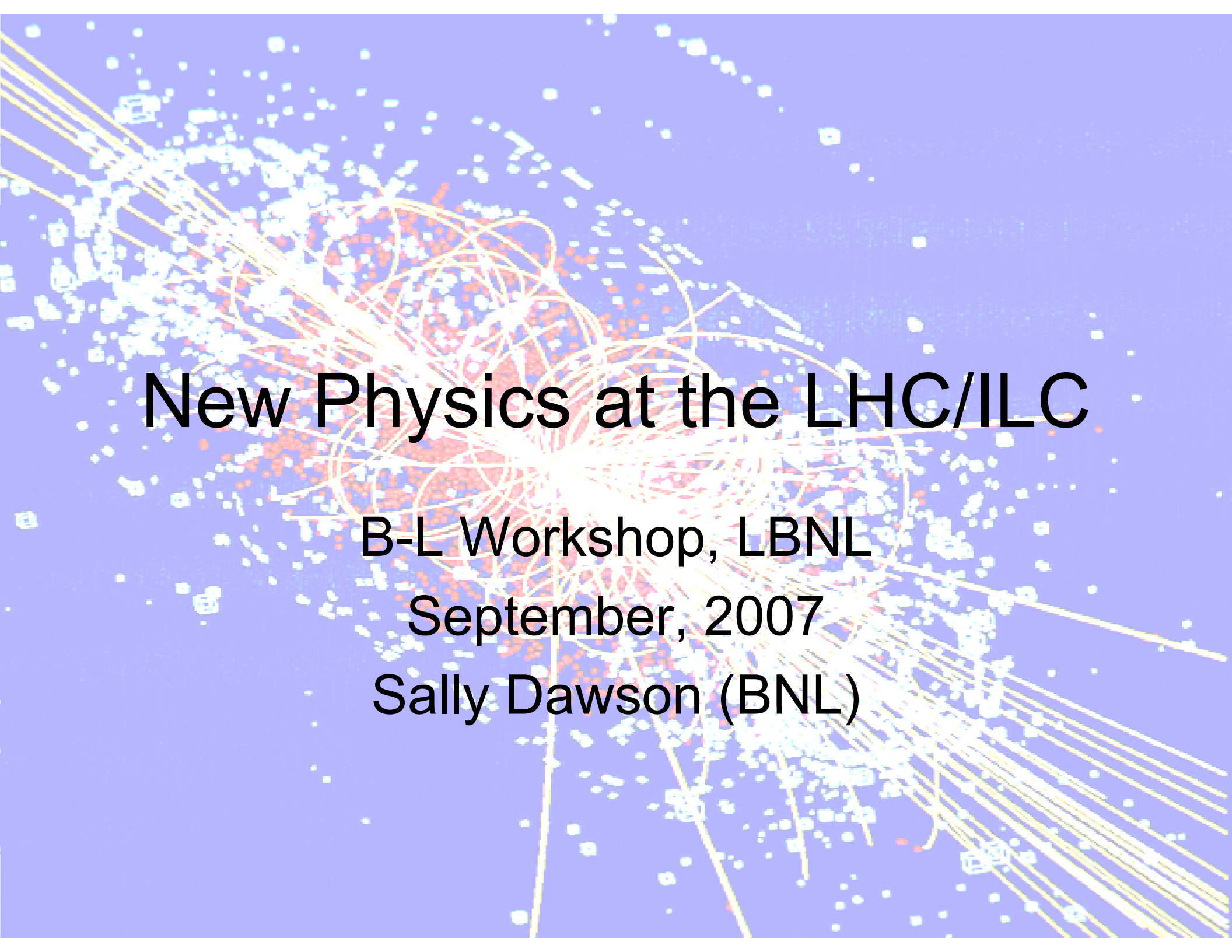


New Physics at the LHC/ILC

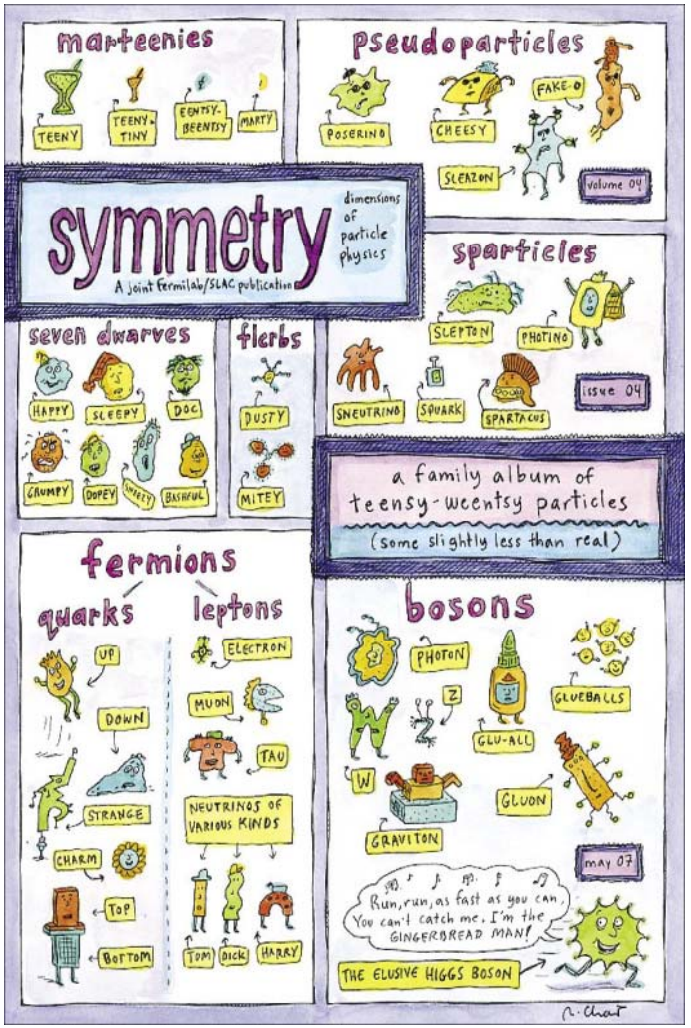
B-L Workshop, LBNL

September, 2007

Sally Dawson (BNL)

Three Examples:

- The Higgs
- Supersymmetry
- New Z' boson

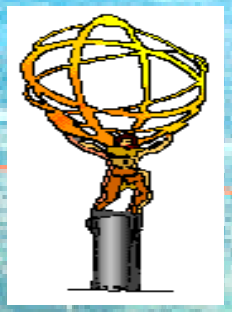


- What do we know from the Tevatron?
- What will the LHC tell us?
- What needs the ILC?

I hope we find something we haven't thought of yet!

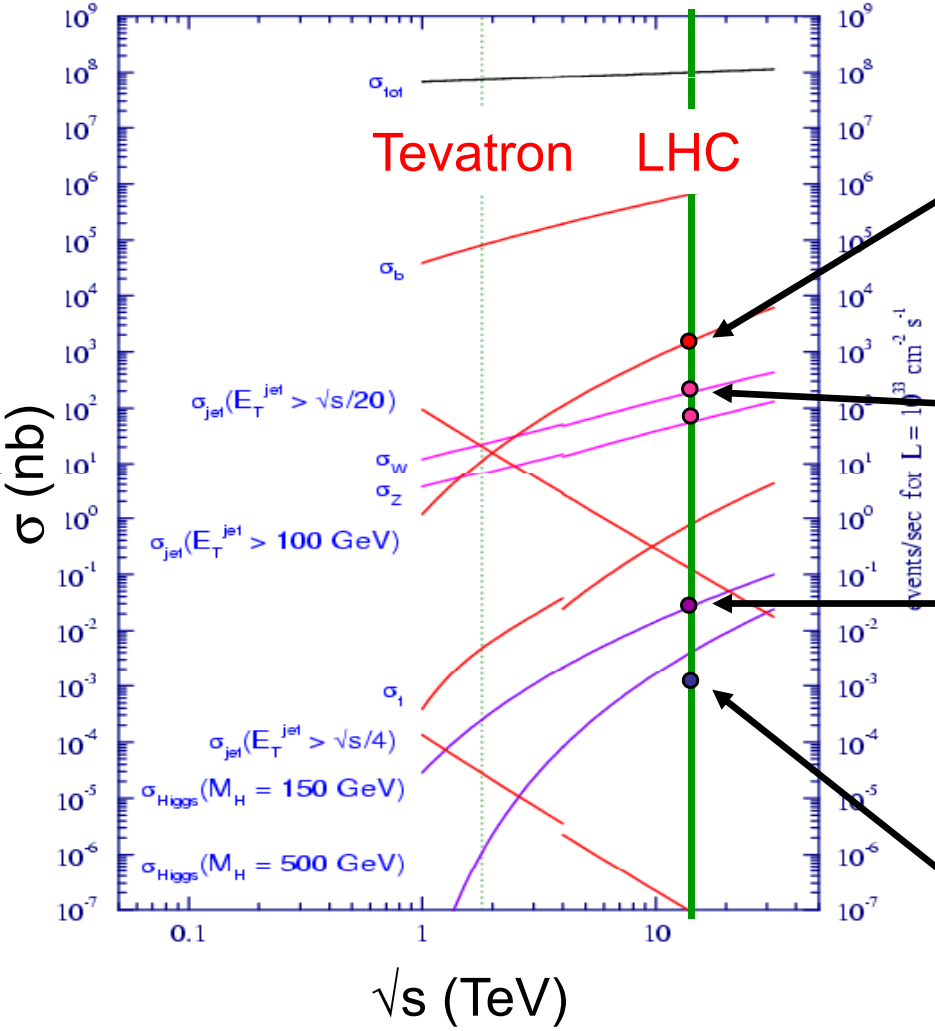
Particle Physics in tne LHC/ILC Era

- Will be data driven



Eagerly anticipating LHC data……

From the Tevatron to the LHC



High p_T QCD Jets

Drell-Yan production of W's & Z's

Gluon fusion of 150 GeV Higgs

1 TeV squark/gluino pair production

- Large increase in cross sections as we go from the Tevatron to the LHC

F. Gianotti, Phys. Rep. 403, 379 (2004)

Early Physics at the LHC

- O(100 pb^{-1}) per experiment by early 2009

Channel	Events/100 pb^{-1} at LHC	Previous # of Events
$W \rightarrow \mu\nu$	10^5	10^4 LEP, 10^6 Tevatron
$Z \rightarrow e^+e^-$	10^5	10^7 LEP, 10^5 Tevatron
$t\bar{t} \rightarrow W^+bW^-\bar{b} \rightarrow \mu\nu X$	10^4	10^4 Tevatron
QCD jets, p_T>1 TeV	$>10^3$	☺
1 TeV Gluino pairs	50	☺

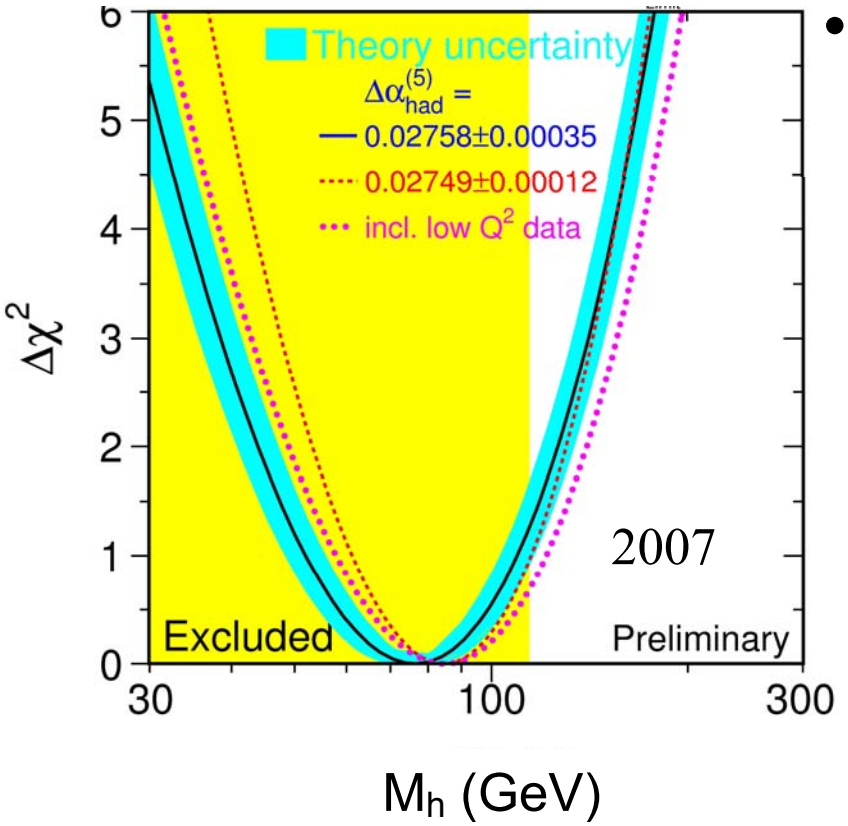
- Early data used to calibrate detectors

  $Z \rightarrow e^+e^-$, $\mu^+\mu^-$ (Tracker, ECAL, Muon chambers calibration)

  $t\bar{t} \rightarrow WbWb$ (Jet scale from $W \rightarrow jj$, b-tag efficiency, etc)

- ***Rediscover SM physics at $\sqrt{s}$=14 TeV: W, Z, top, QCD***

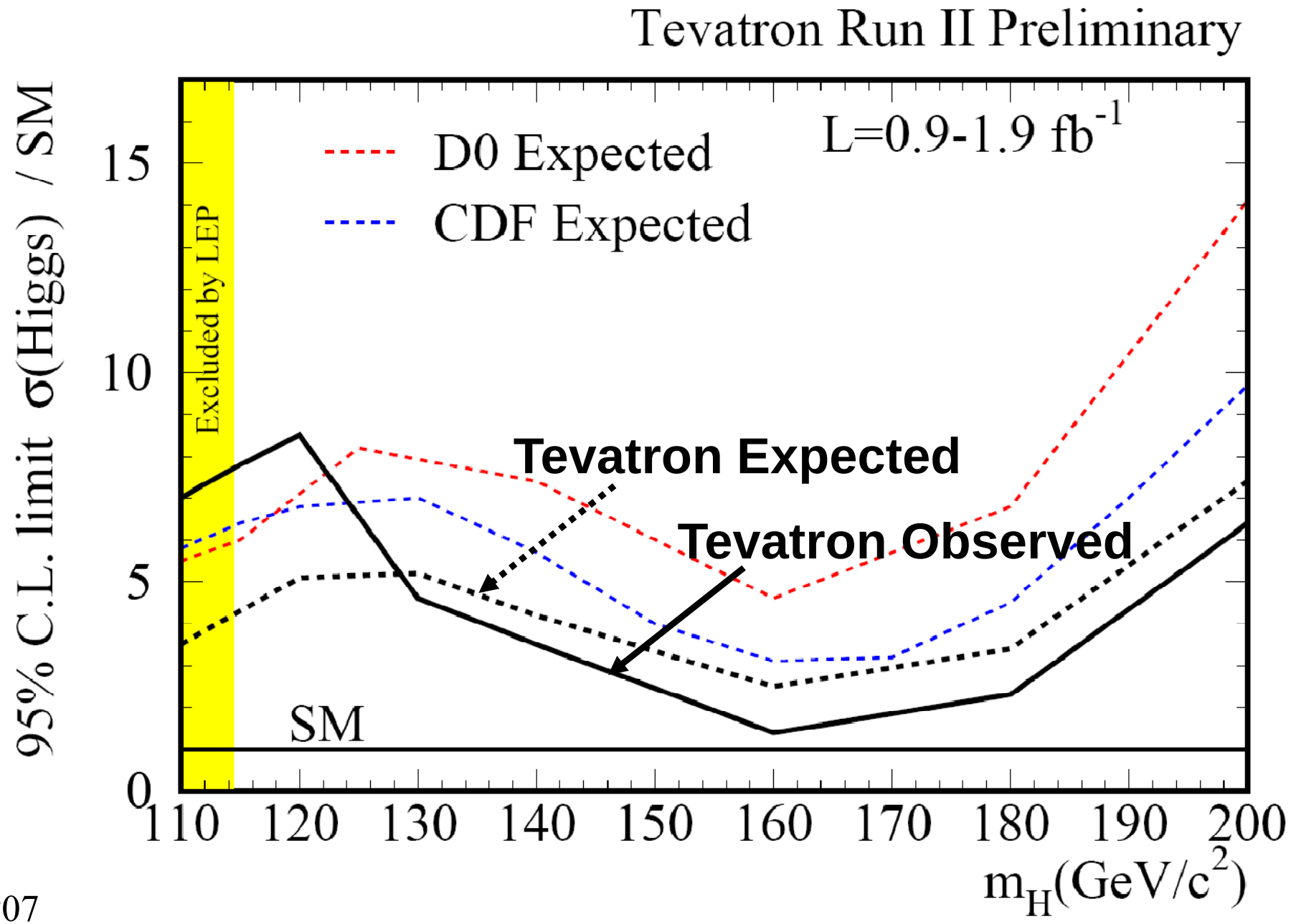
Precision measurements limit Higgs Mass



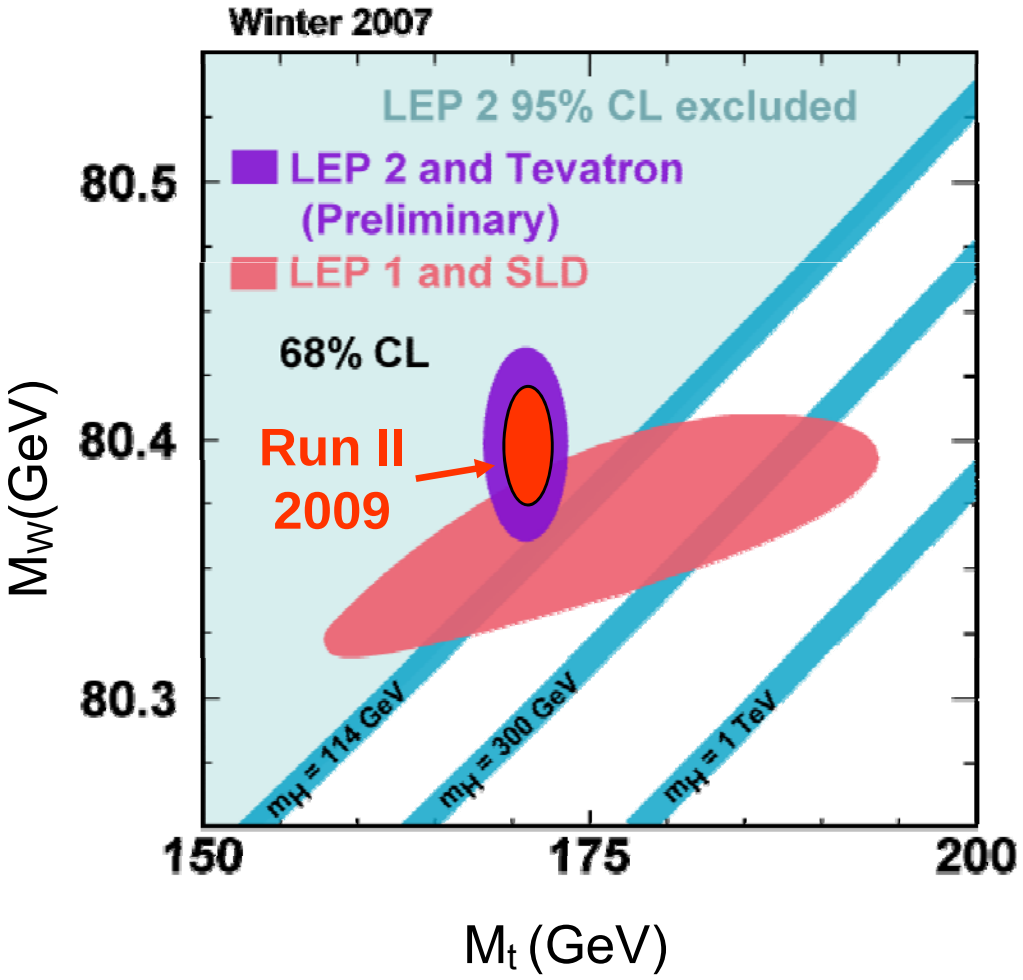
- LEP EWWG (July, 2007):
  - M_t=170.9 ± 1.8 GeV
  - $M_h = 76^{+36}_{-24}$ GeV
  - M_h < 144 GeV (one-sided 95% cl)
  - M_h < 182 GeV (Precision measurements plus direct search limit)

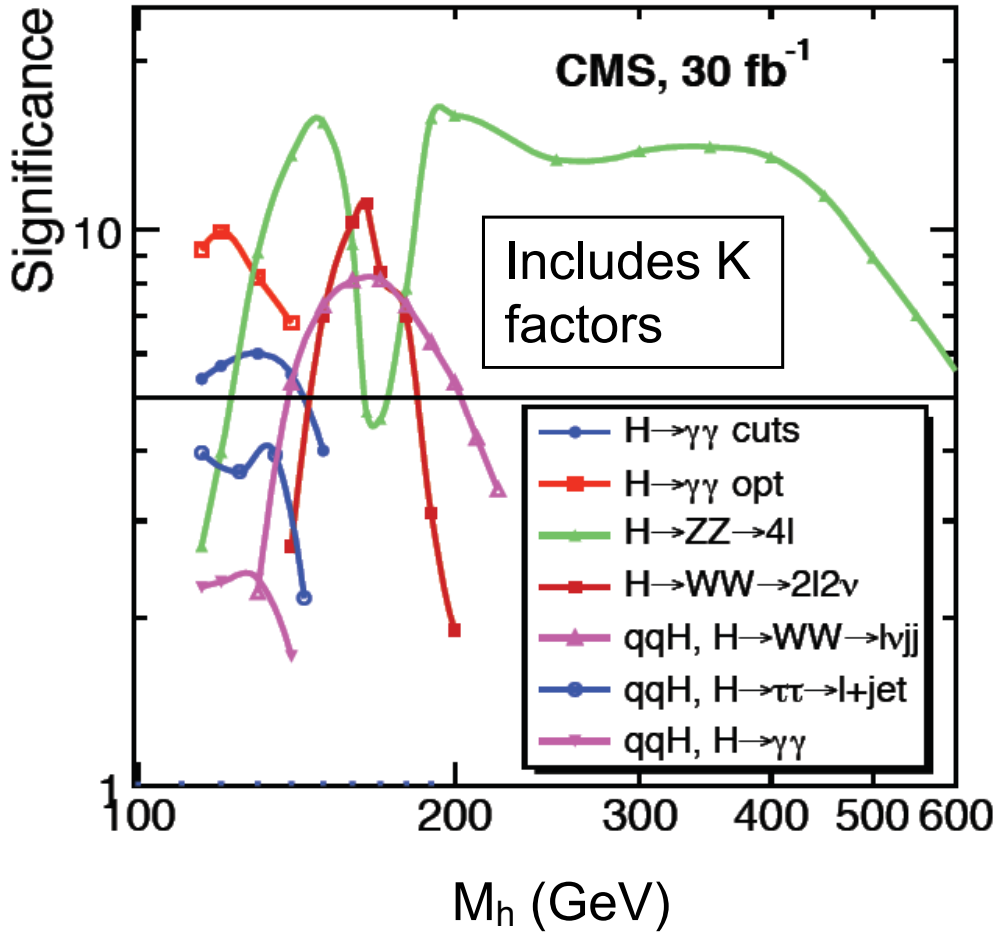
Best fit in region excluded from direct searches

SM Higgs Searches at Tevatron



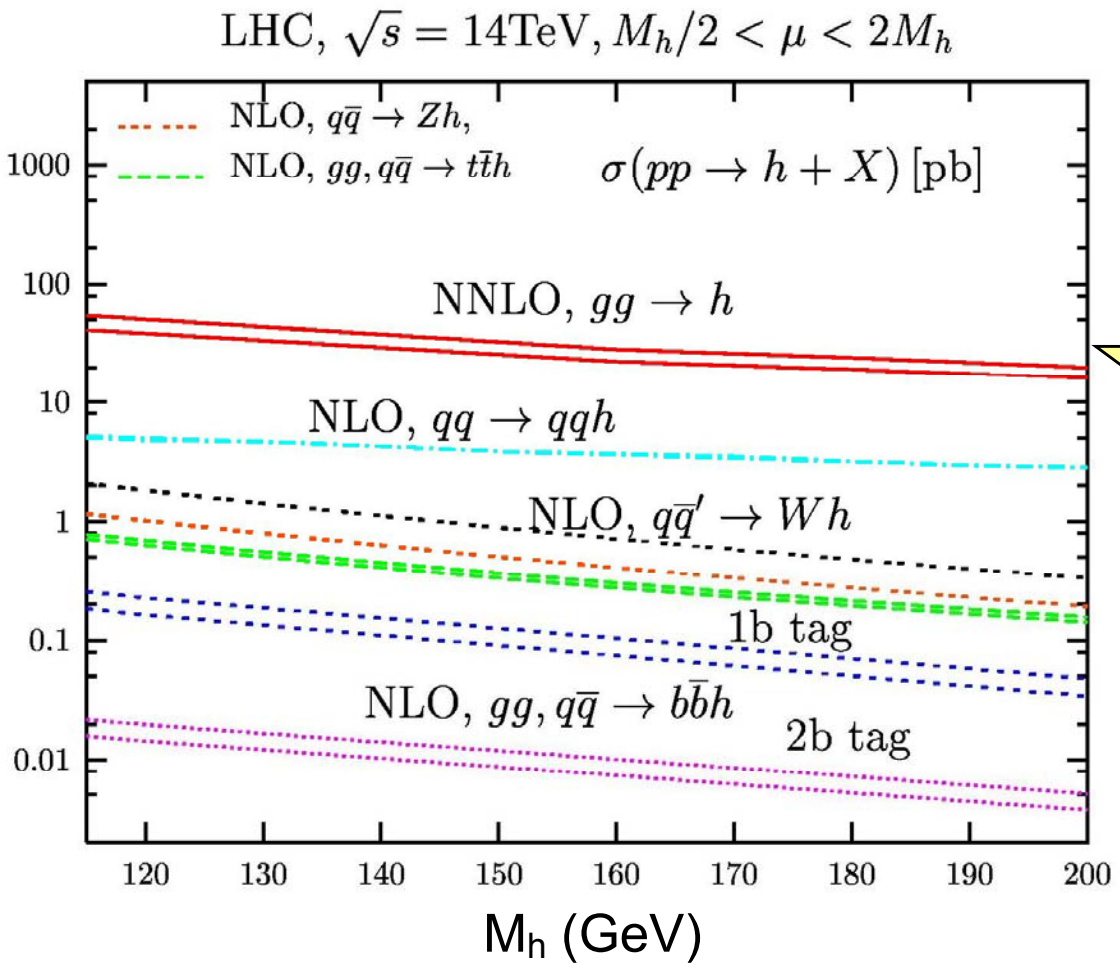
W, Top, and the Higgs





- Will indirect measurements agree with what the LHC sees?

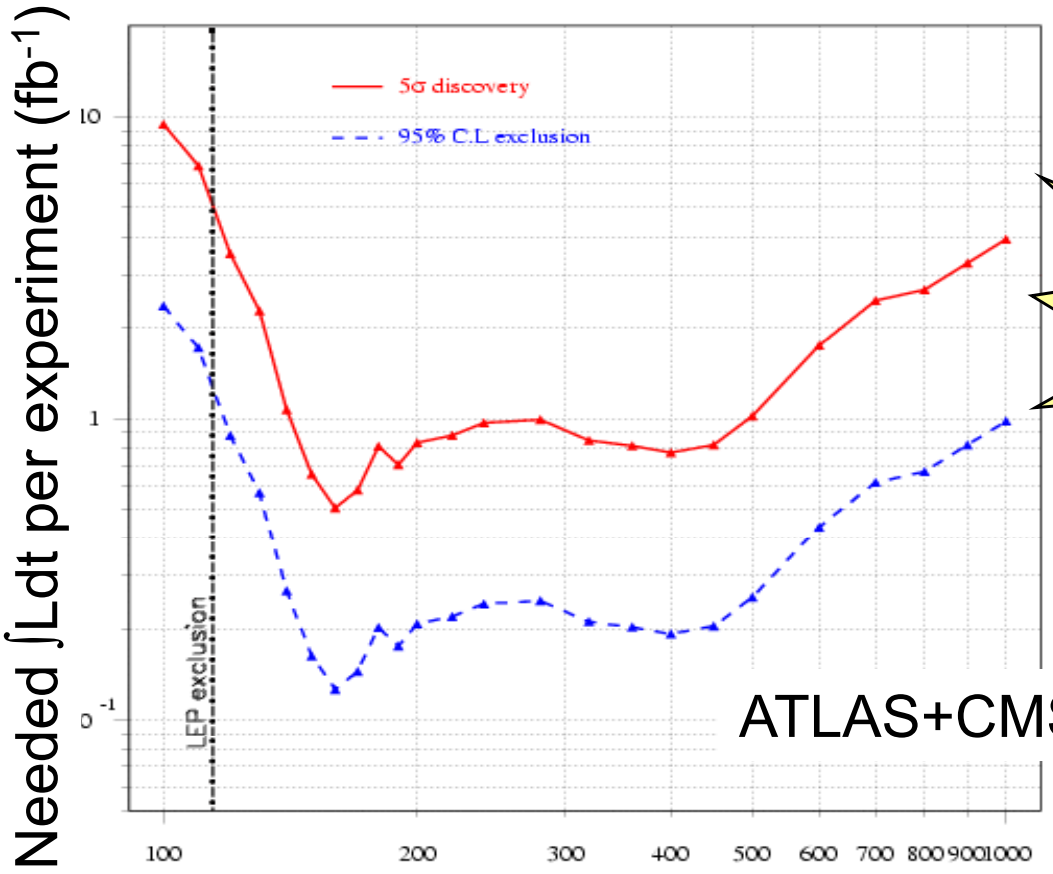
SM Higgs Production at the LHC



Rates well understood

Dawson, Jackson, Reina, Wackeroth, hep-ph/0508293

Higgs discovery potential at the LHC



Assumes well understood detector

1 fb^{-1}: 95% C.L. exclusion

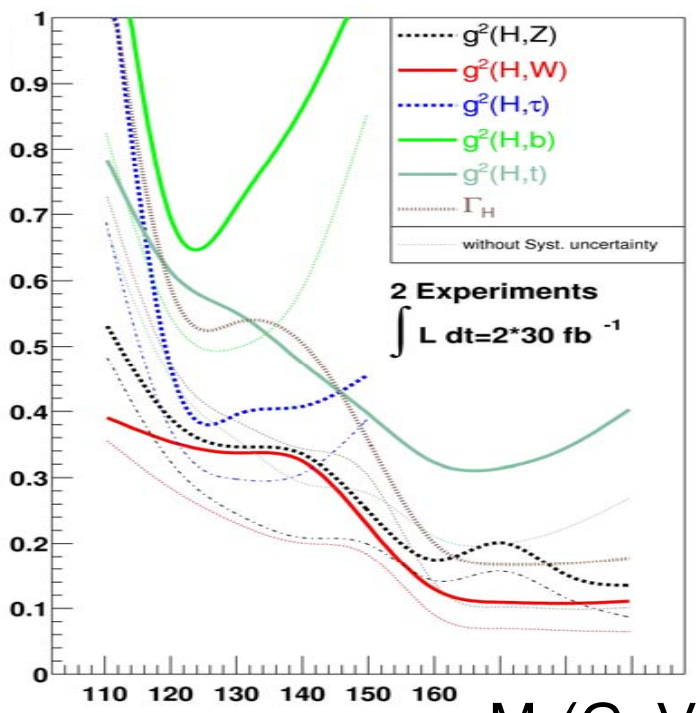
5 fb^{-1}: 5σ discovery

J. Blaising et al, Eur. Strategy Workshop

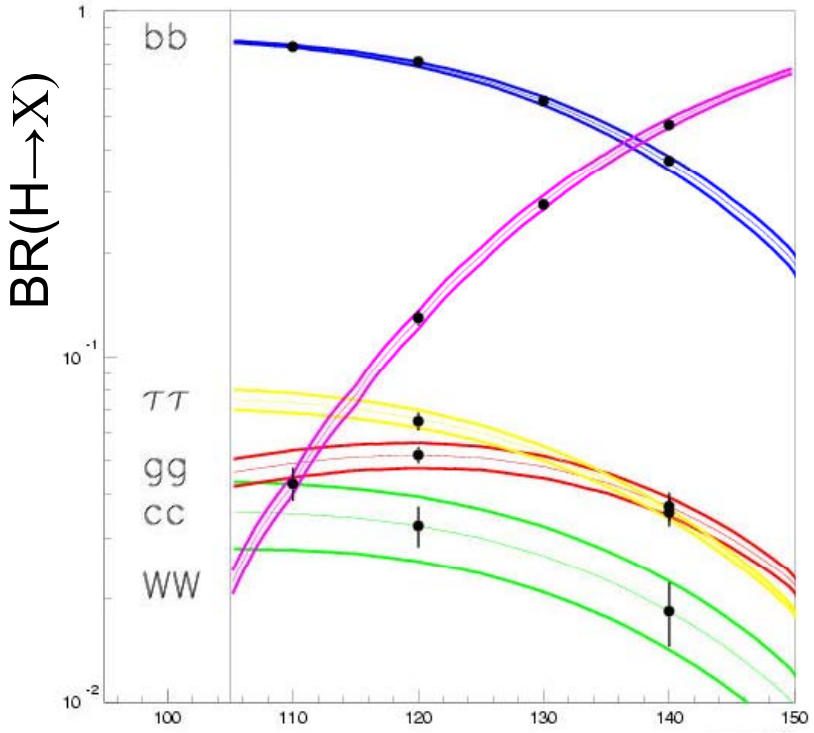
Is Mass Due to a Higgs Boson?

Self coupling of Higgs needed to reconstruct Higgs potential. Extremely challenging at both LHC and ILC

$\frac{\Delta g^2(h,X)}{g^2(h,X)}$



M_h(GeV)



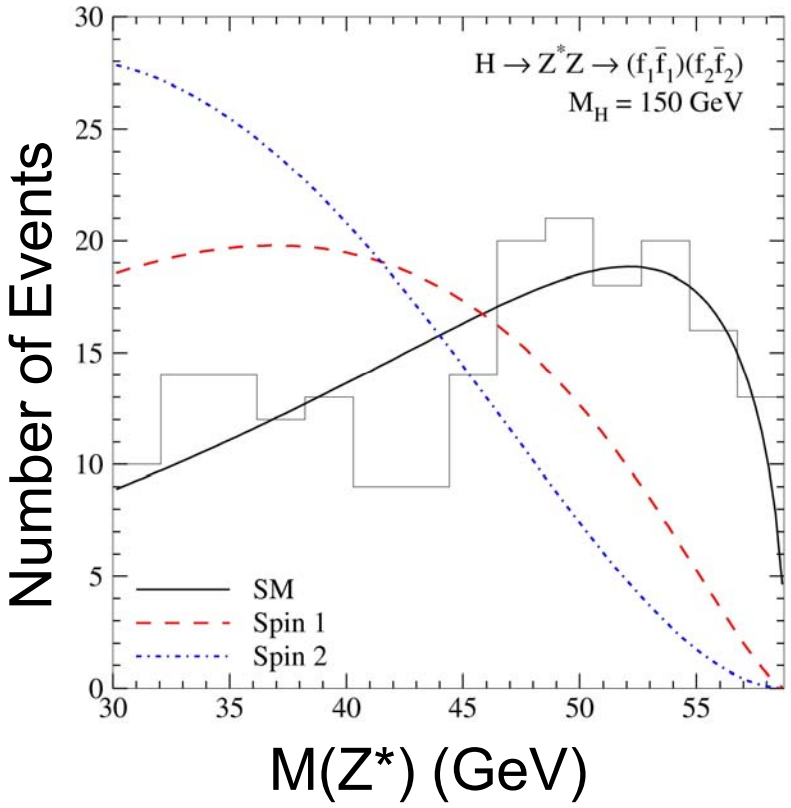
M_h(GeV)

Duhrssen, hep-ph/0406323

Battaglia & Desch, hep-ph/0101165

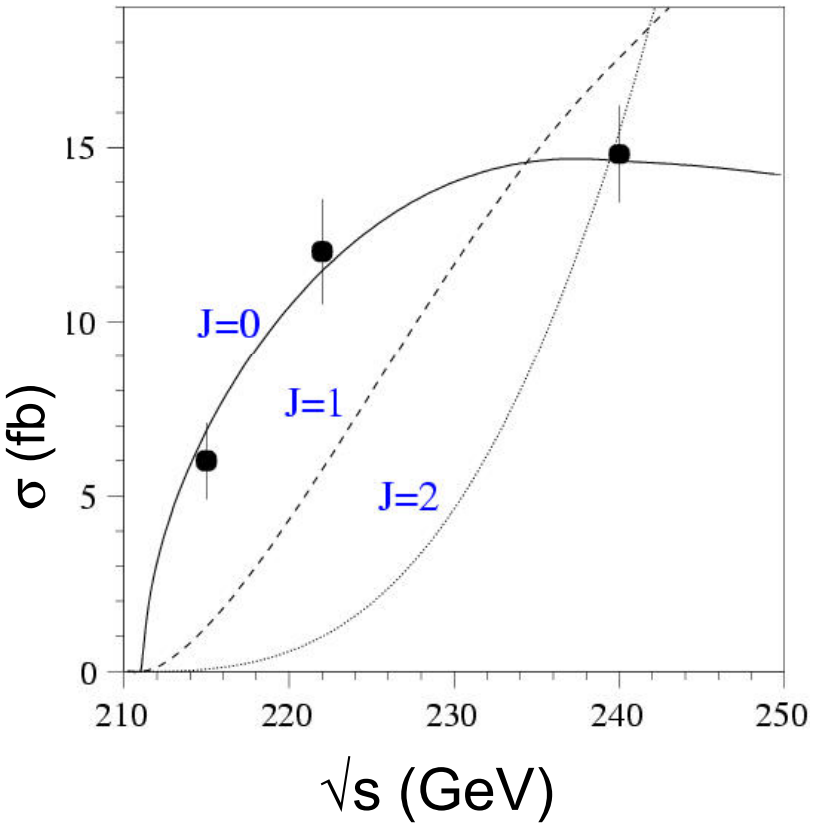
Measuring the spin of the Higgs

LHC with 300 fb^{-1}



➢ Spin is hard at the LHC!

ILC with 20 fb^{-1} /point

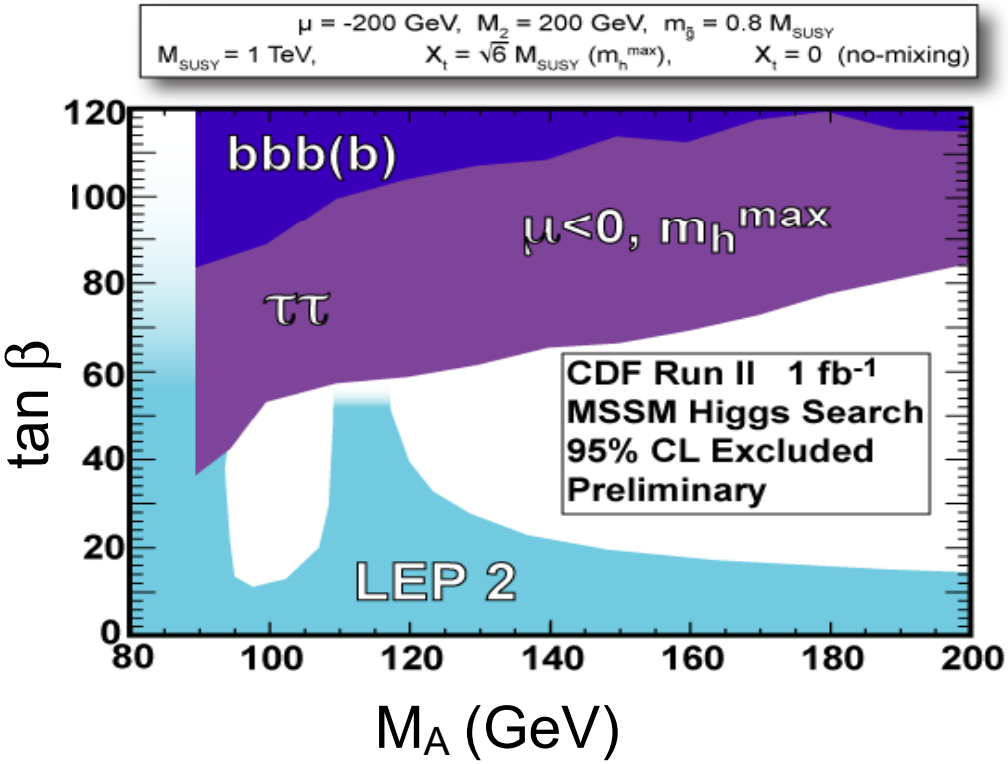


➢ Threshold behavior measures spin at ILC

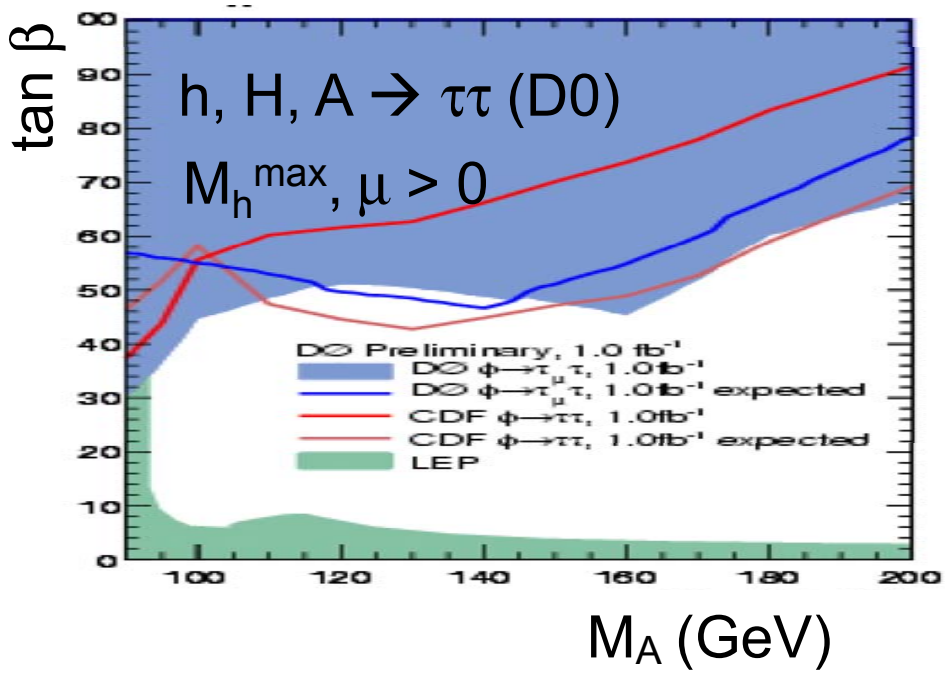
Choi, Miller, Muhlleitner, Zerwas, hep-ph/0210077

J. Aguilar-Saavedra, hep-ph/0106315

MSSM Higgs Searches at the Tevatron

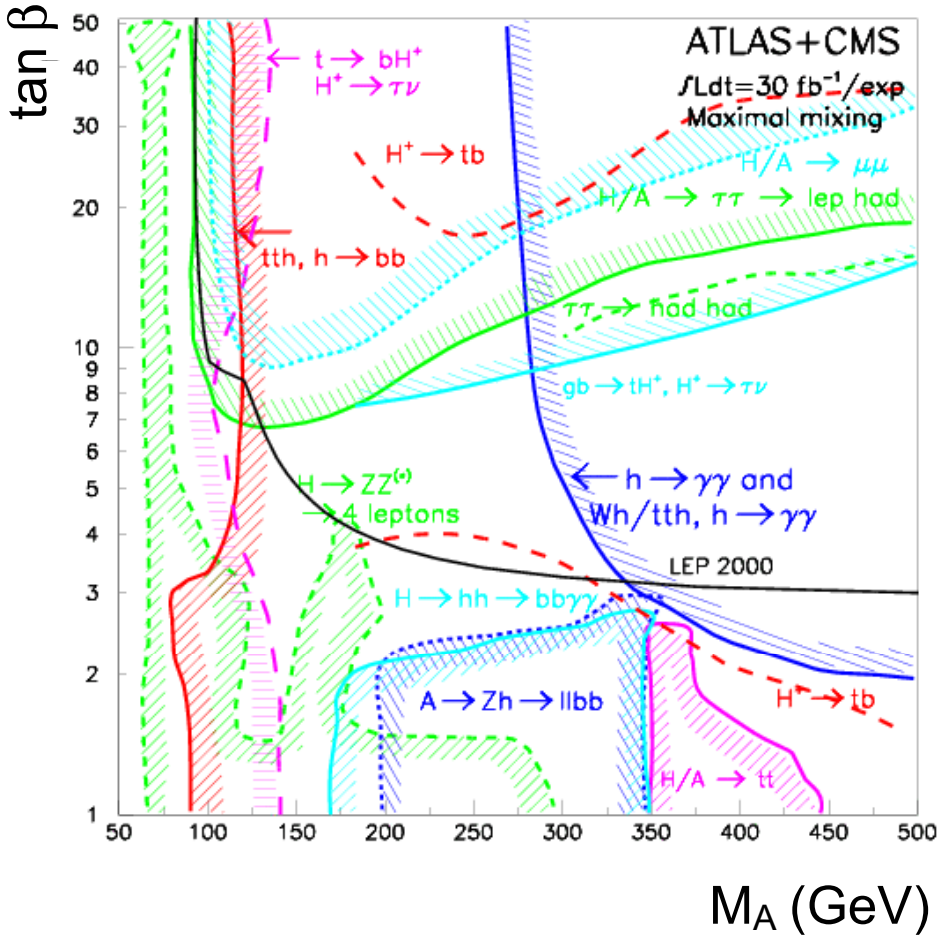


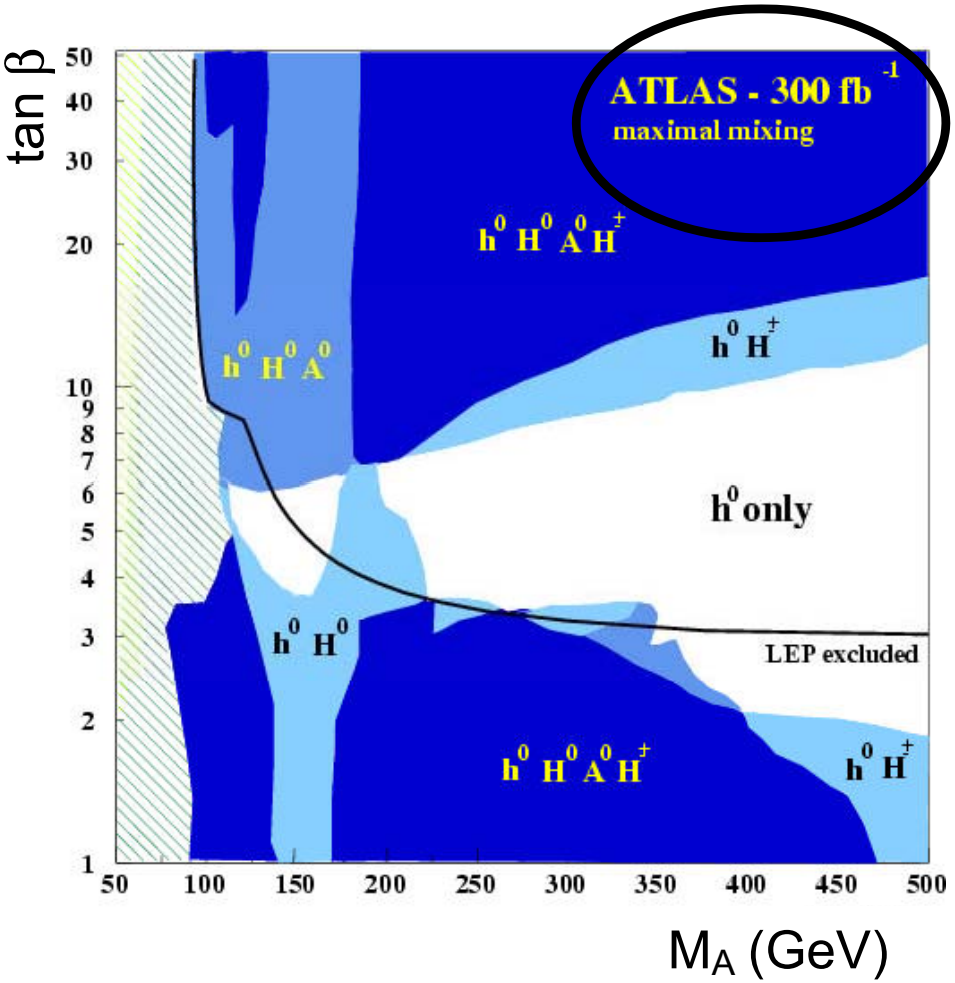
➢Dominant SUSY Higgs production mechanism is $gb \rightarrow b\phi$ for $\tan\beta > 7$



LP07

MSSM Higgs at the LHC





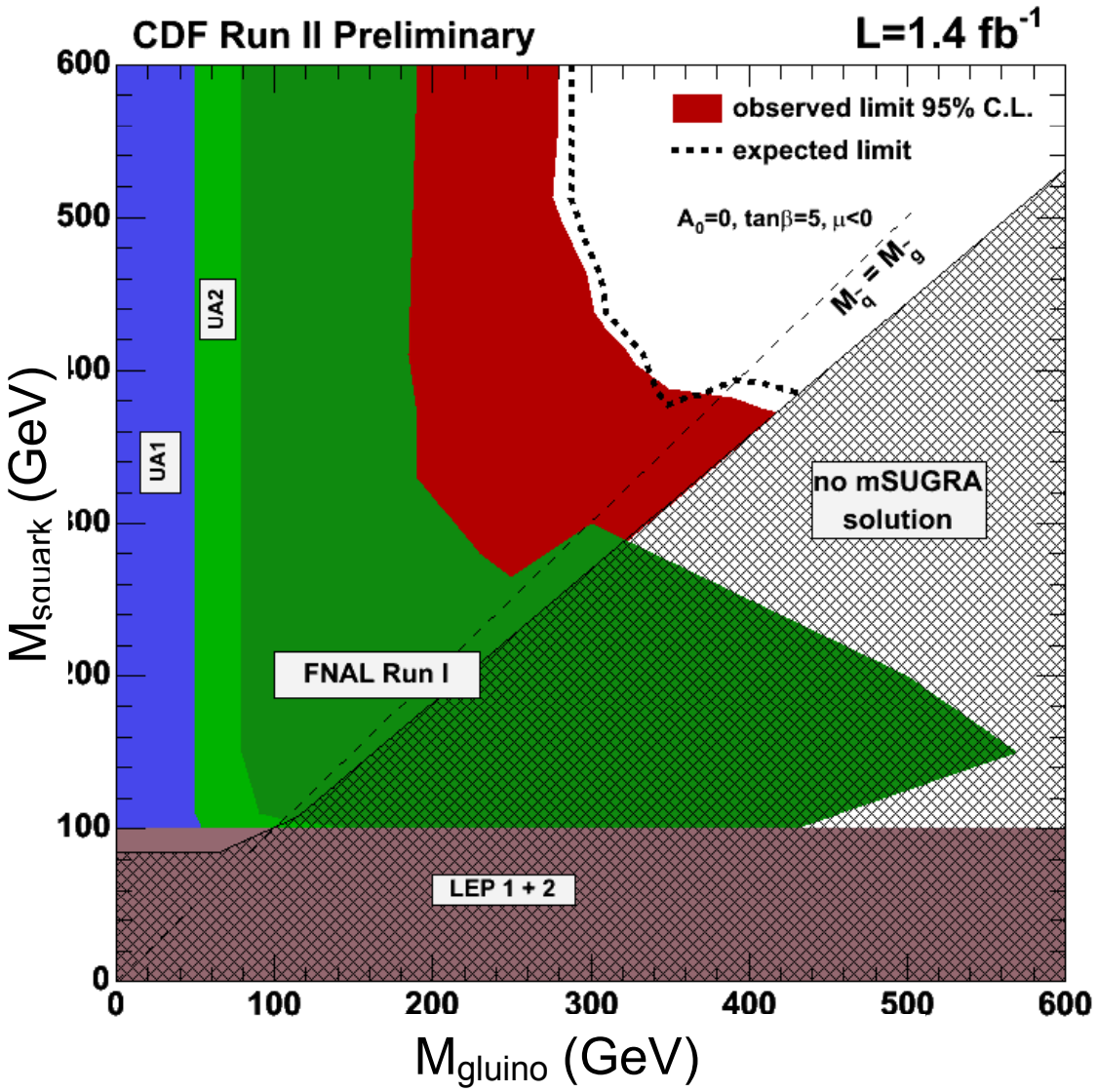
➢ Even with a lot (!) of data there are regions where the LHC can't get all the MSSM Higgs

Squarks & Gluinos at the Tevatron

Strongly interacting SUSY particles have large rates at the Tevatron and LHC

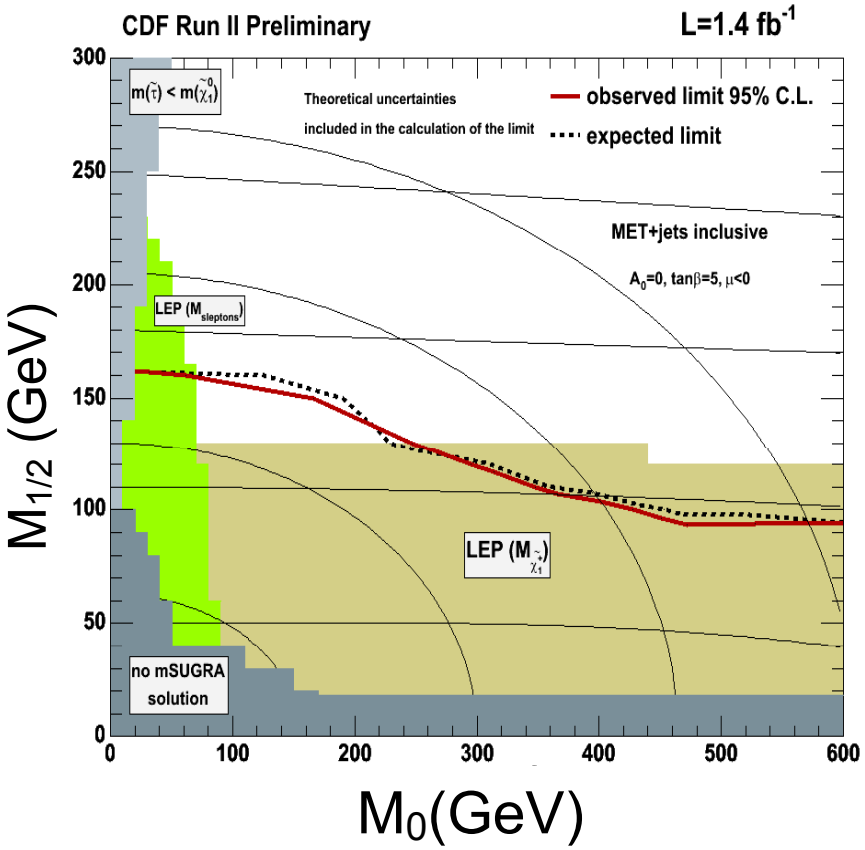
- M_{gluino} > 290 GeV
- If $M_{gluino}=M_{squark}$,

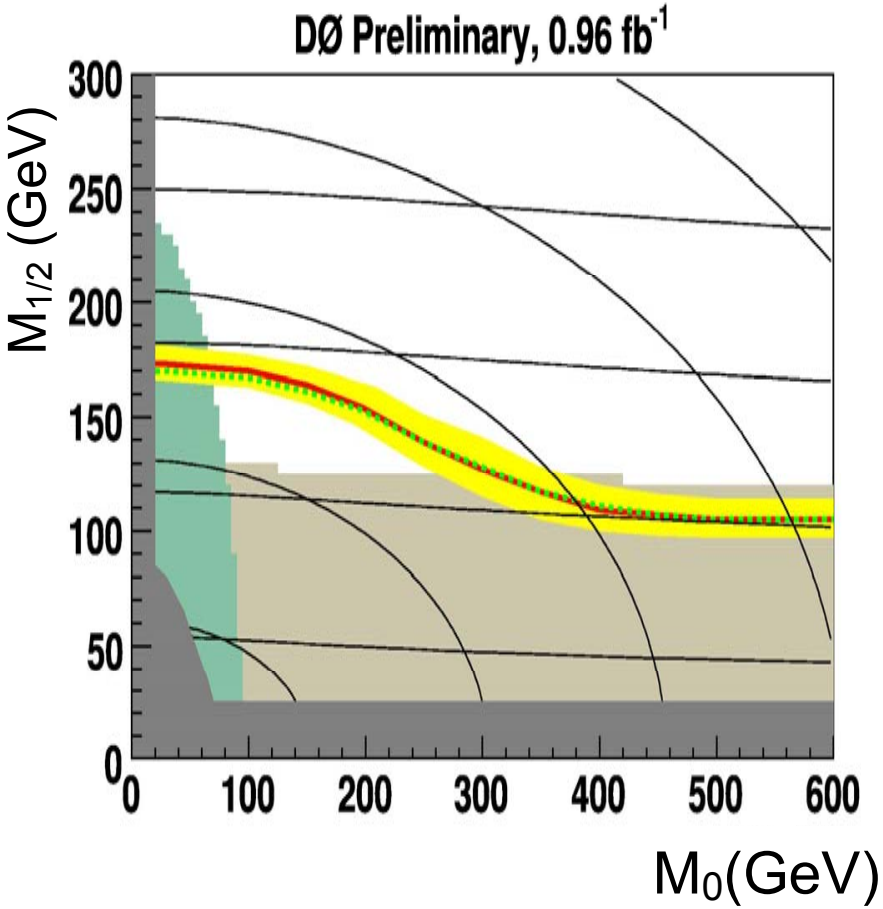
  M > 380 GeV



LP07

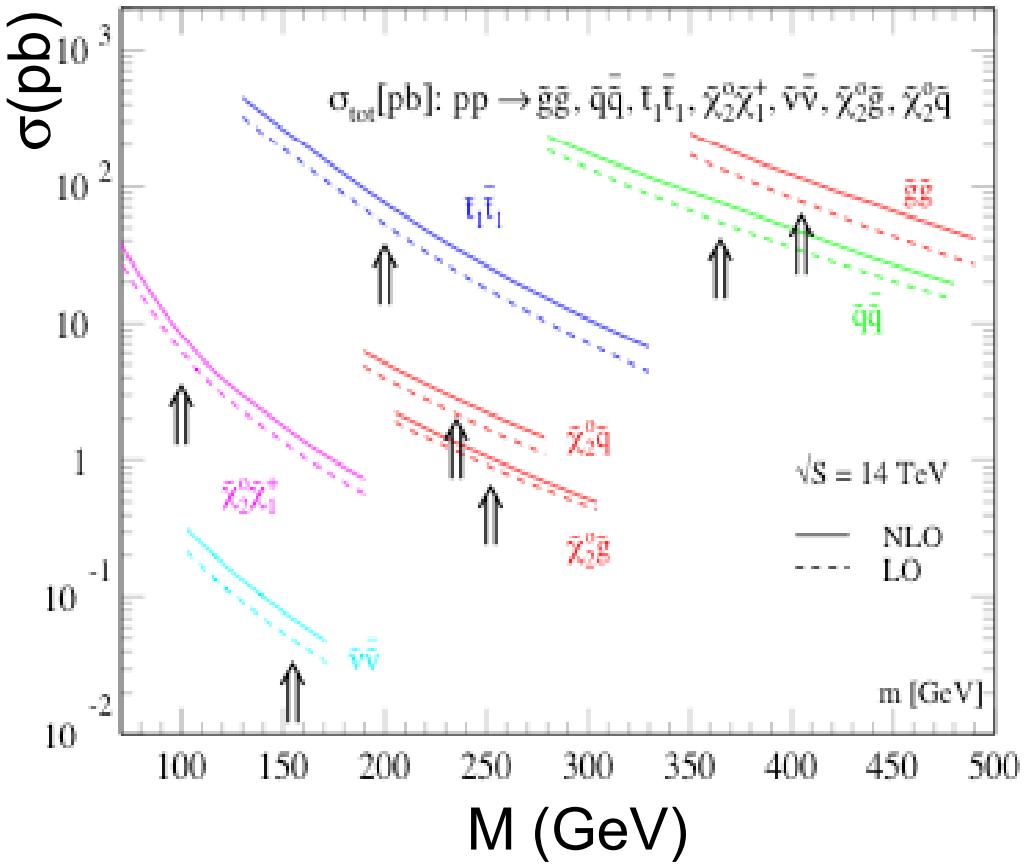
mSUGRA at the Tevatron

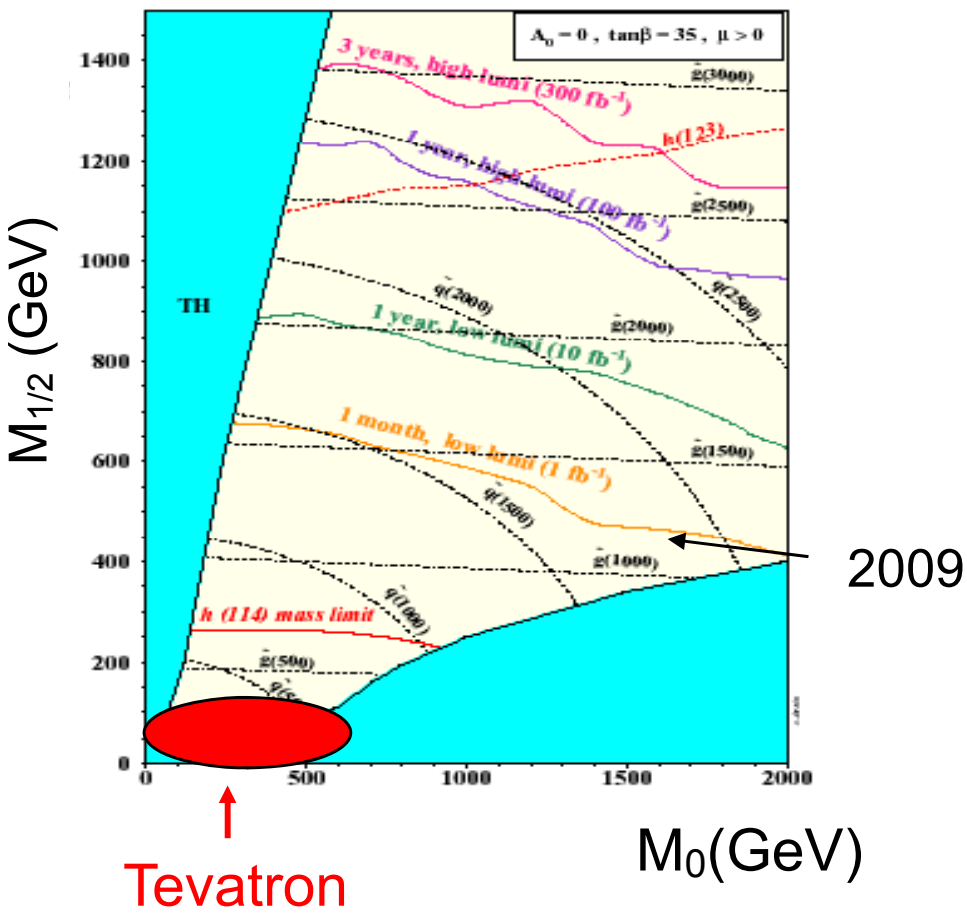




- Tevatron probes just the tip of the iceberg
- mSUGRA is useful framework for study

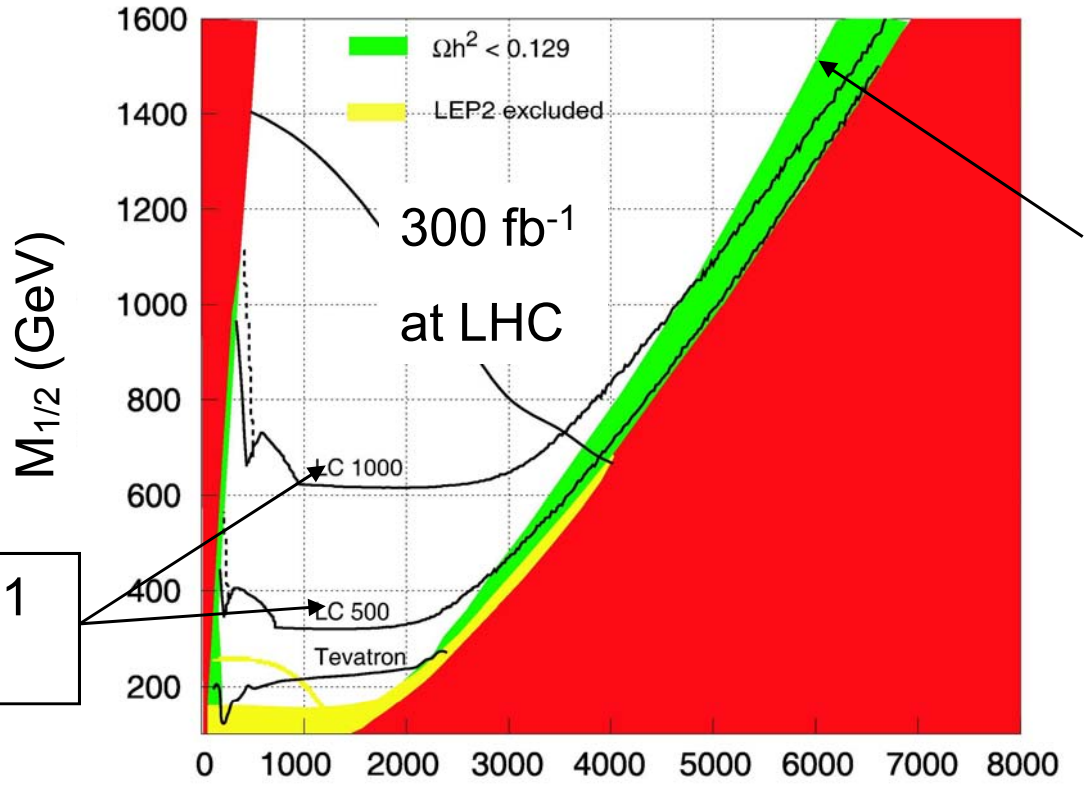
SUSY at the LHC





- Huge rates; well defined signatures
  - M(gluino, squark) ~ 1 TeV gives 100 events with 100 pb^{-1} at LHC
- Immediate improvements over Tevatron limits

If LSP is dark matter, and SUSY is mSUGRA…..LHC and ILC will see SUSY



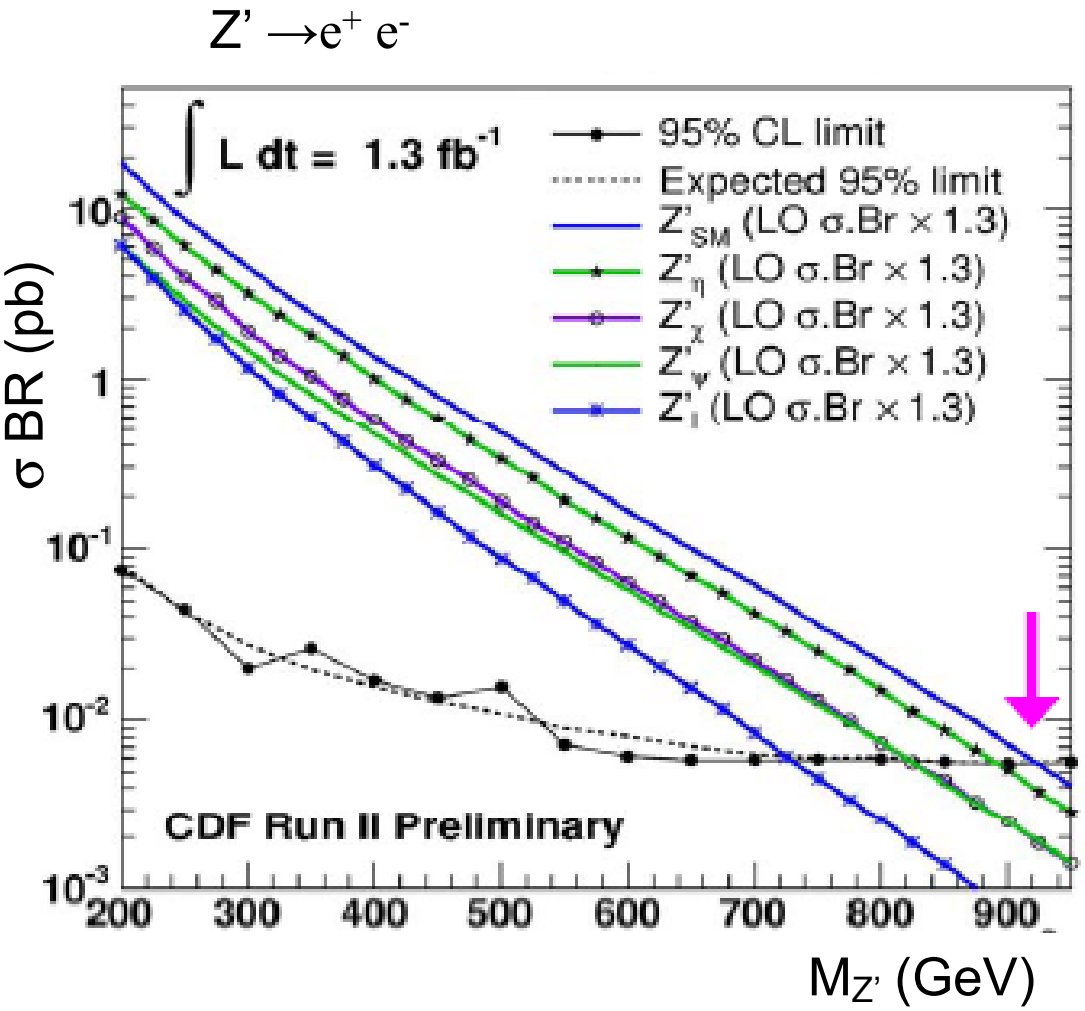
Region allowed in mSUGRA by WMAP with LSP as dark matter

100 fb-1 at ILC

tan β=30, A_0=0, μ>0

Baer, Belyaev, Krupovnickas, Tata, hep-ph/0311351

Z' at the Tevatron



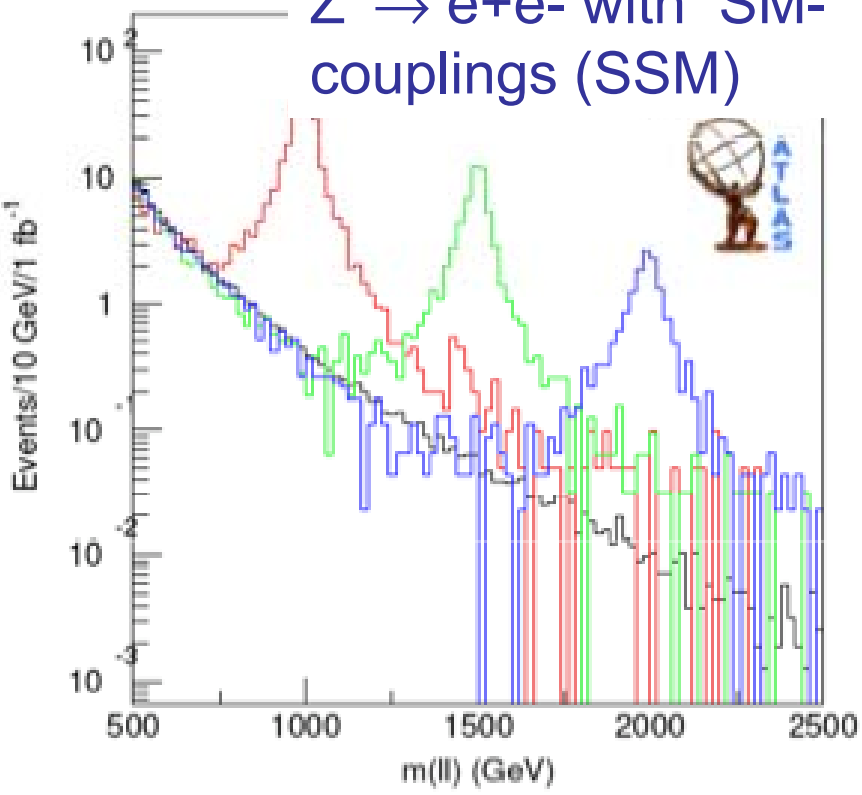
Many different types of Z's are possible

New Z′ boson at the LHC

Z' Mass (TeV)	Events with 1 fb^{-1}	Discovery Luminosity (10 events)
1.0	160	70 pb^{-1}
1.5	30	300 pb^{-1}
2.0	7	1.5 fb^{-1}

- Small SM background
- Narrow peak above background

Z' → e+e- with SM-couplings (SSM)

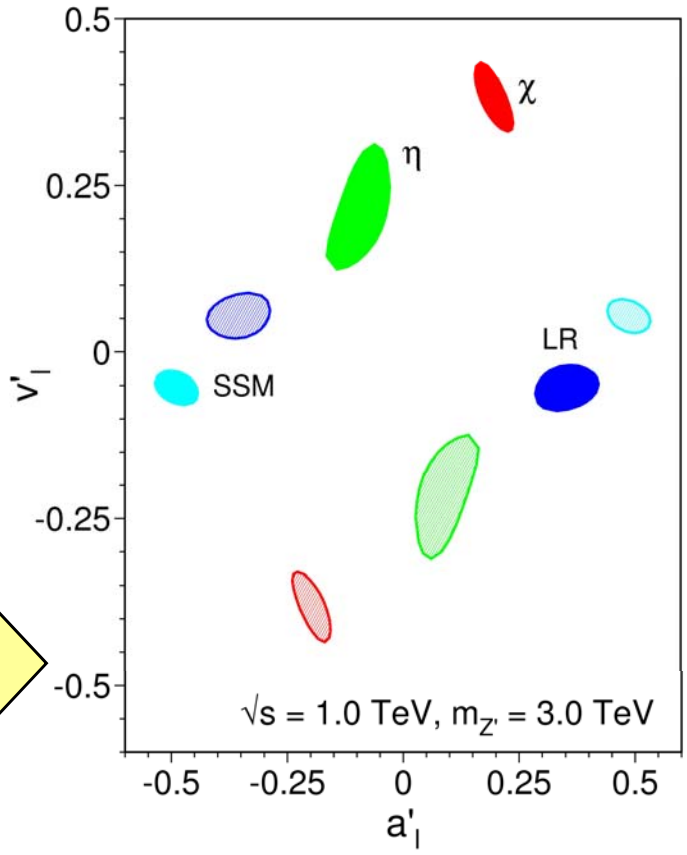


ILC Needed for Z' Coupling Measurement

- Which Z' is it?
  - Kaluza Klein state?
  - Copy of standard model?
  - Extended gauge symmetry?

ILC cleanly distinguishes between models

Z' couplings to leptons



L=1 ab^{-1}, P_-=.8, P_+=.6, ΔP=.5%, Δsys (lep)=.2%

S. Riemann

Conclusions