Physics Opportunities at a Beam Dump Facility at PIP-II and Beyond

Matt Toups

Wed 10 May 2023

Welcome

It is our pleasure to welcome you to Fermilab for this timely workshop on “Physics Opportunities at a Beam Dump Facility at PIP-II and Beyond”

Matt Toups
Fermilab

Jae Yu
UT Arlington

Juan Estrada
Fermilab

Jacob Zettlemoyer
Fermilab

Welcome

It is our pleasure to welcome you to Fermilab for this timely workshop on “Physics Opportunities at a Beam Dump Facility at PIP-II and Beyond”

Matt Toups
Fermilab

Jae Yu
UT Arlington

Juan Estrada
Fermilab

Jacob
Zettlemoyer
Fermilab

Fermilab

Welcome

It is our pleasure to welcome you to Fermilab for this timely workshop on “Physics Opportunities at a Beam Dump Facility at PIP-II and Beyond”

Matt Toups
Fermilab

Jae Yu
UT Arlington

Juan Estrada
Fermilab

Jacob Zettlemoyer
Fermilab

Welcome

It is our pleasure to welcome you to Fermilab for this timely workshop on “Physics Opportunities at a Beam Dump Facility at PIP-II and Beyond”

Matt Toups
Fermilab

Jae Yu
UT Arlington

Juan Estrada
Fermilab

Jacob
Zettlemoyer
Fermilab

Fermilab

Goals of Workshop

Produce a whitepaper delineating the physics case for a beam dump facility at PIP-II

- To be posted on the arXiv soon after the workshop

This whitepaper is intended to serve as input for ongoing strategic planning processes:

- HEP P5 process (immediate)
- Fermilab strategic planning (near term)
- Fermilab Accelerator Complex Evolution (ACE) (longer term)

Your input at this workshop will help define the physics case for a beam dump program at Fermilab and the corresponding requirements for future upgrades to the Fermilab accelerator complex

Physics Opportunities at the Beam Dump Facility in PIP-II and beyond

author[1]

[1]Univ

May 10, 2023

Abstract

Explore the physics opportunities at PIP-II beam dump facilities.

Table of Contents

HEP P5 Process

Accelerator-based dark sector searches at the intensity frontier were identified as a major HEP priority at the last Snowmass

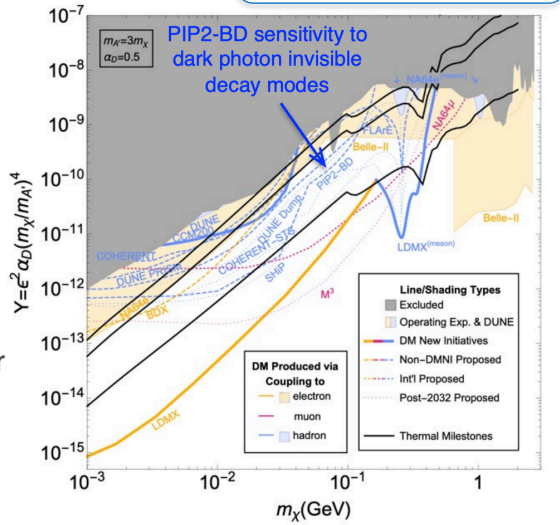
- See Stefania's talk at the BNL P5 town hall

Proton beam dump dark sector searches in particular were highlighted as part of Fermilab's future program at the Fermilab P5 town hall

This workshop will outline the potential scope of such a physics program at Fermilab

High Intensity Proton Beam to Explore Dark Matter Portals

- ACE will also enable excellent opportunities for accelerator-based dark sector searches at modest cost and scale
  - At high energy, proton beam dump searches can probe new parameter space making use of existing accelerator infrastructure and experiments
  - **At low energy**, proton beam dump searches can form part of a new neutrino and dark sector facility that leverages the full power of the PIP-II beam (1-8 GeV beam)



Fermilab

Fermilab

Fermilab Strategic Planning

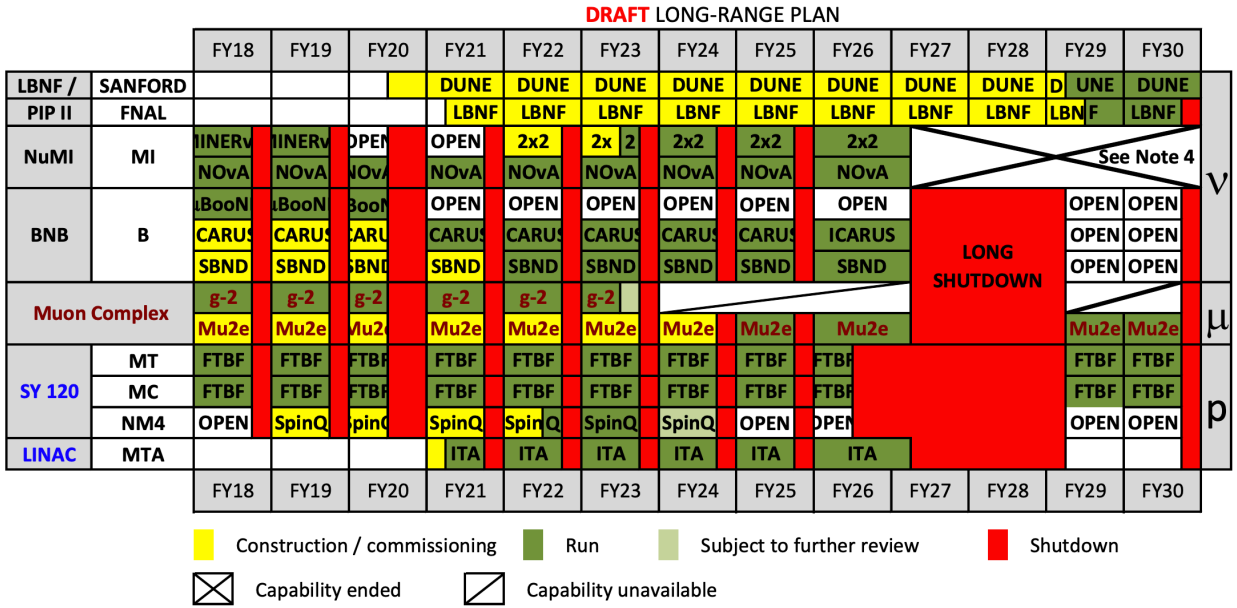
PIP-II linac now under construction and will be completed by the end of the decade

- Can provide among the highest-power ~GeV proton beams in the world

Experimental program currently "on the books" in the PIP-II era makes use of only ~1% of the protons PIP-II can provide

- Yes, this Includes DUNE!

This workshop will make the physics case for a beam dump program, which can leverage the excess capacity provided by PIP-II



Fermilab

Fermilab Accelerator Complex Evolution (ACE)

Plan for the next major upgrade of the Fermilab accelerator complex, seeking support from P5

- See Alexander Valishev's talk at the FNAL P5 town hall

Several options have been studied for the Booster replacement

- See Brenna Flaugher's talk next

Output of this workshop will feed into the process for defining the physics requirements for the accelerator design

- ACE Science Workshop (6/14-6/15)

The Fermilab Accelerator Complex Evolution (ACE)

ACE has two components

- **Upgrades to the Main Injector and target station** will allow DUNE to achieve world-leading results on an accelerated schedule
- **A Booster replacement** will
  - Provide a robust and **reliable** platform for the future of the Fermilab accelerator complex
  - Ensure high intensity for DUNE Phase II → CP Violation *measurement*
  - Enable the **capability** of the complex to serve precision experiments and searches for new physics with beams from 1-120 GeV
  - Create the **capacity** to adapt to new discoveries
  - Supply the high-intensity proton source necessary for future multi-TeV accelerator research

Capability
Capacity
Reliability

5 03/22/2023 Fleming I Fermilab Program

Fermilab

Fermilab

Beam Dump Opportunity at the PIP-II Linac

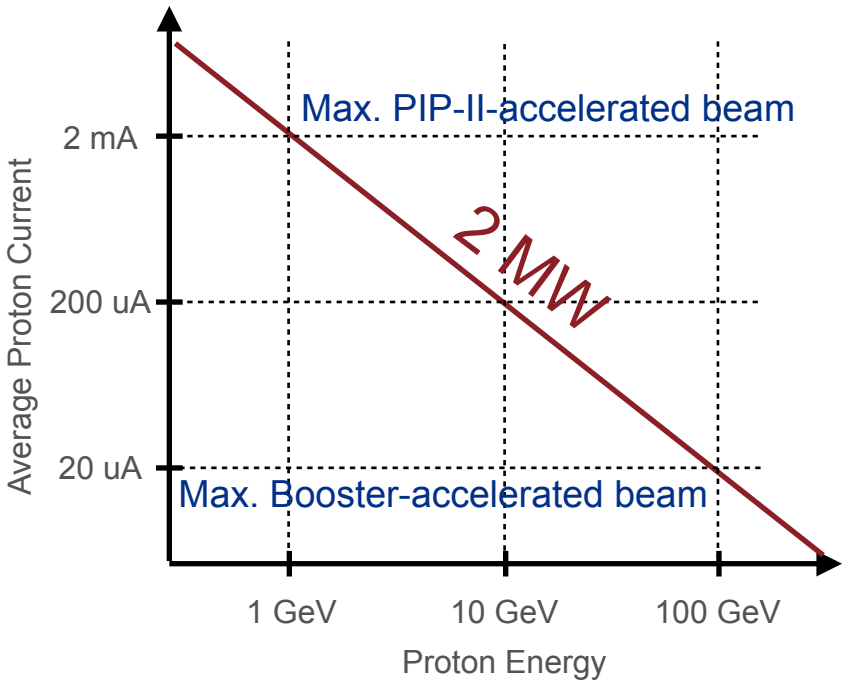
PIP-II linac able to provide significantly more beam than Booster is capable of accelerating

- Can simultaneously provide MW beam power at 800 MeV and MW beam power at 120 GeV

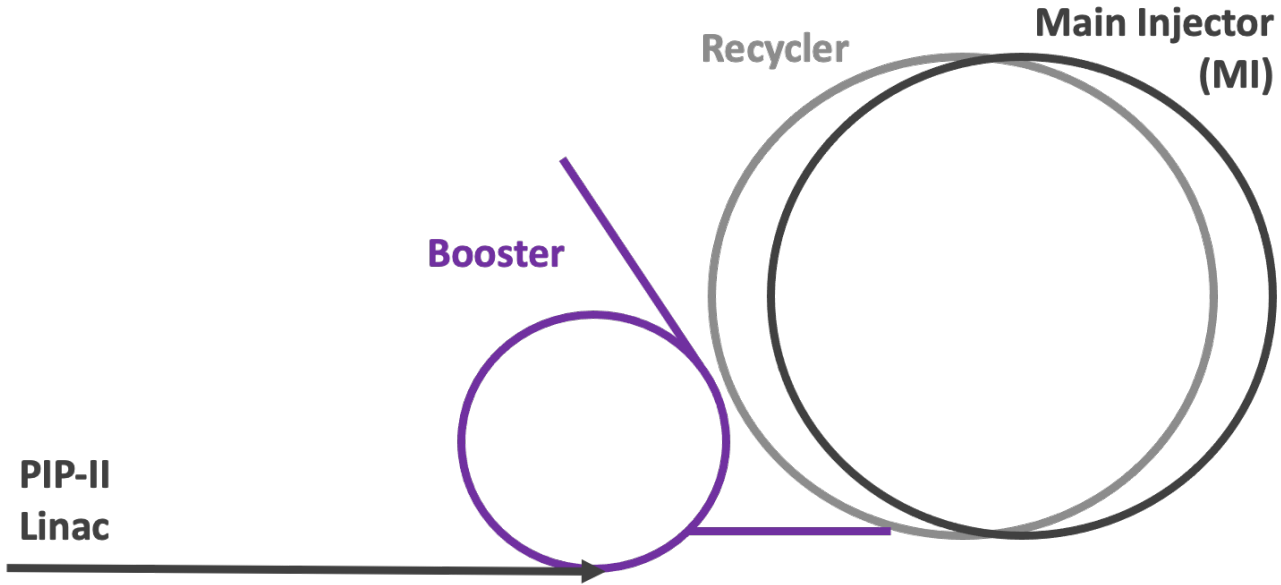
Forward-looking design of the PIP-II linac includes provisions that facilitate future upgrades, including

- CW multi-user mode of operation
- Increase in beam energy to 1 GeV and beyond
- Stub in the beam transfer line to the Booster to provide beam to other users

Excellent opportunity for establishing a high-power proton beam dump facility at Fermilab

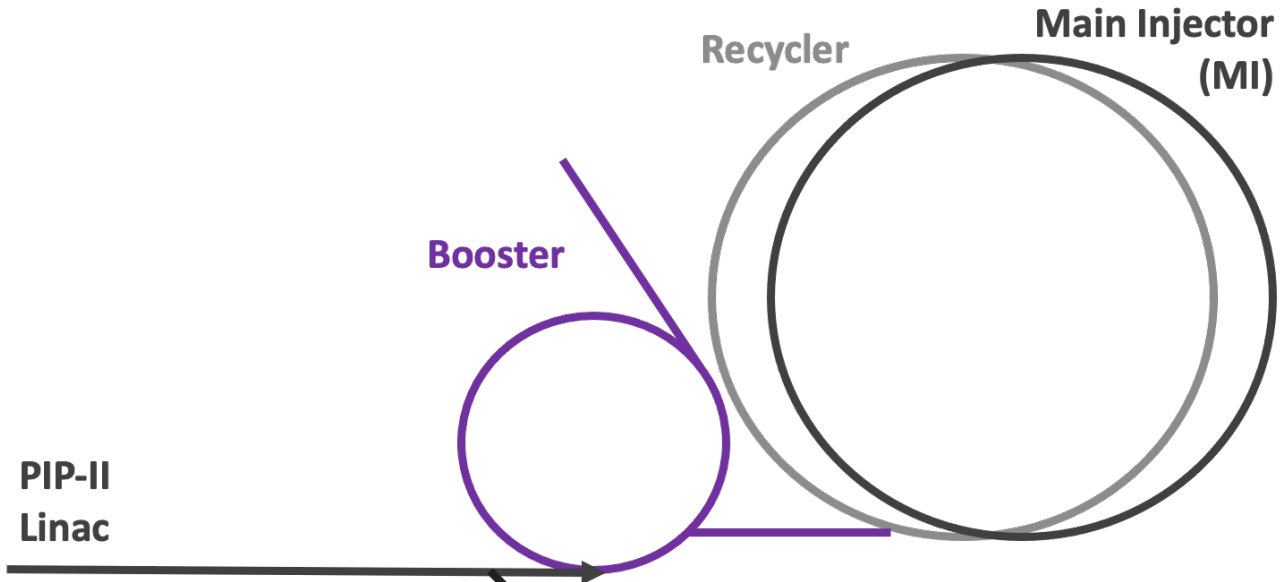


Default Accelerator Configuration



Fermilab

Configuration 1: PIP-II only

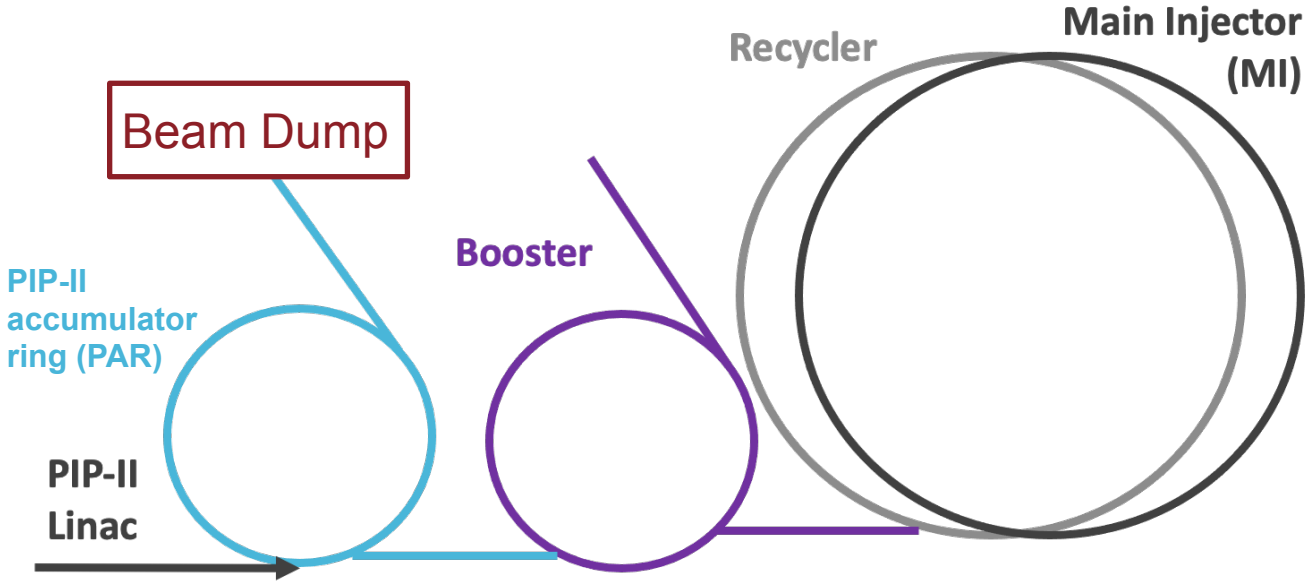


No beam compression

- Highest average power option

Fermilab

Configuration 2: PIP-II Accumulator Ring (PAR)

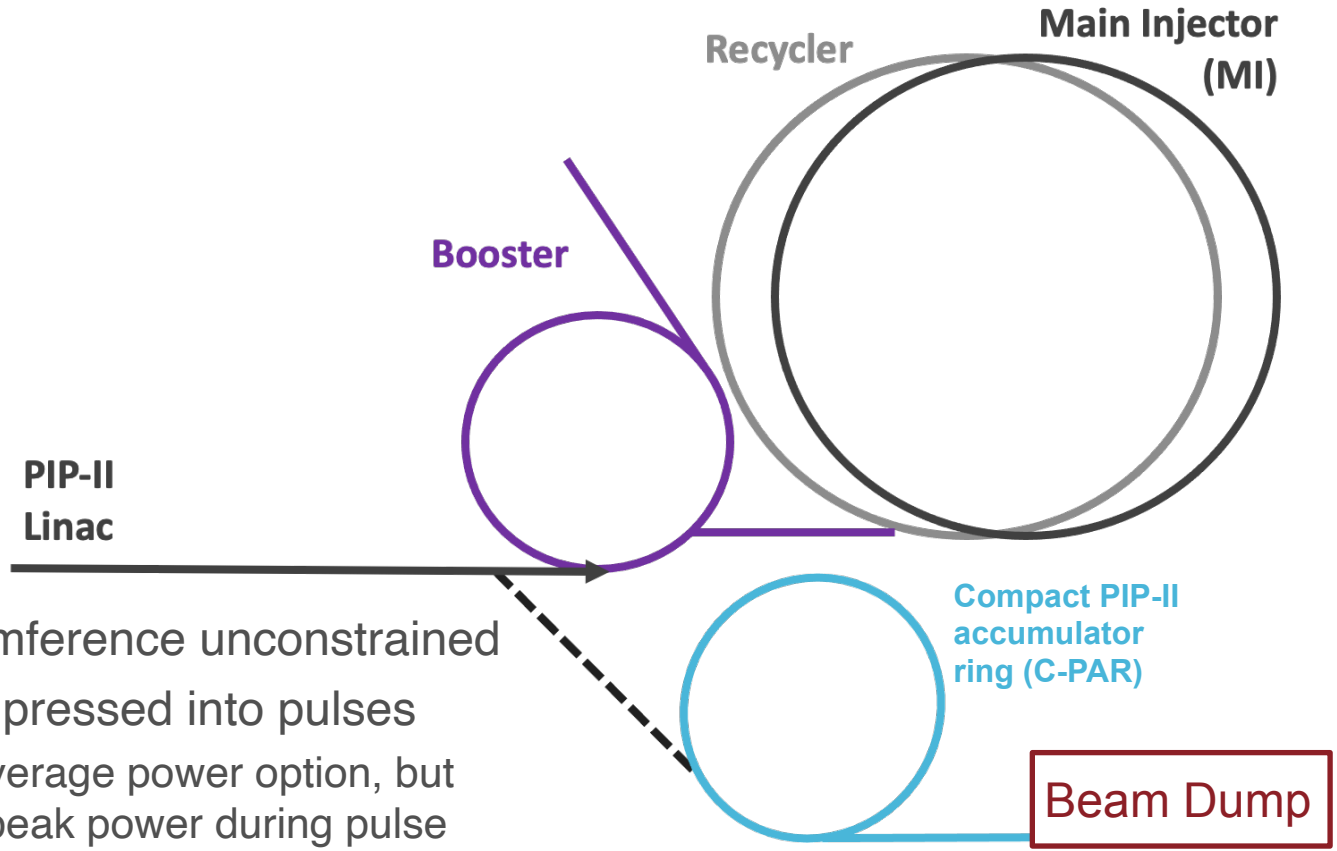


PAR circumference matched to Booster to allow for injection

Beam is compressed into pulses

- Lower average power option, but higher peak power during pulse

Configuration 3: Compact PIP-II Accumulator Ring (C-PAR)



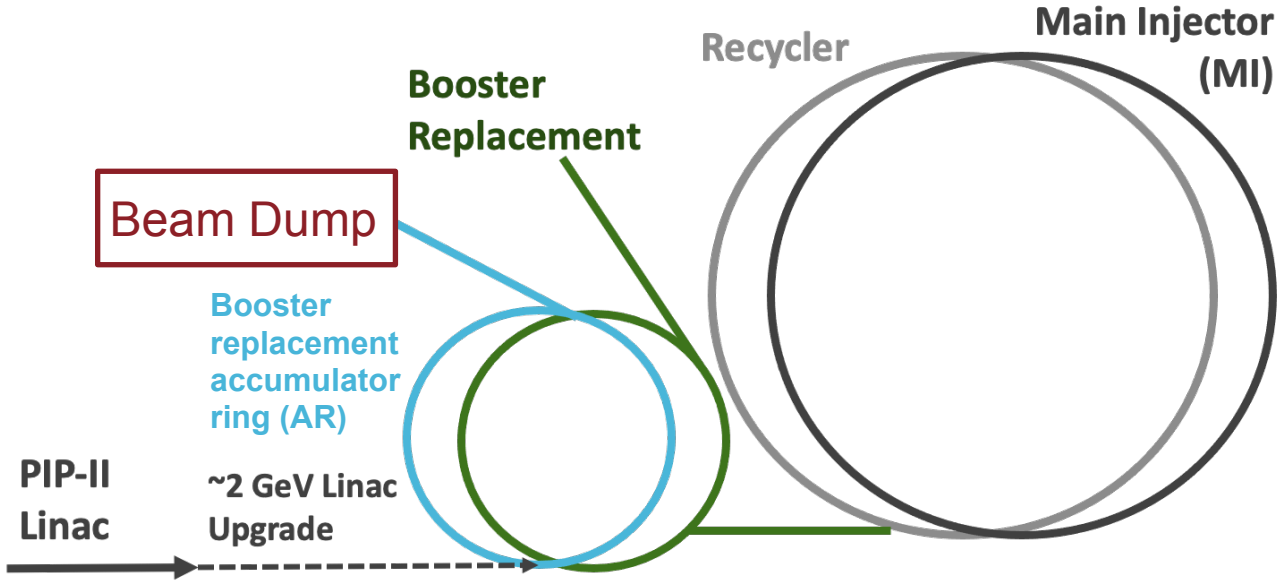
C-PAR circumference unconstrained

Beam is compressed into pulses

- Lower average power option, but highest peak power during pulse

Fermilab

Configuration 4: Booster Replacement Accumulator Ring (AR)



AR circumference matched to Booster Replacement to allow for injection

Beam is compressed into pulses

- Second highest average power option, and also has high peak power during pulse

Not available until timescale of Booster Replacement

Fermilab

Outline of the Workshop

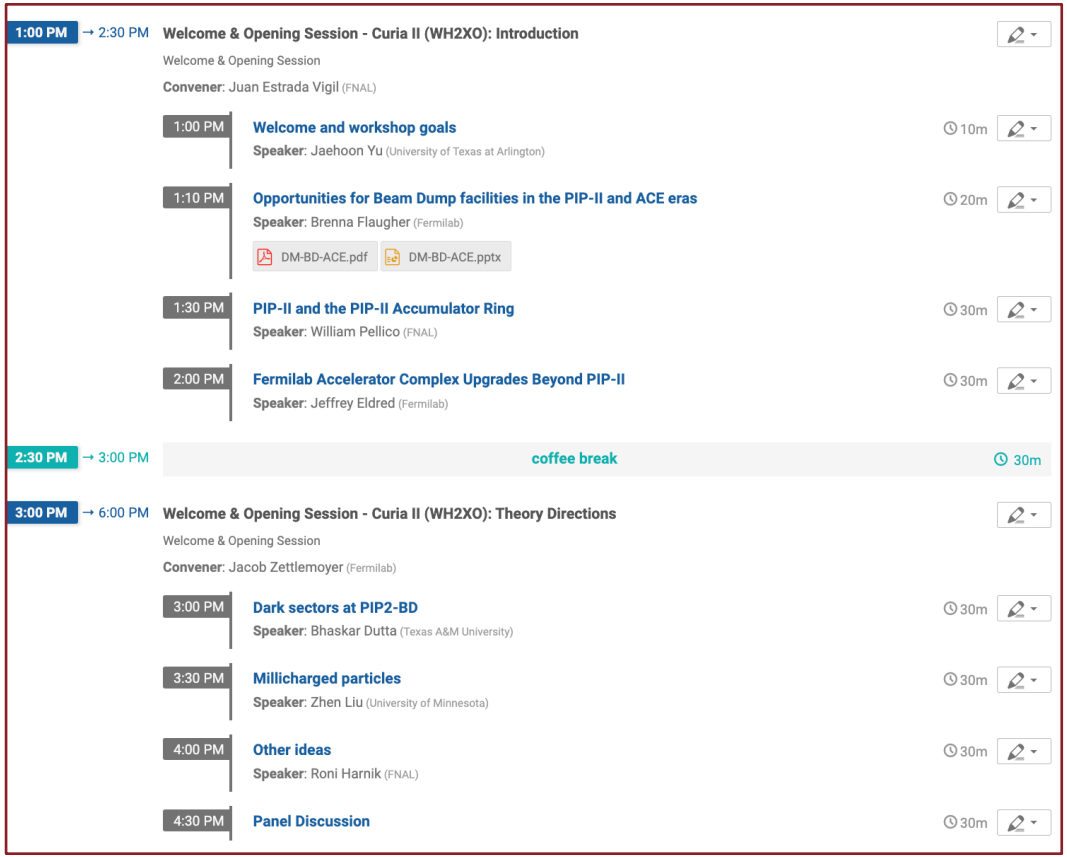
Wednesday afternoon
- Accelerator options
- Theory directions

Thursday morning
- Experiment opportunities and ideas

Thursday afternoon
- Breakout sessions / white paper drafting

Friday morning
- Workshop summaries and farewell

Friday afternoon & Saturday morning
- DAMSA proto-collaboration meeting



Outline of the Workshop

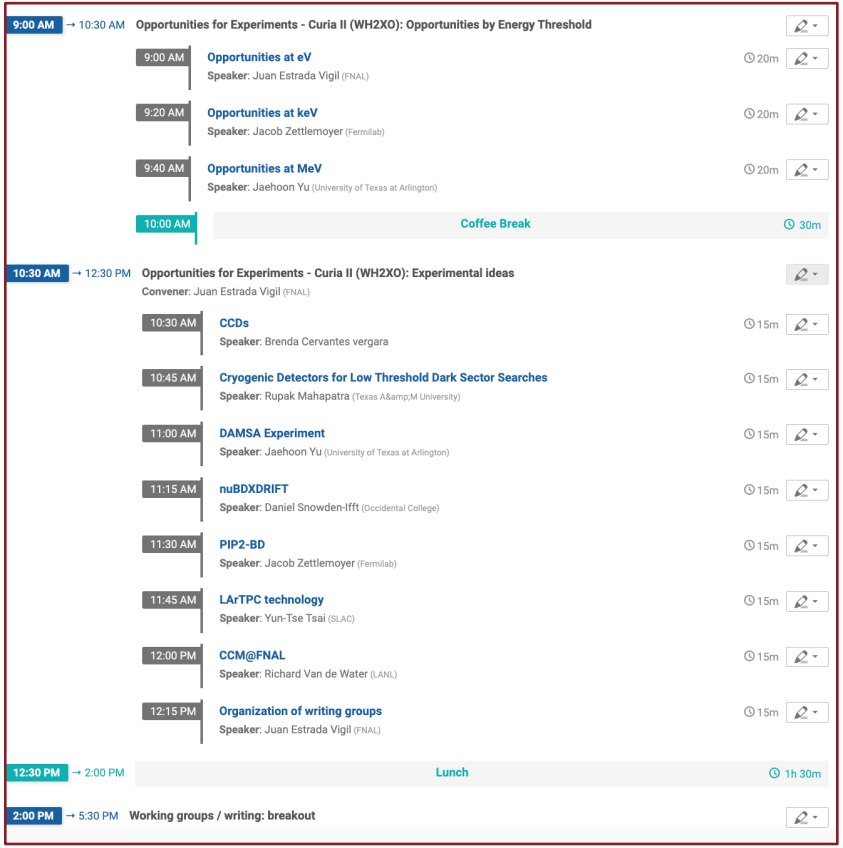
Wednesday afternoon
- Accelerator options
- Theory directions

Thursday morning
- Experiment opportunities and ideas

Thursday afternoon
- Breakout sessions / white paper drafting

Friday morning
- Workshop summaries and farewell

Friday afternoon & Saturday morning
- DAMSA proto-collaboration meeting



Outline of the Workshop

Wednesday afternoon
- Accelerator options
- Theory directions

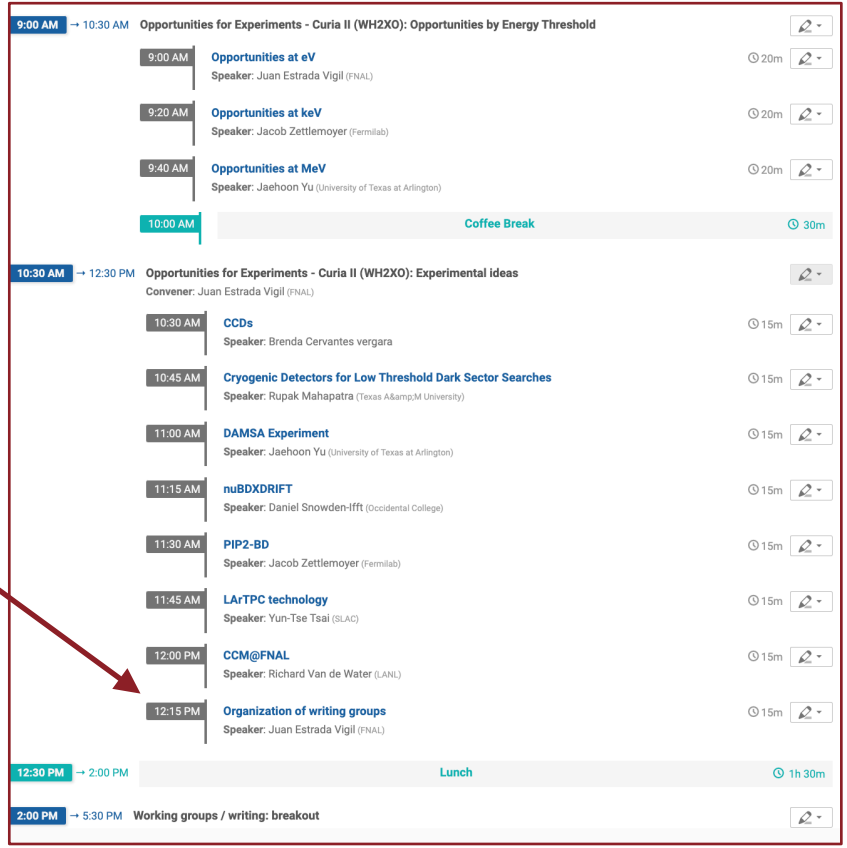
Thursday morning
- Experiment opportunities and ideas

Thursday afternoon
- Breakout sessions / white paper drafting

Friday morning
- Workshop summaries and farewell

Friday afternoon & Saturday morning
- DAMSA proto-collaboration meeting

Organizational talk by Juan



Fermilab

Outline of the Workshop

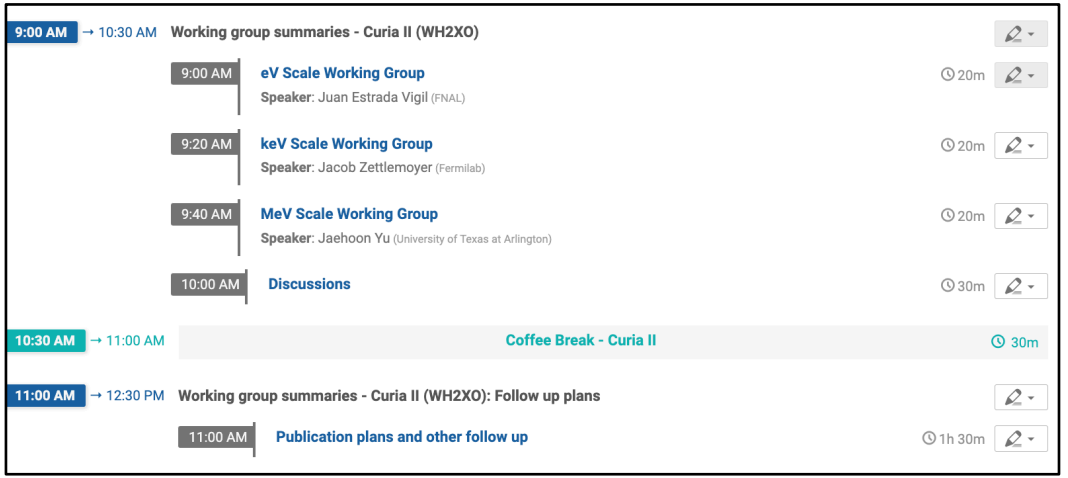
Wednesday afternoon
- Accelerator options
- Theory directions

Thursday morning
- Experiment opportunities and ideas

Thursday afternoon
- Breakout sessions / white paper drafting

Friday morning
- Workshop summaries and farewell

Friday afternoon & Saturday morning
- DAMSA proto-collaboration meeting



Outline of the Workshop

Wednesday afternoon
- Accelerator options
- Theory directions

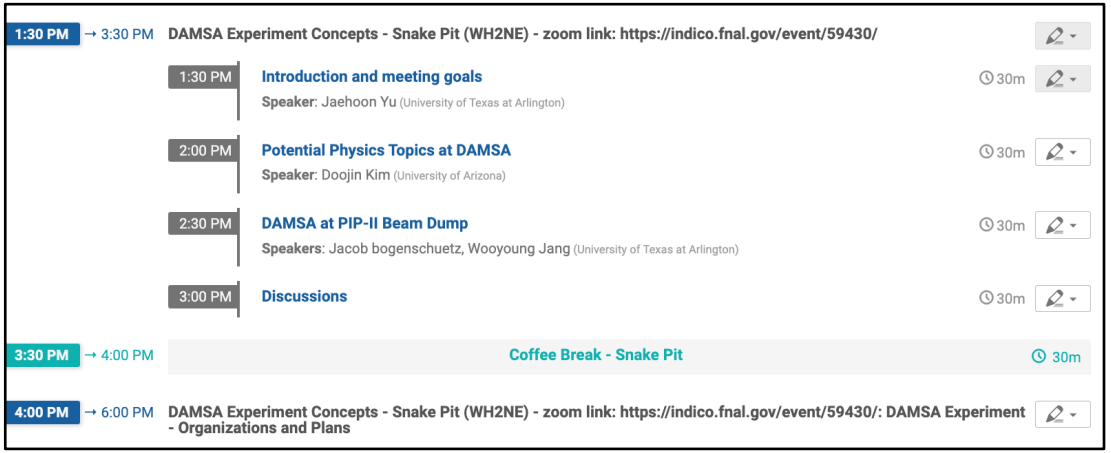
Thursday morning
- Experiment opportunities and ideas

Thursday afternoon
- Breakout sessions / white paper drafting

Friday morning
- Workshop summaries and farewell

Friday afternoon & Saturday morning
- DAMSA proto-collaboration meeting

Friday, March 12



Saturday, March 13

Meeting Logistics

Plenary sessions will be held in Curia II (this room, WH2XO): Plenary zoom

The locations of the breakout sessions Thursday afternoon are as follows:

- Comitium (across the hall, WH2XO): 1st parallel zoom
- Oscillatorium (WH13NW): 2nd parallel zoom
- Dark Side (WH6NW): 3rd parallel zoom

DAMSA sessions on 5/12 and 5/13 will be held in the Snakepit (WH2NE)

Coffee breaks:

- 5/10, 3:30 outside One West (WH1W, down the stairs)
- 5/11, 10:30 outside Curia II
- 5/11, afternoon there is a director's coffee break for the lab at around 3 pm during the breakouts
- 5/12, 10:30 outside Curia II
- 5/12, 3:30 outside Snakepit

Google form for workshop dinner on Thursday at 6:30 pm: Dinner attendance form

Wrap-up

Thank you again for your attendance at this workshop

As a reminder, this meeting is subject to Fermilab's Statement of Community Standards

Now, let's have a lively and productive meeting!