Search For Delayed Photons

Answers to Questions

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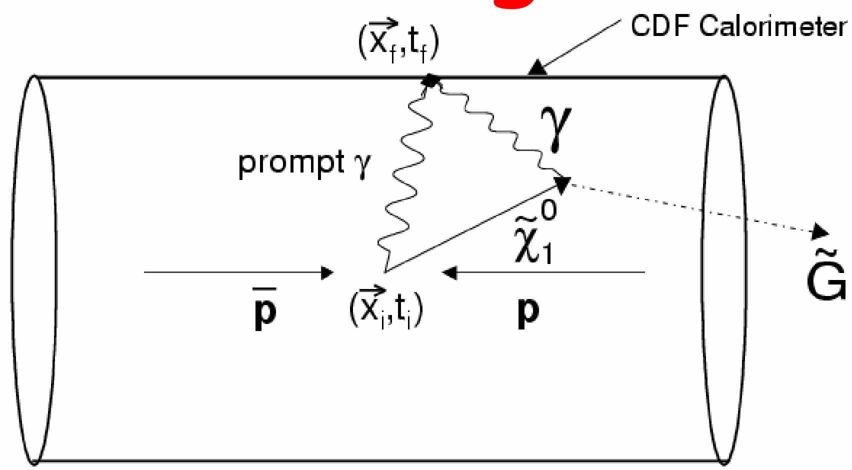


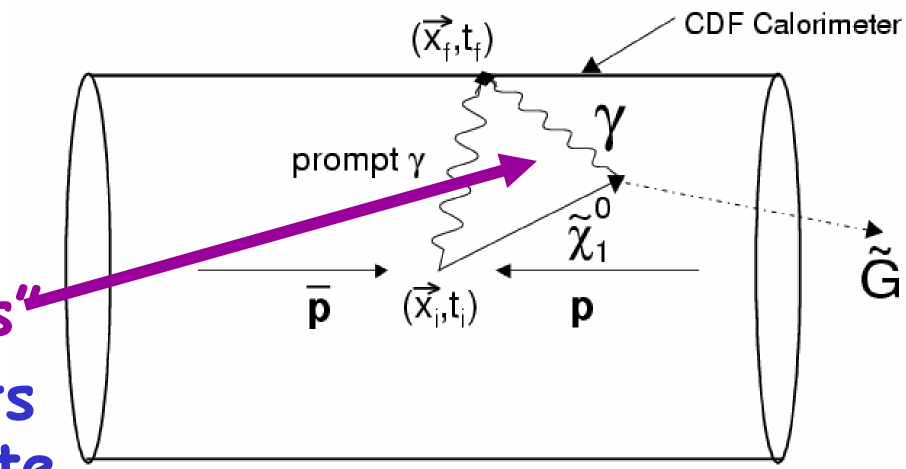
Outline

1. Quick overview of the Analysis and Status
2. The minor changes since the blessing of June 2006
3. Questions and Answers before Re-blessing

This talk may be un-understandable for people who have never see the analysis before

Quick Overview

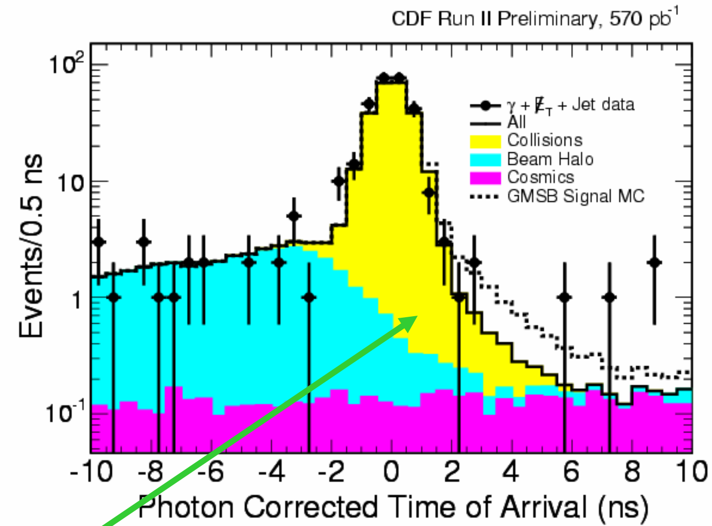
- GMSB SUSY predicts heavy, long-lived Neutralinos that decay into a photon and a Gravitino
- These photons reach the detector later than SM photons →"Delayed photons"
- We search for these events in the γ+Met+Jet final state
- We use kinematic cuts and photon timing from the EMTiming system to separate signal from background



Documentation: CDF Notes 7918, 8015, 7928, 7929, 7960 and 8016

Analysis Blessed June 2006

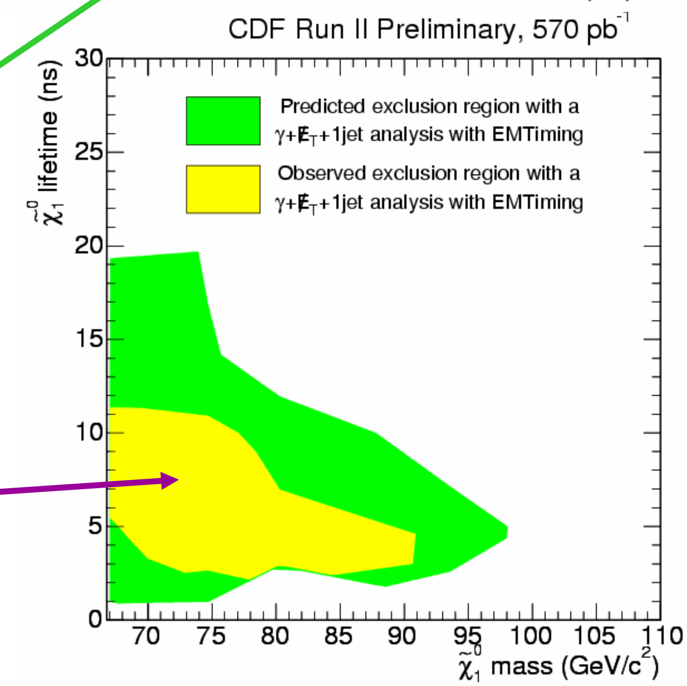
Optimized Cuts:
- photon ET > 30GeV
- MET > 50GeV
- jet ET > 30GeV
- $\Delta\phi$(Met,Jet) > 0.5
- 1.5ns < $t_{Corrected}$ < 10ns



Expected background: 7.6±1.9
- SM: 4.7±1.7
- Beam Halo: 0.7±0.2
- Cosmics: 2.2±0.7

10 Observed Events

Set limits



Minor Changes since Blessing

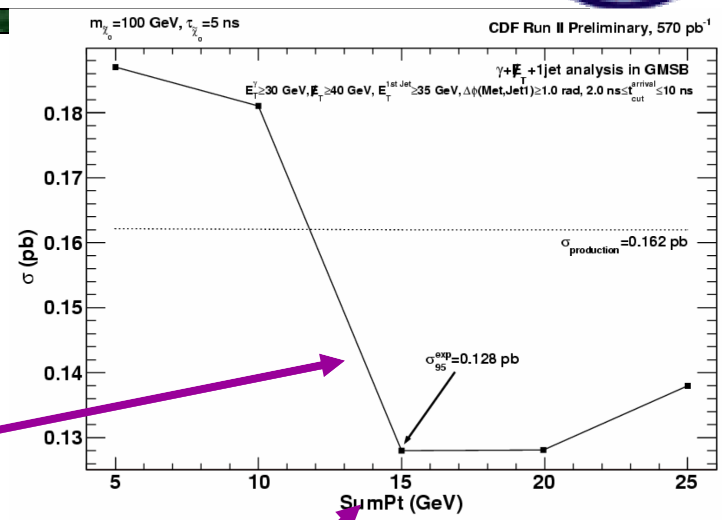
Absolutely no new methodology, just tweaked cuts

Change 1

- Corrected a simple "inconsistency" in the analysis.
  - We use jets with cone size of $\Delta R=0.7$, however we inadvertently applied the cone 0.4 corrections. Now fixed.
- We note that the acceptance was estimated using the same jet procedure as the data so the blessed results are technically correct

Change 2

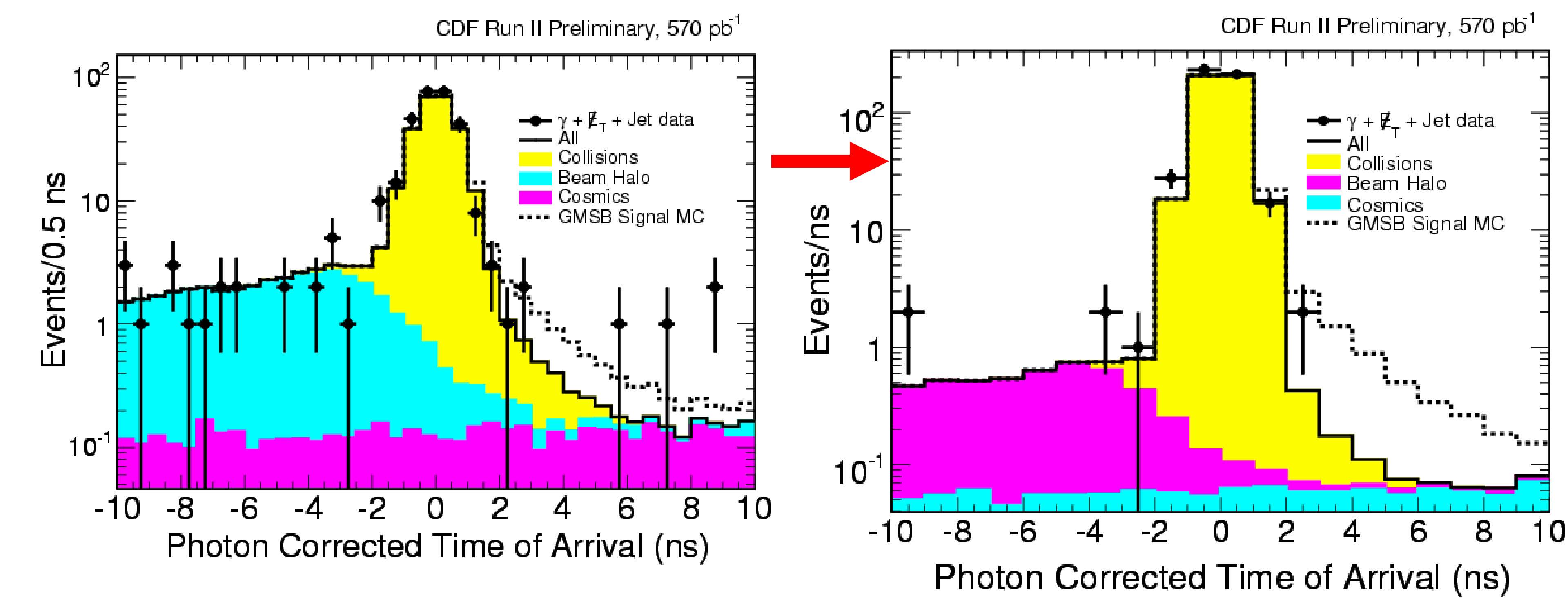
- After change elected to re-optimize
  - Included vertex ΣP_T
  - Most non-collision backgrounds have small ΣPt
- Found new optimal:
  - ΣP_T cut: 10 GeV → 15GeV
  - Met cut: 50 GeV → 40 GeV
  - $\Delta\phi$(Met,jet) cut: 0.5 → 1.0
  - JetET cut: 30 GeV → 35 GeV
  - Timing cut: 1.5ns → 2.0ns
- Change:
  - Bkgnd: 7.9±1.9 → 1.3±0.7
  - Expected limit improved



Change 3

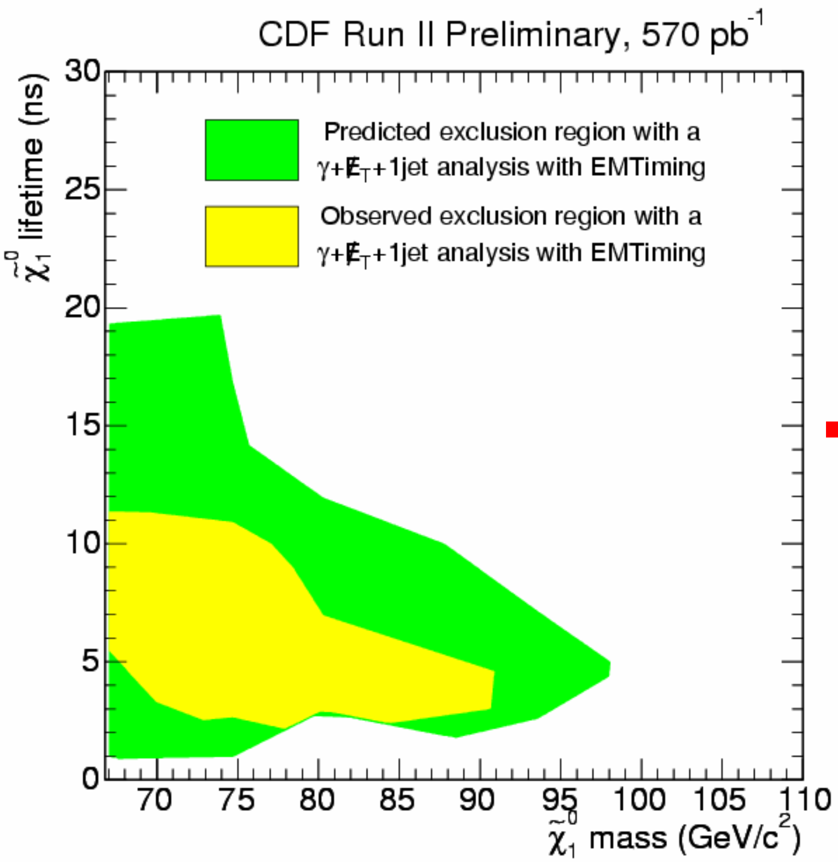
- We parameterized the acceptance to get smoother limit plots using the new limits.
  - (slide coming soon)

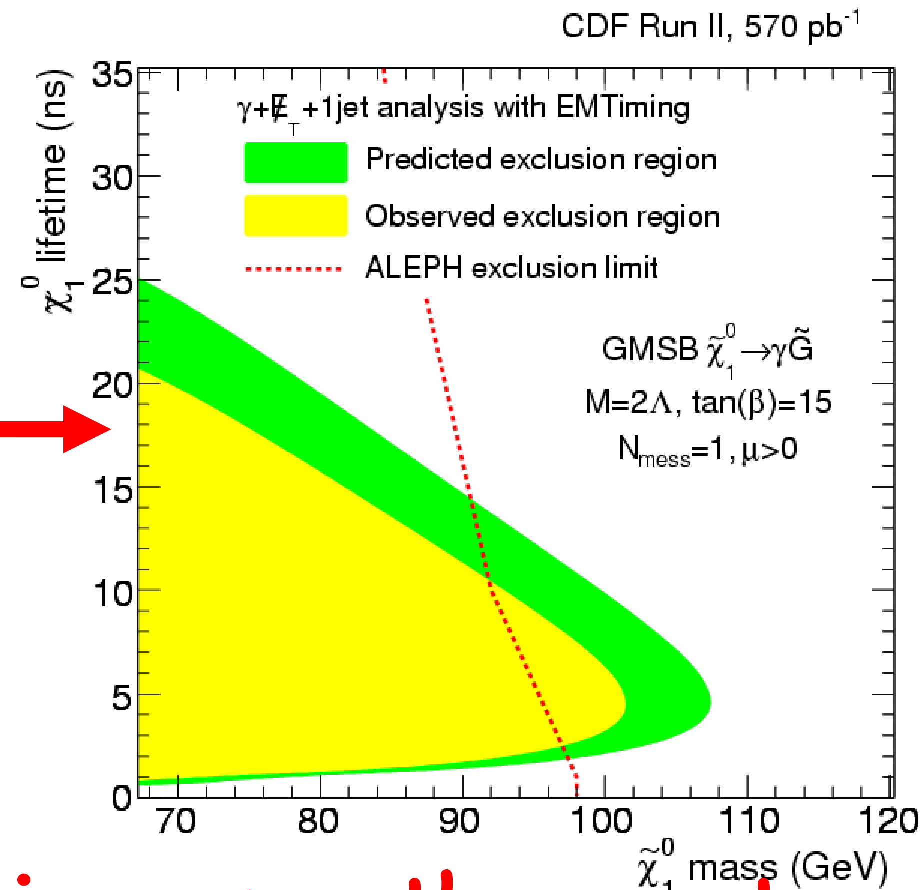
Results Differences: 1



7.9±1.9 expected   1.3±0.7 expected

Results Differences: 2





Bigger exclusion region, smoother contour

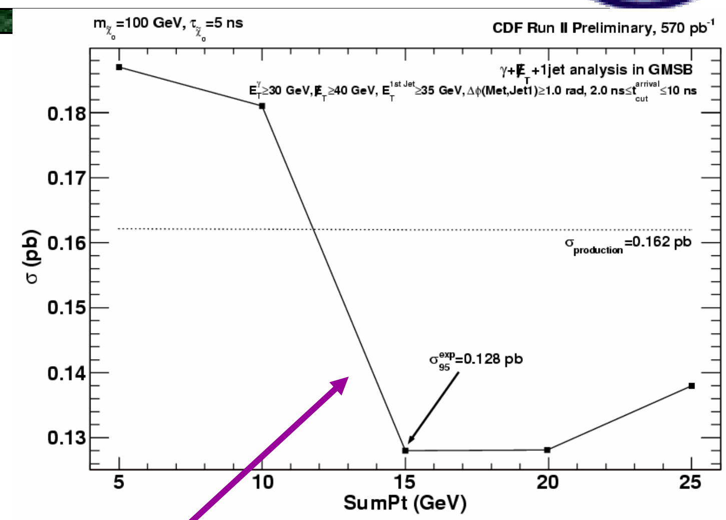
Answers to Questions

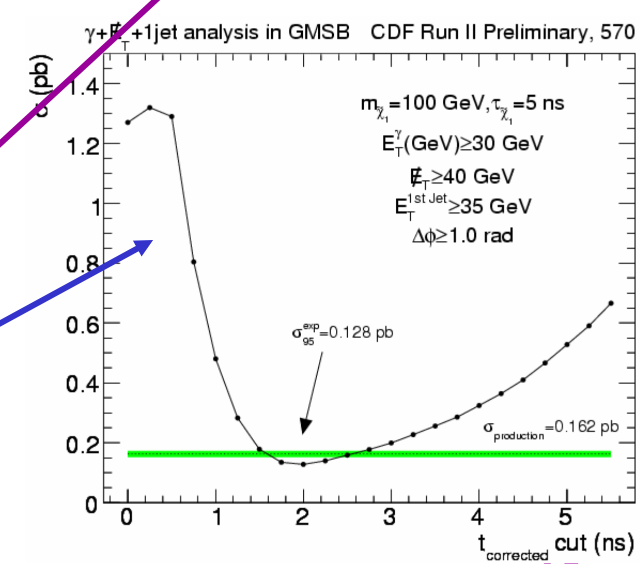
Question 1

Question 1: Authors say that the real power comes from timing, but the analysis have significantly changed due to properly applied jet corrections. So it is not true that timing is all that matters, right?

Answer: Not really right…

- **Fixing the jet energy corrections helps because the fake jets associated with beam halo and cosmics aren't as promoted as much as they should have been. Not a big effect.**
- **The dominant <u>change</u> is from the re-optimization including the increased vertex ΣPt cut.**
- **However, the timing is the most powerful cut**



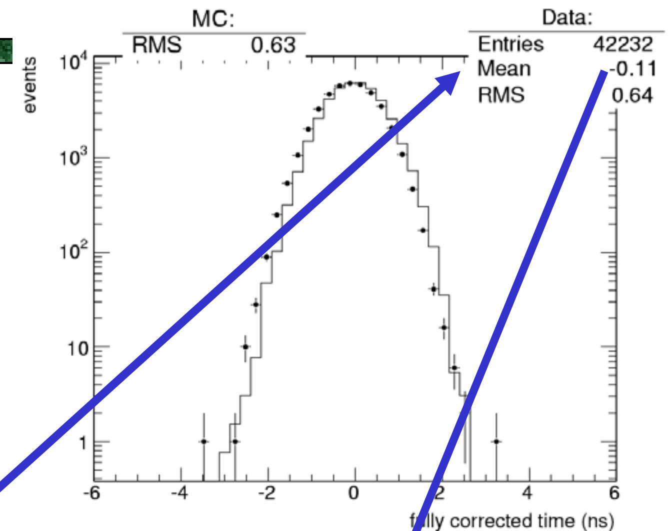


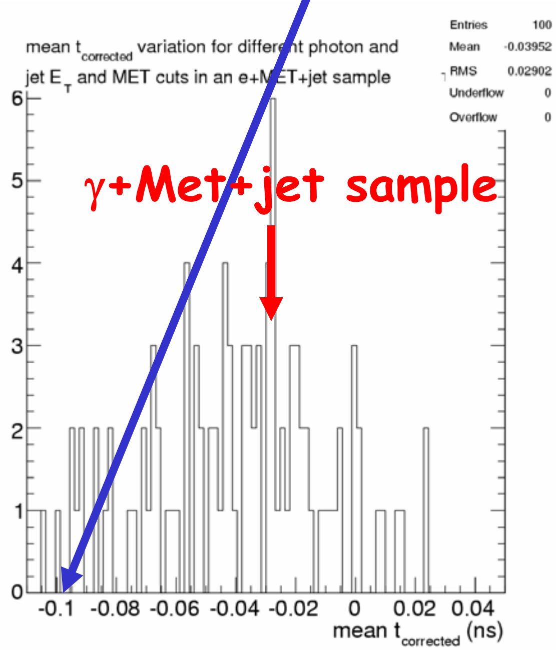
Question 2

Question 2: In the talk it looks like the timing MC doesn't do a good job of predicting the data. Can you explain this? Is this a problem?

Answer:

- The plot is from CDFNote 7928 and compares W->enu events to our MC
- The mean value of that sample:-110 ps. Plot: Ensemble of W samples with different jet, met and electron Et cuts. Not terribly different
- After all γ+Met+jet data set after all kinematic cuts: Mean = -30 ps±30ps.
- To cover potential variation: Take 200 ps variation to estimate systematic variation on background and acceptance





Question 2 Cont:

Does it affect us?

- Background estimate:
  - Dominates systematic uncertainty → 1.3±0.7
  - However, statistical fluctuations dominate the total uncertainty on the expected observation
- Acceptance:
  - Dominates acceptance uncertainty: 6.7%
  - Others close: photon ID efficiency (5%), PDF production cross section uncertainty(5.9%).

Bottom line: 200ps systematic variation both easily covers the variations and doesn't overly affect our sensitivity when taken in conjunction with all the other errors.

Question 3

Question 3: Why don't you use the vertex that is closest in time to the photon? It might reduce the background and help your analysis.

Answer 1: Lots of reasons to good reasons to choose the highest ΣP_T vertex

- Simple, elegant, and nothing wrong with it. Procedure is easy to understand and produces Gaussian timing distributions
- Very effective: Background=1.3±0.7, other backgrounds sum to 0.5. Getting rid of it wouldn't be a huge help
- Wrong vertex rate estimated to be 3±1%. This is small and consistent with the fraction of events produced outside the region |Z|<60 cm

Question 3: Cont…

Answer 2: Many disadvantages to biasing our analysis to pick the "best of N" vertices.

- The acceptance would go down. Infinite luminosity $\rightarrow$ no signal sensitivity
- Need a luminosity-dependent parameterization of the extra vertices for backgrounds and acceptance
- Method only helps if correct vertex identified
  - Really loose vertex quality?
  - Consider collisions at |Z|>60cm?
  - Do we consider low ΣP_T vertices?
- Other systematic biases we haven't though of?

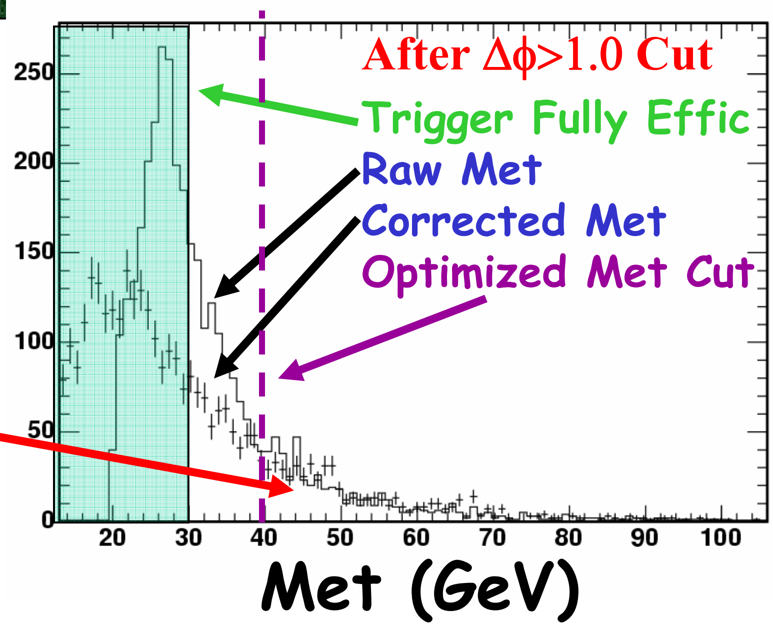
Bottom line: Nothing wrong with the method. It's simple, elegant and robust. Works well.

Question 4

Question 4: Why use Raw Met? Wouldn't Met corrections be better?

Answer: We cut on Met in conjunction with $\Delta\phi$(Met,Jet)

- Cutting on Raw or corrected Met doesn't make a difference
- Clean, simple and effective
- Done before (CDFNotes 2541, 5610 and 6381)
- Cut on same value as in W_NOTRACK. Easy trigger efficiency measurement!



Bottom line: Nothing wrong with the method. Clean, simple and robust

Question 5

Question 5: On theoretical cross-section errors: do the 3-4% overall uncertainty sound right to you? Shouldn't they be the same as the Tri-lepton analysis?

Answer:

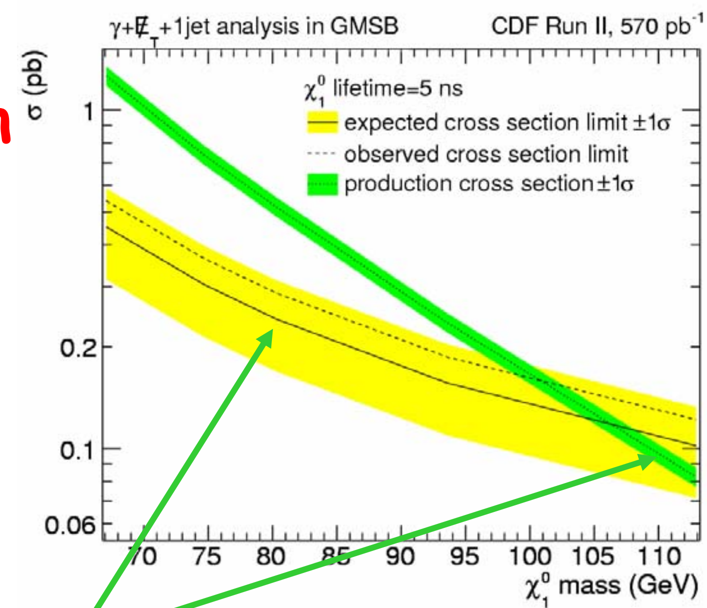
- Our number was incorrectly reported (sorry).
- Comparison:
  - In CDF 8389, Table 16, lists 7%. We believe this is PDF and Q^2 added in quadrature.
  - We PDF of 5.9%, Q^2 gives 2.4%. Adding in quadrature gives 6.4%
  - Quite remarkable agreement since they use mSUGRA and we use GMSB

Question 6

Question 6, Request: show limits without convoluting systematics from theory. Also, error bands on the plots

Answer: Done. Notes:

- Experimental errors:
  - Acceptance: ~8%
  - Production cross section: ~6%
  - Total: ~10%. Can't see difference. Keep total.
- Production x-sec error on plot
- 1σ variation on the expected limit
  - As expected, the observed limit is well with expectations



Conclusions

- We have an elegant and robust analysis
- No method changes since blessing in June 2006
- Minor tweaks to cut values → Slight, but worthwhile improvement
- Answered questions
- In GPS process, solid PRL draft exists
- Looking to re-bless this week