Motivation for ECT* workshop

# Scattering and annihilation electromagnetic processes

ECT, Trento, February 18-23, 2013

The electromagnetic structure of the hadrons can be described in terms of form factors. For a nucleon, two form factors are necessary to describe the charge and magnetic distributions.
Form factors are considered fundamental quantities as their experimental values constitute a stringent test for any model which, after describing the static properties of a particle, like masses or magnetic moments should be also able to describe the dynamical *content*. They are measurable and data can be extracted from differential cross sections and polarization observables in elementary reactions. The basic tools to investigate hadron structure are the elementary processes electron proton elastic scattering, electron-positron annihilation into hadrons, and proton-antiproton annihilation into lepton pairs.

New interest recently aroused due to the achievements in high energy accelerators: high intensity beams, high resolution spectrometers, full coverage detectors; but especially to the availability of polarized beams, targets and hadron polarimeters. A large experimental effort has been devoted to the determination of hadron form factors, at electron accelerators, as JLab, MAMI (Mainz), MIT-Bates on one side, at electron colliders as Novosibirsk, Frascati, Beijing (and also BaBar, Belle) and proton-antiproton rings (LEAR, FermiLab, and in next future, FAIR). Recent, very precise data from the GEp Collaboration at JLab, have been obtained using the polarization method, suggested many years ago by the Kharkov School (A.I. Akhiezer and M. P. Rekalo, 1967). These data have shown a decreasing of the ratio of electric to magnetic form factor of the proton, in disagreement with the previous data based on polarized cross section measurements (Rosenbluth method, 1950). As no shortcoming has been found in the experimental procedure, possible explanations have been suggested, which rely to radiative corrections at higher order, or to the reaction mechanism. The situation should still be clarified. BESIII is currently acquiring data in order to measure proton and neutron form factors in the time like region, in electron-positron annihilation into a nucleon-antinucleon pair, with energy scan and also using initial state radiation; the first results are expected soon. At PANDA (FAIR) full simulations with a realistic detector give promising results on the possibility to access form factors at very large values of the momentum transfer squared as well as in the unphysical region, when a pion is also emitted. The BESIII and PANDA form factors programs are somewhat complementary, the former accessing the threshold region, the latter probing asymptotic behavior.

Although analytical considerations require that a unified description of form factors should be at the basis of the interpretation of all existing data, and fundamental symmetry properties of electromagnetic and strong interactions give prescriptions for a coherent description of annihilation and scattering channels, at least at lowest order of perturbation theory, the physics communities who work in these fields are quite dispersed. Large efforts are done in modelling the hadron structure and in interpreting the data in specific kinematic regions, but very few developments take in consideration the data in their globality.

Therefore we find timely and necessary to gather the physicists working in the field of hadron structure, in order to emphasize and give priority and efforts to a satisfactory and complete description of the nucleon in the entire kinematical region. It is worth to note that the study of form factors has been initiated decades ago, and in the 60's in Italy and in Soviet Union, particularly, there were ideas in the directions we indicated above. In this context, basic contributions to find a bridge between scattering and annihilation channels were done by A. Zichichi, R. Gatto, N. Cabibbo, S. M. Bilenkyi, V. Z. Wataghin, A. Akhiezer, M. P. Rekalo.

Another aspect, which we would like to clarify and to revive for present and future experiments, is the problem of the reaction mechanism. We would like to focus the discussions during the workshop to the understanding of the interplay between the reaction mechanism and the hadron structure. The simple and elegant formalism that relates the matrix element and the form factors is based on the hypothesis of one photon exchange. At large values of the energy and momentum transfer achieved by modern experiments and due to the required precision, one has to take into account carefully radiative corrections. There are hints that higher order corrections could seriously affect the observables and those aspects should be coherently developed, in narrow connection with experimentalists.

The possibilities offered by the infrastructures of ECT* constitute an invaluable help in organizing such meeting. We expect physicists from Germany, France, Italy, USA, Russia, China, Slovakia, Belorussia and Ukraine.

## Coordinators


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## Organizers


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# Programme

The workshop will consist in **10 sessions** of **3 hours** each.
There will be 'long' **50 min** talks and 'short' **30 min** talks.
The first ones either to discuss specific points, where details are necessary, or general, review talks, to cover many aspects of a subject. The second ones will be dedicated to a specific, important results obtained in theory or experiment.
Particular attention to presentations, views and comments from students.
In the afternoons discussions around posters and round tables may be organized.

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| **Monday morning** | | | | |
| Session I: | 09.00 | 09.30 | | Registration |
| *Introductory* | 09.30 | 09.45 | 0 | Opening |
| | 09.45 | 10.40 | 1 | Introductory session |
| | 10.40 | 11.00 | | Coffee Break |
| | 11.00 | 11.45 | 2 | Historical aspects on nucleon FFs |
| | 11.45 | 12.30 | 3 | Review on Experiment and Theory |
| **Monday afternoon** | | | | |
| Session II: | 14.30 | 15.15 | 1 | Radiative corrections |
| *Radiative corrections* | | | | to EM processes |
| | 15.15 | 16.00 | 2 | Application to experiments |
| | 16.00 | 16.30 | | Coffee Break |
| | 16.30 | 17.00 | 3 | Methods, reactions, kinematics |
| **Tuesday morning** | | | | |
| Session III: | 09.30 | 10.15 | 1 | Nucleon models in SL and TL reg. |
| *Nucleon models in SL* | 10.15 | 10.45 | 2 | Dispersion relations |
| *and TL regions - I* | 10.45 | 11.15 | | Coffee Break |
| | 11.15 | 12.00 | 3 | Constituent quarks |
| | 12.00 | 12.30 | 4 | Interesting kinematical regions |
| | | | | (threshold, asymptotics) |
| **Tuesday afternoon** | | | | |
| Session IV: | 14.30 | 15.15 | 1 | Soliton Models |
| *Nucleon models in SL* | 15.15 | 16.00 | 2 | Constituent quarks |
| *and TL regions - II* | 16.00 | 16.30 | | Coffee Break |
| | 16.30 | 17.00 | 3 | $N\bar{N}$ potentials |

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| **Wednesday morning** | | | | |
| Session V: | 09.30 | 10.15 | 1 | TL-FFs perspectives |
| *$p\bar{p}$ annihilations* | 10.15 | 10.45 | 2 | Interpretation of TL-FFs |
| | 10.45 | 11.15 | | Coffee Break |
| | 11.15 | 12.00 | 3 | $p\bar{p} \to \mu^+\mu^- X$ |
| | 12.00 | 12.30 | 4 | $p\bar{p} \to e^+e^-\pi^0$ |
| **Wednesday afternoon** | | | | |
| Session VI: | 14.30 | 15.15 | 1 | Recent results from JLAB |
| *Crossed channels:* | | | | GEp experiment |
| *ep elastic scattering* | 15.15 | 16.00 | 2 | Low energy *ep* scattering |
| | 16.00 | 16.30 | | Coffee Break |
| | 16.30 | 17.00 | 3 | Radiative corrections |
| | 17.00 | 17.30 | 4 | High energy p polarimetry |
| **Thursday morning** | | | | |
| Session VII: | 09.30 | 10.15 | 1 | $e^+e^- \to N\bar{N}$ at BESIII |
| *Crossed channels:* | 10.15 | 10.45 | 2 | Radiative corrections |
| *$e^+e^-$ annihilations* | 10.45 | 11.15 | | Coffee Break |
| | 11.15 | 12.00 | 3 | ISR results from BABAR |
| | 12.00 | 12.30 | 4 | |
| **Thursday afternoon** | | | | |
| Session VIII: | 14.30 | 15.15 | 1 | Antiproton polarisation |
| *Crossed channels:* | 15.15 | 16.00 | 2 | Proton radius |
| *pe elastic scattering* | | | | Coulomb corrections |
| | 16.00 | 16.30 | | Coffee Break |
| | 16.30 | 17.00 | 3 | *pe* scattering applications |
| **Friday morning** | | | | |
| Session IX: | 09.30 | 10.10 | 1 | JLAB at 12 GeV |
| *Future projects* | 10.10 | 10.50 | 2 | FAIR perspectives |
| *$e^+e^-$ annihilations* | 10.50 | 11.20 | | Coffee Break |
| | 11.20 | 12.00 | 3 | BESIII status |
| | 12.00 | 12.30 | 4 | Conclusions |