

Kalanand Mishra - hyperlinked curriculum vitae (July 2014)

Fermilab MS-205, Batavia, IL ☎ 630-840-2417 ✉ kalanand@fnal.gov 🌐 <http://kmishra.net>

Education

- 2008 Ph.D. (Experimental Particle Physics), [University of Cincinnati](#), Ohio, USA. Thesis title: “*Experimental Study of Three-body Cabibbo-suppressed D^0 Decays and Extraction of CP Violation Parameters*”. Thesis advisers: Brian Meadows and Michael Sokoloff.
- 2000 M.S. (Physics), [Jawaharlal Nehru University](#), New Delhi, India.

Positions

- 2008–Present: Research Associate at [Fermilab](#) on [CMS experiment](#) at the [LHC](#) at [CERN](#)
- 2003–2008: Research Assistant at [Stanford Linear Accelerator Center](#) on the [BABAR](#) experiment

Physics data analysis accomplishments

- **Higgs boson in $H \rightarrow WW$ (2011–2014):** Excluded [existence of heavy Higgs states](#) other than $H(125)$ up to the mass of about $1000 \text{ GeV}/c^2$. The result was featured on the cover of *European Physics Journal* in June 2013 and [elsewhere](#). Led $H \rightarrow WW$ semi-leptonic analysis efforts at CMS.
- **Quartic gauge couplings (2013–2014):** Made [the first measurement](#) of three-vector-boson production at the LHC that led to the most stringent limits on anomalous quartic gauge boson couplings.
- **Electroweak corrections (2013):** For Snowmass report [performed a survey](#) of the most abundant processes in pp collisions for sensitivity to electroweak corrections at $\sqrt{s} = 8, 14, 33,$ and 100 TeV .
- **$WW+WZ$ cross section & trilinear gauge couplings (2011–2013):** Led analysis of the first [diboson observation](#) in the semileptonic channel at the LHC, thus setting the most stringent limits on charged anomalous trilinear gauge boson couplings.
- **Performance of jet substructure at high pileup (2012):** For BOOST-2012 report performed a [study of the effect of high pileup](#) on jet grooming techniques.
- **Jet substructure (2012):** Performed [a comprehensive study](#) of jet substructure in dijet and W/Z +jets events as a [ground work for \$WH \(\rightarrow bb\)\$ and high mass \$WW\$ analyses](#) at CMS using boosted jets.
- **Anomalous bump in $W+2$ -jet (2011):** Co-led CMS study of the dijet mass spectrum in $W+2$ -jet events. [Conclusively excluded](#) existence of an anomalous bump near $150 \text{ GeV}/c^2$ [reported by](#) the CDF collaboration and predicted by theoretical models such as technicolor and leptophobic Z' .
- **W and Z boson production rates (2010):** With better than 2% experimental uncertainty these [measurements](#) are the most precise at any hadron collider and played a major role in physics commissioning of the CMS detector. Co-led the Z boson analysis team consisting of 26 people.
- **High mass resonances (2009):** Searched for [new physics in dijet events](#) and set strong constraints on a variety of phenomena such as technicolor, axigluons, colorons, W' , Z' , and contact interactions.
- **CP violation in charm decays (2006–2008):** Measured [CP asymmetry](#) in neutral D meson rare decays to three pions or two-kaons-and-a-pion at [BABAR](#) setting 1% upper bound on its magnitude.
- **Measurement of Cabibbo-Kobayashi-Maskawa phase γ (2004–2007):** This phase is the only source of direct CP violation in the quark sector of the Standard Model. [Measured it in interference](#) between rare B meson decays to D^0 and \bar{D}^0 mesons both of which decay to same final state particles.

Physics calibration accomplishments

- **Jet energy scale calibration (2008–2010):** [Calibrated](#) jet energy scale using p_T -balance in γ/Z +jet events and achieved better than 3% precision for central jets. Developed [jet-ID](#) for CMS.

- **Electron calibration (2008–2010):** Led team effort to measure efficiency, energy scale, and resolution.
- **Particle identification for BABAR (2004–2006):** Measured efficiency and fake rate for kaon, pion, electron, muon, and proton identification as function of 4-momenta and charge. Wrote a monitoring tool to track efficiency variations with time.

Hardware accomplishments

- **Upgrade of hardware trigger (2012–2014):** The CMS Level-1 trigger from circa 2012 would severely compromise physics capability at 13 TeV. With a four-fold increase in event rate, the p_T threshold for each lepton would need to be raised significantly causing large acceptance drops for W, Z, top, and Higgs. To help mitigate this situation I got involved in the trigger [upgrade for 2015 data-taking](#), specifically to bring down the electron-photon rate by improving reconstruction algorithms in the firmware.
- **Cherenkov detector (2005–2006):** Ran operations of the [BABAR Cherenkov detector](#), responsible for overall daily operations. Co-led its upgrade effort during summer 2005 shutdown, which included replacement of power-supply electronics and cooling system.

Software and other technical accomplishments

- **Citation of physics publications (2014):** Wrote *iCite* – a lightweight package to query and analyze citation statistics and h-Index for an author or collaboration ([code & documentation](#)).
- **Trigger emulator (2013–14):** Co-developed software to emulate the architecture and features of the upgraded CMS calorimeter hardware trigger for 2015 data taking ([code](#), [documentation](#)).
- **Jet substructure (2012–14):** Wrote code to use pattern recognition in jet substructure to enhance signal-over-background by reducing the ambient noise contribution ([code](#), [documentation](#)).
- **Building complex data chain (2010–13):** Co-developed software to analyze data with leptons, jets, and missing energy in the final state ([code](#), [documentation](#)). It was used in the CMS measurements of Higgs boson, multi-boson production, and anomalous gauge interactions and in new physics searches.
- **Lepton efficiency (2008–10):** Co-developed software to compute lepton efficiency using $Z \rightarrow \ell^+ \ell^-$ events, where $\ell = e, \mu, \text{ or } \tau$ ([code](#), [documentation](#)). In the *tag and probe* method, one uses one of the leptons as “tag” and the invariant mass constraint to measure efficiency of the second lepton (called “probe”). It has been used in hundreds of CMS measurements including the Higgs boson discovery.
- **Jet energy calibration (2008–10):** Co-developed a framework to identify high energy particle jets and calibrate their energy scale ([code](#), [documentation](#)). Used in all CMS measurements.
- **Particle identification using machine learning (2006–08):** Co-developed optimal particle ID (called *KM selectors* after my initials) for kaon, pion, electron, and proton that led to 50% reduction in false positive and gave BABAR a significant advantage over competing experiments ([code](#), [documentation](#)).

Leadership/Management

2014	Co-organizer, Aspen 2014 international conference on High Energy Physics , Aspen, CO.
2013–2014	Co-organizer, LPC Coffee Hour , discussion forum at the LHC Physics Center at Fermilab.
2013	Co-organizer, Helmholtz Alliance Workshop on Anomalous Quartic Couplings , Dresden, Germany. Main organizer, Workshop on Gauge Boson Couplings , Fermilab.
2013	Main organizer, Hands-on Advanced Tutorial Sessions on Jet Substructure , Fermilab.
2013	Member, international advisory committee, PIPS 2013 symposium , West Java, Indonesia.
2010–2013	Organized tutorials on physics analysis with jets for CMS Data Analysis Schools .
2012–2013	Led BOOST2012 subgroup charged with the study of jet grooming & pileup subtraction.

2011–2012	Co-led CMS analysis group on the study of the dijet mass spectrum in $W+2$ jet events .
2009–2012	Led development of tag & probe machinery to compute lepton efficiency in CMS.
2010–2011	Co-led CMS analysis team on the Z boson cross section measurement .
2008–2010	Responsible for electron efficiency measurements. My team provided tables of electron efficiency and data/simulation scale factors to the CMS collaboration.
2006–2008	Responsible for development of the “ultimate” particle identification algorithms using machine learning for the <i>BABAR</i> detector.
2005–2006	Co-led operations and upgrade of the <i>BABAR</i> Cherenkov detector.

Teaching & Outreach

2008–2014	Contributed to “ Saturday Morning Physics ”. Started by Nobel laureate Leon Lederman in 1979, it is a series of nine lectures and tour visits given by Fermilab scientists with the purpose of increasing the understanding of modern physics among high school students.
2013	Gave hands-on tutorials on the topics of jet substructure and statistical techniques during a series of Hands-on Advanced Tutorial Sessions (HATS) at Fermilab.
2010–2013	Taught a series of short courses on physics analysis with jets during <i>CMS Data Analysis Schools</i> in 2010, 2011, 2012, and 2013. Each course consisted of a short (2 hours) and a long (3 days) exercise. Participants included graduate students, postdocs, and faculty .
2012	Answered public questions during Ask-a-Scientist outreach lectures at Fermilab.
2010	Gave tutorial in Hadron Collider Physics Summer School on data–theory comparisons.
2003–2004	Taught laboratory and recitation courses to engineering, medical, and physics undergraduates. Helped students with assignments and graded their performance.

Mentoring

2012–2014	Kevin Siehl (Wayne State Univ., <i>Anomalous Gauge Couplings in WW</i>), Cristian Vega (Universidad San Francisco de Quito, Ecuador, <i>CMS Trigger Upgrade</i>), Ajay Kumar (Delhi Univ. India, <i>$H \rightarrow WW$</i>), Wei Zou (Peking Univ. China, <i>VBF Higgs in $H \rightarrow WW$</i>).
2012 Summer	Geoffrey Fatin (U. Buffalo) and Joseph Flanigan (U. Wisconsin, Milwaukee) from the REU program at Wayne State. Studied $WW\gamma$ production with a boosted hadronic W .
2011 Summer	Kristina Krylova (Buffalo) and Kellen McGee (Johns Hopkins) from the REU program at Wayne State. Studied gauge boson trilinear couplings.
2009–2010	Mikhail Makouski (Kansas State Univ., <i>Z boson cross section</i>), Sunil Bansal (Panjab Univ., <i>jet energy calibration</i>), Mehmet Deliomeroğlu (Bogazici Univ., <i>electron efficiency vs. jet multiplicity</i>), Kittikul Kovitanggoon (Texas Tech, <i>hadronic W reconstruction</i>), David Bjergaard (Johns Hopkins, <i>lepton efficiency in CMS</i>).

Refereeing

2013–2014	Referee for Physical Review Letters .
2010–2014	CMS internal reviewer for the following analyses - Search for $W'/\text{techni-}\rho$ in WZ decay , <i>Phys. Lett. B</i> 740 , 83 (2015). - Search for a heavy charged Higgs decaying to $t\bar{b}$ or $\tau\nu$, HIG-13-026 (2014) . - Measurement of $VZ \rightarrow Vbb$ cross section ($V = W, Z$) , <i>Eur. Phys. J. C</i> 74 2973 (2014). - Measurement of double parton scattering in $W+2$-jet process , <i>JHEP</i> 1403:032 (2014). - Measurement of $WZ \rightarrow 3l\nu$ cross section , SMP-12-006 (2013) . - Measurement of charged particle multiplicities in pp interactions , <i>JHEP</i> 1101:079 (2011).
2010–2014	Fermilab institutional reviewer of CMS papers, led the group review in some cases.

Selected talks

Sept 2013	WIN 2013, Natal, Brazil, “ Spin-parity measurement of the 126 GeV resonance at CMS ”.
-----------	---

July 2013	Invited talk, Snowmass Energy Frontier, Seattle, “ <i>Electroweak corrections at high \sqrt{s}</i> ”.
May 2013	Invited talk, PIPS 2013, West Java, Indonesia, “ <i>The Frontier of HEP and the LHC</i> ”.
Apr 2013	Review talk, LHC Electroweak Working Group, CERN, “ <i>Anomalous QGC sensitivity</i> ”.
Jan 2013	Invited talk, Workshop on QCD Physics, Fermilab, “ <i>Scale choices for complex processes</i> ”.
Dec 2012	Invited talk, US ATLAS workshop, U. Chicago, “ <i>CMS measurements of jet substructure</i> ”.
Sept 2012	Invited talk, Workshop on EWK corrections, Durham, “ <i>EWK measurements at CMS</i> ”.
Sept 2012	Wine & Cheese seminar, Fermilab, “ <i>New Physics in Diboson Events at CMS</i> ”.
Aug 2012	Invited talk, QCD@LHC 2012, MSU, “ <i>W/Z+jets (incl. heavy flavor) at LHC</i> ”.
July 2012	BOOST 2012, Valencia, Spain, “ <i>Performance of jet substructure with pileup</i> ”.
July 2012	ICHEP 2012, Melbourne, Australia, “ <i>WW, WZ and ZZ production at CMS</i> ”.
Oct 2011	Invited talk, Lattice 2011, Fermilab, “ <i>Technicolor searches at colliders</i> ”.
Aug 2011	APS-DPF, Brown Univ., Providence, “ <i>Study of Diboson Production at CMS</i> ”.
May 2011	Invited talk, EWSB 2011, U. Wisc., Madison, “ <i>CMS Higgs Search Results & Prospects</i> ”.
Dec 2010	Conference on First LHC Data, U. Michigan, “ <i>W and Z Physics at CMS</i> ”.

Made > 400 presentations in various working meetings: <https://indico.cern.ch/search?p=mishra+kalanand>

Publications

- A primary author and led key parts of the analysis effort in the following publications:

- [1] A.M. Sirunyan *et al.* [CMS Collaboration], “Search for anomalous couplings in boosted WW/WZ $\rightarrow \ell\nu q\bar{q}$ production in proton-proton collisions at $\sqrt{s} = 8$ TeV”, *Phys. Lett.* **B772**, 21 (2017). I was part of the core analysis team.
- [2] S. Chatrchyan *et al.* [CMS Collaboration], “Search for a Higgs boson in the mass range from 145 to 1000 GeV decaying to a pair of W or Z bosons”, *JHEP* **10**, 144 (2015). I led the analysis of $H \rightarrow WW \rightarrow \ell\nu q\bar{q}$ channel.
- [3] S. Chatrchyan *et al.* [CMS Collaboration], “A Search for WW γ and WZ γ production in pp collisions at $\sqrt{s} = 8$ TeV”, *Phys. Rev.* **D90**, 032008 (2014). I was part of the core analysis team.
- [4] A. Altheimer *et al.* [BOOST2012 participants], “Boosted objects and jet substructure at the LHC”, *Eur. Phys. J.* **C74**, 2792 (2014). I led the subgroup to study the effect of pileup on jet substructure.
- [5] S. Chatrchyan *et al.* [CMS Collaboration], “Search for a standard-model-like Higgs boson with a mass of up to 1 TeV at the LHC”, *Eur. Phys. J.* **C73**, 2469 (2013). I led the analysis of $H \rightarrow WW \rightarrow \ell\nu q\bar{q}$ channel.
- [6] S. Chatrchyan *et al.* [CMS Collaboration], “Studies of jet mass in dijet and W/Z+jet events”, *JHEP* **05**, 090 (2013). I was part of the 4-member team that carried out this analysis and wrote paper.
- [7] S. Chatrchyan *et al.* [CMS Collaboration], “Measurement of the sum of WW and WZ production with W+dijet events in pp collisions at $\sqrt{s} = 7$ TeV”, *Eur. Phys. J.* **C73**, 2283 (2013). I edited the paper.
- [8] S. Chatrchyan *et al.* [CMS Collaboration], “Study of the dijet mass spectrum in $pp \rightarrow W$ +jets events at $\sqrt{s} = 7$ TeV”, *Phys. Rev. Lett.* **109**, 251801 (2012). I was the editor of the paper.
- [9] S. Chatrchyan *et al.* [CMS Collaboration], “Measurements of Inclusive W and Z Cross Sections in pp Collisions at $\sqrt{s} = 7$ TeV”, *JHEP* **10**, 132 (2011). I co-led the Z cross section analysis.
- [10] S. Chatrchyan *et al.* [CMS Collaboration], “Determination of Jet Energy Calibration and Transverse Momentum Resolution in CMS”, *JINST* **6**, P11002 (2011). I contributed to JEC absolute scale correction.
- [11] V. Khachatryan *et al.* [CMS Collaboration], “Measurements of Inclusive W and Z Cross Sections in pp Collisions at $\sqrt{s} = 7$ TeV”, *JHEP* **01**, 080 (2011). I co-led the Z cross section analysis.
- [12] V. Khachatryan *et al.* [CMS Collaboration], “Search for Dijet Resonances in 7 TeV pp Collisions at CMS”, *Phys. Rev. Lett.* **105**, 211801 (2010). I was part of the core analysis team.
- [13] B. Aubert *et al.* [BABAR Collaboration], “Search for CP Violation in Neutral D Meson Cabibbo-suppressed Three-body Decays”, *Phys. Rev. D* **78**, 051102 (2008). I was the editor of the paper.

- [14] M. Gaspero, B. Meadows, K. Mishra, and A. Soffer, “Isospin analysis of D^0 decay to three pions”, *Phys. Rev. D* **78**, 014015 (2008). I was part of the 4-member analysis team and wrote the paper.
 - [15] B. Aubert *et al.* [BABAR Collaboration], “Constraints on CP violation parameters with a Dalitz plot analysis of $B^\pm \rightarrow D_{\pi^-\pi^+\pi^0} K^\pm$ ”, *Phys. Rev. Lett.* **99**, 251801 (2007). I was part of the 4-member analysis team and wrote the paper.
 - [16] B. Aubert *et al.* [BABAR Collaboration], “Amplitude Analysis of the Decay $D^0 \rightarrow K^- K^+ \pi^0$ ”, *Phys. Rev. D* **76**, 011102 (2007). I was the editor of the paper.
 - [17] B. Aubert *et al.* [BABAR Collaboration], “Precise Branching Ratio Measurements of the Decays $D^0 \rightarrow \pi^-\pi^+\pi^0$ and $D^0 \rightarrow K^-K^+\pi^0$ Relative to the $D^0 \rightarrow K^-\pi^+\pi^0$ Decay”, *Phys. Rev. D* **74**, 091102 (2006). I was the editor of the paper.
- A primary author of the following reports or conference proceedings:
 - [1] D. Adams *et al.* [BOOST2013 participants], “Towards an Understanding of the Correlations in Jet Sub-structure,” *Eur. Phys. J.* **C75**, 409 (2015).
 - [2] CMS Collaboration, “Search for additional high mass Higgs bosons in the $H \rightarrow WW \rightarrow \ell\nu q\bar{q}$ decay channel in pp collisions at the LHC”, [CMS-HIG-13-027](#) (2014).
 - [3] J. M. Campbell *et al.*, “Report of Snowmass energy frontier QCD working group,” [arXiv:1310.5189](#) (2013).
 - [4] CMS Collaboration, “Technical Design Report for the Level-1 Trigger Upgrade”, [CMS-TDR-12](#) (2013).
 - [5] J. Anderson *et al.*, “Snowmass Energy Frontier Simulations,” [arXiv:1309.1057](#) (2013).
 - [6] K. Mishra *et al.*, “Electroweak Corrections at High Energies,” [arXiv:1308.1430](#) (2013).
 - [7] K. Mishra, “The frontier of high energy physics and the large hadron collider”, AIP Conf. Proc. **1554**, 9 (2013), [doi: 10.1063/1.4820273](#).
 - [8] CMS Collaboration, “Search for the Standard Model Higgs boson in the $H \rightarrow WW \rightarrow \ell\nu q\bar{q}$ decay channel in pp collisions at the LHC”, [CMS-HIG-13-008](#), [HIG-12-046](#), [HIG-12-021](#), [HIG-12-003](#) (2012–13).
 - [9] K. Mishra, “Study of Diboson Production at CMS”, [APS-DPF 2011 proceedings](#) (2011).
 - [10] CMS Collaboration, “Determination of the jet energy scale”, [CMS-JME-09-005](#) (2009).
 - [11] CMS Collaboration, “Measurement of the Inclusive W and Z Cross Sections”, [CMS-EWK-09-004](#) (2009).
 - [12] K. Mishra, “Experimental Study of Three-body Cabibbo-suppressed D^0 Decays and Extraction of CP Violation Parameters”, [Ph.D. thesis](#) (2008).
 - [13] K. Mishra, “Charmed Meson Dalitz Plot Analysis at BABAR”, [Frascati Physics Series Vol. 46](#), 967 (2007).
 - Listed as an author of several hundred peer-reviewed journal articles whose scientific results were obtained in collaboration with others. Complete list: <http://inspirehep.net/author/K.Mishra.1>
 - **h-index = 104 for all contributed publications** (average citation ~ 70), **14 for publications as a primary author** (average citation ~ 120).
 - A quantitative analysis of the impact of my collaborative publications in comparison to others in the field of particle/particle-astro physics can be found at <http://kmishra.net/iCitePlots>