

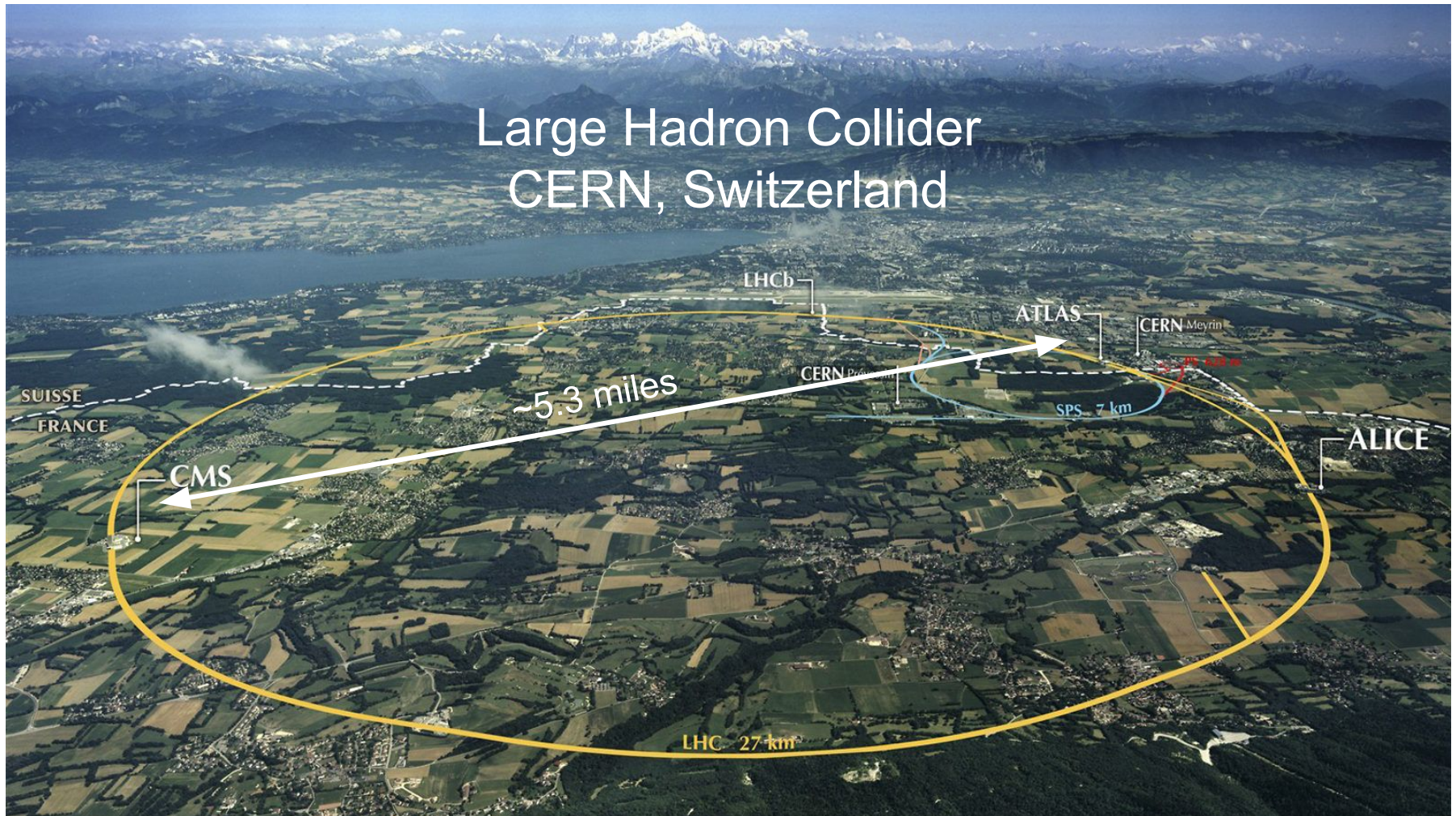
The Berkeley ATLAS group

Simone Pagan Griso
(spagangriso@lbl.gov)
for the ATLAS group

2025 Prospective Graduate Student Open House
Berkeley, March 14th 2025

The Highest-Energy Collider

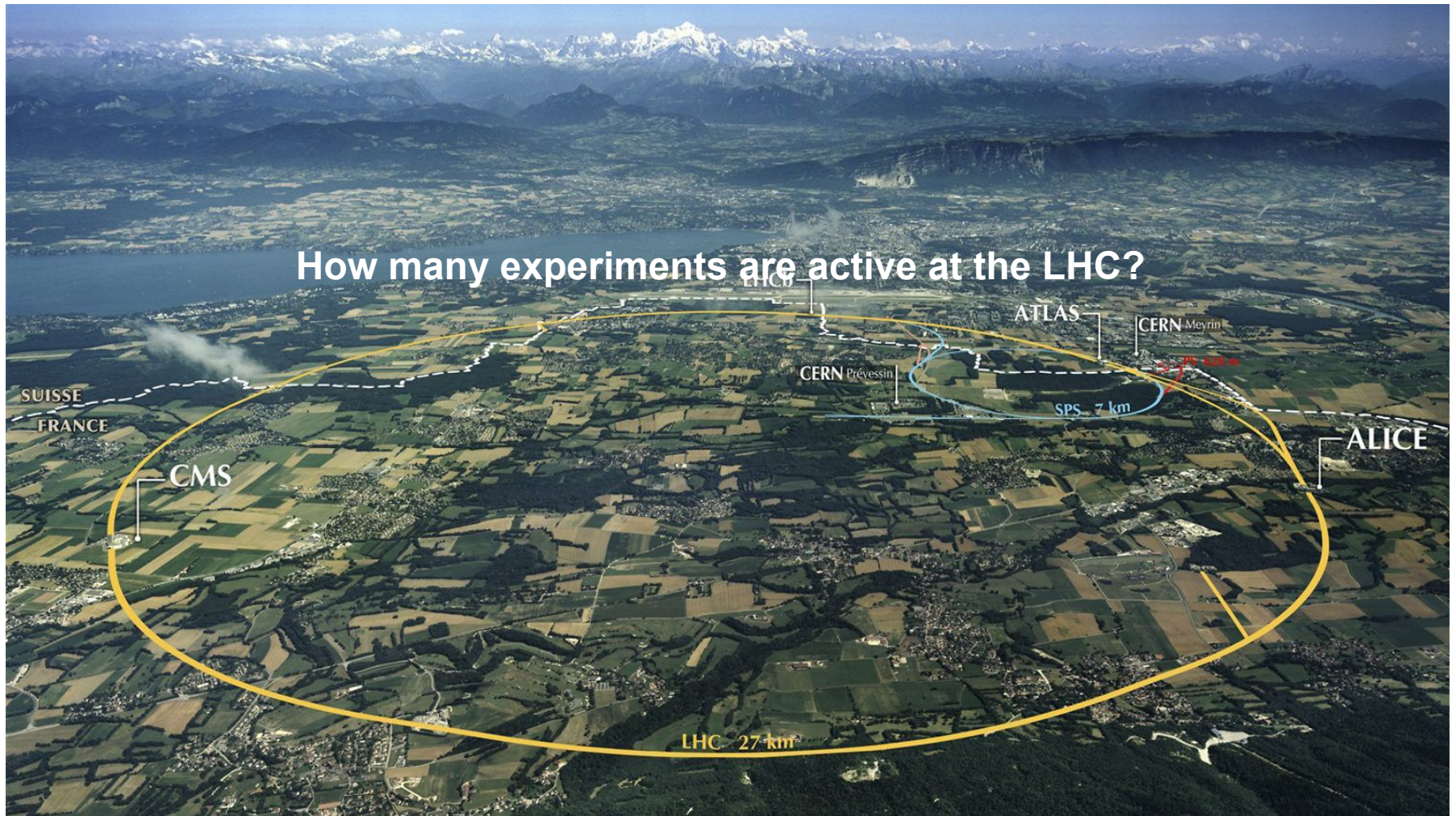
Large Hadron Collider CERN, Switzerland



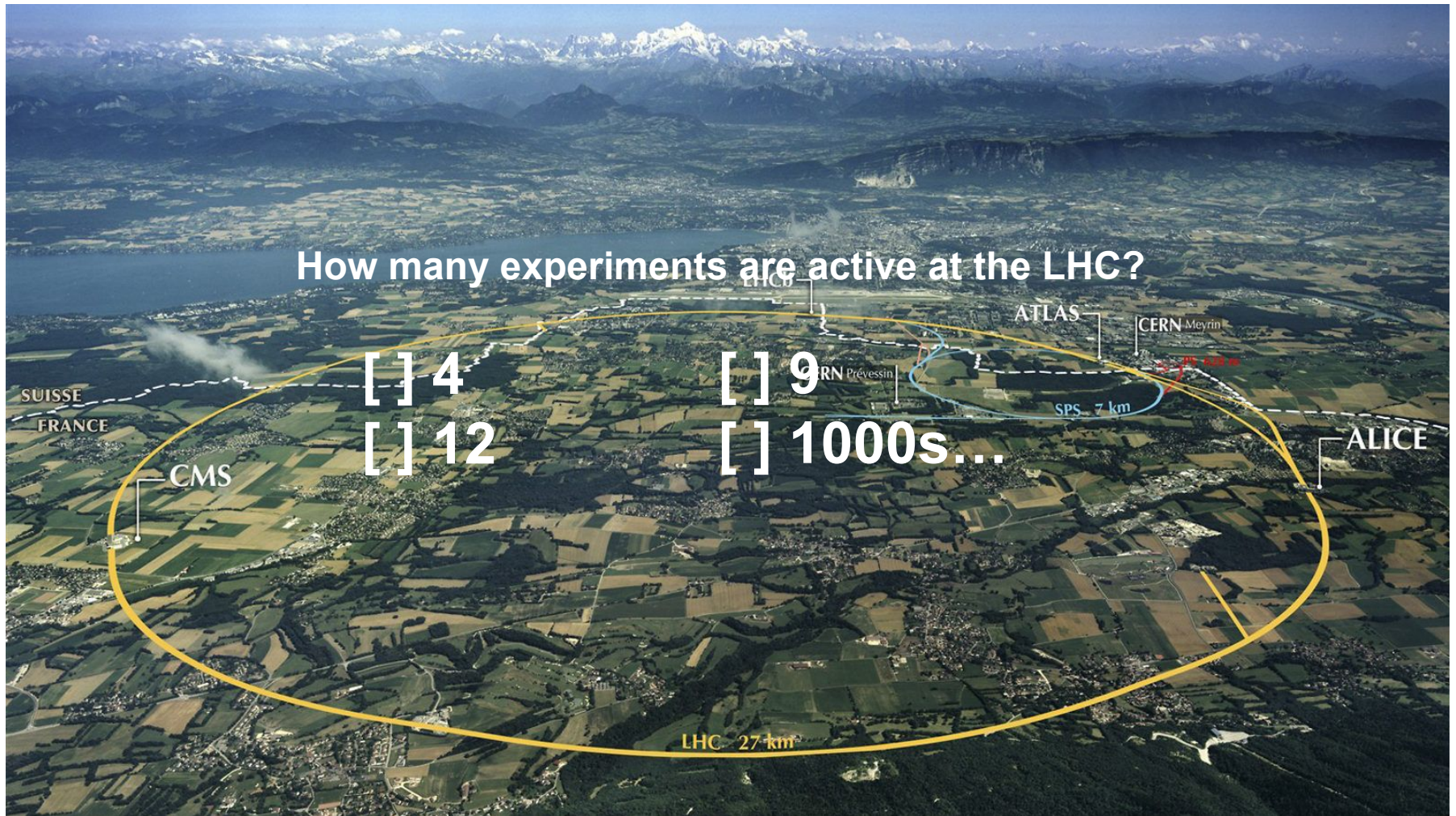
- Collide protons at \sim speed of light, $E_{cm} = 13.6 \text{ TeV} \sim 14,500$ times the proton mass
 - Not one at the time: ~ 2000 bunches of $\sim 10^{11}$ protons each per beam!
- 4 interaction points, $O(100M)$ proton-proton interactions per second, since 2010!
- Collaboration of 10,000+ scientists around the world, $\sim 2,000$ from the U.S.

The Large Hadron Collider

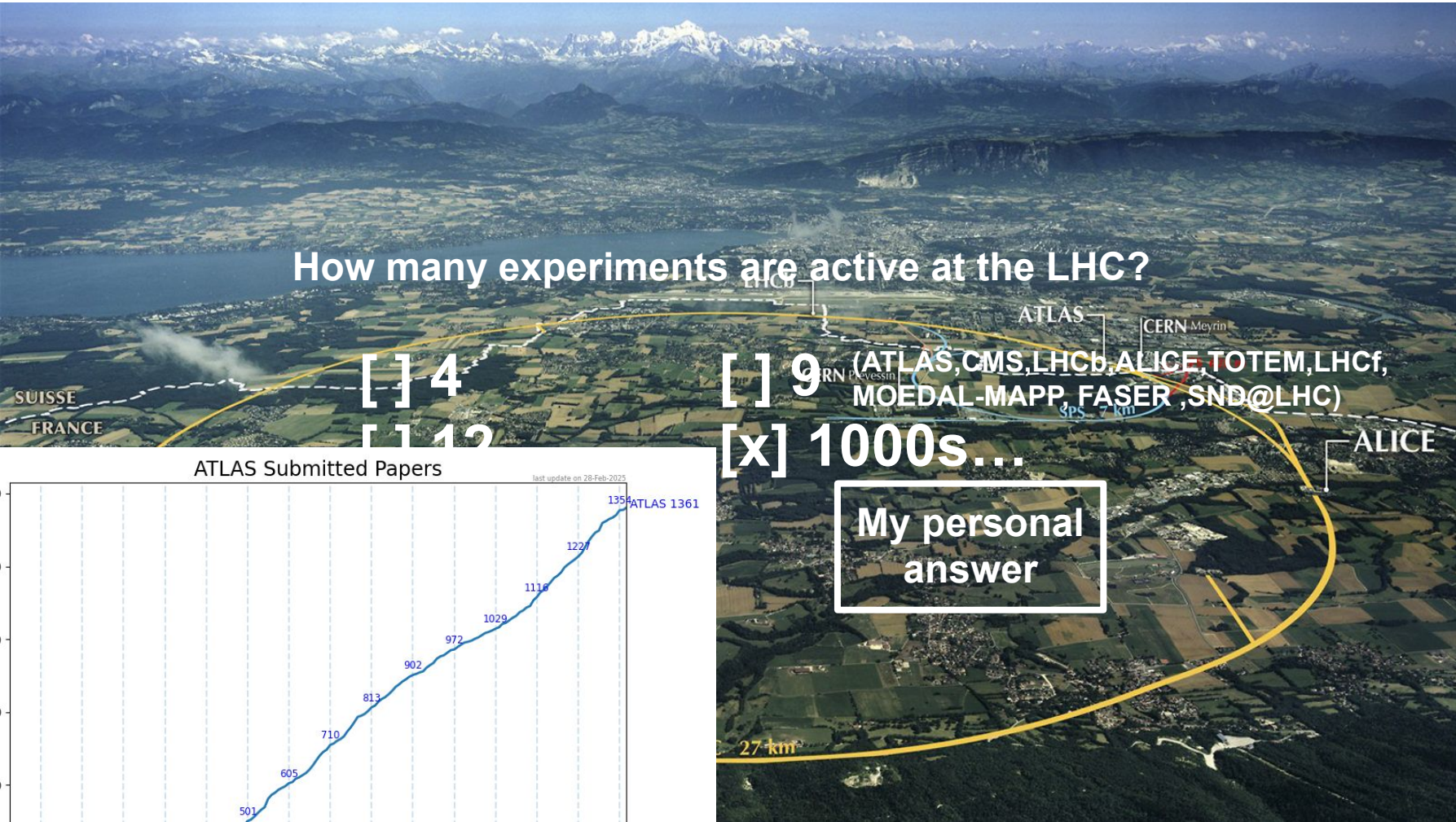
How many experiments are active at the LHC?



The Large Hadron Collider



The Large Hadron Collider



How many experiments are active at the LHC?

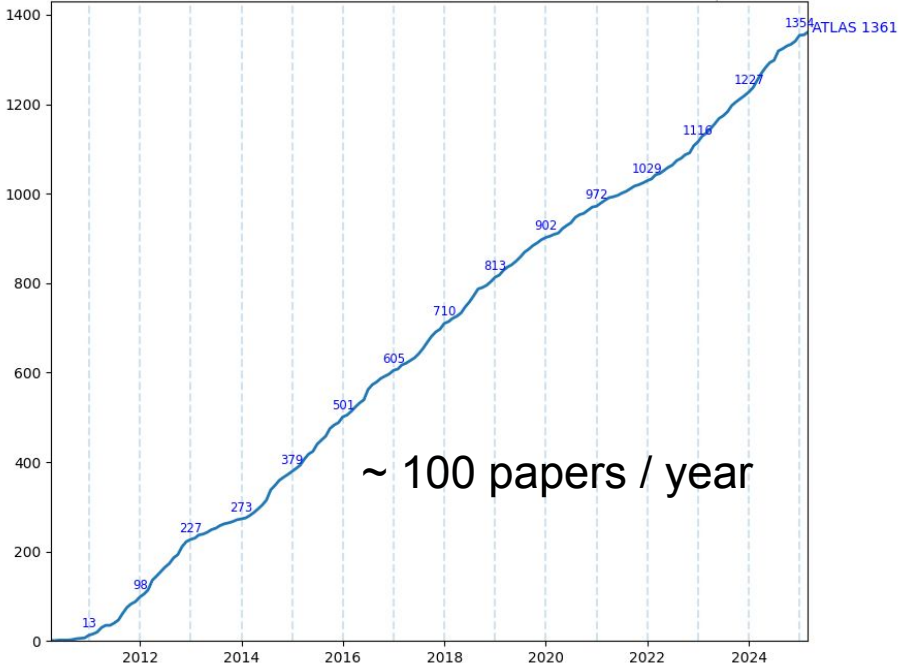
[] 4
[] 12

[] 9 (ATLAS, CMS, LHCb, ALICE, TOTEM, LHCf, MOEDAL-MAPP, FASER, SND@LHC)

[x] 1000s...

My personal answer

ATLAS Submitted Papers

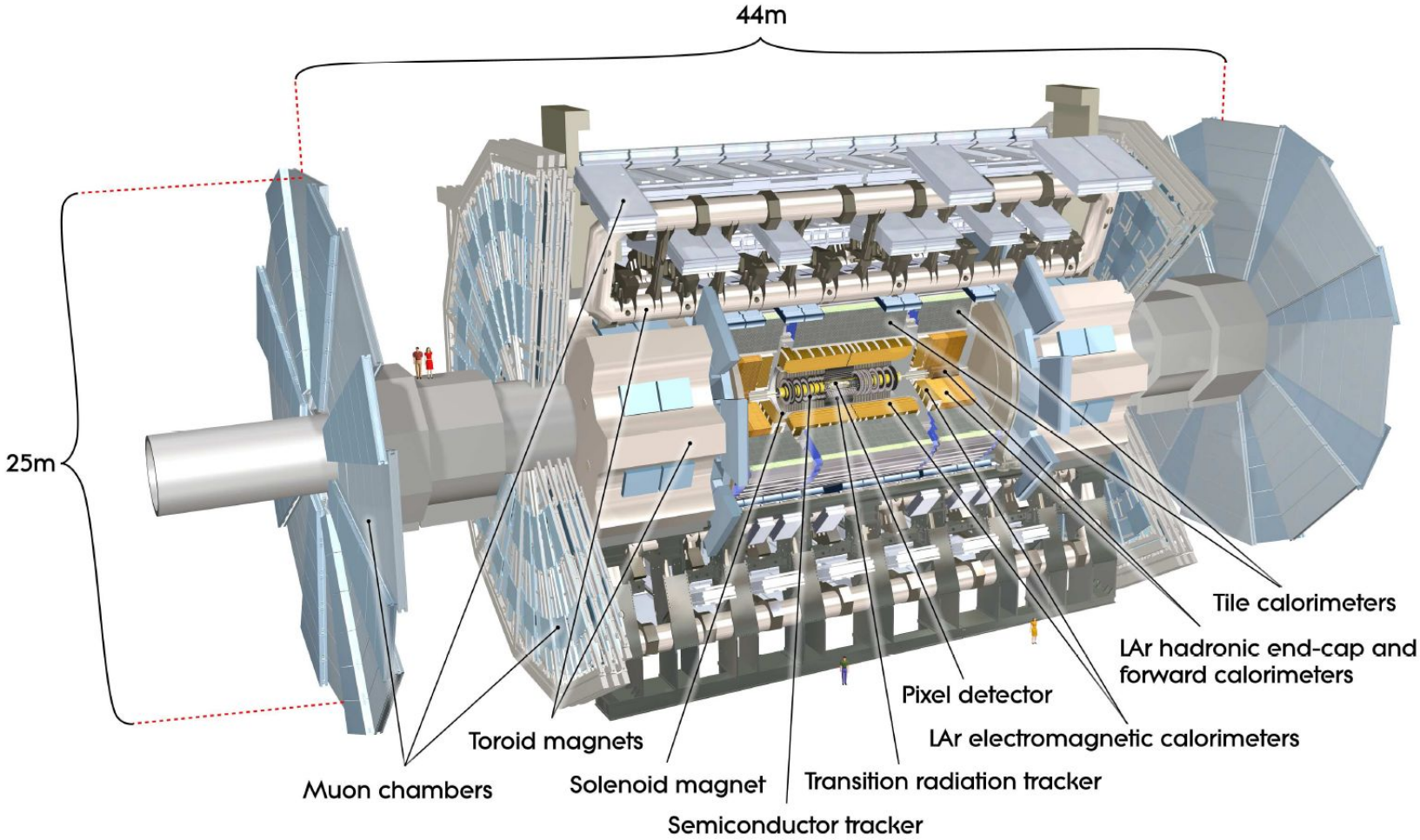


~ 100 papers / year

The ATLAS Detector, Collaboration, ...

The ATLAS detector is one of the two general-purpose particle physics experiments at the LHC

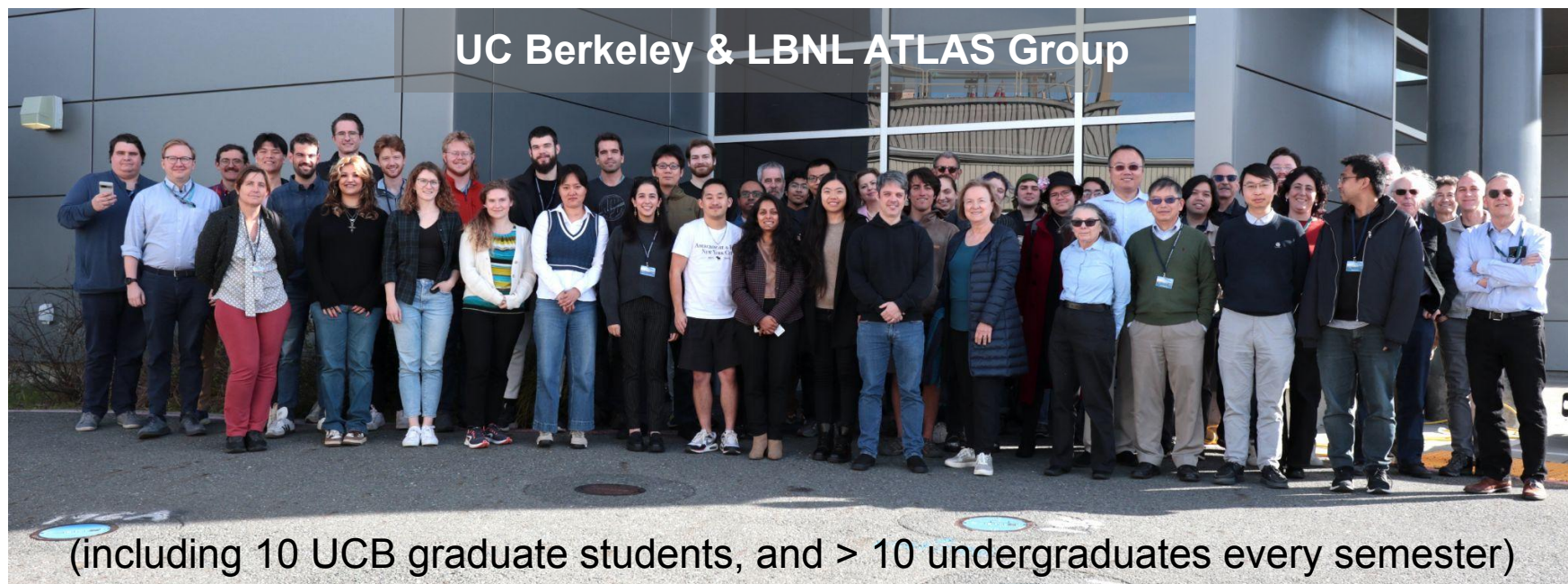
- International collaboration: 174 institutions from 38 countries; 44 from the U.S.



The ATLAS Detector, Collaboration, and the Berkeley group

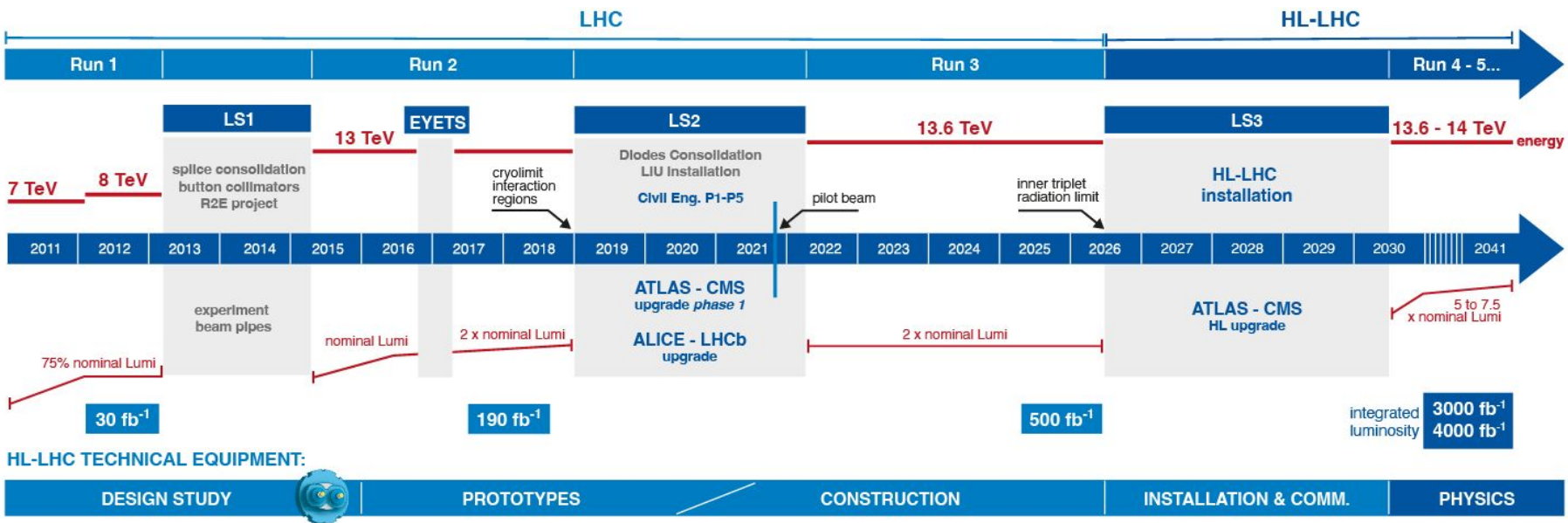
The ATLAS detector is one of the two general-purpose particle physics experiments at the LHC

- International collaboration: 174 institutions from 38 countries; 44 from the U.S.
- UC Berkeley and Lawrence Berkeley National Lab operate as a single group in the experiment
- We are the largest U.S. group with graduate students



The LHC timeline

The physics program at the LHC will span over three decades; in terms of the amount of data, we are at the beginning (~10%) of a long journey for discoveries



Run-1

2011 - 2012, 7 TeV - 8 TeV, 25 fb⁻¹
Higgs discovery 2012 with 10 fb⁻¹

Run-2

2015 - 2018, 13 TeV, 150 fb⁻¹

Run-3

2022 - 2025, 13.6 TeV, ~ 300 fb⁻¹
 65 fb⁻¹ collected so far

High Luminosity LHC (HL-LHC)

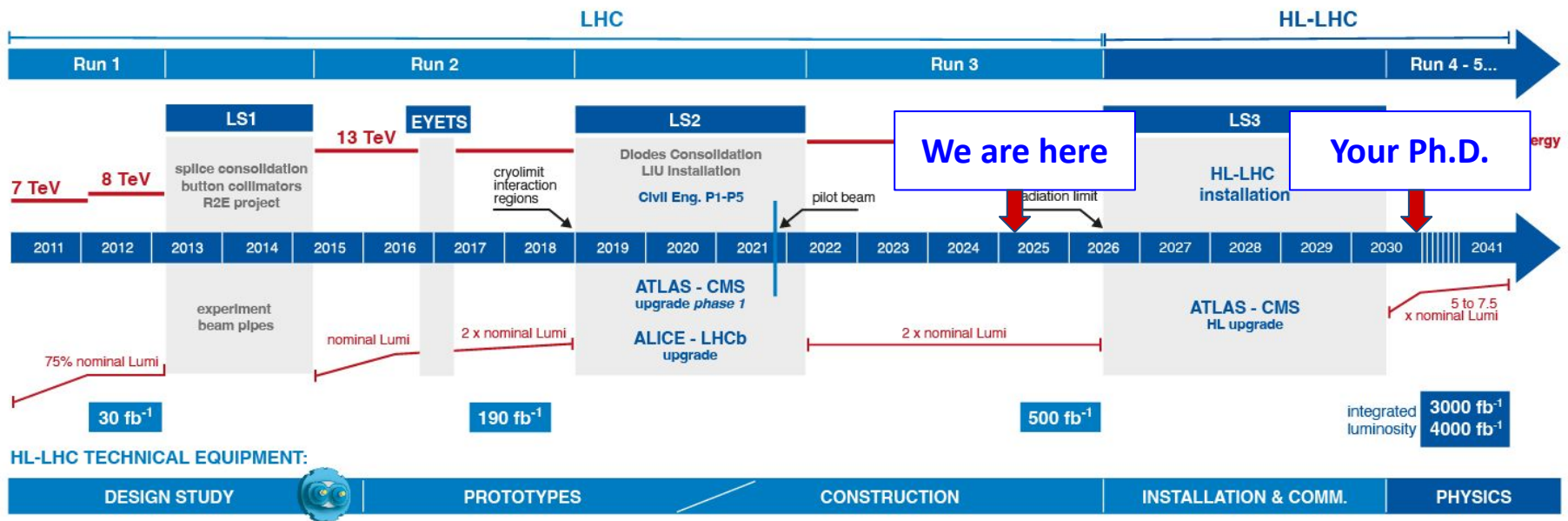
2030 → 2041, 14 TeV, ~2500 fb⁻¹

We are at in the middle of Run3

- Analyze Run-3 data
- Upgrade the detector for the HL-LHC
- Prepare for HL-LHC analysis

The ~~LHC~~ Your Ph.D. timeline

The physics program at the LHC will span over three decades; in terms of the amount of data, we are at the beginning (~10%) of a long journey for discoveries



We strive for our Ph.D. students to acquire experience in multiple areas of the collaboration activities

- Detector R&D
- Computing and Software
- Data analysis → thesis topic

(at least two of the above)

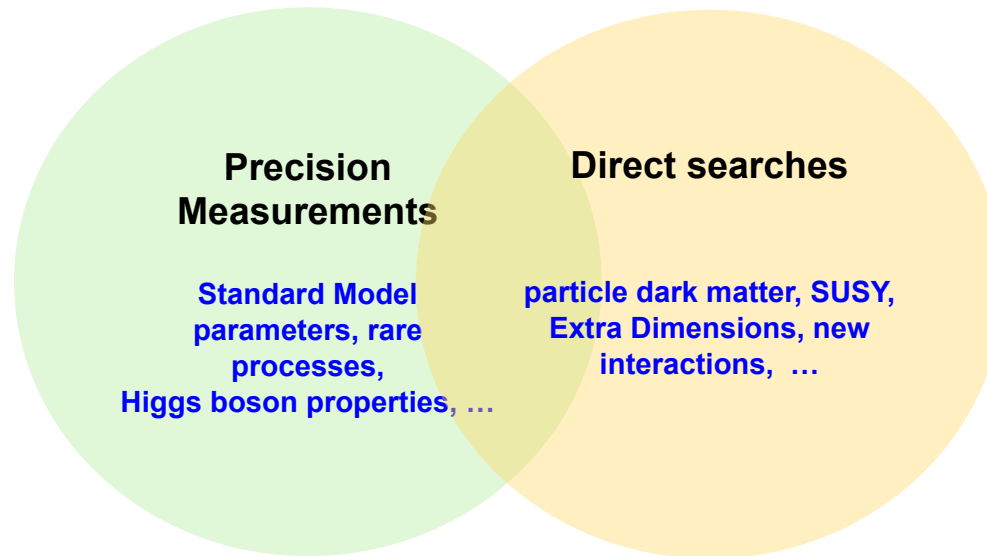
Our group is collaborative and students can work with a range of people during their time at Berkeley

Areas of research of the Berkeley group: data analysis

We work on the ATLAS experiment to understand the fundamental principles of nature.

Two broadly complementary approaches

- Test the prediction of Standard Model using **precision measurements**
- **Direct searches** for new physics signals



We know new physics is there! Many proposed solutions are out there as well

- The **Higgs boson has become a tool for discovery**; the Higgs boson plays a role in many new physics theories
- Berkeley group covers many different areas of ATLAS physics program
 - Based on individual interests and opportunities (upgrade, anomalies etc..)

Areas of research of the Berkeley group: computing and software

- **New software and framework to fully exploit detector and modern computing architectures**
- **Significant expertise: Computational Research Division (CRD)** scientists are members of ATLAS group; Dr. Marshall is the ATLAS Computing Coordinator
- Opportunities to explore and exploit advanced computational technologies
 - Use **High Performance Computers at National Energy Research Scientific Computing Center** to perform routine analysis work
 - **AI accelerators** available: GPU, novel AI chips (SambaNova, GraphCore IPU)
- Prof. Gray is a founding member of NSF funded IRIS-HEP software institute
 - Projects on track reconstruction algorithms using novel architectures and machine learning

High Performance Computing Systems (HPCs)



Areas of research of the Berkeley group: detector R&D

At the HL-LHC, ATLAS will become a new experiment. Many aspects of ATLAS will be upgraded

We're a leader in the construction of the original ATLAS tracker, and has been leading the R&D and construction for the new tracker

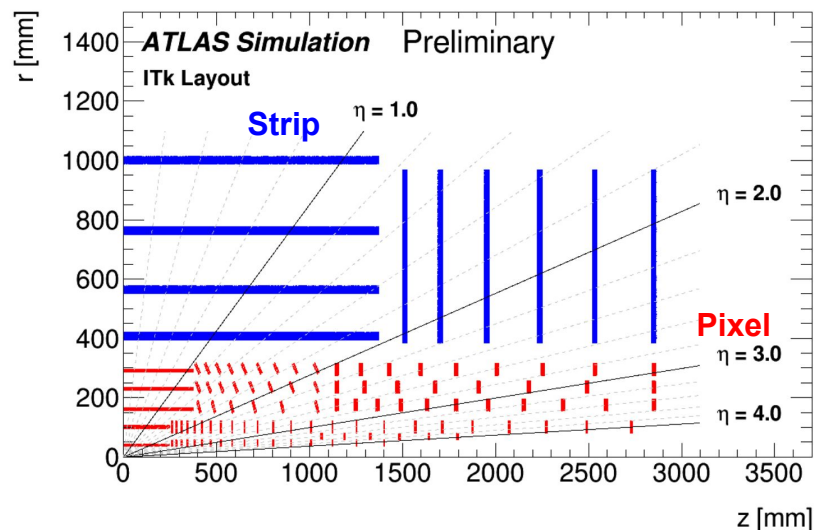
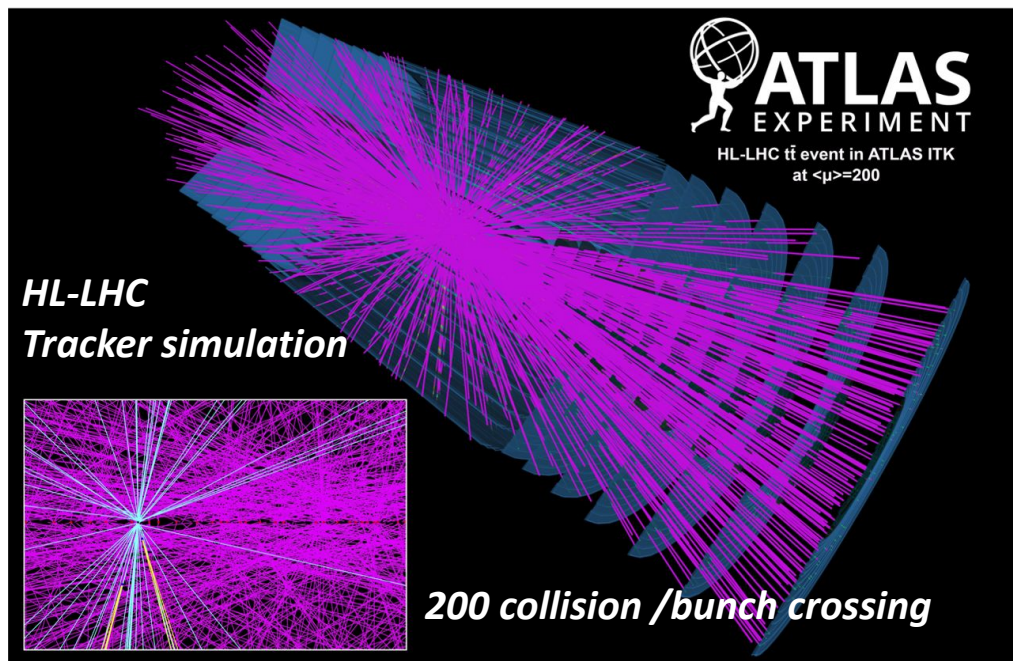
- all new silicon tracker
- Silicon sensor area is over 2000 ft²

LBNL has major responsibilities

- Assembly and testing of sensors and electronics components used to locate charged particles
 - Development of firmware and software used for data acquisition during testing and data-taking
- => **see ATLAS lab-tours for more details**
- Will naturally evolve in responsibilities for operation of the HL-LHC detector

Upgraded detector => new opportunities and new ideas

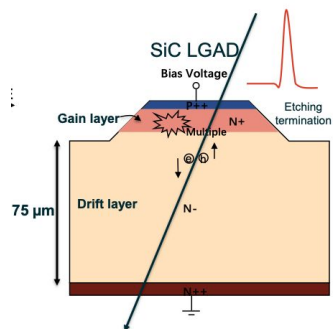
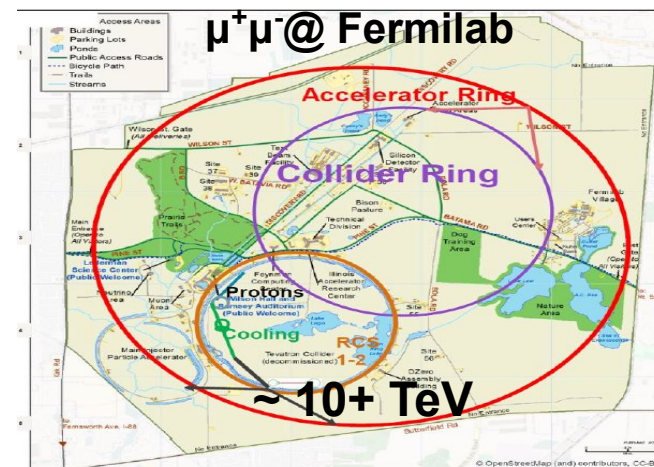
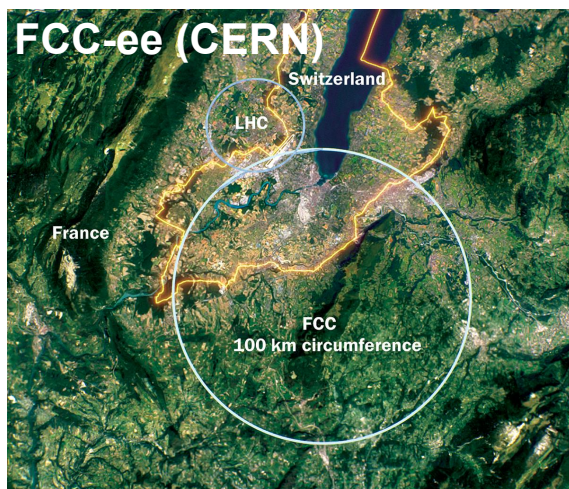
- New particle reconstructions algorithm, non-standard signatures



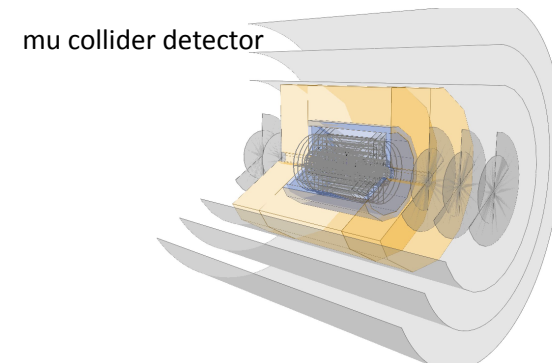
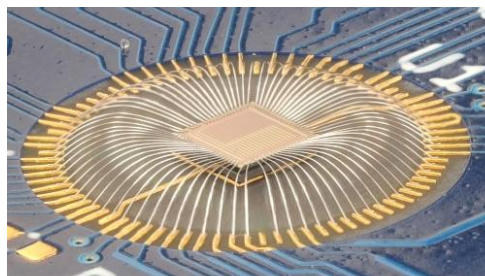
Areas of research of the Berkeley group: future colliders

- **Future of Collider physics**

- New Particle Physics Project Prioritization Panel report pave the path to future large projects
- LBNL current activities:
 - Hardware R&D activities (new generation electronics design, new materials)
 - Detector design studies based on simulation (tracking for muon collider)
- **Opportunities to contribute part-time to these areas as well**



Sensors with new materials (Si-C)



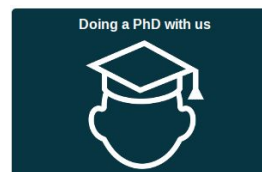
Closing remarks

The LHC is a great tool to probe a wide range of questions in particle physics

As a joint University/National Lab group, we are unique in the U.S., and this means graduate students have the opportunity and resources to do big things

We have a strong track record of mentoring and training grad students that has led to successful outcomes for students pursuing careers in both academia and industry.

www.physics.lbl.gov/atlas/



| Name | Now at... | Thesis title | | | |
|-------------------|--|--|------------------|--|--|
| Patrick McCormack | Postdoc MIT | Observation and measurement of $\gamma\gamma \rightarrow W+W-\gamma\gamma \rightarrow W+W-$ in pppp collisions at $\sqrt{s} = 13$ TeV using the ATLAS detector | Alexander Sood | Center for Neuroscience University of California, Davis, Davis, CA | Evidence for the production of two W bosons with the same electric charge and two jets in 20.3 fb ⁻¹ of pp collisions at $\sqrt{s}=8$ TeV using the ATLAS detector |
| Jennet Dickinson | Postdoc at Fermilab | ATLAS Measurements of the Higgs Boson Coupling to the Top Quark in the Higgs to Diphoton Decay Channel | Ana Ovcharova | Data Scientist at Capital One | Measurement of the top quark pair differential cross-section at high top quark transverse momentum in $\sqrt{s} = 8$ TeV proton-proton collision data collected with the ATLAS detector at the LHC |
| Emily Duffield | Data Scientist at Information Technology at Sleep Number Corporation | Observation of the electroweak production of two W bosons with the same electric charge in association with two jets in pppp collisions at $\sqrt{s}=13$ TeV with the ATLAS detector | Peter Loscutoff | Principal Data Strategist at Clover Health | Search for resonant WZ to $l\nu$ production using 13 fb ⁻¹ in $\sqrt{s}=8$ TeV p-p collisions with the ATLAS detector |
| Tova Holmes | Assistant Prof, University of Tennessee | A Search for Supersymmetry in Events with a Z Boson, Jets, and Missing Transverse Energy in pp Collisions with $\sqrt{s}=13$ TeV with the ATLAS Detector | Louise Skinnari | Assistant Professor at Northeastern University | A Search for Physics Beyond the Standard Model using Like-Sign Muon Pairs in pp Collisions at $\sqrt{s}=7$ TeV with the ATLAS Detector |
| Brad Axen | Data Scientist at Square | A Search for Long-Lived, Charged, Supersymmetric Particles using Ionization with the ATLAS Detector Search for Long-Lived, Charged, Supersymmetric Particles using Ionization with the ATLAS Detector | Joe Virzi | Software Engineer Telepath Corporation | A Measurement of the Underlying Event Distributions in Proton-Proton Collisions at $\sqrt{s}=7$ TeV in Charged-Particle Jet Events using the ATLAS Detector at the Large Hadron Collider |
| Jackie Brosamer | Engineering Lead, Business Platform at Square | Measurement of jets produced in top quark events using the $e\mu$ final state with 2 b-tagged jets in pp collisions at $\sqrt{s}= 8$ TeV with the ATLAS detector | Andre Bach | Data Scientist at Patreon | Search for Pair Production of a New b' Quark that decays into a Boson and a Bottom Quark with the ATLAS Detector at the LHC |
| Robert Clarke | Submarine Officer and US Navy Ensign | A Search for Lepton-Flavor-Violating Decays of the 125 GeV Higgs Boson with Hadronically Decaying Tau Leptons in the 20.3 inverse femtobarns using the $\sqrt{s}=8$ TeV Dataset Collected in 2012 by the ATLAS Detector at the Large Hadron Collider | Seth Zenz | Lecturer at Queen Mary | Properties of Jets Measured with Charged Particles with the ATLAS Detector at the Large Hadron Collider |
| David Yu | Postdoc at Brown University | Searches for new phenomena using events with three or more charged leptons in pp collisions at $\sqrt{s}=8$ TeV with the ATLAS detector at the LHC | Maxwell Scherzer | Vice President at Goldman Sachs | Measurement of the $\Upsilon(1S)$ Production Cross Section in Proton-Proton Collisions at Center of Mass Energy 7 TeV |
| | | | Michael Leyton | Lecturer at Cal Poly | Minimum Bias Measurements with the ATLAS Detector at the CERN Large Hadron Collider |
| | | | Lauren Tompkins | Associate Professor, Stanford | A Measurement of the proton-proton inelastic scattering cross-section at $\sqrt{s}=7$ TeV with the ATLAS detector at the LHC |

Backup

The ATLAS Senior group



Three UC faculty members, more than 16 LBNL staff scientists from *Physics*, *Computational Research*, and *Engineering* divisions

Graduate students can work with faculty members or lab scientists



Many leadership positions in ATLAS held by senior members as well as postdocs

A few examples for members of this group *in the past five years*:

Fabio Cerutti (Physics Coordinator, Higgs Convener, Publication Committee chair)

Kevin Einsweiler (Electronics Deputy Coordinator, Upgrade coordinator)

Heather Gray (Data Preparation convener, Simulation coordinator)

Timon Heim (ITk FE chip coordinator)

Zachary Marshall (Computing coordinator, SUSY group convener)

Benjamin Nachman (HLRS convener, Rad Damage convener)

Simone Pagan Griso (LHC Long-lived Particles WG convener, Publication and Authorship Committee member, Upgrade Physics Group convener)

Majorie Shapiro (DCC coordinator)

Haichen Wang (Publication Committee, H->gamma gamma sub-group convener)

Maurice Garcias-Sciveres (ITk Pixel FE-chip Coordinator)



Maria Mironova (PMG Weak Boson Processes group convener)

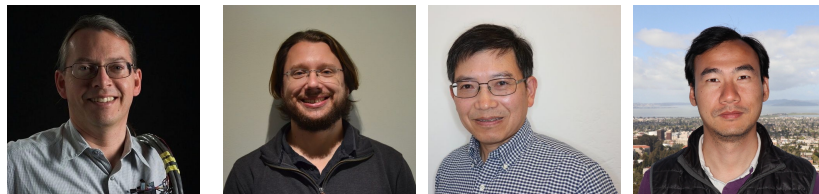
Louis-Guillaume Gagnon(Upgrade Tracking convener)

Elliot (Higgs and Light Resonance Searches (HLRS) convener)

Carlo Varni (Upgrade Tracking convener)

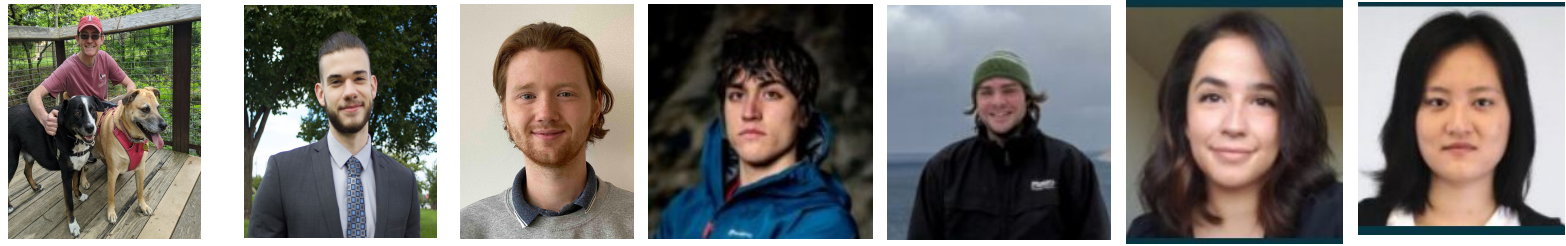
Hongtao Yang (Higgs combination group convener)

* former members of the group



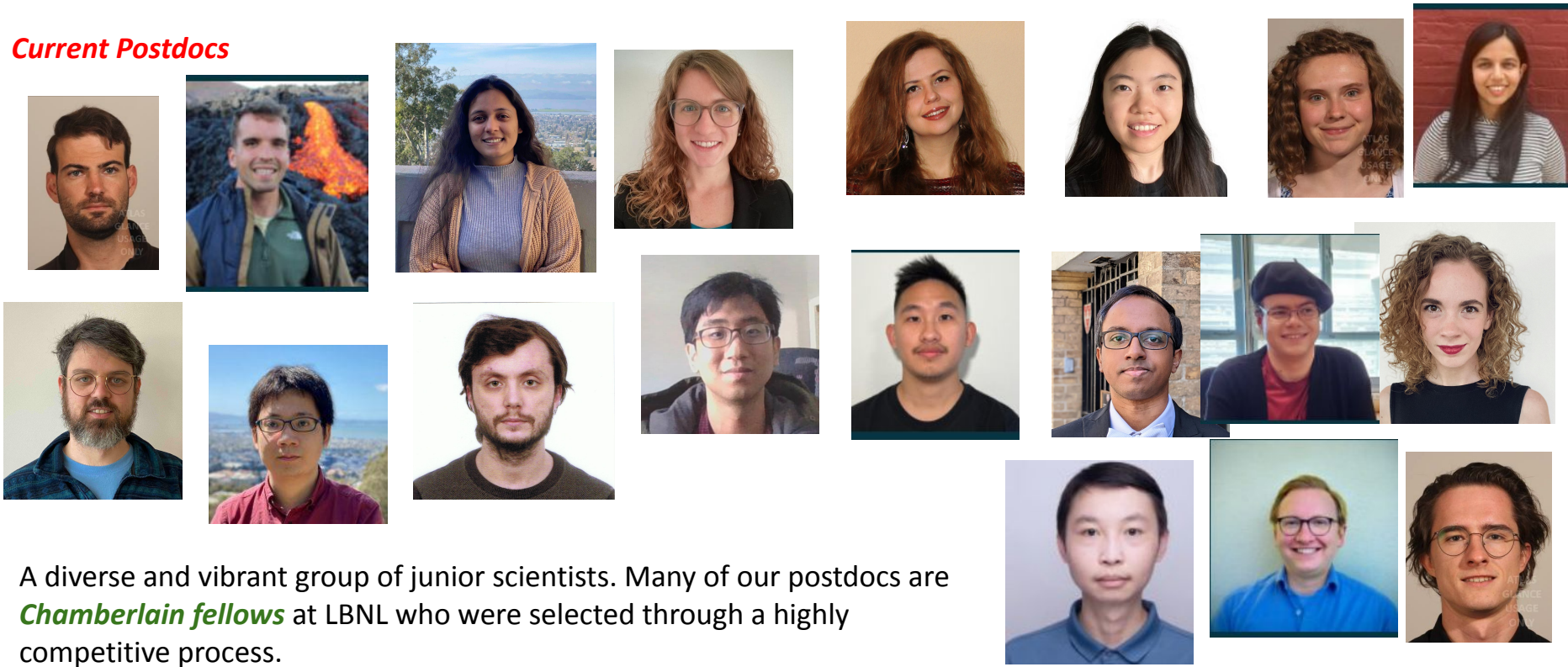
Graduate Students and Postdocs

Current Graduate students (several NSF fellows)



+ 3 more..

Current Postdocs



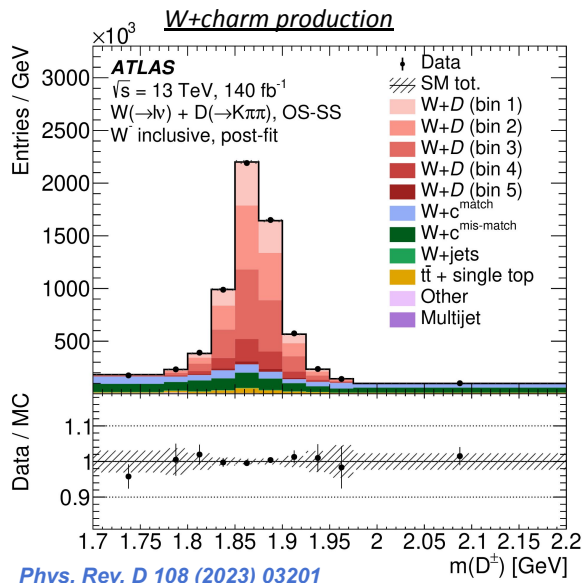
A diverse and vibrant group of junior scientists. Many of our postdocs are **Chamberlain fellows** at LBNL who were selected through a highly competitive process.

Physics Analysis Themes - recent highlights

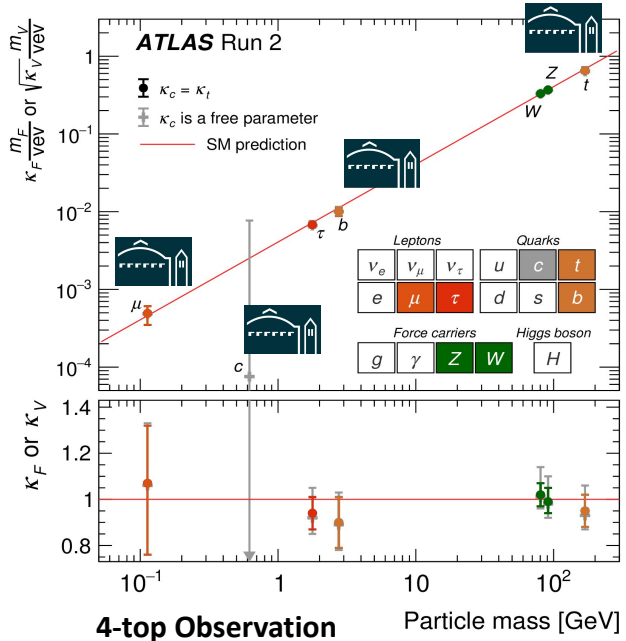
Standard Model measurements Understanding the **Higgs Boson**

Searches for new physics, esp. **Long Lived Particles**

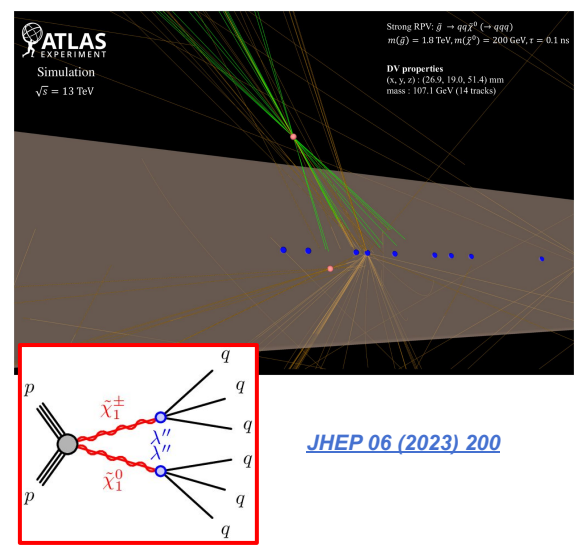
Improve bkg understanding to Higgs and BSM



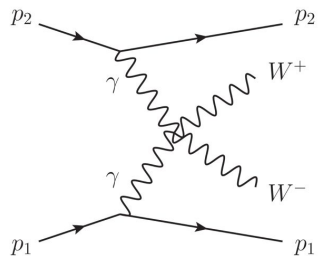
Higgs boson couplings



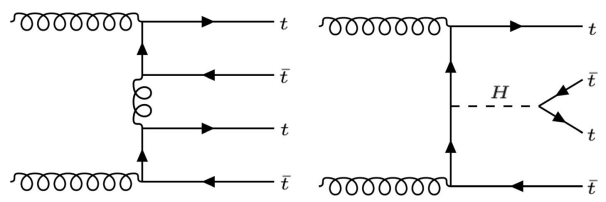
Displaced hadrons and photons



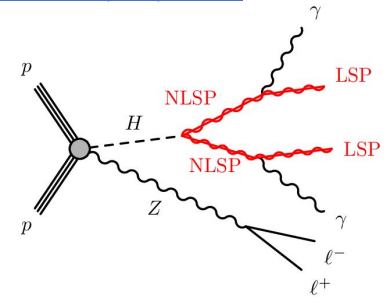
Obs. of rare processes. Ex: Vector Boson Scattering to test the electroweak theory



[Phys. Lett. B 816 \(2021\) 136190](#)



[Phys. Rev. D 108 \(2023\) 032016](#)



Machine learning is used extensively throughout our physics program