# Status of Project X and India Collaboration

**Steve Holmes**

**IIFC Meeting**
**April 8, 2011**

# Outline

- Fermilab Long Range Plan
- Project X Reference Design
- R&D Plan
- Timeline & Strategy
- Collaboration Strategy

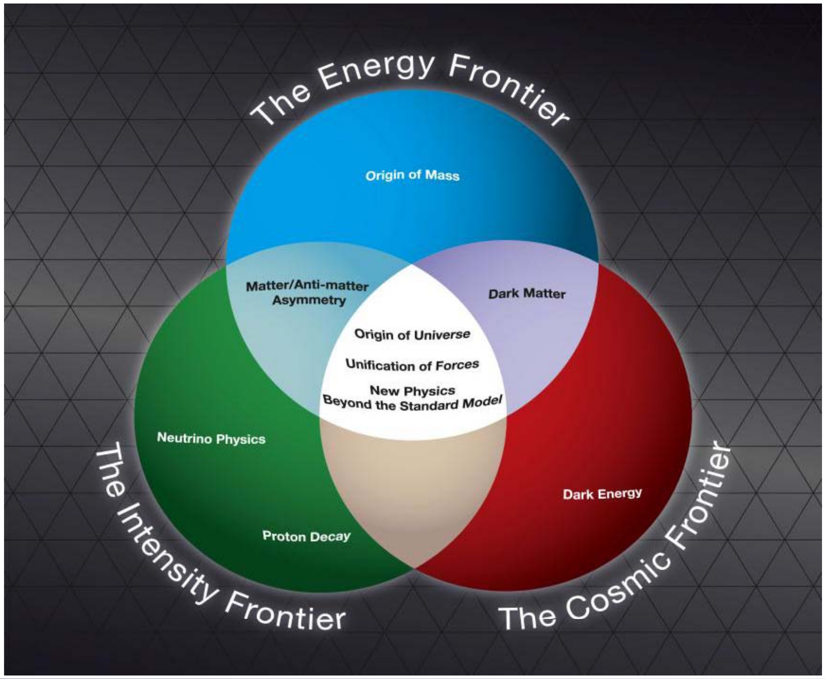
**Project X website: http://projectx.fnal.gov**

# Fermilab Long Range Plan

Fermilab is the sole remaining U.S. laboratory providing facilities in support of accelerator-based Elementary Particle Physics. Fermilab is fully aligned with the strategy for U.S. EPP developed by HEPAP/P5.

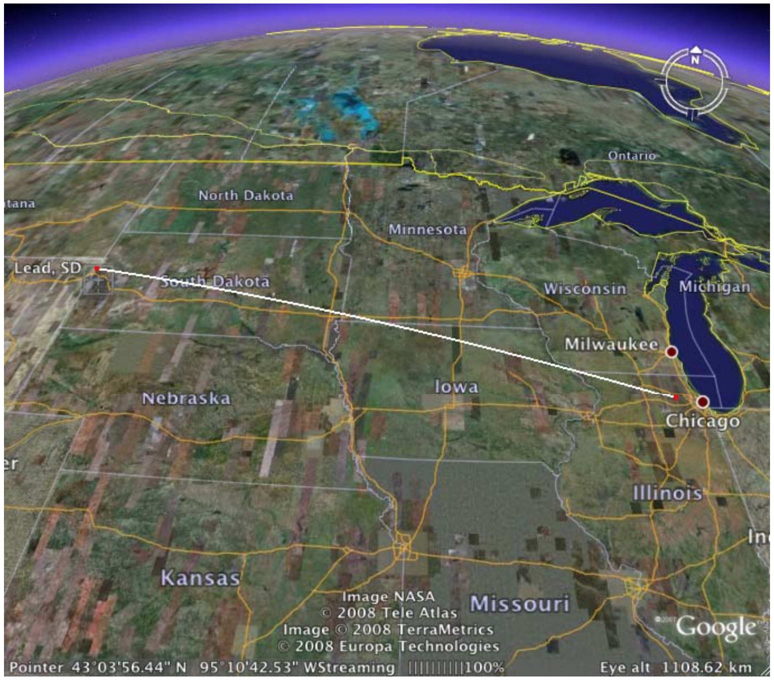
⇒ ***The Fermilab strategy is to mount a world-leading program at the <u>intensity frontier</u>, while using this program as a bridge to an <u>energy frontier</u> facility beyond LHC in the longer term.***

***Project X is the key element of this strategy***



# Mission

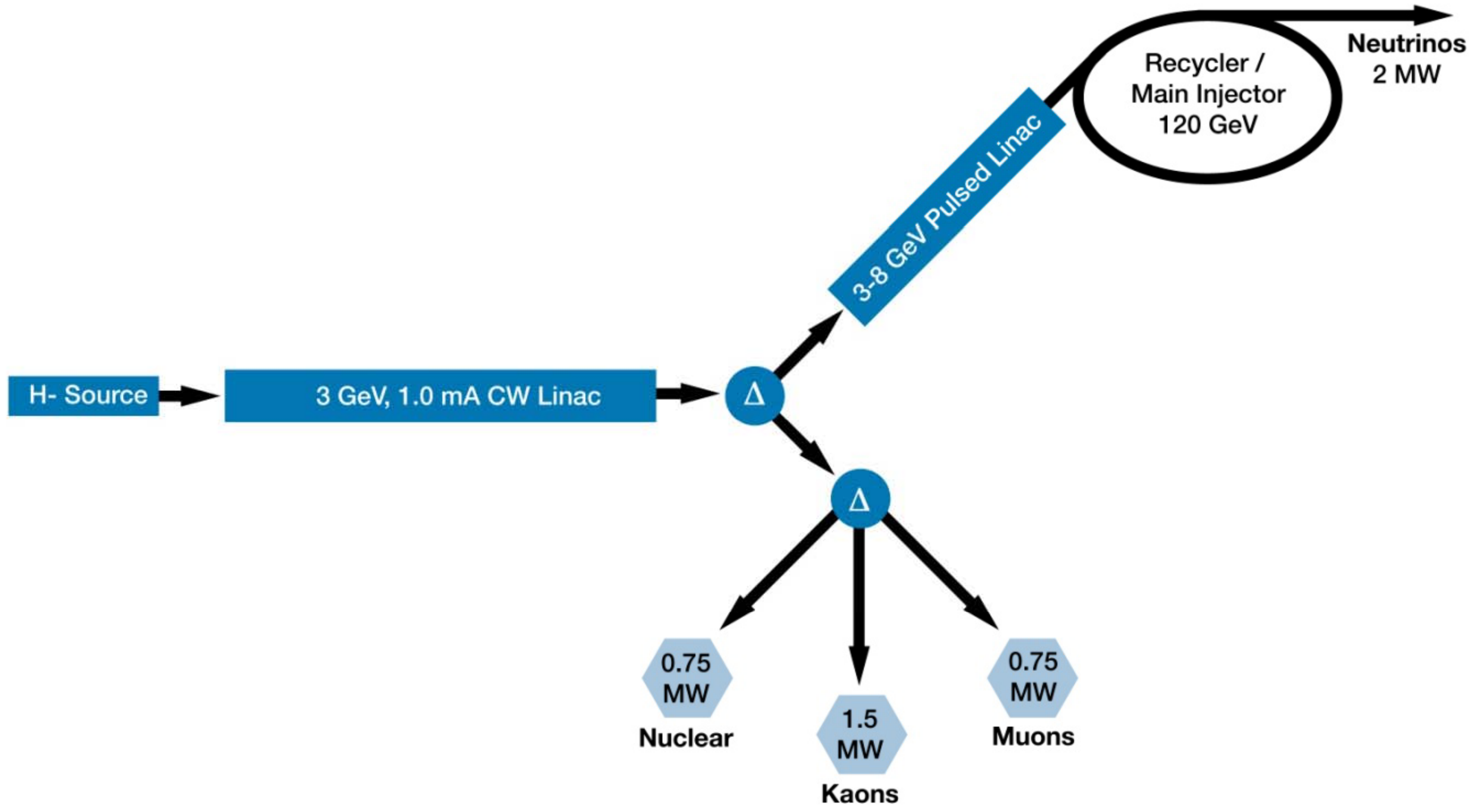
- A neutrino beam for long baseline neutrino oscillation experiments
  - 2 MW proton source at 60-120 GeV
- High intensity, low energy protons for kaon and muon based precision experiments
  - Operations simultaneous with the neutrino program
- A path toward a muon source for possible future Neutrino Factory and/or a Muon Collider
  - Requires ~4 MW at ~5-15 GeV
- Possible missions beyond P5
  - Standard Model Tests with nuclei and energy applications



# Concept Evolution

- Three Project X configurations have been developed, in response to perfromance limitations identified at each step:
  - Initial Configuration-1 (IC-1)
    - 8 GeV pulsed linac + Recycler/MI
    - Fully capable of supporting neutrino mission
    - Limited capabilities for rare processes
  - Initial Configuration-2 (IC-2)
    - 2 GeV CW linac + 2-8 GeV RCS + Recycler/MI
    - Fully capable of supporting neutrino mission
    - 2 GeV too low for rare processes (Kaons)
    - Ineffective platform for Neutrino Factory or Muon Collider
  - Reference Design
    - 3 GeV CW linac + 3-8 pulsed linac + Recycler/MI
    - Ameliorates above deficiencies

# Reference Design



# Reference Design Capabilities

- 3 GeV CW superconducting H- linac with 1 mA average beam current.
  - Flexible provision for variable beam structures to multiple users
    - CW at time scales >1 μsec, 10% DF at <1 μsec
  - Supports rare processes programs at 3 GeV
  - Provision for 1 GeV extraction for nuclear energy program
- 3-8 GeV pulsed linac capable of delivering 300 kW at 8 GeV
  - Supports the neutrino program
  - Establishes a path toward a muon based facility
- Upgrades to the Recycler and Main Injector to provide ≥ 2 MW to the neutrino production target at 60-120 GeV.

⇒ Utilization of a CW linac creates a facility that is unique in the world, with performance that cannot be matched in a synchrotron-based facility.

Project X

# Functional Requirements

| Requirement | Description | Value |
| --- | --- | --- |
| **L1** | Delivered Beam Energy, maximum | 3 GeV (kinetic) |
| **L2** | Delivered Beam Power at 3 GeV | 3 MW |
| **L3** | Average Beam Current (averaged over >1 μsec) | 1 mA |
| **L4** | Maximum Beam Current (sustained for <1 μsec) | 5 mA |
| **L5** | The 3 GeV linac must be capable of delivering correctly formatted beam to a pulsed linac, for acceleration to 8 GeV | |
| **L6** | Charge delivered to pulsed linac | 26 mA-msec in < 0.75 sec |
| **L7** | Maximum Bunch Intensity | $1.9 \times 10^{8}$ |
| **L8** | Minimum Bunch Spacing | 6.2 nsec (1/162.5 MHz) |
| **L9** | Bunch Length | <50 psec (full-width half max) |
| **L10** | Bunch Pattern | Programmable |
| **L11** | RF Duty Factor | 100% (CW) |
| **L12** | RF Frequency | 162.5 MHz and harmonics thereof |
| **L13** | 3 GeV Beam Split | Three-way |
| **P1** | Maximum Beam Energy | 8 GeV |
| **P2** | The 3-8 GeV pulsed linac must be capable of delivering correctly formatted beam for injection into the Recycler Ring (or Main Injector). | |
| **P3** | Charge to fill Main Injector/cycle | 26 mA-msec in <0.75 sec |
| **P4** | Maximum beam power delivered to 8 GeV | 300 kW |
| **P5** | Duty Factor (initial) | < 4% |

# Project X Functional Requirements

| Requirement | Description | Value |
|---|---|---|
| **M1** | Delivered Beam Energy, maximum | 120 GeV |
| **M2** | Delivered Beam Energy, minimum | 60 GeV |
| **M3** | Minimum Injection Energy | 6 GeV |
| **M4** | Beam Power (60-120 GeV) | > 2 MW |
| **M5** | Beam Particles | Protons |
| **M6** | Beam Intensity | 1.6 x $10^{14}$ protons per pulse |
| **M7** | Beam Pulse Length | ~10 μsec |
| **M8** | Bunches per Pulse | ~550 |
| **M9** | Bunch Spacing | 18.8 nsec (1/53.1 MHz) |
| **M10** | Bunch Length | <2 nsec (fullwidth half max) |
| **M11** | Pulse Repetition Rate (120 GeV) | 1.2 sec |
| **M12** | Pulse Repetition Rate (60 GeV) | 0.75 sec |
| **M13** | Max Momentum Spread at extraction | 2 x $10^{-3}$ |
| **I1** | The 3 GeV and neutrino programs must operate simultaneously | |
| **I2** | Residual Activation from Uncontrolled Beam Loss in areas requiring hands on maintenance. | <20 mrem/hour (average)<br><100 mrem/hour (peak) @ 1 ft |
| **I3** | Scheduled Maintenance Weeks/Year | 8 |
| **I4** | 3 GeV Linac Operational Reliability | 90% |
| **I5** | 60-120 GeV Operational Reliability | 85% |
| **I6** | Facility Lifetime | 40 years |
| **U1** | Provisions should be made to support an upgrade of the CW linac to support an average current of 4 mA. | |
| **U2** | Provisions should be made to support an upgrade of the Main Injector to a delivered beam power of ~4 MW at 120 GeV. | |
| **U3** | Provisions should be made to deliver CW proton beams as low as 1 GeV. | |
| **U4** | Provision should be made to support an upgrade to the CW linac such that it can accelerate Protons. | |
| **U5** | Provisions should be made to support an upgrade of the pulsed linac to support a duty factor or 10%. | |
| U6 | Provisions should be made to support an upgrade of the CW linac to a 3.1 nsec bunch spacing. | |

# Pulsed Linac

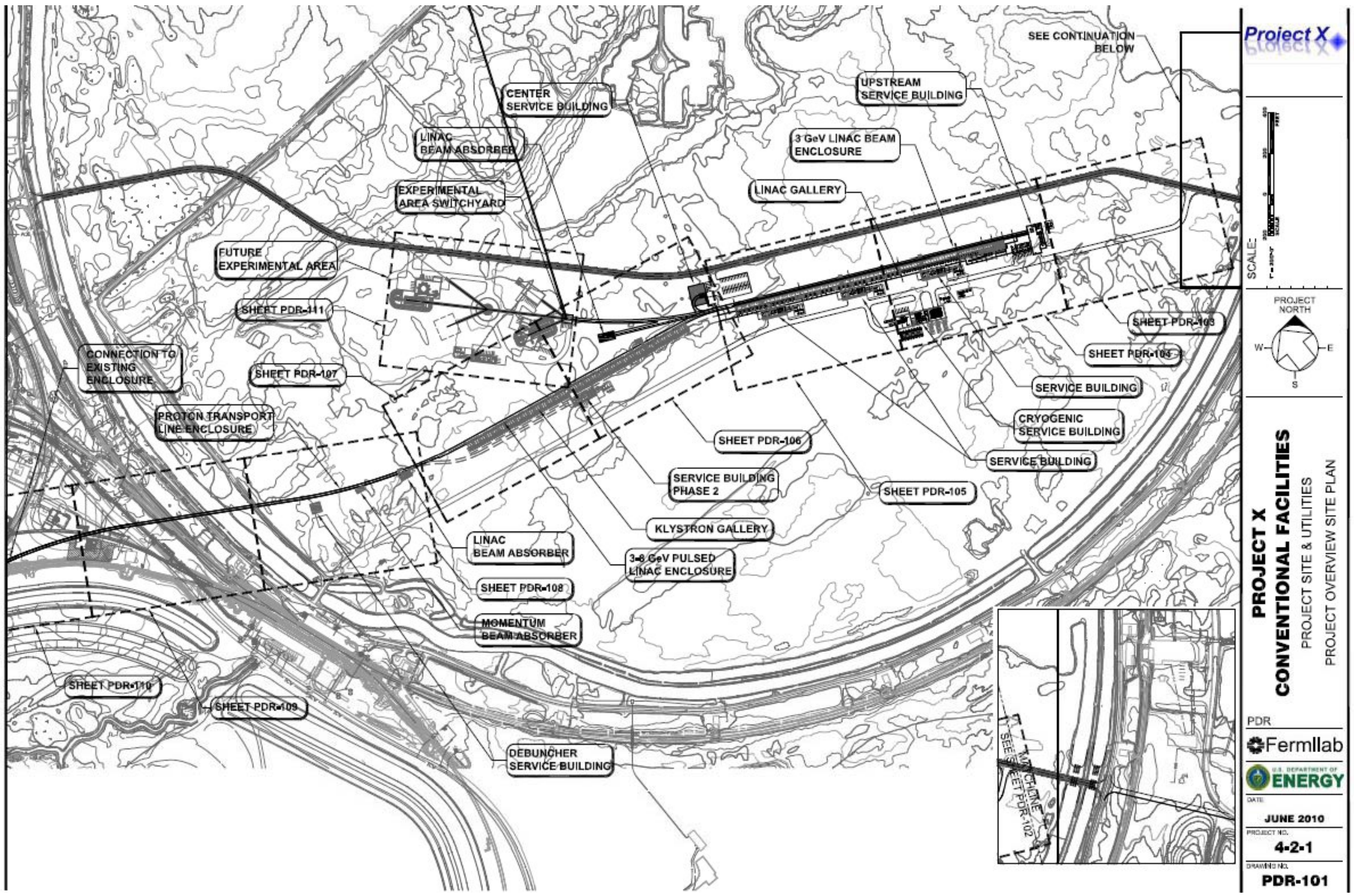
- The Reference Design utilizes a superconducting pulsed linac for acceleration from 3 to 8 GeV
- ILC style cavities and cryomodules
  - 1.3 GHZ, $\beta$=1.0
  - 28 cryomodules (@ 25 MV/m)
- ILC style rf system
  - 5 MW klystron
  - Up to four cryomodules per rf source
- Must deliver 26 mA-msec to the Recycler every 0.75 sec. Options:
  - 1 mA x 4.4 msec pulses at 10 Hz
    - Six pulses required to load Recycler/Main Injector
  - 1 mA x 26 msec pulses at 10 Hz
    - One pulse required to load Main Injector

# Project X — Performance Goals

| | | |
|---|---|---|
| **Linac** | | |
| Particle Type | $H^-$ | |
| Beam Kinetic Energy | 3.0 | GeV |
| Average Beam Current | 1 | mA |
| Linac pulse rate | CW | |
| Beam Power | 3000 | kW |
| Beam Power to 3 GeV program | 2870 | kW |
| **Pulsed Linac** | | |
| Particle Type | $H^-$ | |
| Beam Kinetic Energy | 8.0 | GeV |
| Pulse rate | 10 | Hz |
| Pulse Width | 4.3 | msec |
| Cycles to MI | 6 | |
| Particles per cycle to MI | $2.6\times10^{13}$ | |
| Beam Power to 8 GeV | 340 | kW |
| **Main Injector/Recycler** | | |
| Beam Kinetic Energy (maximum) | 120 | GeV |
| Cycle time | 1.4 | sec |
| Particles per cycle | $1.6\times10^{14}$ | |
| Beam Power at 120 GeV | 2200 | kW |

simultaneous

# Siting



SEE CONTINUATION BELOW
UPSTREAM SERVICE BUILDING
CENTER SERVICE BUILDING
3 GeV LINAC BEAM ENCLOSURE
LINAC BEAM ABSORBER
LINAC GALLERY
EXPERIMENTAL AREA SWITCHYARD
FUTURE EXPERIMENTAL AREA
SHEET PDR-111
SHEET PDR-103
SHEET PDR-104
CONNECTION TO EXISTING ENCLOSURE
SHEET PDR-107
SERVICE BUILDING
CRYOGENIC SERVICE BUILDING
PROTON TRANSPORT LINE ENCLOSURE
SHEET PDR-106
SERVICE BUILDING
SERVICE BUILDING PHASE 2
SHEET PDR-105
KLYSTRON GALLERY
LINAC BEAM ABSORBER
3-8 GeV PULSED LINAC ENCLOSURE
SHEET PDR-108
MOMENTUM BEAM ABSORBER
SHEET PDR-110
SHEET PDR-109
DEBUNCHER SERVICE BUILDING
Project X
SCALE
PROJECT NORTH
W
E
S
PROJECT X
CONVENTIONAL FACILITIES
PROJECT SITE & UTILITIES
PROJECT OVERVIEW SITE PLAN
PDR
Fermilab
ENERGY
JUNE 2010
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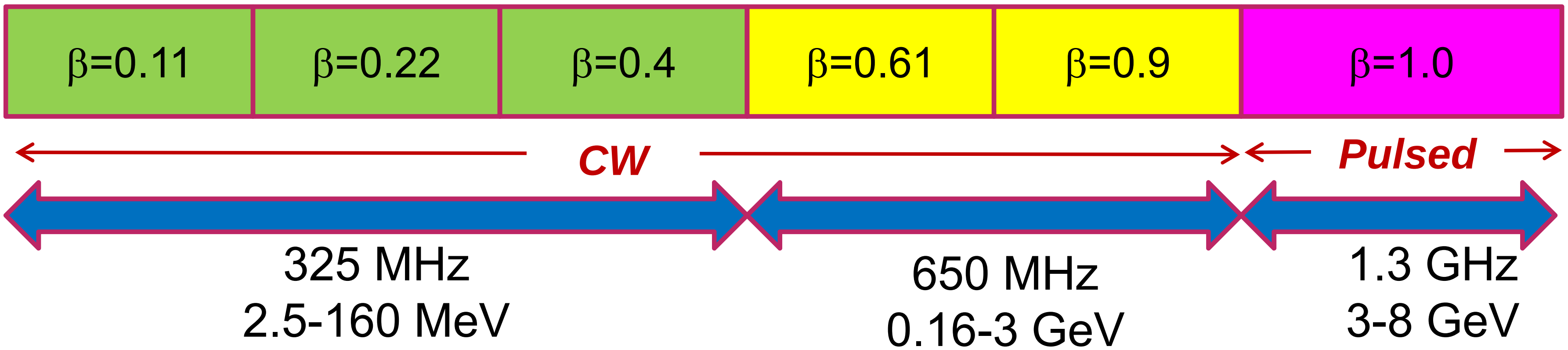
PDR-101

# R&D Program

- The primary elements of the R&D program include:
  - Development of a wide-band chopper
    - Capable of removing bunches in arbitrary patterns at a 162.5 MHz bunch rate
  - Development of an H- injection system
    - Require between 4.4 – 26 msec injection period, depending on pulsed linac operating scenario
  - Superconducting rf development
    - Includes six different cavity types at three different frequencies
    - Emphasis is on $Q_0$, rather than high gradient
      - Typically 1.5E10, 15 MV/m (CW)
      - 1.0E10, 25 MV/m (pulsed)
    - Includes appropriate rf sources
    - Includes development of partners
- Goal is to complete R&D phase by 2015

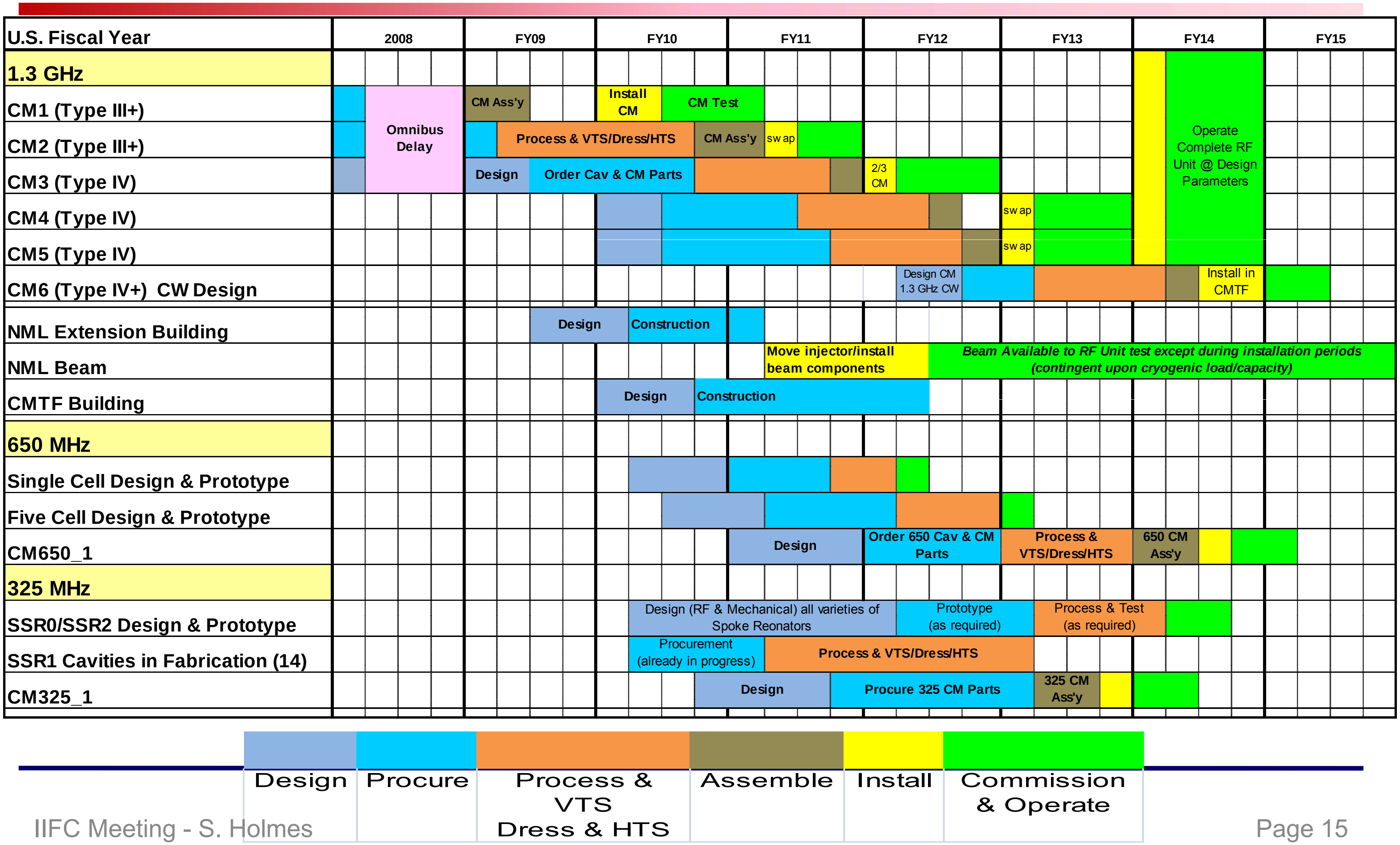
# SRF Linac
## Technology Map




| Section | Freq | Energy (MeV) | Cav/mag/CM | Type |
|---|---|---|---|---|
| SSR0 ($\beta_G$=0.11) | 325 | 2.5-10 | 18 /18/1 | SSR, solenoid |
| SSR1 ($\beta_G$=0.22) | 325 | 10-42 | 20/20/ 2 | SSR, solenoid |
| SSR2 ($\beta_G$=0.4) | 325 | 42-160 | 40/20/4 | SSR, solenoid |
| LB 650 ($\beta_G$=0.61) | 650 | 160-460 | 36 /24/6 | 5-cell elliptical, doublet |
| HB 650 ($\beta_G$=0.9) | 650 | 460-3000 | 160/40/20 | 5-cell elliptical, doublet |
| ILC 1.3 ($\beta_G$=1.0) | 1300 | 3000-8000 | 224 /28 /28 | 9-cell elliptical, quad |

# SRF Development

## Integrated ILC/ Project X Plan



# SRF Development
## Cavity/ CM Status

- 1300 MHz
  - 88 nine-cell cavities ordered
  - ~ 44 received (16 from U.S. industry, AES)
  - ~ 30 processed and tested, 8 dressed
  - 1 CM built (DESY kit) + second under construction (U.S. procured)
    - CM1 is now cold and about to initiate rf testing
- 650 MHz: No Cavities yet
  - MOU signed with Jlab for 2 single cell $\beta$ =0.6 cavities
  - Order for six $\beta$ = 0.9 single cell cavities in industry
  - $\beta$=0.9 cavities under development at RRCAT
- 325 MHz:
  - 2 SSR1 $\beta$ =0.22 cavities (Roark, Zannon) both VTS tested
  - 1 SSR1 dressed and under test at STF
  - 2 SSR1 being fabricated at IUAC
  - 10 SSR1 ordered from Industry (Roark)
- Design work started on 325 and 650 MHz CM

# Test Facilities

- New Muon Lab (NML) facility under construction for ILC RF unit test
  - Three CM's driven from a single rf source
  - 9 mA x 1 msec beam pulse
  - Large extension and supporting infrastructure under construction
    - Refrigerator to support full duty factor operations
    - Horizontal test stands for all frequencies
    - Building extension for additional CM's and beam diagnostic area
- The Meson Detector Building (MDB) Test Facility ultimately comprises:
  - 2.5 – 10 MeV beam (p, H-): 1% duty factor, 3 msec pulse
    - 325 MHz superconducting spoke cavity beam tests
    - Chopper tests
    - $H^-$ beam instrumentation development
  - Shielded enclosures and RF power systems for testing individual, jacketed 1.3 GHz, 650 MHz, and 325 MHz superconducting RF cavities

# Strategy and Timeline

- Reference Design is the facility that meets the mission requirements
  - We expect to build this, or something very close
- Strategy for CD-0 being developed with DOE
  - CD-0 = "Approve Mission Need"
  - Staging:
    - 3 GeV CW linac
    - Rare processes initial physics program
  - Cost range:
    - Cost vs. performance
  - Intensity Frontier Physics Workshop:
    - Neutrinos
    - Rare processes
    - Nuclear
    - Late summer/early fall
- Timeline
  - CD-0: Late 2011/early 2012
  - Approve Start of Construction: Late 2015/early 2016
  - 5 year construction period (spans two Indian 5-year plans)

$\Rightarrow$ Project X could be up and running in ~2020

Project X

# Collaboration

- A multi-institutional collaboration has been established to execute the Project X RD&D Program.
  - Organized as a "national project with international participation"
    - Fermilab as lead laboratory
    - International participation established via bi-lateral MOUs.
  - Collaboration MOUs for the RD&D phase outlines basic goals, and the means of organizing and executing the work. Signatories:

| | | |
|---|---|---|
| ANL | ORNL/SNS | BARC/Mumbai |
| BNL | MSU | IUAC/Delhi |
| Cornell | TJNAF | RRCAT/Indore |
| Fermilab | SLAC | VECC/Kolkata |
| LBNL | ILC/ART | |

- It would be natural for collaborators to continue their areas of responsibility into the construction phase.

Project X

# Review of Current Institutional Responsibilities

| | Front End | Cav & CMs | RF | Cryo | Instru | Cntrls | MI/Recycler | Beam Trnspt | Accel Phys | Systm Integ | Test Facil |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ANL | | X | X | | | | | | X | | |
| BNL | | X | | | | | | X | | | |
| Cornell | | X | | | | | X | | | | |
| Fermilab | X | X | X | X | X | X | X | X | X | X | X |
| LBNL | X | | | | X | | | | X | | |
| SNS | | | | | X | | | | | | |
| MSU | | X | | X | | | | | | | |
| TJNAF | | X | | | | | | | | | |
| SLAC | X | | X | | | | X | | X | | X |
| ILC/ART | | X | | | | | | | | | X |
| BARC | X | X | X | X | X | | | | | | X |
| IUAC | | X | | X | | | | | | | |
| RRCAT | | X | X | X | | | | | | | X |
| VECC | | X | | X | | | | | | | |

# India-Fermilab Collaboration


- Phase 1 and 2 (R&D)
  - Collaboration initiated in 2007
    - ILC/SRF
  - Reorientation to High Intensity Proton Accelerator in 2009
    - SRF at low betas
  - Expanded into other technical areas in 2010
    - All major technical components in the CW linac
  - Formalized management structure for IIFC implemented in 2010
- Phase 3 (Construction)
  - In process of outlining a schedule of Indian deliverables
  - Alignment of Indian technical aspirations with Project X requirements
  - Indian participation in installation and commissioning of Project X
  - Two Indian projects under discussion
    - SNS: 1-2 GeV linac + ring
    - ADS: ~1 GeV CW linac

# Indian Collaboration
# Phase 3

- Accelerating cavities
  - 325 MHz: SSR1, SSR2
  - 650 MHz; $\beta$=0.6, 0.9
- RF Power
  - 325 MHz
  - 650 MHz
- Cryomodules
  - 325 MHz: focusing solenoids
  - 650 MHz: focusing quadrupole + other components
- Cryogenic Plant
- Instrumentation/controls
  - 325 MHz: BPMs, LLRF components
  - 625 MHz: BPMs, LLRF components
- Personnel
  - ~20 Scientist/engineer
    - Management, design, fabrication, installation, commissioning

# Summary

- Project X is central to Fermilab's strategy for development of the accelerator complex over the coming decade
  - World leading programs in neutrinos and rare processes
  - Potential applications beyond elementary particle physics
- A mature design concept has been established, offering capabilities that are unique among any high intensity facility in existence or under design
  - 2 MW to the neutrino program over 60-120 GeV
  - 3 MW to the rare processes program
  - Flexible provision for variable beam formats to multiple users
- R&D underway with very significant investment in srf infrastructure and development
- Strategy for moving the project forward is being developed with DOE
  - Likely staging with CW linac as initial stage
- Indian collaboration has been a primary driver in getting Project X to where it is today
- Project X could be constructed over the period ~2016 – 2020

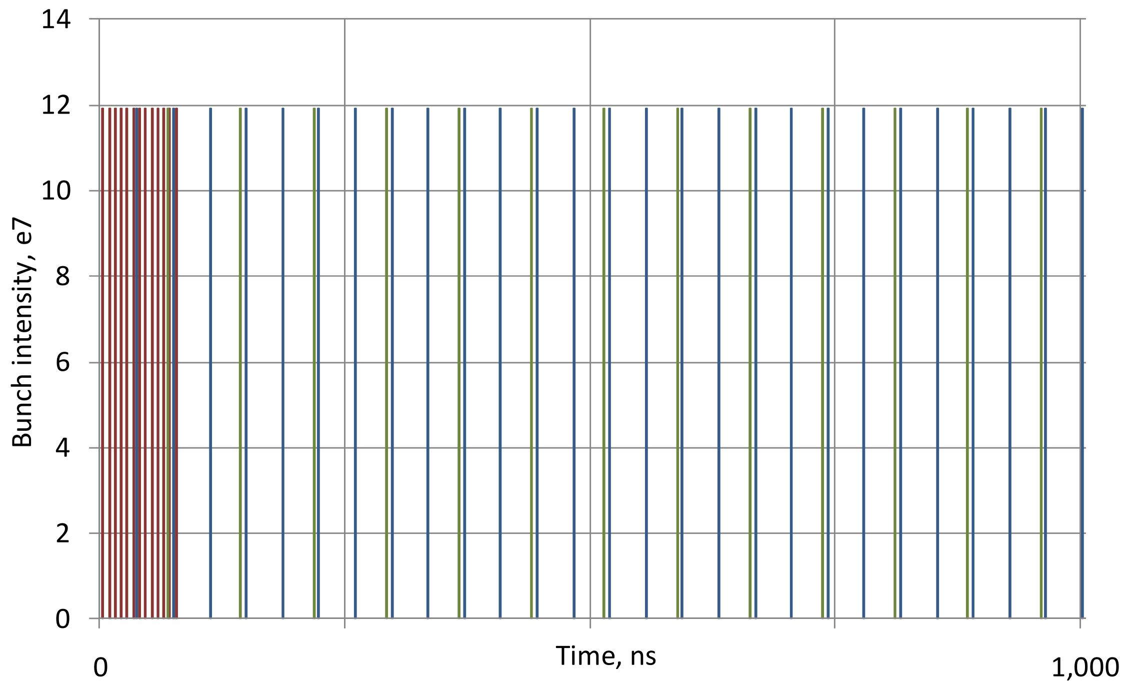
# Backup Slides

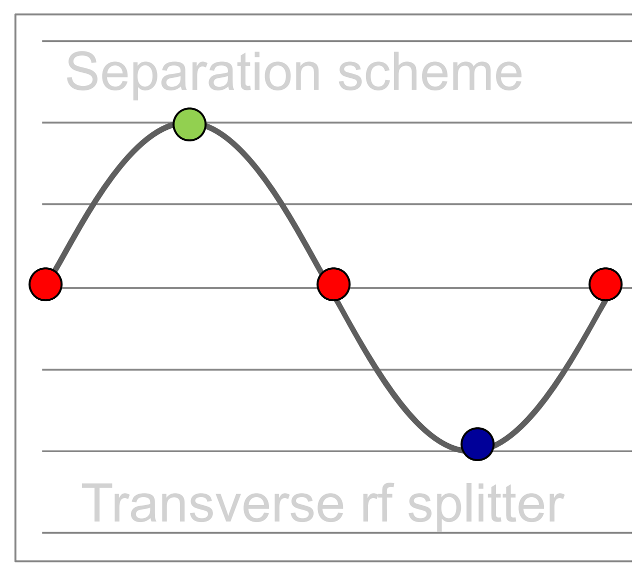
# Operating Scenario
## 3 GeV Program

1 μsec period at 3 GeV

| | |
|---|---|
| Muon pulses (12e7) 162.5 MHz, 80 nsec | 750 kW |
| Kaon pulses (12e7) 27 MHz | 1500 kW |
| Nuclear pulses (12e7) 13.5 MHz | 750 kW |

Ion source and RFQ operate at 6.2 mA
83% of bunches are chopped @ 2.5 MeV ⇒ maintain 1 mA over 1 μsec

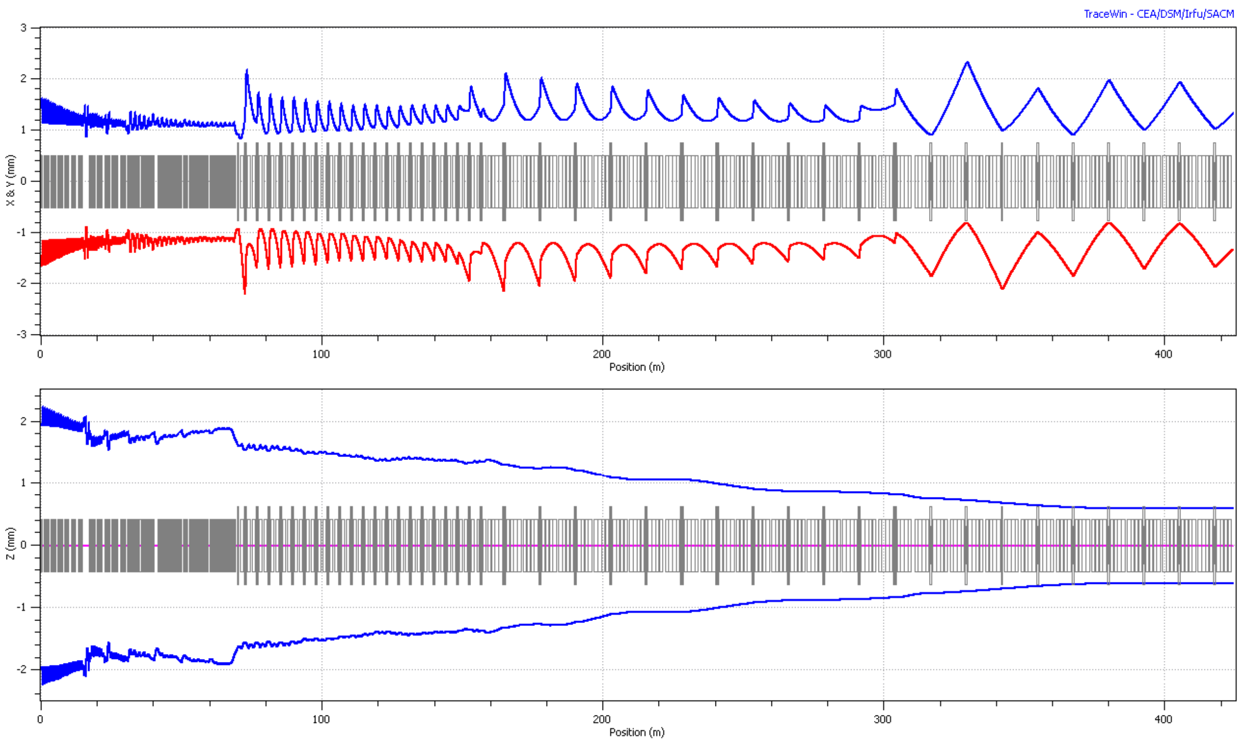


# SRF Development
## 1300 MHz

- Cavity development is being undertaken in the U.S. as part of the ILC program
  - ILC goal: 31.5 MV/m (average CM gradient); $Q_0=8x10^9$
  - Project X goals:
    - CW: G=16 MV/m; $Q_0=1.5x10^{10}$
    - Pulsed: G=25 MV/m; $Q_0=1x10^{10}$
- Development undertaken by a U.S. consortium of labs/universities/industry
  - Fermilab, JLab, Argonne, Cornell
  - Cavites from U.S. and European vendors
- Substantial investment in infrastructure at Fermilab
  - Vertical and horizontal test stands
  - Cavity and cryomodule assembly areas
  - ILCTA_NML
  - Goal is to have capability of 1 CM/month by 2015

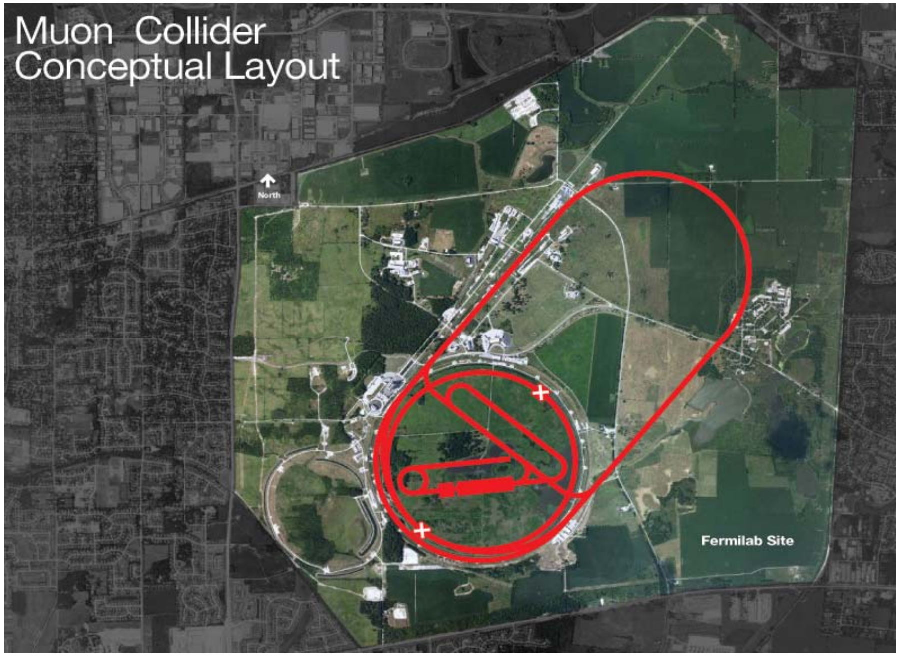
# 3 GeV CW Linac
## Beam Dynamics at 1 mA




- 1 $\sigma$ beam envelopes
  - Transverse (upper)
  - Longitudinal (lower)

# Project X — Joint PX/NF/MC Strategy

- Project X shares many features with the proton driver required for a Neutrino Factory or Muon Collider
  - NF and MC require ~4 MW @ 10± 5 GeV
  - Primary issues are related to beam "format"
    - NF wants proton beam on target consolidated in a few bunches; Muon Collider requires single bunch
  - Project X linac is not capable of delivering this format

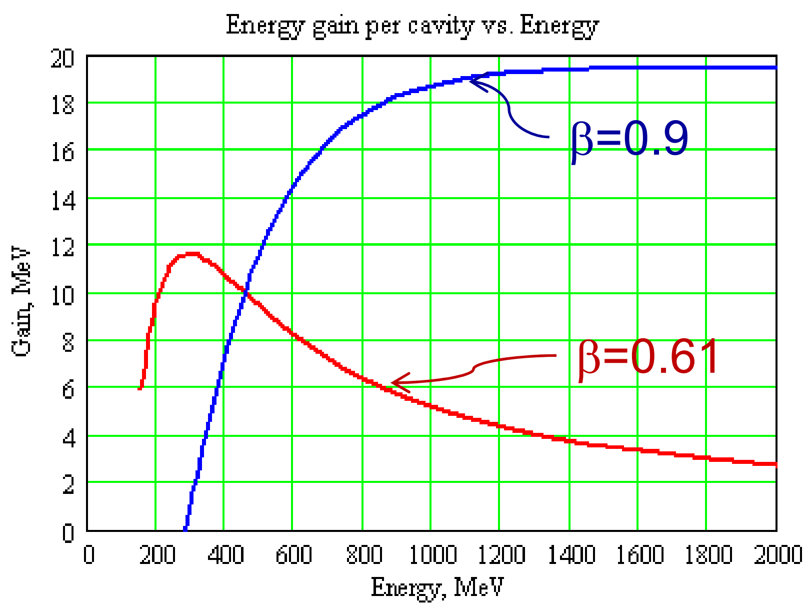


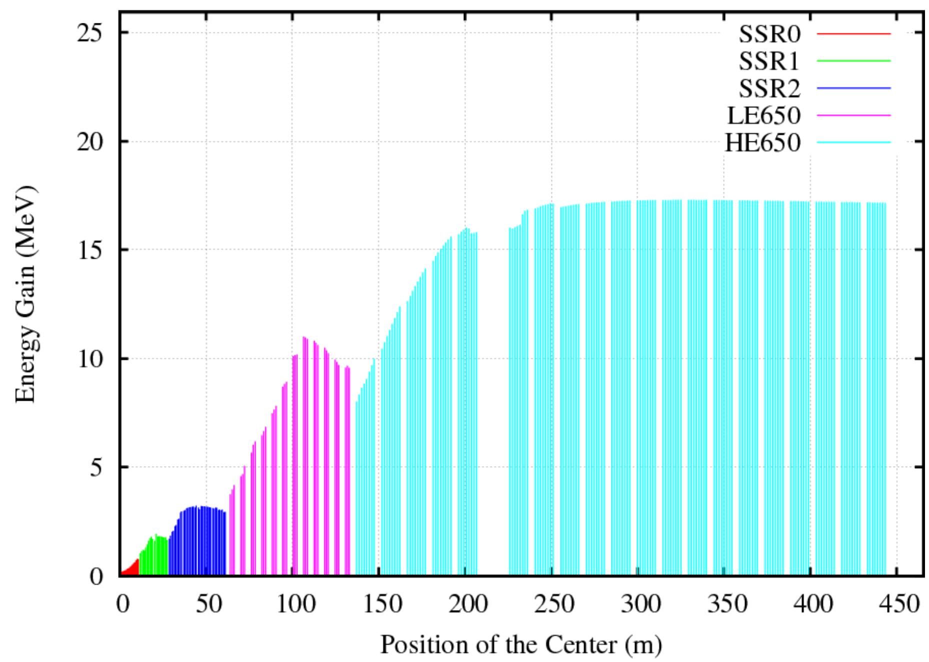

⇒ It is inevitable that a new ring(s) will be required to produce the correct beam format for targeting.

# Accelerator Requirements:
## Rare Processes

| | Proton Energy (kinetic) | Beam Power | Beam Timing |
|---|---|---|---|
| Rare Muon decays | 2-3 GeV | >500 kW | 1 kHz – 160 MHz |
| (g-2) measurement | 8 GeV | 20-50 kW | 30- 100 Hz. |
| Rare Kaon decays | 2.6 – 4 GeV | >500 kW | 20 – 160 MHz. (<50 psec pings) |
| Precision $K^0$ studies | 2.6 – 3 GeV | > 100 $\mu$A (internal target) | 20 – 160 MHz. (<50 psec pings) |
| Neutron and exotic nuclei EDMs | 1.5-2.5 GeV | >500 kW | > 100 Hz |

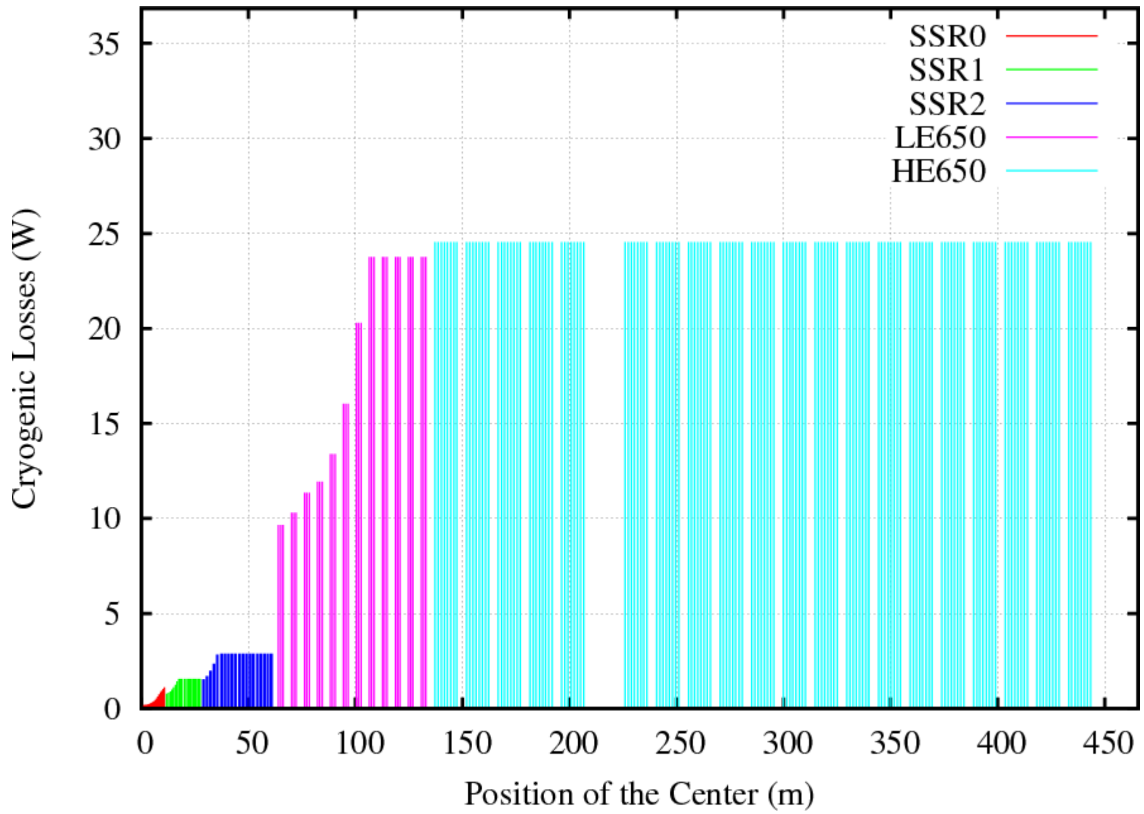
# 3 GeV CW Linac
# Energy Gain per Cavity



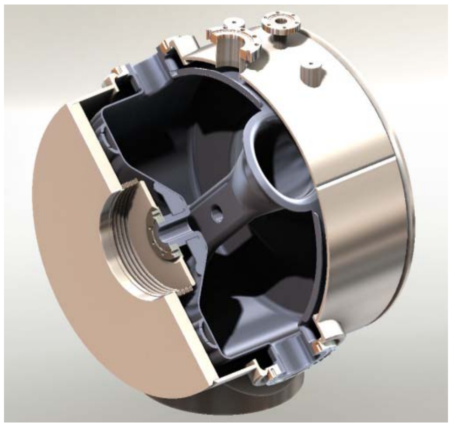

- Based on 5-cell 650 MHz cavity
  - Crossover point ~450 - 500 MeV
- Single cavity per power source
  - Solid State, IOT

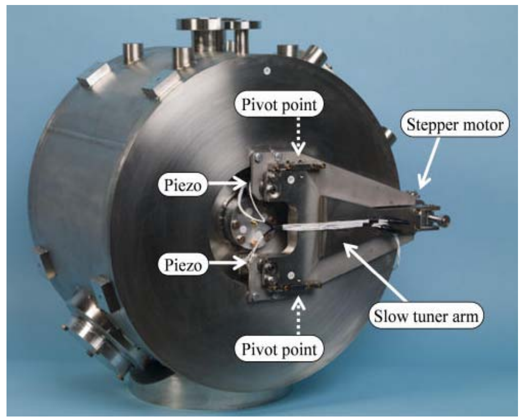
# 3 GeV CW Linac
## Cryogenic Losses per Cavity

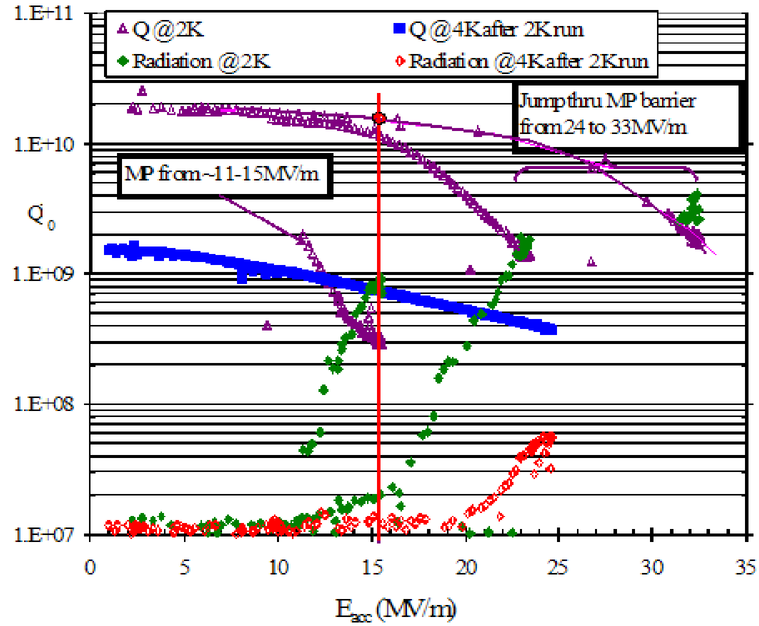



- ~42 kW cryogenic power at 4.5 K equivalent

# SRF Development
## 325 MHz

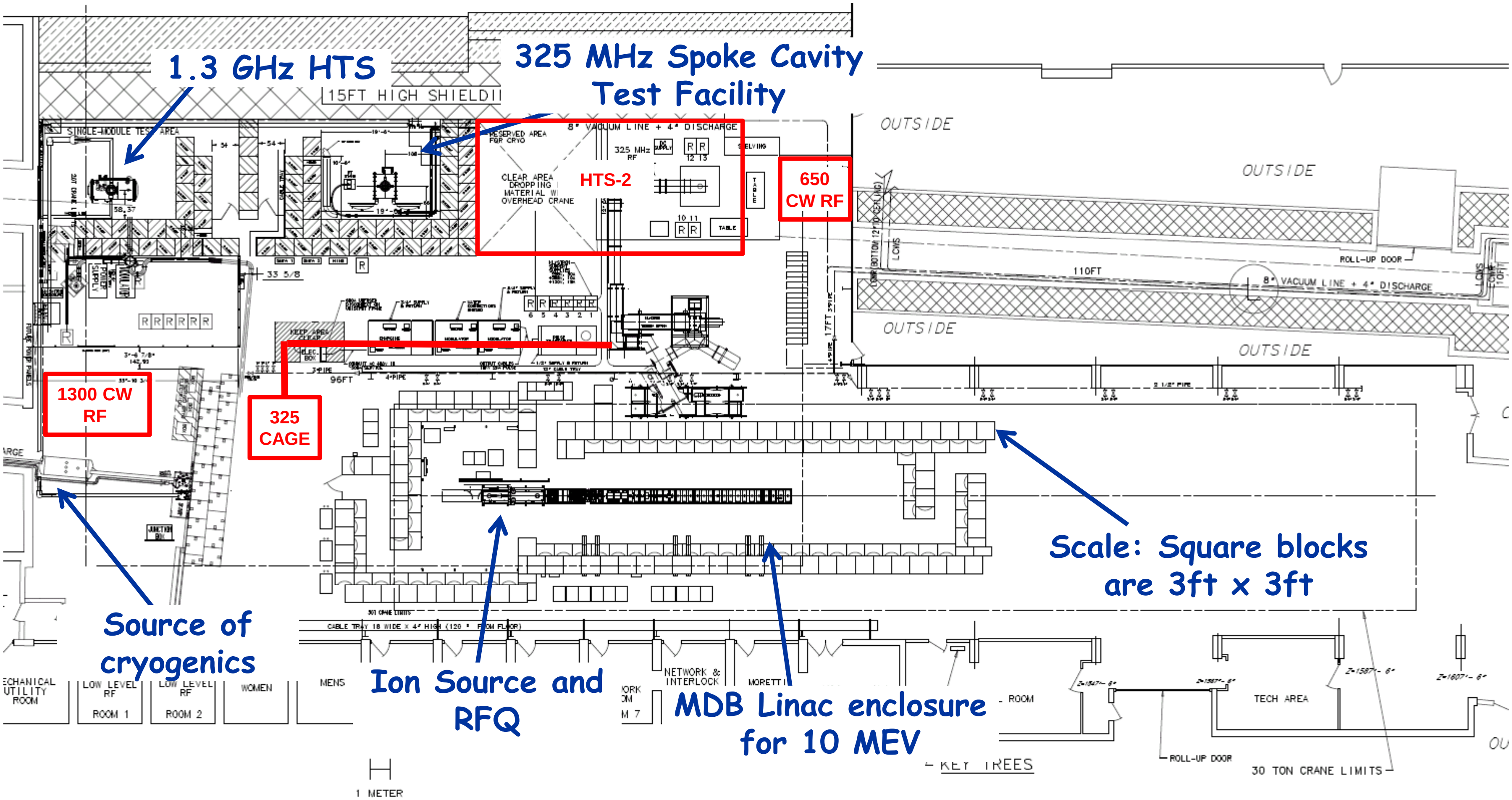





- SSR1 (β=0.22) cavity under development
  - Two prototypes assembled and tested
  - Both meet Project X specification at 2 K
- Preliminary designs for SSR0 and SSR2

# MDB Test Facility Layout



# ILCTA_NML Facility

# Project X — Expansion of NML Facility

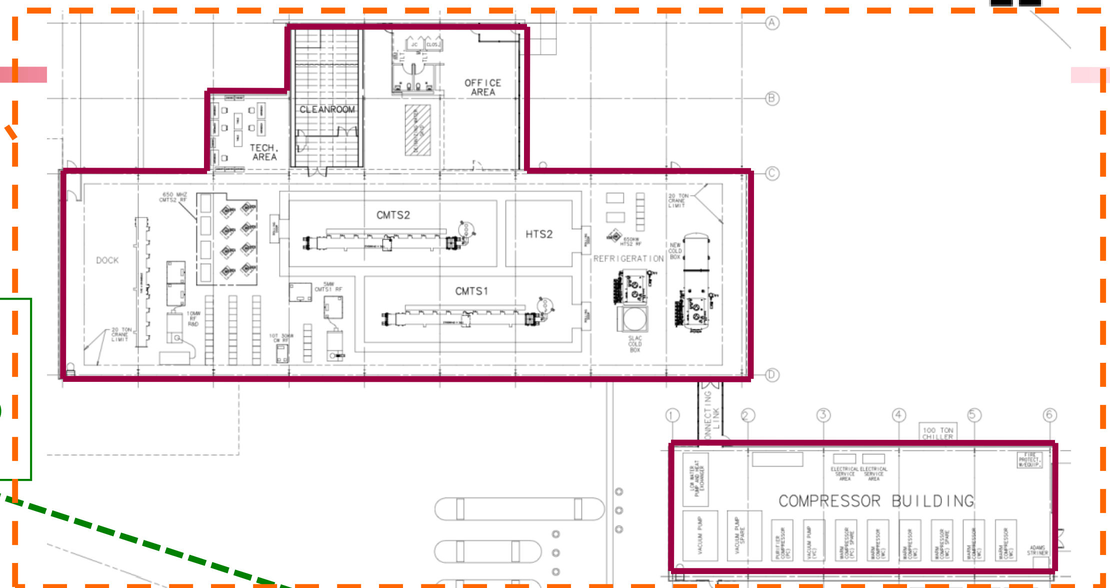
**New Cryoplant & CM Test Facility**

(300 W Cryogenic Plant, Cryomodule Test Stands, 10 MW RF Test Area)

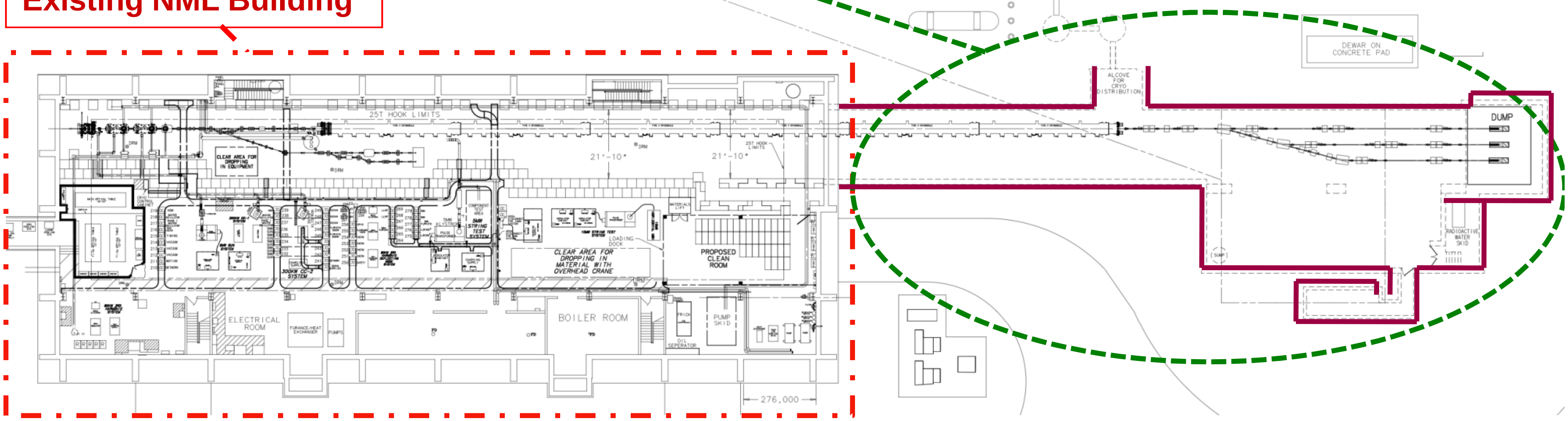
Funded by ARRA

**New Underground Tunnel Expansion**

(Space for 6 Cryomodules (2 RF Units), AARD Test Beam Lines)




**Existing NML Building**



# Future NML Complex

Project X

# NML Schedule/Milestones

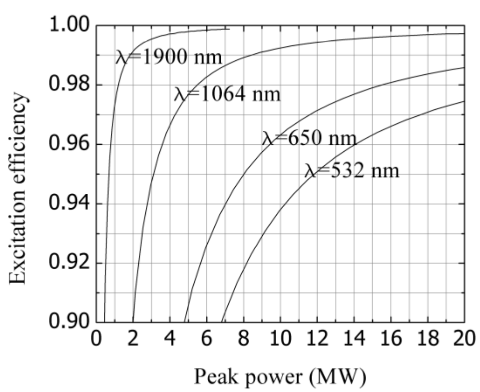
| | |
|---|---|
| • Phase-1 Cryogenic System Operational | (August 2007) |
| • Delivery of First Cryomodule to NML | (August 2008) |
| • Begin Civil Construction of NML Expansion | (March 2010) |
| | |
| • First Cryomodule Ready for Cooldown | (Fall 2010) |
| • Cold RF Testing of First Cryomodule | (Fall 2010) |
| • Start Construction of CMTF Building | (Fall 2010) |
| • Delivery of 2nd Cryomodule to NML (S1) | (2010) |
| • Install Injector & Test Beam Lines | (2011) |
| • First Beam | (2012) |
| • New Cryoplant Installation/Operation | (2013-14) |
| • RF unit test with beam | (2014) |

# R&D Program
# H- Injection

- RDR Configuration
  - Inject and accumulate into the Recycler with single turn transfer to MI
  - Injection charge 26 mA-ms (1 mA – 4.3 ms – 6 injections and 10 Hz)
- Optional Configuration of interest
  - Inject 1 mA directly into the Main Injector in a single pulse over 26 ms, bypassing the Recycler
    - Reduced complexity
    - Reduced linac energy, from 8 to 6 GeV
- Default technology Carbon Foil Charge Exchange (stationary foil)
  - Low beam current/long injections time creates many "parasitic" interactions, and dominate the foil issues:
    - Foil heating, beam loss, emittance growth. (c.f. 1 mA$\rightarrow$ 2300 turns)
  - The number of parasitic hits is determined by injection insertion design, number of injection turns (linac intensity and injection time), linac and ring emittance, painting algorithm, foil size and orientation.
  - Issues appear manageable up to about 4.3 msec (400 turns).

# R&D Program
# H- Injection

- Injection Stripping technologies (2300 turns)
  - Unique foil implementation designs-> moving, rotating, segmented
  - Laser Assisted Stripping (3 Step process)
    - Laser Power Estimates




Estimates by T. Gorlov, SNS

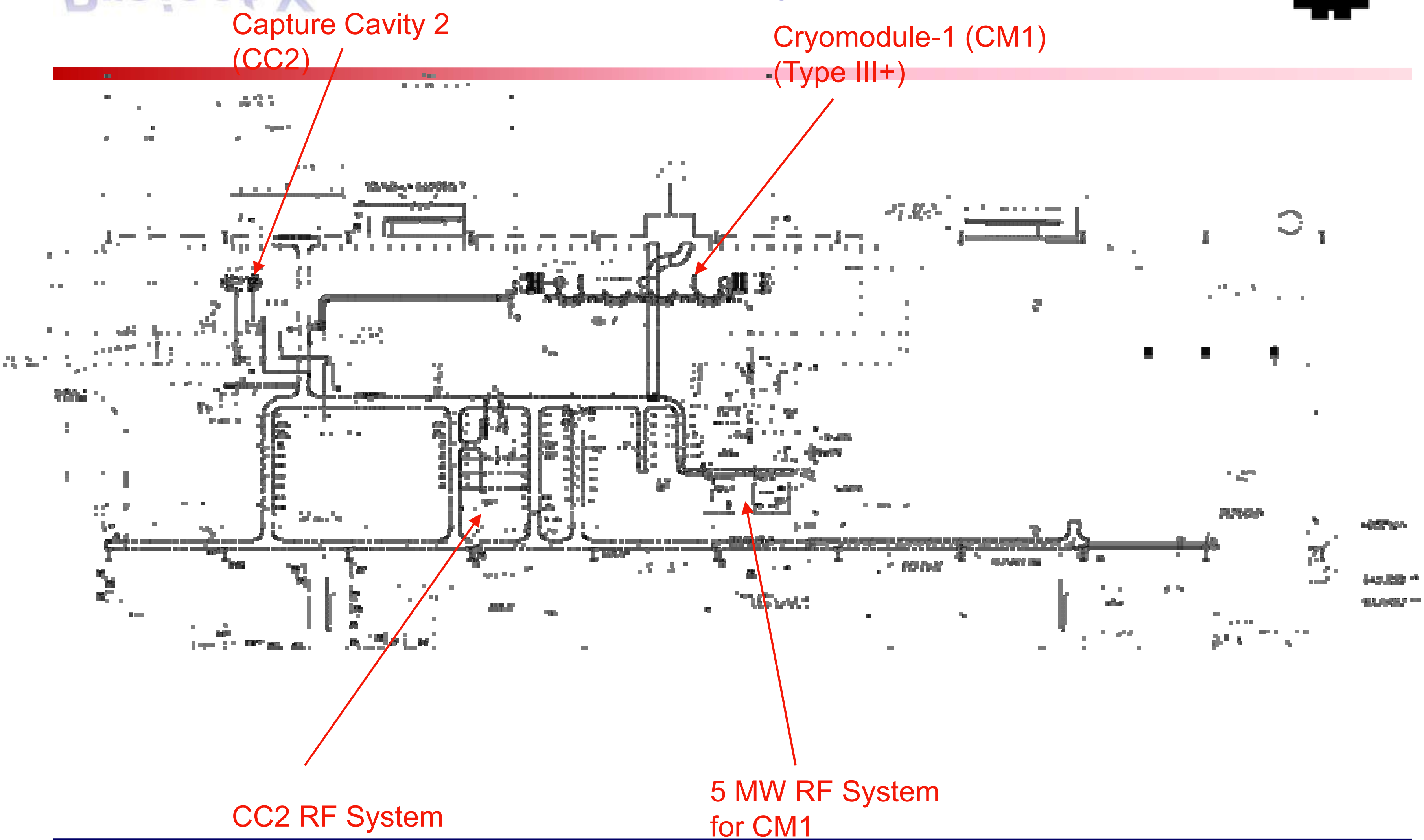
| Laser parameters | SNS | Prj X |
|---|---|---|
| Wavelength [nm] | 355 | 1064 |
| Pulse length [ps] | 30 | 28 |
| Pulse freq. [Mhz] | 400 | 325 |
| Pulse duration [ms] | 1 | 1 to 30 |
| Rep rate [Hz] | 60 | 10 to 1 |
| Peak Power [MW] | 0.39 | 5 to 10 |
| Pulse Energy [mJ] | 0.03 | 0.4 – 0.7 |
| Power @pulse freq [kW] | 12 | 130 - 230 |

    - Implementation Options
      - Direct illumination (advances in cryogenic laser amplifiers)
      - Build up cavity (low power laser but requires cavity in high radiation area)
      - Use higher wavelength (i.e. 2 mm) to reduce laser power by factor of 4 or 5

# NML Cryogenic System

- NML Cryogenic System Plan
  – Start with two 625 W (4K) Tevatron satellite Refrigerators and large vacuum pump ( ~ 60 W at 1.8 K)
  – Move 1000 W (4 K) BABAR refrigerator from SLAC
  – Add new 250 W (2 K) refrigerator
- Status
  – Installed Refrigerator room & helium storage tanks
  – Tevatron Satellite Refrigerator #1 operational - 8/07
  – Tevatron Satellite Refrigerator #2 operational – 4/10
  – Distribution system - Feedbox, Feed Cap & End Cap installed
  – Vacuum pump and Frick compressor
  – Capture Cavity-2 (CC2) Cooled to 2K – 10/09
  – Cryomodule-1 (CM1) Cool down to 2K – Fall, 2010
  – 250 W refrigerator on order

# Phase-1 Layout of NML



## HINS "Six-Cavity Test" Goals Statement

Bob Webber

October 28, 2009

Beams Document 2986-v2, High Intensity Neutrino Source R&D Program Goals Statement, specifically defines the goals of the Fermilab HINS program. The second of the four stated goals is:

*Demonstrate the use of high power RF vector modulators to control multiple RF cavities driven by a single high power klystron for acceleration of a non-relativistic beam*

The HINS "Six-Cavity Test" is an intermediate configuration of the front-end of the HINS Linac for achieving this particular goal in a period that precedes the availability of cryogenics required by superconducting solenoid magnets in the baseline HINS design.
The "Six-Cavity Test" configuration consists of the ion source and 2.5 MeV RFQ followed by a beam line comprising six HINS room-temperature RF cavities with individual vector modulators, quadrupoles for transverse focusing, beam diagnostics devices, and a beam absorber. The single 325 MHz Toshiba E3740A-Fermi klystron provides RF power for the RFQ and all six cavities.

# MBD Short Term Plan

- November
  - Re-install RFQ and re-connect to ion source
  - Begin Six-Cavity Test RF power distribution system installation
- December
  - Re-condition RFQ with RF power
  - Begin installation of Six-Cavity Test cabling and other prep work
- January 2011
  - Re-commission 2.5 MeV beam
  - 2.5 MeV beam energy, emittance, energy spread and bunch length measurements
- March - May
  - Six-Cavity Test beam line and supporting systems installation
  - Begin preliminary tests of installed Six-Cavity Test subsystems
  - Commission new klystron
- June
  - Six-Cavity Test commissioning
- July
  - Install H- ion source

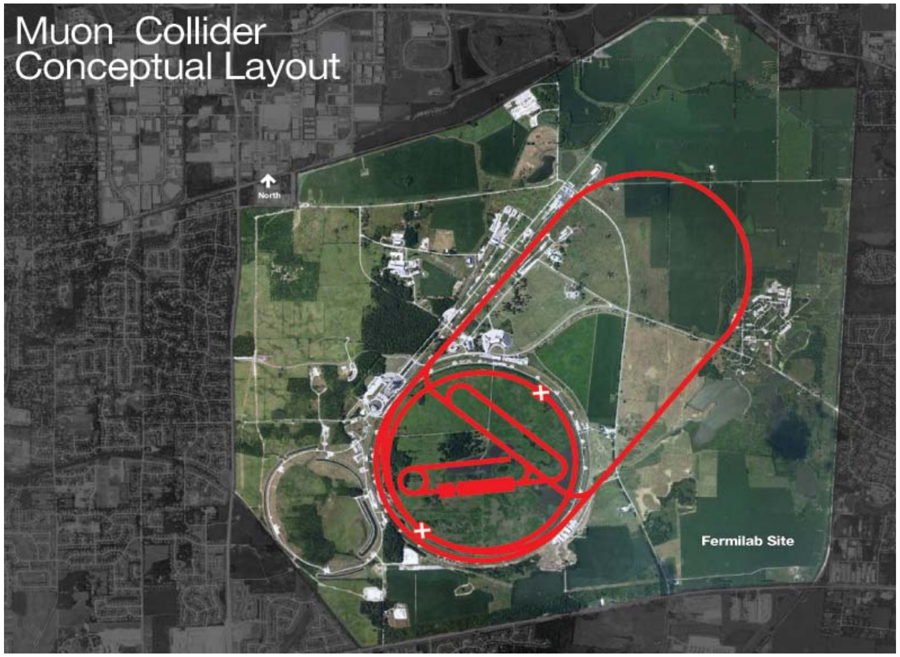
# RF Unit Test Facility at NML

Project X

Status: conditioning couplers for CM1, cool down in Sept

# Joint PX/NF/MC Strategy

- Project X shares many features with the proton driver required for a Neutrino Factory or Muon Collider
  - NF and MC require ~4 MW @ 10± 5 GeV
  - Primary issues are related to beam “format”
    - NF wants proton beam on target consolidated in a few bunches; Muon Collider requires single bunch
  - Project X linac is not capable of delivering this format




⇒ It is inevitable that a new ring(s) will be required to produce the correct beam format for targeting.