Working Group II: “MET Signatures”

- This meeting: focused on LHC results and new/improved analyses
- Future: will focus on Implications
  - Interpretation of discovery
  - Implications of discovery (or not) for future facilities
Some issues raised

• Format of expt. results / tools for interpretation
  • $\sigma xA$ ?
  • SMS limits ?
  • Likelihoods (workspaces) ?
  • Additional CL contours ?

• Comment from one experimental colleague:
  • “Experiments have provided many data types, little feedback from theory so far”

• Comment from one theoretical colleague:
  • “We keep requesting, but the experiments are not responding”

• Reality:
  • there is no common, experiment-wide rule for expressing results
  • very heterogeneous: depends on analysis, analysers, approval

• Suggest common WG2/3 sub-group to study this topic
  • form concrete proposals
Some issues raised

• **problem:** \( \sigma \times A = N \times L \)
  - Acceptance, \( A \), is model and analysis dependent
  - arbitrary new physics model is not well defined

• **For exclusion limits,**
  - one could quote the acceptance for the SM (well defined)
  - must then evolve SM acceptance to NP acceptance
    - object efficiency driven (are these useful to provide?)
    - simulation driven (clearly useful, but how valid?)
Some issues raised

- **Fast Detector Simulation**
  - Can in principle make one’s own (tune it to published results)
    - not as difficult as one might think
  - Key: stay within the toy sim’s region of validity!
  - Corollary: do not use outside region of validity!
    - rare phase-space regions are difficult to model correctly
    - rare phase-space regions also tend to be the most interesting for most models!

- **Why prefer an experiment blessed Det Sim?**
  - “I want to make sure my results are realistic” (Good!)
  - “I want a reference for the tools I use” (Irrelevant!)
  - “I want my results to be credible” (Bad!)
    - precisely what the experimentalist fears: someone will use “ATLAS/CMS” blessed tools to study an invalid region of the tool and say: “it must be OK because I used ATLAS/CMS blessed tools!”

- **If 20% is good enough, then Delphes, should be OK…**
  - if more precision is needed, then it is becoming an “analysis”
  - nevertheless, the interest in a “blessed” fast toy det sim is clear!
Some issues raised

- Prioritized list of analyses not covered
  - Not models! Analyses!
    - different signatures
    - different regions of phase-space
  - Interplay of difficult SUSY signatures vs searches for exotic signatures: MET vs non-MET searches
    - what is the coverage of all searches on difficult to find SUSY searches?
  - Put into categories (e.g. Low MET, soft jets....how low, how soft?)
    - what is the model coverage in each category? what is the priority of each category?

- Missing any critical analysis methods
  - counting n-WIMPS, etc

- Missing any critical analysis objects?
  - kinematic variables (a la MT2, alpha_T, etc)
  - boosted objects (jet substructure, etc)

- What are the efficiency/systematic limits of
  - MET, jets, b-jets, taus, leptons, photons, charged pions, etc...
Some issues raised

- Challenges to getting to difficult regions
  - trigger
  - SM backgrounds
  - experimental apparatus
  - ignorance of existence

- Aids to getting to difficult regions
  - ISR! need common prescription for both ATLAS and CMS

- How does the physics potential evolve with machine conditions (luminosity)? High pT vs subtle signatures
  - online (trigger),
  - offline (PU reconstruction),
  - analysis (NP sensitivity)
Some issues raised

• **Model independent searches**
  • Look-elsewhere-effect: Challenging, but understood
  • Systematics: Challenging, and sometimes not understood

• **Some Observations:**
  • Single top discovered as a sliver of excess on large bkg! **Predicted!**
  • Wjj excess observed! **Not Predicted!** Jury still out! (NP? not NP?)
  • One needs a plan before(!) observation.
    • how to handle this is a challenge when one does not necessarily have a prediction a priori.

• **LHC data analysis is all about compromises:**
  • MET vs jet pT vs n-leptons/photons, etc (fact of reality)
    • strongly dependent on experimental apparatus, LHC running conditions, etc
  • inclusive vs exclusive (less model sensitive vs more model sensitive)
    • inclusive: one can easily miss a subtle signature
    • exclusive: one can easily miss a gross signature

• **Model independent searches very useful!**
  • ...but not a silver bullet!
Identified topics that require further study or new approaches

Signal/model regions to further explore:

• Direct production of third generation squark, EW gauginos, and sleptons
• Stop production in gluino decays
• 4-body gluino decays
• Classify difficult models and develop possible new search strategies
• Can RPV searches be useful for multi-jet, low MET, low p_T final states
• Exp’t limits in the pMSSM
Further Studies: Cont.

- Effectiveness of mono-jet searches for compressed spectra: optimization of ADD searches for SUSY/DM?
- Expand global fits to other SUSY breaking models
- Development of new techniques, such as boosted jets for NP searches
- Further work on effective DM theories and counting MET particles. New channels and/or observables?
- Examine validity of Simplified Model Approach: what are the limitations?
- How do we handle complex scenarios?
Much overlap with WGs 1&3!

- Interplay between non-susy and susy MET searches
- Interplay between non-susy and susy non-MET searches
- Invisible Higgs searches
- Higgs production in SUSY cascades (stop decays)

We need to coordinate!
Looking towards the final report

**Discoveries @ 7 TeV:**
- Identify observables to interpret discovery
- Identify future facilities needed to determine underlying theory

**No Discoveries @ 7 TeV:**
- Identify scenarios that are excluded (e.g., 4\textsuperscript{th} gen)
- Identify scenarios with theoretical tension (e.g., mSUGRA)
- Identify scenarios that are untouched and still valid
- Implications for future facilities: what is impact of higher scale of NP?
7 TeV Results Linked to Many Future Facilities

Energy Frontier:
- LHC: 14 TeV, lumi upgrade, energy upgrade
- LC: ILC, CLIC, (e⁺e⁻ Higgs Factory?)

Intensity Frontier:
- Flavor Factories: Super-B, LFV exp’ts
- Neutrino Exp’ts

Cosmic Frontier:
- Direct and Indirect Detection of DM
The Road Ahead

Future Meetings:
• Propose Next WG2 Meeting: 7-8 November @ CERN
• Possible Joint WG2/3 Meeting?
• Possible topics:
  • Presentation Experimental Results (formats, etc)
  • Development of Report (start filling in outline)

WG2 Wiki:
• Wiki page is set up – will go live soon
• Will be linked to workshop website
• Please sign up and contribute!!!

Outline of WG2 Report Chapter:
• Available for Nov WG2 meeting
No Obvious Signs of New Physics YET

• 1st 6 months of a 20 year program!
• NP could be at ~2 TeV or more complicated than the simplest scenarios
LHC puts supersymmetry in doubt

www.bbc.co.uk

Results from the Large Hadron Collider have all but killed the simplest version of a theory that physicists had hoped would update the current model of sub-atomic physics.
If there are no discoveries by the end of the year, we need to coherently deliver a positive public message.

**Hmwk:** What is the best message to deliver ?!?!
Future Directions/Goals

• **Future:**
  • what do the 7 TeV results imply for 14 TeV?
    • where should we invest our resources?
  • what do the 7 TeV results imply for CLIC?
    • motivate specific R&D activity based on physics

• **Formulate a plan to identify and anticipate which analysis are not currently covered and are of high priority**
  • Such analyses should inform about physics at 7 TeV physics & where to look at 14 TeV
  • Such analyses should also provide possible insight for CLIC
  • light stops is one extremely good, well motivated example

• **Next steps: possible WG sub-groups**
  • Presentation of Experimental Results Group
  • Missed Analyses Categories Group
  • Phenomenology Interpretation Group
  • others?