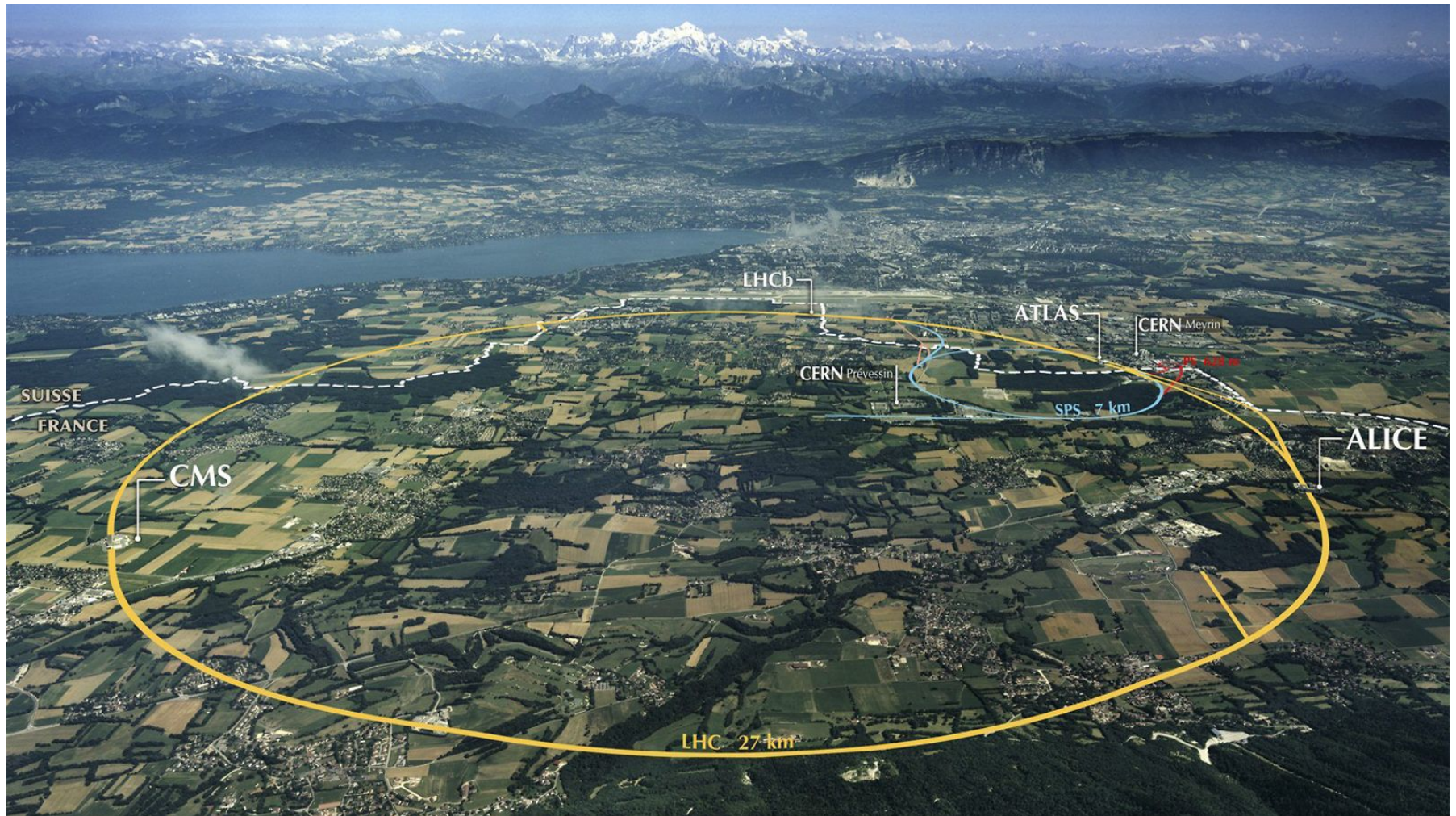


The Berkeley ATLAS group

Elisabetta Pianori
for the ATLAS group

2024 Prospective Graduate Student Open House
Berkeley, March 15th 2024

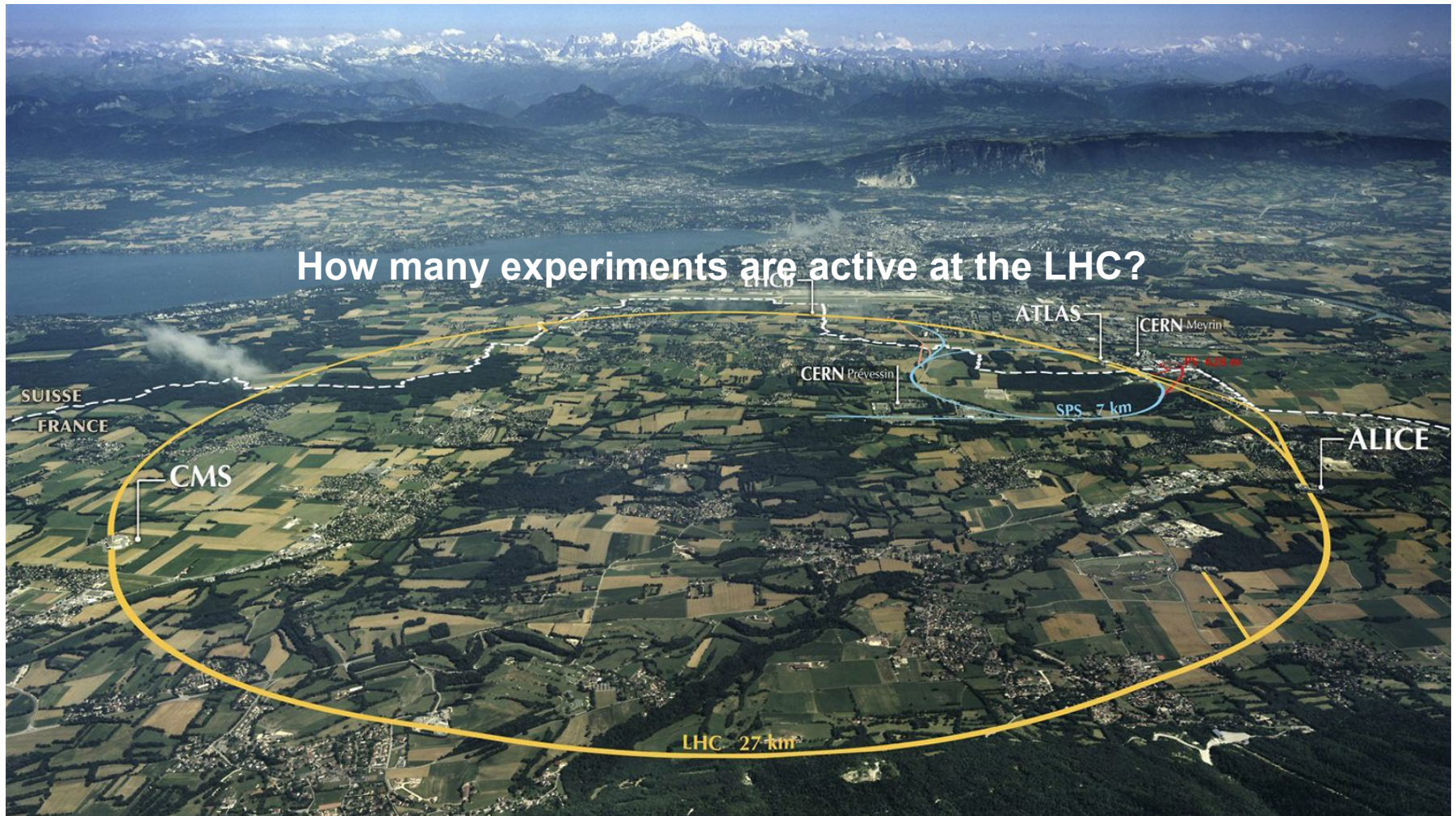
The Large Hadron Collider



World's highest energy particle collider

- 7, 8, 13, 13.6 TeV of proton-proton center-of-mass energy
- 4 interaction points, $O(100M)$ proton-proton interactions per second, since 2010!

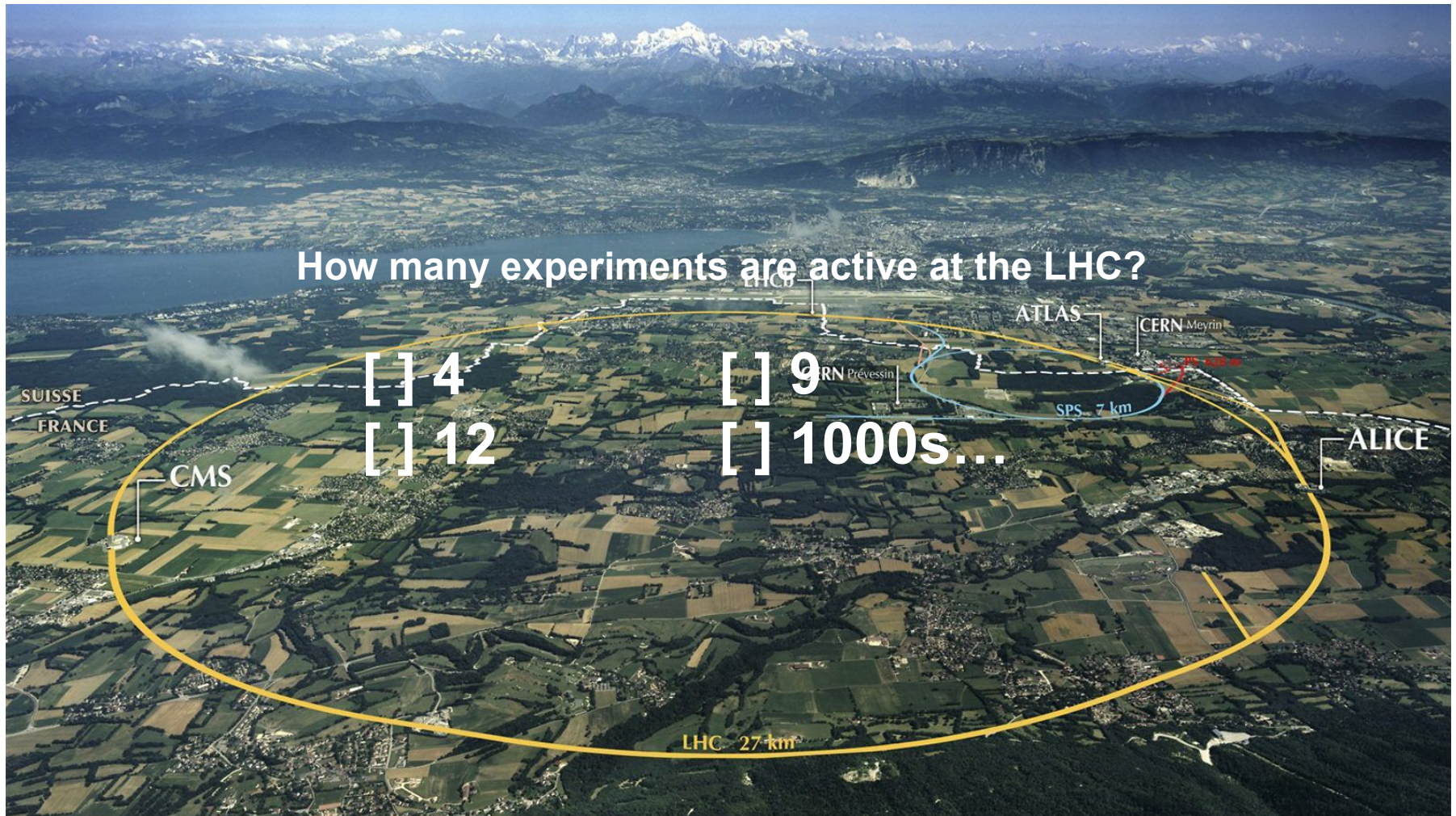
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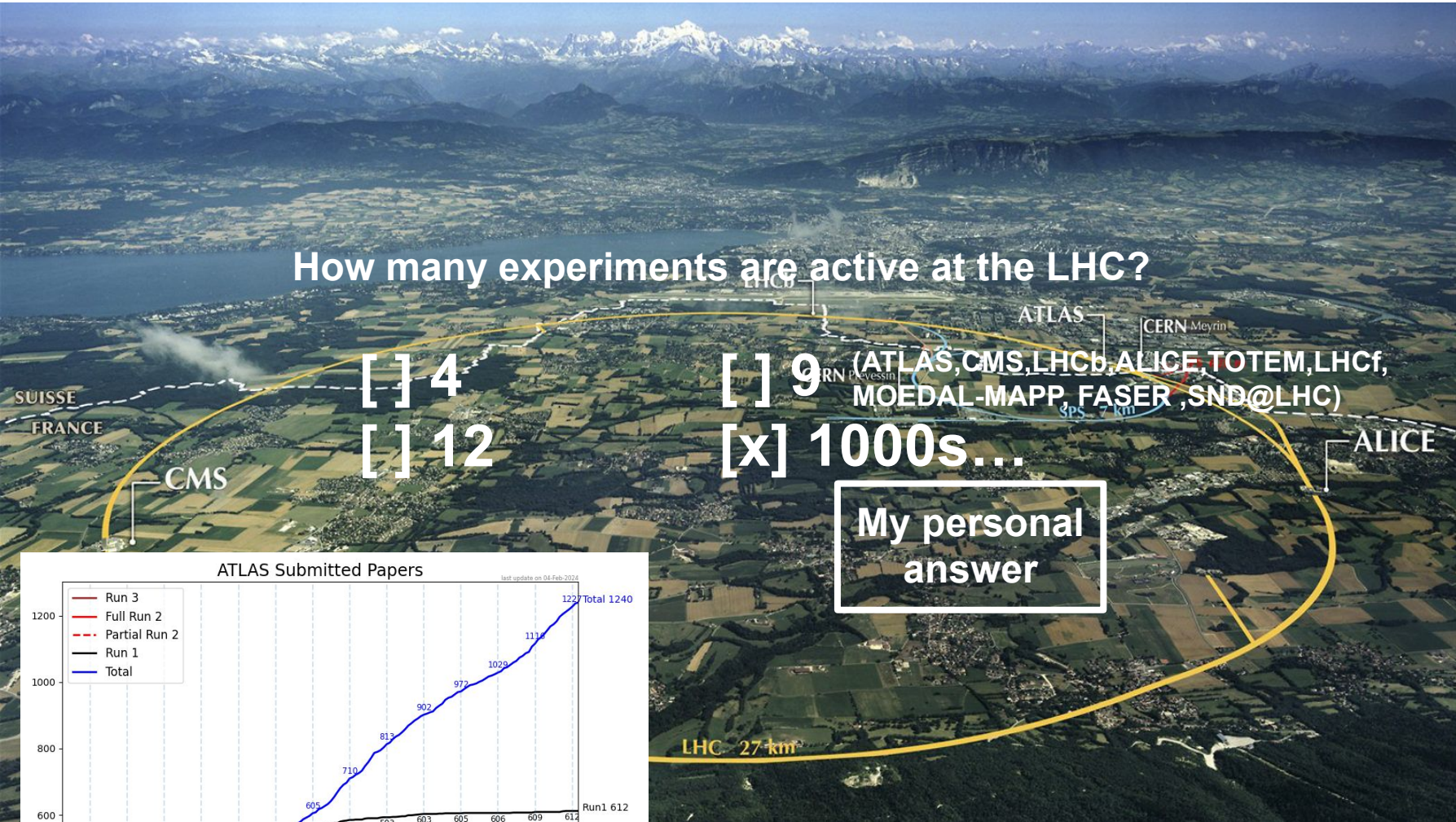
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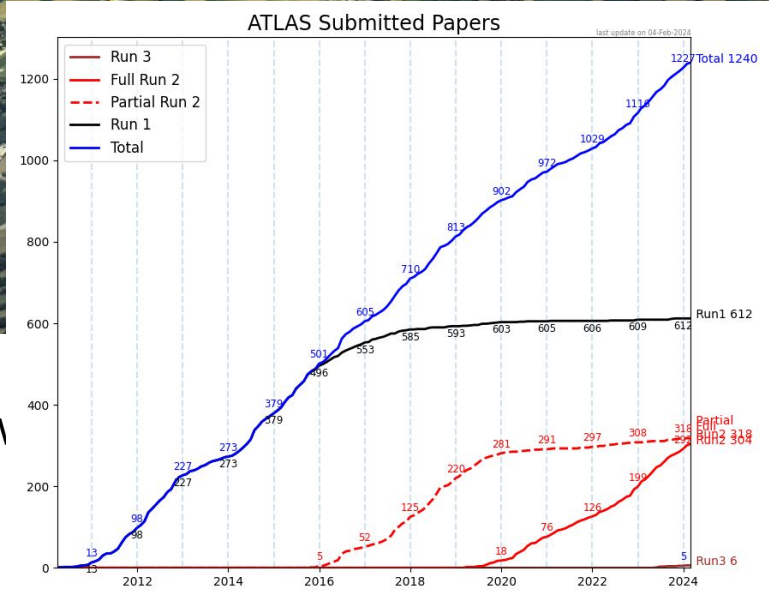


How many experiments are active at the LHC?

[] 4
[] 12

[] 9 (ATLAS, CMS, LHCb, ALICE, TOTEM, LHCf, MOEDAL-MAPP, FASER, SND@LHC)
[x] 1000s...

My personal answer

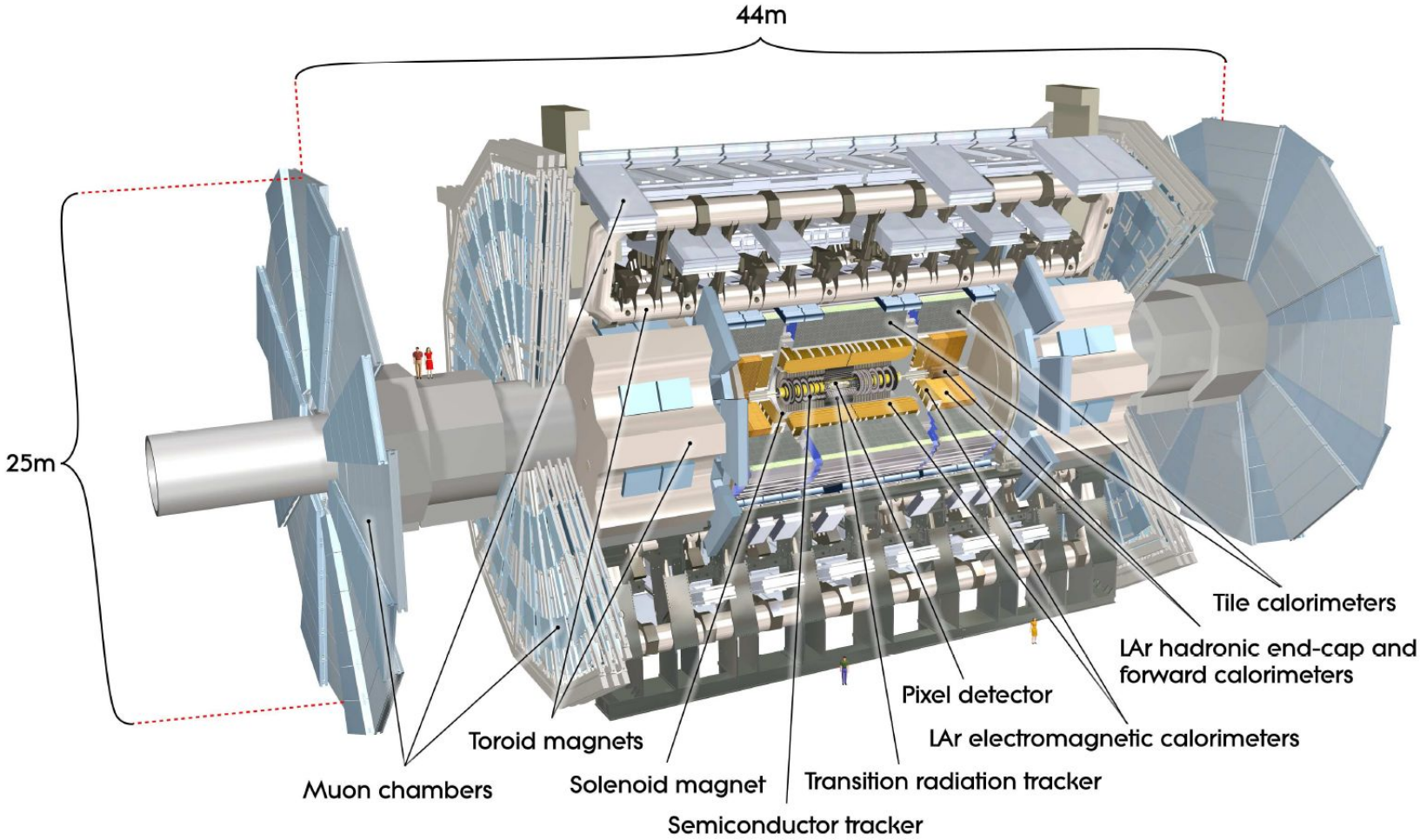


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The ATLAS Detector, Collaboration, ...

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

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2023



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2023



2024



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)

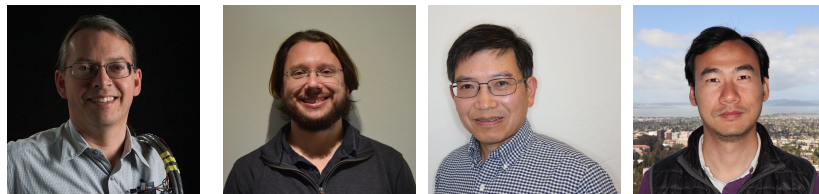
Louis-Guillaume Gagnon(Upgrade Tracking convener)

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

Carlo Varni (Upgrade Tracking convener)

Hongtao Yang (Higgs combination group convener)

* former members of the group



The ATLAS Senior group



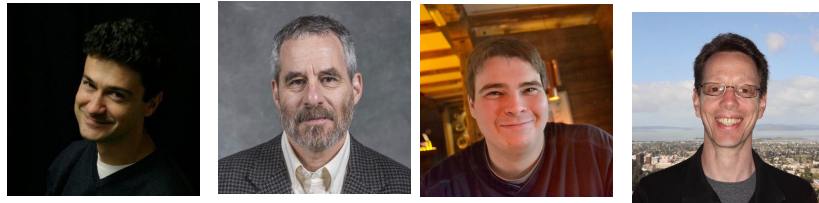
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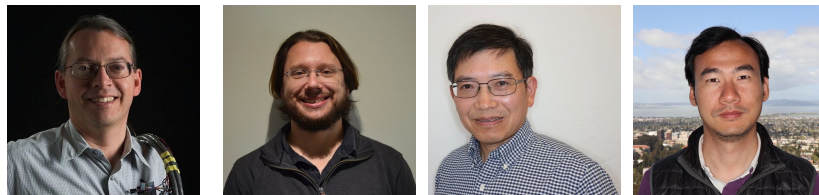
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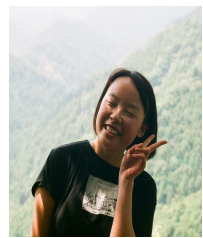
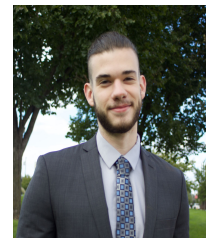
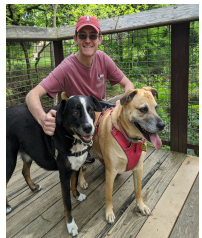
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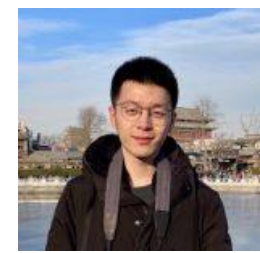
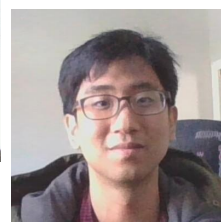
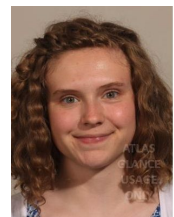
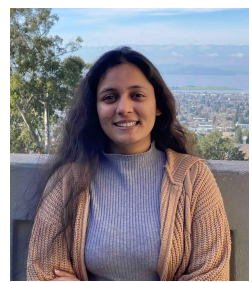
Graduate Students and Postdocs

Current Graduate students (several NSF fellows)



+ 7 more..

Current Postdocs

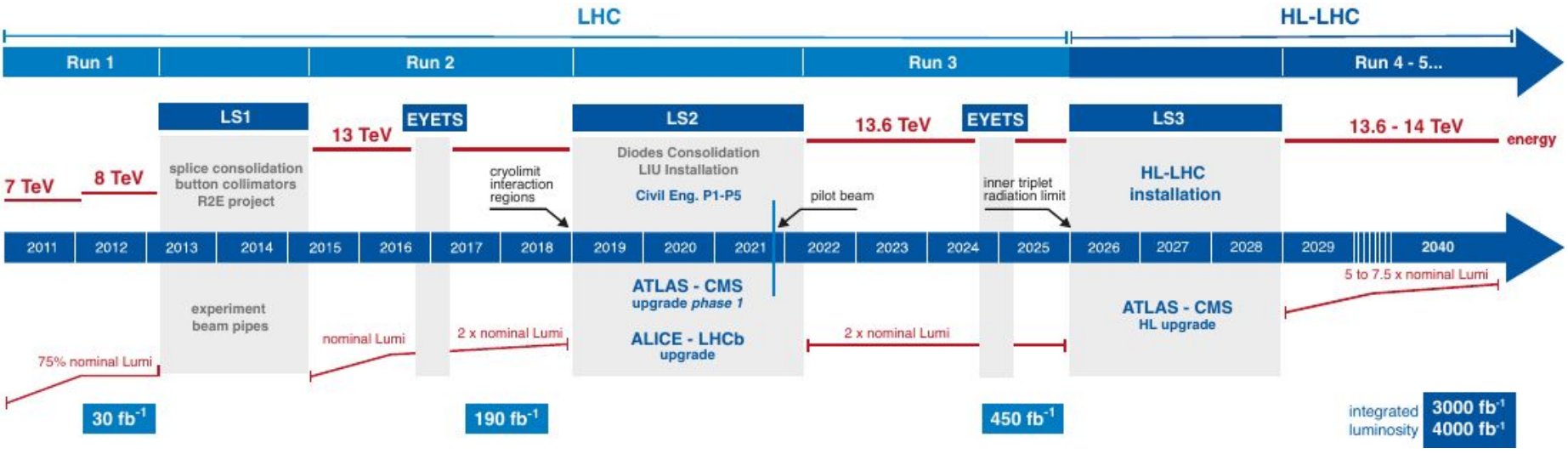


A diverse and vibrant group of junior scientists. Many of our postdocs are **Chamberlain fellows** at LBNL who were selected through a highly competitive process.



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

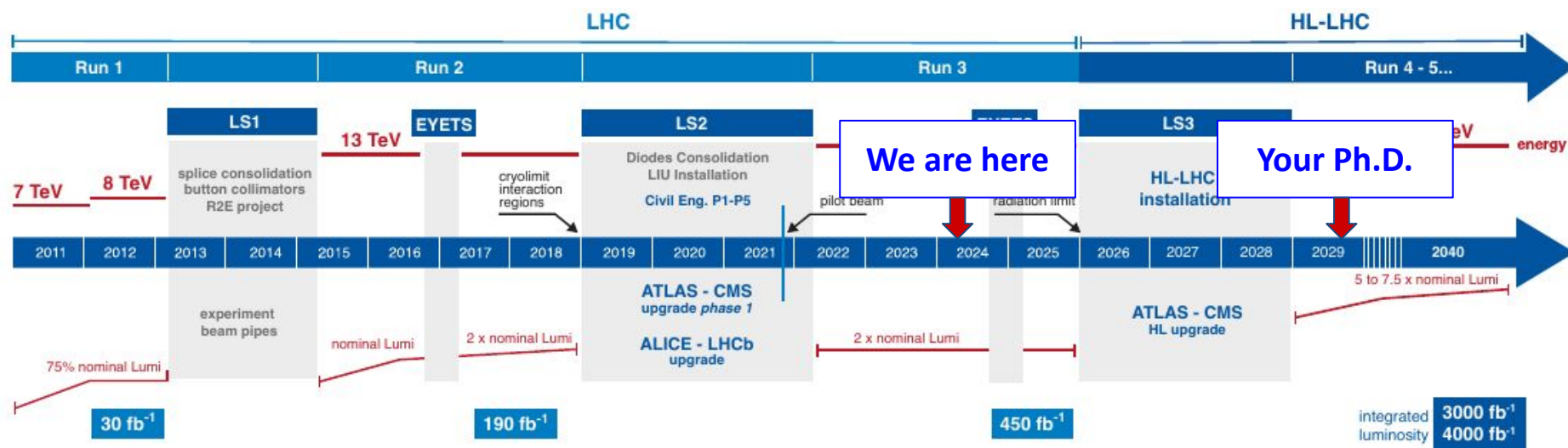
Run-3
 2022 - 2025, 13.6 TeV, ~ 300 fb⁻¹
 65 fb⁻¹ collected so far

High Luminosity LHC (HL-LHC)
 2029 → 2040, 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



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)

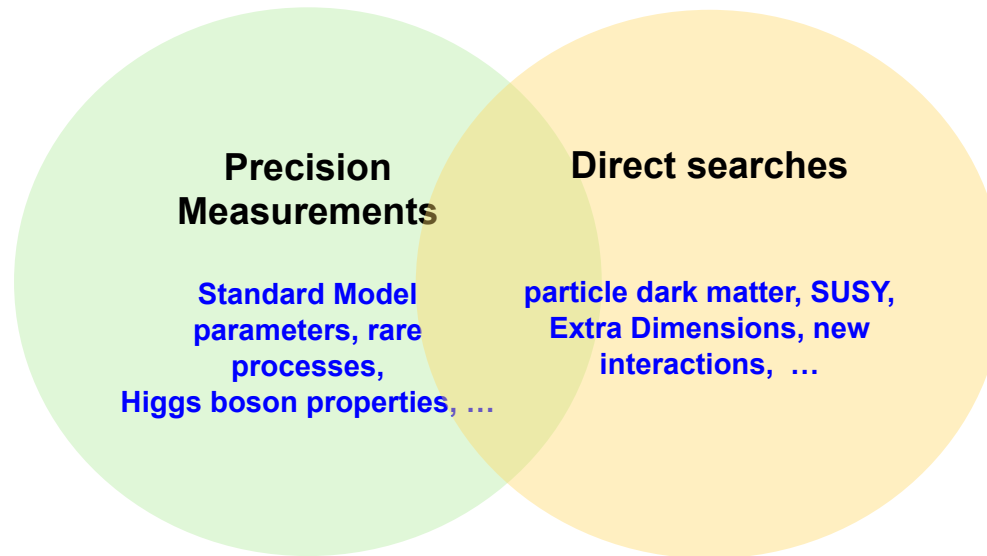
Our group is collaborative and students can work with a range of people during their time at Berkeley

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

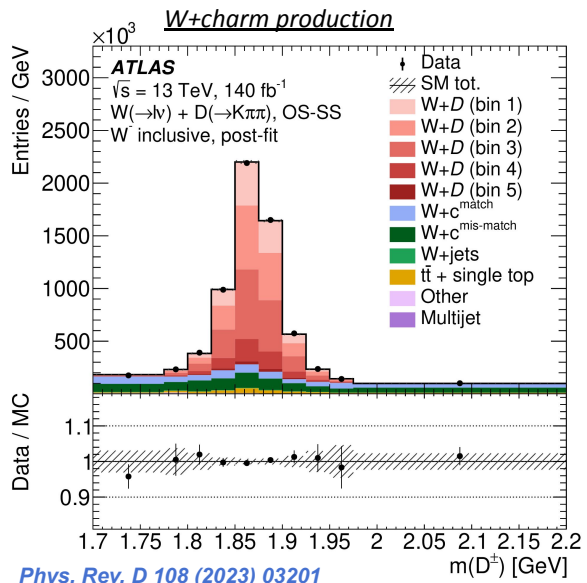
- The **Higgs boson has become a tool for discovery**; the Higgs boson plays a role in many new physics theories
- Berkeley group covers many different areas of ATLAS physics program
 - Based on individual interests and opportunities (upgrade, anomalies etc..)

Physics Analysis Themes - recent highlights

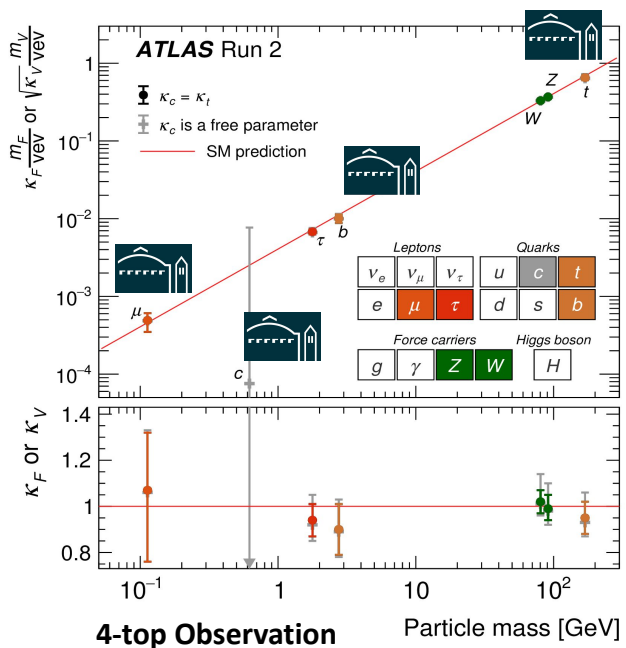
Standard Model measurements Understanding the **Higgs Boson**

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

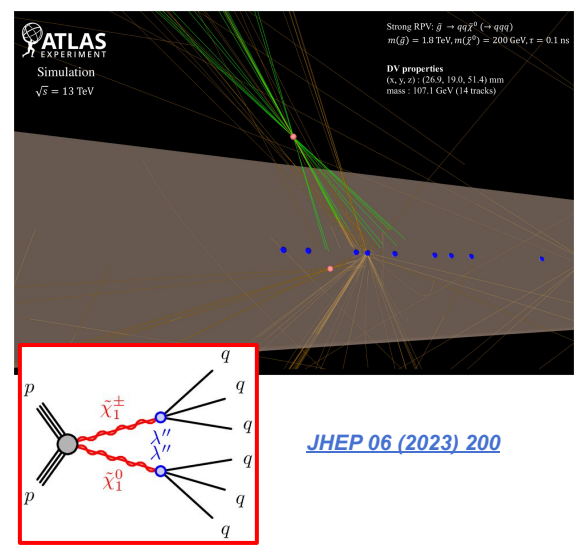
Improve bkg understanding to Higgs and BSM



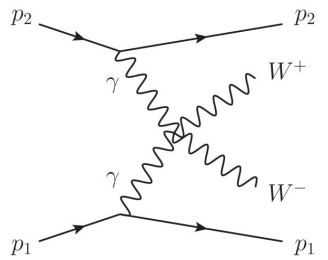
Higgs boson couplings



Displaced hadrons and photons

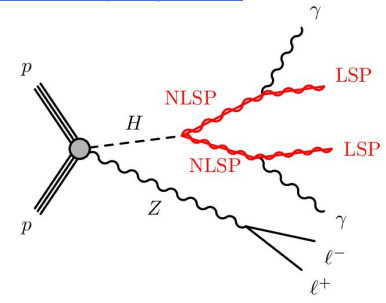


Obs. of rare processes. Ex: Vector Boson Scattering to test the electroweak theory



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

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



Machine learning is used extensively throughout our physics program

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

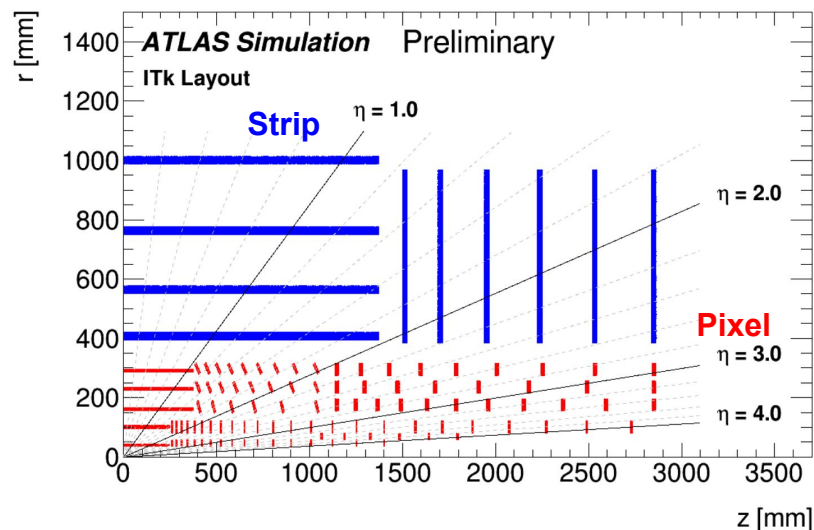
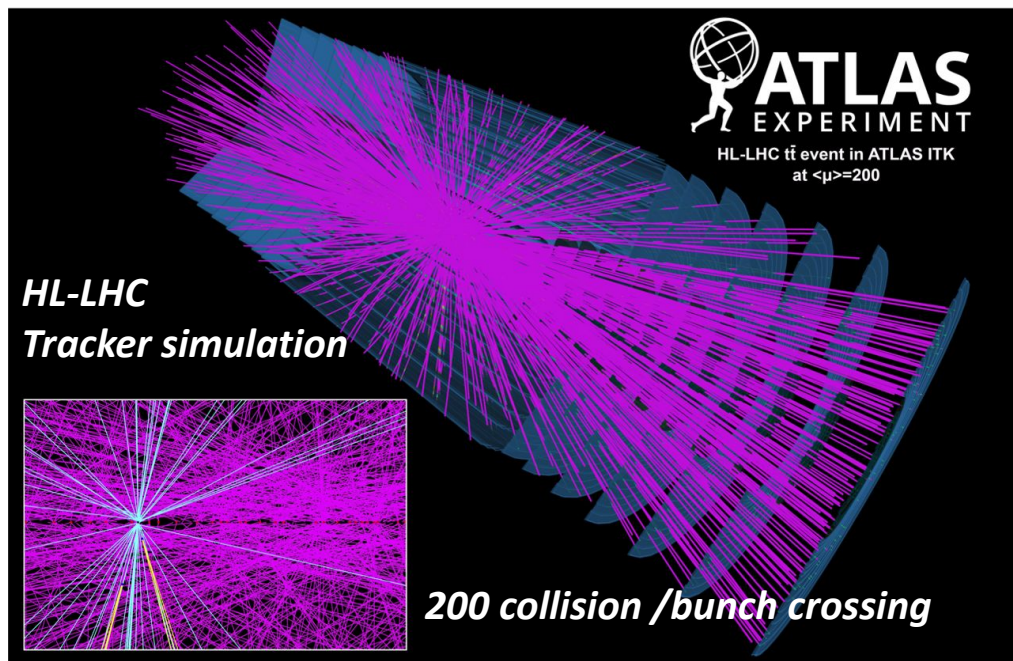
- all new silicon tracker
- Silicon sensor area is over 2000 ft²

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

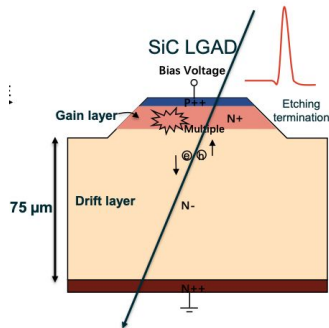
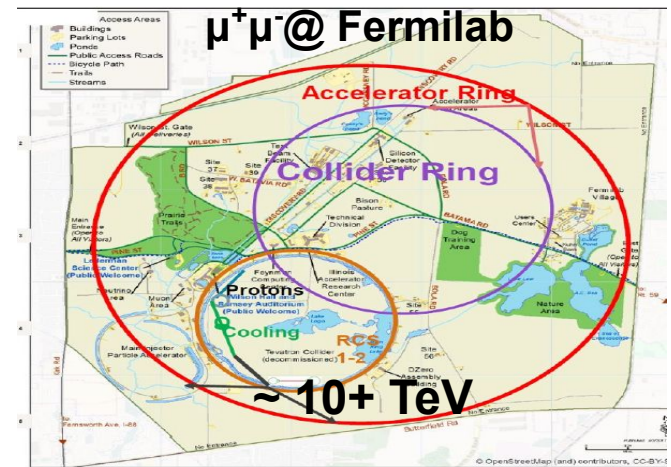
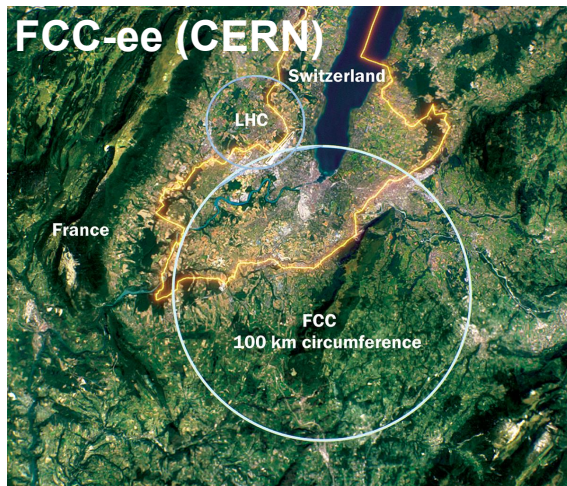
- New particle reconstructions algorithm, non-standard signatures



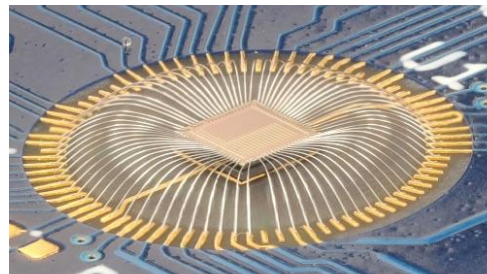
Areas of research of the Berkeley group: future colliders

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**

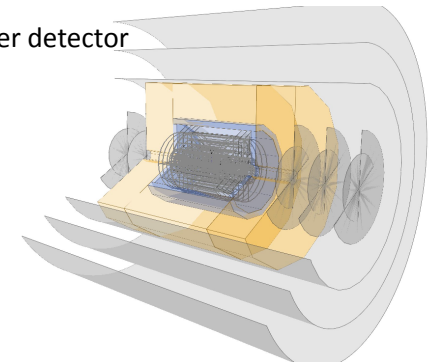


Sensors with new materials (Si-C)



28nm ASIC design with timing information

mu collider detector



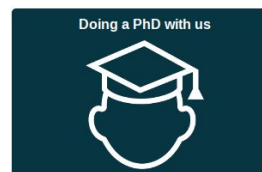
Closing remarks

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 lead 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