The High Intensity Future of Fermilab

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Fermilab and University of Chicago
ICHEP, Melbourne
July 7, 2012

U.S. DEPARTMENT OF ENERGY

Fermilab

The Intensity Frontier at Fermilab

The standard model is a very successful theory.

But is not complete; can not answer many deep questions

2020s

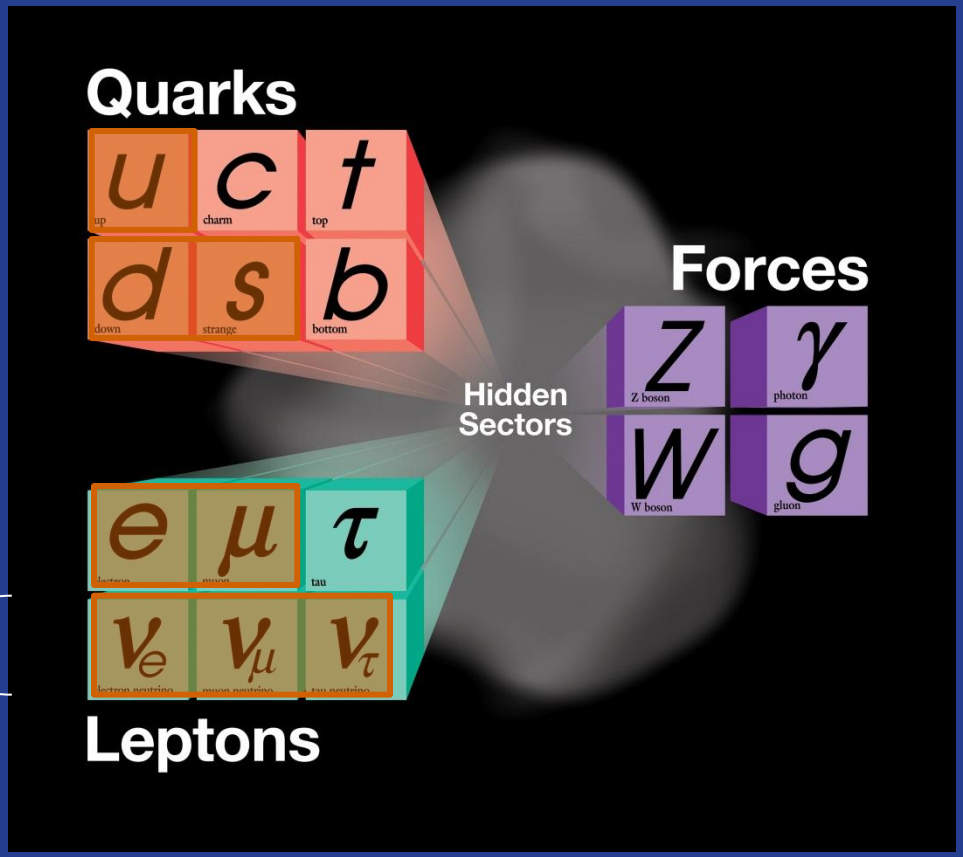
+

2030s

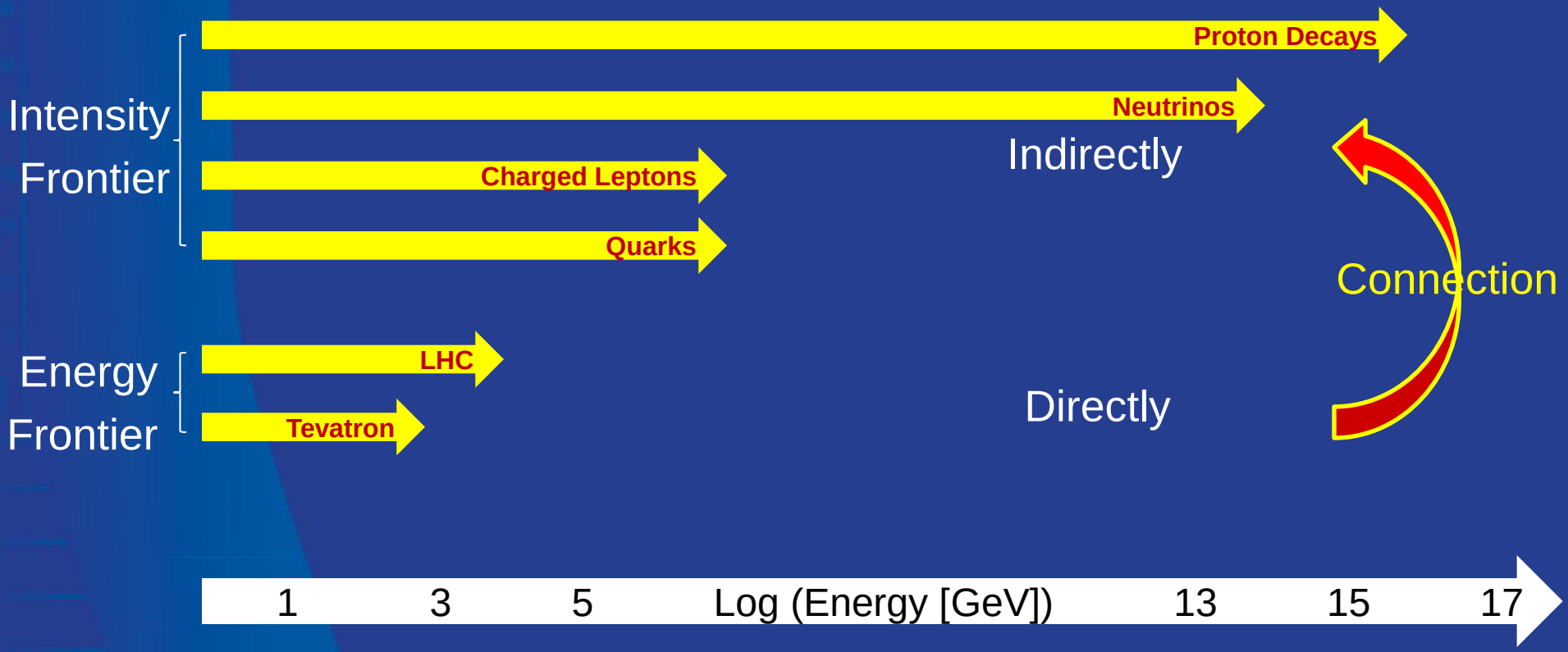
2010s

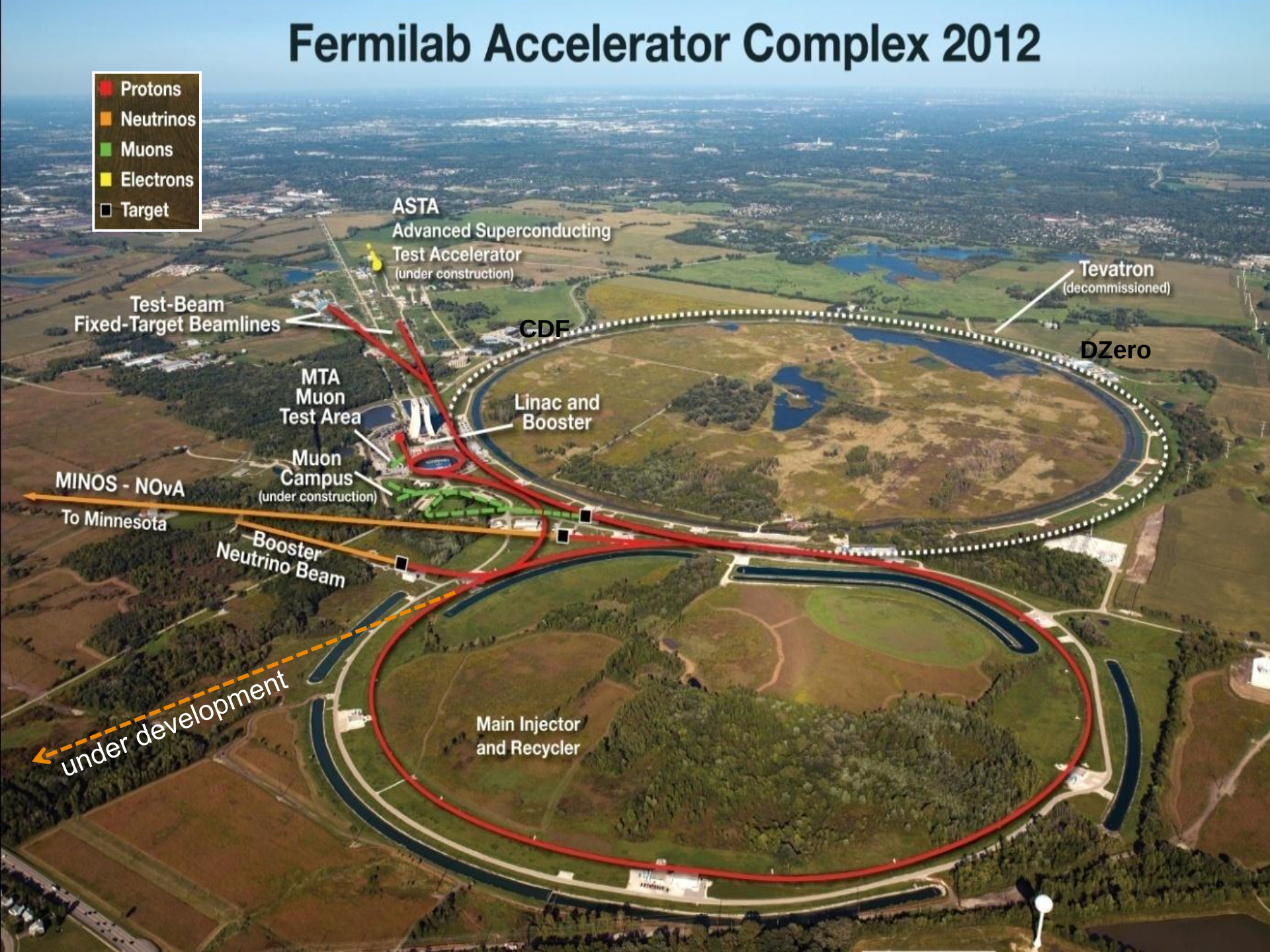
+

now

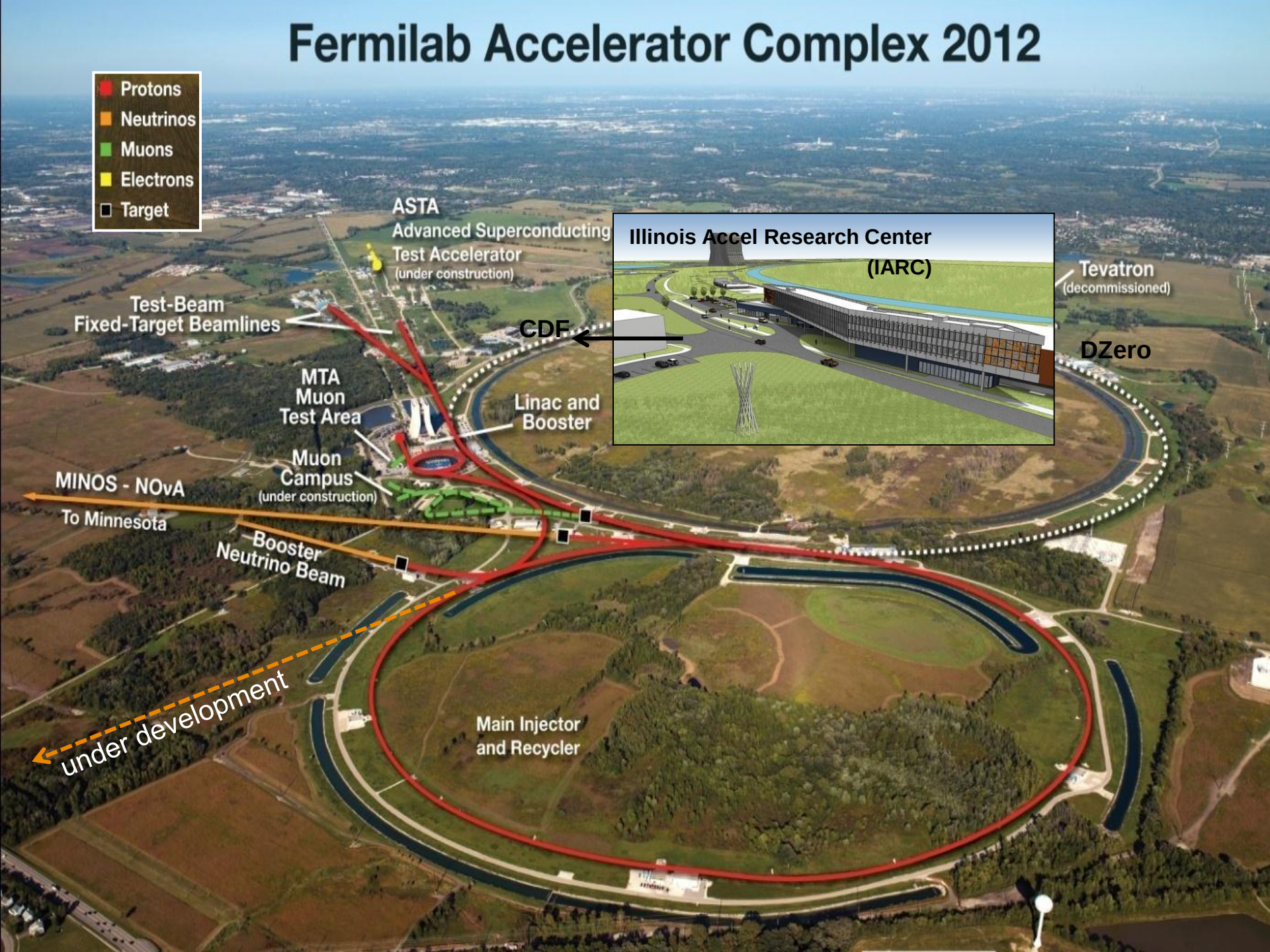


Experimental reach (model dependent)




Fermilab Accelerator Complex 2012
Protons
Neutrinos
Muons
Electrons
Target
ASTA
Advanced Superconducting
Test Accelerator
(under construction)
Tevatron
(decommissioned)
Test-Beam
Fixed-Target Beamlines
CDF
DZero
MTA
Muon
Test Area
Linac and
Booster
Muon
Campus
(under construction)
MINOS - NOvA
To Minnesota
Booster
Neutrino Beam
under development
Main Injector
and Recycler

Fermilab Accelerator Complex 2012



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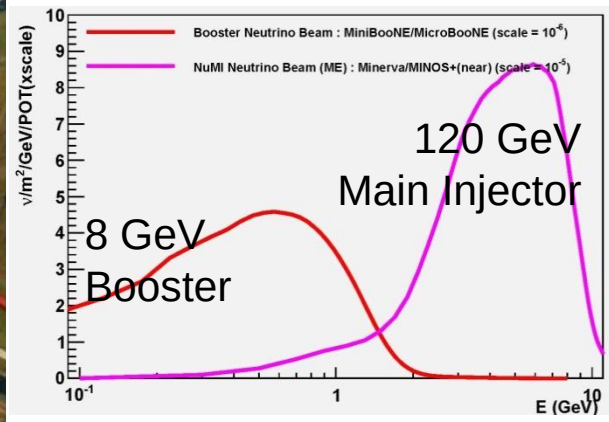
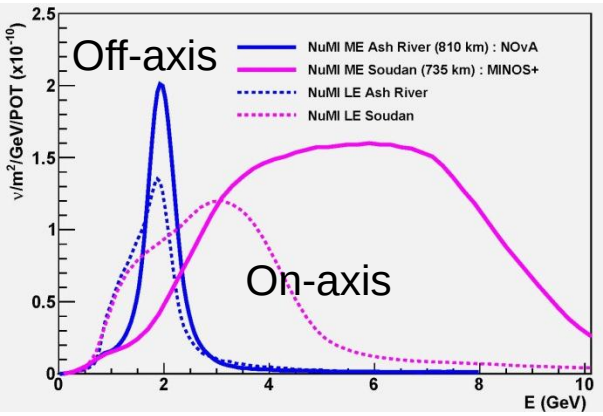
Illinois Accel Research Center
(IARC)

Tevatron
(decommissioned)

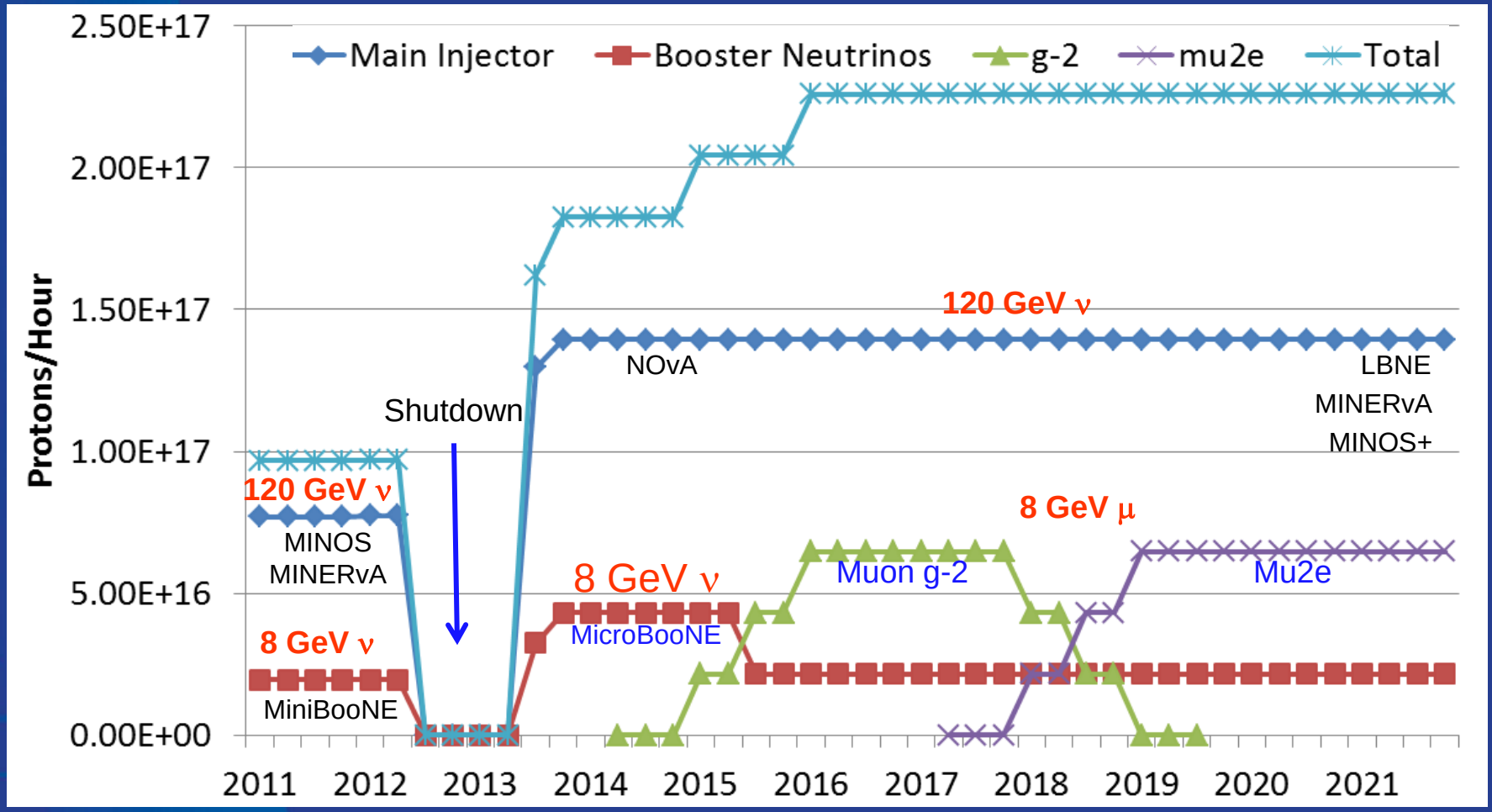
DZero

diverse (tunable) and intense beams of neutrinos
unmatched in the world today





Accelerator Improvement Plan (Proton Sources)



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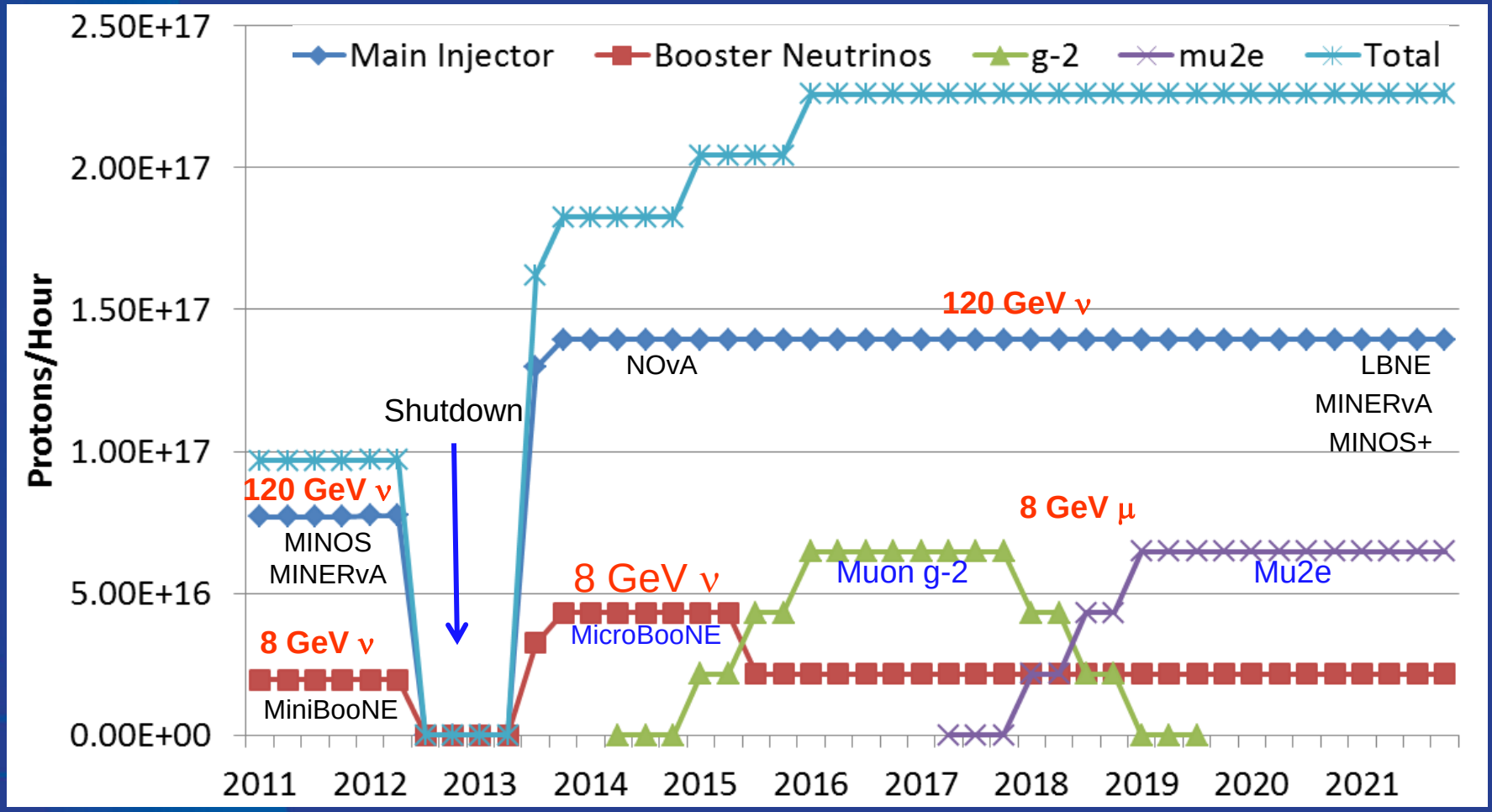

Project X | **R&D** | **Phase-1 Construction**

Neutrino Program (this and next decades)

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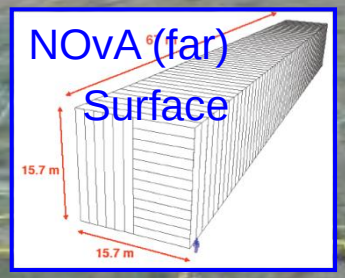
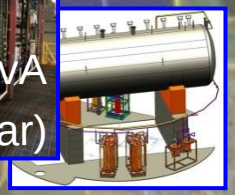
under construction
online 2013
(700 kW)



operating
since 2005
(350 kW)

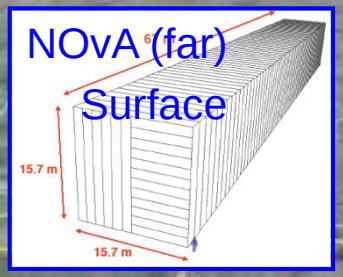
735 km
810 km



MicroBooNE
under construction
(LAr TPC)

Neutrino Program (this and next decades)

under construction
online 2013
(700 kW)



operating
since 2005
(350 kW)

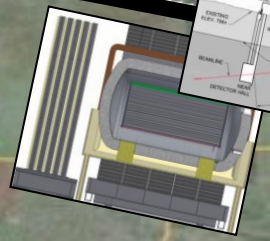
Far detector
(34 kton LAr TPC)

LBNE under development

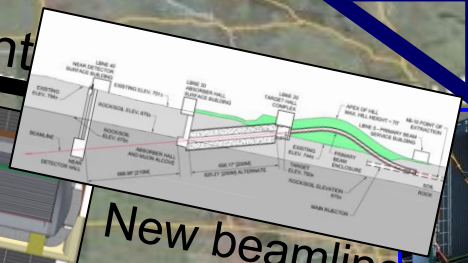
1300 km

735 km
810 km

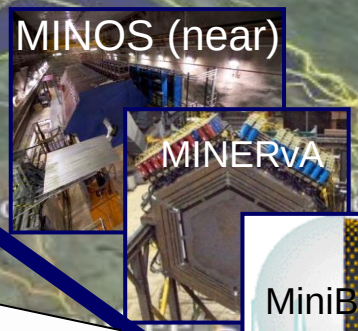
Neutrinos (mass hierarchy, CP violation)
Proton decay
Supernovae neutrinos
……



New beamline
Near detector

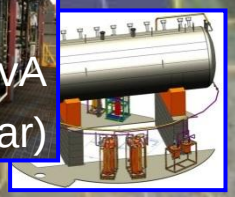


MINOS (near)



MINERvA

MiniBooNE

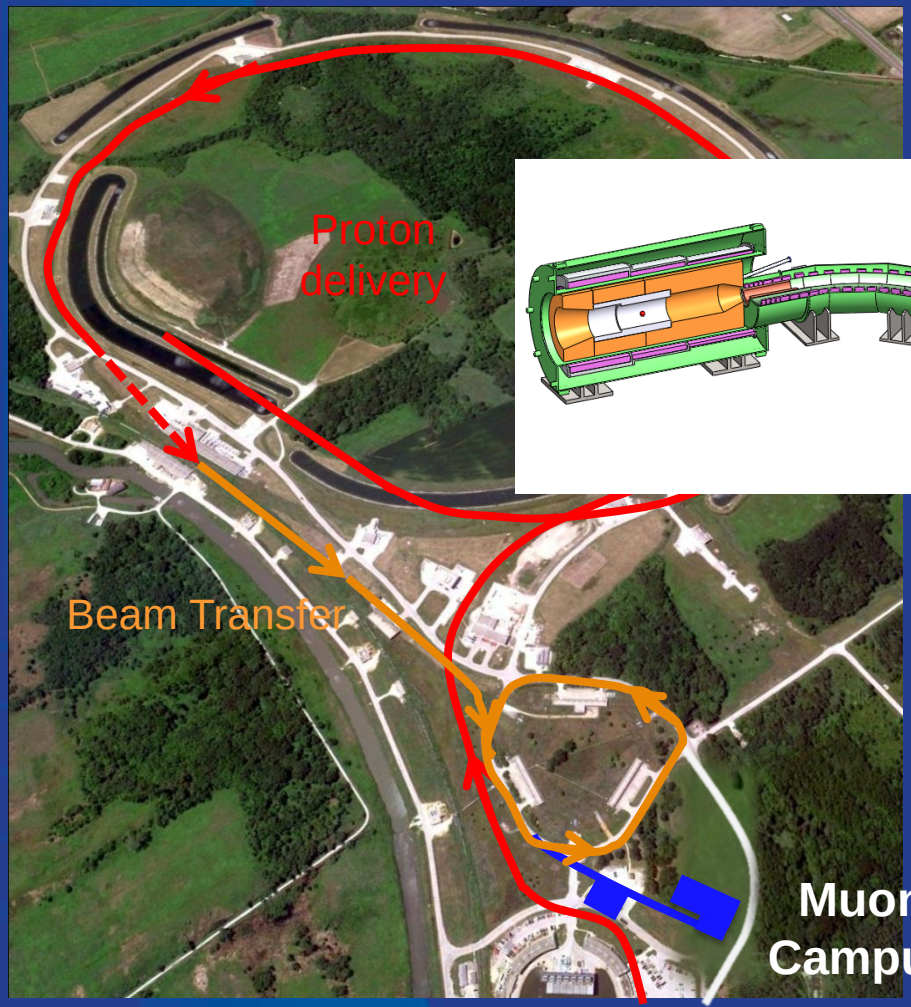


MicroBooNE
under construction
(LAr TPC)

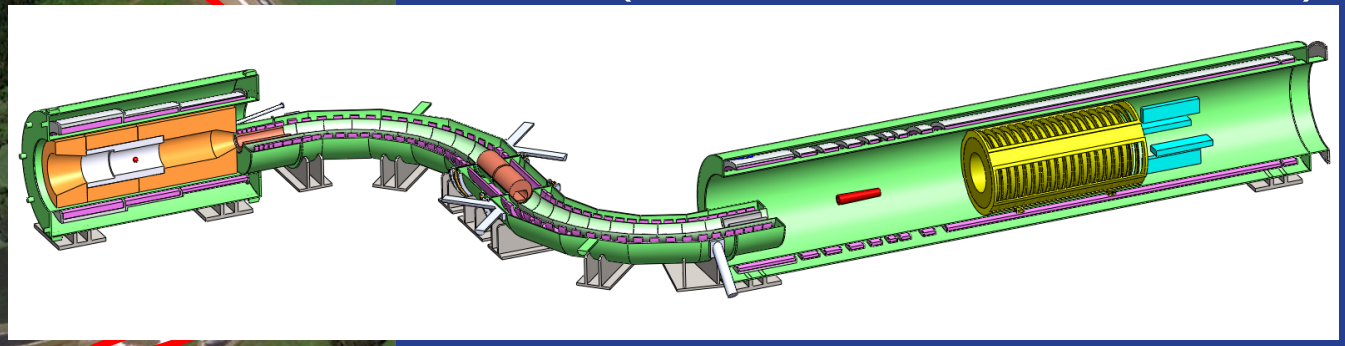
Developed a phased approach:

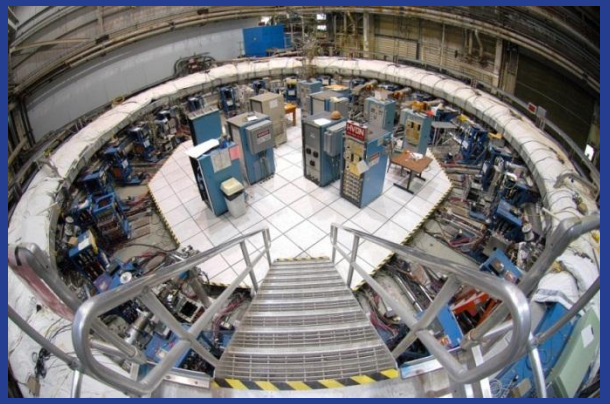
Stage 2 approval – expected by this Christmas

Muon Program (this decade)



Mu2e (muon to electron conversion)





Muon g-2

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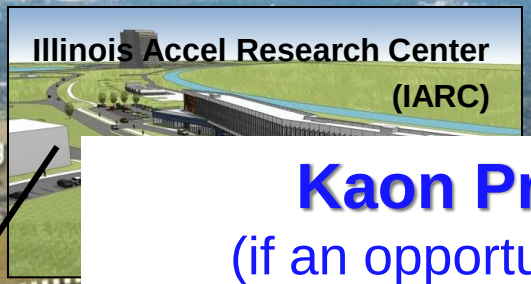
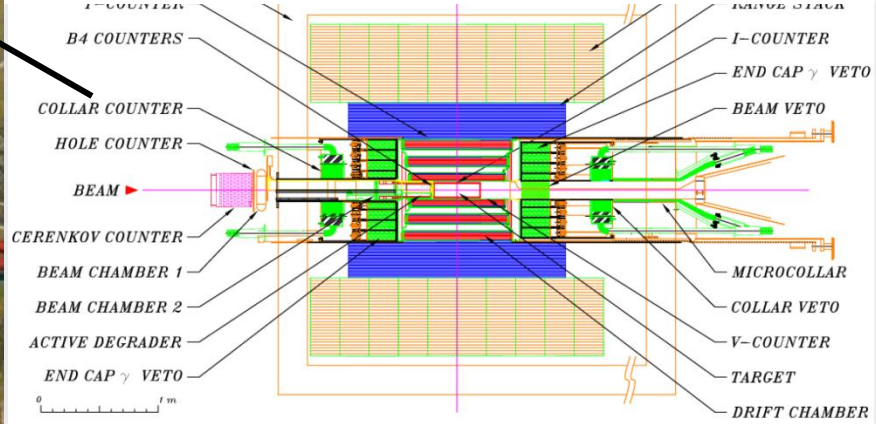
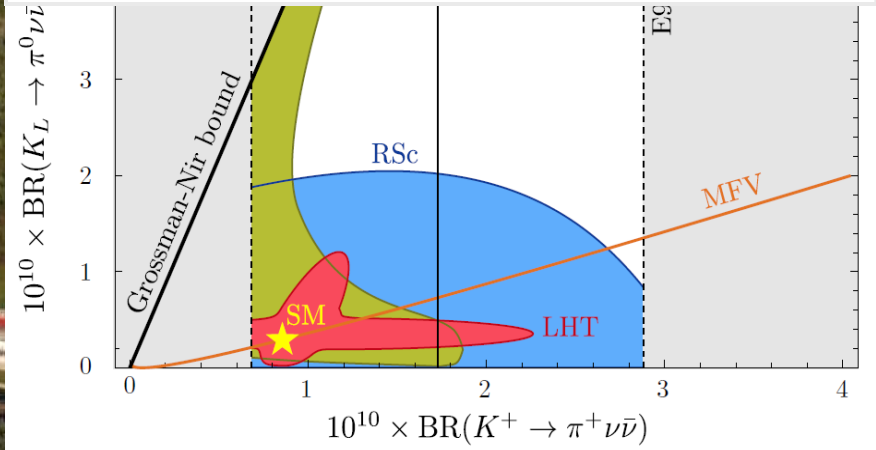


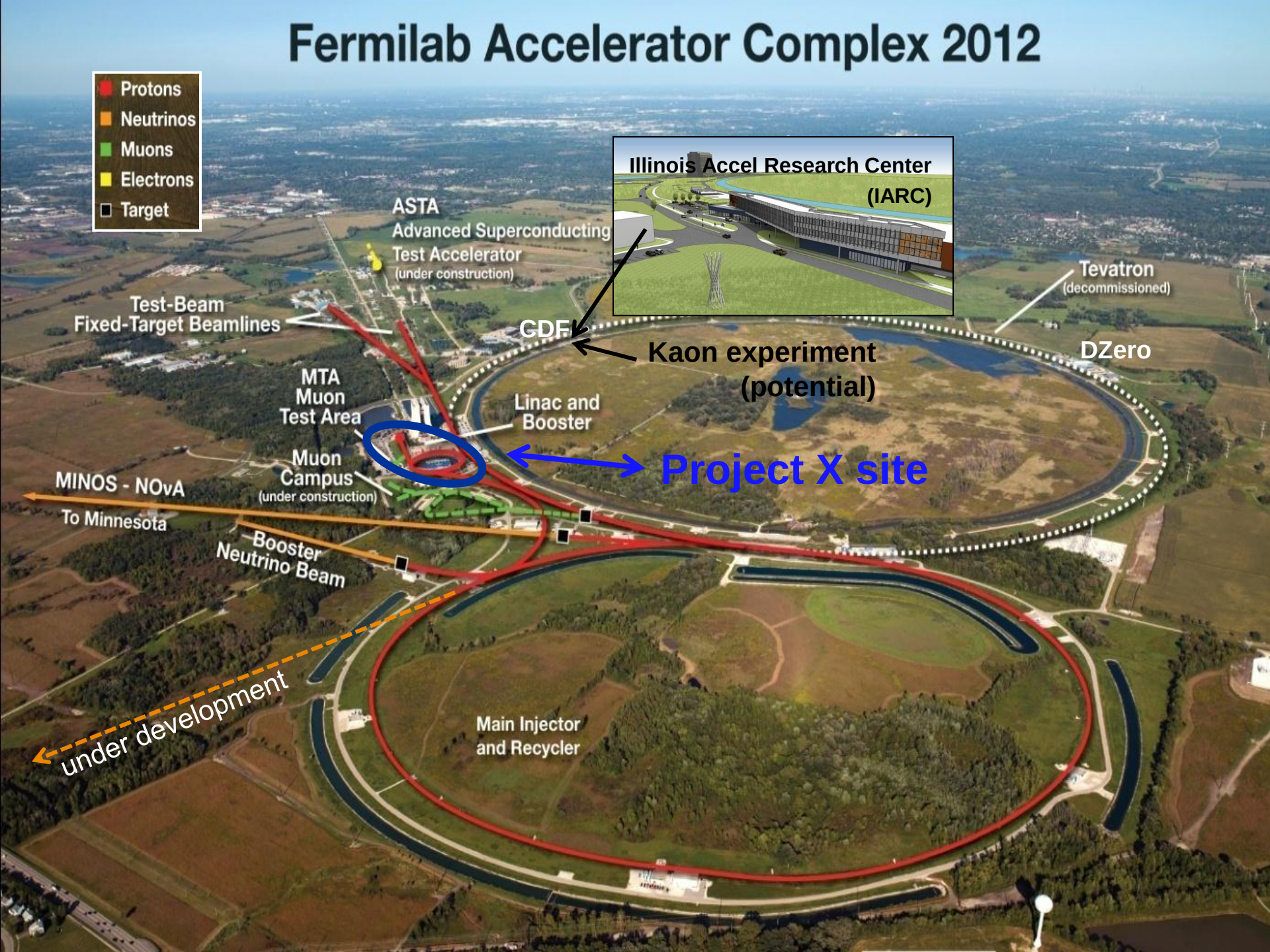
Kaon Program

(if an opportunity arises)

1,000 $K^+ \rightarrow \pi^+ \nu\nu$ events (SM rate~10^{-10})



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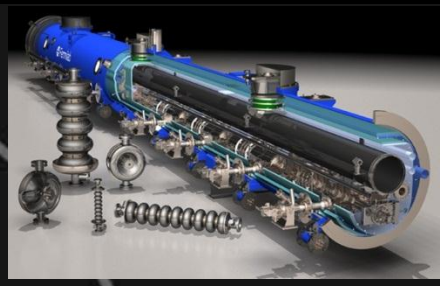
Project X

Powerful (> 5 MW) and flexible (162 MHz) proton source

Explore new physics in unprecedented breadth and depth

Establish a versatile technical foundation for future accelerators



Neutrinos to LBNE

2.4 MW @60-120 GeV
neutrinos

3 MW CW @3 GeV
for rare processes
muons, karons, nuclei

1 MW CW @1 GeV
nuclei (EDMs, nuclear energy)

Transfer into Main Injector & Recycler

8 GeV Pulsed Proton Beam

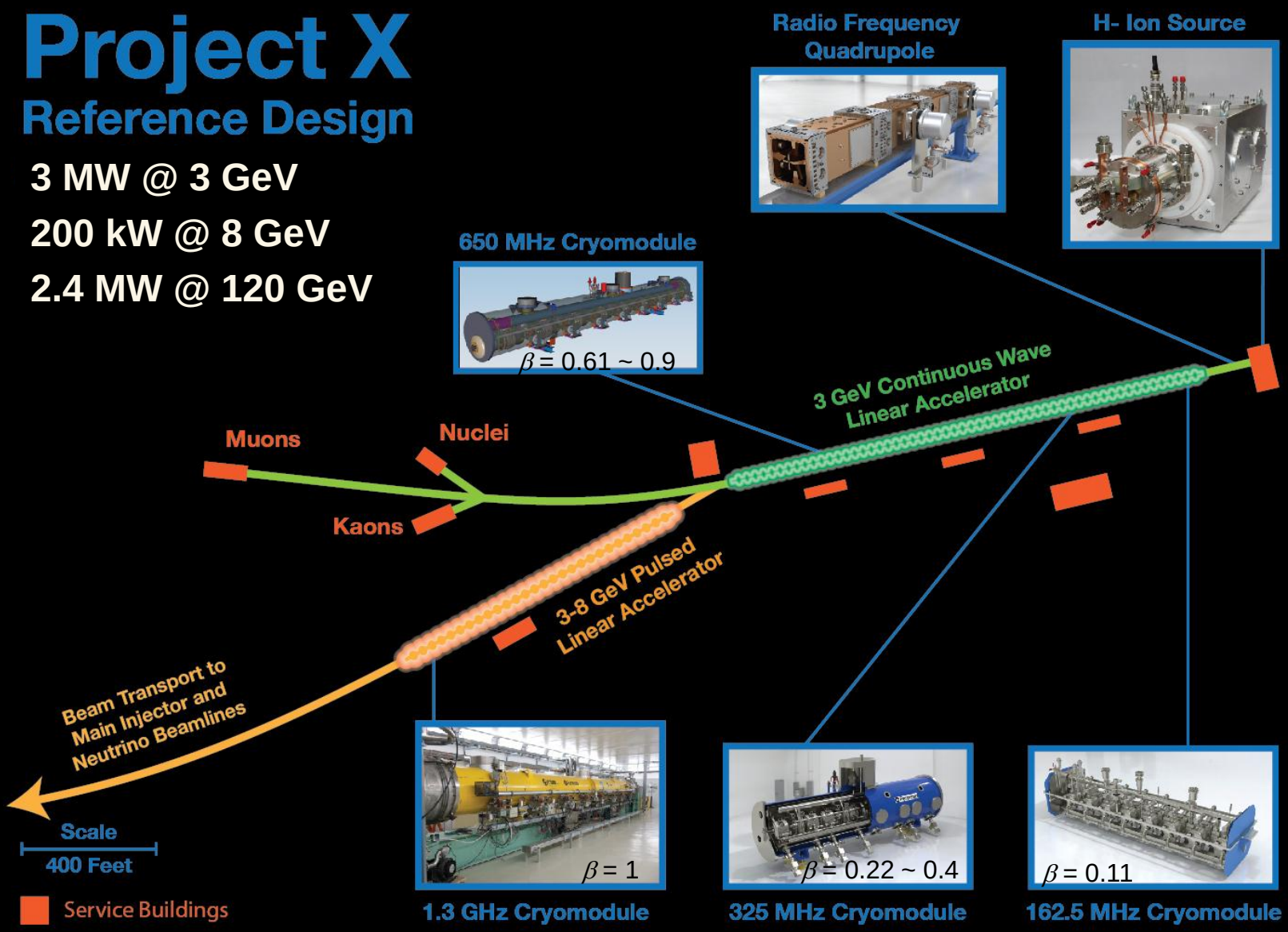
200 kW @8 GeV
Neutrinos, muons

Project X
Reference Design

3 MW @ 3 GeV

200 kW @ 8 GeV

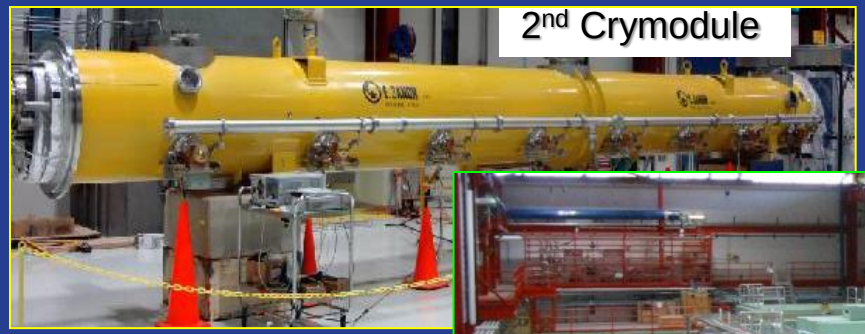
2.4 MW @ 120 GeV



Argonne National Laboratory • Brookhaven National Laboratory • Fermi National Accelerator Laboratory • Lawrence Berkeley National Laboratory
Pacific Northwest National Laboratory • Oak Ridge National Laboratory / SNS • SLAC National Accelerator Laboratory
Thomas Jefferson National Accelerator Facility • Cornell University • Michigan State University • ILC/Americas Regional Team
Bhaba Atomic Research Center • Raja Ramanna Center of Advanced Technology • Variable Energy Cyclotron Center • Inter University Accelerator Center

SRF Development: 1.3 GHz (ILC)

- 90 nine-cell cavities ordered; 60 received (32 from U.S. industry:16 from AES, 16 from Niowave-Roark)
- ~ 40 processed and tested, ~20 dressed
- 2 CMs built: one from a DESY kit and a second U.S. procured

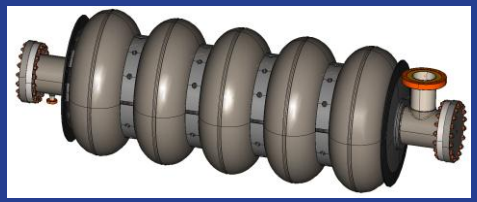


SRF Development: 650 MHz

- JLab built two single-cell β =0.61 cavities

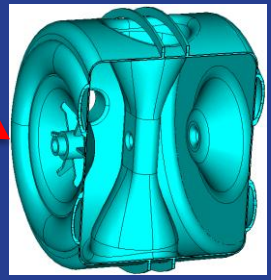
- Six β = 0.9 single-cell cavities built by U.S. industry

- Order for six β = 0.61 (2 JLab, 2 FNAL design) single-cell cavities in industry
- Five-cell design complete for β_G = 0.9 cavities
  - four 5-cell cavities on order from AES
  - two expected in FY12

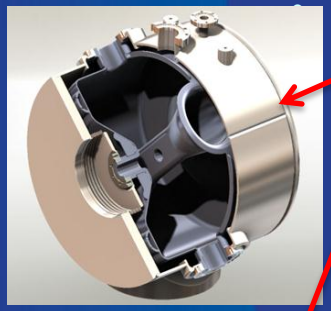


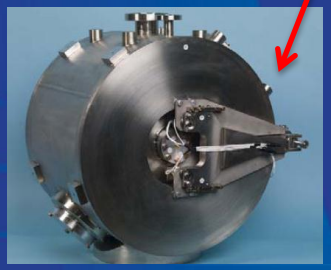
SCRF Development: 325 MHz and 162.5 MHz

- SSR2(β_G = 0.47) Single Spoke Resonator
  - EM design complete
  - Mechanical design in progress

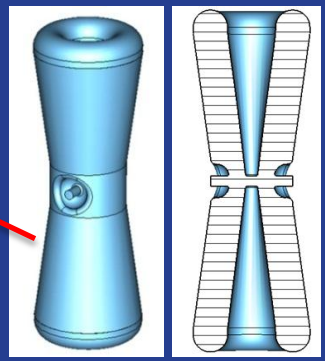


- SSR1 (β_G = 0.22) Single Spoke Resonator
  - Initiated under HINS program → more advanced
  - 8 prototype cavities to date
    - 3 tested as bare cavities at 2K
    - One dressed and tested at 4.8K





- HWR (β_G = 0.11) Half Wave Resonator
  - EM and mechanical design underway at ANL
  - Similar to cavities & CM already manufactured by ANL



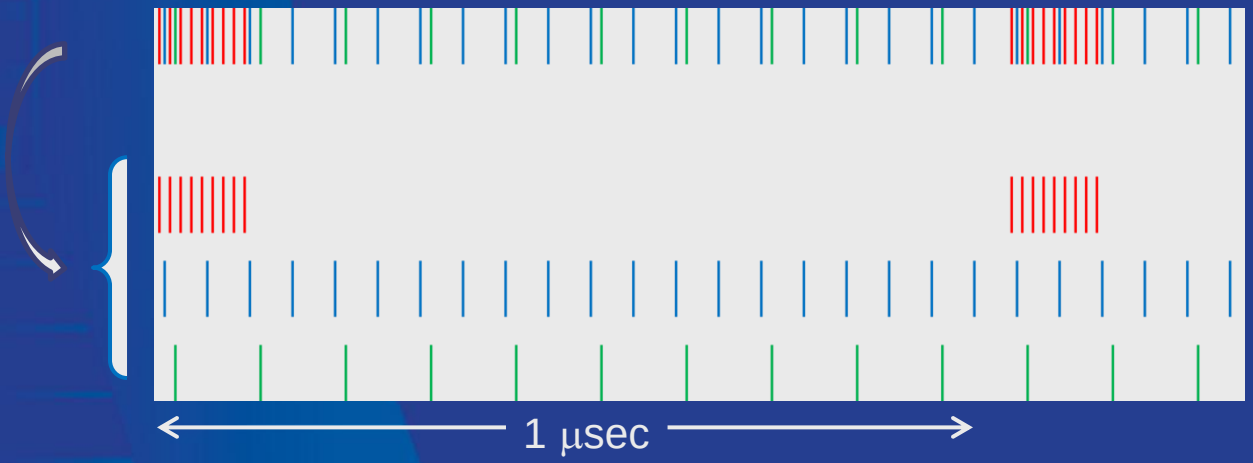
Operating Scenario for High Power Campus

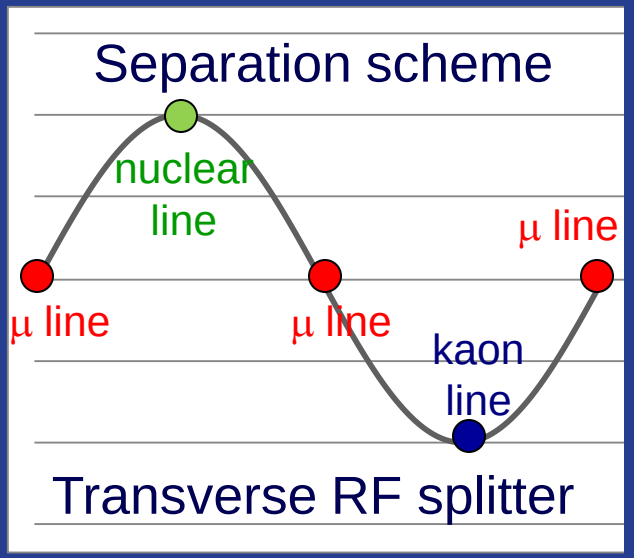
1 μsec period at 3 GeV

Muon pulses (12e7) 162.5 MHz, 80 nsec	700 kW
Kaon pulses (12e7) 27 MHz	1540 kW
Nuclear pulses (12e7) 13.5 MHz	770 kW

Ion source and RFQ operate at 4.4mA; 77% of bunches are chopped @2.1MeV

⇒ maintain 1 mA over 1 μsec



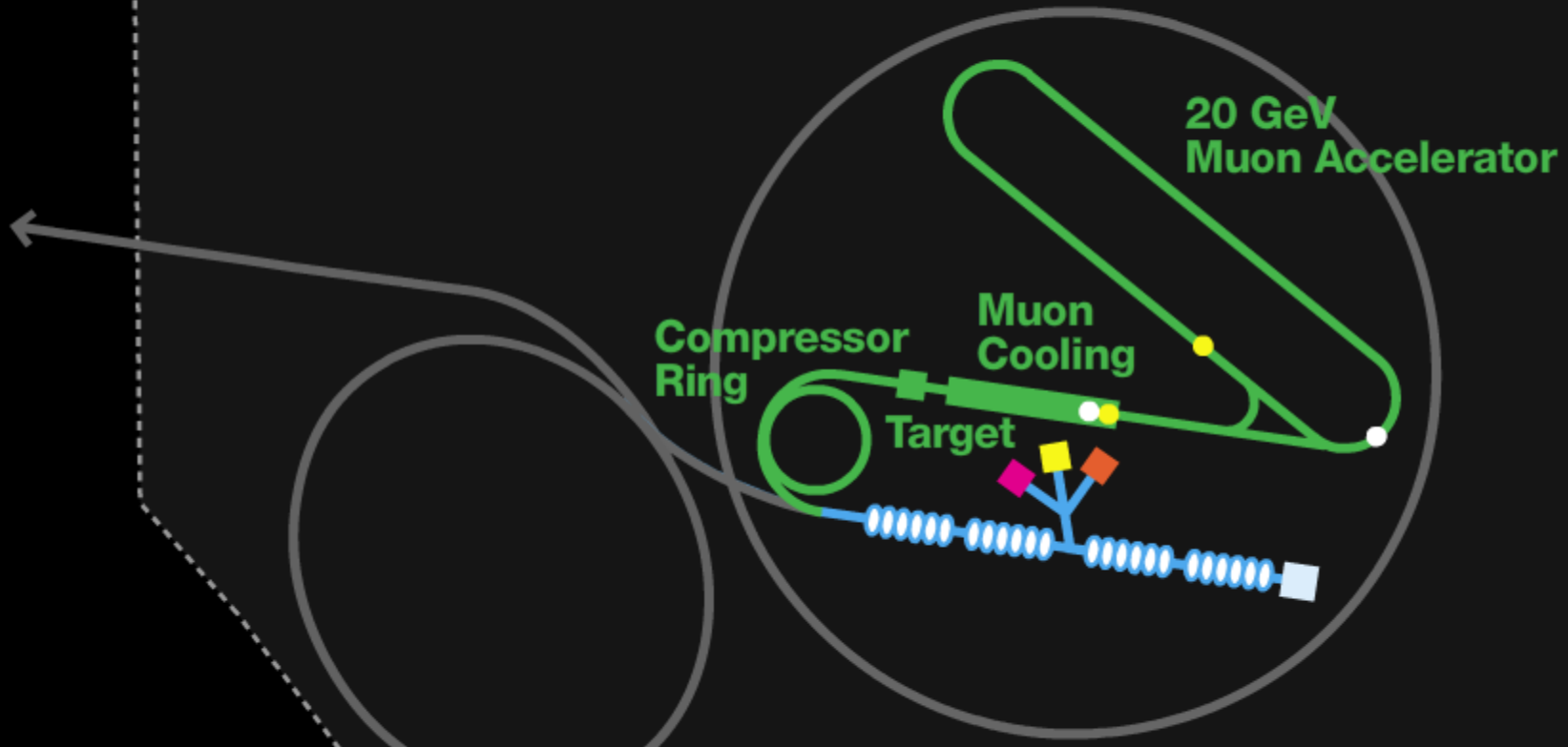


Project X Injector Experiment (PXIE)

- PXIE is the centerpiece of the Project X R&D program
  - Integrated systems test for Project X front end components
- Collaboration between Fermilab, ANL, LBNL, SLAC, India

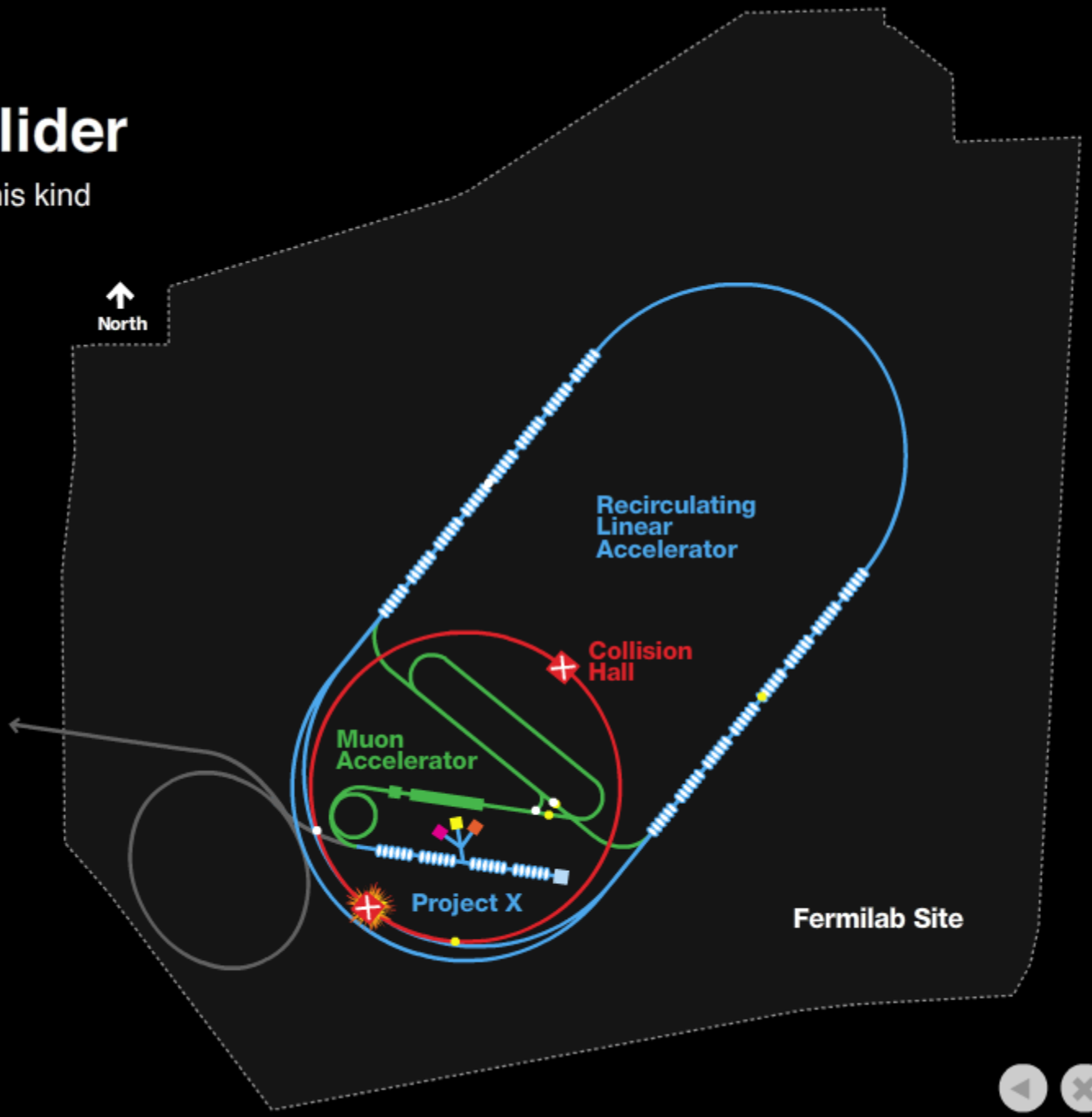
Muon Beamline & Neutrino Factory

Highest-intensity muon and neutrino source in the world



Muon Collider

The first collider of this kind



Summary

- Fermilab continues to operate most of its existing accelerators with enhanced capabilities and next generation experiments (2010s)
- Project X is a staged evolution of the best assets of the Fermilab accelerator complex with the revolution in super-conducting RF technology; Each Stage of Project X will raise many boats of the Intensity Frontier in particle physics, with a program scope of more than 20 world-leading particle physics experiments and an associated robust user community.
- A path toward a muon source for possible future Neutrino Factory and/or a Muon Collider
- Project X R&D underway with very significant investment in SCRF
  - Emphasis on the CW linac/Stage 1 components, including front end development program (PXIE)
- Significant effort is being invested in defining Project X physics programs associated with all stages