

Physic Opportunities at the Booster Replacement

Path Forward

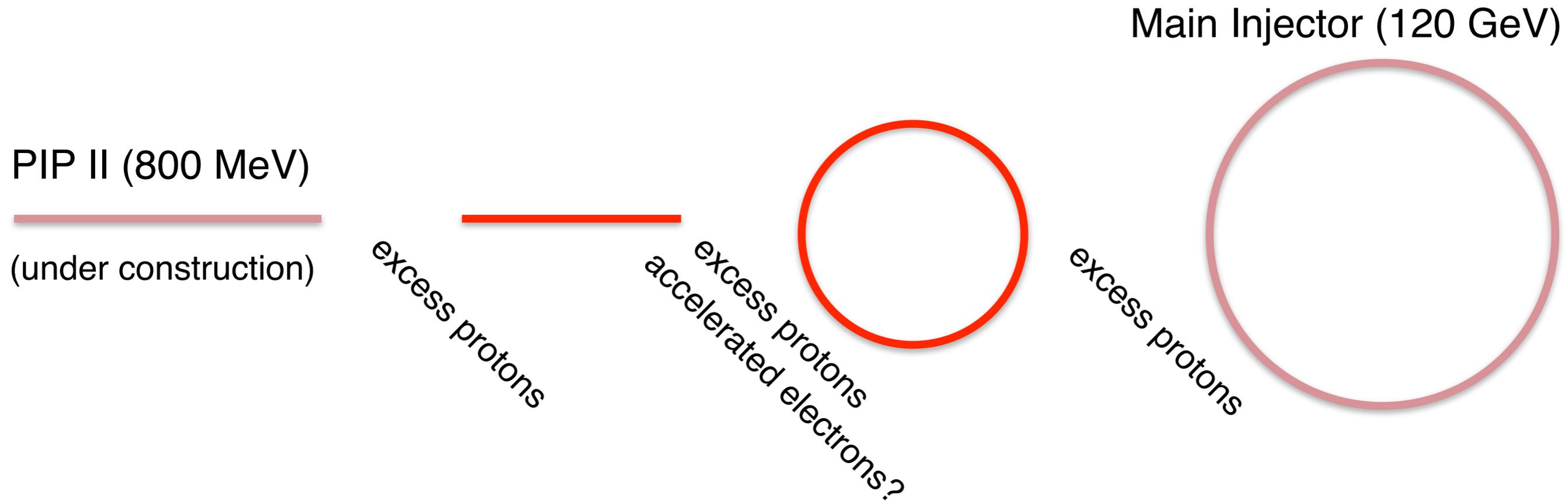
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Accelerator Working group: Mike Syphers, Jonathan Jarvis, Alexander Valishev, Eduard Pozdeyev, Sam Posen, Jeff Eldred, Ioanis Kourbanis, Alex Romanenko, Bob Zwaska.

This workshop: Physics Opportunities



What physics opportunities do these open?

- New dark sector searches?
- New precision tests?
- Acceleration of electron or other in the Linac?
- ...

We would like your input!

A Wish List

- In this introduction I will present a wish list of input we would like to receive.
- It is intended to be broad and forward looking (recall, the booster was built in 1971!), but also to capture low hanging fruit.
- No details here.
The intention is to provoke the proponents to engage, (and I'll tell you how to do that, even during a pandemic).
- Members of the working group are working on some items in the list. Preliminary information in the talks the follow.

Dark Sector Searches

- Dark Sector Searches were less on the collective radar screen during the Project X study. Important to cover.
- **Low energy protons ($\sim 0.8 - 1$ GeV):**
Some of the most powerful limits on dark sector models come from re-analysis of LSND (stopped pions). Can a dedicated setup improve the reach?
- **Medium energy protons (~ 10 GeV, perhaps more):**
MiniBoone has demonstrated the reach of a beam dump search for nuclear and electron recoils. Can a dedicated setup improve the reach? Would going higher in energy help?

See next talk by Matt Toups

Input wish list: Dark Sector Searches

- **High energy Protons (120 GeV):**

Some interesting possibilities with the “usual” ν near detectors [e.g. recent millicharge limit from ArgoNeuT]. However, nearer setups have been shown to cover complementary ground [e.g. SeaQuest]

Berlin et al, Phys.Rev.D 98 (2018)

See talk by Stefania Gori

- **Medium-Low energy Protons:**

A 3-ish GeV proton beam can produce a large number of stopped kaons. e.g. JSNS². Are there new opportunities for dark searches?

e.g. Jordan et al. Phys.Rev.D 98 (2018)

Dark Sector Searches

- **Electron beams:**

Have already set legacy limits [e.g. E137, milliQ]. There are significant improvements to be had:

- Electron beam dumps: e.g. BDX
- Missing momentum experiments: e.g. LDMX

Berlin, Blinov, et al, Phys.Rev.D 99 (2019)

- **Muon experiments:**

A muon missing momentum experiment has interesting reach to models related to $g-2$ and DM that like heavy flavor.

See talk by Gordan Krnjaic and Nhan Tran

Neutrino Physics

- New opportunities in neutrino physics:
 - **Low energy, stopped pion source:** study of CeveNS and/or enhanced sterile searches. Are the beam requirements different than dark sector searches?
Talk by Matt Toups
 - **Low/Medium energy, stopped kaon source:** Are there interesting opportunities with KDAR neutrinos beyond JSNS²?
K. Kelly et al *Phys.Rev.D* 101 (2020)
 - **Medium Energy (8-10 GeV):** What is the reach of an enhance SBN program?

Muon Physics and CLFV

- **Mu2e:**

An explicit goal of the Booster Replacement is to supply 0.8 GeV CW protons to phase 2 of Mu2e. What is the optimum?

- **$\mu \rightarrow 3e$ and $\mu \rightarrow e\gamma$:**

Highly motivated CLV channels explored at PSI. Are there opportunities to advance these searches further at Fermilab's muon campus with upgraded beam?

Talk by Andrei Gaponenko

- **Muon accelerator R&D and neutrino factories:**

Not pursued in the US following P5. But can we leave the door open if the future warrants a return to the energy frontier?

Hadron Properties

- Eta factory (e.g. REDTOP) - a proposal to search for rare eta decays (10^{13} η s, 10^{11} η s)
- Kaon experiments: interest in the US may be re-kindled if anomalies arise at KOTO and/or NA62.
- Proton and other EDM searches: sensitive to new physics and CP violation at the multi TeV scale. Can they compete with non-accelerator searches?
- N-Nbar Oscillation: Sensitive to very high scale physics and baryon number violation.
- ...
- Many of these were covered in the Project X physics book. What have we learned since? what are the needs?

Project X physics book, 1306.5009

Last but not least:

What are we missing?

New ideas?

Providing Input

- We will collect input from the community in a (semi-)open overleaf (LaTeX) document with a simple structure:

Subsection 1:

A short explanation of the
physics and motivation (1-2 pages).

*Welcome to re-use a snowmass letter of intent you may be writing.
make use of previous studies, e.g. cosmic visions, Project X.*

Subsection 2:

Basic Accelerator Requirements (template).

Filling out a template “form”:
Species, Energy, Intensity, Beam time structure, other reqs.

Providing Input

- The template can be viewed here:

<https://www.overleaf.com/read/scgtzvbngfxr>

- To make a contribution, **please send me an email**, and I will create a template section and send you a link to edit the document. (roni@fnal.gov)
- A menu of physics opportunities will stimulate discussion for a next zoom meeting, (date TBA).
- The final menu of possibilities may feed into a snowmass white paper (TBD).

Our Input

- As a warm-up, to set an example, and because we are genuinely interested, we are gearing up to include our own two pagers.
- These will be briefly presented in the coming talks:

Low and Medium energy Protons Dark sector searches and ν physics	Matt Toups, Richard Van de Water, Angela Fava
Dark Sector Searches with 120 GeV Protons	Stefania Gori, Nhan Tran
Dark Sector Searches with Electrons and muons	Gordan Krnjaic, Nhan Tran
Charged Lepton Flavor Violation	Andrei Gaponenko

- Interested parties are welcome to contribute, sign on, endorse, or provide independent input.

Summary

- **Our aim is to inform the design of Fermilab's path to 2.4 MW which was mandated by P5.**
- The goal is to leave the door open to a broad and exciting set of possibilities
- What experiments do we envision?
- What accelerators are needed?

- Our working group is providing some answers (upcoming talks) and is **seeking additional community input.**
- We encourage information from:
 - Eta factory, Kaon experiments, N-Nbar, Proton EDM, muon accelerator R&D, ...and new ideas!