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Accelerator & Underground Capabilities for High Energy Physics

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Accelerator Capabilities

What are long term "big questions" regarding accelerator-based HEP capabilities

- How can one build a collider at the 10 - 30 TeV constituent mass scale?
- What is the farthest practical energy reach of accelerator-based high-energy physics?
- How would one generate 10 MW or more of proton beam power?
- Can multi-megawatt targets survive and if so, for how long?
- Can plasma-based accelerators achieve energies & luminosities relevant to high-energy physics?
- Can accelerators be made 10x cheaper per GeV? or per MW?

These are issues for the long term future

Areas of inquiry included specific questions

Energy Frontier

- ❖How high a luminosity is possible for the LHC?
  - ➢ How high an energy is possible in the LHC tunnel?
  - ➢ Could a Higgs factory be built in the LHC tunnel?

- ❖Can ILC and CLIC designs be improved using new technologies?

- ❖Can one design a multi-TeV μ+μ- collider?

Areas of inquiry included specific questions (cont'd)

Intensity Frontier:

- What secondary beams are needed for Intensity Frontier experiments?
  - What proton beams are needed to generate these secondary beams,
  - Can these be made by existing machines?
- What accelerator capabilities at heavy flavor factories are required to realize the full range of physics opportunities?
- What are new physics opportunities using high power electron & positron beams?

Accelerator test facilities

- What is broad range of test capabilities existing or needed for developing accelerator capabilities

Summary conclusions – Energy Frontier

- To *maximize exploration* of the Energy Frontier, *full exploitation of the LHC* is the highest priority of the hadron-collider program
  - With renewed interest in a ~100 TeV scale collider, we recommend participation in the CERN-led international study
- As described in its Technical Design Report (TDR), the ILC is technically ready to proceed to construction
  - An experienced cadre of U.S. accelerator physicists &engineers is capable and ready to work on ILC
- Vigorous, integrated U.S. research toward demonstrating feasibility of a muon collider is highly desirable.
  - The current funding level is inadequate to assure timely progress.

Summary conclusions – Intensity Frontier

- Next generation Intensity Frontier experiments require beam intensities & timing structures beyond capabilities of any existing accelerator

- Fermilab's proposed, multi-stage Project X would yield a world-leading capability
  - Could serve multiple experiments over an energy range 0.25 – 120 GeV

- DAEδALUS / IsoDAR– Decay At Rest short baseline, anti-neutrino experiments based high power cyclotrons
  - Strong industrial & international laboratory connections

Intensity Frontier using electron beams

- Relevant technologies of super flavor-factories exploit strong synergy with light sources & damping rings for lepton colliders
  - Continuing U.S. involvement would maximize physics opportunities

- All electron-ion colliders studied recently would be based at an existing accelerator lab with center-of-momentum energies range from 14 GeV to 2000 GeV
  - Recirculating, energy recovery linacs (ERLs) are a key technology

Cross-cutting frontier-accelerator issues

- Understanding & controlling beam loss is a major challenge for frontier accelerators
- Superconducting RF technology – Most modern high power proton facilities rely superconducting radio frequency (SRF) acceleration
  - Needs optimization for medium gradient, CW operation
- Isochronous ring cyclotrons are also good candidates for high continuous (CW) power at energy < 1 GeV
- Sustained, focused research into high-power (> 1 MW) target technology is essential to frontier accelerators
  - Conduct R&D in the context of a broad international collaboration of interested laboratories

Long range accelerator research

- ❖ Innovations in acceleration & beam transport techniques such as plasma and dielectric wakefield acceleration have significant potential to reduce the size of future facilities
- ❖ Long-term research including fundamental accelerator and beam physics theory & simulation will expand the technical options for any future accelerator-based facility
  - ➢ Personal option: this area is often underfunded in preference to project related research
- ❖ Focused engineering development is *no substitute* for innovative R&D.

Underground Detector Capabilities

On behalf of Gil Gilchriese

Relevance of underground capabilities

- Underground facilities/capabilities are essential for support of the world-wide experimental program
    - Direct dark matter experiments
    - Neutrinoless, double-beta decay ($0\nu\beta\beta$) experiments
    - Atmospheric, reactor, solar, supernova neutrino experiments
    - Proton decay
    - Connections to astrophysics, nuclear and earth science, & detectors for non-proliferation
- Roughly 1,000 US scientists now participate in underground experiments
    - Includes US-led Antarctica effort)
- May grow by 30 – 50% over next decade

Existing/Planned Facilities

- No technical showstoppers to create underground/ice space for planned activities for next 10-20 years
- World-wide "general purpose" space is expected to about double by end of decade
  - Assumes anticipated expansion in non-US underground capabilities
- Significant non-US underground capabilities for specific neutrino experiments is planned
- Plans for expansion of underground facilities in the United States are less developed.
  - Currently, there are no approved plans with federal funding for significant expansion of underground capabilities in the U.S.

Key goals for the U.S. planning process

- It is critical that US scientists continue to be supported to take advantage of future international & domestic underground facilities
- Put LBNE underground to realize its full science potential!
  - Makes it an anchor of possible future domestic underground capabilities at SURF
- Maintain leading U.S. roles in many of the future dark matter, *0*ΩΩΩ & a large variety of Ω experiments.
  - Improved coordination and planning of underground facilities (overseas & domestic) is required to maintain this leading role, including the use of US infrastructure
  - Maintaining an underground facility that can be expanded to house the largest dark matter and $0\nu\beta\beta$ experiments would guarantee a strong US to role in world-wide program of underground physics

Thank you

Questions?