

Clarence Wret

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Employment

07/16/2018 — Today

Postdoctoral Researcher, Robert Marshak fellow, University of Rochester,
Visiting Scientist, *Imperial College London.*

Based at Fermilab, collaborating on the T2K, DUNE, and MINERvA experiments

T2K I convene the oscillation analysis and the near-detector constraints groups, and am an active developer, analyser and manager of key analysis software. I have worked on the simultaneous near and far detector oscillation analysis framework, developing the near-detector selections, data and simulation processing, the NEUT neutrino interaction generator, the T2KReWeight systematics package, and the neutrino generator comparison tool NUISANCE. I am responsible for writing T2K's 2020 oscillation analysis into publication, and have participated in several paper-writing committees. I was involved in the T2K near detector upgrade programme and participated in its neutron test beam runs at Los Alamos National Laboratory. I serve on the board of the Neutrino Scattering Theory Experiment Collaboration (NuSTEC).

T2K-SK I convene the T2K beam and SK atmospheric joint oscillation analysis. Combining the experiments increases statistics, and correlates and constrains shared systematics, leading to world-leading precision on numerous oscillation parameters. I am focussing on improving the ND280 selections and developing the interaction model to enable ND280 to reliably constrain the SK atmospheric events.

T2K-NOvA I have partaken in the T2K-NOvA joint oscillation analysis since its conception, in which I have significantly contributed to unifying the interaction model and prepared the oscillation analysis framework. I presented on the status of the project on behalf of both collaborations at the US-Japan Symposium of High Energy Physics in Hawaii in 2019.

DUNE I am involved in the prototype for the DUNE near detector, in which the MINERvA experiment is being repurposed for the ArgonCube 2x2 demonstrator at Fermilab. I am leading the disassembly, storage, and reassembly of MINERvA around ArgonCube, and working on the MINERvA DAQ to communicate with the ArgonCube system. For the DUNE near detector proposal, I have studied the detector simulations, written the data products, reconstruction, tracking, and estimators for the Temporary Muon Spectrometer (TMS) detector, critical for the day-one physics-ready near detector. For the DUNE Technical Design Report, I partook in developing and implementing the interaction model used in the long baseline neutrino oscillation analysis, and advised the oscillation analysers on methods and statistical techniques used on T2K.

Supervision At Rochester I have supervised a Master's student on fitting neutrino interaction models to published MINERvA data using NUISANCE. I am actively advising PhD students on the T2K oscillation analyses, implementing new selections and systematic uncertainties. I have also supervised MINERvA PhD students on implementing alternative interaction models, and working with NUISANCE to make multi-generator predictions for publications.

Selected publications and notes

Publications "Constraint on the Matter-Antimatter Symmetry-Violating Phase in Neutrino Oscillations", *K. Abe et al.*, [Nature 580, 339-344 \(2020\)](#), arXiv:1910.03887

"Improved constraints on neutrino mixing from the T2K experiment with 3.13×10^{21} protons on target", *K. Abe et al.*, [Phys. Rev. D 103, 112008 \(2021\)](#), arXiv:2101.03779

"Long-baseline neutrino oscillation physics potential of the DUNE experiment", *DUNE collaboration*, [Eur. Phys. J. C \(2020\) 80: 978](#), arXiv:2006.16043

“Search for Electron Antineutrino Appearance in a Long-baseline Muon Antineutrino Beam”, *K. Abe et al.*, *Phys. Rev. Lett.* 124, 161802 (2020), [arXiv:1911.07283](#)

“Tuning the GENIE Pion Production Model with MINERvA Data”, *P. Stowell et al.*, *Phys. Rev. D* 100 072005 (2019), [arXiv:1903.01558](#)

“NUISANCE: a neutrino cross-section generator tuning and comparison framework”, *P. Stowell et al.*, *JINST* 12 P01016 (2017), [arXiv:1612.07393](#)

“Deep Underground Neutrino Experiment (DUNE), Far Detector Technical Design Report, Volume II: DUNE Physics”, *B. Abi et al.*, *FERMILAB-PUB-20-025-ND* (2020), [arXiv:2002.03005](#)

“Nuclear binding energy and transverse momentum imbalance in neutrino-nucleus reactions”, *T. Cai et al.*, *Phys. Rev. D* 101, 092001 (2020), [arXiv:1910.08658](#)

“Using world charged pion–nucleus scattering data to constrain an intranuclear cascade model”, *E. S. Pinzon Guerra et al.*, *Phys. Rev. D* 99, 052007 (2018), [arXiv:1812.06912](#)

Internal notes “Constraining the Flux and Cross Section Models with Data from the ND280 Detector using FGD1 and FGD2 for the 2020 Joint Oscillation Analysis”, T2K-TN-395, 2020

“Measuring PMNS parameters in a joint ND280-SK analysis using MCMC”, T2K-TN-393, 2020

“Assessing the effect of cross-section model uncertainties on the T2K oscillation analyses with simulated data studies”, T2K-TN-396, 2020

“T2K ND280 and Super-Kamiokande acceptances for T2K-NOvA phase space analyses”, 2019

“NIWG model and uncertainties for 2019-2020 oscillation analysis”, T2K-TN-344, 2020

“Muon antineutrino and neutrino charged current multiple pion selections in antineutrino mode”, T2K-TN-273, 2020

“DUNE-US Near Detector Preliminary Design Report; TMS Chapter”, 2020

Misc. “Behind the Paper: CP-violation in Neutrino Oscillations”, *Nature—On Your Wavelength*, 2020

Selected talks and posters

Talks Neutrino Seminar Series (FNAL, 2019): “Neutrino interaction uncertainties in the GeV region: Past, Present, and Future”.

NuFact (Cagliari, 2021): “Neutrino interaction modelling and uncertainties for T2K analyses”.

NuSTEC, Neutrino-Nucleus Pion Production in the Resonance Region (Pittsburgh, 2019): “Impact of Neutrino-Nucleus Scattering Measurements on Resonance Modeling”.

Tensions in Neutrino-Nucleus Scattering (Pittsburgh, 2019): “Tuning the GENIE interaction model to MINERvA single pion production data” and “Constraining systematics at T2K with near-detector data”.

NuFact (Blacksburg, 2018): “The Role of Cross Sections in the Oscillation Analysis: The T2K Experience” and “Recent Cross Section Results from the T2K Experiment”.

MINERvA+NOvA meeting (FNAL, 2018): “Comparing the MINERvA and NOvA nominal and tuned models with NUISANCE”.

T2K+NOvA meeting (FNAL, 2018): “Comparing the T2K and NOvA nominal and tuned models with NUISANCE”, “The T2K ND280 and SK acceptance maps” and “Selections entering T2K oscillation analyses at ND280 and SK”.

NuInt and State of the Nu-tion workshop (Toronto, 2017): “NUISANCE, a framework for comparing and fitting neutrino interaction generators”.

Seminars University of Chicago, 2021: “Recent results from the Tokai-to-Kamioka (T2K) experiment”.

Caltech, 2020: “Recent results from the Tokai-to-Kamioka (T2K) experiment”.

Posters US-Japan Symposium on High Energy Physics (Honolulu, 2019): “Progress on a joint NOvA-T2K oscillation analysis”.

NuInt (Toronto, 2017): “NUISANCE, Neutrino Interaction Synthesiser Aggregating Constraints from Experiments”.

Awards and Scholarships

Postdoc Robert Marshak Fellowship: Awarded by the University of Rochester to support young scientists to pursue innovative research.

PhD Institute of Physics (UK): Supported travel grant for NuInt attendance. NuInt: Received funding from conference to present talk and poster on NUISANCE. NVIDIA GPU grant: Supported by NVIDIA hardware.

Undergraduate Willinska Stiftelsen: Awarded in 2011, 2012, 2013 for academic merit at UCL. Nya Gyllensteen: Awarded in 2012 to allow continuation of studies in London. Stiftelsen AAA: Awarded in 2011, 2012 for academic merit at UCL. Felix Neuberghs stipendiefond: Awarded in 2010 for academic merit at University of Gothenburg and Hvitfeldtska Gymnasiet to encourage studies abroad.

Computing

Languages Developer experience in C, C++, Fortran, CUDA, python, bash, and markup languages such as toml and xml, with formal training in C++ and CUDA. Frequent user of html5, and the Arduino IDE.

Accelerators Developer of OpenMP accelerated code for multi-threaded applications. Implemented CUDA and OpenMP in oscillation analysis framework on T2K. Rudimentary use of OpenACC for GPGPU applications. OpenMP and CUDA implementations on T2K reduced analysis times by $\times 14$.

HEP tools Experienced user of neutrino interaction generators NEUT, GENIE, and NuWro. Developer of the NEUT generator, experience in model development and Monte Carlo methods. Experience of running GEANT4 and edep-sim to study detector design choices on DUNE, using custom GDML geometries. Experienced user of the ROOT and CERNLIB libraries. Deployed and maintained frameworks on various super-computers and clusters.

Profilers, debuggers Frequent user of debuggers such as gdb and cuda-gdb. Have extensively used optimisation profilers like valgrind (massif, memcheck, cachegrind, callgrind), gperftools, and the NVIDIA visual profiler. Implemented Continuous Integration/Development (CI/CD) for numerous packages.

Others Undergraduate projects in Mathematica and Matlab, focussed on modelling dynamic systems. Experienced git, svn, and cvs user. Experienced Debian Linux and Windows user. Experienced \LaTeX user.

Education

10/01/2014 — 07/13/2018

Experimental High Energy Physics, PhD, Imperial College London.

Studied neutrino interaction modelling and using the near-detectors on T2K to minimise uncertainties in the oscillation analyses. On-site ECal expert for the ND280 detector during my stay in Japan. Funding provided through the UK Science and Technology Facilities Council (STFC), Institute of Physics (IoP) and sponsorship by NVIDIA.

[PhD thesis](#)

Title *Neutrino Oscillations, Near-detector Fitting and Interaction Physics at T2K*

Supervisor Dr. Morgan Wascko

Description **Near-detector simulation fitting**

My PhD thesis provided oscillation analyses at T2K with systematics constraints using external and near-detector neutrino data. The analysis was fully adopted for T2K's 2020 δ_{CP} constraints, published in Nature. I was responsible for the near-detector analysis, which reduced uncertainty on neutrino event rates at SK from 14% to 4%. I also made substantial improvement to the framework in terms of efficiency and methodology.

External neutrino scattering data

I investigated the current models' ability to predict published data and provided updated constraints on single pion production parameters for T2K. This machinery grew into the NUISANCE project (nuisance.hepforge.org)—an open-source framework providing users with the ability to compare and tune multiple neutrino interaction generators to over 290 published datasets. I remain an active developer and NUISANCE now has users from T2K, MINER ν A, NO ν A, DUNE and MicroBooNE and is referenced by the Particle Data Group (PDG).

Generator development

I extensively worked with M. Kabirnezhad implementing a single pion production model for T2K and SK. I also extended the existing Rein-Sehgal implementation.

Detector experience, hardware

I was assigned ECal expert for the T2K ND280 detector during my long-term stay in Japan. I was supported with hardware from NVIDIA.

Teaching and outreach

Supervision Supervised three Master's students during my PhD, working on evaluating methods of neutrino energy reconstruction in a high pressure time projection chamber for DUNE.

Outreach Organised student seminars and "coders club" events for the Imperial HEP group. Volunteered for Royal Society's LHCb and ALPHA "anti-matter matters" stall at the Imperial College Festival. Local helper for Neutrino 2016.

09/01/2010 — 06/01/2014

Theoretical Physics, MSci., University College London, First class Hons.

Thesis on global neutrino oscillation fits. Focus on high energy physics and cosmology.

Master's thesis

Title *Determining the Neutrino Mass Hierarchy from Global Neutrino Oscillation Experiments*

Supervisors Prof. Jenny Thomas, CBE

Description I developed a custom three flavour neutrino oscillation fitter, used to perform joint fits and sensitivity studies with public neutrino oscillation data from reactor (Daya Bay, RENO, Double Chooz, KamLAND) and accelerator (MINOS, T2K) experiments to study the neutrino mass hierarchy. I assisted in PMT R&D for the Cherenkov detectors in mine PitS experiment (CHIPS).

09/01/2009 — 05/01/2010

Physics, kandidat (BSc.), University of Gothenburg, Sweden.

Completed first year of undergraduate before moving to UCL – Awarded highest distinction.

Electronics & semi-conductors, Chalmers University of Technology, Sweden.

Emphasis on practical circuit-board work and simulations in PSpice – Awarded highest distinction.

01/08/2006 — 01/06/2009

International Baccalaureate, Hvitfeldtska Gymnasiet, Sweden, 37/45.

"Extended essay" on cosmic muon decay, conducted at University of Gothenburg which was awarded highest distinction. Studied physics, mathematics, and chemistry at "higher level".