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The Mainz high-precision proton form factor measurement

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Form factors offer a direct approach to fundamental properties of the nucleons like the radius and charge distribution. Renewed interest was stirred up by the 5 sigma discrepancy between a recent determination of the proton radius from the Lamb shift in muonic hydrogen and preceding electron scattering results. The low-q shape of the form factors might also contain a direct signal of a pion cloud around the nucleus and is a strong test of hadron models. In my talk, I will discuss the electron scattering experiment performed with the 3-spectrometer-facility of the A1 collaboration at MAMI in Mainz, Germany. The data set covers the Q^2-range from 0.004 to 1 $(\mathrm{GeV/c})^2$ and includes about 1400 separate cross section measurements, spanning the range of scattering angles from below 20° to above 120° at six beam energies between 180 and 855 MeV, with statistical uncertainties below 0.4%. The 3-spectrometer-setup allowed for a simultaneous monitoring of the luminosity and overlapping and redundant measurements of the cross section to achieve stringent control over systematic uncertainties. Beam stabilization systems and redundant current measurements further limit systematic effects. The measured cross sections were analyzed with the standard Rosenbluth separation technique and by employing direct fits of a large set of form factor models. The high redundancy of the data set allowed us to extract the form factors up to 0.6 $(\mathrm{GeV/c})^2$ with very small uncertainties and to give a new, precise value for the proton radius from electron scattering. From the form factors, the charge distribution and Zemach moments were calculated. The latter constitute important input for the theoretical corrections of the muonic Lamb shift experiment. However, the revised values can not explain the discrepancy. Further possible explanations include higher order QED-corrections, vacuum effects or even physics beyond the standard model.