Analysis Tutorial

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December 1, 2022

Fun4All: Now what?

- Chris gave an overview talk on Fun4All
- Ejiro gave a talk on how to run a simulation with a Fun4All macro
- Now what? How do I get analysis going?
- Where do I find information?
- What about when I have questions?

Resources for Getting Started

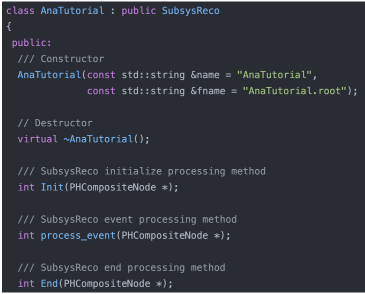
- Many resources exist to help you and guide you
  - Doxygen - code browser/documentation link
  - Github - code browser/documentation link
  - Mattermost/email communications with colleagues
    - To join mattermost, email Jin Huang : jhuang@bnl.gov
  - HEP Software Foundation (HSF) tutorials link
- Some guides and/or code that may be helpful to get you going:
  - Tutorial packages link
  - Coresoftware packages (remember, it's all Fun4All!) link
- I'll focus on the `AnaTutorial`, which is a self contained tutorial analysis package. link

Core Pieces of an Analysis

- Analysis package
  - Can be thought of as source code, or backend code
  - Does the analysis work
  - SubsysReco module(s)
  - Interacts with the node tree, etc.
- Macros
  - Runs the simulation/reconstruction/analysis
  - Tells Fun4All what to do, takes input/output files, etc.

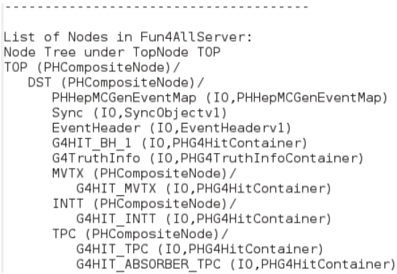
Analysis Module

- Analysis modules *must* inherit from SubsysReco base class. Tells Fun4All how to treat it
- Several methods called by Fun4All:
  - `Init(PHCompositeNode *topNode)`
  - `InitRun(PHCompositeNode *topNode)`
  - `process_event(PHCompositeNode *topNode)`
  - `ResetEvent(PHCompositeNode *topNode)`
  - `EndRun(const int runnumber)`
  - `End(PHCompositeNode *topNode)`
- Each houses the analysis code that you want to run at a given time in processing (initially, for each event, and at the end of the job)
- Take advantage of existing infrastructure, e.g. `CreateSubsysRecoModule.pl <Module Name>`



```
class AnaTutorial : public SubsysReco
{
 public:
  /// Constructor
  AnaTutorial(const std::string &name = "AnaTutorial",
              const std::string &fname = "AnaTutorial.root");

  // Destructor
  virtual ~AnaTutorial();

  /// SubsysReco initialize processing method
  int Init(PHCompositeNode *);

  /// SubsysReco event processing method
  int process_event(PHCompositeNode *);

  /// SubsysReco end processing method
  int End(PHCompositeNode *);
```

The Node Tree



```
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List of Nodes in Fun4AllServer:
Node Tree under TopNode TOP
TOP (PHCompositeNode)/
   DST (PHCompositeNode)/
      PHHepMCGenEventMap (IO,PHHepMCGenEventMap)
      Sync (IO,SyncObjectv1)
      EventHeader (IO,EventHeaderv1)
      G4HIT_BH_1 (IO,PHG4HitContainer)
      G4TruthInfo (IO,PHG4TruthInfoContainer)
      MVTX (PHCompositeNode)/
         G4HIT_MVTX (IO,PHG4HitContainer)
      INTT (PHCompositeNode)/
         G4HIT_INTT (IO,PHG4HitContainer)
      TPC (PHCompositeNode)/
         G4HIT_TPC (IO,PHG4HitContainer)
         G4HIT_ABSORBER_TPC (IO,PHG4HitContainer)
```
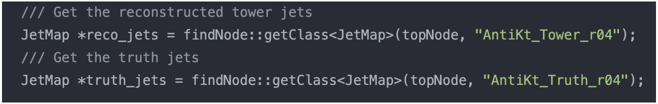

. . . .

- The node tree is where all of the data is stored in any Fun4All job
- Users interact with the node tree to analyze, create, manipulate data that they are interested in
- Nodes are accessed by asking the node tree



```
/// Get the reconstructed tower jets
JetMap *reco_jets = findNode::getClass<JetMap>(topNode, "AntiKt_Tower_r04");
/// Get the truth jets
JetMap *truth_jets = findNode::getClass<JetMap>(topNode, "AntiKt_Truth_r04");
```

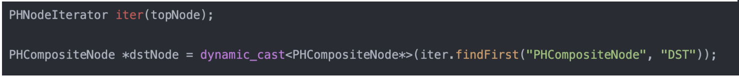
Object type (`JetMap`)

Node tree to search (`topNode`)

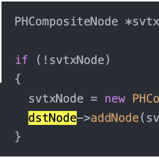
Node name on node tree (`AntiKt_Truth_r04`)

Nodes on Node Tree

- The beauty of Fun4All - any object can be put on the node tree
- You can create an analysis class that puts some new data structure on the node tree (e.g. a map of some arbitrary type)
- Find the subnodes you want to create a new node on:



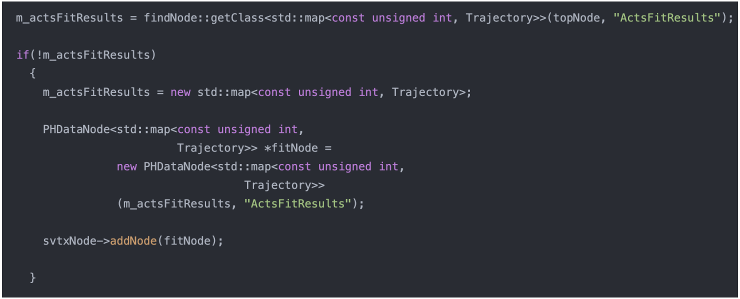
```
PHNodeIterator iter(topNode);

PHCompositeNode *dstNode = dynamic_cast<PHCompositeNode*>(iter.findFirst("PHCompositeNode", "DST"));
```



```
PHCompositeNode *svtx

if (!svtxNode)
{
  svtxNode = new PHCo
  dstNode->addNode(sv
}
```

Nodes on Node Tree

- The beauty of Fun4All - anything can be put on the node tree
- You can create an analysis class that puts some new data structure on the node tree (e.g. a map of some arbitrary type)
- Check that the object isn't already there, and if not, add it to the node tree



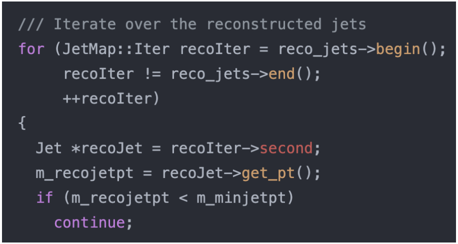
```
m_actsFitResults = findNode::getClass<std::map<const unsigned int, Trajectory>>(topNode, "ActsFitResults");

if(!m_actsFitResults)
  {
    m_actsFitResults = new std::map<const unsigned int, Trajectory>;

    PHDataNode<std::map<const unsigned int,
                        Trajectory>> *fitNode =
               new PHDataNode<std::map<const unsigned int,
                                  Trajectory>>
               (m_actsFitResults, "ActsFitResults");

    svtxNode->addNode(fitNode);

  }
```

Now what

- Now you have the tools to interact with the data nodes on the node tree
- What next?

Analysis

- With the nodes available, you can now analyze them
- Iterate over various nodes in `process_event` to get the information you want (tracks, clusters, hits, etc)
- Save analysis information in a e.g. a ROOT TTree for further analysis



```
/// Iterate over the reconstructed jets
for (JetMap::Iter recoIter = reco_jets->begin();
     recoIter != reco_jets->end();
     ++recoIter)
{
  Jet *recoJet = recoIter->second;
  m_recojetpt = recoJet->get_pt();
  if (m_recojetpt < m_minjetpt)
    continue;
```

Compiling For Fun4All

- Analysis code is compiled with a Makefile, autogen file, and configure file
- autogen is always the same, configure is always the same, Makefile has some specifics needed for your analysis package. See `AnaTutorial` for examples here
- Libraries are installed to your install directory, where all personally compiled libraries should exist (otherwise, Fun4All picks up the nightly build libraries)
- `CreateSubsysRecoModule.pl` will create these for you automagically

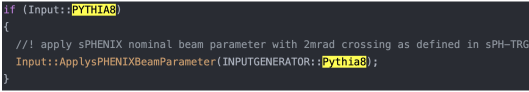
```
$ cd AnaTutorial/src
$ mkdir build
$ cd build
$ ../autogen.sh \
--prefix=/some/path/to/your/inst
$ make install
```

Running Your Analysis

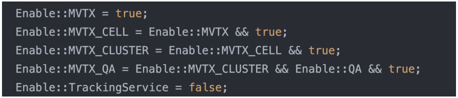
- You've written your analysis, compiled your code, and are ready to do some analysis
- Now we turn to the macros repository, which tells Fun4All what to run

Fun4All Macro

- The Fun4All macro is the conductor for your simulation job
- There are two ”sections” that you can choose to tailor to your simulation needs
  - Event generation (`Input::`)
  - Detector configuration (`Enable::`)
- Fun4All only runs what is registered with the `Fun4AllServer`, in the order it is registered
- Don’t forget to add your analysis module to Fun4All!
- Once you’re ready to run, `root.exe MyFun4AllMacro.C`



```
if (Input::PYTHIA8)
{
  //! apply sPHENIX nominal beam parameter with 2mrad crossing as defined in sPH-TRG
  Input::ApplysPHENIXBeamParameter(INPUTGENERATOR::Pythia8);
}
```



```
Enable::MVTX = true;
Enable::MVTX_CELL = Enable::MVTX && true;
Enable::MVTX_CLUSTER = Enable::MVTX_CELL && true;
Enable::MVTX_QA = Enable::MVTX_CLUSTER && Enable::QA && true;
Enable::TrackingService = false;
```

That's It!

- That's all there is to it
- Remember, Fun4All only runs what you tell it to run
- The macros are completely modular, e.g. you can create a macro that only produces simulated data, a macro that only reconstructs the simulation, etc.
- The default macro does all of this in one go, but it doesn't have to be this way

Last Thoughts

- There exists useful documentation online, use it
  - e.g. Recorded tutorials here or (more recently) here, example analysis packages, etc.
- Nonetheless, don't hesitate to ask your colleagues via mattermost, email, etc.
- Happy analyzing!
- You can give the `AnaTutorial` a try right out of the box - take a look at the package and follow the instructions in the README
- Developers checklist : make sure you can do these before the workfest! https://wiki.sphenix.bnl.gov/index.php/SoftwareDevelopmentChecklist
- Let's try it out in real time now