28th March 2000

CERN Search Combinations

W. J. Murray

RAL

Talk overview

- **CERN groups and timescales**
- **Comparison of Higgs and SUSY groups**
- **Janot-Lediberder**
- **Conclusion**

Why are there CERN groups?

(My personal opinion)

- **LEP 1 groups seen to be very useful**
  - **e.g. Electroweak and b-physics**
- **Desire to make best use of the machine**
  - **Many searches benefit from quadruple lumionsity**
- **Emergence of ALEPH 4-jet `problem'**
- **Political desire for CERN to be seen to be a collaboration**

CERN timeline

- **LEP Energy raised to WW threshold 1996**
- **SUSY and Higgs groups est. end 1996**
  - **4 experiments and theory division**
- **Results regularly sent to conferences**
- **Procedures still being improved Mar 2000**
  - **SUSY W.G. Meeting on 27th on common systematics!**
- **Higgs and SUSY groups use different techniques!**
- ***Fast* results for run decision 20th July 2000**

Comparison of the Problem

Higgs Group	*SUSY Group*
3 Channels H, hA, H^+H^-	17 channels: Stop, Sbottom, neutralino, selectron, smoun, stau, stable, single photon, double photon etc.
LR based limits appropriate	Limits independent of signal amplitude needed
Worth maximizing performance for those channels	Small performance penalty acceptable.

Why not just put a limit on the cross-section ?

- **The LEP energy constantly changes**
- **Combining energies needs SOME model**
  - **at what energy do you quote the cross-section limit?**
  - **Are limits at various energies equally useful? SUSY w.g. usually yes, Higgs no.**
- **A common models is to use an average energy - but be careful near threshold.**

LR or non-LR method?

- **Likelihood ratio is OPTIMAL. Use it if you can!** **=>OK for Higgs**
- **By definition it REQUIRES a complete model** **=>Annoying for SUSY**
- **SUSY w.g. introduce variation, to remove cross-section changes with energy.**
  - **Small loss of power, much more practical**
  - **Kinematically incompatible data removed**

Data used in Higgs W.G.

- **Each experiment provides:**
  - **Events seen at each energy**
    - **Each event with 1 or 2D information, e.g. mass, b-tag**
  - **Distributions expected in the above for background at each energy**
  - **Software to calculate expected signal distribution for any Higgs mass**
- **6 energies * 5 channels * 4 experiments = 120plots *for SM*!**

Data used in SUSY W.G.

- **Each experiment provides:**
  - **Matrix of events seen at each energy compatible with given (M_c^0, M_Y)**
  - **Distributions expected in the above for background at each energy**
    - **Subtractable and non-subtractable**
  - **Signal efficiencies at each point**
- **8 energies * 4 experiments = 24 sets of matrices for each channel**

Limits

- **CL_s & Obratsov (Bayes with constant prior in s) compared.**
  - **very similar but better limits from CL_s**
- **CL_s used to set limits, as preferred method, others occasionally.**
- **Updating a limit needs all old data.**

Discoveries!

- **CL_b used as `discovery indicator'**

- **LEP 2 doesn't have any discoveries.**
  - **Aleph 4-jet excess `closest thing'**
    - **Very unlikely excess in 1 experiment**
    - **Exchange of event 4-vectors, real and simulated,intensive detector studies, *no conclusion***
    - **It did not appear in a second run**

Janot - LeDiberder combination

- **CERN/PPE-97-053 `Combining Limits'**
- **Technique for combining CL's directly**
  - **No recourse to the selected events**
  - **Much less information needed**
  - **Almost optimal**
  - **CANNOT MAKE A DISCOVERY**
- **Useful for the PDG?**

Janot - LeDiberder part II

- **Democratic prescription:**
  - **Uses only the measured CL_s to produce combined one**
  - **Dangerous is experimental sensitivites differ**
- **Elitist prescription**
  - **Needs CL, <CL>, background rate**
  - **<CL> background ensemble must be calculated**
  - **Combined CL better *ON AVERAGE* than individual ones**
  - **Optimal if background follows their assumed shape.**
  - **Limits are safe *Frequentist* limits**
- **Good way to combine limits if you do not have the details of the data.**

Summary

- **Co-operation essential to confirm discoveries**
- **Co-operation sometimes hard**

- **LEP minds are concentrated by the decision to switch off (or extend running) in July**

……wish us luck!