

# FGT Simulation & Reconstruction Group

Interested persons

Tyler Alion USC/FNAL

Locations

Xinchun Tian USC

Tom Junk FNAL

Soumya Das FNAL

Nitali Dash HRI (India)

Jyotsna Singh HRI (India)

And more... These are  
just the people who  
have recently  
communicated

Baba Potukuchi Jammu (India)

Anwindar Kaur Panjab (India)

Biao Wang SMU (Texas)

Check me on  
locations, I may have  
made a mistake

**15 October 2015**

Repository Page: <https://cdcvs.fnal.gov/redmine/projects/dunefgt/repository>

Meeting Category Page: <https://indico.fnal.gov/categoryDisplay.py?categId=515>

# 10:30am ND Working Group Meetings

- Biweekly **Near Detector** meetings

<https://indico.fnal.gov/categoryDisplay.py?categId=514>

- Biweekly **Near Detector Physics** meetings **THIS WEEK**

<https://indico.fnal.gov/categoryDisplay.py?categId=500>

- **Today** there will be a 10:30am CST NDWG meeting on using VALOR to calculate systematic error for each option:

<https://indico.fnal.gov/conferenceDisplay.py?confId=10594>

# Outline

- Goals and Motivations
- Explain existing design
  - Geometry
  - G4 Simulation (of each subsystem)
  - Detector Electronics
- Task list
  - What needs to be done immediately?
  - Discuss prerequisite understanding
  - Who does what?

# Immediate Goal: Task Force

- Geometry
- Event Generators
- Geant 4 Simulation
- Detector Electronics Simulation

Good enough simulation  
with initial samples  
by **December**

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- Calibration / Hit Finding
  - Clustering Hits / Track Finding
  - Particle ID
  - Event ID

Defined data products with cheater  
modules and basic reconstruction  
by **January 12** — Collaboration Meeting

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**Goal by Meeting:** first sim-reco with output which feeds into VALOR.  
The physics doesn't have to be right, the machinery should be there.

# Immediate Goal: VALOR

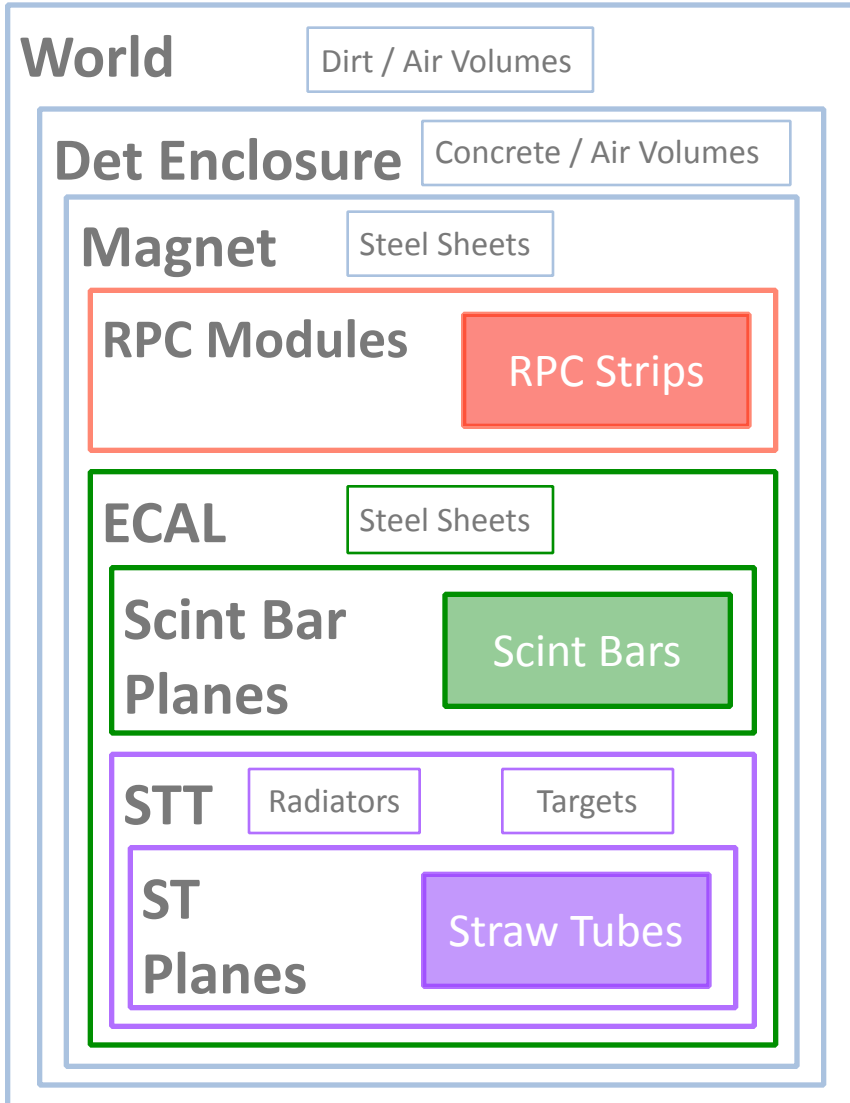
- VALOR is an analysis framework to fold all uncertainty (Cross Section, Flux, Detector) into oscillation fitting → look at error for each ND option
- In many different event topologies, fit:
  - (CC)  $E_{\nu_{is}}$  and  $Y_{Bj}$  distributions
  - (NC)  $E_{\nu_{is}}$  distributions
- We need to reconstruct the individual particle energies as best we can
- What will we have to cheat to do this in time? What will Ar options cheat?

# Geometry

- Use GDML
  - generated by python scripts
  - parsed by ROOT for C++ interface and display
  - parsed by Geant 4 for simulation
- Good enough STT and ECAL GDML exist
- **General Geometry Description (GGD)**
  - Soon we will use this to generate our GDML Thanks to Brett Viren!
  - Standalone on git hub good for newcomers without accounts
    - great documentation: <https://github.com/brettviren/gegede>
  - Legitimate Python package, could even work with the dune-params python package
  - I am working on a fgt package depending on GGD, where we will develop for now: <https://github.com/tyleralion/duneggd>

# Geometry

Volume Hierarchy:



Each bolded volume will have its own GGD file dedicated to building all of its sub volumes. This partition eases collaboration and multiple versions

Each colored volume will have its own array of C++ Geometry and Simulated objects

In under a week, I will have all GGD set up and others will be able to begin work. The design easily allows multiple people to be working on this at the same time

UTILITY PACKAGE  
(ART SERVICE MODULE)

Utilities

- DetectorProperties
- TimeService
- other

Geometry

NuTools

Simulation

Chain:

EventGenerator

NDG4

DetSim

(Package of ART  
producer modules)

Products living in  
NuTools/  
SimulationBase  
or HiSoft/  
Simulation

MCTruth

SimTube

SimScintBar

MCParticle

RawDigit

Input to  
Reconstruction

DATA PRODUCTS



# NuTools G4Base Package

## Mandatory G4 User Actions

### ConvertMCTruthToG4

**G4VUserPrimaryGeneratorAction**

“MCTruth” is the output of our generators

### DetectorConstruction

**G4VUserDetectorConstruction**

- Parse GDML with G4GDMLParser
- Set Detector Field (B field)

### G4VUserPhysicsList

- Default to QGSP\_BERT, can select from others in G4PhysListFactory
- Registers any other G4VPhysicsConstructors
- Subject to change with G4 v10

## G4Helper

Much of the code you would write in a standalone simulation

- Instantiates Detector Construction
- Registers any parallel worlds
- Sets physics lists, potentially with extra physics constructors
- Resets ConvertMCTruthToG4 and applies command “/run/beamOn 1” every time *G4Run* is called

## FGTG4\_module

ART Producer Module

- Instantiates G4Helper
- Passes GDML to Detector Construction
- Passes parallel worlds
- Tells helper to initialize physics
- Manages any other additional User Actions
- For each event, tells helper to run the simulation. (*G4Run*)

## UserActionManager

Singleton class used by both the helper and the user to set mandatory and additional user actions

# STT G4 Simulation

## G4Base (NuTools)

- Construct detector
- Register parallel world

## Geometry Package:

### StrawTubeGeo

- One for each ST boundaries in world coordinates

## NDG4 Package:

### StrawTubeReadoutGeometry

#### G4VUserParallelWorld

Uses G4SDManager to set a Sensitive Detector for each Straw Tube logical volume



### StrawTubeReadout

#### G4VSensitiveDetector

Sensitive version for each ST

- Parameterize Drift of Ionization Electrons
  - ★ • Drift Velocity
  - Ionization Energy (W)
- Add Ionization Electrons onto simulation objects

## Simulation Package:

### SimTube One for each ST with hits

- Create IDEs (generally for each g4 step) mapped from time tick (tdc) since numElectrons will be the pulse

### IDE (id and energy)

- x, y, z in world coordinates
- Energy — TrackID
- Number of ionization electrons



Digitization needs to be written

### RawDigit

TWO for each ST with hits

Vector of digitized pulse height (adc) indexed per time tick (tdc). One for each end of wire.

★ Nitali Dash wrote and pushed this a few days ago, still work to do

★ These need to be better estimated or calculated

# ECAL G4 Simulation

## G4Base (NuTools)

- Construct detector
- Register parallel world
- Set User Actions

## Geometry Package:

### ScintBarGeo

- One for each SB boundaries in world coordinates

## NDG4 Package:

### SimScintBarListAction

UserAction (NuTools class)

For each G4Step, check that it is inside a ScintBarGeo. If it is, then add the energy deposition to the corresponding SimScintBar object

## Simulation Package:

### SimScintBar One for each SB with hits

- Create IDEs (generally for each g4 step) mapped from time tick (tdc)

### IDE (id and energy)

- x, y, z in world coordinates
- Energy — TrackID

★ Digitization needs to be written

### RawDigit

TWO for each SB with hits

Vector of digitized pulse height (adc) indexed per time tick (tdc). One for each end of wire.

Soumya is already working diligently on improving and verifying this code, and will transition into writing this digitization

# MuonID G4 Simulation

## G4Base (NuTools)

- Construct detector
- Register parallel world
- Set User Actions

## Geometry Package:

### RPCStripGeo

One for each strip boundaries in world coordinates

## NDG4 Package:



## Simulation Package:

### SimRPCStrip

One for each strip with hits

#### IDE (id and energy)

- x, y, z in world coordinates
- Energy
- TrackID

★ Digitization needs to be written

### RawDigit

One for each SB with hits

Vector of digitized pulse height (adc) indexed per time tick (tdc).

- Use parallel world or user action?
- Considering LArSoft AuxDet code  
—> parallel world

# Detector Electronics

- **Impulse Response:** Input schematics to SPICE
  - One for STT, maybe one for ECAL and MuonID
  - Who is working on these?
- **Convolution:** (simulation: digitization)  
$$\text{ADC}(\text{tdc}) = (\text{impulse response}) * (\text{drift electron pulse})(\text{tdc})$$
  - Drift electron pulse: directly from SimTube map (done)
- **Deconvolution:** (reconstruction: calibration)
- Need to parameterize the difference between the **readouts on each end** in the STT and ECAL
  - pulse height attenuation...
- Without electronics response: for now assume perfect deconvolution and use the drift electron pulse for waveform

# Time Service

- First write simulation without a time service
  - (globally assumes  $t_0=0$ , all times are g4 time from primary)
- Then incorporate service into simulation and digitization
  - Adds a detector clock time globally
- This will be useful when considering event pileup

# Event Display


- Event Displays in the ART framework can be tricky. Two ways:
  - Use NuTools EventDisplayBase (examples for working with art)
  - Use any other display and figure out ART architecture in ROOT  
ROOT EVE, several other DUNE/MicroBooNE displays to look into
- As soon as I figure out a good design (suggestions welcome), there will be work to jump in on here.
- Anyone have experience here?

# Immediate Task List

- **Geometry** (Write GGD files for entire FGT)
  - ECAL: Soumya
  - STT starting from my basic: Tyler
  - MuonID starting from scratch: ???
  - Geometry C++ Interface: Tyler
- **Geant 4**
  - Move STT drift parameterization from user action to sensitive detector, limit step size to .2mm (configurable) Nitali has begun, I am helping
  - Implement a G4VPhysicsConstructor including Transition Radiation
  - Write MuonID simulation (I need to work on this a bit before others can)
- **Digitization**
  - Simulate impulse response in SPICE (STT, ECAL, MuonID?)
  - Parameterize difference between waveforms on opposing readouts
  - Write signal service to convolute/deconvolute signal
- **Event Display**



# What To Learn

- [mrb/git](#): version control
- mrb/cmake: building
- [art](#): data formatting/handling
  - very thorough [workbook](#)
- [nutools](#): Generator, Display, and G4 Bases
- [dunefgt wiki](#)
  - Hard to document while still so fluid.
  - Best to combine reading wiki, reading the source code, and calling (7045791588), emailing (tylerdalion@gmail.com), or skyping (@tylerdalion) me with any questions
- [Example Job](#): produce 1 single muon event
  - more/better examples to come 

Let's do this thing!

Questions?

Suggestions?

Volunteers?