Lawrence Berkeley National Laboratory
Recent Work

Title
THE HISPET PROJECT: STATE OF THE ART

Permalink
https://escholarship.org/uc/item/7fp199w0

Author
Guerra, A. Del

Publication Date
1984-09-01

eScholarship.org Powered by the California Digital Library
University of California

LBL-19481
c2

Lawrence Berkeley Laboratory
UNIVERSITY OF CALIFORNIA

Physics Division

JUL 15 1985
LIBRARY AND
DOCUMENTS SECTION

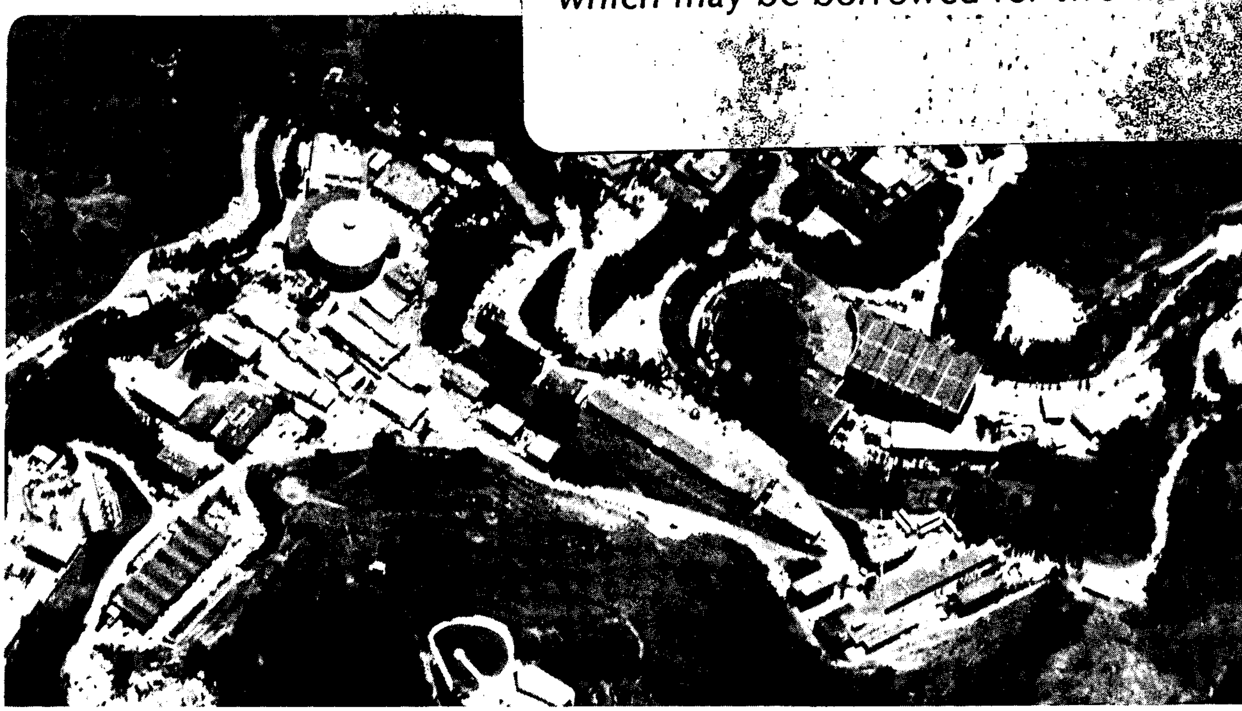
Presented at the VII International Conference on Positron Annihilation, New Dehli, India, January 6-11, 1985

THE HISPET PROJECT: STATE OF THE ART

A. Del Guerra, G.K. Lum, V. Perez-Mendez, and G. Schwartz

September 1984

TWO-WEEK LOAN COPY
This is a Library Circulating Copy which may be borrowed for two weeks



LBL-19481
c.2

Prepared for the U.S. Department of Energy under Contract DE-AC03-76SF00098

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

ISTITUTO NAZIONALE DI FISICA NUCLEARE

Sezione di Pisa

INFN/TC-85/2
8 Marzo 1985

A.del Guerra, G.K.Lum, V.Perez-Mendez and G.Schwartz:

THE HISPET PROJECT: STATE OF THE ART

Servizio Documentazione
dei Laboratori Nazionali di Frascati

Permission to reproduce granted May 23, 1985 by A. Del Guerra.

Istituto Nazionale di Fisica Nucleare
Sezione di Pisa

INFN/TC-85/2
8 Marzo 1985

THE HISPET PROJECT: STATE OF THE ART (+)

A. Del Guerra(1), G.K. Lum(2,x), V. Perez-Mendez(2) and G. Schwartz(1)

(1) Dipartimento di Fisica, Università di Pisa, Piazza Torricelli 2, 56100 Pisa, and INFN, Sezione di Pisa, 56010 S. Piero a Grado (PI), Italy

(2) University of California, Lawrence Berkeley Laboratory, Berkeley, Ca. 94720, USA

Presented at the "VII Intern. Conf. on Positron Annihilation", New Dehli, India, 6-11 January 1985

We present the state of the art of the HISPET project: a HIgh Spatial resolution Positron Emission Tomograph based on MultiWire Proportional Chambers with lead-glass dense drift-space converters. HISPET will be capable of imaging three-dimensional distributions of a positron emitting radioisotope within a typical volume of 3 liters. It will have a volume sensitivity of ~ 100000 c/s per 0.1 μCi/ml, a signal to noise (true to accidental coincidences) ratio of 3:1 and an intrinsic spatial resolution of less than 4.5 mm (FWHM).

1.- A SUITABLE DETECTOR FOR THE ANNHILATION PHOTONS

The detection of 511 keV γ-rays with a MWPC requires the use of a high density, high Z converter with a large surface to volume ratio. We have developed a converter made of glass capillaries with a high lead content (80% PbO by weight, glass density of 6.2 g/cm^3), fused to form honeycomb matrices (1). The lead glass matrices are treated in a H_2 reduction process to form a uniform resistive layer on the inner walls of each tube. The Compton or Photoelectron produced by the photon interacting within the converter has a finite range which depends on its energy. If it reaches the gas region within the tube, a number of primary ionization electrons are produced. A voltage difference applied between the ends of the tubes drifts these primary electrons along the electric field lines within the tube towards the chamber avalanche region. A schematic diagram of the detector is shown in figure 1.

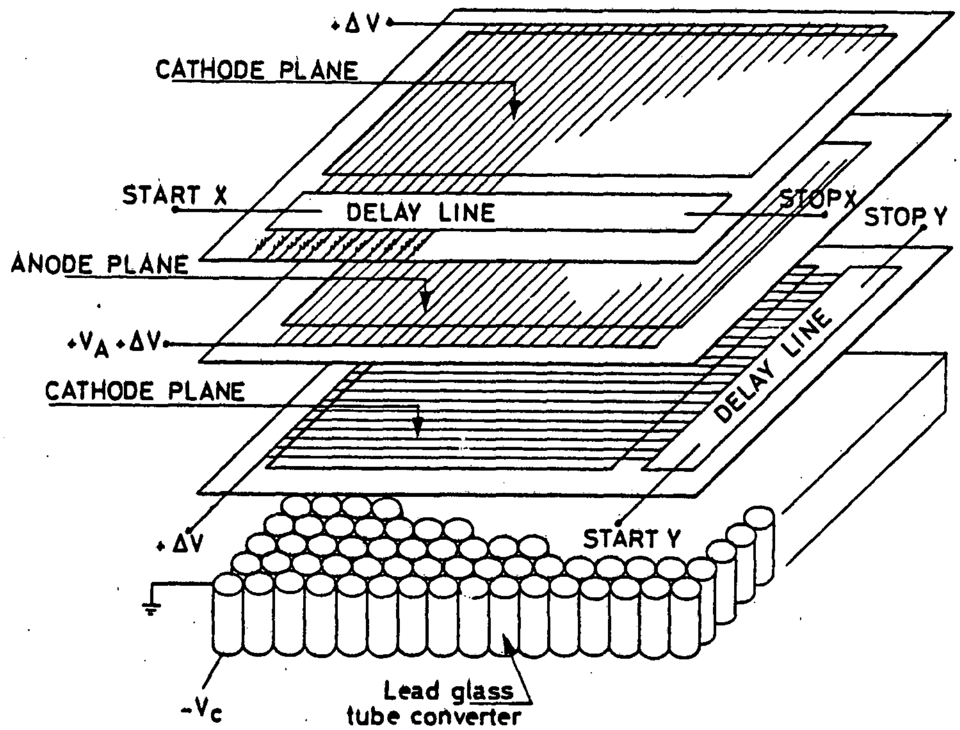


Fig. 1 Schematic drawing of a MWPC equipped with delay line readout and a single layer of lead-glass tube converter.

Various size capillaries of different tube diameters and wall thickness have been tried. Our best results have been obtained with a matrix of lead-glass tubing with 0.48 mm inner diameter, 0.06 mm wall thickness, which gives a measured efficiency of 6.5% for a 1 cm thick converter (2). The experimental efficiency measurements for the various converter types agree very well with the Monte Carlo predictions (3).

A well known figure-of-merit parameter for a "large area" positron camera is $\varepsilon^2/2\tau$, where ε is the detection efficiency (for 511 keV γ-rays) of one element and τ is the FWHM of the time resolution (in our case the transit time of the primary ionization electrons within the glass-tube matrix). Thus, for a given efficiency, the gas mixture with the highest electron drift velocity should be used to improve the time resolution. With a gas filling of Argon-Methane (70-30) at 3 atm a time resolution of $\sim$ 100 ns (FWHM) has been measured for a 1 cm thick converter (2).

To measure the x- and y- coordinate of the interacting photon we have been using delay line readout (figure 1). Fast delay lines (specific delay 8 ns/cm) are capacitively coupled to tha cathode wires. For each coordinate the signal from one end of the delay line is used as the START and the signal from the other end as the STOP of a Time to Digital Converter. The time difference is directly related to the coordinate position. Using simple integrated amplifiers and comparator electronics a spatial resolution of 1.3 mm (FWHM) has been measured with a test chamber along the coordinate parallel to the anode wire (4). The spatial resolution along the other direction is determined by the spacing of the anode wires (typically 2 mm).

2. THE MWPC-PET PROTOTYPE

We have studied this type of detector for medical applications in Positron Emission Tomography. For this purpose we have built a first prototype positron camera which consists of two 50 x 50 cm^2 MWPC, each equipped with a 2 cm thick lead-glass converter plane (80% PbO by weight, glass density of 6.2 g/cm^3, inner and outer diameters of a tube 1.33 and 1.59 mm, respectively). Fast delay line readout, capacitively coupled to the cathode planes, is used for both coordinates. The prototype has been completed (see fig. 2) and is now being tested at the Departement of Physics of Pisa University.

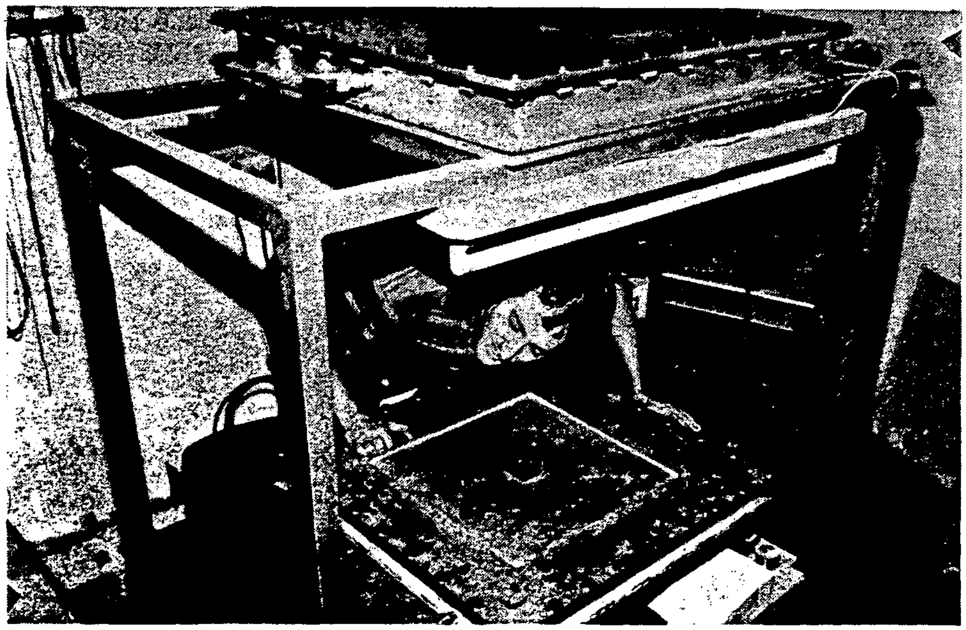


Fig. 2 The MWPC-PET prototype, now being tested at the Departement of Physics of the University of Pisa.

3. THE HISPET DESIGN

Based on our latest experimental results (2), we have designed a large positron camera, HISPET. It will consist of six modules arranged so as to form the lateral surface of a hexagonal prism. Each module of HISPET will have two MWPC and two 1 cm thick converter planes (0.48 and 0.60 mm ID and OD, respectively) (see figure 3).

The glass we had been using until recently was 79% PbO by weight. The relatively high cost of the drawn glass ($500-600 per pound for tubes of the above dimensions) is due primarily to technical difficulties in drawing the capillaries. Specifically, glass with 79% PbO content devitrifies very easily during the drawing process. Glass with a slightly lower PbO content (Schott RS-520) is much easier (and, therefore, less costly) to draw into tubes of the desired dimension. For this reason we are now experimenting with this glass (71% PbO, 5,2 g/cm^3). We have thoroughly studied the properties of this glass when reduced in hydrogen (5). In addition, we have performed a detailed Monte Carlo calculation (3) which shows that the efficiency of the 71% PbO glass is essentially the same as that of the 79% PbO glass. We are currently preparing converters with the Schott RS-520 glass.

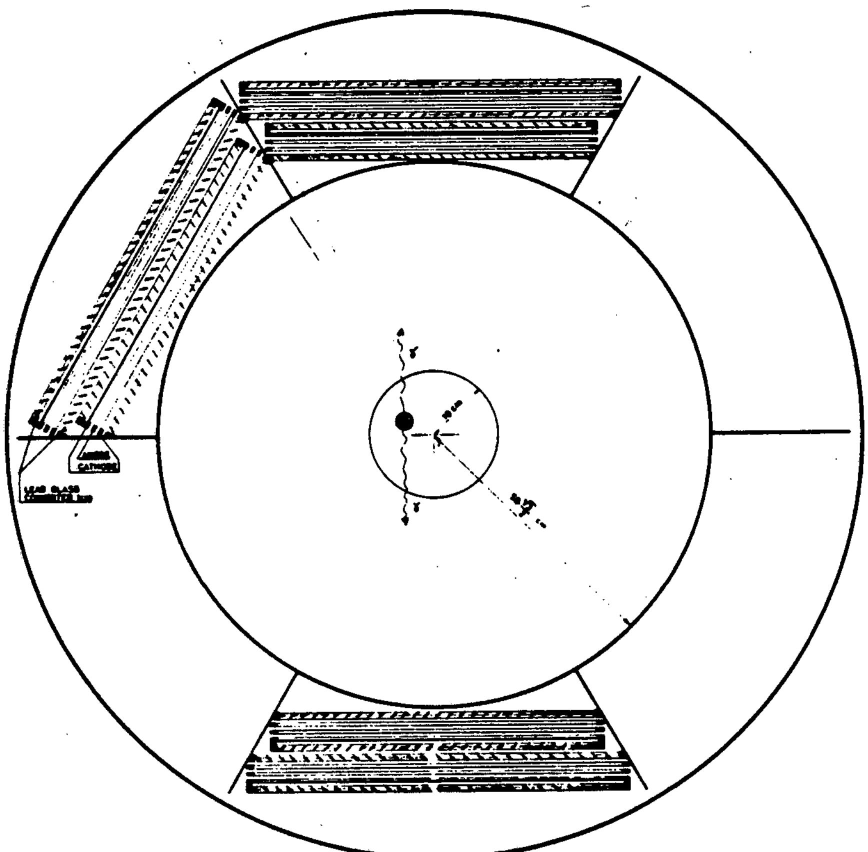


Fig. 3 Schematic drawing of HISPET: only three modules are shown.

Table 1 gives the expected design performance of the completed tomograph. The HISPET project has now started and is expected to be completed in early 1987.

Table 1

Characteristics and Performance of HISPET

Number of modules	6
Characteristics of each module:	
Number of MWPC	2
Number of layers of converter for each MWPC	2
Active area of the first layer	45x45 cm^2
Converter tubes diameter (I.D.)	0.48 mm
Total converter thickness	4 x 1 cm
Efficiency for 511 KeV γ-rays	22.5%
Covered solid angle	2π
Performance of the tomograph in air:	
Coincidence efficiency for β^+ decay	2.2%
Coincidence resolving time	100 ns
Spatial resolution (point-like ^{18}F source), FWHM	$\lesssim$ 4.5 mm
Performance of the tomograph for a uniform activity in a cylindrical water phanton (10 cm long x 10 cm radius):	
Accidental coincidences to true coincidences ratio	1/3
Source strength	~ 300 μCi
Volume sensitivity	100000 c/s per 0.1 μCi/ml
Compton distributed noise	~ 30%

(+) Work supported in part by the US Departement of Energy under Contract No. DE-AC03-76 SF00098 and No. DE-AC03-76SF00515, and by MPI (Italy), under contribution University 40% (1983), and by CNR (Italy), under contribution Comitato 02 (1983), and contract 83.02410.11 Comitato 11 (1983).

(x) Present address: Lockheed Missiles and Space Co., Inc., Sunnyvale, California, USA.

REFERENCES

(1) G.K.Lum, M.I.Green, V.Perez-Mendez, and K.C.Tam, IEEE Trans. Nucl. Sci, NS-27 (1980) 157.

(2) R.Bellazzini, A.Del Guerra, M.M.Massai, W.R.Nelson, V.Perez-Mendez, and G.Schwartz, IEEE Trans.Nucl.Sci., NS-31 (1984) 645.

(3) A.Del Guerra, M.Conti, and W.R.Nelson, "Use of EGS for Monte Carlo Calculations in Positron Imaging", Paper H25, presented at the VII "International Conference on Positron Annihilation", New Delhi, 6-11 January 1985, to be published in the Proceedings.

(4) A.Del Guerra et al.; Proc. "Intern.Conf. on Applications of Physics to Medicine and Biology", Trieste 1982, G.Alberi, Z.Bajzer, P.Baxa, eds. (World Scientific, Singapore, 1983), p.355.

(5) G.Schwartz, M.Cinti, M.Conti, A.Del Guerra, M.Di Fino, R.Habel, and L.Righini, 1985 in preparation.

This report was done with support from the Department of Energy. Any conclusions or opinions expressed in this report represent solely those of the author(s) and not necessarily those of The Regents of the University of California, the Lawrence Berkeley Laboratory or the Department of Energy.

Reference to a company or product name does not imply approval or recommendation of the product by the University of California or the U.S. Department of Energy to the exclusion of others that may be suitable.

LAWRENCE BERKELEY LABORATORY
TECHNICAL INFORMATION DEPARTMENT
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720