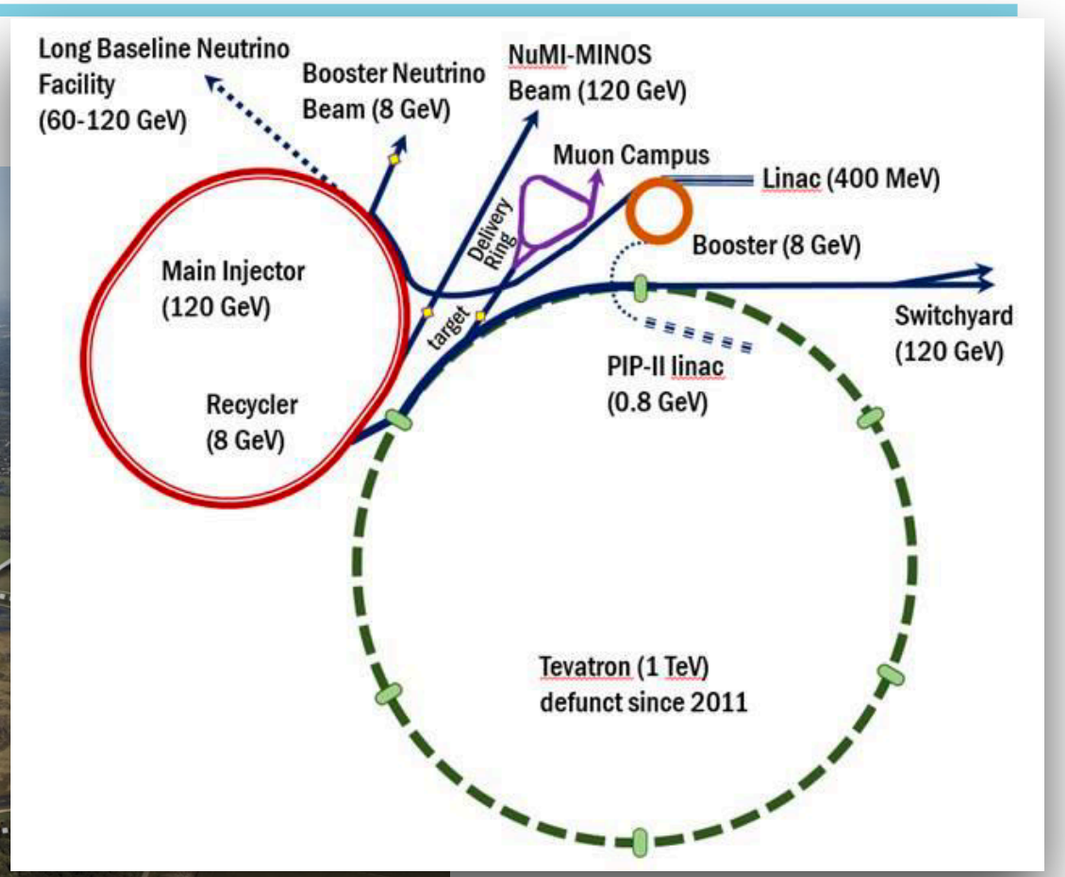
The Future of the Fermilab Accelerator Division in 10 minutes

Athula Wickremasinghe
On behalf of the Accelerator Division at Fermilab
New Perspective 2020
21 July 2020

Fermilab Accelerator Complex

Bird's-eye view of Fermilab beams

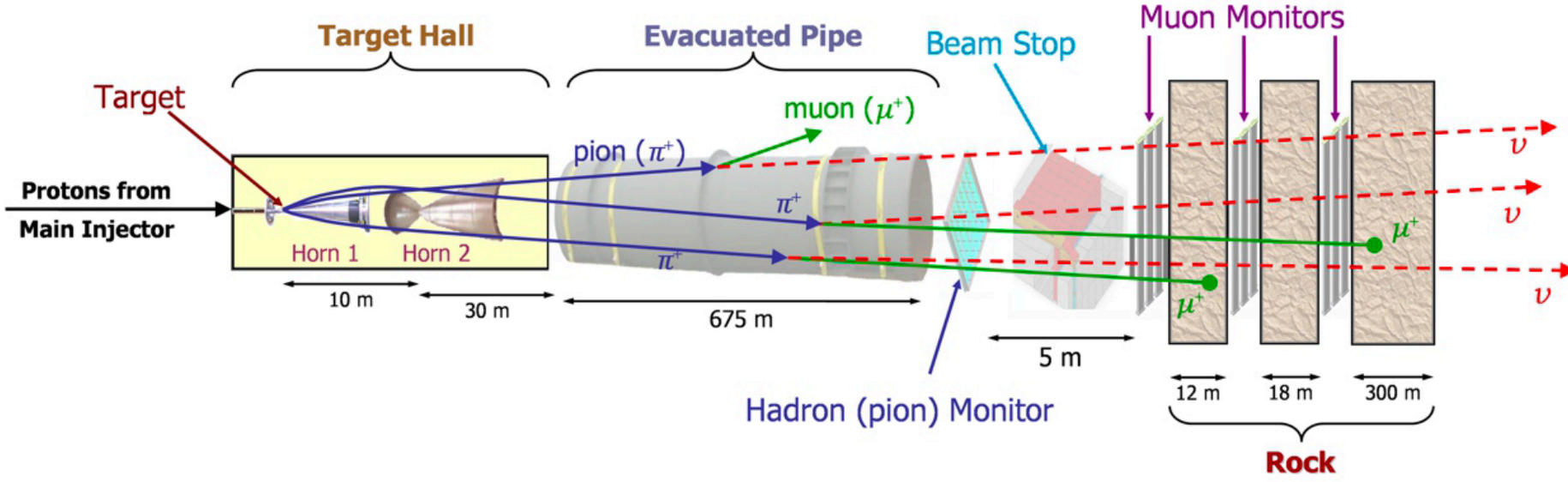


Fermilab

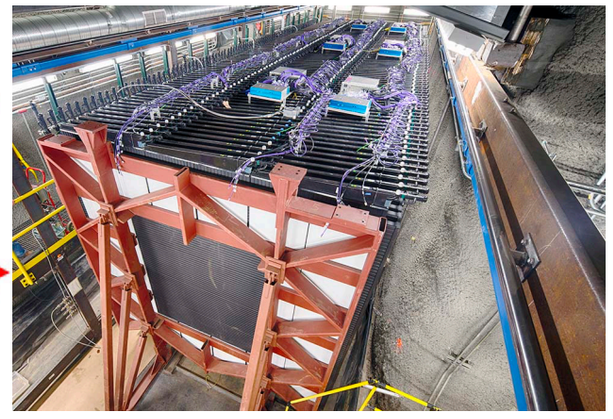
List of Upgrades and Future Plans

- NuMI beamline upgrades for 1-MW beam operations
- Mu2e plans
- IOTA studies
- Artificial Intelligent and Machine Learning efforts
- Fermilab Robotics

NuMI beamline Upgrades



Neutrino Experiments



» Planing to upgrade the beamline components to reach 1-MW beam power

» Gradually increase the beam power with faster cycle times

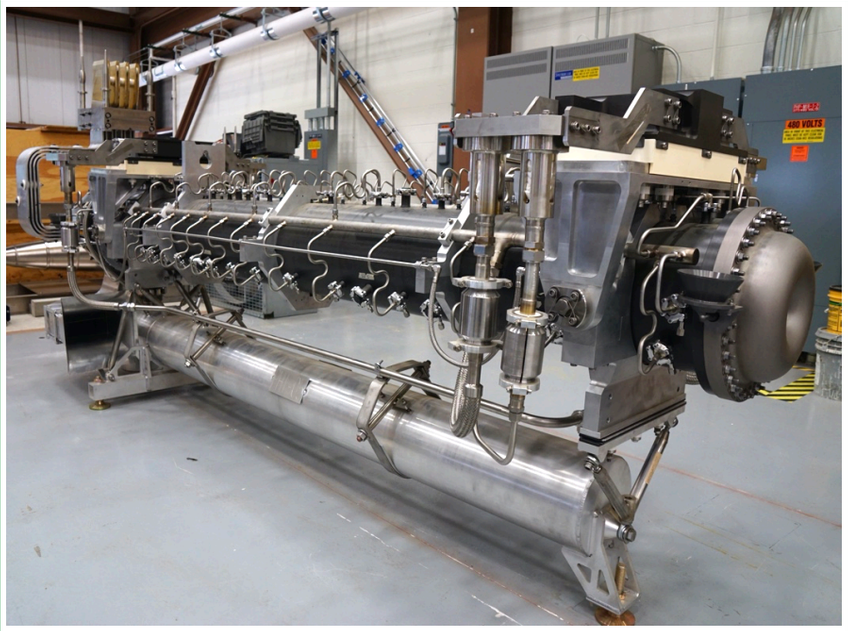
2019 summer shutdown	2020 summer shutdown
1 MW target installation	1 MW horn 1 installation
Target & Horn 1 RAW (Radioactive Water) upgrade	Stripline air diverter T-block
Target chase cooling / air upgrade	Target and horn 1 module drives
Target chase supplemental shielding	Hadron beam monitor & absorber

Fermilab

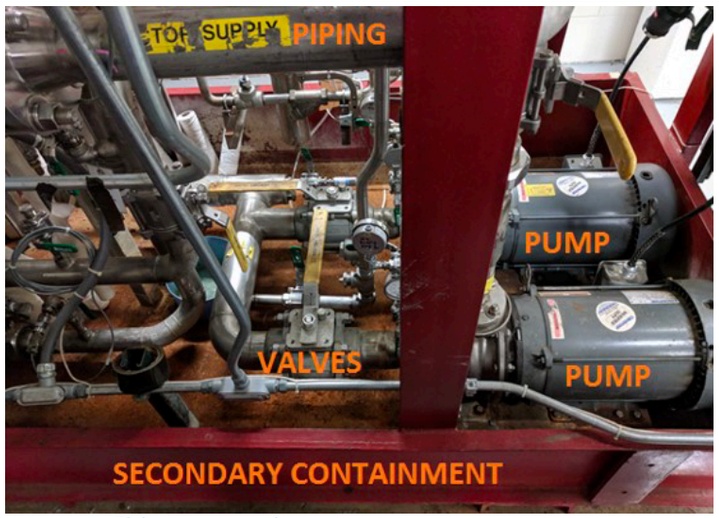
NuMI beamline Upgrades

We are getting ready to operate the NuMI beamline with 1-MW beam operations

1-MW NuMI target has been installed during the summer shutdown in 2019

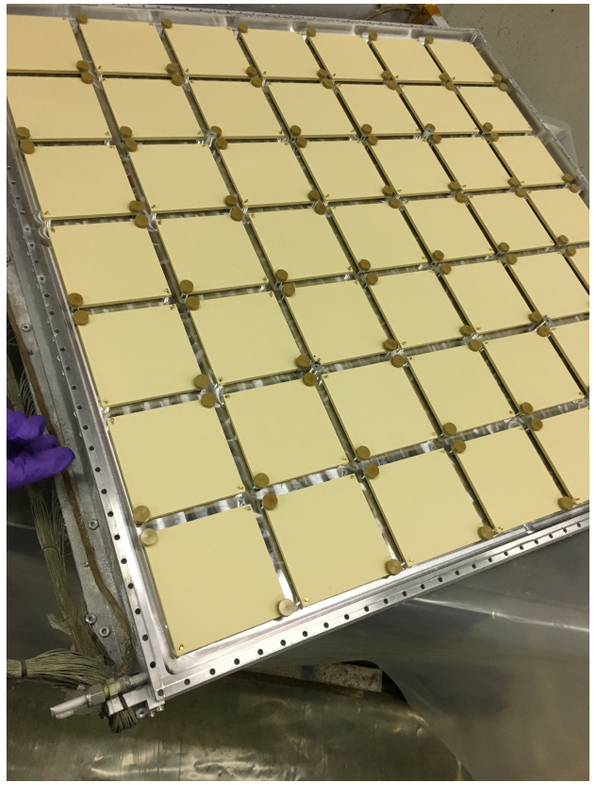


1MW horn 1 preparation is ongoing



Radioactive Water pump upgrades in 2019

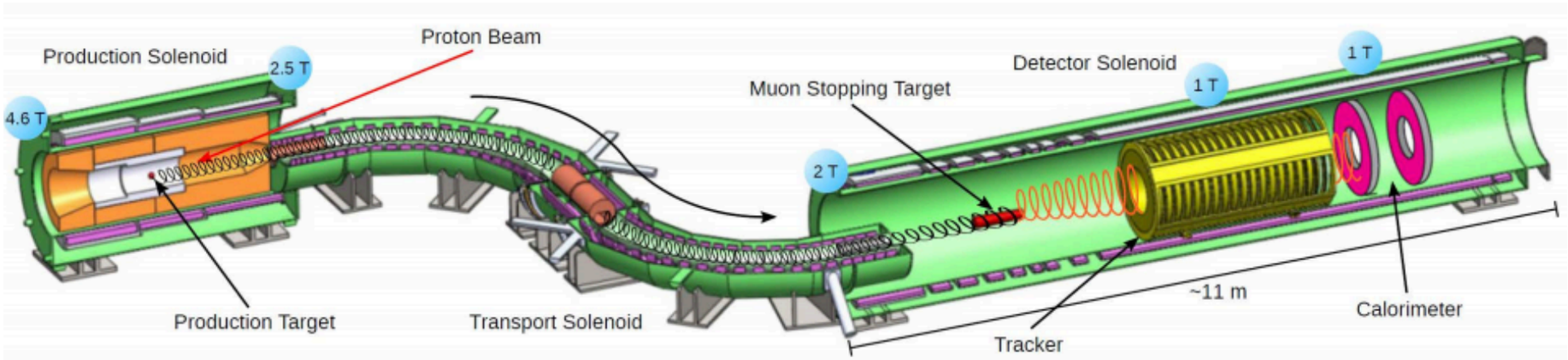
Old hadron monitor will be replaced with a new hadron monitor in 2021



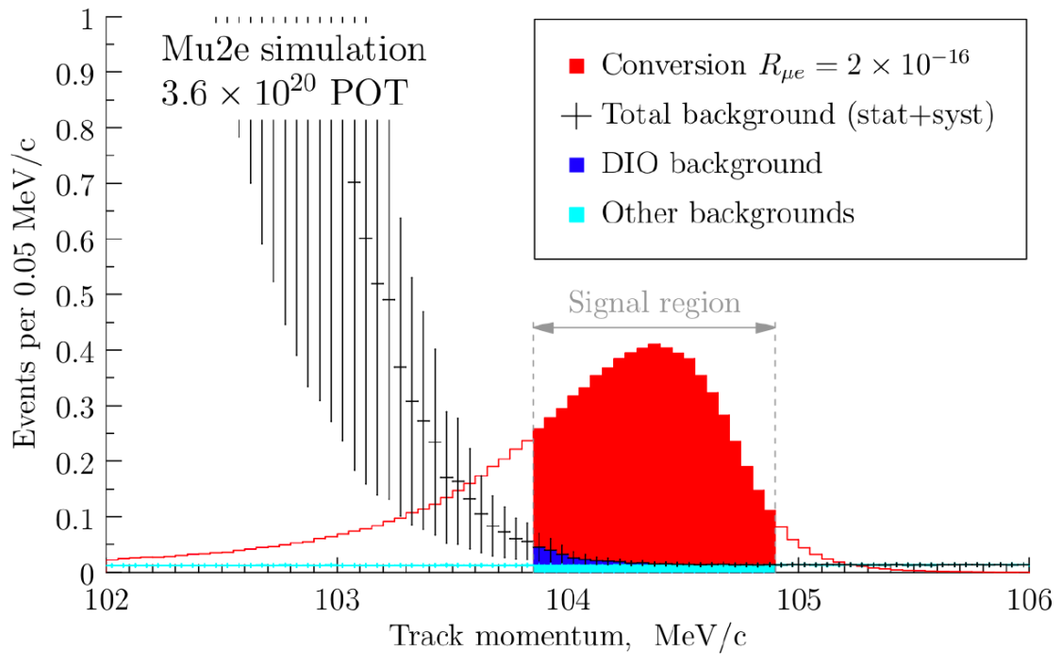
Fermilab

Mu2e beamline updates

Main Goal: **The Mu2e experiment is looking for evidence that a muon can change into an electron and nothing else. This explains the Charged Lepton Flavor Violation (CLFV) in the Standard Model (SM) of particle physics**

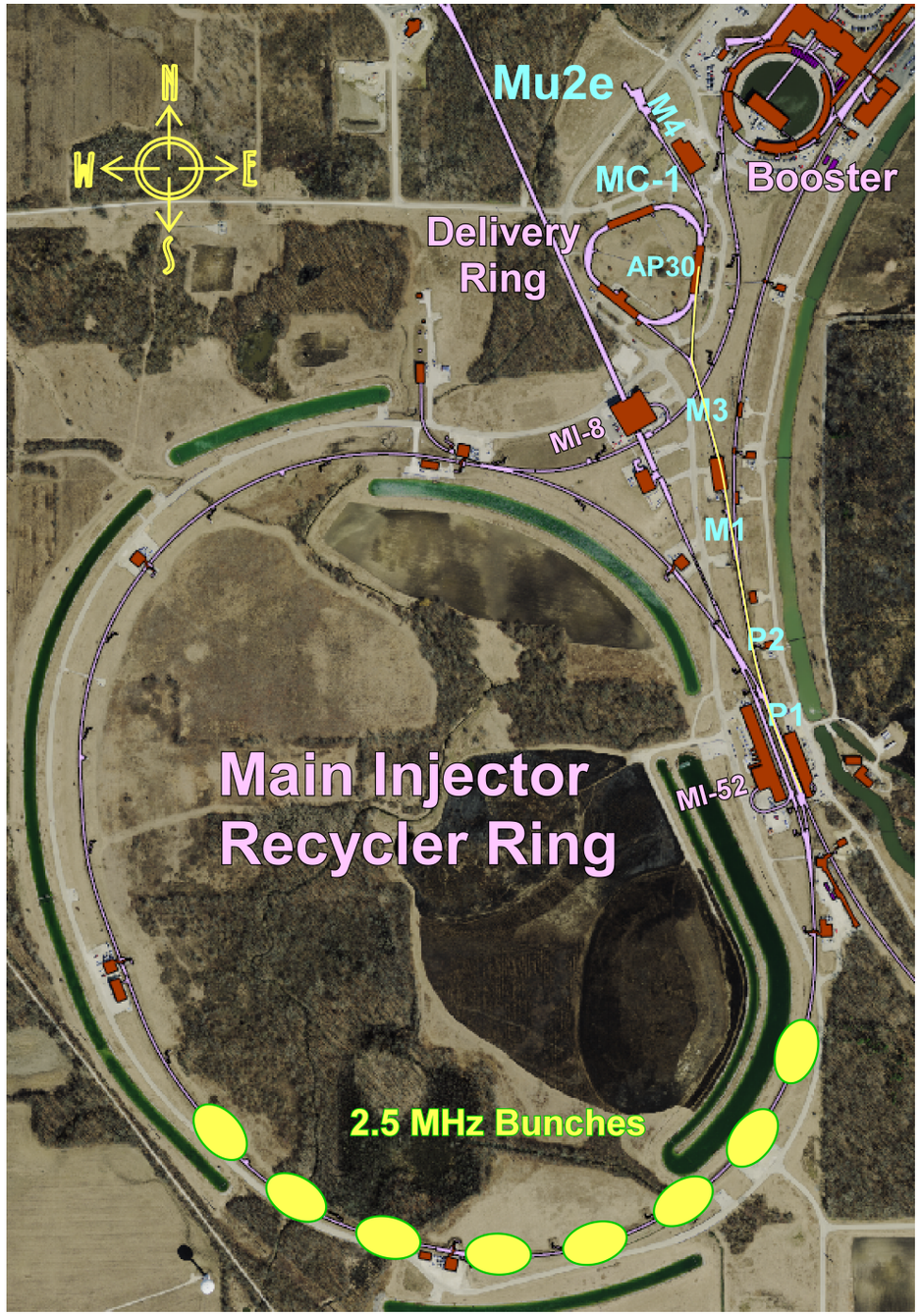


- **The Mu2e experiment is under construction at the Fermilab Muon Campus.**
- **The experiment will begin operations in 2022, and will require about 3 years of data-taking.**

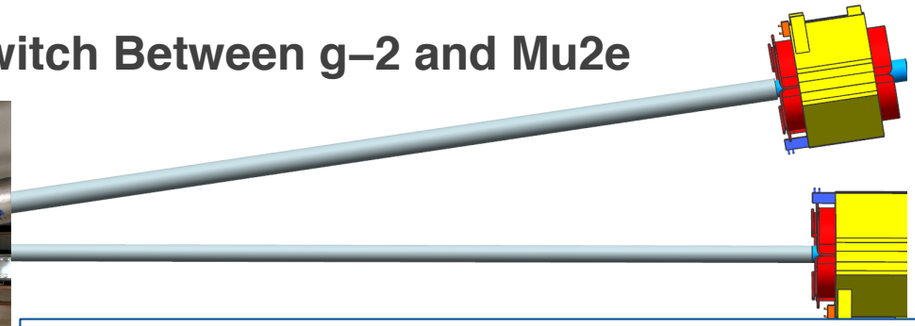


Fermilab

Mu2e beamline updates

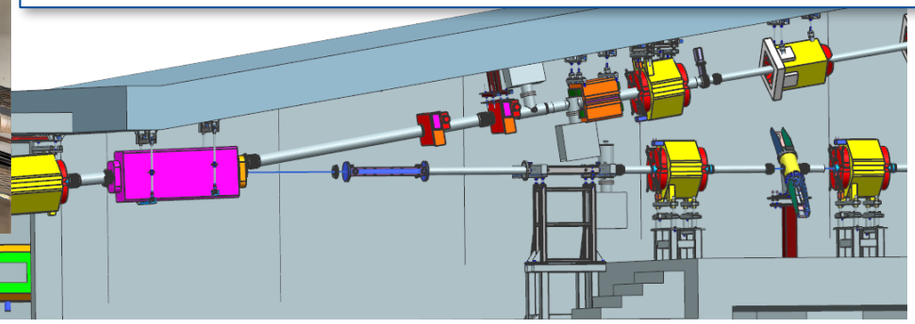


Rotating Dipole to Switch Between g–2 and Mu2e

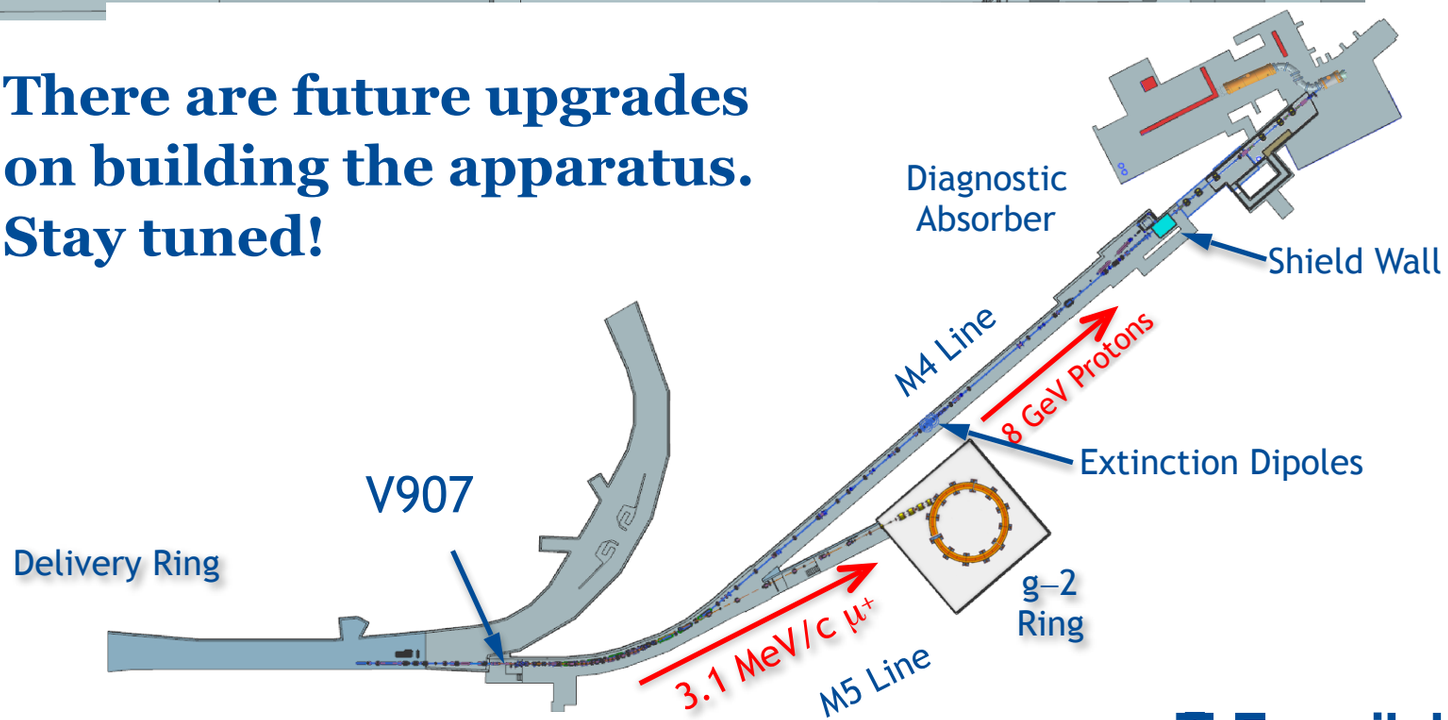


V907 is a vertical dipole

- **pitched up to run muon beam to g-2**
- **pitched down to run protons to Mu2e**



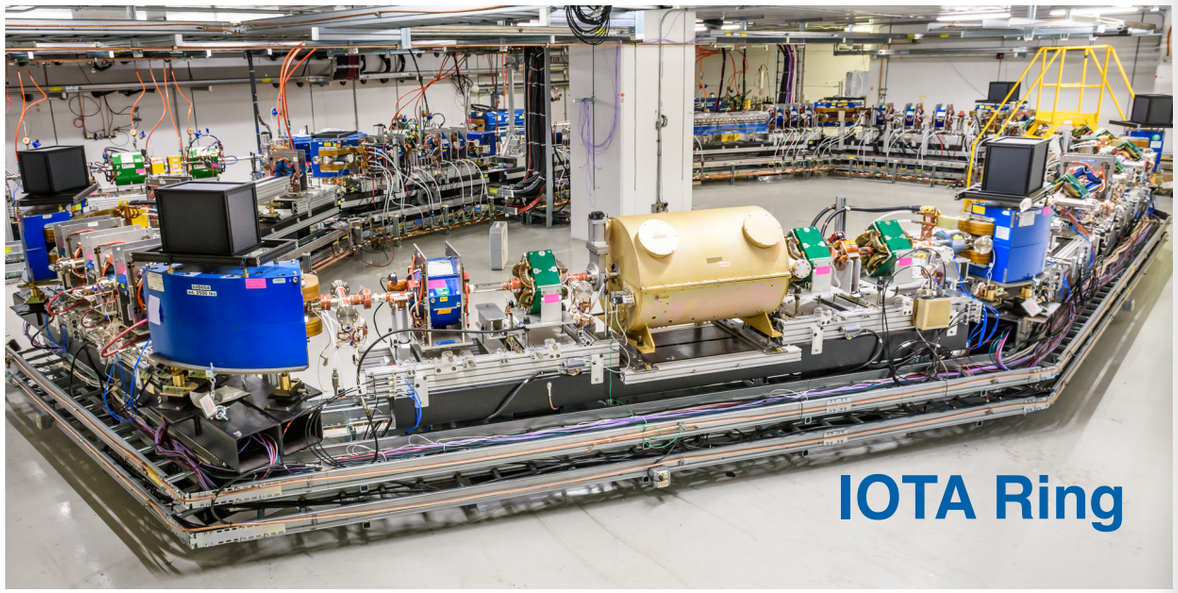
There are future upgrades on building the apparatus. Stay tuned!



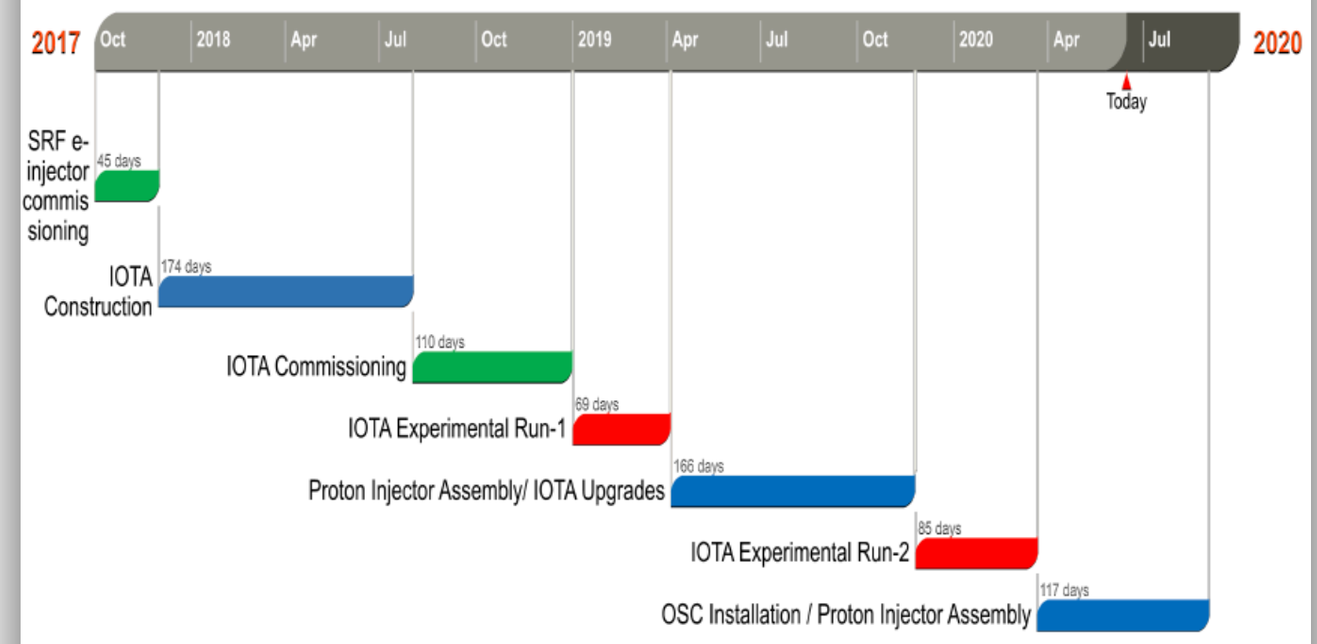
Fermilab

IOTA (Integrable Optics Test Accelerator)

The facility is dedicated to research and education in beam physics and accelerator technology



IOTA/FAST Recent Timeline



Research Staging:

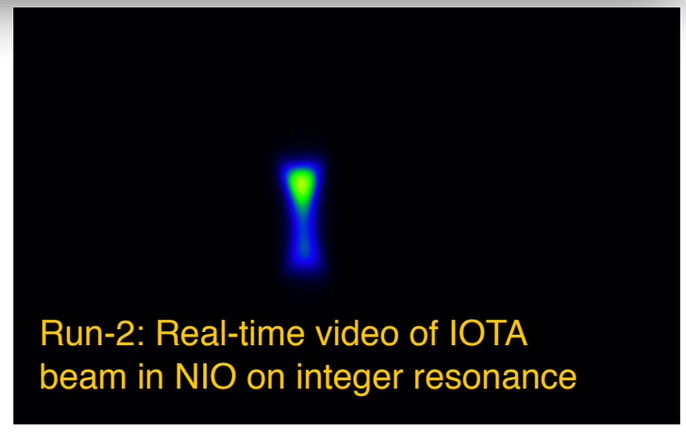
Nonlinear Integrable Optics

- **Phase I – Single-particle motion stability using electron beams**

– Run-1 2019, Run-2 2020

- **Phase II – intense-beam studies with protons**

– 2021 and beyond



Run-2: Real-time video of IOTA beam in NIO on integer resonance

Optical Stochastic Cooling

- **Without optical amplifier :– Run-3 2020*(Delayed due to the covid19)**
- **With optical amplifier :– 2022 and beyond**

Reference:
https://indico.fnal.gov/event/43231/contributions/187342/attachments/129553/157411/2020-06-15_Strategy_CollaborationMeeting.pdf

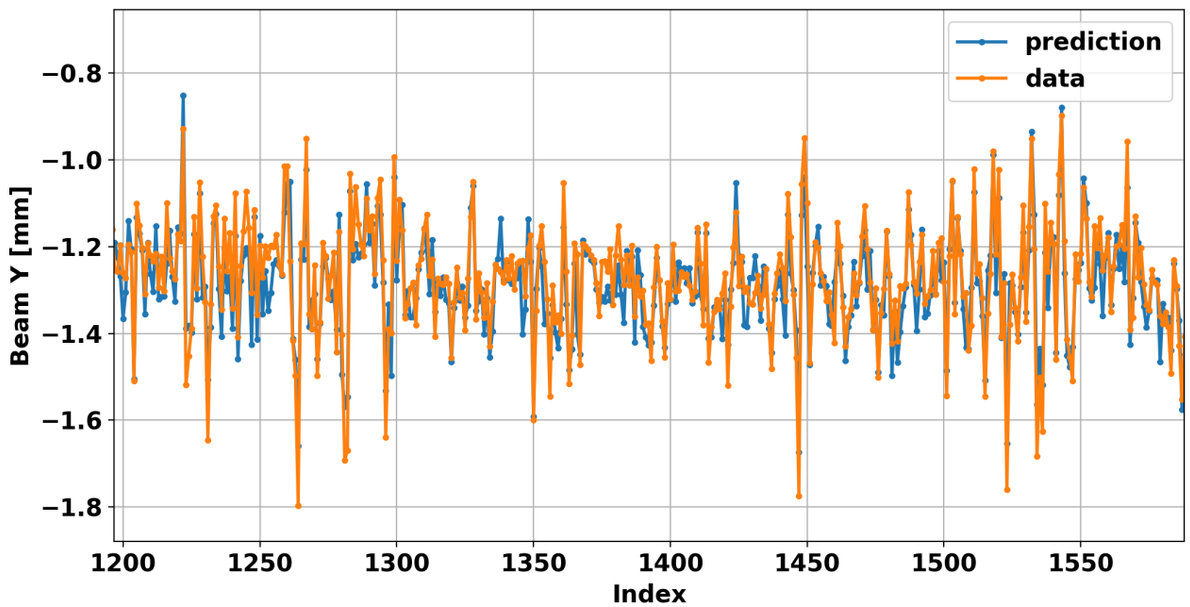
Fermilab

AI / ML efforts

AD has started implementing AI technology to improve the accelerator system performance by considering following factors:

- **Saving energy**
- **Identifying / predicting incidents**
- **Detecting anomaly**
- **Tuning beam parameters**
- **Optimizing beam quality**
- **Predicting beam parameters for QA**

Example of predicting beam position:
NuMI proton beam at the target



AI / ML efforts

Project	Description	Group
AI for superconducting magnet quenching	Early determination of conditions for superconducting magnet quenching	Cristian Boffo, Vittorio Marinozzi, Stoyan Stoynev et al
The ACORN: Accelerator Controls Operations Research Network	Modernize the accelerator control system and replace end-of-life accelerator power supplies to enable future operations of the Fermilab Accelerator Complex	Erik Gottschalk and the AD Controls Department
Automated image categorization and data mining for AD e-Log	The Main Control Room's e-log will use ML to automatically categorize all existing and future image attachments, and make text in the images searchable	Kyle Hazelwood, Jason St. John
NuMI beamline and target ML	NuMI beamline monitoring system for QA with ML predictions on beam parameters, identifying and predicting incidents	Athula Wickremasinghe, Katsuya Yonehara
Booster Gradient Magnet Power Supply (GMPS) Control via AI	Improve GMPS injection field stability with proactive compensation for external influences.	Gabe Perdue, Kiyomi Seiya, Jason St. John
User Facility AI proposals	AD Accelerator energy conservation AI, Anomaly detection, Data mining	William Pellico, Jason St. John et al
Longitudinal Beam Tomography	Automatic disentangling of slip-stacked Main Injector bunches for precision characterization	Kyle J Hazelwood
PIP2IT adaptive beam current signal monitoring	Environment-aware ML to remove noise artifacts from beam current measurement devices in low- and medium-energy sections of test stand	Eduard Pozdeyev, Michelle Ibrahim and Pavlo Lyalyutskyy

Robotics

AD scientists and engineers are introducing robotics to minimize the radiation exposure

RVR (Remote Viewing Robot)

360 and regular cameras, both with real-time image and video streaming to an iPad or phone

Future Upgrades:

- **Adding radiation detectors**
- **Sensors to automate the robot**
- **Robotic arms**

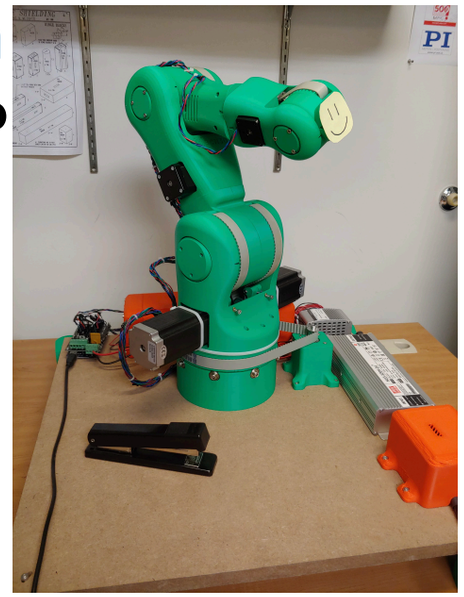
Project Leader:
Kris Anderson

5-Axis Robotic Arm

Designed to mount onto RVR for remote -control camera positioning

- **Now in testing stage**

Project Leader:
Noah Curfman



Magnetic Field-Mapping System – NuMI Horn

Updating the motion-control system that moves the 3D hall probe along the NuMI horn's center axis while the horn pulses

- **Open-source code to control new motor drive**
- **Linear position sensors**
- **Data acquisition system**

Project Leader:
Adam Watts

Fermilab

Robotics

UIC – Visually Identifying Objects Using Machine Learning System

Use computer vision and ML to identify and locate bolts on a flange arbitrarily oriented in space

Status

- **ML algorithm to detect bolts of various sizes has been created, tested, and evaluated**
- **Working on object detection script to use with a commercial 3D stereo camera**

Project Leaders:
Katsuya Yonehara, Patrick Hurh

UIC – Radiation Mapping UAV

Outfit a quadcopter to produce a 3D coordinate map integrated with radiation data

Status

- **Drone has been assembled**
- **Integration of temperature sensor (prototype), camera and Geiger-Mueller tube in progress**
- **Software development for data process in initial stages**

Project Leaders:
Katsuya Yonehara
Patrick Hurh

List of other projects / proposals:

- **UIC – Radioactive Dust Collector - PL: Noah Curfman, Rob Ridgway**
- **Robot Inside LAr Detector - PL: Bill Pellico, Mayling, Wong-Squires, Sam Zeller**
- **NIU Exoskeleton Study - PL: Mayling Wong-Squires, Don Peterson (NIU), Simon Kudernatsch (NIU)**

Thank you!
On behalf of the Accelerator Division

Thanking to AD colleagues for doing all activities even with COVID19 difficult time