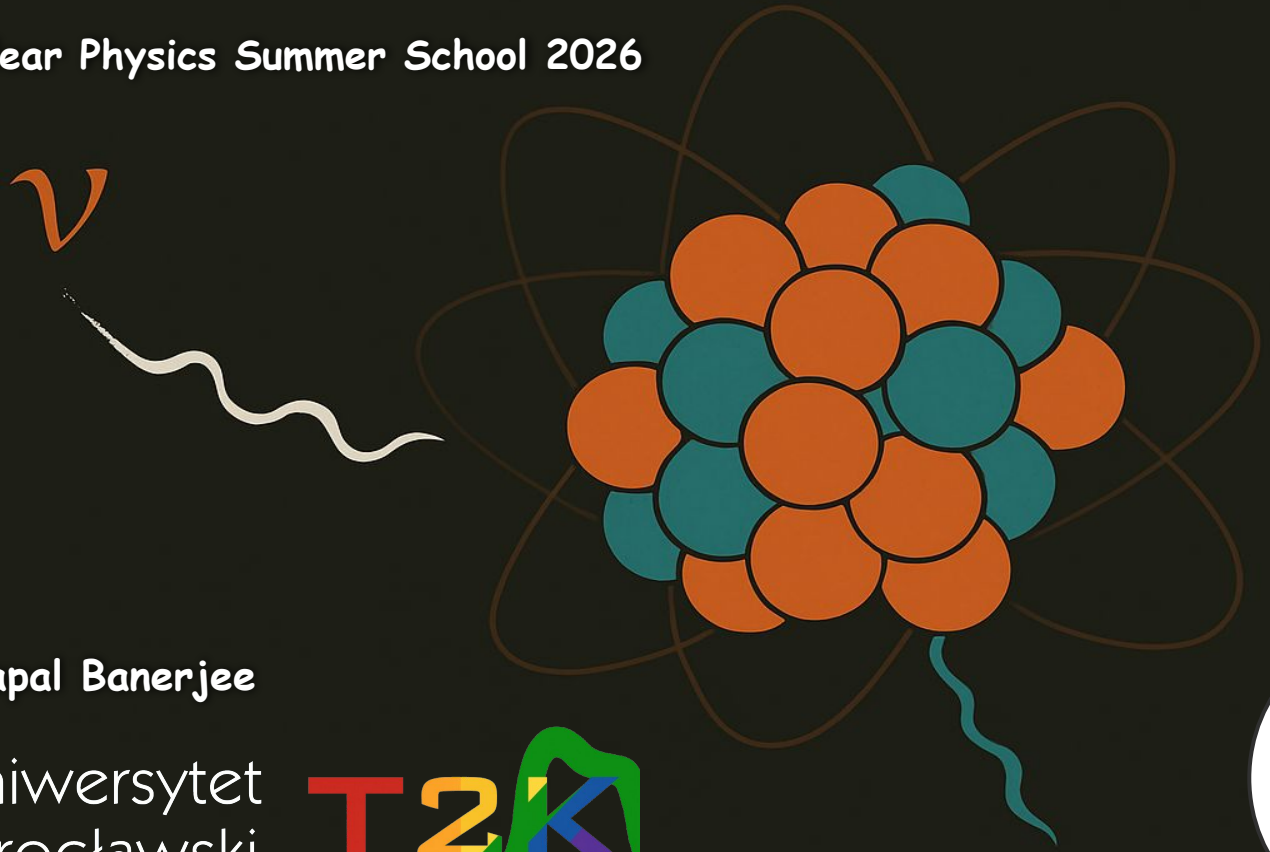
A Taste Of Playing With Neutrinos & Nuclei In A MC Generator In 5 minutes!

National Nuclear Physics Summer School 2026



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T2K

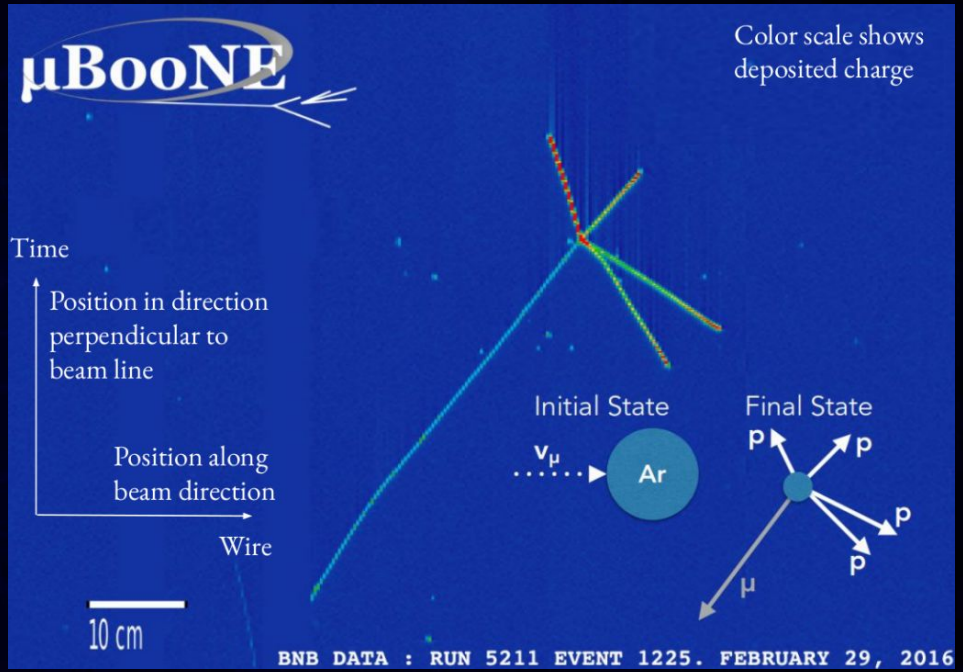
NuWro Wrocław Neutrino Event Generator

@WhoamI

- PhD scholar at University of Wroclaw, Poland
- **Developer of NuWro Monte Carlo event generator**, a generator of lepton-nucleus events
- Part of T2K collaboration in Japan
- Working on building lepton-nucleus interaction model at ~ 1 GeV (For this highly energetic room : Low energy)
- Contact : rwik.dharmapal@uwr.edu.pl

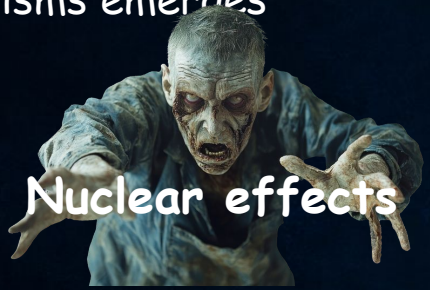
Motivation

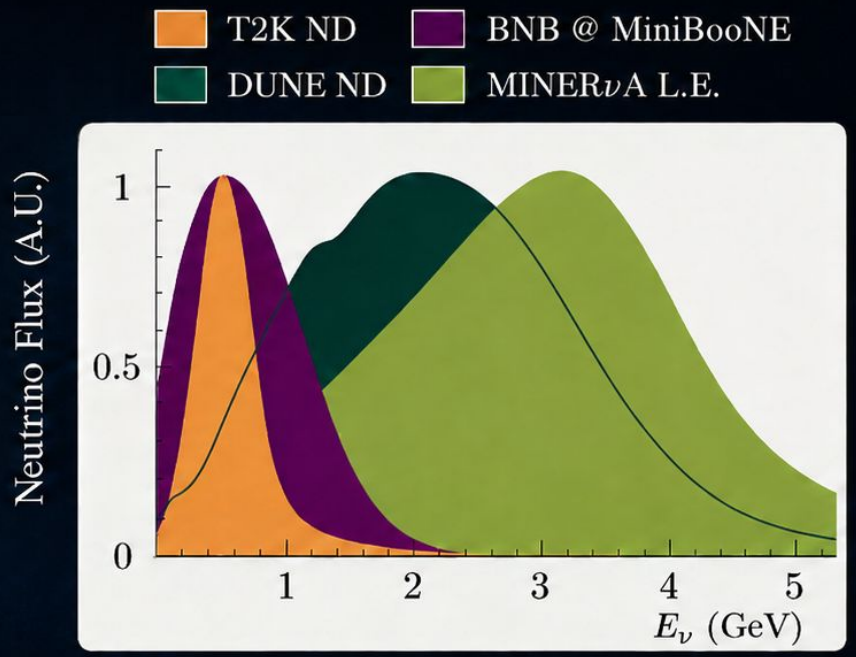
- Neutrinos oscillate! Dream of ν community is extracting oscillation parameters
- We do not see ν. We see final state particles after interaction with detector
- Accelerator ν beam has wide energy range
- You try to reconstruct ν energy to infer oscillation parameters.
- Precise determination of neutrino-nucleus cross-section crucial to extract oscillation parameters

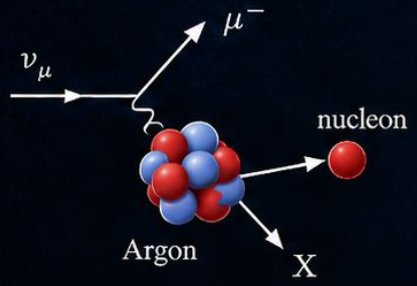


Context

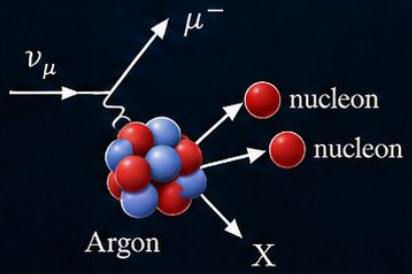
- Neutrinos are usually NOT produced at fixed energies
- Various complex interaction mechanisms emerges



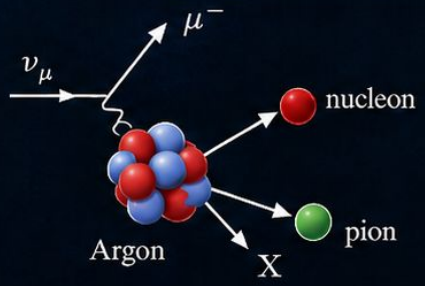




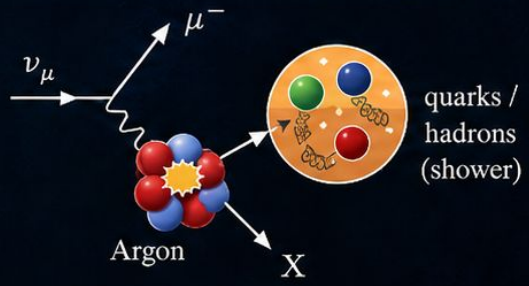
Quasielastic (QE)



Meson exchange current (MEC)

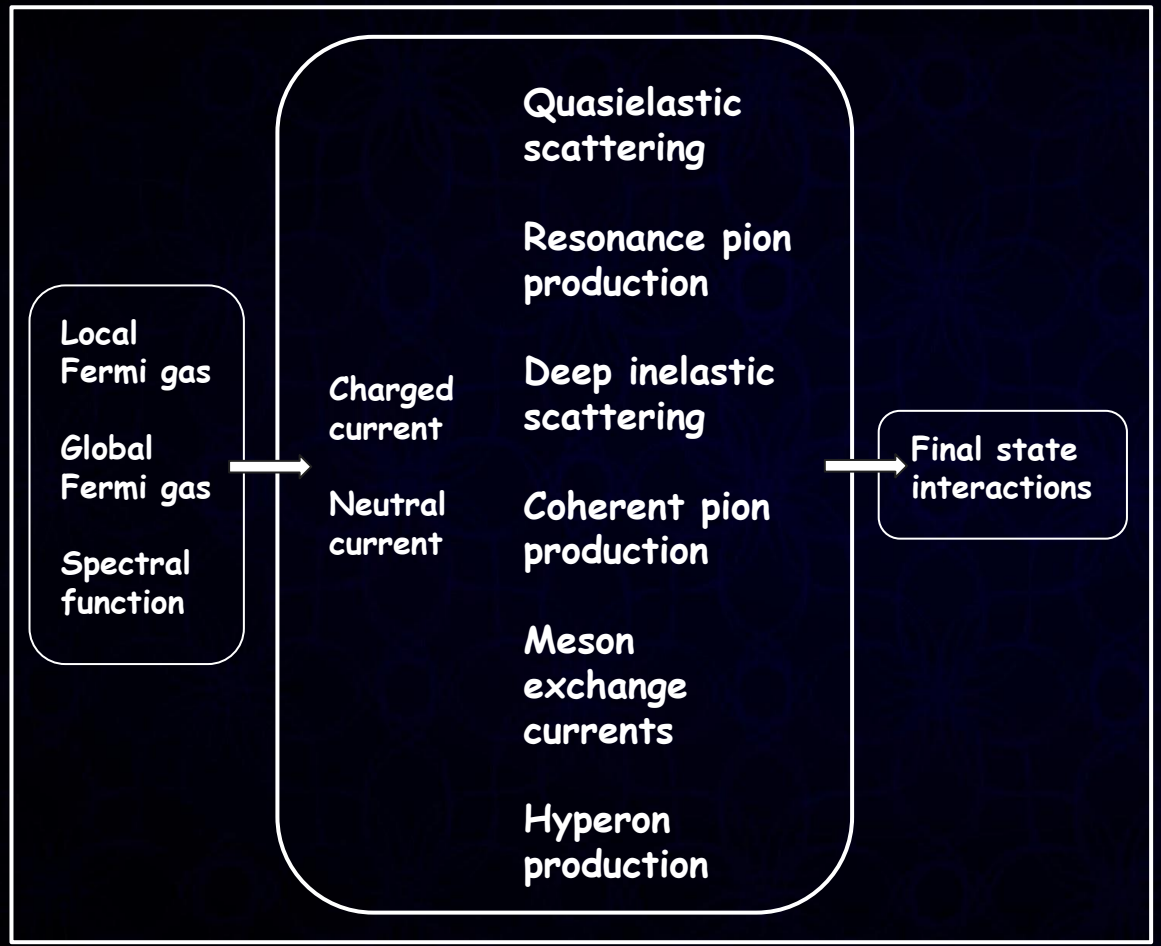


Resonance (RES)



Deep inelastic scattering (DIS)

NuWro blackbox



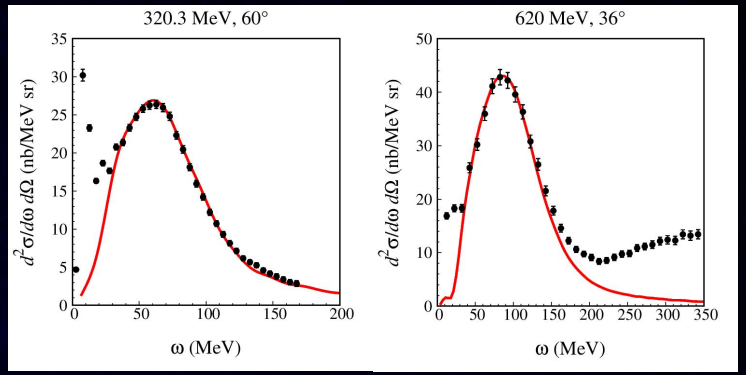
- Developed by ~15 people since 2004
- Written in C++, output is a ROOT file with easy to analyse event object
- Covers energy from ~100 MeV to ~100 GeV
- Used in various experiments worldwide
- https://github.com/NuWro/nuwro Latest released version : NuWro 25.11


Improving nuclear initial state modeling :
Implementation of spectral functions to sample realistic bound-nucleon momentum and removal energy
Short range NN correlation :
Inclusion of correlated nucleon pairs, producing nearly back-to-back emission in 20% of events due to short range tensor forces
Final state interactions:
Consistent model of nuclear transparency and hadronic rescatterings by intranuclear cascade, inside a nuclear optical potential
Some of my PhD works

I am at the end of my talk with few of my results

- The main direction is implementation of better theoretical models
- It is important to develop different approaches, different generators and compare with different data
- Good quality of MC generators is essential for future neutrino oscillations program
- In the last ~10 years physics models implemented in MCs have improved significantly. But miles to go!

electron-Carbon inclusive scattering data



neutrino-Argon exclusive scattering data