BaBar Muon ID

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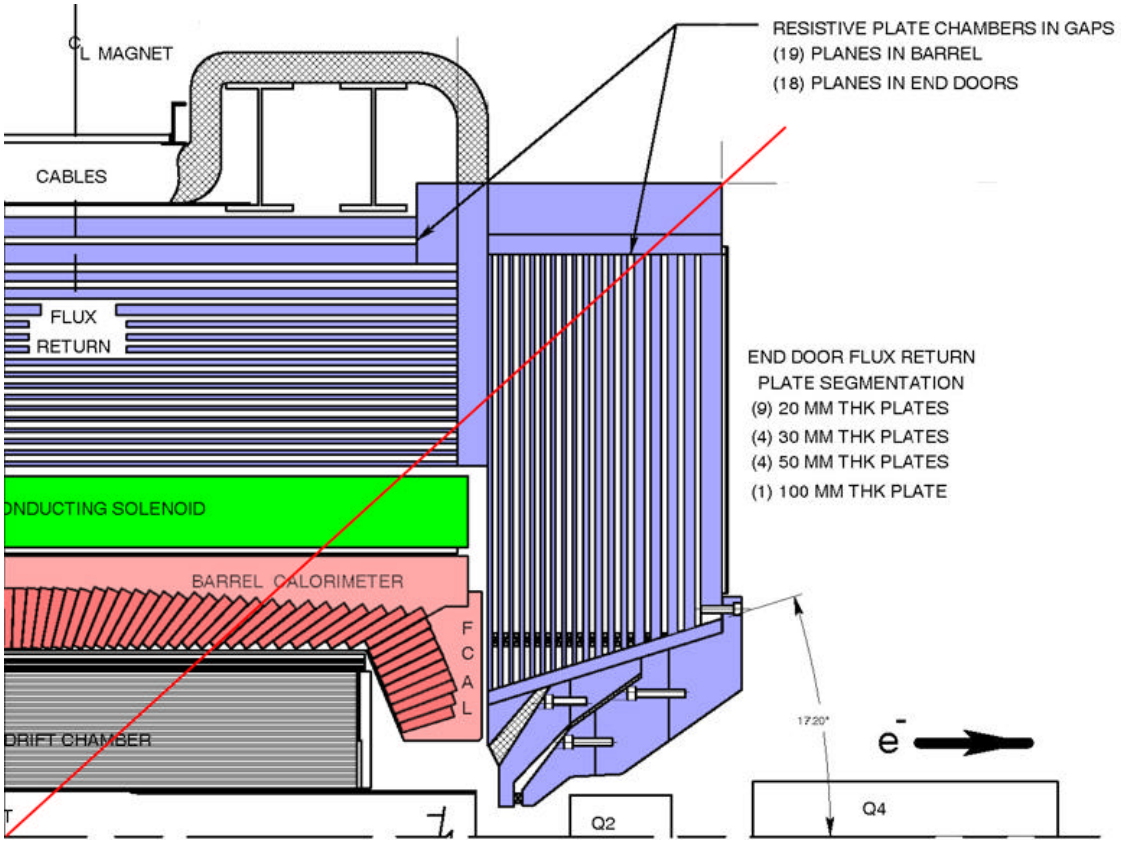
Outline

- IFR detector
  - Single layer RPCs
  - Graded steel thickness
  - Barrel-65 cm, Endcaps - 60 cm
- Clustering
  - Charged track clusters
  - Neutral clusters
- Muon selectors
  - 5 selectors with differing efficiency and pion rejection
  - Variables
  - Efficiency vs time
  - Selector development
- KL selectors
  - Variables
- IFR Upgrade plans

Instrumented Flux Return -IFR



- Instrumented Flux Return
  - 342 barrel RPCs
  - 432 endcap RPCs
  - 32 cylindrical RPCs
- Electronics
  - ~3300 Front end cards
    - 16 strips/FEC digital info.
- Gas
  - 35% Freon 134A. 4.5% isobutane, 60.5% argon
  - 2-3 volume changes/day

Clustering

- 1D clusters
  - Strip hits in each view of a layer are combined in 1D clusters
- Charged clusters
  - Drift chamber tracks extrapolated to IFR layers
  - 1D clusters within 17 σ_{ms} are associated with the track.
- Neutral clusters
  - Hits associated with charged tracks are removed from the list
  - 2D clusters made
    - 2 or more layers
    - Include all 1D clusters within a specified cone
  - 2D clusters combined into 3D neutral clusters

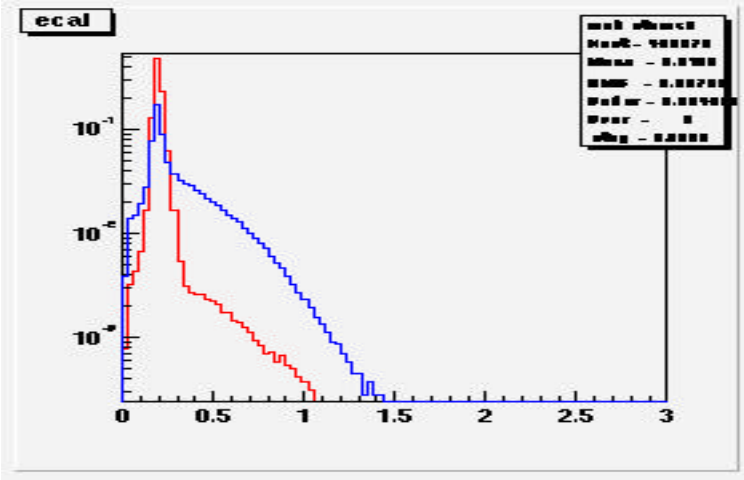
Muon ID variables

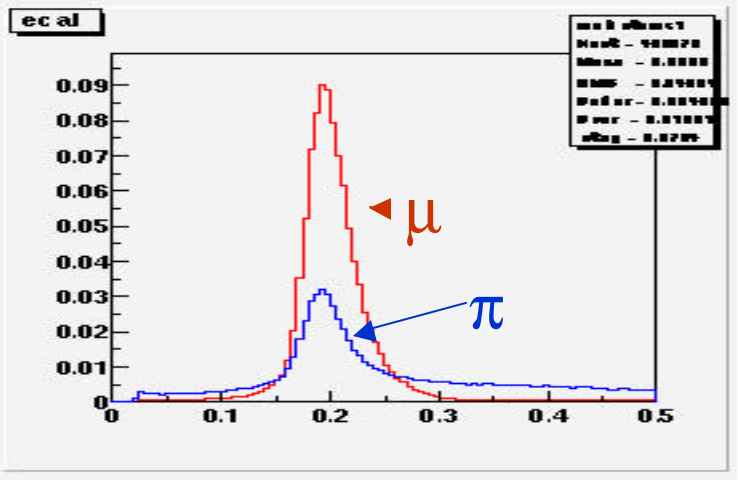
- The energy released in the ECAL (E_{cal}).
- The number of IFR hit layers in a cluster (N_L).
- The first IFR hit layer in the cluster.
- The last IFR hit layer in the cluster.
- The measured number of interaction lengths traversed by the track (λ).
- The number of interaction lengths expected to be traversed by the track in the muon hypothesis (λ_{exp}).
- The χ^2/d.o.f of the IFR hit strips in the cluster w.r.t the track extrapolation (χ^2_{trk}).
- The χ^2/d.o.f of the IFR hit strips w.r.t a 3rd order polynomial fit of the cluster (χ^2_{fit}).
- The total number of IFR hit strips in the cluster.

EMC energy

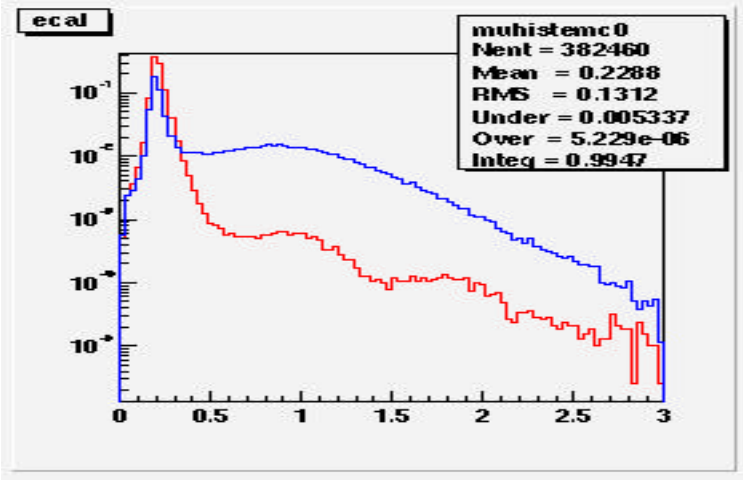
All candidates
no cuts

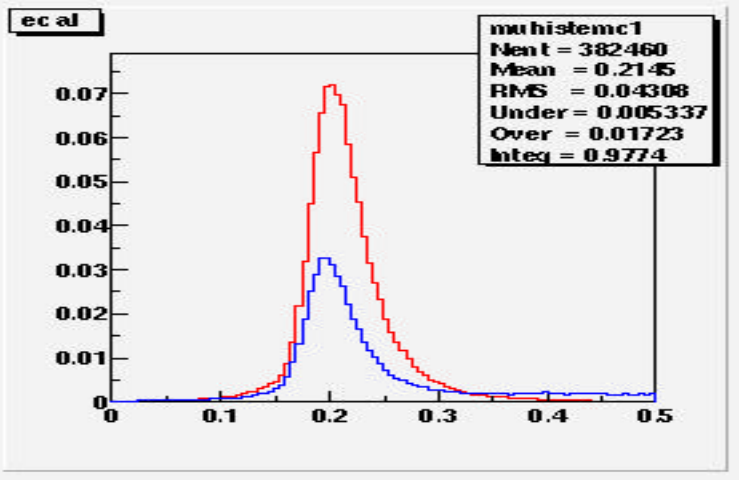
p< 1.5 GeV/c





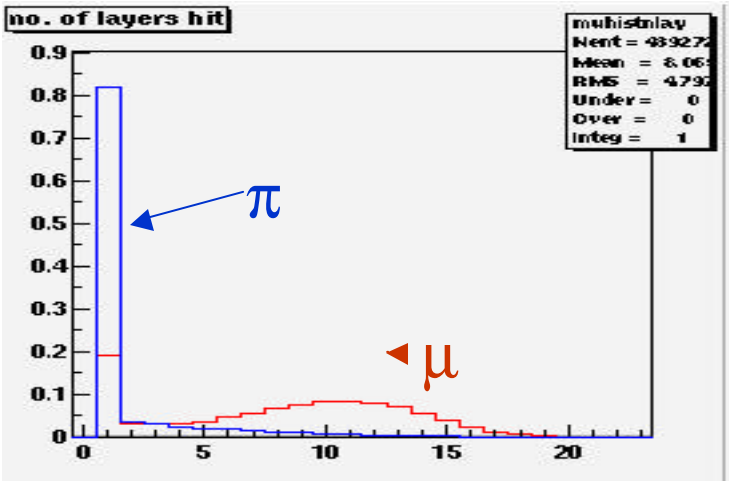
p> 1.5 GeV/c

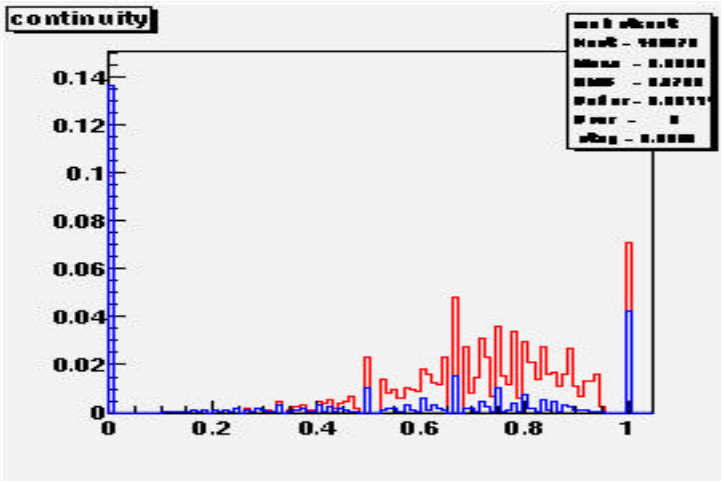




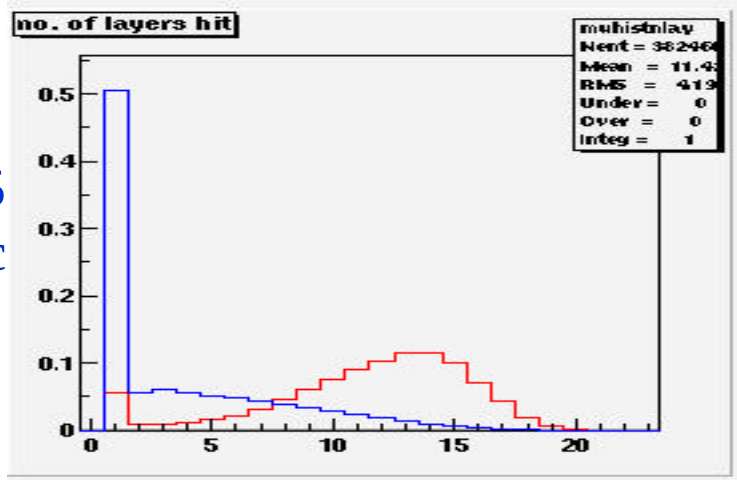
of layers, hit continuity

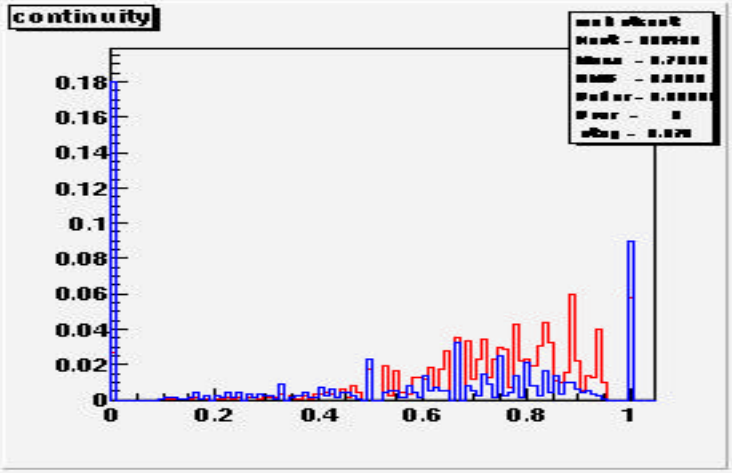
p< 1.5 GeV/c





p> 1.5 GeV/c

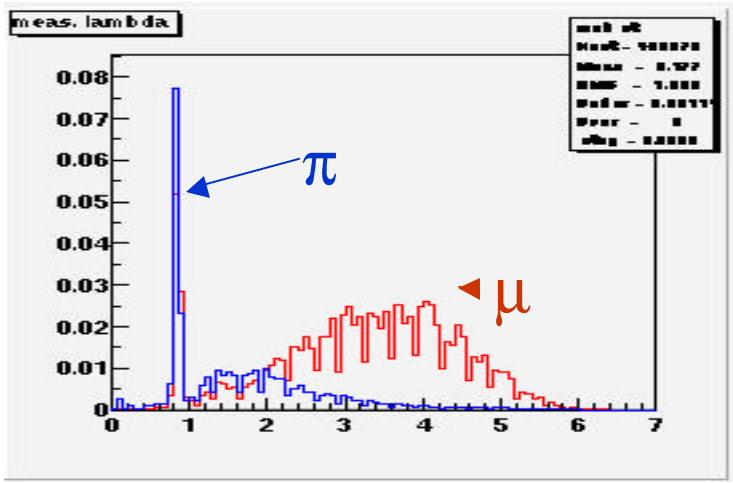


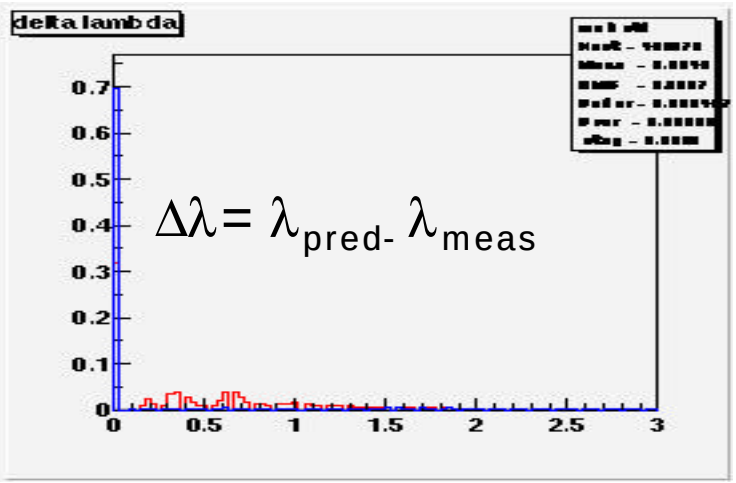


λ_{meas}, $\Delta\lambda$

All candidates
no cuts

p< 1.5 GeV/c





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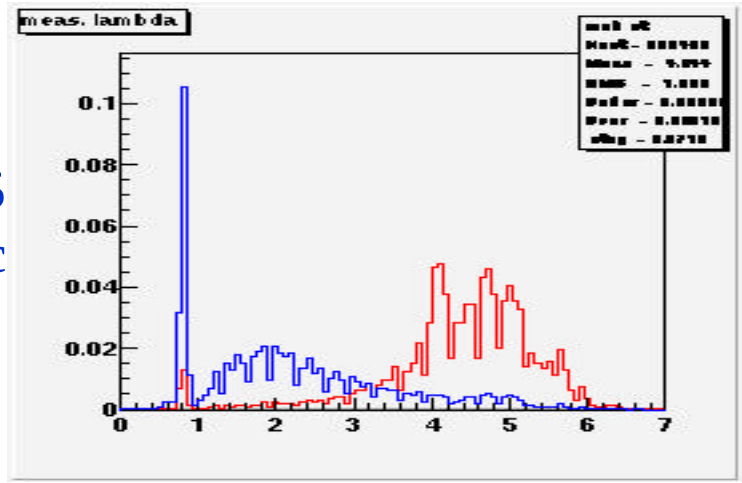
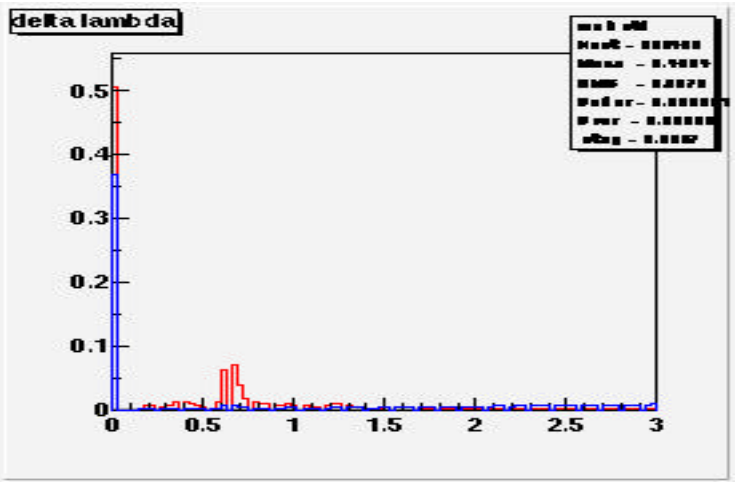
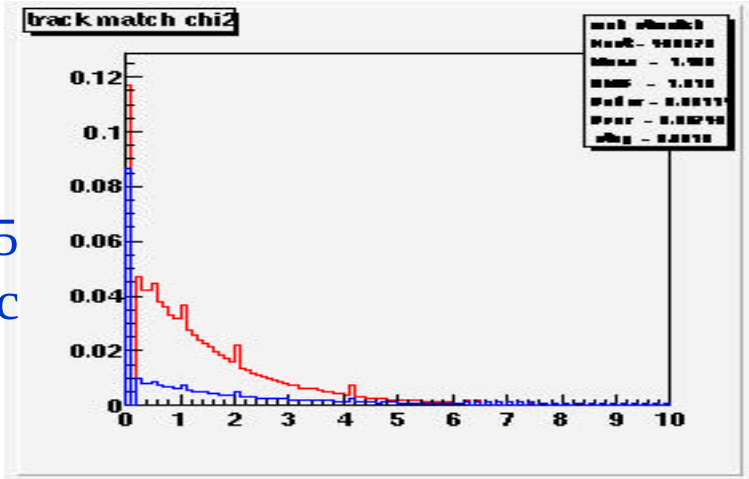


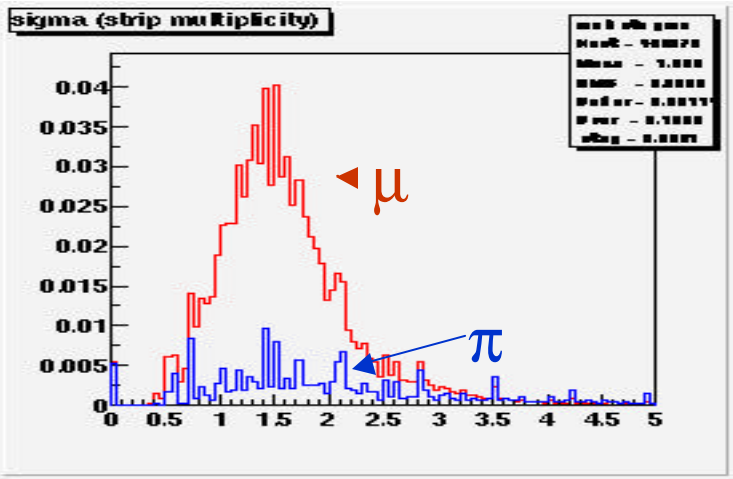


Track match χ^2, $\sigma_{multiplicity}$

All candidates
no cuts

p< 1.5 GeV/c





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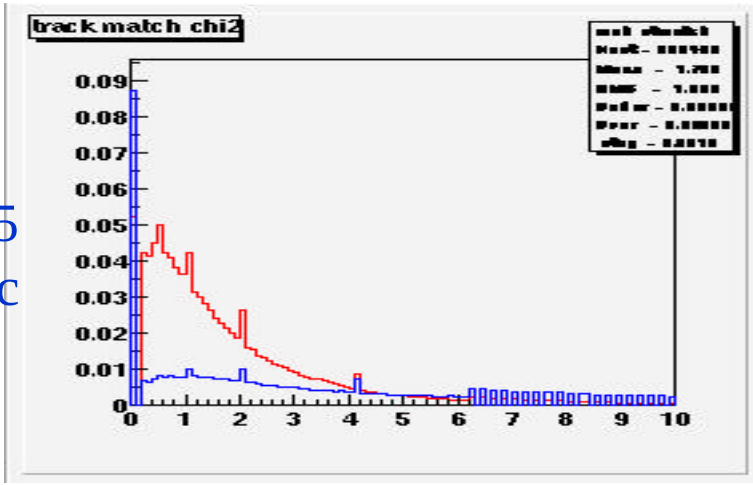
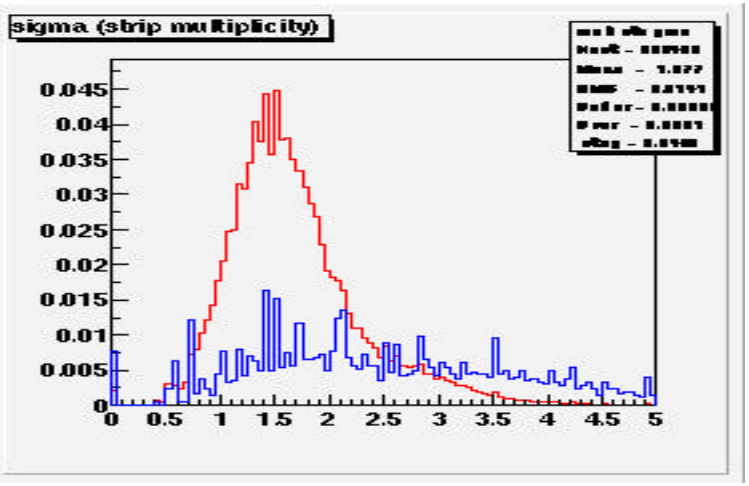


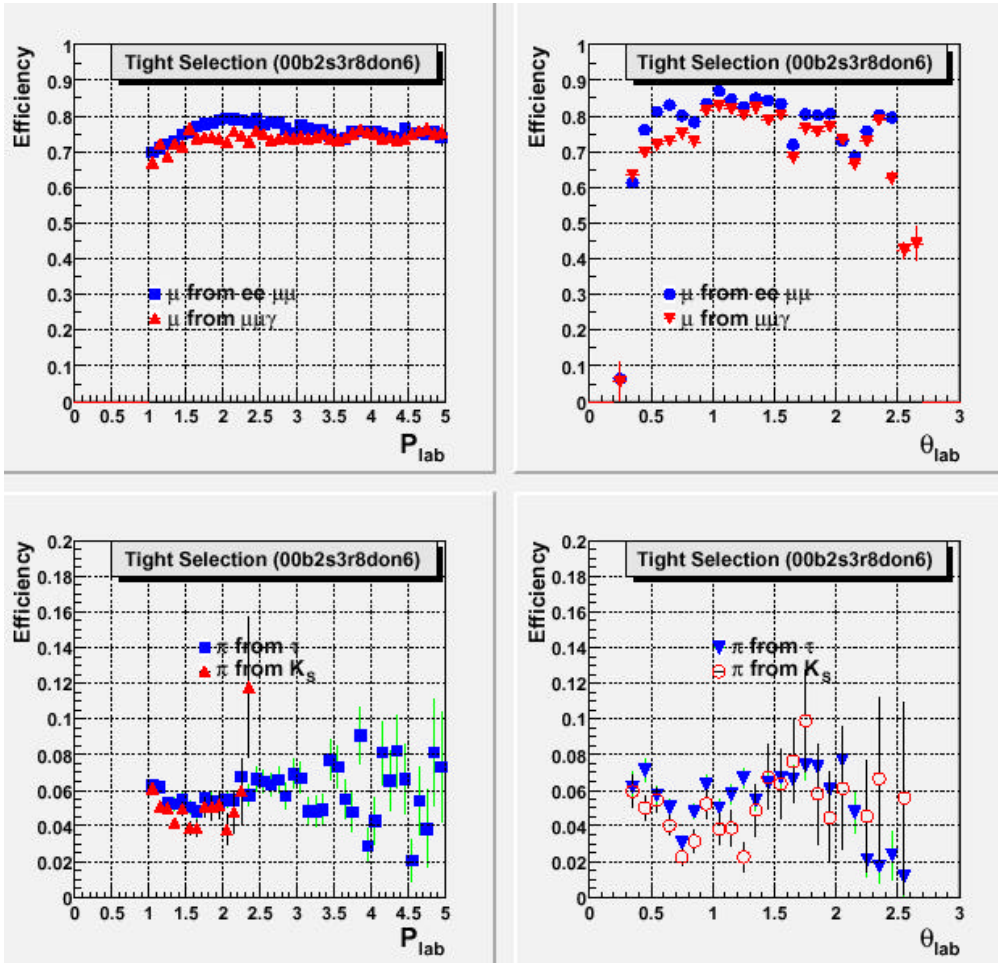


Muon selectors

- 5 muon selectors
- MinI - based on EMC energy only
- Very loose, loose, tight, & very tight selectors add cuts based on IFR reconstructed charge track variables

Selection Variables	Tight	Loose
E_{cal}	$[0.05, 0.4]$	< 0.5
No. of Layers (N_L)	> 2	> 2
Meas. Lambda (λ_{meas})	> 2.2	> 2
Delta Lambda ($\Delta\lambda$)	< 1	< 2
Track Fit Chisq. (χ^2_{fit})	< 3	< 4
Track Match Chisq. (χ^2_{mat})	< 5	< 7
Track Continuity (T_C)	$> .3$	$> .2$
Average Strip Mult. ($\bar{m}$)	< 8	< 10
Sigma Strip Mult. (σ_m)	< 4	< 6

Selector performance

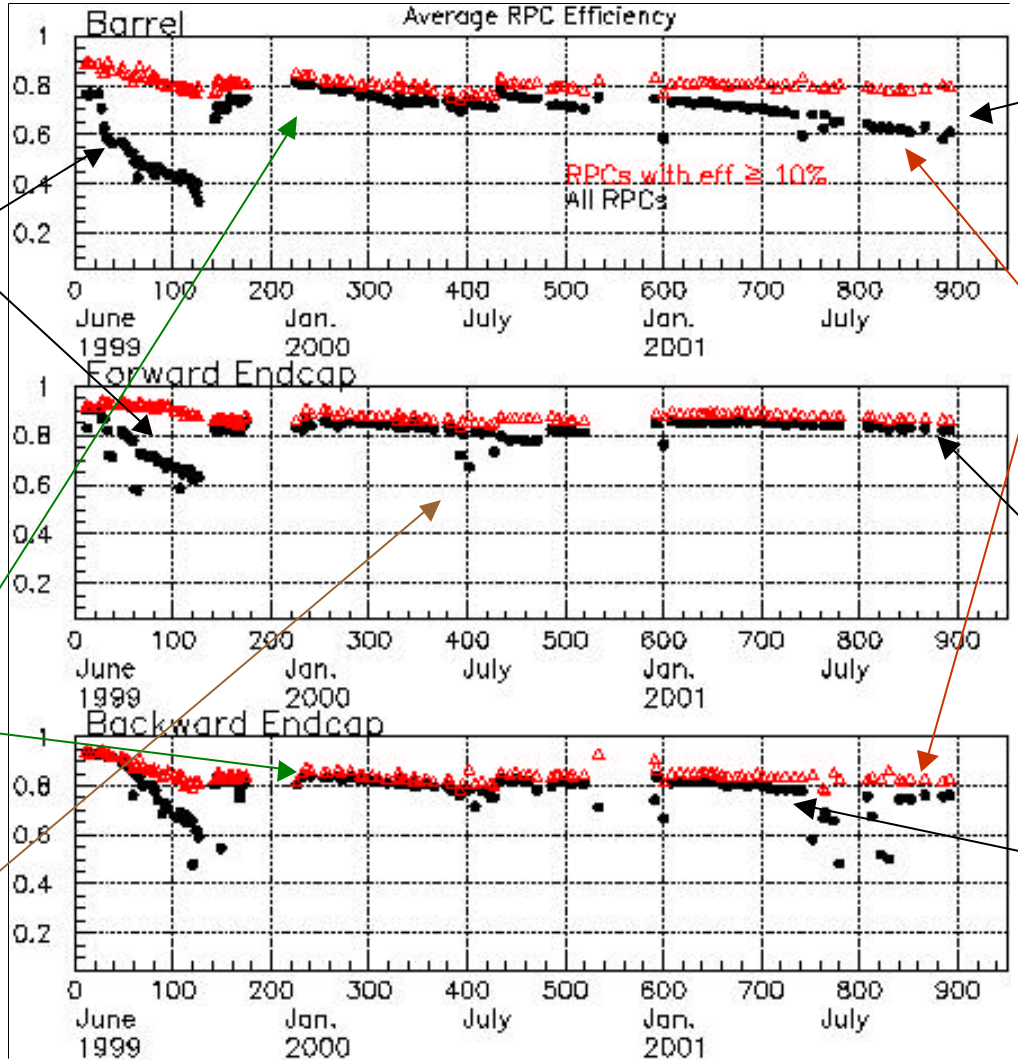


RPC Efficiency 1999-2001

Summer 1999 29-33° C temperatures inside BABAR steel cause high currents and force many RPCs to be disconnected

RPC efficiencies did not recover fully after cooling added

Electronics problems



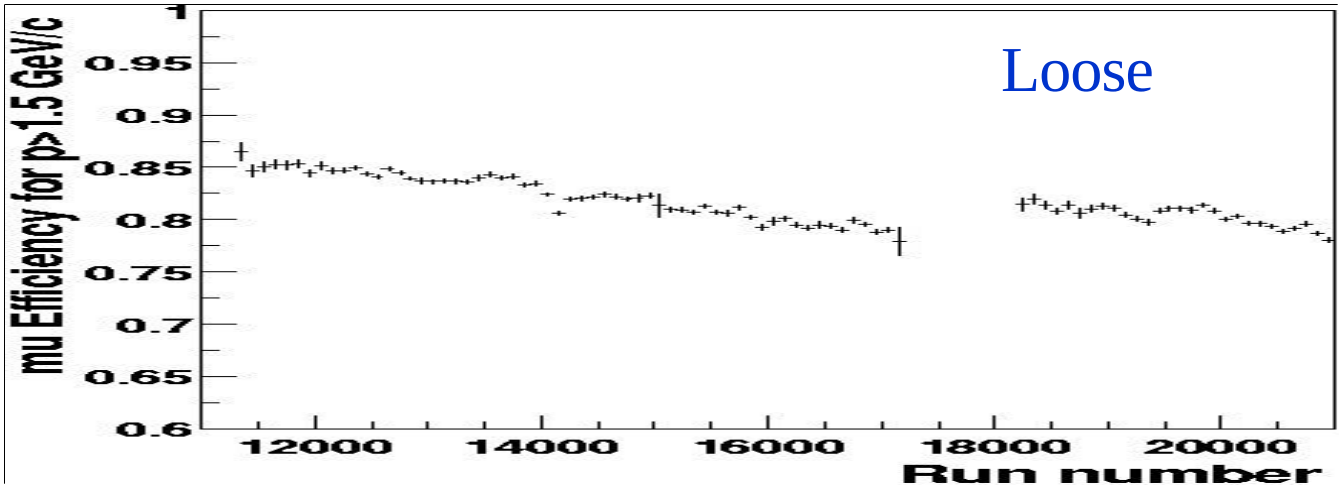
-1.2 %/month

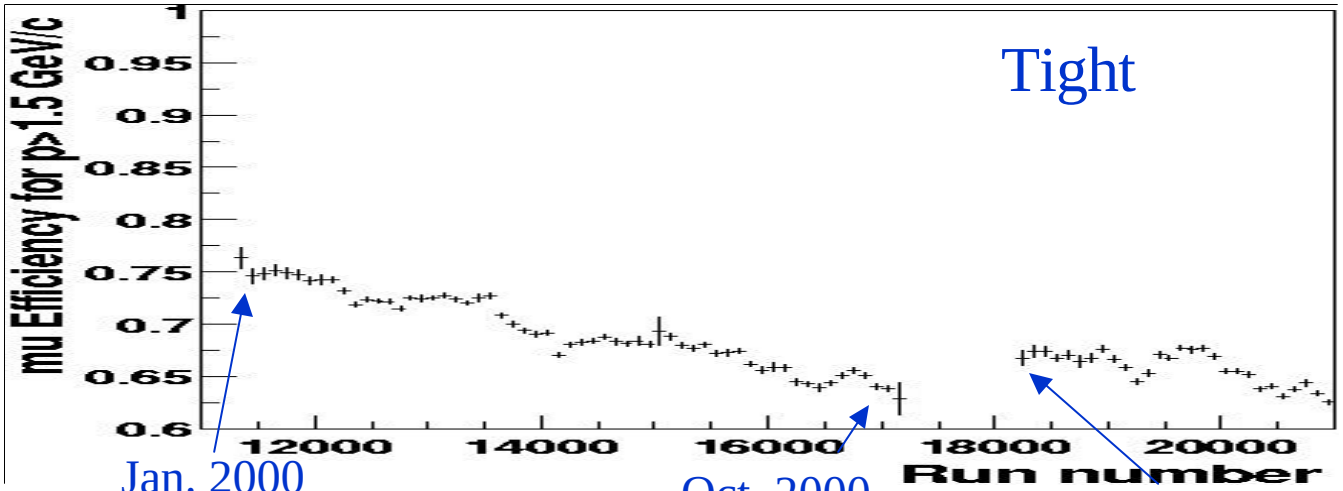
RPC efficiencies continue to decline in 2000 - 2001

-0.36 %/month

-0.93 %/month

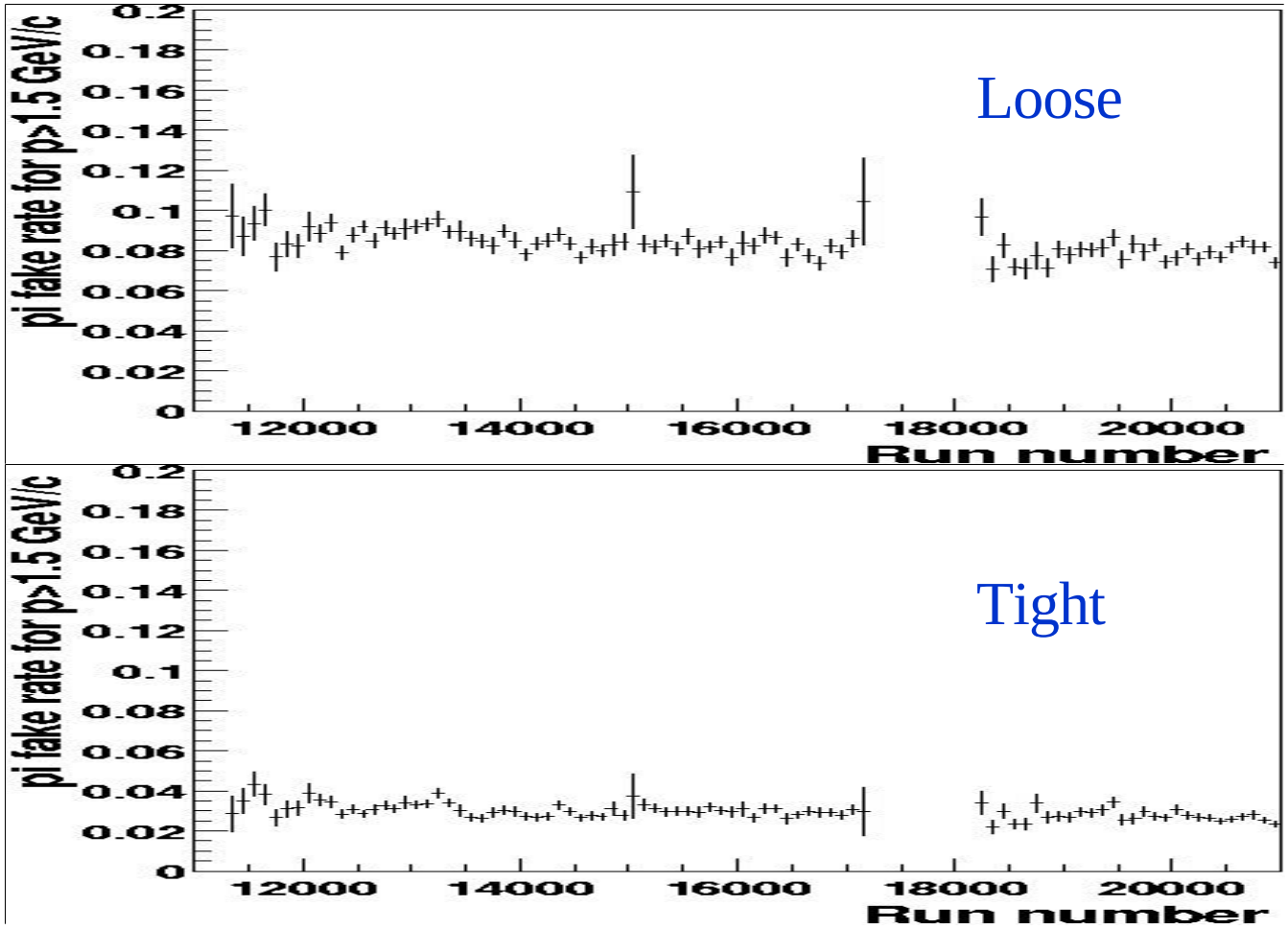
Selector efficiency vs. time





$\mu\mu\gamma$ sample

Pion misid. vs. time



τ1-3 prong sample

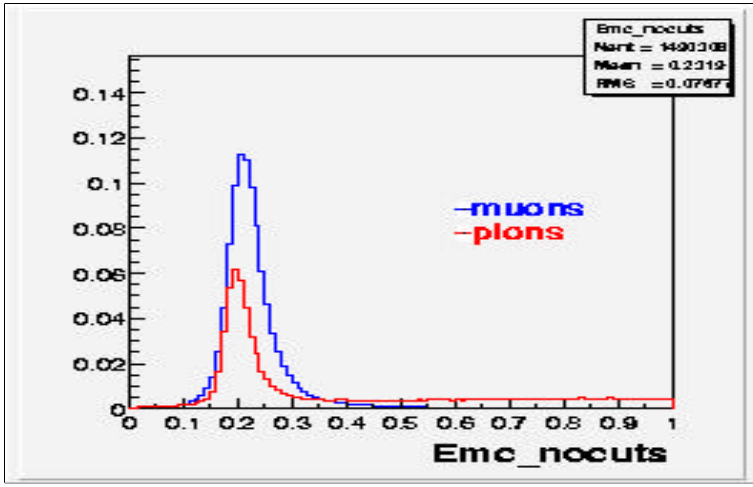
Future plans

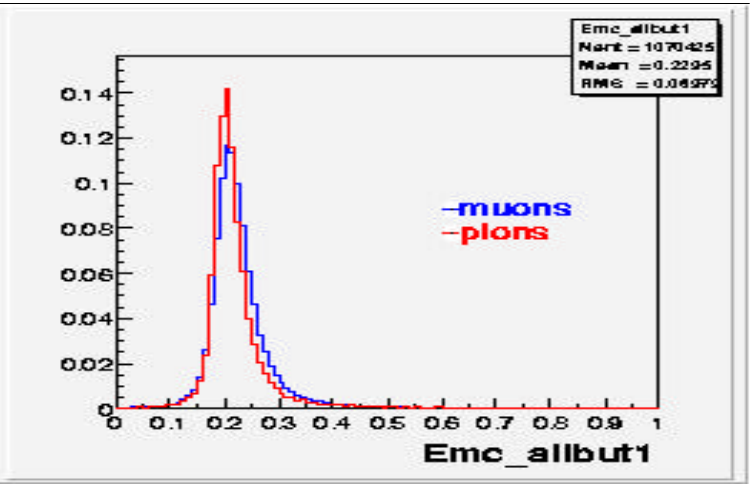
- Pursuing several paths to improving/maintaining muon ID efficiency
  - Hardware changes
    - RPC efficiency
      - Restore RPCs
      - Replace RPCs
    - Add absorber

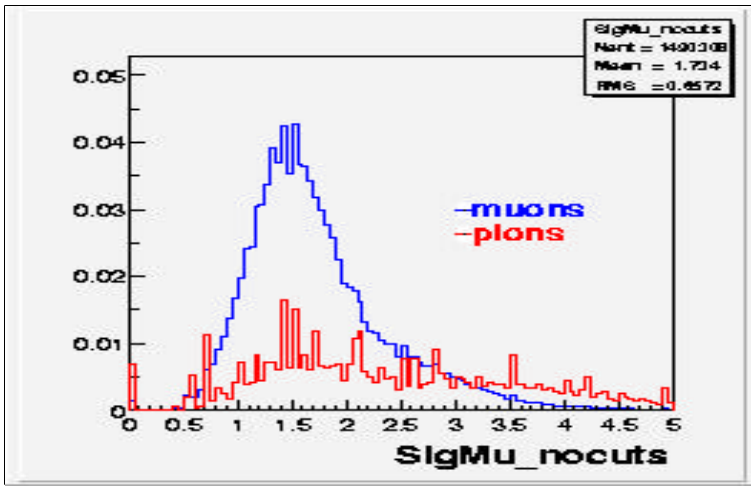
    } Forward Endcap upgrade
  - Improve selector performance with standard variables
    - Likelihood selector ←
  - Develop new variables
    - Efficiency weighted λ

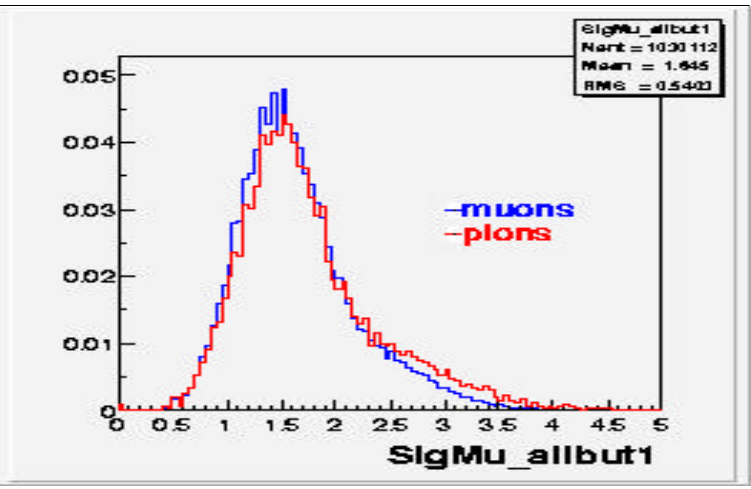
Discriminating power

Apply all tight cuts except for cut under study









Discriminating power

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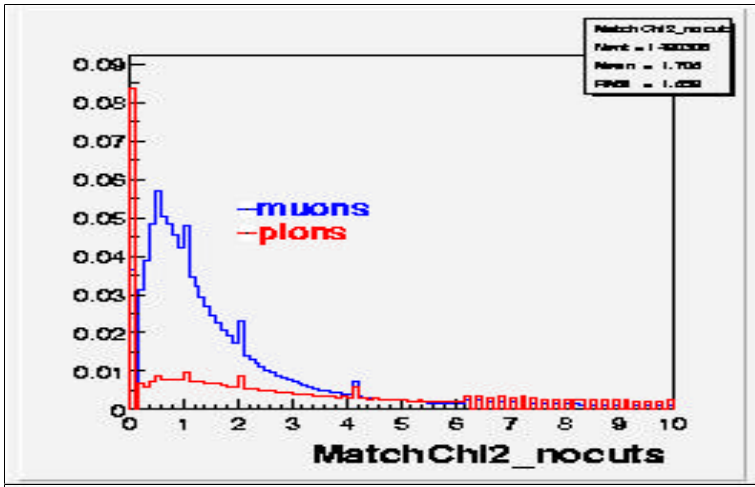
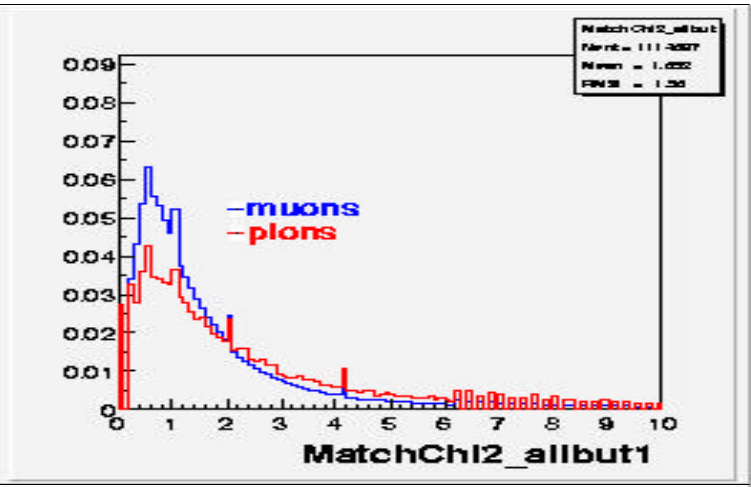
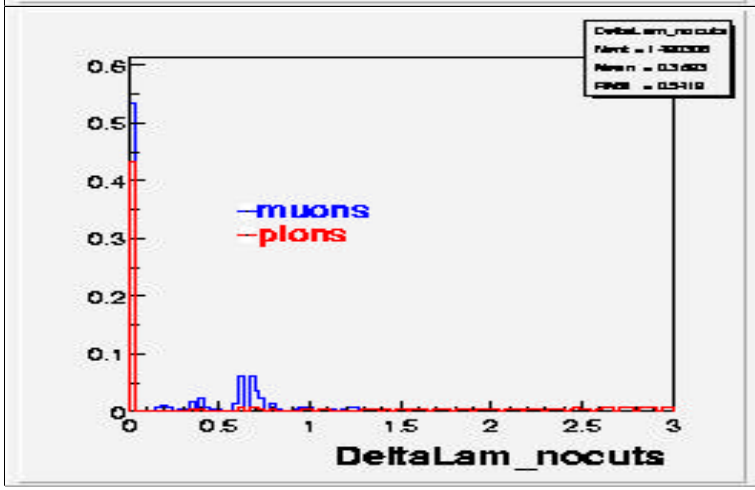
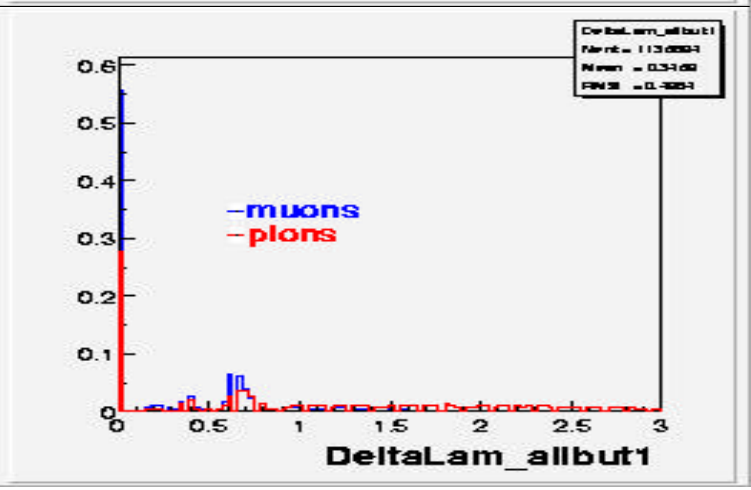




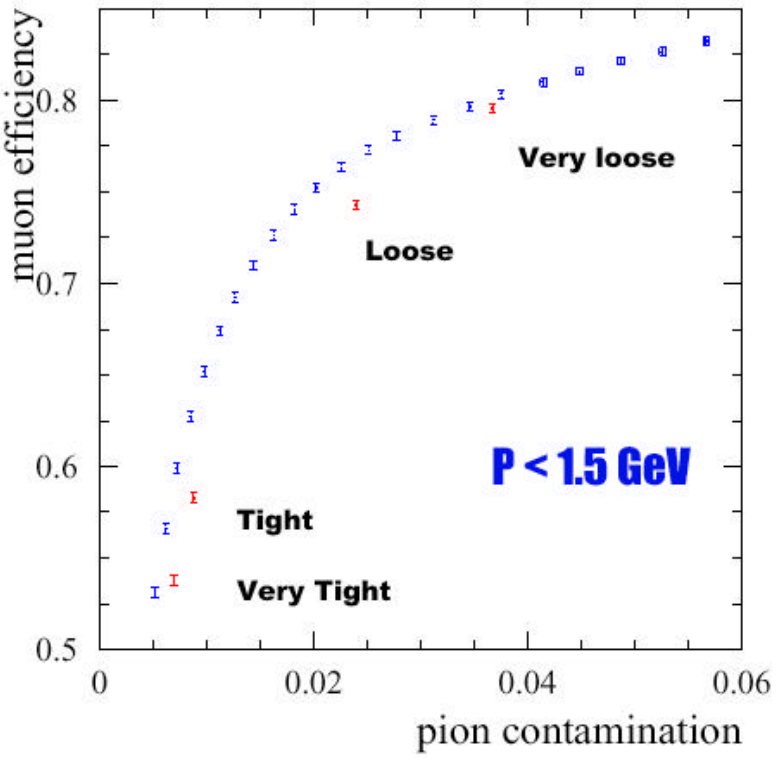


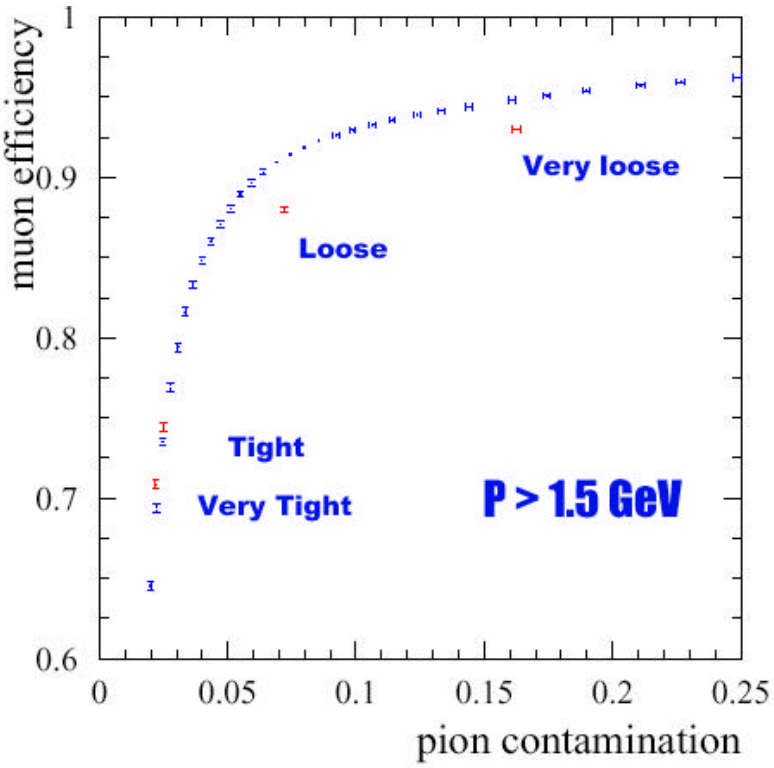


μ -ID Likelihood selector - efficiency vs π contamination

Blue points for different choices of likelihood ratio

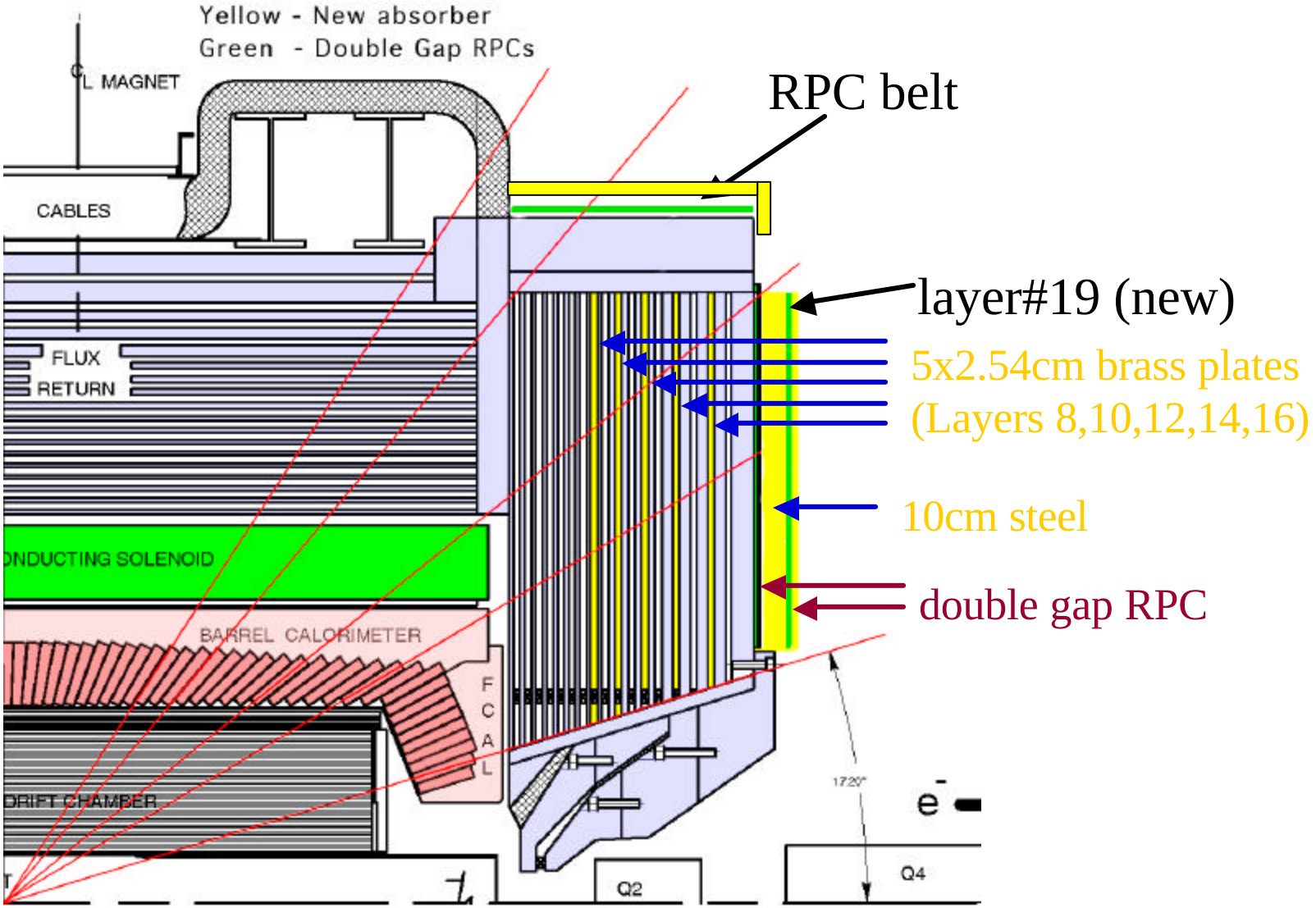
Red points for cut based selection





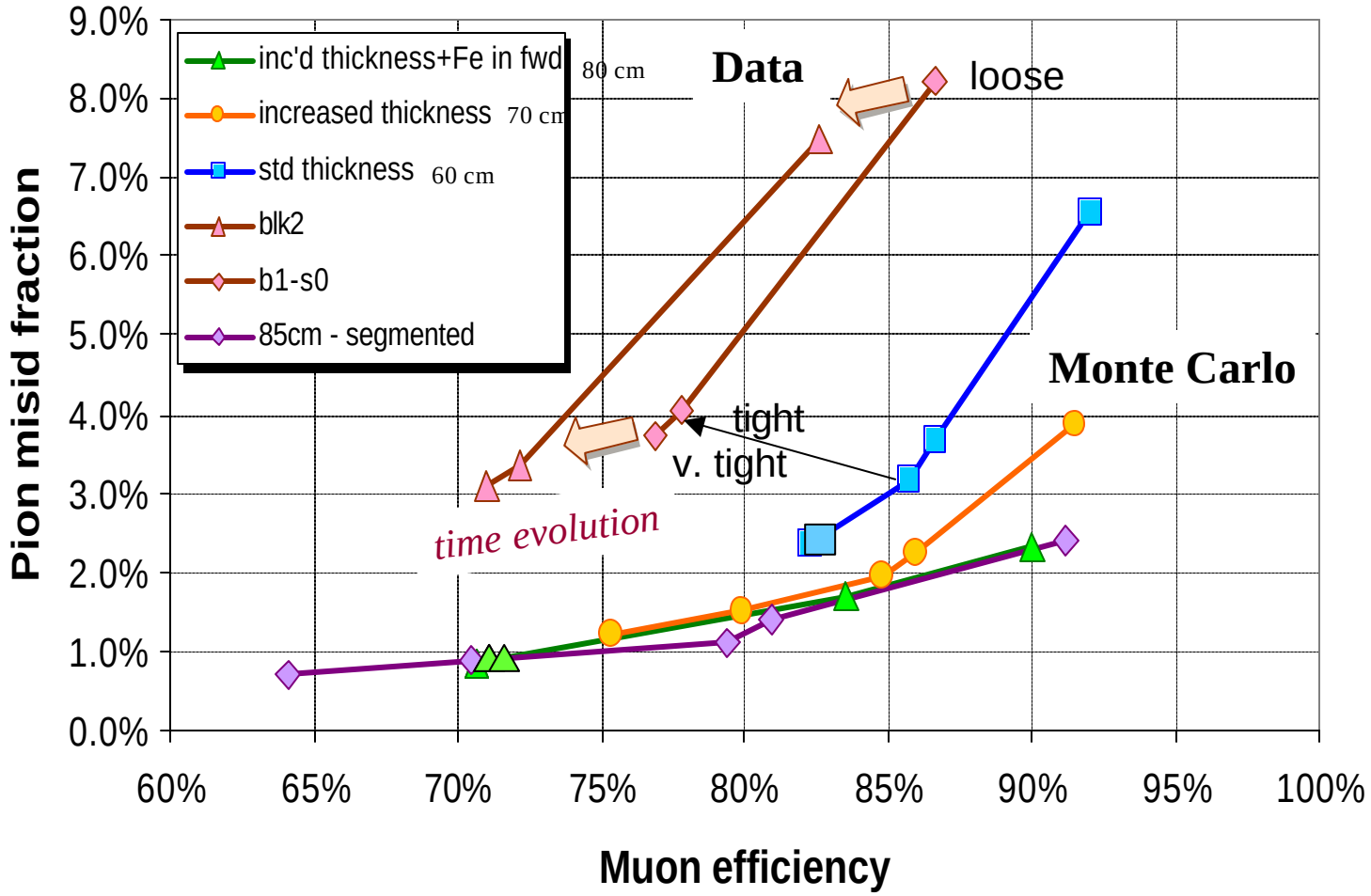
Guglielmo De Nardo

Forward Endcap Upgrade



Monte Carlo *vs* Data (Endcap)

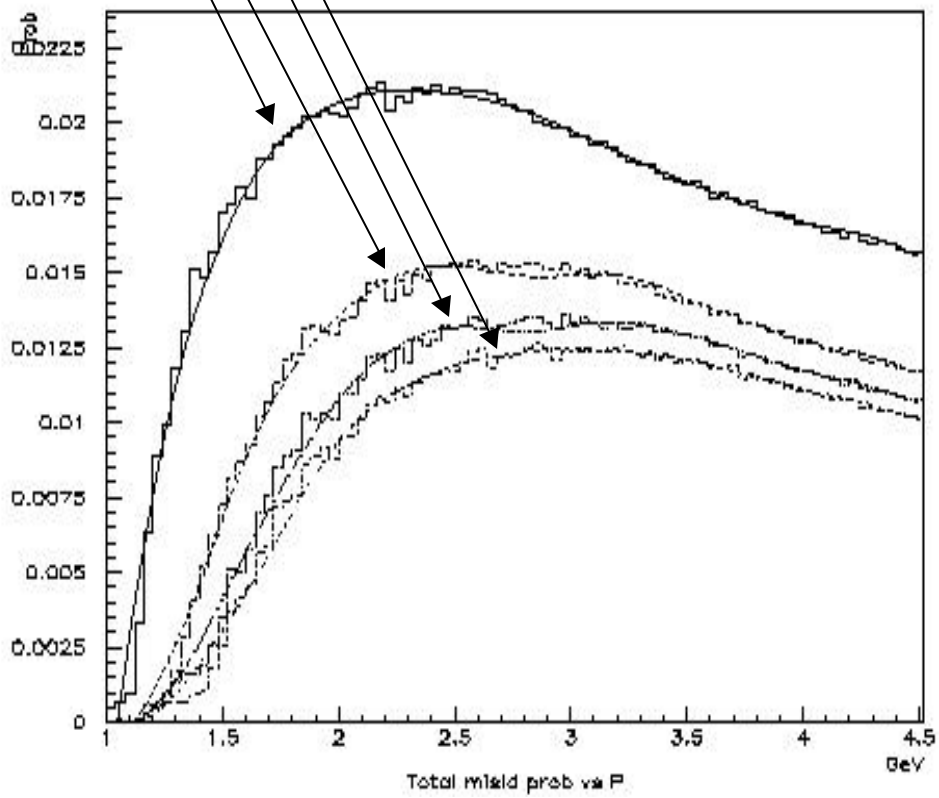
- Pion contamination is slightly higher in Data than in MC

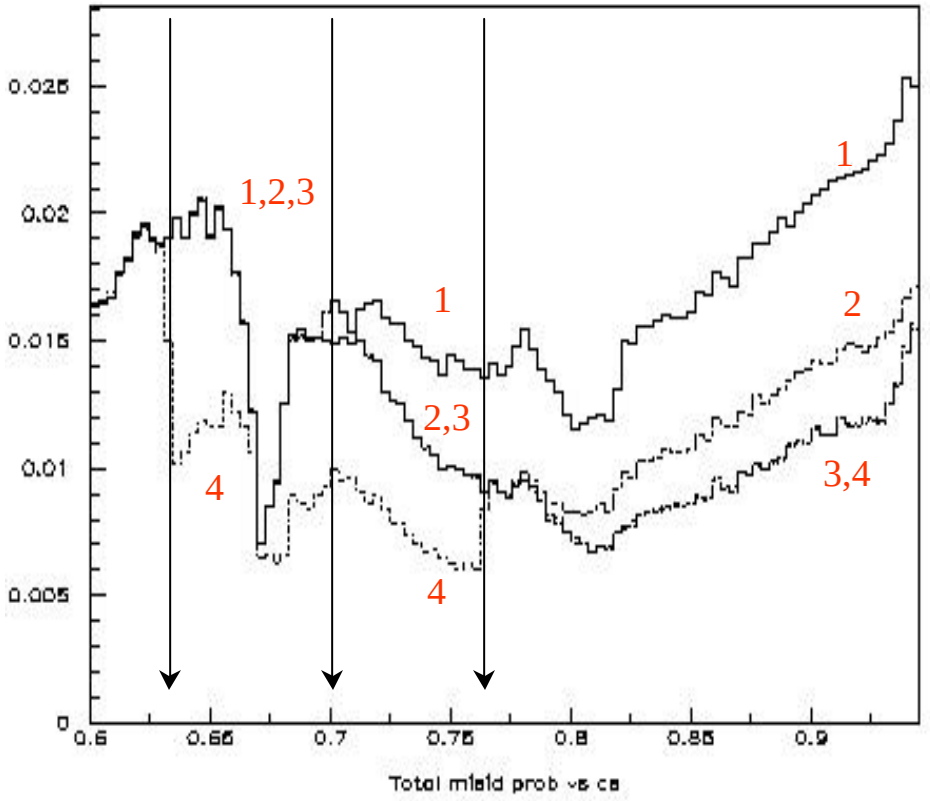


Toy MC Predictions

Standard (1)
+ brass absorber (2)
+ brass + 10cm Fe (3)
+ brass + 10cm Fe + RPC belt (4)

cosq > 0.7	brass absober
cosq > 0.76	layer #19
0.63 < *cosq* < 0.76	RPC belt
0.60 < *cosq* < 0.63	barrel only





Summary

- RPC inefficiencies degrading muon ID performance with time
  - Lower purity selectors least effected
  - Tight selectors performance $\propto$ to RPC efficiency
- Modest improvements possible with algorithm changes
- Restoring RPC efficiency particularly in the outer layers has the highest priority.