**IBM Quantum**

# 2022 Quantum Error Correction Summer School

Student Guide

# About

We are excited to welcome you to the 2022 Quantum Error Correction (QEC) Summer School!

In just a few weeks, you will join the next generation of QEC researchers to participate in a series of mini-courses on foundational topics and the latest theoretical and experimental results, taught by expert leaders in the field of QEC.

Our aim is to give you a working knowledge of QEC and share the latest results in the field. You will get the chance to contribute to cutting-edge research that will benefit the quantum computing industry and the world.

The school is designed to be very interactive and provide many opportunities for all participants, students, lecturers, and guests to interact and start or continue research partnerships. We strongly encourage you to take full advantage of these opportunities while at the school.

# Updates and Staying Connected

## Online Syllabus

We encourage you to use this guide as your resource for all the information needed for the Quantum Error Correction Summer School. However, as we may have schedule updates, added speakers, social event news, etc. as the school progresses, we've also created this online Syllabus for you to download the latest Student Guide and view the most recent updates. Please make sure to bookmark this page and check back for news.

## Slack Channel

A private Slack Channel on the Qiskit Workspace has been created for you to connect with our organizing team and other students ahead of the school start date with any questions you might have. Please click here to join the Qiskit Workspace and message @anamaria once you've joined to be added to the private Slack channel.

## Pre-Summer School Call

We will be hosting a virtual call ahead of the summer school for you to meet some of the organizing team for a review of the school schedule, what to expect on your first day, and to answer any questions you may have. We will be sending calendar invites via email and the call will be recorded for those who are unable to attend live.

   Date: Wednesday, July 15 at 9:15AM EDT                LINK TO JOIN

## Questions?

Please email qiskit.events@us.ibm.com with any questions or post them in the dedicated Slack Channel once you have access.

# Code of Conduct

IBM and the QEC Summer School are dedicated to our values of treating every individual with respect and dignity. In the interest of fostering an open and welcoming environment, all participants, including attendees, speakers, sponsors, volunteers, online contributors, and IBM employees are expected to show courtesy for each other and our community by creating a harassment-free experience for everyone, regardless of age, personal appearance, disability, ethnicity, gender identity and expression, body size, level of experience, nationality, race, religion, caste, or sexual identity and orientation. Expected behavior applies to both online and offline engagement within the community.

**Read our full [Code of Conduct](#)**.

**QEC Summer School Event Values**

- Be Engaged: Connect with each other & have FUN!
- Be Inclusive: Use shared language, be empathetic, & be aware of different cultures and backgrounds
- Be Respectful: Respect each other, & use respectful language
- Be Positive: Assume the best intentions, & have forward-looking outlook
- Be You!!! Share about yourself and your goals, be real, be genuine, & let yourself be comfortable

Throughout the summer school, if you encounter any offensive behavior or violations of the Code of Conduct, we encourage you to report the violation by submitting [this form](#). All reports are treated with the strictest level of confidentiality, and we have an absolute zero-tolerance policy on any form of retaliation.

The organizing team and admins are all here to support the event and community - so please feel comfortable reaching out directly with any questions, concerns, or reports as well. See the [Meet the Organizing Team](#) section for contacts.

This community continues to be open, friendly, and welcoming, and with your support, we will be able to maintain that throughout this summer school, and in the years to come. Thank you!

# Health and Safety

The QEC Summer School will follow COVID-19 guidelines implemented by IBM, as well as all venue, city, and state guidelines.

Below are the current guidelines, which may be updated at any time by IBM and local authorities:

- All participants must be fully vaccinated, and we highly encourage being up to date on any booster vaccines for COVID-19 (per CDC, with vaccines approved by the CDC or WHO).
- Participants flying internationally must comply with all U.S. laws and regulations for individuals entering the United States.
- Mask requirements will reflect county/local guidelines at the time of the event. For further information please click here.
- COVID-19 tests will be available on-site.
- Social distancing (6 feet) and frequent hand washing are highly encouraged.
- The venue will have enhanced cleaning, ventilation, and other building protocols.
- Participants are encouraged to conduct daily health screening and to isolate themselves at the hotel if feeling unwell or experiencing any symptoms. At any given time, there may be colds, flu and COVID-19 variants circulating, so it's important not to expose others when you have any symptoms or are feeling unwell.
- Required medical exceptions will be accommodated. Please contact qiskit.events@us.ibm.com for special accommodation requests.

**We will provide color-coded wristbands on your first day for you to indicate your social distancing levels.**

**Red = Keep your distance**          **Yellow = Elbows & fist bumps welcome**          **Green = Come on over!**

# Schedule

Each week will feature advanced lectures, Q&A sessions, invited guest talks, student talks, problem sessions, and social activities. The days will be intensive, but we truly believe we have created an enriching and well-rounded course that will introduce you to internationally renowned QEC researchers and enable you to be a leader in the QEC field.

Please click here to jump to the end of the document for the full schedule.

## Weekly Topics

| Week 1 | Week 2 | Week 3 | Week 4 |
|---|---|---|---|
| QEC Foundations | Fault Tolerance – Logistical Gates | QEC Decoding | LDPC Codes |
| Bosonic Code Foundations | Experimental QEC – Bosonic Codes | Experimental QEC – Trapped Ions | Experimental QEC – Superconducting Qubits |
| Programming QEC Decoders | Programming QEC Decoders | Programming QEC Simulations | Programming QEC Simulations |

## *Activities / Sessions

**Lectures** – In depth overview of the weekly topics.

**Unstructured Time** – Open time for you to use as needed to catch up on studies, relax, collaborate with other students or mentors, etc.

**Student Talks** – Short student research talks. Sign up here.

**Guest Lectures** – Invited talks from various leading QEC researchers, followed by social time to chat with them.

**Q&A Sessions** – Optional time for you to ask the lecturer questions regarding that morning's lecture.

**Open Problems** – Review and discuss open problems for the lecturer's topics.

**Crazy Ideas** – An interactive session for people to present research ideas & crazy ideas in a short format.

**Social Time / Events** – Optional social activities for you to make the most out of your time at Tarrytown! More details will be provided as we get closer to the school.

*Please note all activities require your attendance, with the exception of the Q&A Sessions and the Social Time / Events, however we hope you will join in all activities!*

## Social Events

The IBM team is excited to put together social activities to ensure you're able to connect with other students, lecturers, and mentors. <u>All social events are optional</u>, but we hope you will join in as many as possible.

**July 4, 2022 @ 6:00PM**: Fourth of July BBQ on the West Terrace
> To celebrate the 4th of July and your arrival, we will be hosting a casual outdoor barbeque, weather permitting.

**July 7, 2022 @ 6:00PM**: Women in Quantum Social
> We are inviting locally based women working in the field of quantum to meet with all our students and enjoy hors d'oeuvres and refreshments for an evening of socializing and networking.

**July 14 @ 1:30PM**: IBM Yorktown Lab Visit
> Students will have the opportunity to head to the IBM Thomas J. Watson Research Center in Yorktown, New York, to see the center, take a tour of the labs, and meet with researchers.

**July 16 @ 1:00PM**: Hudson River Cruise
> Join us as we take an early afternoon cruise on the Hudson River!

**July 21 @ 6:00PM**: Diversity Panel
> Panel highlighting diverse leaders in QEC and quantum & sparking conversations on promoting a more diverse quantum community and workforce.

**July 23**: TBA Social Event

**July 28 @ 12:30PM**: IBM Research BBQ at Yorktown Campus *(Date TBC)*
> The IBM Research team has invited the QEC Summer School to join them in a summertime barbeque on campus!

**July 29**: TBA Social Event

**July 30**: TBA Social Event

Please continue to check the QEC Summer School Syllabus for the latest updates.

*\* Some social events may include alcoholic refreshments that will only be offered to attendees 21 years or older.*

Please note, on weekdays, mealtimes should be taken <u>according to the course schedule</u> to ensure you don't miss any of the required activities. For more details on meal offerings, please review the Meal section below.

| **Weekdays** *(with evening guest lecture)* | **Weekdays** *(without evening guest lecture)* | **Weekends** |
|---|---|---|
| Breakfast: 7:00AM – 8:55AM<br>Lunch: 12:30PM – 1:25PM<br>Dinner: 6:00PM – 6:55PM | Breakfast: 7:00AM – 8:55AM<br>Lunch: 12:30PM – 1:25PM<br>Dinner: 6:00PM – 9:00PM | Breakfast: 7:00AM – 9:30AM<br>Lunch: 12:00PM – 1:30PM<br>Dinner: 6:00PM – 9:00PM |

Beverages and light snacks will be offered in the Atrium Lobby daily from 8:00AM to 5:00PM.

# Meal Details

All meals, unless otherwise noted for social events, will take place in the Winter Palace room in the Biddle Mansion and served buffet-style. Weather permitting, you are welcome to take your plate or a take-out box and go sit outside on the West Terrace.

Breakfast: Hot Buffet Breakfast featuring omelets and waffles made to order.
Lunch: Full hot and cold lunch buffet with beverage service.
Dinner: Buffet featuring market fresh daily menus.

In addition to the full meals, coffee, teas, juices, sodas, infused waters, morning continental breakfast items / afternoon snacks, candies and fruit will be offered in the Atrium Lobby daily from 8:00AM to 5:00PM.

All special dietary requirements have been accounted for by the hotel and confirmed via the Student Guide email if submitted with your Student Travel Form. If a special dietary requirement was not mentioned in the email or you have additional comments/questions, please reach out to qiskit.events@us.ibm.com.

# Meet the Team

Members from this team will be on-site throughout the summer school to assist you with any in-person organizational questions or needs. We still encourage you to reach out to qiskit.events@us.ibm.com with any questions.

**Dr. Drew Vandeth**
Chair, Organizing Committee
IBM Quantum
dsvandet@us.ibm.com

**Dr. Andrew Cross**
Organizing Committee
IBM Quantum
awcross@us.ibm.com

**Dr. Tomas Jochym-O'Connor**
Organizing Committee
IBM Quantum
tjoc@ibm.com

**Anamaria Rojas**
Community Event Manager
IBM Quantum
anamaria@ibm.com

**Josiane Emorine**
Program Manager, Key Events
IBM Quantum
emorine@us.ibm.com

**Kallie Ferguson**
Community Management Lead
IBM Quantum
kallie.ferguson@ibm.com

## QEC Summer School Organizing Committee

| Nikolas Breuckmann<br>University College London | Dr. Andrew Cross<br>IBM Quantum | Shruti Puri<br>Yale University |
|---|---|---|
| Ben Brown<br>IBM Quantum | Yvonne Y. Gao<br>University of Singapore | Barbara Terhal<br>Delft University |
| Ken Brown<br>Duke University | Dr. Tomas Jochym-O'Connor<br>IBM Quantum | Dr. Drew Vandeth<br>IBM Quantum |

## Lecturers

| **QEC – Foundations**<br>Steve Flammia, AWS | **Bosonic Codes – Foundations**<br>Shruti Puri, Yale University<br>Arne Grimsmo, AWS | **Fault Tolerance – Logical Gates**<br>Ben Brown, IBM Quantum<br>Daniel Litinski, PsiQuantum |
|---|---|---|
| **Decoding – Current Directions**<br>Christopher Chubb, ETH Zurich<br>Earl Campbell, Riverlane | **LDPC Codes – Current Directions**<br>Nikolas Breuckmann, UCL<br>Nicolas Delfosse, Microsoft | **Experimental QEC –<br>Superconducting Qubits**<br>Maika Takita, IBM Quantum<br>Antonio Córcoles, IBM Quantum<br>Andreas Wallraff, ETH Zurich |
| **Experimental QEC – Bosonic Codes**<br>Michel Devoret, Yale University<br>Alex Eickbusch, Yale University<br>Vladimir Sivak, Yale University | **Experimental QEC – Trapped Ions**<br>Ken Brown, Duke University<br>Ciaran Ryan-Anderson, Quantinuum | **Programming Decoders**<br>James Wootton, IBM Quantum<br>**Programming QEC Simulations**<br>Andrew Cross, IBM Quantum |

## Invited Speakers

| Dan Gottesman | Sergey Bravyi | Liang Jiang | Chen Wang | Leo DiCarlo |
|---|---|---|---|---|
| University of Maryland | IBM Quantum | University of Chicago | UMass Amherst | TU Delft |
| **Aleksander Kubica** | **Michael Vasmer** | **Anirudh Krishna** | **Guanyu Zhu** | **Ted Yoder** |
| AWS | Perimeter Institute | Stanford University | IBM Quantum | IBM Quantum |

*More speakers may be announced, please check the QEC Summer School event page for the latest details.*

# Resources & Recommended Reading

We strongly recommend you review the below resources and readings prior to the start of the QEC Summer School.

## Software Packages

- Python 3.6 or later
- Jupyter Notebook
- Qiskit
- Suggested Tool: Anaconda

To install Qiskit, you can follow the instructions provided here or watch this video.

## Qiskit Resources

- Qiskit Textbook
- Contributing to Qiskit (required for code contributions!)
- Qiskit Tutorials
- Qiskit Runtime Overview

## Recommended Introductory References

- Introduction to Quantum Error Correction via the Repetition Code
- Measurement Error Mitigation
- Quantum Error Correction: An Introductory Guide
- An Introduction to Quantum Error Correction and Fault-Tolerant Quantum Computation
- Steve Girvin - Introduction to Quantum Error Correction [Video]
- Chapter 10 of Nielsen and Chuang, *Quantum Computation and Quantum Information*

# Location and Weather

The 2022 IBM Quantum Error Correction Summer School will take place in person at the Tarrytown House Estate in Tarrytown, New York, United States of America.

## About the Area

As we continue to plan social events for the QEC Summer School, we will make sure to incorporate activities in the local area for you to make the most of your experience while at Tarrytown. However, we encourage you to explore the area independently as your free time allows.

The Tarrytown House Estate rests on the eastern bank of the Hudson River, at the southernmost point of Tarrytown, in Westchester County, New York. Steeped in history and old-world charm, Tarrytown strikes a perfect balance between nature and culture. On your time off, you can enjoy outdoor activities such as walking, hiking, and biking; browse the village's many fine shops, stores, and emporiums; and visit storied attractions, including the homes of prominent residents like Washington Irving and the Rockefeller family. If you're looking to venture further, you can take a quick trip to Manhattan by car or train.

Learn more about the area.

## Weather

July in Tarrytown, NY has an average daily high temperature of around 82°F/27.8°C and a low of 63°F/17.2°C and it is sunny about 60% of the time. The relative humidity for New York in July fluctuates between 52% (mildly humid) and 91% (very humid), rarely falling below 35% (comfortable) or reaching as high as 100% (very humid).

We recommend you pack accordingly for hot outdoor and cooler indoor temperatures with air conditioning.

# Accommodations and Amenities

## Tarrytown House Estate

Just 25 miles from Midtown Manhattan in New York's exclusive Westchester County, this hotel blends historical charm with modern conveniences in this spectacular Lower Hudson Valley lodging and meeting facility.

Located on 26-acres overlooking the Hudson River Valley, Tarrytown House Estate on the Hudson features impressive 19th-century mansions, a carriage house and a cottage, as well a contemporary atrium-style building that houses conference facilities and guest rooms. Learn more about the Tarrytown House Estate.

## Guestrooms and Amenities

All participants will be staying in single guestrooms with either two double beds or one king bed. *Room preference to be provided based on availability.*

        Check-In: Monday, July 4, 2022 @ 4:00PM
        Check-Out: Sunday, July 31, 2022 @ 11:00AM

*If you arrive before check-in time or depart after check-out time, you will be able to leave your bags with the front desk.*

**Guestroom Amenities**

| Free Wi-Fi | Work Desk and Chair | HD TV with Cable | Refrigerator |
|---|---|---|---|
| Housekeeping | Hair Dryer | Bathroom Toiletries | Room Service (*additional cost*) |

**Venue Amenities**

| Fitness Center | Outdoor Pool | Tennis, Basketball, Volleyball Courts | Bocce Ball and Horseshoes | Jogging and Bike Trails |
|---|---|---|---|---|

## Additional Guests

Attendees are permitted to have additional guests stay with them during the summer school. The Organizing Team must be notified of any guests sharing your room prior to the start of the school via email at qiskit.events@us.ibm.com. Please note, guests are not permitted to attend summer school events without written approval by IBM.

## Laundry

The Tarrytown House Estate recently reinstated their laundry services, and these will be available for you to use during your stay in July. Additional details will be shared prior to your arrival.

# Ground Transportation

## Arrival Times on July 4th

As a reminder, we will have a 4th of July Barbeque at 6:00PM to celebrate your arrival and the holiday!

If you are flying in on July 4th, your arrival time at the venue will be determined by your flight arrival time and transfer time between the airport and the venue. If you arrive before check-in time (3:00PM), you will be able to leave your bags with the front desk.

If you're arriving by train or car, please plan to be at the Tarrytown House Estate between 2:30PM and 6:00PM on July 4th.

If you need to arrive earlier or later by train on July 4th, please reach out to us at qiskit.events@us.ibm.com by June 27th for assistance with transportation from the Tarrytown Train Station.

## Personal Vehicles

Participants are allowed to bring their own vehicles to the property, but you must inform the team by emailing qiskit.events@us.ibm.com. Please note there is no charge for self-parking, but please make sure to park in the designated parking lots listed in the Property Maps section.

## Ground Transportation from Airport

Ground transportation will be provided and arranged by IBM for all students arriving at local airports on July 4th (JFK, LGA, EWR, HPN).

You will receive a separate email with ground transfer details (and confirmation of your pick-up time and location) no later than Wednesday, June 22nd.

## Getting to Tarrytown House Estate from NYC

If you are traveling by train to New York City, or arriving in the New York area prior to July 4th, we recommend you travel to Tarrytown on July 4th via the Metro-North Railroad. It is the fastest and easiest way to get to the venue.

IBM will reimburse the cost of a one-way Metro-North Railroad ticket from Grand Central Station in New York City to the Tarrytown Train Station, or the equivalent cost for a different departing station, for all those arriving on July 4th.

**One-Way Ticket Fare from Grand Central Station to Tarrytown Station**: $11.25 (Off-Peak/Holiday Ticket Price)

**Metro-North Railroad Timetable for July 4th** *(We recommend arriving between 2:30PM and 6:00PM)*

| Grand Central Departure Time | 1:20PM | 1:45PM | 1:49PM | 2:20PM | 2:45PM | 2:49PM | 3:20PM | 3:45PM | 3:49PM | 4:20PM | 4:45PM | 4:51PM | 5:15PM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tarrytown Arrival Time | 2:14PM | 2:24PM | 2:39PM | 3:14PM | 3:24PM | 3:39PM | 4:14PM | 4:24PM | 4:39PM | 5:14PM | 5:24PM | 5:43PM | 5:54PM |
| *Hotel Shuttle Departure Time | 2:30PM | | | 3:30PM | | | 4:30PM | | | 5:30PM | | 6:00PM | |

\* IBM will provide a shuttle service from the Tarrytown Train Station to the Tarrytown Estate at the times listed in the above table. If you need to arrive earlier or later by train on July 4th, please reach out to us at qiskit.events@us.ibm.com before June 27th for assistance with transportation from the Tarrytown Train Station.

## Departing on July 31st

We will coordinate rides back to local airports and the Tarrytown Train Station on July 31st and will provide schedule information as we get closer to the date.

If you have any questions regarding local transportation, please email qiskit.events@us.ibm.com.

# What to Bring

We will provide basics like notepads and pens, but as with any school, we strongly recommend you bring all the necessary items to assist with your studies and work. We have listed a few below, but recommend you plan thoroughly to ensure you have all the necessary materials.

Please note, underline having a laptop is a requirement for the Summer School. Limited opportunities will be provided to go to local convenience stores and pharmacies if any last-minute item is needed.

**Technology**
Laptop & Charger      Converter to US Electrical Outlets      Backpack
Notebooks      Pens/Pencils      Headphones

**Basics**
Clothing for at least 1-2 weeks (Laundry services to be provided)      Standard Everyday Toiletries
Sunblock      Sunglasses
Face Mask      * Cash or credit cards
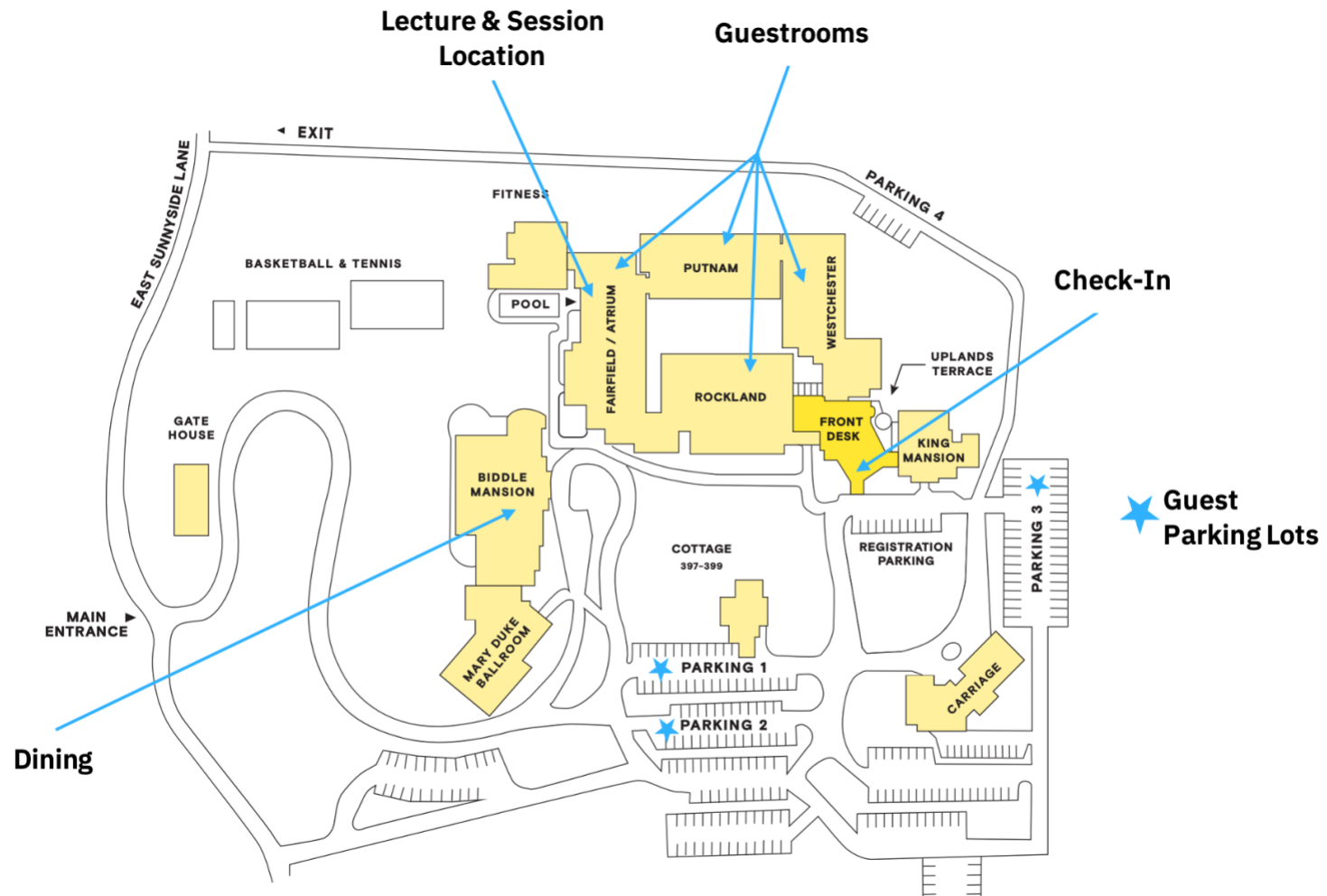
**\*\* Optional**
Sportswear + Sneakers      Hiking Clothing + Boots
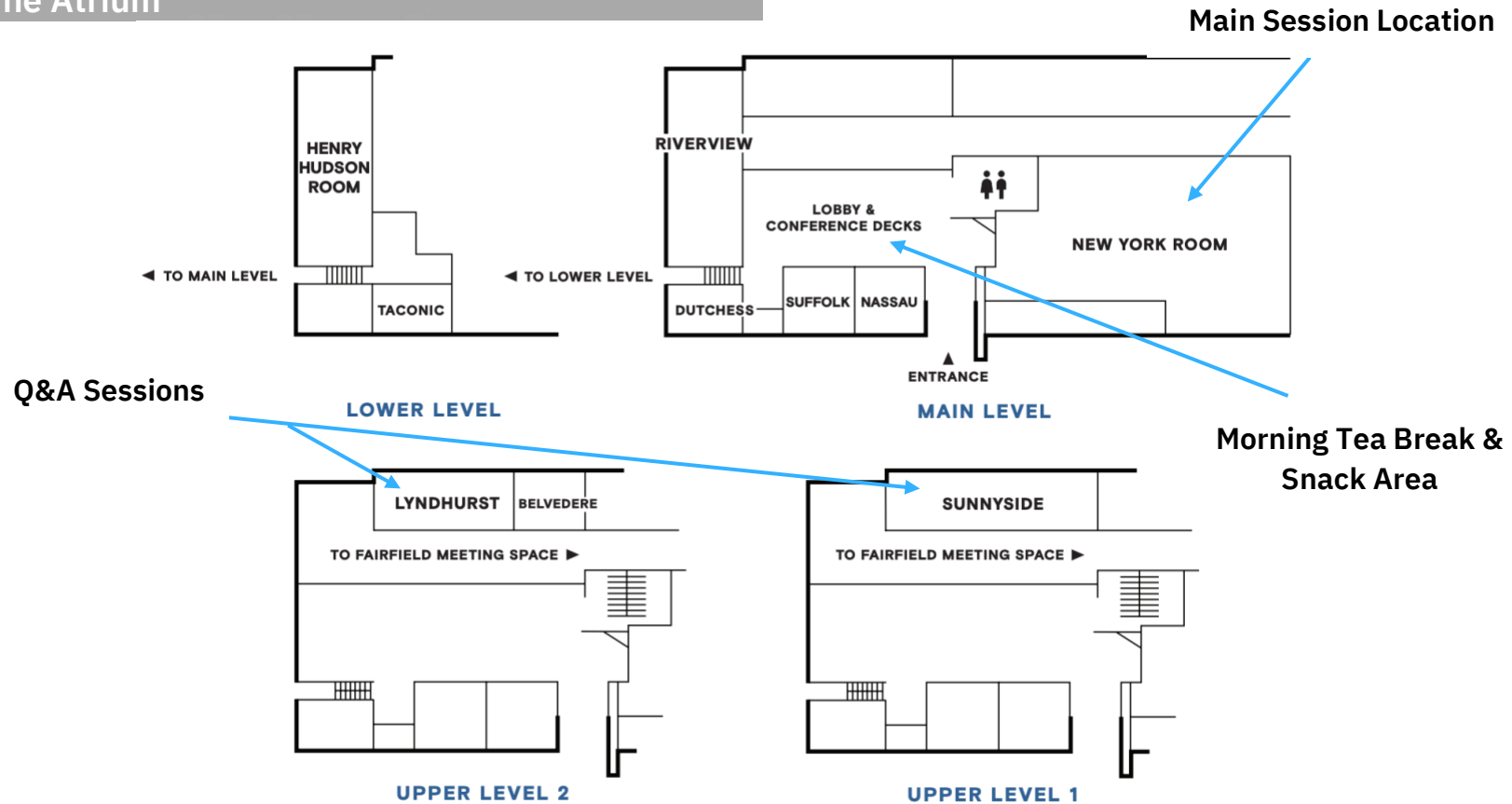Swimwear + Sandals      Water Bottle

*\* Bring USD if you want to purchase things around town. There are no currency exchange services available at the Tarrytown House Estate.*

*\*\* These items are recommended for the social events or if using Venue Amenities such as the pool or fitness center.*

# Property Maps

## The Atrium



**Main Session Location**

**Q&A Sessions**

**Morning Tea Break & Snack Area**

HENRY HUDSON ROOM

◄ TO MAIN LEVEL

TACONIC

**LOWER LEVEL**

RIVERVIEW

◄ TO LOWER LEVEL

LOBBY & CONFERENCE DECKS

NEW YORK ROOM

DUTCHESS   SUFFOLK   NASSAU

▲ ENTRANCE

**MAIN LEVEL**

LYNDHURST   BELVEDERE

TO FAIRFIELD MEETING SPACE ►

**UPPER LEVEL 2**

SUNNYSIDE

TO FAIRFIELD MEETING SPACE ►

**UPPER LEVEL 1**

**New York Room**: Daily lectures, guest lectures, open problem sessions, student talks, and crazy ideas.

**Lyndhurst & Sunnyside**: Q&A Sessions

**Atrium Lobby**: Snacks, coffee/tea will be provided daily from 8:00AM to 5:00PM. This area can also be used as a casual hang-out area in between sessions or in the evenings.

**Riverview**: Room is set up exclusively for students to use for hack-time, working sessions, game-time, etc. Boardgames, whiteboards and notepads will be provided.

**All other labeled rooms**: Can be used for additional smaller and private working sessions.

## The Biddle Mansion

**Opening & Closing Dinners**

**Dining**

EAST TERRACE

WEST TERRACE

HUDSON RIVER

WINTER PALACE

TERRACE

MARY DUKE BALLROOM

IRVINGTON SUITE

GARDEN ROOM

SUN PORCH

LINDEN ROOM

LOBBY

LIBRARY

ENTRANCE

**MAIN FLOOR**
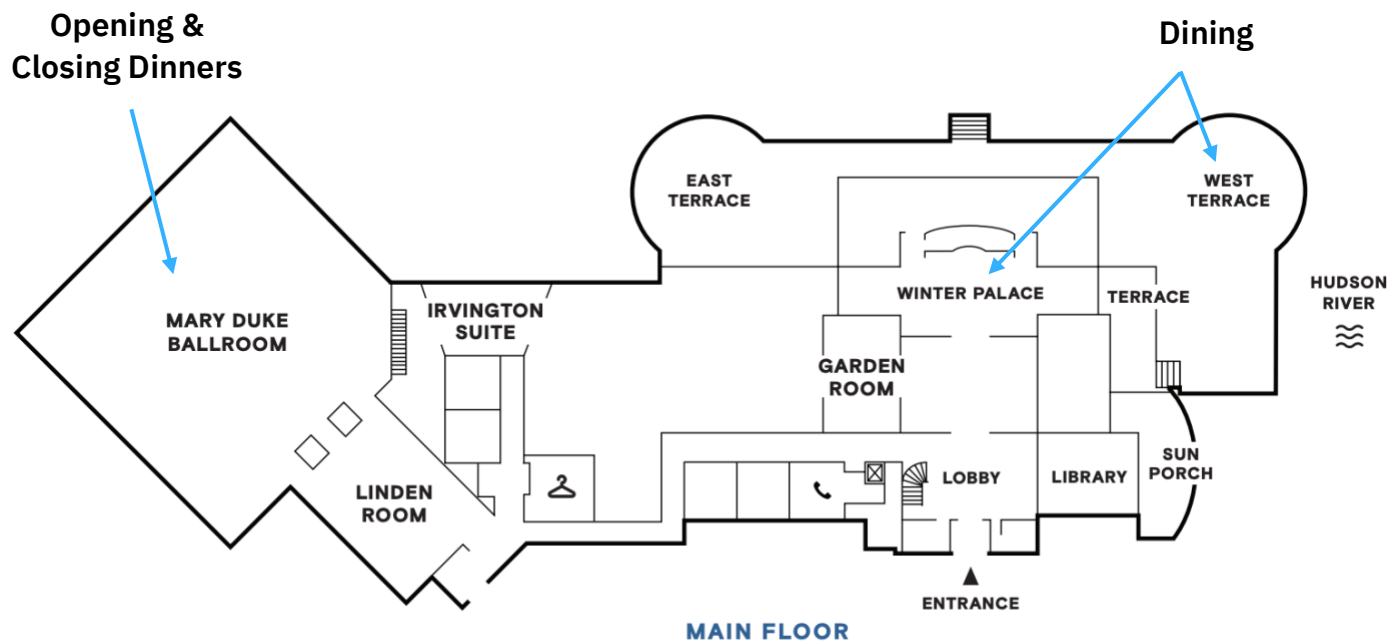
All daily meals, unless otherwise noted for social events, will take place in the Winter Palace room in the Biddle Mansion and served buffet-style. Weather permitting, you are welcome to take your plate or a take-out box and go sit outside on the West Terrace.

The opening & closing dinners will take place in the Mary Duke Ballroom.

Please check the Meal section for further details.

# Full QEC Summer School Schedule

Please note this schedule is a working document and subject to change. [The latest version can be found in the Syllabus](#).

**Week 1**

**QEC Foundations**
**Bosonic Code Foundations**
**Programming QEC Decoders**

| Time | Activity | Location/Room | Mon 4 | Tue 5 | Wed 6 | Thr 7 | Fri 8 | Sat 9 | Sun 10 |
|---|---|---|---|---|---|---|---|---|---|
| 7:00AM - 8:55AM | Breakfast | Biddle Mansion - Winter Palace/West Terrace | | Breakfast | | | | | |
| 9:00AM - 10:30AM | Lecture I | New York | | QEC Foundations Steve Flammia, AWS | Programming QEC Decoders James Wootton, IBM Quantum | Bosonic Code Foundations Shruti Puri, Yale University Arne Grimsmo, AWS | Bosonic Code Foundations Shruti Puri, Yale University Arne Grimsmo, AWS | QEC Foundations Steve Flammia, AWS | |
| 10:30AM - 11:000AM | Morning Tea Break | Atrium Lobby | | Morning Tea Break | | | | | |
| 11:00AM - 12:30PM | Lecture II | New York | | Bosonic Code Foundations Shruti Puri, Yale University Arne Grimsmo, AWS | QEC Foundations Steve Flammia, AWS | QEC Foundations Steve Flammia, AWS | Programming QEC Decoders James Wootton, IBM Quantum | Bosonic Code Foundations Shruti Puri, Yale University Arne Grimsmo, AWS | |
| 12:30PM - 1:25PM | Lunch | Biddle Mansion - Winter Palace/West Terrace | | Lunch | | | | | |
| 1:30PM - 2:00PM | Q&A Sessions | Sunnyside | Students Arrive | Q&A Session QEC Foundations Steve Flammia, AWS | Q&A Session Programming QEC Decoders James Wootton, IBM Quantum | Q&A Session Bosonic Code Foundations Shruti Puri, Yale University Arne Grimsmo, AWS | Q&A Session Bosonic Code Foundations Shruti Puri, Yale University Arne Grimsmo, AWS | Q&A Session QEC Foundations Steve Flammia, AWS | Study/Off Breakfast: 7:00AM - 9:30AM Lunch: 12:00PM - 1:30PM Dinner: 6:00PM - 9:00PM |
| 2:00PM - 2:30PM | | Lyndhurst | | Q&A Session Bosonic Code Foundations Shruti Puri, Yale University Arne Grimsmo, AWS | Q&A Session QEC Foundations Steve Flammia, AWS | Q&A Session QEC Foundations Steve Flammia, AWS | Q&A Session Programming QEC Decoders James Wootton, IBM Quantum | Q&A Session Bosonic Code Foundations Shruti Puri, Yale University Arne Grimsmo, AWS | |
| 2:30PM - 4:30PM | Unstructured Time | N/A | | Unstructured Time | | | | | |
| 4:30PM - 5:00PM | Open Problems, Student Talks, Crazy Ideas | New York | | Unstructured Time | Unstructured Time | Open Problems - Part I QEC Foundations Steve Flammia, AWS | Crazy Ideas Session IDA Rules Drew Vandeth, IBM Quantum | Open Problems - Part II Bosonic Code Foundations Shruti Puri, Yale University | |
| 5:00PM - 5:30PM | | | | | | Open Problems - Part I Bosonic Code Foundations Shruti Puri, Yale University | | Open Problems - Part II QEC Foundations Steve Flammia, AWS | |
| 5:30PM - 6:00PM | Unstructured Time | N/A | | Unstructured Time | | | | | |
| 6:00PM - 6:55PM | Dinner | Biddle Mansion - Winter Palace/West Terrace | 4th of July Event @ West Terrace | Opening Dinner @ Mary Duke Ballroom | Dinner | Social Event: Women in Quantum Social | Dinner | | |
| 7:00PM - 8:00PM | Guest Lectures/Social Time | New York | | Keynote Speaker, Daniel Gottesman, UMD Mary Duke Ballroom | Guest Lecture Natalie Brown, Quantinuum | @ Carriage Room | Guest Lecture Liang Jiang, The University of Chicago | Unstructured Time | |
| 8:00PM - 9:00PM | Social | Atrium Lobby | | Speaker Social | Speaker Social | | Speaker Social | | |

# Week 2

**Fault Tolerance - Logistical Gates**
**Experimental QEC - Bosonic Codes**
**Programming QEC Decoders**

| Time | Activity | Location/Room | Mon 11 | Tue 12 | Wed 13 | Thr 14 | Fri 15 | Sat 16 | Sun 17 |
|---|---|---|---|---|---|---|---|---|---|
| 7:00AM - 8:55AM | Breakfast | Winter Palace/West Terrace | Breakfast | | | | | | |
| 9:00AM - 10:30AM | Lecture 1 | New York | Fault Tolerance – Logical Gates Ben Brown, IBM Quantum Daniel Litinski, PsiQuantum | Programming QEC Decoders James Wootton, IBM Quantum | Experimental QEC – Bosonic Codes Alec Eickbusch & Vladimir Sivak, Yale University | Experimental QEC – Bosonic Codes Alec Eickbusch, Yale University Vladimir Sivak, Yale University | Fault Tolerance – Logical Gates Ben Brown, IBM Quantum Daniel Litinski, PsiQuantum | Hudson River Cruise @ 1:30PM Breakfast: 7:00AM - 9:30AM Lunch & Dinner: TBA | Study/Off Breakfast: 7:00AM - 9:30AM Lunch: 12:00PM - 1:30PM Dinner: 6:00PM - 9:00PM |
| 10:30AM - 11:000AM | Morning Tea Break | Atrium Lobby | Morning Tea Break | | | | | | |
| 11:00AM - 12:30PM | Lecture 2 | New York | Experimental QEC – Bosonic Codes Michel Devoret, Alec Eickbusch, & Vladimir Sivak, Yale University | Fault Tolerance – Logical Gates Ben Brown, IBM Quantum Daniel Litinski, PsiQuantum | Fault Tolerance – Logical Gates Ben Brown, IBM Quantum Daniel Litinski, PsiQuantum | Programming QEC Decoders James Wootton, IBM Quantum | Experimental QEC – Bosonic Codes Alec Eickbusch & Vladimir Sivak, Yale University | | |
| 12:30PM - 1:25PM | Lunch | Winter Palace/West Terrace | Lunch | | | | | | |
| 1:30PM - 2:00PM | Q&A Sessions | Sunnyside | Q&A Session Fault Tolerance – Logical Gates Ben Brown, IBM Quantum Daniel Litinski, PsiQuantum | Q&A Session Programming QEC Decoders James Wootton, IBM Quantum | Q&A Session Experimental QEC – Bosonic Codes Alec Eickbusch & Vladimir Sivak, Yale University | Social Event: IBM Yorktown Lab Visit | Q&A Session Fault Tolerance – Logical Gates Ben Brown, IBM Quantum Daniel Litinski, PsiQuantum | | |
| 2:00PM - 2:30PM | | Lyndhurst | Q&A Session Experimental QEC – Bosonic Codes Michel Devoret, Alec Eickbusch, & Vladimir Sivak, Yale University | Q&A Session Fault Tolerance – Logical Gates Ben Brown, IBM Quantum Daniel Litinski, PsiQuantum | Q&A Session Fault Tolerance – Logical Gates Ben Brown, IBM Quantum Daniel Litinski, PsiQuantum | | Q&A Session Experimental QEC – Bosonic Codes Alec Eickbusch & Vladimir Sivak, Yale University | | |
| 2:30PM - 4:30PM | Unstructured Time | N/A | Unstructured Time | | | | Unstructured Time | | |
| 4:30PM - 5:00PM | Open Problems, Student Talks, Crazy Ideas | New York | Student Talks | Student Talks | Open Problems – Part I Experimental QEC – Bosonic Codes Alec Eickbusch & Vladimir Sivak, Yale University | Open Problems – Part II Fault Tolerance – Logical Gates Ben Brown, IBM Quantum Daniel Litinski, PsiQuantum | | |
| 5:00PM - 5:30PM | | | | | Open Problems – Part I Fault Tolerance – Logical Gates Ben Brown, IBM Quantum Daniel Litinski, PsiQuantum | Unstructured Time | Open Problems – Part II Experimental QEC – Bosonic Codes Alec Eickbusch & Vladimir Sivak, Yale University | | |
| 5:30PM - 6:00PM | Unstructured Time | N/A | Unstructured Time | | | | | | |
| 6:00PM - 6:55PM | Dinner | Winter Palace/West Terrace | Dinner | | | | | | |
| 7:00PM - 8:00PM | Guest Lectures/Social Time | New York | Guest Lecture Chen Wang, UMass Amherst | Unstructured Time | Guest Lecture TBD | Unstructured Time | Guest Lecture Guanyu Zhu, IBM Quantum | | |
| 8:00PM - 9:00PM | Social | Atrium Lobby | Speaker Social | | Speaker Social | | Speaker Social | | |

# Week 3

## QEC Decoding
## Experimental QEC - Trapped Ions
## Programming QEC Simulations

| Time | Activity | Location/Room | Mon 18 | Tue 19 | Wed 20 | Thr 21 | Fri 22 | Sat 23 | Sun 24 |
|---|---|---|---|---|---|---|---|---|---|
| 7:00AM - 8:55AM | Breakfast | *Winter Palace/West Terrace* | Breakfast | | | | | | |
| 9:00AM - 10:30AM | Lecture 1 | *New York* | QEC Decoding Christopher Chubb, ETH Zurich Earl Campbell, AWS | Programming QEC Simulations Andrew Cross, IBM Quantum | Experimental QEC - Trapped Ions Ken Brown, Duke University Ciaran Ryan-Anderson, Quantinuum | Experimental QEC - Trapped Ions Ken Brown, Duke University Ciaran Ryan-Anderson, Quantinuum | QEC Decoding Christopher Chubb, ETH Zurich Earl Campbell, AWS | | |
| 10:30AM - 11:000AM | Morning Tea Break | *Atrium Lobby* | Morning Tea Break | | | | | | |
| 11:00AM - 12:30PM | Lecture 2 | *New York* | Experimental QEC - Trapped Ions Ken Brown, Duke University Ciaran Ryan-Anderson, Quantinuum | QEC Decoding Christopher Chubb, ETH Zurich Earl Campbell, AWS | QEC Decoding Christopher Chubb, ETH Zurich Earl Campbell, AWS | Programming QEC Simulations Andrew Cross, IBM Quantum | Experimental QEC - Trapped Ions Ken Brown, Duke University Ciaran Ryan-Anderson, Quantinuum | | |
| 12:30PM - 1:25PM | Lunch | *Winter Palace/West Terrace* | Lunch | | | | | | |
| 1:30PM - 2:00PM | Q&A Sessions | *Sunnyside* | Q&A Session QEC Decoding Christopher Chubb, ETH Zurich Earl Campbell, AWS | Q&A Session Programming QEC Simulations Andrew Cross, IBM Quantum | Q&A Session Experimental QEC - Trapped Ions Ken Brown, Duke University Ciaran Ryan-Anderson, Quantinuum | Q&A Session Experimental QEC - Trapped Ions Ken Brown, Duke University Ciaran Ryan-Anderson, Quantinuum | Q&A Session QEC Decoding Christopher Chubb, ETH Zurich Earl Campbell, AWS | Social Event TBA Breakfast: 7:00AM - 9:30AM Lunch & Dinner: TBA | Study/Off Breakfast: 7:00AM - 9:30AM Lunch: 12:00PM - 1:30PM Dinner: 6:00PM - 9:00PM |
| 2:00PM - 2:30PM | | *Lyndhurst* | Q&A Session Experimental QEC - Trapped Ions Ken Brown, Duke University Ciaran Ryan-Anderson, Quantinuum | Q&A Session QEC Decoding Christopher Chubb, ETH Zurich Earl Campbell, AWS | Q&A Session QEC Decoding Christopher Chubb, ETH Zurich Earl Campbell, AWS | Q&A Session Programming QEC Simulations Andrew Cross, IBM Quantum | Q&A Session Experimental QEC - Trapped Ions Ken Brown, Duke University Ciaran Ryan-Anderson, Quantinuum | | |
| 2:30PM - 4:30PM | Unstructured Time | *N/A* | Unstructured Time | | | | | | |
| 4:30PM - 5:00PM | Open Problems, Student Talks, Crazy Ideas | *New York* | Student Talks | Student Talks | Open Problems - Part I Experimental QEC - Trapped Ions Ken Brown, Duke University Ciaran Ryan-Anderson, Quantinuum | Crazy Ideas Session | Open Problems - Part II QEC Decoding Christopher Chubb, ETH Zurich Earl Campbell, AWS | | |
| 5:00PM - 5:30PM | | | | | Open Problems - Part I QEC Decoding Christopher Chubb, ETH Zurich Earl Campbell, AWS | | Open Problems - Part II Experimental QEC - Trapped Ions Ken Brown, Duke University Ciaran Ryan-Anderson, Quantinuum | | |
| 5:30PM - 6:00PM | Unstructured Time | *N/A* | Unstructured Time | | | | | | |
| 6:00PM - 6:55PM | Dinner | *Winter Palace/West Terrace* | Dinner | | | Social Event: Diversity Panel @ Mary Duke Ballroom | Dinner | | |
| 7:00PM - 8:00PM | Guest Lectures/Social Time | *New York* | Guest Lecture Aleksander Kubica, AWS | Unstructured Time | Guest Lecture Michael Vasmer Perimeter Institute | Dinner | Guest Lecture Leo DiCarlo QuTech | | |
| 8:00PM - 9:00PM | Social | *Atrium Lobby* | Speaker Social | | Speaker Social | Unstructured Time | Speaker Social | | |

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# Week 4

**LDPC Codes**
**Experimental QEC - Superconducting Qubits**
**Programming QEC Simulations**

| Time | Activity | Location/Room | Mon 25 | Tue 26 | Wed 27 | Thr 28 | Fri 29 | Sat 30 | Sun 31 |
|---|---|---|---|---|---|---|---|---|---|
| 7:00AM - 8:55AM | Breakfast | Winter Palace/West Terrace | Breakfast | | | | | | |
| 9:00AM - 10:30AM | Lecture 1 | New York | LDPC Codes Nikolas Breuckmann, UCL Nicolas Delfosse, Microsoft | Programming QEC Simulations Andrew Cross, IBM Quantum | Experimental QEC - Superconducting Qubits Maika Takita & Antonio Córcoles, IBM Quantum Andreas Wallraff, ETH Zurich | Experimental QEC - Superconducting Qubits Maika Takita, IBM Quantum Antonio Córcoles, IBM Quantum Andreas Wallraff, ETH Zurich | LDPC Codes Nikolas Breuckmann, UCL Nicolas Delfosse, Microsoft | | |
| 10:30AM - 11:000AM | Morning Tea Break | Atrium Lobby | Morning Tea Break | | | | | | |
| 11:00AM - 12:30PM | Lecture 2 | New York | Experimental QEC - Superconducting Qubits Maika Takita & Antonio Córcoles, IBM Quantum Andreas Wallraff, ETH Zurich | LDPC Codes Nikolas Breuckmann, UCL Nicolas Delfosse, Microsoft | LDPC Codes Nikolas Breuckmann, UCL Nicolas Delfosse, Microsoft | Programming QEC Simulations Andrew Cross, IBM Quantum | Experimental QEC - Superconducting Qubits Maika Takita & Antonio Córcoles, IBM Quantum Andreas Wallraff, ETH Zurich | | |
| 12:30PM - 1:25PM | Lunch | Winter Palace/West Terrace | Lunch | | | | Lunch | | |
| 1:30PM - 2:00PM | Q&A Sessions | Sunnyside | Q&A Session LDPC Codes Nikolas Breuckmann, UCL Nicolas Delfosse, Microsoft | Q&A Session Programming QEC Simulations Andrew Cross, IBM Quantum | Q&A Session Experimental QEC - Superconducting Qubits Maika Takita & Antonio Córcoles, IBM Quantum Andreas Wallraff, ETH Zurich | Social Event: IBM Research BBQ at Yorktown *Date TBC* | Q&A Session LDPC Codes Nikolas Breuckmann, UCL Nicolas Delfosse, Microsoft | Social Event TBA Breakfast: 7:00AM - 9:30AM Lunch & Dinner: TBA | Students Depart Breakfast: 7:00AM - 9:30AM |
| 2:00PM - 2:30PM | Q&A Sessions | Lyndhurst | Q&A Session Experimental QEC - Superconducting Qubits Maika Takita & Antonio Córcoles, IBM Quantum Andreas Wallraff, ETH Zurich | Q&A Session LDPC Codes Nikolas Breuckmann, UCL Nicolas Delfosse, Microsoft | Q&A Session LDPC Codes Nikolas Breuckmann, UCL Nicolas Delfosse, Microsoft | | Q&A Session Experimental QEC - Superconducting Qubits Maika Takita & Antonio Córcoles, IBM Quantum Andreas Wallraff, ETH Zurich | | |
| 2:30PM - 4:30PM | Unstructured Time | N/A | Unstructured Time | | | | Unstructured Time | | |
| 4:30PM - 5:00PM | Open Problems, Student Talks, Crazy Ideas | New York | Student Talks | Student Talks | Open Problems - Part I Experimental QEC - Superconducting Qubits Maika Takita & Antonio Córcoles, IBM Quantum Andreas Wallraff, ETH Zurich | Crazy Ideas Session | Open Problems - Part II LDPC Codes Nikolas Breuckmann, UCL Nicolas Delfosse, Microsoft | | |
| 5:00PM - 5:30PM | Open Problems, Student Talks, Crazy Ideas | New York | | | Open Problems - Part I LDPC Codes Nikolas Breuckmann, UCL Nicolas Delfosse, Microsoft | | Open Problems - Part II Experimental QEC - Superconducting Qubits Maika Takita & Antonio Córcoles, IBM Quantum Andreas Wallraff, ETH Zurich | | |
| 5:30PM - 6:00PM | Unstructured Time | N/A | Unstructured Time | | | | | | |
| 6:00PM - 6:55PM | Dinner | Winter Palace/West Terrace | Dinner | | | | | Closing Dinner @ Mary Duke Ballroom | |
| 7:00PM - 8:00PM | Guest Lectures/Social Time | New York | Guest Lecture Anirudh Krishna, Stanford University | Unstructured Time | Guest Lecture, Ted Yoder, IBM Quantum | Unstructured Time | Social Event TBA | Keynote Speaker Sergey Bravyi IBM Quantum | |
| 8:00PM - 9:00PM | Social | Atrium Lobby | Speaker Social | | Speaker Social | | | Speaker Social | |

## Questions & Next Steps

Please continue to reach out to us at qiskit.events@us.ibm.com with any questions you might have and don't forget to join the Slack Qiskit Workspace and message @anamaria once you've joined to be added to the private Slack channel.

We look forward to seeing you in July!

2022 QEC Summer School
Organizing Committee

IBM **Quantum**