positive' signal, the SFs must be shielded from ambient light while allowing the 'health-threatening' radiation to reach the SF. Our way to provide robust and selective shielding is to place the SF in a 'ambient light-excluding' tubing. This 'light- excluding' tubing must act as a 'High-Pass' photon filter.

For our device, we use the fact that 1/16" aluminum will transmit most body-penetrating gamma/X-rays with less than 5% attenuation. But ambient light, electrons with energy < 1 MeV, and all other radio-nuclide charged particles will be stopped by the aluminum tubing. (This aluminum shield will also prevent SF response to alpha particles from radio-nuclides, which are not 'Skin-penetrating', and do not constitute a health-threat because they are easily absorbed by clothing or air.) Thus, aluminum tubing with ~ 1/16" thick wall provides proper shielding and a robust enclosure.

The Al tube 'ends' must be made 'light-tight'. For long (> 1') SFs, the SFs may be placed in a polymer tube before inserting it in the Al tube, to prevent the SF from sagging, and to keep the SF 'centered'.

Thus, SFs allows radiation detection over a long, one-dimensional region with a single PMT. Flexibility can be achieved using a bundle of fine SFs ('imaging' is not needed). However, the scintillation light must travel along the SFs to the PMT without great attenuation, and without unreproducible losses to all support structures. The latter, very important, condition can be achieved if the scintillation light travels to the PMT by guided, contact-tolerant, 'light piping', as now described.

To allow 'light-piping' to a distant light detector without unreproducible losses to SF support structures, the scintillating fiber should have one or more cladding layer(s) of material with an index of refraction lower than the index of refraction of the core fiber, and a thickness comparable to at least a wavelength of the light propagated. With this method, placement and environmental contact of the fiber are not critical. Freedom from variable SF contact losses is an essential property for a reliable, radiation detection sensor which is independent of device support conditions.

ADVANTAGES AND REQUIREMENTS USING PHOTOMULTIPLIER TUBES (PMTs)

The advantages of PMTs for radiation detection are high speed and high gain/volume (compactness).

The SF converts radiation to visible light. The high gain, compact PMT converts visible light into a proportional output voltage. To retain an output voltage proportional to a fast changing radiation level, an appropriate radiation detection system (SF/PMT) bandwidth must be established at the PMT output.

The SF/PMT detection response time is established with an integrating RC (resistor-capacitor) series circuit at the PMT output. We used a response time (= 3*RC, for ~ 95% of a step response) of 0.067 seconds (comparable to fast human response) for most testing. With this response time, large ‘solar’ signal spikes can be integrated into the signal background, and thus prevent nonlinear overload in the ‘downstream’ circuit. However, since the ‘upstream’ PMT response time is ~ 0.000017 seconds (20 kHz PMT passband), one can achieve radiation detection response times between ~ 0.000017 seconds and ~ 1 second by choice of C alone. (Response times > 0.1 second, if needed, can be achieved by digital averaging.) Matching response time to detection needs is an important benefit of our device.

One end of the SF goes into the PMT. If the SF has a transverse size of 5 mm or less, the PMT can be small and battery-powered. This allows compact, portable, radiation detection without external power.

SF cross-section shapes can be ‘round’ or ‘square’. Either shape will suffice, but ‘square’ will be preferable because it has a higher efficiency for ‘light piping’. This may require a means of coupling a ‘square’ SF to a ‘round’ PMT input. We use a ‘broached’ transition piece made of aluminum.

Commercially available SFs have transverse sizes from 0.25 mm to 5.0 mm. A preferred SF transverse size (for maximum signal) is 5.0 mm. This SF will have a ~ 7 mm diagonal size, making it appropriate for a compact, battery- operated, PMT with an 8 mm diameter (our battery-operated PMT) light input.

SF/PMT RADIATION DETECTION FOR AIRPLANE/SHIP BAGGAGE/PACKAGE/CARGO

Only a single SF/PMT is needed for detection. Cargo, containers, air/ship baggage/package, vehicles, and people can be quickly tested for radioactivity using the device. Little additional circuitry is needed with the high gain PMT. With health-threatening radiation, LEDs can be directly driven by the PMT.

We used a 4" (open-face) SF/PMT radiation detector, with attachments for medical applications, which was used for testing. A 1" to 2" SF/PMT (without medical attachments) is a convenient size for portable radiation detection (e.g., for use by ‘Responders’, or combined with Metal Detectors).

We also used a 1’ and 6’ SF/PMT radiation detectors (with aluminum tube shielding). The 1’ and 6’ SF/PMTs were used for test cases where longer SFs would be beneficial. The 1’ SF/PMT is also a convenient size for radiation detection when combined with X-ray Scanners or Metal Detectors.

The length for a single SF/PMT unit is typically between 2/3 inches and 6 feet, with the longer lengths being preferable for increased coverage, if space allows. The 1/e attenuation length of a 5 mm SF is ~ 15 feet. Smaller diameter SFs have shorter 1/e attenuation lengths, and may not be appropriate for long SFs. Longer radiation detection lengths (e.g., > 6 ft) can be achieved with several SF/PMT units ‘in a line’.

The best location of the SF is above or below a moving belt or unloading vehicle. The above location would be set by the baggage/..... height, and slope of the moving belt/carrier. The best above location of the SF/PMT is that which allows the closest approach of the inspected item to the SF/PMT without physical obstruction. However, for this case, the SF/PMT attachment must also allow accidental contact of baggage/... with the SF, without damage. Belowmoving belt or unloading locations are preferred.

A suitable ‘shielding enclosure’ (to protect the SF from ambient light, weather and other interferences) would be any material which is opaque to visible light, transparent to the radiation to be detected, and can provide robust support for the SF/PMT structure. As noted earlier, a thin-wall (1/16") aluminum tube can be used to house the SF attached to the PMT. The SF/PMT should also be easily removed from its supporting structure, for quick, convenient, dosimetry measurements and detector transfer. Our portable, battery-operated radiation detector is especially useful for this feature. A cart-mounted device would also offer mobility.

SF/PMT RADIATION DETECTION FOR VEHICLES

Scintillating Fibers can check vehicles for radiation at US border points, where all vehicles must stop.

Radiation detection, using the SF, would best be from the underside, side or top of the vehicle.

The preferred shape/size of the SF is, again, a square cross-section of 5 mm transverse size, with a ‘practical’ maximum length of 6 feet (~ the width of a typical vehicle, and an ‘easily’ handled SF length).

The ‘light shielding’ SF cover described above can be used for US roadways. The SF in the Al tube housing would be used ‘on’ the roadbed, or ‘in’ roadbed grooves, for underside radiation detection.

An ‘on’ roadbed configuration would be used for low-speed, underside, detection of radiation. The SF can be put between two, tapered, polymer or metal plates with ~ 1.5" tapered thickness. The plate thickness must be greater than the Al tube width to prevent excessive tire contact with the Al tube.

An ‘in’ roadbed configuration would be used for high-speed, underside, detection of radiation. The SF, in Al tube, must be put in roadbed grooves deep enough (> 1.5") to prevent tire contact with the tube.

Vehicles can be ‘screened’ for radioactive contents while traveling at speeds of 65 mph. But such high speed testing of vehicles should be made using the ‘in’ road SF/PMT groove described above. This configuration is needed because of the vehicle speed, not the detector limitations.

SF/PMT RADIATION DETECTION FOR BURIED OBJECTS

Buried radioactive objects can obviously be detected, depending on their radioactivity & earth absorption.

Buried non-radioactive objects may be detected using natural earth radioactivity. This ‘absorption’ detection depends on the object’s absorption (given roughly by its size and density), & the earth ‘natural’ radiation & absorption. A simple test for an ‘absorption detection’ possibility is to place an absorbing object (e.g., a lead bar) on the ground and check for a signal decrease as the SF/PMT passes over it.

EYES AND HANDS FREE ‘AUDIO’ SF/PMT RADIATION DETECTION

A shortcoming of radiation detection with a detector meter or light is that it requires a person to monitor, constantly, the detector with his/her eyes and hands. Converting detector ‘voltage’ to ‘sound frequency’ allows eyes and hands free ‘audio’-detection of radiation. The audio frequency gives the quantitative magnitude of the radiation. It can be useful in many cases, especially for ‘walking’ people (e.g., Responders). This measurement method is similar to that used for metal detection. It would offer similar ‘user’ conveniences for radiation detection.

To provide ‘audio’ detection of radiation, the voltage output of the PMT is fed to a small voltage-to-frequency converter. The human ear/brain can discern small, relative frequency changes over a range of ~ 100X. At high dose_rates, measurements give an audible note with pitch proportional to the dose_rate. At low dose_rates, (a few % of) the gamma ray traversals thru a 5 mm transverse SF can be audio-detected by a SF/PMT. ‘Noise-Canceling’ headphones can be helpful in a noisy environment.

Only the change in pitch (or pulse pitch ‘slurring’, or pulse counting) is needed for most radiation detection. This method also provides a unique, sensitive, fast, ‘signature’ of radiation, especially at low radiation levels. This ‘audio’ detection can also be quickly confirmed by reversing the direction of the SF/PMT motion. With ‘audio’ detection, eyes are free for other tasks, such as walking, avoiding obstacles, and helping victims. Hands are also free for other tasks.

Audio Test Results have provided a quantitative example of fast, low-level, audio SF/PMT radiation detection.

‘LOCALIZED’ AND ‘DIRECTIONAL’ RADIATION MEASUREMENTS

Finding radiation sources is easy using the fast response of the SF/PMT. This detection can rapidly and safely localize radiation sources (e.g., for side-by-side, radiation containing, bags on a moving belt, or radiation threats detected by Responders). With battery-operation, the SF/PMT can conveniently give radiation source direction and magnitude found by Responders, or among many bags/packages/... in a large staging area, or, with non-metallic shield, can conveniently be added to a hand-held metal detector.

The direction and angular size of a radiation source can be found by quickly sweeping the SF direction thru space. A maximum or minimum signal can occur when the SF is pointed toward the source, depending on the method used to locate the radiation direction (see next paragraph).

Directional detection can be coupled with simple, ordinary, ‘head-pointing’ if the SF/PMT is mounted on headgear. With vertical mounting and 3-sided SF shielding anisotropy, this method gives a maximum signal for localization. With horizontal mounting and no shielding (giving a ‘sharper’ minimum signal for localization) the alternate method uses the SF length/absorption length ratio.

Directional radiation source location is an important feature in both finding and avoiding radiation. ‘Head-pointing’ methods would be especially useful for ‘Responders’ because it is ‘eyes and hands free’.

‘Localized’ and ‘directional’ measurements allow simple, quick, quantitative detection of radiation location, size and strength. Convenient for this detection is the small size, light weight, and battery-operation of the SF/PMT.

But, because human response time can be much less than 1 second, sub-second radiation detection time is a necessary property for fast, directional, radiation detection.

SF/PMT RADIATION DETECTION FOR MOVING SOURCE/DETECTOR APPLICATIONS

The SF/PMT device can be used as a FIXED DETECTOR for a FAST MOVING SOURCE. Fast detection at postal processing rates (30,000 letters per hour) for radio-nuclides in letters and packages is easy. No contact, and no process modification, is required because of the ‘passive’ (no output radiation) nature, and the simple ‘add-on’ nature of the SF/PMT radiation detection device.

The SF/PMT device can be used as a FAST MOVING DETECTOR for a FIXED SOURCE.

Detection of radiation with a SF/PMT is possible with helicopter, Unmanned Aerial Vehicle (UAV), ‘model airplane’, any vehicle, or walking, because of its speed, simplicity, portability & light-weight.

With SF/PMTs, airplanes, autos, and walkers (Responders) can provide high spatial or time resolution for ‘moving- radiation detection’. These methods are especially useful for fast radiation detection ‘thru small rubble holes’ and ‘down narrow streets/alleys’, where shielding will limit radiation detection time.

SF/PMT detection of ship-based radioactivity, using a moving Pilot boat, is also possible.

Detection of radiation by emission or by absorption or attenuation is possible. The latter method may be useful since absorption/attenuation depend primarily on size and density. However, the latter method requires using natural radiation emanating below the objects searched.

Fast, GPS-located, ‘radiation mapping’ is possible. This does not require a fixed/known speed or route. Radiation and location data can even be automatically radioed to control locations for instant mapping.

A portable, battery-operated, SF/PMT has other uses. Used with data logging, the device can also be quickly lowered thru any vertical hole or tube > 1" in diameter for fast ‘depth’ radiation readings.

Detectable PMT signals and dose_rates of radiation with a SF/PMT radiation detector have been calculated.

RADIATION UNITS, SF/PMT DETECTION SENSITIVITY, AND SAFE RADIATION LIMITS

The SI unit of ionizing radiation dose_rate is Grays/second. 1 Gray (Gy) is the dose which imparts 1 Joule of ionizing energy to 1 kilogram of matter. 1 Gray = 100 Rad (cgs). The more commonly measured unit (‘exposure’ or ‘ion producing’ capability of radiation in air) is the Roentgen (R). Though not fully equivalent, the units can be related by 1 Gy = 114 R in STP air. For biological effects, the Sievert (Sv) and Rem unit are often used. 1 Gy = 1 Sv = 100 Rem, for X rays, gamma rays and electrons.

The PMT voltage output is related to the average <Dose_Rate> over the SF sensor by the formula:

PMT_Voltage_Out[V] = <Dose_Rate>[Gray/sec] * Sensor_Volume[m3] *
Sensor_Density[kgm/m3] * PMT_Gain[V/W]* Efficiency

where Sensor_Volume is the SF volume which absorbs the <Dose_Rate>, Sensor_Density is ~ 103 [kgm/m3] (similar to human body), and PMT_Gain can be up to ~ 1011 Volts-out/Optical-Watts-in. Efficiency gives the fraction of the SF ionizing radiation which is converted to measurable light at the PMT Input. Efficiency for Cs-137 gamma rays is ~ 3*10-3 for a 5 mm square, multi-coated, SF < 9 feet long. Efficiency is not needed for dosimetry results because in typical operation, only ‘relative’ measurements are used. A fast, simple calibration with an ‘exempt’ source can be made.

The voltage response of a 4" SF/PMT detecting uniform Cs-137 radiation of ~ 1.7 Gray/year using a PMT_Gain of 7*1010 [Volts-out/Watts-in] with response time of < 0.06 seconds has been demonstrated.

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For a SF of L[inches], the Dose_rate & PMT_Out (for PMT_Gain of 7*1010 [V/W]) are related by

<Dose_rate> [Gray/Year] ~ (120/L)*PMT_Out[V]

This relation is controlled by PMT_Gain, and is limited by noise. But fast radiation detection is achieved even for important (and prevalent) ‘Compton Scattered’ radiation.

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The SAFE RADIATION EXPOSURE TIME for humans is approximately given by

SAFE RADIATION EXPOSURE TIME [Years] ~ L/(120*PMT_Out[V])

‘Safe’ exposure times are when the accumulated Dose is < 1 Gray, an approximate medical limit.

‘Non-safe’ exposure times can be ‘alerted’ with a LED or an audible sound, triggered by the PMT.

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A battery-operated 1" to 2" SF/PMT is well suited for easy mounting on a headpiece, providing a sub-second and directional alert for radiation that would be ‘health-harming’ in an 8 hour period.

A ‘Head-to-Toe’ radiation sweep with a small, portable SF/PMT will take only seconds. This speed and battery-operation will be important if many people must be checked for radiation contamination.

The SF/PMT Speed Performance for Radiation Detection and Human Health has been calculated.

X-RAY & METAL DETECTORS CAN’T ‘SEE’, & SHIELDING CAN’T ‘HIDE’, RADIATION

For PENETRATING/IONIZING radiation, a ‘shielding-doesn’t-help’ conclusion applies. This is because ‘shielding’ is often more readily detected than the radiation source radio-nuclide. This ease of detection with X-ray scanning for example, is because all shielding for penetrating/ionizing radiation relies on preventing high-energy photon transmission. But this photon transmission is required for X-ray scanning. Since ‘shielding’ can be more readily detected by X-ray scanning than the source radio-nuclides (e.g., medical seeds) themselves, one may avoid radiation detection by simply omitting the ‘shielding’. Thus, a radiation detector for unshielded sources, in addition to X-ray scanning, is needed.

If a terrorist accepts self-harm, then carrying a radio-nuclide, unshielded, through metal detection devices, is an alternate way to avoid detection. Radioactive pellets (e.g., medical seeds) can easily be made electrically insulated from each other. With electrical insulation, it will be impossible to see (large signal), electrically-touching pellets by ‘eddy-current’ metal detection. Thus, a radiation detector for unshielded sources, in addition to metal-detection, is needed. (N.B., A fast SF/PMT radiation detector, with a non-metallic, opaque shield can be easily combined with a hand-held metal detector.)

'Imperfect' Shielding: Radiation thru holes/cracks in shielding/rubble is easily seen with a fast moving SF/PMT. This is not true for slow detectors which will 'time average' the response. FAST response thus allows better detection. (Other 'imperfect-shielding' of buried radiation may also be observable.)

THE DETECTION OF NON-PHOTON RADIATION TYPES WITH THE SF/PMT DEVICE

Our SF/PMT device can be used for the detection of non-photon radiation types (electrons, protons, alpha particles, neutrons, ...) using SFs for these radiations and energy ranges.

SUMMARY: RADIATION DETECTION SENSITIVITY AND SPEED

It is easy to decrease detection speed. (This is often done in electronic circuitry to increase 'detection sensitivity'). Increasing detection speed is more difficult, and often impossible, to effect. This is the 'fundamental' advantage of starting with fast radiation detection.

FAST radiation detection provides protection when all geometry and materials are not totally known. FASTdetection can test more area in a given time.

An estimate of the detection time needed for 'moving' (source/detector) radiation detection is given by:

DETECTION TIME < DETECTING DISTANCE/DETECTING VELOCITY

Based on the 20 μsecond SF/PMT response time, detection at 60 mph is possible for 1 mm cracks/holes in shielding. The detection time regimes above correspond to i) small detecting distances (e.g., Responders walking thru rubble) and/or ii) large Detecting Velocities (e.g., fast 'fly/drive-overs'). Example: One can detect, in 1/1000th second, a dose_rate which would not be health-harming until 1 year exposure had passed. This is achieved with Signal/Noise ~ 100/1 and a SF only 1.2" long.

One rule for radiation safety prevails: A large radiation DOSE_RATE signal, no matter what its detected time duration, means a possible immediate, and a certain ultimate (after clean-up) threat to human health and national security. This is why FAST radiation detection is needed.

SUMMARY: ADVANTAGES OF THE SF/PMT RADIATION DETECTION METHOD

The most important advantage of the SF/PMT radiation detection method is its measurement SPEED.

It is a simple, 'add-on' and 'non-contact' device. No delay in 'set-up' or normal procedure occurs.

It is an ‘eyes-free’ and ‘hands-free’ radiation detection device. No ‘Responder’ impairment will occur.

It can be used for directional or small area or large area measurements.

It is small, light-weight, battery-operated, portable, passive, and fully automatic.

It can easily be mounted on a Responder’s headpiece. No encumbrance results.

It will be difficult to ‘cheat’.

It is cheap and uses existing components.

No research is needed for immediate use.

THE TEST OF THE SF/PMT DEVICE

The radiation detection SENSITIVITY AND SPEED performance and the ‘FALSE-POSITIVE’ REJECTION performance of the device have been tested and confirmed. Here are the details.

SENSITIVITY & SPEED TEST FOR HIGH ENERGY RADIO-NUCLIDES: We have used 0.662 MeV gamma ray emitting Cs-137 for testing. These tests were made at K&S Associates (an Accredited Dosimetry Calibration Laboratory), with K&S Radiation Physicists, Larry Bryson & Richard Hardison. (Special thanks to Thomas Slowey, President, K&S Associates, for these measurements.)

The SF/PMT signal (obtained in 80 millisec) from 68 mCi of Cs-137 ‘body-penetrating’ gamma rays @ ~ 2 feet, giving 0.15 Gray/month (~ 20 mR/hr), using 4" of a 5 mm square SF has been measured. This time includes ~ 10 millisec radiation ‘turn on/turn off’ time. The signal shows ‘statistical noise’.

Measurements were also made with a weak, 8.2 microCurie (‘exempt’), calibrated, Cs-137 source.

The PMT rms-output-noise, at PMT gain of 7*1010 [Volts-out/Watts-in], was estimated to be ~ 4 microvolts/(ResponseTime [sec])0.5).

Our tests also show a linear SF/PMT response to radiation activity and dose_rate over more than a factor of 1,000X. Our tests thus show the fast detection as needed for HomeLand Security. Our tests also show sensitivity sufficient to detect ‘threatening’ radiation in much less than 0.1 second. This radiation level is substantially less than the ‘long-term occupational radiation limit’ established by Federal and International Standards.

SENSITIVITY & SPEED TEST FOR LOW ENERGY RADIO-NUCLIDES: We have used 0.028 MeV gamma emitting I-125 seeds for testing. The tests were made at Tallahassee Memorial

Hospital (TMH) for MED-TEC, Inc., with TMH Medical Physicists, David Patterson & James Martin.

We measured the SF/PMT signal for five I-125 seeds, with 4 non-radioactive spacers, in a standard needle, using a 5 mm SF/PMT and an ADC/PC graph with a time scale of 0.164 sec/div. The distance from seed to SF center was ~ 16 mm. Radiation activity (mCi) and mV were used for the detected signal. The results show that fast detection is possible even at low radiation energies.

FALSE-POSITIVE REJECTION TEST: To test the rejection of fast 'FALSE-POSITIVE' signals, we have measured 'solar' radiation spikes, in a low shielding location, with and without signal integration.

Our data show day-time 'solar' spikes, and the disappearance of these 'solar' spikes after sunset.

PATENT AND MARKETING STATUS

US Patent 6,713,765 for 'Scintillating Fiber Radiation Detector For Medical Therapy' has been granted to L. R. Testardi by the US Patent and Trademark Office (USPTO). Two other USPTO Patents by Galileo Scientific are pending for SF/PMT Radiation Detection.

A FDA 510(k) Pre-Market Clearance has been granted for this device when used for medical dosimetry.

A Marketing Agreement with a US company for 'SF/PMT Medical Dosimetry' has been obtained.

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