Electromagnetic form factors with Muons

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Outline

Simulation statistics

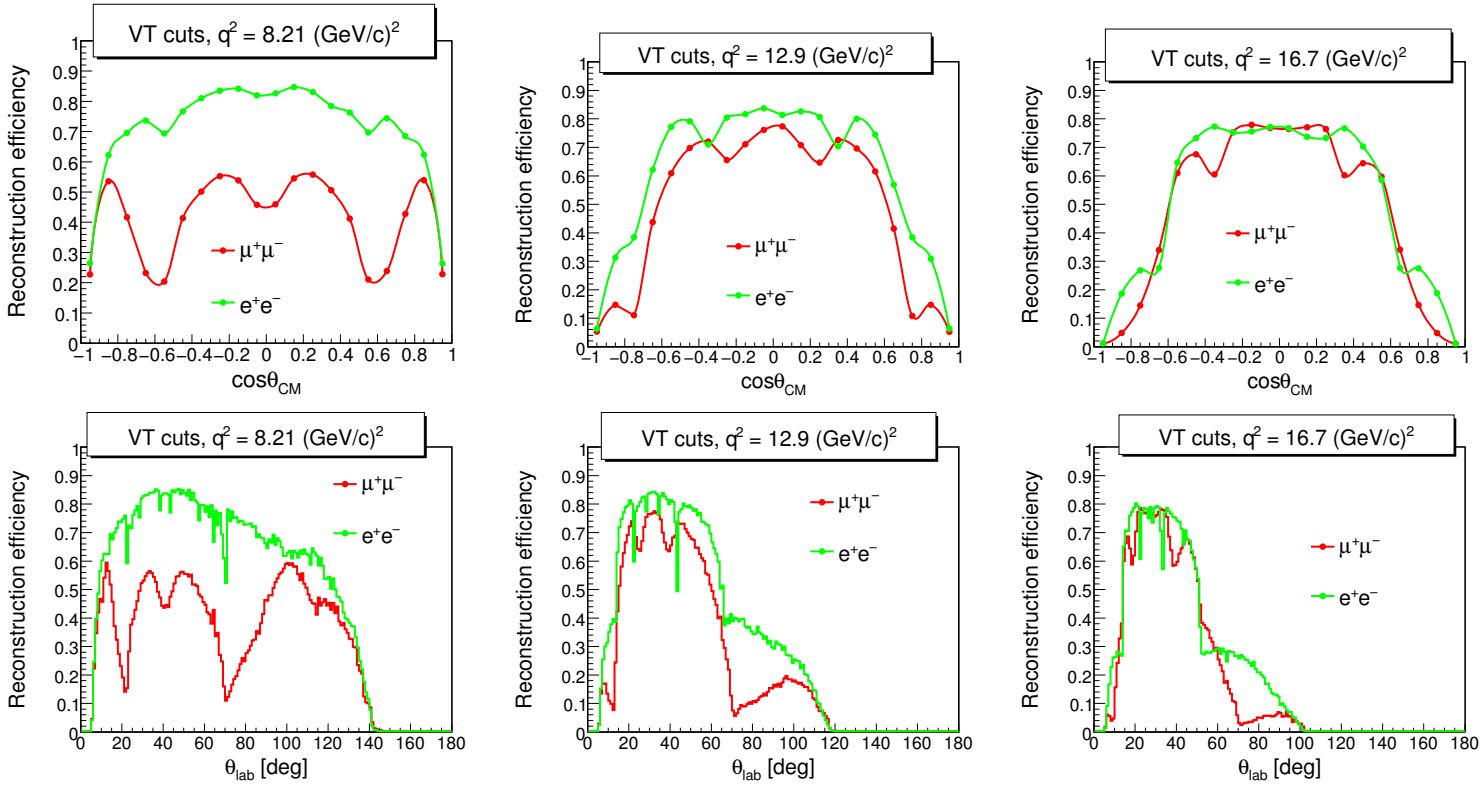
Background:

	3.3 GeV/c 8.2 (GeV/c)^2	5.9 GeV/c 12.9 (GeV/c)^2	7.9 GeV/c 16.7 (GeV/c)^2
$\pi^+\pi^-$	10^8	10^8	$2 \cdot 10^8$

Signal:

	1.7 GeV/c 5.4 (GeV/c)^2	3.3 GeV/c 8.2 (GeV/c)^2	5.9 GeV/c 12.9 (GeV/c)^2
$\mu^+\mu^- \rightarrow$			
$G_e = 0$	10^6	10^6	10^6
$G_e = G_m$	10^6	10^6	10^6
$G_e = 3 \cdot G_m$	10^6	10^6	10^6

Electron and muon detection efficiencies



Plots by Gosia Sudol

Studied cuts

PID and LH cuts:

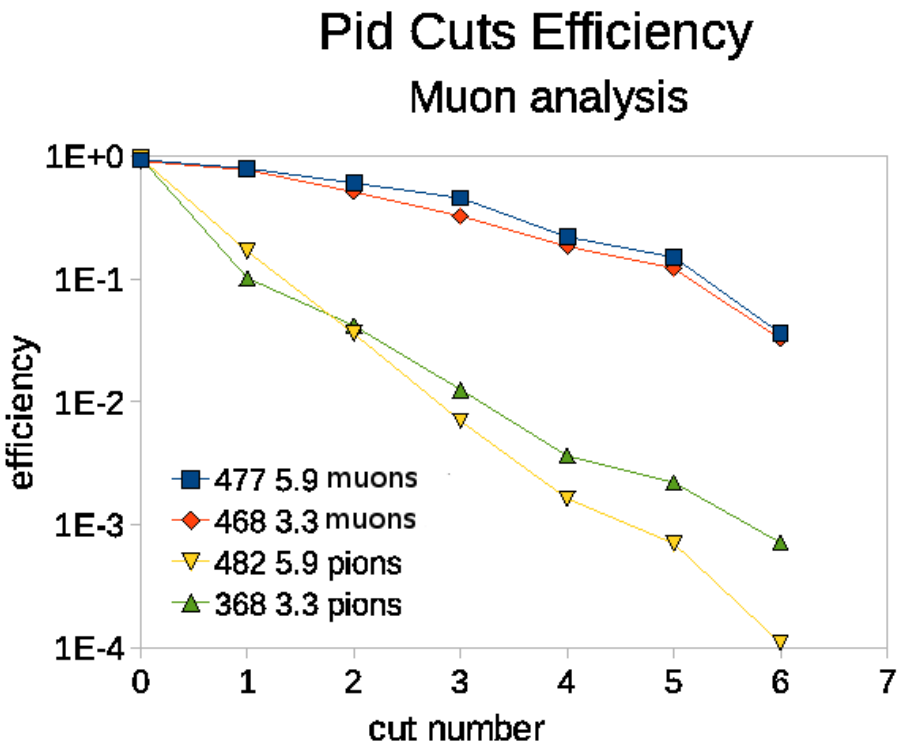
1. Very Loose (VL): 19.99%
2. Loose (L): 45%
3. Tight (T): 70%
4. Very Tight (VT): 85%
5. Likelyhood (LH) $>$ 90%
6. LH $>$ 95%

Kinematical fit:

1. $CL(\mu^+\mu^-) > 10 \times CL(\pi^+\pi^-)$
2. $CL(\mu^+\mu^-) > 50 \times CL(\pi^+\pi^-)$
3. $CL(\mu^+\mu^-) > 100 \times CL(\pi^+\pi^-)$
4. $CL(\mu^+\mu^-) > 150 \times CL(\pi^+\pi^-)$
5. $CL(\mu^+\mu^-) > 200 \times CL(\pi^+\pi^-)$
6. $CL(\mu^+\mu^-) > 300 \times CL(\pi^+\pi^-)$

1. $CL(\mu^+\mu^-) > 10^{-9}$
2. $CL(\mu^+\mu^-) > 10^{-3}$
3. $CL(\mu^+\mu^-) > 10^{-2}$
4. $CL(\mu^+\mu^-) > 0.1$
5. $CL(\mu^+\mu^-) > 0.4$
6. $CL(\mu^+\mu^-) > 0.5$

Background suppression

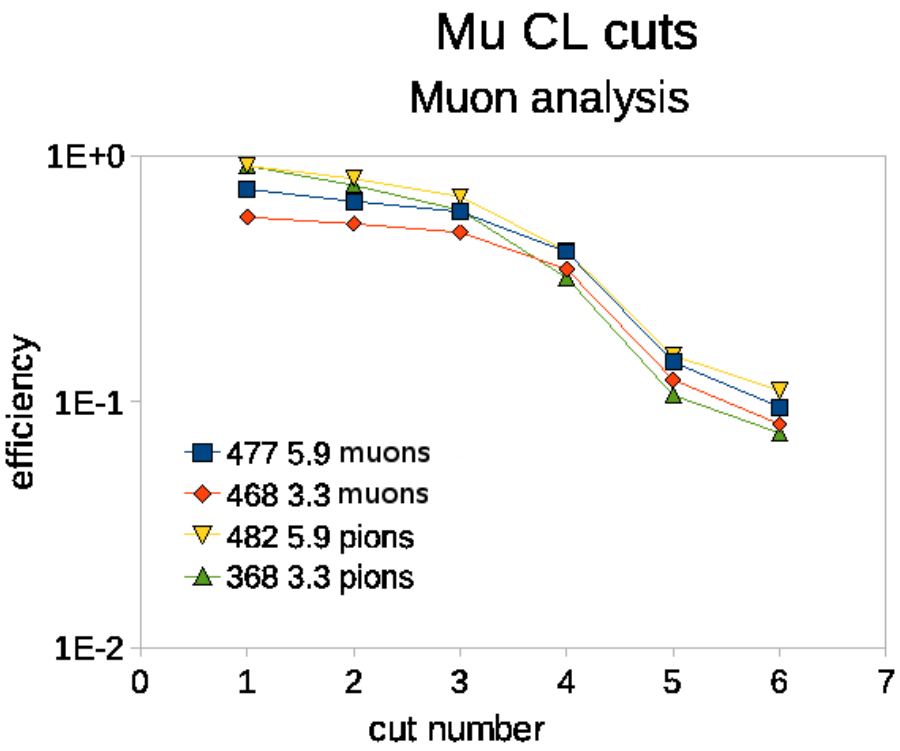


Cut	Pions 5.9	Muons 5.9	Pions 3.3	Muons 3.3
VL	16.81	79.37	10.16	77.33
L	3.6	60.44	4.18	51.07
T	0.7	45.71	1.26	32.59
VT	0.16	22.02	0.36	18.4
90%	0.07	15.05	0.22	12.24
95%	0.01	3.62	0.07	3.23

1. VL
2. L
3. T
4. VT
5. LH $>$ 90%
6. LH $>$ 95%

- The signal to noise ratio increases with LH level.
- The final cut have been selected to be:
LH $>$ 95%

Background suppression



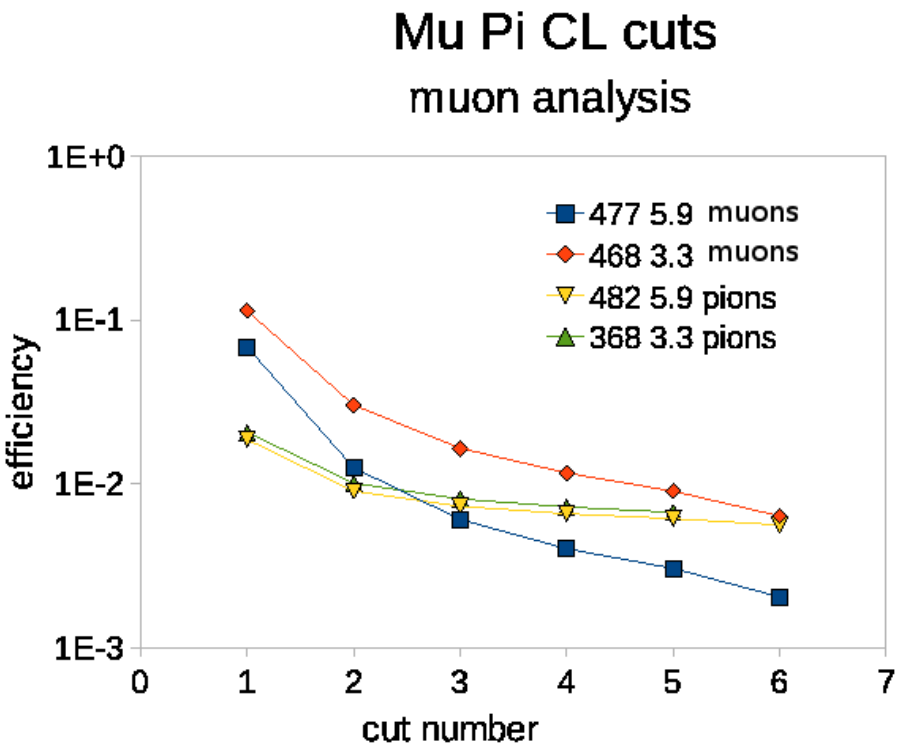
Cut	Pions 5.9	Muons 5.9	Pions 3.3	Muons 3.3
10e-9	91.23	73.25	91.32	56.39
10e-3	80.99	65.45	76.05	53.01
10e-2	68.54	59.35	60.27	48.94
0.1	41.04	40.76	31.96	34.66
0.4	15.42	14.49	10.63	12.29
0.5	11.11	9.52	7.46	8.1

1. $CL(\mu^+\mu^-) > 10^{-9}$
2. $CL(\mu^+\mu^-) > 10^{-3}$
3. $CL(\mu^+\mu^-) > 10^{-2}$
4. $CL(\mu^+\mu^-) > 0.1$
5. $CL(\mu^+\mu^-) > 0.4$
6. $CL(\mu^+\mu^-) > 0.5$

- The μ CL cut affects in the same way signal and background

$CL(\mu^+\mu^-) > 10^{-3}$

Background suppression



Cut	Pions 5.9	Muons 5.9	Pions 3.3	Muons 3.3
10	1.86	6.82	2.06	11.36
50	0.9	1.25	1.01	3.02
100	0.73	0.6	0.81	1.64
150	0.65	0.4	0.72	1.16
200	0.61	0.3	0.67	0.9
300	0.56	0.2	0	0.63

1. $CL(\mu^+\mu^-) > 10\times CL(\pi^+\pi^-)$
2. $CL(\mu^+\mu^-) > 50\times CL(\pi^+\pi^-)$
3. $CL(\mu^+\mu^-) > 100\times CL(\pi^+\pi^-)$
4. $CL(\mu^+\mu^-) > 150\times CL(\pi^+\pi^-)$
5. $CL(\mu^+\mu^-) > 200\times CL(\pi^+\pi^-)$
6. $CL(\mu^+\mu^-) > 300\times CL(\pi^+\pi^-)$

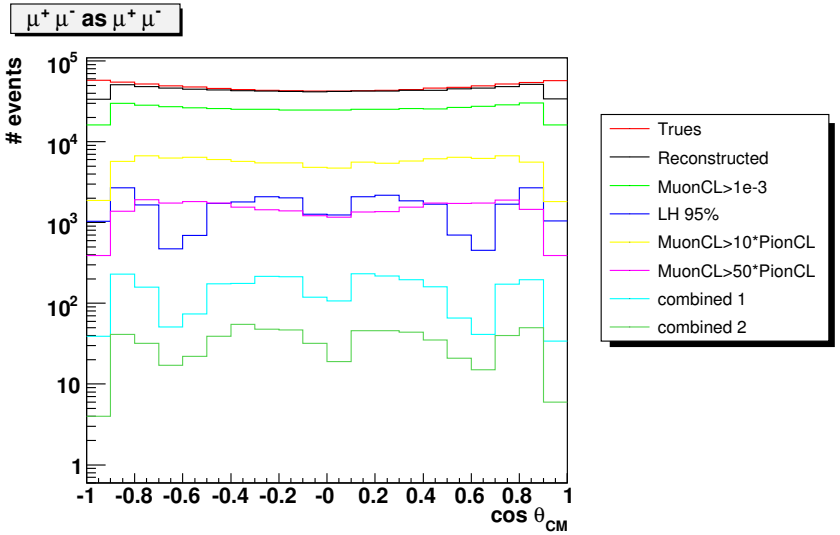
- More restrictive cuts reduce the signal to noise ratio
- $CL(\mu^+\mu^-) > 10\times CL(\pi^+\pi^-)$

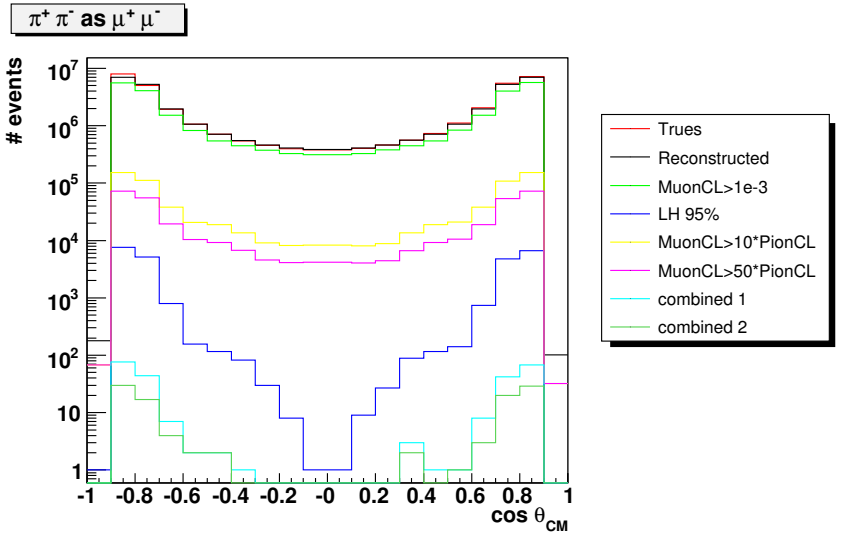
and

- $CL(\mu^+\mu^-) > 50\times CL(\pi^+\pi^-)$

Cuts effect on muons and pions angular distributions at 3.3 GeV/c

Signal: 1 000 000 events
Background: 36 950 000 events



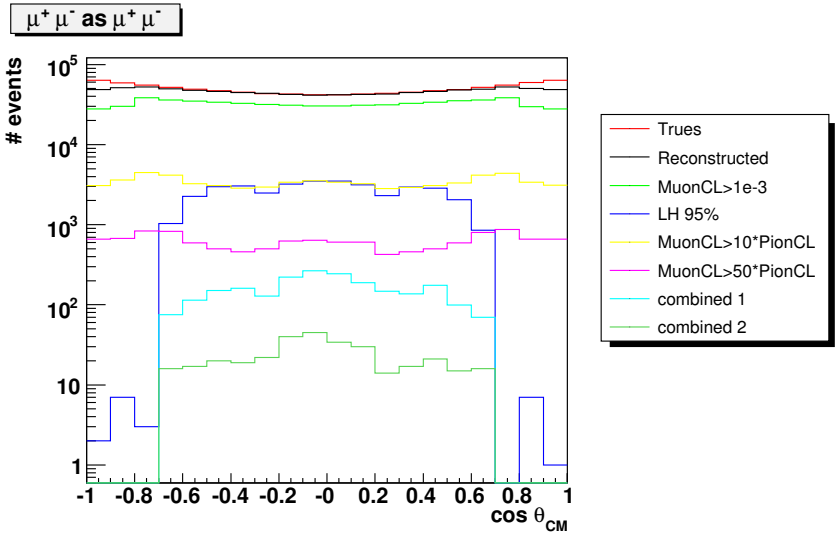


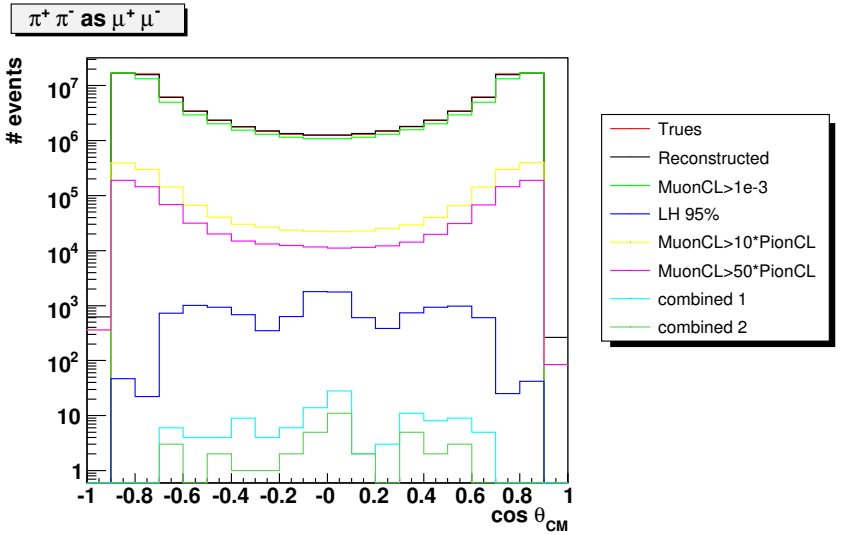
Combined 1: LH $>$ 95%,CL(μ)$>$ 10^{-3} and CL(μ)$>$ 10 CL(π)
Combined 2: LH $>$ 95%,CL(μ)$>$ 10^{-3} and CL(μ)$>$ 50 CL(π)

Combined 1: 2872 muons (0.30%), 256 pions ($7{\cdot}10^{-4}$)
Combined 2: 659 muons (0.07%), 110 pions ($3{\cdot}10^{-4}$)

Cuts effect on muons and pions angular distribution at 5.9 GeV/c

Signal: 1 000 000 events
Background: 112 165 000 events





Combined 1: LH $>$ 95%,CL(μ)$>$ 10^{-3} and CL(μ)$>$ 10 CL(π)
Combined 2: LH $>$ 95%,CL(μ)$>$ 10^{-3} and CL(μ)$>$ 50 CL(π)

Combined 1: 2179 muons (0.22%), 113 pions (10^{-4})
Combined 2: 326 muons (0.03%), 37 pions ($3{\cdot}10^{-5}$)

Conclusions

- More work on this analysis is needed in order to confirm the results.
- High background suppression implies drastic signal reduction in the case of muons.
- Electron channel seems to be of higher utilty for Form Factors separation.