Proton Plan for Neutrinos

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Protons for Neutrino Experiments

- Accelerator Complex provides
  - 8 GeV protons to Booster Neutrino Beam (BNB)
    - MiniBoone
    - MicroBoone (future)
  - 120 GeV protons to NuMI Target
    - MINOS
    - MINERvA
    - NOνA (future)
    - LBNE (future)
  - 8 GeV protons to pbar source
    - g-2, Mu2e (future)
- Series of upgrades to increase proton flux

Proton Plan

- 2004: "A three year plan for increasing the proton intensity delivered to the 120 GeV and 8 GeV neutrino beams, with upgrades to the Linac, Booster, and Main Injector"
  - Beam Quality and Aperture
    - Reducing beam loss to allow more total protons to be accelerated while still maintaining reasonable levels of activation
  - Repetition Rate limitations
    - Making improvements which will physically allow the Booster to operate at a higher average repetition rate (9.5-10 Hz) than the 7.5 Hz it began with.
  - Reliability and Stability
  - Beam intensity in MI for NuMI
    - Multibatch operation and slip stacking, increasing the acceptance, and removing beam halo at injection

Proton Plan

- Goals:
  - Finish by 2008, operate through 2015
  - Maximum Average Repetition Rate: 9 Hz
  - Maximum Hourly Rate: 1.4e17
  - Average Hourly Rate: 9e16
- Completed in 2009 shutdown (installation of corrector packages)

- Linac
  - 7835 Power Amplifiers
  - Quad Power Supplies
  - Instrumentation (descoped)
  - 200 MHz LLRF upgrade
- Booster
  - ORBUMP
  - Corrector Packages
  - Alignment
  - Drift Tube Cooling
  - Limits on Repetition Rate
  - Instrumentation (descoped)
  - 30 Hz Harmonic (descoped)
  - γ_t jump (descoped)
  - Solid State RF (descoped)
- Main Injector
  - Large Aperture Quads
  - Collimators
  - NuMI Slip Stacking
  - RF Upgrade

Proton Plan 2

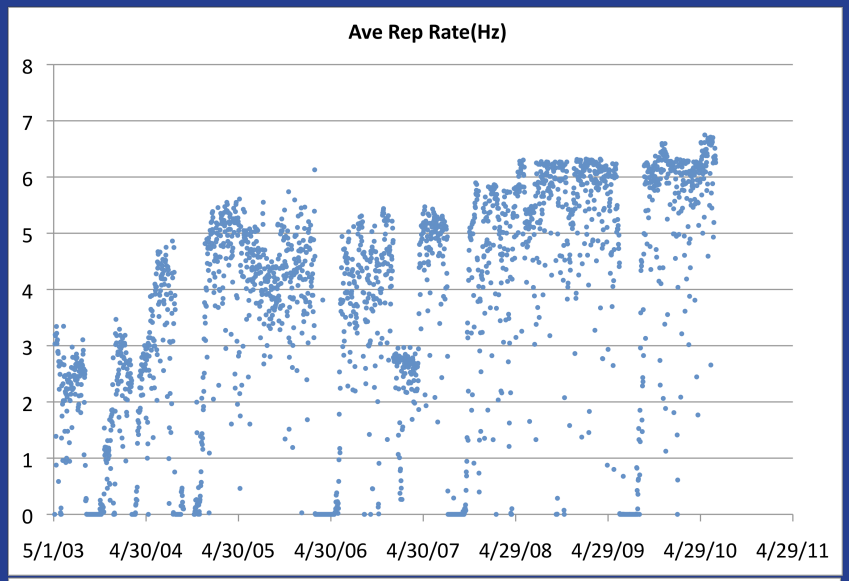
- Upgrades to Recycler Ring, Main Injector, and NuMI Target hall to support 700 kW (1 MW) 120 GeV protons for NOνA
  - Convert Recycler to proton accumulation ring
  - Shorten MI cycle to 1.33 seconds
  - New target and horn designs
  - Assumed success of Proton Plan, does not address 8 GeV protons
  - Became part of NOνA project December 2006
- Goals:
  - 4.9e13/pulse @ 120 GeV to NuMI Target
  - 1.33 second cycle
  - 95% MI efficiency

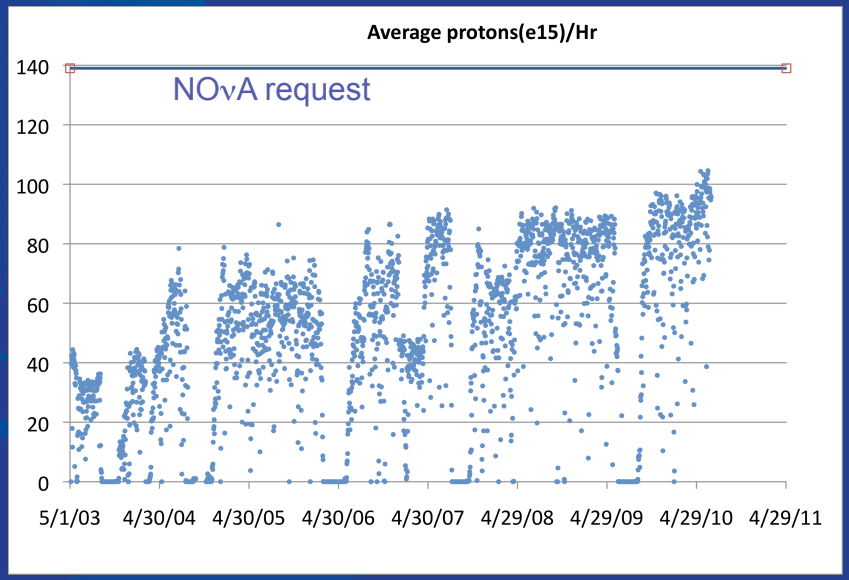
Proton Economics

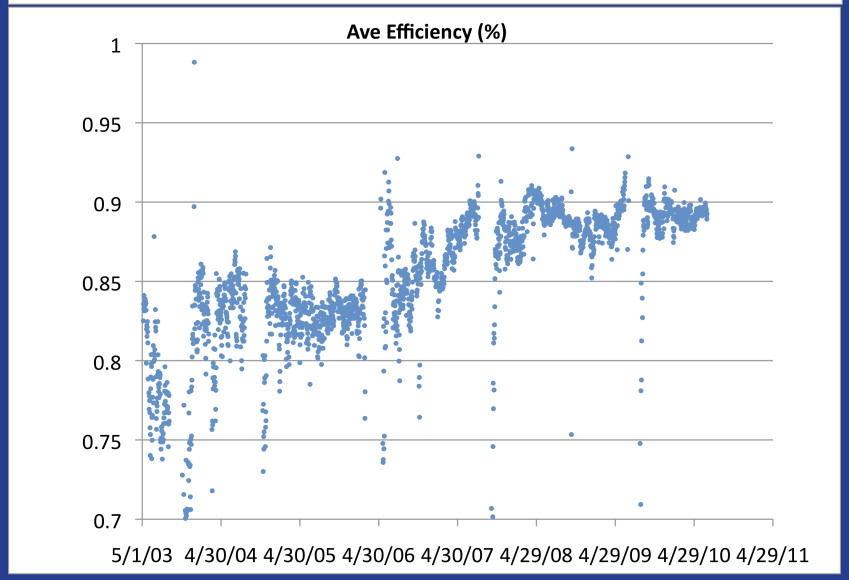
- Dominated by requests at 8 GeV
  - NOνA: 9 Hz, 4.3e12/pulse ⇒ 1.39e17/hour
    - 700 kW at 120 GeV, 1.33 sec MI Cycle
  - MicroBoone: 3 Hz, 4e12/pulse ⇒ 0.43e17/hour
  - Mu2e: 4.5 Hz, 4e12/pulse ⇒ 0.65e17/hour
    - 6 pulses per 1.33 sec MI Cycle
    - Needs to fit around NOνA pulses as uses Recycler to send protons to Accumulator
- SY120 Program (SeaQuest, Test Beam) does impact NOνA Main Injector cycles

Current Booster Performance

- ~7.5 Hz (6.7 Hz w/ beam)
  Hardware capable of ~9 Hz
- 1e17/hour (pushing administrative operational limits)
- 89% efficiency







The Plan

- To support operation through 2020-2025(?)
  - NOνA: 700 kW at 120 GeV on NuMI target
    - Combined two shutdowns into one
    - Moved resources into support of accelerator work
    - On schedule for 11 month shutdown starting in Mar 2012 with 3 months of float
  - Do need additional improvements
    - Booster Solid State Upgrade
      - Improved reliability of RF Power Amplifiers
    - Increase repetition rate to 15 Hz
      - Improved electrical infrastructure
      - Improved cooling for RF cavities
      - Requires solid state upgrade
    - New shielding assessment and associated shielding improvements
      - Operational limits
      - Additional shielding in tunnel
      - Office occupancy

Task Force within the Accelerator Division

- To identify
  - The known knowns: we know we need to do and know how (have an engineered solution)
    - e.g., Solid State RF
  - The known unknowns: we know we need to do but don't know how (don't have an engineered solution)
    - e.g., ferrite tuner cooling, Anode power supply
  - The unknown unknowns:
    - e.g., reliability questions at 15 Hz operation

- How to meet the program requests and operate for a period of 10-15 years (both reliably and efficiently)

Task Force Charge

- The charge to the Proton Source Task Force is:
  - Determine the vulnerabilities of each major subsystem in the Proton Source system including
    - The H- sources and pre-accelerators
    - The low energy drift tube Linac
    - The RF System for the low energy Linac including power amplifier tubes and other associated tubes
    - The 8-GeV Booster magnet systems
    - The 8-GeV vacuum system
    - The 8-GeV RF cavities and modulators
    - The controls and interlocks of all Proton Source systems
  - Review the planned upgrades of the H- sources, the Booster RF system, and the 15Hz upgrade.
    - Identify weaknesses
  - Develop a cost estimate

The Plan

- Plan in support of NOνA
  - Well defined in RR, MI, and NuMI target hall
  - Does assume 9 Hz, 1.4e17/hour capability from Booster
- Address vulnerabilities in Linac, Booster, & MI
  - Specific upgrades known
  - Scale: up to $70 M (not in a resource loaded schedule)
  - *Opportunity for use of NOνA contingency $? (John Cooper in Detector Parallel session)*
- Task Force created to address questions and develop plans
  - Report by end of summer
  - *Best time scale: overlap with 2012 shutdown*

Backup slides

Vulnerabilities

- Pre-accelerators (Source + Cockroft-Walton)
- Low energy Linac
  - Power Amplifiers
  - Modulator Electronics
- 8 GeV Booster Reliability
  - Main Booster Combined Function Magnets
  - Booster RF System
    - Power amplifiers
    - Cavities
  - Booster beam losses
  - Booster shielding
  - Old water and power systems

Task Force Leaders for Subsystems

- Modulators
  - Howie Pfeffer
- Low Energy Linac
  - Paul Czarapata
- High Energy Linac Reliability
  - Peter Prieto
- Linac Controls
  - Mike Kucera
- Linac Power Distribution
  - Steve Hays
- Linac LCW Systems
  - Bob Slazyk

Task Force Leaders (Con't.)

- Linac and Booster Vacuum
  - Dave Augustine
- Linac and Booster Pulsed Systems
  - George Krafczyk
- High Level RF (includes Booster Cavities)
  - John Reid
- Low Level RF
  - Craig Drennan
- Booster Magnets
  - Jim Lackey
- Booster Controls
  - Sharon Lackey

Task Force Leaders (Con't.)

- Pre-acclerator Upgrades
  - Bob Webber, Jim Steimel, Chuck Schmidt
- Booster Shielding Assessments
  - John Anderson
  - Peter Kasper

Proton Economics

- g-2: 4.5 Hz, 4e12/pulse ⇒ 0.65e17/hour
  - 6 pulses per 1.33 sec MI Cycle
  - Needs to fit around NOνA pulses as uses Recycler to send protons to Accumulator
- SY120 takes 120 GeV MI cycles away from neutrinos
  - 5-10% power reduction to 120 GeV target
  - Not a significant demand at 8 GeV