Search for SUSY with light

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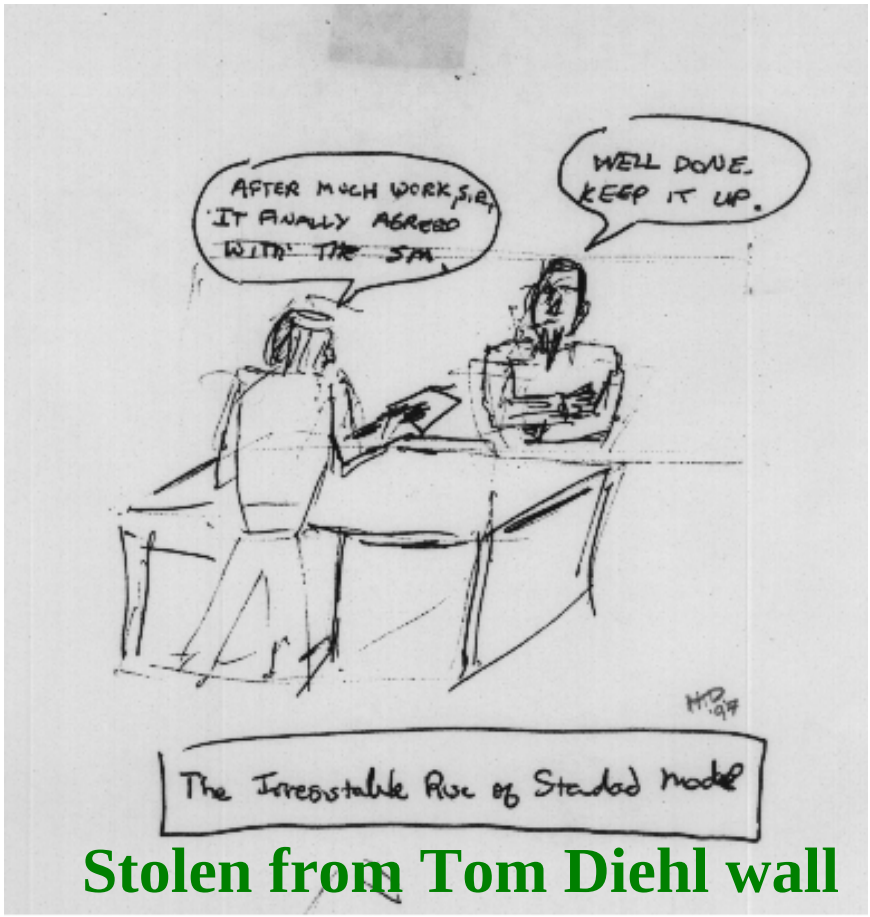
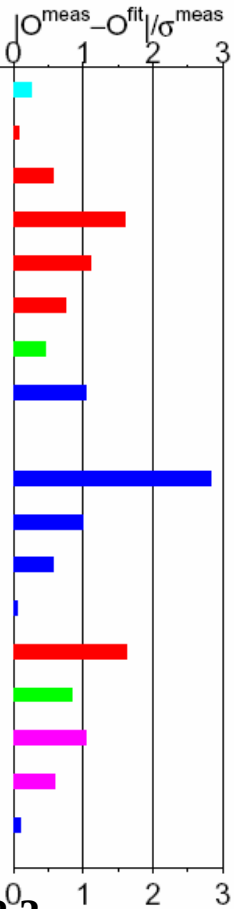
for DØ Collaboration

The Irresistible Rise of Standard Model



Stolen from Tom Diehl wall

	Measurement	Fit
$\Delta\alpha^{(5)}_{had}(m_Z)$	0.02761 ± 0.00036	0.02770
m_Z [GeV]	91.1875 ± 0.0021	91.1874
Γ_Z [GeV]	2.4952 ± 0.0023	2.4965
σ^0_{had} [nb]	41.540 ± 0.037	41.481
R_l	20.767 ± 0.025	20.739
$A^{0,l}_{fb}$	0.01714 ± 0.00095	0.01642
$A_l(P_\tau)$	0.1465 ± 0.0032	0.1480
R_b	0.21630 ± 0.00066	0.21562
R_c	0.1723 ± 0.0031	0.1723
$A^{0,b}_{fb}$	0.0992 ± 0.0016	0.1037
$A^{0,c}_{fb}$	0.0707 ± 0.0035	0.0742
A_b	0.923 ± 0.020	0.935
A_c	0.670 ± 0.027	0.668
A_l(SLD)	0.1513 ± 0.0021	0.1480
$\sin^2\theta^{lept}_{eff}(Q_{fb})$	0.2324 ± 0.0012	0.2314
m_W [GeV]	80.425 ± 0.034	80.390
Γ_W [GeV]	2.133 ± 0.069	2.093
m_t [GeV]	178.0 ± 4.3	178.4



New!

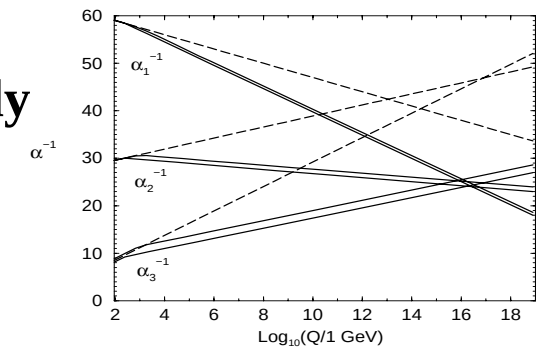
m_t[GeV] 172.5 ± 2.3

Still a low energy approximation…

Hierarchy Problem and SUSY

- Hierarchy problem – problem with fundamental scalars:
  - If you want your theory to break at Λ, the mass of scalar must be $O(\Lambda)$.
  - To achieve EWSB, mass of Higgs must be O(100 GeV), not O(10000000000000000 GeV)
  - What is the probability that quadratically divergent contributions to the Higgs boson mass will accidentally cancel each other up to Plank energy?

- Supersymmetry (SUSY)
  - Between fermions and bosons (each SM fermion has a SUSY boson partner)
  - Higgs mass corrections for bosons and fermions have opposite signs – **corrections cancel precisely**
  - Mass of Higgs is below 130 GeV
  - SUSY must be broken
    - Otherwise SUSY particles would have been found by now…

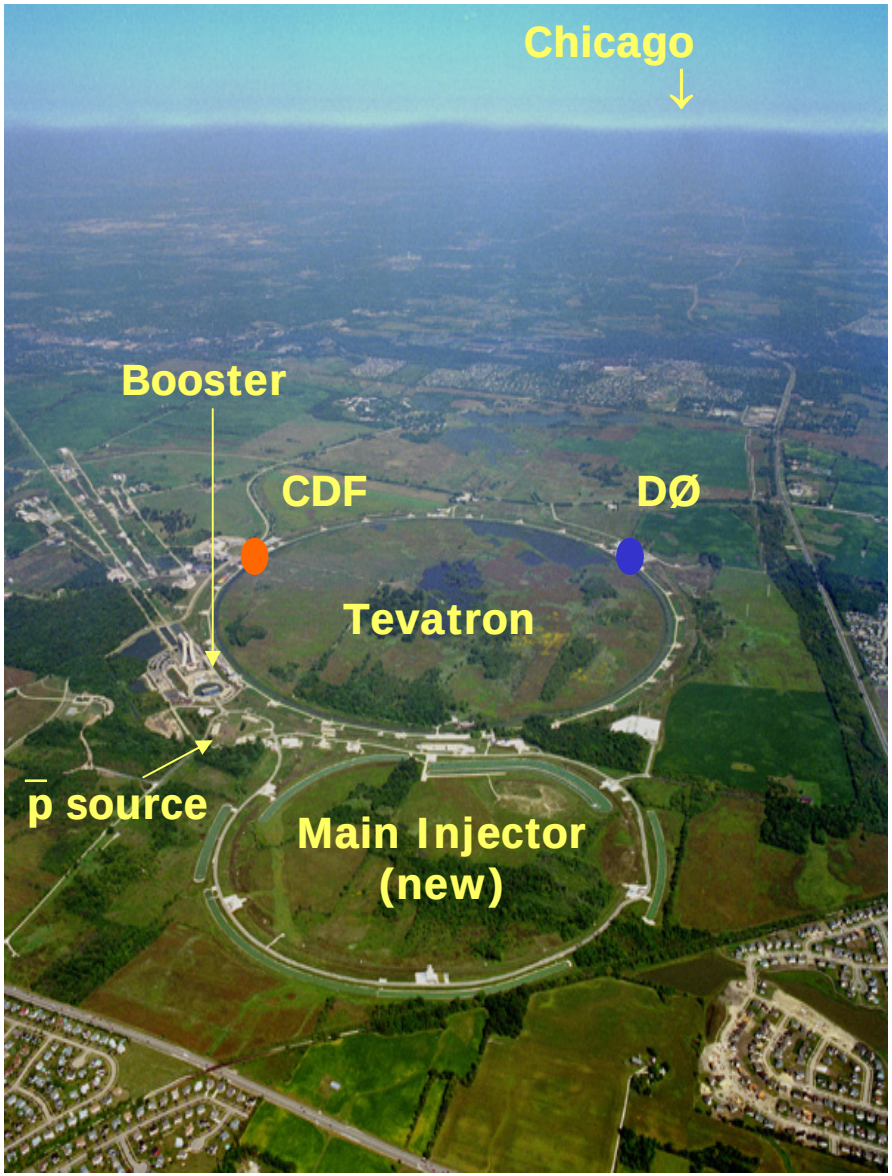


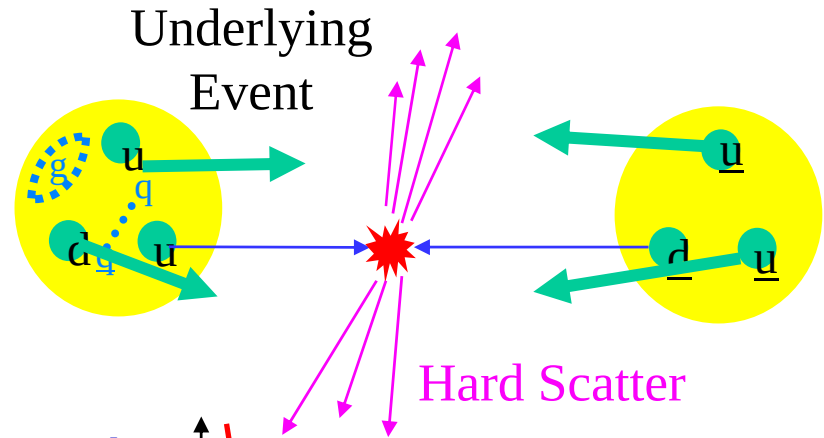
Gauge-mediated SUSY

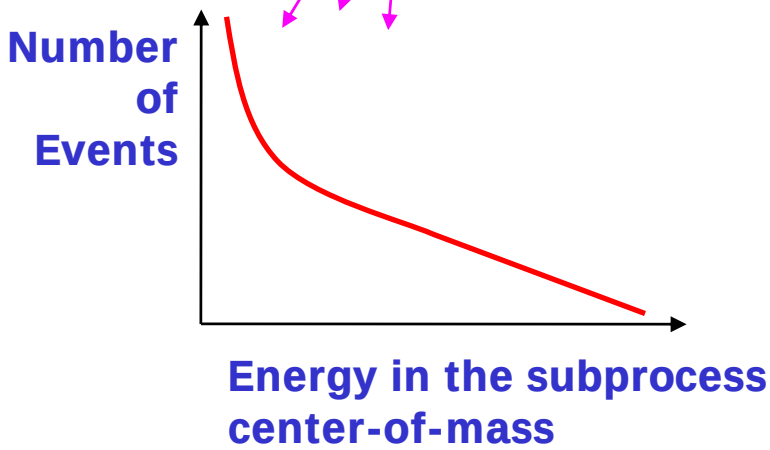
- One of the models with SUSY broken by new gauge field ("messenger")
- Phenomenology:
  - Gravitino is very light (<< MeV) and is LSP
  - NLSP is slepton or neutralino
  - If NLSP is neutralino, then
    - Final state includes two photons

$$p\bar{p} \to gauginos \to W, Z, \gamma + \chi_1^0 \chi_1^0 \to$$
$$\to \gamma\gamma + \tilde{G}\tilde{G} + X$$

Fermilab Tevatron Collider





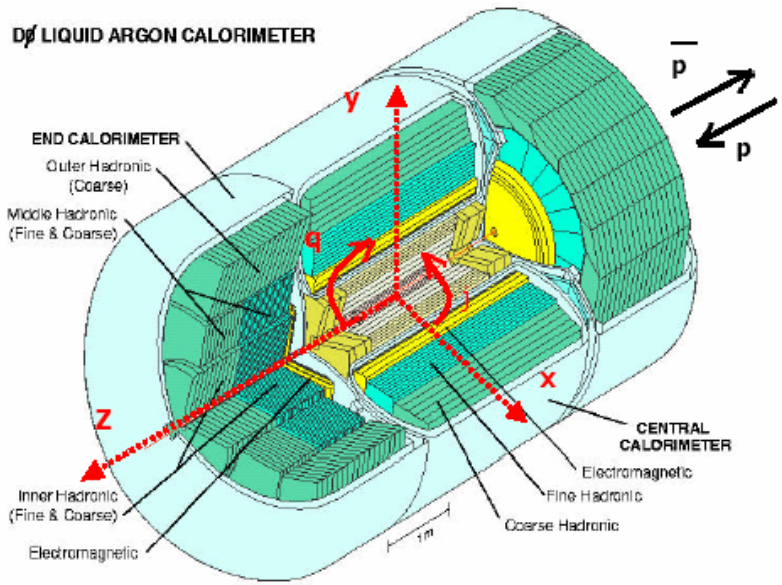


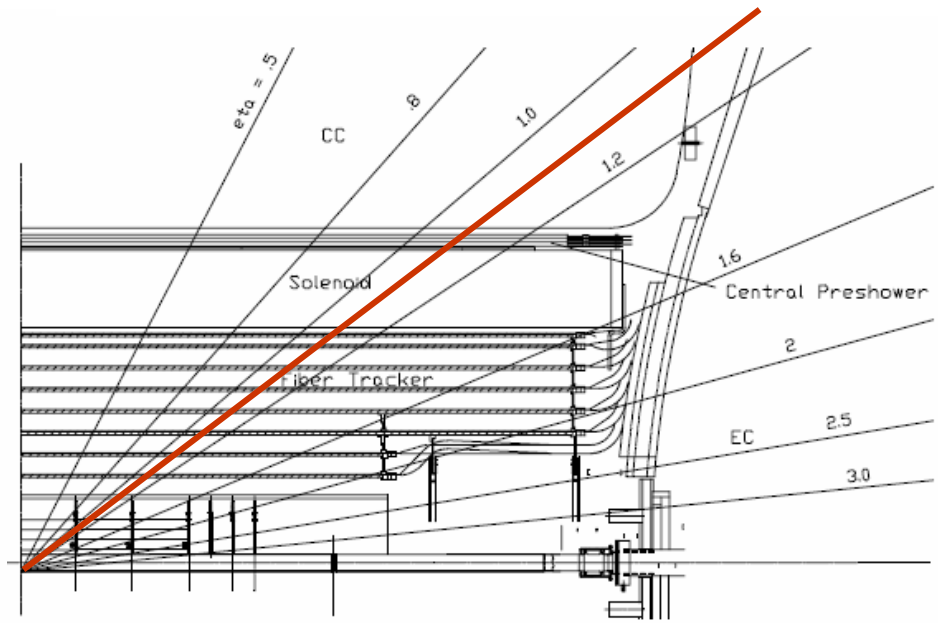
$$p\bar{p} \rightarrow gauginos \rightarrow W, Z, \gamma + \chi_1^0 \chi_1^0 \rightarrow$$
$$\rightarrow \gamma\gamma + \tilde{G}\tilde{G} + X$$

2 photons + missing E_T

Analysis Overview

- Single EM triggers: ~1 fb^{-1} before quality selections (about 8 times Run I data)
- Use central calorimeter only for photon identification
- More sophisticated photon ID
  - Central Preshower Detector





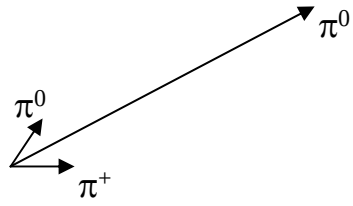
Backgrounds

- Physics backgrounds are negligible
- All instrumental backgrounds can be determined from data

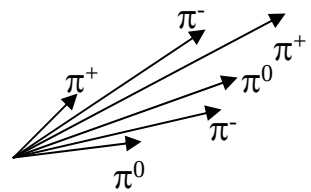
largest

without true MET *-fake MET*

- QCD: $\gamma\gamma$, γ+j, j+j (jet is faking γ)
- Drell-Yan (lost tracks)



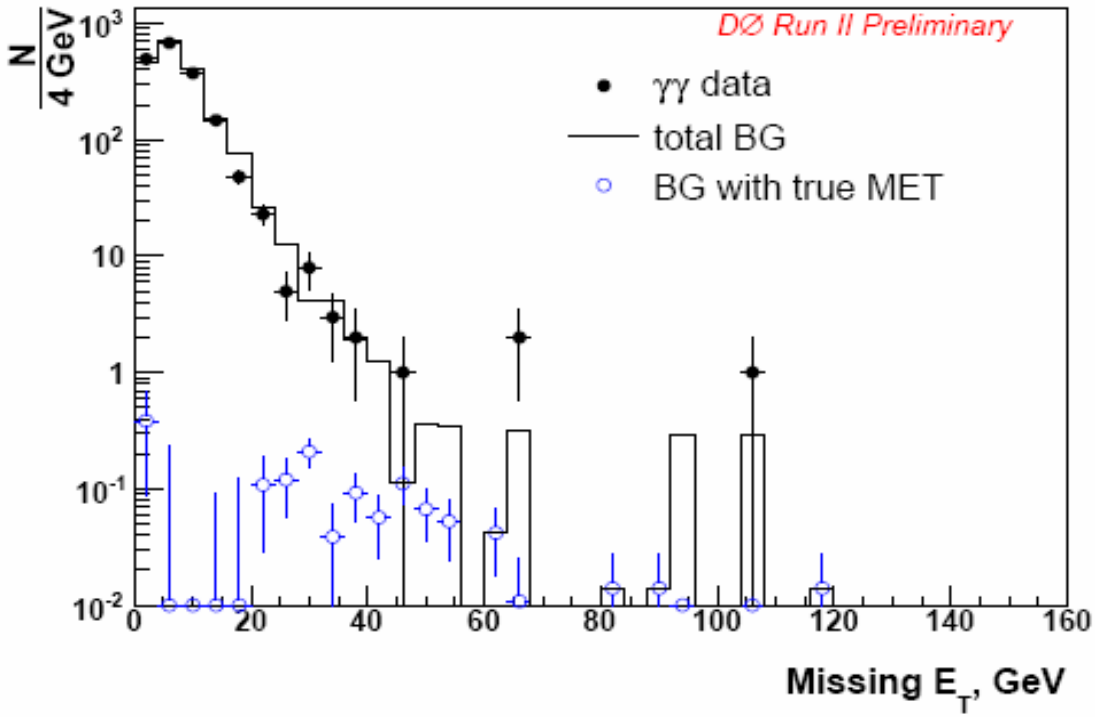
EM jet

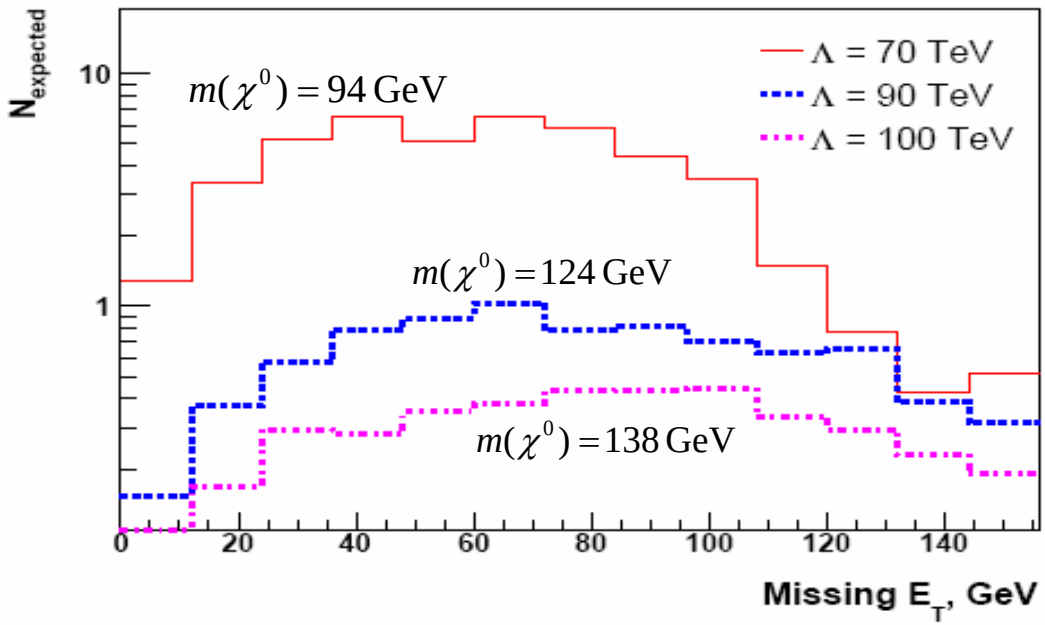


normal jet

with true MET *-fake γ*

- $W\gamma \rightarrow e\nu\gamma$ (lost track)
  $Wj \rightarrow e\nu j$ (lost track, fake γ)
- $Z \rightarrow \tau\tau \rightarrow ee + X$ (lost tracks)
- $tt \rightarrow ee + X$ (lost tracks)
- WW, WZ, ... (lost tracks)


DØ Run II Preliminary
γγ data
total BG
BG with true MET
N / 4 GeV
Missing E_T, GeV


Λ = 70 TeV
Λ = 90 TeV
Λ = 100 TeV
m(χ⁰) = 94 GeV
m(χ⁰) = 124 GeV
m(χ⁰) = 138 GeV
N_expected
Missing E_T, GeV

Data (DØ Run II Preliminary)

	Total events	$\not\!\!E_T < 12$ GeV	$\not\!\!E_T > 45$ GeV
$\gamma\gamma$	1790	1549	4
$e\gamma$	1469	1189	22
hh	6114	5172	6
QCD BG to $\gamma\gamma$			1.8 ± 0.7
QCD BG to $e\gamma$			1.4 ± 0.6
		$e\gamma$ total	20.6 ± 4.4
		$e\gamma$ BG to $\gamma\gamma$	0.28 ± 0.06
Total BG to $\gamma\gamma$			2.1 ± 0.7

See 4 events with MET > 45 GeV, expect 2.1 ± 0.7

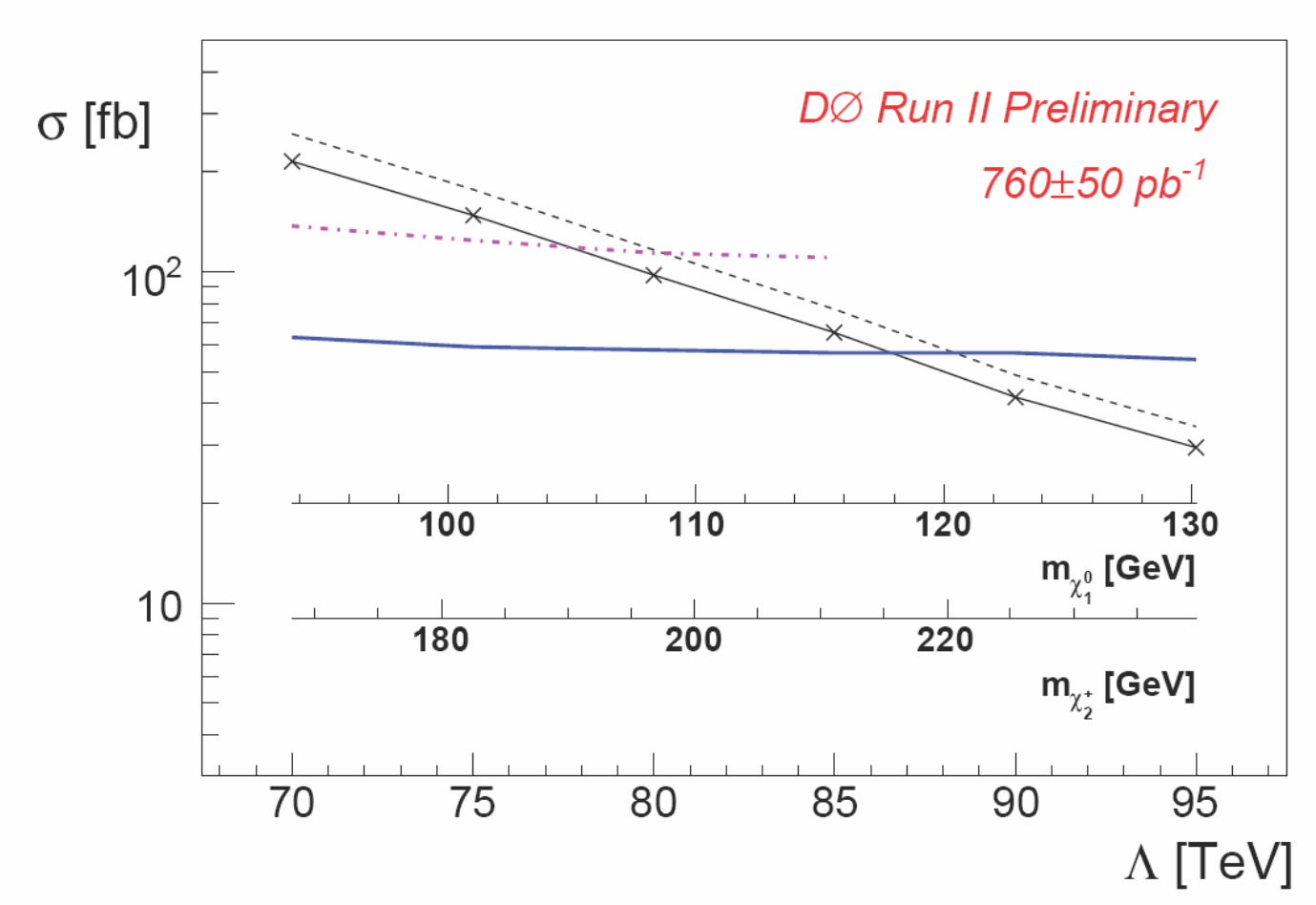
Limit Setting

- Use Bayesian limit calculator to set limits
  - $\tan\beta=15$, $\mu>0$, $M_{mess} = 2\cdot\Lambda$

Λ, TeV	$m_{\chi_1^0}$, GeV	$m_{\chi_1^+}$, GeV	σ_{TOT}^{LO}, fb	K-factor	Efficiency	95% CL Limit, fb
70	93.7	168.2	215.	1.207	0.167 ± 0.025	63.4
75	101.0	182.3	148.	1.197	0.180 ± 0.027	59.2
80	108.5	198.1	97.5	1.187	0.183 ± 0.027	58.0
85	115.8	212.0	65.4	1.177	0.186 ± 0.028	56.9
90	123.0	225.8	41.8	1.167	0.186 ± 0.028	56.9
95	130.2	239.7	29.5	1.157	0.195 ± 0.029	54.2

TABLE III: Points on the GMSB model Snowmass slope: their cross-sections, efficiencies and cross-section limits.

The sources of error on signal efficiency are the error on the EM ID (10%),MC statistics (5%), trigger efficiency (4%), track match veto (3%) and PDF uncertainties (4%).

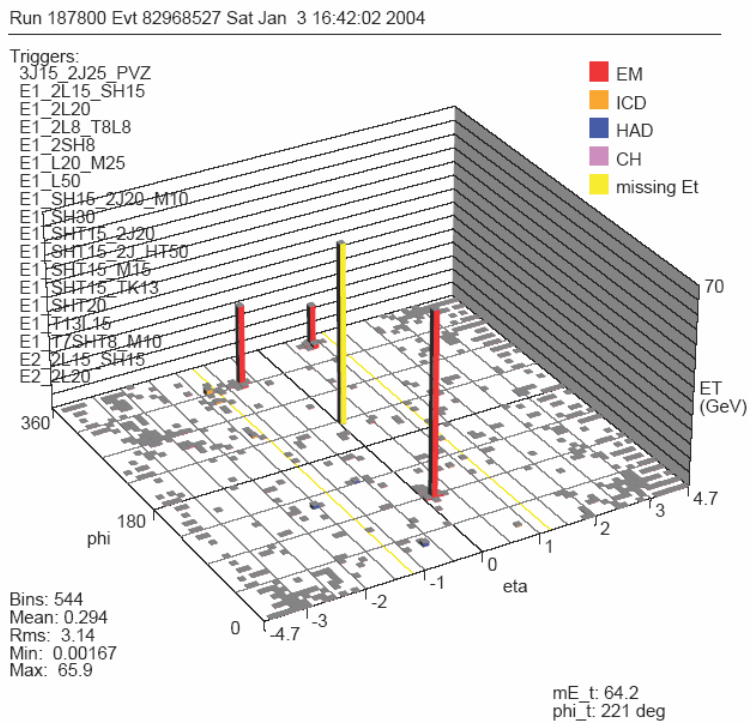


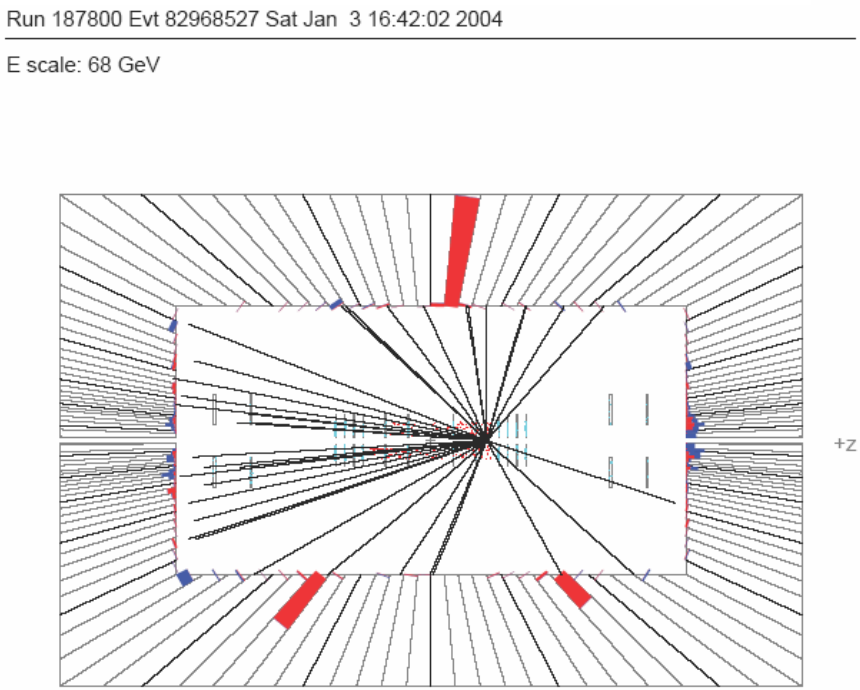
- $\Lambda > 88.5$ TeV
- $M(\chi_1^0) > 120$ GeV, $M(\chi_1^+) > 220$ GeV

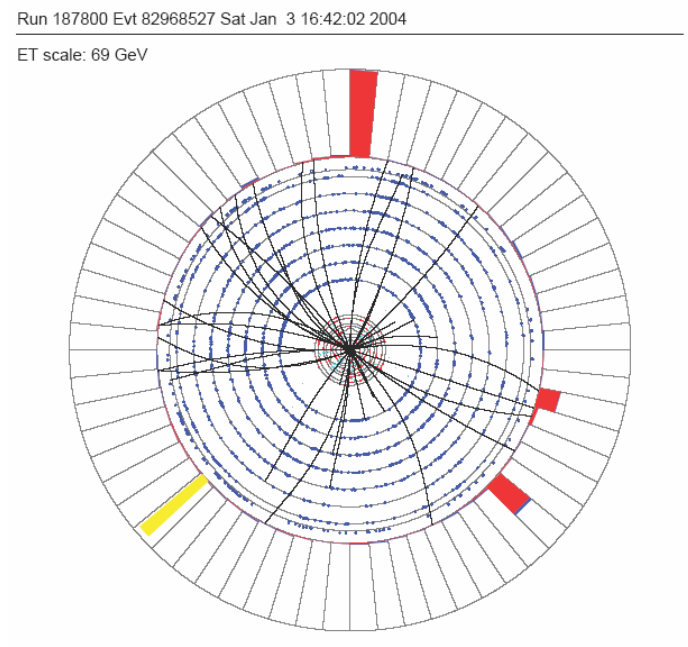
High MET events

MET = 66.4 GeV

“Lennox”





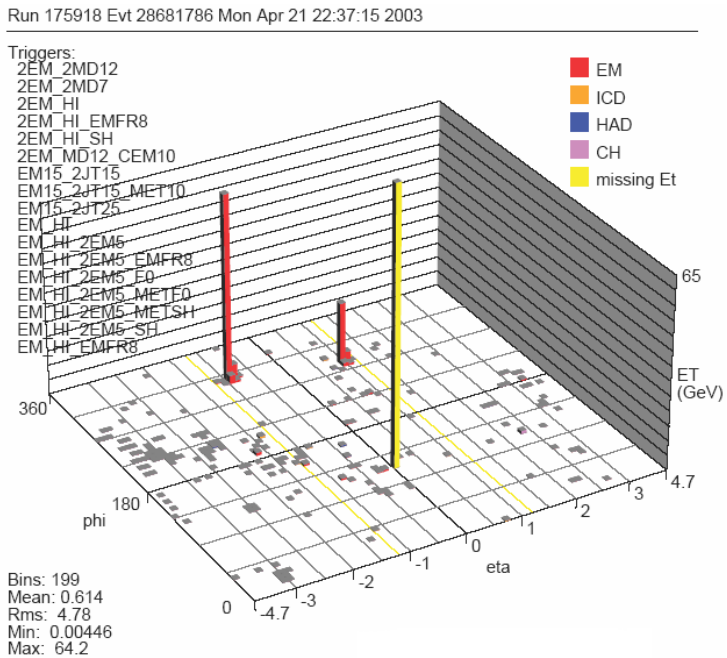


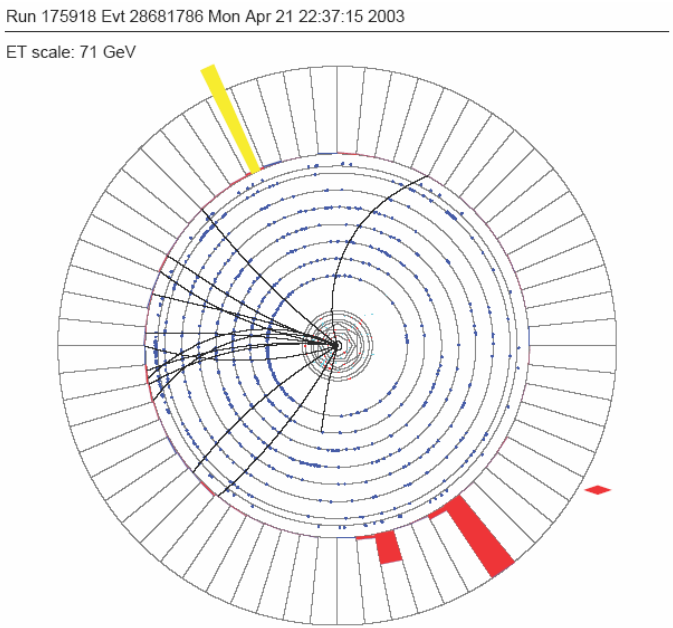
High MET events

MET = 105.2 GeV

M(γγ) = 110 GeV

"Wizzle"





Summary

- No evidence for GMSB SUSY
- Most stringent limits in the world

- More work is ongoing to search for SUSY in $\gamma\gamma\ell$+MET final state
  - Expect results in summer!