V. Ravindran

Curriculum Vitae

The Institute of Mathematical Sciences
IV Cross Road, CIT Campus, Taramani
Chennai 600 113, India
☎ *+91 44 22543208*
FAX *+91 44 22541586*
✉ *ravindra@imsc.res.in*

Personal Information

Nationality Indian Date of Birth 9th October, 1965

Research Interests

- Yang-Mills theory, QCD, Higgs physics, Collider Physics Phenomenology
- Quantum field theory techniques: multi-leg, multi-loop computations in QCD
- Soft gluon resummation, infra-red structure of QCD multi-loop amplitudes
- Spin and model identification at the Large Hadron Collider (LHC)
- Parton shower and matching using aMC@NLO

Technical Skills

Language C, Fortran, Mathematica, Maple, FORM
Packages QGRAF, FIRE, LITERED, Reduze 2, Gnuplot

Education

1982–1985 **Bachelor of Science (Physics major)**.
Voorhees college, University of Madras, Vellore 632 001, India

1985–1987 **Master of Science (Physics)**.
Govt. Arts College, University of Madras, Thiruannamalai, India

1987–1993 **Ph. D. (Theoretical Physics)**.
Institute of Mathematical Sciences, Chennai 600 113, India

Work Experience

1994–1995 **PDF**, , Tata Institute of Fundamental Research, Mumbai.
1996–1997 **PDF**, , Physical Research Laboratory, Ahmedabad.
1997–1999 **PDF**, , DESY, Zeuthen, Germany.
1999–2000 **Faculty (Fellow D)**, , Harish-Chandra Research Institute, Allahabad.
2000–2001 **Faculty (Reader E)**, , Harish-Chandra Research Institute, Allahabad.
2001–2004 **Faculty (Asso.Prof F)**, , Harish-Chandra Research Institute, Allahabad.
2004–2010 **Faculty (Asso.Prof G)**, , Harish-Chandra Research Institute, Allahabad.
2010–2012 **Faculty (Prof H)**, , Harish-Chandra Research Institute, Allahabad.
2012–2019 **Faculty (Prof H)**, , The Institute of Mathematical Sciences, Chennai.
2019–Now **Faculty (Prof I)**, , The Institute of Mathematical Sciences, Chennai.

Invited talks in India:

I have attended most of the meetings on High Energy Physics in India. In addition, I regularly visit institutes and universities for a colloqium or seminars. Some of the important meetings where I had given planery talks are listed below:

- Workshop on High Energy Physics Phenomenology-II, S N Bose National Centre, Calcutta, Jan 1991.
- Workshop on High Energy Physics Phenomenology-III, Matscience, Madras, Jan 1994.
- Discussion Meeting on Effective Field Theories and QCD, CTS, Bangalore, Aug 1994.
- Micro workshop on Hard Probes, TIFR, Bombay, Dec 1994.
- XI DAE Symposium on HEP, Vishva Barathi University, Santiniketan, Jan 1995.
- Topical meeting on Particle Physics and Cosmology, Mount Abu, Oct 1995.
- Discussion Meeting on Deep Inelastic Scattering, CTS, Bangalore, Nov 1995.
- Golden Jubilee Symposium on Gravitation and Particle physics, Physical Research Laboratory, Ahmedabad, Dec 1996.
- Linear Collider Meeting, Tata Institute of Fundamental Research(TIFR), Mumbai.
- Working group summary, Workshop on High Energy Physics Phenomenology-VII, Harish-Chandra Research Institute, Allahabad, 4 - 15 Jan 2002.
- 9th International Symposium on Particles, Strings and Cosmology (PASCOS 03), Mumbai (Bombay) India, 3-8 Jan 2003.
- 3rd Indian Linear Collider Working Group Meeting, TIFR, Mumbai, 8-10 May 2003.
- 4th Indian Linear Collider Working Group Meeting, IISc, Bangalore, 8-10 Oct 2003.
- Interaction meeting on Linear Collider, Indian National Science Academy, New Delhi, Nov. 10-11, 2003.
- XI Workshop on High Energy Physics Phenomenology (WHEPP-VIII) Indian Institute of Technology, Mumbai, January 5-16, 2004
- THEP-I, Indian Institute of Technology, Roorkee, March 16-20, 2005
- Theory Seminar, Physical Research Laboratory, Ahmedabad, October 12-16, 2005
- VIII Workshop on High Energy Physics Phenomenology (WHEPP-VIII), Institute of Mathematical Sciences, Chennai, 03 January - 14 January, 2006
- Working group summary, IX Workshop on High Energy Physics Phenomenology, Institute of Physics, Bhubaneswar, 3-14 January 2006.
- Workshop on High Energy Physics Phenomenology-IV, S N Bose National Centre, Calcutta, Jan 1996.

- Workshop on LHC Physics, TIFR, Mumbai,India,September 2-8,2006
- Topical Meeting on Physics at the Large Hadron Collider, Harish-Chandra Research Institute, Allahabad 16-21 Dec. 06.
- Lectures in a "School on QCD" November 25 - 30, 2007, at Harish-Chandra Research Institute, India.
- 'Higgs Hunters' Meeting, Visva-Bharati, Santiniketan, during February 7-9, 2008.
- 'The physics of warped extra dimensions' IIT Kharagpur, India, between 21st and 23rd February, 2008.
- HEPCOS-2008, Centre for Theoretical Physics, Jamia Millia Islamia during March 11 and 12 , 2008.
- RECAPP Meeting 2008, Harish-Chandra Research Institute, Allahabad, September 21 - October 4, 2008.
- Theory Seminar, Center for High Energy Physics, IISc, Bangalore, October 2008.
- Theory Seminar, Institute of Mathematical Sciences, Chennai, 4th June ,2009.
- WORKSHOP ON HIGH ENERGY PHYSICS PHENOMENOLOGY (WHEPP XI) , Physical Research Laboratory, Ahmedabad, 2 - 12th January 2010
- SERC review meeting, IIT Mumbai, May 21-22, 2010
- India-CMS Meeting, NISER , IOP Campus, Bhubaneswar , 28th - 30th October 2010
- The Workshop on Synergy between High Energy and High Luminosity Frontiers, TIFR, Mumbai, January 10-12, 2011
- LHC discussion meeting, Santiniketan, January 27-30, 2011
- Lecture Workshop on pQCD and Higgs Physics, Mumbai, 7th to 10th of January 2013.
- SUSY and DM, CHEP, Bangalore, 3-5 October 2013.
- Annual meeting of Indian Academy of Science Chandigarh, 8-10 November 2013.
- WHEPP13, Puri, 12-19 November 2013.
- What is next at the LHC, TIFR, Mumbai 6-8 January 2014.
- Symposium on Astroparticle and Nuclear Physics, Jamia Millia Islamia, New Delhi, 21-22 January 2014.
- EWSB and flavour physics ,IIT Guwahati, 20-22 February 2014.

Invited talks/seminars abroad :

I have been regularly invited to several international research institutions for short and long term visits, seminars, colloqiums. In addition, I visit these institutions to carry out collaborative research works with scientists working there. Being in the International Advisory Board of RADCOR (International Symmposium on Radiative Corrections), I am involved in organising the international meeetings, once in two years. I also organised RADCOR 2011 in Mahabalipuram, India. I am a principal investigator of two projects, namely Indo-Italian and Indo-Belgian and also a member of Indo-French. Hence, I regularly visit the research centers in Italy and France for collaborative purpose. Since my area of research centers around the studies at the Large Hadron Collider (LHC), I regularly visit Theory Group at, CERN, Geneva for a month every year.

- DPG-German Physical Society Meeting, Univ. of Freiburg, Germany, 23-27, March 1998.
- 6th International Workshop on Deep Inelastic Scattering and QCD (DIS 98), Brussels, Belgium, 4-8 Apr 1998.
- Zeuthen Workshop on Elementary Particle Theory: Loops and Legs in Gauge Theories, Rheinsberg, Germany, 19-24 Apr 1998.
- 3rd UK Phenomenology Workshop on HERA Physics, Durham, England, 20-25 Sep 1998.
- 7th International Workshop on Deep Inelastic Scattering and QCD (DIS 99), Zeuthen, Germany, 19-23 Apr 1999.
- United Kingdom-QCD Network Meeting , The Netherlands during 2000
- Invited talk, Lorentz Institute, Univ. of Leiden, The Netherlands, June, 2002.
- 7th DESY Workshop on Elementary Particle Theory: Loops and Legs in Quantum Field Theory, Zinnowitz, Germany, 25-30 Apr 2004.
- HERA and the LHC - A Workshop on the Implications of HERA for LHC Physics: CERN - DESY Workshop 2004/2005, CERN, Geneva, Switzerland, 26-27 Mar 2004.
- HERA and the LHC - A Workshop on the Implications of HERA and LHC Physics, Hamburg, Germany, 21-24 Mar 2005.
- 7th International Symposium on Radiative Corrections (RADCOR) Application of Quantum Field Theory to Phenomenology, Shonan Village, Japan October 2-7, 2005
- Theory Seminar, Laboratoire de Physique Theorique et Hautes Energies, Universite Paris 6 et Paris, France, 28th July, 2006.
- Japanese French meet, KEK, Japan, December 2006.
- Theory Seminar, Centre de Physique Theorique,Ecole Polytechnique, Paris, France 17th July, 2007
- International Symposium on Radiative Corrections (RADCOR), Florence, Italy, October 2007.
- Theory Seminar, Univ. of Wuppertal, Germany, 8th August 2007.

- Theory Seminar, Univ. of Aachen, Germany, September 2007.
- Theory Seminar, Theory group, DESY-Zeuthen, Germany, May 2008.
- Theory Seminar, Centre de Physique Theorique,Ecole Polytechnique, Paris, France 3rd July, 2008
- "Renormalization Group-2008" Conference dedicated to 80th Anniversary of Professor Shirkov, September 1-5, 2008, Dubna, Russia
- 9th International Symposium on Radiative Corrections, RADCOR 2009 in Ascona, Switzerland from 24th-31st October 2009
- Laboratoire d'Annecy-le-Vieux de Physique Théorique(LAPTH) France from 1st to 30th November 2009
- Theory group, CERN, Organisation Europeenne Pour La Recherche Nucleaire, European Organization for Nuclear Research at Geneva, Switzerland from 30th-November to 13th December 2009.
- Loops And Legs In Quantum Field Theory 15th to 20th April, 2012, Wernigerode, Germany
- Attended Les Houches, France during 03-6-2013 - 12-6-2013
- RADCOR 2013, 22-27 September 2013, Lumley Castle Hotel, Durham, England
- Loops and Legs 2014 at Weimar, Germany, 27 April to 2 May 2014
- RADCOR 2015 - Loopfest, UCLA, USA, 15-19 June 2015
- Loops and Legs 2016, Leipzig, Germany, 24-29 April 2016
- Precise theory for precise experiments , Vietnam ,September 25 - October 02 2016
- Theory Seminar at KIT, Germany during 09-11 May 2016
- Theory Seminar at CP3, Belgium during 12 14 May 2016
- Theory Seminar LAPTH, Annecy, France during 19 May 2016
- Theory Seminar MITP, University of Mainz, Germany during 22 to 24 May 2016
- Theory Seminar Physics Department,University of Milan, Italy, during 12-13 June 2017

Organising/Chairing/Co-ordinating Conferences/Symposiums:

- Member of "International Advisory Board" (**IAB**) of International Symposium on Radiative Corrections (RADCOR), Application of Quantum Field Theory to Phenomenology (Since 2012).
- Organised several national level schools on perturbative Quantum Chromodynamics and High Energy Physics meetings, workshops such as RECAPP Workshops at the Harish Chandra Research Institute, Allahabad, Member of the organising committee of Department of Atomic Energy (DAE) meeting.

  Chaired a conference session at Loops and Legs in Quantum Field Theory, 20-25 April 2008, Sondershausen, Germany
- Chaired a conference session in Nu Horizons '08 , 13-15 February 2008, Harish-Chandra Research Institute, India
- Coordinator of working Group, Quantum Chromodynamics at WHEPP-VII, HRI, Allahabad, January 4-15, 2002.
- Coordinator of working Group, Quantum Chromodynamics at WHEPP-IX, IOP, Bhubaneswar, January 3-14, 2006.
- Organised and given series of lectures in "School on QCD at LHC" , Harish-Chandra Research Institute, November 25 - 30, 2007.
- Organised a international meeting on "Getting Ready for Physics at the LHC" , Harish-Chandra Research Institute, Februray 16 - 20, 2009.
- Coordinator of working Group, "Physics at LHC", WORKSHOP ON HIGH ENERGY PHYSICS PHENOMENOLOGY (WHEPP XI) , Physical Research Laboratory, Ahmedabad, 2 - 12th January 2010
- Coordinator of working Group, "Perturbative QCD at the LHC", WORKSHOP ON HIGH ENERGY PHYSICS PHENOMENOLOGY (WHEPP XII), 02 - 15 January, 2012, Mahabaleswar.
- Convener of "RADCOR 2011", 10th International Symposium on Radiative Corrections (Applications of Quantum Field Theory to Phenomenology) 26-30 September 2011 Radisson Resort Temple Bay, Mamallapuram, India
- Chaired a session in RADCOR 2013, 22-27 September 2013, Lumley Castle Hotel, Durham, England

Visiting Positions :

- Visiting Scientist at DESY-Zeuthen, Germany,and Lorentz Institute, The Netherlands from 01-06-2000 to 31-07-2000
- Visiting Scientist at Lorentz Institute, The Netherlands from 01-06-2002 to 30-06-2002
- Visiting Scientist at CERN, Geneva, Switzerland from 01-07-2002 to 31-07-2002
- Visiting Scientist at ICTP, Trieste, Italy from 01-08-2002 to 31-08-2002
- Visiting Scientist at DESY-Zeuthen, Germany, from 01-09-2002 to 30-11-2002
- Visiting Scientist at DESY-Zeuthen, Germany, from 01-05-2004 to 31-07-2004
- Visiting Scientist at CERN, Geneva, Switzerland from 01-08-2004 to 30-10-2004
- FOM Associate Fellow at Lorentz Institute, The Netherlands from 01-06-2006 to 30-08-2006
- Visiting Scientist at Laboratoire de Physique Theorique et Hautes Energies, Univ. Paris,France from 26-07-2006 to 28-07-2006
- JSPS Visiting Scientist at KEK, Japan from 01-11-2006 to 30-12-2006
- FOM Associate Fellow at Lorentz Institute, The Netherlands from 01-05-2007 30-07-2007
- Visiting Scientists Centre de Physique Theorique, Ecole Polytechnique,Paris, France from 16-07-2007 to 20-07-2007
- Visiting Scientist at DESY-Zeuthen, Germany, from 20-04-2008 to 27-06-2008
- Visiting Scientists Centre de Physique Theorique, Ecole Polytechnique,Paris, France from 28-06-2008 to 19-07-2008
- Visiting Scientists LAPTH, Annecy, France from 01-11-2009 to 30-11-2009
- Visiting Scientist at CERN, Geneva, Switzerland from 01-12-2009 to 13-12-2009
- Visiting Scientist at CERN, Geneva, Switzerland from 02-4-2012 to 15-4-2012
- Visiting Scientist at CERN, Geneva, Switzerland from 12-6-2013 to 28-6-2013
- Visiting Scientist at CERN, Geneva, Switzerland from 3-5-2014 to 24-5-2014
- Visiting Scientist at CERN, Geneva, Switzerland from 20-6-2015 to 14-7-2015
- Visiting Scientist at CERN, Geneva, Switzerland from 01-5-2016 to 31-5-2016
- Visiting Scientist (on Sabbatical) at Physics Department, University of Zurich, Switzerland from 01-4-2017 to 30-6-2017
- Visiting Scientist (on Sabbatical) at Physics Department, University of Mainz, Germany from 01-10-2017 to 30-12-2017

- Short term visitor at Karlshrue Institute Technology, Karlshrue, Germany
- Short term visitor at UC Louvain Center for Cosmology, Particle Physics and Phenomenology, Louvain, Belgium
- Short term visitor at University of Tuebingen, Tuebingen, Germany
- Short term visitor at Laboratoire d'Annecy-le-Vieux de Physique Théorique, LAPTH, Annecy, France.
- Short term visitor at Mainz Insitute of Theoretical Physcis, MITP, University of Mainz, Germany
- Short term visitor at the Physics Department,University of Milan, Italy

Fellowships and Awards:

- JSPS Visiting Scientist at KEK, Japan from 01-11-2006 to 30-12-2006
- FOM Associate Fellow at Lorentz Institute, The Netherlands from 01-06-2006 to 30-08-2006
- FOM Associate Fellow at Lorentz Institute, The Netherlands from 01-05-2007 30-07-2007
- Visiting Professor, Pauli Center Theoretical Studies, ETH, Zurich, Switzerland from 1.04.2017 to 30.06.2017.
- Visiting Professor, Mainz Institute of Theoretical Physics, Mainz, Germany, from 1.10.2017 to 25.12 2017.
- Elected as Fellow of Indian Academy of Science (IAS) in 2012.
- Elected as Fellow of Indian National Science Academy (INSA) in 2019.

Teaching:

- Ph.D Curriculum at Harish-Chandra Research Institute:

  Teaching every year advanced level courses to our Ph.D students who undertake the pre-doctorate program at Harish-Chandra Research Insitute.
- Guest Faculty at the SERC School on High Energy Physics, Harish-Chandra Research Institute, Allahabad January 2001.
- Delivered 9 lectures on Perturbative QCD at the XXII SERC Main School in High Energy Physics, University of Hyderabad, Hyderabad 18 - 27 Jan. 2007.
- Delivered 5 lectures in "School on QCD at LHC" , Harish-Chandra Research Institute, November 25 - 30, 2007.
- Delivered 2 lectures in "Advanced School on Radiative Corrections at the LHC", at Saha Institute of Nuclear Physics April 4-11, 2011.
- Delivered 2 lectures CTEQ-Fermilab School on QCD and Electroweak Phenomenology at Pontificia Universidad Católica del Perú, Lima, Peru, 30 July - 9 August 2012.
- Ph.D Curriculum at Institute of Mathematical Sciences:

  Teaching advanced level courses to Ph.D students who undertake the pre-doctorate program at Insitute of Mathematical Sciences.

Refereeing Duties (Ph.D Thesis):

- Academic co-ordinator for "Regional Centre for Accelerator-based Particle Physics (RECAPP), Harish-Chandra Research Institute, Allahabad, India.
- **Ph.D. Thesis** examiner for Mr. Subhadip Mitra ,the Department of Physics, Indian Insitute of Technology, Kanpur, India.
- **Ph.D. Thesis** examiner for Ms. Pratishruti Saha, University of Delhi, India.
- **Ph.D. Thesis** examiner for Mr. Sangem Rajesh, Indian Institute of Science, Bangalore, India **Ph.d Thesis** examiner for Mr Tanmay Maji, Indian Institute of Technology, Kanpur, India
- **Ph.D. Thesis** examiner for Mr. Dagaonkar Sumeet Kartik Kumar, Indian Institute of Technology, Kanpur, India
- Guiding post graduate students who visit our institute during their summer vacation.

Refereeing Duties (Scientific works for Journals):

- Physical Review Letters
- Physical Review D
- Physics Letters B
- International Journal of Modern Physics A
- Pramana - Journal of Physics
- Indian Journal of Physics

Internationl Collaborations

- Principle Investigator of **Indo-Italian** project 2017-2019
- Principle Investigator of **Indo-Belgium** project 2018-2020
- Member of **Indo-French** project till 2019

Computer skills:

- Experience with numerical programming using Fortran (including parallel computations), symbolic programming using Mathematica, Maple, FORM and advanced physics tools such as CalcHEP, Qgraf, Madgraph, aMC@NLO, FIRE, LiteRed, REDUZE.
- Developed several symbolic packages using FORM to perform next to next to leading order (NNLO) perturbative QCD corrections to various observables at the collider experiments.
- Developed a numerical code based on two cut off phase space slicing method to compute the NLO QCD corrections to important observables in the Standard Model as well as in the beyond SM.
- Codes are developed in a such away that new models and processes can be incorporated easily.
- Most of these numerical codes are parallelised and can run on clusters/supercomputers.
- Developed codes to perform 2,3 and 4 point amplitudes upto two loop level in QCD for zero and single mass scale problems.

Organisational work:

- Coordinator for the QCD Working Group, Workshop on High Energy Physics Phenomenology (WHEPP-VII), Harish-Chandra Research Institute, Allahabad, 4 - 15 Jan 2002.
- Coordinator for the QCD working Group" at IX Workshop on High Energy Physics Phenomenology, Institute of Physics, Bhubaneswar, 3-14 January 2006.

  The main focus of these working groups was on issues in the computation of perturbative QCD to various high energy processes. Many important higher order QCD corrections were initiated during these workshops and these efforts have started to show results with important contributions from India in this field.
- Member of the National Organising Committee of BSMLHC 2009, organised at Indian Association for the Cultivation of Science, Kolkata, January 15-17, 2009.
- Member of the National Organising Committee of the Workshop on High Energy Physics Phenomenology, Physical Research Laboratory, Ahmedabad, January 2010.
- Coordinator of the working group in Workshop on High Energy Physics Phenomenology, Tata Institute of Fundamental Research, January 2012.

Guiding experience:

Apart from teaching Ph.D students, I have been actively involved in guiding students for their Ph.D. These students have worked on areas such as perturbative Quantum Chromodynamics (pQCD), higher order QCD radiative corrections, precision physics, Higgs physics, large extra dimension models and effective field theory approach to study beyond the Standard Model physics. The works delivered from us play an important role in physics studies at the Large Hadron Collider at CERN, Geneva. Some of the pQCD results from our group belong to the catagory of most precise predictions in the context of Higgs rapidity distribution, Drell-Yan production from pQCD and Jet functions in Soft Collinear Effective theory and they are widely used by the experimental high energy physics community.

- Ph.D. Students (completed):
  - Anurag Tripathi, completed in 2009
  - Manoj Mandal, completed in 2015
  - Maguni Mahakhud , completed in 2015
  - Taushif Ahmed , completed in 2016
  - Narayan Rana , completed in 2016
  - Prasanna Kumar Dhani, completed in 2017
  - Pulak Banerjee, completed in 2017
  - Amlan Chakraborty, completed in 2020
  - Pooja Mukherjee, completed in 2021
  - A.H. Ajjath, completed in 2021
  - Aparna Sankar, completed in 2022
  - Surabi Tiwari, completed in 2022

  Current Ph.D. Students:
  - Vaibav Pathak
  - Sourav Goyal

  Co-guide to Ph.D. Students:
  - Neelima Agarwal, completed in 2011.
  - Arpan Kundu,
  - Lalit Saini completed in 2023.
  - Toshali Mitra completing in 2023.
- Post Doctoral Fellow:
  - Dr K. Hasagawa
  - Dr M.C. Kumar
  - Dr Goutam Das
- Ph.D students collaborated

– Dr Swapan Kumar Majhi
– Dr Ambresh Shivaji
– Dr Javier Mazzitelli
– Dr Satyajit Seth
– Ms Arunima Bhattacharya

Administrative Duties:

I have served as Chairman and Member of most of the Academic and Adminstrative committees of Harish Chandra Research Institute and the Institute of Mathematical Sciences. The committees that I served and their roles are given below:

- Foriegn travel committee: The commitee's job is to go over the application from the faculty and students/PDFs who plan to go aborad for meetings/conferences/visits/schools etc for short and long terms and recommand for the travel, conference fee, living expenses subject to the entitlement.
- Guest house and canteen commitee: The committee will regularly meet and discuss the running of the guest house, improving the facilities on regular basis and infrastructure related matters and providing accomdation for the visitors and conference participants.
- Students hostel and canteen committe: The committee will regularly meet and discuss matters related to students, improving the quality of the their stay and food.
- Faculty housing committee: The committee takes care of the housing allottement, improving the quality of the accommodation. It has been actively involved in getting bigger campus for the IMSc staff including those from administraton as the present one can accommodate only junior faculties.
- Medical Committee: The commitee overseas policies related to medical rules of the instiutes and suggest modifications that will help the members of the institute. At HRI, during my stay as convenior of the commitee, I was actively involved in bringing CHSS rules in place since 2012.
- Computer Commitee: The committee role is to provide necessary computer facilities and related infrastructure at the institute. It requires upto date knowledge on the developments in the computer front and their requirements of the scientific and administrative staff and of the students and PDFs. Involved in getting suitable staff for running the computer center and the cluster facility.
- Library commitee: The committee takes stock of requirement of the scientific staff and PhD students and postdocs. I was involved in computerising the entire library and also restructuring the facilities so that the librarty is efficiently used. I was involved in introducing RFD coding of all the books and also access card facilities for the users.
- Science outreach Commitee: The committee is involved in organising scientific outreach activies everyyear at the insitute. We involve students and PDFs to run a day long program where students from neighbouring schools are invited to participate. There will be lectures from our scientific staff and demonstration of experiments by our students and PDFs during the event.
- PDF selection Commitee: The committee regularly meets and goes over the recommendations of the faculty to select suitable PDFs for the institute. In addition, the committee assess the achievements of the PDFs and decide on their extensions. It also advices the groups to monitor the PDFs.

Significant Contributions:

- The Higgs boson, the corner stone of the Standard Model, was discovered at the Large Hadron Collider (LHC) in 2013. My works on predicting its cross section very precisely within the perturbative Quantum Chromodynamics (QCD) have played the most important role in the discovery. Using the state-of-the-art quantum field theoretic techniques, I had shown that QCD effects not only increase the cross section by a factor of two but also reduce the theoretical uncetainties significantly. This paper belongs to "renowned paper" on hepspires with about 856 citates and in addition it is cited by all the publications from LHC, CERN on the Higgs boson discovery and the subsequent studies.

- I have developed an elegant framework that can provide predictions for the inclusive and semi-inclusive observables for Higgs boson as well as Drell-Yan productions at three loop level in QCD in the threshold limit. These belong to the most precise results available till today in the collider physics studies, appeared as "two papers in Physical Review Letters".

- I have studied two and three loop QCD corrections to several local operators that contribute to Higgs boson and Drell-Yan productions. Studing them in SU(N) gauge theory, we have solved a long standing problem of understanding single pole structure of the gauge theory amplitudes and demonstrated the structure of infrared sigle pole is related to collinear and soft anomalous dimension in a peculiar way.

- I have developed a most general formalism that resumms threshold logarithms for the rapidity distributions of Higgs boson and Drell-Yan pairs produced at the LHC. This is the most accurate resummation formalism for the rapidity distribution. This approach has been applied to rapidity distribution of Higgs boson production and the Drell-Yan production at next-to-next-to leading logarithmic accuracy.

- I have set up an effective field theory approach to study the Higgs couplings to the particles of the Standard Model in a model independent way. I have considered all the relevant higher dimensional operators that can capture these effects. This goes by the name "Characterisation of Higgs boson" and it is widely used by the CMS/ATLAS collaborations at the LHC for constraining the Higgs couplings.

- I have set up a formalism to make precise predictions from QCD for the inclusive cross sections for Drell-Yan, production of pair of vector bosons in models with large extra-dimensions. We have developed the methodology to include two loop QCD contributions to partonic channels that contribute to these observables. Since our results are the most precise ones, they are used by the experimentalists to constrain the model parameters measured at the LHC.

- Perturbative methods developed in QCD to study the physics at the hadron colliders can be used to study $\mathcal{N} = 4$ supersymmetric theories as they share many universal structures. I have investigated certain BPS operators and a Konishi operator to understand the principle of maximum transcendentality. We have also determined anomalous dimension of the twist two operators that share many properties with those of QCD.

Impact of the works on HEP Experiments:

- The study on the properties of the Higgs boson has been going on at the LHC. My works on the next to leading order (NLO) predictions for the differential distributions and the next to next to leading order (NNLO) predictions for the total cross section for the Higgs production have been used by both Tevatron and LHC experimental groups for their analysis. In addition, our results on resummed rapidity distribution of Higgs bosons give the most precise predictions from the theory.
- In hadron colliders the leptonic and photonic final states provide very useful informations on new physics searches. The bounds on the model parameters can be obtained from the experimental data in these channels provided precise predictions are available from the theory. Any such analysis K-factor that parameterizes the potential higher order QCD effects which are often large at present collider energies. Our predictions for K-factors are being used by both CDF at the Tevatron and CMS at the LHC to set search limits on the parameters in extra dimension models such as ADD and RS.

Highlights of my Recent Works:

My current research focuses mainly on perturbative aspects of Quantum Chromodynamics (QCD) and its application to high energy scattering processes. This involves deeper understanding of perturbative structure of multi-loop and multi-leg QCD amplitudes which constitute the higher order QCD radiative corrections to various observables at hadronic colliders such as Tevatron at Fermi lab and Large Hadron Collider (LHC) at CERN.

- **Higgs production at NNLO and beyond:**

  I have been working on the impact of higher order QCD effects to various SM processes such as Drell-Yan and Higgs boson productions at hadron colliders. Our predictions for NLO QCD corrections to differential distributions $d^2\sigma/dp_T/dy$ and NNLO QCD corrections to total cross section for the Higgs production plays an importan role for various physics studies at Tevatron and LHC. We also found that the total cross section is dominated by the soft and virtual gluons. This is of interest for the resummation of large corrections which occur near the boundary of phase space. Such corrections have already been taken into account for these studies through various resummation methods. In order to reduce the renormalisation scale uncertainty at N^3LO level we have developed a novel technique using renormalisation group invariance to resum all the scale dependent to logarithms to all orders in the perturbation theory. This gives reliable predictions for the Higgs production at the LHC.

- **Higgs Characterisation:**

  With more data from the LHC, the effective field theory approach is one the powerful methods to study the characterisation of the Higgs boson discovered at the LHC. Given that there are large number of higher dimensional operators, a systematic approach in a automated framework is essential. Using MadGraph 5 and aMC@NLO, we have incorporated relevant higher dimensional opertors along with next to leading order QCD effects to study spin and parity properties of the Higgs boson.

- **Infra-red pole structure of QCD amplitudes:**

  Two loop computation on the quark and gluon form factors in $SU(N)$ gauge theory computed by us elucidates the origin of the second order infra-red single pole terms and they are found to be equal to the second order singular part of the anomalous dimension plus a universal function. Our observation on the single pole structure of the form factors completes the challenging problem of understanding the infra-red structure of such amplitudes. Based on this, it is now possible to understand the complete infra-red structure of multi-parton amplitudes in $SU(N)$ gauge theories and are extended to non-perturbative regions of conformally invariant theories using AdS/CFT correspondence.

- **Soft gluon resummation and N^3LO results:**

  The infra-red structure of QCD amplitudes supplemented with renormalisation group invariance provides useful guidance to compute the dominant QCD effects, namely soft gluon corrections to various observables. In this context, I have determined the soft distribution functions to N^3LO level for DIS, hadro-production in e^+e^- collisions, Drell-Yan and Higgs

production processes using mass factorisation theorem and the perturbative results that are known upto three loop level in QCD. I have also extended this approach to resum these effects for rapidity distributions of Higgs boson and pair of leptons. Using these distributions I have obtained threshold enhanced QCD corrections as well as the exponents of resumed cross sections beyond two loop level for various inclusive processes. The results are found to reduce various scale uncertainties making the predictions stable.

- **NLO QCD corrections for BSM physics:**

  Models of extra dimensions have dominated the theoretical literature on physics beyond the standard model. It is important to incorporate NLO QCD corrections to these processes in order to quantify the size of the effects and to see how robust the leading order estimate of the cross-section is with respect to these corrections. Our predictions are now used to study these models at Tevatron and at the LHC. They include processes such as Drell-Yan, Di-photon, WW and ZZ productions where the gravitons appear at propagator level and also processes where real gravitons are emitted along with photon/W/Z. We found that at the LHC ($\sqrt{S} = 14TeV$) the K-factors for all these processes are rather large ($K = 1.6$), indicating the importance of accounting for these QCD corrections in the experimental search for TeV-scale gravity. Our approach has been extended to other BSM searches such as R-parity violation SUSY, unparticles etc at colliders. We have also successfully completed a first NNLO QCD computation for the resonant production cross section of neutral/charged slepton at the hadron colliders. We have also obtained two loop QCD radiative corrections to graviton mediated processes in both ADD and RS models. This is the first result of this kind in the BSM models and it shows significant reduction in theoretical uncertainties and improves the theoretical predictions significantly.

- **Higher orders with Parton Shower:**

  Combining fixed order perturbative results and the parton shower Monte Carlo (PS) can cover most of the kinematical regions in order to consistently include resummation in the collinear limit and also allow us to study more exclusive final states and provide predictions as realistic as possible to the experimental situations. One can also include various hadronisation models to simulate final state configurations. Recently, using aMC@NLO which uses MC@NLO formalism and FKS subtraction methods in the MadGraph framework, we have studied di-lepton, di-vector boson signals at the LHC in both ADD and RS models upto NLO in QCD with parton showering to obtain various kinematic distributions.

Highlights of my Earlier Works:

Unravelling the structure of hadrons in terms of its constituents has always been a challenging problem both experimentally as well as theoretically due to non-perturbative nature of strong interaction dynamics. There have been dedicated experiments both in USA and Europe for this purpose. Models based on the low energy behaviour of the hadrons and the Yang-Mills theory on strong interaction dynamics, namely Quantum Chromodynamics paved way to understand the data from these experiments. Thanks to very precise computations using perturbative QCD, we now know have a complete quantitative picture of hadrons in terms of its perturbative constituents namely quarks and gluons, often called partons. The partonic contributions to momentum and spin of the hadrons can be precisely determined as function of the energy at which they are probed through spin independent and spin dependent parton distribution functions (PDFs). The PDFs are non-perturbative in nature and are often extracted from the experiments using results of various observables computed in perturbative QCD beyond leading order in perturbative expansion. These PDFs not only carry information on how various partons contribute to the structure of the hadron, they, being process independent quantities, can also help in quantitative predictions for other observables involving same hadrons in the initial states. For example, PDFs of proton extracted from deep inelastic experiments can be used to predict observables in proton proton colliders.

- My earlier works were mostly on the study of various spin dependent and spin independent observables using perturbative QCD in order to disentangle various partonic contributions to the structure of the proton. I have studied them in the context of deep inelastic scattering experiments with polarised proton through charged and neutral current reactions, Drell-Yan process and jet productions in polarised hadron-hadron collisions. I have also studied systematically the effects of virtual mass and QCD corrections to photon structure functions which can be measured in double tag $e^+e^- \to e^+e^-X$ experiment. I have given the physical interpretation of these new structure functions and emphasized the importance of them in double tag experiments.

- The measurement of polarised fragmentation functions of quarks and gluons into polarised Λ will be useful to test various existing models to explain Λ production. I have studied the Q^2 evolution of the polarised fragmentation functions of quarks and gluons in perturbative QCD using the Altarelli-Parisi evolution equations governing them. In addition, I have computed the important next leading order corrections to production cross sections taking into account all the partonic subprocess which reduce the theory uncertainty resulting from factorisation scale.

- Small x behaviour of PDFs are peculiar due to failure of standard resummation methods. To solve this one has to resort to a resummation of large logs that result in the small x regions. I have studied the quantitative consequences of the resummation of the small-x contributions to the anomalous dimensions beyond next-to-leading order in α_s and up to next order in $\ln(1/x)$ (NLx) in a framework based on the renormalization group equations. I found large and negative effects leading to negative values for the total splitting function $P_{gg}(x, \alpha_s)$ already for $x \leq 0.01$ at $Q^2 \leq 20GeV^2$. I found that the terms less singular than those under consideration turn out to be quantitatively important and need to be included.

- The study of e^+e^- collisions is very important to extract standard model parameters such as $\sin^2\theta_W$ and electro-weak couplings v_q, a_q very precisely.I have made an analytical calculation

of the second order contribution to the forward-backward asymmetry A_{FB}^H and the shape constant a^H for heavy flavour production in e^+e^- collisions.

- The other standard model parameter which is of current interest both experimentally and theoretically is strong coupling constant α_s. The coupling α_s can be extracted very precisely in heavy flavour production of e^+e^- collisions. I have performed the heavy flavour mass corrections to the order α_s corrected longitudinal (σ_L) and transverse (σ_T) cross sections in e^+e^- collisions. Its effect on the value of the running coupling constant extracted from the longitudinal cross section is investigated.

Significant Contributions:

- The Higgs boson, the corner stone of the Standard Model, was discovered at the Large Hadron Collider (LHC) in 2013. My works on predicting its cross section very precisely within the perturbative Quantum Chromodynamics (QCD) have played the most important role in the discovery. Using the state-of-the-art quantum field theoretic techniques, I had shown that QCD effects not only increase the cross section by a factor of two but also reduce the theoretical uncetainties significantly. This paper belongs to "renowned paper" on hepspires with about 856 citates and in addition it is cited by all the publications from LHC, CERN on the Higgs boson discovery and the subsequent studies.

- I have developed an elegant framework that can provide predictions for the inclusive and semi-inclusive observables for Higgs boson as well as Drell-Yan productions at three loop level in QCD in the threshold limit. These belong to the most precise results available till today in the collider physics studies, appeared as "two papers in Physical Review Letters".

- I have studied two and three loop QCD corrections to several local operators that contribute to Higgs boson and Drell-Yan productions. Studing them in SU(N) gauge theory, we have solved a long standing problem of understanding single pole structure of the gauge theory amplitudes and demonstrated the structure of infrared sigle pole is related to collinear and soft anomalous dimension in a peculiar way.

- I have developed a most general formalism that resumms threshold logarithms for the rapidity distributions of Higgs boson and Drell-Yan pairs produced at the LHC. This is the most accurate resummation formalism for the rapidity distribution. This approach has been applied to rapidity distribution of Higgs boson production and the Drell-Yan production at next-to-next-to leading logarithmic accuracy.

- I have set up an effective field theory approach to study the Higgs couplings to the particles of the Standard Model in a model independent way. I have considered all the relevant higher dimensional operators that can capture these effects. This goes by the name "Characterisation of Higgs boson" and it is widely used by the CMS/ATLAS collaborations at the LHC for constraining the Higgs couplings.

- I have set up a formalism to make precise predictions from QCD for the inclusive cross sections for Drell-Yan, production of pair of vector bosons in models with large extra-dimensions. We have developed the methodology to include two loop QCD contributions to partonic channels that contribute to these observables. Since our results are the most precise ones, they are used by the experimentalists to constrain the model parameters measured at the LHC.

- Perturbative methods developed in QCD to study the physics at the hadron colliders can be used to study $\mathcal{N} = 4$ supersymmetric theories as they share many universal structures. I have investigated certain BPS operators and a Konishi operator to understand the principle of maximum transcendentality. We have also determined anomalous dimension of the twist two operators that share many properties with those of QCD.

Impact of the works on HEP Experiments:

- The study on the properties of the Higgs boson has been going on at the LHC. My works on the next to leading order (NLO) predictions for the differential distributions and the next to next to leading order (NNLO) predictions for the total cross section for the Higgs production have been used by both Tevatron and LHC experimental groups for their analysis. In addition, our results on resummed rapidity distribution of Higgs bosons give the most precise predictions from the theory.
- In hadron colliders the leptonic and photonic final states provide very useful informations on new physics searches. The bounds on the model parameters can be obtained from the experimental data in these channels provided precise predictions are available from the theory. Any such analysis K-factor that parameterizes the potential higher order QCD effects which are often large at present collider energies. Our predictions for K-factors are being used by both CDF at the Tevatron and CMS at the LHC to set search limits on the parameters in extra dimension models such as ADD and RS.

List of Ten Best Publications

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