The Scientific Program:

Conducting Experiments at IOTA/FAST

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IOTA/FAST Scientific Committee (ISC)

Fermilab
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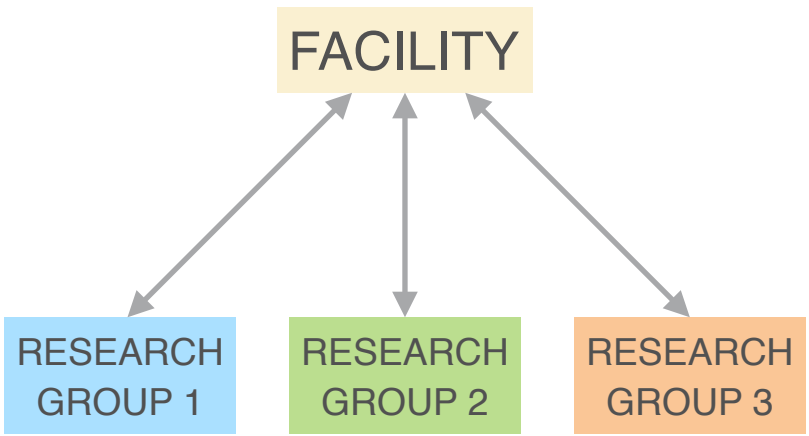
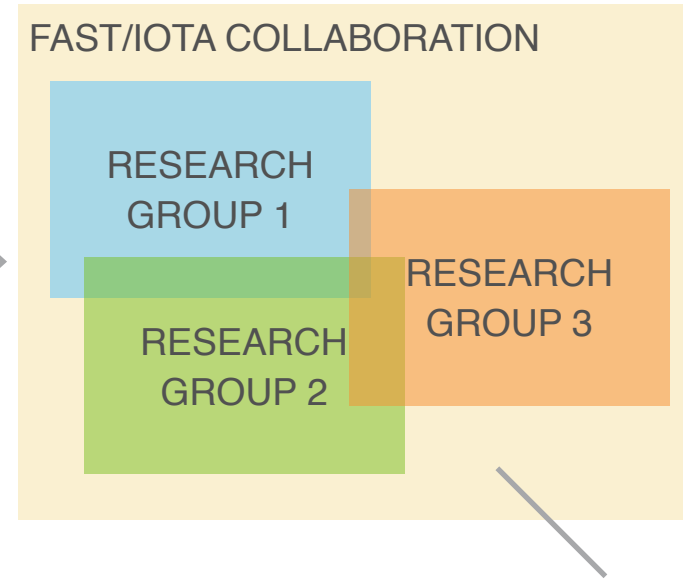
indico.fnal.gov/e/62181

Collaboration Models: How Do We Operate?

Facility with users



Collaboration with research groups



Uniform experimental procedures, requirements, affiliation, safety

Strengths
– agile: control over apparatus, schedule
– time scale: experiment cycle ~ 1–2 years

Challenges
– large overlap between groups
– sharing resources
– managing multiple projects in parallel

Precious resource for the particle physics community!

Resources: FAST Web Pages

fast.fnal.gov

Organization

- Accelerator Directorate
- FAST Calendars
- E-Log +

Public

- In The Media
- Papers
- Pictures/Video

Resources

- Meetings +
- Teams *
- Procedures +
- Experimental Program
- FAST Redmine
- IOTA Redmine
- NIU AARD GitHub *
- Synoptic Controls
- Java Controls
- FAST Devices +
- Plot Launcher +

Resources: ISC Wiki

IOTA/FAST Scientific Committee (ISC)

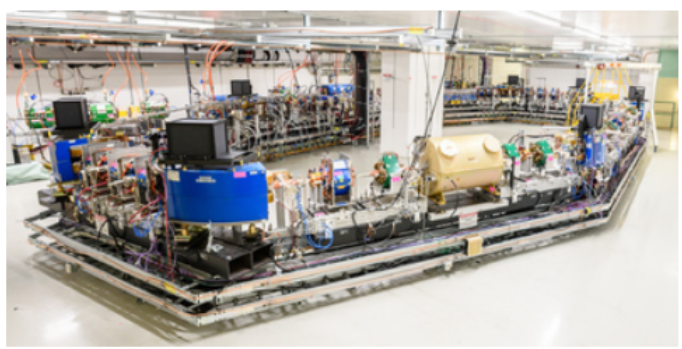
+ Overview Activity Documents Wiki Files Settings

New wiki page Edit Watch Lock Rename Delete History

Proposing an experiment at IOTA/FAST

- Proposal submission guidelines: Beams-doc-7363
- Proposal template [PDF] [LaTeX]
- Note on data storage options for IOTA/FAST experiments: Beams-doc-8245

- Presentation given at the FAST/IOTA Collaboration Meeting (October 2021)
- Presentation given at the FAST/IOTA Collaboration Meeting (June 2020)
- Presentation given at the FAST/IOTA Collaboration Meeting (June 2019)



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IOTA
FAST Linac
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Attachments

Contacts

IOTA/FAST Scientific Committee (ISC)		
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Alexander Valishev	630-840-2875	valishev@fnal.gov

cdcvs.fnal.gov/redmine/projects/ifsc/wiki/

Experiments in Run 4

5 experiments in IOTA, 2 in the FAST linac

Run 4 (1 April 2022 - 23 October 2023)

IOTA

ID	Acronym	Title	Spokesperson / Fermilab Liaison	LOI (optional)	Proposal	Presentation	Status	Beam Time	Reports
I-401	NIOLD	IOTA Experiment Nonlinear Optics: Landau Damping	N. Eddy (FNAL)		original revised final	Mar 25, 2022	approved	12 8-h shifts	
I-403	CLARA	Coherence Length of Undulator Radiation	S. Nagaitsev (JLAB) / A. Romanov (FNAL)	PDF	PDF	Sep 9, 2022	approved	(18 x 8 h) + (3 x 4 h) shifts	
I-405	NIO	Nonlinear Integrable Optics	A. Valishev (FNAL)		Beams-doc-9715	Feb 24, 2023	approved	(20 x 8 h) + (4 x 4 h) shifts	
I-406	SETI	Single-Electron Tracking in IOTA	A. Romanov (FNAL)		Beams-doc-9762	June 16, 2023	approved	(3 x 2 h) + (7 x 8 h) shifts	
I-407	LADR	Low-Alpha Demonstration Research	J. Jarvis and M. Wallbank (FNAL)		PDF	Sep 9, 2023	conditional approval	10 4-h shifts	

FAST Linac

ID	Acronym	Title	Spokesperson / Fermilab Liaison	LOI (optional)	Proposal	Presentation	Status	Beam Time	Reports
I-402	FAST-GREENS	Tapering Enhanced Stimulated Super-Radiant Amplification: Gamma-Ray High Efficiency Enhanced Source	P. Musumeci (UCLA) / D. Broemmelsiek (FNAL)		original final	Apr 4, 2022	approved	3 shift blocks, 10 x 8 h each	Cropp's PhD Thesis Instruments 7, 42 (2023)
I-404	NEB	Noise in Intense Electron Bunches	S. Nagaitsev (JLAB) / J. Ruan (FNAL)	PDF	original final	July 14, 2023	approved	(2 x 4 h) + (3 x 8 h) shifts	

cdcvs.fnal.gov/redmine/projects/ifsc/wiki/

Background on Experiments and Proposals

Proposals can be submitted any time. The ISC meets regularly, with special meetings as needed (e.g., during a run, when new ideas may emerge)

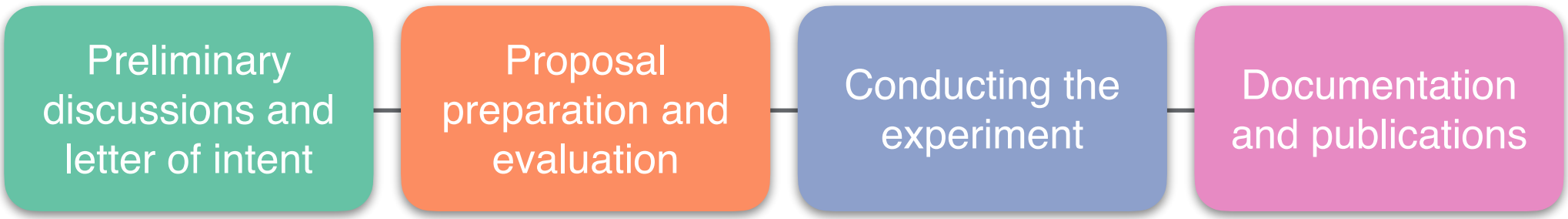
An '**experiment**' is defined by the scope of the proposal and it is **completed within one experimental run**.

A '**research program**' can span **multiple runs** and include **more than one experiment or proposal** (e.g.: nonlinear integrable optics, optical stochastic cooling, undulator radiation from single electrons)

Experiments designate a **Spokesperson** or Principal Investigator (PI) and, optionally, a **Deputy Spokesperson**. If both are external, a **Fermilab Liaison** must be identified.

The Experiment Cycle

Main phases of an experiment:



Preliminary Discussions and Letter of Intent

The project is discussed with interested parties and with Fermilab staff.

A **letter of intent** is sent by e-mail to one of the members of the ISC. The LOI is an **informal written document** (from a few paragraphs up to 4 pages).

The LOI helps define the scope of the experiment, makes the ISC aware of the request, and starts the proposal preparation process.

The LOI is optional, but recommended.

Proposal Preparation and Submission

The **formal proposal** is a **detailed written document** describing the scientific and technical aspects of the experiment.

The proposal includes:

- title
- personnel, with specific roles and responsibilities [e.g., see credit.niso.org]
- purpose and methods
- required beam conditions
- apparatus and necessary infrastructure
- run plan and shift request
- internal and external resources
- supporting documents and other relevant information

A template with instructions is available on the ISC web site
cdcvs.fnal.gov/redmine/projects/ifsc/wiki

The **written proposal** is sent by e-mail to the ISC. An **oral presentation** is scheduled to discuss the proposal.

A well prepared and well written proposal is essential for the success of an experiment.

Scientific and Technical Reviews

The **scientific review** is carried out by the ISC. Evaluation is based upon scientific merit, as defined, for instance, by current literature, support of independent experts or relevance to the Fermilab program.

The **technical review** is coordinated by the Head of the FAST Facility Department. It includes safety, feasibility, resource availability, schedule and impact on other projects.

The **outcome** of the reviews may be

- ***rejection*** — with written motivation
- ***deferral*** — if more preparatory work is needed
- ***approval*** — the experiment is included in the experimental program and operations schedule

Scheduling and Data-Taking Phase

For approved experiments:

- The **schedule** is determined by the **Run Coordinator**
- The shift schedule takes into account **priorities** and **compatibility** with other studies
- The schedule incorporates **flexibility**
  - to allow external collaborators to participate
  - to mitigate the challenges of simultaneously setting up experiments, collecting data, and running preliminary analyses
- Experimenters are expected to give **brief periodic updates** during the run (e.g.: 10-minute status reports at the weekly Friday meetings)

Documentation and Publications

It is expected that approved experiments

- **Maintain a web site** with documents, pictures, data, computer code, internal notes, papers, etc. Infrastructure at Fermilab is available through Fermi Redmine, if experimenters choose this option. Dedicated data storage is also available.

We have made progress, but we can do a better job. Documentation and reproducibility of research is essential. Moreover, tools developed for one experiment may be useful for other studies.

- **Publish results** as soon as possible (at least one report within 6 months of run). There are various publication **options**, depending on the nature of the results:
  - peer-reviewed **journals**: *Phys. Rev. Lett., Phys. Rev. Accel. Beams, Nucl. Instrum. Methods, J. Instrum.,* …
  - conference **proceedings**: IPAC, LINAC, …
  - Fermilab **reports**:
    - » physics notes (FERMILAB-FN)
    - » technical memos (FERMILAB-TM)
  - Accelerator **notes**:
    - » Beams-doc: (`beamdocs.fnal.gov`)

Run 4 reports are due Apr 23, 2024

Examples of Recent Publications

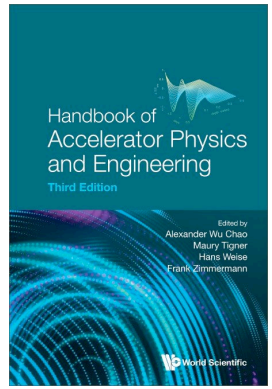
Optical stochastic cooling
Nature 608, 287 (2022)
PRAB 27, 012801 (2024)

Properties of undulator radiation
PRAB 23, 090703 (2020)
PRAB 24, 040701 (2021)
PRL 126, 134802 (2021)

Single-electron tracking
JINST 16, P12009 (2021)
JINST 17, P02014 (2022)

Long-range wakefields in srf cavities
PRAB 25, 064402 (2022)

Chapters on IOTA in accelerator handbook and in Bernal's book



PhD Theses

Completed recently

– **Nikita Kuklev**, “Experimental Studies of Nonlinear Integrable Optics,” (Kim / Valishev, UChicago, 2021)
– **Ihar Lobach**, “Statistical Properties of Undulator Radiation: Classical and Quantum Effects,” (Nagaitsev / Stancari, UChicago, 2021)
– **Frederick Cropp**, “High-Performance Accelerator Modeling: Toward Improving Controls and Diagnostics for High-Brightness Beams in Experiment,” (Musumeci / Ruan, UCLA, 2023)
– **Austin J. Dick**, “Computational Modeling, Simulation and Potential Applications of Optical Stochastic Cooling,” (Piot / Jarvis, NIU, 2023)

Upcoming

– **Ben Simons** (NIU)
– **John Wieland** (MSU)
– **MaryKate Bossard** (UChicago)
– **Sergei Kladov** (UChicago)

A Dedicated Channel: JINST Special Issue

Special Issue of JINST dedicated to IOTA/FAST Beam Physics, initiated by Vladimir Shiltsev

Wide scope: theory and modeling; experimental results; technical reports; instrumentation

Alexander Valishev and I serving as **Editors**

Several articles already included

Examples of candidate contributions:

- experimental results from Run 4
- diagnostic systems (beam-position monitoring, synchrotron radiation, feedback damper/waker)
- models and simulations

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Journal of Instrumentation

Accelerator Science and Technology Research at the Fermilab Integrable Optics Test Accelerator

Editors

Giulio Stancari and Alexander Valishev from Fermi National Accelerator Laboratory

The Integrable Optics Test Accelerator (IOTA) at Fermilab is a storage ring dedicated to beam physics research. Its purpose is threefold: to address the challenges posed by future high-intensity machines, such as instabilities and losses; to carry out basic research in beam physics; and to provide education and training for scientists and engineers.

IOTA is unique in its research mission, as well as in its flexibility and accuracy. It has a circumference of 40 m and a relatively large aperture (50 mm). It is easily reconfigurable to accommodate the installation of different experiments. Because of the quality of the instrumentation, the magnetic lattice can be precisely controlled. In addition, the lattice was designed to have significant flexibility to enable a wide variety of studies. IOTA can store electrons up to 150 MeV or protons at 2.5 MeV.

Because of synchrotron-radiation damping, electrons are suited to the study of linear and nonlinear single-particle effects. Proton dynamics, on the other hand, is dominated by space charge. Electrons were circulated for the first time in August 2018. Proton beams will become available in 2021 and will open up research on high-intensity beams.

The IOTA research program includes the experimental study of nonlinear integrable focusing systems based on special magnets or on electron lenses. Because of their nonlinearity, these systems generate a betatron tune spread that protects the beam from instabilities through Landau damping. Integrability ensures that the nonlinear system does not reduce the dynamic aperture of the machine, therefore preserving beam lifetime and emittance. Several other topics will be studied in IOTA, such as the experimental demonstration of optical stochastic cooling and the compensation of space-charge effects. In addition, IOTA has the capability of storing single electrons. Experiments on the spatial and temporal distribution of undulator radiation from single electrons are under way.

This Special Issue of the Journal of Instrumentation includes articles on the research conducted at IOTA, technical reports on the facility, descriptions of the instrumentation used for beam diagnostics, and discussions of the experimental results.

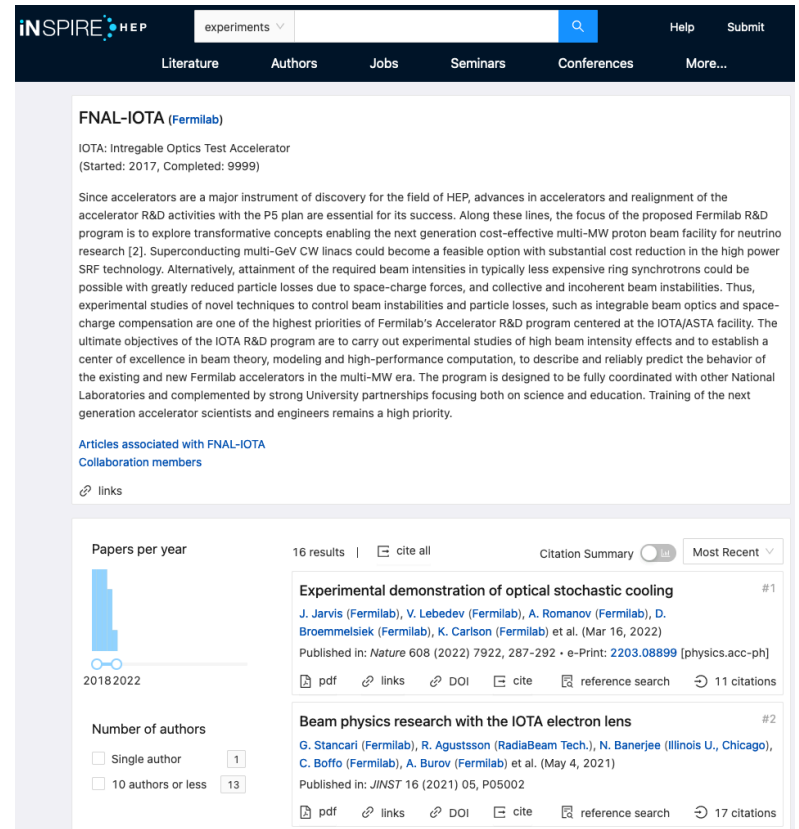
Giulio Stancari and Alexander Valishev
Fermi National Accelerator Laboratory

https://iopscience.iop.org/journal/1748-0221/page/extraproc90

Practical Matters for Collaborators

Familiarize yourself with the **Fermilab Technical Publications resources and processes** at techpubs.fnal.gov

Please update your **profile on InspireHEP.net** to reflect your affiliation with the "FNAL-IOTA" experiment. Very few members. Helpful for literature searches and summaries.



If you are not on the IOTA_Collaborators@listserv.fnal.gov **e-mail list** and you would like to be included, please let us know (general announcements, low-traffic list)

A Few Remarks

Assets

Rich research program

Wide range of expertise

Limitations

Deliver approved experiments

Train the next generation

Maintain focus over long runs

Suggestions for Improvement

Increase scientific and technical exchange of information to strengthen sense of collaboration: impromptu discussions, short talks at Friday meetings, tutorial workshops, etc.

Maintain a portfolio of well defined projects for interns, students, theses

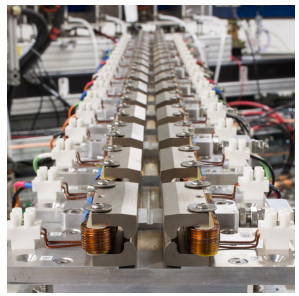
External collaborators — make clear commitments, in various forms: lead a research area, take charge of a piece of apparatus, provide people & funding, etc.

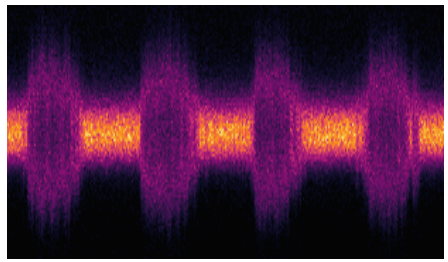
Fermilab management — make processes simple and efficient, so that researchers can focus on science, technology, operations and mentoring

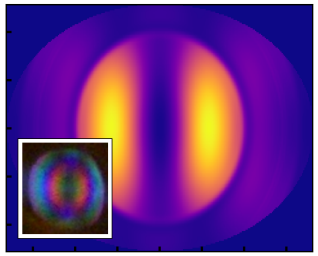
“Cool Toys, Papers and People”

What's the outcome of our activities?

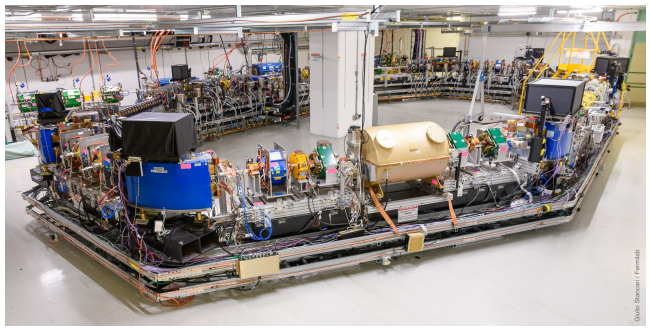
Novel instrumentation
State-of-the-art apparatus







Scientific research
Technological advances



Education and training
Bonds and relationships from working together on interesting and challenging projects

“The good old days are now.”