Subgroup 4: Physics & Reconstruction

Breakout Session Slides

LBNC Meeting at CERN

Ryan Patterson

June 23, 2017

High level coordination

Physics Coordination

Ryan Patterson
Deputy: Elizabeth Worcester

No org. changes since last LBNC meeting

Most recent additions (*c*. Jan 2017) shown **in red**

Theory conveners shown **in green**

Physics groups

FD Sim & Reco
Xin Qian
Tingjun Yang
Alex Himmel

ND Physics
Mike Kordosky
Steve Manly

Long Baseline
Matt Bass
Dan Cherdack
Mayly Sanchez
Silvia Pascoli

BSM/Exotics
Alex Sousa
Jae Yu

Nucleon Decay
Jen Raaf
Michel Sorel

Atmospherics
Hugh Gallagher
Alessandra Tonazzo

Low-*E* / SNB
Ines Gil Botella
Kate Scholberg
Alex Friedland

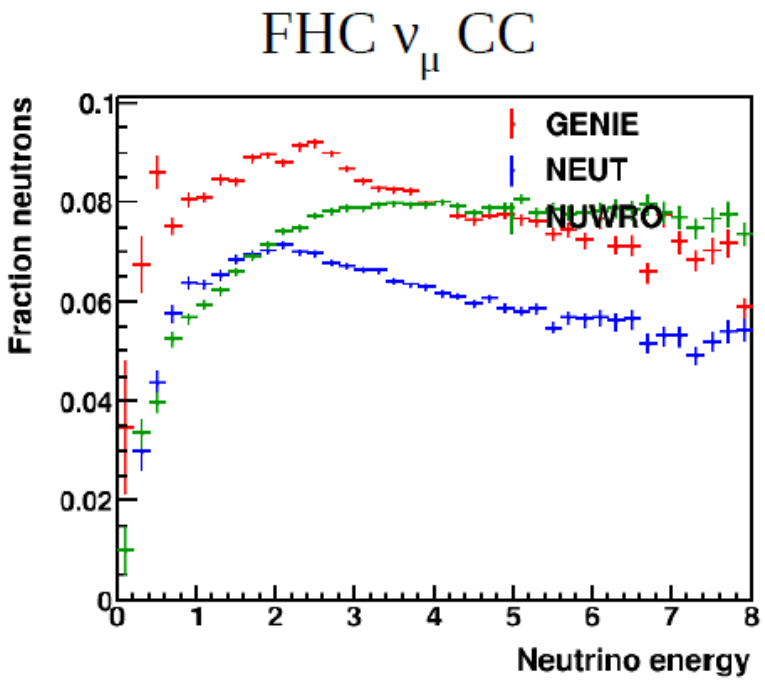
Cosmogenics
Dan Dwyer
Vitaly Kudryavstev

(*i*) ND + LBL Physics activities

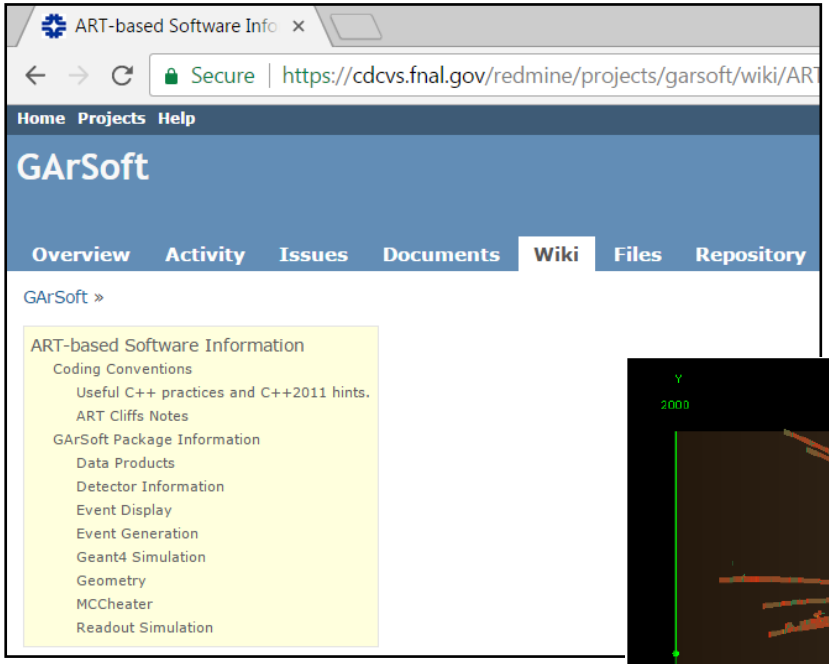
- **ND and LBL physics groups** will continue to have **strong connections**
- **Breakdown of responsibilities** spelled out in DUNE Management Plan
- **Short version:**
  - ***LBL WG*** *responsible for overall oscillation measurement strategy, FD event selections, signal fitting, overall uncertainty budget*
  - ***ND WG*** *responsible for ND software tools, developing useful ND event selections/samples, neutrino scattering models and uncertainties*
  - ***Physics Coordinators*** *and* ***WG conveners*** *responsible for ensuring cross-group coordination*
  - ***All above*** *are responsible for supporting ND Concept Study*

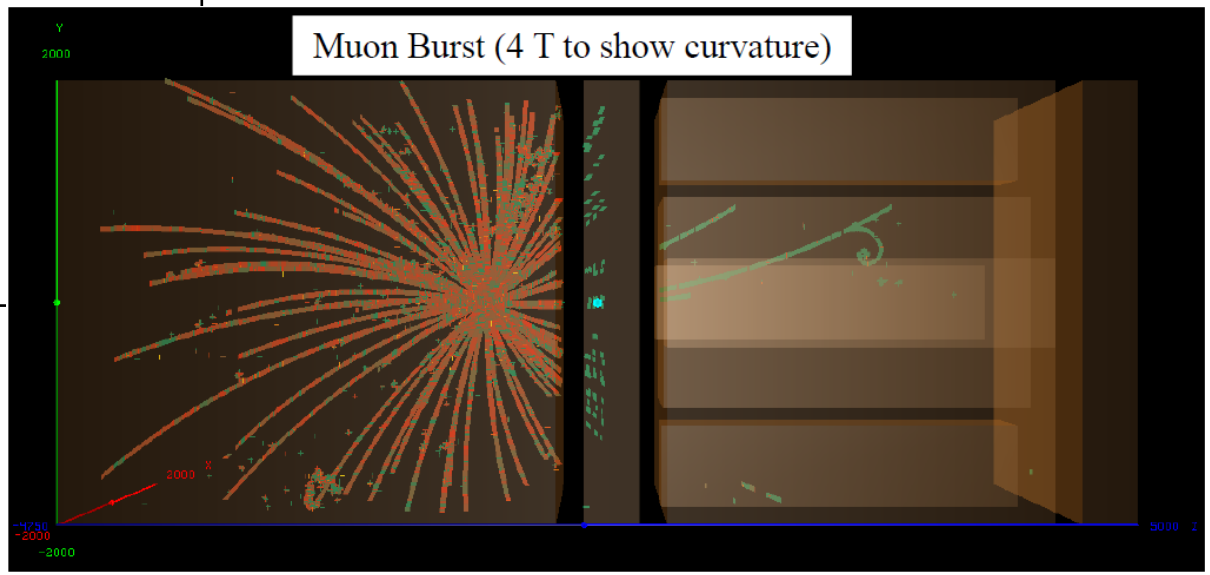
A few highlights…

Neutron energy fraction in ν-Ar scattering in different generators. Studies differences between Far and Near detectors.



Moving sim/reco tools for GArTPC to LArSoft

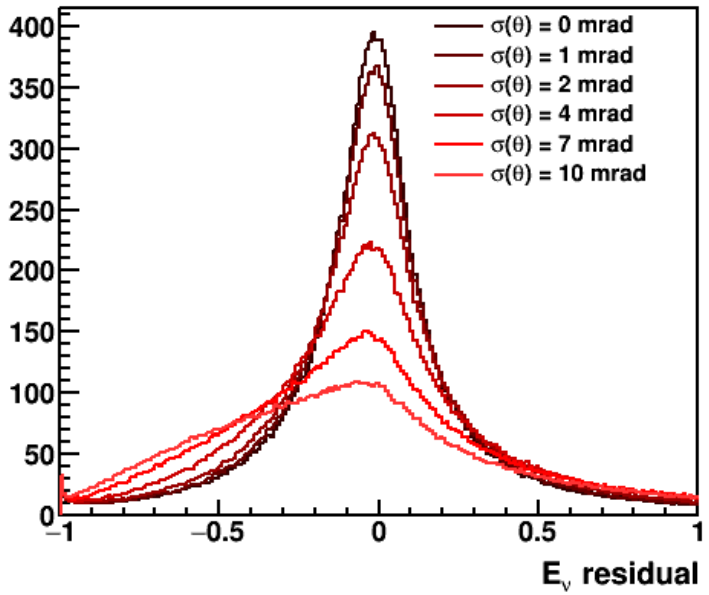


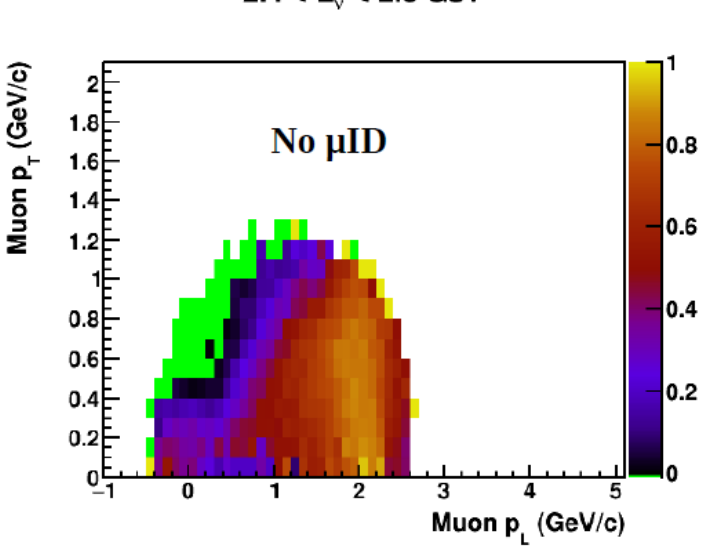


ND General Geometry Description (GGD) tool

A few highlights…

Muon containment studies for LAr ND
(vs. kinematics, LAr geometry)





Studies of intrinsic limits on ν+e scattering
w.r.t. flux normalization, shape measurements

- **Org. note:**
  - New biweekly **Joint LBL/ND Software** meeting
    (run by one LBL WG convener and one ND WG convener)
  - Share updates, plans, tools
  - Coordinate file formats, file production requirements

(*ii*) Long-baseline oscillations – fitting software

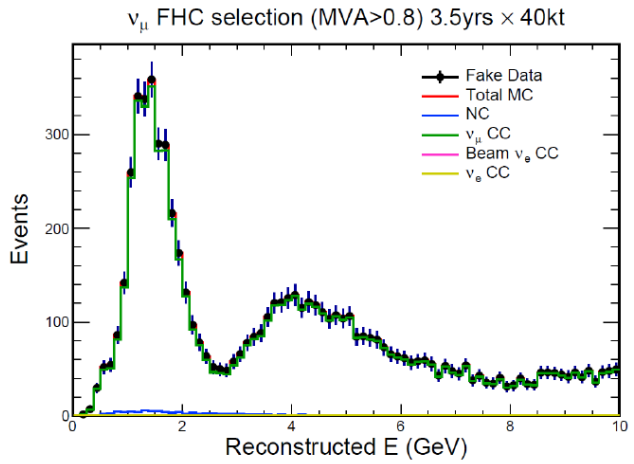
- Following the ND Task Force, the LBL WG has **responsibility for LBL oscillation fitting code**

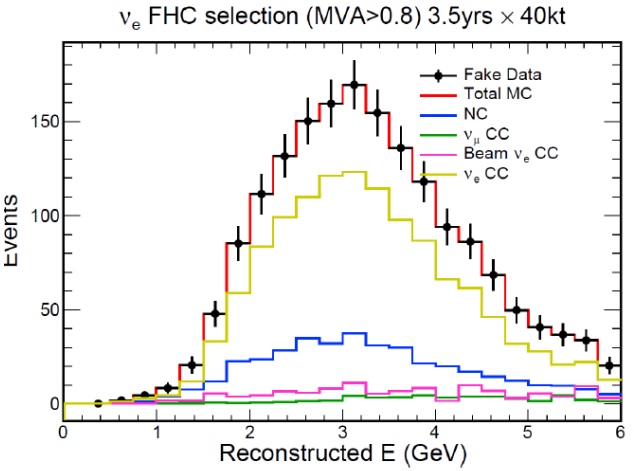
- Fitting tools **must support a range of activities**:
  - "**long" term** (→ full TDR sensitivities)
  - **short term** (→ ND Concept Study support)

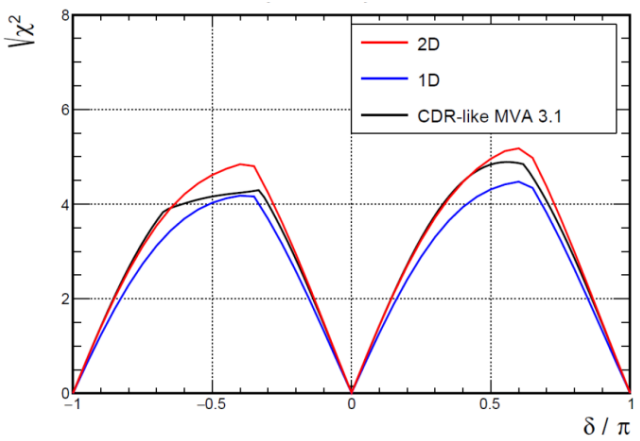
- *Recent step:* **Port of CAFAna** to DUNE *(from NOvA)*
  - Large existing user base
  - Ample documentation, open source code
  - Designed for low barrier-to-entry and fast runtimes (quick studies)

- Port finalized at last collaboration meeting, including cross section and flux systematics. Also: ability to swap cross section models.
  [C. Backhouse, C. Marshall, K. Bays]

- **At right:** plots from CAFAna using official production files
  (details of the plots not too important here, just their existence)
- Complementary to **VALOR** system that served as backbone to ND TF activity.
  [C. Andreopoulos, S. Dennis, L. Escudero]
- Other efforts in this space (*e.g.*, LFit [T. Junk]) under discussion.
- LArSoft-to-GLoBES interface still maintained – and useful! [M. Bass, E. Worcester]
- LBL and Reco group jointly working on revamping FD and ND ntuple file formats
  (improved consistency, convenience; less arcana)

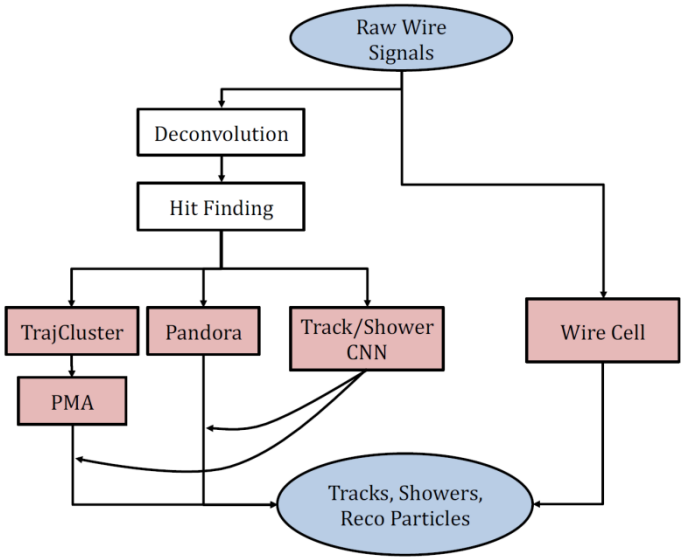




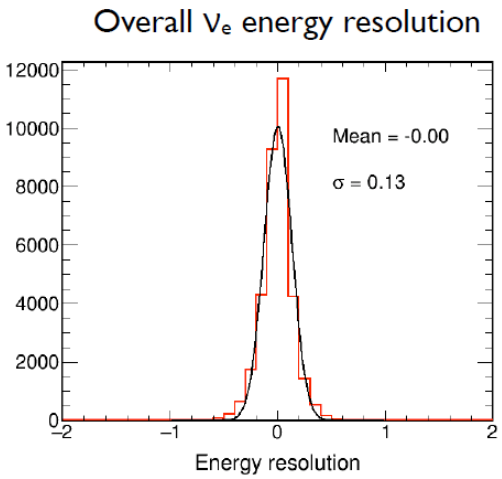


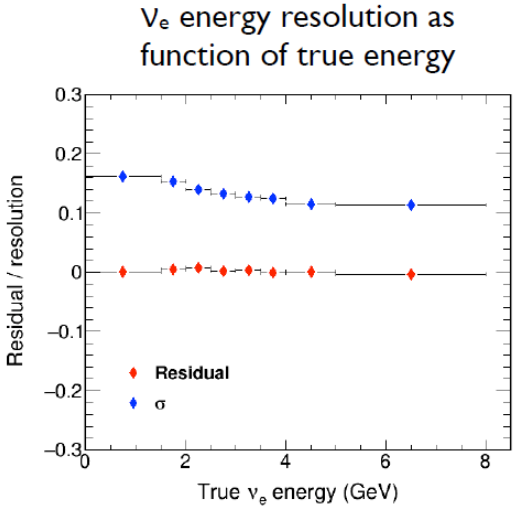
(*iii*) FD event reconstruction and selection

- A. Himmel's talk yesterday summarized details. As a reminder…
- Multiple worthwhile reconstruction paths pursued. Recent progress in track/shower CNNs; first Pandora tunings for DUNE
- Continuing ν_e **and** ν_μ **event selection** improvements: staying abreast of newest reco chains; χ^2-based cut tunings



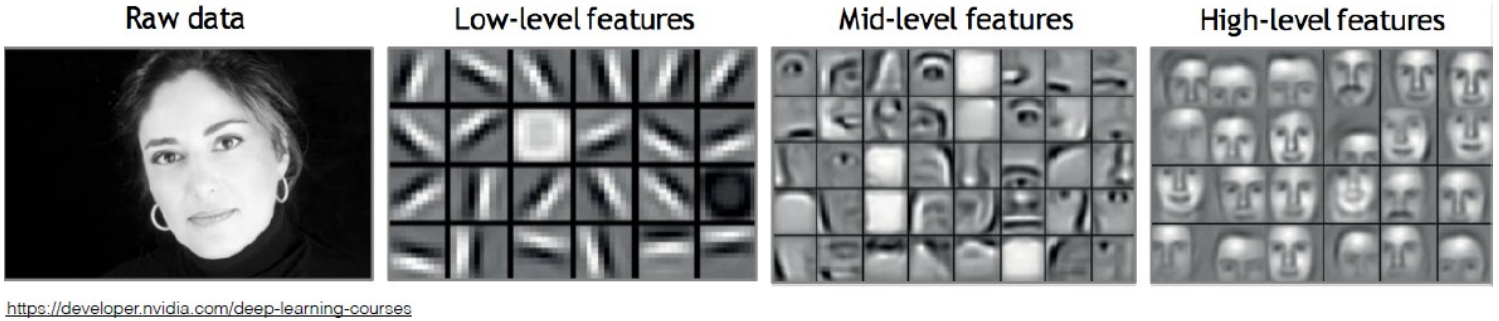
From **A. Himmel**'s talk yesterday



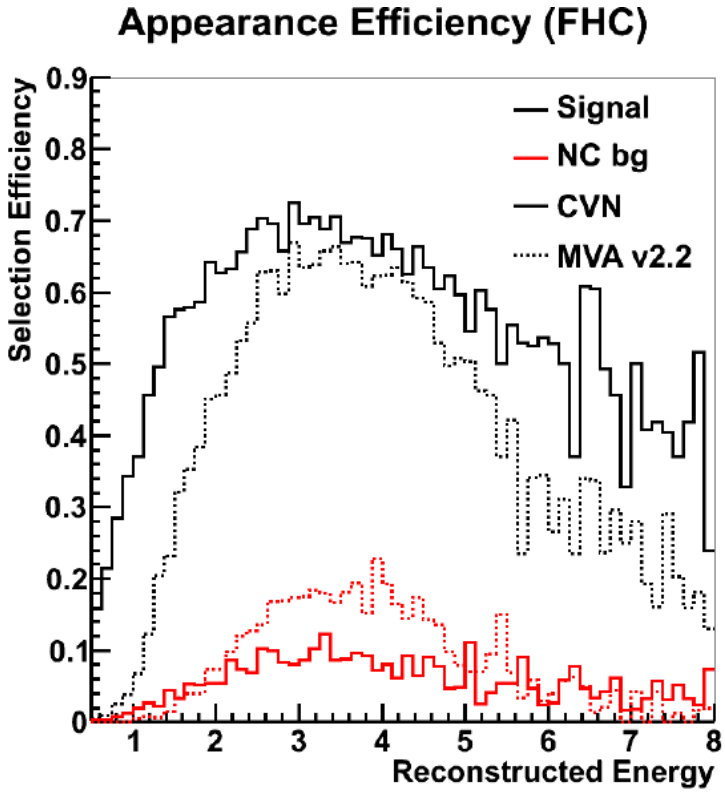


At left: improvements in FD energy reconstruction

- **Major advance:** port of NOvA's "CVN" (Convolutional Visual Network) to DUNE [A. Radovic et al.]



- Inputs are the (nearly) raw images from the **three 2D detector views**
- **For initial implementation**:
  - *nearly straight copy of NOvA network*
  - *no DUNE-specific optimizations*
  - *coarse binning in the drift direction*
  - *image truncation in transverse directions*
  - *small-ish training set*
- **Leading performance** (plot at right)
  - *Tentative: another +10% sig, -40% bg in hand beyond what's shown here!*



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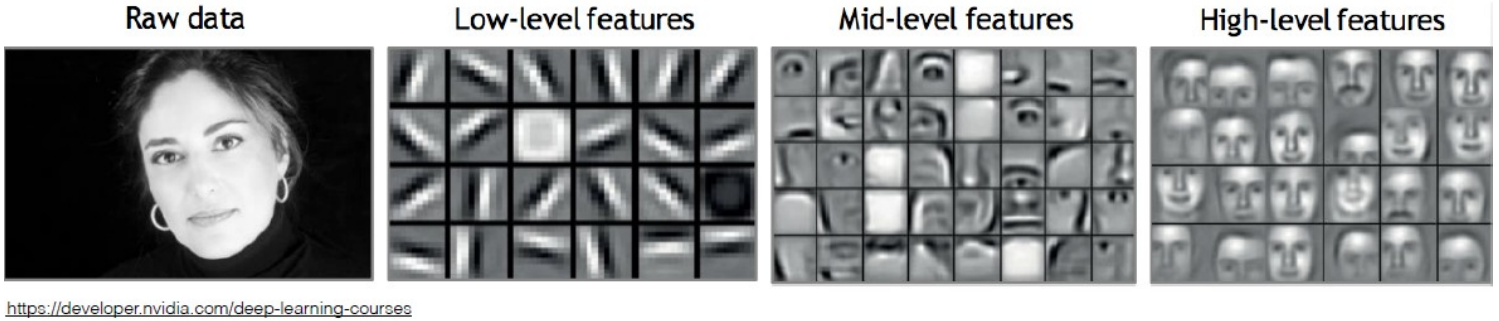

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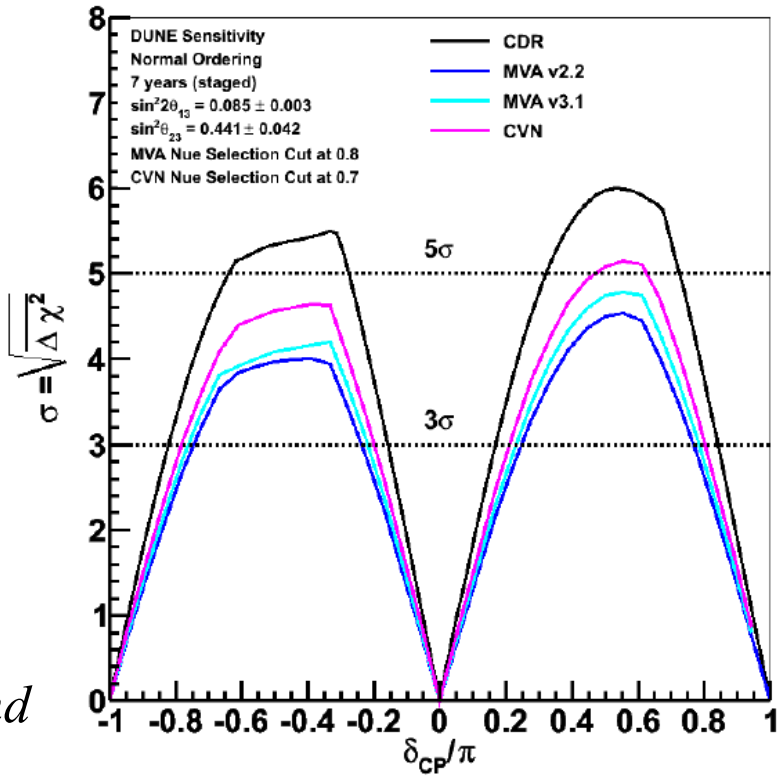
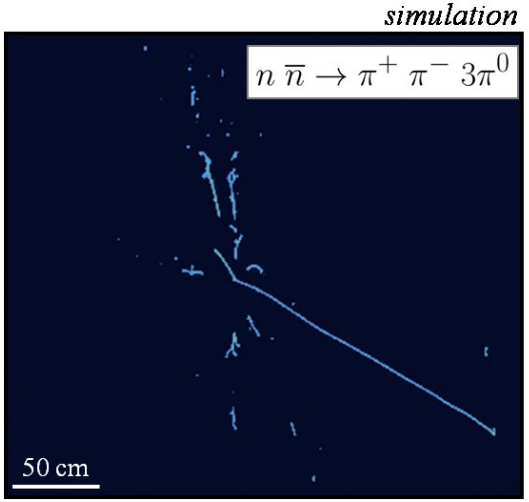


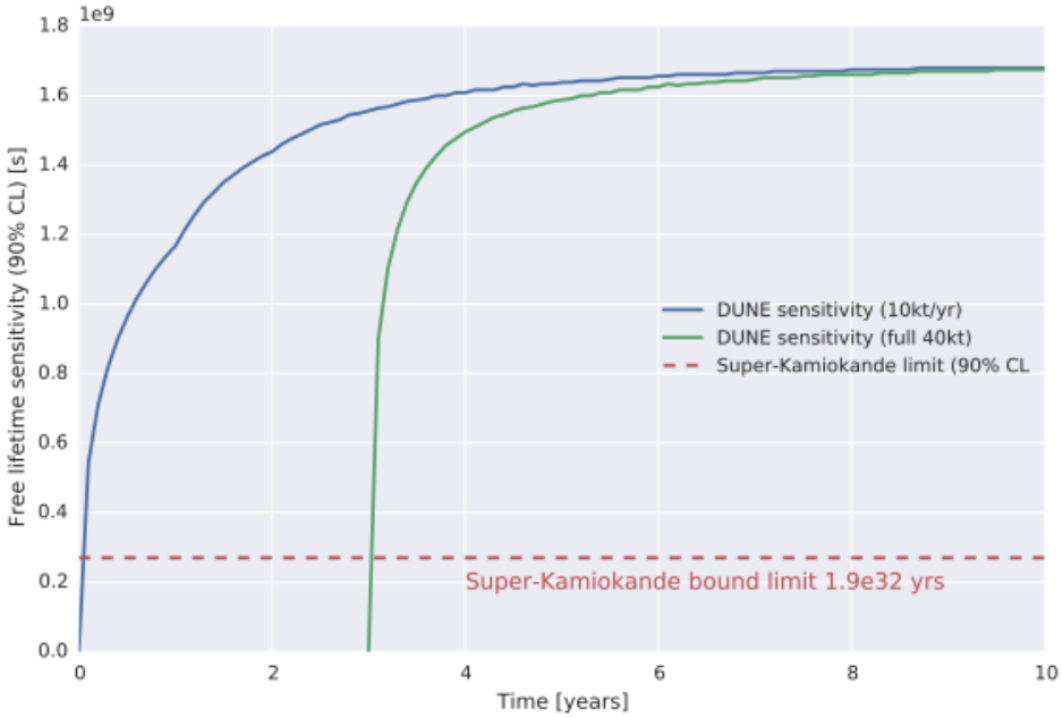
A few additional highlights…

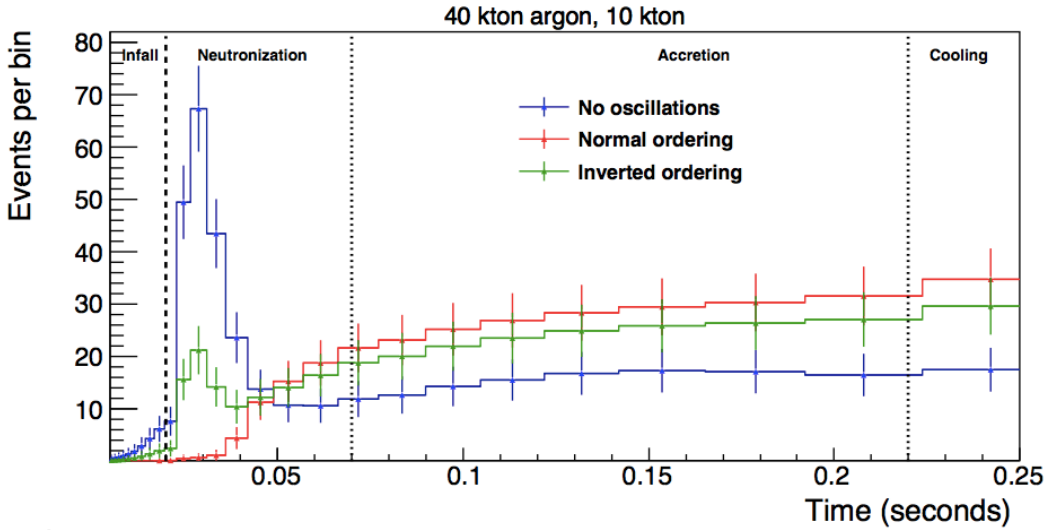
(far from exhaustive)

End-to-end analysis for n-nbar oscillation!

Sensitivity:
~5x current
Super-K limit







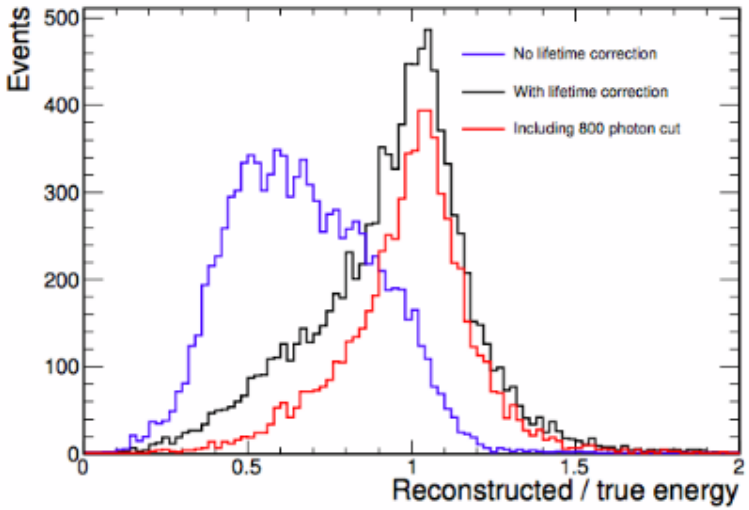
MSW flavor transitions folded into DUNE supernova rate predictions

(Incorporated into SNOwBLoES; also now in github to expand contributor base)

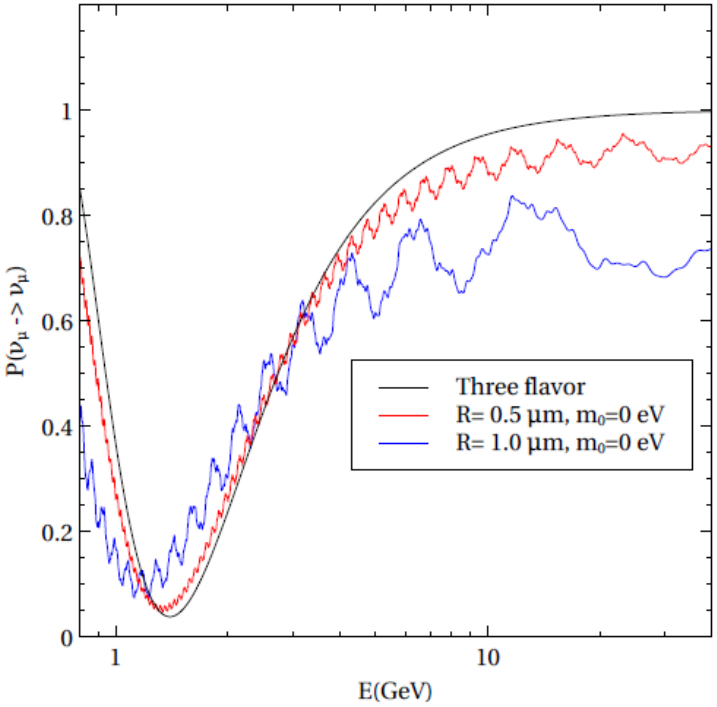
A few additional highlights…

(far from exhaustive)

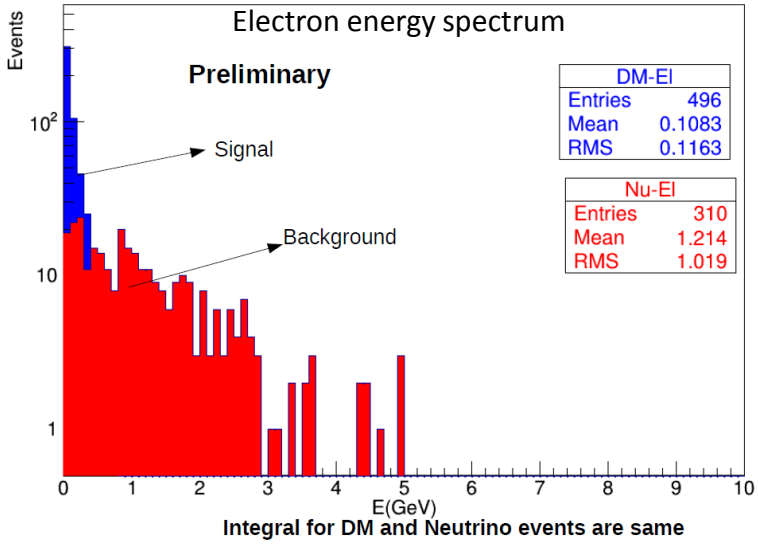
Low energy event (*e.g.*, SNB ν) energy reconstruction incorporating photon detection system for lifetime correction



LED model (Arkani-Hamed, Dimopolous, and Dvali (1998)) implemented



Light dark matter event generator; studies of detector acceptance and spectra



High-level milestones from last LBNC meeting

- Have continued on the planned track. "Status colors" updated below.
- In a couple of slides, will add detail to future milestones to reflect the ramp-up of TDR work.

  - **Q1 2017: Update long-baseline sensitivity calculations**
  - **Q1 2017: Complete assessment exercise**
  - **Q1 2017: Input to final task force reports**
  - **Q2 2017: Launch and populate approved plots page**
  - **Q2 2017: Incorporate tools developed for task forces into physics working groups**
  - **Q4 2017: Determine physics analysis results needed for detector TDR**
  - **Q1 2018: Determine methods to be used for primary results in physics TDR**
  - **Q3 2018: Finalize physics results for detector and physics TDRs**
  - **Q1 2019: Final physics TDR**

(*iv*) Physics Volume of the TDR

- **Physics Volume Editors:**
  Albert De Roeck
  Jon Urheim

- **Working closely with Physics Coordinators** to define scope, timeline, and milestones for production of the Physics Volume

- Care to be taken at the **boundaries between Physics Volume** and **Detector Volume(s)**
  - For the most part things fall clearly on one side vs. other, but there are certainly ambiguous areas
    (*e.g.*, description of the electronics simulation)

TDR Physics Volume: Timeline and Milestones

Jun 2017 — **Define high-level outline, scope** — *today*

Establish document workflow

Aug 2017 — **WGs present detailed outlines, key plots and tables**

(Iteration and adjustments likely, esp. at boundaries.)

For key plots/tables:

- What technical steps are still needed to make each?
- Planned delivery date for proof-of-principle for each?

[Should be Jan 2018 or May 2018 in most cases]

Sep 2017 — **LArSoft integration complete where applicable**

Jan 2018 — **Demonstrate proof-of-principle plots**, *as due Jan 2018*

May 2018 — **Demonstrate proof-of-principle plots**, *remainder*

Checkpoint: **For each high-level scientific goal**

Achieved? Clear path to success by Jan 2019?
Alternative strategies required?

Sep 2018 — **Supplemental internal documentation ready for review**

Jan 2019 — **Analyses frozen. Final plots and numbers assembled.**

Feb 2019 — **Begin internal review of complete draft**

Apr 2019 — **Final version ready for external review**

Recommendations

2017-113 / 22-Mar-17 / Physics

Develop a set of physics performance metrics for the TDR with corresponding development plans by May 2017 so that DUNE can monitor future progress

Response: A timeline and associated milestones have been established in consultation with the TDR Physics Volume editors. The milestones relate both to physics performance and to software/technical readiness. DUNE docdb-3878

Additional schedule notes

- **LBL WG** had a Hack Days workshop Feb 2017
- **SNB WG** has it's next Hack Days workshop August 2017
- **DUNE Physics Week:** Nov 14 – 17, 2017

  - Bridge unusually large gap between August and January meetings this cycle

Discussion…