$Z \to \mu\mu$ rejection in $W \to \mu\nu$ analysis

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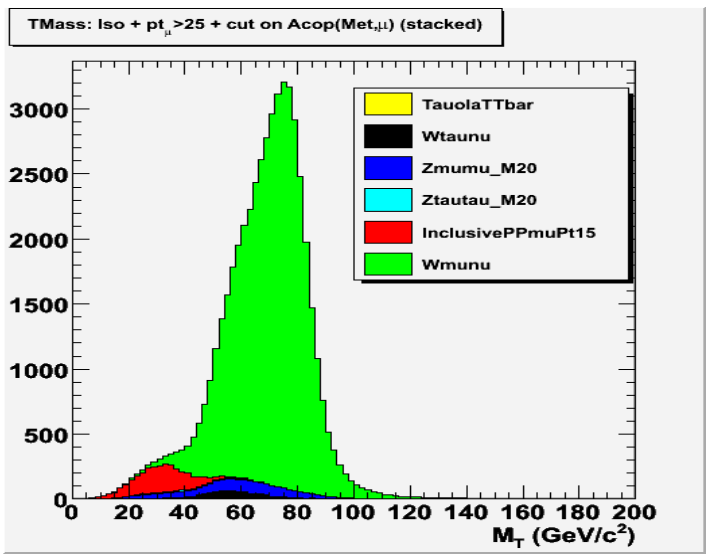
CERN, 21 May 2009

Motivation

With PFMet the most important background is $Z \rightarrow \mu\mu$

See Massimo's talk at 07/05/2009 EWKμ meeting

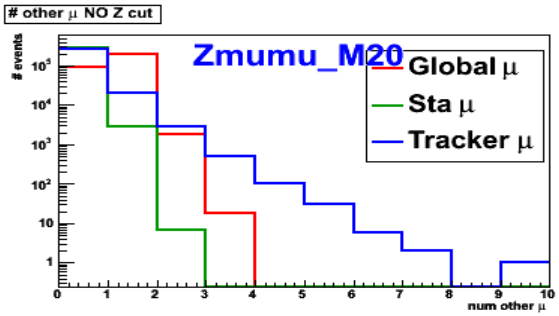


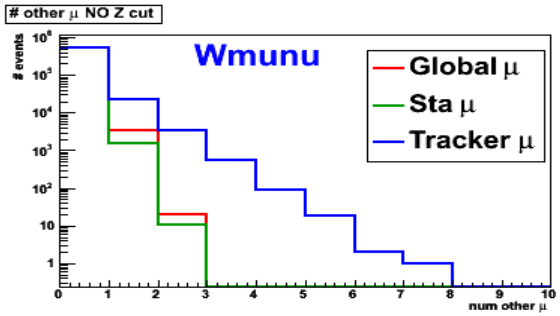
Channel	Counts	Counts ($> 50\mathrm{GeV}$)	Total
$W \rightarrow \mu\nu$	45887	43024	43024
$t\bar{t}$	110	106	
$W \rightarrow \tau\nu$	809	584	
$Z \rightarrow \mu\mu$	2173	1489	2341
$Z \rightarrow \tau\tau$	169	59	
QCD	2546	103	

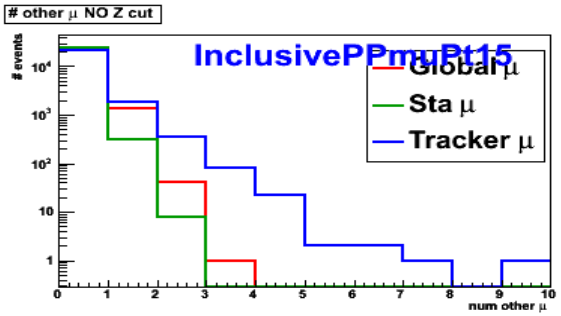
Actual $Z \rightarrow \mu\mu$ selection

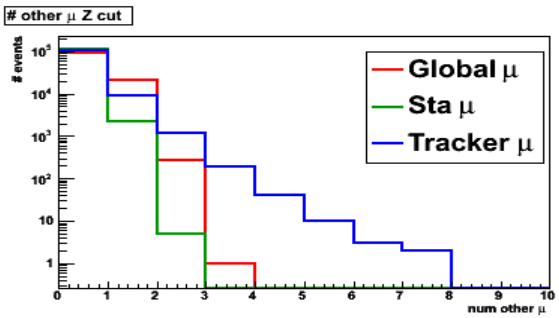
Reject events with > 2 `global` μ with $p_t > 20$ GeV

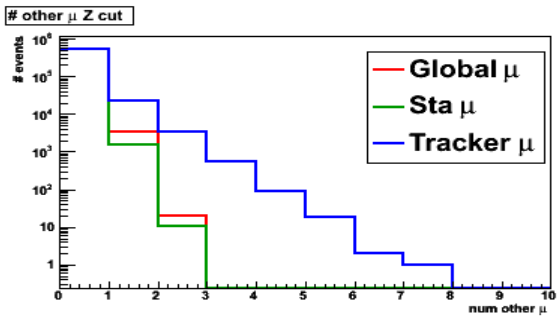
How many "other" μ's do we have?

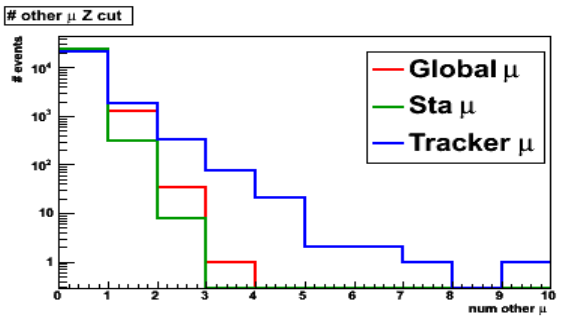












of "other" μ found in the event, excluding the leading

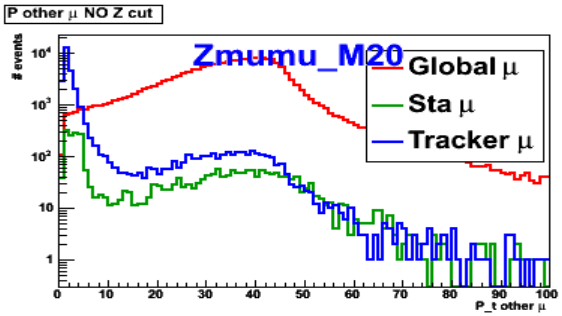
Global, StandAlone, Tracker exclusive!

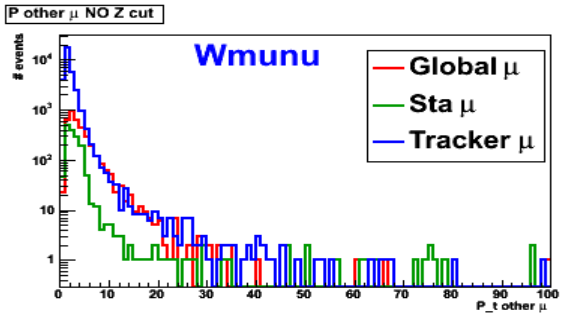
Bottom plot are after Z selection (as explained before)

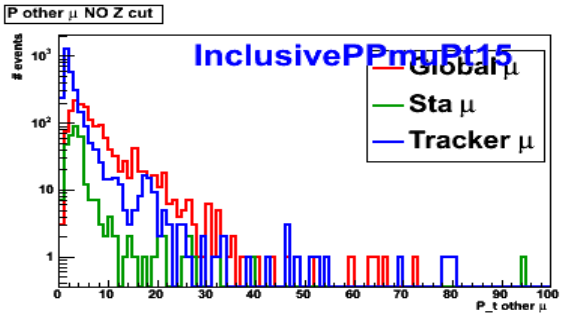
$\sim$ 20% of Z events have still a second global μ after Z rejection

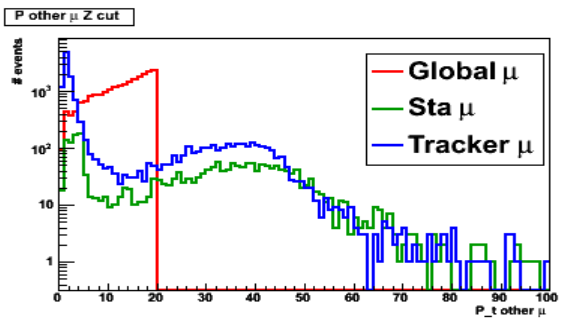
# of Trackerμ seems uncorrelated with physics...

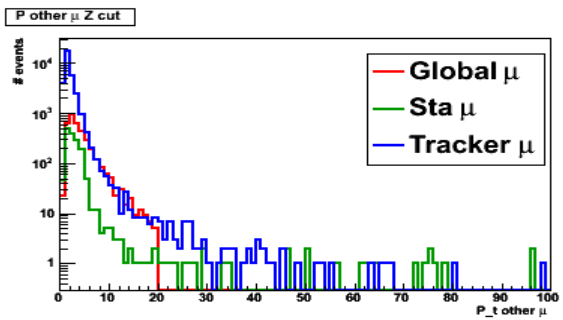
Second muon momentum

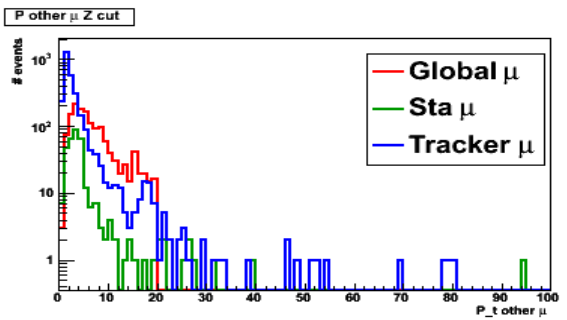












p_t of "other" μ found in the event, excluding the leading

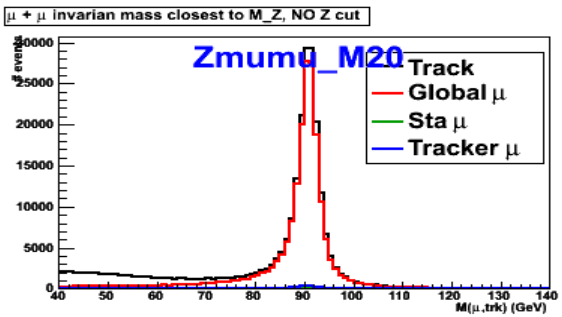
Global, StandAlone, Tracker exclusive!

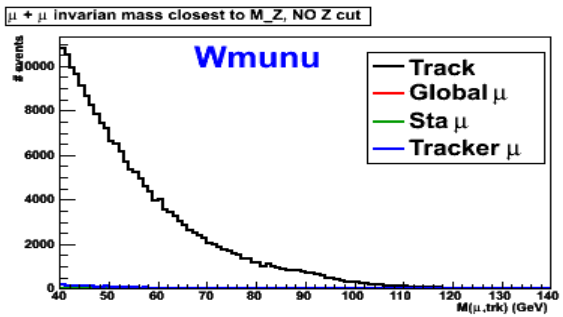
Bottom plot are after Z selection (as explained before)

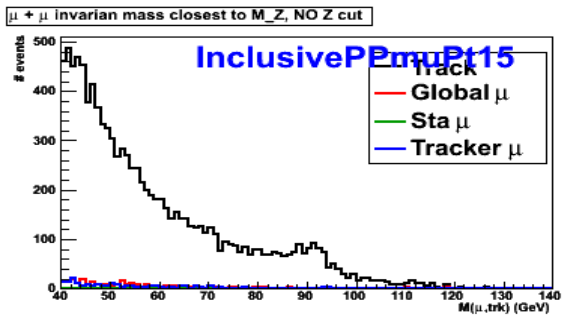
We can cut at lower p_t for second μ

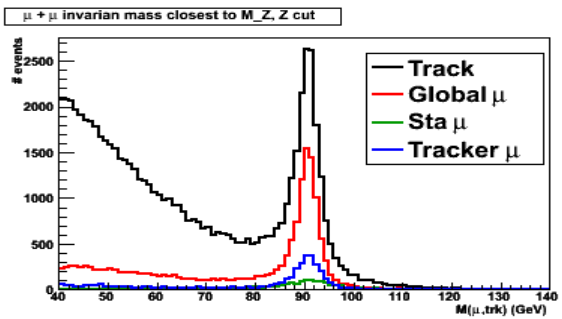
Cut also on non globalμ at high p_t

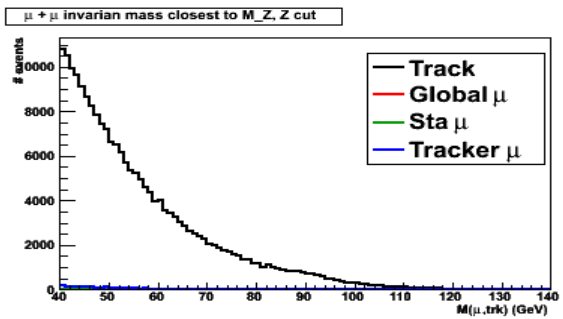
Invariant Mass

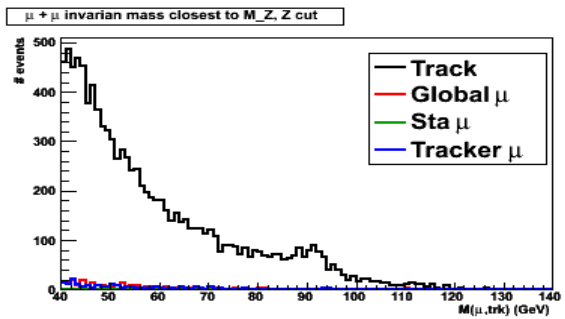












$M_{\mu,\mu}$ of leading with "other" opposite Q μ or track found

Select μ or track by M_{inv} closest to M_Z

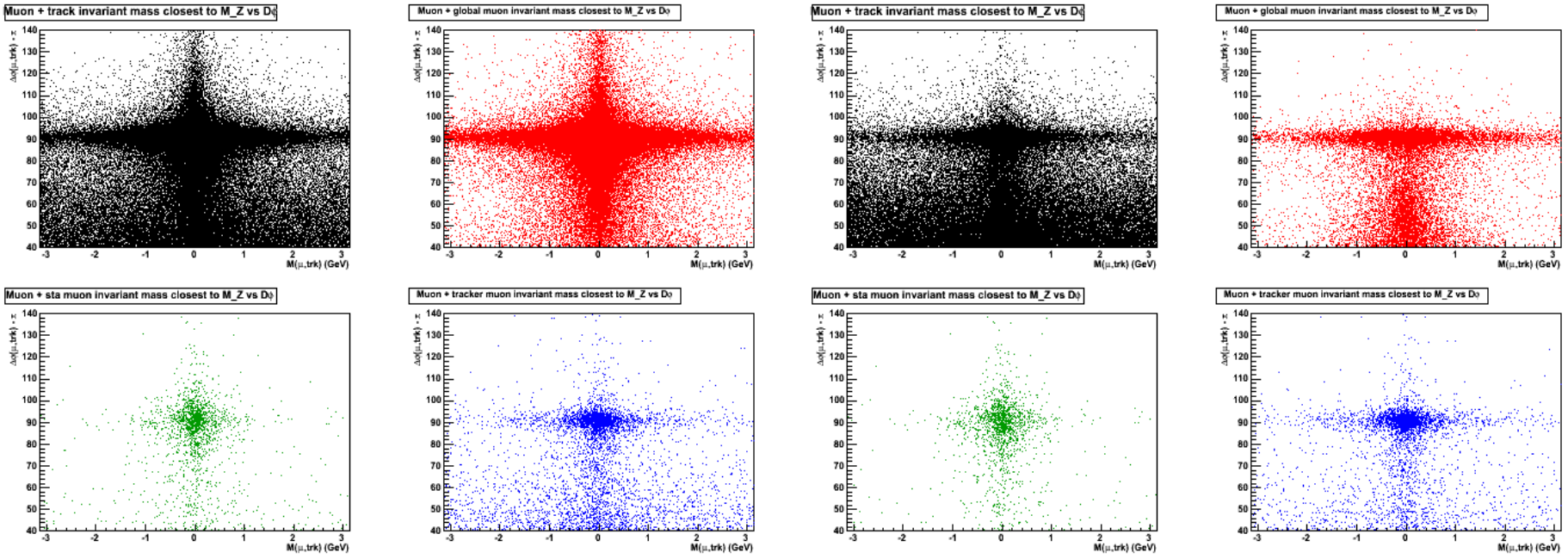
Generic track, (Global, StandAlone, Tracker exclusive)

Bottom plot are after Z selection (as explained before)

Clear evidence of Z peak in Z sample for globalμ and track

In QCD, peak in $M_{\mu,trk}$ due to bias and combinatorics

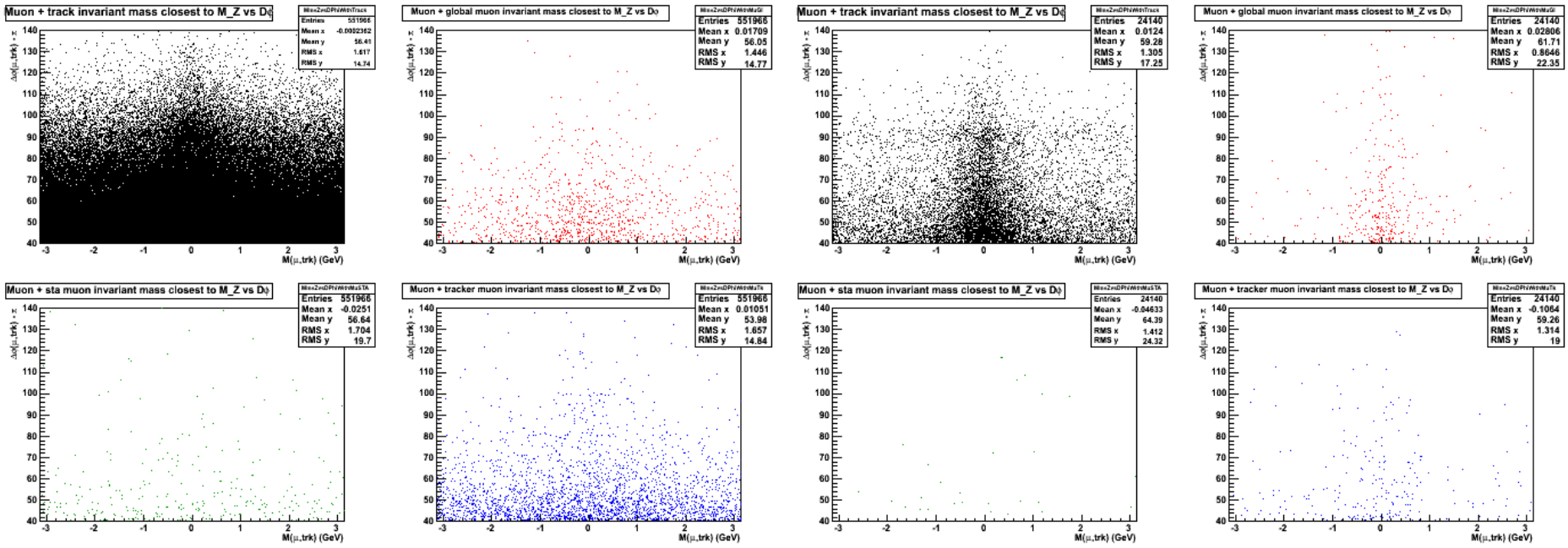
Invariant Mass Vs DPhi for $Z \longrightarrow \mu\mu$



$M_{\mu,\mu}$ vs $\Delta\phi - \pi$ of leading with "other" opposite Q μ or track

Generic track, (Global, StandAlone, Tracker exclusive)
Left plots are before Z selection, right ones after
Clear evidence of Z peak in Z sample for globalμ and track
$\Delta\phi = 0$ means μ back to back with other $\mu/track$.

Invariant Mass Vs DPhi $W \rightarrow \mu\nu$ and QCD



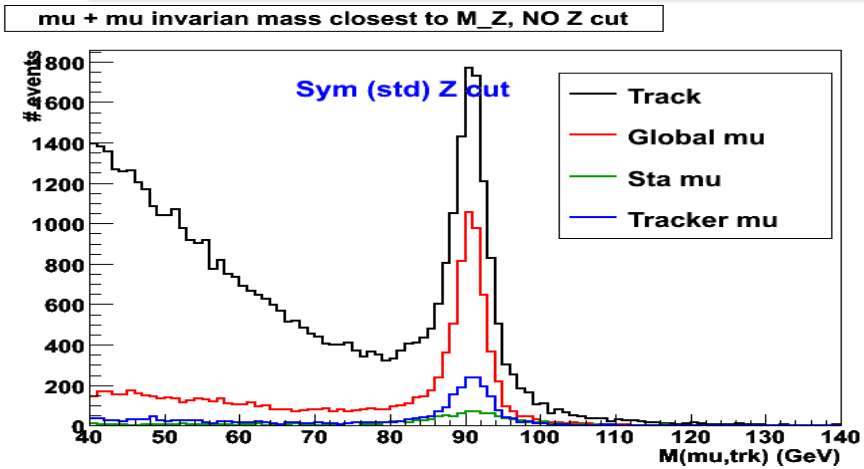
$M_{\mu,\mu}$ vs $\Delta\phi - \pi$ of leading with "other" opposite Q μ or track

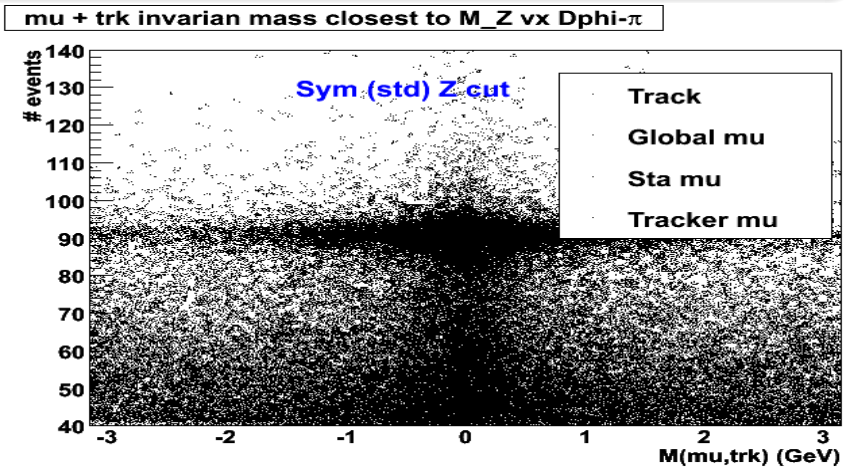
Generic track, (Global, StandAlone, Tracker exclusive)
Left plots are $W \rightarrow \mu\nu$ selection, right ones QCD
Almost no peak (but QCD with track, as seen before)
An other handle to reduce $Z \rightarrow \mu\mu$ signal

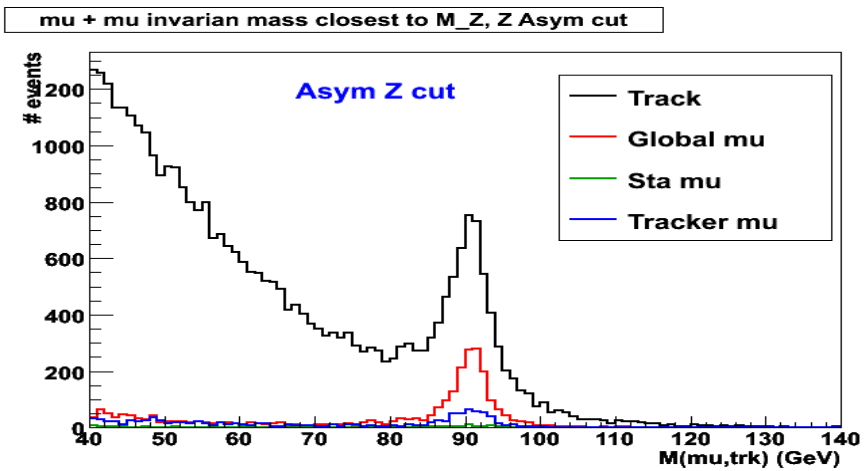
How many events can we reject?

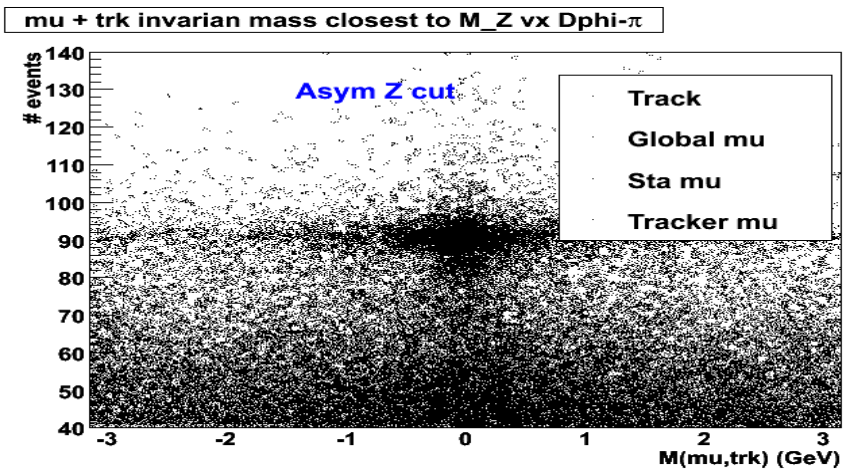
Asymmetric p_t cut

First μ: global and $p_t > 20$ GeV;
Second μ: global or standalone or tracker with $p_t > 10$ GeV;



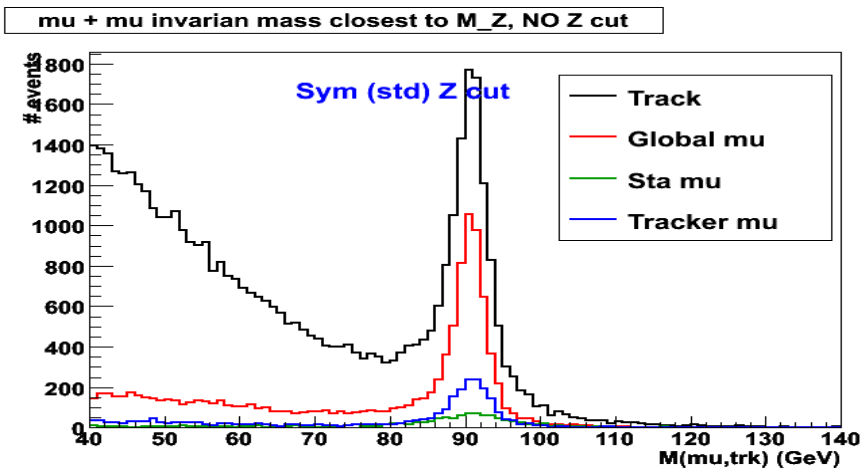


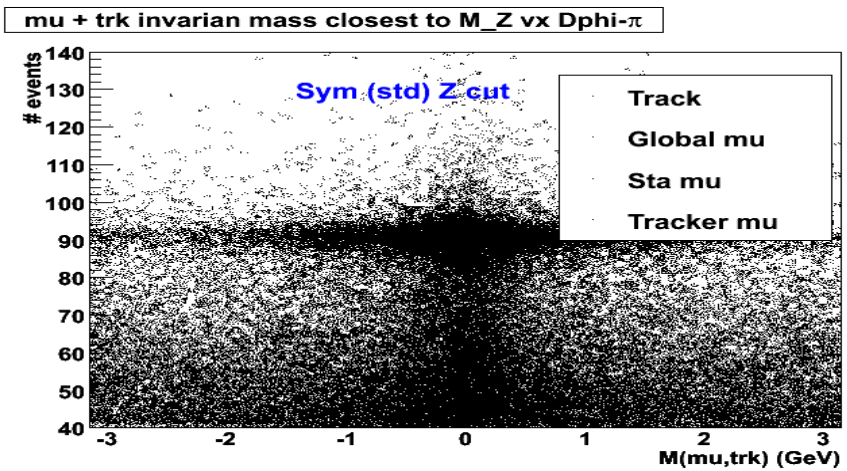


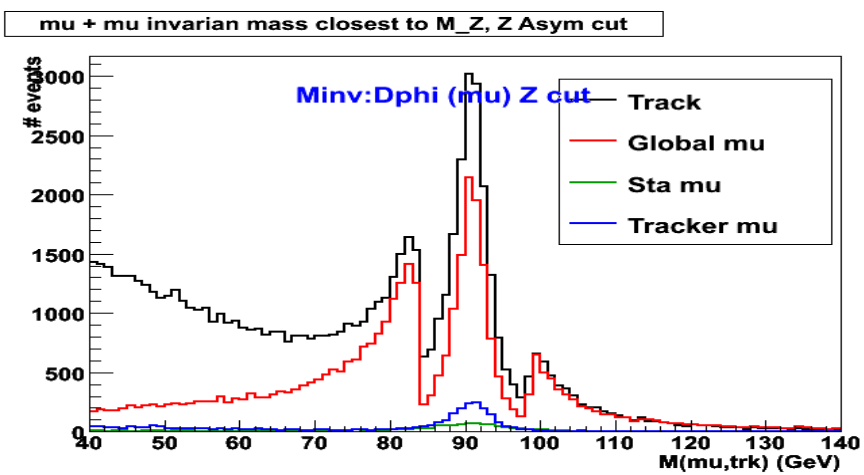


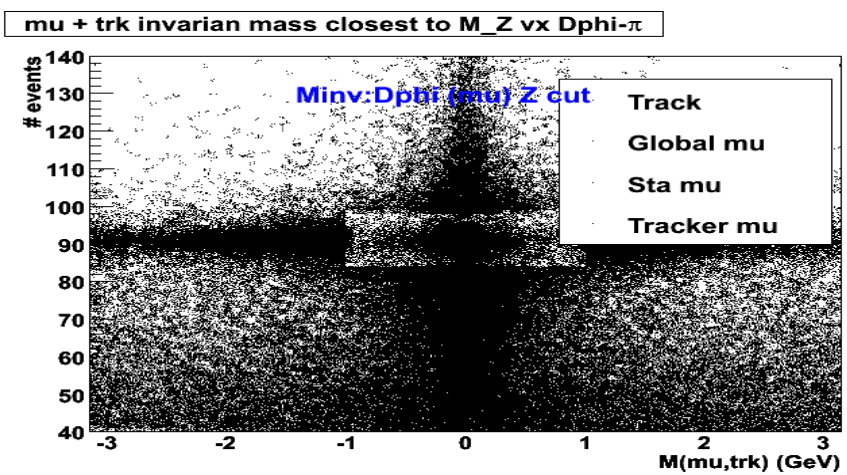
Cut in M_{inv} : $\Delta\phi$ plane

Consider only global-global μ pairs;
$|M_{\mu,\mu} - M_Z| < 7.5$ GeV && $|\Delta\phi_{\mu,\mu}| < 1$;



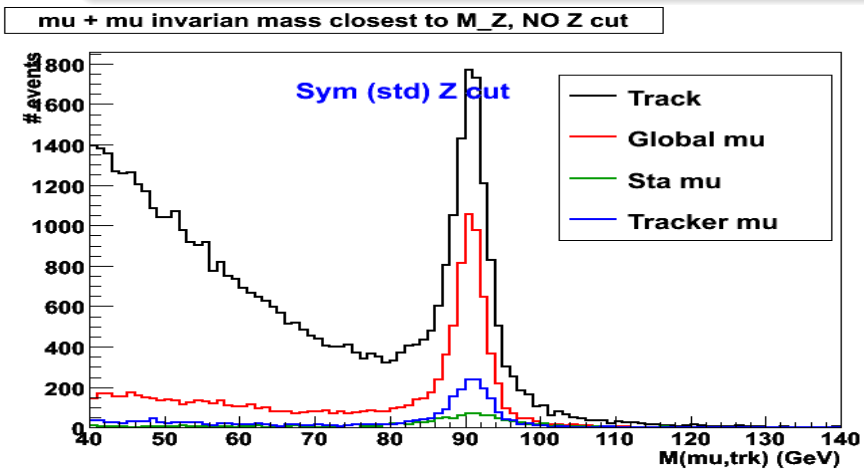


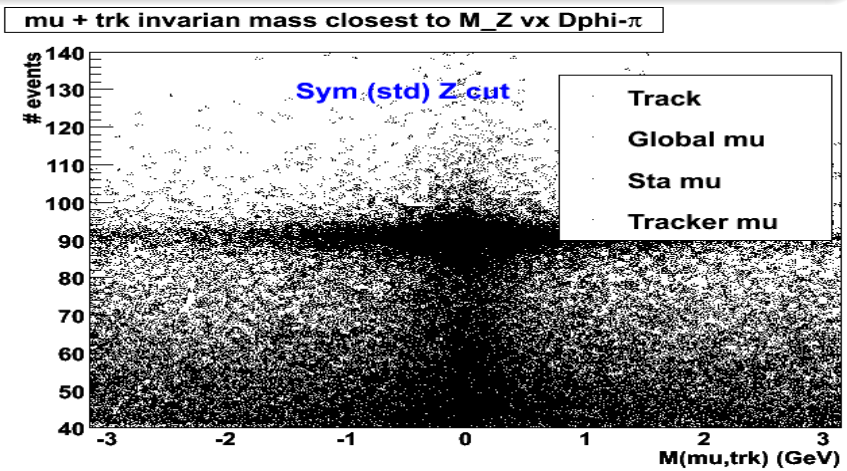


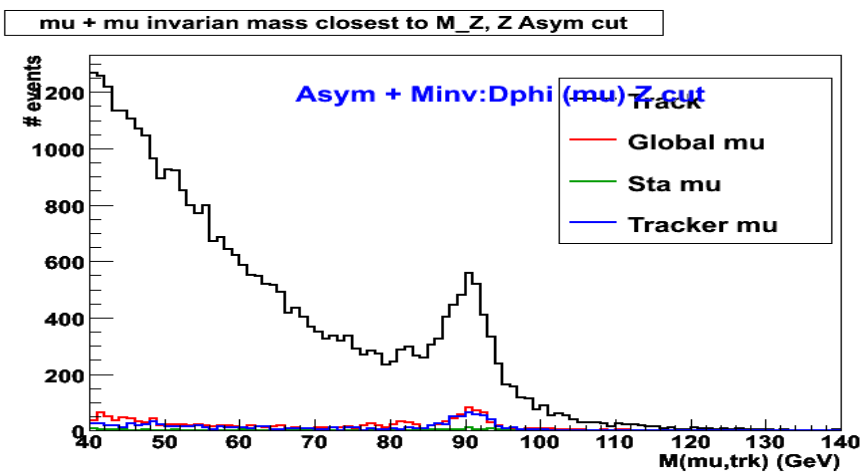


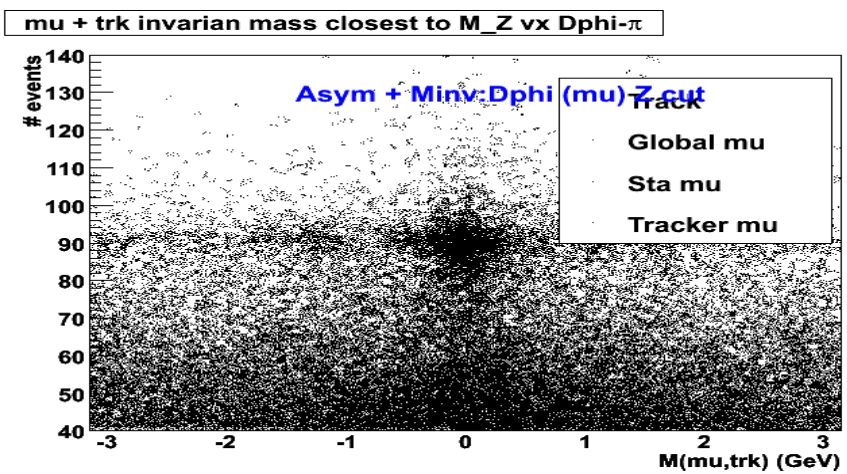
Cut in M_{inv} : $\Delta\phi$ plane + Asymmetric p_t cut

Consider only global-global μ pairs;
$|M_{\mu,\mu} - M_Z| < 7.5$ GeV && $|\Delta\phi_{\mu,\mu}| < 1$;
$Pt_{\mu^1} > 20$ GeV&&$Pt_{\mu^2} > 10$ GeV;



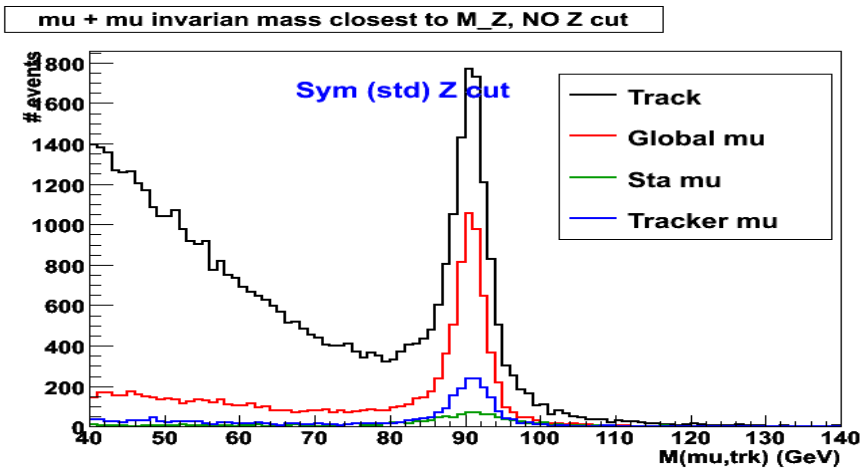


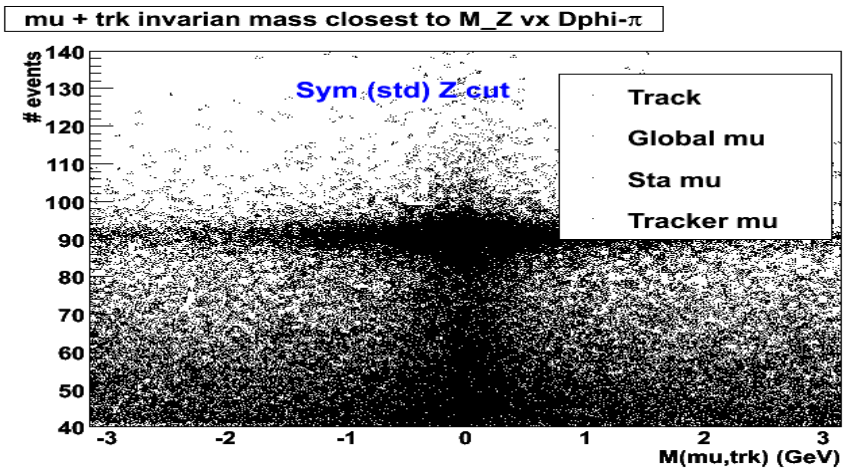


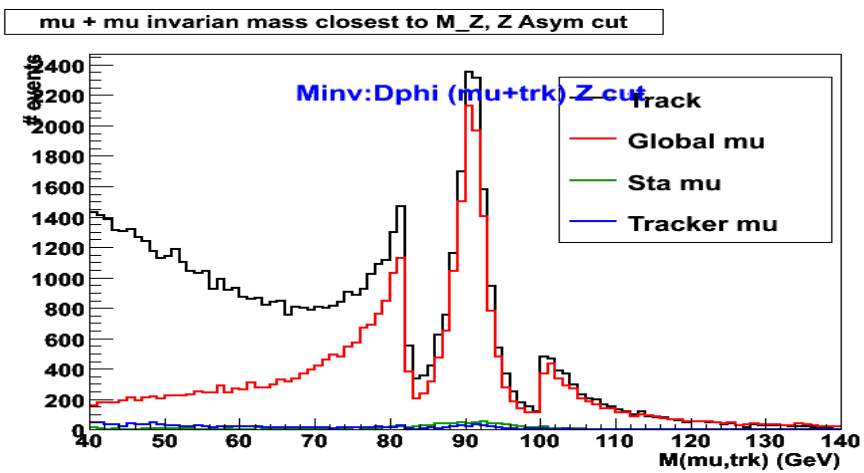


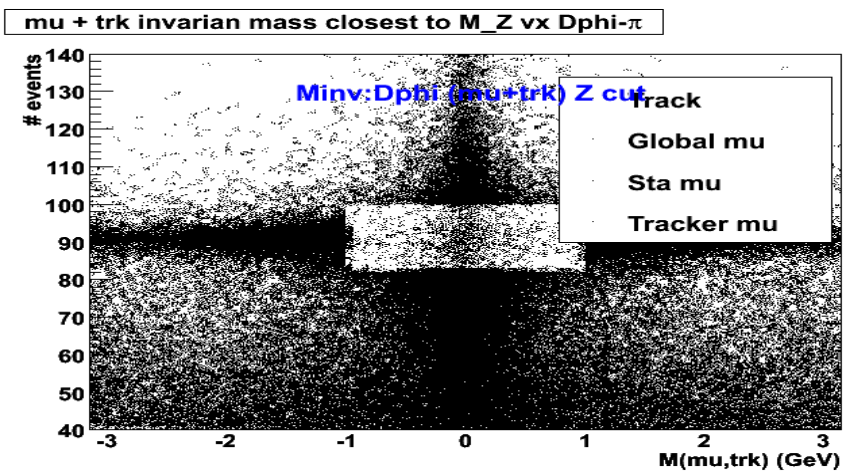
Cut in M_{inv} : $\Delta\phi$ plane

Consider global and any other track (opposite charge) pairs;
$|M_{\mu,\mu} - M_Z| < 9$ GeV && $|\Delta\phi_{\mu,\mu}| < 1$;



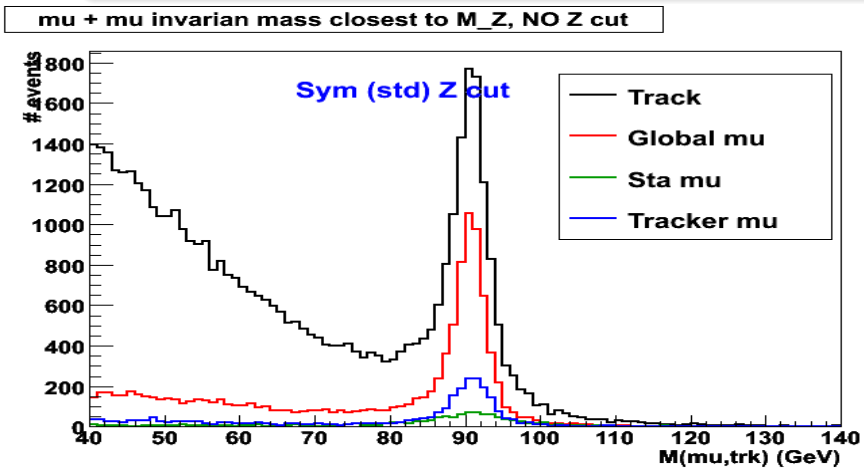


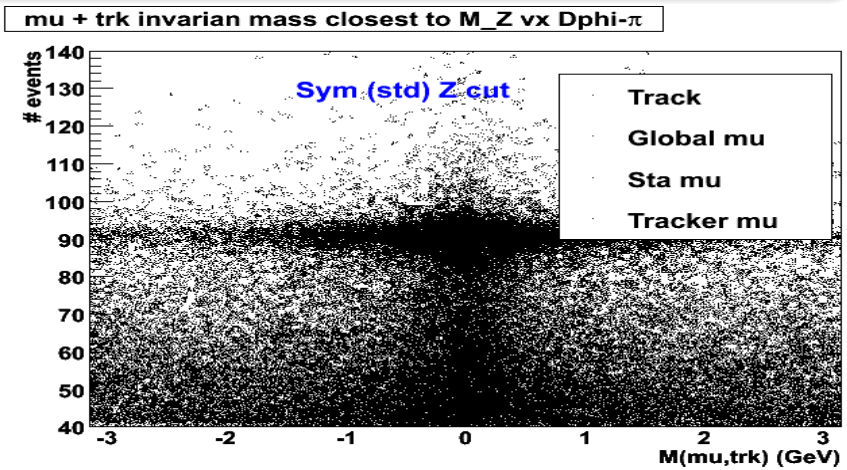


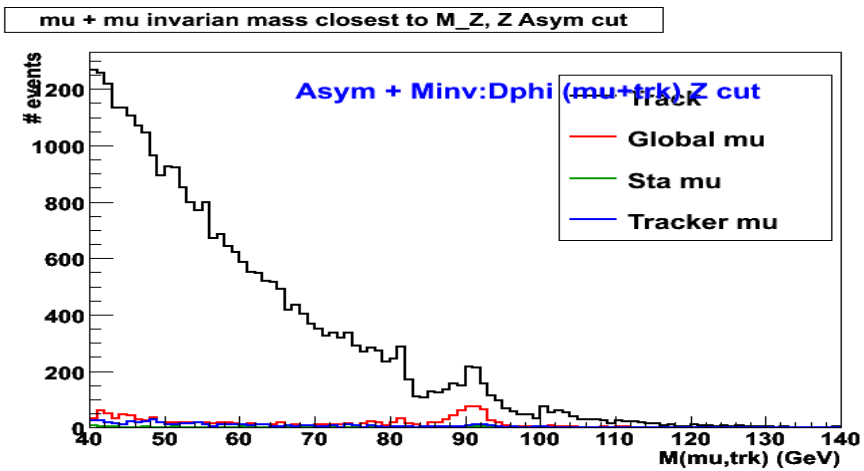


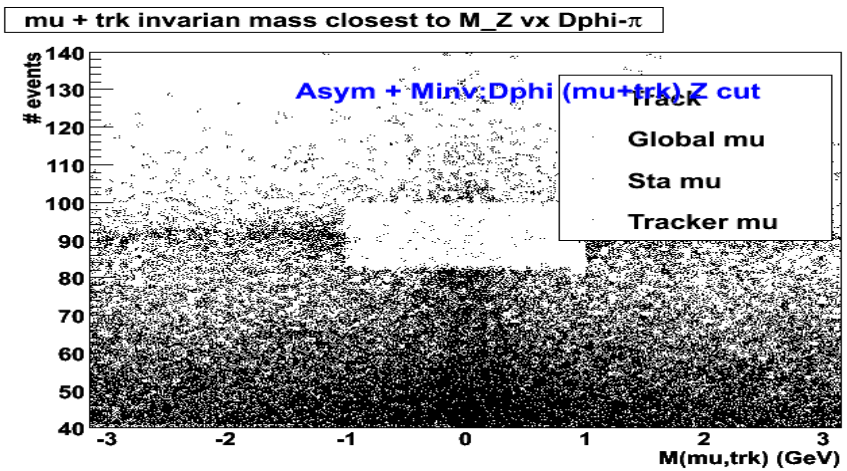
Cut in M_{inv} : $\Delta\phi$ plane + Asymmetric p_t cut

Consider global and any other track (opposite charge) pairs;
$|M_{\mu,\mu} - M_Z| < 9$ GeV && $|\Delta\phi_{\mu,\mu}| < 1$;
$Pt_{\mu^1} > 20$ GeV&&$Pt_{\mu^2} > 10$ GeV;









Signal to background ratio

NB: $W \to \mu\nu$ with only $\sim 20\%$ statistics (job still running...)
Only $W \to \mu\nu$, QCD and $Z \to \mu\mu$ analyzed,
for "other" background kept previous numbers.

Channel	# ev	# ev $M_T > 50$ GeV	Total	$S/\sqrt{B}$
Sym p_t cut				
$W \to \mu\nu$	47983	44985	44985	
$Z \to \mu\mu$	2089	1432	2284	$\frac{S}{\sqrt{B}} = 941$
QCD	2524	103		
Other	1088	749		
Asym p_t cut				
$W \to \mu\nu$	47928	44933	44933	
$Z \to \mu\mu$	1764	1339	2188	$\frac{S}{\sqrt{B}} = 960$
QCD	2496	100		
Other	1088	749		
Asym $p_t + M_{inv} : \Delta\phi_{\mu,\mu}$ cut				
$W \to \mu\nu$	47926	44931	44931	
$Z \to \mu\mu$	1733	1330	2180	$\frac{S}{\sqrt{B}} = 962$
QCD	2496	100		
Other	1088	749		
Asym $p_t + M_{inv} : \Delta\phi_{\mu,trk}$ cut				
$W \to \mu\nu$	47448	44483	44483	
$Z \to \mu\mu$	1643	1298	2143	$\frac{S}{\sqrt{B}} = 960$
QCD	2469	97		
Other	1088	749		

- Limited gain in $S/\sqrt{B}$
- Reduce Z events by $\sim 20\%$ but only by $\sim 10\%$ in signal region $M_T > 50$ GeV
- Cut $Z \to \mu\mu$ events in Z peak, but in most events second μ is not seen.

Conclusion

- Actual $Z \rightarrow \mu\mu$ rejection is too loose;
- Can be tighten with an asymmetic p_t cut, including also lesser quality muon for 2^{nd} μ;
- Also can cut on *Minv vs* $\Delta\phi$.
- Anyhow, the overall gain is limited: most of rejected $Z \rightarrow \mu\mu$ are outside the signal region;
- $Z \rightarrow \mu\mu$ irreducible (?) background [2^{nd} μ is not seen] is unaffected.