Required changes for thread safety and some observations

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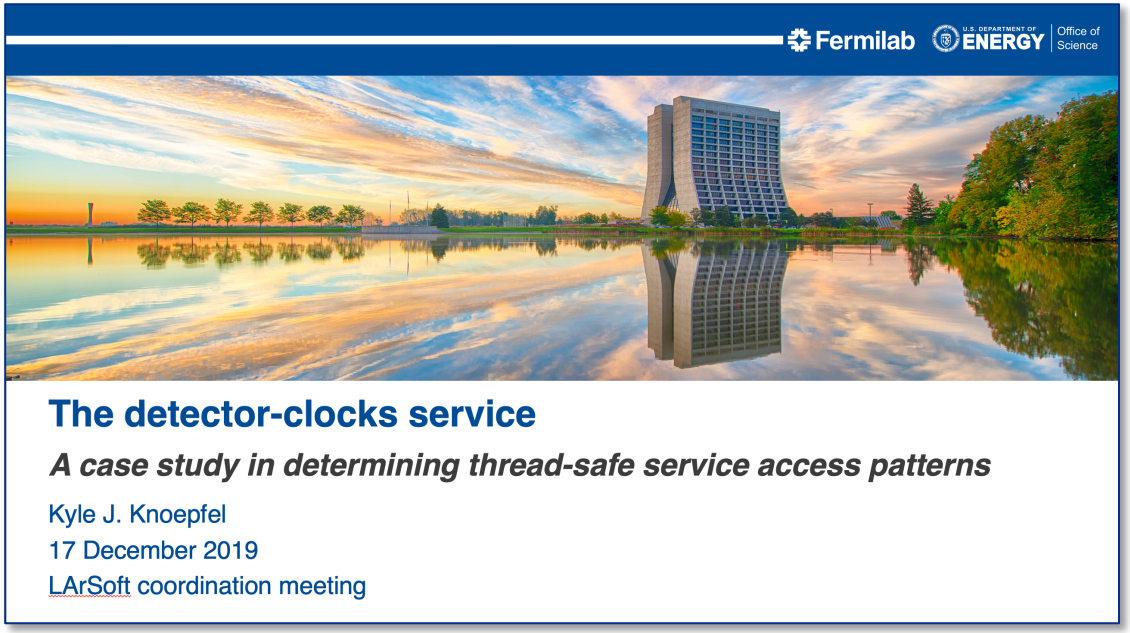
19 May 2020

LArSoft coordination meeting

From previous meetings



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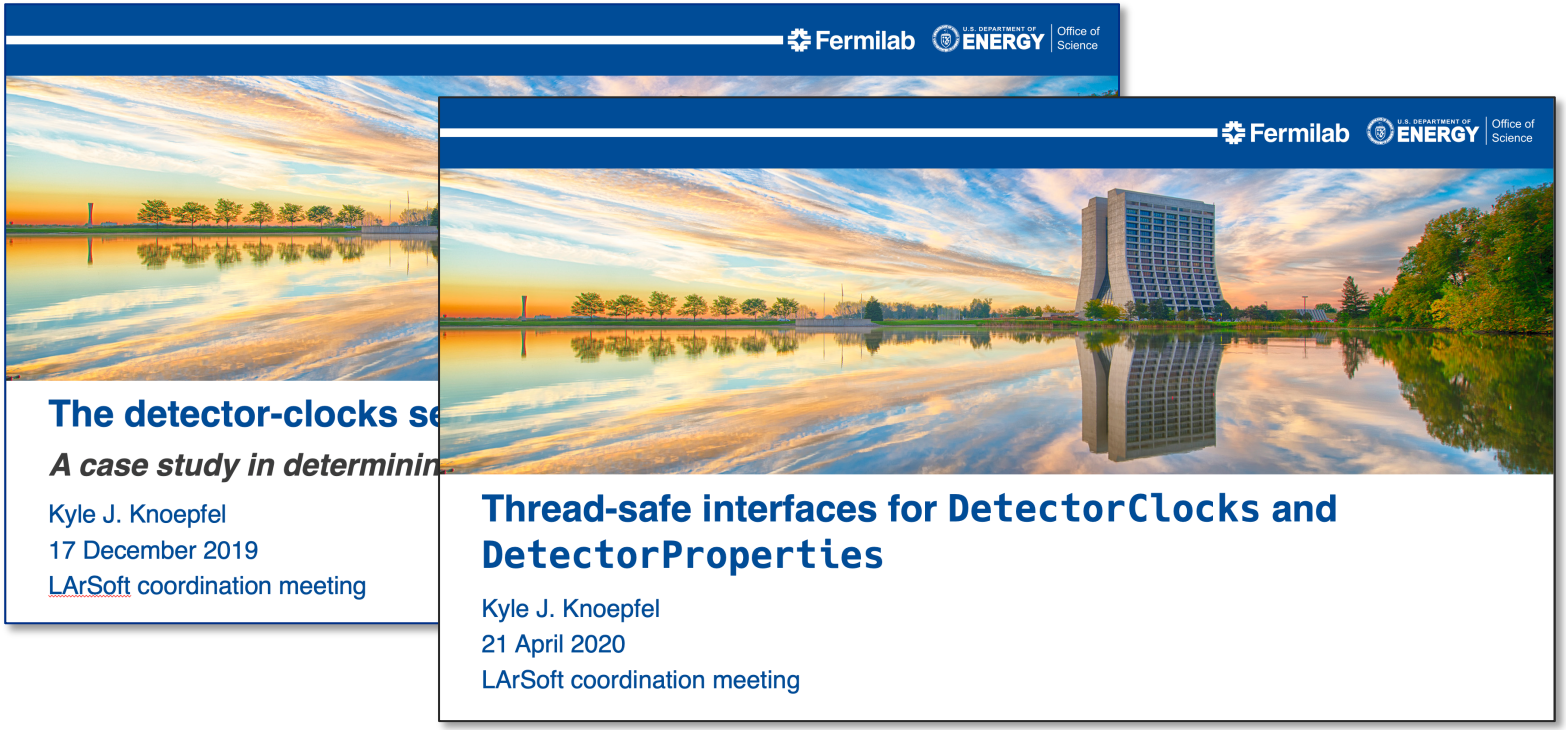

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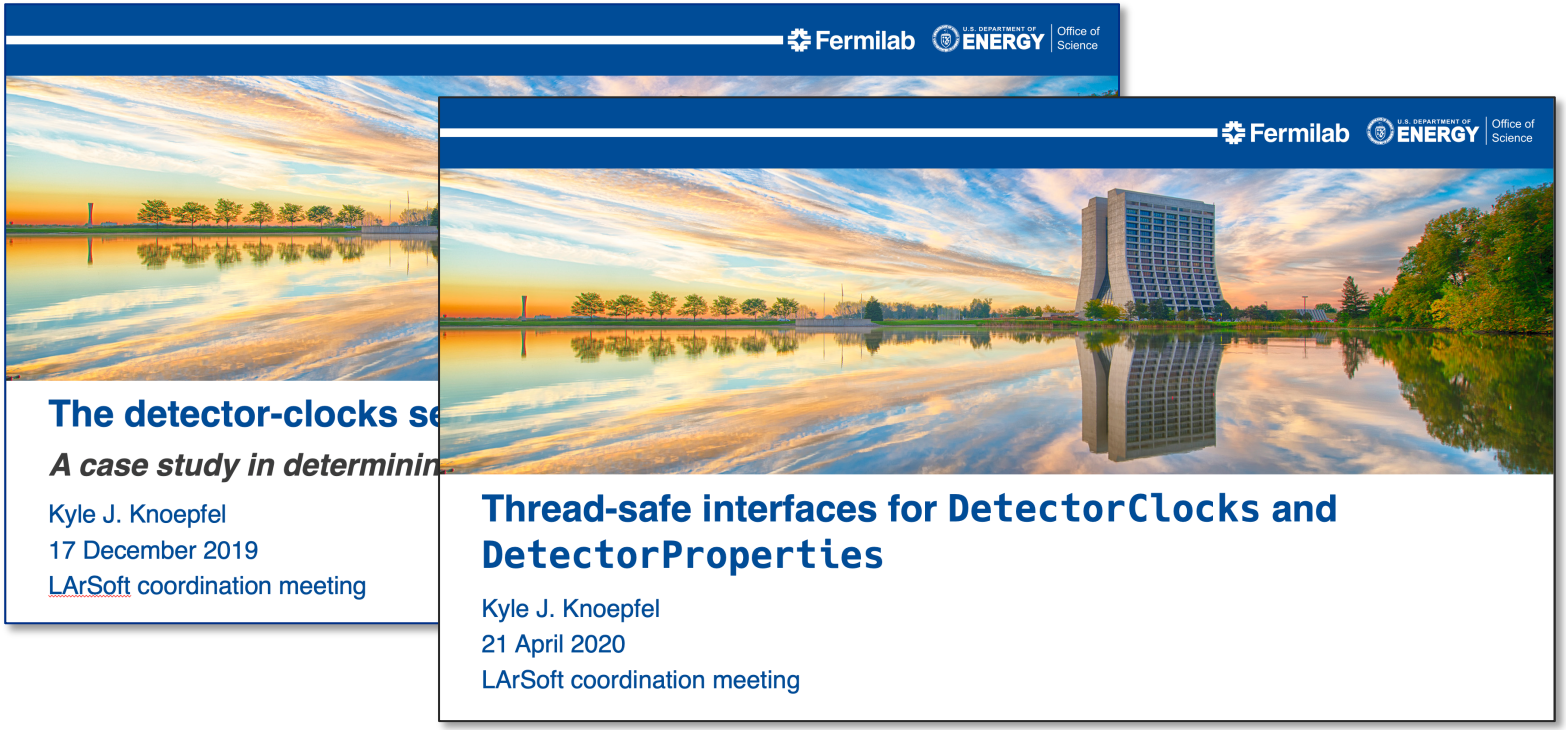

This talk presents final details

Proposal from April 21

- **Proposal:** The “persistent data structures” approach should be adopted for the `DetectorClocks` and `DetectorProperties` providers and services.

- Data structures are constant upon creation; adjusting the data structure dynamically occurs by layering newly created objects upon extant ones.

- This proposal agreed upon at the last coordination meeting.

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What does `DetectorClocks` look like?

- As only events within a subrun can be processed concurrently at the moment, only event-level data must be thread-safe.
- The majority of the `DetectorClocks` interface still exists, but there is an extra layer in between called `DetectorClocksData`.

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Old interface

```
using detinfo::DetectorClocksService;

MyProducer::MyProducer(ParameterSet const& pset)
{
  ServiceHandle<DetectorClocksService const> clocks;
  double beam_time = clocks->BeamGateTime();
}


void MyProducer::produce(art::Event& e)
{
  ServiceHandle<DetectorClocksService const> clocks;
  double beam_time = clocks->BeamGateTime();
}
```

New interface

```
using detinfo::DetectorClocksService;

MyProducer::MyProducer(ParameterSet const& pset)
{
  ServiceHandle<DetectorClocksService const> clocks;
  auto const clockData = clocks->DataForJob();
  double beam_time = clockData.BeamGateTime();
}

void MyProducer::produce(art::Event& e)
{
  ServiceHandle<DetectorClocksService const> clocks;
  auto const clockData = clocks->DataFor(e);
  double beam_time = clockData.BeamGateTime();
}
```


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What does `DetectorProperties` look like?

- As only events within a subrun can be processed concurrently at the moment, only event-level data must be protected.
- The majority of the `DetectorProperties` interface still exists, but there is an extra layer in between called `DetectorPropertiesData`.

Old interface

```
using detinfo::DetectorPropertiesService;

MyProducer::MyProducer(ParameterSet const& pset)
{
  ServiceHandle<DetectorPropertiesService> detProp;
  double dv = detProp->DriftVelocity(…);
}


void MyProducer::produce(art::Event& e)
{
  ServiceHandle<DetectorPropertiesService> detProp;
  double dv = detProp->DriftVelocity(…);
}
```

New interface

```
using detinfo::DetectorPropertiesService;

MyProducer::MyProducer(ParameterSet const& pset)
{
  ServiceHandle<DetectorPropertiesService> detProp;
  auto const dPropData = detProp->DataForJob();
  double dv = dPropData.DriftVelocity(…);
}

void MyProducer::produce(art::Event& e)
{
  ServiceHandle<DetectorPropertiesService> detProp;
  auto const dPropData = detProp->DataFor(e);
  double dv = dPropData.DriftVelocity(…);
}
```


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DetectorProperties under the covers…

- Some aspects of DetectorProperties relies on DetectorClocks.
- Although this is implicit, if you are using DetectorClocks and DetectorProperties in the same scope, you can optimize slightly.

```
using DetClocks = ServiceHandle<detinfo::DetectorClocksService>;
using DetProps = ServiceHandle<detinfo::DetectorPropertiesService>;

MyProducer::MyProducer(ParameterSet const&)
{
  auto const clockData = DetClocks{}->DataForJob();

  auto const dPropData1 = DetProps{}->DataForJob();       // Internally creates 'clockData' object
  auto const dPropData2 = DetProps{}->DataFor(clockData); // More efficient
}

void MyProducer::produce(art::Event& e)
{
  auto const clockData = DetClocks{}->DataFor(e);

  auto const dPropData1 = DetProps{}->DataFor(e);         // Internally creates 'clockData' object
  auto const dPropData2 = DetProps{}->DataFor(clockData); // More efficient
}
```


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Consequences of this design

- Configurations can remain the same.
- Code using the `DetectorClocks/Properties` services must know if event-level data or global data is needed.
- Framework-agnostic code that creates a `DetectorClocks/Properties` service handle must be adjusted to receive the correct information.
  - Can no longer access the provider directly through service.

```
MyProducer::MyProducer(ParameterSet const& pset)
{
  auto clocks = lar::providerFrom<detinfo::DetectorClocksService>();    // ! Compile-time error
  auto dprop = lar::providerFrom<detinfo::DetectorPropertiesService>(); // ! " "
}
```

- The provider/service hierarchies still exist, and the providers are usable with gallery programs, albeit with a different interface.

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Other breaking changes

- In short: "**remove as much mutable state as possible**"
  - Many 'reconfigure' functions in larreco have been removed.
  - `detinfo::ElecClock` interface has changed
  - Many `BackTracker` functions now require a `DetectorClocksData` argument.
  - Various `larreco` class interfaces now take a `DetectorClocksData` and/or `DetectorPropertiesData` argument.
- *Tangential:* `boost::optional` use has been replaced with `std::optional`
- Any code using `DetectorPropertiesData` must link against `lardataalg_DetectorInfo`.
- ArgoNeuT's detector-properties service in `lardata/Utilities` has been refactored into a provider and a service.
  - First step toward moving the ArgoNeuT-specific services from lardata to argoneutcode.

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LegacyLArG4

- Custom physics lists in larsim are currently enabled through the use of static variables constructed whenever `liblarsim_LegacyLArG4.so` has been loaded.
- This is a weak design as one must be careful when the library is loaded.
- With the adjusted interface, LArSoft's custom physics lists are no longer created automatically at library load time.
  - An explicit call must be made in the constructor of (e.g.) LArG4 to load them:

```
LArG4::LArG4(fhicl::ParameterSet const& pset)
  : art::EDProducer{pset}
  , …
  , fAllPhysicsLists{art::ServiceHandle<DetectorPropertiesService>()->DataForJob()}
{
   MF_LOG_DEBUG("LArG4") << "Debug: LArG4()";
   …
}
```


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Disentangling detector clocks/properties

- `DetectorProperties` has provided sampling-rate and trigger-offset accessors.
  - But those functions rely only on the clocks service.

Replace:	`auto detprop = lar::providerFrom<detinfo::DetectorPropertiesService>();`
	`auto rate = detprop->SamplingRate();`
	`auto offset = detprop->TriggerOffset();`

With:	`auto clockData =`
	`  art::ServiceHandle<detinfo::Detector**Clocks**Service>()->DataFor(e);`
	`auto rate = **sampling_rate**(clockData);`
	`auto offset = **trigger_offset**(clockData);`

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Disentangling detector clocks/properties

- `DetectorProperties` has provided sampling-rate and trigger-offset accessors.
  - But those functions rely only on the clocks service.

Replace:	`auto detprop = lar::providerFrom<detinfo::DetectorPropertiesService>();`
	`auto rate = detprop->SamplingRate();`
	`auto offset = detprop->TriggerOffset();`

With:	`auto clockData =`
	`  art::ServiceHandle<detinfo::DetectorClocksService>()->DataFor(e);`
	`auto rate = sampling_rate(clockData);`
	`auto offset = trigger_offset(clockData);`

- I see a lot of places like this:

```
double timetick = sampling_rate(clockData) * 1e-3; // time sample in us
```

- In the future, I suggest an interface like:

```
double timetick = sampling_rate<microseconds>(clockData);
```


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Removed files

- The following files had dependencies on detector clocks and properties, but they were not used anywhere in the LArSoft code base or in experiment's develop branches.

larreco/Calorimetry/
- LinearEnergyAlg.*

larreco/RecoAlg/CMTool/CMTAlgMatch/
- CFAlgo3DAngle.*
- CFAlgoChargeDistrib.h
- CFAlgoStartPointCompat.*
- CFAlgoStartPointMatch.*
- CFAlgoStartTimeCompat.*
- CFAlgoVolumeOverlap.*
- CFAlgoWireOverlap.*
- *CMTAlgMatch-TypeDef.h*
- *LinkDef.h*
- *bin*

larreco/RecoAlg/CMTool/CMTAlgMerge/
- CBAlgoShortestDist.*
- CBAlgoShortestDistNonEndPoint.*
- CBAlgoShortestDistSmallCluster.*
- CBAlgoStartInCone.*
- CBAlgoStartInPoly.*
- CBAlgoTrackSeparate.*
- *CMTAlgMerge-TypeDef.h*
- *LinkDef.h*
- *bin*

larreco/RecoAlg/CMTool/CMTAlgPriority/
- *CMTAlgPriority-TypeDef.h*
- *LinkDef.h*
- *bin/*
- *lib/*

larreco/RecoAlg/CMTool/CMToolBase/
- *CMTool-TypeDef.h*
- *LinkDef.h*
- *lib/*

larreco/RecoAlg/CMTool/mac

- If this is a problem, let me know.

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Observations in experiment code

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Unnecessary typing

- There were many places where detector-clocks/properties pointers were being cached but not used.
  - This creates a maintainability problem, and a lot of extra time porting code.
  - **If you're not using a variable, please remove it.**

- There were many places where code was repeated from one module to another.
  - Cut-and-paste is easy upfront, but it is a maintenance nightmare.
  - Each place in the code has to be updated whenever the interface changes.
  - **Refactor the code so that you "don't repeat yourself" (DRY).**

- **If you want multi-threaded code sooner, please remove duplicate code.**

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Numerics

- Many places where code could be clearer, more concise, and more efficient:

Replace …	with …
`TMath::Xyz(…)` *[e.g. `TMath::Sqrt(…)`]*	`std::xyz(…)` *[e.g. `std::sqrt(…)`]*
`std::pow(x, 0.5)`	`std::sqrt(x)`
`std::pow(x, 2)`	`cet::square(x)`
`std::sqrt(std::pow(x, 2) + std::pow(y, 2))`	`std::hypot(x, y)`

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Miscellany

- **Passing by value vs. reference**
  - Understand in which contexts it makes sense to pass by value, and when it makes sense to pass by reference.
  - My general guidance:

```
if size of data == 8 to 24 bytes:
  pass by value
else
  pass by reference
```


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Miscellany

- **Passing by value vs. reference**
  - Understand in which contexts it makes sense to pass by value, and when it makes sense to pass by reference.
  - My general guidance:

```
if size of data == 8 to 24 bytes:
  pass by value
else
  pass by reference
```

- **Highly nested logic**
  - If there is a lot of whitespace to the left of your code, then you probably need to refactor the code.

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Misc

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sense

ctor

```
                                                true_mu_median_len_ratio->Fill((float(med_ftrstmu-med_laststmu))/mud_tlen);
                                                true_all_trk_median_dedx->Fill(med_allk);
                                                true_all_trmu_median_dedx->Fill(med_allmu);
                                              } // trk g4 match
                                            } // getting true mu
                                          } // getting scttering particles
                                        } // 2 nd loop over geant list for P
                                      } // getting stopping K
                                    } // getting primary K...
                                  } // 1 st loop over geant list for P...
                                } // break indicator...
                                //} // Mu mom cut ....
                                //} // Med all mu dE/dx...
                              } // Mu PIDA .....
                              //} // Med all K dE/dx...
                            } // K PIDA cut ......
                            //} // K/Mu min-max hit cut .....
                            //} // Muon tracklength cut ......
                          } // K/Mu open angle cut .....
                        } // K/Mu energy gradient cut.....
                      } // decay mu connected to start of K
                    } // primary mu is connected to end of K
                    ////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////

                      } // decay mu is contained...
                    } // more than 10 hits for dec mu....
                    //} // 3rd loop over ical for i_2 track....
                  } // trklen cut for decaying mu
                } // 3 rd loop over tracks
              } // primay K and primay Mu distance matching....
            } // pri K contained...
          } // more than 10 hits for Pri K...
          //} // 2 nd loop over ical for i_1 track....
        } // pri K >= 10 cm
      } // 2 nd loop over tracks...
    } // more thans 10 hits for pri mu...
    //} // 1 st loop over cal of i track...
    //} // calorimetry info saved...
  } // primary mu >= 60 mc ...
} // 1 st loop over tracks....
} // tracks > 3 in the event....
} // track infomation is saved.....
}// is not data (is MC) if statement.........
```

Time to refactor…

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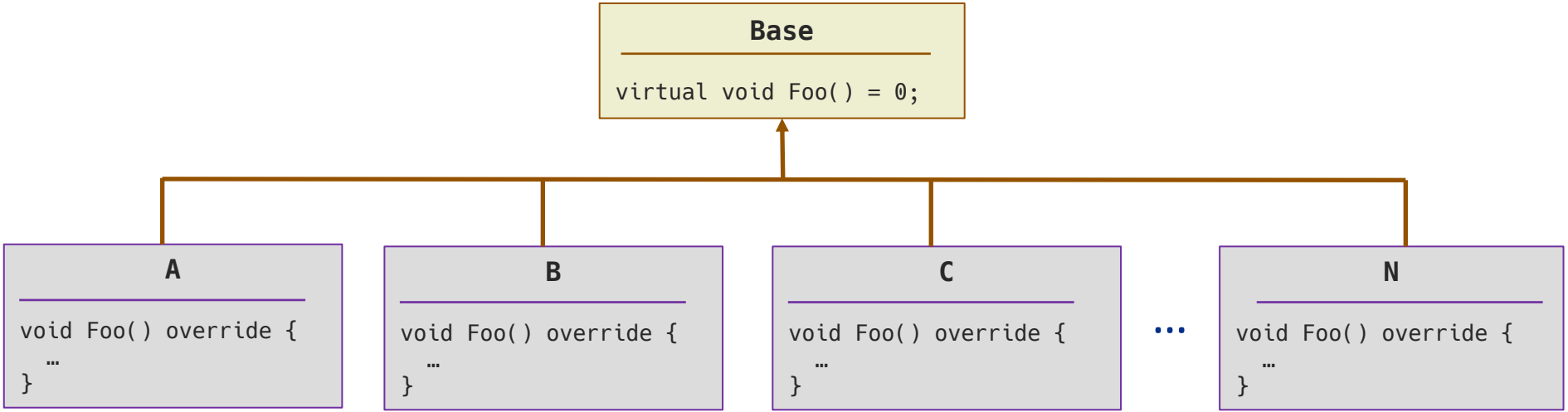
Challenges with inheritance



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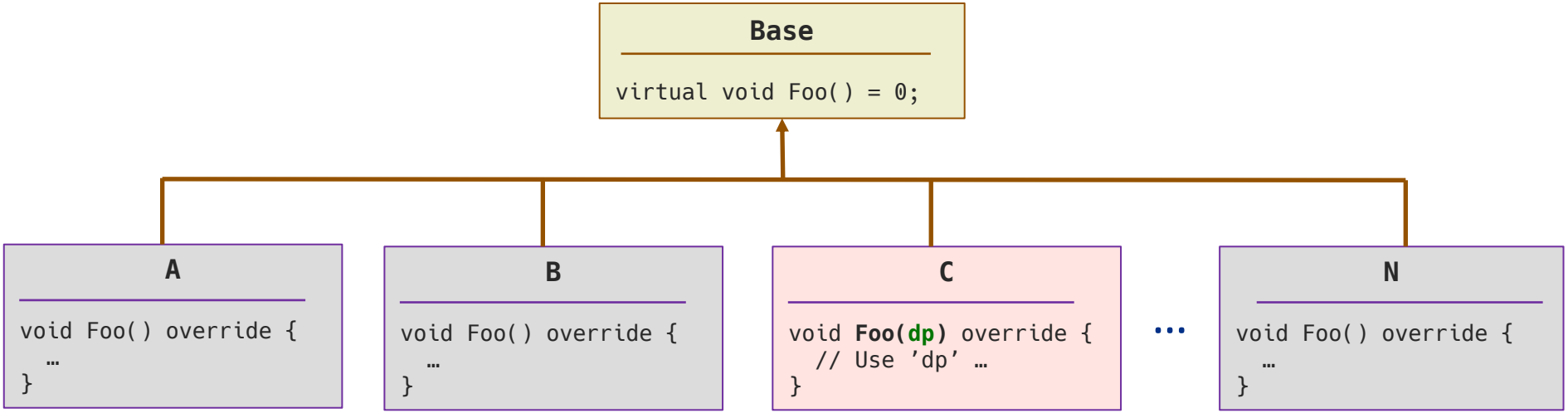

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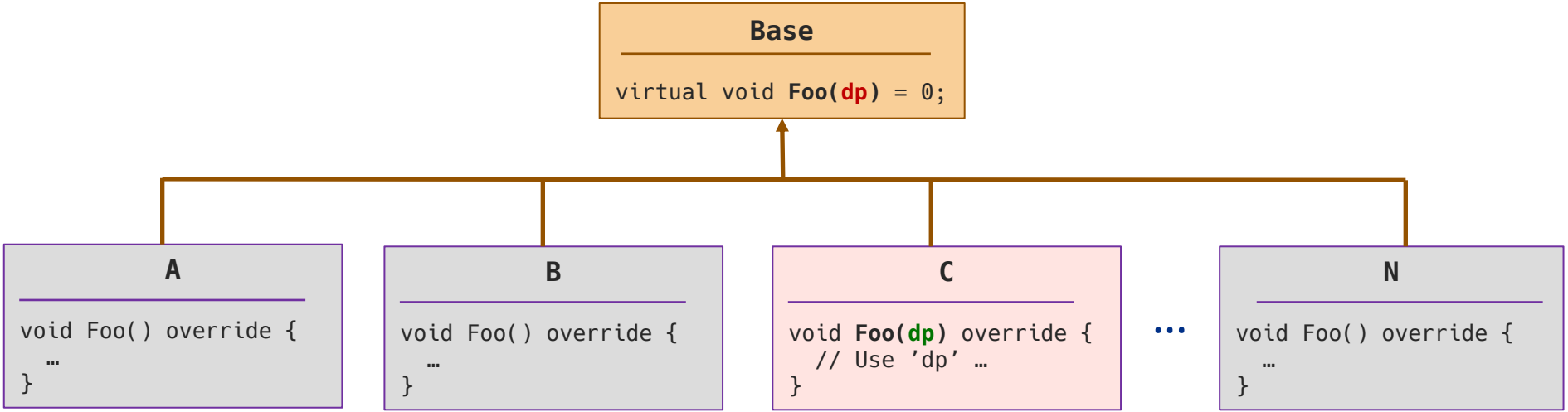

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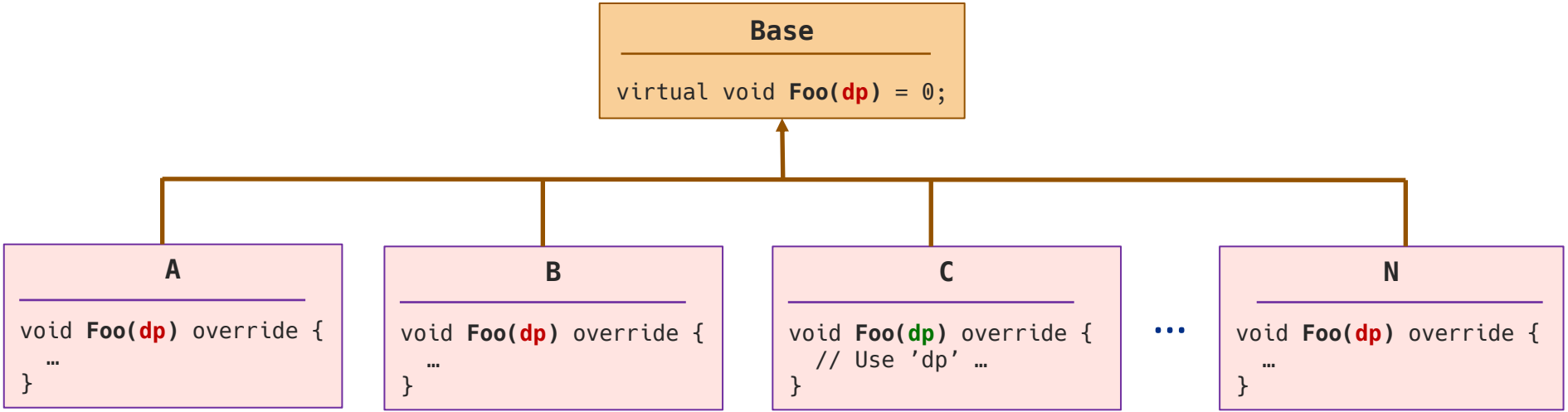

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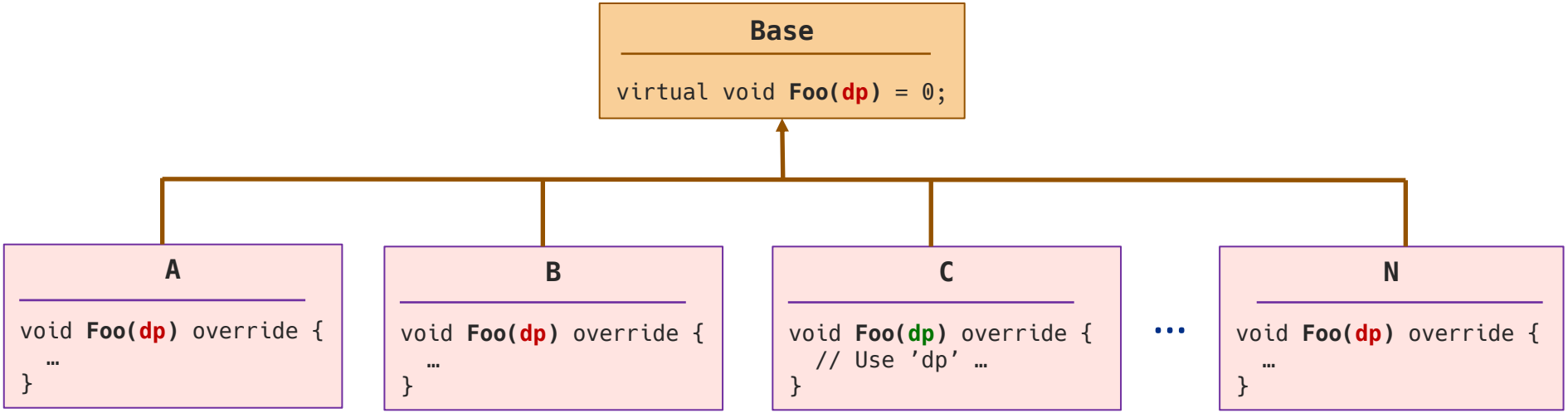
Challenges with inheritance



- If only one implementation requires an interface change, all are affected.
- Before you implement and start using an interface:
  - Make sure it is the best solution for the task to be accomplished.
  - Expect to have to adjust the interface over time.

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Library dependencies

- Some products support target-based CMake library specifications:
  - **ROOT**: Replace (e.g.) `${ROOT_CORE}` with `ROOT::Core`
  - **Boost**: Replace (e.g.) `${Boost_FILESYSTEM_LIBRARY}` with `Boost::filesystem`
- Remove the `Boost::system` (or `${Boost_SYSTEM_LIBRARY}`) dependency from your CMakeLists.txt files.
- All modules or services compiled with `simple_plugin` or `art_make` have some basic libraries included automatically.

Modules	`art_Framework_{Core,Principal}, art_Persistency_{Common,Provenance}, art_Utilities`
	`canvas, fhiclcpp, cetlib, cetlib_except,`
	`Boost::filesystem`

Services	`art_Framework_Services_Registry, art_Persistency_Common, art_Utilities`
	`canvas, fhiclcpp, cetlib, cetlib_except,`
	`Boost::filesystem`

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Conclusions

- Aim to have PRs and experiment feature branches ready by tomorrow (Wednesday) morning.
- Feature branch names will be `feature/knoepfel_detector_services`
- Please look at the feature branches to determine how some of the experiment-specific interface has changed.
  - If you have concerns, please contact me.
- Thank you for your patience.
  - This has been a long slog, but many LArSoft underpinnings will either be thread-safe or be easier to make thread-safe.

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