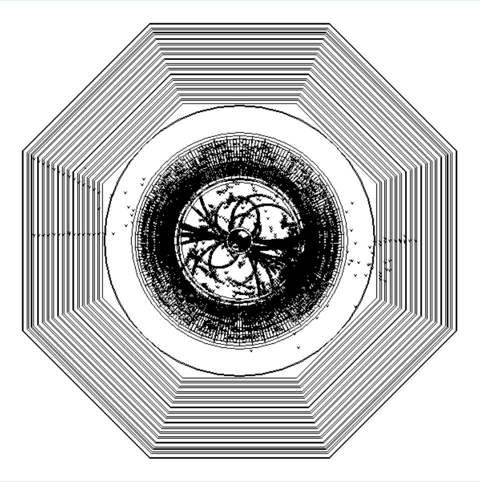
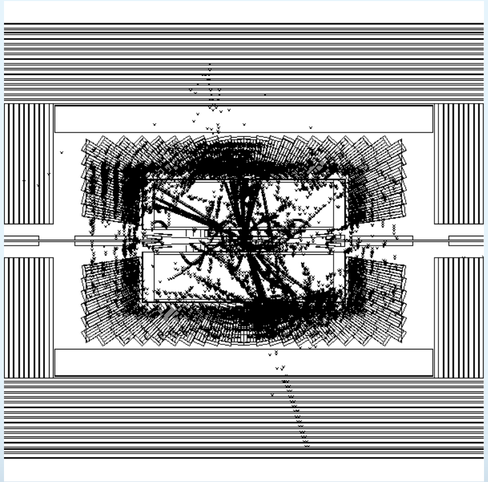
Linear collider muon detector: the LDC design





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SNOWMASS Aug. 2005

Agenda

- Few words on the task of the μ system
  - μ-identification and energy leakage measurements.
- Implementation
- The TESLA-TDR design
- Performances
  - Identification
  - Energy measurement
- Conclusions

What do leptons buy for us

- Identifying leptons has obvious advantages in sorting out events characteristics:
  - e.g. direct identification of the W charge
  - direct fermion/antifermion type identification
  - direct flavor identification
- It can help out on the instrumental side too:
  - Semileptonic decays imply neutrino's presence, hence energy missing.

Electrons vs. muons

Both electrons and muons are identified calorimetrically:

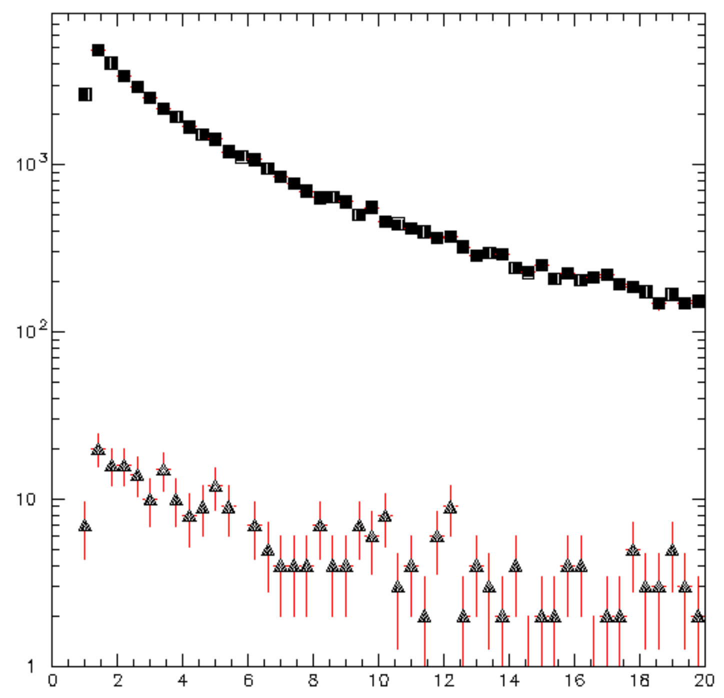
- Electrons on radiation length scale
- Muons on interaction length scale
  - identification based on lack of interaction
  - energy loss just for ionization
  - need to follow the non-interacting candidate after a substantial # of interaction lengths.

No need to measure momentum. Track association is good enough to guarantee matching between TPC and muon detector.

Design feature

- Muon detectors are then bound to be at the biggest radius (need to integrate many λ)
- Big radial distances also mean high momentum threshold $\longrightarrow$ need a backup system for low momentum tracks.
- Low momentum identification difficult:
  - π and μ look alike
  - many more π at low momenta.

Know your friend and foe



- Here is the momentum spectrum for PRIMARY particles coming from the STANDARD MODEL MIX.
- In black the hadrons
- μ have the red error bar
- Overall we have in 4000 evt's 952 μ's and 51,000 hadrons.

Design feature

- The performance tests for any complex system are tied with the way software procedures work.
- In order to have the hardware feature to stand up, one should, at least in the beginning, to use software as naïve as possible.
- Simulated events should be simple and controllable

Single particle studies

- Try to use simple events to design the hardware.
- Check afterward that more complicate events do not cause derated performances.
- Functionalities needed:
  - Muon id .
  - Measure energy leaking out of the coil.
- Simulation used: Brahms with the TDR default options.

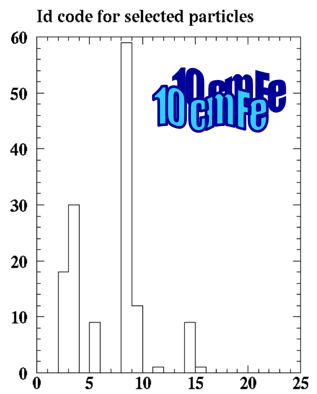
Identification algorithm

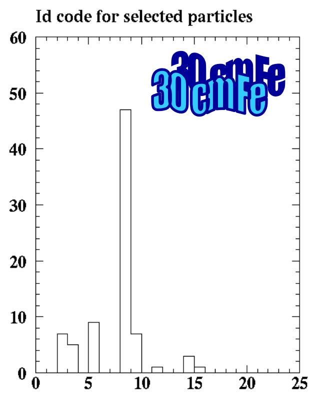
- As mentioned before the method is (on purpose) very naïve.
  - Loop on all the hits in the first plane of the μ-system and try to build a stub of hits that extends in depth, matching the θ and ϕ of the hits in the other active planes of the detector
  - Define as a μ-candidate a stub that is more then xx planes deep.
  - Match the stub with one extrapolated track in the central tracker. (θ and ϕ at the first plane)

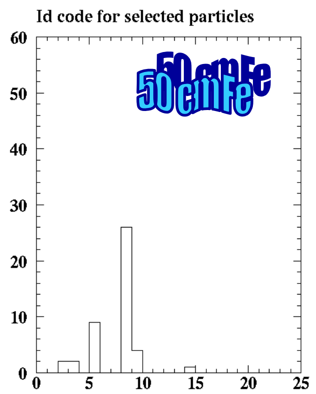
Single particle studies

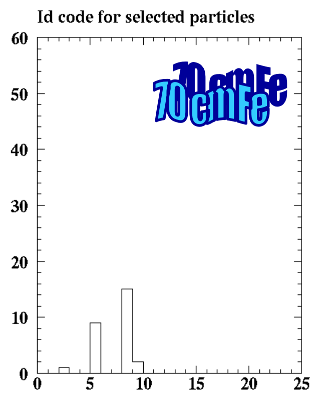
- Generated 10,000 single π with flat momentum and angle distributions.
- Looked at misid. probabilities and energy leakage.
- Used as a baseline detector the TESLA-TDR muon system.
- The system consists of 12 active detector planes in the barrel, 11 in the end caps. Longitudinal segmentation 10 cm Fe 11/10 (barr/e.c). times +1 plane after 50 cm. (total thickness 1.5 m Fe fixed by flux return considerations.
- Realistic efficiencies put in *by hand*.

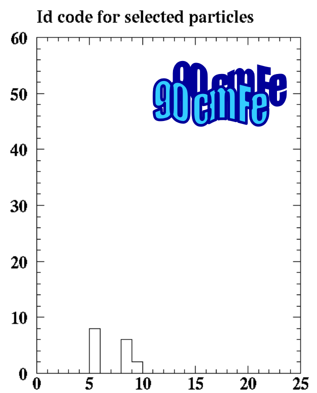
π Misidentification vs. thickness



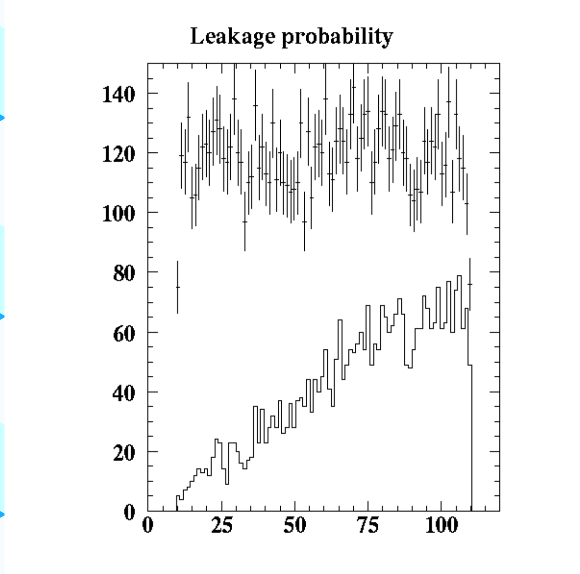


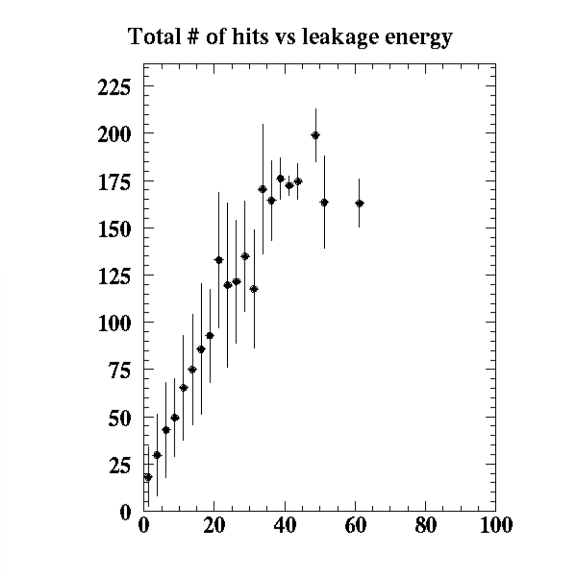


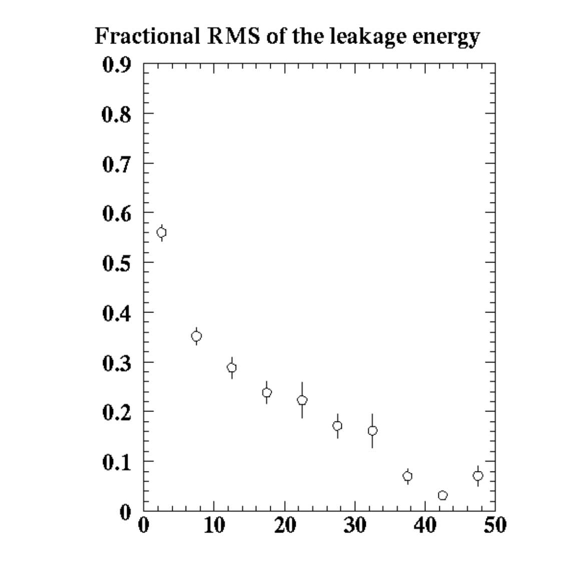




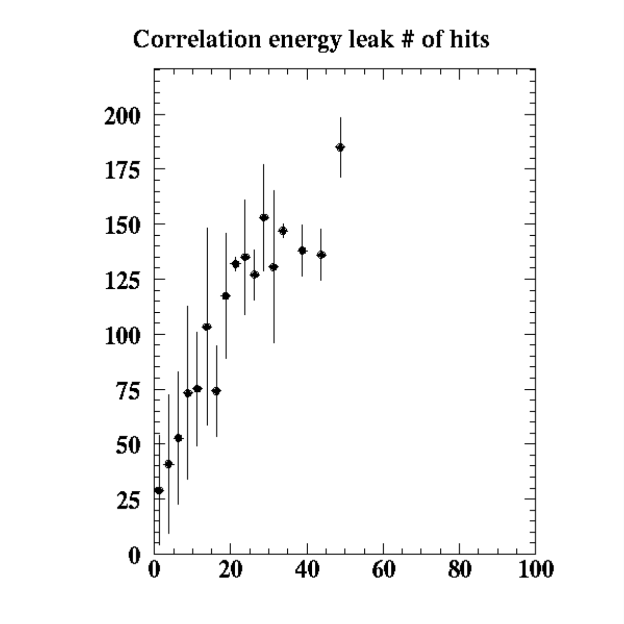
Energy leakage single π

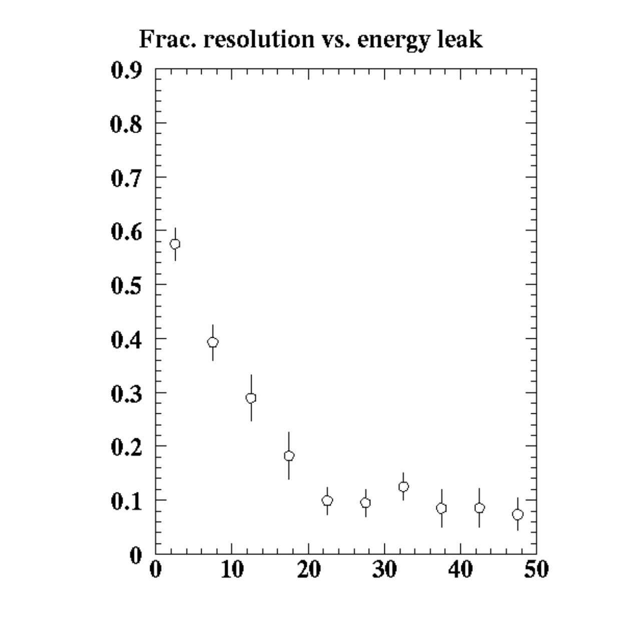






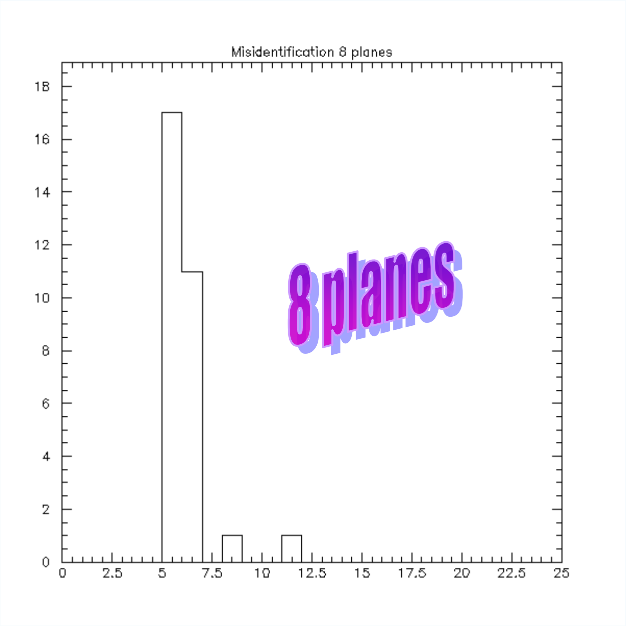
Energy leakage
Standard Model Mix

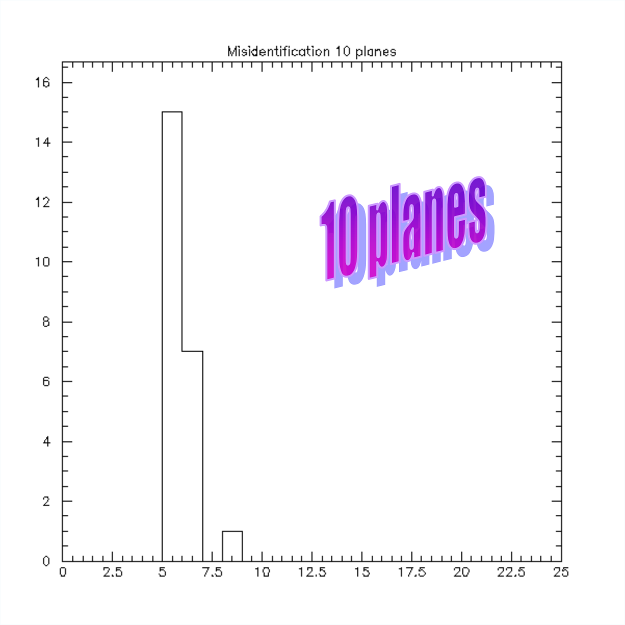




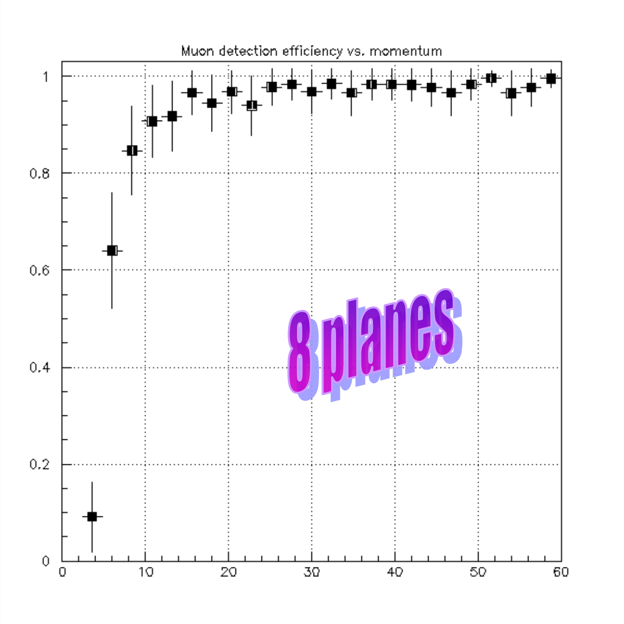
- 81% of the events cause (non-μ) hits in the muon system.
- 9.5% of the events drop more than 1 GeV in the muon system

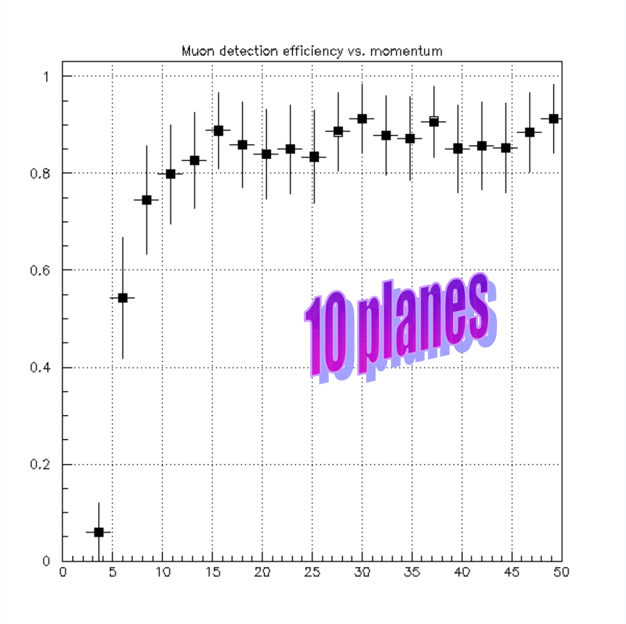
Misidentification Standard Model Mix





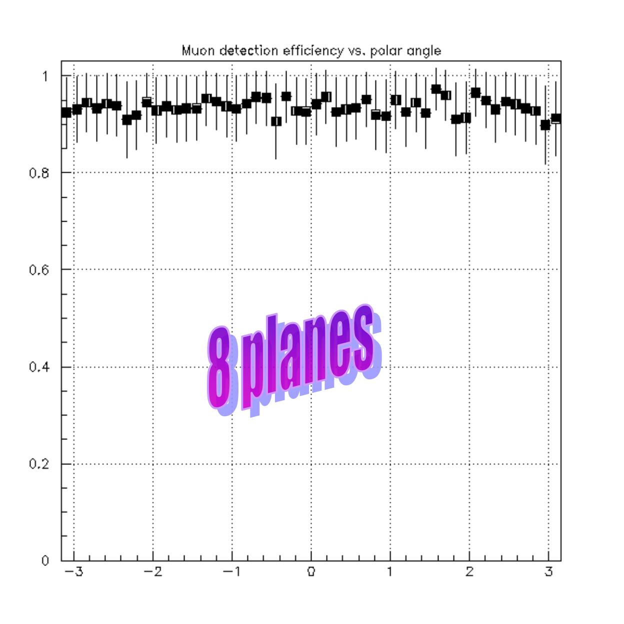
What about efficiency ?

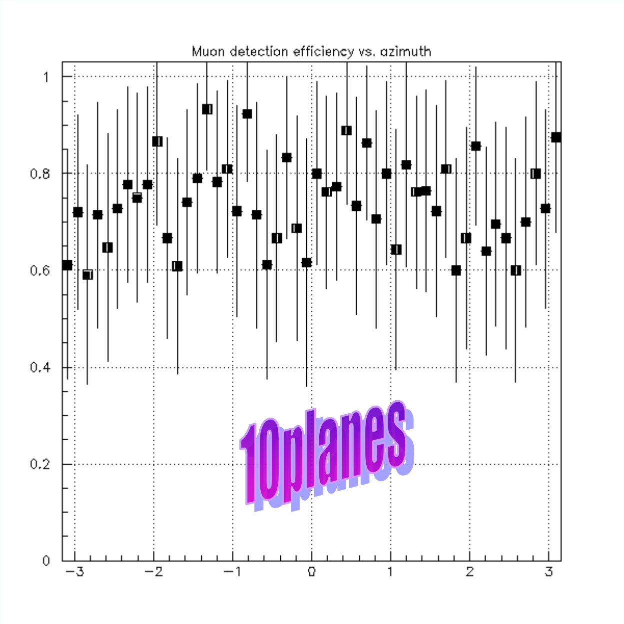




- Single μ detection efficiency vs. momentum
- Requiring xx planes for the stub

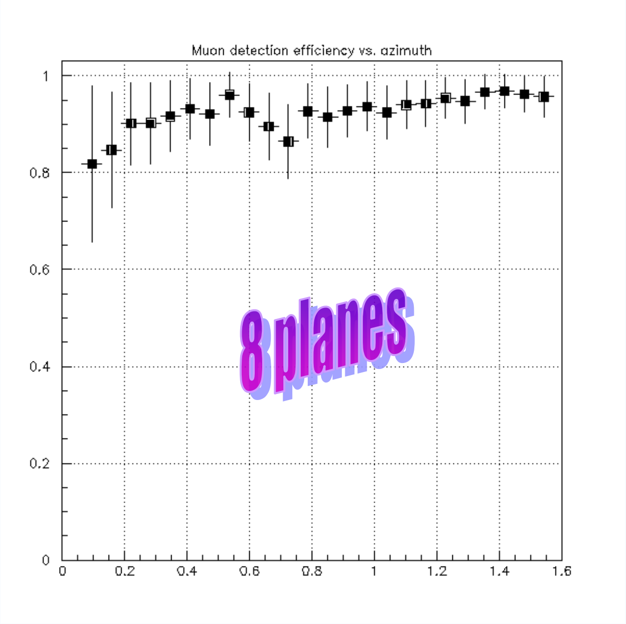
What about efficiency ?

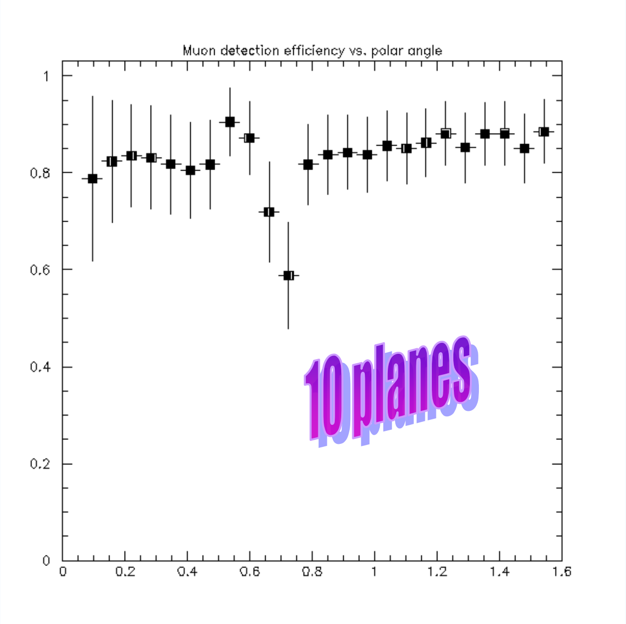




- Single μ detection efficiency vs. azimuth
- Requiring xx planes for the stub

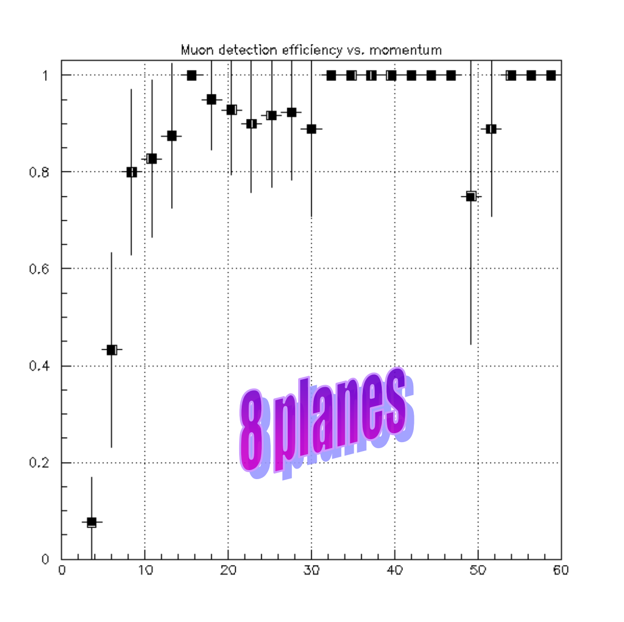
What about efficiency ?

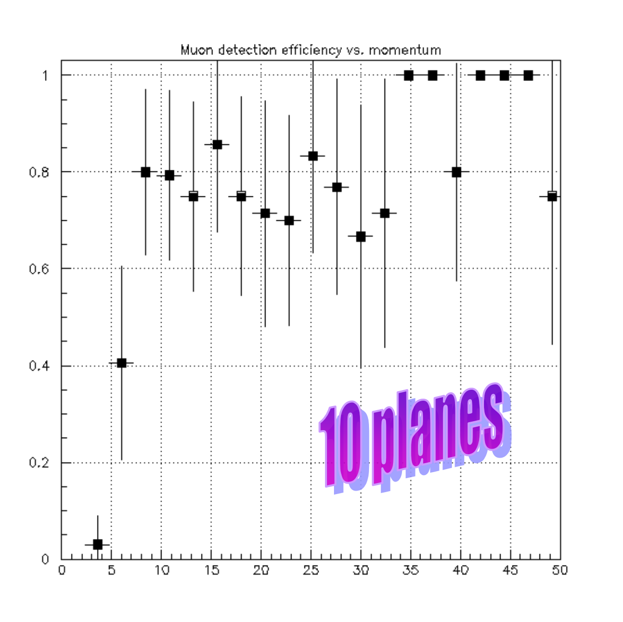




- **Single μ detection efficiency vs. polar angle**
- **Requiring xx planes for the stub**

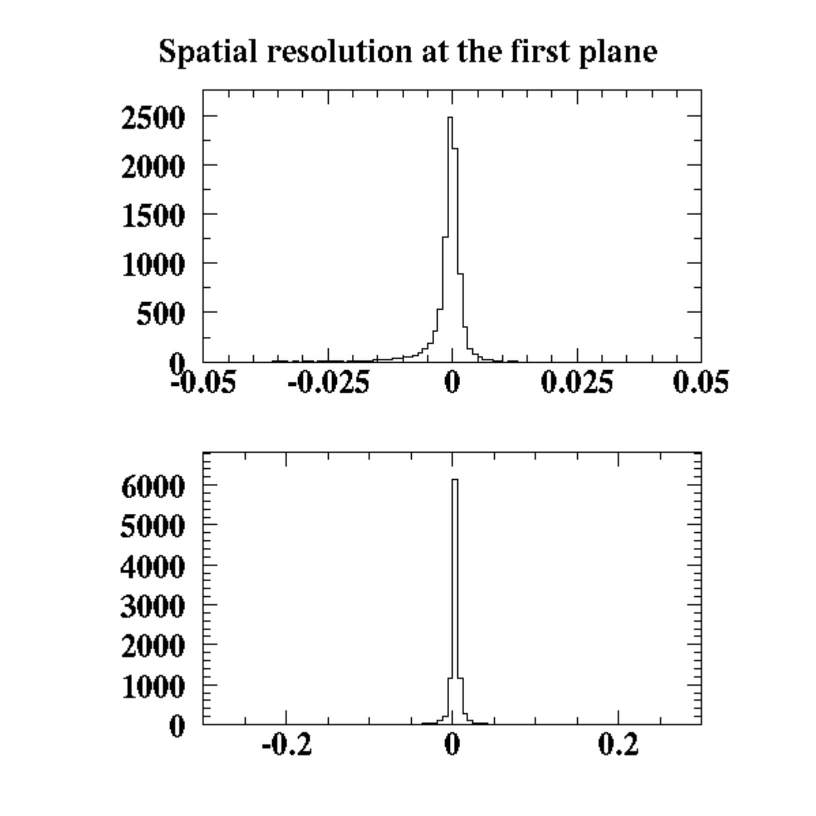
What about efficiency ?





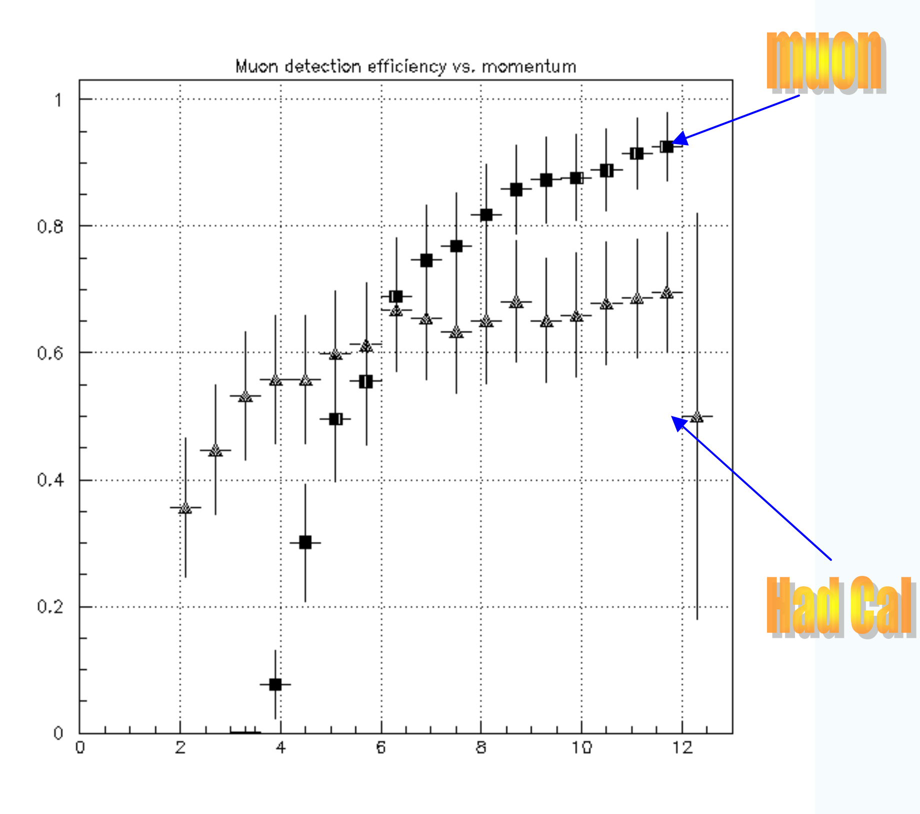
- Standard Model μ detection efficiency vs. momentum

Requirements on spatial resolution



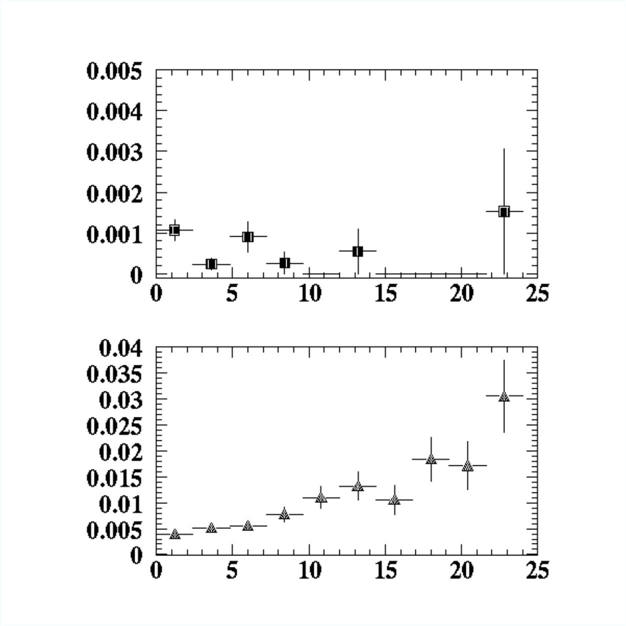
- θ and ϕ r.m.s. at the first detector plane.
- The distribution width sets the spatial resolution scale for the detectors: working out the figures one gets 1.5-2.0 cm.

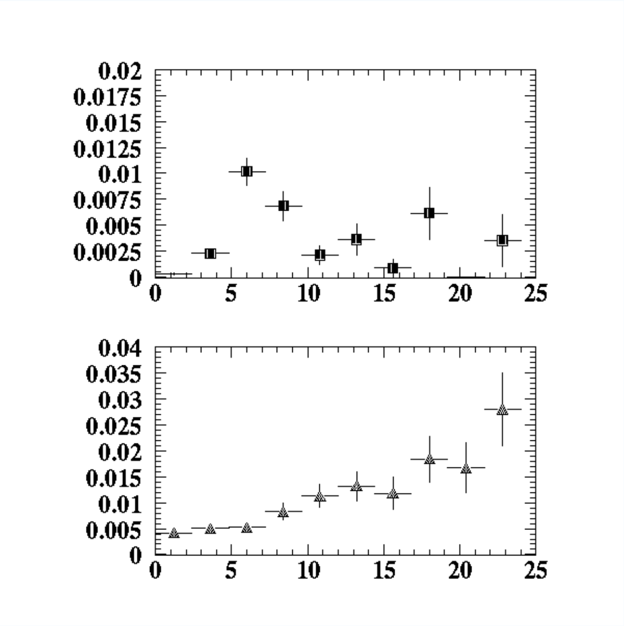
Few words about low momenta



- Given the B-field and the radius of the system it is impossible to detect μ below 5 GeV/c.
- Using the Had cal one might be able to alieviate the problem.
- However in ZZ/Zγ/WW events the background is prohibitive.

Few words about low momenta (cont.)





Fake and true ratios for muons

μ–system

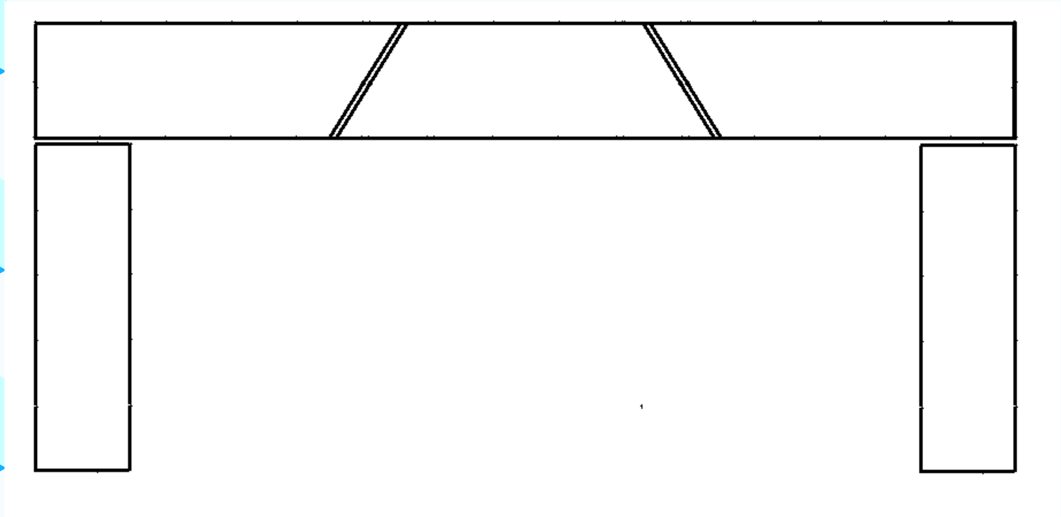
μ-analysis

Fake and true ratios for muon

Had. Cal

SNARK

How do we break it down



- Barrel: way to big to make it on piece.
- Break it in three pieces so minimizing transition region by slanting.
- If the barrel has to be long, then insert the end-caps in.
  - The aspect ratio for the end-caps less favorable
  - Detectors shape more complicated, so better if smaller…..

Conclusions

- The μ-system design from the TESLA-TDR seems to cope with the anticipated Physics program for the ILC.
- Muon detection efficiency and background contamination seem to be under control.
- Low energy μ's could be detected: what needs to be looked at, is the Physics background from $\gamma\gamma$ events: we need a complete simulation for these events ($\gamma\gamma \longrightarrow \mu\mu$)
- Energy leakage behind the coil, seems to be not very important; it can, however, be measured to a meaningful level.