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A NEW MONOCHROMATIC AND POLARIZED PHOTON BEAM AT FRASCATI

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In 1962, R. H. Melbourne[1] and F. R. Arutynian[2] pointed out that backward Compton scattering of an intense polarized Laser beam by high energy electrons would produce a beam of monoenergetic and polarized photons of much higher energy. Successively this process has been studied and detected experimentally by various people[3,4,5,6]. Later[7,8] it has been pointed out that the high average current circulating in a storage ring and the high Laser power available inside a Laser cavity could produce a γ-ray beam of sufficient intensity to be used for photonuclear research. In the backward direction the γ-ray energy depends only on the emission angle with respect to the direction of the electron beam. Moreover the differential cross-section is strongly peaked in this direction and therefore the photons can be collimated in order to select a narrow energy band with some compromise with the beam intensity. A few years ago a project was undertaken at the Frascati National Laboratory to produce a beam of intermediate energy photons using the high energy electrons circulating in the storage ring Adone.

This paper reports the first experimental results recently obtained. The main features of the projected beam were[9,10]:

a) a photon energy continuously adjustable between $\sim$ 5 and $\sim$ 80 MeV, obtained varying the primary electron energy between 370 and 1500 MeV;

b) a photon intensity between $\sim 10^5$ and $\sim 10^7$ photons/sec. depending on the electron current, electron energy, Laser power and photon energy resolution required;

c) an energy resolution of the order of or better than 1% (FWHM);

d) a linear polarization of the γ-ray beam of the order of 99% and the possibility to obtain circularly polarized photon with a reduced intensity and some changes in the apparatus. Helicity conservation for relativistic electrons ensures that the polarization of the γ-ray beam is very similar to that of the Laser light.

Additional features of this beam are the high duty cycle and a low background of photons of different energy. The time structure of the photon beam is the same as that of the electrons circulating in the storage ring: pulses as short as 1.5 ns. separated by 117 ns. The bremsstrahlung on the residual gas in the vacuum chamber is the only source of background γ-rays in our beam. These characteristics should make this facility the most advanced tool presently available for the study of many features of photonuclear reaction in the energy region (5-80 MeV), around and above the giant dipole resonance.

The experimental apparatus is shown in Fig. 1. An argon ion Laser beam is align-

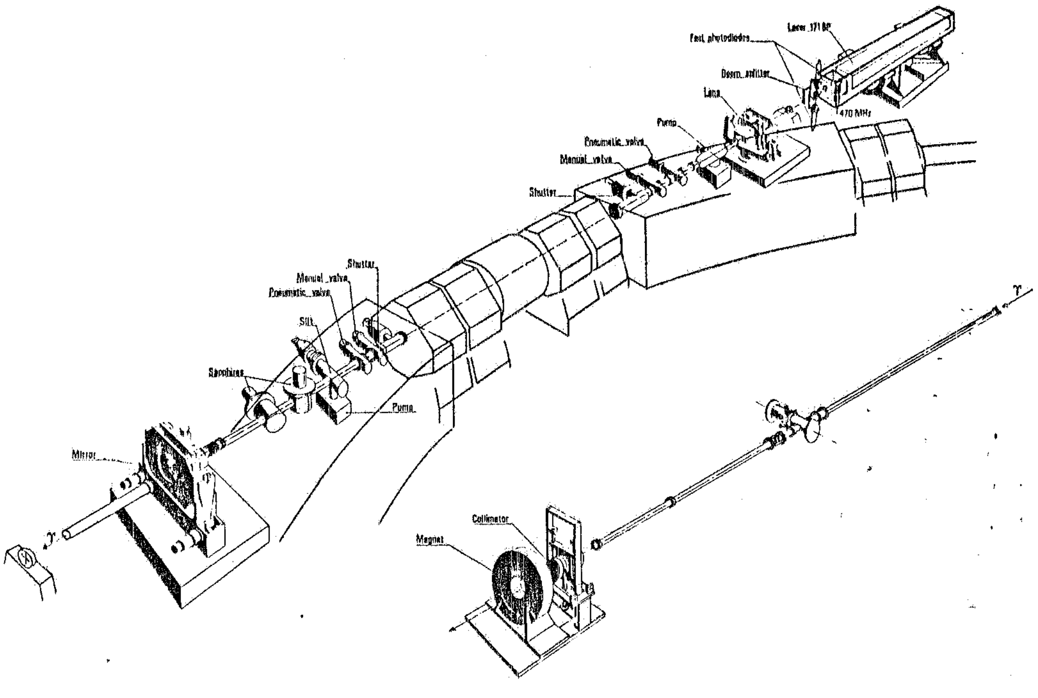

FIG. 1 - Exploded view of the interaction region.

ed along the axis of the Adone straight section 2 with an accuracy of the order of 10^{-5} rad. (the divergence of the electron beam being of the order of 10^{-4} rad.). The Laser light is injected into the vacuum pipe through and anti-reflecting coated lens and goes to a fully reflecting mirror at the end of the optical bench. On its way back from the mirror it strikes head-on with the incoming electron beam. The scattering angle of the γ-ray beam is defined by a collimator situated at 45 m from the middle of the interaction region. The experimental hall is located after the collimator.

A Laser cavity dumping system(11) driven at the same frequency (8, 568 MHz) of the Adone RF accelerating system produces short (10-20 ns) bunches of Laser light. Adjusting the time delay between the electron and Laser pulses we can define the interaction region in the center of the straight section where the phase space of the electron beam is minimum(12).

Preliminary measurements have been carried out for comparison with the design parameters. The photon intensity has been measured with a Na-I(Tl)(6''x4'') detector and a Lead Glass Čerenkov counter (5 radiation lengths) located on the beam line as shown in Fig. 2. The photons were counted in coincidence with a trigger derived

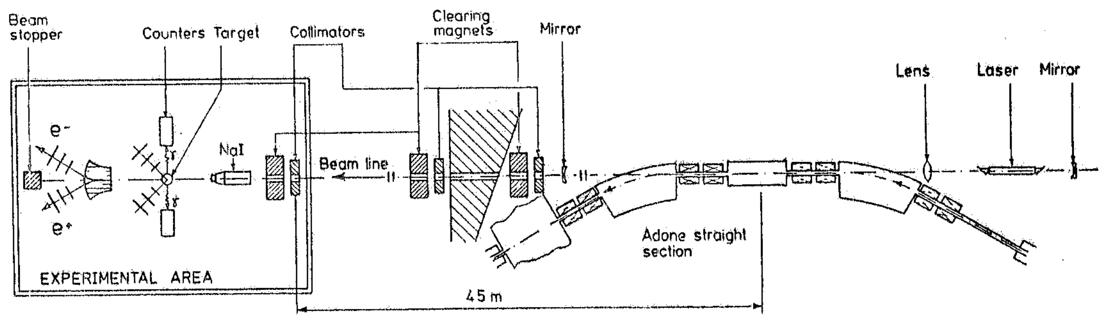

FIG. 2 - General plan of the experimental area.

from Adone's RF system and correlated in time with the arrival of γ-rays on the detector.

The counting rates obtained over almost all the available energy range and corrected for the efficiency of the detectors are shown in Fig. 3. The quoted errors, mainly systematic, are due to misalignement effects between the colliding beams and

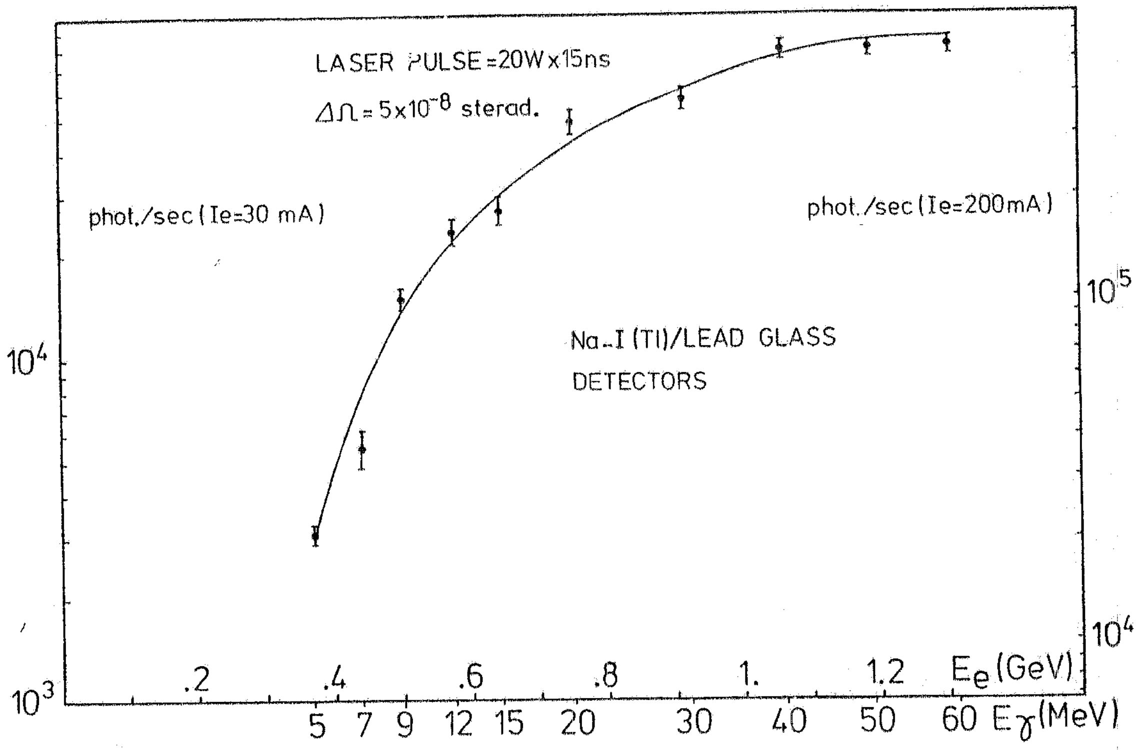

FIG. 3- Results of the intensity measurements with the Na-I(Tl) and Lead Glass Cerenkov counters.

the uncertainties in the efficiency of the detector and in the measurement of Laser power. The reported data refer to an electron current of 30 mA, a Laser energy per pulse of 3×10^{-7} J(=20 w x 15 ns) and a collimation solid angle of 5×10^{-8} sterad. The full line represents a fit of the experimental data. For electron energies greater than 750 MeV, we have good agreement with the results of a Monte-Carlo calculation(13), obtained under the assumption that the electron beam parameters are given by the usual storage ring theory(12) plus anomalous lengthening correlated to a radial enlargement. At lower energy there is a progressive disagreement that is at present under study. Since the maximum electron current we can have is 200 mA, the photon intensity we can presently have ranges from about $2\cdot10^{4}$ /sec to $6\cdot10^{5}$ /sec over all the explored energy range (see scale on the right hand side Fig. 3).

The energy resolution was measured up to E=12 MeV by means of a Ge-Li(120 cm^3) detector and a solid angle ranging from 6×10^{-9} to 6.5×10^{-8} sterad. The experimental results are presented in Fig. 4 for $\Delta\Omega$ =1, 2×10^{-8} sr. but similar results hold also for

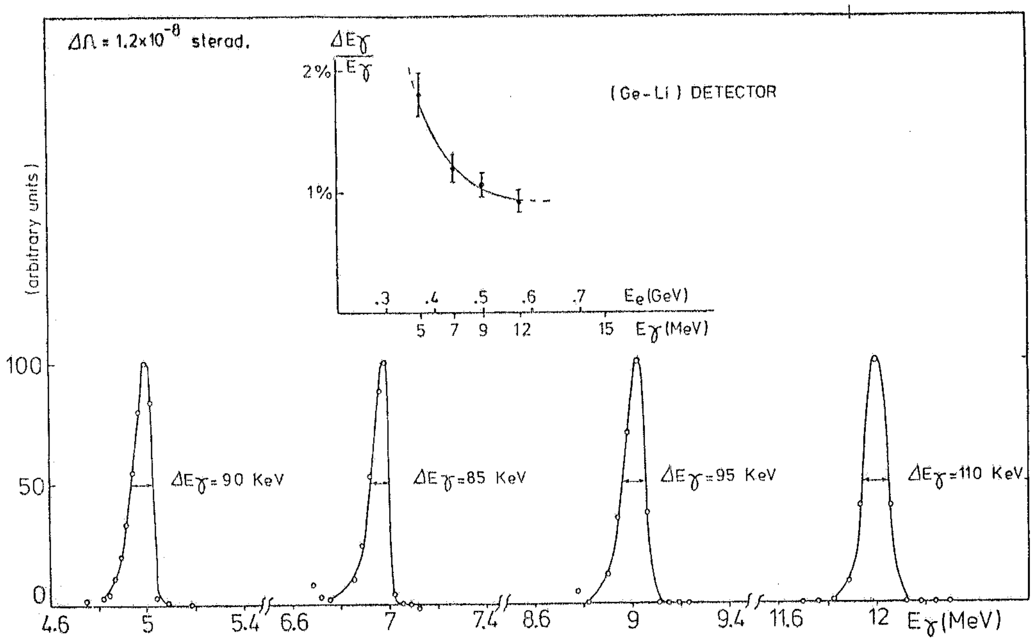

FIG. 4 - Beam energy resolution and full peaks obtained with a Ge-Li detector after background and Compton tail subtraction.

different values of $\Delta\Omega$. The quoted numbers indicate the energy resolution of the photon beam to very from about 1% to 2% over the explored energy range. Fig. 4 shows also some typical responses at four different energies, obtained after Bremsstrahlung and Compton tail subtraction in the region of the full energy peaks.

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