



IOTA/FAST Scientific Program:

Intro to 2016 Meeting, Status, Progress, Plans

Vladimir SHILTSEV, Accelerator Physics Center/AD

IOTA/FAST Scientific Program Meeting

June 14, 2016

Ab Ovo: US HEP Community Plan = P5 (2014)

	Intensity Frontier Accelerators	Hadron Colliders	e^+e^- Colliders
Current Efforts 0-10 yrs	PIP PIP-II	LHC HL-LHC	ILC
Next Steps 10-20 yrs	Multi-MW proton beam	Very high-energy pp collider	1 TeV class energy upgrade of ILC*
Further Future Goals 20+ yrs	Neutrino factory*	Higher-energy upgrade	Multi-TeV collider*

*dependent on how physics unfolds

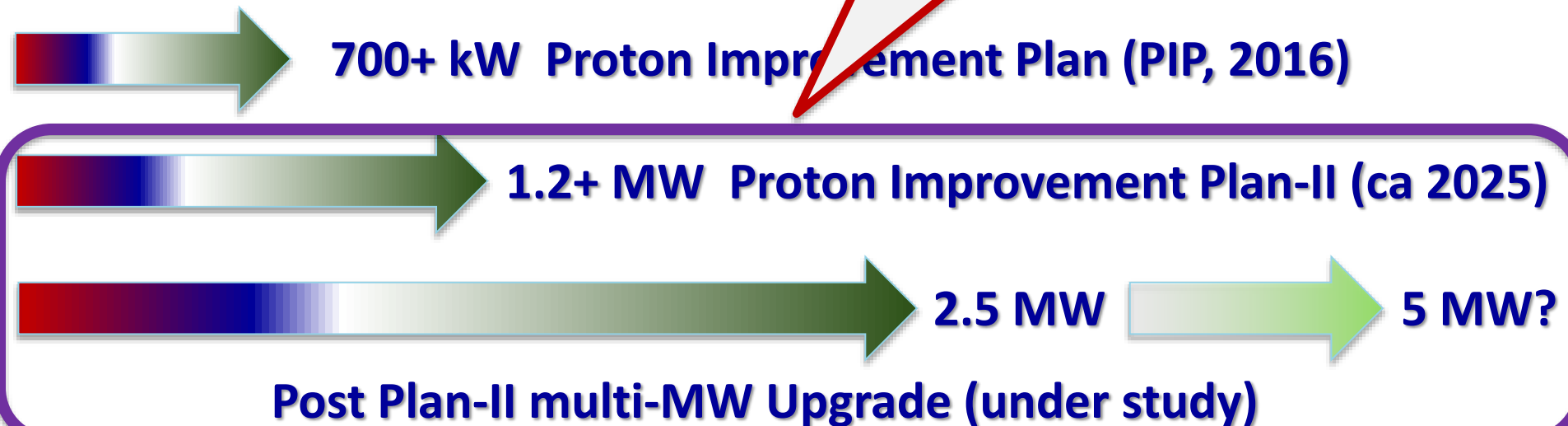
- Key points on the Intensity Frontier HEP:
 - “CP-violation sensitivity” → need **900 kt × MW × yrs**
 - **R12:** build LBNF/DUNE **40 kt LAr**
 - Then 400kW → >50 years to get 900 kt × MW × yrs
 - **R14:** build PIP-II linac to **get >1 MW**
 - current plan 40 kt × 1 MW × 5 yrs = > **200 kt × MW × yrs**
 - **R23/26:** accelerator R&D (facilities) toward **multi-MW**
 - say, 40 kt × 2.5 MW × 7 yrs = remaining **700 kt × MW × yrs**

Intensity Frontier HEP Accelerators



Challenges → need
R&D @ Beam Facilities

EVOLUTION OF INTENSITY FRONTIER ACCELERATORS



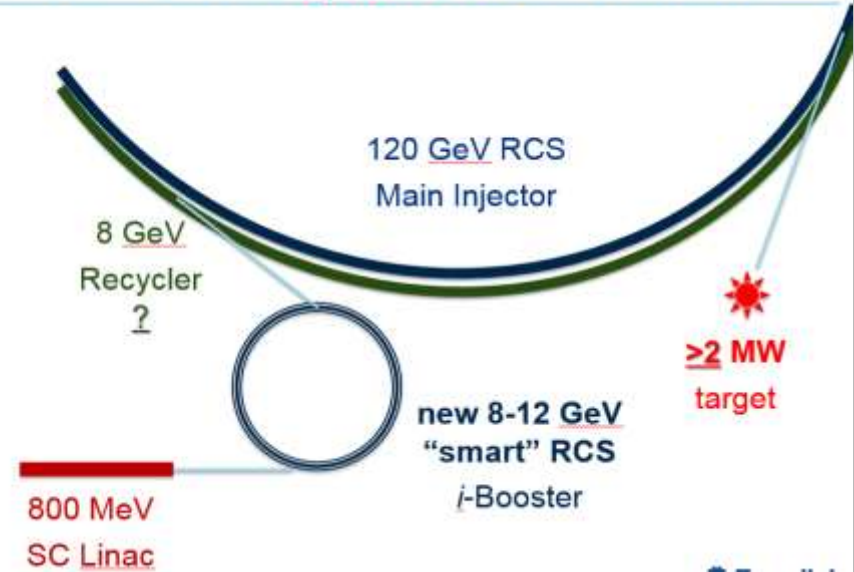
Post PIP-II multi-MW Upgrade = Replace Booster

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

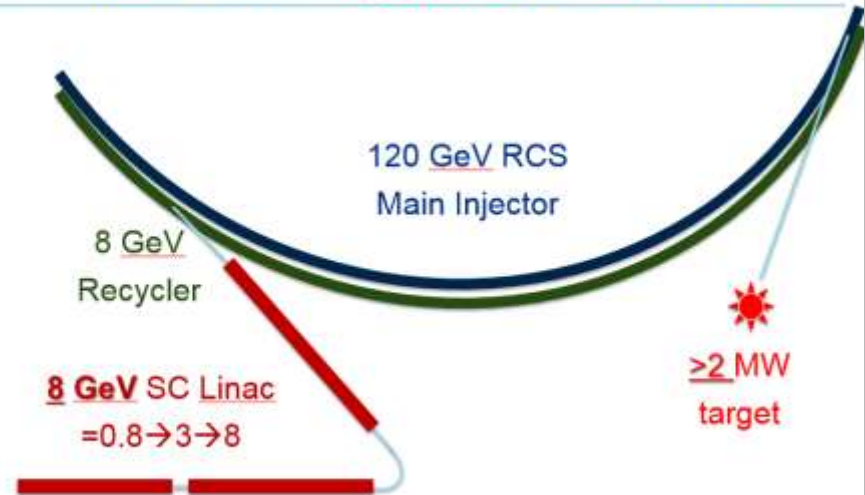
Cost-effective options:

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

PIP-III “multi-MW”- **Option A: 8+ GeV smart RCS**



PIP-III “multi-MW” - **Option B: 8 GeV linac**



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 $\sim 3\text{-}5\%$ in Booster and MI synchrotrons
 - (Very challenging after 50 years of development)
- Need to develop tools for
 - Space-charge countermeasures
 - Beam halo control
 - Single-particle and coherent beam stability

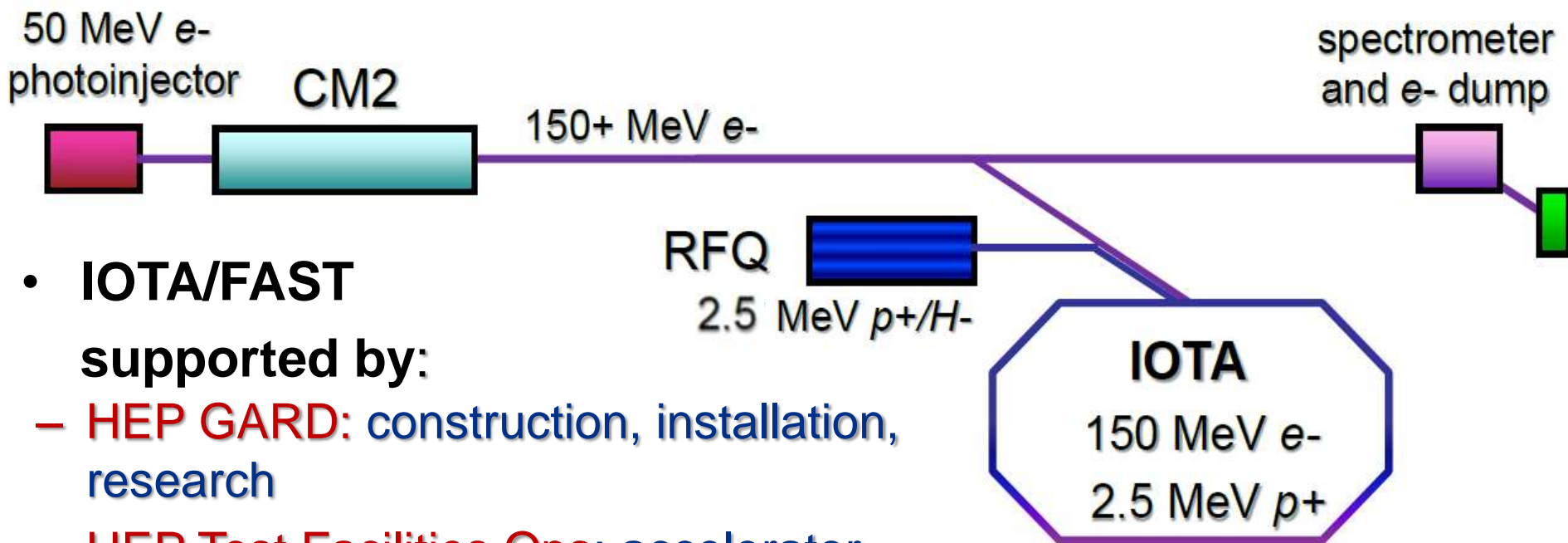
IOTA/FAST : Blessed by HEPAP GARD Plan (2015)

- **Recommendation 2:** Construct the IOTA ring, and conduct experimental studies of high-current beam dynamics in integrable non-linear focusing systems. (p. 9, 18)
 - GARD thrust: Accelerator and Beam Physics
- **Recommendation 3:** Support a collaborative framework among laboratories and universities that assures sufficient support *in beam simulations and in beam instrumentation to address beam and particle stability including strong space charge forces.* (p. 9, 17)
 - GARD thrust: Accelerator and Beam Physics



FAST/IOTA in NML: Definitions

- FAST/IOTA is Accelerator R&D Facility that consists of:
 - IOTA ring itself
 - Its two injectors = FAST (Fermilab Accelerator Science and Technology) facility
 - Both occupy the 18,000 sq ft NML facility building



- IOTA/FAST**

supported by:

- HEP GARD:** construction, installation, research
- HEP Test Facilities Ops:** accelerator operations, NML building
- Collaborators:** components, research

FAST/IOTA Program Organization

S.Nagaitsev
Chief Accelerator Officer

V.Shiltsev, APC
FAST/IOTA Program Director

Construction and Operations

J.Leibfritz, MS
Construction
Installation, Engin'ng
Facility Operations

A.Valishev, APC
IOTA Construction
Commissioning
Beam Operations

E.Harms
SRF Installation
SRF Commissioning

D.Broemmelsiek
Beam Operations
Beam Commissioning

E.Prebys, APC
RFQ Re-Commiss'ing
RFQ Relocation

Beam Physics Research

A.Valishev, APC
Intensity Frontier Exps
Space-Charge Collab'n

A.Valishev, APC
Integrable Optics
experiments (e-/p+)

G.Stancari, APC
e-lens program, Space
-Charge Compensation

S.Chattopadhyay, NIU
Advanced Physics Exp's
University Collaborations
International Collaborations

Opt.Stoch.Cooling
(V.Lebedev, et. al)
Single e- Correl.
(Swapan C., et. al)
Channeling X-ray
(P.Piot, et. al)
other experiments

IOTA Experiments: Intensity Frontier Science

- **E1.1-1.3: Integrable Optics**

- #1: IO with non-linear magnets, tests with electrons
 - Pls: Valishev, Nagaitsev
- #2: IO with non-linear magnets, tests with protons
 - Pls: Valishev, Prebys
- #3: IO with e-lens(es), tests with protons
 - Pls: Stancari, Valishev

- **E1.4-1.6: Space-Charge Compensation & Studies**

- #4: SCC with e-lens(es), tests with protons
 - Pls: Stancari, Shiltsev
- #5: SCC with e-columns, tests protons
 - Pls: Shiltsev, Thangaraj
- #6: General SC studies with protons (vs P , Q , Q' , optics errors, etc)
 - Pls: ???

FAST/IOTA Exp's: Accelerator & Beam Physics

- E2.1-2.5:
 - #1: X-ray crystal radiator
 - Pls: Piot
 - #2: Optical Stochastic Cooling
 - Pls: Lebedev
 - #3: Single electron quantum optics
 - Pls: Dixon
 - #4: Beam optics of SRF cavities
 - Pls: Piot
 - #5: Laser-plasma e- injector to IOTA
 - Pls: Romanov, ?

June 2015 : Renaming ASTA → FAST

Subject **FAST Facility Announcement**

6/11/2015 3:05 PM

To beamsdivlst@listserv.fnal.gov <beamsdivlst@listserv.fnal.gov>☆, Nigel S. Lockyer☆, T **13 more**

Cc Hema Ramamoorthi☆, Stephany Unruh☆

Please see following message from Sergei Nagaitsev.

Dear Colleagues,

I am writing today to introduce a new name to describe one of our accelerator R&D and test facilities.

The FAST (Fermilab Accelerator Science and Technology) Facility encompasses the R&D and test infrastructure that is presently located in the New Muon Lab building and its recently constructed extension.

FAST consists of:

1. The IOTA ring (a storage ring for experimental research with electrons and protons)
2. An electron injector (a 300-MeV SRF-based photo injector)
3. A proton injector (a conventional ion source followed by a 2.5-MeV RFQ)
4. All associated conventional, rf and cryo infrastructure presently housed in the New Muon Lab and its extension.

The FAST Facility's mission is to provide the test infrastructure critical to the research and development of future accelerators for the US HEP community as well as for our university, international, and commercial partners.

Sergei

(S.Nagaitsev, FNAL, AD Head)

Dec. 2015: Briefing OHEP on GARD at IOTA/FAST

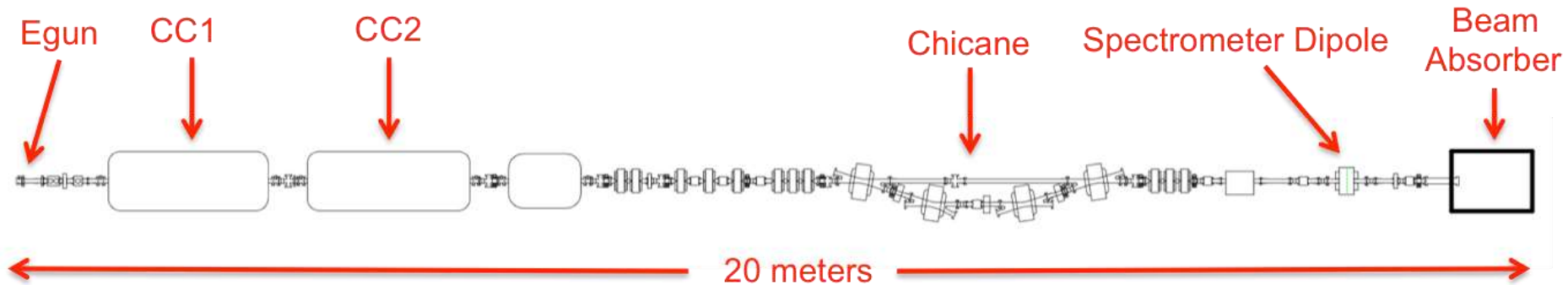
- One day meeting in Germantown:
 - Dec.17
 - To report technical progress and plans
 - For all GARD “thrusters”
 - Based on “realistic” budget as communicated to/agreed with DOE OHEP for FY16-18
 - For FAST/IOTA: “resource-loaded” plan for construction, commission and research
- (Overall conclusion – positive)

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+*
<i>beam operations</i>			

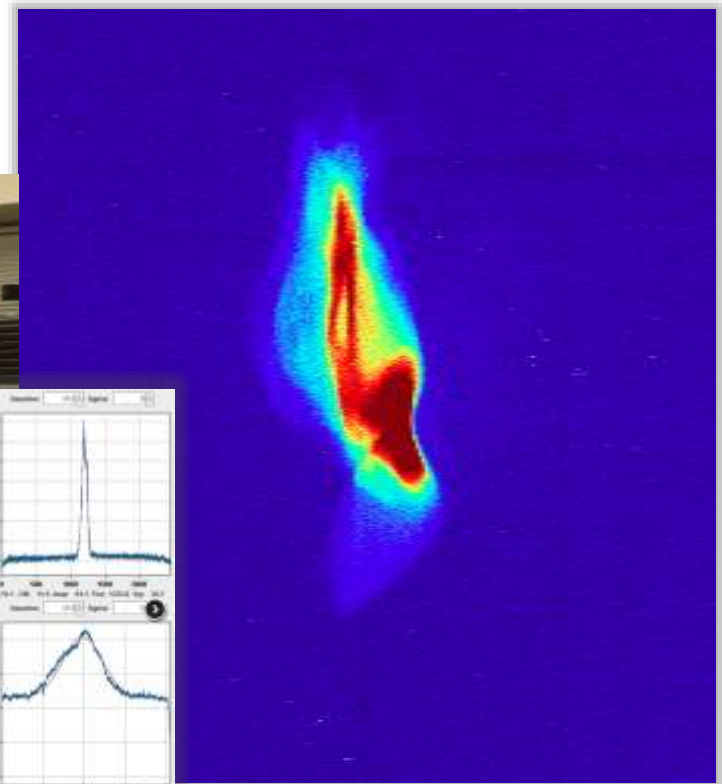
- contingent on \$\$: FY17-20 - under current budget scenario...together with OHEP GARD management we explore options to accelerate start of research by 1 year (1.48M\$ supplemental)

May 2016 : IOTA Electron Injector 50 MeV

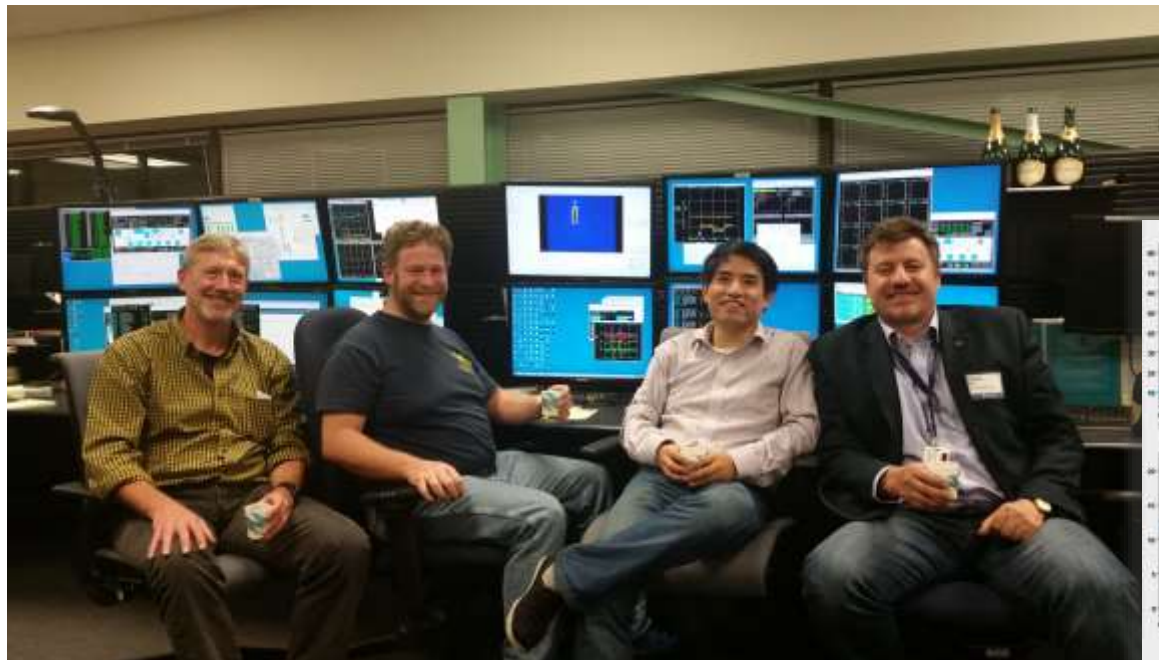


52.5 MeV e^- beam through FAST injector !

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



5/17/2016



May 16, 2016: “Both CC’s work, beam thru!”



DOE OHEP Operations Review: May 15-18, 2016

- Review of the FAST/IOTA “Facilities Operations” KA250201



Jerry Leibfritz tours the Review committee (G.Neil, S.Prestemon, K.Jones, LK Len, B.Strauss) – in FAST

2016 Operations Review Committee Summary (excerpts):

(general comments)

- The Accelerator Test Facility infrastructure at FNAL is a national (and international) resource with many unique capabilities, and OHEP is the nominal steward of these facilities.
- Generally well aligned with P5. Very systematic and dogmatic in this area.
- **(comment)** Operations cost for FAST/IOTA will need to increase as the facility comes online. This increase cannot come at the expense of other test facilities in the same B&R code without significant impact to ongoing projects/programs, as their scope is independent.

Recommendations:

(none for FAST/IOTA)

May 21, 2016: Fermilab Director Nigel Lockyer visits FAST



05-21-2016 - Nigel Lockyer visited on 05-20-2016.

Dear Vladimir and FAST Team Members,
Thank you for your time yesterday. It is obvious a lot of work has gone into getting the facility to this point. It was a pleasure to meet our first experiment student, Alexei, good luck with getting all those guys to work for you! I am also glad that I could help you turn the machine back on.

FAST represents the beginning of a new era at Fermilab where accelerator science becomes an important and productive part of the laboratory program. Keep up the good work. Everyone will notice.

Thank you again,
Nigel



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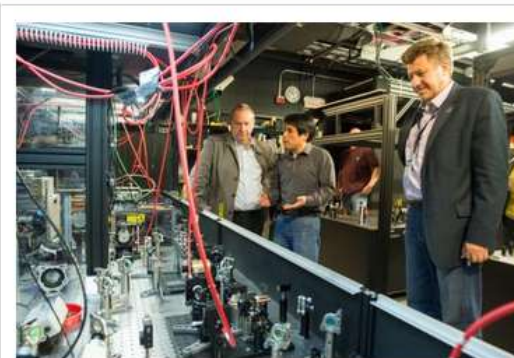
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Interact



New beginning at FAST: Research accelerator reaches design beam energy

June 8, 2016 | [Leah Hesla](#)



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 4th Annual Meeting

- **25 Partners:**

- ANL, Berkeley, BNL, BINP, CERN, Chicago, Colorado State, IAP Frankfurt, JINR, Kansas, LANL, LBNL, ORNL, Maryland, Universidad de Guanajuato 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



Students at IOTA/FAST

2015 Graduates



Sriharsha Panuganti

PhD
NIU



Frederic Lemery

PhD
NIU



David P. Lopez

MSci
Universidad de
Guantajuato
(Mexico)

DOE Early Career Research Proposals

2016 Award

Chad Mitchell –

our collaborator from the Lawrence Berkeley National Laboratory, Berkeley, CA - selected by the Office of High Energy Physics for the Early Career Research Proposal award “*Compensation of Nonlinear Space Charge Effects for Intense Beams in Accelerator Lattices*”



IOTA/FAST Program Support

- Construction/installation: GARD (HEP)
- Operations: Acc.Test.Facility (HEP)
- Research:
 - GARD (HEP) “Accelerator & Beam Physics” thrust
 - NSF Accel. Sci. program
 - Early Career Awards
 - LDRD
 - SBIRs
 - Lab’s/University grants

We are trying to help all collaborators to get support
(letters, etc)

This Meeting (4th in Series) is 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 IOTA
 - Further develop the scientific program of the facility with full synergistic support from the community
 - Help and enhance the national and international developments collaboratively to ensure the success of the program.
-
- There will be a tour of the New Muon Lab after the meeting.
 - You are also invited to attend the Festa Italiana event held tonight 8pm - 11pm at the Kuhn Barn - in the Village
 - Tomorrow, “big” Fermilab Users Meeting

Back up slides