Working Group Report

Physics Landscapes Session

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Goals and Intentions

This group has a dual-purpose.

1 How do the solutions to analysis problems for searches for new physics at the Tevatron generalize to the LHC?

2 How will searches and measurements at the Tevatron impact theoretical predictions for the LHC?

Hopes and Plans

⋆ The plan is to work on these questions over the next year.

⋆ Today's talks should give us the initial kick-off and motivation.

⋆ We will try to identify tasks and form groups to tackle them during this workshop and immediately afterward.

⋆ Send us your ideas and suggestions!

(from our e-mail messsages:)

Suggestions / Instructions for the speakers:

- Experimenters, please report on the latest results from the Tevatron experiments, and then consider how the given analysis would be generalized to LHC conditions (as best you can).
- Experimenters, if you can, consider the impact of Tevatron discoveries on the basic LHC start-up plan, including both subdetector systems and triggers.
- Theorists, please consider the possible sequence of results first from Run II, and then from the first year of LHC. We are interested in the connection between these two, and in particular would like to understand how Tevatron results will shape the physics picture at the start-up of the LHC.

Remarkably, the speakers took these instructions seriously and delivered truly insightful talks.
$\longrightarrow$ and excellent starting point for the working group!

There were 15 talks

- 6 from experimenters
- 9 from theorists

Talks were typically 25 minutes long and well packed with information.

→ See the posted pdf files for details.

→ Today we will bring out only those points which bear directly on the purposes of the workshop (with apologies).

(Next time we will insist on more time devoted to discussion.)

Volker Büscher

Multi-lepton and Tau Signatures of New Physics

- need to worry about ID efficiency and acceptance at high p_T
- for muons, mass resolution
- LHC should be ready for quick confirmation of a signal from the Tevatron
- SUSY tri-lepton searches require huge MC samples to estimate backgrounds - a practical problem
- relatively low-p_T thresholds means conversions are a problem
- NN used by DØ in τ-ID – calibration must be done with care
- it is essential to maximize the acceptance

Song Ming Wang

Signatures for New Physics from Jets and Missing Energy

- $\not\!\!E_T$ analysis very sensitive to jet energy scale uncertainties
- experience from the Tevatron
  - electroweak backgrounds - natural source of $\not\!\!E_T$ - measure them!
  - jet energy scale!
  - large geometric converage + hermiticity for $\not\!\!E_T$ resolution (especially tails)
  - calorimeter channel inter-calibration is not easy but very important
  - must be quick to handle dead or hot channels – and fix them!
  - monitoring important to catch bad channels
  - good operation of other sub-detectors important, such as muon detectors and vertex reconstruction
  - watch out for beam halo, large beam losses, and cosmic rays

Yuri Gershtein

Photon-based Signatures from GMSB SUSY and Xtra-Dim

- photon simulation must be tuned *via electrons*
  - no clean source of photons (radiative Z's?)
  - also no source of single, isolated electrons at high E_T
  - conversions also a problem
- expect to see smarter algorithms at Tevatron before LHC turns on
- Tevatron results will influence LHC background calculations
  - $d\sigma/dM_{\gamma\gamma}$
  - instrumental backgrounds
- LHC could make a quick confirmation of a Tevatron discovery but
  - take a lesson from the Tevatron: *Be Ready!*
  - time constraint at start-up comes from understanding the detector – it is not, initially, a question of integrated luminosity, or, who has the best detector
  - easy to overlook: how to split data into reasonable sub-samples? what data format? *Settle these things early!*

Simona Rolli – Search for Leptoquarks

- Tevatron searches are basically event counting, with a fairly simple cut-based selection.
- New techniques needed in order to gain sensitivity past ~ 300 GeV
- ATLAS study follows closely the Tevatron analyses,
  concludes sensitivity up to ~ 1.3 TeV
- CMS study also based on a similar cut-based selection
  - looked at effect of pile-up on lepton isolation – not negligible
  - not much impact on $\not\!\!E_T$
  - claim remarkable mass resolution – is this realistic?

Maria Spiropulu

1.96 TeV physics input to 14 TeV detector and triggering start-up

- "As late as possible, but ahead of time."
- event rates are huge
- early low-luminosity running important for calibration and shake-down
- the trigger
  - more advanced algorithms implemented in lower level triggers
  - use more 'commodity' products
  - despite this, great flexibility
- hope to incorporate Tevatron knowledge on calibration and back-up triggers
- study effects of pile-up and be prepared!

Daniela Bortoletto

Heavy Flavor Tagging and Collider Searches for $\tilde{t}$ and $\tilde{b}$

- LHC topologies studied so far are quite complicated compared to TeVatron ones
  $$\tilde{t}_1 \to c\,\tilde{\chi}_1^0 \text{ and } \tilde{t}_1 \to b\,\ell\,\not{E}_T \text{ and } \tilde{b}_1 \to b\,\tilde{\chi}_1^0$$
- some initial studies have already been done, but they could not use any *realistic* simulation of b-tagging
- implementation of TeVatron analysis in LHC framework, and *validation of LHC techniques with Tevatron data*, might facilitate preparation for a discovery
  - What were the differences between simulations and real life at the Tevatron?
  - Do b-tagging efficiency and fake rate change with the luminosity and number of primary vertices?
  - create micro-DST's of the good Tevatron events with and without b-jets to test LHC software
  - how badly does mis-alignment affect b-tagging?
  - how do you calibrate the b-tagging results – using MC generators? which ones?
- As usual: *hard work is necessary.*
  (And from Tevatron experience, there are never enough people to do it. . .)

Georg Weiglein — SUSY Benchmarks after Run II

- care about external constraints when they have a direct theoretical connection to collider processes
- be wary of un-conventional Higgs decays – and look for complimentarities
- Naturally the benchmarks will become obsolete, in which case the Tevatron can give guidance.
- A good measurement of M_t is extremely important!
- Don't forget the Tevatron can rule out the Higgs up to ~ 130 GeV
- If the Tevatron sees something, to what extent can the LHC help identify it?

Howie Baer — Supersymmetry, DM and Collider Physics

- at Tevatron, $\tilde{\chi}_1^{\pm}\,\tilde{\chi}_2^0$ dominates over $\tilde{q}$,$\tilde{g}$
- at LHC, $\tilde{q} + \tilde{g}$ dominates
- estimates of reach in $(m_0, m_{1/2})$ plane confirmed by other simulations

Gordy Kane

Intrepreting New Physics Signals at Hadron Colliders

- asks: *What do we do to disentangle signals of new physics?*
- Use *patterns* of inclusive signatures
- Develop this at the Tevatron, be ready for the LHC
- advocates serious development of jet-charge techniques

Ken Lane **Technicolor**

- Technicolor particles definitely in range of the LHC, maybe Tevatron
  $\Longrightarrow$ falsifiable
- plea for more extensive studies of reach

Satya Nandi – Signals from Universal Extra Dimensions

- Tevatron has an interesting reach for UED, but not well studied
  - very nice signals in jets+$\not{E}_T$, but need BG calculations
  - also quite good: $\gamma\gamma$+$\not{E}_T$
- one problem is there is no generally available event generator

Tim Tait – Z''s at the Tevatron and the LHC

- nice model-independent formalism for experimental results
  - $\sigma \times BR$ is OK, but not the best
  - separate couplings factors from "form factors" which depend on parton luminosities, etc.
  - possible in the narrow-width approximation
- place bounds on the Z' quantities *directly*
- example contours
- apply this to real Tevatron results, use better estimates for LHC reach

Zack Sullivan – Searching for W''s at Hadron Colliders

- note a model-independent anlaysis possible in $W' \to t\bar{b}$
- quick simulation for LHC – finds that existing generators are *really wrong*
  - W+JJ background is very dangerous
  - $\sigma(WJJ) \gg \sigma(WJ)$ due to resonant loop diagrams
- W' limits provide strong constraints on non-SUSY models
  - Can the analyses be improved?
  - more NLO calculations are needed!

Csaba Balazs – A Tevatron-LHC Synergy Written in the Stars

- incorporate constraints from EWBG as well as DM
- upshot for colliders is a 'dangerous' region for $\tilde{t}_1 \to c\,\tilde{\chi}_0^1$ in which the mass difference $\Delta M = M(\tilde{t}) - M(\tilde{\chi})$ is only about 15 GeV
  - experimenters need to think about new triggers
  - ongoing work in DØ soon a result from CDF!
- What about LHC?

Dave Rainwater – **Heavy SUSY Pairs plut Jets at LHC**

- SUSY-Madgraph used.
- *extra* jets are very liekly!
- must repeat the 'kinematic edges' analyses
- We should study extra jets in $t\bar{t}$ pairs in Tevatron data, use this as input to simulations
  - (This was started in Run I and needs to be picked up again in Run II.)

Plans for this Working Group

Consider how to proceed for the next year:

- We cannot cover all possible "physics landscapes," so we will select a few topics and work to obtain solid and detailed result in each of them.
- We hope to continue to *mix theorists and experimenters* on each of these topics – we view the forging of connections and bridges between theorists and experimenters as an important goal for this workshop.
- We sent around a sign-up sheet and
  - 74 people signed and provided e-mail addresses
  - 25 said they are ready to work!

  This is a wonderful pool of talented person-power.
- We will form teams to tackle the selected topics and encourage them to work toward individual publications.

- The results would also be summarized and synthesized (?) in the proceedings. *However*, a given contribution would have to pass a list of requirements to be included, for example:
  1. experimental studies must use an advanced simulation and make use of appropriate Tevatron techniques
  2. theoretical studies must draw explicit connections between results from the Tevatron (positive or negative) and the LHC
  3. no simple re-iterations of previous work...
- We will monitor progress through intermediate meetings (Dec?) and invite contributions that are sharply focussed on the selected topics and the goals of the TeV4LHC.

- *Question for the Organizers:* How should we coordinate work, share results, divide tasks, and otherwise handle overlaps with the other working groups?
  - We do not want to step on anyone's toes –
    and we do not want to fail in our task either.

  Please institute some mechanism to help with this aspect of the workshop.

Proposed Topics

- The $\not\!\!E_T$ spectrum and *e.g.* evidence for extra dimensions.
  - inject more realism into this experimental study (and the others, too)
  - adopt Tevatron techniques for controling *fake* $\not\!\!E_T$
  - evaluate impact of jet energy scale, PDF uncertainties, instrumental backgrounds, and the underlying event
- Investigate light $\tilde{t}_1$ and $\tilde{b}_1$ signals at the LHC
  - is discovery feasible?
  - what triggers are needed? (recall small ΔM case)
  - study b and c-tagging – *especially for very high energy jets*
- What is the Z' and W' reach at the LHC, for *realistic simulations*?
  - scrutinize lepton-ID, especially at high energies (calorimetry, tracking . . .)
  - impact of underlying event on isolation
  - note W' search involves large $\not\!\!E_T$
  - what can be done with di-jets (already quite 'interesting' at Tevatron)
  - verify previous background calculations

- advanced reconstruction of electrons which Brems
  - identify and handle asymmetric calorimeter clusters
  - this is mainly a 'tools' study with wide ranging applications
  - DØ can investigate this directly with data
- lepto-quark and techni-color signals
  - current simulations are not very realistic
  - impact of underlying event on lepton isolation, and jet reconstruction?
  - existing techniques are based on tevatron analyses and probably are not optimal for the LHC
  - work can proceed in parallel with the Tevatron analyses

- Extend model-independent approaches like the one proposed by *Carena, Daleo, Dobrescu & Tait*
  - render Tevatron results in this formalism
  - What happens if you hypothesize an extra $SU(2)$, ie., W''s ?
  - make contact with the experimental studies for Z' (above)

- Identify cases in which Tevatron data is essential
  - as input to theoretical calculations (models).
  - to interpret signals seen at both Tevatron and LHC

- Gordy Kane proposes looking at 'patterns' of data to select-out the best candidates models.
  - can we come up with test cases (in the spirit of the benchmark points and slopes)?
  - what kinds of 'inclusive' measurements make sense?

We invite participant to join in these working groups –

and to suggest their own.

$\longrightarrow$ *discussion in cafeteria at 3pm.*

(This information will be posted in the Landscapes web page this weekend.)