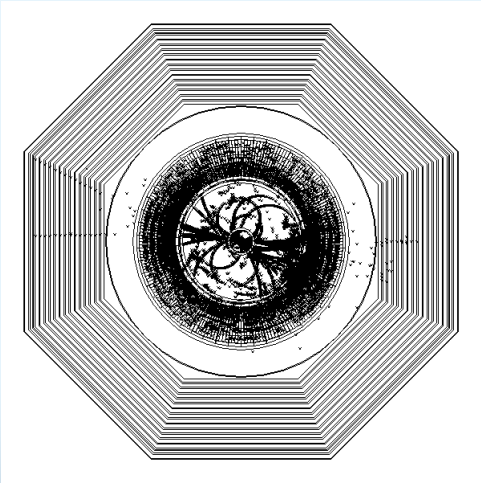
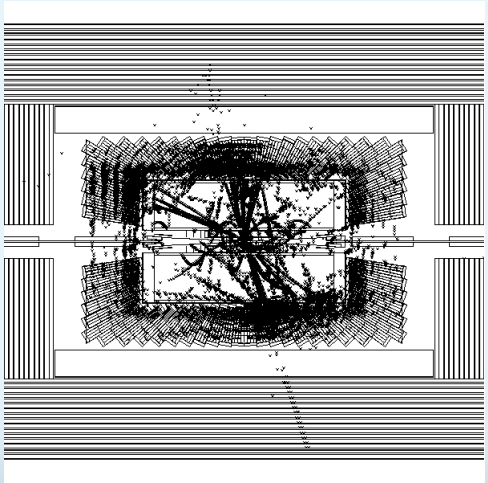
Linear collider muon detector: an update from the ECFA study





Marcello Piccolo

Paris, April 2004

Agenda

- Performance studies
- An interesting measurement in the super symmetric compartment.
- Help from the Had-cal
- The Standard Model background.
- Conclusions

Brahms V308 simulation run

- The 3.08 version of Brahms has been used to run many thousands events.
- I had to put in few fixes on vector dimensions in order to cure “rare” occurrences of run time errors.
- As of now runs of 10,000 events (typically 2-3 days on a P-IV @ 2.5 GHz) go through without problems.
- Few hit files have been produced: I can run on them changing selection criteria and/or analysis techniques:
  - bb events, gauge boson production, Standard model mix.
- Time wise the hit file analysis takes one tenth of the production to run.

Check performance on a hard physics process

- Bench-marking on real physics is always the right way to design and optimize a detector.
- Muon detectors have in general hard times to detect low energy leptons: so one is lead to use the full calorimetric system to attempt identification
- I had a preliminary look at the low energy capability of TESLA-TDR detector (1-10 GeV/c momentum range)

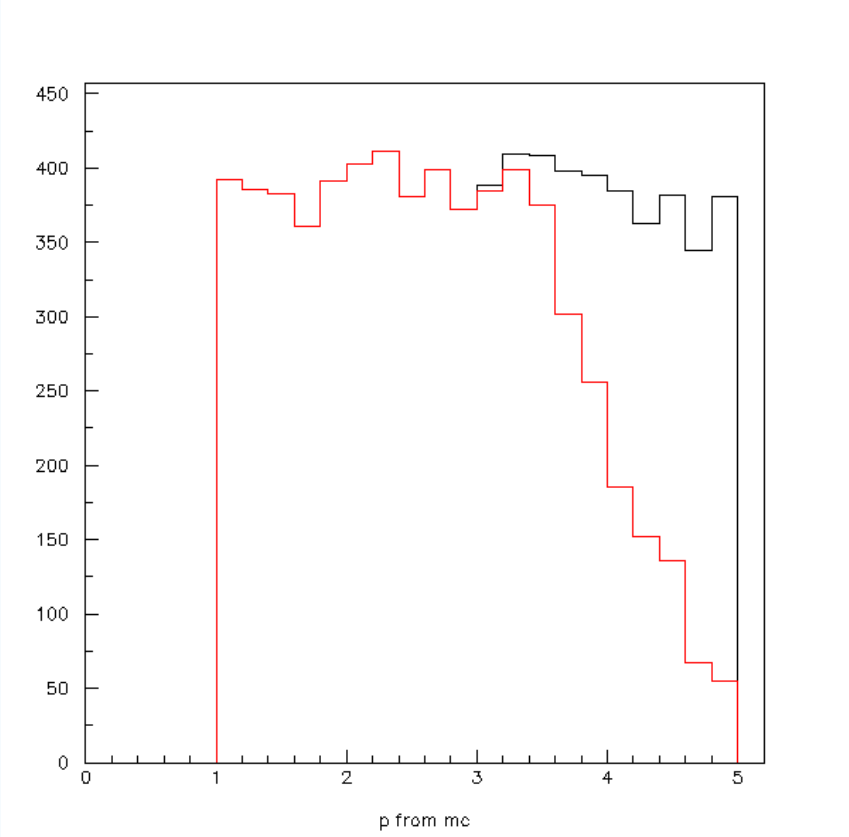
Why low energy leptons (μ) ?

- The rationale to check how low energy μ's will be seen in the detector comes from the CMSSM.
- The data from WMAP hint the possibility that , if super-symmetry is present in nature, and the LSP is indeed the bulk of dark matter, then actual data favor a model in which the mass difference between sleptons and the neutralinos is very small.
- The lepton spectrum resulting from the above transition will then be very soft. (~ few GeV/c)

A first look at the low energy region

- Started with single particle studies: generated 10000 positive μ and 10000 positive π.
- Flat momentum and angle distributions 0.-10. GeV/c.
- Angular region studied covers the total solid angle with the exclusion of 100 mrad. at 0 and π.
- The procedure used was the SNARK (fortran) package: it does the energy/particles flow: the particle assignment has been used out of the procedure without attempting any kind of optimization.

The calorimeters role in μ identification



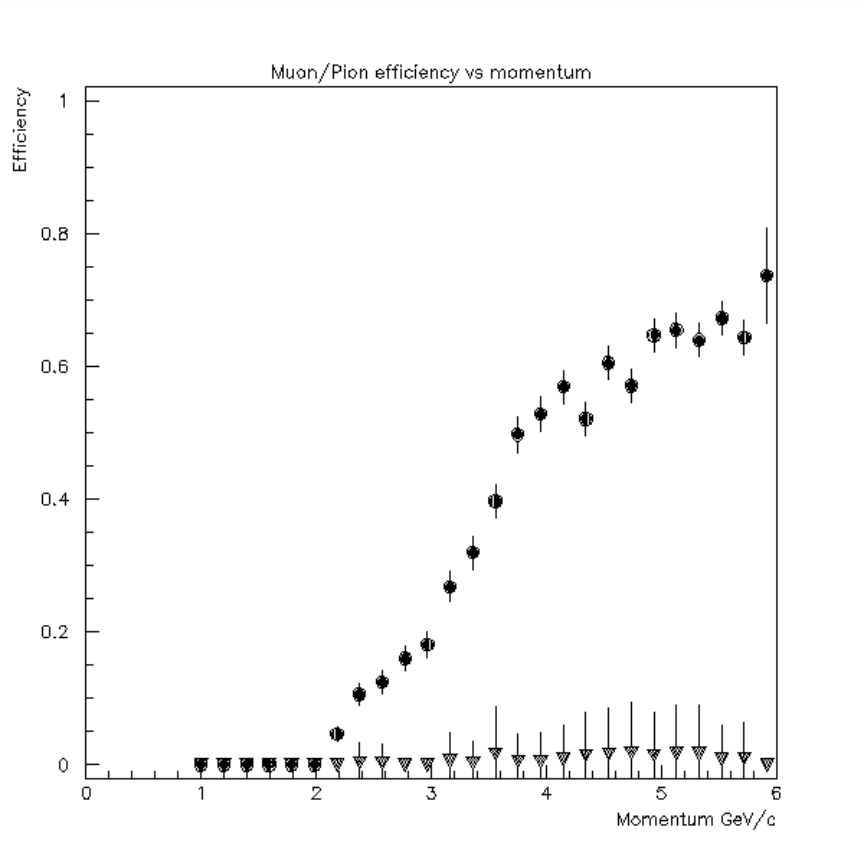
Here, in black, is the momentum spectrum for the generated muons.

The red lines represent the momentum spectrum for muons that do not produce hits in the muon system.

The threshold around 3-4 GeV/c is evident.

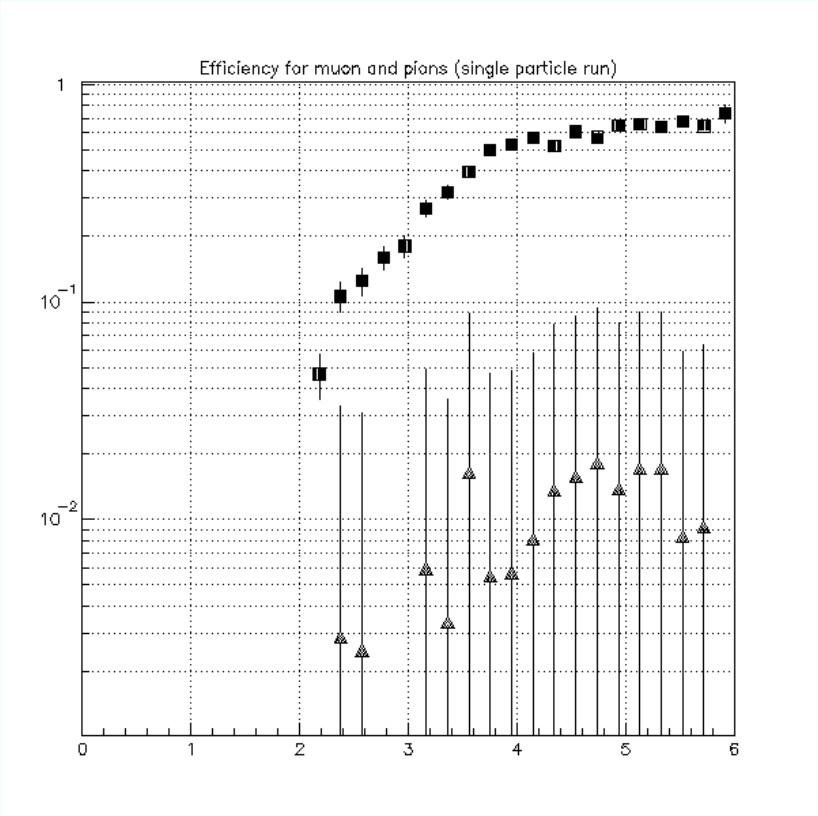
It is clear that muon-id cannot be provided by the muon detector in this momentum region, so we have to use the had-cal.

Efficiency for muons



- Here is the efficiency vs. momentum the had-cal + snark yield.
- The π run results in the efficiency plotted with the triangles.
- Efficiency in the ball park of 1% for π's .

Efficiency for muons



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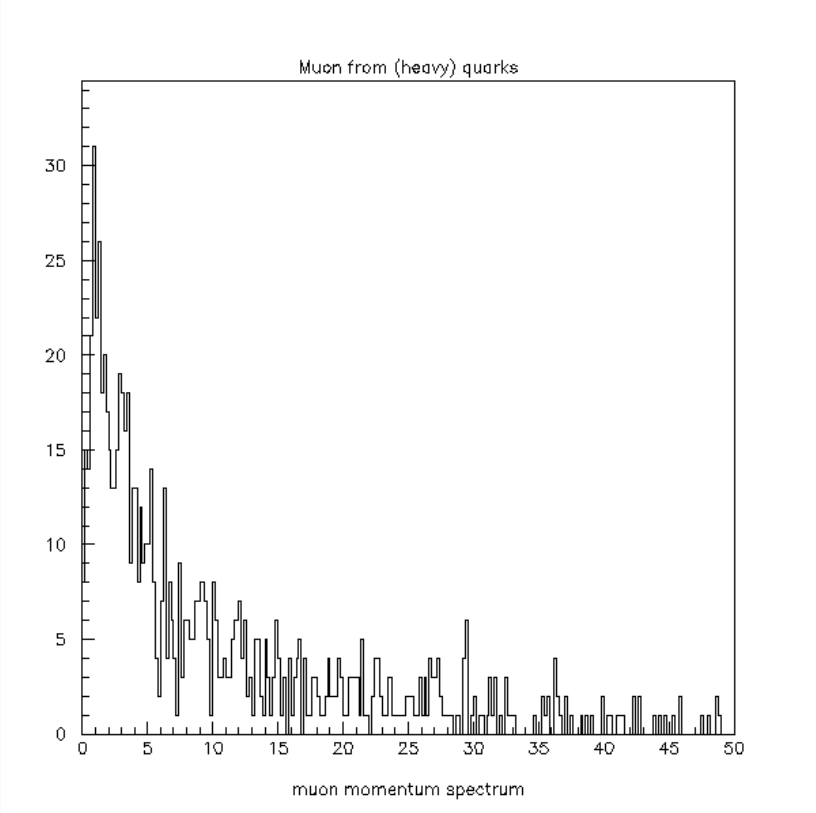
Muon-id: the low momentum end

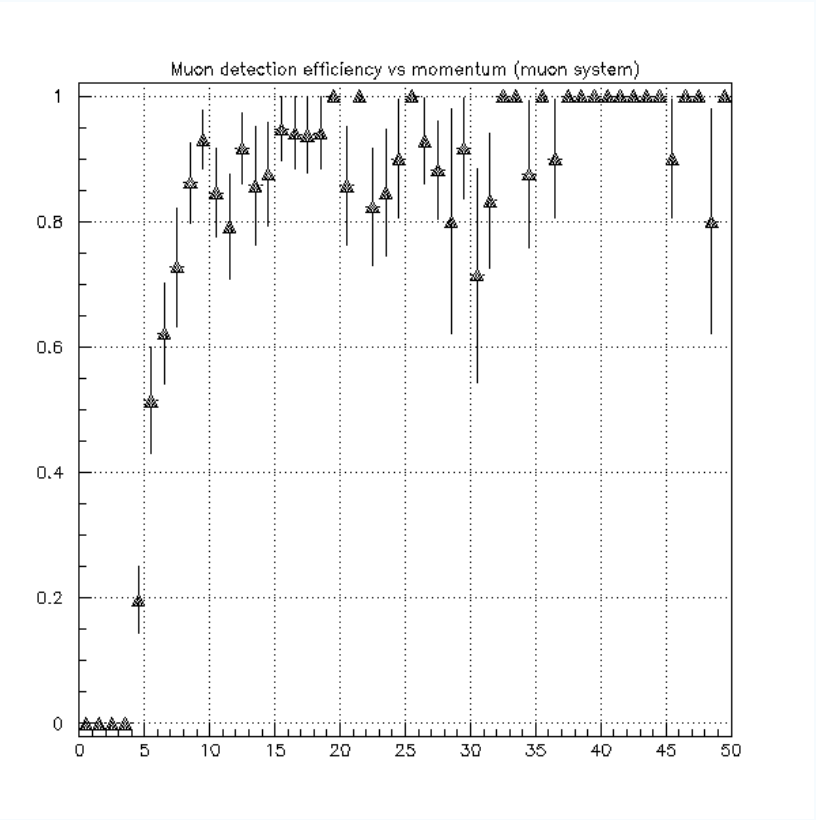
- Judging from single particles runs the situation seems bearable, taking also into account that no optimization has yet been attempted on lepton identification on the had-cal.
- However single particles results are always on the optimistic side.
- Background from Standard Model and from peripheral processes have to be evaluated.

Standard Model runs



- I ran a "Standard Model Mix" (courtesy of Marco Battaglia)
- The processes are mainly Z, WW , ZZ production so the background relevant to the close mass pairs come from semileptonic decay of quarks.
- The leptonic momentum spectrum at the generation level is shown .
- It is important to stress that roughly 15% of the events contain a "semimuonic decay jet".
  - These events have to be tagged: they have by definition missing energy.

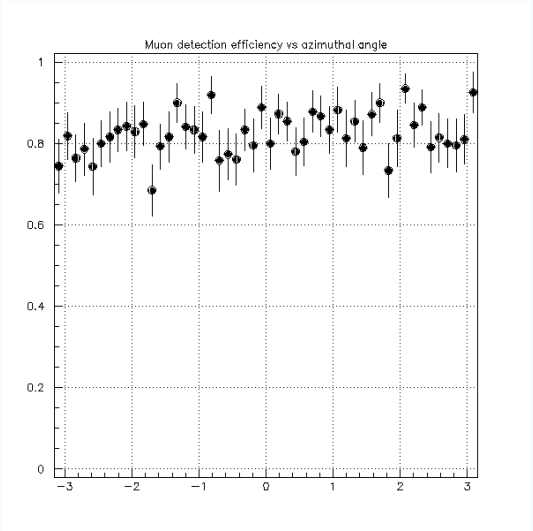
Results from the Standard Model mix

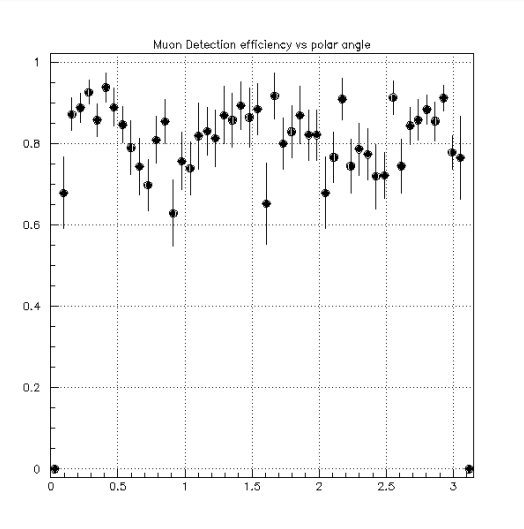


- Here is the muon id performance of the muon system.
- Within the statistics limitations, the muon detector seems to perform reasonably well.
- The sample refers to ~10000 events.

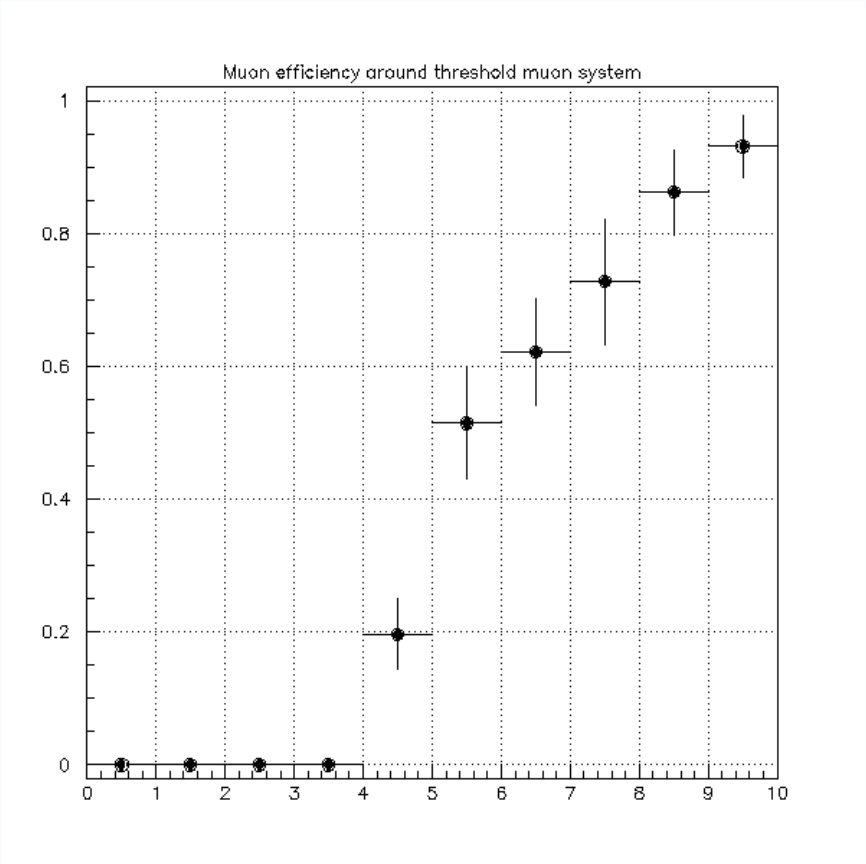
Results from the Standard Model mix

- Here the polar and azimuthal behavior of the efficiency are shown.



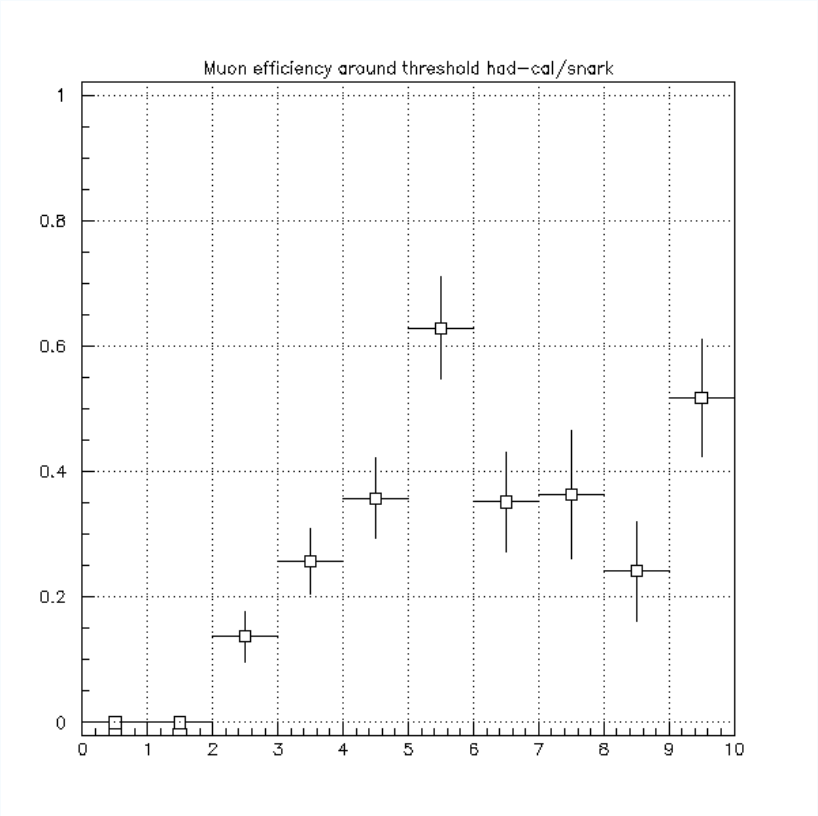


Now the low energy region



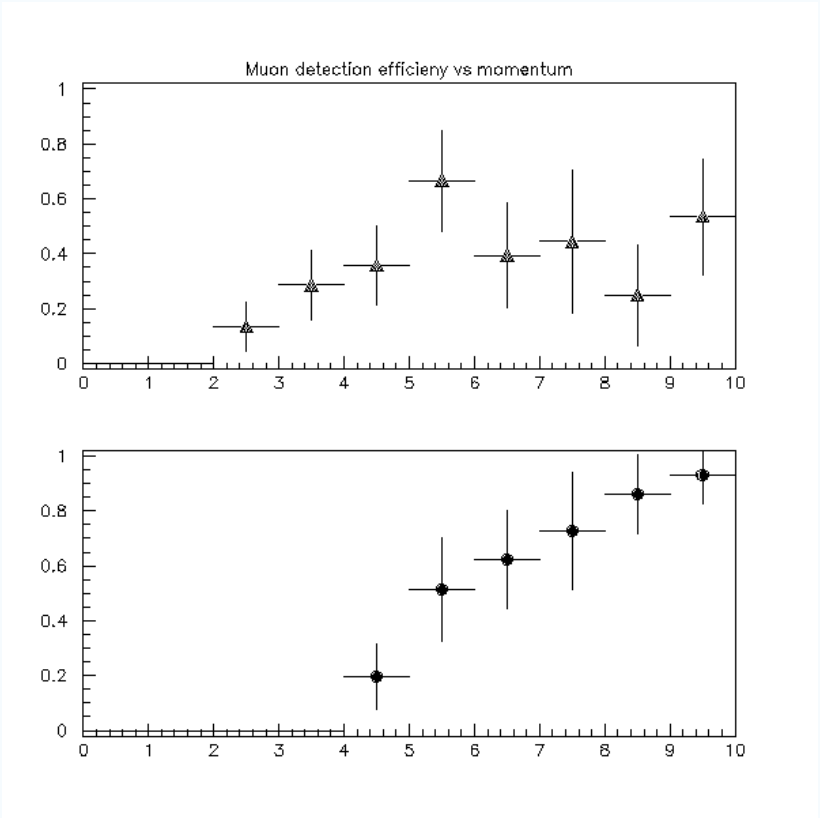
- Here the muon detection efficiency for energy below 10 GeV can be seen.
- Details of the efficiency turn-on show, as expected, that dimensions and B field do not allow a good coverage of the low energy region.

Now the low energy region



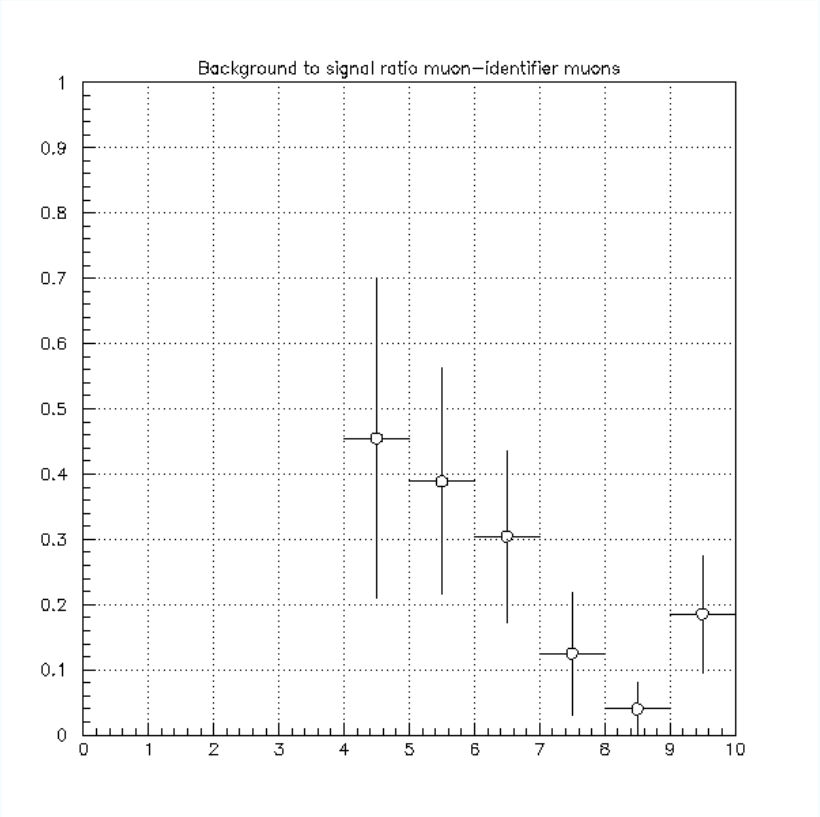
- Here is what the had-cal + snark yield .
- One should stress again that no optimization attempt has been done yet.
- The straight muon tag as given by the software is used..

Threshold comparison



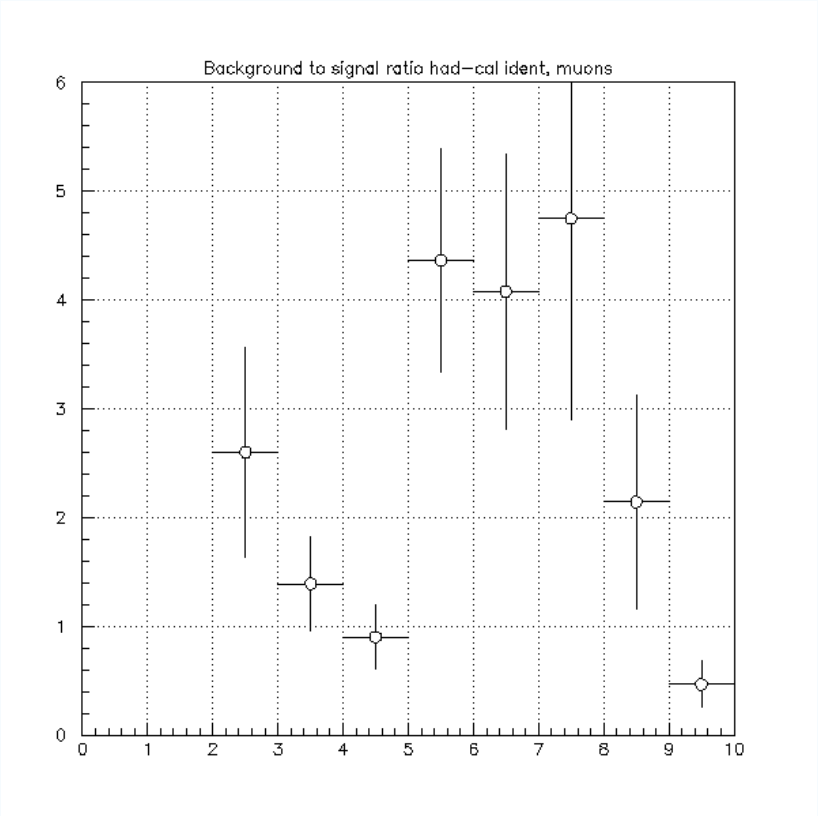
- Using the had-cal clearly improves the low energy acceptance for muons.
- The hard limit the one is confronted with (for what the TESLA design is concerned is around 2 GeV/c.

A more detailed look to the threshold



- Here is the other relevant information concerning performances for muon identification: background to signal ratio.
- The muon system does a reasonable job, even if at the lowest range oh the acceptance, one pion every two and one half muons sneaks in.

A more detailed look to the threshold (cont.)



- Here one can see where the real problem sets in using (only) the had-cal: the background to signal ratio is very poor, so that what is classified as muon from the calorimetric system has a very high probability of being a hadron instead…

Outlook

- The performances of the muon detector are confirmed with the Standard Model mix.
- Low energy muons are hard to identify: the had cal sees them , but the signal to background ratio is very poor.
- The had-cal and muon detector should be used together to improve on signal to background ratio.
- At momenta below 3.5 GeV/c the muon identifier does not come into play at all, so improvements, if any should come from a new analysis technique.
- The most dangerous background for low energy lepton pairs, $\gamma\gamma$ events has yet to be evaluated.

Conclusions

- The simulation results of the TDR are confirmed with the newer version of Brahms and the events generated with the “Standard Model mix”.
- Low energy muons are hard to pick, but there are good physics reasons to hunt for them.
- A joint effort had-cal+muon identifier should be staged to cover the region 3.5-5.0 GeV/c.
- Below that one should look into an optimized muon identification using only the had-cal .