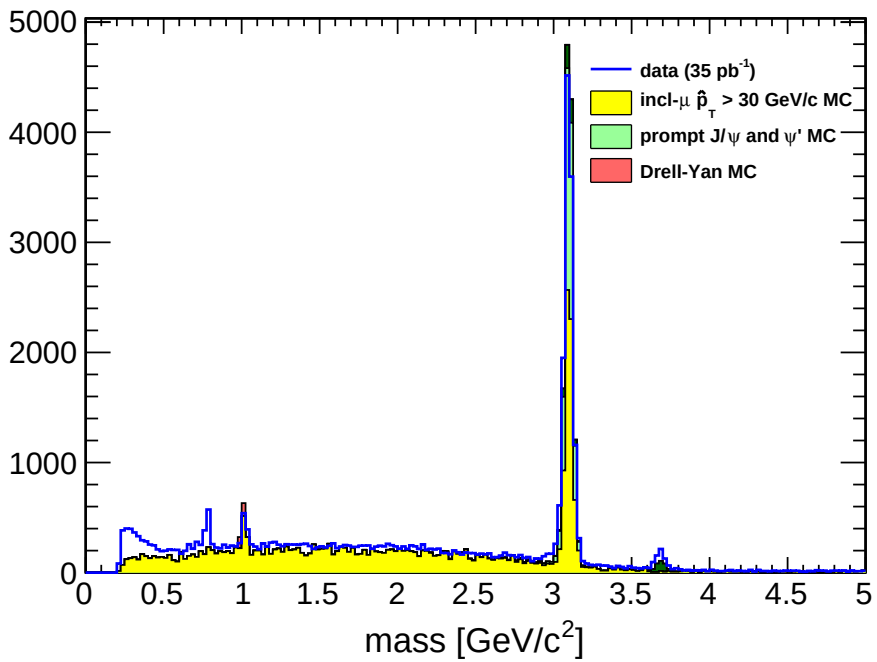
Introduction

A study of the low-p_T dimuon spectrum (background control sample). Normalized by cross-section except prompt J/ψ (factor of 2 too high, reduced by hand).

Baseline cuts:

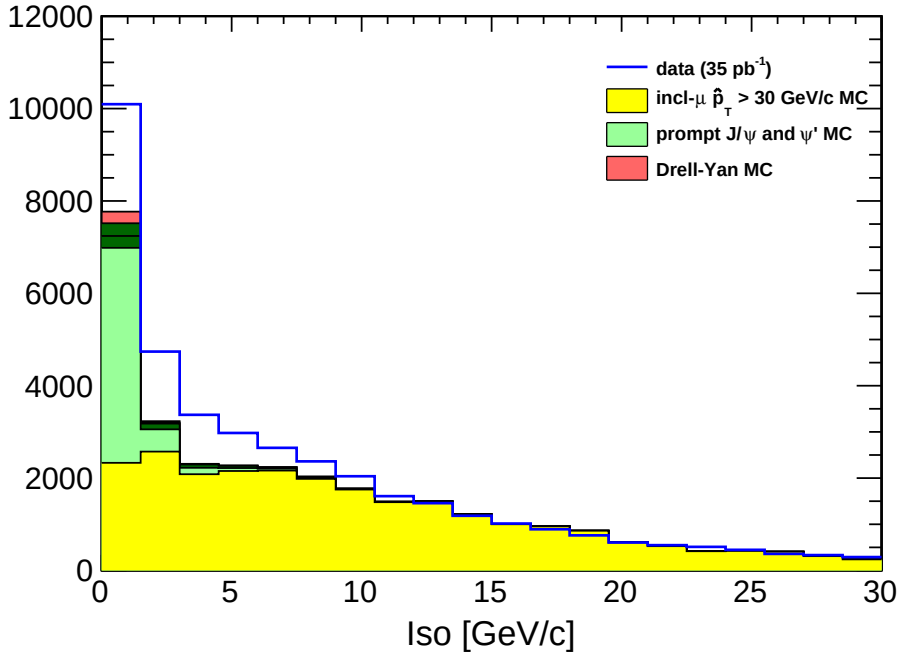
- exactly two opposite-sign muons per event; mass < 5 GeV/c^2
- one muon $p_T > 12$ GeV/c, $|\eta| < 1$ (for trigger)
- the other $p_T > 5$ GeV/c, $|\eta| < 2.4$
- dimuon $p_T < 80$ GeV/c (where backgrounds $\gg 1$ pb)



Isolation as a tool

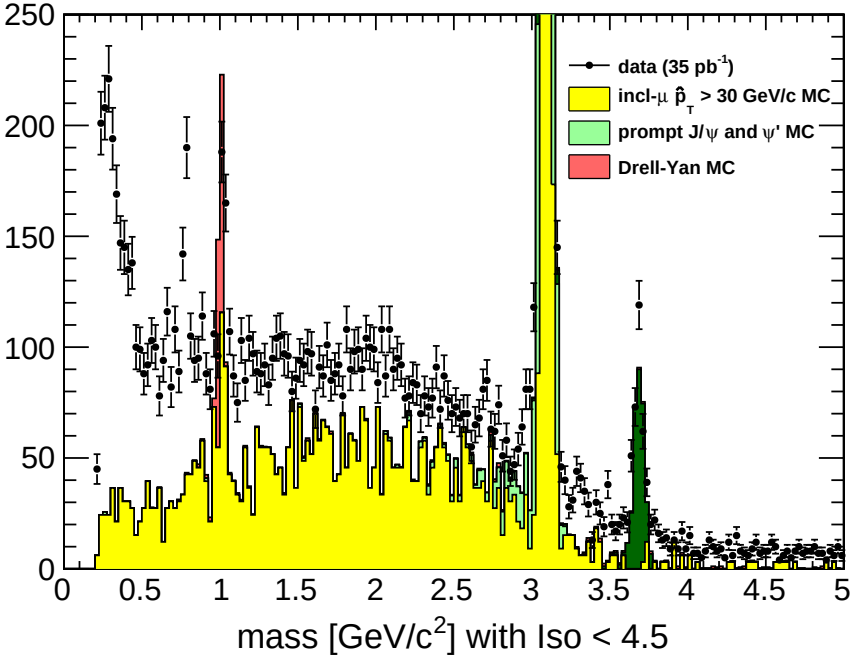
$$Iso = \sum_{\text{non-}\mu\text{ tracks}} \begin{cases} p_T & \text{if } \Delta R < 0.5 \text{ and } p_T > 1.5 \text{ GeV}/c \\ 0 & \text{otherwise} \end{cases}$$

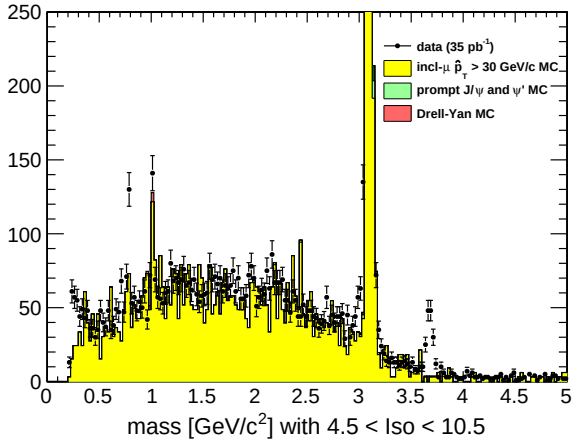
- "isolated:" $Iso < 4.5$ GeV/c (first three bins)
- "iso-sideband:" $4.5 < Iso < 10.5$ GeV/c (next four bins)
- "non-isolated:" $Iso > 10.5$ GeV/c (the rest of the distribution)

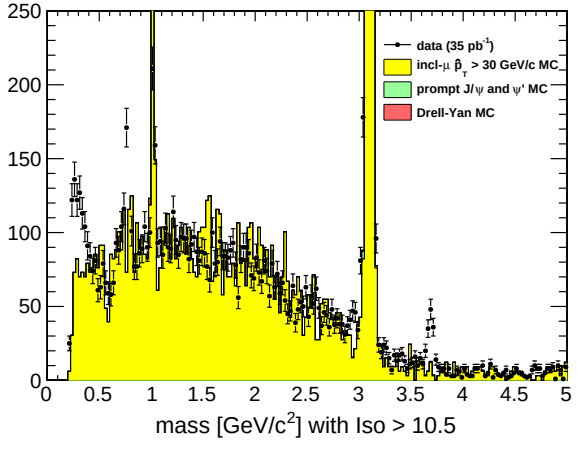


Mass in isolation bins

- Excess in isolated data across the mass spectrum ($1.1 < \text{mass} < 2.9$ GeV/c^2)
- Special excess in mass < 0.5 GeV/c^2, wider than a resonance

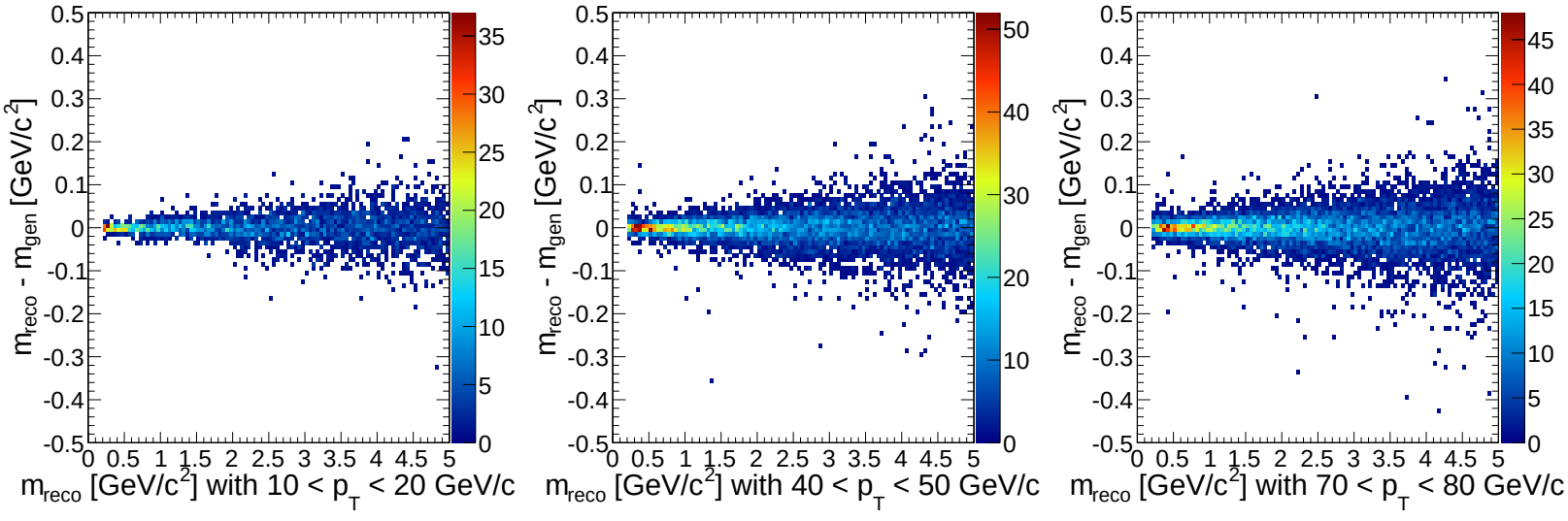






It's not smearing at low mass

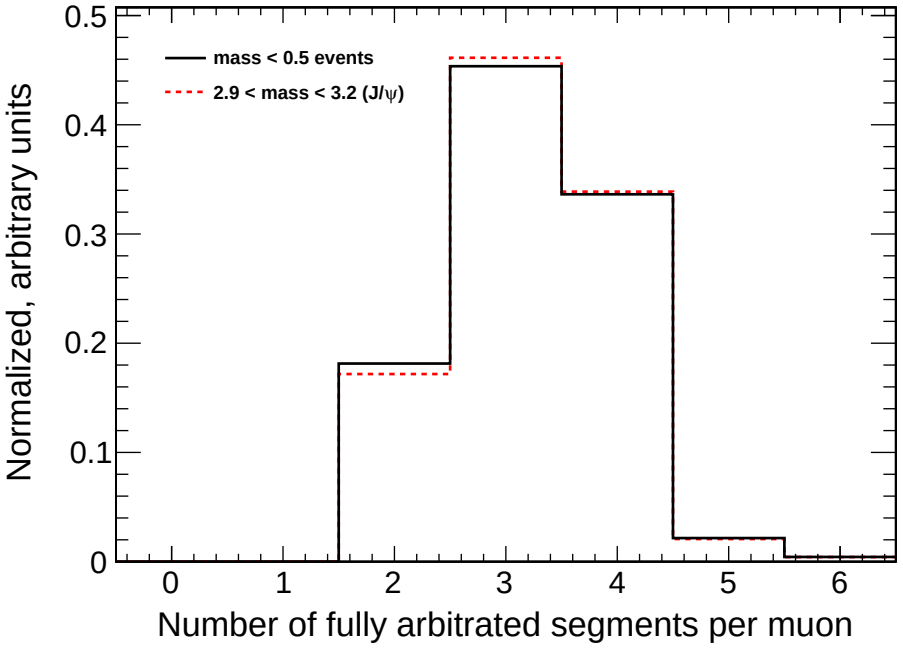
- What if the low-mass part is due to smearing (not in the MC)?
- Quick mass resolution plots from pair-gun

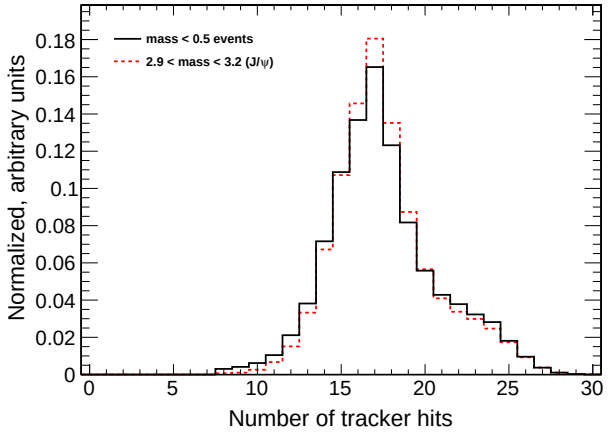


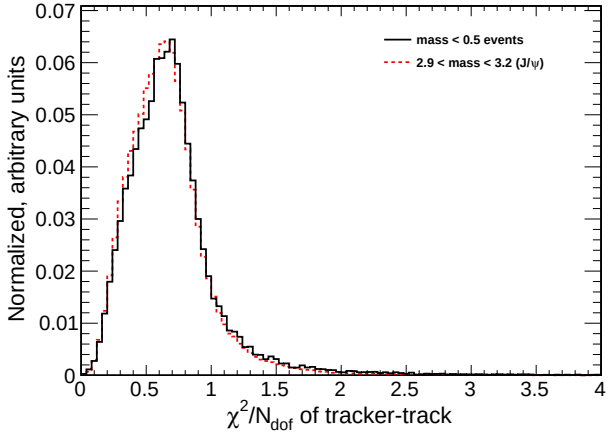
- I suppose this alone doesn't prove that such a thing isn't happening in the real data, but we know that the K_S mass peak is not significantly wider in data than MC

They're not bad muons

- Compare muon quality distributions in the mass < 0.5 GeV/c^2 region (black) with the same distributions in the J/ψ peak (red)
- Normalized to equal area (all data)

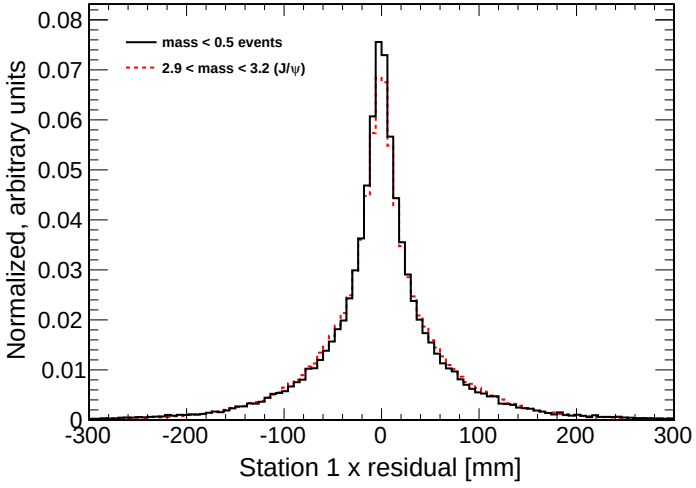


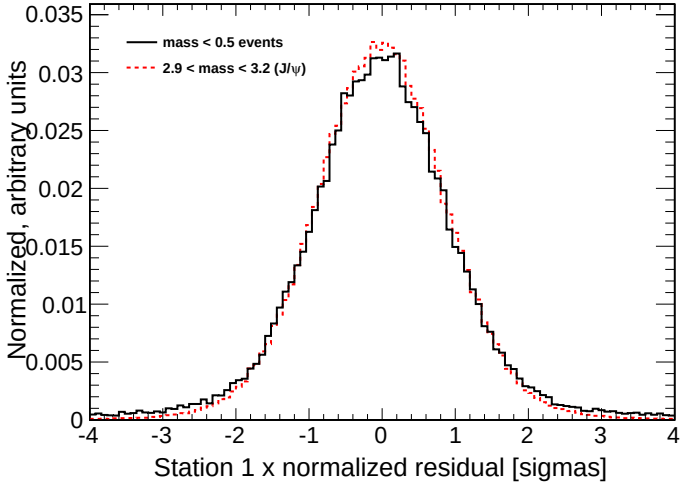


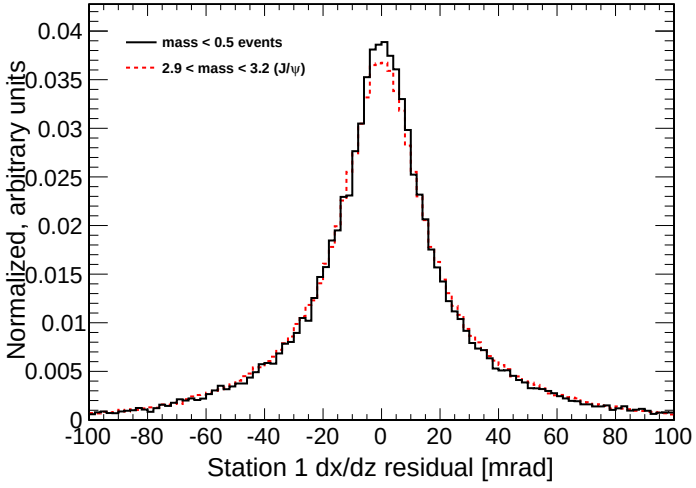


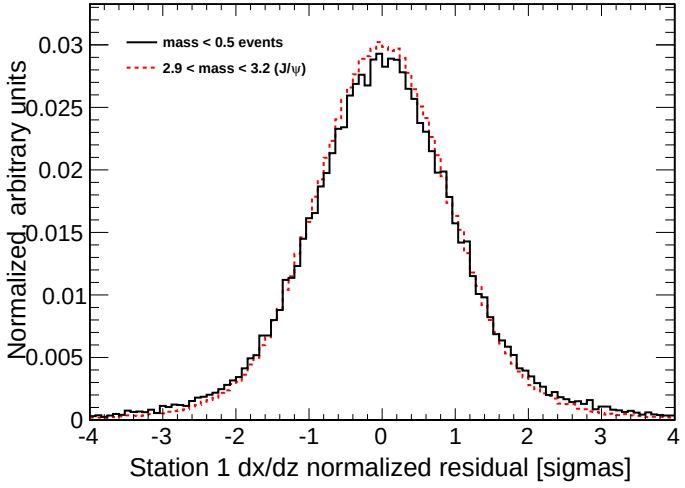
They're not bad muons

- Residuals distributions in station 1 (of both barrel and endcap)



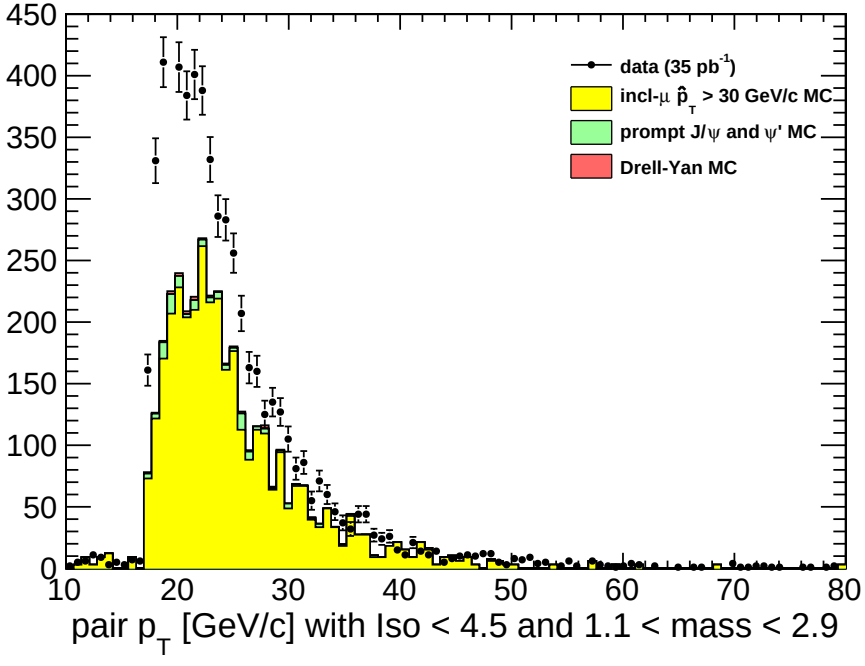


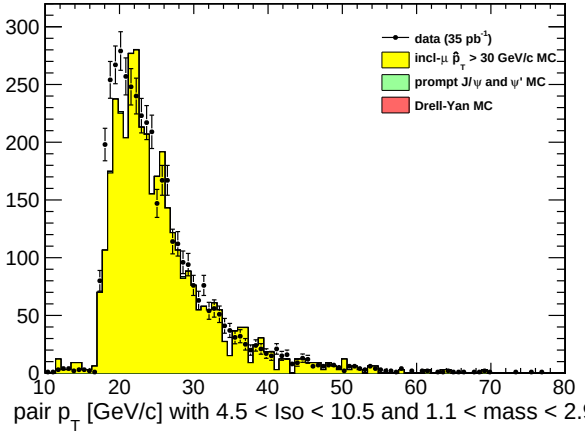


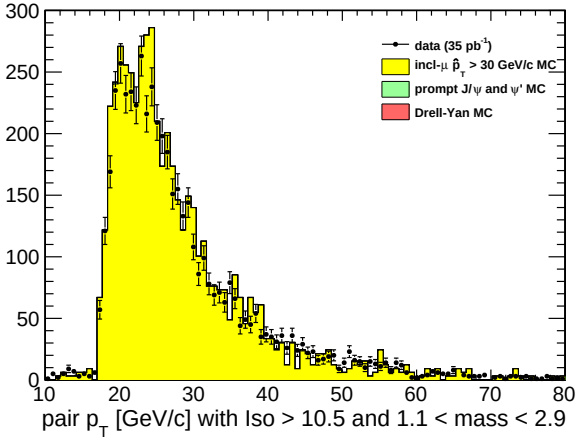


p_T distributions

- Now check dimuon vector-sum p_T distribution of the $1.1 <$ mass < 2.9 GeV/c^2 region (continuum)
- Isolated component (below) is not much different from the rest

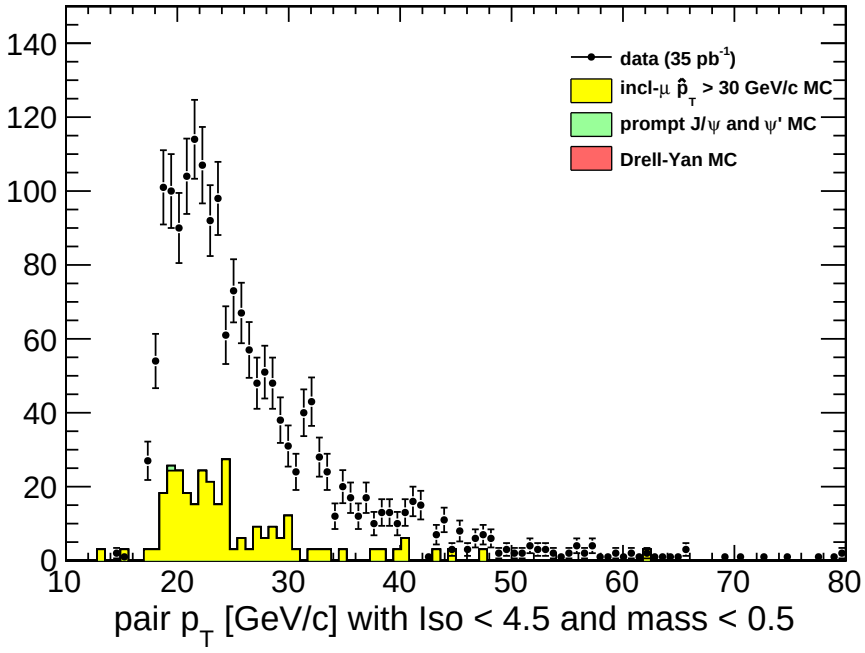


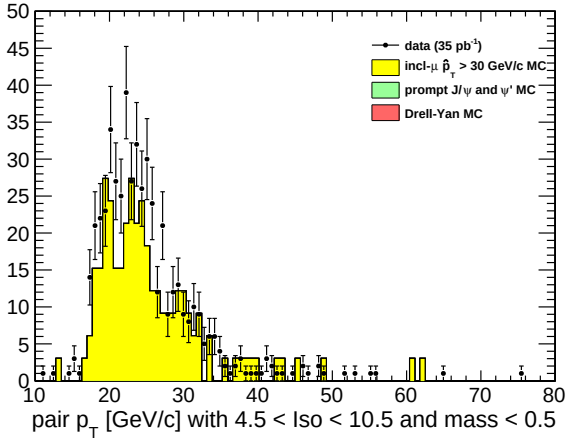


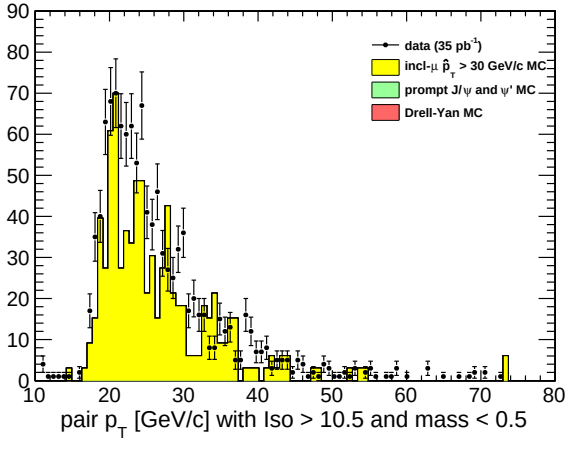


p_T distributions

- Same for mass < 0.5 GeV/c^2 region

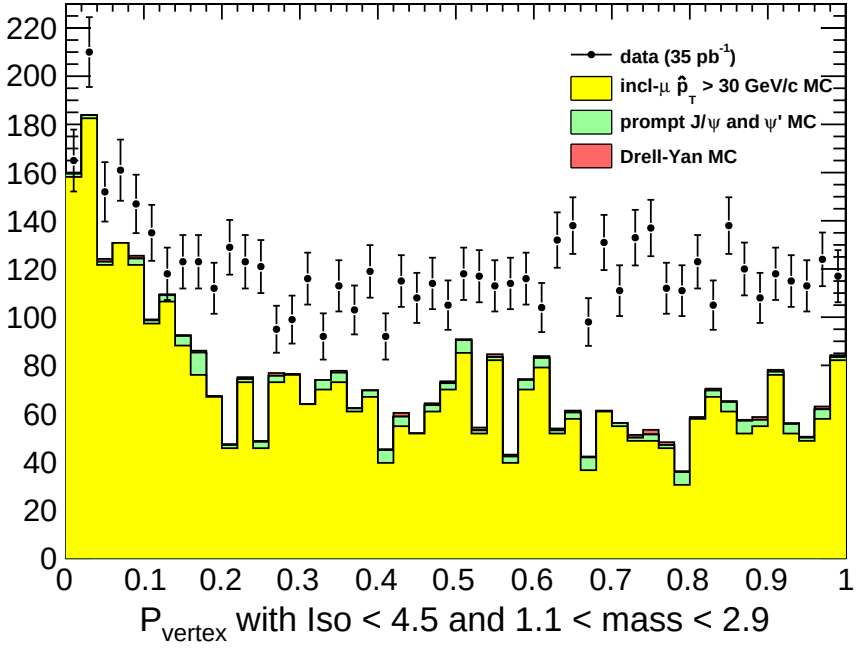


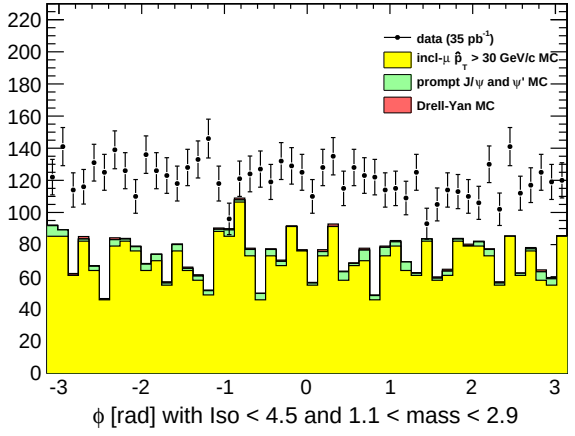


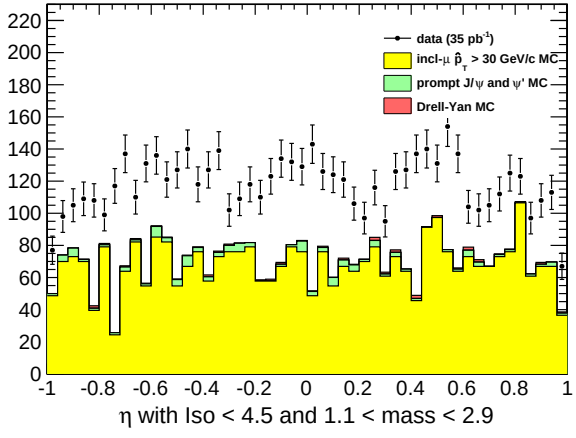


Other variables

- This is the $1.1 < \text{mass} < 2.9$ GeV/c^2 region (continuum) in P_{vertex}, ϕ, η
- Studying only the isolated component
- $b\bar{b}$ has poor P_{vertex} because the two muons sometimes come from different decays



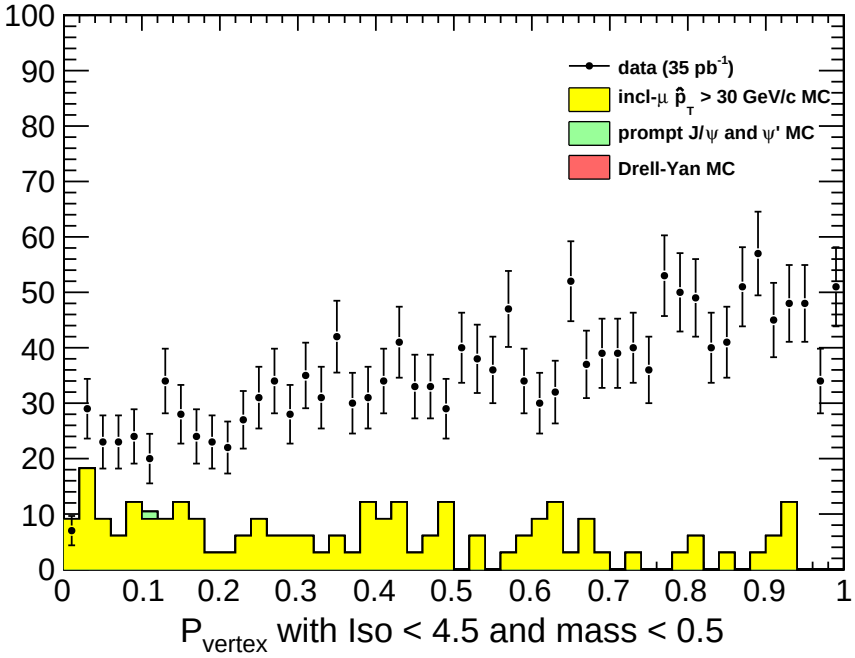


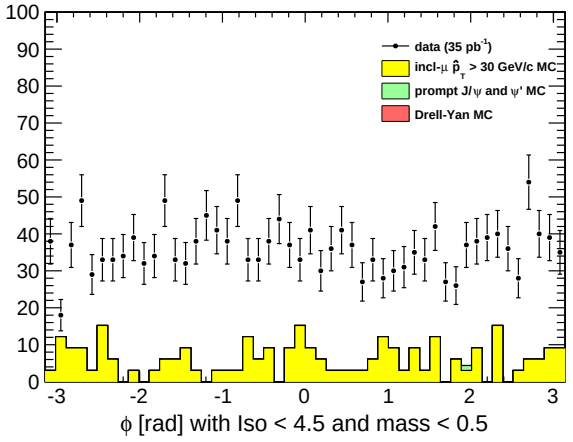


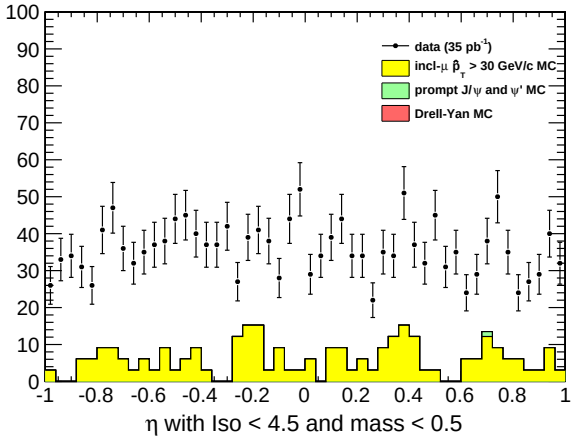
Other variables

- This is the mass < 0.5 GeV/c^2 region in P_{vertex}, ϕ, η
- Studying only the isolated component
- These very small opening angles apparently have a bias toward high P_{vertex} (errors are underestimated)

  (same for continuum: see prev page)

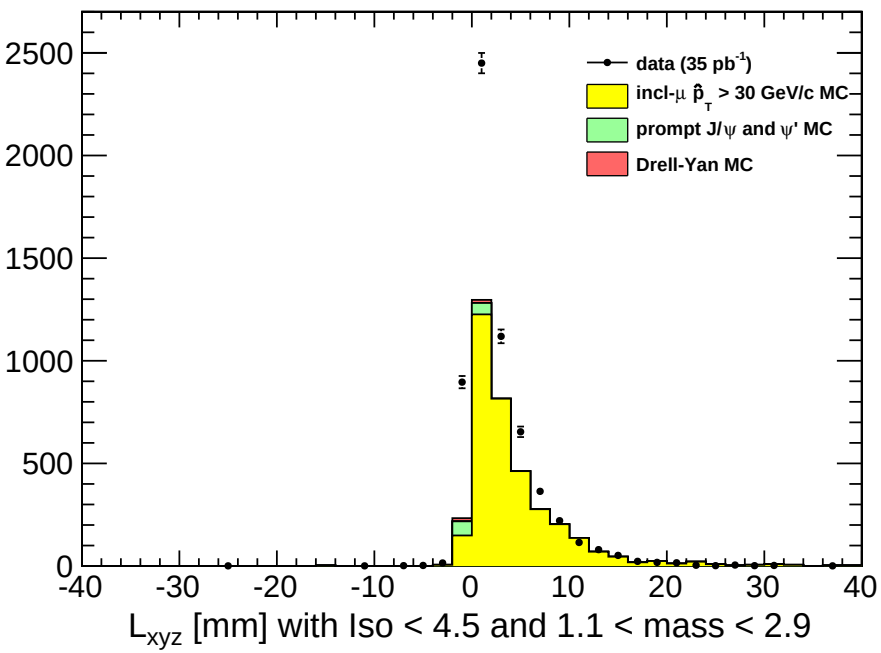


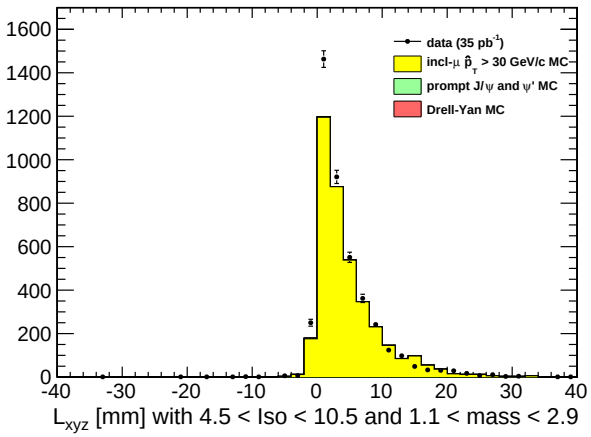


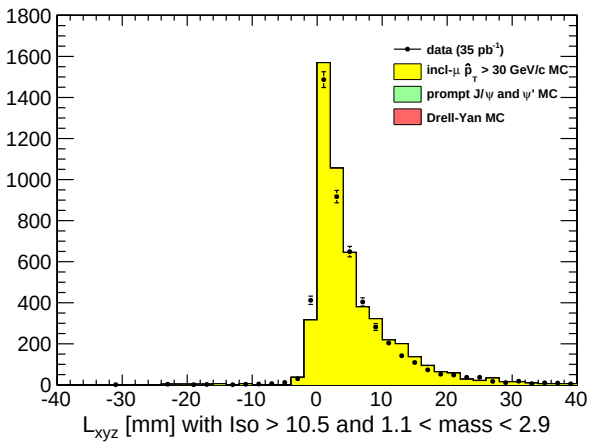


Flight significance

- This is the $1.1 < \text{mass} < 2.9$ GeV/c^2 (continuum) in $L_{xyz} = \vec{x} \cdot \vec{p}/|\vec{p}|$ where $\vec{x}$ is the displacement between the dimuon vertex and the closest primary vertex in z
- Left edge (wrong-direction flights) is resolution; right tail is $\gamma c\tau$
- Beampipe is at 30 mm

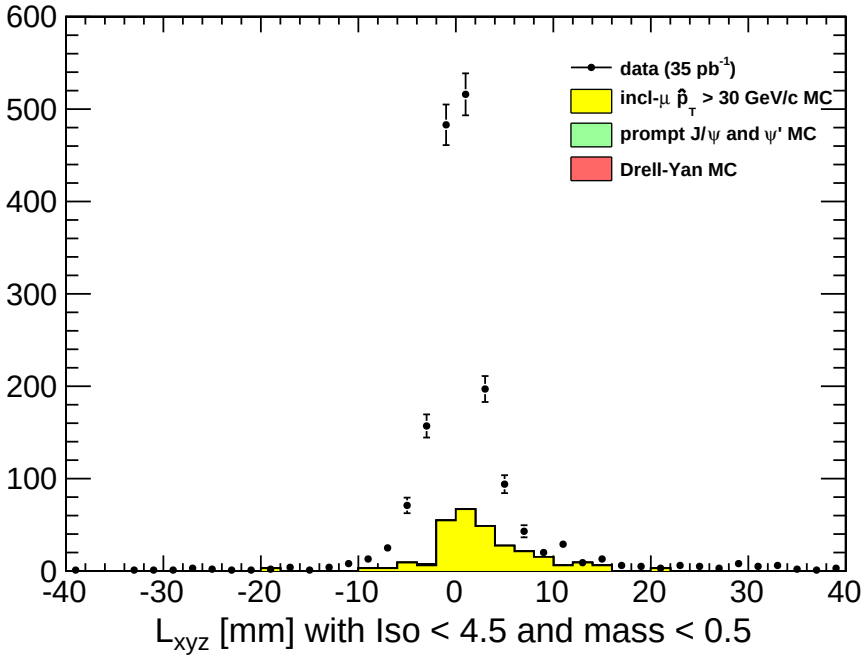


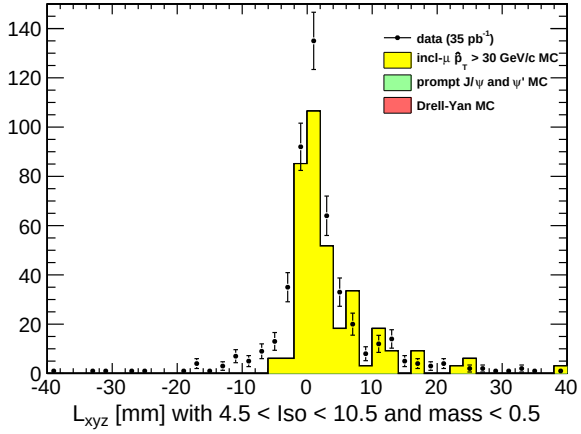


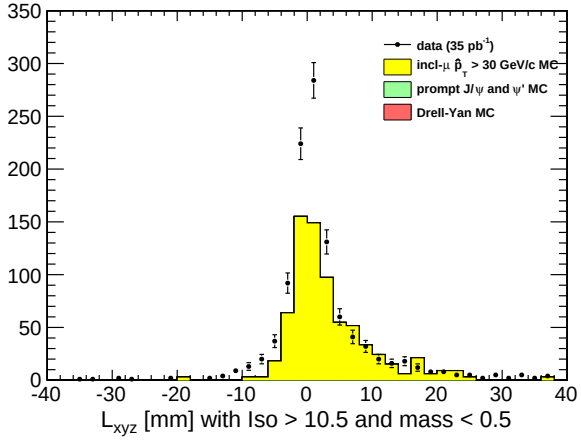


Flight significance

- This is the mass < 0.5 GeV/c^2 in L_{xyz}
- Left edge (wrong-direction flights) is resolution; right tail is $\gamma c\tau$
- Beampipe is at 30 mm ($\gamma \to \mu\mu$ conversions would happen primarily at the beampipe)

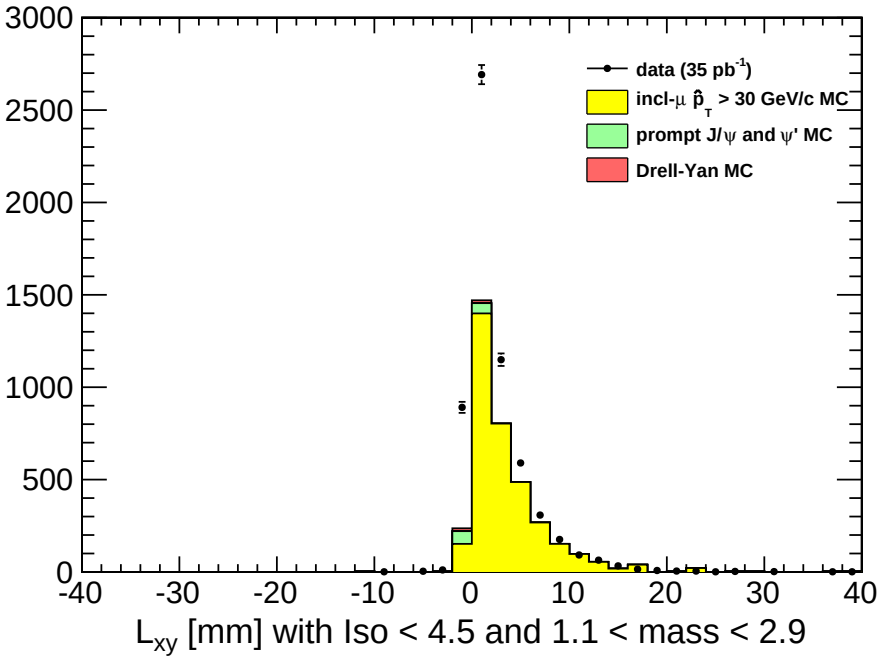


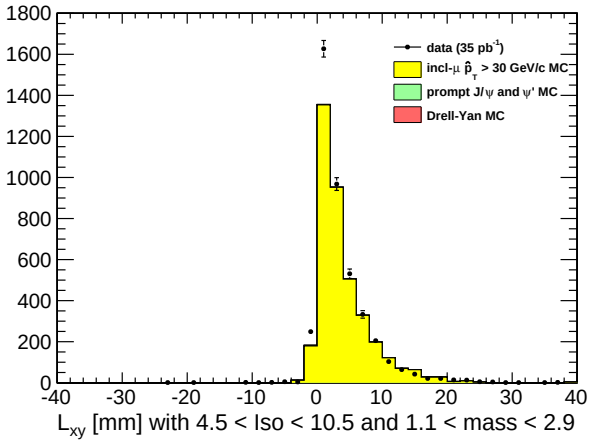


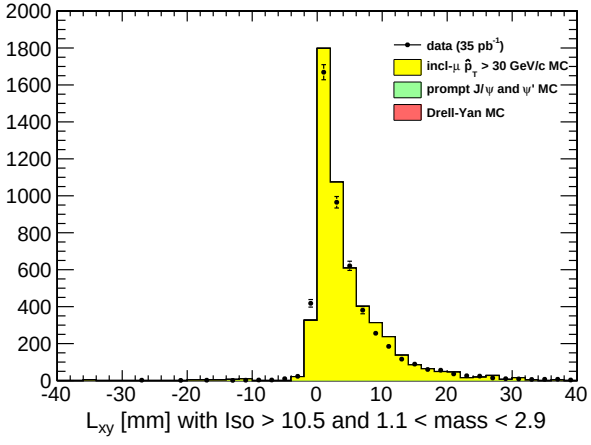


Flight significance

- Repeat for $L_{xy} = \vec{x}_{2D} \cdot \vec{p}_{2D} / |\vec{p}_{2D}|$ in case you think there's a bias in using z because the closest primary vertex was identified using closeness in z
- This is the $1.1 < \text{mass} < 2.9$ GeV/c^2 continuum

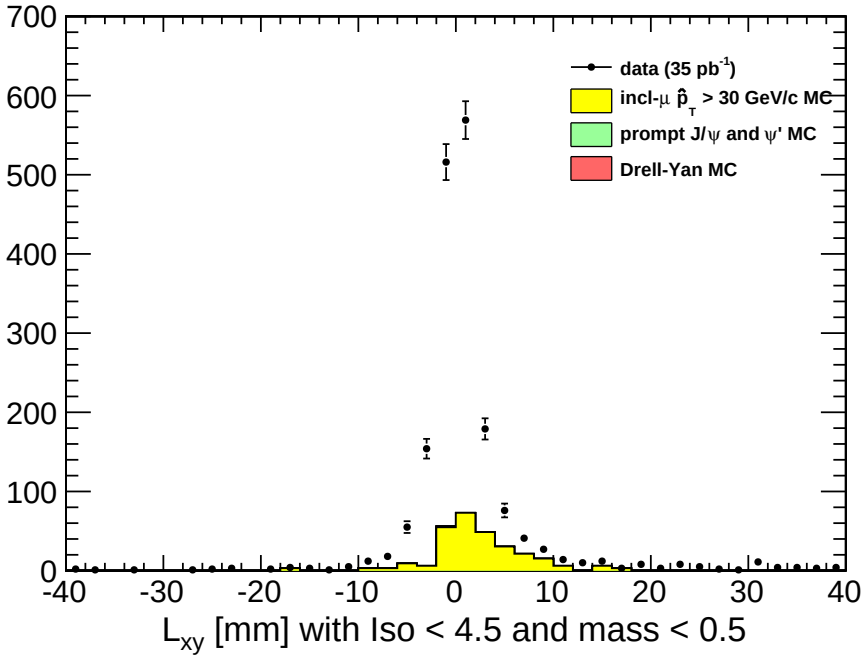


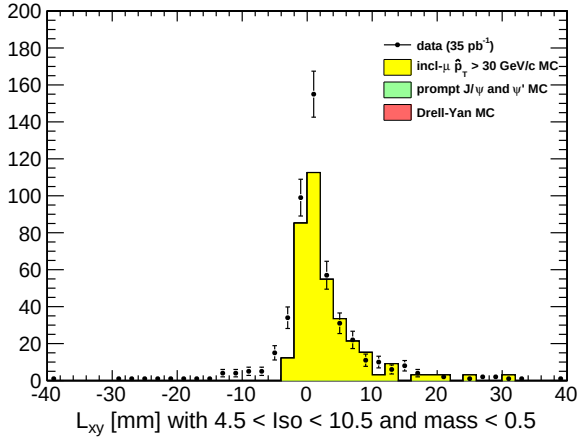


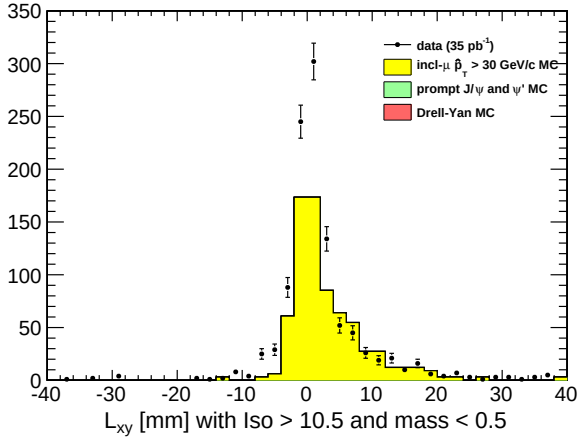


Flight significance

- Repeat for $L_{xy} = \vec{x}_{2D} \cdot \vec{p}_{2D} / |\vec{p}_{2D}|$ in case you think there's a bias in using z because the closest primary vertex was identified using closeness in z
- This is the mass < 0.5 GeV/c^2 excess







What is certain

- There's a significant class of events in data, not in this set of MC, with the following properties:
  - isolated
  - real dimuons (not fake tracks or decays-in-flight or anything)
  - good vertex (not expected of all $b\bar{b}$)
  - appear at the origin (not expected of all $b\bar{b}$ or any $\gamma \to \mu\mu$ conversions)
  - a continuum and a sharp excess at low mass (too wide to be a resonance)
- tried checking angular distribution of muons in the rest frame (check for vector versus uncorrelated), but this is highly sculpted by cuts

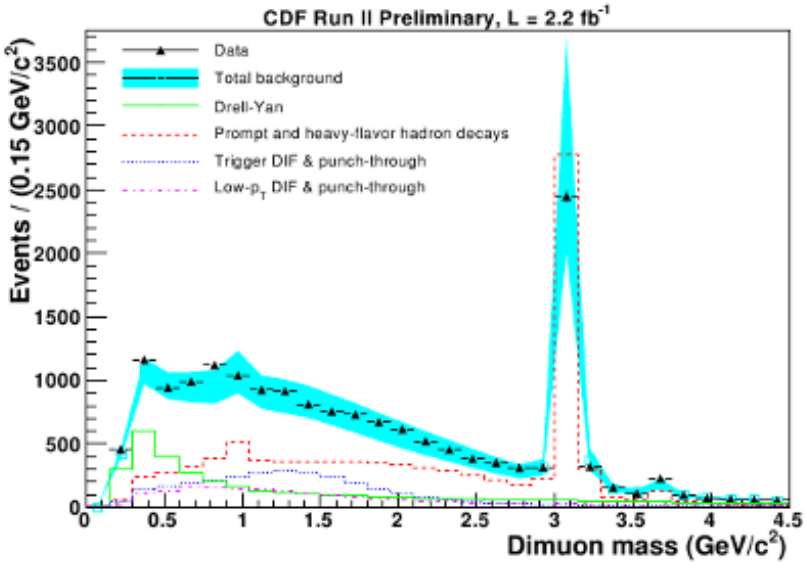
What is likely

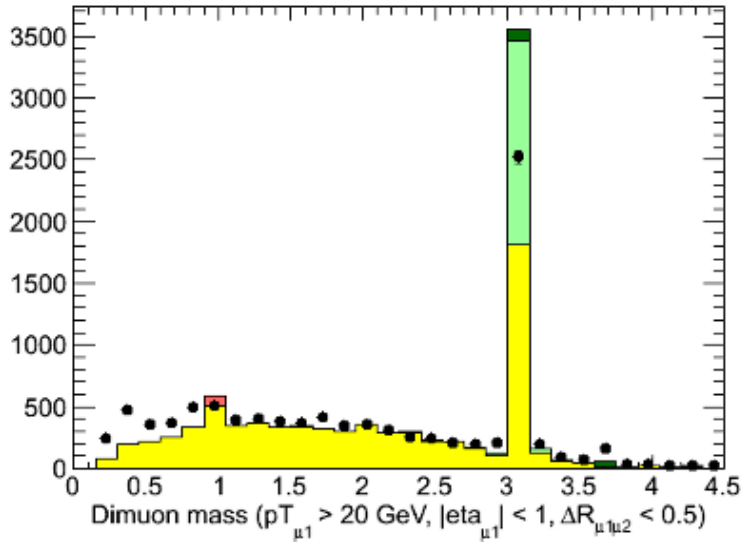
- The continuum, at least, is Drell-Yan— there must be a problem with the Drell-Yan MC (privately generated, only change from official sample: $0 < \sqrt{s} < 5$ GeV/c^2 instead of $20 < \sqrt{s} < 40$ GeV/c^2).

Found a CDF paper on this

- Use the same binning, same cuts:
  - minimum p_T by applying $\Delta R < 0.5$ (but still $p_T < 80$ GeV/c!)
  - ask for one $p_T > 20$ GeV/c muon
  - for this plot, I *don't* rescale prompt J/ψ by a factor of two

`http://www-cdf.fnal.gov/publications/cdf10013_dimuon_lowmasshighpt.pdf`





- Their Drell-Yan Monte Carlo looks like our missing piece
- Why is the yield similar??? (note difference in integrated luminosities: 2.2 fb^{-1} vs. 0.035 fb^{-1})