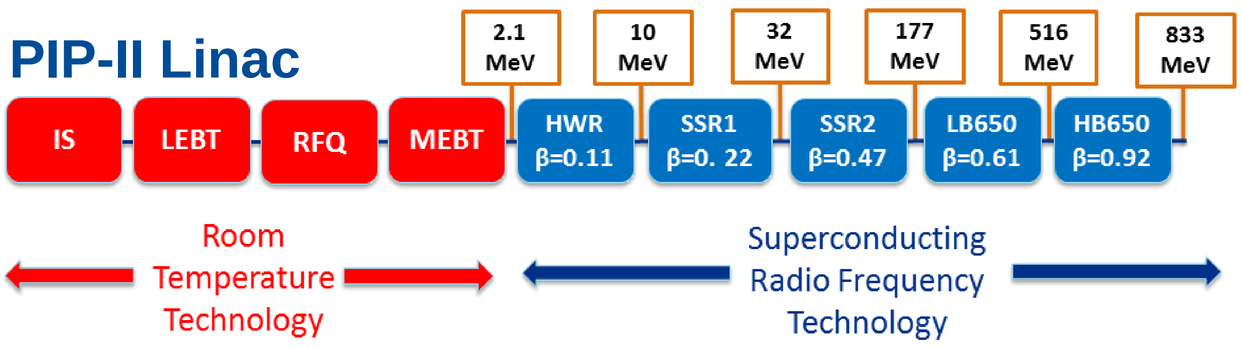
IBIC 2019, Malmo, Sweden

Beam Instrumentation Challenges for the Fermilab PIP-II Accelerator *

V. Scarpine, N. Eddy, D. Frolov, M. A. Ibrahim, L. Prost, V. A. Shemyakin, R. Thurman-Keup, Fermi National Accelerator Laboratory, Batavia, IL 60510 USA

The PIP-II Project

The PIP-II project at Fermilab is building a superconducting Linac to fuel the next generation of intensity frontier experiments. Capitalizing on advances in superconducting radio-frequency (SRF) technology, five families of superconducting cavities will accelerate H− ions to 800 MeV for injection into the Booster. Upgrades to the existing Booster, Main Injector, and Recycler rings will enable them to operate at a 20 Hz repetition rate and will provide a 1.2 MW proton beam for the Long Baseline Neutrino Facility.

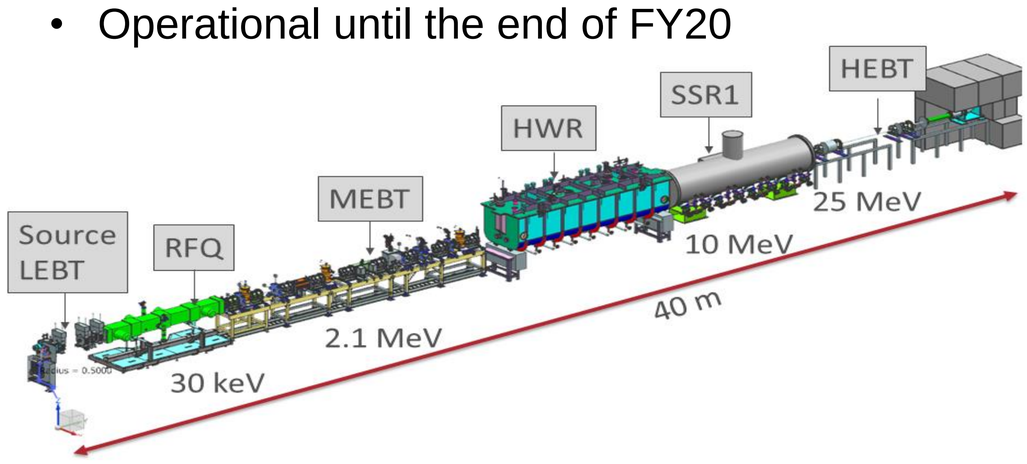


Beam Parameters

Linac	PIP-II
Delivered Beam Energy (kinetic)	800 MeV
Particles per Pulse	6.7×10^{12}
Average Beam Current in the Pulse	2 mA
Pulse Length	550 μs
Pulse Repetition Rate	20 Hz
Bunch Pattern	Programmable
Booster	**Value**
Injection Energy (kinetic)	800 MeV
Extraction Energy (kinetic)	8 GeV
Particles per Pulse (extracted)	6.5×10^{12}
Beam Pulse Repetition Rate	20 Hz
Recycler Ring / Main Injector	**Value**
Injection Energy (kinetic)	8 GeV
Extracted Beam Energy	60-120 GeV
Beam Power (120 GeV)	1.2 MW
Cycle Time (120 GeV)	1.2 sec
Potential Upgrades	
Upgrade potential	2.4 MW

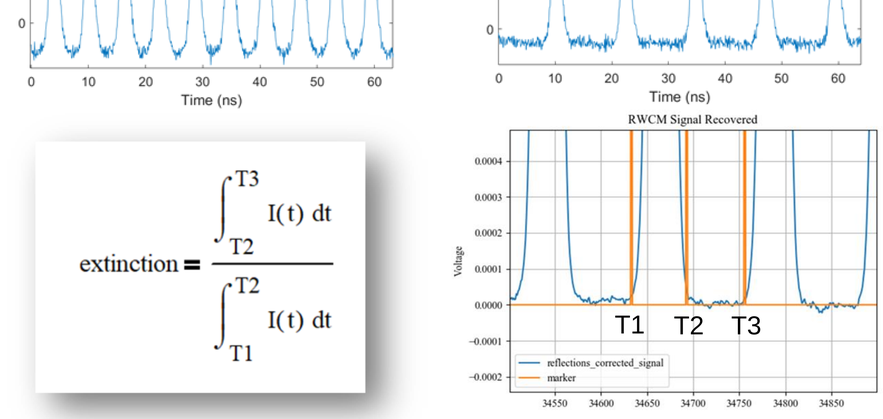
The PIP-II Injector Test (PIP2IT)

- Testing of the front-end of PIP-II accelerator
- Supports HWR and SSR1 CM testing with beam
- Retires a significant number of technical risks
- Test of bunch-by-bunch chopper
- Testing of beam instrumentation
- Operational until the end of FY20



MEBT Chopper Measurement

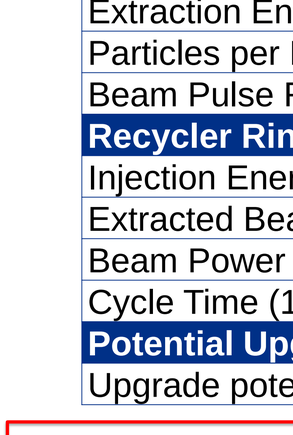
- Use Wall Current Monitor to study MEBT chopper extinction
- Limited by signal reflections

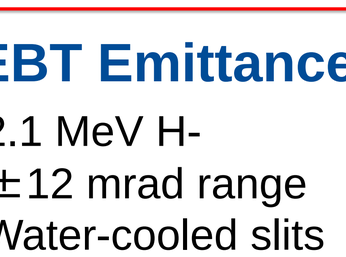


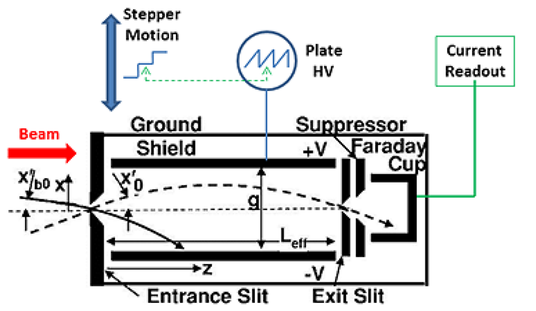
$$\text{extinction} = \frac{\int_{T2}^{T3} I(t)\,dt}{\int_{T1}^{T2} I(t)\,dt}$$

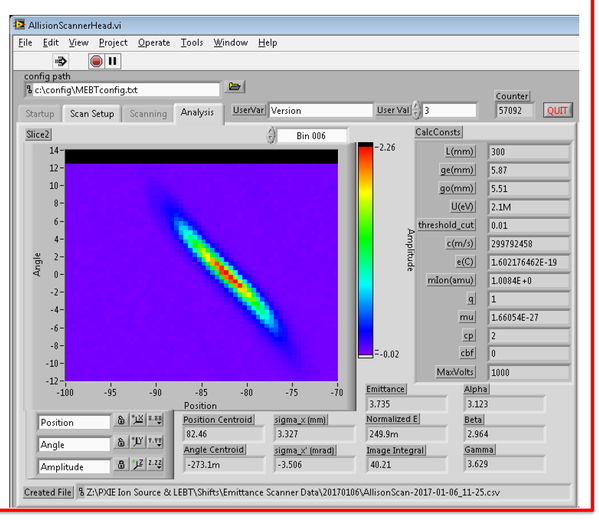
MEBT Emittance Monitor

- 2.1 MeV H-
- ±12 mrad range
- Water-cooled slits

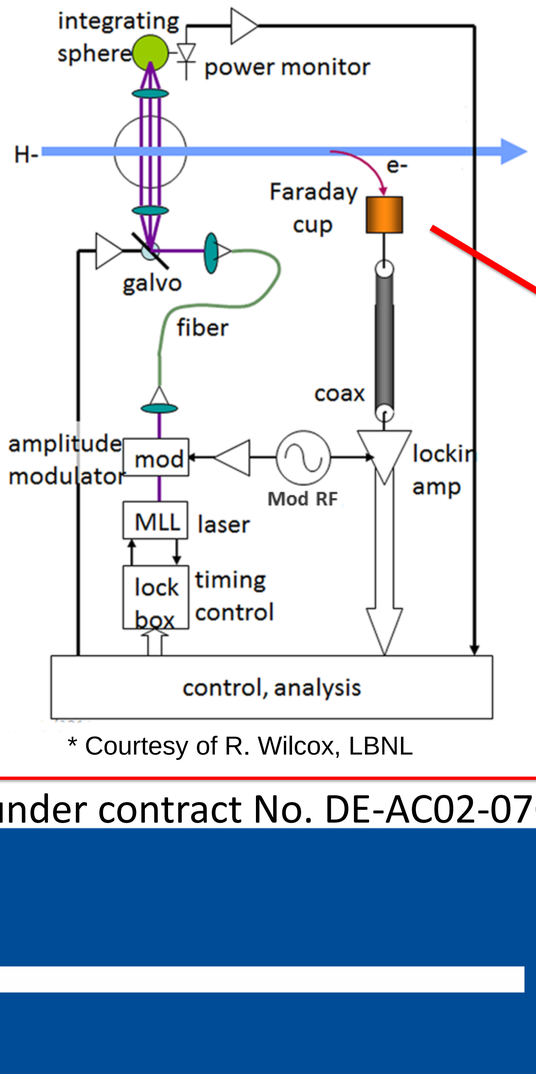




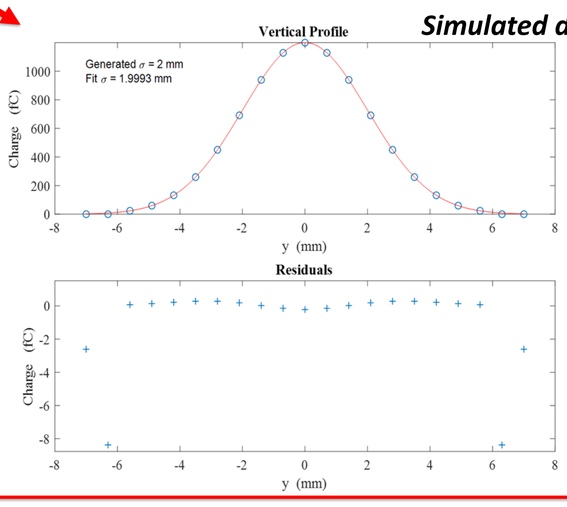




Laser Profile Monitor $H^- + \gamma \rightarrow H^0 + e^-$



- Non-invasive measurement
- 162.5 MHz, psec all-fiber mode-locked laser (MML)
  - Amplitude modulate
- Lock-in amplifier detection



Laser
- 1 W
- 6 ps rms

H^-
- 2.1 MeV
- 2 mA
- 500 μs

* Courtesy of R. Wilcox, LBNL

* This work was supported by the U.S. Department of Energy under contract No. DE-AC02-07CH11359