Energy Frontier
Final Words

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CPM for Snowmass
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We have had an exhilarating two days of the workshop.

Thank you to the subgroup convenors.

Thank you to all of you who came to contribute.

The summer of 2013 will be a watershed moment for the study of TeV scale physics:

We will have the full data set (20-30 fb-1) from the 7/8 TeV LHC.

The "Higgs-like particle" may (or may not) become a "Higgs".

New particles beyond the Higgs may be discovered or will be highly constrained.

Important intellectual questions will be on the table:

What do we need to know about the "Higgs" particle ?

What experimental program is needed ?
What can we learn ?

What is the new picture of physics beyond the Standard Model ?

What does this imply for searches ?
Is new physics beyond our reach,
or it is hidden in the current data?
What precision knowledge of the Standard Model
do we need to search effectively, and how can we obtain it?

These physics questions must be answered to address issues of new facilities. And, there are important questions here also.

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1. **In light of circa 2013 results what physics can be achieved before ~2018**

   ...at design specifications with $\int \mathcal{L}\, dt$ ~100 fb^{-1})?

2. **What are the LHC high luminosity physics goals for**

   ..."Phase 1": circa 2022 with $\int \mathcal{L}\, dt$ of approximately 400 fb^{-1}

   ..."Phase 2": circa 2030 with $\int \mathcal{L}\, dt$ of approximately 3000 fb^{-1}

   How do the envisioned upgrade paths inform those goals?

   Specifically, to what extent is precision Higgs Boson physics possible?

3. **Does a Higgs Boson @ ~125 GeV/c^2 call for a "Higgs Factory"?**

4. **What are the physics cases for accelerators beyond 2025?**

   High energy LHC? High energy lepton collider? Lepton-hadron collider? VLHC?

Answering these questions means defining and carrying out many projects.

We spent much time yesterday trying to define them.

Please see the slides collected on the agenda pages.

3. Organize a set of simulation studies to evaluate the level of precision that can be achieved on Higgs physics measurements for the range of choices of accelerator facilities and detector capabilities under consideration by the Facilities/Instrumentation groups. Include studies of search sensitivities for non-minimal Higgs sectors. (This is the main experimental charge.)

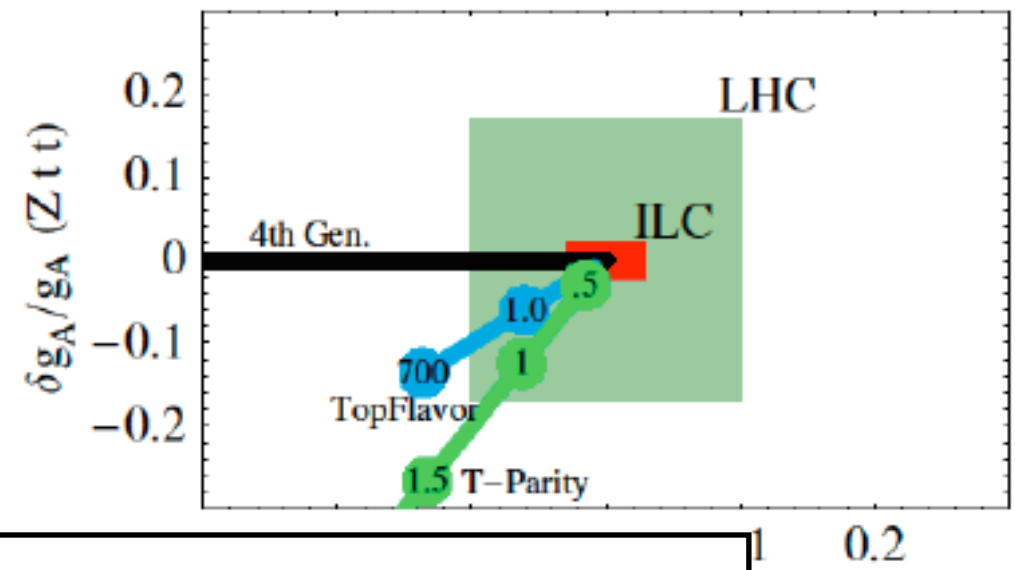
a) To what degree can a particular experimental program ascertain whether the resonance at 125-126 GeV is the Standard Model Higgs boson? To what precision can each of the measured properties of the Higgs boson be determined and tested against SM

- Exception is the PDF uncertainty, where we have not made a dedicated effort to constrain the PDFs within the analysis: current PDF uncertainty is 10 MeV at the Tevatron, total M_w uncertainty is 15 MeV
- We need to address specific PDF degrees of freedom to answer the question:
  - Can we achieve total uncertainty on M_w < 10 MeV at the Tevatron? 5 MeV at the LHC ?

- There may be particles that can be primarily identified in a flavor (or lepton # or baryon #) violating (or at least non trivial) channel
  - classic examples are RPV decays in SUSY or certain flavor gauge bosons - others??

- The top quark mass is a renormalization scheme-dependent quantity. Does this ambiguity have an impact on the measurements of the top quark mass at a hadron collider with the current or ultimate precision?

- Lepton collider: study Ztt and γtt couplings



Question 1b

- Once we have the NLO and NNLO calculations, how do we (experimentalists) use them?
- If a theoretical calculation is done, but it can not be used by any experimentalists, does it make a sound? Or create a citation?

(1) Models & Topics

Discussion Topics

100 TeV

gauge-mediated

5th ED

Little-higgs strong couplings

- Higgs (composite, extra higgs, ...)
- DM
- SUSY
- Naturalness (top partners)
- Dark Sector (Hidden Valley)
- EW (2

	14 TeV (300/fb)	14 TeV (3000/fb)	33 TeV	100 TeV
Exotic Higgs Decays	*	*	*	*
Composite Higgs	*	*		
Dark Matter	*	*		
~~SUSY~~ - α_s		*		
$-\alpha_{EW}$	*			

We will explore these questions at workshops between now and Snowmass.

We expect to have 2 large Energy Frontier workshops, probably in early April and early July, and a theory workshop in early June at the KITP. All of the arrangements are tentative at this moment. We hope to firm them up soon.

Our subgroups will have many smaller working meetings.

The schedule of these meetings will be posted at

http://www.snowmass2013.org/tiki-index.php?page=Energy+Frontier+Study+Workshops

There are many physics issues to chew on, but, beyond this, we need to think about community issues.

The following remarks are personal,

but these are things that are on my mind as I listen to the discussions at this meeting.

There is no US-based energy frontier accelerator on the horizon.

A majority of US high energy experimenters are collaborators on LHC experiments. The LHC has a promising program extending to 2030 and beyond.

The next global energy frontier accelerator may well be a Higgs factory in Japan.

This picture raises two difficult questions:

1. How do we explain our participation in the energy frontier to our departments, to Congress, to the public ?

Are we are shipping money and students abroad to help our competitors make major discoveries ?

or

Are we leveraging large investments made by others so that American students at working at American universities can make central intellectual contributions to the most important problems in science ?

If the second statement is correct, we need to explain and document it, and sell this viewpoint to communities outside HEP.

THE WHITE HOUSE
WASHINGTON

August 8, 2012

Dr. Howard Gordon
Brookhaven National Laboratory
Mail Stop 510A
P.O. Box 5000
Upton, NY 11973-5000

Dr. Gordon:

On behalf of the Obama Administration, I would like to congratulate the US-ATLAS collaboration on the discovery of the Higgs boson. The successful culmination of the long quest for the Higgs boson represents a triumph for fundamental science and paves the way for a deeper und

Dr. Joel N. Butler
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P.O. Box 500
Batavia, IL 60510-5011

Sincerely,

John P. Holdren
Director, Office of Science and Technology Policy

Dr. Butler:

On behalf of the Obama Administration, I would like to congratulate the US-CMS collaboration on the discovery of the Higgs boson. The successful culmination of the long quest for the Higgs boson represents a triumph for fundamental science and paves the way for a deeper understanding of the universe.

2. What is the role of Fermilab in this picture of US HEP ?

Fermilab should be the host of a vibrant US-based program in HEP at the Intensity Frontier.

Fermilab - and the electron X-ray labs - should be custodians of expertise in accelerator physics that benefits the rest of science.

Fermilab, through the LPC, should be the face of US participation in the CMS experiment.

Fermilab should be the face of US participation in a Higgs factory in Japan.

my (controversial) opinion:

All of the above are required for Fermilab to have a secure future.

We have much to talk about in the next year.

We have fascinating intellectual problems in front of us,
and vexing questions about where our community is going.

It is up to us to provide the answers.

It is up to us to provide a narrative that will convince others.

The opportunity is there, but we must grasp it.