DIS reconstruction module

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Reconstructing DIS kinematic variables

- Leptonic (electron) reconstruction: `LeptonDIS`
  - Overview
  - Usage
- Add hadronic reconstruction: `DISReconstruction`
  - Status
- Currently, neither have real PID (including ePID) implemented!

Analysis modules have three main functions

`Init`	Runs once at the beginning
`process_event`	Runs for each event
`End`	Runs once at the end

LeptonDIS::Init

- Create output ROOT file/tree
- Define head-on Lorentz vectors for hadron and electron beam
- Default beam energy configuration is 10x100
- User can change with:
  LeptonDIS::SetBeamEnergies(double Ee, double Eh);

LeptonDIS::process_event

```
int LeptonDIS::process_event(PHCompositeNode* topNode) {

        mEventCounter++;
        if(mEventCounter % 1000 == 0) {
                cout << "Event " << mEventCounter << endl;
        }

        GetNodes(topNode);

        ResetVariables();

        MCEventInfo();
        LeptonRecon();

        mTree->Fill();

        return Fun4AllReturnCodes::EVENT_OK;

}
```

`GetNodes(topNode)`

From `TopNode`, get:

- `SvtxTrackMap` (reconstructed tracks)
- `TruthInfoContainer` (for fake "PID")
- `PHHepMCGenEventMap` (for HEPMC info)

`LeptonRecon()`

Step 1: Get reconstructed electron track

- Loop over truth-level primary particles to find primary electron:
  - Require PID == 11
  - Require parent ID == 0
- Loop over reconstructed tracks to find match to truth-level primary electron

Need to replace this step with real ePID
(would require adding in calorimeter information)

LeptonRecon()

Step 2: Correct for beam crossing angle

```
TLorentzVector LeptonDIS::CorrectCrossingAngle(TLorentzVector vecIn) {

        TLorentzVector vecOut = vecIn;
        vecOut.RotateY(mCrossingAngle/2.);
        vecOut.Boost(sin(mCrossingAngle/2.),0,0);
        return vecOut;

}
```

- Correct both truth and reconstructed tracks
- Default crossing angle is 25 msr
- User can specify with:
  `LeptonDIS::SetCrossingAngle(double xingAngle);`

LeptonRecon()

Step 3: Calculate DIS variables

- Use corrected Lorentz vectors to define/calculate variables of interest
  - Track variables p_x, p_y, p_z, $|p|$, θ, ϕ
  - DIS variables x_B, Q^2, W^2, y, η
- For comparison, also get x_B, Q^2 from `PHHepMCGenEventMap` node

Usage example

```
Fun4AllServer *se = Fun4AllServer::instance();

TString outFile = “lepton_recon_ep_10x100nc_q2_2.root”;

LeptonDIS* fDISRecon = new LeptonDIS();
fDISRecon->SetOutputFile(outFile);
fDISRecon->SetBeamEnergies(10., 100.);
fDISRecon->SetCrossingAngle(25.e-3);
se->registerSubsystem(fDISRecon);
```

Output of LeptonDIS

```
Attaching file lepton_recon_ep_10x100nc_q2_2.root as _file0...
(TFile *) 0x7fad1eeab440
root [1] T->Show(0)
======> EVENT:0
 event           = 1
 rec_track       = 1
 hepmc_xB        = 0.0149382
 hepmc_Q2        = 3.17224
 rec_tr_px       = 1.7058
 rec_tr_py       = -0.103479
 rec_tr_pz       = -9.25652
 rec_tr_p        = 9.41295
 rec_tr_th       = 2.95903
 rec_tr_ph       = -0.0605885
 g4_tr_px        = 1.72587
 g4_tr_py        = -0.105488
 g4_tr_pz        = -9.36909
 g4_tr_p         = 9.52731
 g4_tr_th        = 2.95909
 g4_tr_ph        = -0.0610454
 rec_tr_y        = 0.06873
 rec_tr_Q2       = 3.12885
 rec_tr_xB       = 0.0113812
 rec_tr_W2       = 272.665
 rec_tr_eta      = -2.3898
 g4_tr_y         = 0.0574099
 g4_tr_Q2        = 3.16462
 g4_tr_xB        = 0.0137811
 g4_tr_W2        = 227.35
 g4_tr_eta       = -2.39015
```

Reconstructed track

Truth (G4) track

Reconstructed DIS

Truth (G4) DIS

DISReconstruction

- Also want to look at hadronic reconstruction methods
- Requires additional nodes for:
  - Calorimeter clusters
  - Event vertex
  - Track projections

DISReconstruction::process_event

```
int DISReconstruction::process_event(PHCompositeNode* topNode) {

        mEventCounter++;
        if(mEventCounter % 1000 == 0) {
                cout << "Event " << mEventCounter << endl;
        }

        GetNodes(topNode);

        ResetVariables();

        MCEventInfo();
        LeptonRecon();
        JacquetBlondelRecon();
        JacquetBlondelRecon_useTracks();

        mTree->Fill();

        return Fun4AllReturnCodes::EVENT_OK;

}
```

Standard JB

Use tracks over clusters if available

Track/cluster matching

- For pure JB, need to exclude clusters from scattered electron
- For cluster/track hybrid, need to exclude clusters from included tracks
- Project track to calorimeter and calculate $\Delta\eta$, $\Delta\phi$ with cluster
  - Matching track/cluster if $\Delta\eta^2 + \Delta\phi^2 < 0.05$

DISReconstruction status

- Jacquet Blondel reconstruction implemented
  - Not using real PID or ePID
- Debugging segfault issue with latest simulation:
  `CaloRawClusterEval.cc: No such file or directory`

- Meant to run on fun4all DSTs...
  - Does not include full information from Clusterizer Afterburner?
- Best path forward...?
  - Event evaluator + afterburner
  - Analysis module with fun4all clusterizer

Summary

- Analysis module for leptonic reconstruction (sans ePID) ready to use: https://github.com/tylerkutz/LeptonDIS
- Best approach for hadronic reconstruction methods?