Accelerator Complex

Mike Lindgren
Mary Convery

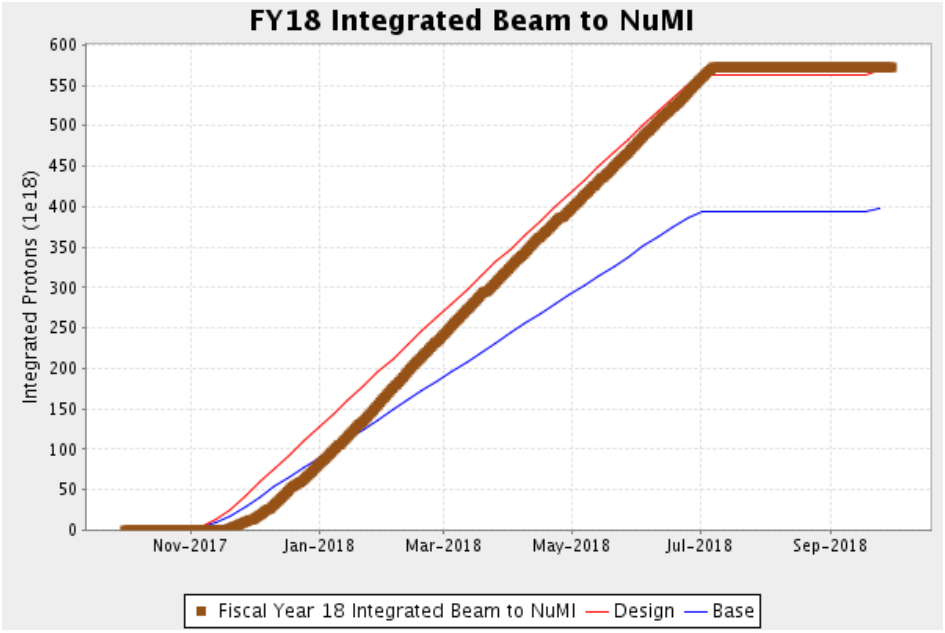
PAC Meeting

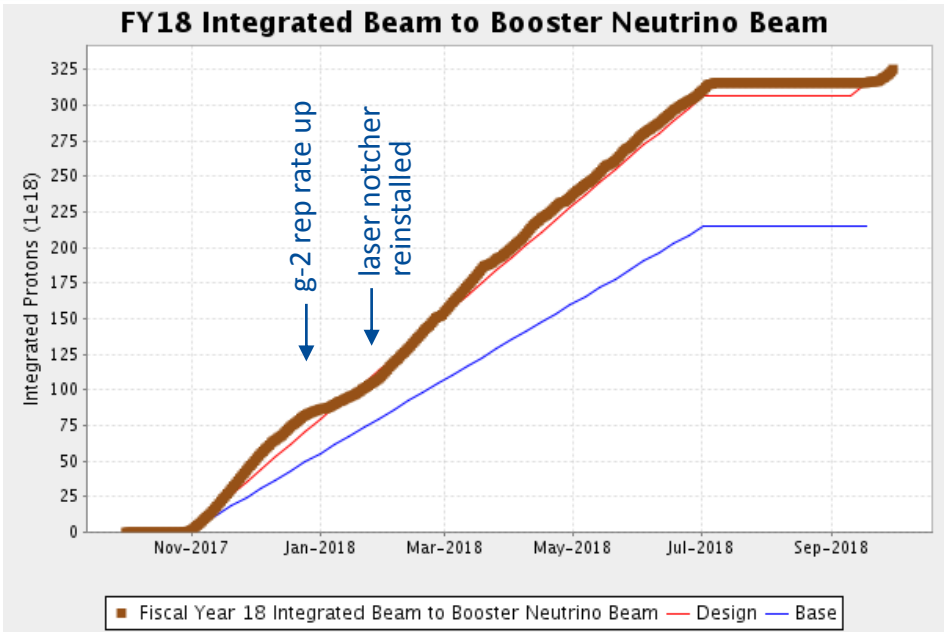
17 January 2019

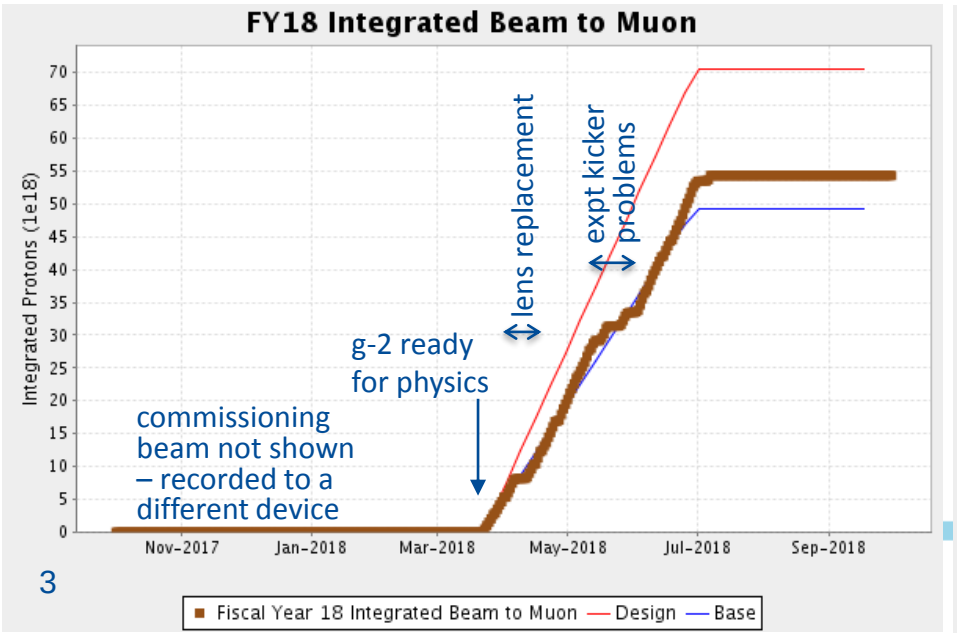
Accelerator Operations priorities for FY18-19

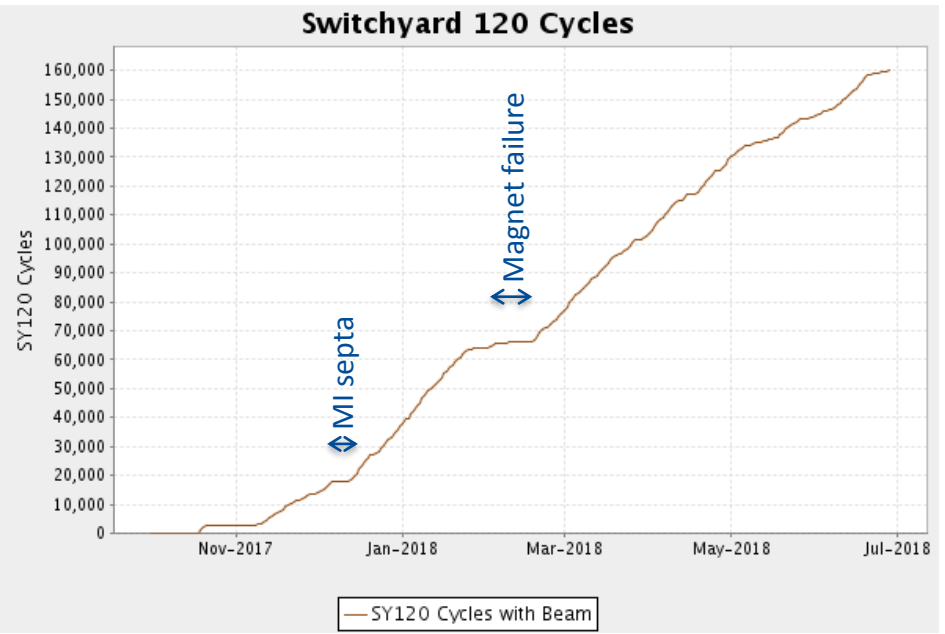
- Deliver beam to NOvA at 700+ kW beam power
- Deliver beam to the g-2 experiment
  - Achieved PEMP Notable in FY18
- Deliver beam to SBN experiments (MicroBooNE)
- Support the test beam program
- Complete the Proton Improvement Plan, designed to ensure a useful operating life of the Linac through 2025 and the Booster through 2030
- Develop and execute PIP-I+ to increase beam power to NOvA to ~900 kW prior to PIP-II

FY18 accelerator performance

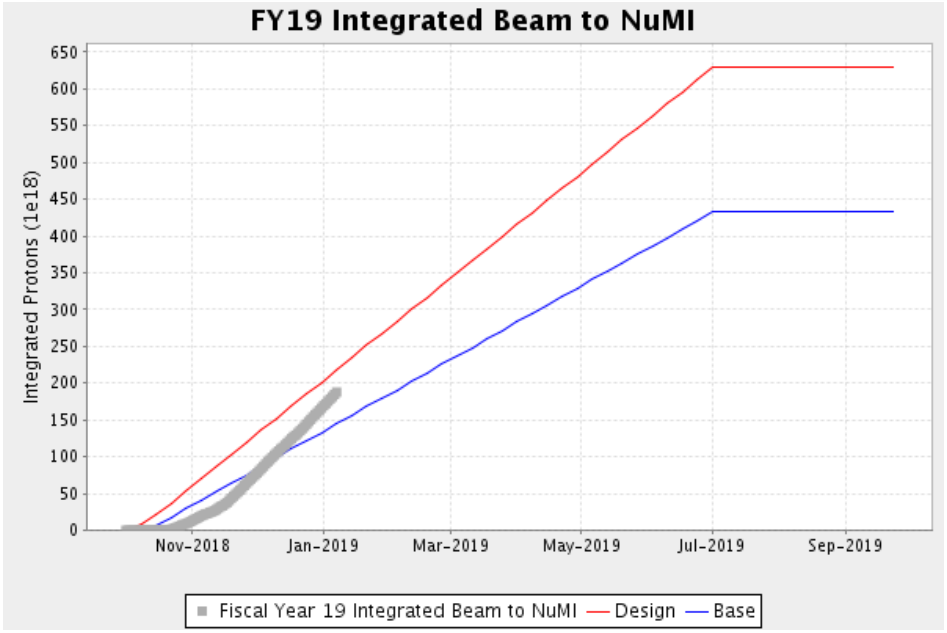


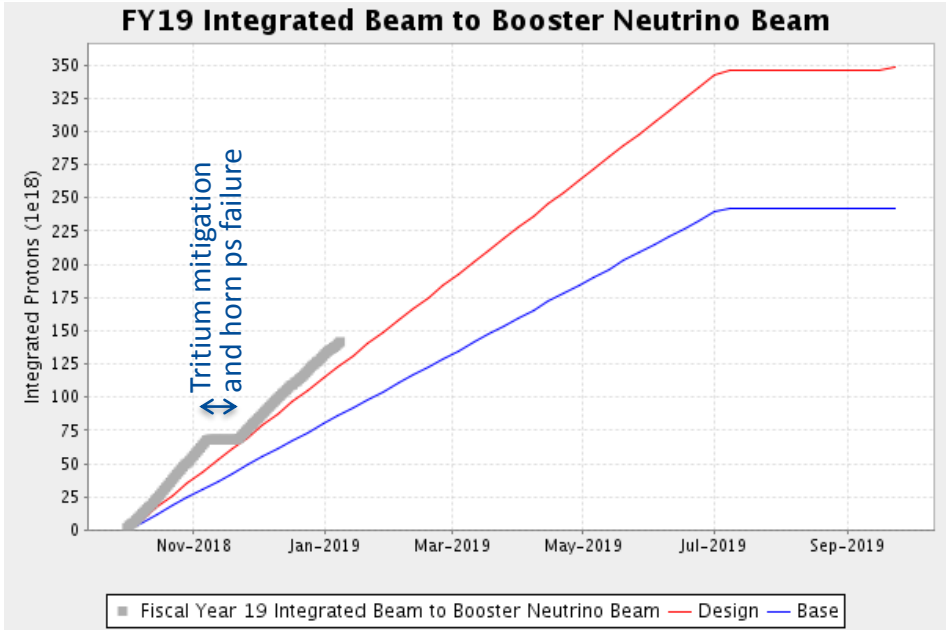


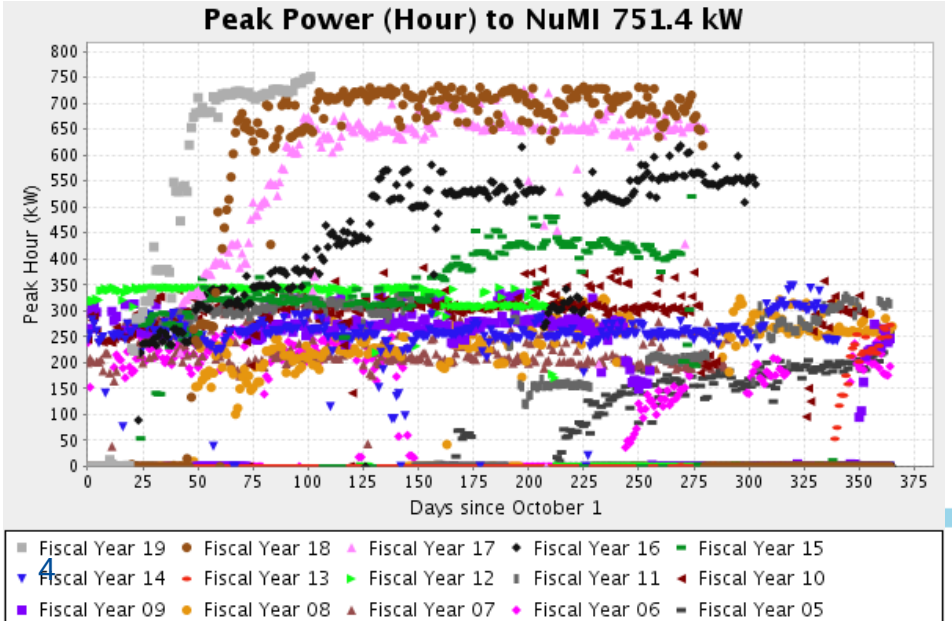




FY19 accelerator performance to NuMI and BNB



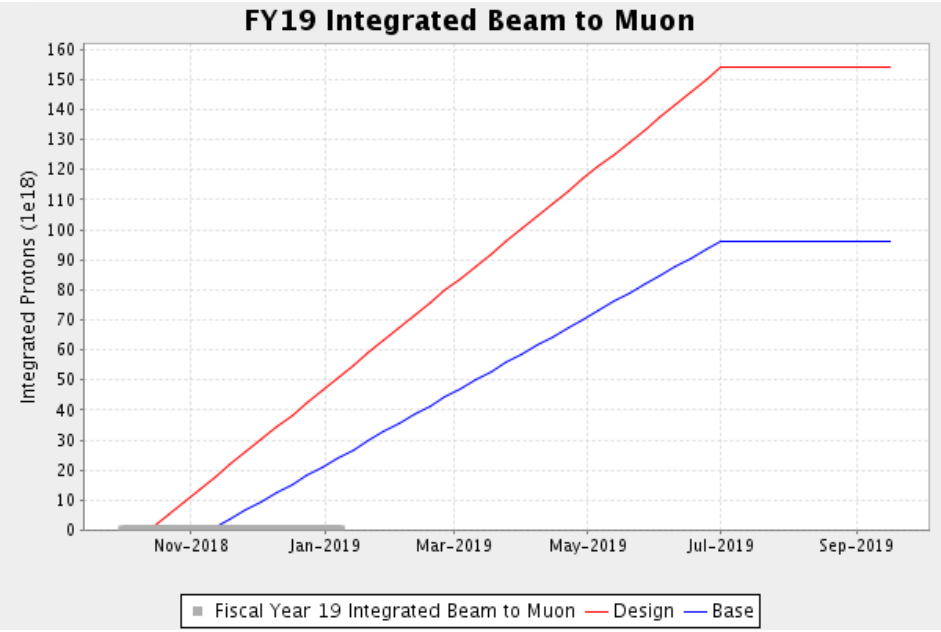


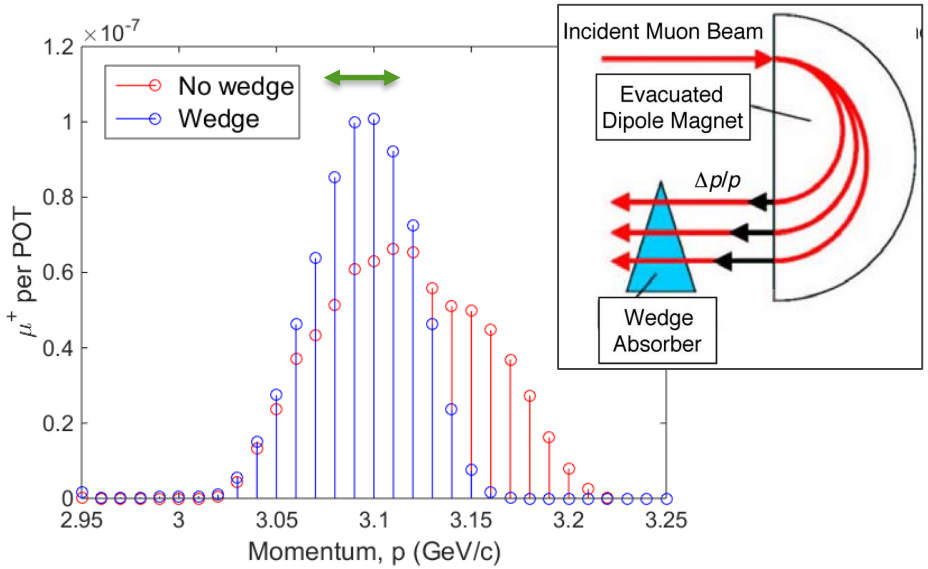


- Note that NuMI and especially BNB benefit when g-2 is not running
- BNB horn charging power supply was repaired by converting units for running in opposite polarity; will no longer be able to run in negative polarity

Fermilab

FY19 accelerator performance to Muon Campus

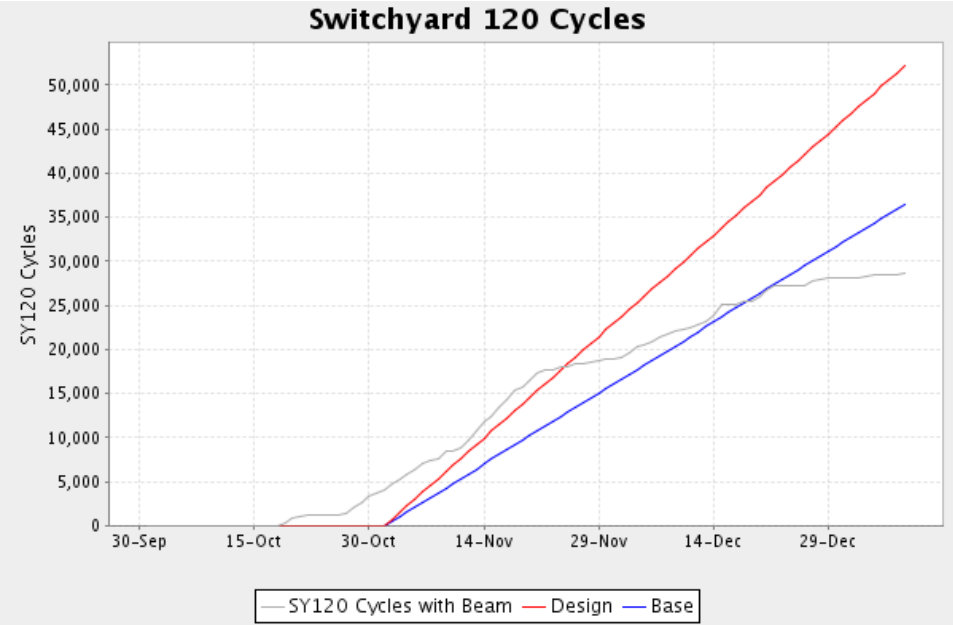


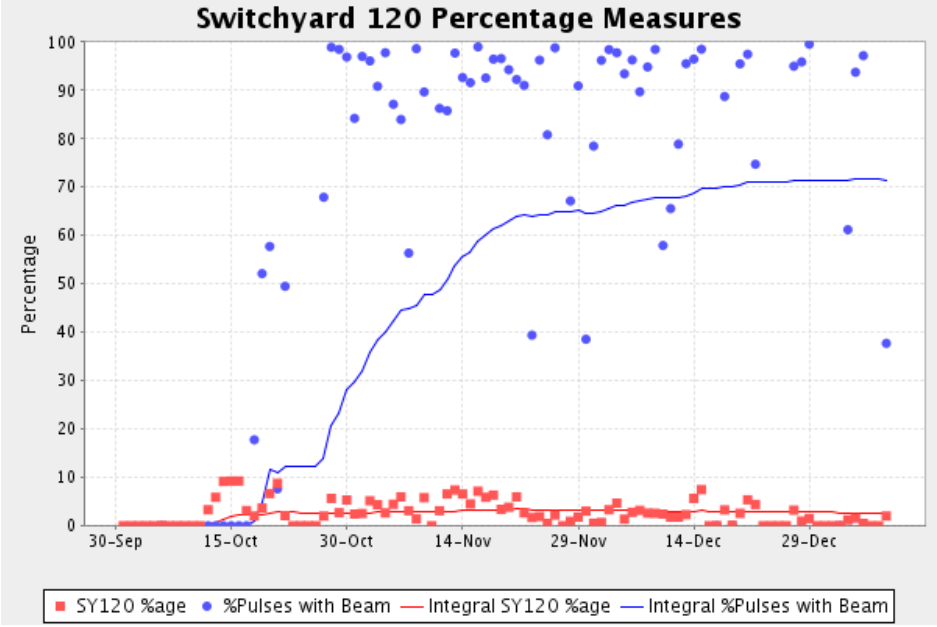


- May modify red/blue lines to start when g-2 is ready for physics
- Note that g-2 would have lost one month of beam due to a chiller failure for the Recycler 2.5 MHz RF due to new procurement rules that deter Time & Materials contracts for emergency repairs
  - This did affect Mu2e beam studies
- Installed muon momentum cooling wedges to maximize muons in the momentum acceptance of ring for up to 20% gain

Fermilab

FY19 accelerator performance to SY120

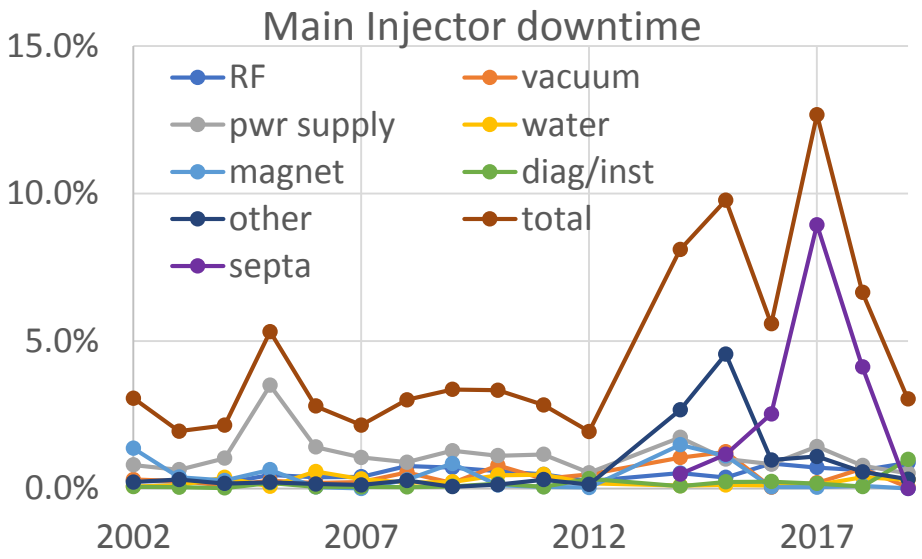




- Want to track performance to test beam in some way
- Counting cycles with beam works for all experiments regardless of requested intensity
- Red line for SY120 assumes 1 pulse per minute with typical accelerator uptime plus 70% experiment uptime

MI septa

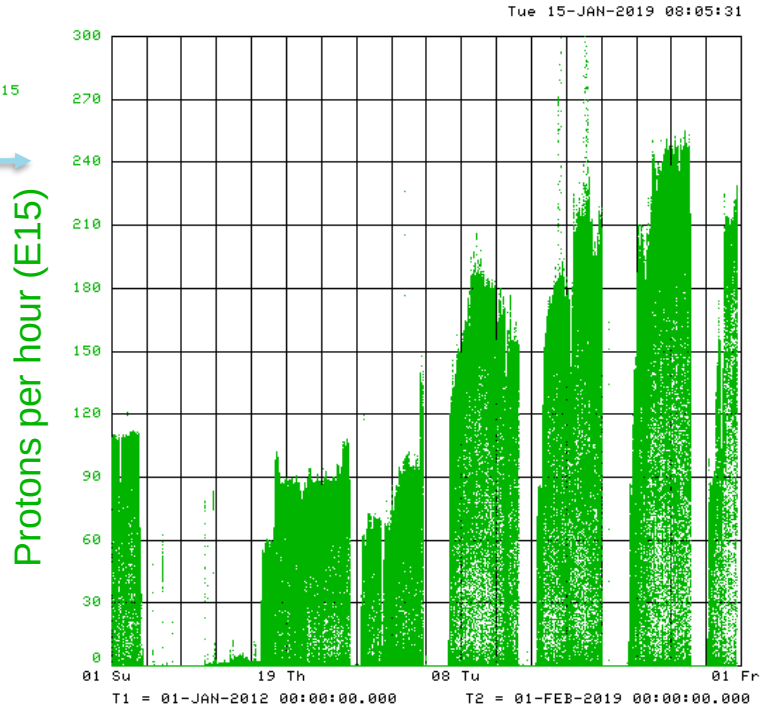
- Established a task force a year ago to address the MI septa which had become a significant source of downtime due to broken wires and vacuum problems
- As end wires break, field changes and nearby wires are more likely to break

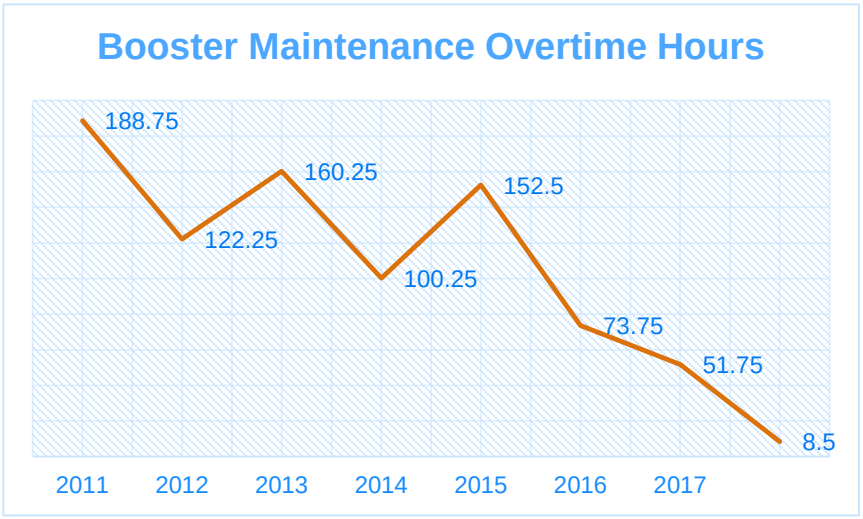


- Removed pbar kicker after RGA scans indicated poor vacuum was due to leaking fluorinert – no vacuum issues or broken wires since
- Fabricating spare septum (converting 2 mil spare to 4 mil)
- No conclusive explanation from tensile tests and visual inspections of broken wires
- Maybe fluorinert contributed to sparking or other wire damage?

Proton Improvement Plan complete

- Able to deliver 2.4x10^{17} protons/h when NOvA, SBN, g-2 all taking beam
- Upgrades including Marx modulators in the Linac and additional RF stations in the Booster have improved reliability



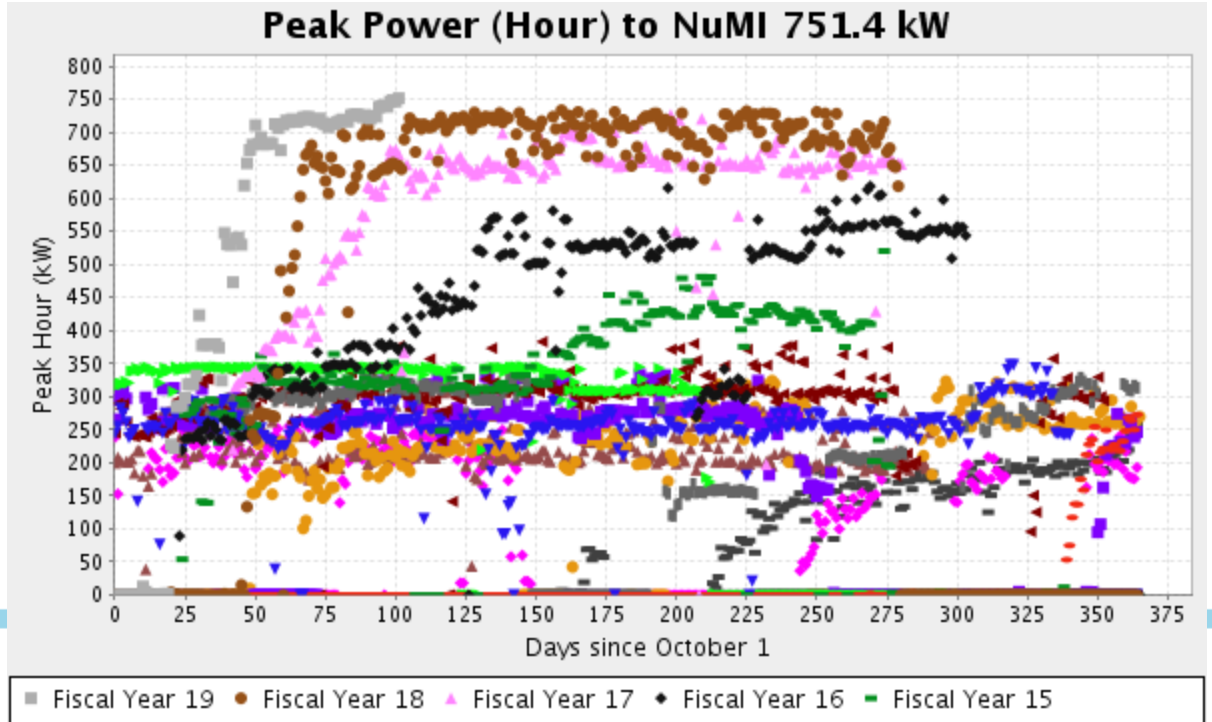


PIP-I+

- NuMI Target Systems AIP (target station robust up to 1 MW)
  - Approved
- Booster Intensity (loss reduction)
  - Transverse and longitudinal dampers*, collimators*, beam physics
  - Ready to execute when approval/funds available
- Booster D-magnets (loss reduction)
  - 4 new defocusing combined function magnets with larger aperture
  - Working on resource-loaded schedule
- Main Injector gamma-t jump* (loss reduction)
  - 18 quadrupoles of new design and power supplies
  - Working on resource-loaded schedule; would be good to start design/prototyping
- Booster RF cavities (reliability, loss reduction)
  - Build 21 cavities like PIP prototype – higher voltage, larger aperture
  - Working on resource-loaded schedule

Timescale of 900 kW to NOvA

- Target station expected to be ready for ~1MW after FY20 shutdown
  - Have been able to inch up power to ~750kW with g-2 and SY120 off within existing constraints on intensity per pulse to target
  - After FY19 shutdown, power limit will be ~850kW
- Timescale of significantly increasing beam power to NOvA depends on funding profile from DOE
  - Had positive discussion last week



Fermilab

Accelerator Advisory Committee comments on PIP-I+

- The work scope presented at AAC 2017 to deliver higher beam power to NOvA and prepare parts of the accelerator complex outside the PIP-II scope has been delayed, making prioritization and scheduling even more critical. Would the priorities of the revised work scope produce the maximum possible number of POT, given the constraints presented?
- *The team has presented a sound plan with a revised and prioritized scope to increase beam power to 900 kW and to prepare the target systems for PIP-II* [sic]*. This will allow a maximum number of protons on target.*

Accelerator Modernization review

- Have identified
  - ~$5.5M obsolete controls hardware
  - ~$1M Proton Source upgrades excluding PIP-I+ (most already done on PIP)
  - ~$20M Main Injector / Recycler upgrades excluding PIP-I+ (MI now 20 yrs old)
  - ~$3.5M External Beams upgrades, mostly SY120, $340k to replace obsolete BNB horn charging power supply
  - ~$3M Muon Campus upgrades of components from Pbar era
  - ~$1M safety upgrades (tech shop safety, new rad detectors)

Accelerator Controls System

- Need modernization beyond replacing obsolete hardware
- PIP-II does not plan to use ACNET; we want to modernize complex in an integrated plan with PIP-II
- Held a workshop in September including representative AD “users” and controls experts from other labs
- Putting together a task force to determine requirements
- Preparing a job opening for leader of the upgrade effort

Accelerator Advisory Committee comments on controls

- Assess and comment on the Fermilab Accelerator Control System (ACNET) Upgrade under consideration.
- *A global strategy for the full complex is needed: hardware consolidation; controls system upgrade; PIP-II. The time-line for developing this strategy is demanding, but it is important that appropriate choices are made at this stage. Resources, both material and personnel, are limited.*
- *The controls infrastructure choices are critical and have far reaching consequences. Due time should be given to carefully evaluating the options and making sure that the chosen solution(s) fully meet the present and future needs of the complex. Requirements must be clearly established.*
- Some comments:
  - It is definitely time to move on.
  - Supporting both architectures in the long term would place too much of a strain on the limited resources.
  - EPICS, after careful evaluation, would appear a reasonable choice.
  - A re-think at some level should be performed, but given the resources and time-scale, an in-house development is ruled out. But it would certainly be instructive to at least canvas other possibilities.

Accelerator Studies

- A program of studies in the Booster has been proposed to investigate issues with high-intensity proton beam physics
  - Space charge, longitudinal dynamics, coherent instabilities, etc
  - Not an issue for us at current intensities but could be in the future
  - Collaboration with CERN, other interested labs
  - Propose ~4 weeks of studies in June, estimate 80h of dedicated studies (no beam to users), other parasitic, = 1-2% of FY19 run time
  - Will plan studies to be as efficient as possible
- In addition we have studies planned as part of the Booster Intensity subproject of PIP-I+
  - These will pay off in increased beam to users
  - Plan on 1 shift (8h) per month for dedicated studies

Accelerator Advisory Committee comments on studies

- Proposed Booster Space Charge Summer Studies
  - Assess the proposed Fermilab-CERN Booster study program (2019). The proposed program will incur loss of beam up-time to the experimental program. Does the proposed program have a high impact potential for accelerator physics and future machines? Does the AAC support/endorse proposing the study program to the Fermilab Physics Advisory Committee?
  - *The proposed program does have a high potential impact. In fact the committee was quite surprised that regular machine studies are not done. The AAC does endorse and support proposing the study program to the Fermilab Physics Advisory Committee.*
  - Recommendations:
    - Consider prioritizing the list of studies that has been presented, starting with the most impactful on future operations getting highest weight. Consider to distribute the studies over several years.
    - Seriously consider adding regular beam studies to the operation schedule.

Summary

- Met goals for accelerator performance in FY18
- On track in FY19 for NuMI and BNB, ready to deliver beam to g-2 when experiment is ready
- Proton Improvement Plan was completed successfully
- PIP-I+ received some approval and funding this year; working to increase NuMI beam power as soon as possible
- Planning 8h/mo of dedicated beam studies as part of PIP-I+
- Planning ~4 weeks of parasitic and dedicated beam studies in June with expected impact 1-2% of total beam delivery