Proton Driver Status Report

G. W. Foster
Fermilab UEC

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8 GeV Superconducting Linac

• New idea incorporating concepts from both the Spallation Neutron Source (SNS) and TESLA.
  – Copy SNS Linac design up to 1.3 GeV
  – Use “TESLA” Cryomodules from 1.3 - 8 GeV
  – H⁻ Injection at 8 GeV in Main Injector

==> “Super-Beams” in Fermilab Main Injector:
  – 2 MW Beam power at BOTH 8 GeV and 120 GeV
  – Small emittances ==> Small losses in Main Injector
  – Minimum (1.5 sec) cycle time
  – MI Beam Power Independent of Beam Energy

  ==> (flexible neutrino program)
8 GeV Superconducting Linac
With X-Ray FEL, 8 GeV Neutrino & Spallation Sources, LC and Neutrino Factory

- Neutrino “Super-Beams”
- Main Injector @2 MW
- Short Baseline Detector Array
- 8 GeV neutrino
- Off-Axis Anti-Proton
- SY-120 Fixed-Target
- Damping Rings for TESLA @ FNAL With 8 GeV e+ Preacc.

8 GeV Linac
~ 700m Active Length
1% LC Systems Test
Recirculating Linac for Neutrino Factory

Neutrino Target & Long-Pulse Spallation Source?

X-RAY FEL LAB

Target and Muon Cooling Channel
Bunching Ring

8 GeV Linac

VLHC at Fermilab

Fermi National Accelerator Laboratory
8 GeV SC Linac Proton Driver

• A Bridge Program to the Linear Collider
• Near Term Physics Program (neutrinos+)
• Multiple HEP Destinations & Off-Ramps
• A seed project for Industrial Participation

50 cryomodules, 12 RF stations, ~1.5% of LC
Recent Developments

- 1st Round of Proton Driver Design Studies Completed ~2003
- PD Recommendation by FNAL Long-Range Planning Committee
- New Design Iteration Started
  - Goal: CD-0 Documentation by End of ’04
  - Both Synchrotron and SCRF Linac (emphasized)
- ITRP Cold Technology Selection
  - FNAL Director’s Statement favoring SCRF Linac Option
- APS Neutrino Study Boosts Case for Proton Driver
- Physics Workshop for Proton Driver Successful & Well Attended
- DoE Request for Near Term CD-0 Candidates
- SMTF Collaboration EoI: PD – ILC Synergy; DoE Briefing

FNAL’s New Director will find PD ready for a “GO” decision
Proton Driver Charge (machine)

- Goal: CD-0 Documentation by End of ’04

- Both Synchrotron and SCRF Linac (emphasized)
  - Common Performance Specs and Cost Basis
    (synchrotron “cost advantage” ~ disappears with apples-to-apples comparison)

- External Review of Accelerator Physics

- Investigation of Outside Collaboration
PD Work in Progress ...

• Weekly meetings in specific technical areas (four + cost)
• Visits from experts & workshops
• Prototypes of key components
• Develop Collaborations
Linac Technical Strategy

• TESLA compatible frequency chosen
  – Prototypes & vendors exist for 7/8 of linac
  – Complete overlap with LC test facility

• Staging Stand-Alone Linac Beam Power
  – Cut Klystron count from 42 → 12
  – Preserve 2 MW beam power in MI

• Adopt “Pulsed RIA” SCRF front end
Cost Driver: Klystrons per GeV

Spallation Neutron Source: 96
FNAL Linac Upgrade: 20
X-Band (warm) NLC: 8.13
8 GeV Linac (2 MW): 5
8 GeV Linac (0.5 MW): 1.5
TESLA: 1.1

Klystrons Per GeV Beam Energy
Proton Driver Linac Parts

1. MAIN “TESLA” LINAC (1-8 GeV)
   ~ Exact copy of TESLA, 1.5% of LC

2. Beta<1 “Squeezed TESLA” Linac
   ~ “SNS” SCRF linac at f = 1300 MHz

3. “Pulsed RIA” Front End Linac
   ~ spoke SCRF cavities at 325 MHz

4. H- Source & RF Quad
   ~ Copy of JPARC 325 MHz front end
0.5 MW with TESLA Frequencies & SCRF F.E.

"Pulsed RIA"
SCRF Linac
325 MHz
0 - 120 MeV

"Squeezed TESLA"
Superconducting Linac
1300 MHz
0.087 - 1.2 GeV

"TESLA" LINAC
1300 MHz, Beta = 1
8 Klystrons
COLLABORATION

• Will be key to the success of
  – the SCRF Proton Driver
  – the ILC test facility

… and can speed up both if they are the same project.
Proton Driver Linac - Technology Flow

JHF (KEK)  RIA (ANL)  SNS (JLAB)  FNAL ANL / SNS

325 MHz RFQ and Klystron
SCRF Spoke Cavities
Linac Accel. Physics
SNS Production Experience
β < 1 Cavity Design
Fast Ferrite Shifters
Pulsed Modulators

325 MHz RFQ and Klystron

“PULSED RIA”

SNS / RIA
Beta < 1
Elliptical Cavity Linac

“SNS / RIA”

Elliptical Cavity SCRF Linac
Beta = 1
1300 MHz

New FNAL Proton Source
Linear Collider Test Facility

PROTON DRIVER

Main Injector @2 MW

FNAL Proton Plan Upgrades
8 GeV beams: P, n, v, μ, e...
Technological & HEP Applications

Beam Transport and Collimation Design

NUMI Beamline & Infrastructure

Neutrino Super-beams

Other Labs & Universities
JHF 325 MHz RFQ and Klystrons for TESLA-Compatible* Front End

JHF 325 MHz RF Quad

* TESLA frequency = 1300 MHz
  = 4*325 MHz

JHF 325 MHz
3 MW Klystron

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Single- and double-spoke resonator

LANL (APT)

Figure 1: Los Alamos-built 350 MHz, $\beta=0.175$, single-spoke niobium cavity

ANL (RIA)

Figure 5: A 345 MHz, double-spoke, three-gap cavity for $\beta=0.4$. A niobium prototype has been built and tested at Argonne National Laboratory
End-to-End Beam Physics of TESLA-Compatible Linac (P. Ostroumov, ANL)

Graphs showing beam size and RMS emittance growth factor as a function of distance.
8 GeV Superconducting Linac
TECHNICAL SUBSYSTEM DESIGNS EXIST AND WORK

SNS Cavity Fabrication
- Deep drawing & machining
- Dumb-bells
- Frequency adjust
- Welding
- SNS $\beta=0.61$
- Tuning

SNS Cavities (JLAB)

FNAL/TTF Modulators

“TTF Style” Cryomodules

805 MHz RF Distribution in Tunnel
- RF DISTRIBUTION FOR ONE 805 MHz CRYOMODULE
- (12 total)
- WAVEGUIDE TUNER OPTION

TESLA RF Distribution
* w/ phase shifters

Civil Const. Based on FMI

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Advanced RF Distribution
(Coaxial Phase Shifter Option)

RF FROM KLYSTRON

DIRECTIONAL COUPLER (POWER SPLIT)

CIRCULATOR AND LOAD

MAGIC TEE AND CAVITY RF POWER COUPLER

COAXIAL FERRITE STUB TUNER AND WAVEGUIDE TRANSITION

YET!
THE NEXT STEP

• There is a 100% overlap in the plans for the next step of the SCRF Proton Driver and the SCRF Linear Collider:
  
  **Set up 1 GeV of TESLA linac**
  
  – At Fermilab
  
  – With as many US-built components as possible
Multi-Lab Collaboration on SRF Development
Over a Broad Range of Applications

US Institutions involved in Discussions:

- Argonne National Laboratory (ANL)
- Brookhaven National Laboratory (BNL)
- Cornell University
- Fermilab
- Jefferson Laboratory (JLAB)
- Lawrence Berkeley National Laboratory (LBNL)
- Los Alamos National Laboratory (LANL)
- MIT-Bates Laboratory
- National Superconducting Cyclotron Laboratory (MSU)
- SLAC
- Oak Ridge National Laboratory/(SNS)
- Northern Illinois University (NIU)
- U. of Pennsylvania (Penn)

- International: KEK, DESY, INFN, Tesla Collaboration...discussions
Four Research Areas of SMTF

FNAL Meson Area SM&TF Layout Concept

- Proton Driver & RIA Linac Test
- 1.3 GHz Cryomodule Test
- CW Test
- A0 Photoinjector & Beam Tests
- Connection to Meson Area Cryo Plant

150 Meters
Three Phases of ILC Beam Line

1.3 GHz Cryomodule Test Facility

1a) 

1b) 

2) 

3) 

FY05-06

FY06-07

FY07-08
Proton Driver Linac at SMTF

325 MHz Klystron – Toshiba E3740A (JPARC)

115kV Pulse Transformer
Modulator Capacitor / Switch / Bouncer
Charging Supply

RFQ
MEBT
RF Distribution Waveguide

SCRF Spoke Resonator Cryomodules

Ferrite Tuners

Single Klystron Feeds SCRF Linac to E > 100 MeV
ILC – PD Synergy Examples

• The ILC is becoming interested in:
  – Proton Driver’s Fast Phase Shifters as a way to reduce electrical costs
    (… see RF talks at SLAC ILC Workshop)
  – Proton Driver’s Long-pulse (3 msec) modulators as an approach to cost savings (… drops Klystron Count)

➢ Bidirectional technology flow!
Proton Driver Strategic Plan

• The CD-0 Documentation for the Proton Driver will be complete in early 2005

• The current allocation of resources (for either ILC or PD) is insufficient for a reasonable start to SMTF.

• The next director must establish the priority for Proton Driver & SMTF