Brookhaven National Laboratory

U.S. DEPARTMENT OF ENERGY

# EDIT school @ BNL

Gabriella Carini & Michael Begel

20240116

@BrookhavenLab


Brookhaven National Laboratory

# BNL - EDIT 2023

Application submission closed on June 30th
- ~80 entries
- some duplications and incomplete
- ~55 being evaluated

Notification of acceptance by July 31st

https://www.bnl.gov/icfa-editschool/


Home | Enrollment Application | Agenda | Logistics | Contact Us

## Purpose

**EDIT** (Excellence in Detector and Instrumentation Technologies) is a school series that is devoted to young researchers, in their graduate studies or in their first year as post docs, seeking to acquire a deeper knowledge on the major aspects of detectors and instrumentation technologies for particle physics. The school comprises lectures and four courses with hands-on experiments, including beam tests, on silicon sensors, silicon systems, calorimetry and gas detectors.

## Program Overview

View Full Program

- Silicon Sensors: Design, Fabrication, and Testing
- Integrated Electronics for Detector Readouts
- Data Acquisition Systems for Quick Prototyping of Detectors Readout and an Experiment
- Liquid Argon Detectors: Physics, Design, and Operation
- Liquid Scintillators: Properties, Fabrication, and Analysis
- RF Cosmology: Techniques, Instrumentation, and Data
- Quantum Network: Concepts, Components, and Capabilities

## Training Enrollment Application

To be eligible to participate, all applicants **must submit their application online by June 30, 2023**. Applicants will receive notification of acceptance by July 31, 2023. Please contact the training coordinator if you have questions.

Apply Now Application submission is now closed.

## Local Organizers

- Gabriella Carini (BNL)
- Michael Begel (BNL)
- Hucheng Chen (BNL)
- Sara Capp (BNL)

## Sponsors and/or Co-sponsors

- International Committee for Future Accelerators (ICFA)
- Department of Energy (DOE)

## Accommodations

When booking your reservation, **you may need to guarantee** your room with a credit card. Check with your hotel about their **cancellation policy** and if they offer shuttle service. Details...

## EDIT Instrumentation Schools

View Past Schools

## Important Dates

| | |
|---|---|
| April 12, 2023 | Enrollment application opens |
| June 30, 2023 | Enrollment application closes |
| July 31, 2023 | Notification of enrollment acceptance (by e-mail) |
| August 1, 2023 | Registration (for accepted applicants) opens |
| August 31, 2023 | Additional registration deadline for all participants who do not have an active appointment with Brookhaven Lab |
| August 31, 2023 | Registration (for accepted applicants) closes |

## Training Information

**Dates:** October 10–20, 2023

**Event ID:** 000004865

**Venue:**
Brookhaven National Laboratory
Upton, NY 11973 USA

Meeting location and directions

**Training Coordinator:**
Sara Capp

(631) 344-7290
(631) 344-3674
scapp@bnl.gov

**Note:** This event falls under **Exemption D** (Formal classroom training held at Federal facilities, which does not exhibit indicia of a formal conference as outlined in the Conference/Event Exemption Request Form.)

# Program Overview

- **Silicon Sensors: Design, Fabrication, and Testing**
  - Learn about the principles and applications of silicon sensors
  - Explore the methods and tools for creating silicon sensors
  - Perform bench tests and beam tests to evaluate the performance of silicon sensors
- **Integrated Electronics for Detector Readouts**
  - Learn about the role and functions of integrated electronics in detector readouts
  - Explore the methods and tools for developing ASICs for various sensors
  - Perform signal processing and data acquisition using integrated electronics
  - Verify the functionality and reliability of integrated electronics using simulation tools
- **Data Acquisition Systems for Quick Prototyping of Detectors Readout and an Experiment**
  - Learn about data acquisition devices and their efficient use in software at different abstraction levels
  - Explore the tools and methods for fast prototyping of an embedded DAQ systems based on OEM devices
  - Perform Digital Signal Processing in FPGA synchronized to a Real-Time OS microcontroller
- **Liquid Argon Detectors: Physics, Design, and Operation**
  - Learn about the advantages and challenges of liquid argon detectors
  - Explore the physics principles and phenomena involved in liquid argon detectors
  - Design and construct liquid argon detectors and testbeds
  - Operate and measure the performance of liquid argon detectors and testbeds
- **Liquid Scintillators: Properties, Fabrication, and Analysis**
  - Learn about the applications and characteristics of liquid scintillators
  - Explore the properties and behaviors of liquid scintillators
  - Design and fabricate liquid scintillator detectors from benchtop to scale-up deployment
  - Calibrate and analyze the data from liquid scintillator detectors
- **RF Cosmology: Techniques, Instrumentation, and Data**
  - Learn about the goals and challenges of RF cosmology
  - Explore the techniques and methods for observing the 21cm absorption/emission line of neutral hydrogen
  - Learn about designing and constructing RF telescopes and related instrumentation
  - Process and interpret the data from RF cosmology observations
- **Quantum Network: Concepts, Components, and Capabilities**
  - Learn about the potential applications and benefits of quantum networks
  - Explore the fundamentals and concepts of quantum network
  - Design and implement quantum network components and protocols
  - Demonstrate and evaluate quantum network capabilities

# Program Overview

## EDIT School 2023

Oct 10 – 20, 2023
US/Eastern timezone

Enter your search term

- Overview
- Attestation -- to be completed by all participants
- Timetable -- block view
- Timetable -- full view
- Contribution List
- Speaker List

Coordinator: Sara Capp
scapp@bnl.gov
(631) 344-7290

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### EDIT Instrumentation Schools

View Past Schools

### Brookhaven Lab Anti-Harassment Policy

At Brookhaven National Laboratory (BNL) or BNL-sponsored events, discriminatory behavior or harassment of conference participants or presenters will not be tolerated. Please refer to the BNL Anti-Harassment Policy.

### Additional Information

- What to do in an Emergency
- Add Event to Calendar
- Identification Requirements for Guests and Visitors
- Access to Brookhaven Lab
- Food at Brookhaven Lab
- Delayed Opening/Closing Info
- Local Weather

**Starts** Oct 10, 2023, 8:00 AM
**Ends** Oct 20, 2023, 6:30 PM
US/Eastern

Gabriella Carini
Hucheng Chen
Michael Begel
Sara Capp

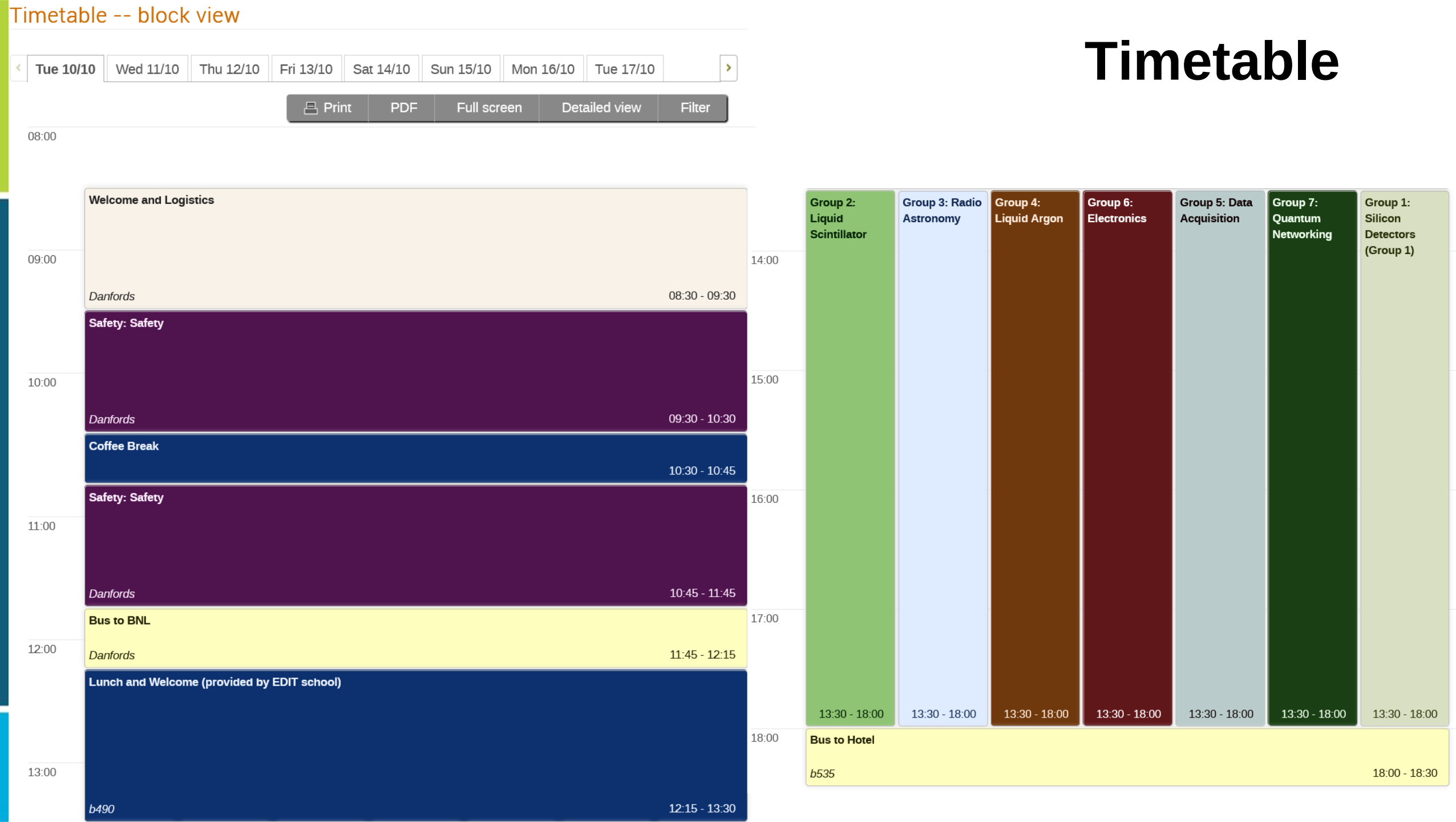
Long Island Railroad Schedules
Map from Danfords to BNL
Restaurants in Port Jefferson

**Surveys**
There is an open survey.
Fill out the survey

Help | Contact

Brookhaven National Laboratory

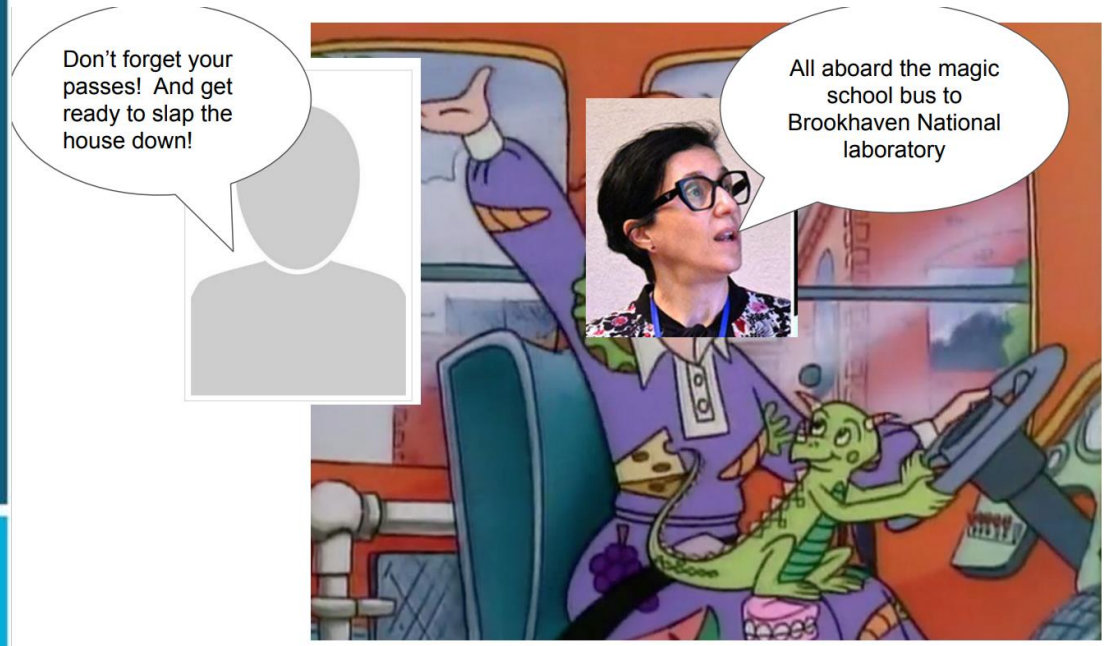
# Timetable


Timetable -- block view
Tue 10/10
Wed 11/10
Thu 12/10
Fri 13/10
Sat 14/10
Sun 15/10
Mon 16/10
Tue 17/10
Print
PDF
Full screen
Detailed view
Filter
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
Welcome and Logistics
Danfords
08:30 - 09:30
Safety: Safety
Danfords
09:30 - 10:30
Coffee Break
10:30 - 10:45
Safety: Safety
Danfords
10:45 - 11:45
Bus to BNL
Danfords
11:45 - 12:15
Lunch and Welcome (provided by EDIT school)
b490
12:15 - 13:30
Group 2: Liquid Scintillator
13:30 - 18:00
Group 3: Radio Astronomy
13:30 - 18:00
Group 4: Liquid Argon
13:30 - 18:00
Group 6: Electronics
13:30 - 18:00
Group 5: Data Acquisition
13:30 - 18:00
Group 7: Quantum Networking
13:30 - 18:00
Group 1: Silicon Detectors (Group 1)
13:30 - 18:00
Bus to Hotel
b535
18:00 - 18:30

# Venues – students feedback: hotel and lab

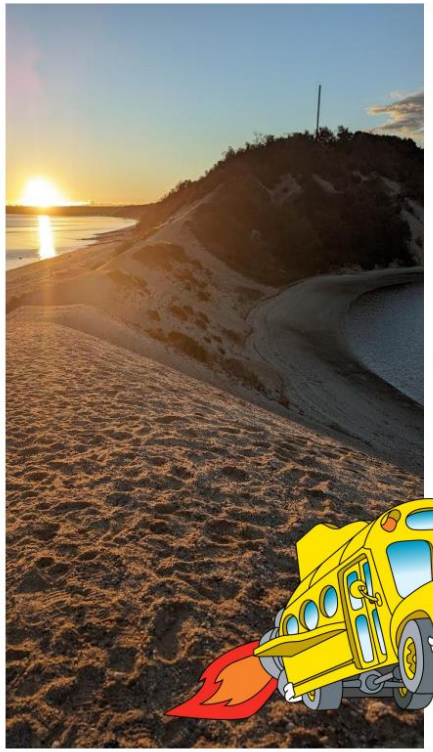
**Specifically asked for feedback**
**It was the subject of group presentations (last day)**

## Group 2's thoughts on EDIT 2023

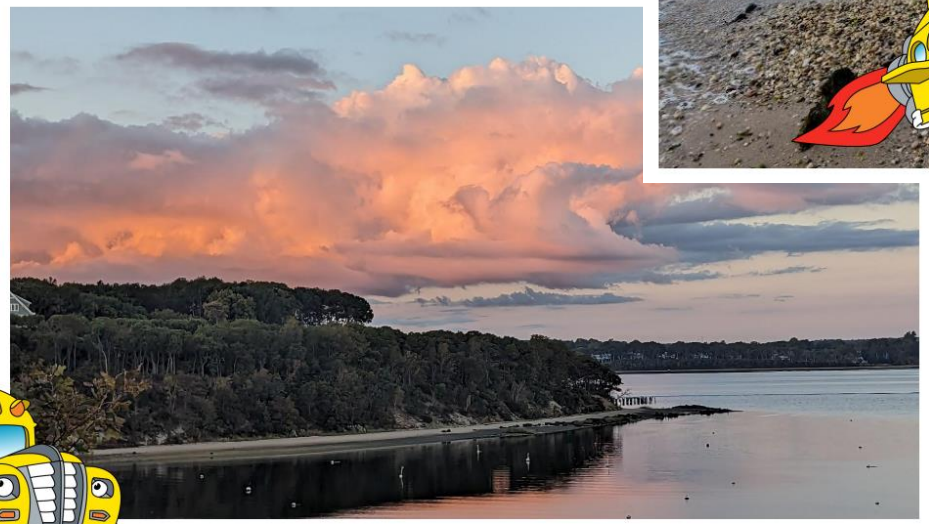



# Venues – students feedback: hotel and lab

And the evenings!



The mornings…



# Venues – students feedback: hotel and lab

Waiting for all the bureaucracy …

Thank You!



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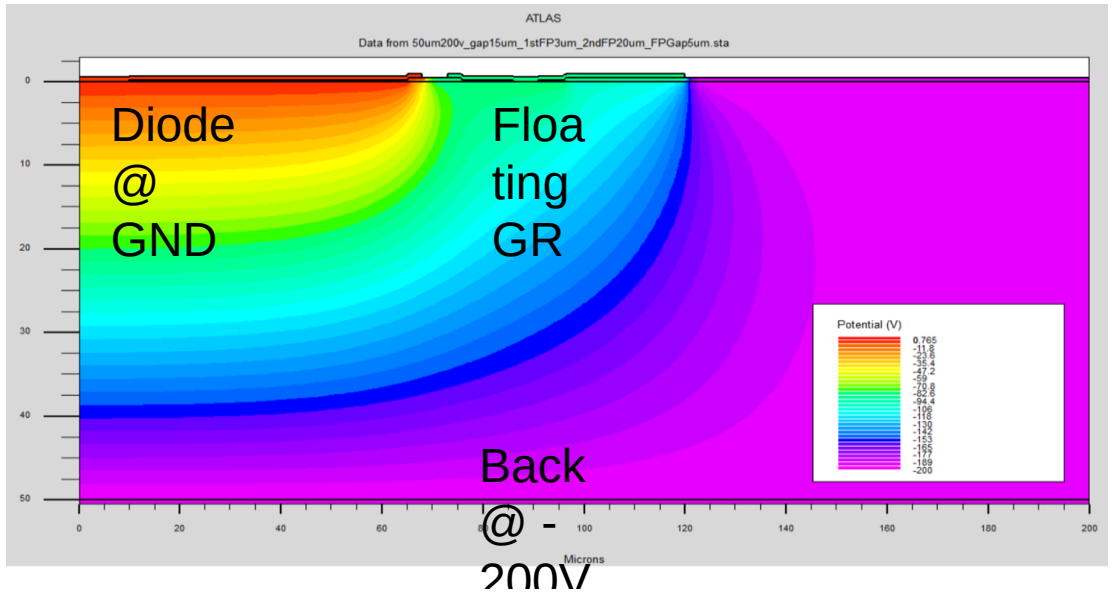
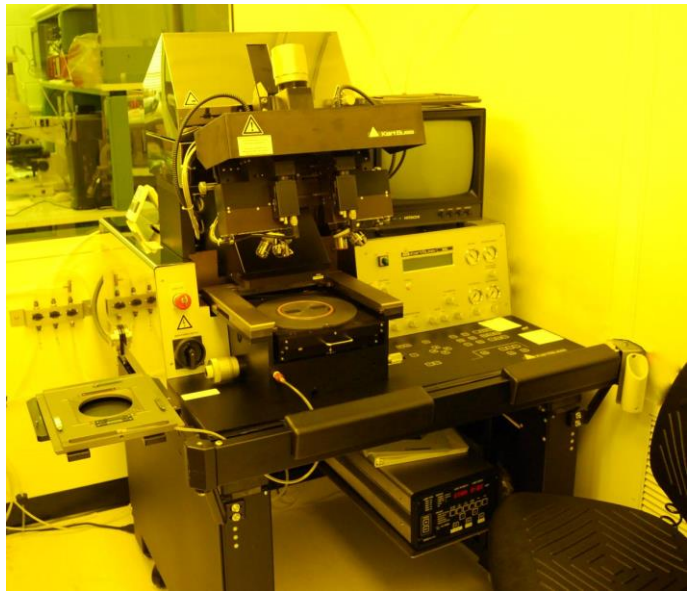
# Silicon Sensors: design and fabrication

**Lectures** will provide an overview of the physics of silicon sensors and their scientific and industrial applications. *They also learned about other semiconductors (i.e., high-Z materials).*

**Laboratory sessions** will include: test at the probe station, TCAD simulations, and clean room process overview.

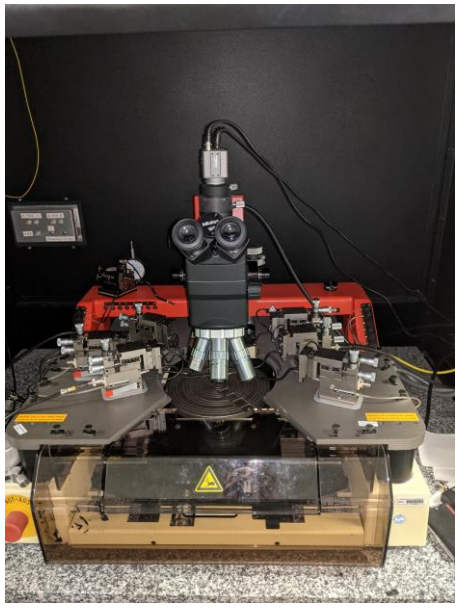



**TCAD simulations:**
Using SILVACO, the students will simulate the process flow to build, the physics and the electrical characteristics of a few silicon devices.



**Class-100 Clean Room:**
Students will go through the process steps to create a semiconductor sensor

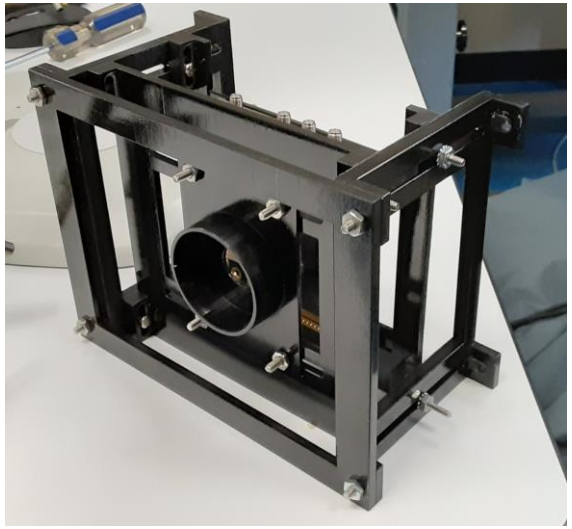
- Furnaces (oxidation and annealing)
- Lithography
- Sputtering
- Etching
- Cleaning



**Tests:**
Static characterization at the probe station of silicon devices (e.g., LGADs, microstrip, silicon drift detectors)

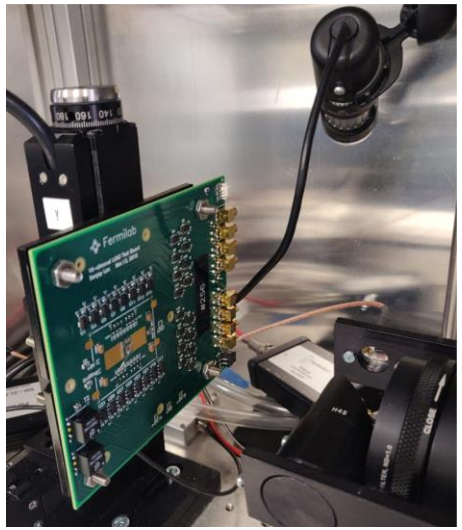
- Current-voltage (I-V)
- Capacitance-Voltage (C-V)
- Stability tests

# Silicon Sensors: testing



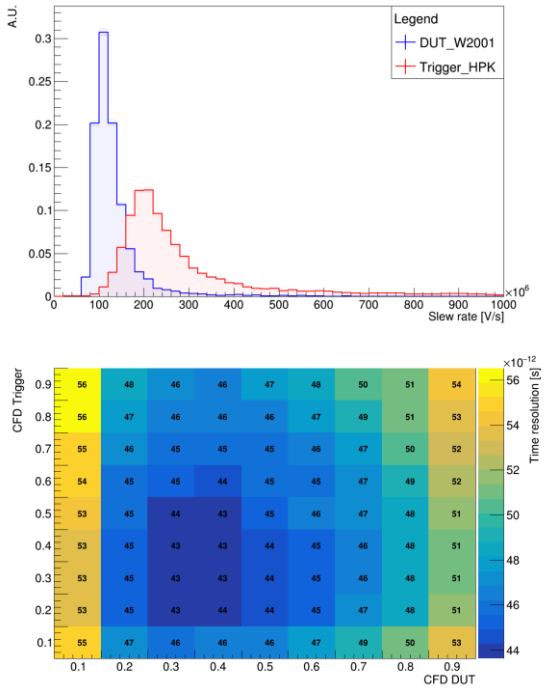
**Characterization at Betascope**

Students will measure gain and time resolution of a silicon sensor using betas from a $^{90}$Sr source



**Transient Current Technique**

Students will map the response of the sensor using a focused IR laser with micrometric precision




## Data Analysis

Students will analyze waveforms obtained in lab and at test-beam using a python3 framework.

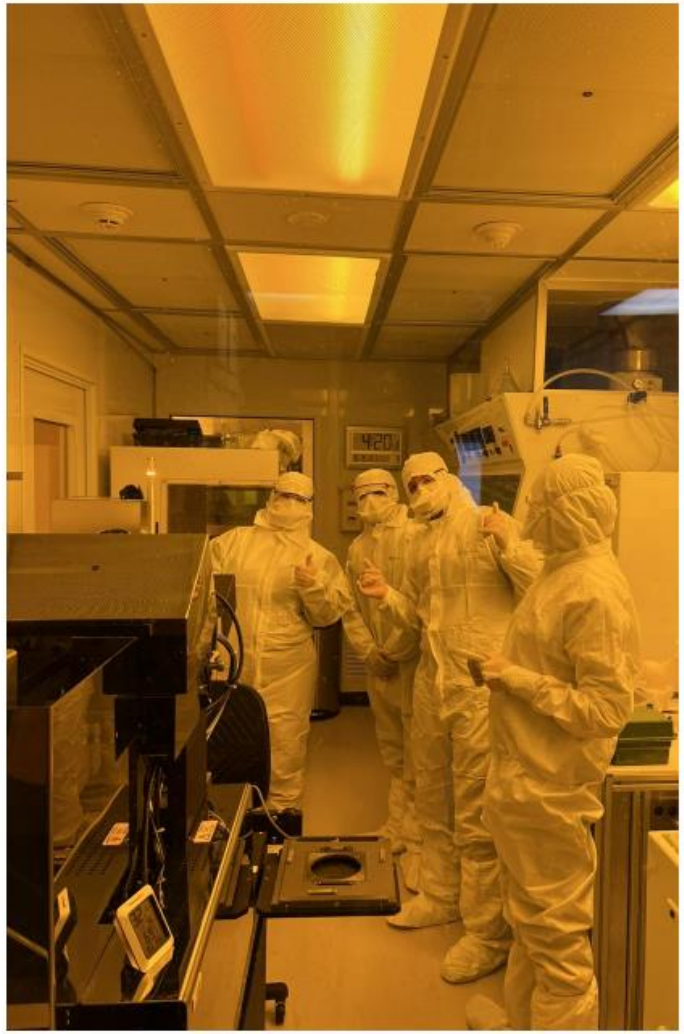
We will provide base functionalities (data loading, plotting, …); students will extrapolate physical quantities from waveform features

## Characterization at Test Beam

Measure space and time resolution of an LGAD silicon sensor at a real test beam facility. The sensor will be mounted on a custom made silicon telescope.

Students will set up the data taking from the accelerator control room, acquire data, and extrapolate the sensor space resolution by exploiting 4D data from the telescope.

# Silicon activities – students feedback: cleanroom



Heisenberg in clean room ( 100 particles /$m^3$ ) to create “chips” ?



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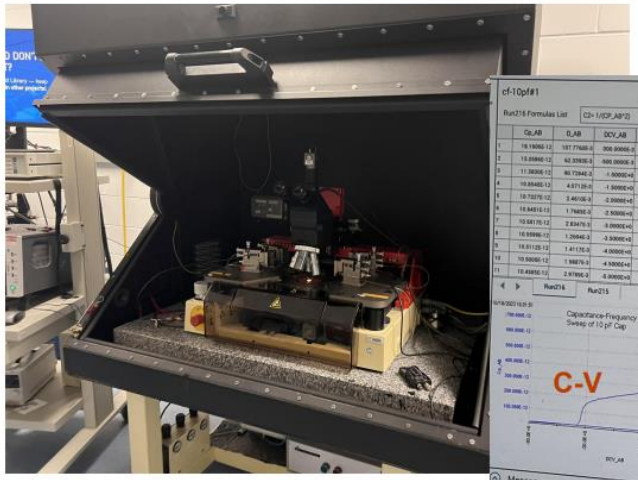
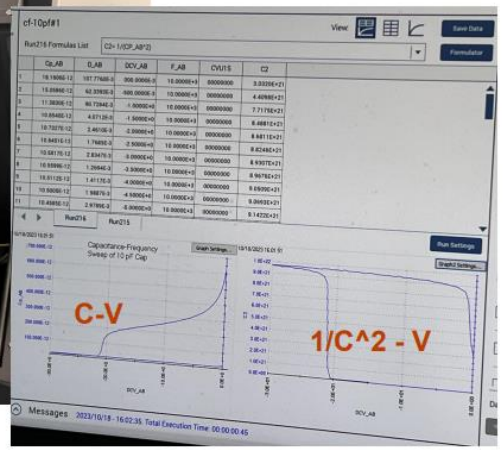
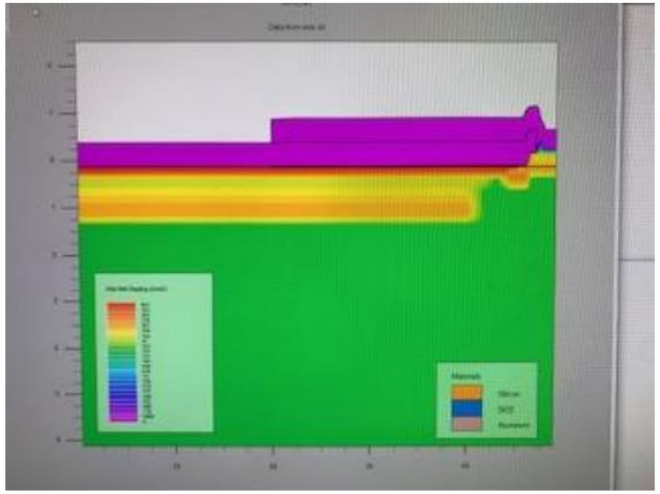
# Silicon activities – students feedback: sims/tests

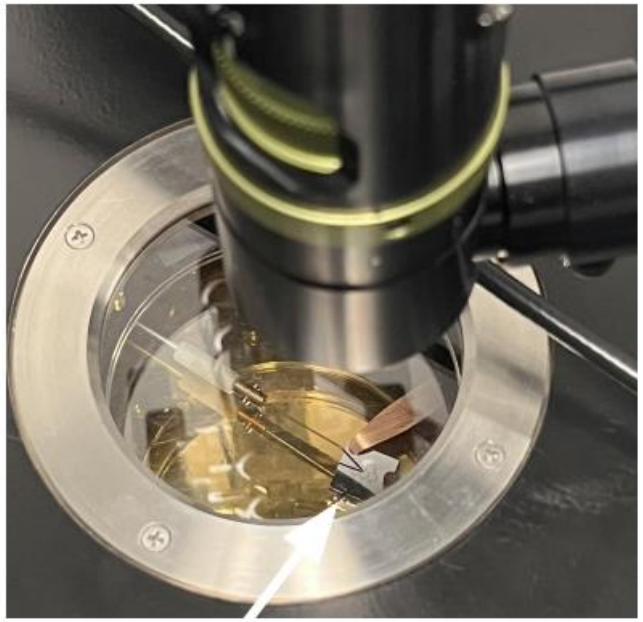





Probing P-N diode, Photodiode & LGAD detectors to get the I-V & C-V characteristics plot.



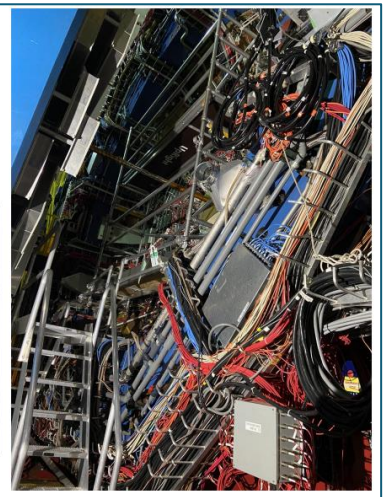
LGAD simulated using TCAD



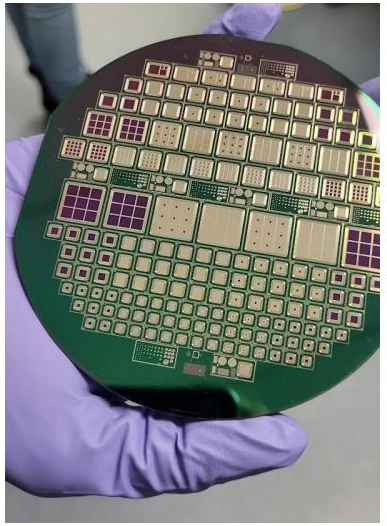
Probe Station for Germanium Sensor.

Cool things we saw

Strip AC LGAD silicon sensor



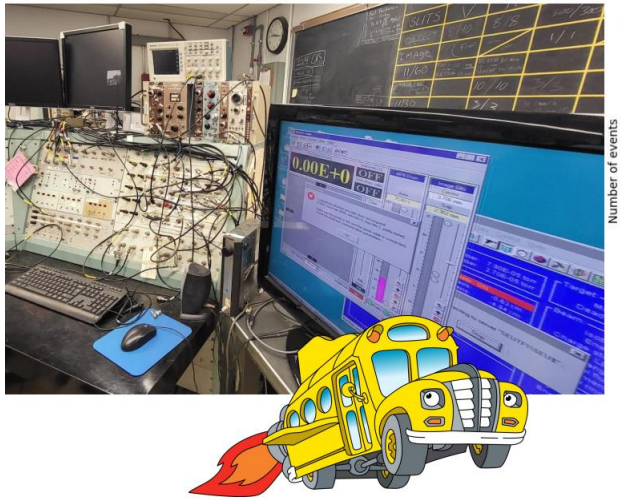
STAR experiment



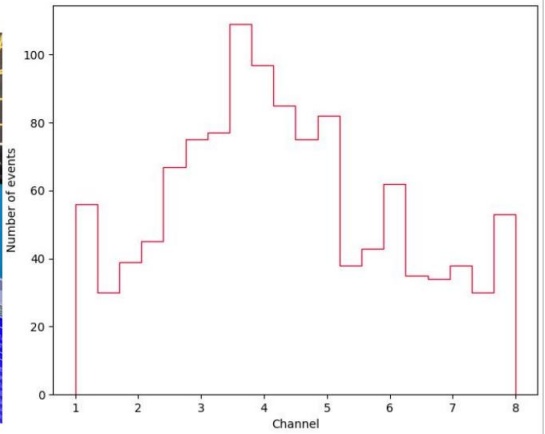
# Silicon activities - students feedback: Tandem

Irradiating a poor silicon sensor :(

Beam testing with the latest technology



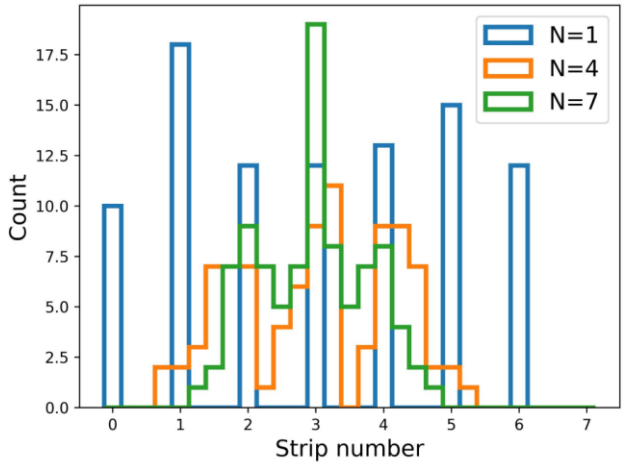
Tried to estimate beam shape…



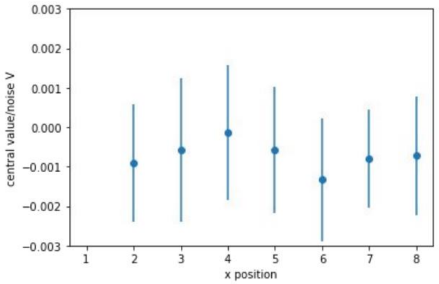

… would be nice to get more than 40min to work on this

TANDEM

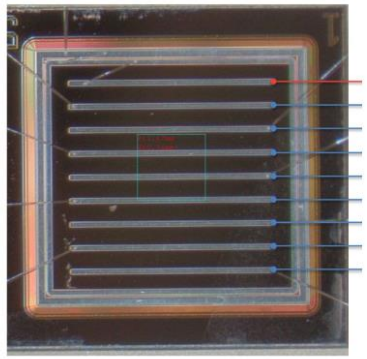
Beam profile constructed as a weighted mean of the strip position of the N strips with highest amplitude, with weights given by peak amplitude.

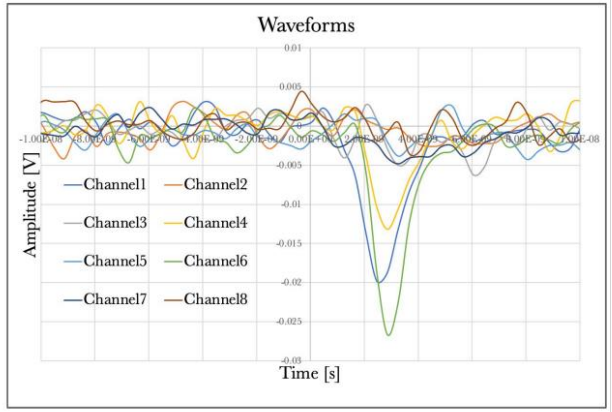



Tandem plot 2

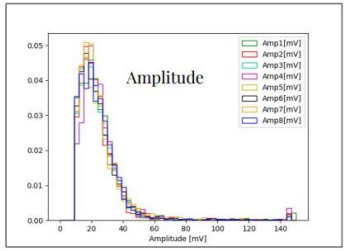


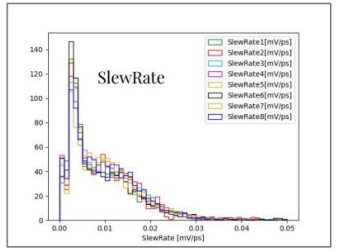

# Silicon activities - students feedback: Tandem

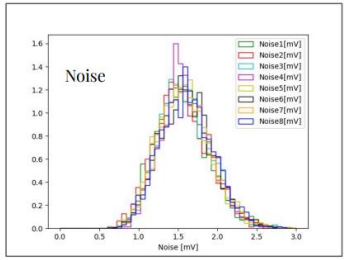


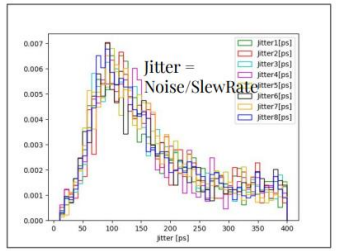



## Tandem Beam Test Analysis




**Proton beam onto a single AC-LGAD.**

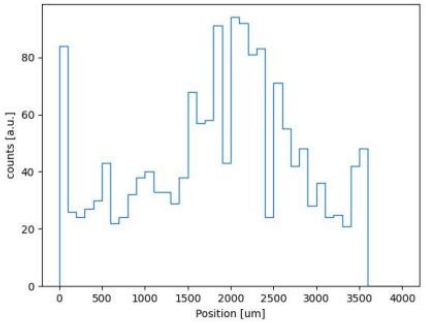
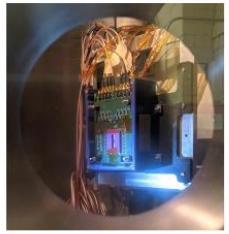



*Figure 1.* Position of hits on strip sensor array, calculated as centre-of-mass.



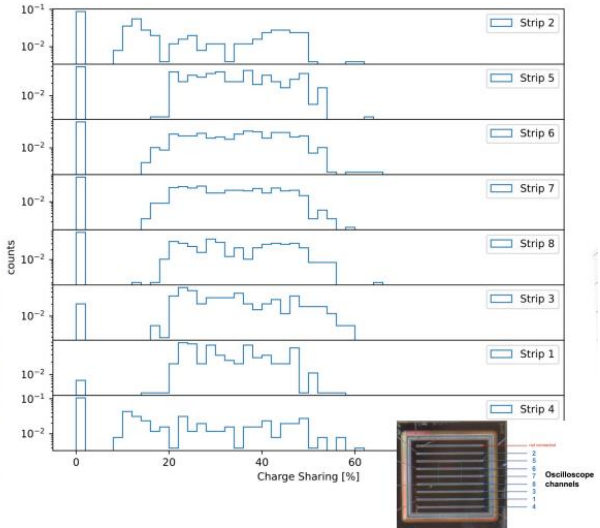
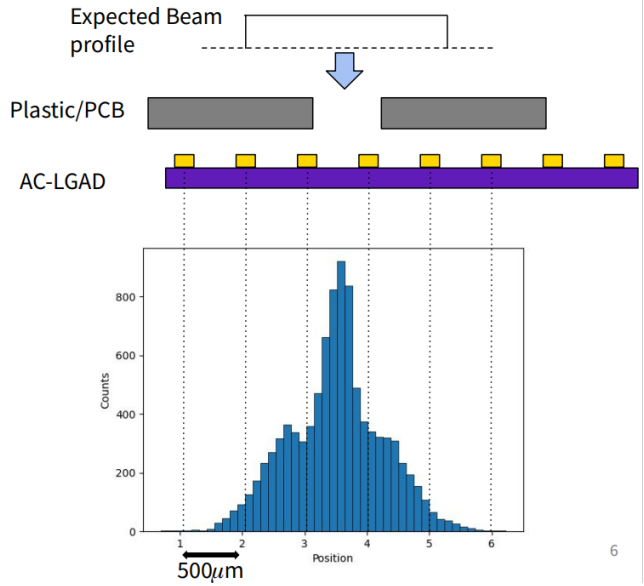



*Figure 2.* Charge-sharing proportion for each centre. The strips are listed in physical order from top to bottom of the sensor array.

## Testbeam - beamprofile

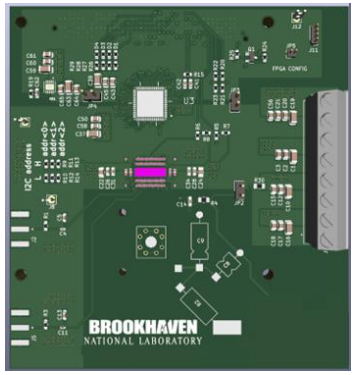
- Uniform beam profile expected
- Attenuated due to plastic/pcb with hole in front
- Calculate weighted mean using amplitudes from 8 strips (charge sharing) -> position distribution
- weighted_position=SUM(amplitude[mV]*strip[#])/SUM(amplitude[mV]



# ASIC design and testing

**Get familiar with the off-the-shelf electronics**

Students will get familiar with the functionality and capabilities of the Artix7 FPGA-based system




**ASIC Board**

Students will get familiar with the design considerations towards PCB design for an ASIC testing purposes

## Project

Students will get familiar with the fast-prototyping platform and programming methods.

They will learn and implement basic structures on FPGA and Real-Time Operating System, including:

- counters, timing, generation and acquisition of real signals with high speed
- FPGA – RT communication methods, RT OS application design patterns
- GUI

### Application Specific ADC testing system

Students will prepare the ADC ASIC testing system starting from an empty project.

Final system consists of an ADC PCB controlled by an FPGA and a Real-Time OS controlling FPGA and handling the data.

Students will prepare all necessary blocks for ADC control and data handling as well as a dedicated user interface for data display.

### Application Specific Integrated Circuit design 101

Students will gain basic understanding of microelectronics and its central role to detector systems.

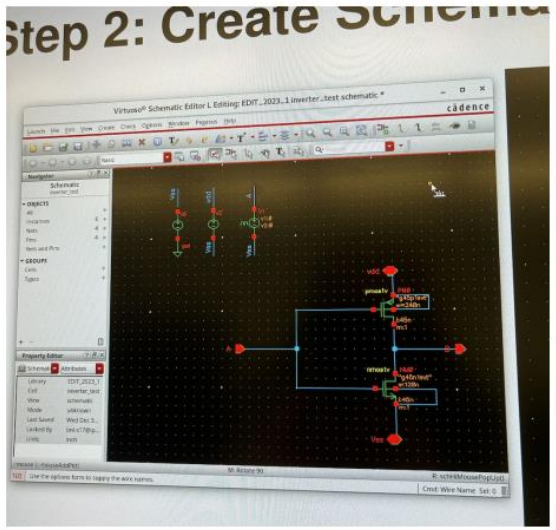
Students will have the opportunity to gain familiarity with desing tools and technology platforms.

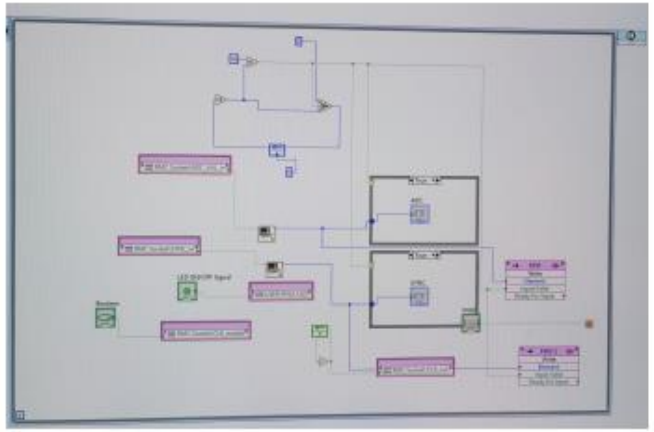
A series of PC stations will be made available for small groups of students woirking with mentors.

Lectures will preceed the hands-on-training.

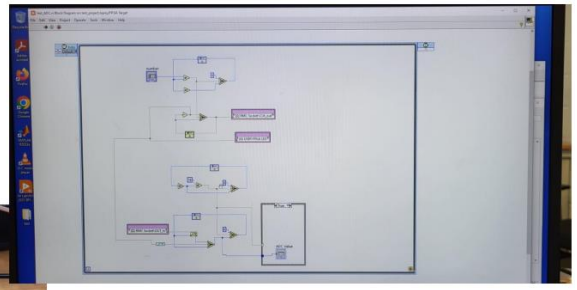
Brookhaven National Laboratory

# Microelectronics/ASICs design – Readout testing and DAQ: students feedback



Data Acquisition Systems



# Liquid Argon Detectors

- **Lectures**: LArTPC principle and cryogenic system, LArTPC reconstruction, LArTPC cold Electronics
- Labs: Students divided into small groups between two test stands
  - Local 260 L LAr system cryogenic operation
  - Cryogenic system operation/monitoring
    - Refilling LN2 dewar from 6000-gallon supply tank
    - Change LN2 supply for 260-L system cryogenic operation
    - Assembly for new inline filter
    - Leak check the for new inline filter (follow with activation if time permits)
    - LXe transfer(if time permits)
  - Cold Electronics test stand (may be combined with other cryolectronics tests)

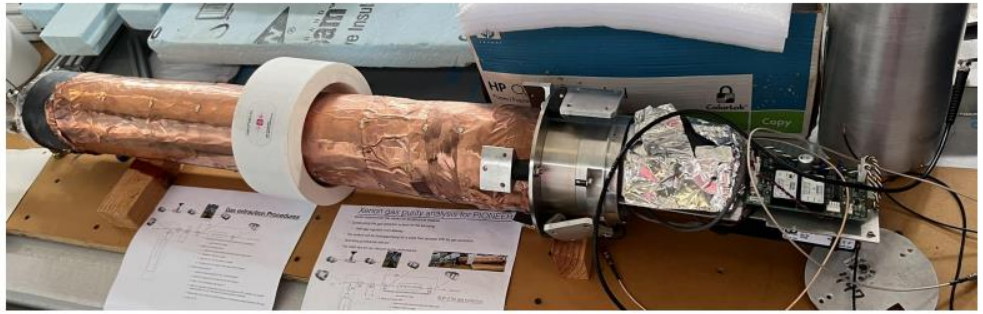
*NuSTEAM students visiting the LAr R&D facilities (20-L cyrostat on left and 260-L on right) in July 2022.*

# Liquid Argon Detectors - students feedback

## Liquid Argon

Layers of thin aluminium foils surrounding the vacuum cryostat.

Liquid Nitrogen used for condensing Argon gas after purification.



Liquid Xenon containing scheme. How many screws did you open ?



Brookhaven National Laboratory

# Liquid Argon Detectors - students feedback

Day 8 Liquid Argon

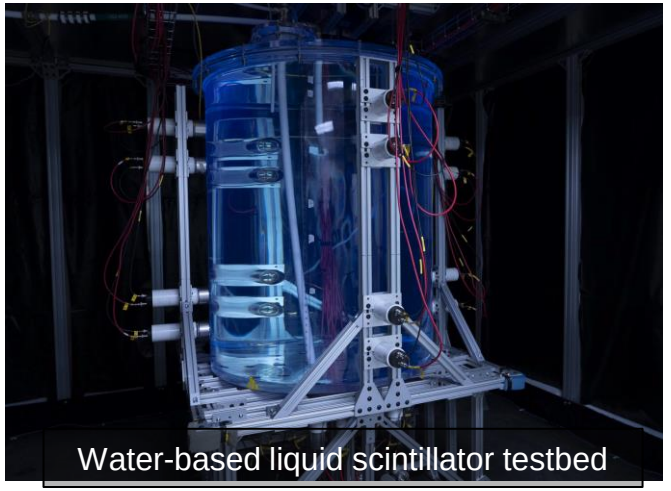

Brookhaven National Laboratory

# Liquid Scintillator Detector

- Two groups of student for hands-on-activities
- Two lectures (one-hour each) to cover (1) nature of scintillator detector, and (2) scintillator-based particle experiments
- Two lab courses (3-hour each)

  Lab-A: preparation and characterization of liquid scintillator; hand-on experience for students to prepare LS samples and measure their performances using benchtop instrument.

  Lab-B: data-taking and -analysis at 1-ton Testbed; students will observe the configuration and operation of a ton-scale detector and learn of DAQ and analysis tool to analyze muon and alpha events.



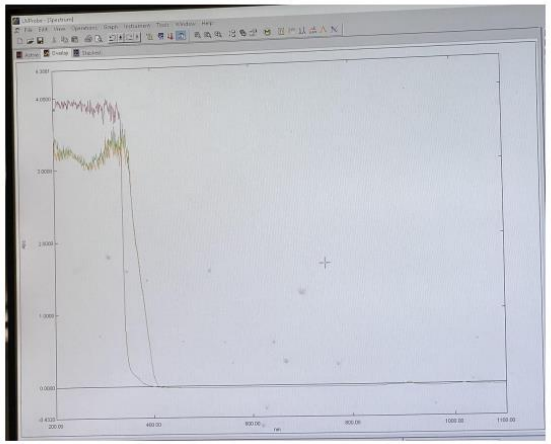
Water-based liquid scintillator testbed

*1000 L Sequential-Mixing Reactor System in Liquid Scintillator Production Facility (LSPF) at BNL.*

Brookhaven National Laboratory

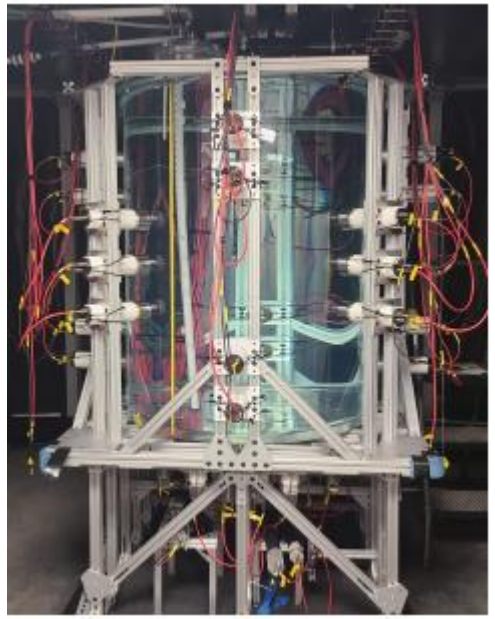
# Liquid Scintillator Detectors - students feedback

## Liquid Scintillator



Shift (towards right) of absorption spectra in DIN with the addition of PPO & MSB.


Thin-film Vacuum distillation system for purification for liquid scintillator.



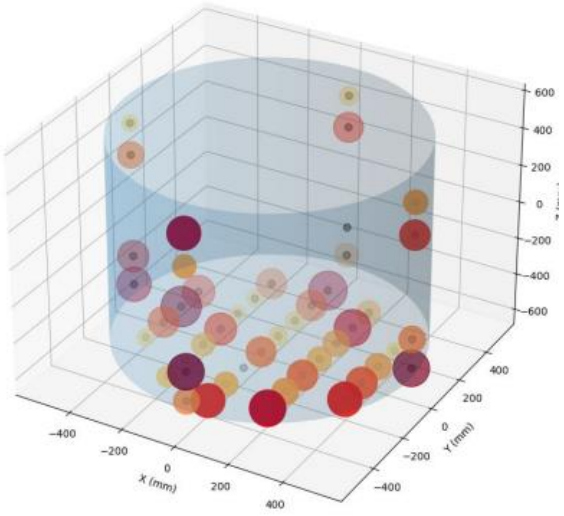
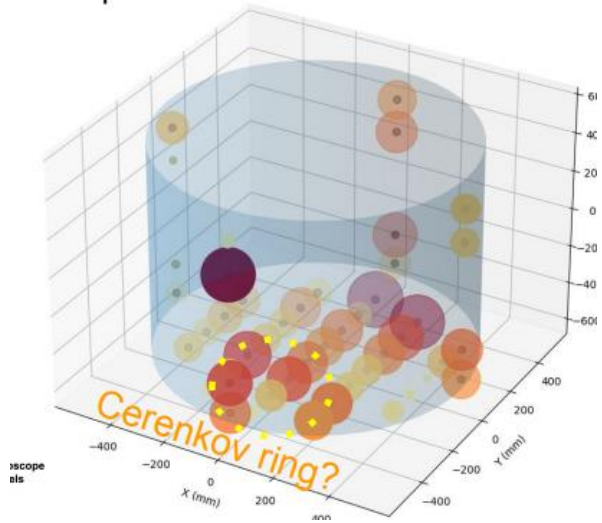


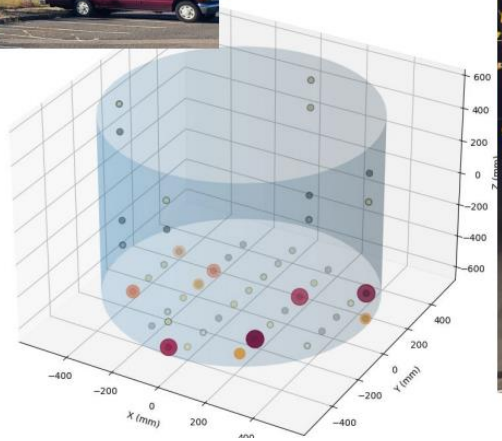

*Figure 3.* BNL1T triggers and PMT responses.



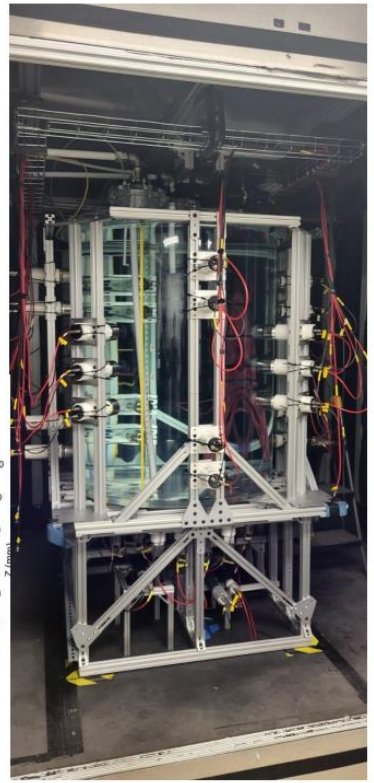

Brookhaven National Laboratory

# Liquid Scintillator Detectors - students feedback

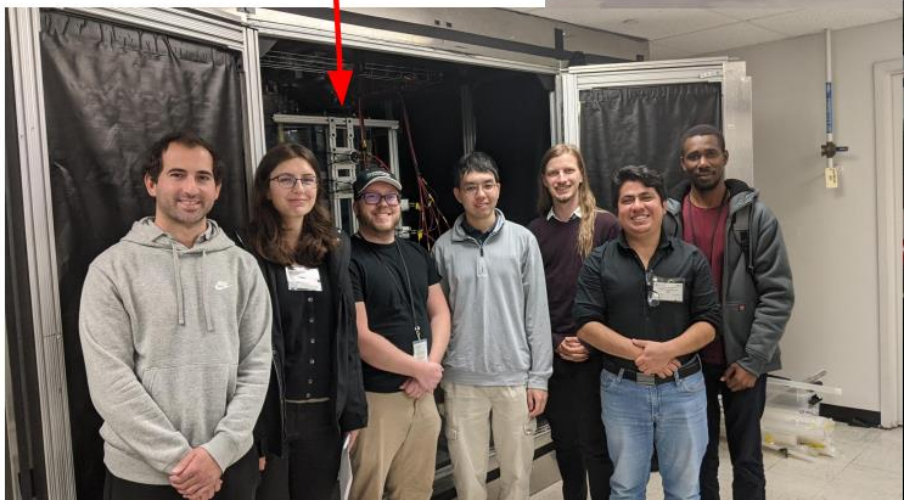
Liquid scintillators




## Scintillating Stuff!



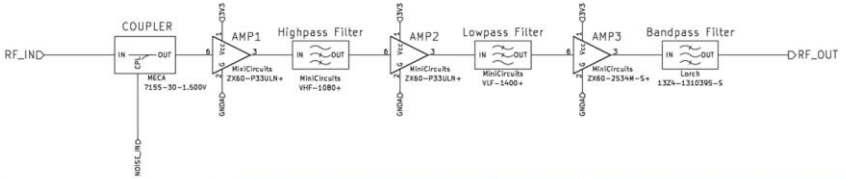
There is 1T tank hiding back there

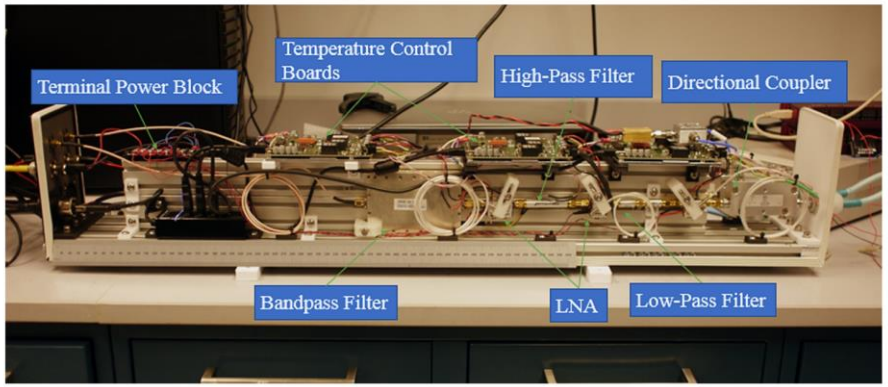


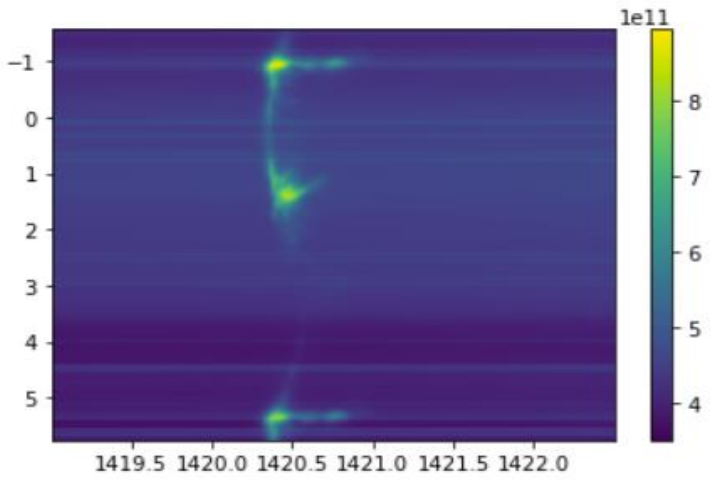
# Radio Astronomy

Experiments to detect the 21cm transition line of neutral hydrogen across a wide range of redshifts are at the forefront of astrophysics and cosmology.
**Lectures** will cover: (1) an overview of radio cosmology and the 21cm line in particular, (2) RF instrumentation for astronomy, and (3) drone beam calibration systems.

The Baryon Mapping Experiment (**BMX**) located onsite at BNL is an ideal teaching telescope. It offers students the opportunity for *hands on work with RF hardware and astrophysical data taken on location*.



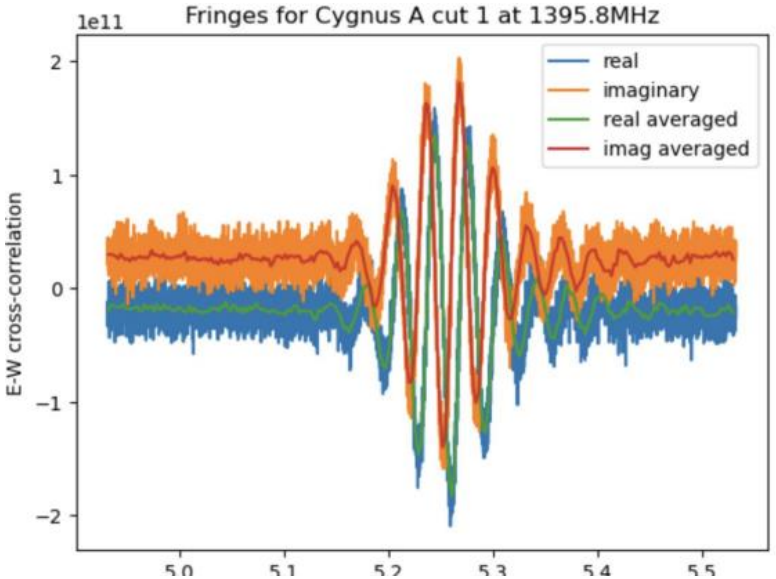

**Laboratory activities** include:

- RF signal chain construction and measurements. Including use of RF components, signal generators and vector network analyzers.
- Data analysis including RFI processing and astrophysical signal detection. (Milky Way seen in BMX data to left)

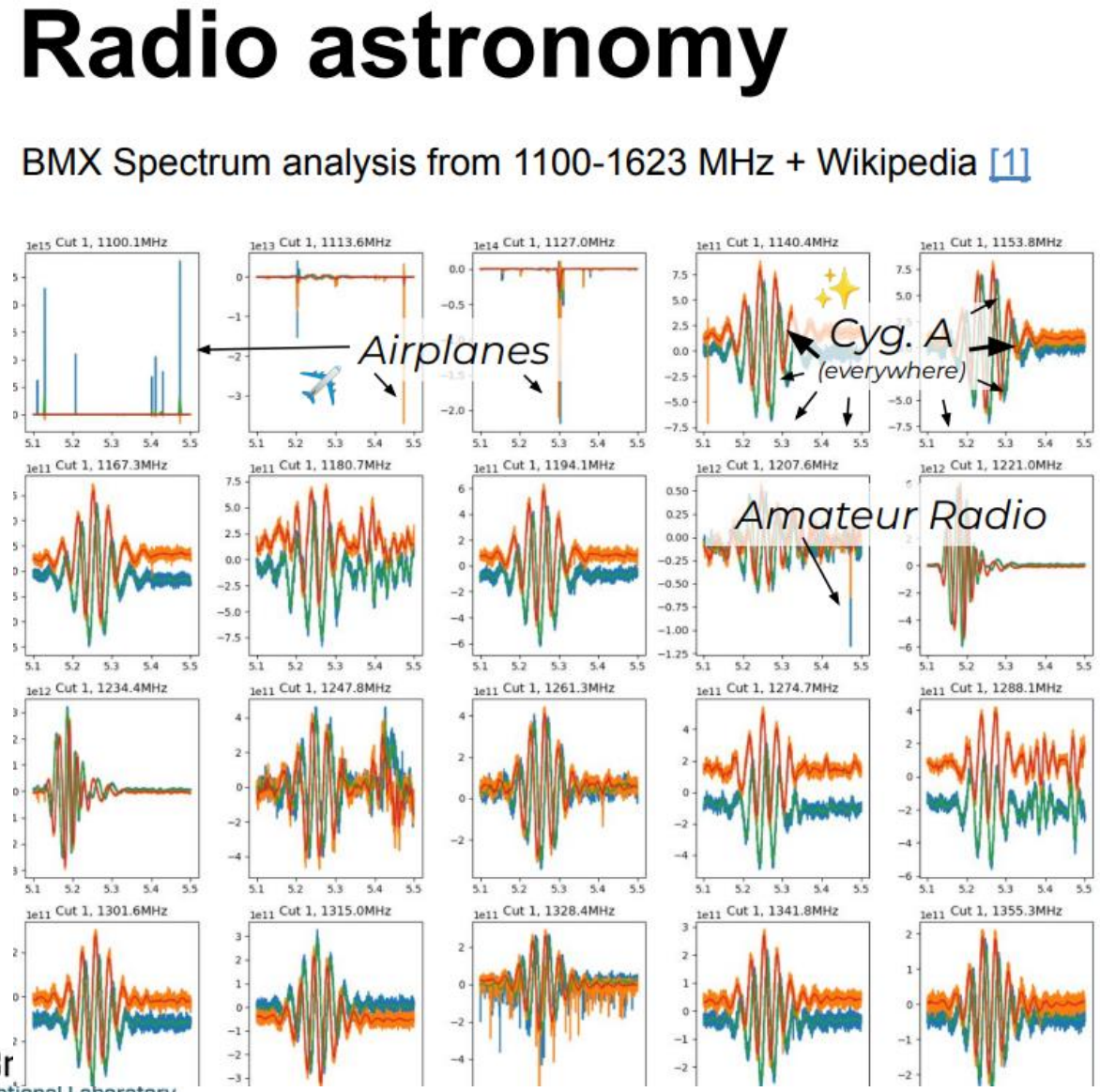
# Radio Astronomy - students feedback

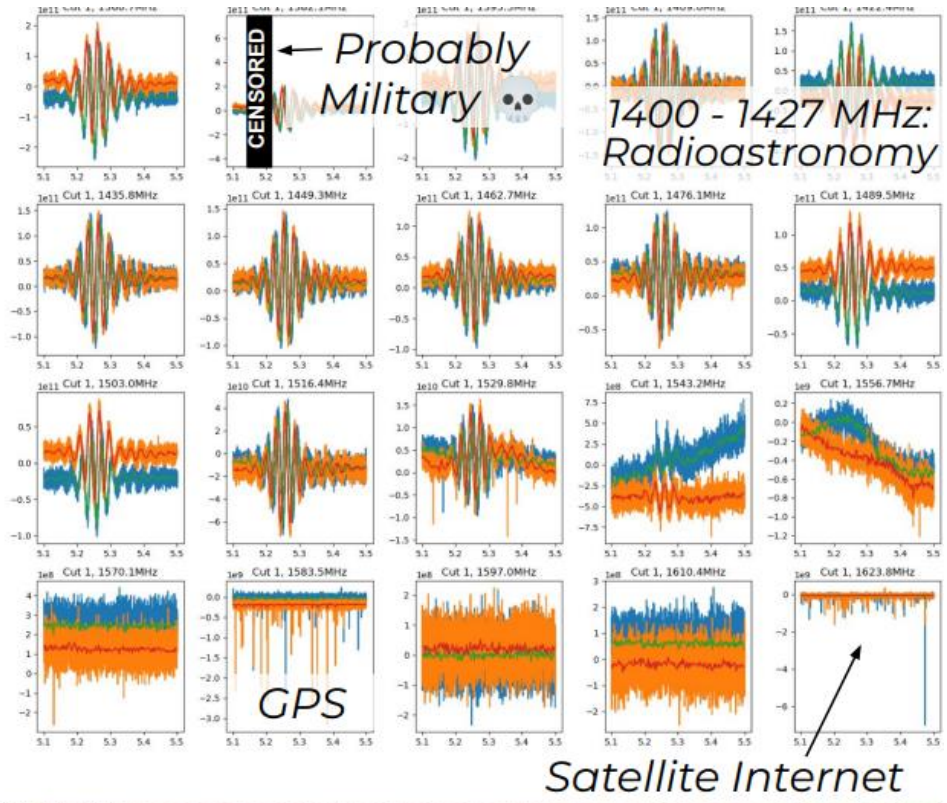
## Radio Astronomy

Getting to see the BMX telescope was fun! The lab activity could have benefited from dedicated computers already setup with the python code (like the Electronics lab). The time saved could have allowed for more in-depth activities (Justine's lab activity idea sounded very interesting!)



# Radio Astronomy - students feedback



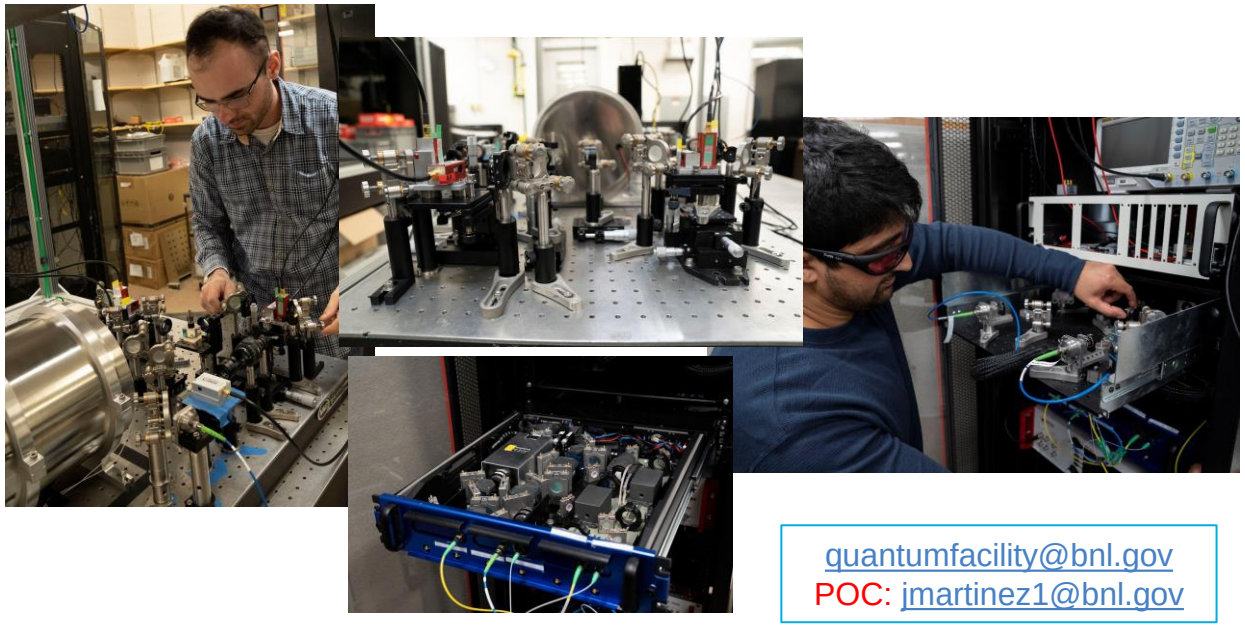




# QN: First Experimental Facility Open to the User Community

https://www.bnl.gov/instrumentation/quantum/

Quantum technologies and the fabric of the quantum economy is enriched by allowing:

- Users to test, benchmark, validate, and develop new concepts and ideas, as well as software and devices.
- Accelerate the development of q. technology and the fabric of the q. economy
- Contribute to the development of a diverse quantum-smart workforce

quantumfacility@bnl.gov
POC: jmartinez1@bnl.gov

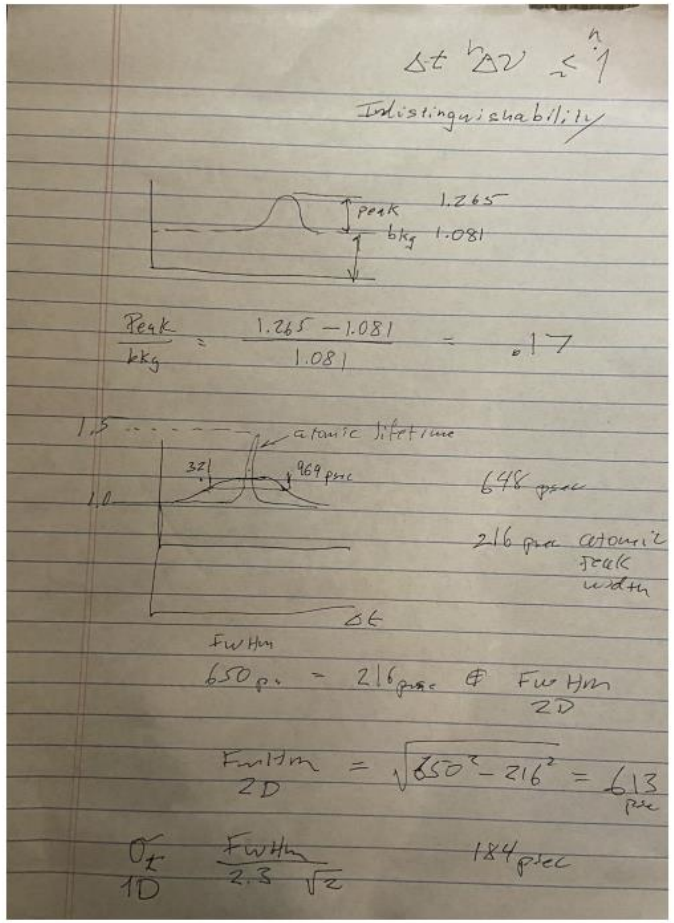
- ✓ We have the legal framework in place that allows us collaboration with private sector, academia, and government.
- ✓ We are exploring collaborations with early users.
- ✓ Increased involvement within the QED-C.

# QIST- students feedback

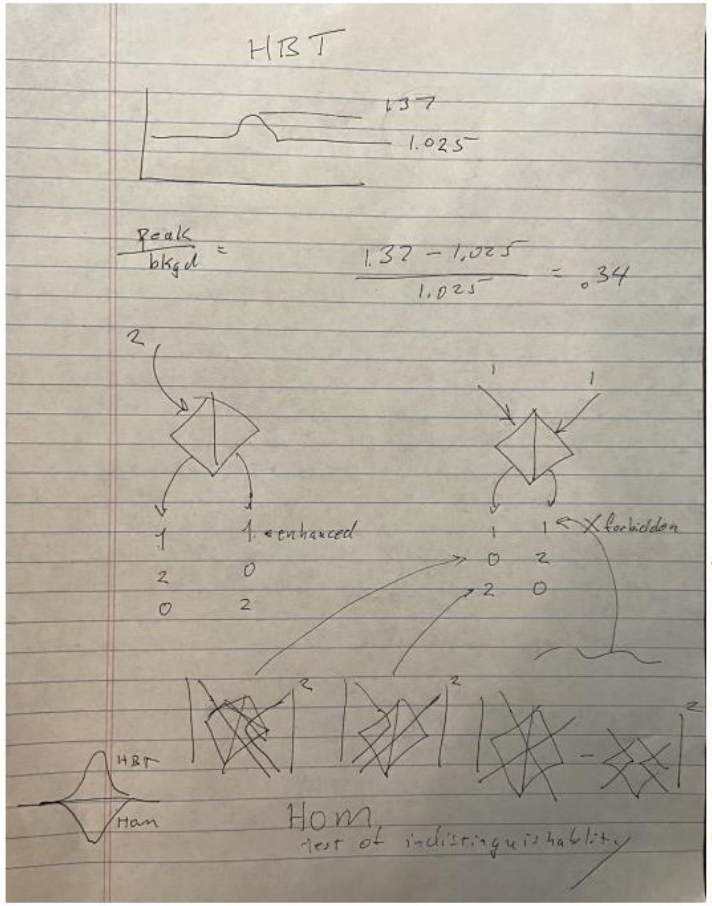
- Seeing multiple different experimental setups was interesting and made for good pacing.
- Cool to see smaller scale local


## Quantum Networking lesson

Observing photon clumps



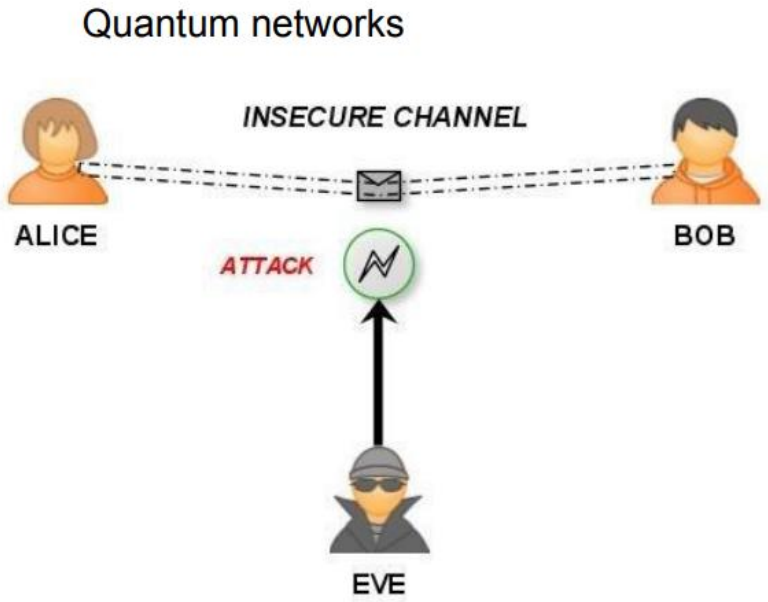

Hanbury Brown and Twiss effect: boson clumps

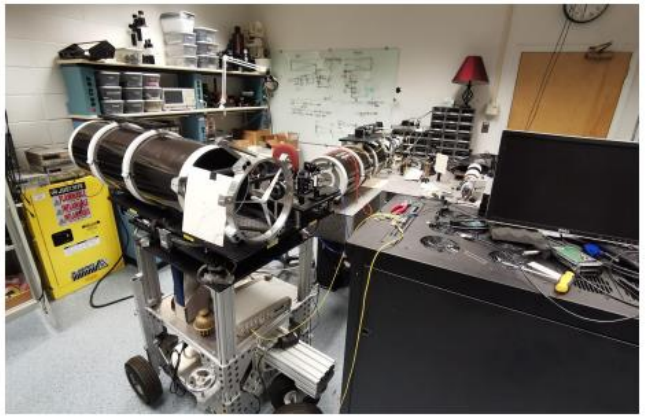


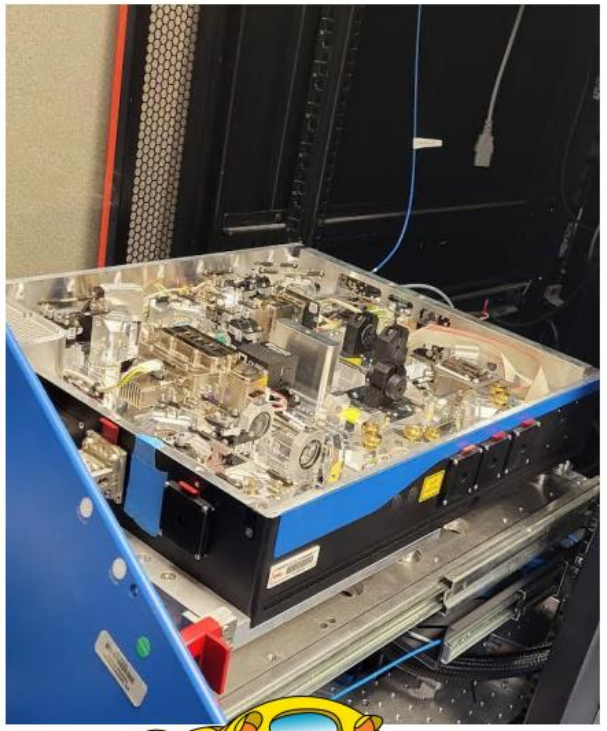

Calculating jitter in our instrument

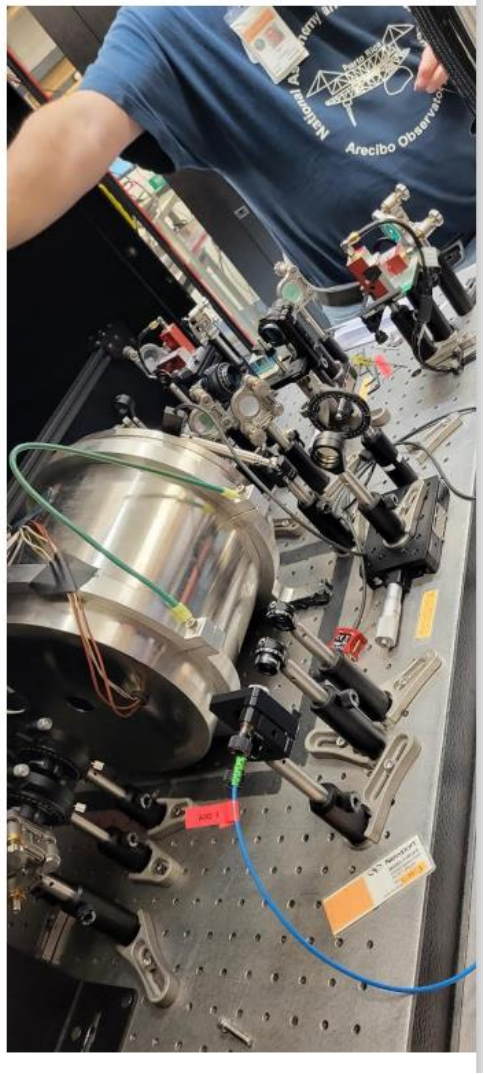
Hong–Ou–Mandel effect: if two indistinguishable photons enter a beam splitter, they can't exit with one photon in each mode

# QIST- students feedback



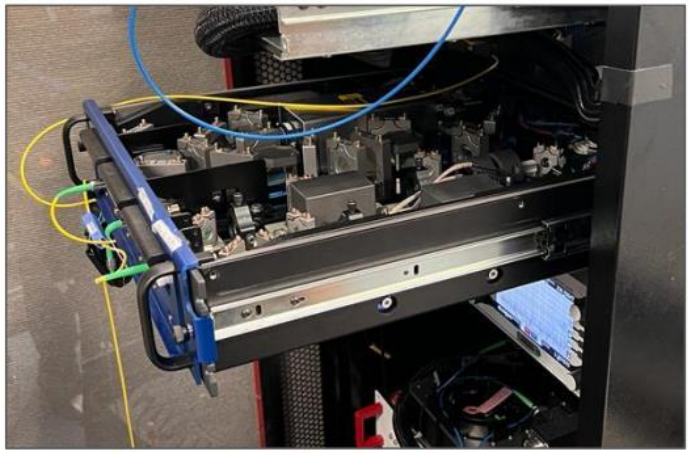





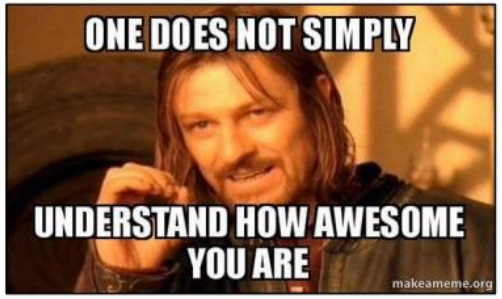


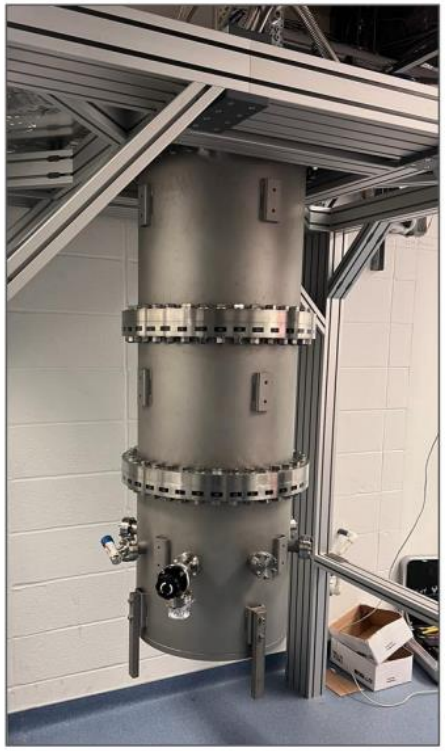
# QIST- students feedback

## Q-Future is @ BNL

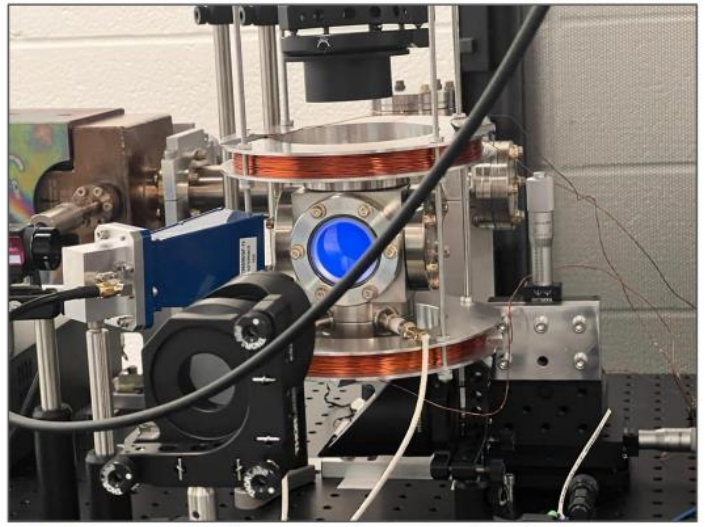


Quantum Optical Memory



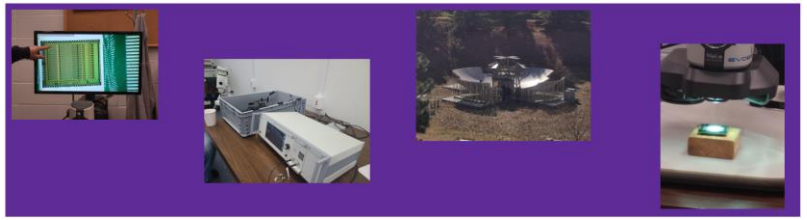



Semiconducting circuits at milliKelvin



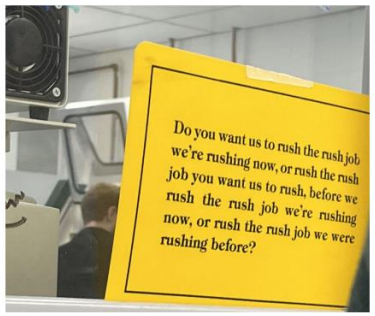
Ultracold atoms at microKelvin using lasers.

# Final verdict: the Emoji Review



- Silicon Sensors: Design, Fabrication, and Testing 😷
- Integrated Electronics for Detector Readouts 🤯
- Data Acquisition Systems for Quick Prototyping of Detectors Readout and an Experiment 🧐
- Liquid Argon Detectors: Physics, Design, and Operation 🥶
- Liquid Scintillators: Properties, Fabrication, and Analysis 🔥
- RF Cosmology: Techniques, Instrumentation, and Data 🤩
- Quantum Network: Concepts, Components, and Capabilities 🤔
- Test beam and Tours 🏃‍♂️🏃‍♂️🏃‍♀️💨

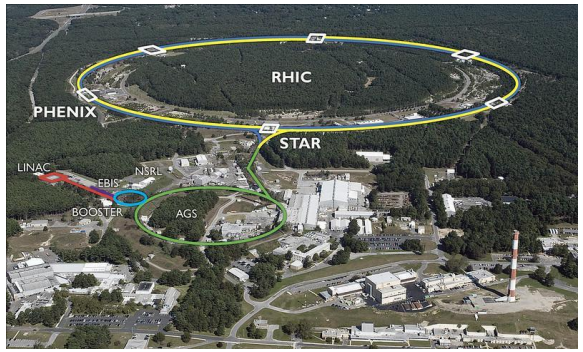
Best sign →





🏃‍♂️ 🚶‍♂️

# Tours some of the BNL facilities




*Relativistic Heavy Ion Collider at BNL. Other parts of the accelerator complex are also indicated.*

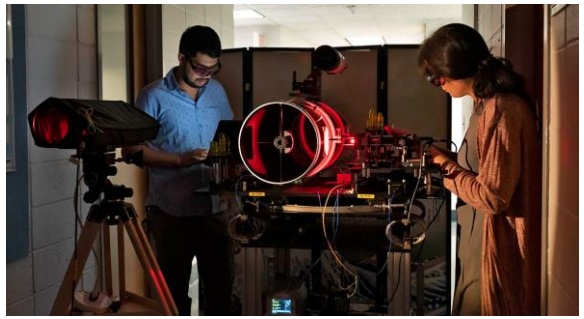
*NASA Space Radiation Laboratory (NSRL) at BNL.*

*Single Event Upset Test Facility at BNL's Tandem van de Graff accelerator.*

*BNL's ATF is the only laser facility in the world operating with a picosecond-and terawatt-class CO2 laser in the Chirped Pulse Amplification (CPA) regime.*

*National Synchrotron Light Source II (NSLS-II) at BNL.*

*Center for Functional Nanomaterial (CFN) at BNL.*

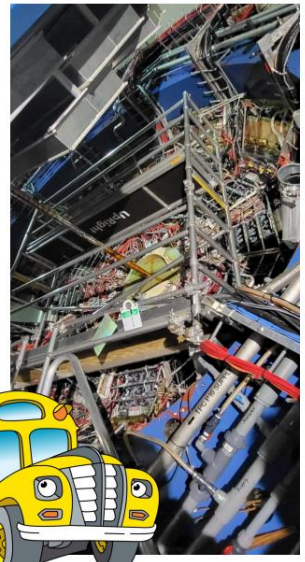


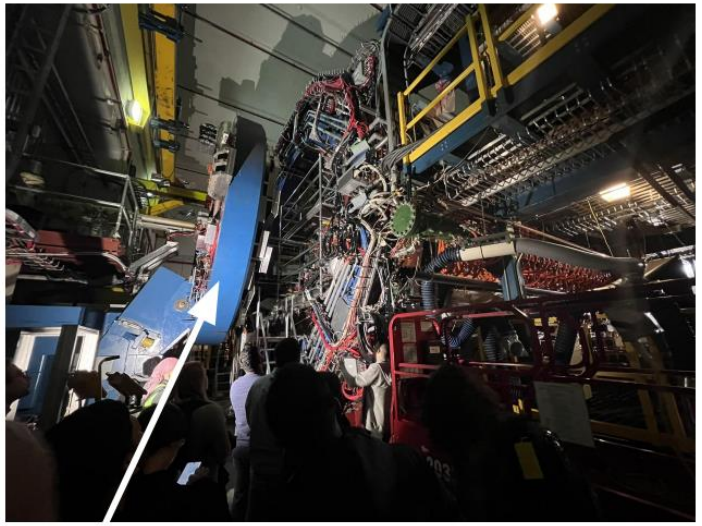
*Free-space optical ilnk as part of the Quantum Network Facility at BNL.*

*RHIC-ATLAS Computing Facility as part of the BNL Scientific Data and Computing Center.*

# Tours
# Students feedback

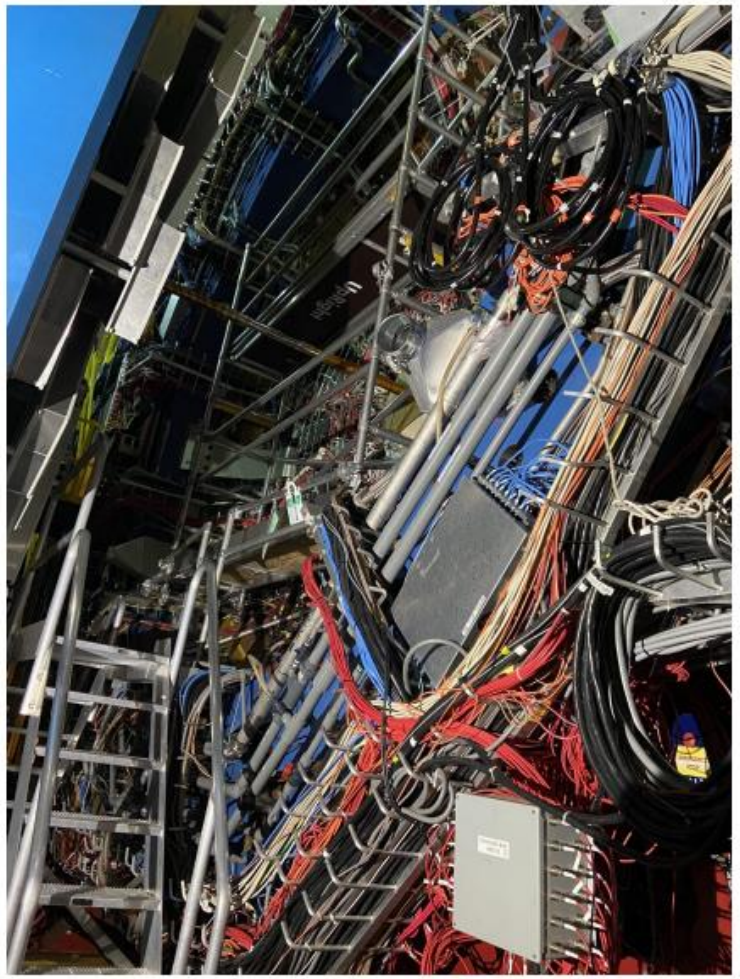
Awesome particle detectors!



TOF (left) and Central Barrel Detector.

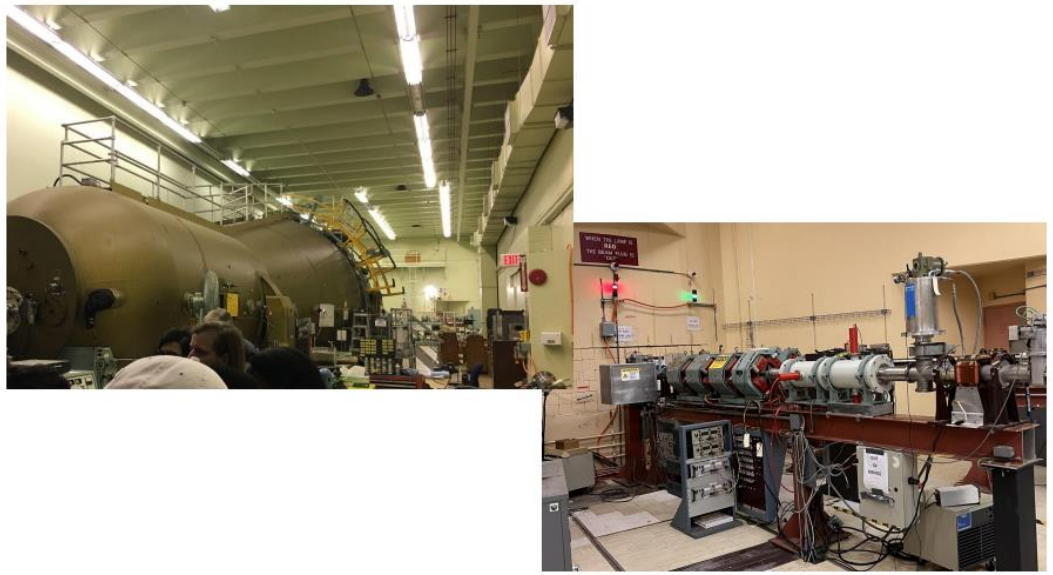
I cannot be on top of the world but surely was on top of STAR :)



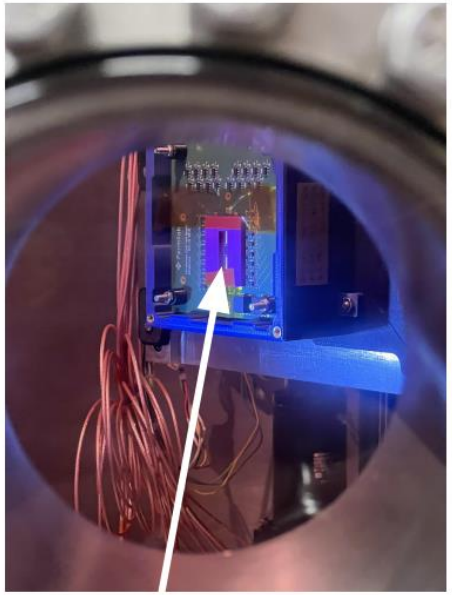
STAR experiment

# Tours – students feedback

## Facility Tour - Tandem



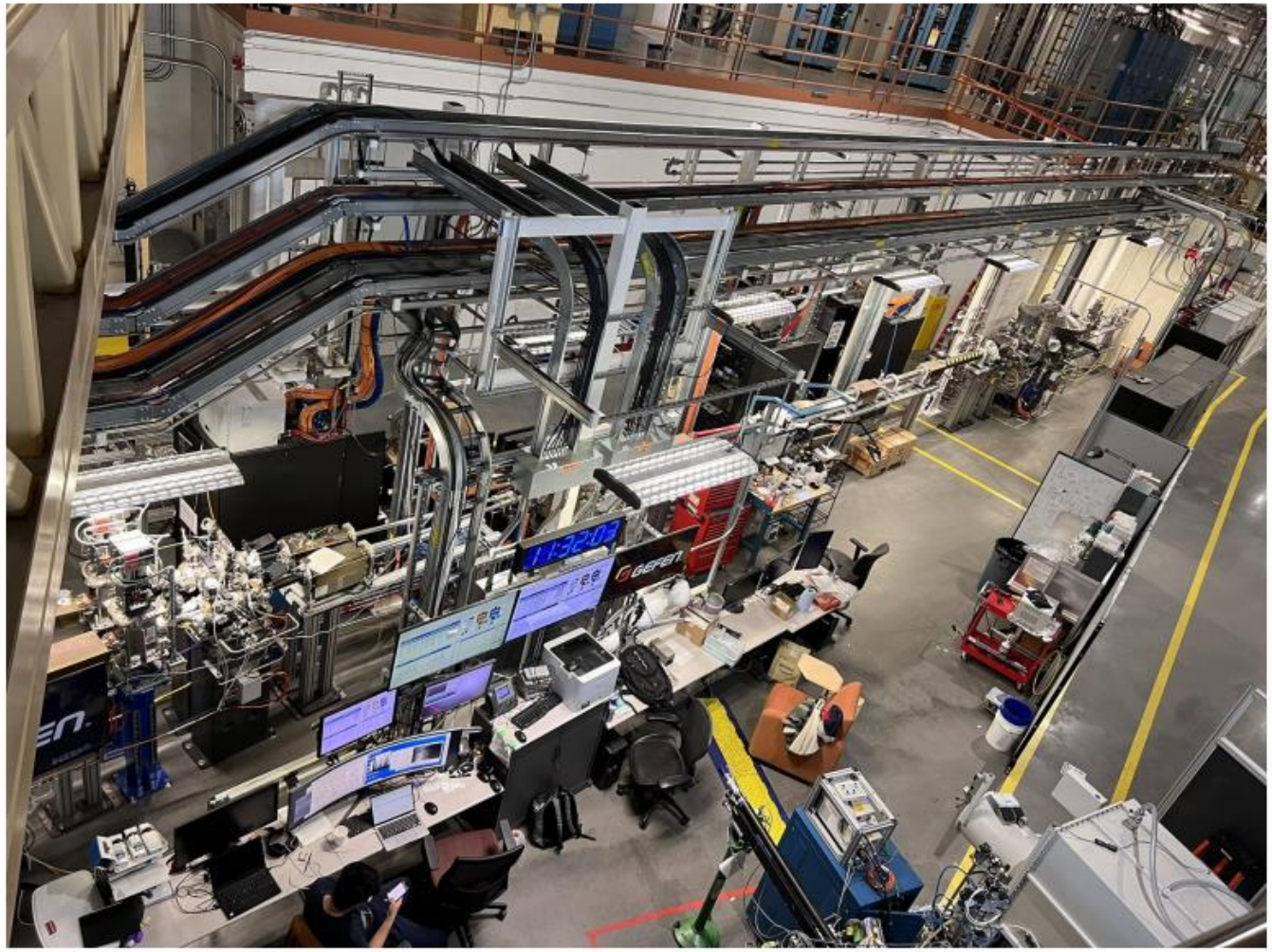
Beam pipe from Tandem Van-de graaff accelerator with proton beam.



Testing of AC-LGAD detector with proton beam at Tandem

# Tours – students feedback

Facility Tour - NSLS-II

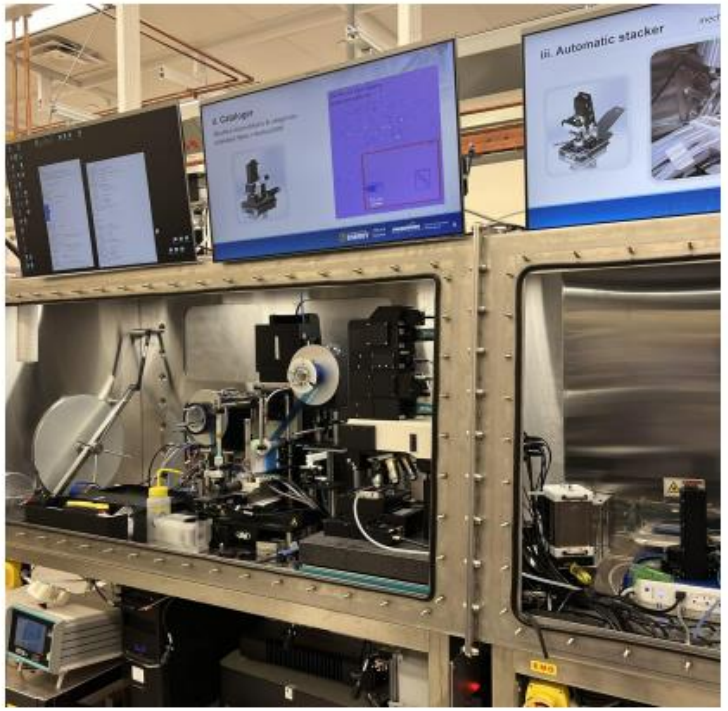



Synchrotron X-ray beam from 3 GeV electron beam used for different scientific study.

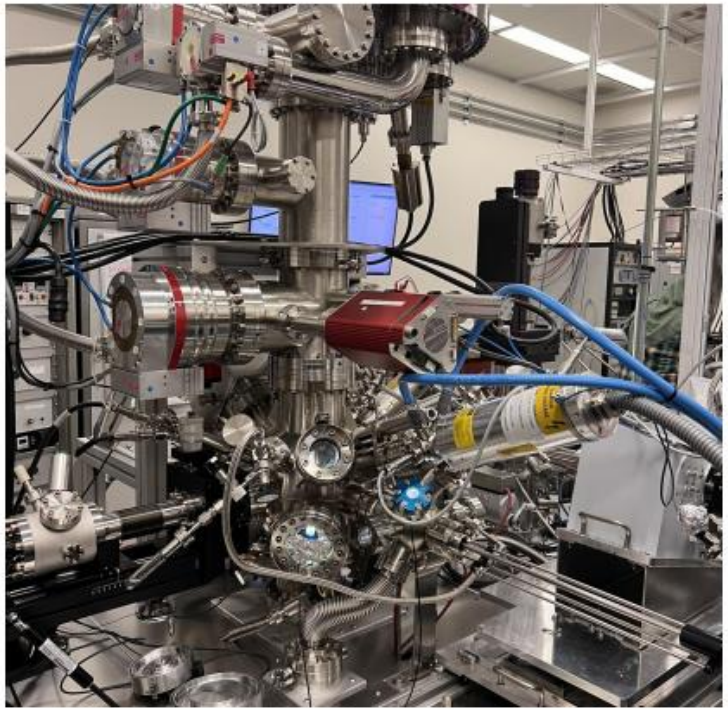
# Tours – students feedback

## Tour to CFN


1 Million $ fsec (psec at back) laser setup for study like quantum dots.




Automatic single surface (2D layer) production on a substrate ( Quantum Press )



Xray-Fluorosence Electron Spectroscopy to detect elements upto 1-2 thin nano surface.

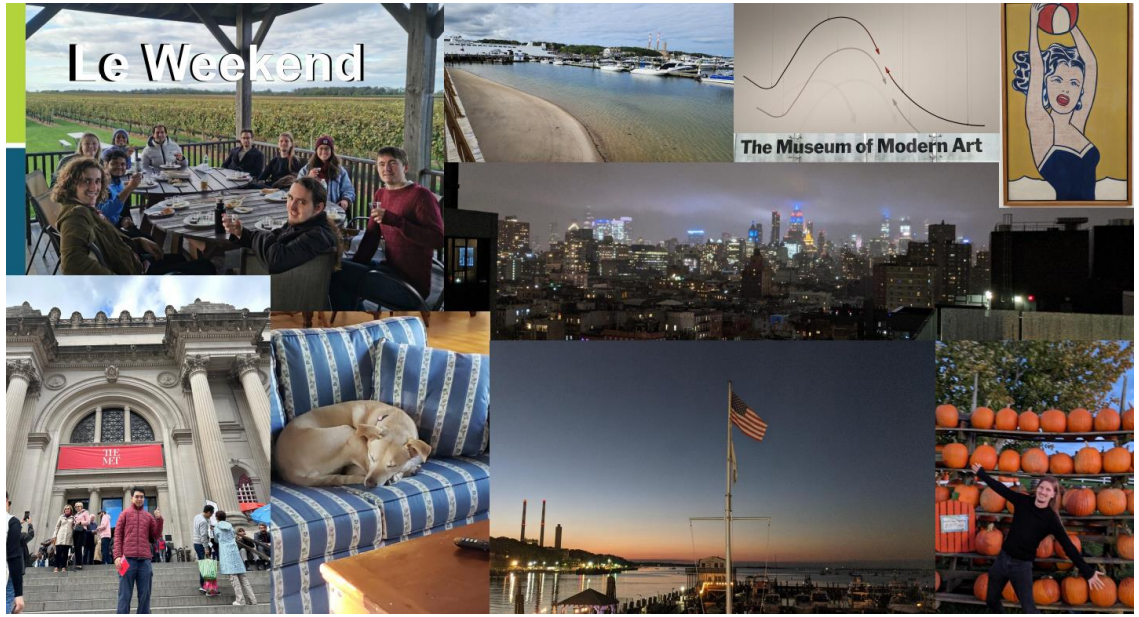
# Recreation & Weekends in NYC and Long Island

Instrumentation Division lobby

Manhattan, New York City

Long Island hiking trails and beaches

# Recreation & Weekends – students feedback



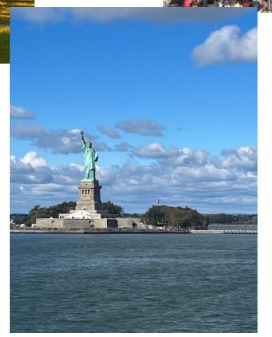

…and the weekend!

Oyster Fest in Oyster Bay

## Weekend Activities

Visiting Pindar Vineyards

Oyster Fest in Oyster Bay, NY

Visiting NYC-liberty statue

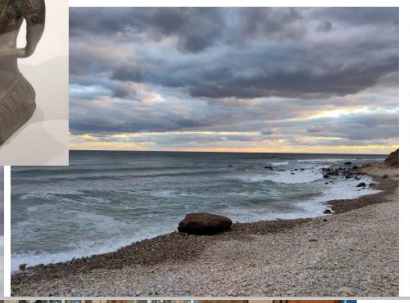
New York + North Fork

# Recreation & Weekends students feedback

Weekend Shenanigans





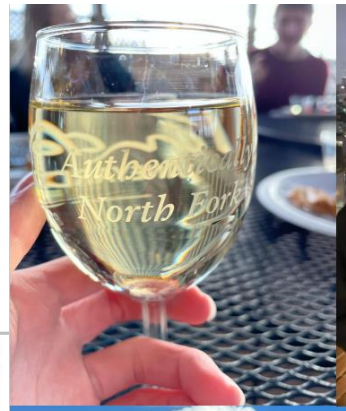



Social Dinner(s)



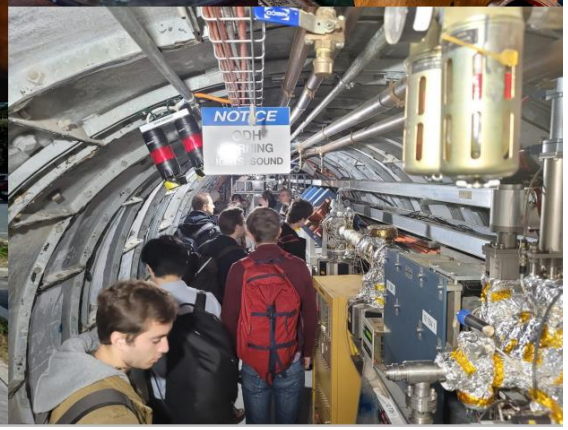




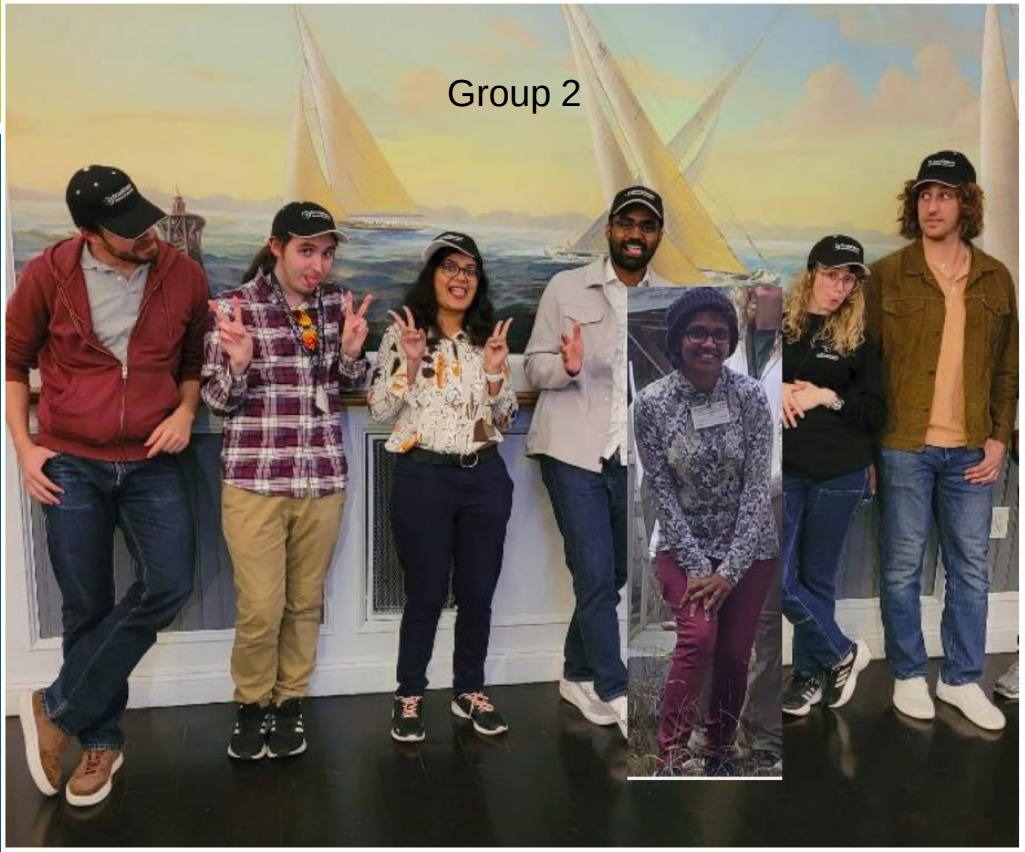




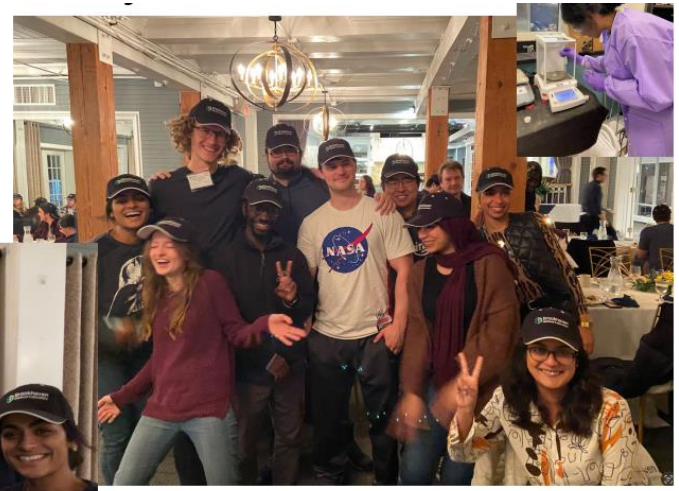




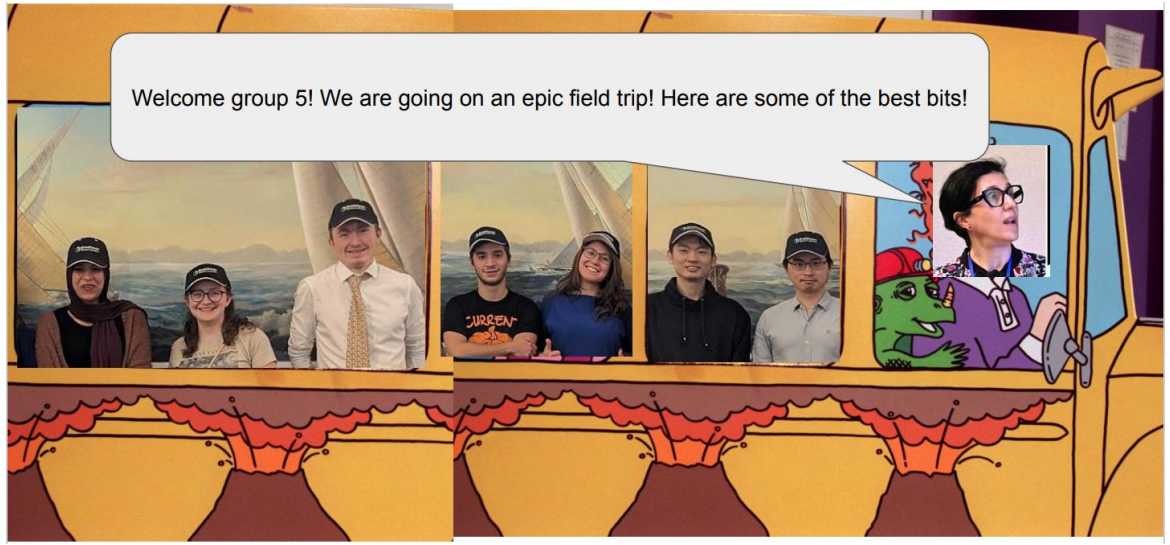
# Statistics – 48 participants

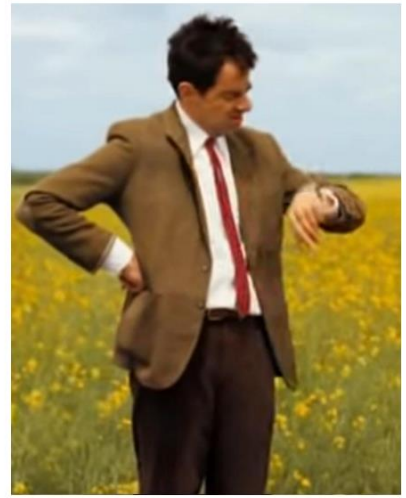

Group 3

# Statistics – 48 participants



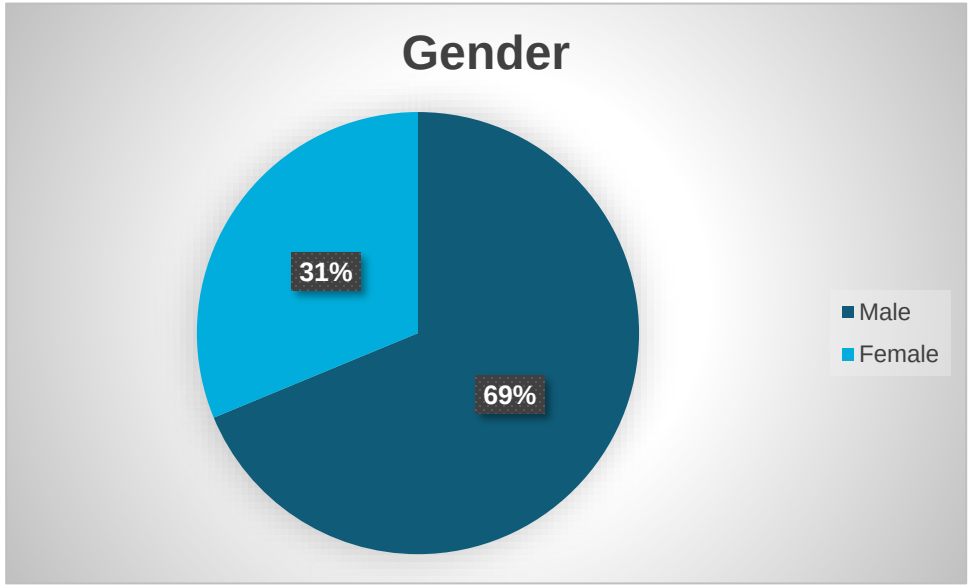

Group - 6 taking pictures at 6 pm

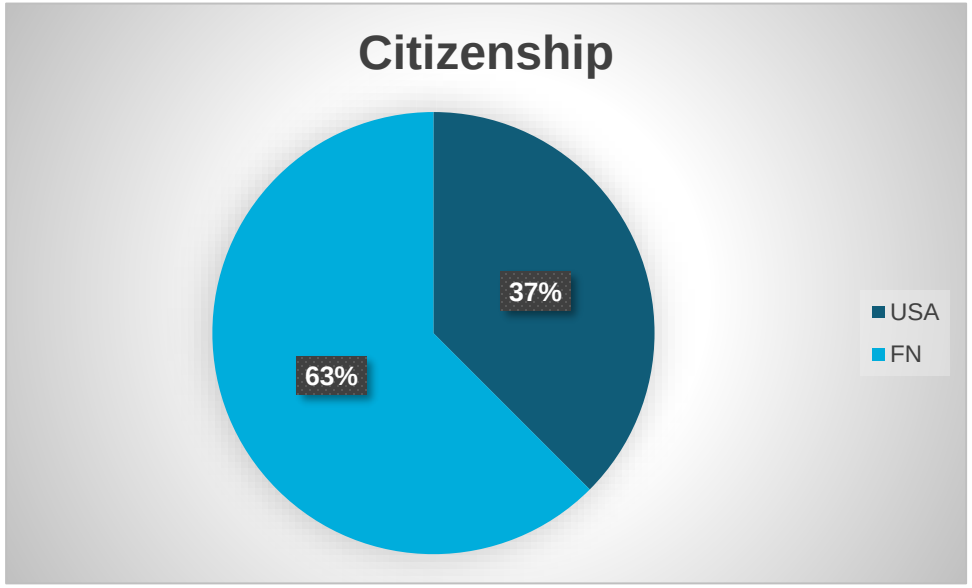


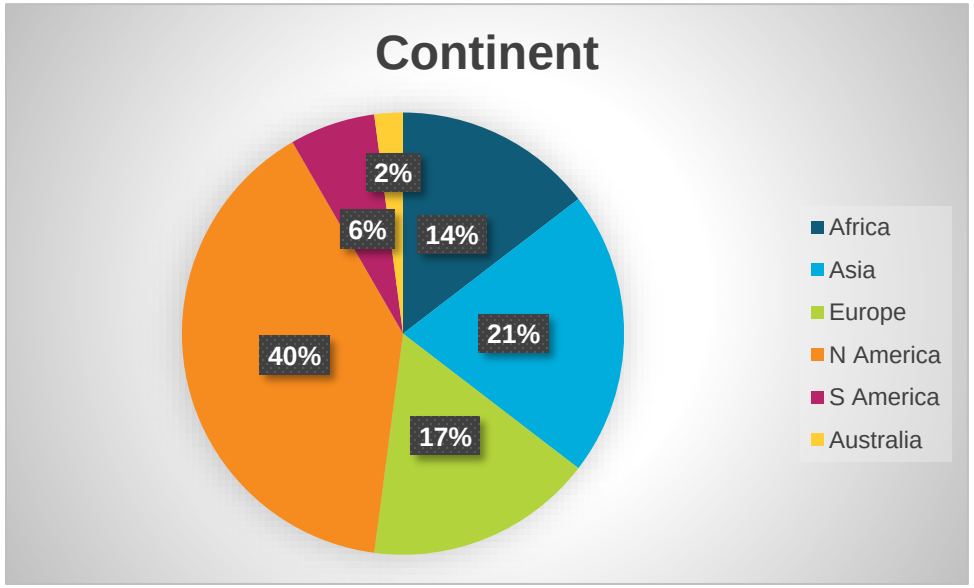
Meanwhile Michael

Thank You!


# Statistics – 48 participants



# Our people – EDIT school BNL engagement

Gabriella Carini & Michael Begel - Organizers
Sara Capp - Logistics
Matthew Rumore – Safety
Ann Emrick, Chris Otto - Operation
Krysten Noren – Tour protocol

**Silicon/Semiconductors**
Gabriele Giacomini, Abdul Rumaiz , Alessandro Tricoli, Francesca Capocasa, Gabriele D'Amen, Wei Chen

**Microelectronics/ASICs**
Grzegorz Deptuch, Soumyajit Mandal, Prashansa Mukim, Arif Iqbal

**Readout/DAQ**
Piotr Maj, Dominick Gorni

**Liquid Argon**
Yichen Li, Shanshan Gao, Haiwang Yu, Chao Zhang, Eric Raguzin

**Liquid scintillators**
Minfang Yeh, Milind Diwan, Richard Rosero, Guang Yang

**Radio Astronomy**
Benjamin Saliwanchik,William Tyndall (Yale U), Paul O'Connor, Justine Haupt

**QIST**
Paul Stankus, Julian Martinez-Rincon, Joanna Zajac, Justine Haupt

**Integration**
Joe Pinz, Antonio Verderosa, Tim Kersten

**The one and only Sara Capp**

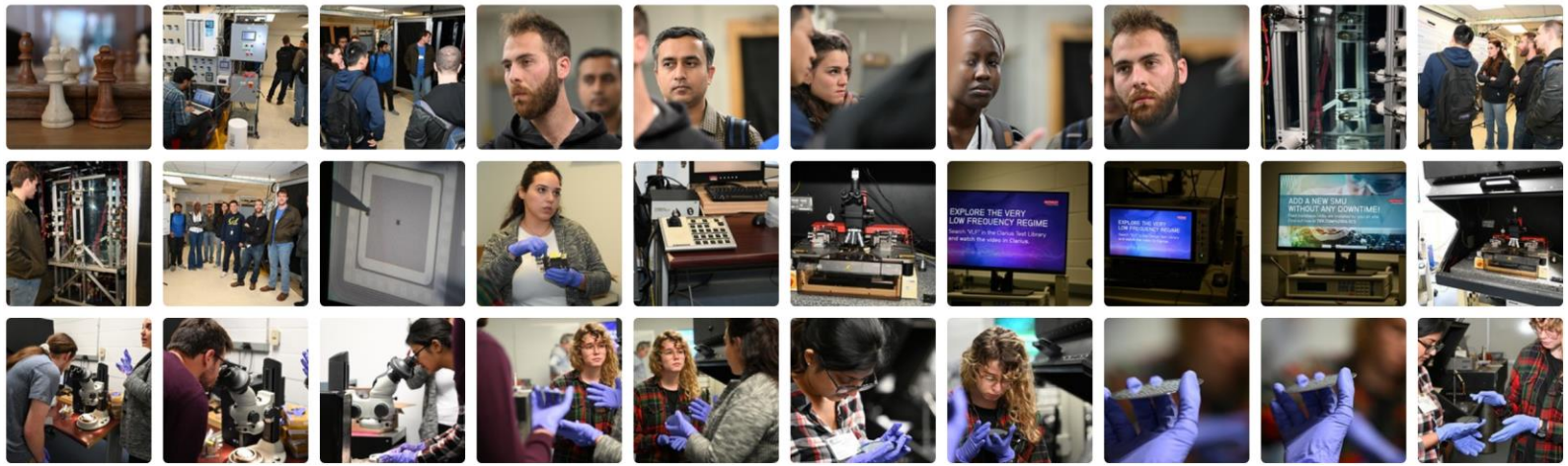
…and many more that were too busy to reply to the headcount request!

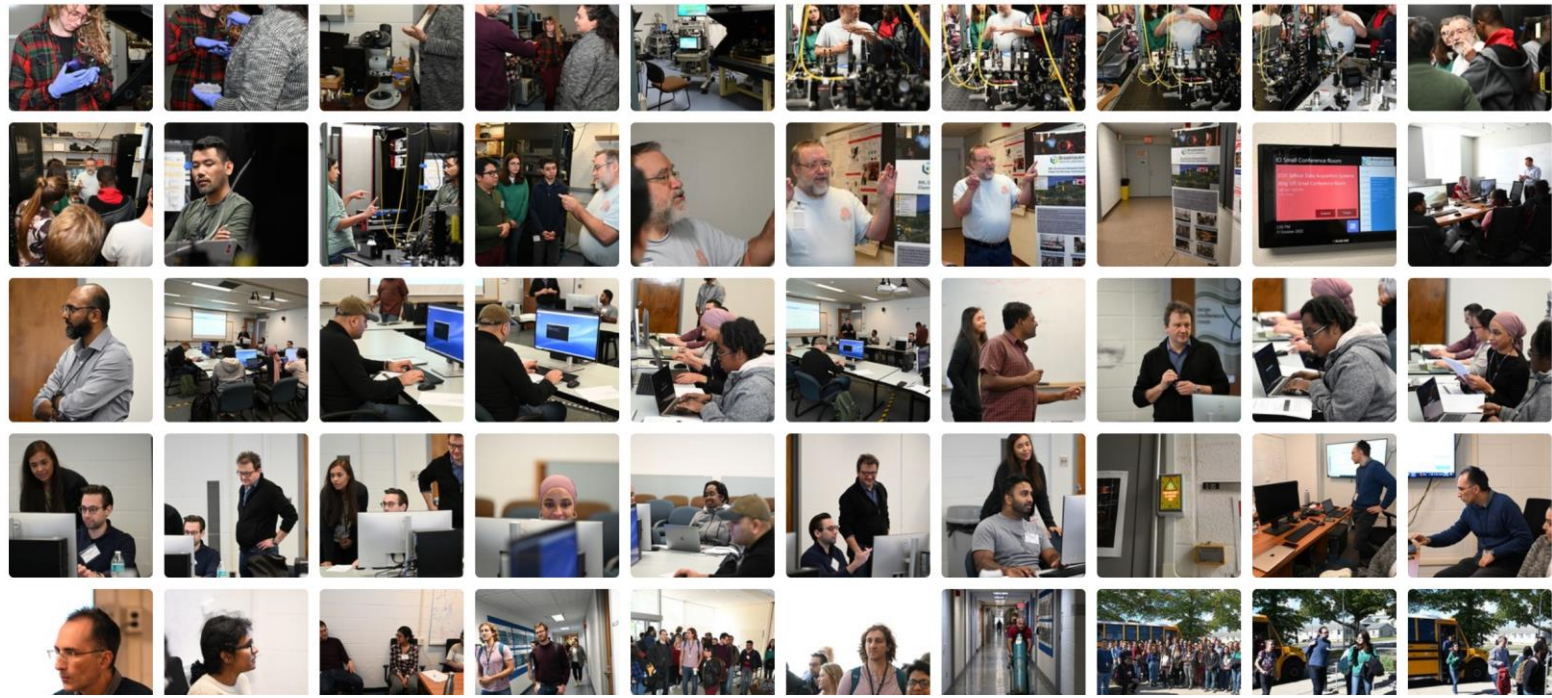

We made it!
Thanks for
listening
Brookhaven
ational Laboratory


Thank You
Brookhaven
National Laboratory

2023-10-16


2023-10-11



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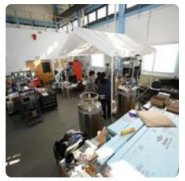
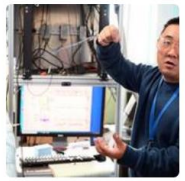
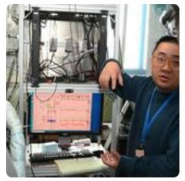
2023-10-10



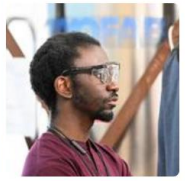












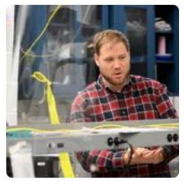




































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