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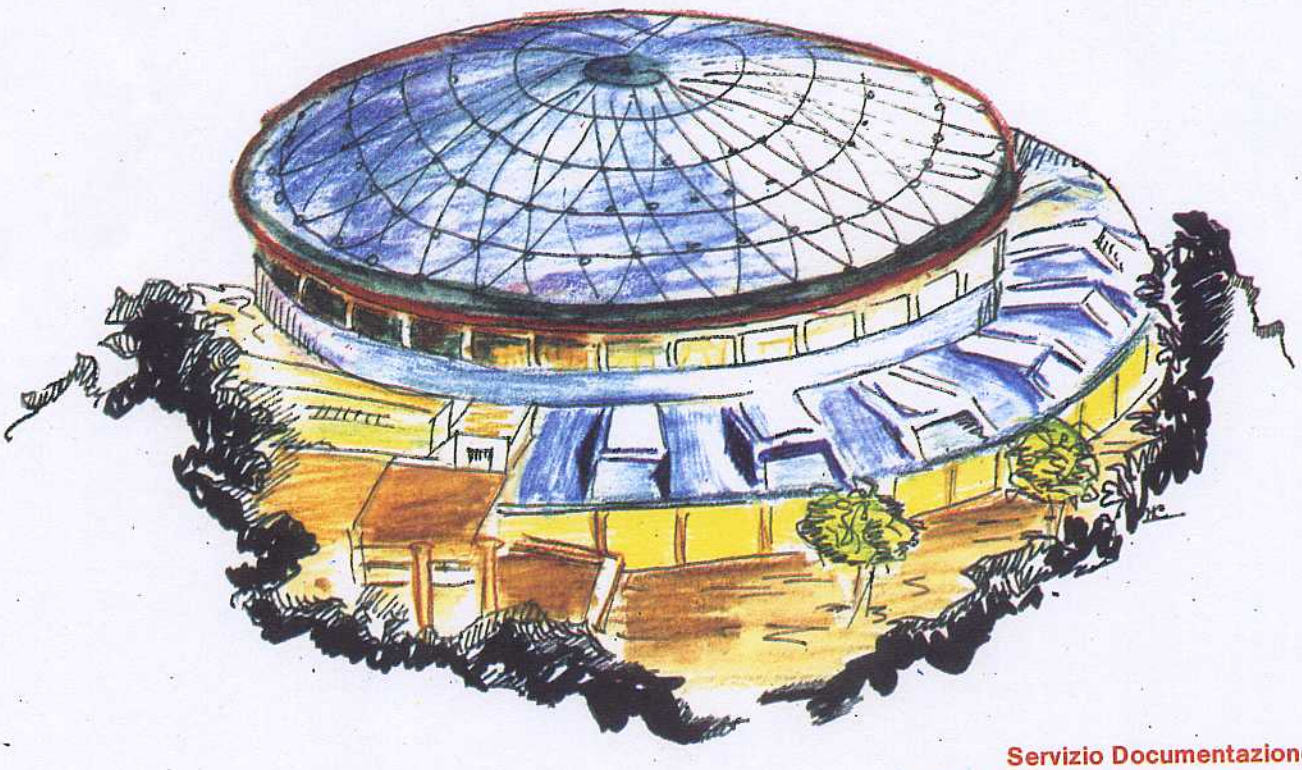
A. Bramon:

HADRONIC FORM FACTORS

Contribution to the DAΦNE Physics Handbook



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Hadronic Form Factors

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High luminosity e^+e^- machines are the ideal tool to investigate the electromagnetic (e.m) form-factors (F.F.) of hadrons for time-like values of the γ four-momentum $q^2 > 0$. These F.F. - generically denoted by $F(q^2)$- contain valuable information on the structure of hadrons and parametrize in a quantitative way how they behave in comparison with point-like objects [1].

In the low-energy region to be covered by DAΦNE two main types of e.m. F.F. can be measured:

(i) (elastic) pseudoscalar F.F., by means of the reactions $e^+e^- \to P\bar{P}$, with $\bar{P} \neq P = \pi^+, K^+$ and K^0, and

(ii) transition (or conversion) F.F., through $e^+e^- \to P\gamma$ and $e^+e^- \to P\gamma^* \to Pl^+l^-$, with $P = \pi^0, \eta$ and η'.

Other reactions, such as $e^+e^- \to VP$, where V stands for an on-mass-shell vector meson, require energies around the ϕ mass (for the $\rho\pi$ case), but more often somewhat above. Such is also the case for the proton [2], neutron [3] and other baryon F.F.[4] in $e^+e^- \to B\bar{B}$.

Pseudoscalar e.m. F.F. $F_P(q^2)$ in the time-like region have already been measured in various e^+e^- machines for $P = \pi^+, K^+$ and K^0, see for instance the results in Figs.1 and 2, reproduced from sect.4 of this Chapter [5].

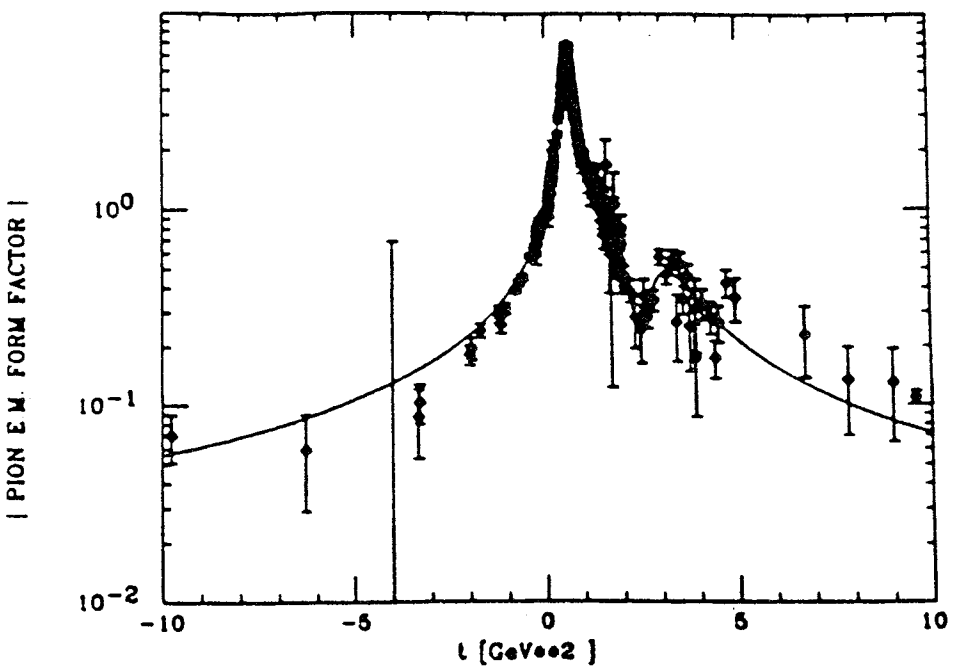

FIG. 1

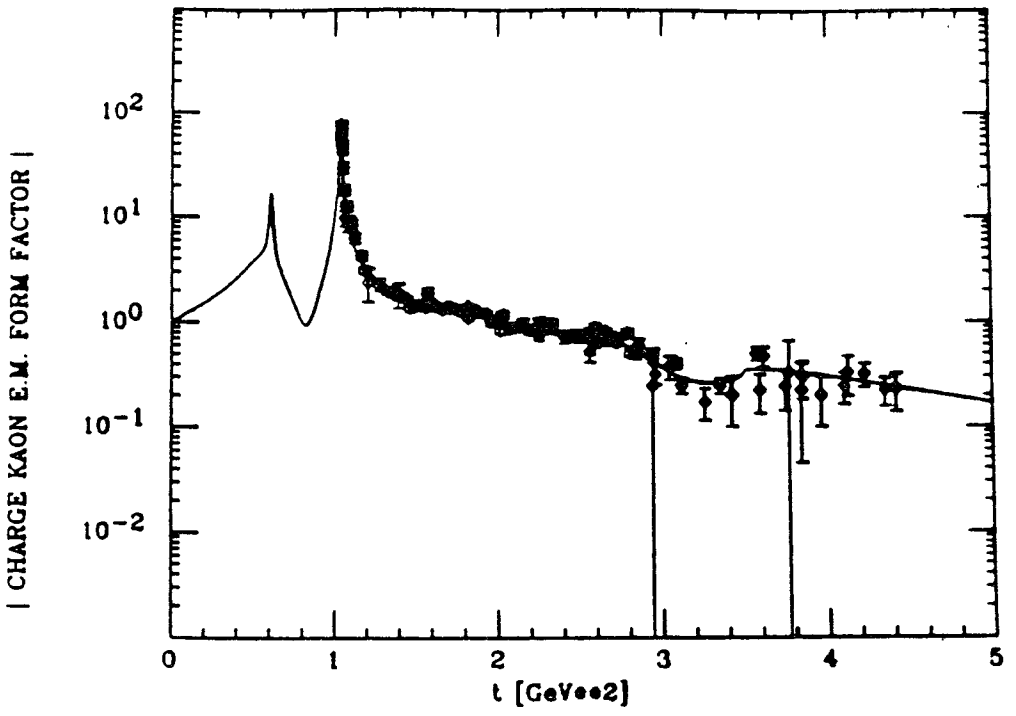

FIG. 2

These measurements complement those coming from the space-like F.F. measurements. However they are rather scanty [6] and more data are obtained if inverse electroproduction $PN \to e^+e^-N$ (for $q^2 > 0$) and P-electroproduction $eN \to ePN$ (for $q^2 < 0$) are considered. The time-like measurements are however much cleaner and precise than all the ones above, which rely on the pseudoscalar exchange assumption. As a result, the single (due to symmetry arguments) F.F. of each P-meson is known in a wide kinematical region including $q^2 = 0$ where the so-called pseudoscalar charge-radii are defined, i.e. $< r_P^2 > \equiv 6 \frac{dF_P(q^2)}{dQ^2}|_{q^2=0}$.

As is well known, these $F_P(q^2)$ are strongly dominated by the lowest mass vector mesons $V = \rho^0, \omega$ and ϕ. Higher mass (excited) states are expected to modify slightly this picture. Their inclusion has led to interesting and more or less sophisticated models [5, 7], whose accuracy and validity will be tested at DAΦNE, as discussed in section 4 of this chapter.

Transition form-factors to be measured in $e^+e^- \to P\gamma$ are also complemented by other measurements. At lower, time-like values of q^2 one has some data from $\eta \to \gamma\gamma^* \to \gamma\mu^+\mu^-$ (and related) decays, while $\gamma\gamma^* \to \pi^0, \eta, \eta'$ subprocesses in higher energy e^+e^--machines have furnished accurate data on these F.F. in the space-like region. Again, at $q^2 = 0$ one defines the so-called slope-parameter b_P, with known values for $P = \pi^0, \eta, \eta'$. The possibility of having not one, but two off-mass-shell photons is also of interest. At DAΦNE one should measure $e^+e^- \to P\gamma^* \to Pl^+l^-$ ($l = \mu$ is more sensitive than $l = e$), while $\gamma^*\gamma^* \to P^0$ would complement for two space-like photons. Again one expects a dominance of VM effects and connection with processes such as $\omega \to \pi^0 l^+ l^-$ [8]. This is discussed in section 3 of the present

chapter.

A recent summary on experimental results on e^+e^- annihilation at low energies can be found in ref.[1], which contains also a complete list of references and the main phenomenological issues. This is also the case for the review [9], where further data and their phenomenological meaning on radiative low-mass meson decays are discussed. A brief, but recent discussion on the theoretical description of π^0, η and η' transition F.F. can be found in ref.[10].

Apart from the interest in their own (hadron structure), the knowledge of the various F.F. of low energy mesons is also relevant in precision tests of QED. More precisely, $(g-2)_\mu$ depends on the pion F.F. near threshold, as discussed in the next section [11].

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