The ILC/LHC Physics Session

- Session speakers
- Highlights
- Observations/Summary

Jim Alexander,
David Rainwater,
Tim Tait and
William Trischuk
July 22, 2006

Speakers

Wednesday afternoon

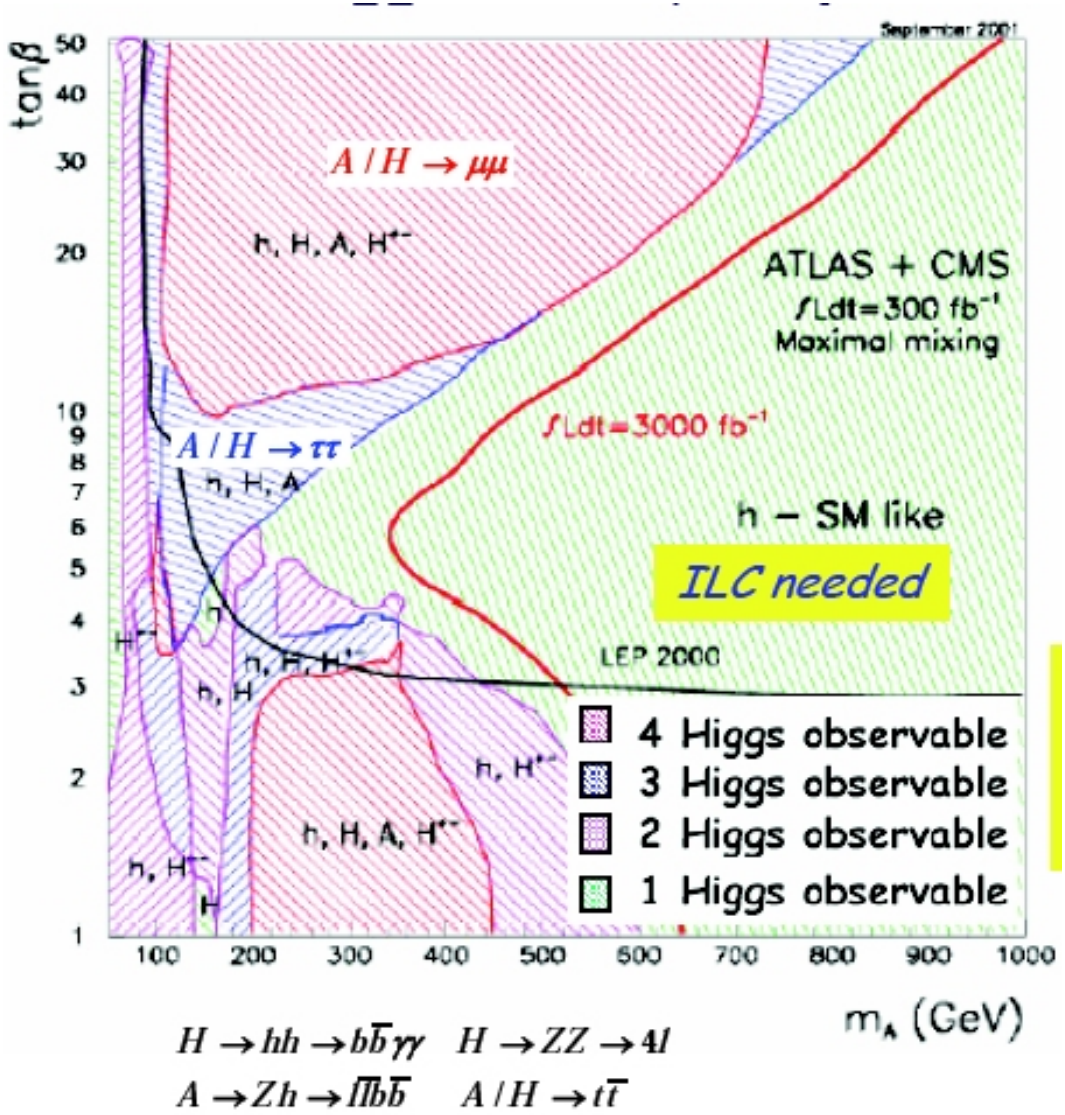
- The LHC Landscape
  (Georges Azuelos, Montreal)
- Z' Physics
  (Steve Godfrey, Carleton)
- Top couplings
  (Aurelio Juste, Fermilab)

Friday morning

- Strong EWSB
  (Tim Barklow, SLAC)
- SUSY with Heavy Sfermions
  (Gudrid Moortgat-Pick, CERN)
- Optimal $\not{E}_T$ Observables
  (Bob McElrath, UC Davis)

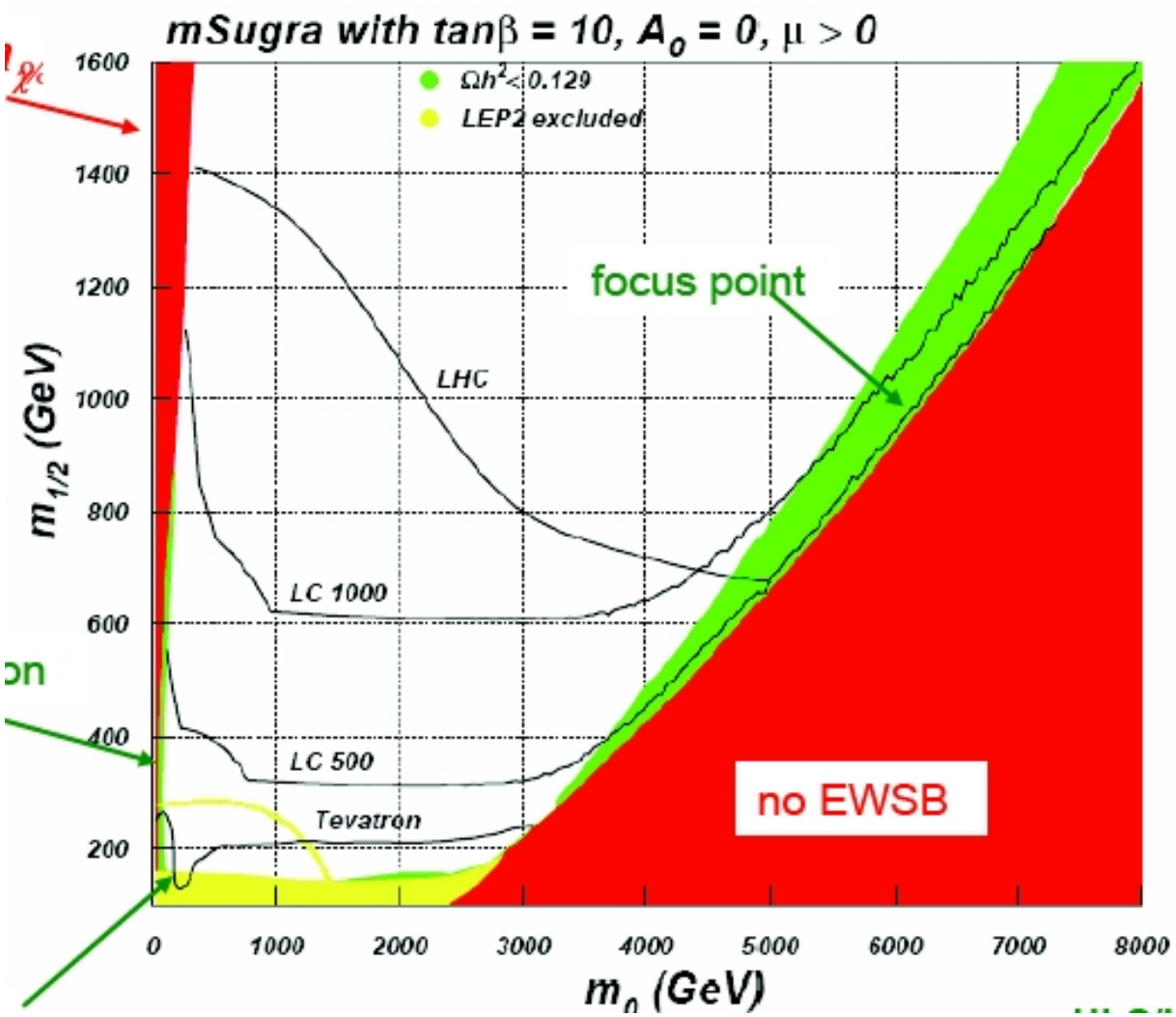
LHC Prospects (Georges Azuelos)

- Gave an overview of ATLAS + CMS physics capabilities



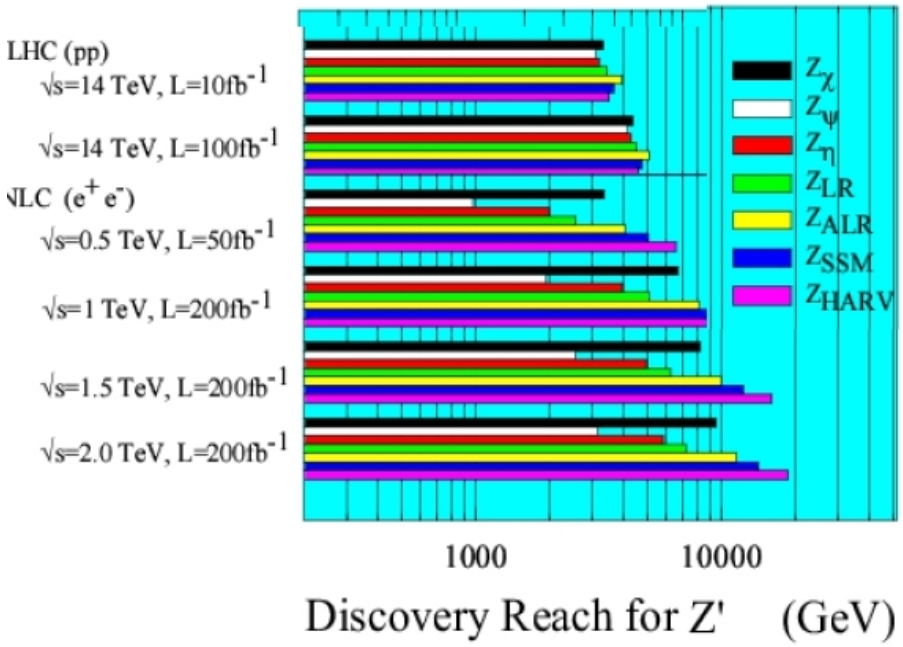
SUSY Higgs at LHC/ILC

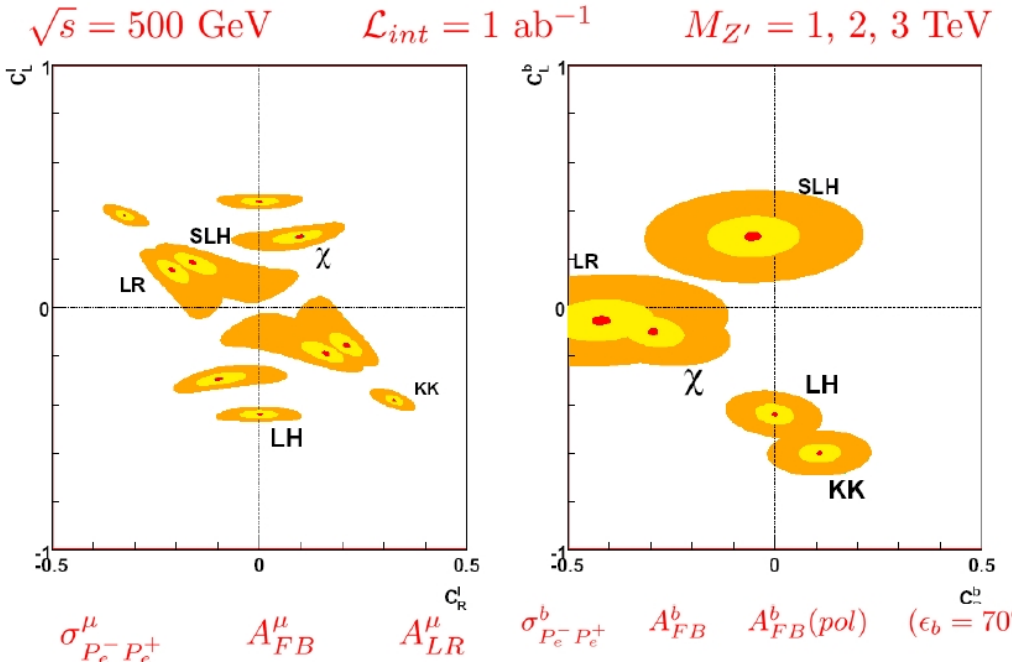
- Large regions in $m_0, m_{1/2}$ plane
  inconsistent with astronomical observations
- "Focus point" particularly amenable to ILC input



Properties of Z' Bosons (Steve Godfrey)

- Z' sensitivities for ILC and LHC
- ILC better in many cases
  - Indirect searches are model dependent
- Solve coupling ambiguities?
- If electron couplings are known

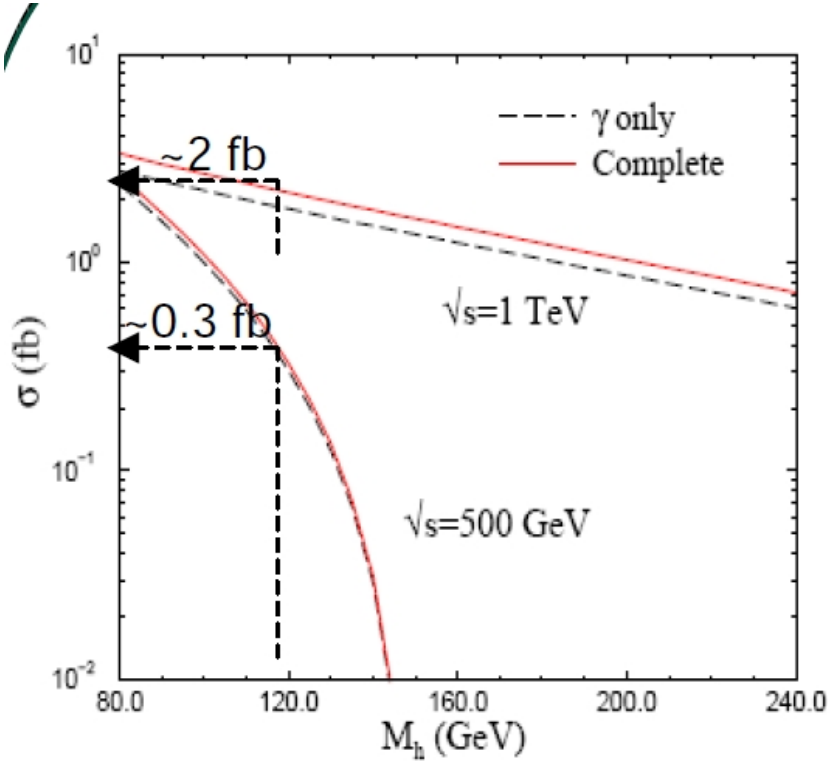




Top Couplings (Aurelio Juste)

- Top coupling is Order (1)
  - Explanation for Electroweak scale?
- 10-100k events per year at LHC
  - 15 % precision on top-Higgs coupling
- 50-500 events per year at 10^{34}
  - b-tagging keeps ILC in the game
  - 5-10 % precision possible

New $t\bar{t}H$ cross-sections at the ILC



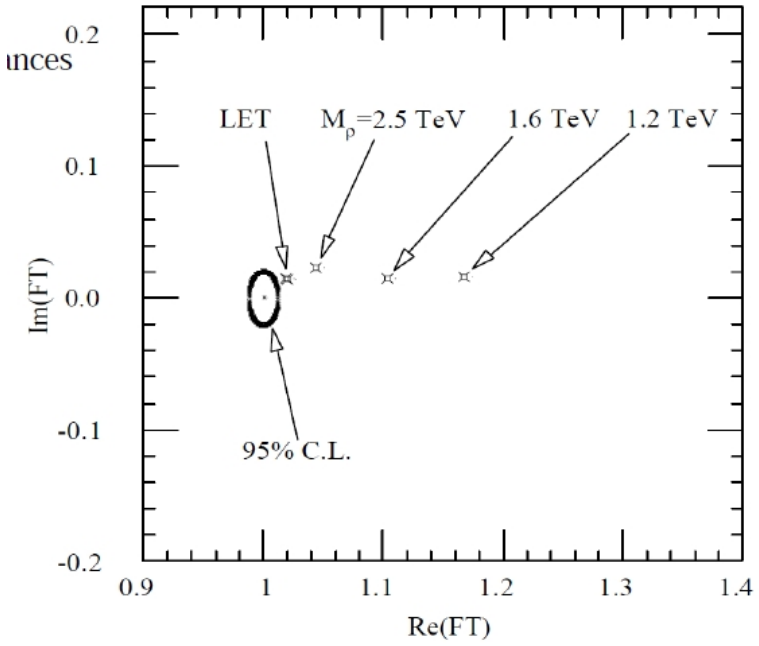
Strong Electroweak Symmetry Breaking (Tim Barklow)

- If heavy W^+W^- resonances are observed at LHC
- Can measure their form factors at ILC

$$F_T = 1 + s\Sigma a_i / M_i^2$$

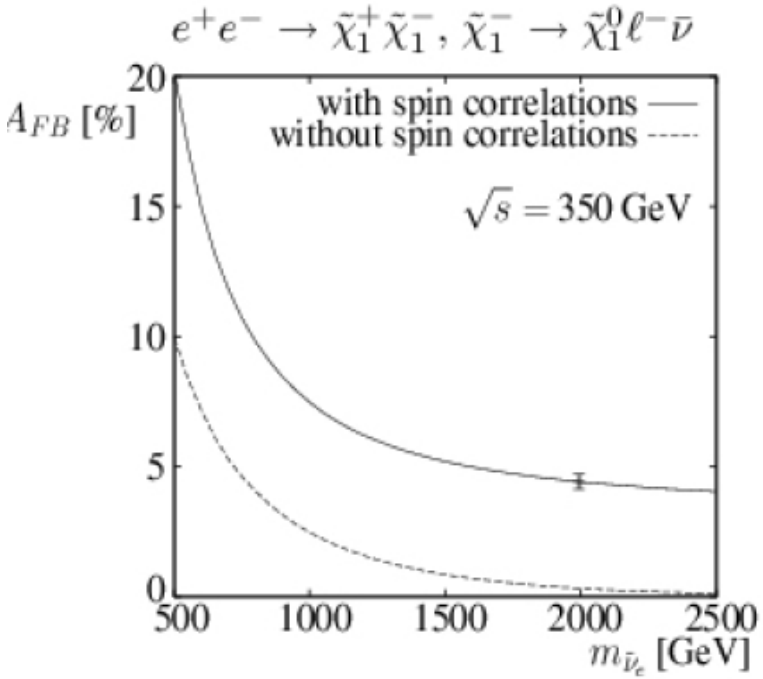
- While LHC can observe on-shell resonances up to several TeV
- Amplitude form factors are sensitive to multi-TeV resonances ILC

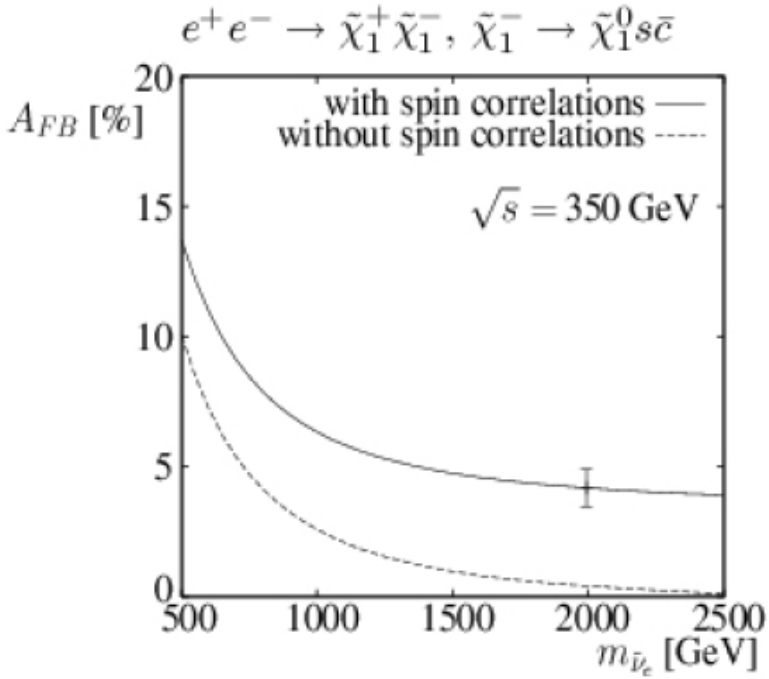
- Form factors give information about spin of resonance observed



SUSY with Heavy Sfermions (Gudrid Moortgat-Pick)

- In this scenario only neutralinos directly produced at ILC
- Decay product angular correlations sensitive to sfermion propagators
- A_{FB} sensitive to $\tilde{\nu}$ mass





- Constrain $1900 \leq m_{\tilde{\nu}} \leq 2100$ GeV
- Should include theory systematics, but more observables will help

Optimal Missing Energy Observables (Bob McElrath)

- Reviewed physics analysis from a statisticians perspective
- Statisticians solved "Missing Data" problem with E/M algorithms
- Form a likelihood:

$$L(\mathbf{Y}|\mathbf{X},\mathbf{X}') = \prod_{i=1}^{N} P(\mathbf{x}_i, \mathbf{x}'_i|\mathbf{Y}).$$

- X: observables, X': missing observables, Y: parameters (M, Γ etc.)
- Ratio of likelihoods for two hypotheses Y and $Y^{(n-1)}$

$$= \frac{1}{N}\sum_{i,j=1}^{N} \frac{\int \log|P(x_i,x'|\mathbf{Y})P(x_j,x'|\mathbf{Y}^{(n-1)})\,dx'}{\int P(x_j,x'|\mathbf{Y}^{(n-1)})\,dx'}$$

- Iterate and converge on right answer
- Challenge is to incorporate systematic uncertainties and backgrounds

Precision Electroweak Measurements at LHC and Beyond

- LHC and ILC will continue to improve SM Electroweak precision

	now	Tev. Run IIA	Run IIB	LHC	LC	GigaZ
$\delta \sin^2\theta_{\rm eff}(\times 10^5)$	17	78	29	14–20	(6)	1.3
δM_W [MeV]	34	27	16	15	10	7
δm_t [GeV]	5.1	2.7	1.4	1.0	0.2–0.1	0.1
δm_h [MeV]	—	—	$\mathcal{O}(2000)$	200	50	50

- Some of the most difficult measurements to make
- Among the most un-reliable projections we can make

Precision at Hadron Colliders

- Often hear:

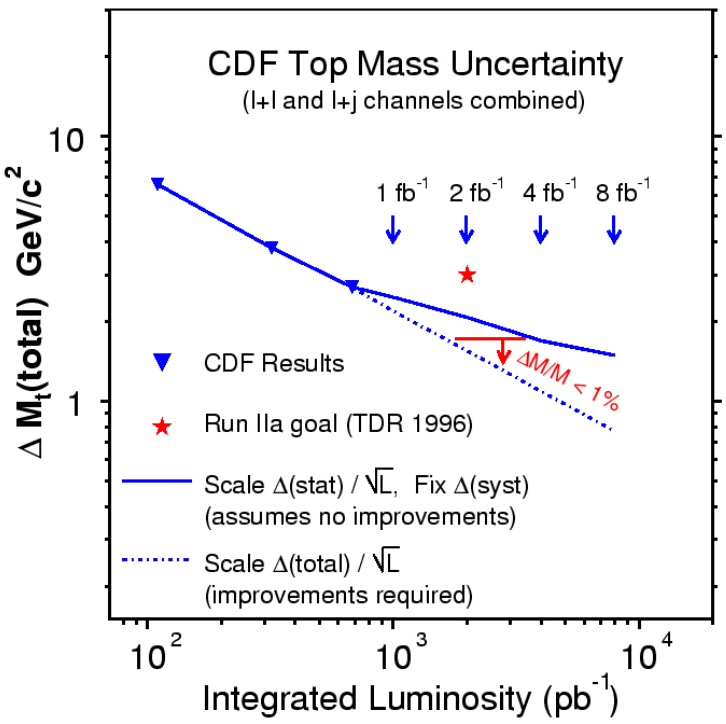
  "e^+e^- machines are cleaner"

  "Hadron colliders can't make precision msmts

- Historical perspective
  - LEP met "Yellow Book" expectations
  - Hadron collider often surpass goals
  - Data makes you smarter

- LHC-ILC interplay
  - Not a matter of competition
  - Better understand the complementarity!

- CDF-II Δm_t projection



Summary

- Many examples of synergy between LHC and ILC measurements
- While the LHC will turn on first
  - Perhaps not as fast we had hoped
  - LHC physics menu can learn ILC physics case

    Imitation is the sincerest form of flattery

  - LHC discoveries will clarify questions for the ILC
- Sessions like this
  - Consider how ILC might be optimised, based on initial LHC results
  - Sharpen arguments for ILC in a post-LHC world
  - Consider ultimate, combined precision from both machines