How to get rid of the Standard Model

Searches for new Phenomena at Hadron Colliders

Outline

* Who is Eckhard von Toerne?
* How to get rid of the Standard Model?
* Extensions of the SM
* Experiments at the Energy Frontier
* Experimental Challenges at Hadron Colliders
* Beyond the LHC
* Summary and Conclusion

Eckhard von Toerne

* Ph.D. 1998, (Bonn University, Germany)
  Thesis: Search for SM Higgs Boson at LEP-II with OPAL
* CLEO-III Silicon Detector readout electronics (Ohio State University)
* Commissioning of the Silicon Detector
* Color-suppressed hadronic B decays, observation of $\overline{B}^0 \to D^{(*)0}\ \pi^0$, **QCD corrections to weak decays**
* Chair of CLEO's rare/hadronic B analysis group
* Research Associate with Ohio State University, located at Cornell

My Research Interests

* Higgs Physics
* Silicon Detector Technology
* Readout Electronics
* B Meson decays
* Statistical Methods (Likelihoods, etc)
* Low Energy Phenomena
    - Quark Fragmentation, R Measurements, Radiative J/ψ Decays

How to get rid of the Standard Model?

* Answer: We can't, really…
* …because the SM is an effective theory below and at the electroweak scale
* SM is well established, (except for neutrino sector)
* Physicists are searching for extensions of the SM. (These theories might also be effective theories, valid up to a larger scale)

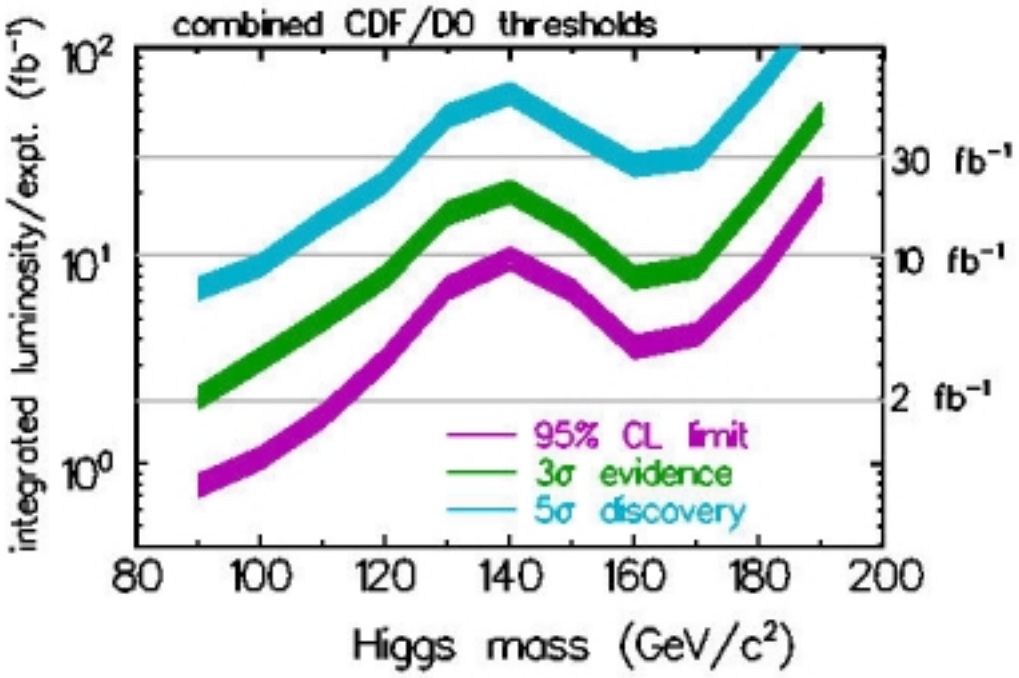
Extensions of the Standard Model: MSSM

* Heavy supersymmetric partner with $\Delta J=1/2$
* Good opportunity to observe first hints of MSSM in the Higgs sector
* Two SU(2) dublets -> 5 observable Higgs states
* all Higgs boson masses are constrained
* $m_h < 130$ GeV
* h couplings and branching fractions need to be measured with high accuracy

Another Example: Extra Spatial Dimensions

* Extra dimensions are either warped or flat and Standard Model particles are confined to 3+1 subspace
* Kaluza-Klein Excitations of Gravitons could exist at the TeV scale, in principle with a clear experimental signature due to Spin 2
* Gravitational excitations either leave the detector undetectred or decay into jets, leptons, γ

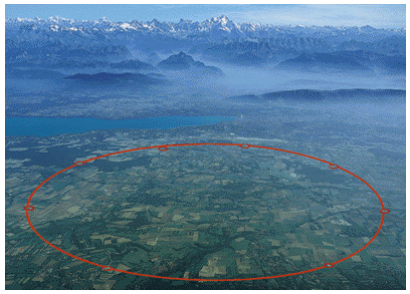
Experiments at the Energy Frontier: Tevatron



Refined experimental methods might make a decisive difference in sensitivity (3 or 5 σ)

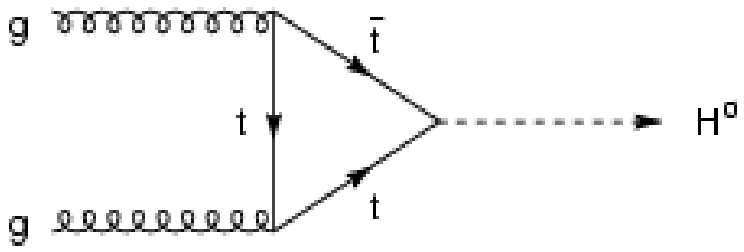
Example: Higgs Search at Lep-II went from cut-based methods to ANN or Likelihoods

Biggest difference between e+e- and hadron colliders are **trigger requirements**

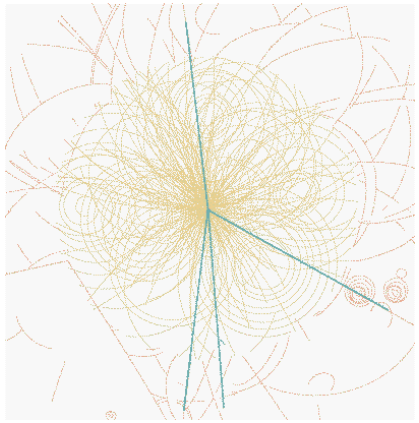


Experiments at the Energy Frontier, LHC

* LHC has Higgs discovery potential over large energy range
* Search Channel vary with Higgs mass and involve SI-tracking, calorimetry, muons
* The construction of the LHC experiments is a major HEP effort in the next years and one of the main tasks for the new Northeastern faculty



Experimental Challenges at Hadron Colliders



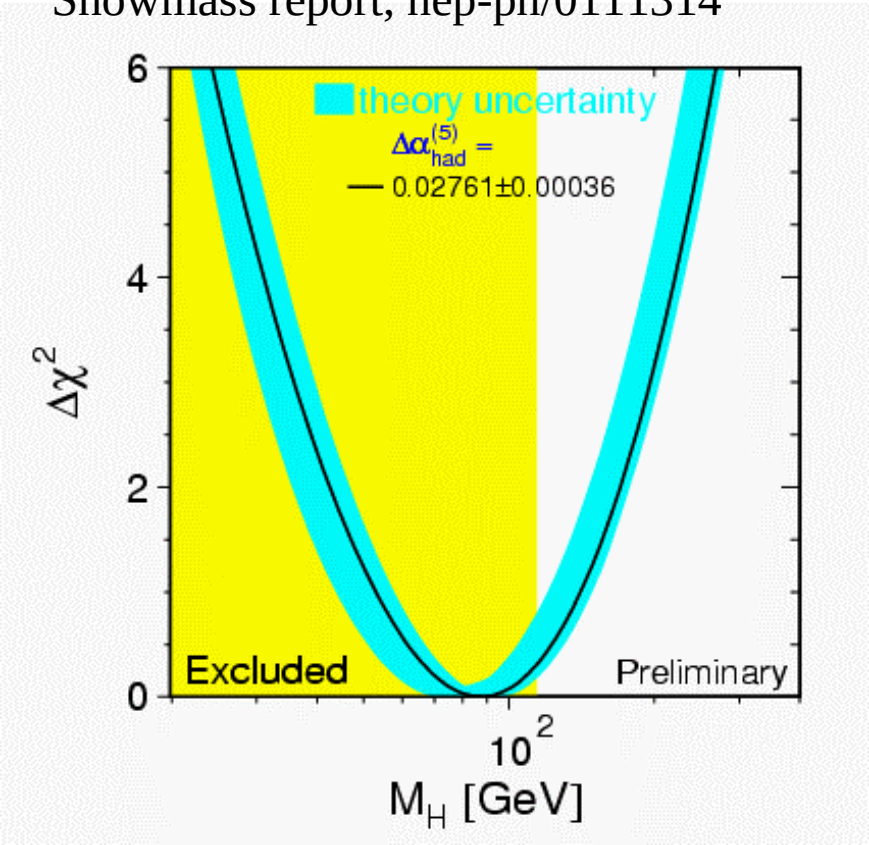
* Trigger
* Jet environment (Tevatron)
* Multiple Events + Jets (LHC)
* tracking, b-tagging
* System integration at large detectors, up to $>10^7$ channels
* Electronics and Readout software
* Although not a Hadron Collider physicist myself, I have experience with many of these issues

The Standard Model Strikes Back

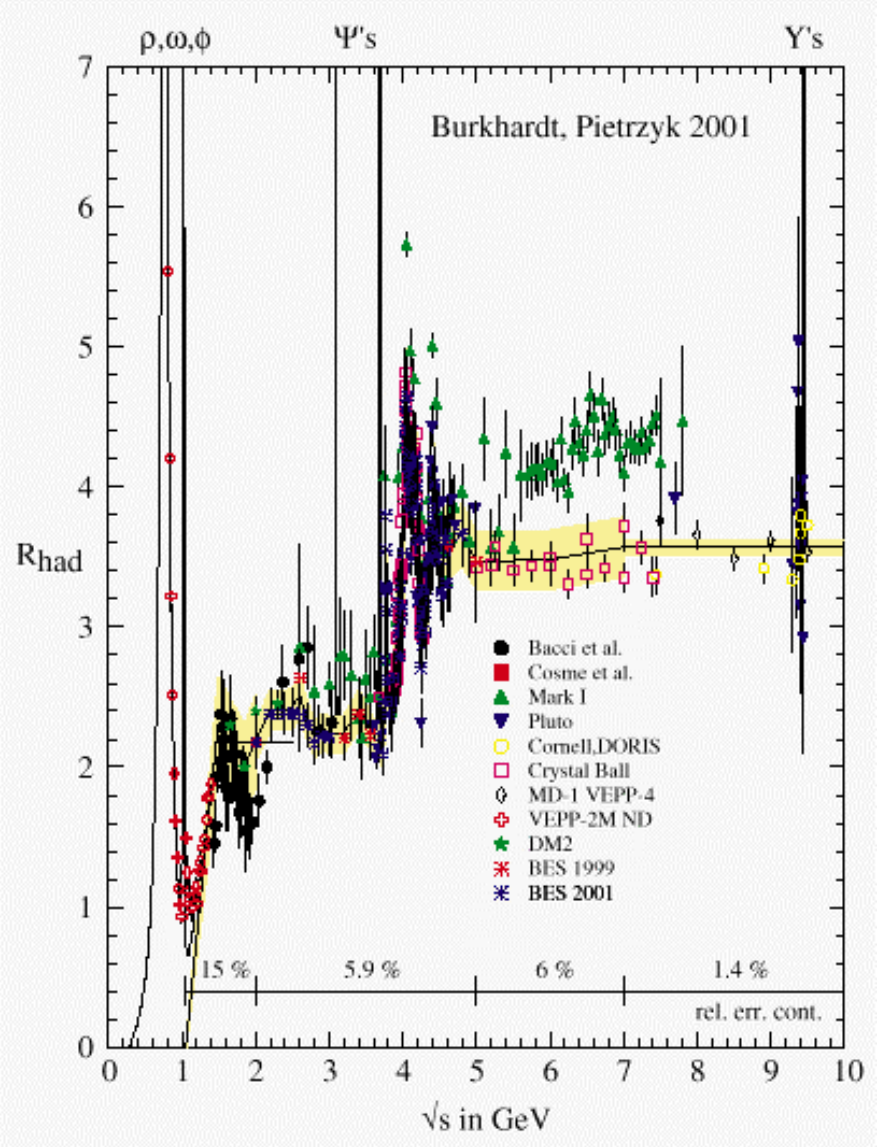
* The Tevatron and LHC experiments might bring about the biggest success of the Standard Model: The discovery of the Higgs boson with a mass in agreement with precision electroweak fits and no other new phenomena...
* Fit sensitive to $\log(m_H/m_Z)$
* Side Remark: Low-energy R measurements enter fit via hadronic corrections to $\alpha_{QED}(m_Z)$

Precision Electroweak Fits

See e.g. D.R. Wood et al.,
Snowmass report, hep-ph/0111314



Fit Minimum excluded by LEP-II Higgs search



Beyond the LHC

* The Experimentalist's Heaven:
  One experiment to build, one to analyze data from

* What comes after the LHC?
  - Linear Collider?
  - GigaZ?
  - VLHC?
  - Muon Collider + Neutrino Factory?

Summary

* Hadron Colliders at Energy Frontier have the potential to discover phenomena beyond the Standard Model
* first hints of new physics in Higgs sector (MSSM)
* Spectrum of ~TeV states (gravitational KK-excitations)
* It is important to understand the QCD background and the interplay between electroweak physics and QCD
* Physics is experimentally challenging (Experience in SI tracking, Calorimetry, Trigger, multi-detector components, system integration
* Physicists need to be versatile (that was always true).