Search for Charginos and Neutralinos with the DØ Detector

DPF 2009

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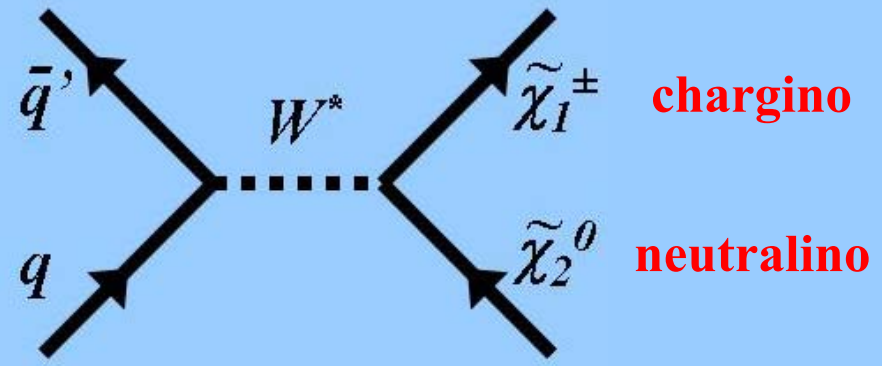
Outline

1. Trileptons

2. Dark photons

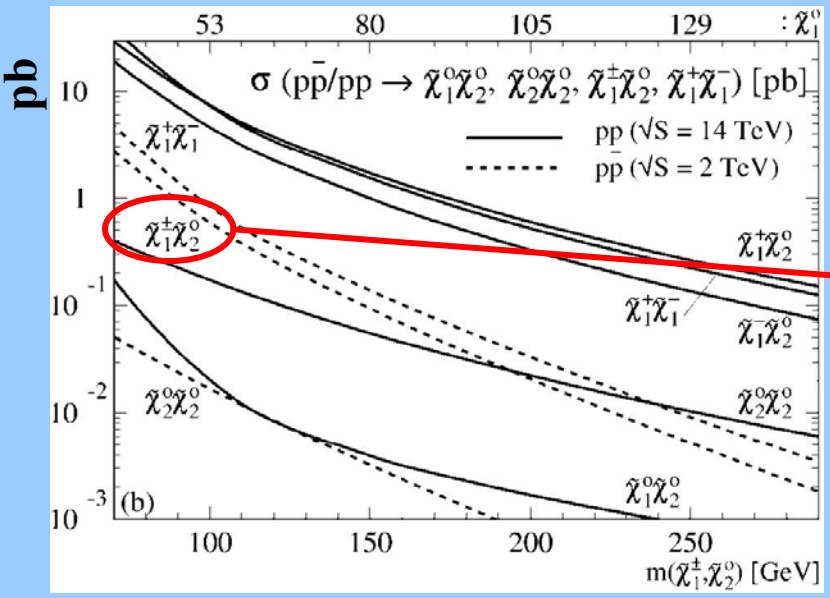
Associated Production

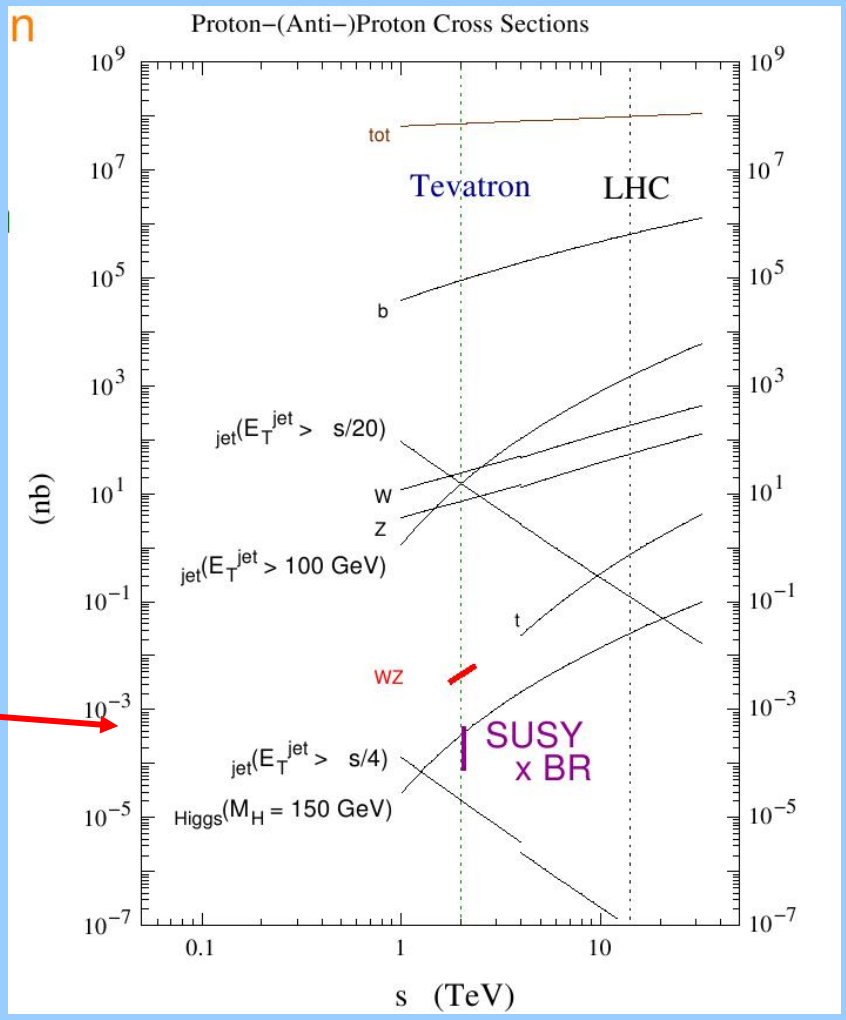


chargino

neutralino

from W. Beenakker, PLR 83, 3780 (1999):

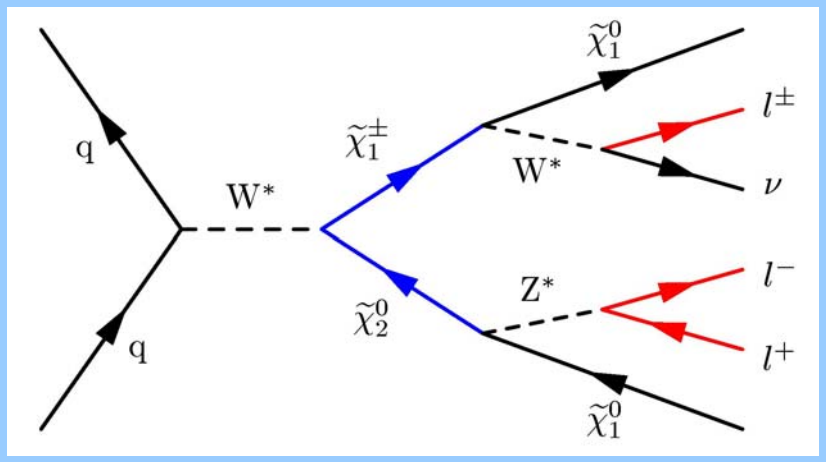


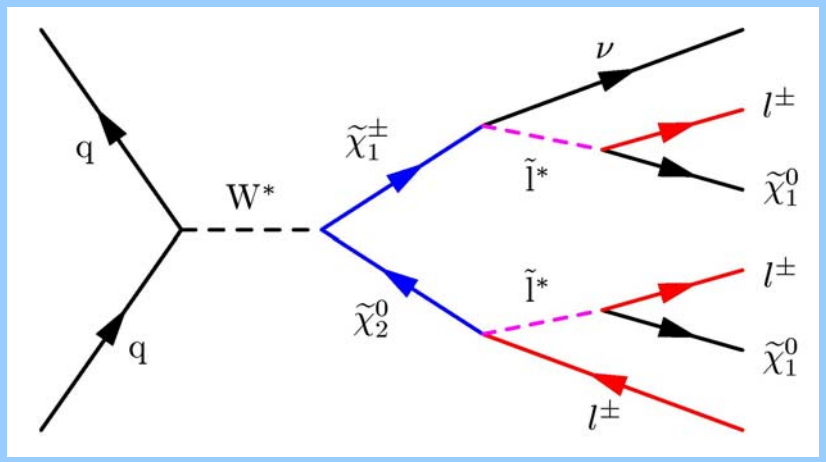


- **Small cross section – requires small backgrounds**

Trileptons

- **Use leptonic decays to improve signal to background**





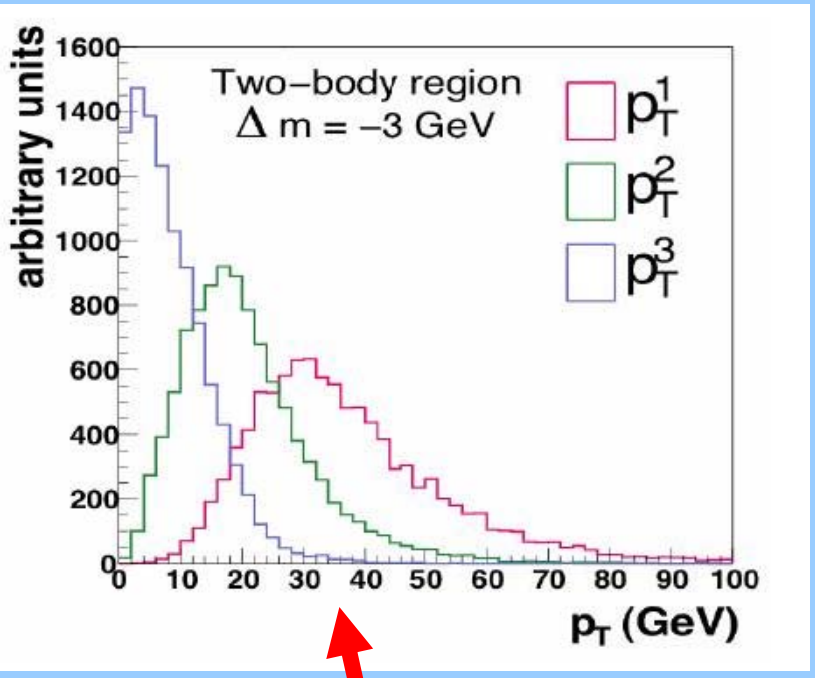
- **very few SM sources with 3 isolated leptons**
- **kinematics depend upon mass relations**
- **mSUGRA benchmark model:**

A_0=0, tanβ=3, μ>0

	m_0	$m_{1/2}$	$m_{\tilde{\chi}_1^{\pm}}$	$m_{\tilde{\chi}_2^0}$	$m_{\tilde{\chi}_1^0}$	$m_{\tilde{\ell}}$	$m_{\tilde{\nu}}$
SUSY 2	150	170	107	109	59	168	179
SUSY 1	150	250	177	176	95	161	220

Trileptons

- **Use leptonic decays to improve signal to background**



one example part of phase space

- **very few SM sources with 3 isolated leptons**
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A_0=0, tanβ=3, μ>0

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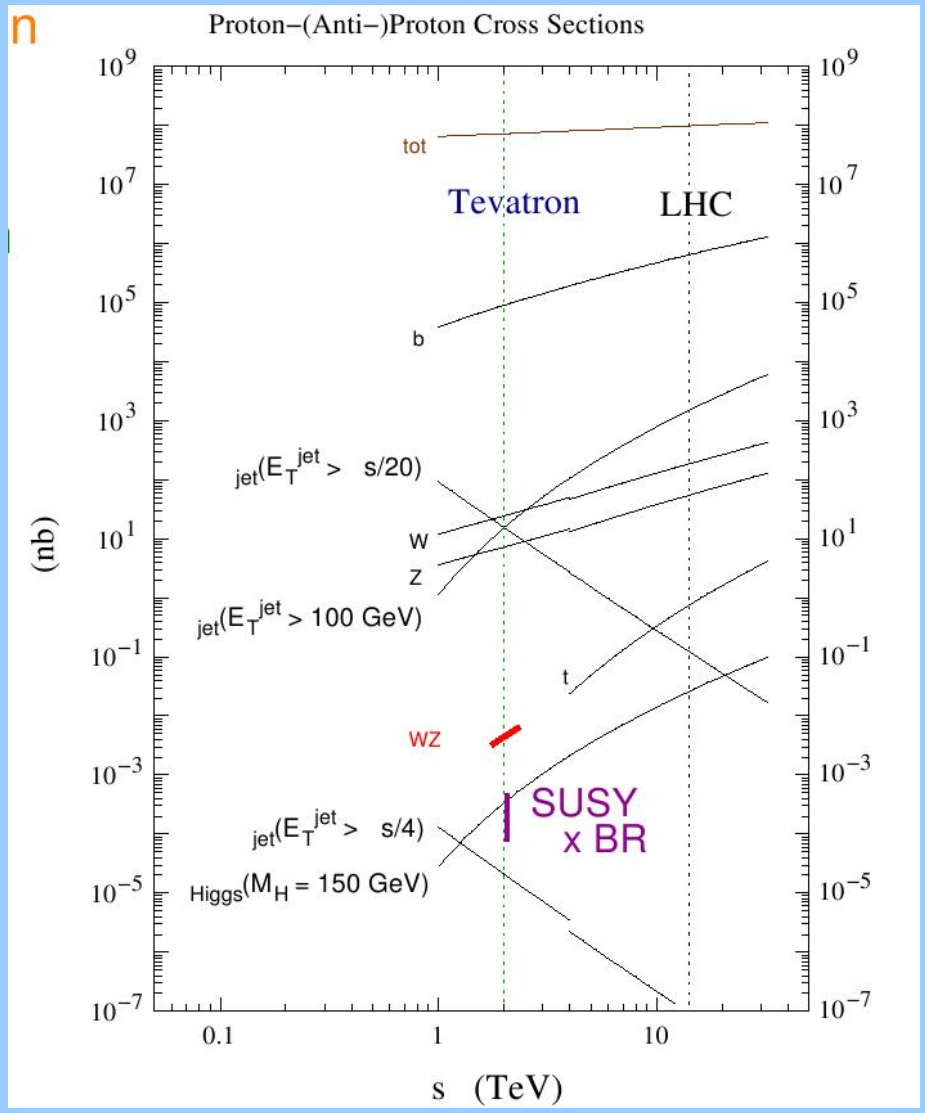
Backgrounds

- Multijet and W
  - two isolated leptons
- Z/γ*
  - missing transverse energy
- W and Z/γ* and top
  - third isolated track
- dibosons
  - natural SM background



Trilepton Channels

electron e	muon μ	tau lepton τ	isolated track ℓ
energy in EM calorimeter	track in muon system	hadronic decay = narrow jet	central track without nearby activity

- Require two leptons + isolated track
  - isolated track allows for higher efficiency at low pT
- Optimize selection for high mass and low mass scenarios
- Five channels analyzed and combined
- Tau channels are new!

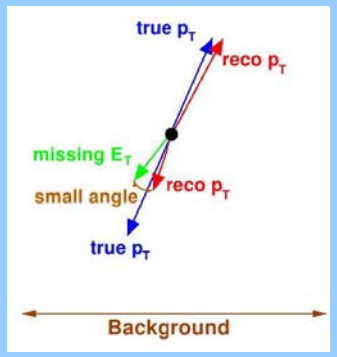
High Mass	SUSY1
Low Mass	SUSY2

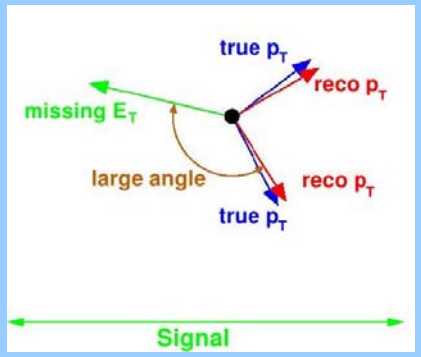
eeℓ	eμℓ	μμℓ	μττ	μτℓ
2.3 fb^{-1}			1 fb^{-1}	

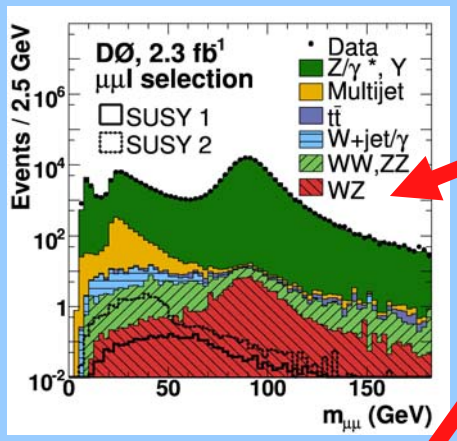
Optimized Selection

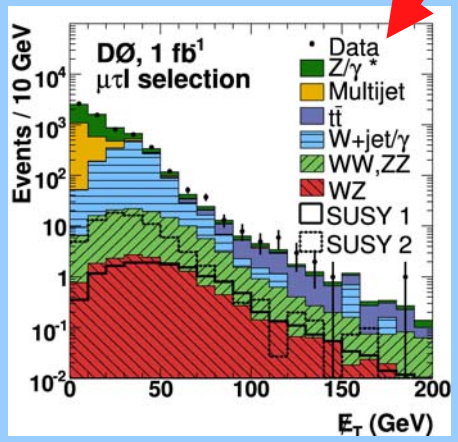
- $p_T(l)$
- $m(l_1 l_2) < Z$ peak
- $\Delta\varphi(l_1 l_2)$
- $\not\!\!E_T$
- m_T^{min}
- $p_T(track)$
- $m_T(track)$
- m(l,track)
- anti-W
- $\not\!\!E_T \times p_T^{track}$

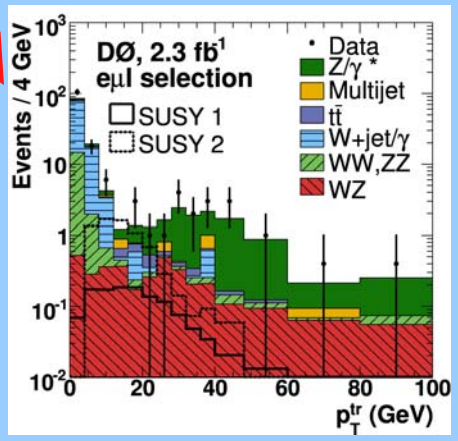
$\mu\tau$ channels : $\Delta\phi(\not\!\!E_T, track)$

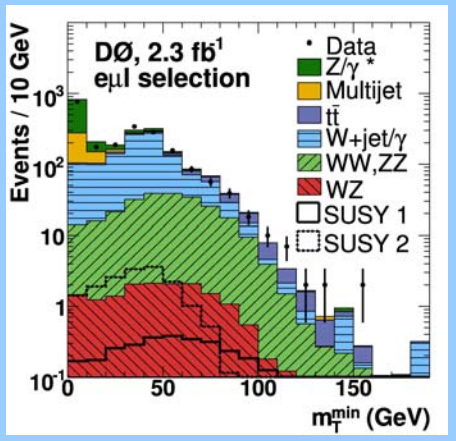












Each channel optimized separately

Detailed Selection

	Selection	μμℓ		eeℓ		eμℓ	
		low p_T	high p_T	low p_T	high p_T	low p_T	high p_T
I	p_T^{l1} , p_T^{l2} (GeV)	>12, >8	>18, >16	>12, >8	>20, >10	>12, >8	>15, >15
II	$m(\ell_1\ell_2)$ (GeV)	$\in$[20,60]	$\in$ [0,75]	$\in$ [18,60]	$\in$ [0,75]	-	-
	$\Delta\varphi(\ell_1\ell_2)$ (rad)	< 2.9	< 2.9	< 2.9	< 2.9	-	-
III	$\not\!\!E_T$	> 20	> 20	> 22	> 20	> 20	> 20
	Sig($\not\!\!E_T$)	> 8	> 8	> 8	> 8	> 8	> 8
	m_T^{min}	> 20	> 20	> 20	> 14	> 20	> 15
	jet-veto H_T	-	< 80	-	-	-	-
IV	p_T(track) (GeV)	> 5	> 4	> 4	> 12	> 6	> 6
V	m_T(track) (GeV)	> 10	> 10	> 10	> 10	> 10	> 8
	$m(\ell_{1,2}$, track) (GeV)	$\notin$ [80,110]	-	-	-	< 70	< 70
VI	anti-W	-	-	tight likelihood	-	tight likelihood hit in inner 2 layers very tight μ isolation Σp_T(track)<1 GeV	
VII	$\not\!\!E_T \times p_T$(track)	> 200	> 300	> 220	-	-	-
	p_T^{bal}	< 4	< 4	< 4	< 4	< 2	< 2

Trilepton Results

	eeℓ		eμℓ		μμℓ	
	high pT	low pT	high pT	low pT	high pT	low pT
Data	0	2	0	2	4	4
Bkgd	0.8±0.1	1.8±0.2	0.5±0.1	0.8±0.2	2.0±0.3	1.2±0.2

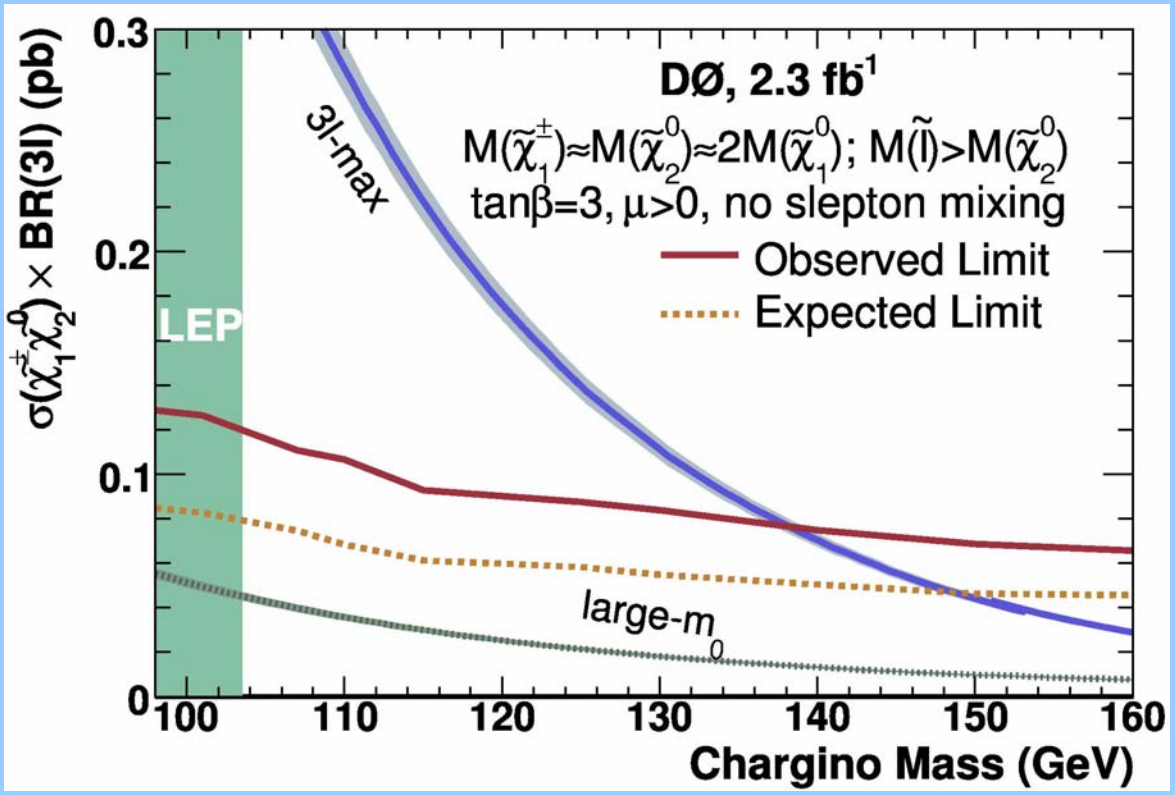
	μττ	μτℓ
Data	1	0
Bkgd	0.8±0.2	0.8±0.1

- Good agreement with expected background
- Largest backgrounds are diboson

- Systematic uncertainties include luminosity, trigger/id efficiencies, energy calibration, PDFs, and multijet background

Cross Section Limit

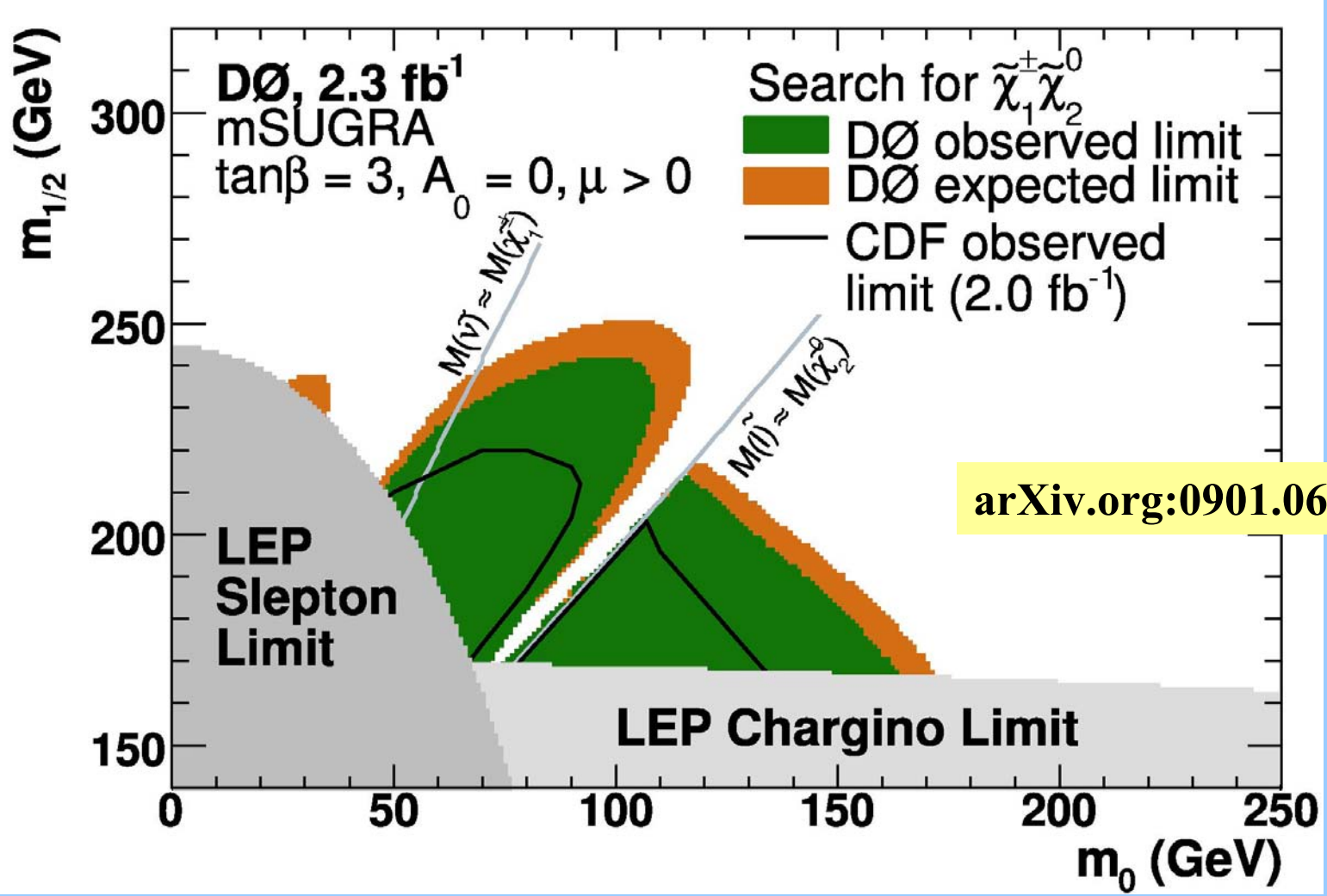
	Low pT	High pT
Bkgd	5.4 ±0.4 (stat) ±0.4 (syst)	3.3 ±0.3 (stat) ±0.3 (syst)
Data	9	4
SUSY signal	9.3 ±0.3 (stat) ±0.8 (syst)	0.9 ±0.1 (stat) ±0.1 (syst)



arXiv.org:0901.0646

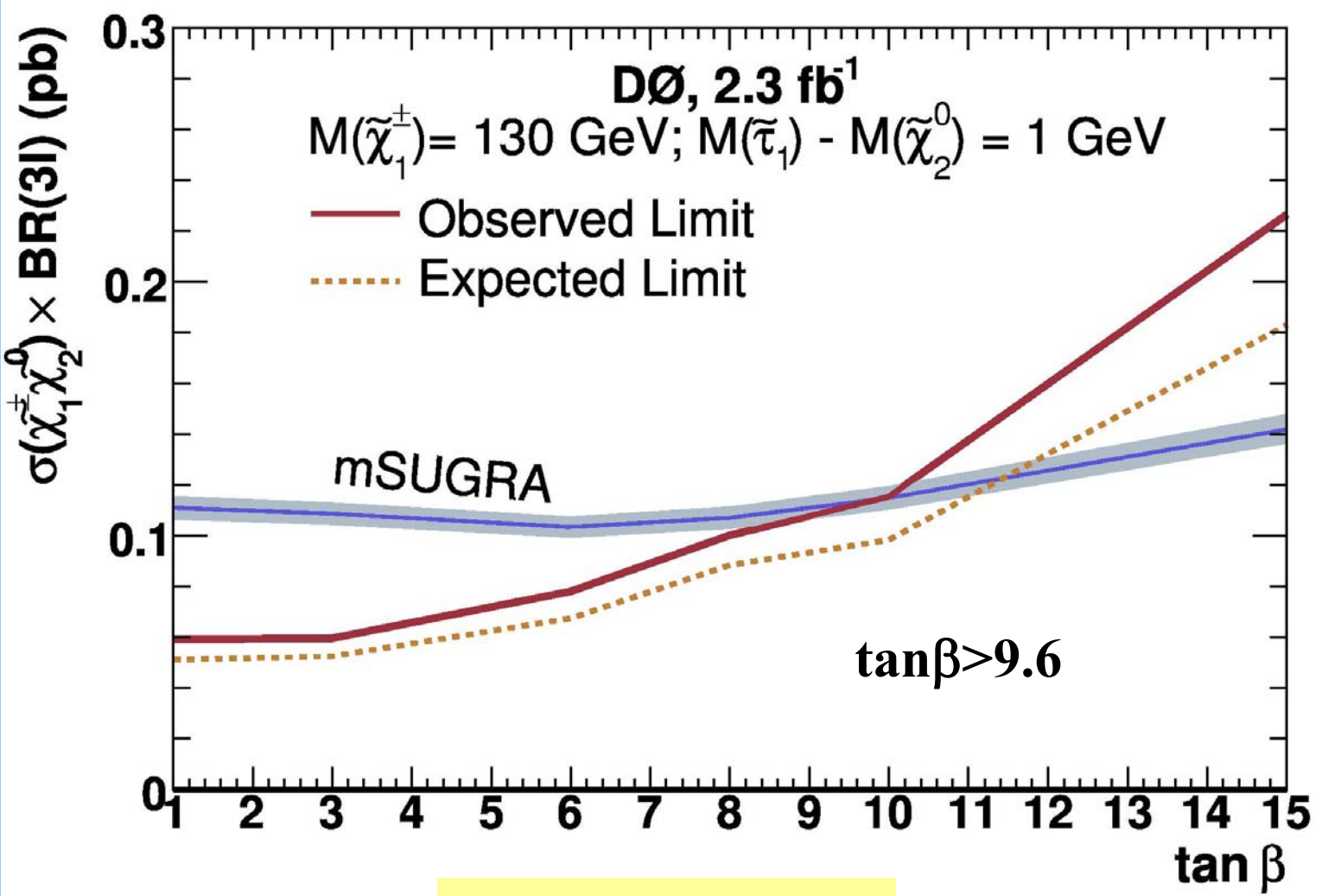
for 3l-max: $m(\chi_1^{\pm}) > 138$ GeV
(145 GeV expected)

mSUGRA Limits



arXiv.org:0901.0646

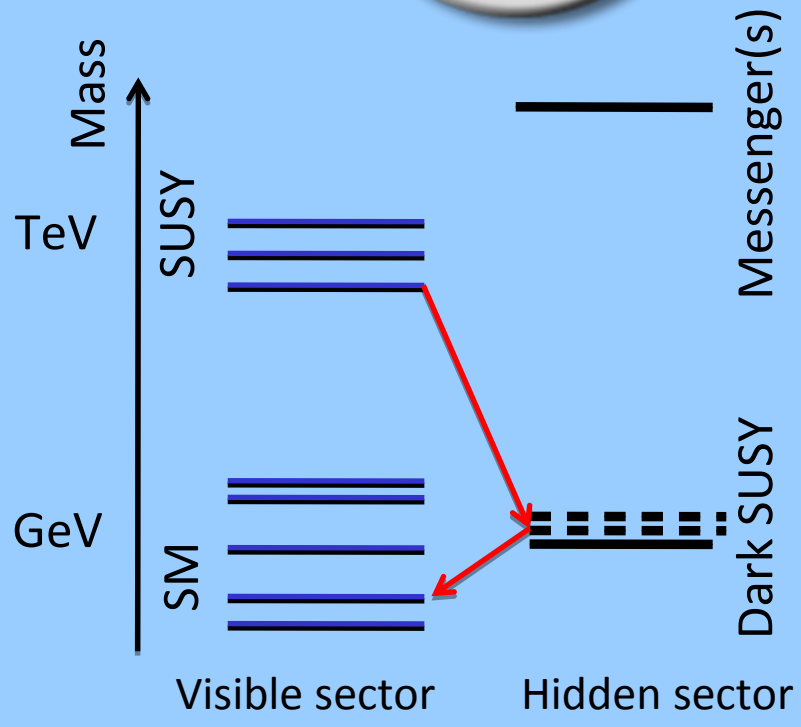
tanβ Limit



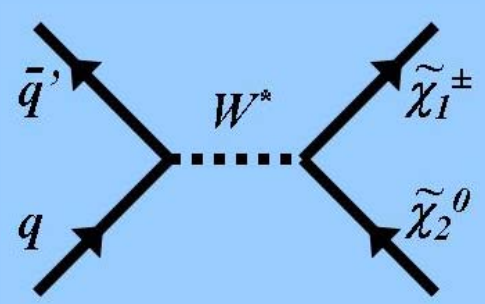
arXiv.org:0901.0646

The Light Dark Side of SUSY

- **Recent results from PAMELA, ATIC, EGRET, FERMI-LAT, HESS**
  - **cosmological results → particle physics solution?**
- **N. Arkani-Hamed et al., (Phys.Rev.D79:015014,2009)**
  - **propose excess due to decay of WIMP ~500-800 GeV**
- **"dark SUSY"**
  - **SUSY with a hidden valley**
  - **dark particles can be light (not very massive ~ GeV)**

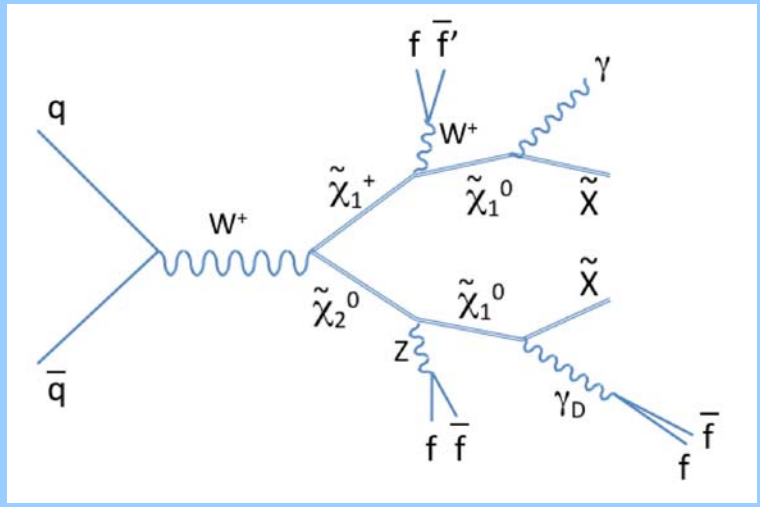


Production and Decay



- Still look for associated production of charginos and neutralinos
  - GMSB instead of mSUGRA

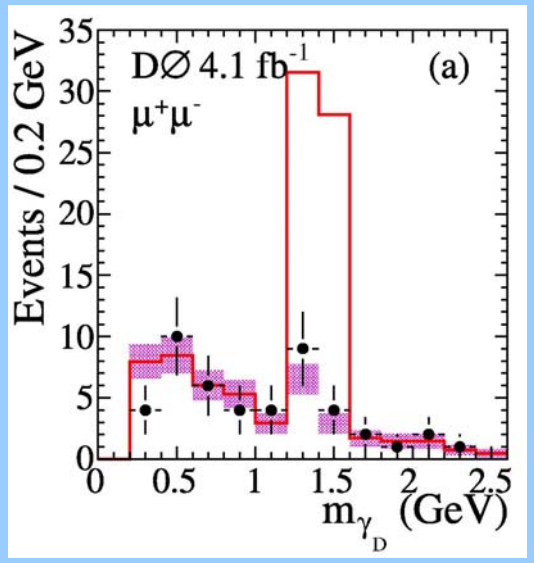
- Now χ_1^0 decays to either
  - photon + dark LSP
  - dark photon + dark LSP
- Dark photon (~ GeV mass) decays to fermion pair

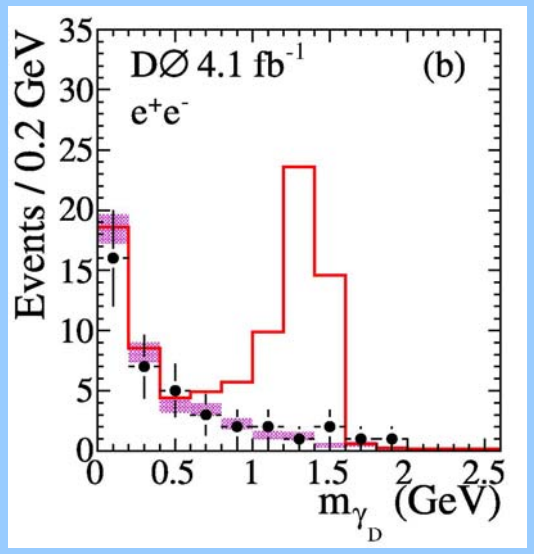


- Search for ee or μμ pair with small opening angle
  - same production → radically different signal

Dark Selection

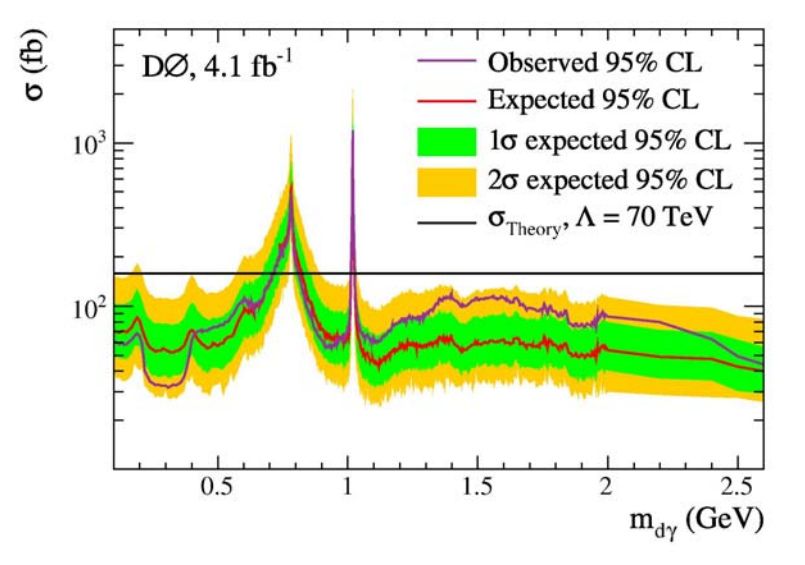
- At least one photon $E_T > 30$ GeV
- $\not\!\!E_T > 20$ GeV
- Two spatially close ($\Delta R < 0.2$) tracks (not back-to-back with photon)
- Track pair isolated
  - $\Sigma p_T^{tracks}(\Delta R<0.4) < 2$ GeV
- Track pair matched to muon or electron candidate
- Backgrounds estimated from data control regions
- No excess observed





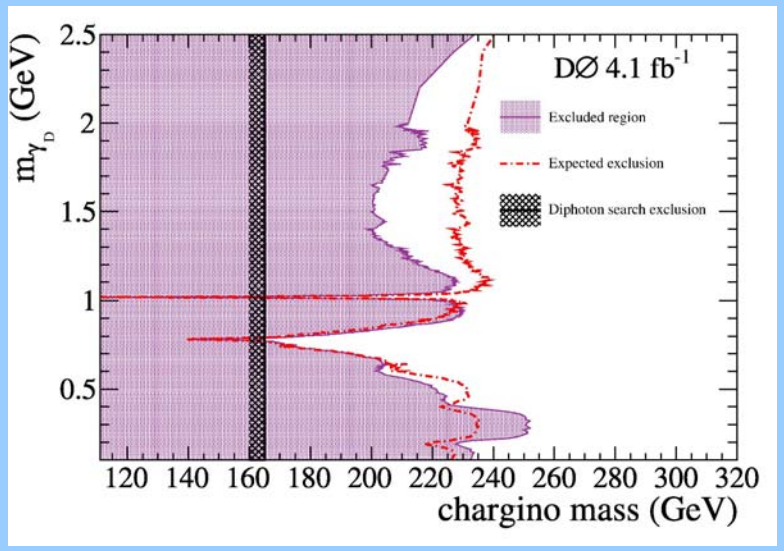
data
background
signal

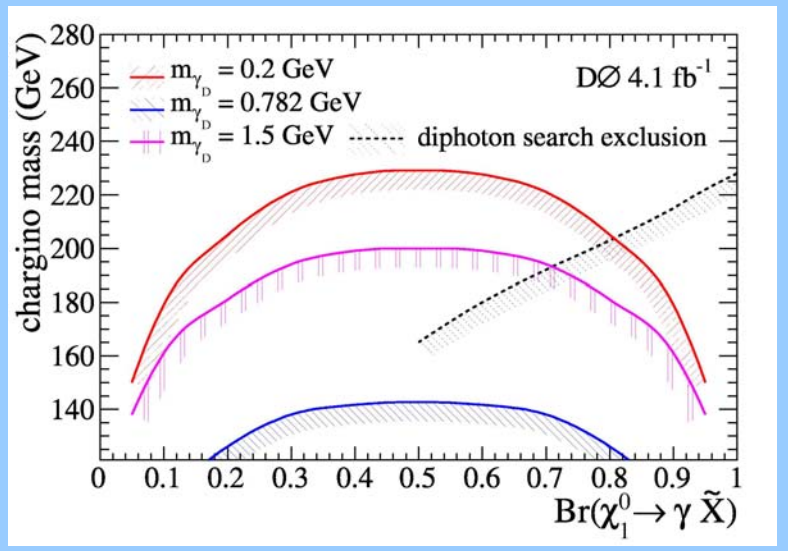
Limits



- **Limits depend upon**
  - **dark photon mass**
  - **chargino mass**
  - **chargino BR**

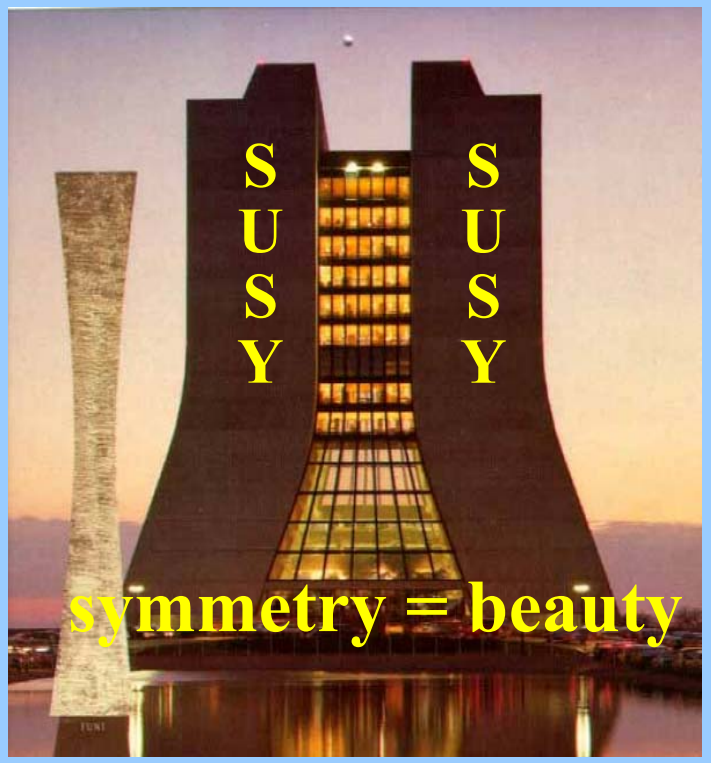
arXiv.org:0905.1478





Conclusions

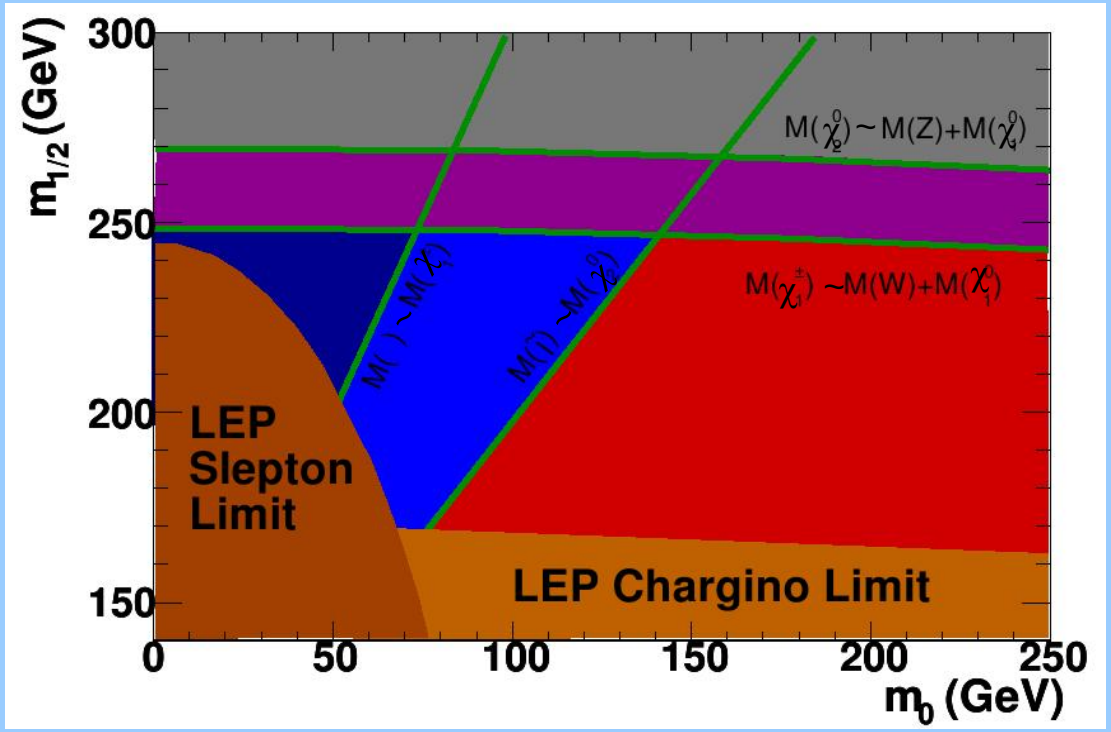
- **DØ has recent results in traditional and non-traditional searches for charginos and neutralinos**
  - **trileptons arXiv.org:0901.0646**
  - **dark photons arXiv.org:0905.1478**
  - **still haven't found the beauty of SUSY, but we still searching**



- **We have excluded new phase space in SUSY**

http://www-d0.fnal.gov/Run2Physics/WWW/results/np.htm

$m_{1/2}$ vs m_0 Plane



- $m_{\tilde{\chi}_2^0} > m_{\tilde{\chi}_1^0} + M_Z$
  - ▲ Decays via real Z bosons
- $m_{\tilde{\chi}_1^\pm} > m_{\tilde{\chi}_1^0} + M_W$
  - ▲ Decays via real W bosons
- $m_{\tilde{\chi}_1^\pm} < m_{\tilde{\chi}_1^0} + M_W$ and $m_{\tilde{\chi}_1^\pm} < m_{\tilde{\ell}}$
  - ▲ Decays via virtual Sleptons and W bosons
- $m_{\tilde{\chi}_2^0} > m_{\tilde{\ell}}$
  - ▲ Decays via real Sleptons
- $m_{\tilde{\chi}_1^\pm} > m_{\tilde{\nu}}$
  - ▲ Decays via real sneutrinos

Dark Photon BR