



Removing deprecated stuff from recob::Track

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Introduction

- New `recob::Track` interface introduced in early 2017
- This came with the deprecation of several outdated features
- In many cases such features were maintained for backwards compatibility
 - `dQ/dx` (`fdQdx` data member, `NumberdQdx` and `DQdxAtPoint` methods)
 - `NumberFitMomentum` method
 - Various methods based on `TVector3` or `TMatrixD`
 - Old constructor
- After almost 2 years it's time to cleanup the interface from the old junk
 - indeed all those concepts are not actively used anymore
 - still they are present in a large fraction of the larsoft code

- For reference:

- [https://cdcvcs.fnal.gov/redmine/projects/larsoft/wiki/From_ROOT_vectors_\(TVector3\)_to_ROOT_GenVector](https://cdcvcs.fnal.gov/redmine/projects/larsoft/wiki/From_ROOT_vectors_(TVector3)_to_ROOT_GenVector)

recob : : Track deletions

- One data member: `std::vector< std::vector <double> > fdQdx;`
 - when present in old files, it cannot be accessed anymore! This is actually good, it should not be accessed, **use `anab::Calorimetry` instead!**
- Two constructors, e.g:
 - `Track(std::vector<TVector3> const& xyz,
std::vector<TVector3> const& dxdydz,
std::vector<TMatrixD > const& cov,
std::vector< std::vector <double> > dQdx,
std::vector<double> fitMomentum,
int ID)`
- A few methods:
 - `size_t NumberFitMomentum()`
 - `TVector3 Vertex(), TVector3 End(), TVector3 LocationAtPoint(p)`
 - `TVector3 VertexDirection(), TVector3 EndDirection(), TVector3 DirectionAtPoint(p)`
 - `void TrajectoryAtPoint(unsigned int p, TVector3& pos, TVector3& dir)`
 - `void Extent(std::vector<double> &xyzStart, std::vector<double> &xyzEnd),`
 - `void Direction(double *dcosStart, double *dcosEnd)`
 - `size_t NumberCovariance(), TMatrixD CovarianceAtPoint(p), TMatrixD VertexCovariance(), TMatrixD EndCovariance()`
 - `size_t NumberdQdx(geo::View_t view), const double& dQdxAtPoint(unsigned int p, geo::View_t view)`
 - `void GlobalToLocalRotationAtPoint(uint p, TMatrixD& r), void LocalToGlobalRotationAtPoint(uint p, TMatrixD& r)`

recob : : Track additions

- Function names can now be used for proper return type:
 - Location methods returning `Point_t const&: Vertex(), End(), LocationAtPoint(i)`
 - Direction methods returning `Vector_t: VertexDirection(), EndDirection(), DirectionAtPoint(i)`
 - Covariance methods returning `const SMatrixSym55&: VertexCovariance(), EndCovariance()`
- Most methods now have an overloaded version templated on the return type
 - easy and clean transition for downstream code relying on `TVector3` or `TMatrixD`
 - allows usage of different types as well!
 - e.g. for position/direction/momentum: provided they can be constructed with 3 floats:

```
template<typename T> inline T Start() const {  
    auto& l = Start();  
    return T(l.X(), l.Y(), l.Z());  
}
```
- The interface is mirrored in `recob : : TrackTrajectory` and `recob : : Trajectory`

Impact of the changes

- These (breaking) changes are captured in branches named *feature/cerati_double2float_v2_breaktrack_deldepr* of the following packages:
 - lardataobj, lardata, lareventdisplay, larpandora, larreco, larana
 - ubcrt, ubana, ubcore, ubobj, ubreco, ublite
 - dunetpc
 - argoneutcode, lariatsoft, sbndcode
- The total number of files affected is 142
 - in >90% of the cases the change is trivial
 - in a few cases the change was not trivial but the functionality is the same
 - in even less cases the functionality is broken, but happens for code deprecated or unused

Trivial changes

- Just change TVector3 to auto or Point_t or Vector_t

```
larreco/Calorimetry/Calorimetry_module.cc
177 177 for(size_t trkIter = 0; trkIter < tracklist.size(); ++trkIter){
178 178
179 179     decltype(auto) larEnd = tracklist[trkIter]->Trajectory().End();
180     //store track directional cosines
181     double trackCosStart[3]={0.,0.,0.};
182     double trackCosEnd[3]={0.,0.,0.};
183     tracklist[trkIter]->Direction(trackCosStart,trackCosEnd);
184 180
185 181     // Some variables for the hit
186 182     float time;           //hit time at maximum
... ..
252 248     // find track pitch
253 249     double fTrkPitch = 0;
254 250     for (size_t itp = 0; itp < tracklist[trkIter]->NumberTrajectoryPoints(); ++itp){
255         const TVector3& pos = tracklist[trkIter]->LocationAtPoint(itp);
256         const auto& pos = tracklist[trkIter]->LocationAtPoint(itp);
257         const double Position[3] = { pos.X(), pos.Y(), pos.Z() };
258         geo::TPCID tpcid = geom->FindTPCATPosition ( Position );
259         if (tpcid.isValid) {
... ..
341 337             continue;
342 338         }
343 339         double angleToVert = geom->WireAngleToVertical(vhit[ii]->View(), vhit[ii]->WireID().TPC, vhit[ii]->WireID().Cryostat) - 0.5*::util::pi<>();
344         const TVector3& dir = tracklist[trkIter]->DirectionAtPoint(vmeta[ii]->Index());
345         const auto& dir = tracklist[trkIter]->DirectionAtPoint(vmeta[ii]->Index());
346         double cosgamma = std::abs(std::sin(angleToVert)*dir.Y() + std::cos(angleToVert)*dir.Z());
347         if (cosgamma){
348             pitch = geom->WirePitch(0)/cosgamma;
... ..
349 345         else{
350 346             pitch = 0;
351 347         }
352         TVector3 loc = tracklist[trkIter]->LocationAtPoint(vmeta[ii]->Index());
353         auto loc = tracklist[trkIter]->LocationAtPoint(vmeta[ii]->Index());
354         xyz3d[0] = loc.X();
355         xyz3d[1] = loc.Y();
356         xyz3d[2] = loc.Z();
```

Trivial changes

- Replace `TVector3::Mag()` with `Point_t::R()`

```
larana/CosmicRemoval/TrackContainment/TrackContainmentAlg.cxx
310 310     for(size_t i_p=0; i_p<geo.Nplanes(); ++i_p)
311 311         std::cout << "\t\tPlane " << i_p << " " << geo.NearestWireID(tracksVec[i_tc][i_t].End(),i_p).Wire << std::endl;
312 312         std::cout << "\tLength=" << tracksVec[i_tc][i_t].Length() << std::endl;
313 313         std::cout << "\tSimple_length=" << (tracksVec[i_tc][i_t].End()-tracksVec[i_tc][i_t].Vertex()).Mag() << std::endl;
313 313         std::cout << "\tSimple_length=" << (tracksVec[i_tc][i_t].End()-tracksVec[i_tc][i_t].Vertex()).R() << std::endl;
314 314     }//end debug statements if track contained
315 315
316 316 }//end loops over tracks
```

- Replace e.g. `TVector3` operator `[0]` with `Point_t::X()`

```
larana/OpticalDetector/TrackTimeAssocAna_module.cc
236 236
237 237
238 238     // Fill track variables
239 239     fTEnd1X = Tracks.at(0)->Vertex()[0];
240 240     fTEnd1Y = Tracks.at(0)->Vertex()[1];
241 241     fTEnd1Z = Tracks.at(0)->Vertex()[2];
242 242     fTEnd2X = Tracks.at(0)->End()[0];
243 243     fTEnd2Y = Tracks.at(0)->End()[1];
244 244     fTEnd2Z = Tracks.at(0)->End()[2];
239 239     fTEnd1X = Tracks.at(0)->Vertex().X();
240 240     fTEnd1Y = Tracks.at(0)->Vertex().Y();
241 241     fTEnd1Z = Tracks.at(0)->Vertex().Z();
242 242     fTEnd2X = Tracks.at(0)->End().X();
243 243     fTEnd2Y = Tracks.at(0)->End().Y();
244 244     fTEnd2Z = Tracks.at(0)->End().Z();
245 245
246 246     fTLength = Tracks.at(0)->Length();
247 247
```

Easy changes

- Replace e.g. `LocationAtPoint(i)` with `LocationAtPoint<TVector3>(i)`
 - this is the most typical change

```
larana/OpticalDetector/FlashHypothesisCreator.cxx
29 29  FlashHypothesisCollection fhc(geom->NOpDets());
30 30  for(size_t pt=1; pt<track.NumberTrajectoryPoints(); pt++){
31 31      if(interpolate_dEdx)
32      fhc = fhc + CreateFlashHypothesesFromSegment(track.LocationAtPoint(pt-1),
33                                                  track.LocationAtPoint(pt),
34                                                  0.5*(dEdxVector[pt]+dEdxVector[pt-1]),
35                                                  providers,pvs,opdigip,Xoffset);
36 36      else
37      fhc = fhc + CreateFlashHypothesesFromSegment(track.LocationAtPoint<TVector3>(pt-1),
38                                                  track.LocationAtPoint<TVector3>(pt),
39                                                  dEdxVector[pt-1],
40                                                  providers,pvs,opdigip,Xoffset);
41 41  }
```


Code duplication

- In way too many places `recob::Track::Length()` was re-implemented locally.
- The central version changed with the new `recob::Track` (supporting the case of invalid hits), so these local version are now potentially buggy and were changed to return the central version

```
dune/TrackFinderDUNE/TrackAnaCT_module.cc
121 121 //-----
122 122 double length(const recob::Track& track)
123 123 {
124     double result = 0.;
125     TVector3 disp = track.LocationAtPoint(0);
126     int n = track.NumberTrajectoryPoints();
127
128     for(int i = 1; i < n; ++i) {
129         const TVector3& pos = track.LocationAtPoint(i);
130         disp -= pos;
131         result += disp.Mag();
132         disp = pos;
133     }
134     // mf::LogVerbatim("output") << " length (track) " << result;
135     return result;
124 return track.Length();
136 125 }
137 126
138 127 // Length of MC particle.
```

Usage of Extent and Direction

- In the old interface the usage of `Extent` and `Direction` was inconsistent, with one taking an array and the other a vector of double.
- Moving to a templated version and choosing a `TVector3` return type is transparent wrt the rest of the code (`TVector3` supports `operator[]`)

```
ubana/TPCNeutrinoIDFilter/Algorithms/NuMuCCSelectionIIAlgMCC7.cxx
160 160     std::vector<double> trkenddcosy(tracklist.size());
161 161     std::vector<double> trkenddcosz(tracklist.size());
162 162     std::vector<double> trklen(tracklist.size());
163     double larStart[3];
164     double larEnd[3];
165     std::vector<double> trackStart;
166     std::vector<double> trackEnd;
163     TVector3 larStart;
164     TVector3 larEnd;
165     TVector3 trackStart;
166     TVector3 trackEnd;
167 167     for (size_t i = 0; i<tracklist.size(); ++i){
168         trackStart.clear();
169         trackEnd.clear();
170         for(int j=0; j<3; ++j) {
171             larStart[j] = 0.;
172             larEnd[j] = 0.;
173         }
174         tracklist[i]->Extent(); //trackStart,trackEnd);
175         tracklist[i]->Direction(larStart,larEnd);
168         std::tie(trackStart,trackEnd) = tracklist[i]->Extent<TVector3>();
169         std::tie(larStart,larEnd) = tracklist[i]->Direction<TVector3>();
176 170     trkstartx[i]     = trackStart[0];
177 171     trkstarty[i]     = trackStart[1];
178 172     trkstartz[i]     = trackStart[2];
```

Templating `pma::Dist2`

- Lots of code uses `pma::Dist2(TVector3, TVector3)`
- Another version already exists, using `Vector3D`
- Replacing with a templated version (on both arguments) makes it support also `Point_t` and make the transition straightforward
 - the template arguments are automatically deduced, so no change in downstream code!

```
larreco/RecoAlg/PMAlg/Utilities.h
42 42     double Dist2(const TVector2 & v1, const TVector2 & v2);
43 43     double Dist2(const Vector2D & v1, const Vector2D & v2);
44 44
45 45     double Dist2(const TVector3 & v1, const TVector3 & v2);
46 46     double Dist2(const Vector3D & v1, const Vector3D & v2);
47 47     template <typename T, typename U> double Dist2(const T & v1, const U & v2) {
48 48         double dx = v1.X() - v2.X(), dy = v1.Y() - v2.Y(), dz = v1.Z() - v2.Z();
49 49         return dx * dx + dy * dy + dz * dz;
50 50     }
51 51
52 52     size_t GetHitsCount(const std::vector< pma::Hit3D* >& hits, unsigned int view);
53 53     double GetSummedADC(const std::vector< pma::Hit3D* >& hits, unsigned int view = geo::kUnknown);
```

Other non trivial cases

- As a general rule, no interface is changed in the downstream code. Exceptions are a couple of cases with functions used only locally:
 - ubreco/ShowerReco/ProximityClustering/CosmicFilter_module.cc:
 - `SqDist(const Point_t& pt)`
 - ubcrt/CRT/CRTeffStd_module.cc:
 - `SortTrackPoints(const recob::Track& tk, vector<Point_t>& sorted_trk)`
- In a few cases a `TVector3` was constructed from the old vertex interface
 - now moved to `Point_t`

```
ubana/TPCNeutrinoIDFilter/Algorithms/ChargedTrackMultiplicityAlg.cxx
197 197     art::Ptr<recob::Vertex> vertex(vertexVecHandle, vertexIdx);
198 198
199 199     // Get the position of the vertex
200     // Ultimately we really want the vertex position in a TVector3 object...
201     double vertexXYZ[3];
202
203     vertex->XYZ(vertexXYZ);
204
205     TVector3 vertexPos(vertexXYZ[0],vertexXYZ[1],vertexXYZ[2]);
200     auto vertexPos = vertex->position();
206 201
207 202     if(inFV(vertexPos.X(),vertexPos.Y(),vertexPos.Z()))
208 203     {
```

Deprecating the old constructor: relatively easy changes

- Replace old constructor (with dummy dQdx, momentum, covariance) with new constructor (after converting vectors to proper type)

```
larreco/TrackFinder/CCTrackMaker_module.cc
447 447 // are possibly broken clusters but we will consider these when matching between planes
448 448 fMergeErrorCut = 10;
449 449
450 // some junk vectors to satisfy the recob::Track constructor
451 std::vector< std::vector<double> > dQdx;
452 std::vector<double> mom(2, util::kBogusD);
453 // prepare a bogus covariance matrix so that the TrackAna module doesn't bomb
454 TMatrixD cov(5,5);
455 for(unsigned short ii = 0; ii < 5; ++ii) cov(ii, ii) = 1;
456 std::vector<TMatrixD> tmpCov;
457 tmpCov.push_back(cov);
458 tmpCov.push_back(cov);
459 450 std::vector< art::Ptr<recob::Hit > > tmpHits;
460 451 std::vector< art::Ptr<recob::Cluster > > tmpCls;
461 452 std::vector< art::Ptr<recob::Vertex > > tmpVtx;
...
694 685 // track
695 686 // make the track
696 687 size_t tStart = tcol->size();
697 recob::Track track(trk[tIndex].TrjPos, trk[tIndex].TrjDir, tmpCov, dQdx, mom, tID);
688 recob::Track track(recob::TrackTrajectory(recob::tracking::convertCollToPoint(trk[tIndex].TrjPos),
689 recob::tracking::convertCollToVector(trk[tIndex].TrjDir),
690 recob::Track::Flags_t(trk[itr].TrjPos.size()), false),
691 0, -1., 0, recob::tracking::SMatrixSym55(), recob::tracking::SMatrixSym55(), tID);
698 692 tcol->emplace_back(std::move(track));
699 693 size_t tEnd = tcol->size();
700 694 // PFParticle - track association
...
740 734 for(unsigned short itr = 0; itr < trk.size(); ++itr) {
741 735 // ignore already saved tracks
742 736 if(trk[itr].ID < 0) continue;
743 recob::Track track(trk[itr].TrjPos, trk[itr].TrjDir, tmpCov, dQdx, mom, trk[itr].ID);
737 recob::Track track(recob::TrackTrajectory(recob::tracking::convertCollToPoint(trk[itr].TrjPos),
738 recob::tracking::convertCollToVector(trk[itr].TrjDir),
739 recob::Track::Flags_t(trk[itr].TrjPos.size()), false),
740 0, -1., 0, recob::tracking::SMatrixSym55(), recob::tracking::SMatrixSym55(), trk[itr].ID);
744 741 tcol->emplace_back(std::move(track));
745 742 tmpHits.clear();
746 743 for(ipl = 0; ipl < nplanes; ++ipl)
```

Deprecating the old constructor: complicated cases

- In these cases the functionality of the code is changing (not dramatically, but noticeably).
- I believe they are not actively being used by any experiment.

- `larreco/RecoAlg/StitchAlg.cxx`
 - Merges tracks.
 - Removed `dQdx`, added flags, adapted usage of momentum and covariance
 - the new track will have `fHasMomentum` set to true only if true for all input tracks

- `larreco/TrackFinder/TrackCheater_module.cc`
 - Fills a `recob::Track` from simulation information.
 - Removed `dQdx` and momentum magnitudes, fill momentum vector instead of direction

- `larreco/TrackFinder/Track3DKalmanSPS_module.cc`
 - creates tracks from `recob::SpacePoints`, also produces a validation `TTree`
 - removed `dQdx` and momentum magnitudes from produced `recob::Track` (but it is still in `TTree`), fill momentum vector instead of direction

Removing NumberdQdx and DQdxAtPoint

- In these cases the functionality of the code is changing, in a couple of cases significantly.
- However, I believe they are just analyzers and/or not actively being used by any experiment.
- For now, where a functionality is 'broken', a big WARNING is added:
 - should we throw an exception instead? should we deprecate or delete the code?
- `lardata/ArtDataHelper/Dumpers/DumpTracks_module.cc`
 - not dumping dQdx information anymore.
- `larpandora/LArPandoraAnalysis/PFParticleTrackAna_module.cc`
 - commented out parts where calorimetry information of the output `TTree` are filled, added warning.
- `ubana/TPCNeutrinoIDFilter/Algorithms/NuMuCCSelectionIIAlg.cxx`
 - track dQdx accessed only if calibrated calorimetry not available (should not be used anyways!). Commented out, added warning.
- `larreco/Calorimetry/GeneralCalorimetry_module.cc`
 - module relies on track dQdx (commented out entire produce method, added warning). **Only file now completely unfunctional.**
- `larreco/DirOfGamma/MergeEMShower3D_module.cc`
 - code where tracks are merged into showers (author now left the field). Commented out specific part, added warning.
- `dunetpc/dune/FDSensOpt/IniSegReco_module.cc`
 - track dQdx info accessed inside an if which is probably never true. Commented out specific part, added warning.

```
/*
*****
WARNING
*****
/* The dQdx information in recob::Track has been deprecated
/* since 2016 and in 11/2018 the recob::Track interface was
/* changed and DQdxAtPoint and NumberdQdx were removed.
/* Therefore the code below is now commented out
/* (note that it was most likely not functional anyways).
/* For any issue please contact: larsoft-team@fnal.gov
*****
*/
```

Next steps

- Agree on deprecation strategy
- Still unresolved tension between “fitted” (i.e. with covariance matrices and chi2) and “unfitted” tracks
 - original plan was that “unfitted” use `recob::TrackTrajectory` while “fitted” use `recob::Track`.
 - it’s now easier since the interface is mirrored, but it may not be easy to digest for experiments
 - an alternative could be to rename `recob::TrackTrajectory` as `recob::Track`, and `recob::Track` as something like `recob::FittedTrack`
 - this will be more transparent since most people currently use ‘unfitted’ `recob::Tracks`
 - or the simplest solution would be to add a bool that says if the track was “fitted” or not
 - kind of giving up on the original plan of different products, but definitely very easy to achieve

Conclusions

- Cleaned up `recob::Track` interface, finally
- As a result we have:
 - more efficient, more flexible, and cleaner code
 - removed dangerous code duplication
 - identified deprecated code
- All larsoft and experiment code has been fixed, but private user code may be broken with these changes
 - this presentation should cover most or all cases, please forward to anybody having issues
 - or just get in touch with the larsoft team
- Still some items on the to do list
 - we should find an way to complete them without too much hassle

lardataobj (10 files)

[https://cdcv.sfnal.gov/redmine/projects/lardataobj/repository/diff?](https://cdcv.sfnal.gov/redmine/projects/lardataobj/repository/diff?utf8=%E2%9C%93&rev=bb0838c86ee8ddfa8957bfb05d99b86e0e9536bf&rev_to=c3e93037810426d27b9d704ad5e07741cd21dbfa)

[utf8=%E2%9C%93&rev=bb0838c86ee8ddfa8957bfb05d99b86e0e9536bf&rev_to=c3e93037810426d27b9d704ad5e07741cd21dbfa](https://cdcv.sfnal.gov/redmine/projects/lardataobj/repository/diff?utf8=%E2%9C%93&rev=bb0838c86ee8ddfa8957bfb05d99b86e0e9536bf&rev_to=c3e93037810426d27b9d704ad5e07741cd21dbfa)

modified: lardataobj/RecoBase/Track.cxx
 modified: lardataobj/RecoBase/Track.h
 modified: lardataobj/RecoBase/TrackTrajectory.cxx
 modified: lardataobj/RecoBase/TrackTrajectory.h
 modified: lardataobj/RecoBase/TrackingTypes.h
 modified: lardataobj/RecoBase/Trajectory.cxx
 modified: lardataobj/RecoBase/Trajectory.h
 modified: lardataobj/RecoBase/classes_def.xml
 modified: test/RecoBase/TrackTrajectory_test.cc
 modified: test/RecoBase/Trajectory_test.cc

lardata (2 files)

[https://cdcv.sfnal.gov/redmine/projects/lardata/repository/diff/lardata?](https://cdcv.sfnal.gov/redmine/projects/lardata/repository/diff/lardata?utf8=%E2%9C%93&rev=00906d1102a29939ca9d30ef33bd37bb89cb579d&rev_to=cb8d5ac8c3146cf8bbcb93e46103db6678b54e7e)

[utf8=%E2%9C%93&rev=00906d1102a29939ca9d30ef33bd37bb89cb579d&rev_to=cb8d5ac8c3146cf8bbcb93e46103db6678b54e7e](https://cdcv.sfnal.gov/redmine/projects/lardata/repository/diff/lardata?utf8=%E2%9C%93&rev=00906d1102a29939ca9d30ef33bd37bb89cb579d&rev_to=cb8d5ac8c3146cf8bbcb93e46103db6678b54e7e)

modified: lardata/ArtDataHelper/Dumpers/DumpTracks_module.cc
 modified: lardata/ArtDataHelper/TrackUtils.cxx

lareventdisplay (1 file)

[https://cdcv.sfnal.gov/redmine/projects/lareventdisplay/repository/diff/lareventdisplay?](https://cdcv.sfnal.gov/redmine/projects/lareventdisplay/repository/diff/lareventdisplay?utf8=%E2%9C%93&rev=d1ddc5bc2487166f373342b303afacf1f5540438&rev_to=bb6d212bd6b8d7a1823558b20c196d5f8efe7f2d)

[utf8=%E2%9C%93&rev=d1ddc5bc2487166f373342b303afacf1f5540438&rev_to=bb6d212bd6b8d7a1823558b20c196d5f8efe7f2d](https://cdcv.sfnal.gov/redmine/projects/lareventdisplay/repository/diff/lareventdisplay?utf8=%E2%9C%93&rev=d1ddc5bc2487166f373342b303afacf1f5540438&rev_to=bb6d212bd6b8d7a1823558b20c196d5f8efe7f2d)

modified: lareventdisplay/EventDisplay/RecoBaseDrawer.cxx

larpandora (5 files)

[https://cdcv.sfnal.gov/redmine/projects/larpandora/repository/diff/larpandora?](https://cdcv.sfnal.gov/redmine/projects/larpandora/repository/diff/larpandora?utf8=%E2%9C%93&rev=0c420066a156ff96d7600b121158034923e72a60&rev_to=00929212428aff38c13bc1516b4c05c26f3ed81a)

[utf8=%E2%9C%93&rev=0c420066a156ff96d7600b121158034923e72a60&rev_to=00929212428aff38c13bc1516b4c05c26f3ed81a](https://cdcv.sfnal.gov/redmine/projects/larpandora/repository/diff/larpandora?utf8=%E2%9C%93&rev=0c420066a156ff96d7600b121158034923e72a60&rev_to=00929212428aff38c13bc1516b4c05c26f3ed81a)

modified: larpandora/LArPandoraAnalysis/PFParticleTrackAna_module.cc
 modified: larpandora/LArPandoraAnalysis/PFParticleAnalysis_module.cc
 modified: larpandora/LArPandoraAnalysis/PFParticleCosmicAna_module.cc
 modified: larpandora/LArPandoraAnalysis/PFParticleHitDumper_module.cc
 modified: larpandora/LArPandoraAnalysis/PFParticleMonitoring_module.cc

larreco (23 files)

[https://cdcv.sfnal.gov/redmine/projects/larreco/repository/diff/larreco?](https://cdcv.sfnal.gov/redmine/projects/larreco/repository/diff/larreco?utf8=%E2%9C%93&rev=b6c493ab4cae59cd32417be0206798516ac65f8e&rev_to=a094e37c3c81d1bc4926d914fceb399fa8bdc11f)

[utf8=%E2%9C%93&rev=b6c493ab4cae59cd32417be0206798516ac65f8e&rev_to=a094e37c3c81d1bc4926d914fceb399fa8bdc11f](https://cdcv.sfnal.gov/redmine/projects/larreco/repository/diff/larreco?utf8=%E2%9C%93&rev=b6c493ab4cae59cd32417be0206798516ac65f8e&rev_to=a094e37c3c81d1bc4926d914fceb399fa8bdc11f)

modified: larreco/Calorimetry/Calorimetry_module.cc
 modified: larreco/Calorimetry/GeneralCalorimetry_module.cc
 modified: larreco/Calorimetry/TrackCalorimetryAlg.cxx
 modified: larreco/DirOfGamma/MergeEMShower3D_module.cc
 modified: larreco/DirOfGamma/EMShower3D_module.cc
 modified: larreco/RecoAlg/EMShowerAlg.cxx
 modified: larreco/RecoAlg/PMAlg/Utilities.cxx
 modified: larreco/RecoAlg/PMAlg/Utilities.h
 modified: larreco/RecoAlg/StitchAlg.cxx
 modified: larreco/RecoAlg/TcShowerAlg.cxx
 modified: larreco/RecoAlg/TrackMomentumCalculator.cxx
 modified: larreco/RecoAlg/TrackShowerSeparationAlg.cxx
 modified: larreco/TrackFinder/MuonTrackingEff_module.cc
 modified: larreco/TrackFinder/CCTrackMaker_module.cc
 modified: larreco/TrackFinder/CosmicTracker_module.cc
 modified: larreco/TrackFinder/SpacePts_module.cc

modified: larreco/RecoAlg/TrackMomentumCalculator.cxx
 modified: larreco/RecoAlg/TrackShowerSeparationAlg.cxx
 modified: larreco/TrackFinder/MuonTrackingEff_module.cc
 modified: larreco/TrackFinder/CCTrackMaker_module.cc
 modified: larreco/TrackFinder/CosmicTracker_module.cc
 modified: larreco/TrackFinder/SpacePts_module.cc
 modified: larreco/TrackFinder/Track3DKalmanSPS_module.cc
 modified: larreco/TrackFinder/Track3DKalman_module.cc
 modified: larreco/TrackFinder/Track3Dreco_module.cc
 modified: larreco/TrackFinder/TrackAna_module.cc
 modified: larreco/TrackFinder/TrackCheater_module.cc
 modified: larreco/VertexFinder/PrimaryVertexFinder_module.cc
 modified: larreco/WireCell/MergeWireCell_module.cc

larana (9 files)

[https://cdcv.sfnal.gov/redmine/projects/larana/repository/diff/larana?](https://cdcv.sfnal.gov/redmine/projects/larana/repository/diff/larana?utf8=%E2%9C%93&rev=579cf63f3cff25586b43fe6dd910db73c854fadfb&rev_to=d356cf5a1f3f3b8c97abbae7d6318c9e0642b314)

[utf8=%E2%9C%93&rev=579cf63f3cff25586b43fe6dd910db73c854fadfb&rev_to=d356cf5a1f3f3b8c97abbae7d6318c9e0642b314](https://cdcv.sfnal.gov/redmine/projects/larana/repository/diff/larana?utf8=%E2%9C%93&rev=579cf63f3cff25586b43fe6dd910db73c854fadfb&rev_to=d356cf5a1f3f3b8c97abbae7d6318c9e0642b314)

modified: larana/CosmicRemoval/BeamFlashTrackMatchTaggerAlg.cxx
 modified: larana/CosmicRemoval/CosmicPFParticleTagger_module.cc
 modified: larana/CosmicRemoval/CosmicTrackTagger_module.cc
 modified: larana/CosmicRemoval/TrackContainment/TrackContainmentAlg.cxx
 modified: larana/CosmicRemoval/TrackContainment/TrackContainmentAlg.hh
 modified: larana/OpticalDetector/FlashHypothesisCreator.cxx
 modified: larana/OpticalDetector/TrackTimeAssocAna_module.cc
 modified: larana/ParticleIdentification/MVAAlg.cxx
 modified: larana/TOfinder/PhotonCounterT0Matching_module.cc

ubert (4 files)

[https://cdcv.sfnal.gov/redmine/projects/ubert/repository/diff/ubert?](https://cdcv.sfnal.gov/redmine/projects/ubert/repository/diff/ubert?utf8=%E2%9C%93&rev=892ea66ca47104a9933e4169f0b2d1116db4f714&rev_to=24860294243d8fc64df64fff653595464d4b0101)

[utf8=%E2%9C%93&rev=892ea66ca47104a9933e4169f0b2d1116db4f714&rev_to=24860294243d8fc64df64fff653595464d4b0101](https://cdcv.sfnal.gov/redmine/projects/ubert/repository/diff/ubert?utf8=%E2%9C%93&rev=892ea66ca47104a9933e4169f0b2d1116db4f714&rev_to=24860294243d8fc64df64fff653595464d4b0101)

modified: ubert/CRT/CRTeffStd_module.cc
 modified: ubert/CRT/T0recoCRTAnal_module.cc
 modified: ubert/CRT/T0recoCRT_module.cc
 modified: ubert/CRT/TrackDump_module.cc

ubana (38 files)

[https://cdcv.sfnal.gov/redmine/projects/ubana/repository/diff/ubana?](https://cdcv.sfnal.gov/redmine/projects/ubana/repository/diff/ubana?utf8=%E2%9C%93&rev=cd7462b976fe4026574ef6007a53910a21b32cda&rev_to=83f43c8dab90a4daee4e0dbec89f6c71226629ae)

[utf8=%E2%9C%93&rev=cd7462b976fe4026574ef6007a53910a21b32cda&rev_to=83f43c8dab90a4daee4e0dbec89f6c71226629ae](https://cdcv.sfnal.gov/redmine/projects/ubana/repository/diff/ubana?utf8=%E2%9C%93&rev=cd7462b976fe4026574ef6007a53910a21b32cda&rev_to=83f43c8dab90a4daee4e0dbec89f6c71226629ae)

modified: ubana/AnalysisTree/AnalysisTree_module.cc
 modified: ubana/AnalysisTree/MCTruth/MCTruthBase/MCTruthAssociations.cpp
 modified: ubana/Calibrations/Diffusion_module.cc
 modified: ubana/Calibrations/Kplane2_module.cc
 modified: ubana/Calibrations/LifetimeQAQC_module.cc
 modified: ubana/Calibrations/Lifetime_module.cc
 modified: ubana/Calibrations/ValidateLifetime_module.cc
 modified: ubana/Calibrations/XYZcorrection_module.cc
 modified: ubana/Calibrations/XYZvalidation_module.cc
 modified: ubana/ChargedTrackMultiplicity/DataOFF/CTMDataOFFAna_module.cc
 modified: ubana/ChargedTrackMultiplicity/DataON/CTMDataONAna_module.cc
 modified: ubana/ChargedTrackMultiplicity/MC/CTMMCAna_module.cc
 modified: ubana/CosmicTagging/CosmicFlashTagger_module.cc
 modified: ubana/HSNAnalysis/HsnFinder/DataObjects/DecayVertex.cxx
 modified: ubana/LEEPPhotonAnalysis/DetectorObjects.h

modified: ubana/CosmicTagging/CosmicFlashTagger_module.cc
 modified: ubana/HSNAnalysis/HsnFinder/DataObjects/DecayVertex.cxx
 modified: ubana/LEEPPhotonAnalysis/DetectorObjects.h
 modified: ubana/LEEPPhotonAnalysis/FillTreeVariables.cxx
 modified: ubana/LLApp/OpT0FinderApp/MuCST0Finder_module.cc
 modified: ubana/LLApp/OpT0FinderApp/MuCSTTrackFinder_module.cc
 modified: ubana/LLApp/OpT0FinderApp/T0TrackCalib_module.cc
 modified: ubana/TPCNeutrinoIDFilter/Algorithms/AltNuMuCCInclusiveAlg.cxx
 modified: ubana/TPCNeutrinoIDFilter/Algorithms/ChargedTrackMultiplicityAlg.cxx
 modified: ubana/TPCNeutrinoIDFilter/Algorithms/ModNuMuCCInclusiveAlg.cxx
 modified: ubana/TPCNeutrinoIDFilter/Algorithms/NuMuCCInclusiveAlg.cxx
 modified: ubana/TPCNeutrinoIDFilter/Algorithms/TrackPairPlusVertexAlg.cxx
 modified: ubana/TPCNeutrinoIDFilter/Algorithms/NuMuCCSelectionIIAlg.cxx
 modified: ubana/TPCNeutrinoIDFilter/Algorithms/NuMuCCSelectionIIAlgMCC7.cxx
 modified: ubana/TPCNeutrinoIDFilter/TPCNeutrinoIDAna_module.cc
 modified: ubana/UBXSec/Algorithms/ACPTAlgo.cxx
 modified: ubana/UBXSec/Algorithms/TPCObjectFilter.cxx
 modified: ubana/UBXSec/Algorithms/UBXSecHelper.cxx
 modified: ubana/UBXSec/Algorithms/VertexCheck.cxx
 modified: ubana/UBXSec/Modules/ACPTTagger_module.cc
 modified: ubana/UBXSec/Modules/CandidateConsistency_module.cc
 modified: ubana/UBXSec/Modules/CosmicFlashMatch_module.cc
 modified: ubana/UBXSec/Modules/FlashMatchCalib_module.cc
 modified: ubana/UBXSec/Modules/NeutrinoFlashMatch_module.cc
 modified: ubana/UBXSec/Modules/StoppingMuonTagger_module.cc
 modified: ubana/UBXSec/Modules/UBXSec_module.cc

ubcore (1 file)

https://cdcv.s.fnal.gov/redmine/projects/ubcore/repository/diff/ubcore?utf8=%E2%9C%93&rev=60175b61f58fc075f7734b70cf26935203efad8a&rev_to=2b5dd3ed6003284eef3415e604a5bf8fb7b90a5c
 modified: ubcore/DQMTTools/GoodRunSelectionAna_module.cc

ubobj (1 file)

https://cdcv.s.fnal.gov/redmine/projects/ubobj/repository/diff/ubobj?utf8=%E2%9C%93&rev=d0dd6b5d58c3f5fcaec5eedb24e15f2d26067aba&rev_to=6a8dec389c3175f844647d5b66b66ecfe6a0efe5
 modified: ubobj/UBXSec/TPCObject.cxx

ubreco (11 files)

https://cdcv.s.fnal.gov/redmine/projects/ubreco/repository/diff/ubreco?utf8=%E2%9C%93&rev=4f4274af1333a1fe25458b0ea25440e7308a3003&rev_to=3a1046208fdb66a71d8e57ecf51fd42958ee8af5
 modified: ubreco/MuCS/MuCSTTrackTagger_module.cc
 modified: ubreco/ShowerReco/Pi0Ana/CosmicBackgrounds_module.cc
 modified: ubreco/ShowerReco/Pi0Ana/Pi0AnalyzerDATA_module.cc
 modified: ubreco/ShowerReco/Pi0Ana/Pi0Filter_module.cc
 modified: ubreco/ShowerReco/Pi0Ana/Pi0PhysicsDATA_module.cc
 modified: ubreco/ShowerReco/Pi0Ana/Pi0Physics_module.cc
 modified: ubreco/ShowerReco/ProximityClustering/CosmicFilter_module.cc
 modified: ubreco/T0Reco/CosmicTaggingAnodeCathodePiercing_module.cc
 modified: ubreco/T0Reco/T0RecoAnodeCathodePiercingAna_module.cc
 modified: ubreco/T0Reco/T0RecoAnodeCathodePiercingValidationAna_module.cc
 modified: ubreco/T0Reco/T0RecoAnodeCathodePiercing_module.cc

ublite (1 file)

https://cdcv.s.fnal.gov/redmine/projects/ublite/repository/diff/ublite?utf8=%E2%9C%93&rev=2aa557b3d81591586bbacd8681161d3de3045dd0&rev_to=432e050127f60e2ed62752cca5ab3bb7132761
 modified: ublite/LiteMaker/ScannerAlgo.template.h

dunetpc (22 files)

https://cdcv.s.fnal.gov/redmine/projects/dunetpc/repository/diff?utf8=%E2%9C%93&rev=45ecb47b8db7546425921eb149d20b5d7b3b2582&rev_to=db7bb8e5a03be1c7830bed762fedef3d108ddb39
 modified: dune/AnaTree/AnalysisTree_module.cc
 modified: dune/CTree/CTree35t_module.cc
 modified: dune/EventGenerator/ProtoDUNEbeamDataProducts/ProtoDUNEBeamTPCMatching_module.cc
 modified: dune/FDSensOpt/IniSegAlg/IniSegAlg.cxx
 modified: dune/FDSensOpt/IniSegReco_module.cc
 modified: dune/FDSensOpt/MVAAlg/MVAAlg.cxx
 modified: dune/FDSensOpt/NueAna_module.cc
 modified: dune/FDSensOpt/ShSeg_module.cc
 modified: dune/Gaps/GapWidth_module.cc
 modified: dune/HitAnalysis/RecoTrack_module.cc
 modified: dune/HitAnalysis/SignalToNoise_module.cc
 modified: dune/HitFinderDUNE/EmLikeHits_module.cc
 modified: dune/Protodune/PhysicsWeek/MichelEventSelection_module.cc
 modified: dune/Protodune/dualphase/AnaRootParser_module.cc
 modified: dune/Protodune/dualphase/Purity_module.cc
 modified: dune/Protodune/singlephase/XYZcalibration/XYZcalibration_module.cc
 modified: dune/Protodune/singlephase/dEdxcalibration/dEdxcalibration_module.cc
 modified: dune/Protodune/singlephase/BeamEvent_module.cc
 modified: dune/TrackFinderDUNE/TrackAnaCT_module.cc
 modified: dune/TrackingAna/CosmicEfficiency_module.cc
 modified: dune/TrackingAna/ProtonIdentification_module.cc
 modified: dune/TrackingAna/TrackingEfficiency_module.cc

argoneutcode (4 files)

modified: AnalysisTree/AnalysisTreeT962_module.cc
 modified: ArgoneutEventSelection/ArgoneutCCInclusiveFilter_module.cc
 modified: ArgoneutEventDisplay/MinosDrawer.cxx
 modified: MatchTracks/MatchTracks_module.cc

lariatsoft (9 files)

modified: LArIATAnaModule/AnaTreeT1034_module.cc
 modified: LArIATAnaModule/Lifetime_module.cc
 modified: LArIATAnaModule/MCAnalysis_module.cc
 modified: LArIATFilterModule/ShowerFilter_module.cc
 modified: LArIATFilterModule/WCTrkMatchToTPCtrkFilter_module.cc
 modified: LArIATRecoModule/MichelWfmReco_module.cc
 modified: LArIATRecoModule/WC2TPCTrackMatch_module.cc
 modified: LArIATRecoModule/CosmicTrackerT1034_module.cc
 modified: LArIATRecoModule/SpacePointsT1034_module.cc

sbndcode (1 file)

modified: sbndcode/AnalysisTree/AnalysisTree_module.cc