Slides for

Round Table on Future Colliders

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The Future starts *Now*: LHC Run 2

LHC Run 2 is just beginning

- **Significant increase in energy: 8 → 13(+) TeV**
- **Increase in instantaneous luminosity and integrated luminosity**
- **→ Significant increase in physics reach compared with Run 1**

- **Run 2 is the start of an extended campaign of progressive enhancements of potential of the LHC.**
- **→ Measurements and discoveries from Run 2, Run 3, and beyond may provide guidance to future directions.**

Building for Discovery: Strategic Plan for U.S. Particle Physics in the Global Context

Report of the Particle Physics Project Prioritization Panel – May 2014

What did P5 have to say about the future, and future colliders in particular?

P5 strategic plan identified 5 interconnected, science "drivers"

- **Use the Higgs boson as a new tool for discovery.**
- **Explore the physics associated with neutrino mass.**
- **Identify the new physics of Dark Matter.**
- **Test the nature of Dark Energy, and probe the physics of the highest energy scales that governed the very early Universe.**
- **Search for new particles and interactions; new physical principles.**

- Explored at Energy Frontier with colliders

P5: Near-term and Mid-term High-energy Colliders

LHC thru HL-LHC

"The enormous physics potential of the LHC should be fully exploited."

"Complete the LHC phase-1 upgrades and continue the strong collaboration in the LHC with the phase-2 (HL-LHC) upgrades of the accelerator and both general-purpose experiments (ATLAS and CMS). …"

"… The LHC upgrades constitute our highest-priority near-term large project."

ILC

"Interest expressed in Japan in hosting the ILC is an exciting development."

- An e+e- collider can provide the next outstanding opportunity [after LHC/HL-LHC] to investigate the properties of the Higgs in detail.
- The ILC is the most mature in its design and readiness for construction.

"Motivated by the strong scientific importance of the ILC and the recent initiative in Japan to host it, …"

"… the U.S. should engage in modest and appropriate levels of ILC accelerator and detector design in areas where the U.S. can contribute critical expertise. Consider higher levels of collaboration if ILC proceeds."

P5: Far-term Future-Generation Accelerators

"The motivation for future-generation accelerators must be the Science Drivers."

"A very high-energy proton-proton collider is the most powerful future tool for direct discovery of new particles and interactions under any scenario of physics results that can be acquired in the P5 time window."

"Participate in global design studies and critical path R&D for future very high-energy proton-proton colliders. Continue to play a leadership role in superconducting magnet technology focused on the dual goals of increasing performance and decreasing costs."

"A multi-TeV *e*+*e*– collider could be based on either the Compact Linear Collider (CLIC) or plasma-based wakefield technology. The wakefield technology would be done as an energy upgrade to the ILC, or located elsewhere."

"Muon colliders can reach higher energies than *e*+*e*– accelerators, but have many technical challenges. Addressing all of the necessary challenges would require a very strong physics motivation based on results from ongoing or future accelerators."

"Pursue accelerator R&D with high priority at levels consistent with budget constraints. Align the present R&D program with the P5 priorities and long-term vision, with an appropriate balance among general R&D, directed R&D, and accelerator test facilities and among short-, medium-, and long-term efforts. Focus on outcomes and capabilities that will dramatically improve cost effectiveness for mid-term and far-term accelerators."

A Simplified Picture of Possible Future HEP Facilities*

	HADRON COLLIDERS	LEPTON COLLIDERS	INTENSITY FRONTIER
CURRENT PROGRAM			
	HL-LHC	**ILC**	**PIP-II**
NEXT STEPS			
	Very high-E p-p collider	**~1 TeV ILC upgrade***	**Multi-MW proton beam**
POSSIBLE FURTHER FUTURE	* dependent upon how physics unfolds		
		Multi-TeV lepton collider*	**Neutrino factory***

* Used by the HEPAP Accelerator R&D Subpanel

Some Personal Remarks

"A very high-energy proton-proton collider is the most powerful future tool for direct discovery of new particles and interactions under any scenario of physics results that can be acquired in the P5 time window."

The need to develop this tool is important and immediate.

- **Addressing the tremendous challenges must start now.**

Challenges are formidable:

1. **Required technical performance must be achieved at affordable cost.**
   - **Particularly, high field superconducting dipole magnets**
   - **Those that solve the technical challenges will enable future discoveries.**
2. **Adequate resources, financial & technical expertise, must be gathered.**
   - **Support will be needed from science community and decision makers**
   - **Scale of project will draw on international community, if not for resources, then for technical expertise.**
   - **Articulating the motivation:**

Exploration + Higgs as a tool for discovery

The case is richer than this, but simply stated, this is enough.

Begin now: Tackle high-priority R&D; Establish critical accel. parameters; Articulate the scientific motivation.

END