Status of NuSystematics

20 Nov 2023

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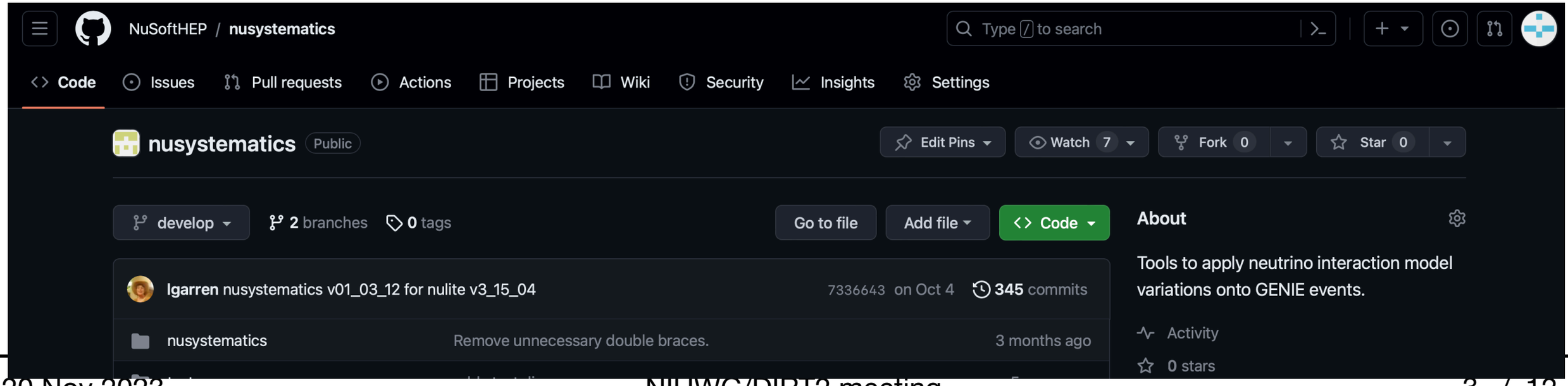
NIUWG/DIRT2 meeting

nusystematics

- Last time (Sep. 11th) I reported few updated features of nusystematics
  - Switching (back) to use art-framework-suite fhiclcpp
  - Useful apps are added back (e.g., Tree maker)
- Plans for moving apart from LarSoft; NuSoftHep
- Plans for validation on DUNE packages with the latest version of the package

New repo. for nusystematics

- New repository for the package; NuSoftHep/nusystematics
  - "Admin"s have full control of the repo; e.g., merge PRs
- Currently just a copy of LarSoft/nusystematics
  - Several things are under discussion..
  - Once everything's are settled, I will issue a new tag (v02_00_00)
- Please make PRs if you have any available features
  - Against my repo until NuSoftHep is finalized



DUNE package validation

- SBN/FD approach
  - LarSoft-based
  - Plan is to use "larnusystematics"
    - Only package that directly depends on nusystematics
    - larnusystematics/**DataFormats**: Define weight data formats to be saved in the art/ROOT output
      - "Header" info and "per-Neutrino" info
    - larnusystematics/**App**: Define a module that takes an art::Event and "produces" art products
  - Tested on "*schellma_mc.fardet-hd.fd_mc_2023a.v09_78_01d01.hit-reconstructed.prodgenie_nu_dune10kt_1x2x6.fcl.prod_v4*":

"NuSystEventWeightProducer" output product:

```
NuSystEventWeight | LarNuSystEventWeightModule. | ..................... |
art::Assns<simb::MCTruth,std::map<std::string,std::vector<double>
>,void>........................... | .....2
NuSystEventWeight | LarNuSystEventWeightModule. | ..................... |
std::vector<std::map<std::string,std::vector<double> >
>..................................... | .....2
```

DUNE package validation - FD

"NuSystEventWeightAnalyzer" printouts:

beginRun: Header information

```
%MSG-i NuSystEventWeightAnalyzer:   NuSystEventWeightAnalyzer:NuSystEventWeightAnalyzerModule@BeginRun  20-
Nov-2023 07:14:32 CST run: 1061
beginRun(const art::Run& run) called
%MSG
%MSG-i NuSystEventWeightAnalyzer:   NuSystEventWeightAnalyzer:NuSystEventWeightAnalyzerModule@BeginRun  20-
Nov-2023 07:14:32 CST run: 1061
ParameterSet
- Name: GENIEReWeight_LArNuSystDefault_ZExpA1CCQE
- RWType: 1
- Parameters:
  - Name: ZExpA1CCQE
    - CV: 0
    - Variations:  -1 1 -2 2 -3 3

%MSG
%MSG-i NuSystEventWeightAnalyzer:   NuSystEventWeightAnalyzer:NuSystEventWeightAnalyzerModule@BeginRun  20-
Nov-2023 07:14:32 CST run: 1061
ParameterSet
- Name: GENIEReWeight_LArNuSystDefault_ZExpA2CCQE
- RWType: 1
- Parameters:
  - Name: ZExpA2CCQE
    - CV: 0
    - Variations:  -1 1 -2 2 -3 3
```

DUNE package validation - FD

"NuSystEventWeightAnalyzer" printouts:

analyze: event loop

```
Begin processing the 1st record. run: 1061 subRun: 1 event: 1 at 20-Nov-2023 07:14:32 CST
%MSG-i NuSystEventWeightAnalyzer:   NuSystEventWeightAnalyzer:NuSystEventWeightAnalyzerModule@BeginModule  20-Nov-2023 07:14:32 CST run: 1061 subRun: 1 event: 1
analyze(const art::Event& e) called
%MSG
0-th MCTruth
- ParameterSet name: GENIEReWeight_LArNuSystDefault_AhtBY
weights: 1 1 1 1 1 1
- ParameterSet name: GENIEReWeight_LArNuSystDefault_BhtBY
weights: 1 1 1 1 1 1
- ParameterSet name: GENIEReWeight_LArNuSystDefault_CV1uBY
weights: 1 1 1 1 1 1
- ParameterSet name: GENIEReWeight_LArNuSystDefault_CV2uBY
weights: 1 1 1 1 1 1
- ParameterSet name: GENIEReWeight_LArNuSystDefault_CoulombCCQE
weights: 0.995737 1.00427 0.991477 1.00854 0.987221 1.01281
...
```

* This EDAnalyzer is the guideline for the LarSoft-based CAFMakers

DUNE package validation - ND

- 2x2/ND does not use LarSoft
  - Tested one of the most recent "2x2+MINERvA" caf:

`/dune/data/users/jwolcott/nd/nd-lar-reco/caf/PicoRun4.1/2x2+MINERvA-v0/`

  - File contents:

```
TFile**     /dune/data/users/jwolcott/nd/nd-lar-reco/caf/PicoRun4.1/2x2+MINERvA-v0/
PicoRun4.1_1E17_RHC.larnd.00000.caf.root
 TFile*     /dune/data/users/jwolcott/nd/nd-lar-reco/caf/PicoRun4.1/2x2+MINERvA-v0/
PicoRun4.1_1E17_RHC.larnd.00000.caf.root
  KEY: TTree cafTree;1 cafTree // StandardRecord
  KEY: TTree globalTree;1 globalTree // SRGlobal
  KEY: TTree mvaTree;1 mvaTree
  KEY: TTree meta;1 meta
  KEY: TTree genieEvt;1   genieEvt // GENIE NtpMCEventRecord
```

  - "CAFTree" contains StandardRecord
    - "rec.mc.nu" are the true neutrino vector per "event"
      - rec.mc.nu[index].genieIdx is the corresponding index of GENIE tree;

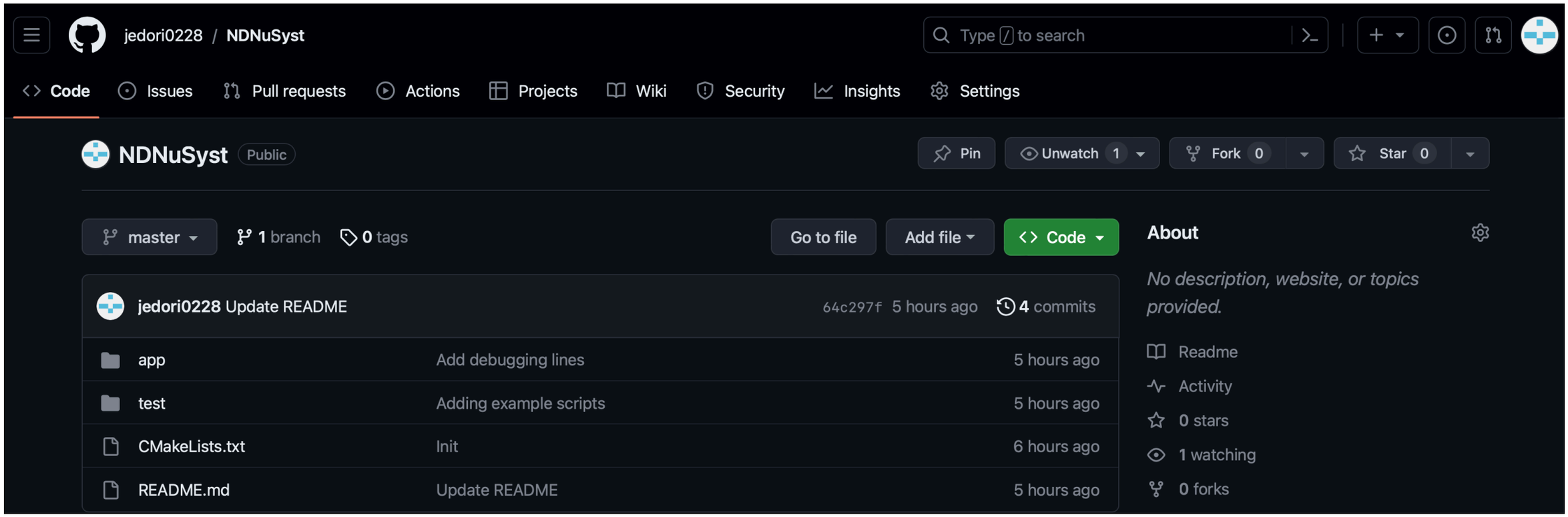
```
@@ Number of CAF events = 199
@@ Number of genie events = 854
```

DUNE package validation - ND

- We can add/update weights to NDCAFs
  - Configure NuSyst from fhicls
    - Save configured "SystParamHeader"s to SRGlobal
  - Loop over "StandardRecord"
    - Loop over TrueInteractions
      - Find the corresponding GENIE Event, retrieve the genie::EventRecord
    - Calculate reweights
    - Update weight variables
  - Fill updated "StandardRecord" to the output Tree

DUNE package validation - ND

- Example package prepared: NDNuSyst
  - Ideally can be copied to NDCAFMaker, but for me it was easy to start as a standalone



- Only depends on ***duneanaobj*** and ***nusystematics***

DUNE package validation - NDNuSyst

```
## Update NDCAF weights
$ UpdateReweight -c paramHeader.GENIE.fcl -i /dune/data/users/jwolcott/nd/nd-lar-reco/caf/
PicoRun4.1/2x2+MINERvA-v0/PicoRun4.1_1E17_RHC.larnd.00000.caf.root -o test.root -N 1
@@ Writting Header
@@ Printing SRGlobal
- (id, name, nshifts) = (0, MFP_pi, 6)
- (id, name, nshifts) = (1, MFP_N, 6)
CAFTree index: 0
- Number of MC particles = 6
  - 0-th neutrino in this CAF event
    - NEUTcode = 26
    - ParamID = 0
      - CV weight = 0
      - RW values = {1.38706, 0.731452, 1.90283, 0.546167, 2.33379, 0.416449}
    - ParamID = 1
      - CV weight = 0
      - RW values = {0.999801, 1.00013, 0.999469, 1.00023, 0.998806, 1.0003}
...
@@ Finalizing output
@@ - Writing globalTree
@@ - Writing cafTree
@@ Closing output

$ root -l output.root
.lsroot [0]
Attaching file output.root as _file0...

(TFile *) 0x3378f70
root [1] .ls
TFile**         output.root
 TFile*         output.root
  KEY: TTree globalTree;1 globalTree
  KEY: TTree cafTree;1 cafTree
```

UpdateReweight module printouts

Updated CAF
(Only added globalTree and StandardRecord)

DUNE package validation - NDNuSyst

```
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  KEY: TTree    globalTree;1    globalTree
  KEY: TTree    cafTree;1       cafTree
```

UpdateReweight module printouts

Updated CAF
(Only added globalTree and StandardRecord)
* Run "ReadCAF -i output.root" to check the output

Summary

- Packages have new home at NuSoftHep
  - Actively working to finalize the move
  - To dial developer
    - We will soon make a new tag, so **please make Pull Requests if you have anything available**
- Validations on DUNE workflows
  - (SBN/)FD
    - An EDProducer is provide by *larnusystematics*
      - Produces an weight product
    - An EDAnalyzer is provided for a guidance to CAFMaker
  - 2x2/ND
    - NDCAF contains GENIE tree, so weights can be easily updated
    - "NDNuSyst" is provided for the NDCAFMaker developers

Backup