Near Detector Optimization Task Force

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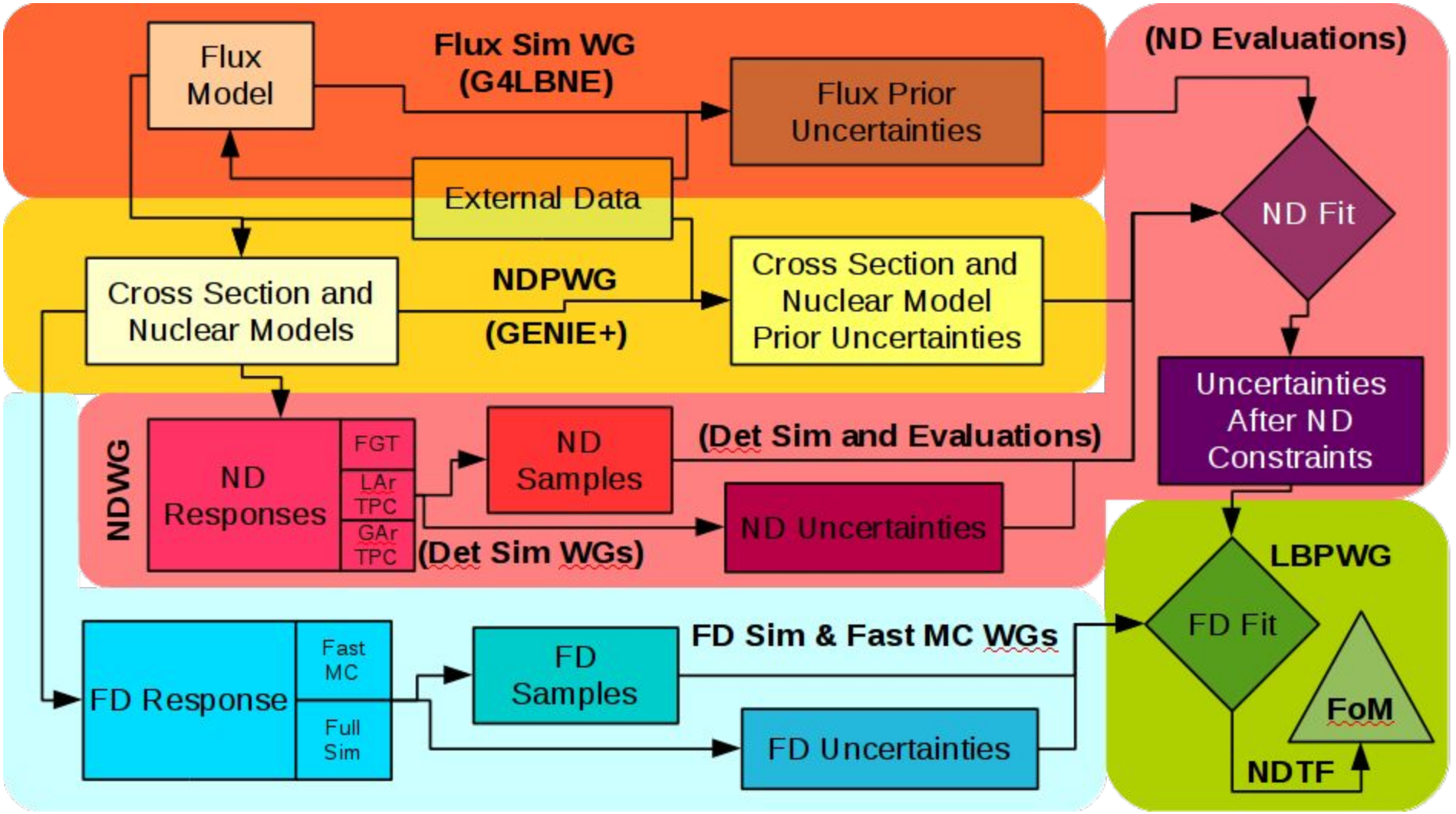
Draft Charge to the Task Force

- 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.

Simulation and Analysis Path



Points of Contact

Flux: Laura Fields
Infrastructure: Robert Hatcher

Cross-Section Models and Systematics: Kendall Mahn → (Rik Gran & Steve Manly)

FGT simulation: Tyler Alion

LAr simulation: Sarah Lockwitz & James Sinclair

GAr simulation: Justo Martin-Albo

VALOR: Costas Andreopoulos

FD Simulation: Tingjun Yang

FD Fit: Daniel Cherdack

Figures of Merit: Brian Rebel

- The points of contact are fully populated, but there is need for more effort within each of the 3 ND simulation efforts.
  - Please contact TF or WG leaders if you're interested

- A number of groups have been stepping forward offering effort

Phase 1 - focus on machinery

Sept 2015 - Jan 2016

- Milestone 1: First complete run through of the machinery (before Arlington meeting)
  - Jan 2016

Phase 2 - incrementally add the necessary physics and improve simulations

Jan 2016 - Sept 2016

- Milestone 2: 2nd run through (before SURF meeting)
  - April 2016
- Milestone 3: 3rd run through to generate material for initial report (before FNAL meeting)
  - August 2016
- Milestone 4: Initial Report
  - September 2016

Phase 3 - final improvements to the physics and simulations

Sept 2016 - Mar 2017

- Milestone 5: Final run through to generate material for final report (before CERN meeting)
  - December 2016
- Milestone 6: Final Report
  - March 2017

2nd Run Through

- Now we get serious about the physics
- Cross-section improvements come to the fore
  - Kendall & Rik & Steve M have put together a wishlist of improvements
  - Costas and his team have implemented a set of systematics in VALOR based on this list with an eye toward model independence
  - Not all items are included, but working examples of each reweighting strategy, and systemic type are included
- Detector geometries for the 3 NDs are OK (perhaps not LAr) now the focus turns to the electronics sim and recon
  - How to mimic state of things 10 years from now, but still have apples to apples comparisons between technologies
  - Simulations are now farily advanced
  - Many reconstruction hurdles loom

2nd Run Through (cont)

- More thought goes into the samples fed into VALOR
  - Fit parameters and samples are being finalized
  - Test fit results are being validated
  - Also need analyses of samples independent of VALOR
- Far detector work is on a great trajectory
  - ND TF just along for the ride!
- Final fit will generate output that can withstand criticism
- Probably little change to flux and flux systematics in 2nd run through
  - In decent shape
  - A lot of work needed to take the next step - LBNF systematics rather than stolen MINERvA systematics

Focus of Updates in this Meeting

- As the time to begin processing grows near each group is focused on:
  - What is feasible for the 2nd run through?
  - What corners need to be cut to ensure the code is ready to produce results for May?
  - What will be easy improvements after the 2nd run through, and what will have to wait until the 3rd run through?

Backups

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

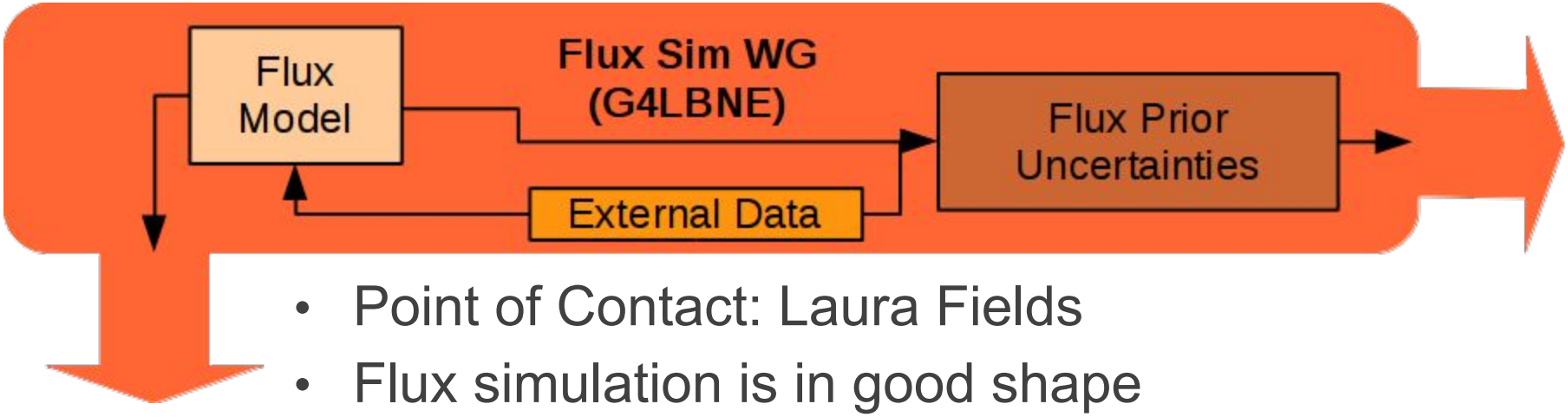
- Adopt and extend the approach of the experiment that is presently at the cutting edge of this work – T2K
- Use the VALOR package for ND fits
  - Inputs
    - Event samples from simulations of the Near Detector options
    - Detailed systematic uncertainties (spectral changes, and priors)
  - Outputs
    - 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

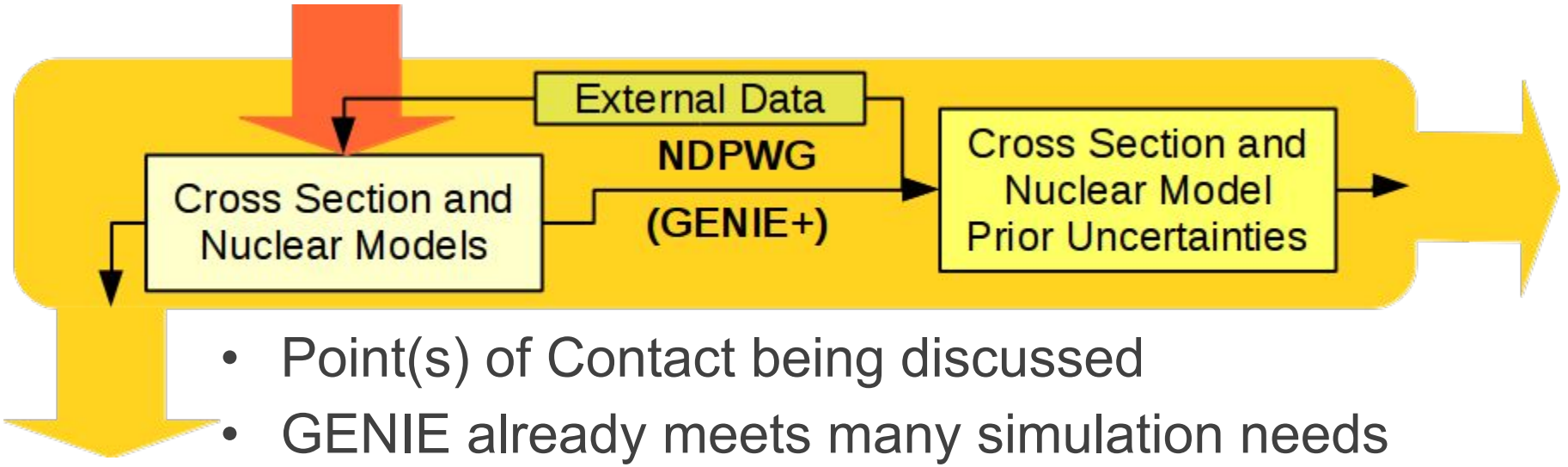
- The work needs to be owned and carried out by the WGs
- NDTF leaders will attend working group meetings
- NDTF leaders, Conveners, and WG leaders will meet as needed
- Each link in the processing chain (see next slide) will have a point of contact

Flux Simulation and Uncertainties



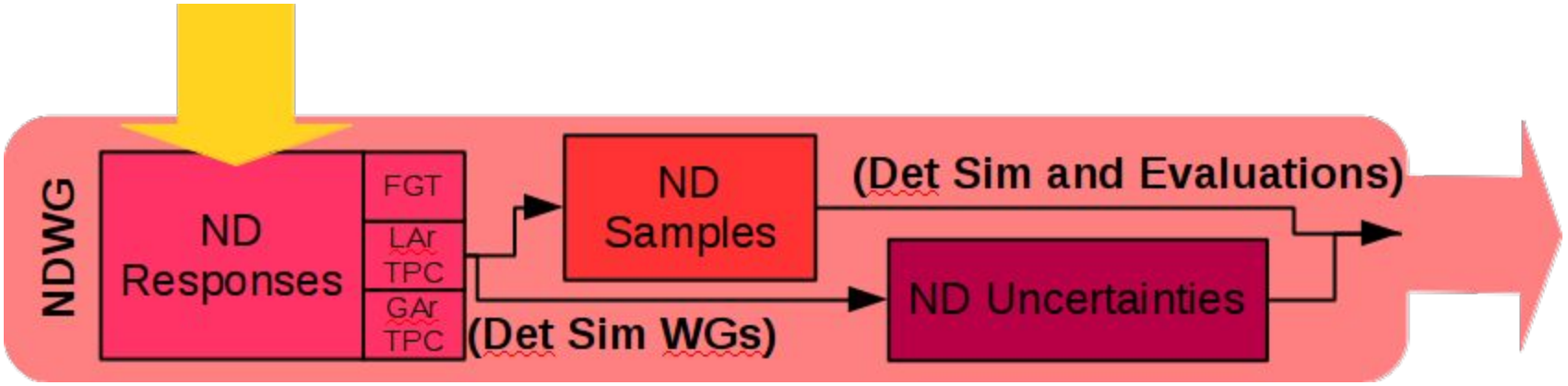
- Point of Contact: Laura Fields
- Flux simulation is in good shape
  - Outputs compatible with GENIE flux driver
  - Incorporates DK2NU
  - Beamline optics uncertainties
- Additional NDTF Needs
  - Hadron production uncertainties
  - Flux covariance matrix encode all uncertainties
  - Stopgap solution: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

Cross Section and Nuclear Models, and Uncertainties



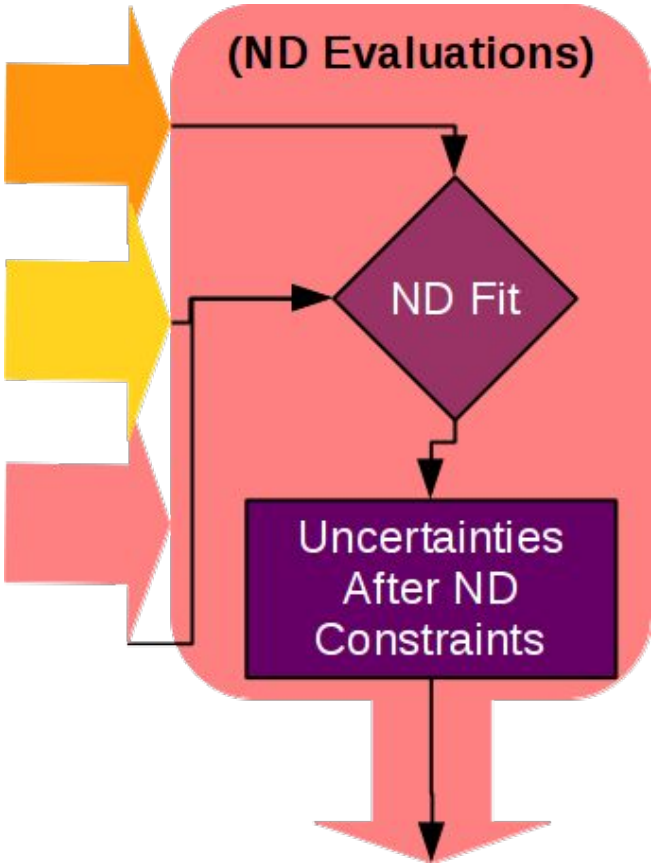
- Point(s) of Contact being discussed
- GENIE already meets many simulation needs
  - Flux driver interface
  - Event generation
- Several key requirements
  - Improved initial nuclear state models
  - Understand FSI model uncertainties and related correlations
  - Retuned systematics with “modern” parameterizations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

Near Detector Response Simulations



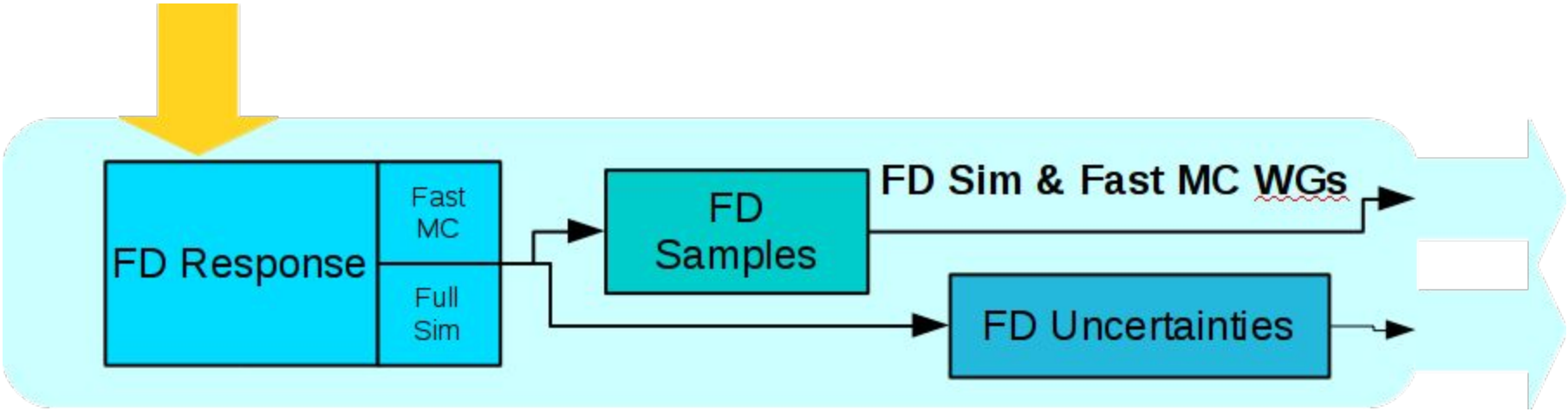
- Points of Contact: Tyler Alion (FGT), Sarah Lockwitz (LAr), Georgios Christodoulou (GAr)
- Event sample (GENIE) files will be provided
- Provide reconstructed quantities for each event
  - Fast MC style simulations
  - Full GEANT4 simulations
- Outputs:
  - Events samples for analysis (in a uniform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

Simulation



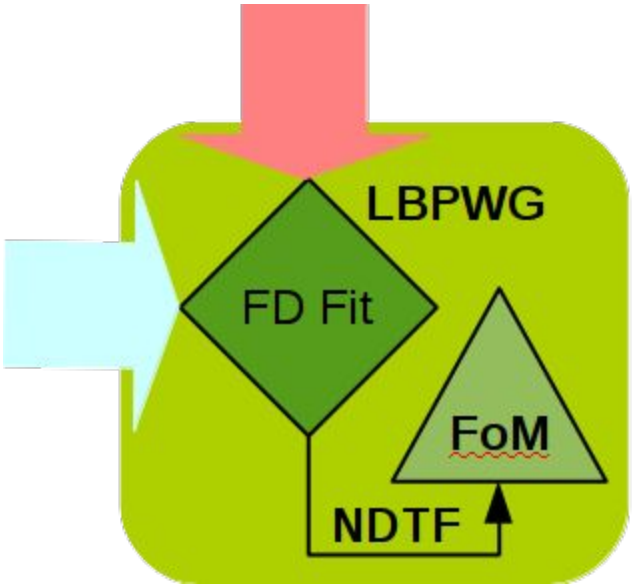
- Point of Contact: Costas Andreopoulos
- Well tested software package developed for T2K and expanded for LBNE, LBNO, and T2HK
- Topologically selected event samples
- Combined fit of all event samples
- Nuisance parameters of the fit cover all sources of uncertainty
- Produces a “post-fit” covariance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

Far Detector Response Simulation



- Point of Contact: Tingjun Yang
- 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

Items not covered in subsequent talks

- We have a weekly meeting of the points of contact for the links in the processing chain
  - Used to drive work
  - WG meetings then largely being used to report work

- A tasklist is being developed at
  - https://docs.google.com/spreadsheets/d/1_oYzHaDXz5M55cAlSYISWcdD31SAZOYiuIHt-TAvpy0/edit#gid=642779652
  - Milestone # given by previous slide
  - Color scheme indicates WG responsible (see Dan's workflow slide earlier in this talk)

- We are pulling together all the software pieces into one tagged and controlled infrastructure
  - Overseen by Robert Hatcher
  - Intended and be useful to live beyond the life of the task force

- We have a Wiki - https://cdcvs.fnal.gov/redmine/projects/dune-ndtf/wiki