



Accomplishments and Plans

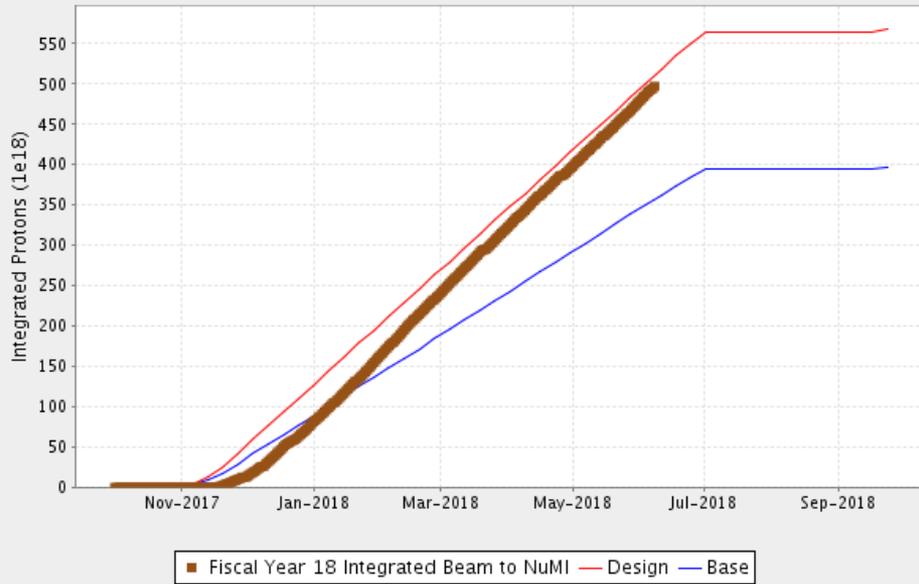
Mary Convery

AD All Hands

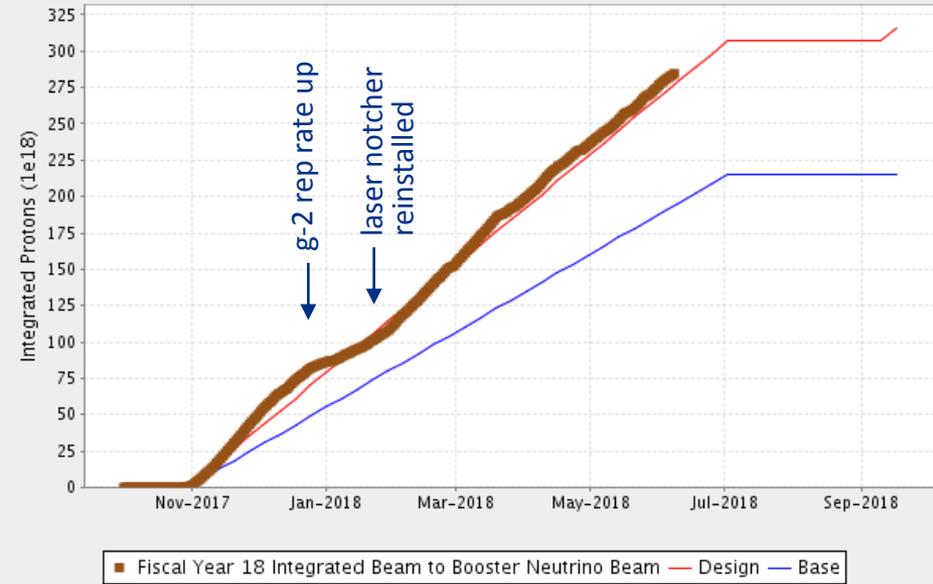
June 12, 2018

FY18 accelerator performance for HEP

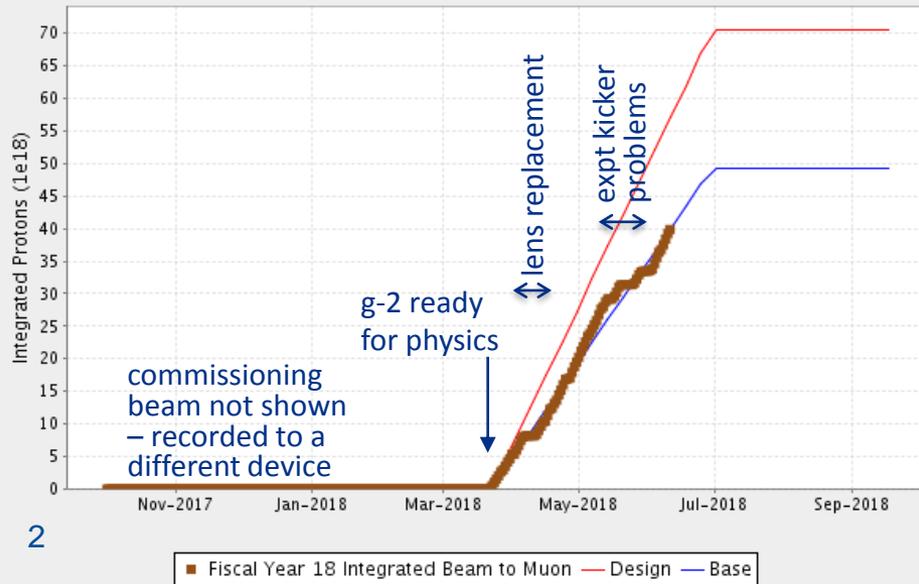
FY18 Integrated Beam to NuMI



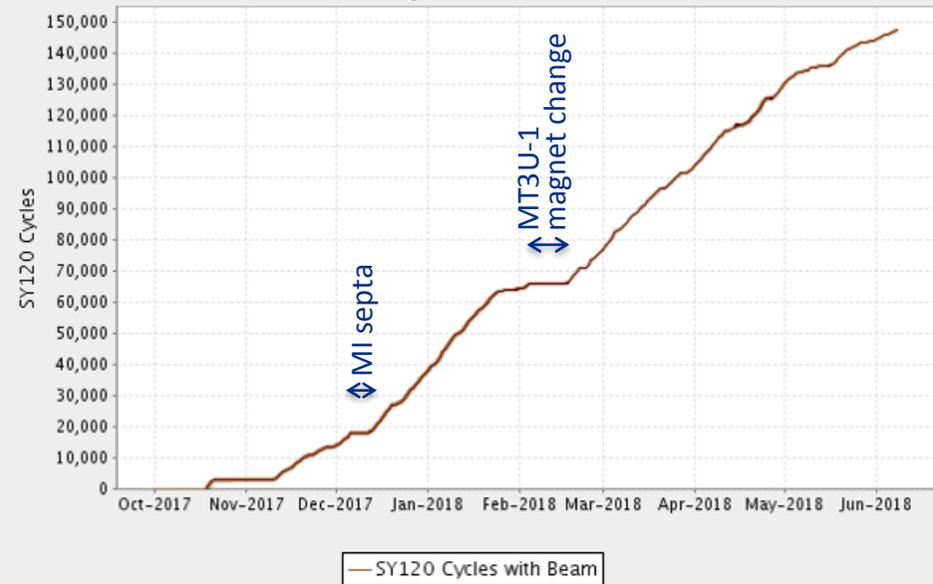
FY18 Integrated Beam to Booster Neutrino Beam



FY18 Integrated Beam to Muon

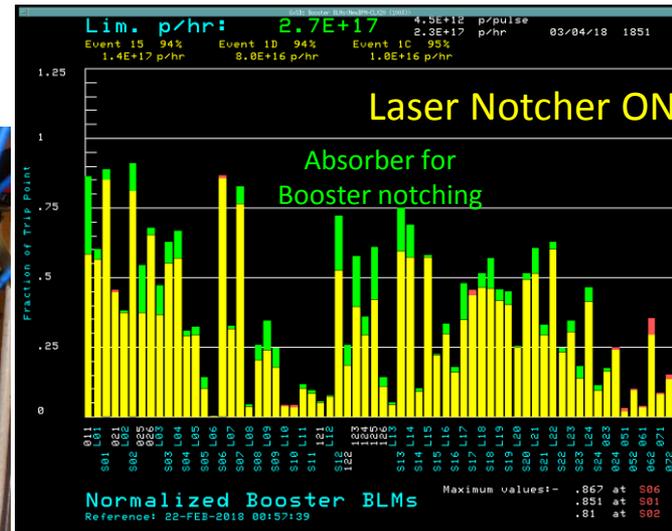
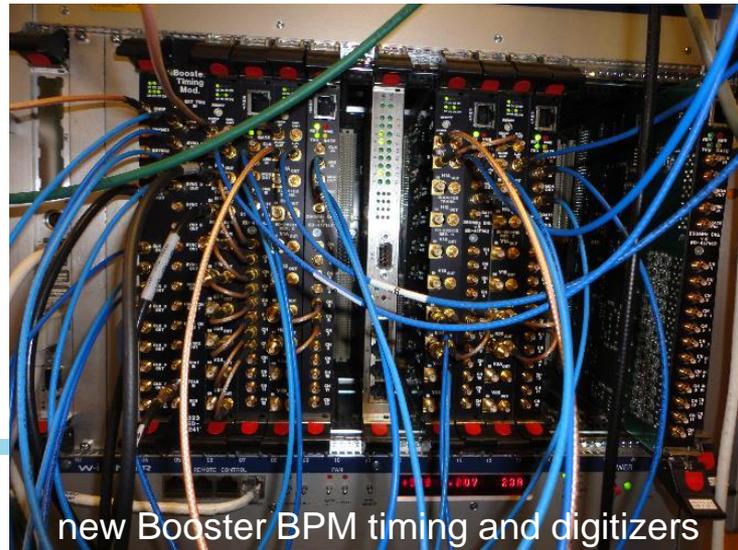
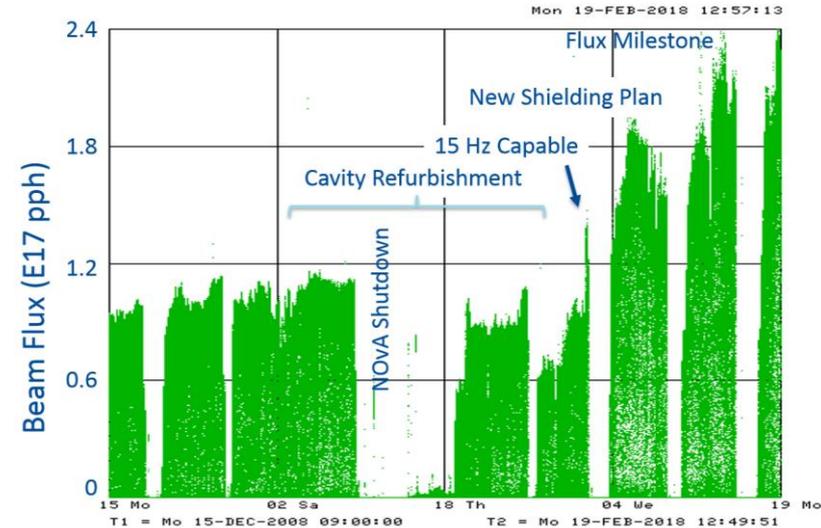


FY18 Integrated Beam to SY120



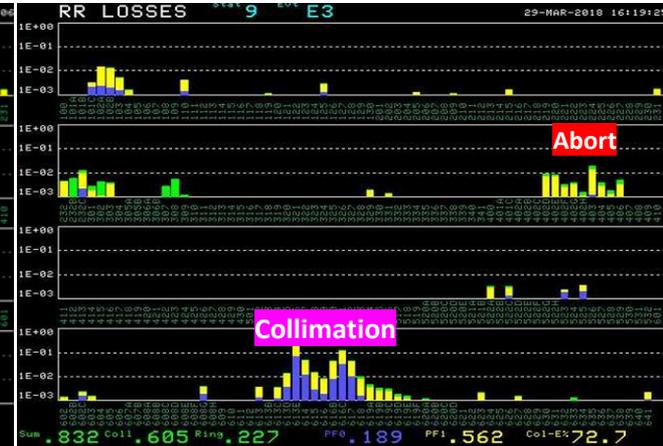
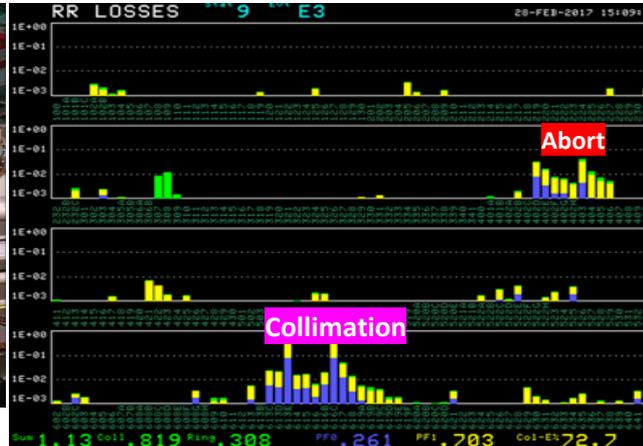
Proton Improvement Plan will complete this summer!

- Running 2.4 E17 protons per hour
- Laser notcher was last critical piece
- Complete Marx modulator installation
- BPM upgrades
- Plan to install prototype replacement cavity (20-Hz capable)
- Will install perpendicular-bias 2nd-harmonic cavity to increase capture at injection



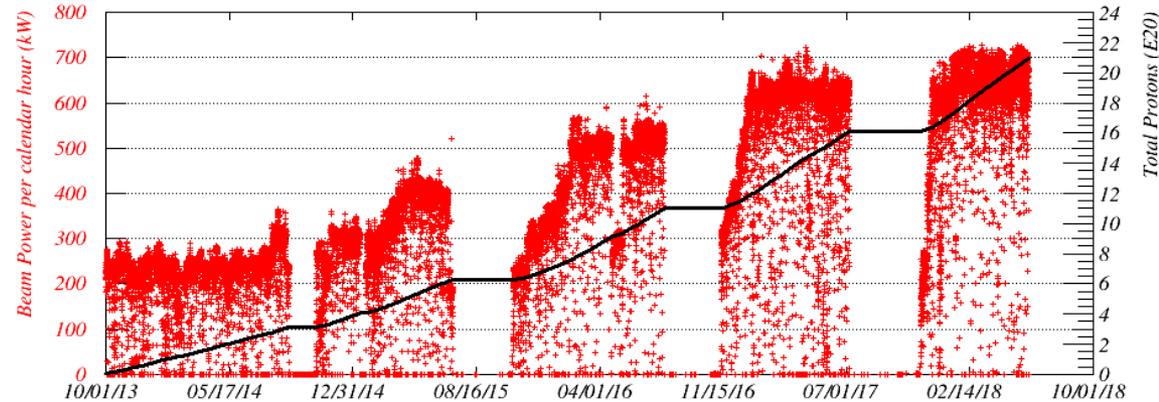
NuMI integrated beam and beam power

- Made aperture improvements in Recycler last shutdown to reduce losses



BEFORE

AFTER

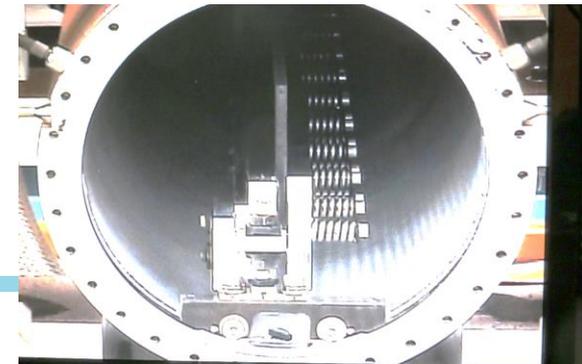
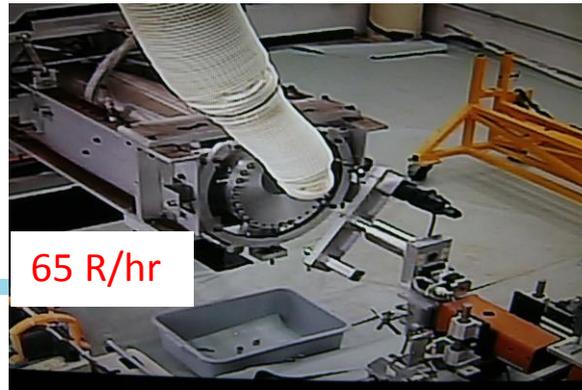
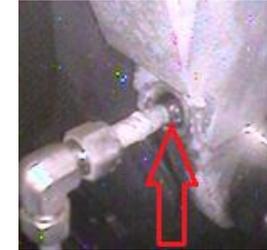


Replaced the Recycler Lambertson with an MLAW and the RR beam pipe with MI beam pipe

- Delivered 21 E20 p to NuMI target since 2013
- Averaging 0.73 E20/mo
- 85% uptime recent years
- Short shutdowns help keep NOvA competitive
- New shielding assessment approved for up to 1.5 MW!

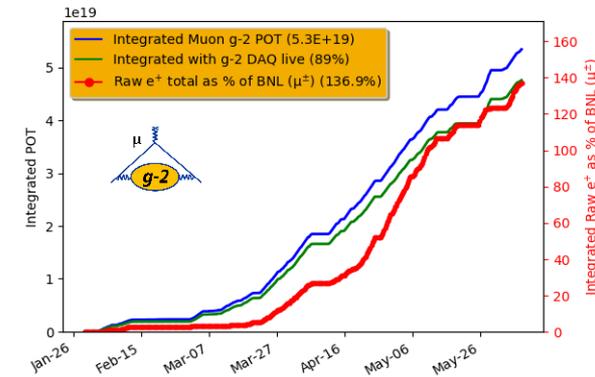
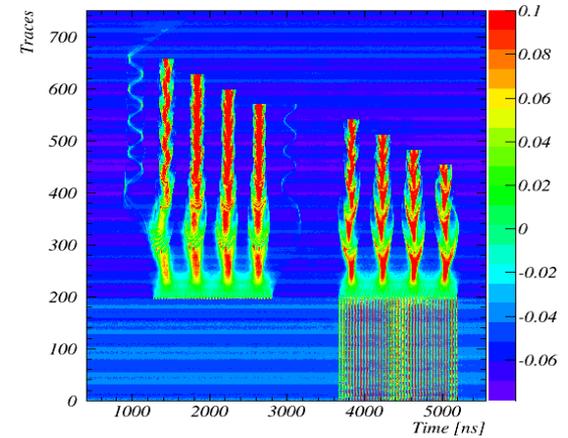
External beamlines and target systems

- Neutrinos for MINERvA, NOvA, MicroBooNE, ANNIE, and MITPC
- Neutrino detector calibration for LArIAT and NOvA test beam
- Supported ~20 test beam experiments in MTest (high demand)
- Updating beamline for E1039 (follow-up to SeaQuest starts 2019)
- Pursuing additional capabilities, such as an irradiation test facility in the former MTA beamline
- Continue producing spare targets and horns
- NuMI Horn 1 PH1-03 has leaking water line
- NuMI target TA-02 has He leak (window) and will be replaced
- Remote autopsy of first target for NOvA (removed in 2016 due to helium leak in window) found no damage to graphite fins
 - Good news for NOvA, MINERvA and future LBNF/DUNE

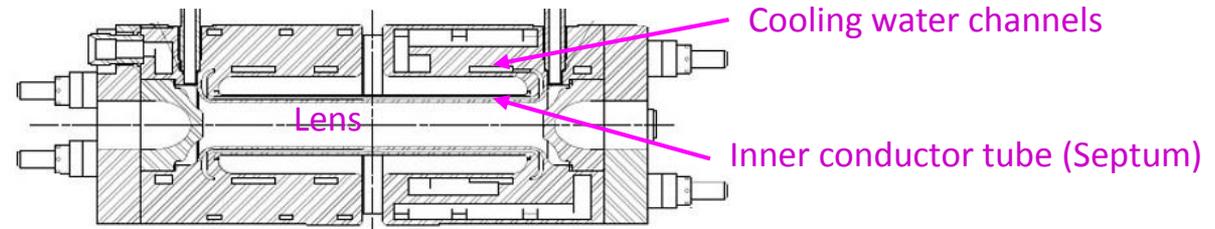


Operating beam to g-2

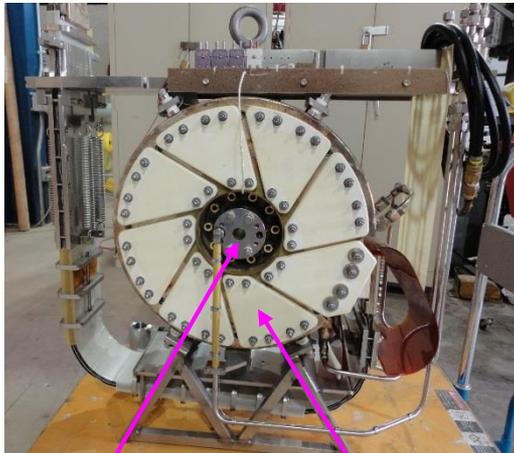
- Recycler commissioned re-bunching of 2 Booster batches into 8 bunches to g-2
- “PEMP notable” of 5000 stored muons/sec average was achieved on January 12
 - (this is a DOE goal where failing would have serious consequences for the lab)
- Experiment has collected more data than the Brookhaven experiment (can publish result)
- Lens changed out:



On April 6 at 9:13am, Lens failed due to a fast and high water conductivity, which is an indication of a septum breach in which RAW water comes into contact with lithium metal which forms lithium hydroxide solution.



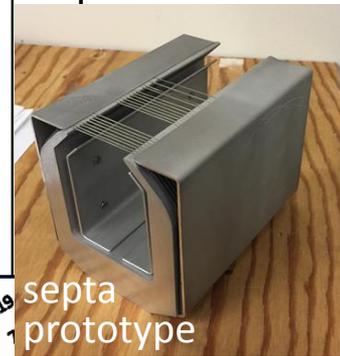
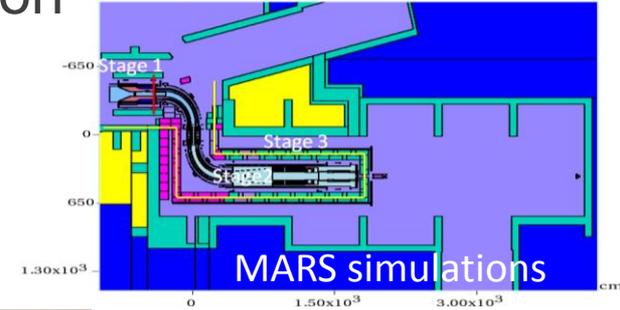
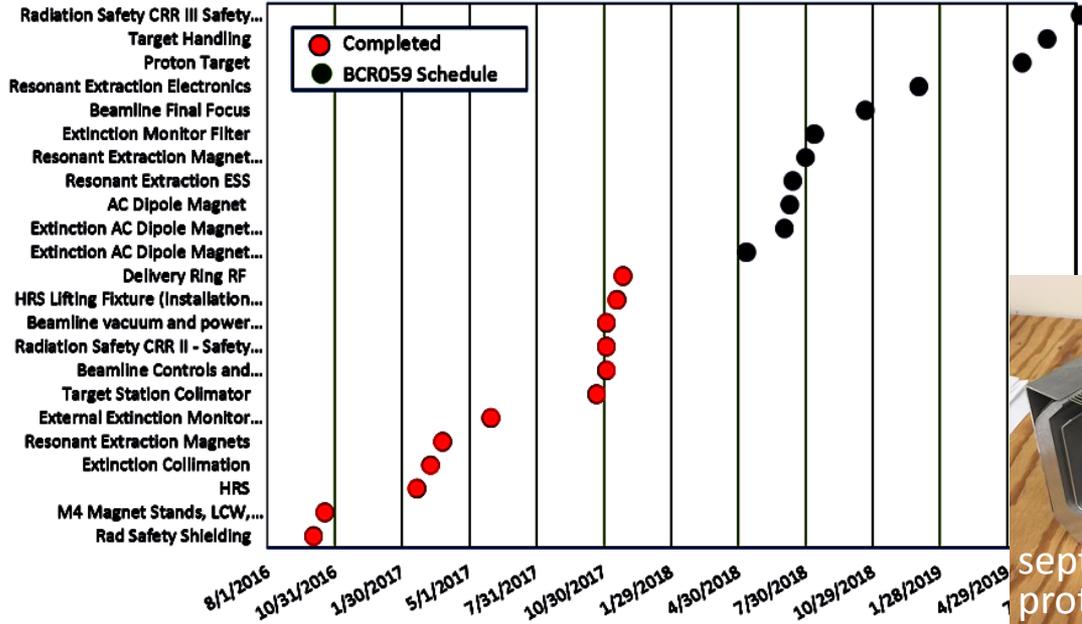
- The previous Lens Change-out took place in August 2010
- Two experts (Tony Leveling, Ryan Schultz) have since left the lab
- TSD team led the effort to have the Lens/transformer changed out smoothly on April 9-10, 2018 [Lens/transformer change-out Elog](#)



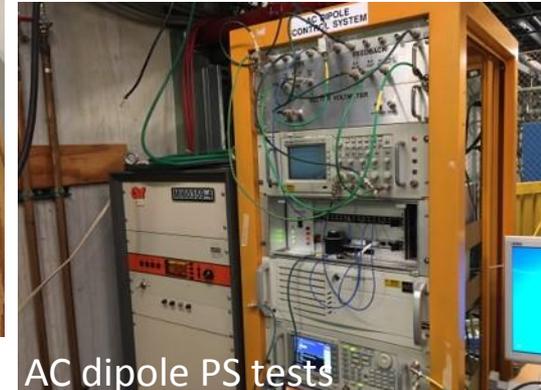
Lithium lens Transformer

Preparing the Muon Campus for Mu2e

- Mu2e Project working its way through Construction Readiness Reviews, then moving forward with construction



septa prototype



AC dipole PS tests



prototype remote handling for target changeout



M4 line

Controls

- Ethernet based Multi-Function Timing Unit developed - first installs scheduled during summer shutdown
- Assembly & test of 25 Ethernet SWIC Scanners for Mu2e
- Extended AD ACNET & Timing Links to SBN Near & Far Detector Buildings and installed IRMs for clock decoding there
- Support for PIP2IT:
 - General controls infrastructure, motion control for scrapers and wire scanners, machine protection, and application software.
- IOTA controls installations
- All Switchyard and F-sector Arcnet/80186 vacuum crate controllers replaced with Ethernet/RaspberryPi cards.
- Seven FIRUS Locations upgraded from Arcnet to Raspberry Pi systems
- Controls installations for new Booster RF stations
- 40-year-old LCW controls at MS2 replaced with PLC based system

Preparation for megawatt beam power

- NuMI beam power currently ~700 kW
- Hoping for approval of Accelerator Improvement Projects to get to 900 kW by ~2021
- PIP-II starts at 1.2 MW with existing Booster
- Upgrade to 2.4 MW with extended linac or new booster
 - PIP-III possibly Rapid Cycling Synchrotron (RCS) with integrable optics (test with IOTA)
- Will need target systems that can withstand high beam power

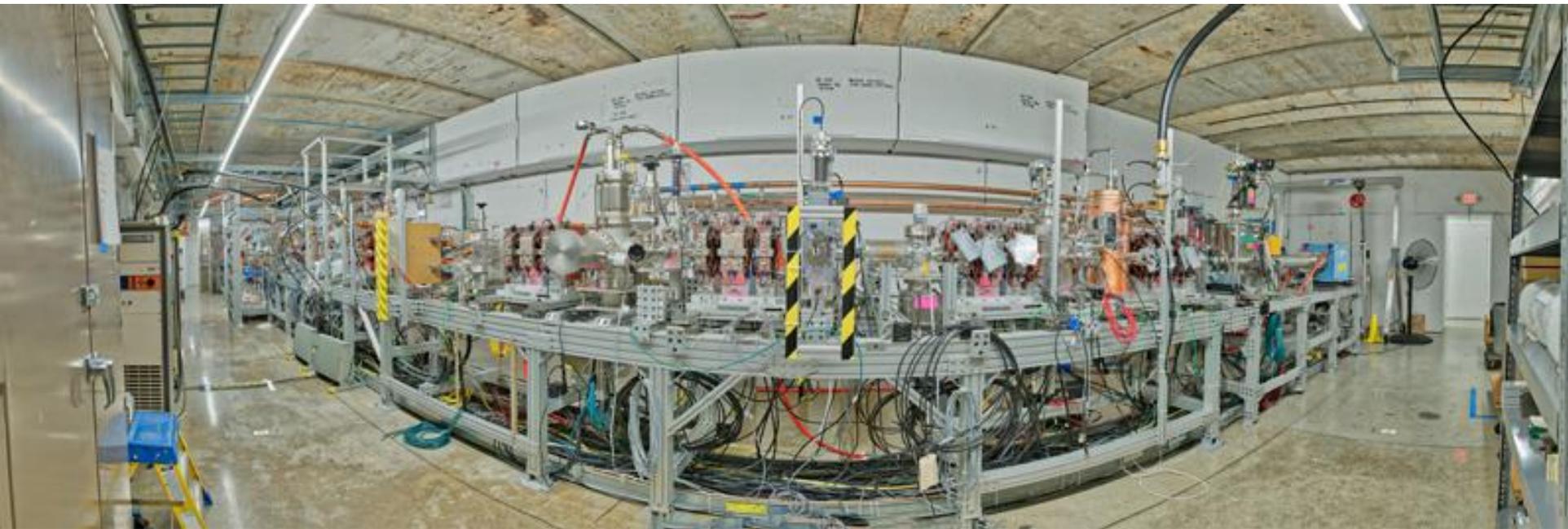
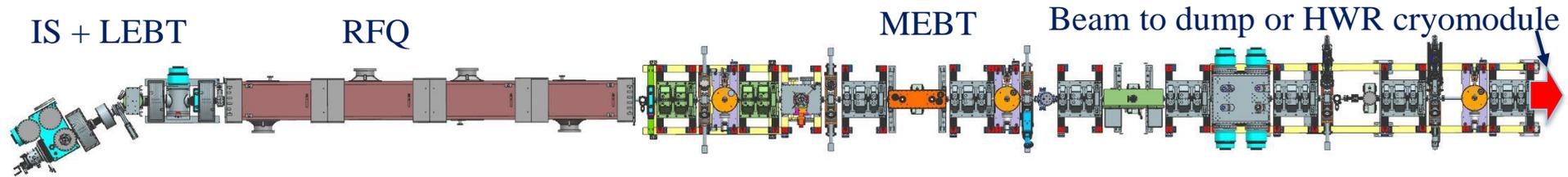
Workshop on Megawatt Rings and IOTA/FAST Collaboration Meeting – May 7-10, 2018

- Summary of PIP and current performance limits
- How to upgrade Fermilab accelerators to 1MW+ beam power
- IOTA status and experiments – relevant for 2.4 MW and Rapid Cycling Synchrotron design
- FAST – experiments and Accelerator Science Initiative



PIP-II Injector Test

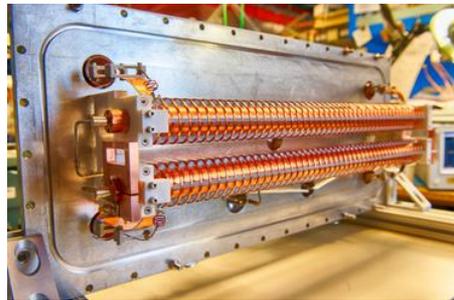
- Warm Front End assembled



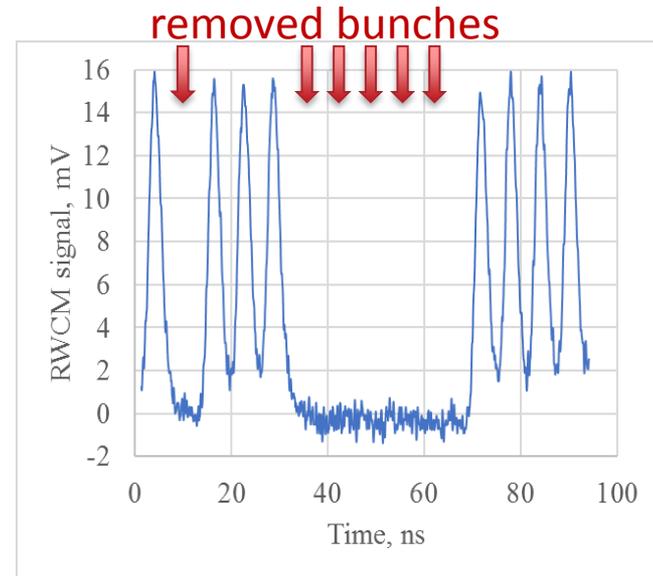
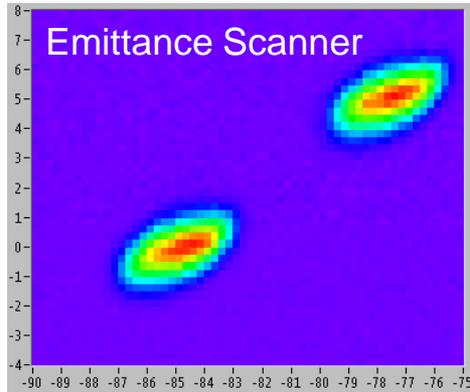
- Will ultimately include low-beta superconducting cryomodules (HWR, SSR1) capable of accelerating 2 mA of beam to 25 MeV

PIP2IT chopper

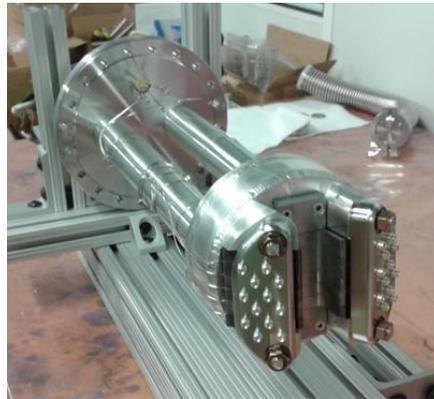
- “Bunch-by-bunch selection” in MEBT removes un-needed bunches
- The selection scheme is being tested at PIP2IT
 - Chopping system: Two kickers working in sync and absorber



200 Ohm kicker

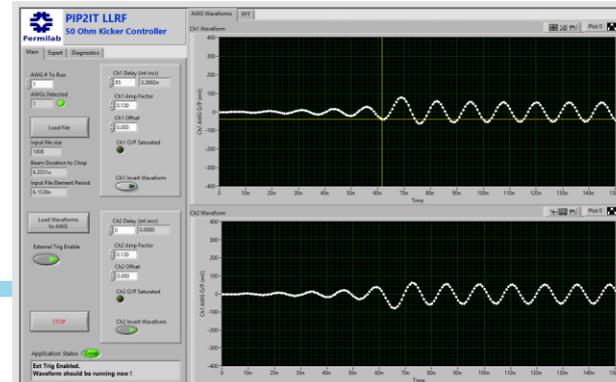


50 Ohm kicker

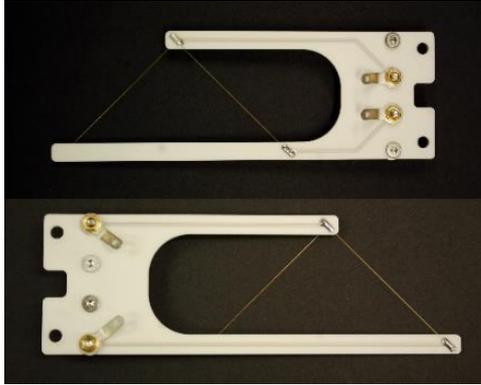


1/4 length absorber prototype

LLRF



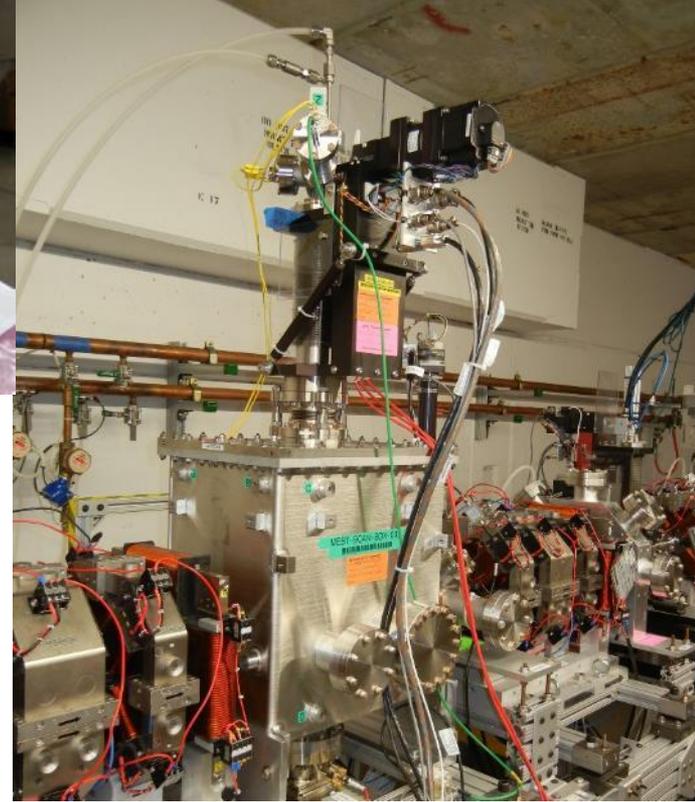
PIP2IT



New design crawling wire



Allison-style emittance scanner



162.5 MHz, 7 kW circulators for Buncher 2 and 3

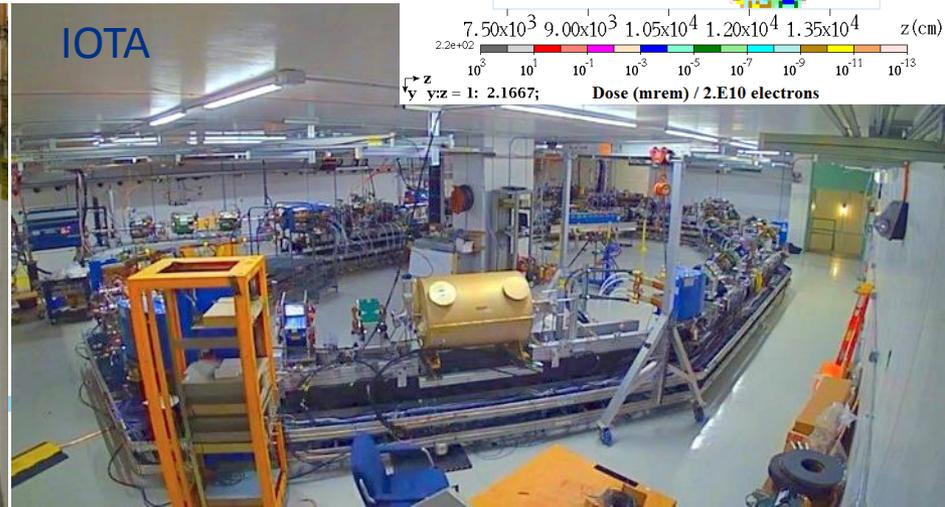
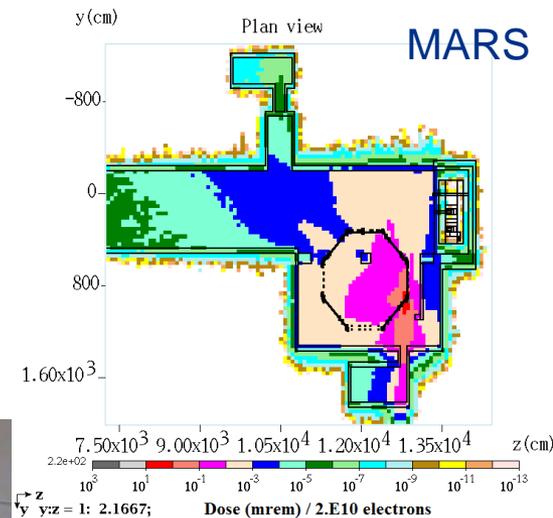


LLRF hardware



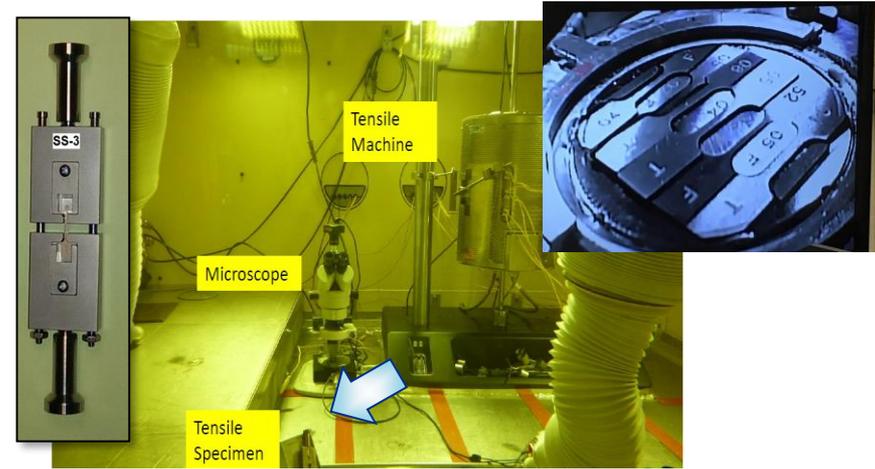
FAST/IOTA

- FAST electron linac complete in 2017, had 2-month run
 - IOTA injector commissioning
 - For the first time, beam accelerated through ILC-type cryomodule to energy 150 MeV in October 2017
 - Achievement of 300 MeV beam in SRF linac
 - Collaboration-driven accelerator-physics experimental program with uptime over 85%
- IOTA construction near completion with commissioning to begin in July-August



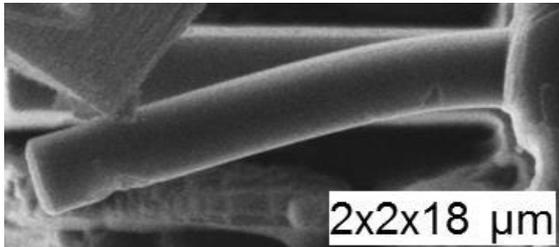
High Power Targetry R&D

- Test properties of potential target materials after irradiation
- RaDIATE Collaboration has grown to 14 institutions including CERN, KEK, JAEA
- Looking into robotics side of advanced targetry technology



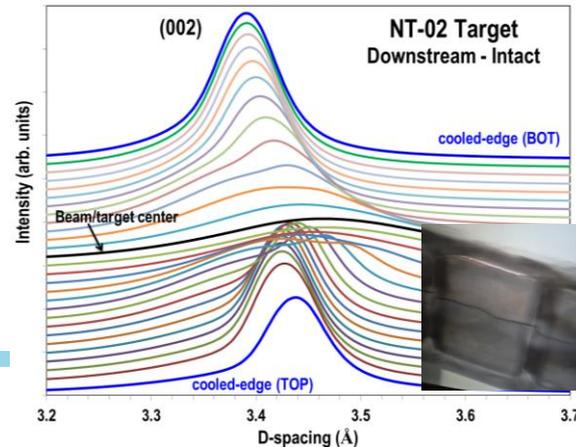
- Irradiated >200 samples at BLIP (181 MeV p beam)
- Radiation damage effects on high-cycle fatigue of titanium alloys (world-first)

Micro-mechanics testing of irradiated beryllium & graphite



Micro-Cantilever bend test

X-Ray diffraction studies of irradiated graphite at NSLS-II



Preparing for world-first test of irradiated materials in-beam thermal shock test at HiRadMat (CERN)

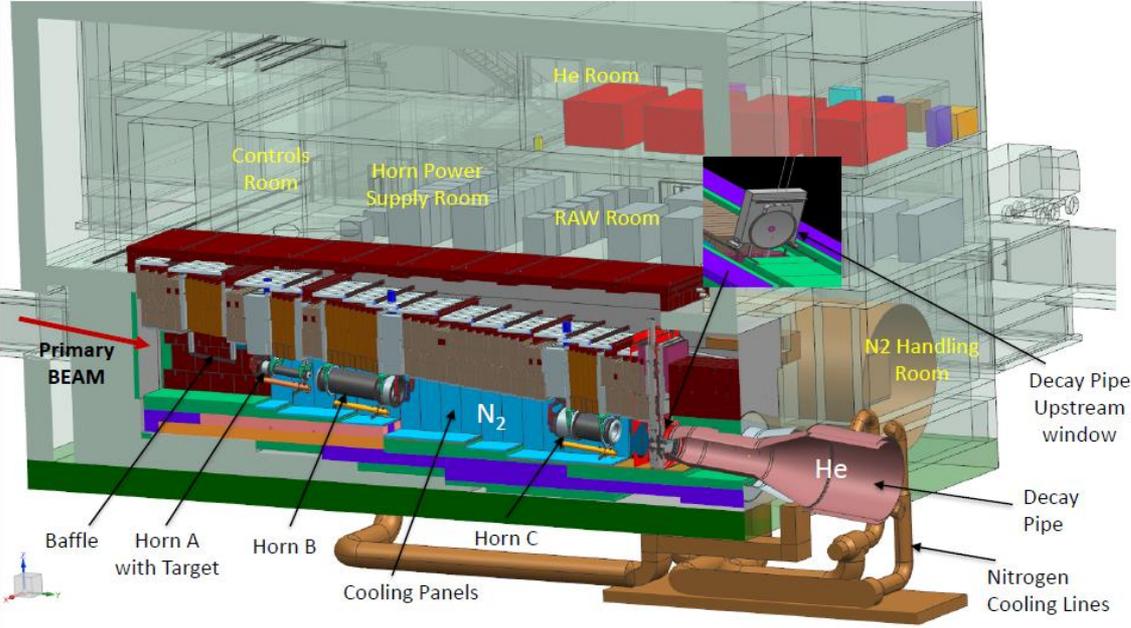
LBNF

- Beam Optimization Review endorsed the new optimized design
- Main changes include three horns of new design (not NuMI-like) and a target of four (instead of two) interaction lengths. We are collaborating with RAL on a fully-helium cooled optimized target.
- With funding back up this year, ramped up effort in the Beamline in April. Preliminary design work started in June on the neutrino beam and is expected to start in August on the remaining Beamline systems.
 - Tested LBNF kicker magnet prototype that was assembled by TD
 - Collaborating with IHEP/China on the production of LBNF corrector magnets, prototyping the upstream decay pipe window, and co-designing a prototype of a SEM hadron monitor
 - Collaborating with KEK/Japan on the prototyping of a horn stripline feedthrough and of a target shield pile hatch cover O-ring seal system for LBNF.
- LBNF/DUNE CD-2 DOE review is planned for October 2019

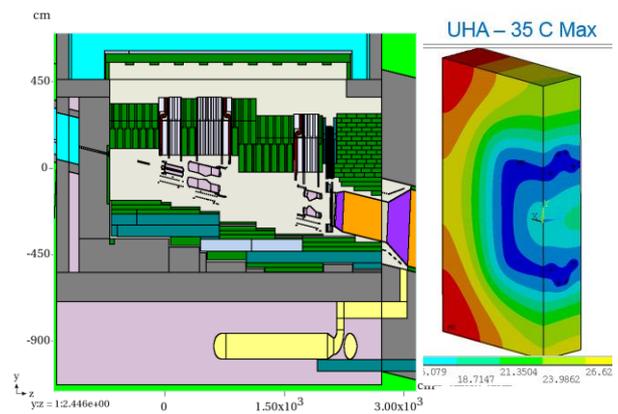
Recent LBNF Beamline progress

- Advanced and improved target shield pile design for better reconfigurability
- Advanced the conventional facilities design for a nitrogen cooled target shield pile and for a fully He-cooled target
- Moved morgue of spent components inside Target Hall for ALARA

LBNF Target Shield Pile and Target Hall Complex



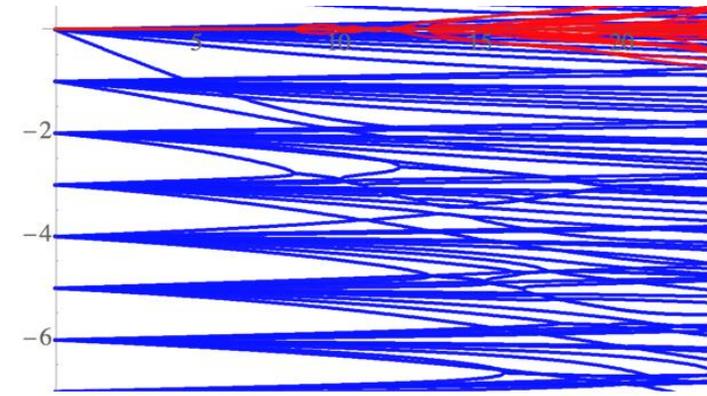
Target Chase: 2.2 m/2.0 m wide, 34.3 m long nitrogen-filled and nitrogen plus water-cooled.



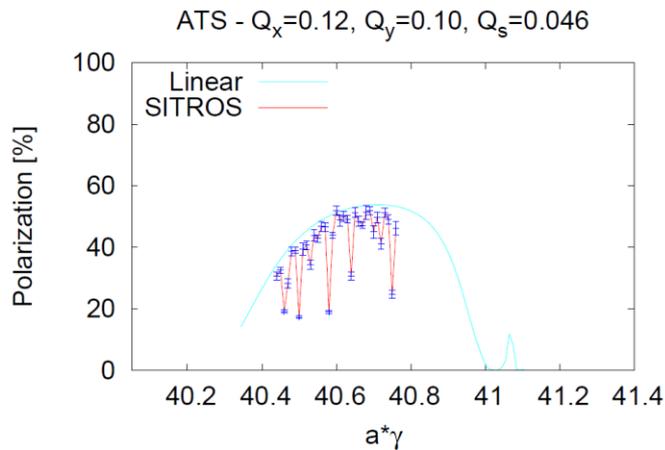
Thorough MARS15 simulations on Fermigrad and ALCF-ANL to justify and optimize the Neutrino Beamline Design with the new target/horn configuration, with results as a basis of FEM thermal/stress analyses and majority of design and ES&H solutions including neutrino fluxes at FD

Accelerator theory group

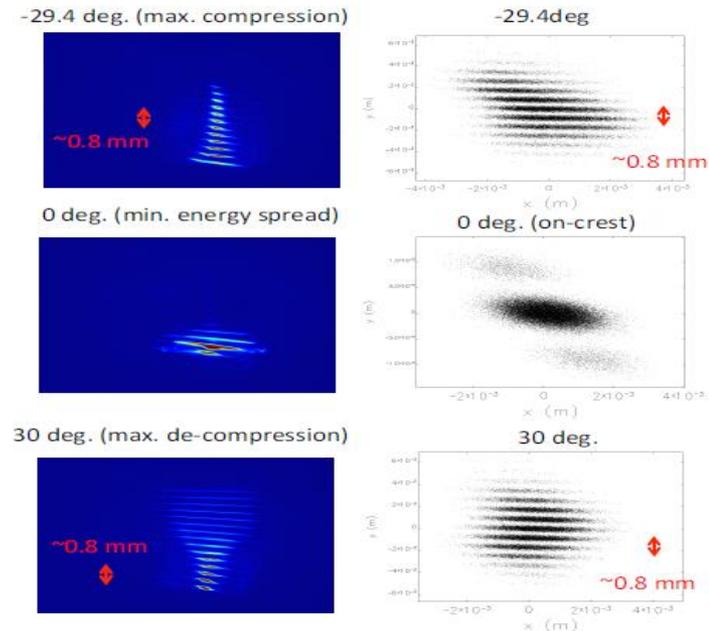
- Theory of coherent instabilities in high-intensity bunched beams and methods of suppression
- Accelerator optics design and correction
- Space charge effects and compensation
- Polarization issues in future circular colliders
- Support for experiments at IOTA/FAST



Head-tail tunes (blue) and TMCI increments (red) in units of Q_s vs bunch intensity



Polarization in eRHIC electron storage ring



Observations (left) and simulations (right) of THz radiation in FAST

Priorities

Experiments' Run Schedule

Fermilab Program Planning 16-Mar-18

LONG-RANGE PLAN: WORKING DRAFT

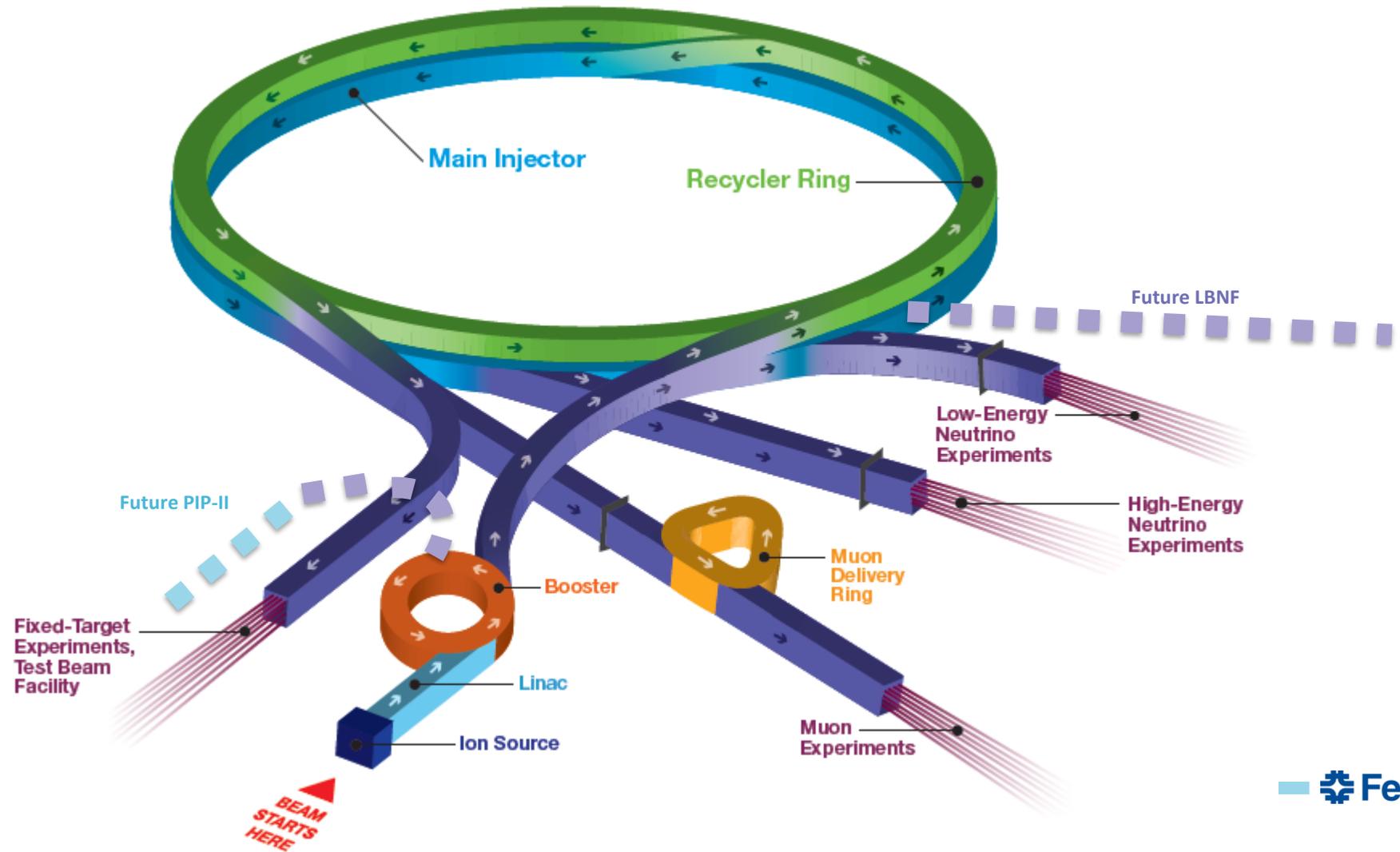
		FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30
LBNF / PIP II	SANFORD FNAL				DUNE	DUNE	DUNE	DUNE	DUNE	DUNE	DUNE	DUNE	DUNE	DUNE
						LBNF	LBNF	LBNF	LBNF	LBNF	LBNF	LBNF	LBNF	LBNF
NuMI	MI	MINERvA	MINERvA	OPEN	OPEN	OPEN	OPEN	OPEN	LONG SHUTDOWN					
		NOvA	NOvA	NOvA	NOvA	NOvA	NOvA	NOvA						
BNB	B	MicroBooNE	MicroBooNE	MicroBooNE	OPEN	OPEN	OPEN	OPEN	LONG SHUTDOWN					
		ICARUS	ICARUS	ICARUS	ICARUS	ICARUS	ICARUS	ICARUS						OPEN
		SBND	SBND	SBND	SBND	SBND	SBND	SBND	OPEN	OPEN	OPEN	OPEN	OPEN	
Muon Complex		g-2	g-2	g-2	LONG SHUTDOWN									
		Mu2e	Mu2e	Mu2e						Mu2e	Mu2e	Mu2e	Mu2e	Mu2e
SY 120	MT	FTBF	FTBF	FTBF	FTBF	FTBF	FTBF	FTBF	LONG SHUTDOWN					
	MC	FTBF	FTBF	FTBF	FTBF	FTBF	FTBF	FTBF						FTBF
	NM4	OPEN	E1039	E1039	E1039	E1039	E1039	OPEN	OPEN	OPEN	OPEN	OPEN		
		FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30

Construction / commissioning
 Run
 Subject to PAC review
 Shutdown

- NOvA will run until long shutdown planned for 2024-26
- MicroBooNE may continue running, ICARUS to start in 2020
- g-2 approved to run into 2020, when Mu2e starts commissioning
- E1039 (SeaQuest with polarized target) starts next year

PIP-II and LBNF

- Received significant funding this year, AD support is critical “All in”
- Aiming for long shutdown 2024-26 to connect to Booster / MI



Accelerator operations priorities for the next year

- Complete the Proton Improvement Plan this shutdown
- Deliver beam to NOvA at 700+ kW beam power
- Meet beam delivery goals for the g-2 experiment
 - Mu2e beam commissioning needs to start in 2020
 - We need to make sure g-2 gets full dataset by then
- Support test beam and E1039
- Deliver beam to SBN experiments (MicroBooNE)
 - When ICARUS turns on in 2020, BNB priority will increase
- Develop and execute Accelerator Improvement Projects (if approved) to increase beam power to NOvA to ~900 kW in 2021 and prepare for PIP-II

*“must
[continue to]
shine”*