Trigger efficiency measurement using $Z \rightarrow \mu^+\mu^-$

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Outline

- Summary of tag&probe analysis (rel.13)
- How to reduce background from W->mu nu?
- Et miss and CaloMuons studies (rel.13 vs rel.14.2.21)
- Rel.14.2.21 vertexing
- Ongoing development of the package InsituTools
- Plans

Introduction

Analysis goal:

- Provide a sample of muon probes selected independently of Muon Spectrometer with a tag&probe method (using Z -> mu mu) to measure MS trigger and reconstruction efficiency
  - the method is based on reconstructed objects only
  - the method is checked using MC truth
  - AOD based analysis using ATHENA PhysicsAnalysisTools

Two developments are discussed here:

- reduce the main background (W->mu nu) using Etmiss and/or CaloMuons
- contribute to realize a common tool for real data analysis -> InsituTool

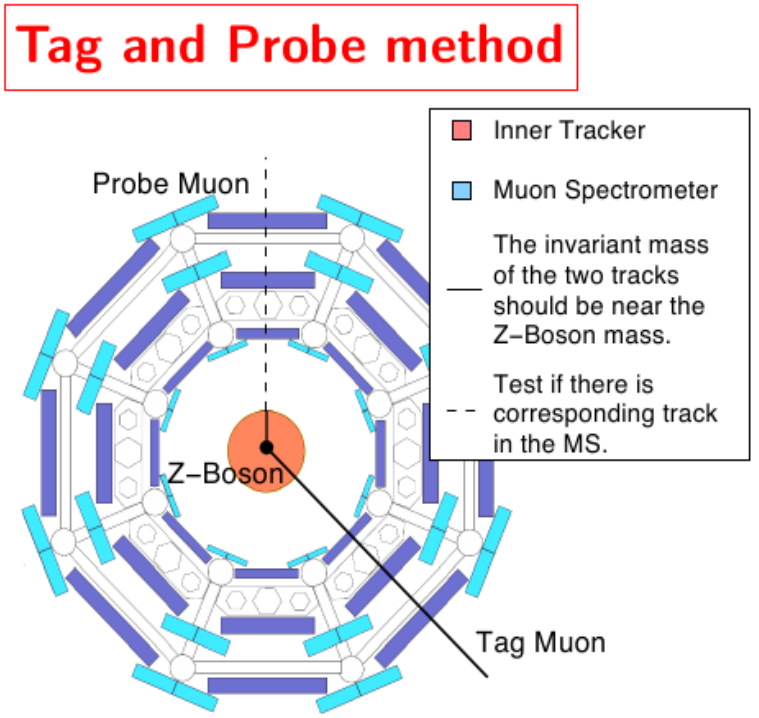
Tag and Probe Method

- Tag selection: combined muon, trigger checked, coming from the primary vertex and isolated (track+calo)
- Probe selection: InDet track in the acceptance, almost back-to-back to the tag and coming from the same vertex, isolated (only track) and in the Z mass range

- Once you have the probe selected: try probe – trigger sector matching, for varius trigger menus and levels

  Efficiency is the # of probes that pass this match over the # of total probes selected.

  Efficiency is calculated vs pt, eta and phi



Summary (rel.13)

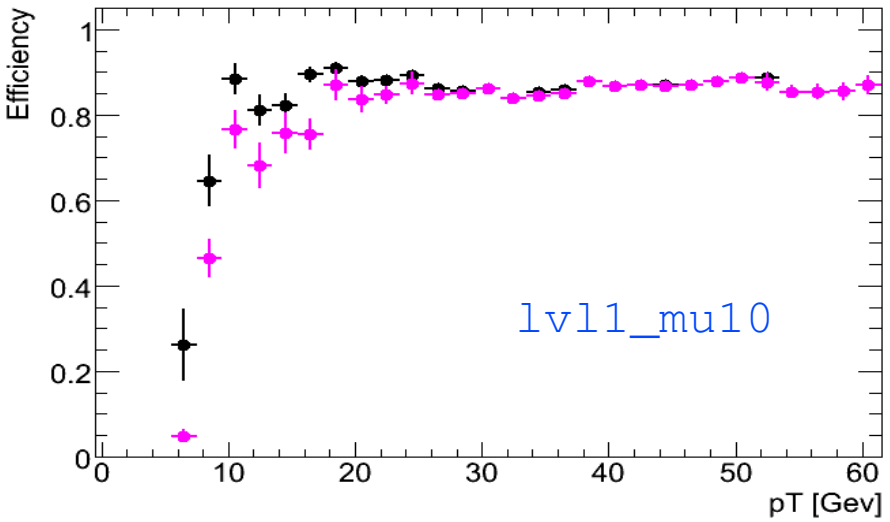
Sample	Xsec [pb]	probe/pb^{-1} (pt > 5 GeV)	probe/pb-1 (pt > 20 GeV)	Sample #
Zmumu	1854	987.33	946.282	5145
Wmunu	14490	17.39	4.926	5105
Ztautau	104.15	0.23	0.192	5146
Zbb	0.68	0.17	0.149	5177
ttbar	5.83	0.02	0.013	5205
bbmu15	270000	1.64	-	5701
bbmu5mu15	1000	0.03	0.005	5714

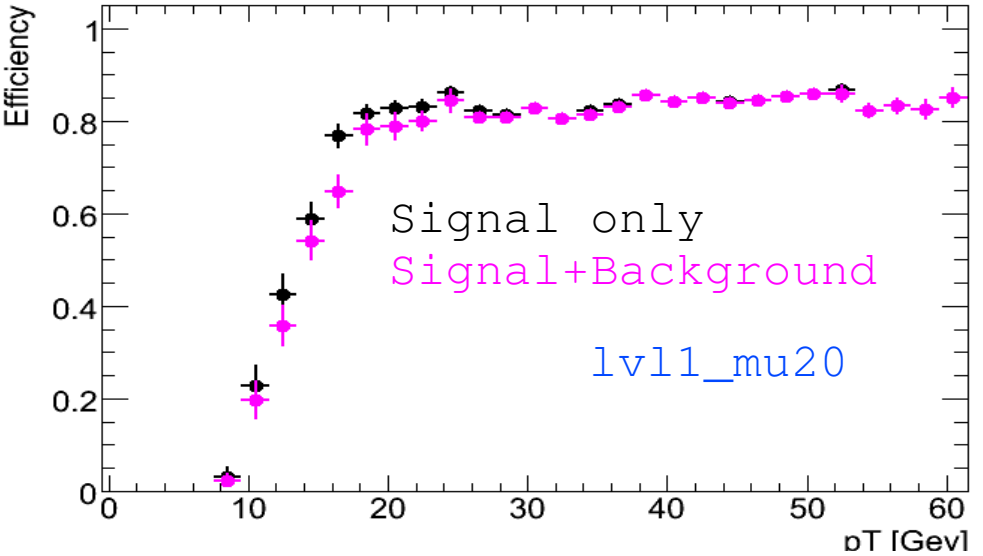
(NLO Xsec x filter efficiency (LO for bb samples))

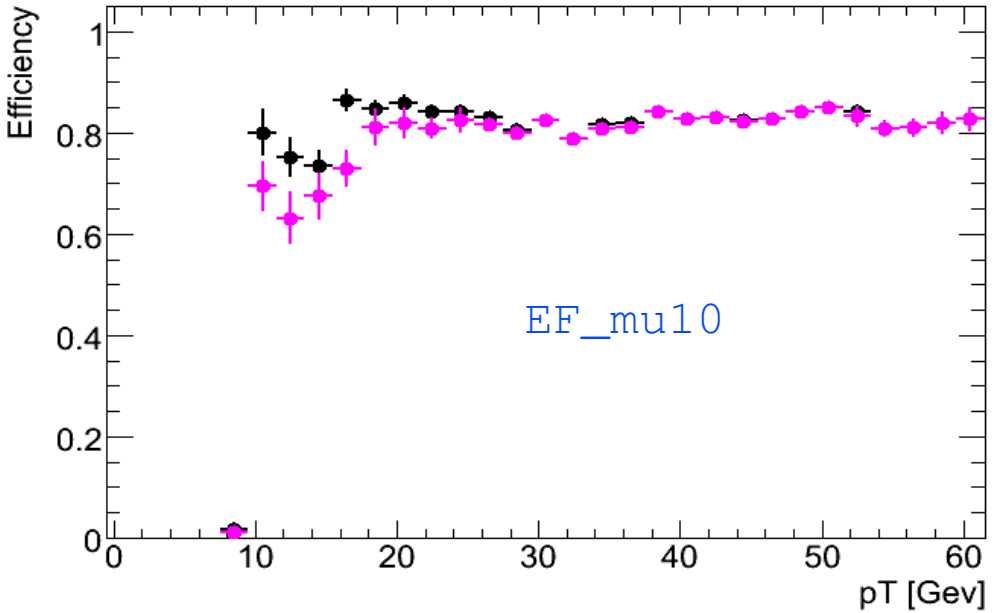
Some relevant number:

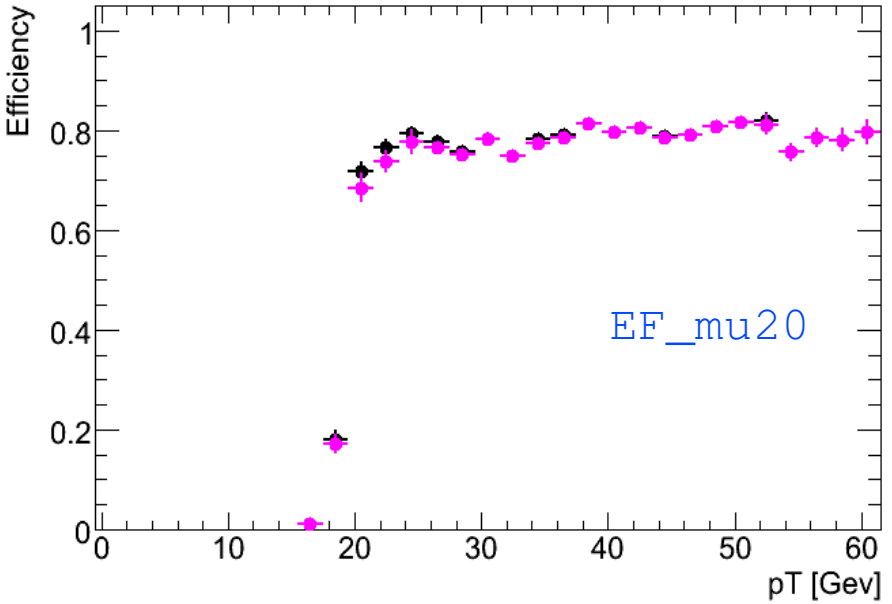
- W background contribution -> 1.7 %
- #probes/pb^{-1} about 1000
- about 1 probe/pb^{-1} in eta-phi bins 0.2x0.2

Trigger Efficiency with Wmunu Background









Step 1: Etmiss

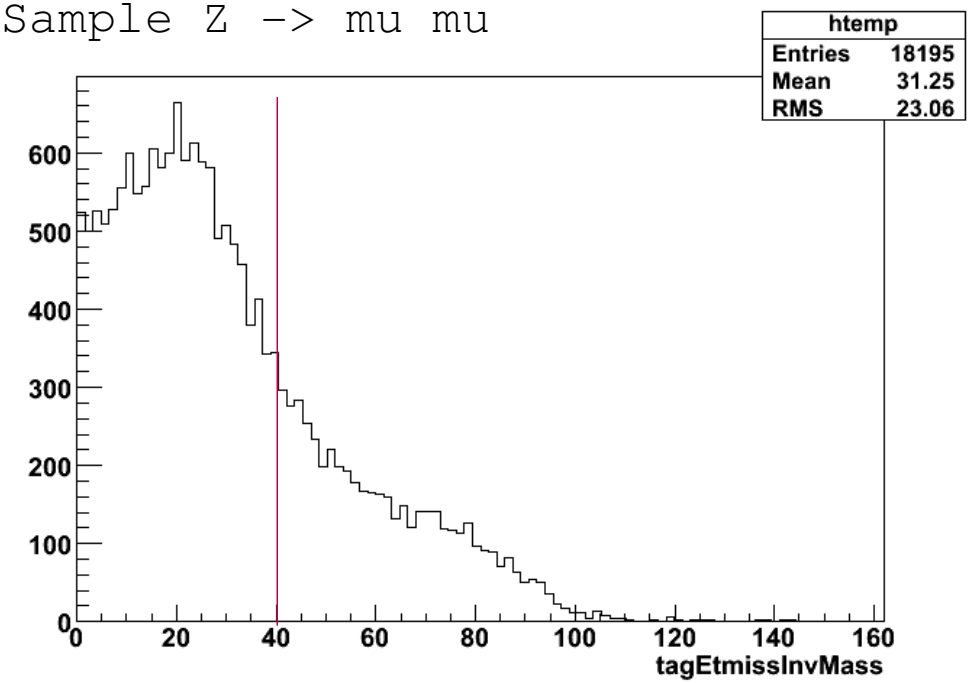
Real topology of W background is one combined muon and back-to-back high Etmiss from neutrino.

What we see? We take the real mu as a tag and another fake InDet track back-to-back to the tag as probe.

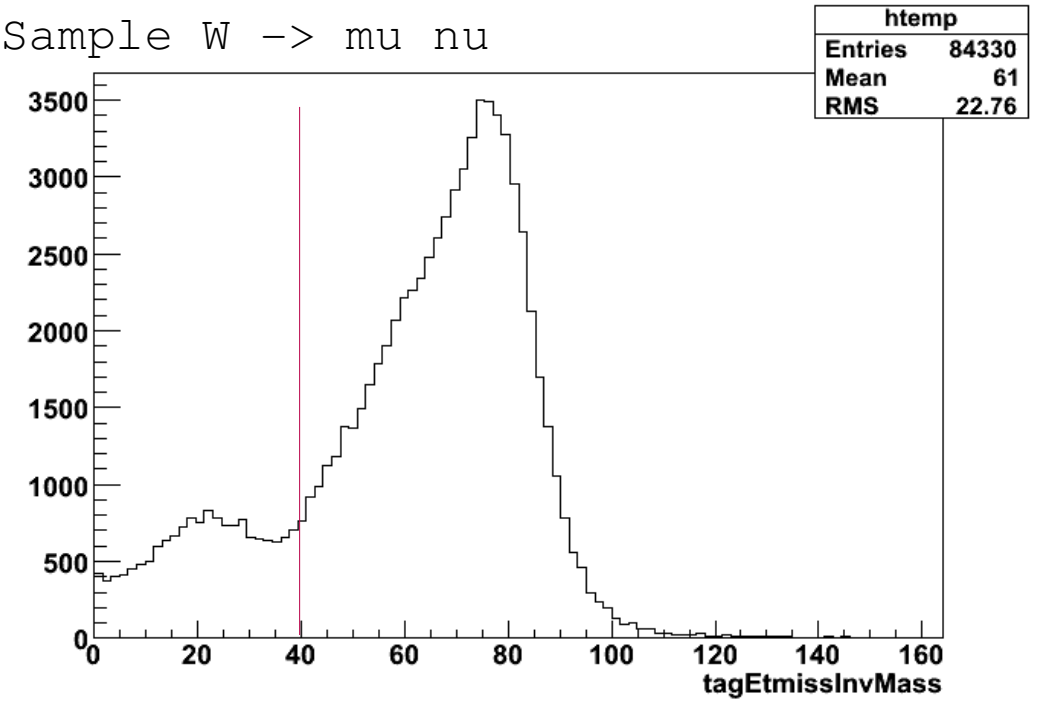
What to do? Remove events with high tag-EtMiss transverse mass back-to-back to the tag.

Transverse mass (tag-EtMiss): $\sqrt{2 * EtMiss * Pt(tag) * (1 - \cos(DPhi))}$

Sample Z -> mu mu



Sample W -> mu nu



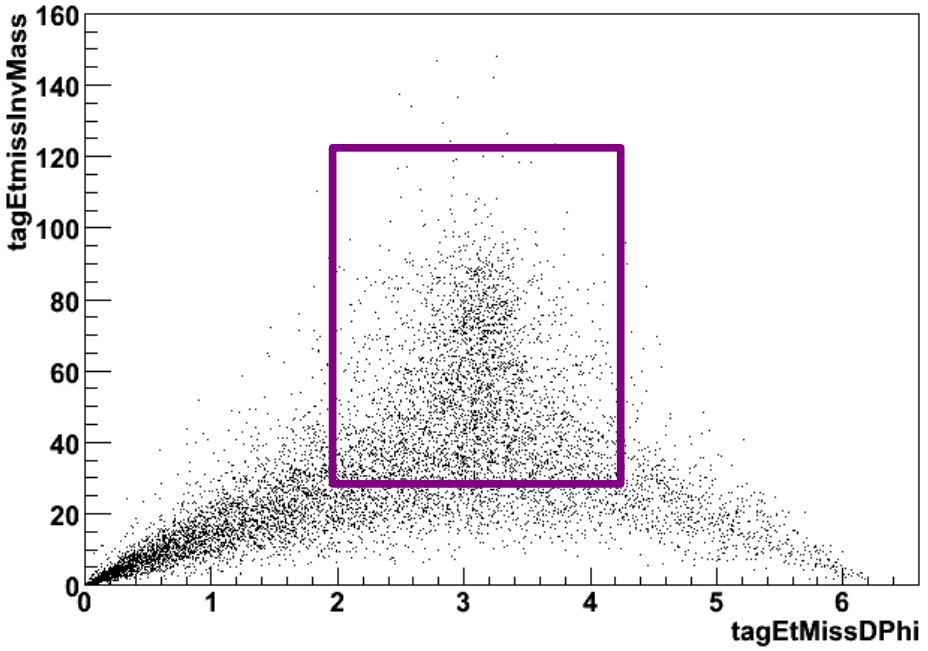
Etmiss cut

In the plane "Transverse mass vs tag-EtMiss delta Phi" the central bulk is cut away.

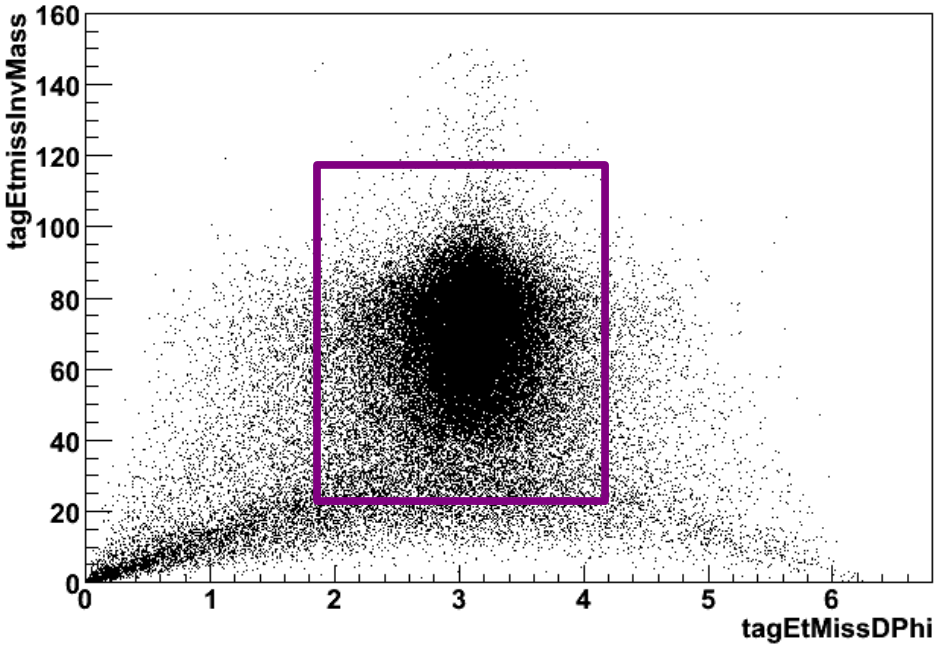
This removes most of the W background BUT a big part of the signal also.

Transverse mass Vs tag-EtMiss DPhi

Sample Z -> mu mu



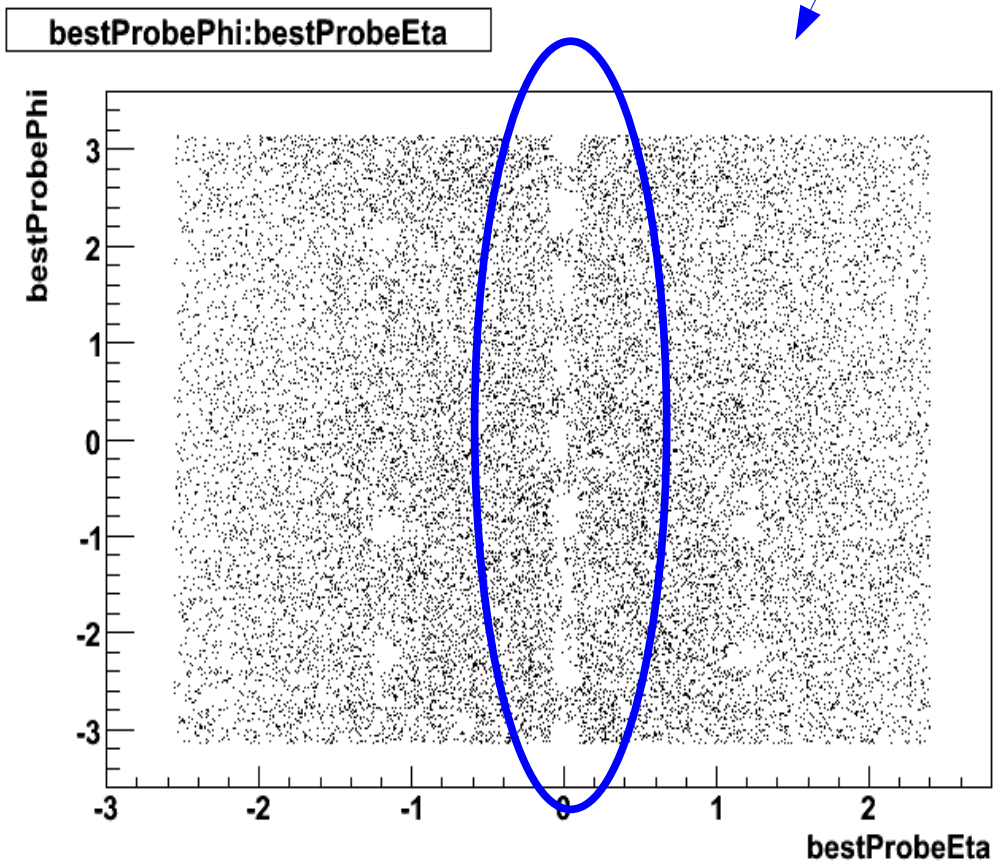
Sample W -> mu nu

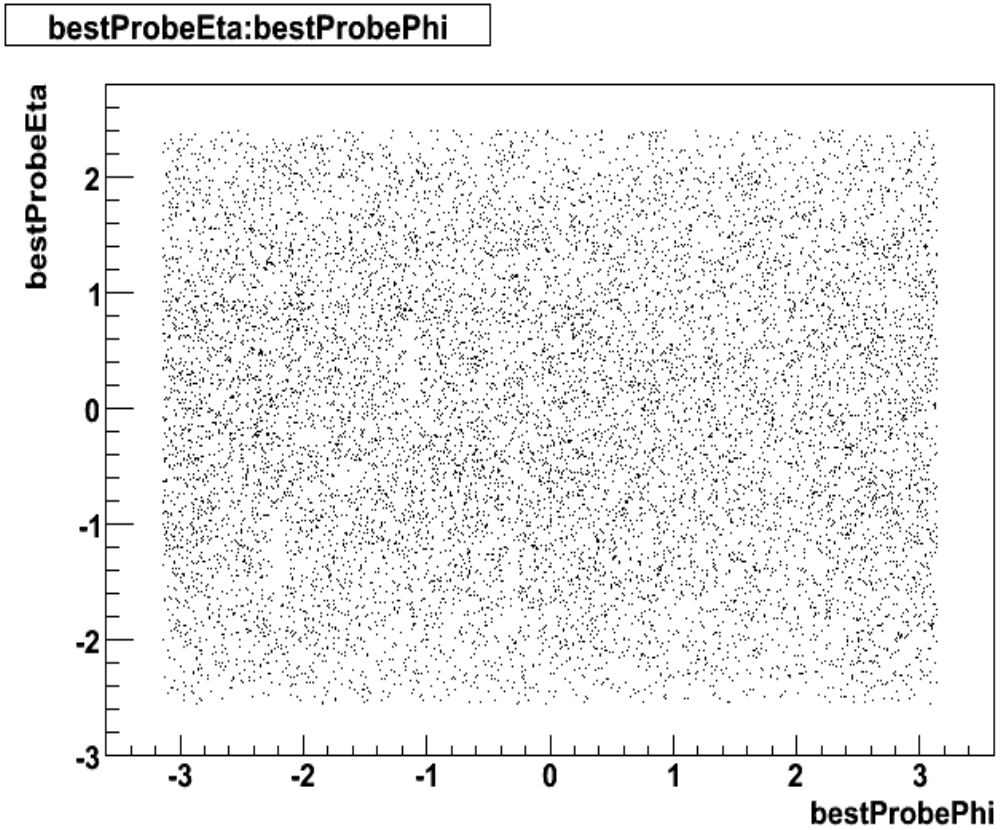


Et Miss studies

Pay attention! If you use **only** combined muons to calculate the Etmiss you have an acceptance bias! If you use **all** muons (low-Pt and calo tagged muons) you are bias free.

The first case is the rel.13, the second one is the rel.14





Step 2: caloMuons

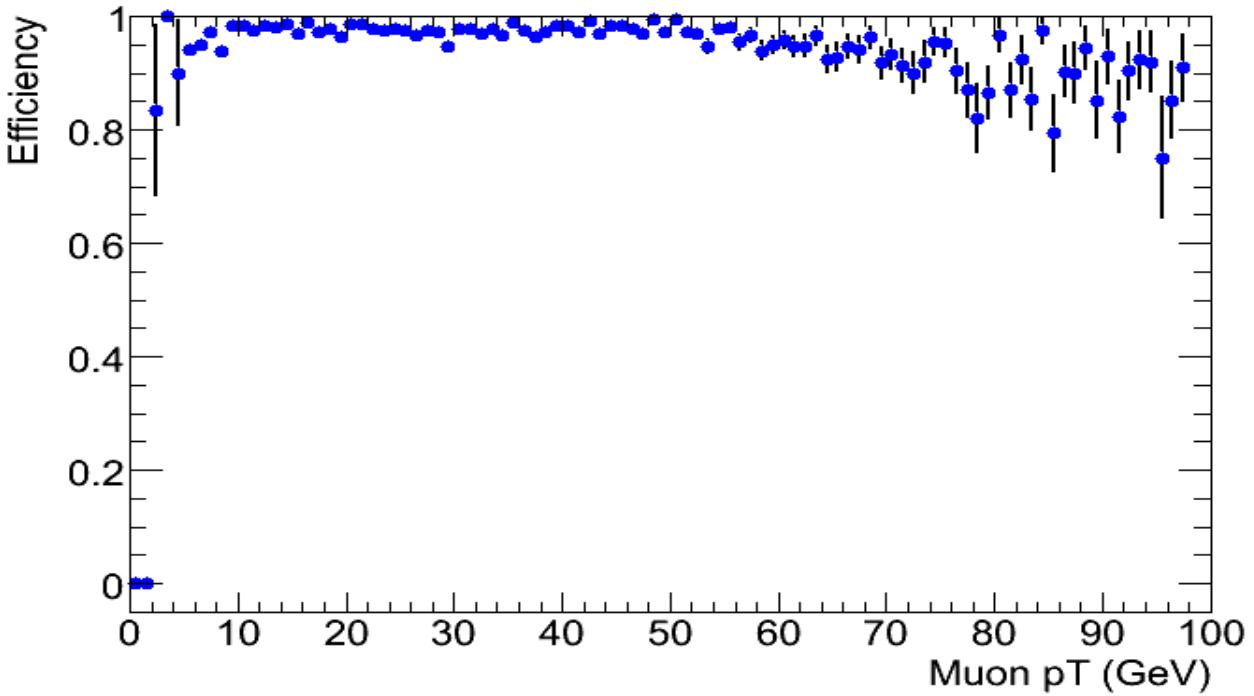
It's possible to check that the probe InDet track has been tagged as a muon by the calo muon id algorithm CaloMuonTag

What is a caloMuon?

InDet track extrapolated to the calorimeter

InDet track isolation cut

Cut on energy deposit in the last tile layer above a give threshold (Theta dependent)



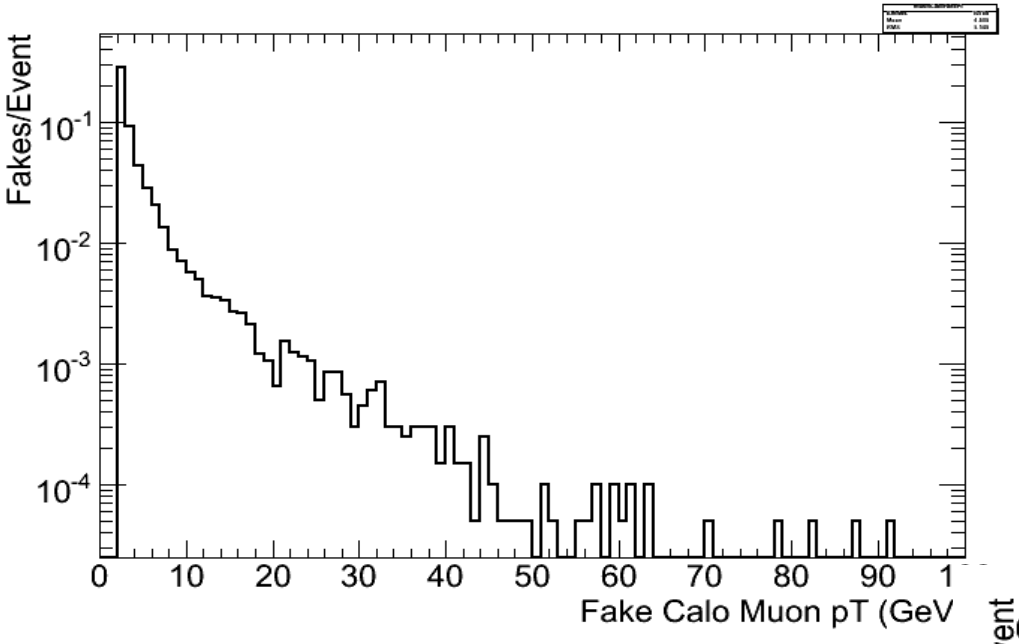
CaloMuons Efficiency: 97.8%

For details on caloMuons see: Muon Identification in the Calorimeter, talk by G.Ordonez (9 Apr. 2008)

caloMuons studies

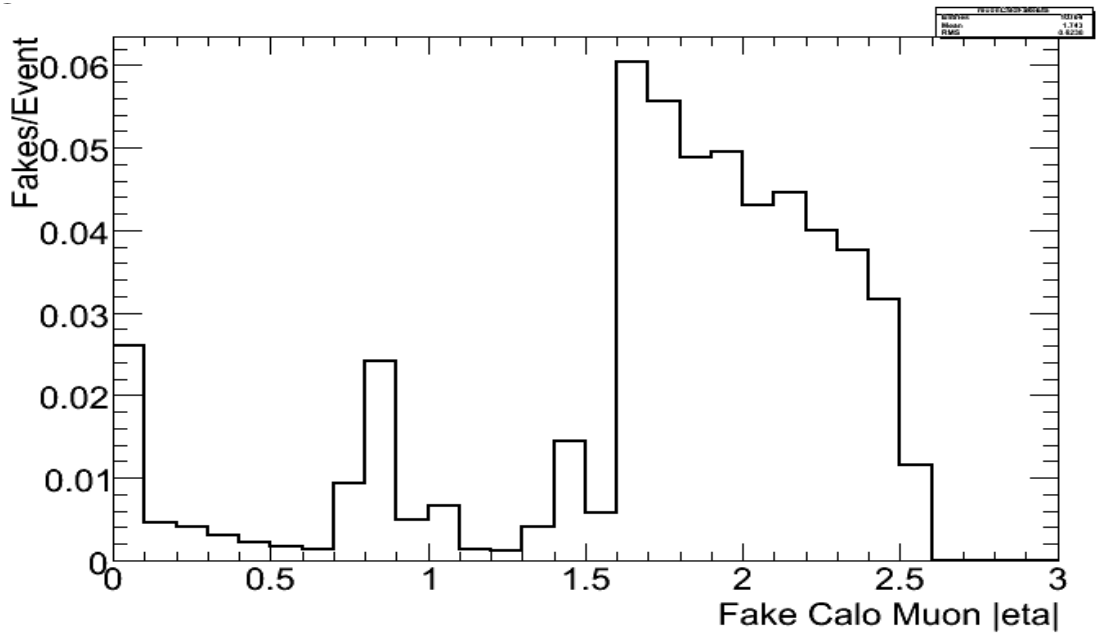
<#Fake/event>: 0.5

<#Fake/event with pt > 5 GeV>: 0.12



Most of fakes are in the end-caps

This has not a big impact on our analysis because the cut is at the end of the probe selection.



Summary rel.14.2.21
Et miss and caloMuons

Signal Z -> Mu Mu
#probes/pb^{-1} = 1165

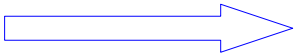
Background W -> Mu Nu
#probes/pb^{-1} = 23

Standard cuts

background: 1.9%

Signal Z -> Mu Mu
#probes/pb^{-1} = 720

Background W -> Mu Nu
#probes/pb^{-1} = 3



Standard cuts + EtMiss

background: 0.4%

Signal Z -> Mu Mu
#probes/pb^{-1} = 1081

Background W -> Mu Nu
#probes/pb^{-1} = 4

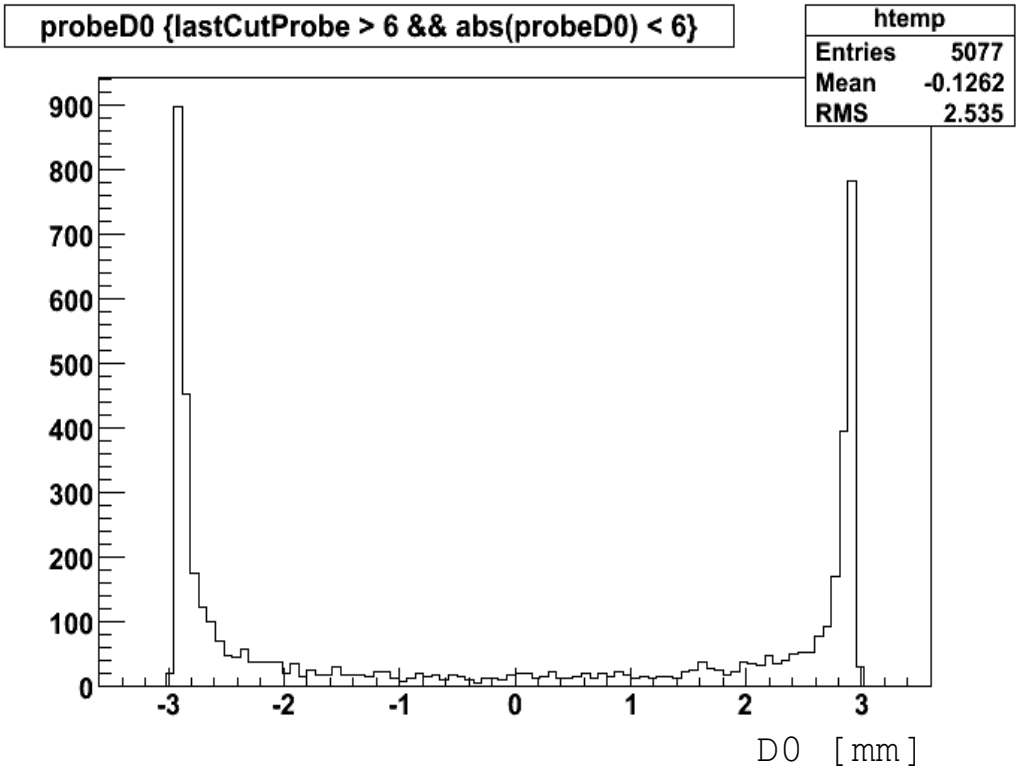
Standard cuts + caloMuons

background: 0.4%
34% more probes than EtMiss case

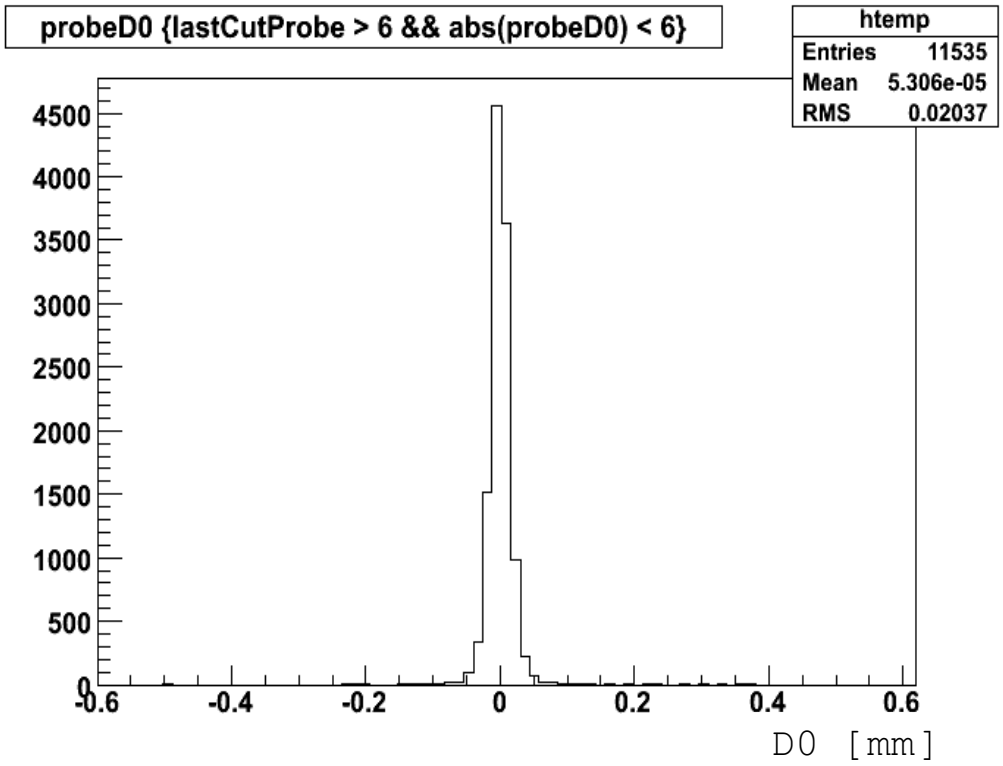
Rel.14.2.21 Vertexing

Rel.14 datasets have been produced with displaced beamspot (about 3mm in the transverse plain).
Calculate the impact parameter with respect to reconstructed primary vertex, no to the nominal one.
This is important with pile-up. -> replace the “best vertex“ with the actual vertex

If you use the nominal vertex (0,0,0)



If you use the reconstructed vertex



InsituTools

InsituTools is a common package (in CVS) for real data analysis. There are tools for electron and muon performance.

[atlas] / offline / PhysicsAnalysis / AnalysisCommon / InsituPerformance / InsituTools / src Repository: atlas Go

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Index of /offline/PhysicsAnalysis/AnalysisCommon/InsituPerformance/InsituTools/src

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InsituTrackPerformanceTools.cxx	1.4	2 months	mschott	See ChangeLog
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MuonProbeCollectorTool.cxx	1.6	6 days	sborroni	See ChangeLog
ZmumuSelectionTool.cxx	1.2	6 days	sborroni	See ChangeLog

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InsituTools

Tag&Probe

We started to develop the tag&probe selection inside the package with Max, Matthias, Hironori and Claudio, to study muon trigger and reconstruction efficiencies.

Structure

There is a common AlgTool (MuonProbeCollectorTool) that creates the tag and the probe collection (StoreGate containers), using various functions (implemented in AlgTools) for various tag&probe selections

In particular we are implementing the tag&probe selection based on Z->mu+mu- events -> ZmumuSelectionTool

The other ones are selection based on Jpsi and CaloTags (work in progress..)

Technicalities

Everything is based on AODs using standard PhysicsAnalysisTools

InsituTools

Ongoing developments on Z-> mu mu

Committed the first version of ZmumuSelectionTool
An important issue is to implement the calculation of some variable of central relevance for the event selection (isolation, d0, z0..)

Configuration jobOption and python scripts not yet committed

Plans

- Define a set of cuts to select Z->mu mu events. We are studing the best set of cuts to select a probe collection with max of statistics and min of background
- Measure muon trigger efficiency, reconstruction efficiency and (trigger|reconstruction) efficiency
- Try to implement a mu+mu- selection from Drell-Yan to increase the overall statistics -> using caloMuons can help in this scope
- Analyze FDR2c data
- For the first data -> try to study standalone tags
- We need rel.14.2.21 background samples that are not available at the moment.