Search for Supersymmetry in Trilepton Final States with the DØ detector

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SUSY 07

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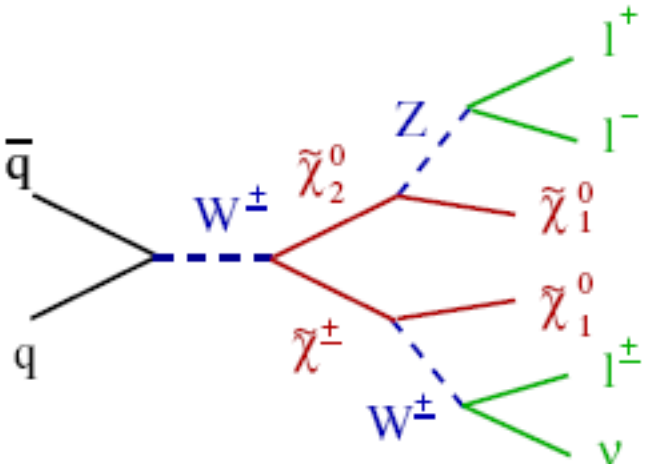
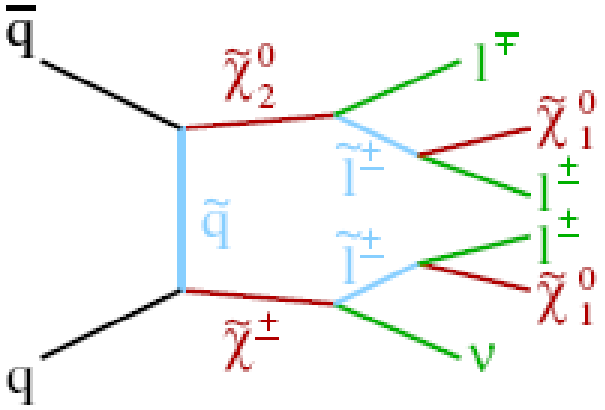
bmb+f - Förderschwerpunkt Elementarteilchenphysik

Großgeräte der physikalischen Grundlagenforschung

- Introduction
- Standard Model backgrounds
- ee/eμ/$\mu\mu$+track analysis
- Like Sign Muon analysis
- Limits
- Conclusion and Outlook

INTRODUCTION



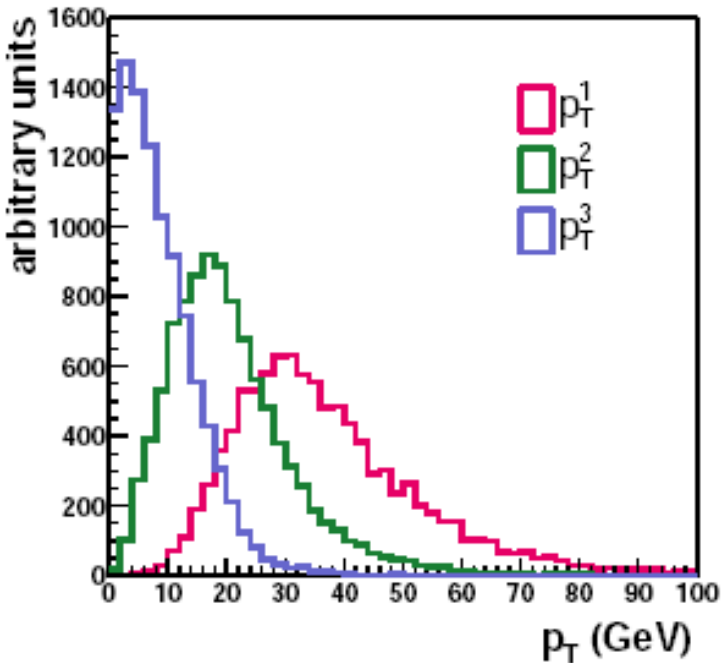


- Assuming R-parity conservation => stable LSP
- LSP escapes detection in the detector

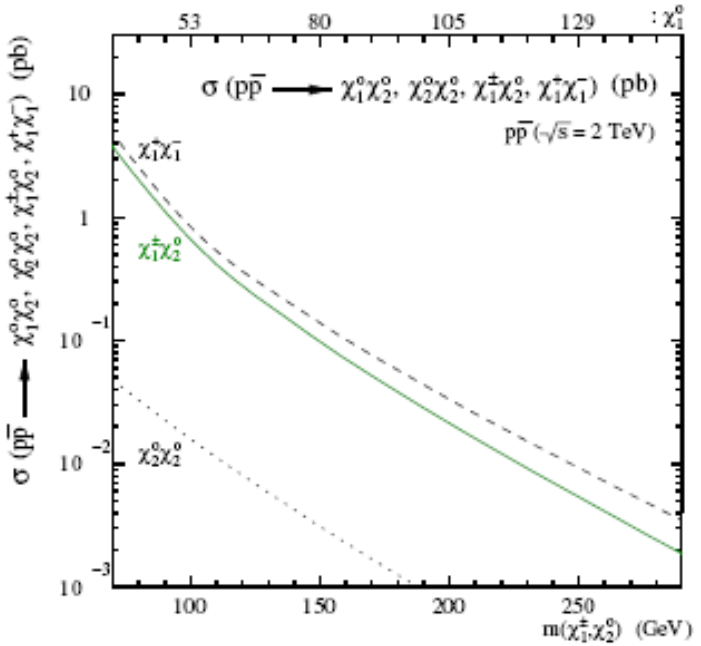
- Associated production of charginos and neutralinos
  - s-channel: via W boson (dominant)
  - t-channel: squark exchange
  - Destructive interference
- Decay of chargino:
  - W bosons and lightest neutralino
  - Slepton and neutrino
- Decay of neutralino:
  - Z bosons and lightest neutralino
  - Slepton and lepton

THREE LEPTON FINAL STATE

- Final state:
  - Three charged leptons
  - Missing Transverse Energy from neutrino/neutralino



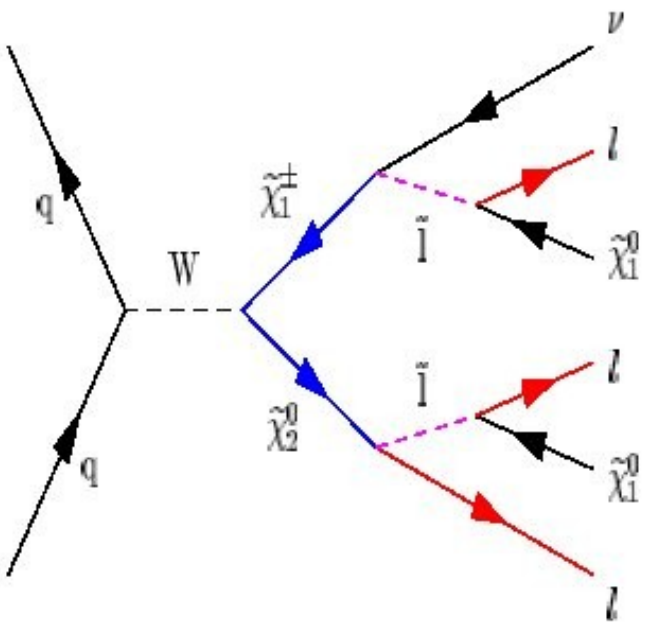
- Relatively clean signal: Golden mode
- Challenges:
  - Third lepton low p_T
  - Small sigma x BR < 0.5 pb



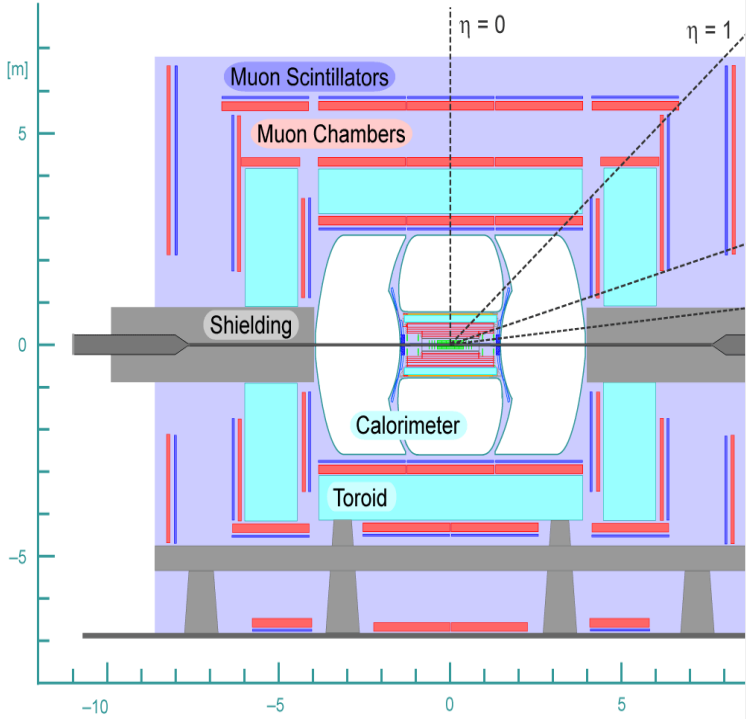
- Four analyses:
  - Like Sign μ (1 fb $^{-1}$): summer 06
  - $\mu\mu$+track, eμ+track (1 fb $^{-1}$): winter 07
  - UPDATED: ee+track (1.7 fb $^{-1}$): summer 07

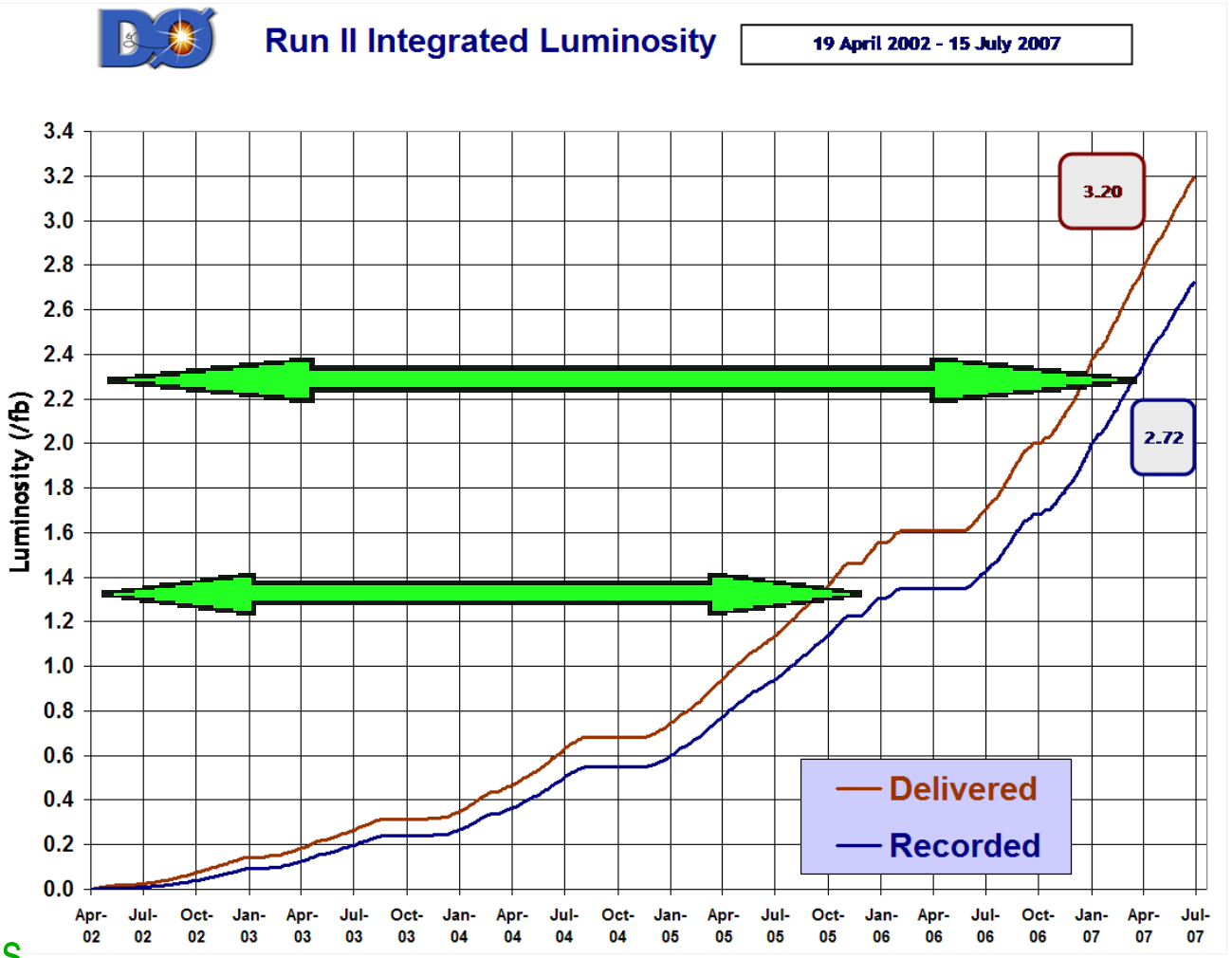
SELECTION STRATEGY

- Dilepton+track analyses:
  - Require two reconstructed leptons (either e or μ)
  - Require significant MET to account for neutralinos/neutrinos
  - Require additional isolated high quality track
    - Higher efficiency than reconstructed lepton
    - Efficient for all lepton flavours
- Large slepton masses -> decay of chargino/neutralino via W/Z dominates
- m(slepton) < m(χ_2):
  - Two body decays of neutralino -> slepton + lepton
  - Mass of slepton close to neutralino
    => very soft third lepton
- Likesign dilepton analysis:
  - Require two reconstructed leptons of same charge
  - Require significant MET to account for neutralinos/neutrinos
  - No requirement of a third object



DETECTOR and LUMINOSITY





- Multipurpose detector:
  - identification of electrons, muons, taus and jets
  - very good eta acceptance
  - fast read out electronics
  - dedicated trigger system to reduce rates

data taking eff ~ 85%

Data analyzed: April 02 – April 07

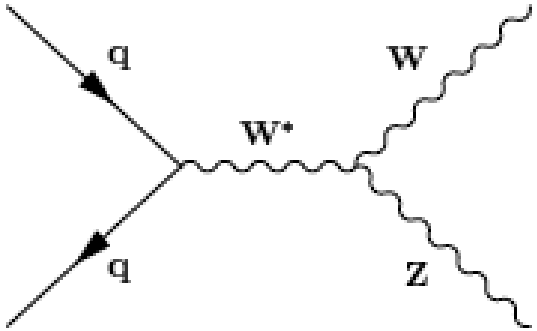
~8 fb^{-1} expected by 2009

SM BACKGROUNDS

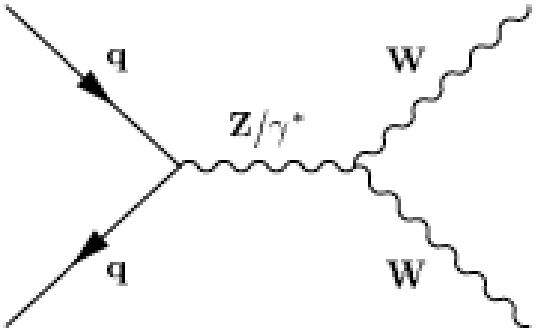
-Vector boson pair production
-Drell Yan/W+jets
-Others: tt, multijets

All backgrounds taken from MC, except QCD => QCD taken from data by reverting lepton identification criteria

	# leptons	true ET-miss	xsec(pb)	Remarks
Signal	3	Yes	0.18	
WZ -> lll ν	3	Yes	0.1100	signal like
ZZ -> ll XX	2-4	Yes/No	0.0700	mismeasurements
WW-> ll ν ν	2	Yes	1.2400	fakes
W-> l ν + γ /jet	1	Yes	2500	fakes
(Z / γ ->ll)+ γ /jet	2	No	250-400	fakes, mismeasurement
ttbar -> ll +2jets	2	Yes	0.7300	fakes, mismeasurement
qqbar -> jets	0	No		fakes, mismeasurement



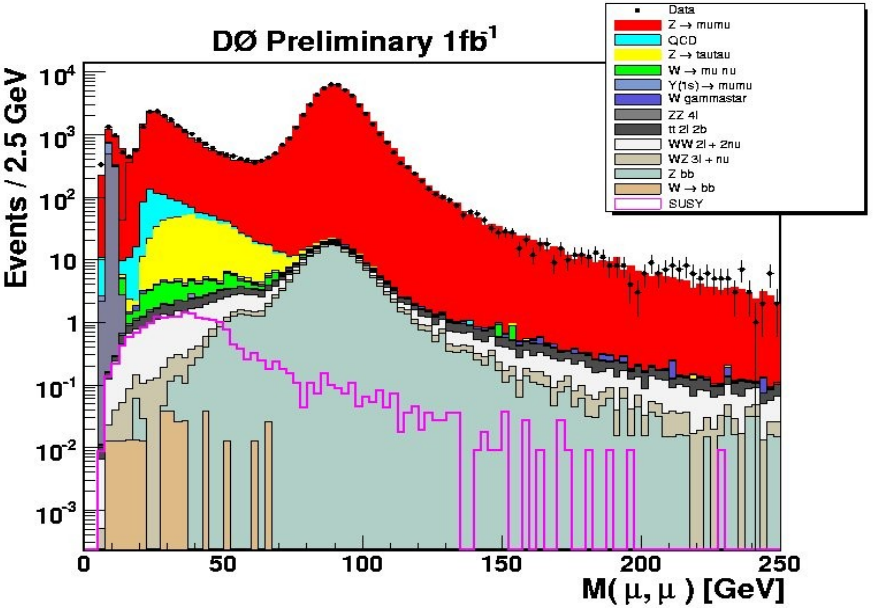
Example of LO WZ

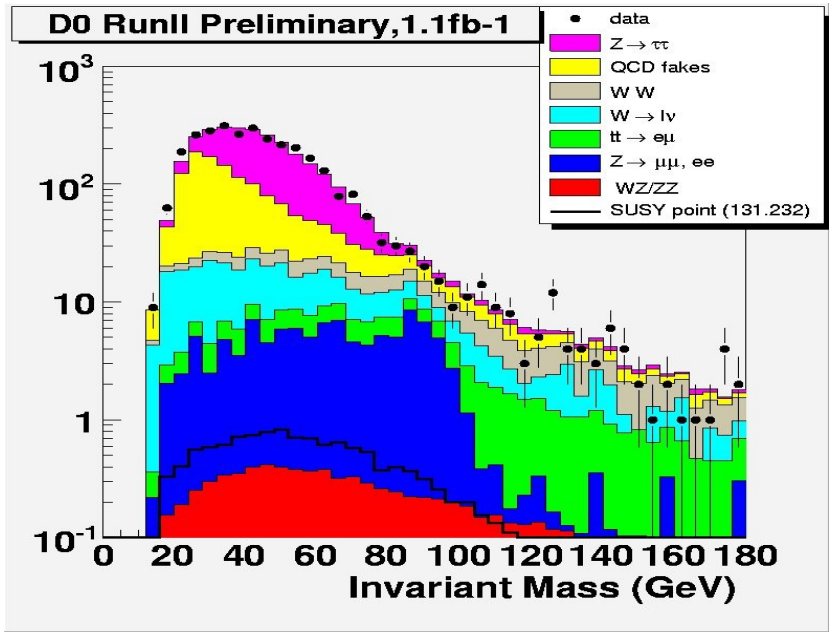


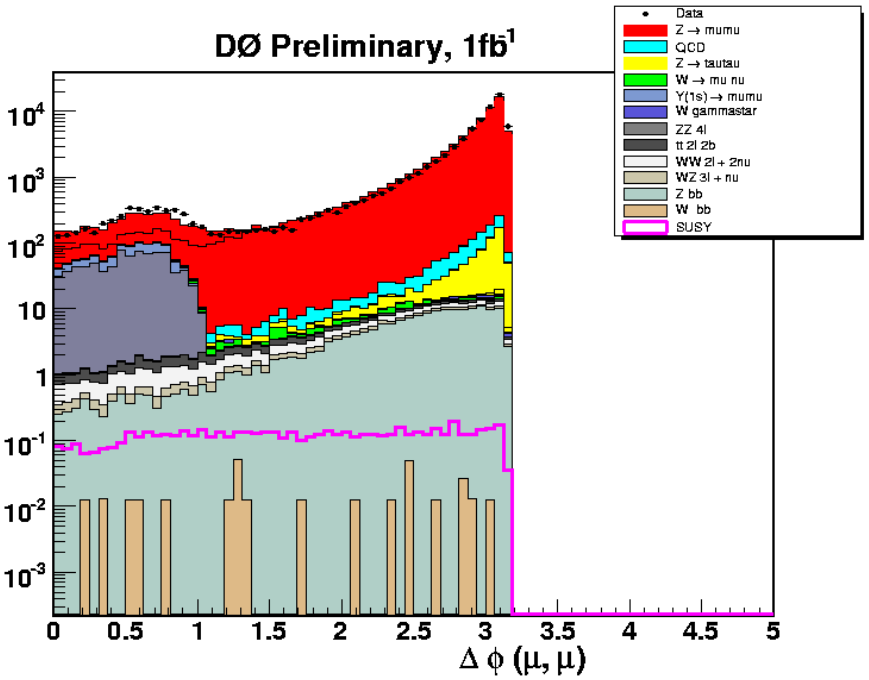
Example of LO WW

2 LEPTONS + TRACK

- **Preselection:**
  - Lepton-ID, p_T > 12 GeV+8 GeV
- **Anti-Z/DrellYan->ll:**
  - M(Y) << M(l,l) << M(Z)
  - $\Delta\phi(l,l) < 2.9$

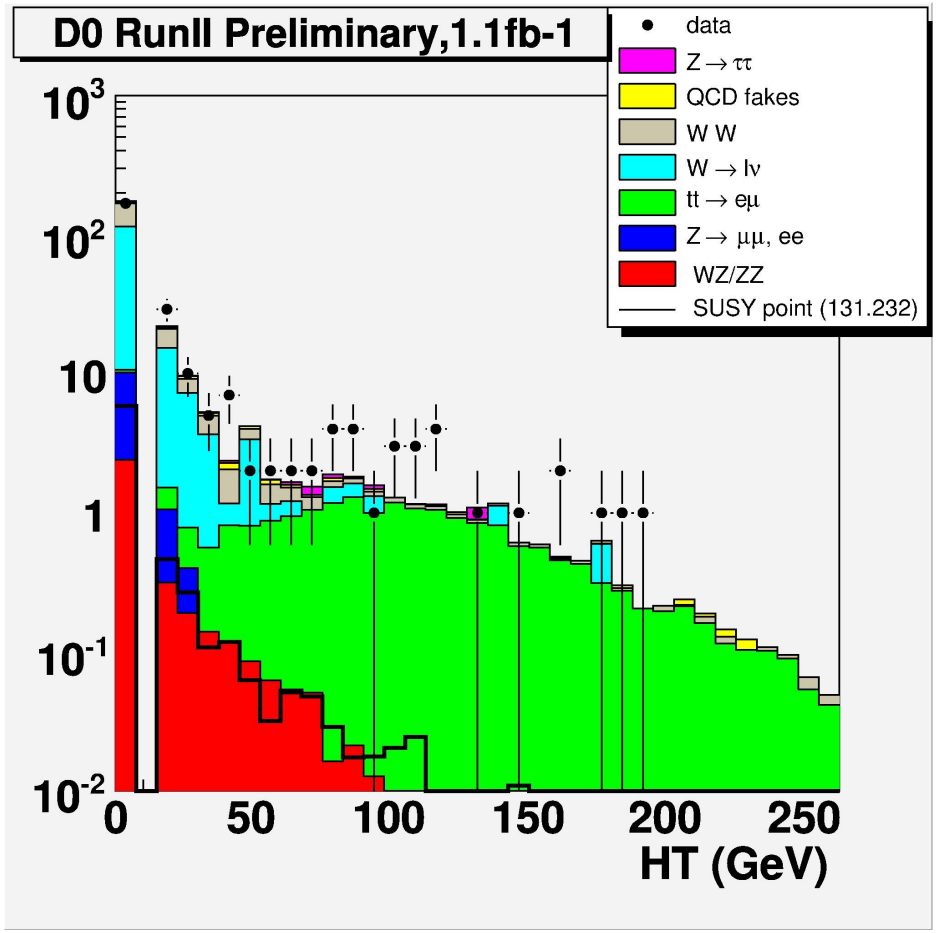


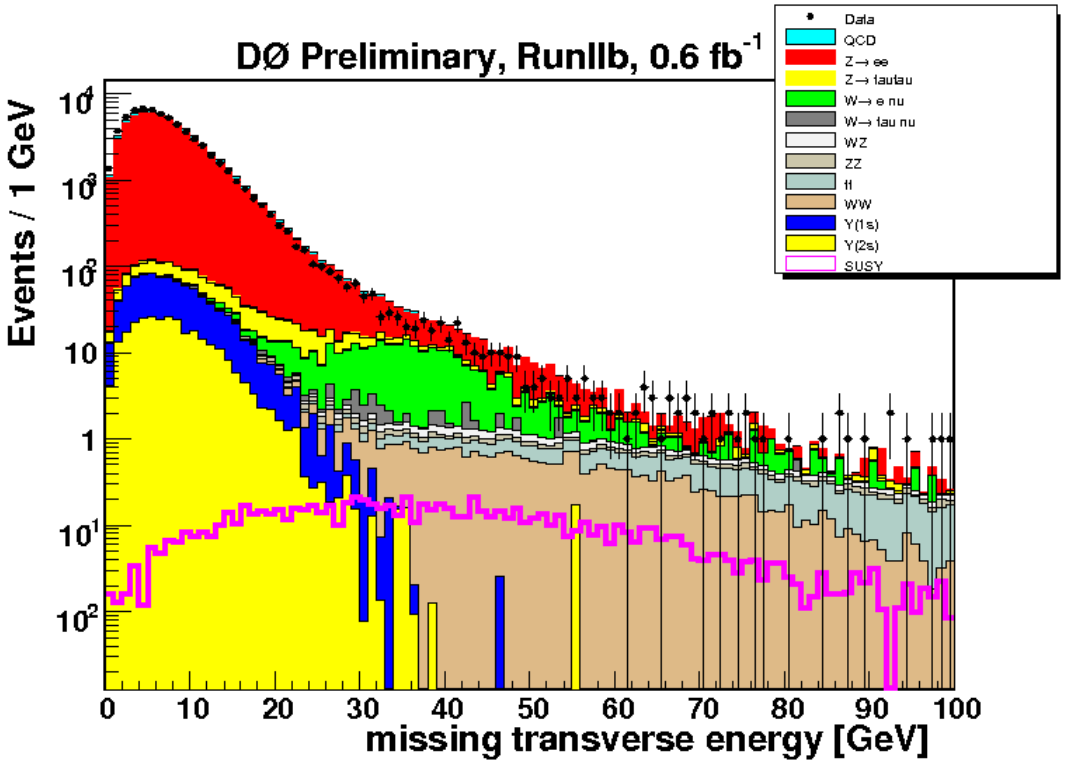




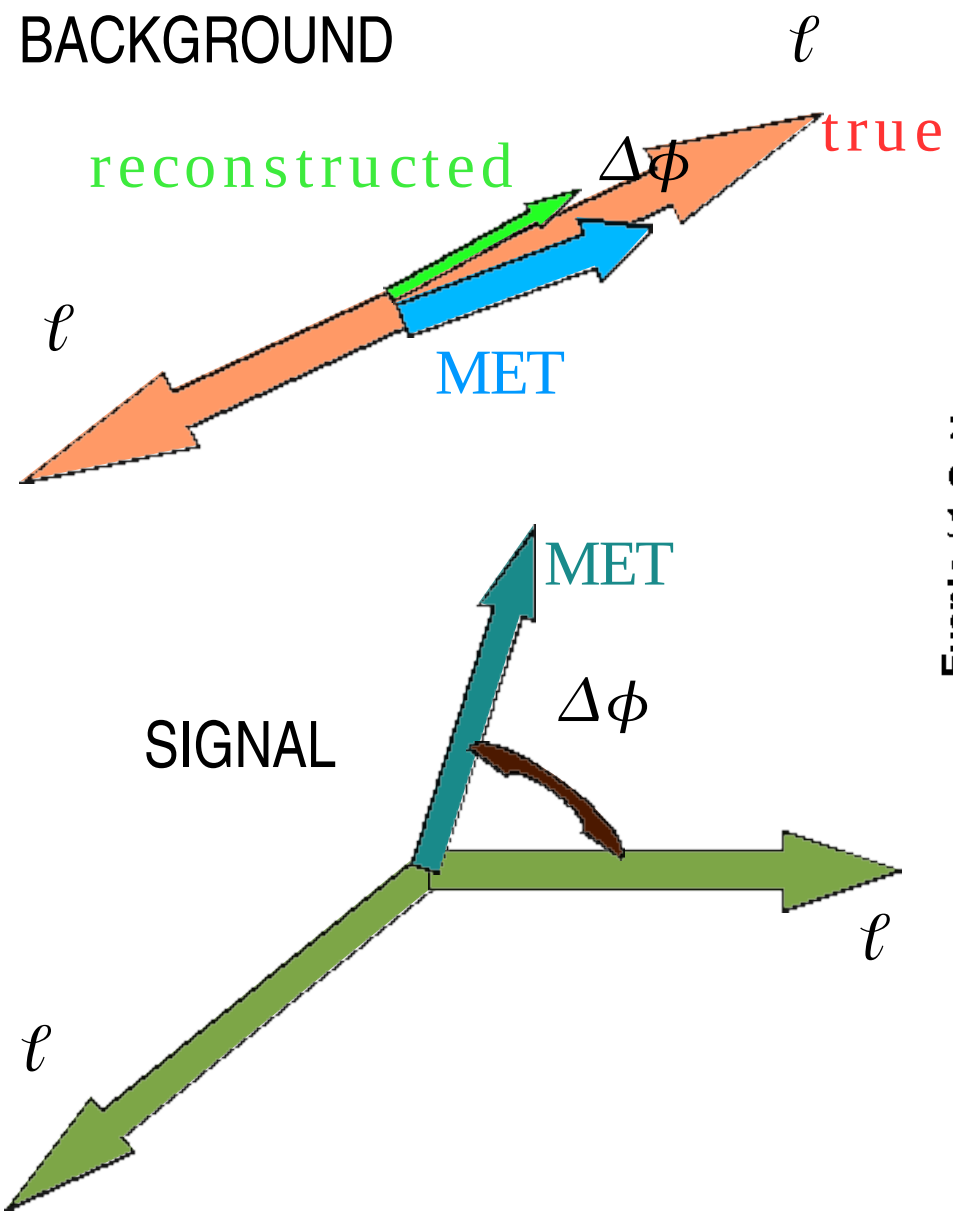
2 LEPTONS + TRACK ctd

- Anti Top:
  - H_T<50 GeV
- Large amount of missing transverse energy:
  - MET > 22 GeV

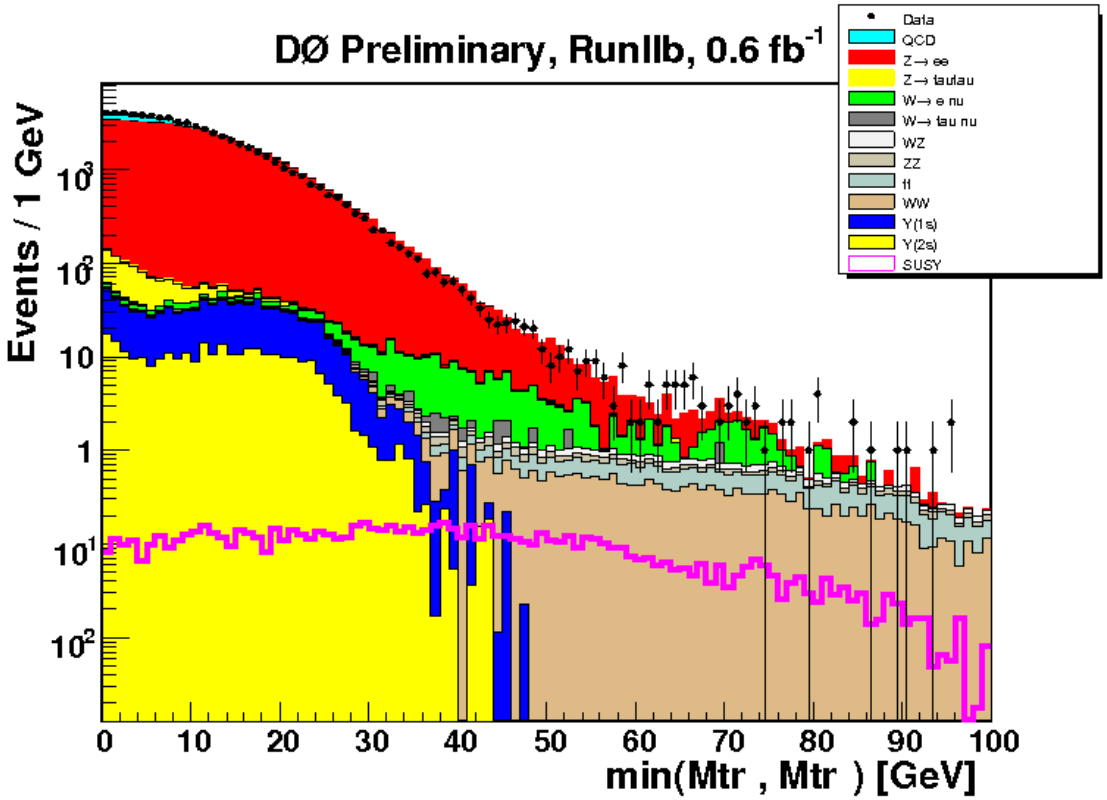




MET FAKED BY MISMEASURED ENERGY

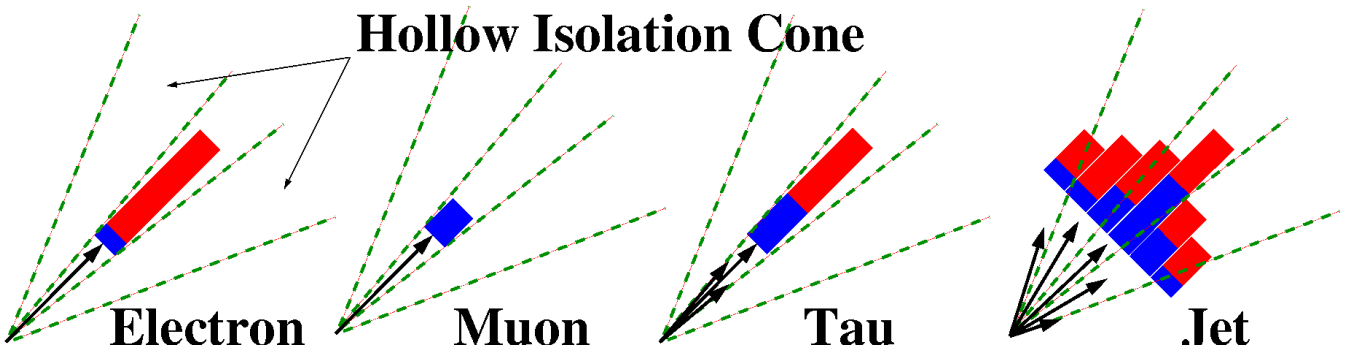


- large MET caused by poorly measured lepton energy will be in the same direction as the lepton => small values of MT.
- MT=√2MET x p_T x (1-cos($\Delta\varphi$(MET, p_T))

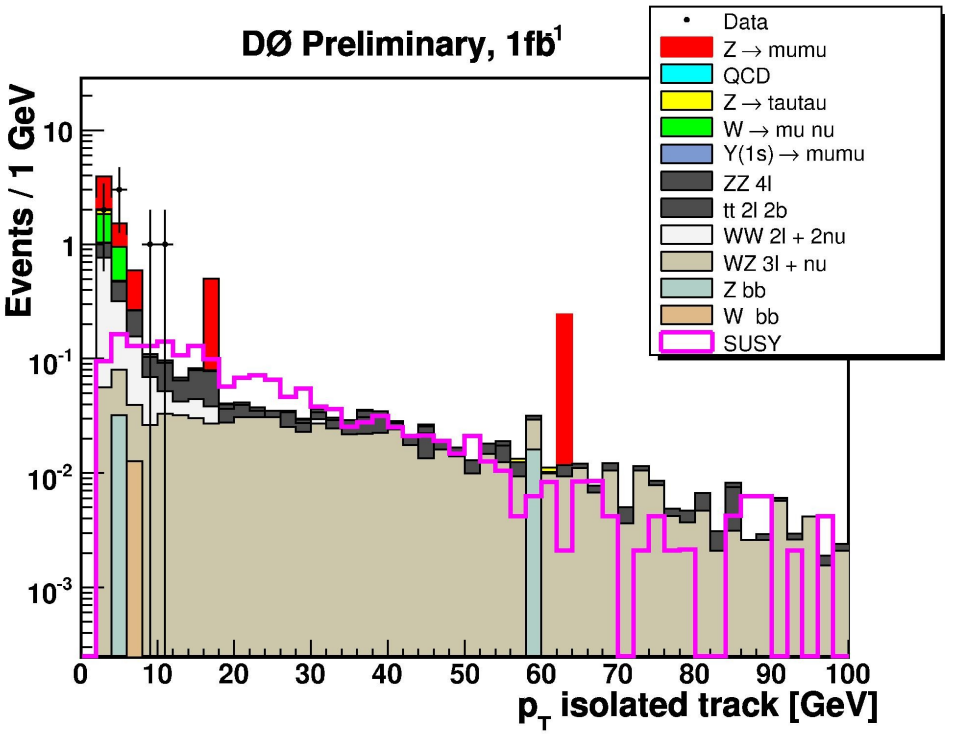


MT > 20 GeV

3rd LEPTON -> isolation

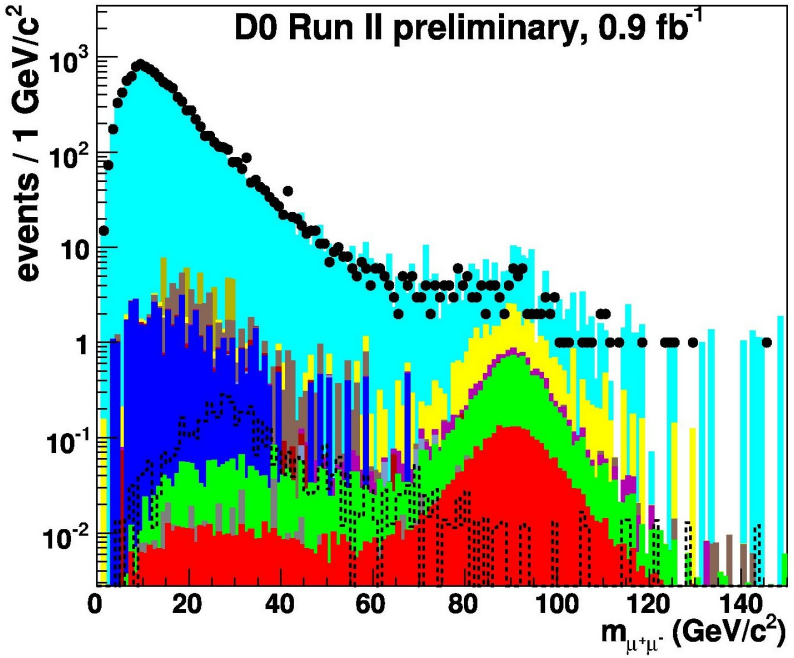


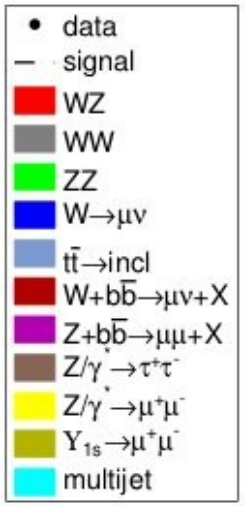
- To increase efficiency, a track is required instead of lepton.
- Isolation in tracker and calorimeter is required to reject background from jets.
  - $\sum p_T$ of other reconstructed tracks in a hollow cone around track < 1 GeV
  - efficient for all leptons flavours (e, μ,τ (1prong, 3prong))

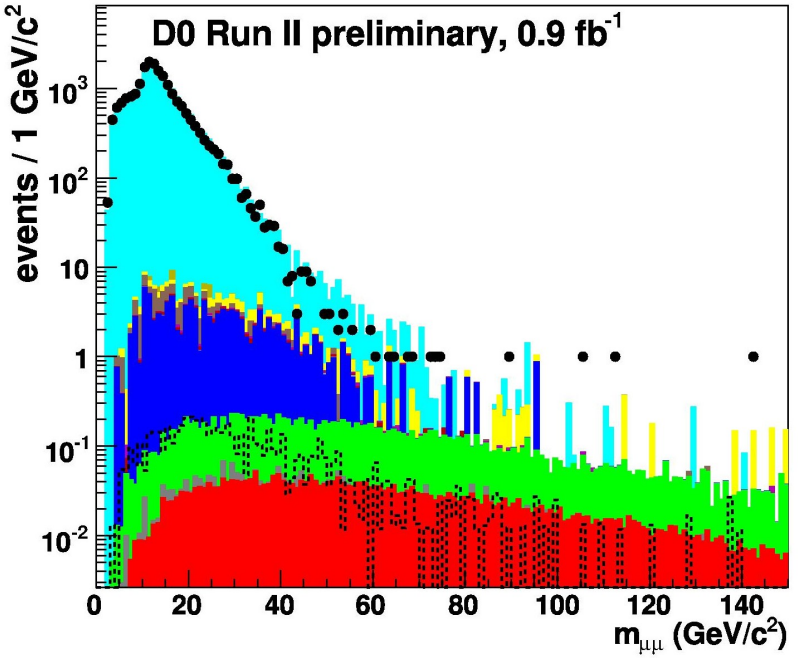


LS μ: BACKGROUNDS

- Likesign dilepton analysis:
  - Require two reconstructed leptons of same charge
  - Require significant MET to account for neutralinos/neutrinos
  - No requirement of a third object
- Important Standard Model background:
  - Multijet production from QCD (b-bbar)
  - Z->ll, W->lν, tt->ll+jets
  - WZ-> lνll, ZZ->ll+XX, WW->ll$\nu\nu$



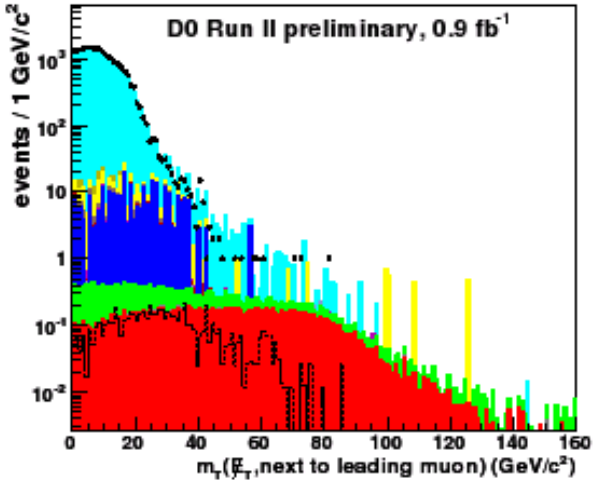


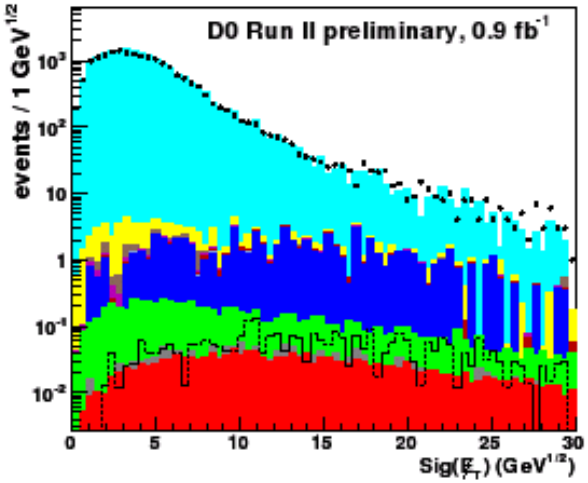


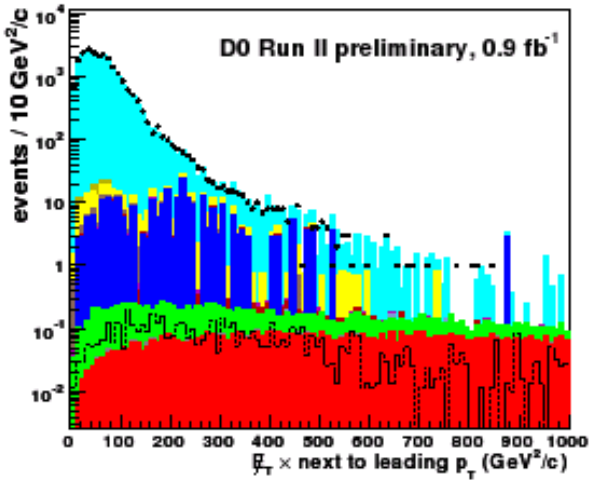
- 25 GeV < M(μ,μ)$_{OS}$ < 65 GeV if OS
- 12 GeV < M(μ,μ)$_{LS}$ < 110 GeV

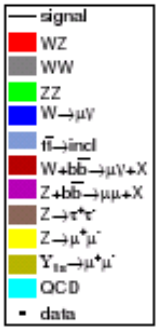
LS μ: MET

- Large MET:
  - MET > 10 GeV
  - 65 GeV>Transv. mass (μ2,MET)>15 GeV
  - MET > 12 x σ(jet||MET)
- MET x $P_T(\mu 2)$:
  - > 160 GeV^2









SUMMARY OF ANALYSES

- ee+track:
  - Expected: $1.0 \pm 0.3 \pm 0.14$ events
  - Observed: 0 events
  - Signal: 0.5 – 2.1 events
  - Dominant Background: Drell-Yan, Di-Boson Production

- eμ+track:
  - Expected: $0.94 \pm 0.4 \pm 0.16$ events
  - Observed: 0 events
  - Signal: 2.0 – 2.6 events
  - Dominant Background: Di-Boson Production

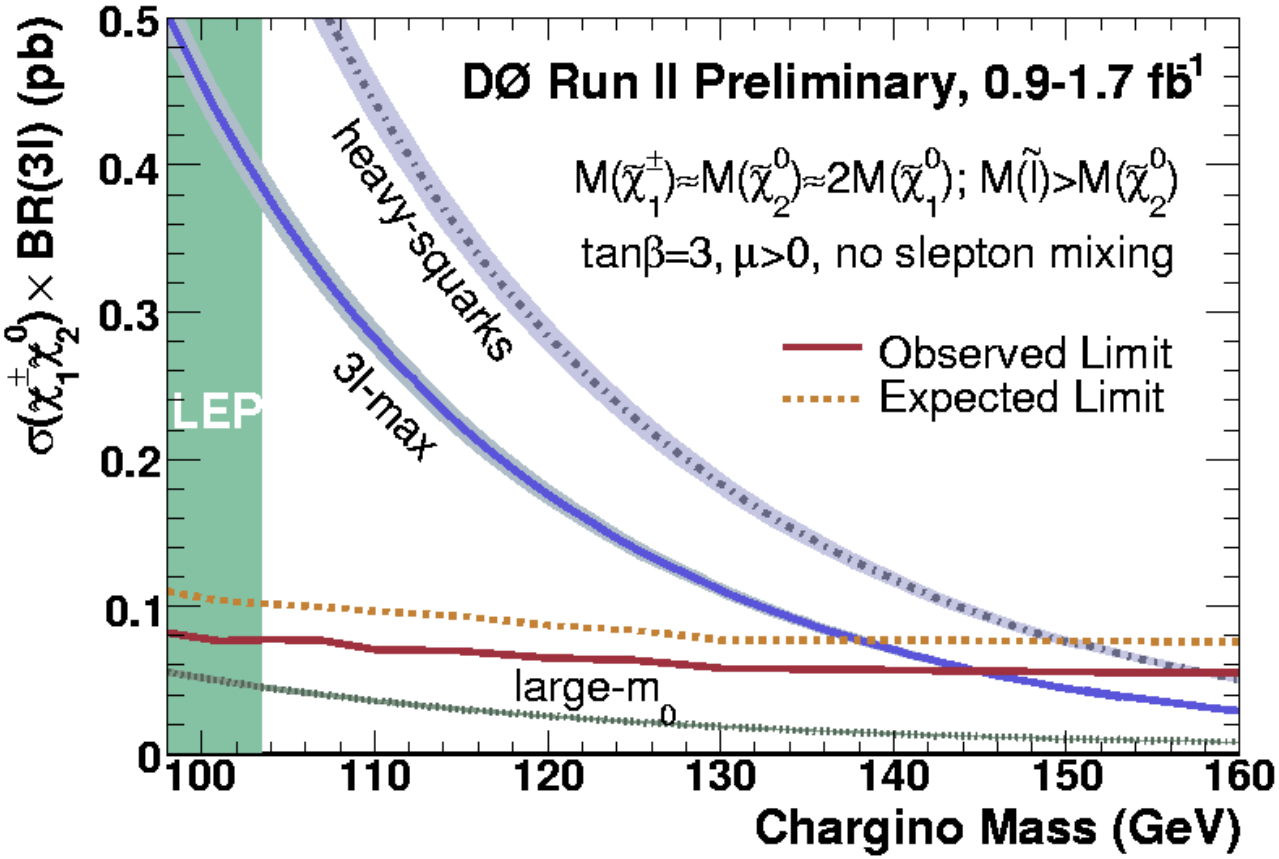
SUMMARY OF ANALYSES II

- $\mu\mu$+track:
  - Expected: $0.32 \pm ^{1.34}_{0.32} \pm 0.05$ events
  - Observed: 2 events
  - Signal: 0.5 – 2.5 events
  - Dominant Background: Di-Boson Production

- LS μ:
  - Expected: $1.1 \pm 0.4 \pm 0.1$ events
  - Observed: 1 events
  - Signal: 0.61 – 3.76 events
  - Dominant Background: QCD, Di-Boson Production

LIMITS

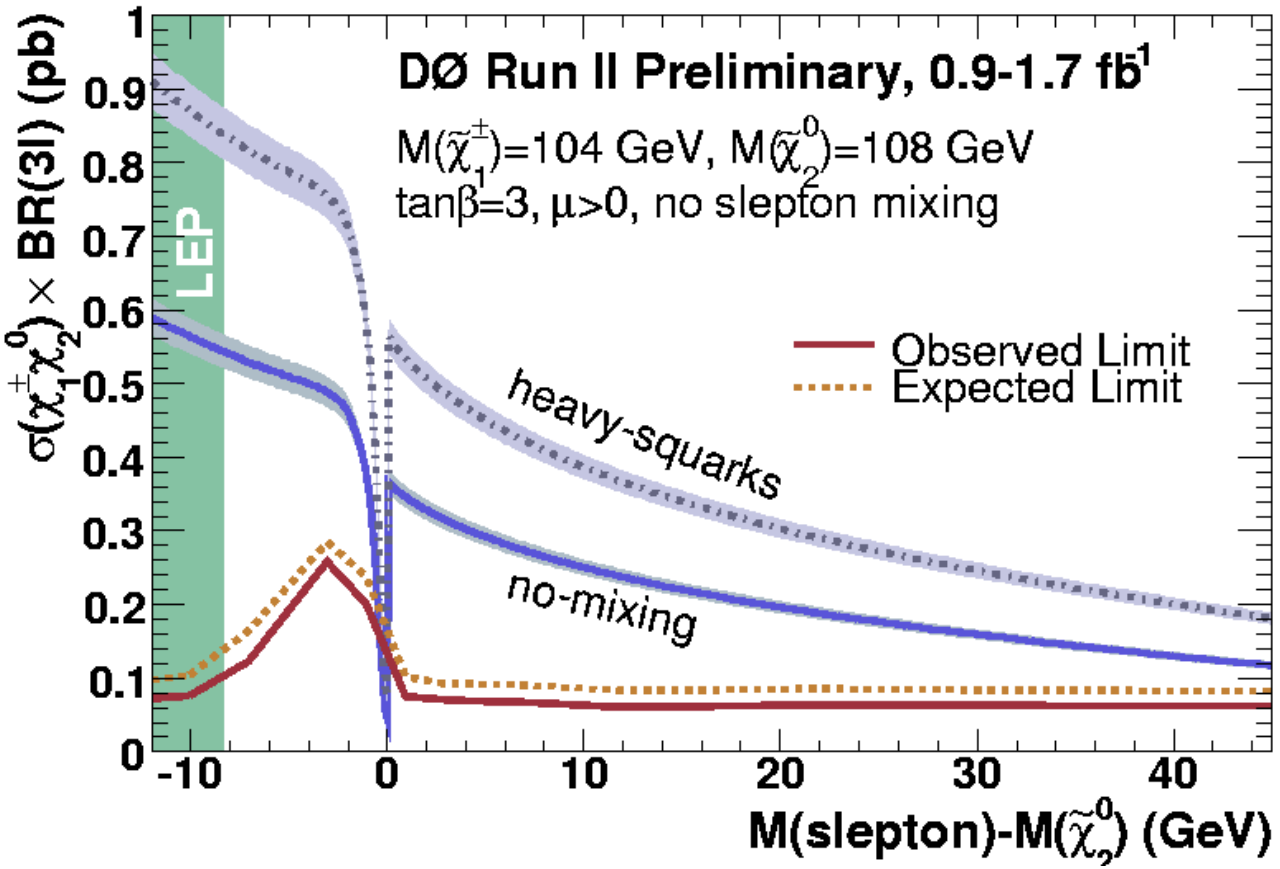
- upper limit σ x BR(3l),
  (modified frequentist approach,
  overlap subtracted from weakest analysis)



-3l-max:
 -m(slepton) ~ m(neu2)
-large m0:
 -W/Z exchange dominates
-heavy-squarks:
 -maximal cross section

- Chargino mass limit of 145 GeV in scenario with enhanced BR into leptons

LIMIT II



- Limit as a function of mass difference between slepton and next to lightest neutralino.

CONCLUSION and OUTLOOK

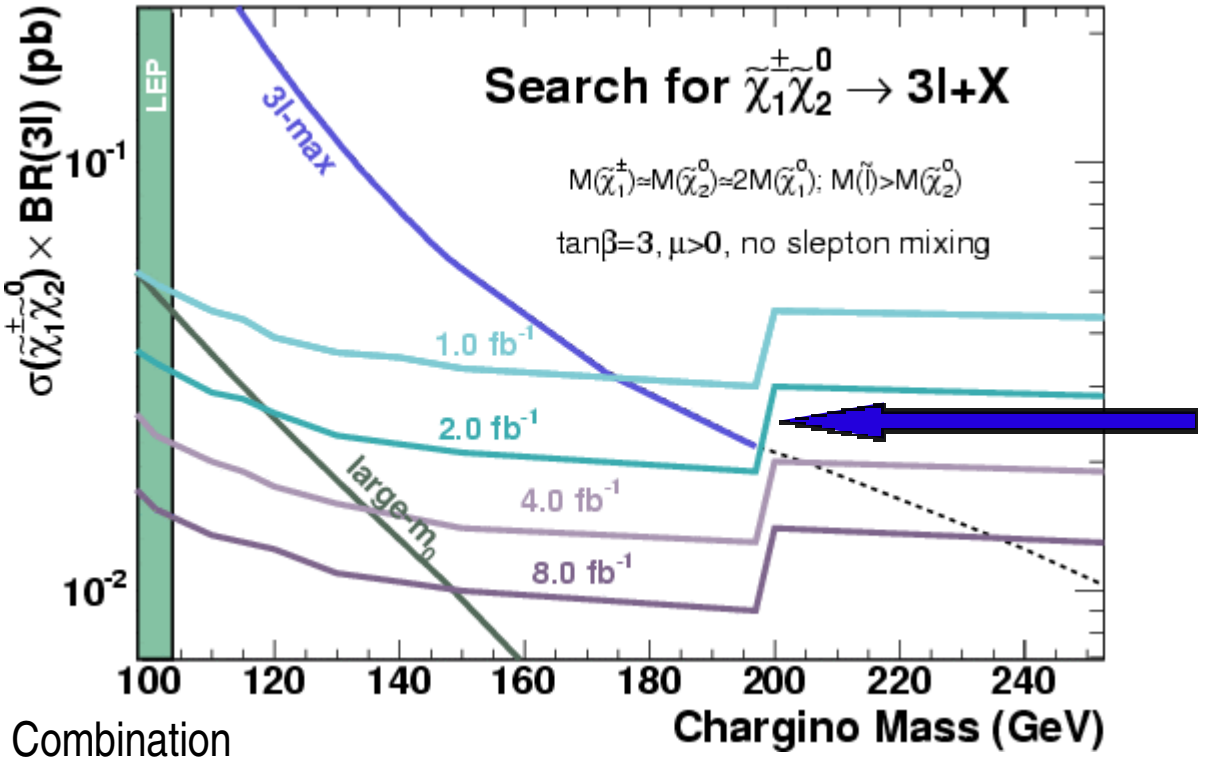
-New search for Charginos and Neutralinos using 1.7 fb $^{-1}$.

-NO EVIDENCE FOR SIGNAL => LIMIT SET

-- Limit on cross section x BR: 0.07 pb

Up to three times more data on tape

~8 fb $^{-1}$ expected by 2009



Tevatron Combination

starting to probe difficult region of phase space with more luminosity

BACK UP

INTRODUCTION

- Super symmetry: sparticles and their SM partners differ in spin by 1/2.

Quark	q	*Squark*	$\tilde{q}_R,\ \tilde{q}_L$	
Lepton	l	*Slepton*	$\tilde{l}_R,\ \tilde{l}_L$	
Neutrino	ν	*Sneutrino*	$\tilde{\nu}$	
Photon	γ	*Photino*	$\tilde{\gamma}$	**4 Neutralinos** $\tilde{\chi}^0$
W-,Z-Boson	$W^{\pm}, Z$	*Wino, Zino*	$\tilde{W}^{\pm}, \tilde{Z}$	
Higgs	$H^{\pm}, H^0$	*Higgsino*	$\tilde{H}_1^0\ \tilde{H}_2^+$	**2x 2 Charginos** $\tilde{\chi}^{\pm}$
	h, A		$\tilde{H}_1^-\ \tilde{H}_2^0$	
Gluon	g	*Gluino*	$\tilde{g}$	

- R-parity: $Rp = (-1)^{3(B-L)+2S}$ -> stable LSP and pair production of SUSY particles.

- mSUGRA: SUSY model with five parameters at GUT scale.
  - simplest gravity mediated SUSY breaking model
    - m_0: Masses of scalars -> sfermion masses
    - m1/2: mass of fermions
    - tanß: ratio of Higgs vacuum expectation values
    - mu: Higgsino mass parameter
    - A: trilinear coupling (Higgs-$Sfermion_L$-$Sfermion_R$)

SIGNAL MONTE CARLO

Three reference points:

	HEAVY	MEDIUM	LIGHT
m0	121	98	88
m1/2	221	192	182
tan beta	3	3	3
mu	>0	>0	>0
A0	0	0	0
Char. mass	150	235	115
Neut2. mass	152	127	118
Neut1. mass	82	69	63
Slepton R.	153	129	119
sigma X Br	0.03	0.12	0.19

Mass of slepton just above the neutralino masses: $m_{\tilde{\ell}_R} \gtrsim m_{\tilde{\chi}_2^0}$

Also: $M(\tilde{\chi}_1^{\pm}) \approx M(\tilde{\chi}_2^0) \approx 2M(\tilde{\chi}_1^0)$

All masses in GeV

CUT FLOW ee+track and LS μ

ee Cut	Data	SM Expected	MSUGRA example
Preselection	118518	113592±119	18
Anti-Z	17459	18306±89	13
Third track	776	650±18	7.6
MET	2	1.97±0.73	4.6
MET x PT(3.track)	0	0.76±0.67	3.5

LSμ Cut	Data	SM Expected	MSUGRA example
Preselection	15234	14922±981	8.4±0.6
Minv OS	3569	3479±232	7.6±0.6
Minv LS	2	2.9±0.8	5.7±0.5
MET	1	1.7±0.6	4.6±0.4
MET x PT(μ2)	1	1.1±0.4	4.0±0.4

CUT FLOW $e\mu/\mu\mu$+track

$e\mu$ Cut	Data	SM Expected	MSUGRA example
Preselection	3105	3080±34	14.4
MET-related	303	286.9±7.1	9.2
Isolated Track	5	5.1±0.9	4.6
Anti-Z, Anti-W	0	0.9±0.4	3.7

$\mu\mu$ Cut	Data	SM Expected	MSUGRA example
Preselection	81927	80373±130	13.3
Anti-Z	7486	8099±53	8.3
MET-related	51	54±4	5.2
Isolated track	4	2.8±1.1	3
MET x PT(3.track)	2	0.3±0.8	1.8

Good agreement between data and Monte Carlo