Application of thermoluminescence for detection of cascade shower I

---- Hardware and software of reader system ----

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ABSTRACT

We developed a reader system for the detection of luminescence induced by heating sensitive material($BaSO_4$:Eu). The reader system is composed of following six instruments; i)Heater, ii)Light guide, iii)Image intensifier, iv)CCD camera, v)Image processor, vi)Micro computer. We report here the efficiencies of these apparatuses, and software utilities for image analysis.

I) Introduction

It has passed about 30 years since Nishimura*[1]* proposed emulsion chamber(EC) of today's type. Since then, it has played a pioneer-like role in the field of ultra high energy physics, where energy of accelerator could never reach. In the very near future, however, super machines, such as TEVATRON, LEP and DESERTRON, are surely to operate subsequently, which cover, or may exceed the energy region nowadays available for EC experiment at mountain station. So, most people think that the observation of air family by means of traditional EC *only* may be closed down soon. In fact, none of emulsion people expect that the current EC continues to work well in a coming decade further.

Under these situations, several groups, particularly those of air shower (AS) and EC*[2]*, are planning to start projects on new phase, combining active detectors(AS array) with passive ones(emulsion like), in order to build an unified picture of shower phenomena both in the atmosphere and the underground. Naturally, the scale of calorimeter thus combined is expected to be much larger, at least ten times or more, than today's.

From these points of view, we decided to develop reader system as well as a new kind of sensitive material*[3]*, thermoluminescence sheet(TLS), which is much more economical and efficient than X-ray film used now.

II) Reader system

Schematic view of reader system is illustrated in Fig. 1, where the use of image intensifier(I.I.) was at first proposed by Okayama group*[4]*.
i)Heater: We use infrared heater of 3 KW, providing uniform thermal beam on hot plate. Heating rate is of course adjustable by controller as we like within the range $\lesssim$ 10°C/sec. Both the heater and the stage attach-

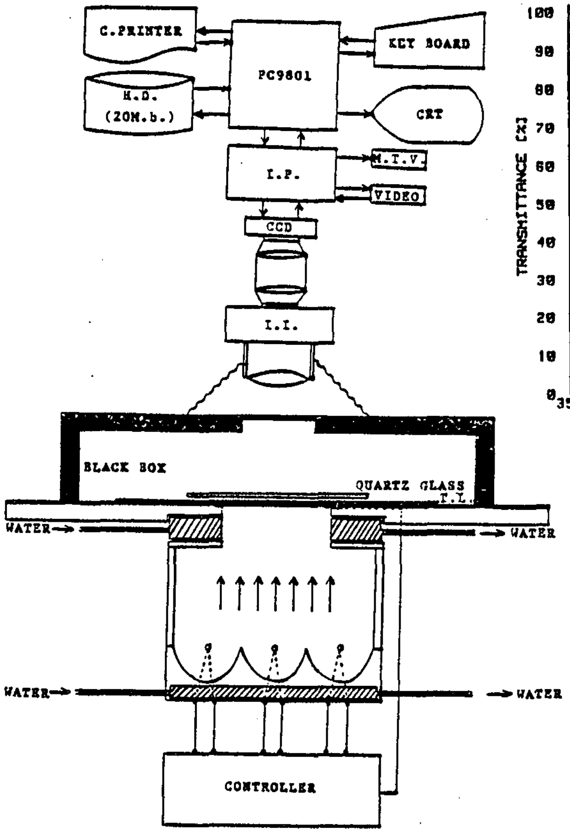

Fig. 1. Schematic view of TL-reader.

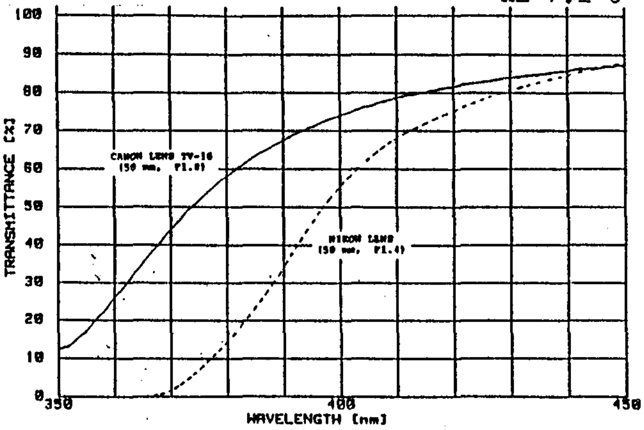

Fig. 2. Transmittance of commercial lens against wave length.

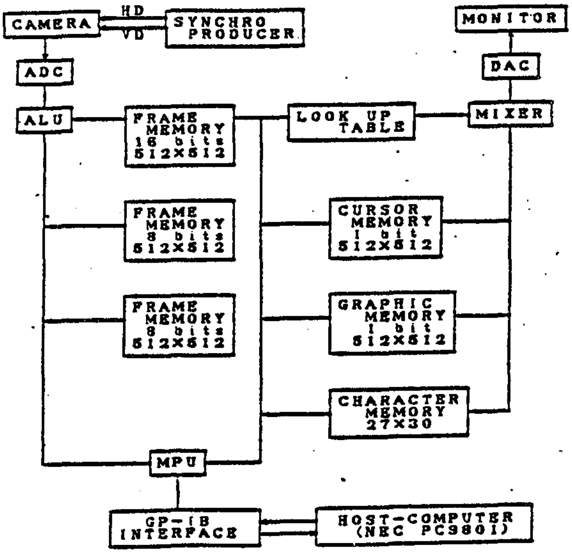

Fig. 3. Block diagram of I.P..

ed with hot plate are cooled by flowing water.

ii)Light guide: Wave length of thermoluminescence being ∿ 375 nm[5], we must use condenser lens transmitting well ultra violet light. We found CANON TV16 lens(50mm, F1.8) is the best among commercial ones. Its transmittance is demonstrated in Fig. 2, where the results of camera lens NIKON(50mm, F1.8) is also shown together. One finds the former is approximately ten times higher than the latter in the ultra violet region.

iii)I.I.(HAMAMATSU PHOTONICS,V2025): The imager incorporates a photocathode, a 2-stage micro-channel plate(MCP) and phosphor screen. The gain is variable within the range 10^2 ∿ 10^6. The effective area of the photocathode is 15mϕ, and the sensitivity for wave length of incident light lies around 350nm ∿ 650nm. THe best resolution of the phosphor screen is ∿ 15 lines/mm, high enough for our purpose.

iv)CCD camera(NEC): Effective number of picture elements is 489 × 384, and the size of effective photocathode area is 2/3 inch. The uniformities both in the geometry and individual photo-sensors are quite well.

v)I.P.(ADS CO.LTD.): Block diagram of I.P. is shown in Fig. 3. Signals from each pixel of CCD are stored in the main frame memory(16bits × 512 × 512). In I.P., we have more frame memories as seen in Fig. 3, which are useful for image analysis. These data stored in frame memory are transmitted to RAM(640 Kb) in host computer PC9801, through GPIB interface.

III) Software system

In Fig. 4, we present the internal relation of software utilities for TL shower analysys. The system is composed of following four functions.

i)EDITOR: This function has mainly two utilities, the one for registration of numerical constants related to chamber structure(dilution factor D_f and position of sensitive material δ), and the other to convert the standard TL transition curves(D_f=1.2, δ=600μm) into those for the chamber just registered. The detail of these calculations will be reported elsewhere. In Fig. 5, we show an example of transition curves for the chamber TLC II *[6]* exposed at Mt. Fuji during one year from August of 1983.

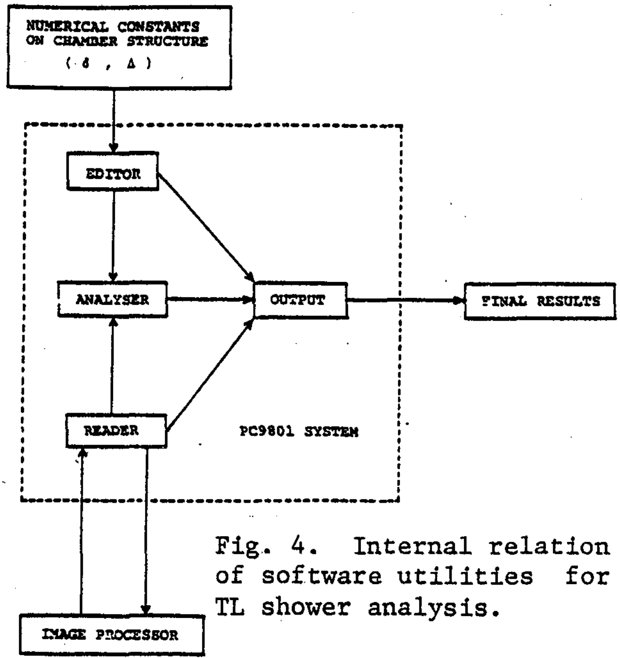

Fig. 4. Internal relation of software utilities for TL shower analysis.

Since the TL emission depends on experimental conditions, such as circumstance of exposure, gain of I.I. and so on, it must be calibrated for the amount of luminescence with use of nuclear emulsion plate, for every exposures, just in the same way as the calibration of X-ray film.

ii)ANALYSER: The function of ANALYSER is to find automatically the best fitting of theoretical ones mentioned above to experimental ones with use of least square method. Then, we get maximum TL luminescence I_{max}, which is approximately proportional to shower energy, and the penetration depth ΔT, familiar parameters in shower analysis.

iii)READER: As mentioned in II-v), the raw data storaged in frame memory of I.P. are transmitted to RAM memory in PC9801 through GPIB. These data are save in hard disk(20 Mb) and/or flopy disk(1 Mb). Utility of READER

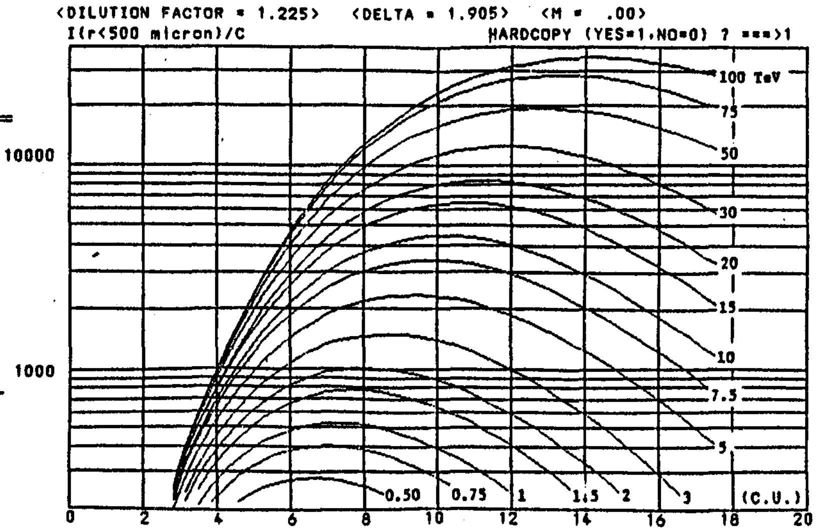

Fig. 5. Example of TL transition curves in the cases of tan θ= 0, initiated by electron-pair primary. Numerical value attached to each curve is shower energy. Conversion factor C denoted at vertical axis is to be determined by the calibration procedure with use of nuclear emulsion plate, as discussed in text.

is to provide following processes.
a)Drawing of glow curve on CRT in real time.
b)Background subtraction.
c)Two dimensional contour map.
d)Three dimensional contour map.
e)Lateral distribution of luminescence.

In Fig. 6, we demonstrate the three dimensional contour map of TL emission, which is obtained by 10 minutes irradiation of Sr^{90}.

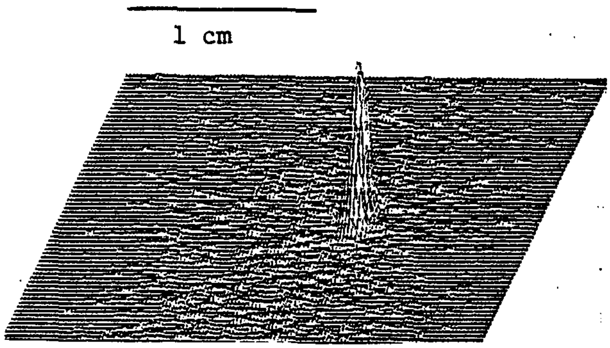

Fig. 6. Three dimensional contour map of TL emission, induced by Sr^{90} irradiation.

iv)OUTPUT: This is to provide utilities related to output processes for all physical quantities, stored in disk through the functions i), ii) and iii), on CRT and/or printer.

IV) Discussions

The reader system presented here is of course not enough for processing a big amount of TL sheets expected from future's super TL-calorimeter. In order to develop the present system further, we are now investigating to use optical fiber, instead of lens system, so as to collect TL light more efficiently, and to move TL-stage automatically to scan large area of TL sheet more quickly.

Results of TL measurements by means of the reader system here is reported in HE 7.1-7 in this volume.

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Numerical calculations on TL transition curves are performed by FACOM M180-II (Institute of Nuclear Study, University of Tokyo) and NEC ACOS750 (Aoyama Gakuin University).

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