Proton Driver

Project Development, Tactics & Strategy

G. W. Foster

Fermilab User's Meeting

June 3, 2004

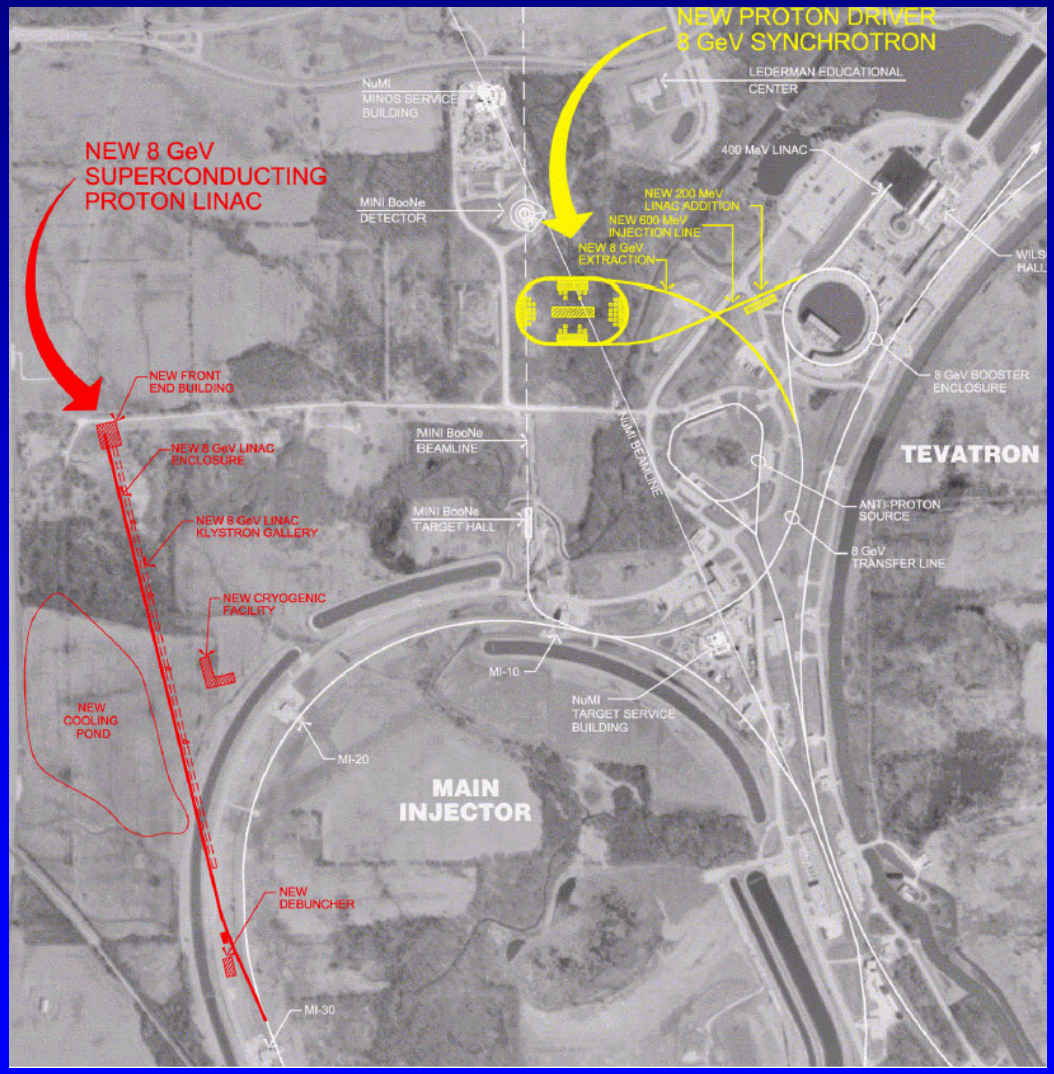
This is *supposed* to be a non-technical talk

… I'll do my best….

Some Developments

- 1st Round of PD Design Studies Completed
- PD Recommendation by FLRPC
- New Design Iteration Started
  - Goal: CD-0 Documentation by End of ’04
  - Both Synchrotron and SCRF Linac (emphasized)
- US SCRF Collaboration enthusiasm for PD
- ITRP Decision Pending

Proton Driver Synchrotron & Linac



- SYNCHROTRON
  - Sited West of the existing booster
  - Re-uses existing linac enclosure
- 8 GeV LINAC
  - Baseline Site injects at MI-30 straight section
  - Others possible

Q: WHAT IS THE SIGNIFICANCE OF THIS NUMBER ?

451

A: this is the number of vacuum tubes required to accelerate beams to 8 GeV in Fermilab's current Proton Source.

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

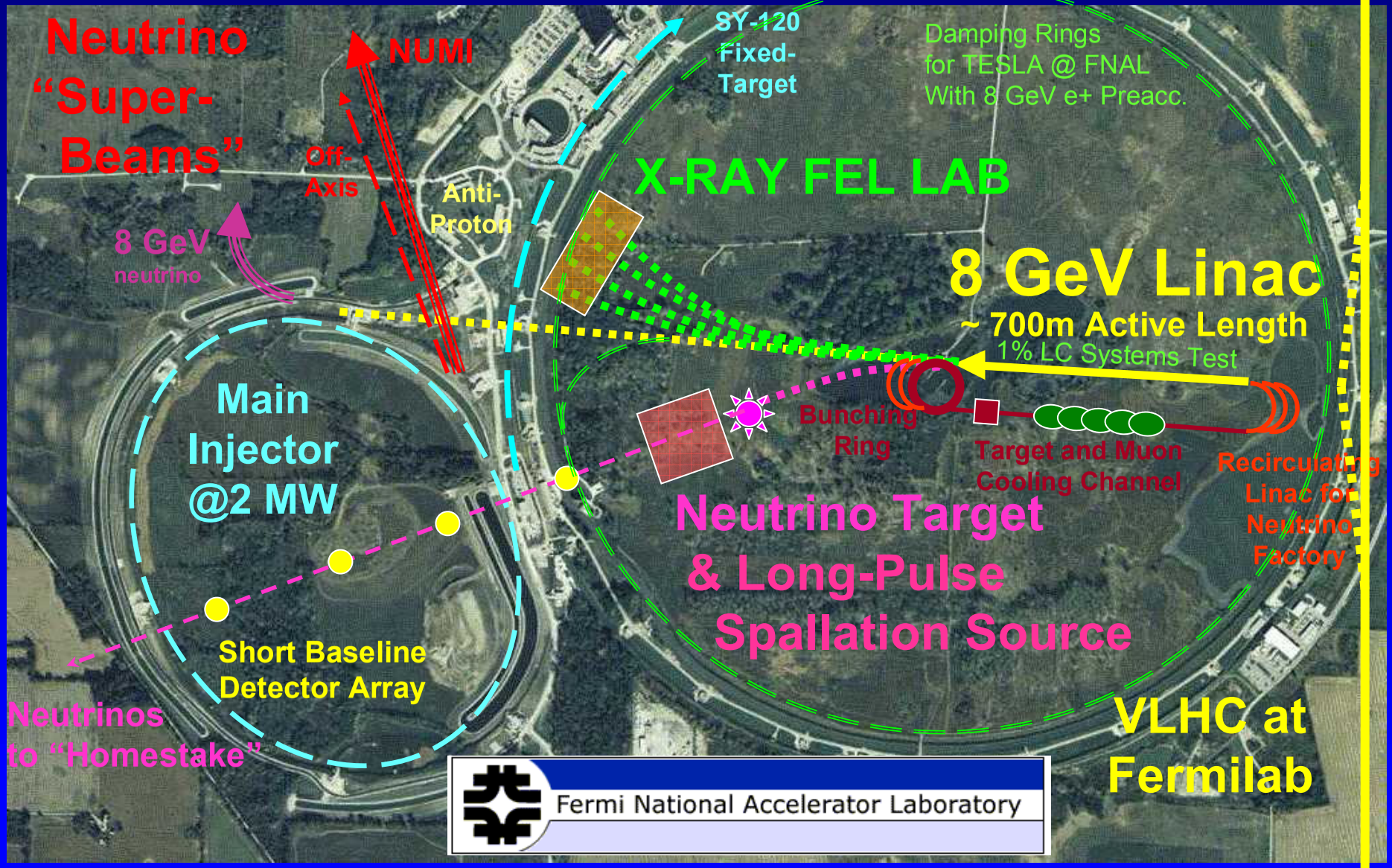
==> "Super-Beams" in Fermilab Main Injector:

- 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



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

New Proton Driver Charge Letter

To: Bill Foster and Steve Geer

From: Michael Witherell

Subject: Next Steps on the Proton Driver

I would like you to assemble and lead a team to achieve the goals recommended by the Fermilab Long Range Planning Committee relative to the Proton Driver, with an emphasis on the superconducting linac as suggested by that committee. For the purpose of this assignment I will define the Proton Driver project as a complete replacement of our current 400 MeV linac and 8 GeV Booster, accompanied by Main Injector upgrades, sufficient to enable the delivery of at least 0.5 MW of average beam power at 8 GeV, and 2.0 MW of beam power at 120 GeV. I am hopeful that the assignment described above can be completed by the end of 2004.

In particular I would like you to initiate and coordinate efforts in the following areas:

- Preparation of documentation sufficient to establish mission need for the Proton Driver as defined by the Department of Energy CD-0 process.
- Development and documentation of the physics case. I would like this to include both support for a forefront neutrino program at Fermilab in the decade of 2010 and beyond, and identification of other opportunities that could potentially be enabled with a Proton Driver facility.
- Completion of comparably scoped cost estimates for the linac and synchrotron options based, to the extent practical, on a common basis of estimate and on common implementation strategies.
  - The cost estimates should specifically include modifications to the Main Injector required to meet the established 2 MW @ 120 GeV criterion.
  - The cost estimates should assume a complete replacement of the existing linac.
  - The implementation strategy should be based upon minimal disruption to the ongoing collider (Run II and BTev) and neutrino programs.
  - The goal is to understand the cost differential between the linac and synchrotron and what benefits are realized for the (presumably) higher cost.
- Documentation and external review of accelerator physics and technology issues for both options, specifically including anticipated beam loss and beam handling issues for both machines. The goal is to put the accelerator physics basis of the superconducting linac at the same level as the (more traditional) synchrotron-based solution.
- Examination and documentation of the siting issues associated with both machines, for both the baseline mission of providing Neutrino Super-Beams and for future development of facilities on the Fermilab site.
- Development and elucidation of an overall strategy for implementing a Proton Driver that is in concert with the shorter term plan of the existing Proton Source and Main Injector improvements being developed under the leadership of Eric Prebys.
- As with any such responsibility you may be asked from time to time to report on Proton Driver progress to various review committees, help with the lab's long range financial planning for such a project, and help inform the Fermilab User Community about the exciting physics prospects of such a facility.

In organizing and undertaking this assignment I would like to collaborate closely with interested parties in all our divisions and sections. I would further ask you to involve institutions outside of Fermilab who might have potential interests in either collaboration on development, construction, and operations of the Proton Driver itself or in the scientific research programs enabled by the facility. I would suggest that a workshop or workshops exploring the accelerator physics and technologies, along with the scientific opportunities would be an important component in proceeding in this direction. The lab will be happy to support you in the arrangements of such workshop(s)

It is my intention that once this information is available the Fermilab directorate will carry out a review that will compare the two prospective Proton Driver technologies with the goal of identifying the option that is best for Fermilab. This will allow the laboratory to proceed expeditiously with a complete Conceptual Design Report for the selected option, along with cost estimates, resource loaded schedules and other required CD-1 documentation, following the establishment of mission need via a formal CD-0 from the Department of Energy.

Action to implement the vision for the future outlined by the Fermilab Long Range Planning Committee is important to securing a healthy and productive future for both Fermilab and for the U.S. The steps described here are an important component of identifying how to best structure Fermilab's future program in areas that address many of the most important questions in science over the coming decade. Steve Holmes will serve as the Directorate point of contact on this activity, and both Steve and I look forward to working closely with you, and the participating divisions, sections, and outside institutions on this. Thank you.

Cc
Div/section heads
Associate Directors
W. Chou
S. Mishra
E. Prebys
J. Jackson

Proton Driver Charge (machine)

- Goal: CD-0 Documentation by End of ’04
- Both Synchrotron and SCRF Linac (emphasized)
  - Common Performance Specs and Cost Basis
- External Review of Accelerator Physics
- Investigation of Outside Collaboration

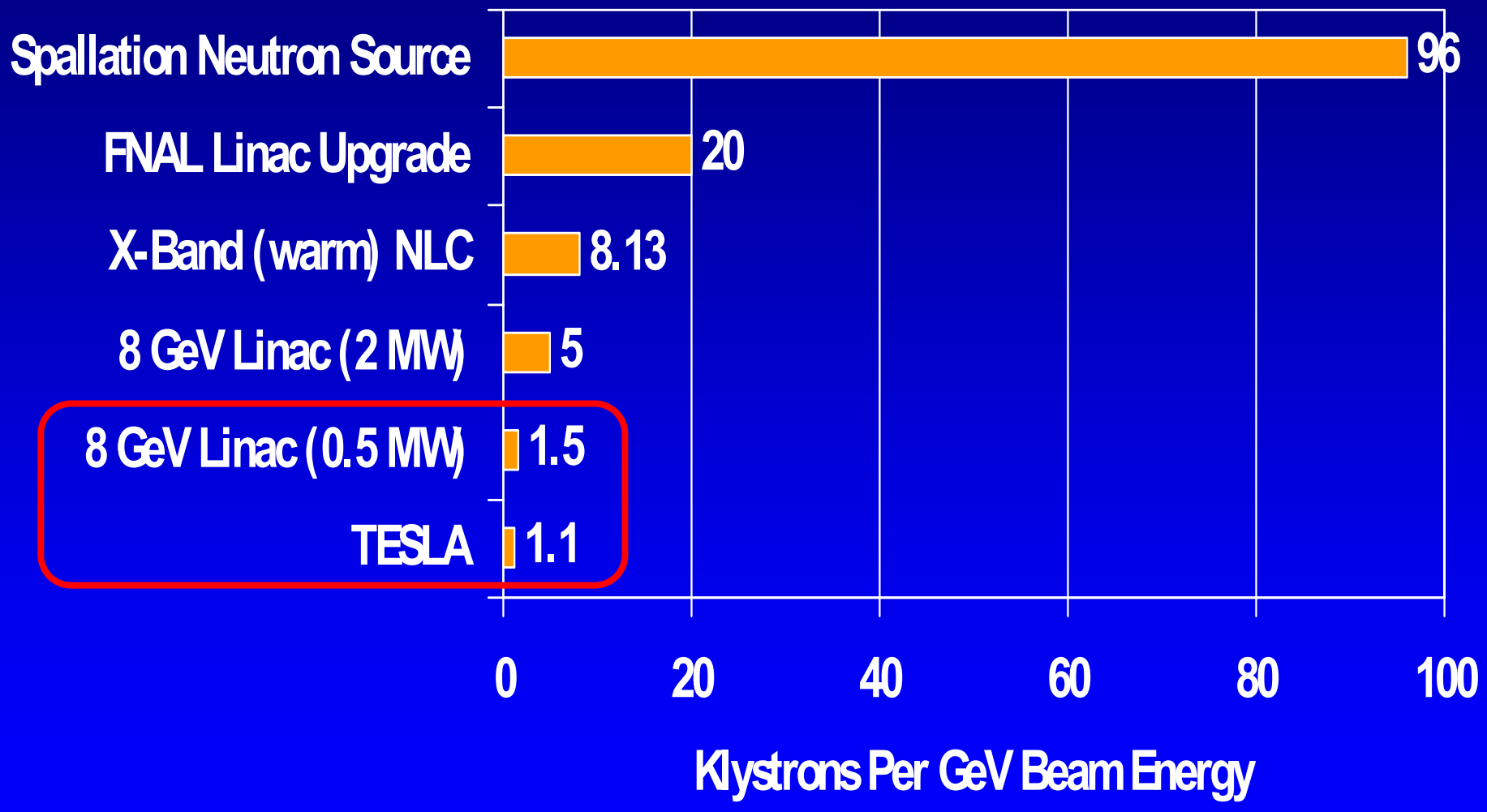
PD Work in Progress …

- Weekly meetings in specific technical areas (four)
- Visits from experts
- Prototype key components
- Develop Collaborations

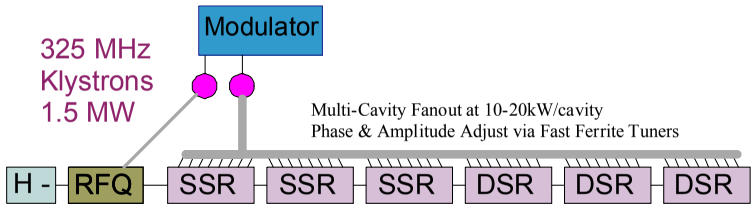
Linac Technical Strategy

- 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



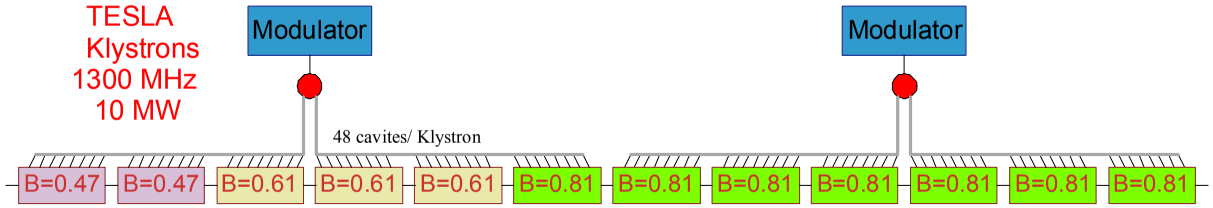
0.5 MW with TESLA Frequencies & SCRF F.E.



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

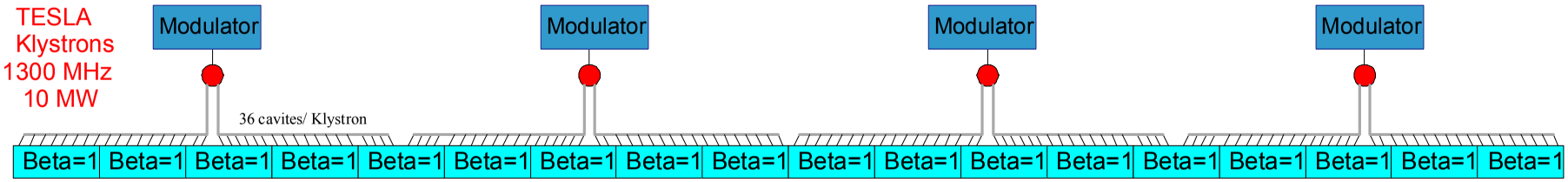
8 GeV 0.5 MW LINAC

- 12 Klystrons (2 types)
- 11 Modulators 20 MW ea.
- 1 Warm Linac Load
- 54 Cryomodules
- ~550 Superconducting Cavities



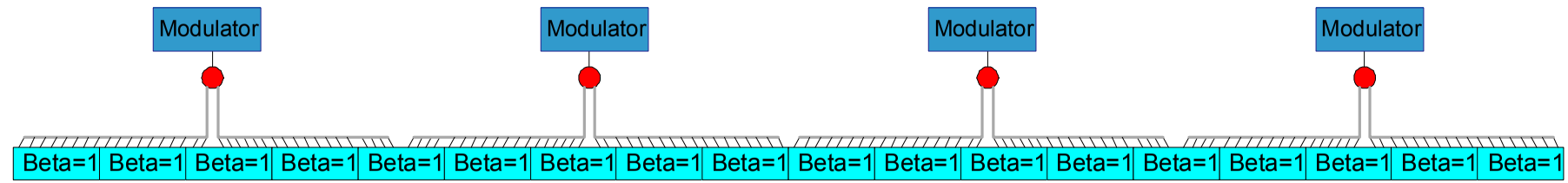
"Squeezed TESLA"
Superconducting Linac
1300 MHz 0.087 - 1.2 GeV

2 Klystrons
96 cavites in 12 Cryomodules



"TESLA" LINAC 1300 MHz Beta=1

8 Klystrons
288 cavites in 36 Cryomodules

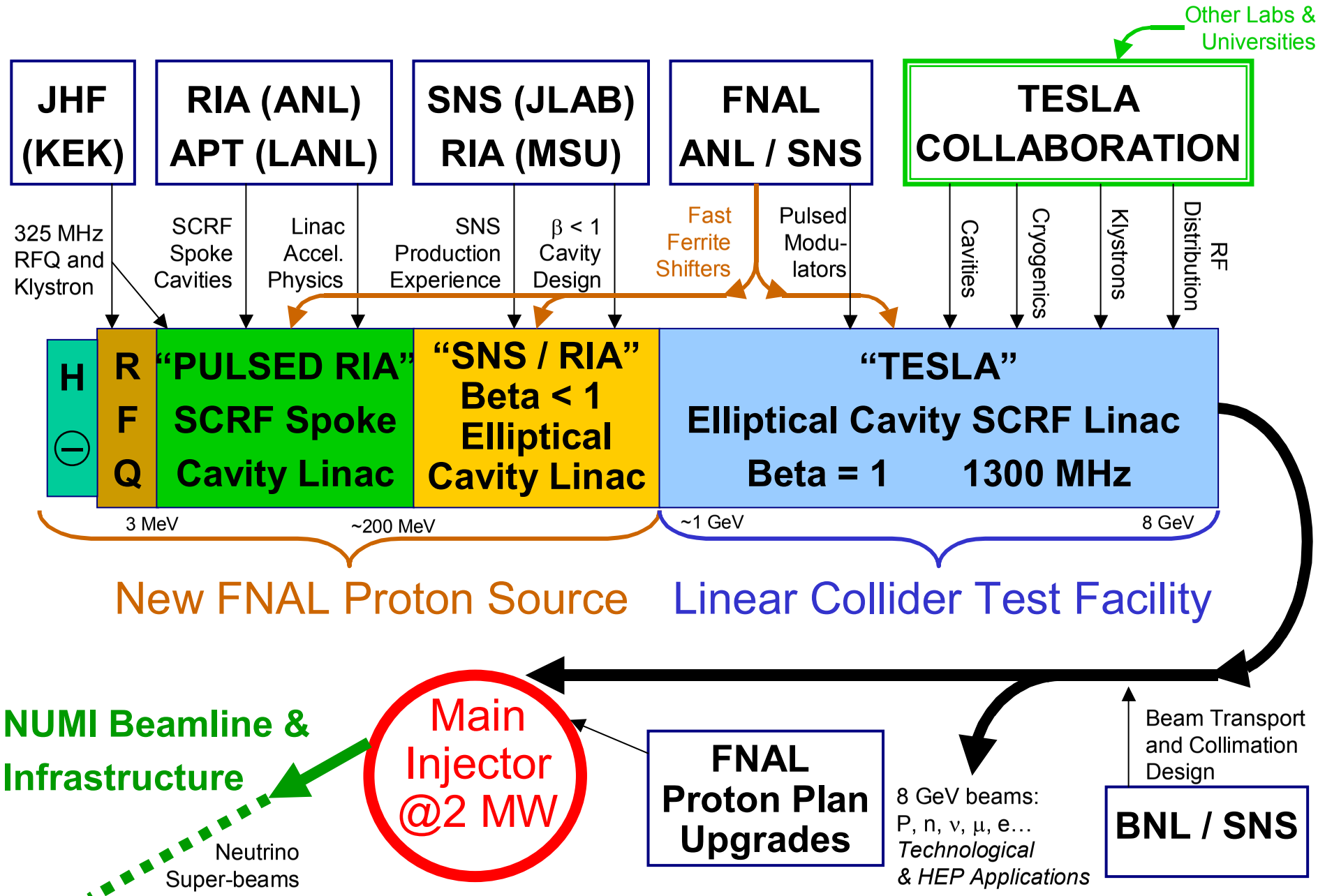


COLLABORATION

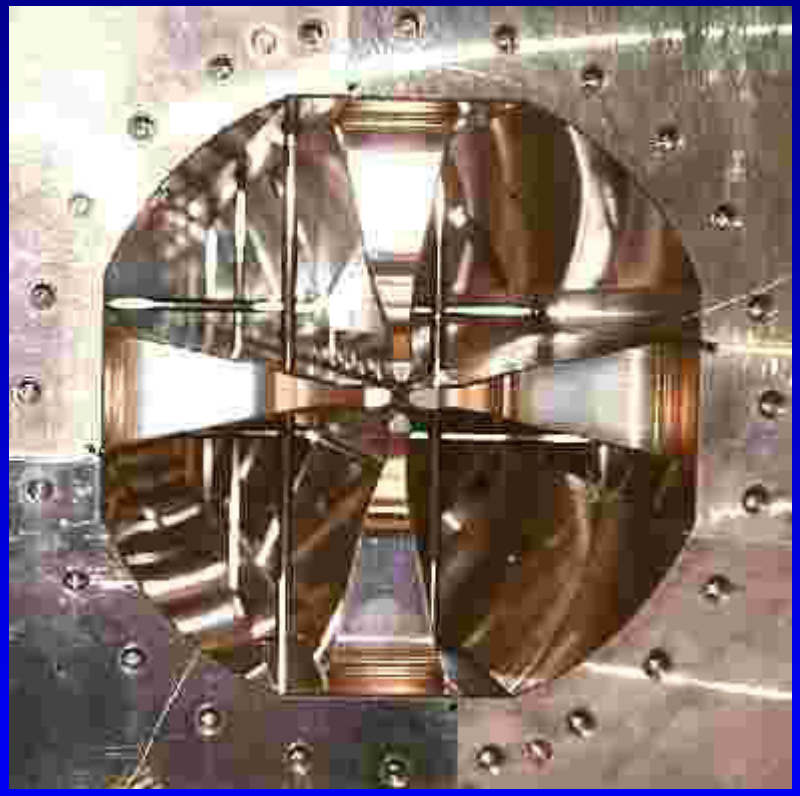
- Will be key to the success of
  - the SCRF Proton Driver
  - the LC test facility

… and can speed up both if they are the same project.

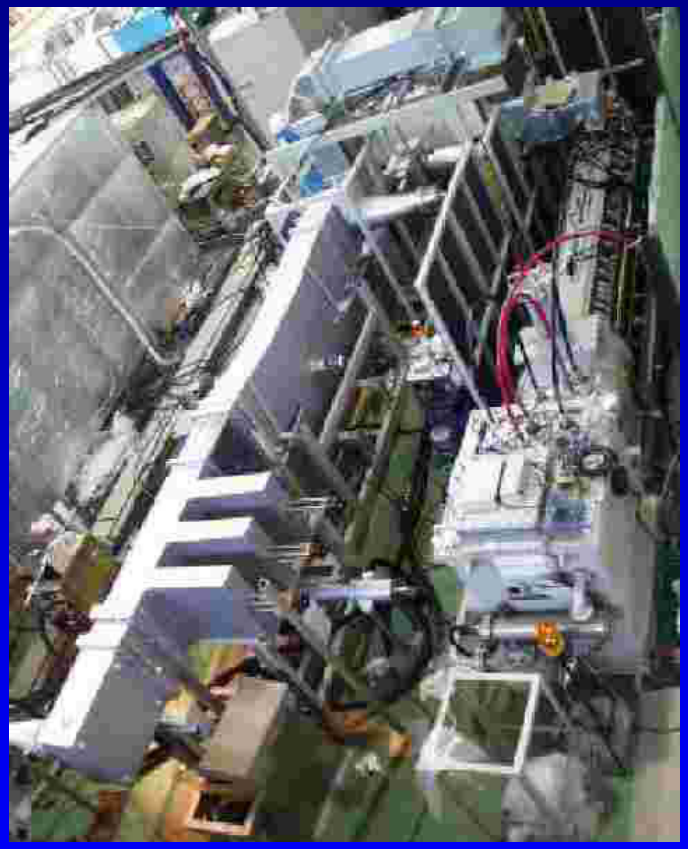
Proton Driver Linac - Technology Flow



JHF 325 MHz RFQ and Klystrons for TESLA-Compatible* Front End



JHF 325 MHz RF Quad



JHF 325 MHz
3 MW Klystron

* TESLA frequency = 1300 MHz
= 4*325 MHz

Single- and double-spoke resonator

LANL (APT)

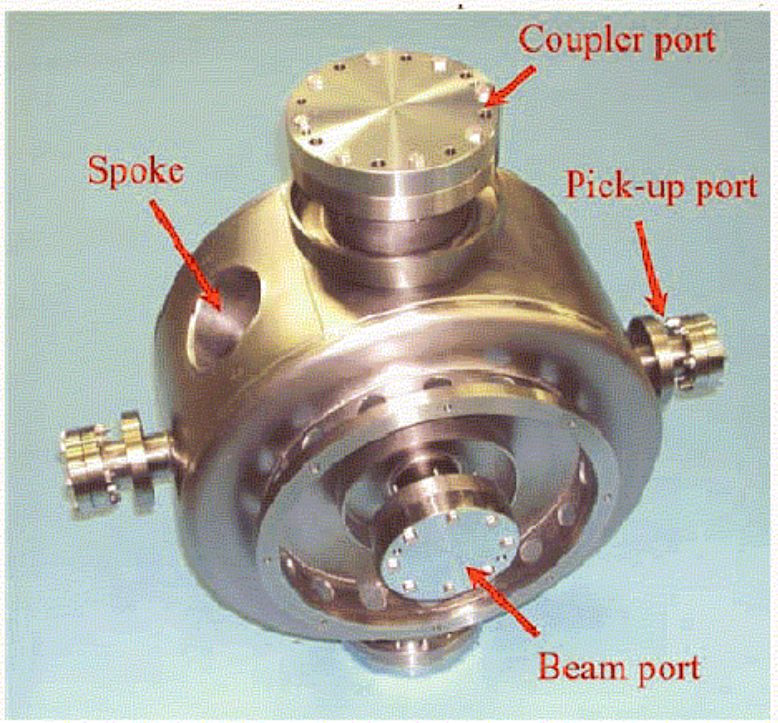


Figure 1: Los Alamos-built 350 MHz, β=0.175, single-spoke niobium cavity

ANL (RIA)

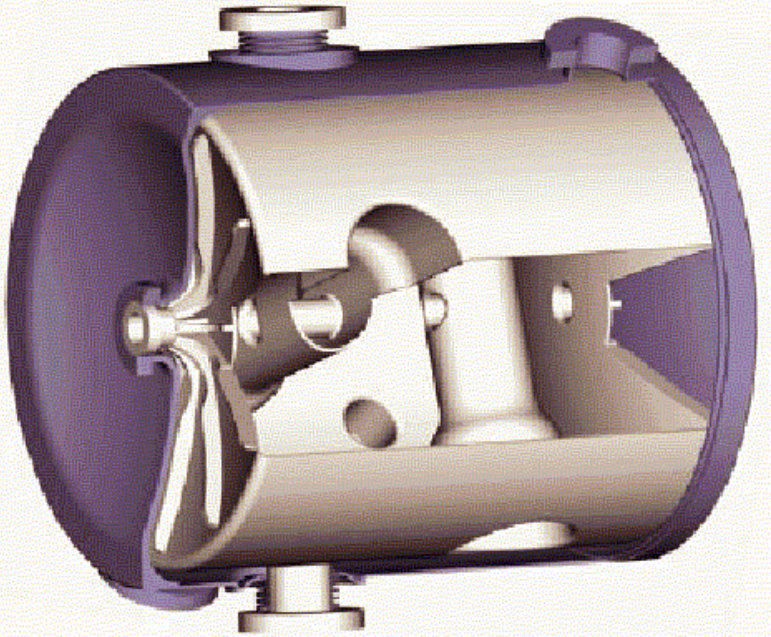
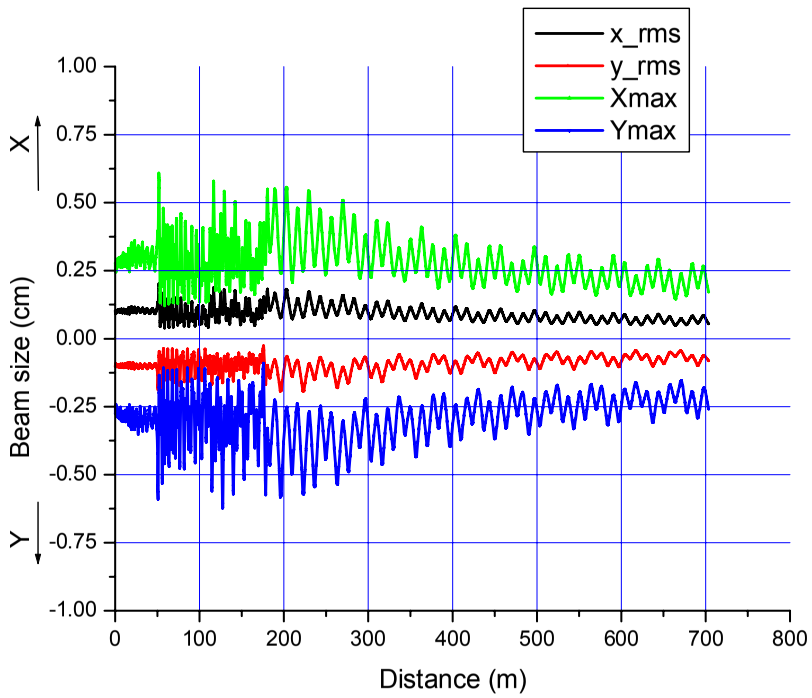
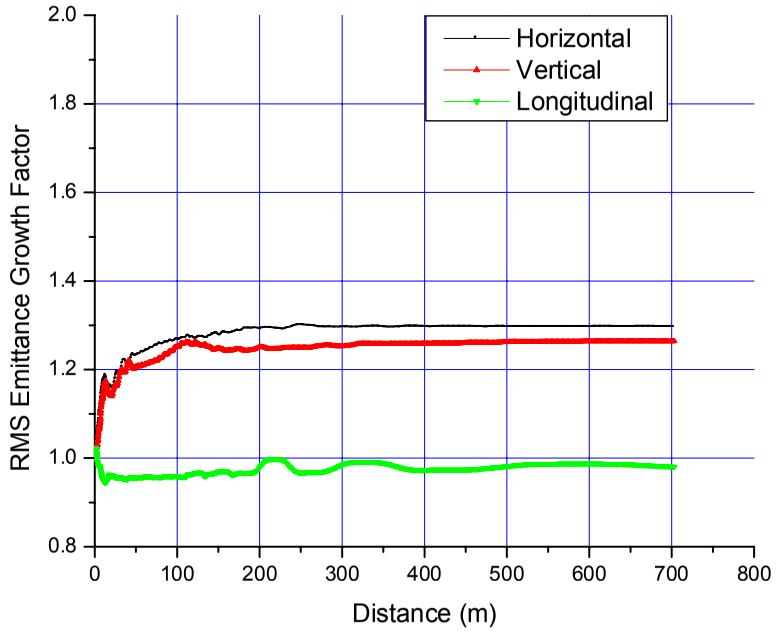


Figure 5: A 345 MHz, double-spoke, three-gap cavity for β=0.4. A niobium prototype has been built and tested at Argonne National Laboratory

End-to-End Beam Physics of TESLA-Compatible Linac

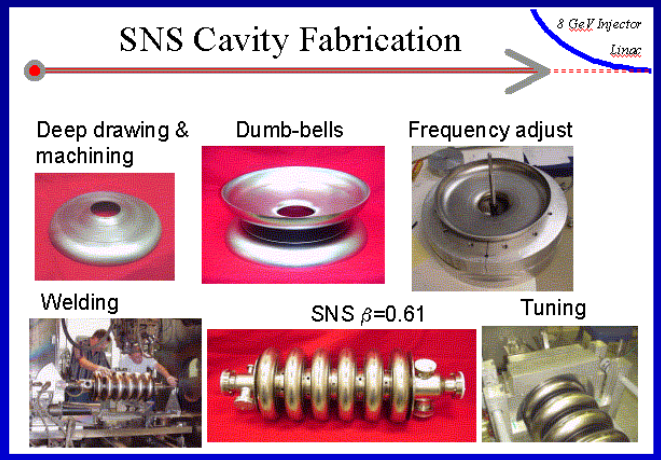
(P. Ostroumov, ANL)





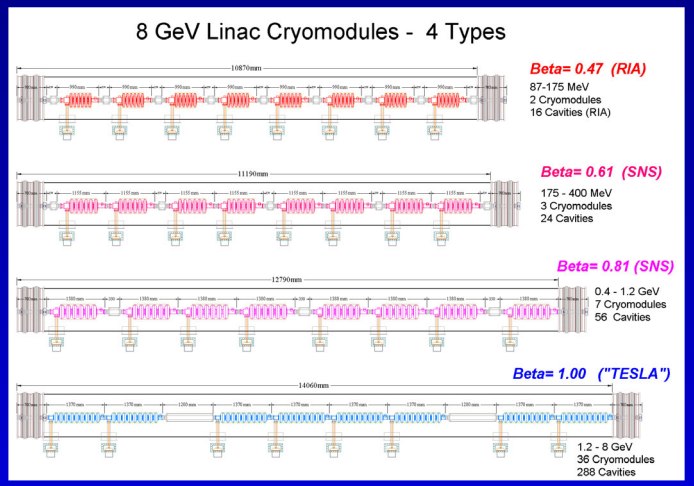
8 GeV Superconducting Linac

TECHNICAL SUBSYSTEM DESIGNS *EXIST* AND *WORK*

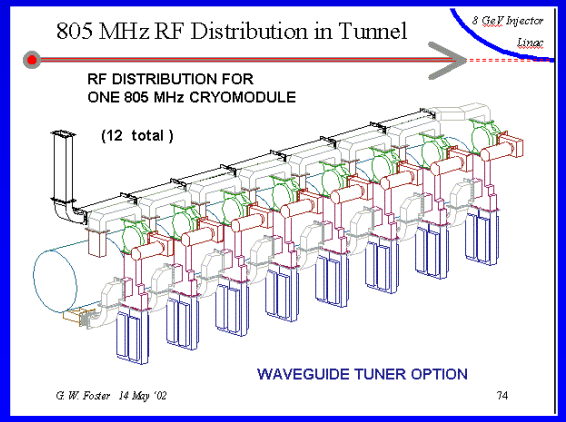


SNS Cavites (JLAB)

FNAL/TTF Modulators

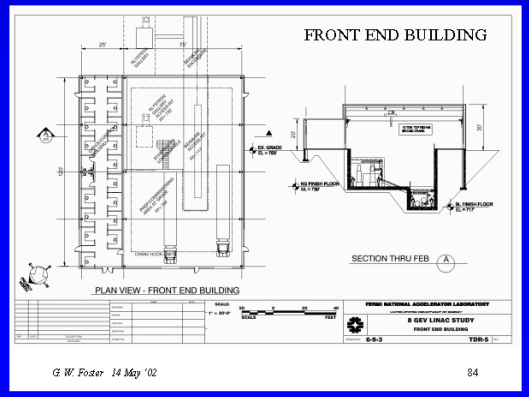


"TTF Style" Cryomodules



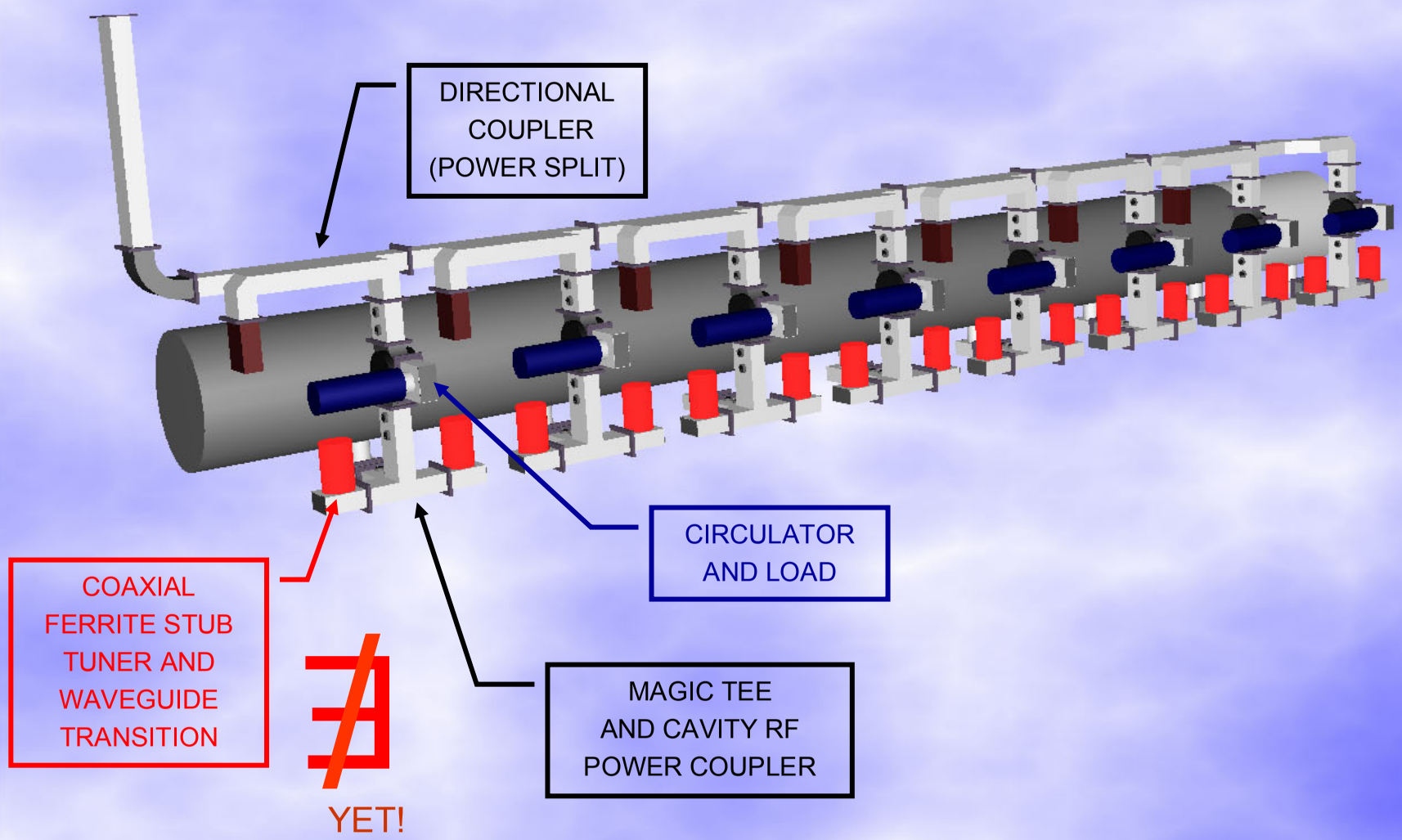
TESLA RF Distribution
*** w/ phase shifters**

Civil Const. Based on FMI



Advanced RF Distribution

(Coaxial Phase Shifter Option)



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

Fermilab's Assets

MESON AREA CRYOGENICS

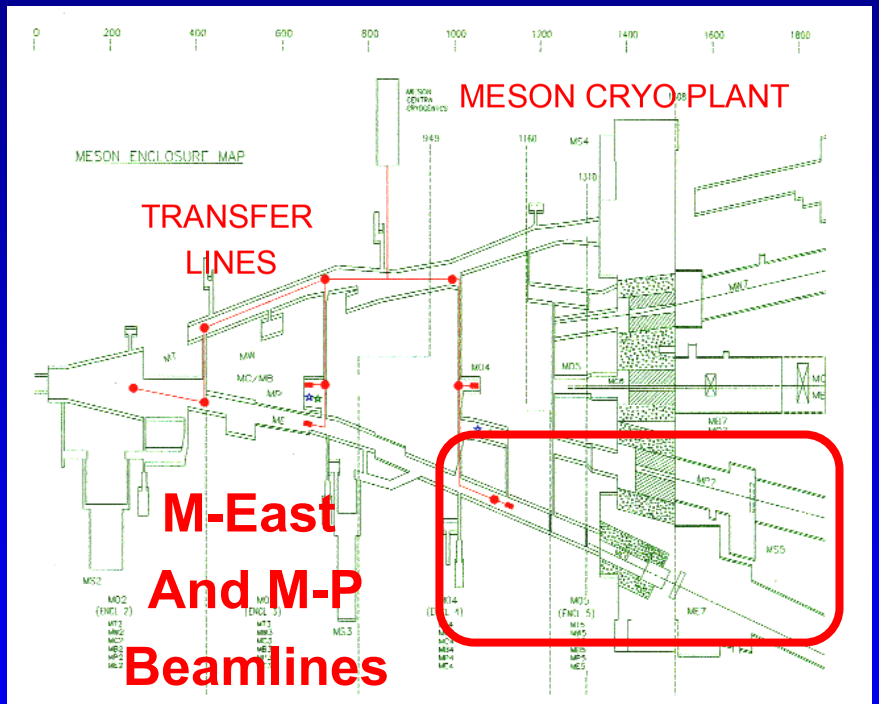


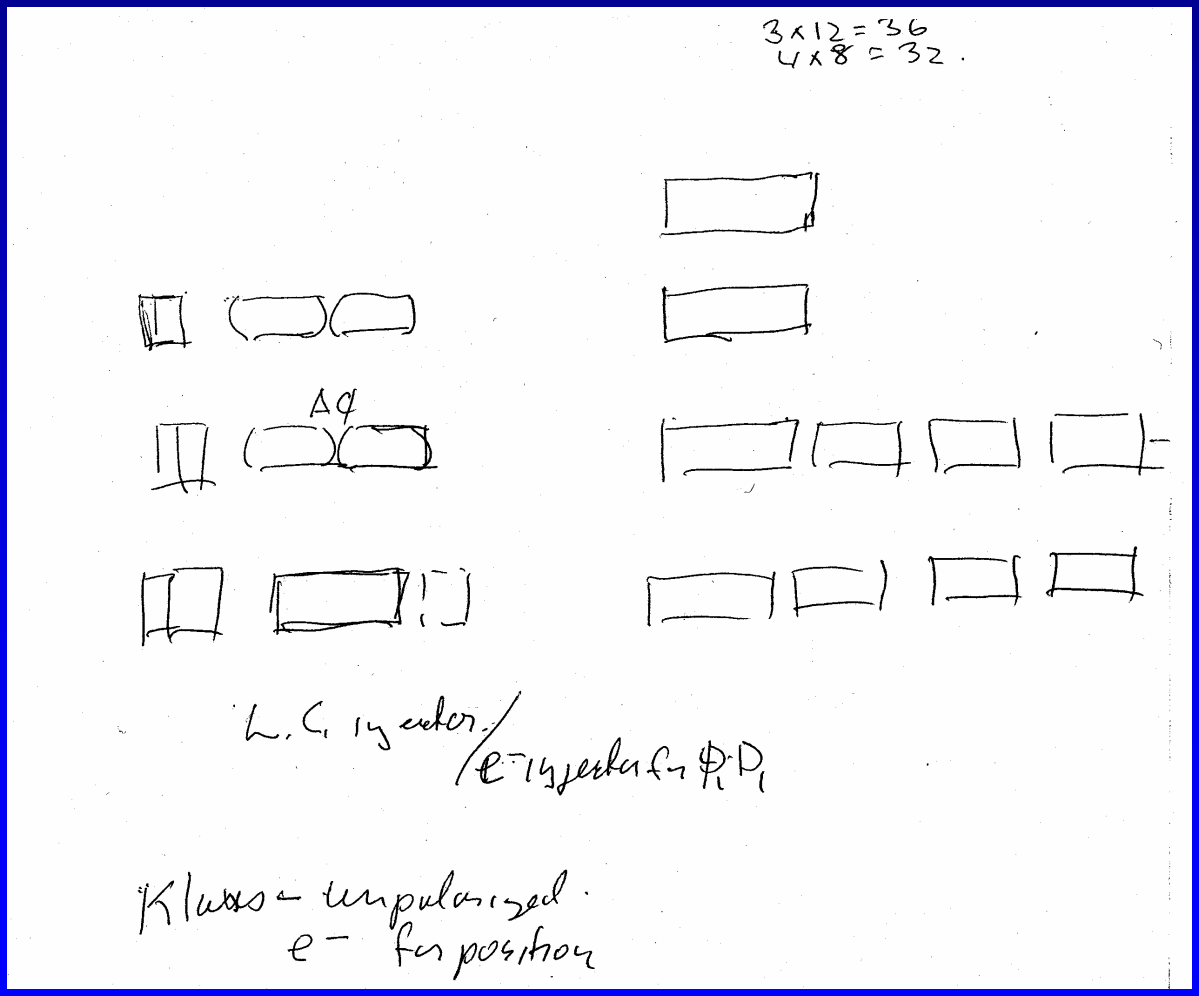
Figure 1 Meson Enclosure Map and Cryogenic Transfer Line Location

- Cryogenics
- Beamlines
- Near-term project: SCRF Proton Driver

Immediate Support for (1) TESLA RF Station and (4) TESLA Cryomodules

Recognize the Handwriting?

cryomodules



time

Helen Edwards

Final Questions

- Is the LC / PD decision point 2008?
- Impact of LC Technology decision
  - on collaboration
  - on US HEP
- Funding Profile & Schedule depending on whether BTeV does / does not survive reviews…