

BASIC INFORMATION

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Areas of scientific interest

Experimental High-Energy physics; Beyond the Standard Model Physics including Neutrino and Dark Matter Physics; Nonstandard Interactions; Detector Development and Data Acquisition Systems.

ACADEMIC AND PROFESSIONAL DETAILS

2.1 Positions Held

- **Post-Doctoral, in the TEXONO Group**
Institute of Physics, Academia Sinica, Taipei, Taiwan. June, 2015 – November, 2019
- **Research Assistant, in the TEXONO Group**
Institute of Physics, Academia Sinica, Taipei, Taiwan. November, 2013 – May, 2015
- **Visiting Research Scholar, in the TEXONO Group**
Institute of Physics, Academia Sinica, Taipei, Taiwan. May, 2012 – October, 2013
- **Associated Member**
CERN July 01, 2010 – August 11, 2010
- **Visiting Research Student, in the TEXONO Group**
Institute of Physics, Academia Sinica, Taipei, Taiwan. November, 2008 – April, 2010
- **Guest Lecturer**
Government College, Dera Bassi, Chandigarh, Punjab, India. August, 2006 – March, 2008

2.2 Education

Ph.D. Physics

Banaras Hindu University, Varanasi, India 2010 – 2015
– Thesis: *Experimental Studies on Electromagnetic Properties of Neutrinos and Dark Matter Searches with sub-keV Germanium Detectors*
– Advisors: Prof. Venktesh Singh¹ and Prof. Henry Tsz-King Wong²
– ¹Department of Physics, Banaras Hindu University, Varanasi, India.
– ²Institute of Physics, Academia Sinica, Taipei, Taiwan.

Master of Science

Panjab University, Chandigarh, India 2002 – 2004
– PHYSICS
– Specialization: *Experimental Techniques in Nuclear Physics*

Bachelor of Science

Panjab University, Chandigarh, India 2000 – 2002
– Graduated with Physics, Mathematics and Chemistry

Intermediate

Punjab School Education Board, Punjab, India 1998 – 2000
– Graduated with Physics, Mathematics and Chemistry

High School

Punjab School Education Board, Punjab, India 1997 – 1998

2.3 Awards and Merits:

- **Academia Sinica Fellowships**
Institute of Physics 2019
- **JSPS HOPE Fellow**
Represent the Academia Sinica at 10th HOPE Meeting with Nobel Laureates 2018
- **Ministry of Science and Technology (Taiwan) Fellowships**
Institute of Physics 2017
- **Junior Research Fellowship awarded by University Grants Commission of INDIA**
Banaras Hindu University 2013
- **Junior Research Fellowship awarded by Department of Science & Technology, India**
Banaras Hindu University 2010
- **Qualified CSIR-JRF (Junior Research Fellow) fellowship in CSIR-UGC exam**
Conducted jointly by CSIR and UGC of INDIA 2007

2.4 Technical Skills:

- Hands on experience with various semiconductor, scintillator and gaseous detectors, related.
- Experience in handling sophisticated electronic instruments and modules.
- Hands on experience in analysis software such as ROOT.
- Programming FORTRAN, C, C++, Python, UNIX shell scripting and LabVIEW.
- Hands on experience on Geant4 simulation.
- Hands on experience in developing data acquisition software based on VME and LabVIEW-FPGA.
- Hands on experience in build the RAID system for large data storage.

RESEARCH EXPERIENCE

3.1 Area of research and scientific impact

The discovery of neutrino masses and mixing is the first direct evidence of physics beyond the standard model of particle physics. It has opened many questions about the neutrino's intrinsic properties such as (1) Are neutrinos their own anti-particles (Dirac or Majorana) ?

(2) What is the absolute neutrino mass scale ?

(3) What is the ordering of the three neutrino masses ?

(4) Do neutrinos and anti-neutrinos oscillate differently ? (Is δ_{CP} non-zero ?)

The existence of dark matter is another robust fact for new physics. It is now well established that about one-quarter of the energy density in the Universe is composed of cold dark matter. Its non-gravitational interactions with normal matter are still unknown.

My research focuses on the experimental exploration of the neutrino electromagnetic interactions, neutrino-nucleus coherent scattering and low-mass WIMP dark matter searches. Taiwan EXperiment On Neutrino (TEXONO) has been pursuing research program on low energy neutrino interactions at the Kuo-Sheng Neutrino Laboratory (KSNL) in Taiwan and light dark matter mass search at China Jinping Underground Laboratory (CJPL) in China with novel germanium-ionization detectors. TEXONO has achieved world-recognized with results on neutrino magnetic moment, neutrino millicharged, the measurements of the neutrino-electron cross-section and electroweak parameters, as well as dark matter searches with germanium detectors.

3.2 Research work carried out during Ph.D.

The theme of my Ph.D. project was to explore electromagnetic properties of neutrino and light dark matter using novel germanium detectors with sub-keV sensitivities. The potential scientific reach depends on the achievable detector threshold with ultra-low background. My Ph.D. research work also focused towards a common goal to achieve the sub-keV threshold and understand the sub-keV background.

In order to achieve 100 eV threshold with a large modular mass, TEXONO has started a dedicated program to study the point-contact germanium (PCGe) detectors. I led a dedicated program to study the point-contact germanium (PCGe) detectors. I characterized and optimized PCGe-detectors response in energy domains near electronic noise-edge, where the signal amplitude is comparable to the pedestal fluctuation. I addressed various experimental issues including signal reconstruction, calibration, signal triggering and selection as well as evaluation of their associated efficiencies. I have tested 20, 40 and 80 kg NaI(Tl) detectors in terms of applied high voltage to PMT, the possible energy dynamic range and their background suppression factors. The NaI(Tl) detectors were then commissioned at KSNL to obtain low and high energy NaI(Tl) spectrum. The PCGe-detector surrounded by well-shaped NaI(Tl) anti-Compton (AC) detector. 16 Plastic scintillator panels associated with 40 PMT's constituted cosmic ray [CR] veto system. I was responsible for optimizing CRV behavior at hardware and software level. Hardware level involves fixing of failure components (like cables, PMT and DAQ insertion slots).

With the advent of detectors with sub-keV sensitivities, atomic ionization has been identified as a promising avenue to probe possible neutrino electromagnetic properties. I started work with theory experts to explore the new interaction channel due to neutrino millicharge and evaluated the interaction cross section using Multi-Configuration Relativistic Random-Phase Approximation. It shows that there is a significant enhancement in cross-section at atomic binding energies compared to that when the electrons are taken as free particles, more importantly, the smoking-gun signatures from the spectral structures are also identified to irrefutably a positive result. After being appointed the data production coordinator, I processed the first analysis of the reactor-off data in sub-keV energy region and derived the constraint on milli-charged neutrino.

The anomalous surface events in p-type PCGe arise from a few millimeters thick transition layer with a weak electric field. The poor charge collection in this region reduces the ionization yield of the events and enhances the background at sub-keV energy region. It may limit the physics sensitivities, and can lead to false interpretation of the data. These anomalous surface events can be characterized by rise time and indeed it is possible to tag them event-by-event by software pulse shape techniques. The differentiation of anomalous surface events versus bulk events can be 100% for large signals. However, there are leakages between both samples both way in sub-keV energy region. I was fully involved in this intense program to devise methods and measure the efficiency factors. Indeed, It was demonstrated that inadequacies to attend these efficiency-corrections properly would contribute to faked positive signals

3.3 Research work during post-doctoral period

I have worked as a Post-Doctoral Research Associate at Institute of Physics, Academia Sinica in Taipei, Taiwan, from 2015 to 2019. During this period I have coordinated various affords of the collaboration to achieve the physics goal and also led a team of students and research assistants on the following tasks:

1. "Run Coordinator" organized the collaboration efforts in KSNL for physics data taking and analysis;
2. Coordinated the computing resource (RAID System) for offline data analysis which provides the most efficient computing environment;
3. Developed the advanced analysis tools to reduce threshold and background in sub-keV germanium detectors, and in particular, data analysis with the complex neural network (AI) algorithms;

4. Worked on novel physics channels for neutrino and dark matter interactions with theory collaborators in Taiwan;
5. I was the responsible person for the simulation packages of Geant software in TEXONO Collaboration and prepared the simulation package in order to study the background index for future multi-purpose ton-scale germanium experiment;
6. I have also coordinated the upgrade commissioning of detectors and experimental hardware at the KS Reactor Laboratory.
7. preparation of scientific publications.

Core Member on searches of the Cold Dark Matter: In addition to the standard WIMP-nucleon spin-independent and spin-dependent channels, I have also explored other exotic dark matter scenarios via atomic ionizations such as WIMP-electron scattering, dark photons, axion-like-particle and heavy sterile neutrinos.

DAQ FPGA Project - To upgrade our data acquisition(DAQ) for saving dead time and lowering the trigger level, I was involved in the project on real-time FPGA DAQ system. I have also developed software tools to gauge experiment's performance and trained new members on the tools. The tools provided following information:

- DAQ Parameters like rate, dead time and file size were monitored.
- CRV behavior: The logical operation output rate for the 16 panels were monitored. In case of any discrepancies troubleshooting at the level of software were performed. If problem persisted it was rectified at the level of hardware.
- ACV behavior: The rate of low and high energy events were monitored.

ADDITIONAL RESEARCH ACTIVITIES

- **Editorial member of TEXONO Collaboration**
- **Editorial member of CDEX Collaboration**
- **CERN Summer Student School 2010**

My research activities during internship can be categorized as following:

- Attend a series of lectures on accelerator physics, particle physics, astro-particle physics, neutrino physics, detector physics, data acquisition systems and electronics.
- Participated in assembly and testing of Resistive Plate Chambers.
- Characterizes the triple-GEM detector which was the key detector for CMS upgrade.

PUBLICATIONS IN REFERRED JOURNALS PUBLICATIONS

33. *Search for Light Weakly-Interacting-Massive-Particle Dark Matter by Annual Modulation Analysis with a Point-Contact Germanium Detector at the China Jinping Underground Laboratory*,
L. T. Yang *et al.* (CDEX Collaboration)
[Phys. Rev. Lett. 123, 221301 \(2019\)](#)
32. *Constraints on Spin-Independent Nucleus Scattering with sub-GeV Weakly Interacting Massive Particle Dark Matter from the CDEX-1B Experiment at the China Jinping Underground Laboratory*,
Z. Z. Liu *et al.* (CDEX Collaboration)
[Phys. Rev. Lett. 123, 161301 \(2019\)](#)
31. *Discovery potential of multiton xenon detectors in neutrino electromagnetic properties*,
Chung-Chun Hsieh *et al.*
[Phys. Rev. D 100, 073001 \(2019\)](#)
30. *Constraints on millicharged particles with low-threshold germanium detectors at Kuo-Sheng Reactor Neutrino Laboratory*,
L. Singh* *et al.* (TEXONO Collaboration)
[Phys. Rev. D 99, 032009 \(2019\)](#)
29. *Constraints on bosonic dark matter with low threshold germanium detector at Kuo-Sheng reactor neutrino laboratory*,
M. K. Singh (L. Singh*) *et al.* (TEXONO Collaboration)
[Chinese Journal of Physics 58, pp 63-73 \(2019\)](#)
28. *Performances of a prototype point-contact germanium detector immersed in liquid nitrogen for light dark matter search*,
Hao Jiang *et al.* (CDEX Collaboration)
[Sci. China-Phys. Mech. Astron. 62 \(3\), 031012 \(2019\)](#).
27. *Neutron background measurements with a hybrid neutron detector at the Kuo-Sheng Reactor Neutrino Laboratory*,
A. Sonay *et al.* (TEXONO Collaboration)
[Phys. Rev. C 98, 024602 \(2018\)](#).
26. *Characterization of the sub-keV Germanium detector*,
M. K. Singh *et al.* (TEXONO Collaboration)
[Indian J Phys 92\(3\):401408 \(2018\)](#)
25. *Limits on Light Weakly Interacting Massive Particles from the First 102.8 kg × day Data of the CDEX-10 Experiment*,
H. Jiang *et al.* (CDEX Collaboration)
[Phys. Rev. Lett. 120, 241301 \(2018\)](#).
24. *Limits on light WIMPs with a 1 kg-scale germanium detector at 160 eVee physics threshold at the China Jinping Underground Laboratory*,
L. T. Yang *et al.* (CDEX Collaboration)
[Chinese Physics C 42, 023002 \(2018\)](#)
23. *Bulk and surface event identification in p-type germanium detectors*,
L. T. Yang *et al.* (CDEX Collaboration)
[Nucl. Instrum. Methods Phys. Res., A 886 13-23 \(2018\)](#)

22. *Constraints on nonstandard intermediate boson exchange models from neutrino-electron scattering*,
B. Sevda *et al.* (TEXONO Collaboration)
[Phys. Rev. D **96**, 035017 \(2017\)](#)
21. *Constraints on axion couplings from the CDEX-1 experiment at the China Jinping Underground Laboratory*,
S. K. Liu *et al.* (CDEX Collaboration)
[Phys. Rev. D **95**, 052006 \(2017\)](#)
20. *Constraints on scalar-pseudoscalar and tensorial nonstandard interactions and tensorial unparticle couplings from neutrino-electron scattering*,
M. Deniz *et al.* (TEXONO Collaboration)
[Phys. Rev. D **95**, 033008 \(2017\)](#).
19. *First results on ^{76}Ge neutrinoless double beta decay from CDEX-1 experiment*,
Li Wang *et al.* (CDEX Collaboration)
[Sci. China Phys. Mech. Astron. **60**, 071011 \(2017\)](#)
18. *Background rejection of TEXONO experiment to explore the sub-keV energy region with HPGe detector*
M.K. Singh *et al.* (TEXONO Collaboration)
[Indian J Phys **91**, 1277-1291 \(2017\)](#)
17. *Design and performance of a hybrid fast and thermal neutron detector*
M.K. Singh *et al.* (TEXONO Collaboration)
[Nucl. Instrum. Methods Phys. Res., A **868** 109-118 \(2017\)](#).
16. *Characterization and performance of germanium detectors with sub- keV sensitivities for neutrino and dark matter experiments*,
A.K. Soma (**L. Singh***) *et al.* (TEXONO Collaboration)
[Nucl. Instrum. Methods Phys. Res., A **836** 67-82 \(2016\)](#).
15. *Atomic ionization by sterile-to-active neutrino conversion and constraints on dark matter sterile neutrinos with germanium detectors*,
Jiunn-Wei Chen *et al.*
[Phys. Rev. D **93**, 093012 \(2016\)](#).
14. *Search of low-mass WIMPs with a p-type point contact germanium detector in the CDEX-1 experiment*,
Zhao. W *et al.* (CDEX Collaboration)
[Phys. Rev. D **93**, 092003 \(2016\)](#).
13. *Constraints on dark photon from neutrino-electron scattering experiments*,
Ş. Bilmis *et al.* (TEXONO Collaboration)
[Phys. Rev. D **92**, 033009 \(2015\)](#).
12. *Constraining neutrino electromagnetic properties by germanium detectors*,
Jiunn-Wei Chen *et al.*
[Phys. Rev. D **91**, 013005 \(2015\)](#).
11. *Study of the material photon and electron background and the liquid argon detector veto efficiency of the CDEX-10 experiment*
SU Jian *et al.* (CDEX Collaboration)
[Chinese Physics C Vol. **39**, 036001, \(2015\)](#).

10. *Constraints on millicharged neutrinos via analysis of data from atomic ionizations with germanium detectors at sub-keV sensitivities*,
Jiunn-Wei Chen (**L. Singh***) *et al.*,
[Phys. Rev. D **90**, 011301\(R\) \(2014\)](#).
9. *Differentiation of bulk and surface events in p-type point-contact germanium detectors for light WIMP searches*,
H.B. Li *et al.* (TEXONO Collaboration)
[Astroparticle Physics **56**, 1 \(2014\)](#).
8. *Atomic ionization of germanium due to neutrino magnetic moments*,
Jiunn-Wei Chen *et al.*
[Physics Letters B **731**, 159 \(2014\)](#).
7. *Limits on light weakly interacting massive particles from the CDEX-1 experiment with a p-type point-contact germanium detector at the China Jinping Underground Laboratory*,
Q. Yue *et al.* (CDEX Collaboration)
[Phys. Rev. D **90**, 091701\(R\) \(2014\)](#)
6. *Limits on light WIMPs with a germanium detector at 177 eVee threshold at the China Jinping Underground Laboratory*,
S. K. Liu *et al.* (CDEX Collaboration)
[Phys. Rev. D **90**, 032003 \(2014\)](#)
5. *Limits on Spin-Independent Couplings of WIMP Dark Matter with a p-type Point-Contact Germanium Detector*,
H.B. Li *et al.* (TEXONO Collaboration)
[Phys. Rev. Lett. **110**, 261301 \(2013\)](#).
4. *First results on low-mass WIMPs from the CDEX-1 experiment at the China Jinping underground laboratory*,
W. Zhao *et al.* (CDEX Collaboration)
[Phys. Rev. D **88**, 052004 \(2013\)](#).
3. *CDEX-1 1 kg point-contact germanium detector for low mass dark matter searches*,
KANG Ke-Jun *et al.* (CDEX Collaboration)
[Chinese Physics C **37**, 126002 \(2013\)](#)
2. *Introduction to the CDEX experiment*,
Ke-Jun Kang *et al.* (CDEX Collaboration)
[Front. Phys. **8**\(4\), 412-437 \(2013\)](#)
1. *Measurement of $\bar{\nu}_e$ -electron scattering cross section with a CsI(Tl) scintillating crystal array at the Kuo-Sheng nuclear power reactor*
M. Deniz *et al.* (TEXONO Collaboration)
[Phys. Rev. D **81**, 072001 \(2010\)](#).

SELECTED LIST OF CONFERENCE PROCEEDINGS

12. Test of Beyond-Standard-Model Scenarios with Low Threshold Germanium Detectors
L. Singh
Proceedings of Science (ICHEP 2018) 114
11. Constraints on Electromagnetic Properties of Neutrinos with Sub-keV Germanium Detectors
L. Singh and H.T. Wong
Springer Proc.Phys. 203, 917-918 (2018)
10. Low Energy Neutrino Physics with sub-keV Ge-Detectors at Kuo-Sheng Neutrino Laboratory
L. Singh and H.T. Wong
Journal of Physics: Conf. Series 888, 012124 (2017).
9. R&D on Sub-keV Ge-Detectors for Studies on Electromagnetic Properties of Neutrino
L. Singh, G. Kiran Kumar and H.T. Wong
Springer Proc.Phys. 174, 305-310 (2016)
8. Neutrino and dark matter physics with sub-keV germanium detectors
A. K. Soma, **L. Singh**, M. K. Singh, V. Singh, H. T. Wong
Pramana - J. phys., Vol. 83, No.5, page-829-838 (2014)
7. Prospects of dark matter direct search under deep sea water in India
V. Singh, V.V.S., **L. Singh** et. al
AIP Conf. Proc. 1524, pp 216-219 (2012).
6. Low Energy Neutrino and Dark Matter Physics with sub-keV Germanium Detectors
A. K. Soma, **L. Singh**, M. K. Singh, V. Singh, H. T. Wong
Pramana - J. phys., Vol. 79, No.5, page-1331-1335 (2012)
5. Measurement of anti-neutrino-electron electron scattering cross section with CsI(Tl) detector array and the Beyond Standard Model constraints
V. Singh, **L. Singh**, A. K. Soma, M. K. Singh, H. T. Wong
AIP Conf. Proc. 1405, 331 (2011).
4. Low Energy Neutrino and Dark Matter Physics with sub-keV Germanium Detectors
L. Singh, A. K. Soma, M. K. Singh, V. Singh, H. T. Wong
AIP Conf. Proc. 1382 , 259 (2011).
3. Study of cosmic ray muons tracks recorded by prototype ICAL (Kolkata): Zenith angle distribution
L. Singh, A. P. Yadav, V. S. Subrahmaniyam, and V. Singh
Proceedings of the DAE Symp. on Nucl. Phys. 56 P. 1098-1099 (2011)
2. Low Energy Neutrino and Astroparticle Physics with sub-KeV Germanium Detector
L. Singh, A. K. Soma, M. K. Singh, V. Singh, H. T. Wong
Proceedings of the DAE Symposium on Nuclear Physics Volume 55 P. 448-449 (2010)
1. Study on anti-neutrino and electron scattering toward constraints on non standard neutrino interaction and unparticle physics
A. K. Soma, **L. Singh**, M. K. Singh, V. Singh, H. T. Wong
Proceedings of the DAE Symposium on Nuclear Physics Volume 55 P. 450-451, (2010)

TALKS AND POSTER PRESENTATIONS IN WORKSHOPS AND CONFERENCES

13. **Talk**
“Probing New Physics with Low Threshold Germanium Detector”
5th International Workshop on Dark Matter, Dark Energy and Matter-Antimatter Asymmetry
National Center for Theoretical Sciences (NCTS) in Hsinchu, December 28-31, 2018.
12. **Talk**
“Constraints on Millicharged Particles with sub-keV Germanium Detectors at Kuo-Sheng Reactor Neutrino Laboratory”,
XXIII DAE-BRNS High Energy Physics Symposium,
Indian Institute of Technology Madras, Chennai, India, December 10-14, 2018.
11. **Talk**
“Test of Beyond-Standard-Model Scenarios with sub-keV Germanium Detectors”,
39th International Conference on High Energy Physics (ICHEP-2018)
Korea Physics Community, Seoul, South Korea, July, 4-11, 2018.
10. **Poster Presentation and Represent the Academia Sinica at 10th HOPE Meeting with Nobel Laureates**
“Studies of neutrino properties and interactions at Kuo-Sheng Reactor Neutrino Laboratory with sub-keV germanium detectors”,
10th HOPE Meetings with Nobel Laureates,
Japan Society for the Promotion of Science (JSPS),
Yokohama, Japan, March 12-15, 2018.
9. **Talk**
“Studies of neutrino properties and interactions at Kuo-Sheng Reactor Neutrino Laboratory with sub-keV germanium detectors”,
XV International Conference on Topics in Astroparticle and Underground Physics (TAUP-2017)
Laurentian University, Sudbury, Canada, July 24-28, 2017.
8. **Poster Presentation**
“Electromagnetic Properties of Neutrinos and Dark Matter Searches with sub-keV Germanium Detectors”,
XXII DAE-BRNS High Energy Physics Symposium,
University of Delhi, India, December 12-16, 2016.
7. **Poster Presentation**
“Low energy neutrino physics and dark matter searches with sub-keV germanium detectors”,
XXVII International Conference on Neutrino Physics and Astrophysics (Neutrino 2016)
Imperial College London, UK, July 4-9, 2016.
6. **Talk**
“Light WIMP Searches with sub-keV modified Germanium Detectors”
Workshop on Light from Dark Side of the Universe
Banaras Hindu University, Varanasi, India, March 17-20, 2015.
5. **Poster Presentation**
“Measurement of anti-neutrino-electron electron scattering cross section with

CsI(Tl) detector array and the Beyond Standard Model constraints”,
**7th International Workshop on Neutrino-Nucleus Interactions in
the Few GeV Region (NuInt 11)**
Dehradun Uttarakhand, India, March 7-11, 2011.

4. **Poster Presentation**

“Low Energy Neutrino and Dark Matter Physics with sub-keV Germanium Detectors”,
**XII International Workshop on Neutrino Factories, Super beams
and Beta beams**,
Tata Institute of Fundamental Research, Mumbai, India, October 20-25, 2010.

3. **Poster Presentation**

*“Probing Physics Beyond the Standard Model with Reactor Neutrinos in the
TEXONO Experiment”*,
**6th International Conference on Physics and Astrophysics of Quark
Gluon Plasma (ICPAQGP 2010)**
Goa, India, December 6-10, 2010.

2. **Talk**

“Neutrino and dark matter physics with sub-KeV germanium detectors”,
XIX DAE-BRNS High Energy Physics Symposium,
Jaipur, India, December 12-18, 2010.

1. **Talk**

“Low energy neutrino and astroparticle physics with sub-KeV germanium detectors”,
55st DAE-BRNS Symposium on Nuclear Physics,
Birla Institute of Technology & Science, Pilani, Jaipur, India,
December 20-24, 2010.