Higgs vs. Machine and Detector Performance (some random thoughts)

A.Raspereza, DESY

International Workshop on Linear Collider
Snowmass, August 23, 2005

Charge of the Group

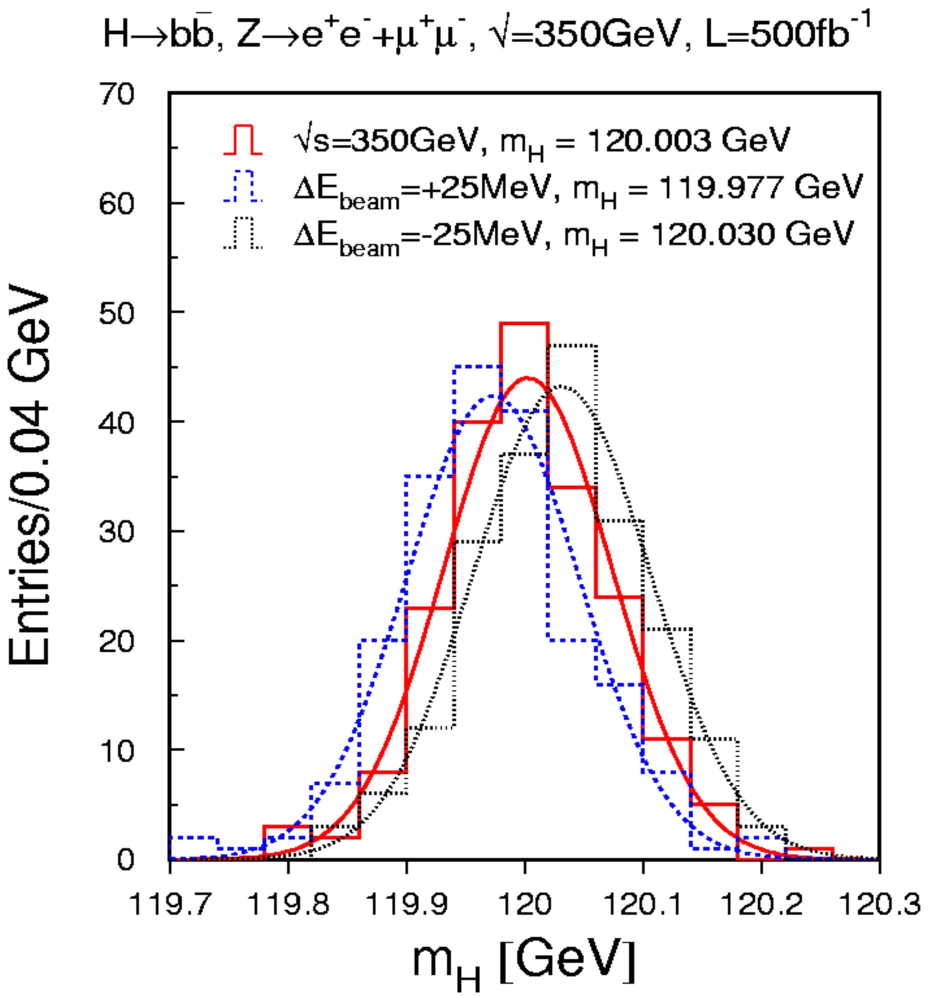
- What are the most important measurements that LC should perform in Higgs physics
- What are the detector, machine and beam criteria that are necessary to allow for these measurements with appropriate precision
- What are the theoretical issues that need to be addressed
- How will these measurements add to what is already known from LHC

Our Role in Detector Optimization

- ILC Collaboration enters the phase of detector and machine optimization
- Expertise of people doing physics analyzes is desperately needed
- Ultimate goal : establishment of mapping between machine, detector and reconstruction software performance and precision of measurements in Higgs sector

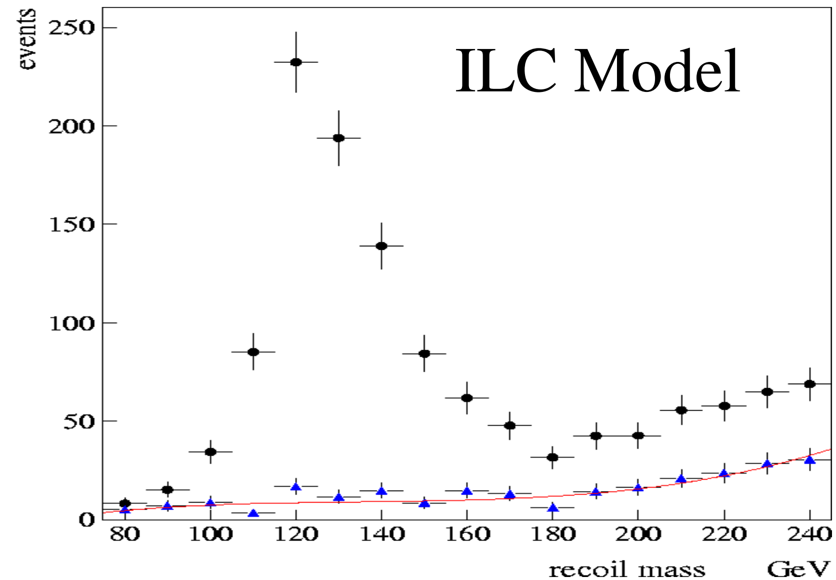
Higgs vs. Machine Performance (Existing analyzes)

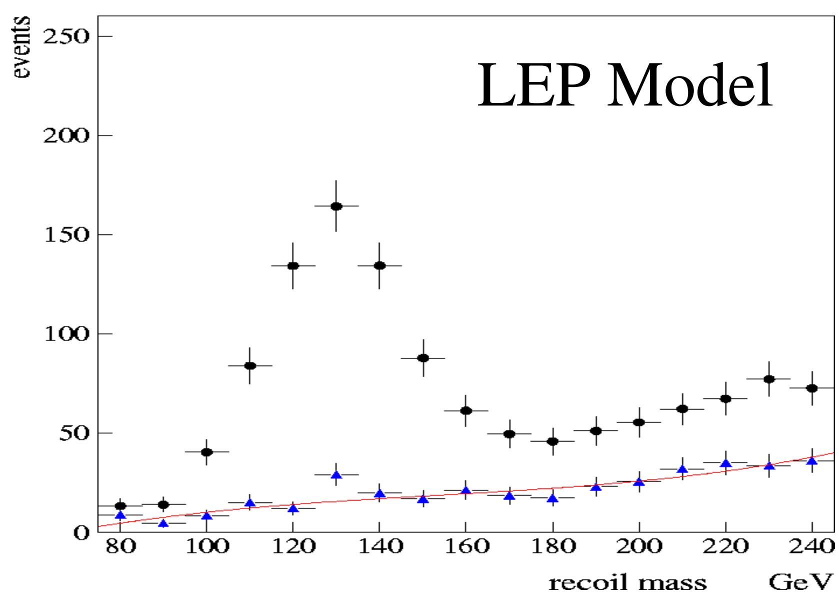
- Issue has been addressed by studies on Higgs mass measurements @ ILC
- One needs $dE_{beam}/E_{beam} < 10^{-4}$ to keep systematic error on Higgs mass below statistical uncertainty
- Beam spread (0.15% for e^- beam and 0.032% for e^+ beam as expected for cold machine) has negligible effect on Higgs boson mass measurement
- Luminosity spectrum can be determined from the analysis of Bhabha events with precision allowing to keep systematic uncertainty on Higgs mass well below statistical one



Higgs vs. Detector Performance (Existing analyzes)

- Impact of jet energy resolution on precision of B (H=>WW) is investigated by J.-C. Brient (LC Note LC-PHSM-2004-001)
- Investigated channel HZ=>WWjj=>lνjjjj
- A 20% loss in precision is observed when simulated jet energy(angular) resolution is downgraded from $30\%/\sqrt{E_{jet}}$ (12 mrad) (ILC detector model) to $60\%/\sqrt{E_{jet}}$ (18 mrad) (LEP detector model)
- One of a few existing analyzes which address the issue of relation between precision of measurements in Higgs sector and detector performance
- Hopefully this study gives rise to a new stream of analyzes addressing Higgs vs. detector performance issues



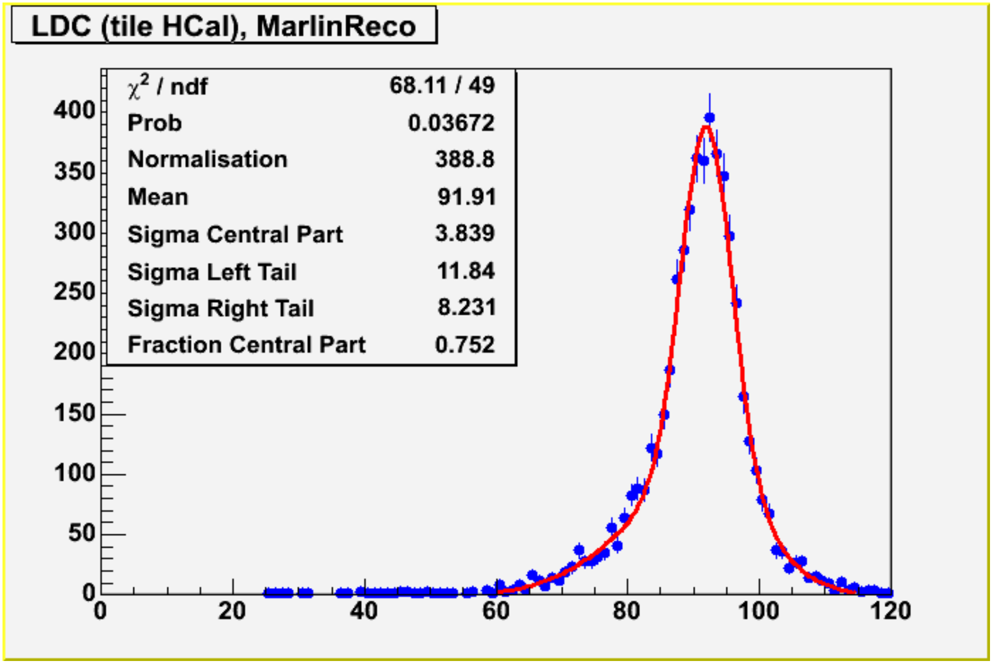


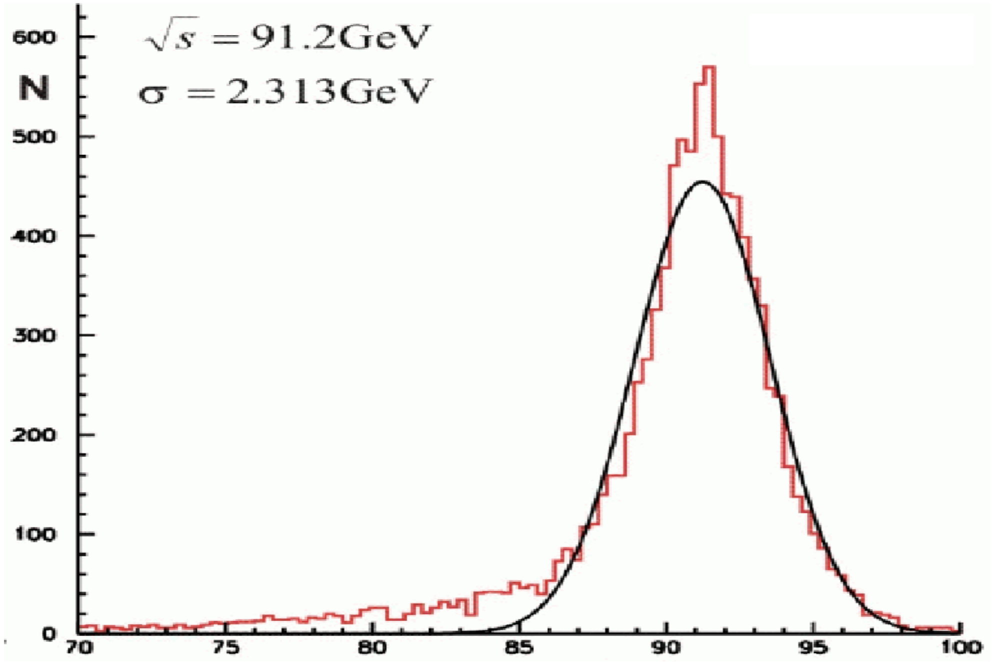
Comments on Existing Higgs Analyzes

- All of the Higgs analyzes @ ILC have been done with fast MC simulators of detector response (Simdet, SGV, *etc*)
- Features of fast MC simulators
  - non-flexible; implement specific detector configuration (Simdet <=> TESLA detector)
  - smears momenta of final state particles according to resolutions anticipated for a given particle type
  - Example : TESLA detector <=> Simdet program
    - $dE/E = 11\%/\sqrt{E}$ for single photons (ECAL performance)
    - $dE/E = 50\%/\sqrt{E}$ for single neutral hadrons (ECAL + HCAL performance)
    - $dP_T/P_T = 7*10^{-5} P_T$ for charged particles (Tracker performance)
  - detector resolution functions for various particle species and detector acceptance are obtained from MC studies with full Geant3/Geant4 based simulation on single particle samples
  - Most of fast MC simulators assume highly performant pattern recognition in the tracking system and calorimeters in multijet events ($dE_{jet}/E_{jet} = 25\%/\sqrt{E_{jet}}$ in Simdet)

Comments on Fast Monte Carlo

- Concerns:
  - Fast MC simulators with hardcoded detector resolution functions are not suitable for detector optimization studies.
  - Do fast simulators realistically emulate detector performance ?
  - Don't we overestimate physics potential of LC ?
- Example Z0=>hadrons events @ Z pole
  - Full simulation + reconstruction   SIMDET





Tools Available on the Market

- Until recently no tools were available to address this issue
  - Absence of dedicated reconstruction tools
  - Absence of flexible detector simulation tools allowing to modify detector geometry
- Situation changed. Now we have :
  - Detector simulators implementing in a flexible way various detector geometries (Mokka with scalable detector models, SLIC, Jupiter)
  - Dedicated reconstruction algorithms (org.lcsim, MarlinReco)
  - flexible fast MC programs, allowing to specify detector resolutions for various types of particles and fudicial cuts, reflecting detector acceptance (see talks by N.Graf and T.Barklow)

Strategy to Address Higgs vs. Detector Performance Issues

- I see two strategies to address Higgs vs. detector performance issues
- Using flexible fast MC simulators
  - New Detector Configuration => dedicated studies with full G4 based program on single particle events => new deduced resolution functions => appropriate parameterization in fast MC => run fast MC => do Higgs analysis => report results to detector experts
  - fast but probably not accurate way, does not take into account pattern recognition inefficiencies

Strategy of Addressing Higgs vs. Detector Issues

- Using full G4 based simulation and realistic reconstruction tools
  - Generate hepevt / stdhep files for your favorite process => feed these files to G4 based simulation program => LCIO files with raw information => feed this files event reconstruction software => LCIO file with reconstructed objects => do analysis on these files => report your results to detector experts
  - time-consuming procedure
  - a more conservative evaluation of ILC physics potential (present reconstruction software needs further optimization)
  - provides estimate of reconstruction software performance
  - emulation of perfect reconstruction is possible (Track and Cluster cheating => perfect particle reconstruction and ID)

Questions to be Answered and Benchmark Channels

- It seems not feasible within short timescale to estimate impact of detector performance on precision in all Higgs channels : let's stick to few key benchmark channels which are crucial for optimization of various detector components.
- List of questions to be addressed in the light of detector optimization studies:
  - Tracking system : HZ=>Xee+Xμμ : How does precision on Higgs boson mass and HZ cross section depend on the track momentum resolution?
  - Vertex detector : H=>hadrons branching ratios : How does the precision on the Higgs branching ratios depend on specific vertex detector configuration (number of layers, position of innermost layer etc)
  - Performance of ECAL : Determination of Higgs CP in H => ττ => ρνρν => $\pi^+\pi^0\pi^-\pi^0\nu\nu$, H=>γγ branching ratio : How does the precision on the photonic Higgs branching ratio depend on ECAL energy and angular resolution? How is precision in determination of Higgs CP influenced by ECAL performance (pattern recognition, π^0 detection efficiency);

Questions to be Answered and Benchmark Channels (continued)

- Calorimeters : what impact a specific option for ECAL and HCAL (absorber material, sensitive element, sampling fraction, granularity) will have on the efficiency of reconstruction of multijet final states in various Higgs channels? How will it be reflected on the jet energy resolution?

- Muon system : HZ=>Xμμ : what improvement can be achieved in ID of high energy muons if tracking and calorimeter information is complemented with muon system; what active element (resistive plate chambers, Sci strips) is preferable; How does the improvement in muon ID affect the analysis performance in HZ=>Xμμ channel

- Overall reconstruction software performance : multijet final states (HZ=>4jets, HHZ=>6jets) : what performance is achieved with currently available reconstruction tools? What performance can be achieved (this question can be answered by emulating perfect PFlow algorithm)? Where reconstruction software developers should put their efforts in order to achieve desirable event reconstruction performance?

Your suggestions, ideas, comments