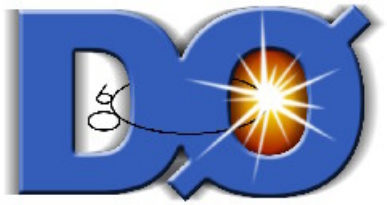


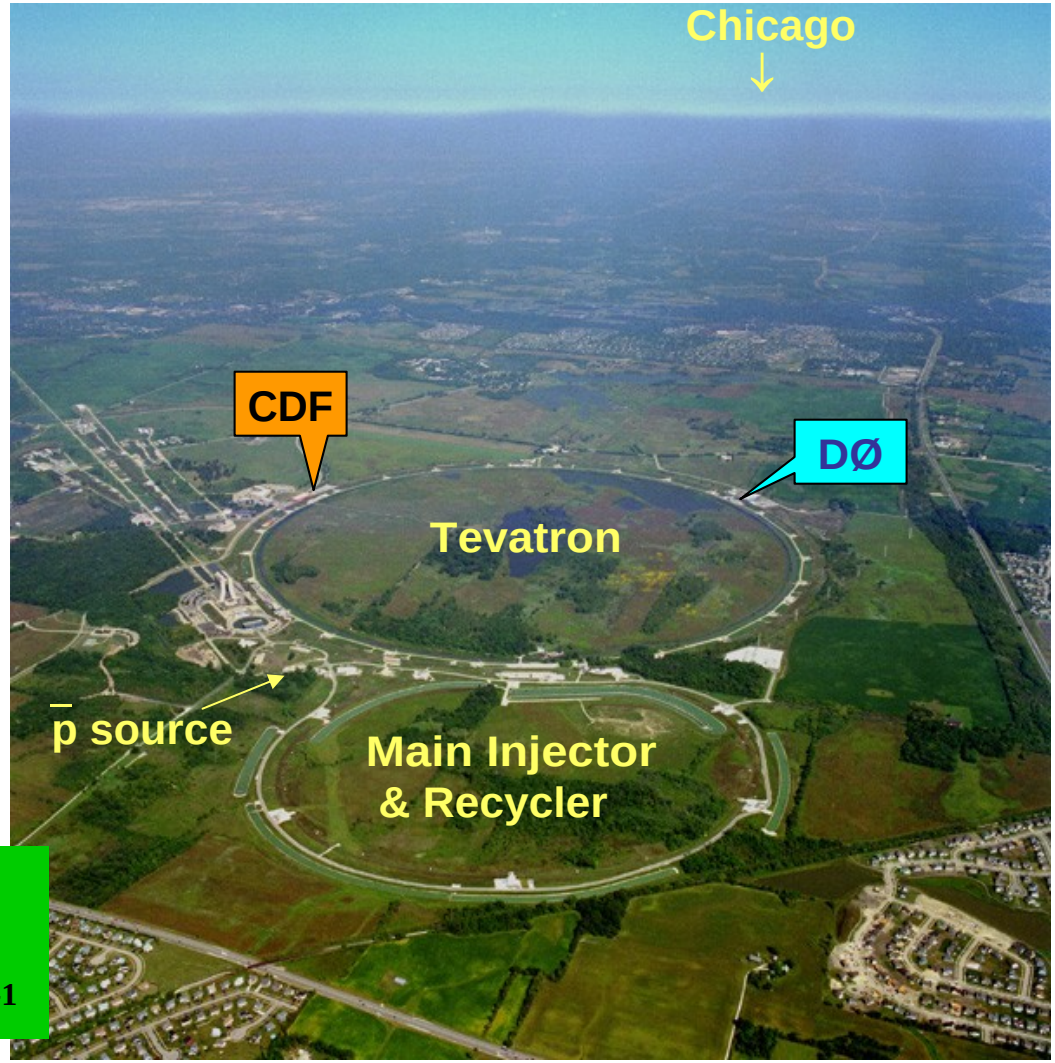
Search for Squarks and Gluinos with the D0 detector

Gérard Sajot

LPSC-Grenoble

The Tevatron at Run II

- New Main Injector : 150 GeV
  (stores protons , shoots to target for antiproton production)
- Higher energy
  (1.96 TeV vs 1.8 TeV)
  => Higher cross sections
  (~30% for SUSY)
- Higher intensity
  6x6 → 36x36 bunches
  3.5 μs → 396 ns
  antiproton "recycler"
  => Higher luminosity
  Run I : 2×10^{31} cm^{-2} s^{-1}
  Run II : 2×10^{32} cm^{-2} s^{-1}
  Record 1.6×10^{32} cm^{-2} s^{-1}



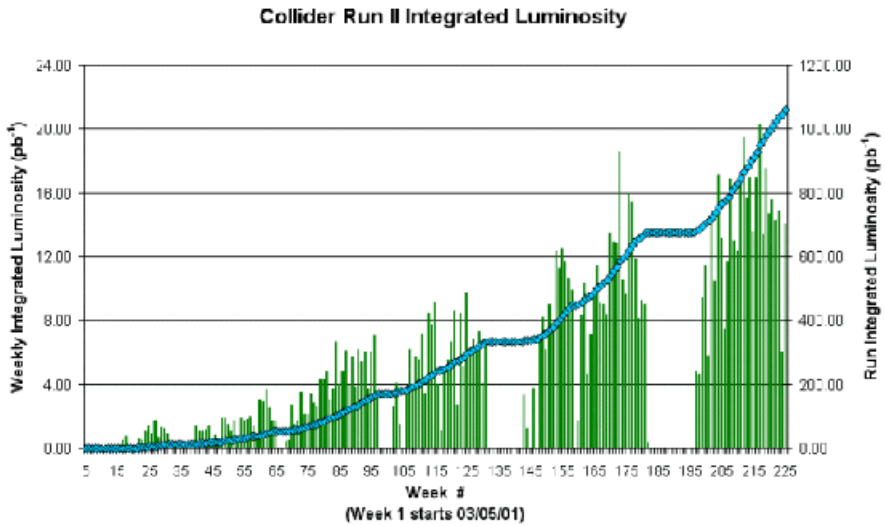
News of the week :
electron cooling successfully tested
-> key ingredient to accumulate 8 fb^{-1}

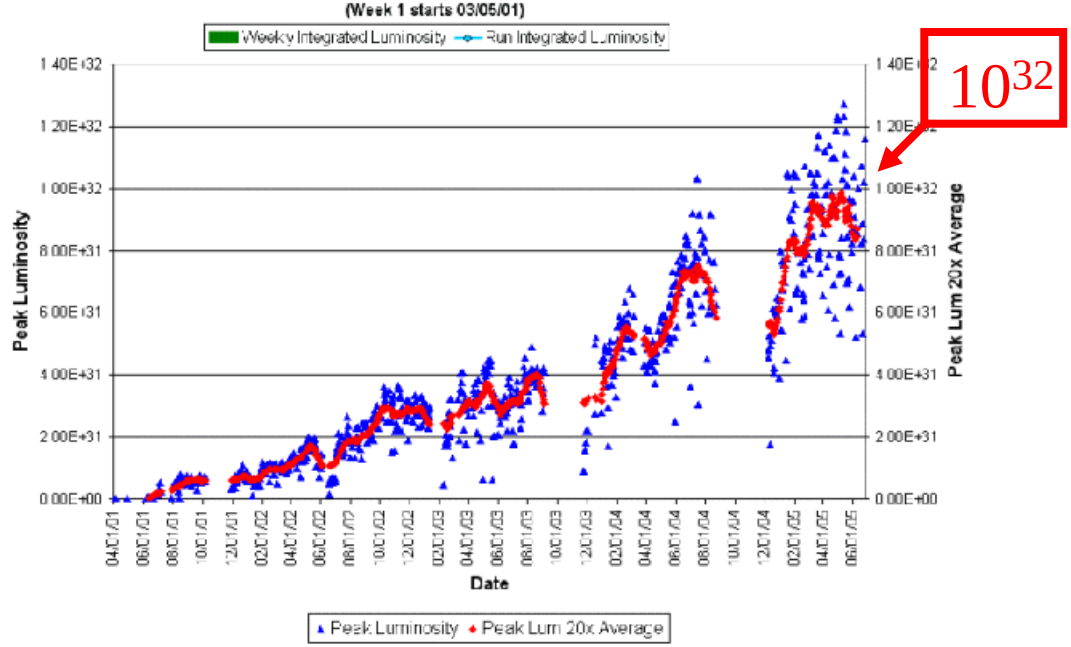
Luminosity performance

In 2005:

- Weekly delivered:
  8 - 16 pb-1
- Peak luminosity:
  6 - 12 10^{31} cm^{-2} s^{-1}
- Data taking efficiency:
  ~ 90%

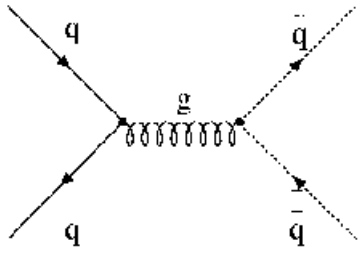
D0 Physics quality data:
~ 800 pb^{-1}



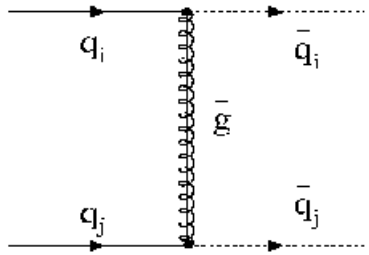


10^{32}

Squarks /Gluinos Production at Tevatron



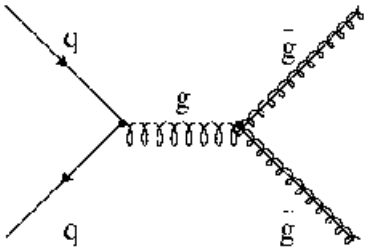
$$p\bar{p} \to \tilde{q}\bar{\tilde{q}}$$



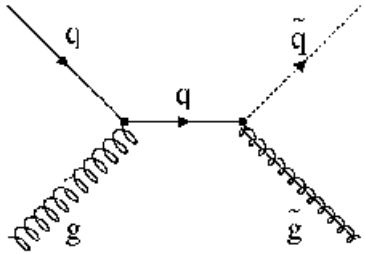
$$p\bar{p} \to \tilde{q}\tilde{q}$$

Strong interaction process

σ~pb



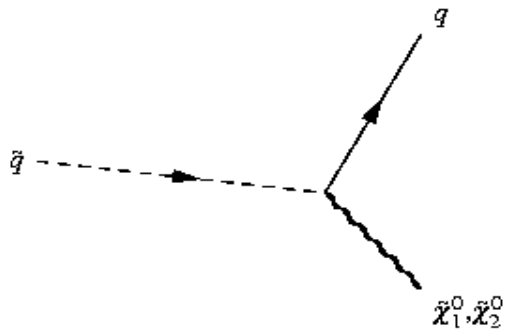
$$p\bar{p} \to \tilde{g}\tilde{g}$$

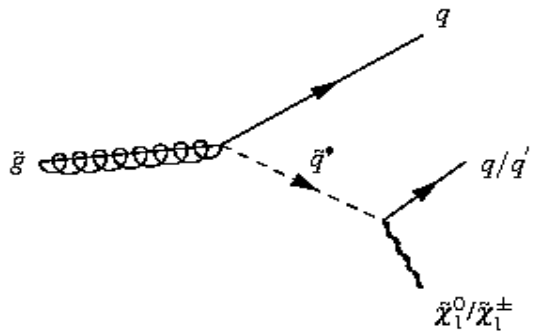


$$p\bar{p} \to \tilde{q}\tilde{g}$$

Dominant process is function of the Susy parameters

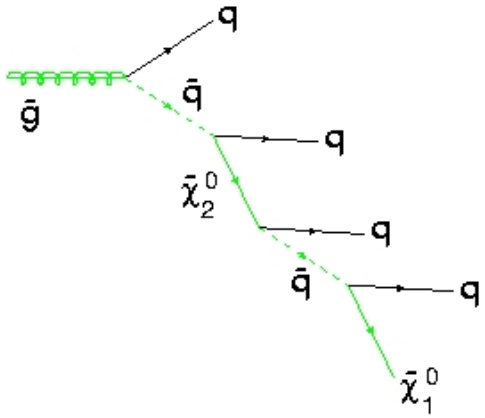
Squarks /Gluinos decay

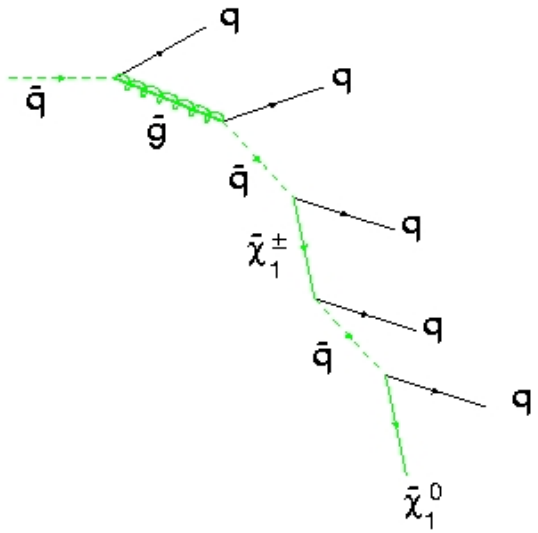




$$\tilde{q} \to q\tilde{\chi}_i^0 \quad \tilde{q} \to q'\tilde{\chi}_1^\pm$$

$$\tilde{g} \to q\bar{q}\tilde{\chi}_i^0 \quad \tilde{g} \to q\bar{q}'\tilde{\chi}^\pm$$

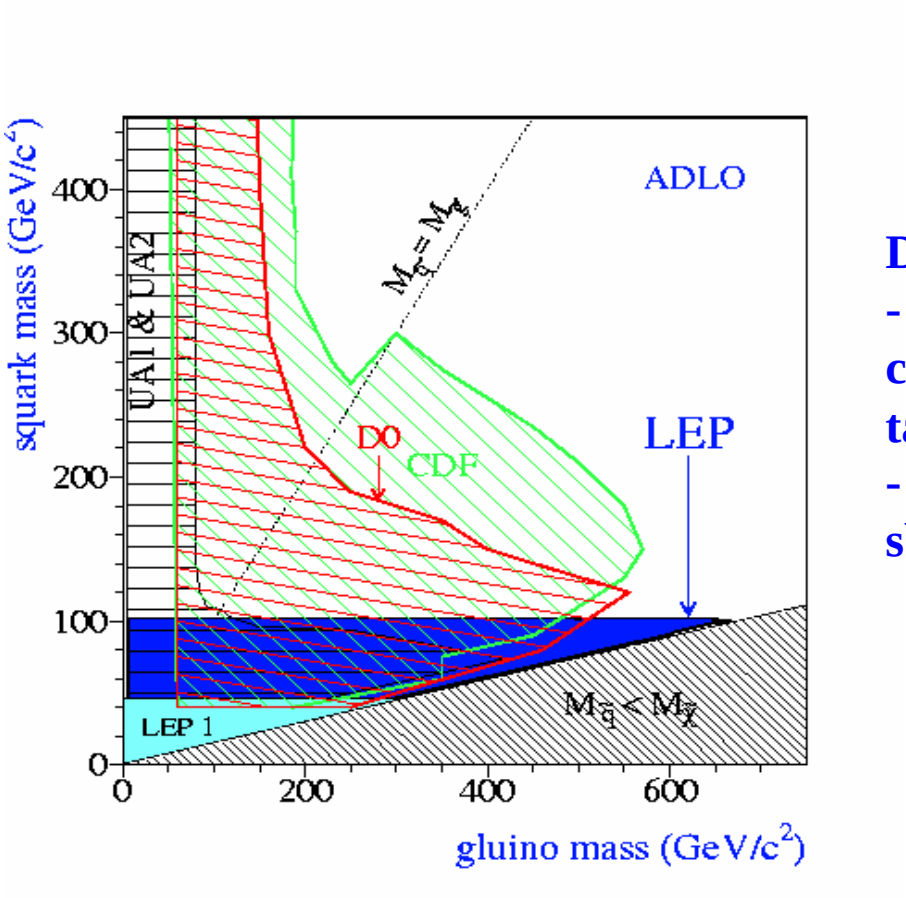




Msquark < Mgluino

Mgluino < Msquark

Run I and LEP heritage



Run I :

- CDF MET+multijets

- D0 Jets + large imbalance in P_T

D0 RunII search :

- mSUGRA parameters selected to allow comparison with CDF and D0 RunI results :

$\tan\beta = 3$, A0 = 0, $\mu < 0$

- 1st and 2nd squark generations + sbottoms production (no stops)

Msquark = mean mass of the 10 squarks

LEP : search for acoplanar jets

http://lepsusy.web.cern.ch/lepsusy

→ Sbottom and Stop search in D0
Talk : P. Ratoff July 20th

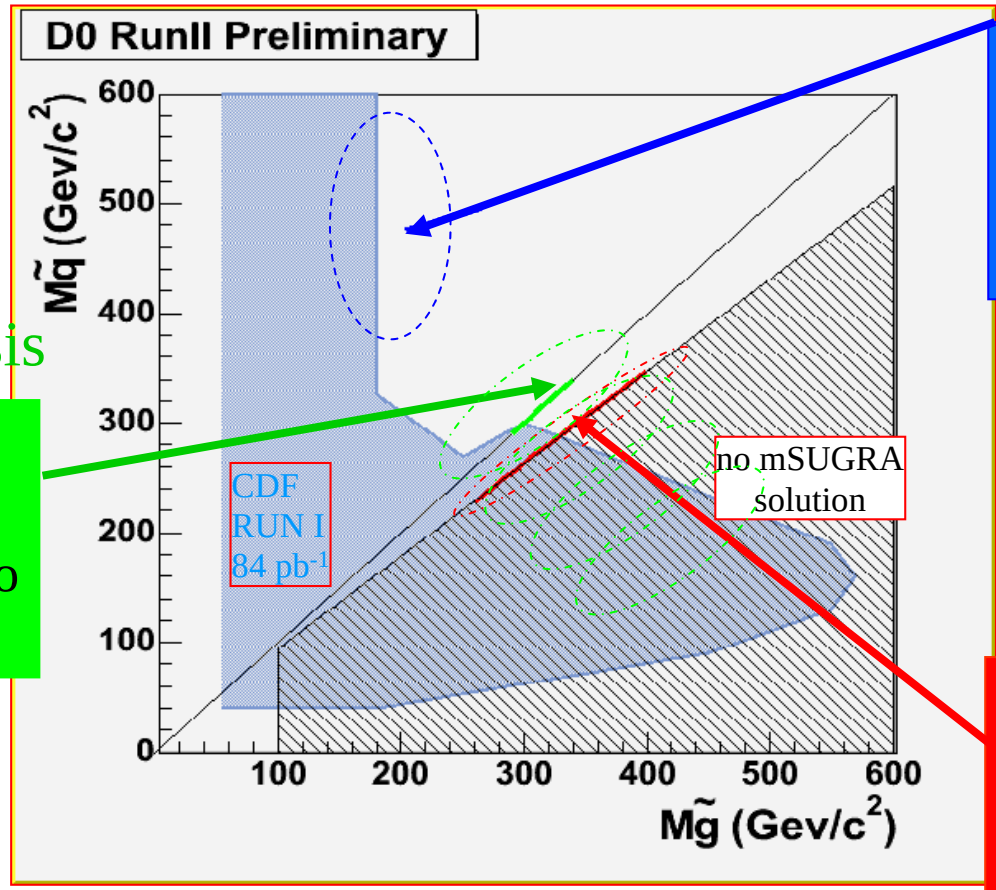
mSUGRA : Event Topology

"gluino" analysis

High m0
(~500 GeV)
Msquark>Mgluino
≥ 4 jets

"3 jets" analysis

Intermediate m0
(~200 GeV)
Msquark≅Mgluino
≥ 3 jets



"dijet" analysis

Low m0 (~ 25 GeV)
Msquark<Mgluino
squark antisquark
acoplanar dijet events

Signal and Standard Model background

•Signal :
Isajet 7.58 (masses)
Pythia 6.202
(generation+sigma LO)
PROSPINO (NLO K factors)

- **Standard Model (Alpgen, pythia)**
  CTEQ5L
  Cross section MCFM

SM process	cross section pb
$Z \to \nu\bar{\nu} + 2j$	174.
$Z \to \nu\bar{\nu} + 3j$	54.2
$Z \to \nu\bar{\nu} + 4j$	16.1
$W \to \tau\nu + 2j$	287.7
$W \to \mu\nu + 2j$	287.7
$W \to e\nu + 2j$	287.7
$Z/\gamma^* \to \tau\tau + 2j$	31.0
$Z/\gamma^* \to \tau\tau + 2j$	26.2
$Z/\gamma^* \to \tau\tau + 2j$	28.3
$Z/\gamma^* \to \mu\mu + 2j$	31.0
$Z/\gamma^* \to \mu\mu + 2j$	26.2
$Z/\gamma^* \to \mu\mu + 2j$	28.3
$Z/\gamma^* \to ee + 2j$	31.0
$Z/\gamma^* \to ee + 2j$	26.2
$Z/\gamma^* \to ee + 2j$	28.3
$t\bar{t} \to b\bar{b}jjjj$	3.09
$t\bar{t} \to b\bar{b}jjl\nu$	2.92
$t\bar{t} \to b\bar{b}l\nu l\nu$	0.69

Trigger and Data pre-selection

❑Integrated luminosity : 310 pb-1 (April 2003-August 2004)

❑Trigger :

L1 : 3 calorimeter trigger towers (E_T > 5 GeV)

L2 and L3 Missing Tranverse energy to the reconstructed jets

(MHT=$|\sum_{jets}\vec{P}_T|$ >20 GeV (L1) and > 30 GeV (L2))

+ after June 2004 :

acoplanarity (azimuthal angle between the 2 leading jets) <170 degrees at L3

- H_T = $\sum_{jets}|\vec{P}_T|$ > 50 GeV at L3

❑ Data pre-selction

MET > 40 GeV

MHT > 40 GeV

at least 2 hadonic jets (EMF<0.95)

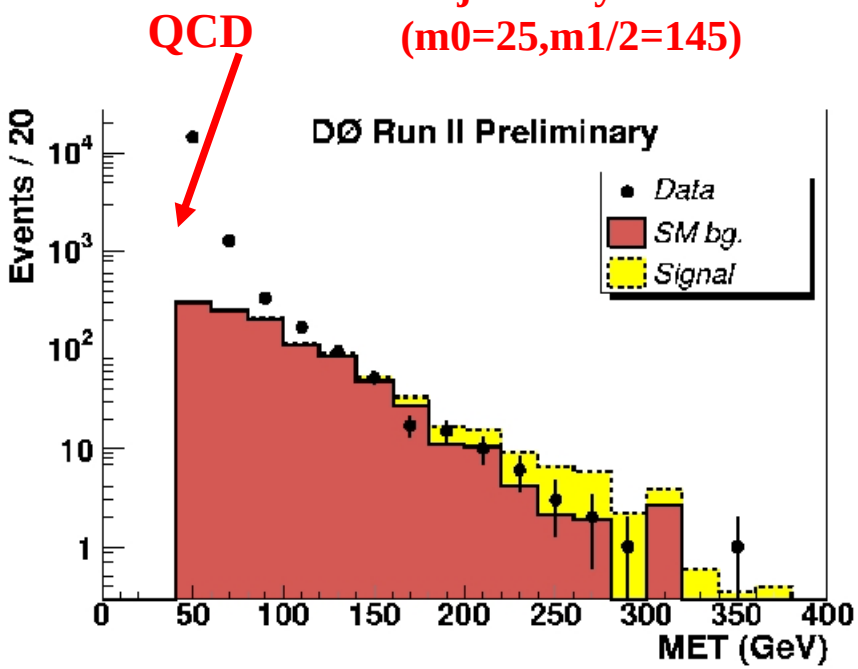
in Central region (|η| <0.8)

P_T 1st leading jet > 60 GeV/c

P_T 2nd leading jet > 40 GeV/c

delta phi < 165

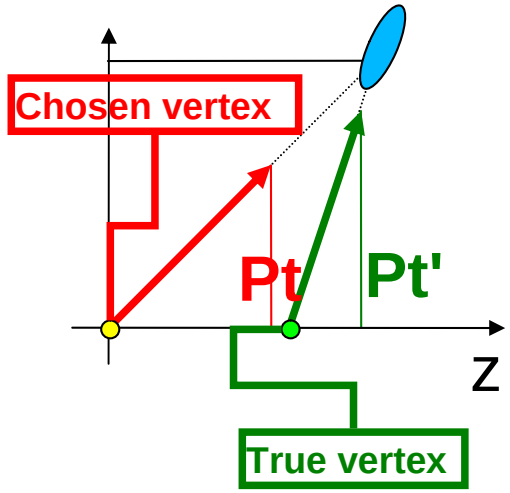
After pre-selection dijet analysis (m0=25,m1/2=145)



Fighting QCD background

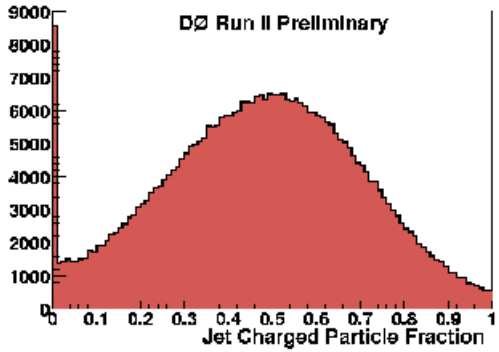
QCD comes from bad/noisy jets + jet energy fluctuation producing MET

- **Jets reconstructed from calorimetry**
  - **-> important to monitor**
  - **" quality of calorimeter data"**
    - **Understanding/curing noise (electronic and external)**
  - **-> have the best possible JES**



- **Misvertexing produces fake MET**

- **Jets are confirmed with charged Particles from primary vertex.**
  CPF > 0.05



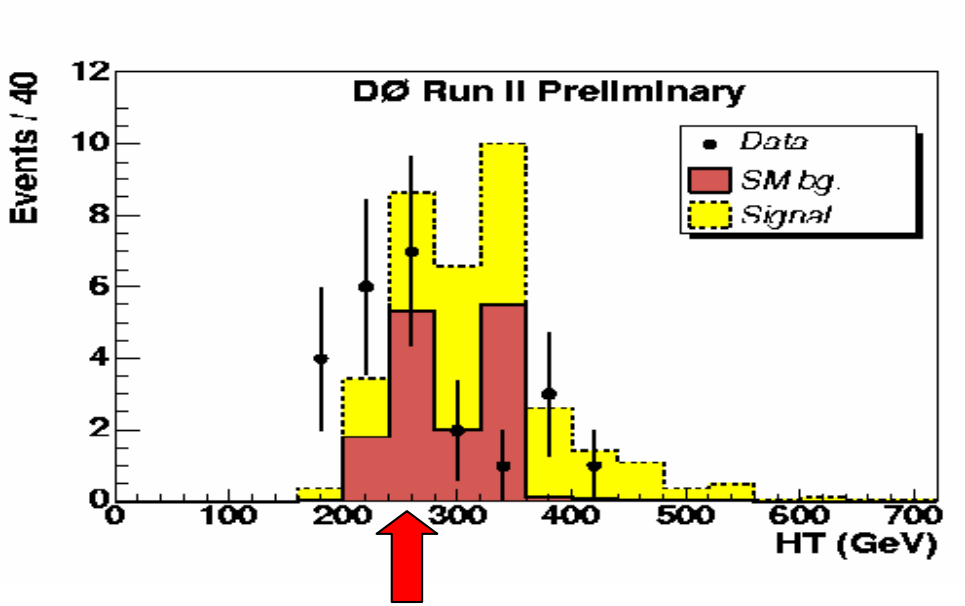
- **Min Delta Phi(MET,jet$_i$) cut**

$$\mathrm{CPF} = \sum \mathrm{Pt\_good\_associated\_tracks} / \mathrm{Pt\_jet}$$

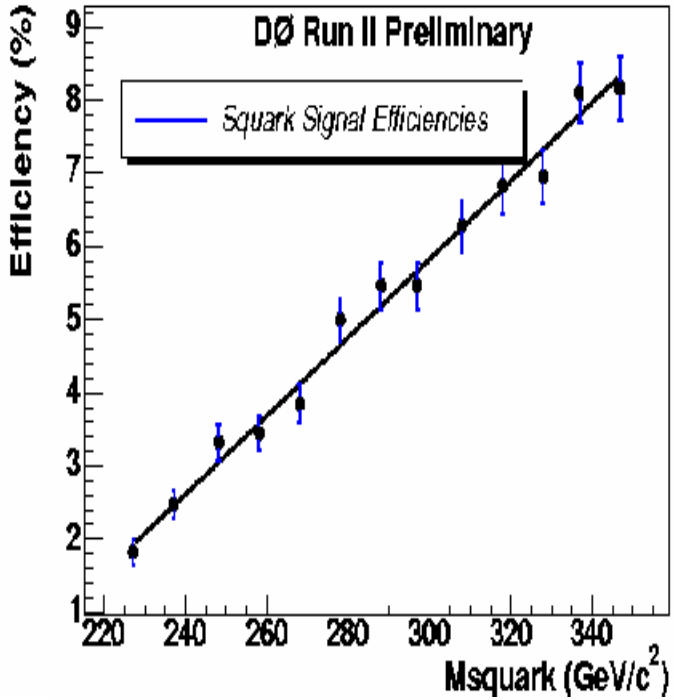
"dijet" analysis : event selection

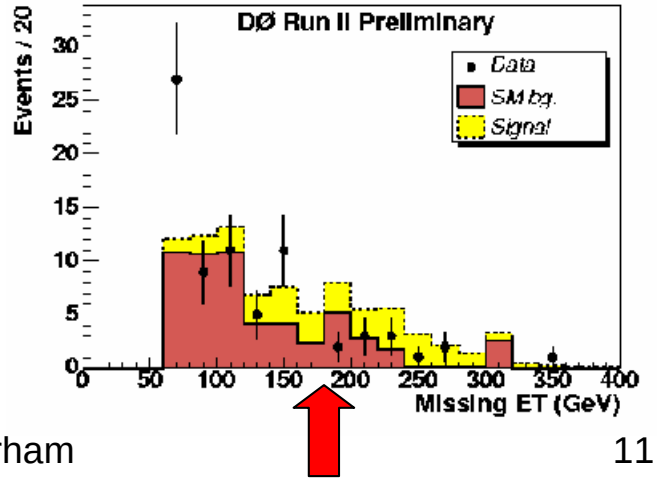
Isolation MET vs jets
Veto EM/muon

- >= 2 jets (60,50)
- MET > 175, HT > 250



*marginal distributions



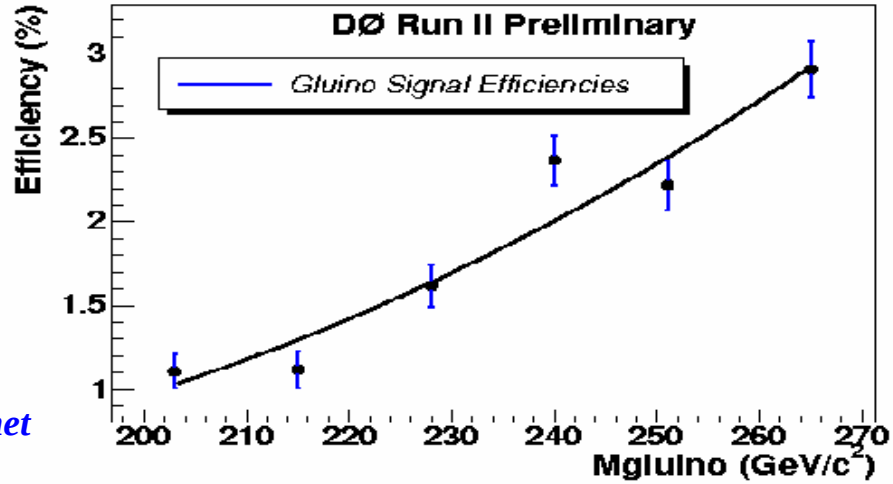


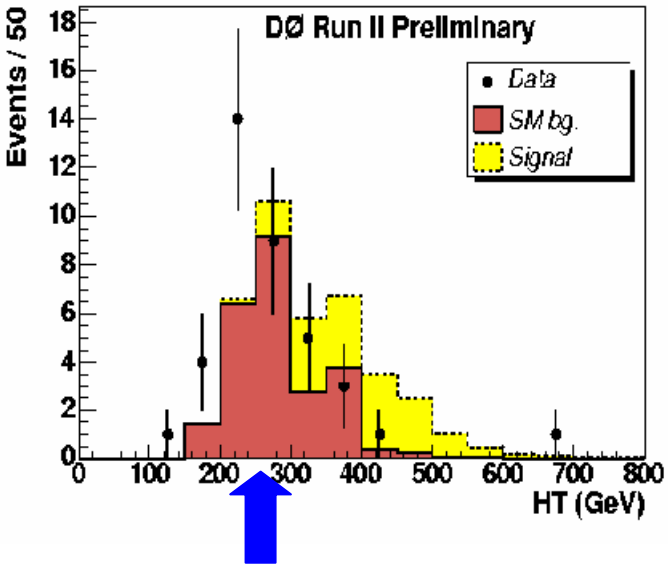
gluino" analysis : event selection

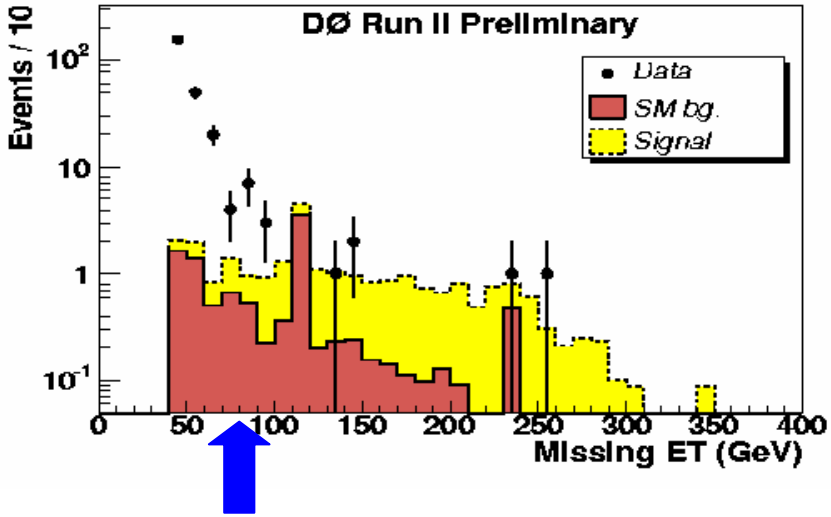
Isolation MET vs jets
Veto EM/muon

- **>= 4 jets (60/40/30/20)**
- **MET > 75, HT > 250**

QCD contribution evaluated from exponential fit at low met



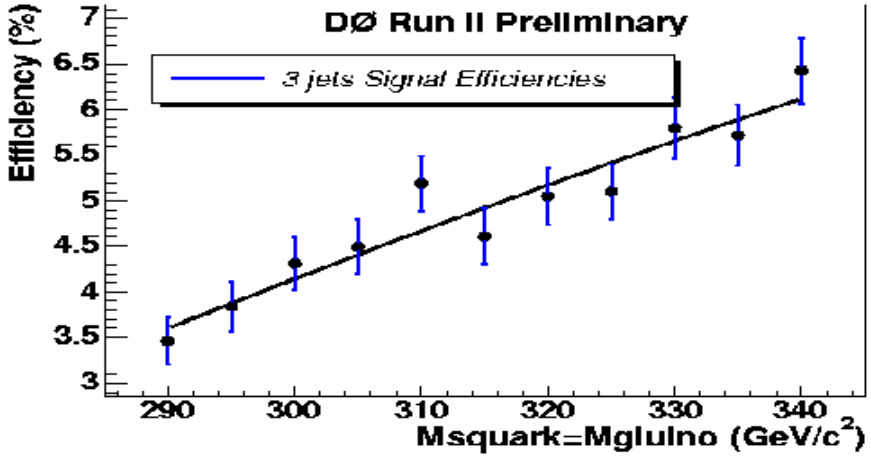


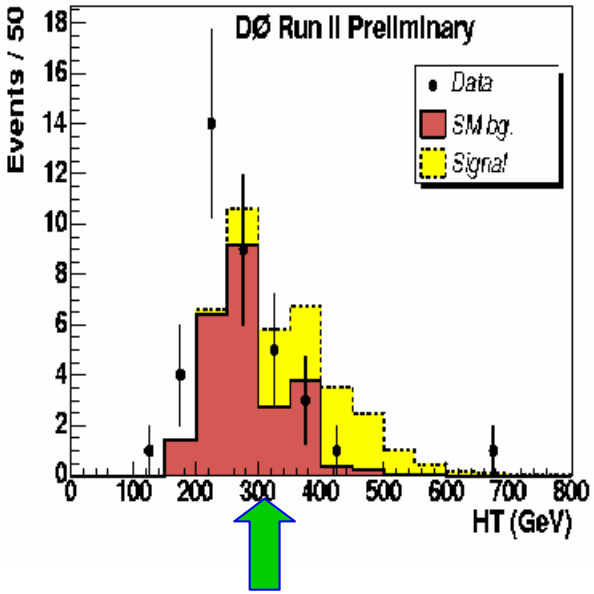


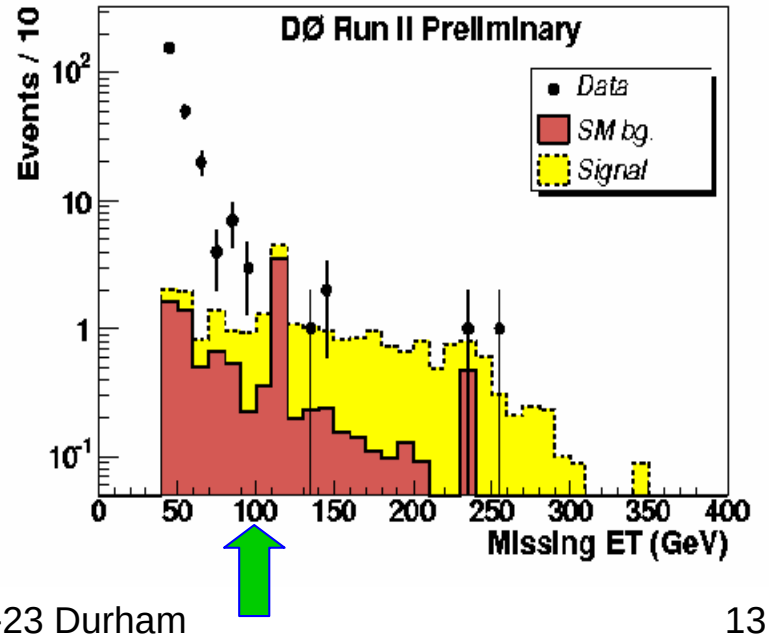
"3 jets" analysis : event selection

Isolation jets vs MET
Veto EM/muon

>= 3 jets (60/40/30)
MET > 100 HT > 325







Results : Data/Background

	Dijet	3 jets	Gluino
QCD	-	-	1.6±0.2
Total Bkg	12.8±5.4	6.1±3.1	7.1±0.9
Data	12	5	10

Statistical uncertainties

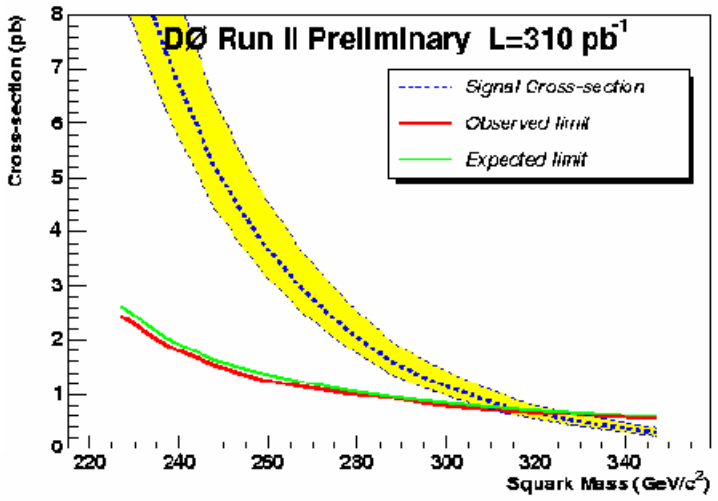
13 40 %

Systematic uncertainties

- JES in Data and MC : 11% to 24%
- Luminosity: ± 6.5%
- SM background Cross Section : ± 7.5%

Upper limits at 95% C.L. on squarks and gluinos

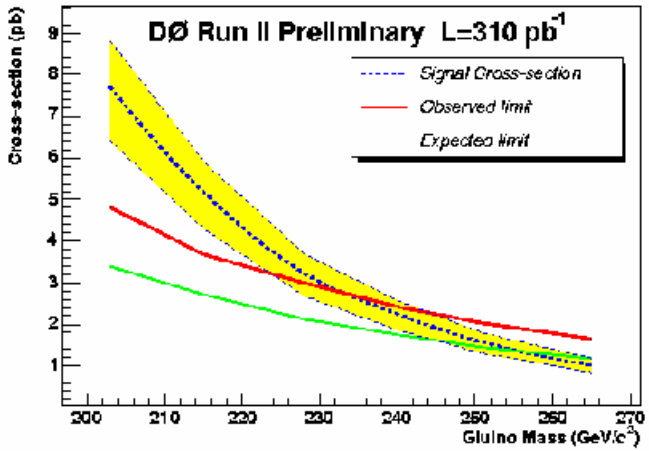
Yellow band : renormalization and factorization scale :
higher → μ=Q/2
central → μ= Q
lower → μ=2 * Q

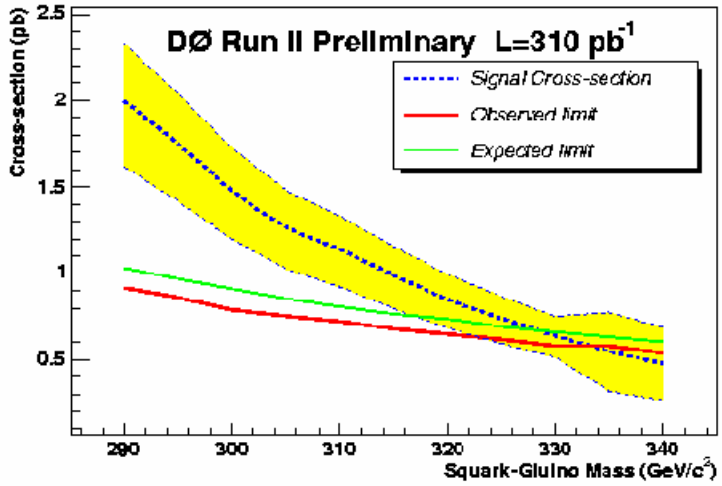


"dijet"
m0 = 25 GeV/c2
Q=m_squark

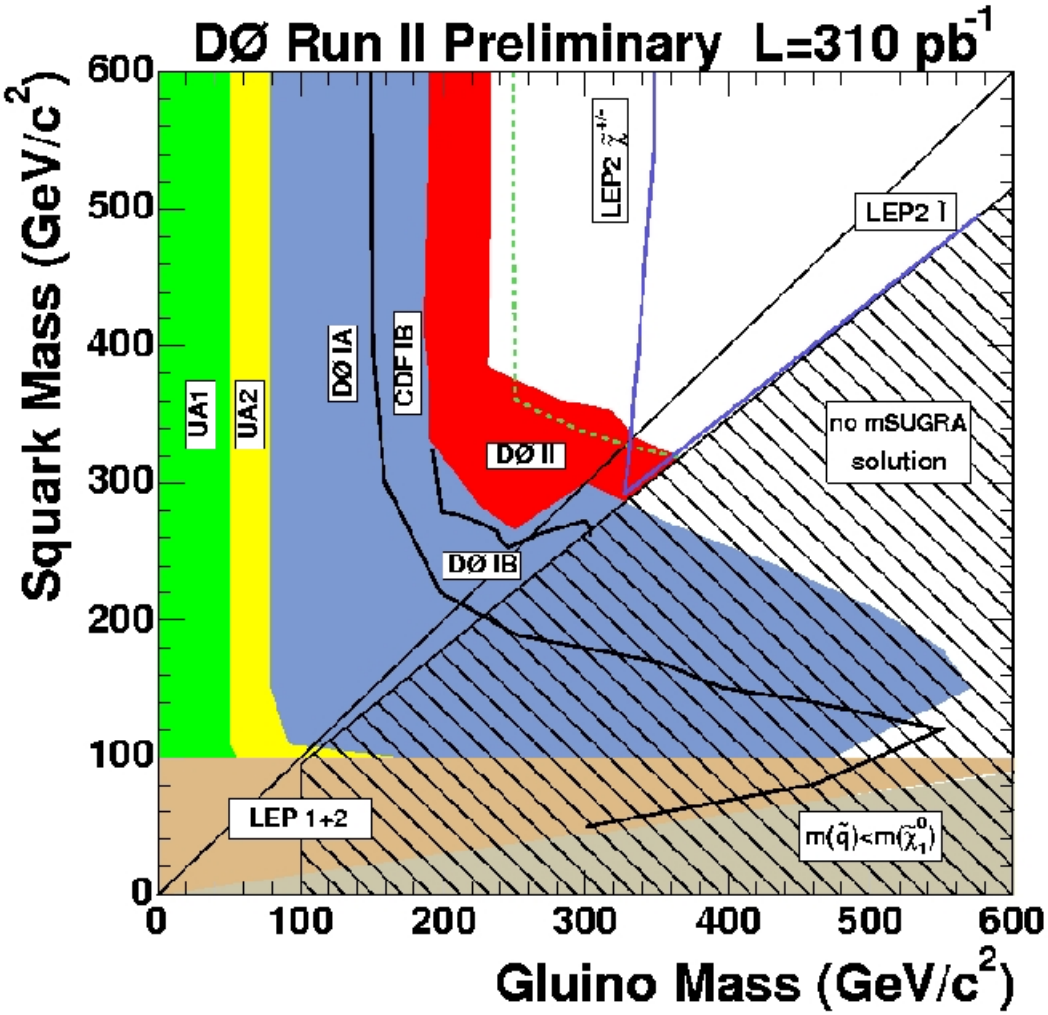
"Gluino"
m0=500 GeV/c2
Q=m_gluino

"3jets"
m_squark=m_gluino
Q=(m_gluino+m_squark)/2





Excluded region at 95 % C.L

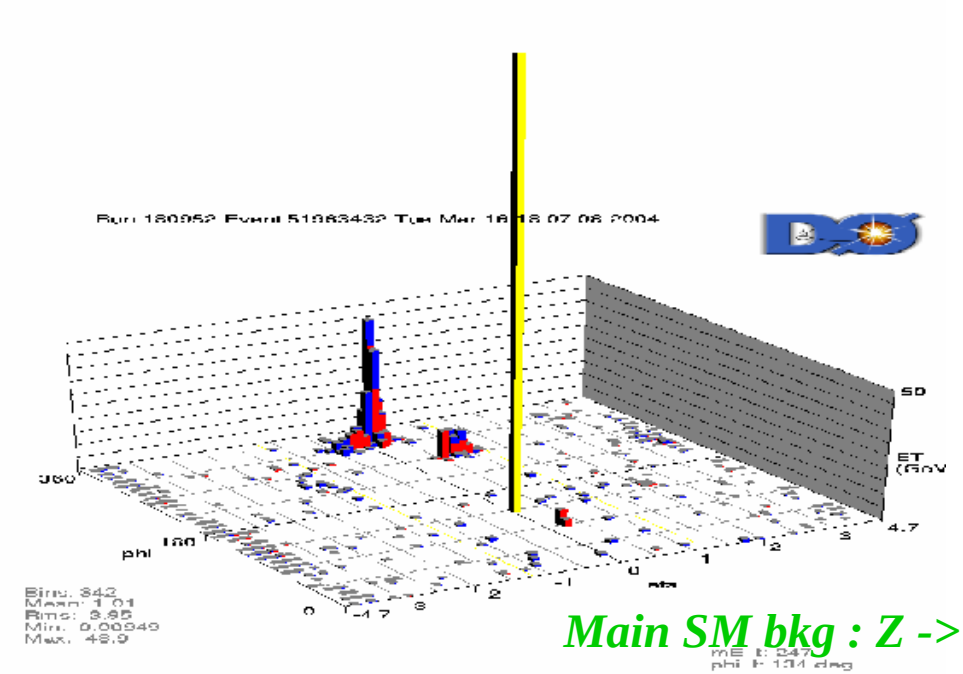


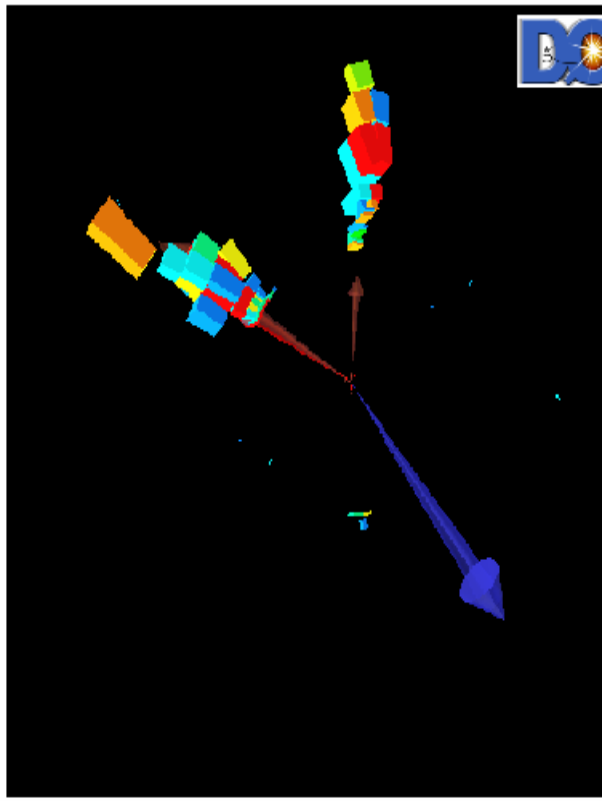
dijet	**m_squark > 318 GeV/c²**	***m0= 25 GeV/c²***
gluino	**m_gluino > 233 GeV/c²**	***m0=500 GeV/c²***
3jets	**m_squark > 333 GeV/c²** **m_gluino > 333 GeV/c²**	***m_squark= m_gluino***

Green line : expected

"dijet" analysis : Highest MET candidate

MET = 354 GeV et
HT = 431 GeV
2 High Pt jets:
jet 1 : 264 GeV/c
jet 2 : 106 GeV/c





Main SM bkg : Z -> νν jets, W->τν jets, μν jets,eν jets

Conclusions

Squarks and **gluinos** have been searched in the Jet + MET topology on 310 pb-1 of data recorded by **D0**

The observed limits are :

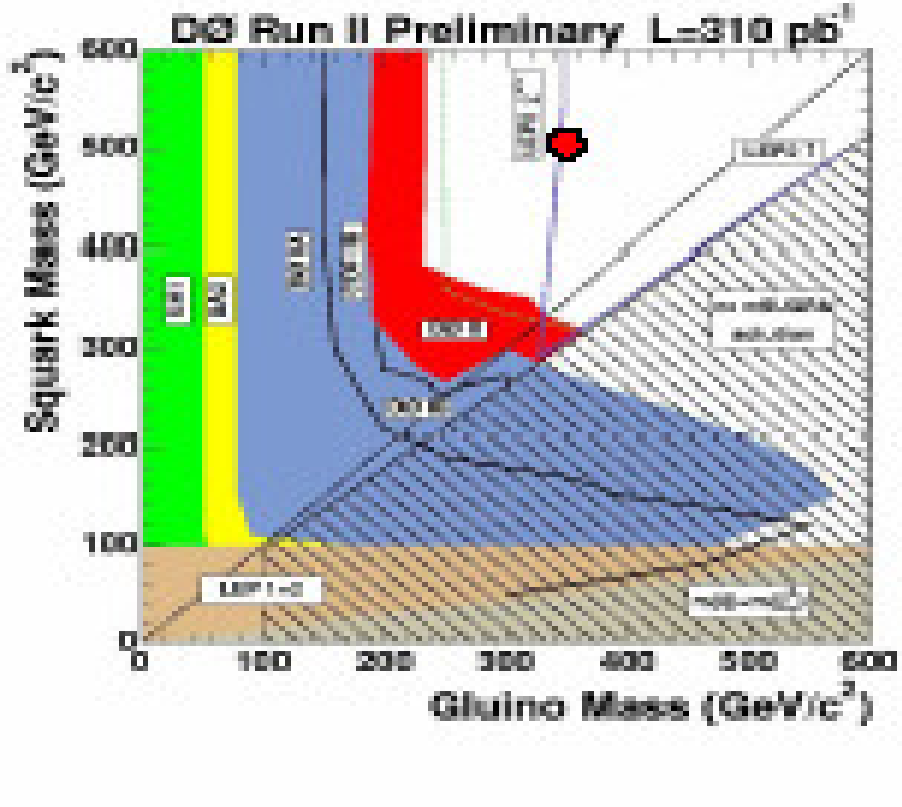
- dijet → **m_squark > 318 GeV/c2** (m0 = 25 GeV/c2)
- gluino → **m_gluino > 233 GeV/c2** (m0 = 500 GeV/c2)
- 3 jets → **m_squark and m_gluino > 333 GeV/c2**

Entering into a domain not yet excluded by LEP2 **(charginos and sleptons searches)**

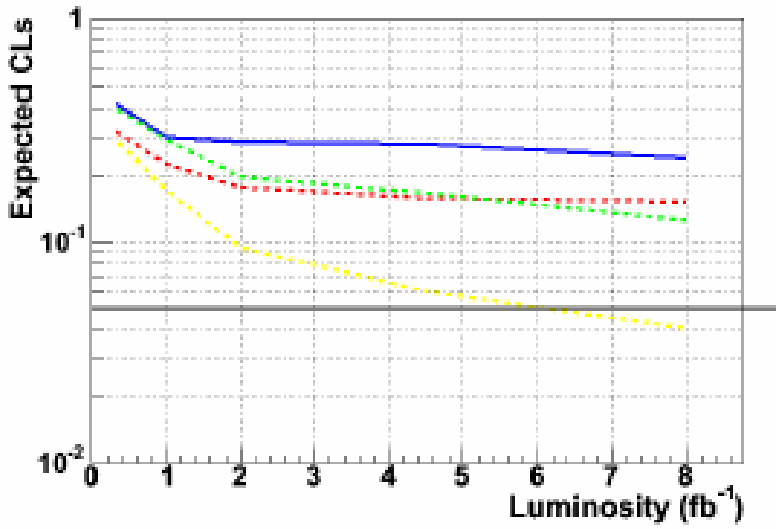
With a data sample of several fb^{-1},
collected at higher energy than for Run I,
with improved detectors,
exploration of a new SUSY territory can be done.
Already a massive improvement of existing
Run I limits has been achieved.

Back-up Slides

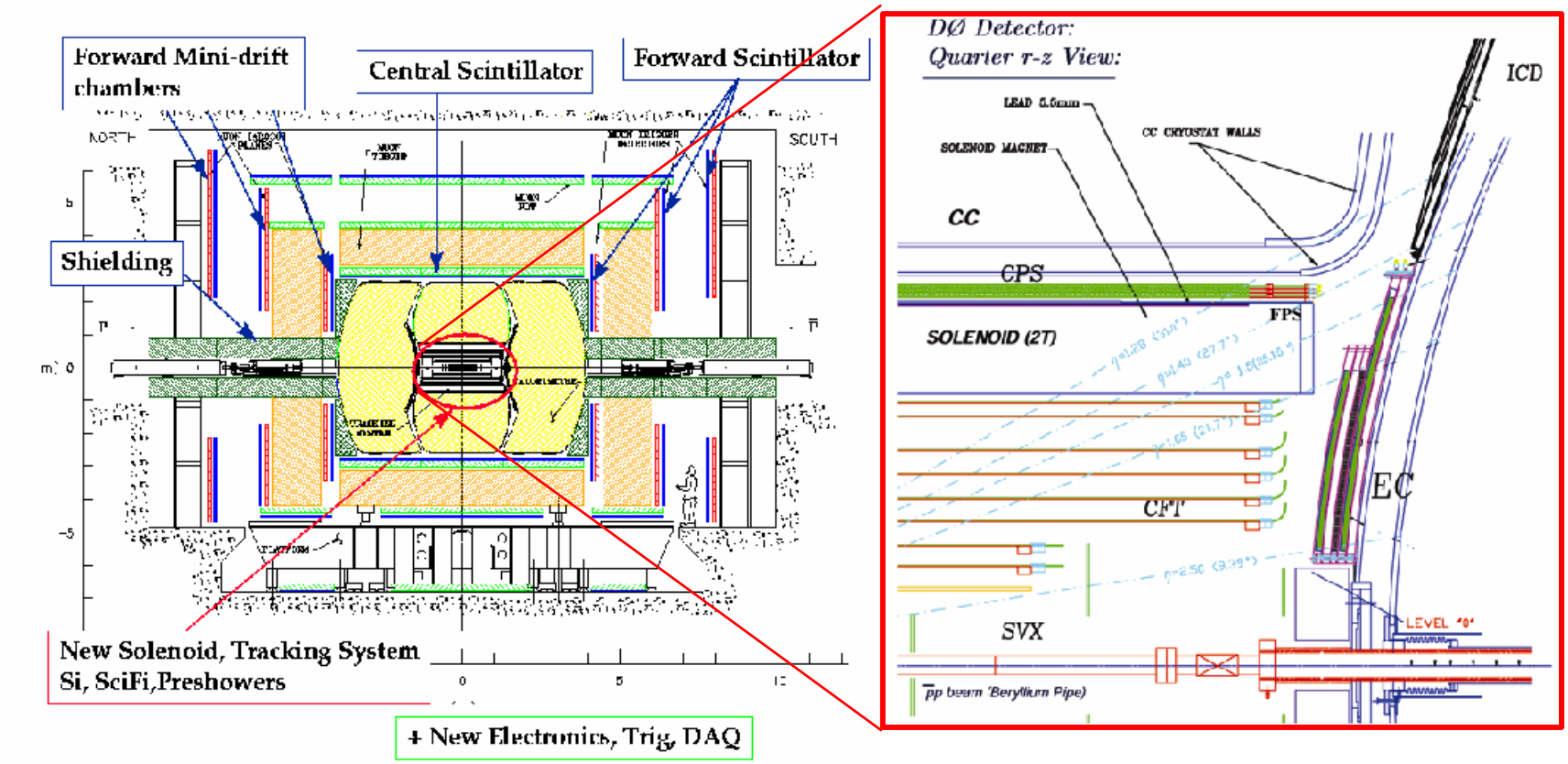
Improving present results



- as now
- back. divided by 2 (same signal effi)
- JES and btag errors divided by 2
- back. and errors divided by 2

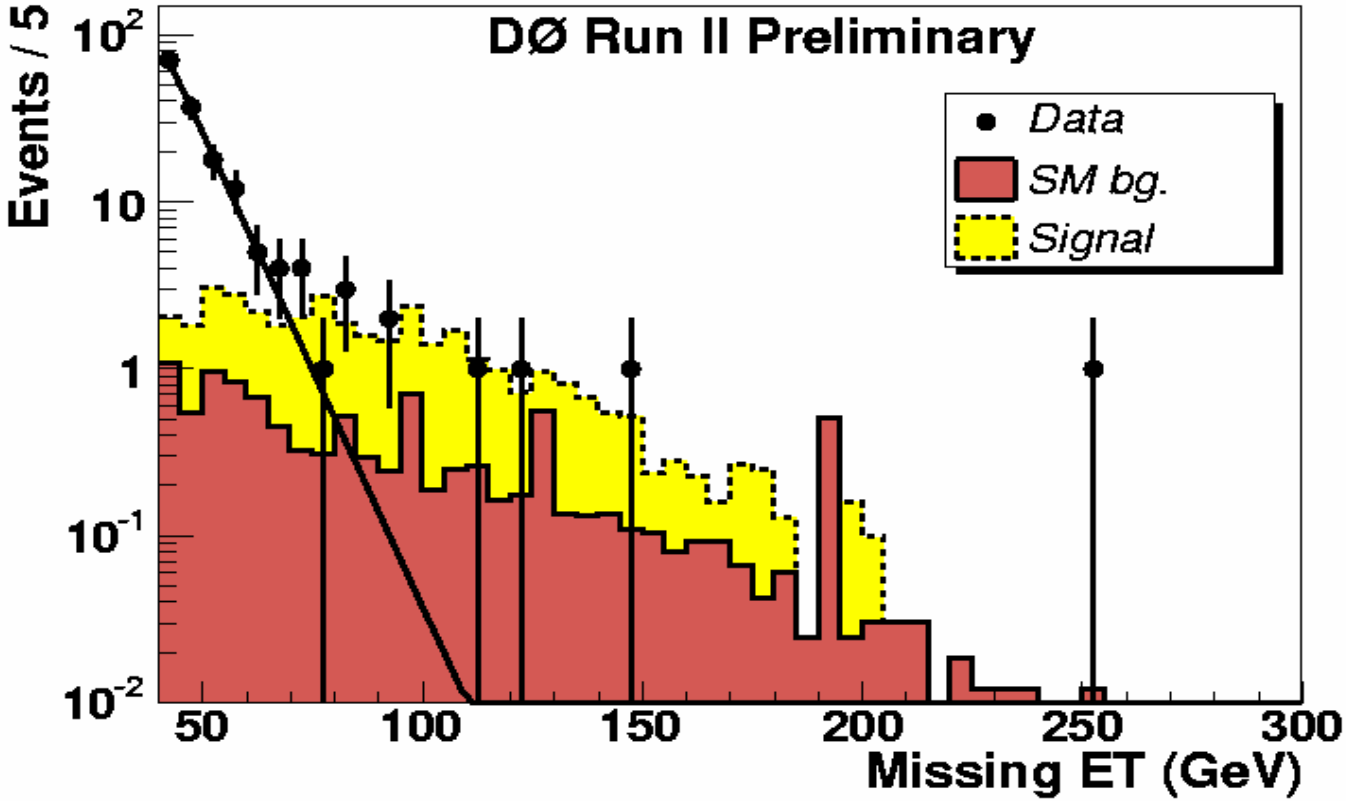


D0 upgrade



- **Solenoid (2T)**
- **Central tracker**
- **Silicon Vertex Detector**
- **Preshower**
- **Calorimeter electronic**
- **Muon forward chamber**
- **DAQ system**
- **Trigger system**

QCD in gluino search

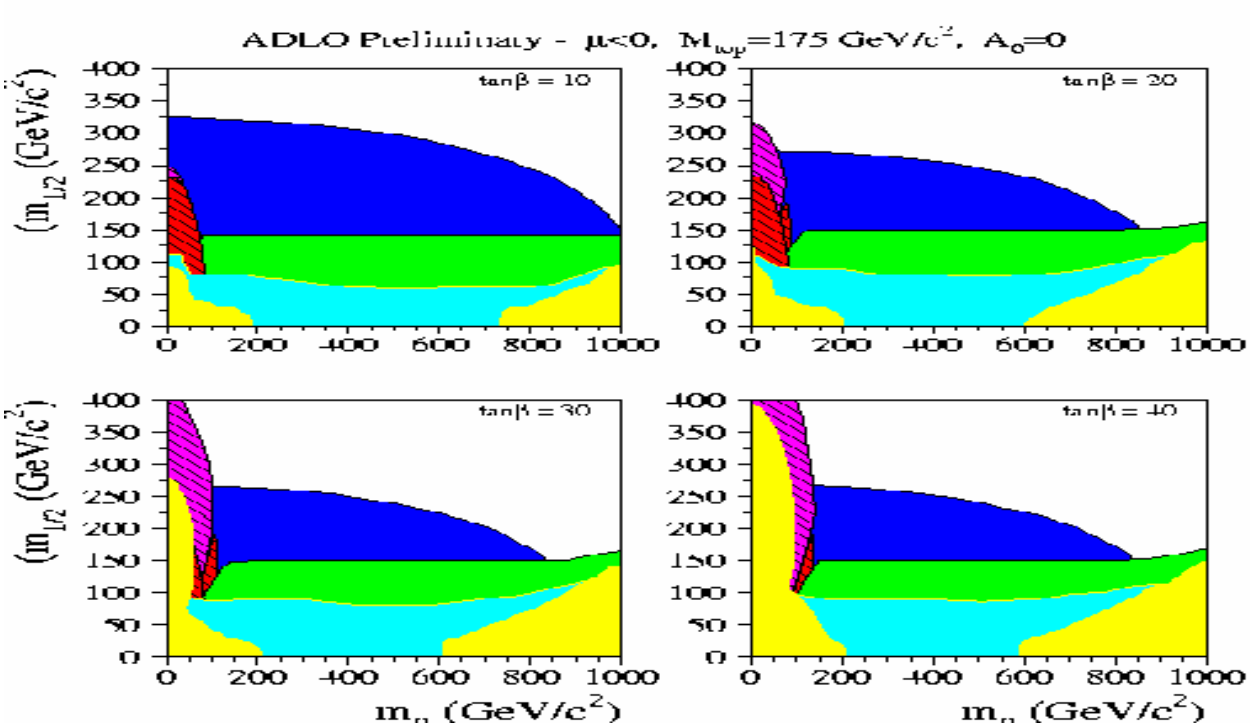


Selection of generated points

"dijet" analysis				"gluino" analysis				"3 jets" analysis			
$(m_0, m_{1/2})$	$m_{\tilde{q}}$	$m_{\tilde{g}}$	σNLO	$(m_0, m_{1/2})$	$m_{\tilde{q}}$	$m_{\tilde{g}}$	σNLO	$(m_0, m_{1/2})$	$m_{\tilde{q}}$	$m_{\tilde{g}}$	σNLO
(25,100)	227	260	9.80	(500,65)	497	203	7.72	(170,109)	290	290	2.00
(25,105)	237	270	7.32	(500,70)	500	215	5.18	(172,111)	295	295	1.75
(25,110)	248	284	5.19	(500,75)	504	228	3.24	(175,113)	300	300	1.48
(25,115)	258	296	3.88	(500,80)	507	240	2.25	(179,115)	305	305	1.27
(25,120)	268	306	2.91	(500,85)	511	251	1.57	(178,118)	310	310	1.14
(25,125)	278	319	2.17	(500,90)	514	265	1.03	(180,120)	315	315	0.99
(25,130)	288	332	1.58					(184,122)	320	320	0.85
(25,135)	297	340	1.25					(188,124)	325	325	0.74
(25,140)	308	353	0.92					(191,126)	330	330	0.64
(25,145)	318	366	0.68					(195,128)	335	335	0.55
(25,150)	328	378	0.52					(199,130)	340	340	0.48
(25,155)	337	386	0.41								
(25,160)	347	399	0.30								

LEP heritage

1:Yellow: no Minimal SUGRA solution: no EWSB or tachyonic particles;
2:Light blue: regions inconsistent with the measurement of the electroweak parameters at LEP1;
3:Green: regions excluded by chargino searches;
4:Red: regions excluded by selectron or stau standard searches;
5:Dark Blue: regions excluded by the search for hZ;
6:Brown: regions excluded by the neutralino stau cascade searches.
7:Magenta: regions excluded by the search for heavy stable charged particles applied to staus.



Mu,<0