

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets

(11) Publication number:

0 000 271**B1**

(12)

EUROPEAN PATENT SPECIFICATION(45) Date of publication of patent specification: **02.12.81**(51) Int. Cl.³: **H 01 J 47/06, G 01 T 1/29**(21) Application number: **78300075.5**(22) Date of filing: **23.06.78**

(54) **Cathode plate, position sensitive neutral particle sensor using such a cathode plate, sensing system and camera both using such a sensor.**

(30) Priority: **24.06.77 GB 2659677**(43) Date of publication of application:
10.01.79 Bulletin 79/1(45) Publication of the grant of the European patent:
02.12.81 Bulletin 81/48(84) Designated Contracting States:
DE FR NL

(73) Proprietor: **NATIONAL RESEARCH DEVELOPMENT CORPORATION**
P.O. Box 236 Kingsgate House 66-74 Victoria
Street
London SW1E 6SL (GB)

(72) Inventor: **Bateman, James Edmond**
5 The Orchard Badswell Lane
Appleton, Abington Oxfordshire (GB)
Inventor: **Connolly, John Francis**
Kiln Corner Little Heath Road
Tilehurst, Reading Berkshire (GB)

(74) Representative: **Irish, Vivien Elizabeth**
Patent Department National Research
Development Corporation P.O. Box 236
London SW1 E6SL (GB)

(56) References cited:

FR - A - 2 176 496**IEEE TRANSACTIONS ON NUCLEAR SCIENCE,**
vol. NS—19, nr. 3, June 1972, New York, USA**G. CHARPAK** "Some recent progresses in
particle detection", pages 152—157**KERNENERGIE**, vol. 12, nr. 4, April 1969, Berlin,
H. HELFER et al. "Ortsempfindliches Parallel-
draht-Zählrohrsystem", pages 132—133**Nuclear Instruments and Methods**, Vol. 106,
1979, page 397 ff.**NUCLEAR INSTRUMENTS AND METHODS**, vol.
117, Nr. 2, 1974, Amsterdam, NL**U. SHIMONI et al.** "Investigations on metal
converters for gamma-ray detection and
mapping", pages 599—603**NUCLEONICS**, vol. 24, nr. 7, July '66, New York,
USA**B. R. PULLAN et al.** "Measuring radionuclide
distribution with crossed-wire spark chambers",
pages 72—75**PHYSICS IN MEDICINE AND BIOLOGY**, vol. 20,
nr. 1, January 1975, London GB**R.A. REYNOLDS et al.** "A multiwire proportional
chamber positron camera: initial results", pages
136—141**PHYSICS IN MEDICINE AND BIOLOGY**, vol. 23,
nr. 3, May 1978, London GB**J.E. BATEMAN and J.F. CONNOLLY** "A
multiwire proportional gamma camera for
imaging ⁹⁹Tc_m radionuclide distributions",
pages 455—470**REPORT CERN—77—01**, 6 January 1977,
Geneva, CH**A.P. JEAVONS et al.** "A new position-sensitive
detector for thermal and epithermal neutrons"
page 1

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European patent convention).

Cathode plate, position sensitive neutral particle sensor using such a cathode plate, sensing system and camera both using such a sensor

This invention relates to a cathode plate for use in a position-sensitive neutral particle sensor comprising an insulating support having a cathode array of spaced metal strips arranged adjacent and edge to edge, the metal of which the strips are formed being such that an incident neutral particle gives rise to an ionising particle which is either a photoelectron or a Compton electron and which escapes from the cathode plate. Such neutral particles are X-rays, γ -rays and neutrons. This invention relates further to a position sensitive neutral particle sensor using such a cathode plate, and to a sensing system and to a camera both using such a sensor.

A cathode plate according to the first part of claim 1 is known from FR—A—2 176 496. From the journal 'Physics in Medicine and Biology', Vol. 20, 1975, page 136—141 a position sensitive particle sensor is known for detecting γ -rays of approximately 510 keV by photoelectrons and Compton electrons produced by them, the sensor comprising a lead foil having cathode arrays which are parallel and closely spaced, with the strips of neighbouring cathode arrays being mutually orthogonal; means for connecting each strip of each cathode array to a known electrical potential, in the space between the cathode arrays an anode array comprising a plurality of spaced wires, means for connecting all of the wires in each anode array to a source of electrical potential; means for supplying a gas to the volume around each anode array; and means for sensing separately the presence of an induced electrical charge in at least one strip of both cathode arrays adjacent one anode array and for providing output signals representing the orthogonal position of the neutral particle in the cathode arrays, and having the features of claims 8 and 9. From the journal 'Nuclear Instruments and Methods', Vol. 117, No. 2, 1974, pages 599—603, a multiple position-sensitive neutral particle sensor is known comprising a plurality of cathode plates. From the Report CERN—77—01, 6 January 1977, it is known to detect thermal neutrons by detection of the electrons produced by them in a gadolinium foil. From the journal 'Kernenergie' 12, No. 4, 1969, pages 132—133 a γ -ray sensor is known comprising a position-sensitive neutral particle sensor and a collimator arranged to allow the passage of γ -rays only in a direction substantially perpendicular to the plane of the cathode arrays.

From these papers the physics of converting a neutral particle to a photoelectron or a Compton electron is known; for conversion of a particular neutral particle having a known energy, the appropriate metal and its thickness can be determined according to known principles.

The invention is intended to increase the detection efficiency of a position-sensitive

neutral particle sensor by a cathode plate having for a given incident neutral particle an optimized gain of ionizing particles escaping from the cathode plate.

In order to solve this problem, according to the invention, a cathode plate as previously described has an insulating support having a thickness which prevents absorption of said ionising particle, having a cathode array on each face, and the thickness of each metal strip in each cathode array is approximately half the preferred thickness provided from theoretical calculations.

Particular embodiments of the cathode plate according to the invention are claimed in claims 2—6.

Also according to the invention, a position-sensitive neutral particle sensor comprises a plurality of cathode plates as previously described, the cathode plates being parallel to each other and closely spaced with the strips in the cathode arrays on adjacent faces of neighbouring plates being mutually orthogonal and the two outer cathode plates having cathode arrays only on the inner side of the insulating support;

means for connecting each strip of each cathode array to a known electrical potential;

in each space between the cathode plates an anode array comprising a plurality of spaced wires;

means for connecting all of the wires in each anode array to a source of electrical potential.

means for supplying a gas to the volume around each anode array; and

means for sensing the presence of an induced electrical charge in at least one strip of both cathode arrays adjacent one anode array, the induced electrical charge resulting from the arrival in the sensor of a neutral particle, and for providing output signals representing the orthogonal position of that neutral particle in those cathode arrays.

A particular embodiment of the sensor may further comprise means for sensing the arrival of electrons at an anode array.

Further according to the invention, a position-sensitive neutral particle sensing system comprises a sensor as previously described and display means arranged to provide an orthogonal display for each of the received particles.

Further according to the invention, a camera comprising a sensor as previously described is claimed in claims 10 and 11.

In the accompanying drawings, Figure 1 is an exploded sketch view illustrating how a single neutral particle is sensed by two arrays of cathode strips and one anode array.

A way of carrying out the invention will be described by way of example with reference to:—

Figure 2, which is a sectional diagram of a neutral particle sensor according to the invention;

Figure 3, which is a schematic diagram of electronic circuitry associated with a particle sensor;

Figure 4, which indicates use of a neutral particle sensor as a medical gamma camera; and

Figure 5, which indicates use of two neutral particle sensors as a medical positron imaging sensor.

In Figure 1, a position-sensitive neutral particle sensor comprises first and second planar cathode arrays 10, 12, and a planar anode array 14, all three arrays being parallel and the anode array being between the cathode arrays.

The first cathode array 10 consists of a series of strips 16 of metal foil, arranged closely spaced edge-to-edge in the cathode plane but insulated from each other; one end of each strip is connected to earth through a 220 kΩ resistor 17, and the other end of each strip is connected to a delay line 18 which can provide an output signal V_1 . The second cathode plane is similar, consisting of a series of strips 20 arranged with their longitudinal direction at 90° to the strips in the first cathode plane, earthed through resistors 19 and connected to a delay line 22 which can provide an output signal V_2 . The anode plane 14 consists of a series of spaced metal wires 24 each connected at one end to a common lead 26 through which a positive electrical potential is supplied to each wire and which also can provide an output signal V_0 through a capacitor 28.

In the Figure, the anode wires are arranged at 45° to the cathode strips. This is not essential; the wires can be parallel to one array of strips, or make an angle other than 0°, 45° or 90° with the cathode strips.

A gas (not shown) such as the gas used in a conventional multiwire proportional counter, is supplied to surround the cathode and anode arrays.

The Figure is not to scale and is exploded so that the sequence of events can be illustrated clearly.

Suppose a source of neutral particles, represented by reference 30, emits a particle along a path 32 towards the sensor. If the metal foil cathodes are of the correct material and thickness, considering the energy of the incident particle, the particle is absorbed by one cathode strip and a fast electron 34 is emitted into the gas; this electron has a speed approaching relativistic values and may be a photoelectron or a Compton electron. The fast electron ionises gas atoms to produce secondary ions and electrons. The ions drift slowly towards the cathode and can be ignored. The electrons are attracted towards the anode along the path 36 and as they approach an anode wire closely, encounter a very high electric field. An avalanche of elec-

trons and positive ions is initiated. The electrons are attracted to the anode wire, and are released into the external anode circuit by the movement of the positive ion cloud 38 away from the anode wires, and generate a negative output signal V_0 at a time which is very shortly after the time of arrival of the initial neutral particle, and can be regarded as indicating the time of that arrival.

The movement of the cloud of ions away from the anode wires also generates an electrostatic induction field 40, which in turn results in a positive charge pulse in several cathode strips in each array. Each strip provides a positive output pulse; the cathode strips immediately above and below the electron avalanche provide the largest signals; adjacent strips receive less charge and provide lower signals. The output pulses from the strips in each cathode array are coupled onto the respective delay lines 18, 22, and the delay lines, in effect, merge the separate pulses to provide a single pulse, slightly spread in time, which travels along the delay line; the time of arrival of the pulse maximum at the delay line output can be related to the position along the delay line of the strip receiving maximum charge. Since the strips in each cathode array are arranged orthogonally, the x—y co-ordinates of the electron avalanche, and thus the position of the received neutral particle, can be determined. Such an arrangement of delay lines and time measurement means is well known in the field of multiwire proportional counters.

It has already been stated that a plurality of sensors according to the invention will be required to provide a sufficiently high detection efficiency for a practical neutral particle counter, and a typical multiple sensor is shown in section in Figure 2.

The multiple sensor comprises twenty cathode arrays 50 and ten anode arrays 52. Each cathode array comprises a series of strips of metal foil supported by a film of a suitable plastics material, such as polyethyleneterephthalate; an example is a Kaptan (Registered Trade Mark) film 12.5 microns thick. The two outer cathodes have metal strips on only the inner side of the film, but the other cathodes have strips, in the same orthogonal direction, on both sides of the film. The films are supported at their edges between spacers 54 which are bolted together to form a rigid stack, and the spacers are bolted to a base board 55.

In a neutral particle sensor according to the invention, as explained above, each cathode array acts as a converter for a neutral particle as well as a position read-out. The material and the thickness of the cathode strips must be chosen in accordance with the energy of the neutral particle to be detected, considering the binding energy of the converter material and the escape probability of a fast electron produced in the material; the escape probability varies with thickness.

For the detection of X-rays having an energy of 60 KeV, such as those emitted by ²⁴¹Americium, each cathode strip in Figure 2 may be made of copper about 5 microns thick.

For the detection of gamma rays having an energy 140 KeV, such as those emitted by ^{99m}Technicium, each cathode strip in Figure 2 may be made of tin about 12.5 microns thick, and a typical multiple sensor would comprise 20 to 25 sensors.

For the detection of gamma rays having an energy of 510 KeV, such as those provided by positron annihilation, each cathode strip in Figure 2 may be made of lead about 125 microns thick, and a typical counter would comprise 10 to 15 sensors.

For the detection of thermal neutrons having an energy of 100 meV each cathode strip in Figure 2 may be made of gadolinium about 10 microns thick.

In the examples of materials and thicknesses given above, each thickness is half the preferred thickness provided from the calculations; this is because each inner cathode array is spaced very close to another cathode array, the combination giving the desired thickness; the insulating film between the two arrays must be very thin to prevent absorption of the fast electrons.

Typically the spacing between each anode and the adjacent cathodes is 4 millimetres. The smaller this gap, the better the spatial resolution of the counter. The anode wires may, for example, be gold-plated tungsten wires 20 microns in diameter, spaced at 2 millimetres.

The baseboard 55 carrying the spacers 54 is supported by lips 64 within a gas-tight enclosure 66, for example a glass fibre-epoxy composite box. Conveniently the array of electrodes 58 and the delay lines 62 are outside the container. A gas inlet tube 68 and gas outlet tube 70 are provided.

Any gas conventionally used in a multiwire proportional counter may be used; the more dense the gas, the better the spatial resolution of the counter. Xenon or 2-2 dimethylpropane or pure isobutane or a mixture of 70% argon and 30% isobutane may be used. It is an advantage of a counter according to the invention, in which the anode-cathode spacing can be quite small, that slightly electronegative gases can be used. In use, the gas is caused to flow continuously through the sensor; the gas may need to be at a pressure higher than atmospheric pressure.

It is to be understood, however, that in a sensor according to the invention, the gas does not convert neutral particles to fast electrons, as in a conventional multiwire proportional counter, but provides a medium in which an electron avalanche and ion cloud can be initiated by a fast electron produced in the cathode of the device by a neutral particle.

Figure 2 shows that some cathode strips are arranged with their length parallel to the plane

of the Figure, such as in cathode arrays 50A, 50B, 50C, while other cathode strips are arranged with their length perpendicular to the plane of the Figure, such as in cathode arrays 50D, 50E.

Considering the former type of array, and considering the section of the Figure to be a vertical section in the x—z plane with z being the co-ordinate in the vertical direction, then all strips vertically above each other have the same x or y co-ordinate. Since the cathode arrays are required to provide only x or y co-ordinates, all the vertically-stacked strips can be bussed, as indicated by the connector 56 for the stack of strips through which the section is taken; the connector 56 is connected to an electrode 58, which is one of a series of electrodes spaced, in the plane perpendicular to the Figure, on a support 60. A delay line 62, of the wire-wound type, is placed in contact with the electrode series. A similar arrangement is used to bus strips having their length perpendicular to the plane of the Figure.

A bussed arrangement allows a much simpler readout system to be used.

The anode arrays are not bussed vertically, because a signal indicating in which anode plane an electron avalanche is received may be required to give the z co-ordinate.

Suitable electrical readout circuitry is shown in Figure 3. The arrays of cathode strips 16 and 20 and the anode wires 24 are indicated schematically. The delay lines 18, 22 are connected through respective amplifiers 72, 74 and discriminators 76, 78, each to one input of respective time-to-amplitude converters (TAC) 80, 82, which supply respectively the x and y signals to a display unit 84. The anode array is connected through an amplifier 86 and discriminator 88 to the other input of each TAC 80, 82. The amplifier 86 is also connected to a linear gate 90 both directly and through the discriminator 88, and the gate is connected to the display unit 84 through a single channel analyser (SCA) 92 and delay device 94.

When a negative pulse, reference 96, is received from one anode plane as an electron avalanche occurs, this pulse is used as a prompt pulse for the circuit. The prompt pulse causes the TAC's 80, 82 to start; arrival of the respective positive pulses 98, 100 from the cathodes through the delay lines stops the TAC's. The TAC output signals indicate the co-ordinates in the x—y plane of an initiating neutral particle event, and a display is provided on the display unit 84 at the corresponding position on the screen.

The prompt pulse also provides a bright-up pulse for the display unit 84, through the SCA 92, which integrates the total charge deposited in the counter by the electron avalanche and acts as a pulse height selector, and through the delay device 94 which delays the bright-up pulse by a time interval required by the display system 84.

If many neutral particles are incident on the multiple sensor, a picture may be built up, either by using a storage oscilloscope as the display unit, or by use of photographic methods or of a digital computer.

It is a particular advantage of a sensor according to the invention that a large sensing area may be provided, for example of the order of one square metre. Such a device may be extremely useful in medical applications. For example, the sensor may be used as a gamma camera to detect gamma radiation emitted by an organ of the human body after the administration of ^{99m}Technetium in suitable form.

An example of such an arrangement is illustrated in Figure 4 in which a gamma camera comprising a multiple position-sensitive neutral particle sensor according to the invention 102, is connected through suitable circuitry 103 to a display unit 104. A collimator 106, consisting of a lead plate 25 millimetres thick and having a matrix of parallel open channels of about 4 millimetres diameter, is arranged between the sensor and a live human body 108. In this arrangement, the collimator 106 absorbs all gamma rays which do not pass substantially vertically upwards, and a two-dimensional picture of a gamma-ray emitting organ is obtained.

In another medical use, instead of ^{99m}Technetium, a positron-emitting substance is administered to a patient. Two multiple position-sensitive neutral particle sensors may be arranged to detect the gamma rays emitted back-to-back by positron annihilation. Such an arrangement is shown in Figure 5 in which two multiple sensors according to the invention 110, 112 are spaced above and below a live human body 114. The sensors are connected through suitable circuitry 116 to a display unit 118 in such a way that only coincident gamma rays are displayed and a reconstruction of the distribution of the positron emitting substance within the live human body is exhibited on the display unit 118 by means of a suitable computer.

Claims

1. A cathode plate for use in a position-sensitive neutral particle sensor comprising an insulating support having a cathode array (50D, 50E) of spaced metal strips arranged adjacent and edge to edge, the metal of which strips are formed being such that an incident neutral particle gives rise to an ionising particle which is either a photoelectron or a Compton electron and which escapes from the cathode plate, characterised by the insulating support having a thickness which prevents absorption of said ionising particle, having a cathode array on each face, and by the thickness of each metal strip in each cathode array being approximately half the preferred thickness provided from theoretical calculations.

2. A cathode plate according to Claim 1 in which both cathode arrays (50D, 50E) are identical and the strips lie in the same orthogonal direction on both sides of the insulating support.

3. A cathode plate according to Claim 1 or Claim 2 for sensing X-rays having an energy of approximately 60 KeV in which both cathode arrays comprise copper strips 5 microns thick.

4. A cathode plate according to Claim 1 or Claim 2 for sensing gamma rays having an energy of approximately 140 KeV in which both cathode arrays comprise tin strips 12.5 microns thick.

5. A cathode plate according to Claim 1 or Claim 2 for sensing gamma rays having an energy of approximately 510 KeV in which both cathode arrays comprise lead strips 125 microns thick.

6. A cathode plate according to Claim 1 or Claim 2 for sensing thermal neutrons having an energy of approximately 100 meV in which both cathode arrays comprise gadolinium strips 10 microns thick.

7. A position-sensitive neutral particle sensor comprising a plurality of cathode plates according to any of Claims 1 to 6, the cathode plates being parallel to each other and closely spaced with the strips in the cathode arrays (50) on adjacent faces of neighbouring plates being mutually orthogonal and the two outer cathode plates having cathode arrays only on the inner side of the insulating support;

means (56, 58) for connecting each strip of each cathode array to a known electrical potential;

in each space between the cathode plates an anode array (52) comprising a plurality of spaced wires;

means for connecting all of the wires in each anode array (52) to a source of electrical potential;

means (66, 68, 70) for supplying a gas to the volume around each anode array (52); and

means (62, 72, 74, 76, 78, 80, 82, 84) for sensing the presence of an induced electrical charge in at least one strip of both cathode arrays (50) adjacent one anode array (52), the induced electrical charge resulting from the arrival in the sensor of a neutral particle, and for providing output signals representing the orthogonal position of that neutral particle in those cathode arrays.

8. A sensor according to Claim 7 further comprising means (86) for sensing the arrival of electrons at an anode array (52).

9. A position-sensitive neutral particle sensing system comprising a sensor according to Claim 7 or Claim 8 and display means (84) arranged to provide an orthogonal display for each of the received particles.

10. A camera sensitive to gamma rays or X-rays comprising a position-sensitive neutral particle sensor (102, 103) according to Claim 7 or Claim 8 and a collimator 106 arranged to

allow passage of gamma rays or X-rays only in a direction substantially perpendicular to the plane of the cathode arrays.

11. A camera sensitive to positrons characterised by comprising two spaced sensors (110, 112) according to Claim 7 or Claim 8, and coincidence sensing means (116) arranged to sense the simultaneous arrival of a neutral particle in each sensing system.

Revendications

1. Plaque cathodique destinée à être utilisée dans un capteur de particules neutres détectant la position comprenant un support isolant ayant un arrangement cathodique (50D, 50E) de bandes métalliques distantes disposées les unes près des autres et bord à bord, le métal dont les bandes sont formées étant tel qu'une particule neutre incidente fait apparaître une particule ionisante qui est soit un photoélectron, soit un électron Compton et qui s'échappe de la plaque cathodique, caractérisée en ce que le support isolant a une épaisseur qui empêche l'absorption de la particule ionisante et a un arrangement cathodique sur chaque face, et l'épaisseur de chaque bande métallique de chaque arrangement cathodique est approximativement égale à la moitié de l'épaisseur préférée donnée par les calculs théoriques.

2. Plaque cathodique selon la revendication 1, caractérisé en ce que les deux arrangements cathodiques (50D, 50E) sont identiques et les bandes sont disposées dans la même direction orthogonale sur les deux faces du support isolant.

3. Plaque cathodique selon l'une des revendications 1 et 2, destinée à détecter des rayons X ayant une énergie d'environ 60 keV, caractérisée en ce que les deux arrangements cathodiques sont des bandes de cuivre de 5 microns d'épaisseur.

4. Plaque cathodique selon l'une des revendications 1 et 2, destinée à détecter des rayons gamma ayant une énergie d'environ 140 keV, caractérisée en ce que les deux arrangements cathodiques comprennent des bandes d'étain de 12,5 microns d'épaisseur.

5. Plaque cathodique selon l'une des revendications 1 et 2, destinée à détecter des rayons gamma ayant une énergie d'environ 510 keV, caractérisée en ce que les deux arrangements cathodiques comportent des bandes de plomb de 125 microns d'épaisseur.

6. Plaque cathodique selon l'une des revendications 1 et 2, destinée à détecter des neutrons thermiques ayant une énergie d'environ 100 meV, caractérisée en ce que les deux arrangements cathodiques comportent des bandes de gadolinium de 10 microns d'épaisseur.

7. Capteur de particules neutres détectant la position, caractérisé en ce qu'il comprend plusieurs plaques cathodiques selon l'une quelconque des revendications 1 à 6, les

plaques étant parallèles les unes aux autres et très rapprochées, les bandes des arrangements cathodiques (50) se trouvant sur les faces adjacentes de plaques voisines étant disposées orthogonalement, les deux plaques externes n'ayant d'arrangement cathodique que sur la face interne du support isolant,

un dispositif (56, 58) de connexion de chaque bande de chaque arrangement cathodique à un potentiel électrique connu,

un arrangement anodique (52) placé dans l'espace séparant les plaques cathodiques et comprenant plusieurs fils métalliques distants,

un dispositif de connexion de tous les fils métalliques de chaque arrangement cathodique (52) à une source de potentiel électrique,

un dispositif (66, 80, 70) destiné à transmettre un gaz au volume entourant chaque arrangement anodique (52), et

un dispositif (62, 72, 74, 76, 78, 80, 82, 84) destiné à détecter la présence d'une charge électrique induite dans au moins une bande des deux arrangements cathodiques (50) adjacent à un arrangement anodique, la charge électrique induite résultant de l'arrivée d'une particule neutre sur le capteur, et à former des signaux de sortie représentant une position orthogonale de cette particule dans ces arrangements cathodiques.

8. Capteur selon la revendication 7, caractérisé en ce qu'il comprend en outre un dispositif (86) de détection de l'arrivée d'électrons sur un arrangement anodique (52).

9. Système de détection de particules neutres avec détection de position, caractérisé en ce qu'il comprend un capteur selon l'une des revendications 7 et 8, et un dispositif d'affichage (84) destiné à donner un affichage orthogonal pour chacune des particules reçues.

10. Caméra sensible aux rayons gamma ou aux rayons X, caractérisée en ce qu'elle comprend un capteur de particules neutres détectant la position (102, 103), selon l'une des revendications 7 et 8, et un collimateur (106) destiné à permettre le passage des rayons gamma ou des rayons X uniquement en direction sensiblement perpendiculaire au plan des arrangements cathodiques.

11. Caméra destinée à détecter des positions, caractérisée en ce qu'elle comprend deux capteurs espacés (110, 112) selon l'une des revendications 7 et 8, et un dispositif de détection de coïncidence (116) destiné à détecter l'arrivée simultanée d'une particule neutre dans chaque système de détection.

Patentansprüche

1. Kathodenplatte zur Verwendung in einem positionsempfindlichen Sensor für neutrale Teilchen, mit einer isolierenden Unterlage, die eine Kathodenanordnung beabstandeter Metallstreifen aufweist, welche benachbart und Kante an Kante angeordnet sind, wobei das Metall, aus denen die Streifen gebildet sind, von der Art

ist, daß ein einfallendes neutrales Teilchen ein ionisierendes Teilchen bewirkt, welches entweder ein Photoelektron oder ein Compton-elektron ist und welches aus der Kathodenplatte entweicht, dadurch gekennzeichnet, daß die isolierende Unterlage eine Dicke aufweist, welche die Absorption des ionisierenden Teilchens verhindert, und eine Kathodenanordnung auf jeder Oberfläche umfaßt, und daß die Dicke jedes Metallstreifens in jeder Kathodenanordnung etwa die Hälfte der bevorzugten Dicke beträgt, die sich aus theoretischen Berechnungen ergibt.

2. Kathodenplatte nach Anspruch 1, dadurch gekennzeichnet, daß beide Kathodenanordnungen (50D, 50E) identisch sind und die Streifen in der gleichen orthogonalen Richtung auf beiden Seiten der isolierenden Unterlage liegen.

3. Kathodenplatte nach Anspruch 1 oder 2 zum Abtasten von Röntgenstrahlen mit einer Energie von etwa 60 keV, dadurch gekennzeichnet, daß beide Kathodenanordnungen aus 5 μm dicke Kupferstreifen bestehen.

4. Kathodenplatte nach Anspruch 1 oder 2 zum Abtasten von Gammastrahlen, die eine Energie von etwa 140 keV aufweisen, dadurch gekennzeichnet, daß beide Kathodenanordnungen aus 12,5 μm dicken Zinnstreifen bestehen.

5. Kathodenplatte nach Anspruch 1 oder 2 zum Abtasten von Gammastrahlen, die eine Energie von etwa 510 keV aufweisen, dadurch gekennzeichnet, daß beide Kathodenplatten aus 125 μm dicken Bleistreifen bestehen.

6. Kathodenplatte nach Anspruch 1 oder 2 zum Abtasten thermischer Neutronen, die eine Energie von etwa 100 MeV aufweisen, dadurch gekennzeichnet, daß beide Kathodenanordnungen aus 10 μm dicken Gadoliniumstreifen bestehen.

7. Positionsempfindlicher Sensor für neutrale Teilchen, gekennzeichnet durch mehrere Kathodenplatten (50) nach einem der vorhergehenden Ansprüche, die parallel zueinander und eng beieinander liegen, wobei die Streifen in den Kathodenanordnungen auf benachbarten Oberflächen benachbarter Kathodenplatten orthogonal zueinander angeordnet sind, und die zwei äußeren Kathodenplatten nur an der Innenseite der isolierenden Unterlage Kathoden-

anordnungen aufweisen, ferner durch eine Einrichtung (56, 58) zum Anschließen jedes Streifens jeder Kathodenanordnung an ein bekanntes elektrisches Potential, eine Anodenanordnung (52) in jedem Zwischenraum zwischen den Kathodenplatten, welche eine Mehrzahl beabstandeter Drähte umfaßt, eine Einrichtung zum Anschließen sämtlicher Drähte in jeder Anodenanordnung (52) an eine elektrische Potentialquelle, eine Einrichtung (66, 70) zur Zuführung eines Gases zu einem Raum-bereich um jede Anodenanordnung (52) herum sowie eine Einrichtung (62, 72, 74, 76, 78, 80, 82, 84) zum Abtasten des Vorhandenseins einer induzierten elektrischen Ladung in wenigstens einem Streifen beider einer Anodenanordnung (52) benachbarten Kathodenanordnungen (50) und wobei die induzierte elektrische Ladung von der Ankunft eines neutralen Teilchens in dem Sensor herrührt, zum Liefern von Ausgangssignalen, die die orthogonale Position dieses neutralen Teilchens in den Kathodenanordnungen wiedergeben.

8. Sensor nach Anspruch 7, gekennzeichnet durch eine Einrichtung (86) zum Abtasten der Ankunft von Elektronen an einer Anodenanordnung (52).

9. Positionsempfindliches Sensorsystem für neutrale Teilchen nach Anspruch 7 oder 8, gekennzeichnet durch einen Sensor nach Anspruch 7 oder 8 und eine Bildaufzeichnungseinrichtung (84) zum Vorsehen einer orthogonalen Bildaufzeichnung für jedes der empfangenen Teilchen.

10. Für Gammastrahlen oder Röntgenstrahlen empfindliche Kamera, gekennzeichnet durch einen positionsempfindlichen Vielfachsensor für neutrale Teilchen (102, 103) nach Anspruch 7 oder 8 sowie einen Kollimator 106, der so angeordnet ist, daß er Gammastrahlen oder Röntgenstrahlen nur in einer Richtung durchläßt, die im wesentlichen senkrecht zur Ebene der Kathodenanordnungen ist.

11. Für Positronen empfindliche Kamera, gekennzeichnet durch zwei beabstandete Vielfachsensoren (110, 112) nach Anspruch 7 oder 8 sowie eine Koinzidenzabtasteinrichtung (116), die darauf eingerichtet ist, die gleichzeitige Ankunft eines neutralen Teilchens in jedem Abtastsystem abzutasten.

55

60

65

7







