Andre Sterenberg Frankenthal

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Education

Cornell University **Ithaca, NY**
Ph.D. Physics 2020
Advisor: Jim Alexander

Cornell University **Ithaca, NY**
M.S. Physics 2017
Advisor: Jim Alexander

Reed College **Portland, OR**
B.A. Physics 2013
Advisors: Johnny Powell and Nelia Mann (senior thesis)

Professional Background

Princeton University **Princeton, NJ**
Physics Department 2020 –
Associate Research Scholar (Dicke Fellow)

Cornell University **Ithaca, NY**
Physics Department 2013 – 2020
Graduate Research Assistant

Honors and Awards

- Princeton Robert H. Dicke Fellowship 2020 –
- Fermilab LPC Guests & Visitors Award 2018 – 2019
- Cornell Graduate Resident Fellowship 2018 – 2020
- Cornell Albert Silverman Memorial Award 2018
- URA Visiting Scholars Program Award, declined 2016
- Cornell Excellence in Physics Teaching Award (Physics 1101) 2013
- Phi Beta Kappa Honor Society 2013

- Reed College Commendation for Excellence in Scholarship (Dean's List) 2009 – 2013
- Brazilian University Entrance Exams, ranked 1st of thousands at CEFET 2009
- Three silver medals in the Brazilian Programming Olympiad 2006 – 2009

Research Experience and Projects

Leadership and Management:

(CMS) Exotica Non-Hadronic Subgroup Convener 2023 –
Coordinate analyses featuring leptons and photons in final state; communicate with group analysts; provide feedback on strategy and implementation; approve analyses for official CMS review.

(CMS) Review Paper on Data Scouting and Data Parking, Editor 2023 –
Coordinate a team of roughly 50 people in the Exotica and B Physics groups to produce an invited review paper (100 pages) in Physics Reports on the topic of the CMS data scouting and data parking techniques.

(CMS) Exotica Data Format Contact 2021 –
Collect and organize data needs of Exotica group; support physics analyzers with data issues; investigate and coordinate efforts to maximize data availability.

(CMS) Muon Calibration and Alignment Convener 2020 – 2022
Manage new tag-and-probe framework to measure muon efficiencies with Apache Spark and Parquet; maintain official CMS muon efficiencies and scale factors; coordinate efforts within the group; prepare tutorials for new (and old) analysts.

(PADME) Language Editor 2020 –
Review and edit papers of the PADME Collaboration before submission.

Physics and Analysis:

(CMS) Search for dark photons in η meson decays 2023 –
Search for dark photon production in $\eta \to \gamma A'$ decays using parked data in Run 3, focusing on dark photon decays to muon pairs.

(CMS) Observation of the rare $\eta \to 2\mu 2e$ decay with data parking 2022 –
Supervise first observation and branching fraction measurement of the rare $\eta \to 2\mu 2e$ decay channel, using CMS parked data collected in 2022 (Run 3).

(PADME) Reconstruction software for the "ETag" detector 2023 –
Wrote software for new PADME detector aimed at disentangling photon and lepton calorimeter energy deposits.

(CMS) Search for inelastic dark matter with electrons 2022 –
Supervise search for inelastic dark matter focusing on displaced, soft, and non-resonant di-electron production collinear with missing transverse momentum.

(CMS) Observation of the rare $\eta \rightarrow 4\mu$ decay with data scouting 2021 – 2023
Made the first observation and branching fraction measurement of the rare $\eta \rightarrow 4\mu$ decay channel, using CMS scouting data collected in 2017 and 2018.

(CMS) Search for self-interacting dark matter 2019 –
Supervise first collider search for self-interacting dark matter, focusing on collinear and displaced lepton jets.

(CMS) Search for inelastic dark matter with muons 2018 – 2023
Pioneered first collider search for inelastic dark matter, focusing on displaced, soft, and non-resonant dimuon production collinear with missing transverse momentum.

(PADME) Calorimeter physics reconstruction and data analysis 2018 –
Implemented template-derived pulse fit procedures to extract energies and hit times of multi-particle signals that arrive closely in time. Give guidance on robust software reconstruction for various sub-detectors.

Hardware and Software:

(CMS) Phase-2 upgrade of the Outer Tracker 2021 –
Led implementation of test systems at Princeton to qualify silicon-based detector modules for the CMS Outer Tracker Phase-2 Upgrade in the High-Luminosity LHC (HL-LHC). Assessed parameters like efficiency, resolution, thermal behavior, noise baseline, and power requirements. Supervised undergraduate students constructing new cosmic ray muon test stand to measure real tracking efficiency.

(CMS) Muon calibration tool with Apache Spark and Apache Parquet 2020 – 2023
Co-developed and maintained the official CMS muon efficiency and scale factor tool that allows analysists to measure and correct for various muon-related detector efficiencies. Built in python and leveraging big-data technologies such as Apache Spark and Apache Parquet for efficient columnar-based data processing.

(PADME) Small-Angle Calorimeter characterization 2017 – 2018
Measured performance of Small-Angle Calorimeter prototype of the PADME Experiment with test beams at Laboratori Nazionali di Frascati (LNF). Performed analysis of data to assess energy and time resolution, and Monte Carlo simulation of optical physics inside PbF2 crystals with Geant4 framework.

(CMS) Pixel test beams – Phase-2 upgrade of the Inner Tracker 2017 – 2020
Led the US-CMS test beam campaign to assess and compare performance of new small-pitch pixel sensors with various readout chips (PSI46, PROC600, RD53A). Measured parameters like pixel hit resolution, efficiency, charge collection, and radiation hardness. Developed tutorials for training of new personnel.

(CMS) Tracker simulations – Phase-2 upgrade of the Inner Tracker 2017 – 2020
Performed tracker simulations using both parametrized simulation software (tkLayout) and full Monte Carlo simulation software (CMSSW). Assessed performance impact of different mechanical prototypes and thermal configurations, helping to optimize design.

(MMAPS) FPGA development for DAQ and calorimeter test beam 2016
Firmware development of custom waveform digitizer used in the calorimeter prototype of the MMAPS Experiment. Used in test beam at LNF to test performance. Firmware written in Verilog for Xilinx Zynq. Built calorimeter prototype for the test.

(Muon g-2) Monitoring and control (M&C) system for the kicker plates 2015 – 2016
Built from the ground up a M&C system for the Muon g-2 kicker system at Fermilab, using System-on-a-Chip (SoC) boards like Arduino and Intel Galileo, and including a JavaScript-based web server handling real-time (RTOS) M&C information.

(Muon g-2) Test beam characterization of calorimeters 2014
Contributed to test beam effort at SLAC to characterize Cherenkov-based PbF_2 calorimeters used in the Muon g-2 Experiment. Wrote Geant4-based Monte Carlo simulations of crystals to compare against the data and played critical role in development and debugging of the test beam DAQ system.

(Muon g-2) Kalman Filter development for straw trackers 2013 – 2014
Wrote a Kalman Filter in C++ for use with the Muon g-2 straw-tube trackers. The algorithm takes straw hits and the magnetic field map around the storage ring as inputs to reconstruct the path of decay positrons throughout the experiment.

(Muon g-2) Optical Monte Carlo simulation of calorimeters 2013 – 2014
Wrote Geant4-based simulation to understand optical physics processes inside the Muon g-2 calorimeter and study detector performance in realistic scenarios.

(EDELWEISS/EUREKA) PMT characterization 2012
Wrote Control & Monitoring (C&M) software for PMTs in the EDELWEISS dark matter search experiment. Studied single photoelectron behavior of PMTs to be used in the next generation of the experiment, EUREKA.

Service and Committee Work

US-CMS Collaboration Meeting at Princeton, organizer 2024

CMS Exotica Workshop at Sapienza University of Rome, organizer 2023

CMS Analysis Review Committee for EXO-22-007 (search for excited tau leptons) 2023

Princeton Dark Cosmos Joint Theory-Experiment Committee, co-creator	2022 –
Referee for Physics Letters B	2022 –
Shedding Light on X17 Workshop at Laboratori Nazionali di Frascati, organizer	2021
Referee for Progress of Theoretical and Experimental Physics	2021 –
Referee for Journal of Instrumentation	2020 –
Cornell Physics Department Colloquium Committee	2015 – 2017

Selected Publications

Listed below are publications that I have led or in which I made major contributions. In total I am an author on 345 publications. For a list of all my publications, please see:

https://inspirehep.net/author/profile/A.Frankenthal.1

CMS Collaboration, *"Enriching the physics program of CMS through data scouting and data parking,"* invited review paper in preparation for Phys. Rept.	2024
CMS Collaboration, *"Physics of dark sectors in CMS,"* invited review paper in preparation for Phys. Rept.	2024
CMS Collaboration, "*Search for inelastic dark matter in events with two displaced muons and missing transverse momentum in proton-proton collisions at √s = 13 TeV*," Phys. Rev. Lett. 132 (2024) 041802, arXiv:2305.11649	2023
CMS Collaboration, "*Observation of the rare decay of the η meson to four muons*," Phys. Rev. Lett. 131 (2023) 091903, arXiv:2305.04904	2023
D. S. M. Alves et al., "*Shedding light on X17: community report,*" Eur. Phys. J. C 83 (2023) 230	2022
PADME Collaboration, "*Cross-section measurement of two-photon in-flight annihilation of positrons at √s=20 MeV with the PADME detector,*" Phys. Rev. D 107 (2023) 012008, arXiv:2210.14603	2022

PADME Collaboration, "*The PADME beam line Monte Carlo simulation,"* J. High Energy Phys. 09 (2022) 233, arXiv:2204.05616 2022

PADME Collaboration, P. Albicocco et al., "*Commissioning of the PADME experiment with a positron beam,*" J. Instrum. 17 (2022) P08032, arXiv:2205.0343 2022

A. Frankenthal, "*Search for dark matter decaying to two displaced muons produced in proton-proton collisions at 13 TeV with the CMS detector, and for dark photons produced in electron-positron fixed-target collisions at 500 MeV with the PADME detector", PhD thesis, Cornell University, 2020* 2020

A. Frankenthal, "*Searching for Dark Photons with PADME*", arXiv:1910.00764 2019

A. Frankenthal, et al., "*Characterization and Performance of PADME's Cherenkov-Based Small-Angle Calorimeter,*" Nucl. Instrum. Meth. A 919 (2019) 89 2019

L. P. Alonzi, et al., "*The calorimeter system of the new muon g -2 experiment at Fermilab*", Nucl. Instrum. Meth. A 824 (2016) 718 2016

A.T. Fienberg, L.P. Alonzi, A. Anastasi, R. Bjorkquist, D. Cauz, R. Fatemi, C. Ferrari, A. Fioretti, A. Frankenthal, et al., *"Studies of an array of PbF2 Cherenkov crystals with large-area SiPM readout",* Nucl. Instrum. Meth. A 783 (2015) 12 2015

J. Grange et al. Muon g-2 Collaboration, "*Muon (g-2) Technical Design Report*", arXiv:1501.06858 2015

Teaching

Introduction to Classical Mechanics for Engineering Majors (Princeton) 2022

Introduction to Mechanics and Special Relativity for Physics Majors (Cornell) 2017

Electronics Laboratory for Advanced Undergraduates (Cornell) 2014, 2015

Standard Model of Particle Physics (grading & office hours) (Cornell) 2014

Introduction to Physics for Pre-Medical Majors, Auto-Tutorial (Cornell) 2013, 2016

Outreach and Tutoring

US-CMS PURSUE Program Mentor 2023 –
Mentor undergraduate students from diverse backgrounds performing research at Princeton as part of the US-CMS Undergraduate Summer Internship Program.

Princeton Physics Department Mentor 2022 –
Mentor undergraduate students at Princeton's Physics Department to help them navigate the path to a successful physics career.

HEPMAP Founder and Developer 2021 –
Created an educational website to engage the public on the exciting topic of high-energy physics experiments around the world.

ParticleBites Writer and Contributor 2019 –
Write blog articles to explain recent particle physics results to a lay audience.

Fuertes Observatory Lecturer 2019 – 2020
Gave public lectures and engaged with students at the Fuertes Observatory on the Cornell University campus.

Arduino Workshop Series Developer 2018 – 2020
Created short Arduino courses for Cornell undergraduate students without any prior programming experience, to introduce them to the vast world of microcontrollers and showcase some fun and practical projects that can be done with them.

Undergraduate Resident Advisor 2018 – 2020
Mentor and support over 150 undergraduate students at Cornell as a live-in advisor.

Math Tutor at Reed College 2011 – 2012
Provide tutoring to mathematics students at the Reed College Tutoring Center.

Physics Grader and Tutor 2011 – 2013
Served as class grader and physics tutor at the Reed College Physics Department.

Selected Seminar, Workshop, and Conference Talks

"*Probing low-mass new physics with the CMS data scouting and parking pipelines,*" **Notre Dame** Particle Physics Seminar, South Bend, IN.	2024
"*Probing low-mass new physics with the CMS data scouting and parking pipelines,*" **SLAC** FPD Seminar, Palo Alto, CA.	2023
"*The Piper at the Gates of Dome: Probing low-mass new physics with the CMS data scouting and parking pipelines,*" **Cornell University** HEP Seminar, Ithaca, NY.	2023
"*The Piper at the Gates of Dome: Probing low-mass new physics with the CMS data scouting and parking pipelines,*" **Rutgers** HEP Seminar, New Brunswick, NJ.	2023
"*Light dark matter in the lab: Uncovering new low-mass physics with high-energy accelerators,*" MPRG Symposium, **Max Planck Institute for Nuclear Physics**, Heidelberg, Germany.	2023
"*Searches for inelastic dark matter and compressed spectra models with the CMS Experiment,*" Online Seminar, **Centre for High Energy Physics (CHEP) at the Indian Institute of Science**, Bengaluru, India.	2023
"*The Piper at the Gates of Dome: Probing low-mass new physics with the CMS data scouting and parking pipelines,*" **Fermilab** Wine & Cheese Seminar, Batavia, IL.	2023
"*PADME Experiment and the search for X17,*" DarkLight@ARIEL Collaboration Meeting, **TRIUMF** (virtual), Vancouver, Canada.	2023
"*Probing low-mass physics with high-energy accelerators,*" Physics Seminar, **Boston University**, Boston, MA**.**	2023
"*First results of the PADME Experiment and near-term plans,*" UCLA Dark Matter 2023, **UCLA**, Los Angeles, CA**.**	2023
"*First search for inelastic dark matter at the LHC with the CMS detector,*" UCLA Dark Matter 2023, **UCLA**, Los Angeles, CA.	2023
"*Search for BSM Physics in CMS*" LISHEP 2023, **State University of Rio de Janeiro**, Rio de Janeiro, Brazil.	2023

"*Dark Matter Studies with the PADME Experiment*" PPC 2022: XV International Conference on Interconnections between Particle Physics and Cosmology, **Washington University in St. Louis**, St. Louis, MO. 2022

"*Computing tag-and-probe efficiencies with Apache Spark and Apache Parquet*," **PyHEP** 2021, Virtual. 2021

"*Search for inelastic dark matter in proton-proton collisions with the CMS detector at CERN and for dark photons in electron-positron collisions with the PADME detector at INFN*", **Cornell University**, Ithaca, NY. 2020

"*The Hidden World of Dark Matter,*" SSO Seminar, **Oregon State University**, Corvallis, OR. 2019

"*Dark Matter in the Lab: Searching for Dark Sector Physics with Accelerators,*" Physics of the Universe Seminar, **University of Oregon**, Eugene, OR**.** 2019

"*The Dark Side of the Force: Searching for Dark Sector Physics with Colliders and Fixed-Target Experiments,*" **TRIUMF** Special Seminar, Vancouver, CA. 2019

"*A Bridge Between Two Worlds: Dark Photons in the Lab*," **Reed College** Seminar, Portland, OR. 2019

"*Dark Matter in the Lab: Searching for the Dark Sector with Accelerators,*" **Cornell University** Physics Department Lunch Talk, Ithaca, NY. 2019

"*How to Search for Dark Matter,*" Fuertes Observatory Lecture Series, **Cornell University**, Ithaca, NY**.** 2019

"*Search for Inelastic Dark Matter with the CMS Detector,*" Dark Matter at the LHC 2019 Workshop, **University of Washington**, Seattle, WA**.** 2019

"*Searching for Dark Photons with PADME,*" 2019 Meeting of the Division of Particles and Fields of the American Physical Society, **Northeastern University**, Boston, MA. 2019

"*Search for Dark Photons with CMS and Fixed-Target Experiments,*" New Perspectives 2019, **Fermilab**, Batavia, IL. 2019

"*The Dark Side of the Force: Searching for Dark Sector Physics,*" Weekly Colloquium, **Union College**, Schenectady, NY. 2019

"*Thesis Seminar*", **Reed College** Physics Colloquium, Portland, OR. 2013

Student Supervision and Mentoring

Graduate Students:

- Gage DeZoort (Princeton) — Displaced τ-lepton reconstruction with GNNs
- Sam Higginbotham (Princeton) — Search for pseudoscalars in $H \to aa \to 2\mu 2e$
- Bennett Greenberg (Princeton) — OT Phase-2 Upgrade and $\eta \to 2\mu 2e$ search
- Joaquin Castaneda (Nebraska) — Search for self-interacting DM
- Sam Bright-Thonney (Cornell) — Search for inelastic DM
- Tres Reid (Cornell) — Search for inelastic DM

Undergraduate Students:

- Elena Vlaskovic (Edmonds College) — Cosmic ray muon stand for OT Phase-2 Upgrade
- Luan Hernandez (UPRM) — Cosmic ray muon stand for OT Phase-2 Upgrade
- Natasha Greenstein (Princeton) — Studies of bilepton models
- Kasia Krzyzanska (Princeton) — Studies of rare η meson decays
- Neil Minet (Cornell) — CMS IT Phase-2 Upgrade – pixel thermal studies
- Arthur Campello (Cornell) — CMS pixel thermal studies and MMAPS studies
- Aditi Kabra (Cornell) — PADME data reconstruction software
- Kyle Fitzgerald (Cornell) — CMS IT Phase-2 Upgrade – pixel mechanics simulation
- Connor Daly (Cornell) — Muon g-2 DAQ development and testing

Skills

- Programming languages: Extensive experience with C, C++, Python, HTML, CSS, JavaScript, Mathematica; some experience with Intel and PIC assembly, Verilog, VHDL, Scala, Haskell, SQL
- Operating systems: Windows, Linux, MacOS
- Toolkits/libraries/technologies: ROOT, Geant4, tkLayout, Apache Spark, Apache Parquet, matplotlib, pandas, uproot, awkward
- Electronics/microcontrollers/FPGAs: Extensive experience with Arduino, Raspberry Pi, PIC, Xilinx (Zynq); some experience with Altera/Intel Cyclone, circuit schematic & board design
- Languages: Portuguese (native), English (fluent), French (intermediate), Hebrew (basic), German (basic)