Units in sPHENIX

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Ongoing exercise

- **Working with Dave and Dennis to utilize Rave techniques on events with displaced vertices**
  - Producing events with hard b-jets to test the algorithms
  - Alan has produced the code to convert sPHENIX tracks (Helix) to Rave format (pseudo-Euclidean) for vertexing

- **Writing out Pythia8 events in HepMC format**
  - Several examples in P8 which take .cmnd configuration files (main42 did the trick for me) and write directly to HepMC (“.dat”?) files.

- **HepMC files are great for debugging**
  - Simple ASCII format, documented in HepMC manual
  - Fun4AllHepMCInputManager useds HepMC::IO_GenEvent class for this

HepMC example

(from Dave…)

```
HepMC::Version 2.07.00.a01
HepMC::IO_GenEvent-START_EVENT_LISTING
E 0 -1 3.0789589136870312e+01 1.5704768642733433e-01 7.7224668081736772e-03 124 0 112 1 2 0 1 1.0000000000000000e+00
N 1 "0"
U GEV CM
C 5.9762706079466428e+00 5.9762706079466428e+00
F -1 1 3.0147778288242838e-01 3.1878811335121671e-01 3.0789589136870312e+01 1.3966393879579325e-02 1.4090903386977013e-01 0 0
V -1 0 0 0 0 0 0 1 0
P 3 -1 0 0 3.0147778288242836e+01 3.0147778288242836e+01 0 21 0 0 -3 1 2 101
V -2 0 0 0 0 0 0 1 0
P 4 1 0 0 -3.1878811335121672e+01 3.1878811335121672e+01 0 21 0 0 -3 1 1 102
V -3 0 0 0 0 0 0 2 0
P 5 -5 -2.5689608578373080e+00 3.0304442567521054e+01 -4.4830750414983154e+00 3.1114253342238307e+01 4.7999999999999998e+00 23 0 0 -4 1 2 101
P 6 5 2.5689608578373080e+00 -3.0304442567521054e+01 2.7520419946194830e+00 3.0912336281126205e+01 4.7999999999999998e+00 23 0 0 -8 1 1 102
…
V -111 0 -1.2046778309105208e+00 1.2584176609990431e+01 -5.7991118077571480e-01 1.3671967047147607e+01 0 2 0
P 218 22 -1.7432860223780144e-01 5.2589363796733957e-01 -8.3534008024789122e-02 5.6029680572835183e-01 0 1 0 0 0 0
P 219 22 -8.4481772109262707e-02 3.6690821295696924e-01 4.8764144453627215e-02 3.7965345821985130e-01 0 1 0 0 0 0
V -112 0 -1.2046717470772186e+00 1.2584168965815408e+01 -5.7991102302209752e-01 1.3671959664409000e+01 0 2 0
P 220 22 1.6994751572650929e-01 2.9321946747041949e-01 -1.6994397230515931e-02 3.3933556215415622e-01 0 1 0 0 0 0
P 221 22 -2.5200986094743871e-02 2.3237741244529882e-02 -3.8862178204744830e-03 3.4499058063132408e-02 0 1 0 0 0 0
```

Vertices are given by “V” entries (negative barcodes)
and the particles “P” who emerge from them (positive barcodes)

You can wade through parton, unstable and stable hadron
parts of the record (if you choose!)

HepMC vs. evaluator

```
V -99 0 -1.8791418802189784e-02 6.2693999887418334e-02 -3.7714998348810178e-03 6.7156024793842958e-02 0 3 0
P 192 -413 -4.1324589309736881e+00 1.3498791123344324e+01 -7.9758328830067760e-01 1.4281874645439240e+01 2.0102799999999998e+00 2 0 0 -103 0
P 193 -211 -1.1166383819162922e+00 2.9894530921109803e+00 -1.6441871794336549e-01 3.1984721924085382e+00 1.3957000000000000e-01 1 0 0 0 0
P 194 211 -3.7543480948320102e-01 1.0594273833719763e+00 -1.2466497390582025e-01 1.1394554962890358e+00 1.3957000000000000e-01 1 0 0 0 0
…
V -106 0 -2.6578483399758275e-02 9.4467176228892294e-02 -5.1309526623265125e-03 1.0267367732687382e-01 0 2 0
P 207 211 -6.5028485519149526e-01 7.4155525034051306e-01 -2.0680288438360744e-01 1.0173602115712925e+00 1.3957000000000000e-01 1 0 0 0 0
…
V -107 0 -3.6555139393443861e-02 1.2128781608257394e-01 -7.1972765118757014e-03 1.2908600355517483e-01 0 3 0
P 209 -211 -1.0415872045837113e+00 4.4214243685890136e+00 -3.2453119749494147e-01 4.5561713790147040e+00 1.3957000000000000e-01 1 0 0 0 0
P 210 211 -8.3348051877494611e-01 2.8354103822997172e+00 4.3870475190941538e-01 2.9910171272458945e+00 1.3957000000000000e-01 1 0 0 0 0
…
V -96 0 3.5617779152678254e-02 -3.3165880498509509e-01 2.3762236680353491e-02 3.4262135085033574e-01 0 2 0
P 186 2112 9.5557571623897108e-01 -7.6874596254851451e+00 1.1964527059113370e+00 7.8945836689031550e+00 9.3957000000000002e-01 1 0 0 0 0
P 187 -211 6.2645065185769189e-01 -2.2205301715225523e+00 5.1250791980443455e-01 2.3675596749854417e+00 1.3957000000000000e-01 1 0 0 0 0
```

```
root [1] ntp_gtrack.Scan("flavor:primary:vx:vy:vz:px:py:pz","primary>0")
*****************************************************************************************************************
*    Row   *    flavor *   primary *        vx *        vy *        vz *        px *        py *        pz *
*****************************************************************************************************************
*        0 *       211 *         1 *         0 *         0 *         0 * 0.3623497 * 0.3485727 * -0.754648 *
*        1 *      -211 *         1 *         0 *         0 *         0 * 1.3603812 * 1.3114930 * 0.0163461 *
*        2 *       211 *         1 *         0 *         0 *         0 * -0.187398 * 0.3143416 * 0.1519640 *
*        3 *      -211 *         1 *         0 *         0 *         0 * 0.6977151 * -0.313027 * -0.003222 *
…
*       22 *      -211 *         1 *         0 *         0 *         0 * 0.1891922 * 0.0374565 * 0.4983737 *
*       23 *       211 *         1 * -0.187914 * 0.6269400 * -0.037714 * -0.375434 * 1.0594273 * -0.124664 *
*       24 *      -211 *         1 * -0.187914 * 0.6269400 * -0.037714 * -1.116638 * 2.9894530 * -0.164418 *
*       25 *      -211 *         1 * -0.187914 * 0.6269400 * -0.037714 * -0.302221 * 0.8647127 * -0.058912 *
*       26 *       211 *         1 * -0.265784 * 0.9446717 * -0.051309 * -0.650284 * 0.7415552 * -0.206802 *
*       27 *       211 *         1 * -0.365551 * 1.2128781 * -0.071972 * -0.833480 * 2.8354103 * 0.4387047 *
*       28 *      -211 *         1 * -0.365551 * 1.2128781 * -0.071972 * -1.041587 * 4.4214243 * -0.324531 *
*       29 *     -2212 *         1 * 0.3561777 * -3.316588 * 0.2376223 * 1.0086127 * -6.323421 * -1.80e-05 *
*       30 *      -211 *         1 * 0.3561777 * -3.316588 * 0.2376223 * 0.6264506 * -2.220530 * 0.5125079 *
*       31 *       -13 *         1 * 0.3478891 * -4.164734 * 0.2392754 * -0.659054 * -1.993592 * -0.282338 *
*       39 *     -2212 *         1 *         0 *         0 *         0 * 1.8716776 * -0.163835 * -0.046443 *
```

Evaluator is showing values 10x HepMC!

The issue

- **Comparing Mike's evaluator output from ntp_gtracks (truth tracks) showed:**
  - The vertices from the displaced truth vertices had values of O(1 cm)
  - Referring back to the HepMC output showed that the same tracks had values of O(1 mm)
  - The latter is the expected range given typical B meson ctau of ~500 microns
    * gamma

- **Took a few iterations between me, Dennis and Alan to convince ourselves that there was a systematic factor of 10 between**
  - HepMC output
  - Input to G4

- **All evidence was that the tracking was doing the right thing, given the tracks propagated by G4**

Where to look?

- **g4main/<u>HepMCNodeReader.cc</u> is correctly adjusting for the units in the HepMC event and the GenEvent (I checked this by changing the HepMC units!)**

```
  PHHepMCGenEvent *genevt = findNode::getClass<PHHepMCGenEvent>(topNode,"PHHepMCGenEvent");
  HepMC::GenEvent *evt = genevt->getEvent();
…

  const double mom_factor = HepMC::Units::conversion_factor( evt->momentum_unit(), (HepMC::Units::MomentumUnit) (genevt-
>get_momentumunit()));
  const double length_factor = HepMC::Units::conversion_factor( evt->length_unit(), (HepMC::Units::LengthUnit) (genevt-
>get_lengthunit()) );
  for ( HepMC::GenEvent::vertex_iterator v = evt->vertices_begin();
        v != evt->vertices_end(); ++v )
    {
      finalstateparticles.clear();
      for (HepMC::GenVertex::particle_iterator p = (*v)->particles_begin(HepMC::children); p != (*v)-
>particles_end(HepMC::children); ++p)
        {
          if (isfinal(*p))
            {
              finalstateparticles.push_back(*p);
            }
        }
      if (finalstateparticles.size())
        {
          double xpos = (*v)->position().x()*length_factor;
          double ypos = (*v)->position().y()*length_factor;
          double zpos = (*v)->position().z()*length_factor;
```

Puts final state particles into PHG4InEvent node, with a vertex in units according to “length_factor”…which is 10

But why?

- **Check the phhepmc/ <u>Fun4AllHepMCInputManager.cc</u> which is what makes the GenEvent in the first place**

```
Fun4AllHepMCInputManager::Fun4AllHepMCInputManager(const string &name, const string &nodename, const string &topnodename) :
  Fun4AllInputManager(name, nodename, topnodename),
  isopen(0),
  events_total(0),
  events_thisfile(0),
  readoscar(0),
  momentumunit(HepMC::Units::GEV),
  lengthunit(HepMC::Units::MM),
  topNodeName(topnodename),
  ascii_in(NULL),
  evt(NULL),
  save_evt(NULL),
  filestream(NULL),
  unzipstream(NULL)
{
  Fun4AllServer *se = Fun4AllServer::instance();
  topNode = se->topNode(topNodeName.c_str());
  PHNodeIterator iter(topNode);
  PHCompositeNode *dstNode = se->getNode(InputNode.c_str(), topNodeName.c_str());

  PHHepMCGenEvent *genevent = new PHHepMCGenEvent(momentumunit,lengthunit);
  PHIODataNode<PHObject> *newnode = new  PHIODataNode<PHObject>(genevent,"PHHepMCGenEvent","PHObject");
  dstNode->addNode(newnode);
  return ;
}
```

So the GenEvent is in MM, while the HepMC event is in CM: naturally gives a length scale factor of 10!

Conclusions

- **Thanks for the detective work: Alan, Chris, Dennis**
  - Things seem to be working yesterday afternoon. Alan propagated fixes to git.
- **Wouldn't have been an issue in many studies until now, since for most particles 10*0 = 0**
- **Are we in general validating steps like this?**
  - When converting a file format, do we have sanity checks that what you have after reading in corresponds to the input file?
- **Good to try new problems (e.g. displaced vertex reco) to check different aspects of the code**