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

Dmitry Khaneft

University of Mainz

Orsay
January 12, 2012

Outline

Monte Carlo Simulations

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

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

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

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

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

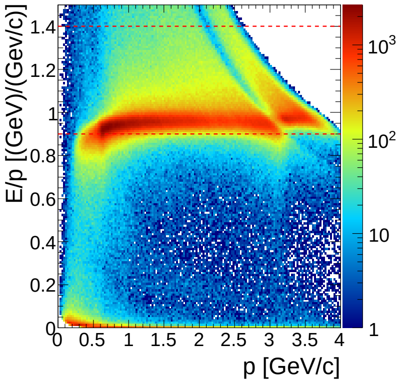
Selection criteria for e^+e^-

- 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

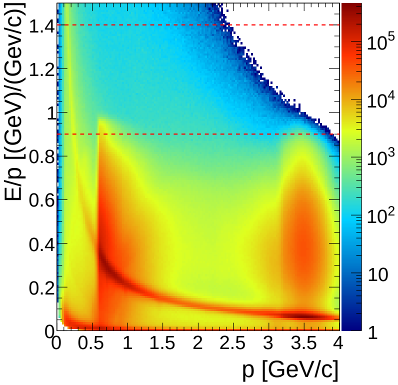
where E is the energy, p is the momentum and dE/dx_{STT} is the energy loss in STT of the reconstructed particle.

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

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

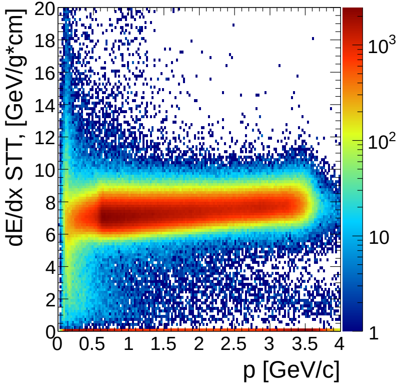


$\bar{p}p \to \pi^+\pi^-$

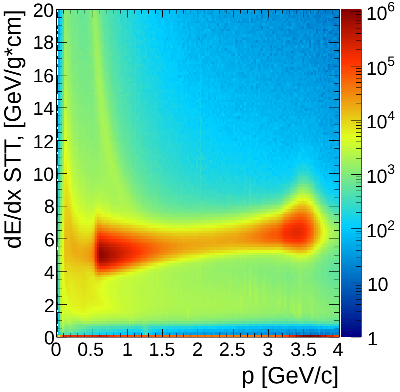


Energy loss in STT

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

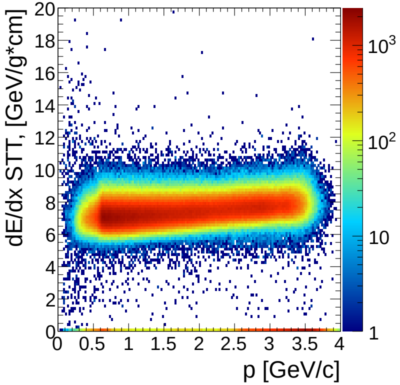


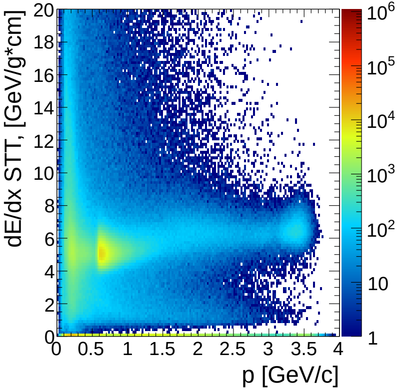
$\bar{p}p \to \pi^+\pi^-$



Energy loss in STT after E/p cut

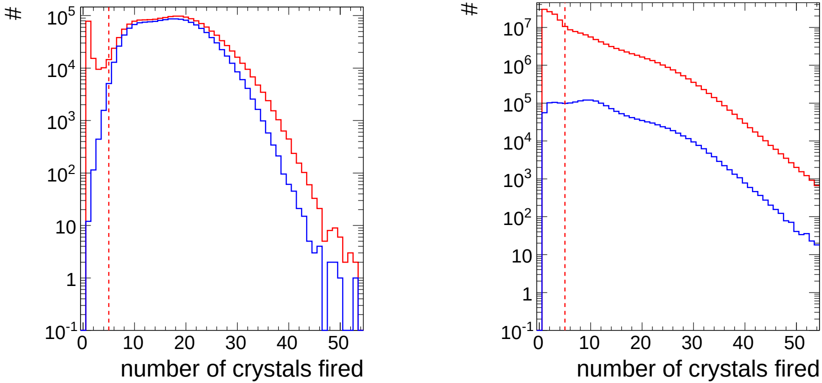
$\bar{p}p \to e^+e^-$ $\bar{p}p \to \pi^+\pi^-$





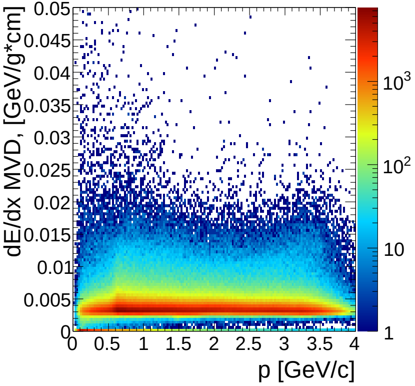
Number of crystals fired in the EMC

$\bar{p}p \to e^+e^-$ $\bar{p}p \to \pi^+\pi^-$

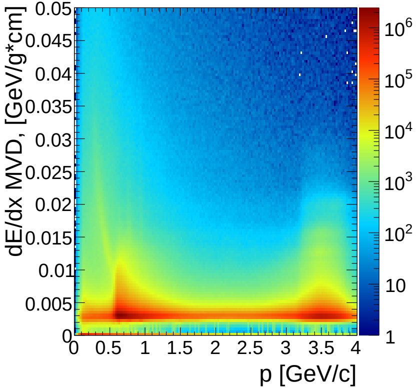


Energy loss in MVD

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

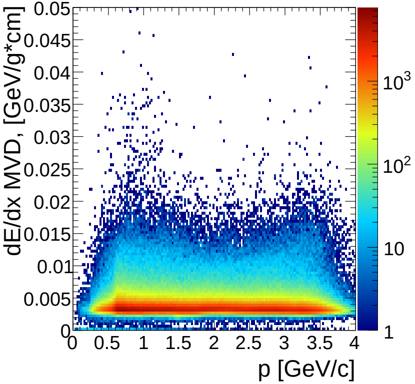


$\bar{p}p \rightarrow \pi^+\pi^-$

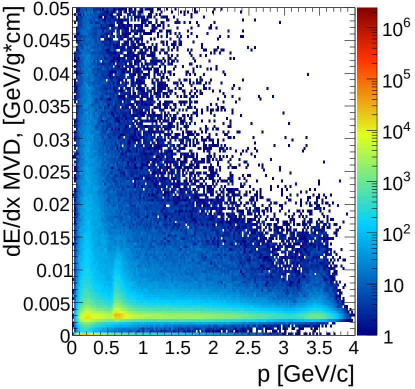


Energy loss in MVD after E/p cut

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

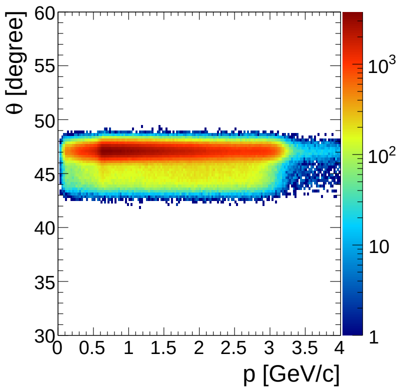


$\bar{p}p \rightarrow \pi^+\pi^-$

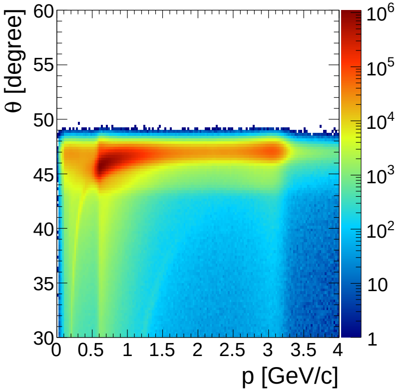


Cherenkov angle provided by barrel DIRC

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

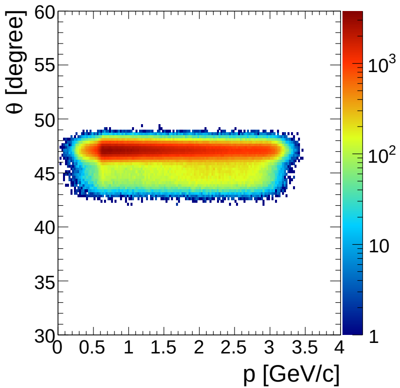


$\bar{p}p \rightarrow \pi^+\pi^-$

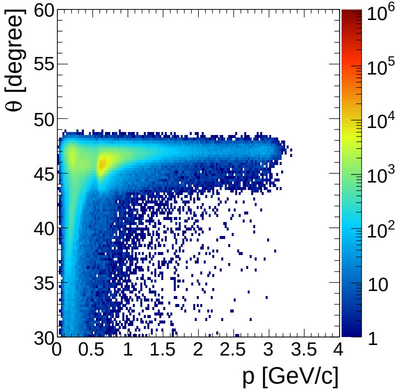


Cherenkov angle provided by barrel DIRC after E/p cut

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

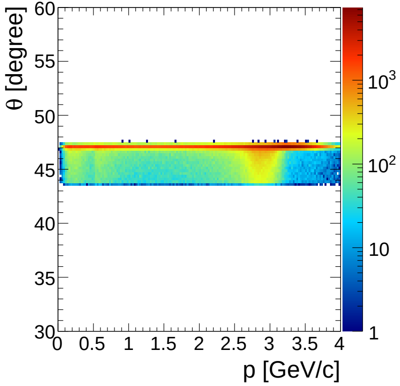


$\bar{p}p \to \pi^+\pi^-$

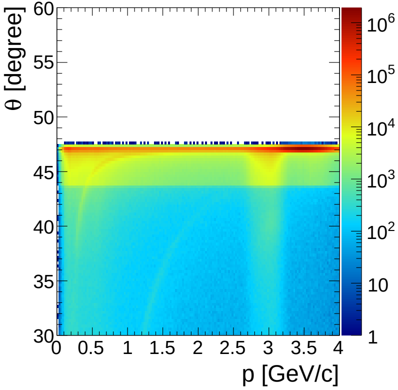


Cherenkov angle provided by disc DIRC

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

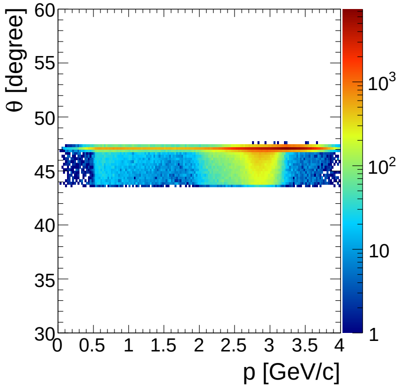


$\bar{p}p \to \pi^+\pi^-$

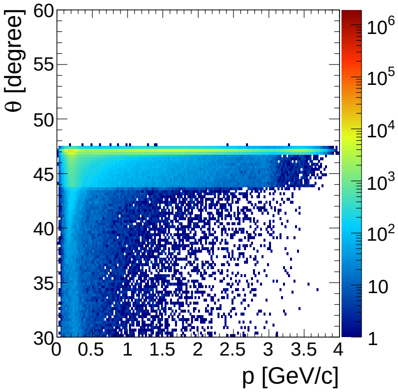


Cherenkov angle provided by disc DIRC after E/p cut

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

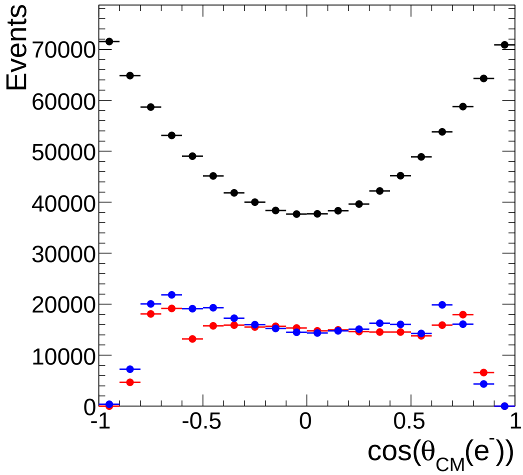


$\bar{p}p \rightarrow \pi^+\pi^-$



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

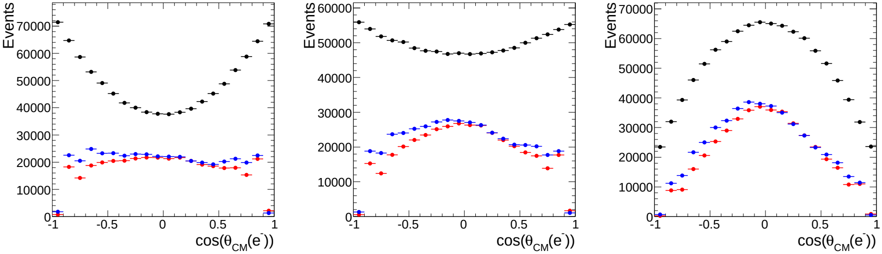
$\bar{p}p \rightarrow e^+e^-$



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

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

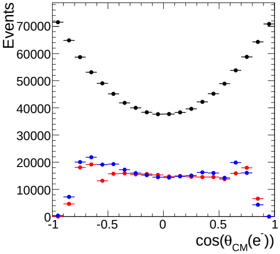
$G_E/G_M = 0$ $G_E/G_M = 1$ $G_E/G_M = 3$



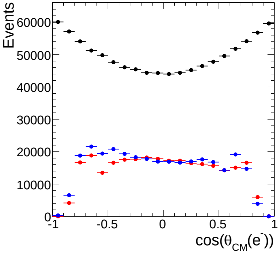
$cos(\theta_{CM})$ of generated and reconstructed particles

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

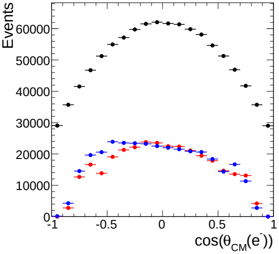
$G_E/G_M = 0$



$G_E/G_M = 1$



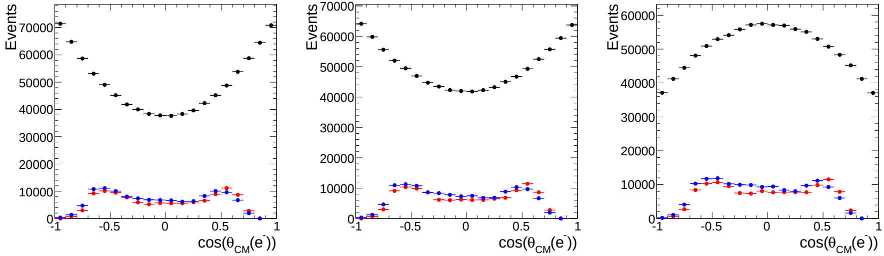
$G_E/G_M = 3$



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

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

$G_E/G_M = 0$ $G_E/G_M = 1$ $G_E/G_M = 3$



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

$p(\bar{p}) = 1.7 GeV/c$	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

$p(\bar{p}) = 3.3 GeV/c$	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

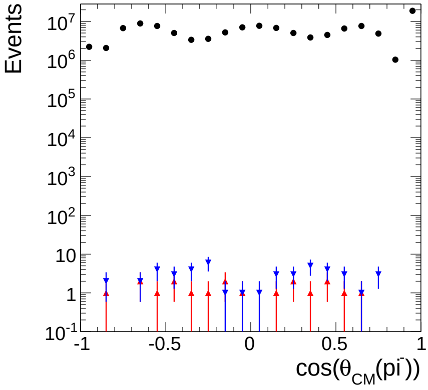
Number of e^+e^- pairs left after the cuts

$p(\bar{p}) = 6.4 GeV/c$	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

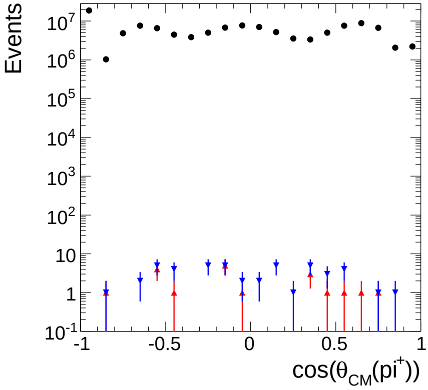
$cos(\theta_{CM})$ of generated and reconstructed pions

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

π^-



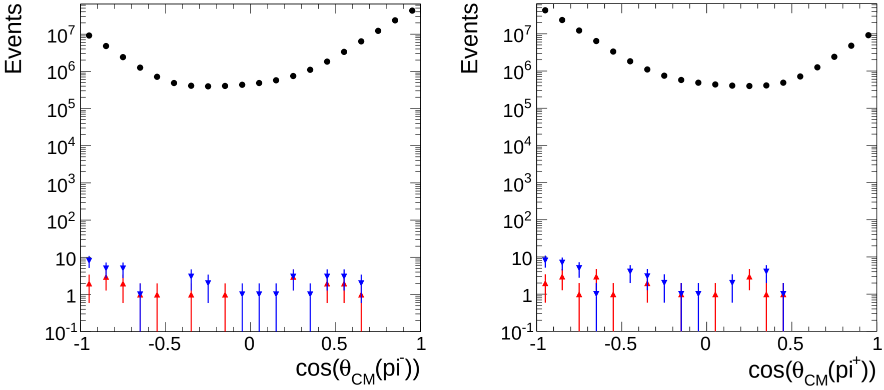
π^+



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

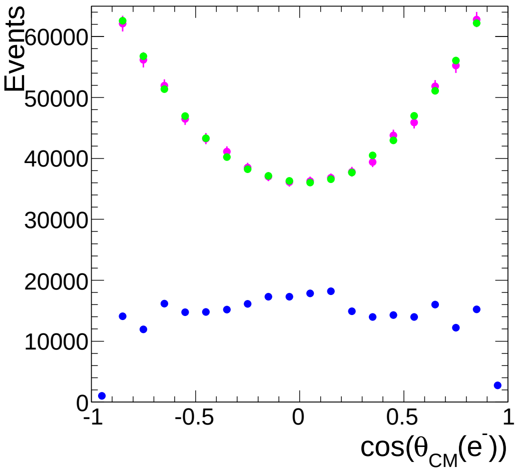
$\bar{p}p \rightarrow \pi^+\pi^-$, $p(\bar{p}) = 3.3\,GeV/c$

π^- π^+



Efficiency correction

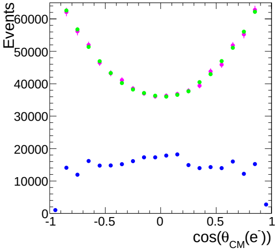
$\bar{p}p \to e^+e^-$



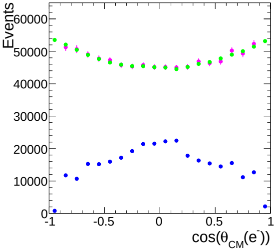
Efficiency correction

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

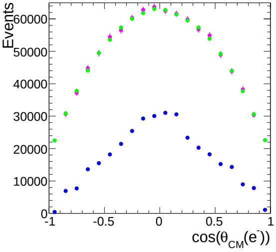
$G_E/G_M = 0$



$G_E/G_M = 1$



$G_E/G_M = 3$

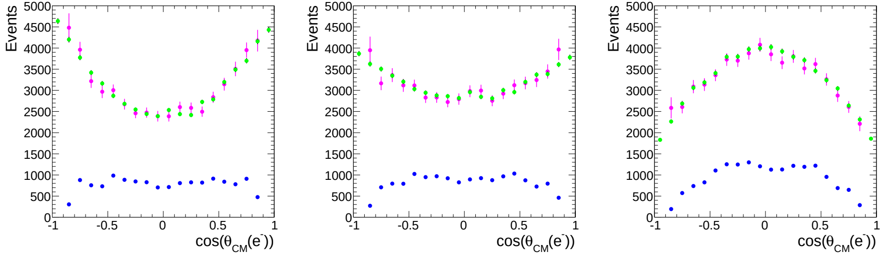


*assuming an integrated luminosity of $L = 2fb^1$, which is expected for each data point in four months data taking, with 100% efficiency and full acceptance.

Efficiency correction

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

$G_E/G_M = 0$ $G_E/G_M = 1$ $G_E/G_M = 3$

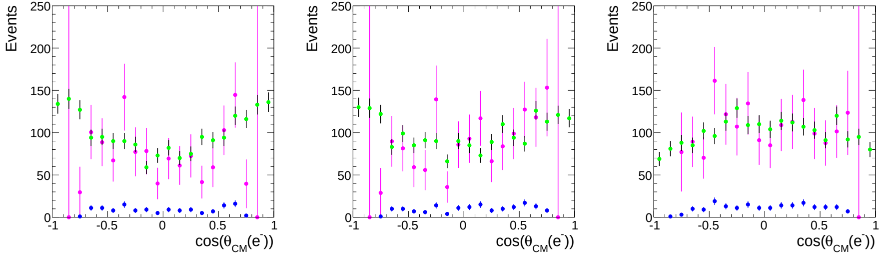


*assuming an integrated luminosity of $L = 2fb^1$, which is expected for each data point in four months data taking, with 100% efficiency and full acceptance.

Efficiency correction

$\bar{p}p \to e^+e^-$, $p(\bar{p}) = 6.4GeV/c$, $N = 2.0 * 10^3$*

$G_E/G_M = 0$ $G_E/G_M = 1$ $G_E/G_M = 3$



*assuming an integrated luminosity of $L = 2fb^1$, 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