

Mellon College of Science | Annual Report

January – December 2023

[Due to Dean's Office February 16, 2024]

1. PERSONAL DATA

- **Name:** John Alison
- **Andrew ID:** jalison
- **Department:** Physics
- **Academic Title:** Assistant Professor
- **Administrative Appointments:** None

2. RESEARCH IN 2023 **[Teaching Track Faculty optional]**

- **ORCID ID:** [0000-0003-0843-1641](https://orcid.org/0000-0003-0843-1641)
- **ResearcherID:** N/A
- **Research Area** [keywords]: High-Energy Physics
- **Research Description** [3-5 sentences]: I study the Higgs boson with the CMS experiment at the Large Hadron Collider. A major component of this research is studying the Higgs boson decays to b-quark jets using advanced machine learning techniques. My group is also building next-generator detector modules for the High-Granularity Calorimeter, an upgrade to the existing CMS detector. We will do automated module assembly, wire bonding, and testing for over 5000 silicon modules. This work will all be done in-house on CMU's campus.

SCIENTIFIC COLLABORATIONS IN 2023

[Internal to CMU and external; indicate international collaborations. Add rows if needed.]

Research Subject	Collaborator(s)/Collaboration Name	Collaborator's Affiliation*
High-Energy Physics	CMS Collaboration	N/A
Machine Learning	Autonlab	CMU
High-Energy Physics	ATLAS Collaboration	N/A

*if applicable

LEADERSHIP POSITIONS IN SCIENTIFIC COLLABORATIONS IN 2023

[Add rows if needed.]

Name of Collaboration	Position, Title, Role
CMS	b-tagging convenor ("L2" leadership position)
CMS	Leading ZZ/ZH->4b Analysis
CMS	HGC Module Assembly at CMU

FUNDING IN 2023

External Grants Funded in 2023 (new funding in 2023) [Add rows if needed].

Source	Title	PI / Co-I	Time Period of Grant	Total Amount	Amount Available to me in 2023
DOE	High-Energy Physics Research	Co-I	3 years	\$4.98M	300k

External Grants Submitted in 2023 and Pending [Add rows if needed].

Source	Title	PI / Co-I	Time Period of Grant	Total Amount Requested	Amount Expected for me per year
NSF	Early Career (2021)	PI	5 years	\$ 1 M	\$ 1 M

External Grants Submitted but Rejected in 2023 [Add rows if needed].

Source	Title	PI / Co-I	Time Period of Grant	Total Amount Requested	Amount Requested for me per year

Other Sources of Support Available in 2023 [e.g., Start-up, discretionary funds, etc. Use estimates if needed. Add rows if needed].

Source	PI / Co-I	Time Period of Grant	Total Amount	Amount Available to me in 2023*
Start up	PI	NA	~300k	~300k
CMS Upgrade	CO-I	4 years	~1M	~200k

*if applicable.

PUBLICATIONS IN 2023

[Okay to refer to full List of Publications; e.g. See papers 4-8 in List of Publications.]

- Articles Published:
 - 49 total: (See list of publications for details)
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- Articles Submitted / under Review:
 - (See list of publications)
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 -
- Patents Requested / Granted:
 - N/A
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PRESENTATIONS IN 2023

Conference / Workshop Presentations [Add rows if needed].

Title of Presentation	Name of Conference	Date	Location	Invited / Contributed Talk / Poster?
CMS B-tagging Workshop B-tagging in CMS Status and Future Plans	CMS Btagging workshop	07/2023	Brussels, Belgium	Invited Talk
Open Questions in Particle Physics	MelFest	05/2023	Chicago, IL	Invited Talk

Colloquium / Seminar Presentations [Add rows if needed].

Title	Date	Location

3. EDUCATIONAL ACTIVITIES IN 2023

TEACHING IN 2023

Semester	Course #	Title	FCE: Course	FCE: Instructor	# of Students
Spring	33211	Physics 3: Modern Essentials	4.15	3.92	19

Learning Objectives

[CMU asks every instructor to include teaching objectives in a course syllabus to support learning and student success. More information on how to articulate learning objectives can be found at the website of the [Eberly Center](#) .

Copy/paste the learning objectives from the courses you taught in 2023. State course #, title and semester taught.]

- Course #33211 Title: Physics 3: Modern Essentials Semester: Spring

The first part of the course will focus on the motivation for – and implications of – Einstein’s theory of relativity. Relativity is the correct way to think about space and time. The necessary mathematics is simple, but the concepts challenge our everyday intuition.

The second part of the course introduces Quantum Mechanics, the basic theory used to describe the microscopic world. We will briefly discuss its historical development and how – by completely changing our view of reality – we were finally able to account for basic features of our everyday lives. Here again, the concepts are challenging, but the mathematical formalism is straightforward.

The class will improve your skill in thinking through and solving physics problems and apparent philosophical paradoxes. One of the main goals of the course is to develop reliable intuition for relativistic and quantum physics.

Unique Teaching Contributions

[List your unique contributions to the MCS teaching mission.]

Itemized description:

- The governor's school course introduced advanced high-school students to the physics behind the Higgs Boson. I think this will turn out to be a powerful recruiting mechanism for the particle physics group at CMU
- In teaching Introduction to Nuclear and Particle Physics (33-444), aimed at advanced physics majors, I tried to give the course I wish I had taken as an undergraduate. I emphasized the theoretical underpinnings of the Standard Model of particle physics and its experimental verification. The first part of the course focused on the implications of combining Quantum Mechanics and Special Relativity. The second part discussed experimental methods for measuring elementary particle interactions and ended with a survey of areas of active research including the study of the Higgs boson and the physics of neutrino mixing. Preparing this course was a lot of fun. Because there are not really any good textbooks at the appropriate level, preparing for this course gave me an opportunity to distill information from my own notes and more advanced resources

ADVISING AND MENTORING IN 2023

Junior Faculty [Add rows if needed.]

Name	Time Period	Mentoring Activity*
Matteo Cremonisi	Since 2022	Proposal/Physics advice
Valentina Dutta	Since 2022	Proposal/Physics advice

* can include being official mentor, co-teaching, proposal advice, award nomination, etc.

Postdoctoral Researcher [Add rows if needed; **Teaching Track Faculty optional**]

Name	Time Period	Research Subject	Funding Source*
Patrick Bryant	Oct 2018 - Present	High-Energy Physics	DOE grant
Alejandro Gomez	Oct 2023 - Present	High-Energy Physics	DOE grant

*can include own grant, shared grant, fellowship, external funds, etc.

Graduate Student [Add rows if needed; **Teaching Track Faculty optional**]

Name	Time Period	Research Subject	Expect. Grad.	Funding Source*
Chuyuan Liu	Fall 19-present	Di-Higgs / HGC Clustering	2025	AI Institute / Start-up
Wesley Terrill	Spring 20-present	B-Jet Trigger / Soft-leptons	2026	TA

Sindhu Murthy	Fall 20-present	HGC production / 4b physics	2027	TA
Aniket Khanal	Fall 23 - present	HH->bbWW	2029	TA

*can include own grant, shared grant, fellowship, TA funded by Department, etc.

Undergraduate Student [Add rows if needed.]

Name	Time Period	Major	Mentoring Activity*
Letian Tang	2022- present	Physics	Machine Learning 4b
Shujin Li	2022- present	Physics	B-Tagging at CMS
Luke Frisoli	Fall 2023	Physics	Strange Quark identification
Chris Berman	Fall 2023	Physics	Strange Quark identification
Sam Hobbeheydar	Fall 2023-present	Physics	HH->bbWW

*can include research advisor, academic advisee, etc.

Others [e.g., other researchers, lab technical staff, exchange students, etc. Add rows if needed.]

Name	Role	Time Period	Funding Source*
Jessica Parshook	Electronics Engineer II	2019 - present	CMS Project Funds
Eva Klobier	Electronics Engineer	9/2023 - present	CMS Project Funds

*can include own grant, shared grant, fellowship, external funds, department supported, etc.

THESIS COMMITTEES IN 2023 [internal and external; add rows if needed; **Teaching Track Faculty optional**]

Name of Thesis Candidate	Department	Time Period
Tianping Gu	Physics (PITT)	2021- Present
Huang, Wenjie	Physics (PITT)	2023 - Present

OUTREACH ACTIVITIES IN 2023 [Add rows if needed.]

Type	Subject	Audience	Date	Location
Governor's School	Higgs Boson	Advanced High-School Students	Summer	CMU

4-day on campus workshop	Teacher training program	High-school Physics Teachers	June	On-campus
Field Trip	Research at CMU	High-school students	Summer	On-campus

4. SERVICE IN 2023

- **Departmental Committees:** [indicate committee chair, member, leadership roles, etc.; all with time periods].
 - Outreach Committee (chair) Spring, Summer, 2023
 - Outreach Committee member Fall 2023
- **College Committees:** [indicate committee chair, member, leadership roles, etc.; all with time periods].
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- **University Committees:** [indicate committee chair, member, leadership roles, etc.; all with time periods].
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5. CITIZENSHIP IN 2023

DIVERSITY ACTIVITIES IN 2023 [can include organizing or attending diversity training, workshops; outreach to minorities; recruitment activities, etc.].

Itemized description with time period

- Outreach and Recruitment of women in Physics
- Participate in the CMS Mentoring program
- Various outreach (listed above) also targets underrepresented minorities
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PROFESSIONAL ACTIVITIES IN 2023 [e.g., Membership of Editorial Boards, Organizing Committees of Conferences, Scientific Panels and Advisory Boards, Reviews of Publications (list journals), Review of Research Proposals (list agencies), Consulting Activities, etc.].

Itemized description with time period

- Conveener CMS B-tagging group
- Editorial Board Member on CMS
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RECOGNITION AND AWARDS IN 2023

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6. FUTURE

CMU is redefining scientific discovery by leveraging our strengths in computation, engineering, artificial intelligence, automation, data analysis and human ingenuity to change the way foundational science is taught and conducted.

How do your faculty responsibilities (research, teaching, outreach, etc.) relate to this vision going forward?

[e.g., connections to other departments within and outside MCS or CMU? How does your work align with and/or involve computation, automation, engineering, computation, and technology, or education initiatives? New research ideas? Any ideas, etc.?].

Three short paragraphs.

- 1) My research relies heavily on computation and advanced statistical analysis. My group is working closely with members of the CMU statistics department (Kussela and Wasserman) on applying methods of Optimal Transport (OT) to the Di-Higgs background measurement. OT is a statistical method to find the minimal work needed to map one distribution to another under a given metric. OT promises to provide confidence and robustness in the background model and has the potential to offer new insights into ways the 4b background measurement can be further improved. This work has also inspired additional background modeling techniques based purely on OT which is being written up in a series of data science/statistics papers.
- 2) There are many opportunities for significant improvement through advanced machine learning techniques in my physics program. The Di-Higgs analyses all rely critically on b-tagging performance and b-jet energy resolution. These are both problems of large dimensionality where – especially in the trigger – smarter use of underlying input distributions can lead to major gains. My group is pursuing these improvements and I am well-positioned within the collaboration to implement these changes.
- 3) The HGC module construction at CMU will require significant automation to allow us to keep the production throughput and quality high. We have procured several robots/vision systems that will allow us to automated assembly at high-rate.

What questions do you have about the Future of Science at MCS? [e.g., new science building, cloud lab, science initiative, intellectual future of MCS, etc.]

- How can we foster serendipitous interactions among faculty across departments (and colleges) ?

Where do you see yourself and your career in 5 years? [e.g., teaching, advising, research trajectory; change of research direction; professional development; administrative aspirations, etc.].

Three short paragraphs

- In five years, I will have completed building detector components for the LHC calorimeter upgrade. My leadership of this project should allow me to play a leading role in construction of the next generation collider detectors.
- I see myself in close collaboration with both the CMU statistics and Machine Learning groups. By this time we should be able to demonstrate clear improvements from both disciplines in Particle Physics.
- In five years, I would like to start seeing direct impacts of outreach efforts. By building local connections with the community we should be in a position to foster and profit from the development of local talent.

7. SELF-ASSESSMENT

What is the one most important contribution that you have made to advance your career and recognition in 2023? [e.g., research, education, etc.]

One short paragraph

- The most important contribution I have made in 2022 is the ZZ/ZH/HH $\rightarrow$ 4b analysis. This is now the most sensitive single channel result on di-Higgs production and improved the sensitivity of the previous result (which uses the same data) by a factor of two. We introduced new methods to validate the background model and implemented advanced machine learning techniques throughout the analysis.

Thinking about the main responsibilities (teaching, research, advising, operations, etc.) of your employment at MCS/CMU, for this year **what is your biggest point of pride and/or contribution**?

- Establishing the high-school teachers program. Two years ago, I organized a virtual, two-day pilot of the teachers program. The program attracted 27 Pittsburgh-area high-school physics teachers from a broad mix of schools: both public and private, urban and suburban. This year, we continued our four day in-person program on-campus. Teachers participating in the program earned continuing education credits required by the state through the CMU Gelfand center. We held discussion sessions on how CMU can help teachers to better engage high-school students and motivate them to pursue careers in physics.

8. OTHER IMPORTANT ISSUES

Do you have general questions, comments or feedback? Please use this space to ask your questions, make your comments or give your feedback here. Thank you for your time.

- Thank you for all your support of the physics department. Its clearly making a difference! Good luck with the dean search.