

Feasibility study: proton time-like electromagnetic form factors with the \bar{P} ANDA experiment

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Zichichi cross-section

Zichichi cross-section, in one-photon approximation, contains information on G_E and G_M

$$\frac{d\sigma}{d\cos\theta} = C[|G_M|^2(1 + \cos^2\theta) + \frac{|G_E|^2}{\tau}(1 - \cos^2\theta)]^*$$

where

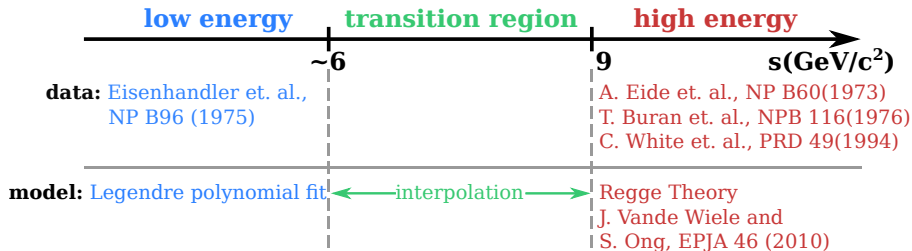
$$C = \frac{\pi\alpha_s^2}{8M^2\sqrt{\tau(\tau-1)}}$$

$$|G_M| = \frac{22.5}{(1+q^2/0.71)^2(1+q^2/3.6)} \text{ for } G_E/G_M = 1$$

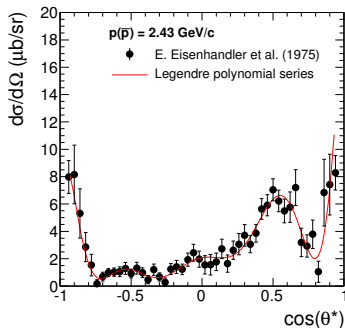
* A. Zichichi, S. M. Berman, N. Cabibbo, R Gatto, Nuovo Cim. 24, (1962) 170.

* E. Tomasi-Gustafsson and M. P. Rekalo, Phys. Lett. B 504, (2001) 291.

Challenge: background



An event generator for the background channel $\bar{p}p \rightarrow \pi^+\pi^-$ was developed in Mainz (M. Zambrana)



$\bar{p}p \rightarrow e^+e^-$ simulation

Expected number of events for $|\cos\theta| < 0.8$ in the $\bar{p}p$ center of mass frame

$q^2 [\text{GeV}/c]^2$	$N_{G_E/G_M=1}$
5.4	829535
7.27	111109
8.21	49641
11.0	6503
12.9	2328
13.8	1365

for integrated luminosity $\mathcal{L} = 2\text{fb}^{-1}$

Efficiency and suppression study

Events were generated within $|\cos\theta| < 0.8$ range in the $\bar{p}p$ center of mass frame

$q^2 [\text{GeV}/c]^2$	$\bar{p}p \rightarrow e^+e^-$ $G_E/G_M = 1$	$\bar{p}p \rightarrow \pi^+\pi^-$
5.4	10^6	10^8
7.27	10^6	-
8.21	10^6	10^8
11.0	10^6	-
12.9	10^6	-
13.8	10^6	10^8

Simulation was performed @**HIMSTER** cluster of **Helmholtz-Institut Mainz**

Selection criteria

- Two particles in the final state
- Particle identification probability
 - Ratio of the deposited energy in the EMC and momentum given by the tracking system
 - Shower shape in the EMC
 - Muon signal
 - Energy deposit in the gas tracker
 - Energy conservation

Selection performance

Signal reconstruction efficiency and background suppression

$q^2 [GeV/c]^2$	$e^+e^-(10^6)$ $G_E/G_M = 1$	$\pi^+\pi^-(10^8)$
5.4	42.3%	0 events
7.27	41.8%	—
8.21	43.0%	16 events
11.0	37.8%	—
12.9	33.0%	—
13.8	32.4%	5 events

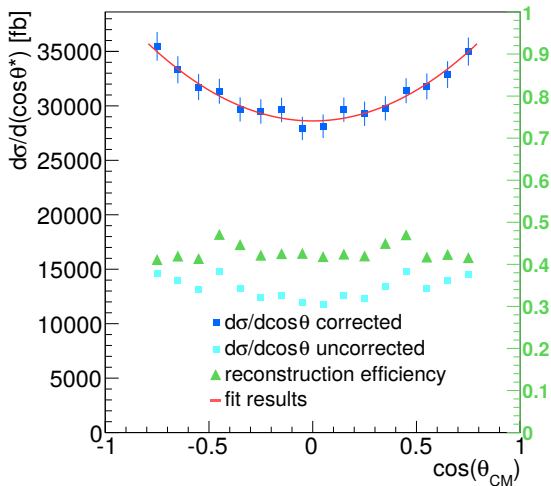
G_E and G_M extraction

- Efficiency correction
 - Sample with expected number of events
 - Independent sample for the efficiency correction
- Angular distribution fit
- Extraction of G_E and G_M from the fit function

$$\frac{d\sigma}{d\cos\theta} = C |G_M|^2 [(1 + \cos^2\theta) + \frac{|R|^2}{\tau} (1 - \cos^2\theta)]$$

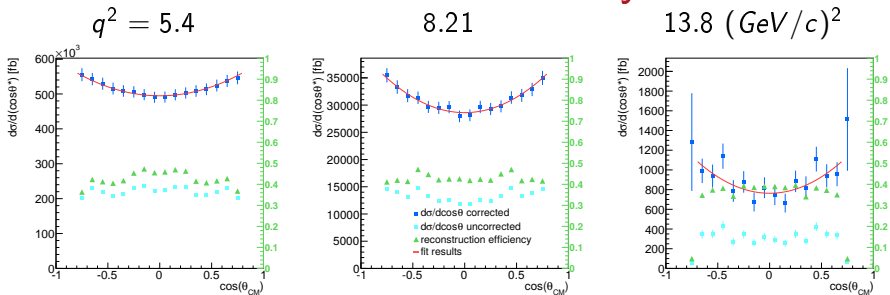
Reconstructed performance

Statistical errors only



Reconstructed performance

Statistical errors only



$R = G_E/G_M$ extracted from the fit

Statistical errors only (PANDA)

