LBNE Physics Tools Summary

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LBNE Software Readiness Meeting
December 10, 2014

Physics Tools Except for 35t Work

Personnel
Software Tools
Far Detector
CERN Beam Test
Near Detector
Beam Simulations
Fast MC
Interface to GEANT
Nuclear Modeling Generators

Physics Tools Personnel

Much more university involvement than lab involvement in physics tools
- leadership
- group members doing work

Different categories of people
- Students (undergrad and graduate)
- Postdocs
- Faculty
- Lab personnel

Notoriously difficult to draw up a resource-loaded schedule

Peoples' time is fragmented.
Skill sets are uneven.
High turnover – skill loss and need to train new people

Strong international contributions:
- UK
- Brazil
- Italy
- India
- Poland
- Czechoslovakia
- Russia
- Armenia

As of the May 2014 DOE Review, the self-reported involvement in PT is 55 FTE's spread over 153 people.
(FTE's somewhat over-reported, and some physics sensitivity FTE is classified as sim/reco FTE)
Single FTE's make a huge difference! 10*0.1 FTE is not 1 FTE (meetings, task switching, reporting)

Tools provided, supported, or licensed for LBNE PT use

- Redmine
- git
- svn
- cmake
- mrb
- ups
- CVMFS
- BlueArc disk
- TotalView
- jobsub
- dCache
- SAM
- Enstore
- GEANT4
- GENIE
- ROOT
- Fermigrid
- SLF
- Networking
- FermiCloud (so far just used for testing)
- DocDB
- SharePoint
- Central web services
- AFS
- Authentication services
- FIFEMON
- OSG access
- OSG monitoring
- VOMS
- Service Desk
- Desktop support

And many thanks for the C++ summer school

Far Detector Software Work

T. Junk, M. Stancari, M. Convery, T. Yang

De-prioritized in favor of 35t – same people involved, not enough to do both.

Re-use of code and ideas planned, of course.

Channel simulation routines and channel map algorithms were split so as not to impede work on FD during 35t work and vice versa.

Main challenges of FD compared with 35t: Scale!

- More memory needed per event
- More CPU needed per event
- File size
- Geometry representation taking up memory
- Databases (e.g. more dead and noisy channels in the FD).

Detector and Cryostat are still being designed – need agility in the geometry description.

We addressed memory and CPU issues (MicroBooNE also hit some of them and came up with different solutions that we also like).

Gianluca Petrillo has been very proactive in helping us with memory and CPU issues

CERN Beam Test

People needed: Same kinds of skills and interests as for 35t, FD, LArIAT, and MicroBooNE. Stiff competition for personnel and focus.

Software needed:

Detector Geometry: Would like to try the new GGD tools from B. Viren

-- CERN beam test geometry needs a caretaker

Detector/Cryostat/Beam are still being designed – need agility in the geometry description.

Simulation, Reconstruction and Analysis Tasks are wide open.

- Tracking efficiency
- PID
- Momentum Resolution
- Shower Reco

Containment studies underway: T. Kutter, J. Huang , T. Junk

Near Detector Software Started but Needs Lots of Work (and people)

Good starting progess from T. Alion and X. Tian.
See DocDB 9484 (July Collab meeting)

Fine-Grained Tracker G4 simulation, “hisoft”, patterned on larsoft

Redmine page (repository and wiki):

https://cdcvs.fnal.gov/redmine/projects/lbnend

ND will provide many thesis topics for graduate students!

Beam Simulations Progress

Current work:

G4LBNE V3 Geometry: P. Lebrun
coded up in G4 calls in C++. Controllable via G4 input cards

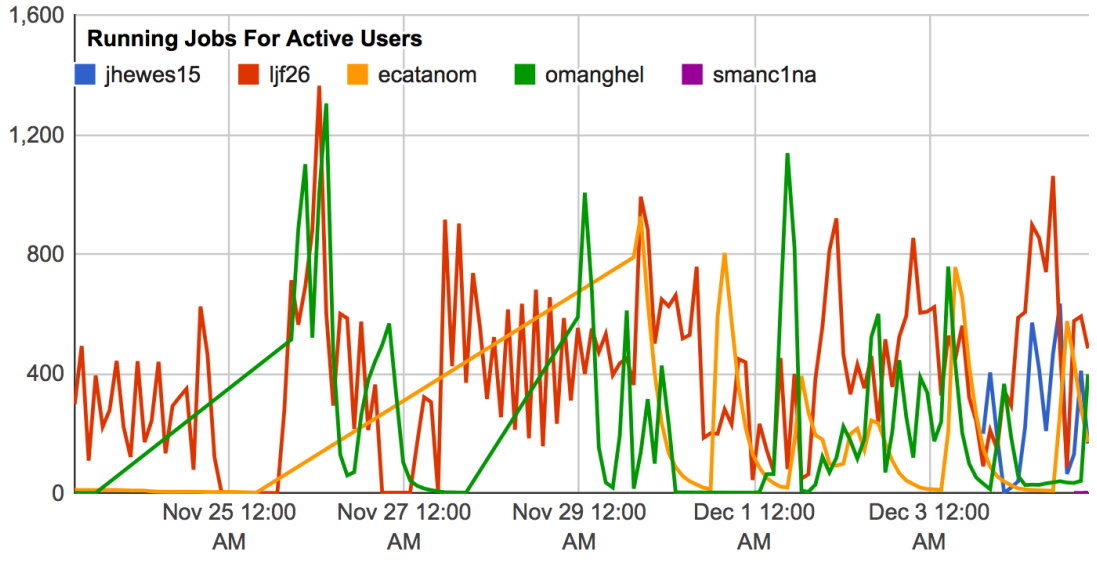
Optimization of the target and horn configuration – L. Fields
studies have followed the chain through the fast MC

Beam design and physics sensitivity – J. Losecco

Characterization of particle production positions: A. Bashyal

Beam simulations is a big piece of our computing effort!

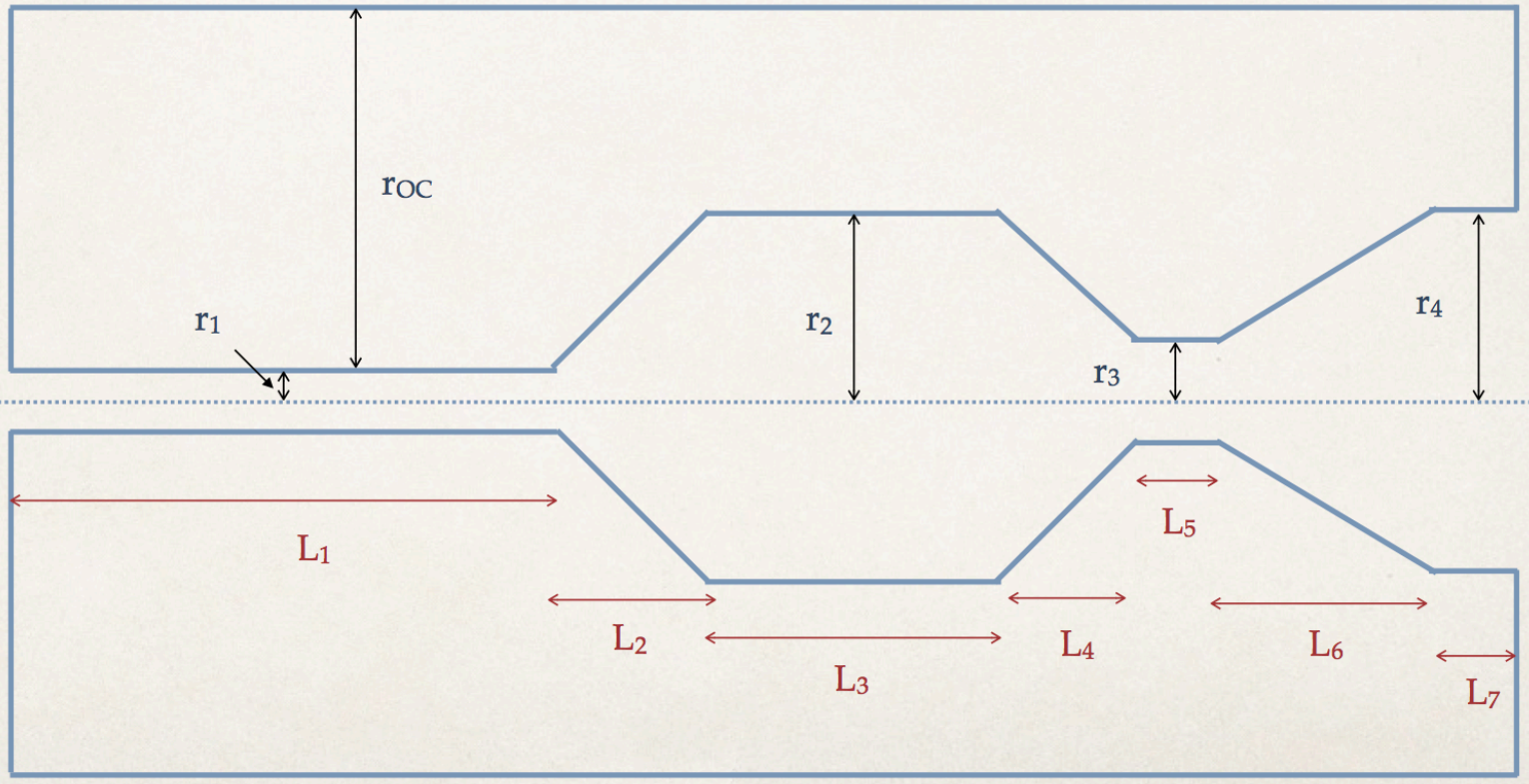
ljf26 == Laura Fields



Laura Fields is Optimizing the Target and Horn Configuration using a Genetic Algorithm

Review of Optimization Procedure

- For the latest optimization, I'm using Paul's simple polycone version of Horn 1 and an LBNO-like shape



Review of Optimization Procedure

- Procedure: I use a genetic algorithm that optimizes approximate CP sensitivity

$$S = S_{\text{nominal}} + \sum_{\substack{\text{j} \\ \text{flavors}}} \sum_{\substack{j \\ \text{E bins}}} (\Delta S(\Delta\Phi))$$

"fitness" of a particular beam configuration

Change in flux observed in a given beam configuration WRT to nominal

A function obtained by using the Fast MC to study changes in sensitivity when the flux in individual bins of neutrino energy and flavor are varied by various amounts from the nominal configuration

L. Fields

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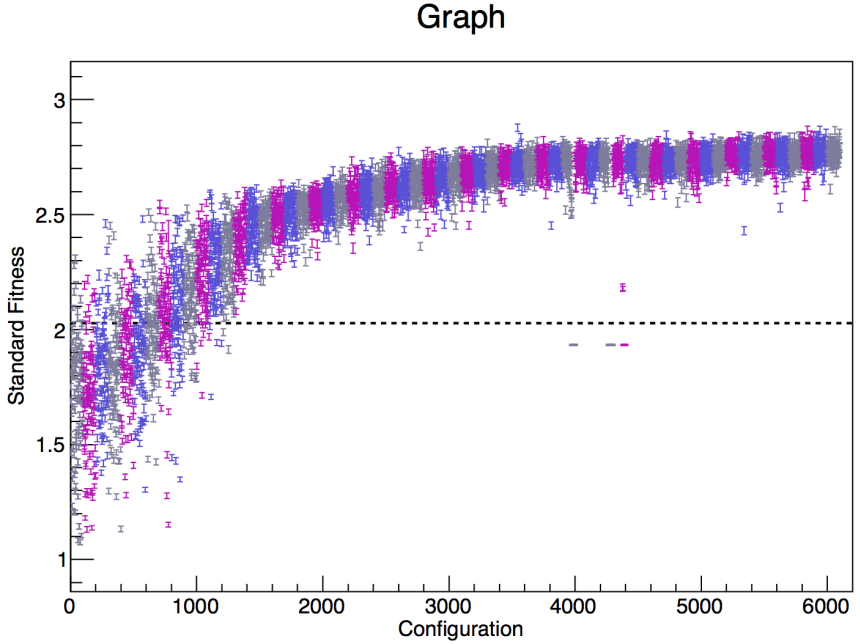
Genetically Optimized Target and Horn Configuration

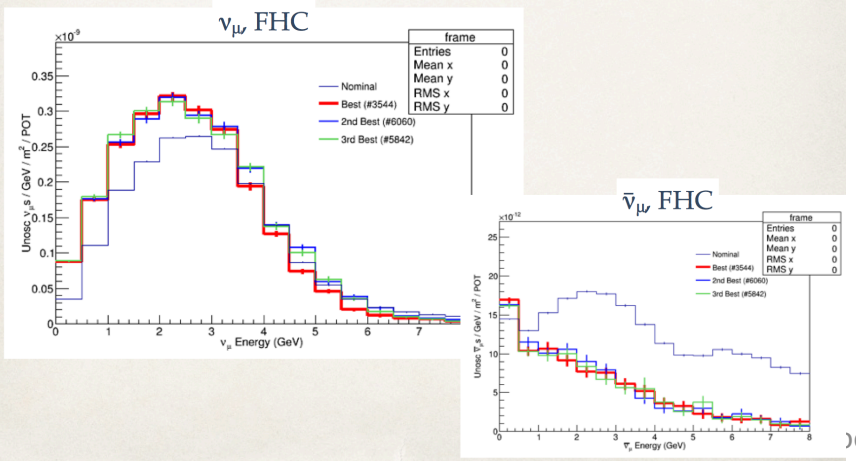
Figure of Merit vs. training optimization epoch: “generation”

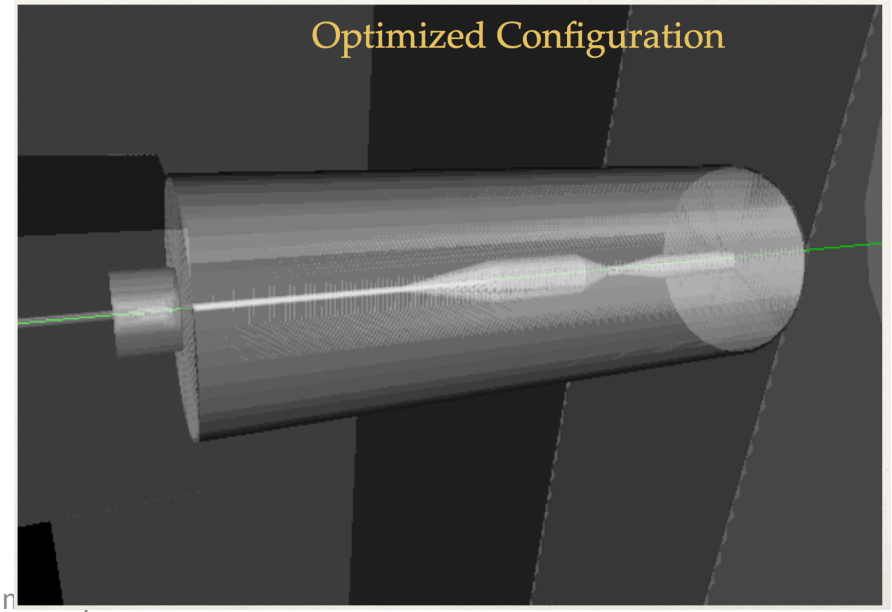


L. Fields

Results: Best Fluxes

- Best fluxes:





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Beam Simulation Software Infrastructure

Main package: G4LBNE. Dependencies: GEANT4, ROOT, dk2nu

Prefer to have high-quality visualization tools available. S. Park was able to use commercial CAD tools to great effect (found some bugs in the geometry with it too)

Software repository: git with Redmine collaborative tools

Build: Standalone make. Built with externals in ups or standalone installs

Highly portable.

Need to roll with the punches from the target design group: High-power targets are thicker and require more cooling.

They have to fit inside the horns, and so optimization of the system includes constraints from constructibility, operability, and maintenance.

Fast MC

Dan Cherdack, group leader.

Code base: Redmine-assisted svn repository
Standard make builds

Primary Externals: GENIE, GLoBES, ROOT
LBNE-specific code: parameterizations of detector response to each particle species: e, mu, p, pi, K, photons

Efficiency
PID
Energy resolution

-> propagate to reconstructed neutrino energy resolution for fully contained and partially contained events

Parameterizations are largely guesswork at this time

FastMC produces our sensitivity plots for δ_{CP} and Mass Hierarchy
FastMC is critical for propagating the effects of systematic uncertainties
FastMC is used to optimize the beam configuration

Computing needs are "modest"

~hundreds of batch slots in spiky usage

Storage is not large (GENIE MC truth trees and flux files)

Can always run more studies of course. Mostly now to propagate nuclear modeling uncertainties

GEANT Group Interface

- Regular attendance at D. Elvira's meetings by L. Fields, D. Cherdack, T. Junk
- Group focuses on physics list tuning
  - LBNE has no data yet, so no contribution to tuning.
  - We are very interested in LArIAT's contribution to GEANT modeling of particle interactions in LAr
  - CERN beam test will contribute also – need to get the right people together to define the proper analyses and useful inputs to GEANT modeling

Nuclear Models and Generators

As for GEANT, we cannot contribute yet as we have no data

Some LBNE collaborators are also prominent GENIE collaborators and contributors:

C. Andreopoulos
C. Mariani
R. Hatcher

Tuning of GENIE to available data ongoing. Interesting nuclear correlations spotted by ArgoNeuT for example have yet to go in.

Anticipate large tuning work when LArIAT, MicroBooNE, and JLab e-Ar experiments get underway.

GENIE computational issues may be appropriate targets for SCD to address (if not already).

- Spline files
- Complex geometries and materials (maybe this is just an experiment issue)

Extras

Interface with FNAL Scientific Computing Division

Fermilab SCD supports:

ART (framework) large team of support personnel: C. Green, J. Kowalkowski, M. Paterno, L. Garren, K. Knoepfel, and others

LArSoft: E. Snider, G. Petrillo

SAM and Enstore: large multi-experiment support team. LBNE rep: Q. Li

Code repositories and Redmine: https://cdcvs.fnal.gov/redmine/projects

Database infrastructure (but we have to write our on database schema)

A Run Database is critical – searchable documentation for runs beyond what's in the file metadata. I don't know of plans to get one going. All experiments have one.

Conditions database – J. Paley of ANL has volunteered. Support from FNAL (I. Mandrichenko) for infrastructure. Do we need a full-blown conditions DB for the 35t? Some propose more informal conditions data exchange out of iFIX to the offline – may be sufficient. Doubtless we'll turn some knob whose value is not in a DB and have to record it somewhere.

LBNE Software and Computing Group

L. Sexton-Kennedy and M. Potekhin

Weekly meetings Thursdays at 2:00 PM Central time.

https://indico.fnal.gov/categoryDisplay.py?categId=394

Lots of progress on
- S&C requirements
- Code build tools
- Continuous Integration and Testing
- Code distribution
- Data management and distribution
- Geometry Description Tools
- Software releases and infrastructure
- DOE review

People to talk to to get involved (incomplete list!)
Geometry: B. Viren, M. Potekhin
Build tools: L. Garren, B. Viren. B. Morgan, P. Gartung
Continuous Integration and Testing: E. Church
Data Handling and Distribution: Q. Li, M. Potekhin, A. Boehnlein
Software Releases: D. Adams
Grid processing: M. Potekhin
New Users: T. Junk and E. Berman

Software Infrastructure: S. Timm
Collaborative tools:
E. Berman and M. Potekhin