Recap of Previous Grants Accomplishments

Dave Toback
Texas A&M University
QPix Collaboration Meeting (9/13/2023)

Outline

- Meet the group
- Physics Studies
  - Lightless reconstruction
  - Phenomenology: applying QPix to a measure of $\sin^2(\theta_W)$
- Service: Simulations and Reconstruction Software
  - Release & Package Manager Duties
  - qpixg4, qpixrtd, and qpixrec Packages

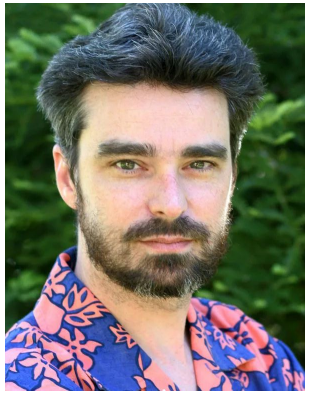
Meet the Texas A&M Group

Dr. Dave Toback
Principle Investigator

Dave Elofson
Graduate Student (6th yr)

Ben Meleton
Graduate Student (2nd yr)

Erika Munoz
Undergraduate Student (Sr)



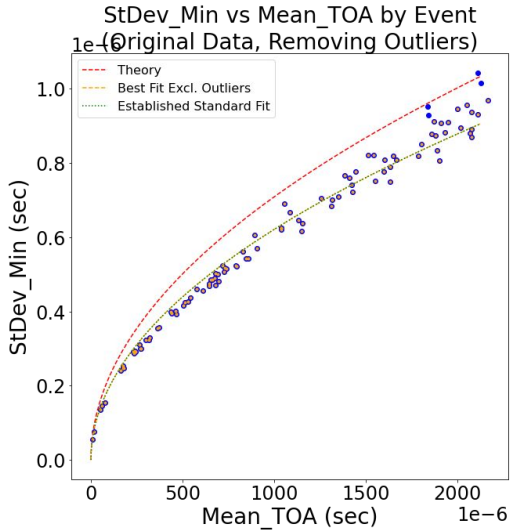
Dr. Michael Kelsey
Research Scientist

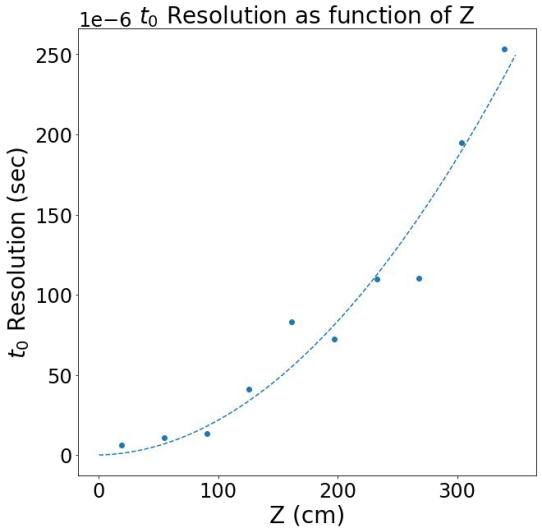
Carter Eikenbary
Graduate Student (3rd yr)

Nolan Tenpas
Graduate Student (2nd yr)

Physics Studies: Lightless Reconstruction

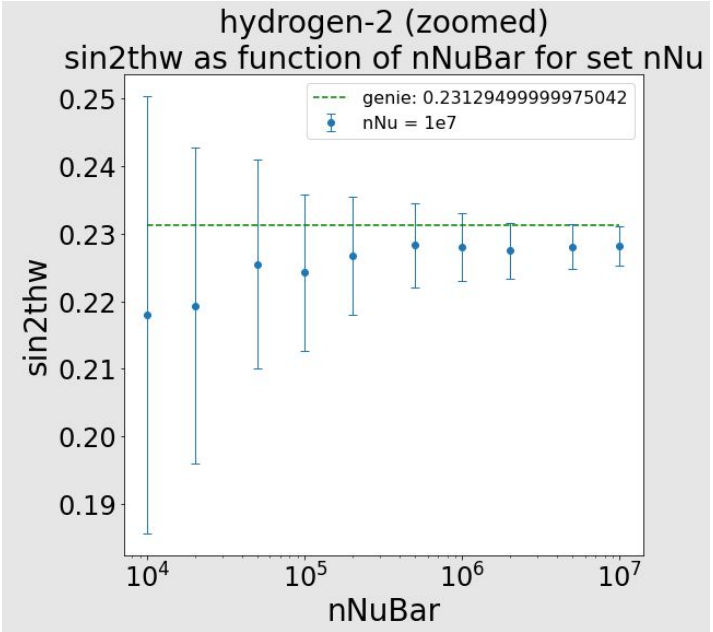
- Primary effort has been on simulation software and reconstruction (more soon)
- Results on the right for fully simulated events with simple reconstruction
  - RMS and TOA of the electron swarm
  - Focus on the pixel with the smallest RMS
- The pair of results allows us to determine the t_0 of the event without using a light trigger with only small biases
  - Gives a Z dependent t_0 resolution
  - For Z~300cm, resolution for t_0 is 175us and 28.8cm in Z
- Allows for 3D reconstruction of all hits for use in track and vertex reconstruction





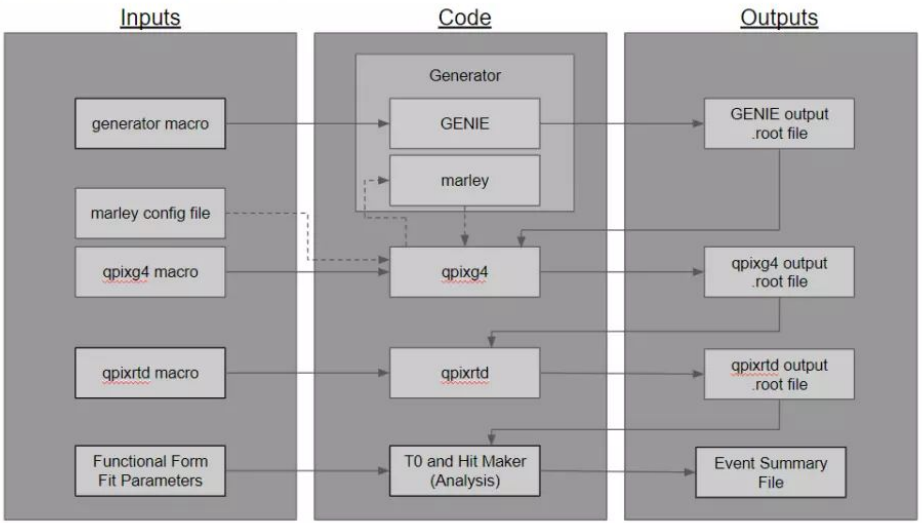
Physics Studies: Using QPix to measure $\sin^2(\theta_W)$

- Phenomenology study to see how well we can measure $\sin^2(\theta_W)$ with a QPix detector and a neutrino beam
- Follow the methods used by NuTeV
  - Count NC and CC events and extract a result using the Paschos-Wolfenstein relations
  - They had about 1.6M nu-events and 0.35 nubar events which gave a relative uncertainty of 1.4%
- First results from a perfect detector using genie simulation are promising
  - Starting with an isoscalar target we mostly get back the input value with a resolution that drops as a function of the number of neutrino interactions
  - Can determine corrections for switching to an argon target
- Plan is to add in expected efficiencies and mis-reconstruction rates to see how well we could do



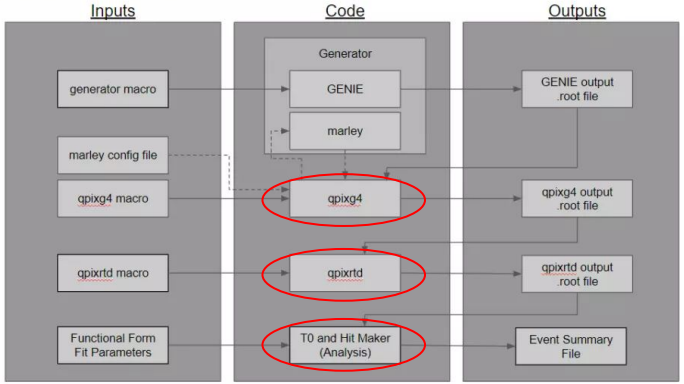
Simulation and Reconstruction Software: Release and Package Management

- All the pieces of simulation and reconstruction software are organized into Packages within a Software Release
  - See two-part talk on current status and plans for future development
  - Designed to maintain order and clarity as multiple developers continue to work on the various packages
- Documentation on Wiki
  - Instructions on how to get packages as well as run them
  - Documentation for each package



Packages: qpixg4, qpixrtd, qpixrec

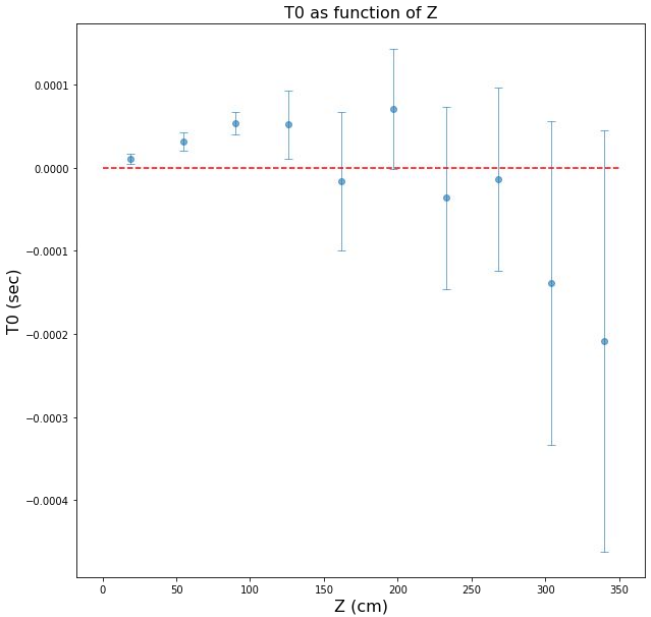
- **qpixg4** - *Particle tracks in LAr for a standard DUNE APA*
  - Now able to use Geant4's multithreading capabilities
  - Enabled input of genie-produced root files
- **qpixrtd** - *simulates the drift, diffusion and recombination of electrons in the electron swarm produced by particle tracks, as well as the pixel response*
  - Added a flag to turn on/off event window cuts
  - Downsampling to improve speed in progress
  - Other methods for processing time and memory
- **qpixrec** - *reconstructs events based on the qpix output (currently only lightless)*
  - Includes all lightless reconstruction
    - Determines the event t_0
    - Produces file with x, y, z for every pixel



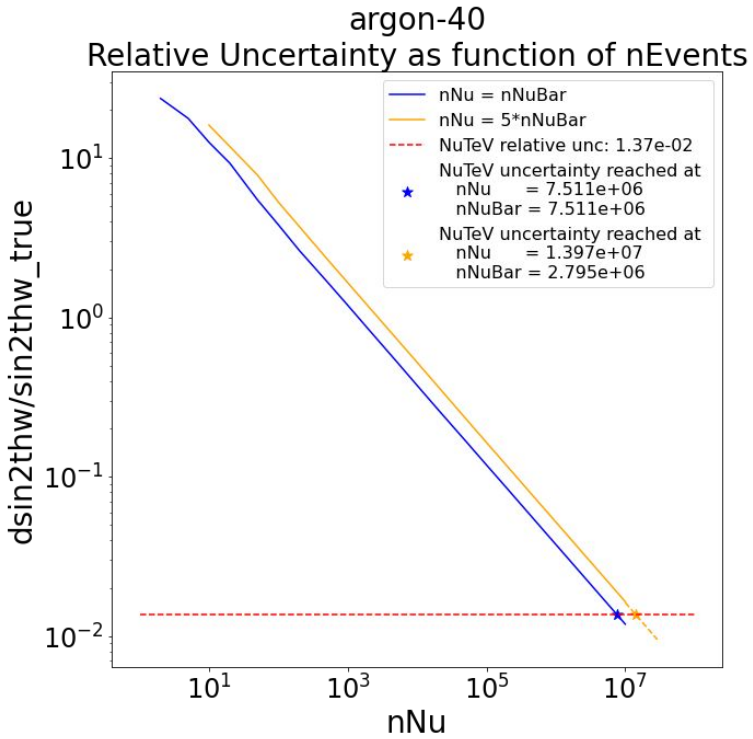
Backups

T0 biases vs. Z

Only small biases in t0 measurement as a function of Z



Resolution as a function of nu-bars



Previous Grant Accomplishments

- Physics Studies
  - Lightless Event Reconstruction
  - Applying QPix to a measurement of $\sin^2(\theta_W)$
- Simulation Coding Contributions
  - Release & Package Management
  - Code Development