

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

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Outline

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- 2 CPU/HDD usage
- 3 Selection criteria
- 4 Results of the simulations
- 5 Efficiency correction
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Monte Carlo Simulations

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

- $\rho(\bar{p}) = 1.7, 3.3, 6.4[\text{GeV}/c] \rightarrow s = 5.4, 8.21, 13.8[\text{GeV}/c]^2$
- $G_E/G_M = 0.0, 1.0, 3.0$
- $N = 10^6$

$$\bar{p}p \rightarrow \pi^+\pi^-$$

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

CPU/HDD usage per $\bar{p}p \rightarrow e^+e^-$ 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 $\bar{p}p \rightarrow \pi^+\pi^-$ 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^-

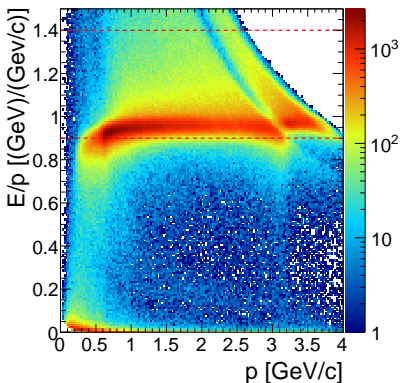
- The event must have only one positive and one negative particle after reconstruction
- For both the positive and the negative particle in the $\bar{p}p$ CM frame

$$\sqrt{s}/2 - \lambda < E < \sqrt{s}/2 + \lambda$$
 where $\lambda = 0.2(\sqrt{s}/2)$
- For both the positive and the negative particle, $0.9 < E/p < 1.4$
 $[(\text{GeV})/(\text{GeV}/c)]$
- For both the positive and the negative particle, cut on dE/dx_{STT}
- Both the positive and the negative particle must fire more than 5 crystals in the EMC

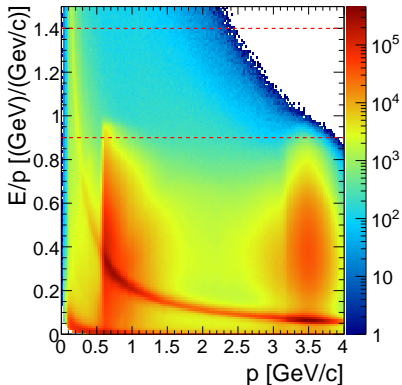
where E is the energy, p is the momentum and dE/dx_{STT} is the energy loss in STT of the reconstructed particle.

Results of the simulation using deposited energy from EMC and momentum provided by tracking

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

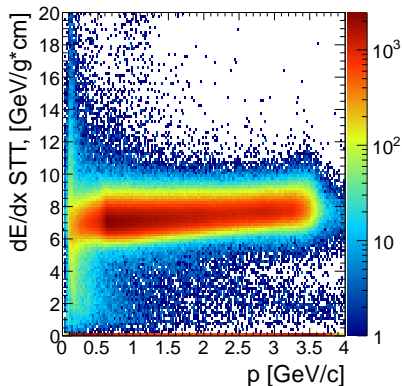


$$\bar{p}p \rightarrow \pi^+\pi^-$$

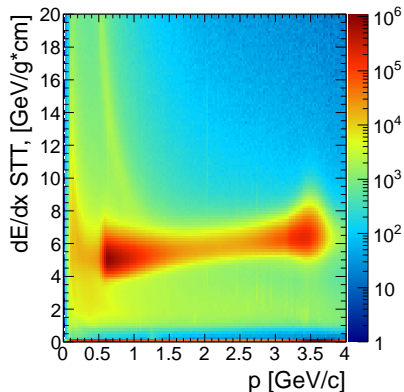


Energy loss in STT

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

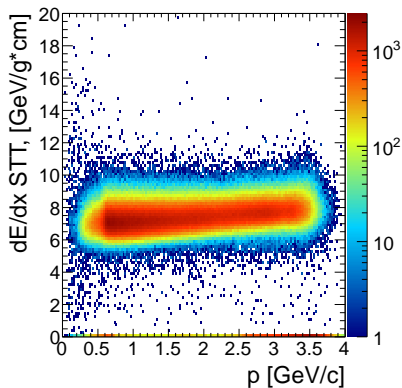


$$\bar{p}p \rightarrow \pi^+\pi^-$$

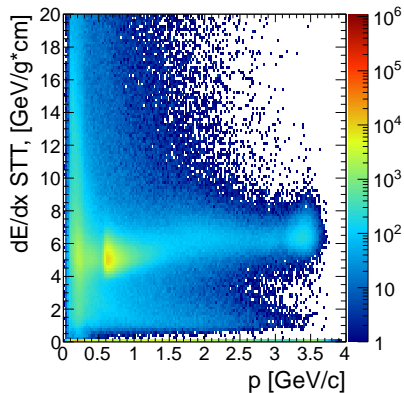


Energy loss in STT after E/p cut

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

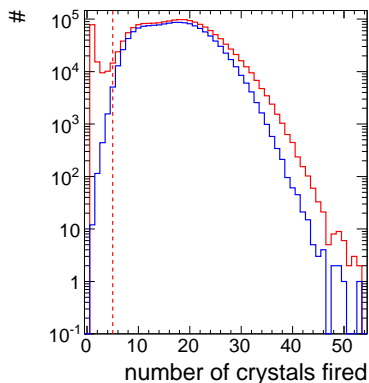


$$\bar{p}p \rightarrow \pi^+\pi^-$$

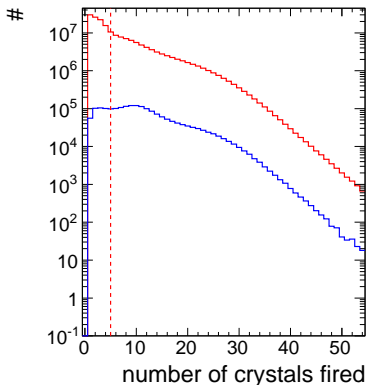


Number of crystals fired in the EMC

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

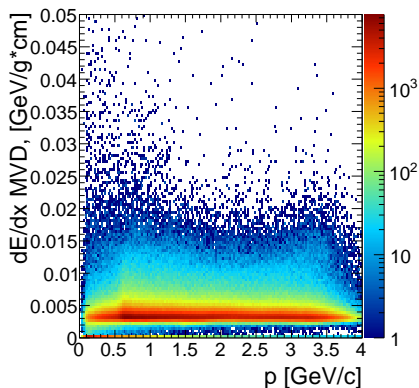


$$\bar{p}p \rightarrow \pi^+\pi^-$$

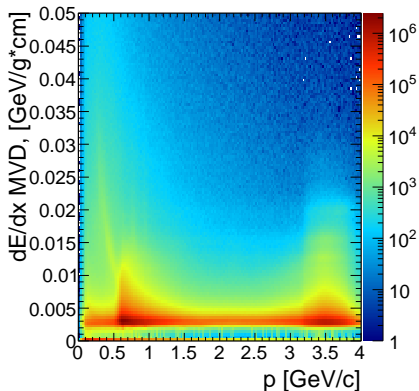


Energy loss in MVD

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

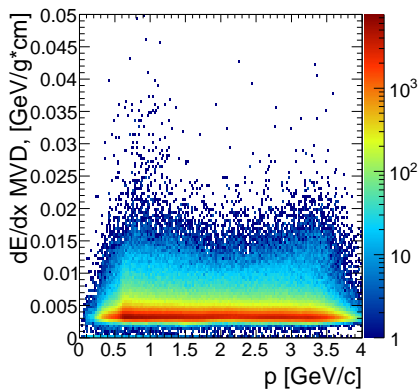


$$\bar{p}p \rightarrow \pi^+\pi^-$$

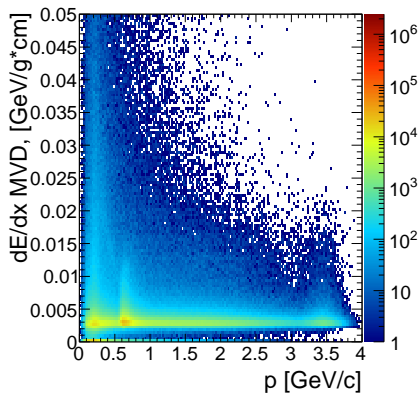


Energy loss in MVD after E/p cut

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

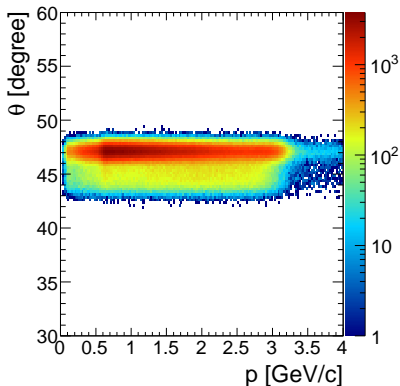


$$\bar{p}p \rightarrow \pi^+\pi^-$$

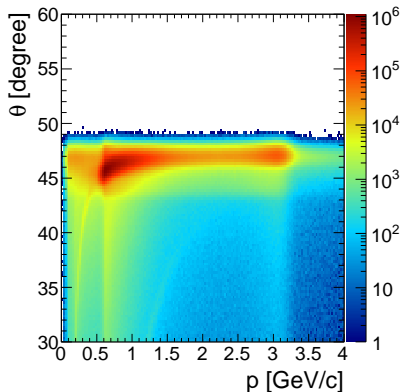


Cherenkov angle provided by barrel DIRC

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

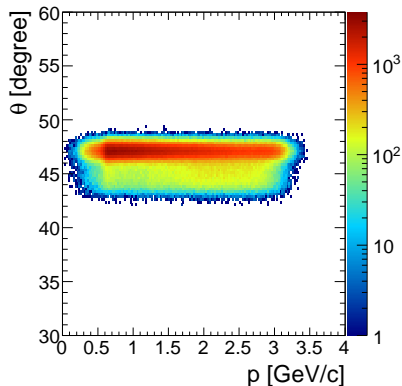


$$\bar{p}p \rightarrow \pi^+\pi^-$$

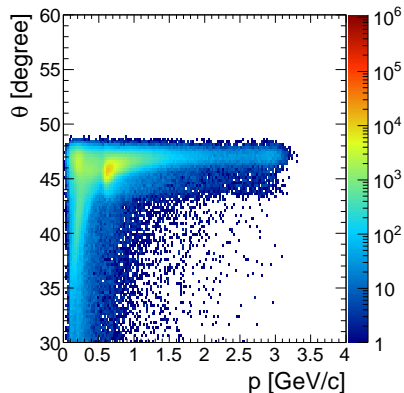


Cherenkov angle provided by barrel DIRC after E/p cut

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

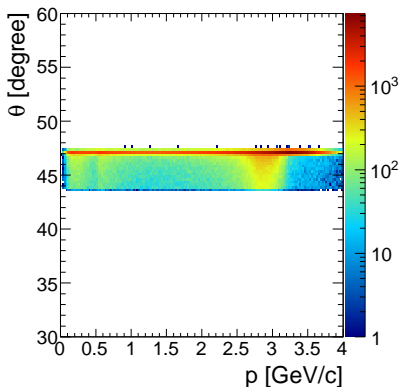


$$\bar{p}p \rightarrow \pi^+\pi^-$$

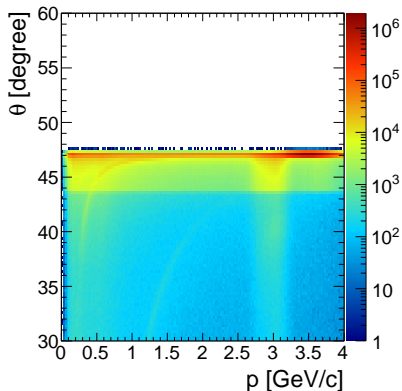


Cherenkov angle provided by disc DIRC

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

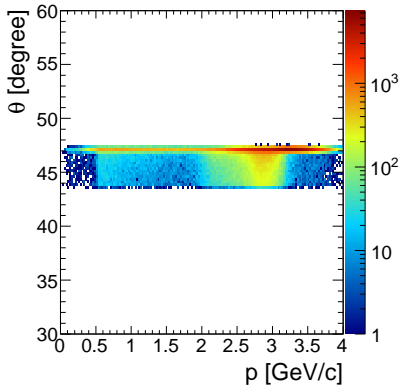


$$\bar{p}p \rightarrow \pi^+\pi^-$$

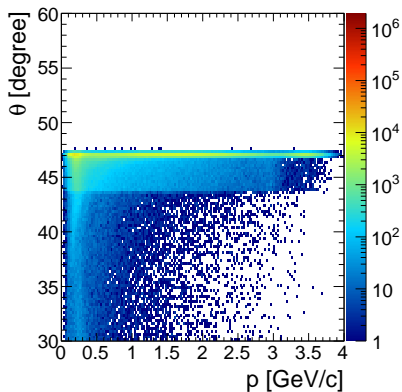


Cherenkov angle provided by disc DIRC after E/p cut

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

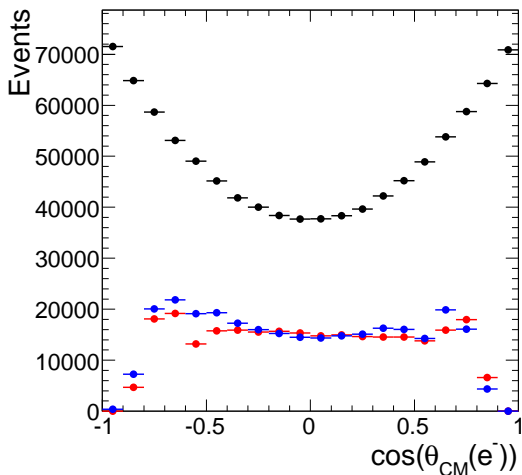


$$\bar{p}p \rightarrow \pi^+\pi^-$$



$\cos(\theta_{CM})$ of generated and reconstructed particles

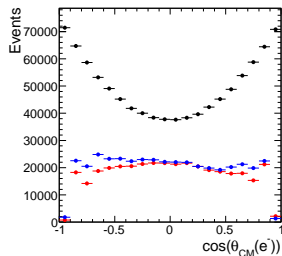
$$\bar{p}p \rightarrow e^+e^-$$



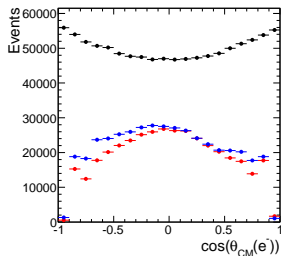
$\cos(\theta_{CM})$ of generated and reconstructed particles

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

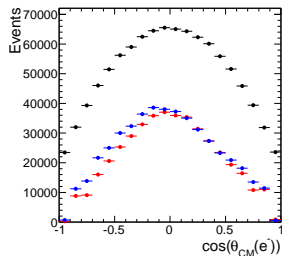
$$G_E/G_M = 0$$



$$G_E/G_M = 1$$



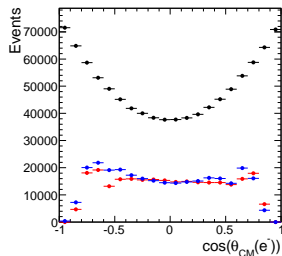
$$G_E/G_M = 3$$



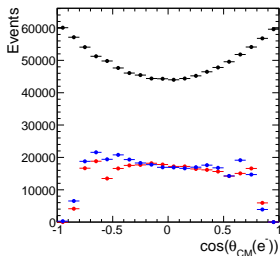
$\cos(\theta_{CM})$ of generated and reconstructed particles

$$\bar{p}p \rightarrow e^+e^-, p(\bar{p}) = 3.3\text{GeV}/c$$

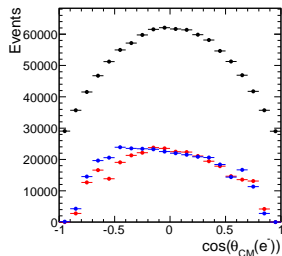
$$G_E/G_M = 0$$



$$G_E/G_M = 1$$



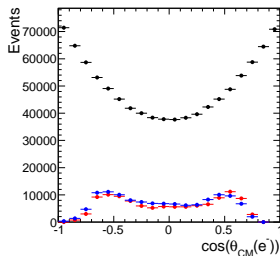
$$G_E/G_M = 3$$



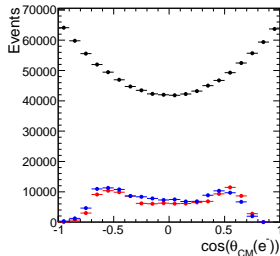
$\cos(\theta_{CM})$ of generated and reconstructed particles

$$\bar{p}p \rightarrow e^+e^-, p(\bar{p}) = 6.4 \text{ GeV}/c$$

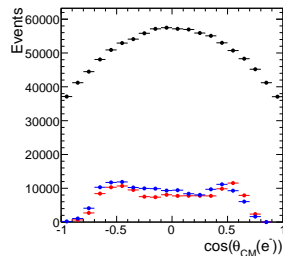
$$G_E/G_M = 0$$



$$G_E/G_M = 1$$



$$G_E/G_M = 3$$



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

$p(\bar{p}) = 1.7 \text{ GeV}/c$	e^+e^-	e^+e^-	e^+e^-	$\pi^+\pi^-$
G_E/G_M	0	1	3	-
Monte Carlo	10^6	10^6	10^6	$1.18 * 10^8$
Reconstructed, E/p only [raw]	671789	693238	736018	18870
Reconstructed, E/p only [cal]	679208	699140	736624	23389
Reconstructed, all cuts [raw]	345505	369083	416965	19
Reconstructed, all cuts [cal]	385188	407571	453615	46

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

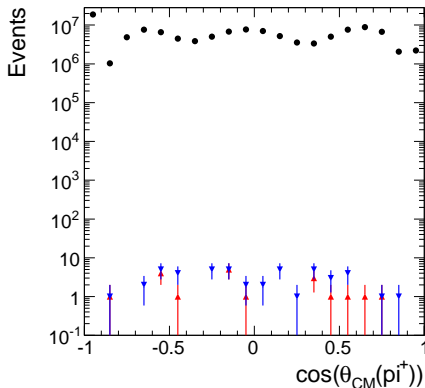
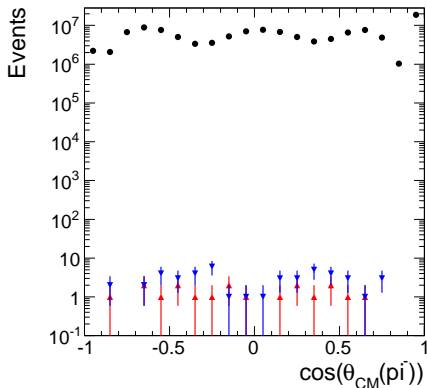
$p(\bar{p}) = 3.3 \text{ GeV}/c$	e^+e^-	e^+e^-	e^+e^-	$\pi^+\pi^-$
G_E/G_M	0	1	3	-
Monte Carlo	10^6	10^6	10^6	$1.13 * 10^8$
Reconstructed, E/p only [raw]	612284	627293	669042	39480
Reconstructed, E/p only [cal]	605598	619833	659180	69050
Reconstructed, all cuts [raw]	253404	266618	304387	19
Reconstructed, all cuts [cal]	275577	285850	324193	34

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

$p(\bar{p}) = 6.4 \text{ GeV}/c$	e^+e^-	e^+e^-	e^+e^-
G_E/G_M	0	1	3
Monte Carlo	10^6	10^6	10^6
Reconstructed, E/p only [raw]	472986	486727	529612
Reconstructed, E/p only [cal]	461182	474381	515372
Reconstructed, all cuts [raw]	108728	113713	128039
Reconstructed, all cuts [cal]	118298	124433	142283

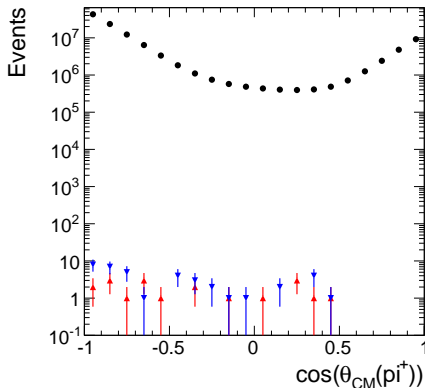
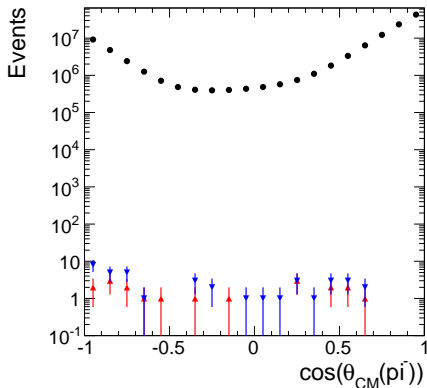
$\cos(\theta_{CM})$ of generated and reconstructed pions

$$\bar{p}p \rightarrow \pi^+\pi^-, p(\bar{p}) = 1.7\text{ GeV}/c$$

 π^-
 π^+


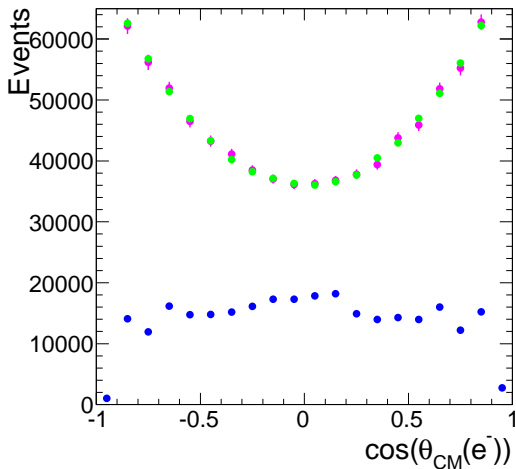
$\cos(\theta_{CM})$ of generated and reconstructed pion

$$\bar{p}p \rightarrow \pi^+\pi^-, p(\bar{p}) = 3.3\text{GeV}/c$$

 π^-
 π^+


Efficiency correction

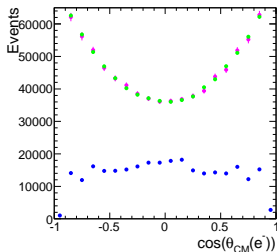
$$\bar{p}p \rightarrow e^+e^-$$



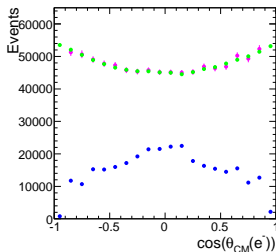
Efficiency correction

$$\bar{p}p \rightarrow e^+e^-, p(\bar{p}) = 1.7 \text{ GeV}/c, N = 9.6 * 10^5*$$

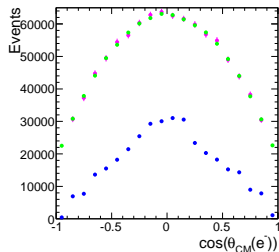
$$G_E/G_M = 0$$



$$G_E/G_M = 1$$



$$G_E/G_M = 3$$



*assuming an integrated luminosity of $L = 2 \text{ fb}^{-1}$, which is expected for each data point in four months data taking, with 100% efficiency and full acceptance.

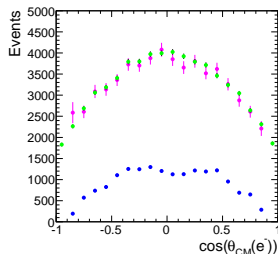
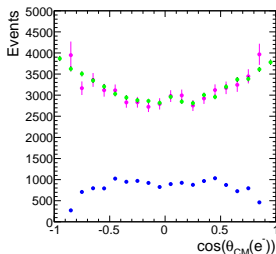
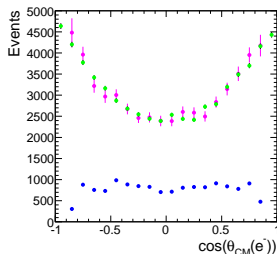
Efficiency correction

$$\bar{p}p \rightarrow e^+e^-, p(\bar{p}) = 3.3\text{GeV}/c, N = 6.4 * 10^4*$$

$$G_E/G_M = 0$$

$$G_E/G_M = 1$$

$$G_E/G_M = 3$$



*assuming an integrated luminosity of $L = 2\text{fb}^{-1}$, which is expected for each data point in four months data taking, with 100% efficiency and full acceptance.

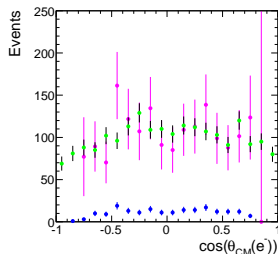
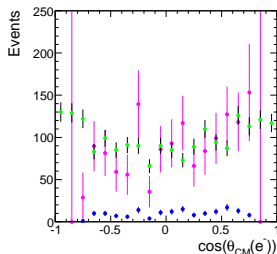
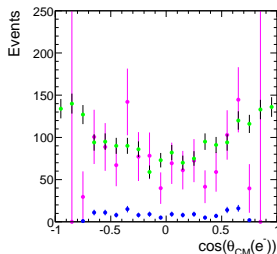
Efficiency correction

$$\bar{p}p \rightarrow e^+e^-, p(\bar{p}) = 1.7\text{GeV}/c, N = 2.0 * 10^3*$$

$$G_E/G_M = 0$$

$$G_E/G_M = 1$$

$$G_E/G_M = 3$$



*assuming an integrated luminosity of $L = 2\text{fb}^{-1}$, which is expected for each data point in four months data taking, with 100% efficiency and full acceptance.

Summary

- Developed set of cuts gives signal efficiency about 11 – 45%
- Achived background rejection factor about 10^6