Fermilab | U.S. DEPARTMENT OF ENERGY | Office of Science

Fermilab Operations and Future Projects

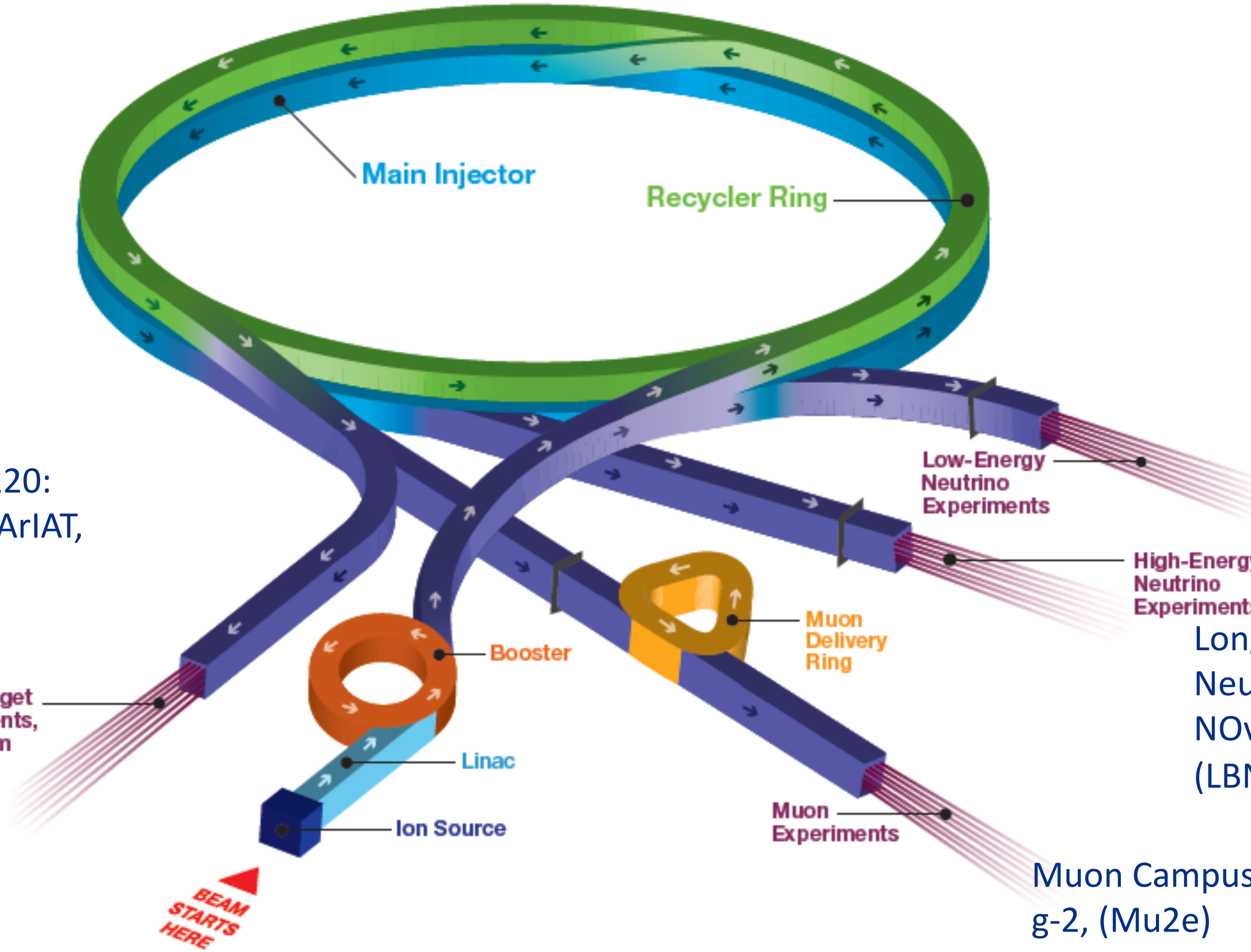
Brian Chase

for Fermilab LLRF Group

LLRF2017 Barcelona

LLRF2017 Low Level Radio Frequency Workshop

Fermilab accelerator complex



SwitchYard120: SeaQuest, LArIAT, test beam

Short Baseline Neutrino: MicroBooNE (ICARUS, SBND)

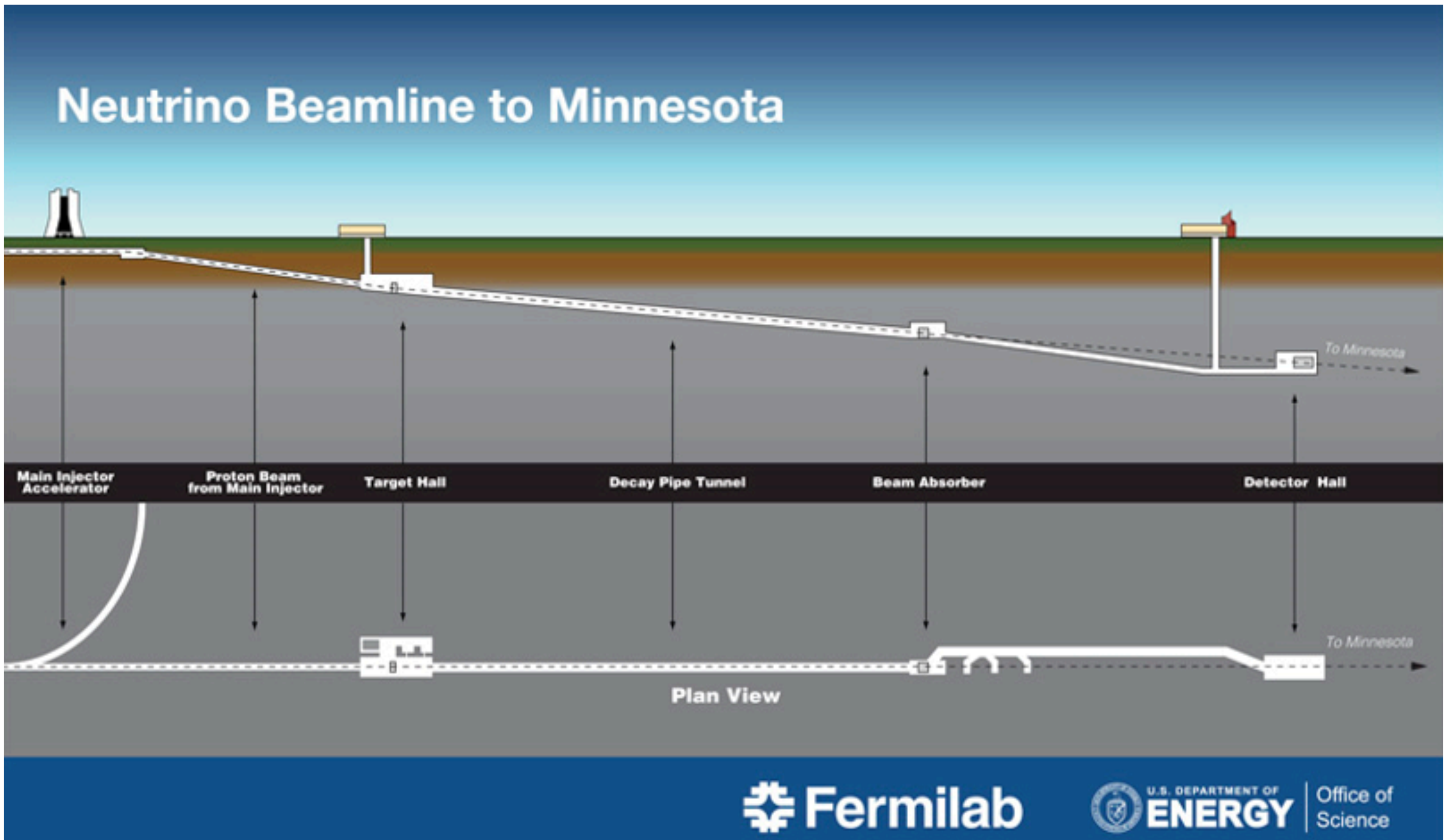
Long Baseline Neutrino: NOvA, MINERvA (LBNF/DUNE)

Muon Campus: g-2, (Mu2e)

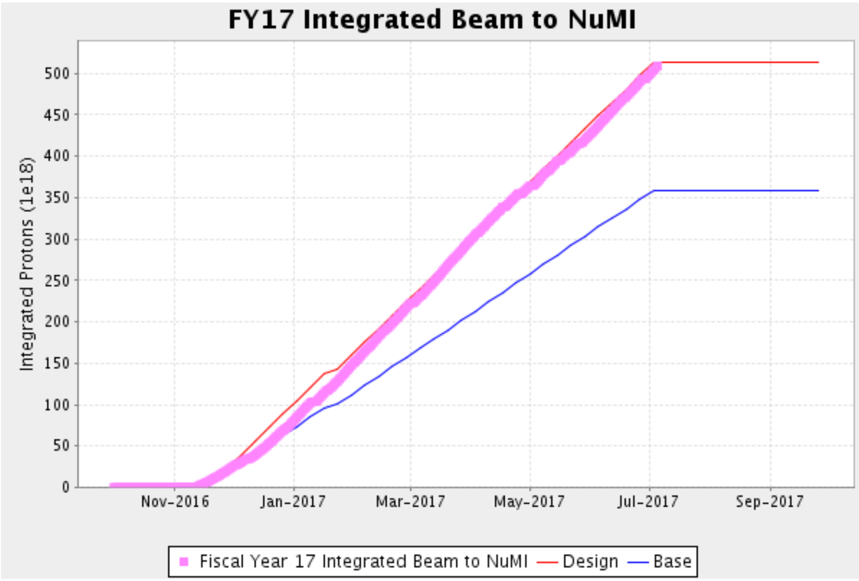
NuMI Beam Line

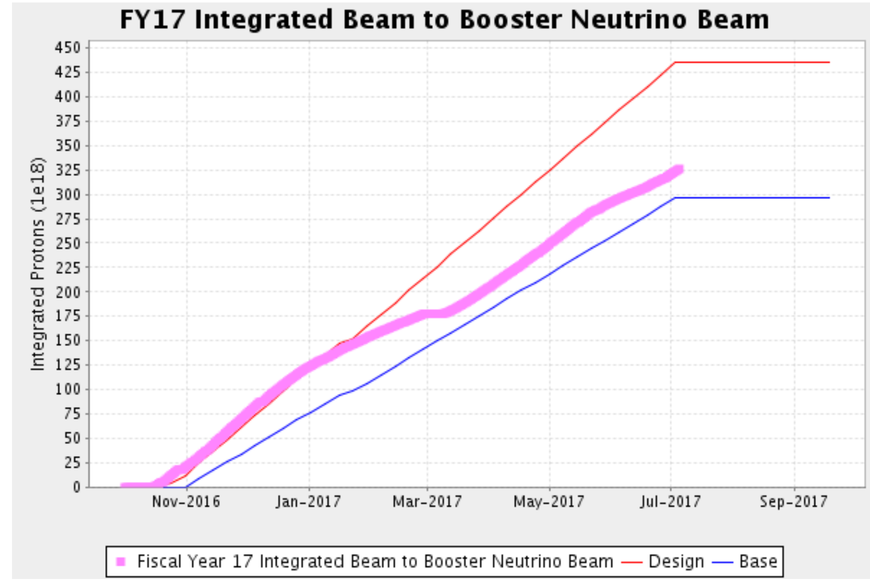
- Making Neutrinos

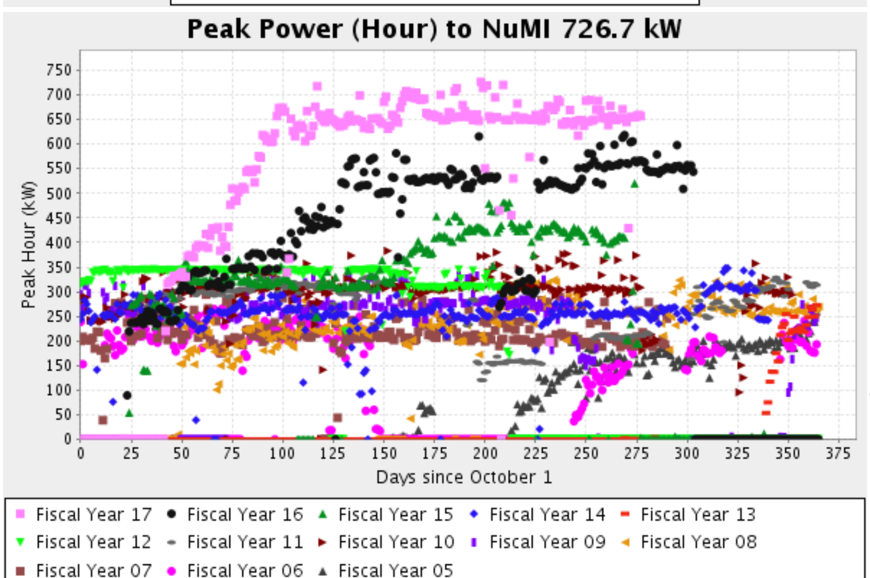
  120 GeV protons from the Main Injector strike a target making a shower of particles including many pions.   Pions decay into a muon and a neutrino.



FY17 Accelerator performance goals met







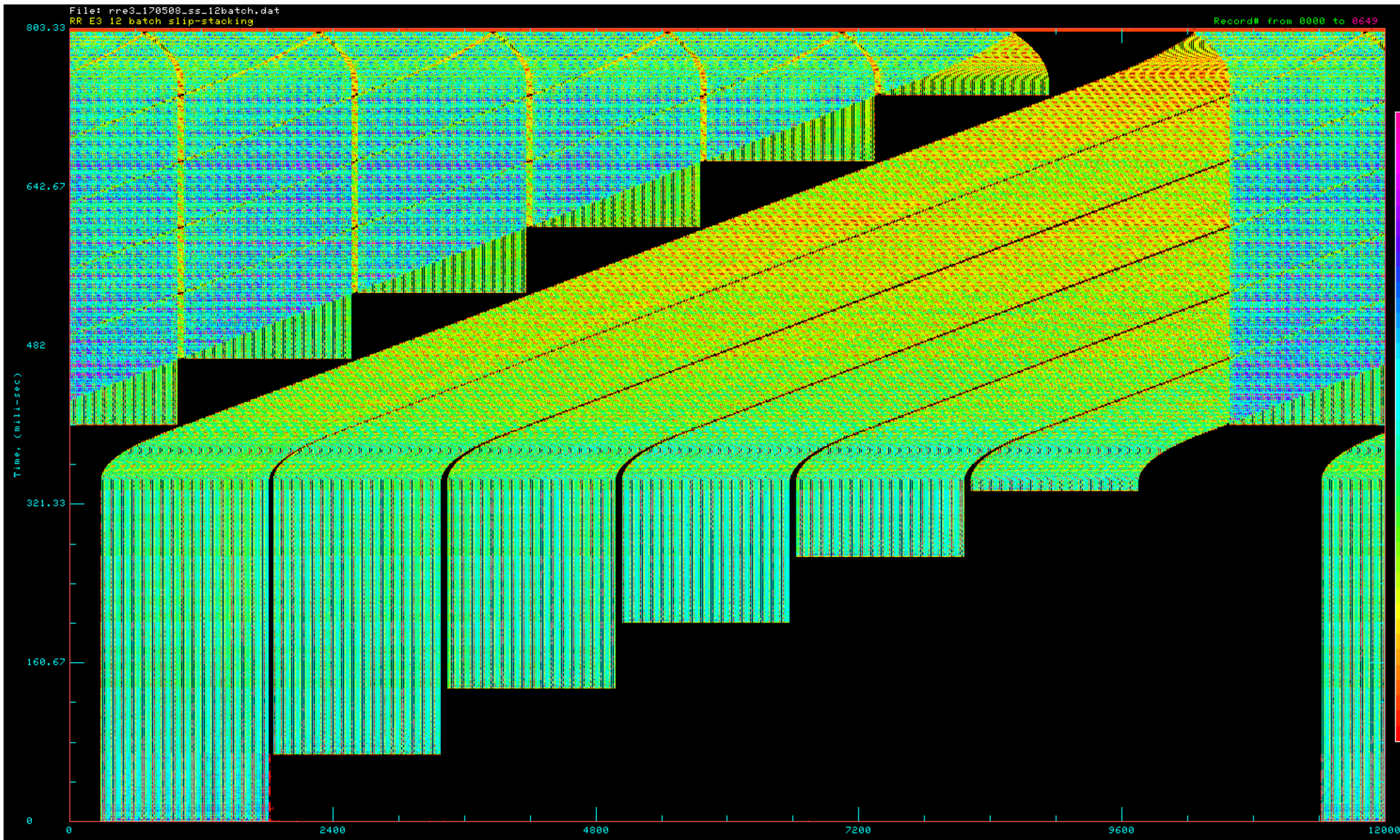
- Final modifications for new Booster shielding assessment (up to 2.7x10^{17} protons per hour) were put in place in March

- Running above 700 kW to NuMI (630 kW when 10% of timeline to SY120 fixed-target program)

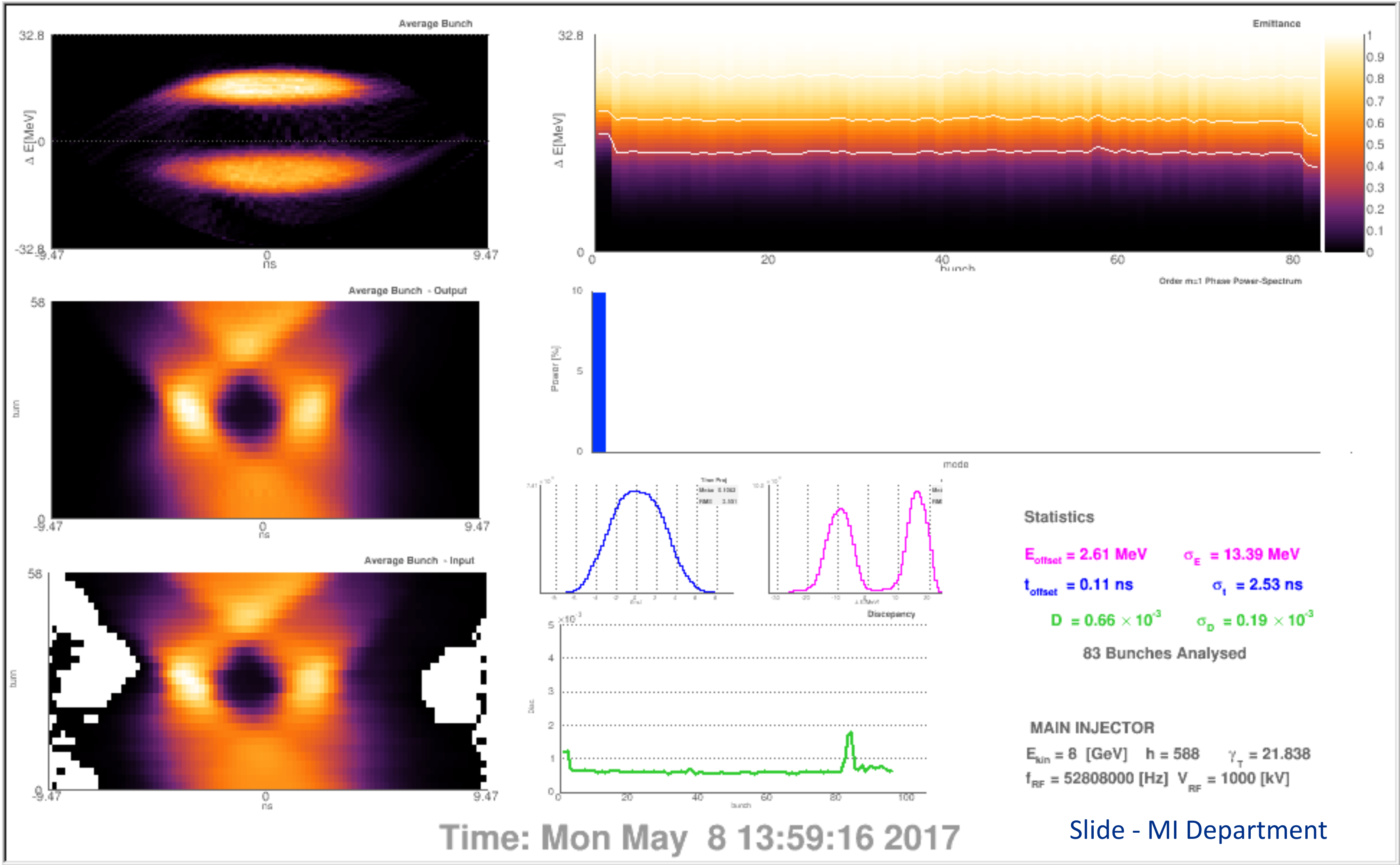
Slip Stacking in the Recycler Ring

Increase Intensity and Beam Power

Slip two groups of Booster 82 bunch batches past each other in momentum space in the Recycler and extract to the Main Injector and capture with large buckets

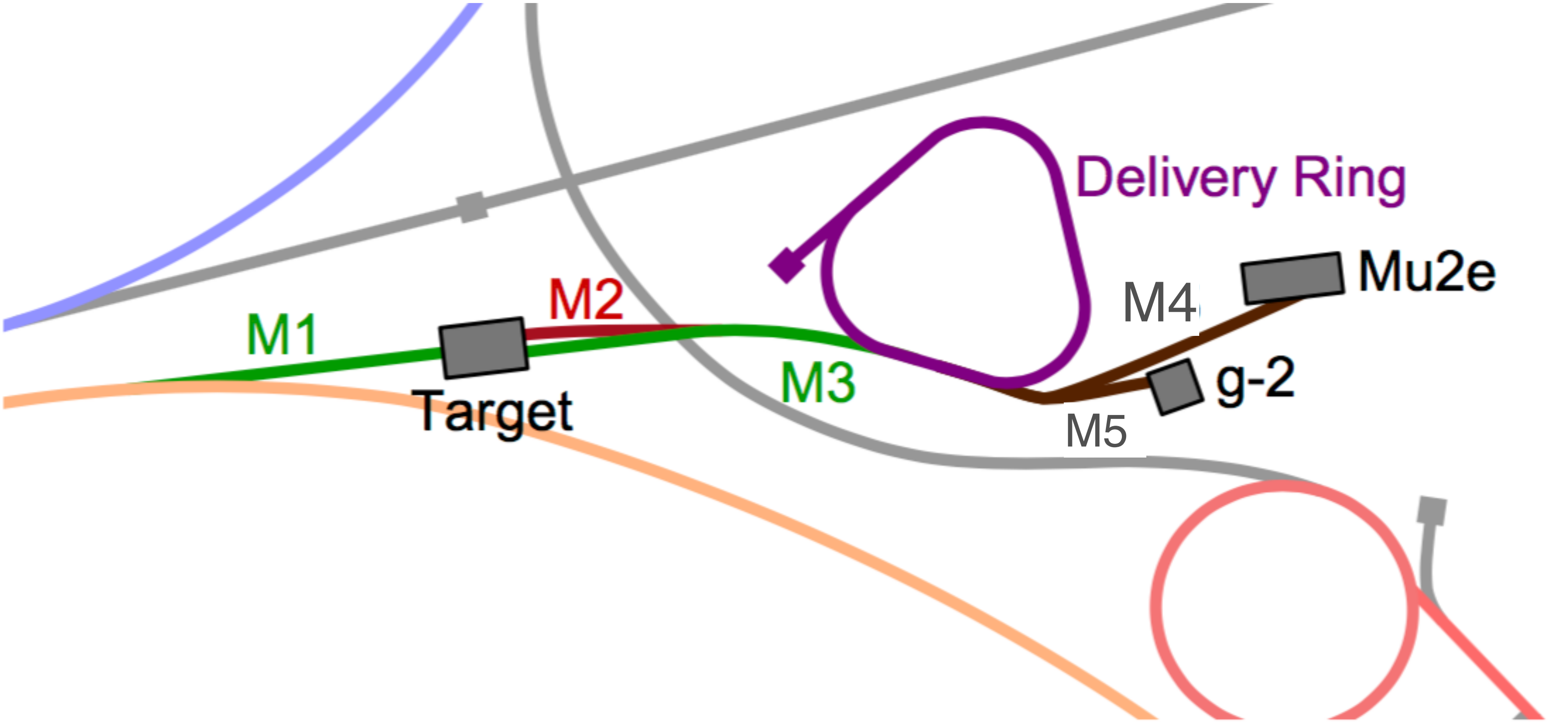


WCM Tomography analysis, MI injection from RR



Slide - MI Department

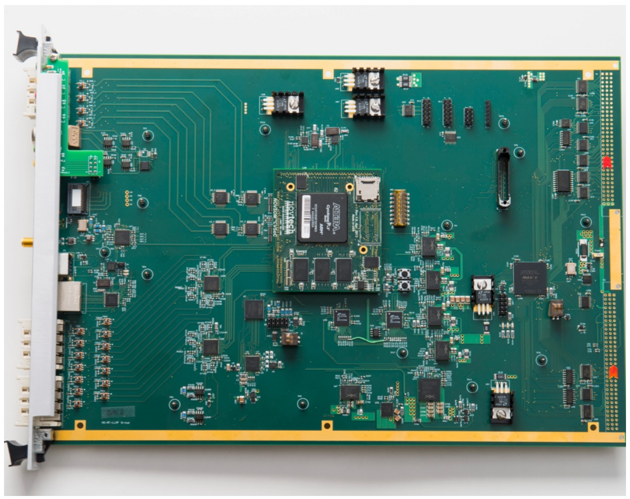
Muon Campus



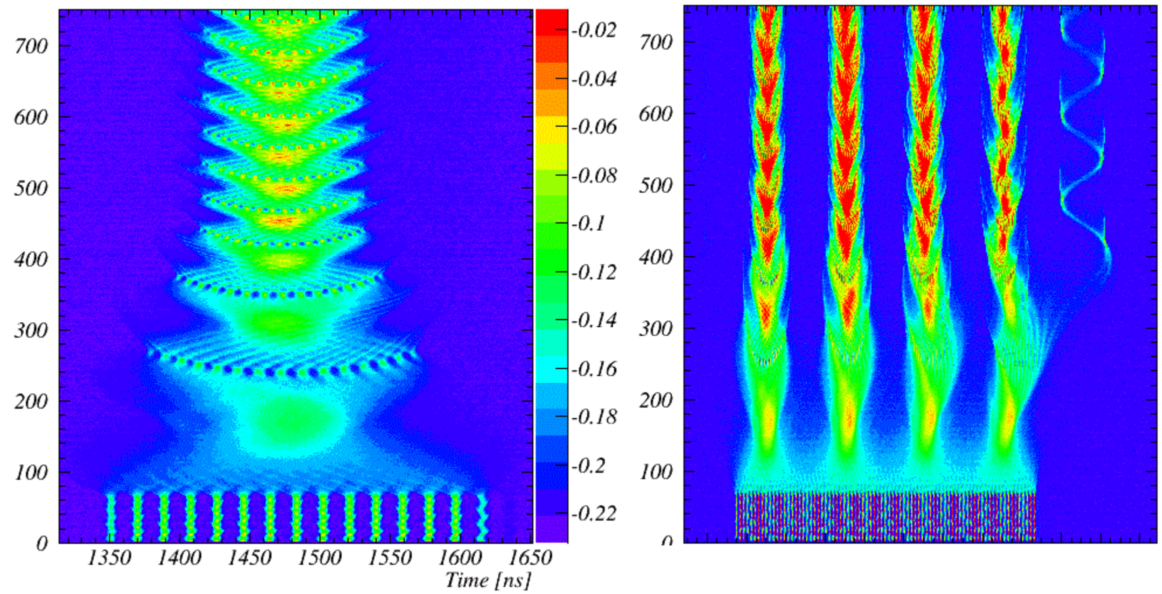
The Muon Campus consists of the Delivery ring, associated beamlines, the target, the g-2 experiment, and the Mu2e experiment. The five beamlines, designated M1 through M5, direct beam to the Delivery ring and from the ring to the experiments. The path that the beam takes through the Muon campus depends on which experiment is taking beam. For this reason, only one experiment is run at a time.

G-2 and Mu2e

New LLRF 2.5 MHz Recycler system



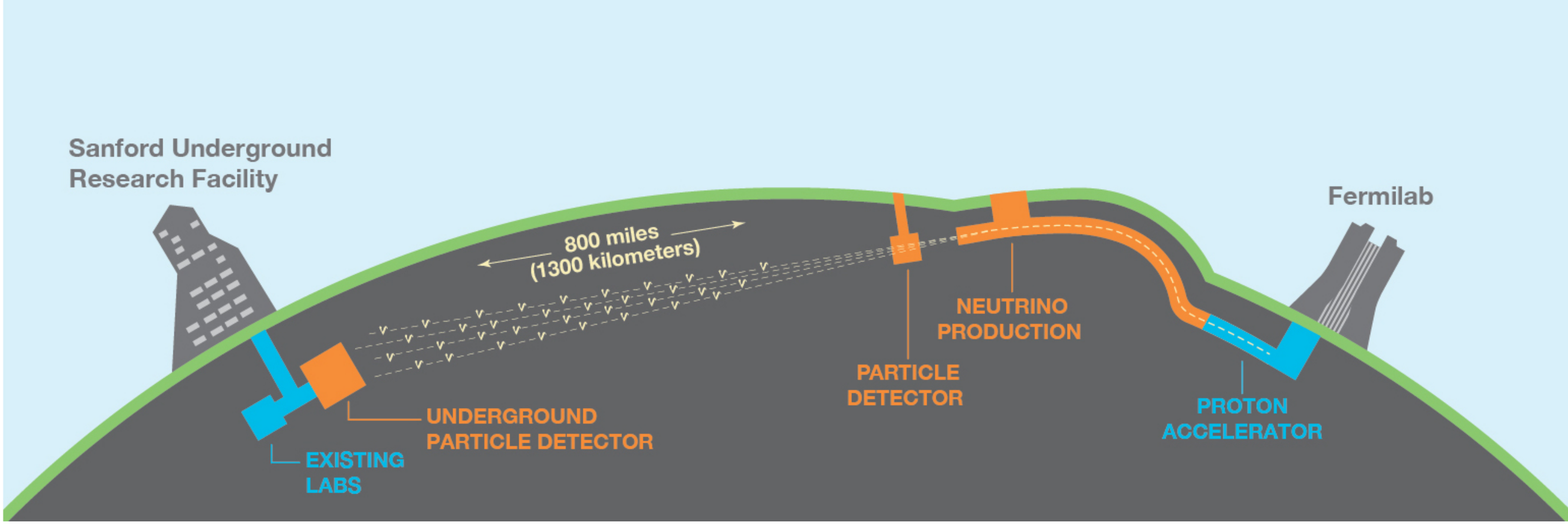
SOC- MFC
LLRF Controller
VXI or Networked Device



First 53 MHz to 2.5 MHz Coalescing in RR

P-11 LLRF System for the Fermilab Muon g-2 and Mu2e Projects

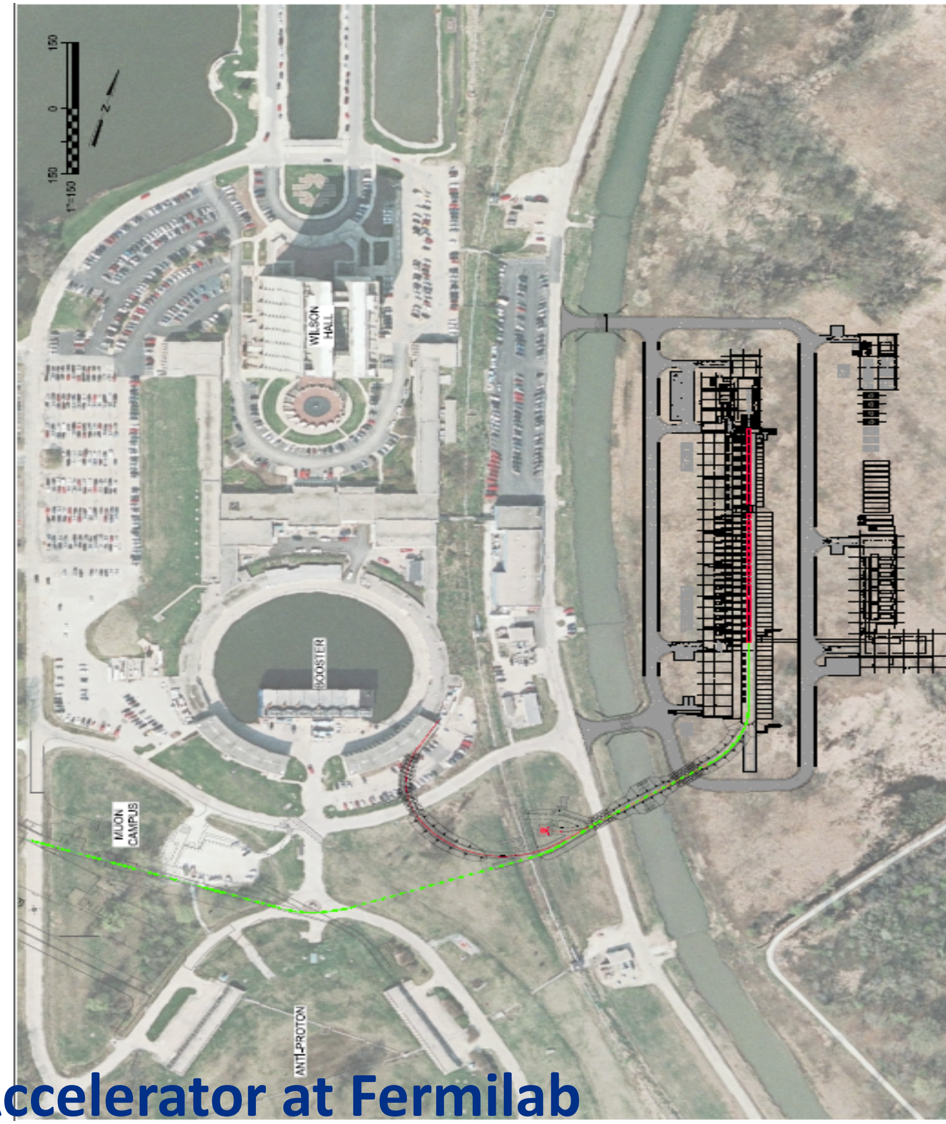
DUNE



The Deep Underground Neutrino Experiment (DUNE) is a leading-edge, international experiment for neutrino science and proton decay studies. DUNE will consist of two neutrino detectors. One detector will record particle interactions near the source of the beam, at Fermilab. A second, much larger, detector will be installed more than a kilometer underground at the Sanford Underground Research Laboratory in Lead, South Dakota — 1,300 kilometers downstream of the source.

Proton Improvement Plan 2 (PIP-II)

- PIP – II is a 20Hz, 800 MeV, superconducting H- LINAC that will replace the existing 400 MeV copper LINAC and increase average beam power from the Main Injector to 1.2 MW
- Challenges for LLRF
  - 10^-4 field regulation
  - Support both CW and Pulsed operation
  - Narrowband cavities with large Lorentz Force Detuning and small power overhead
- There is a large project collaborative effort with India's DAE including LLRF and Instrumentation



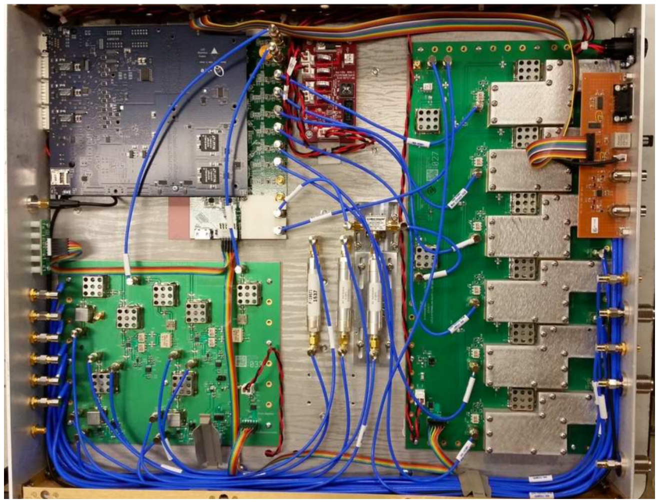
Session 3 **LLRF for the PIP-II Accelerator at Fermilab**

Fermilab

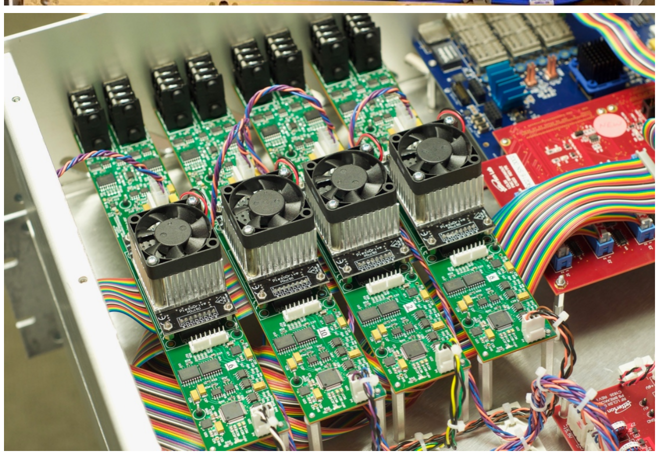
LCLS-II

SLAC | Jefferson Lab – Thomas Jefferson National Accelerator Facility | Berkeley Lab | Fermilab

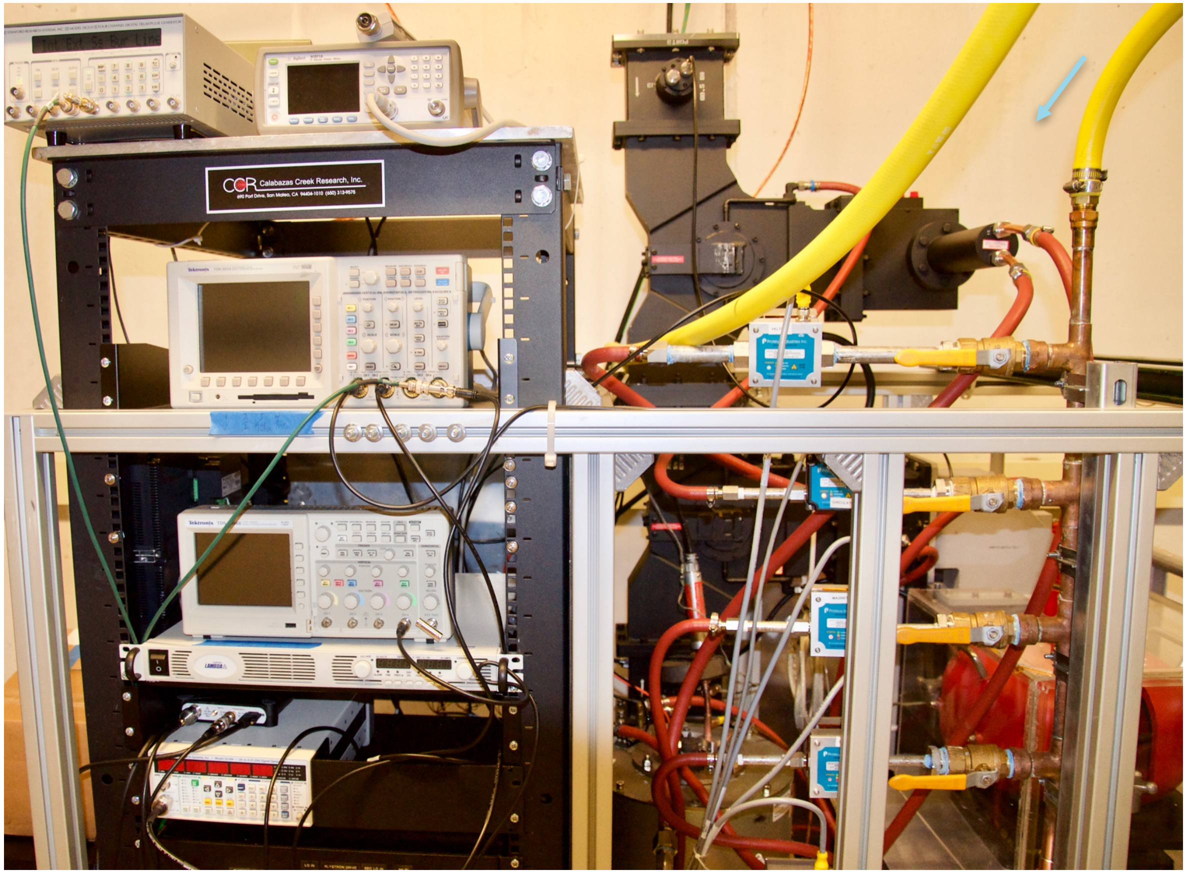
Fermilab team is part of the LCLS-II LLRF design collaboration and is heavily involved with the Fermilab Cryomodule Test Stand(CMTS)



Shown are the RF Station controller, Resonance Control and the LCLS-II rack at CMTS with enclosure entrance in the background



CCR 1.3 GHz 100 kW magnetron testing at Fermilab



Session 4 **Wideband Control for Magnetron Driven Cavities**

2017 Full Solar Eclipse – near Carbondale, IL

Moon as solar photon amplitude modulator (9.5 TW)

FNAL Talks and Posters

- Session 3 **LLRF for the PIP-II Accelerator at Fermilab**, Jonathan Edelen
- Session 4 **Wideband Control for Magnetron Driven Cavities**, Brian Chase
- Session 7 **Automatic phase calibration for RF cavities using beam-loading signals**, Jonathan Edelen
- Session 8 **Tutorial: Microphonics active control and compensation possibilities**, Joshua Curtis-Einstein
- **P-11 LLRF System for the Fermilab Muon g-2 and Mu2e Projects**
- **P-23 Experience with the PIP-II Injector Test**
- **P-31 Adaptive beam loading compensation in room temperature bunching cavities**
- **P-74 SoC Architectures in LLRF at Fermilab**