Search for Supersymmetry at CDF **using Trileptons**

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Particle Physics Seminar

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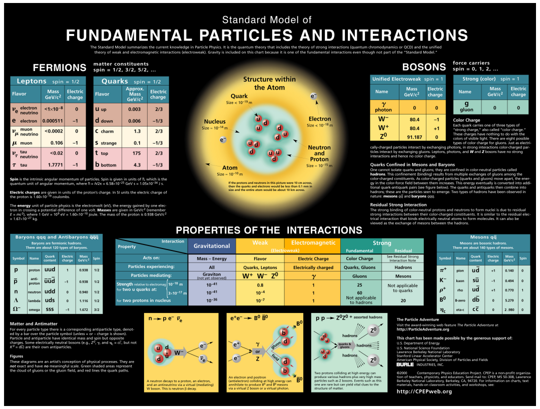
OUTLINE

- PART I : Introduction
- PART II : Data and Analysis
- PART III : Interpreting the Results

PART I
Introduction

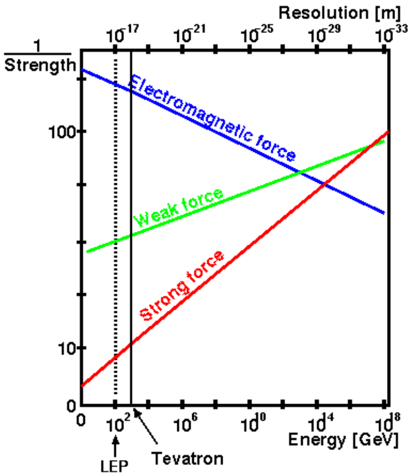
Beyond Standard Model

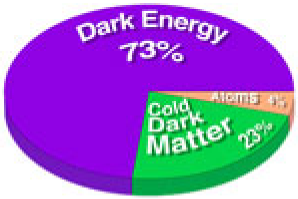
Standard Model does fantastic job of explaining our world (up to EWK scales)
Precision tests upto few parts per million confirm SM



BUT,

- Including gravity
- What is Dark Matter/Dark Energy?
- Matter-Antimatter asymmetry in the universe
- Why three generations?
- Hierarchy problem

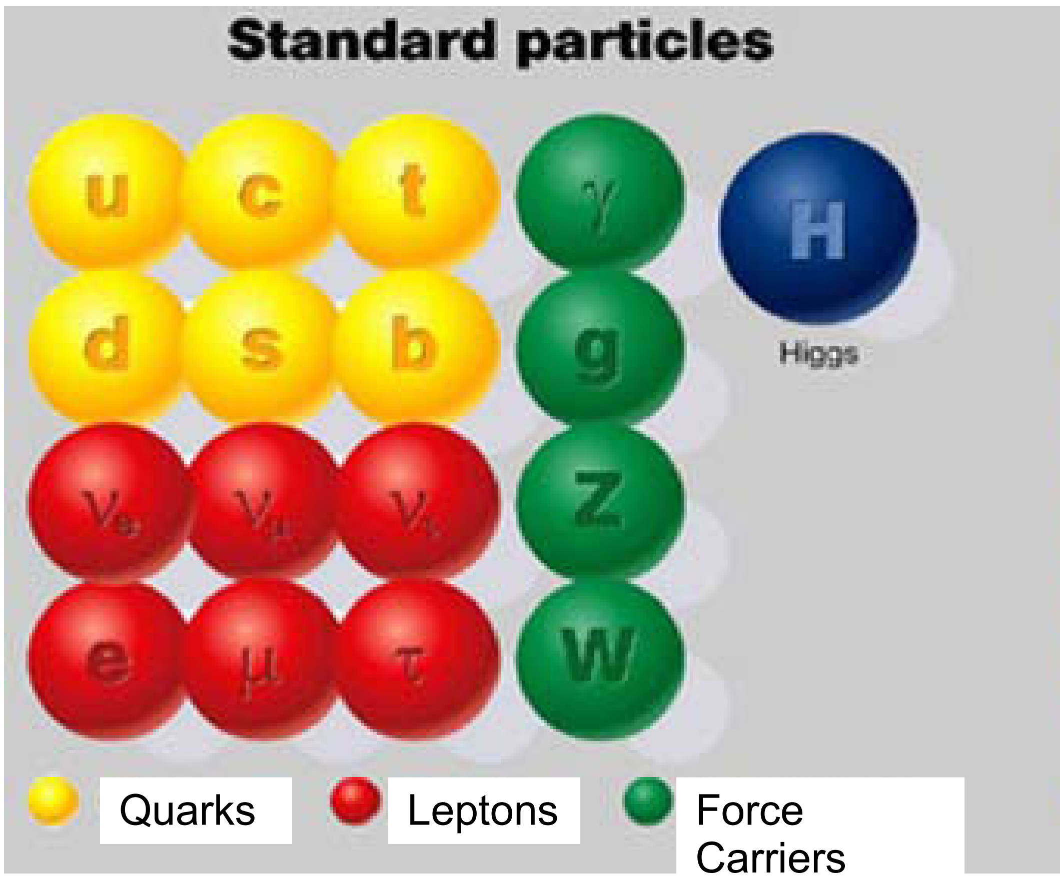




Supersymmetry

Proposes a new symmetry

Fermions ↔ Bosons



Every fermion has a boson superpartner & vice versa

R-parity : $R_p = (-1)^{3(B+L)+2s}$

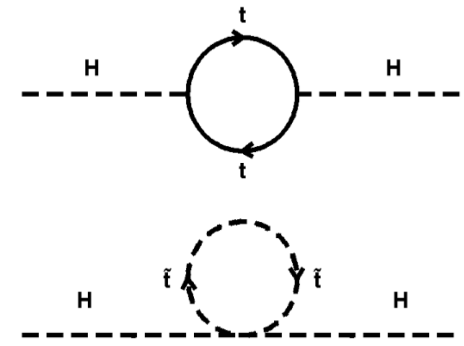
electron → selectron

$R_p=1$ $R_p=-1$

photon → photino

$R_p=1$ $R_p=-1$

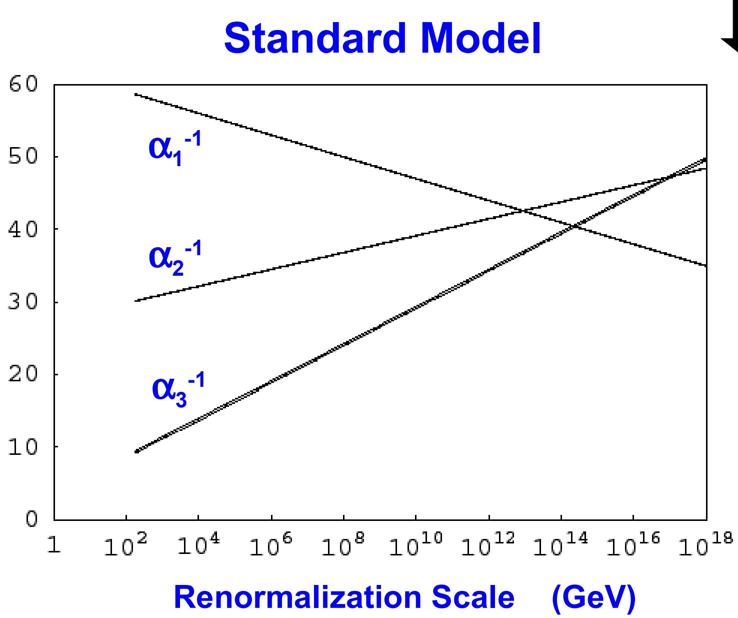
Supersymmetry

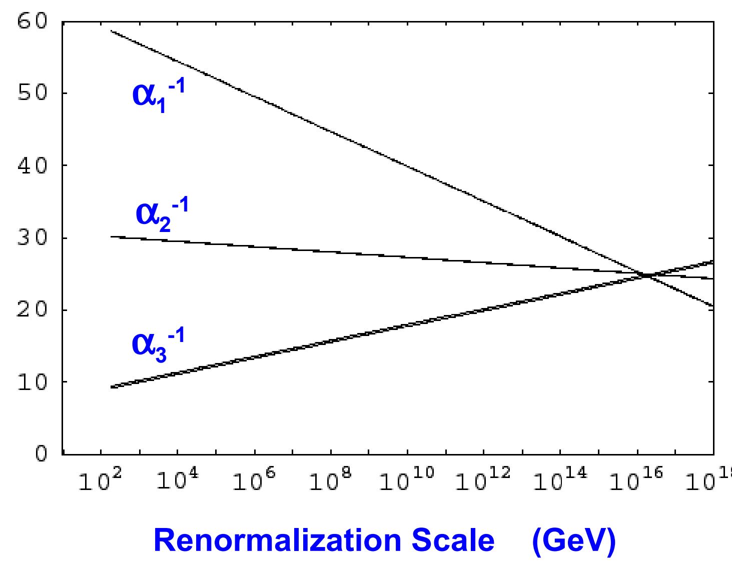


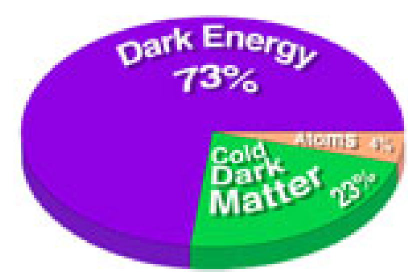
Supersymmetry solves the hierarchy problem

Also provides an excellent dark matter candidate (R_p conservation → LSP)

Gauge couplings are unified much better





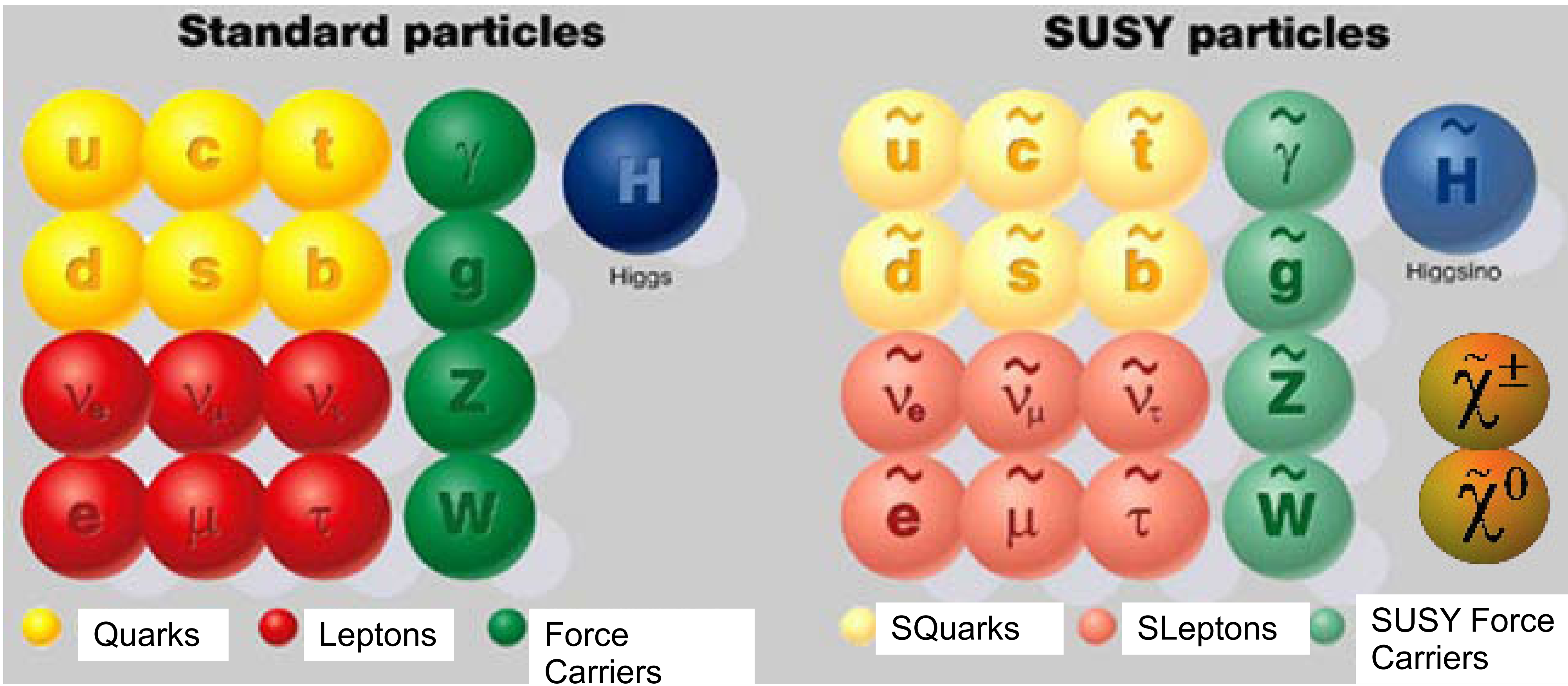


27 down, 73 to go!!

Particles x 2 Supersymmetry

Proposes a new symmetry

Fermions ↔ Bosons



mSUGRA

mSUGRA -- minimal SUper GRAvity grand unification

why? a) Widely used as a standard candle by Run I, LHC TDR's etc.

b) Manageable due to five parameters

Defined by five parameters

m_0 : common scalar mass at GUT scale

$m_{½}$: common gaugino mass at GUT scale

$M_1(GUT)=M_2(GUT)=M_3(GUT)= m½$

tan(β) : ratio of Higgs vacuum expectation values

A_0 : common trilinear scalar interaction at the GUT scale (Higgs-sfermionR-sfermionL)

sign(μ) : μ is the Higgsino mass parameter ($|\mu^2|$ determined by EWSB)

Signal Benchmark Point (BP) with parameters :

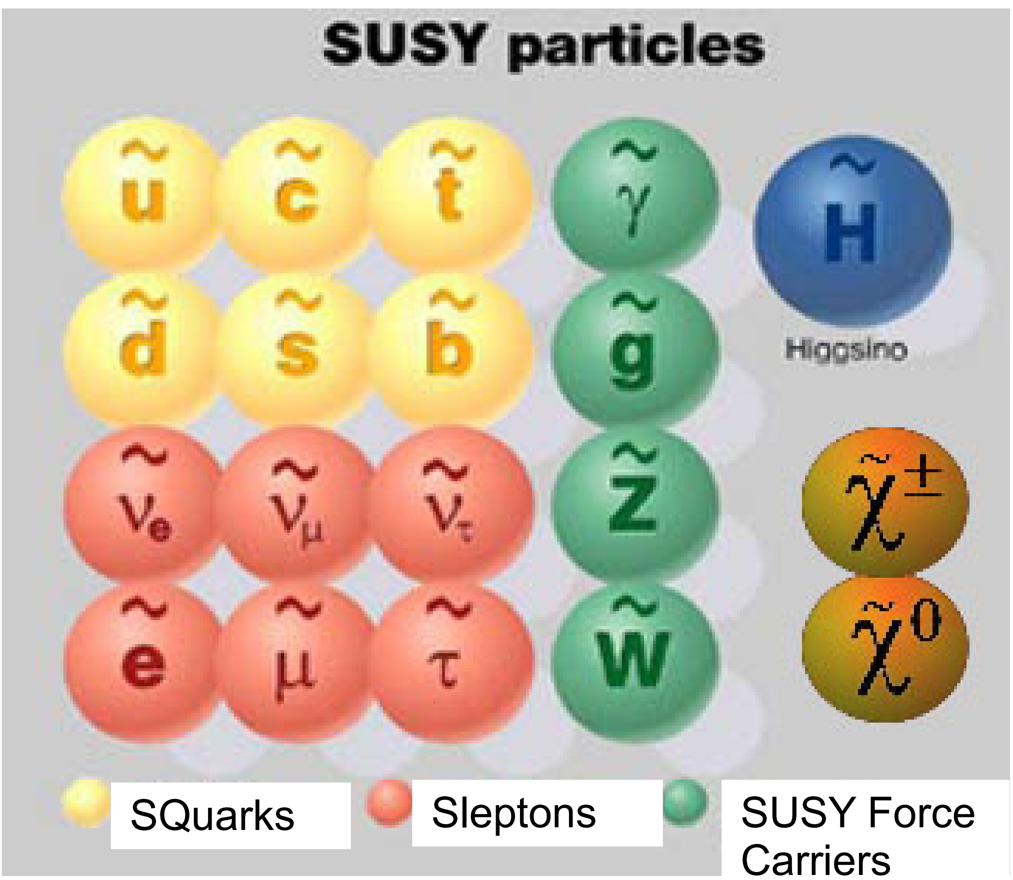
mSUGRA m_0=60, $m_{½}$=190, tan(β)=3, A_0=0, μ>0

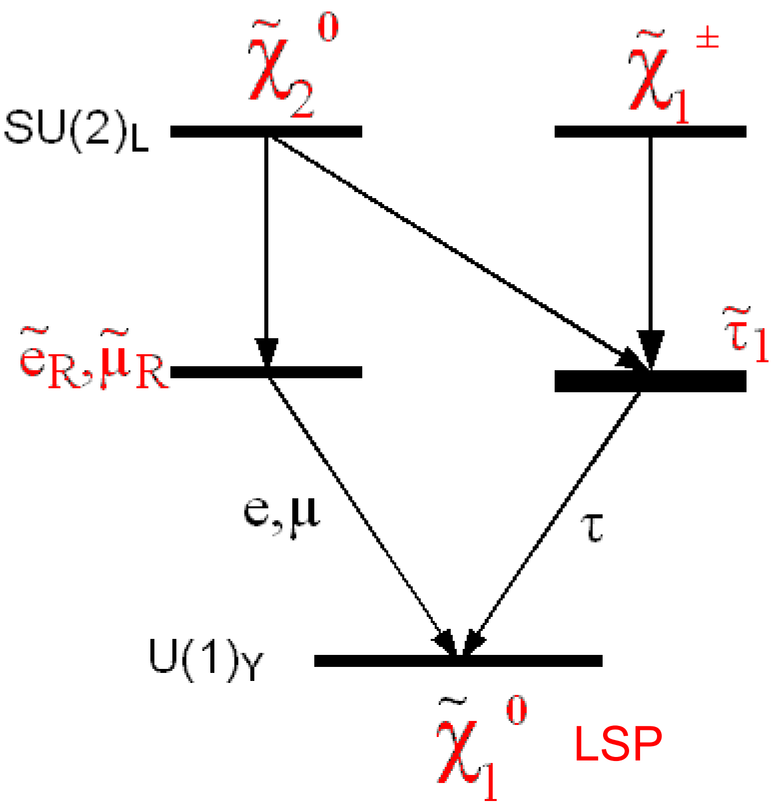
Spectrum (at BP) GeV

$\tilde{\chi}_2$	124
$\tilde{\chi}_1^{\pm}$	122
$\tilde{\chi}_1^0$	66
$\tilde{e}_L$	149
$\tilde{e}_R$	101
$\tilde{\tau}_1$	100
$\tilde{\tau}_2$	150
$\tilde{g}$	477
$\tilde{u}_R$	421
$\tilde{d}_L$	439

Charginos and Neutralinos

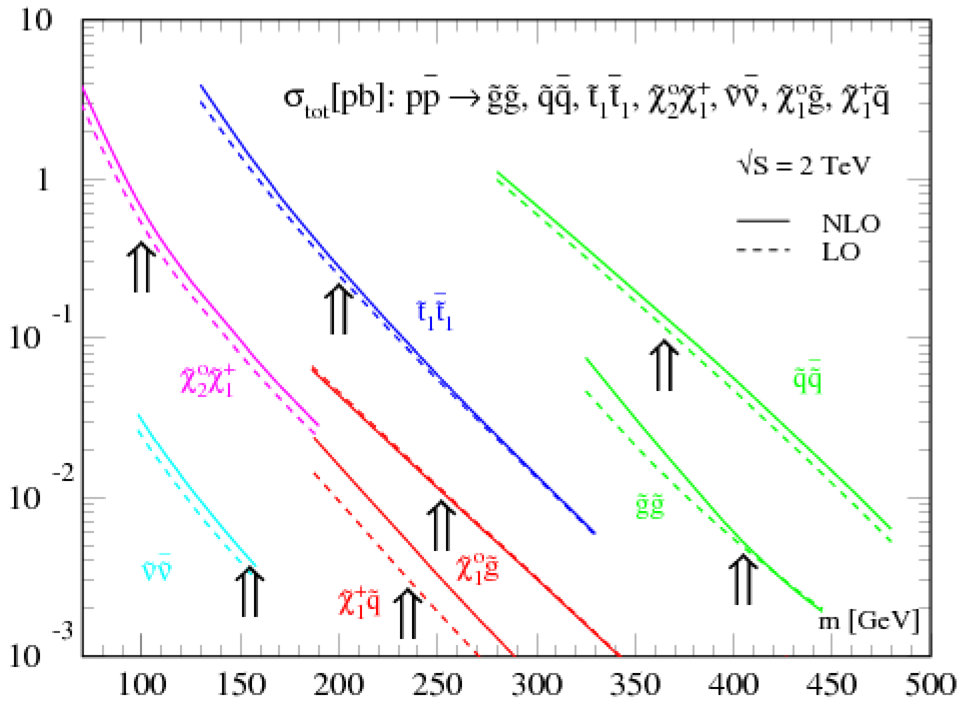
- W's and Z's of Supersymmetry
- Charginos($\chi^{\pm}$) & Neutralinos (χ^0) are mixtures of the higgsino, binos and winos.
- There are four neutralinos and two charginos.





Supersymmetric Particles

T. Plehn, PROSPINO



One can (and does) look for all types of supersymmetric particles :

- Squarks (Stops and Sbottoms)
- Gluinos
- Chargino-Neutralinos

But Chargino-Neutralino decays are good experimentally because they **decay to leptons** (among other things) which makes identifying them easier .

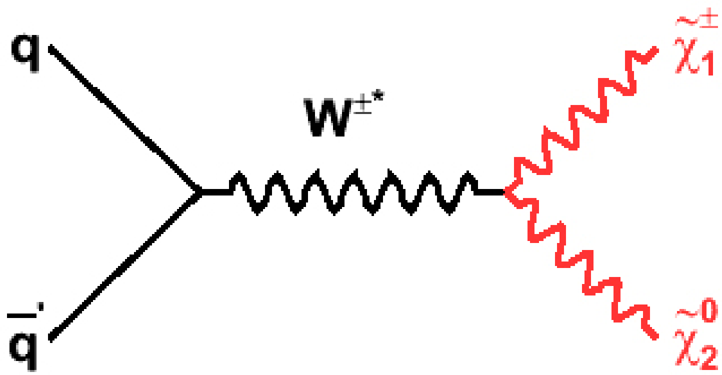
Chargino/Neutralino Production & Decay

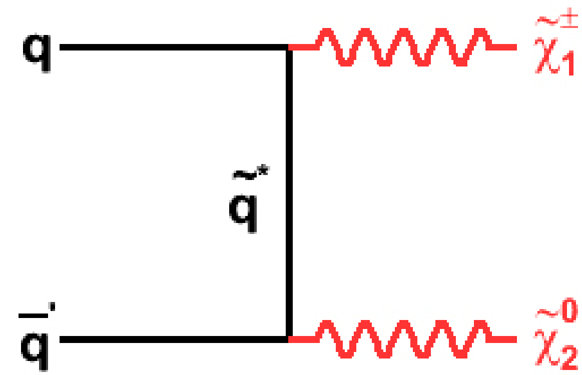
We assume R_p is conserved –
SUSY particles are produced in pairs, they decay to the lightest supersymmetric particle (LSP) which is stable

Production of chargino and neutralino via s-channel and t-channel

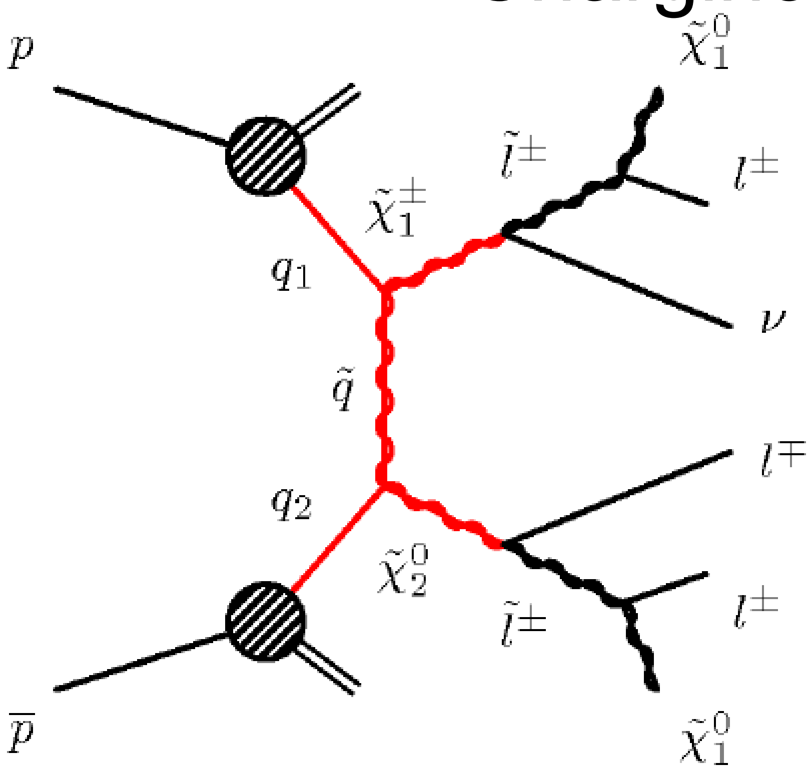
Decay of chargino/neutralino via
- virtual W,Z,sleptons (3-body)
- through intermediate slepton states(two 2-body decays)

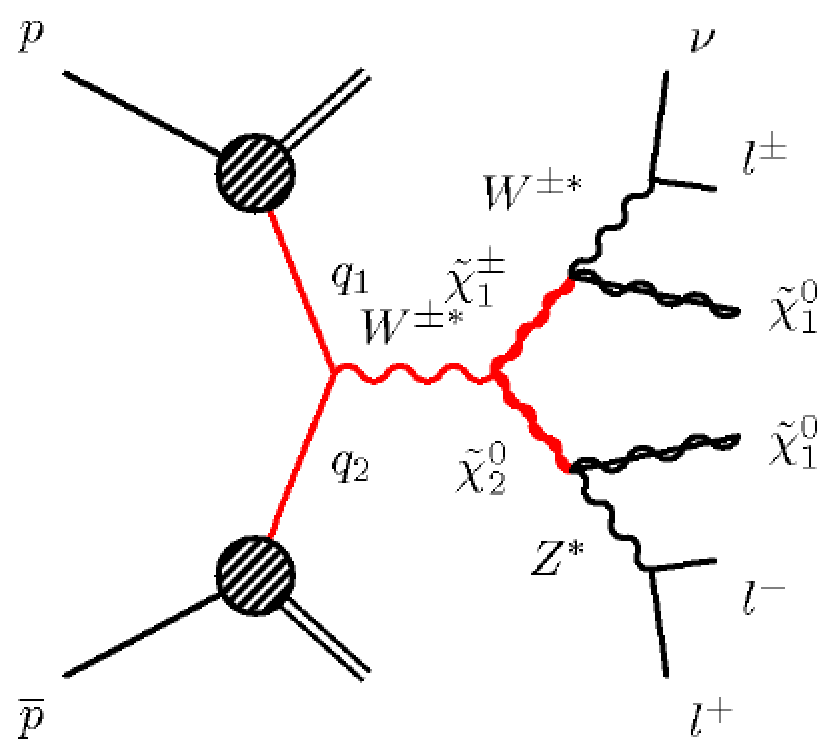
Chargino/Neutralino Production



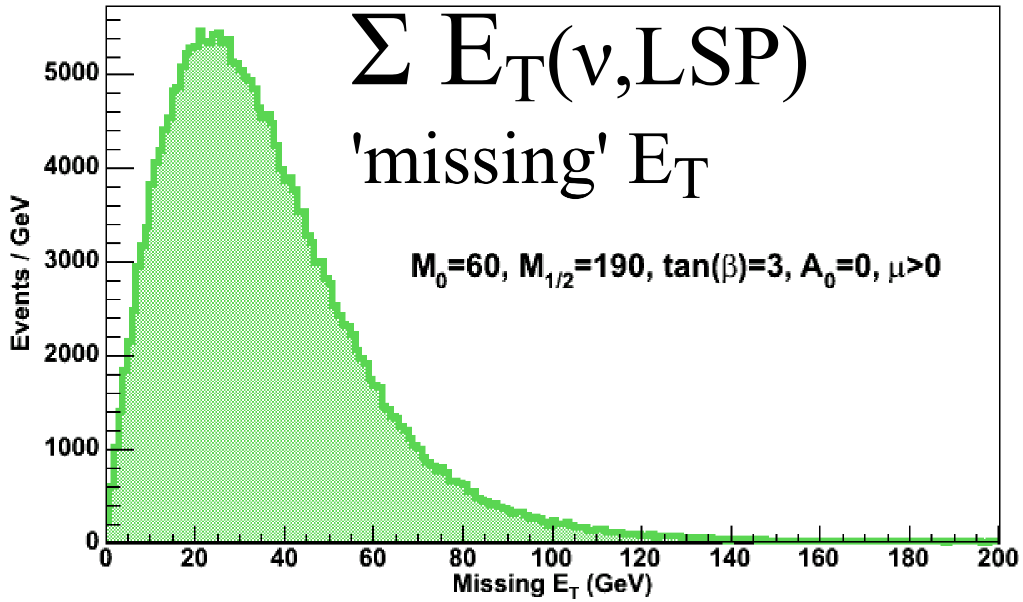


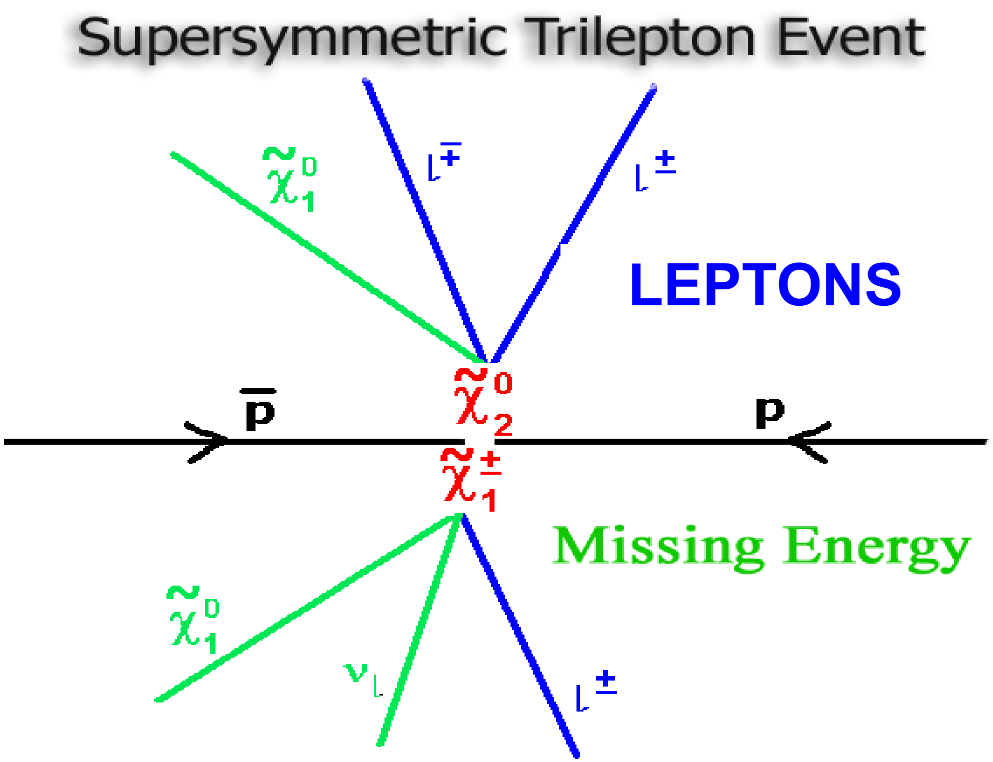
Chargino/Neutralino Decay

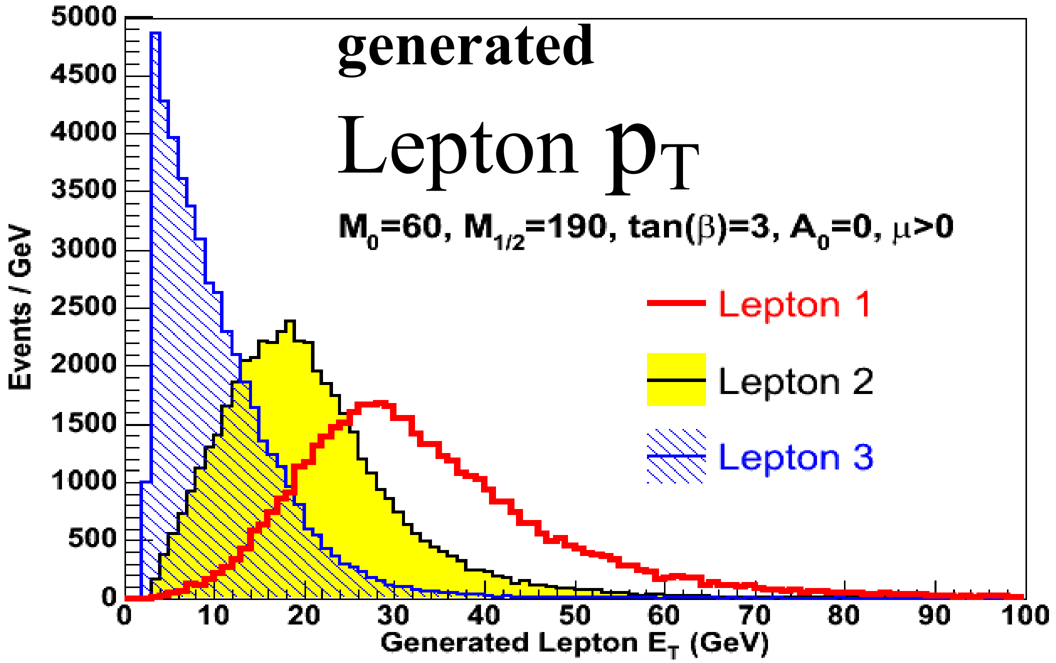




Signature of Interest







Signal and Background Cross sections

SIGNAL = 3 leptons + MET

σ(Signal)~0.5pb, for benchmark point Mass(Chargino) = 120 GeV/c^2

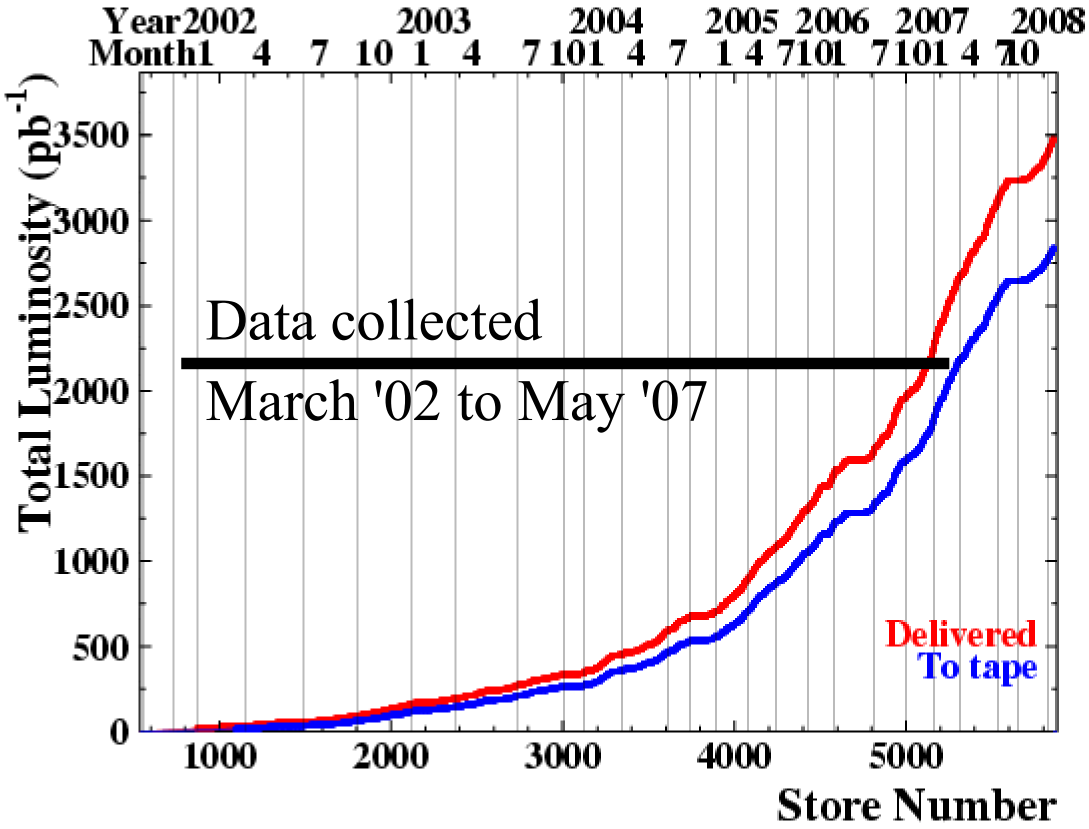
MET=missing transverse energy

Process	σ(bkg)/σ(sig)	What it has	What it needs
$WZ \rightarrow lll\upsilon$	~ 1	3 leptons + MET	-
$ZZ \rightarrow llll$		≥ 3 leptons	MET
$WW \rightarrow ll\upsilon\upsilon$		2 leptons + MET	1 lepton
Top-pair	~ 10	3 leptons + MET	-
$DY \rightarrow ll$	~ 1000	2 leptons	1 lepton + MET
$Z\gamma \rightarrow ll\gamma$	~ 30	≥ 3 leptons	MET
$W \rightarrow l\upsilon$	~ 5000	1 lepton + MET	2 leptons

PART II
Data and Analysis

Data

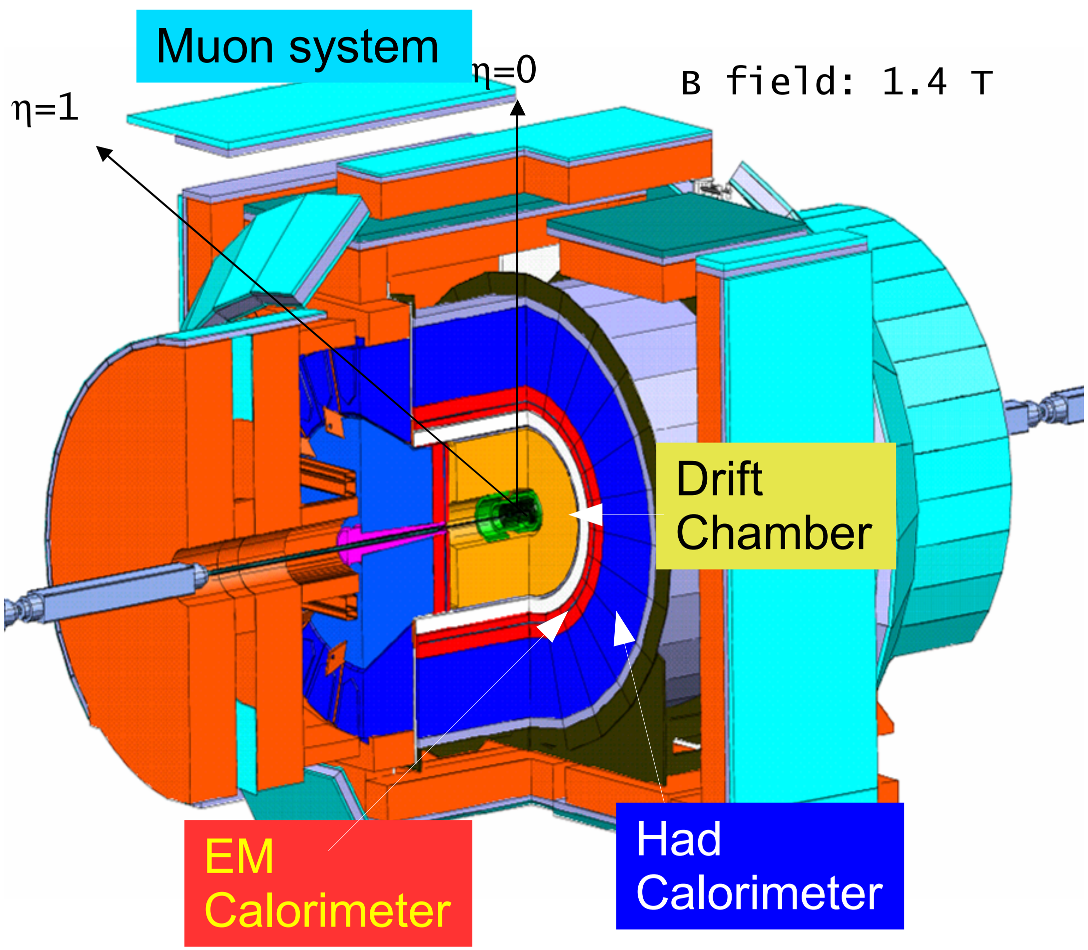
Proton-antiproton collisions at 1.96 TeV

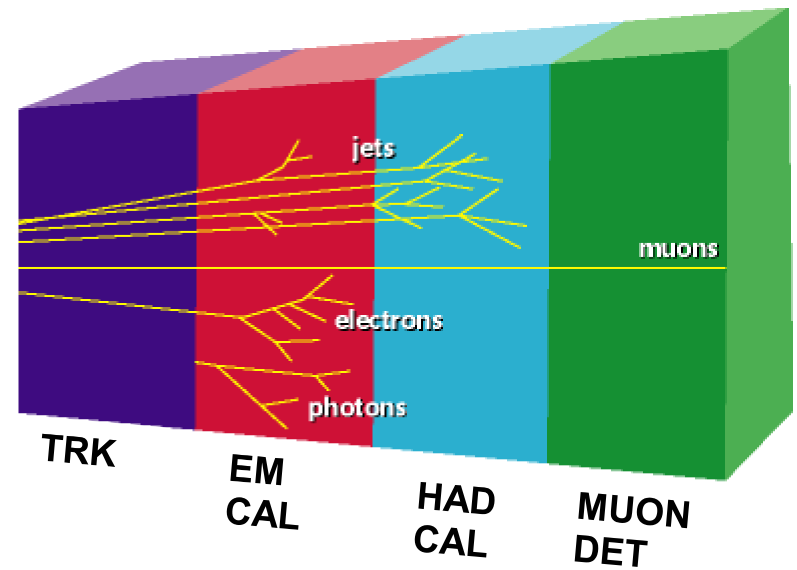


Thanks to Accelerator Division!!

Total Integrated Luminosity for this result is 2.0 fb^{-1}

CDF Detector

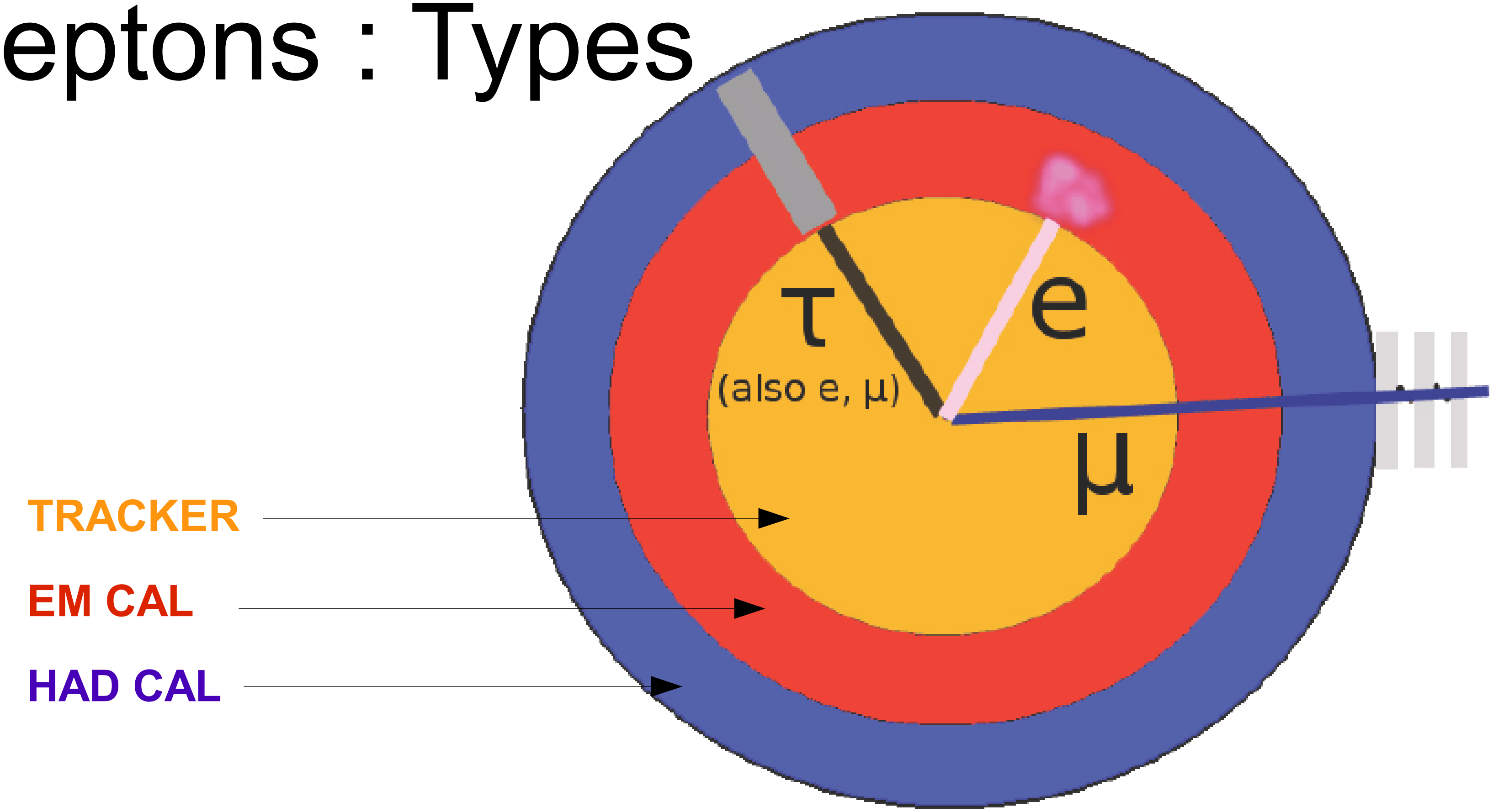




Multipurpose Detector :

radially outward – silicon detector, tracking chamber, EM and Had Calorimeters, Muon systems

Three Leptons : Types



Electrons are a track [charged particle] + EM shower

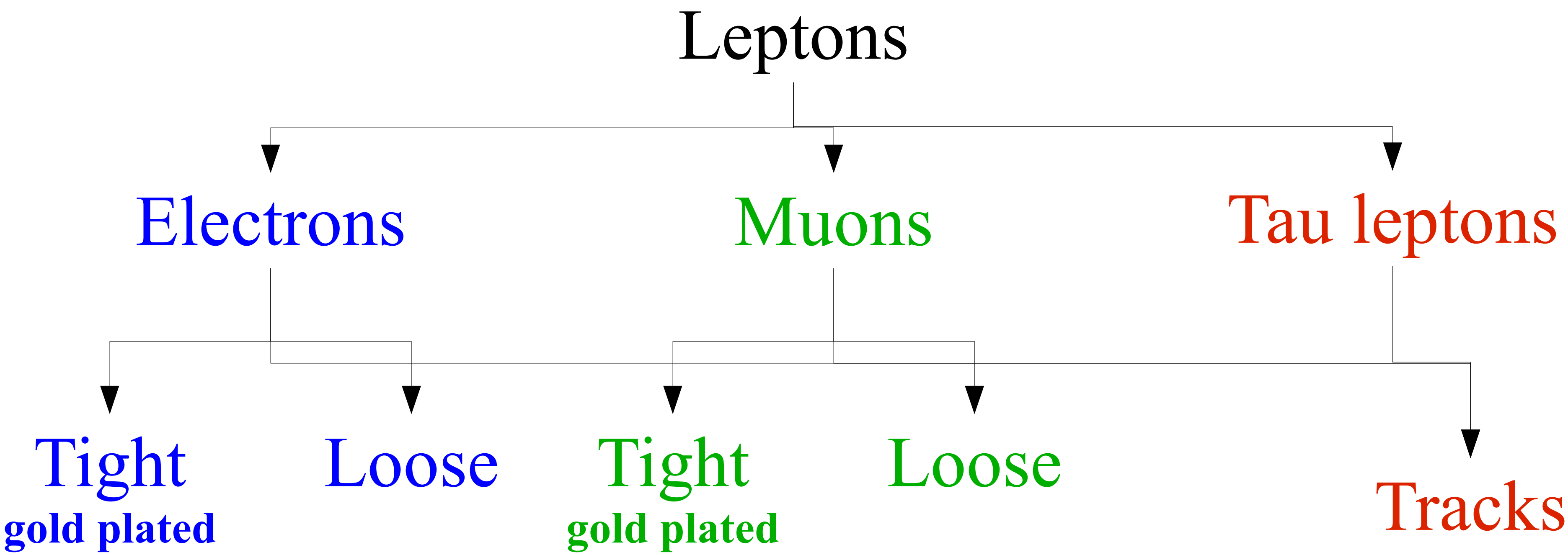
Muons are a track + MIP + signal in muon systems

Tau-leptons decay to electrons or muons (see above) BR=35%

decay hadronically single-prong (1 charged particle) BR=50%

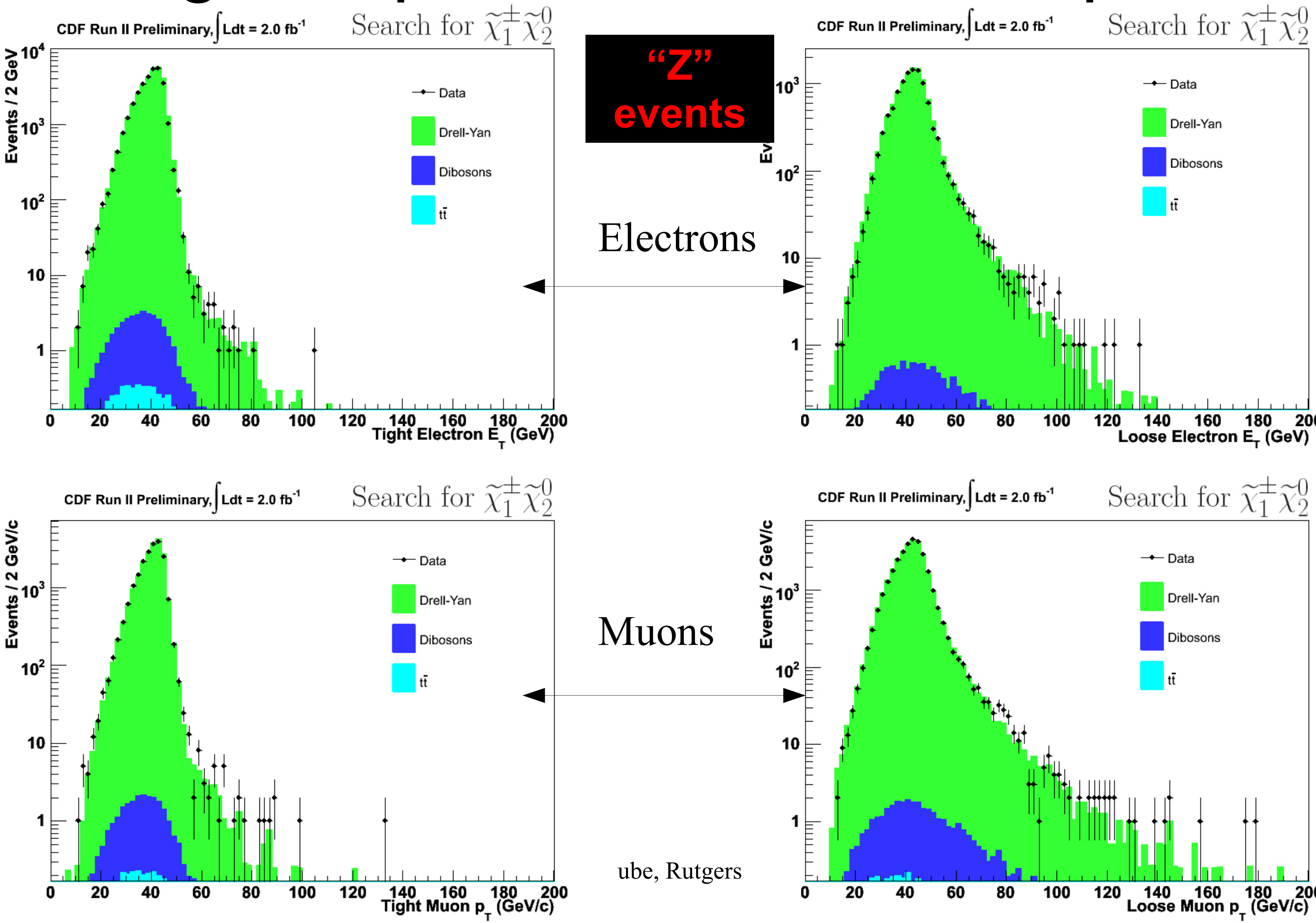
use an 'isolated' track to identify single-prong decays

Three 'Leptons' : Types



For example, Loose Electron has E/p < 2 and HadE/EmE < 5%
Tight Electron has additional requirements based on shower shape of electron in calorimeter, pointing of track to calorimeter shower etc.

Tight Leptons   Loose Leptons



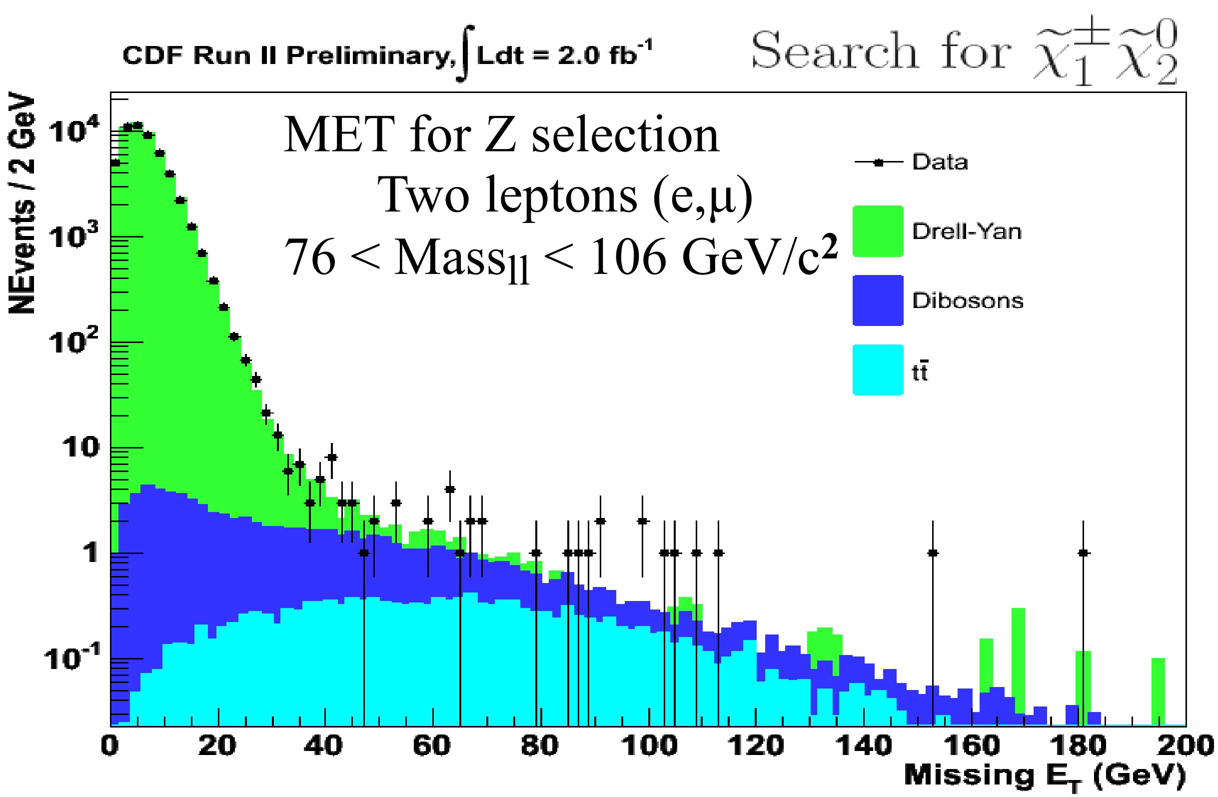
ube, Rutgers

Missing E_T

Missing energy known in transverse direction → missing E_T or MET

MET is calorimeter based

Real MET → Neutrinos (and SUSY particles, if they exist)



Instrumental MET →

- mismeasurement of jet energies
- not accounting for muons

We correct MET

✓ for jets

✓ for muons

Setting up the Analysis

Perform an unbiased counting experiment :

- Define event selection
- Test predictive ability in a set of control regions
- Predict number of events in signal box
- Look at data and claim discovery or set limit.

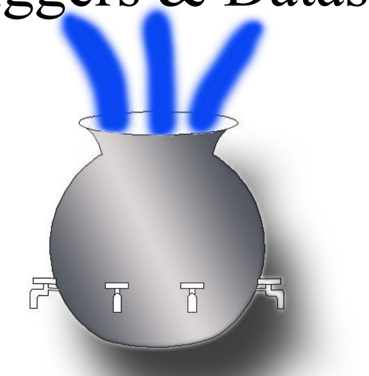
Different from 1fb-1 published result

Setting up the Analysis

Challenge : Overlapping datasets with multiple trigger paths.

Channels in this analysis are

A) Mutually **exclusive** and,
B) Ordered in terms of purity (S/B).



Setting up the Analysis

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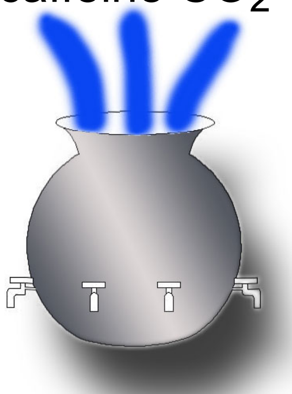


S/B

Find three tight leptons

Else, two tight leptons and a loose lepton.

Else, one tight and two loose leptons.

Else, two tight leptons and one isolated track.

Else, one tight, one loose lepton and one isolated track.

Setting up the Analysis

The five exclusive channels :

Channel	E_T (P_T) GeV
3 tight leptons OR 2 tight leptons + 1 loose electron	**15, 5, 5**
2 tight leptons + 1 loose muon	**15, 5, 10**
1 tight lepton + 2 loose leptons	**20, 8, 5 (10 if loose muon)**
2 tight leptons + 1 Track	**15, 5, 5**
1 tight lepton, 1loose lepton, 1 Track	**20, 8(10 if loose muon), 5**

The five exclusive channels constitute

five independent experiments within CDF

SM Backgrounds

Our signature is three leptons + missing energy –
What SM processes also look like this?

Process

WZ 3 leptons + missing E_T

ZZ 4 leptons ← **Three Real Leptons**

top-pair 3 leptons + missing E_T

DY 2 leptons

WW 2 leptons + missing E_T

a) + γ conversion ← **Two Leptons + 'Fake'**

b) + track from underlying event

c) + hadron misidentified as lepton

W+jets 1 lepton + missing E_T ← **One Lepton + 'Fake' + Track**

a) + track from jets

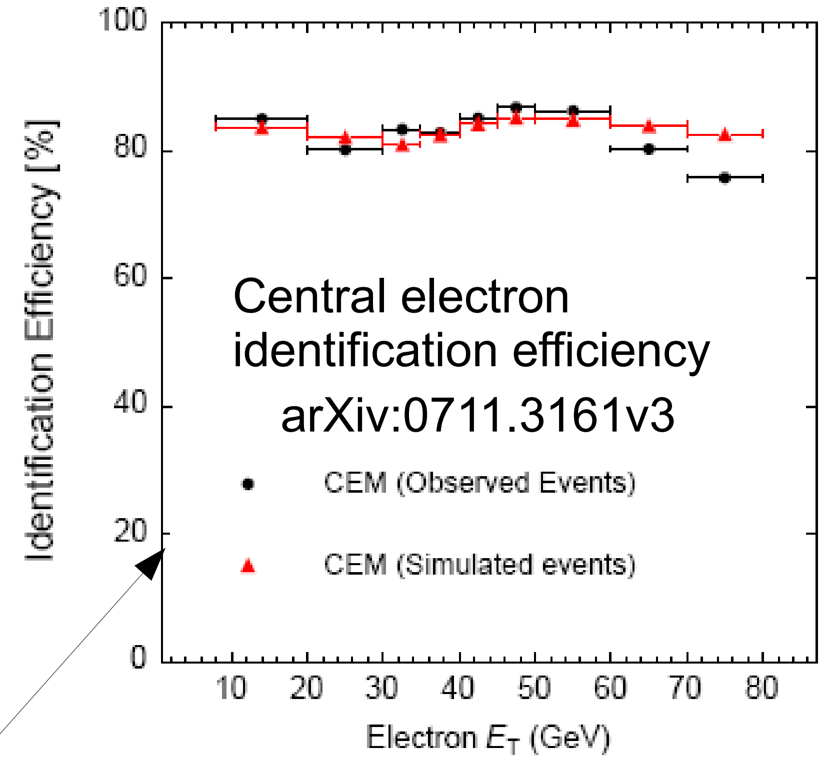
b) + hadron misidentified as lepton

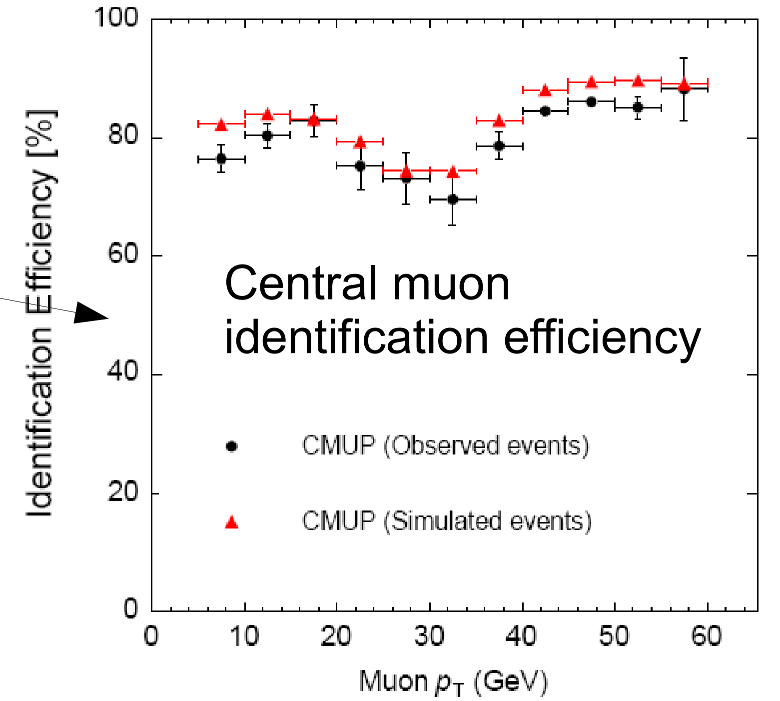
Estimating Backgrounds

Three real leptons :
Backgrounds from WZ, ZZ, top-pair are obtained from Monte Carlo(MC) simulations.

DY + γ :
also obtained from MC simulations.

Lepton identification efficiencies
and trigger efficiencies
used to get correct predictions in MC.





Estimating Backgrounds

Rate for Leptons :

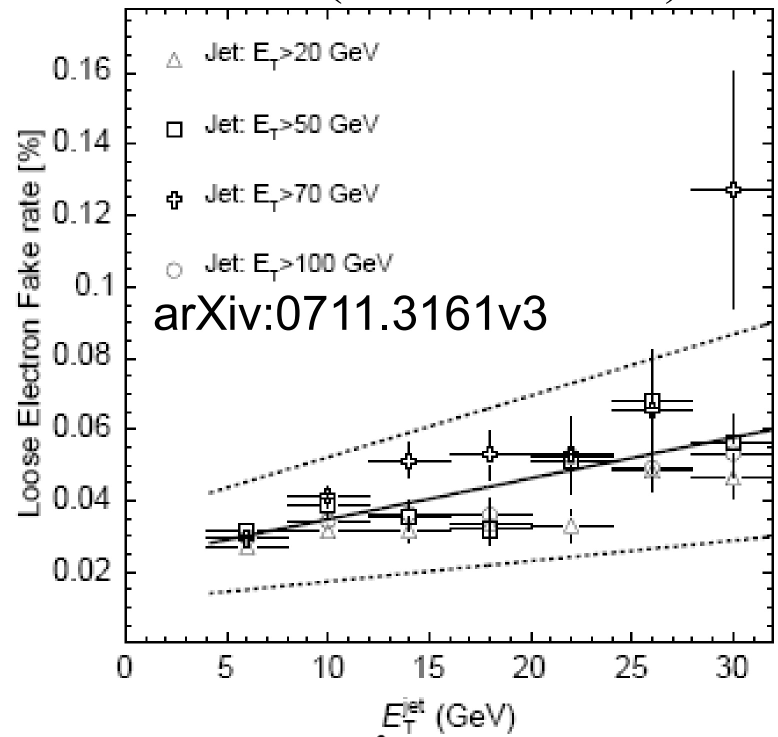
DY + (had→lep)

WW + (had→lep)

W+jets + (had→lep)

Estimated in **DATA**

Rate (Jet→Electron)



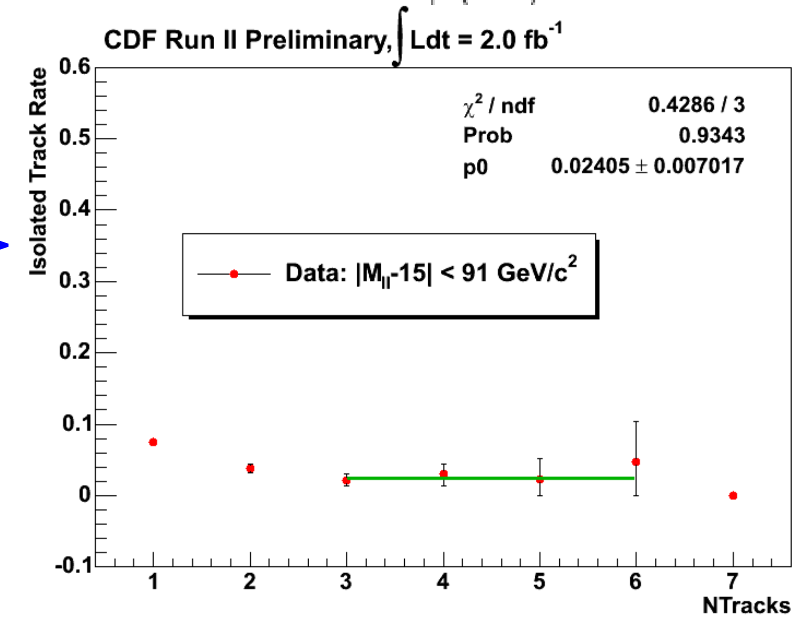
Rate for Candidate Tracks:

DY + track

WW + track

Estimated in **MC**

(but, normalized to data)



Reducing Backgrounds

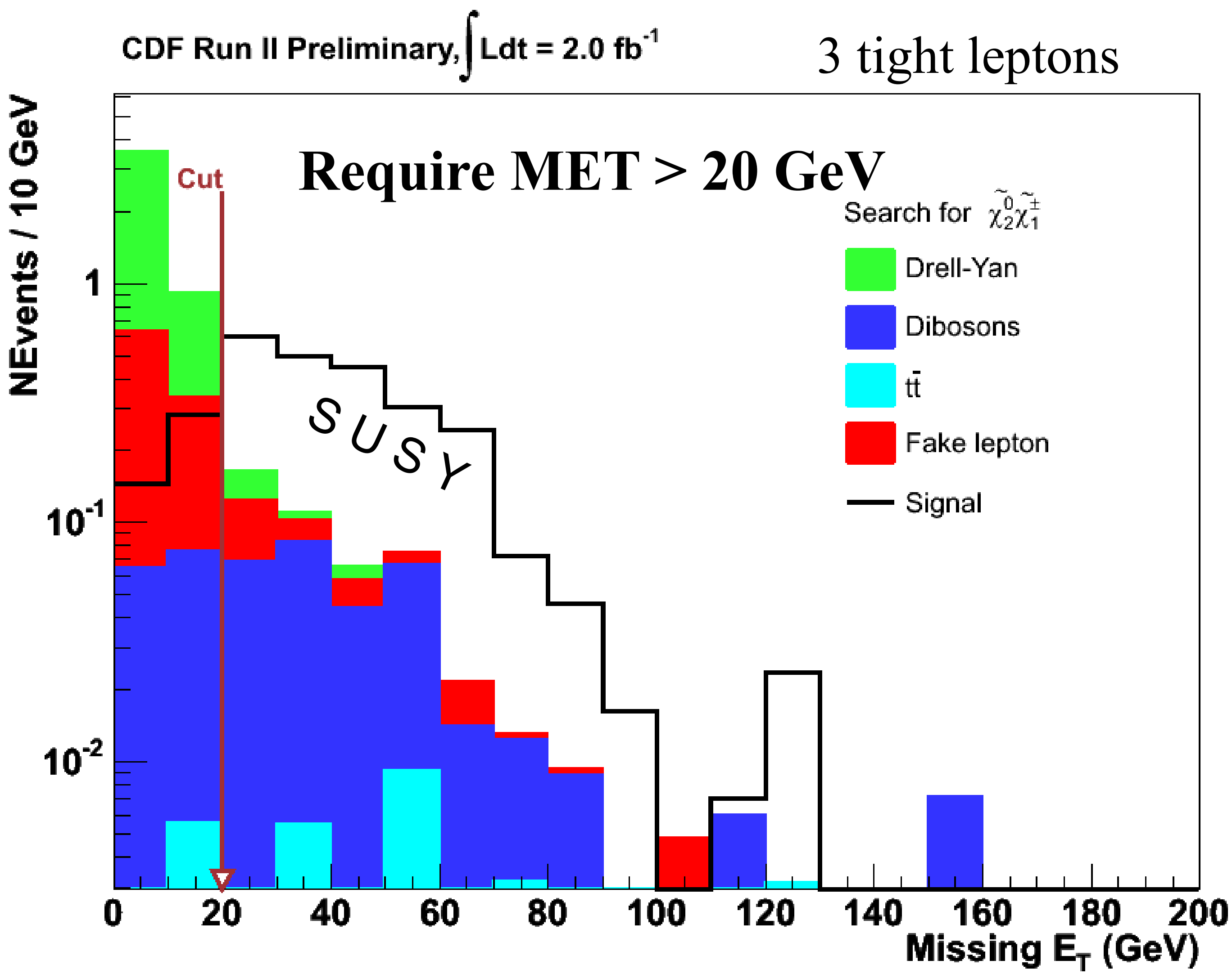
Process		How to reduce?
Drell-Yan + γ Drell-Yan + track	low MET	make MET cut
top-pair production hadrons faking leptons	has jets	require no more than 1 jet

Dibosons : WZ,ZZ — on-shell contribution of Z can be removed by a invariant mass cut for the Z.

off-shell contribution for ZZ → make MET cut

off-shell contribution is irreducible for WZ

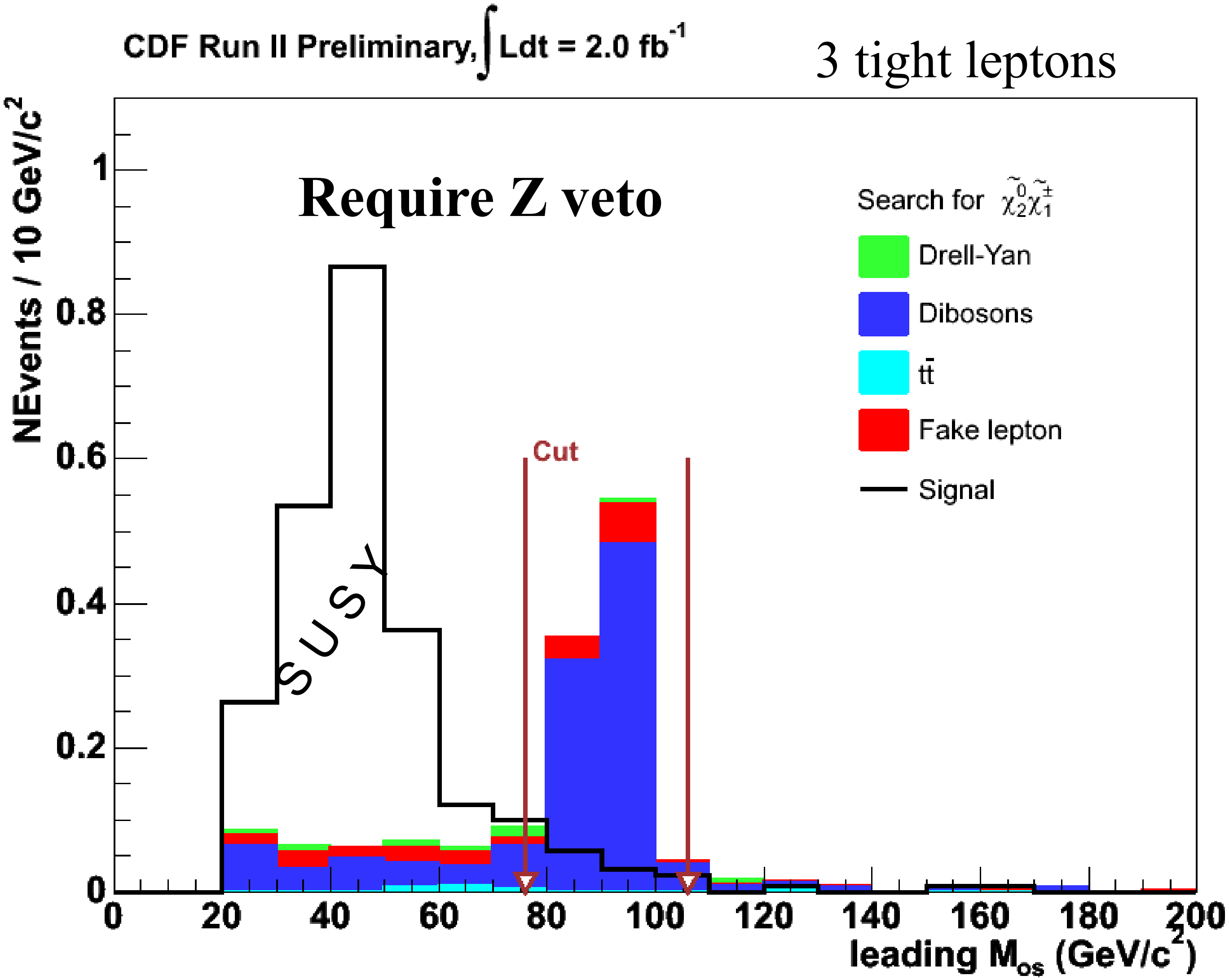
Reducing Backgrounds: Drell-Yan, ZZ



After all other selections are made

Signal : mSUGRA m_0=60, $m_{1/2}$=190, tan(β)=3, A_0=0, μ>0, $M(\chi_1^\pm)$=120 GeV/c^2

Reducing Backgrounds: WZ, ZZ on shell



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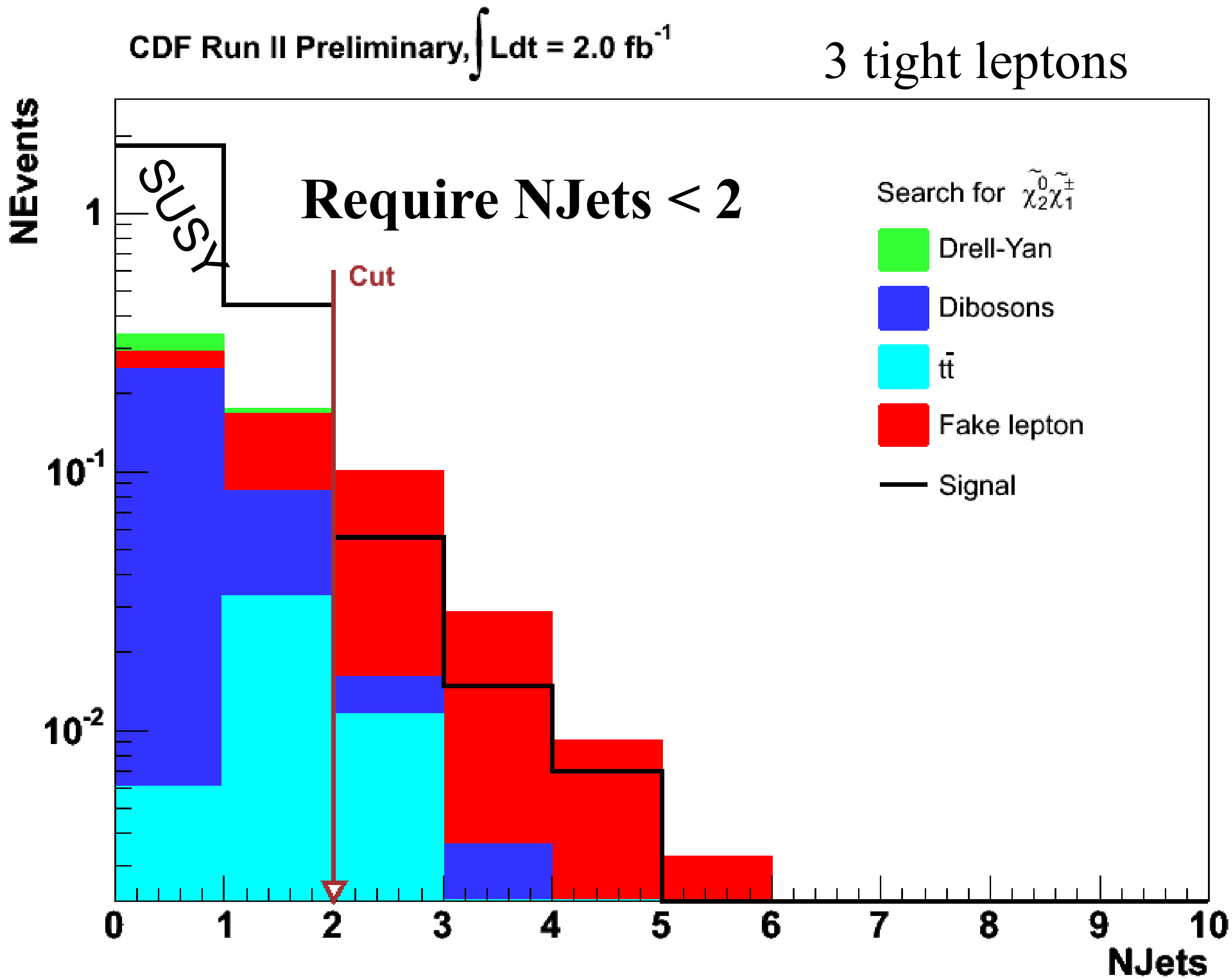
Reducing Backgrounds: top-pair, fakes

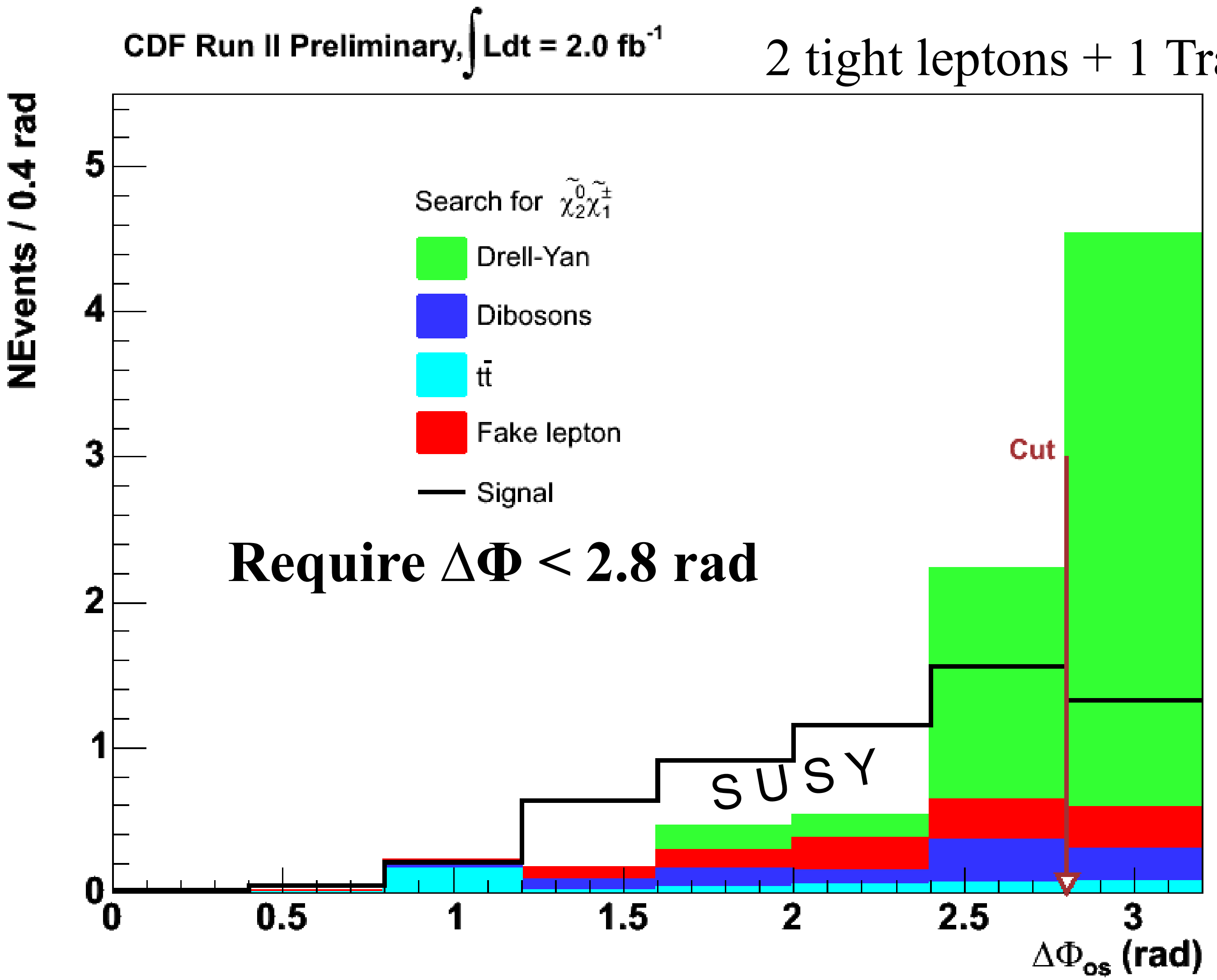


After all other selections are made

Signal : mSUGRA m_0=60, $m_{1/2}$=190, tan(β)=3, A_0=0, μ>0, $M(\chi_1^{\pm})$=120 GeV/c^2

Reducing Backgrounds: residual DY

2 tight leptons + 1 Track



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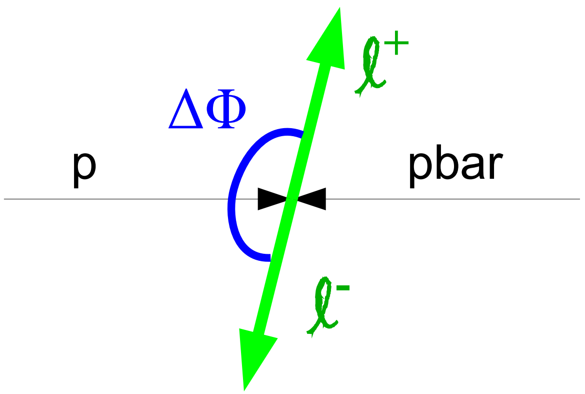

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Setting up the Analysis

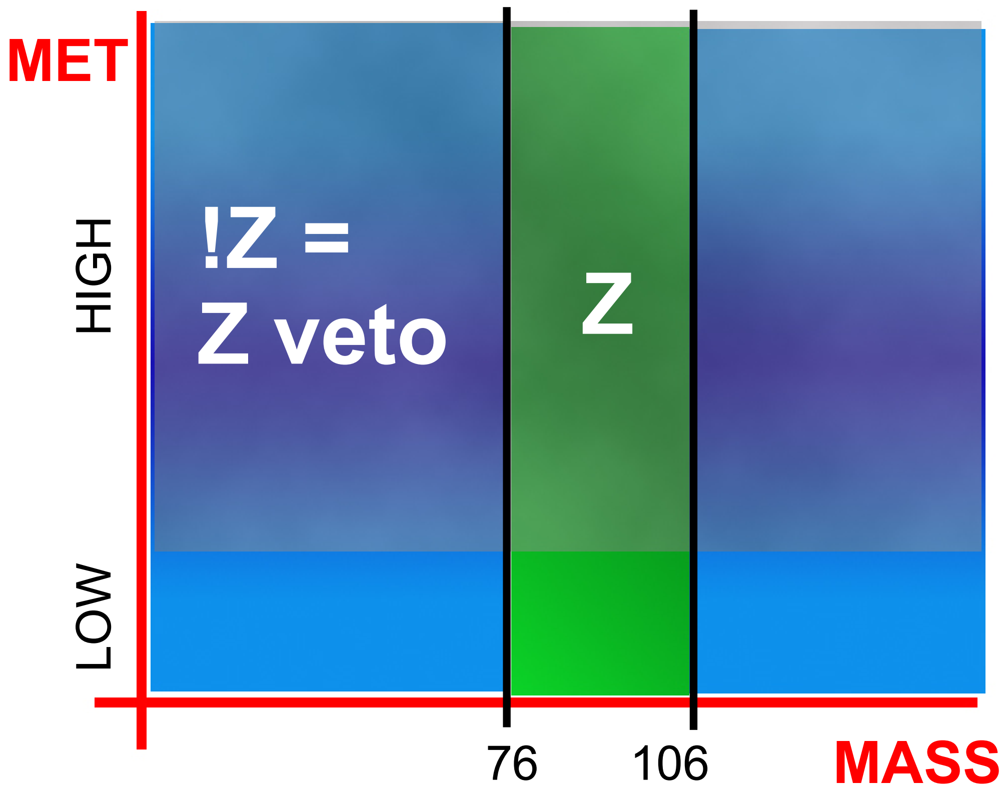
Perform an unbiased counting experiment :

- Define event selection
- Test predictive ability in a set of control regions
- Predict number of events in signal box
- Look at data and claim discovery or set limit.

TEST WITH TWO LEPTONS FIRST

We will add third later in the talk

Two leptons before Three : High Stat Control Regions



Use Z events to test luminosity,
High P_T leptons,

Use Z-veto to test low mass DY,
Low P_T leptons

Z : $76 < M_{\ell\ell} < 106$ GeV/c^2

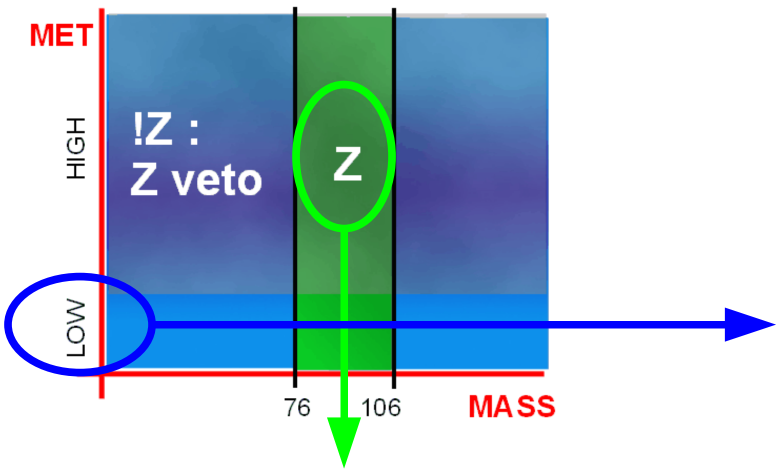
!Z : 'not' Z or Z veto

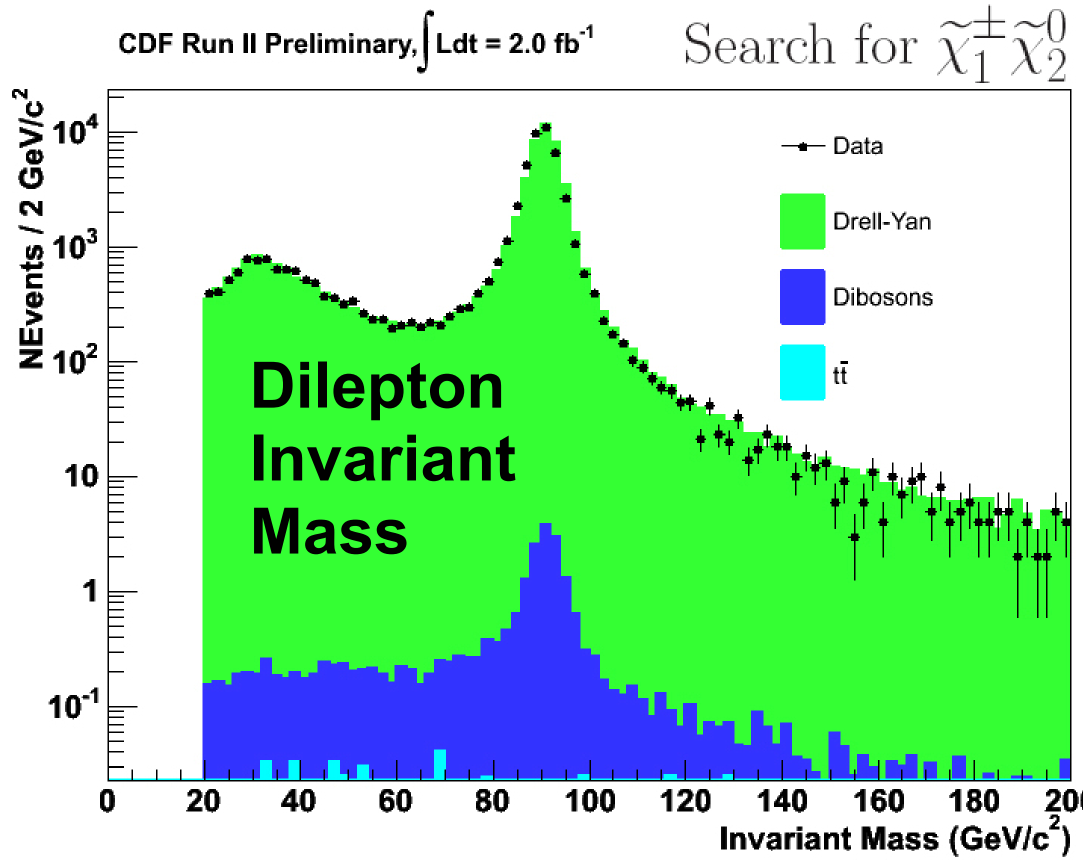
Use MET distributions to test corrections to missing E_T

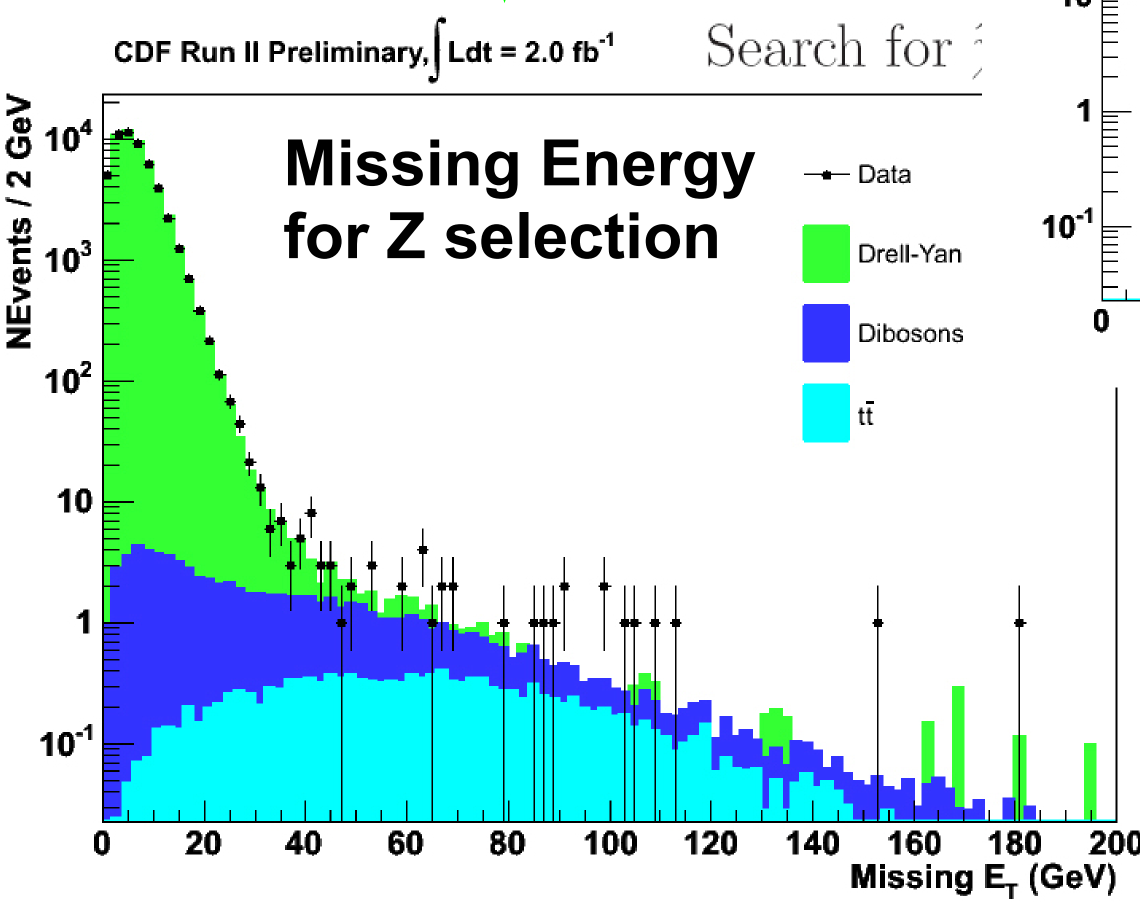
Use kinematic distributions to test agreements.

Split by flavor content (ee,μμ,eμ) to test agreements.

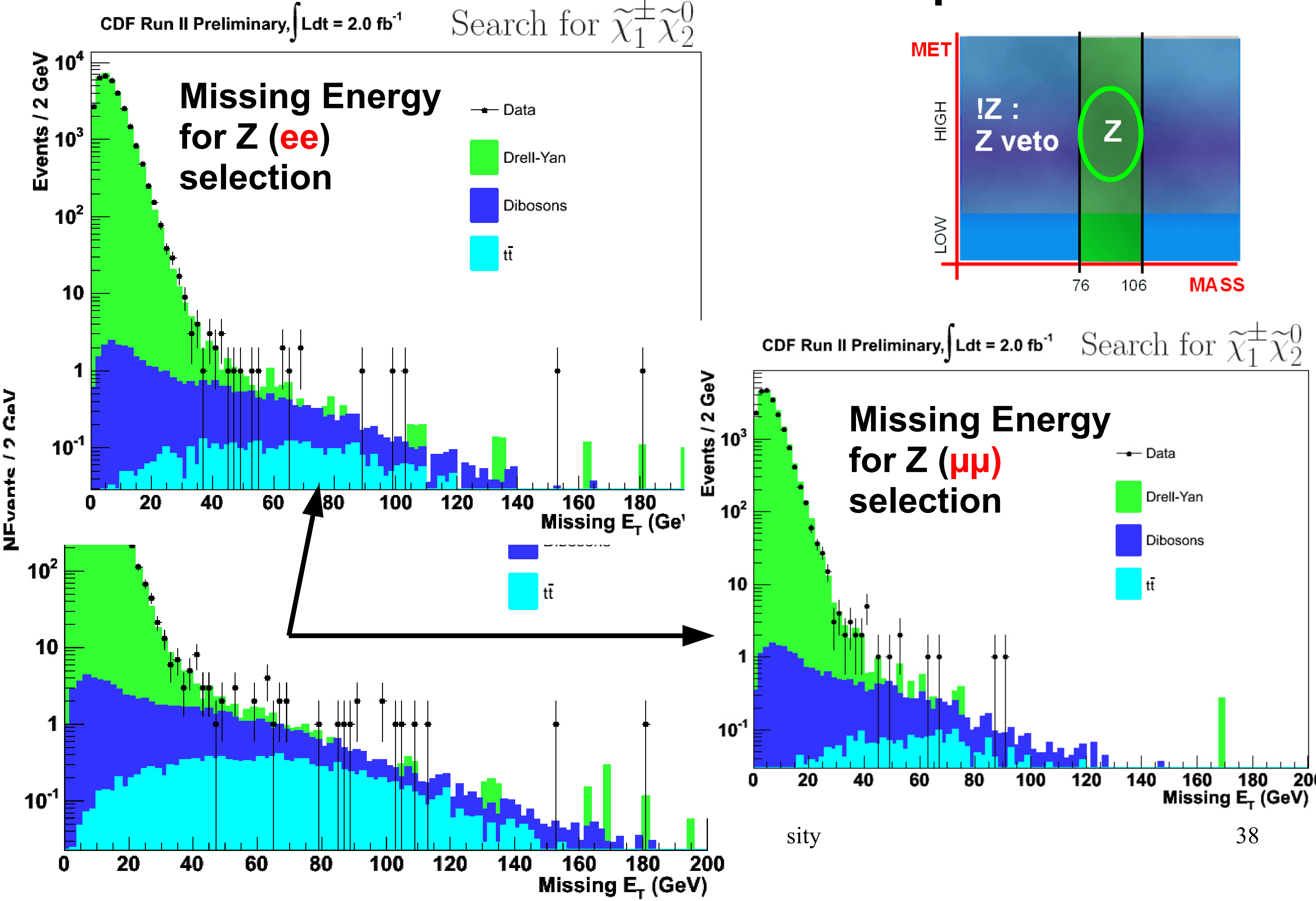
Control Regions : Dileptons







Control Regions : Dileptons



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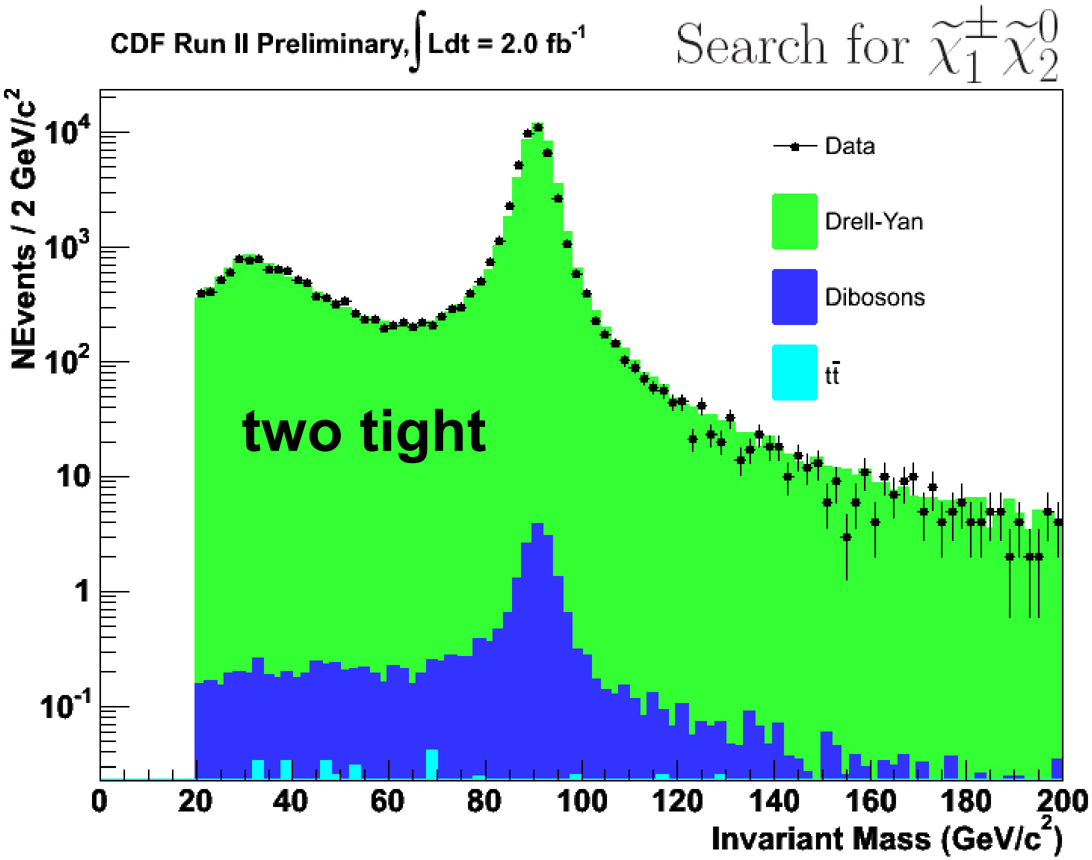
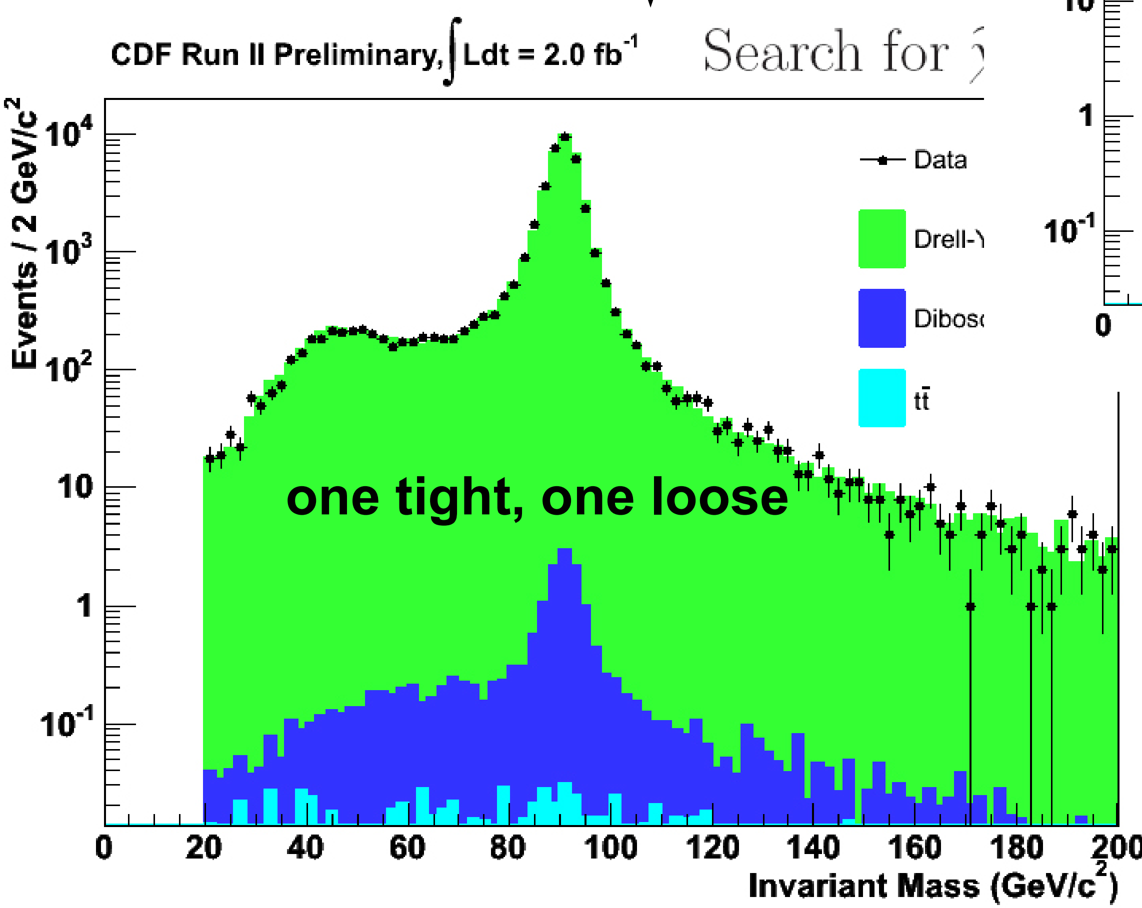
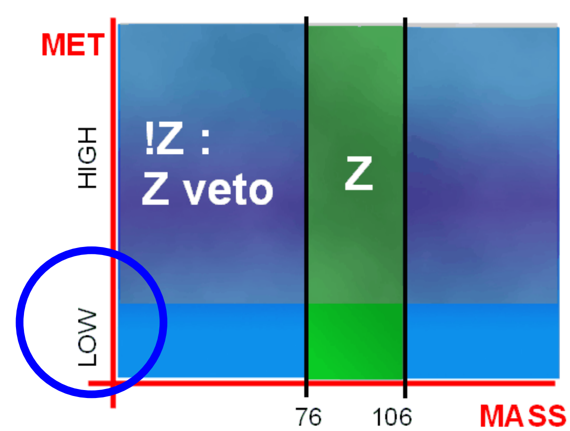
Control Regions : Dileptons

Dilepton Invariant Mass







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Control Regions : Dileptons

CDF RUN II Preliminary $\int \mathcal{L}dt = 2.0\ \text{fb}^{-1}$: Search for $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$

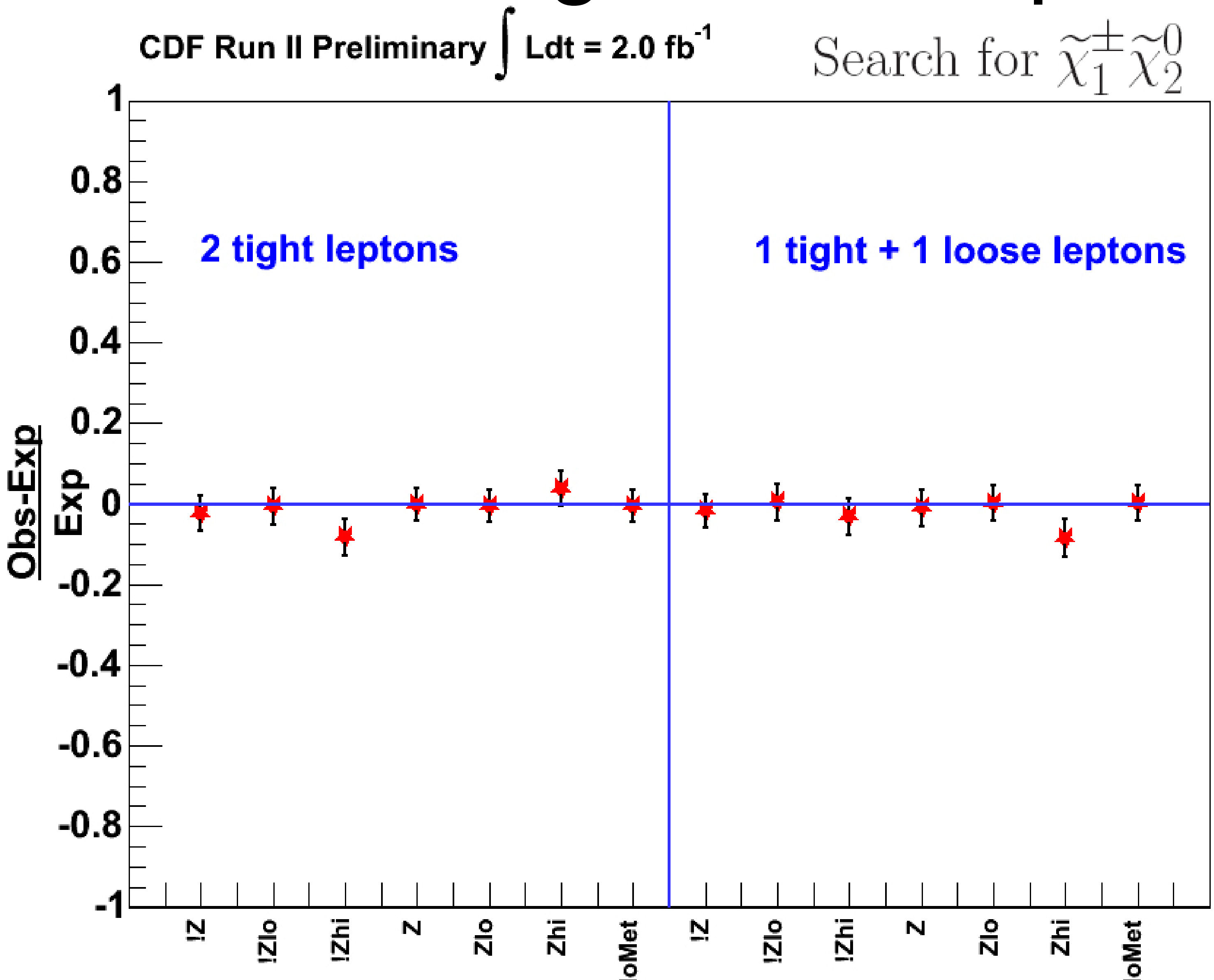
Name	$Z \rightarrow ee$	$Z \rightarrow \mu\mu$	$Z \rightarrow \tau\tau$	WW	WZ	ZZ	$t\bar{t}$	Expected	Observed
2tight									
!Z	9847.8	5034.7	1310.2	93.3	1.6	7.1	57.1	16352 ± 716	15966
!Zlo	7705.6	4240.6	477.7	4.7	0.1	2.3	1.0	12432 ± 569	12352
!Zhi	858.4	205.5	550.3	83.5	1.4	3.6	55.0	1758 ± 80	1612
Z	31178.2	19870.4	21.9	22.4	6.3	35.8	15.0	51150 ± 2034	51042
Zlo	25577.6	16665.6	11.1	1.6	0.2	13.4	0.2	42270 ± 1682	42093
Zhi	1261.1	741.5	6.4	19.0	5.8	15.9	14.4	2064 ± 92	2143
lo	33349.6	20903.9	488.7	6.3	0.3	15.7	1.2	54766 ± 2212	54445
Z(ee)	31178.3	0.0	6.7	6.5	4.0	21.9	4.7	31222 ± 1710	31074
$Z(\mu\mu)$	0.0	19867.7	3.9	4.6	2.3	13.9	3.0	19895 ± 1102	19942
!Z(ee)	9847.9	0.0	497.8	29.9	1.1	4.3	18.3	10399 ± 617	10033
$!Z(\mu\mu)$	0.0	5015.4	243.2	18.2	0.4	2.3	10.9	5290 ± 352	5198
$e\mu$	0.0	21.9	580.4	56.5	0.1	0.5	35.1	694 ± 47	761

Control Regions : Dileptons

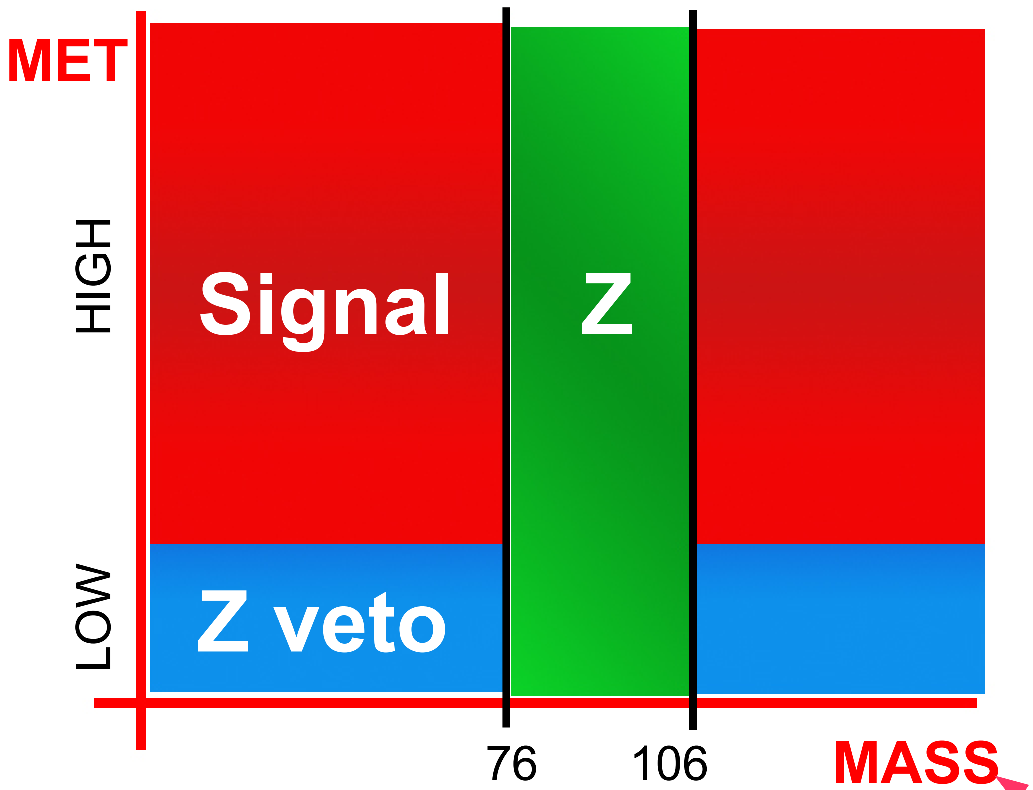
CDF RUN II Preliminary $\int \mathcal{L}dt = 2.0\ \text{fb}^{-1}$: Search for $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$

Name	Z→ ee	Z→ $\mu\mu$	Z→ $\tau\tau$	WW	WZ	ZZ	$t\bar{t}$	Expected	Observed
				2tight					
!Z	**9848**	**5035**	**1310**	**93.3**	**1.6**	**7.1**	**57.1**	**16532 ± 716**	**15966**
!Zlo	7705.6	4240.6	477.7	4.7	0.1	2.3	1.0	12432 ± 569	12352
!Zhi	858.4	205.5	550.3	83.5	1.4	3.6	55.0	1758 ± 80	1612
Z	31178.2	19870.4	21.9	22.4	6.3	35.8	15.0	51150 ± 2034	51042
Zlo	25577.6	16665.6	11.1	1.6	0.2	13.4	0.2	42270 ± 1682	42093
Zhi	1261.1	741.5	6.4	19.0	5.8	15.9	14.4	2064 ± 92	2143
lo	33349.6	20903.9	488.7	6.3	0.3	15.7	1.2	54766 ± 2212	54445
Z(ee)	31178.3	0.0	6.7	6.5	4.0	21.9	4.7	31222 ± 1710	31074
Z($\mu\mu$)	0.0	19867.7	3.9	4.6	2.3	13.9	3.0	19895 ± 1102	19942
!Z(ee)	9847.9	0.0	497.8	29.9	1.1	4.3	18.3	10399 ± 617	10033
!Z($\mu\mu$)	0.0	5015.4	243.2	18.2	0.4	2.3	10.9	5290 ± 352	5198
eμ	0.0	21.9	580.4	56.5	0.1	0.5	35.1	694 ± 47	761

Control Regions : Dileptons



Ready for Three Leptons



High MET, Z-veto is now signal box

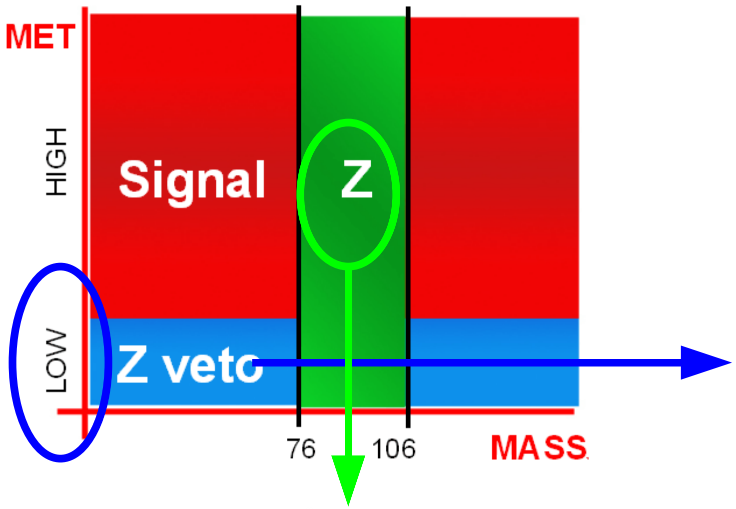
Use Z events to test MET

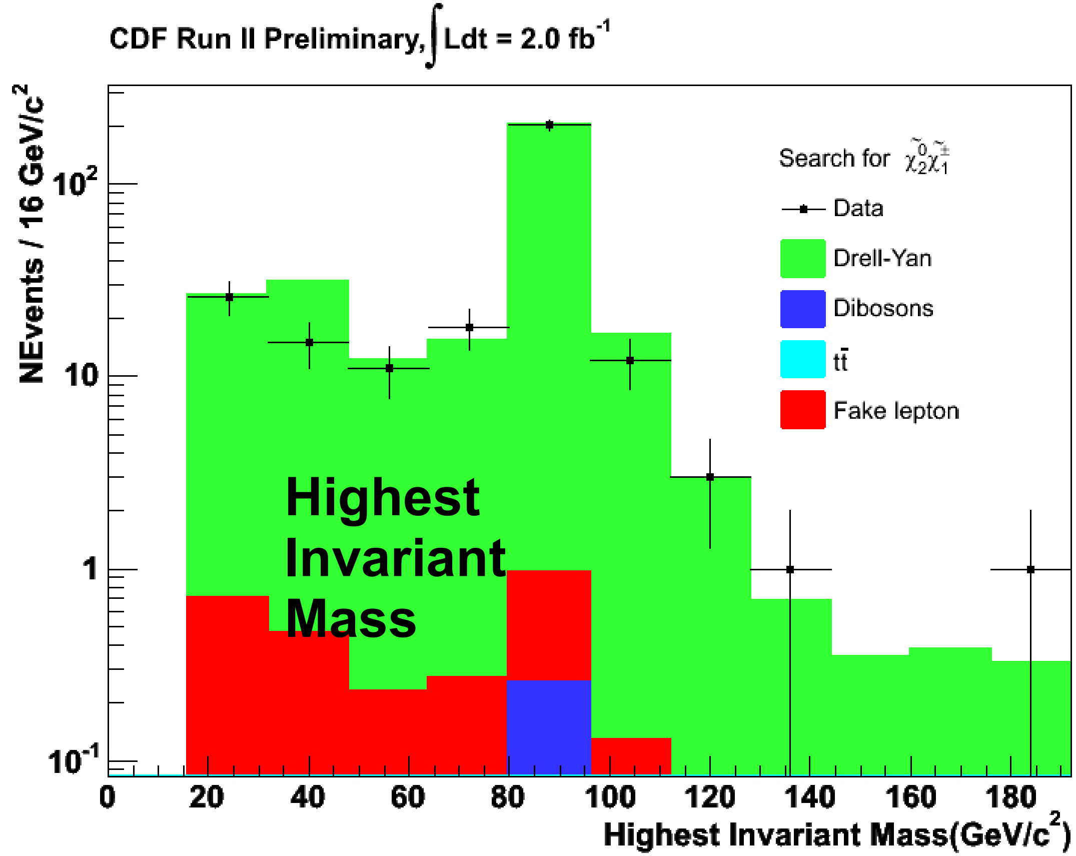
Use high MET Z region to test dibosons (WZ,WW)

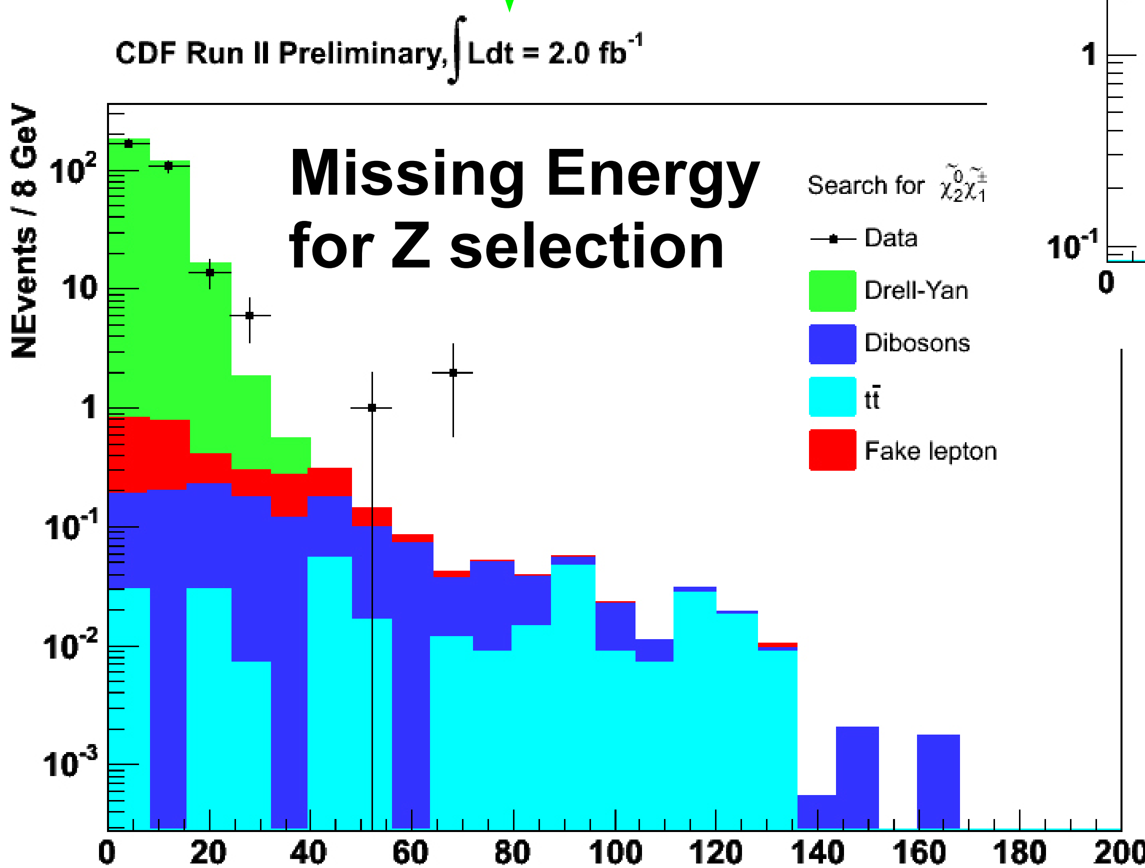
Test 'fake' estimations in Z events and low-mass, low-MET events.

Trileptons = two opposite charge pairs. Take higher to define control regions.

Control Regions : Trileptons

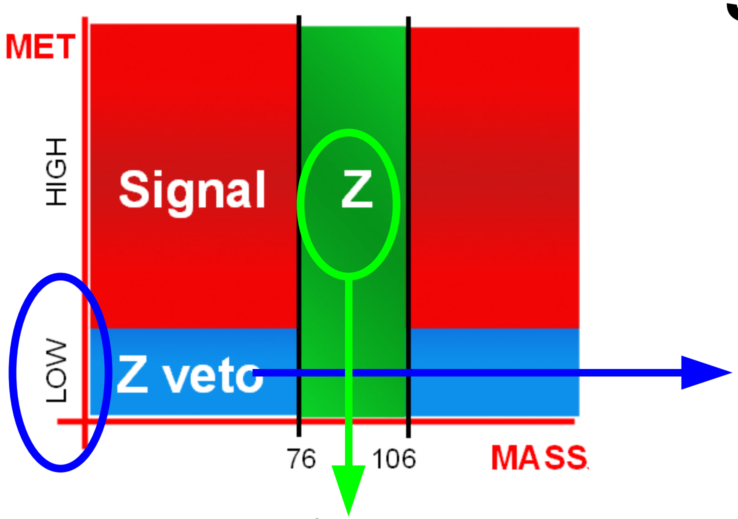


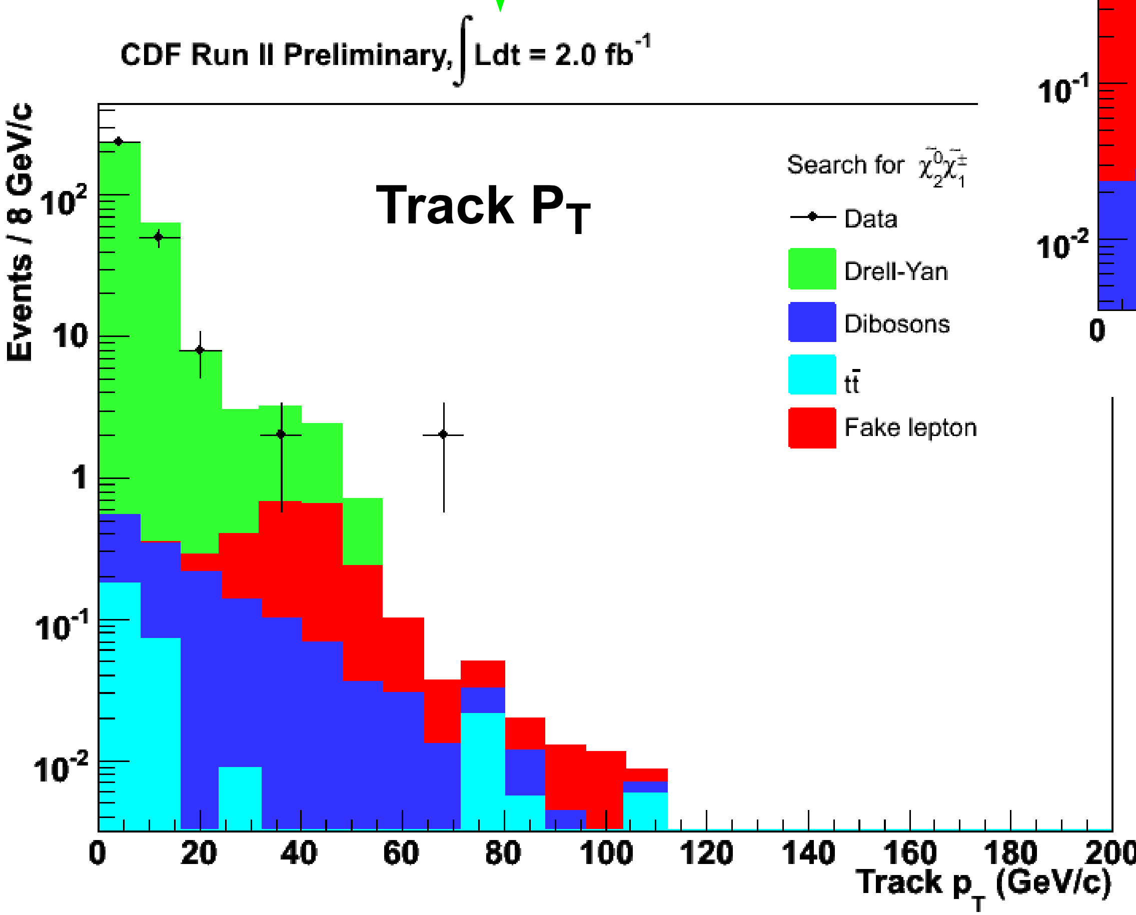


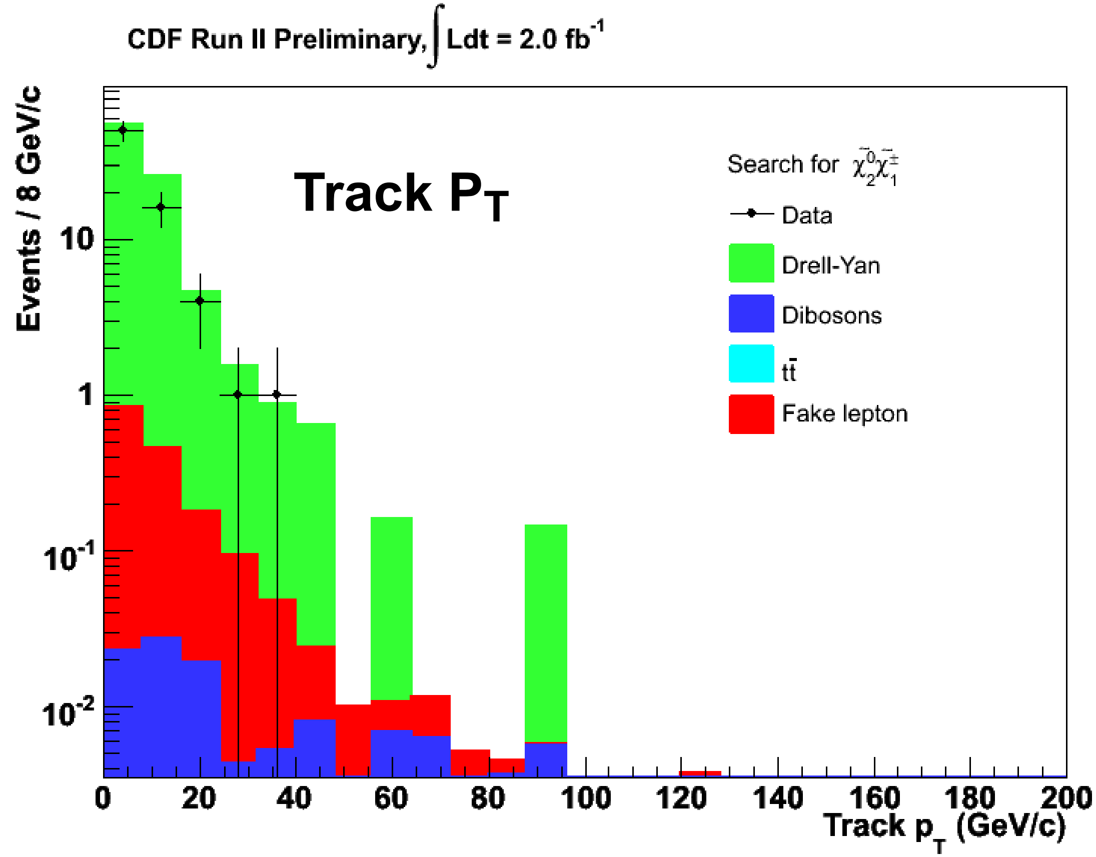


Selection :
2 tight leptons + 1 Track

Control Regions : Trileptons

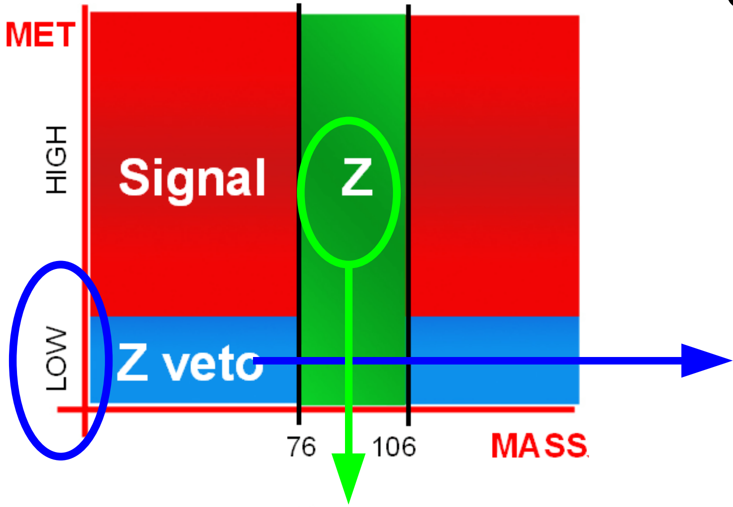


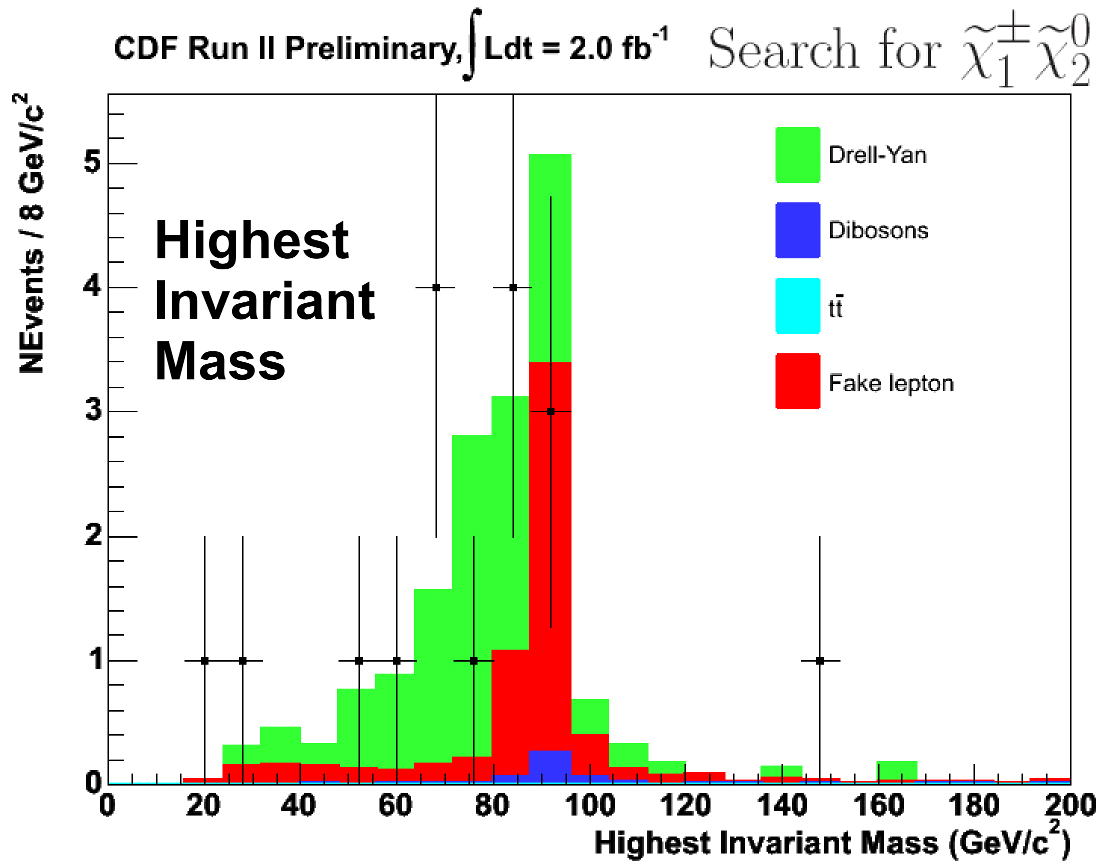


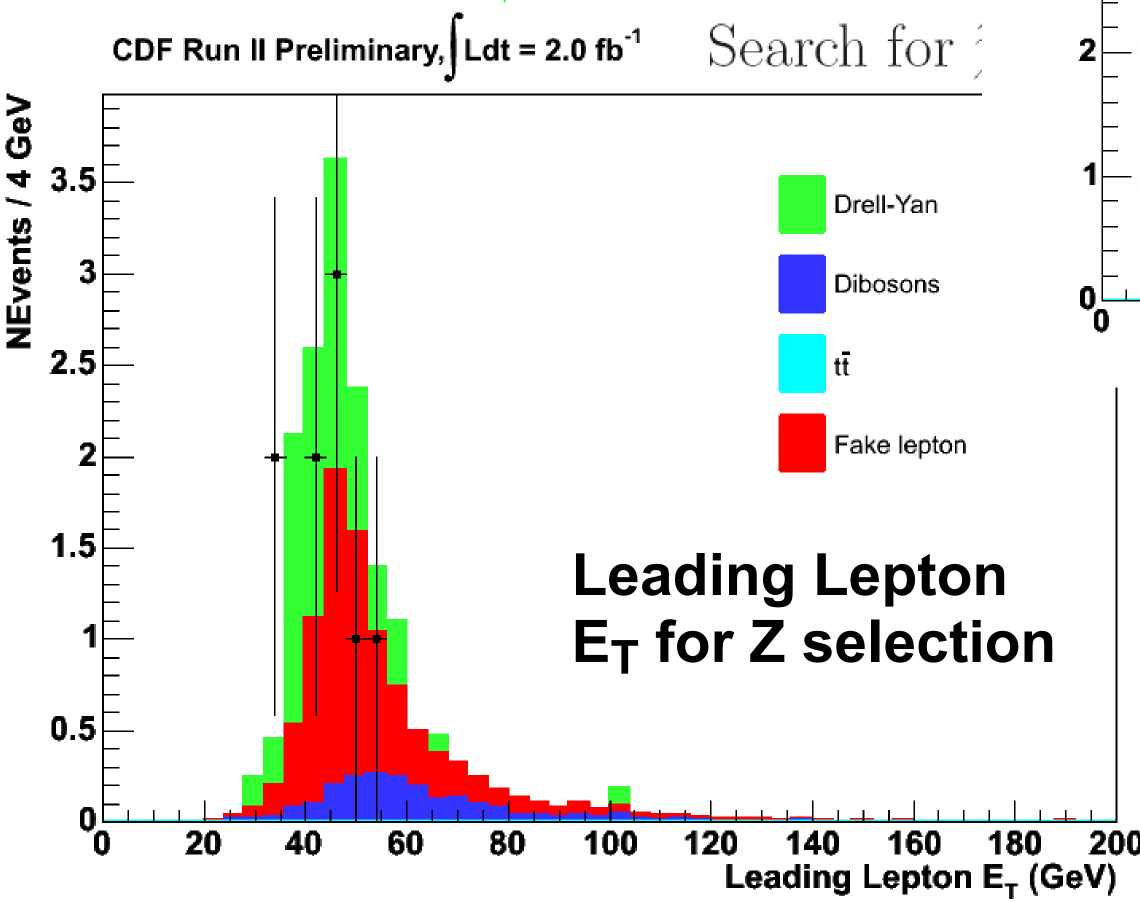


Selection :
2 tight leptons + 1 Track

Control Regions : Trileptons







Selection :
3 Tight Leptons

Control Regions : Trileptons

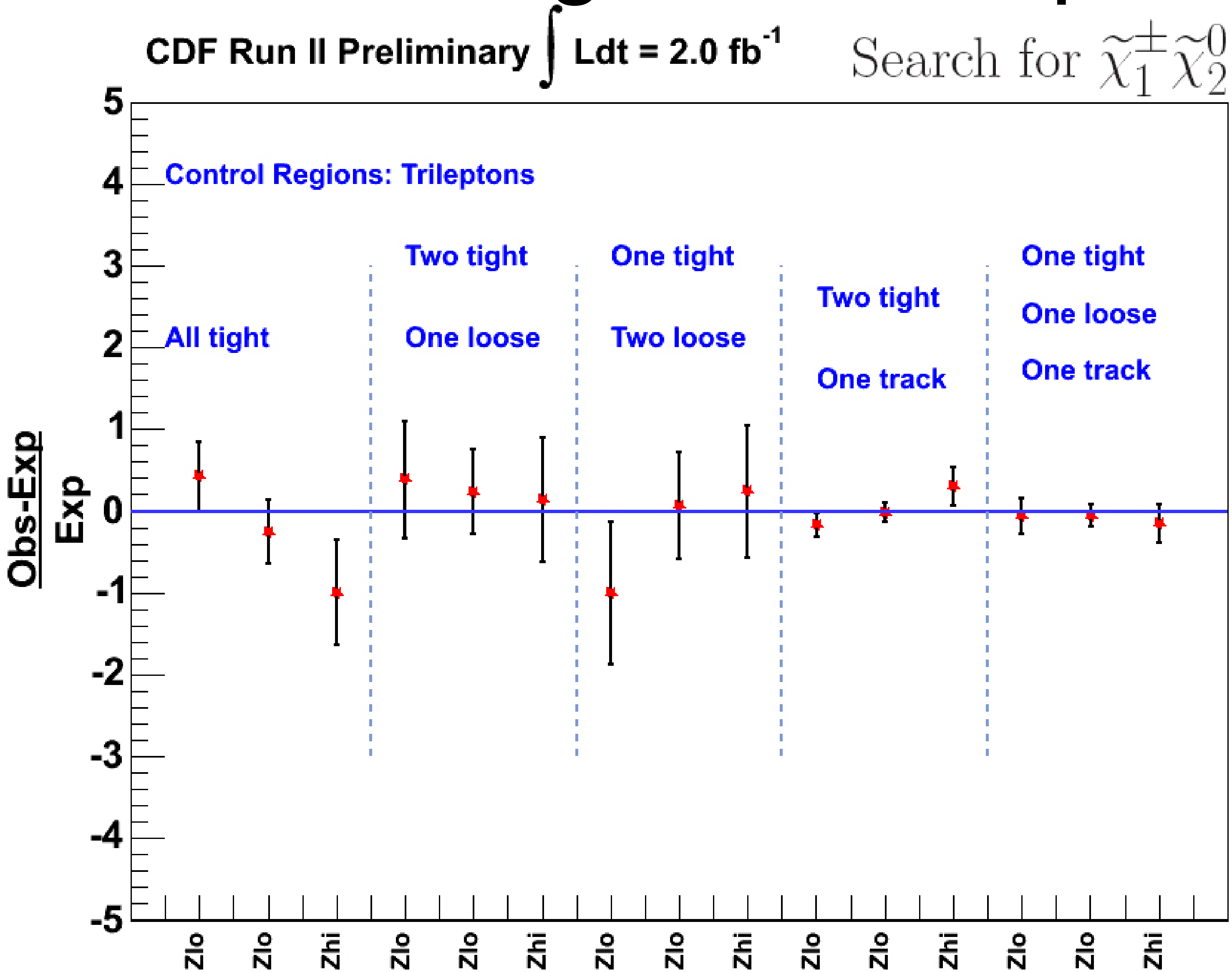
CDF RUN II Preliminary $\int \mathcal{L}dt = 2.0\ \text{fb}^{-1}$: Search for $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$

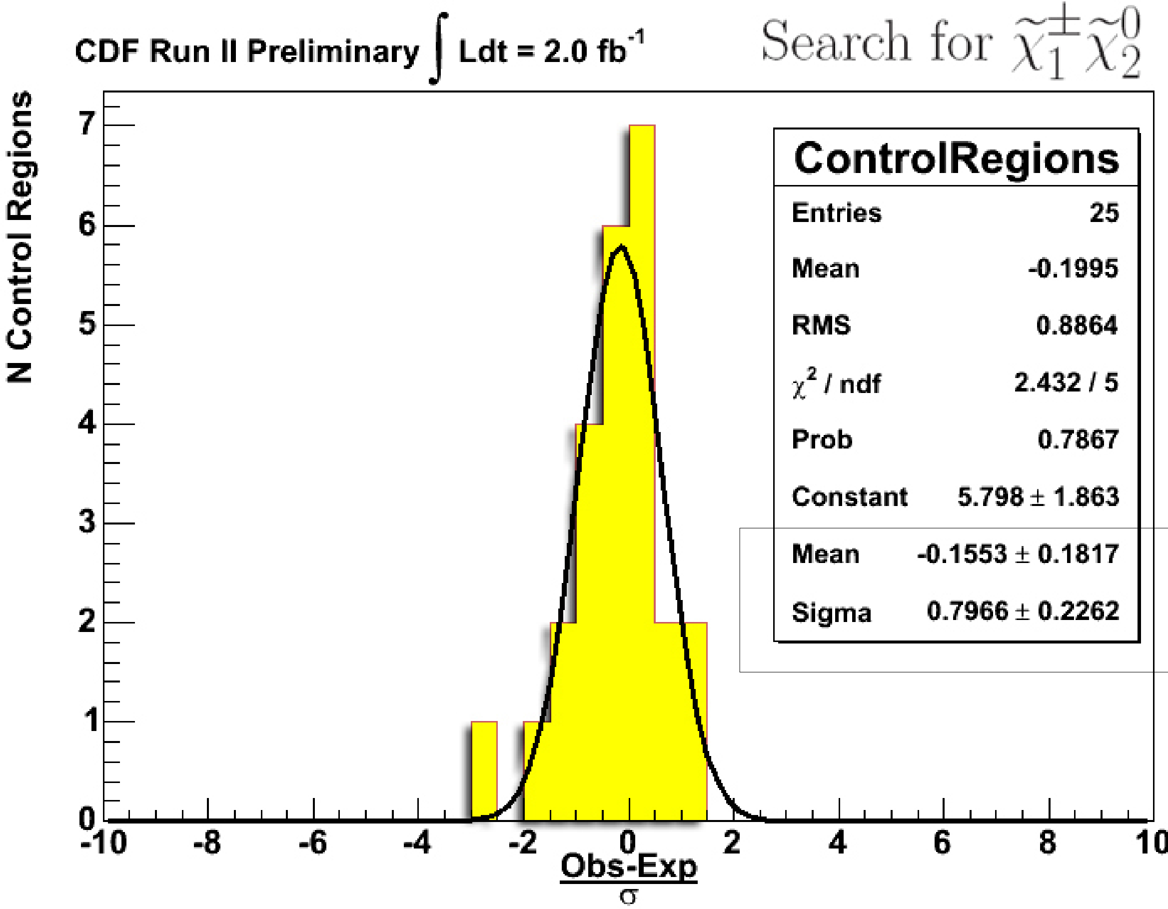
Name	Z→ ee	Z→ $\mu\mu$	Z→ $\tau\tau$	WW	WZ	ZZ	$t\bar{t}$	Fakes	Expected	Observed
3tight										
lo	7.58	2.92	0.00	0.00	0.05	0.57	0.00	6.01	17.1 ± 5.3	17
!Zlo	3.73	1.25	0.00	0.00	0.04	0.17	0.00	1.14	6.3 ± 2.7	9
Z	4.67	2.17	0.00	0.01	1.30	0.82	0.02	7.68	16.7 ± 5.7	9
Zlo	3.86	1.67	0.00	0.00	0.01	0.40	0.00	4.87	10.8 ± 4.2	8
Zhi	0.00	0.09	0.00	0.01	1.23	0.30	0.02	1.06	2.7 ± 1.7	0
2tight,1loose										
lo	0.74	3.38	0.00	0.00	0.04	0.31	0.00	2.57	7.0 ± 3.0	9
!Zlo	0.64	1.09	0.00	0.00	0.02	0.10	0.00	0.33	2.2 ± 1.5	3
Z	0.10	2.69	0.00	0.00	1.09	0.64	0.01	3.13	7.7 ± 3.2	8
Zlo	0.10	2.29	0.00	0.00	0.02	0.21	0.00	2.24	4.9 ± 2.5	6
Zhi	0.00	0.08	0.00	0.00	1.05	0.34	0.01	0.28	1.8 ± 1.3	2
1tight,2loose										
lo	0.57	1.81	0.00	0.00	0.03	0.19	0.00	1.68	4.3 ± 2.3	3
!Zlo	0.12	0.96	0.00	0.00	0.00	0.07	0.00	0.29	1.4 ± 1.3	0
Z	0.64	1.09	0.00	0.00	0.70	0.32	0.02	2.63	5.4 ± 2.7	6
Zlo	0.45	0.84	0.00	0.00	0.03	0.12	0.00	1.39	2.8 ± 1.9	3
Zhi	0.19	0.09	0.00	0.00	0.62	0.14	0.02	0.57	1.6 ± 1.3	2

CDF RUN II Preliminary $\int \mathcal{L}dt = 2.0\ \text{fb}^{-1}$: Search for $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$

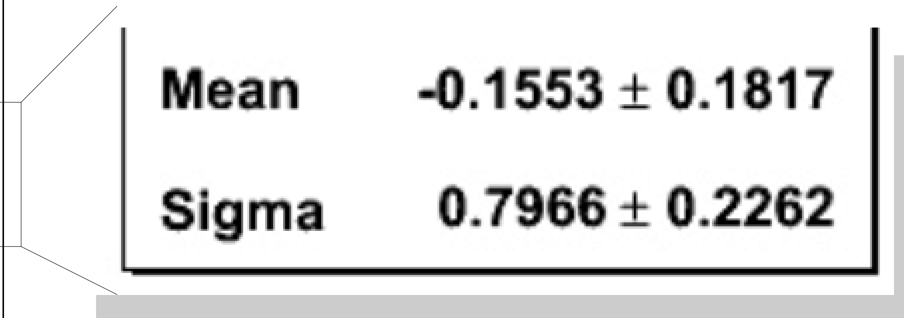
Name	Z→ ee	Z→ $\mu\mu$	Z→ $\tau\tau$	WW	WZ	ZZ	$t\bar{t}$	Fakes	Expected	Observed
2tight,1Track										
lo	168.37	138.84	1.73	0.02	0.02	0.35	0.02	2.39	312 ± 35	290
!Zlo	49.31	35.84	1.61	0.01	0.01	0.10	0.00	1.57	88 ± 13	72
Z	166.42	140.97	0.12	0.13	0.32	0.77	0.29	1.82	311 ± 34	299
Zlo	119.06	103.00	0.12	0.01	0.01	0.25	0.02	0.83	223 ± 26	218
Zhi	14.67	10.40	0.00	0.09	0.30	0.41	0.27	0.67	27 ± 6	34
1tight,1loose,1Track										
lo	55.02	170.96	0.74	0.01	0.01	0.24	0.05	1.37	228 ± 30	214
!Zlo	6.64	25.38	0.74	0.00	0.00	0.08	0.03	0.90	34 ± 7	31
Z	69.45	202.01	0.15	0.11	0.27	0.56	0.30	1.13	274 ± 35	246
Zlo	48.38	145.58	0.00	0.01	0.00	0.15	0.02	0.47	195 ± 26	183
Zhi	8.59	17.69	0.00	0.10	0.27	0.32	0.28	0.48	28 ± 6	23

Control Regions : Trileptons





Control Region Summary



- Pull for 25 uncorrelated control regions shown, overall 51 control regions, split by lepton flavor, purity and hundreds of distributions
- This is where we spent most time and effort.
- Ready to open the Signal Box, but first - a look at the systematic uncertainties

Systematic Uncertainties

Backgrounds

hadrons faking leptons
underlying event → tracks ~ 10%

Lepton identification ~ 2%
Jet energy scale ~ 2 to 5 %
Process Cross-section ~ 5%

Signal

Signal cross section~ 10%

Lepton identification ~ 4%
Initial/Final State radiation ~ 4%

Common to both
Luminosity ~ 6%
PDF ~ 2%

FINAL PREDICTIONS

CDF Run II Preliminary, $\int L dt = 2.0\ fb^{-1}$

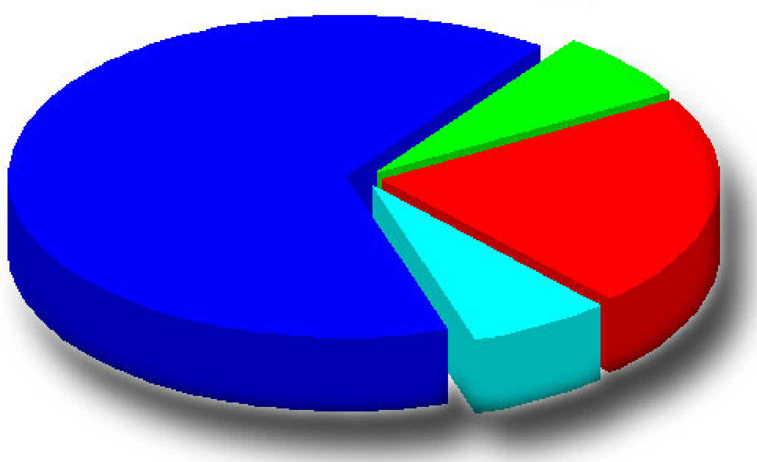
Channel	Signal	Background	Observed
3tight	2.3±0.1±0.3	0.5±0.04±0.1	
2tight,1loose	1.6±0.1±0.2	0.3±0.03±0.03	
1tight,2loose	0.7±0.1±0.1	0.1±0.02±0.02	
Total trilepton	4.6±0.2±0.6	0.9±0.1±0.2	
2tight,1Track	4.4±0.2±0.6	3.2±0.5±0.5	
1tight,1loose,1Track	2.4±0.1±0.3	2.3±0.5±0.4	
Total dilepton+track	6.8±0.2±0.9	5.5±0.7±0.9	

FINAL PREDICTIONS

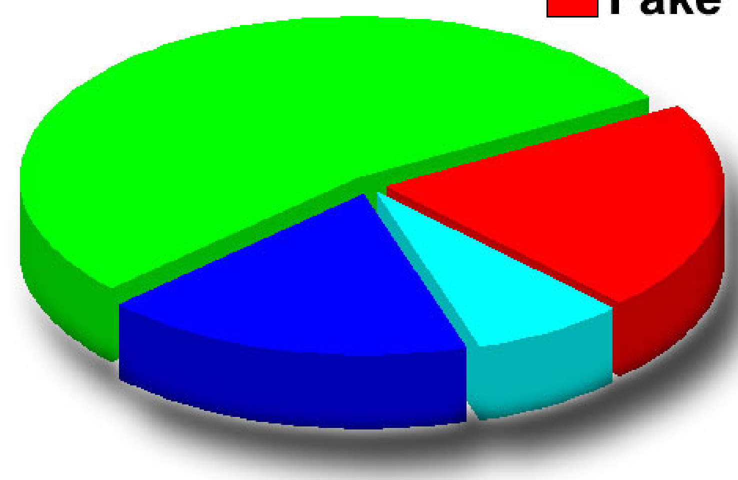
Breakdown of Backgrounds

CDF Run II Preliminary, $\int L dt = 2.0\ fb^{-1}$

ALL THREE LEPTONS
Total ~ 1 event



TWO LEPTONS
AND A TRACK
Total ~ 5.5 events



FINAL PREDICTIONS

CDF Run II Preliminary, $\int Ldt = 2.0\ fb^{-1}$

Channel	Signal	Background	Observed
3tight	2.3±0.1±0.3	0.5±0.04±0.1	
2tight,1loose	1.6±0.1±0.2	0.3±0.03±0.03	
1tight,2loose	0.7±0.1±0.1	0.1±0.02±0.02	
Total trilepton	4.6±0.2±0.6	0.9±0.1±0.2	
2tight,1Track	4.4±0.2±0.6	3.2±0.5±0.5	
1tight,1loose,1Track	2.4±0.1±0.3	2.3±0.5±0.4	
Total dilepton+track	6.8±0.2±0.9	5.5±0.7±0.9	

TOTAL EXPECTED SIGNAL = 11.4 events

Signal : mSUGRA m_0=60, $m_{½}$=190, tan(β)=3, A_0=0, μ>0, $M(\chi_1^{\pm})$=120 GeV/c^2

FINAL PREDICTIONS

CDF Run II Preliminary, $\int L dt = 2.0\ fb^{-1}$

Channel	Signal	Background	Observed
3tight	2.3±0.1±0.3	0.5±0.04±0.1	1
2tight,1loose	1.6±0.1±0.2	0.3±0.03±0.03	0
1tight,2loose	0.7±0.1±0.1	0.1±0.02±0.02	0
Total trilepton	4.6±0.2±0.6	0.9±0.1±0.2	1
2tight,1Track	4.4±0.2±0.6	3.2±0.5±0.5	
1tight,1loose,1Track	2.4±0.1±0.3	2.3±0.5±0.4	
Total dilepton+track	6.8±0.2±0.9	5.5±0.7±0.9	

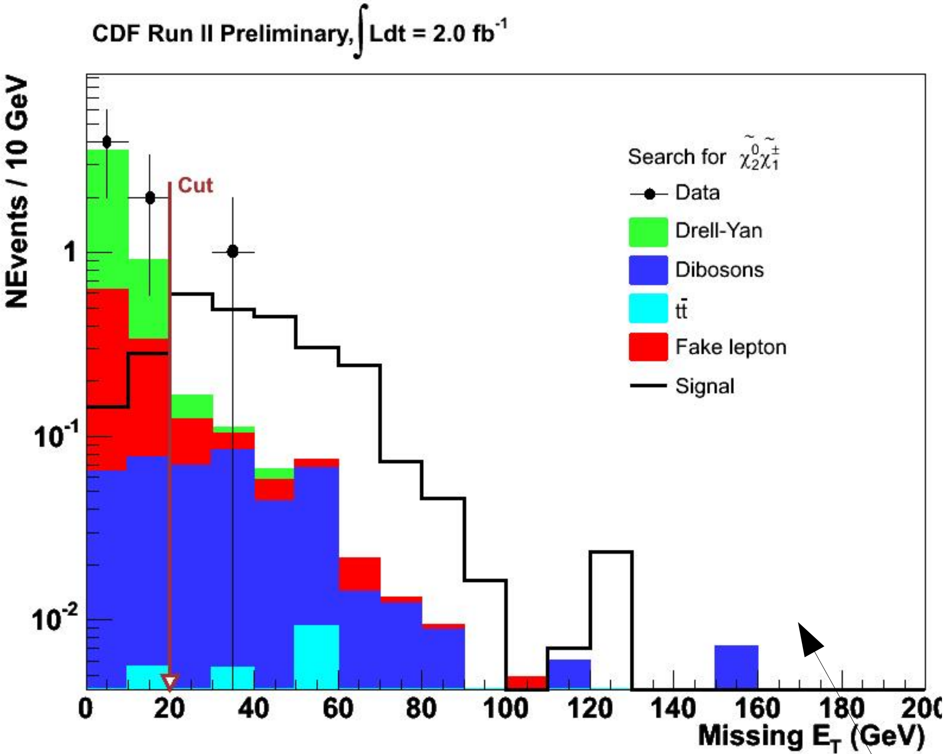
Signal : mSUGRA m_0=60, $m_{1/2}$=190, tan(β)=3, A_0=0, μ>0, $M(\chi_1^{\pm})$=120 GeV/c^2

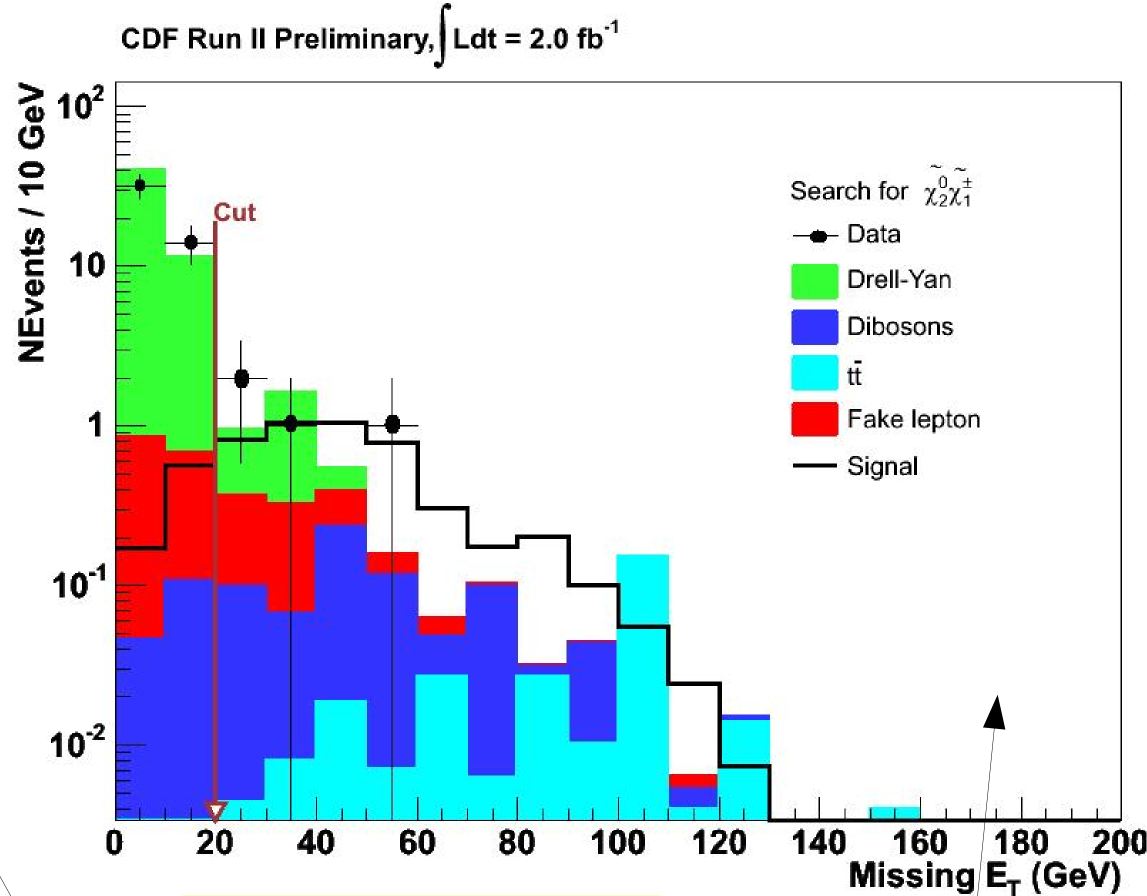
FINAL PREDICTIONS

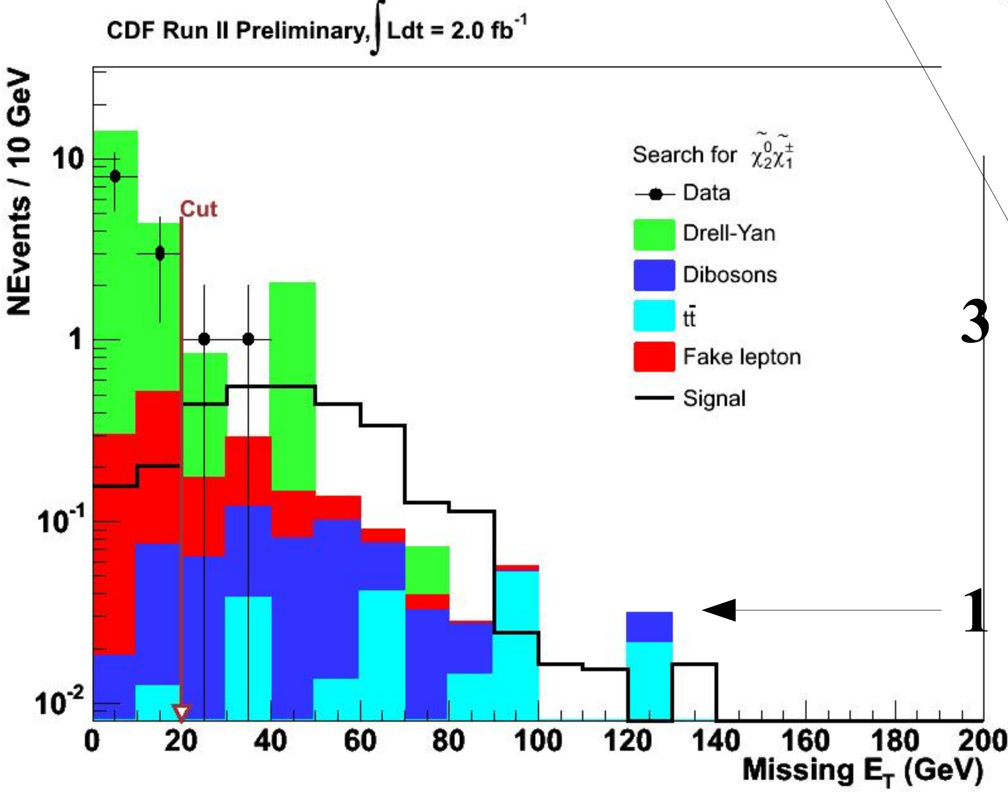
CDF Run II Preliminary, $\int L dt = 2.0\ fb^{-1}$

Channel	Signal	Background	Observed
3tight	2.3±0.1±0.3	0.5±0.04±0.1	1
2tight,1loose	1.6±0.1±0.2	0.3±0.03±0.03	0
1tight,2loose	0.7±0.1±0.1	0.1±0.02±0.02	0
Total trilepton	4.6±0.2±0.6	0.9±0.1±0.2	1
2tight,1Track	4.4±0.2±0.6	3.2±0.5±0.5	4
1tight,1loose,1Track	2.4±0.1±0.3	2.3±0.5±0.4	2
Total dilepton+track	6.8±0.2±0.9	5.5±0.7±0.9	6

Signal : mSUGRA m_0=60, $m_{½}$=190, tan(β)=3, A_0=0, μ>0, $M(\chi_1^{\pm})$=120 GeV/c^2







Missing E_T

3 tight → 1 event

2 tight, 1 Track → 4 events

1 tight, 1 loose, 1 Track → 2 events

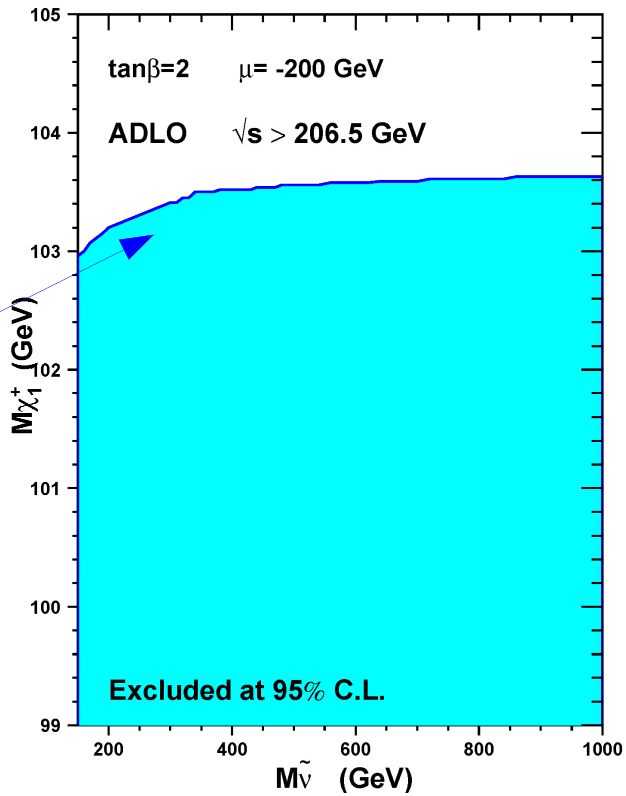
PART III
Interpreting the Results

Present State of Knowledge

We place limits on production cross section times branching ratio as a function of parameters of interest in mSUGRA

LEP results : directly applicable

Charginos must have mass > 103.5 GeV/c^2



mSUGRA

mSUGRA -- minimal SUper GRAvity grand unification

why? a) Widely used as a standard candle by Run I, LHC TDR's etc.

b) Manageable due to five parameters

Defined by five parameters

m_0 : common scalar mass at GUT scale

$m_{1/2}$: common gaugino mass at GUT scale

$M_1(GUT)=M_2(GUT)=M_3(GUT)= m_{1/2}$

$\tan(\beta)$: ratio of Higgs vacuum expectation values

A_0 : common trilinear scalar interaction at the GUT scale (Higgs-sfermionR-sfermionL)

$\mathrm{sign}(\mu)$: μ is the Higgsino mass parameter ($|\mu^2|$ determined by EWSB)

Signal Benchmark Point (BP) with parameters :
mSUGRA $m_0=60$, $m_{1/2}=190$, $\tan(\beta)=3$, $A_0=0$, $\mu>0$

Spectrum (at BP) GeV

$\tilde{\chi}_2$	124
$\tilde{\chi}_1^{\pm}$	122
$\tilde{\chi}_1^{0}$	66
$\tilde{e}_L$	149
$\tilde{e}_R$	101
$\tilde{\tau}_1$	100
$\tilde{\tau}_2$	150
$\tilde{g}$	477
$\tilde{u}_R$	421
$\tilde{d}_L$	439

mSUGRA

mSUGRA -- minimal SUper GRAvity grand unification

why? a) Widely used as a standard candle by Run I, LHC TDR's etc.

b) Manageable due to five parameters

Defined by five par

m_0 : common s

$m_{1/2}$: common g

M_1(GU

$\tan(\beta)$: ratio of Hi

A_0 : common t

GUT scale

sign(μ) : μ is the H

($|\mu^2|$ determined by EWSB)

We fix

$\tan(\beta) = 3$

$A_0 = 0$

$\mu > 0$

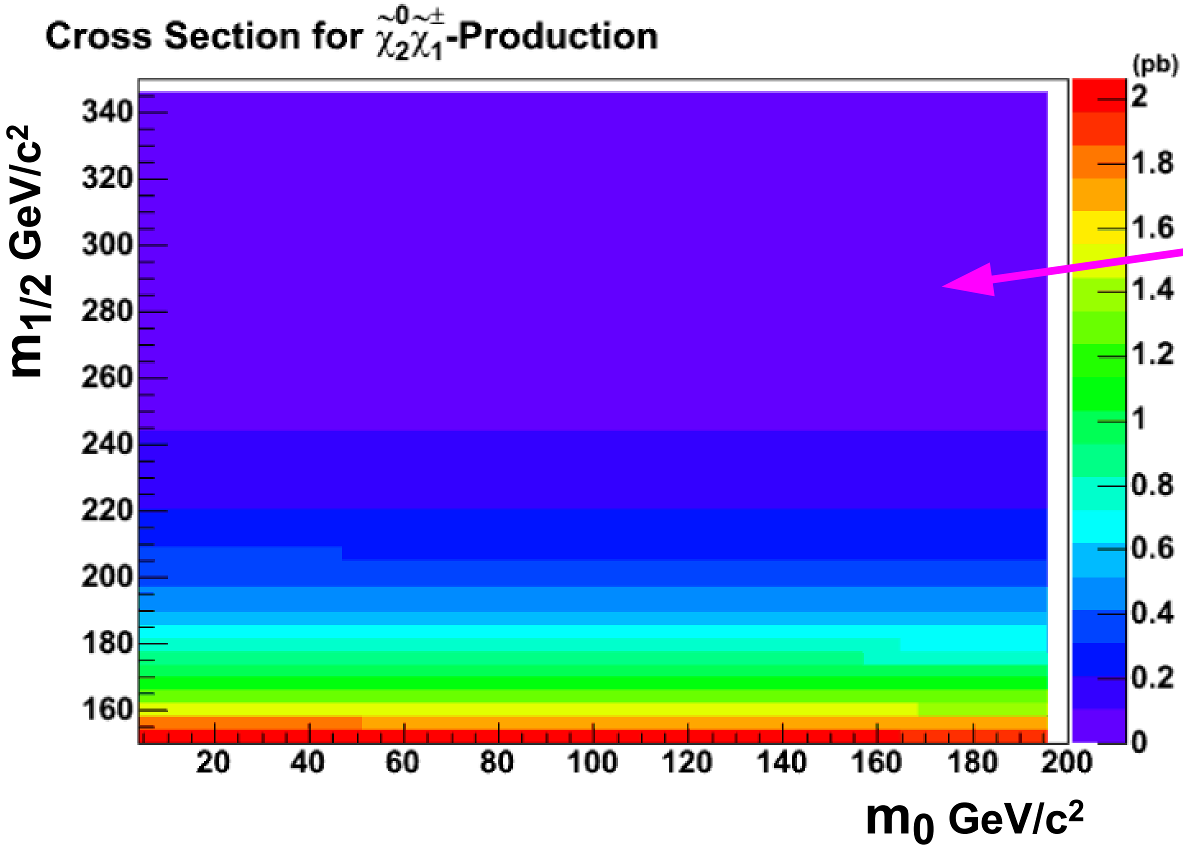
Spectrum (at BP) GeV

	124
	122
	66
	149
	101
	100
$\tilde{\tau}_2$	150
$\tilde{g}$	477
$\tilde{u}_R$	421
$\tilde{d}_L$	439

Signal Benchmark Point (BP) with parameters :
mSUGRA m_0=60, $m_{1/2}$=190, $\tan(\beta)$=3, A_0=0, μ>0

mSUGRA Features of interest : σ

$$m(\widetilde{\chi}_2^0) \approx m(\widetilde{\chi}_1^\pm) \qquad m(\tilde{e}_R) = m(\tilde{\mu}_R) \approx m(\tilde{\tau}_1)$$



$$\sigma(p\bar{p} \rightarrow \widetilde{\chi}_2^0\widetilde{\chi}_1^\pm)$$

Cross section is a smooth function of chargino mass, hence $m_{1/2}$

mSUGRA Features of interest

$$M(\widetilde{\chi}_2^0, \widetilde{\chi}_1^\pm) > M(\tilde{\ell})$$

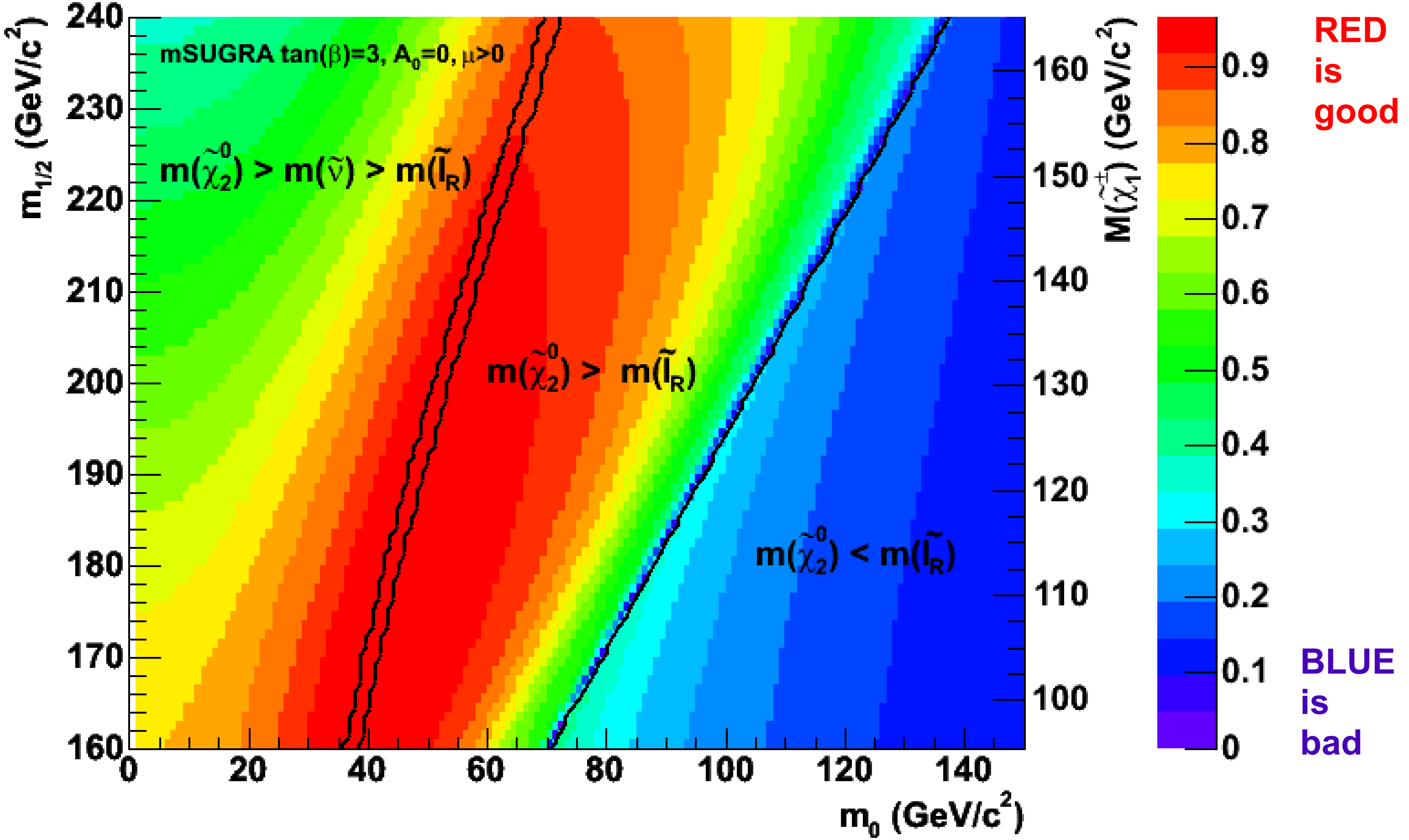
$$\widetilde{\chi}_2^0 \to \tilde{\ell}^\pm \ell^\mp, \tilde{\ell}^\pm \to \ell \widetilde{\chi}_1^0 \quad \widetilde{\chi}_1^\pm \to \tilde{\ell}^\pm \nu, \tilde{\ell}^\pm \to \ell \widetilde{\chi}_1^0$$

$$M(\widetilde{\chi}_2^0, \widetilde{\chi}_1^\pm) < M(\tilde{\ell})$$

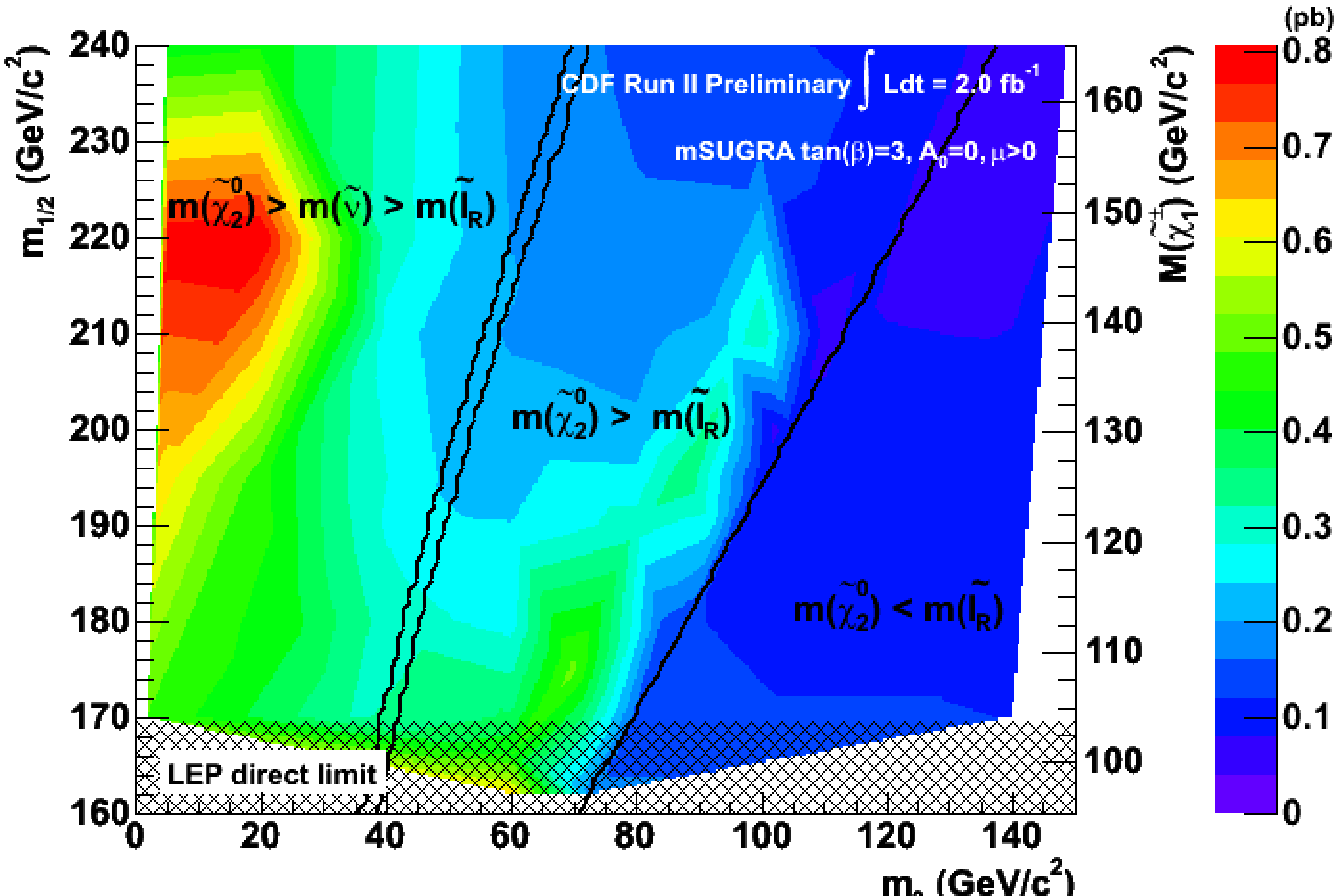
$$\widetilde{\chi}_1^\pm - - - W^* \widetilde{\chi}_1^0 - - - \ell^\pm \nu \widetilde{\chi}_1^0$$

$$\widetilde{\chi}_2^0 - - - Z^* \widetilde{\chi}_1^0 - - - \ell^\pm \ell^\mp \widetilde{\chi}_1^0$$

$$BR(\widetilde{\chi}_2^0\widetilde{\chi}_1^{\pm} \rightarrow 3\ell)$$



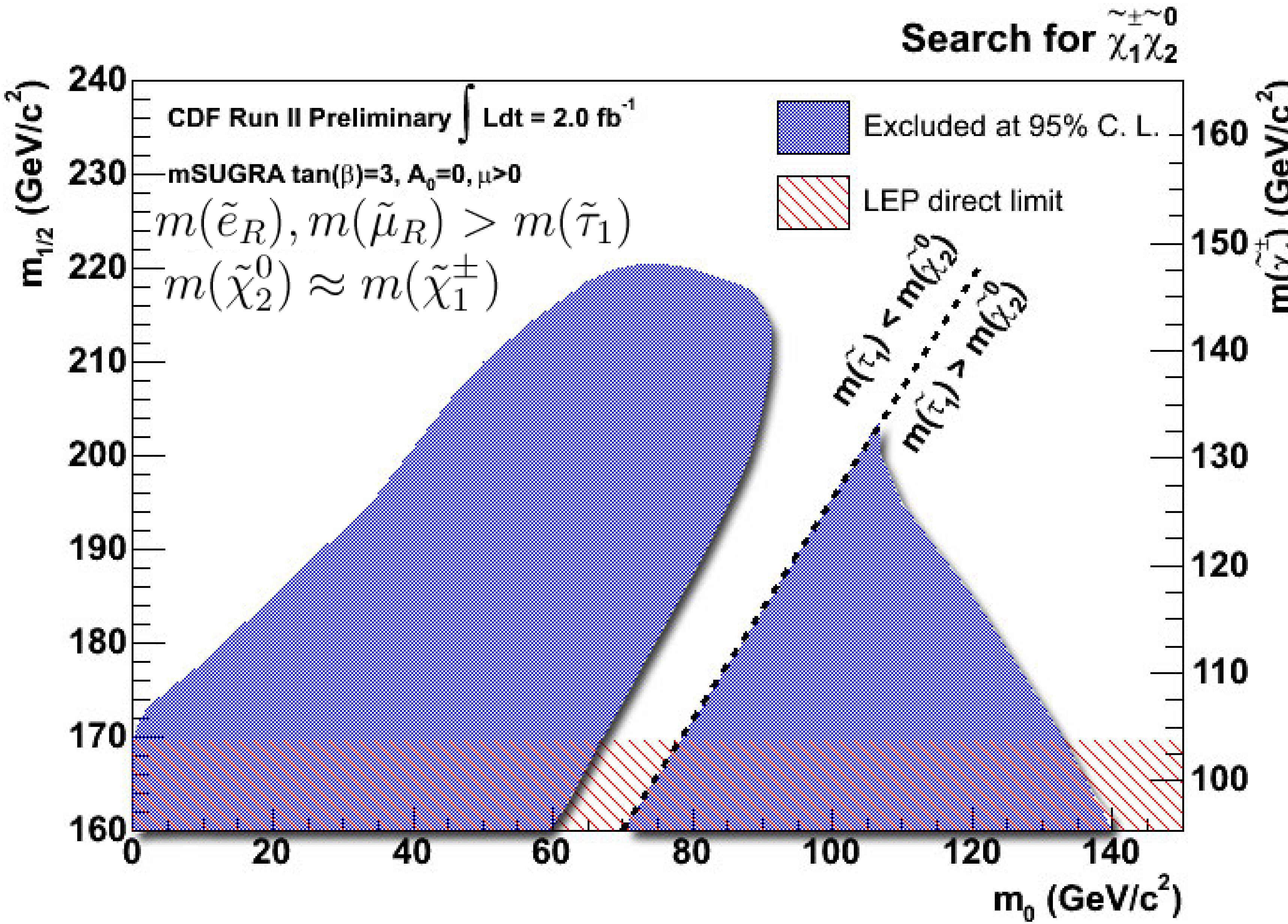
Observed Limits on σ×BR



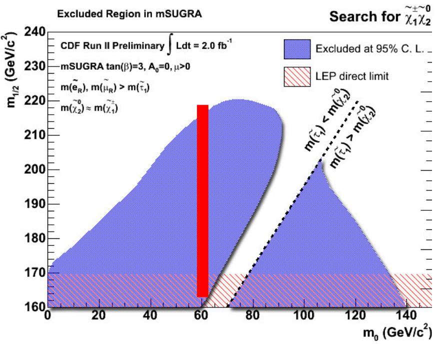
RED is bad

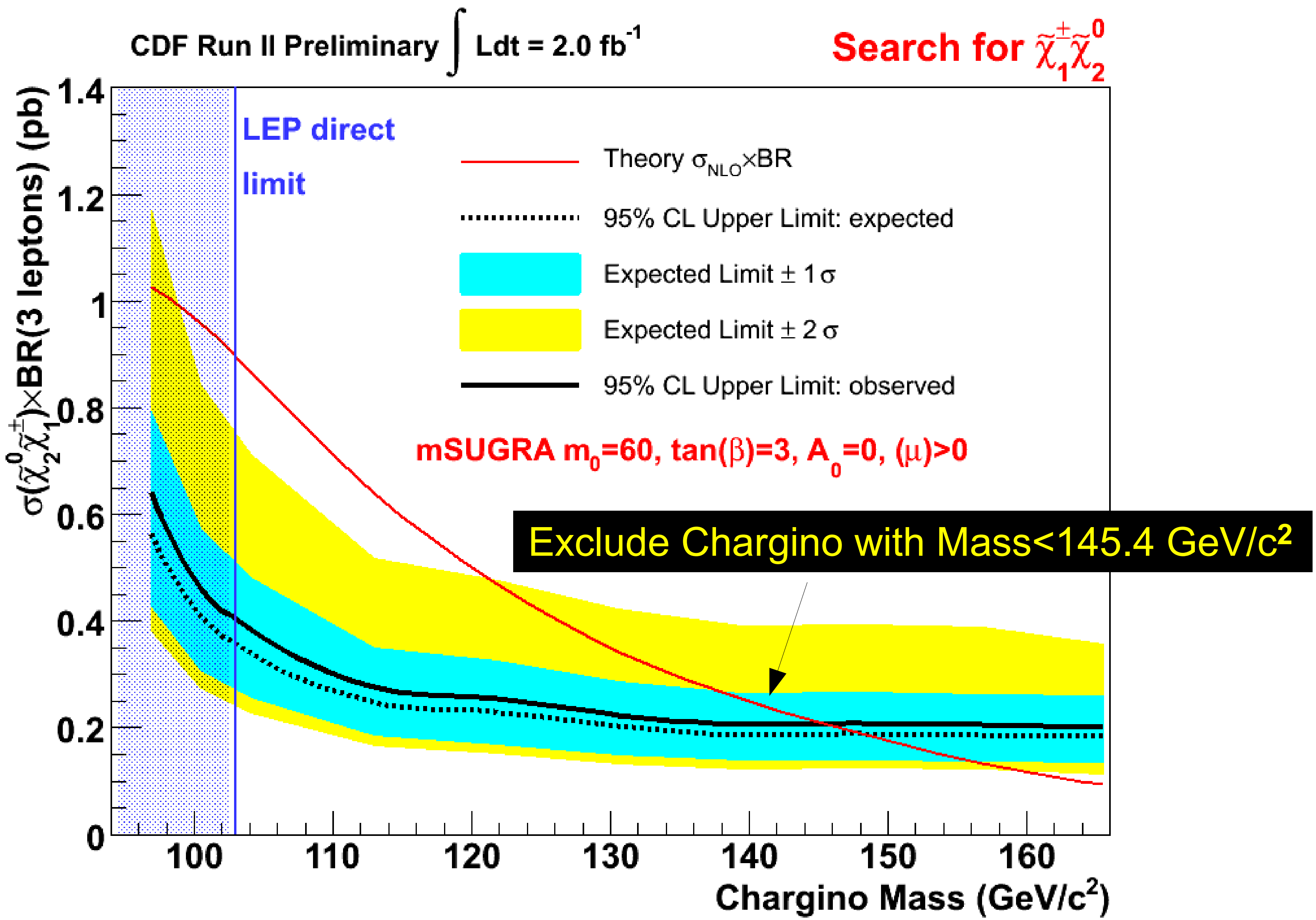
BLUE is good

Observed Exclusion

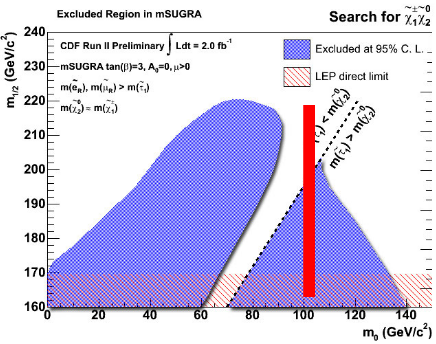


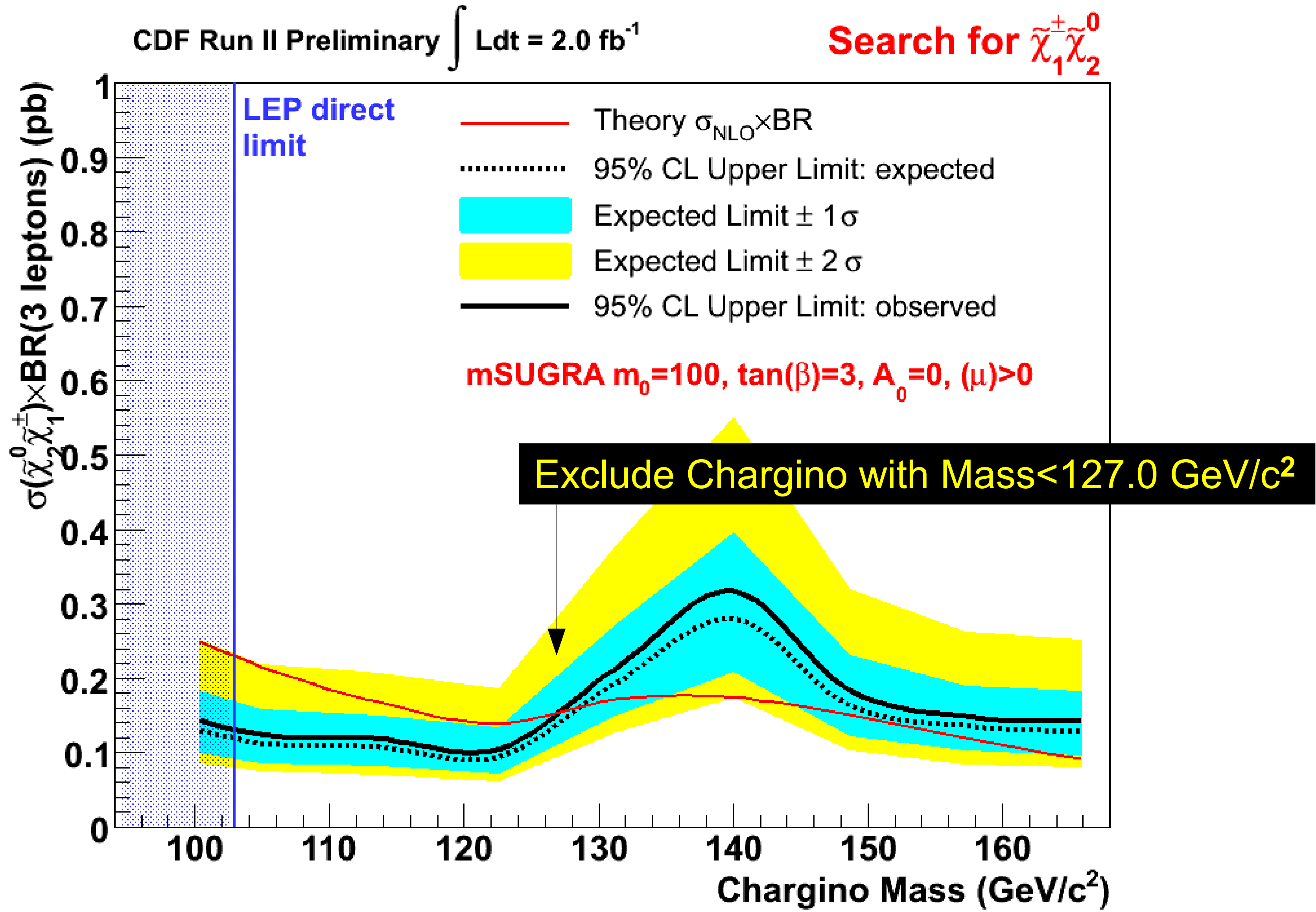
Mass limits for m_0=60 GeV/c^2





Mass limits for m_0=60 GeV/c^2





Summary

- We analyzed 2 fb^{-1} of 1.96 TeV p-pbar collisions at CDF. For benchmark mSUGRA parameters, we expected ~12 SUSY events.
- We have a unified analysis – channels with all combinations of leptons (e,μ) in parallel; channels with two leptons and track to add sensitivity to tau leptons.
- Our observation of 7 events is consistent with the standard model expectation of 6.4 events.

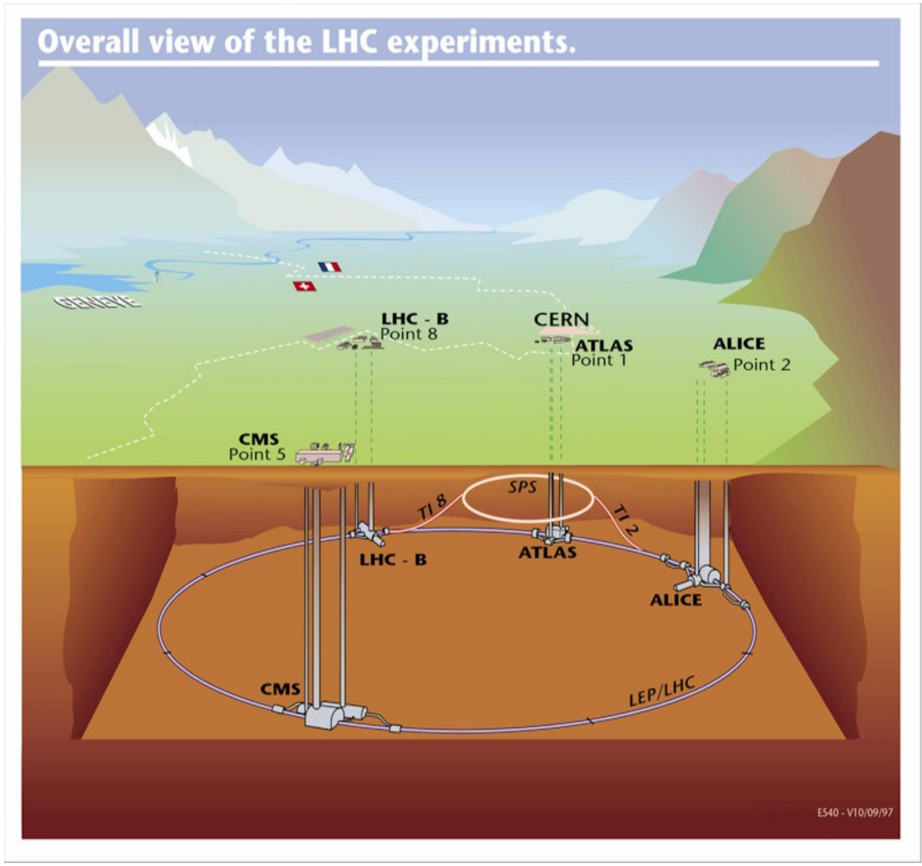
We present an exclusion region in mSUGRA plane

We now have first mSUGRA chargino mass limits since LEP

Outlook

- We are working on making our results less model-dependent. For example, what does tan(β) dependence imply for experimental limits?

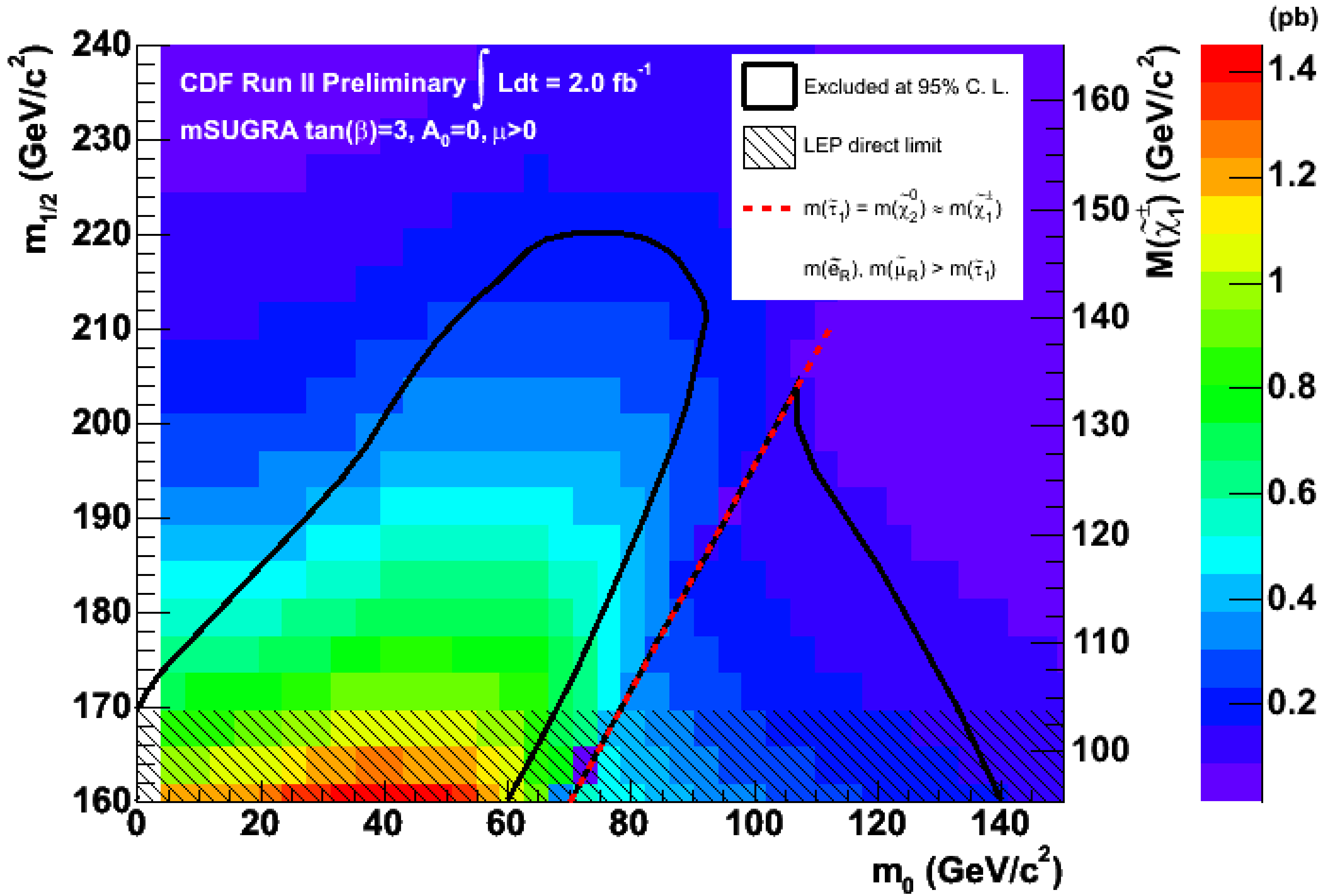
- We can take our understanding and then try and apply it to LHC (CMS & ATLAS). This will be a good way for me to learn about LHC as well!



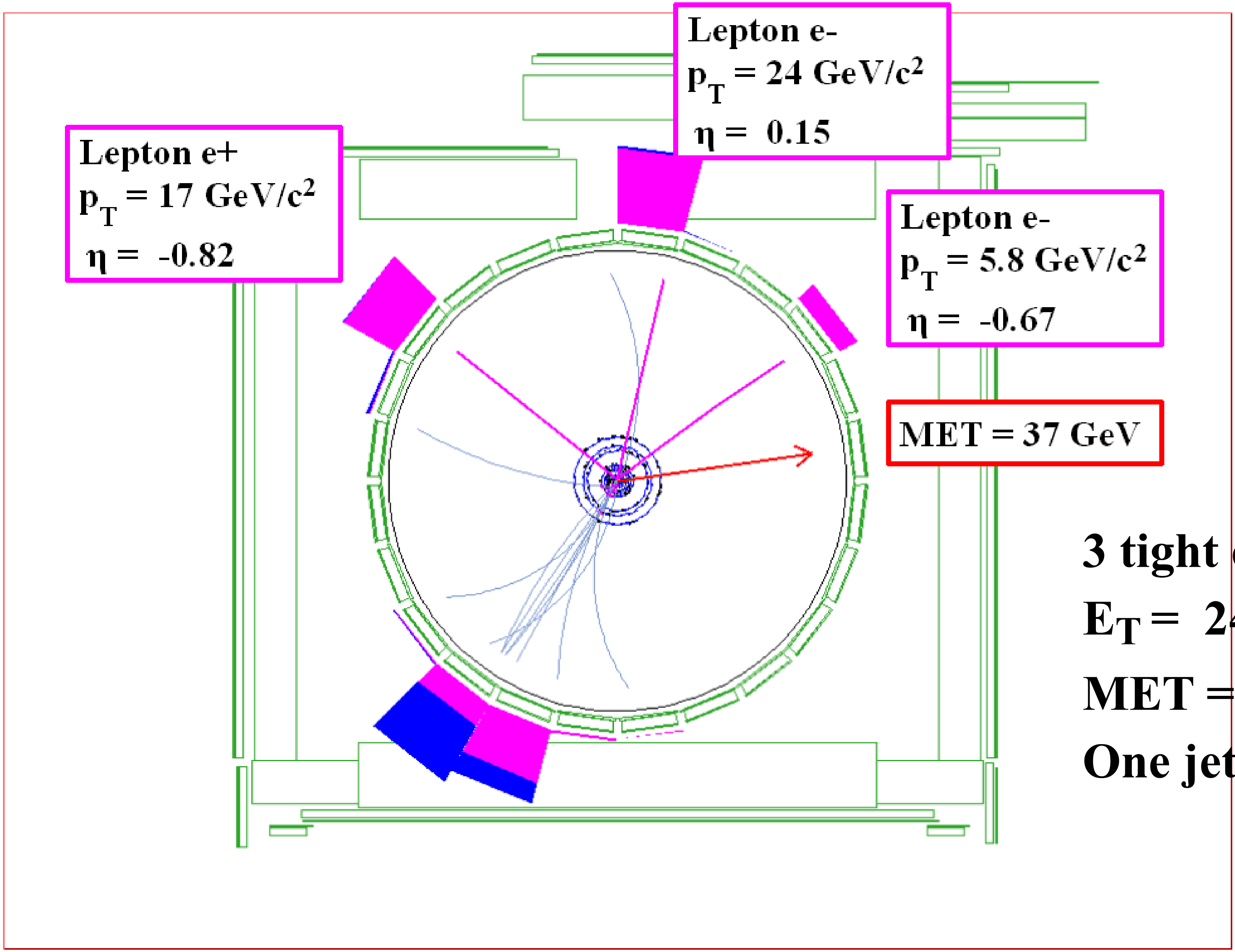
Thanks!

BACKUP

Observed Exclusion



3 Tight Lepton Event

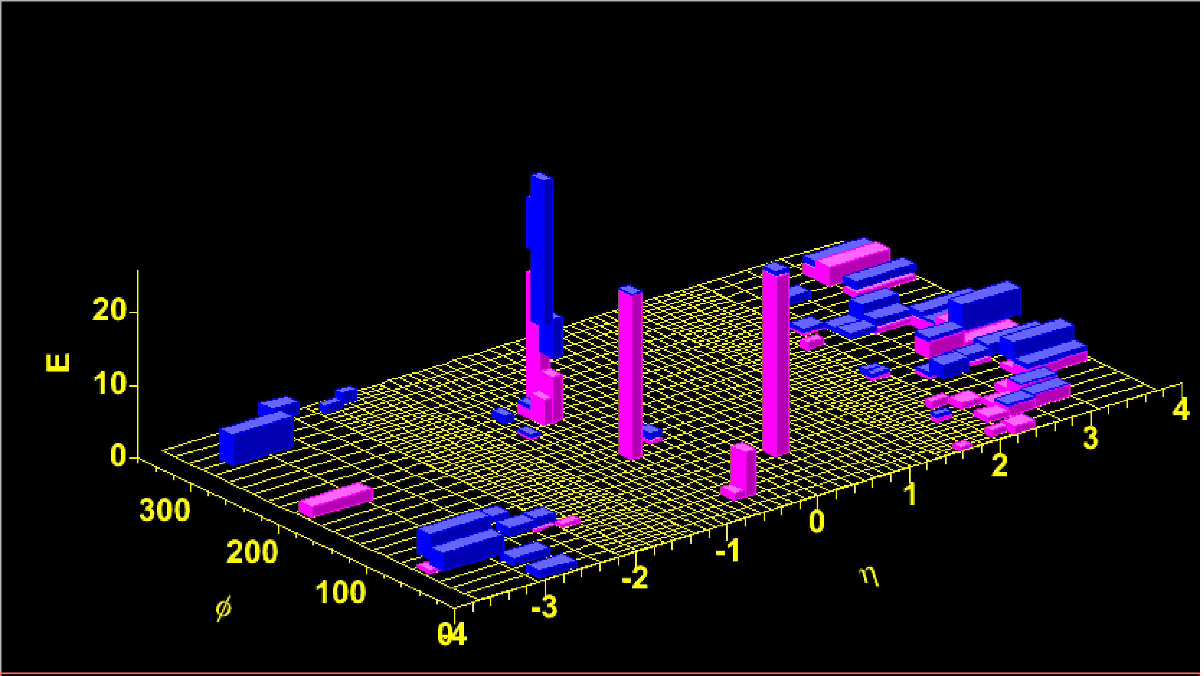


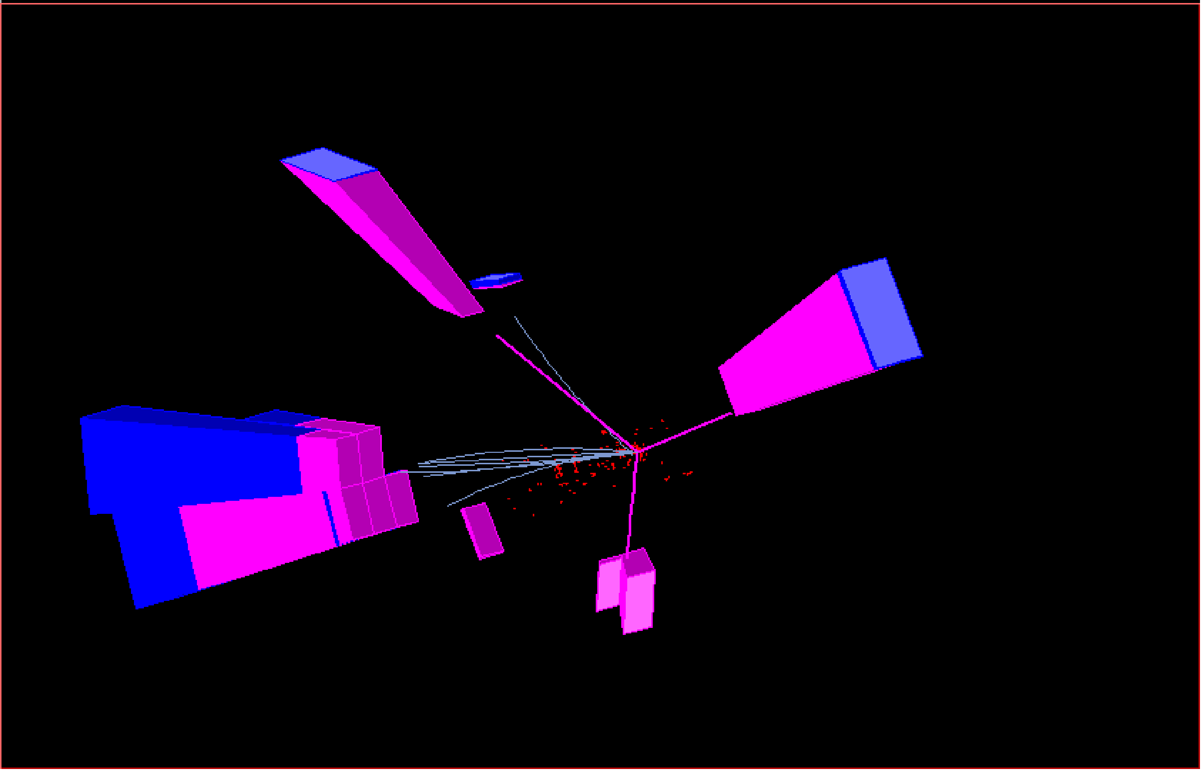
3 tight electron event

E_T = 24 , 17 , 6 GeV

MET = 37 GeV

One jet, Jet E_T = 60 GeV





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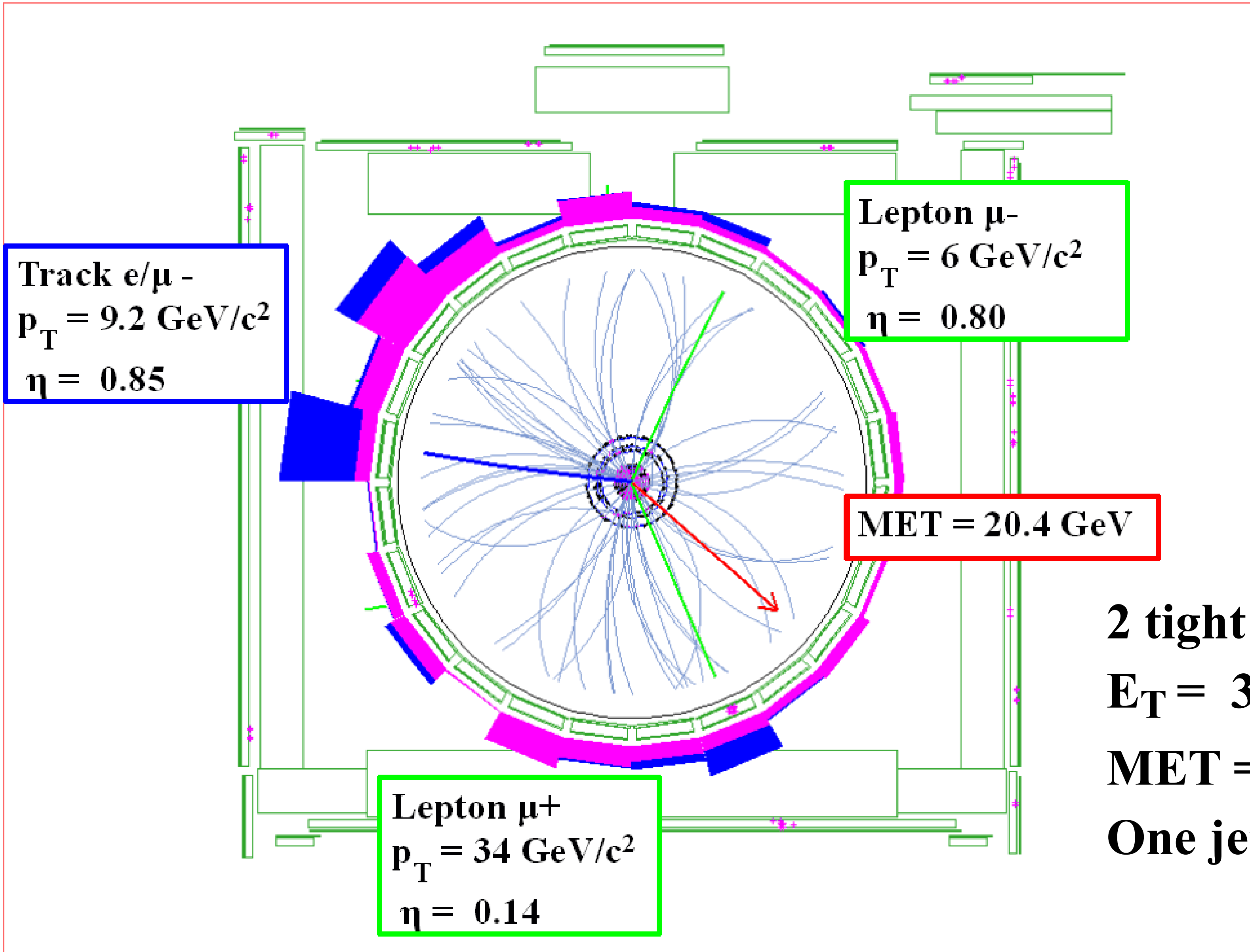
EVENTS



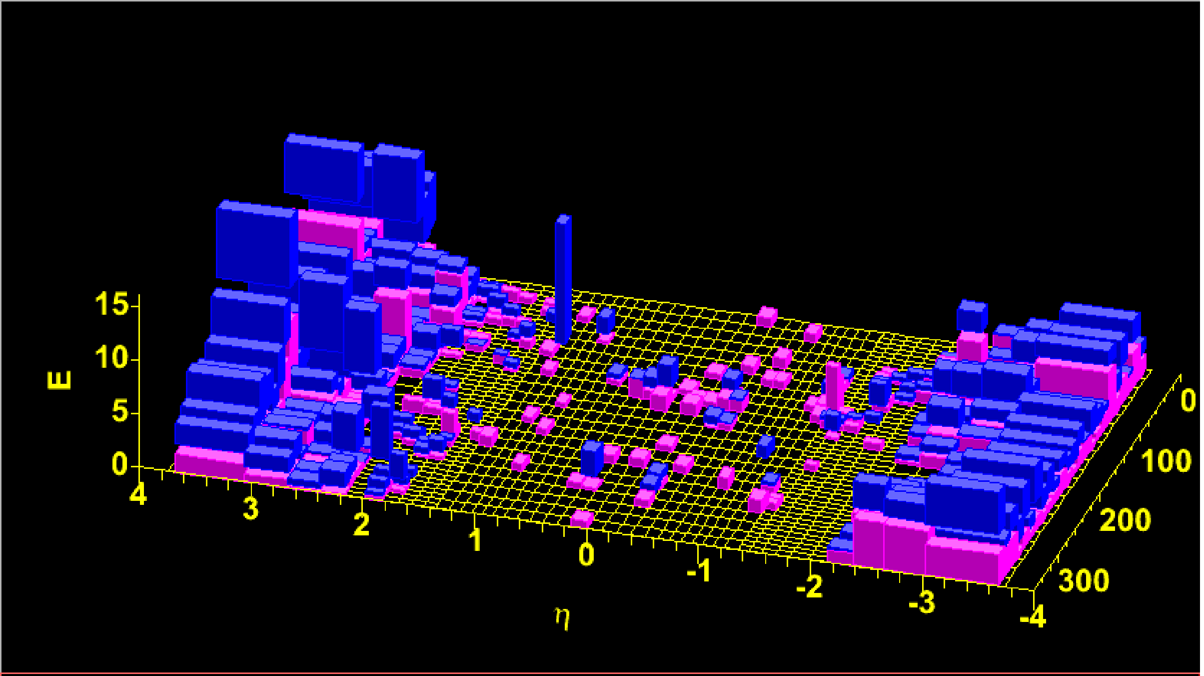
2 tight muons + 1 Track

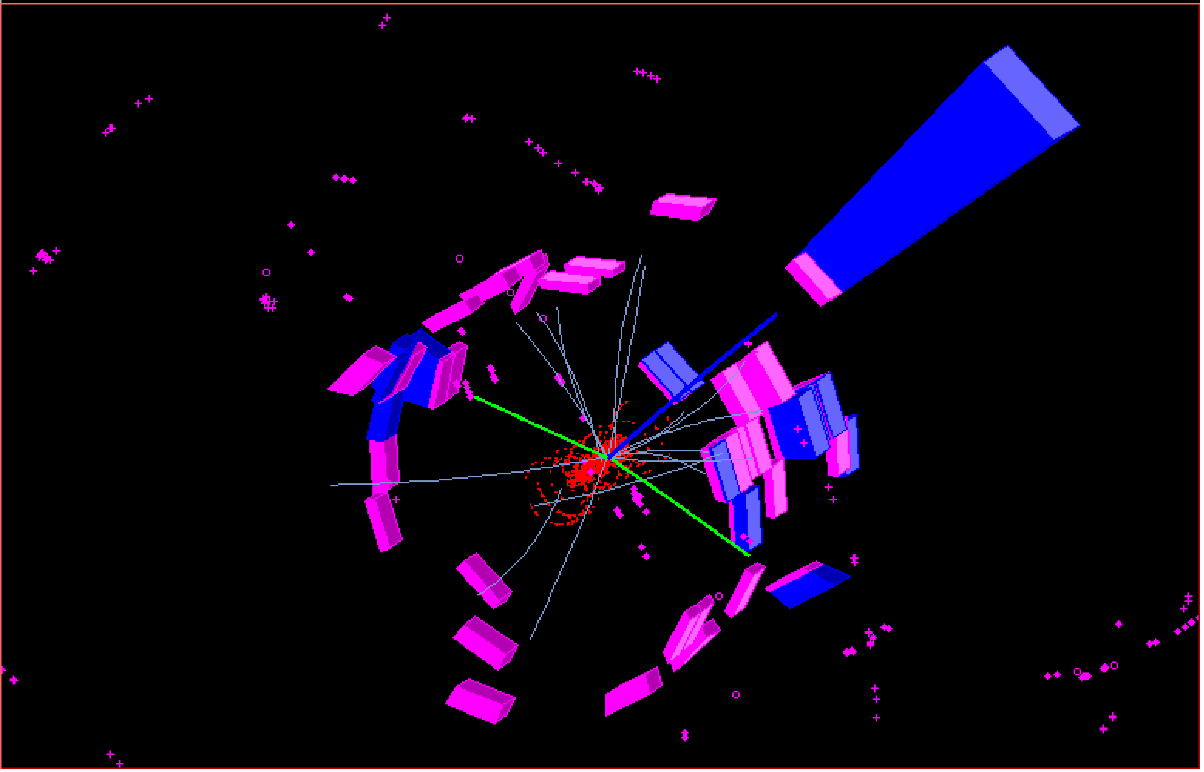
E_T = 34 , 6 , 9 GeV

MET = 20.4 GeV

One jet, Jet E_T = 22 GeV

EVENTS





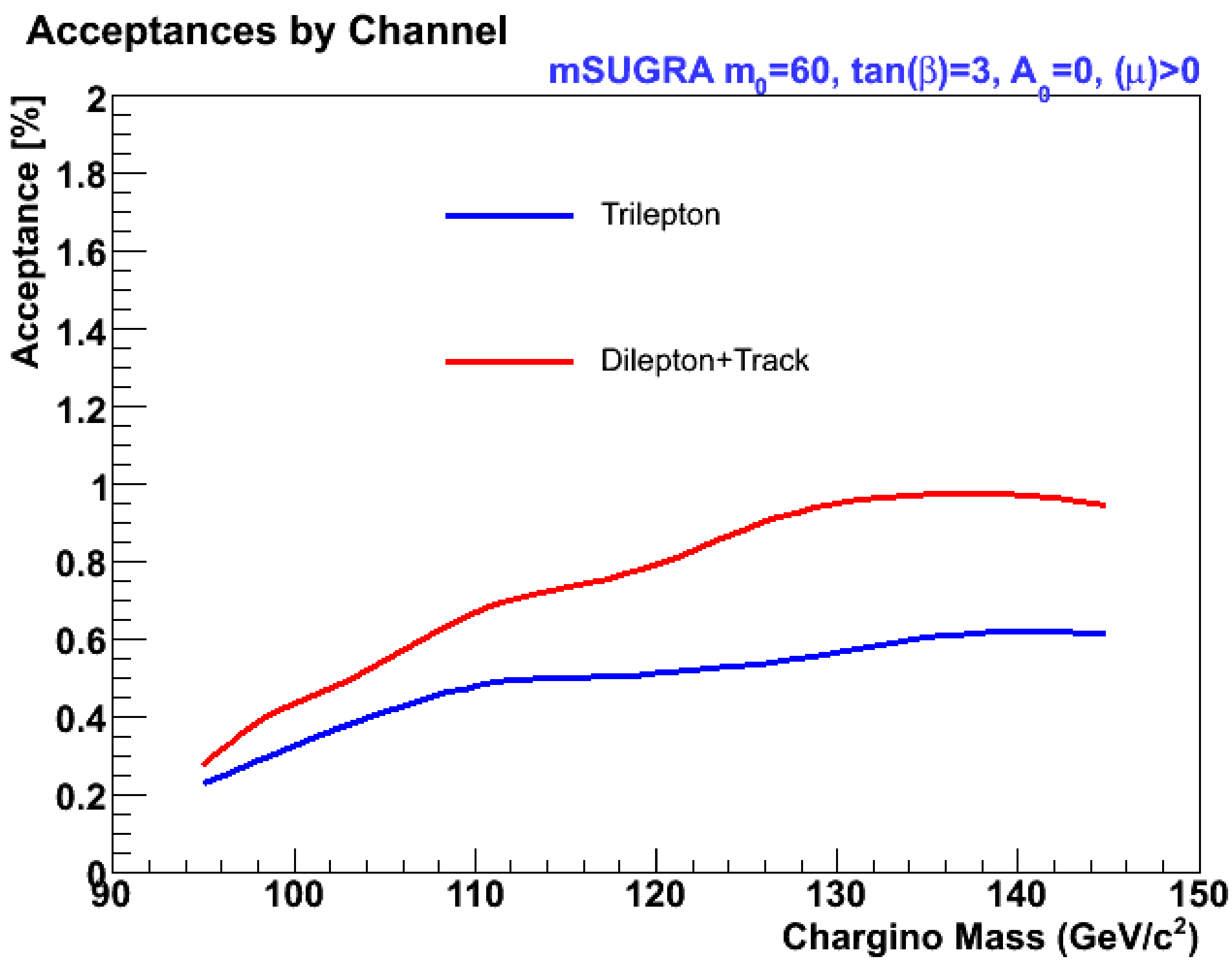
2 tight muons + 1 Track

E_T = 34 , 6 , 9 GeV

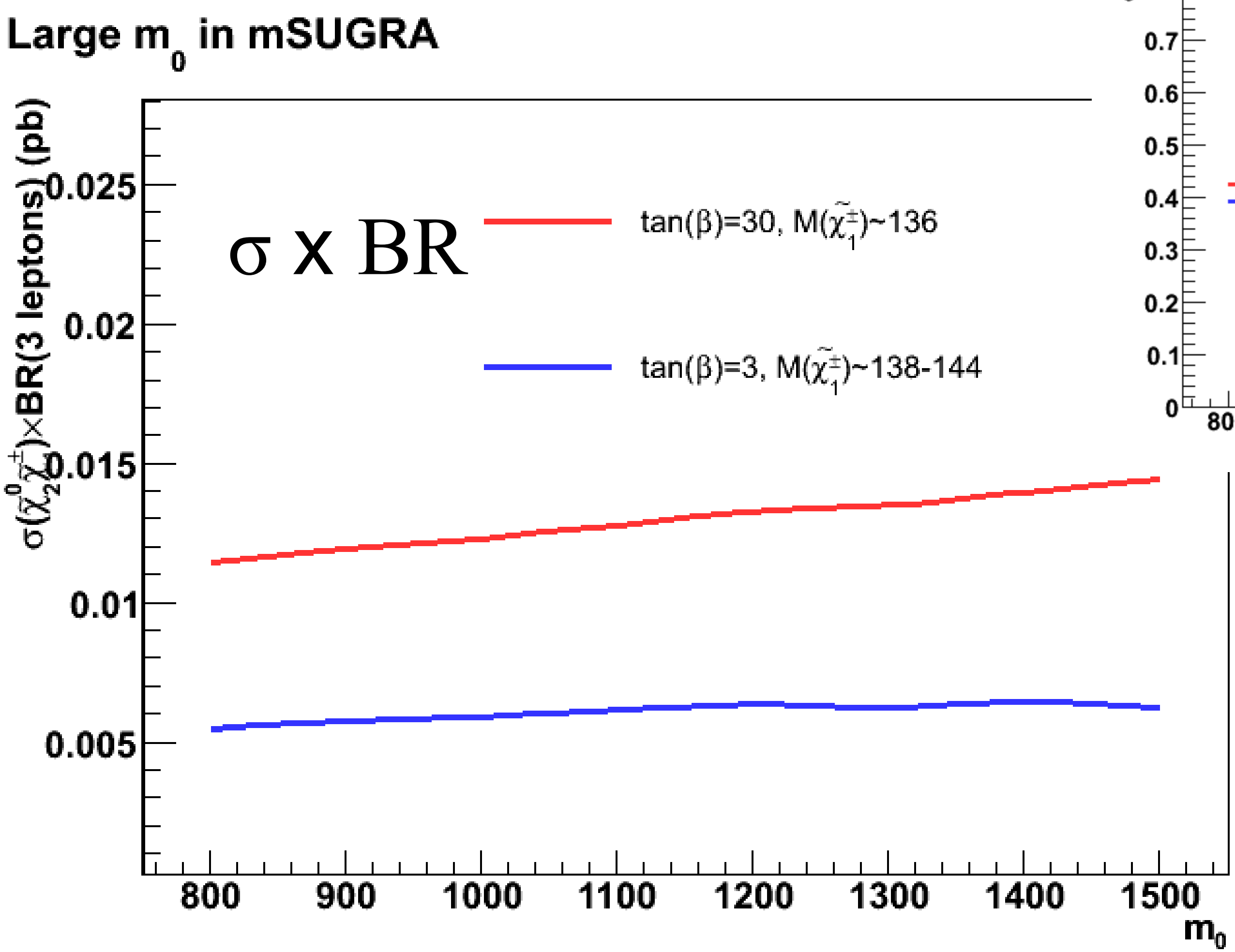
MET = 20.4 GeV

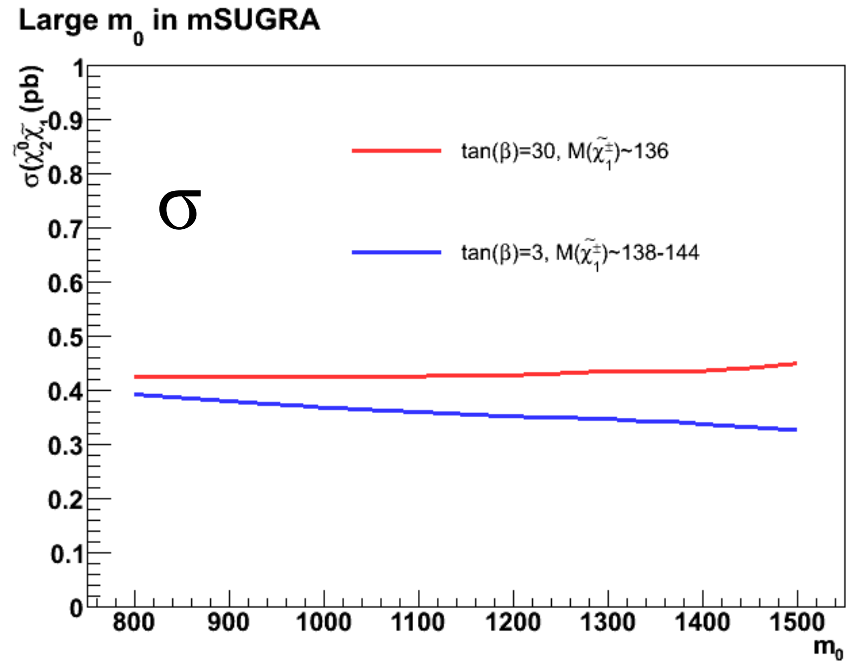
One jet, Jet E_T = 22 GeV

Signal Plots : Acceptances by Channel



Signal Plots : Large m_0



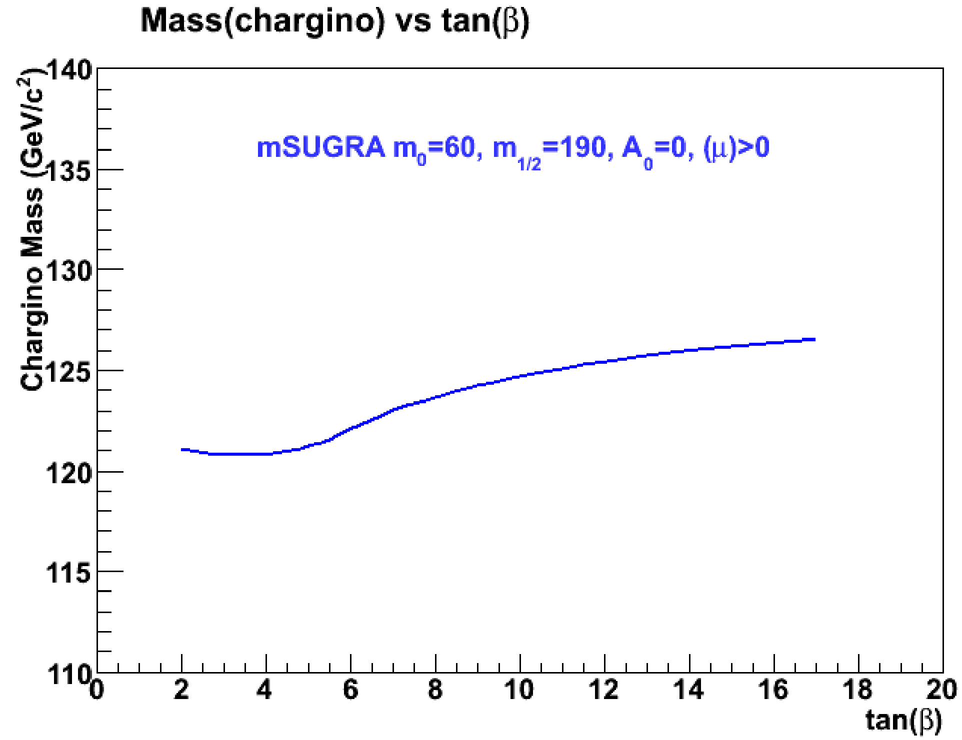


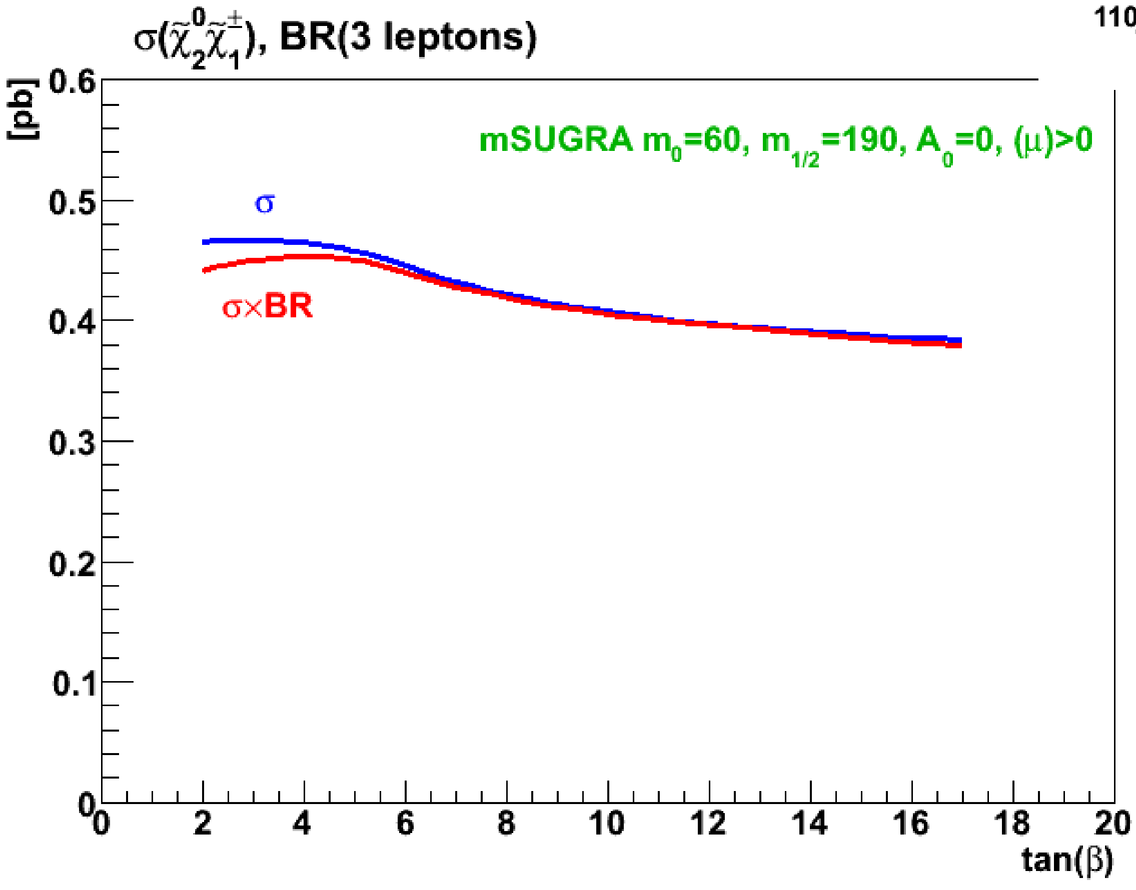
$\tan(\beta) = 30$

$\tan(\beta) = 3$

$m_{1/2} = 190$, $A_0 = 0$, $\mu > 0$

Signal Plots
tan(β) variation





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Cross Sections : Tevatron & LHC

T. Plehn, PROSPINO