Guidelines for Benchmark Group Calculations, v1.2

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1. Introduction

We're trying to focus on creating a minimal set of distributions and rates, with a guided early pass at the detector characteristics necessary to accomplish future VLHC physics goals.

2. Goals

Outputs are hopefully of three sorts, in order of decreasing importance (for a Snowmass document):

1. Cross section calculations in figure form for the potentially interesting reactions.

2. Rate Spreadsheet calculations using the calculated cross sections for rates for all reactions...one spreadsheet for each plot. Cross sections should be tabulated at $\sqrt{s} = 14, 28, 40, 100, 200\,\text{TeV}$, so some numerical output from the plots may be needed if the curves are hard to read. Spreadsheet templates are available by email from Ashutosh (kotwal@phy.duke.edu) and by Thursday afternoon, from the E4 website, http://snowmassserver.snowmass2001.org/Working_Group_E4/ .

3. For selected reactions, distributions of kinematical quantities at four-vector level, in order to set the broad geometrical and topological requirements for a detector. To this end, a separate Detector Spreadsheet (last page) will be used to score various detector characteristics for each reaction, 0 = not necessary, 1 = necessary, 2 = absolutely critical.

4. For selected processes, simulations of varying complexities with a simple detector configuration. To this end, Frank Paige has made available V7.54 of ISAJET which has a direct connection to a PAW or ROOT based toy detector.

5. Background simulation and evaluation.

6. For selected processes, simulations of a sophisticated nature.

We consider Outputs 1 and 2 as minimal and progress or completion of 3-6 as great progress.

2.1. Work Underway

The processes that we are working on are of two sorts, true VLHC physics reactions and "Engineering" reactions which probe potential detector capabilities.

2.2. Engineering Reactions.

A set of processes which can serve as a mental normalization for the very different kinematical regimes of these machines seemed important. Additionally, these may serve as calibration tools.

1. Top quark production may serve as a laboratory of hadron jet scale calibration, missing E_T calibration and lepton calibration. We are seeking to understand the kinematics of heavily boosted top quark pairs to explore the coverage of these quantities in a detector. The suggested output of these calculations should be scatterplots of E_T vs rapidity for jets, leptons, and b's, plus the distribution of missing E_T and number of jets.

2. gauge *WW* Production may also serve as a test of calorimeter dynamic range.

3. Inclusive Z production as a benchmark for lepton rapidity range.

4. High energy dijet production, such as might be produced in excited quark production, techni-states, and heavy *Z*'s.

2.3. Physics Reactions.

Standard Model

- top physics
- bottom physics
- total cross section
- dijet physics
- inclusive jets
- dibosons
- tribosons
- dilepton final states

Higgs Physics

- gg fusion
- WW fusion
- tth
- tri-higgs couplings
- di-higgs production
- associated higgs production

$W_L W_L$ pair production

Beyond Standard Model

- SUSY
  - messenger sector
  - inverse hierarchy models
  - gluino-pairs
  - squark-pairs
  - charged Higgs pairs
  - heavy A
  - 2 SUSY higgs production
- Technicolor
  - rho, eta
  - topcolor

Exotics

- compositeness
- extra dimensions
- WIMP-like objects
- lepto-quarks
- excited quarks
- heavy 4^{th} generation
- anomalous astrophysics?

2.4. Plots Needed

Cross sections for sets of reactions (see below) should be log-lin plots of σ vs $\sqrt{s}$ with 12 decades of vertical axis and horizontal axes from 1 to 200 TeV. Additional plots of quantities like σ vs M for different machine settings are great.

Cross section plots (and corresponding spreadsheets) should include plots grouped in according to the following suggested sets:

Plot 1. Standard Model Higgs production, single Higgs: gg fusion, WW fusion.

Plot 2. Standard Model Higgs production, associated production of single Higgs: WH, ZH, ttbarH.

Plot 3. Standard Model Higgs production, double Higgs processes:

Plot 4. Heavy object production: *W'/Z'*, leptoquarks, excited quarks. Evaluate for the following masses: M = 600, 6000, 60,000, 100,000 GeV/c^2 .

Plot 5. Technicolor processes.

Plot 6. Standard Model processes: ttbar, bbar, total cross section, inclusive W, dijets above 20 GeV, *WW*, *WZ* *Wg*, etc.

Plot 7. MSSM SUSY sparticle processes: gluino pair, MSSM squark pair production.

Plot 8. SUSY sparticle processes for beyond-MSSM models: Inverted Hierarchy Models, SO(10), etc.

Plot 9. SUSY Higgs particle production: Massive A, charged Higgs, etc.

Plot 10. Exotics and Extra Dimensions:

Recall that we would like to correlate every plot with a Rate Spreadsheet, available from Ashutosh.

E-4 Hadron Collider Benchmarks Group

score:REACTION	central calorimetry, central muon, |eta|<2	forward calorimetry, |eta|<4.5	far forward calorimetry, |eta|<6	central muon, |eta|<2	forward muon, |eta|<4.5	far forward muon, |eta|<6	b tagging	superior EM resolution e/gamma	superior jet resolution	electron/photon ID	missing ET	forward tracking |eta|<3	far forward tracking |eta|<5	gamma pointing	
1. STANDARD MODEL															
top physics															
bottom physics															
total cross section															
dijet physics															
inclusive jets															
dibosons															
tribosons															
dilepton final states															
2. HIGGS PHYSICS															
gg fusion															
WW fusion															
tth															
tri-higgs couplings															
di-higgs production															
associated higgs production															
3. BEYOND STANDARD MODEL															
3.1 SUSY															
messenger sector															
inverse hierarchy models															
gluino-pairs															
squarkino pairs															
charged Higgs pairs															
heavy A															
3.2 SUSY HIGGS PRODUCTION															
3.3 TECHNICOLOR:															
rho, eta															
3.4 WW PAIR PRODUCTION															
4 EXOTICS															
compositeness															
extra dimensions															
lepto-quarks															
excited quarks															
heavy 4th generation															
anomalous astrophysics?															