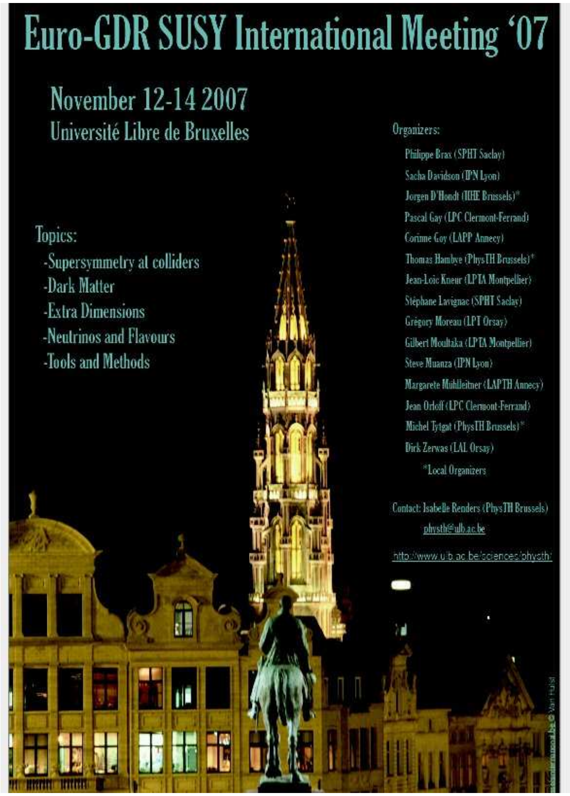
Search for Higgs-Bosons and Supersymmetry at the Tevatron

Volker Büscher

Universität Bonn



Euro-GDR SUSY International Meeting '07

November 12-14 2007
Université Libre de Bruxelles

Topics:
-Supersymmetry at colliders
-Dark Matter
-Extra Dimensions
-Neutrinos and Flavours
-Tools and Methods

Organizers:
Philippe Brax (SPHT Saclay)
Sacha Davidson (IPN Lyon)
Jorgen D'Hondt (IIHE Brussels)*
Pascal Gay (LPC Clermont-Ferrand)
Corinne Goy (LAPP Annecy)
Thomas Hambye (PhysTH Brussels)*
Jean-Loic Kneur (LPTA Montpellier)
Stéphane Lavignac (SPHT Saclay)
Grégory Moreau (LPT Orsay)
Gilbert Moultaka (LPTA Montpellier)
Steve Muanza (IPN Lyon)
Margarete Mühlleitner (LAPTH Annecy)
Jean Orloff (LPC Clermont-Ferrand)
Michel Tytgat (PhysTH Brussels)*
Dirk Zerwas (LAL Orsay)
*Local Organizers

Contact: Isabelle Renders (PhysTH Brussels)
physth@ulb.ac.be

http://www.ulb.ac.be/sciences/physth/

- The SM Higgs sector
  - indirect constraints from precision measurements
  - the search for the SM Higgs boson
- Non-minimal Higgs sectors
- Supersymmetry
  - loop corrections to precision variables: M_W, m_t
  - loop corrections to rare decays: $B_s \rightarrow \mu\mu$
  - direct searches: Squarks/Gluinos, Charginos/Neutralinos

Full set of results available at:

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

http://www-cdf.fnal.gov/physics/physics.html

The Tevatron Collider

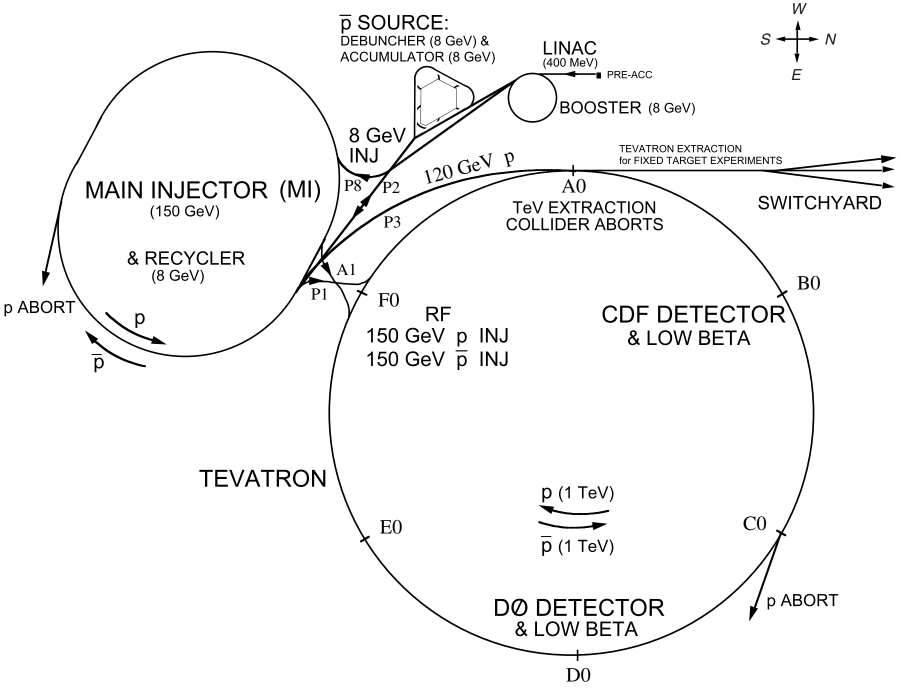
Proton Antiproton Collider

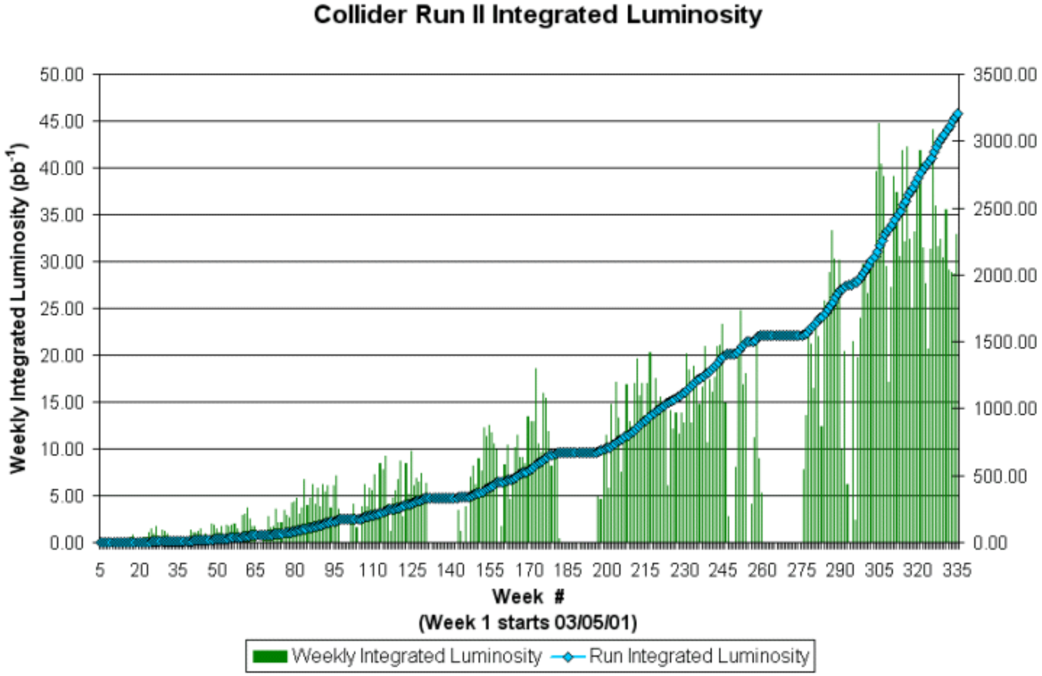
Centre-of-mass energy: 1.96 TeV

Integrated Luminosity: 3.2 fb^{-1} so far

Peak luminosity: $2.8 \times 10^{32}\ \text{cm}^{-2}\text{s}^{-1}$

Expecting to accumulate 6-9 fb^{-1} by 2009/10





Electron Cooling in operation

The Tevatron Collider

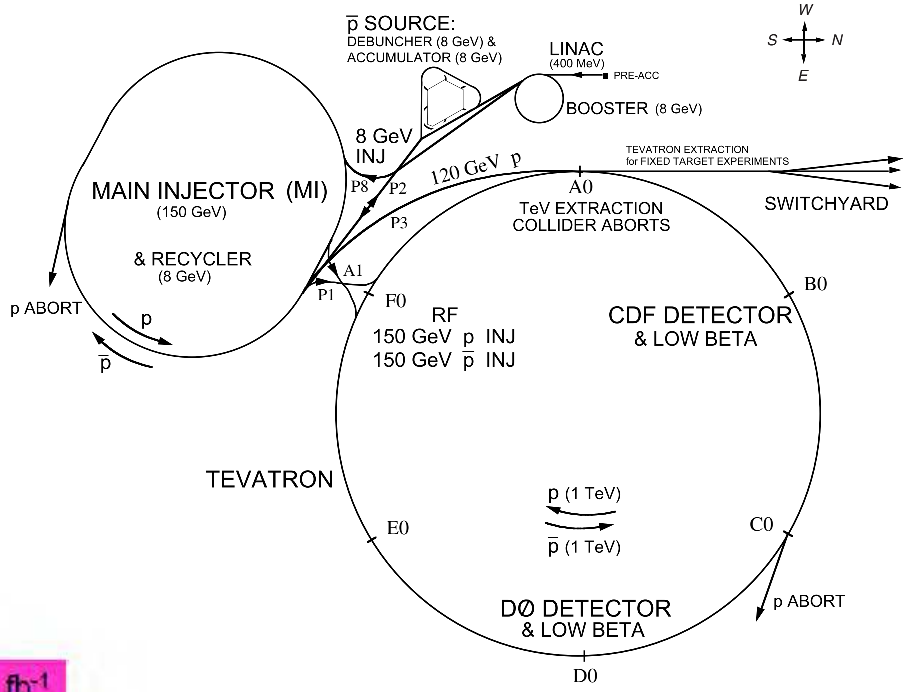
Proton Antiproton Collider

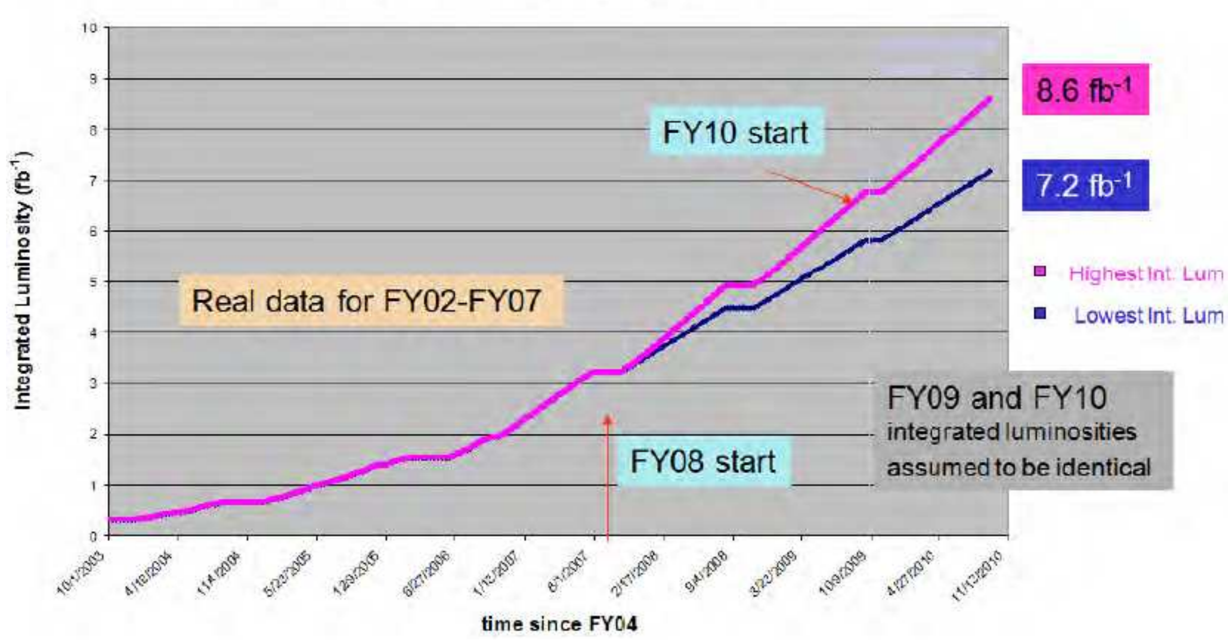
Centre-of-mass energy: 1.96 TeV

Integrated Luminosity: 3.2 fb^{-1} so far

Peak luminosity: 2.8$\times10^{32}$ cm^{-2}s^{-1}

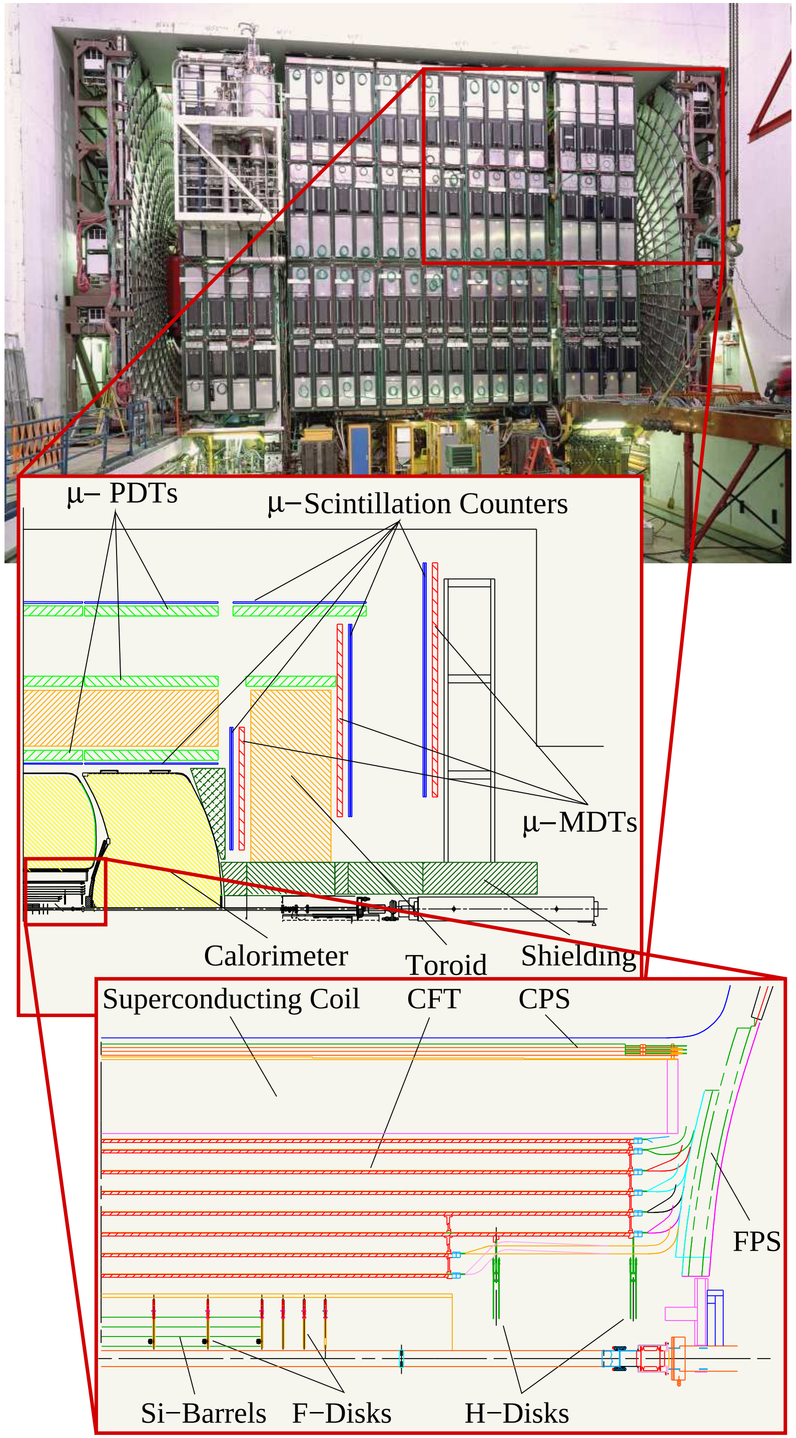
Expecting to accumulate 6-9 fb^{-1} by 2009/10





Electron Cooling in operation

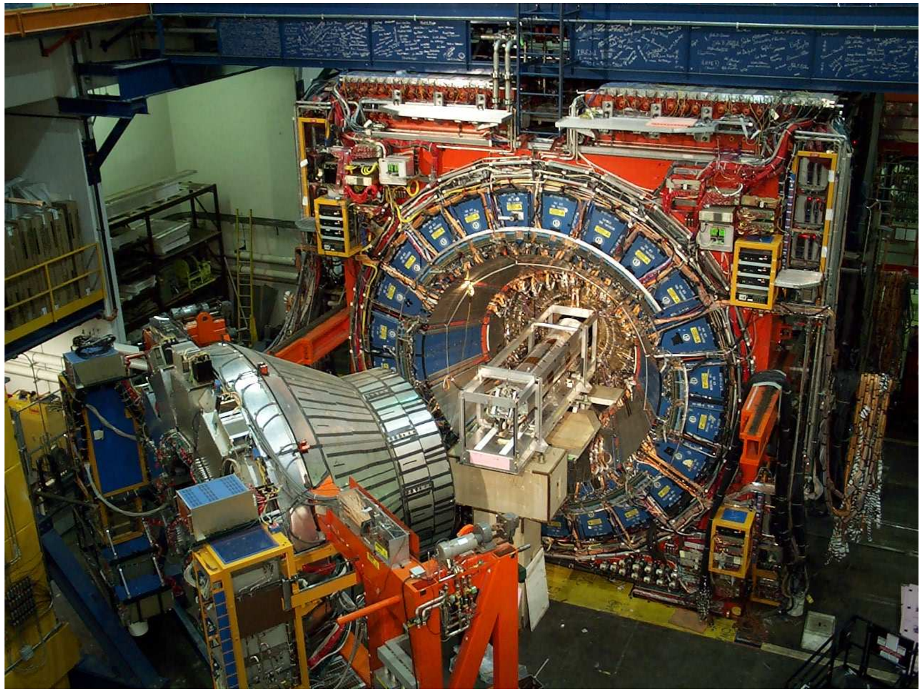
The Tevatron Experiments



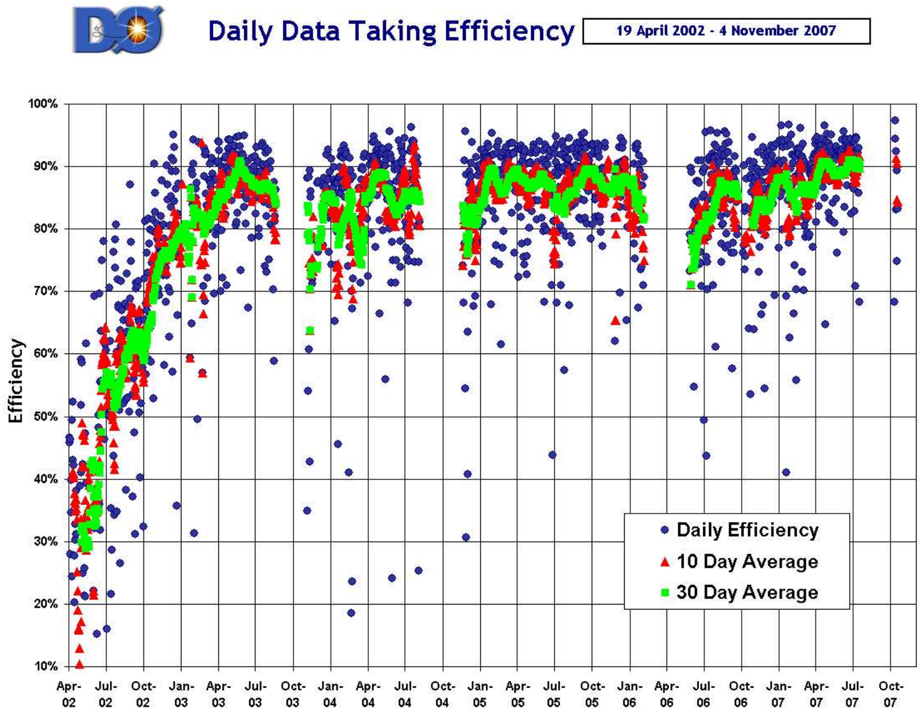
Two General-Purpose Detectors:	**CDF**	**DØ**
Electron acceptance	$\lvert\eta\rvert < 2.0$	$\lvert\eta\rvert < 3.0$
Muon acceptance	$\lvert\eta\rvert < 1.5$	$\lvert\eta\rvert < 2.0$
Silicon Precision tracking	$\lvert\eta\rvert < 2.0$	$\lvert\eta\rvert < 3.0$
Hermetic Calorimeter	$\lvert\eta\rvert < 3.6$	$\lvert\eta\rvert < 4.2$

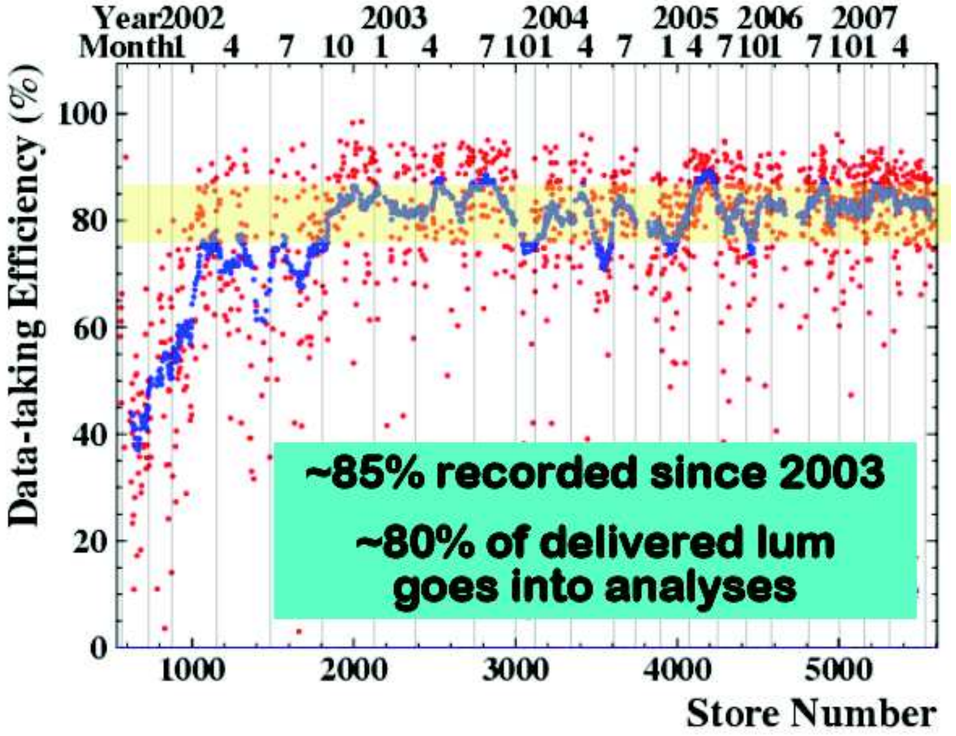
Powerful trigger systems (2.5 MHz→100 Hz)

- Dilepton triggers starting at $p_T > 4$ GeV
- Jets+$\not{E}_T$ triggers with $\not{E}_T > 25$ GeV



The Tevatron Experiments – Data-Taking Efficiencies



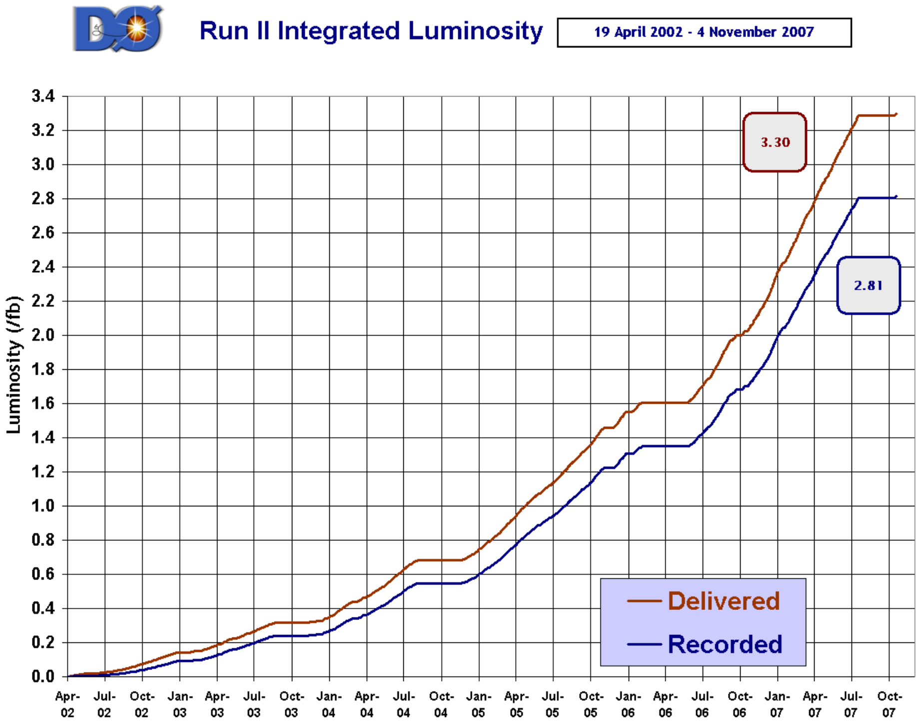


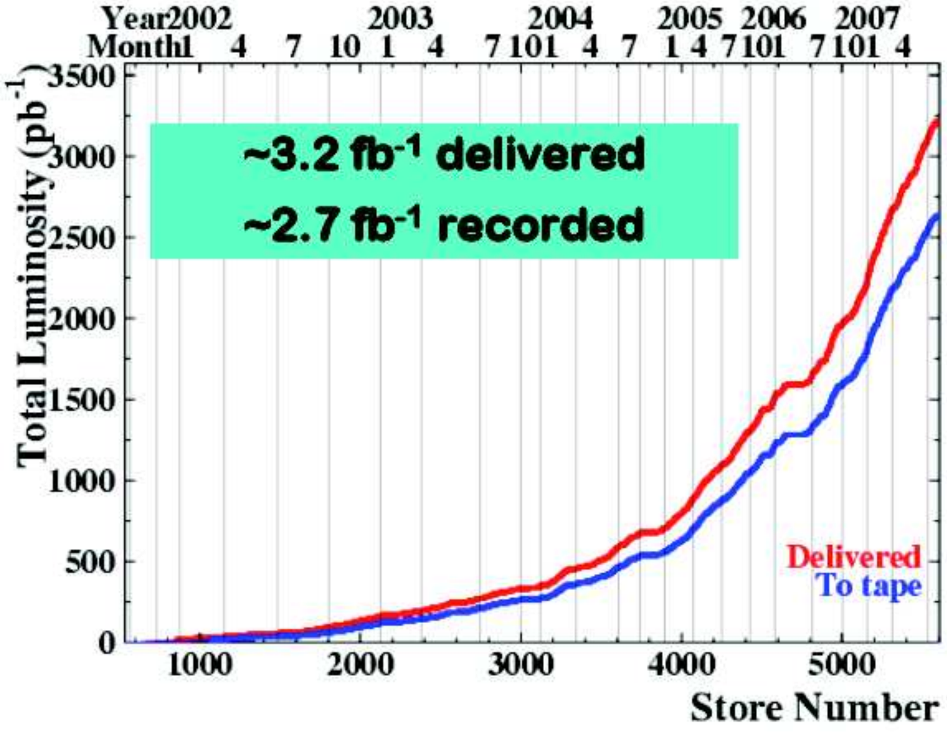
~85% recorded since 2003

~80% of delivered lum goes into analyses

- Experiments operating stably at average efficiencies of 80–85%

The Tevatron Experiments – Datasets





- **2.8 + 2.7 fb^{-1} recorded by DØ + CDF**
- **Most results presented here based on 1–2 fb^{-1}**

Physics at the Tevatron

Tevatron: Proton-Antiproton Collider at $\sqrt{s}=1.96$ TeV, collisions every 396 ns

- **Advantage: High centre-of-mass energy**

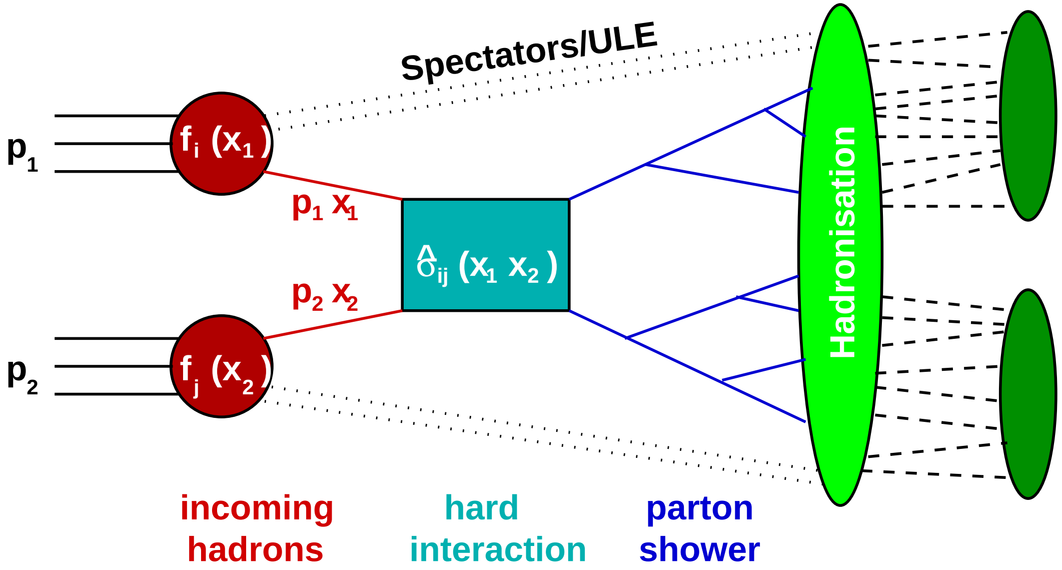
  → production of massive particles (LEP: m $\lesssim$ 100 GeV)

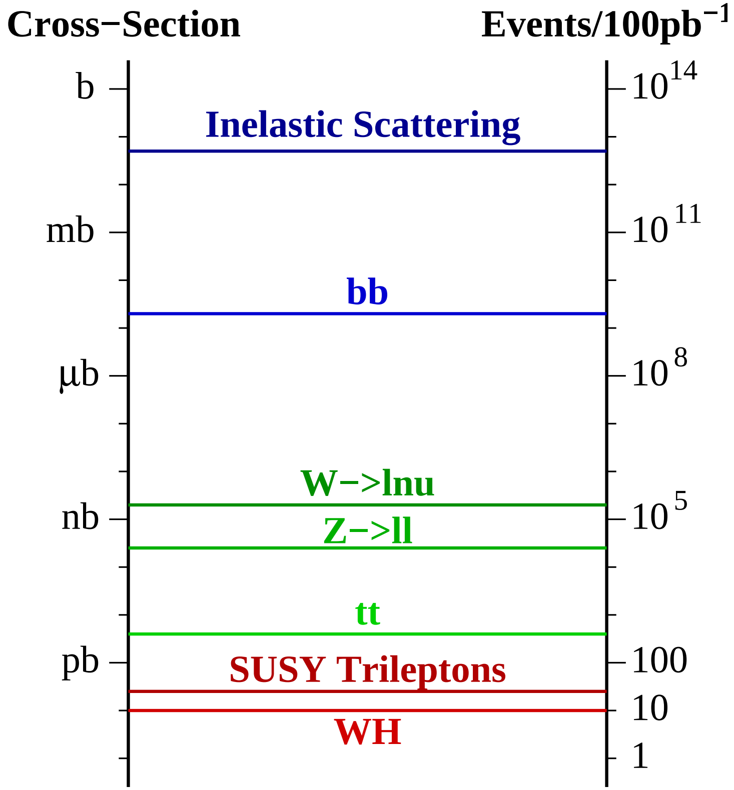
- **Disadvantage: Strong Interaction**

  → huge event rates for jet production

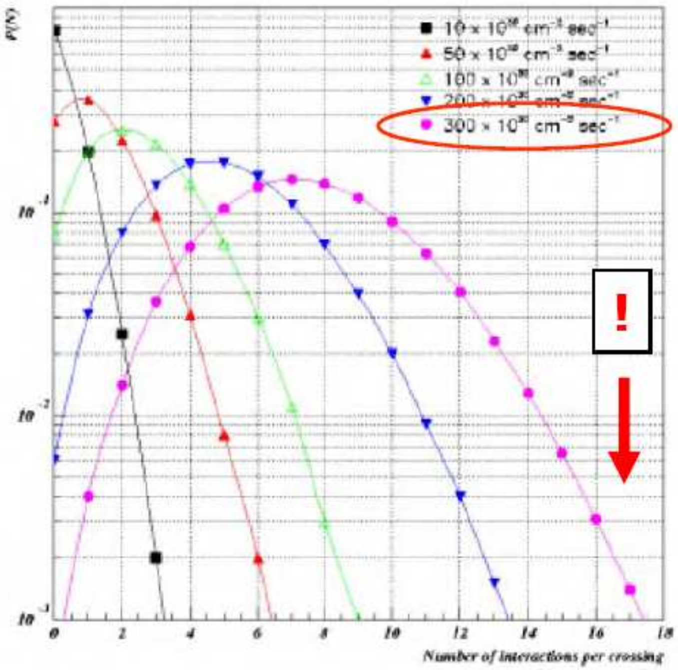
  → multiple interactions per crossing

  → complicated final states:
    - particles from fragmentation of $p/\bar{p}$ remnants
    - gluon radiation → jets

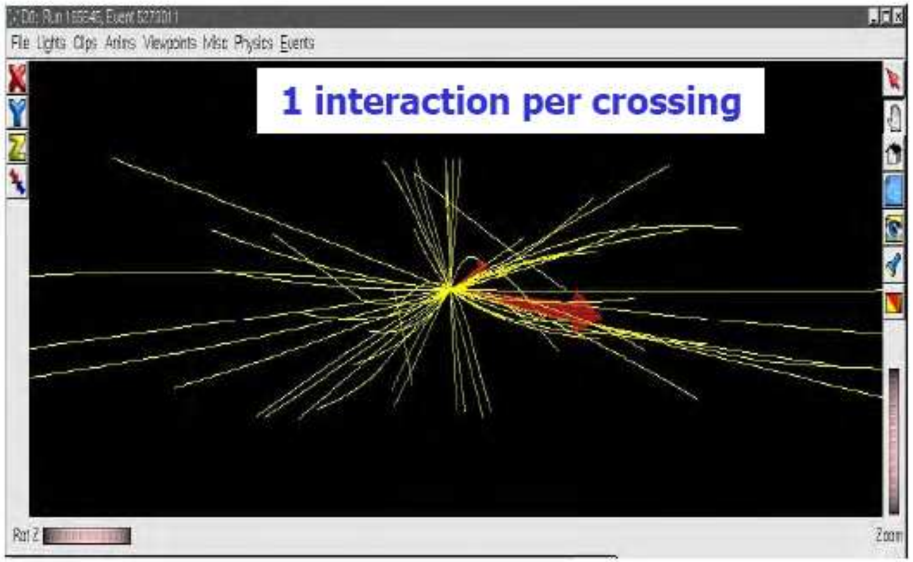




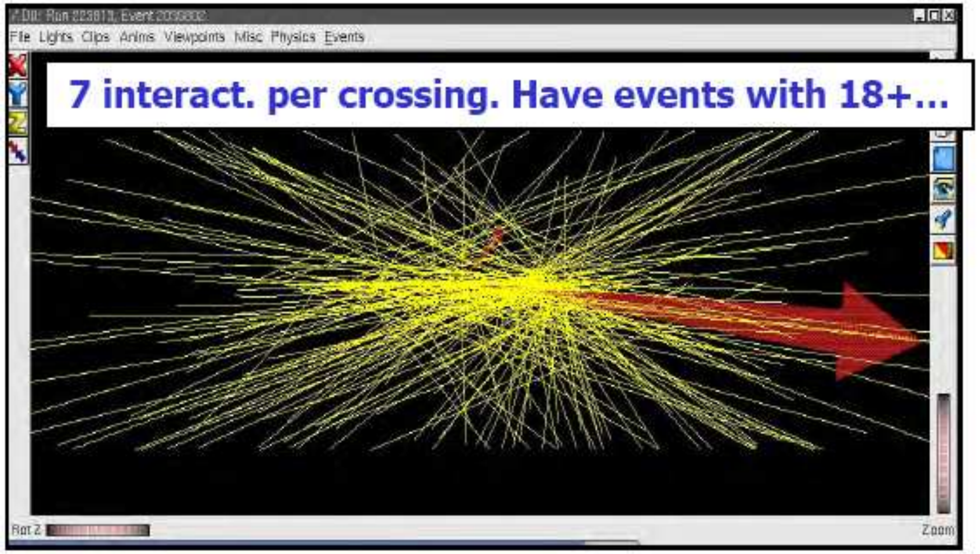
Experimental Challenges – High-Lumi Running



- Highest-Lumi runs: average 7 interactions/crossing
- Tails extend to 18 interactions/crossing!
- Operating well beyond original design:
  inner layer DØ CFT running at occupancy>30% !!!
- After detector/trigger/reconstruction upgrades:
  stable efficiencies with minimal loss vs. inst. lumi



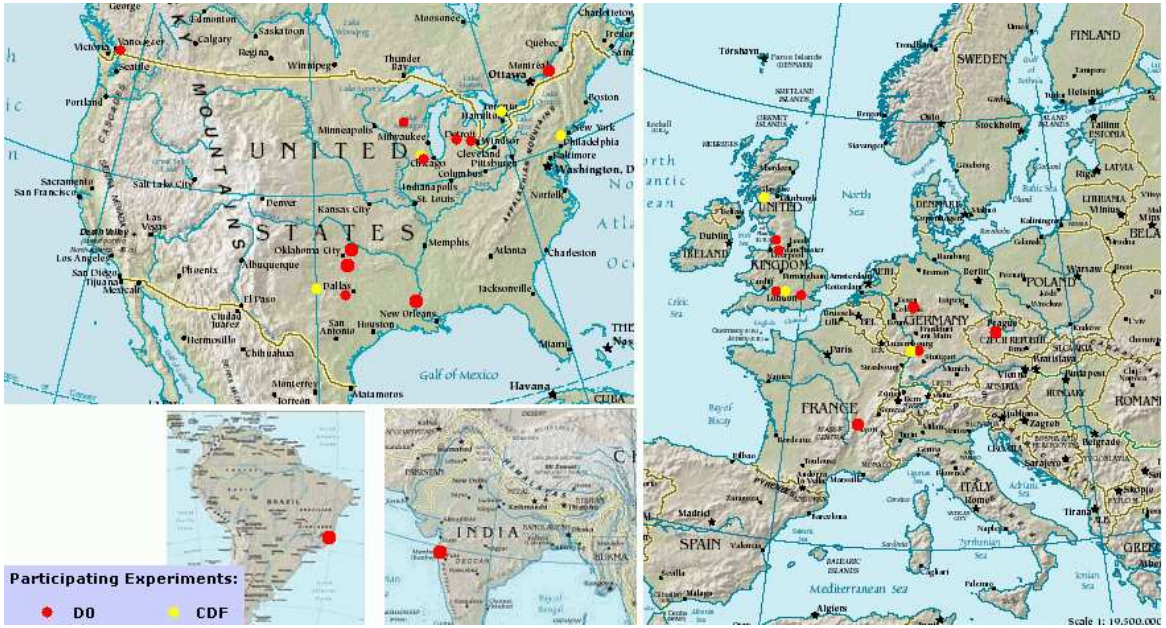
1 interaction per crossing

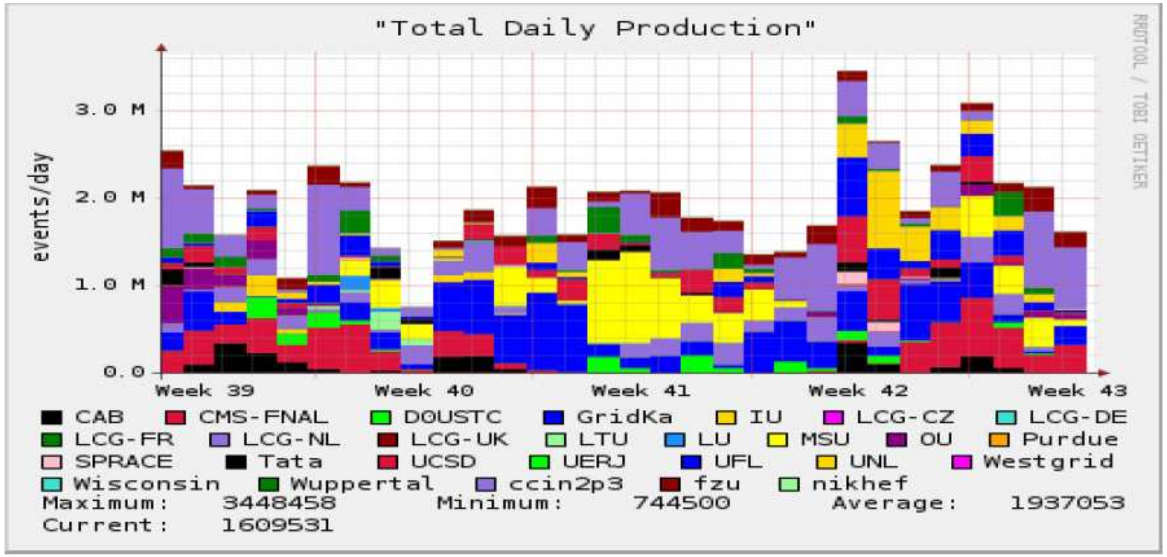


7 interact. per crossing. Have events with 18+...

Experimental Challenges – Computing

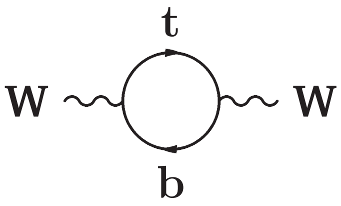
- DØ User Analysis: peaks of 35 Billion Events per month
- DØ MC Production: 2–3 Million fully simulated Events produced per day (on the GRID)



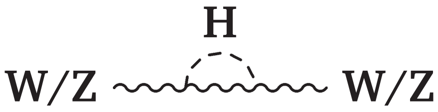


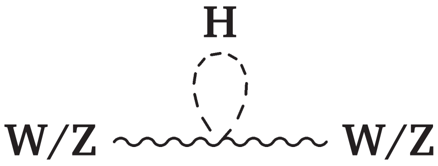
Pinning down EWSB at the Tevatron

Standard Model relates m_H, m_t, m_W via radiative corrections:

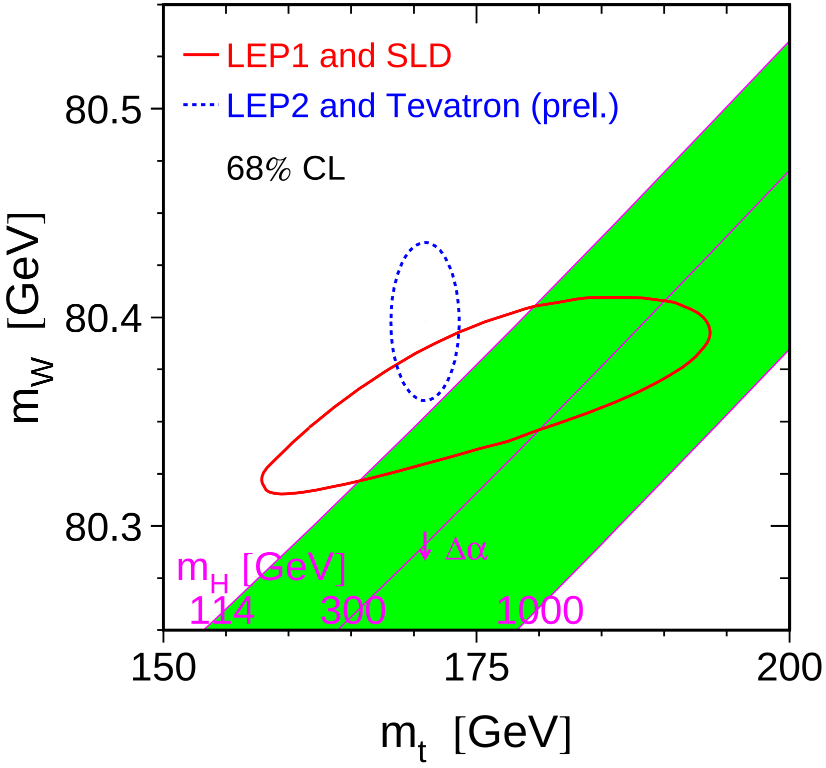


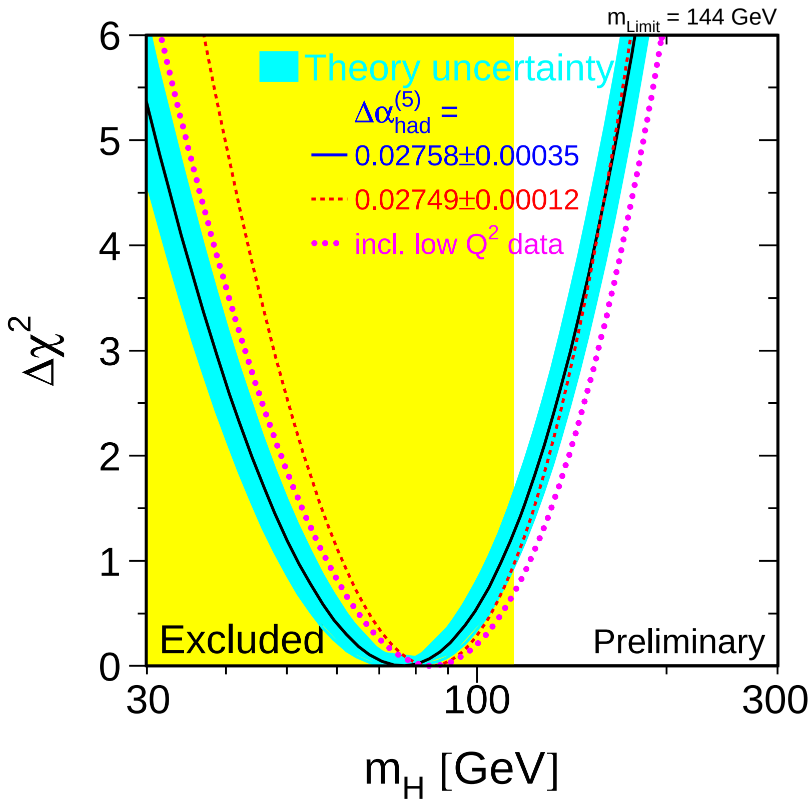
$\sim m_{\mathrm{top}}^2$





$\sim \ln \frac{m_{\mathrm{H}}}{m_{\mathrm{W}}}$

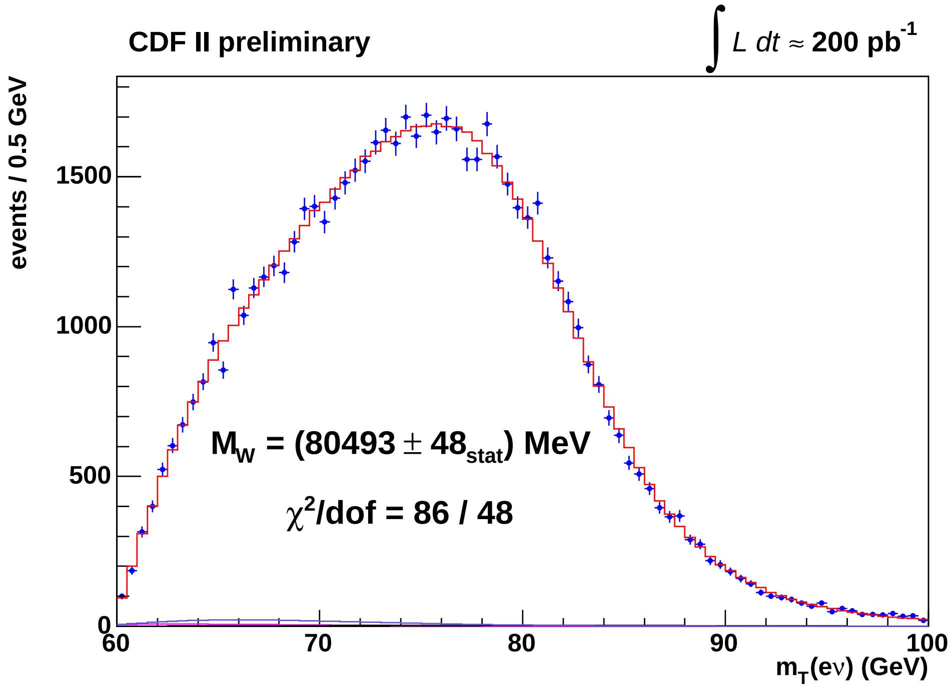


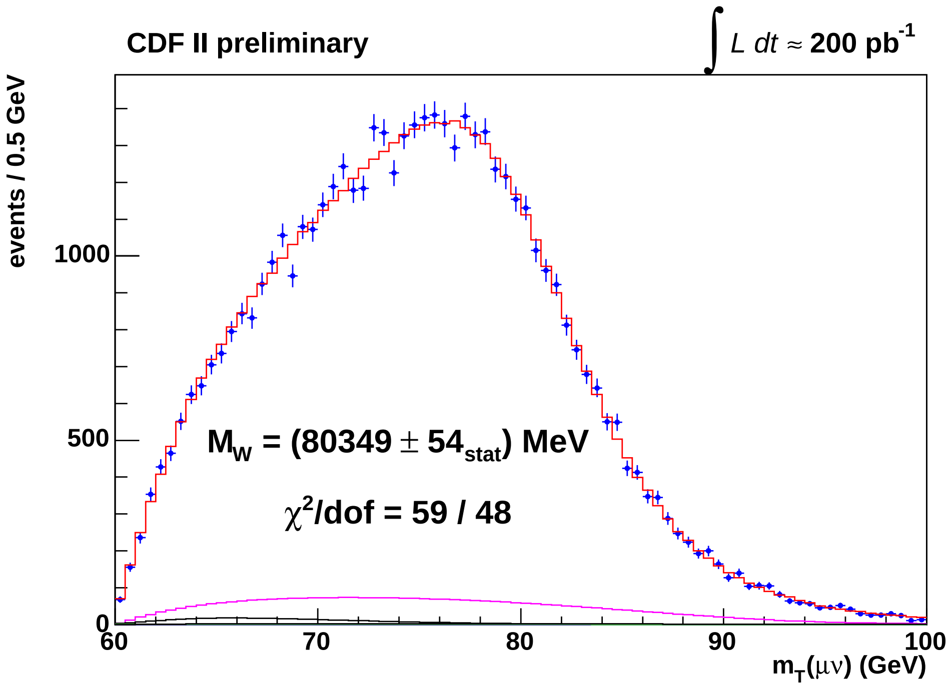


→ Indirect constraints on Higgs boson mass:

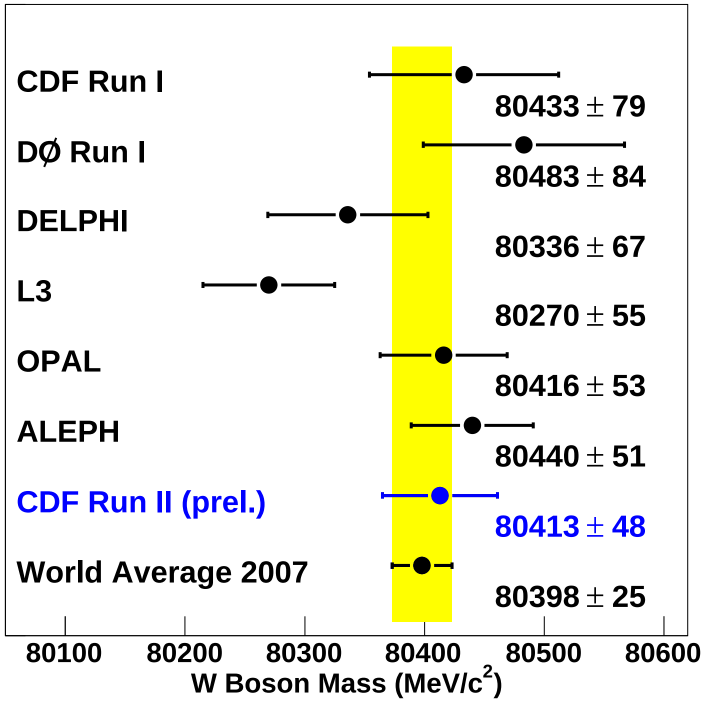
$m_H = 76^{+33}_{-24}$ **GeV and** $m_H < 144$ **GeV at 95% C.L.**

W Mass





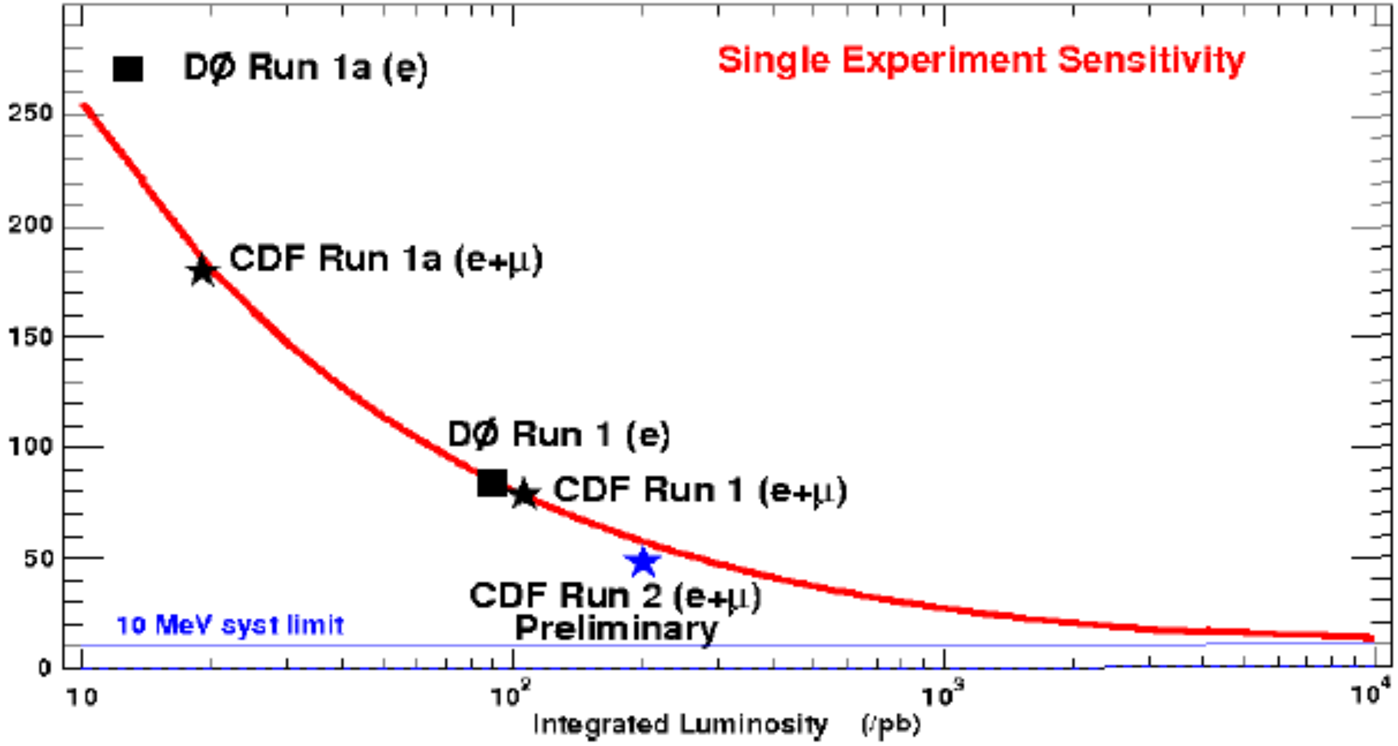
- First Run II measurement now available
- Single most precise measurement todate
- Error on world average reduced by 14%



W Mass

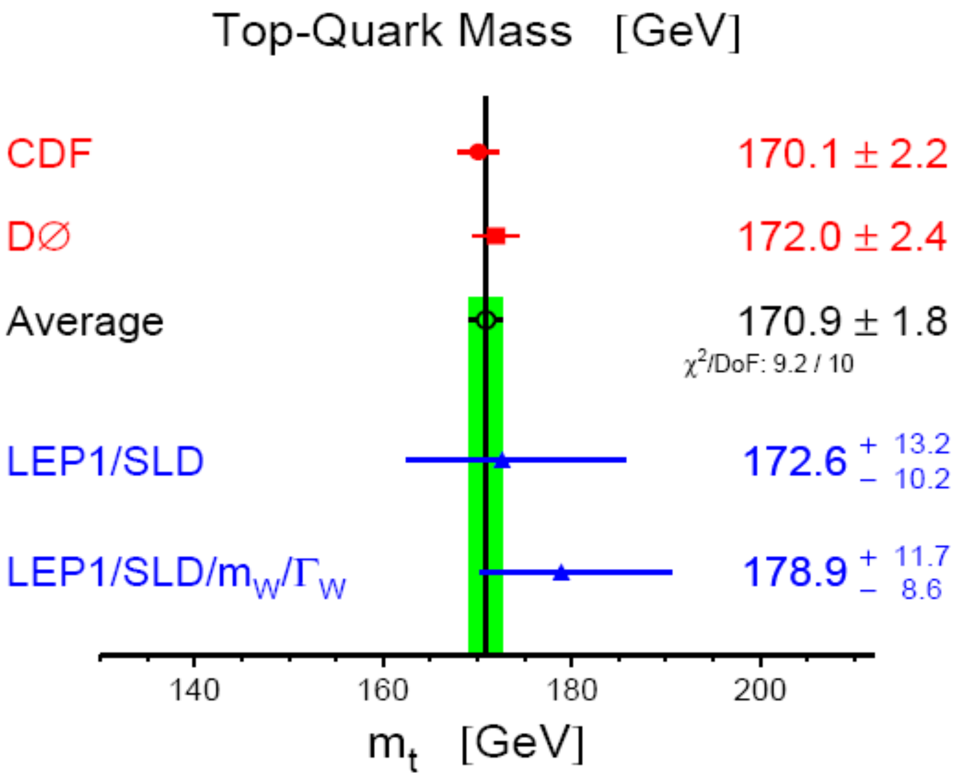
m_T Systematic (MeV)	Electrons	Muons	Common
Lepton Scale	30	17	17
Lepton Resolution	9	3	0
Recoil Scale	9	9	9
Recoil Resolution	7	7	7
Lepton Removal	8	5	5
Backgrounds	9	9	0
$p_T(W)$ model	3	3	3
Parton Distributions	11	11	11
QED radiation	11	12	11
Total Systematic	39	27	26
Statistical	48	54	0
Total Uncertainty	62	60	26

- extremely challenging measurement
- huge effort to calibrate and model momentum and energy scale
- CDF projection: 15-20 MeV with full dataset



Top Quark Mass

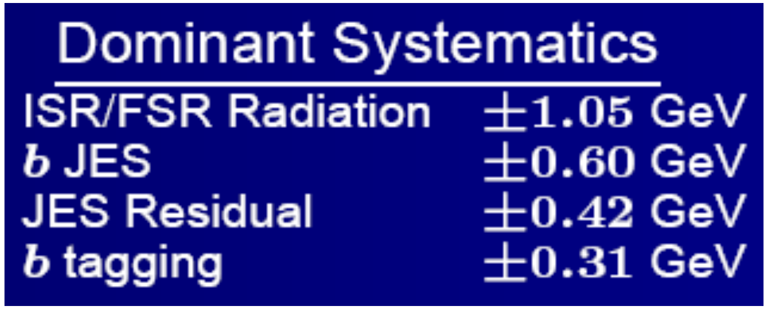
New Tevatron combined measurement: $m_t = 170.9 \pm 1.8$ GeV



Measurements in all channels are consistent:

all-hadronic:	**172.2**	**±**	**4.1**	**GeV**
lepton + jets:	**171.2**	**±**	**1.9**	**GeV**
dilepton	**163.5**	**±**	**4.5**	**GeV**

Top Quark Mass

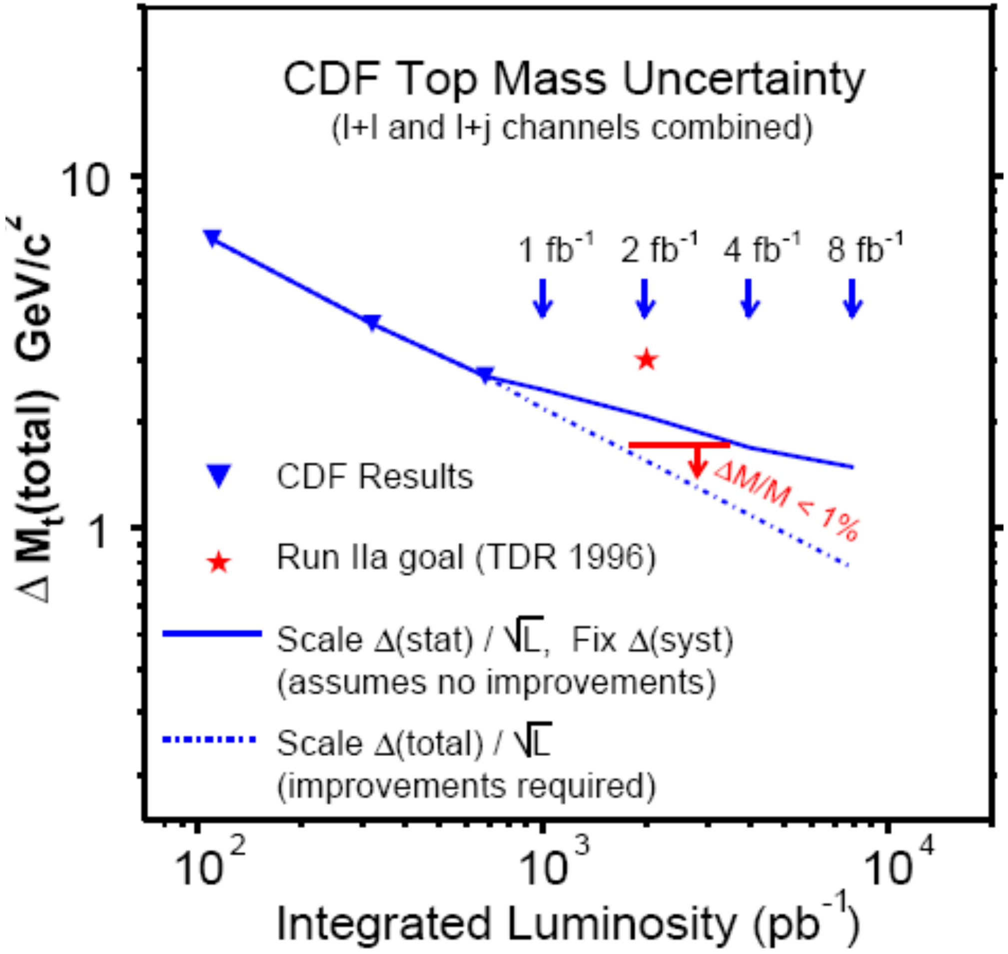


Dominant Systematics	
ISR/FSR Radiation	±1.05 GeV
b JES	±0.60 GeV
JES Residual	±0.42 GeV
b tagging	±0.31 GeV

(CDF l+jets)

Dominant Systematics	
Relative *b*/light JES	±0.57 GeV
b fragmentation	±0.54 GeV
Signal Fraction	$^{+0.53}_{-0.24}$ GeV
Signal Modeling	±0.45 GeV

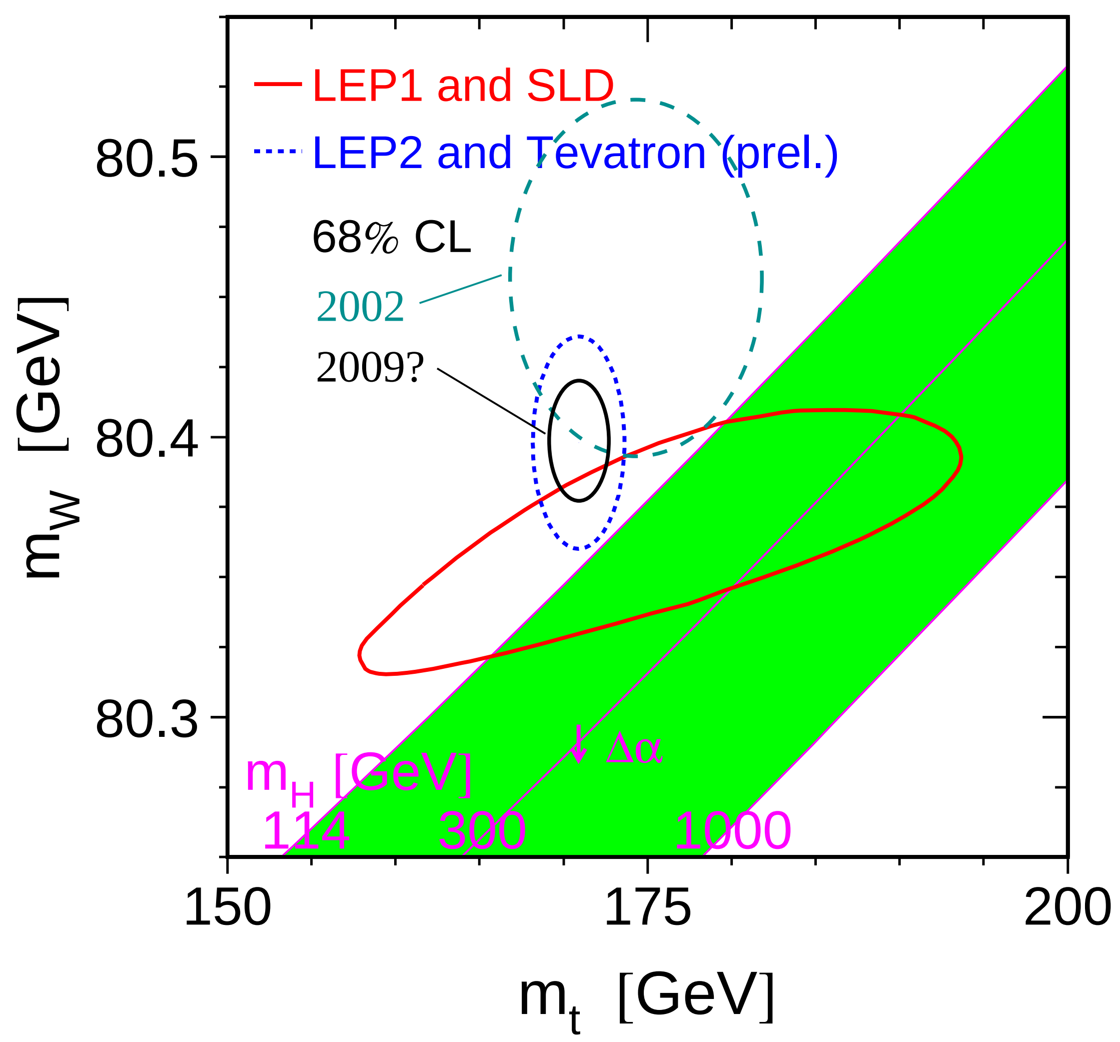
(DØ l+jets)



Major effort underway to reach an ultimate Run II precision of close to 1 GeV

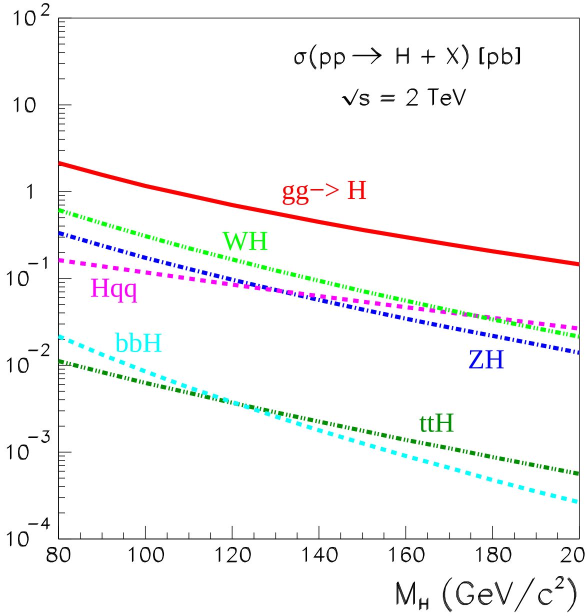
Pinning down EWSB at the Tevatron

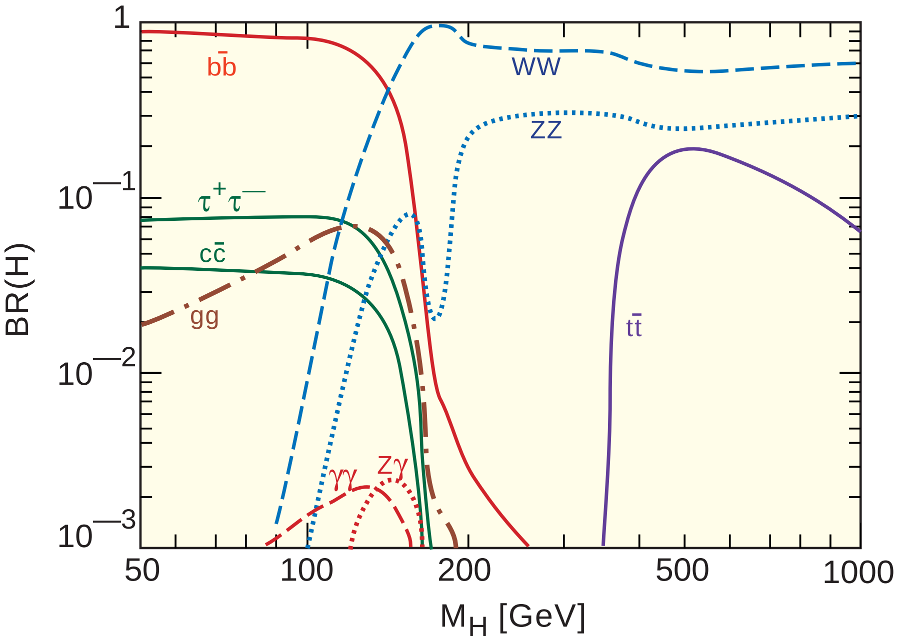
Projected uncertainties for 8 fb^{-1}: Top mass ±1.2 GeV and W mass ±15-20 MeV



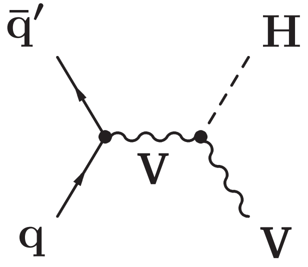
Great interest in confronting precision measurements with direct searches for Higgs boson

Search for Higgs Bosons – Production and Decay


Production Cross-Sections


Branching Ratios

Light Higgs bosons ($m_H \lesssim 135$ GeV):



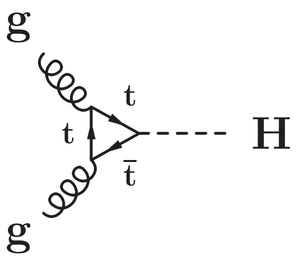
Dominant decay mode: H⟶b$\bar{\text{b}}$

Production: in association with W,Z

⟶ leptonic W,Z-decays provide best signature

⟶ b-tagging to suppress background from W/Z+jets

Heavy Higgs bosons ($m_H \gtrsim 135$ GeV):



Dominant decay mode: H⟶WW

Production: Gluon-Gluon Fusion

⟶ relatively high cross-section

⟶ clean 2-lepton+$\not\!\!E_T$ signature via H⟶WW⟶$l\nu l\nu$

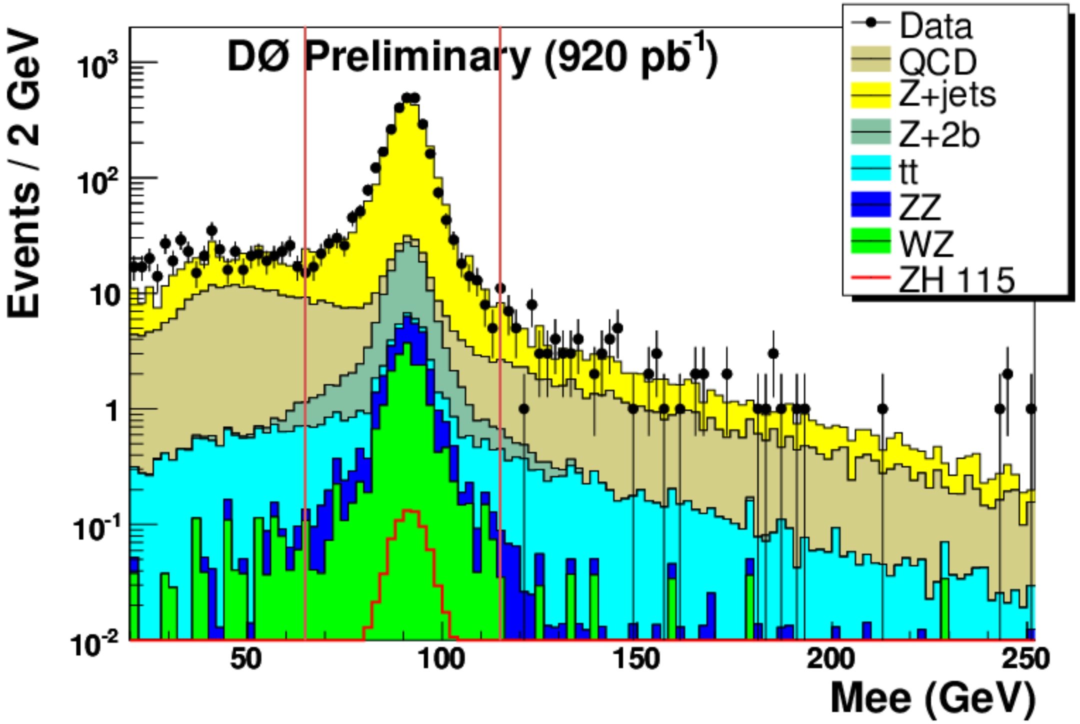
Search for low-mass Higgs Boson

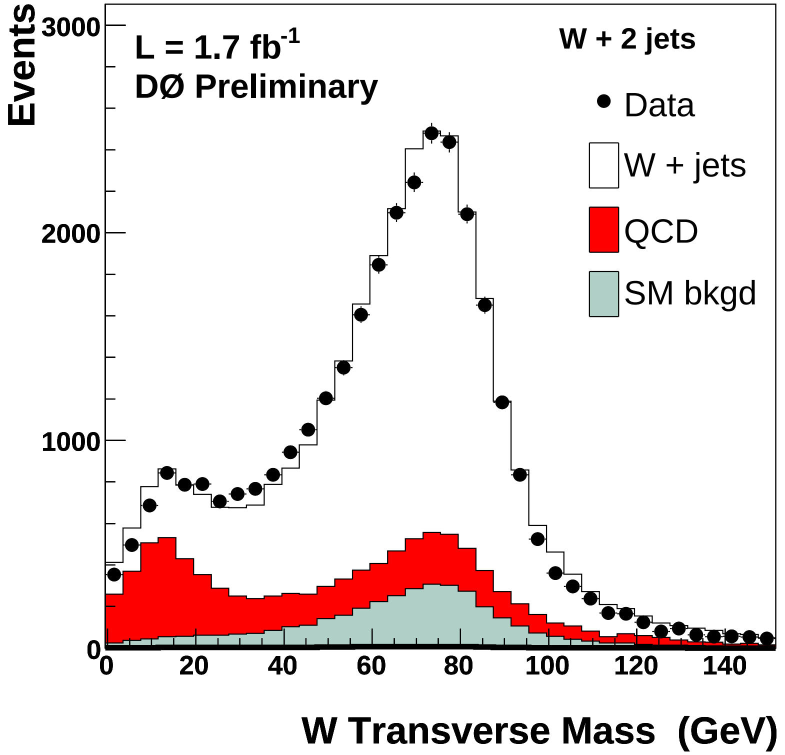
For best sensitivity, need to combine many channels:

$$WH \to \ell\nu \mathrm{b\bar{b}},\ ZH \to \nu\bar{\nu}\mathrm{b\bar{b}},\ ZH \to \ell^{+}\ell^{-}\mathrm{b\bar{b}}\ \text{(with } \ell\text{=e,}\mu\text{)}$$

Challenge: very low signal rates, massive backgrounds from V+jets

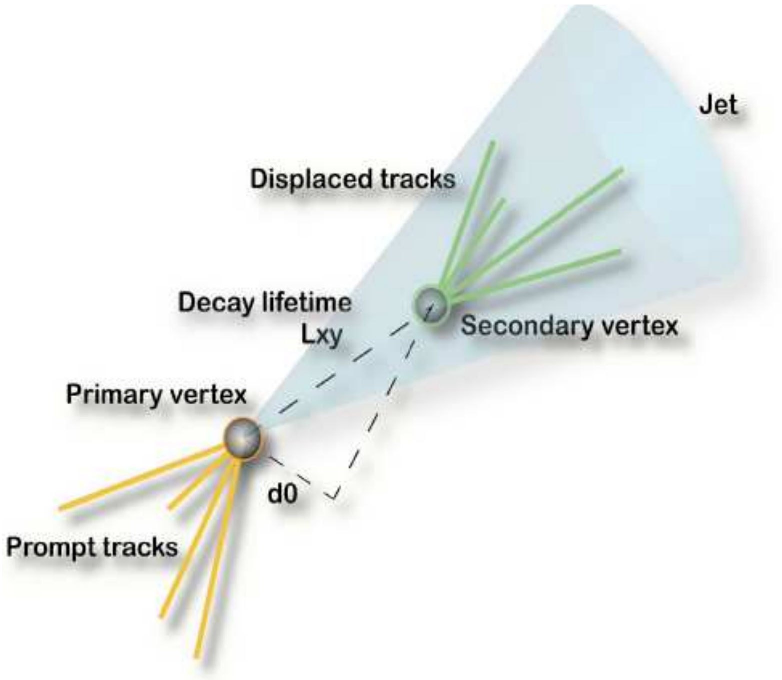
First step: select events consistent with W/Z+2 jets





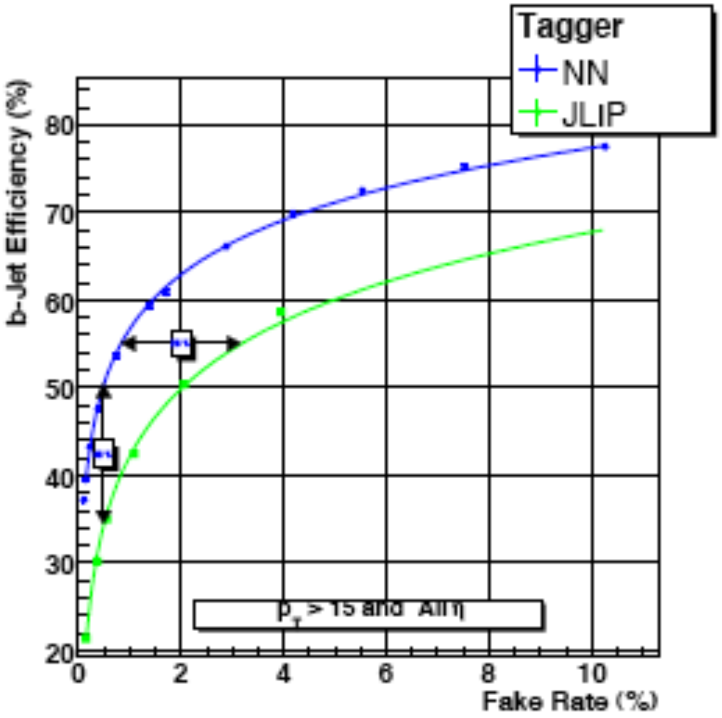
Search for low-mass Higgs Boson

Second step: b-tagging



Exploiting B-meson lifetime, mass and decay modes to separate b- from light-quark jets:

- impact parameter
- secondary vertices
- vertex mass
- vertex track multiplicity
- soft leptons

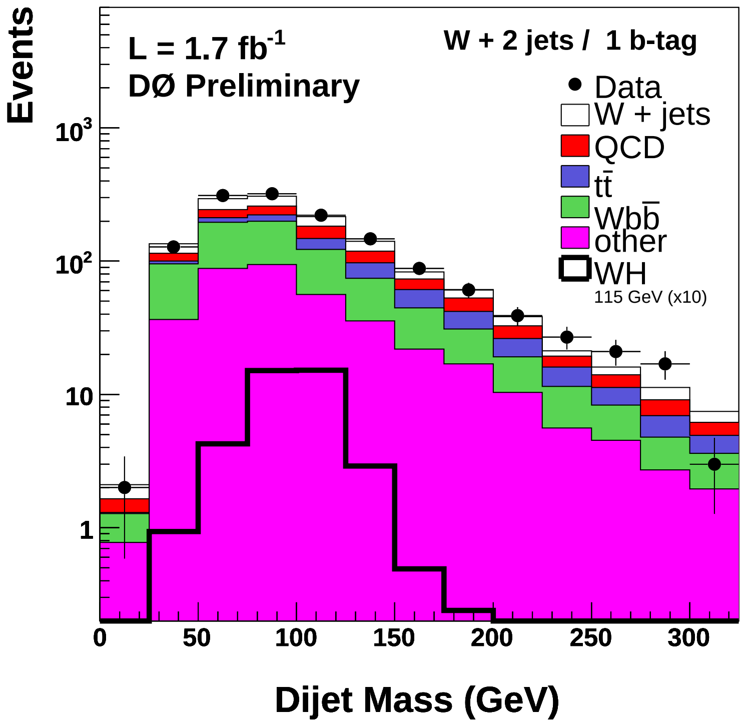


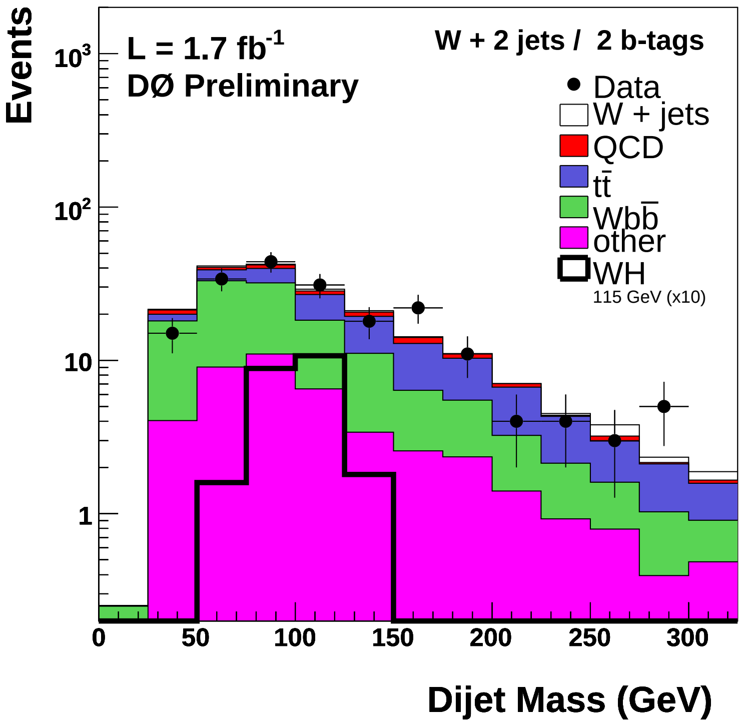
Similar strategies in both experiments:

- use neural networks for optimal combination of tagging information
- use several NN operating points to define channels with high/low s/b:
  - 1 tight b-tag (low s/b, “single tag”),
  - 2 loose b-tags (high s/b, “double tag”)

Search for low-mass Higgs Boson

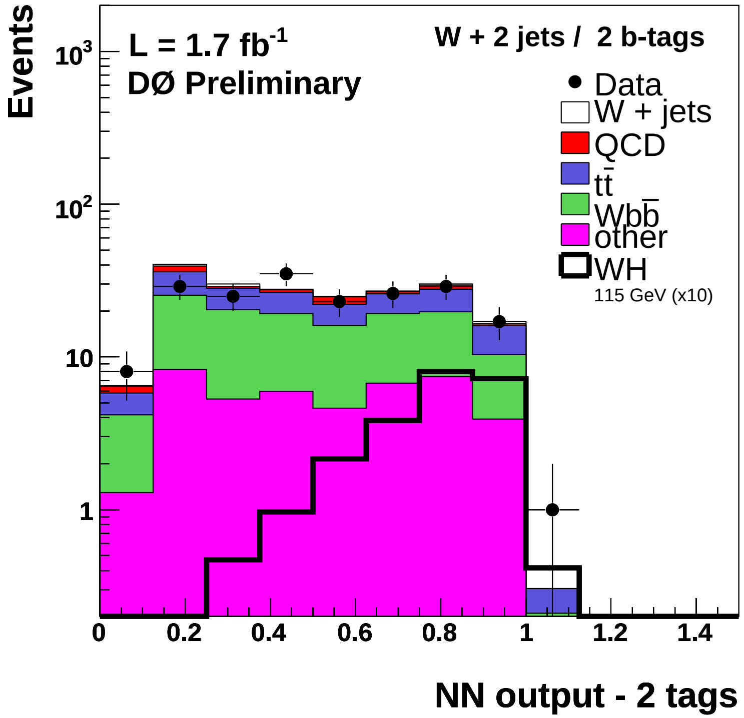
- Backgrounds dominated by W/Z+bb, $t\bar{t}$
- Main handle: invariant mass of two b-jets

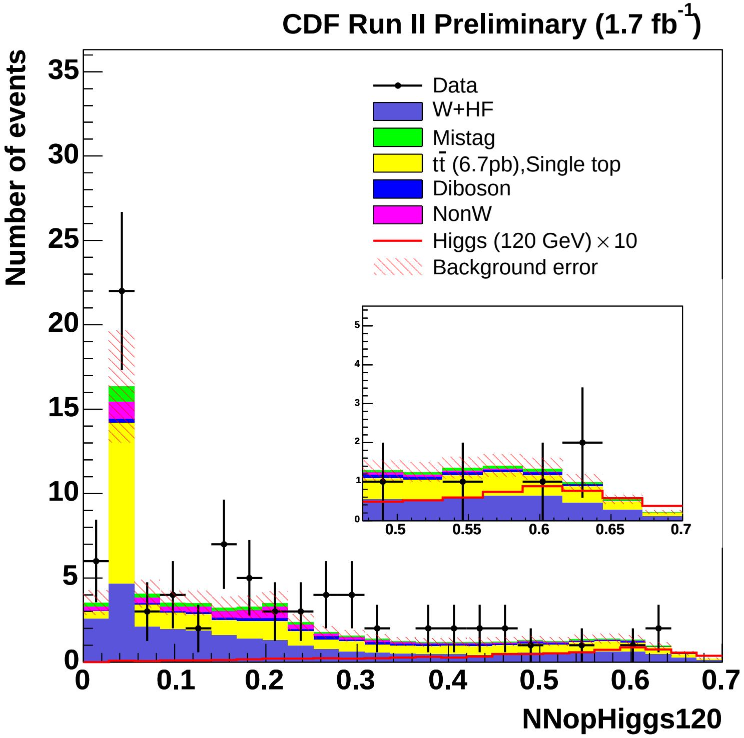




Search for low-mass Higgs Boson

- For optimal separation power, use neural networks:





Note: signal-to-background ratios are at most 10-20%

→ need full combination of all channels to reach sensitivity

→ need to control systematics at a level ≪10%!

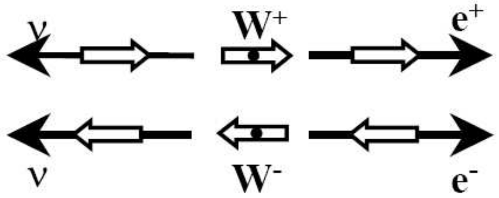
Main concern: modeling of V+jets backgrounds

- shapes: from MC (alpgen, MCFM, CKKW)
- normalisation: combination of (N)NLO cross-sections and sideband-fitting

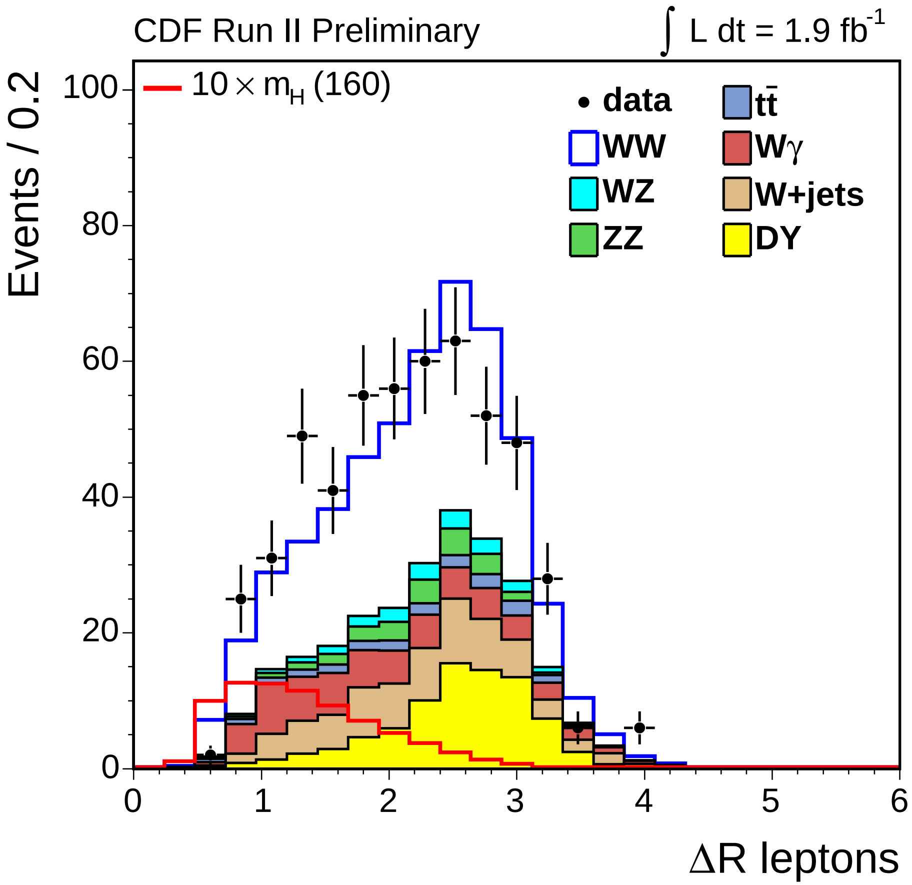
Search for high-mass Higgs Boson: $H\longrightarrow WW$

Main irreducible background: $WW\longrightarrow \ell\nu\ell\nu$

Additional information: angular correlations exploiting spin of Higgs boson



→ Charged leptons from Higgs decay tend to have small opening angle $\Delta\Phi$



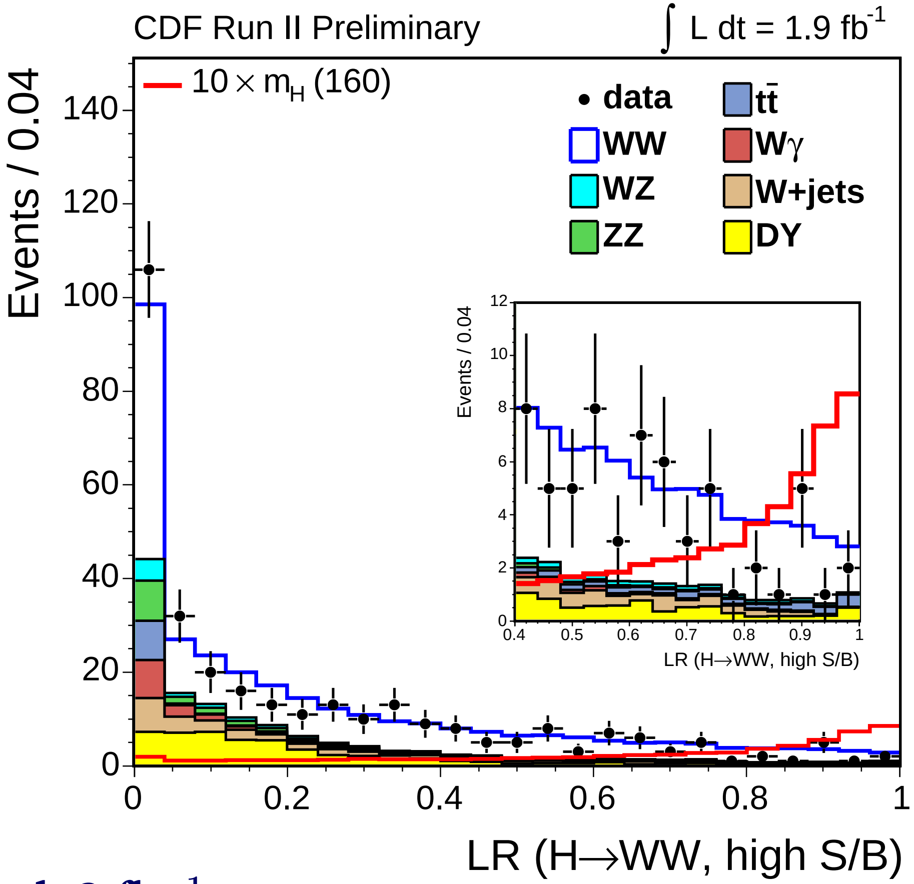
For best sensitivity, use multivariate techniques

Search for high-mass Higgs Boson: H⟶WW

- For each event, use full kinematic information x_{obs} to calculate probabilities that event comes from signal (P_H) and background (P_B):

$$P_{H/B}(x_{obs}) = \frac{1}{\sigma_{H/B}} \int dy^{n}_{true}\, \sigma^{theory}_{H/B}(y_{true})\, \epsilon(y_{true})\, G(x_{obs}, y_{true})$$

- Then calculate likelihood ratio $\frac{P_H}{P_H+P_B}$ for optimal separation of signal and background:

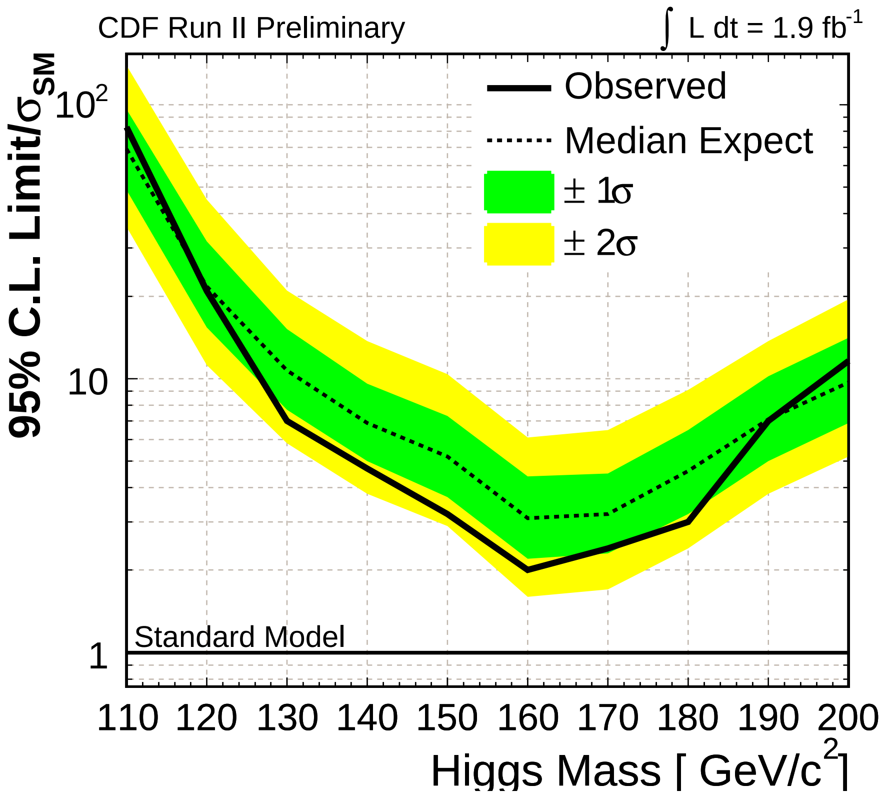


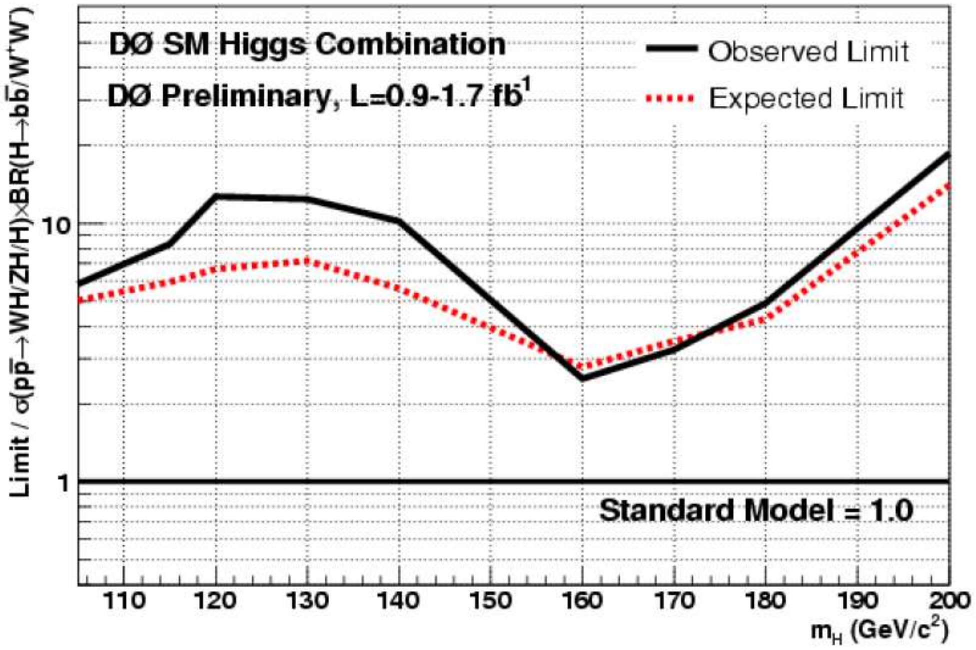
CDF, “high s/b” channel, 2 fb^{-1}:

expect 1.6 Higgs events (m_H=160 GeV) on top of 6 background events!

Search for high-mass Higgs Boson: H⟶WW

Results from CDF (2 fb^{-1}) and DØ (1–1.7 fb^{-1}):

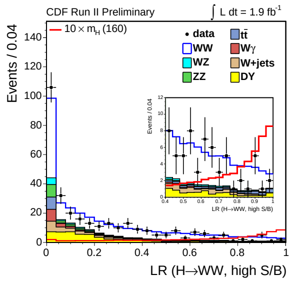


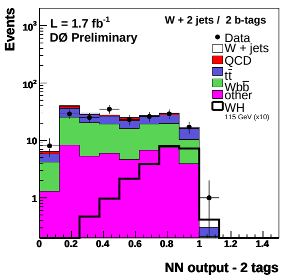


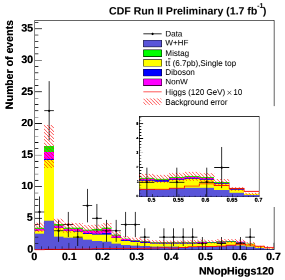
Tevatron Full Combination

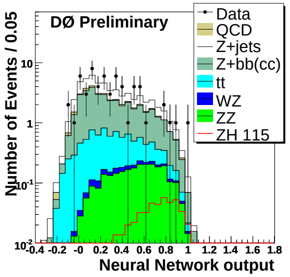
Massive exercise in advanced statistics

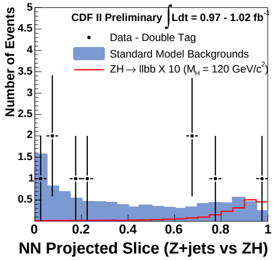
- – currently combining 28 different channels
- – full distributions of final variables are analyzed
- → 28 NN/LR/Mass distributions











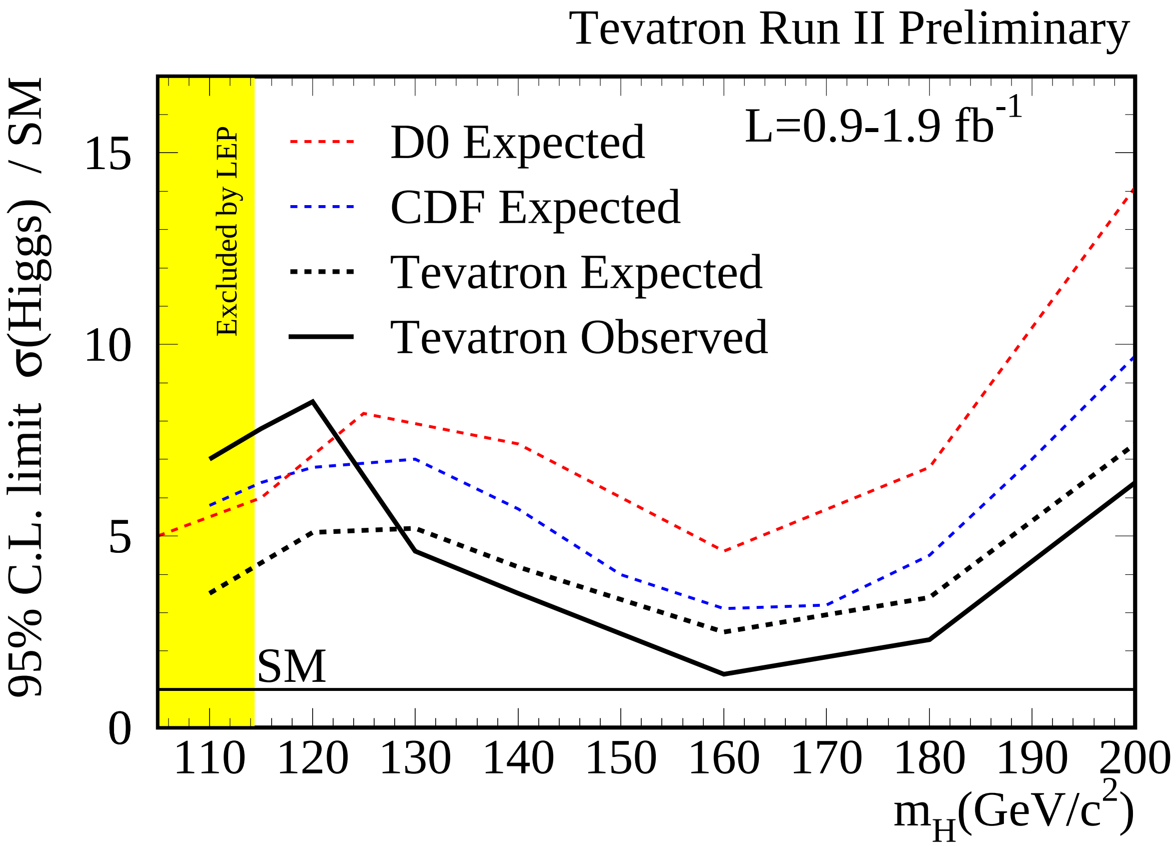
$>$ 50 different sources of systematic uncertainties are considered

- – taking into account correlations bin-to-bin and channel-to-channel
- → $>$50 300x300 covariance matrices...

Systematic uncertainties need to be constrained in sidebands

- → very complicated procedure...
- – used several techniques (Bayesian, mod. frequentist) and 4 independent programs to cross-check calculations
- → results agree within 10%

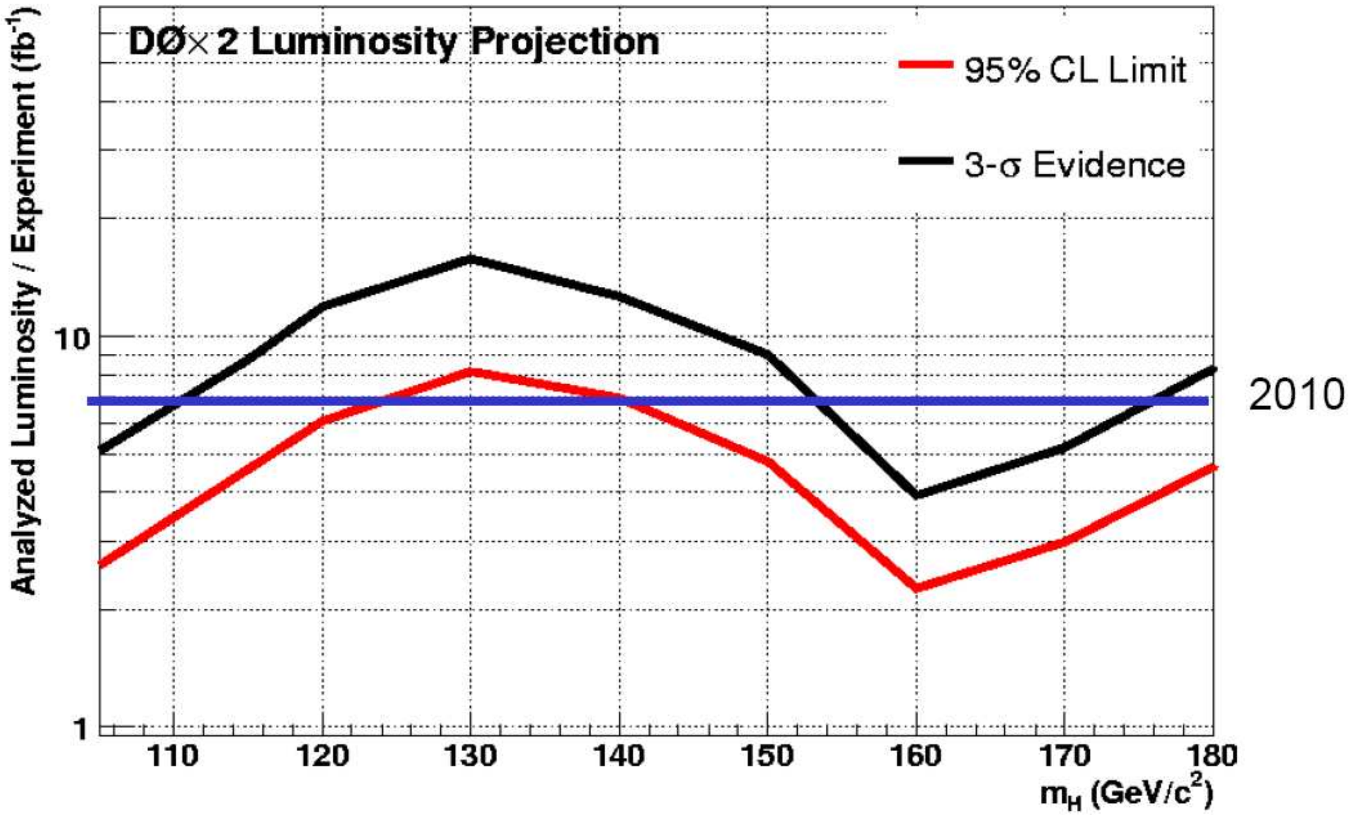
Tevatron Full Combination



Without DØ Fall Updates!

- **Sensitivity improvement still scaling faster than luminosity**
- **Further improvements in pipeline:**
  - **use multivariate techniques in all channels**
  - **more channels: WH→WWW (CDF), H→ZZ, hadronic WW, tau modes, ...**
  - **improved b-tagging (DØ Silicon Layer 0)**
- **Exciting times are ahead!**

Tevatron Full Combination



- Sensitivity improvement still scaling faster than luminosity
- Further improvements in pipeline:
  - use multivariate techniques in all channels
  - more channels: WH→WWW (CDF), H→ZZ, hadronic WW, tau modes, ...
  - improved b-tagging (DØ Silicon Layer 0)
- Exciting times are ahead!

Supersymmetry

The idea: particle physics is symmetric under transformation fermion ↔ boson

→ implies one supersymmetric partner for each SM particle

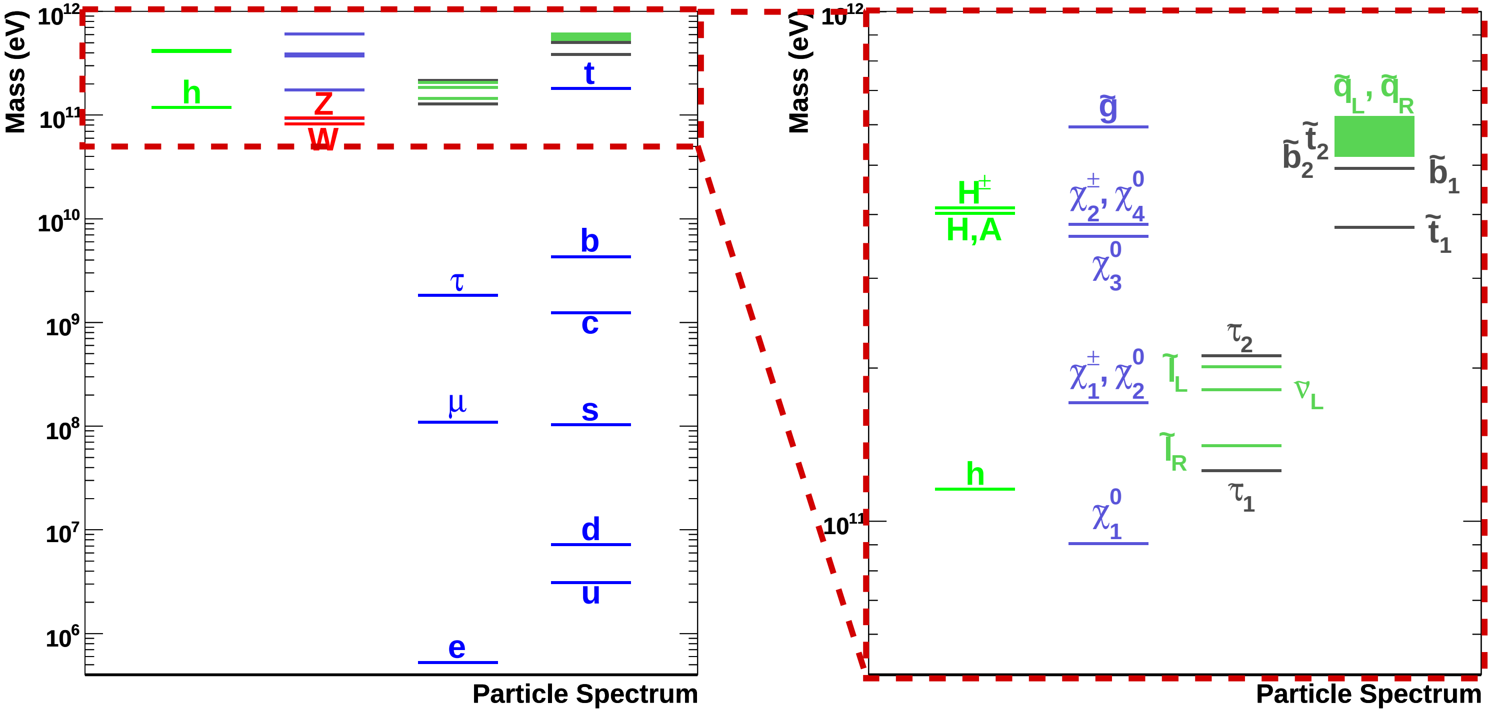
Superpartners are heavy → SUSY must be broken

- Details of SUSY breaking mechanism unknown

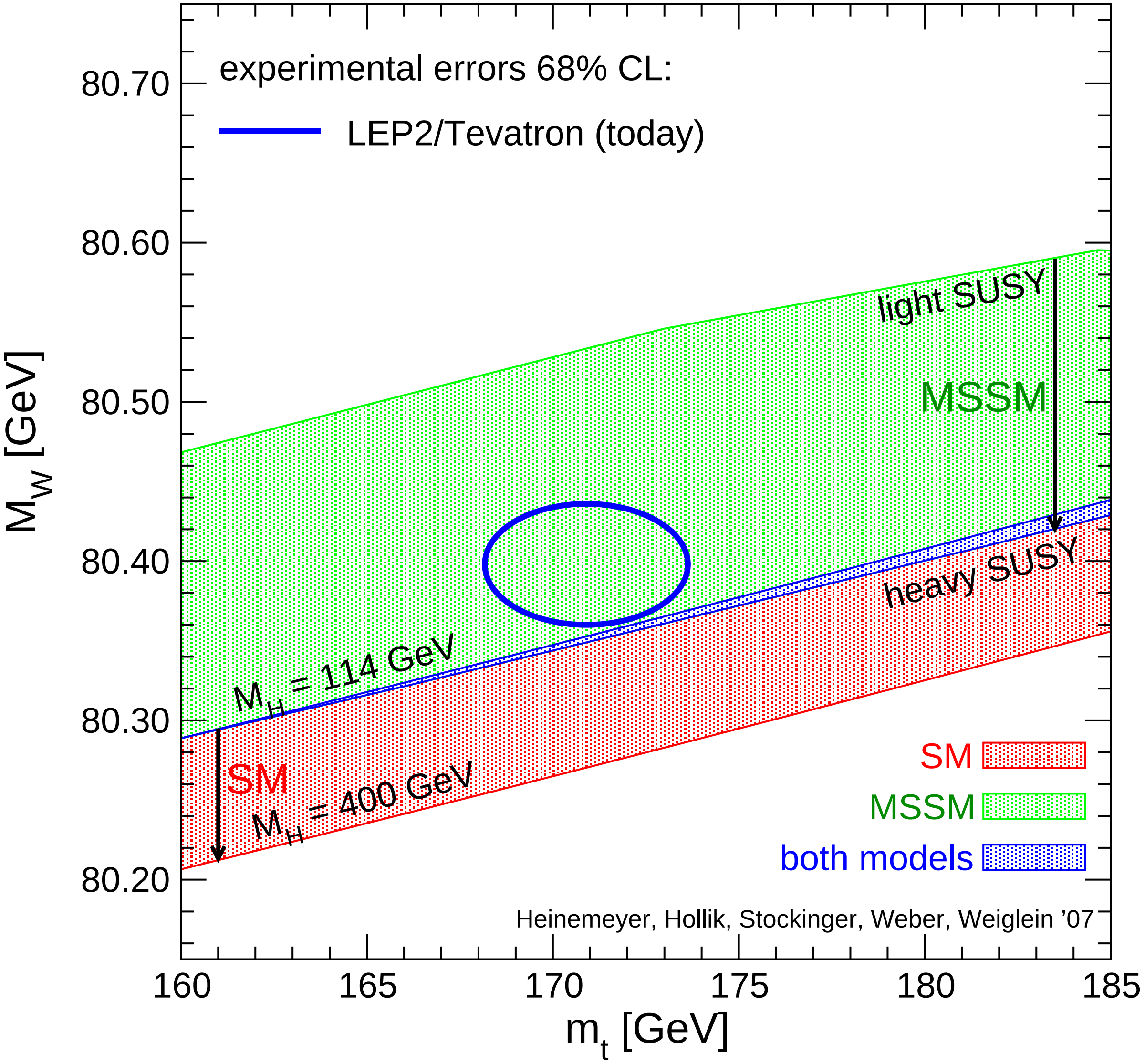
→ need to consider several models: gravity-, gauge-, anomaly-mediated breaking

Predictions:

- Many new SUSY particles: Charginos/Neutralinos/Gluinos, Squarks, Sleptons
- Extended Higgs sector: 5 physical Higgs bosons h,H,A,$H^{\pm}$

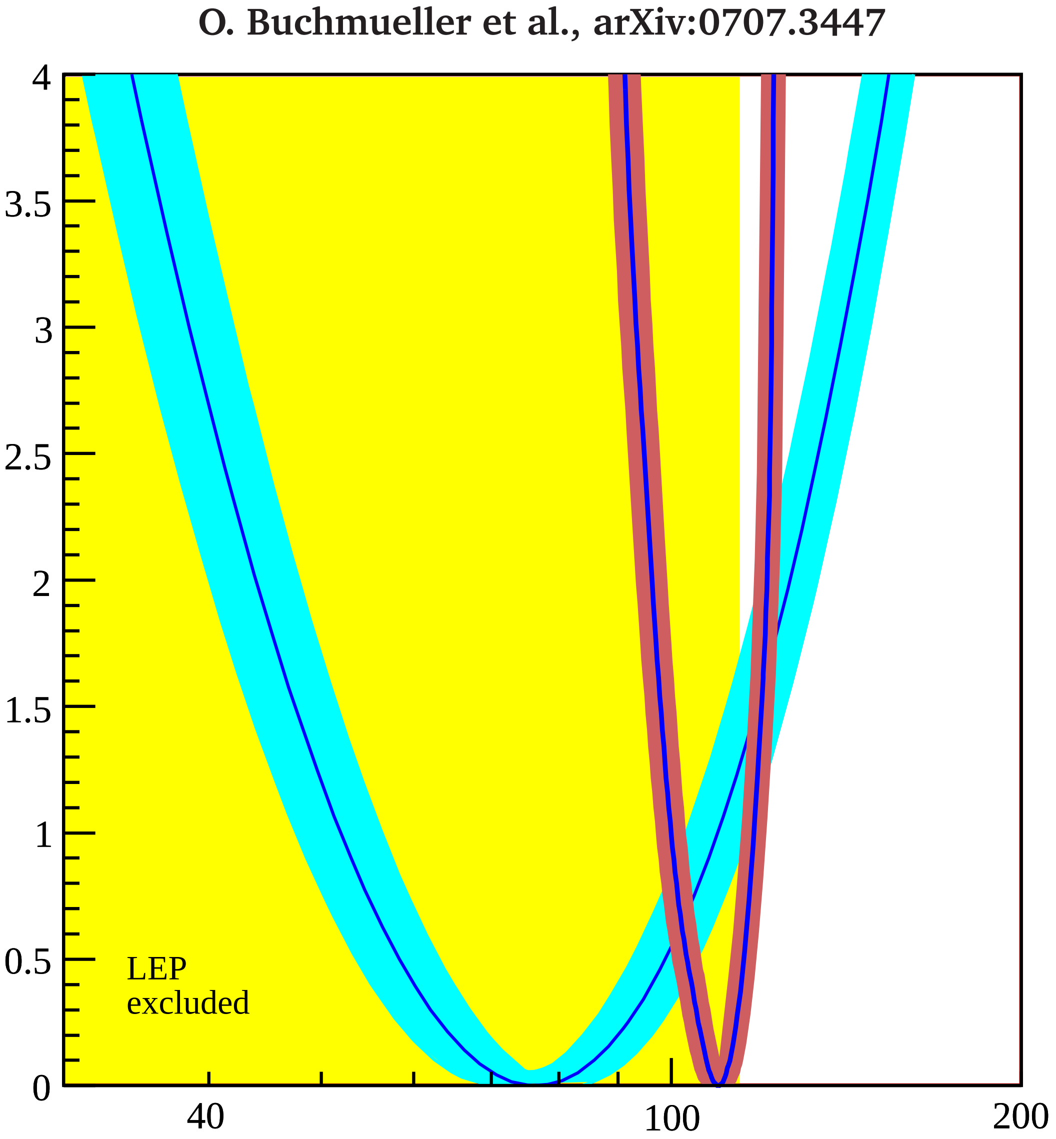


M_W vs. m_t for SM vs. MSSM



- **Supersymmetric theories predict additional particles that modify loop corrections**
- **Lightest MSSM Higgs boson: $m_h \lesssim 135$ GeV**

Blue Band Plot for SM vs. MSSM



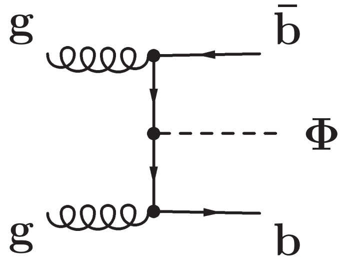
- Adding constraints from CDM, b→sγ etc. allows prediction of m_h in MSSM:

$$m_h = 110\,^{+8}_{-10}\,(\mathrm{exp}) \pm 3\,(\mathrm{theo})\ \mathrm{GeV}$$

Search for SUSY Higgs

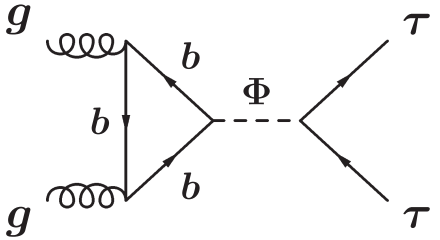
Important: Higgs-$b\bar{b}$-coupling depends on tanβ

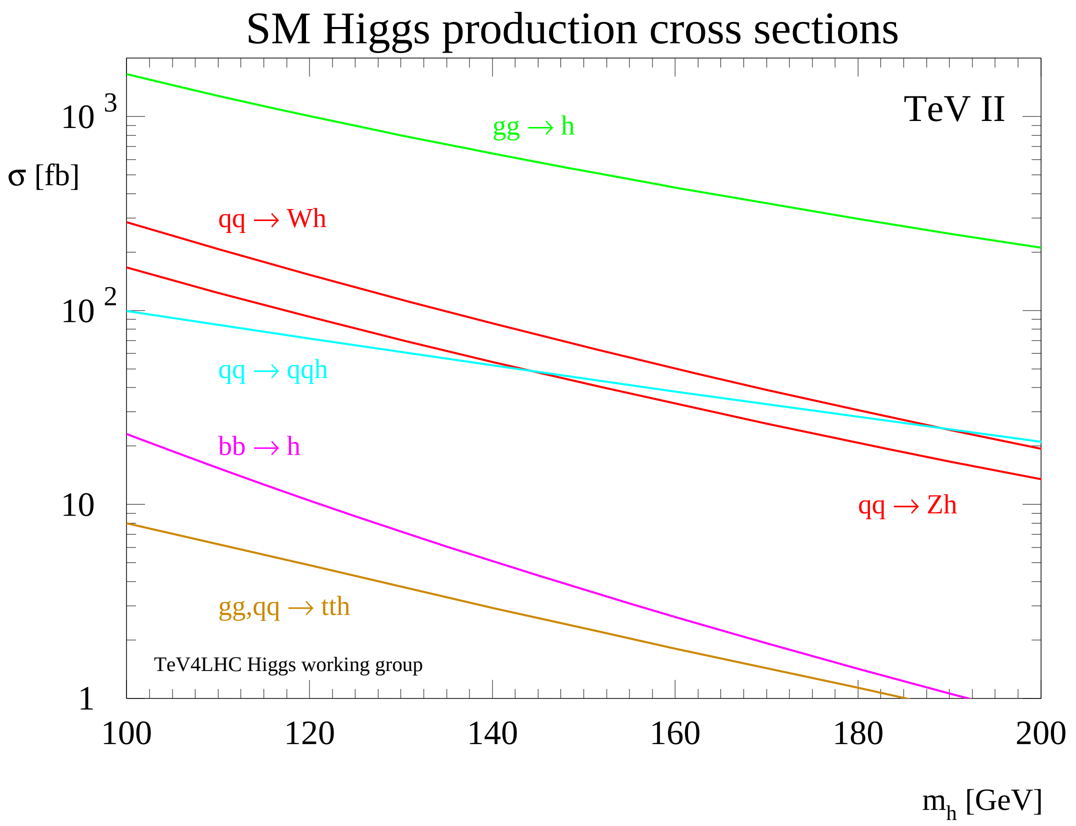
→ **large cross-sections for Higgs production at high tanβ**

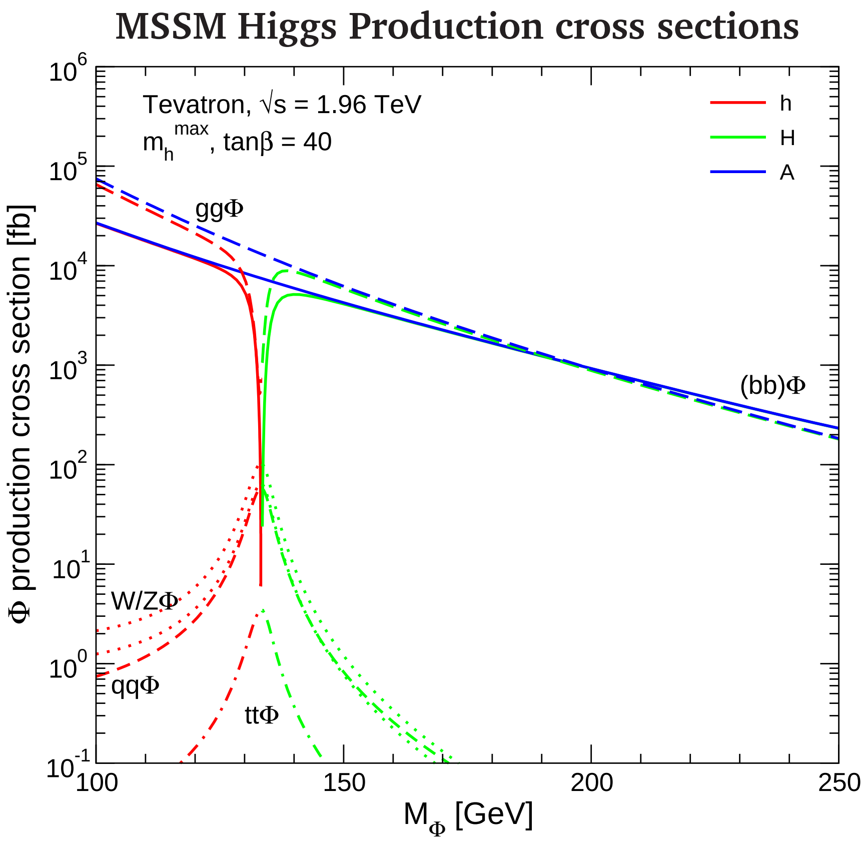


Additional search channels at high tanβ:

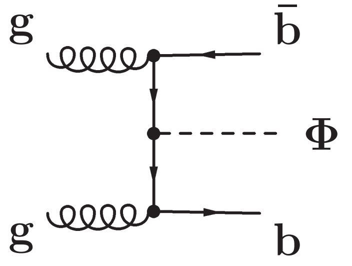
- **associated production with bb: bbΦ with $\Phi \to$ bb,$\tau\tau$**
- **enhanced gluon fusion cross-section: gg$\to \Phi \to \tau\tau$**



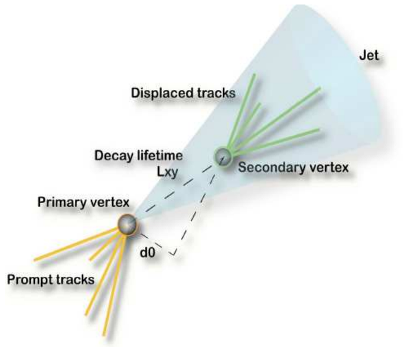


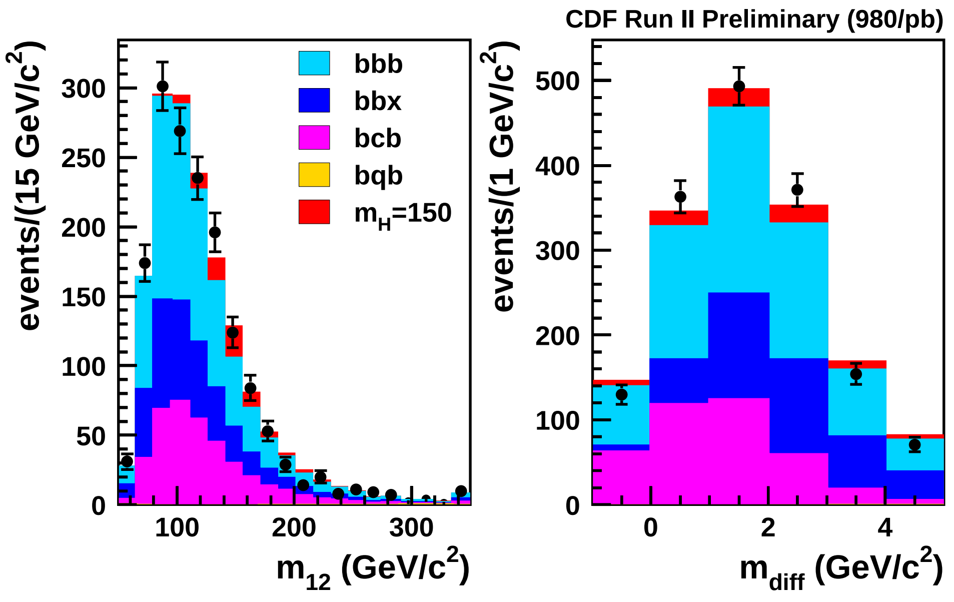


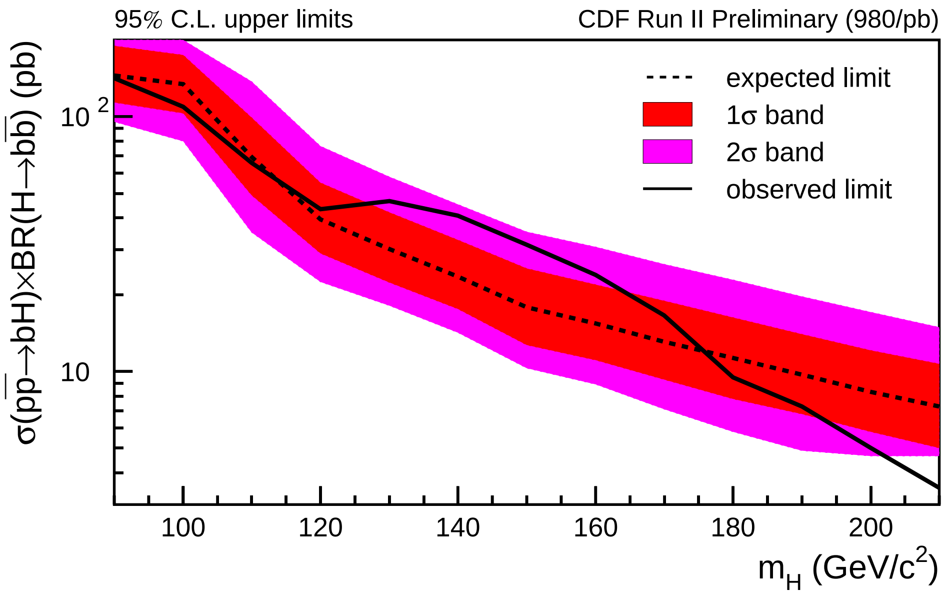
Search for SUSY Higgs: $\Phi b(b)\rightarrow bbb(b)$



- Selection: at least 3 b-jets
- Backgrounds: multijet production
  - modelled extrapolating from 2-tag data
- Reconstruction of Higgs boson mass in $b\bar{b}$ spectrum
- Additional variable: $m_{diff} = m_{SV}^{j1} + m_{SV}^{j2} - m_{SV}^{j3}$
  - sensitive to flavour composition of the 3 b-tagged jets
- Limits derived from 2D-template fits to both variables







Search for SUSY Higgs: $\Phi \rightarrow \tau\tau$

Mode	Fraction (%)	Comments
$\tau_e\tau_e$	3	Large DY BGND
$\tau_\mu\tau_\mu$	3	Large DY BGND
$\tau_e\tau_\mu$	6	Small QCD BGND
$\tau_e\tau_h$	23	Golden
$\tau_\mu\tau_h$	23	Golden
$\tau_h\tau_h$	41	Large QCD BGND

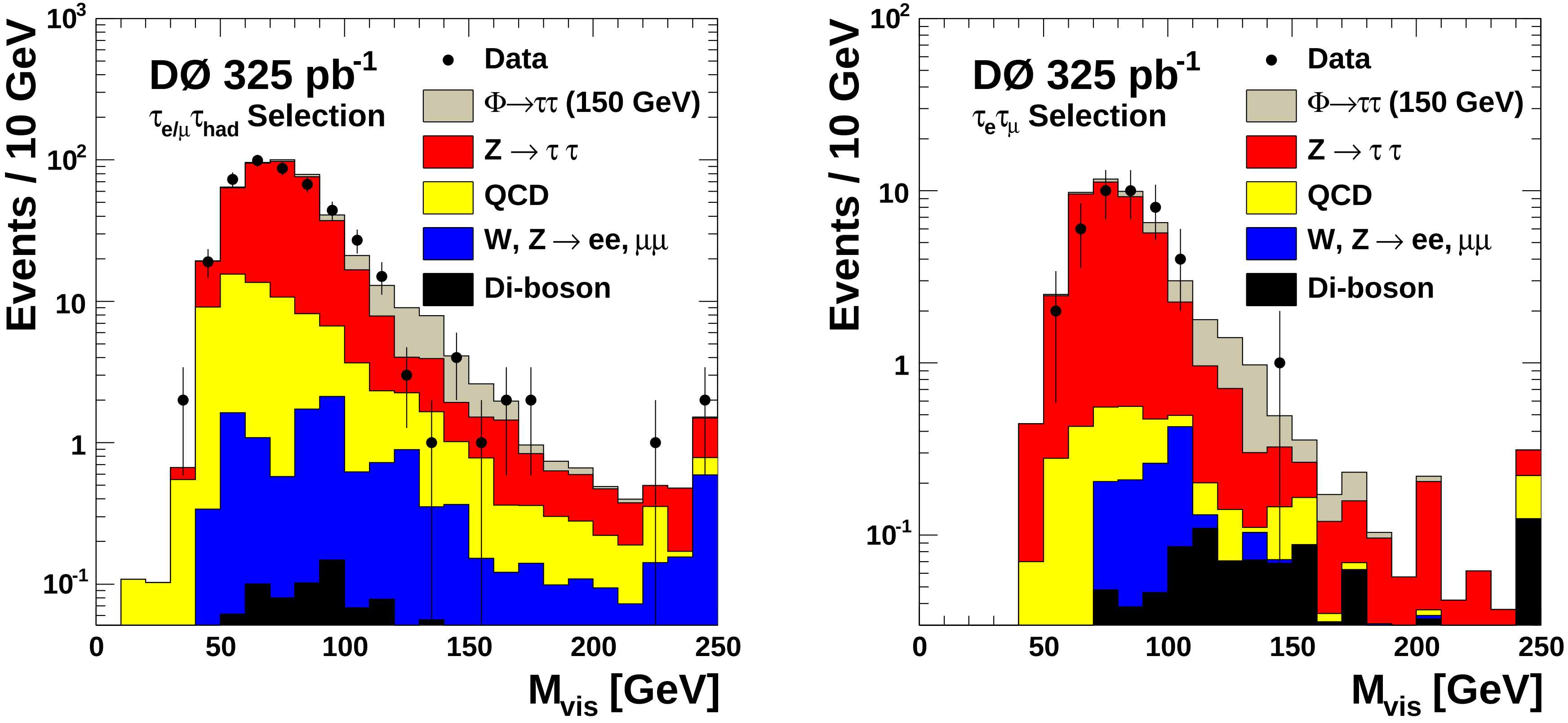
Selections:

A) two isolated taus with one leptonic tau decay

B) isolated electron and muon

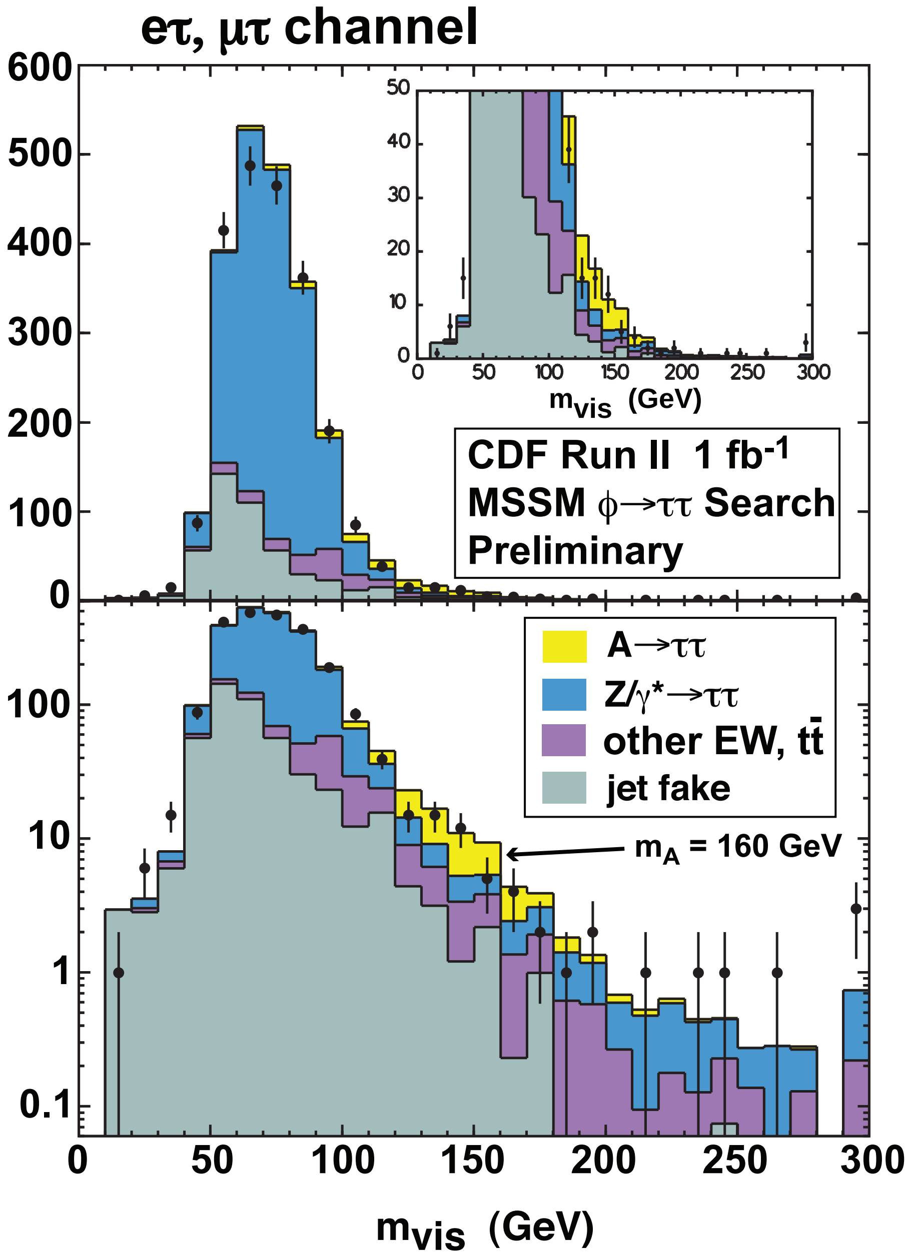
- Irreducible background from $Z \rightarrow \tau^+\tau^-$
- Reconstruction of effective mass from visible tau decay products and $\not\!\!E_T$

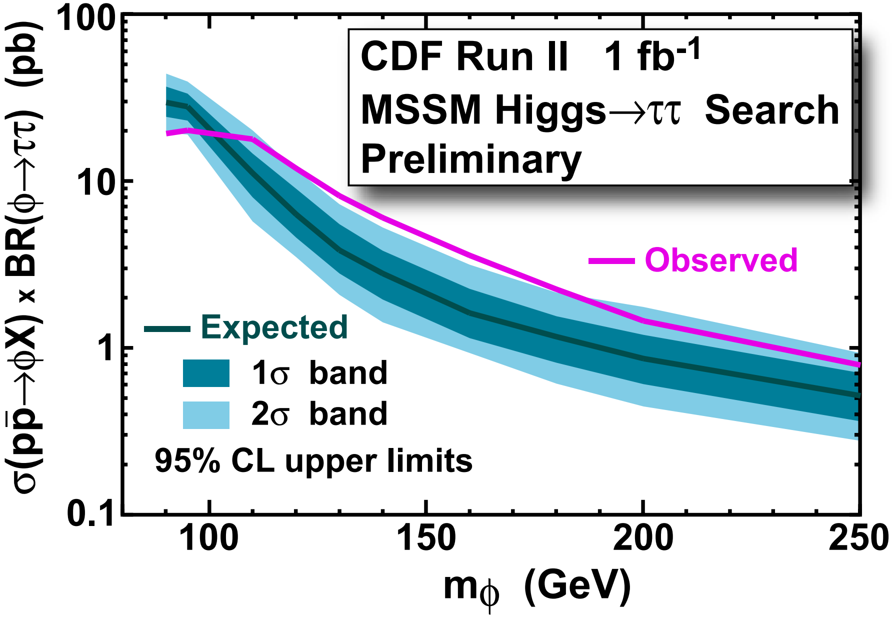
Summer 2006



Search for SUSY Higgs: $\Phi \to \tau\tau$

January 2007: new CDF results with 1 fb^{-1}

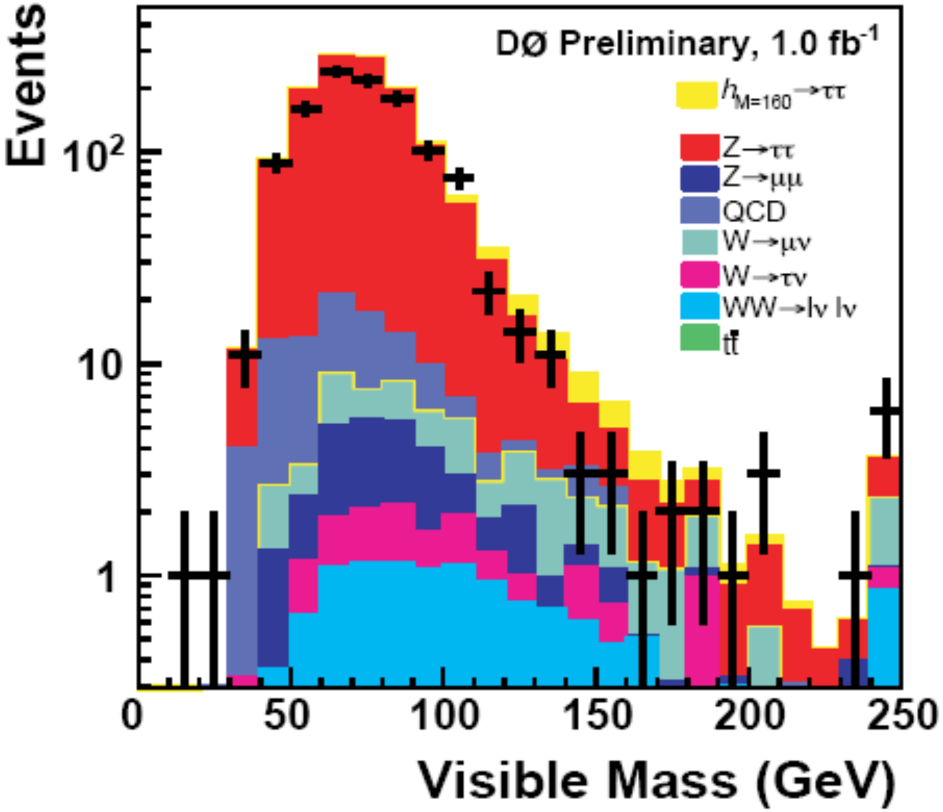


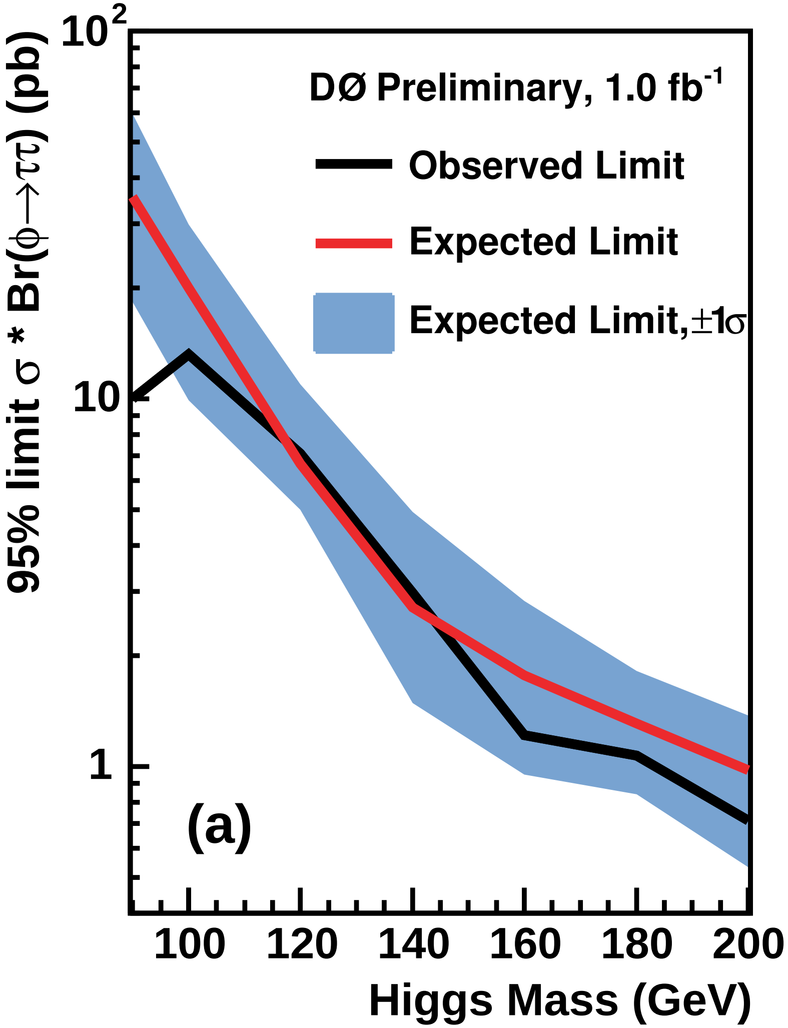


- 2σ excess at $m_A \approx 150$ GeV
- would correspond to tan$\beta \approx 50$
- confirmed by DØ?

Search for SUSY Higgs: $\Phi \longrightarrow \tau\tau$

February 2007: new DØ results with 1 fb^{-1}

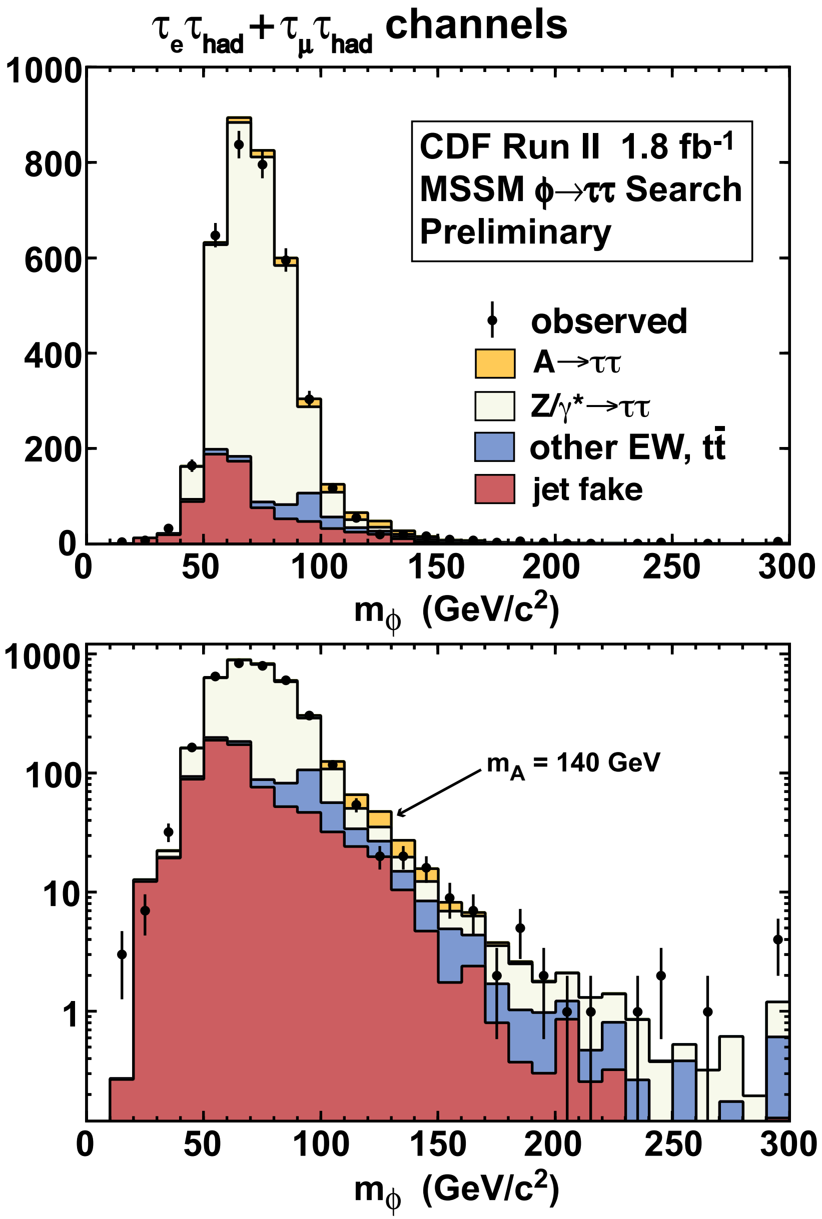


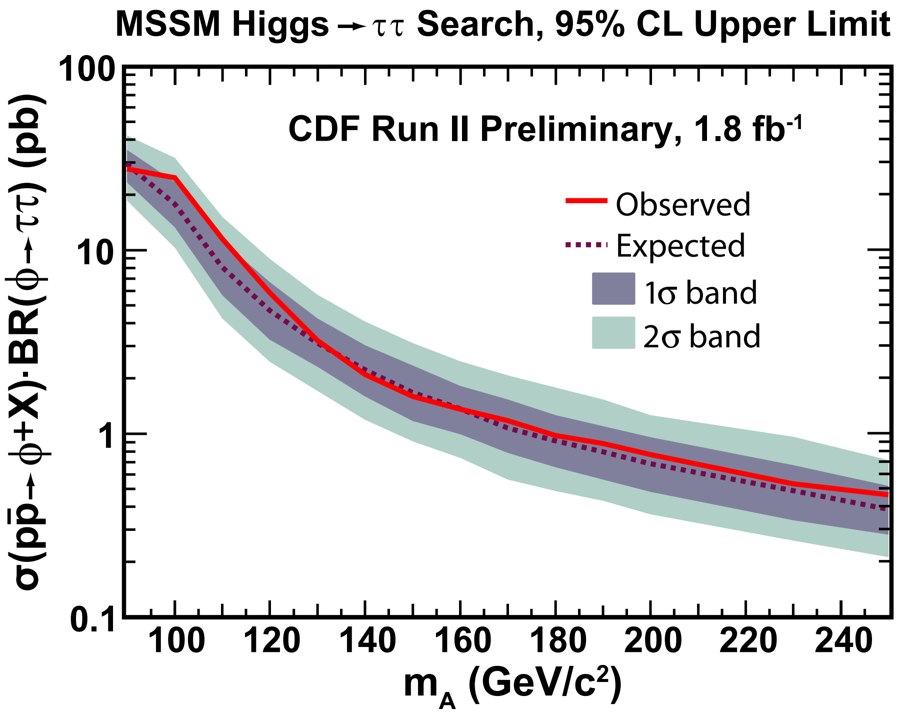


→ unfortunately no confirmation of signal

Search for SUSY Higgs: $\Phi \rightarrow \tau\tau$

October 2007: new CDF results with 1.8 fb^{-1}



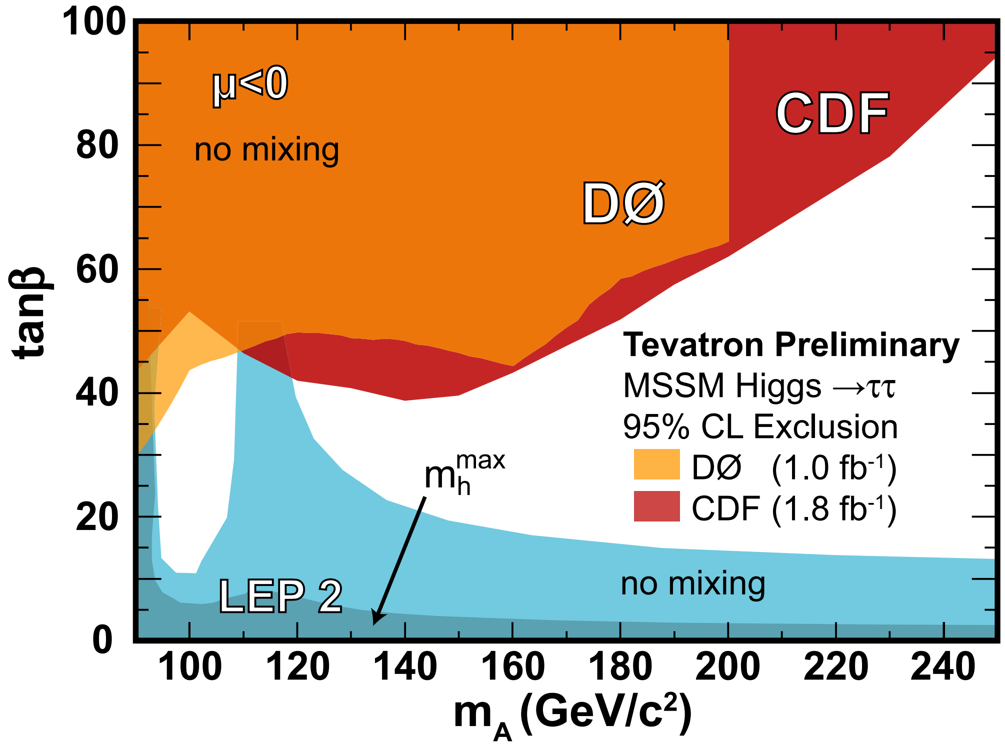


– Excess is gone

Search for SUSY Higgs: $\Phi \to \tau\tau$

Interpretation within MSSM: limits on tanβ as a function of m$_A$

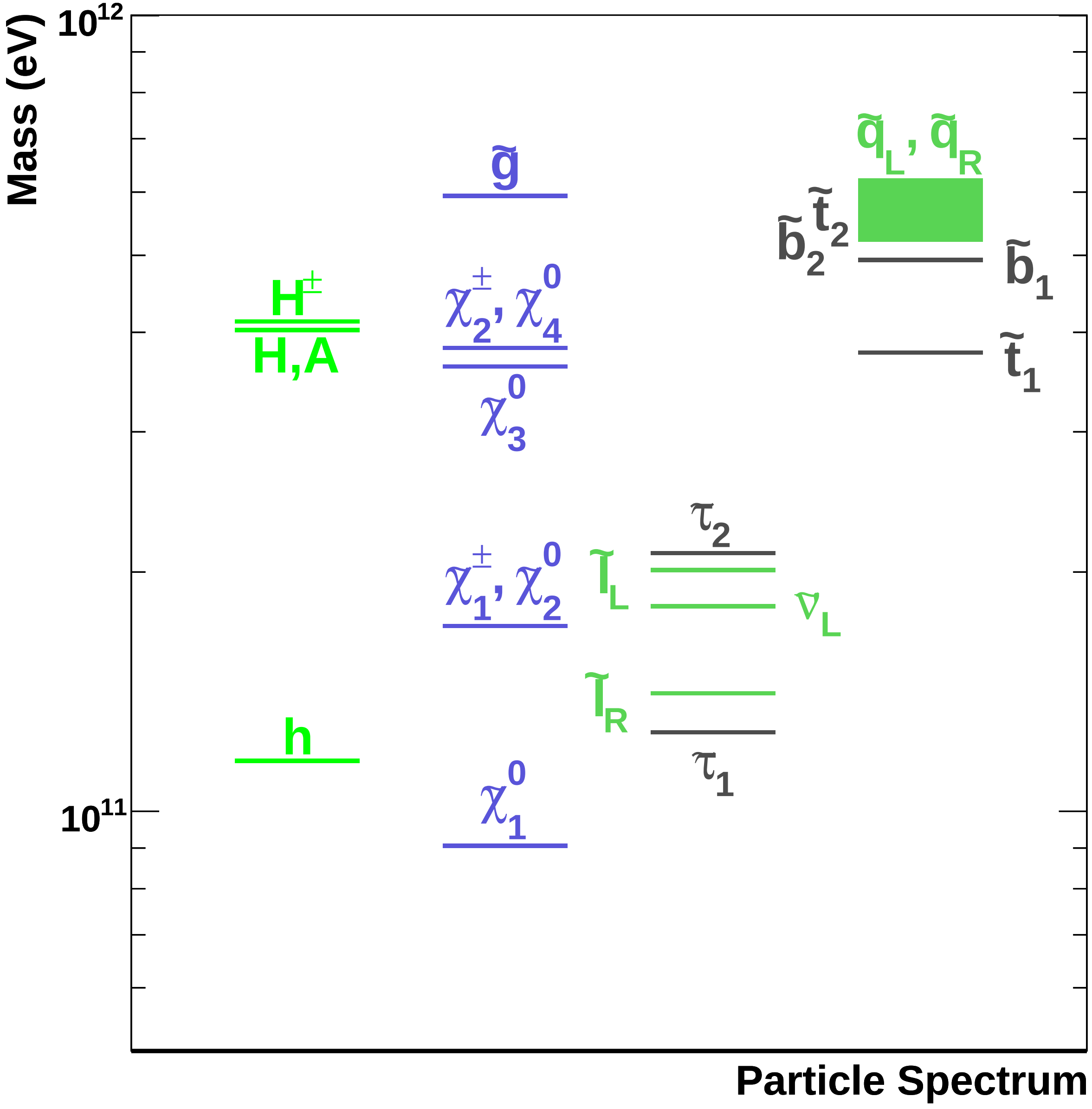
- based on DØ 1 fb^{-1} $\mu\tau_h$, CDF 1.8 fb^{-1} $\mu\tau_h$, $e\tau_h$, $e\mu$
- limits from bbh channels currently not competitive
- no Tevatron combination yet
- benchmark scenarios: no-mixing and mhmax



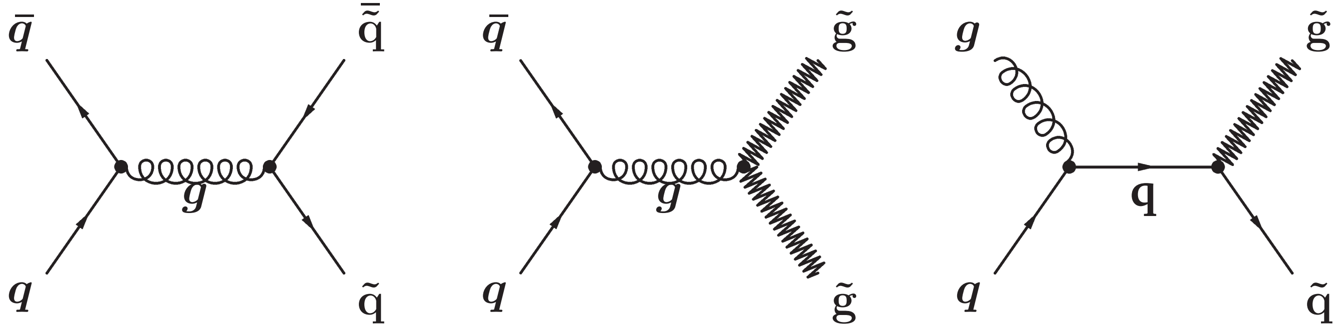
Expect to reach sensitivity to tan$\beta \approx 20$ with full Run II dataset

In addition: expect to probe large m$_A$ with WH/ZH channels

What other particles does SUSY predict?



Search for Supersymmetry – Squarks/Gluinos



- **Squarks/Gluinos produced via strong interaction**

  → large cross sections at hadron colliders

- **Decays: jets + LSP**
  - LSP assumed to be stable ($\not\!R_p$ conserved)

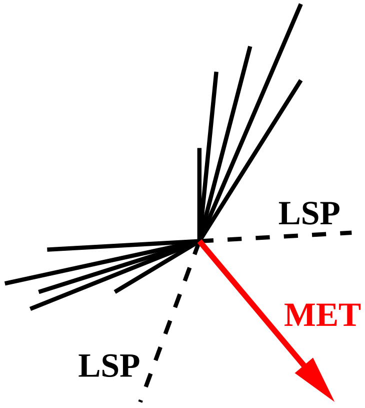
  → Signature: jets + $\not\!\!E_T$

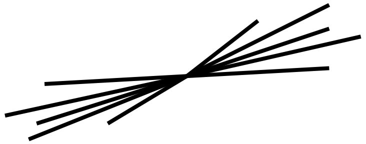
- **Data collected with dedicated triggers:**

  acoplanar jets + $\not\!\!E_T$

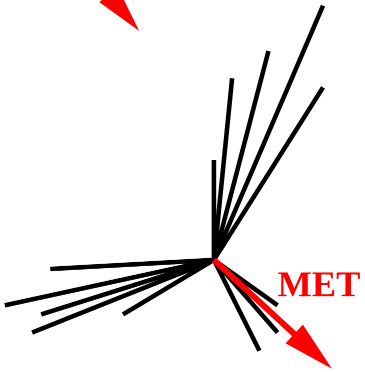
Mass region	Main Channel	Signature
$m_{\tilde{q}} < m_{\tilde{g}}$	$\tilde{q}\tilde{q}$	2j + $\not\!\!E_T$
$m_{\tilde{q}} > m_{\tilde{g}}$	$\tilde{g}\tilde{g}$	4j + $\not\!\!E_T$
$m_{\tilde{q}} \approx m_{\tilde{g}}$	$\tilde{q}\tilde{q}$,$\tilde{q}\tilde{g}$	3j + $\not\!\!E_T$

$\tilde{q}\tilde{q} \longrightarrow qq + \not\!\!E_T$





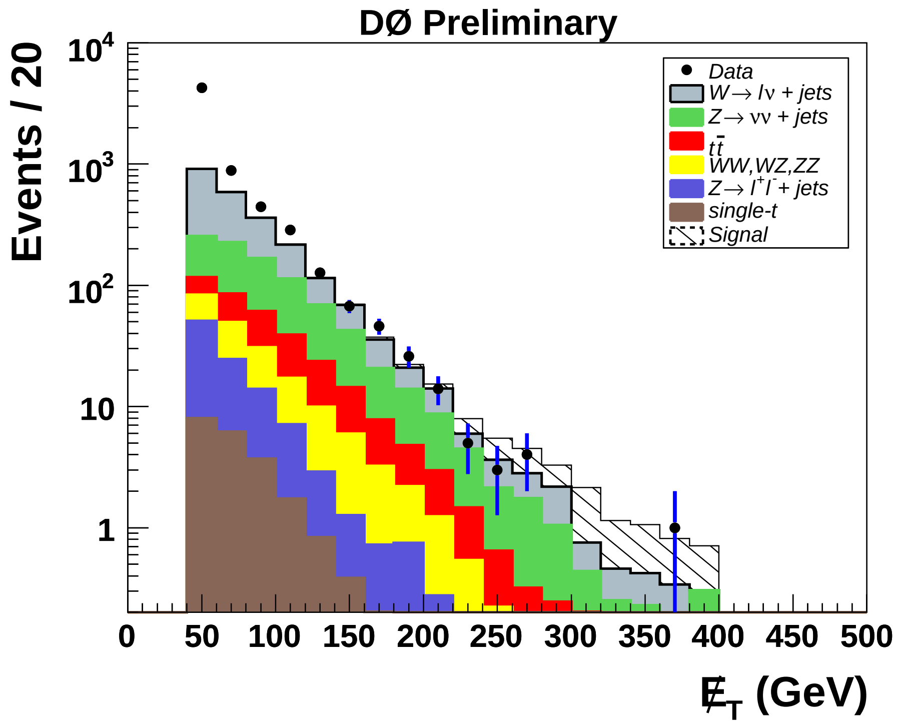
Dijet Background



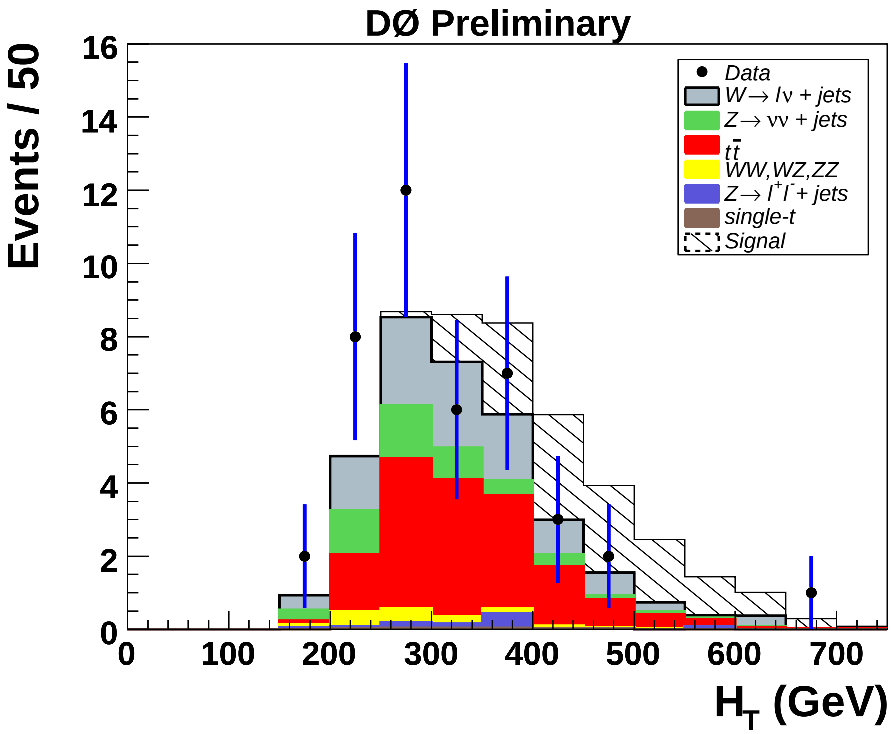
3-jet Background

Search for Supersymmetry – Squarks/Gluinos

2j+$\not\!\!E_T$ analysis

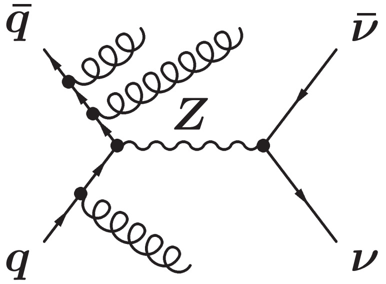


3j+$\not\!\!E_T$ analysis



Main backgrounds:

- Multijets with fake $\not\!\!E_T$
- W+jets with W$\to$ $e\nu, \mu\nu, \tau\nu$
- Z+jets with Z$\to$ $\nu\bar{\nu}$

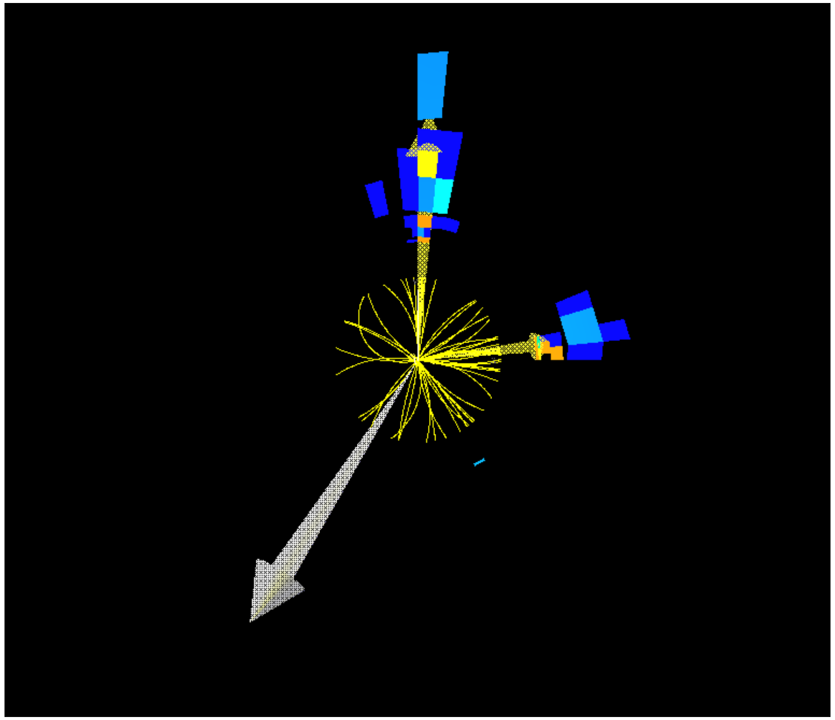


Main selection cuts:

- 2/3/4 jets and large $\not\!\!E_T$
- angular separation $\not\!\!E_T$, jets
- isolated lepton veto

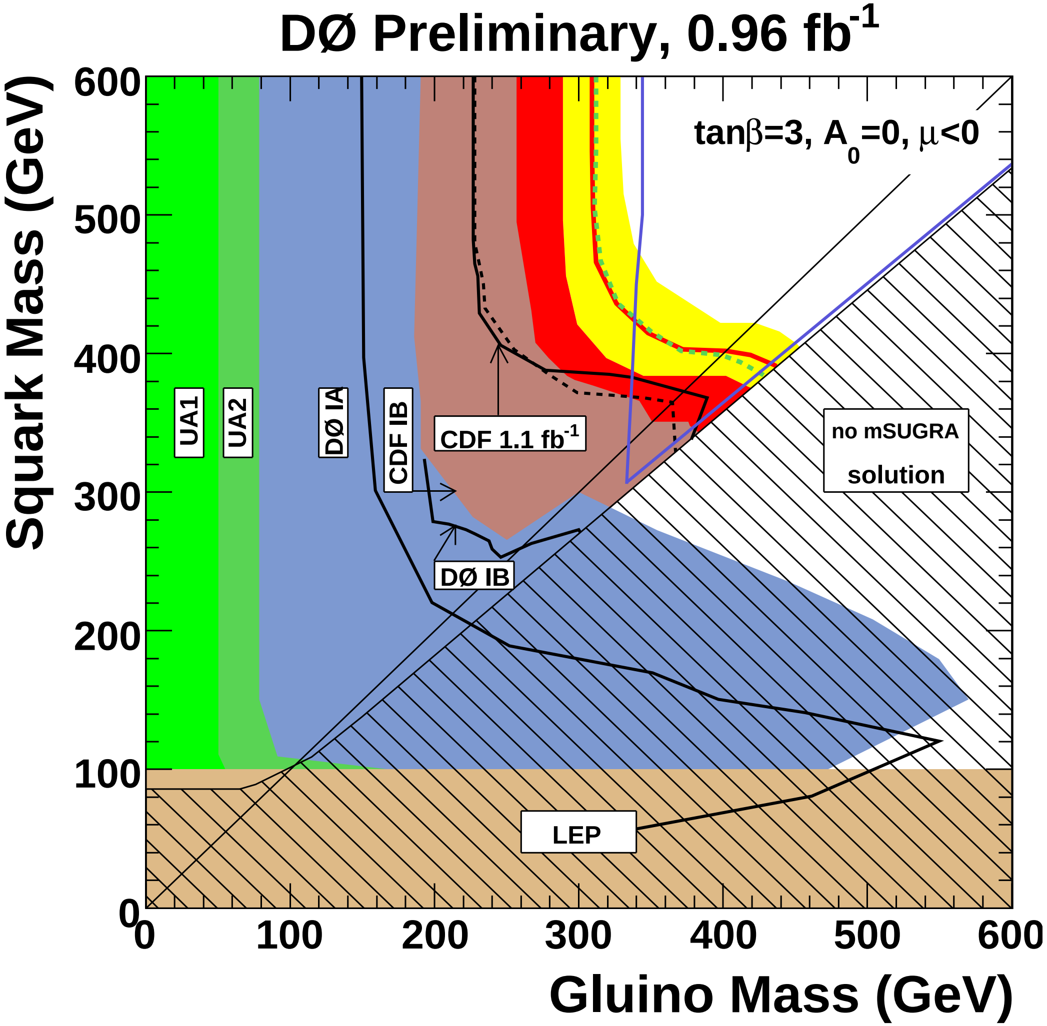
Mass region	Main Channel	Signature	$\not\!\!E_T$	$H_T = \sum p_T^{jet}$	Exp. Bckgd.	Data
$m_{\tilde{q}} < m_{\tilde{g}}$	$\tilde{q}\tilde{q}$	2j + $\not\!\!E_T$	>225 GeV	>300 GeV	7.5±1.7	5
$m_{\tilde{q}} > m_{\tilde{g}}$	$\tilde{g}\tilde{g}$	4j + $\not\!\!E_T$	>100 GeV	>300 GeV	33±6	34
$m_{\tilde{q}} \approx m_{\tilde{g}}$	$\tilde{q}\tilde{q}$,$\tilde{q}\tilde{g}$	3j + $\not\!\!E_T$	>150 GeV	>400 GeV	6.1±1.3	6

Search for Supersymmetry – Squarks/Gluinos



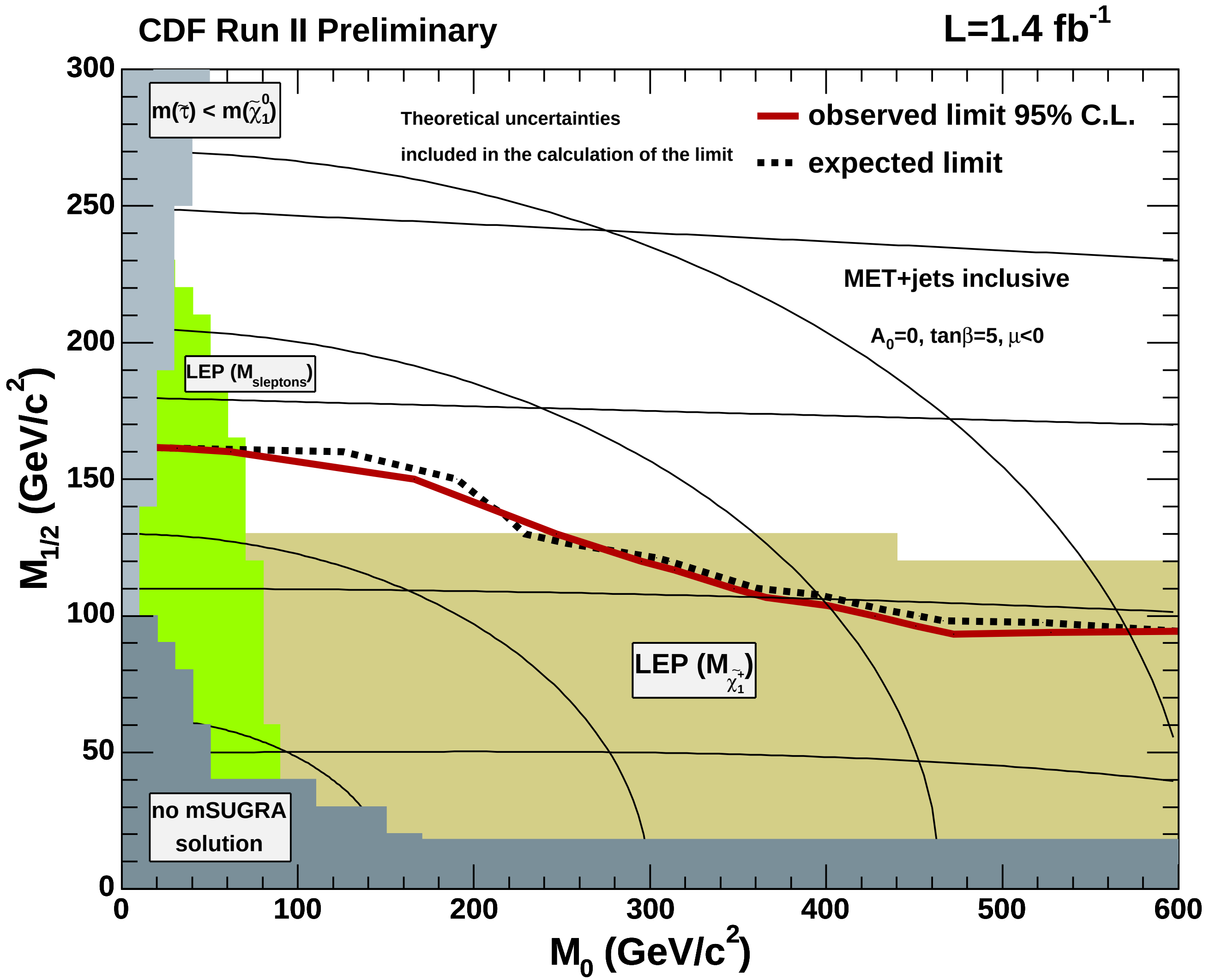
$\tilde{q}\tilde{q}$ candidate event

($\not\!\!E_T$=368 GeV, p_T^{j1}=282 GeV, p_T^{j2}=174 GeV)



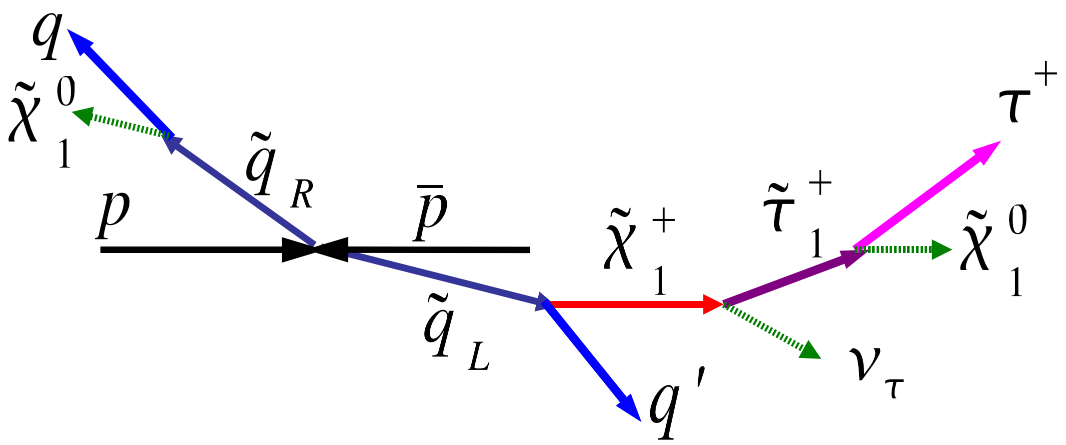
- No evidence for squark/gluino production at the Tevatron
- New limits in squark/gluino mass plane (mSUGRA: $tan\beta = 3$, $A_0 = 0$, $\mu < 0$)
- Sensitivity beyond indirect limits from LEP

Search for Supersymmetry – Squarks/Gluinos



- No evidence for squark/gluino production at the Tevatron
- New limits in squark/gluino mass plane (mSUGRA: $tan\beta = 3$, $A_0 = 0$, $\mu < 0$)
- Sensitivity beyond indirect limits from LEP

Search for Supersymmetry – Squarks/Gluinos



High tanβ → light staus

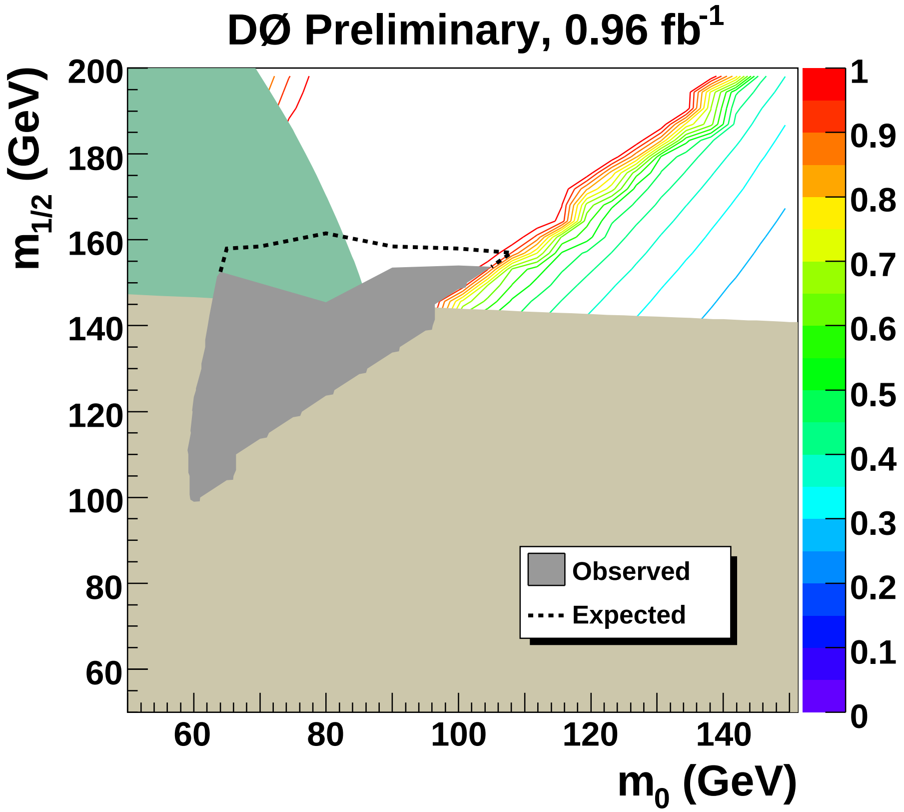
→ cascade decays of squarks to taus

DØ (1 fb^{-1}):

- dedicated search in τ+jets+$\not{E}_T$
- 1.7 events expected, 2 observed

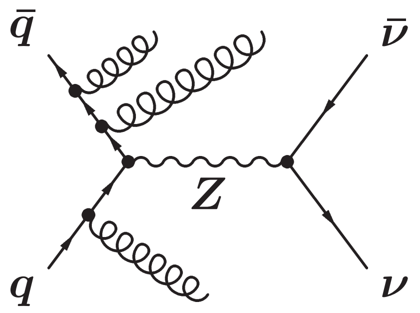
→ mSUGRA exclusion contour:

tanβ=15, A$_0$=-2m$_0$, $\mu < 0$

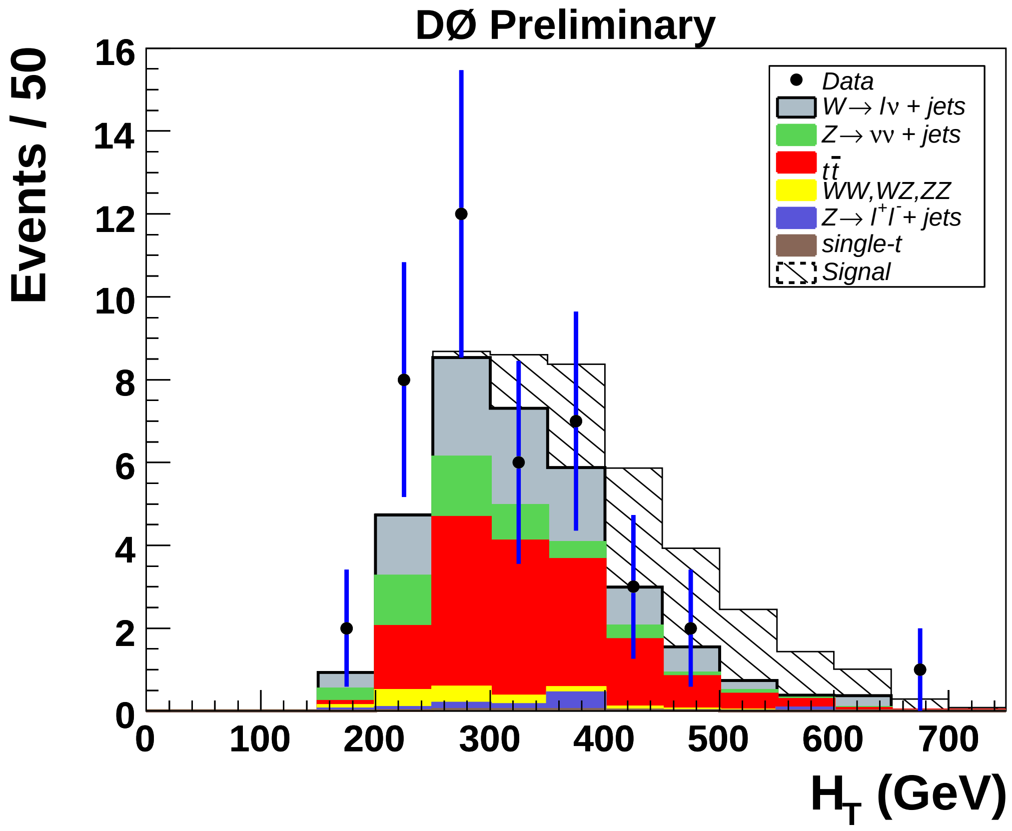


Search for Supersymmetry at LHC – V+jets Background

- Search for SUSY in Jets+$\not\!\!E_T$ is flagship analysis at the LHC
- Modelling of V+jets backgrounds is crucial
- Default pythia modelling is not adequate

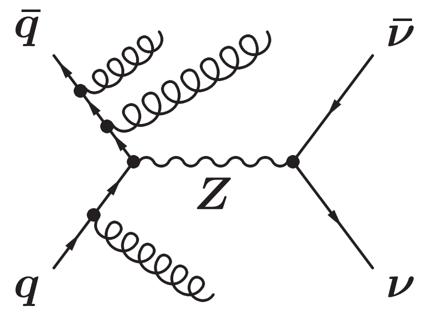


DØ Squark/Gluino Search

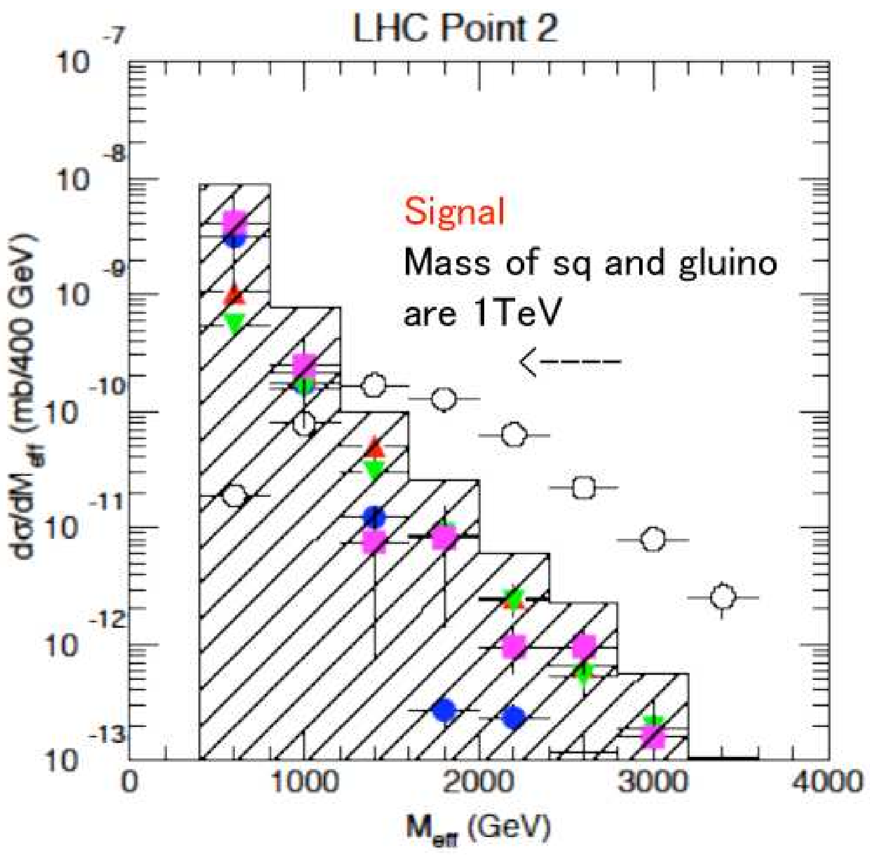


Search for Supersymmetry at LHC – V+jets Background

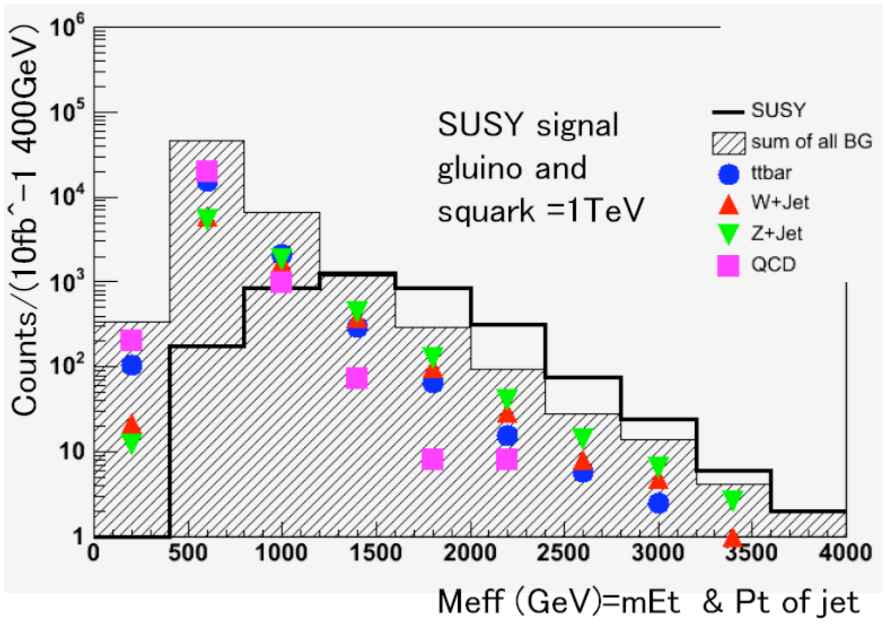
- Search for SUSY in Jets+$\not{E}_T$ is flagship analysis at the LHC
- Modelling of V+jets backgrounds is crucial
- Default pythia modelling is not adequate



ATLAS TDR Study (Parton Shower MC)



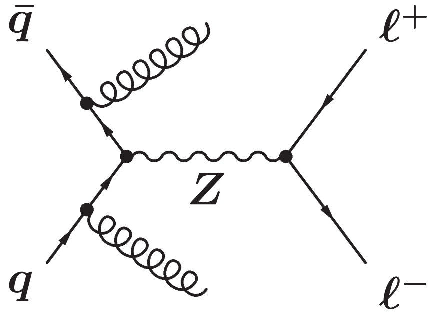
New Study (Matrix Element MC)



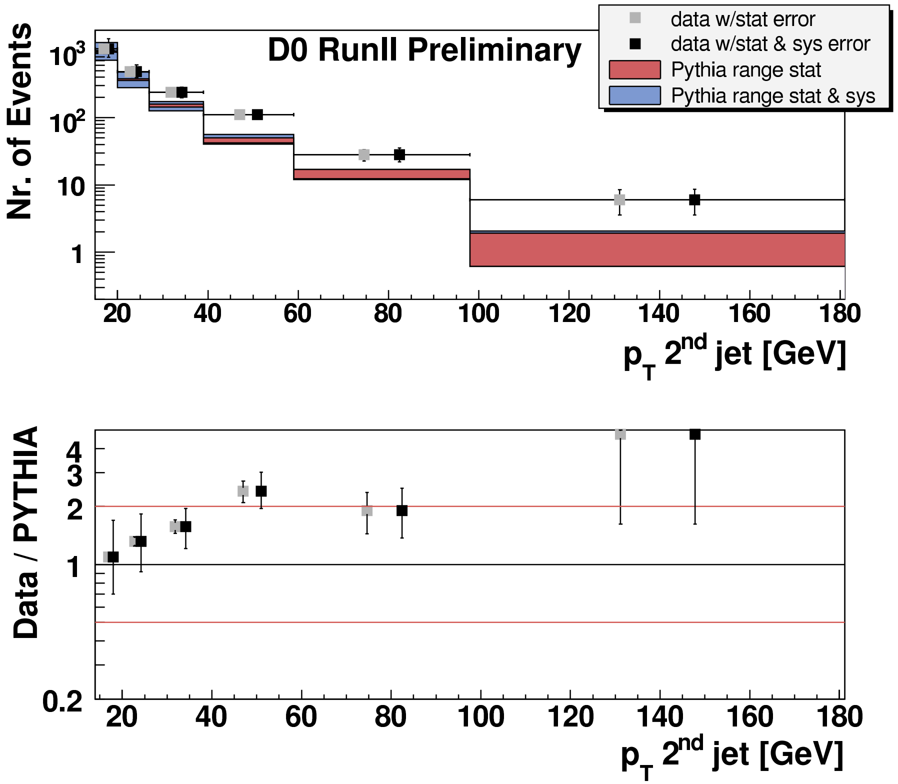
(S. Asai et al.)

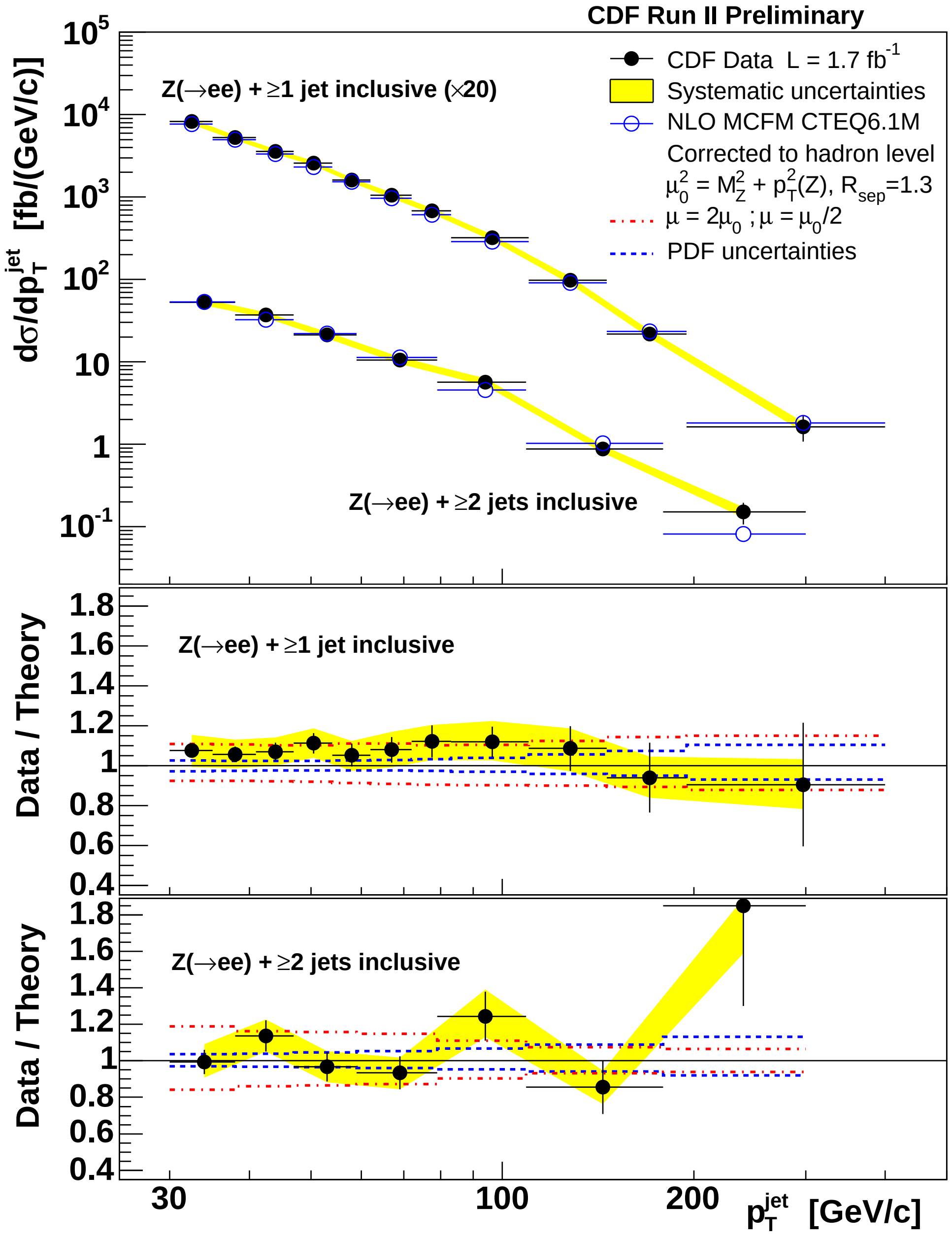
Vector Boson plus Jet Production at the Tevatron

Dedicated Analyses to test new MC Generators in Z+jets data



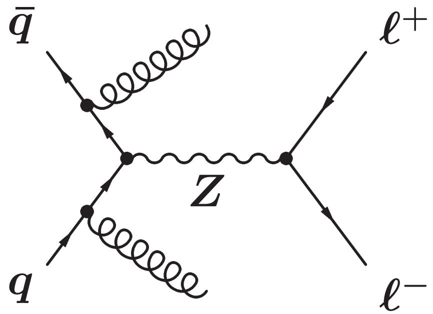
DØ Data vs. PYTHIA



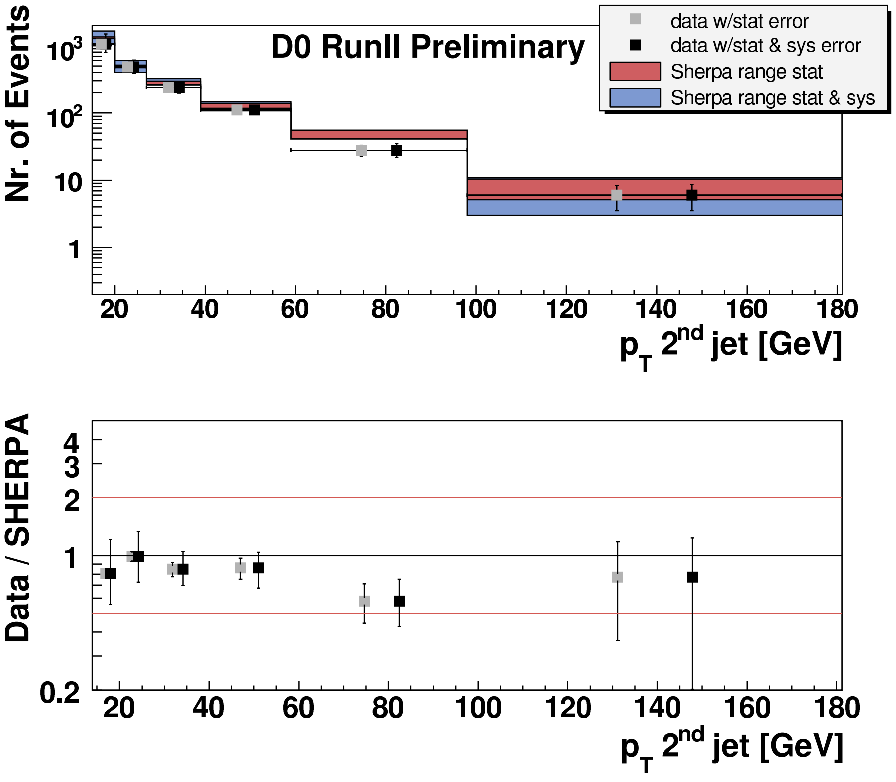


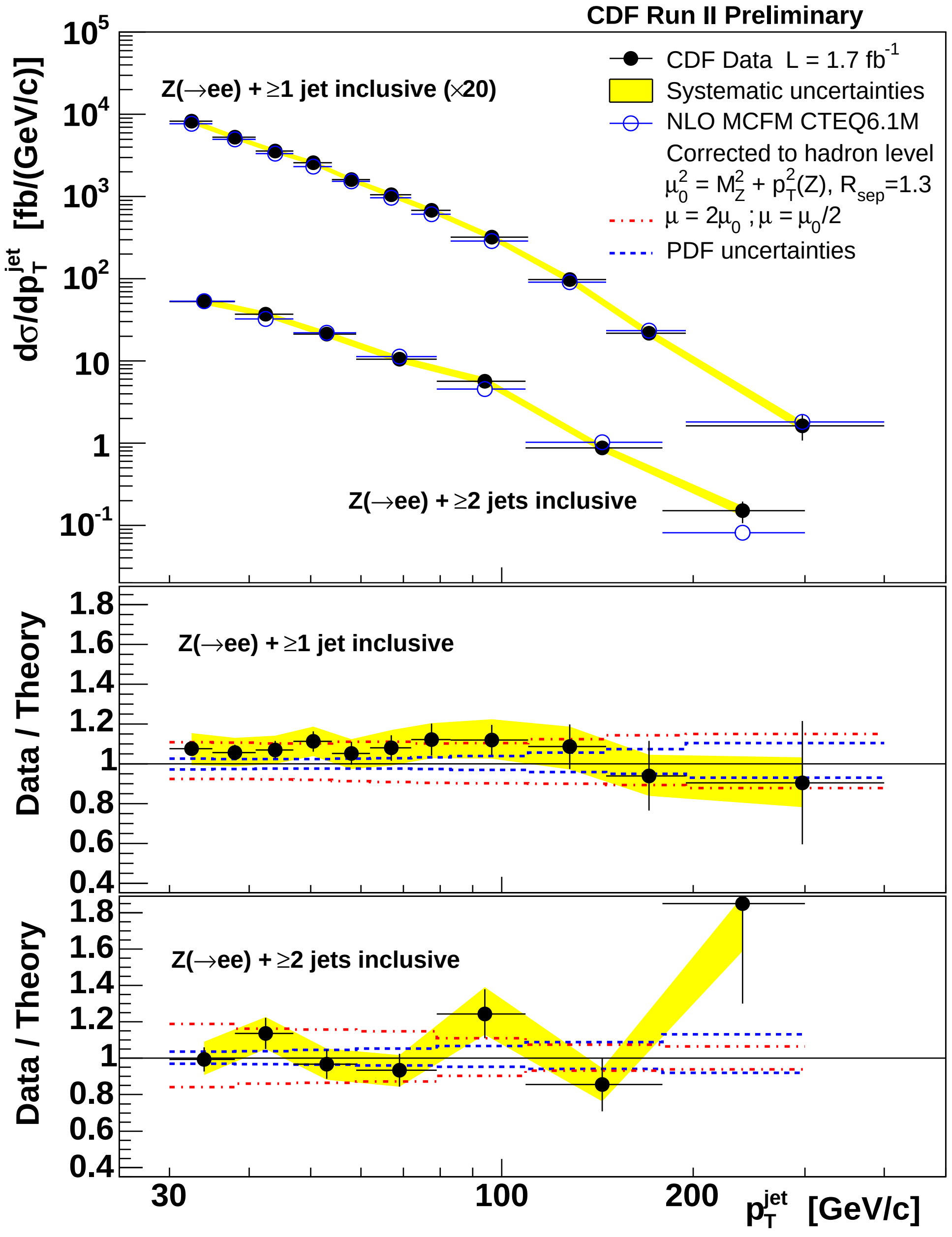
Vector Boson plus Jet Production at the Tevatron

Dedicated Analyses to test new MC Generators in Z+jets data

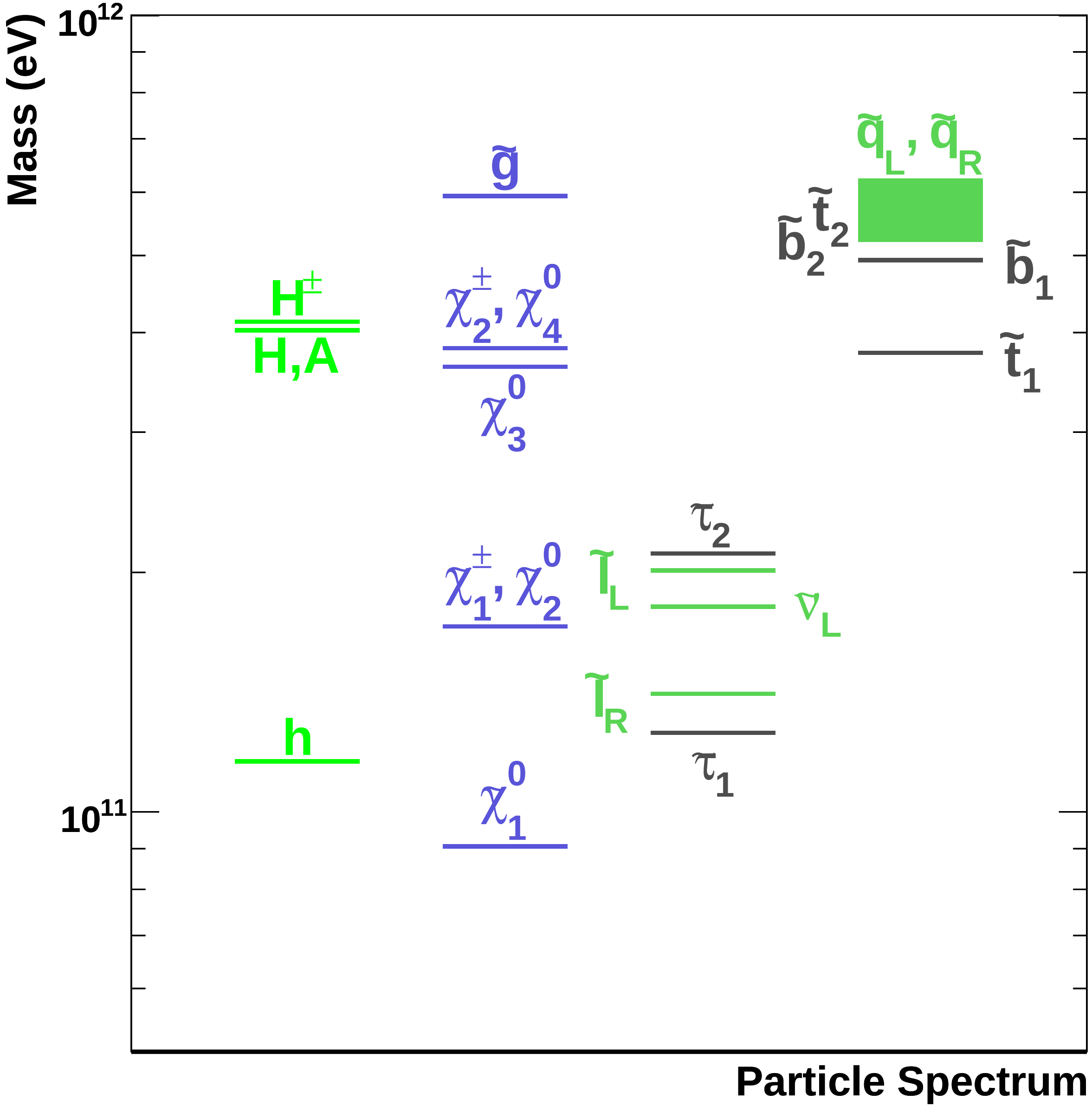


DØ Data vs. SHERPA





What other particles does SUSY predict?

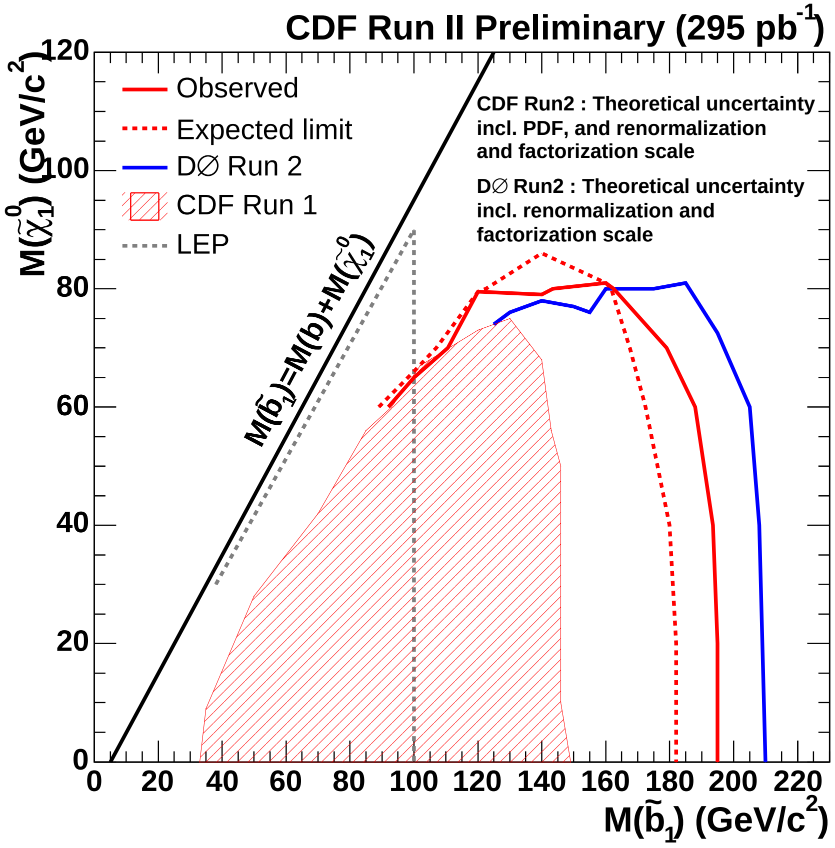


Search for Supersymmetry – Sbottoms/Stops

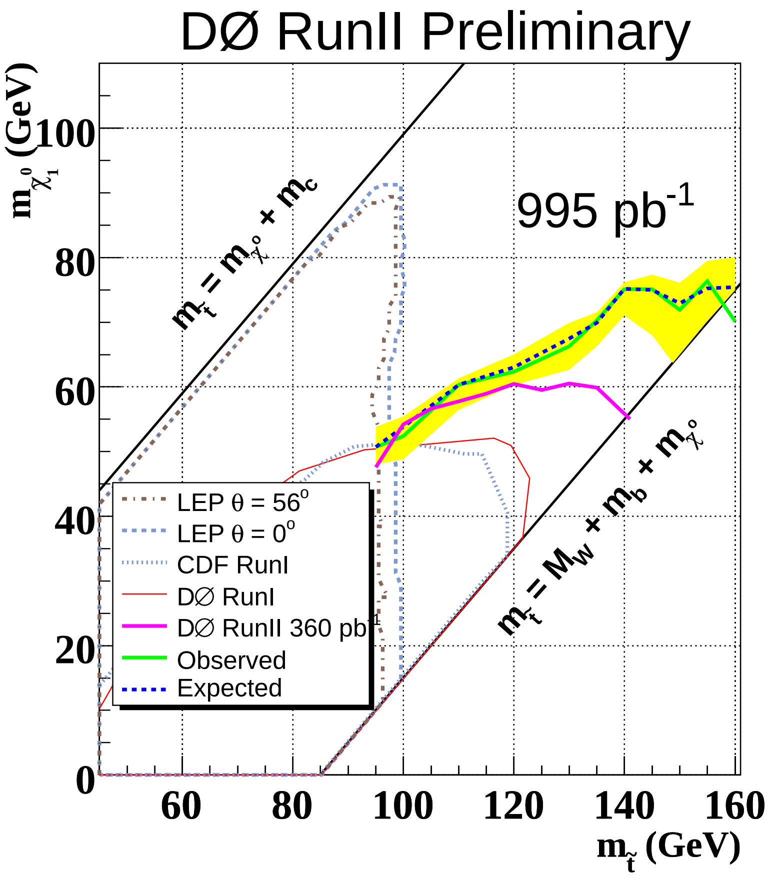
Dedicated searches for light sbottom or stop quarks

- can use b- and charm-tagging to substantially reduce backgrounds
- still significant potential with more integrated luminosity

$$\tilde{\mathrm{b}} \to b + \tilde{\chi}_1^0$$



$$\tilde{\mathrm{t}} \to c + \tilde{\chi}_1^0$$

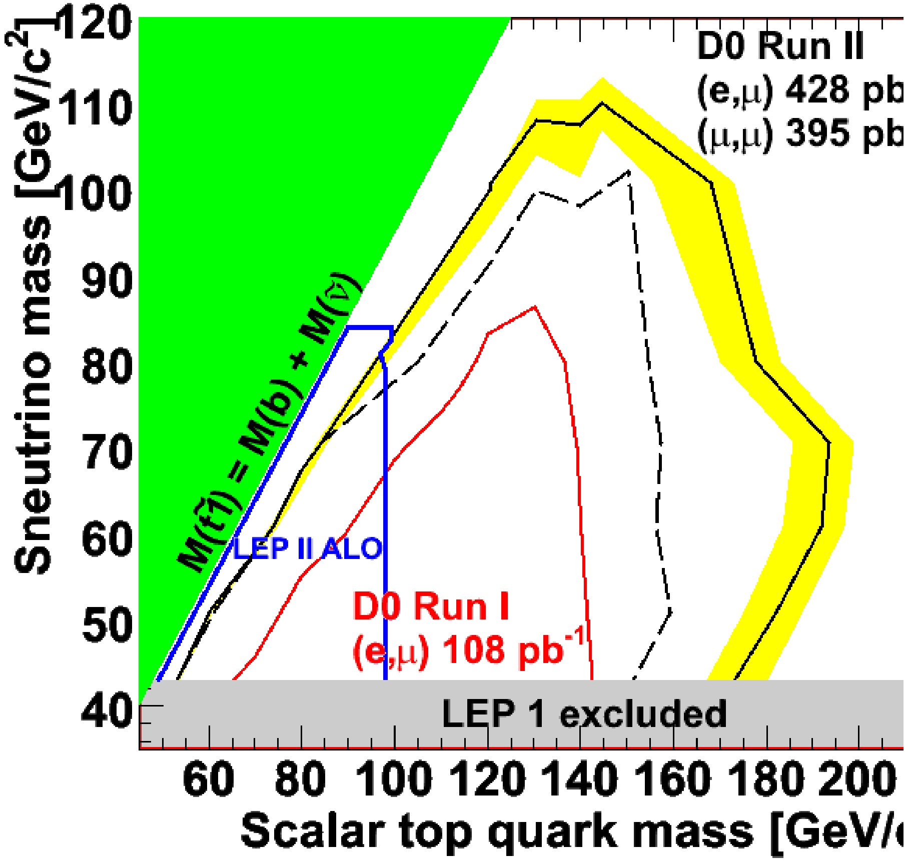


Search for Supersymmetry – Sbottoms/Stops

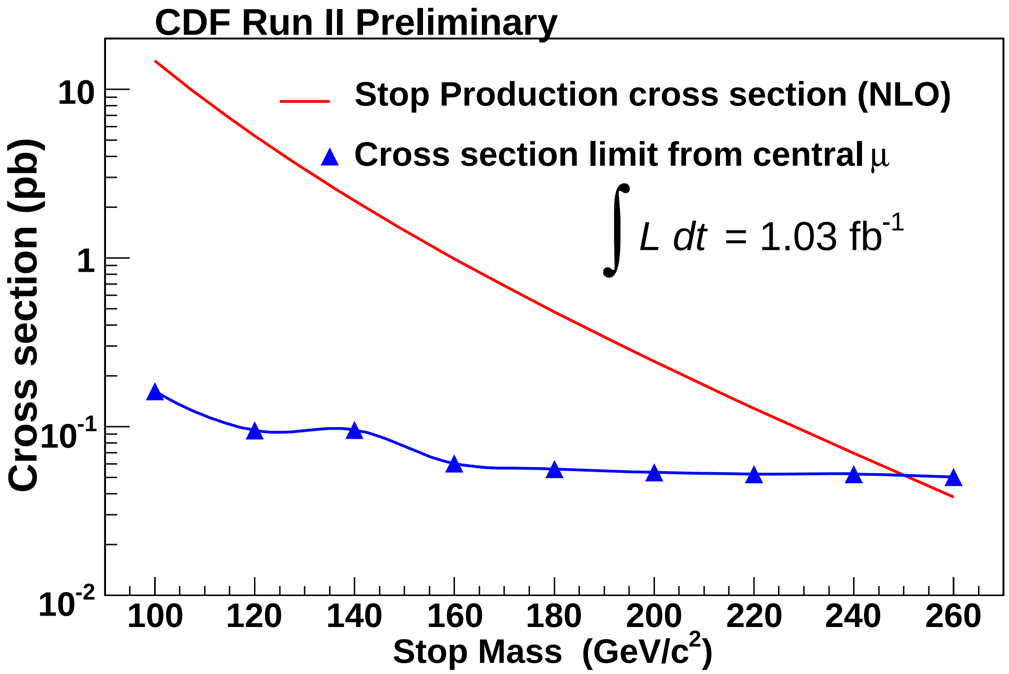
Dedicated searches for light sbottom or stop quarks

- can use b- and charm-tagging to substantially reduce backgrounds
- still significant potential with more integrated luminosity

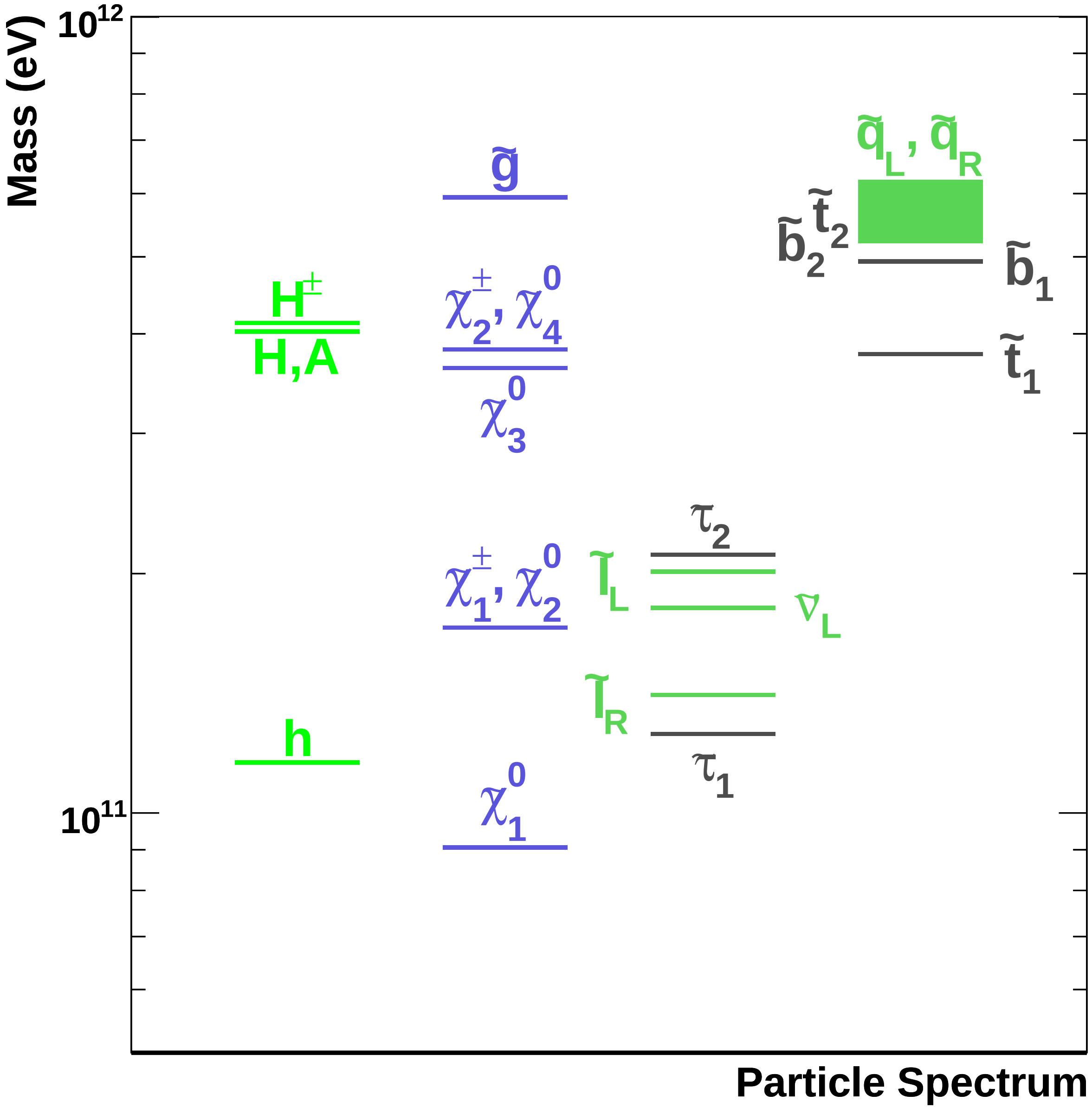
$\tilde{t} \to b + \ell + \tilde{\nu}$



stable stop quarks

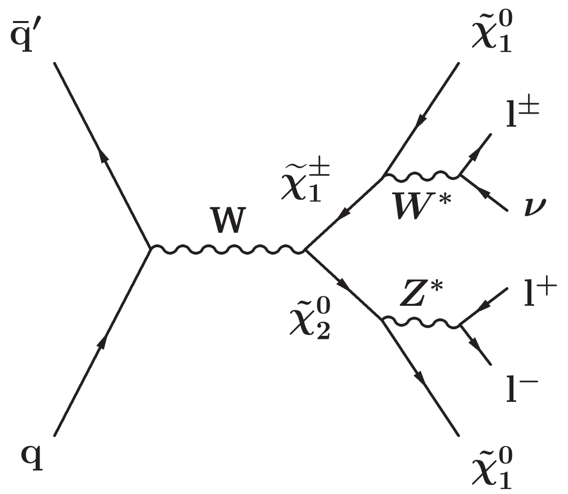


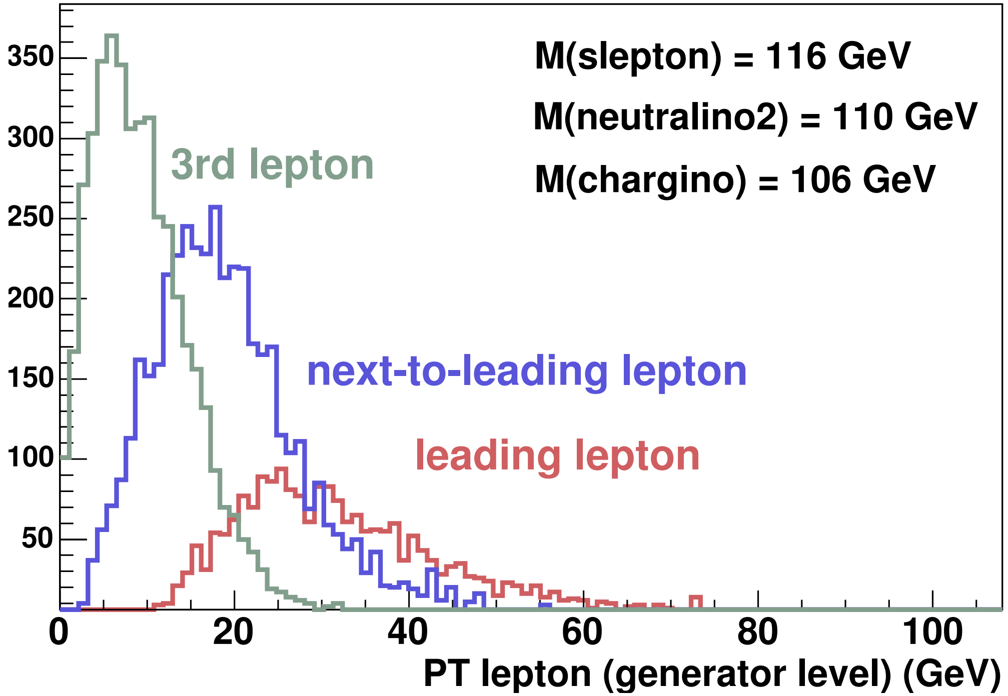
What other particles does SUSY predict?



Search for Charginos and Neutralinos

- Production cross section (electroweak) relatively small
  → need clean leptonic signature to suppress backgrounds
- Golden channel: $\tilde{\chi}^\pm \tilde{\chi}^0_2 \longrightarrow 3\ell + \not{E}_T$
- Experimental Challenge: low-p_T leptons
  → need multilepton triggers with low thresholds
  → need efficient lepton identification at low p_T





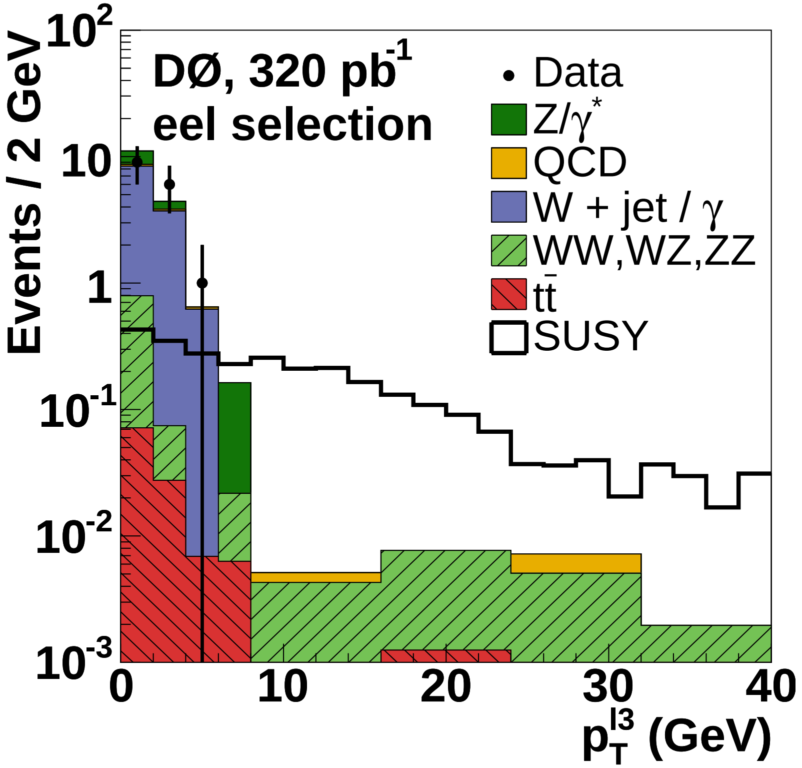
Search for Charginos and Neutralinos

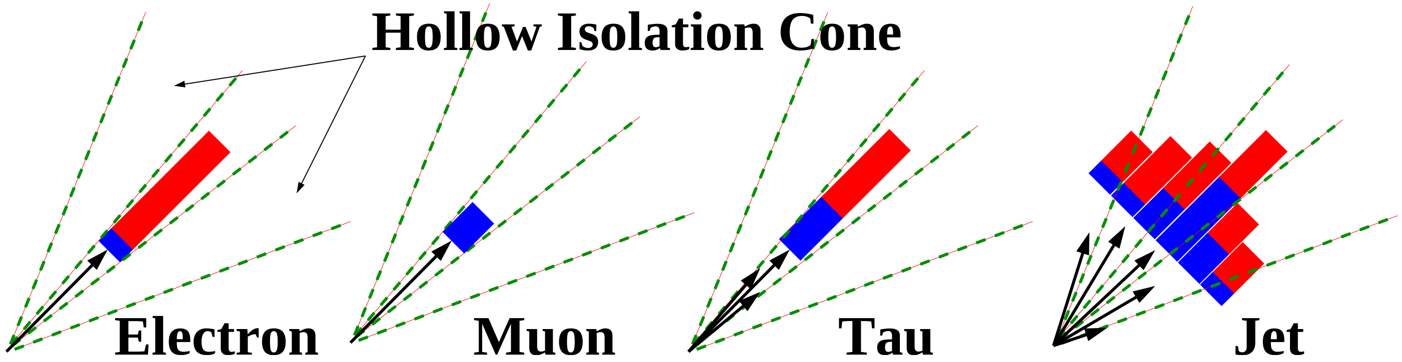
Analysis Strategy:

- two identified leptons plus isolated track
- isolation criteria designed to be efficient for electrons, muons and hadronic τ-decays

Transverse momentum thresholds (DØ):

Selection	$p_T^{\ell 1}$	$p_T^{\ell 2}$	$p_T^{\ell 3}$
$ee\ell$	$>$12 GeV	$>$8 GeV	$>$4 GeV
$e\mu\ell$	$>$12 GeV	$>$8 GeV	$>$7 GeV
$\mu\mu\ell$	$>$11 GeV	$>$5 GeV	$>$3 GeV
ls-$\mu\mu$	$>$11 GeV	$>$5 GeV	–





Search for Charginos and Neutralinos

DØ Results (0.9–1.7 fb^{-1}):

Selection	Expected Background	Observed	Signal (m$_{\tilde{\chi}^\pm}$=110 GeV)
$ee\ell$	1.8±0.7	0	6.8±0.4
$e\mu\ell$	0.9±0.4	0	4.0±0.2
$\mu\mu\ell$	0.3±0.8	2	2.5±0.2
ls-$\mu\mu$	1.1±0.4	1	4.2±0.7
Combined	4.1±1.2	3	17.5±0.8

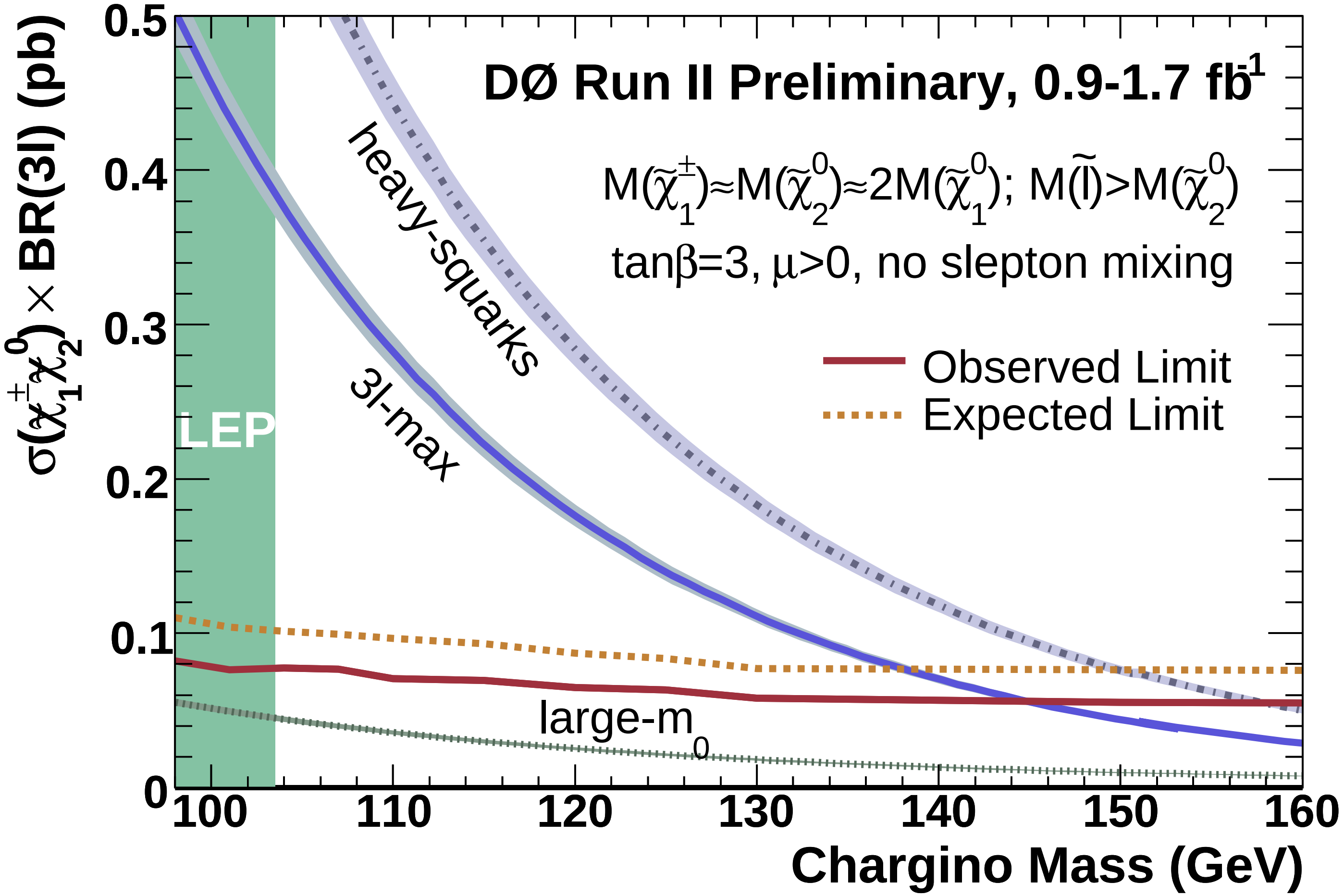
CDF Results (0.7–1.1 fb^{-1}):

	$e^\pm e^\pm$	$e^\pm\mu^\pm$	$\mu^\pm\mu^\pm$	$e\ell\ell$	$\mu\ell\ell$	eet	$\mu\mu\ell$
Expected Background	2.96	4.00	0.92	0.75	1.26	0.97	0.41
Uncertainty	±0.48	±0.57	±0.12	±0.36	±0.27	±0.28	±0.11
Observed	4	8	1	0	1	3	1

$\longrightarrow$ No evidence for chargino/neutralino production

$\longrightarrow$ Limits on product of cross section and leptonic branching fraction

Search for Charginos and Neutralinos



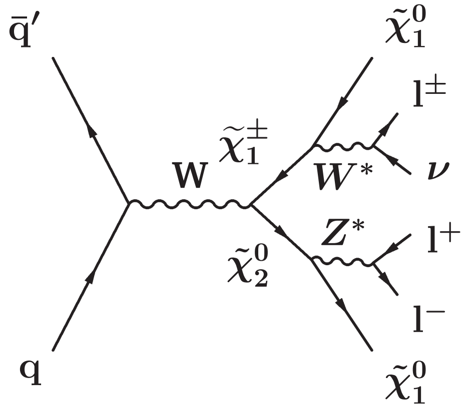
Limits constrain SUSY beyond LEP chargino limits:

- **3ℓ-max scenario: $m_{\tilde{\chi}^{\pm}} > 145$ GeV**

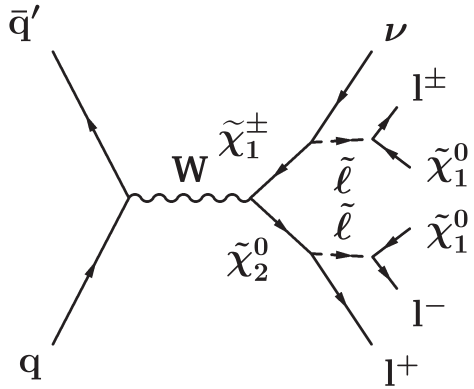
Updates with 3 fb^{-1} datasets currently in progress

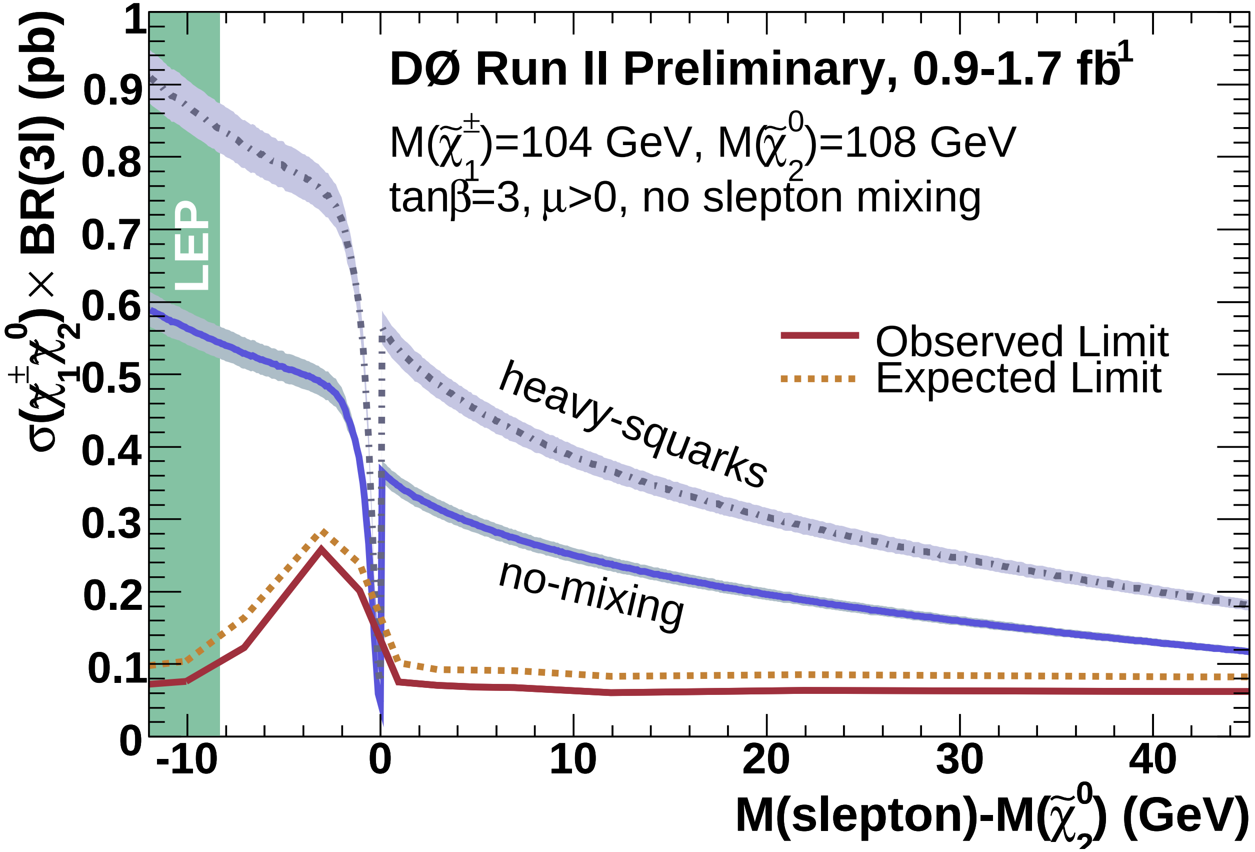
Search for Charginos and Neutralinos

Heavy sleptons:



Light sleptons:





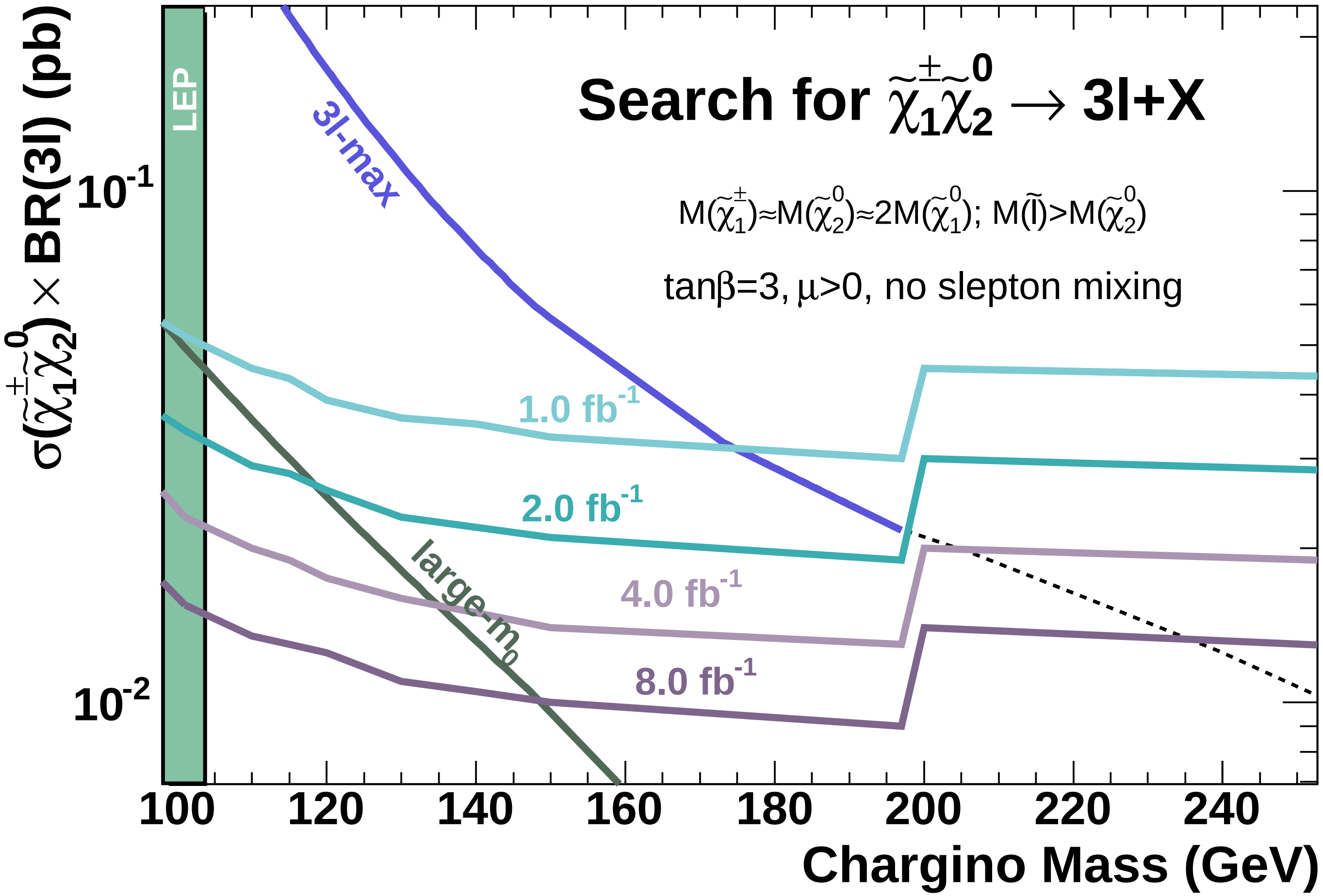
$\Delta M<0$: two-body decays into real sleptons

- $\Delta M<-6$ GeV: good efficiency, high branching fractions
- -6 GeV$<\Delta M<0$: very soft third lepton → limit set by ls-$\mu\mu$-analysis

$\Delta M>0$: three-body decays via slepton- and W/Z-exchange

- $\Delta M \gtrsim 0$: slepton-exchange maximal → large BR(3ℓ): "*3l-max scenario*"
- $\Delta M \gg 0$: W/Z-exchange dominates → small BR(3ℓ): "*large-m_0 scenario*"

Search for Charginos and Neutralinos



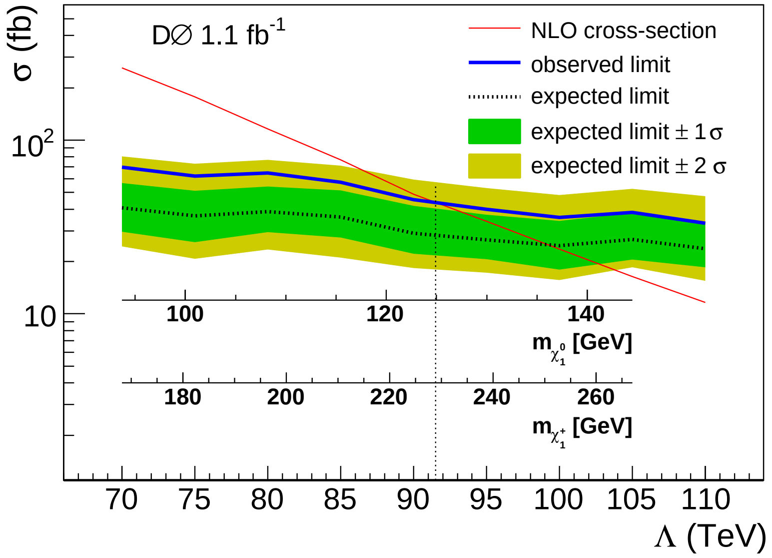
Run IIb projections (combining CDF and DØ):

- 3ℓ-max scenario: will probe $m_{\tilde{\chi}^{\pm}} > 200$ GeV
- large-m_0 scenario: sensitive up to $m_{\tilde{\chi}^{\pm}} \approx 150$ GeV

Updates with 3 fb^{-1} datasets currently in progress

Beyond mSUGRA

Many other SUSY models on the market → large variety of SUSY searches at the Tevatron

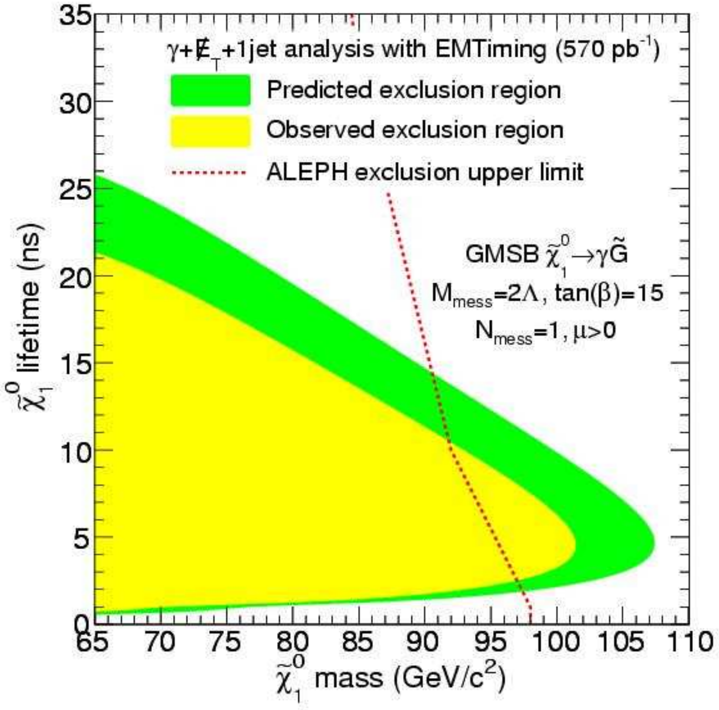


Gauge-Mediated SUSY Breaking

- Inclusive $\gamma\gamma + \not\!\!E_T$: charginos excluded up to 229 GeV (DØ)
- Long-lived neutralinos: limits up to 101 GeV (CDF)

Anomaly-Mediated SUSY Breaking

- Stable charginos: excluded up to 174 GeV (DØ)



Split Supersymmetry

- Long-lived Gluinos $\tilde{g} \to g\tilde{\chi}_1^0$:

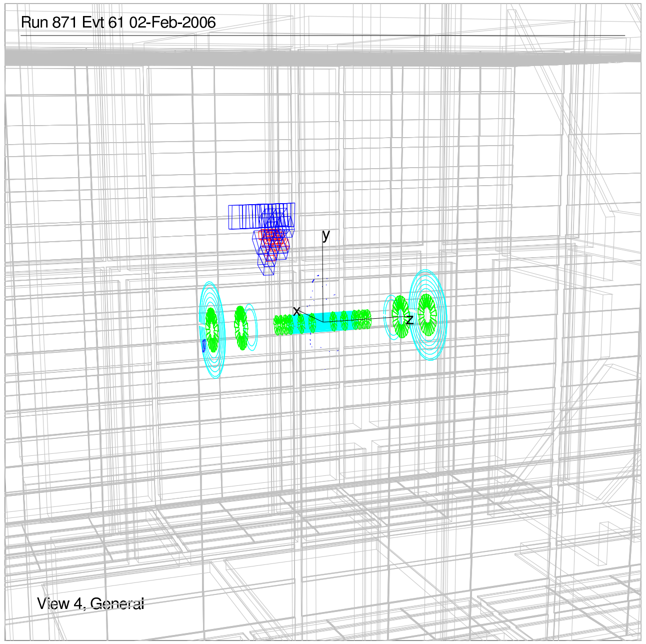
  limits up to 320 GeV for lifetimes up to 100 hours (DØ)

R-Parity Violation

- LLE couplings: limits on charginos up to 234 GeV (DØ)

Beyond mSUGRA

Many other SUSY models on the market → large variety of SUSY searches at the Tevatron



Gauge-Mediated SUSY Breaking

- Inclusive $\gamma\gamma + \not\!\!E_T$: charginos excluded up to 229 GeV (DØ)
- Long-lived neutralinos: limits up to 101 GeV (CDF)

Anomaly-Mediated SUSY Breaking

- Stable charginos: excluded up to 174 GeV (DØ)

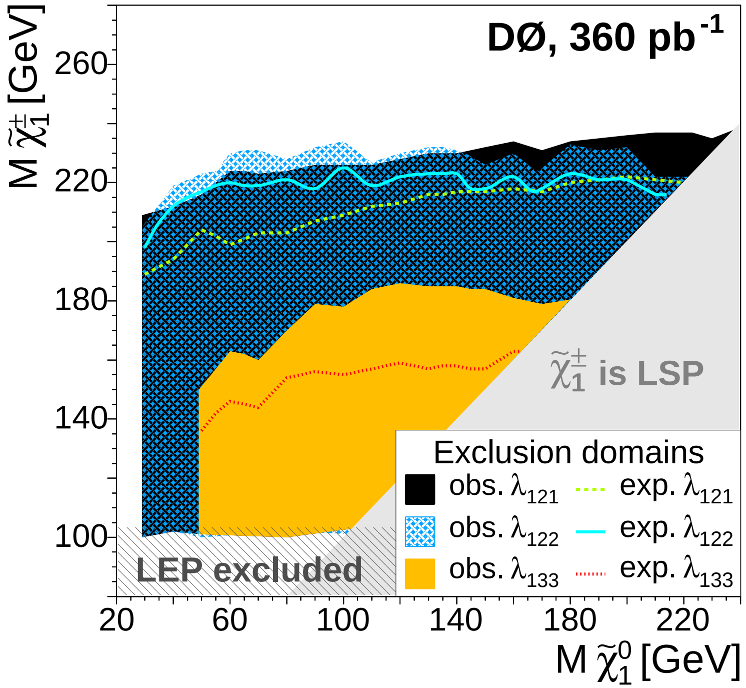
Split Supersymmetry

- Long-lived Gluinos $\tilde{\mathrm{g}} \to g\tilde{\chi}_1^0$:

  limits up to 320 GeV for lifetimes up to 100 hours (DØ)

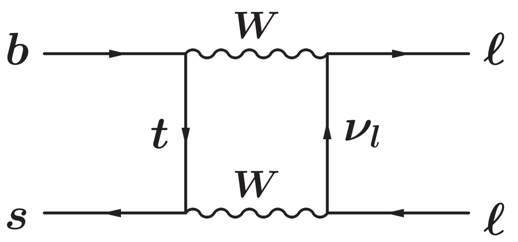
R-Parity Violation

- LLE couplings: limits on charginos up to 234 GeV (DØ)

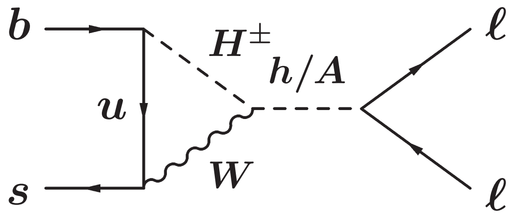


Supersymmetry and rare decays: $B_s \to \mu^+\mu^-$

SM prediction: BR($B_s \to \mu^+\mu^-$)=3.8×10^{-9}



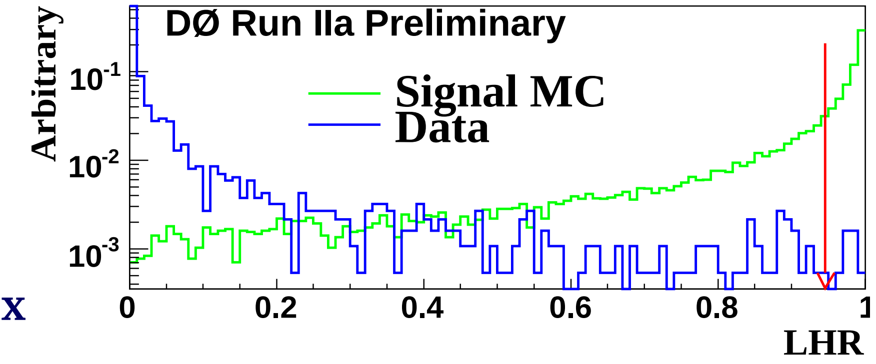
MSSM: enhancement $\sim(\tan\beta)^6$

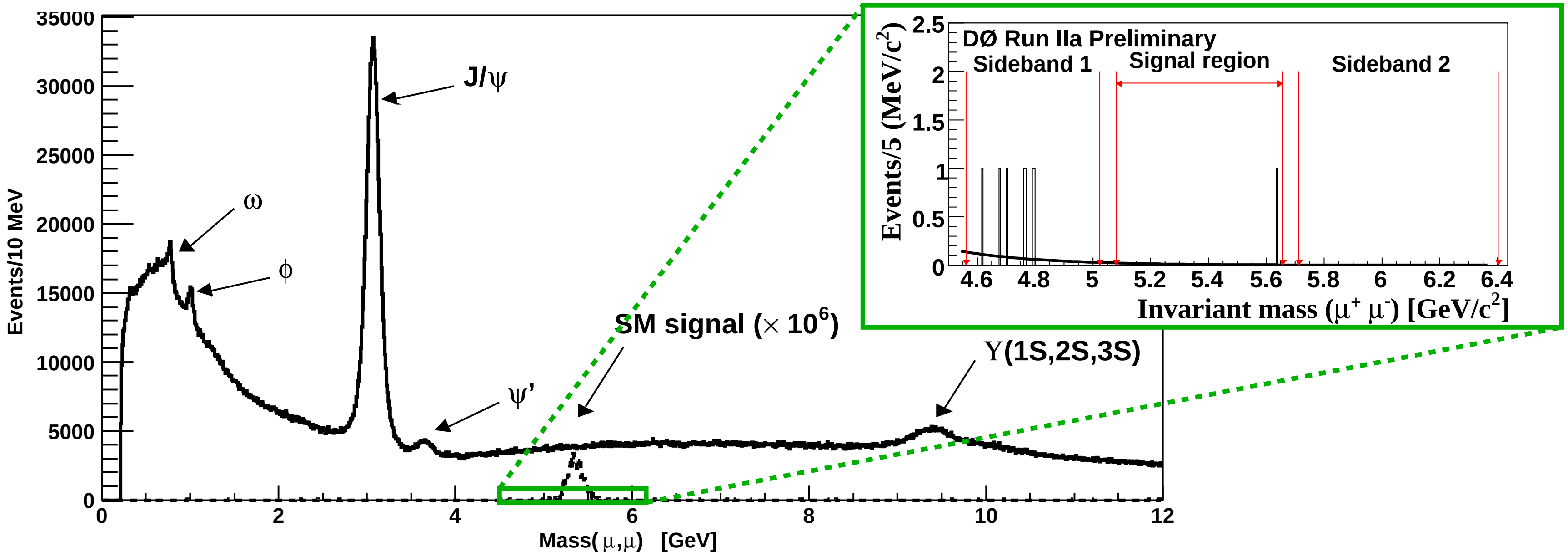


→ significant at high tanβ: BR=$O(10^{-7})$

→ complementary to trilepton search

- Tevatron: large production rate for B_s
- Selection: two isolated muons, displaced vertex





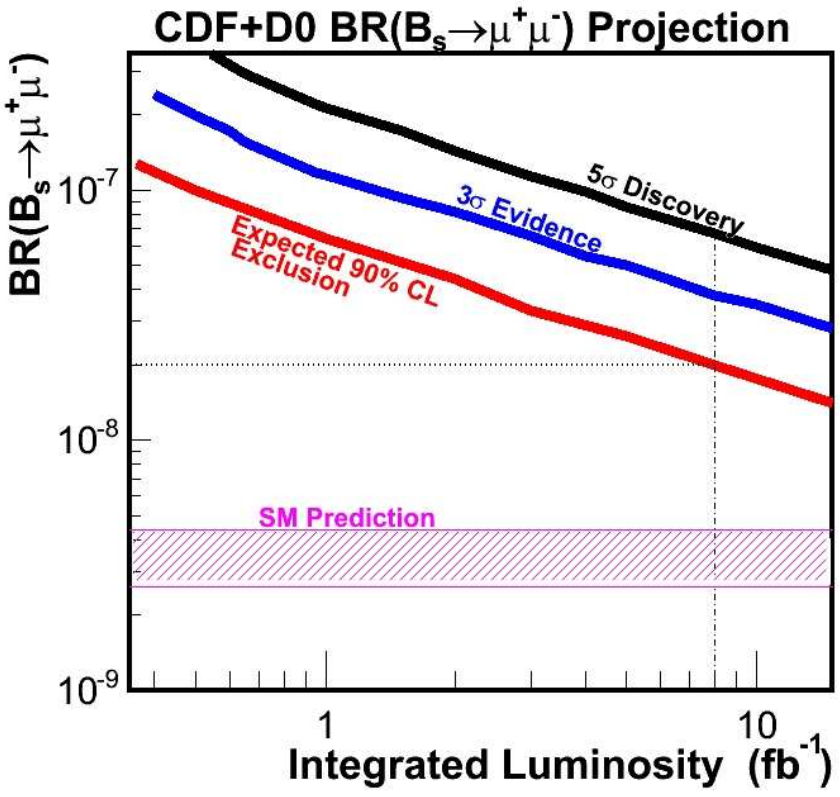
Supersymmetry and rare decays: $B_s \rightarrow \mu^+\mu^-$

Results (limits at 95% C.L.):

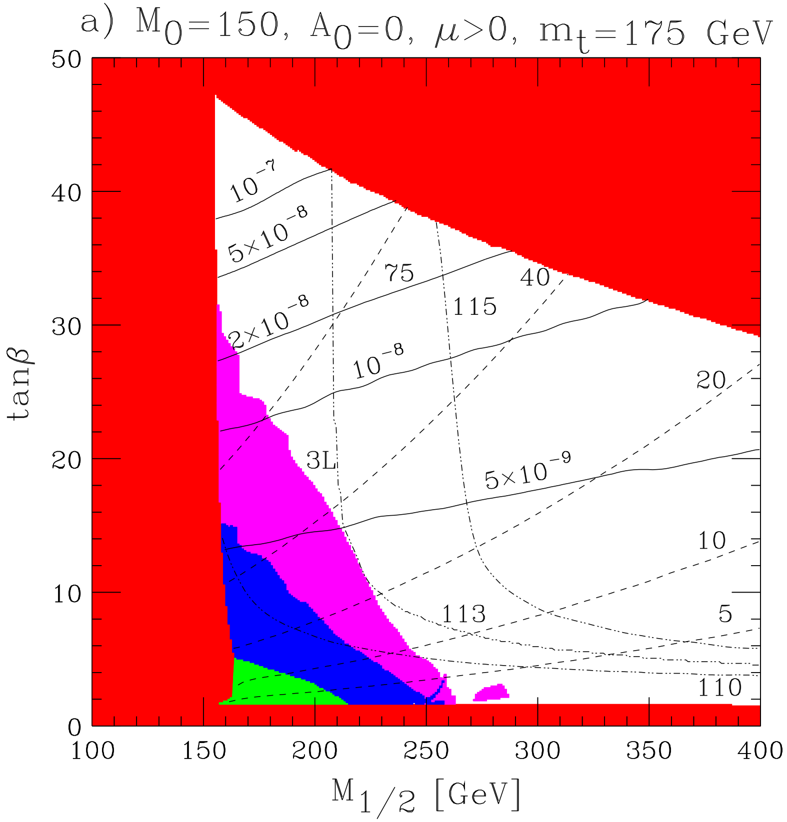
DØ (2 fb^{-1}): 2.3±0.5 expected, 3 observed → $BR(B_s \rightarrow \mu^+\mu^-) < 9.3\times10^{-8}$
CDF (2 fb^{-1}): 3.7±1.0 expected, 3 observed → $BR(B_s \rightarrow \mu^+\mu^-) < 5.8\times10^{-8}$

Projection for Run IIb: sensitivity will approach 10^{-8}

→ will test large part of SUGRA parameter space



Dedes, Dreiner, Nierste, Richardson
(hep-ph/0207026)

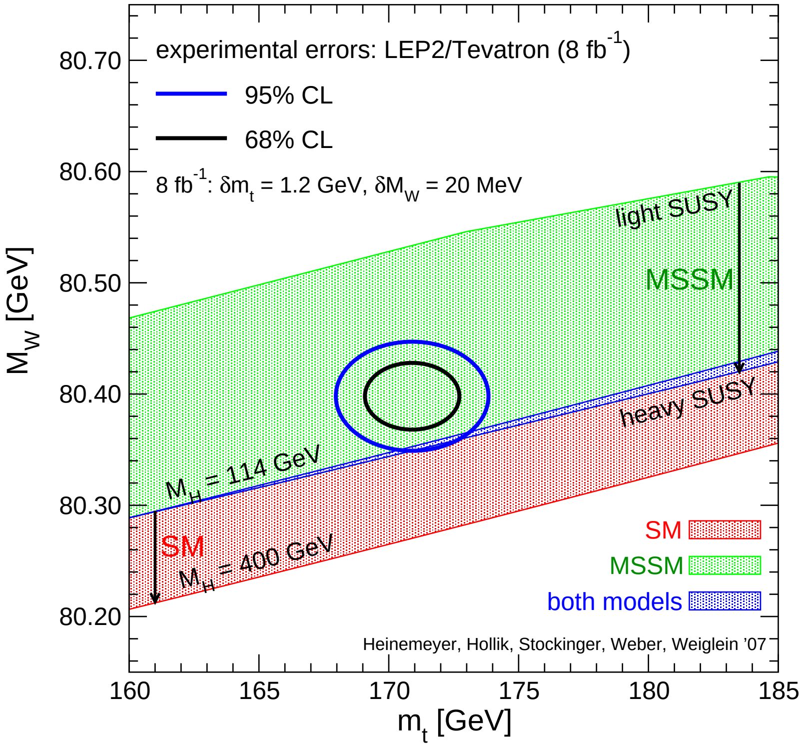


Conclusions

- Tevatron Collider has reached design luminosity, 3.2 fb^{-1} delivered so far
- Improved measurements of top and W mass constraining SM Higgs boson
- Higgs searches on the way to reaching sensitivity
- Probing Squarks/Gluinos/Charginos up to 390/310/140 GeV
- Preparing for LHC physics with dedicated measurements at the Tevatron

Conclusions

- Tevatron Collider has reached design luminosity, 3.2 fb^{-1} delivered so far
- Improved measurements of top and W mass constraining SM Higgs boson
- Higgs searches on the way to reaching sensitivity
- Probing Squarks/Gluinos/Charginos up to 390/310/140 GeV
- Preparing for LHC physics with dedicated measurements at the Tevatron



Let's hope we stay away from the dark side!