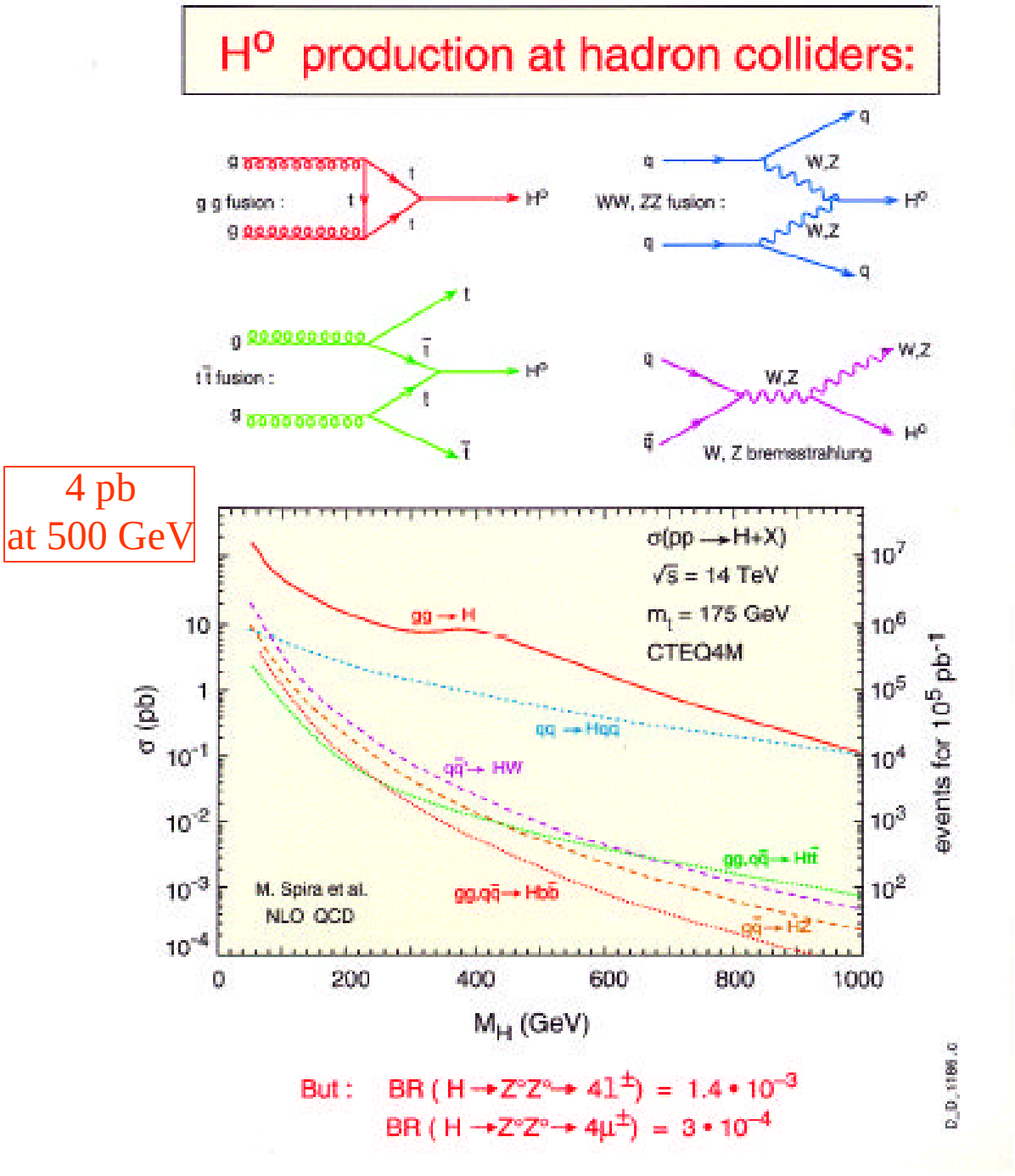
Intermediate/Heavy Higgs at a Linear Collider

While precision data disfavors $M_H > 160$ GeV, models can be made that are consistent with the Standard Model and allow for a heavier Higgs.

- LC contributions beyond LHC?
  - absolute BRs (WW/ZZ)
  - Higgs to top pairs
- Analysis techniques?
  - Higgs production modes
  - W/Z decay modes
  - Signal extraction
  - Background removal (6 fermions)
- Methods
  - Event yields estimates
  - Monte Carlo simulation

LHC Capabilities

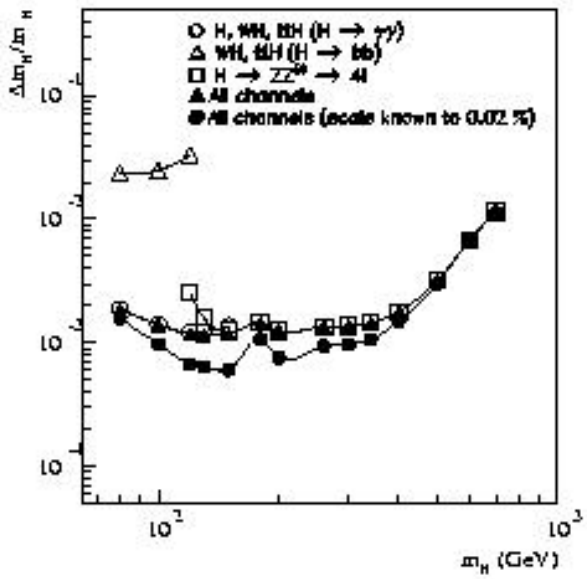
(Daniel Denegri,Circle Line Talk)

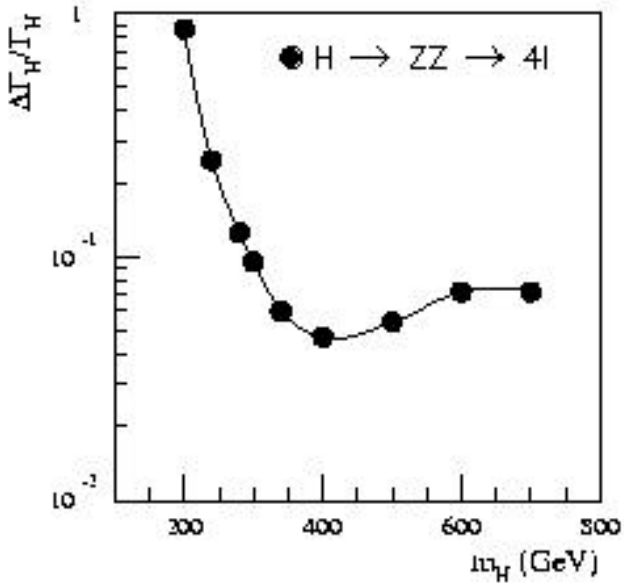


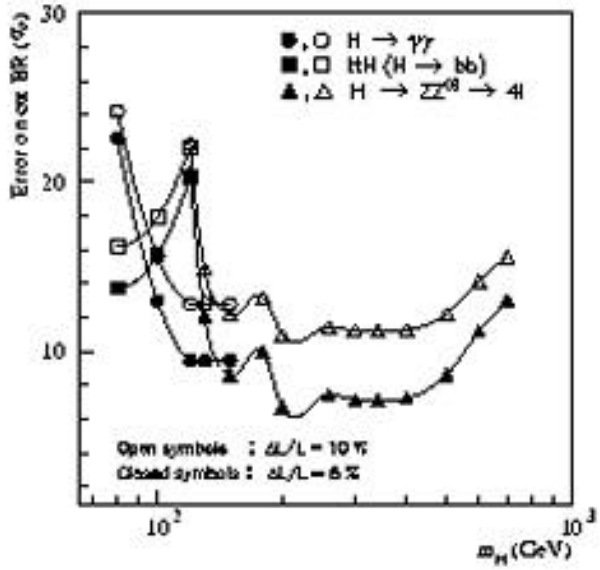
LHC Capabilities

(ATLAS TDR Chap 19: 300 fb-1)

Use 4l modes where l=e or μ







For M(Higgs) = 500 GeV

σ x B(4l) = 3.2 fb

390 events (A x ε =40%)

Mass measured to…… 0.3 %

Width measured to……. 6 %

B(H->ZZ) measured to… 12 %

(assuming 10% luminosity error)

Note: for M(Higgs) >700 GeV, the width becomes so large as to change what it means to make a precision measurement.

Estimate of LC Capabilities

TESLA 800 GeV luminosity: 5 x 10^34
http://www.desy.de/~njwalker/ecfa-desy-wg4/parameter_list.html
Assume 5 yrs running at 10^7 s/year
gives $\int L$ = 2500 fb^-1 or 40K Higgs

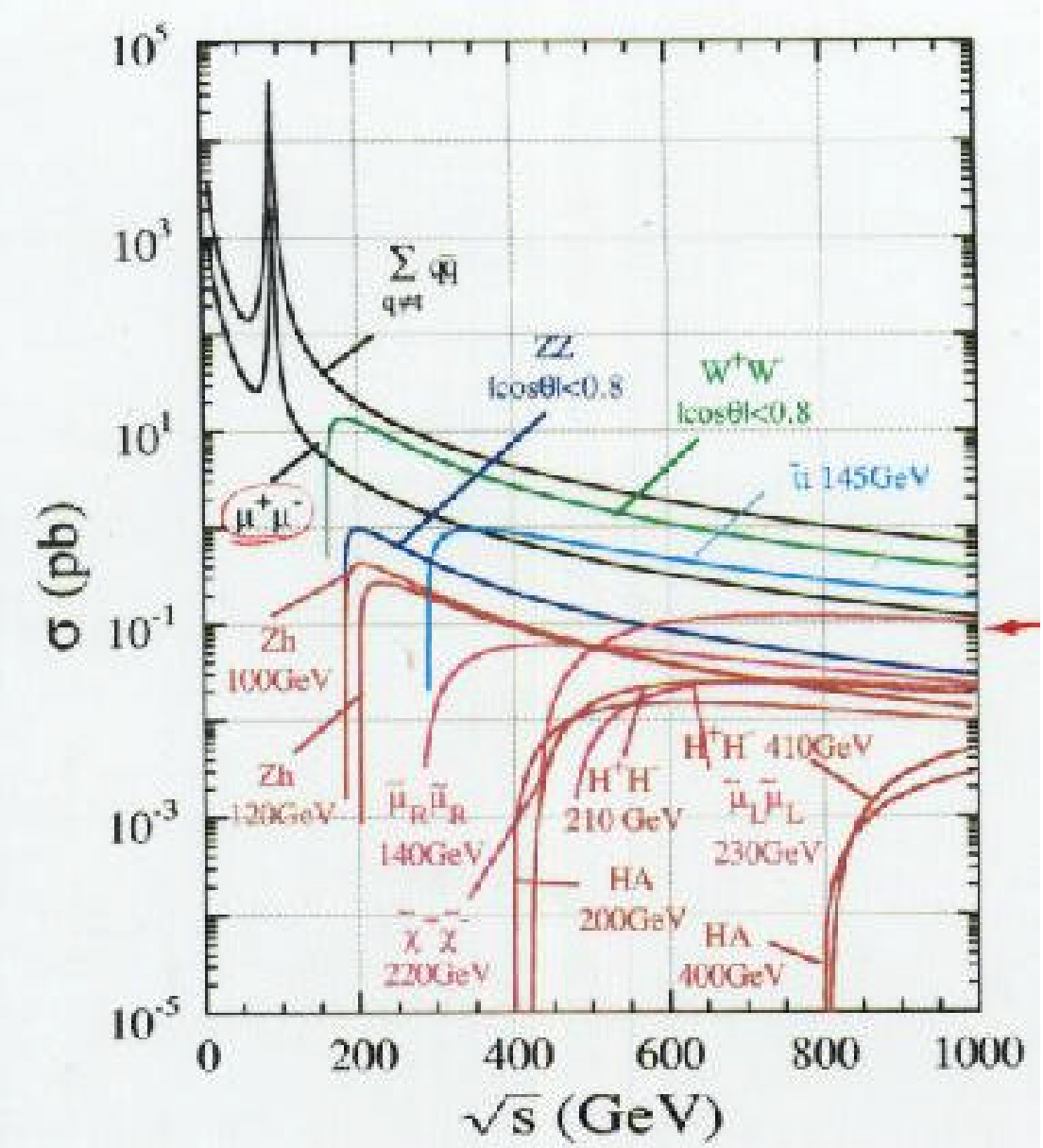
$\sqrt{s}$ = 800 GeV
M(H) = 500 GeV
Γ(H) = 70 GeV
$\sigma(H\nu\nu)$ = 10 fb
$\sigma(HZ)$ = 6 fb
B(WW) = 55%
B(ZZ) = 25%
B(ttbar) = 20%

Assume 100% efficiency, no backgrounds, no systematic uncertainties:

$tt \to ll\nu\nu bb$: 0.16 fb : 395 evts
$tt \to l\nu cs bb$: 0.47 fb : 1185 evts
$tt \to l\nu jj bb$: 0.47 fb : 1185 evts
$tt \to ccss bb$: 0.36 fb : 889 evts
$tt \to csjj bb$: 0.71 fb : 1778 evts
$tt \to jjjj bb$: 0.36 fb : 889 evts
$tt \to$ other: 0.67 fb : 1679 evts

$WW \to ll\nu\nu$: 0.43 fb : 1100 evts
$WW \to l\nu cs$: 1.30 fb : 3300 evts
$WW \to l\nu jj$: 1.30 fb : 3300 evts
$WW \to ccss$: 0.98 fb : 2400 evts
$WW \to csjj$: 1.96 fb : 4900 evts
$WW \to jjjj$: 0.98 fb : 2400 evts
$WW \to$ other: 1.85 fb : 4600 evts
$ZZ \to llll$: 0.018 fb : 46 evts
$ZZ \to ll\nu\nu$: 0.109 fb : 272 evts
$ZZ \to llbb$: 0.083 fb : 207 evts
$ZZ \to llcc$: 0.067 fb : 169 evts
$ZZ \to lljj$: 0.230 fb : 575 evts
$ZZ \to \nu\nu\nu\nu$: 0.160 fb : 400 evts
$ZZ \to \nu\nu bb$: 0.243 fb : 608 evts
$ZZ \to \nu\nu cc$: 0.198 fb : 496 evts
$ZZ \to \nu\nu jj$: 0.677 fb :1692 evts
$ZZ \to bbbb$: 0.092 fb : 231 evts
$ZZ \to bbcc$: 0.151 fb : 377 evts
$ZZ \to bbjj$: 0.514 fb :1286 evts
$ZZ \to cccc$: 0.062 fb : 154 evts
$ZZ \to ccjj$: 0.420 fb :1049 evts
$ZZ \to jjjj$: 0.716 fb :1789 evts
$ZZ \to \tau X$: 0.267 fb : 668 evts

LC Backgrounds



Dominate backgrounds are WW, ZZ, tt production and are of order 1 pb (can be reduced with polarized beams).

Next Steps for study

- Mass(Higgs) Determination
  - Use recoil method
  - How precise to measure M_H?
    - M_W, M_t, and M_H are known
    - New physics?
- Total Width
  - Measure directly
  - Can LC do better than LHC?
  - New Physics?
- BR and couplings
  - LC looks cleaner for HZ vs $H\nu\nu$
  - What is LHC ability for couplings?
- Spin and parity determination
- Theory of a very heavy SM Higgs
- Estimates -> Generator Level -> Full MC