Study of potential of Super$B$ experiment to discover lepton flavour violation with the decays $\tau \to \mu\mu\mu$

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Table of Contents

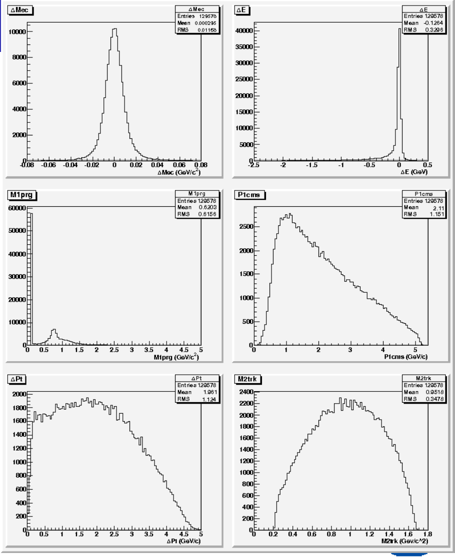
Event Preselection

I use different cuts created by Adrian:

- BGFMultiHadron Filter
- L3OutDch or L3OutEmc triggers
- Total momentum: $p < 10$ GeV
- for each tracks:
  - Polar Angle: $0.41 < \theta < 2.46$ rad
  - Transverse momentum: $p_T > 0.1$ GeV
- Total charge for the tracks equal zero
- Recontructed 1-3 Topology
- Mass of the reconstructed particle: $1.70 < \tau Mass < 1.85$

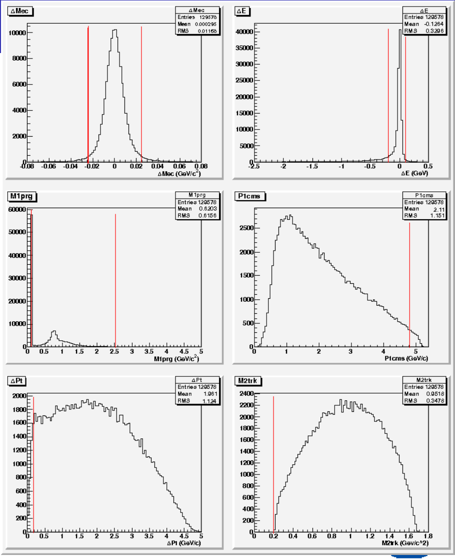
The 6 variables:

- $\Delta E = E_{rec} - E_{beam}$
- $\Delta M_{ec} = \sqrt{E_{rec}^2 - \vec{p_{rec}}^{\,2}} - m_\tau$
- M_{2trk}: signal hemisphere two track invariant mass.
- M_{1prg}: 1 prong hemisphere invariant mass.
- p_1^{cms}: 1 prong hemisphere momentum.
- Δp_T: missing transverse momentum.

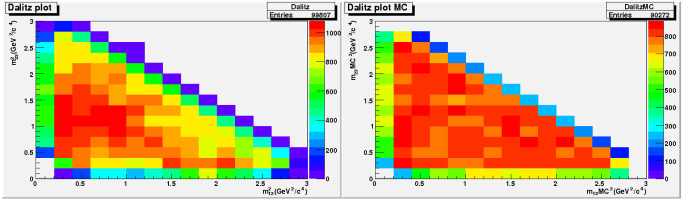


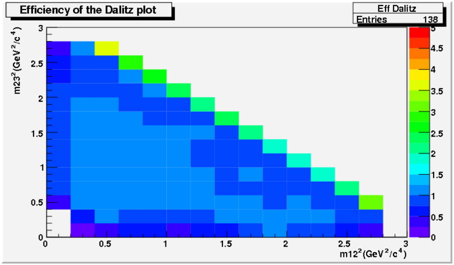
The 6 variables:

- $-0.025 < \Delta M_{ec} < 0.025$ GeV/c^2
- $-0.2 < \Delta E < 0.1$ GeV
- $0.1 < M_{1prg} < 2.5$ GeV/c^2
- $p_1^{cms} < 4.8$ GeV/c
- $\Delta p_T > 0.2$ GeV/c
- $M_{2trk} > 0.2$ GeV/c^2



Dalitz plot


Dalitz plot
Dalitz
Entries 99807
m^2_{23}(GeV ^{2}/c ^{4})
m^2_{12}(GeV ^{2}/c ^{4})
Dalitz plot MC
DalitzMC
Entries 90272
m_{23}MC ^{2}(GeV ^{2}/c ^{4})
m_{12}MC ^{2}(GeV ^{2}/c ^{4})


Efficiency of the Dalitz plot
Eff Dalitz
Entries 138
m23 ^{2}(GeV ^{2}/c ^{4})
m12 ^{2}(GeV ^{2}/c ^{4})

Particle Identification

I use the performance of Muon BDT Selectors found in:

C. O. Vuosalo, A. V. Telnov, K. T. Flood
Muon Identification Using Decision Trees.
BABAR Analysis Document #1853, Version 3, March 18, 2010.

And I obtained a efficiency of 10,60 $\pm$ 0.013 % for the *BABAR*'s configuration and 12,94 $\pm$ 0.013 % with the Super$B$'s configuration.

I use FastSim (version V0.2.4) to create the file of events.

	number of events	configuration of SVT	configuration of DCH	efficiency for the Data (in%)
Super*B*	500K	baseline	baseline	12.94 ± 0.013
	100K			12.92 ± 0.028
	50K			12.90 ± 0.04
	50K	baseline	longbwdfwd	12.58 ± 0.04
			longbwd	13.09 ± 0.04
			longfwd	12.60 ± 0.04
			shortfwd	12.81 ± 0.04
	50K	long barrel	baseline	13.29 ± 0.04
			longbwdfwd	13.01 ± 0.04
			longbwd	13.24 ± 0.04
			longfwd	12.97 ± 0.04
			shortfwd	12.69 ± 0.04
	50K	lampshade	baseline	12.93 ± 0.04
			longbwdfwd	13.12 ± 0.04
			longbwd	13.19 ± 0.04
			longfwd	13.15 ± 0.04
			shortfwd	12.91 ± 0.04

The background

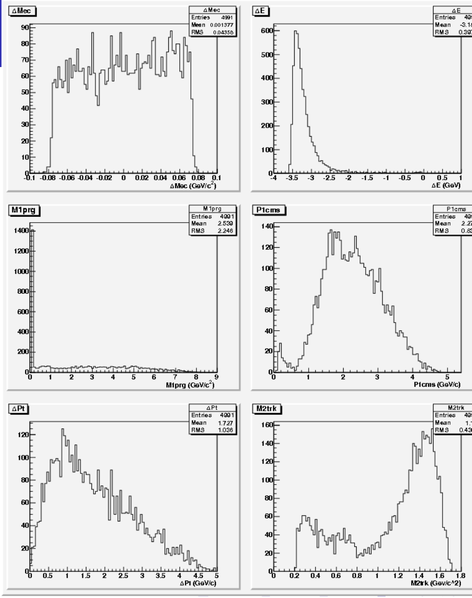
I study the decay $\tau \to \pi\pi\pi$ like background.

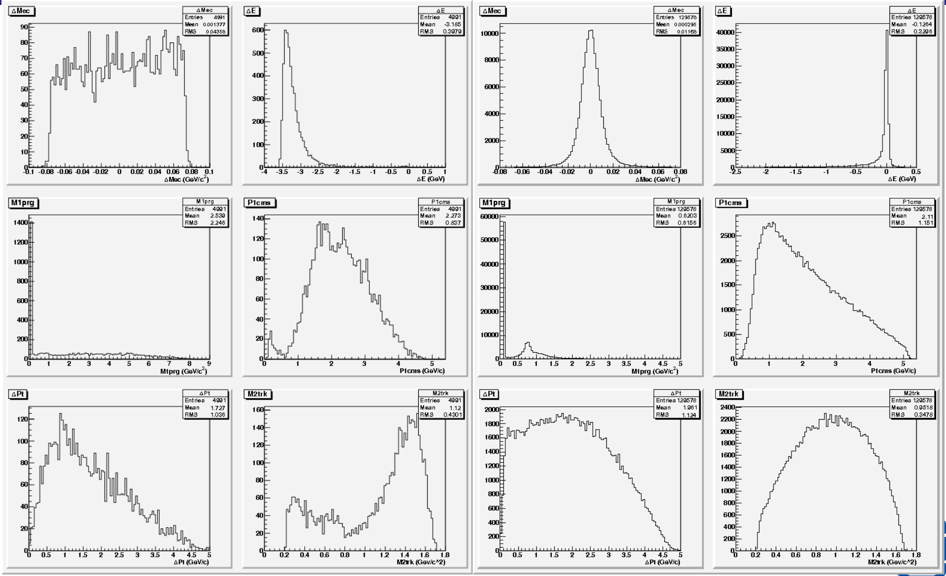
I obtained only 2 events form a 2 million events file. Corresponding to the efficiency of reconstruction: ε_{rec}.

Finally I compute the $N_{expect}(\tau \to \pi\pi\pi)$ define like:

$$N_{expect}(\tau \to \pi\pi\pi) = 2 \times N_{\tau^+\tau^-} \times {\varepsilon_{MID}}^3 \times \varepsilon_{rec} \times \mathcal{B}(\tau \to \pi\pi\pi)$$
$$N_{expect}(\tau \to \pi\pi\pi) = 1.63 \text{ events}$$

where ε_{MID} is the efficiency for fake rate selector for a muon.




ΔMec
ΔMec Entries 4991 Mean 0.001377 RMS 0.04356
ΔMec (GeV/c^2)
ΔE
ΔE Entries 4991 Mean -3.185 RMS 0.3979
ΔE (GeV)
ΔMec
ΔMec Entries 129578 Mean 0.000295 RMS 0.01158
ΔMec (GeV/c^2)
ΔE
ΔE Entries 129578 Mean -0.1264 RMS 0.3296
ΔE (GeV)
M1prg
M1prg Entries 4991 Mean 2.539 RMS 2.246
M1prg (GeV/c^2)
P1cms
P1cms Entries 4991 Mean 2.273 RMS 0.837
P1cms (GeV/c)
M1prg
M1prg Entries 129578 Mean 0.6203 RMS 0.6156
M1prg (GeV/c^2)
P1cms
P1cms Entries 129578 Mean 2.11 RMS 1.151
P1cms (GeV/c)
ΔPt
ΔPt Entries 4991 Mean 1.727 RMS 1.036
ΔPt (GeV/c)
M2trk
M2trk Entries 4991 Mean 1.12 RMS 0.4301
M2trk (Gev/c^2)
ΔPt
ΔPt Entries 129578 Mean 1.961 RMS 1.124
ΔPt (GeV/c)
M2trk
M2trk Entries 129578 Mean 0.9518 RMS 0.3478
M2trk (Gev/c^2)

I use the software AFit (using version 5.26 of ROOT).

I compute the upper limits at 90% of confidence with $N_{expect}^{sign} = 3.62$ and $N_{expect}^{back} = 1.63$ and I obtained:

$N_{90}^{UL} = 11.89$ for the signal and $N_{90}^{UL} = 6.23$ for the background.

Corresponding to $B_{90}^{UL} = 6.56 \times 10^{-10}$ for the signal.

Finally I compute the upper limit in assuming that I have only the signal, I obtain: $N_{90}^{UL} = 6.99$

Conclusion

We can see a great difference between upper limit with the signal and background ($N_{90}^{UL} = 11.89$) and with only the signal ($N_{90}^{UL} = 6.99$).

Thus this decay is very sensitive to background and so this decay needs more study for the different backgrounds for a $75ab^{-1}$ data sample.