Proton Improvement Plan

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Fermilab

Outline

- Introduction
- Proton Source Review
- Proton Source Improvement Plan
- Current Proton Source Projects and Effort
- Conclusion

Introduction

The Fermilab Proton Source (PS) consists of:

- The Pre-Acc, Linac, and 8 GeV Booster accelerators
- Three transport lines
- Three beam absorbers
- Two low energy beam facilities
  - The Neutron Therapy Facility
  - The Muon Test Area

Designed and built over 40 years ago, the Proton Source remains largely unchanged. The ability to deliver 8 GeV protons has been essential for successes of the Run II, neutrino, and test-beam programs. These machines are expected to deliver ever higher performance to support the laboratory's experimental High Energy Physics objectives for the next decade or longer.

Proton Source Review

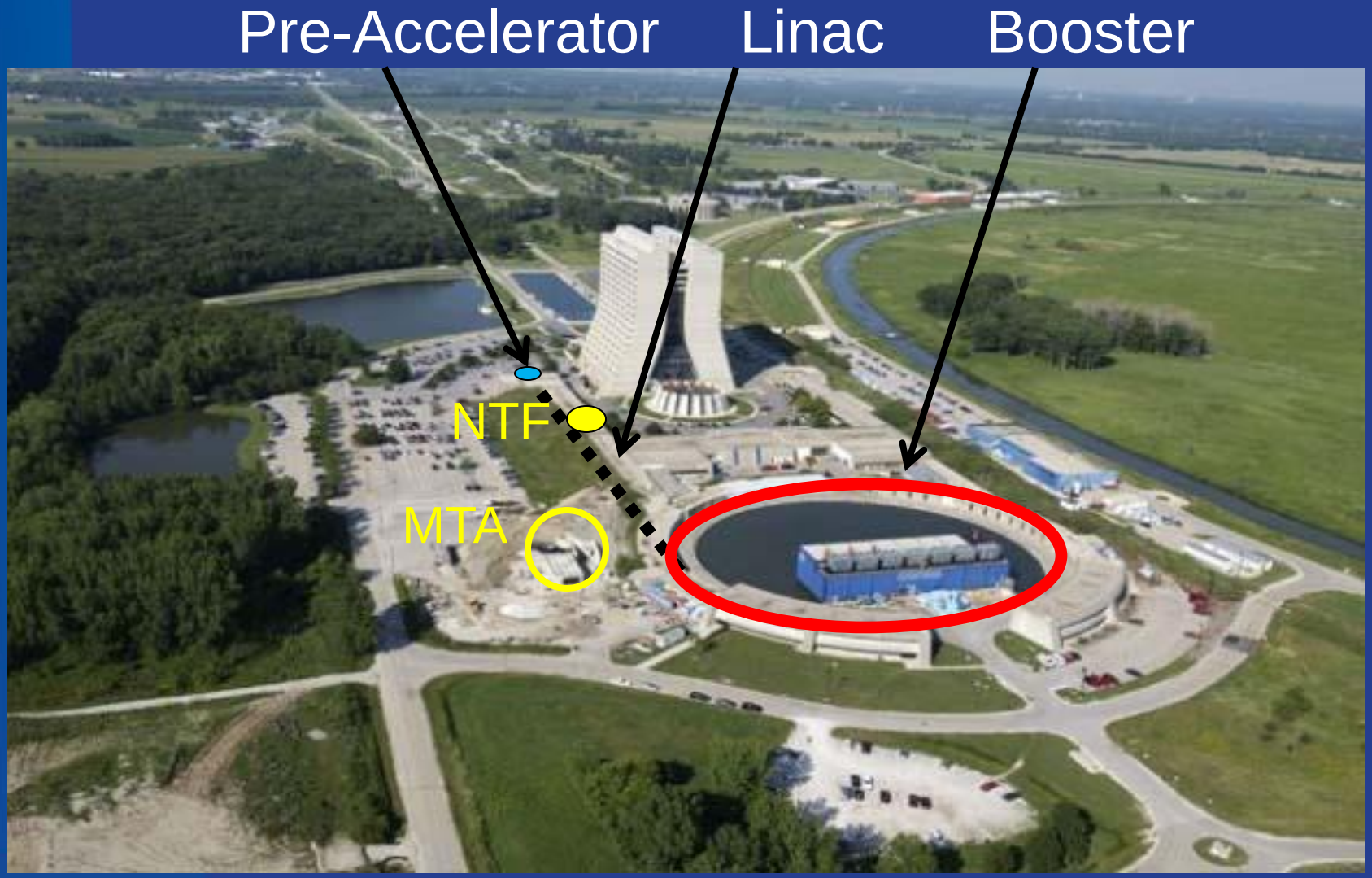
Pre-Acc/Linac

- A 400 MeV negative hydrogen ion accelerator comprising:
  - 25 keV H-minus magnetron ion source
  - Two 750 keV electrostatic Cockcroft Walton accelerators
  - 116 MeV, 201.25 MHz drift-tube (Alvarez) linac
  - 805 MHz side-coupled cavity linac to 400 MeV

Booster

- 8 GeV, 15 Hz synchrotron with a 474 meter circumference .
  - Using multi-turn injection and a stripping foil, 400 Mev Beam is injected into the Booster from the Linac via the 400 MeV transport line.
  - Booster accelerates the beam from 400 MeV to 8 GeV in about 35 milliseconds.
  - Booster 8 GeV proton beam is extracted down the MI-8 line for the Main Injector or the 8 GeV neutrino experiments

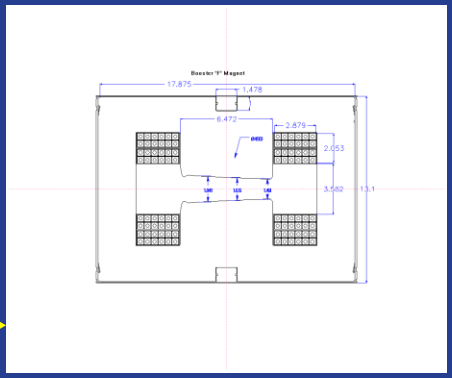
Proton Source Review – PS Layout

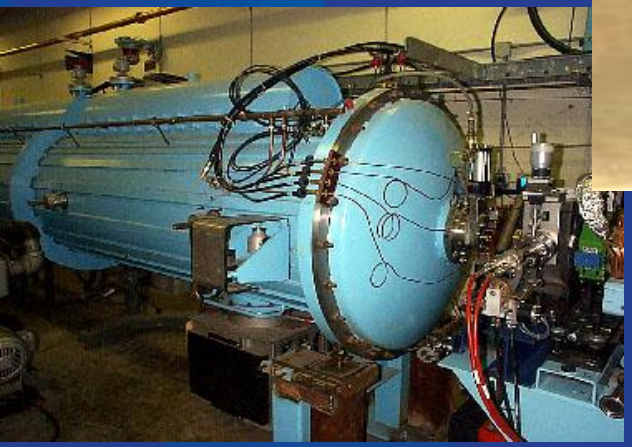


Proton Source Review – Basic Hardware

800 MHz Klystron
High Energy Linac

Booster
Gradient
Magnet



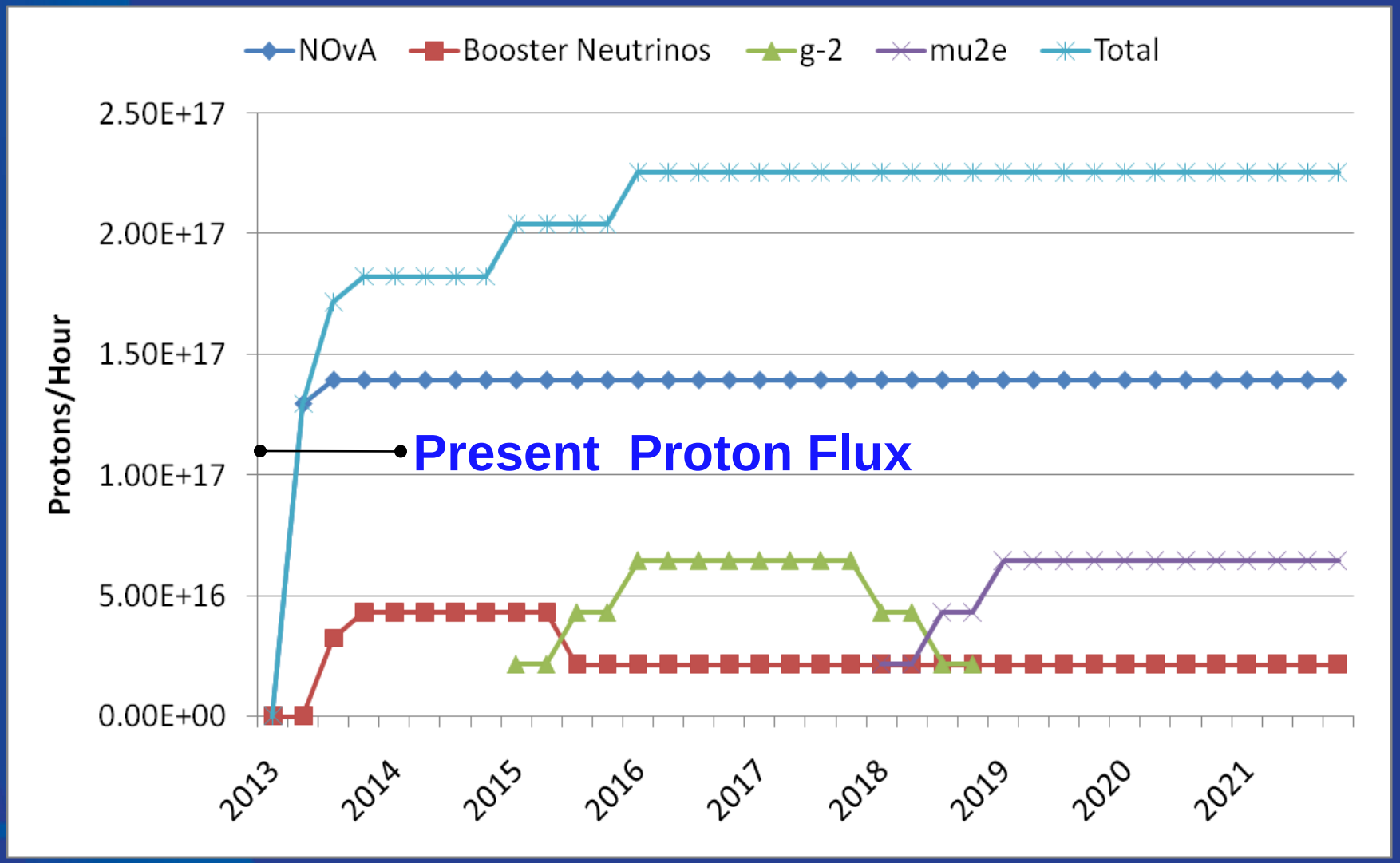


200 MHz Alvarez LE
Accelerating Cavity

Proton Source Improvement Plan (PIP)

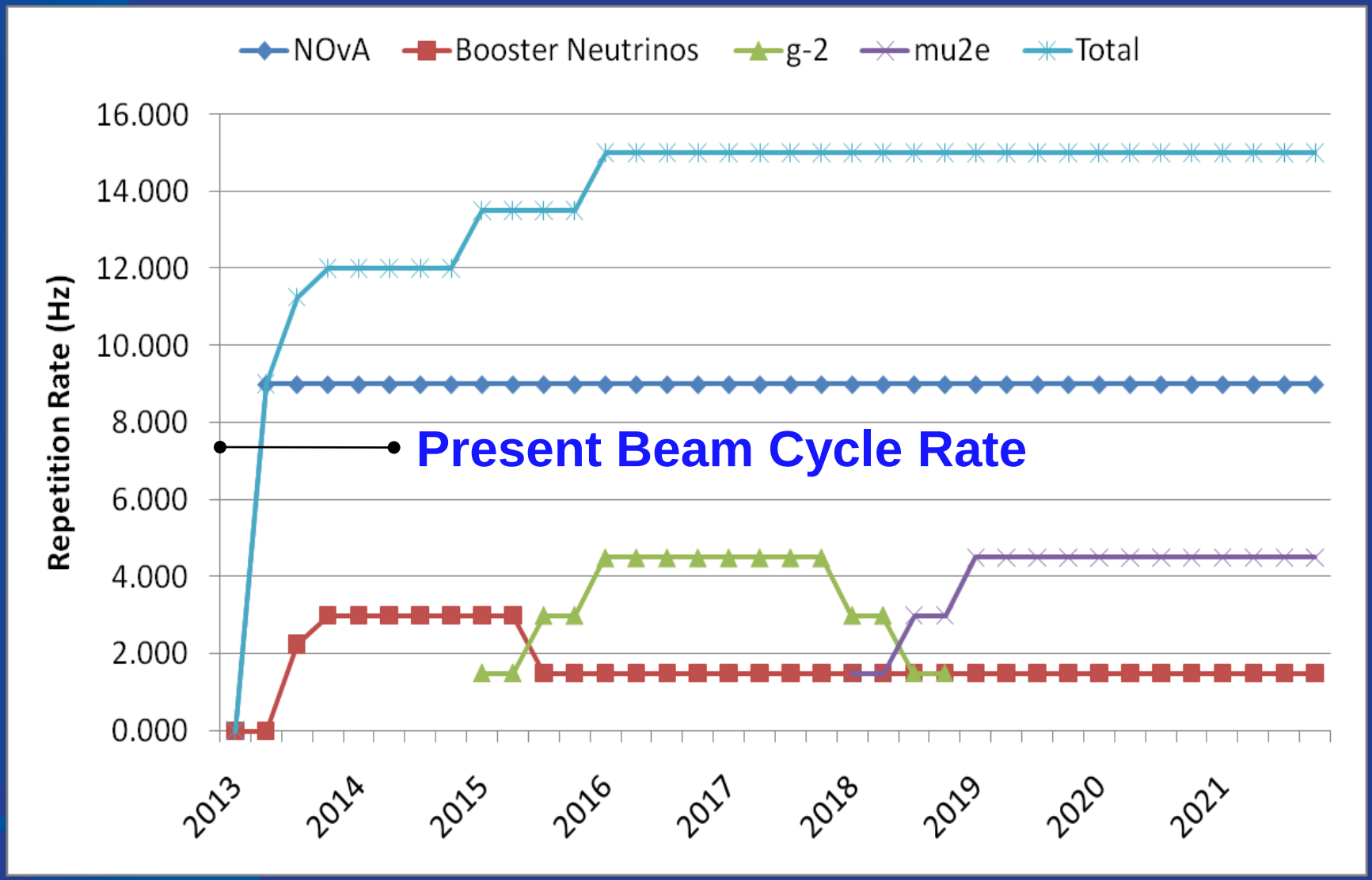
- A recognition that, until the Project-X linear accelerator is operational, the entire domestic accelerator-based high-energy physics program is powered by the 40+ year old Proton Source.
- Despite age-related issues of reliability and availability of spare components, demands on the Proton Source continue to increase.
- Experiments that have received Fermilab PAC approval or are in the DOE CD-process expect a factor of two increase of the current proton delivery rate within the coming decade.

Proton Source Improvement Plan (PIP)



Proton source throughput goals for the next decade.

Proton Source Improvement Plan (PIP)



Beam repetition rate goals through the next decade

Proton Source Improvement Plan Goals

The goals of the Proton Improvement Plan are to:

- Increase the beam repetition rate from the present ~7 Hz to 15 Hz
- Eliminate major reliability vulnerabilities and maintain reliability at present levels (>85%) at the full repetition rate
- Eliminate major obsolescence issues
- Increase the proton source throughput, with a *goal* of > 2E17 protons/hour
- Ensure a useful operating life of the proton source through at least 2025

Proton Source Improvement Plan Scope

The scope of the Proton Improvement Plan includes:

- Upgrading or replacing components required to reach the Booster 15 Hz repetition rate
- Replacing components that risk poor reliability
- Replacing obsolete or soon to be obsolete components
- Doubling the 8 GeV Beam Flux
  - Studying beam dynamics to diagnose performance limitations and develop mitigation strategies
  - Implementing operational changes to reduce beam loss
    - Beam flux will be increased by cycle rate not by increased cycle intensity

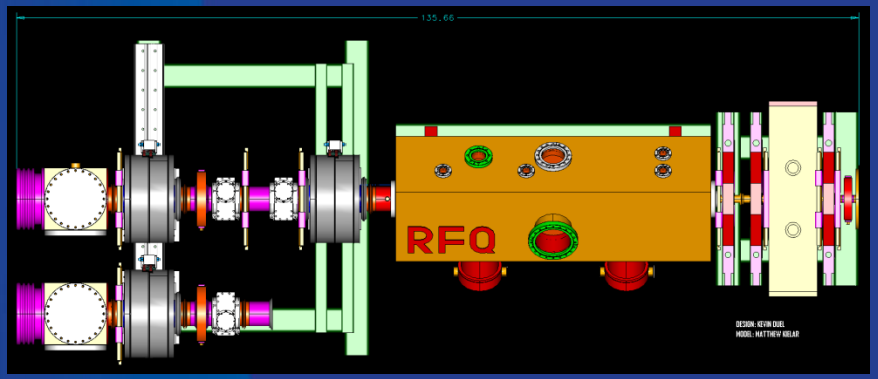
Proton Source Improvement Plan Scope – Major Items/Categories

- **The Cockcroft-Walton system**
- **Drift Tube Linac RF Power Systems**
- **Booster RF Solid State Program**
- **Booster RF Cavities, Tuners, Anode Supplies, and Bias Supplies**
- **Beam Instrumentation and Controls**
- **Linac and Booster Conventional Systems**
- **Vacuum system upgrades**
- **Booster Gradient Magnet Spares**

Current Proton Source PIP Work Underway

Pre-Acc and Linac

- Cockcroft Walton Replacement
  - Started FY09 using operating funds
  - Completion set date June FY12



- Linac Dump Repair
- Linac Optics
- High Power RF 201.25 MHz Drive System
- Buildup of 7835 Power Tube Inventory

Booster

- Solid State RF Power Drivers
  - First solid state system installed FY04
  - Solid state project tasks started FY06
  - 4 of 19 solid state stations now installed
- Collimator System Review
- Cogging System Upgrade
- Booster Orbit/Aperture Work
- Fast Kicker (Built – Testing)
- Booster Gradient Magnet
  - Build Spare Inventory
  - Prepare Required Hardware

Proton Source Improvement Plan Timeline Constraints

The timeline for the implementing PIP depends upon:

1. Funding
    1. M&S funding profile
    2. Capturing engineering design effort to match the M&S profile
2. Manpower
    1. Identifying qualified personnel
    2. Committing key personnel to the effort for several years
3. Project Development
    1. Reaching sound technical solutions to challenging and expensive problems that are now just in a pre-conceptual stage
4. Operational Beam Constraints
    1. Integrating necessary machine studies and shutdowns with ongoing operational commitments

Proton Source Improvement Plan
Initial M&S Cost Estimates (Millions of $)

Project Management	**--**
DTL High Power RF System	**13**
Pre-Acc RFQ Completion	**.750**
New Booster RF Cavities	**18**
Booster Tuner System Upgrade	**2**
Doubling beam throughput (Physics)	**--**
Collimator system	**1.5**
Instrumentation and Control	**1.5**
BRF Anode and Bias supplies & test stand	**1.7**
Booster Solid state systems	**3.7**
Conventional Systems Upgrades	**2.3**
Vacuum System Upgrades	**.4**
TOTAL	**44.85**

Best-effort cost estimates based on experience and recent similar procurements. Estimates for the larger cost elements should be considered as appropriate at the conceptual level

Proton Source Improvement Plan FY Funding Profile Guidance

Year	M&S Funding (Millions)
FY12	6.2
FY13	6.2
FY14	13.3
FY15	12.3
FY16	6.4

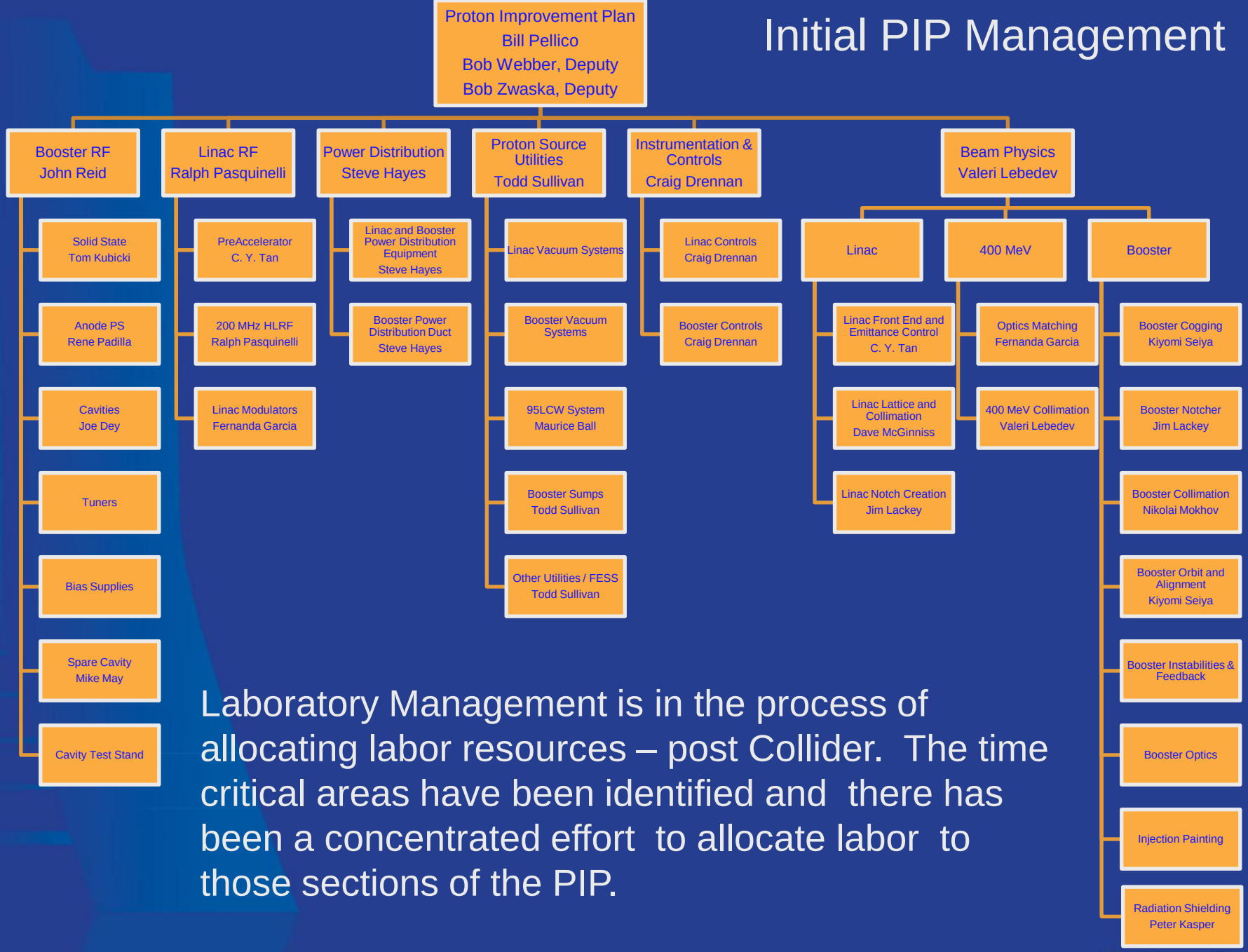
These numbers were provided as guidance for PIP planning. Some items in the plan are ready to be procured even in FY11. Areas that require additional design/engineering work must be allocated labor resources consistent with the out-year M&S profile.

Proton Source Improvement Plan
Labor Estimate

- Labor estimates were developed by the responsible support departments and based upon current work. As with the cost estimates, labor estimates for the large projects are just in the initial planning stages and should be considered as a first pass estimates.

Project Management	**9**
DTL High Power RF System Phase	**50**
Pre-Acc RFQ Completion	**10**
New Booster RF Cavities	**39**
Booster Tuner System Upgrade	**6**
Doubling beam throughput (Physics)	**8**
Collimator system	**7**
Instrumentation and Control	**15**
BRF Anode and Bias supplies & test stand	**6**
Booster Solid state systems	**9**
Conventional Systems Upgrades	**5**
Vacuum System Upgrades	**6**
TOTAL (Units FTE years)	**170**

Initial PIP Management



Laboratory Management is in the process of allocating labor resources – post Collider. The time critical areas have been identified and there has been a concentrated effort to allocate labor to those sections of the PIP.

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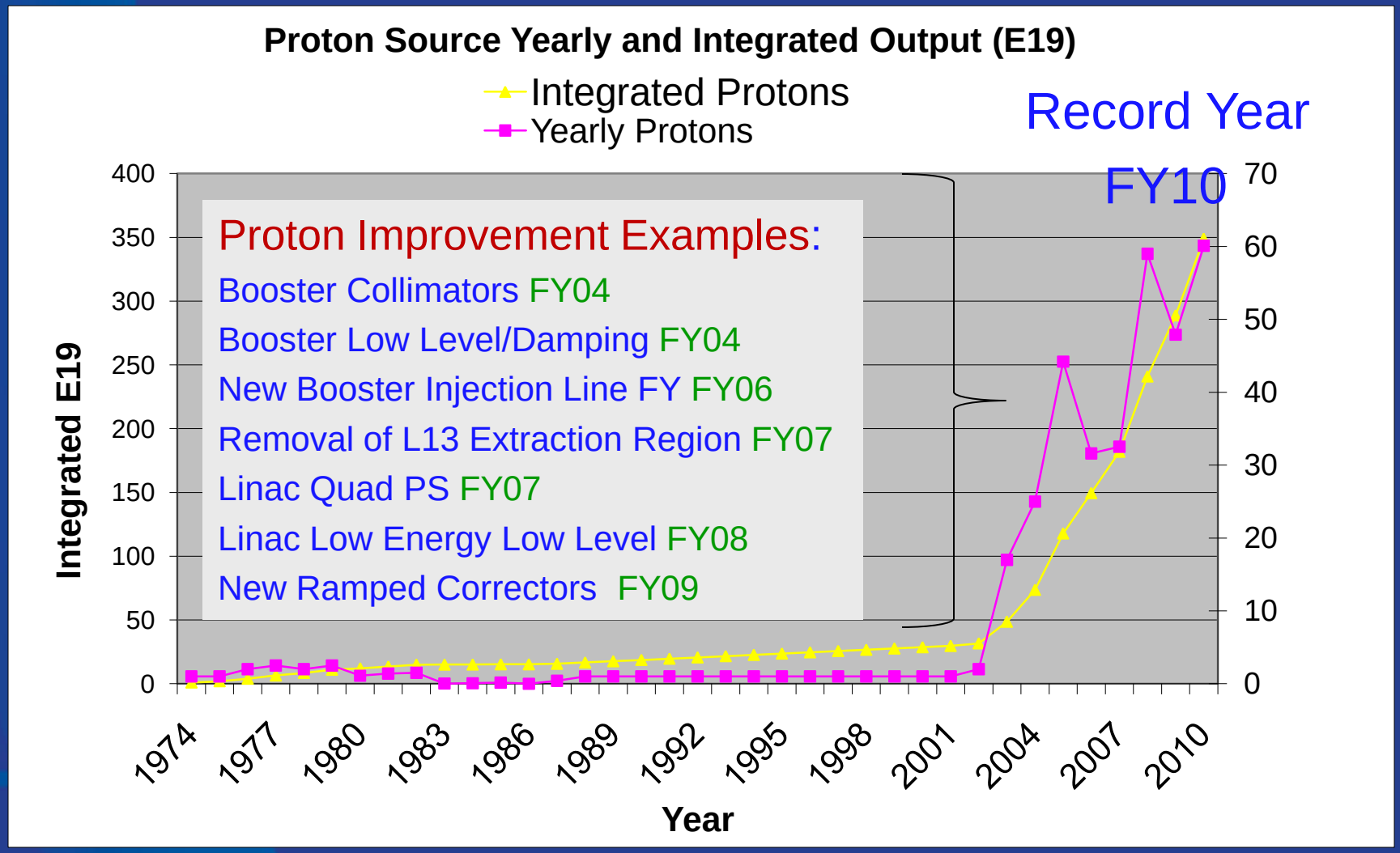
Upgrade Success - Historical Performance



Proton Source Improvement Plan Summary

- The Proton Source has faithfully served the needs of the Fermilab program for more than 40 years.
- Demands for doubling the proton throughput with continued highly reliable operation necessitate a dedicated program of improvements to secure the viable operation of the Proton Source for the next 15+ years.
- A plan at the level of 45M$ M&S over the next five fiscal years has been developed.
- Staffing at the level of ~33 FTEs per year is required to carry out the plan.
- Improvement Plan funds must be in addition to the current annual operating funding for the plan to be successful.

References

- [1] A Plan for Delivery of 8-GeV Protons through 2025, Beams-doc-3781, http://beamdocs.fnal.gov/ADpublic/DocDB/ShowDocument?docid=3781
- [2] Proton Source Task Force Report, Beams-doc-3660, http://beamdocs.fnal.gov/ADpublic/DocDB/ShowDocument?docid=3660
- [3] Proton Source December 2010 Workshop,
- http://beamdocs.fnal.gov/ADpublic/DocDB/DisplayMeeting?conferenceid=114