1. **NAME OF INITIATIVE:** Fermilab Proton Driver/SCRF Linac
Fermilab Proton Driver (Superconducting Linac Preferred Option)

List of major collaborating institutions (including non-US partners).

A. No collaboration has yet formed as this is an unapproved project. However, the R&D program and subsequent construction is expected to be carried out in collaboration with the nascent U.S. SMTF Collaboration. Interested parties include ANL, BNL, Cornell University, JLab, LANL, LBNL, MIT, MSU, and ORNL.
B. Members of TESLA X-FEL collaboration, including DESY, INFN, also have common interests.
C. In the event the ITRP recommendation is for a cold linear collider we expect close collaboration with participants in the major systems engineering test for the International Linear Collider.
D. Potential exists for collaboration with institutions in Europe, India and China interested in cloning the technical design of the Proton Driver linac for their indigenous Spallation Neutron Source and Linac-Driven Transmutation projects.

2. SCIENTIFIC JUSTIFICATION:

Physics goals. How does it fit into the global physics goals for the entire field.

A. Particle Physics goals:

1. *Neutrino physics.* A full exploration of the neutrino sector will require both super beams and next-generation detectors. While the exact details of the experimental detectors will be motivated by results of ongoing experiments, the need for a Proton Driver is already clear. The long lead times for accelerator-based initiatives argues for an expeditious start.
   Concepts for both synchrotron and superconducting linac based Proton Drivers are being explored. However, the SCRF linac is preferred as, when coupled with the existing Fermilab Main Injector, it offers the unique advantage of flexibility in the ability to deliver the maximum (2 MW) beam power at a variety of beam energies from 8 GeV to 120 GeV. This permits a flexible neutrino program that can evolve in response to upcoming discoveries, and eliminates the risk of investing in a proton driver at the “wrong energy”.
2. *Enhancement of the broad-based physics program at Fermilab.* This potentially includes intense kaon and muon beams, antiproton experiments, and classical fixed-target experiments at the Main Injector. In the longer term, the Linac Proton Driver could drive a neutrino factory or eventually a muon collider. Ultra-low emittance beams provided by the linac would eventually reduce the cost and increase the performance of a next-generation hadron collider sited at Fermilab. Other possible applications include a pulsed neutron source or free-electron laser for materials research.
3. *Linear Collider Synergy.* Most (7 GeV out of 8 GeV) of the Proton driver linac is technically identical to the TESLA main linac for the linear collider. In the event of a cold technology recommendation the Proton Driver provides simultaneously a cutting edge high energy physics program and a technology development program that could provide the technical foundation for a US bid to host the linear collider.

B. Accelerator Physics Goals

1. *Applying the Low-Cost TESLA Design to a Proton Linac.* Successful application of the cost breakthroughs of the TESLA design to a proton linac will change the way proton accelerators are built, increase their performance, simplify their operation, and reduce running costs.
2. *Fermilab Proton Source longevity*. Numerous reliability and lifetime concerns have been identified for Fermilab's proton source. The existing Linac and Booster will require significant investment and refurbishment simply to keep them functional over the next decade. An all-new proton driver is a superior alternative.
3. *Provide a focus for future beam physics excellence at Fermilab.* During the last two decades while Fermilab has been carrying the baton for operations at the world's highest energy accelerator, it is evident that FNAL's commitment to accelerator R&D has suffered. The variety of beam types and potential applications based on the SCRF Linac Proton Driver should help change this.

C. How does it fit into the global physics goals for the entire field?

The neutrino super beams program has, in principle, competition from both Europe and Japan. European competition suffers from the financial strain of the LHC and is unlikely to mount a credible challenge to a timely program of neutrino super beams in the U.S. The Japanese JPARC program is already in construction with a MW class proton source. Its neutrino program is limited by a number of factors. The drive beam for neutrino production is shared between neutron spallation, transmutation, and other projects. Site limitations make it difficult to mount a long-baseline program. Finally, the historical choice of IMB-style Water Cherenkov detectors popular in Japan limits the range of neutrino physics accessible.

3. VALIDATIONS FOR SCIENTIFIC JUSTIFICATION:

Examples of recommendations and supporting statements from the committees, panels, and the community at large.

a. Fermilab Long-Range Planning Committee (FLRPC) recommended this as Fermilab's next near-term accelerator project.
b. Neutrino Super Beam Facility is element of the Office of Science 20-year plan.
c. Enthusiastic reactions at closeout of FNAL's 2004 DoE Annual Program Review and Accelerator Advisory Committee.
d. APS Neutrino Study will recommend construction of US super beam facility.

4. DESIRED SCHEDULE:

List major milestones (month & year) such as design complete, construction start, construction complete, etc.

1/04 Design Study completed http://tdserver1.fnal.gov/project/8gevlinac/DesignStudy
8/04 APS Neutrino Study recognizes need for Proton Driver
10/04 Critical R&D (Ferrite Phase Shifter) full power tests succeed
1/05 Documentation complete for CD-0 ; initiate conceptual design
5/05 CD-1 Review
10/06 Construction Start
1/12 First Beam

5. ROUGH ESTIMATE OF COST RANGES:

Whatever the best information available (e.g. $M +/-30~50%, $150~250M, etc.). Total cost range including non-DOE funding (if any other funding sources are assumed and if known, state from where and how much. Also indicate remaining R&D cost to go.

Design Study estimates: $370M for bare H- Linac with 2 MW stand-alone beam power, and $250M for synchrotron with 0.5 MW stand-alone beam power. Next design iteration will have both machines at same (0.5 MW) beam. Both options support 2 MW operations of the Main Injector.

Not included are Main Injector upgrades needed to support 2 MW. These are expected to be in the range of $30M-$50M. These may be partially paid for as part of the ~$30M "proton plan" to support higher intensity operations in the near term.

Also not included are Detector and Beamline upgrades for 2 MW operation. One could chose to either: a) bundle these as part of the Proton Driver project; or b) to deliver a "clean" accelerator project and a separate detector project as was done for the Main Injector & NUMI/MINOS.

The total cost range, factoring in the scope uncertainties for the detectors, beamline, and scope of the proton plan, is $300M-$700M.

External Funding Possibilities:

The major plausible source of external support is the Linear Collider collaboration. If the Proton Driver becomes formally merged with the Engineering Test Facility for the ILC, then in-kind contributions (in the form of TESLA cryomodules, RF systems, etc) would directly defray proton driver costs. As an optimistic case, if 1/3 of the cryomodules & RF systems for the PD/ETF were contributed from each region, this would defray ~40% of the cost of the SCRF Proton Driver.

A second plausible source of come from in-kind contributions from potential collaborators in India and China who are specifically interested in cloning the multi-mission SCRF linac as a means of bootstrapping accelerator technology in their region. Most of the technical components are within their current technical capabilities, and discussions are beginning.

Indicate remaining R&D costs

Strictly speaking, very small "Research" costs are needed in the sense that commercial vendors (mostly European) exist for all technical components of the 8 GeV linac. If necessary, orders for all technical components could be placed today by duplicating existing components. An exception to this are the fast-ferrite phase shifters, with R&D completion expected by the end of CY'04.

"Development" costs targeting linac cost reduction are given in the next section. This is mainly a program of production prototypes which will reduce technical contingency needed for the project. A Proton-Driver specific development budget of $5M/year, in conjunction with an aggressive SMTF program costing a similar amount, could complete the development in 2-3 years.

6. DESIRED NEAR TERM R&D:

Major activities needed to be completed before start construction.

A. Set up and operate one TESLA RF Station (four cryomodules). This prototypes the main β=1 section of the Proton Driver linac. This program is shared completely with the SMTF/TESLA/ILC (cold) program.
   a. One RF station represents 10% of the 8 GeV linac.
   b. Goal is to produce cryomodules at few × the projected cost for TESLA volume production.

B. Prototype and test a "TESLA-compatible" β =0.8 cryomodule.
   a. This prototypes most of the remaining 1 GeV of the 8 GeV linac.

C. Feasibility test of Superconducting front-end linac (3 MeV < E < 100 MeV)
   a. Not critical since copper alternative exists (~$10M more expensive)
   b. RFQ from KEK, spoke resonators from RIA, potential collaboration.
   c. Demonstrate front-end emittance before project start to reduce performance risk.
   d. Demonstrate Fast Ferrite phase shifters needed to use "TESLA-style RF" (one Klystron feeds many cavities) in a proton linac.

7. BRIEF DESCRIPTION OF LABORATORY'S ANTICIPATED ROLE:

Expected unique capabilities to be provided by lab. Rough estimate of human resources from lab (#FTE in what type labor).

A. Expected unique capabilities to be provided by lab
   a. Main Injector capable of supplying beams in the 8-120 GeV range.
   b. Extensive cryogenic experience and infrastructure for SMTF
   c. Best site for proton Driver
   d. Possible site for Linear Collider

B. Rough estimate of human resources from lab
   a. R&D program ~50 FTE, ~40% engineer, 40% tech, 20% physicist.
   b. Doubles during construction.
   c. About half is shared with SMTF/ETF project.