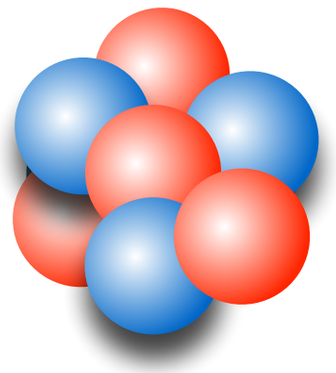
Summary of the “Neutrino–Nucleus Interactions in the Standard Model and Beyond” Workshop

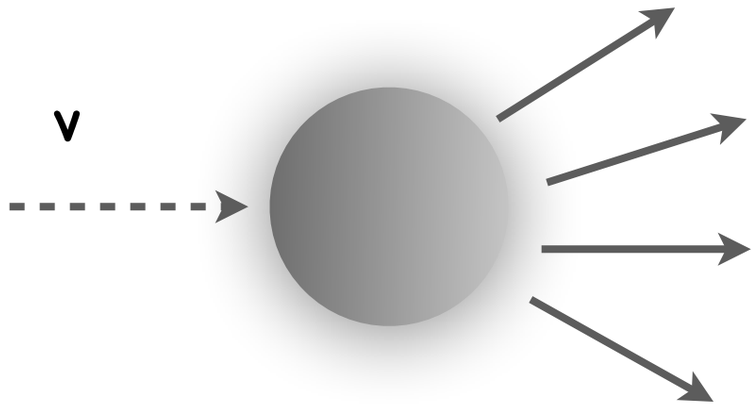
Noemi Rocco , Vedran Brdar

February 12th, 2021

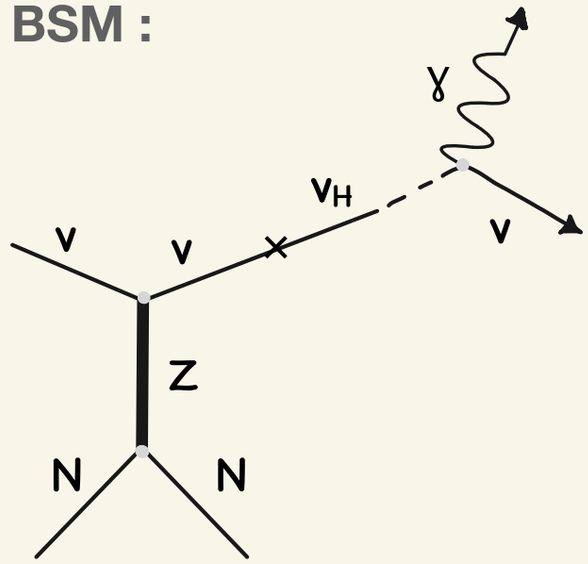
Addressing Neutrino-Oscillation Physics

Nuclear Physics:

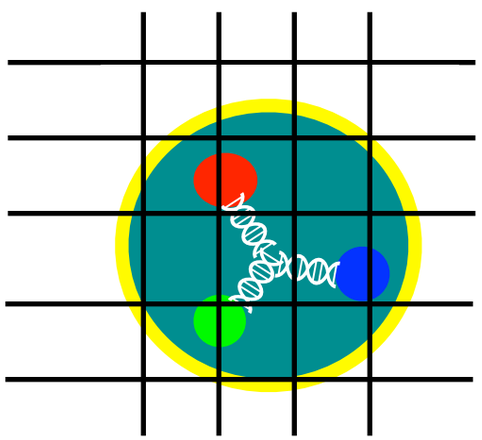




BSM :

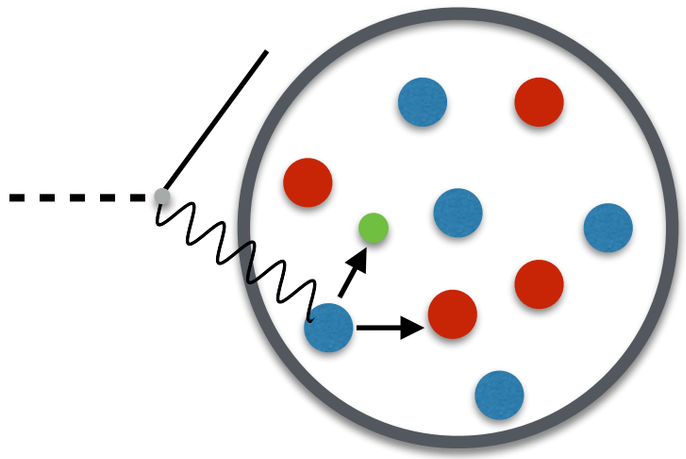


Lattice QCD :



Simulate neutrino-nucleus interactions to untangle neutrino oscillations from the measured interactions

Event Generator :



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Overview of the Workshop

- Workshop virtually hosted by **CERN's Theoretical Physics Department and the Neutrino Platform**. Jan 17 to 21, 2022. Organizers: V. Brdar, J. Kopp, J Yu, and NR

Goal of the workshop: Discuss recent advances in the theory of neutrino-nucleus interactions and their phenomenological consequences, in particular:

  - impact of neutrino **cross-section uncertainties** on the determination of **neutrino oscillation parameters**
  - relevance of **cross-section** measurements for **BSM searches**
  - interplay between **particle** and **nuclear** physics in the **low energy region**

- Different sections of the Workshop: (https://indico.cern.ch/event/1047442/timetable/)
  - Neutrino Cross Sections and Event Generators
  - Physics Beyond the Standard Model
  - Neutrino Physics at Low Energies
  - Led Discussion sessions

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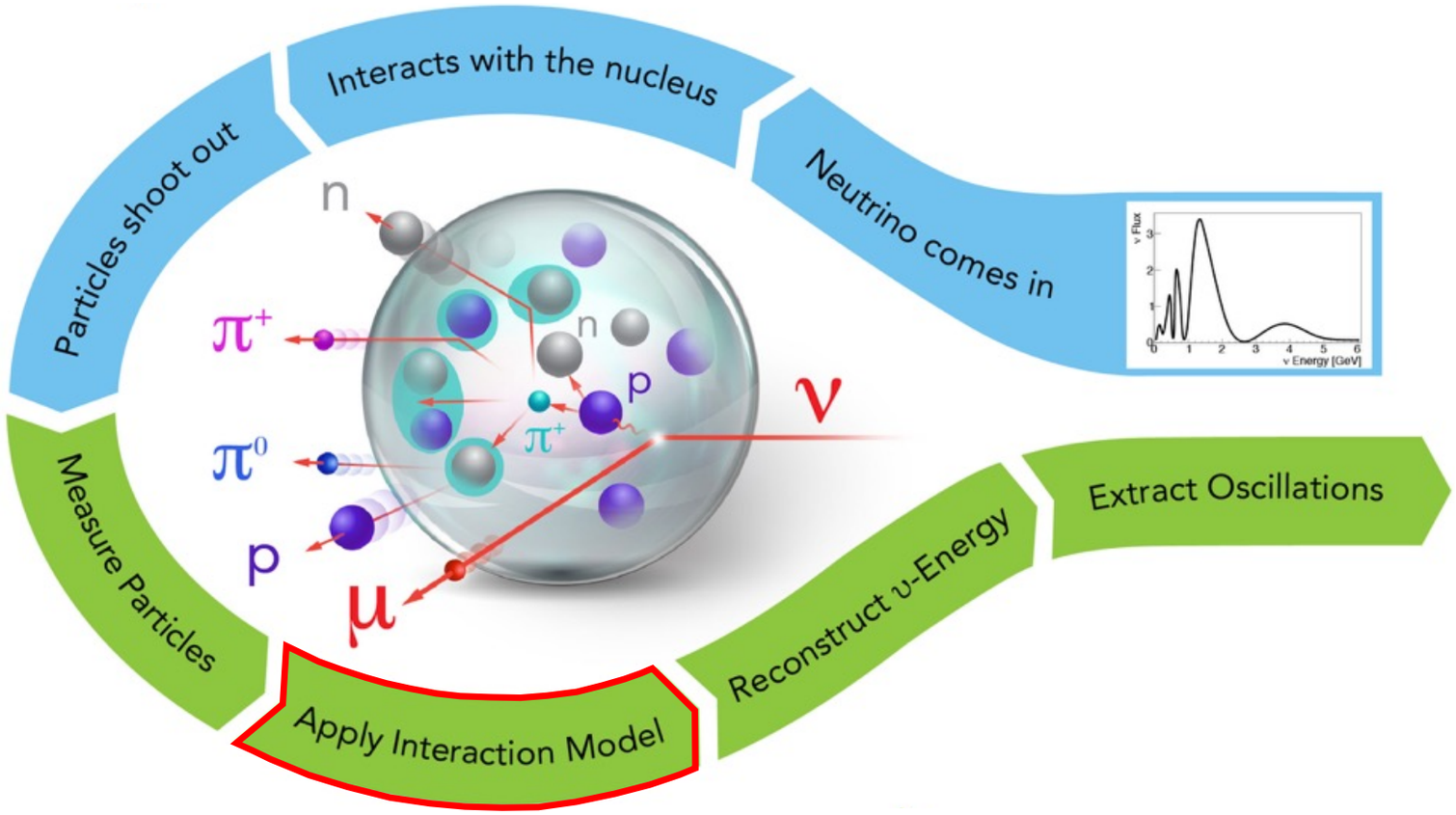
Addressing Neutrino-Oscillation Physics

Electrons for Neutrinos: new results towards precision oscillation measurements

Or Hen (MIT)

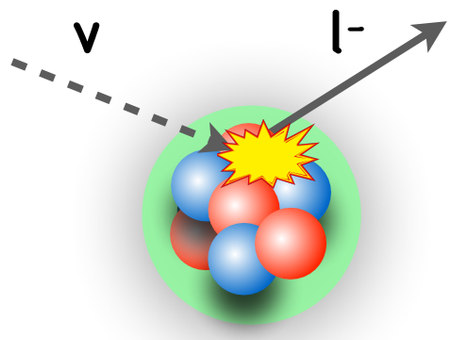
Test the interaction models' accuracy in event generators using similarities between electrons and *v*



Detectors measure the **neutrino interaction rate:**

$$N_e(E_{\rm rec}, L) \propto \sum_i \Phi_e(E, L)\sigma_i(E) f_{\sigma_i}(E, E_{\rm rec}) dE$$

Measured — Wanted — Theory Input



A precise determination of σ(E) is crucial to extract ν oscillation parameters

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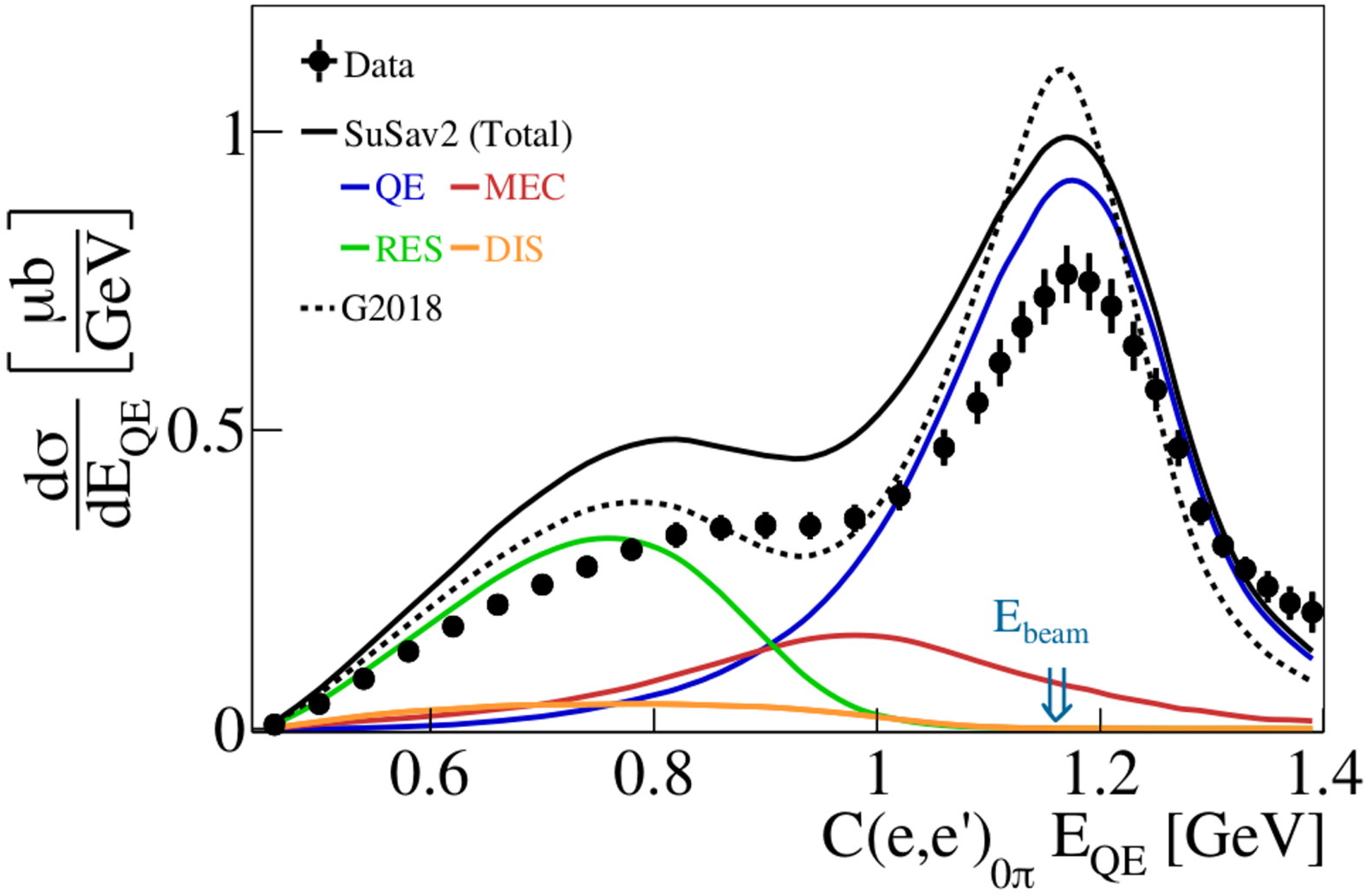
Addressing Neutrino-Oscillation Physics

Electrons for Neutrinos: new results towards precision oscillation measurements

Or Hen (MIT)

$$E_{QE} = \frac{2M\epsilon + 2ME_l - m_l^2}{2\left(M - E_l + |k_l|\cos\theta_l\right)}$$

Unprecedented accuracy in the determination of **neutrino-argon cross section** is required to achieve design sensitivity to CP violation at DUNE



Their results indicate the need for substantial improvement in the accuracy of the neutrino interactions' models and simulations

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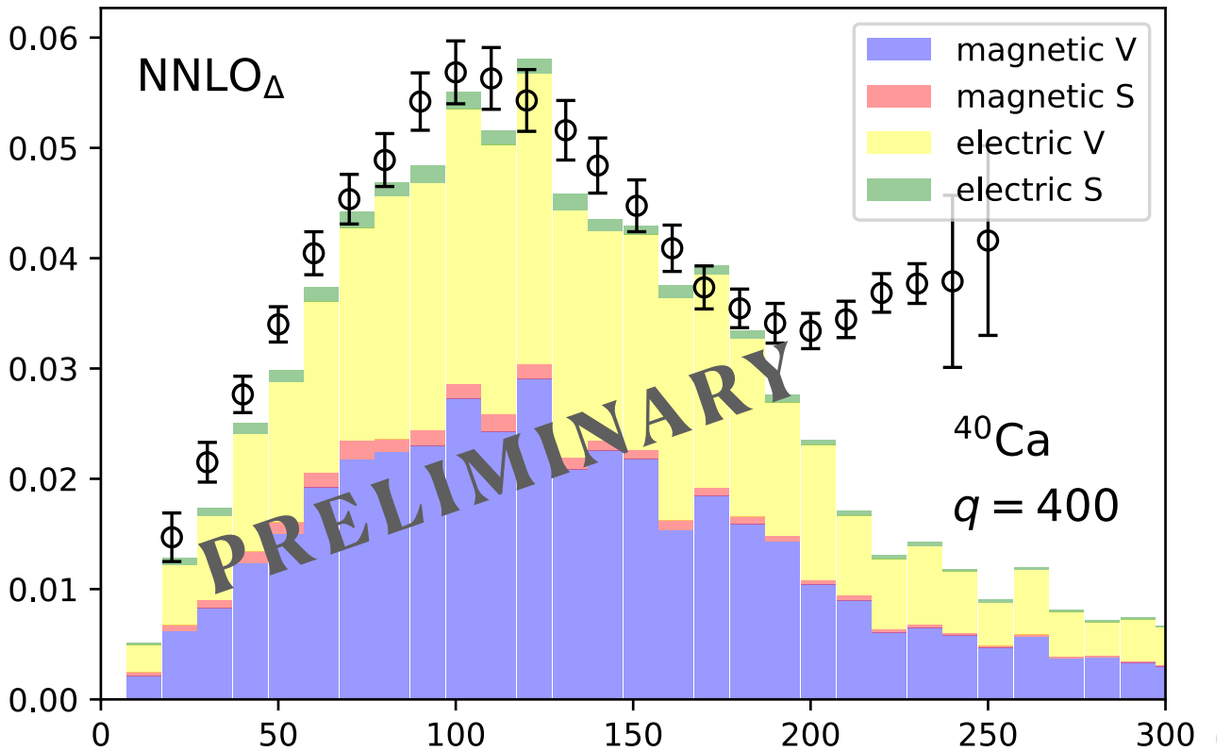
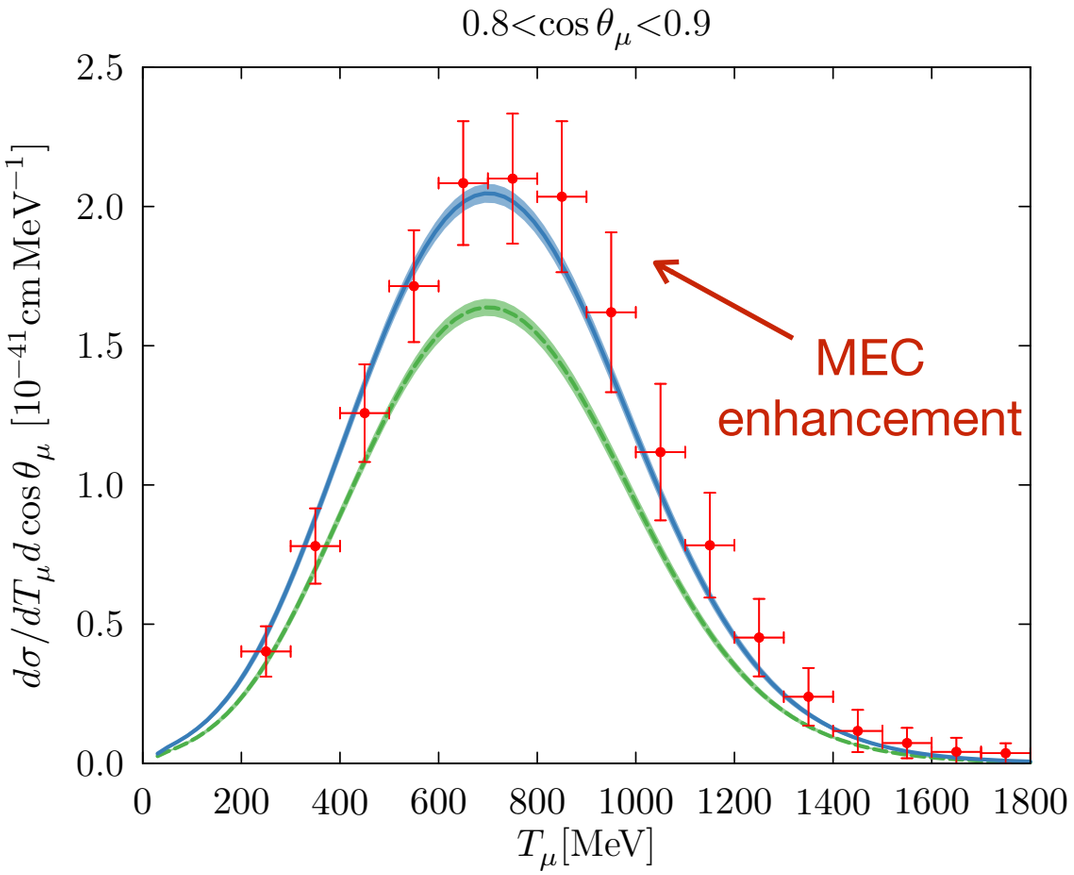
Description of the Interaction Vertex—Ab initio

Transverse Response of ^{40}Ca, Couple Cluster



Coupled cluster theory for neutrino scattering
Joanna Sobczyk (Mainz)

MiniBooNE cross section, Green's Function MC



GREEN'S FUNCTION MONTE CARLO PREDICTIONS OF NEUTRINO-NUCLEUS CROSS SECTION

Alessandro Lovato (ANL)

Limitations: correctly encompass relativistic effects, access to exclusive channels

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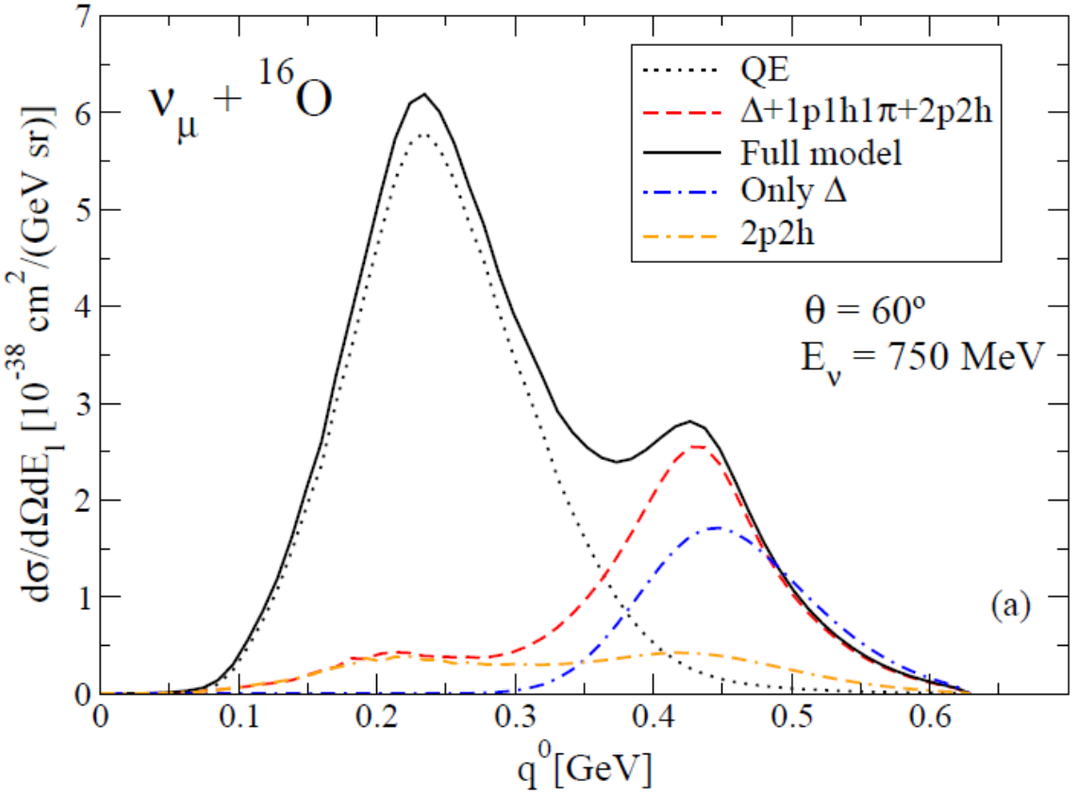
Description of the Interaction Vertex—Factorization

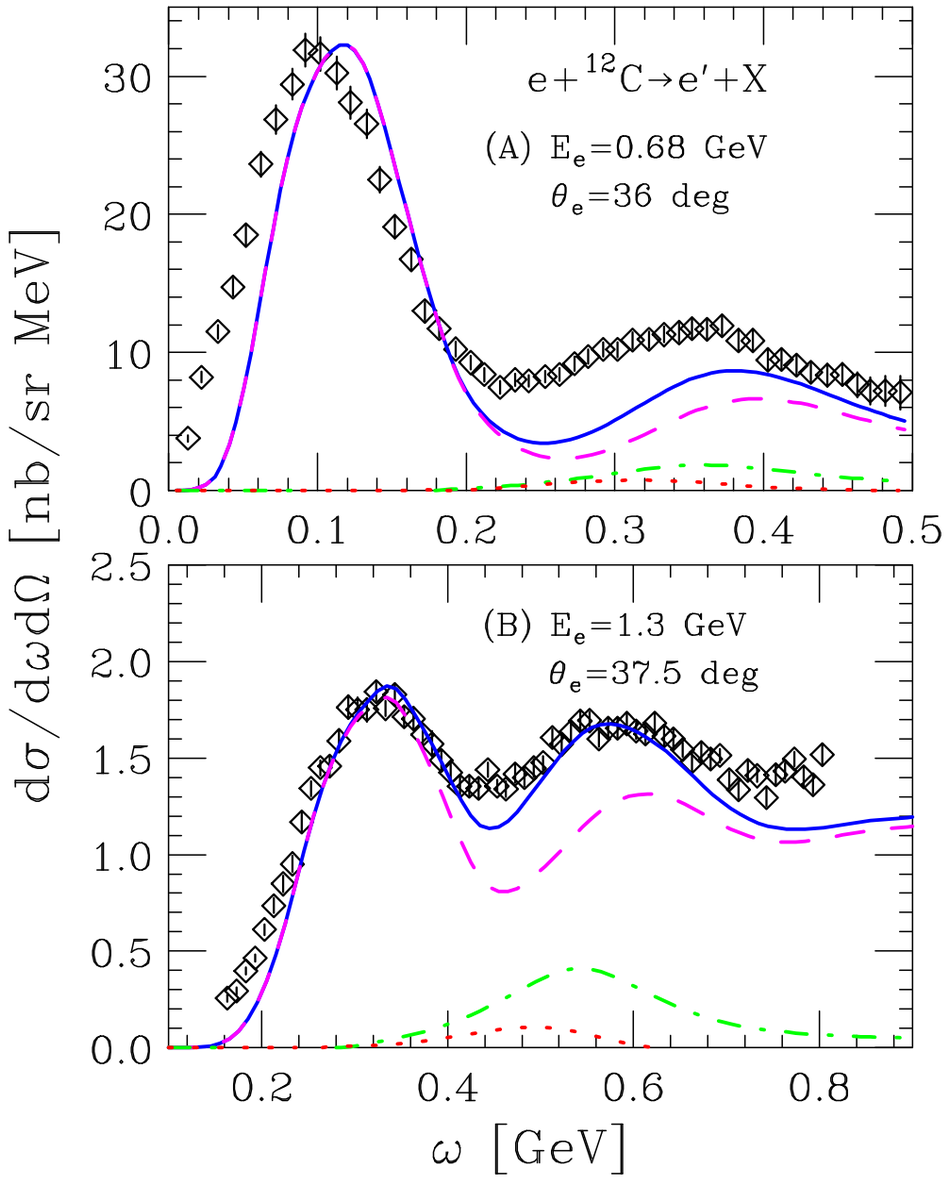
Inclusive cross section CC, Valencia Model



Coupled cluster theory for neutrino scattering
Juan Nieves (IFIC)

These models rely on approximations but can describe the different reaction mechanisms

Electron scattering, Spectral Function



Factorisation as a Unified Framework for the Description of Neutrino-Nucleus Interactions

Omar Benhar (INFN)

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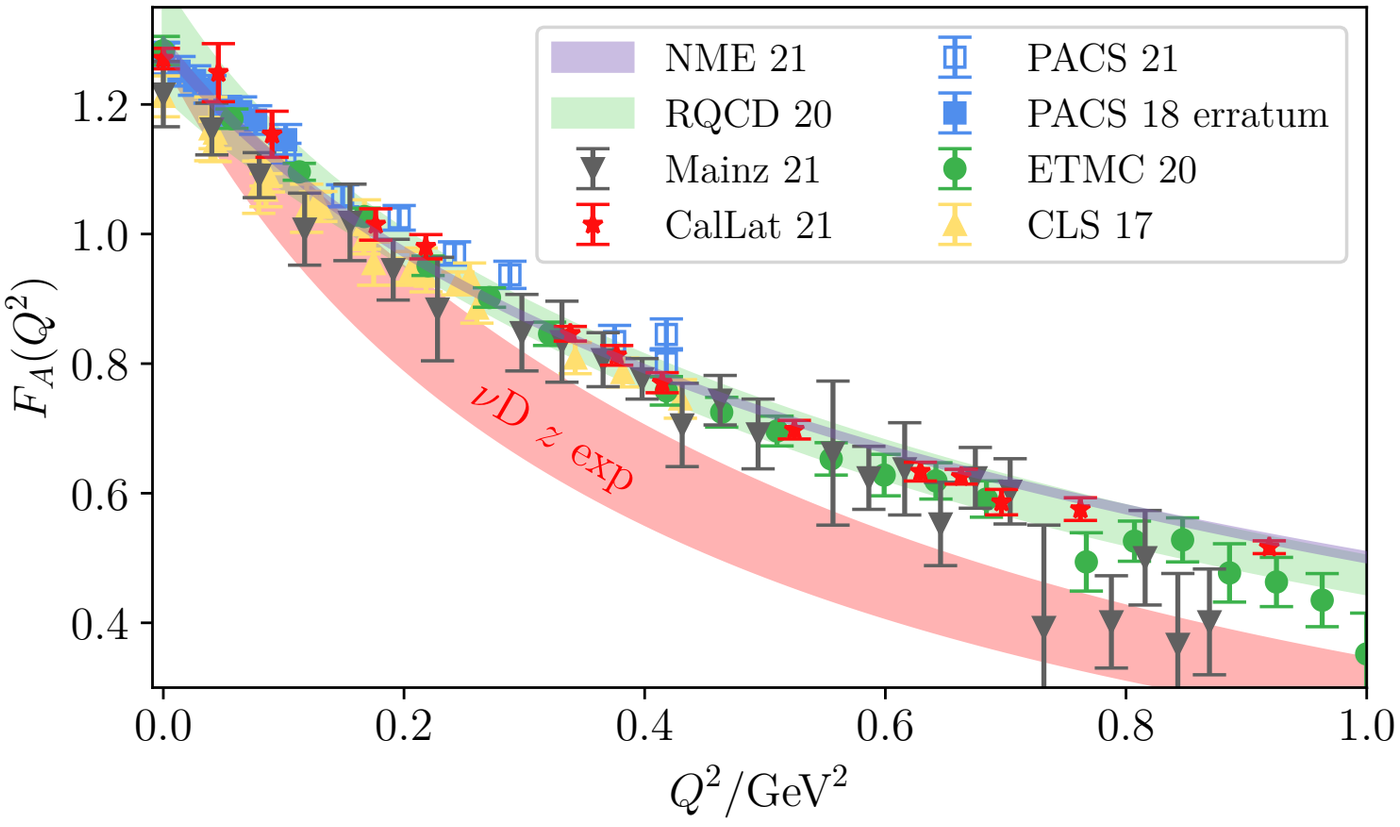
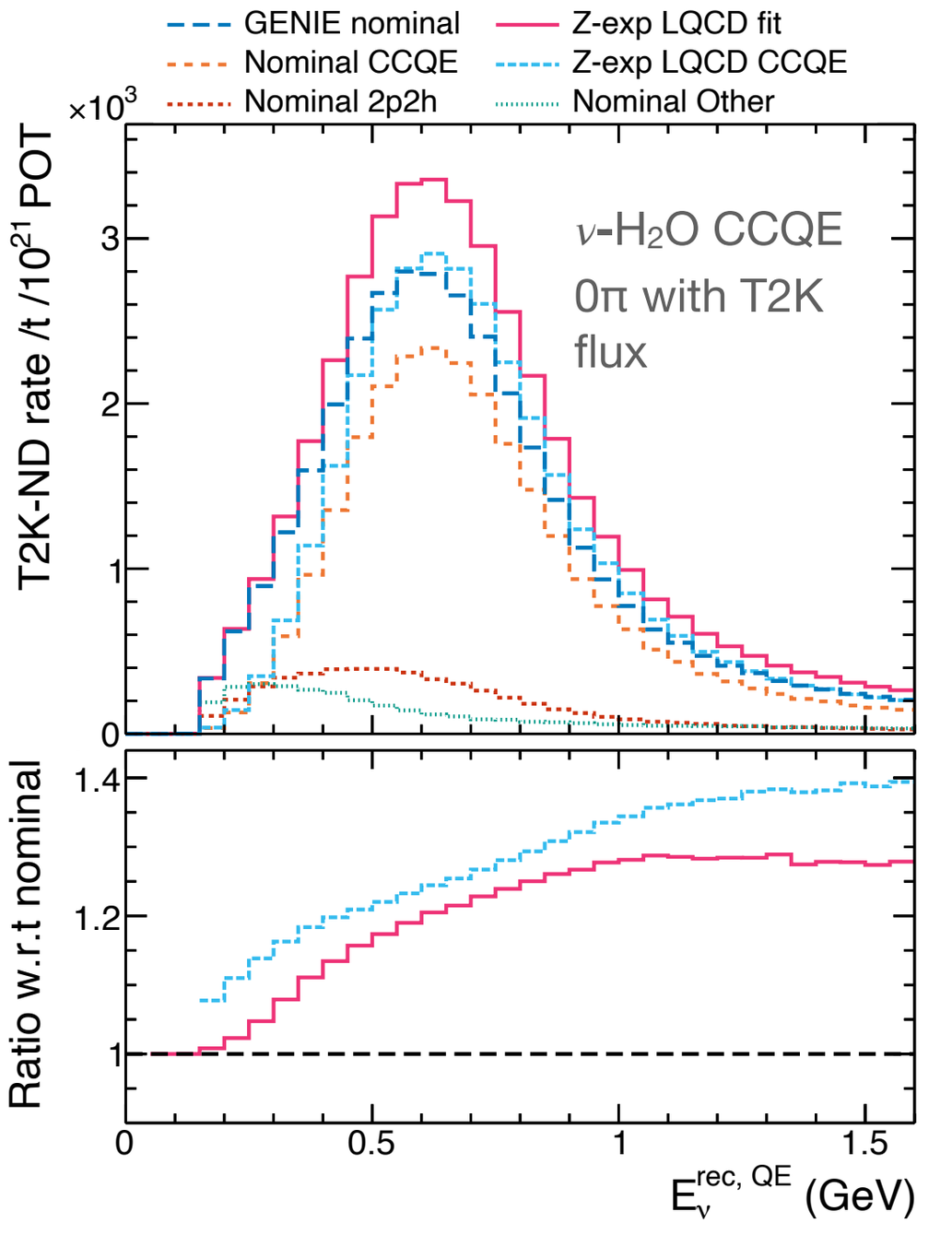
Latest developments from LQCD

Lattice QCD for Neutrino Experiments, Andreas Kronfeld



Lattice slopes are smaller than those extracted from νd (LQCD single-lattice spacing result)

LQCD Axial form factor with all systematics controlled in ~1 year



CCQE is 30% larger with LQCD axial form factor instead of default.

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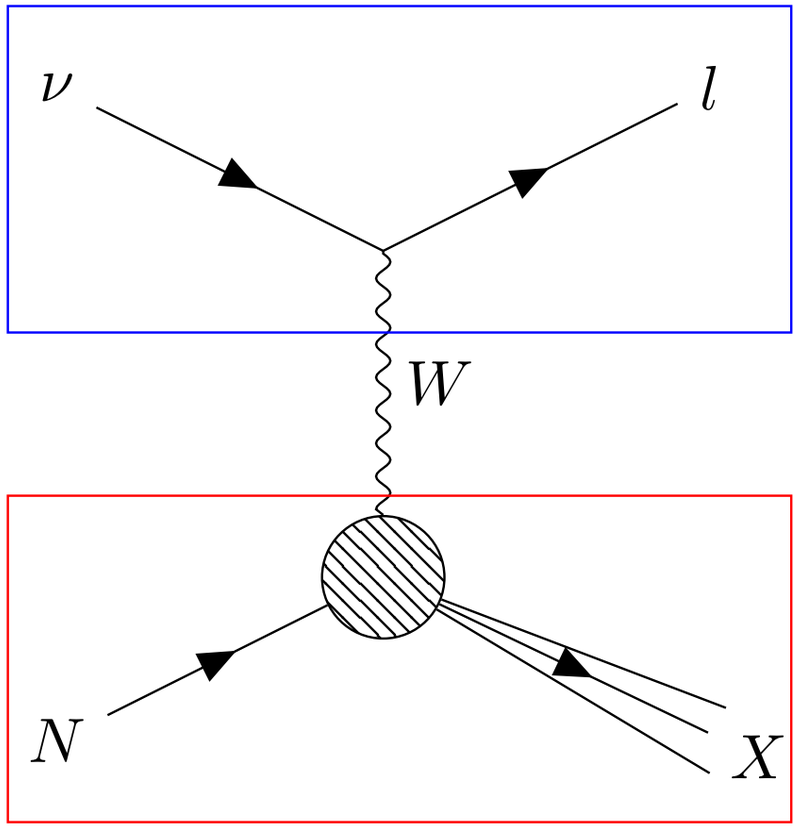
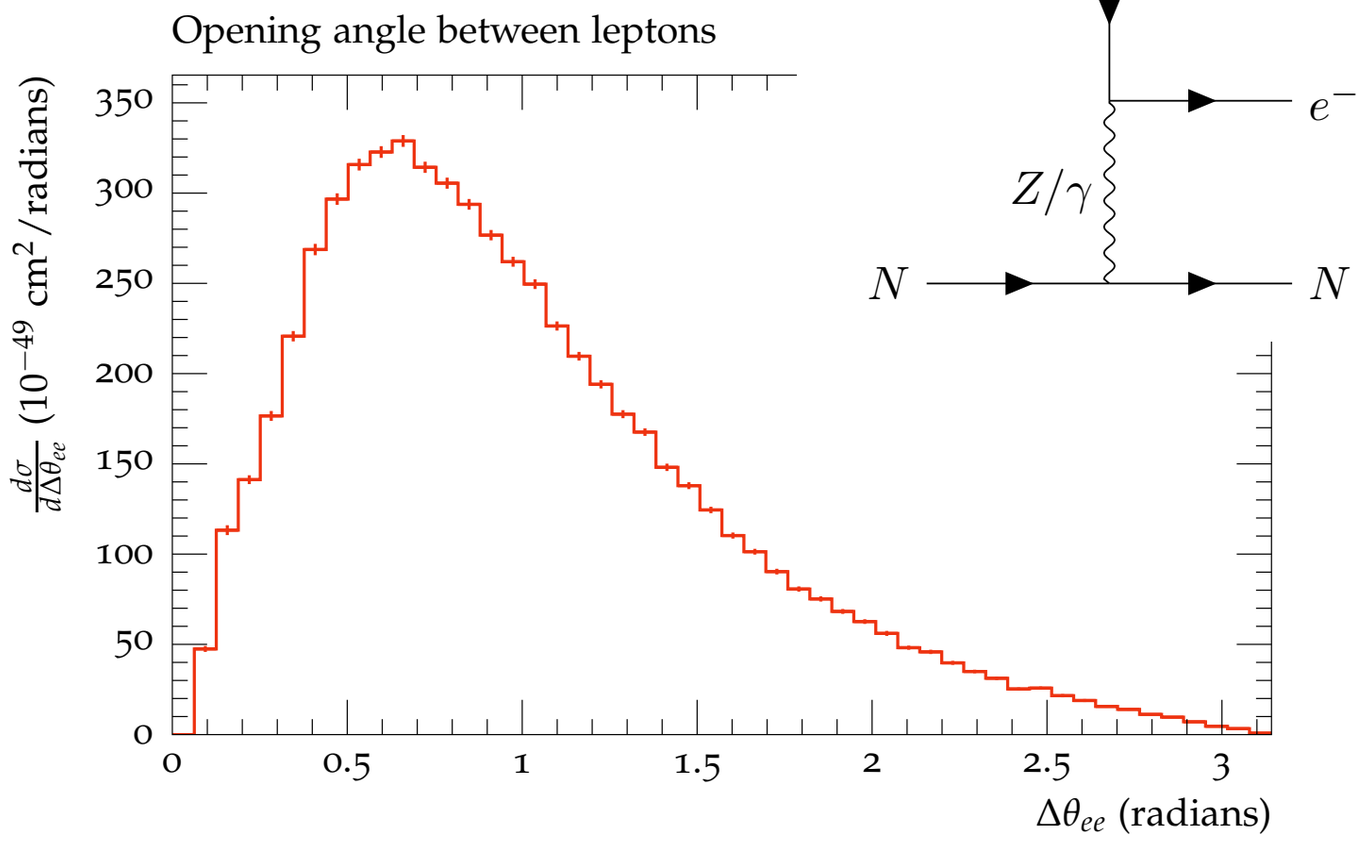
Simulating BSM physics

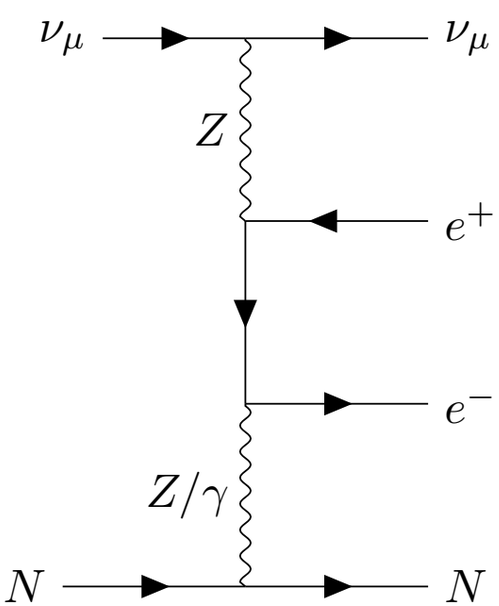


- Use LHC tools to calculate the leptonic tensor in an automated way: input in Universal FeynRules Output (UFO) format
- Automated calculations of BSM contributions currently not included in event generators

A Novel Event Generator for the Automated Simulation of Neutrino Scattering

J. Isaacson (FNAL)





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