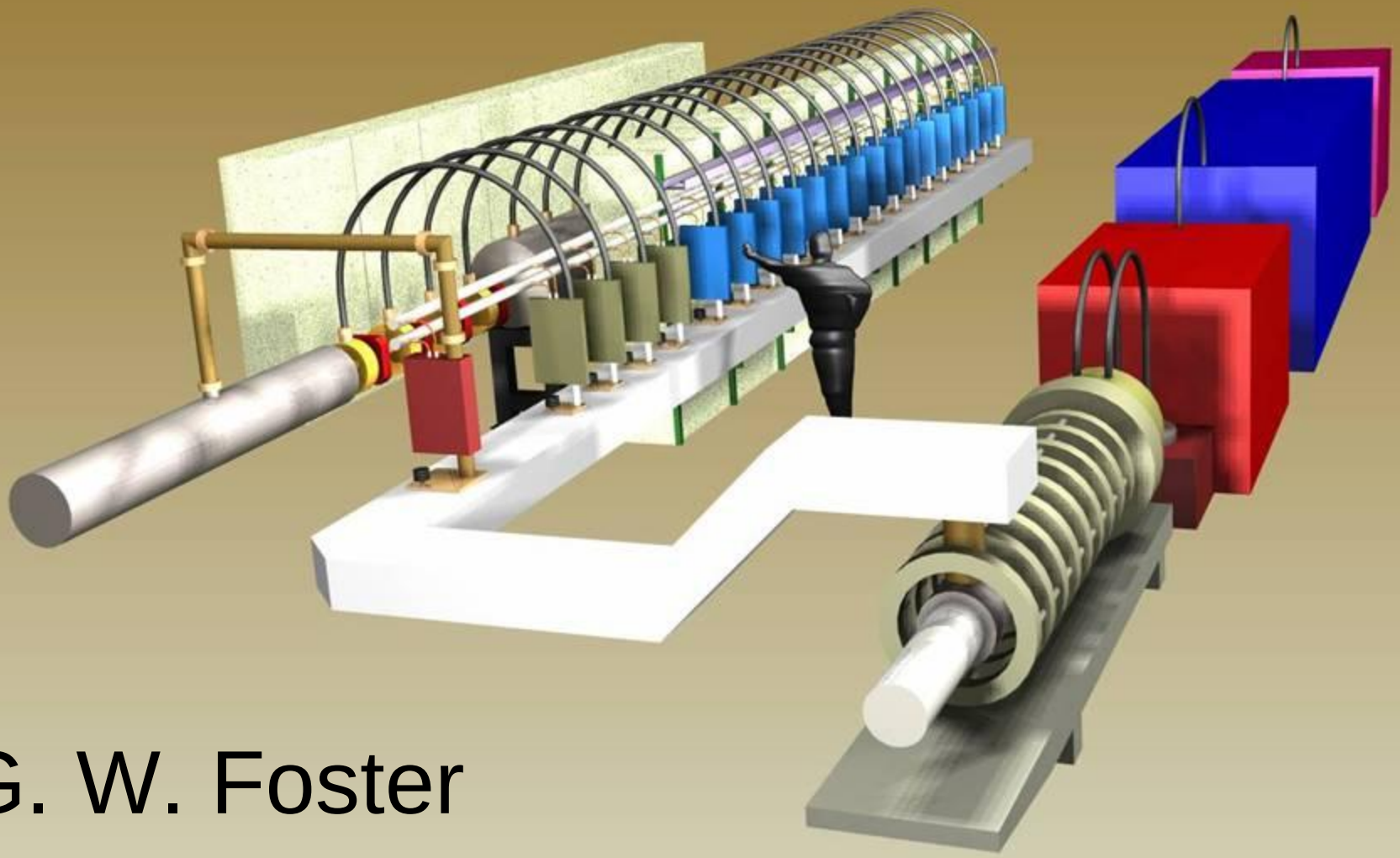
Proton Driver Status Report



G. W. Foster
Fermilab UEC

Nov 13, 2004

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

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

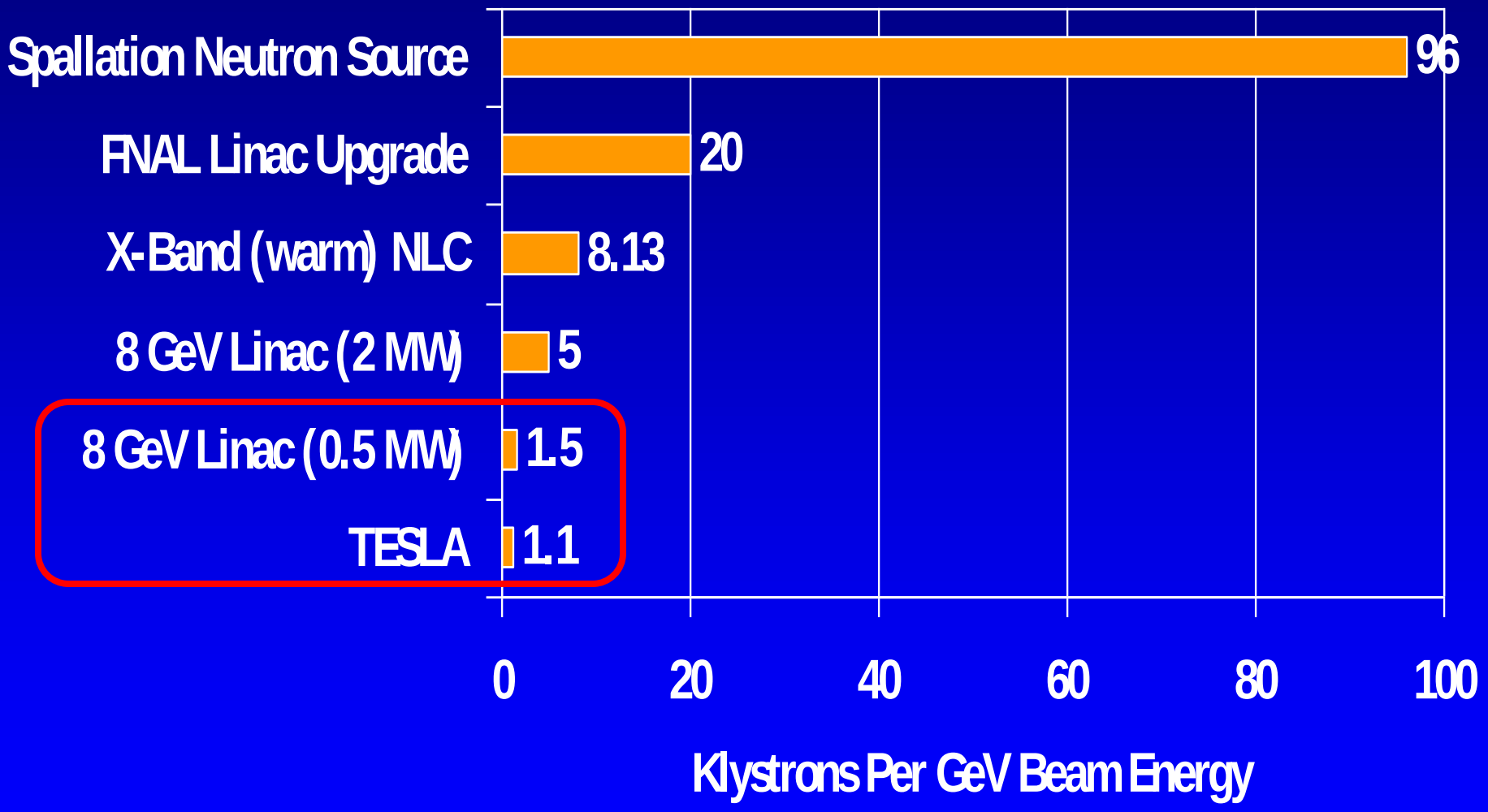
PD Work in Progress …

- 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

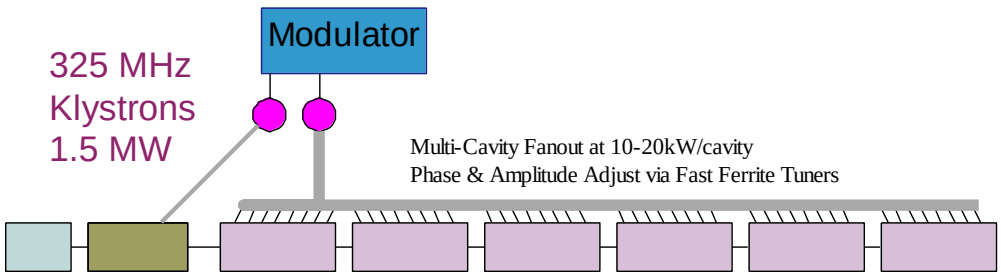
Cost Driver: Klystrons per GeV



Proton Driver Linac Parts

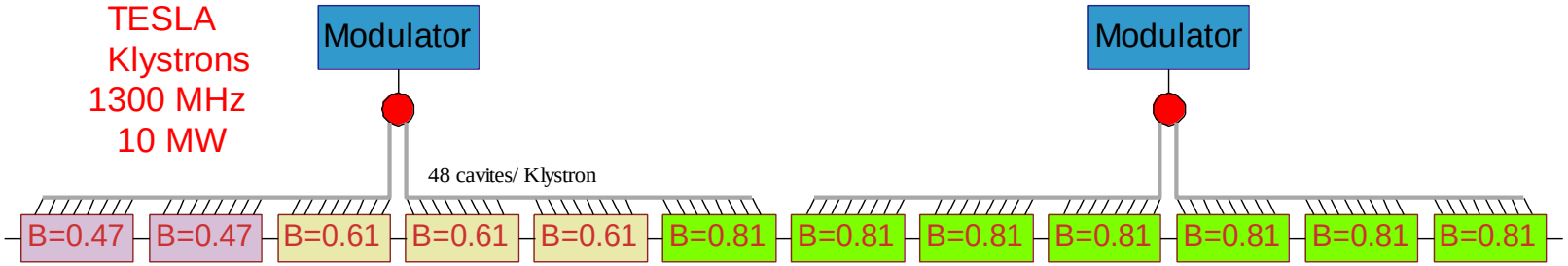
1. MAIN “TESLA” LINAC (1-8 GeV)
   - ~ Exact copy of TESLA, 1.5% of LC
2. Beta<1 “Squeezed TESLA” Linac
   - “SNS” SCRF linac at f = 1300 MHz
3. “Pulsed RIA” Front End Linac
   - spoke SCRF cavities at 325 MHz
4. H- Source & RF Quad
   - ~ Copy of JPARC 325 MHz front end

0.5 MW with TESLA Frequencies & SCRF F.E.



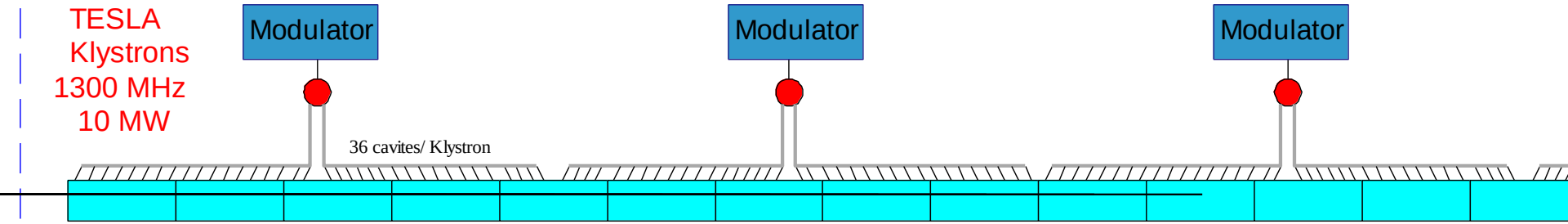
"Pulsed RIA"
SCRF Linac
325 MHz
0 - 120 MeV

8 GeV
12 K
11 M
1 W
54 C
~550 S



"Squeez
Superco
1300 MH

2 Klystron
96 cavites



"TESLA" LINAC 1300 MHz Beta=1

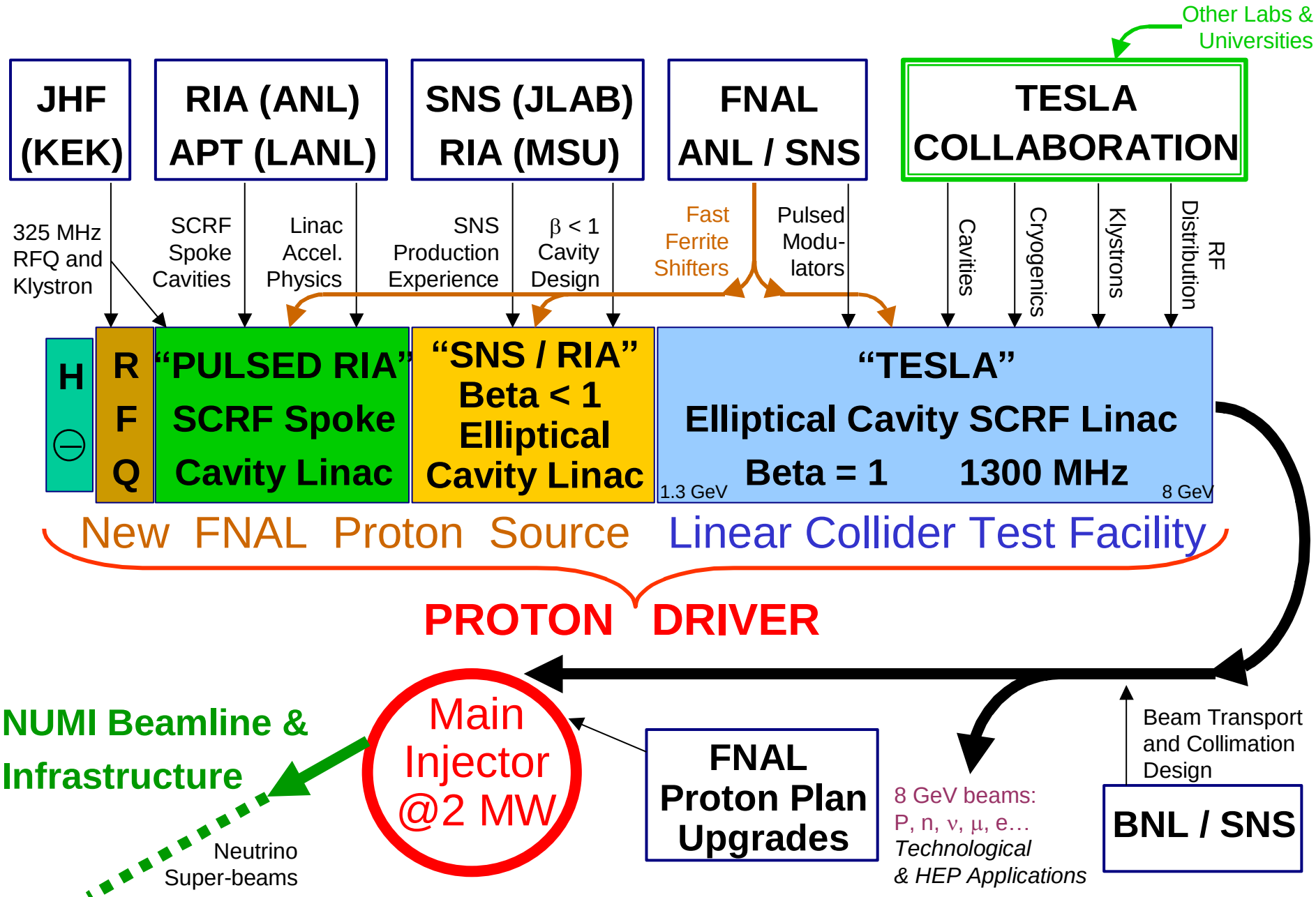
8 Klystron

COLLABORATION

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

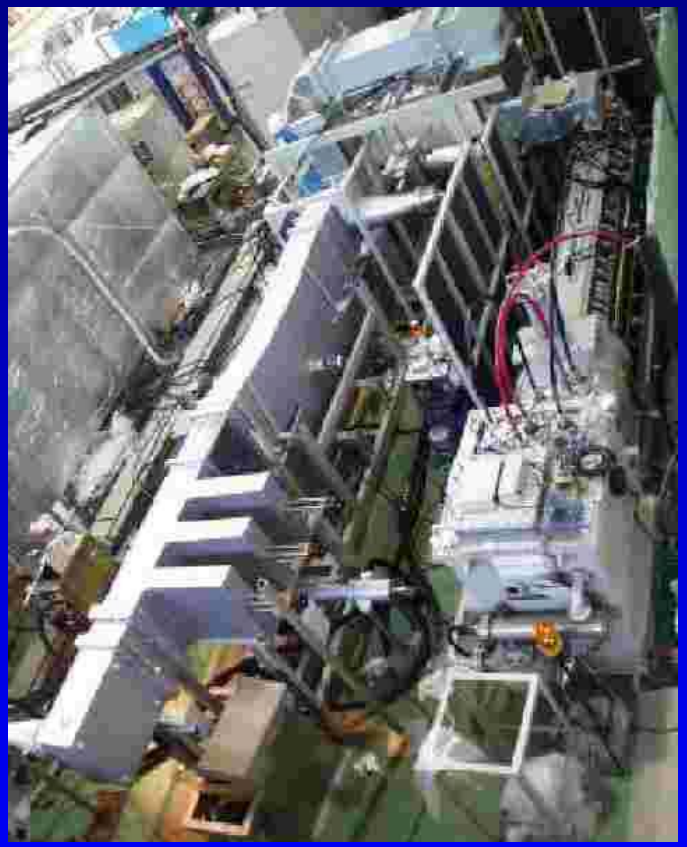
… and can speed up both if they are the same project.

Proton Driver Linac - Technology Flow



JHF 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)

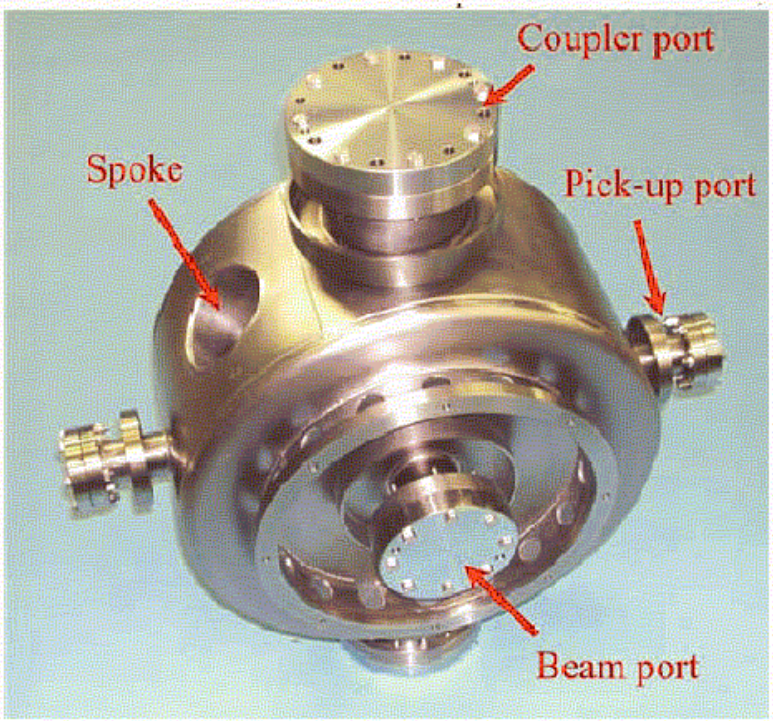


Figure 1: Los Alamos-built 350 MHz, β=0.175, single-spoke niobium cavity

ANL (RIA)

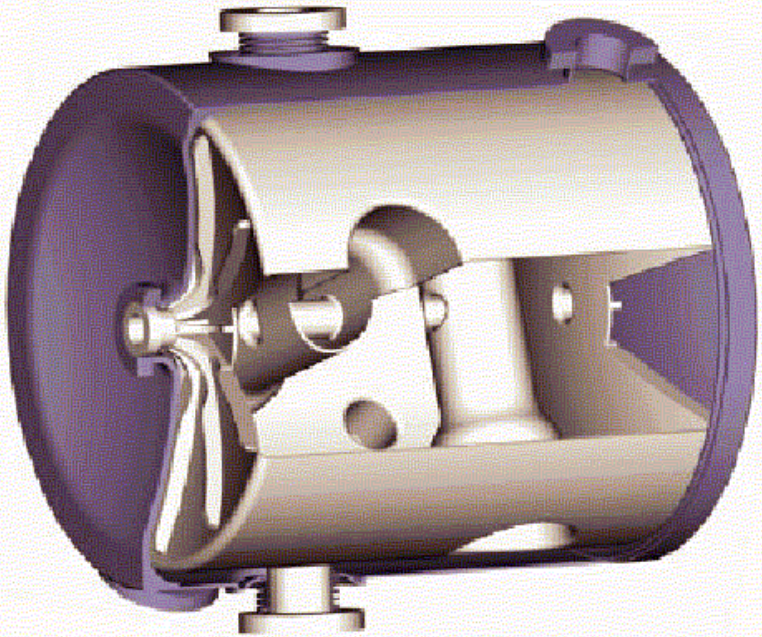
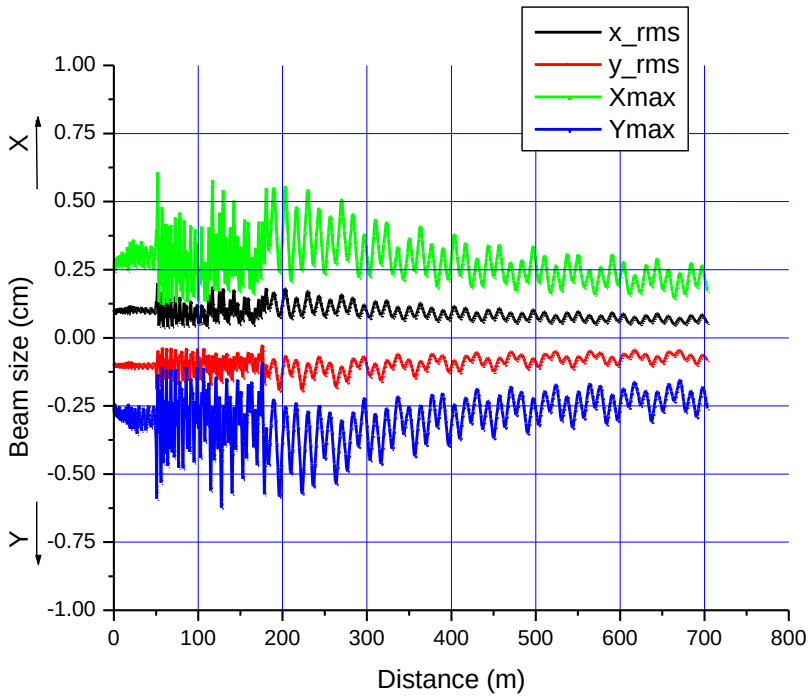
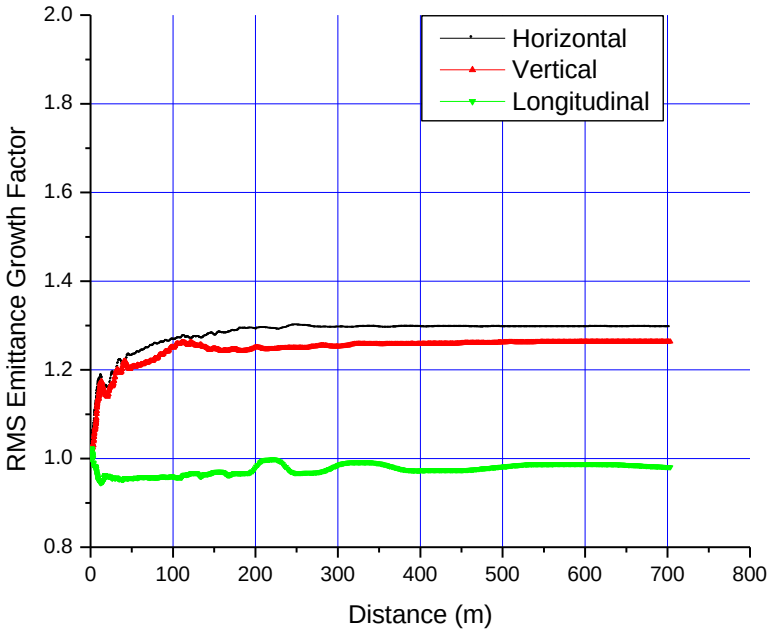


Figure 5: A 345 MHz, double-spoke, three-gap cavity for β=0.4. A niobium prototype has been built and tested at Argonne National Laboratory

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

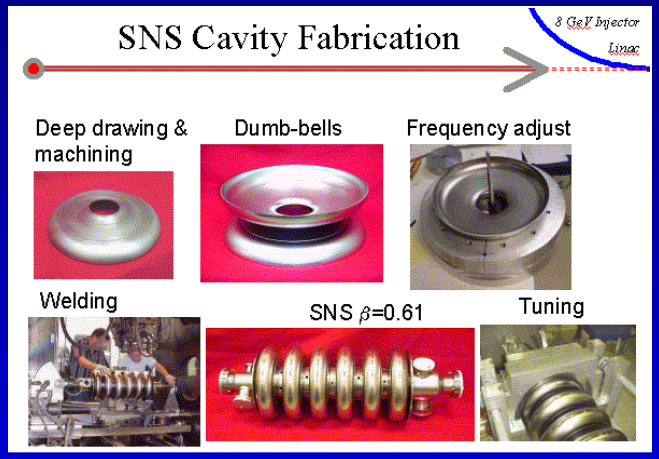
(P. Ostroumov, ANL)





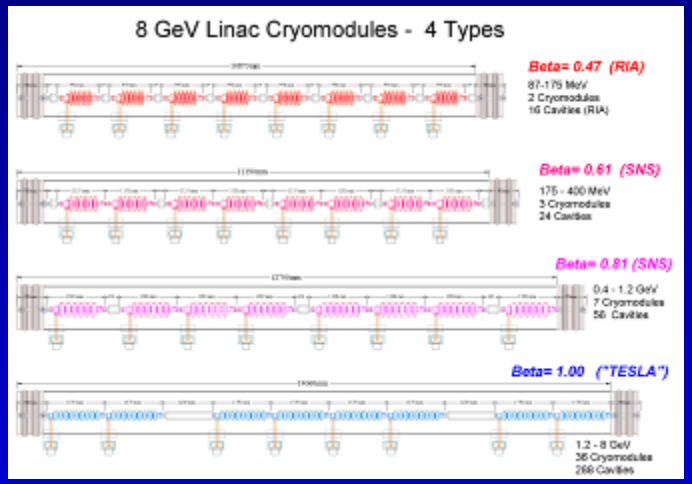
8 GeV Superconducting Linac

TECHNICAL SUBSYSTEM DESIGNS *EXIST* AND *WORK*

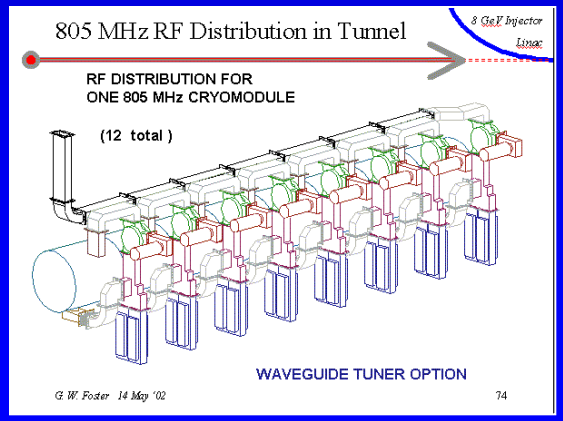


SNS Cavites (JLAB)

FNAL/TTF Modulators

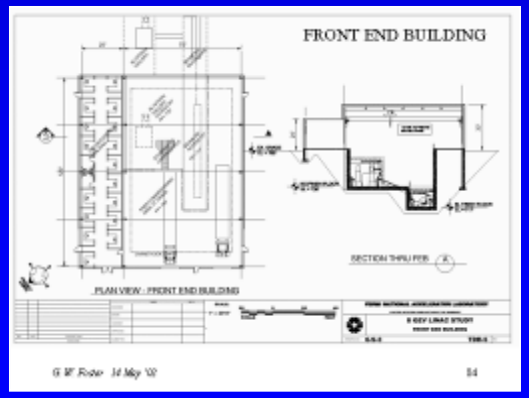


"TTF Style" Cryomodules



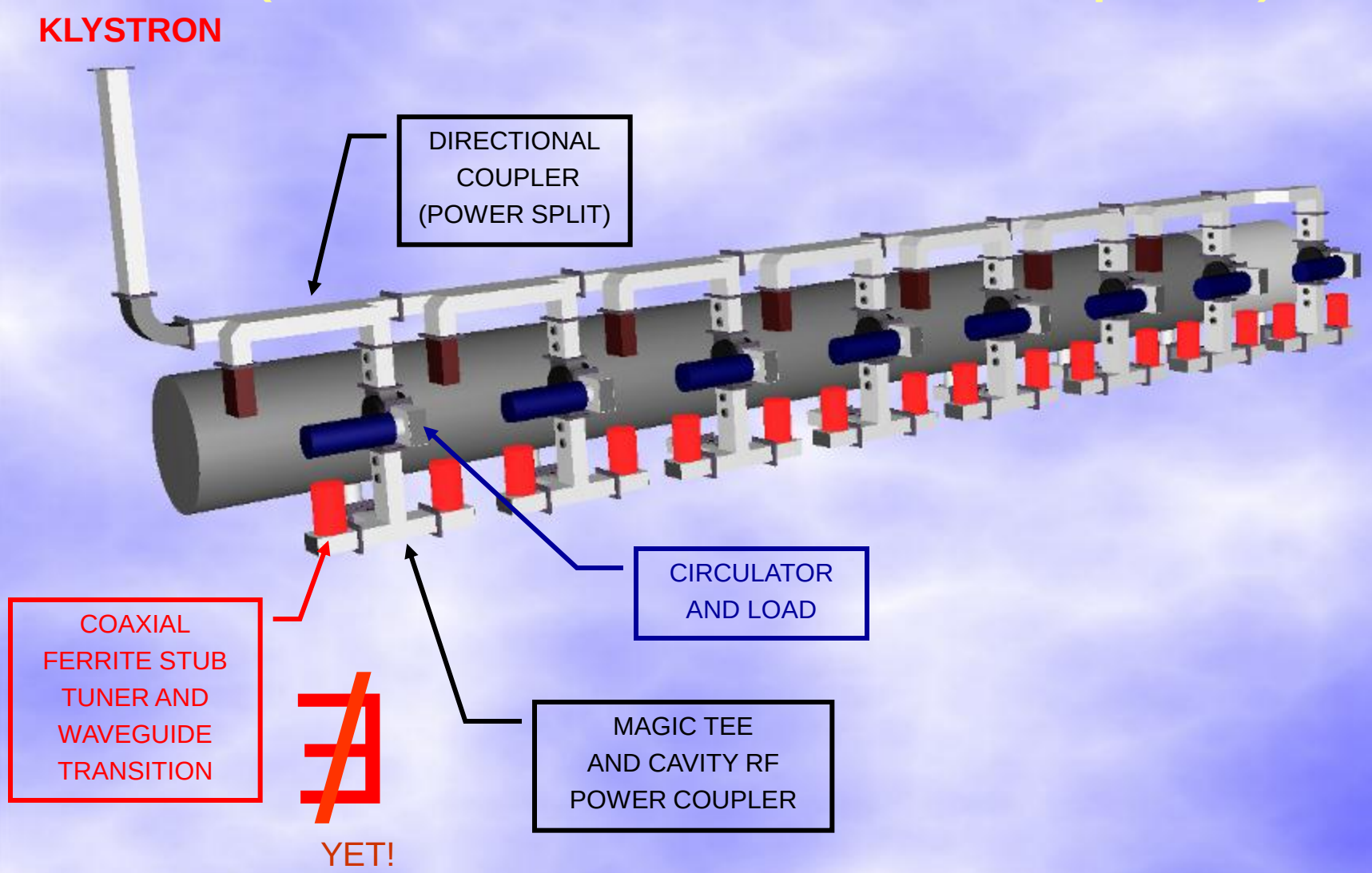
TESLA RF Distribution
*** w/ phase shifters**

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:

<u>Set up 1 GeV of TESLA linac</u>

  – At Fermilab

  – With as many US-built components as possible

Multi-Lab Collaboration on SRF Development Over a Broad Range of Applications

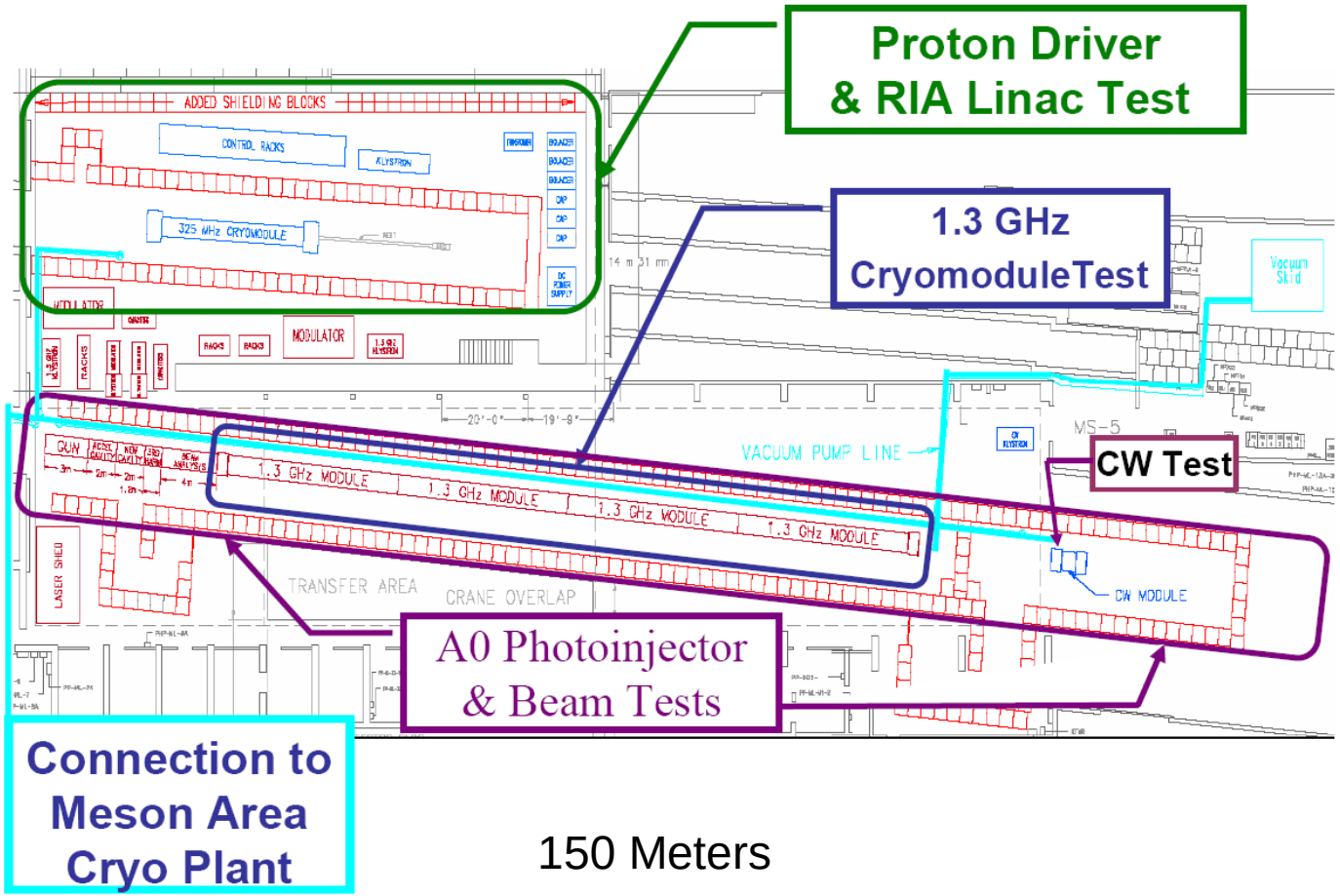
US Institutions involved in Discussions:

- 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

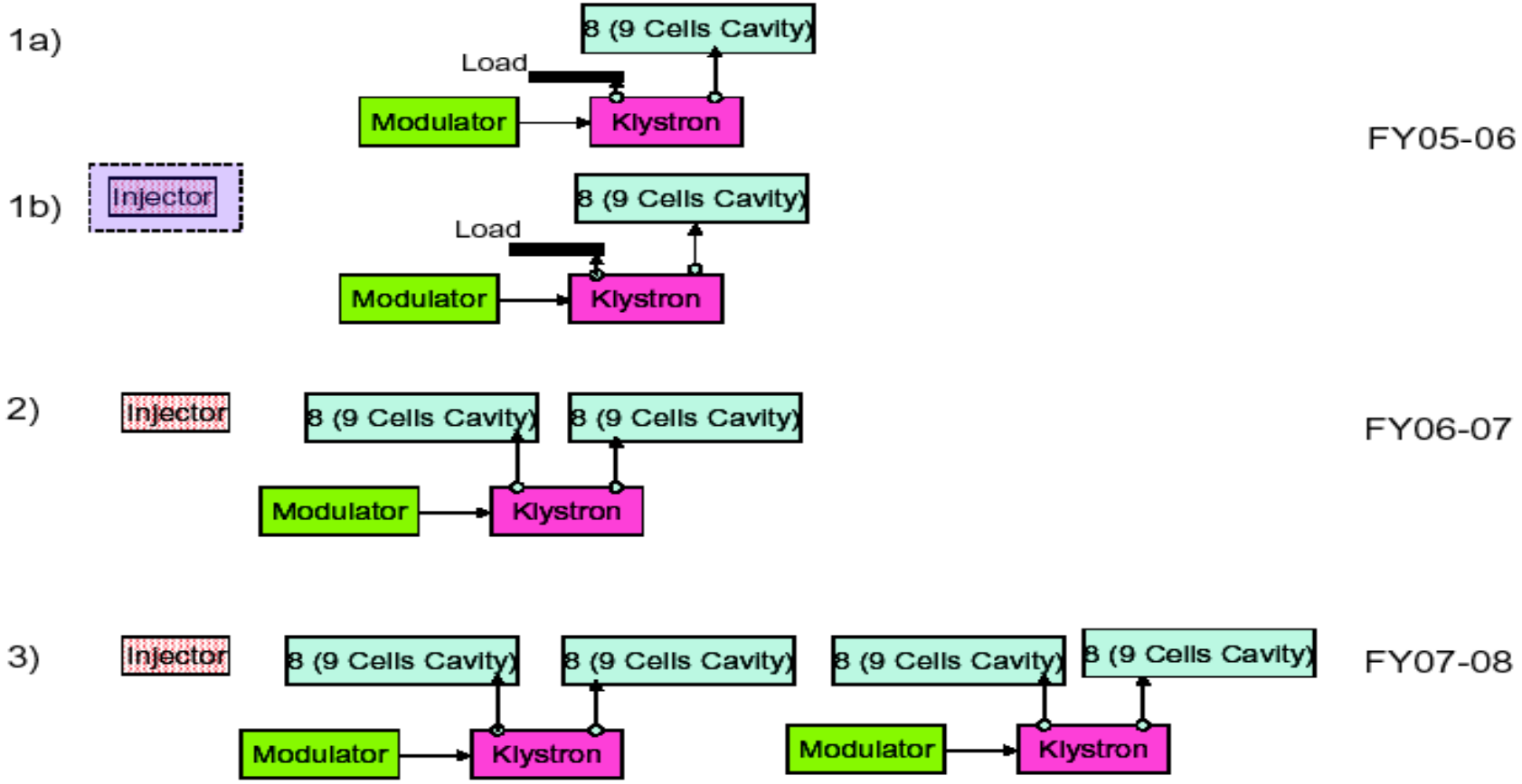
FNAL Meson Area SM&TF Layout Concept



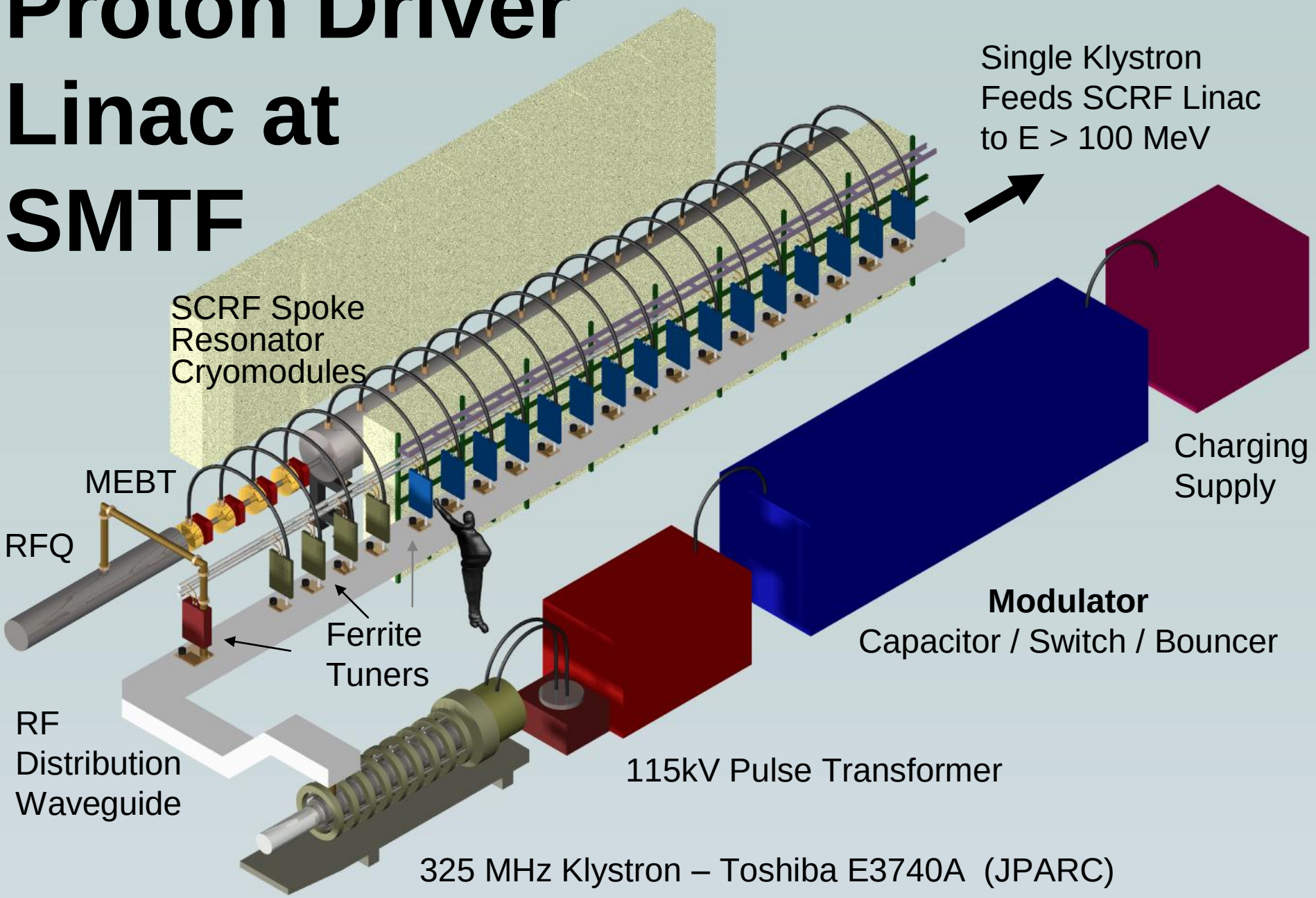
150 Meters

Three Phases of ILC Beam Line

1.3 GHz Cryomodule Test Facility



Proton Driver Linac at SMTF



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