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Limits on Gauge Mediated Supersymmetry Breaking Models in Diphoton Events with Missing Transverse Energy at CDF II

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Outline

Blessed on 04/30/09 (CDF NOTE 9575)

Blessed plots and page:

http://txpc1.fnal.gov/~elee/ggMet/reblessed/note.html

- Introduction and Previous Searches
- Background Sources
- Analysis Strategy
- Optimization and Setting Limits
- Conclusion and Plan

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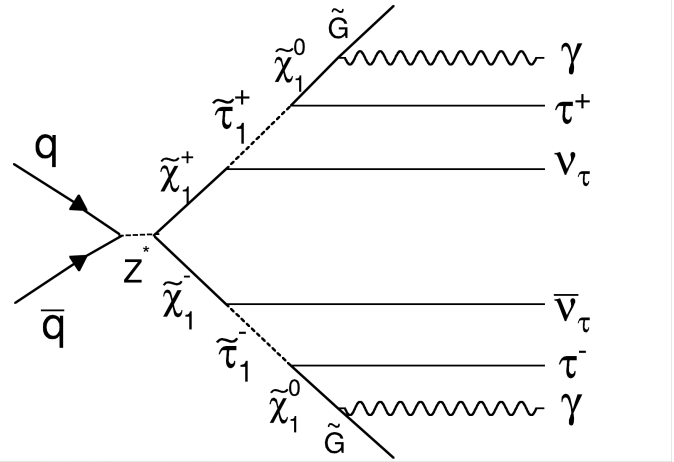
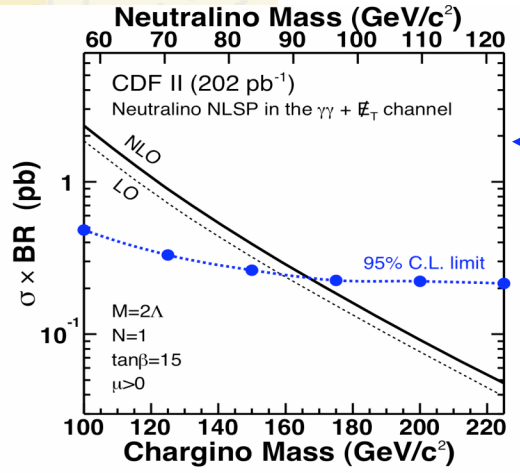
Dominant Signal Process



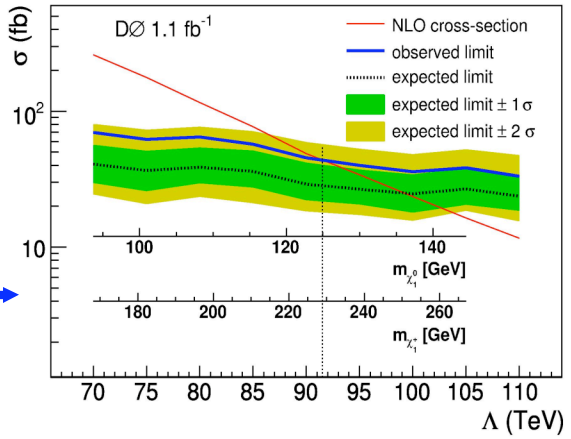
- Looking for $\tilde{\chi}_1^0 \rightarrow \gamma + \tilde{G}$
- Both neutralinos decay in the detector ⇒ Two photons
- $\gamma\gamma + \not{E}_T$: Optimal for low lifetimes ($\tau < 2$ ns)

D.Toback and P.Wagner, Phys.Rev.D70, 114032 (2004)



Previous Search at CDF (202 pb^{-1})
Phys.Rev.D71, 031104 (2005)

Recent Search at DØ (1.1 fb^{-1})
Phys.Lett.B659, 856 (2008)



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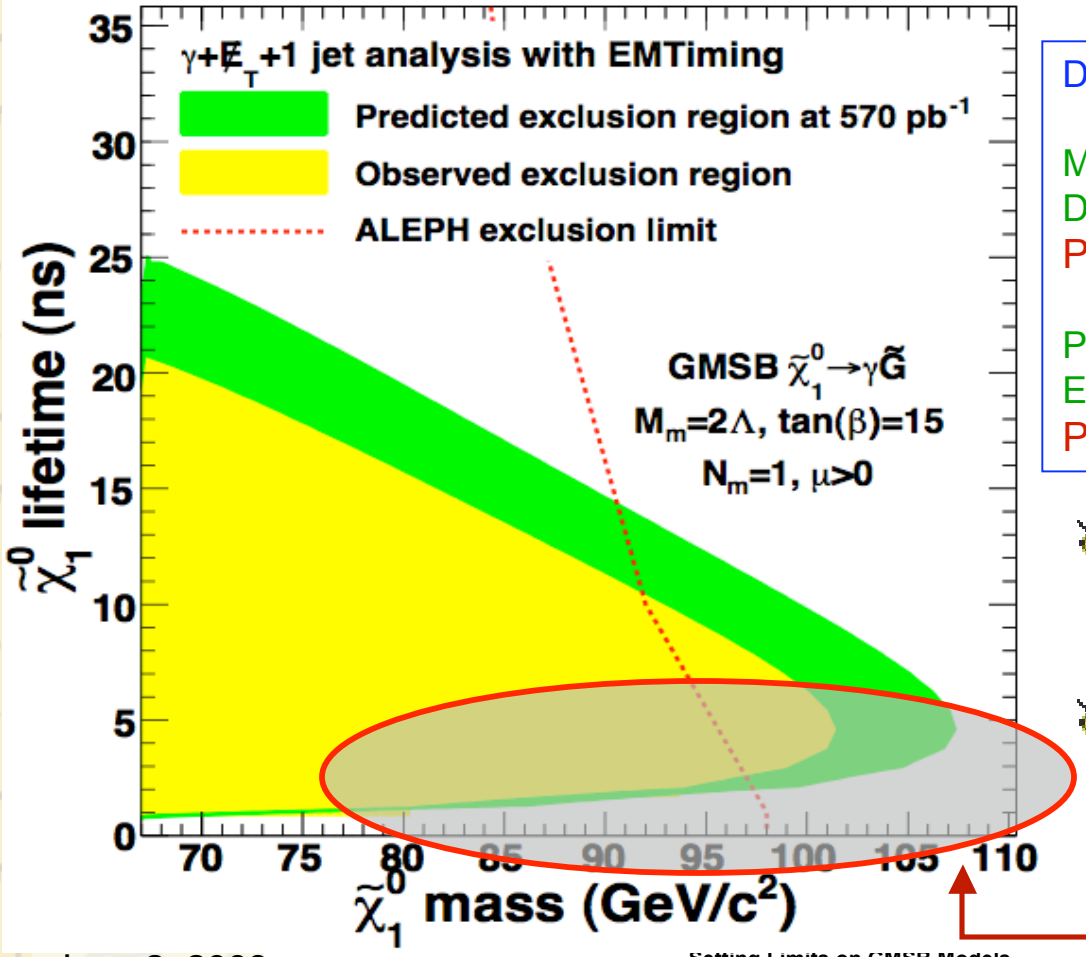
Exclusion Region from the Delayed Photon Search



Delayed Photon Analysis

M.Goncharov, V.Krutelyov, E.Lee, D.Toback and P.Wagner
Phys. Rev. Lett 99, 121801 (2007)

P. Geffert, M.Goncharov, V.Krutelyov, E.Lee, D.Toback and P.Wagner
Phys. Rev. D 78, 032015 (2008)

- Single Delayed Photon :
  Not sensitive to prompt or low lifetimes
- Trying to understand our sensitivity here and for larger masses

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Analysis Overview

- An *a priori* analysis where we create a presample.

  ⇒ Require diphoton events to pass the global event selection, photon ID, clean-up cuts, and non-collision background removal cuts
- Estimate the backgrounds for the presample as a function of various cuts
- Optimize with background predictions and signal acceptance
- Open the box

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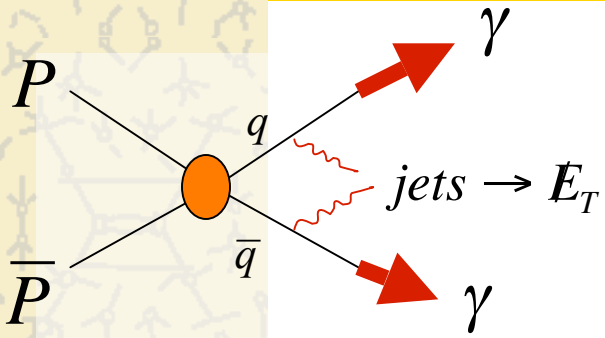
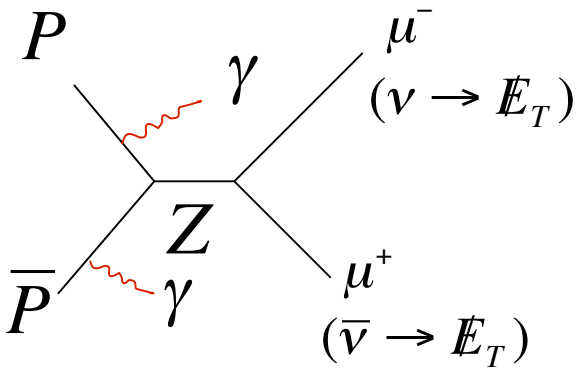
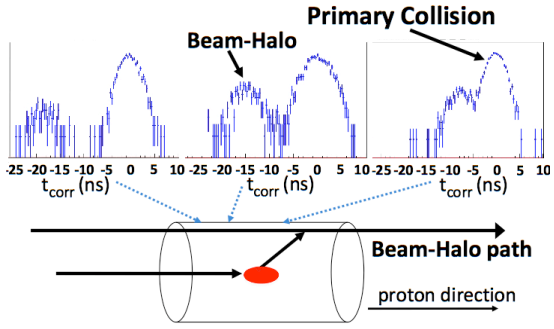
Background Sources and Datasets



QCD Background



EWK Background

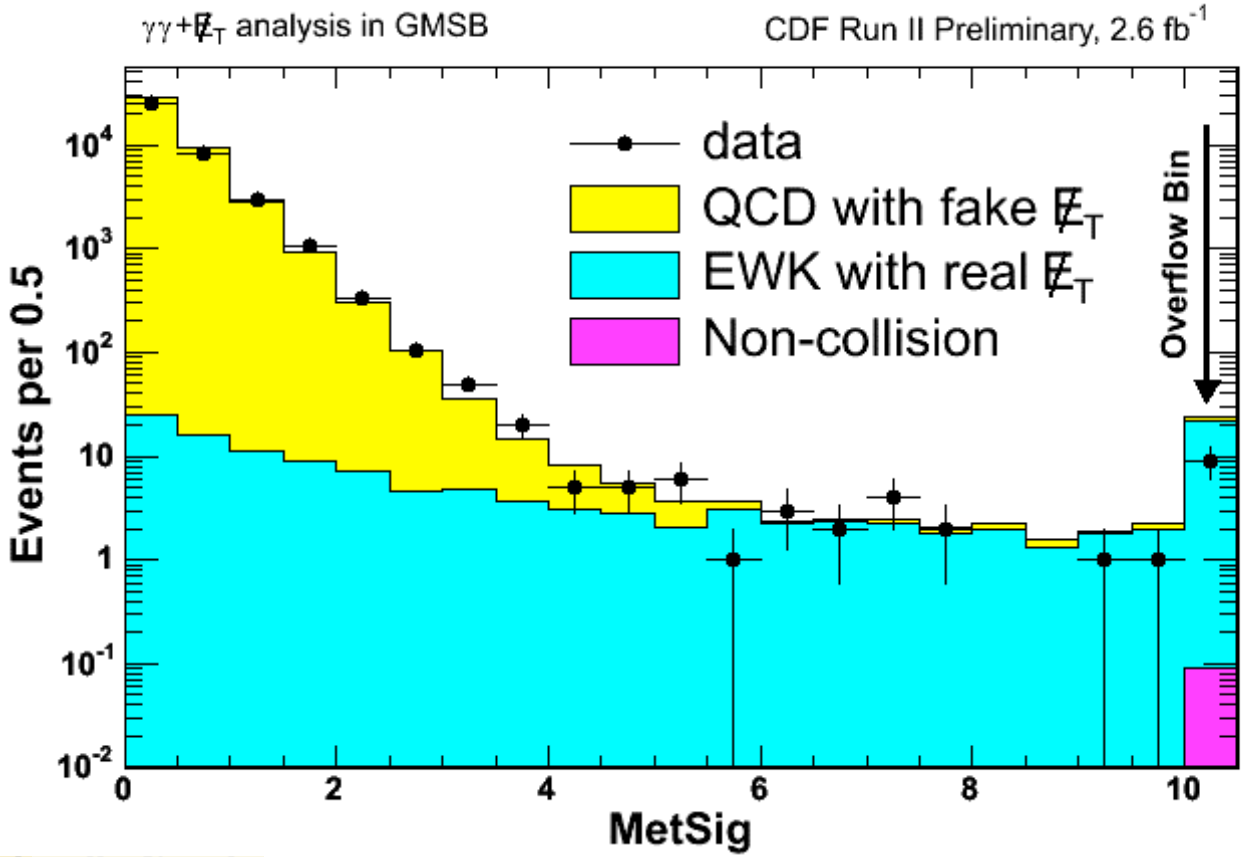


Non-Collision Background
: Cosmic and Beam Halo

- Luminosity = 2.6 fb^{-1}
- Triggers : DIPHOTON_12 (iso), DIPHOTON_18 (no iso), PHO_50 (no iso), PHO_70 (no HadEm)
- Central Photon of $E_T > 13$ GeV
- Standard Photon ID cuts and Phoenix rejection cut
- Event Quality Cuts: $N_{vx12} \geq 1$, Highest ΣP_T Vertex, $|Z_{vx}| < 60$ cm
- Vertex Re-assignment and Met Clean-Up cuts
- Cosmics and Beam Halo removal cuts

Results of the γγ presample

- We developed a Model of Missing E_T Resolution to separate out events with fake Met from QCD



Met Model: CDF NOTE 9184

Backgrounds well modeled

Optimization Strategy and Expected Limits

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- Take the pre-sample and then do an optimization
- Pick a GMSB parameter point (mass=140 GeV, lifetime=0 ns) and find the optimal cuts by calculating the lowest 95% C.L. expected cross section limit.
- Use the standard cross section limit calculator taking into account the expected no. of background events, acceptance, luminosity and their errors
- Pick a single set of optimization variable cuts (next slide)
- Map it out as a function of neutralino mass and lifetime.

The Optimization Cuts

- MetSig : get rid of QCD with fake Met
  - GMSB prodcution has mostly real Met
- H_T : get cascade decays from heavy particles
  - GMSB has lots of H_T, compared to SM backgrounds, from the gaugino pair's cascade decays
- $\Delta\phi$ (γ_1,γ_2) : get rid of back-to-back photons and wrong vertex
  - EWK backgrounds with large H_T are typically a high E_T photon recoiling against W boson, which is highly boosted ⇒ The two photons in the final state are mostly back-to-back.
  - The high E_T diphoton with large H_T from QCD are mostly back-to-back with fake Met

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Optimization Results

H_T > 200 GeV
$\Delta\phi(\gamma_1,\gamma_2)$ < π–0.35 rad
MetSig > 3

- Example point

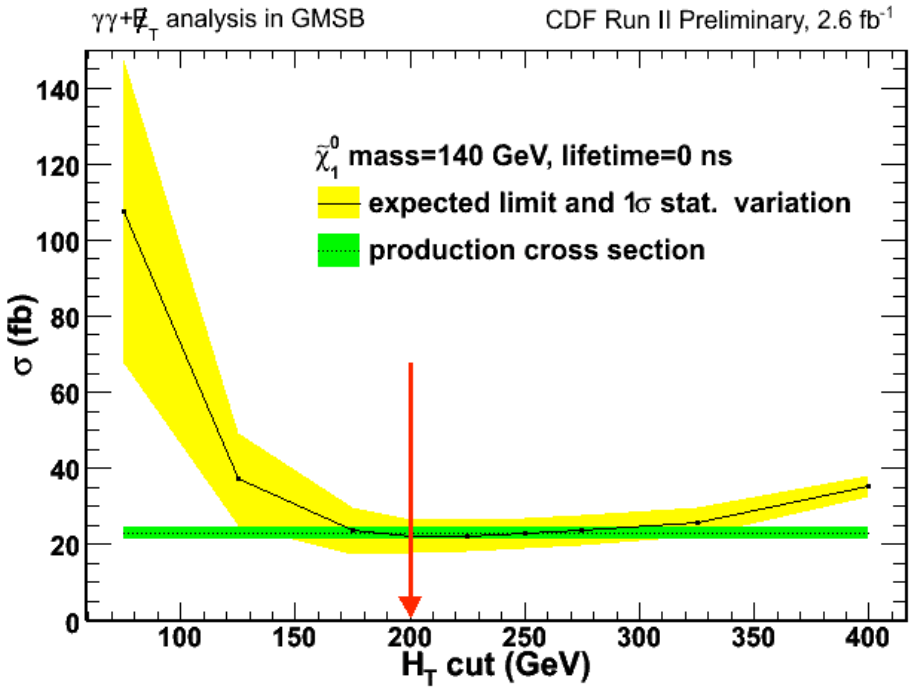
$m(\chi^0_1)$=140 GeV, τ (χ^0_1)=0 ns

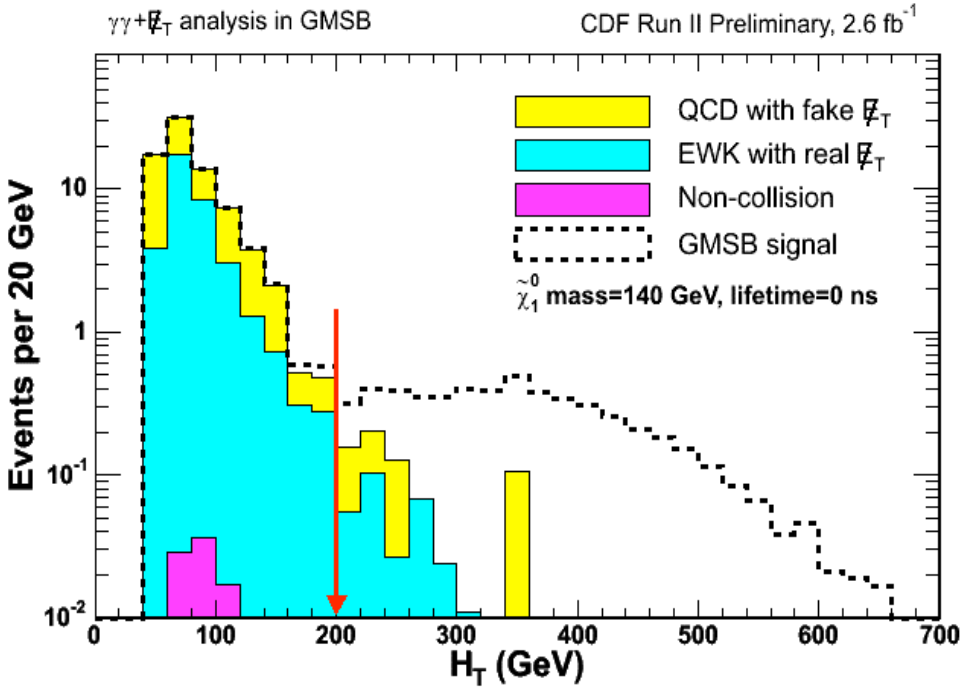
- Acceptance : 7.80 ± 0.54 (%)
- Luminosity : 2.6 ± 0.2

σ_{exp} = 22.08 fb
σ_{prod} = 22.97 fb

Background Estimations	
EWK	0.77 ± 0.21 ± 0.22
QCD	0.46 ± 0.22 ± 0.10
Non-Collision	0.001 + 0.008 - 0.001
Total	1.23 ± 0.30 ± 0.24

95% C.L. Expected Cross Section Limit and N-1 Plot: H_T





- **While varying a cut all other variables held at optimal cuts**
- **N-1 plot for background distributions along with GMSB MC signal shows good separation**

Data distribution and N-1 Plots

We open the box: 0 events observed

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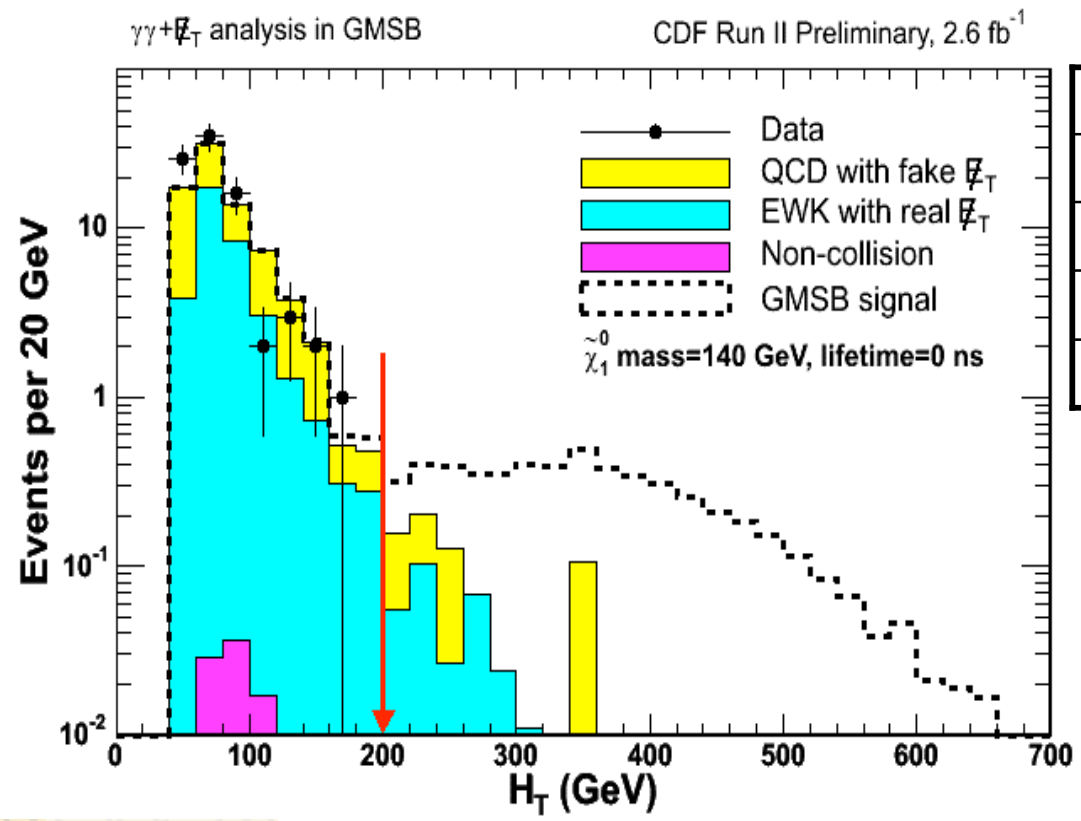

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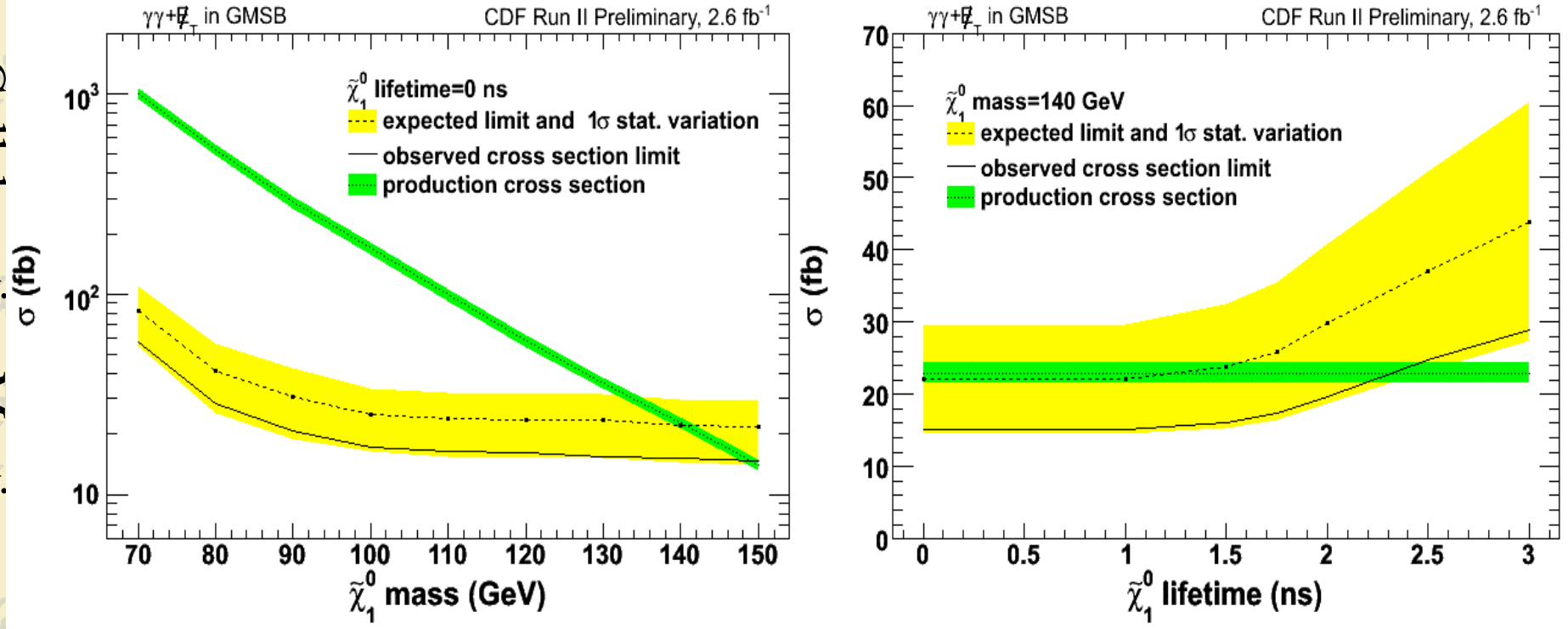
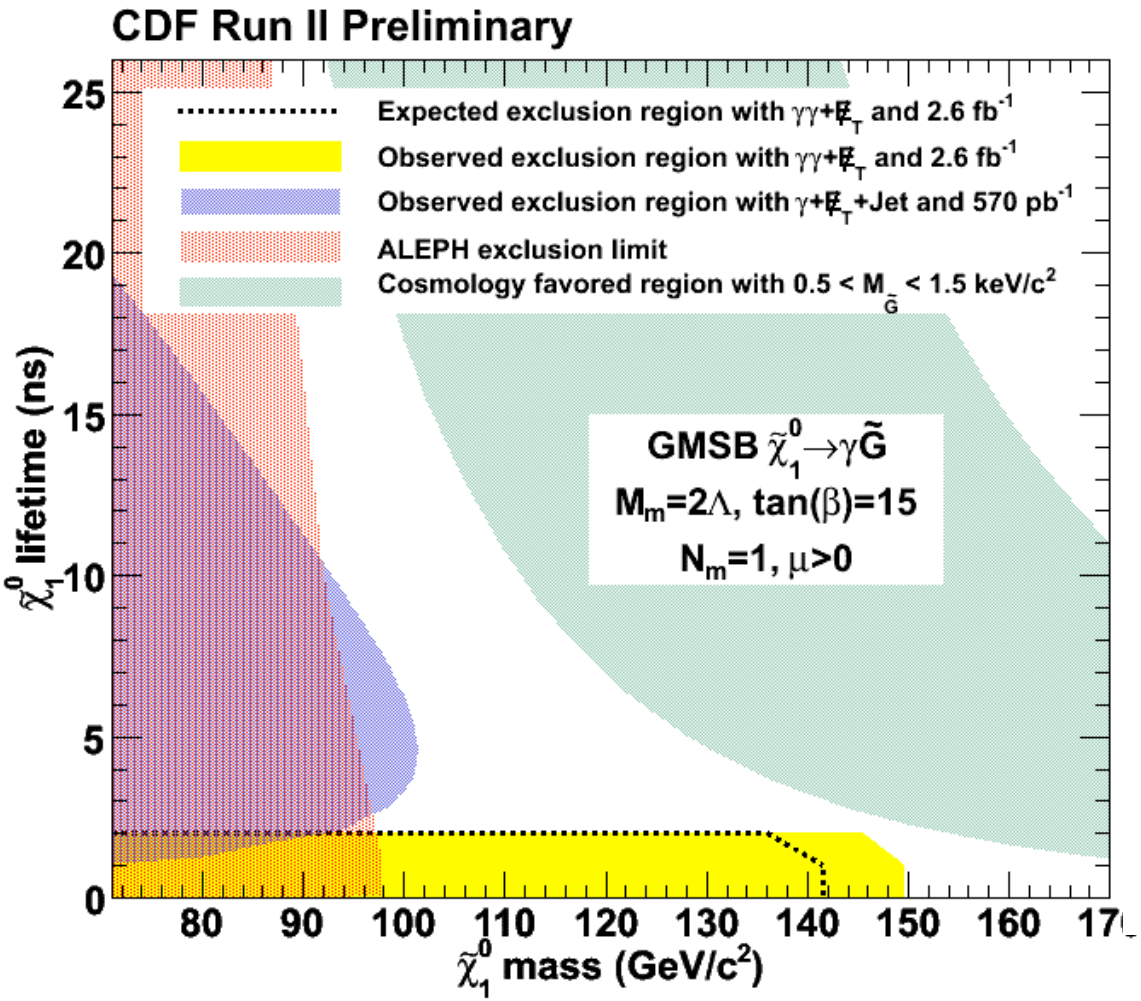
- For a distribution all other variables held at optimal cuts
- Everything is well modeled

Cross Section Limits vs. Neutralino mass (for τ = 0 ns) and lifetime (for m=140 GeV)



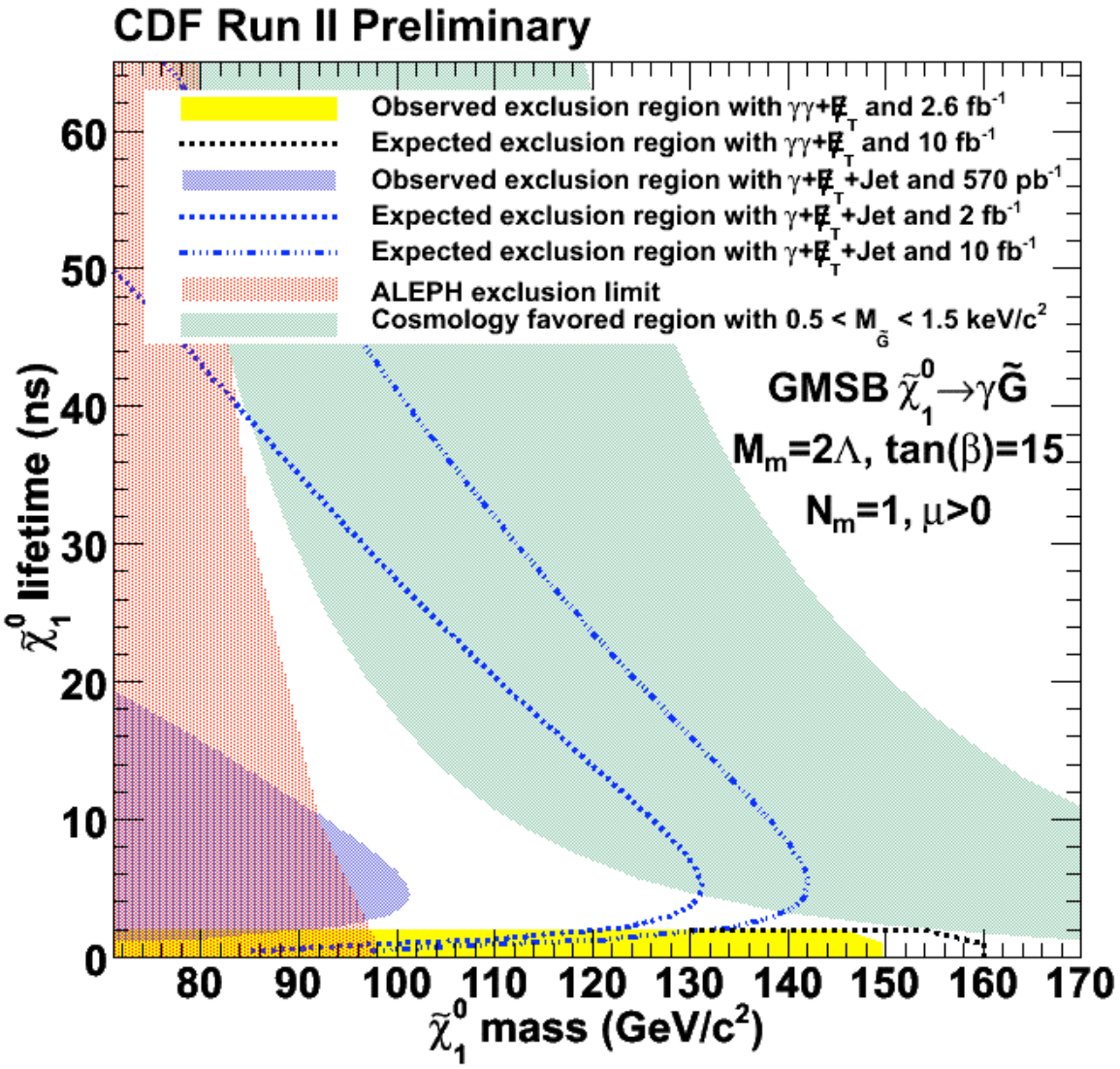
- Using the optimal cuts: Ht > 200 GeV $\Delta\phi(\gamma_1,\gamma_2) < \pi - 0.35$ rad MetSig >3
- Expected (Observed) neutralino mass limit 141 GeV (149 GeV) for τ=0 ns
- Exclude neutralino lifetime up to ~2.3 ns for m=140 GeV

Exclusion Region



- Exclude up to ~ 149 GeV for τ < 2 ns. (Beyond DØ Limit = 125 GeV)
- New Limits extend the sensitivity in both mass and lifetime. (goes above the Delayed Photon Analysis)
- We are nearing the cosmology favored region (green band)
- We stop artificially at 2 ns

Prospects for the future



- For high luminosity we calculate the cross section limits assuming:
  - all backgrounds scale linearly with luminosity
  - their uncertainty fractions remain constant
- $\gamma\gamma+\not\!\!E_T$: will extend mass limits up to 160 GeV with 10 fb^{-1}
- The next generation delayed photon analysis will cover up high lifetime region

Conclusion and Plan

- Optimization:
  Ht > 200 GeV, $\Delta\phi(\gamma_1, \gamma_2) < \pi - 0.35$, Metsig > 3
- Exclude neuralino mass 149 GeV
  for lifetime < 2 ns.
- World BEST Limit
- Next generation delayed photon analysis is coming soon as a complementary search- sensitive to higher lifetimes (> 2 ns)
- Requested GPS
- Have strong PRL draft in hand

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Back Up Slides

Good Runs, Triggers, Data Sets and Preselection Cuts

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- Data Stntuples: cdfpstn: cdipa(d,h,i,j) , cdfpstn: bhelb(d,h,i,j)
- Triggers : DIPHOTON_12 (iso), DIPHOTON_18 (no iso), PHO_50 (no iso), PHO_70 (no HadEm)
- Goodrun list: The good run list v.23 (up to and including period 17)
- Luminosity = 2.59 fb^{-1} with 6% uncertainty
- Code Release: cdfsoft 6.1.4, Stntuple dev_243
- Data Samples : $\gamma\gamma$ sample, $W \rightarrow e\nu$ sample (study EWK with real $\not\!\!E_T$), $Z \rightarrow e^+e^-$ sample (study QCD with fake $\not\!\!E_T$)
- Pre-Selection Cuts:
  - $N_{vx12} \geq 1$, Highest ΣP_T Vertex, $|Z_{vx}| < 60$ cm
  - Two Central Photons ($E_T > 13$ GeV)
  - Standard Photon ID cuts and Phoenix rejection cut
  - PMT Spikes, Cosmics and Beam Halo removal cuts

Standard Central Photon ID Cuts

	Requirements
Calorimeter fiduciality	central
Photon E_T	>13 GeV (7 GeV for pre-selection)
CES fiduciality	$\|X_{CES}\|$<21.0 cm; 9.0 cm<$\|Z_{CES}\|$<230.0 cm
Average CES χ^2	<20
Had/Em	<0.055+0.00045*E_T
Corrected CalISO	<2.0+0.02(E_T-20) or <0.1*E_T if E_T<20.0 GeV
TrkISO	<2.0+0.005*E_T
N3D	N3D=0,1
Trk P_T (if N3D=1)	<1.0+0.005*E_T
2nd CES (wire or strip)	<0.14*E_T if E_T<18 GeV or <2.4+0.01*E_T if E_T>18 GeV

Phoenix rejection	No photons matched to phoenix track
PMT spike rejection	|pmt1-pmt2|/(pmt1+pmt2)<0.65

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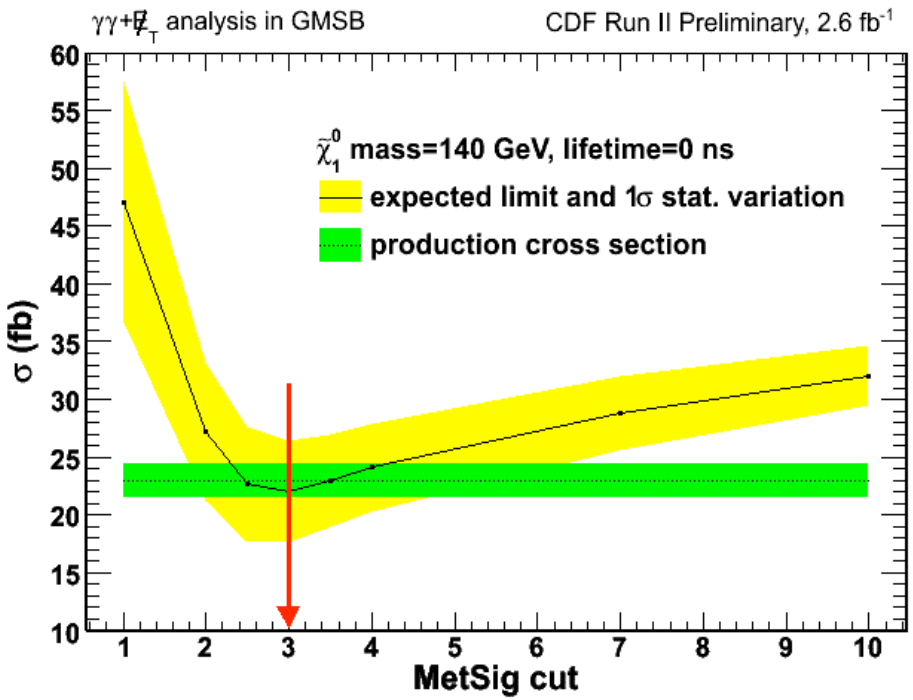
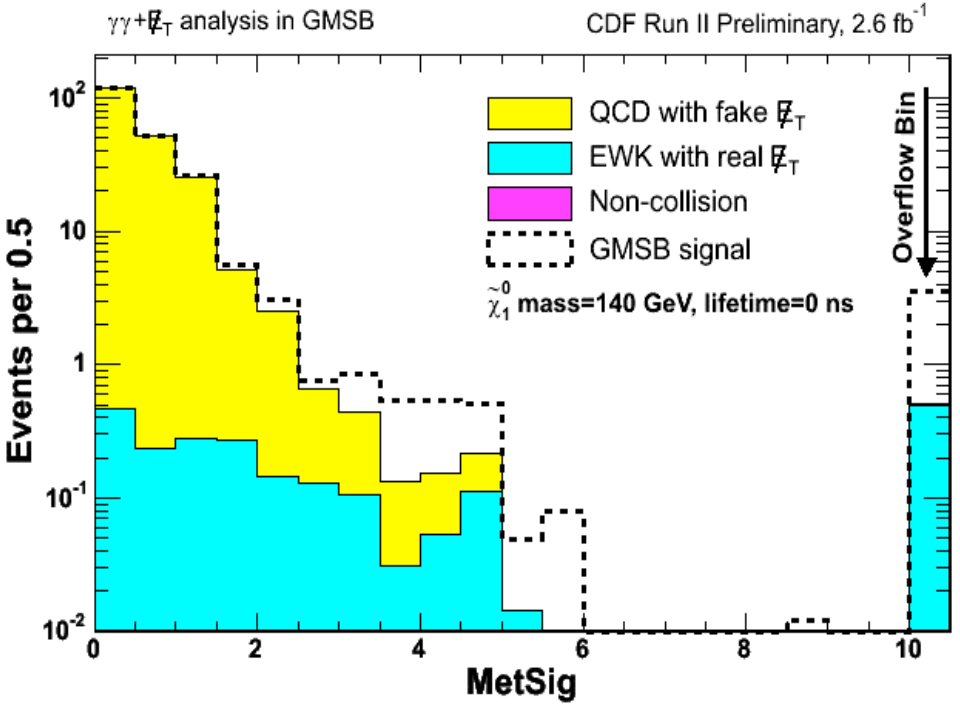
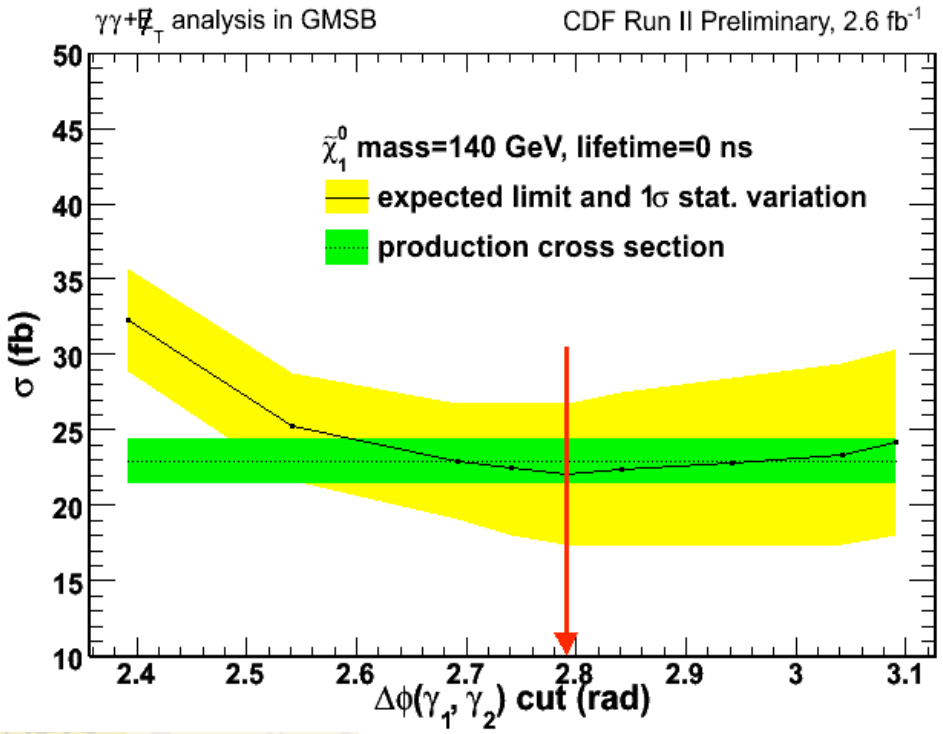
95% C.L. Expected Cross Section Limit and N-1 Plot: MetSig

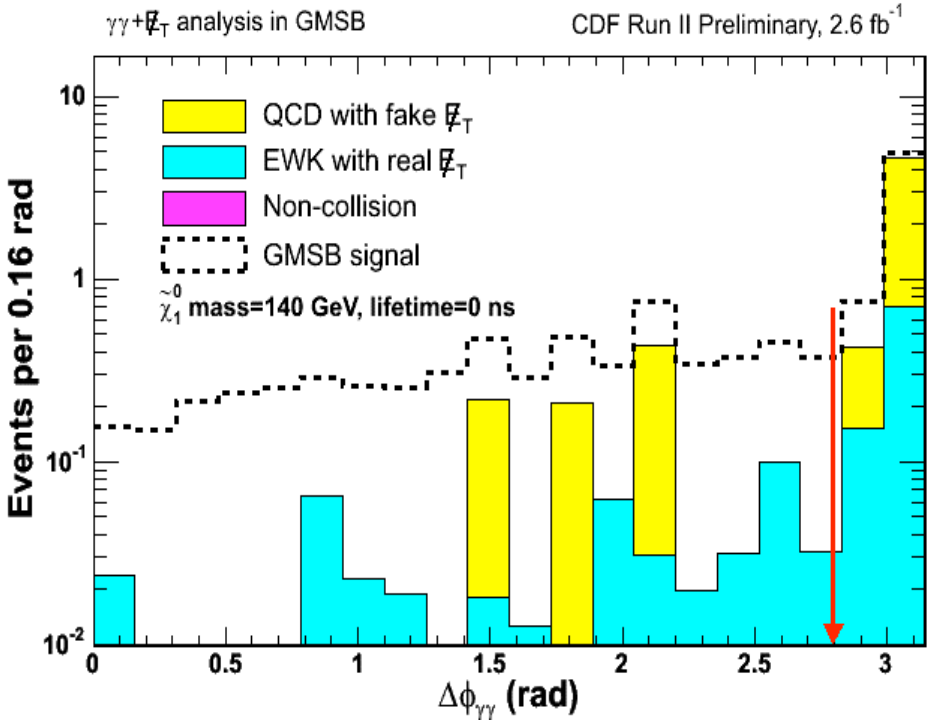




- **While varying a cut all other variables held at optimal cuts**
- **N-1 plot for background distributions along with GMSB MC signal shows good separation**

95% C.L. Expected Cross Section Limit and N-1 Plot: $\Delta\phi(\gamma_1,\gamma_2)$





- **While varying a cut all other variables held at optimal cuts**
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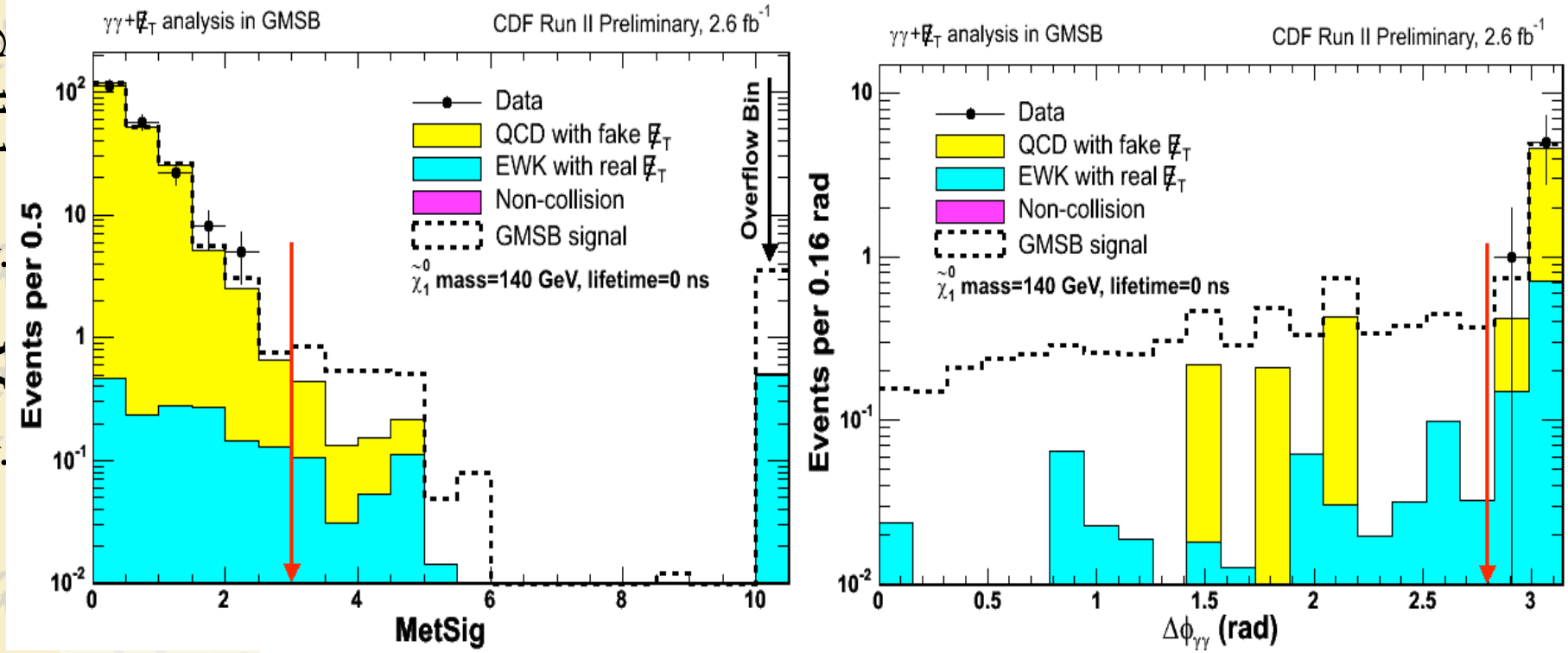
More N-1 Plots



- For a distribution all other variables held at optimal cuts