Fermilab U.S. DEPARTMENT OF ENERGY Office of Science

Vth IOTA/FAST Annual Meeting/Workshop:

Intro to the 2017 Meeting, Status, Progress, Plans

Vladimir SHILTSEV, Accelerator Physics Center/AD

IOTA/FAST Scientific Program Meeting

June 6, 2017

https://indico.fnal.gov/conferenceDisplay.py?ovw=True&confId=13616

2017 IOTA/FAST COLLABORATION MEETING

June 6, 2017 *OTE (IARC)*
US/Central timezone

Search

Overview

Timetable

Contribution List

Speaker index

Book of abstracts

Registration

Registration Form

List of registrants

Support: Lisa Lopez x3674

FNAL is completing construction of the Integrable Optics Test Accelerator (IOTA) at the Fermilab Accelerator Science and Technology (FAST) facility. In Spring-Summer 2016, its photoinjector was commissioned and several beam experiments with 50 MeV electrons had been carried out. In 2017, the 1.3 GHz SRF cryomodule (CM2) will boost the energy further to 150-300 MeV range, as needed for injection in the IOTA ring. The 300 MeV beam commissioning will again be followed by a period of beam studies. Installation of the ring itself progresses fast and the first circulating electron beam in IOTA is expected in early 2018. That will make IOTA available for the first advanced nonlinear dynamics studies on integrable optics and other critical one-of-a-kind unique quantum optical experiments. Commissioning of the IOTA RFQ-based 70 MeV/c proton/ion injector in 2019 will open the era of the advanced experiments and studies of beam dynamics in high-intensity proton beams, including the space-charge effects and space-charge compensation.

The Fermilab team has taken great care in a flexible design of the IOTA ring allowing mounting of very special and characteristically unique experiments that will demand flexibility of optics and rapid re-configuration of its set-up as demanded by experiments. Many external collaborators from the academic and national laboratory communities within US and internationally joined us in shaping the accelerator R&D program where this special community will have a vested interest and will direct and own the experimental program.

This annual meeting - **5th** in series - will allow the participants to review the status of the facility, share the results of the first studies and tests, evaluate the progress toward key advanced beam physics experiments at FAST/IOTA and to develop further the scientific program of the facility with full synergistic support from the community, helping and enhancing the national and international developments collaboratively.

Warning!

- **Emergency Warning** at 10:00 a.m. – right before Aliaksei Halavanau's talk. Should last no more than 25 seconds.

- Also – We need a count and NAMES of those who want to get on the **IOTA/FAST tour** at lunch (facility is pre-operational, ODH area… Fermilab or local attendees will have other chances).

2016 IOTA/FAST Meeting – IVth Annual June 14, 2016

My talk: 1.Facility News & Plans

2. Budget / Effort / People

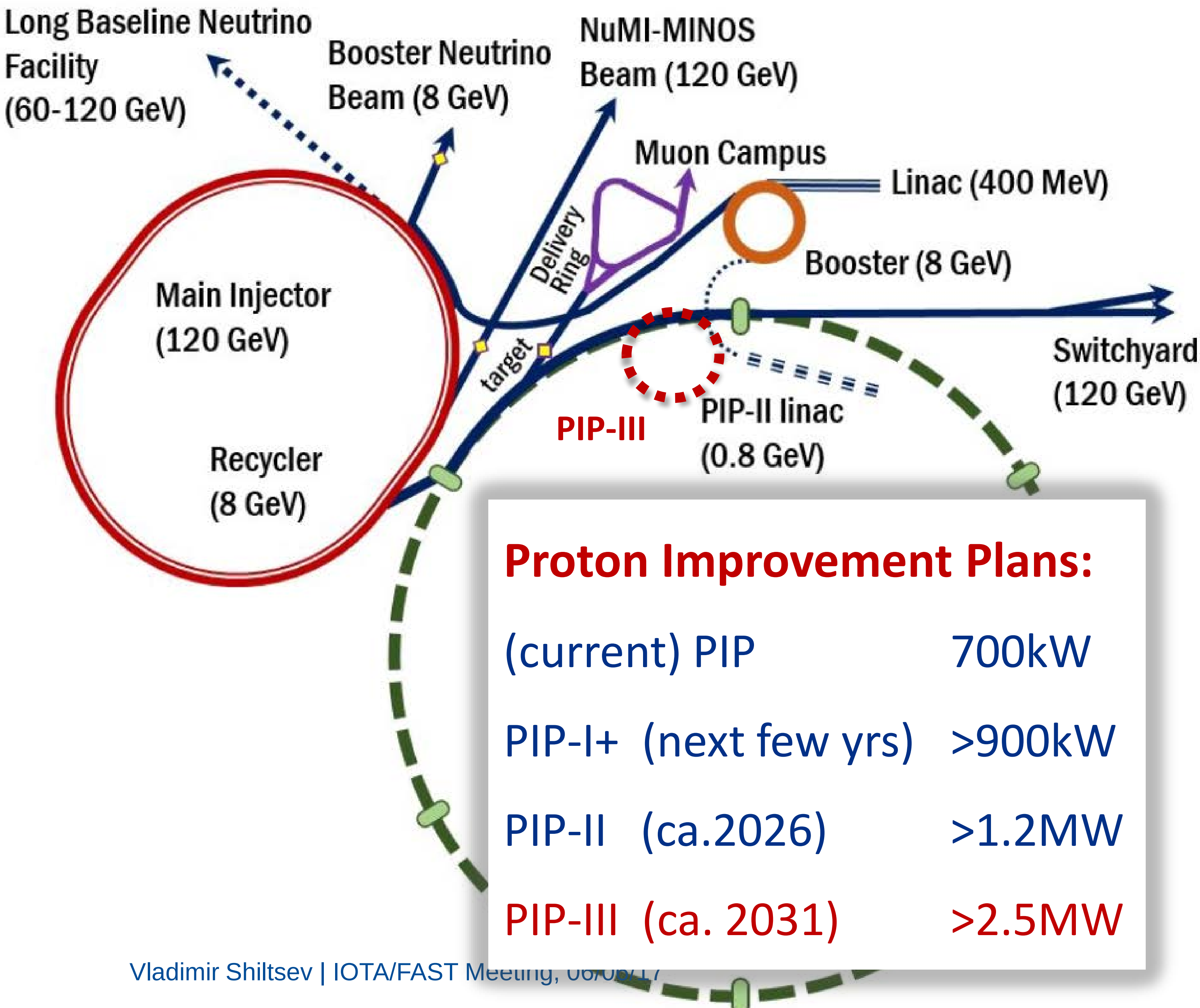
3. Science News

4. Conferences/Accolades

5. This meeting / expectations

Fermilab

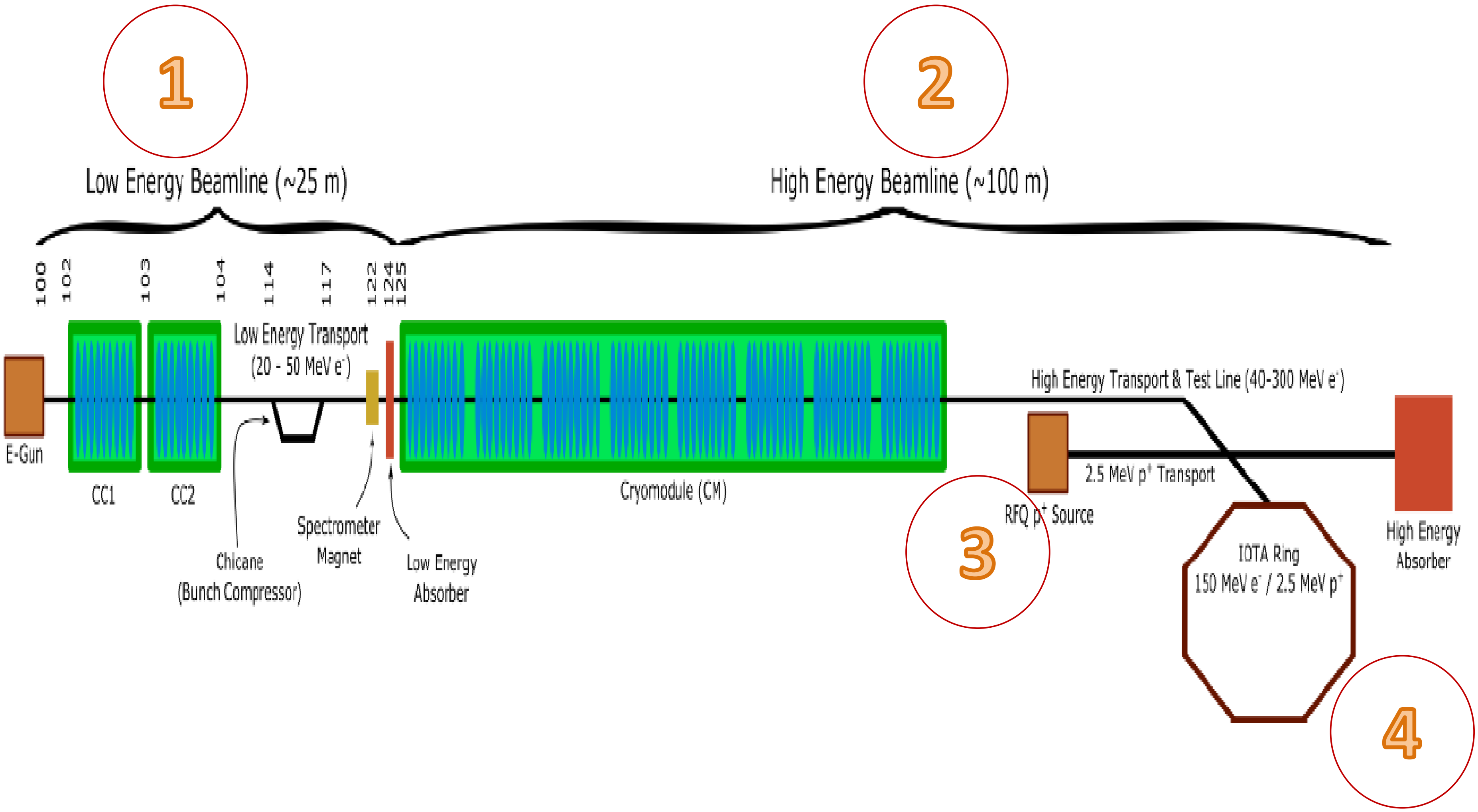
US HEP Evolution and Our Role in It



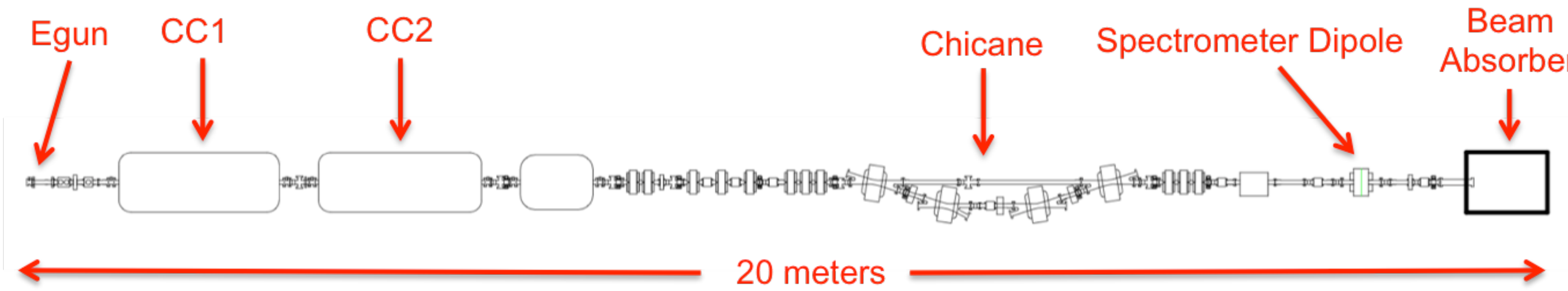
Proton Improvement Plans:

(current) PIP	700kW
PIP-I+ (next few yrs)	>900kW
PIP-II (ca.2026)	>1.2MW
PIP-III (ca. 2031)	>2.5MW

IOTA/FAST Layout

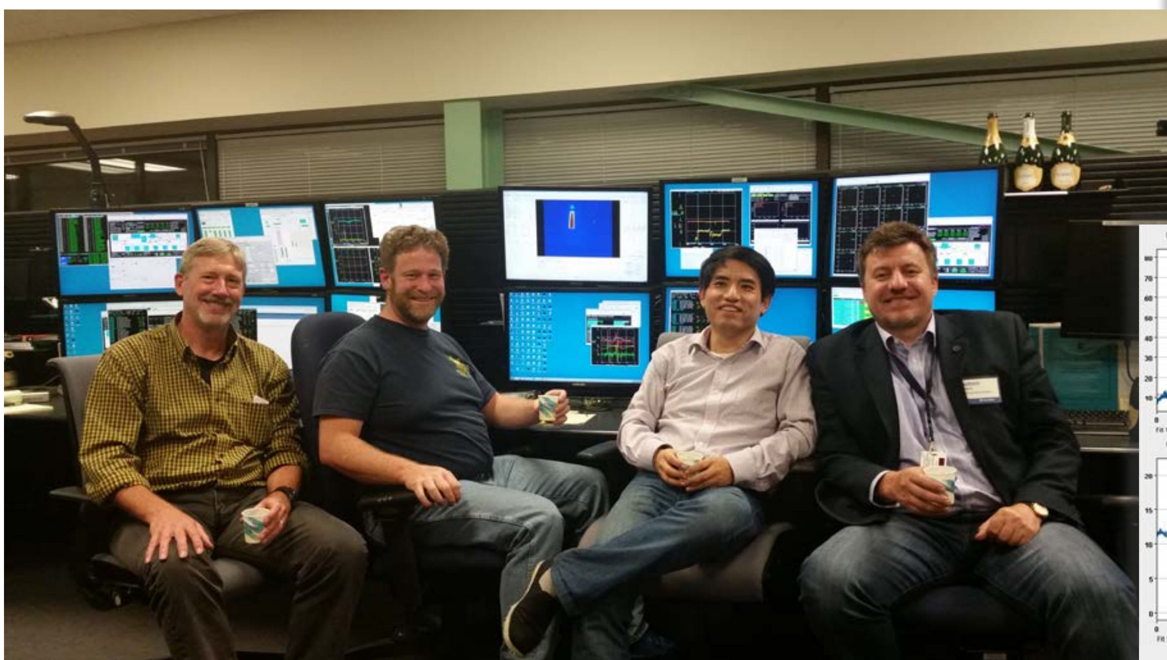


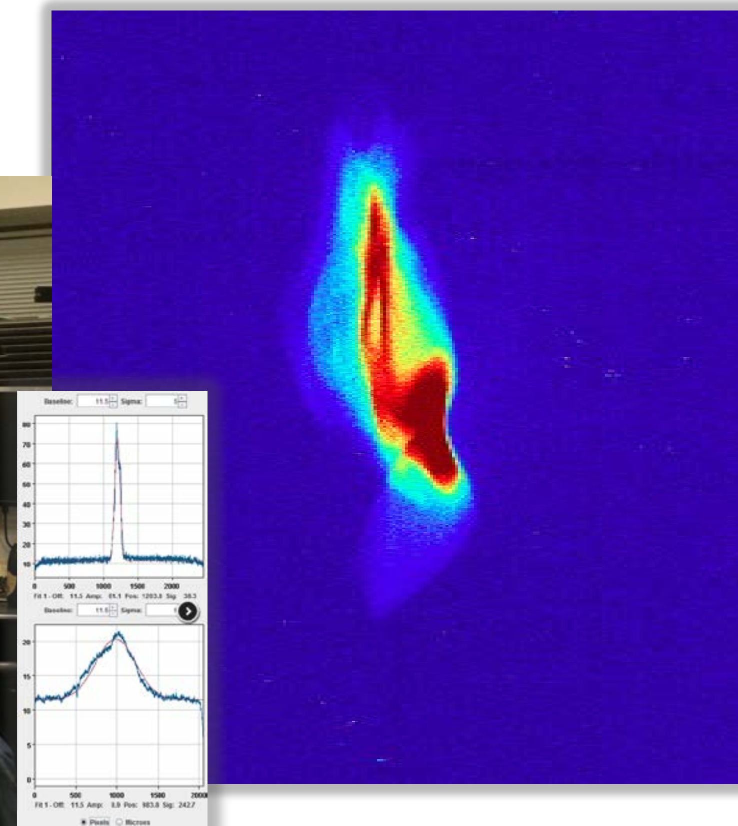
Past Year Highlights: e- Injector 50 MeV



52.5 MeV *e*[-] beam through FAST injector

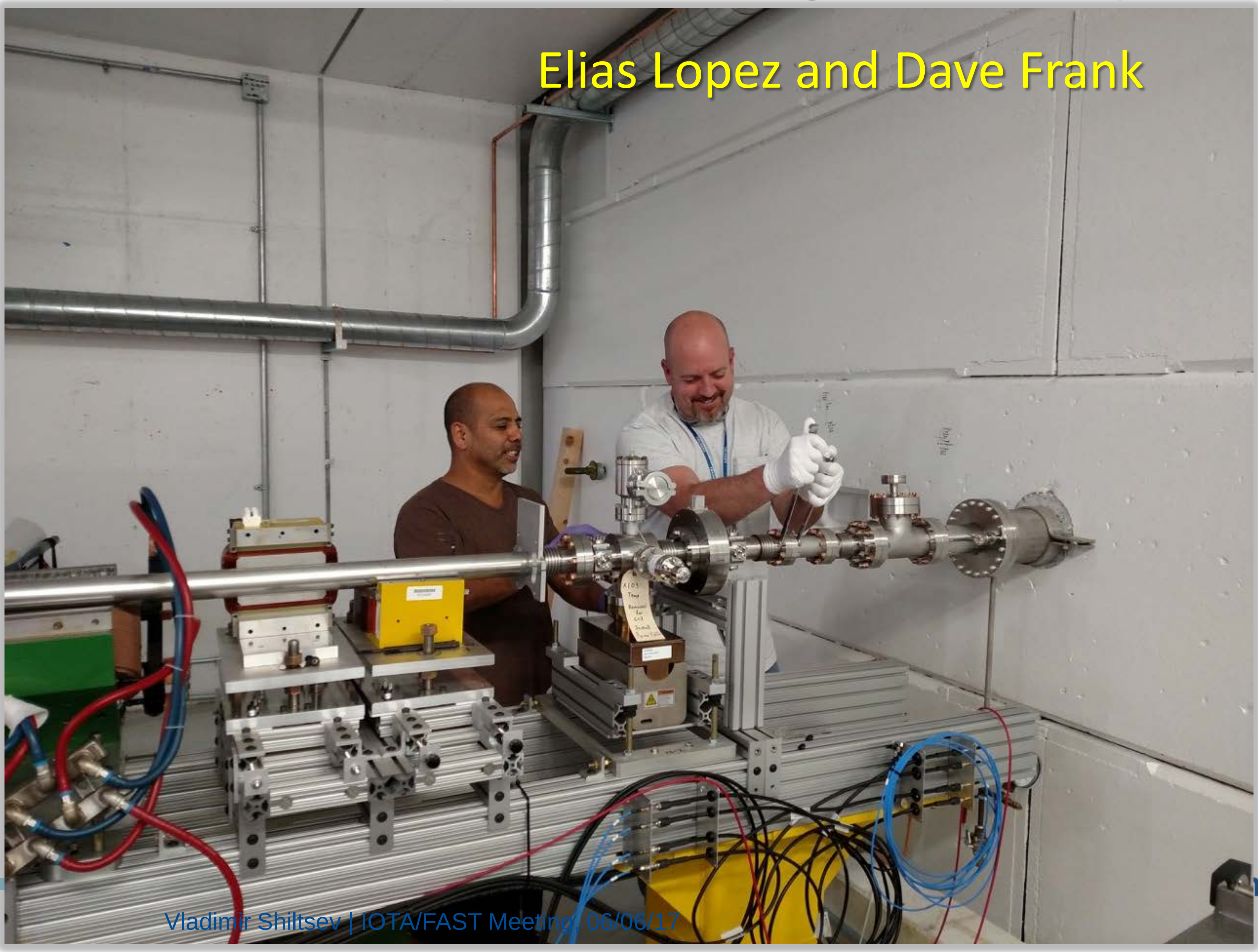
May 16, 2016: Beam accelerated by both Capture Cavities #1 and #2: 4.5 MeV (gun)+28MeV+20MeV



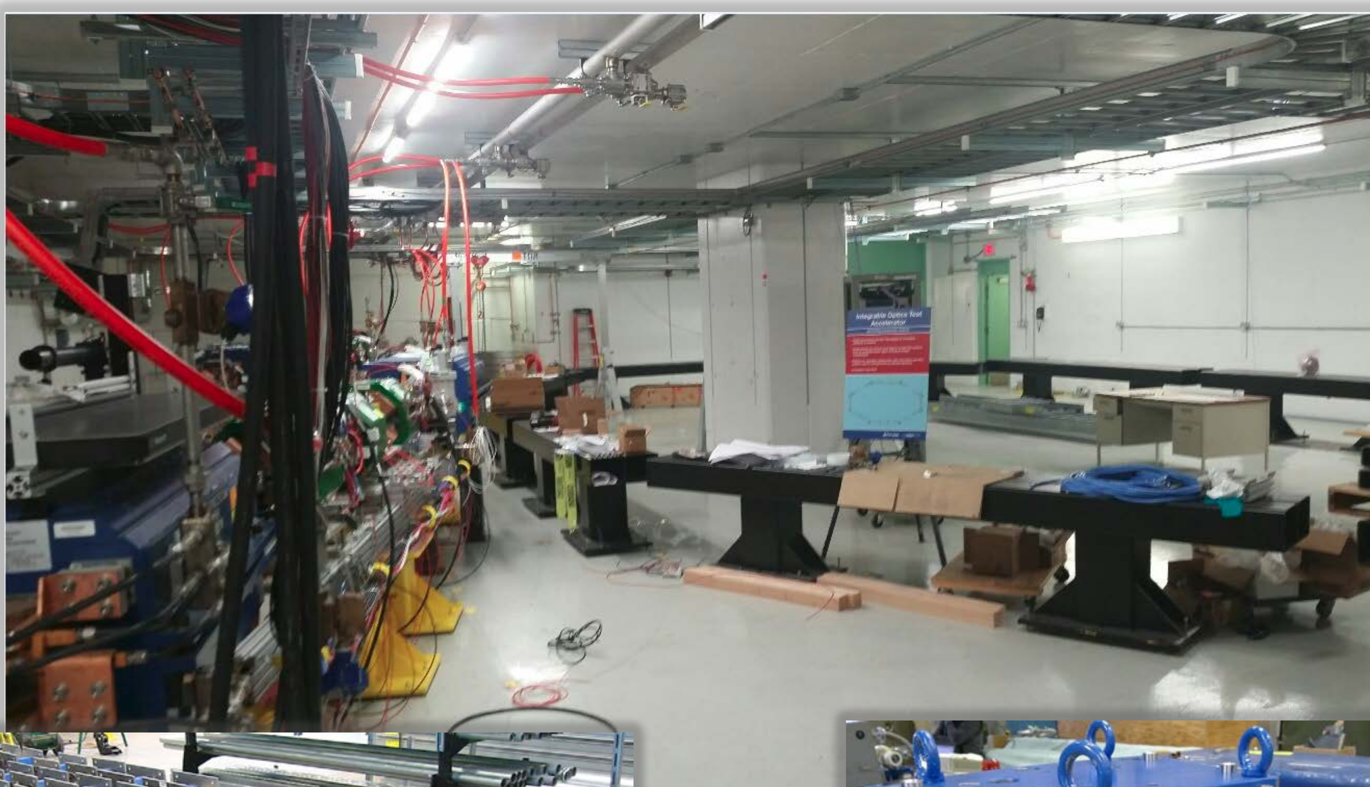


FY17 Highlights :
300 MeV beam line installed

FAST Vacuum system contiguous! May 26



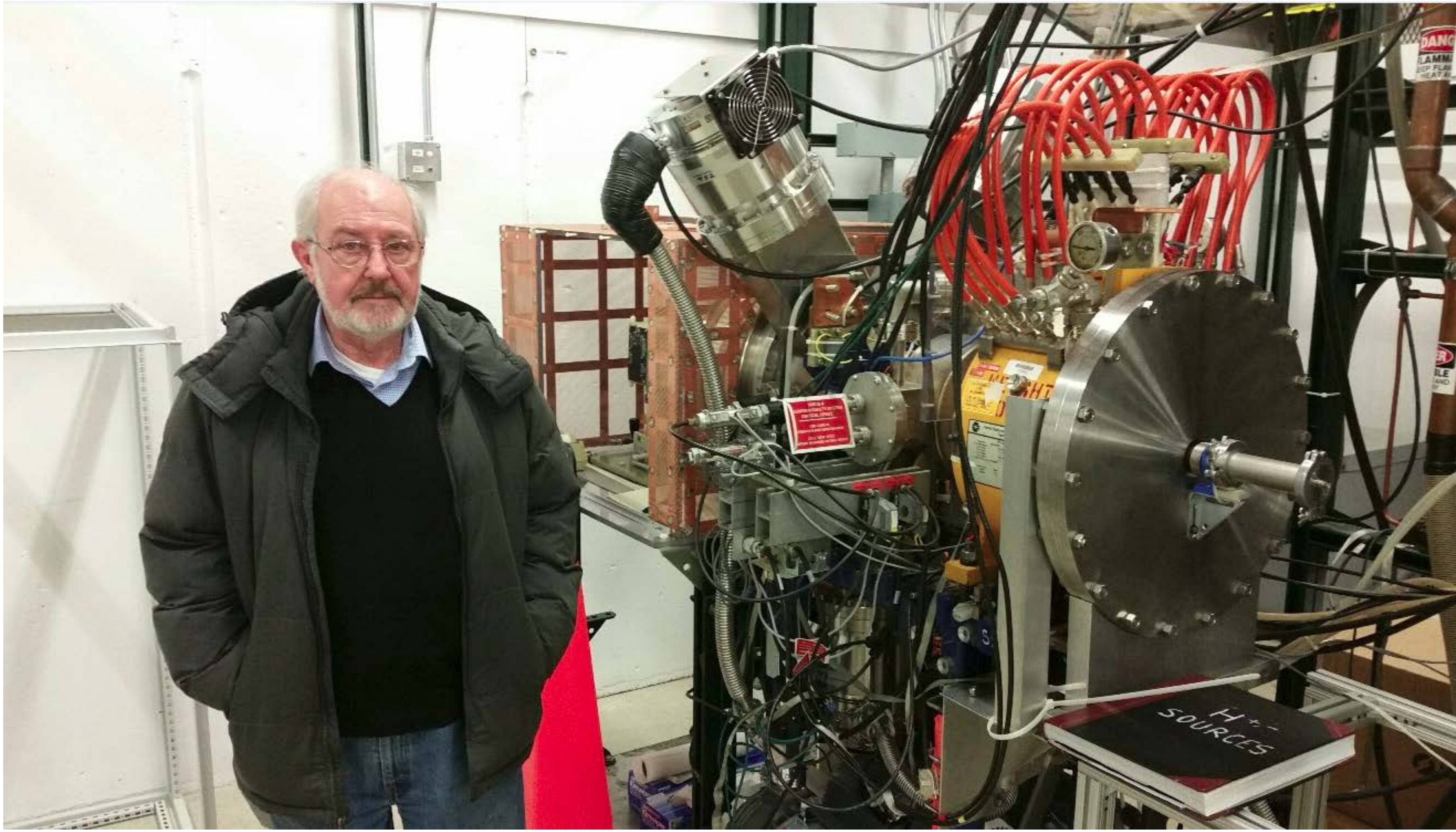
Highlights: IOTA magnets delivered and tested, girders installed, IO-NL magnet delivered, etc



IOTA: Integrable Optics Non-Linear magnet #1 – delivered!

Thanks, Radiabeam!

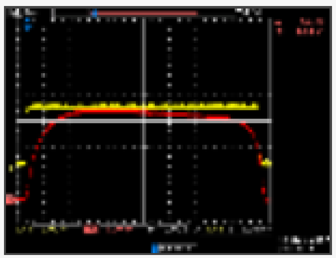
Highlights: p+/H- source commissioned in MDB



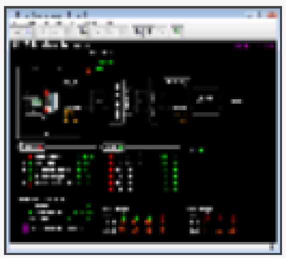
Tue 2017-05-30 11:13:28

Dean Edstrom (edstrom) **Kermit Carlson (kermit)**
Henryk Piekarz (hpiekarz)

An arc has been struck in the IOTA Proton Source (HINS Cave). The traces shown below are the generator pulse (channel 1) and a current measurement from the arc modulator through a toroid (channel 2; 10V:1A, padded into the scope by 20dB for 1.75V ~ 1.225A on the arc). The arc voltage through the temporary Lambda bulk supply is set to 29.2 V. All other parameters (filament, solenoid, valve, vacuum, etc) are reading back correctly through ACNET as shown below.



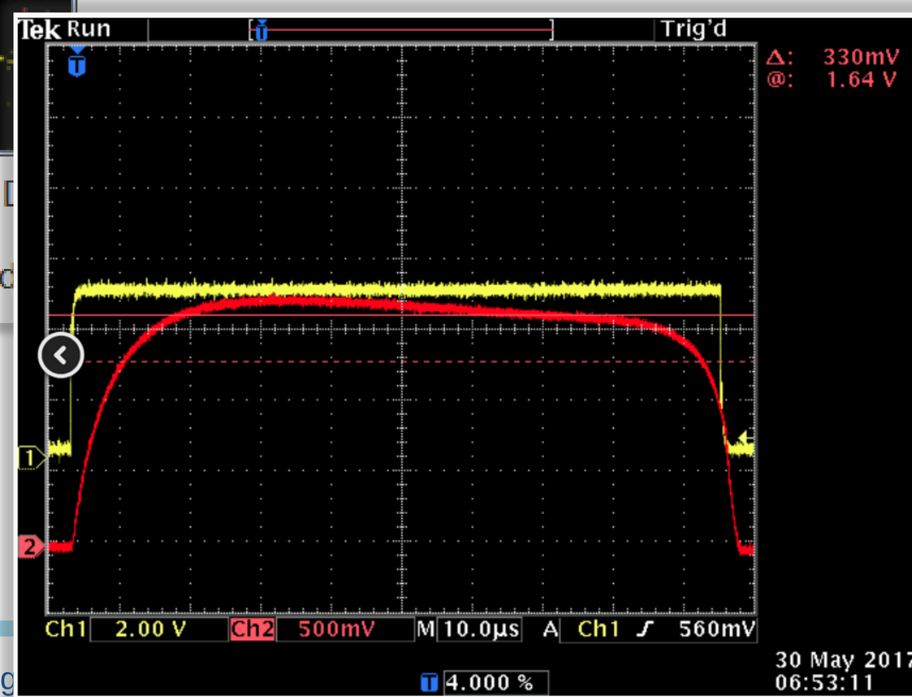
Arc on the Scope...



IPA Synoptic

Source D

Logs: FAST | Categories: IOTA Proton Injector | Id



IOTA/FAST Facility Plan

Last year expectations:	Status:
• FY16:	
– 50 MeV e- beam thru CC1-CC2	– done (06/2016)
– Beam studies with 50 MeV beam	– done (2016)
– Finish installation of high energy beamline from CM2 to beam dump	– finished in FY17
• FY17:	
– 300 MeV beam thru CM2 to beam dump	– “happening now”
– 300 MeV beam commissioning and studies	– summer 2017
– Finish construction and install IOTA	– now in 2018
• FY18:	
– 150 MeV e- beam injected in IOTA	– Yes, in FY2018
– Finish IOTA commissioning, start R&D(NL-IO)	– commissioning
• FY19:	
– Move 2.5 MeV proton RFQ to FAST	– move in FY19-20
– Commission IOTA proton injection, so research with protons can start in FY20	– FY19 will be year of e-IOTA R&D

Physics: First (Experimental) Research Paper

PHYSICAL REVIEW ACCELERATORS AND BEAMS **20,** 040102 (2017)

Analysis and measurement of the transfer matrix of a 9-cell, 1.3-GHz superconducting cavity

A. Halavanau,[1,2] N. Eddy,[2] D. Edstrom,[2] E. Harms,[2] A. Lunin,[2] P. Piot,[1,2]
A. Romanov,[2] J. Ruan,[2] N. Solyak,[2] and V. Shiltsev[2]

[1]*Department of Physics and Northern Illinois Center for Accelerator & Detector Development, Northern Illinois University, DeKalb, Illinois 60115, USA*
[2]*Fermi National Accelerator Laboratory, Batavia, Illinois 60510, USA*
(Received 27 January 2017; published 13 April 2017)

Superconducting linacs are capable of producing intense, stable, high-quality electron beams that have found widespread applications in science and industry. The 9-cell, 1.3-GHz superconducting standing-wave accelerating rf cavity originally developed for e^+/e^- linear-collider applications [B. Aunes, *et al.* Phys. Rev. ST Accel. Beams **3**, 092001 (2000)] has been broadly employed in various superconducting-linac designs. In this paper we discuss the transfer matrix of such a cavity and present its measurement performed at the Fermilab Accelerator Science and Technology (FAST) facility. The experimental results are found to be in agreement with analytical calculations and numerical simulations.

DOI: 10.1103/PhysRevAccelBeams.20.040102

JINST article (2017)

Up-to-Date facility and R&D Plan

… that's not all !

Jinst

Published by IOP Publishing for Sissa Medialab

Received: *December 20, 2016*
Accepted: *January 29, 2017*
Published: *March 6, 2017*

TECHNICAL REPORT

IOTA (Integrable Optics Test Accelerator): facility and experimental beam physics program

S. Antipov,[a] D. Broemmelsiek,[a] D. Bruhwiler,[b] D. Edstrom,[a] E. Harms,[a] V. Lebedev,[a] J. Leibfritz,[a] S. Nagaitsev,[a] C.S. Park,[a] H. Piekarz,[a] P. Piot,[a,1] E. Prebys,[a] A. Romanov,[a] J. Ruan,[a] T. Sen,[a] G. Stancari,[a] C. Thangaraj,[a] R. Thurman-Keup,[a] A. Valishev[a] and V. Shiltsev[a,2]

[a] *Fermi National Accelerator Laboratory, Batavia, Illinois 60510, U.S.A.*

[b] *RadiaSoft LLC, Boulder, Colorado 80304, U.S.A.*

E-mail: shiltsev@fnal.gov

Abstract: The Integrable Optics Test Accelerator (IOTA) is a storage ring for advanced beam physics research currently being built and commissioned at Fermilab. It will operate with protons and electrons using injectors with momenta of 70 and 150 MeV/c, respectively. The research program includes the study of nonlinear focusing integrable optical beam lattices based on special magnets and electron lenses, beam dynamics of space-charge effects and their compensation, optical stochastic cooling, and several other experiments. In this article, we present the design and main parameters of the facility, outline progress to date and provide the timeline of the construction, commissioning and research. The physical principles, design, and hardware implementation plans for the major IOTA experiments are also discussed.

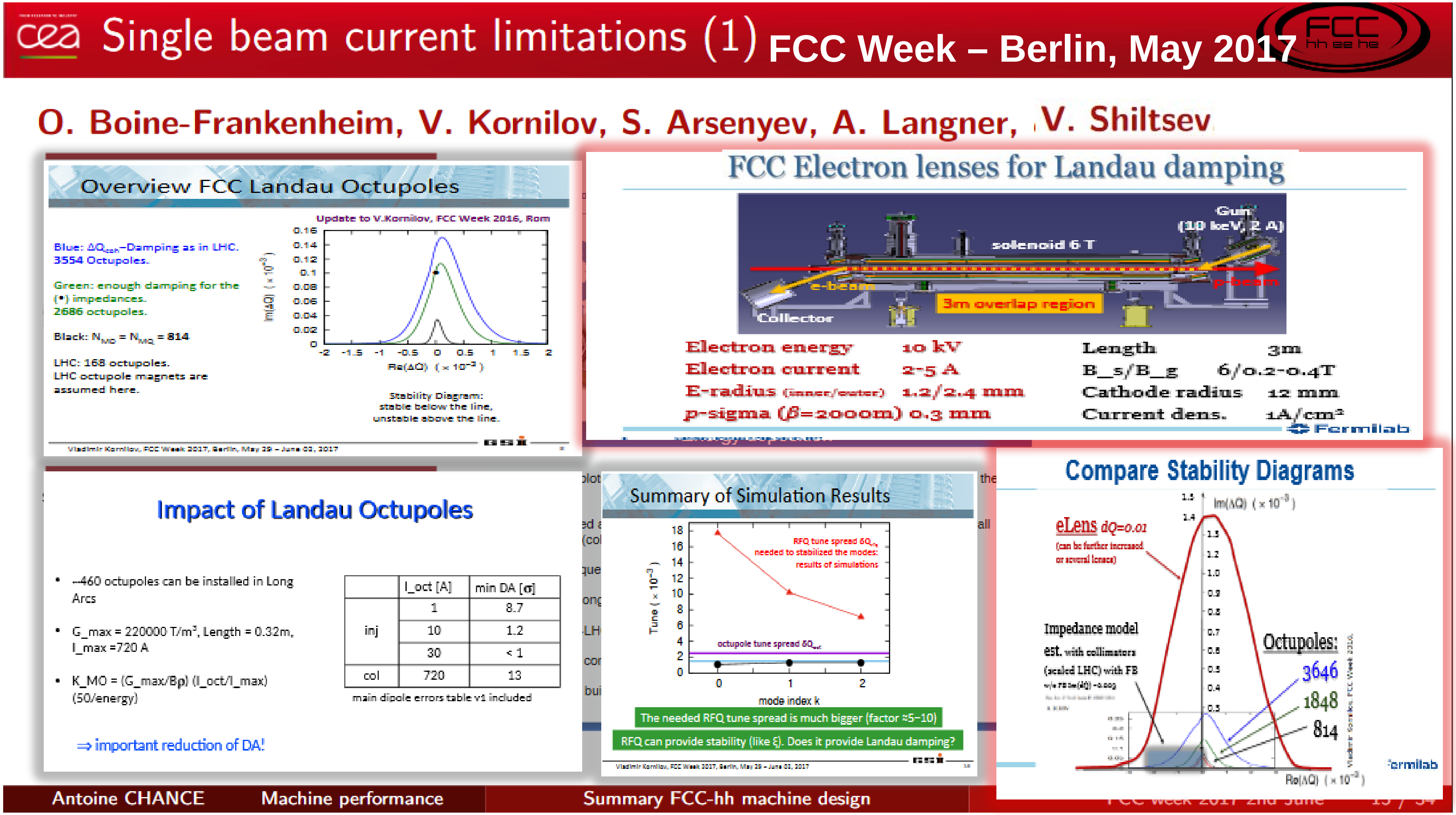
Keywords: Beam dynamics; Instrumentation for particle accelerators and storage rings — high energy (linear accelerators, synchrotrons); Instrumentation for particle accelerators and storage rings — low energy (linear accelerators, cyclotrons, electrostatic accelerators); Beam-line instrumentation (beam position and profile monitors; beam-intensity monitors; bunch length monitors)

[1] Also at Northern Illinois University, DeKalb, Illinois, 60115, U.S.A..
[2] Corresponding author.

doi:10.1088/1748-0221/12/03/T03002

2017 JINST 12 T03002

FCC : Future Circular Collider (100 km, 100 TeV)



→ IOTA Experiment to demo Landau e-lens effects

Conferences/Papers: see at fast.fnal.gov

Main Page

FAST Papers, Articles, and Presentations

NIM Sec A May 2016	*Simulation of a cascaded longitudinal space charge amplifier for coherent radiation generation*	A. Halavanau, P. Piot
Physical Review Accelerators and Beams April 2017	*Analysis and measurement of the transfer matrix of a 9-cell, 1.3-GHz superconducting cavity*	A. Halavanau, et al
NIM Sec B April 2017	*Development of a Watt-level Gamma-ray Source Based on High-repetition-rate Inverse Compton Scattering*	D. Mihalcea, A. Murokh, P. Piot, J. Ruan
Dec. 2016	*Commissioning and First Results From Channeling Radiation At FAST*	A. Halavanau, et al
Oct. 2016	*A High-level Python Interface To The Fermilab Acnet Control System*	P. Piot, A. Halavanau
INSPIRE HEP 2016	*Development of a Synchrotron Radiation Beam Monitor for the Integrable Optics Test Accelerator*	Andrea Scarpelli (Ferrara U.)
INSPIRE HEP 2016	*Devolopment of a Python Based Emittance Calculator at Fermilab Science & Technology (FAST) Facility*	A.T. Green (NIU)

NAPAC2016 - Proceedings
Chicago, IL, USA

InvOral

Proposed Experimental Validation of Hamiltonian Perturbation Theory in IOTA

- **D.L. Bruhwiler**, N.M. Cook, C.C. Hall, R.A. Kishek, S.D. Webb
  RadiaSoft LLC, Boulder, Colorado, USA
- S. Nagaitsev, A.L. Romanov, A. Valishev
  Fermilab, Batavia, Illinois, USA

The Integrable Optics Test Accelerator (IOTA) is a small ring under construction to explore advanced concepts in beam dynamics, initially with electron pencil beams to emulate single-particle dynamics and later with low-energy proton beams including significant space charge tune depression. Hamiltonian perturbation theory and simulations with Synergia, Warp and other codes are being used to develop an experimental program for beam dynamics, including the highly nonlinear 'elliptic' magnet originally proposed by Danilov and Nagaitsev. The results suggest a number of experiments that could be performed at IOTA. For example, small changes in the linear tune and the strength of the elliptic magnet can be used to control dynamic aperture. Both electron and proton beams can be used to measure the tune spread as a function of the elliptic magnet strength, for comparison with theory. Space charge driven halo formation due to envelope oscillations can be measured over a range of elliptic magnet strengths. Theoretical and computational results will be presented to guide future decisions regarding experimental diagnostics for IOTA.

ContrOral

Analytical theory for McMillan map

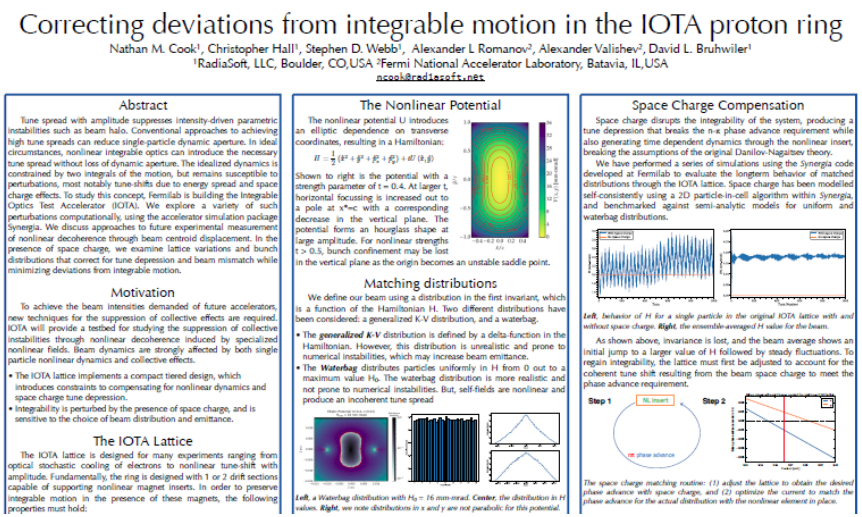
- **T. Zolkin**, S. Nagaitsev
  Fermilab, Batavia, Illinois, USA

McMillan map is an important discrete time model of 1D transverse nonlinear accelerator lattice. We provide a full analytical theory based on parametrization of individual canonical biquadratic curves*. Using the normal forms provided in* we were able to generalize this result to entire phase-plane of finite trajectories and calculate mechanical action-angle coordinates. The bifurcation map for canonical McMillan map including stability of fixed points is provided. In addition, we discuss the connection of these results with possible 2D generalizations - axially symmetric and 2D-magnetostatic McMillan lenses.

8th International Particle Accelerator Conference

COPENHAGEN, DENMARK, 2017 MAY 14—19

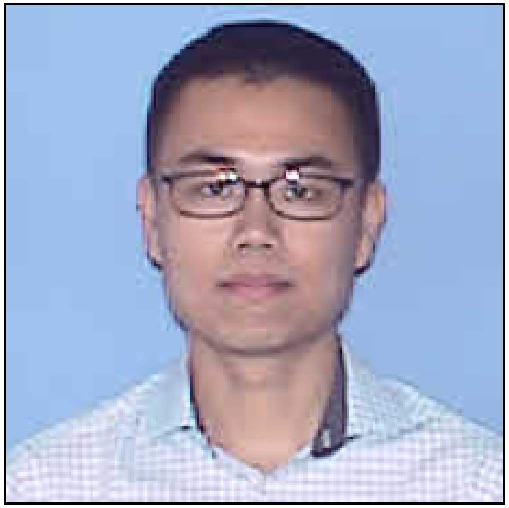
IPAC17



NAPAC16 Student Poster Awards: IOTA/FAST Collaborators

- Gerrit Bruhaug, Idaho State University, *The Design and Construction of a Resonance Control System for the IOTA Storage Ring*;
- Auralee Edelen, Colorado State University, *Neural Network Based Controls for Particle Accelerators*;
- Aliaksei Halavanau, Northern Illinois University, *Method for Measuring the Electron-Beam Magnetization*.

Summer Interns at IOTA/FAST : US, International



Yuan Shen Li

Year: 2016
Program: Lee Teng
College: Carleton College, Northfield, Minn
Home: Singapore, Singapore
Mentor: Tanaji Sen

Nadezda Afonkina

Year: 2016
Program: PARTI
College: Aix-Marseille University, Marseille,
Home: Moscow, Russia
Mentor: James Santucci

Andrea Scarpelli

Year: 2016
Program: PARTI
College: University of Ferrara, Ferrara, Italy
Home: Ravenna, Italy
Mentor: Giulio Stancari

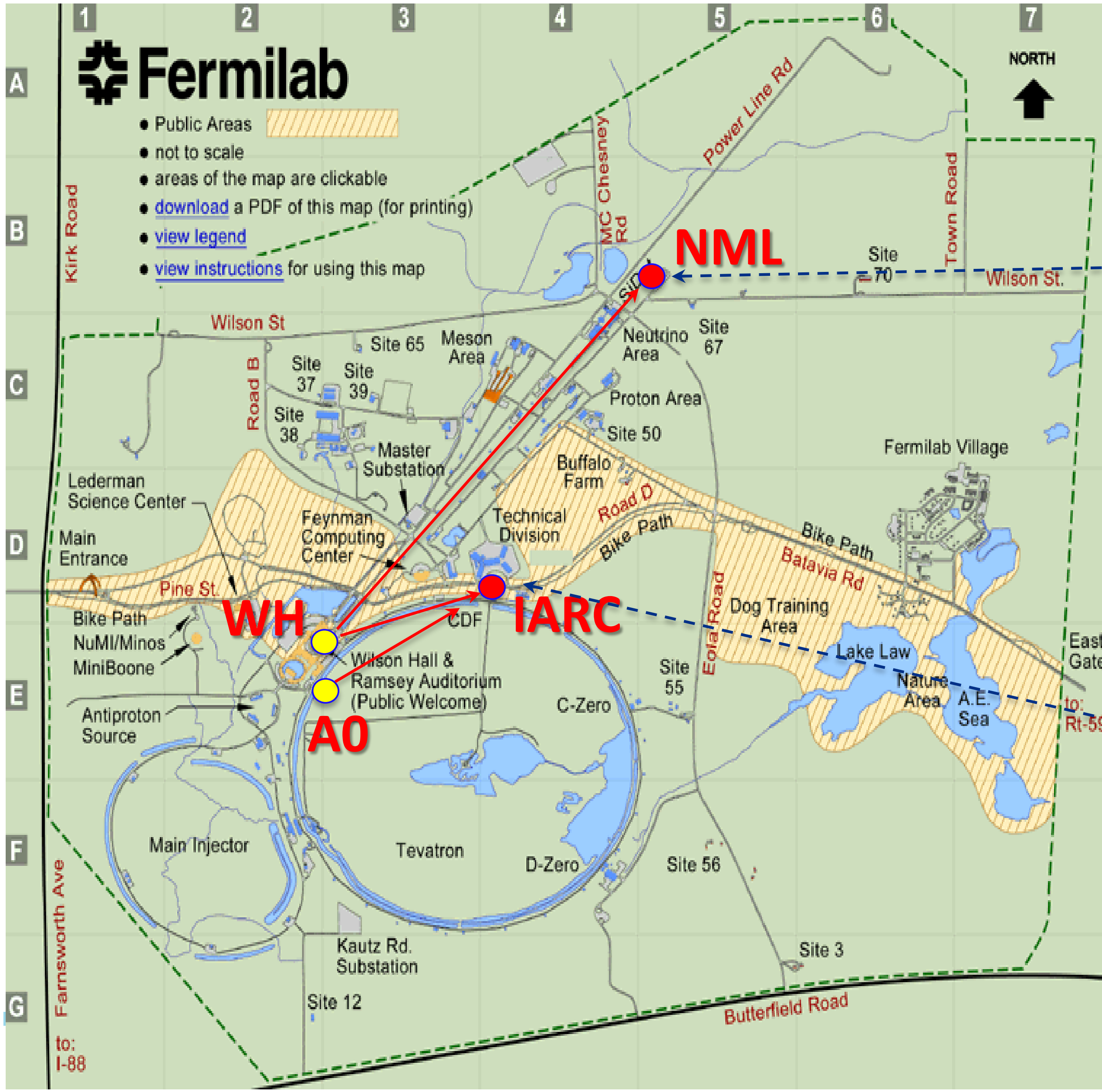
Summer Students

Optimization of the Diode-Pumped Solid State Nd:YLF Amplifier Chain for the 263 nm Drive Laser at the FAST Facility

Julie M. Gillis
Department of Physics
Department of Chemistry and Biochemistry
Bayer School of Natural and Environmental Science
Duquesne University
Pittsburgh, PA 15282

James K. Santucci and Jinhao Ruan
Fermilab Accelerator Science and Technology (FAST) Facility
Accelerator Division
Fermi National Accelerator Laboratory
Batavia, IL 60510

Important Note : We (APC) have moved !



NML: Sasha Valishev

IARC: Lisa Lopez

Fermilab

This Meeting (5th in Series) is to:

- Four blocks of presentations:
    i. Status and near term plans of the facility and its parts
    ii. Beam studies and tests: 2016 results; 2017 plans
    iii. Progress of the Integrable Optics experiment @ IOTA
    iv. Other experiments at IOTA/FAST
- Two coffee breaks (AM and PM) and group photo at noon.
- There will be a tour of IOTA/FAST at lunch
- Qs/Issues: contact Lisa Lopez or me.
- You are also invited to attend the Festa Italiana event held tonight 6pm - 11pm at the Kuhn Barn - in the Village
- Tomorrow, “big celebration” – Fermilab’s 50th anniversary!

http://50.fnal.gov/


Festa
ITALIANA
Tuesday, June 6, 2017
From 8pm @ Khun Barn
Fermilab Village
Cultural
Association of
Italians at
Fermilab
Fermilab
50 Years of Discovery
FOOD
Pomodoro E Mozzarella
Pomodoro E Mozzarella
1850 W. Main Street
St. Charles, IL 60174
630-549-0589
ISACCO
Isacco Kitchen
131 S. 1st St.
St. Charles, IL 60174
630-444-0202
LIVE MUSIC
Italian Band
LaTosca
Chicago-based
gypsy-italo-jazz
ensemble

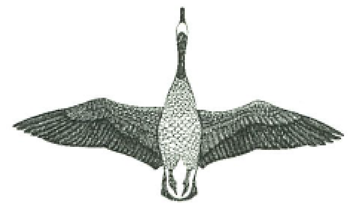
"Fermilab - 50" Events : WH2 Exhibition

A Lasting Mark:

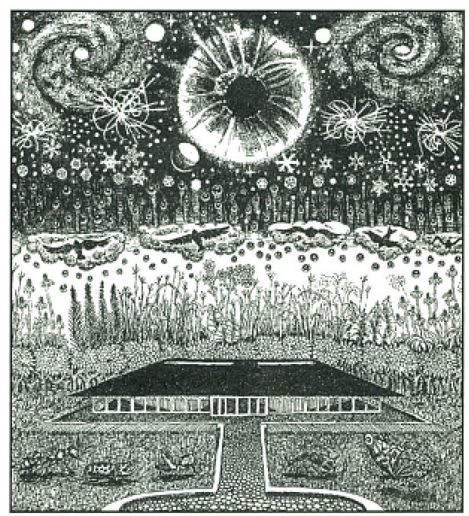
artist Angela Gonzales
at Fermilab 1967- 1998

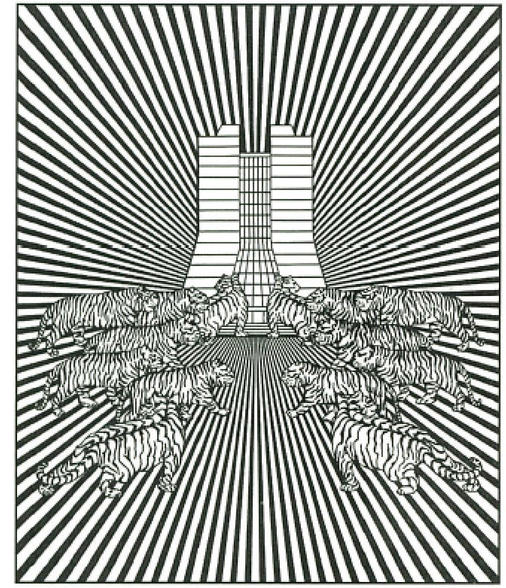
June 1, 2017
to
September 30, 2017

Fermilab Art Gallery
events.fnal.gov/art-gallery/



Her work displays complexity, humor, broad vision and strong craftsmanship. Motifs appear repeatedly and in delightful combination. She celebrated the immense range of subjects probed in physics, from subatomic particles and human-scale structures to far-off galaxies. Sometimes, all of these elements appear together in a single composition.



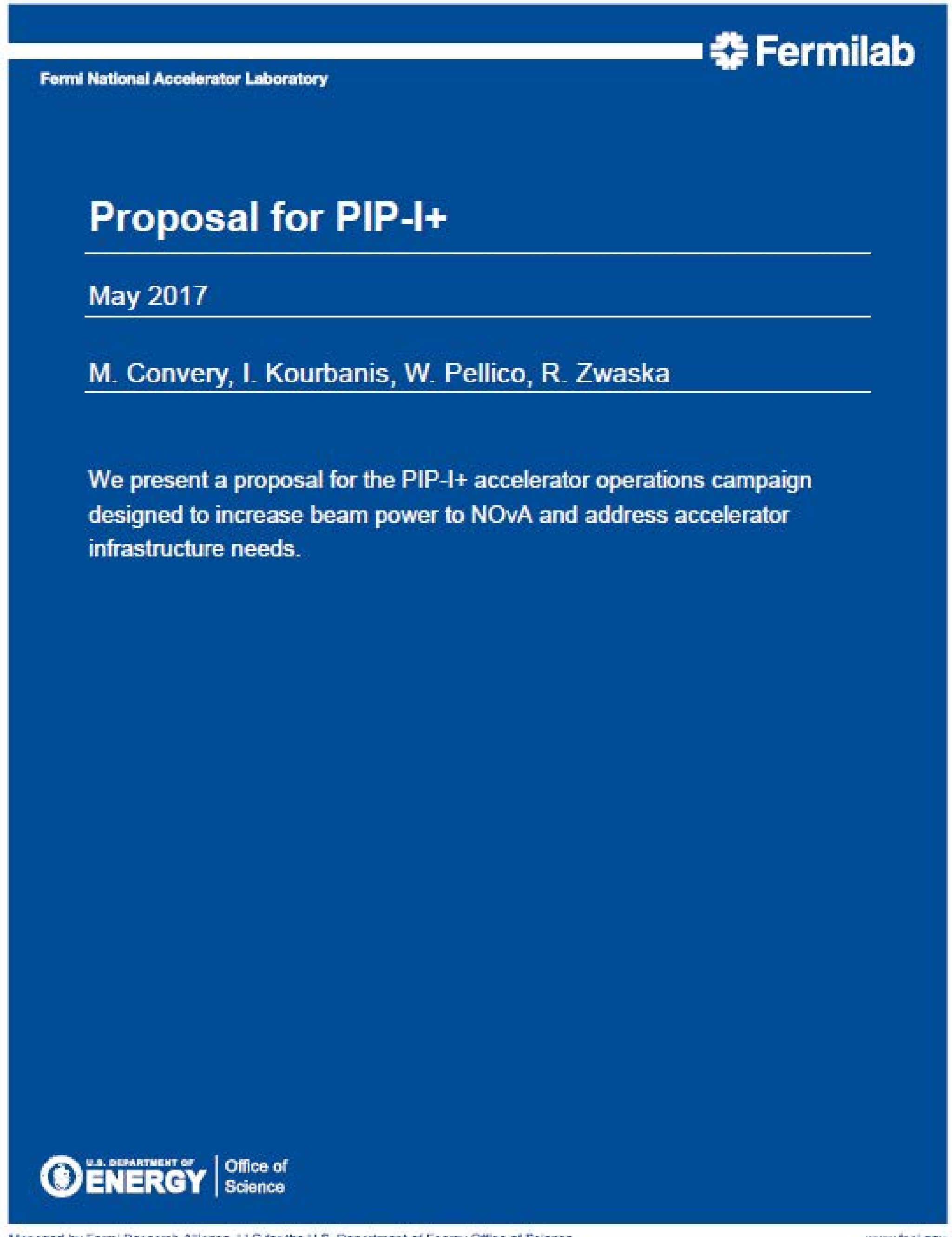


As Fermilab celebrates its 50th year, we are delighted to present this exhibit as a toast to the vision, efforts, creativity and accomplishments of those who created this lab. Angela Gonzales' artwork captured the lab's spirit and provided a visual history of Fermilab's scientific exploration and discovery. Those who work here are grateful for the lasting mark she left.

Open: M-F, 8 - 4:30
Exhibit tours: 10 am,
June 24, July 22, Aug 26

Let’s Have a Productive Meeting !

PIP-I+


Fermilab

Fermi National Accelerator Laboratory

Proposal for PIP-I+

May 2017

M. Convery, I. Kourbanis, W. Pellico, R. Zwaska

We present a proposal for the PIP-I+ accelerator operations campaign designed to increase beam power to NOvA and address accelerator infrastructure needs.

U.S. DEPARTMENT OF ENERGY | Office of Science

Managed by Fermi Research Alliance, LLC for the U.S. Department of Energy Office of Science

www.fnal.gov

June, 2016: In the news http://news.fnal.gov

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News

Newsroom

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Useful links

- Symmetry magazine
- Interactions

Interact

New beginning at FAST: Research accelerator reaches design beam energy

June 8, 2016 | Leah Hesla

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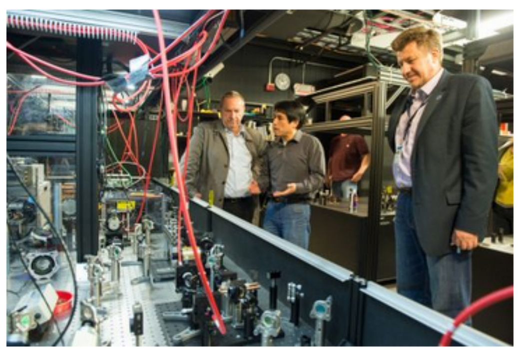

Fermilab accelerator scientist Jinhao Ruan (center) shows Fermilab Director Nigel Lockyer (left) the laser setup for the FAST photoinjector. Vladimir Shiltsev (right) is director of the Fermilab Accelerator Physics Center. Photo: Reidar Hahn

On May 16, Fermilab sent an electron beam with an energy of 50 million electronvolts, or MeV, through the photoinjector at the Fermilab Accelerator Science and Technology facility (FAST), achieving a major design goal for the accelerator – and marking the beginning of a new accelerator science program at the laboratory.

"This is a major milestone for our general accelerator R&D," said Vladimir Shiltsev, head of the Fermilab Accelerator Physics Center. "The delivery of this beam marks the start of a new program here – new facility, new science capabilities," Shiltsev said.

The delivery of 50-MeV beam is the first step in establishing an accelerator R&D facility that will serve as one of America's leading test beds for cutting-edge, record-high-intensity particle beam research. Once complete, FAST will provide scientists and engineers from around the world with a place to study the science of high-intensity particle beams and superconducting radio-frequency acceleration, the technology on which nearly

Today: Collaboration’s 5th Annual Meeting

- **25 Partners:**
  - ANL, Berkeley, BNL, BINP, CERN, Chicago, Colorado State, IAP Frankfurt, JINR, Kansas, LANL, LBNL, ORNL, Maryland, Universidad de Guantajuato Mexico, Michigan State, NIU, Oxford, RadiaBeam Technologies, RadiaSoft LLC, Tech-X, Tennessee, Vanderbilt
- **NIU-FNAL:** Joint R&D Cluster
- Publications, presentations at conferences, workshops, etc

FOCUSED WORKSHOP ON SCIENTIFIC OPPORTUNITIES IN IOTA

28-29 April 2015 *Wilson Hall*
US/Central timezone

2015

IOTA Construction and Research Timeline (2016)

	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)