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D. Babusci, A. Barile, S. Bianco, R. Casaccia, L.E. Casano, M. Capogni,  
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**PERFORMANCES OF HEAD-ON Pb-SCIFI CALORIMETRIC  
MODULES**

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## PERFORMANCES OF HEAD-ON Pb-SCIFI CALORIMETRIC MODULES

D. Babusci<sup>1</sup>, A. Barile<sup>3</sup>, S. Bianco<sup>1</sup>, R. Casaccia<sup>1</sup>, L.E. Casano<sup>3</sup>,  
M. Capogni<sup>3</sup>, A. D'Angelo<sup>3</sup>, L. Daniello<sup>1</sup>, D. Fabbri<sup>1</sup>, F.L. Fabbri<sup>1</sup>,  
G. Gatta<sup>1</sup>, M. Giardoni<sup>1</sup>, B. Girolami<sup>4</sup>, D. Hertzog<sup>2</sup>, S. Hughes<sup>2</sup>,  
M. Lindozzi<sup>1</sup>, D. Moricciani<sup>3</sup>, L. Passamonti<sup>1</sup>, N.I. Qazi<sup>1</sup>,  
P. Reimer<sup>2</sup>, V. Russo<sup>1</sup>, S. Sarwar<sup>1</sup>, R. Tayloe<sup>2</sup>, M. Ventura<sup>1</sup>,  
L. Votano<sup>1</sup>, A. Zallo<sup>1</sup>

<sup>1</sup> Laboratori Nazionali di Frascati

<sup>2</sup> University of Illinois at Urbana-Champaign

<sup>3</sup> INFN, Sezione Roma II

<sup>4</sup> Istituto Superiore di Sanità and INFN, Sezione Sanità

*presented by S. Bianco*

### Abstract

This article reports on performances of head-on Pb-scintillating fibres e.m. calorimetric modules ('H.O.P.S. ') exposed to a 20-80 MeV tagged photon beam. Good linearity and energy resolution better than  $6\%/\sqrt{E}$  were achieved therefore showing that this technique is suitable for experimentation at  $\phi$ -factories, even at the lowest end of the photon energy range.

## 1 Introduction and Motivations

Experimentation at a  $\phi$ -factory machine demands an apparatus able to detect and to precisely reconstruct neutral and charged multipion and semileptonic final states from  $K_{S,L}$  decays. By far, the e.m. calorimeter is the most challenging detector since it is expected to efficiently reconstruct low energy (20-300 MeV) photons with very good spatial and energy resolution [2].

Calorimetric modules composed of plastic scintillating fibres embedded in lead (1:1 volume ratio or larger), with fibres parallel to the direction of the impinging photon ('head-on'), are a promising technique for a  $\phi$ -factory calorimeter: they are well-suited as tail-catchers after high-resolution CsI(Tl)[1, 3], or Pb-SCIFI tracking sections, whilst they are the natural solution for a calorimeter's endcaps. Relevant advantages are their good energy resolution, density (1.65 cm radiation length), low energy threshold. Furthermore they are fast, thus allowing time-of-flight measurements and triggering, hermetic, low-cost and permit simple rear readout. We are considering this technique also for application at high energy, in the upgrade of central region of the E687 Outer E.M. Calorimeter (Fermilab).

Such modules are an established technique in the 0.1 – 10 GeV energy range. Previous results [5] have shown the possibility of attaining energy resolutions as good as

$$\frac{\sigma}{E} \sim \frac{6.3\%}{\sqrt{E[\text{GeV}]}}$$

We extend this measurements down to 20 MeV using a tagged photon beam.

## 2 Assembly of H.O.P.S.

Two modules have been tested (fig.1). Module A [4] utilizes OPTECTOR S101-S 1 mm scintillating fibres and BICRON BC600 optical cement. Module B uses OPTECTOR S101-S 1 mm scintillating fibres and NE581 optical cement. In both modules the fibres-to-lead-to-glue volume ratio is identical ( $\sim 50 : 35 : 15$ ), as well as the external dimensions ( $9.8 \times 9.8 \times 22 \text{ cm}^3$ ).

In the *hand-made* assembly, fibres cut to measure are aligned in a grooved frame to form one layer. Fibres layers are then interspaced with previously glued, grooved lead plates.

The light emitted by the fibres is transported by a 25 cm long light guide, coupled to the H.O.P.S. module via a 1 mm air gap. The light signal is detected by a 10-dynode EMI-9902KB photomultiplier tube glued to the light guide. Both light guide and H.O.P.S. module are wrapped in aluminum foil and black tape.

## 3 Test and performances of H.O.P.S.

The LADON photon beam [6] is obtained via Compton scattering of argon laser photons off the ADONE ring electrons. The beam energy was varied from 20 MeV to 80 MeV. A microstrip solid state detector tags the beam momentum by measuring the momentum of the scattered electron. The single strip energy resolution obtained is about  $\pm 2\%$  at 80 MeV. The diameter of the beam-spot at the H.O.P.S. is  $\sim 2.5 \text{ mm}$ .

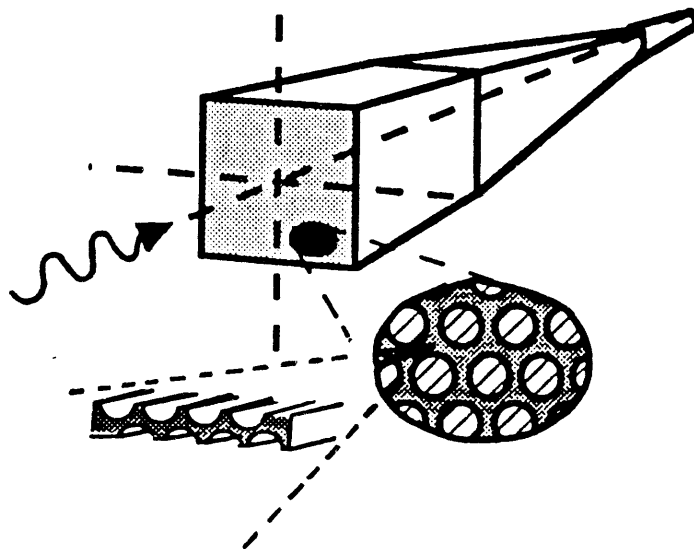


Figure 1: Schematical sketch of the H.O.P.S. modules tested, with detailing on the structure of the grooved Pb plates.

Both modules were tested at various endpoint energies of the LADON beam using the microstrips information to finely bin the photon's energy. The ADC gate is enabled by the coincidence between a fast signal from a scintillation counter backing the entire SSD and the signal from the H.O.P.S. module. Fig.2 shows the distribution of the energy deposited in a module: a binning of  $\pm 2$  MeV is applied for the incoming photon energy by using the tagging information. Study is underway to understand the nature of the background for the distribution in fig.2. The linearity is good throughout the entire energy spectrum as shown by our preliminary analysis (fig.3), while the energy resolution is better than  $6\%/\sqrt{E}$  for both modules down to 20 MeV (fig.4). Errors on the Y axis are purely statistical, while errors on the X axis represent the energy binning.

## 4 Conclusions

We have tested 2 H.O.P.S. with 20 – 80 MeV photons, finding good linearity and excellent energy resolution. We have demonstrated that H.O.P.S. are well suited under these respects even at the lowest photon energy end of a  $\phi$ -factory.

Work is in progress to assemble an experimental setup allowing efficiency measurements at very low energies. The possibility of improving the energy resolution by reducing the fibre's dimension to 0.5 mm and keeping the 1:1 volume ratio is also being considered. Finally, the behaviour of the light attenuation along the fibre is being studied with particular stress to minimise the attenuation in the vicinity of the photomultiplier.

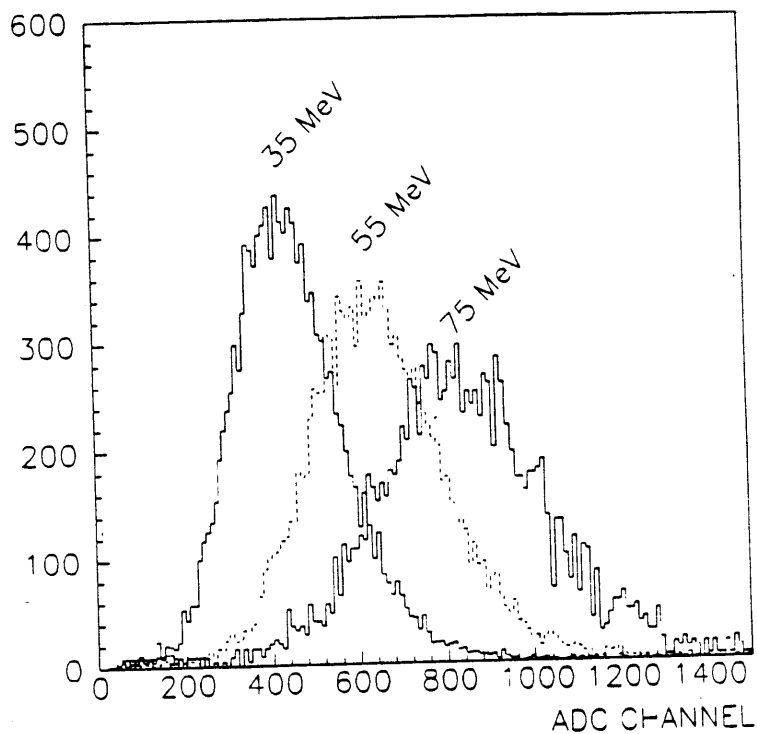


Figure 2: The energy deposit in the H.O.P.S. module. A  $\pm 2$  MeV bin is taken around the nominal value of the incoming photon's energy.

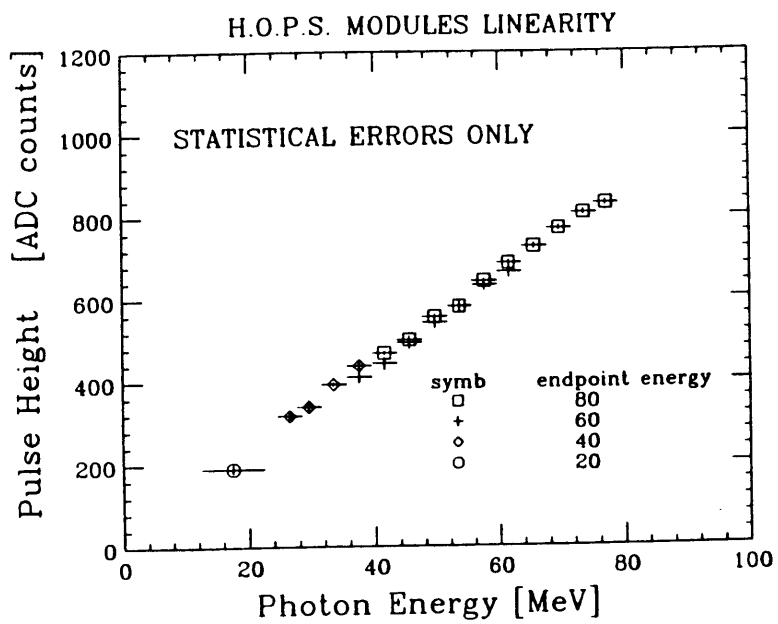


Figure 3: Linearity of the H.O.P.S. modules tested.

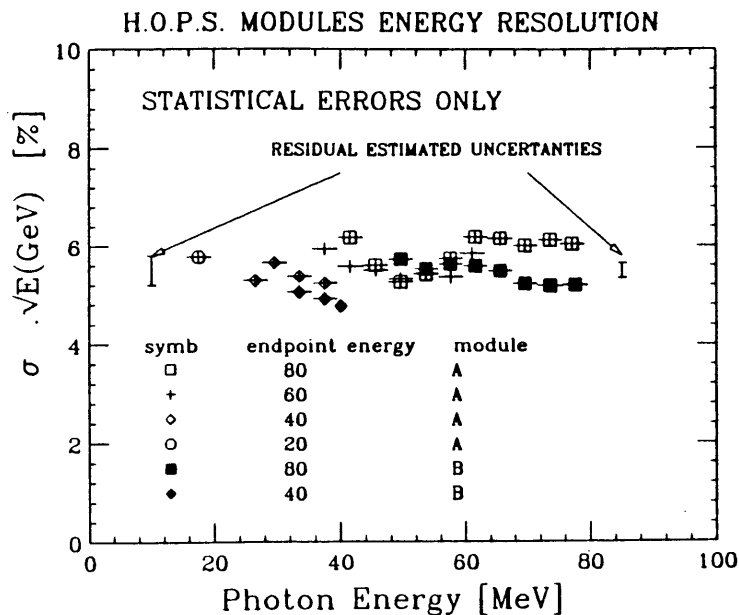


Figure 4: Energy resolution of the H.O.P.S. modules tested.

## 5 Acknowledgements

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