Accelerator Facilities Subgroup Report

S. Holmes, for the Accelerator Facilities Group

Fermilab Steering Committee
July 9-10, 2007

Outline

- Review of Facilities Considered
- ILC Activities and Plan at Fermilab and ILC Scenarios
- Facilities for Neutrino and Precision Measurement Physics

Facilities Considered

- Criteria for consideration:
  - Alignment with the ILC R&D program
  - Effective utilization of accelerator assets freed after the end of Run II
  - Alignment with the goals of the physics WGs
  - Realizable over the next 5-10 years
  - (Colliders with capabilities beyond ILC considered in WG 5)
- Information associated with each potential facility
  - Brief description/basics of operation
  - Anticipated performance parameters
  - Anticipated cost range (<$100M, $100M – $0.5B, >$0.5B)
  - Critical R&D issues that need to be resolved before construction
  - Estimated construction duration
  - Potential synergies and/or conflicts with ILC and other programs
- 14 Facilities considered

Facilities Considered

NAL Steering Group : Synoptic Table of Facilities Considered (06/11/07)

Facility	Description	Beam Parameters	Cost Time Operations	Reference Presentatio
6 GeV ILC Linac	ILC Linac Test Facility		Medium Med ?	
High Intensity Proton Sources	Convert from 6 GeV ILC Test Linac to 8 GeV Proton Linac. Couple with an upgraded Main Injector	120 GeV, 2MW proton sources	Large Med ?	Presentatio
ILC Damping Ring Test Facility	Use the Tevatron tunnel for ILC Damping Ring test facility		Medium Med ?	Presentatio
Super B Factory	Asymmetric e+e- collider Synergy to ILC Damping Ring	Y(4S) (7 on 4GeV) $L > 10^{36}$ cm^{-2} s^{-1}	Large Long Large	Presentatio
Giga-Z	Use ILC technology Stepping stone toward ILC		Large Long Large	
LHC Luminosity Upgrade	Manget upgrade (130 mm NbTi quads) Injector upgrade	x10 higher luminosity	Medium Large -	Presentatio
Proton sources by Reconfiguring FNAL collider complex	Accumulator as a momentum stacker Recycler as a box car stacker Debuncher as an 8 GeV slow spiller, Tevatron as a 120 GeV slow spill strecher	120GeV 0.7-1.2MW, 8GeV slow/fast spill ($4.6x10^{16}$/hr), 120GeV slow spill ($5x10^{12}$/sec)	Small Near Medium	Presentatio
Proton sources with New Booster + 1 GeV Linac			Medium Med ?	Presentation

Facility	Description	Beam Parameters	Cost Time Operations	References Presentations	Physics
Double, 480 GeV, Fast Cycling Proton Accelerator	120 GeV protons from MI → Tevatron → accelerate in double aperture fast cycling SuperFerric (VLHC like) magnet synchrotron	10 MW ‖ of MI cycle rate	Large Long Medium	FNAL-TM-06-192 Presentation	CP Violation in Neutrino
1 TeV protons from the Tevatron	Continued operations of the Tevatron	5×10^{19} protons per year	Small Near Large	Presentation Proposal	Precision EWK Meas.s
Antiproton Sources	Continued operations of the Pbar source for antiproton production and storage. May require 1-2 additional rings for internal target experiments and deceleration/extraction to traps.		Small Near Small?	Presentation Letter of Intent	Hyperon CPV, Charm and Charmonium
Tevatron B physics	CDF/DZero experiments focused on B Physics		Small Near Large		Precision / Rare B meas.s
Beta-beams	Production of (anti-)neutrino beams from beta decay of radio-active ions circulating in a storage ring. Similar concpet to neutrino factory - beta-active isotopes instead of muons		Large Long Large	Presentation Study group	CP Violation in Neutrino
Muon Colling Facility	Engineering test and R&D facility to demonstrate advanced technology for the muon Collider		Small Med ?	Presentation	-
Colliders beyond ILC/LHC	Muon colliders VLHC	1-4 TeV mu+mu- colliders, 40-200 TeV proton-proton colliders	Large Long Large	Presentation	Direct searches for New Physics beyond ILC / LHC Scale

For each facility :

1. Brief description/basics of operation
2. Anticipated performance parameters
3. Anticipated cost range (<$100M, $100M – $0.5B, >$0.5B)
4. Critical R&D issues that need to be resolved before construction
5. Estimated construction duration
6. Potential synergies with other programs
7. References (when available)

ILC Scenarios

- Scenarios 1-3: ILC built in the US
  - Scenario 1: GDE baseline – Decision in 2010, 2012 construction start
  - Scenario 2: GDE baseline + 2 years
  - Scenario 3: GDE baseline + 5 years
- Scenario 4: ILC built outside US
- Scenario 5: LHC says we need > 800 GeV

We will know in ~2010 if we are in Scenario 1.

Difficulty will come in identifying which scenario we are in if not Scenario 1.

ILC Activities at Fermilab
(Accelerator, all scenarios)

- Technology R&D
  - NML test facility leading to single rf unit test (3 cryomodules)
    - 2010: Technology demonstration
  - US industrialization
    - 2012-2013: Capability of 25 cryomodules/year
    - Potential synergy with Project X
  - Beam dynamics investigation using a 6 GeV linac and damping ring
    - 2013-2015?: B-Factory synergy?
- Site development
  - Site characterizations
  - Site specific designs
  - Public outreach & involvement
- Engineering Design Report
  - US leadership with significant engineering investment

ILC Facilities at Fermilab
6 GeV ILC Linac

- 1% (5-7 GeV) ILC demonstration facility. Consists of:
  - ILC-type electron source (RF photo gun, 50 MeV photoinjector);
  - Main linac in ILC dual-tunnel with ILC type cryomodules (20-28 total) and RF systems;
  - ILC RF distribution supporting 9mA x 1msec x 5 Hz (225 – 315 kW)
  - Beam diagnostics and beam dump.
- Cost range: medium $100-$500M
- Critical R&D needed: reliable demonstration of the ILC design gradient and 90% cavity production yield
- Estimated construction duration : 3-5 years
- Potential synergies : a)ILC DR R&D facility; b)Neutrino research program based on H^- acceleration; c)Muon source;
- References : ILC RDR; D.McGinnis SG4 talk; S.Geer SG5 talk

ILC Facilities at Fermilab
ILC Damping Ring

- Full scale ILC DR R&D facility. Consists of:
  - 5 GeV e- linac (injector)
  - 5 GeV DC low-emittance DR in Tevatron tunnel, capable of providing ILC DR bunch structure and emittance parameters;
  - Low-energy beam transport (LEBT) from DR to 5 GeV linac for emittance preservation and diagnostics studies in ILC linac;
  - Beam diagnostics and beam dump;
  - Positron production target desireable (for e-cloud studies).
- Cost range: medium $100 – 500M
- Critical R&D needed: e-cloud suppression methods (to decide on beam pipe in case of e+ operation)
- Estimated construction duration : 3-5 years
- Potential synergies : Super-B factory
- References: L.Emery talk at SG ; M.Church ILC-docDB-252, 254

LHC Activities at Fermilab
(Accelerator, all scenarios)

- LHC Accelerator Research Program (LARP)
  - Development/demonstration of magnet technology (Nb_3Sn) that could be used for an LHC luminosity upgrade
  - Participation/assistance in LHC commissioning
- LHC Upgrades
  - Potential opportunities:
    - Fabrication of high performance (Nb_3Sn) IR quadrupoles
    - Collimators
    - Crab Cavities
    - Beam-beam compensation (TEL or wires)
  - Possible synergies between SPL and Project X
    - SC linac: 4 GeV x 20 mA x 2 Hz
    - 700 MHz rf system

Facilities for Neutrino and Precision Measurement Physics

- SNuMI (Scenario 1 and 2)
  - Upgrade to 1.3 MW of proton beam power at 120 GeV based on utilization of the Accumulator for proton momentum stacking.
  - Modest beam power can diverted at 8 GeV at expense of the 120 GeV program.
- Project X (Scenario 3, 4, and 5?)
  - Construction of a 8 GeV superconducting H- linac supporting simultaneous delivery of 2.3 MW at 120 GeV and 200 kW at 8 GeV
  - Detailed discussion from Dave
- Tevatron Facilities for Near-Mid Term Program (Scenario 1, 2, and 3)
  - Tevatron based 120 GeV stretcher ring
  - Tevatron based 800 GeV high intensity beam
- Facilities for Long term Program (Scenario 4, 5)
  - Presentation from Group 5

Facilities for Neutrino and Precision Measurement Physics: SNuMI

- Availability of 1.2 MW beam power at 120 GeV, modest beam power at 8 GeV (~12E20 protons/year).
  - Accumulator serves as a momentum stacker, Recycler as a box car stacker Debuncher as an 8 GeV slow spiller.
  - 18 Booster batches per load => 8E13 ppp, 1.33 second cycle time.
- Cost range: Medium $100-500M
- R&D needed: a) resonant extraction from the Debuncher; b) space charge, electron cloud, instabilities, transition loss limitations in AA, RR, MI; c) loss control/collimation in all machines
- Estimated construction duration : 2-3 years
- Potential synergies : Tevatron 120 GeV slow spiller
- References : D.McGinnis talk at SG

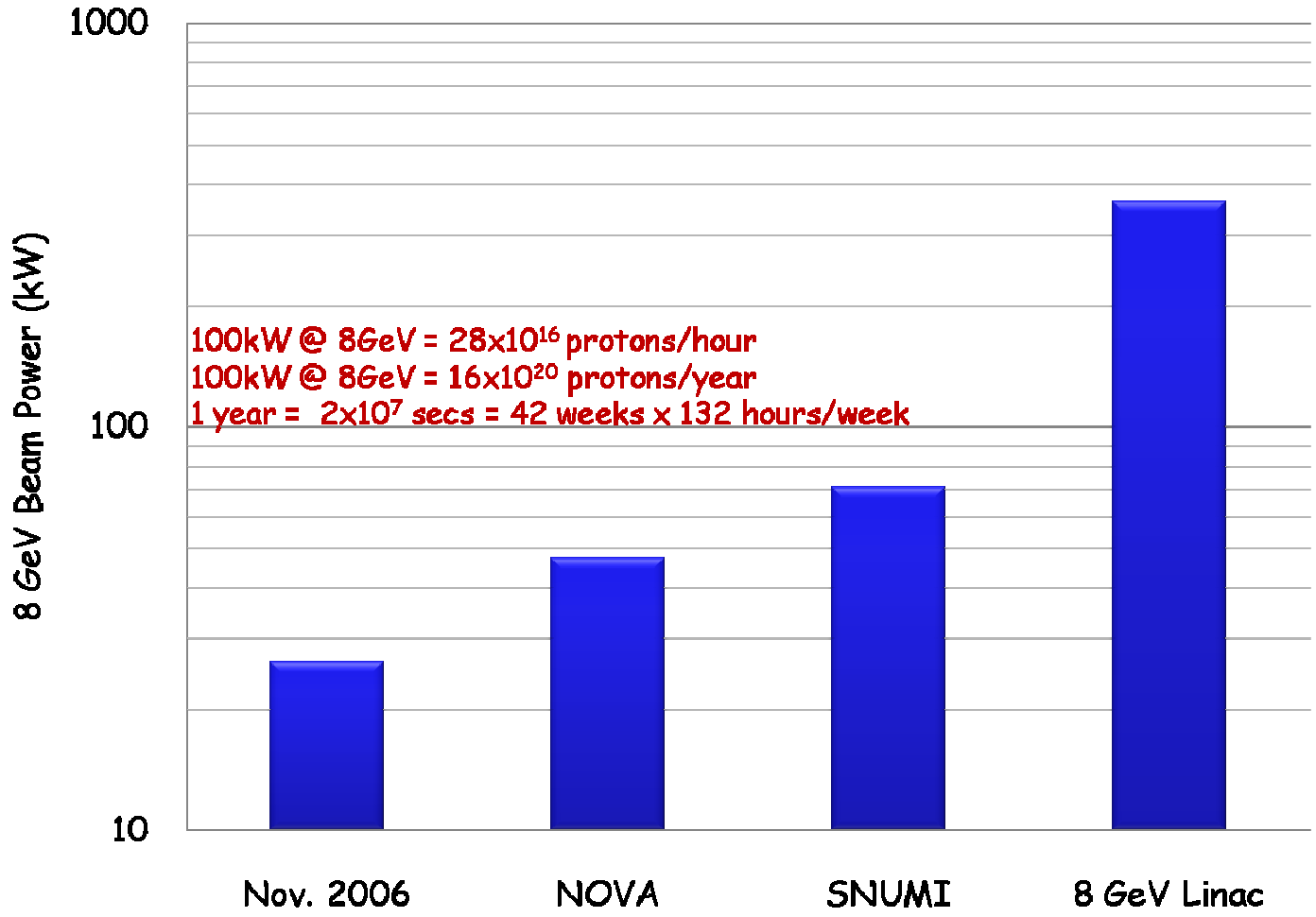
Facilities for Neutrino and Precision Measurement Physics: 120 GeV spiller

- High duty factor 120 GeV slow spill (~4E19 protons/year)
  - Tevatron configured for 120 GeV slow spill/stretcher ring 7.5E13 protons per spill, every 60 seconds
  - 95% duty factor
  - Competes (at 5% level) for protons from the SNuMI program
- Cost range: small <$100M
- Critical R&D needed: a)new Tevatron resonant extraction; b)beam stability; c)loss control and collimation
- Estimated construction duration : 1-2 years
- Potential synergies : SNuMI
- References : M.Syphers beams-doc-2222

Facilities for Neutrino and Precision Measurement Physics: 800 GeV Fixed Target

- High intensity 800 GeV Fixed Target (~4E19 protons/year)
  - Tevatron configured for 7.5E13 protons per spill
  - Cycle time ~40 seconds with < 1 second spill
  - Competes (modestly) for protons from the neutrino program
- Cost range: small <$100M?
- Critical R&D needed: a)Tevatron fast extraction scheme; b)beam stability; c)loss control and collimation; d)recommissioning plan for C0 abort; e)reliability analysis, in particular the magnets (experience is ~1 magnet failure/250K ramps)
- Estimated construction duration : 1-2 years
- Potential synergies : SNuMI
- References : M.Syphers beams-doc-2222

Proton Flux


1000
100
10
8 GeV Beam Power (kW)
100kW @ 8GeV = 28x10^16 protons/hour
100kW @ 8GeV = 16x10^20 protons/year
1 year = 2x10^7 secs = 42 weeks x 132 hours/week
Nov. 2006
NOVA
SNUMI
8 GeV Linac