

# Introduction to LArSoft

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art/LArSoft Course

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# Goals for this session

- Provide overview of LArSoft project, collaboration and software
- Introduce basic concepts and workflows
- Summarize primary LArSoft design principles
- Provide simple example of how to use LArSoft
- Summarize available resources and documentation

# Outline

- What is LArSoft?
- Operation of single-phase LAr TPC
- Primary reconstruction overview
  - Workflow and data structures
- Secondary reconstruction
- Simulation overview
- LArSoft design principles
- Using LArSoft
- Resources

# What is LArSoft?

- A project / collaboration
  - Provide an integrated, art-based, experiment-agnostic set of software tools for LAr neutrino experiments to perform simulation, reconstruction and analysis
    - The core LArSoft (“project”) team maintains infrastructure, architecture, interfaces, coordination, code management and distribution
    - Experiment partners provide technical requirements, development effort and coordination, required experiment-specific plug-ins and configuration
- A body of code
  - Core LArSoft products
    - Experiment-agnostic data structures, algorithms, interfaces, etc
    - Lives in a set of repositories managed by the core LArSoft team
  - Experiment-specific components
    - Detector-specific geometry descriptions, electronics response functions, calibration functions, etc.
    - Live in repositories managed by the experiments

# What is LArSoft?

- The collaboration of experiments, Fermilab, other stakeholders in the project
  - DUNE/35T/LBNF
  - MicroBooNE
  - SBND
  - LArIAT
  - ArgoNeuT
  - NuTools
  - art
  - Pandora
  - Core LArSoft project
  - Future participating experiments, laboratories and projects

The experiments define requirements, schedules, priorities

# What is LArSoft?

- A project / collaboration

- Provide an integrated, art-based, experiment-agnostic set of software tools for LAr neutrino experiments to perform simulation, reconstruction and analysis
  - The core LArSoft (“proj”) interfaces, coordination
  - Experiment partners provide coordination, required

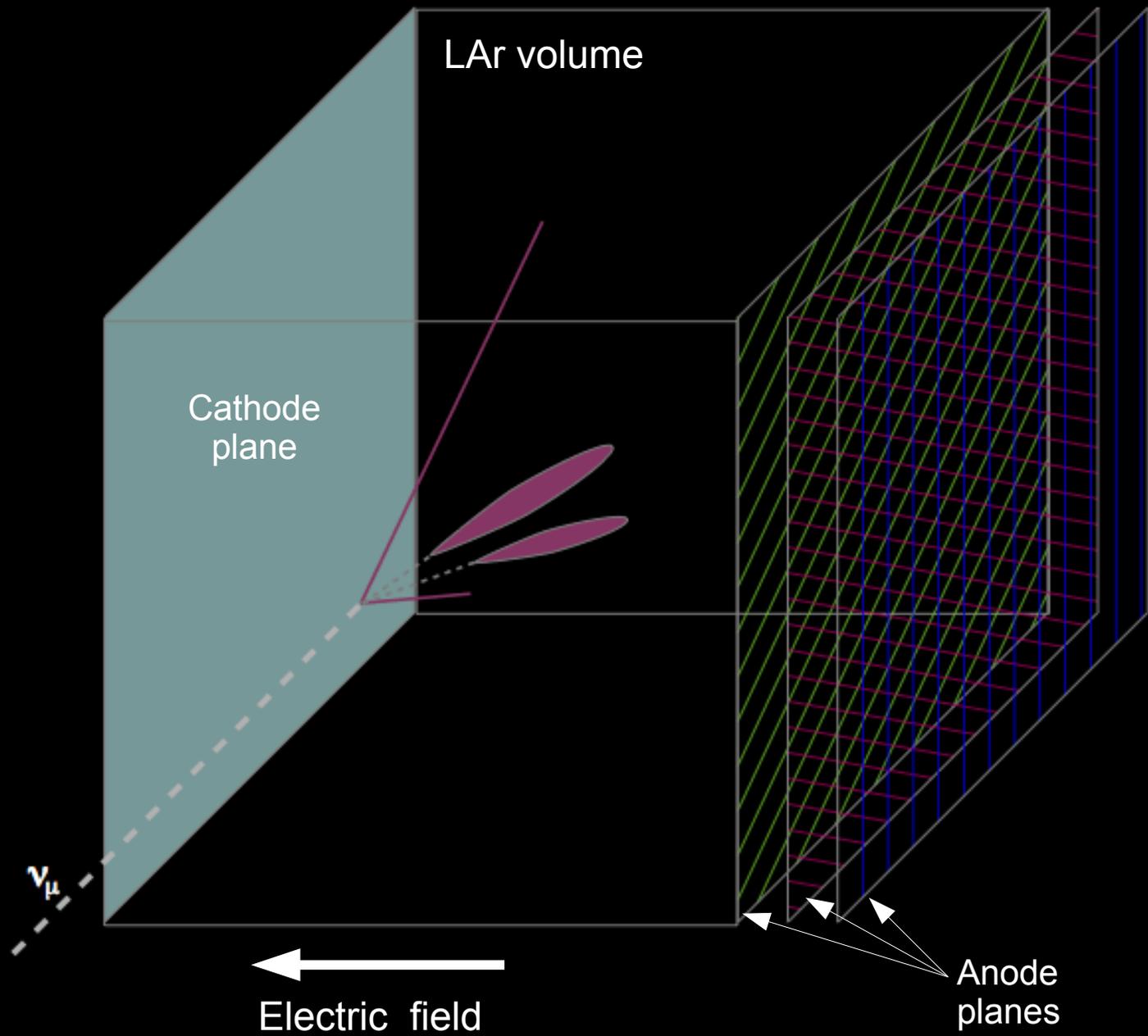
To understand the code and how it is made detector-agnostic, start with the operation of a LAr TPC

- A body of code

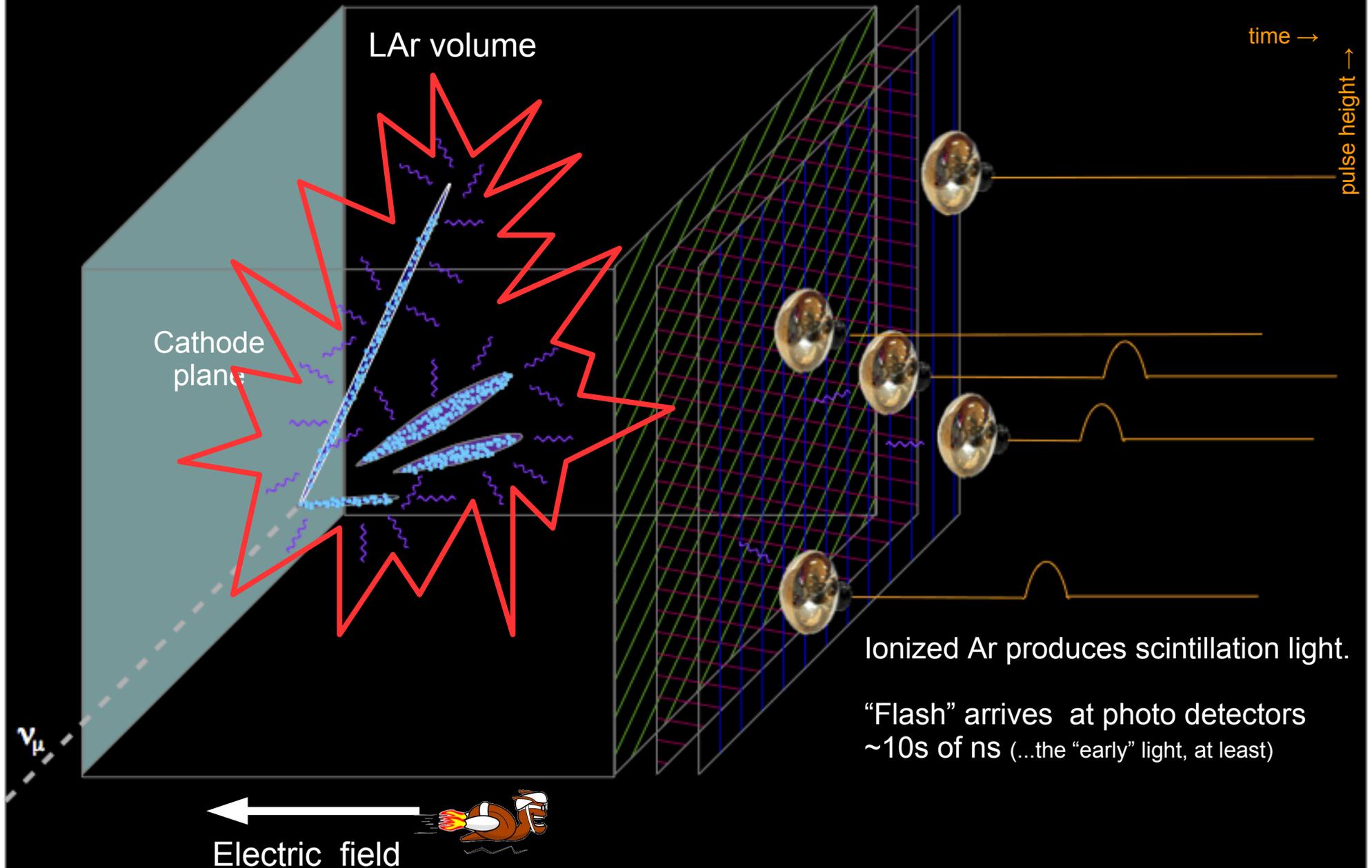
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# Operation of a single-phase LAr TPC

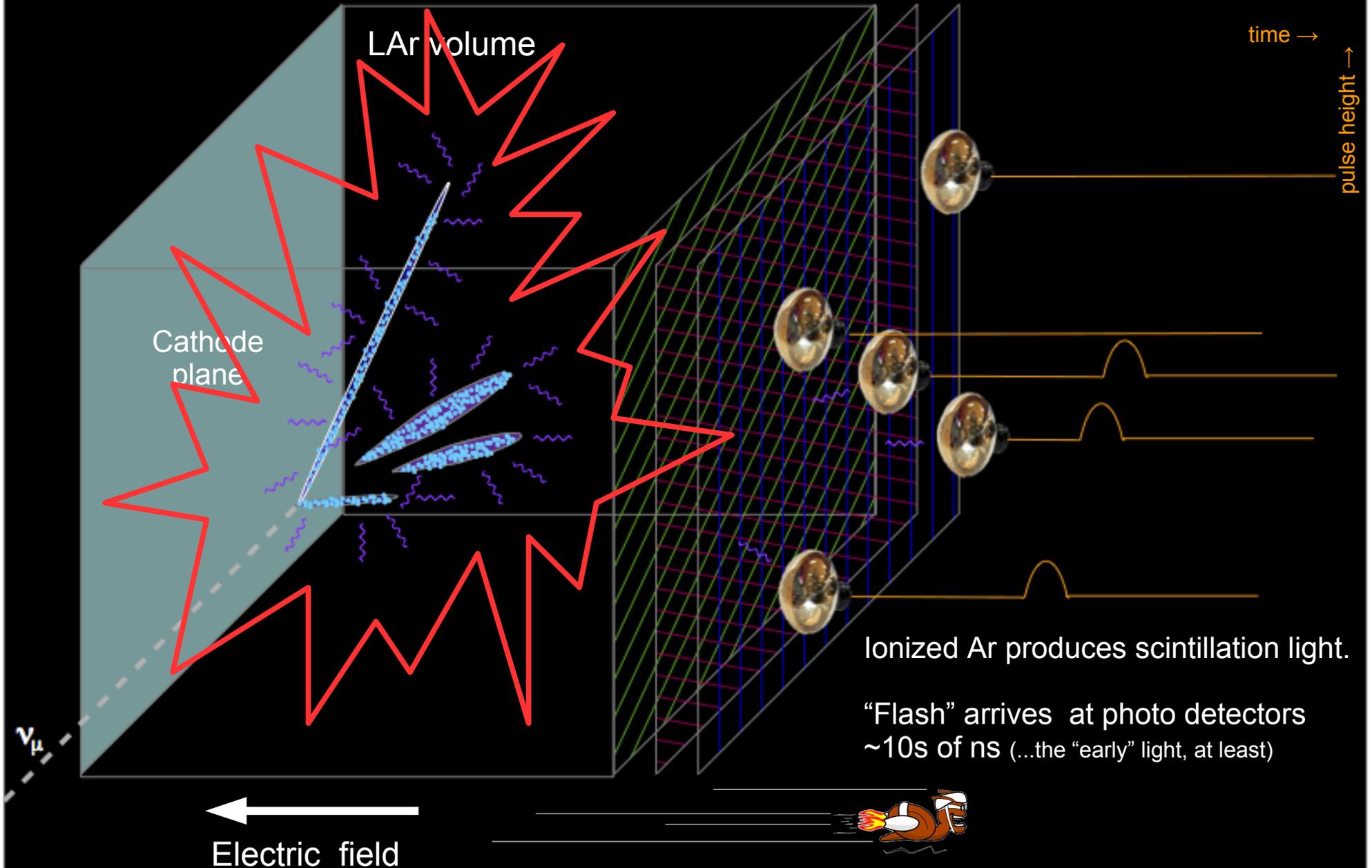
# Operation of single-phase LAr TPC



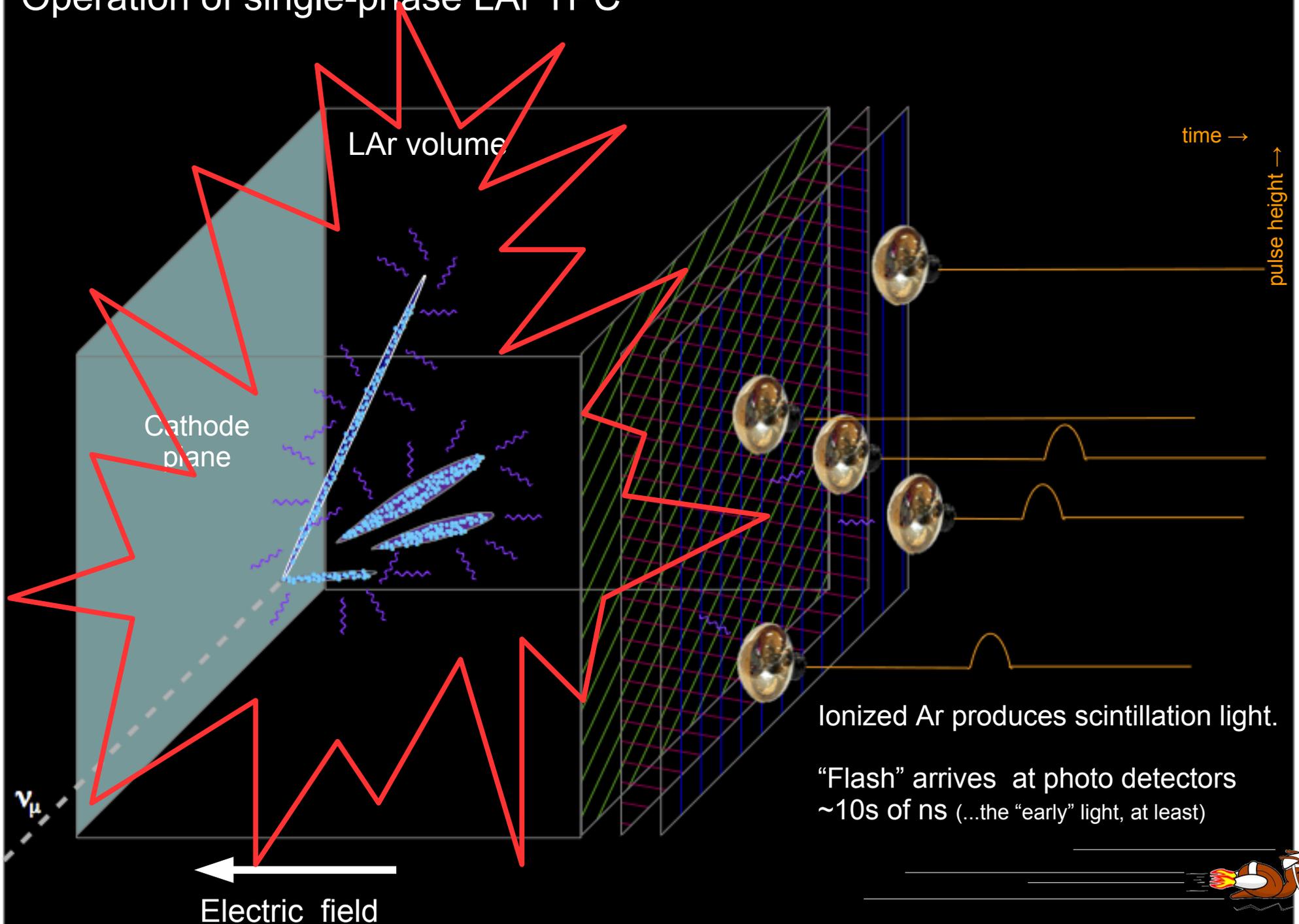
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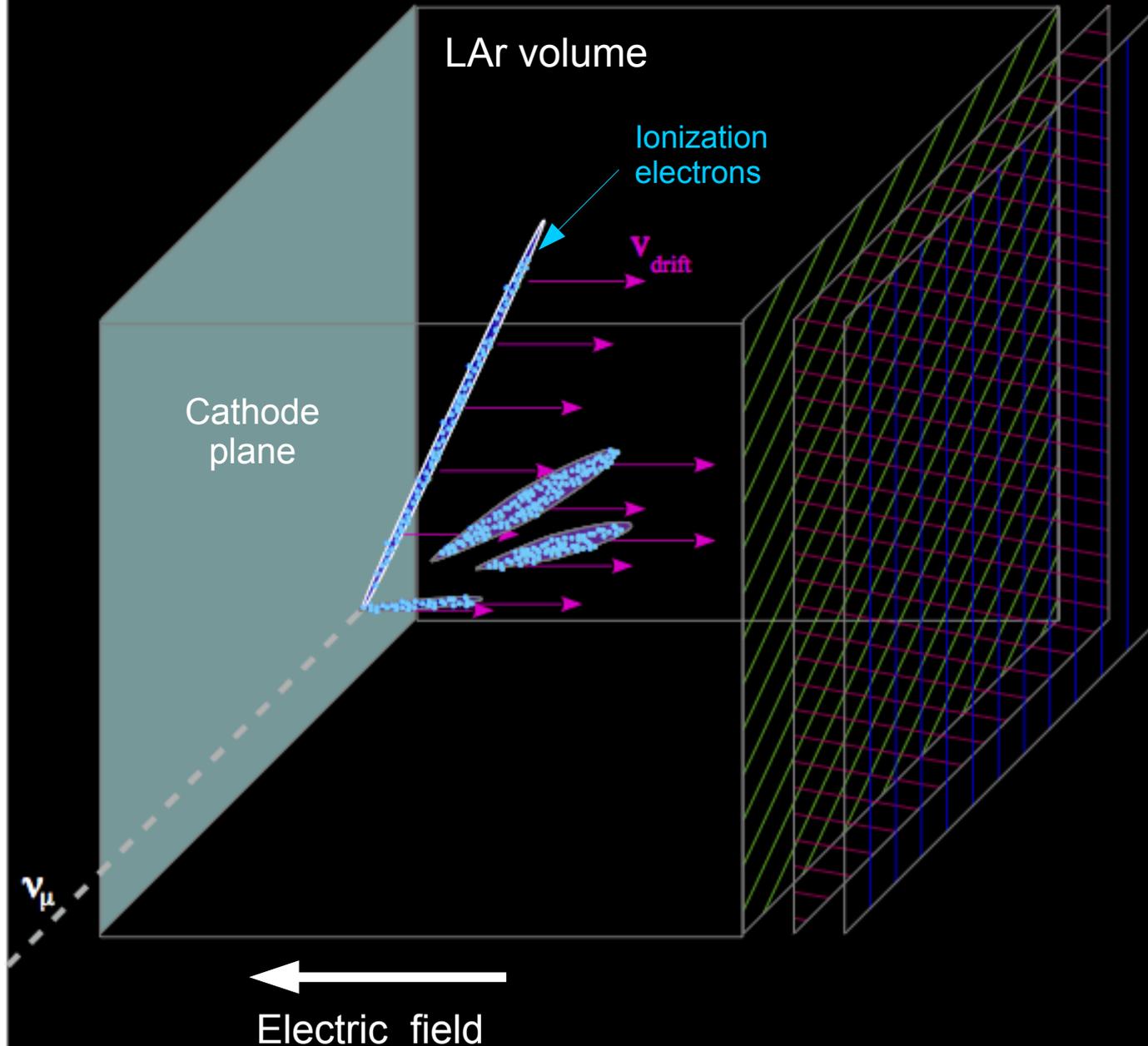
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# Operation of single-phase LAr TPC



# Operation of single-phase LAr TPC



Neutrino interacts with Ar nucleus

Charged secondaries ionize the Ar

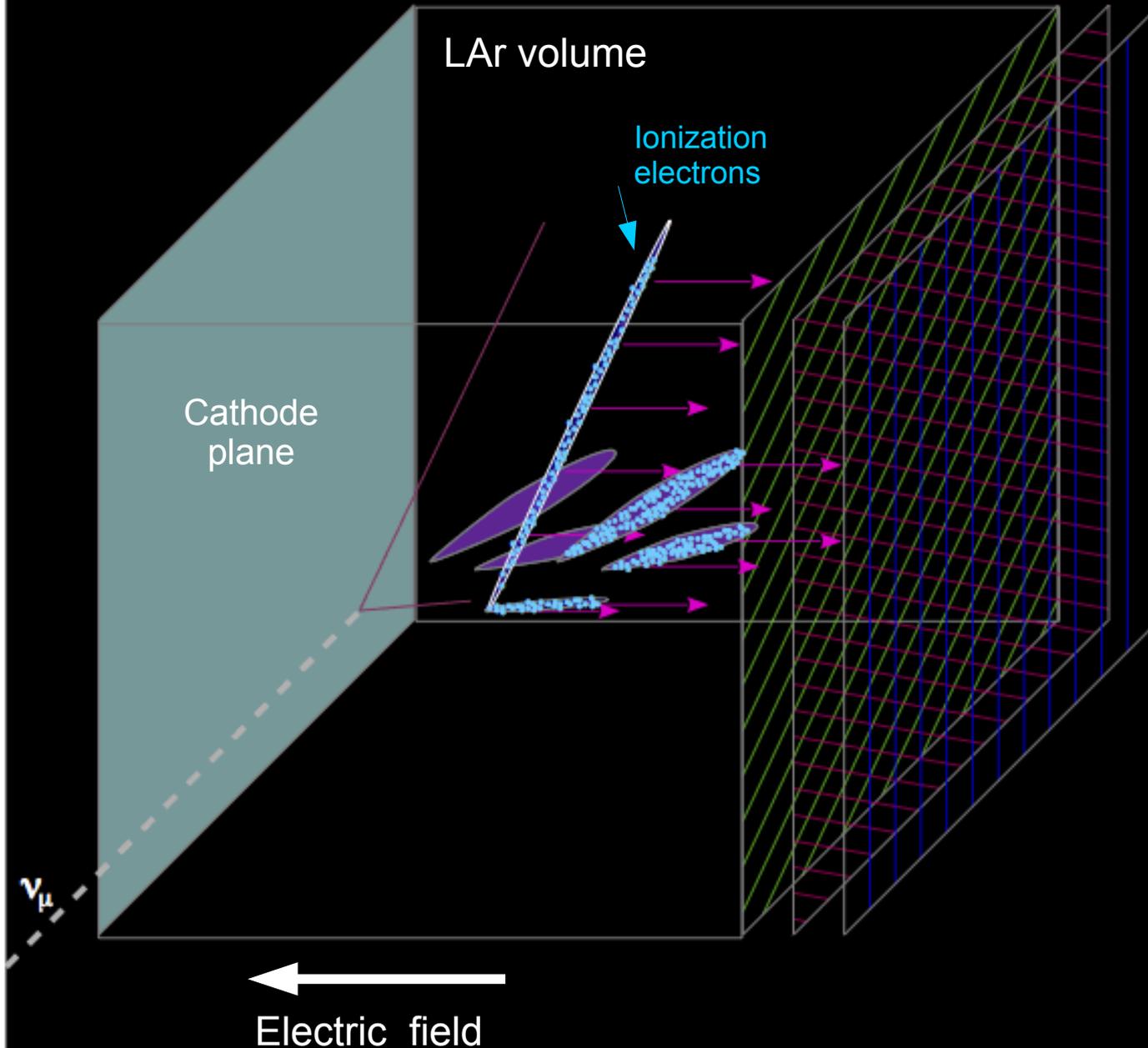
Electrons drift in the electric field toward anode wires

$$v_{drift} \approx 1 - \text{few mm}/\mu\text{s}$$



Max drift time ~ ms!!

# Operation of single-phase LAr TPC



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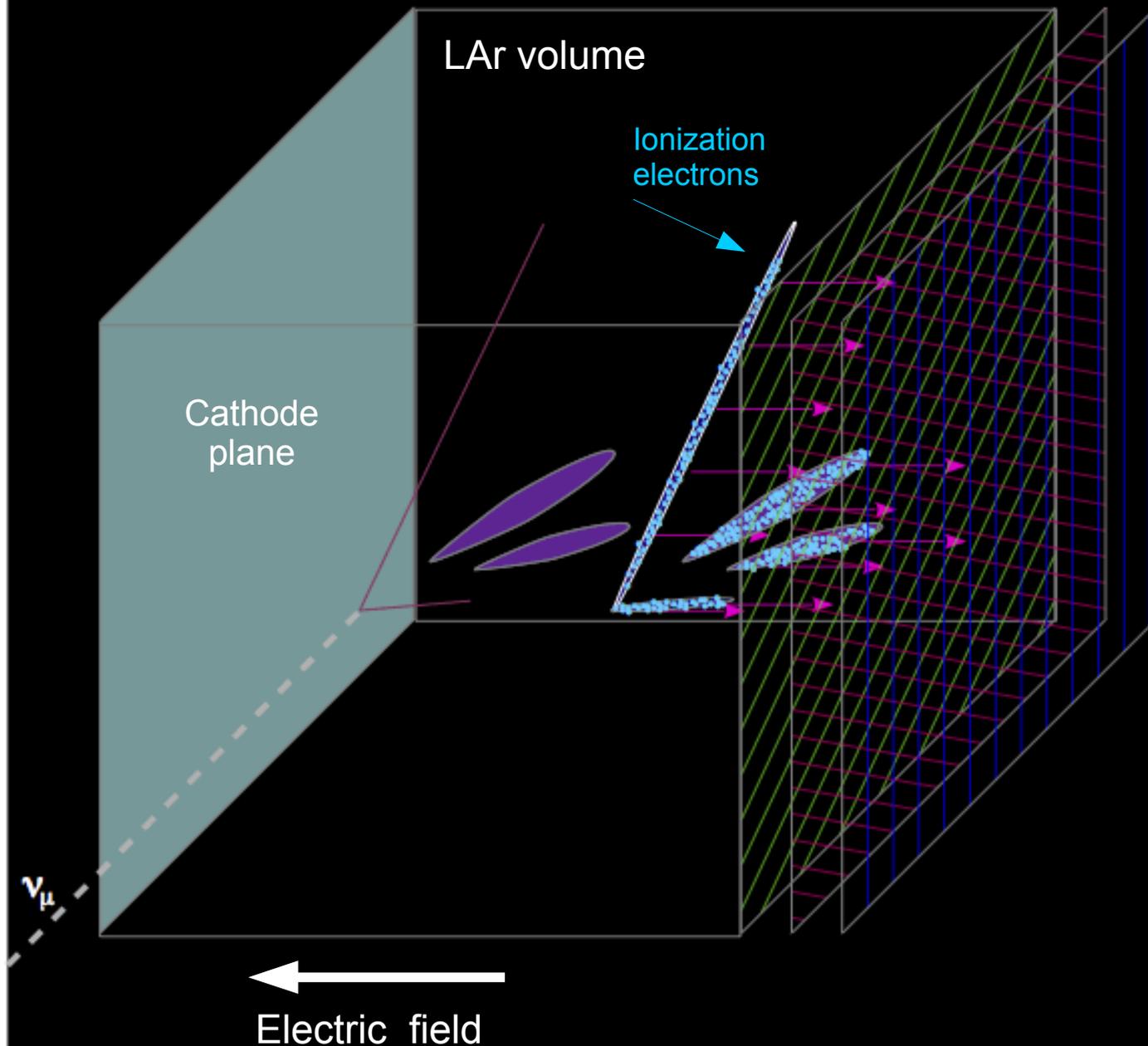
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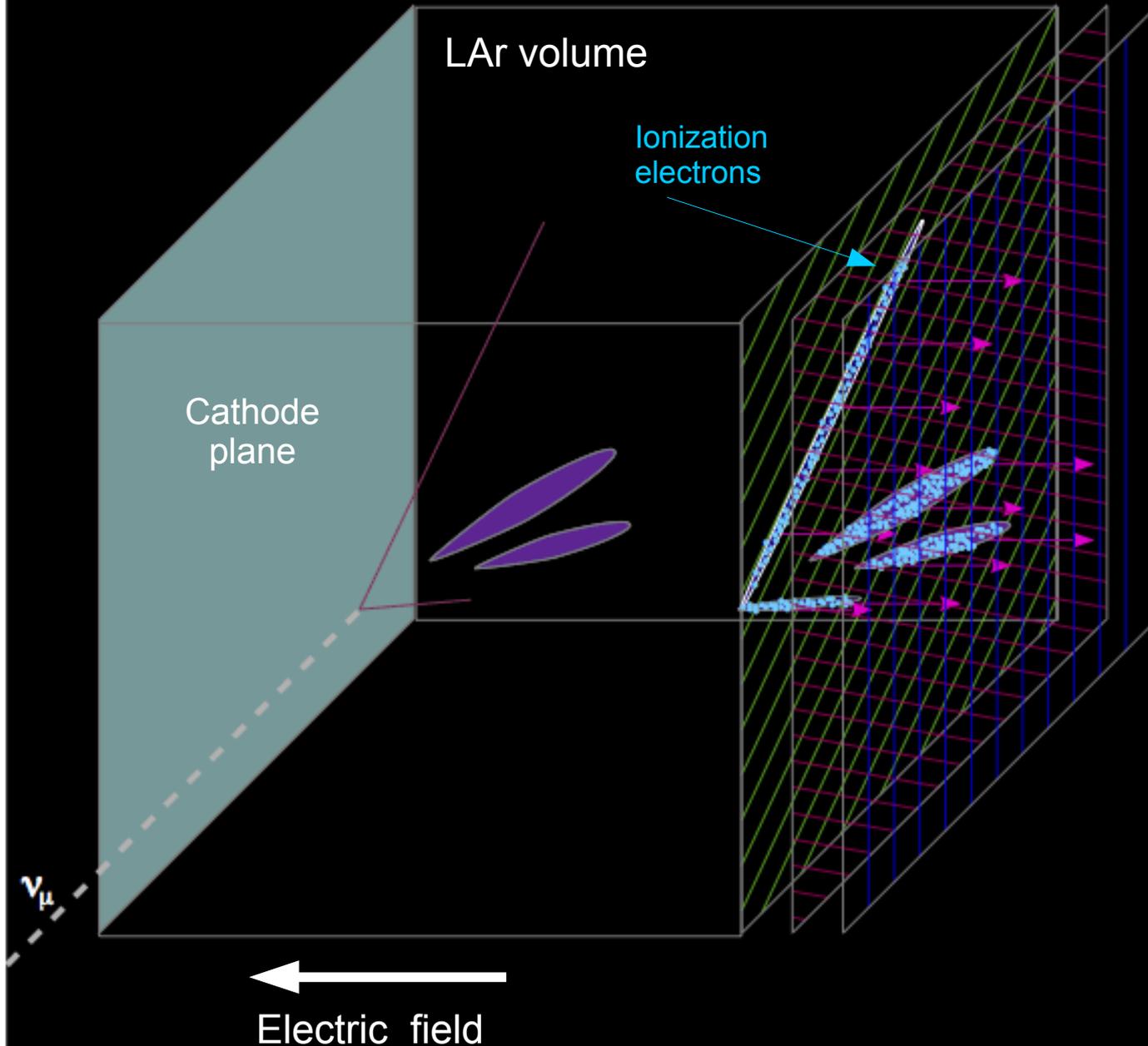
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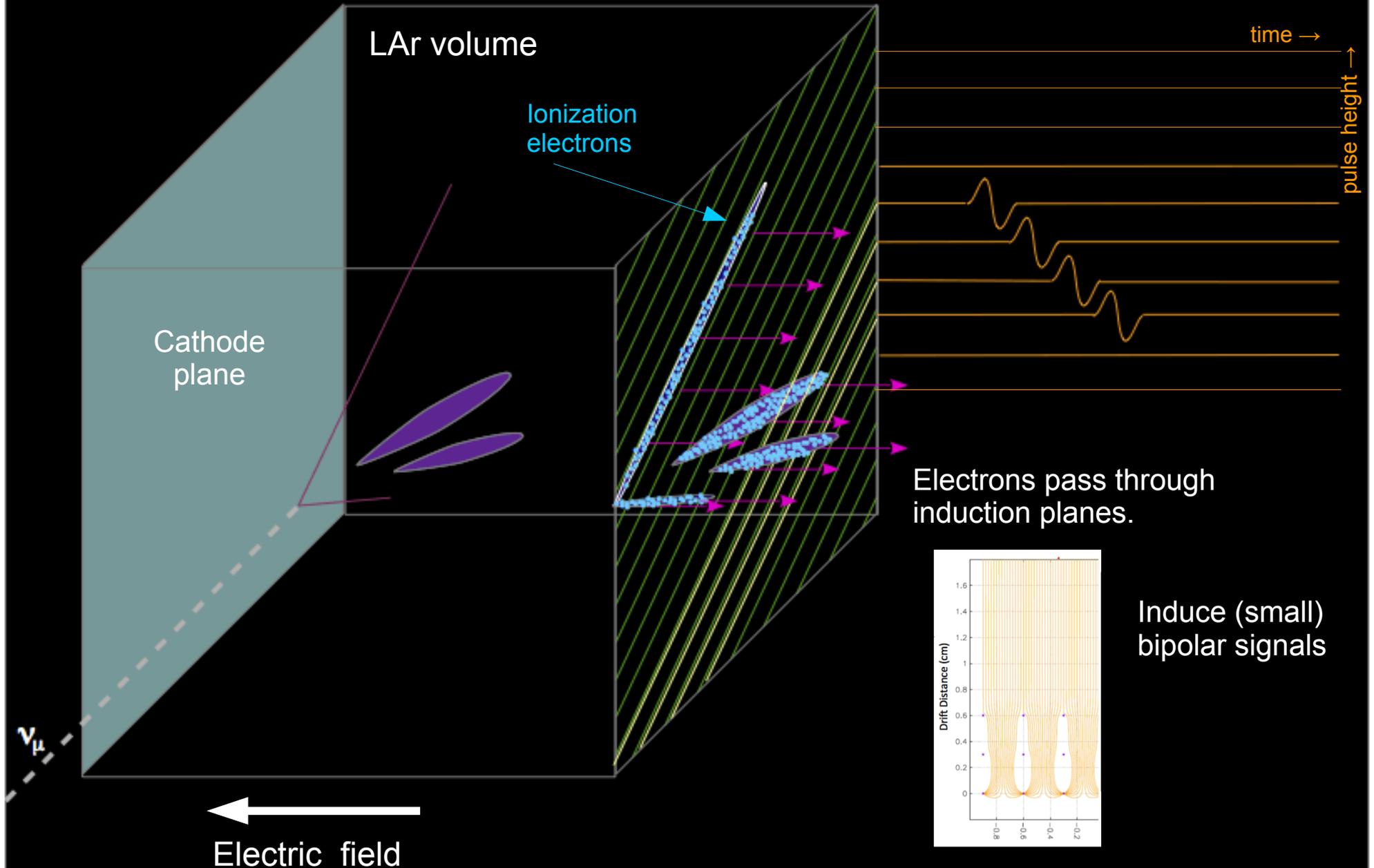
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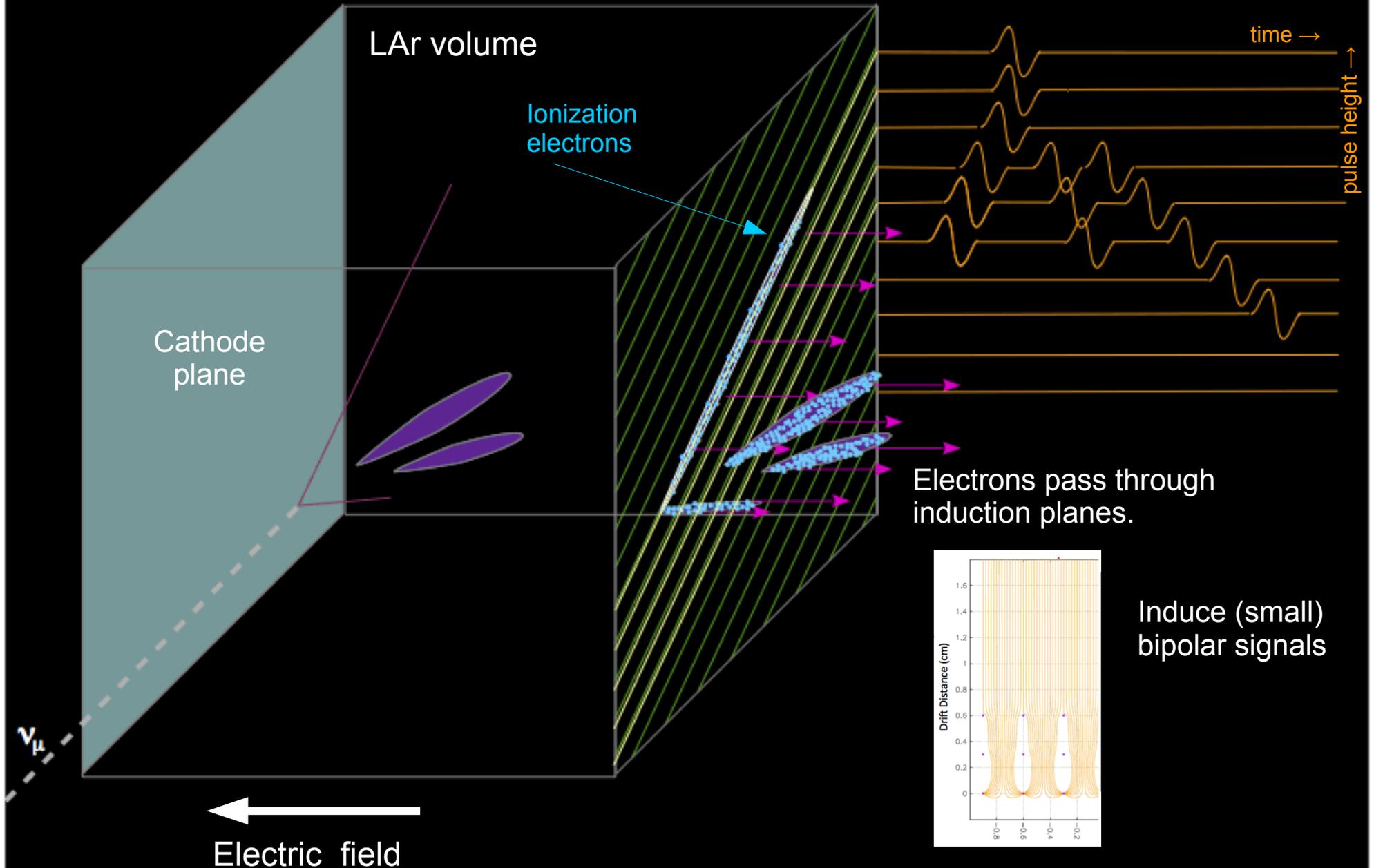


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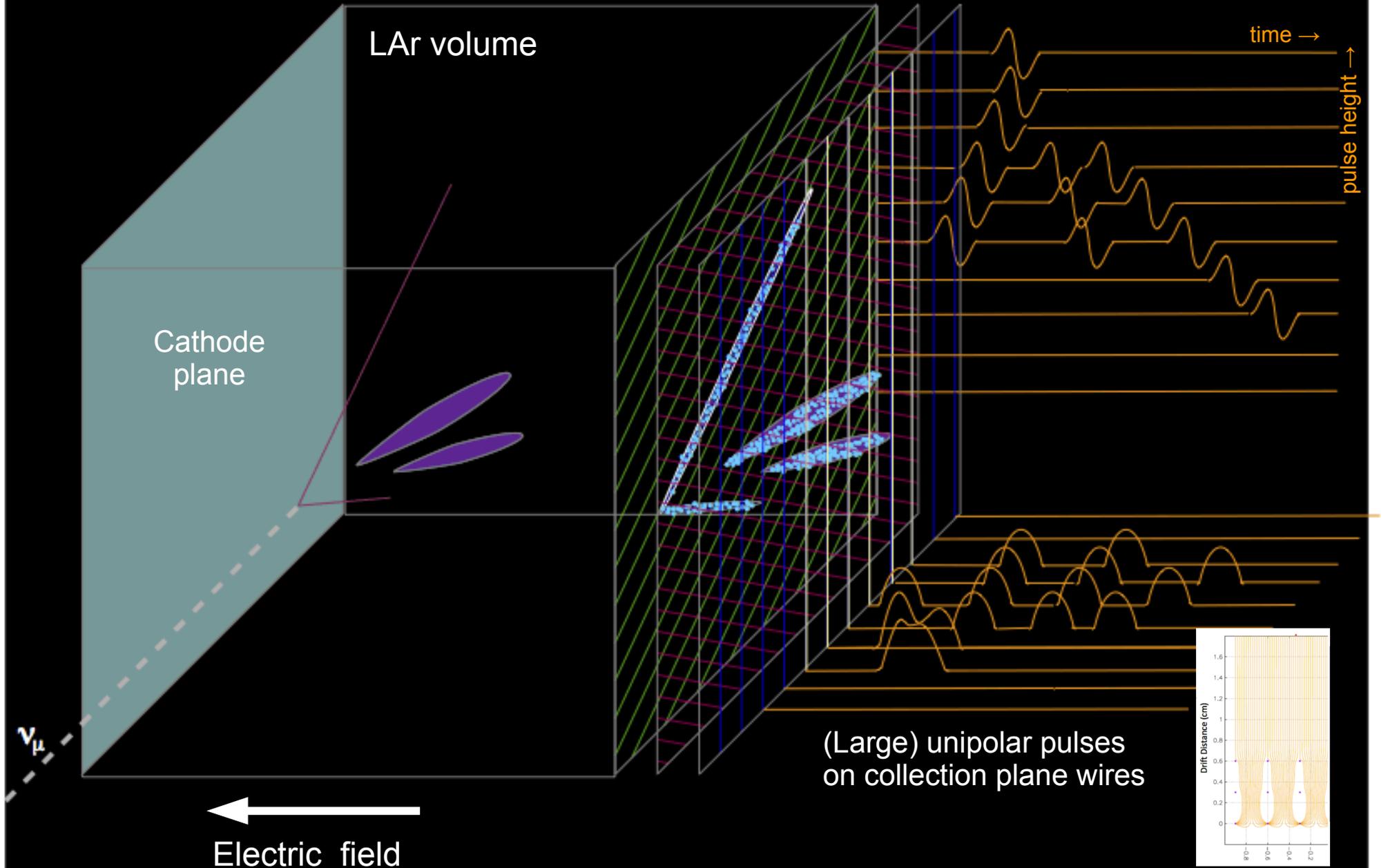
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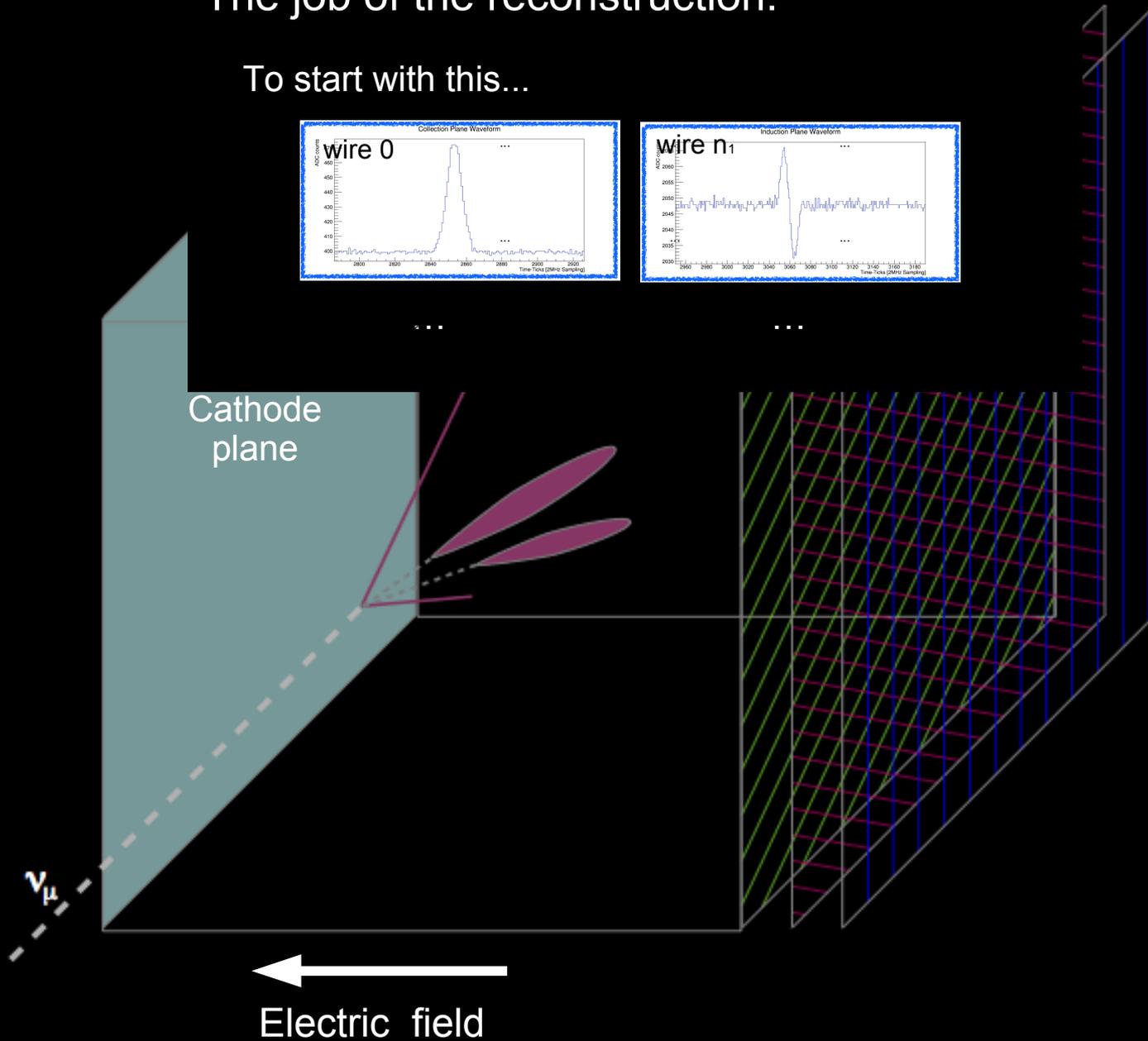
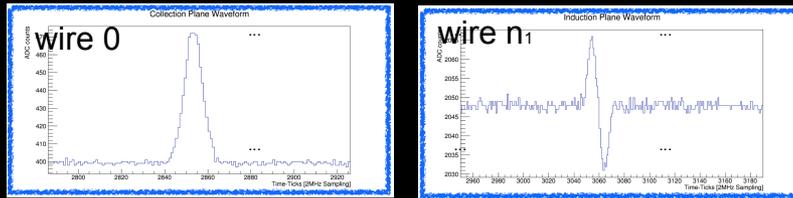
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# Operation of single-phase LAr TPC

The job of the reconstruction:

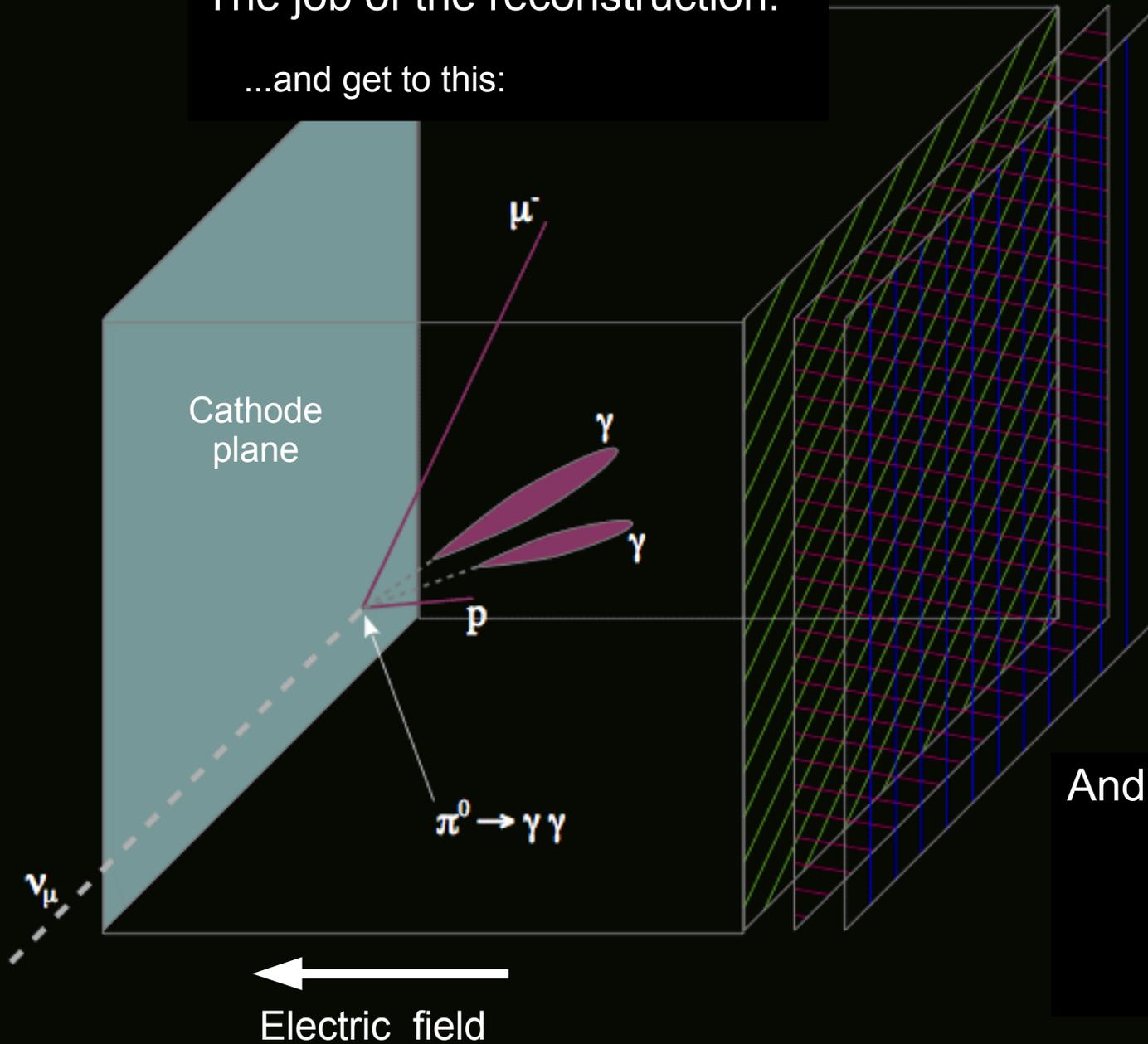
To start with this...



# Operation of single-phase LAr TPC

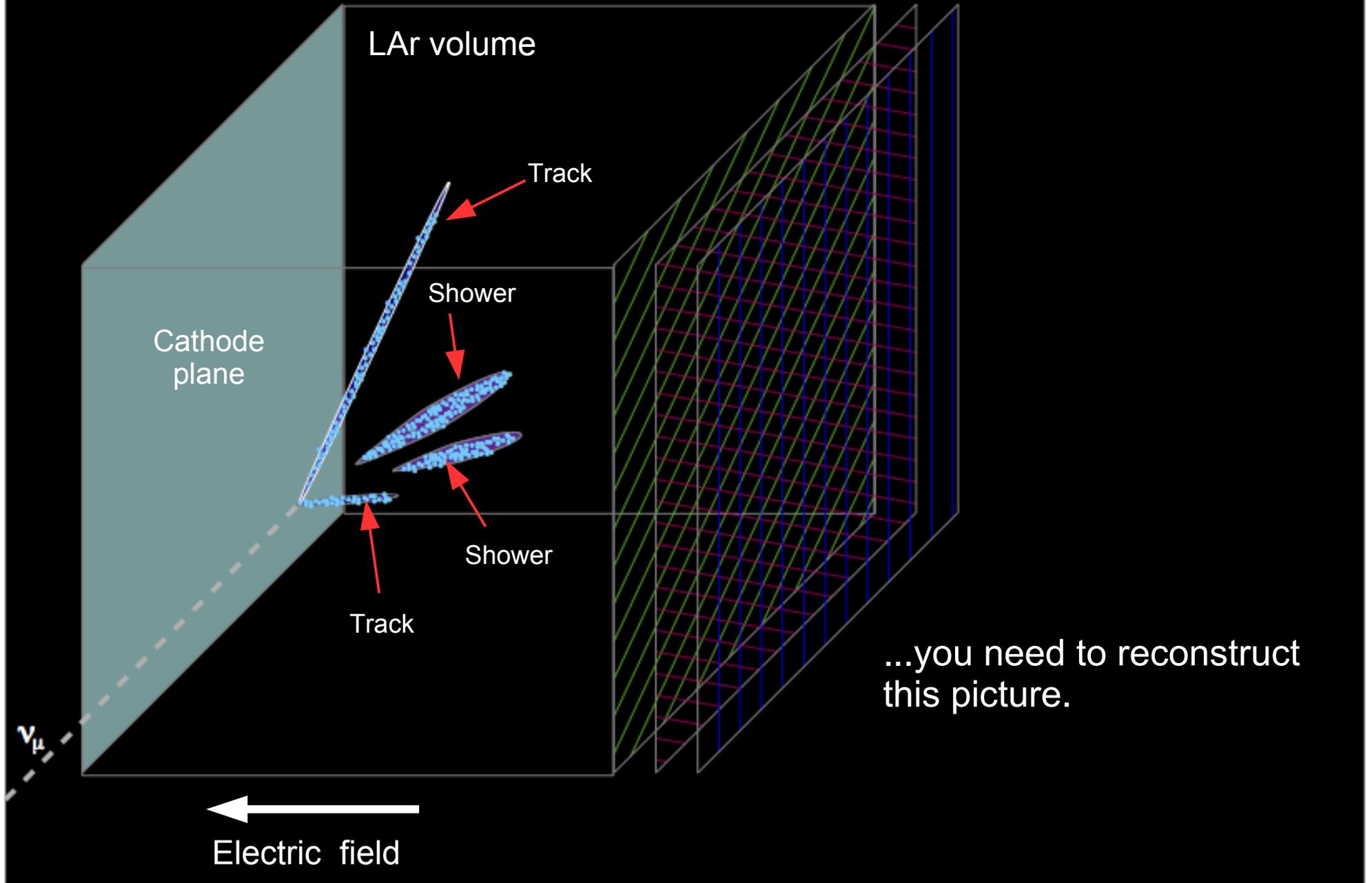
The job of the reconstruction:

...and get to this:

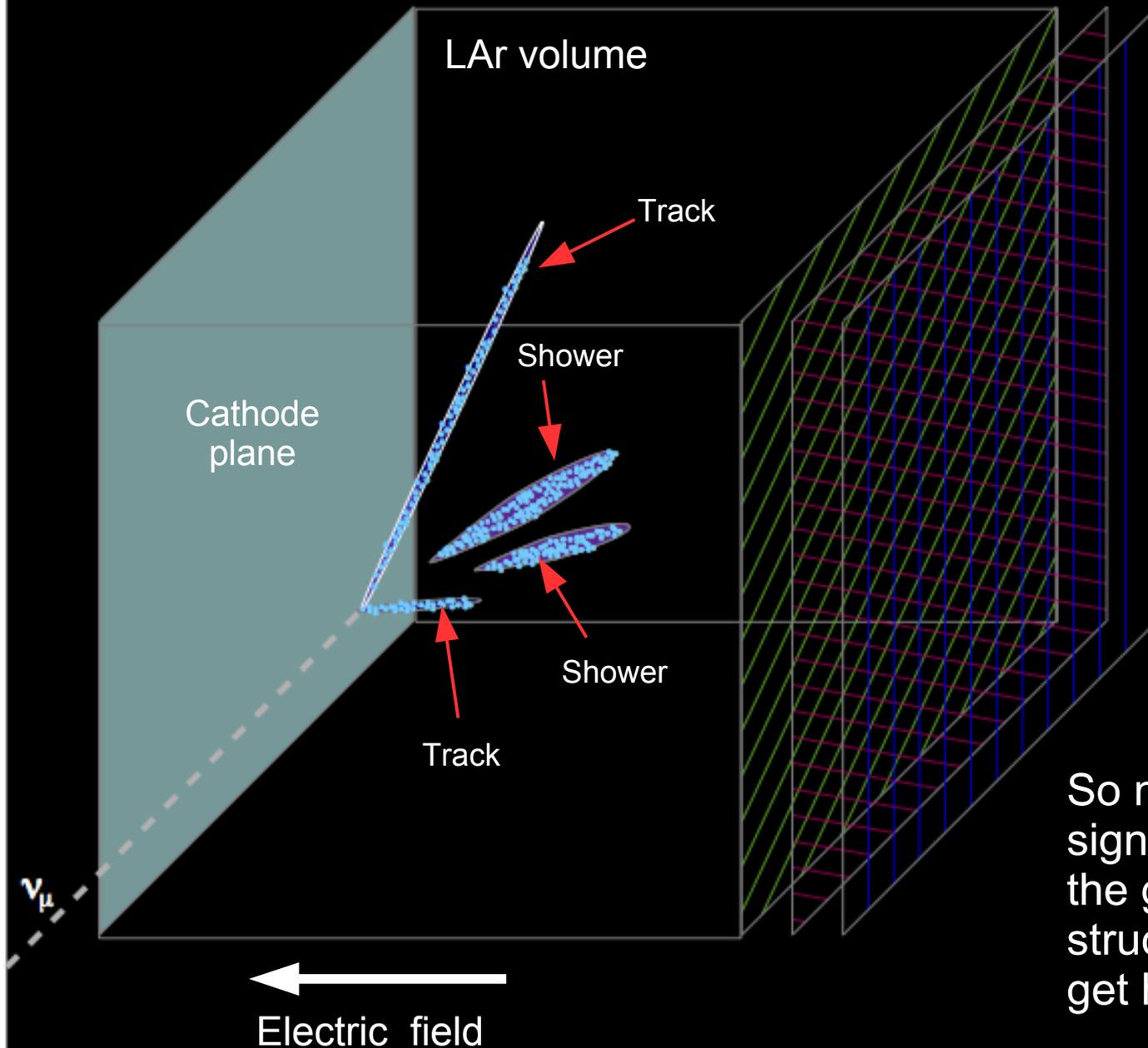


And to get here...

# Operation of single-phase LAr TPC



# Operation of single-phase LAr TPC

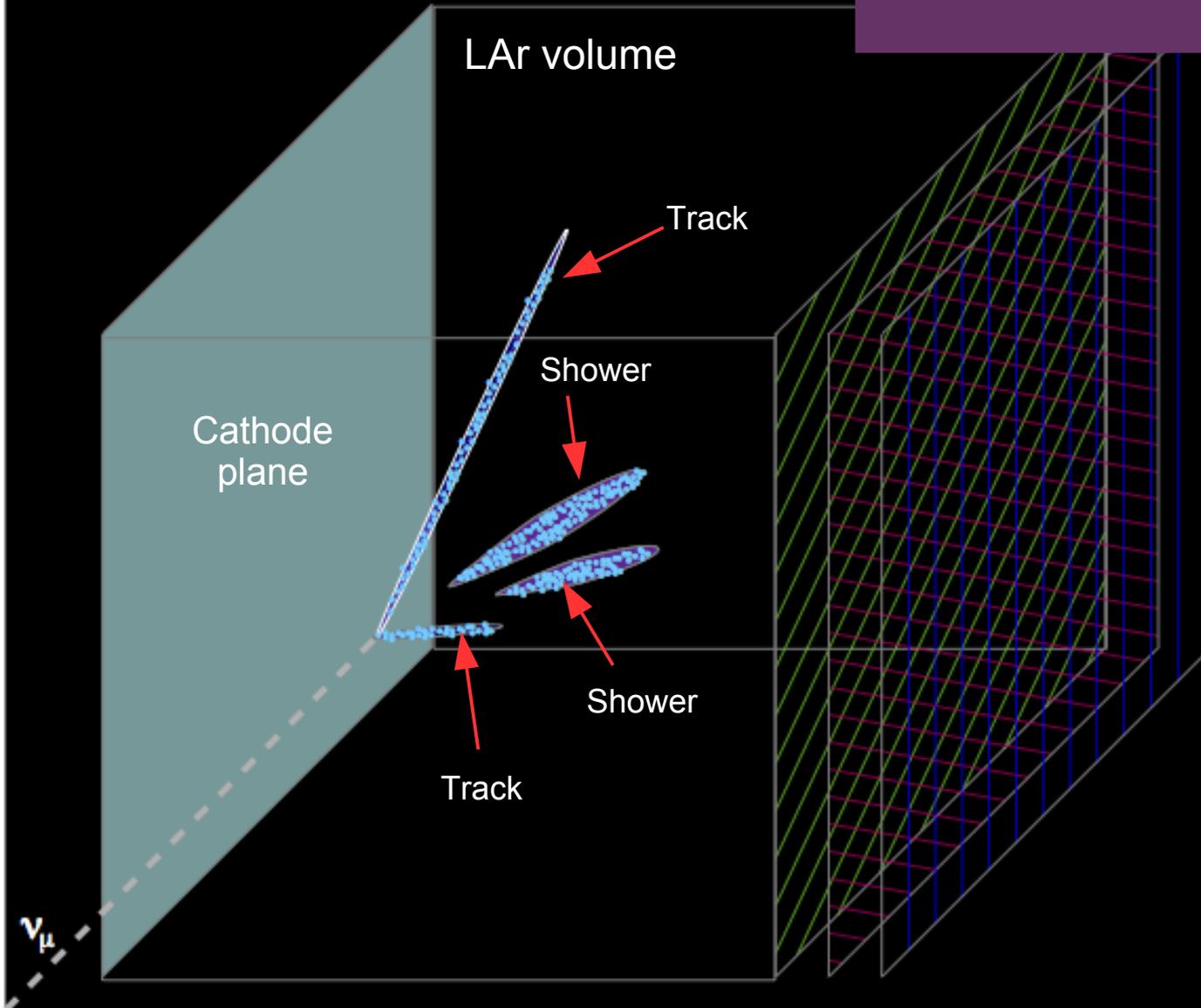


So now start from the raw signals, and walk through the general process, data structures needed to get here.

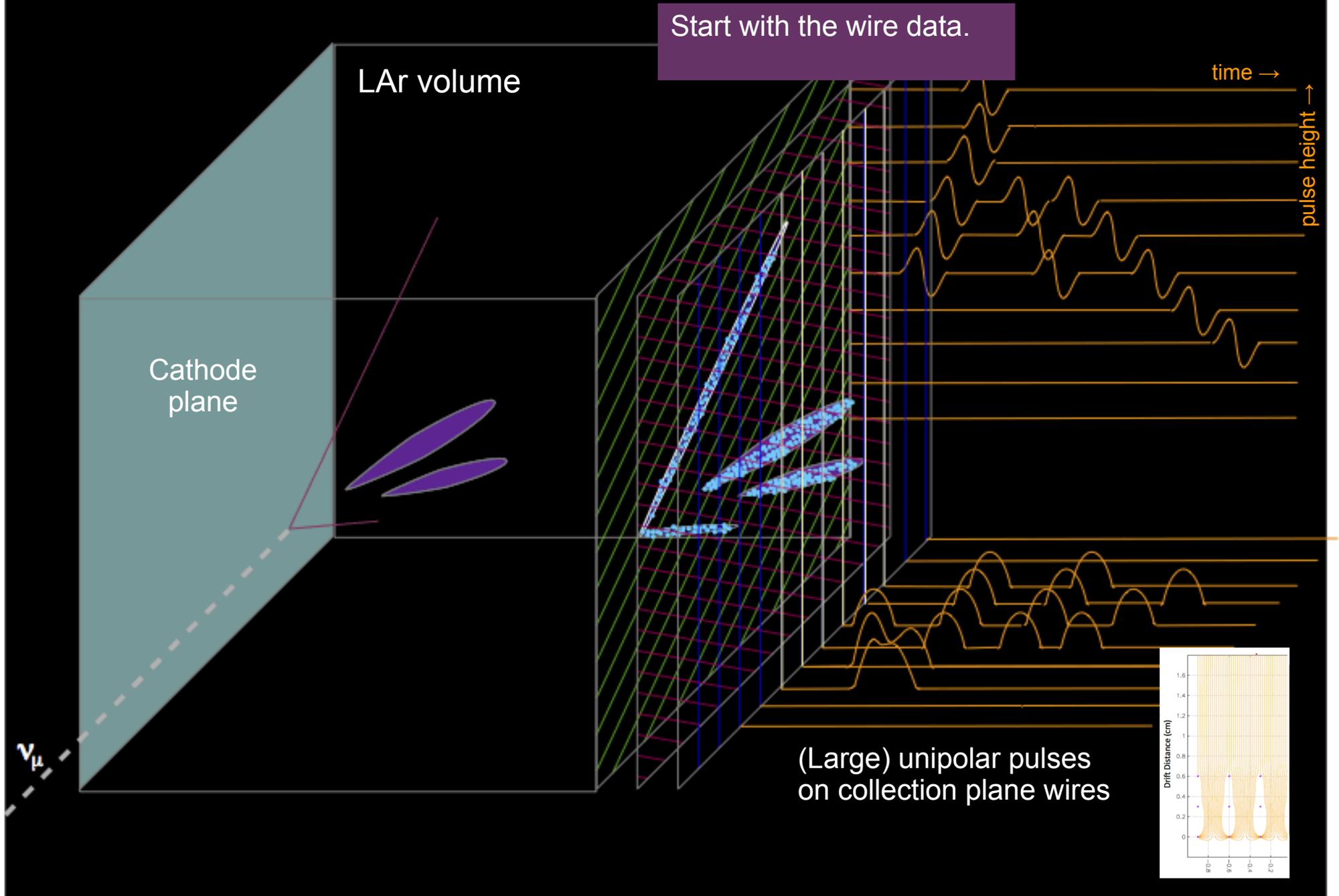
# Primary reconstruction workflow and data structures

# Reconstruction workflow and data structures

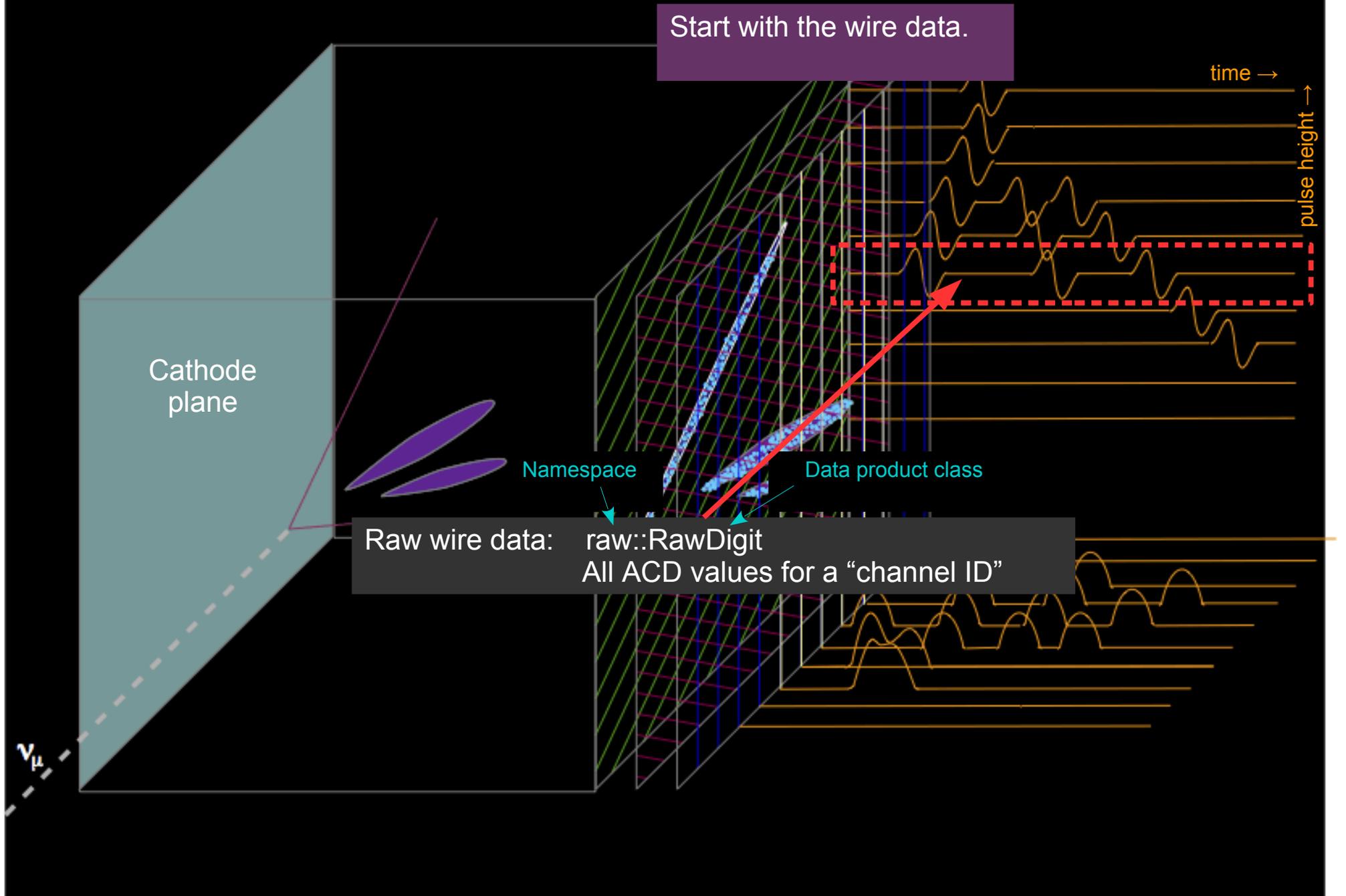
Start with the wire data.



# Reconstruction workflow and data structures



# Reconstruction workflow and data structures



# Reconstruction workflow and data structures

Now need to look for signals associated with particles in the LAr

Two problems to solve first:

- 1) Induction plane signals are completely different from those on collection wires. (So use two algorithms??)
- 2) RawDigits are not calibrated

Cathode plane

Namespace

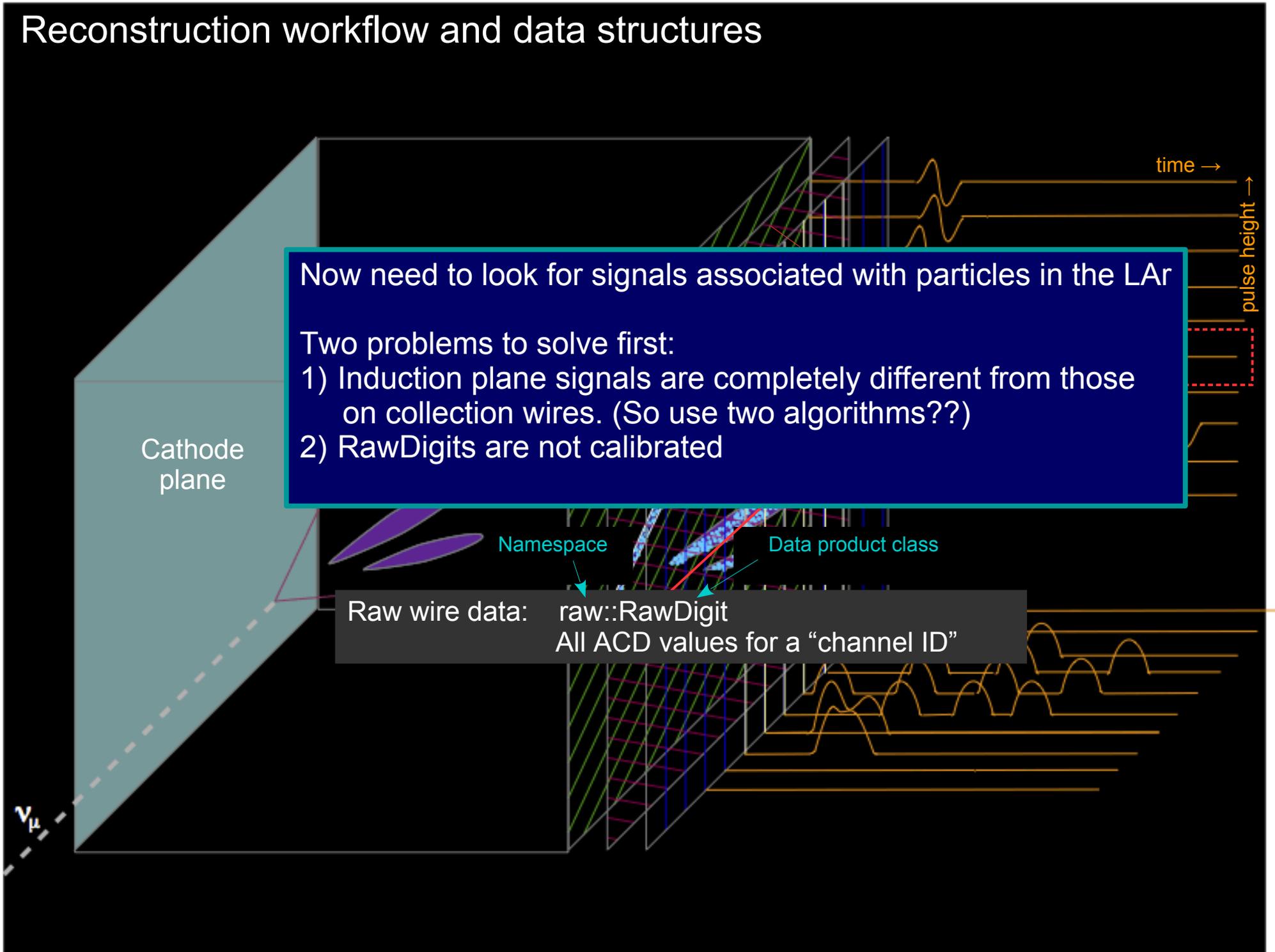
Data product class

Raw wire data: `raw::RawDigit`  
All ACD values for a "channel ID"

time →

pulse height →

$\nu_{\mu}$



# Wire calibration and deconvolution

- Calibration

- Only pedestal subtraction at this phase.  
(Channel gains come later...)

- Deconvolution

- The inverse of the following problem

$$y(t) = (h * x)(t) + n(t)$$

- where  $y(t)$  = measured output signal (raw digits)

$(h * x)(t)$  = convolution of impulse response  $h(t)$  and (unknown) input signal  $x(t)$

$n(t)$  = noise (unknown)

- Can extract an optimal estimate of the signal given:

- impulse response of the front-end electronics
- estimated mean power spectrum for the signal and the noise  
(i.e., the signal-to-noise ratio)

Perform the calculation in the frequency domain

Performed by a number of classes

CalWire ...

CalROI ...

SignalShapingService ...

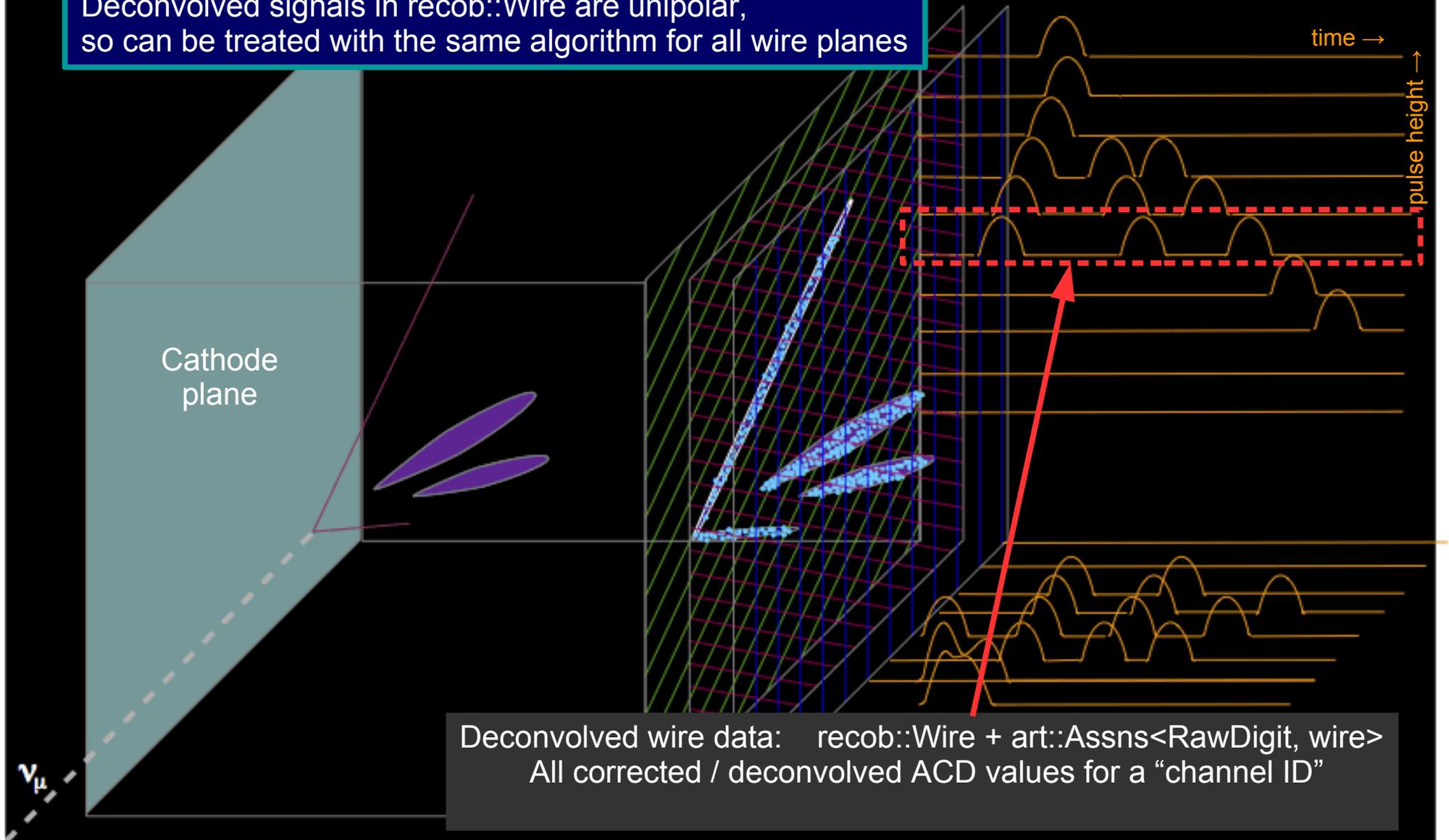
SignalShaping

LArFFT

(Experiment-specific)

# Reconstruction workflow and data structures

Deconvolved signals in `recob::Wire` are unipolar, so can be treated with the same algorithm for all wire planes



Deconvolved wire data: `recob::Wire + art::Assns<RawDigit, wire>`  
All corrected / deconvolved ACD values for a "channel ID"

# Reconstruction workflow and data structures

Deconvolved signals in `recob::Wire` are unipolar, so can be treated with the same algorithm for all wire planes

Cathode plane

For “ROI” algorithms, keep only the values in “regions of interest” (i.e., zero-supressed)

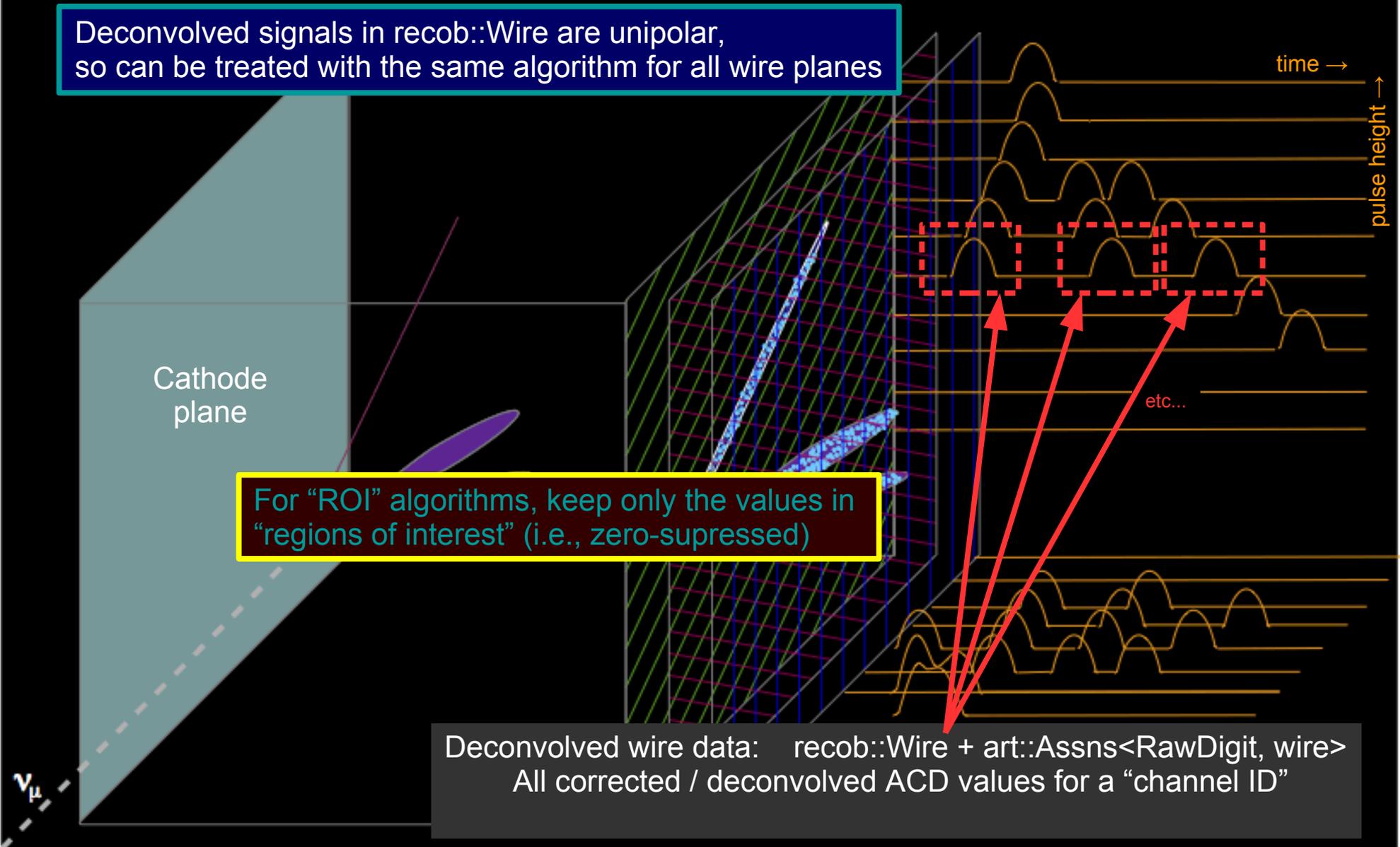
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$v_{\mu}$

time →

pulse height →

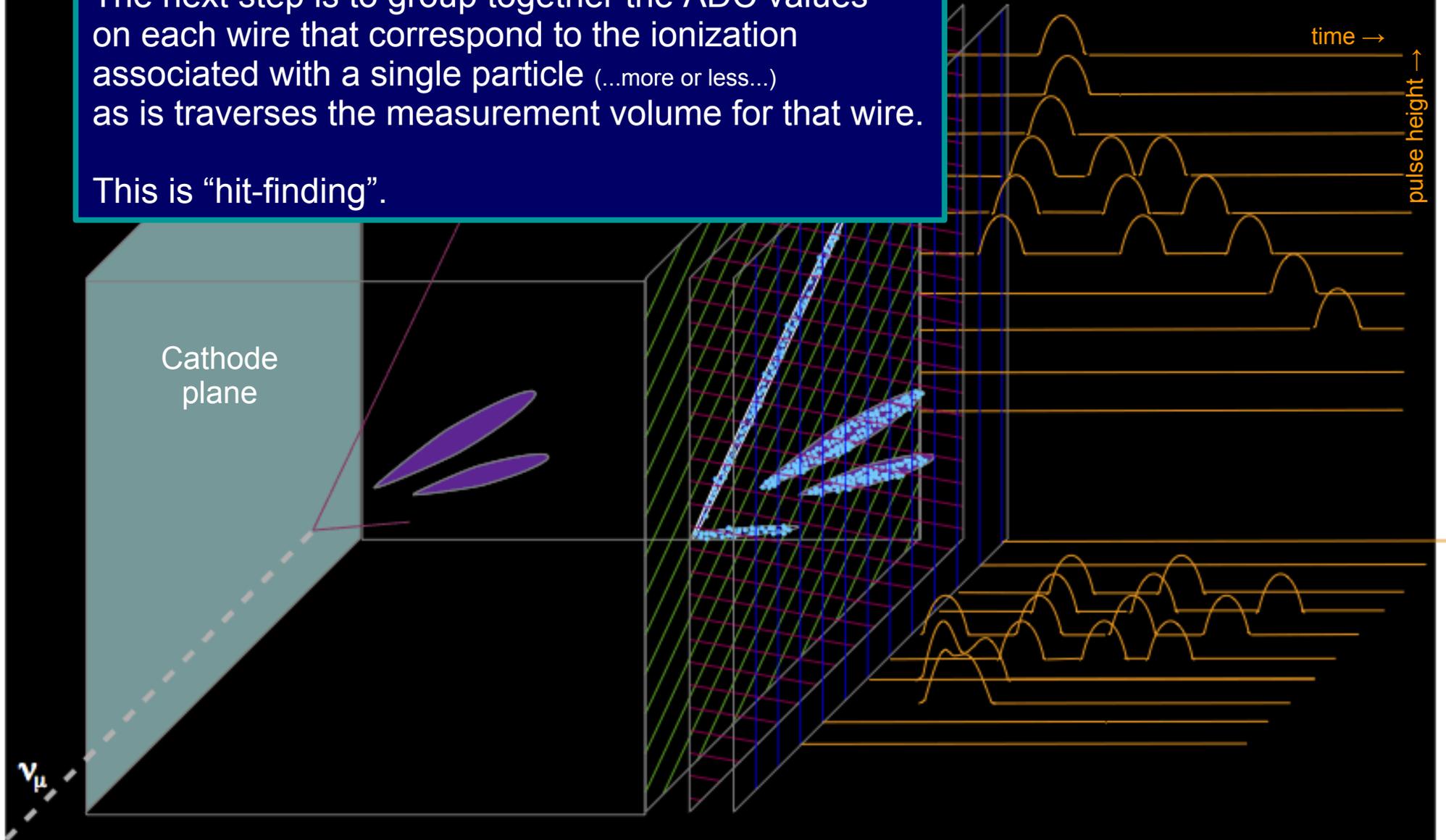
etc...



# Reconstruction workflow and data structures

The next step is to group together the ADC values on each wire that correspond to the ionization associated with a single particle (...more or less...) as it traverses the measurement volume for that wire.

This is “hit-finding”.



# Reconstruction workflow and data structures

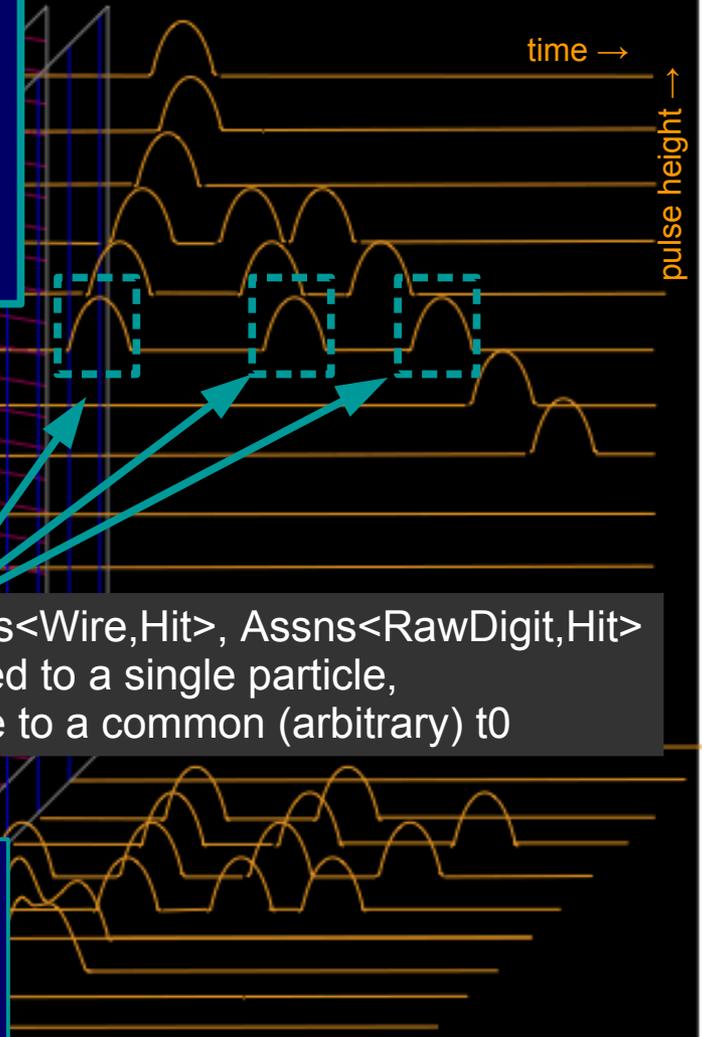
The next step is to group together the ADC values on each wire that correspond to the ionization associated with a single particle (...more or less...) as it traverses the measurement volume for that wire.

This is “hit-finding”.

The output of hit-finding: `recob::Hit + Assns<Wire,Hit>, Assns<RawDigit,Hit>`  
All ADC values on a given wire attributed to a single particle,  
and the arrival time of ionization relative to a common (arbitrary)  $t_0$

Hits are used as input to estimate:

- 1) the actual position of the hit
- 2) the actual charge in the hit, and therefore the energy deposition within the measurement volume of the wire



# Reconstruction workflow and data structures

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Hit-finding performed by:  
CCHitFinder  
GausHitFinder  
RFFHitFinder  
...

$v_{\mu}$

time →

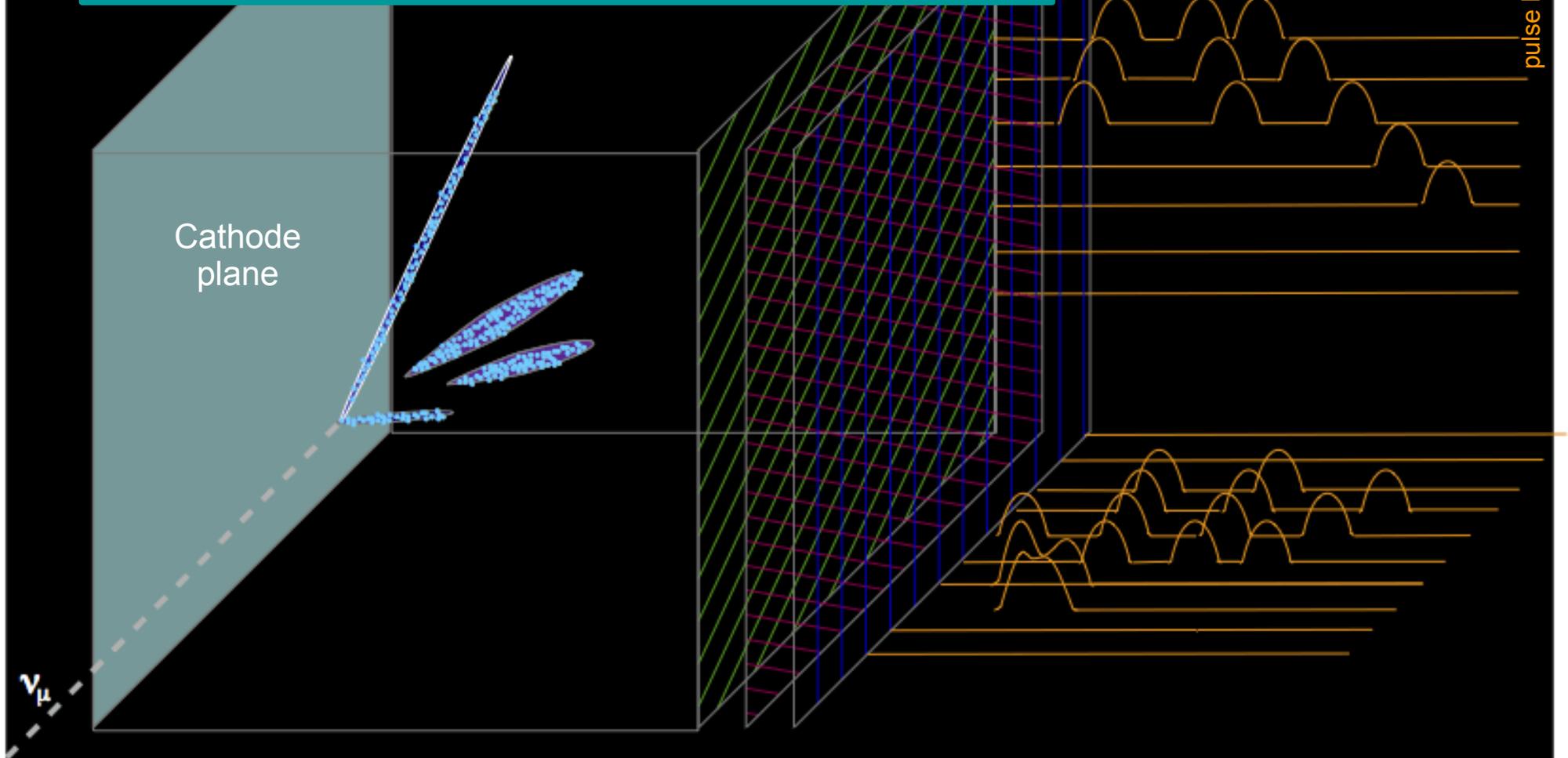
pulse height →

Cathode plane

# Reconstruction workflow and data structures

Now need to start grouping hits into “clusters” that represent the ionization of a single physical entity.

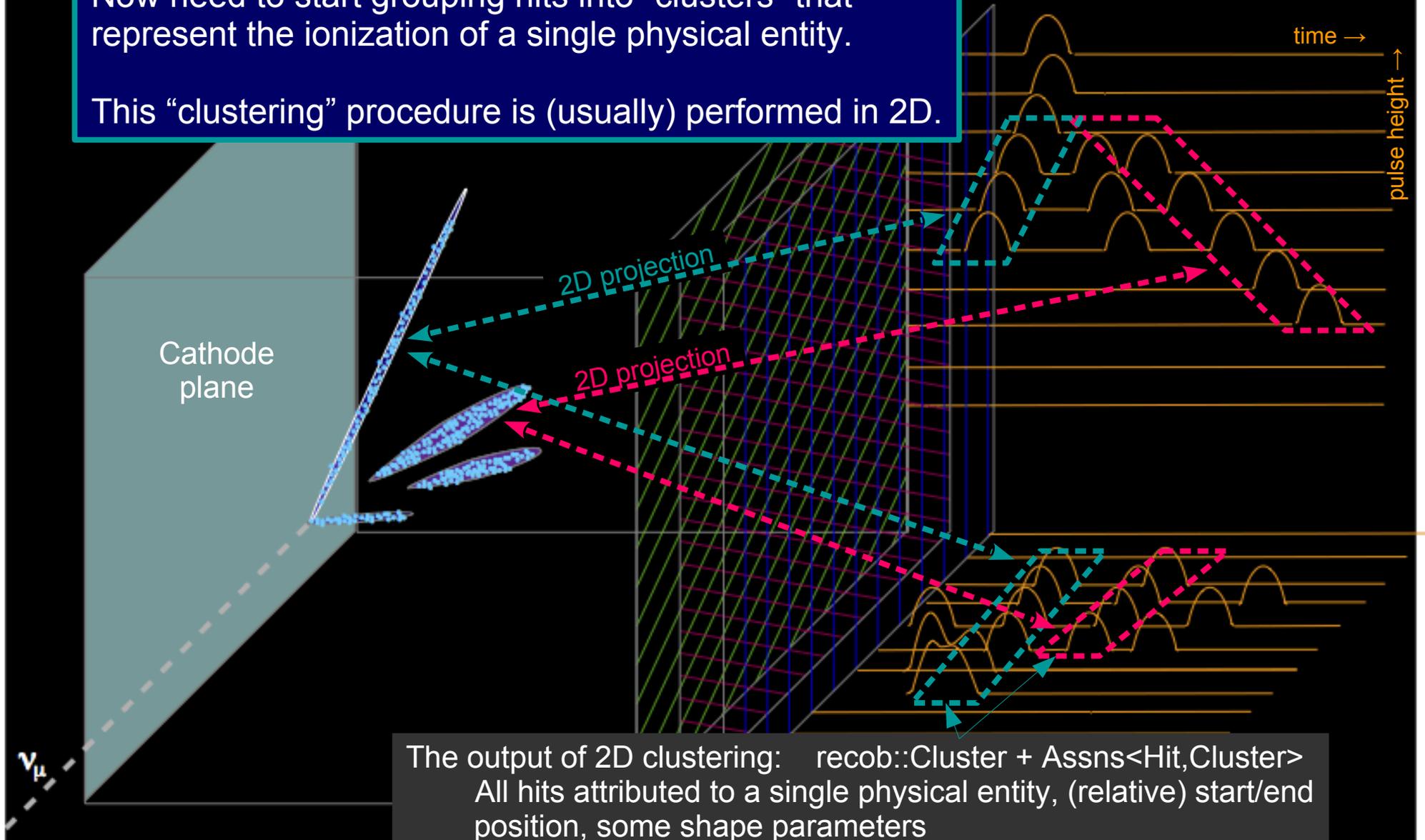
This “clustering” procedure is (usually) performed in 2D.



# Reconstruction workflow and data structures

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The output of 2D clustering: `recob::Cluster + Assns<Hit,Cluster>`  
All hits attributed to a single physical entity, (relative) start/end position, some shape parameters

# Reconstruction workflow and data structures

Now need to start grouping hits into “clusters” that represent the ionization of a single physical entity.

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Algorithms optimized for track-like clusters.

2D cluster-finding performed by:

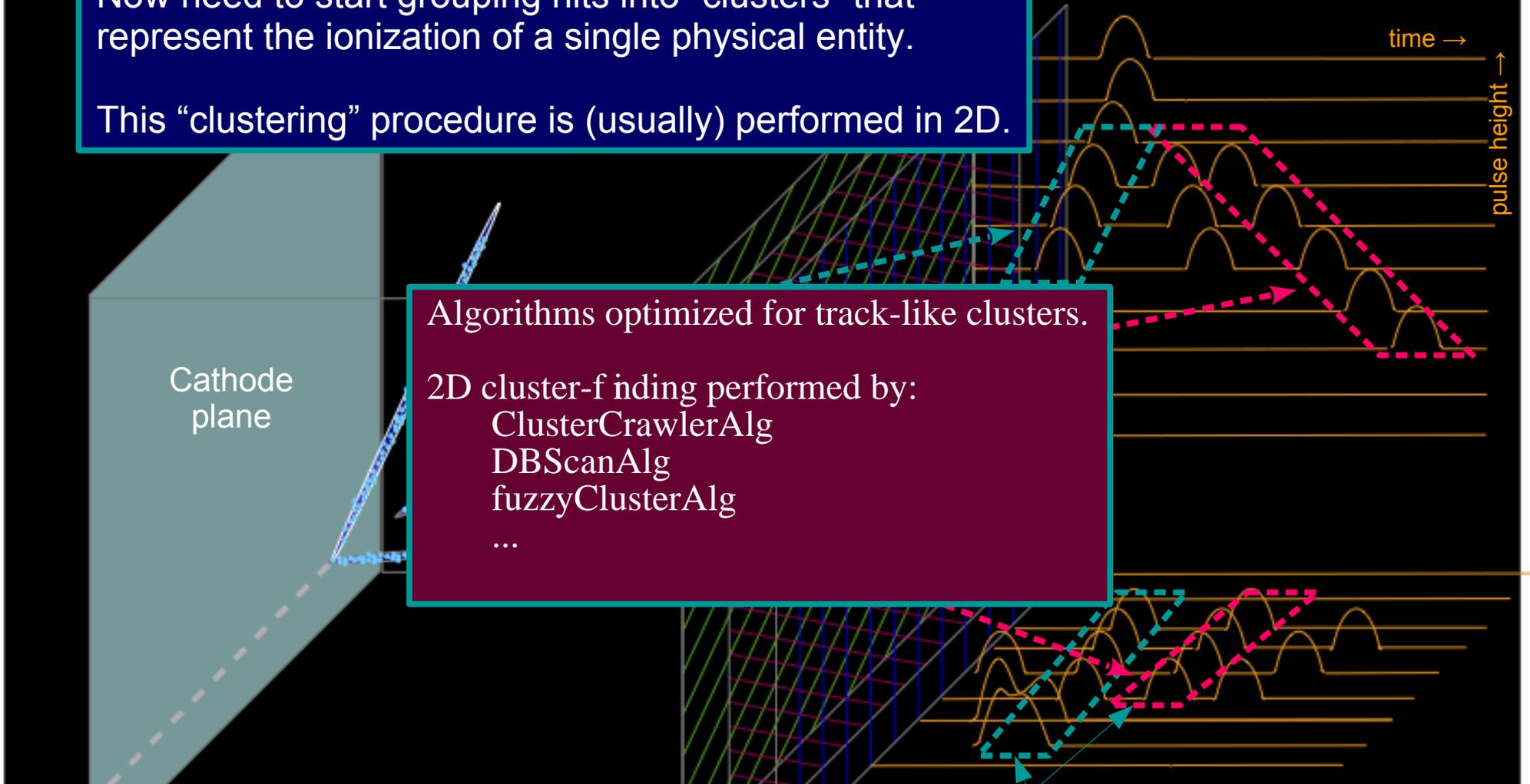
ClusterCrawlerAlg

DBScanAlg

fuzzyClusterAlg

...

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# Reconstruction workflow and data structures

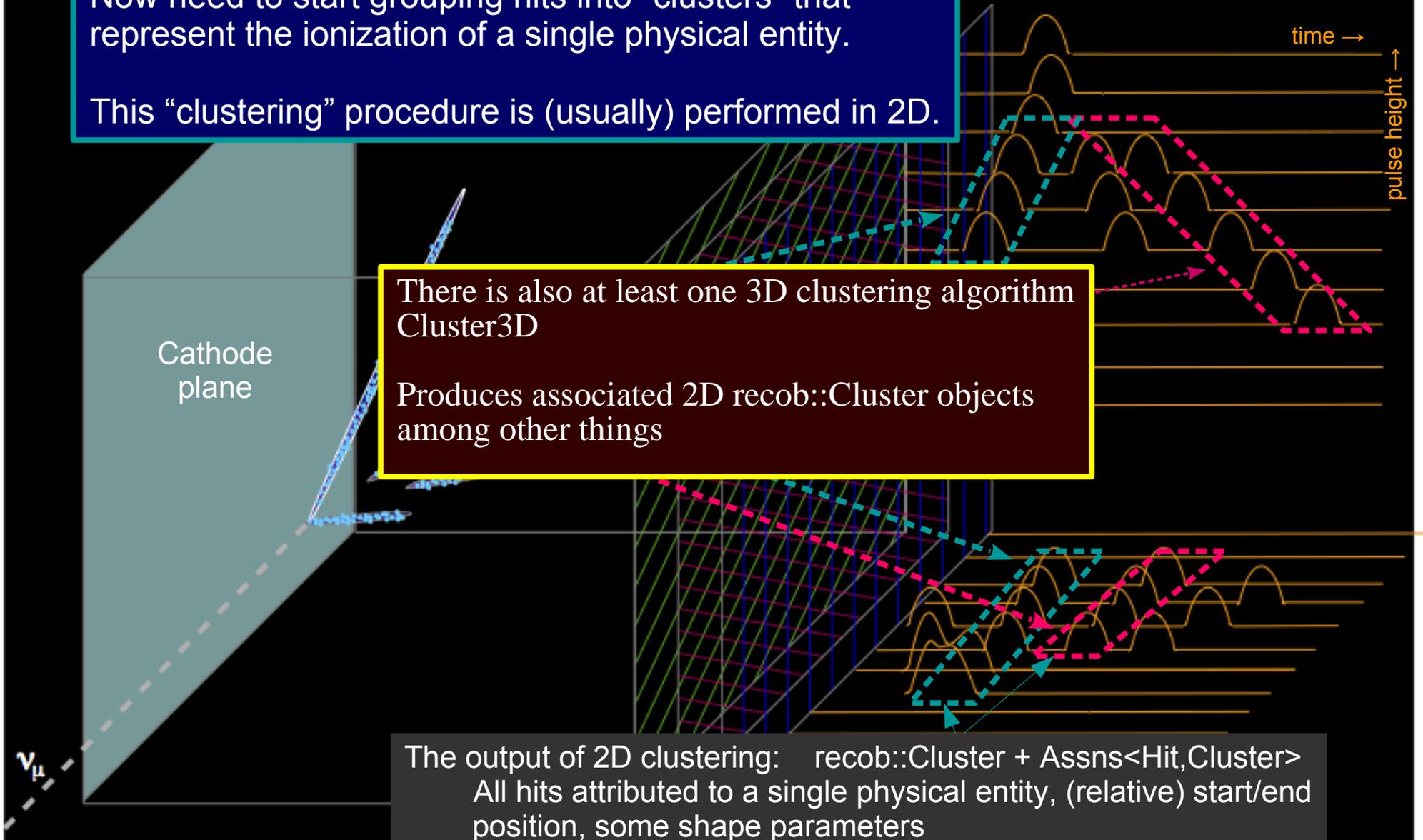
Now need to start grouping hits into “clusters” that represent the ionization of a single physical entity.

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There is also at least one 3D clustering algorithm  
Cluster3D

Produces associated 2D `recob::Cluster` objects  
among other things

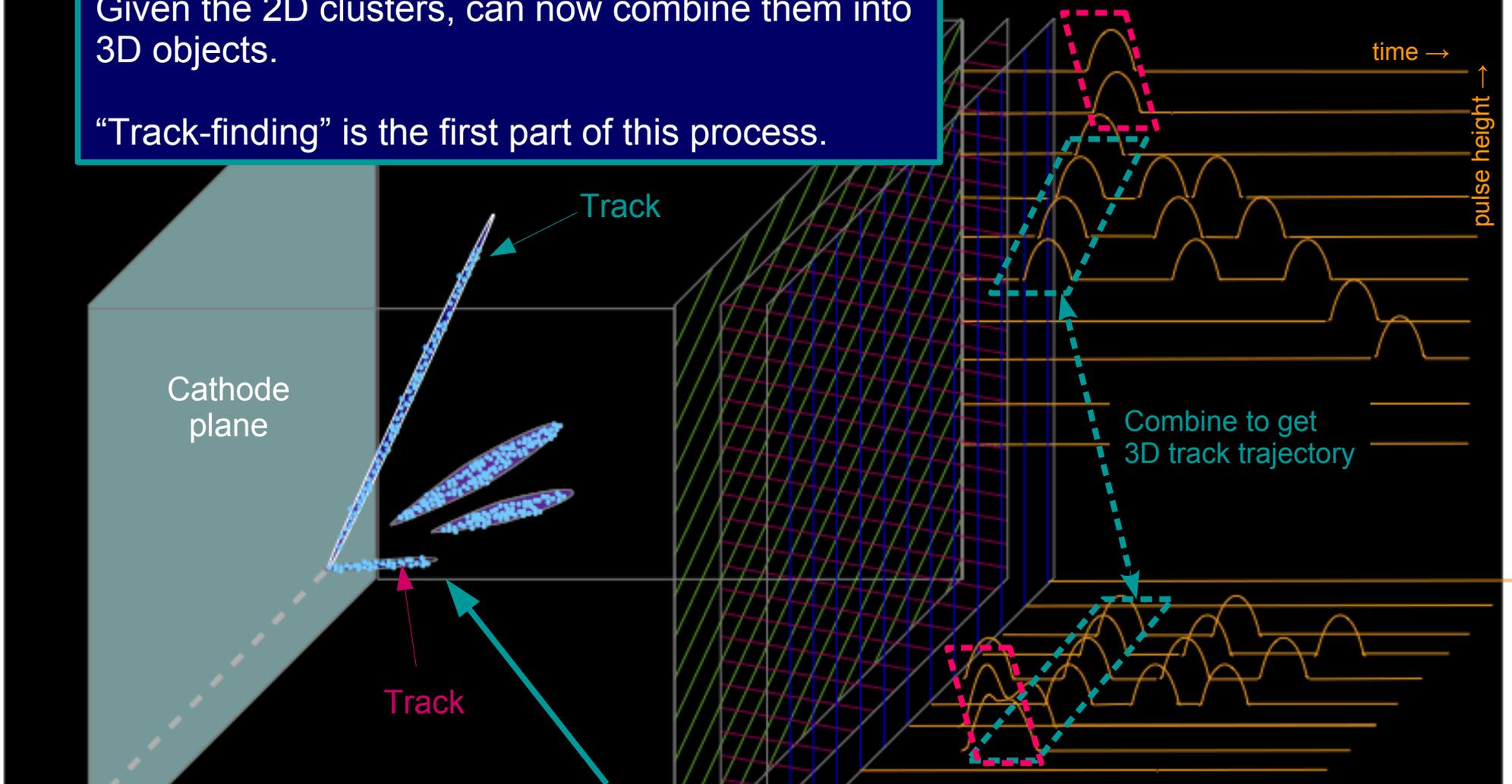
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# Reconstruction workflow and data structures

Given the 2D clusters, can now combine them into 3D objects.

“Track-finding” is the first part of this process.

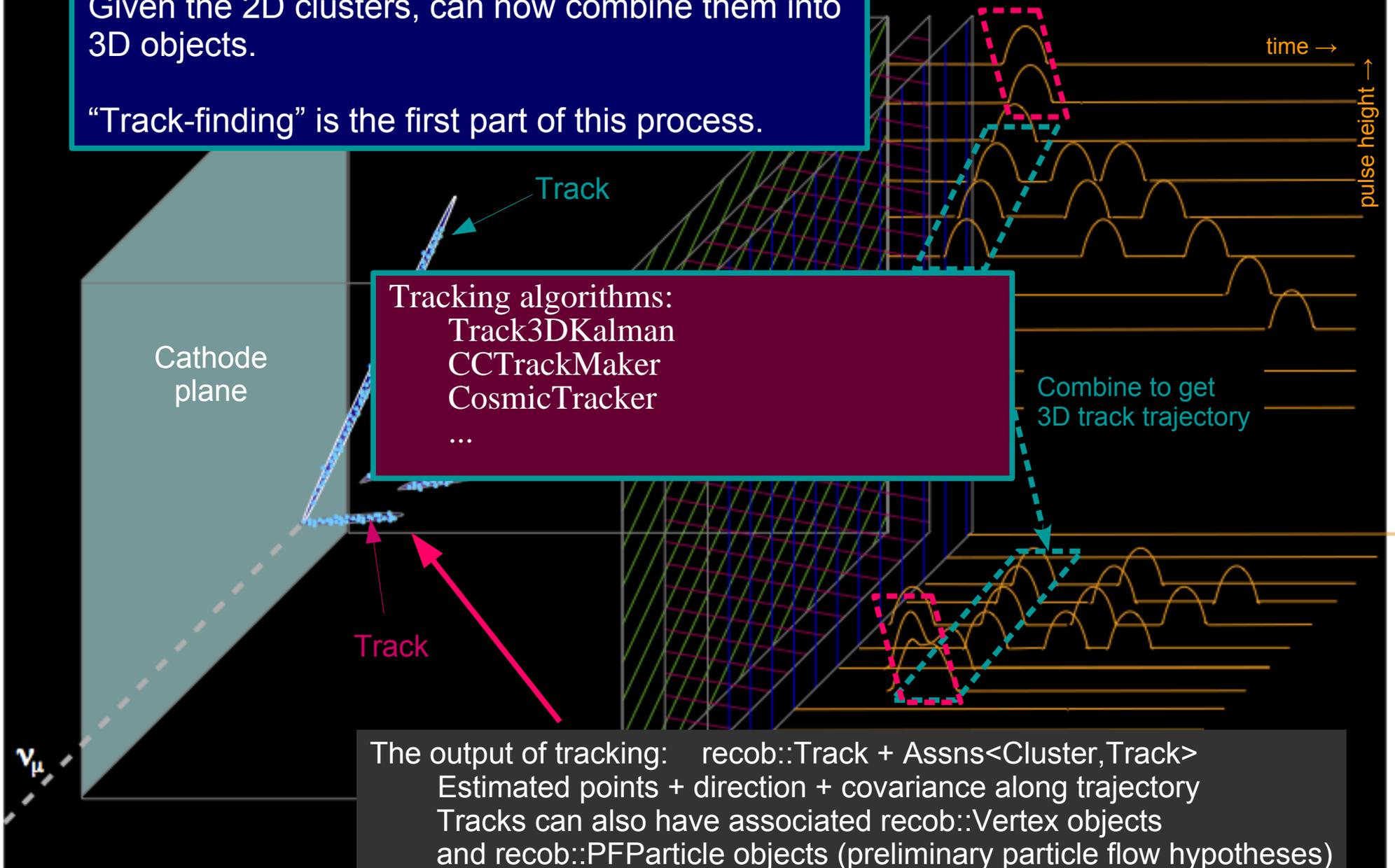


The output of tracking: `recob::Track + Assns<Cluster,Track>`  
Estimated points + direction + covariance along trajectory  
Tracks can also have associated `recob::Vertex` objects  
and `recob::PFParticle` objects (preliminary particle flow hypotheses)

# Reconstruction workflow and data structures

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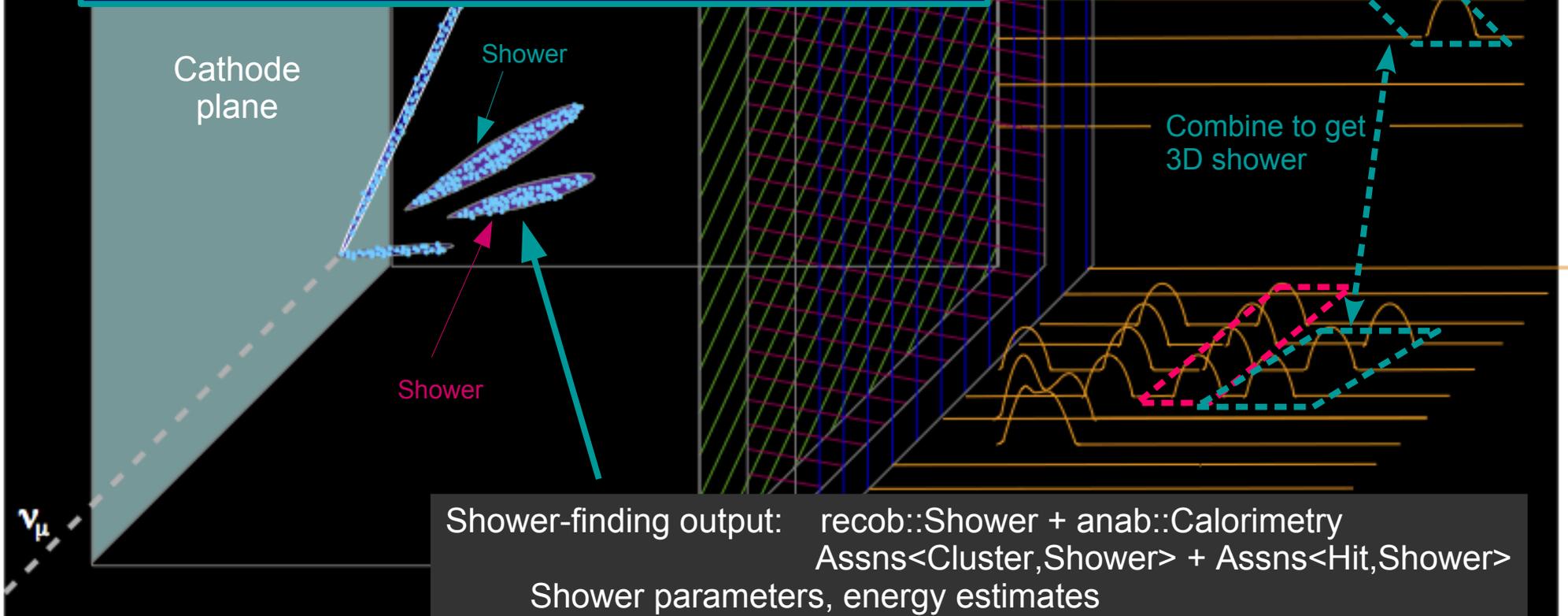
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# Reconstruction workflow and data structures

Clusters can also be part of showers. Finding shower-like clusters is sometimes done at the same time as the shower-finding itself.

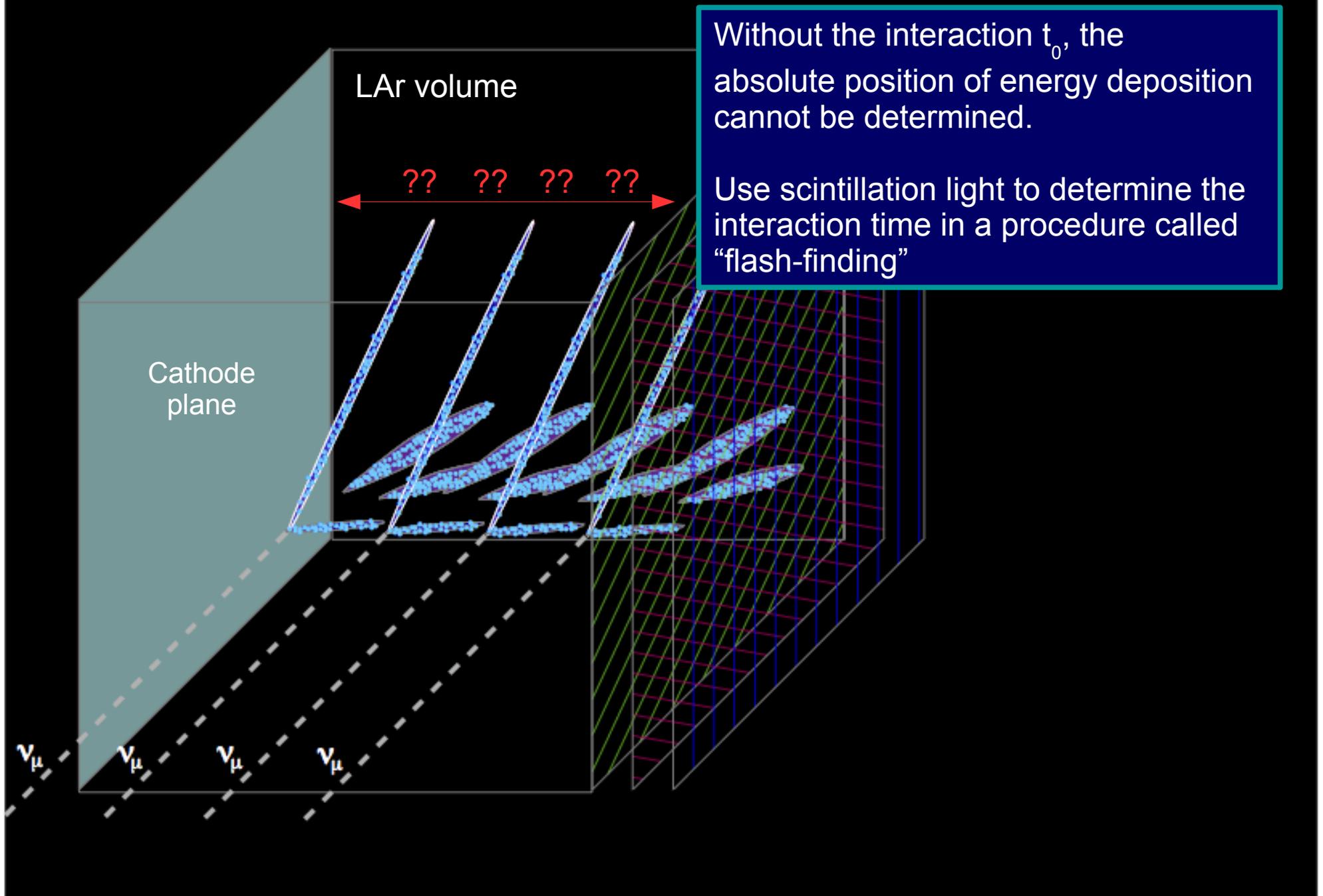
Either way, this step is “shower-finding”

This is also usually the start of calorimetric measurements





# Reconstruction workflow and data structures



# Reconstruction workflow and data structures

LAr volume

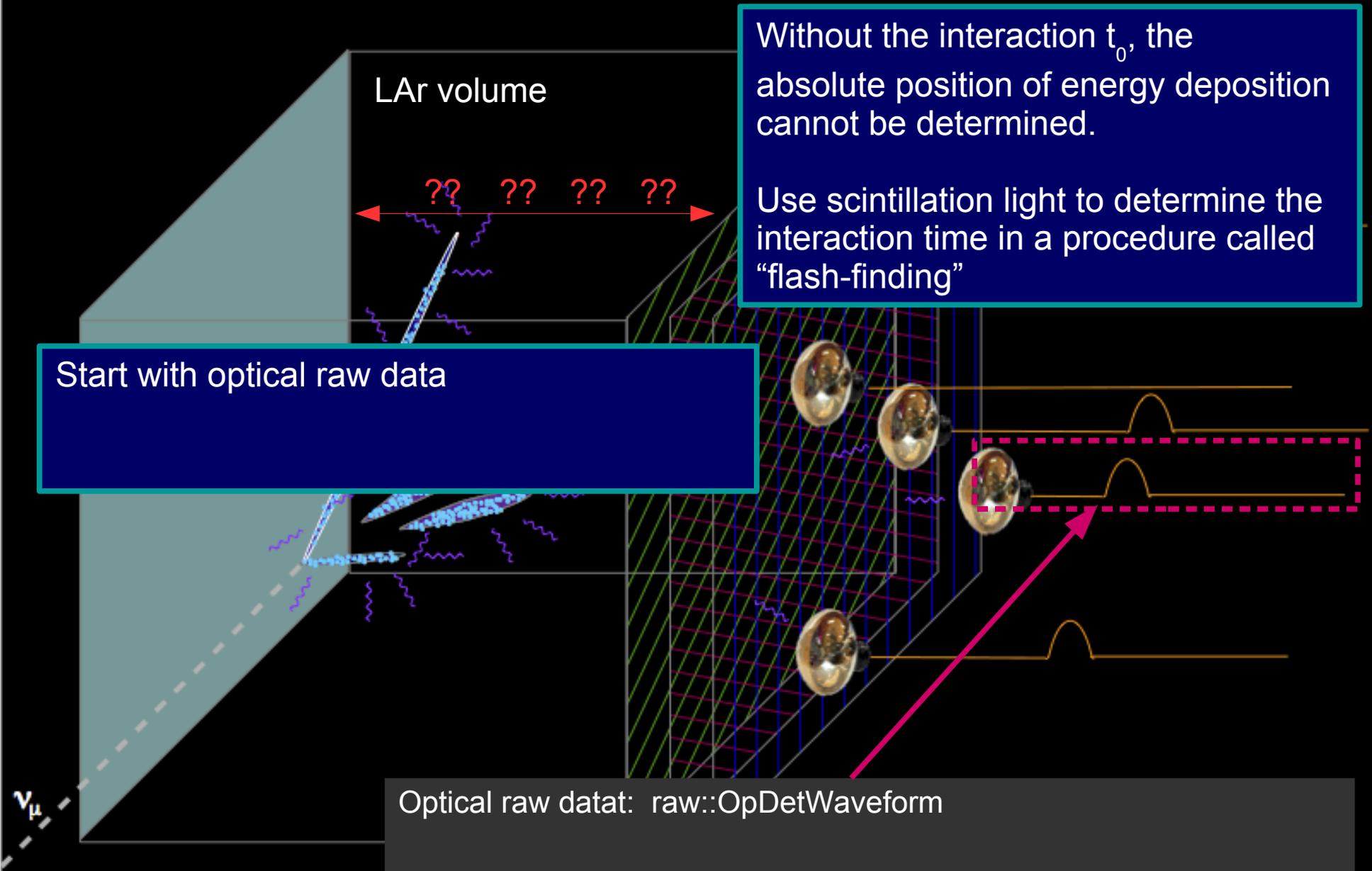
Without the interaction  $t_0$ , the absolute position of energy deposition cannot be determined.

Use scintillation light to determine the interaction time in a procedure called "flash-finding"

Start with optical raw data

Optical raw data: `raw::OpDetWaveform`

$\nu_\mu$



# Reconstruction workflow and data structures

LAr volume

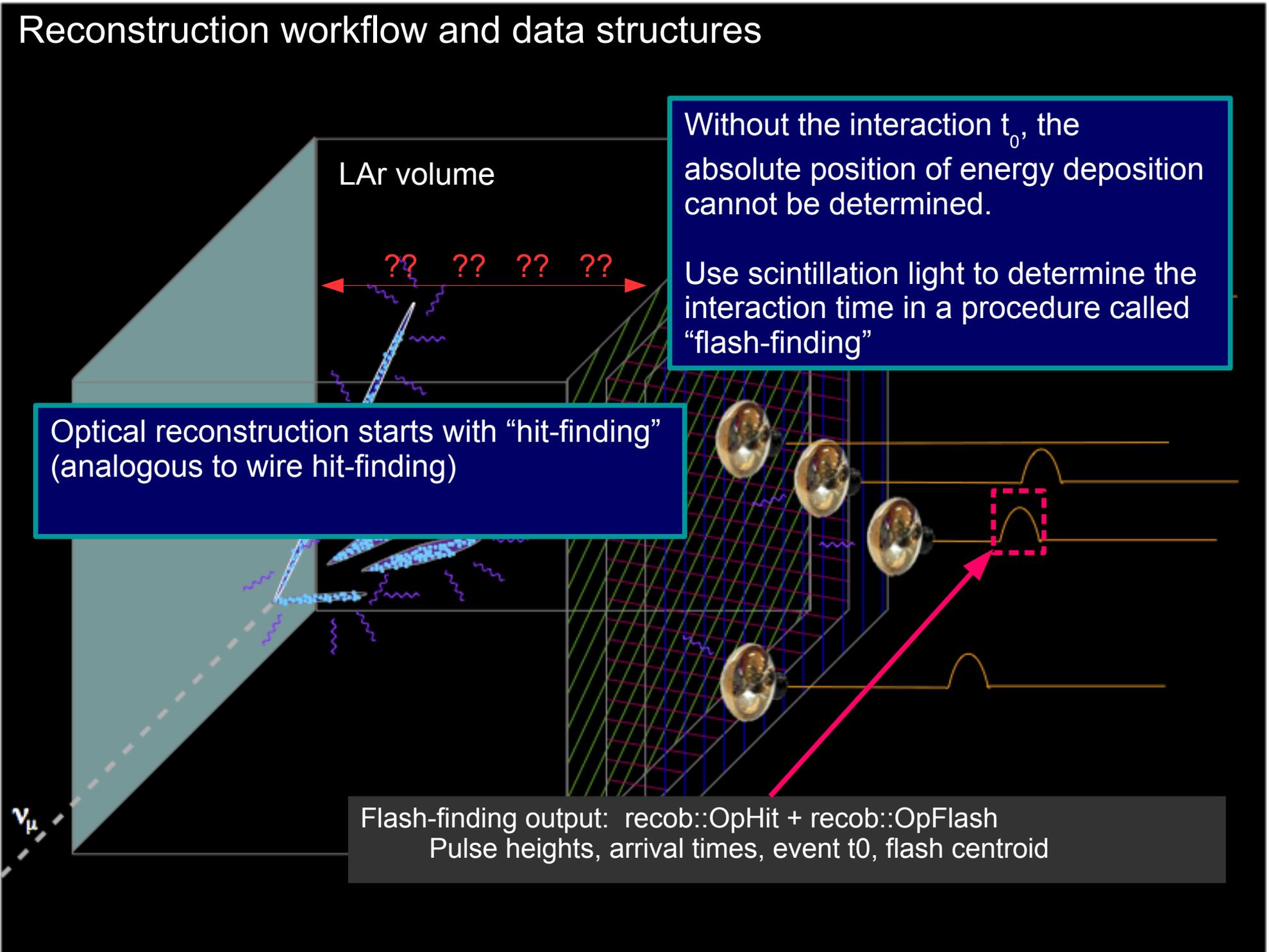
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Optical reconstruction starts with “hit-finding” (analogous to wire hit-finding)

Flash-finding output: `recob::OpHit + recob::OpFlash`  
Pulse heights, arrival times, event  $t_0$ , flash centroid

$\nu_\mu$



# Reconstruction workflow and data structures

LAr volume

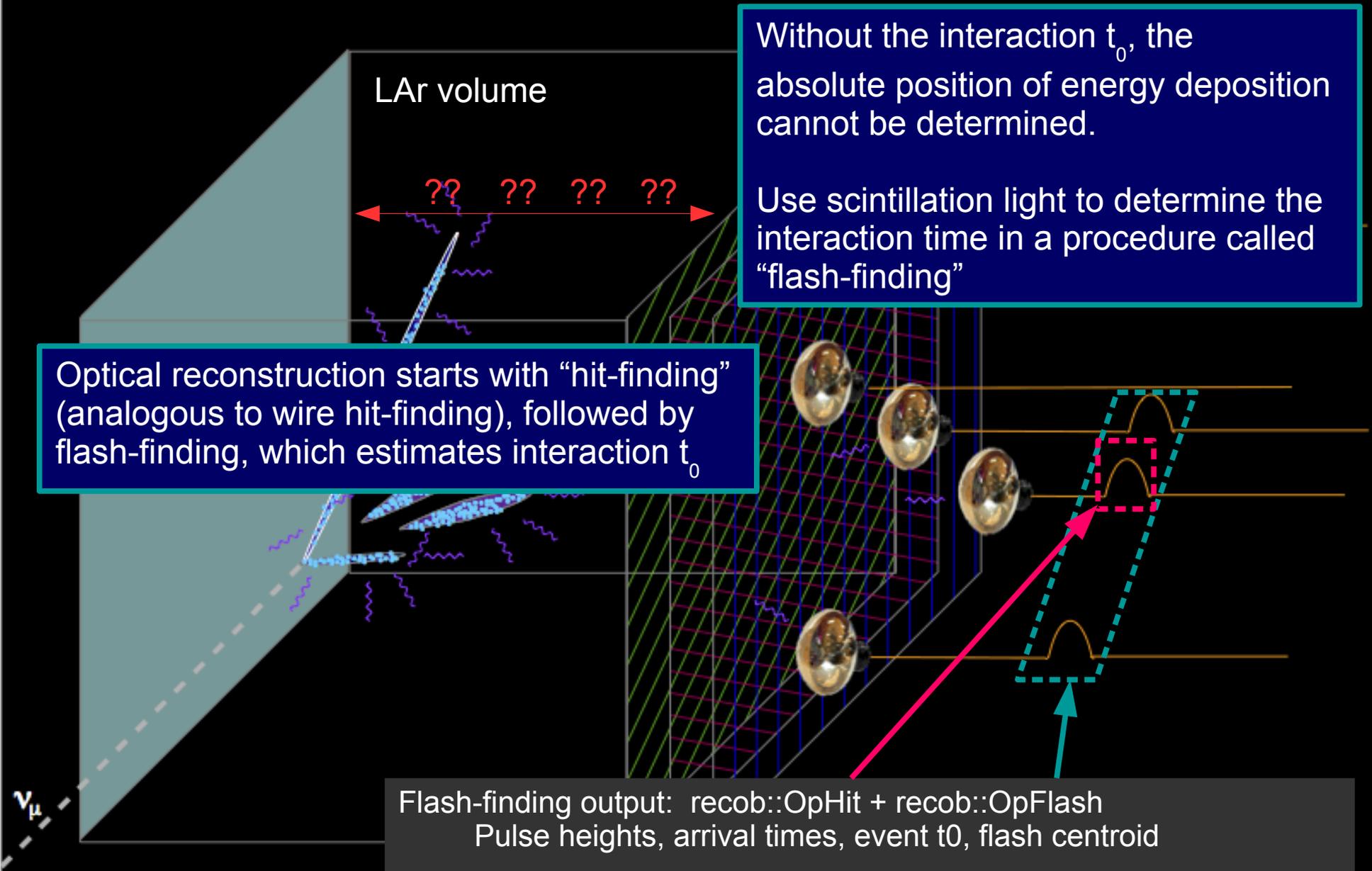
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# Reconstruction workflow and data structures

LAr volume

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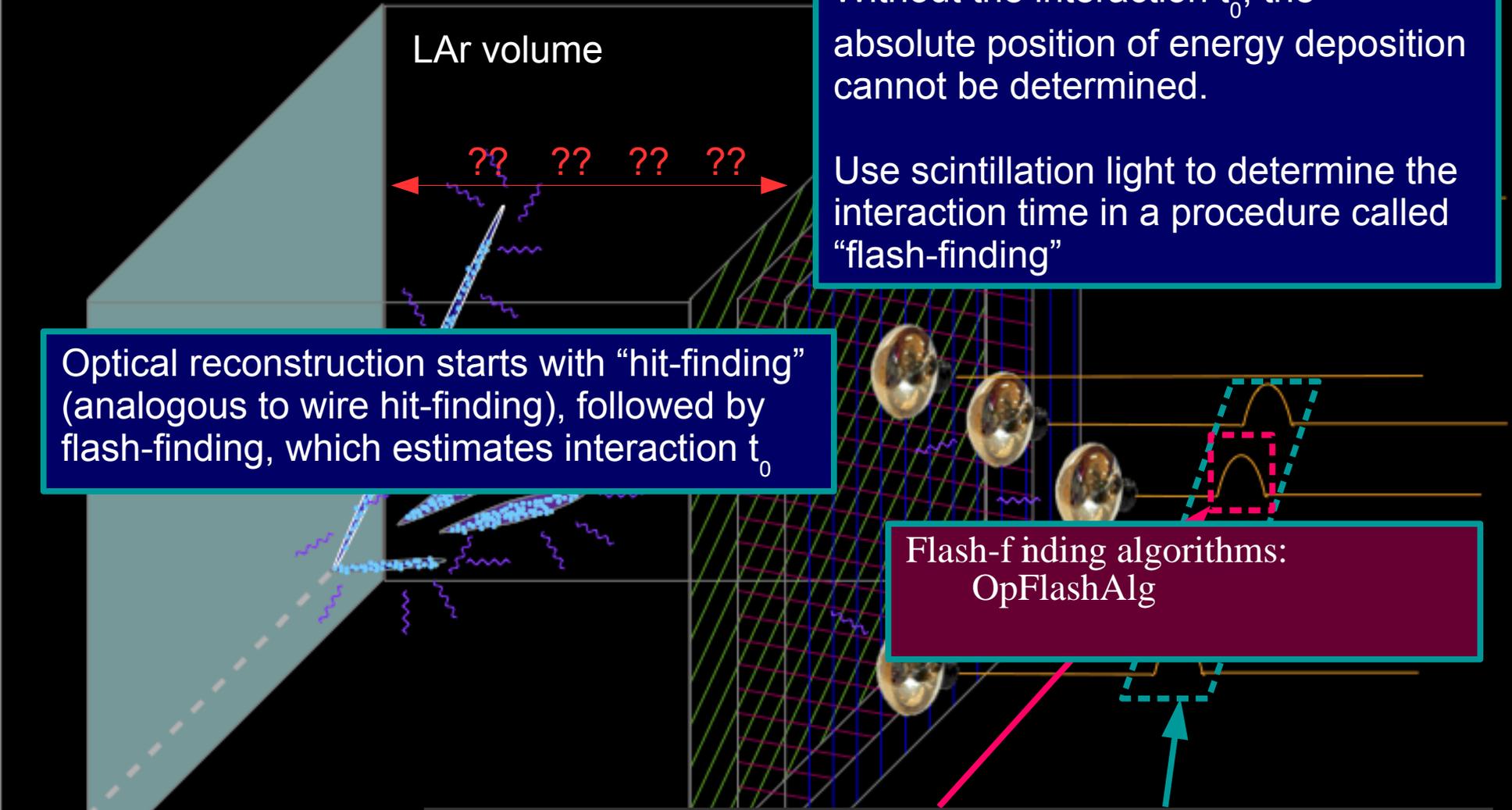
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Flash-finding algorithms:  
OpFlashAlg

Flash-finding output: `recob::OpHit + recob::OpFlash`  
Pulse heights, arrival times, event  $t_0$ , flash centroid

$\nu_\mu$



# Secondary reconstruction

# “Analysis-phase” reconstruction

- Cosmic ray removal

- Particularly important for surface detectors
  - SBN detectors at Fermilab
  - Test beam detectors
- Employs track-finding, clustering, flash-track and flash-cluster matching
- Representative algorithms: CosmicTrackTagger, BeamFlashTrackMatchTagger...
- Output: `anab::CosmicTag`



- Calorimetric measurements

- Energy and  $dE/dx$  estimates for Tracks
- Representative algorithms: CalorimetryAlg, TrackCalorimetryAlg
- Output: `anab::Calorimetry`



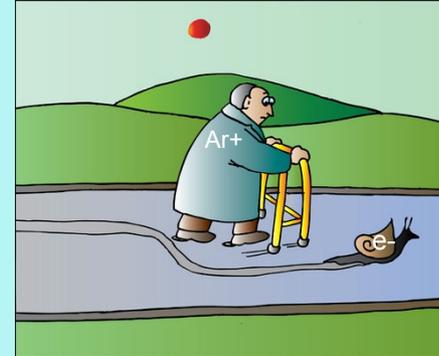
# “Analysis-phase” reconstruction

- Momentum estimation and particle identification
  - Use range,  $dE/dx$  and multiple Coulomb scattering of tracks
  - Representative algorithms: Chi2PIDAlg, PIDAAlg
  - Output: `anab::ParticleID`, `Assns<Track, ParticlePID>`, or `TTree`

# Other complications

- Space-charge distortions

- Ion drift mobilities are about  $10^6\times$  smaller than that of electrons
  - Cation drift velocities are  $\sim \text{nm} / \mu\text{s}$  !!
- High cosmic ray rate for surface detectors introduces significant positive ion load
  - At MicroBooNE, field distortions could reach cm scales
- Need to map and correct for these
- A common service exists to access the offsets



Alexei Talimonov, used w/o permission

- Charge attenuation

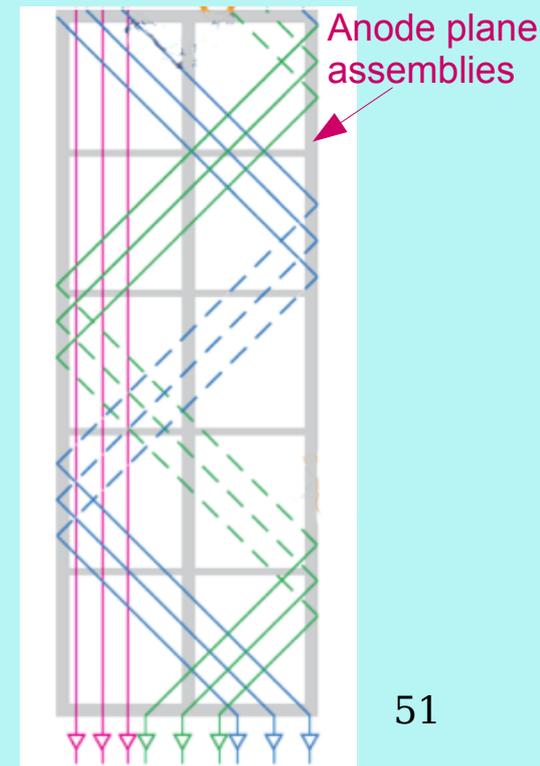
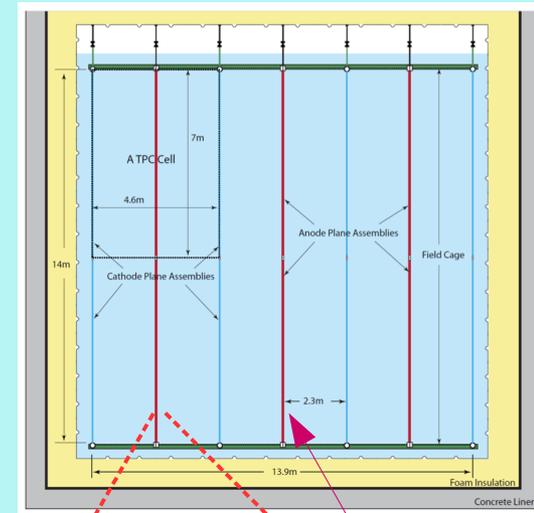
- Electron lifetime can be comparable to maximum drift time
- Effective gain will be drift-length dependent
- Expect to see significant reduction in SNR with drift distance

# Other complications

- Hit disambiguation

- DUNE TPCs have wrapped induction wires
  - See signals in two TPCs, and in many cases, multiple places within the same TPC
- Some LArSoft nomenclature:
  - “Wire”: a segment of a physical wire in an anode plane
    - A geometric concept
  - “Channel”: a readout channel connected to one or more “wires”
    - A DAQ concept

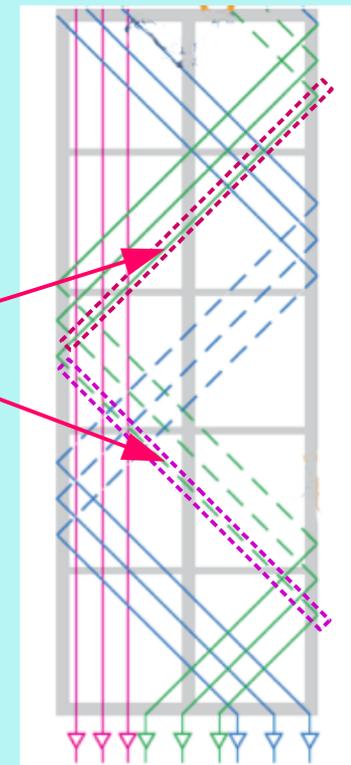
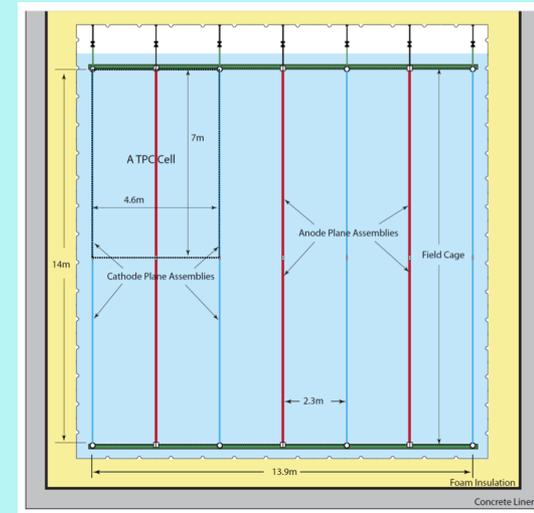
Sectional view of TPCs



# Other complications

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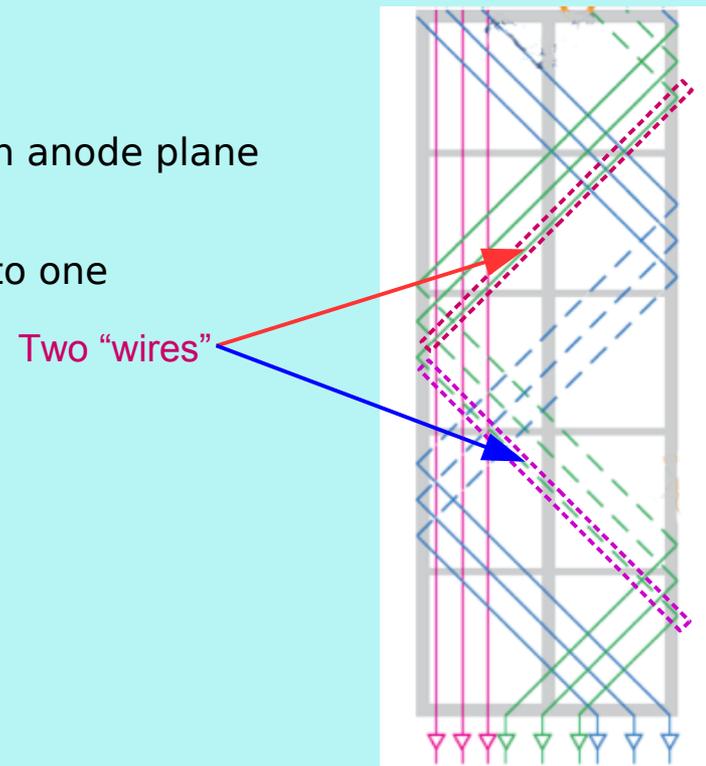
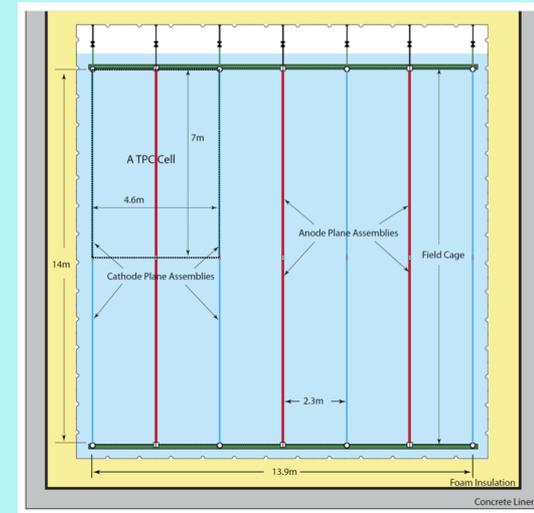
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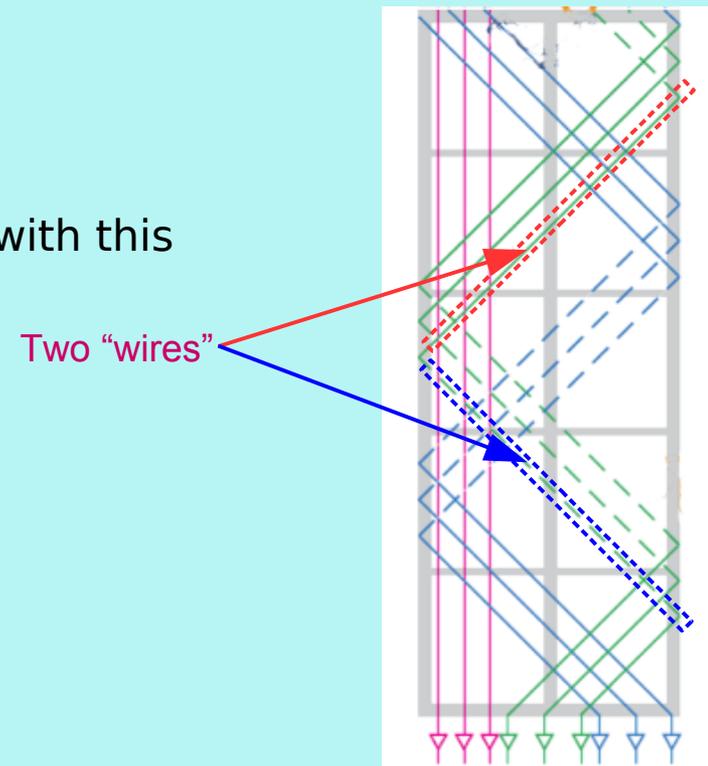
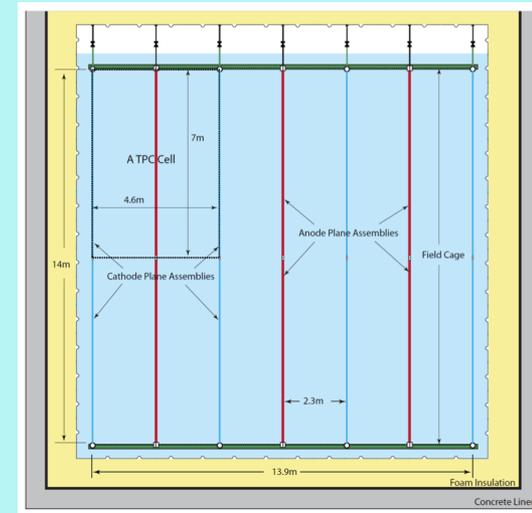
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# Other complications

- Hit disambiguation

- DUNE TPCs have wrapped induction wires
  - See signals in two TPCs, and in many cases, multiple places within the same TPC
- Introduce a disambiguation step to deal with this
  - Resolves the TPC ambiguity of each induction hit
  - Currently performed after hit-finding
    - Existing algorithms use timing information and neighboring activity



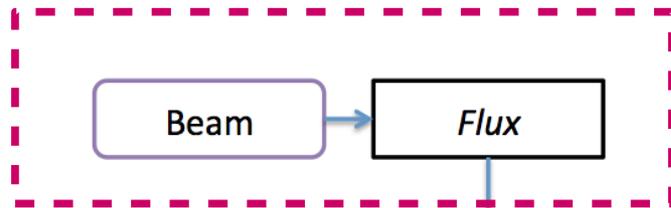
# Other complications

- Dual-phase LAr TPCs
  - Under development / consideration by DUNE
  - Do not yet understand potential implications for LArSoft

# Detector simulation in LArSoft

# Simulation workflow

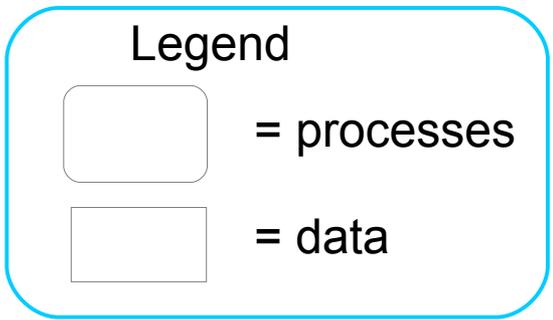
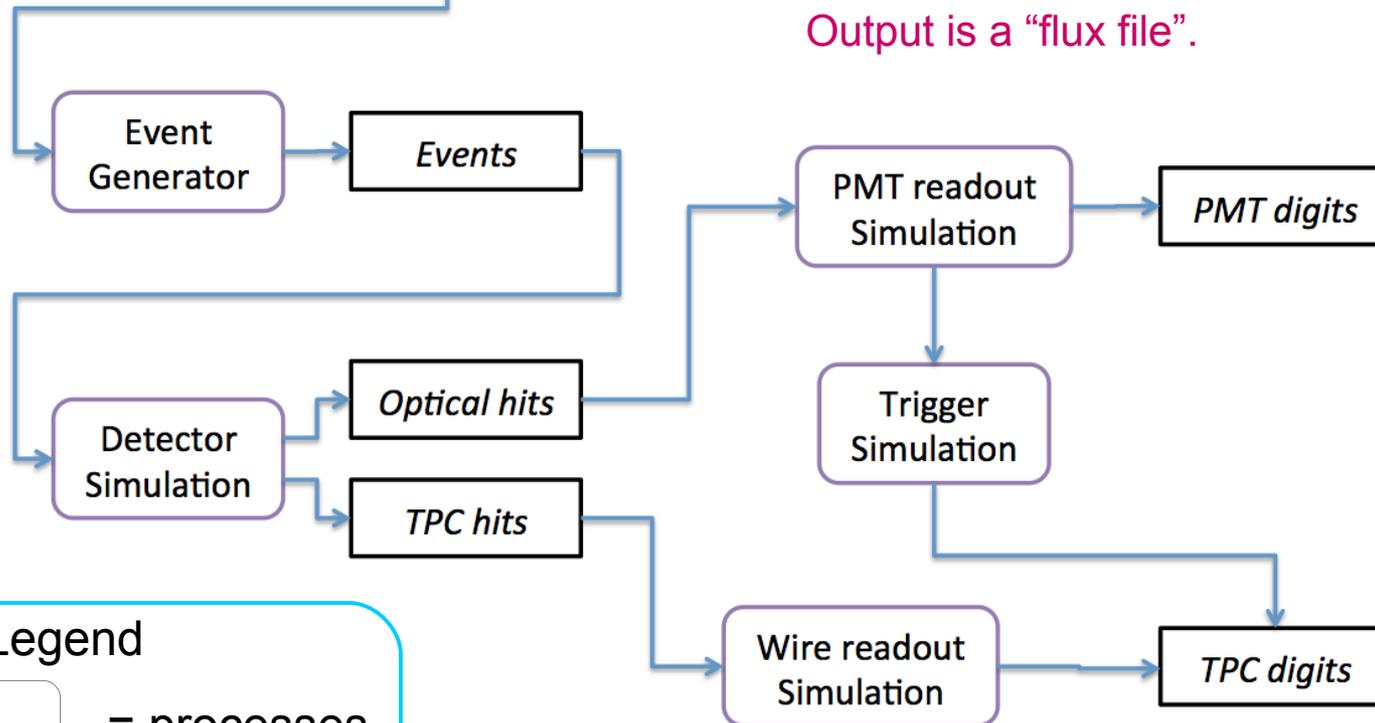
Three phases, typically run separately



## Beam simulation

Momentum, spatial, angular distribution of neutrinos from target incident on detector

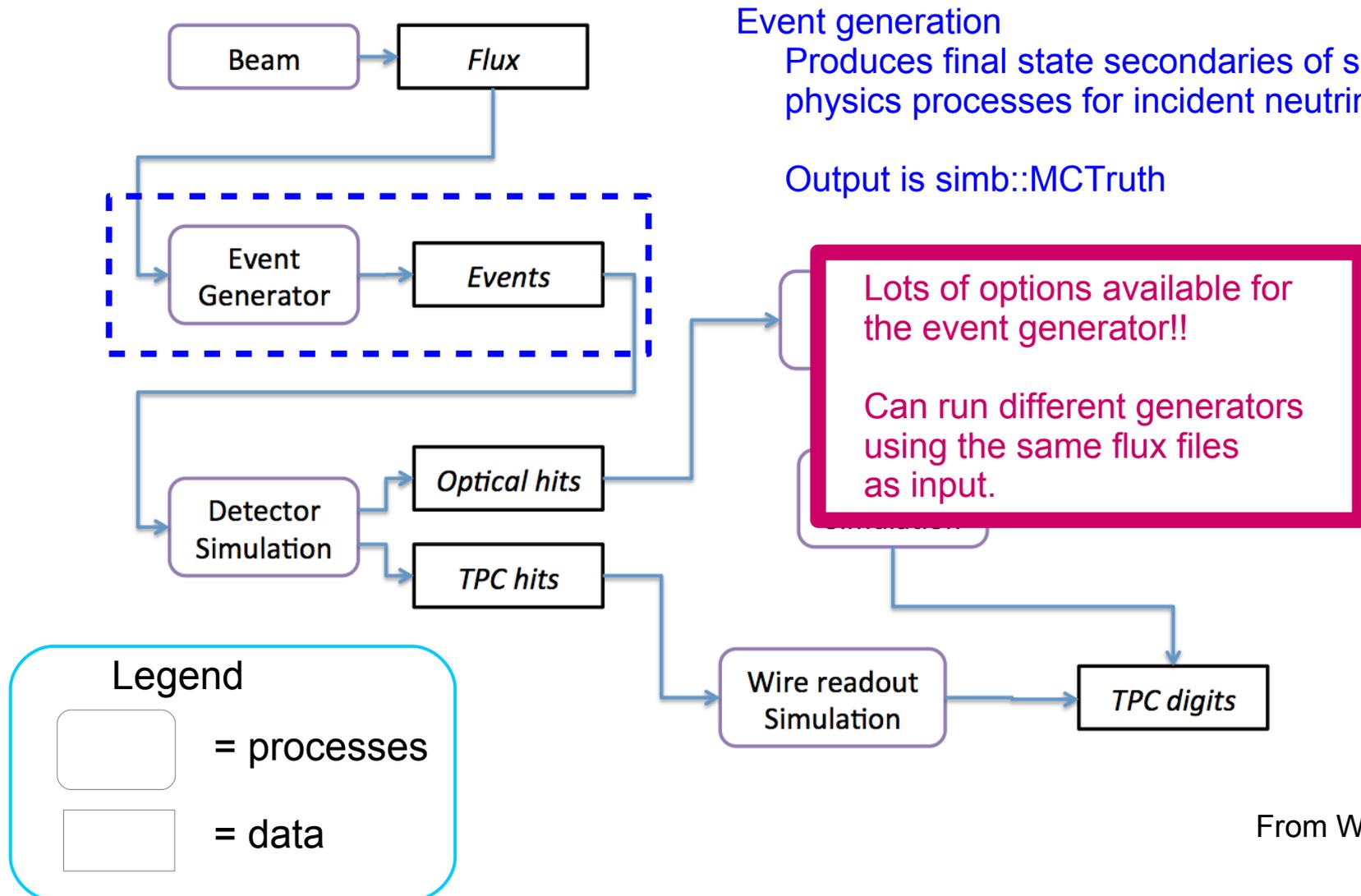
Output is a "flux file".



From W Seligman

# Simulation workflow

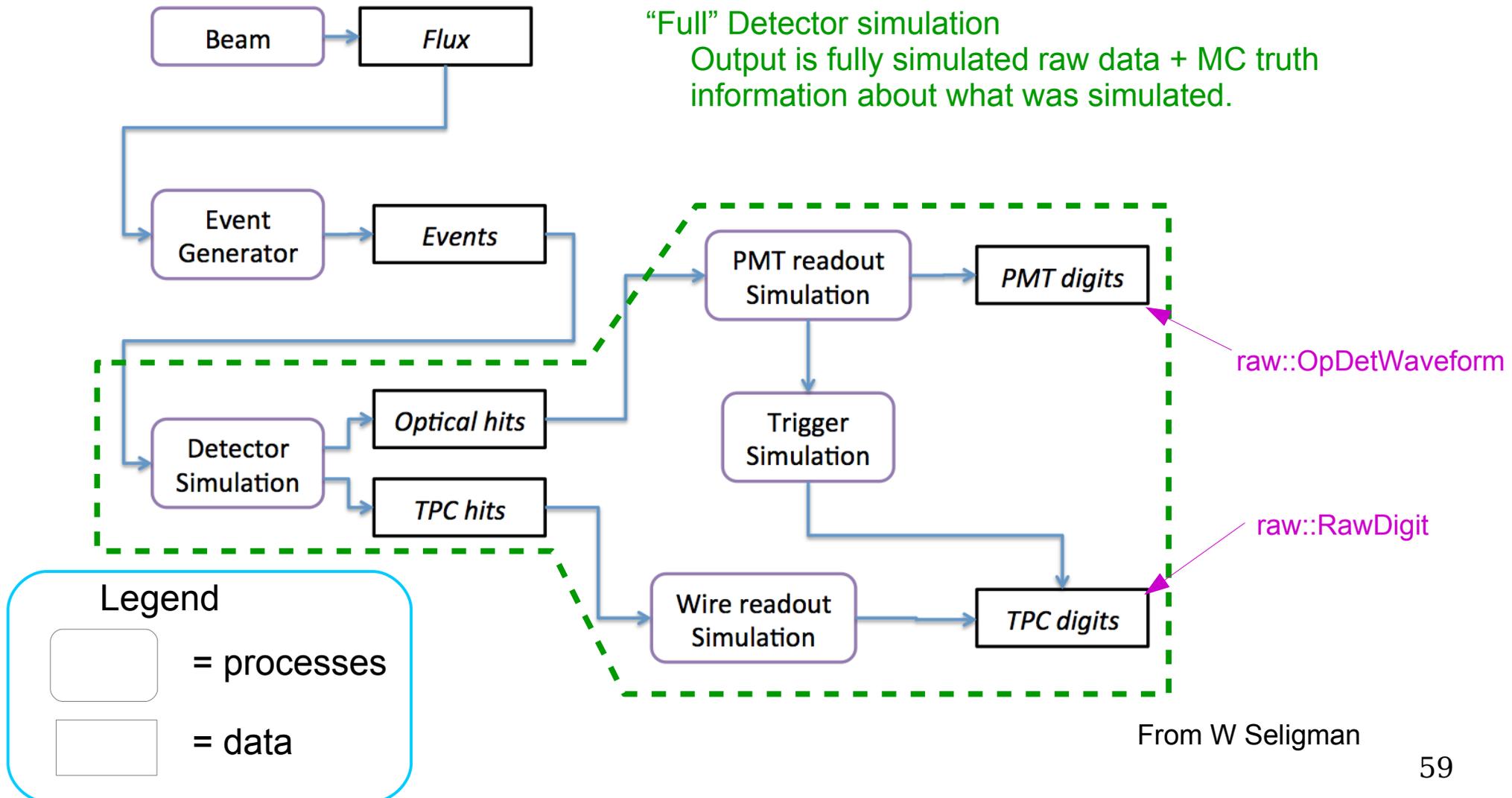
Three phases, typically run separately



From W Seligman

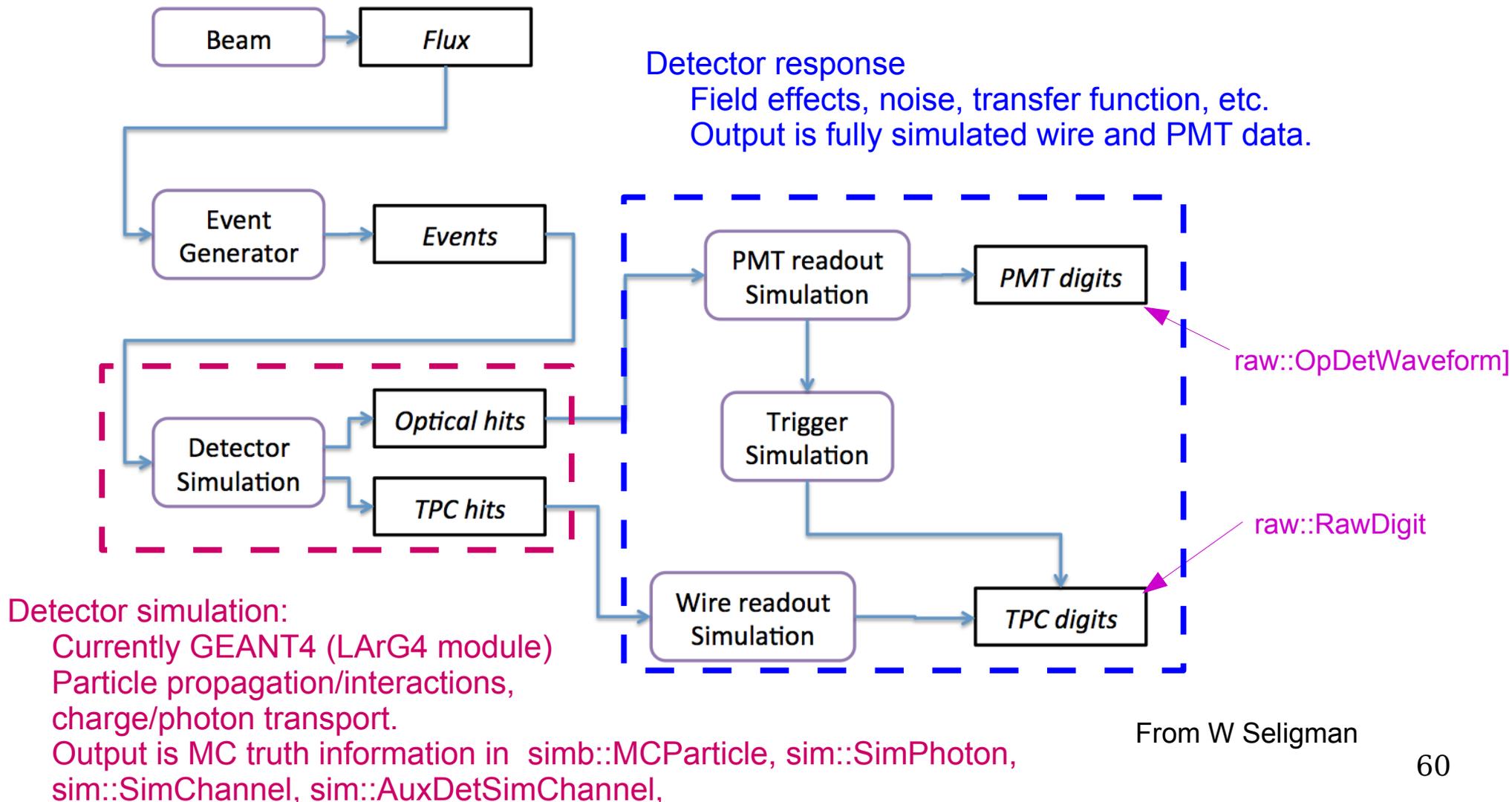
# Simulation workflow

Three phases, typically run separately



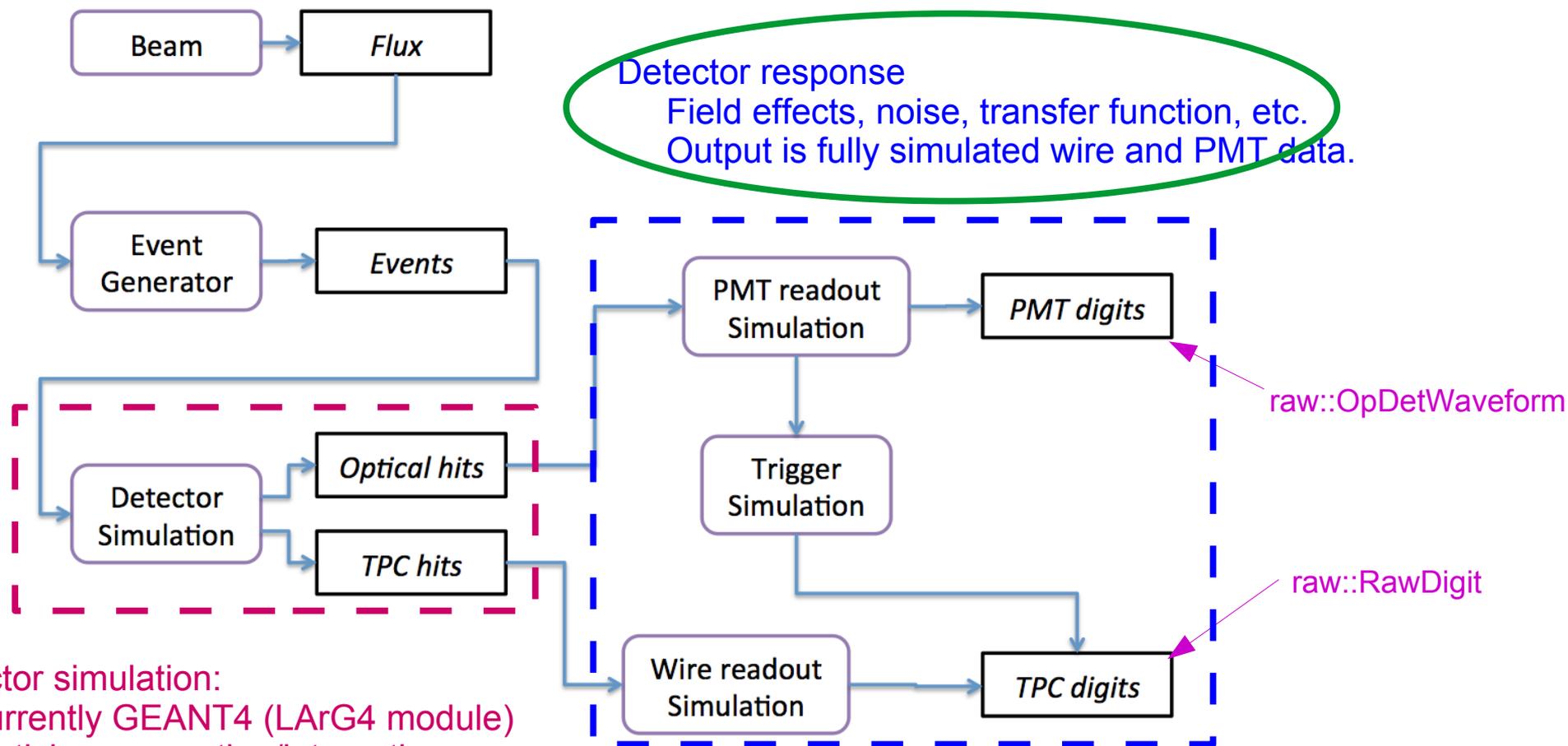
# Simulation workflow

The full detector simulation includes two separable sub-phases



# Simulation workflow

Most detect-specific customizations go into the detector response



## Detector simulation:

Currently GEANT4 (LArG4 module)

Particle propagation/interactions, charge/photon transport.

Output is MC truth information in `simb::MCParticle`, `sim::SimPhoton`, `sim::SimChannel`, `sim::AuxDetSimChannel`,

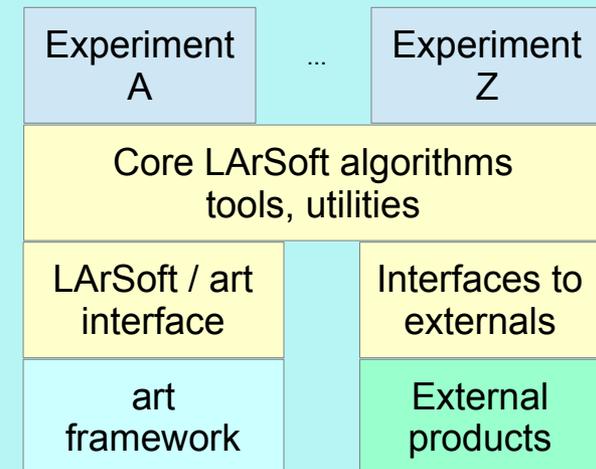
From W Seligman

# LArSoft design principles

# LArSoft design principles and practices



- Detector interoperability
  - The most important design objective for the LArSoft project
  - Define (and use!!) common interfaces for accessing detector-specific configuration information and functionality
  - Applies to geometry, channel mappings, LAr properties, E-field map...
- Separation of framework and algorithm code
  - Encapsulate algorithms, configuration, tools and utilities into a layer that is independent of the art framework
  - Will describe reasons and techniques to achieve this later in the course



## General disclaimer:

In examining the code, you may note that only a portion currently adheres to these principles.

- An on-going architecture review project is intended to address this

**Strongly encourage people to adopt these practices for all new code**

# LArSoft design principles and practices

- Use of standardized algorithm interfaces
  - Define standard interfaces for well-defined steps in the workflow to promote modularity, layering of algorithms
- Modularity
  - Build sophistication by applying algorithms in a layered, iterative structure
- Design / write testable units of code
  - Include unit and integration testing in the development process
  - Follow the practice of continuous integration
    - Perform automated, broad-scale testing at frequent intervals in order to catch unintended side-effects quickly

# LArSoft design principles and practices

- Document code in the source files
  - See many files with no comments at all
  - At very least, need the purpose of the file, how it is used, pre-requisites, assumptions,

# Using LArSoft

# Supported platforms

- Scientific Linux
  - SLF6
  - Have also installed / run this code under:
    - SLC6 (CERN)
    - Redhat 6 (SLAC)
- Mac OSX
  - Mavericks and Yosemite
    - ups qualifiers d13:noifdh and d14:noifdh respectively
- Installation instructions
  - See links in release notes available at [https://cdcvs.fnal.gov/redmine/projects/larsoft/wiki/LArSoft\\_release\\_list](https://cdcvs.fnal.gov/redmine/projects/larsoft/wiki/LArSoft_release_list)

# Releases

- Two types of releases
  - Integration
    - Created weekly or on demand for special purposes
    - Contents approved at Coordination Meetings
      - Head of develop + additional branches approved at a CM or via email
    - May be removed without notice after about a month
      - In practice, we announce our intentions in advance
  - Production
    - Any release designated as “production” by an experiment
    - Created on demand (but usually on the weekly schedule)
    - Contents approved by the experiment declaring production
      - Typically also coordinated through the CM to keep other experiments informed
    - Production releases are retained on disk indefinitely
- List of all available tagged releases
  - [https://cdcvs.fnal.gov/redmine/projects/larsoft/wiki/LArSoft\\_release\\_list](https://cdcvs.fnal.gov/redmine/projects/larsoft/wiki/LArSoft_release_list)

# How to set up and run art/LArSoft

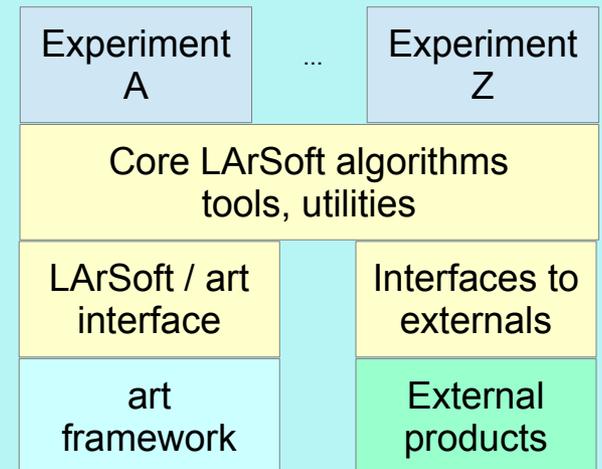
- First point to note

- LArSoft is designed to be run by experiments

- Need detector-specific parts to run it
- So start with the code of your experiment

MicroBooNE	uboonecode
DUNE	lbncode (changing name soon!!)
SBND	lar1ndcode (changing??)
LArIAT	lariatsoft

The setup procedures for each are different  
so refer to the setup relevant setup instructions



- Second point to note

- Do not need a “working area” to run LArSoft. Just need to set up the appropriate products + a fcl file

# How to set up and run art/LArSoft

- The most simple scenario: run from a tagged LArSoft release
  - First, set up the working environment:

```
# Set up ups
source <ups location>/setup
#
# Set up the working environment
# for your experiment
<the setup procedure for your experiment here>

# Set up a LArSoft release
setup larsoft v04_16_00 -q e7:<prof|debug>
```

- In most cases, experiment-specific setup scripts will include all of the above
- Note that setting up for development requires additional steps
- Now run art (the LArSoft version is called `lar`)

```
# List art command-line options
lar --help
#
# Now run LArSoft
#
lar -c <some fcl file>.fcl [-i <input file>]
```

That's it! ...if you have a fcl file and have no code to change

# Setting up and running LArSoft as a developer

- This is the second case of running LArSoft,
  - Applies to people developing LArSoft, or writing analysis software using art
  - Will defer this to the next session, when Saba will talk about how to contribute to LArSoft and use the build tools

# Getting LArSoft to work with a new detector

- LArSoft is really a toolkit
  - It requires a certain amount of detector-specific information and plug-in functionality in order to work
- The minimum needed to run LArSoft for a new detector
  - Define the geometry for the new detector in a GDML file
  - Customize E-field, drift velocity, readout parameters, etc, as needed
  - Customize digitization for simulation, as needed
  - Write a fcl file
  - `lar -c sim_new_det.fcl` → simulated data; `lar -c <reco...>.fcl` → results!!

...A bit over-simplified, but this is basically what happens

# Resources

# LArSoft Redmine site

Redmine sites are called “projects”

<https://cdcvcs.fnal.gov/redmine/projects/larsoft>

The screenshot shows the Redmine interface for the LArSoft project. At the top, there are navigation links: Home, My page, Projects, Help. On the right, it says 'Logged in as esnider' with links for 'My account' and 'Sign out'. Below this is the project name 'LArSoft' and a search bar. A horizontal menu contains tabs for Overview, Activity, Roadmap, Issues, New issue, Gantt, Calendar, Documents, Wiki, Files, Repository, Hudson, and Settings. The 'Overview' tab is selected. The main content area includes a description of the project, a list of instructions for obtaining permission, a list of subprojects, and an 'Issue tracking' section with a list of issue types and counts. On the right side, there is a 'Members' section listing the Manager and Developer roles with their respective names.

This is the home page for the LArSoft Redmine project

Tabs across the top link to different types of content

# LArSoft Redmine site

Redmine sites are called “projects”

<https://cdcvcs.fnal.gov/redmine/projects/larsoft>

Home My page Projects Help

Logged in as esnider My account Sign out

LArSoft

Search: LArSoft

Overview Activity Roadmap **Issues** **New issue** Gantt Calendar Documents **Wiki** Files **Repository** Hudson Settings

Overview

This is the Liquid Argon Software (LArSoft) project. It contains simulation and reconstruction algorithms for LAr TPC detectors.

- To obtain permission to use this site:
  - 1) Log onto redmine with your [Services Account](#)
  - 2) Let us know when you are online
  - 3) We will add you as a developer

If you are off-site and need a FNAL user ID please go [here](#)

Sites for the legacy svn and cvs versions of LArSoft can be found under sub-projects.

- Subprojects: ArgoNeUT code, LAr-Continuous-Integration, LArIND code, LArAdmin, LArAna, LArCore, LArData, LArEventDisplay, LArEvt, LArExamples, LArPandora, LArReco, LArSim, LArSoft-SVN (legacy site), LArUtils, LBNE code, uBooNE code

**Issue tracking**

- Bug: 19 open / 141
- Feature: 26 open / 58
- Support: 8 open / 45
- Idea: 2 open / 7
- Meeting: 0 open / 0
- Milestone: 5 open / 13
- NOvA Simulation Request: 0 open / 0
- Nova Simulation Problem: 0 open / 0
- Necessary Maintenance: 0 open / 0
- Review Request: 0 open / 0
- Task: 0 open / 0

View all issues | Calendar | Gantt

**Members**

Manager: Andrzej Szelc, Brian Rebel, Dave Dynestra, David Schmitz, Elizabeth Sexton-Kennedy, Eric Church, Erica Snider, Gianluca Petrillo, Herbert Greenlee, Katherine Lato, Lynn Garren, Maxim Potelkin, Michael Kirby, Patrick Gartung, Saba Sehrish, Stephen Wolbers, Thomas Junk, Tingjun Yang

Developer: Aaron Miquera Pichardo, Aleena Rafique, Alexander Himmel, Alexander Moss, Allie Hexley, Andrew Blake, Andrew Olivier, Andrew Smith, Andrzej Szelc, Anne Schukraft, Ariana Hackenburg, Augustus Pester, Babu Bhandari, Ben Carls, Benjamin Jones, Brandon Eberly, Brett Viren, Brian Kirby, Brian Page, Brian Rebel, Bruce Baller, Cello Moura, Chen Zhang, Chengyi Chi, Christopher Green, Chun-min Jen, Colton Hill, Corey Adams, Crystal Matteson, David Adams, David Caratelli, David Kaleko, David Mckee, Diego Gamez, Dominic Brallsford, Dorota Stefan, Douglas Davis, Dung Phan, Edward Santos, Elena Gramellini, Eric Church, Erica Snider, Gavin Davies, Georgia Karagiorgi, Geralyn Zeller, Gianluca Petrillo, Gleb Sinev, Glenn Horton-Smith, Hans-Joachim Wenzel, Hector Mendez, Herbert Greenlee, Irene Nutini, Isabella Majoros, Jarrett Moon, Jason St.John, Jennifer Raaf, Jessica Esquivel, John s. Marshall, Johnny Ho, Jonathan Asadi, Jonathan Davies, Jonathan Insler, Jonathan Paley, Jonathan Perkin, Joseph Zennaro, Joshua Spica, Jyoti Joshi, Kalousis Leonidas, Katherine Lato, Katherine Woodruff, Kathryn Sutton, Kazuhiro Terao, Kenneth Herner, Kevin Wood, Leon Rochester, Lynn Garren, Marina David, Martin Auger, Martin Tzanov, Matthew Smylie, Matthew Thiesse, Matthew Toups, Matthew Worcester, Matthias Luethi, Michael Kirby, Michael Mooney, Michael Wallbank, Michael Weber, Michelle Stancari, Mitchell Soderberg, Monica Nunes, Muhammad Elnimr, Nathaniel Tagg, Nicholas Graf, Nicole Periera, Nikolaus Howe, Nuno Fluzza de Barros, Ohana Rodrigues, Ornella Palamara, Pawel Kryczynski, Peter Watkins, Preston Hansen, Randy Johnson, Rashid Mehdiyev, Robert Hatcher, Robert Murrells, Robert Sulej, Roberto Acciarri, Roxanne Guenette, Ruth Pordes, Ryan Linehan, Samantha Fortuna, Samuel Santana, Sarah Lockwitz, Sean Ngo, Seong tae Park, Sepideh Shahsavarani, Serhan Tufanli, Shruti Shrestha, Sowjanya Gollapinni, Spentzouris panagiotis, Taritree Wongjirad, Thales Vieira, Thomas Brooks, Thomas Junk, Thomas Warburton, Thomas Wester, Tia Miceli, Timothy Leoney, Tingjun Yang, Tracy Usher, Tristan Blackburn, Tyler Alion, Vito Di Benedetto, Wesley Ketchum, Will Flanagan, William De rocco, William Foreman, William Seligman, Xiaoyue Li, Xin Qian, Yeeren Low, Yichen Li, Yujing Sun, Yun-tse Tsai, Zarko Pavlovic

Reporter: Mark Convery, Paul Lebrun

This is the home page for the LArSoft Redmine project

Tabs across the top link to different types of content

The most useful tabs:  
Wiki  
Issues  
New Issues  
Repository

# LArSoft wiki

<https://cdcvs.fnal.gov/redmine/projects/larsoft/wiki>

General information  
and documentation

The screenshot shows the LArSoft wiki interface. At the top, there are navigation tabs: Home, My page, Projects, Help. Below that, the LArSoft logo and a search bar containing 'LArSoft'. A secondary navigation bar includes Overview, Activity, Roadmap, Issues, New issue, Gantt, Calendar, Documents, Wiki (selected), Files, Repository, Hudson, and Settings. The main content area lists several articles: LArSoftWiki, Introduction to LArSoft, Using LArSoft, Developing With LArSoft, The LAr forum, Getting LArSoft, LArSoft Internals, and Miscellaneous Links. A right sidebar contains 'Wiki' links: Start page, Index by title, and Index by date. A blue arrow points from a text box to the 'Using LArSoft' article, and a red arrow points from another text box to the 'Quick-start guide to using and developing LArSoft code' link.

Instructions, list of releases, and other useful information.

Quick-start guide to using and developing LArSoft code

# LArSoft issue tracker

<https://cdcvs.fnal.gov/redmine/projects/larsoft/issues>

Home My page Projects Help Logged in as esnider My account Sign out

LArSoft Search: LArSoft

Overview Activity Roadmap **Issues** **New issue** Gantt Calendar Documents Wiki Files Repository Hudson Settings

Issues

Filters

Status open Add filter open

Options

Apply Clear Save

#	Tracker	Status	Priority	Subject	Assignee	Updated
9705	Bug	Assigned	Normal	Temporary fworkaround on optical detector code in larana should be removed for a real fix	Taritree Wongjirad	07/22/2015 02:51 PM
9669	Bug	Assigned	Normal	Cannot display events produced with a different version of geometry	Gianluca Petrillo	07/21/2015 02:10 PM
9289	Bug	Accepted	High	pedestal inconsistency		06/24/2015 04:45 PM
9268	Feature	New	Normal	Passthru for CET_TEST make_test suite in trigger, workflow		06/22/2015 02:12 PM
9264	Feature	Assigned	Normal	Support reconstruction of objects from channel/time space	Gianluca Petrillo	06/22/2015 11:00 AM
9254	Feature	New	Normal	Update Doxygen version to support markdown		06/19/2015 02:14 PM
9108	Bug	Resolved	Normal	Processing multiple files		06/25/2015 12:29 AM
8992	Bug	Assigned	Normal	SimChannel::TDCIDEMap index range	William Seligman	06/23/2015 10:59 AM
8954	Idea	Assigned	Low	New geometry features	Gianluca Petrillo	06/19/2015 03:00 PM
8927	Feature	New	Normal	Web server with expanded storage capacity.		05/26/2015 09:21 AM
8926	Feature	Assigned	Normal	FTS Dropbox for AnalysisTree ntuples	Herbert Greenlee	06/15/2015 04:47 PM
8925	Feature	New	Normal	Experiment-independent channel filter in geometry service		05/27/2015 09:57 AM
8924	Feature	New	Normal	Experiment-independent access to database information in DetectorProperties		05/26/2015 08:54 AM
8923	Feature	New	Normal	Experiment-independent access to database calibration information in LArProperties		05/26/2015 08:54 AM

Issues

View all issues  
Summary  
Calendar  
Gantt

Custom queries

Issues by Age  
LArSoft only (no experiment code)  
List With Due Date  
List by Status  
List by Status and Assignee

We track bugs, problems with LArSoft-related infrastructure, requests for support and new features, questions...

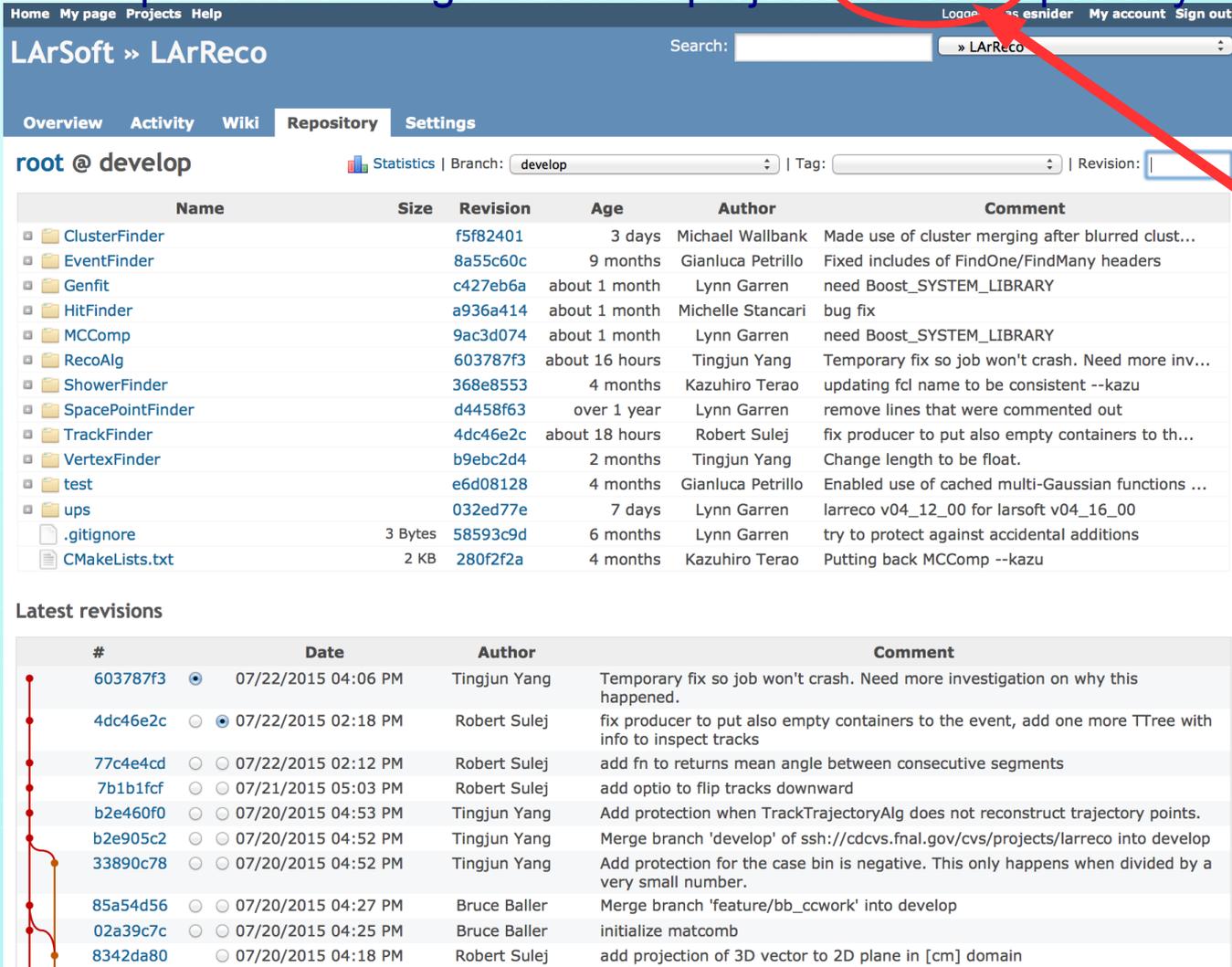
Open a new ticket using the “New Issue” tab if you have any of the above

Create a new issue using this tab.

Must be logged into Redmine using your Fermilab **services account** and password

# LArSoft Redmine code browser ...

<https://cdcvns.fnal.gov/redmine/projects/larreco/repository>



Name	Size	Revision	Age	Author	Comment
ClusterFinder		f5f82401	3 days	Michael Wallbank	Made use of cluster merging after blurred clust...
EventFinder		8a55c60c	9 months	Gianluca Petrillo	Fixed includes of FindOne/FindMany headers
Genfit		c427eb6a	about 1 month	Lynn Garren	need Boost_SYSTEM_LIBRARY
HitFinder		a936a414	about 1 month	Michelle Stancari	bug fix
MCComp		9ac3d074	about 1 month	Lynn Garren	need Boost_SYSTEM_LIBRARY
RecoAlg		603787f3	about 16 hours	Tingjun Yang	Temporary fix so job won't crash. Need more inv...
ShowerFinder		368e8553	4 months	Kazuhiro Terao	updating fcl name to be consistent --kazu
SpacePointFinder		d4458f63	over 1 year	Lynn Garren	remove lines that were commented out
TrackFinder		4dc46e2c	about 18 hours	Robert Sulej	fix producer to put also empty containers to th...
VertexFinder		b9ebc2d4	2 months	Tingjun Yang	Change length to be float.
test		e6d08128	4 months	Gianluca Petrillo	Enabled use of cached multi-Gaussian functions ...
ups		032ed77e	7 days	Lynn Garren	larreco v04_12_00 for larsoft v04_16_00
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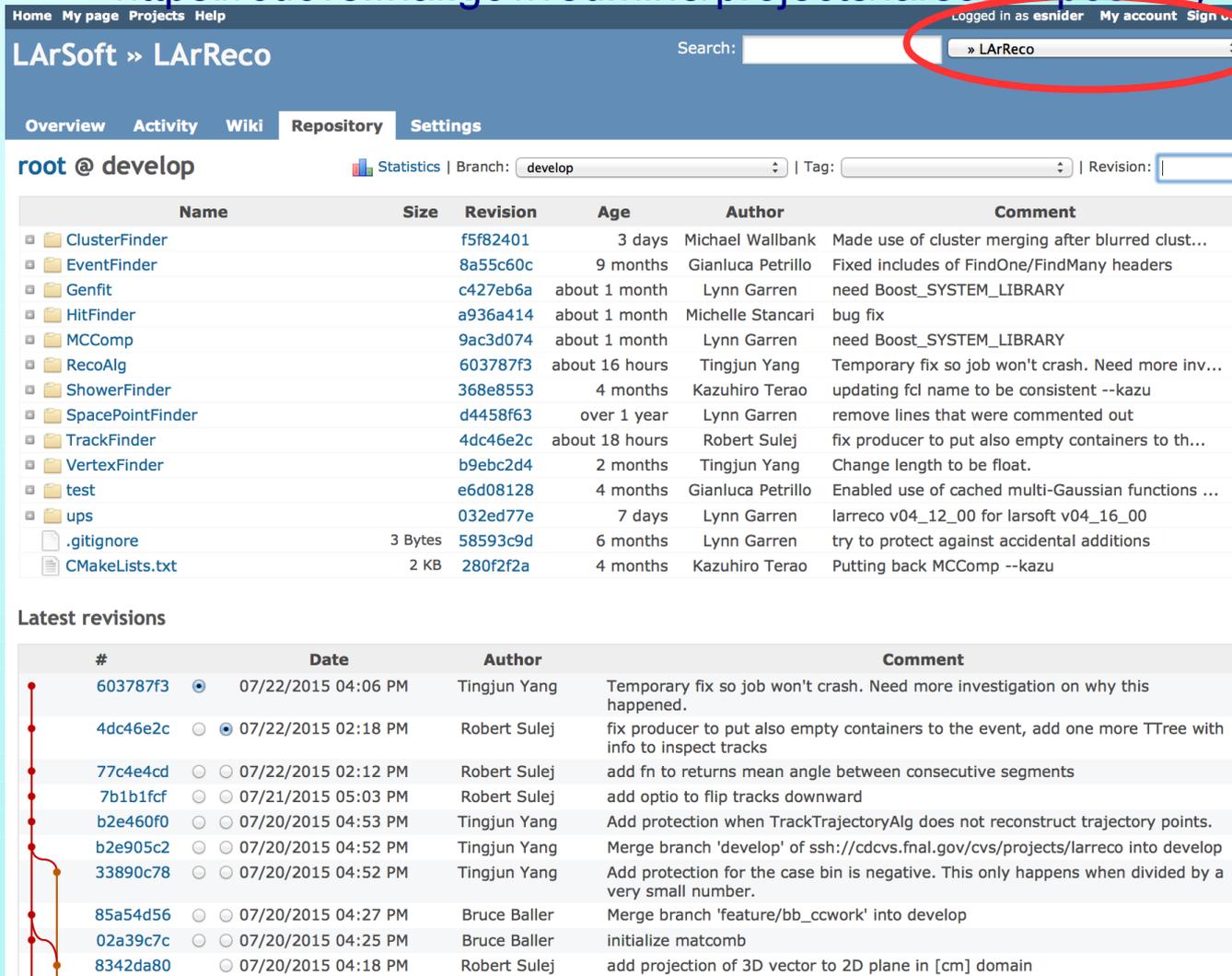
  

#	Date	Author	Comment
603787f3	07/22/2015 04:06 PM	Tingjun Yang	Temporary fix so job won't crash. Need more investigation on why this happened.
4dc46e2c	07/22/2015 02:18 PM	Robert Sulej	fix producer to put also empty containers to the event, add one more TTree with info to inspect tracks
77c4e4cd	07/22/2015 02:12 PM	Robert Sulej	add fn to returns mean angle between consecutive segments
7b1b1fcf	07/21/2015 05:03 PM	Robert Sulej	add optio to flip tracks downward
b2e460f0	07/20/2015 04:53 PM	Tingjun Yang	Add protection when TrackTrajectoryAlg does not reconstruct trajectory points.
b2e905c2	07/20/2015 04:52 PM	Tingjun Yang	Merge branch 'develop' of ssh://cdcvns.fnal.gov/cvs/projects/larreco into develop
33890c78	07/20/2015 04:52 PM	Tingjun Yang	Add protection for the case bin is negative. This only happens when divided by a very small number.
85a54d56	07/20/2015 04:27 PM	Bruce Baller	Merge branch 'feature/bb_ccwork' into develop
02a39c7c	07/20/2015 04:25 PM	Bruce Baller	initialize matcomb
8342da80	07/20/2015 04:18 PM	Robert Sulej	add projection of 3D vector to 2D plane in [cm] domain

Each LArSoft repository lives in a separate Redmine project which is specified here.

# Navigating between LArSoft sub-projects

<https://cdcvs.fnal.gov/redmine/projects/larsoft/repository>



The screenshot shows the Redmine interface for the LArSoft repository. At the top, there are navigation links: Home, My page, Projects, and Help. The user is logged in as 'esnider'. The main header displays 'LARSoft » LARReco' and a search bar. A red circle highlights a pull-down menu in the search bar that is currently set to 'LARReco'. Below the header, there are tabs for Overview, Activity, Wiki, Repository, and Settings. The 'Repository' tab is active, showing the current branch as 'develop'. A table lists the repository contents, including folders like ClusterFinder, EventFinder, Genfit, HitFinder, MCComp, RecoAlg, ShowerFinder, SpacePointFinder, TrackFinder, VertexFinder, test, and ups, along with files like .gitignore and CMakeLists.txt. Each entry shows its name, size, revision ID, age, author, and comment. Below the repository list, there is a section for 'Latest revisions' with a table showing the most recent changes, including revision numbers, dates, authors, and comments.

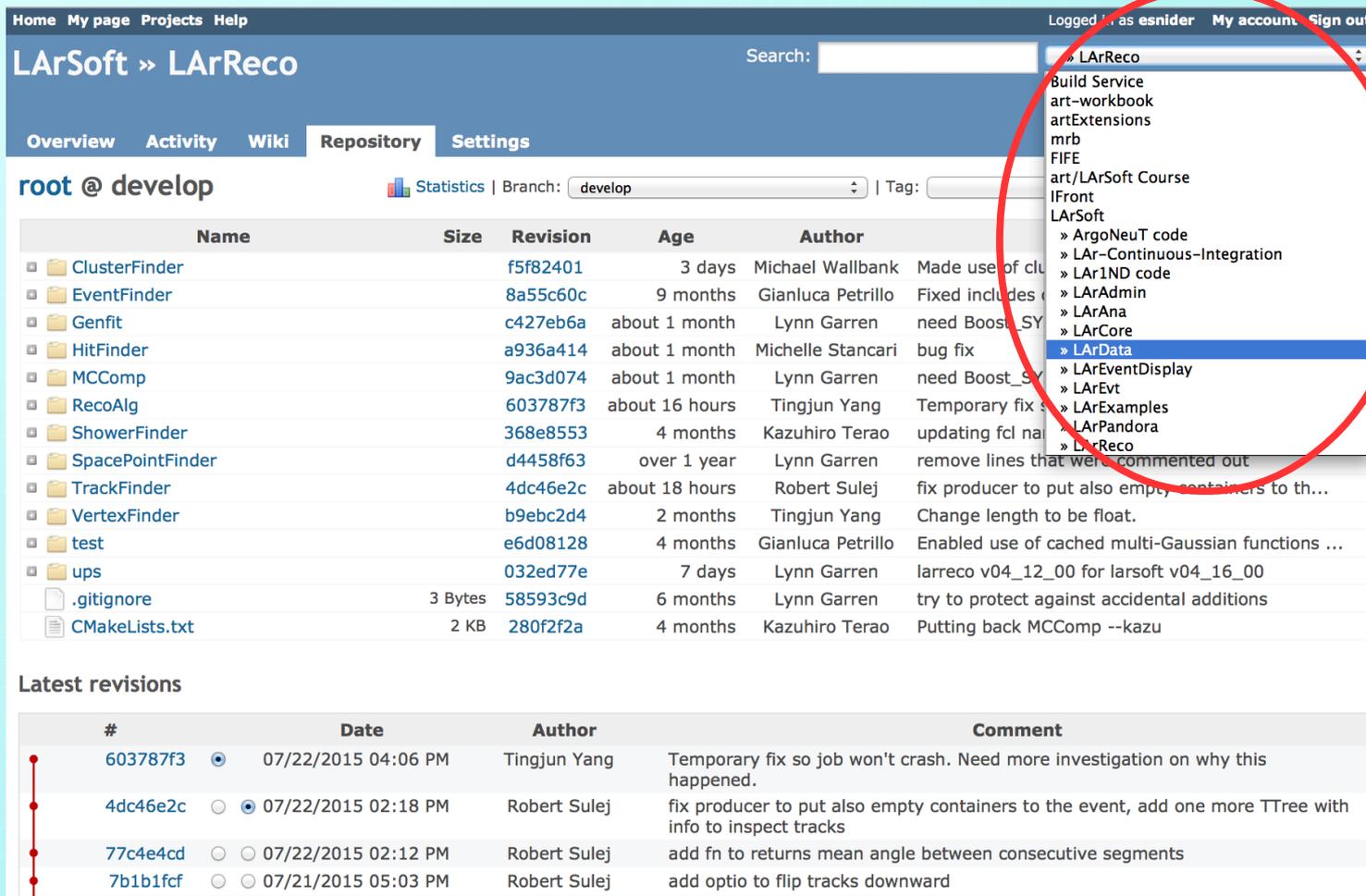
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SpacePointFinder		d4458f63	over 1 year	Lynn Garren	remove lines that were commented out
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.gitignore	3 Bytes	58593c9d	6 months	Lynn Garren	try to protect against accidental additions
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Can use the project navigation pull-down to get to the desired project.

# Navigating between LArSoft sub-projects



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Name	Size	Revision	Age	Author	Comment
ClusterFinder		f5f82401	3 days	Michael Wallbank	Made use of clu...
EventFinder		8a55c60c	9 months	Gianluca Petrillo	Fixed includes
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77c4e4cd	07/22/2015 02:12 PM	Robert Sulej	add fn to returns mean angle between consecutive segments
7b1b1fcf	07/21/2015 05:03 PM	Robert Sulej	add optio to flip tracks downward

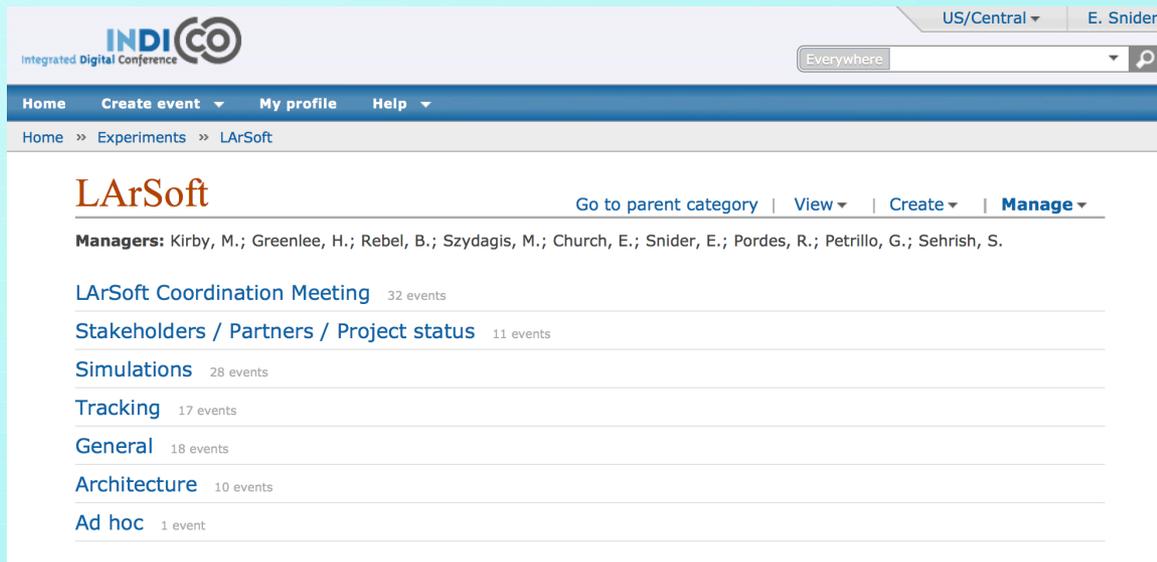
Can use the project navigation pull-down to get to the desired project.

# LArSoft Indico site

- Slides and documents from meetings are posted to Indico

<https://indico.fnal.gov/categoryDisplay.py?categId=233>

- Or from the Indico home page: <https://indico.fnal.gov/index.py>, follow “Experiments”, then “LArSoft” links to arrive at the LArSoft page



The screenshot shows the Indico website interface for the LArSoft category. At the top, there is a navigation bar with 'Home', 'Create event', 'My profile', and 'Help'. Below this, a breadcrumb trail reads 'Home >> Experiments >> LArSoft'. The main content area features the 'LArSoft' title with a search bar and options to 'Go to parent category', 'View', 'Create', and 'Manage'. A list of managers is provided: Kirby, M.; Greenlee, H.; Rebel, B.; Szydagis, M.; Church, E.; Snider, E.; Pordes, R.; Petrillo, G.; Sehrish, S. Below the managers, several event categories are listed with their respective event counts: LArSoft Coordination Meeting (32 events), Stakeholders / Partners / Project status (11 events), Simulations (28 events), Tracking (17 events), General (18 events), Architecture (10 events), and Ad hoc (1 event).

Can upload slides on the page for the particular meeting...

...but, must be logged in using your **Indico account** and password

# Resources

- LArSoft dOxygen documentation system:
  - <http://nusoft.fnal.gov/larsoft/doxsvn/html/index.html>
- LAr reconstruction software forum: <http://www.larforum.org/forum>
  - Help with general problems in LAr software
  - So far almost entirely focused on LArSoft...
- LArSoft email list: [larsoft@fnal.gov](mailto:larsoft@fnal.gov)
  - General announcements. Often technical questions also.
  - Can self-subscribe. See <http://listserv.fnal.gov/> for instructions.
- LArSoft Coordination Meeting
  - Bi-weekly at 13:00 Central Time. July 28 is the next one.
  - Remote connections via ReadyTalk. Slides posted to LArSoft Indico site.
- LArSoft wiki: <https://cdcvs.fnal.gov/redmine/projects/larsoft/wiki>
  - [Quick-start guide to using and developing LArSoft code](#)
  - See also <https://cdcvs.fnal.gov/redmine/projects/uboonecode/wiki>
- LArSoft issue tracker
  - <https://cdcvs.fnal.gov/redmine/projects/larsoft/issues/new>

# Core LArSoft support team

- Core team members

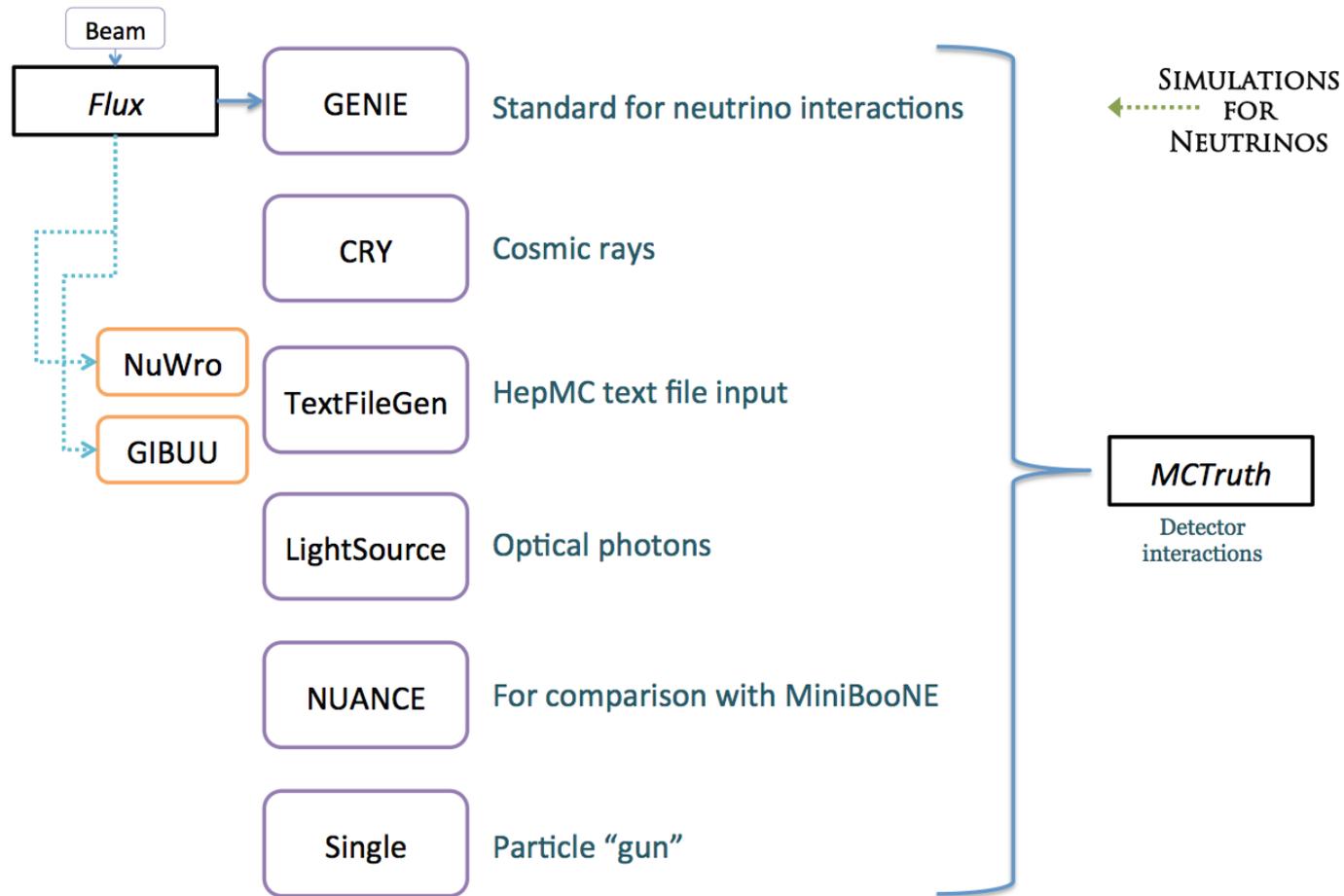
- Technical lead: Erica Snider  
[erica@fnal.gov](mailto:erica@fnal.gov)
- Project manager: Ruth Pordes  
[ruth@fnal.gov](mailto:ruth@fnal.gov)
- Lead developer: Gianluca Petrillo  
[petrillo@fnal.gov](mailto:petrillo@fnal.gov)
- Developer: Saba Sehrish  
[ssehrish@fnal.gov](mailto:ssehrish@fnal.gov)
- Code management and distribution: Lynn Garren  
[garren@fnal.gov](mailto:garren@fnal.gov)
- CI operations and testing support: Vito di Benedetto  
[vito@fnal.gov](mailto:vito@fnal.gov)

Email / visit any of the project team!!

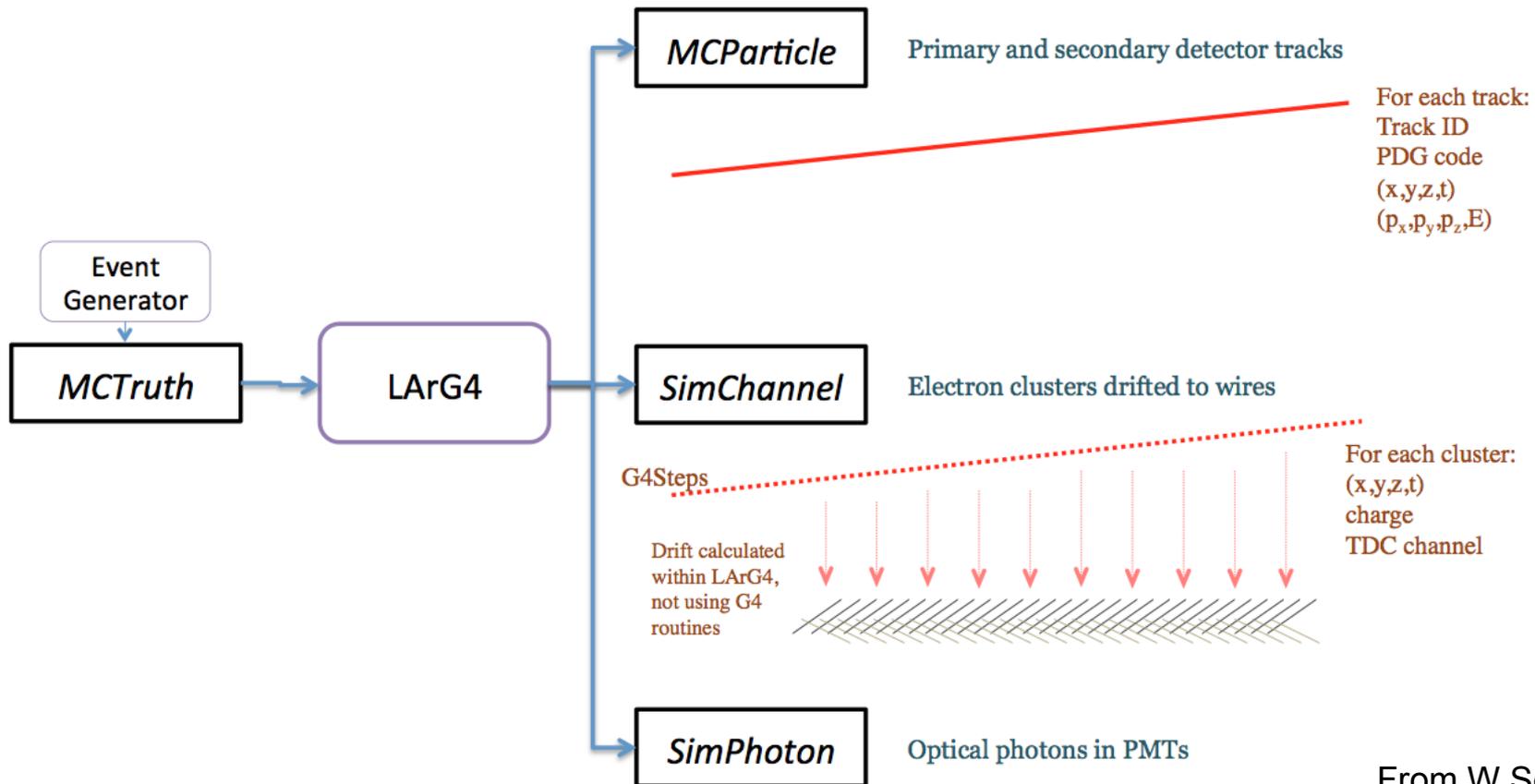
The end

# Backup

# Event generators



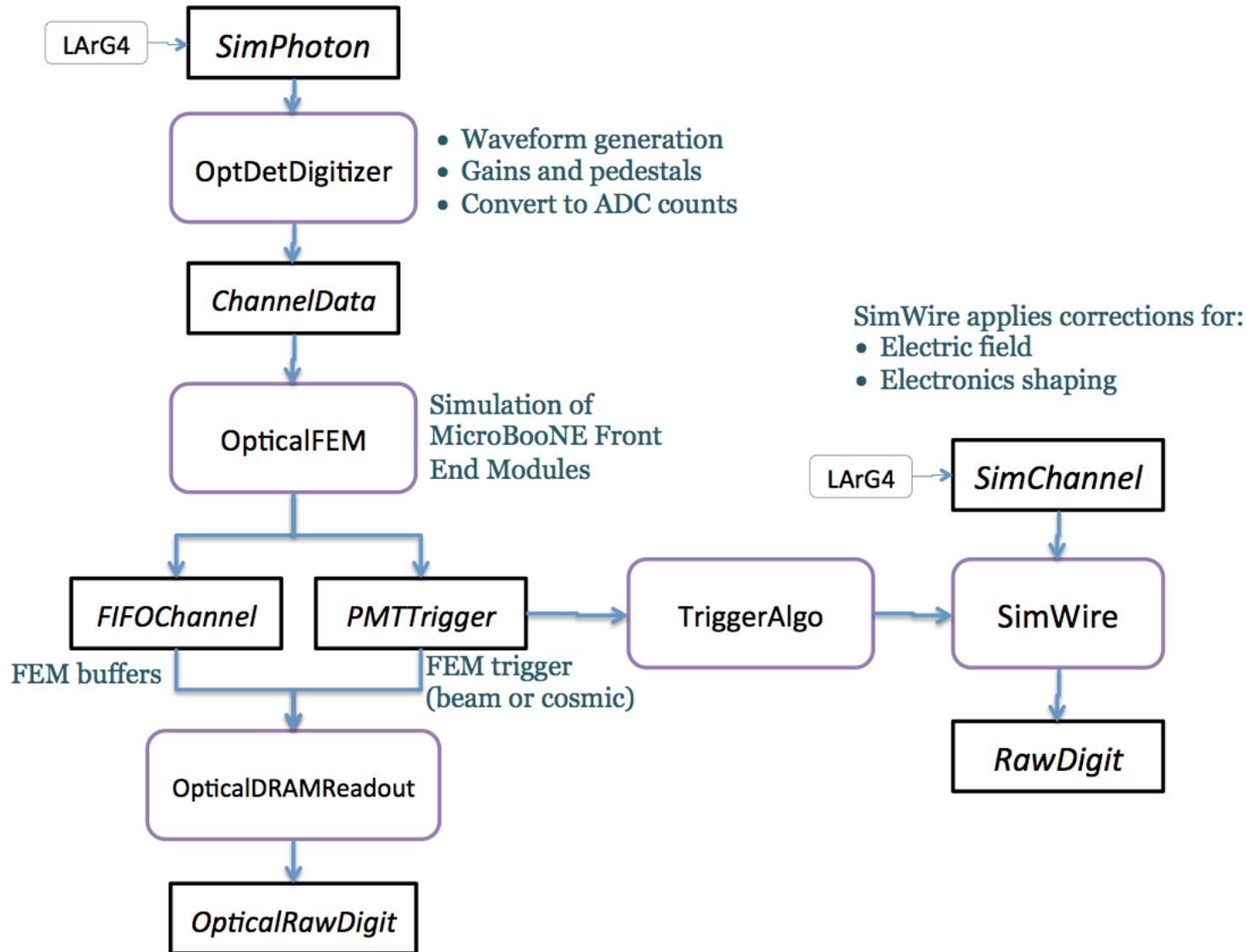
# Detector simulation



From W Seligman

# Simulation task workflow

## Detector response and digitization



# LArSoft design principles and objectives



- Detector interoperability

- The most important design objective for the LArSoft project
- Requires care to define (and use!!) common interfaces for accessing detector-specific configuration information
- Good example: access to detector geometry information
  - A single interface that accommodates different (albeit very similar) geometries
    - Most differences a matter of configuration only
    - Also have detector-specific implementations of the interface where needed
  - Carefully avoid implied geometrical assumptions in algorithms
    - Position of the first plane or wire, the wire spacing, etc.
  - Introduced structures to facilitate generic loops over geometrical elements
    - Define detector / DAQ element IDs at all levels of detector geometry hierarchy
    - Can thereby avoid explicit reference to indices for loops, etc.
- Also applies to
  - Access to calibration data, LAr properties, detector properties, E-field map, handling of common metadata for data files...
- Have compiled a long list of do's and don'ts to ensure interoperability

# LArSoft design principles and objectives

- Separation of framework and algorithm code

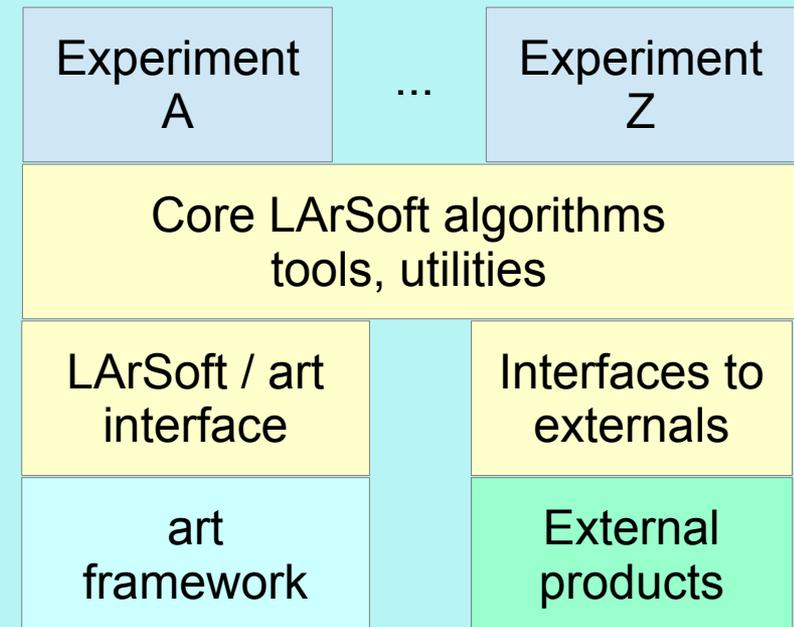
- Encapsulate algorithms, configuration, tools and utilities into a layer that is independent of the framework

- Why??

- Allow testing of small units of algorithm code outside the framework
- Provide greater flexibility in using algorithms
- To provide a means of integrating LArSoft code (data products and algorithms) with external frameworks

- e.g., LArLite used by MicroBooNE for algorithm development, testing

See [art guidance for writing modules](#) for further discussion



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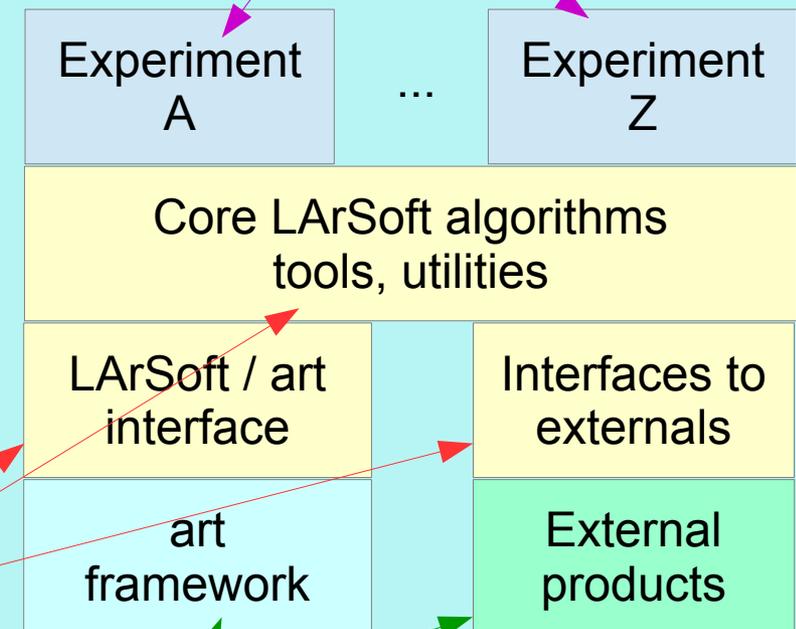
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Owned, maintained exclusively by individual experiments



All this code lives in LArSoft repositories

Provided by third parties

# LArSoft design principles and objectives

- Separation of framework and algorithm code (cont'd)
  - How??
    - Adhere to particular design patterns for the “LArSoft / art interface” code
      - I.e, art modules and services (to be discussed later)
    - Access framework functionality only within the interface code
      - Includes finding input data, writing output data, retrieving any required services, making filter decision calls, etc.
    - Pass all required data, utility classes into algorithms, and all output data back out

General disclaimer: In examining the code, you may note that only a portion of the existing code adheres to this and the other design principles.

- The on-going architecture review project is intended to address this

Strongly encouraging people to adopt this practice for new code.

# LArSoft design principles and objectives

- Standardized algorithm interfaces
  - Define standard interfaces for well-defined steps in the workflow so that:
    - Multiple algorithms that address specific problems can share interfaces
  - Promote greater modularity, layering of algorithms
  - Generally enhances flexibility of the code
- Modularity
  - Build sophistication by applying small, targeted algorithms in a layered, iterative structure
  - Leads to code that is more easily tested, more maintainable, more flexible

# LArSoft design principles and objectives

- Continuous integration

- A development scheme in which changes to the main branch of development are integrated and tested frequently
  - At every push to the develop branch
  - Every night
  - At every release
- Primary LArSoft goals
  - Ensure that code performs as intended
  - Facilitate early detection of problems created in one experiment due to changes introduced by another experiment
  - Ensure that all major features in the develop branch work at all times
- Are now operating a continuous integration system for LArSoft
  - Currently runs at every push to develop branch
  - Can be triggered manually to run on a non-develop branch of a user's choosing



Requires that code authors write tests!

See <https://cdcvs.fnal.gov/redmine/projects/lar-ci/wiki> for details