Near Detector Optimization Task Force

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Draft Charge to the Task Force

- The near detector optimization task force is charged to:
  - Develop GEANT4 simulations of the reference design near detector and possible alternatives
  - Perform a full end-to-end simulation connecting the measurements in the near detector to the far detector systematics using, for example, the VALOR framework
  - Evaluate the potential benefits of augmenting the reference design with
    - a LAr-TPC
    - the use of a High Pressure Gaseous TPC
  - Produce a first report on their findings to the DUNE Technical Board by July 2016 and a final report by December 2016.

- We have begun by developing a few axioms …

Axioms

- The Task Force will evaluate ND options based just on science
  - Budgetary and other concerns can wait
  - Task force charged with making science based recommendations and any decisions by the collaboration will likely include other factors.
- Near Detector performance is judged by its ability to improve the sensitivity of DUNE to CPV
  - Any Near Detector optimized this way will be very capable of the other analysis envisaged for the Near Detector
  - Sensitivity to other physics will be a secondary consideration; cannot degrade oscillation physics
- The ND should allow for measurements on the same target nucleus as the FD (Ar)
  - T2K oscillation systematics increased by target nucleus differences
  - Should include a clear and proven path to extracting cross section measurements on the target nucleus

How to Optimize the CP Violation Oscillation Analysis

- Adopt and extend the approach of the experiment that is presently at the cutting edge of this work – T2K

- Use the VALOR package for ND fits
  - Inputs
    - Event samples from simulations of the Near Detector options
    - Detailed systematic uncertainties (spectral changes, and priors)
  - Outputs
    - Fits of all possible nuisance parameters for a FD fit
    - A covariance matrix that encodes all prior and correlations

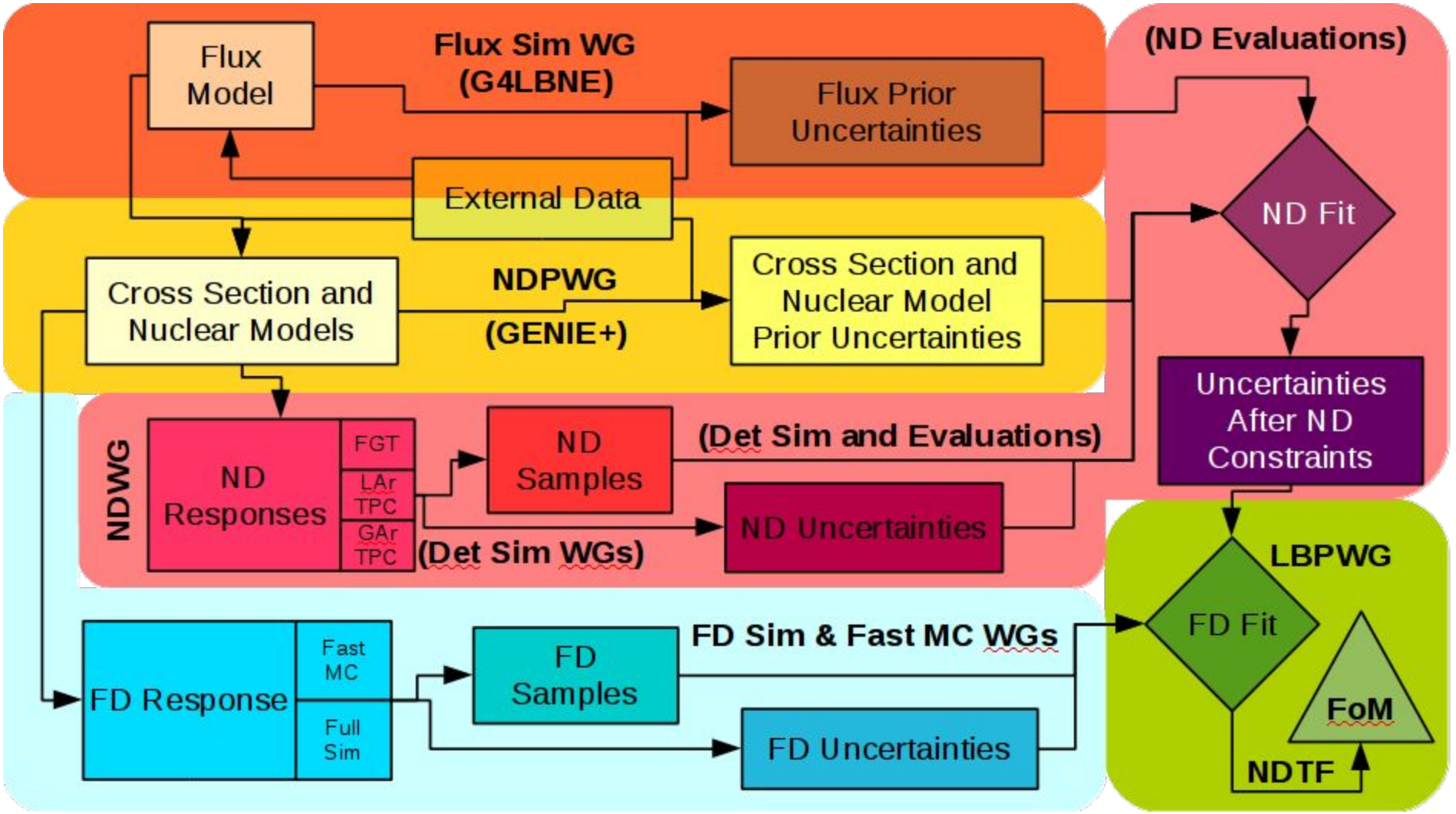
- Oscillation parameter fits with FD event samples
  - Several current tools in use and development
  - A full VALOR ND+FD fit is also a good possibility

Interaction and Communication with Working Groups

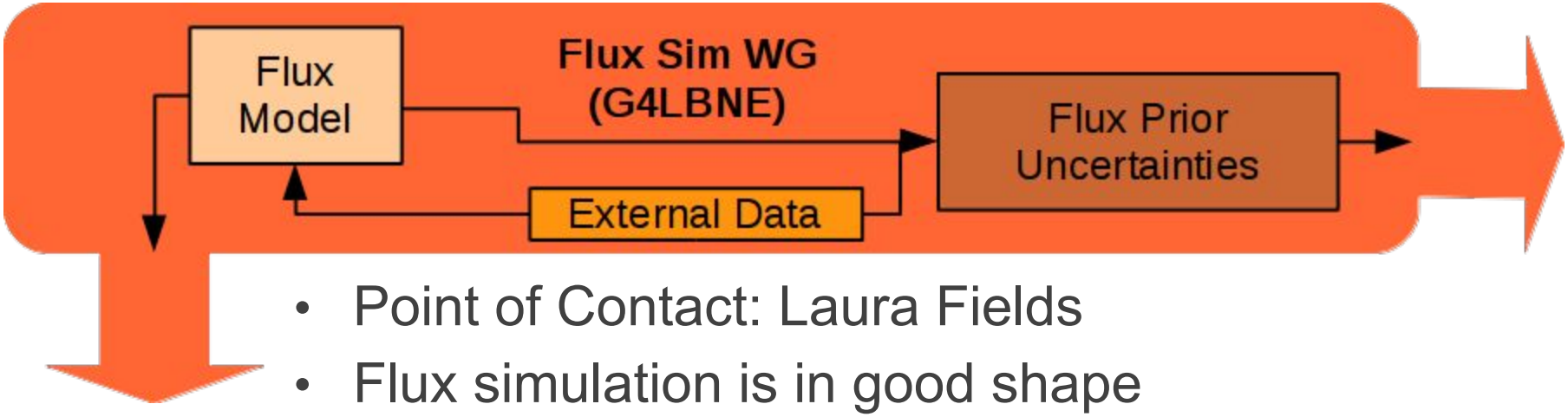
- Physics
  - Far Detector WG
  - Near Detector Physics WG
- Near Detector
  - Straw Tube Tracker WG
  - Liquid Argon TPC WG
  - Gaseous Argon TPC WG
  - ND Evaluation WG
- Software and Computing
  - Beam Sim & Syst WG

- The work needs to be owned and carried out by the WGs
- NDTF leaders will attend working group meetings
- NDTF leaders, Conveners, and WG leaders will meet as needed
- Each link in the processing chain (see next slide) will have a point of contact

Simulation and Analysis Path

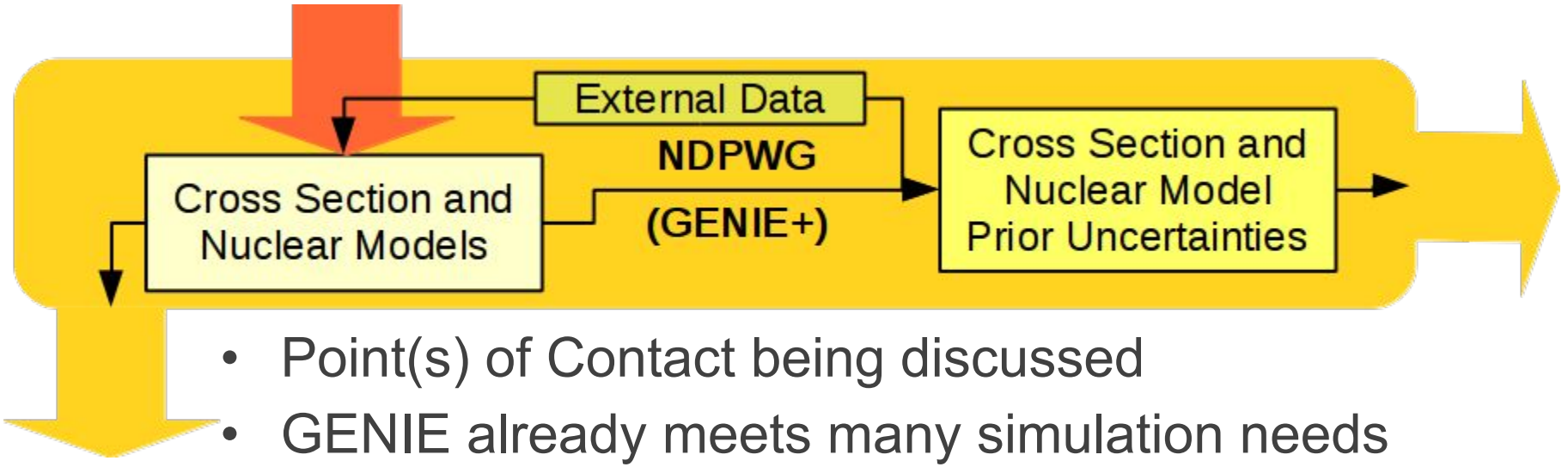


Flux Simulation and Uncertainties



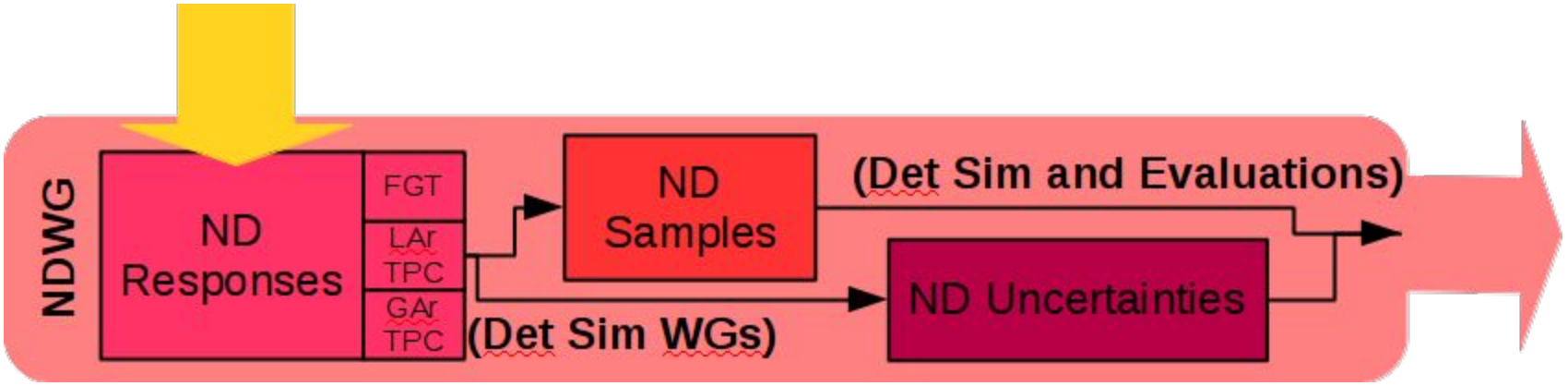
- Point of Contact: Laura Fields
- Flux simulation is in good shape
  - Outputs compatible with GENIE flux driver
  - Incorporates DK2NU
  - Beamline optics uncertainties
- Additional NDTF Needs
  - Hadron production uncertainties
  - Flux covariance matrix encode all uncertainties
  - Stopgap solution: Use Minerva correlation matrix with G4LBNE normalization uncertainties

Cross Section and Nuclear Models, and Uncertainties



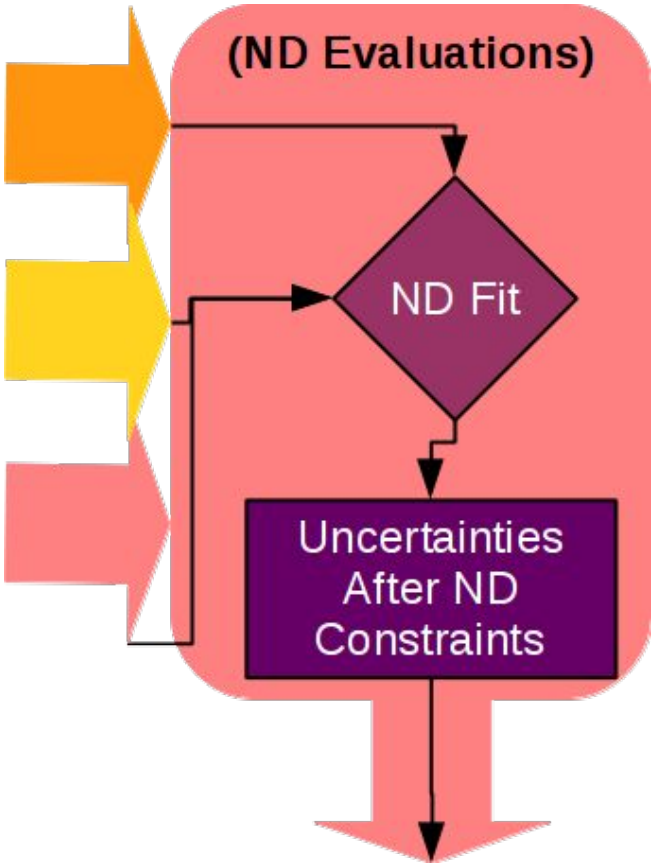
- Point(s) of Contact being discussed
- GENIE already meets many simulation needs
  - Flux driver interface
  - Event generation
- Several key requirements
  - Improved initial nuclear state models
  - Understand FSI model uncertainties and related correlations
  - Retuned systematics with “modern” parameterizations
  - External comparisons / validation

Near Detector Response Simulations



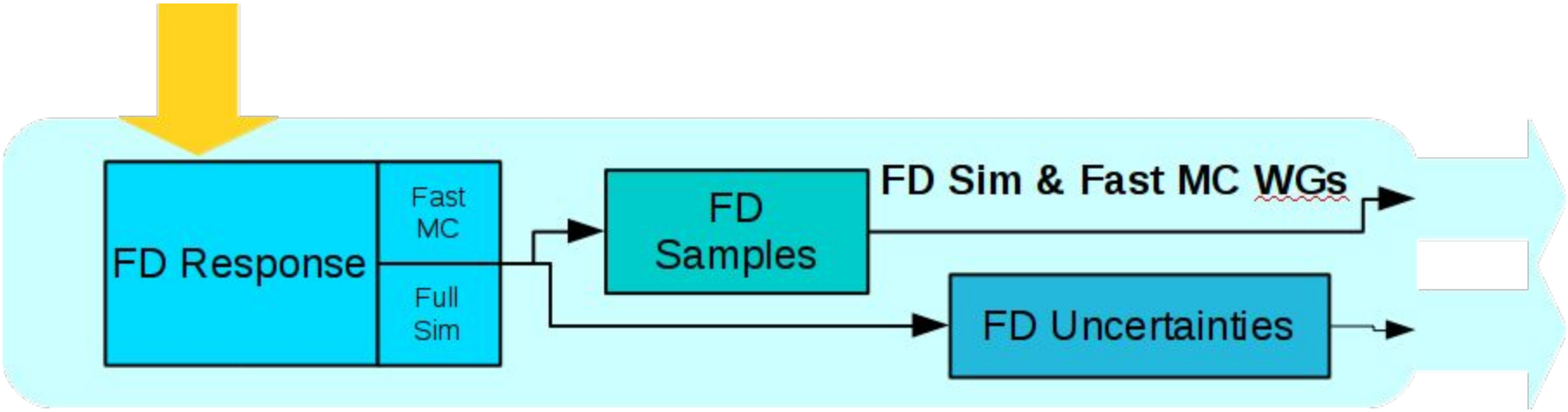
- Points of Contact: Tyler Alion (FGT), Sarah Lockwitz (LAr), Georgios Christodoulou (GAr)
- Event sample (GENIE) files will be provided
- Provide reconstructed quantities for each event
  - Fast MC style simulations
  - Full GEANT4 simulations
- Outputs:
  - Events samples for analysis (in a uniform format)
  - Detector related systematics (e.g. acceptances, energy scales)

Simulation



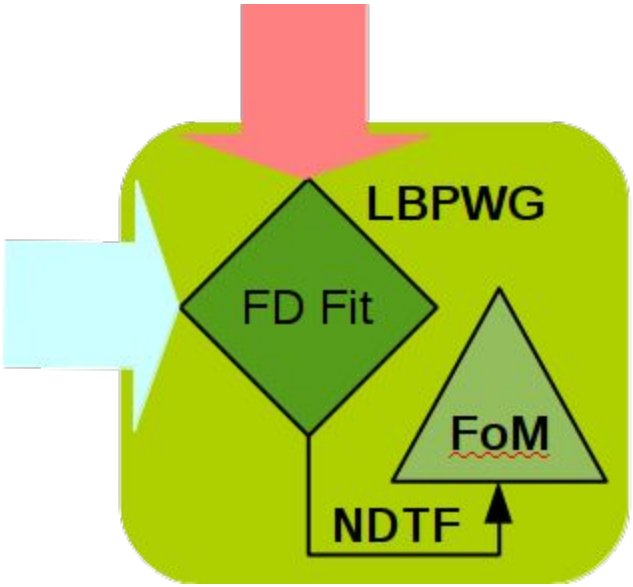
- Point of Contact: Costas Andreopoulos
- Well tested software package developed for T2K and expanded for LBNE, LBNO, and T2HK
- Topologically selected event samples
- Combined fit of all event samples
- Nuisance parameters of the fit cover all sources of uncertainty
- Produces a “post-fit” covariance matrix encoding all ND constraints
  - Directly determine impact on uncertainties
  - Input to FD oscillation fits

Far Detector Response Simulation



- Point of Contact: Elizabeth Worcester
- Generate event samples for combined fits
- Estimate acceptance and energy scale uncertainties
- Currently use a parameterized det. resp. (Fast MC)
  - Works well, but may miss subtleties of a full simulation
  - Needs to be updated based on the latest studies and microBooNE data
- Full det. resp. simulation and reconstruction timescale?

Oscillation Analysis Fits and Metrics for the NDTF



- Point of Contact Dan Cherdack
- Combined fit of 4+ FD samples
  - Current GLoBES based software (MGT)
  - New analysis package / fitting code
- Nuisance parameter constraints
  - Encoded in covariance matrix
  - One matrix per ND configuration
  - Compare with no ND, as well
- Study sensitivity to CPV / δ_{cp} resolution
- Determine metrics which encapsulate the impact of each ND on the studies
  - Report will primarily consider CPV
  - Secondary consideration given to measurements of other oscillation parameters and the science program of the ND

Short Term Goal

- Short Term Goal: Conduct a complete run through of the entire machinery as soon as possible
  - Stripped down and corners cut
  - Discover major issues as soon as possible
  - Give the wider collaboration a better sense early on for how this will all work
- Focus on machinery and interfaces
- Three Questions being addressed by each link in the chain
  - What is in place now?
  - What need to be in place for a first run through of the machinery?
  - What could/should be put in place in the next 12 months?

Schedule

Phase 1 - focus on machinery

Sept 2015 - Jan 2016

- Milestone 1: First complete run through of the machinery
  - Jan 2016

Phase 2 - incrementally improve the physics and simulations

Jan 2016 - Mar 2017

- Milestone 2: Run through to generate material for initial report
  - August 2016
- Milestone 3: Initial Report
  - September 2016
- Milestone 4: Final run through to generate material for final report
  - February 2017
- Milestone 5: Final Report
  - March 2017