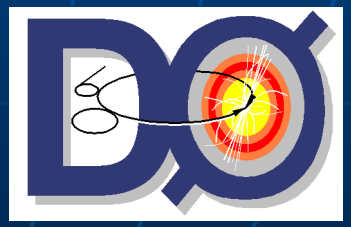
Searches for Gauge Mediated Supersymmetry at the Tevatron

Pierre Lutz (IN2P3/LAL and IRFU/SPP)
on behalf of CDF and D0 collaborations



Covered analyses

- CDF : PRL 104 (2010) 011801 with 2.6 fb^{-1}
  Limits on GMSB Models using Diphoton events with MET at CDFII
- D0 : conference note to be submitted with 6.3 fb^{-1} (not only GMSB, also UED)

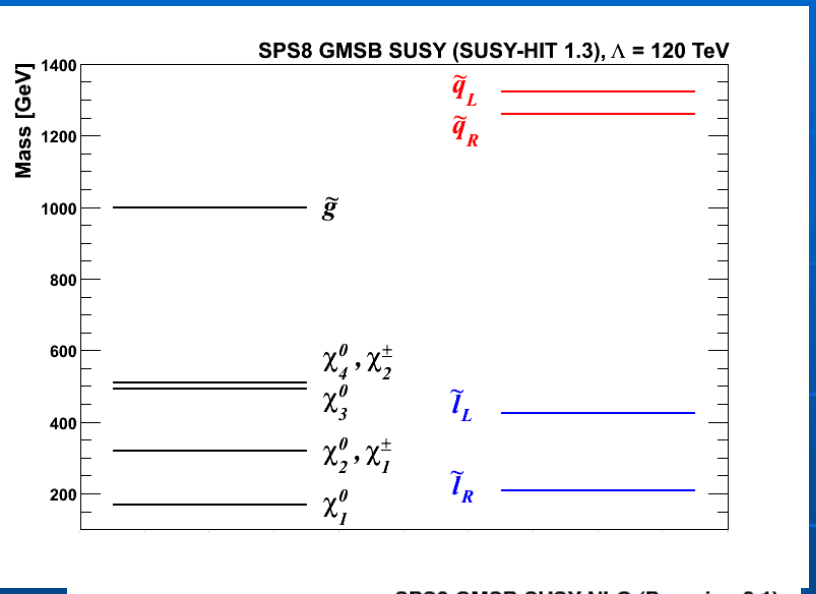
Search for new physics in diphoton events with large MET using 6.3 fb^{-1} of data from ppbar collisions at 1.96 TeV

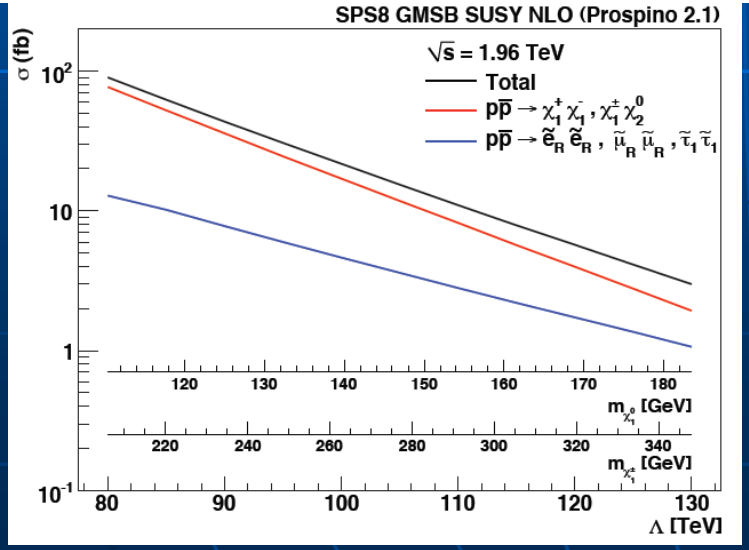
- Both are « searches in $\gamma\gamma$+MET events »
- Not only increase in stat., but improved analyses.

Gauge-Mediated SUSY Breaking

- SUSY breaking energy scale : Λ~100 TeV
- Squarks, gluinos, sleptons are heavy
- Gravitino is LSP (0.5 – 1.5 keV)
- Phenomenology driven by NLSP nature
- If χ^0 NLSP : $\chi_1^0 \rightarrow \tilde{G}\gamma$
- R-parity conserved : $\gamma\gamma$+MET as final state

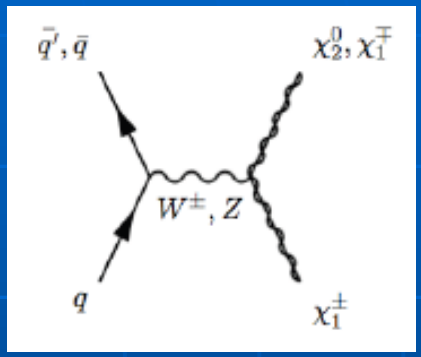
Minimal GMSB (N_{mes}=1,SPS8)



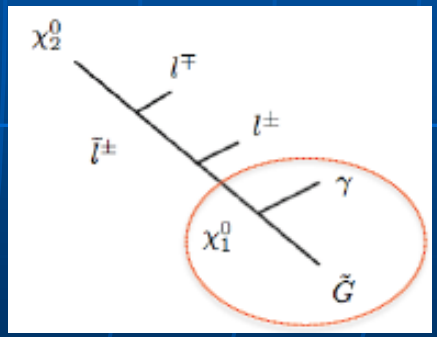


insure χ^0 NLSP

only 5 parameters !



primary production modes



example decay chain

$$\chi_1^0 \to \tilde{G}\gamma$$

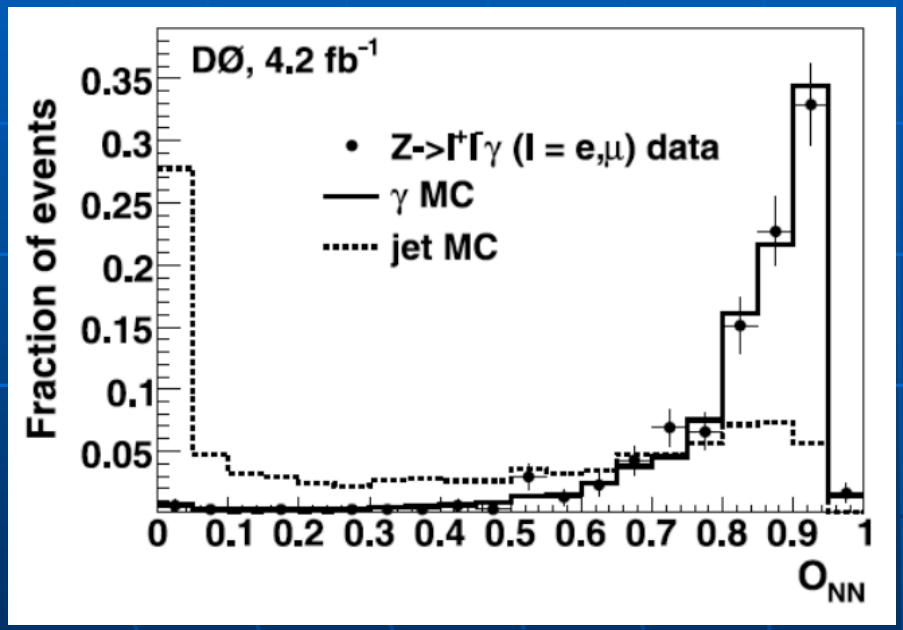
Event selection summary

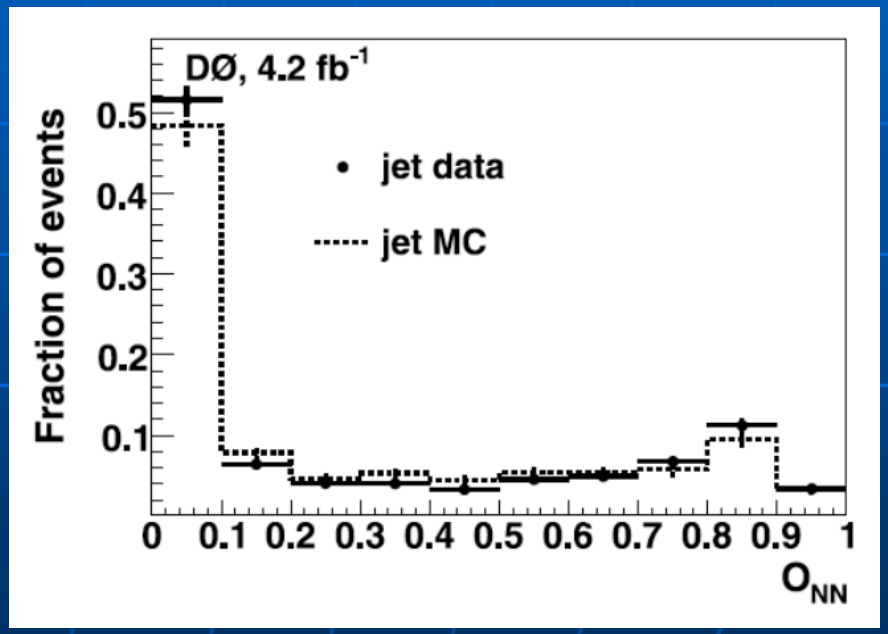
- Select di-photon events
  - DO improvement with a NN
- Find the event vertex
  - EM pointing (DO)
  - EM timing (CDF)
- Cuts to reduce instrumental MET sources
  - CDF improvement with MET model

common to both, emphasize only improvements

Photon identification

An improved photon identification achieved by using a neural network, with 5 input variables, describing the shape and isolation of the shower, discriminant between true γ and misidentified jets.





for same eff. ~2 improvement in rejection, allowing improved formulation of bkgd model

from PLB 690 (2010) 108

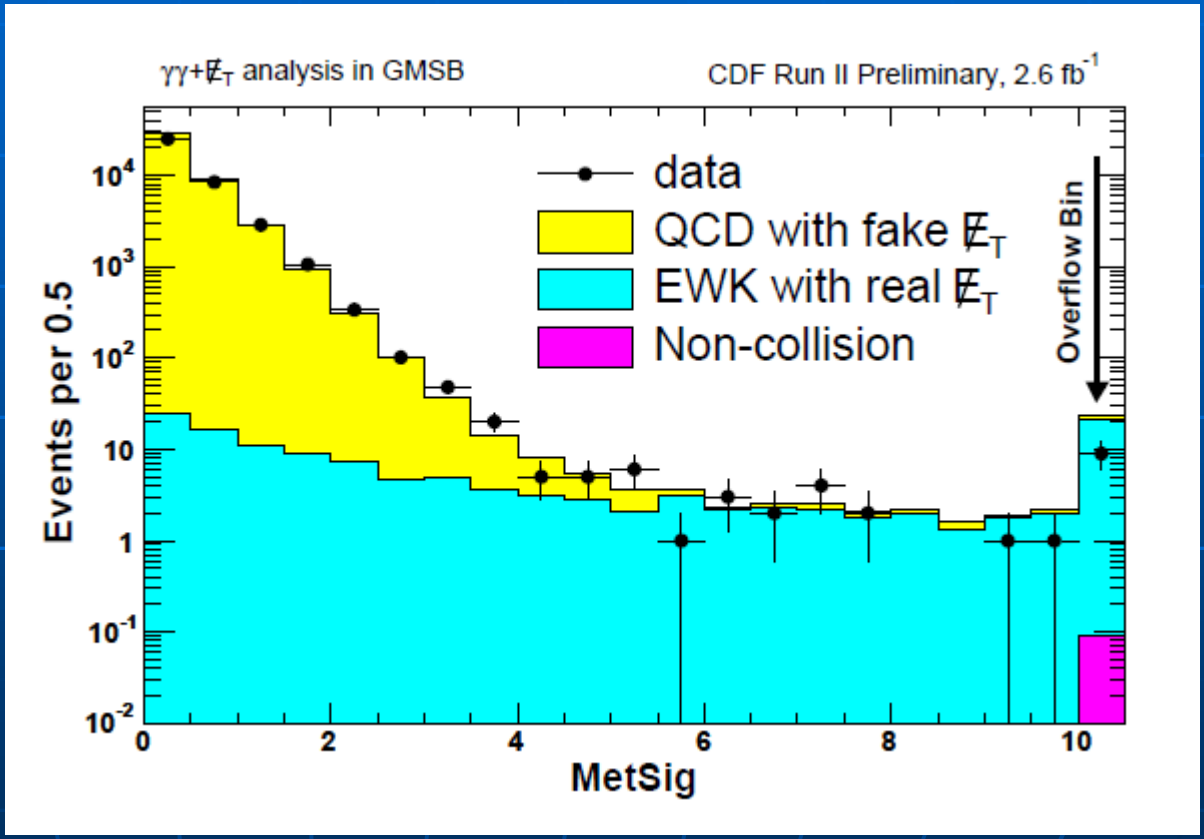
Vertexing

- Wrong vertex = wrong MET !
- CDF : uses the photon timing system to reject most of cosmics induced diphoton and beam-halo events.
- D0 makes use of the preshower to check if both photons are pointing near the primary vertex (event is removed if not)
- Consequence : only ~prompt decays of χ° can be considered (for both CDF and D0)

MET Model

significance computed from the p-value to see fluctuations in the energy measurement to produce a MET greater or equal to the observed one

Fake MET has low significance.
Note the exponential behaviour for fake MET



Backgrounds

- Instrumental, with no inherent MET

1. SM $\gamma\gamma$ (40%) due to γ mismeasurement
2. γ+jets (jet faking a photon)

- Genuine MET

1. Wγ, W-jet, arising from a missed e track
2. W/Z+$\gamma\gamma$ (real MET coming from νs)

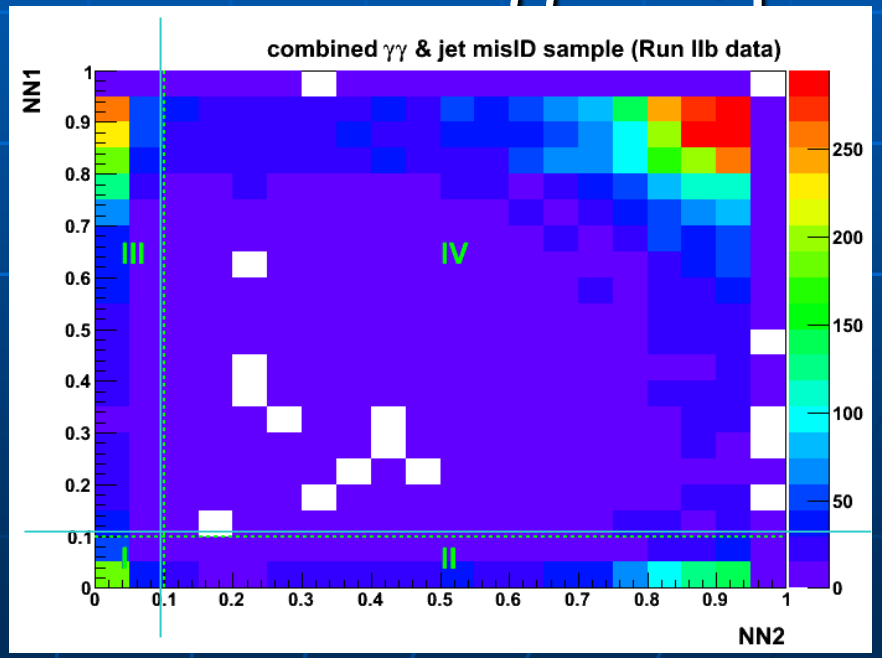
- All are measured from data control samples (but small W/Z+$\gamma\gamma$ from MC)

Data Control samples

From variations of the track veto and NN, form data control samples to estimate background contributions to the $\gamma\gamma$ sample

Sample	TrkVeto	NN
$\gamma\gamma$	P , P	P , P
ee	F , F	P , P
eγ	F , P	P , P
jet misID	P , P	F , P/F

region IV : $\gamma\gamma$ sample
regions I+II+III : jet misID sample



MET modeling

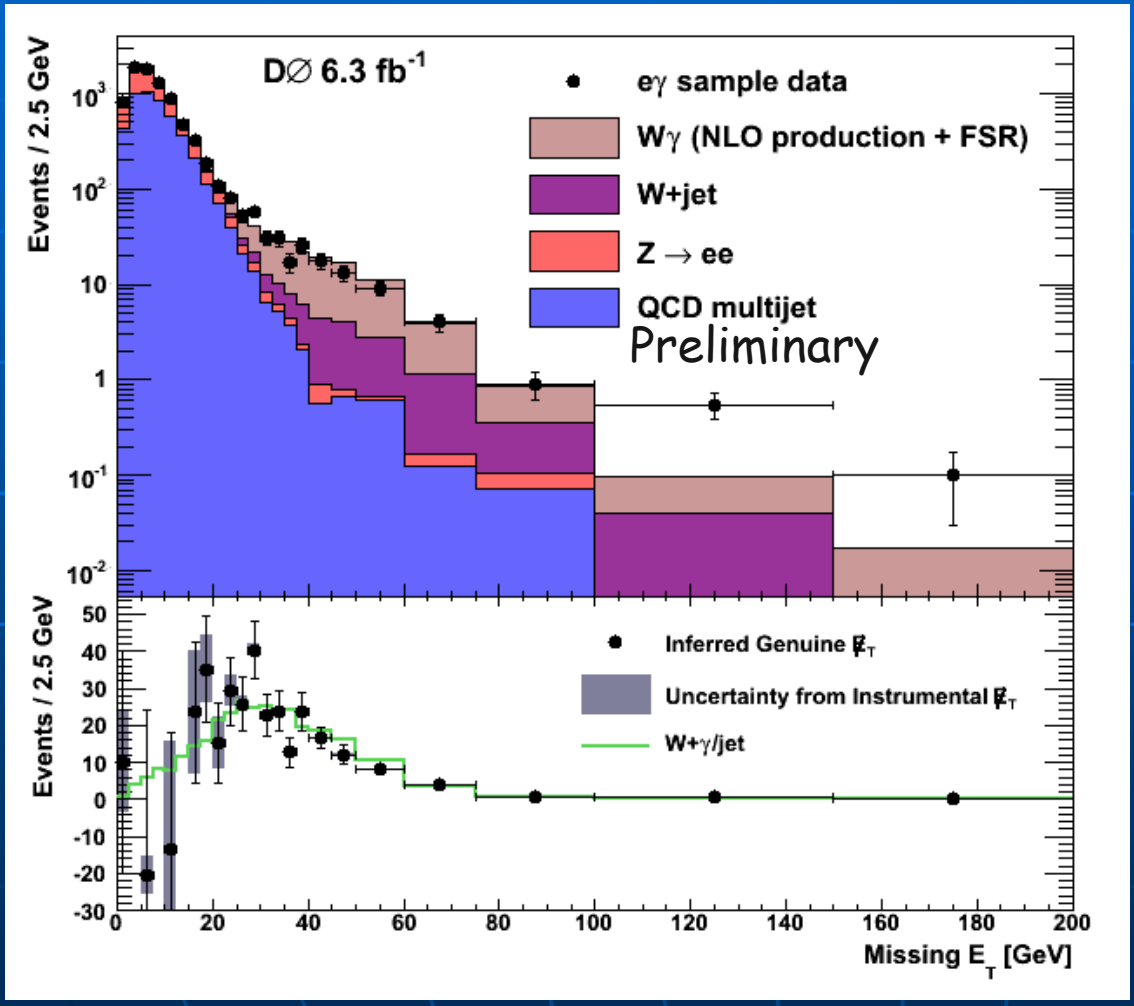
- MET shape:

1. In SM $\gamma\gamma$: modeled with Z → ee data sample, cross cheked with SM $\gamma\gamma$ MC (used as systematics)
2. In mis-identifed jet events : modeled with jet misID DATA sample (at least one « γ » failing NN)

- Normalization : on MET<10 GeV, by fitting the SM $\gamma\gamma$ and misID jet relative contributions.
- Electron misID contribution is derived from the $e\gamma$ sample. Differences can be attributed to $W\gamma$ and W+jet processes

Background estimation developed with Run IIb $\gamma\gamma$ sample data blinded in the MET > 50 GeV region.

Complete elec misID prediction

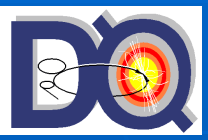


Difference between eγ data and instr. MET with the croos check from Wγ and W+jet

This difference, when multiplied by the e -> γ fake rate, constitutes the ele misID contribution to the diphoton MET

Systematic Uncertainties

similar for both analyses



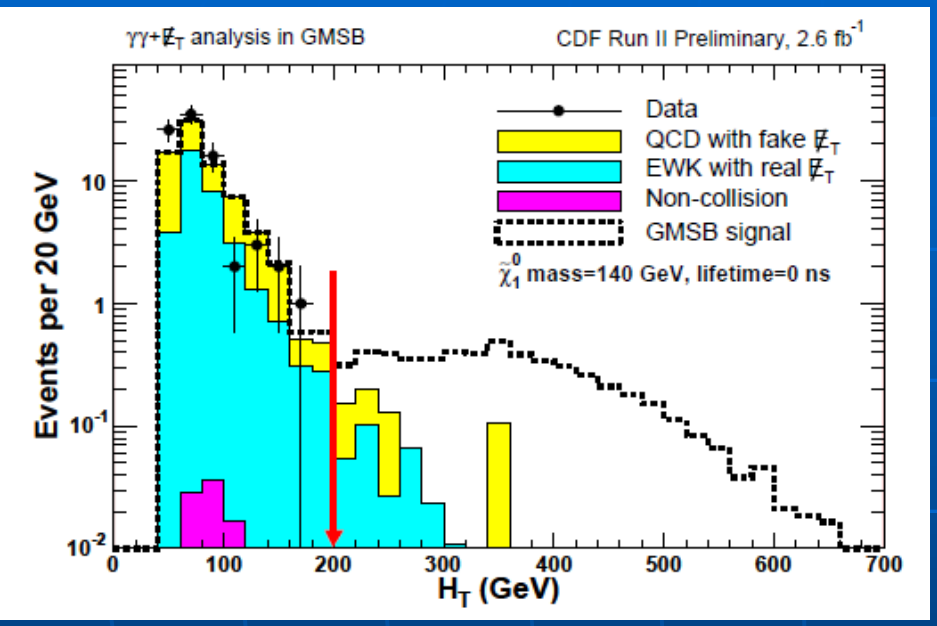
Associated with bkgrnds estimated from data

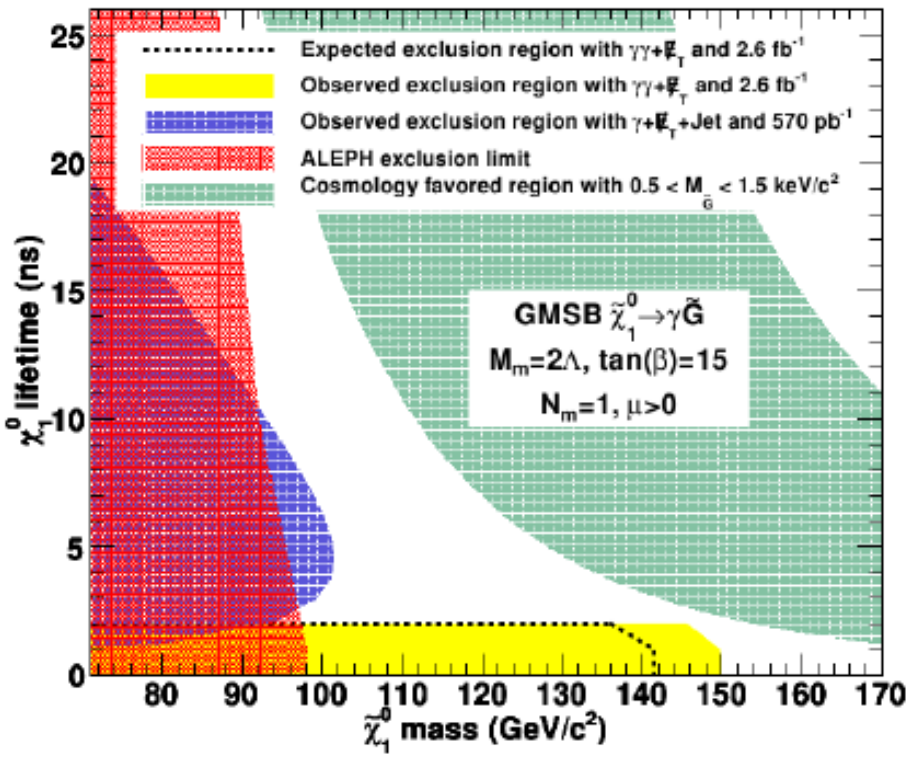
- $\gamma\gamma$ MET shape
- Jet misID MET shape
- Rel. normalisations
- Overall norm. from uncertainty in e faking γ rate

Associated with contributions estimated from MC

- Luminosity (6.1%)
- Single EM trigger efficiency (2%)
- Photon ID eff. (3%)
- Data/MC CPS-PV (3%)
- PDFs (5% for GMSB)

Results (1)



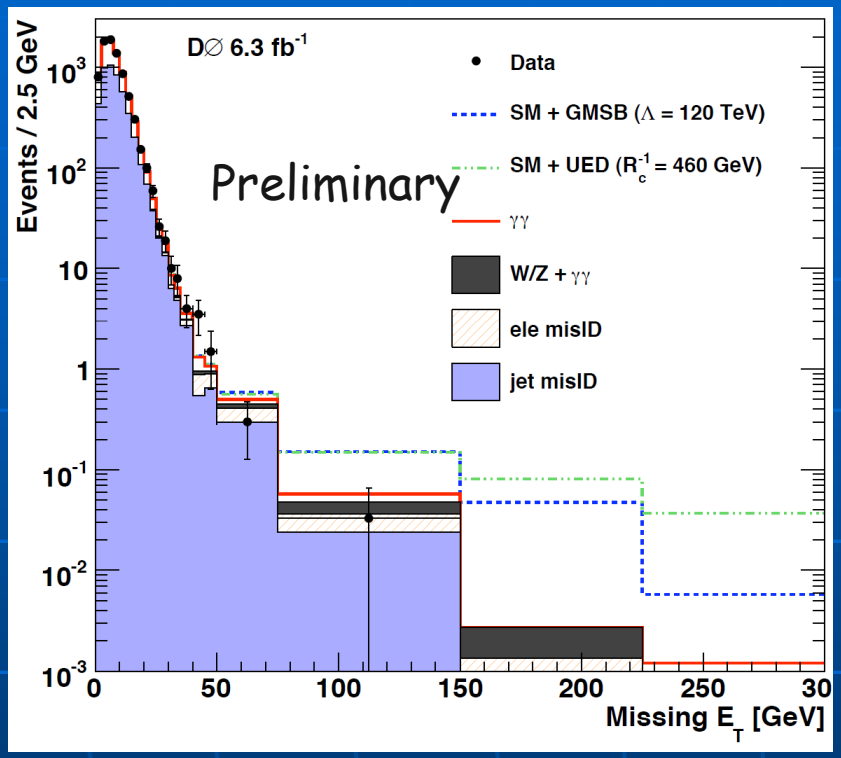


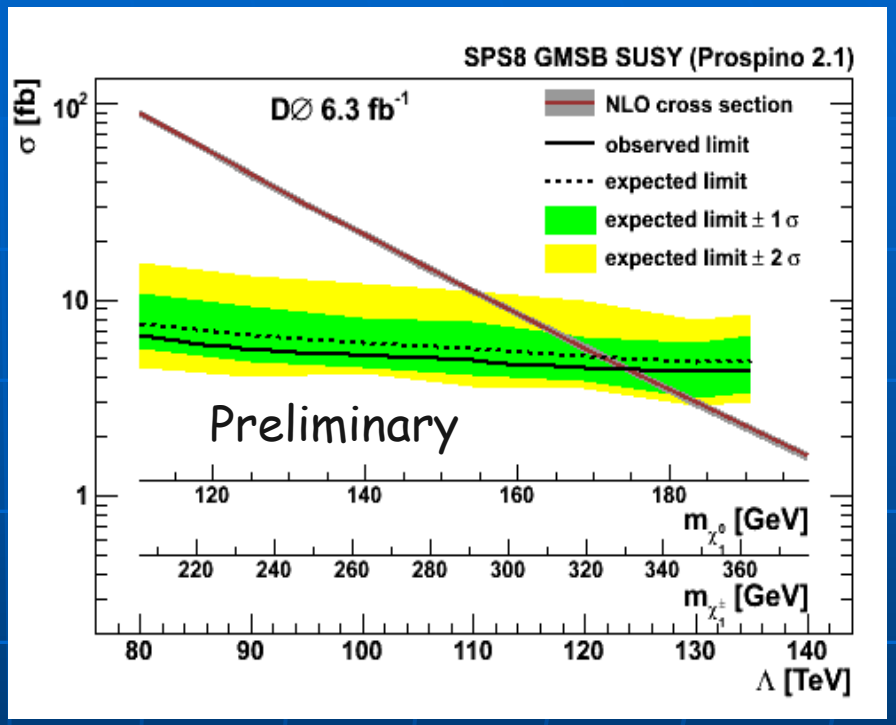
Background Source	Expected Rate±Stat±Sys
Electroweak	0.77±0.21±0.22
QCD	0.46±0.22±0.10
Non-Collision	$0.001^{+0.008}_{-0.001} \pm 0.001$
Total	1.23±0.30±0.24

Data : no event observed

χ^0 mass > 149 GeV/c^2 (95% CL)

Results (2)





Observed MET consistent with SM

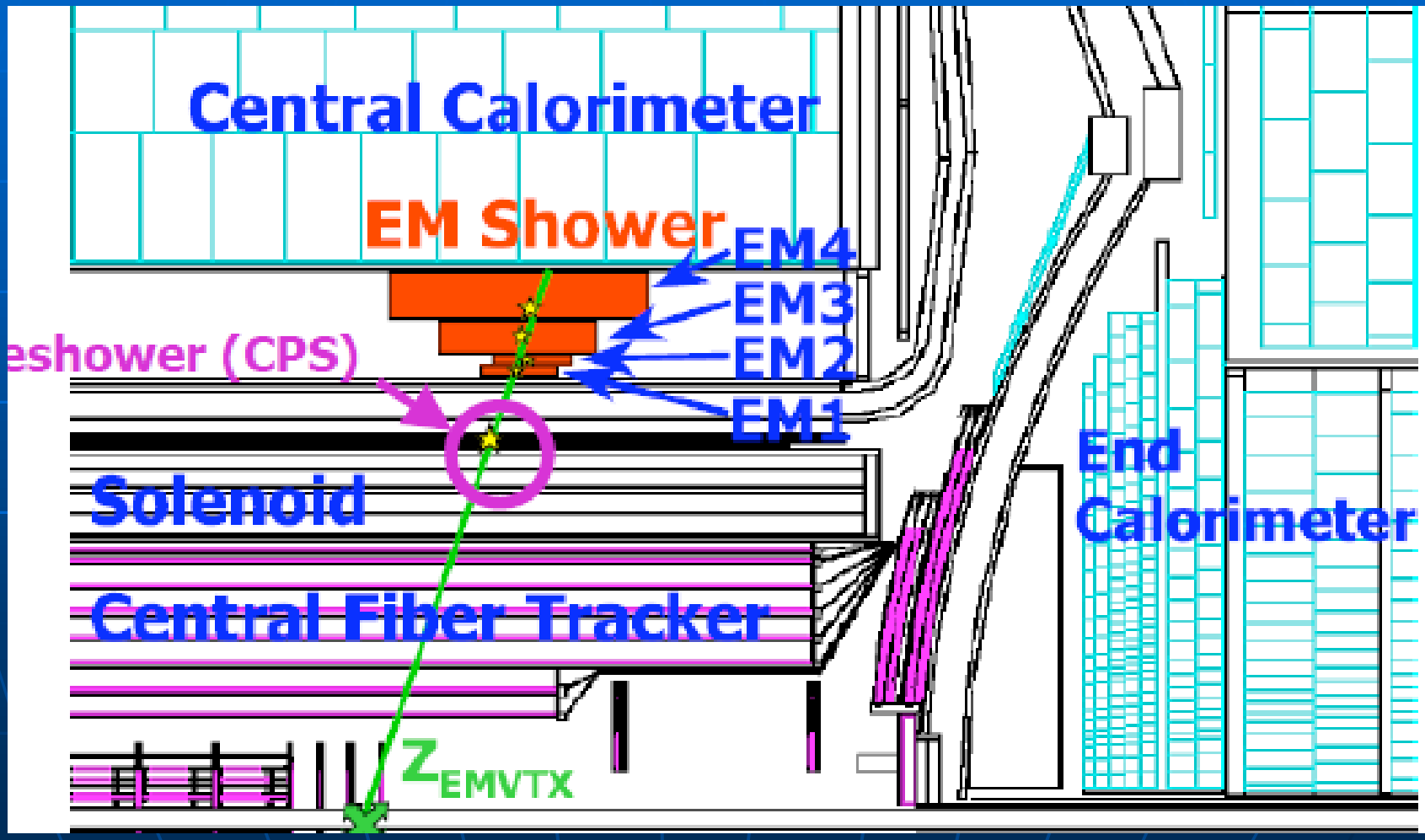
Limits :
Λ<**124 TeV** excluded (95% CL)
χ^0 mass > 175 GeV/c^2 (95% CL)

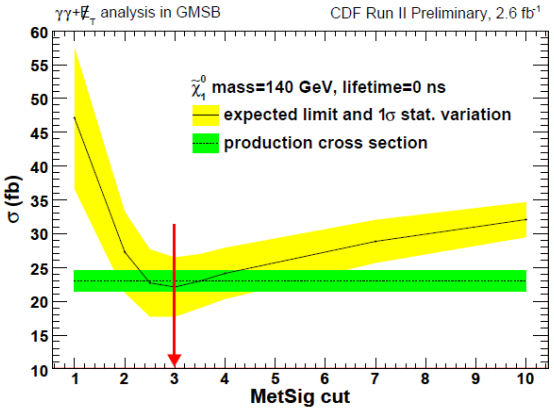
Conclusions

- CDF and D0 performed a search for GMSB in the $\gamma\gamma$+MET final state
- Used improved methods to remove instrumental and SM backgrounds
- $\gamma\gamma$ sample MET distribution consistent with SM prediction
- Using 6.3 fb^{-1} of data, D0 sets the most stringent limit on SPS8 slope to date :
- $\Lambda > 124$ TeV @ 95% CL (or $\chi^{\circ} > 175$ GeV)

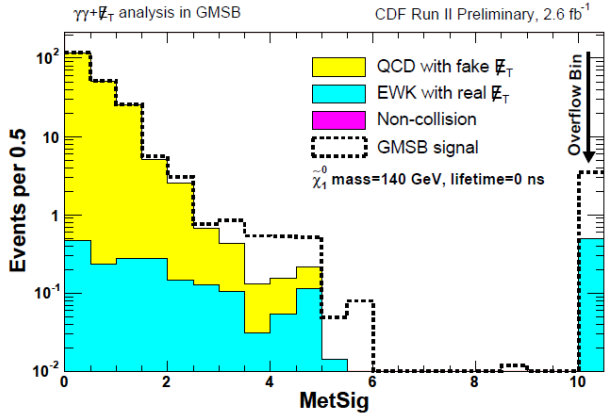
Backup slides

D0 preshower

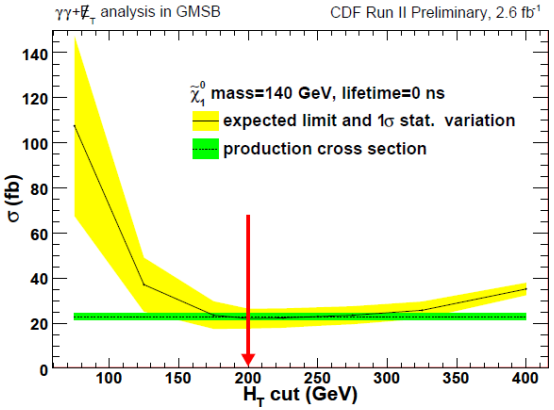




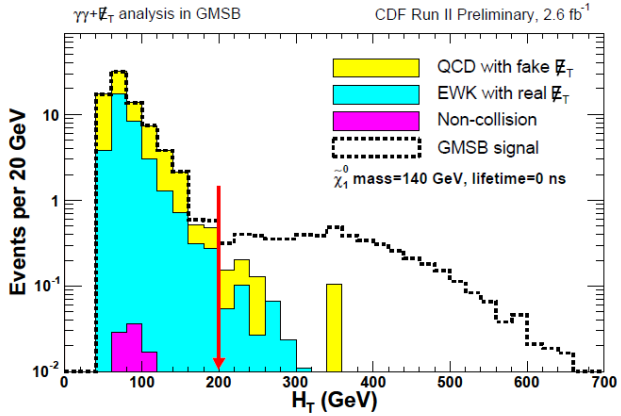
(a)



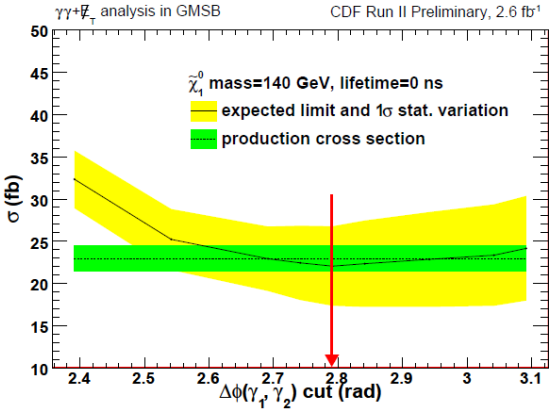
(b)



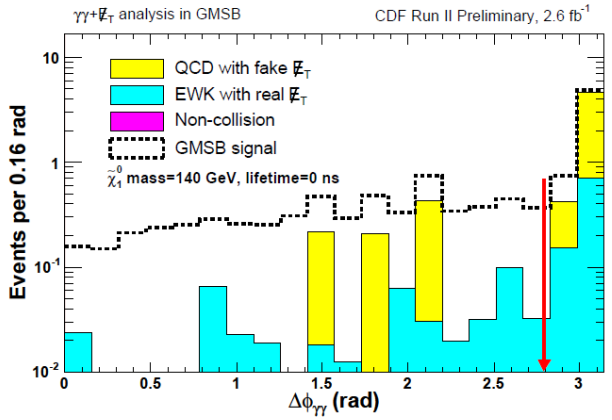
(c)



(d)



(e)



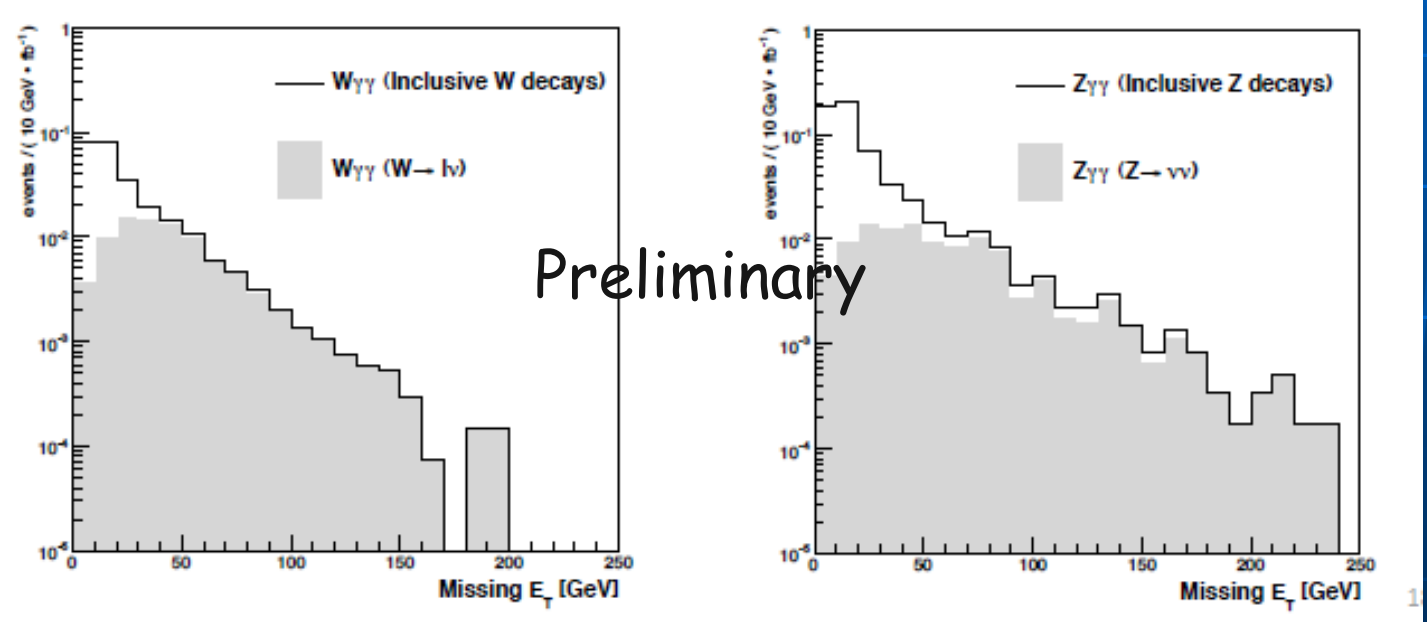
(f)

The expected 95% CL cross section limit as a function of the 3 final variables for an example point mχ° = 140

The N_1 predicted kinematic distributions after the optimized requirements (right)

The W/Z+γγ processes

Rare SM γγ+MET estimated from MC (Baur for CDF, MADGRAPH for DO)



Preliminary

1.64 +- 0.13 Wγγ events

3.65 +- 0.29 Zγγ

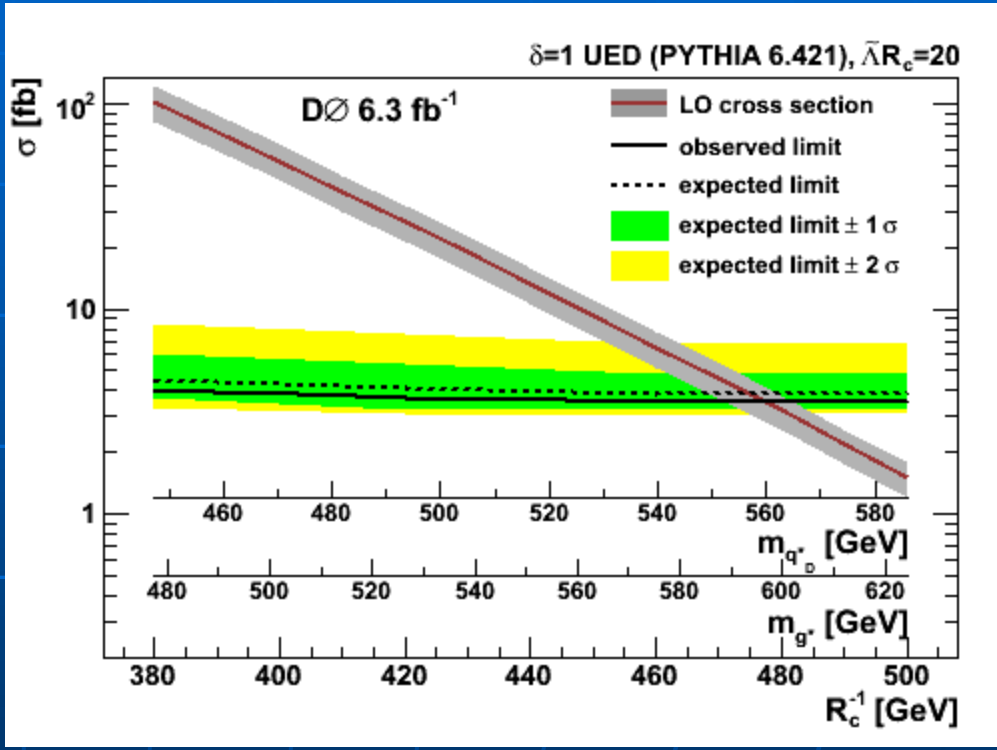
Expected number of evts for all MET values (inclusive decay modes)

UED interpretation

4+N dim. space, compactification radius R, and gravitational interactions violating KK parity

LKP (the KK photon γ^* decays gravitationally to $G\gamma$

Thus the same final state !



$R^{-1} > 477$ GeV @ 95%CL