New Particles & Forces

what are the search strategies?
how do we evaluate them?

Gershtein, Luty, Narain, Wang, Whiteson

Questions to be answered

- Higgs discovery brought old questions to the fore
  - Hierarchy, vacuum stability, …
  - Yet we still do not know what kind of new physics is there
- **Big tasks**
  - To fully explore the origin of electroweak symmetry breaking in light of the discovery of a Higgs-like particle at the LHC.
  - To investigate the naturalness (or lack thereof) of the electroweak (TeV) scale
  - To investigate the origin of dark matter

Mapping these questions to actual physics analyses…

BENCHMARK MODELS TO COMPARE THE DISCOVER REACH OF FUTURE FACILITIES IN THE EXPLORATION OF THE ENERGY FRONTIER.

There are a large variety of theoretical frameworks and specific models that attempt to address these questions. The purpose of this subgroup is to assess the opportunities for discovery in these scenarios. We have identified the models for possible exploration in this report in the list below.

Note that the list of signals and the number of future facilities to be considered are almost certainly too long to explore them all. There may also be opportunities that are missed in the above. The next step in the process is to identify which studies will take place, for which we need the active input and participation of the particle physics community.

We also intend to capitalize on the studies done for the European Study Group.

- Exploration of the observed Higgs-like particle

The discovery of the Higgs-like particle at the LHC is the most important step forward in understanding the electroweak interactions since the discovery of the W and Z bosons.
Fully capitalizing on this discovery is one of the top priorities for research in the high-energy frontier in the coming decade.

While the Higgs subgroup is charged with detailed investigation of its properties, there is a connection to new particles here since even the SM-like the Higgs can be a portal to new physics and
hidden sectors. In particular, studies of non-standard decays (i.e. leptonic jets) should be investigated

- Dark Matter

The relic abundance of dark matter is a strong hint that the origin of dark matter may be a WIMP, which may be searched for at colliders. The study of dark matter at the
high-energy frontier overlaps strongly with other theoretical ideas discussed below.

- Supersymmetry with stable LSP
- Little Higgs with T-parity
- Model-independent searches for dark matter
- MET searches (e.g. monojets)

The models+signals will likely be contained in the other theoretical ideas discussed below.

In specific frameworks (e.g. supersymmetry) it is possible to directly compare the reach of collider dark matter searches with the that of dark matter direct detection experiments. This can be used to get ideas of the reach of these experiments, but in general the collider and direct detection experiments give complementary information.

- Supersymmetry

The theoretical motivation for supersymmetry is very strong, but so far no signal has been observed. This motivates extending the reach of existing searches for models, as well as looking for models with special features that would hide them from conventional searches.

- Conventional spectra (split spectrum, stable LSP)
- jets + MET
- electroweak chargino/neutralino production
- multilepton searches
- Squeezed SUSY spectrum
- large ISR signals
- R-parity violating
- multijet and multilepton signals with small MET
- Naturalness-motivated spectra (light stop)
- b or t rich final states

- Composite or Partially Composite Higgs

Models of this kind can explain the existence of the light Higgs-like particle. They include models where the Higgs is a psuedo-Nambu Goldstone (composite Higgs and "little Higgs") and models where the Higgs mixes with a strongly-coupled sector. There are also "holographic" versions of these
theories where the composite dynamics is replaced by extra dimensions.

The study of the Higgs sector of these models is discussed separately above, so the list below focusses on the other signals of these models.

- Little Higgs
- Top partner searches
- Universal extra dimensions
- Squeezed spectra of KK partners (similar to squeezed SUSY)
- Composite Higgs
- Double Higgs production
- Warped extra dimensions
- ttbar resonances, W/Z/h resonances (similar signal also in composite Higgs models)

- Bottom-up Tests of Naturalness

http://www.snowmass2013.org/tiki-index.php?page=The+Path+Beyond+the+Standard+Model

- Way too many to have high quality studies

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- Way too many to have high quality studies
- Did we miss anything?

Asking the right questions

- In the end, we want the result to inform the P5
- We need to decide which are the right studies to perform to understand what kind of physics potential different facilities have
  - i.e. if we have SLHC data, we should look for heavy gluinos and Z', but if heavy gluinos and Z' were the main things we are interested in, SLHC is the wrong machine to use
  - it is probably much more important to build SLHC to explore the statistically limited or kinematically hard scenarios
    - compressed spectra – where we have to rely on large ISR radiation
    - RPV / light colored resonances – where we have to go into boosted regime
    - …

Decision trees?

- If we consider SLHC, is it a right decision to run with the same type of trigger menu if we do not find new physics in the first 14 TeV run?
  - What would the alternative look like? When does one decide to give up on new physics in isolated leptons etc at the SLHC?
- What are the right questions for new particles at the ILC? Muon collider? VLHC?

Next Steps

- Two talks now – SUSY & Exotica perspectives
- Discussion session tonight at 19:30 in WH3NE
- *Get involved!*
  - is there anything missing from the charge?
  - what physics areas are you interested in? Do you have studies in mind?
  - what working group structure we need
  - how do we cooperate between groups
  - what is our final product?
- Meeting in January (tentative 14-16, west coast?)
  - Should have reports from the studies that have begun – by the end of that meeting we should have a good idea of what kind of studies will converge in time for Snowmass