Some Studies of the G3X Matching χ^2 for CMU

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Outline

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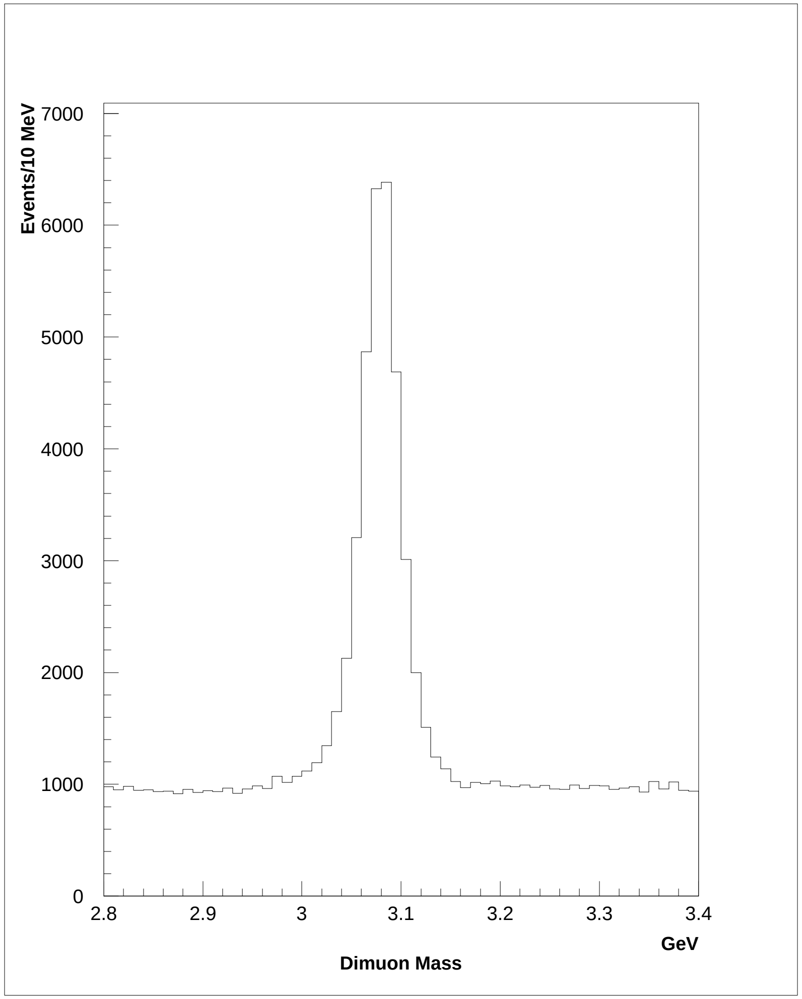
  - General procedure
- Exploration of the Δx (only) χ^2
  - Wild speculation
- Exploration of the Δx (only) χ^2
  - More wild speculation
- Discussion

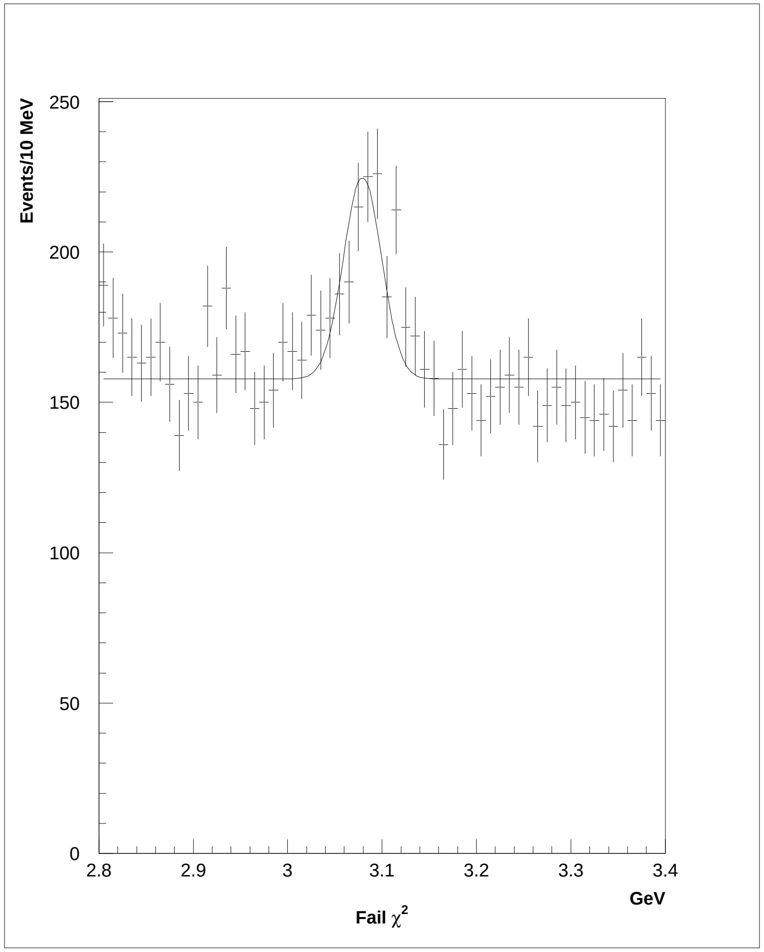
Dataset Description

- I used ~25,000 CMU-CMU J/ψ's
  - Started from the "Beata sample"
    - Production as of some time in the past
  - Dropped CdfMuon objects and reran the 4.7.1 linker
- Warning! Not every plot shown is of the full data sample or has exactly the same selection
  - If I draw a comparison on a slide, I was careful to make sure that it was valid
  - Taking a number from one slide and comparing to one on another may not be.
- I tried to spare you pages and pages of identical looking plots



General Procedure

- For efficiencies
  - Fit the J/ψ sample to a single Gaussian on a flat background
  - Split into "passing" and "failing" samples. Refit, holding the mass and width fixed from the previous step.
- For distributions
  - Divide into "signal + background" (3.0-3.2 GeV) and "background" (2.8-3.0 and 3.2-3.4) samples
  - The plots shown have the normalized background subtracted off



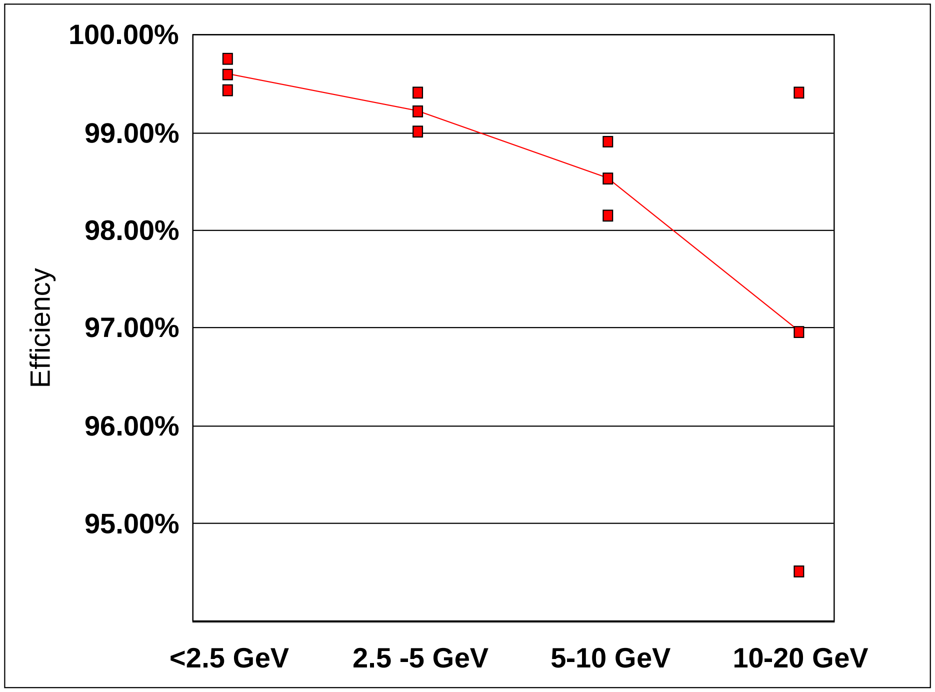
Chi-squared for Δx

- Try to duplicate the cuts in CDF-1986 (Run1)
  - The calorimeter material is unchanged
  - Minor changes to tracking and muons
  - Should be close to Run 1
- Measured $\varepsilon(\psi) = 99.19 \pm 0.17\%$ (w/Run 1 cuts)
  - Corresponds to $\varepsilon(\mu) = 99.6 \pm 0.1\%$
  - Run 1A with an equivalent z-cut was $99.3 \pm 0.1\%$
  - So, the agreement is pretty good.

I should have stopped there!

pT dependence of the x-position χ^2

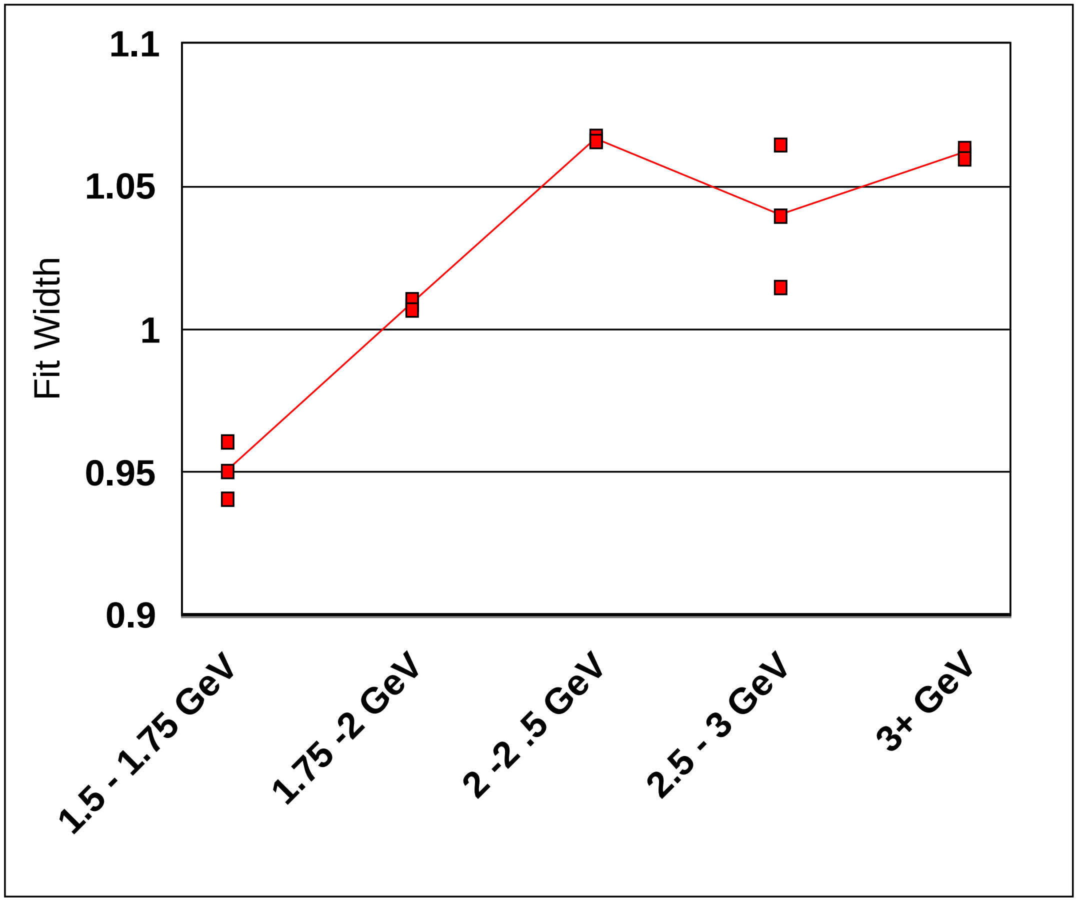
- Divding this in bins of pT(ψ) shows that this is not quite flat.



- My first thought was “Maybe the chi-squared is not entirely flat in pT(μ).

Fitted widths vs. p_T(mu)

- The signed square root of the χ^2 (the "pull") should be Gaussian
  - It is
  - I'll spare you the plots
- It should also be flat in $p_T(\mu)$
  - It's not
  - This is not a reflection of the 30 cm cut
    - I see that cut in the data and it's beyond the fit range
    - Changing the fit range doesn't do much (except improve the 4th point)

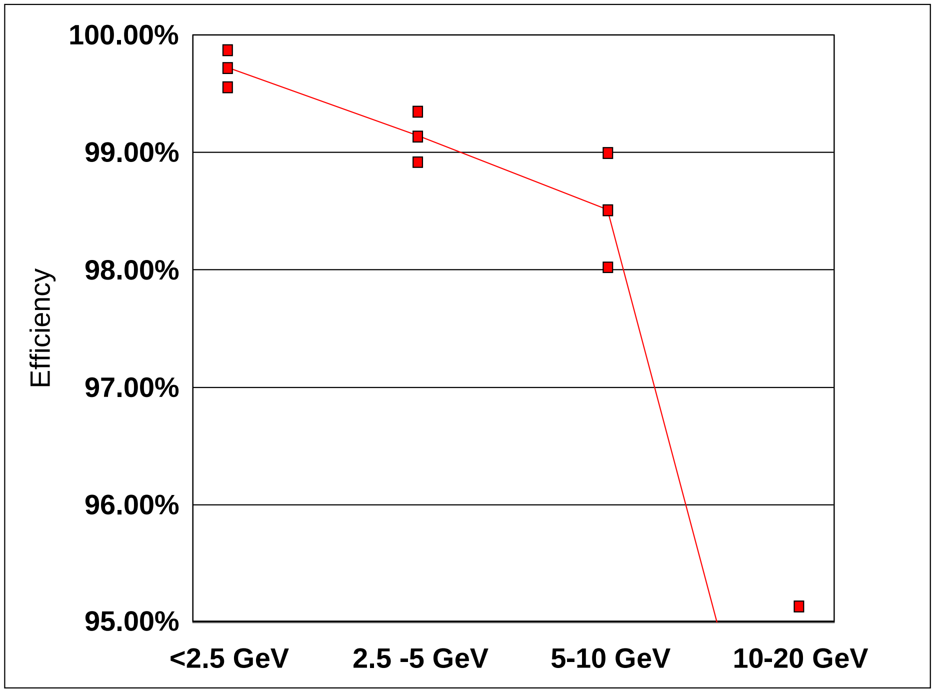


Flattening the χ^2 variable

- Below 2 GeV
  - Scale linearly in $p_T(\mu)$ from 0.94 at 1.4 GeV to 1.06 at 2 GeV
  - This is almost certainly not the best way to fix this
- Above 2 GeV
  - Scale by 1.06
- Results
  - Below 2 GeV, σ = 0.98
  - Above 2 GeV, σ = 1.00
  - Therefore, we've removed about 80% of the p_T dependence.
- J/ψ efficiency change
  - Recovers about 35% of the J/ψ's that were lost to the χ^2 cut.
  - $\varepsilon(\psi)$ was 98.7 ± 0.2%
  - $\varepsilon(\psi)$ becomes 99.1 ± 0.2%
  - The difference is real
    - Remember, I look at the subtracted distributions
- Background rejection change
  - 15% of the background was rejected
  - This becomes 13%

pT dependence of the x-position χ^2 (after the fix)

- The trend is unchanged
  - The first three bins are consistent with what they were before the fix
  - The last bin is as well, but the uncertainties are too large to say much of anything
- The overall efficiency is slightly higher
  - i.e. the inefficiency is 35% smaller
- This fix did good things, but didn't change this at all



Conclusions on G3X

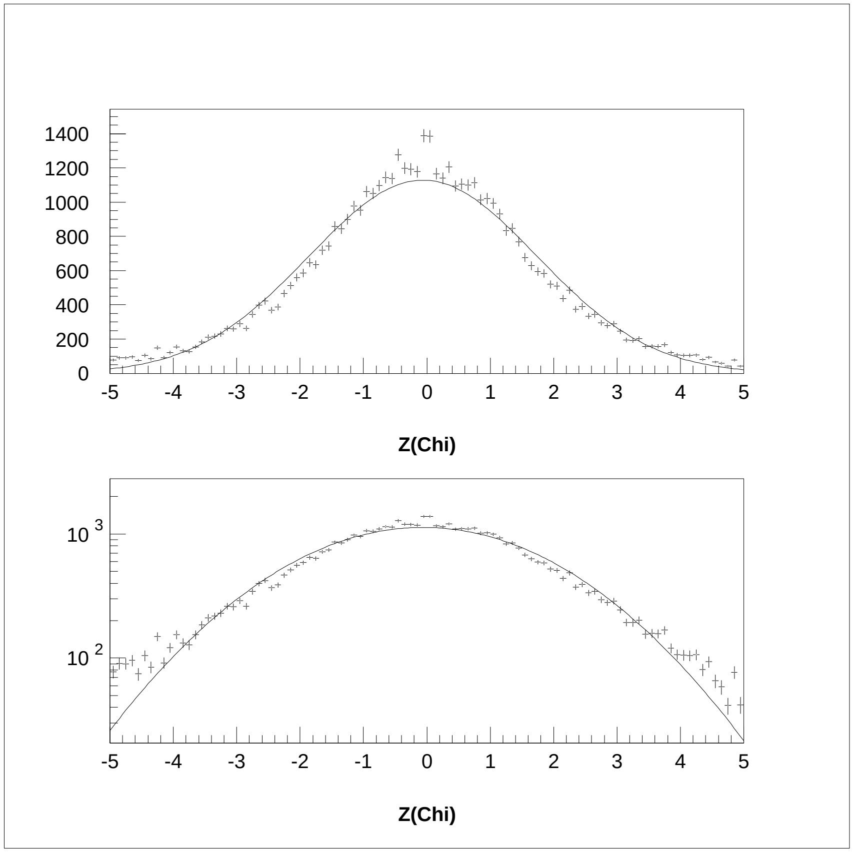
- G3X gives us the extrapolation uncertainty “out of the box” to within ±5 or 6%.
  - That’s 2mm on the multiple Coulomb scattering of a 3 GeV muon 3.5m from the production point
  - We probably do not know the detailed composition of the calorimeters to ±5 %
    - GEANT will do no better than its input data
- A crude rescaling tunes away 80% of this
  - Recovers 35% of the rejected J/ψs
  - Lets in ~15% more background
- How to react to this probably takes some discussion

Speculations on pT

- We've tuned the χ^2 distribution to be flat in p_T
  - That the efficiency is not flat implies the problem is in the tails of the distributions, not the core
- Most mass distributions of the events that fail χ^2 cuts have the J/ψ shifted ½σ towards higher mass.
  - Could this just be a selection bias?
    - Tracks that are misreconstructed towards higher p_T will have a matching χ^2 window that is too small, and more failures
    - These will also give you a mass that's too high
    - If they are misreconstructed towards lower p_T, the matching χ^2 window will be too big, and the events will likely pass.

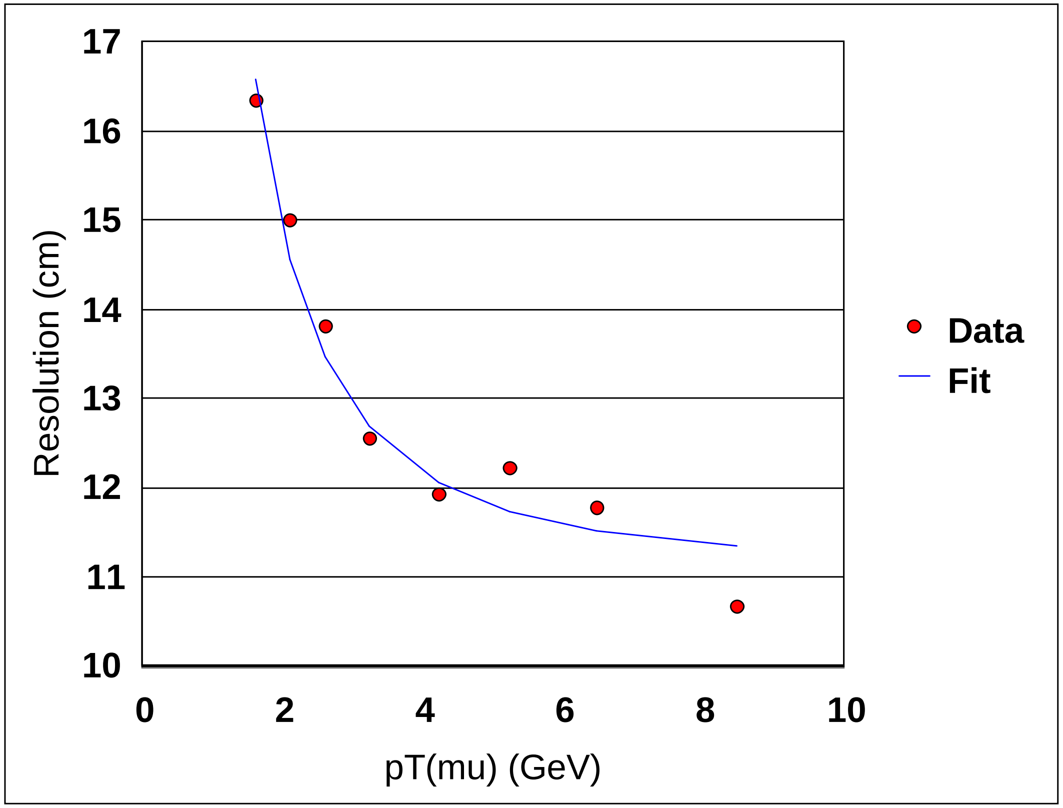
Chi-squared for Δz

- This is the first real look at the z-position χ^2 (it was not filled in production)
- I started with the simple question – "Does this look like a χ^2?"
  - The answer appears to be "no"
  - The distribution is a factor of 1.7 too wide
  - Ken points out that this calculation does not include the intrinsic CMU *z*-resolution, which is comparable to the MCS term.



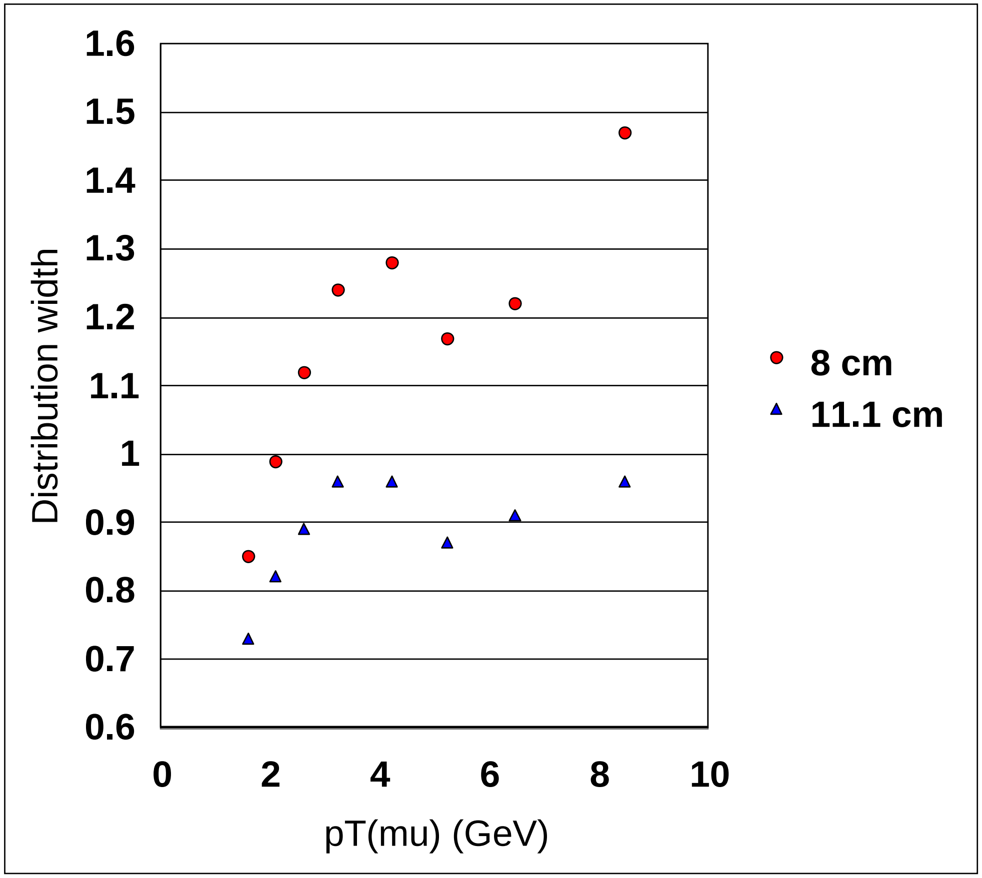
p_T dependence of the z-position χ^2

- If that weren't bad enough…
  - This momentum dependence is stronger than in the x-view
- Fit to a 1/ p_T multiple scattering term and a CMU resolution term:
  - 17 ± 2 cm/ p_T for MCS
  - 11.1 ± 0.8 cm for CMU



Concocting a better χ^2

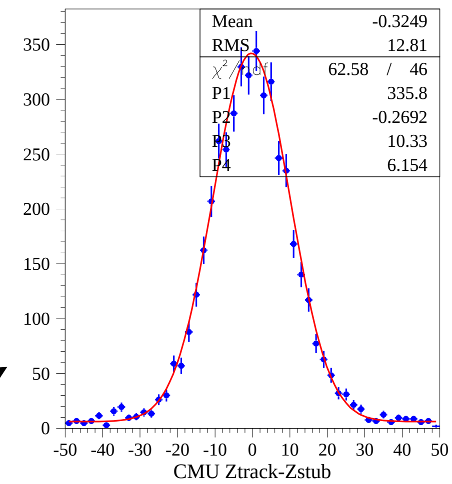
- Start with G3X
- Add a CMU resolution term
  - 11.1 cm
    - Returned by the fit
    - Makes a χ^2 that is too narrow: 0.81 instead of 1
    - Not flat in p_T
  - 8.0 cm
    - Pulled out of thin air
    - Makes the χ^2 have the right overall width
    - *Still* not flat in p_T



What's Going On?

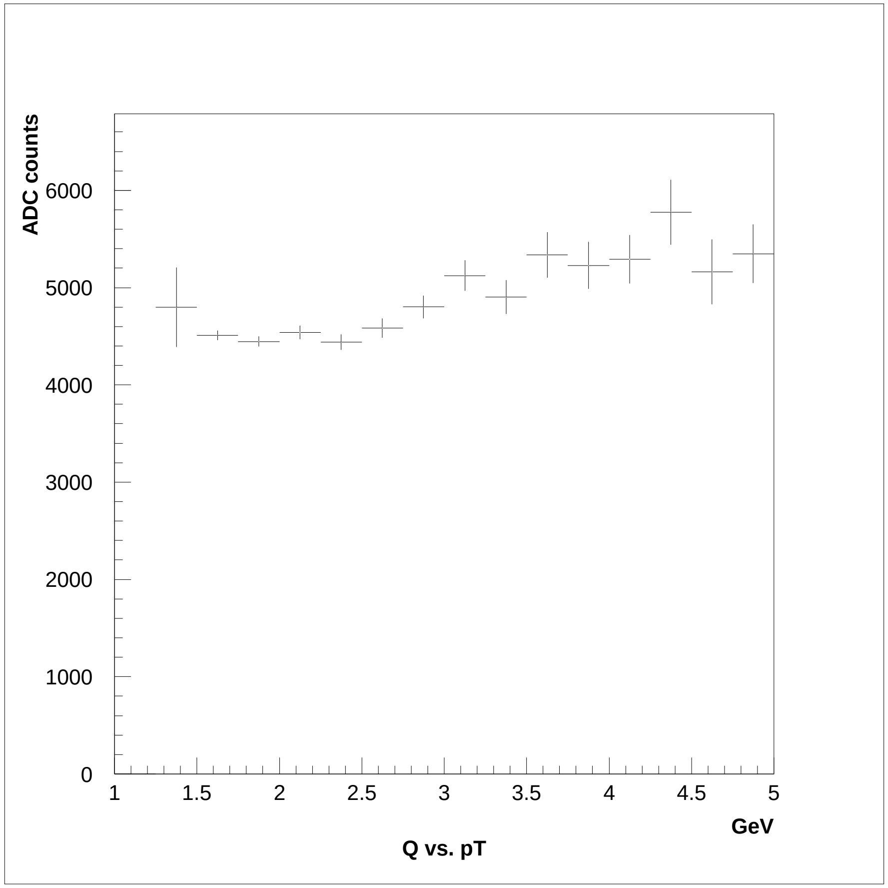
- The problem can't be with G3X
  - It gets Δx right to within ±5%
  - The multiple scattering is the same (within geometry) for Δx and Δz
    - I have verified this: it's not just how it's supposed to work
- COT stereo failures unlikely
  - Functional form is wrong
  - J/ψ mass still looks okay
- CMU z-resolution the best candidate
  - This can be explained by having this resolution vary from 14 cm at low p_T to 10 cm at high p_T
    - In fact, 10 cm at high p_T is what is expected

high-P_T muons



Why a Change in CMU z-resolution?

- As far as I know, it's never been validated that this is independent of p_T
- It's not a problem with 3-hit stubs at low p_T
  - Except in the 1.4-1.5 GeV bins, this distribution is flat
- Low p_T muons are even lower when they hit the CMU
  - Could dE/dx be responsible for the resolution change?
  - It looks like we can see the relativistic rise – but could a 20% change in ionization cause a 40% change in resolution?
  - Are p_T and z uncorrelated?
    - If not, is this effect big enough?



Does a z χ^2 cut do any good?

- Maybe we're spinning our wheels.
- Maybe there simply aren't any events with a good x χ^2 and a bad z χ^2!
- That turns out not to be the case
  - Consider dimuon events with x-position $\chi^2 < 9$ (both muons)
    - 1.5% of J/ψ events have a x-position $\chi^2 < 9 \times (1.7)^2$
    - 6% of sideband events have a z-position $\chi^2 < 9 \times (1.7)^2$
  - Perhaps its not a cut you would make, but there *are* events in this category.

Summary

- The x position χ^2 looks pretty good
  - The value is right to ±5%
  - There are ±1-2% peculiarities still remaining in the efficiencies
  - Today, I'd say it's ready for use for anyone except for cross-section measurements
    - e.g. improving purity for B lifetimes
- We have a z position χ^2
  - It's more problematic
  - It's construction doesn't include CMU resolution
    - ~70% effect
    - The CMU resolution itself looks like it has a 40% problem
      - **Could we think about a stub-by-stub z uncertainty?**