Feasibility studies of proton electromagnetic form factors with the $\bar{\text{P}}$ANDA detector

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Outline

1. Monte Carlo Simulations
2. CPU/HDD usage
3. Selection criteria
4. Results
5. Summary and Outlook

Monte Carlo Simulations

$\bar{p}p \rightarrow e^+e^-$ (November 11 release simulation)

- $p(\bar{p}) = 1.7, 3.3, 6.4[GeV/c] \rightarrow s = 5.4, 8.21, 13.8[GeV/c]^2$
- $G_E/G_M = 0, 1, 3$
- $N = 10^6$

$\bar{p}p \rightarrow e^+e^-$ (November 11 release "data")

- $p(\bar{p}) = 1.7, 3.3, 6.4[GeV/c] \rightarrow s = 5.4, 8.21, 13.8[GeV/c]^2$
- $G_E/G_M = 0, 1, 3$
- $N_{p(\bar{p})=1.7} = 1.1^6, N_{p(\bar{p})=3.3} = 6.4^4, N_{p(\bar{p})=6.4} = 2.0^3$

$L = 2fb^{-1}$

Monte Carlo Simulations

$\bar{p}p \to \pi^+\pi^-$ (August 11 release)

- $p(\bar{p}) = 1.7, 3.3 GeV/c$
- $N = 1.1 * 10^8$

$\bar{p}p \to \pi^+\pi^-$ (Trunk 14569)

- $p(\bar{p}) = 1.7 GeV/c$
- $N = 3.9 * 10^7$

$>$ 30% jobs crushed :(

CPU/HDD usage per $\bar{p}p \to e^+e^-$ event @HIMster cluster in Mainz

$p(\bar{p})[GeV/c]$		1.7	3.3	6.4
CPU [s]	sim	0.47	0.58	0.65
	digi	0.29	0.29	0.32
	reco	2.08	2.05	1.91
	pid	1.19	1.26	1.31
	total	4.03	4.18	4.19
HDD [kB]	sim	20.3	27.0	38.0
	digi	5.9	6.8	7.7
	reco	6.7	6.7	6.5
	pid	1.4	1.4	1.5
	par	0.4	0.4	0.4
	total	34.7	42.3	54.1

CPU/HDD usage per $\bar{p}p \to \pi^+\pi^-$ event @HIMster cluster in Mainz

$p(\bar{p})[GeV/c]$		1.7	3.3	6.4
CPU [s]	sim	0.41	0.36	0.31
	digi	0.31	0.25	0.21
	reco	2.08	1.77	1.31
	pid	1.25	1.02	0.62
	total	4.05	3.4	2.45
HDD [kB]	sim	11.6	12.3	12.7
	digi	5.6	5.9	5.8
	reco	6.5	6.6	4.0
	pid	1.9	1.9	1.2
	par	0.5	0.4	0.4
	total	26.0	27.1	24.1

Selection criteria for e^+e^-

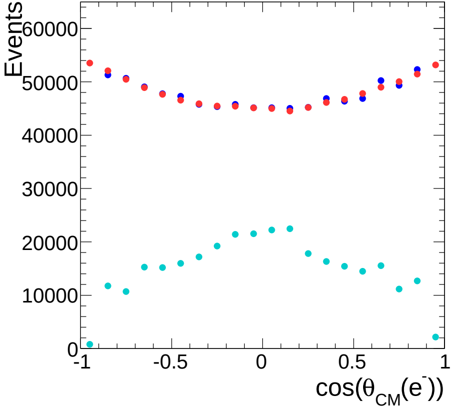
- The event must have only one positive and one negative particle after reconstruction
- For both the positive and the negative particle in the $\bar{p}p$ CM frame
  $\sqrt{s}/2 - \lambda < E < \sqrt{s}/2 + \lambda$
  where $\lambda = 0.2(\sqrt{s}/2)$
- For both the positive and the negative particle, $0.9 < E/p < 1.4$ [(GeV)/(GeV/c)]
- For both the positive and the negative particle, cut on dE/dx_{STT}
- Both the positive and the negative particle must fire more then 5 crystals in the EMC

where E is the energy, p is the momentum and dE/dx_{STT} is the energy loss in STT of the reconstructed particle.

Efficiency correction

$$\bar{p}p \rightarrow e^+e^-, p(\bar{p}) = 1.7 GeV/c, G_E/G_M = 1$$

$$N = 1.1 * 10^6 \text{ at } L = 2fb^{-1}$$



preliminary

- Monte-Carlo
- Reconstructed
- Corrected

Rosenbluth cross section

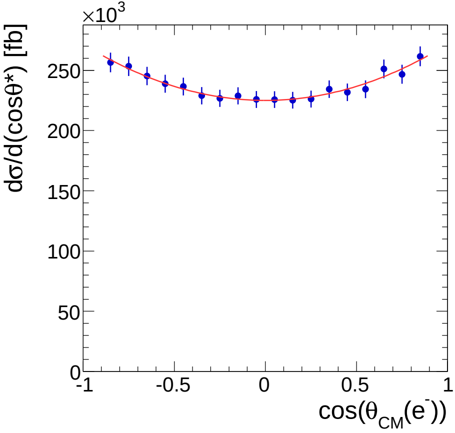
$$\frac{d\sigma}{d\cos\theta} = C[|G_M|^2(1 + cos^2\theta) + \frac{|G_E|^2}{\tau}(1 - cos^2\theta)]$$

where $C = \frac{\pi\alpha^2(\hbar c)^2}{8m_p^2\sqrt{\tau(\tau-1)}}$, $\tau = q^2/4m_p^2$ and
$\theta = angle(e^-\bar{p})$ in $\bar{p}p$ CM frame

Cross section

$$\bar{p}p \rightarrow e^+e^-, p(\bar{p}) = 1.7GeV/c, G_E/G_M = 1$$

$$N = 1.1 * 10^6 \text{ at } L = 2fb^{-1}$$



preliminary

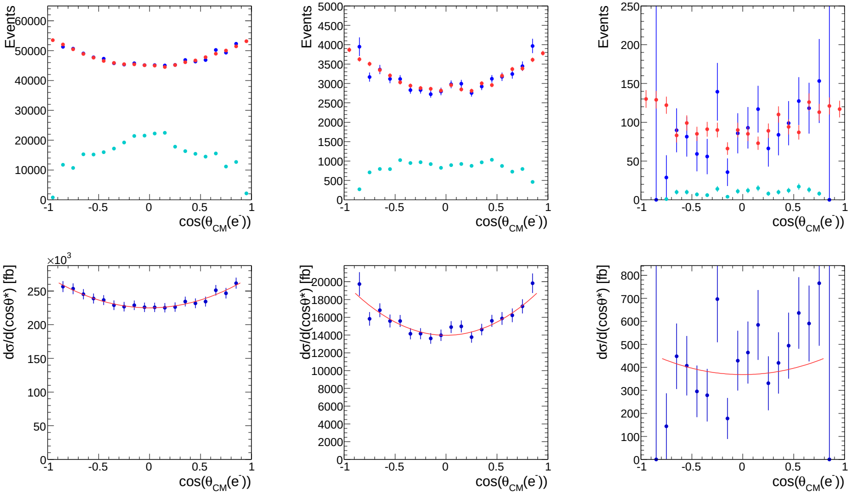
- Cross section
- Rosenbluth fit

$G_E = 0.116 \pm 0.003$

$G_M = 0.115 \pm 0.001$

$\cos(\theta_{CM})$ distribution for $G_E/G_M = 1$

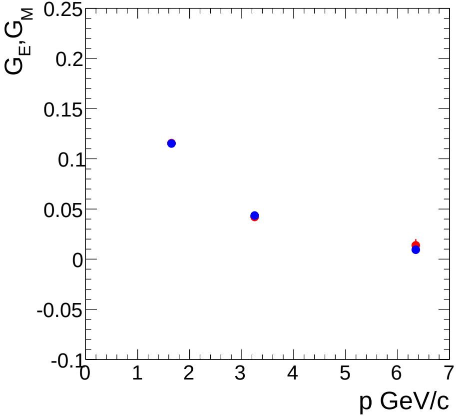
$p(\bar{p}) = 1.7 GeV/c$	$p(\bar{p}) = 3.3 GeV/c$	$p(\bar{p}) = 6.4 GeV/c$
$N = 1.1 * 10^6$	$N = 6.4 * 10^4$	$N = 2.0 * 10^3$



G_E, G_M extracted from Rosenbluth fit

$$\bar{p}p \to e^+e^-, G_E/G_M = 1$$

$$N = 1.1 * 10^6 \text{ at } L = 2fb^{-1}$$



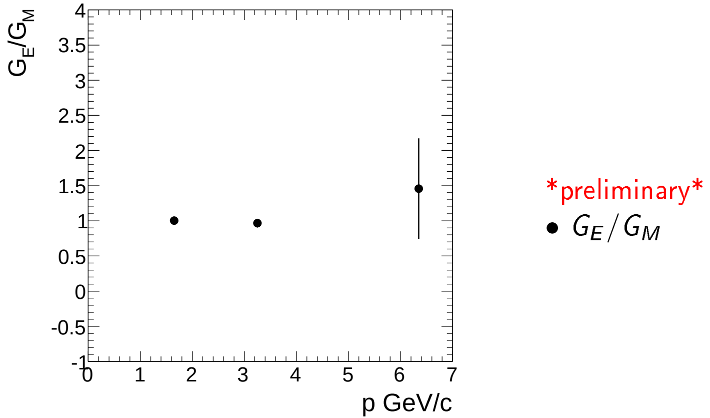
preliminary

- G_E
- G_M

G_E/G_M extracted from Rosenbluth fit

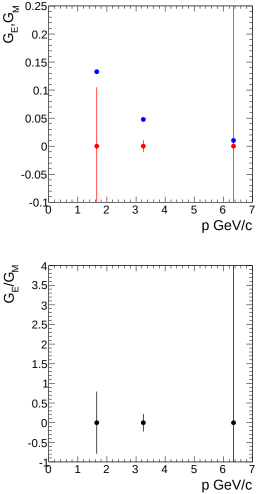
$$\bar{p}p \to e^+e^-, G_E/G_M = 1$$

$$N = 1.1 * 10^6 \text{ at } L = 2fb^{-1}$$

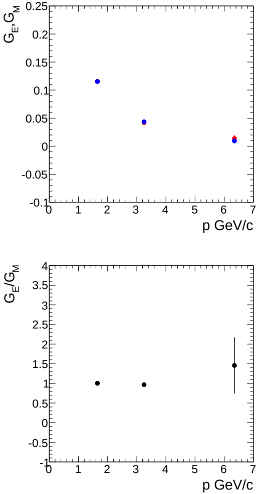


Extracted values of G_E, G_M and G_E/G_M

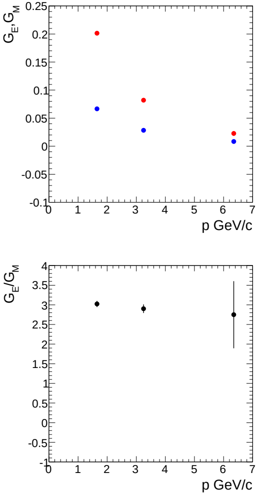
$G_E/G_M = 0$
$N = 1.1 * 10^6$



$G_E/G_M = 1$
$N = 6.4 * 10^4$



$G_E/G_M = 3$
$N = 2.0 * 10^3$



Number of e^+e^- and $\pi^+\pi^-$ pairs left after cuts

$p(\bar{p}) = 1.7GeV/c$	e^+e^-	e^+e^-	e^+e^-	$\pi^+\pi^-(aug11)$
G_E/G_M	0	1	3	-
Monte Carlo	10^6	10^6	10^6	$1.18 * 10^8$
Reconstructed	472959	491111	527317	46
Reconstructed, %	47%	49%	52%	$\ll 1\%$

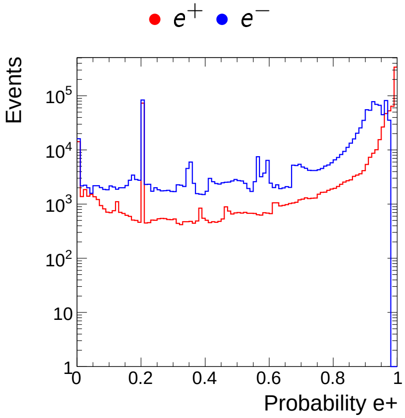
Number of e^+e^- and $\pi^+\pi^-$ pairs left after cuts

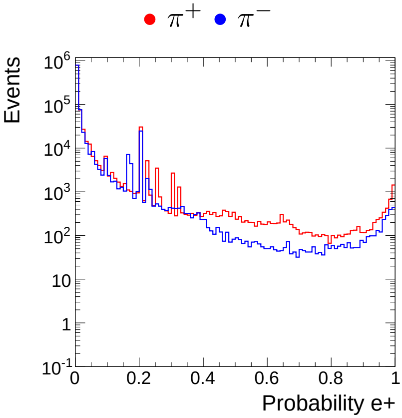
$p(\bar{p}) = 3.3GeV/c$	e^+e^-	e^+e^-	e^+e^-	$\pi^+\pi^-(aug11)$
G_E/G_M	0	1	3	-
Monte Carlo	10^6	10^6	10^6	$1.13 * 10^8$
Reconstructed	412848	428035	468135	34
Reconstructed, %	41%	42%	46%	$\ll 1\%$

Number of e^+e^- pairs left after cuts

$p(\bar{p}) = 6.4 GeV/c$	e^+e^-	e^+e^-	e^+e^-
G_E/G_M	0	1	3
Monte Carlo	10^6	10^6	10^6
Reconstructed	314455	328279	380548
Reconstructed, %	31%	32%	38%

Probability



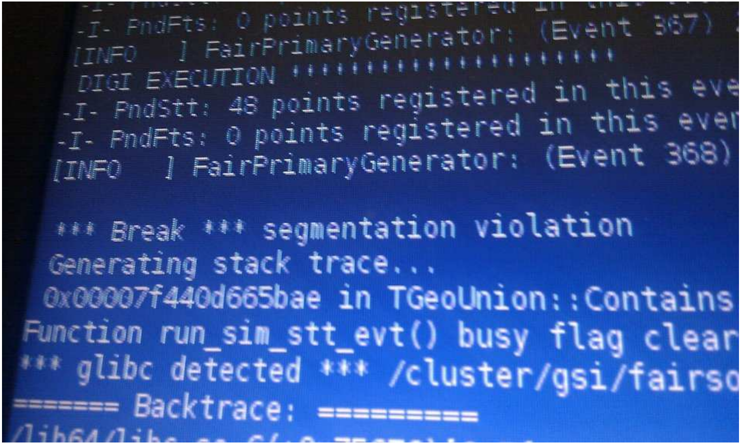


Summary

- Preliminary results for G_E and G_M
- Signal efficiency about $31 - 52\%$
- Background rejection factor about 10^6

Outlook

- Bayesian PID
- Kinematic fitting


-I- PndFts: 0 points registered
[INFO] FairPrimaryGenerator: (Event 367)
DIGI EXECUTION ########################
-I- PndStt: 48 points registered in this eve
-I- PndFts: 0 points registered in this even
[INFO] FairPrimaryGenerator: (Event 368)
*** Break *** segmentation violation
Generating stack trace...
0x00007f440d665bae in TGeoUnion::Contains
Function run_sim_stt_evt() busy flag clear
*** glibc detected *** /cluster/gsi/fairso
======= Backtrace: ==========