

Philip Chang

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Current Research Objectives

My research focuses on multiboson final states as sensitive channels for discovering new physics and precision probes of electroweak interactions, testing the Standard Model at its limits while remaining open to unexpected discoveries. I also contribute to shaping the physics case for future colliders such as the muon collider, where a holistic tracker design can improve tracking performance and help mitigate beam-induced background challenges.. In parallel, I advance computing for high-energy physics through leadership at the UF Tier-2 center. My work includes developing large-scale data processing strategies and leveraging GPUs and heterogeneous computing architectures to accelerate CMS workflows and enable fast-turnaround analyses.

Education and Employment

2022 - Present	University of Florida , Gainesville, FL, USA <i>Assistant Professor</i>
2017 - 2022	University of California, San Diego , La Jolla, CA, USA <i>Postdoctoral Researcher</i>
2011 - 2017	University of Illinois Urbana-Champaign , Urbana, IL, USA <i>Ph.D. in Physics</i> Dissertation — Vector boson fusion produced $H \rightarrow WW^*$ and extended Higgs sector search Advisor — Mark Neubauer
2005 - 2009	University of Illinois Urbana-Champaign , Urbana, IL, USA <i>B.Sc. in Physics</i> Thesis — Search for $B_s \rightarrow J/\psi K^*$ with CDF detector Advisor — Kevin Pitts

Research Experience

2024 - Current	US Muon Collider Collaboration
2017 - Current	CMS Experiment , CERN
2011 - 2017	ATLAS Experiment , CERN
2009	CDF Experiment , Fermilab
2010 - 2011	AdS/CFT studies , University of Illinois Urbana-Champaign

Technical and Computing Experience

2023 - Current	UF Tier-2 Computing Center Manager
2023 - Current	Line Segment Tracking with GPU as-a-service approach

2023 - Current	Rapid and Efficient Analysis software with Columnar Tools Benchmarking workflows, acceleration of columnar tools with GPUs
2019 - Current	Line Segment Tracking (LST) Algorithm for HL-LHC
2011 - 2017	Fast TracKer (FTK) Second Stage Board, Extrapolator Algorithm, Track Finding Algorithm

Analysis Experience

2022 - Current	Vector Boson Scattering Produced VVH to 0, 1, 2 and same-sign leptons Determining the quartic Higgs couplings to W and Z bosons
2021 - Current	Search for New Physics in Three Massive Gauge Boson Processes Comprehensive search for subtle deviations from SM in WWW, WWZ, WZZ, ZZZ processes
2023 - 2025	Simultaneous Measurement of WWZ and ZH→WW Processes Most precise measurement of WWZ cross section
2022 - 2024	Vector Boson Scattering Produced WH to 1 lepton + bb Determining the relative sign of Higgs couplings to W and Z bosons
2019 - 2020	First Observation of Three Massive Gauge Boson Processes Establishing the SM process of WWW, WWZ, WZZ, ZZZ
2017 - 2019	Search for Three W Boson Processes Searched for SM process of WWW and probed photophobic axion models
2012 - 2014	Search for exotic Higgs decay to additional scalars in bbμμ final state Searched for Dark Matter candidate that could explain Fermi-LAT signal
2012 - 2014	First Evidence of Vector Boson Fusion Produced H→WW Study Higgs properties and place best constraint on Higgs to Fermion couplings
2012 - 2014	First Observation of H→WW Study Higgs properties and place best Higgs to W boson couplings.
2011 - 2012	Search for H→WW and Observation of New Resonance at 125 GeV Search for the predicted Higgs boson; Observed new resonance that led to Nobel Prize
2009	Search for B_s→J/ψK* Search to measure B _s mixing parameter

Grants Awarded

06/2024 - 03/2028	Experimental Research at the Energy Frontier in High Energy Physics <i>DOE</i> Andrey Korytov (PI), Philip Chang (co-PI), Jaco Konigsberg (co-PI), Yuta Takahashi (co-PI), Guenakh Mitselmakher (co-PI), Paul Avery (co-PI)
01/2025 - 12/2025	Charting a course toward rapid turnaround of HL-LHC scale analyses: Benchmarking current capabilities and exploring the acceleration of columnar processing via heterogeneous architectures <i>University of Nebraska-Lincoln (Sponsor), NSF (Prime Sponsor)</i> Philip Chang (PI)
01/2024 - 12/2025	USCMS Software and Computing - UF Tier-2 Computing Center <i>University of Nebraska-Lincoln (Sponsor), NSF (Prime Sponsor)</i> Philip Chang (PI)

01/2024 - 12/2024	USCMS HL-LHC R&D Initiative: Deploying GPU algorithms through SONIC <i>University of Nebraska-Lincoln (Sponsor), NSF (Prime Sponsor)</i> Philip Chang (PI)
05/2023 - 3/2024	Energetic Tri-bosons as Heralds of New Physics DOE Philip Chang (PI)
01/2023 - 08/2026	QuarkNet UF <i>University of Notre Dame (Sponsor), NSF (Prime Sponsor)</i> Philip Chang (PI)

Professional Service and Leadership

2023 - Current	HL-LHC R&D Algorithms Coordinator <i>US CMS Operations Program</i>
2023 - Current	Management Board (Early Career Member) <i>LHC Physics Center at Fermilab</i>
2025 - Current	Executive Committee Member (Elected) <i>US LHC User Association (USLUA)</i>
2023 - Current	Research Computing Advisory Committee <i>University of Florida</i>
2024	Reviewer for two different occasions DOE
2023 - 2025	35th Auditor of AKPA (Elected) <i>Association of Korean Physicists in America (AKPA)</i>
2023 - 2025	USCMS Mentorship Committee <i>LHC Physics Center at Fermilab</i>
2020 - 2022	LHC Electroweak Multiboson Subgroup co-Convener <i>LHC Physics Center at CERN (LPCC)</i>
2015 - 2016	Higgs Working Group Trigger co-Contact <i>ATLAS Collaboration</i>
2015 - 2016	VBF Trigger Group co-Coordinator <i>ATLAS Collaboration</i>

Organizational Activities for the Profession

2025	Lepton Photon 2025 , Madison, WI <i>Computing AI & ML Session Chair</i>
2024	37th US-Korea Conference , San Francisco, CA <i>Technical Symposium Session (A-1 Physics) Chair</i>
2024	Inaugural US Muon Collider Community Meeting , Fermilab, IL <i>Plenary Session Chair</i>
2024	Inaugural US Muon Collider Community Meeting , Fermilab, IL <i>Organizing Committee</i>

2024	Mid-Florida Section QuarkNet Day , Gainesville, FL <i>Host</i>
2023	90th Annual Meeting of the Southeastern Section of the APS <i>Parallel Session Chair</i>
2021	EXPAND Mentorship Program , UCSD, San Diego, CA <i>co-Coordinator</i>

Awards & Honors and Fellowships

2025	Breakthrough Prize in Fundamental Physics <i>Breakthrough Prize Board</i> as a part of the ATLAS and CMS Collaboration
2022	Outstanding Young Research Award <i>Association of Korean Physicist in America (AKPA)</i>
2022 - 2021	Distinguished Researcher <i>LHC Physics Center (LPC) at Fermilab</i>
2022 - 2021	Giulio Ascoli Award <i>University of Illinois Urbana-Champaign</i>
2014	Outstanding Graduate Student Award <i>US ATLAS</i>
2014	Young Physicist Lightning Round Winner <i>US LHC User Association (USLUA)</i>
2025	High Energy and Particle Physics Prize <i>European Physical Society</i> as a part of the ATLAS Collaboration
2013	University Fellowship <i>University of Illinois Urbana-Champaign</i>
2008	Undergraduate Research Scholar <i>Shell Foundation</i>
2004	Semi-finalist <i>US Physics Team for 35th International Physics Olympiad</i>

Department Committees and Service

Current	Director of Undergraduate Labs Faculty Search Committee
2024 - Current	Undergraduate Student Awards Committee
2025 - Current	Computing Committee co-Chair
2025 - Current	Ombuds
2024 - 2025	Preliminary Exam Committee
2024 - 2025	Large Course Teaching Committee
2024 - 2025	Grad Student Affairs Committee (GSAC)
2023 - 2025	Computing Committee

- 2023 | **Artificial Intelligence Committee**
- 2023 (Fall) | **Faculty Meeting Recorder**
- 2023 | **High-Energy Physics Experiment faculty search committee.**
- 2023 | **Institute for High Energy Physics and Astrophysics (IHEPA) fellowship selection committee.**

Graduate Student Supervision

- 2025 - Current | **Alexandra Aponte Utani**, PhD Student
LST Algorithm Development for $pT2$ objects
LST with GPU as-a-service approach
- 2025 - Current | **Cedric Broussard**, PhD Student
- 2022 - Current | **Matthew Dittrich**, PhD Student
WWZ and $ZH \rightarrow WW$ Cross section Measurement
LST Algorithm Development for $pT2$ objects
- 2022 - Current | **Eslam Zenhom**, PhD Student
Vector Boson Scattering Produced VVH to 0 leptons in semi-merged final state
- 2023 - 2024 | **Mayra Silva**, MSc
Studying Graph Neural Network applied to LST

Undergraduate Student Supervision

- 2023 - Current | **Hubert Pugzlys**, BSc Student, IRIS-HEP Fellow
Studying Effects of Multi-Layer GNN to LST, Muon Collider Tracking Studies
- 2024 - Current | **Trevor Sabitsch**, BSc Student, IRIS-HEP Fellow
R&D LST tracking with GPU as-a-service for CMS Event Reconstruction
- 2023 - 2025 | **Joseph Mezzetti**, BSc Student
Generating Signal Samples for Dark Photon and tWZ / ttZ processes
- 2024 - 2025 | **Cedric Broussard**, BSc
Study of effects of dim6 SMEFT operators on tWZ and ttZ processes
→ University of Florida Physics PhD program
- 2024 - 2025 | **Amilqar Karam**, BSc
Accelerating Neural Network Inference with Boosted Decision Trees via FPGA
→ Johns Hopkins University Physics PhD program
- 2024 - 2025 | **Tsion (Zion) Dessalegn**, PURSUE Intern Program
Designing and optimizing tWZ signal region
- 2023 - 2025 | **Samuel Sebastian**, BSc Student
Designing and optimizing tWZ signal region

Postdoctoral Scholar Supervision

- 2023 - Current | **Dr. Kelci Mohrman**
Simultaneous WWZ and $ZH \rightarrow WW$ Cross Section Measurement
Optimizing SM Sensitivity to Vector Boson Scattering Produced VVH

Studying Graph Neural Network applied to Line Segment Tracking
Studying dim6 SMEFT Operator Effects on tWZ/ttZ processes
R&D LST tracking with GPU as-a-service approach
Developing Rapid and Efficient Analysis Software with Columnar Tools
GPU acceleration of Columnar Analysis Tools
TOP Physics Analysis Group (PAG) EFT Subgroup Convener
Standard Model Physics PAG EFT forum Contact

Selected Talks

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| 2025 | Measurement of WWZ and ZH production cross sections at $\sqrt{s} = 13$ and 13.6 TeV
<i>Parallel Session Talk (Invited)</i>
08/2025 KSEA US-Korea Conference, Atlanta, GA |
| 2025 | Extreme Computing
<i>Plenary Session Talk (Invited)</i>
07/2025 Physics At The Highest Energies With Colliders (Galileo Galilei Institute), Florence, Italy |
| 2025 | Recent LHC Results
<i>Plenary Session Talk (Invited)</i>
05/2025 Pheno 2025, Pittsburgh, PA |
| 2025 | Computing R&D: How we get to our targets
<i>Parallel Session Talk (Invited)</i>
05/2025 LHCP 2025, Taipei, Taiwan |
| 2025 | Forging New Paths to Unveil the Electroweak Sector
<i>Colloquium</i>
03/2025 Univ. of Florida, Gainesville, FL |
| 2025 | Enhancing Particle Physics Discovery Through Computational Innovation
<i>Parallel Session Talk</i>
03/2025 KSEA Southeastern Regional Conference, Orlando, FL |
| 2024 | Muon Collider the Dream Machine
<i>Parallel Session Talk</i>
08/2024 KSEA US-Korea Conference, San Francisco, CA |
| 2024 - 2025 | Higgs Physics: What is in the vacuum?
<i>Seminar (Invited)</i>
06/2025 PURSUE (USCMS) Program, Fermilab (Virtual)
07/2024 PURSUE (USCMS) Program, Fermilab (Virtual) |
| 2024 | GPU Programming
<i>Lecture (Invited)</i>
05/2024 HSF-India HEP Software Workshop, Delhi, India |
| 2024 | AI for Particle Tracking
<i>Parallel Session Talk</i>
03/2024 KSEA Southeastern Regional Conference, Gainesville, FL |
| 2024 | LHC Future Opportunities
<i>Plenary Session Talk (Invited)</i>
03/2024 The Future of High Energy Physics: A New Generation, A New Vision (Aspen Winter Conference), Aspen, CO |
| 2023 | Line Segment Tracking at CMS
<i>Parallel Session Talk</i> |

	05/2023 Computing in High Energy & Nuclear Physics (CHEP), Norfolk, VA
2022	Recent CMS results on Standard Model Physics <i>Parallel Session Talk</i> 09/2022 Conference on the Intersection of Particle and Nuclear Physics, Lake Buena Vista, FL
2022	Recent CMS results on Higgs physics <i>Parallel Session Talk</i> 08/2022 Conference on the Intersection of Particle and Nuclear Physics, Lake Buena Vista, FL
2022 - 2023	New frontiers of electroweak physics at the LHC <i>Colloquium and Seminars (Invited)</i> 05/2023 PKU / SJTU Collider Physics Forum, Virtual 09/2022 Univ. of Tennessee, Knoxville HEP Seminar, Knoxville, TN 05/2022 Korea Advanced Institute of Science & Technology Colloquium, Daejeon, Korea 05/2022 AKPA-KPS Joint Symposium, Korea (Virtual) 03/2022 Univ. of Alabama Colloquium, Tuscaloosa, AL 03/2022 Univ. of Notre Dame Colloquium, Notre Dame, IN 01/2022 Univ. of Florida Colloquium, Gainesville, FL
2020 - 2022	Observation of production of three massive gauge boson <i>Seminars (Invited)</i> 01/2022 Univ. of Florida HEP Seminar, Gainesville, FL (Virtual) 03/2021 Univ. of Illinois HEP Seminar, Urbana, IL (Virtual) 12/2020 Univ. of Pittsburgh HEP Seminar, Pittsburgh, PA (Virtual) 10/2020 Univ. of California Santa Barbara HEP Seminar, Santa Barbara, CA (Virtual) 10/2020 Univ. of Michigan HEP Seminar, Ann Arbor, MI (Virtual) 09/2020 Univ. of Pennsylvania HEP Seminar, Philadelphia, PA (Virtual) 09/2020 Univ. of Maryland HEP Seminar, College Park, MD (Virtual) 09/2020 KSU/KU/UNL Joint HEP Seminar, Kansas / Nebraska (Virtual) 09/2020 Fermilab Wine & Cheese Seminar, Batavia, IL (Virtual) 08/2020 Korea Institute for Advanced Study HEP Seminar, Seoul, Korea 08/2020 Univ. of Seoul HEP Seminar, Seoul, Korea 08/2020 Seoul National University HEP Seminar, Seoul, Korea 07/2020 Hanyang University HEP Seminar, Seoul, Korea 07/2020 Yonsei University HEP Seminar, Seoul, Korea 07/2020 Korea University HEP Seminar, Seoul, Korea 06/2020 Rice University HEP Seminar, Houston, TX (Virtual) 06/2020 Harvard/MIT LPPC Seminar, Boston, MA (Virtual) 05/2020 UC San Diego HEP Seminar, San Diego, CA (Virtual)
2021	Multiboson physics at CMS <i>Parallel Session Talk (Invited)</i> 04/2021 Korean Physical Society Spring Meeting — Pioneer Symposium, Korea (Virtual)
2020	Search for heavy triboson production in leptonic final states <i>Parallel Session Talk</i> 07/2020 ICHEP 2020, Prague (Virtual)
2020	Parallelizable Track Pattern Recognition in HL-LHC <i>Parallel Session Talk</i> 04/2020 Connecting the Dots Workshop, Princeton, NJ (Virtual)
2019	Measurements of triple gauge boson production in ATLAS and CMS <i>Workshop Talk (Invited)</i> 07/2019 Physics Workshop at the LPC: Multibosons at the Energy Frontier, Batavia, IL
2019	Rare EW multiboson at LHC <i>Plenary Session Talk</i> 05/2019 LHCP 2019, Puebla, Mexico
2019	Electroweak physics with multibosons at CMS <i>Parallel Session Talk</i> 05/2019 Pheno 2019, Pittsburgh, PA

2019	Search for the SM production of WWW events <i>Seminar (Invited)</i> 01/2019 LHC Physics Center Physics Forum, Batavia, IL
2016	Searches for new physics in the Higgs sector <i>Seminar (Invited)</i> 03/2016 Univ. of Pennsylvania (HEP), Philadelphia, PA
2015 - 2016	First evidence for vector-boson fusion $H \rightarrow WW$ <i>Seminar (Invited)</i> 02/2016 Univ. of Cincinnati HEP Seminar, Cincinnati, OH 04/2015 Univ. of Pittsburgh HEP Seminar, Pittsburgh, PA
2015	First evidence for vector-boson fusion $H \rightarrow WW$ <i>Parallel Session Talk</i> 04/2015 APS April Meeting, Baltimore, MD
2015	Advanced Analysis Technique: Squeezing out information <i>Workshop Talk (Invited)</i> 11/2015 4th Chicagoland Pheno-ATLAS Workshop, Chicago, IL
2015	ATLAS VBF Trigger Overview <i>Workshop Talk (Invited)</i> 01/2015 3rd Chicagoland ATLAS-Pheno Meeting, Chicago, IL
2014	Higgs Properties <i>Plenary Talk</i> 09/2014 Physics in Collisions 2014, Bloomington, IN

Selected Talks From Members of My Group on Material from My Research

2025	Dr. Mohrman, Towards rapid and efficient columnar-based analyses at scale <i>Workshop Talk (Invited)</i> 07/2025 Python in HEP (PyHEP) Developer's Workshop 2025
2025	Dr. Mohrman, Multiboson production in CMS <i>Parallel Session Talk</i> 05/2025 Pheno 2025, Pittsburgh, PA
2025	Dr. Mohrman, Exploring nature through the interactions of multiple heavy particles <i>Seminar (Invited)</i> 04/2025 Cornell University HEP Seminar, Ithaca, NY
2025	Dr. Mohrman, WWZ measurement at 13 and 13.6 TeV with 200 fb⁻¹ <i>CMS Week Plenary Physics Session (CMS Collaboration Internal)</i> 02/2025 CMS Collaboration, CERN, Geneva

Public Lectures

2024	An Invitation to Imagine Something from Nothing <i>Public Lecture (Invited)</i> 03/2024 Aspen Center for Physics, Aspen, CO 09/2024 Galesville Astrophysical Society
2024	New Frontiers of Electroweak Physics <i>Public Lecture</i> 02/2024 Mid-Florida QuarkNet Day

2022 | **Then and Now: Developments in the Large Hadron Collider**
Public Lecture
 12/2022 Particle Fever — Science on Screen,ENZIAN Theater, Maitland FL

Teaching Experience

Fall 2025	PHY2060: Enriched Physics 1 w/ Calc , Enrollment 40 <i>Instructor</i>
Spring 2025	PHY2048: Physics 1 w/ Calc , Enrollment 1102*, GatorEval Score: 4.30 <i>Instructor</i> *Primarily instructed a subset of students of 121, who registered to the extra sessions that the department opened last minute to specially accommodate increased incoming Freshmen to UF
Fall 2024	PHY2048: Physics 1 w/ Calc , Enrollment 594, GatorEval Score: 4.26 <i>Instructor</i>
Spring 2024	PHY2048: Physics 1 w/ Calc , Enrollment 903, GatorEval Score: 3.53 <i>Instructor</i>
Fall 2023	PHY2048: Physics 1 w/ Calc , Enrollment 586, GatorEval Score: 3.31 <i>Instructor</i>
Fall 2022	PHY2049: Physics 2 w/ Calc , Enrollment 81, GatorEval Score: 4.38 <i>Led 3 discussion sessions</i>

Publications

As a member of the CMS collaboration (and previously ATLAS collaboration) I am an author on over 1100 articles published on refereed journals. Full list of publications can be found at <https://inspirehep.net/authors/1054464>. Below I list a selected list of publications of which I am a primary author.

Selected Publications

1. CMS Collaboration, "Measurement of WWZ and ZH Production Cross Sections at $\sqrt{s} = 13$ and 13.6 TeV," *Phys. Rev. Lett.*, **135**(9), 091802, 2025, doi:10.1103/6z3d-zjw4, arXiv:2505.20483 [hep-ex]
2. CMS Collaboration, "Study of WH production through vector boson scattering and extraction of the relative sign of the W and Z couplings to the Higgs boson in proton-proton collisions at $\sqrt{s} = 13$ TeV," *Phys. Lett. B*, **860**, 139202, 2025, doi:10.1016/j.physletb.2024.139202, arXiv:2405.16566 [hep-ex]
3. CMS Collaboration, "Observation of the Production of Three Massive Gauge Bosons at $\sqrt{s} = 13$ TeV," *Phys. Rev. Lett.*, **125**(15), 151802, 2020, doi:10.1103/PhysRevLett.125.151802, arXiv:2006.11191 [hep-ex]
4. CMS Collaboration, "Search for the production of $W^\pm W^\pm W^\mp$ events at $\sqrt{s} = 13$ TeV," *Phys. Rev. D*, **100**(1), 012004, 2019, doi:10.1103/PhysRevD.100.012004, arXiv:1905.04246 [hep-ex]
5. ATLAS and CMS Collaborations, "Measurements of the Higgs boson production and decay rates and constraints on its couplings from a combined ATLAS and CMS analysis of the LHC pp collision data at $\sqrt{s} = 7$ and 8 TeV," *JHEP*, **08**, 045, 2016, doi:10.1007/JHEP08(2016)045, arXiv:1606.02266 [hep-ex]

6. ATLAS Collaboration, “Observation and measurement of Higgs boson decays to WW,” *Phys. Rev. D*, **92**(1), 012006, 2015, doi:10.1103/PhysRevD.92.012006, arXiv:1412.2641 [hep-ex]
7. ATLAS Collaboration, “Measurements of Higgs boson production and couplings in diboson final states with the ATLAS detector at the LHC,” *Phys. Lett. B*, **726**, 88–119, 2013, erratum *Phys. Lett. B*, **734**, 406–406, 2014, doi:10.1016/j.physletb.2013.08.010, erratum doi:10.1016/j.physletb.2014.05.011, arXiv:1307.1427 [hep-ex]
8. ATLAS Collaboration, “Observation of a new particle in the search for the Standard Model Higgs boson with the ATLAS detector at the LHC,” *Phys. Lett. B*, **716**, 1–29, 2012, doi:10.1016/j.physletb.2012.08.020, arXiv:1207.7214 [hep-ex]
9. G. Niendorf, T. Reid, P. Wittich, P. Elmer, B. Wang, et al., “Line Segment Tracking in the HL-LHC,” arXiv:2207.08207 [physics.ins-det], 2022
10. P. Chang, P. Elmer, Y. Gu, V. Krutelyov, G. Niendorf, et al., “Segment Linking: A Highly Parallelizable Track Reconstruction Algorithm for HL-LHC,” *J. Phys. Conf. Ser.*, **2375**(1), 012005, 2022, doi:10.1088/1742-6596/2375/1/012005, arXiv:2209.13711 [physics.ins-det]
11. CMS Collaboration, “First observation of production of three massive gauge bosons,” *PoS ICHEP2020*, **2021**, 325, doi:10.22323/1.390.0325
12. ATLAS and CMS Collaborations, “Studies of rare electroweak multiboson interactions at the LHC,” *PoS LHCP2019*, **2019**, 107, doi:10.22323/1.350.0107
13. V. Cavaliere, J. Adelman, P. Albicocco, J. Alison, L.S. Ancu, et al., “Design of a hardware track finder (Fast Tracker) for the ATLAS trigger,” *JINST*, **11**(02), C02056, 2016, doi:10.1088/1748-0221/11/02/C02056
14. G. Volpi, J. Adelman, P. Albicocco, J. Alison, L.S. Ancu, et al., “The ATLAS fast tracker processor design,” *PoS VERTEX2015*, **2015**, 040, doi:10.22323/1.254.0040
15. J. Anderson, A. Andreani, A. Andreazza, A. Annovi, M. Atkinson, et al., “A fast hardware tracker for the ATLAS trigger system,” *Nucl. Instrum. Meth. A*, **718**, 258–259, 2013, doi:10.1016/j.nima.2012.11.133
16. J. Anderson, A. Andreani, A. Andreazza, A. Annovi, M. Atkinson, et al., “FTK: A Fast Track Trigger for ATLAS,” *JINST*, **7**, C10002, 2012, doi:10.1088/1748-0221/7/10/C10002
17. CMS Collaboration, “Line Segment Tracking: Improving the Phase-2 CMS High Level Trigger Tracking with a Novel, Hardware-Agnostic Pattern Recognition Algorithm,” arXiv:2407.18231 [hep-ex], 2024