Muon Reconstruction Algorithms Analysis Report Oct 19, 2011

Hok-Chuen Cheng

University of Michigan

Email: hccheng@umich.edu

Motivation

In the dilepton analysis of dark photon, two or more highly boosted leptons (muons) are expected to be observed. The resulting dimuon pair will be expected to have a very small separation angle. ($\Delta R<0.1$)

In regard to that, we studied the performance of two available muon reconstruction algorithms STACO and MuID on combined (and with tagged) muons in the low mass limit.

Methodology

We looked at events with small separation angle. ($\Delta R<0.1$)

We then determine the performance of the algorithms by looking at the signal-to-background significance of the dimuon invariant mass for ω/ρ, ϕ and J/Ψ resonances.

Data Sets Used

SMWZ muons d3pd's:

From:
data11_7TeV.00178044.physics_Muons.merge.NTUP_SMWZ.r2276_p516_p523_p605_tid440639_00.list

To:

data11_7TeV.00184169.physics_Muons.merge.NTUP_SMWZ.f387_m897_p605_tid452282_00.list

Integrated Luminosity: 980.91pb-1

Pre-selections

PV with the largest ndof

GRL

Removal of bad jets

Trigger: EF_mu18_MG or EF_2mu6

Muon Pt > 20GeV (Seems a bit too tight)

Eta < 2.4

z0_exPV < 10mm

z0sig_exPV < 10 & d0sig_exPV < 10

Definitions/Abbreviations

STACO (mu_staco_xx)

MuID (mu_muid_xx)

Combined (isCombinedMuon = 1)

Combined with tagged (isCombinedMuon = 1 &&
isLowPtReconstructedMuon = 1)

me – muon spectrometer extrapolated

id – inner detector

cb – combined

exPV – extrapolated from primary vertex

Definition of Good Muon

Pt cuts:

mu_me_pt > 6GeV

abs(Mu_me_pt - Mu_id_pt) < 15GeV

Muon Spectrometer Pt

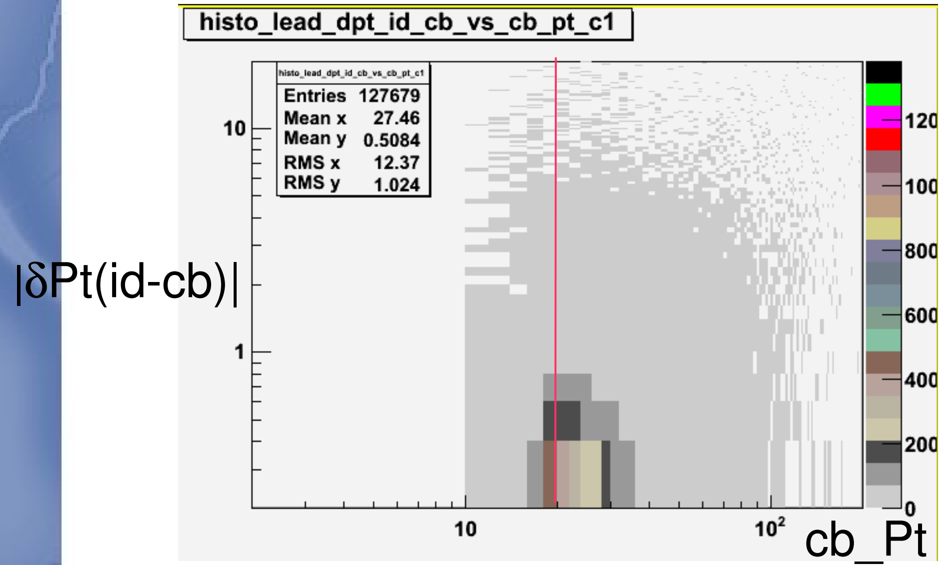
We plotted the following for leading and subleading muons.

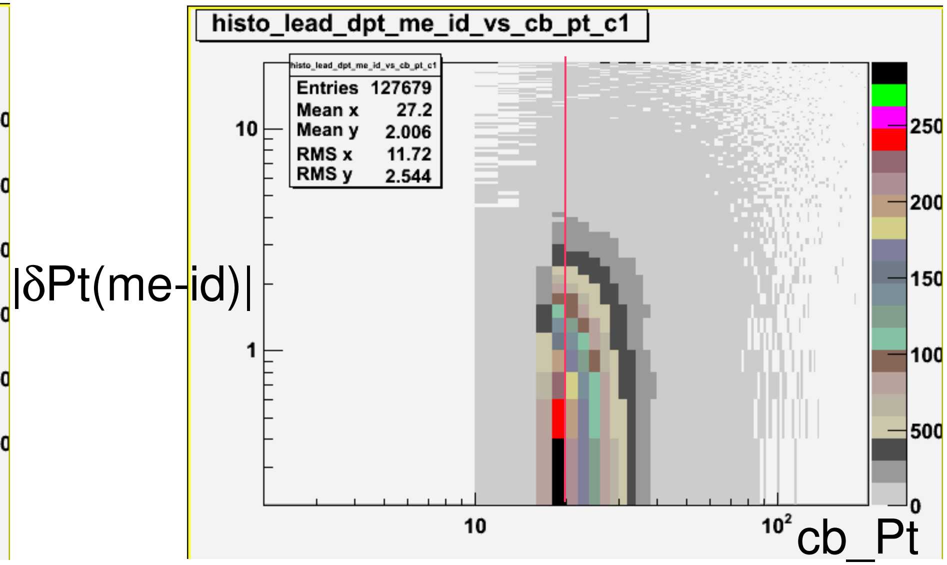
δPt(me_Pt – id_Pt) vs cb_Pt

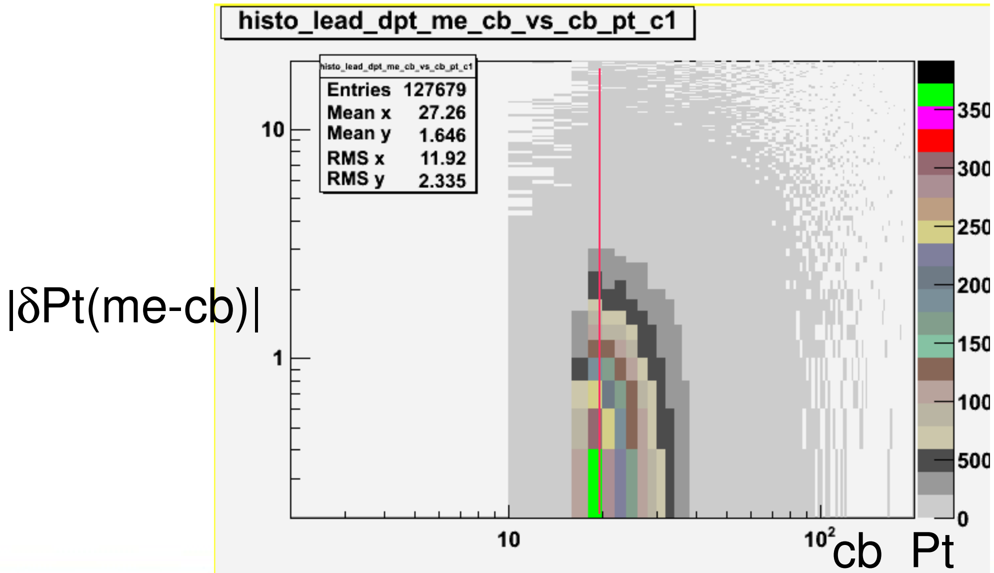
δPt(me_Pt – cb_Pt) vs cb_Pt

δPt(id_Pt – cb_Pt) vs cb_Pt

δPt vs cb_Pt

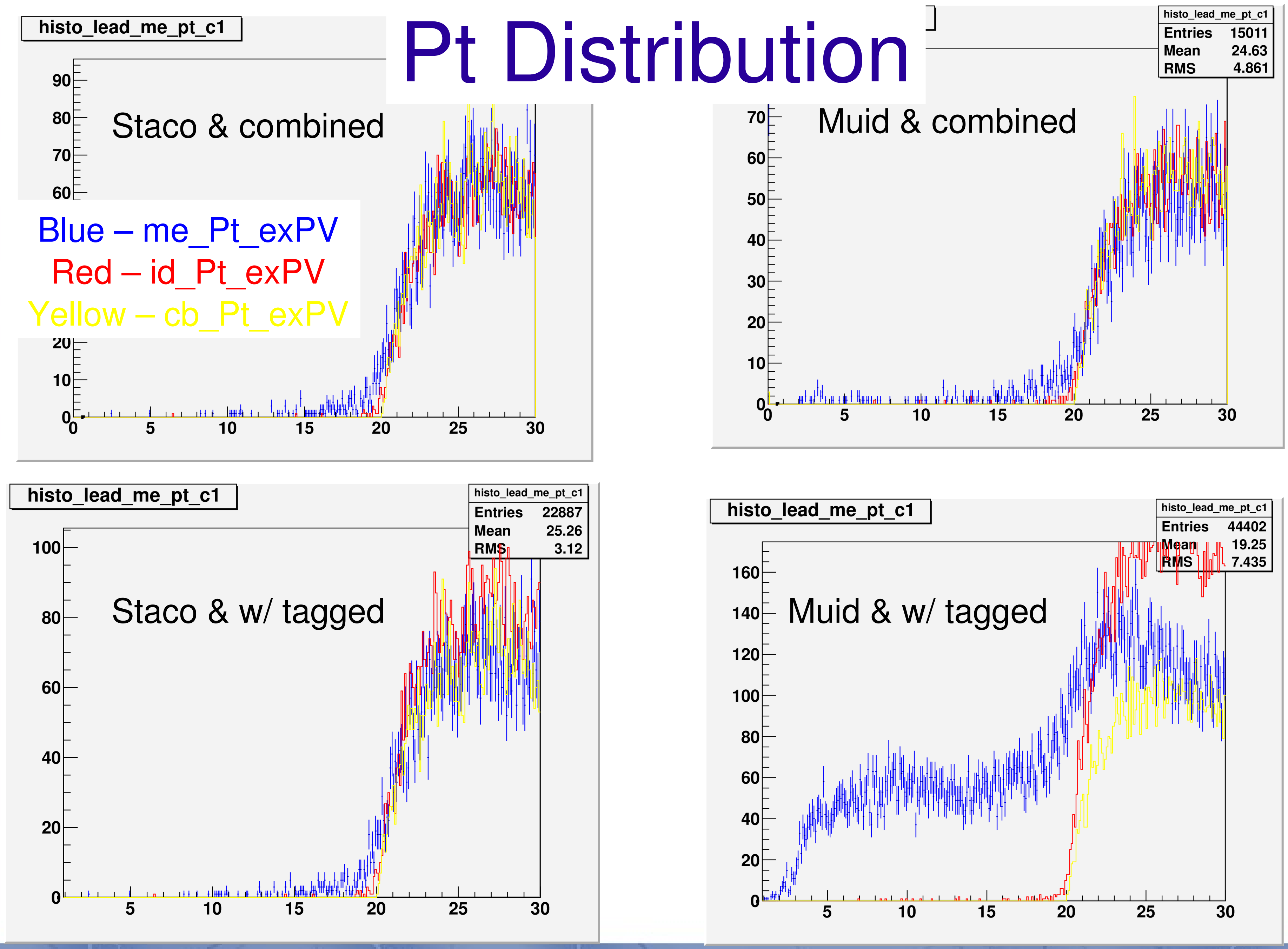






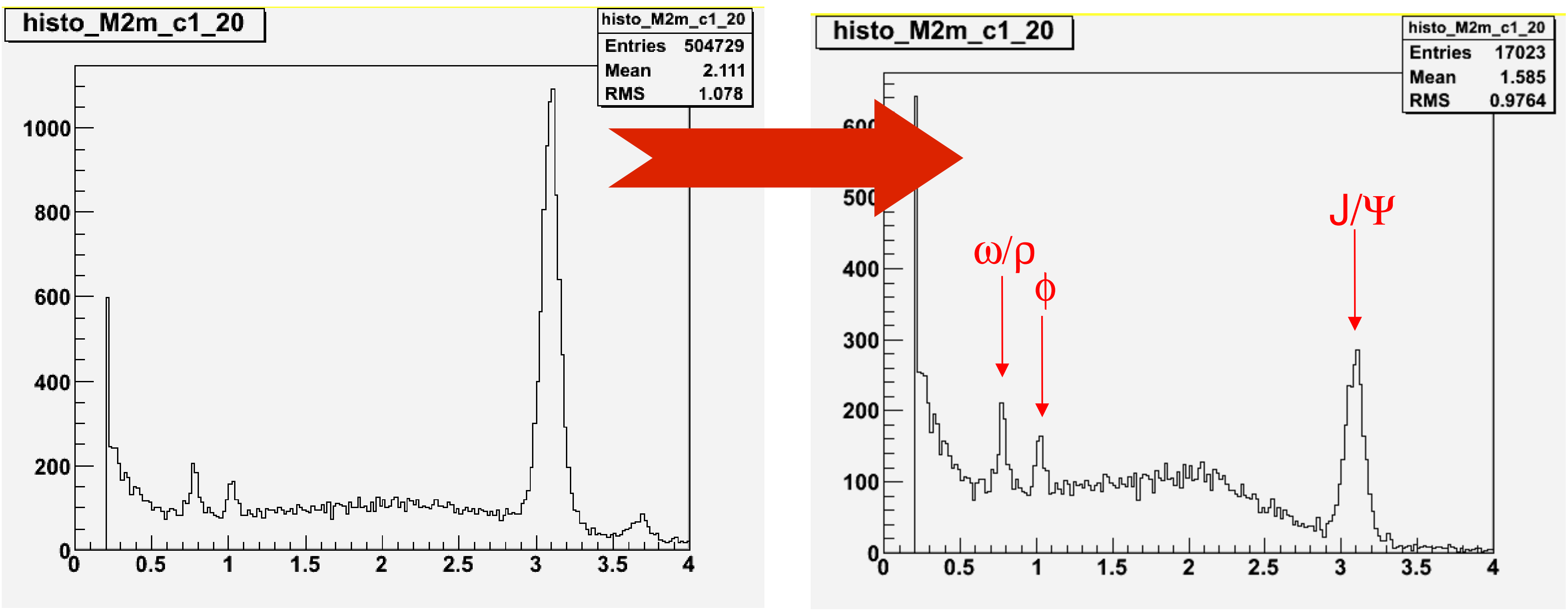
Muid & combined

Pt Distribution

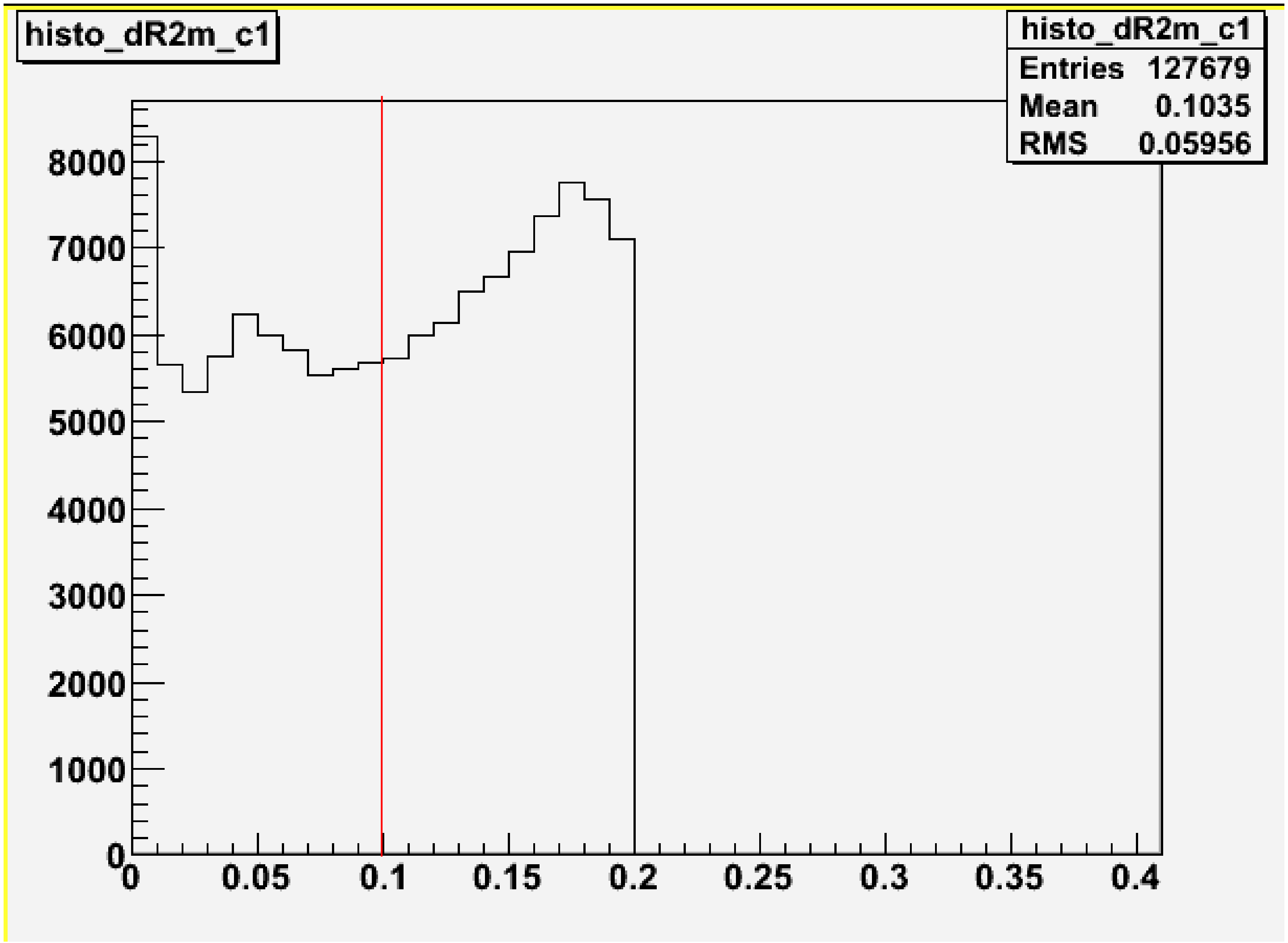


ΔR_2m Cut

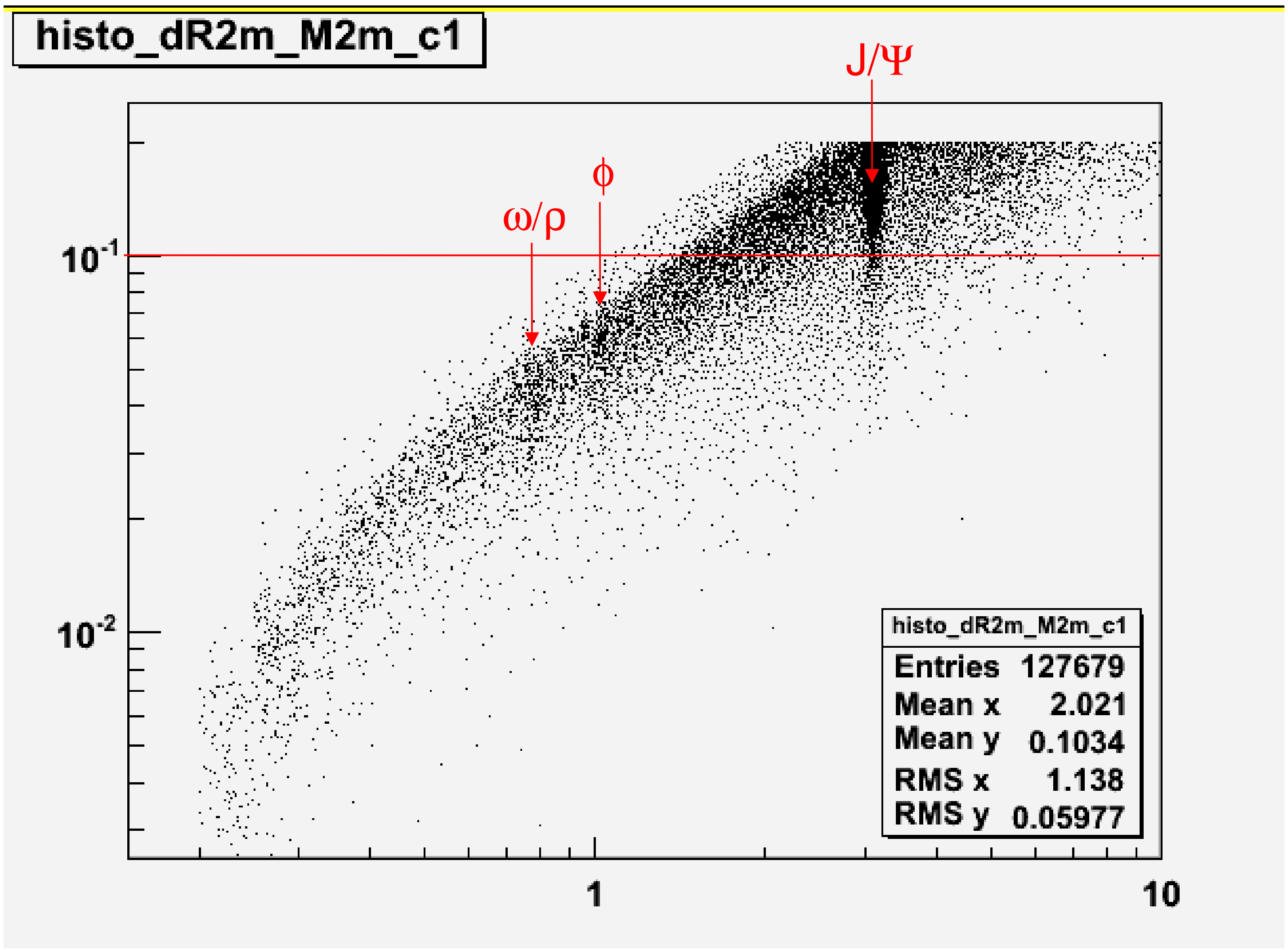
We reduced the background for ρ/ω, ϕ and J/Ψ by adding a ΔR_2m<0.1 cut.



ΔR_2m Distribution

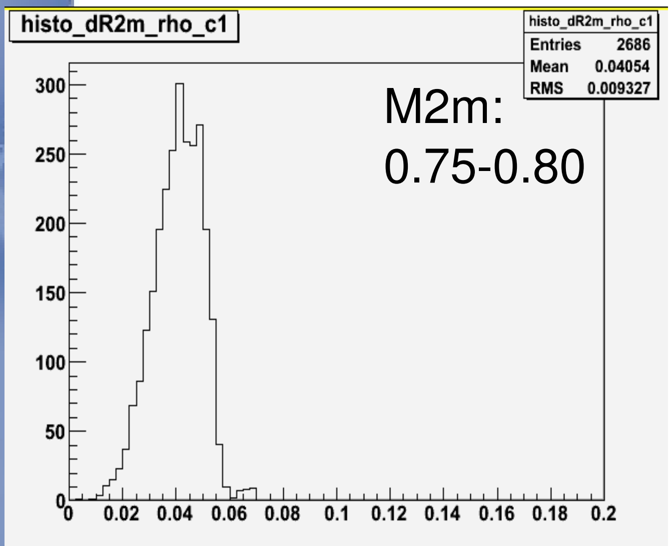


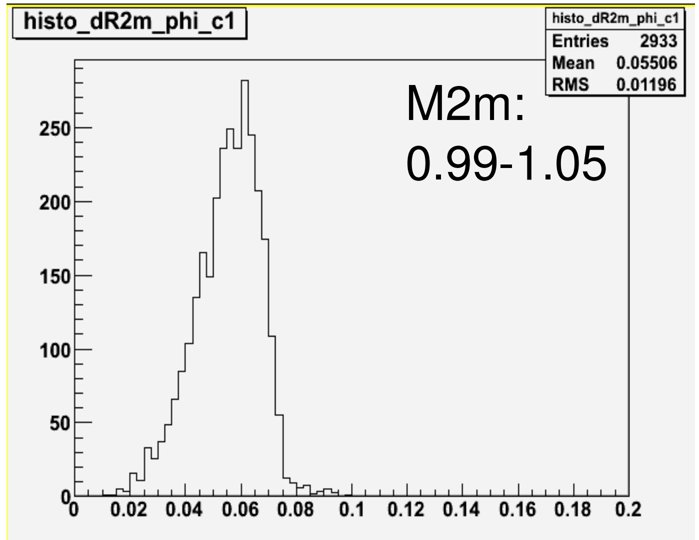
ΔR_2m vs M2m

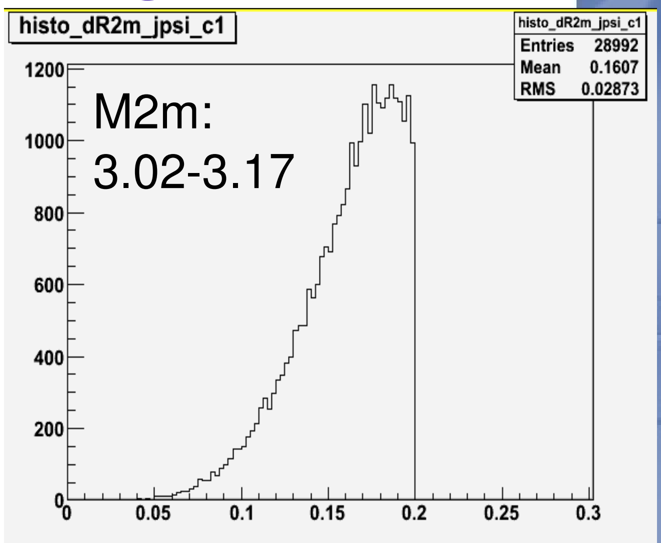


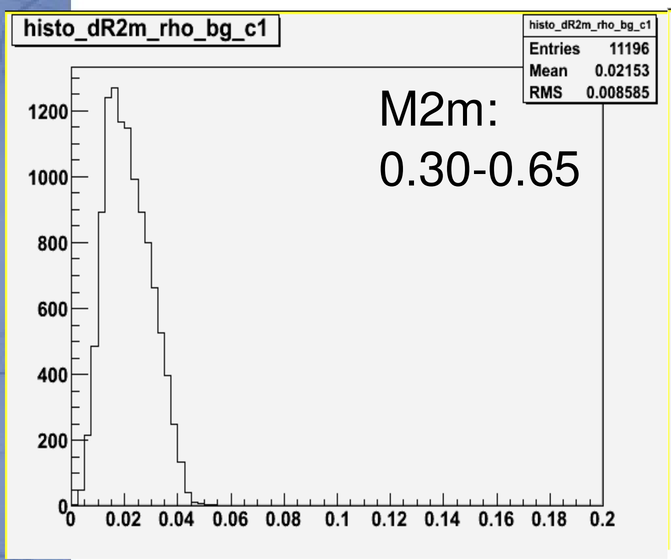
Muid & combined

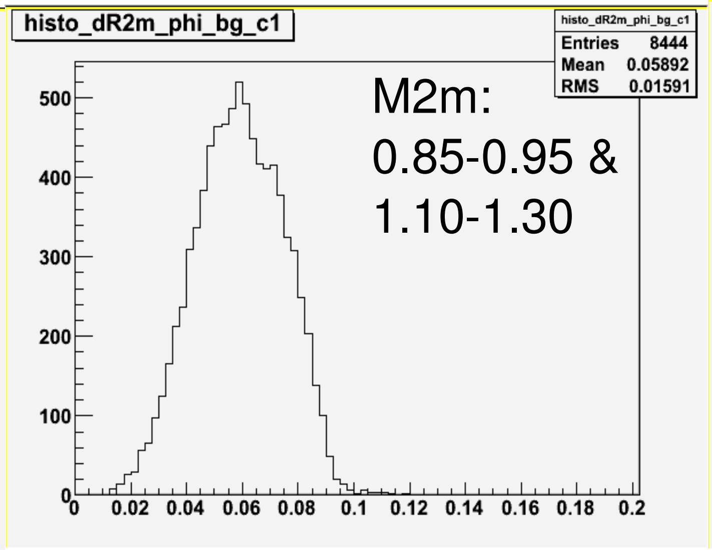
ΔR_2m for Peaks & Background

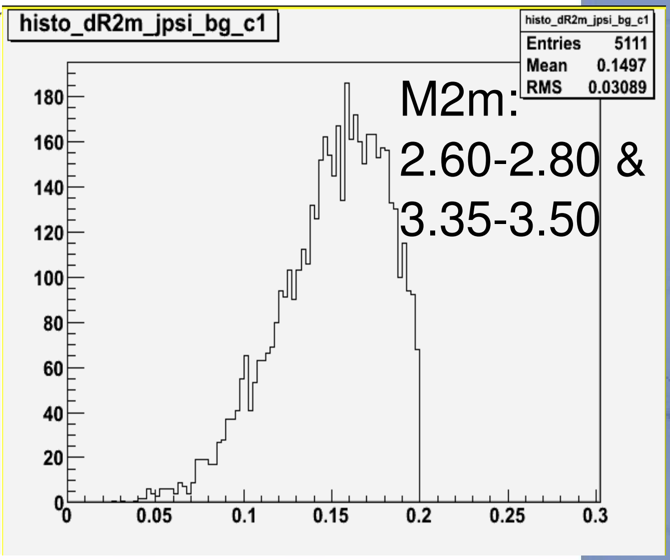






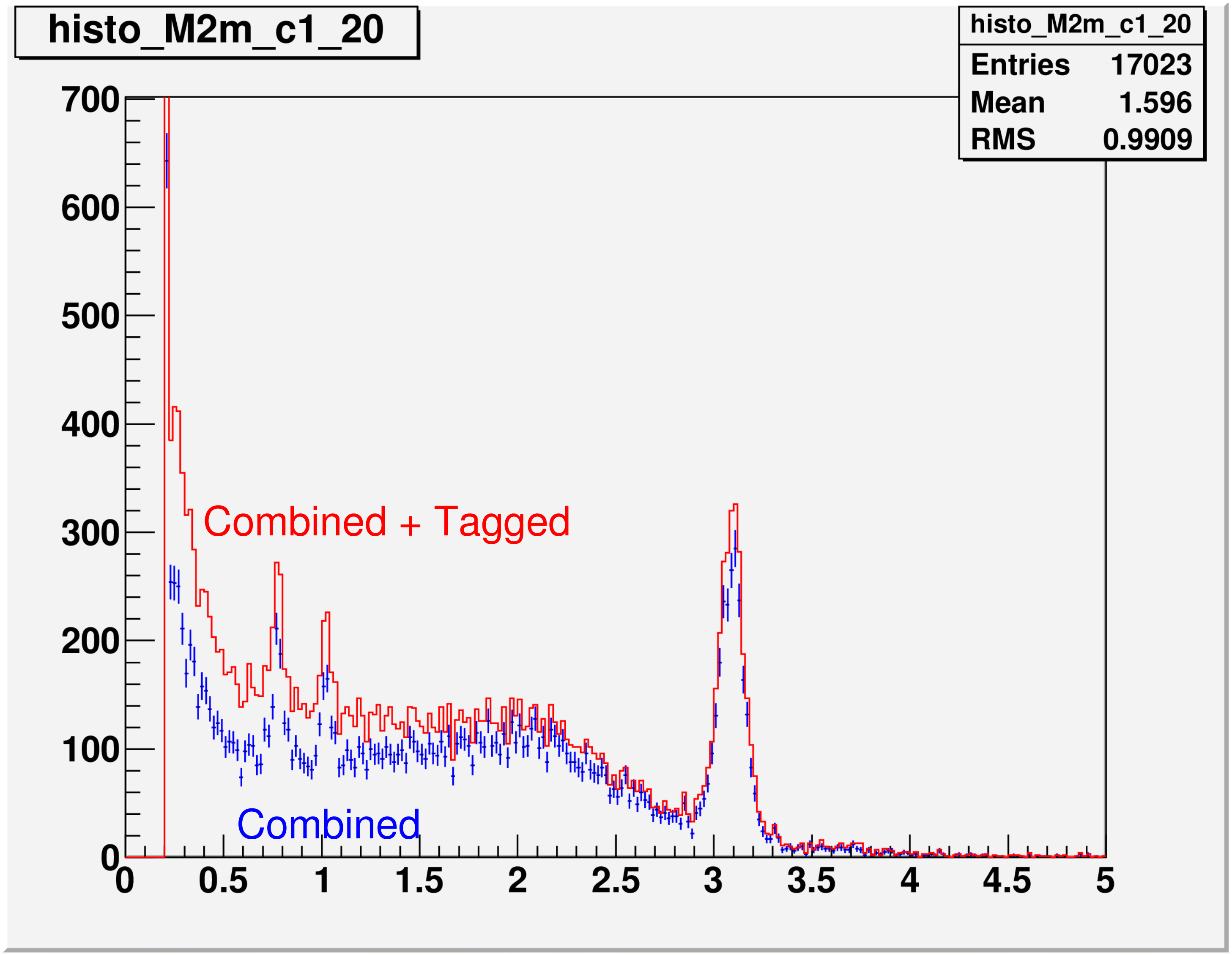




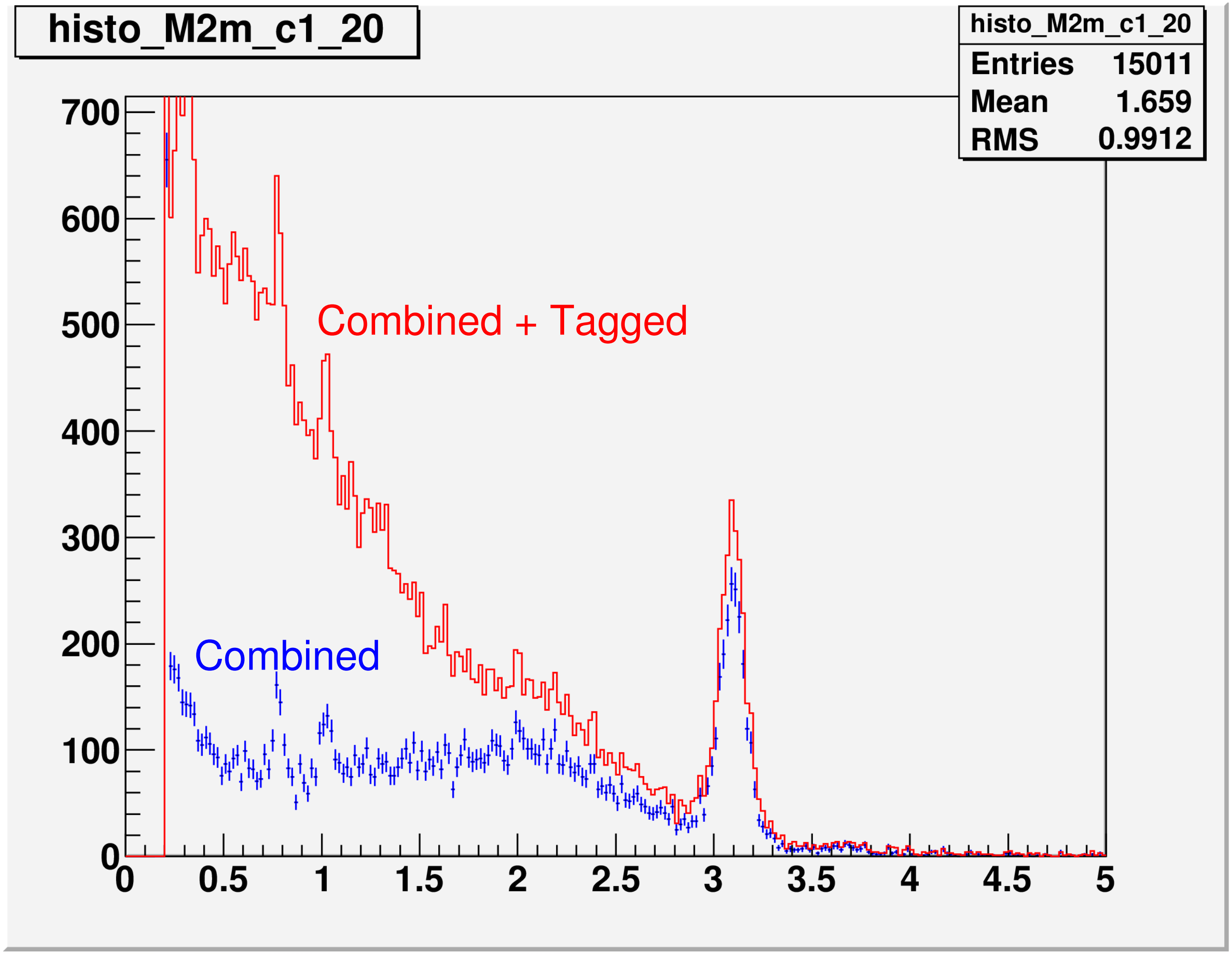


Muid & combined

Dimuon Invariant Mass for Staco



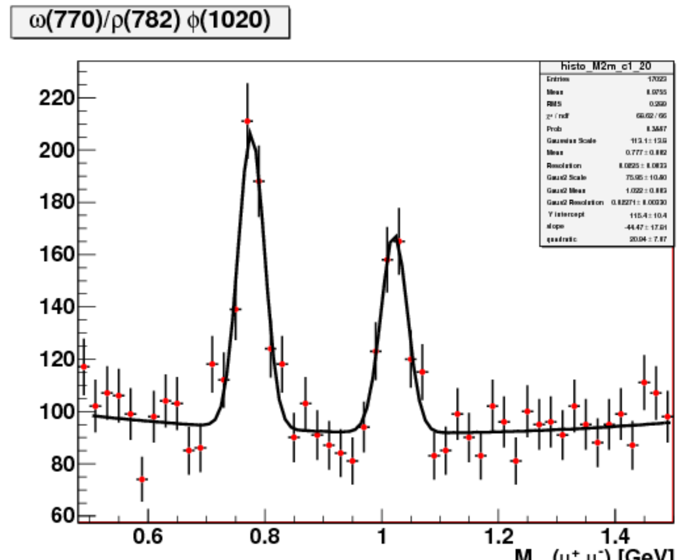
Dimuon Invariant Mass for Muid



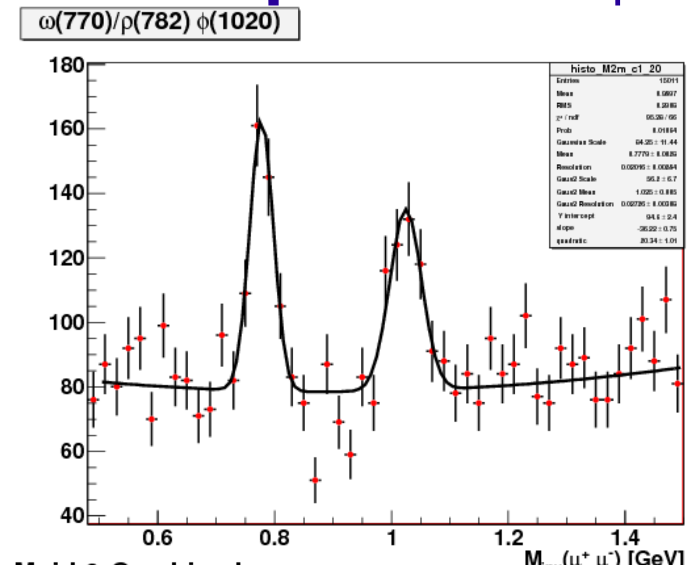
Determining the signal and the background

Gaussian curves and a quadratic background have been used to fit the dimuon invariant mass distribution in the region around the resonances.

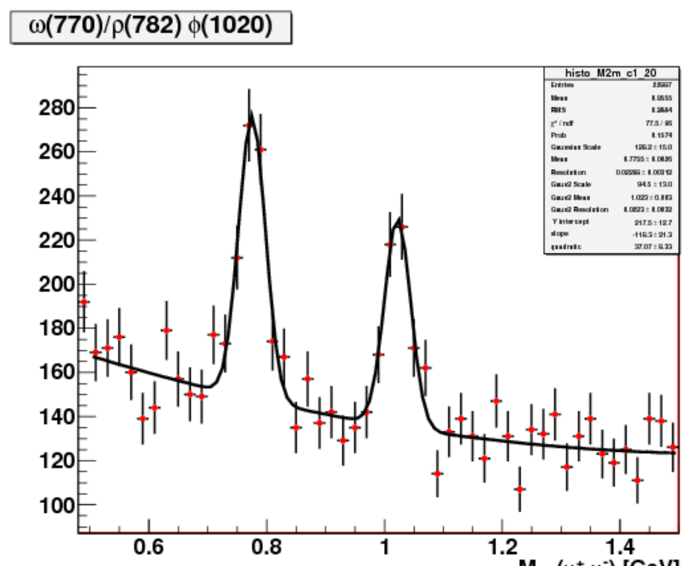
Resonances for ω/ρ and ϕ



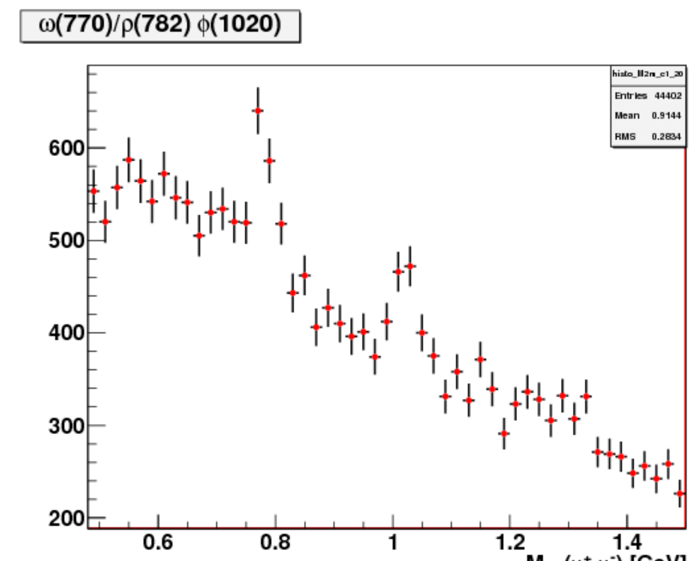
Staco & Combined



Muid & Combined

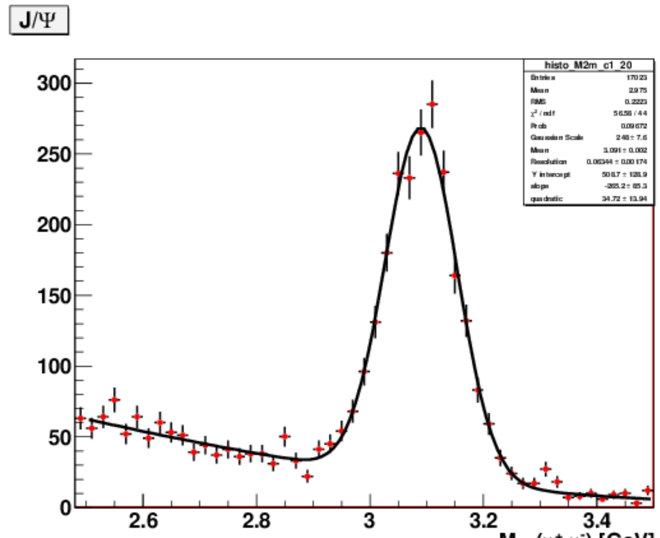


Staco & Combined with tagged

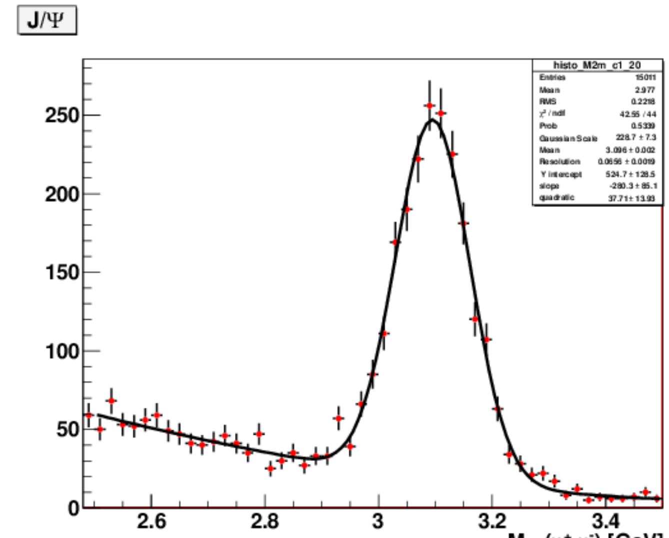


Muid & Combined with tagged

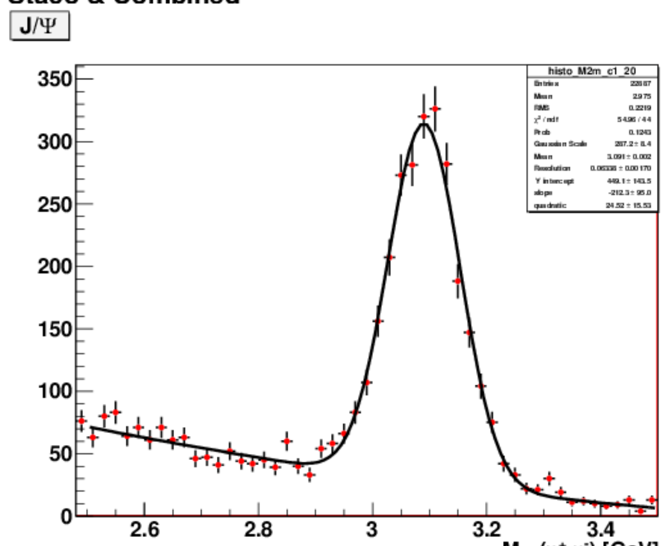
Resonance for J/Ψ



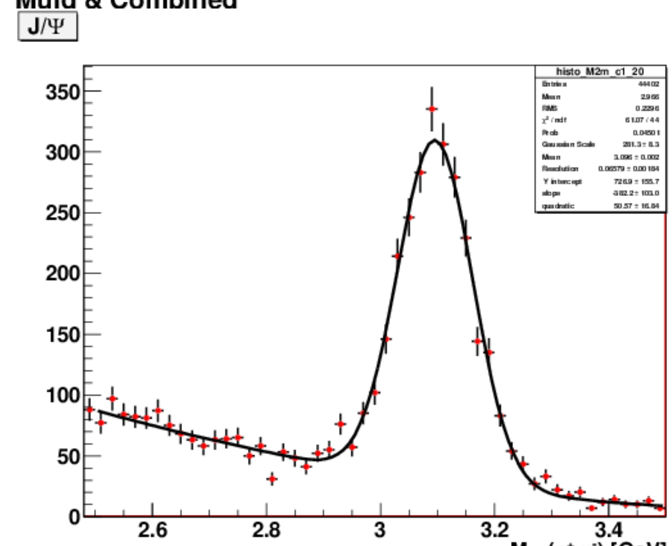
Staco & Combined



Muid & Combined



Staco & Combined with tagged



Muid & Combined with tagged

Signal-to-background significance

We integrated over the region within one standard deviation from the mean of the Gaussian distribution for the signal, and the quadratic curve for the background.

$$\text{signal } S = A\int_{\bar{m}-\sigma}^{\bar{m}+\sigma} e^{-\frac{1}{2}\left(\frac{m-\bar{m}}{\sigma}\right)^2} dm$$

$$\text{background } B = \int_{\bar{m}-\sigma}^{\bar{m}+\sigma} \left(am^2 + bm + c\right) dm$$

$$\text{upper bound} = \frac{S+\sqrt{S}}{\sqrt{B-\sqrt{B}}}$$

$$\text{lower bound} = \frac{S-\sqrt{S}}{\sqrt{B+\sqrt{B}}}$$

$$\begin{array}{c}\text{signal-to-background}\\ \text{significance}\end{array} = \frac{S}{\sqrt{B}}$$

Results

	Muon Recon	Combined or co w/ tagged	Signal (# of events)	Background (# of events)	Signal-to-bgd Significance
ω/ρ	muid	Combined	145.28	158.65	10.18-13.02
	staco	Combined	217.75	210.36	13.54-16.61
	staco	Combined w/ tagged	248.55	335.36	12.38-14.84
ϕ	muid	Combined	131.05	214.86	7.89-10.07
	staco	Combined	147.77	208.91	9.07-11.47
	staco	Combined w/ tagged	180.31	301.67	9.34-11.49
$\omega/\rho + \phi$	muid	Combined	276.33	373.52	13.10-15.57
	staco	Combined	365.50	419.26	16.52-19.26
	staco	Combined w/ tagged	428.86	637.03	15.86-18.18

Results

	Muon Recon	Combined or co w/ tagged	Signal (# of events)	Background (# of events)	Signal-to-bgd Significance
J/Ψ	muid	Combined	1283.67	120.73	108.73-125.96
	muid	Combined with tagged	1582.80	186.79	108.98-123.32
	staco	Combined	1346.31	131.60	109.49-126.18
	staco	Combined with tagged	1556.95	172.23	111.46-126.56

Summary

Staco gave a better signal-to-background significance at low-mass limit compared to muid. (0.77GeV - 1 GeV)

Staco combined or combined with tagged gave similar signal-to-background significances.

Muid combined with tagged gave the worst signal-to-background significance at low-mass limit due to significant increase in the background.

Inconsistency between me_pt, id_pt and cb_pt for muid combined with tagged was observed.

The difference between Staco and Muid diminished as we moved towards higher mass limit. (~3 GeV)