# CSU Exemplars in Physics

Moderated by:
Dr. Frank A. Gomez
Executive Director, STEM-NET
Office of the Chancellor

STEM-NET

https://www2.calstate.edu/impact-of-the-csu/research/stem-net

## Speakers

**John D. Gillaspy, National Science Foundation**
NSF Funding Opportunities for Physics Faculty

**Gina Passante, Cal State Fullerton**
Improving Quantum Information Science Education

**Kathryn Grimm, CSU East Bay**
The Origin of Mass and the Future of Mass: Experimental Studies of the Higgs Boson and the Higgs Potential at the ATLAS Experiment

**Michael Loverude, Cal State Fullerton**
Beyond Procedures: A Research-Based Approach to Teaching Mathematical Methods in Physics

**Hiu Yung Wong, San Jose State**
Understanding Cryogenic Semiconductor Devices

National Science Foundation
WHERE DISCOVERIES BEGIN

# NSF Funding Opportunities for Physics Faculty

*John Gillaspy– National Science Foundation*

**John Gillaspy**, Program Director

Alexandria, VA, Physics Division

jgillasp@nsf.gov

# Disclaimer:

**I will highlight some of the opportunities that I see most often from my perspective as Program Director of Atomic, Molecular, and Optical Experimental Physics, and as a member of the Quantum Leap Challenge Institutes Management Team.**

**This will not be a comprehensive presentation (consider attending an NSF Grants Conference—details at the end of this presentation).**

**Always feel free to reach out to any Program Director for guidance.**

**John Gillaspy**, Program Director

Alexandria, VA, Physics Division

jgillasp@nsf.gov

# Step 1: Find the right program

Use the NSF "Advanced Award Search"

Read Program Descriptions

Talk to NSF Program Directors

Image: The maze of Longleat House, public domain, https://commons.wikimedia.org/wiki/File:Longleat_maze.jpg

# 1. Opportunities from the NSF Physics Division

*--Solicitation NSF 21-593 (re-issued with 2022 dates in a table on p.2). Covers all "Investigator Initiated Research Projects" in the NSF Physics Division (essentially all physics areas except Condensed Matter Physics) .*

*The solicitation follows the Proposal & Award Policies & Procedures Guide (PAPPG) but has additional requirements.*

**John Gillaspy**, Program Director

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# Additional NSF-wide and MPS-wide Solicitations
## (which divert internally to the Physics Division):

- *LEAPS-MPS (22-604) "pre-tenure faculty . . .**at institutions that traditionally do not receive significant NSF funding**, such as minority-serving institutions, predominantly undergraduate institutions and R2 universities."*
- *MPS-Ascend (22-501) Postdocs "who will broaden the participation of groups that are underrepresented in MPS fields "*
- *MPS AGEP-GRS (20-083) & PHY-GRS (next slide)—must have a grant already*
- *RUI (Research at Undergraduate Institutions) (14-579)*
- *CAREER (22-586)*
- *Major Research Instrumentation (18-513)*

**John Gillaspy**, Program Director
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# Special areas of emphasis (not formal solicitations):

*Dear Colleague Letters:*

*20-127 (*Searching for New Physics Beyond the Standard Model of Particle Physics Using Precision Atomic, Molecular, and Optical Techniques*)*

*21-065 (*PHY **Supplements**: Growing a Strong, Diverse Workforce*); PHY-GRS (similar to MPS AGEP-GRS, but more inclusive; women, all institutions, etc.)*

*Meta-Programs:*
*--PD 22-8084 Computational and Data-Enabled Science and Engineering (CDS&E)*

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# 2. Opportunities from outside of the Physics Division

- CMP and EPM in the Division of Materials Research

(Condensed Matter Physics and Electronic & Photonic Materials)

- EPMD in the Engineering Directorate

(Electronics, Photonics and Magnetic Devices)

- Astronomy (separate Division); also: WoU-MMA (WINDOWS ON THE UNIVERSE: THE ERA OF MULTI-MESSENGER ASTROPHYSICS)
- Chemistry (separate Division)
- Mathematical Physics (within DMS)
- QISE and the National Quantum Initiative

Search: “Quantum Information Science and Engineering Research at NSF”
(https://www.nsf.gov/mps/quantum/quantum_research_at_nsf.jsp)

**John Gillaspy**, Program Director

Alexandria, VA, Physics Division

jgillasp@nsf.gov

NSF Funding Opportunities for Physics Faculty

# Hot off the press (posted Sept 12, 2022): NSF 22-630

## Quantum Sensing Challenges for Transformational Advances in Quantum Systems (QuSeC-TAQS)

**Anticipated Funding Amount:** $25,000,000

Preliminary Proposal Due Date(s) (required): December 16, 2022
Full Proposal Deadline(s): April 03, 2023

email: qusec@nsf.gov

**John Gillaspy**, Program Director

Alexandria, VA, Physics Division

jgillasp@nsf.gov

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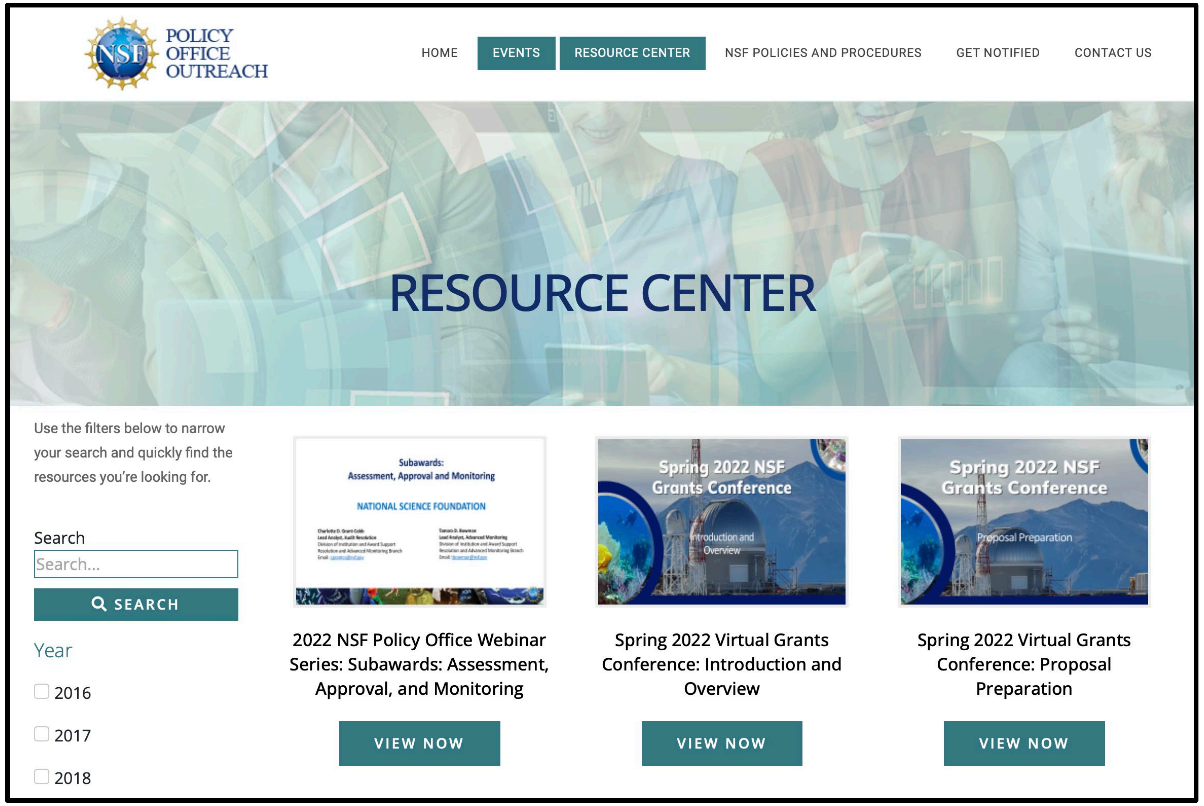
# Consider Attending an NSF Grants Conference:

*https://nsfpolicyoutreach.com/resource-center/*

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NSF Funding Opportunities for Physics Faculty

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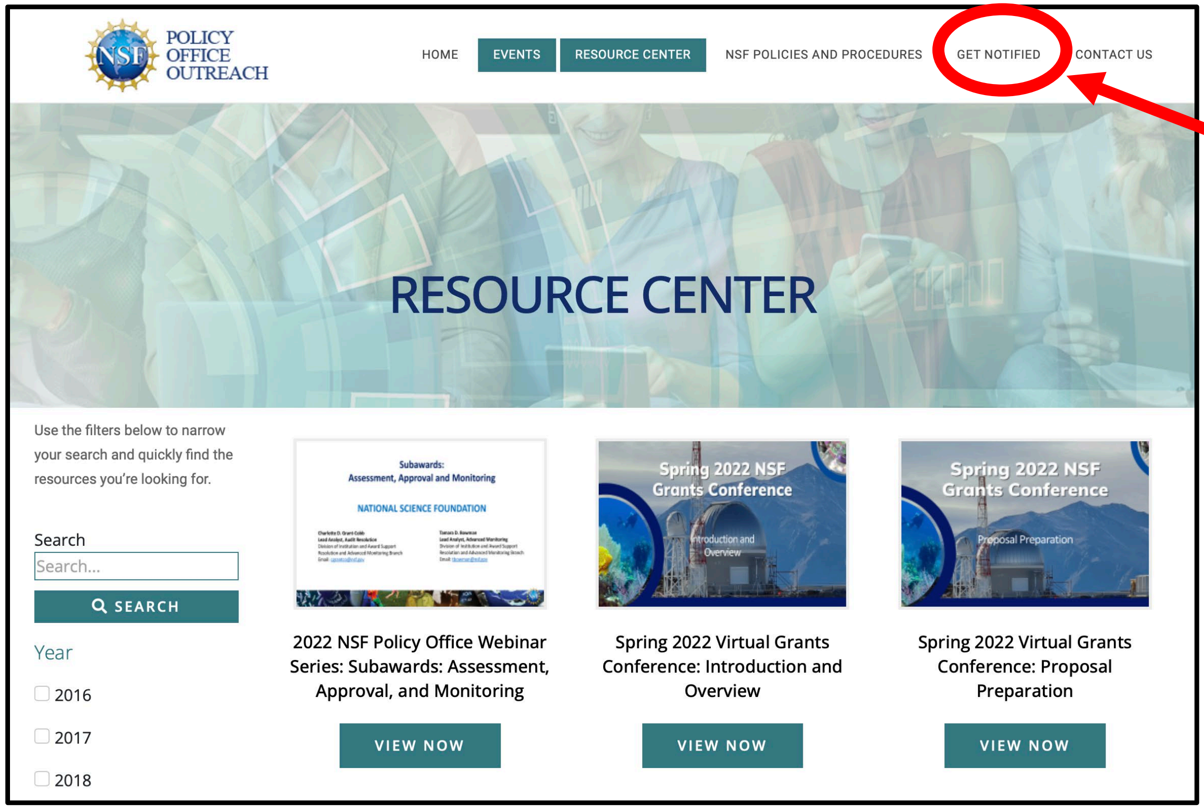
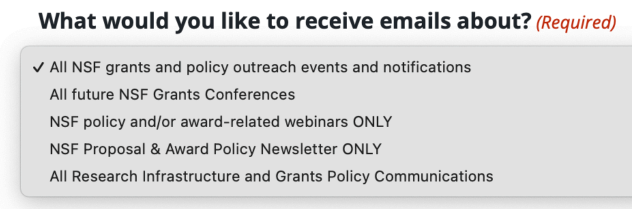



Signup to get notified of these and other resources




**John Gillaspy**, Program Director

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# Looking to the Future:

- **The New NSF TIP Directorate**
  **(TIP: Technology, Innovation and Partnerships)**
  **(Authorized but not Appropriated)**

- **Chips & Science Act**
  **(Authorized but not Appropriated)**

- **Quantum Information Science & Engineering**

**John Gillaspy**, Program Director
Alexandria, VA, Physics Division
jgillasp@nsf.gov

National Science Foundation
WHERE DISCOVERIES BEGIN



# *Recap of some select takeaways:*

- **Help us Broaden Participation of Underrepresented Groups:**
  **LEAPS & ASCEND (pre-tenured faculty & postdocs)**
  **If you have an NSF grant: AGEP-GRS or PHY-GRS**

- **Precision Measurements: DCL 20-127 (use NSF Advanced Award Search to find recent awards with "PM:" in title)**

- **Quantum Sensing/Measurement Teams: NSF 22-630 (QuSeC-TAQS)**

- **Don't be afraid to aim for a CAREER or MRI award**

- **Be aware of physics research opportunities in other NSF Divisions**

**John Gillaspy**, Program Director
Alexandria, VA, Physics Division
jgillasp@nsf.gov

# Questions?

## Contact Information:

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Phone: 703-292-7173

Email:jgillasp@nsf.gov

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CALIFORNIA STATE UNIVERSITY
FULLERTON

# Improving Quantum Information Science Education

*Gina Passante – Cal State Fullerton*

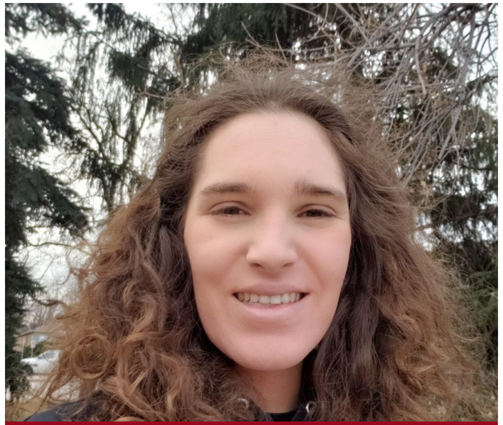
**Gina Passante**, Associate Professor
California State University, Fullerton, Department of Physics
gpassante@fullerton.edu

CALIFORNIA STATE UNIVERSITY FULLERTON

# Improving Quantum Information Science Education

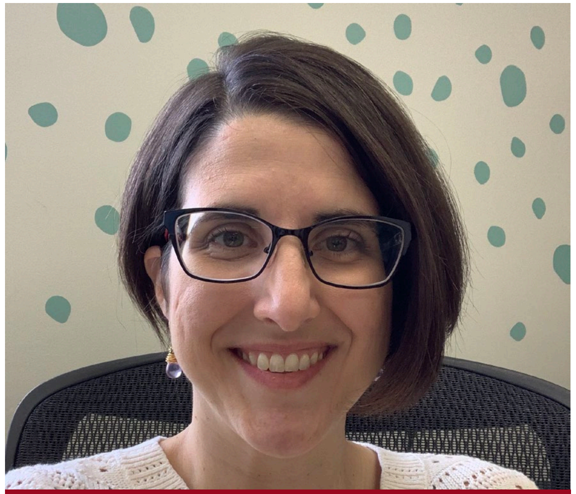
Bethany Wilcox

Steven Pollock



Josephine Meyer

Giaco Corsiglia



Gina Passante

Bianca Cervantes

CSUF

PHY-2011958
PHY-2012147

## Intro to QIS

- Quantum Information Science (QIS) is a term used to describe the fields of
  - Quantum computing
  - Quantum communication
  - Quantum sensing
- The USA has recently made a substantial investment in QIS
- Many institutions are introducing courses, minors, majors, certificates, MS degrees…

## Opportunity

- I am a Physics Education Researcher with a background in QIS
- My research focus had been on how students learn *quantum mechanics*
- With the explosion of courses being developed, it is the perfect time to affect change from the beginning
- Found collaborators that had the right set of skills to join me
- Applied under Integrative Activities in Physics

PHY-2011958
PHY-2012147

## Challenges facing QIS instruction

- Multidisciplinary - Physics, Computer science, Engineering (electrical & computer), Mathematics, and others
- Students come to Intro QIS courses with a range of backgrounds
- There is no standard curriculum

## Who has access to QIS?

Reviewed online course catalogues for QIS courses in 2019

305 institutions surveyed

**Inclusion criteria:**

- Course contained at least 50% QIS content
- Lecture course

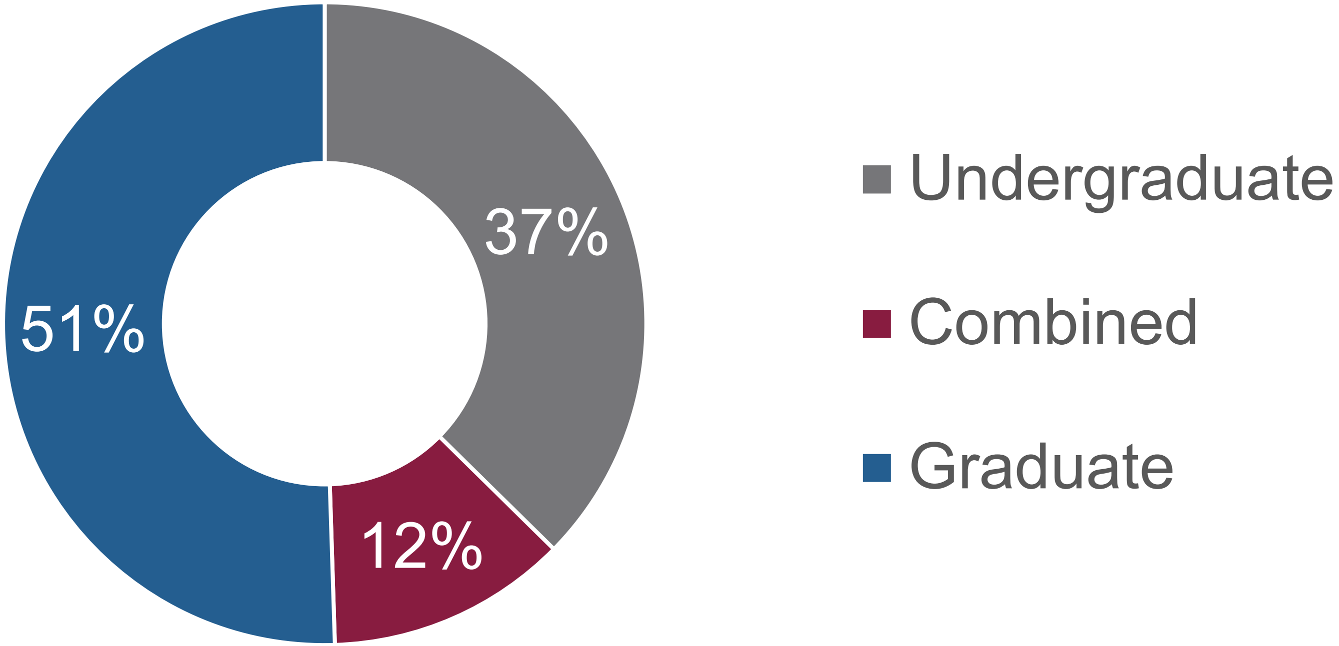
**Excluded:**

- Lab courses
- Special topics courses

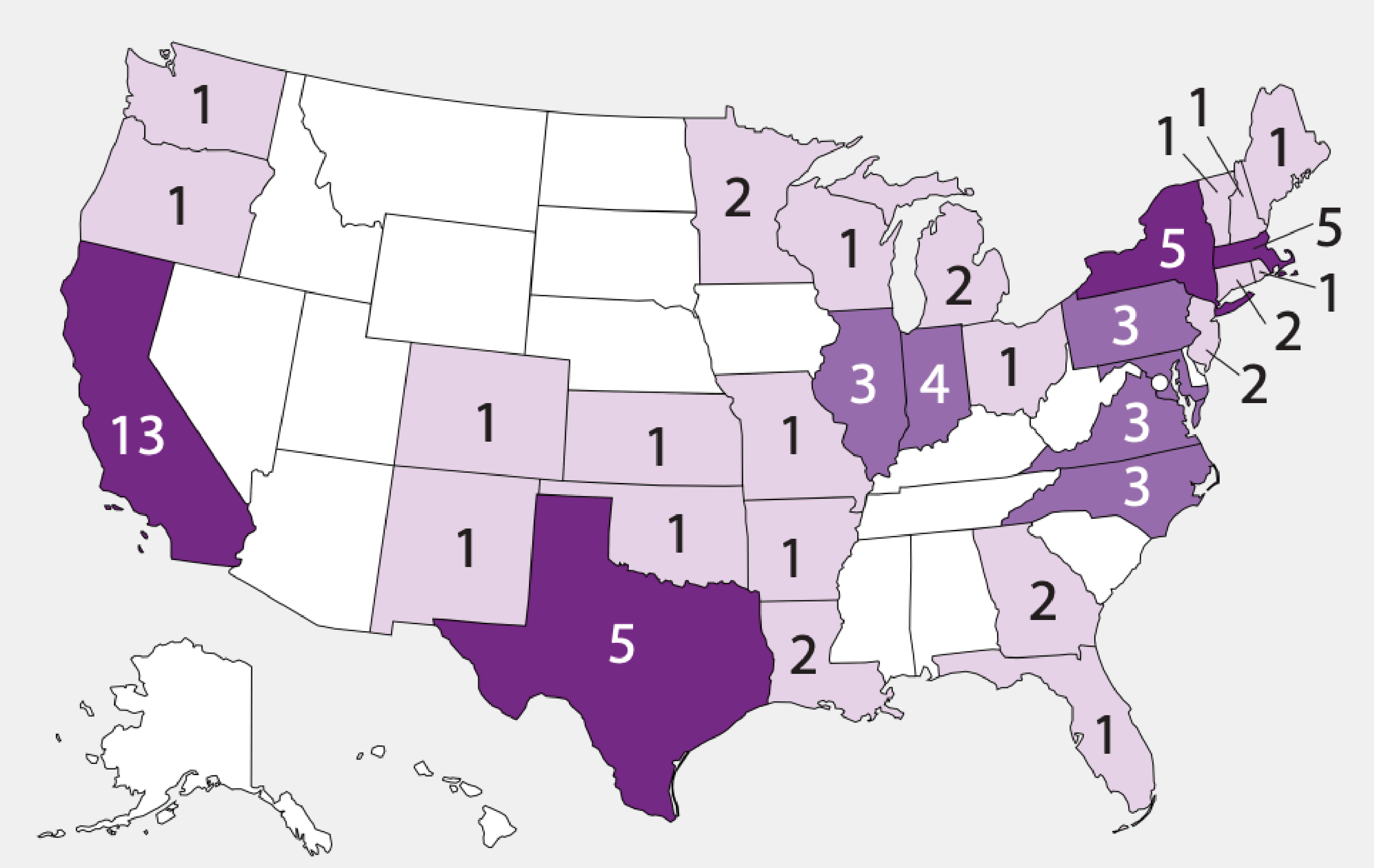
# Who has access to QIS?

24% of all institutions surveyed offered at least one QIS course

Level of courses:

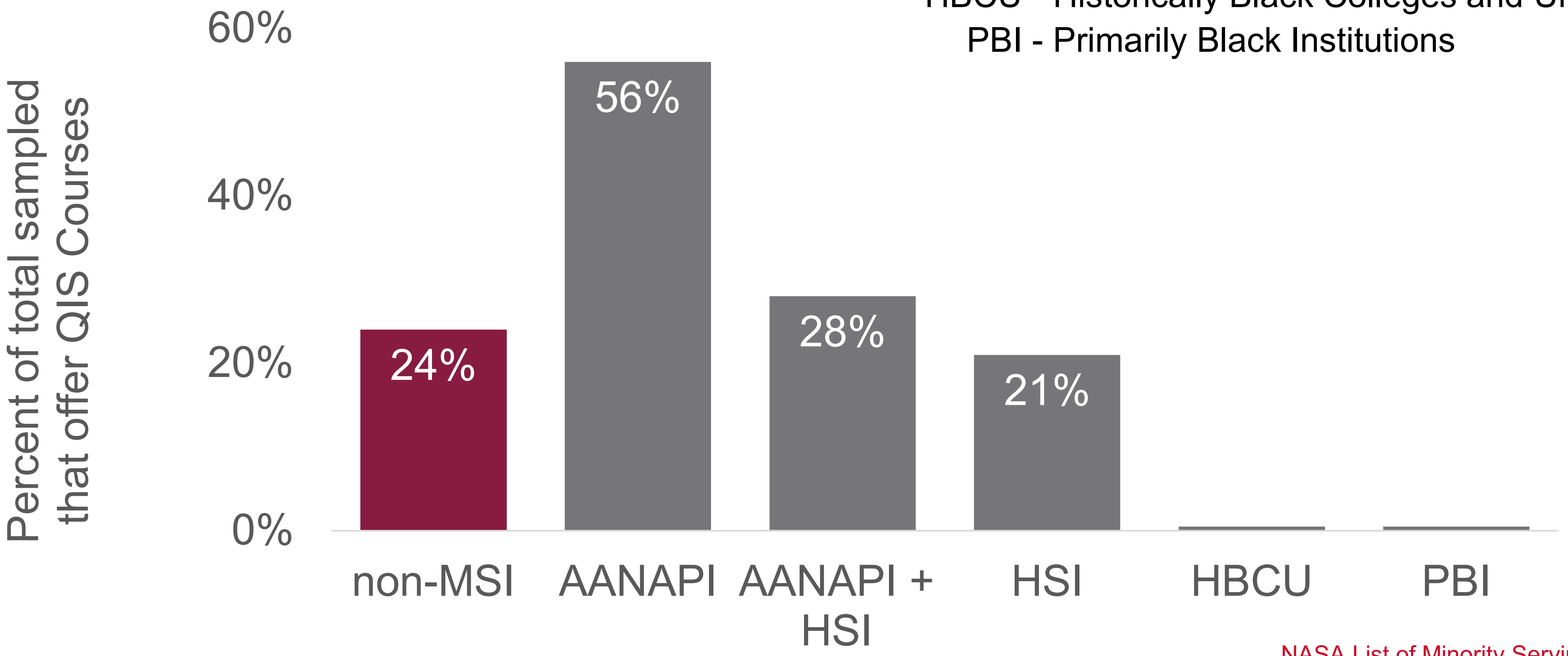


# Who has access to QIS?



## Who has access to QIS?

MSI - Minority Serving Institution
AANAPI - Asian American and Native American Pacific Islander
HIS - Hispanic Serving Institution
HBCU - Historically Black Colleges and Universities
PBI - Primarily Black Institutions




NASA List of Minority Serving Institutions, https://www.nasa.gov/sites/default/files/atoms/files/2020-nasa-list-of-minority-serving-institutions.pdf

## Findings

- Already out of date!
- 24% of all institutions surveyed had at least one QIS course in their course catalog
  - You are more likely to find a course at a PhD-granting institution
- Half of the courses are at the undergraduate level
  - More likely to find UG courses at **private** institutions

B. Cervantes, G. Passante, B. Wilcox, and S. Pollock,
Physics Education Research Conference 2021

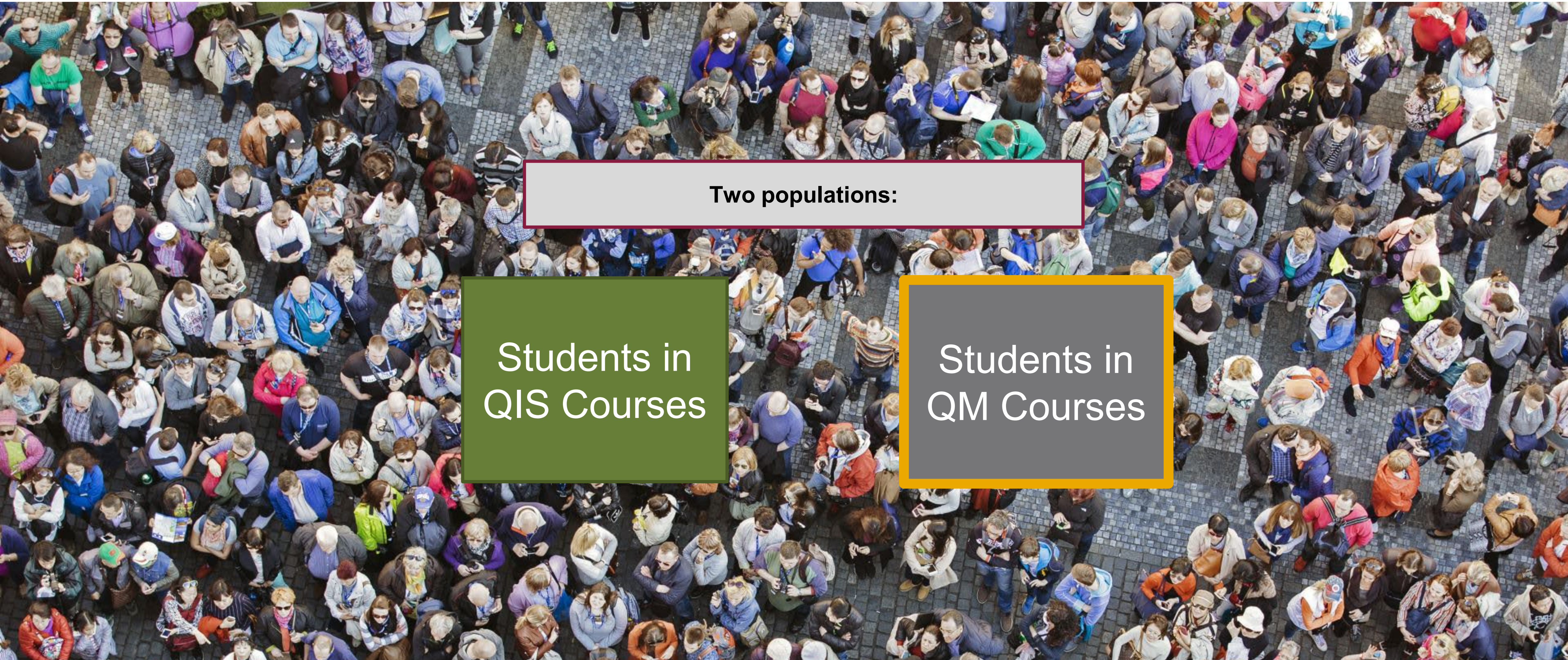
# Our goal: Improve QIS Education

Two populations:

Students in QIS Courses

Students in QM Courses

# Our goal: Improve QIS Education



Two populations:

Students in QIS Courses

Students in QM Courses

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# Adaptable Curricular Exercises in Quantum Mechanics

Gina Passante, Steven Pollock, & Homeyra Sadaghiani

Materials available:
Pre-lecture surveys
Clicker questions
Tutorials
Homework
(and more)

physport.org/curricula/ACEQM

NSF Projects DUE-1626280, 1626594, and 1626482

# Our goal: Improve QIS Education

**Two populations:**

Students in QIS Courses

Students in QM Courses

## Faculty experience

We wanted to get a better idea of what a "typical" QIS course looks like

- We surveyed QIS faculty on their experiences
- 28 faculty of intro QIS courses answered our survey
- 6 of whom also participated in an interview

J. Meyer, G. Passante, S. Pollock, and B.R. Wilcox, *The interdisciplinary quantum information classroom: Themes from a survey of quantum information science instructors,* Phys. Rev. Phys. Educ. Res. **18**, 010150 (2022).

Josephine Meyer

## Faculty experience - Findings

- There is no ‘typical’ course
- Faculty have different thoughts on
  - Learning goals
  - Content to cover
- Faculty agree on
  - They want students to know more math (especially elements of linear algebra)
  - They don’t like the current textbook options

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**Our plan:**

Focus on the ‘intro’ topics

J. Meyer, G. Passante, S. Pollock, and B.R. Wilcox, *The interdisciplinary quantum information classroom: Themes from a survey of quantum information science instructors,* Phys. Rev. Phys. Educ. Res. **18**, 010150 (2022).

Josephine Meyer

## Next Steps

- Research student experiences
- Develop research-based materials
- Dissemination
    - Partnered with AlderSEA to build a website and research how faculty engage with our materials so that we can better suit faculty needs

# Questions?

## Contact Information:

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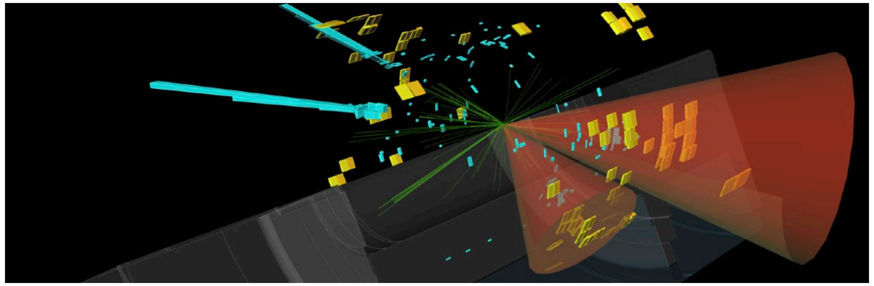
Email: gpassante@fullerton.edu

CALIFORNIA STATE UNIVERSITY, EAST BAY

# The Origin of Mass and the Future of Mass:
## Experimental Studies of the Higgs Boson and the Higgs Potential at the ATLAS Experiment

*Katy Grimm– Cal State East Bay*



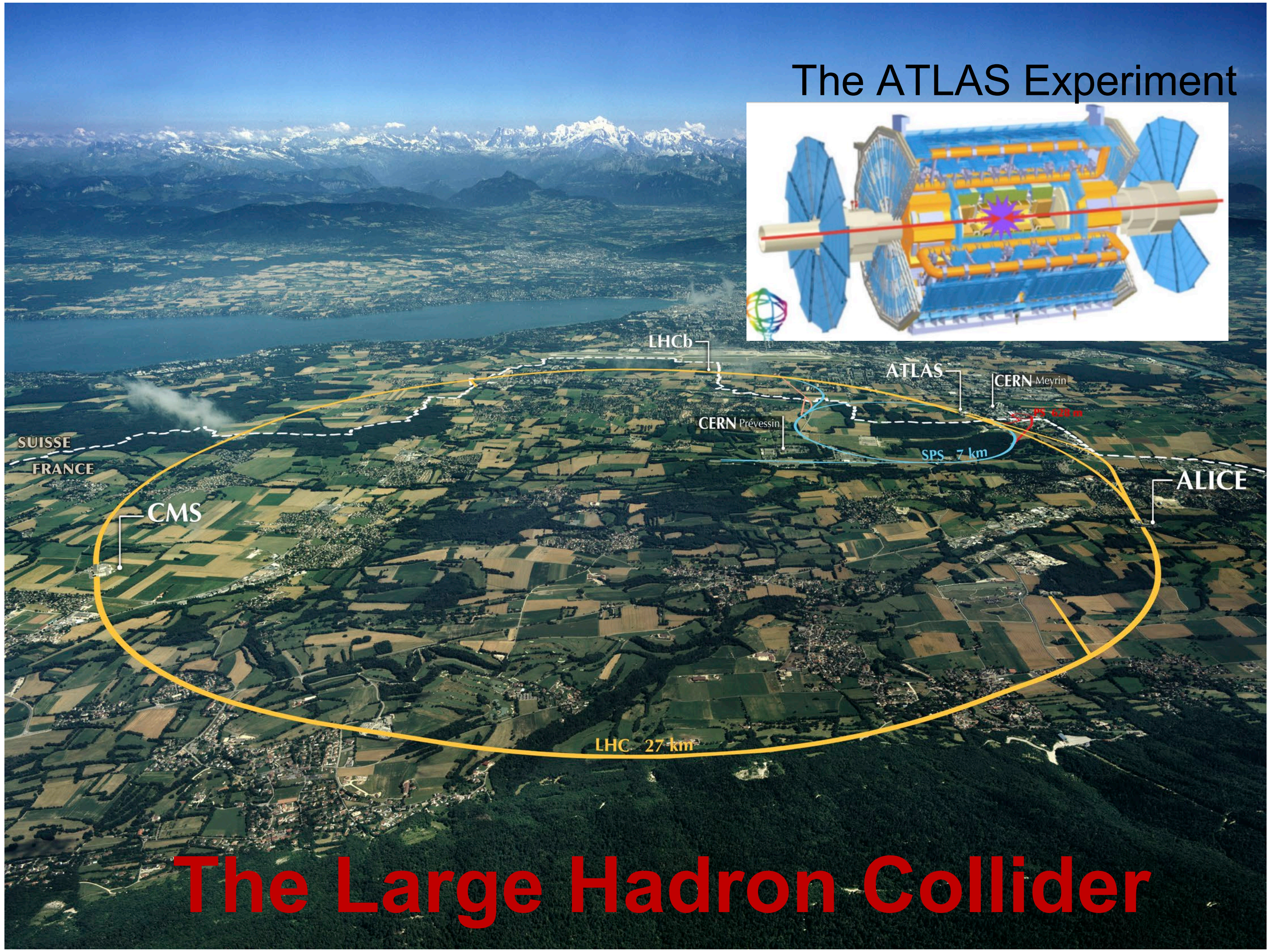

**Kathryn Grimm**, Associate Professor

Cal State East Bay, Department of Physics

Kathryn.Grimm@csueastbay.edu

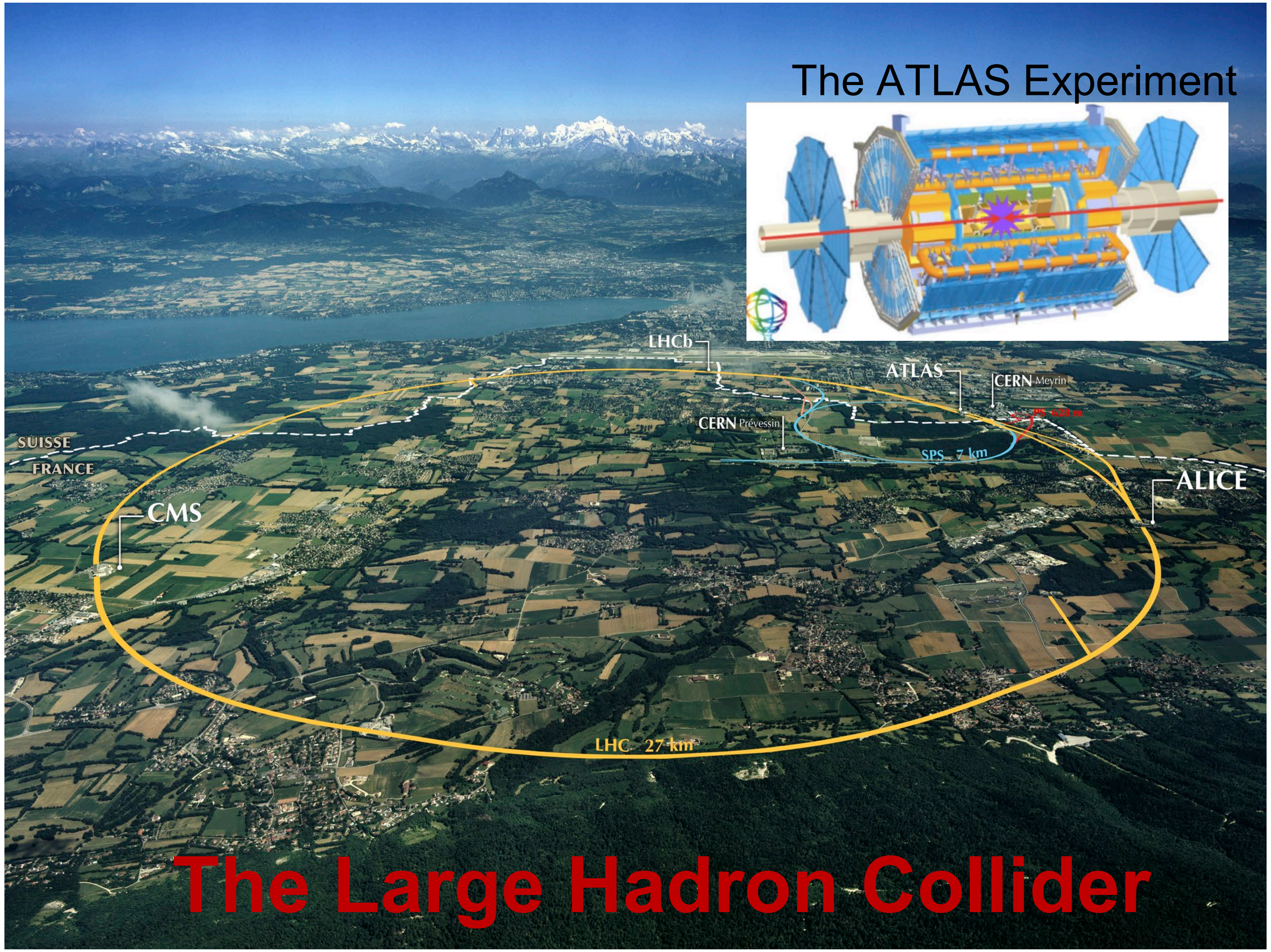
## Project Overview

- Experimental Particle Physics at the CSUs through the ATLAS Experiment:
  - Cal State East Bay (Prof, Post-Doc, Undergrads)
  - Cal State Sacramento (Prof, Undergrads)
  - Cal State Fresno (Prof, Post-Doc, Masters and Undergrads)
- Collaboration between faculty/students across campuses



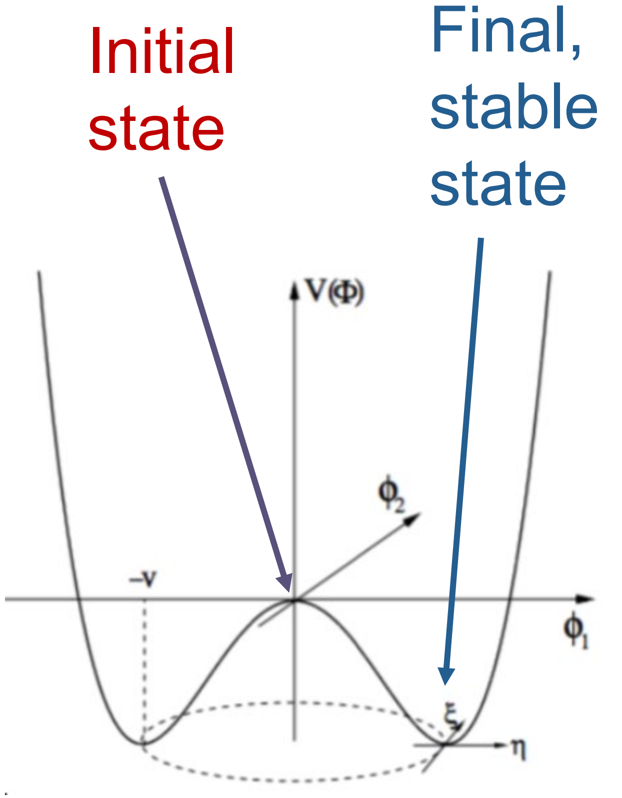
## Project Overview

- In 2012 ATLAS and CMS, experiments at the Large Hadron Collider at the CERN laboratory, saw evidence of the Higgs boson.
- This particle is confirmation of the Brout-Englert-Higgs theory that particles attain mass through interaction with a ("Higgs") field that permeates the universe.
- My work focuses on measurement of the Higgs boson produced in pairs, which can tell us about the Higgs potential

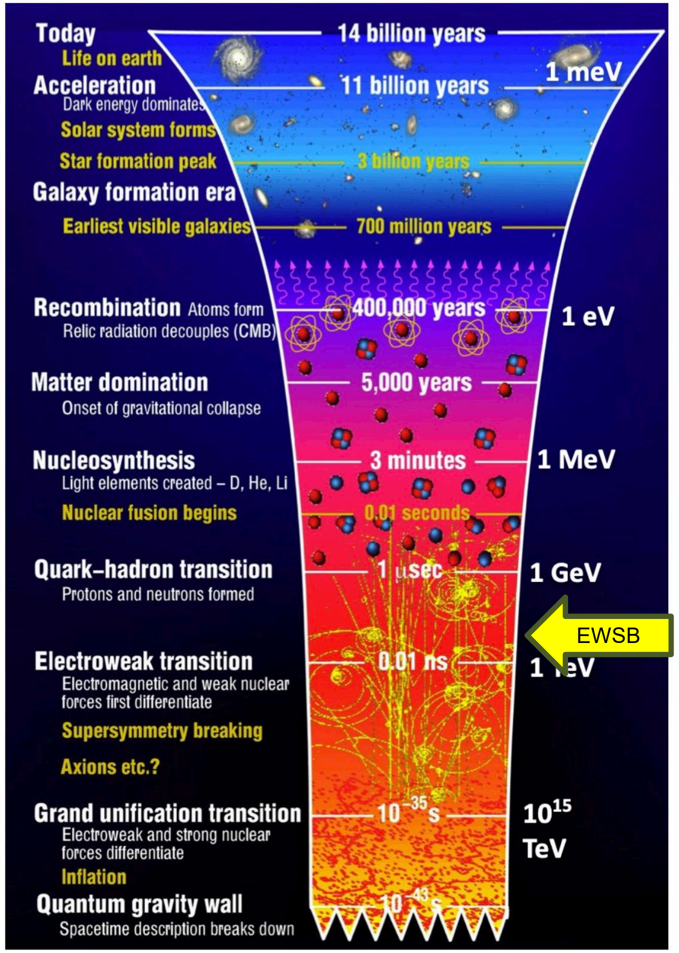


## Background

- As the universe cooled, the quantum fields of forces and particles settled at lower energy levels and with higher levels of stability. For the Electroweak force this led to Electroweak Symmetry Breaking. In the state of lower potential, interactions with the Higgs field now caused particles to acquire mass, in particular the W & Z.
- The gauge bosons of the weak force having mass greatly alters how the weak force behaves.




The Higgs Potential



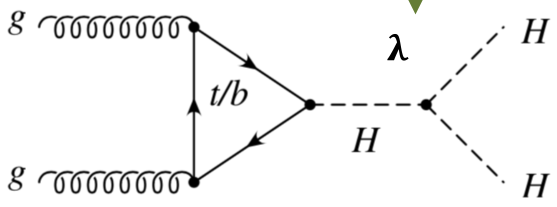



See https://en.wikipedia.org/wiki/Chronology_of_the_universe#The_very_early_universe_2

## Background

- The shape of the Higgs potential that is predicted by the Standard Model can be tested by measuring the **Higgs Self-Coupling**

$$V(\Phi) = \mu^2\Phi^*\Phi + \lambda|\Phi^*\Phi|^2$$

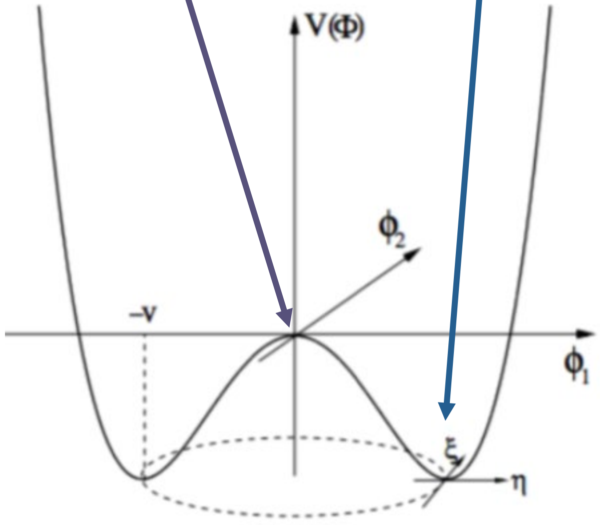



(c)

https://cerncourier.com/a/the-higgs-and-the-fate-of-the-universe/

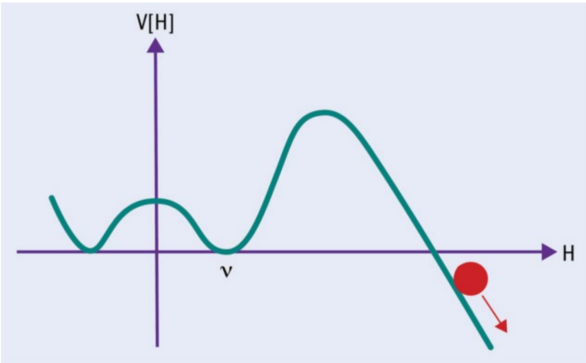
Initial state

Final, stable state




The Higgs Potential

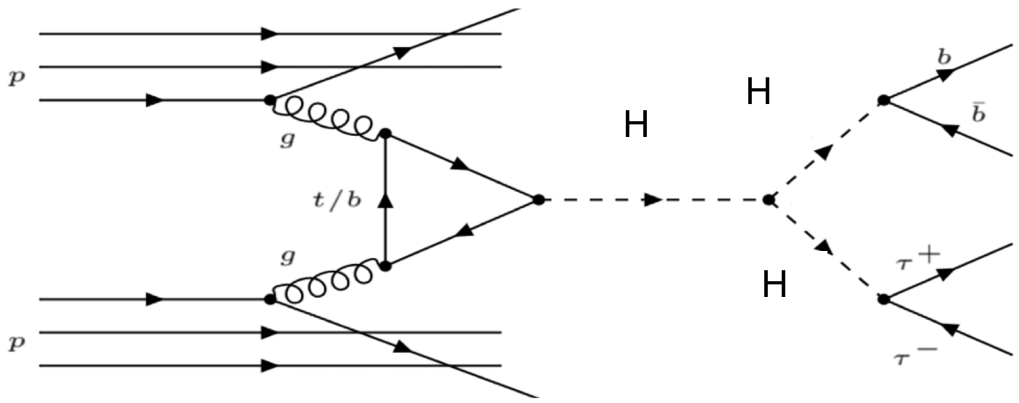
What is the full shape of the Higgs potential?

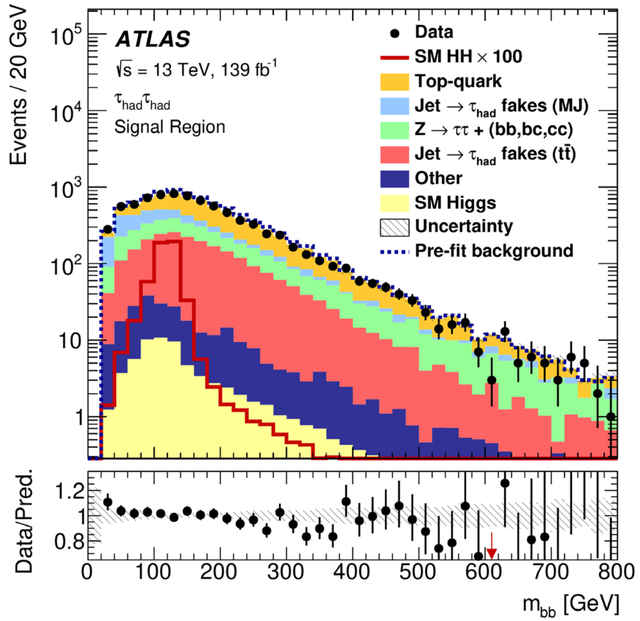



Future of mass?

## Activities

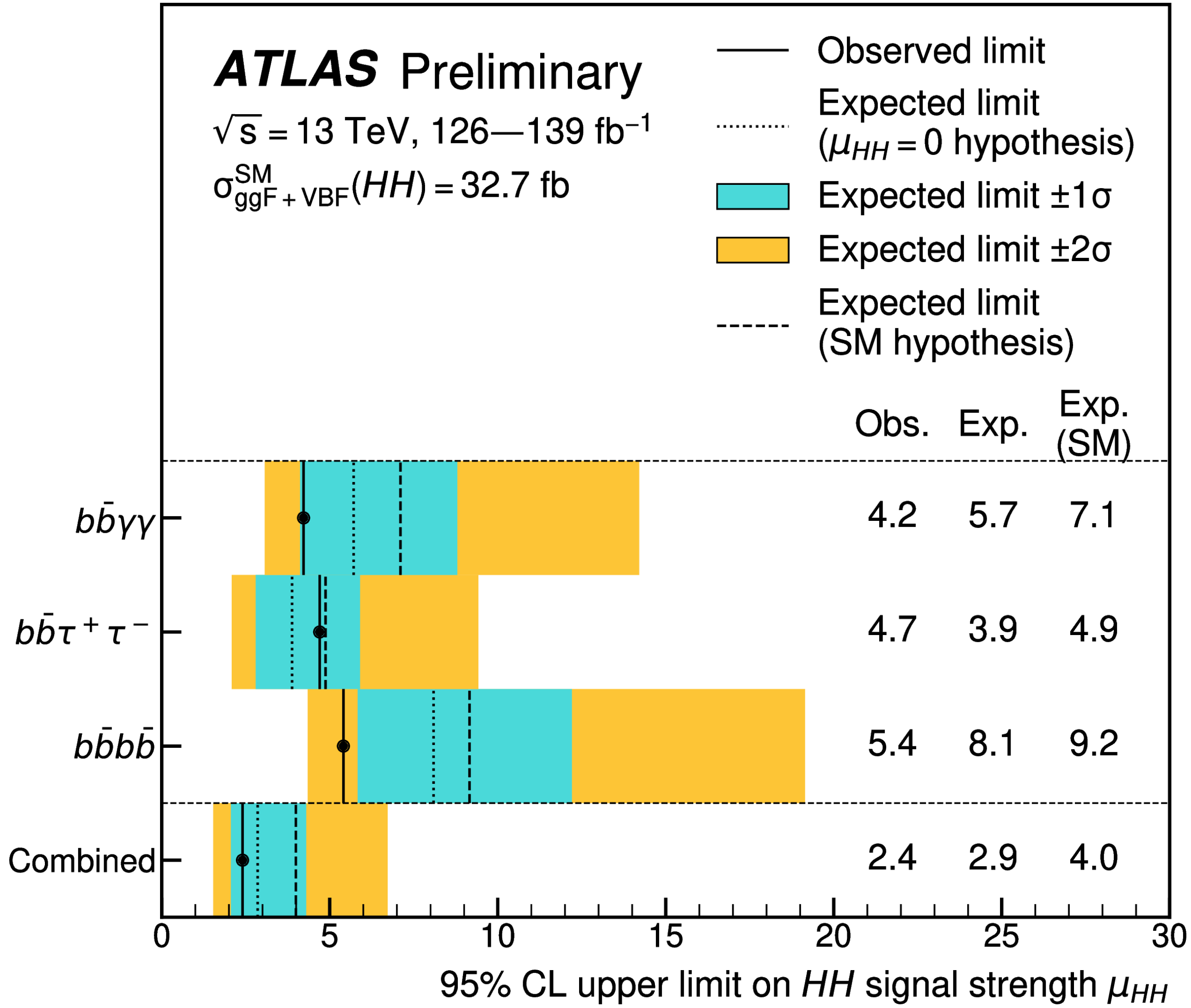
- Work is focused on Higgs production in the final state with two taus and two b quarks.
- This is a very rare process AND there is a lot of background from other processes involving top quarks and strong force “noise” (quarks and gluons)
- Heavy use of Monte Carlo, Machine Learning, Statistical Modeling. (Side note, students from particle physics excel in Silicon Valley Big Data jobs.)



## Results

- Current results from ATLAS set limits ruling out a value of the Higgs self-coupling more than 2.4 times its predicted value.
- New bbtautau result: https://arxiv.org/abs/2209.10910
- ATLAS will collect data over the next three years and then undergo a large upgrade. Full 5-sigma measurement of the Higgs self-coupling is expected after this upgrade, but sensitivity continue to exceed expectations because of innovations in analysis.



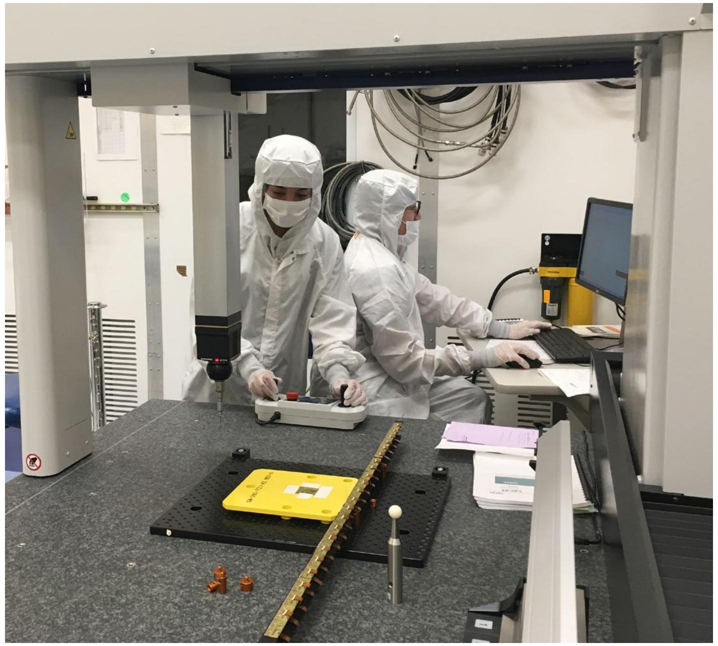

https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2022-050/

# Lessons Learned About Funding

- This work is funded through an NSF grant: AWD_ID=2111511 & AWD_ID=1807374
  - Grant topic: small but meaningful contributions to a “hot topic”; highlight the new diverse group of students exposed to particle physics at Cal State East Bay
- Extra sources of funding are very helpful:
  - A postdoc is shared with US-ATLAS; 0.5 FTE on this Higgs research paid through grant, 0.5 FTE on ATLAS software and computing, paid by US-ATLAS
  - University, US-ATLAS, DOE funds for student research
  - University awards for course release
- Based on experience on NSF/DOE panel reviews:
  - There are a lot of proposals, chance/luck is a big factor, especially from non-R1 institutions
  - Reviewers want proposals that are very current/relevant and with a coherent narrative for what will be accomplished. Worthwhile to attend conferences to stay on top of what is happening in the subfield so that physics objective is relevant
  - NSF panels want Broader Impacts, but this work must be on top of significant proposed physics advancement

# Lessons Learned: Research with Undergrads

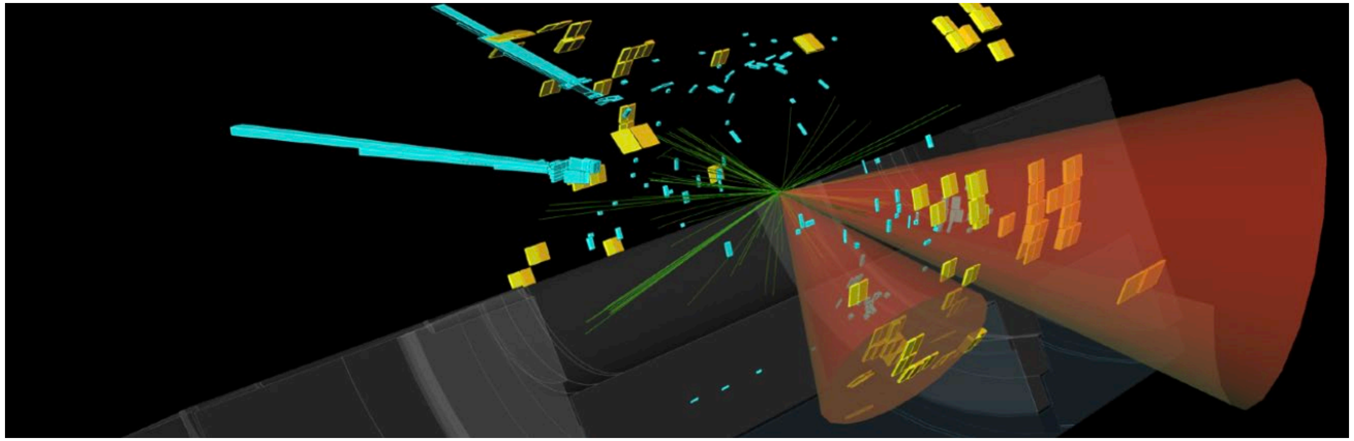
- Programing in python on Jupyter notebooks
  - Much easier for students than past experience with C++ on a terminal (!)
  - Worth taking the time to set this up a tutorial-like package for students– the turnover rate is so high for undergrads because of the few years they have
- Hardware projects particularly good for undergrads– no specialized knowledge needed, just time and effort
- Collaboration with other CSU Campuses: CSU East Bay has only undergraduates, but sometimes work with masters' students from other CSUs
- Hiring of recent graduates (undergrads) can be a good experience for all



Students working on metrology for the ATLAS upgrade at SLAC

## Next Steps/Long-Term Plans

- Maintain Cal State Particle Physics program
  - Important source of new blood in **US** particle physics, which is not very diverse
- Measurement of Higgs self coupling at LHC ~ 2029?
- Depending on results, further studies, or exploration of new topics @ LHC and beyond. Dark matter? QCD?



# Questions?

**Contact Information:**

Name: Kathryn Grimm

Campus/Department: Physics

Phone #: *510-885-3401*

Email: Kathryn.Grimm@csueastbay.edu

# Beyond Procedures: A research-based approach to teaching mathematical methods in physics

*Michael Loverude – CSU Fullerton*

*Collaborators: John Thompson, University of Maine*
*Warren Christensen, North Dakota State University*

Supported in part by PHYS-1912660, PHYS-1406035

**Michael Loverude**, Professor

Department of Physics, CSU Fullerton

mloverude@Fullerton.edu

# Project Overview

- Project goals:

(a) to conduct research on student understanding of mathematics in upper-division physics contexts, with an emphasis on the core mathematical methods and reasoning covered in an intermediate-level mathematical methods course;

(b) to develop a library of modular curricular materials emphasizing mathematical methods and reasoning suitable for use in upper-division physics courses and intermediate mathematical methods in physics courses.

- Based on three findings of our previous work and that of others:

1. *Students have little formal training in sensemaking or thinking like a physicist.*
2. *Many mathematical ideas needed in upper division physics are either not encountered or not learned in introductory math and physics courses.*
3. *Connecting mathematical formalism, which is by design highly decontexualized, to physical contexts, in which context is essential, is challenging for even strong students.*

## Project Overview

- What is the standard model of teaching math for physics majors, and what assumptions seem to underly that model?

1. *Typically, students are taught math in courses that are decontextualized and taught by mathematicians.*
2. *The assumption seems to be that students will now be equipped with mathematical tools that they can now employ in physics contexts.*

HOWEVER! Modern understanding of learning transfer (e.g., Lobato 2012, Wagner 2006) suggests that we should

- Pay attention to sociocultural factors, e.g., the environment in which learning takes place, noting disciplinary differences.
- Assume that knowledge is highly sensitive to context and that applying ideas in new contexts is not effortless or universally successful.

# Project Overview

While theoretical constructs and problem-solving strategies place value on all parts of the process, historically instruction and assessment seem to focus on execution and procedures.

*That's not necessarily the hard part!*

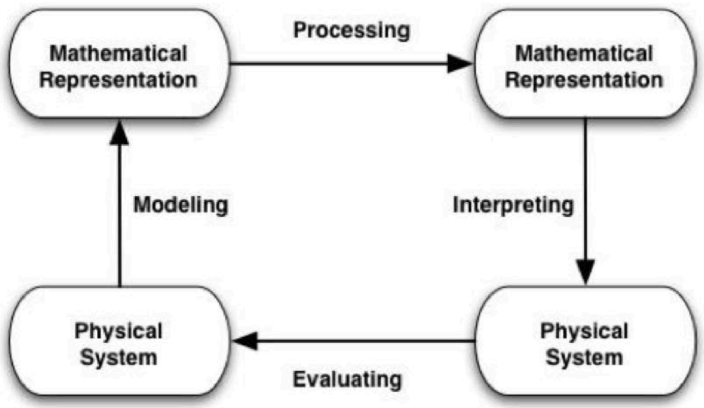



*Figure 4: A model of mathematical modeling*

Kuo and Redish 2018

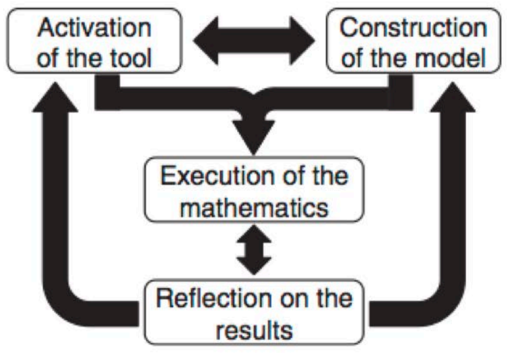



FIG. 1. A visual representation of the ACER framework.

Wilcox et al, 2013

# Project Overview

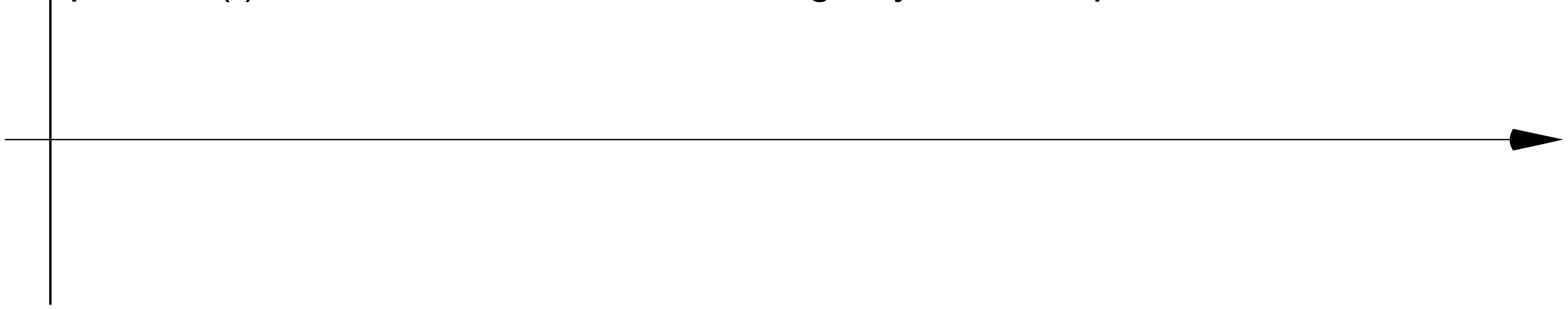
While theoretical constructs and problem-solving strategies place value on all parts of the process, historically instruction and assessment seem to focus on execution and procedures.

*That's not necessarily the hard part!*

Ungraded quiz, Physics 300 (N = 49)

Consider the function $f(t) = Ae^{i\omega t}$ In this function, A and ω are constant and positive.

Sketch the real part of f(t) as a function of time, labeling any relevant points.



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Consider the function $f(t) = Ae^{i\omega t}$   In this function, A and $\omega$ are constant and positive.

Sketch the real part of f(t) as a function of time, labeling any relevant points.

40% partly correct responses (oscillatory)

BUT ~ 45% sketched exponential growth

# Project Overview

While theoretical constructs and problem-solving strategies place value on all parts of the process, historically instruction and assessment seem to focus on execution and procedures.

*That's not necessarily the hard part!*

In relevant sections of Boas, Chapter 2:

- 135 math exercises, 7 proofs
- 15

In electricity we learn that the resistance of two resistors in series is $R_1 + R_2$ and the resistance of two resistors in parallel is $(R_1^{-1} + R_2^{-1})^{-1}$. Corresponding formulas hold for complex impedances. Find the impedance of $Z_1$ and $Z_2$ in series, and in parallel, given:

**6.** (a) $Z_1 = 2 + 3i, \quad Z_2 = 1 - 5i$ (b) $Z_1 = 2\sqrt{3}\, e^{i\pi/6}, \quad Z_2 = 2\, e^{2i\pi/3}$

**7.** (a) $Z_1 = 1 - i, \quad Z_2 = 3i$ (b) $|Z_1| = 3.16,\ \theta_1 = 18.4^\circ; \quad |Z_2| = 4.47,\ \theta_2 = 63.4^\circ$

## An example of a concept

The idea of a vector appears throughout the physics curriculum.  In the beginning:

- motion and forces are described with magnitude and direction
- forces, fields are added using superposition
- vectors are arrows in 1d, 2d, 3d spaces

- BUT upper division physics courses require that students extend this concept
  - vector spaces are generalized to include, e.g,, polynomials, sin / cos, special functions
  - the idea of vectors as arrows breaks down
  - ideas like projections take on new meaning

## Student / postdoc research

- Abolaji Akinyemi (UMaine), evaluation strategies (RUME proceedings 2020, Phys Rev PER submission)
- Anderson Fung, ordinary differential equations (PERC proceedings 2022)
- Pachi Her, matrix multiplication (PERC proceedings 2020, RUME proc submission)
- Mikayla Mays, Fourier series (PERC proceedings 2018)
- Anthony Piña, Integrals in physics texts (PERC proc. 2019)
- Henry Taylor, Function notation in kinematics (PERC proc 2019, RUME proc 2020).
- Zeynep Topdemir, partial derivatives in vector calculus (RUME proc submission)
- Marlene Vega, Brian Farlow (NDSU) unit vectors in plane polar (PERC proc 2016, Phys Rev PER 2019).
- Charlotte Zimmermann (UWashington) expert covariational reasoning in physics and math

# Curricular materials

- As part of the project, we are developing curricular materials for use in math methods and other upper-division physics courses, with a focus on extending the scope of students' knowledge of concepts.

- Guided inquiry tutorial worksheets (2-4 pages)
- In-class 'clicker' style discussion questions
- Supplemental homework exercises that go beyond repeating procedures

# Lessons Learned

Using math in upper-division physics is challenging. The math methods course is intended to help.  But if we simply perform procedures, we are missing an opportunity.

For example, instead of procedural tasks, we could be asking students in math methods better questions:

- Is this expression reasonable?
- Determine the units of the following quantities.
- “Reverse the reasoning.”
- Identify the error(s) in the following expressions.
- Which of these integrals has a physical interpretation?
- Explain why/whether this equation applies to this situation.

# Next Steps/Long-Term Plans

- This project is the second funded relating to this work, we are in year 3 of 3.
- Project was delayed considerably by COVID, and we anticipate at least one no-cost extension.
- Goals for the coming year including filling in research gaps, publishing work, and preparing a web-hosting for the curricular materials, as we have for our thermal physics curriculum.
- Project team is discussing extensions into lower division physics, particularly including collaboration with scholars from Research in Undergraduate Mathematics Education (RUME) community.

# Summary

- The current state of affairs means that many students enter the upper division without much experience with quantitative reasoning.
- The Math Methods course is a great opportunity to give students experience with mathematical sensemaking in physics contexts.
- However, it’s a missed opportunity if we approach the class as another opportunity for practicing decontextualized procedures. Physics is about using math in context, messy though it may be!

# Questions?

## Contact Information:

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# Understanding Cryogenic Semiconductor Devices

*Hiu-Yung Wong – San Jose State University*

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# Project Overview

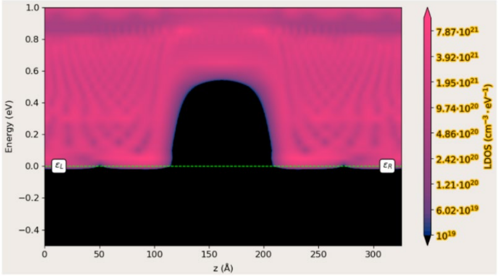
Fundings: NSF CAREER and Industry

**Long Term Career Plan: Establish Cryogenic and Quantum Computing Device Research and Education in SJSU**

**CAREER: Understanding and Modeling of Cryogenic Semiconductor Device Physics down to 4.2K**

| Research Tasks | Education Tasks |
|---|---|
| R1: Test Chip Design and Measurement | E1: Diversified Cryogenic Research Task Force |
| R2: SS Theory Validation | E2: New Cryogenic Device and Circuit Class |
| R3: Unified Mobility and Ionization Models | E3: Outreach to Disadvantaged High-School Students |
| R4: Complete Set of Cryo-CMOS Models | E4: Public Seminar |
| R5: Numeric and ML for Calibration | |

Theory/Simulation



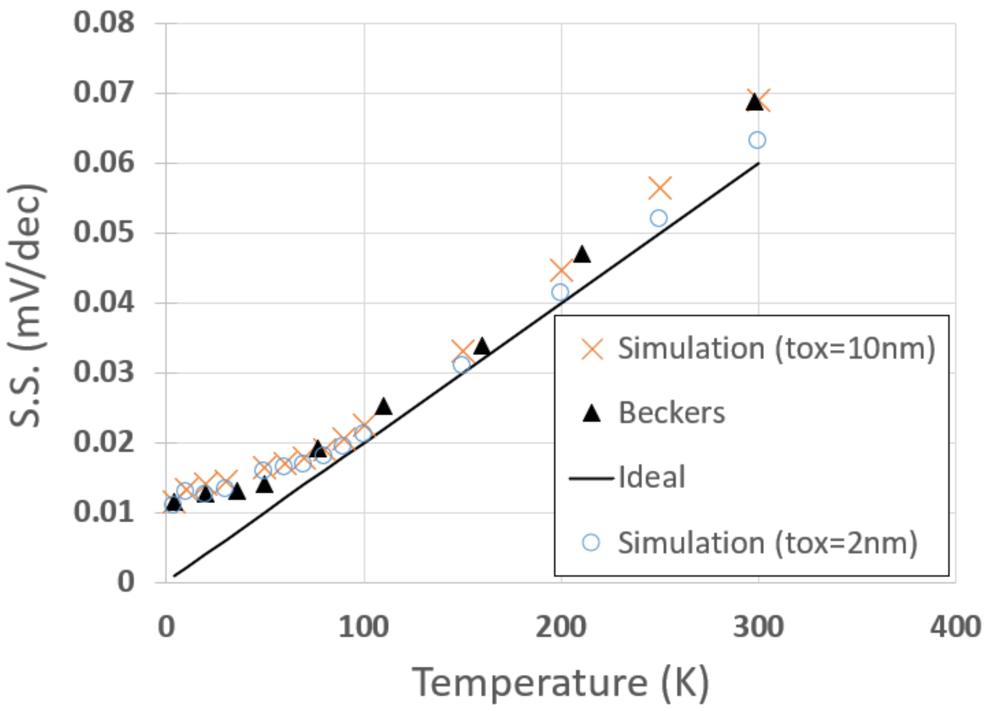
Experiment

Education

# Understanding Cryogenic Semiconductor Devices

## Activities

- Theory/Simulation
  - Calibrated mobility models
  - Proposed theory for abnormal sub-threshold slope
  - Performed 3K *ab initio* simulation
- Experiment
  - Installed Lakeshore TTPX system
  - Measured 4.2K MOSFET mobility
- Education
  - Quantum Computing and Information Specialization in MSEE
  - Created EE226 Cryogenic Nanoelectronics
  - Held outreach class on Quantum Computing



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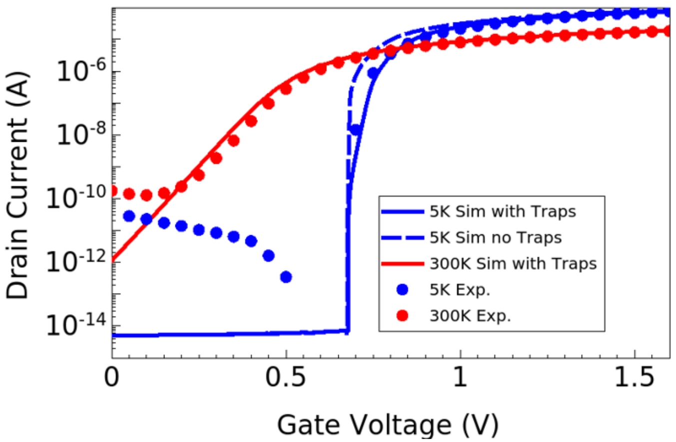
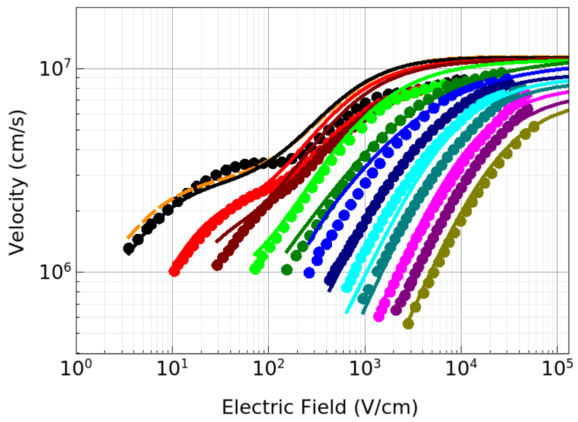
# Understanding Cryogenic Semiconductor Devices

## Results

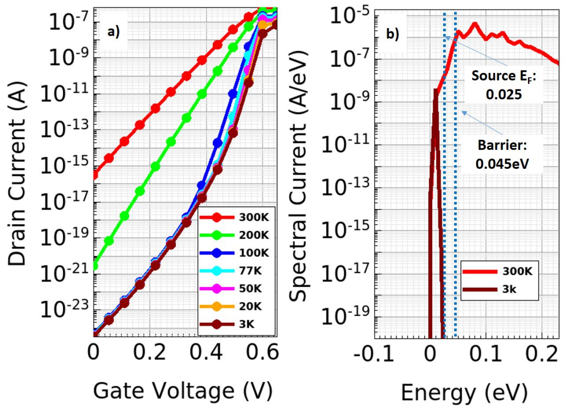
### Fitting exp. using trap theory (SISPAD ‘21)




### Unified mobility model (IEEE TED ‘22)




### Robust 3K ab initio calculation (SSE ‘22)



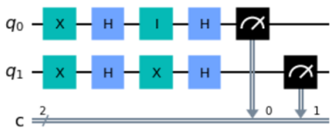

### Test chip tape-out and 4.2K Measurement

### Outreach to high school students

**Advanced Course - Intro to Python Programming - with Machine Learning & Quantum Computing Applications**

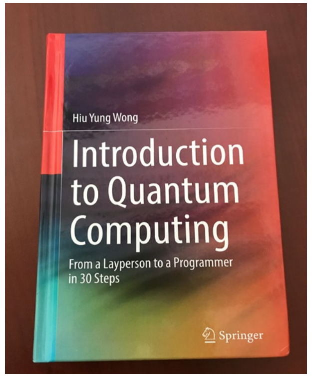
by Silicon Valley Tech Academy

```
MyQC = QuantumCircuit(2,2)
MyQC.x(0)
MyQC.x(1)
MyQC.h(0)
MyQC.h(1)
MyQC.i(0)
MyQC.x(1)
MyQC.h(0)
MyQC.h(1)
MyQC.measure(0,0)
MyQC.measure(1,1)
MyQC.draw('mpl')
```



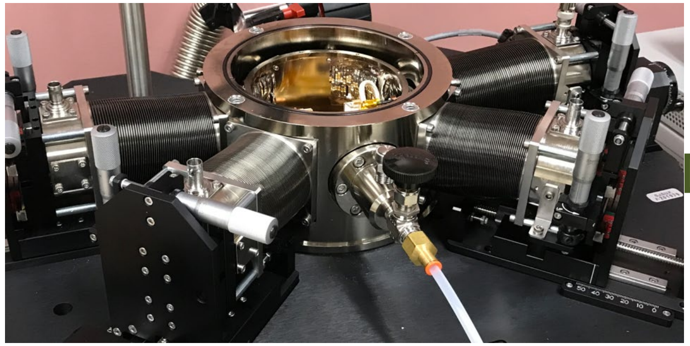

### Textbook Publication

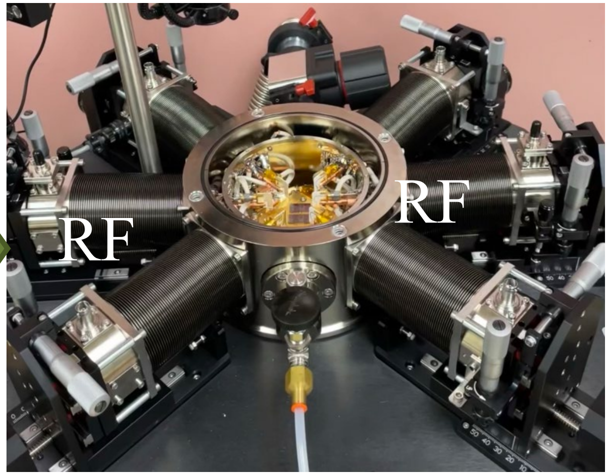
- Free on SpringerLink
- ~30k chapter downloads in 4 months
- Youtube teaching videos available



# Lessons Learned

- PI should be deeply involved in the research process
  - Weekly one-on-one meeting
  - Get the hands "dirty" in both simulation and experiment
  - Meet timelines (based on student's schedule)
  - 5 papers published with 7 students trained (2 female, 3 undergraduate, 1 URM) in 1.5 years
- Expand capability and explore opportunities
  - Initial support: NSF CAREER
  - One endowment funding to expand to RF
  - One industry funding to measure industry chip
  - One pending for more advanced measurement

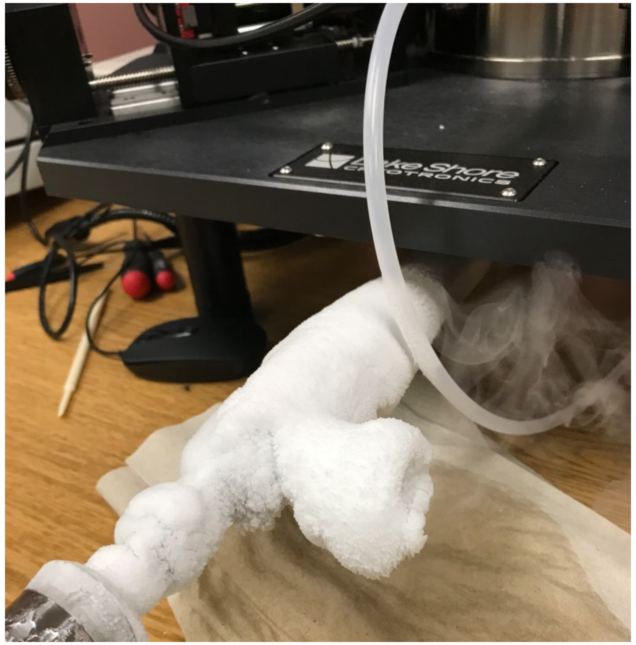




# Next Steps/Long-Term Plans

- Research
  - Measure test chips to collect essential cryogenic data
  - Calibrate all essential models for cryogenic TCAD simulation
  - Use *ab initio* simulation to study the band tail states in MOSFETs
- Education
  - Train students on
    - ML for automatic cryogenic model extraction
    - Cryogenic device physics and experiment
  - Outreach
    - Promote cryogenic electronics and quantum computing
  - Offer EE274 Quantum Computing Architectures in Spring 2023
- Long term: Establish cryogenic and quantum computing device research/education in SJSU

# Summary



- There is plenty of room in the cryogenic regime – *it is cool!*
- With NSF CAREER's support, we jump-started the venture
  - Study the cryogenic device physics through simulations
  - Confirm the theories through tape-out and measurement
- We keep expanding our capability to cryogenic RF regime
- Train a diverse next generation of engineers who
  - understand quantum computing
  - can engineer the quantum computing interface electronics
- We look forward to collaborations by providing cryogenic simulation and measurements

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# Questions?

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# Next Steps/Closing Remarks

Dr. Frank A. Gomez
Executive Director, STEM-NET
Office of the Chancellor

https://www2.calstate.edu/impact-of-the-csu/research/stem-net

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The California State University
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# STEM-NET Upcoming Events

## Virtual Research Café 10.0

Date: Wednesday, October 19, 2022
Time:11am-12pm

Register Here

## STEM-NET November Webcast

Topic: Advances in the Social, Behavioral and Economic Sciences (SBE)
Date: Wednesday, November 30, 2022
Time: 10am- 11:30AM

Register Here

## Join our CSU STEM-NET Community listserv

csustemnet@lists.calstate.edu


## Begin a Conversation with Colleagues and Join our Private CSU STEM-NET Facebook Group

https://www.facebook.com/groups/2629611737269292

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# For more information about STEM-NET visit our website: