Setting Up a C++ Analyzer Replay

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Brief Introduction

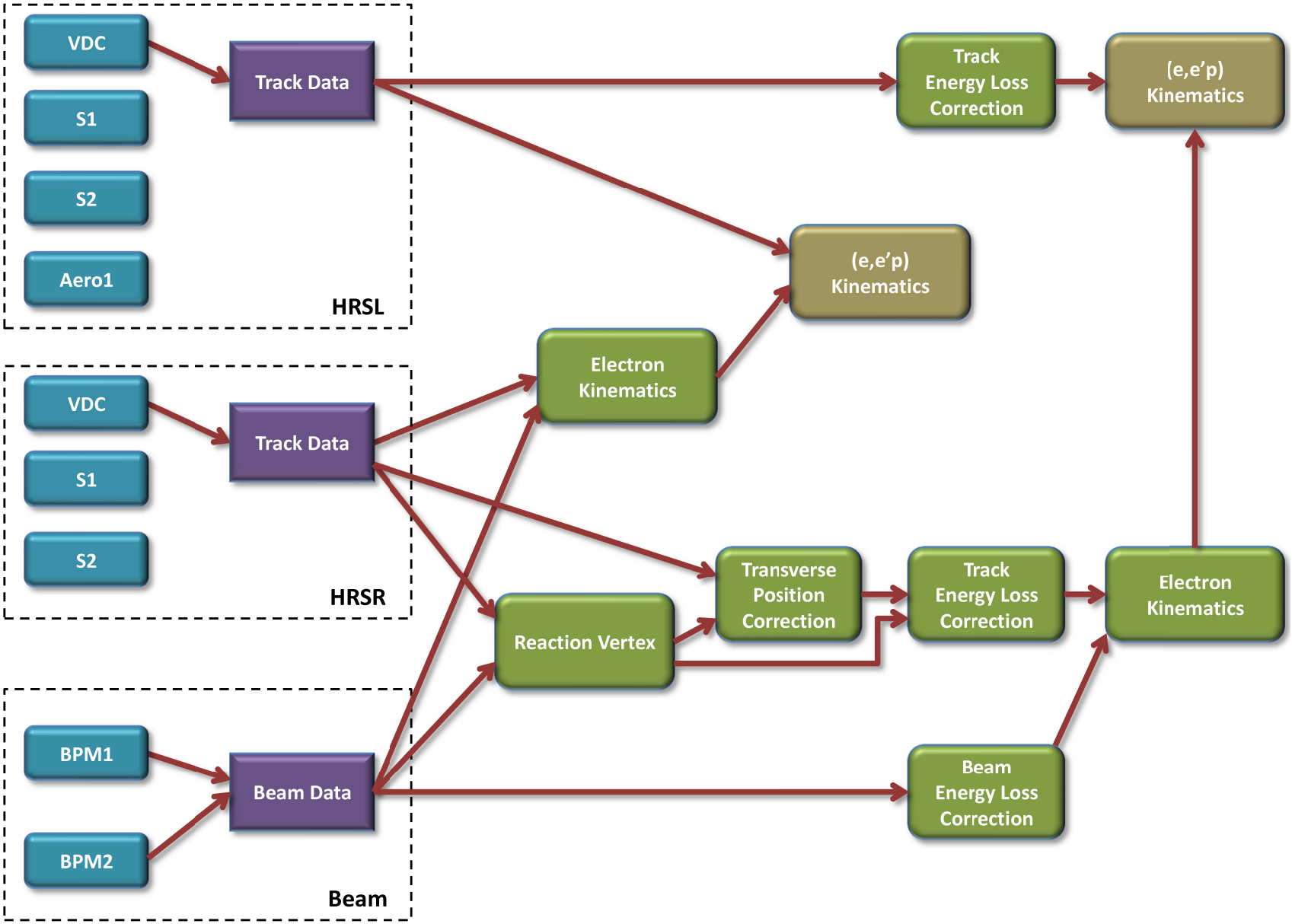
Analyzer Concepts: Analysis Objects

- Any module that produces "results"
- Every analysis object has unique name, *e.g.* R.s1
- Results stored in "global variables", prefixed with the respective module's name, *e.g.* R.s1.nhits

Types of Analysis Objects

- "Detector"
  - Code/data for analyzing a type of detector.
    Examples: Scintillator, Cherenkov, VDC, BPM
  - Typically embedded in an Apparatus
- "Apparatus" / "Spectrometer"
  - Collection of Detectors
  - Combines data from detectors
  - "Spectrometer": Apparatus with support for tracks
- "Physics Module"
  - Combines data from several apparatuses
  - Typical applications: kinematics calculations, vertex finding, coincidence time extraction
  - Toolbox design: Modules can be chained, combined, used as needed

A (complex) Module Configuration Example



Tutorial (Hall A-Specific)

Getting The Software

1. Set up ROOT
2. Download the analyzer source code
3. Unpack and build
4. To install, simply set environment variables

Setting Up The Software on JLab CUE

```
ifarm1102> source /apps/root/5.34.05/setroot_CUE
ifarm1102> wget http://hallaweb.jlab.org/podd/download/analyzer-1.5.25.tar.gz
ifarm1102> tar xzf analyzer-1.5.25.tar.gz
ifarm1102> cd analyzer-1.5.25
ifarm1102> make -j
ifarm1102> setenv PATH ${PWD}:${PATH}
ifarm1102> setenv LD_LIBRARY_PATH ${PWD}:${LD_LIBRARY_PATH}
ifarm1102> analyzer
analyzer [0]
```

More details on the web ▸ docs

Things You'll Need

1. Replay script
   - Defines detectors/apparatuses to be analyzed, kinematics, calculations to be done, file locations, tree variable names etc.
   - Many examples available from previous experiments
   - Simple or fancy ▸ fancy example. Try to start out simple
   - May be compiled
2. Set of database files
   - Usually one file per detector, `db_<name>.dat`
   - Run database, `db_run.dat`, defines beam energy, spectrometer angles
   - `db_cratemap.dat` and `scaler.map`, define decoder parameters
     → get these files from DAQ expert
3. Output definition file
   - Defines which variables to write to the tree in the output ROOT file
4. Raw data (CODA file)

Example Replay Script

```
// Set up left arm HRS with the detectors we're interested in
THaHRS* HRSL = new THaHRS("L", "Left HRS");  // NB: VDC/s1/s2 already included
HRSL->AddDetector( new THaCherenkov("cer", "Gas Cherenkov counter" ));
HRSL->AddDetector( new THaShower("ps", "Pre-shower pion rej."));
HRSL->AddDetector( new THaShower("sh", "Shower pion rej."));
gHaApps->Add(HRSL);

// Ideal beam (perfect normal incidence and centering)
THaIdealBeam* ib = new THaIdealBeam("IB", "Ideal beam");
gHaApps->Add(ib);

// Simple kinematics and vertex calculations
Double_t mass_tg = 12*931.494e-3; // C12 target
THaPhysicsModule *ekine, *rpl, *Lgold;
ekine = new THaElectronKine( "L.ekine", "Electron kinematics L", "L", "IB", mass_tg );
rpl   = new THaReactionPoint( "rpl", "Reaction vertex L", "L", "IB" );
Lgold = new THaGoldenTrack( "L.gold", "LHRS golden track", "L" );
gHaPhysics->Add(ekine);
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// The CODA data file we want to replay
THaRun* run = new THaRun("/rawdata/run_12345.dat");

// Set up and run standard analyzer (event loop)
THaAnalyzer* analyzer = new THaAnalyzer;
analyzer->SetOutFile( "/bigdisk/run_12345.root" );
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Note: Modules are set up by including them in analysis lists

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Note: module names $\longrightarrow$ provide databases, use in output definitions

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Note: HRS already contains `"vdc"`, `"s1"` and `"s2"` detectors

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Note: Choosing output definitions

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Note: Module chaining

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Note: Setting target mass parameter in script, overrides run database

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```

More complex code usually needed to deal with file locations & split runs

Example Database

```
[ tutorial ]$ ls -FR DB
DB:
20120306/  db_cratemap.dat  db_run.dat  scaler.map

DB/20120306:
db_L.s1.dat  db_L.s2.dat  db_L.vdc.dat
```

- Recommended to set `DB_DIR` to point to top-level database directory
- Database files in current directory always take precedence
- Usually only detectors require databases (for the detector map). Physics modules sometimes read the run database (for masses, angles)
- Contents of files depends on corresponding module. (Will switch to consistent key/value format with version 1.6)
- Documentation on the web ▸ docs
- Hall C modules use Hall C-style parameter files

Example Output Definition File

```
# All variables from the GoldenTrack module
block L.gold.*

# Calculated quantities for inclusive electron scattering measured
# by the LHRS, form the ElectronKine physics module
block L.ekine.*

# All LHRS track data (focal plane as well as reconstructed to target)
block L.tr.*
```

- Much more possible
  - Arithmetic expressions
  - Using/defining cuts
  - 1D and 2D histograms
  - EPICS variables
  - Scalers
- Full documentation on the web ▸ docs (Bob Michaels)

FAQ: Help! Where Do I Find Those Variable Names?

Options:

- Inspect each module's `DefineVariables` function
- `Init()` analyzer (instead of `Process()`), then print variable list. May use wildcards to select subsets.

Variable List Printout

```
analyzer [0] .x init.C
analyzer [1] gHaVars->Print("","L.ekine.*")
Collection name='THaVarList', class='THaVarList', size=203
 OBJ: THaVar    L.ekine.Q2      4-momentum transfer squared (GeV^2)
 OBJ: THaVar    L.ekine.omega   Energy transfer (GeV)
 OBJ: THaVar    L.ekine.W2      Invariant mass of recoil system (GeV^2)
 OBJ: THaVar    L.ekine.x_bj    Bjorken x
 OBJ: THaVar    L.ekine.angle   Scattering angle (rad)
 OBJ: THaVar    L.ekine.epsilon Virtual photon polarization factor
 OBJ: THaVar    L.ekine.q3m     Magnitude of 3-momentum transfer
 OBJ: THaVar    L.ekine.th_q    Theta of 3-momentum vector (rad)
 OBJ: THaVar    L.ekine.ph_q    Phi of 3-momentum vector (rad)
 OBJ: THaVar    L.ekine.nu      Energy transfer (GeV)
 OBJ: THaVar    L.ekine.q_x     x-cmp of Photon vector in the lab
 OBJ: THaVar    L.ekine.q_y     y-cmp of Photon vector in the lab
 OBJ: THaVar    L.ekine.q_z     z-cmp of Photon vector in the lab
```

Other Useful Things You Might Need

1. Cut/test definition file
   - Defines logical tests to be evaluated at various analysis stages
   - Special "master" tests at each stage can be used as cuts to reject certain events
2. Environment setup script
   - Shell script to set up environment variables for replay
3. Calibration scripts
   - Special replay scripts
   - Some standardized (VDC time offsets), mostly experiment-specific
   - This is where the real work begins
4. Disk space
   - Output ROOT files tend to be big, and numerous
   - Always ask where to write analysis output
   - Do not write to a home directory. You have been warned!
5. Software Development Kit
   - Skeleton classes for rapid development of your own code
   - Largely self-documenting ▸ download

Using The Tutorial Files

Example g2p optics replay setup ▸ download

Setting Up the Tutorial on JLab CUE

```
ifarm> wget http://hallaweb.jlab.org/data_reduc/AnaWork2013/tutorial-dec13.tar.gz
ifarm> tar xzf tutorial-dec13.tar.gz
ifarm> cd tutorial
ifarm> tar xzf analyzer-1.5.25.tar.gz
ifarm> cd analyzer-1.5.25
ifarm> patch -p1 < ../silence-multihit-warning.patch
ifarm> make -j
ifarm> cd ..
ifarm> source setup.sh
ifarm> ln -s /work/halla/g2p/disk1/ole/g2p_3132.dat.0 data/
ifarm> cd replay
ifarm> analyzer
analyzer [0] .x replay.C
analyzer [1] .x plot.C
```