

Jia Fu Low | Curriculum Vitæ

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Education

2010–2015 **Ph.D., Experimental Particle Physics**, *University of Florida, U.S.*

2006–2008 **B.Sc., Physics**, *University of Nebraska-Lincoln, U.S.*

2004–2005 **A.Sc., Physics**, *Taylor's University College, Malaysia.*

Research Experience (summary)

2016–present **Postdoctoral Associate**, *University of Florida*

Advisor: Prof. Darin Acosta – Experimental particle physics

- Development of the L1 displaced standalone muon trigger in the muon endcaps.
- Development and maintenance of the online control and monitoring software for the L1 endcap muon trigger.
- Development of the HL-LHC upgrade of the L1 endcap muon trigger algorithm and the correlation of the muon trigger with the track trigger. Performance studies using the Phase-2 muon trigger primitives.
- Development of the Phase-1 upgrade L1 endcap muon trigger for improved efficiency and robustness.
- Simulation studies for the HL-LHC upgrade of the L1 track trigger.

2015–2016 **Postdoctoral Fellow**, *Northwestern University*

Advisor: Prof. Mayda Velasco – Experimental particle physics

- Development of the data acquisition system at the Fermilab test beam facility for the high-granularity calorimeter.
- Analysis of an unexpected low-mass dimuon resonance in CMS Run 1.
- CO₂ cooling design for the CMS high-granularity calorimeter.

2012–2015 **Graduate Research Assistant**, *University of Florida*

Advisor: Prof. Jacobo Konigsberg – Experimental particle physics

- Simulation studies for the HL-LHC L1 track trigger design using associative memory (AM) chips for high-speed pattern recognition.
- Missing transverse energy high-level trigger development in preparation for Run 2 physics.
- Search for invisible decays of the Higgs boson H , produced in association with a Z boson, in the decay channel of $H \rightarrow$ invisible particles and $Z \rightarrow b\bar{b}$ at CMS.
- Search for the standard model Higgs boson H , produced in association with a Z boson, in the decay channel of $H \rightarrow b\bar{b}$ and $Z \rightarrow \nu\bar{\nu}$ at CMS.

2009–2010 **Undergraduate Research Intern**, *University of California-Santa Barbara*

Supervisor: Prof. Joseph Incandela – Experimental particle physics

- Search for supersymmetry (SUSY) signatures in the inclusive N-jet hadronic channel at CMS.

- 2007–2008 **Undergraduate Research Assistant**, *University of Nebraska-Lincoln*
Supervisor: Prof. Kenneth Bloom – Experimental particle physics
- Modeling multijet QCD background in the top events at CMS.
- 2008–2008 **Undergraduate Research Assistant**, *University of Nebraska-Lincoln*
Supervisor: Prof. Roger Kirby – Experimental condensed matter physics
- Investigating magneto-optic Kerr effect (MOKE) on thin films.

Teaching Experience

- Jan 2017 **Facilitator for CMS Data Analysis School at the Fermilab 2017**
Pileup and MET reconstruction techniques, dark matter with mono-photon data analysis
- Jan 2014 **Facilitator for CMS Data Analysis School at the Fermilab 2014**
Higgs → bb data analysis
- 2010–2012 **Graduate Teaching Assistant**, *University of Florida*
General Physics I laboratory

Ph.D. Dissertation

- Title *Higgs Searches with Bottom Quarks and Invisible Particles*
- Advisor Prof. Jacobo Konigsberg
- Description Analyzed 18.9 fb^{-1} of 8 TeV data collected by the CERN Compact Muon Solenoid (CMS) experiment to extract the signal of the standard model Higgs boson decaying to bottom quarks in the associated production mode with a Z boson decaying to neutrinos.
- Full text <https://cds.cern.ch/record/2119579>

Selected Publications

Papers

- [1] CMS Collaboration, “The CMS trigger system”, *JINST* **12** (2017), no. 01, P01020, doi:10.1088/1748-0221/12/01/P01020, arXiv:1609.02366.
- [2] CMS Collaboration, “Precise determination of the mass of the Higgs boson and tests of compatibility of its couplings with the standard model predictions using proton collisions at 7 and 8 TeV”, *Eur. Phys. J. C* **75** (2015), no. 5, 212, doi:10.1140/epjc/s10052-015-3351-7, arXiv:1412.8662.
- [3] CMS Collaboration, “Search for invisible decays of Higgs bosons in the vector boson fusion and associated ZH production modes”, *Eur. Phys. J. C* **74** (2014), no. 8, 2980, doi:10.1140/epjc/s10052-014-2980-6, arXiv:1404.1344.
- [4] CMS Collaboration, “Measurement of WZ and ZZ production in pp collisions at $\sqrt{s} = 8 \text{ TeV}$ in final states with b-tagged jets”, *Eur. Phys. J. C* **74** (2014), no. 8, 2973, doi:10.1140/epjc/s10052-014-2973-5, arXiv:1403.3047.
- [5] CMS Collaboration, “Evidence for the direct decay of the 125 GeV Higgs boson to fermions”, *Nature Phys.* **10** (2014) 557–560, doi:10.1038/nphys3005, arXiv:1401.6527.
- [6] CMS Collaboration, “Search for the standard model Higgs boson produced in association with a W or a Z boson and decaying to bottom quarks”, *Phys. Rev. D* **89** (2014), no. 1, 012003, doi:10.1103/PhysRevD.89.012003, arXiv:1310.3687.

Proceedings

- [7] Z. Ahmed et al., “New Technologies for Discovery”, [arXiv:1908.00194](https://arxiv.org/abs/1908.00194).
- [8] CMS Collaboration, “Boosted Decision Trees in the Level-1 Muon Endcap Trigger at CMS”, *J. Phys. Conf. Ser.* **1085** (2018), no. 4, 042042, [doi:10.1088/1742-6596/1085/4/042042](https://doi.org/10.1088/1742-6596/1085/4/042042).
- [9] CMS Collaboration, “Boosted Decision Trees in the CMS Level-1 Endcap Muon Trigger”, *PoS TWEPP-17* (2017) 143, [doi:10.22323/1.313.0143](https://doi.org/10.22323/1.313.0143).

CMS Notes (Internal)

- [10] D. Barducci et al., “Observation of an excess of $\mu^+\mu^- + b$ -jet events at the di-muon mass of 29 GeV in pp collisions at $\sqrt{s}=8$ TeV”, CMS Analysis Note 2015/289 (2016).
- [11] J. Andrejevic et al., “CO₂ cooling test for Phase 2 High-Granularity Calorimeter cassette”, CMS Detector Note 2015/021 (2015).
- [12] J. Berryhill et al., “Search for anomalous HVV couplings in associated Higgs production with H to bb”, CMS Analysis Note 2014/127 (2015).
- [13] M. De Gruttola, J. Konigsberg, and J. F. Low, “Study on missing transverse energy triggers in 2012 and a holistic plan for 2015”, CMS Analysis Note 2014/058 (2014).
- [14] CMS VHbb Team, “Search for invisible Higgs decay in Z(b bbar) H(inv) with 2012 dataset”, CMS Analysis Note 2013/222 (2013).
- [15] CMS VHbb Team, “Search for the Standard Model Higgs Boson Produced in Association with W and Z and Decaying to Bottom Quarks (LHCP 2013)”, CMS Analysis Note 2013/069 (2013).
- [16] CMS VHbb Team, “Search for the Standard Model Higgs Boson Produced in Association with W and Z and Decaying to Bottom Quarks (HCP 2012)”, CMS Analysis Note 2012/349 (2012).

Talks and Posters

- “BDTs in the Level 1 Muon Endcap Trigger at CMS” — *poster* at the Topical Workshop on Electronics for Particle Physics 2017, Santa Cruz, CA. (Sep 2017)
- “Status of Simulation for Associative Memory Approach (Tracker Trigger)” — *parallel talk* at USCMS Annual Collaboration Meeting 2016, College Station, TX. (May 2016)
- “High Luminosity LHC Muon Trigger (Trigger Upgrade)” — *parallel talk* at USCMS Annual Collaboration Meeting 2016, College Station, TX. (May 2016)
- “Search for the standard model Higgs boson decaying to a b-quark pair when produced in association with a W or Z boson at CMS” — *seminar* at Texas A&M University, College Station, TX. (May 2015)
- “Search for invisible Higgs decays in the associated ZH production modes with Z decays to a pair of bottom quarks in 8 TeV pp collisions at CMS” — *poster* at the LHCP Conference 2014, New York City, NY. (Jun 2014)
- “Search for the standard model Higgs boson produced in association with W or Z bosons, and decaying to bottom quarks” — *talk* at Fermilab New Perspectives 2013, Batavia, IL. (Jun 2013)

- “Search for the standard model Higgs boson produced in association with W or Z bosons, and decaying to bottom quarks” — *parallel talk* at the APS April Meeting 2013, Denver, CO. (Apr 2013)

Awards

- Fermilab LPC Guest and Visitor Program for Jun–Sep 2013.
- Fermilab LPC Short Stay Guest Program for Summer/Autumn 2011.
- CERN Non-Member State Summer Student Program 2009.
- UNL Undergraduate Creative Activities and Research Experiences (UCARE) 2007/08, 2008/09.
- UNL Stowell Fund Scholarship 2007/08.
- UNL International Scholar Award 2006/07, 2007/08.
- AIG Foundation Scholarship 2006/07, 2007/08.

Summer Schools

- Fermilab-CERN Hadron Collider Summer School 2012 at Batavia, IL.

Computer Skills

Programming Languages

| | |
|--------------|---------------------------------------|
| Advanced | C, C++, PYTHON, BASH, \LaTeX |
| Intermediate | VERILOG |
| Basic | HTML, CSS, JAVASCRIPT |

Scientific & Technical Software

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|--------------|--|
| Advanced | GIT, ROOT, CMSSW, HTCONDOR, NUMPY, PANDAS, KERAS, TENSORFLOW, SCIKIT-LEARN |
| Intermediate | GEANT, MADGRAPH, PYTHIA, XDAQ |
| Basic | MATLAB, LABVIEW |

Research Experience (detailed)

- 2019/01–present Development of the L1 displaced standalone muon trigger in the muon endcaps.
- *Developing the L1 trigger for displaced standalone muons that appear in BSM models such as SUSY. Created new patterns that increase the acceptance to high- p_T muons with transverse impact parameter d_0 up to 100 cm . Trained a regression neural network that assigns p_T of displaced muons without assuming vertex constraint. Showed preliminary results with roughly 50% efficiency for $p_T > 20$ GeV and $d_0 > 20$ cm at a trigger rate below 10 kHz at 200 PU.*
- 2018/01–present Development and maintenance of the online control and monitoring software for the L1 endcap muon trigger.
- *Developing and maintaining the online software used to control and monitor the trigger electronics, which is critical to ensure high operational efficiency and minimal data loss. Worked closely with the engineer to implement new features and bug fixes.*
- 2016/03–present Development of the HL-LHC upgrade of the L1 endcap muon trigger algorithm and the correlation of the muon trigger with the track trigger. Performance studies using the Phase-2 muon trigger primitives.
- *Developing the algorithm that combines multiple muon detector information using advanced pattern recognition and machine learning techniques, in order to keep the low trigger threshold for endcap standalone muons in the high-PU scenario. Studied the performance of the new Phase-2 trigger primitives from GEM, ME0 and iRPC and reworked the existing algorithm to utilize these trigger primitives. Optimized the pattern shapes used for pattern recognition to reduce PU dependence. Investigated the use of a regression neural network for p_T assignment to include a larger number of input variables than are allowed in the existing BDT-based approach. Demonstrated a rate reduction by 70% for the $p_T > 20$ GeV threshold at 200 PU when all the Phase-2 TPs are included. Also, contributed to the study of the correlation of the muon trigger with the track trigger, which allows the reconstruction of global muons at L1 with p_T resolution of $\sim 2\%$.*
- 2016/03–2018/12 Development of the Phase-1 upgrade L1 endcap muon trigger for improved efficiency and robustness.
- *Created a new emulator for the firmware of the L1 endcap muon track finder that is faster and significantly more accurate than the predecessor, which makes debugging and verification of the firmware easier. Improved the timing assignment and the coordinate conversion in the algorithm. Improved robustness of the trigger by including the RPC trigger primitives. Combined with several other improvements, a factor of 3 rate reduction at the p_T threshold of 25 GeV was achieved compared to the legacy system.*
- 2016/03–2016/12 Simulation studies for the HL-LHC upgrade of the L1 track trigger.
- *Optimized the efficiency of the AM-based track trigger approach with re-optimized trigger towers. Explored the track trigger performance in high- p_T jets. Analyzed the performance of the AM approach vs. the tracklet approach.*

- 2015/09–2016/02 Development of the data acquisition system at the Fermilab test beam facility for the high-granularity calorimeter.
- *Developed a data acquisition system for the CMS high-granularity calorimeter used at the Fermilab test beam program in 2016. A new architecture, the Xilinx Zynq chip, that includes both processor and FPGA components was chosen for the design. An embedded Linux operating system, running on the Zynq, is used to control the software that communicates with the front-end electronics, and transfers data from the front-end to an external machine via ethernet connection.*
- 2015/07–2015/10 Analysis of an unexpected low-mass dimuon resonance in CMS Run 1.
- *An unexpected dimuon excess around 30 GeV was reported in a final state associated with exactly one b -tagged jet and at least one forward jet. Replicated the analysis and validated the selection and objects to make sure the reported events are not due to instrumental effects or software errors. Constructed and tested signal hypotheses using advanced statistical methods.*
- 2015/07–2015/09 CO₂ cooling design for the CMS high-granularity calorimeter.
- *Performed a temperature analysis of a CO₂-cooled high-granularity calorimeter cassette prototype. The requirement that the cassette be held at -30° C (to avoid radiation damage to the silicon sensors) was met. The experimental temperature distribution also showed very good agreement with the simulation.*
- 2014/01–2015/06 Simulation studies for the HL-LHC L1 track trigger design using associative memory (AM) chips for high-speed pattern recognition.
- *Wrote a software framework to simulate the AM approach to a fast L1 track trigger using CMS full-simulation. Performed optimization studies to determine hardware parameters such as the number of patterns and latency. For example, demonstrated that the number of patterns can be reduced by a factor of 20 – 40 than previously thought necessary without worsening latency. Validated results against toy simulation with simplified geometry.*
- 2013/10–2014/03 Missing transverse energy high-level trigger development in preparation for Run 2 physics.
- *Identified the main sources of the E_T^{miss} trigger rates and applied noise rejection at the high-level trigger. Established skeleton configurations for E_T^{miss} triggers that can serve as the templates for more advanced E_T^{miss} trigger configurations. [13]*
- 2013/05–2013/12 Search for invisible decays of the Higgs boson H , produced in association with a Z boson, in the decay channel of $H \rightarrow$ invisible particles and $Z \rightarrow b\bar{b}$ at CMS.
- *Searched for the $Z(b\bar{b})H(invis)$ events that shares the same final state as the $Z(\nu\bar{\nu})H(b\bar{b})$ decay mode. Performed the full analysis as done for the $Z(\nu\bar{\nu})H(b\bar{b})$ analysis (see below). When combined with the VBF $q\bar{q}H(invis)$ and $Z(\ell^+\ell^-)H(invis)$ modes, the analysis established an exclusion limit on $\mathcal{B}(H \rightarrow invis)$ down to 0.58 (expected 0.44) at 95% confidence level, assuming the standard model production cross sections. The $Z(b\bar{b})H(invis)$ decay mode improved the sensitivity by about 10%. [3]*

- 2012/06–2013/05 Search for the standard model Higgs boson H , produced in association with a Z boson, in the decay channel of $H \rightarrow b\bar{b}$ and $Z \rightarrow \nu\bar{\nu}$ at CMS.
- *Performed the full analysis for the $Z(\nu\bar{\nu})H(b\bar{b})$ decay mode including trigger design, search optimizations, multivariate classification, background estimation, Monte Carlo simulation validation, and signal extraction. When combined with two other decay modes, $Z(\ell^+\ell^-)H(b\bar{b})$ and $W(\ell\nu)H(b\bar{b})$, an excess significance of 2.1 standard deviations was observed (expected 2.1). The results were one of the first published Higgs results with the full 8 TeV data and they are an important input to the global Higgs coupling fit. [6]*
- 2009/07–2010/06 Search for supersymmetry (SUSY) signatures in the inclusive N-jet hadronic channel at CMS.
- *Derived techniques to estimate the missing transverse energy (E_T^{miss}) distribution contributed by QCD processes in multijet hadronic events, especially in the high- E_T^{miss} region, in an attempt to detect SUSY signatures.*
- 2007/05–2008/08 Modeling multijet QCD background in the top events at CMS.
- *Reconstructed high-energy particle collisions using simulation data to obtain an early understanding of real collision data. Performed studies including muon identification, top-decay event selection, and QCD multijet background subtraction methods.*
- 2008/01–2008/05 Investigating magneto-optic Kerr effect (MOKE) on thin films.
- *Investigated the magnetic properties of multi-layer thin films using the magneto-optic Kerr effect. The MOKE effects in the first- and second-order diffractions were used to investigate the periodical magnetization in materials imposed by direct laser interference patterning.*