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THE MEPSICRON: A NEW BIDIMENSIONAL PHOTON COUNTING SYSTEM

C. Firmani, E. Ruíz, J. Bohigas and G.F. Bisiacchi

Instituto de Astronomía
Universidad Nacional Autónoma de México

RESUMEN. Presentamos las características más sobresalientes de un nuevo sistema cuenta fotones bidimensional, así como algunos resultados astronómicos obtenidos con el mismo. Algunas de sus propiedades principales son su bajo nivel de corriente obscura, su alta eficiencia en la región espectral del azul y su gran rango dinámico.

ABSTRACT. We present the principal characteristics of a new bidimensional photon counting system (MEPSICRON), as well as some astronomical results obtained with it. Its versatility, low dark current, high efficiency in the blue spectral region and large dynamic range, are but a few of the salient characteristics of the system.

Key words:

I. INTRODUCTION

The MEPSICRON is a two dimensional photon counting system possessing time resolution. The system is made of three basic components: the detector, an electronic device where the position and time of incidence of each event is analyzed (the Pulse Position Analyzer or PPA) and a memory where information is being stored. In this paper we give a brief account of the main characteristics of the system, as well as present some astronomical results in connection to direct imaging and high dispersion spectroscopy.

II. DETECTOR

Figure 1 is a schematic representation of the detector. The first component of the detector is a photocathode where an incident photon may be transformed into an electron. The photocathode has a peak quantum efficiency of 24% at 4000 A, falling down to 14% at 3000 A, and 3.6% at Hα. The electron produced by the photocathode is received by two sets of michrochannel plates where the event is amplified up to 10^8 times. The first set of plates has a V type configuration, whereas the second has a Z type arrangement. The electron cloud produced at the end of the system of microchannel plates is received by the resistive anode. The electron cloud will produce electric currents that travel to each of the four corners of the anode, from where they are sent to be amplified and analyzed by the electronic peripherals.

The principal characteristics of the detector are summarized in Table 1. Several characteristics are worth mentioning. First of all its time resolution of only 200 ns at each pixel makes the detector an excellent instrument in relation to research on fast periodic light signals, such as pulsars. Another important characteristic is its large dynamic range, which is of considerable importance in relation to the detection of, for example, temperature or density dependent line ratios where the contrast between the lines is very high. Two other characteristics that must be mentioned are its almost negligible dark current and the immediate possibility of real time imaging. Finally, the high sensitivity of the detector makes it particularly appealing in relation to faint images. Of course, its high sensitivity also implies an upper limit to the object brightness. But then, the detection of bright images never been a problem in Astrophysics.

III. ELECTRONIC PERIPHERALS

Figure 2 is a block diagram of the MEPSICRON system. The electric signals received

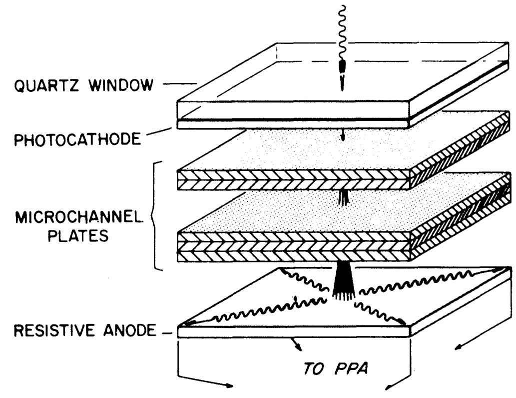


FIGURE 1.- SCHEMATIC REPRESENTATION OF THE DETECTOR

TABLE 1. MEPSICRON Specifications

Sensitive Area Diameter	25 mm
Spatial Resolution (at 6000 A)	42 μm at FWHM (uniform over surface 25 μm pixel size).
Time Resolution	200 ns
Dark current (at -30° C)	6×10^{-5}c s^{-1}pixel^{-1}
Max. Count Rate	100 c s^{-1} pixel^{-1}
Dynamic Range	$\geq10^{6}$
Pixel to pixel sensitivity variation.	$\leq5\%$
Linearity Correction	Uniform
Gain	10^{8} electrons per event
Number of pixels	8×10^{5}
Real time imaging	yes

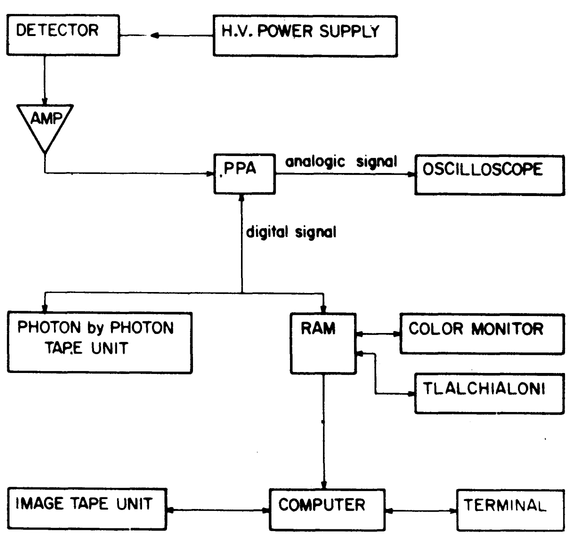


FIGURE 2.- BLOCK DIAGRAM OF THE SYSTEM

at the four corners of the resistive anode are amplified and transferred to the Pulse Position Analyzer (PPA), where the position and time of occurrence of each event is analyzed and codified. At present, the PPA is capable of analyzing up to 30 000 counts per second over the whole surface of the detector. A second generation PPA, ten times as fast as the present one, is under construction and will be in operation by the second semester of 1985. The PPA will produce an analogic signal, which is transferred to an oscilloscope, where and immediate analysis of the system's condition takes place, and a digital signal that can be stored to be scientifically analyzed some time later. The digital signal can be stored either by transferring to a magnetic tape the information about the position and time of occurrence of each event, or by accumulating the number of photons arriving at each position of the two dimensional detector in an ad-hoc memory. This bidimensional random access memory (RAM) is 16 bits deep, has 1024 × 1024 elements (equal to the number of pixels in the detector), and is an integral part of the system. Thus, the MEPSICRON can store 2 MB, and each memory element can register up to 64 000 events. The containts of the memory are displayed in real time in a color monitor that is controlled by a unit called TLALCHIALONI.

The MEPSICRON system ends practically here. But if we want to transfer the information to a more movile record, such as a magnetic tape, or if we want to manipulate the information as we do the observation, we must then have some computing facilities. At present we are using a NOVA in combination with a DATARAM memory unit, a disquette unit for two floppies, an AMPEX magnetic tape unit and an ADM terminal. This old-fashioned computing system will be updated in the near future with the introduction of a Charles Rivers computer.

IV. ASTRONOMICAL RESULTS

a) *Direct Imaging.*

The MEPSICRON has been used in the direct imaging mode in combination with the 2.12m telescope at San Pedro Mártir, Baja California. The detector was placed at the f/7.5 secondary focus of the telescope, yielding a resolution of approximately 0.3" per pixel. The images have been compacted by a factor of 2 in both directions, so that their resolution is approximately equal to 0.6" per pixel.

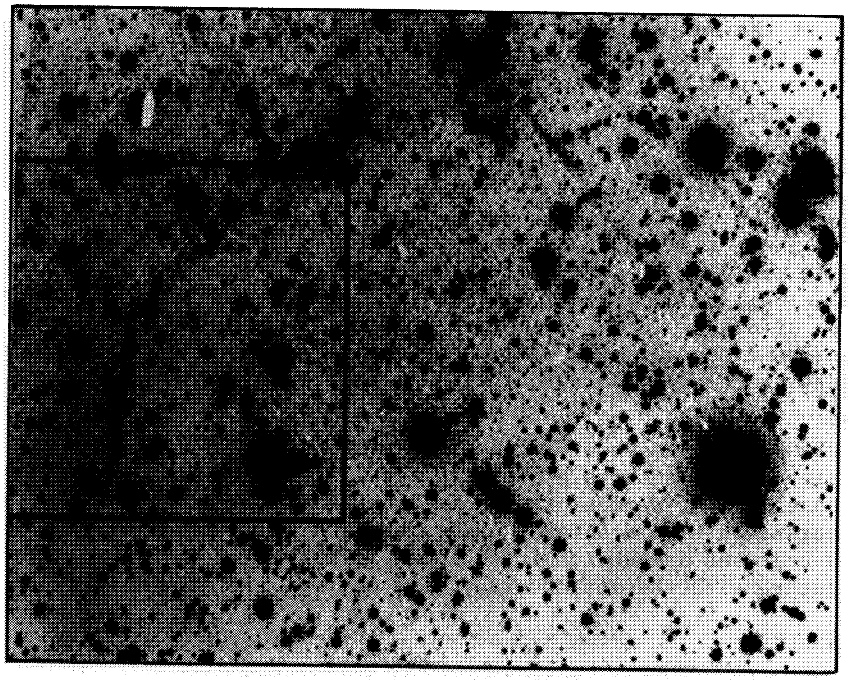
Figure 3 contains two images of Tycho's supernova remnant (SNR); one of them was taken with the Palomar 5 m telescope (van den Bergh *et al.* 1973), the other with the MEPSICRON detector in combination with the system described above. The Palomar image was obtained with red sensitive 103aE plates in combination with an RG2 filter. The exposure time was 2 hours. On the other hand,the MEPSICRON image was taken through a 10 A FWHM Hα interference filter with a 33% peak transmission. In this case the exposure time was 40 minutes, and though this image has been processed by substraction of the sky brightness and the application of a median filter algorithm, the competitiveness of the MEPSICRON detector is apparent. The MEPSICRON image does not contain as many stars as the Palomar plate simply because the filter is not as wide, a limitation of no importance in the hydrogen emission filaments of the SNR.

The detector was also used to obtain images of the outer regions of the globular cluster M15. With interference filters centered at 4255 A (FWHM = 80 A and peak transmittance of 48%) and 6450 A (FWHM = 80 A and peak transmittance of 55%), we were able to obtain the image of stars of m ≅ 21-21.5 in 10 minutes.

b) *High Dispersion Spectroscopy.*

One of the first applications of the MEPSICRON has been with the high dispersion echelle spectrograph, also working in San Pedro Mártir in combination with the 2.12-m telescope. The spectrograph covers a selectable spectral range of 1000 A with a 900 groove mm^{-1} echelette grating. This grating can be replaced with one having 200 groove mm^{-1} echelette grating, that allows a wider wavelength coverage without any loss of resolution, which in the mean is equal to 5 A mm^{-1}.

The blue spectrum of the galaxy MK35, obtained with the 900 A mm^{-1} grating, is shown in Figure 4. The spectrograph entrance slit of width 10" was placed on the galaxy center in the EW direction, and the exposure time was only 10 minutes. This picture exhibits only eight levels of gray, a value far below the dynamic range of the detector. Yet, it can be observed that the [O II] 3726-3728 doublet is perfectly resolved. Another example of high dispersion spectroscopy is shown in Figure 5, where the red spectrum of the galaxy Haro 9 is shown. The exposure time was again equal to 10 minutes. The complex structure of Hα, due to the pronounced velocity field



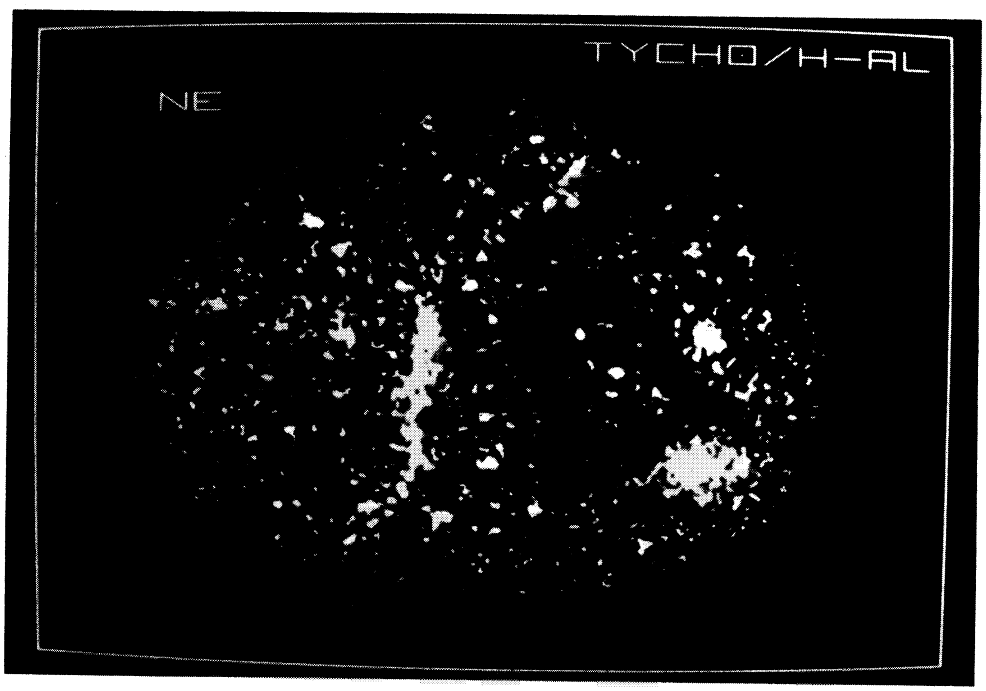


Fig. 3. Optical image of Tycho's SNR. The upper picture is from van den Bergh *et al.* (1973), and the area within the square is the same region covered by the MEPSICRON image shown in the lower part of this figure.

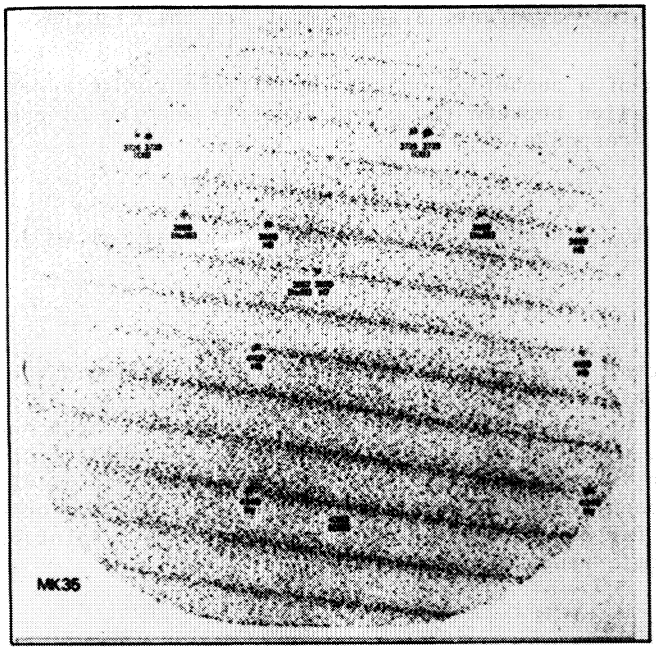


Fig. 4. Blue spectrum of the galaxy Mk35, observed with a 10" slit and 10 minutes exposure time.

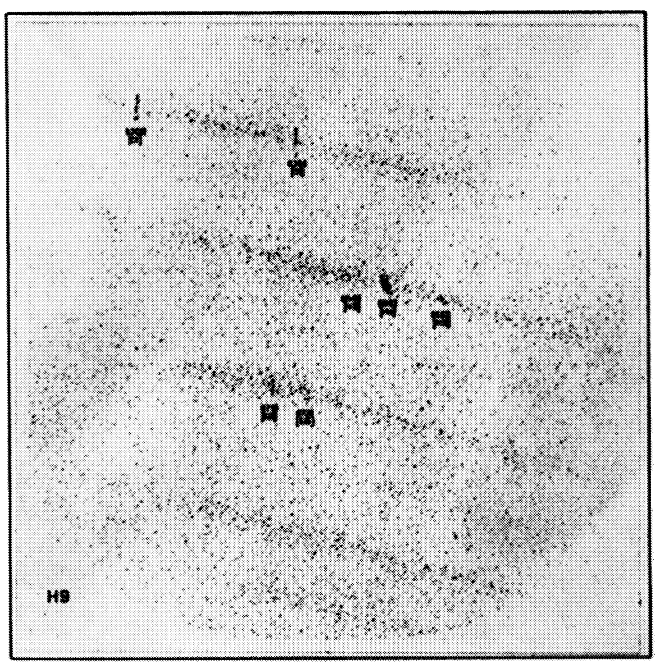


Fig. 5. Red spectrum of the galaxy Haro 9,observed with a 10" slit width and 10 minutes exposure time.

of the galaxy, is immediately apparent. Also evident are the night-sky lines of [O I](at 6300 and 6364 A).

Observations of a number of objects of different magnitudes have allowed us to establish an empirical relation between the count rate (S) and the blue magnitude (m) of an object, at the peak instrumental response:

$$s = 10^{-(m - 13.5)/2.5} \quad . \qquad (1)$$

Thus, for a star of m = 16, a spectrum of 0.4 A FWHM and a signal to noise ratio of 10 is obtained in about an hour.

V. CONCLUSIONS

We believe that the characteristics and tests carried out on the MEPSICRON system, have shown that it is a highly competitive instrument in astronomical observations. Furthermore, the system has also been used in combination with an electron microscope, where it has rendered very positive results in the area of solid state physics (Firmani *et al.* 1984). At present, the system's main competitor is the CCD which, due to its higher quantum efficiency, has a better response in the red, though not in the blue spectral region. On the other hand, the MEPSICRON is clearly in advantage as far as resolution, dark current, time resolution, temperature of operation, linearity and dynamic range are concerned.

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GianFranco Bisiacchi, Joaquín Bohigas, Claudio Firmani, and Elfego Ruíz: Instituto de Astronomía, UNAM, Apartado Postal 70-264, 04510 México, D. F., México.