Weakly Coupled/Narrow Leptonic Resonances at LHC

- Many models predict/allow weakly coupled states more narrow than detector mass resolution at the LHC...
  - → Higgsless models
  - → 2nd KK's in Universal E.D.
  - → Hidden sector/valley models
  - → RS w/ brane gauge/graviton terms
  - → Little Higgs models
  - → TeV E.D. w/ brane terms
  - ⊕ .....

- Such weakly coupled particles could be very light ~few 100's of GeV + have been missed by the Tevatron + precision measurements

... but could be produced as resonances at LHC + ILC [Freitas]

high lumi at low masses

- Consider a specific case...

- Consider a "$Z'(W')$" which doesn't couple to SM fields except by mixing with Z_{SM} (W_{SM}) & all other exotics are more massive

  → Then $Z'/W' \xrightarrow[\sin\phi]{} SM$ so, $\Gamma = \Gamma_{SSM} \sin^2\phi$ & all couplings are small

- This implies $\Gamma_{Z'}/M_{Z'} << 0.01 \approx \frac{\delta M_{ll}}{M_{ll}}$, the dilepton mass resolution

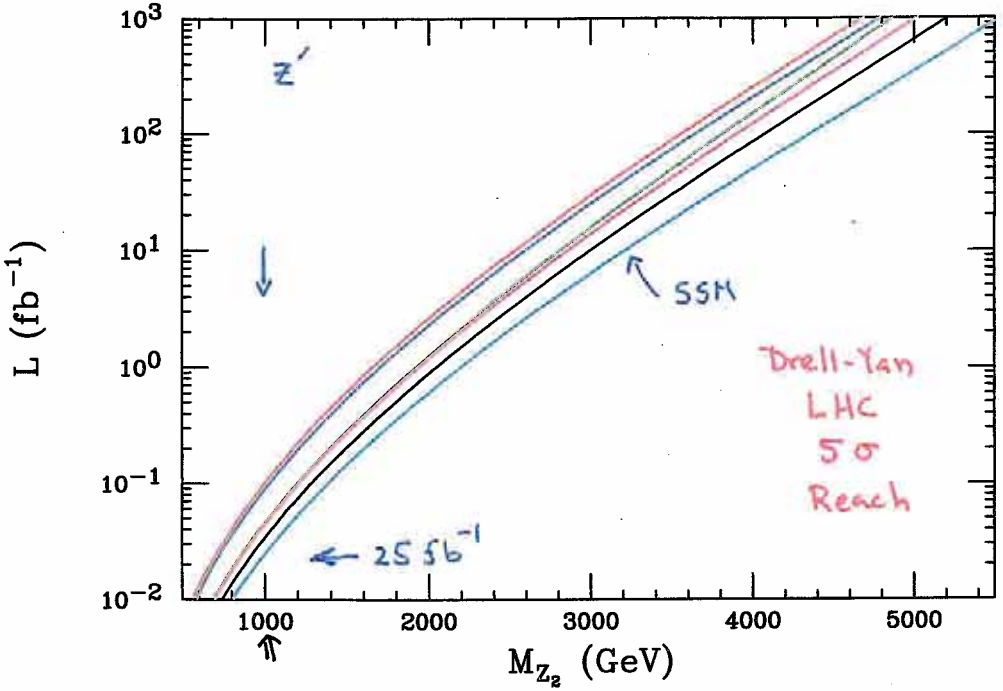
(→ recall, $\Gamma_{SSM}/M_{SSM} \simeq 0.03$!! & is typical of common models usually considered)

⇒ We can imagine such objects w/ $M = 1$ TeV (& may be way less)...

.. then we ask what is the reach (5σ) in g/g_{SSM} at the LHC ?

.. No studies exist & can directly impact ILC ..

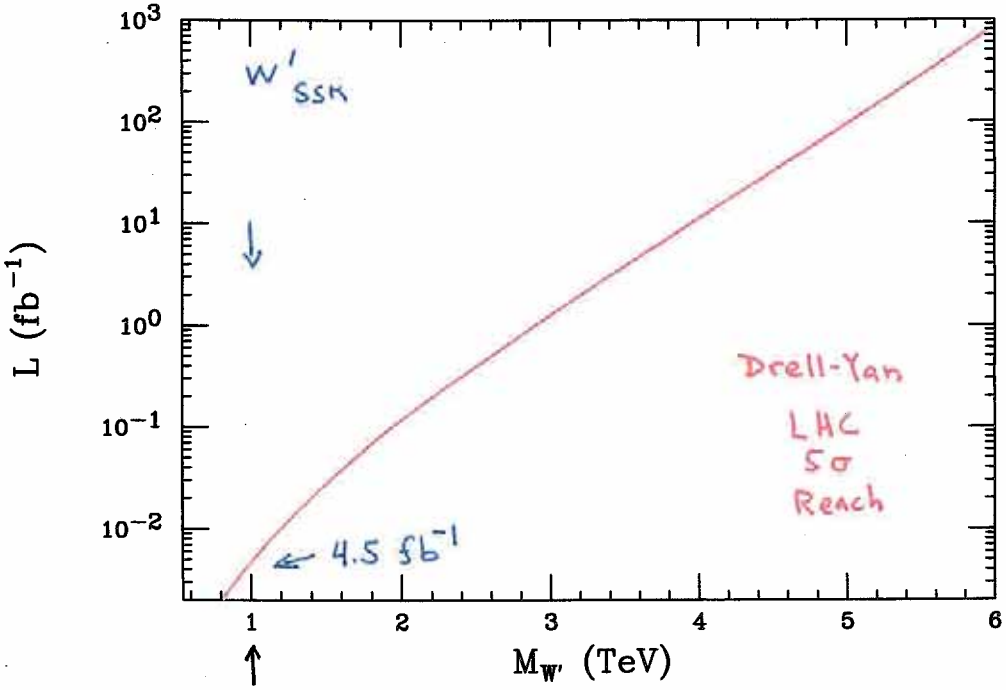
... let's do a 'theory' study ...



For SSM Z', only 25 fb^{-1} needed to see it.
So with 10 fb^{-1} we can proble a Z'
down to $10\,(g/g_{SSM})^2 = \frac{1}{40}$ or

$g/g_{SM} = \frac{1}{20}$ by extrapolation ...

Reach Scaling –



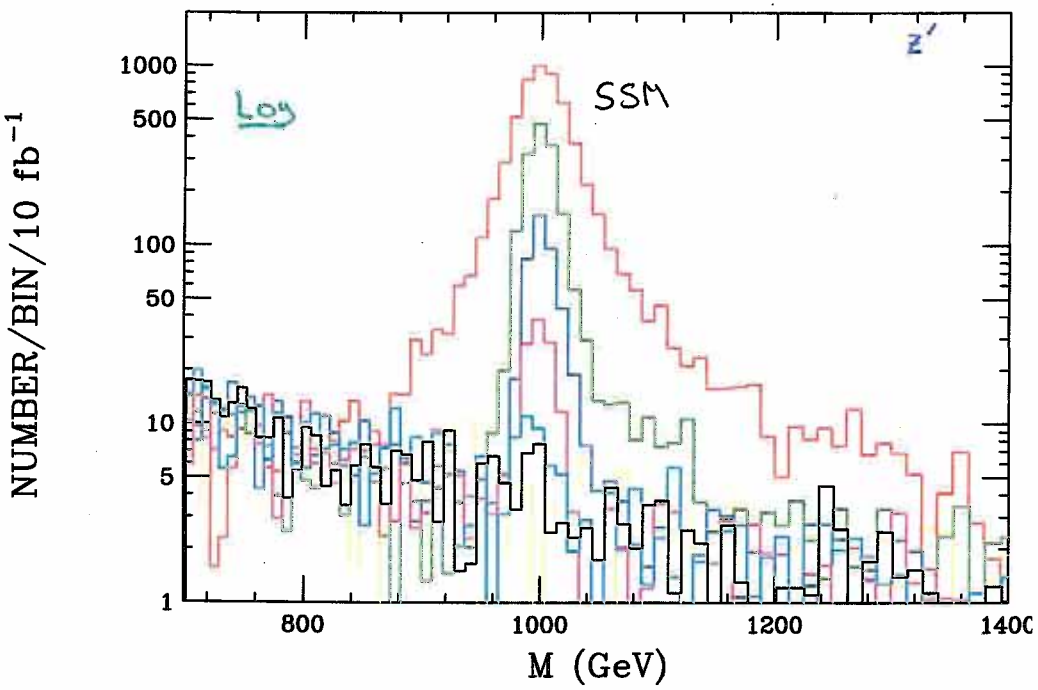
For SSM W', only 4.5 fb^{-1} needed to see it.
So w/ 10 fb^{-1} we can observe a W'
down to $10\left(g/g_{SSM}\right)^2 = 4.5\cdot10^{-3}$ or

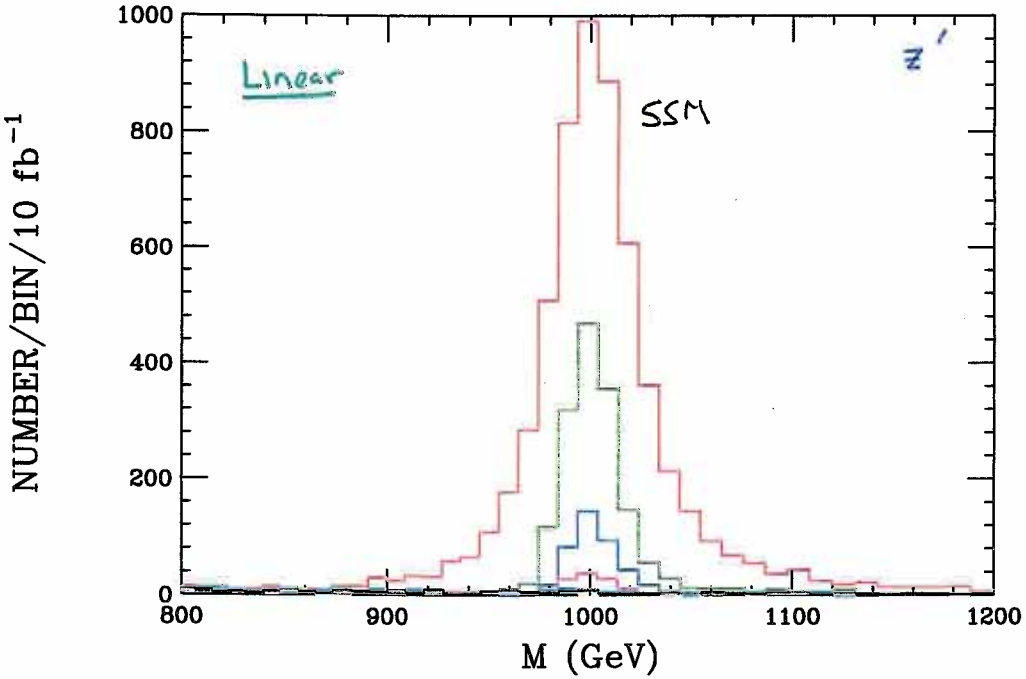
$g/g_{SM} \simeq 1/47$ by extrapolation

Are these the correct reaches
for narrow states?

⇒ Theorist Calculation (3

Z′ Analysis [$\delta M/M = 1\%$]





g/g_{sm}		
1	red	✓
1/2	green	✓
1/4	blue	✓
1/8	magenta	✓
1/16	cyan	??
1/32	black	no!

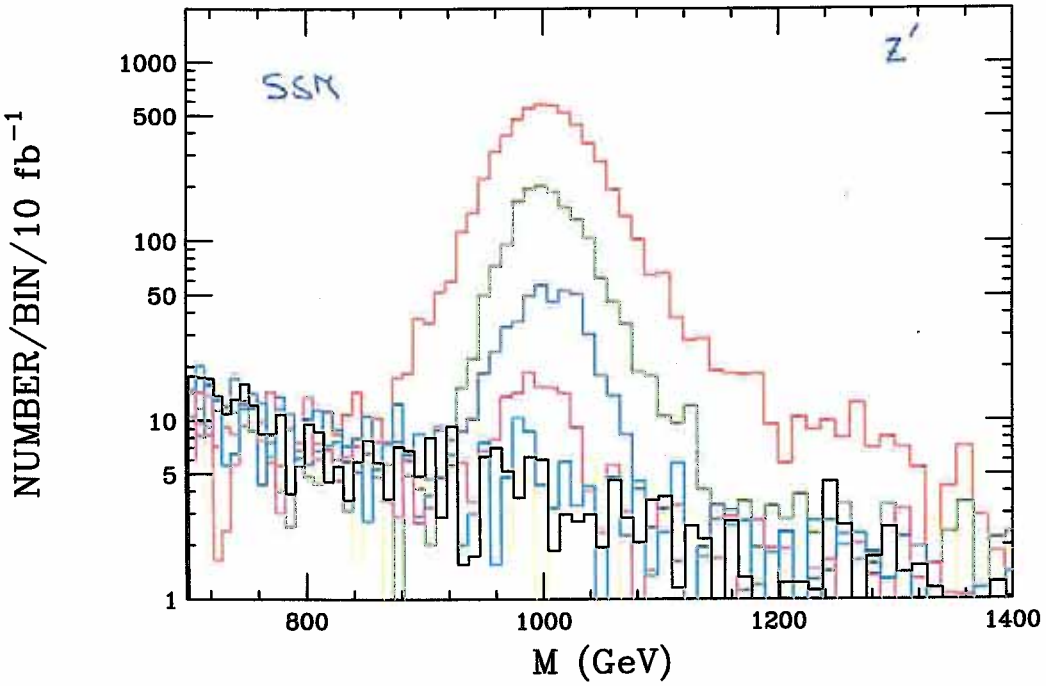
Background : yellow

→ Seems like we lose the signal somewhere near $g/g_{sm} \sim 0.1$

→ ① How does $\delta M/M$ influence results?

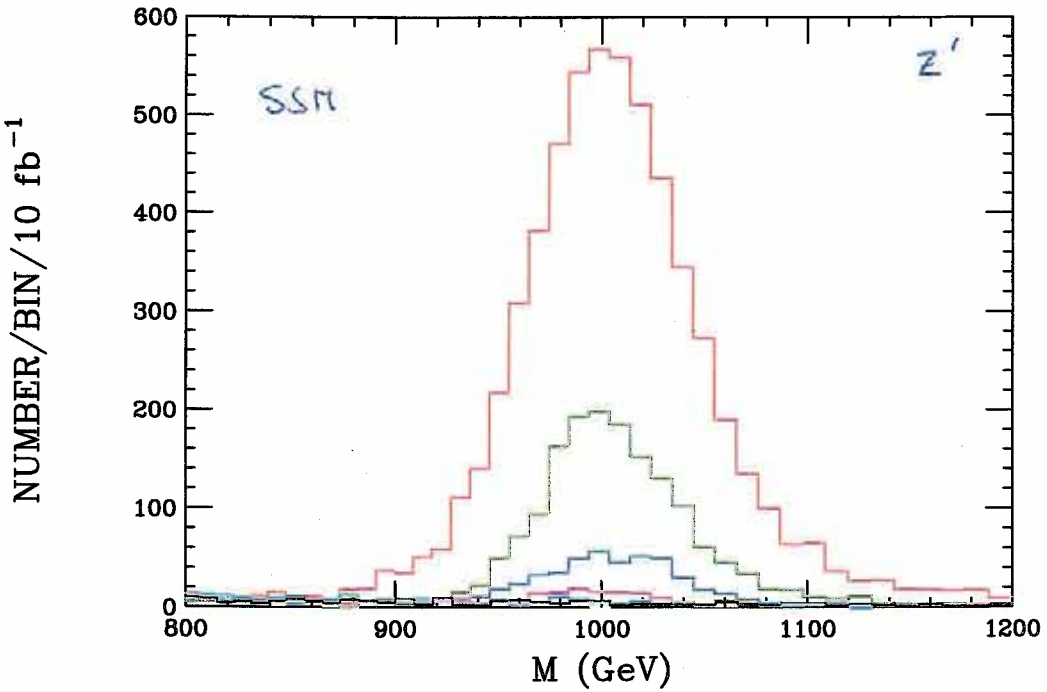
→ ② Can we zoom in on the region $g/g_{sm} \lesssim 0.1$?

Z' Analysis [$\delta M/M = 3\%$]

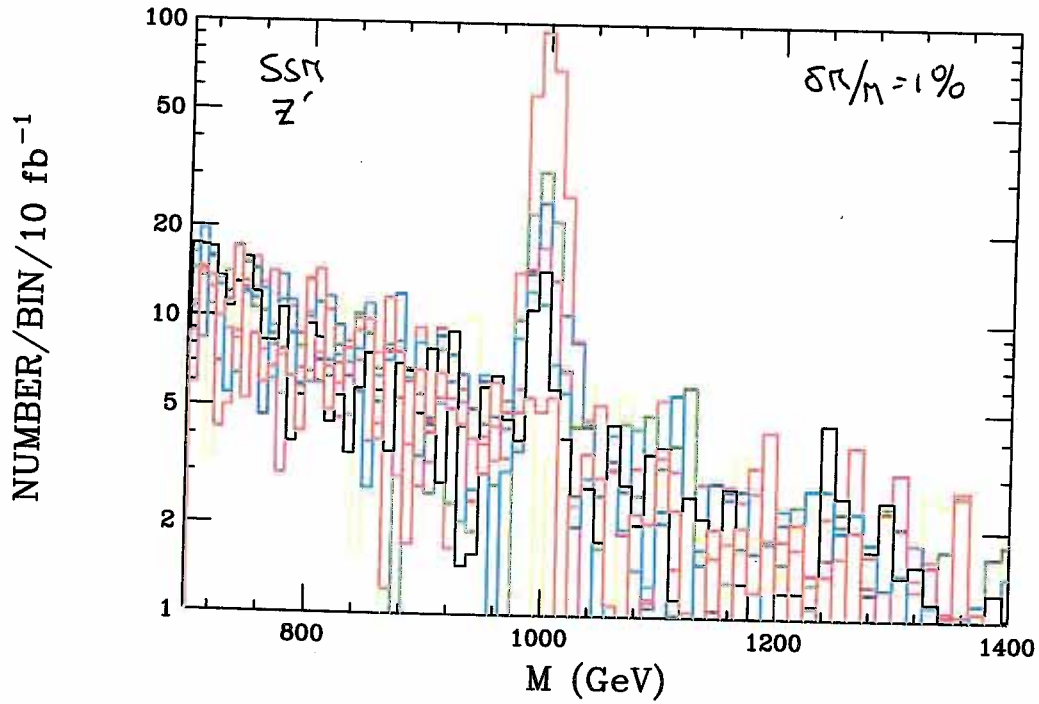


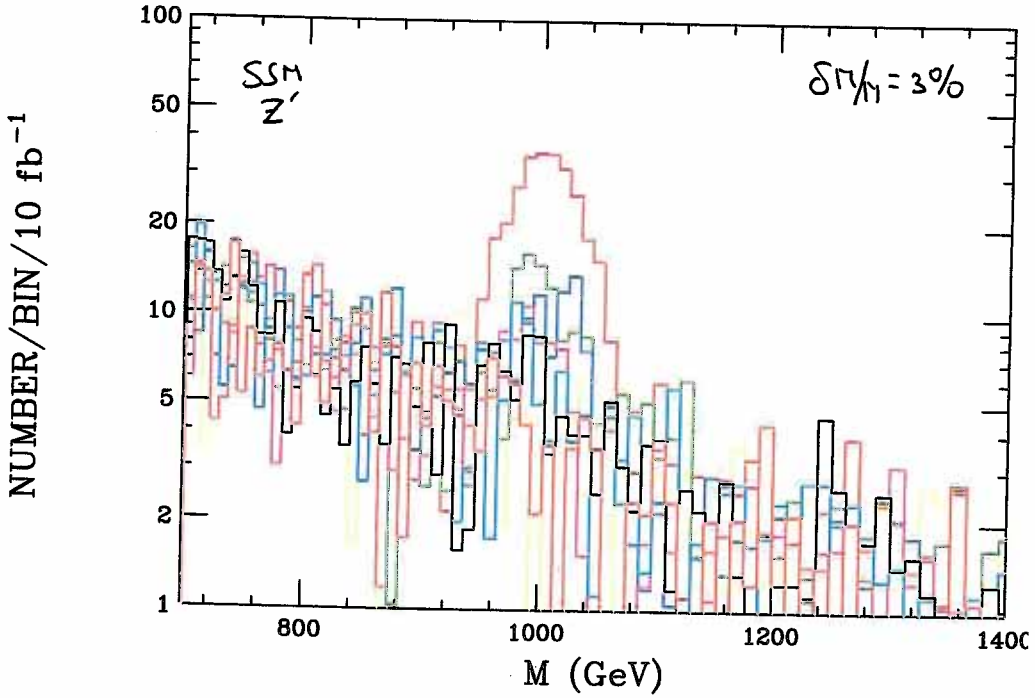
g/g_{SM}		
1	red	✓
1/2	green	✓
1/4	blue	✓
1/8	magenta	✓
1/16	cyan	???
1/32	black	no!
Background	yellow	

→ Again, we seem to die at couplings of $g/g_{SM} \lesssim 0.1$



→ look at smaller couplings...



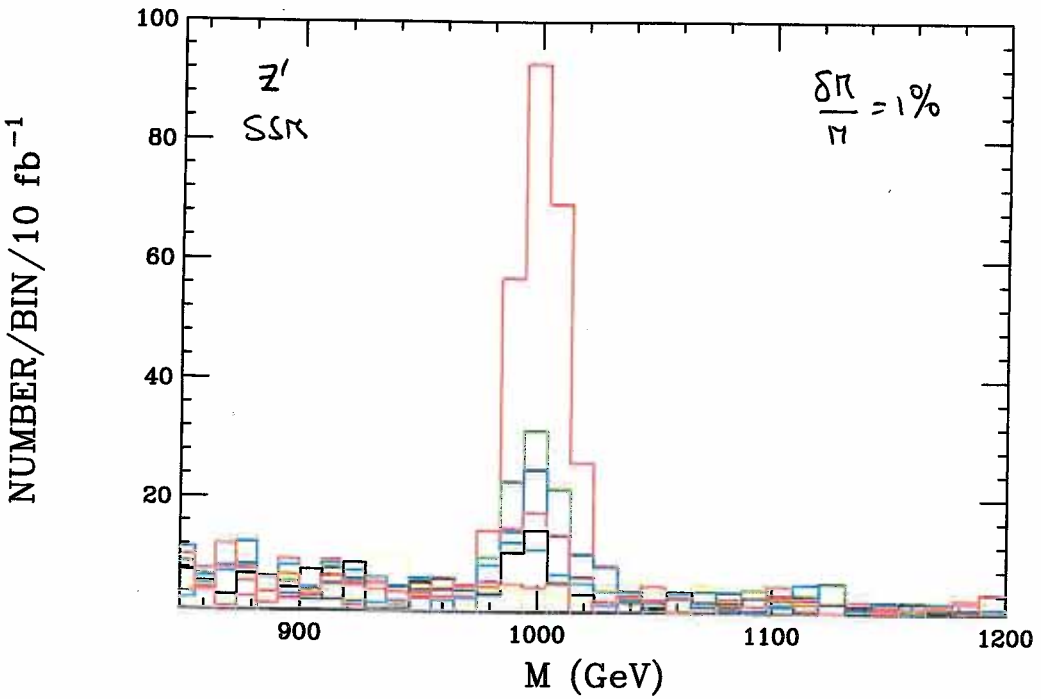


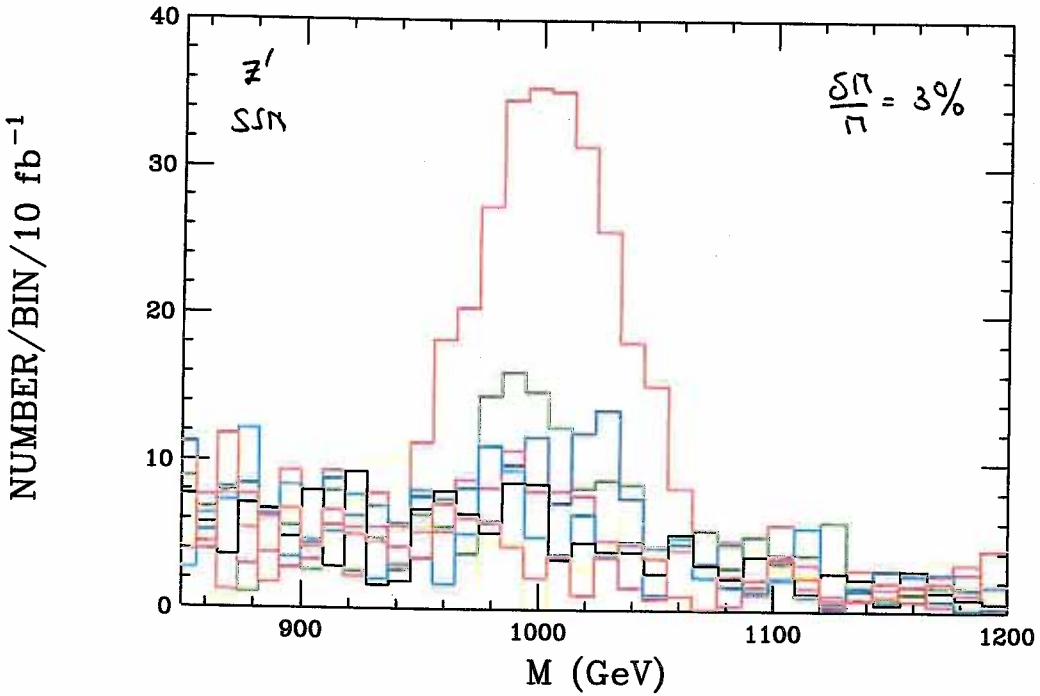
Z′ Analysis : small couplings

g/g_{SM}		1%	3%
0.2	red	✓	✓
0.1	green	✓	✓
0.09	blue	✓	✓
0.08	magenta	✓	?
0.07	cyan	✓	?
0.06	black	✓	?
0.05	red	no	no
Background	yellow		

→ Resolution Effects are important in establishing reach

(At least on log plots)





Z' Analysis: Small couplings

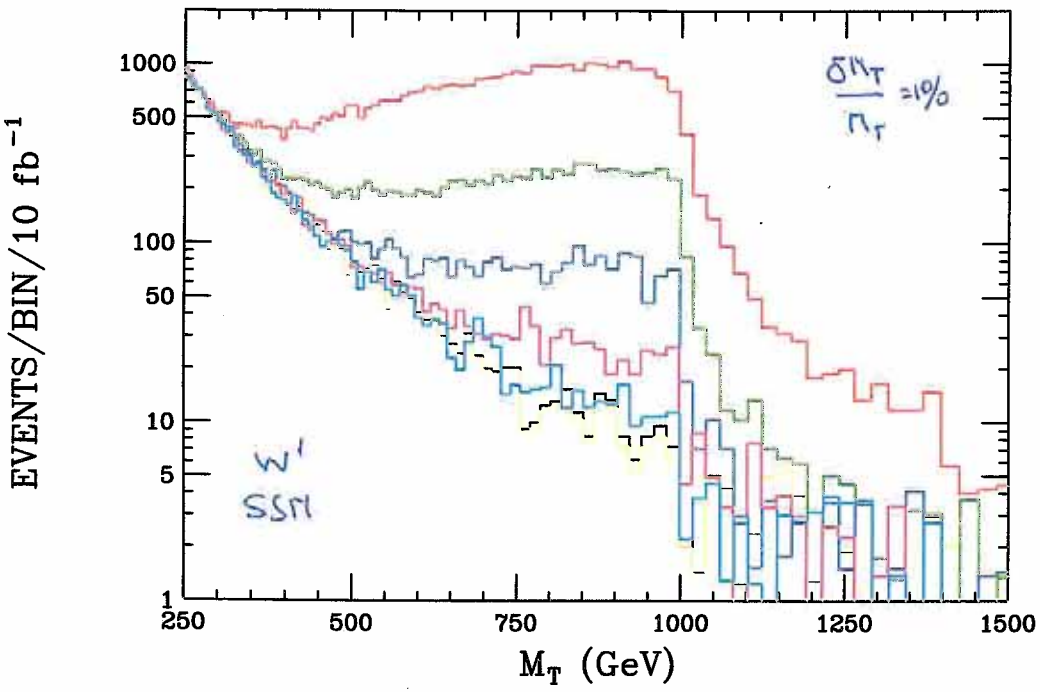
g/g_{sm}		3%	1%
0.2	red	✓	✓
0.1	green	✓	✓
0.09	blue	✓	✓
0.08	magenta	✓	✓
0.07	cyan	✓	?
0.06	black	✓	no?
0.05	red	no	no

Background: yellow

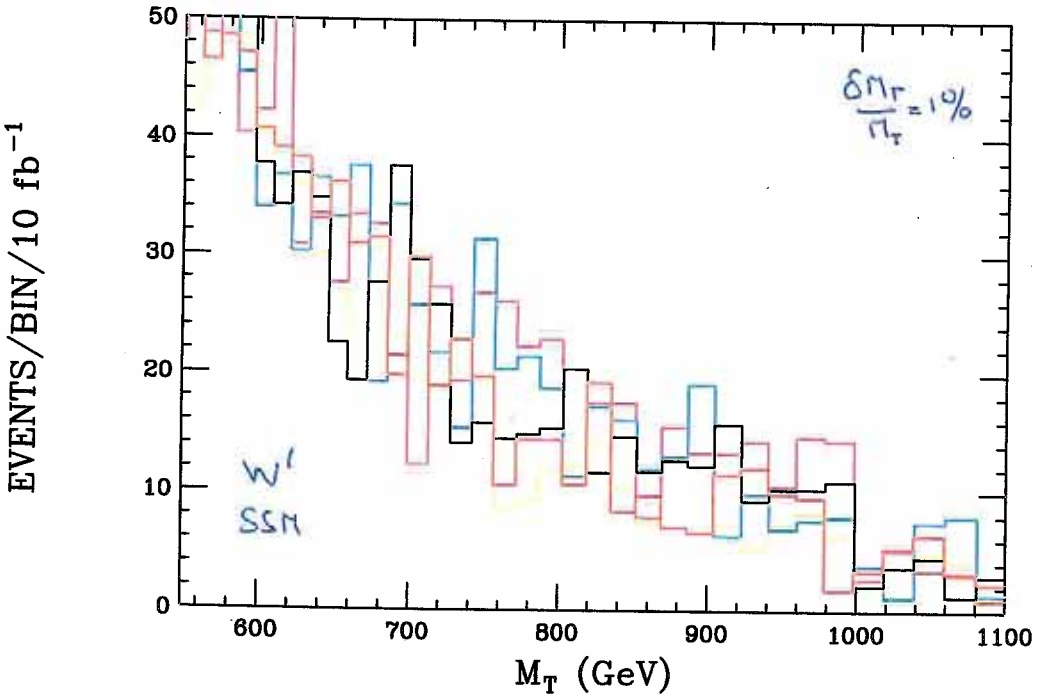
→ In no case do we make it to the anticipated reach of $g/g_{sm} = 0.05$

... but we need a REAL study

W′ Analysis



g/g$_{SM}$		
1	red	✓
1/2	green	✓
1/4	blue	✓
1/8	magenta	✓
1/16	cyan	✓
1/32	black	no
Background	yellow	



g/g$_{SM}$		
0.08	magenta	✓
0.07	Cyan	✓
0.06	black	✓
0.05	red	? No ?
background	yellow	

→ We don't reach g/g$_{SM}$ ≈ 1/47 !

- Light, weakly-coupled states may exist that have been missed by the Tevatron + precision measurements ... but could show up at LHC and be in the ILC mass range ($\lesssim$ 1 TeV)

$\Rightarrow$ What are the real LHC reaches for such states ??

$\Rightarrow$ Simple scaling laws have been shown not to work in the Z' case ..
(and probably true for others)

$\Rightarrow$ We need a real experimental analysis for LHC !