Fermilab

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Beam Physics Topics 1

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Retreat Preparation

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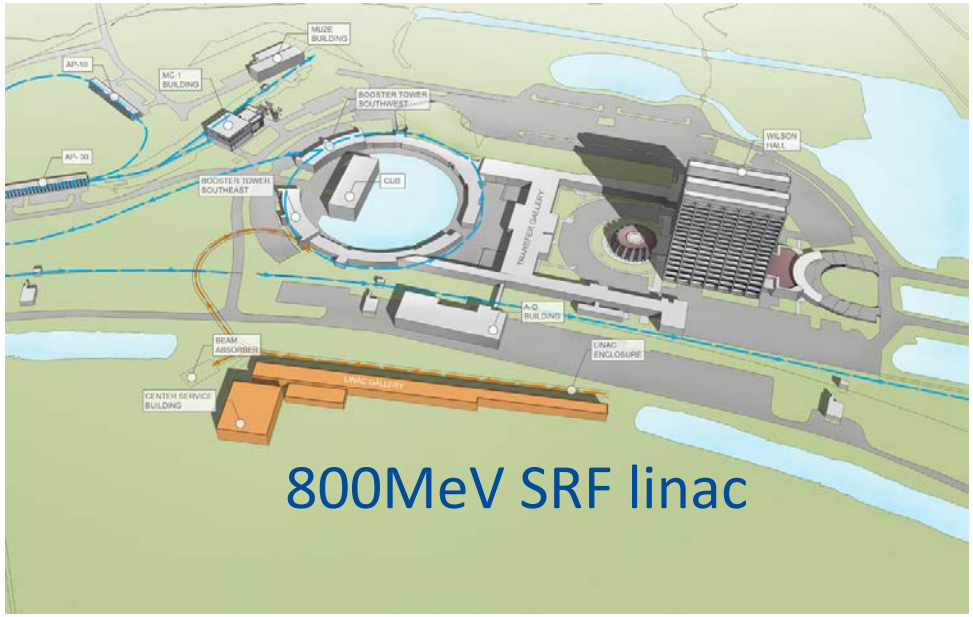
Topics

- PIP-II
- Multi-MW after PIP-II
- FAST/IOTA
- Beam Physics
  - Theoretical Beam Dynamics
  - Computational Beam Dynamics
  - Experimental Beam Dynamics (incl. Space charge, instabilities, electron cloud)

PIP-II

- http://pip2.fnal.gov
- Proton Improvement Plan-II (PIP-II) is Fermilab's plan for providing powerful, high-intensity proton beams to the laboratory's experiments.



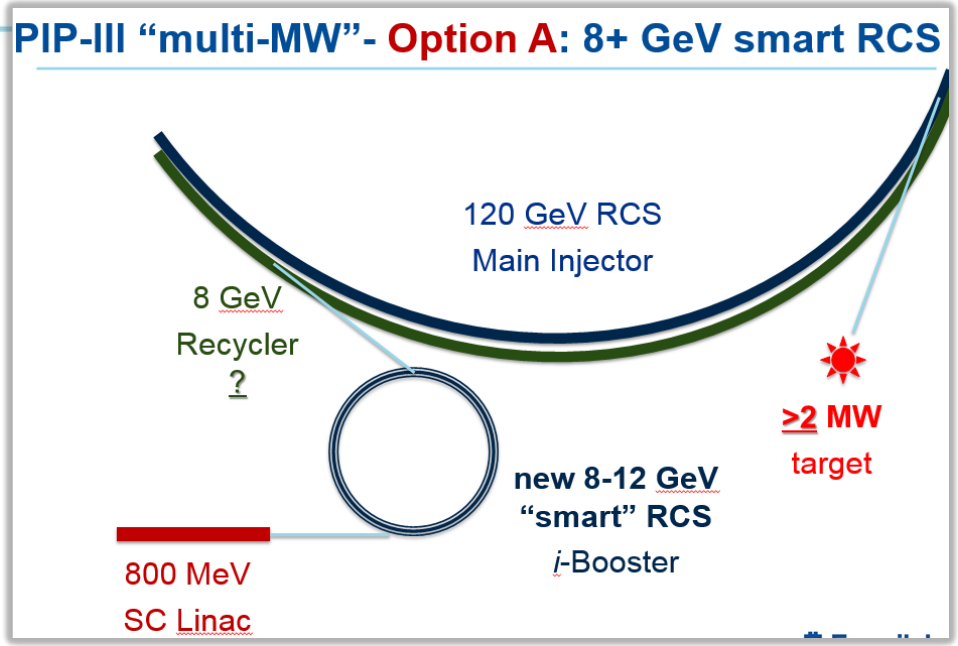
- Selected R&D topics
  - Microphonics
  - Consistent high gradient srf at low beta
  - Booster beam intensity

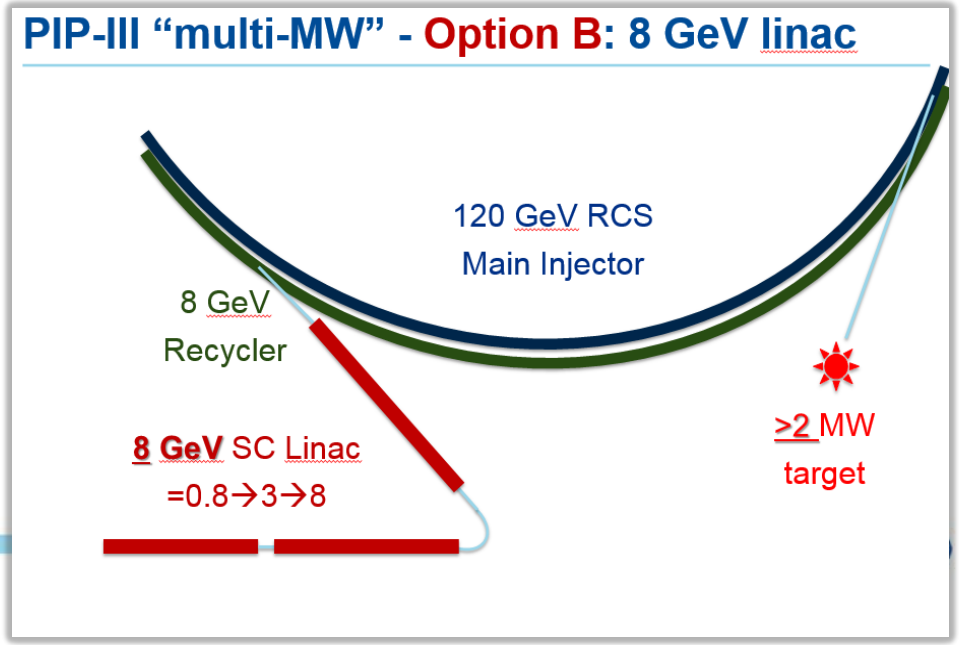
Post PIP-II multi-MW Upgrade = Replace Booster

* Note: technologies of today exists, just costly (JPARC-like RCS, Project X SRF)

Cost-effective options:

- **RCS:** with improved performance beyond current by a **factor of 2-4**:
  - e.g. ***dQ_sc >1*** (vs ~0.25-0.3 now)
  - *Therefore,* ***IOTA/FAST*** **facility and R&D**
- **Linac:**
  - ***SRF R&D*** *towards better performance and lower cost*

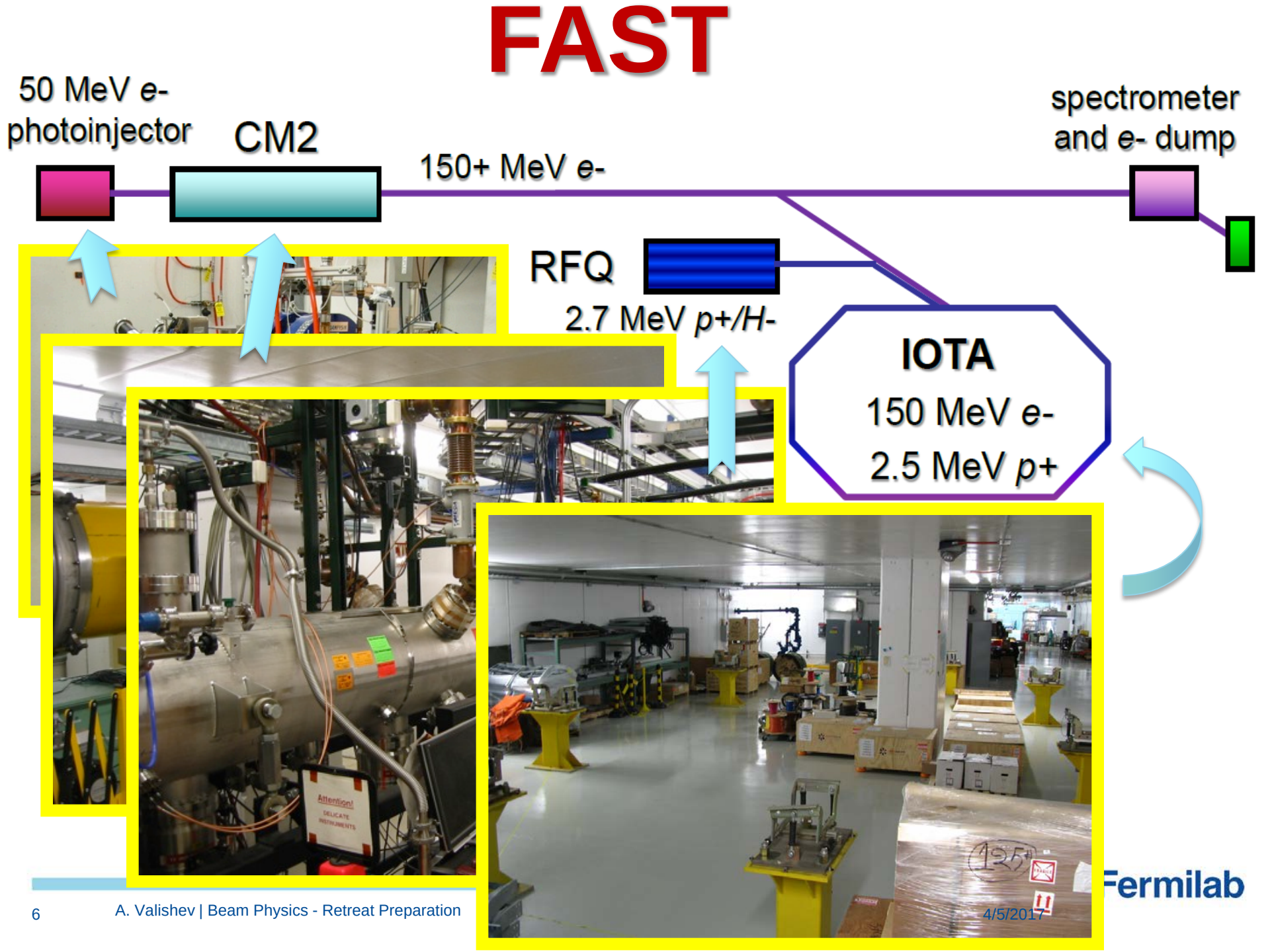




FAST/IOTA : Overarching Motivation – R&D on Intensity Frontier Accelerators for HEP

- To enable multi-MW beam power, losses must be kept well <0.1% at the record high intensity:
  - Need <0.06% for the post PIP-II ~2.5 MW upgrade
  - Present level ~3-5% in Booster and MI synchrotrons
  - (Very challenging after 50 years of development)
- FAST= Fermilab Accelerator Science and Technology facility
- IOTA – Integrable Optics Test Accelerator

FAST


50 MeV e-
photoinjector
CM2
150+ MeV e-
spectrometer
and e- dump
RFQ
2.7 MeV p+/H-
IOTA
150 MeV e-
2.5 MeV p+

Beam Theory and Simulations

- **Major motivation – demands of FNAL complex/upgrades:**
  - Operations, PIP-I, I+, II, III, experiments, IOTA, colliders, etc

- **Advancing beam theory:**
  - *instabilities with space-charge & FB*, *parametric Landau damping, integrable nonlinearities*, *particle-matter interactions*, future *collider limitations and scenarios*, etc

- **Suite of modeling tools, developed at Fermilab:**
  - MARS — Simulations of targetry, beam loss, collimation and background
  - Synergia — Simulations of beam dynamics emphasizing collective effects
  - OPTIM — Beam optics
  - Lifetrac — Single particle dynamics

IOTA Construction and Research Timeline

	Electron Injector	Proton Injector	IOTA Ring
FY15	20 MeV *e*- commiss'd beam tests	Re-assembly began @MDB	50% IOTA parts ready
FY16	50 MeV *e*- commiss'd beam tests	50 keV *p*+ commiss'd	IOTA parts 80+% ready
FY17	150-300 MeV *e*- beam commissioning/tests *	2.5 MeV *p*+ commiss'd beam tests @ MDB	IOTA fully installed first beam ? *
FY18	*e*- injector for IOTA + other research	*p*+ RFQ moved from MDB to FAST *	IOTA commiss'd with *e*- **Research starts (NL IO)**
FY19	*e*- injector for IOTA + other research	2.5 MeV *p*+ commiss'd beam tests	**IOTA research with *e*-** IOTA commiss'd with *p*+
FY20	*e*- injector for IOTA + other research	*p*+ injector for IOTA	**IOTA research with *p*+***

beam operations

- contingent on $$: FY17-20 - under current budget scenario…together with OHEP GARD management we explore options to accelerate start of research by 1 year (1.48M$ supplemental)