# PHOTON PRODUCTION AT HIGH ENERGIES AND SCALING (#177)

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We present results from an NAL experiment[1] in which photon production in nucleon-nucleon collisions has been explored over the energy range 28-300 GeV. This experiment has two useful features:

1. The polyethylene foil target interacts with the internal NAL proton beam during the whole acceleration so that data over the entire s range are taken at every machine cycle.

2. We exploit the Lorentz transformation from cm to laboratory in order to transform the variable x into the longitudinal laboratory momentum $p_{\parallel}$:

$$|x| = 2P_{\parallel}^{*}/\sqrt{s} = E_{\gamma}(\beta_{cm} - \cos\theta_L)/M_p \approx \frac{2E_{\gamma}}{M_p}\sin^2(\theta_L/2).$$

The scaling hypothesis predicts complete independence of the photon energy spectrum from the energy of the incident protons.

We have performed measurements at a fixed laboratory angle $\theta_L = 175°$, corresponding to $P_{\perp}$ from 0 to 40 MeV/c and fractional longitudinal momenta from 0 to 1, and our data therefore reflect directly the x dependence at $P_{\perp} \approx 0$.

Our results are in excellent agreement with the scaling assumption, as shown in Fig. 1 where the gamma yield for fixed x is plotted as a function of the incident energy. Figure 2 shows the photon energy spectra for various bombarding energies. Our lower energy results are in excellent agreement with the extrapolated values of the experiment by Fidecaro et al.[2] who have measured the gamma yield for 24-GeV incident protons. Results at all energies are well described by the thermodynamical model of Hagedorn and Ranft.[3] However, they are in apparent disagreement with the fit of Neuhofer et al.[4] of the gamma yield at the ISR, who find an $\underline{x}$ dependence roughly twice as fast as ours. The discrepancy could be due either to experimental errors or to the fact that the assumption made in Ref. 4 about independence of the variables $p_{\perp}$ and $\underline{x}$ is not valid (recall that the present experiment covers a range of $p_{\perp}$ not previously explored at high energies). Relevant to the reliability of our data are the facts that 1) a $CH_2$ - C subtraction yields the same spectra as the $CH_2$ alone, with 35% of the events coming from the hydrogen in the polyethylene, and 2) energy calibration in the lead glass blocks has been made (in the forward direction geometry) using the known muon line.

## References

[1] J. Pilcher et al., #177.

[2] M. Fidecaro et al., Nuovo Cimento 24, 73 (1962).

[3] R. Hagedorn, Suppl. Nuovo Cimento 3, 147 (1965). The $\pi^0$ yield has been calculated as average between $\pi^+$ and $\pi^-$ yields, with program SPUKSC by H. Grote, R. Hagedorn, and J. Ranft, CERN 1970 (unpublished).

[4] G. Neuhofer et al., Phys. Letters 38B, 51 (1972).

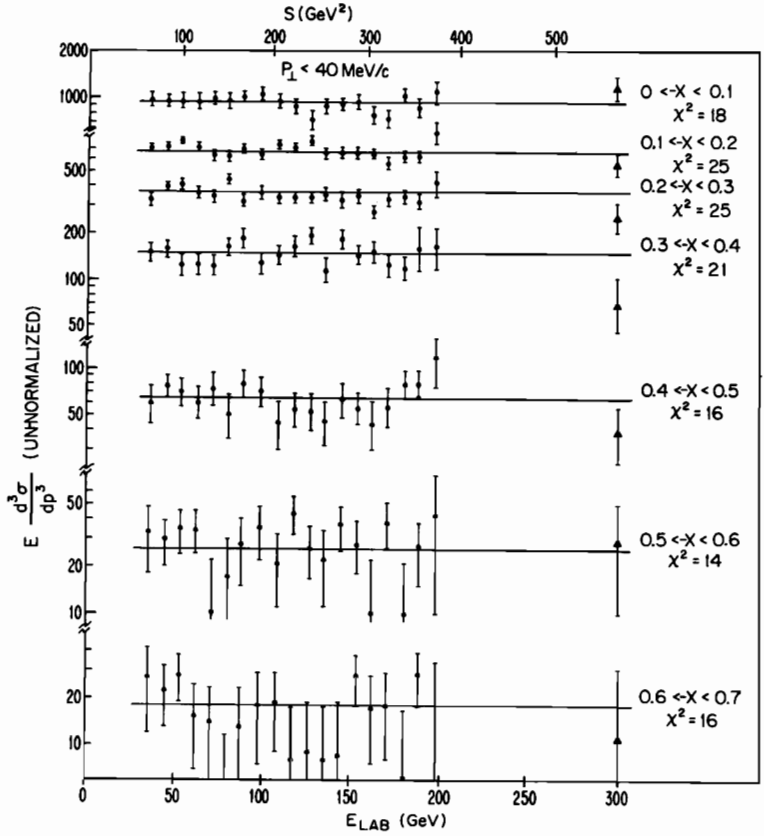


Fig. 1. Event yield as a function of bombarding proton energy. Data are subdivided according to the $\underline{x}$ interval. Data at 300 GeV are taken with the flip target. A straight line fit with zero slope is shown for each $\underline{x}$ region. The values of $\chi^2$ for 19 degrees of freedom suggest good agreement with the scaling hypothesis.

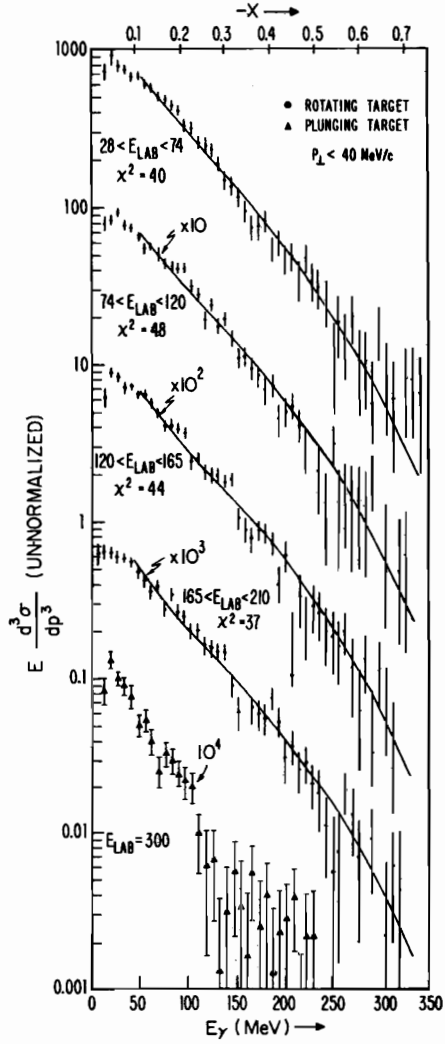


Fig. 2. Photon energy spectra for various bombarding energies. The solid curves give the predictions of the Hagedorn-Ranft model applied to these measurements. The $\chi^2$ values are given for 37 degrees of freedom. The spectrum at 300 GeV bombarding energy was recorded with the flip target.