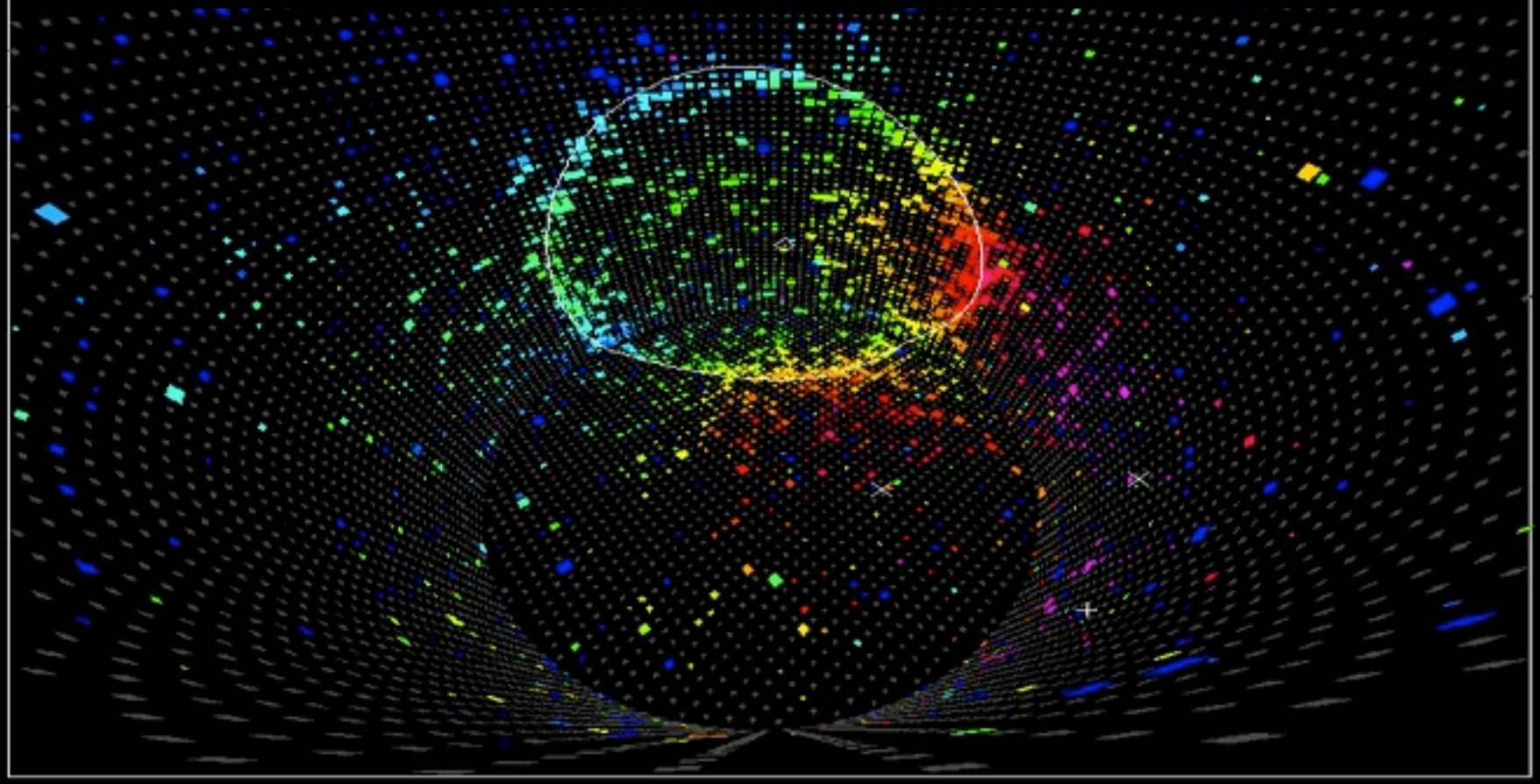
Neutrino Update

Precision Timing in the Next Generation of Cherenkov Detectors



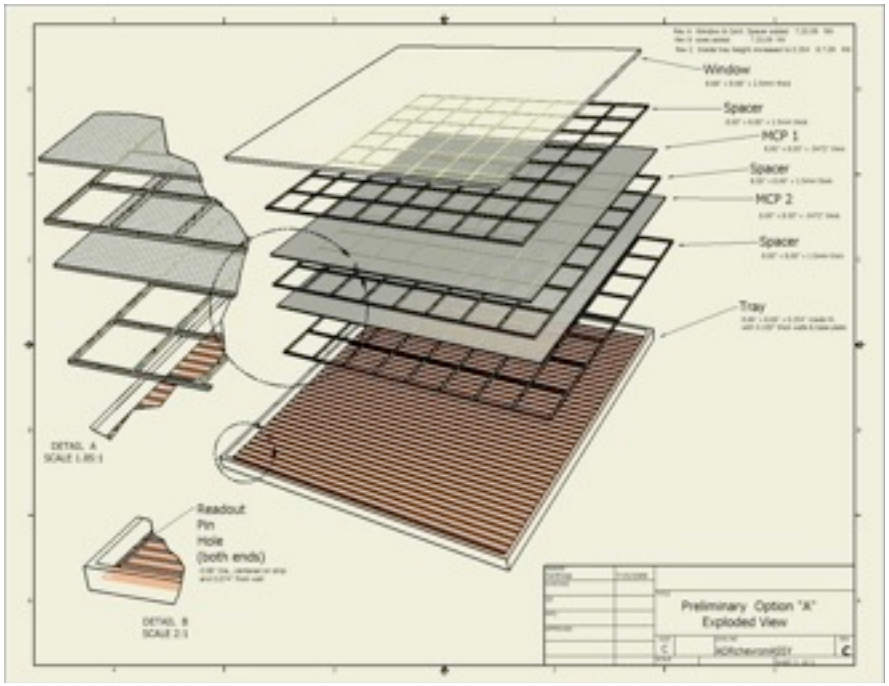
Matthew Wetstein - Enrico Fermi Institute, University of Chicago

HEP Division, Argonne National Lab

LAPPD Collaboration:
Pushing the Limits of the Timing Frontier

Microchannel Plates are an existing photo-multiplier technology known for:

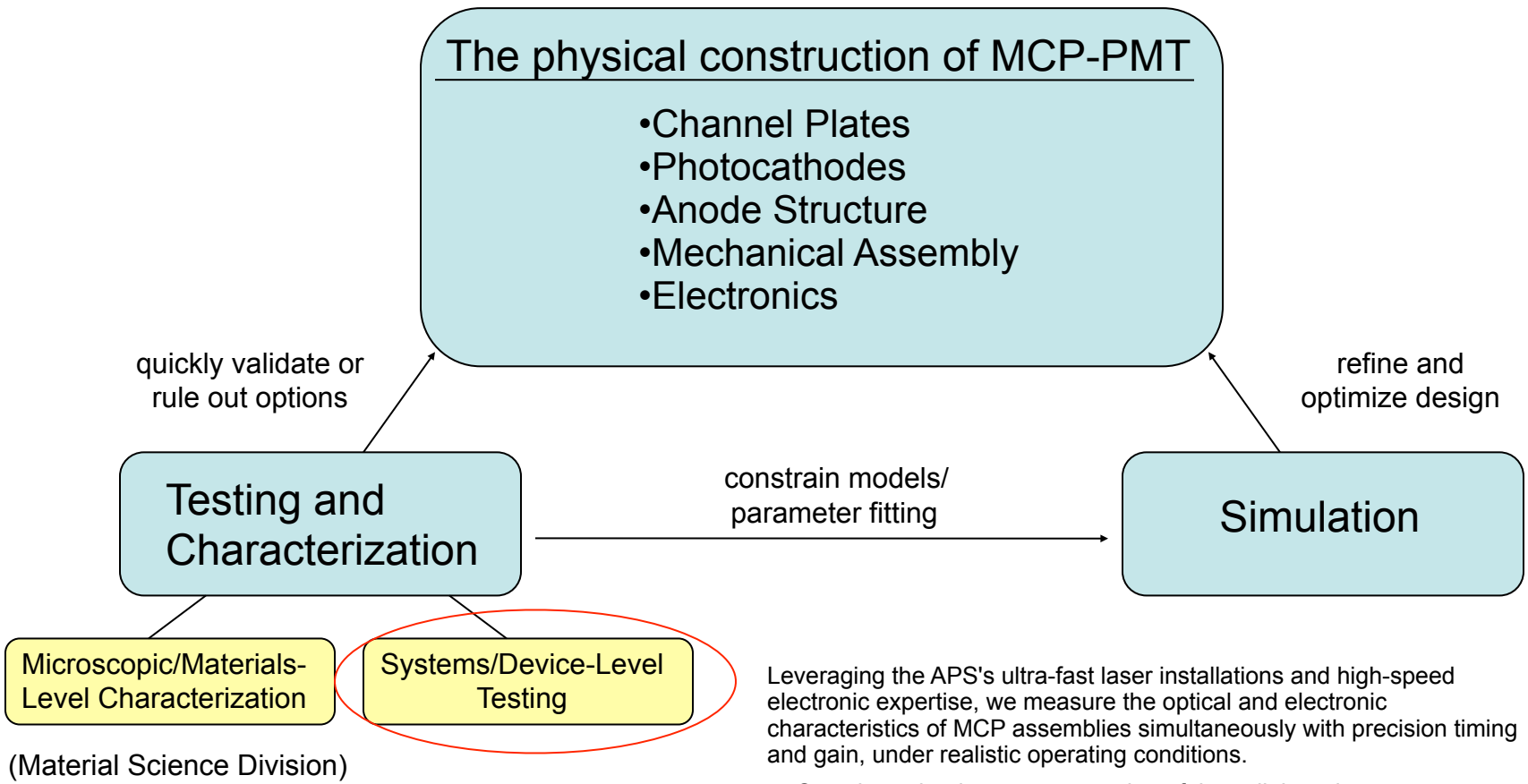
- Picosecond-level time resolution
- Micron-level spatial resolution
- Excellent photon-counting capabilities
- Being expensive



What if we could exploit advances in material science and electronics to develop new methods for fabricating:

- Large area (8"x8"), flat panel MCP-PMTs **(BIG)**
- Preserving that excellent time resolution **(FAST)**
- At competitive costs for particle physics scales **(CHEAP)**

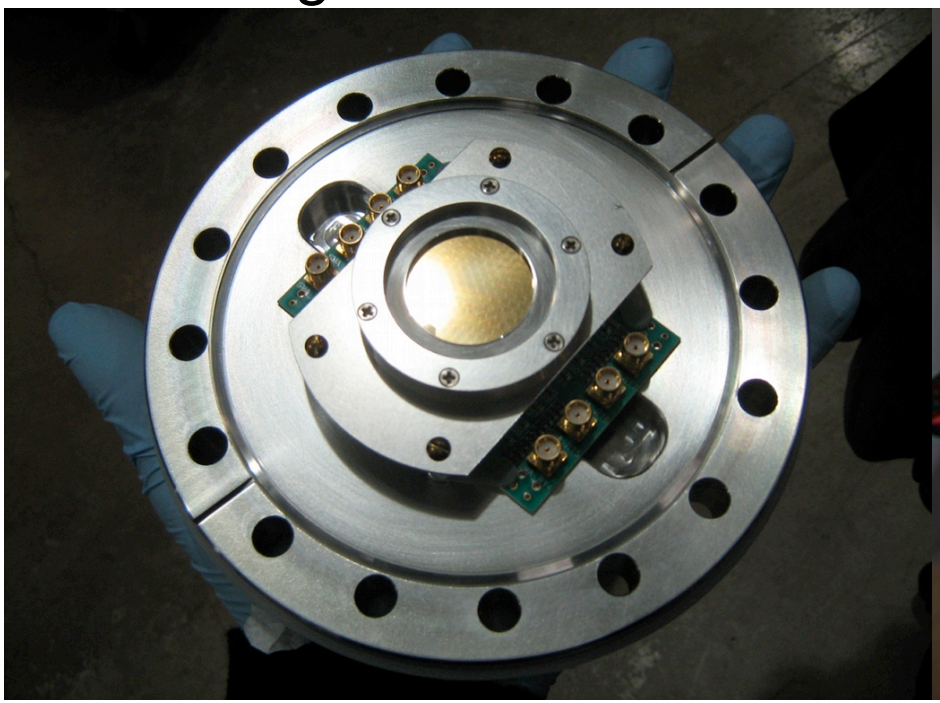
What could this mean for the next generation of neutrino detectors?

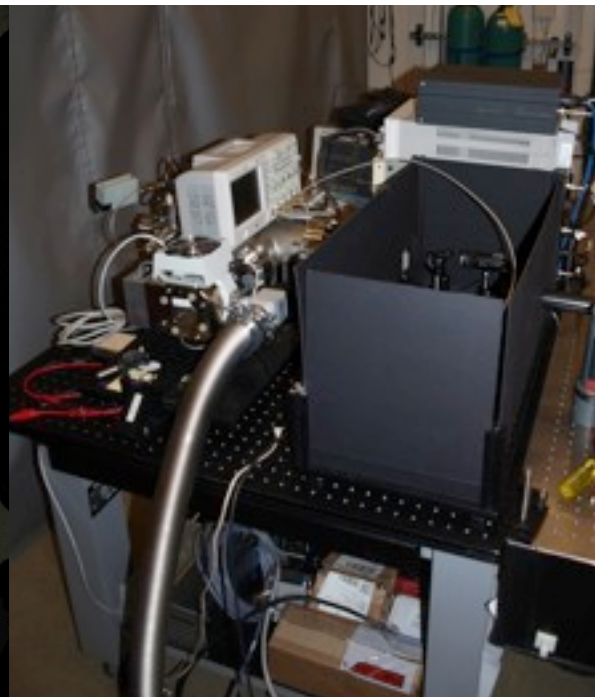


Leveraging the APS's ultra-fast laser installations and high-speed electronic expertise, we measure the optical and electronic characteristics of MCP assemblies simultaneously with precision timing and gain, under realistic operating conditions.

- Cuts through a large cross-section of the collaboration
- Requires close collaboration/coordination with the simulations and fabrication groups

The Testing Lab

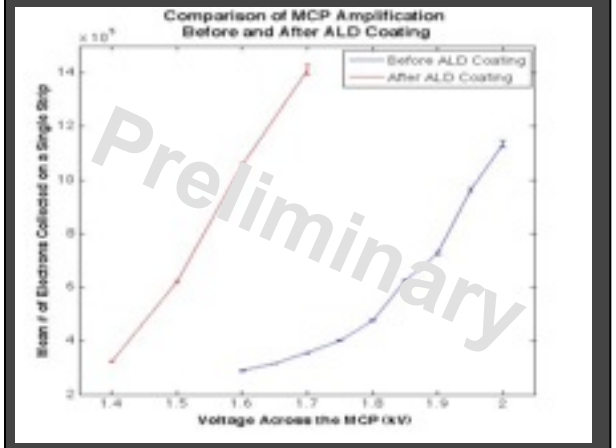


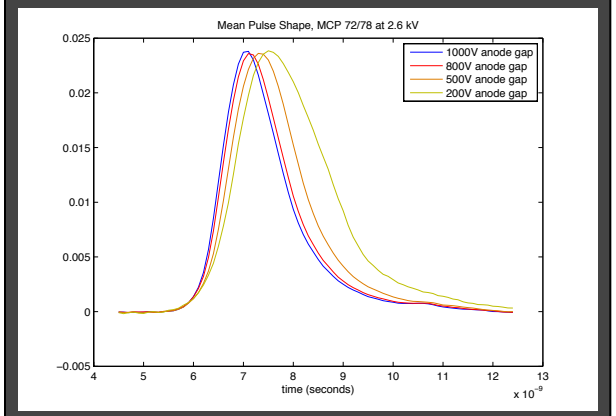


My first year efforts focused primarily on designing, developing, and testing an MCP characterization facility:

- High vacuum system
- Fixtures for assembling various configurations of channel plates, coupled to a stripline anode and photocathode
- Ultrafast laser system and RF electronics
- Development of analysis techniques
- Development of handling and operational techniques
- Automation
- Acquisition of a dedicated laser lab

Early Achievements





B. Adams, M. Chollet (ANL/APS), M. Wetstein (UC, ANL/HEP)

Demonstrated enhanced amplification in commercial microchannel plates, coated with ALD layer.

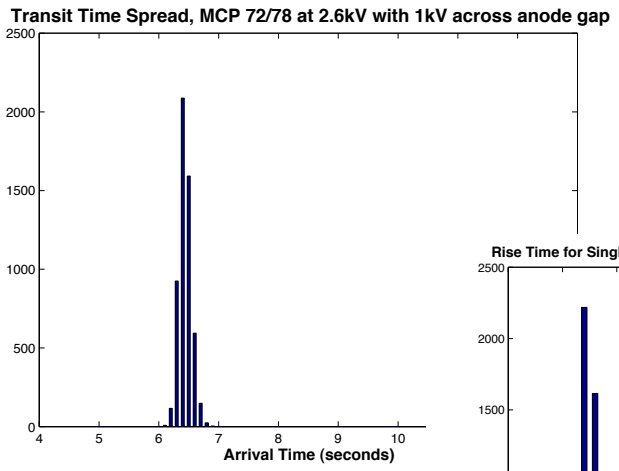
- After characterizing the Photonis MCP, we coat the plates with 10 nm Al_2O_3.
- The "after-ALD" measurements have been taken without scrubbing.
- These measurements are ongoing.

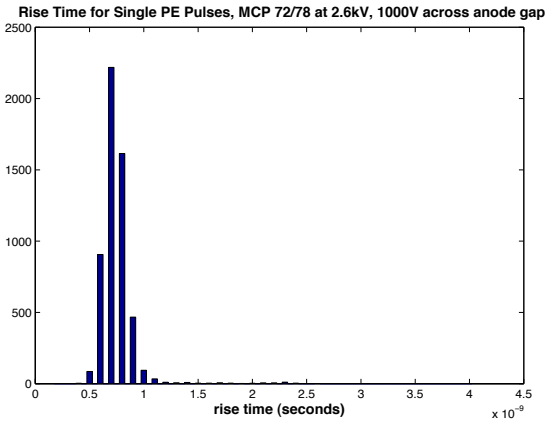
Demonstrated process of MCP fabrication by atomic layer deposition on a 33mm glass filter.

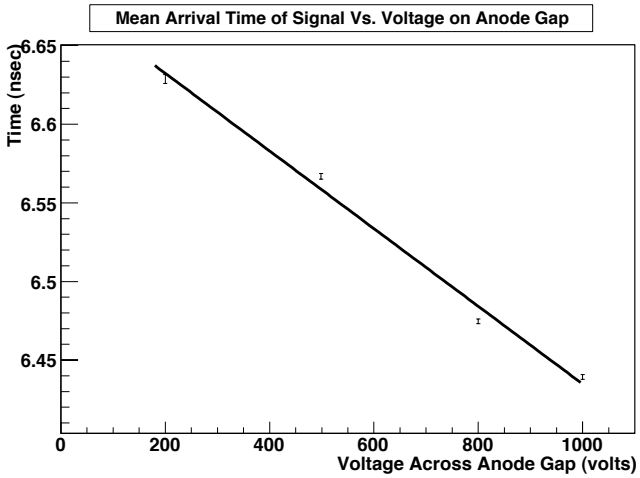
- Able to control resistance of the plates for several different chemistries

Demonstrated >10^5 amplification on pairs of ALD-functionalized glass plates.

Early Achievements







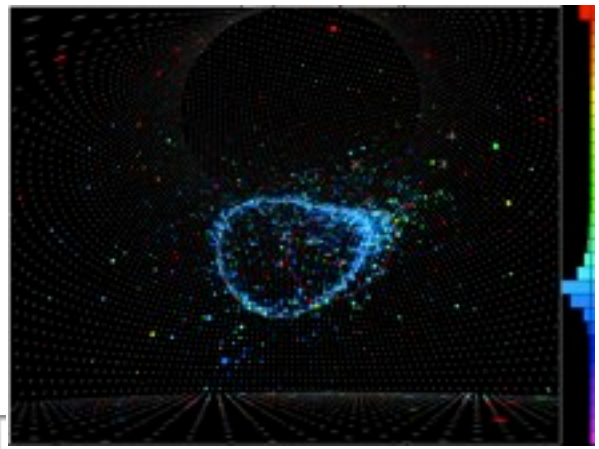
First analysis of the timing characteristics of ALD-based MCPs

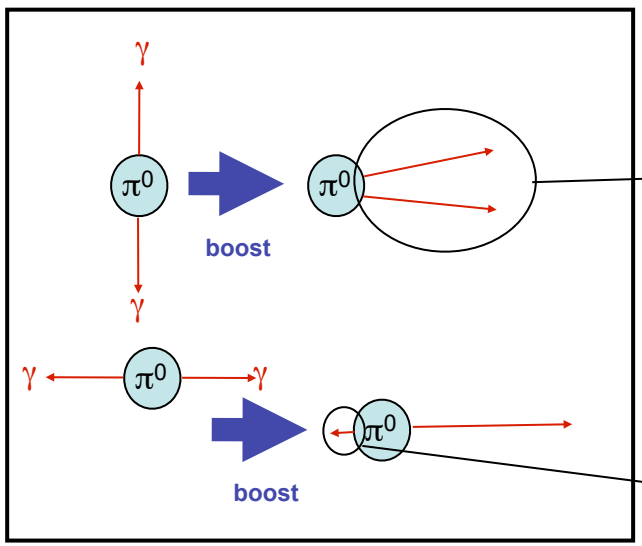
- Aiming for several publications by early fall
- First comparisons with our simulations group (work in progress, but exciting)
- Systematic, fully automated testing of MCPs in our completed system to begin by this Monday!

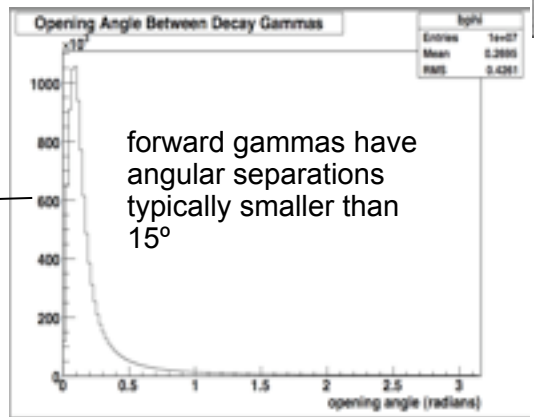
Thinking About Neutrino Applications

As a possible successor to photomultiplier tubes in water-Cherenkov based neutrino experiments

- Provide better coverage
- could use timing information to improve tracking and vertex separation
- might suppress largest reducible background - neutral pion fakes an electron







forward gammas have angular separations typically smaller than 15°

could use improved sensitivity to low momentum gammas with better coverage

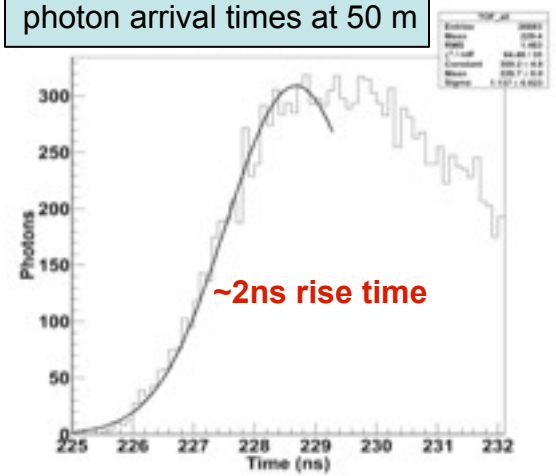
Other Possible Advantages:

- Better magnetic susceptibility (applied magnetic field?)
- Further cost reductions by
  - requiring less bulk mass for the same physics
  - cheaper excavation costs
- better particle ID (ability to resolve the sharpness of ring-edge)
- better able to reconstruct events close to the wall
- Could imagine new tank geometries

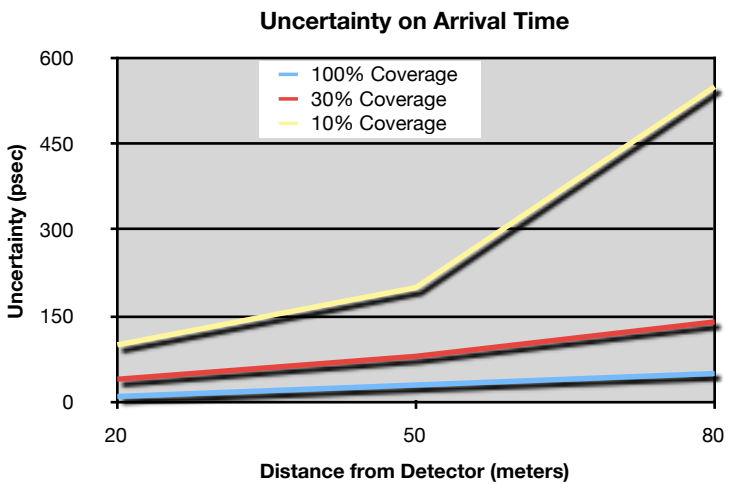
Possible Neutrino Applications

- Chromatic dispersion/scattering/absorption present a problem
- We probably won't need the same time resolution as collider applications
- Still, even at 50 meters, we can expect to do much better than 2 nanosecond resolution in water
- Typical PMT timing resolutions > 1ns

photon arrival times at 50 m



J. Felde, B. Svoboda: UC-Davis

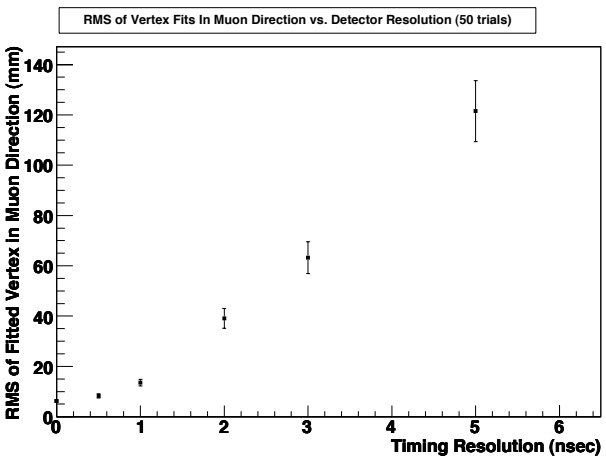


Resolution losses over large distances in water can be recovered with more coverage (photon statistics)

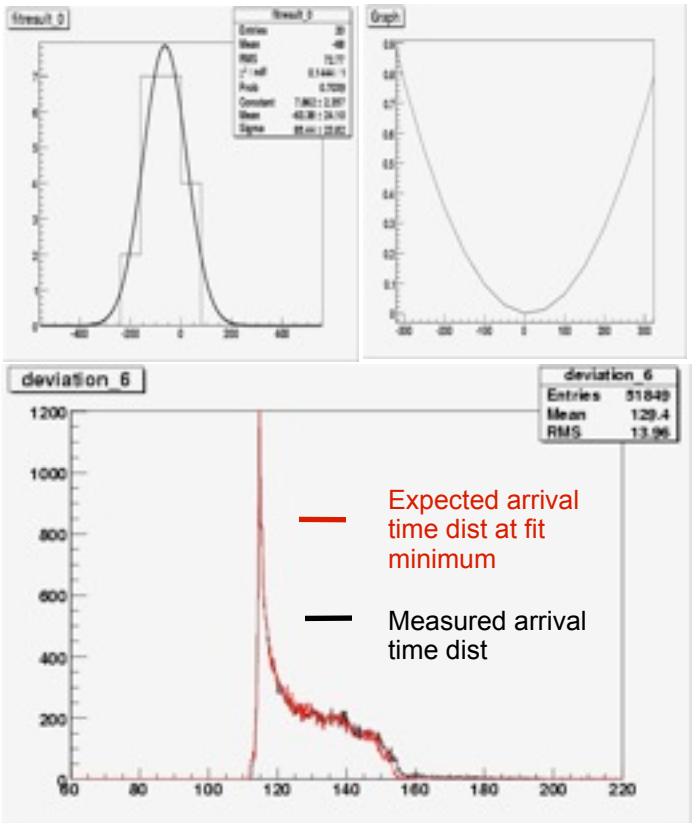
Understanding Timing in Water Cherenkov

TrackFit_x

- Package for analytic track-fitting based on Cherenkov geometry
- Currently optimizing multi-parameter fitting and smoothness of likelihood curve (sanity checks, no chromatic dispersion)
- Goal:
  - to study identification of π^0 backgrounds as a function of time resolution
  - To better understand analysis using large-area, picosecond photodetectors

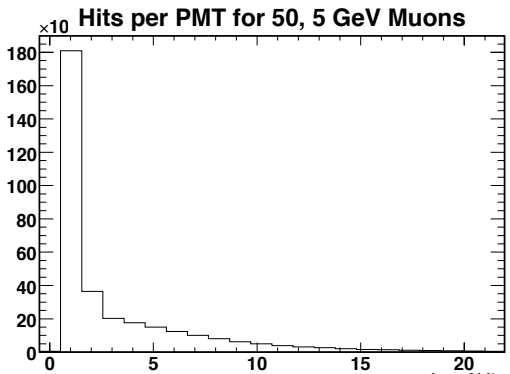


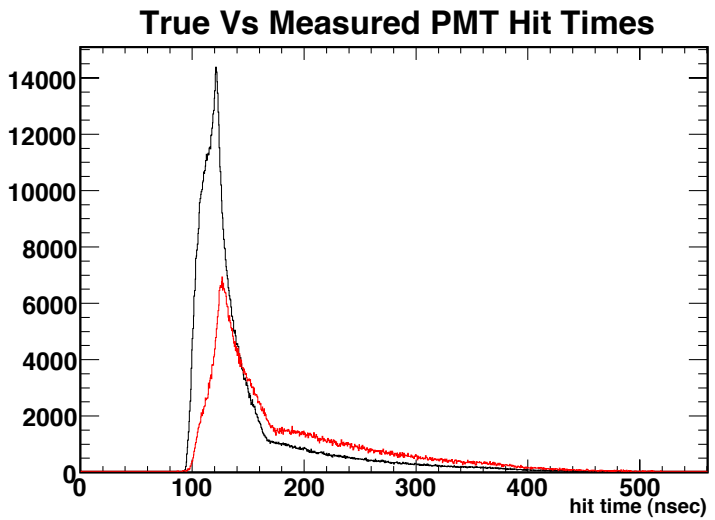
These plots are sanity checks, fitting Cherenkov light from muons, with optical scattering only (no muon multi-scattering, no chromatic dispersion). More realistic cases (including showering particles) soon to follow...



M. Wetstein(ANL/UofC), M. Sanchez (Iowa State/ANL), B. Svoboda (UC Davis)

Next Steps





M. Wetstein(ANL/UofC), M. Sanchez (Iowa State/ANL), B. Svoboda (UC Davis)

- ✓ Generate data directly on the official, LBNE Geant model.
- Apply tracking algorithms directly to PMT data.
- Test tracking algorithms in more realistic scenarios (include chromatic dispersion, etc).
- Coordinate with the LBNE algorithms group.
  - build tools to do particle ID/ring counting
  - keep the algorithms flexible over variations in detector resolution, granularity, and geometry
- Will require a substantial simulation effort
- Could use more manpower...