# SIDIS-EIC

Common Analysis Framework for SIDIS

https://github.com/c-dilks/sidis-eic

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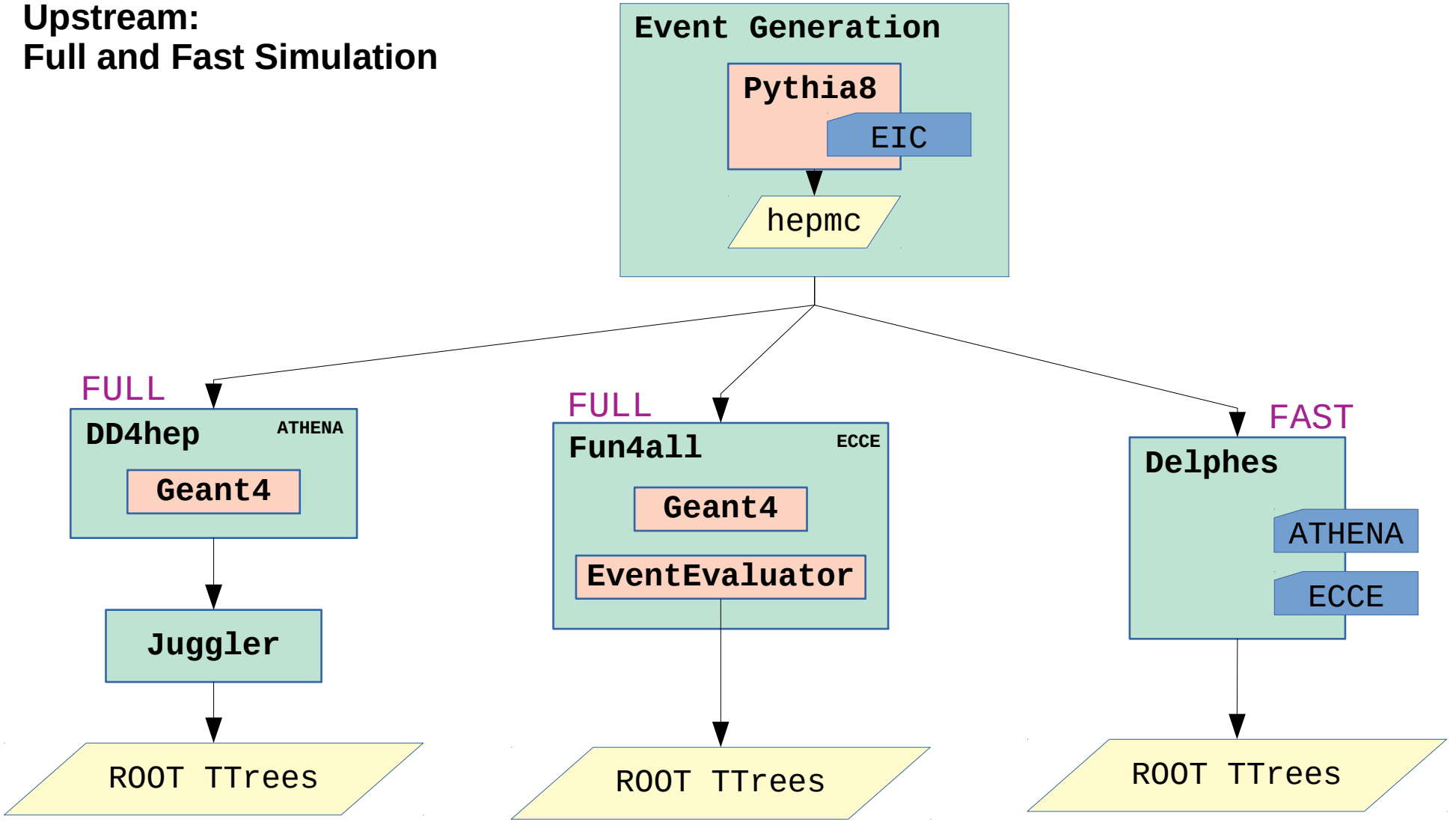
**Upstream:**
**Full and Fast Simulation**



# SIDIS-EIC
# Common Analysis Framework

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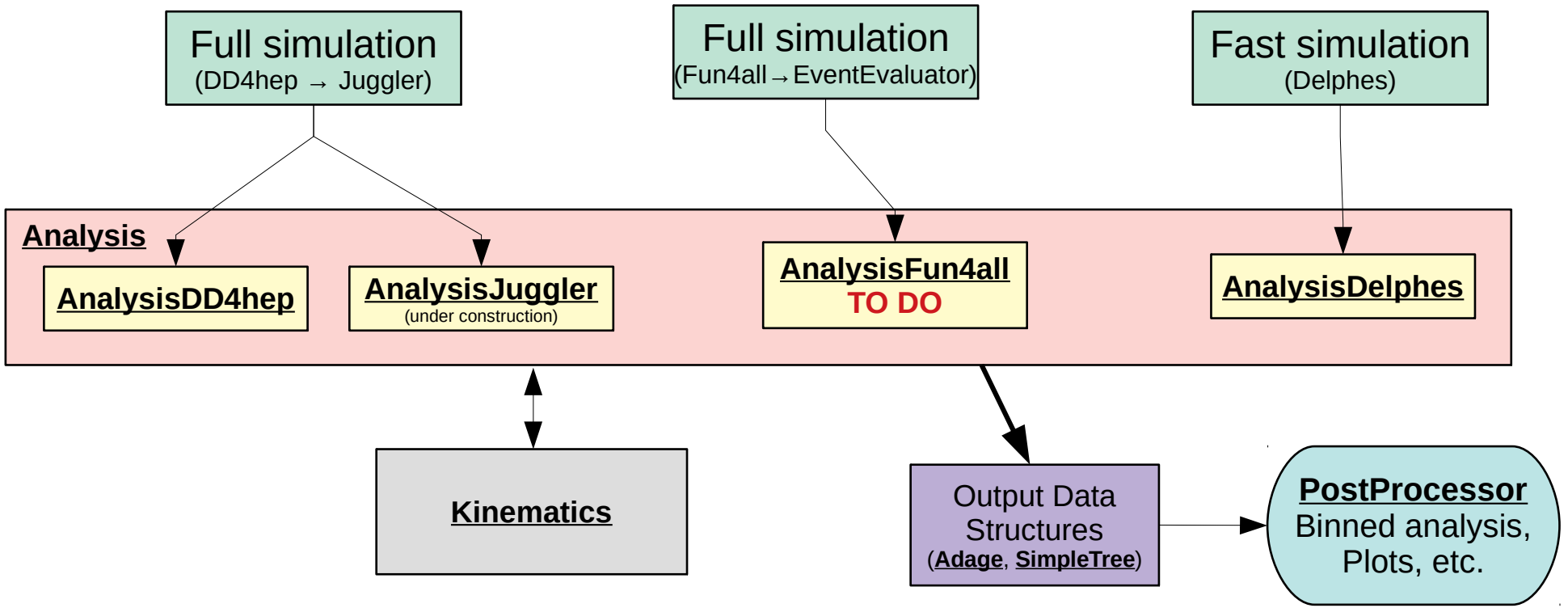
Classes are **underlined**



## Analysis

- Base class **Analysis** provides common functionality
  - Prepare() reads input and initializes:
    - Output data structures
    - Instances of **Kinematics**: one for truth and another for reconstructed
  - Finish() writes to output
  - Contains numerous configuration settings
    - Binning scheme
    - Reconstruction method
    - Final State (single hadrons, jets, … )
  - Includes methods to fill output data structures, called by derived classes

- Derived classes **AnalysisDelphes**, etc. tuned to read respective ROOT trees
  - Execute(): the main method to perform the analysis
    - Analysis::Prepare()
    - Event loop (with sub-loops over tracks, jets, … )
      - Read input TTree variables
      - Set input variables of **Kinematics**
      - Call **Kinematics** calculation methods
      - Fill output data structures
    - Analysis::Finish()

**Kinematics**

- 2 Instances: reconstructed and generated
- Input variables:
  - Beam momenta
  - Scattered electron
  - Hadronic Final State (HFS)
  - Single hadrons (SIDIS)
  - Jets
- Calculations:
  - CalculateDIS(): various reconstruction methods available ( → )
  - CalculateHadronicKinematics(): single hadron SIDIS variables
  - CalculateJetsKinematics(): jet variables
    - Uses fastjet
    - Implemented only for **AnalysisDelphes**
      - **TODO: implement in AnalysisDD4hep & AnalysisFun4all, or separately (AnalysisJets)?**
- Ouput variables:
  - DIS: $Q^2$, x, y, W, …
  - HFS variables: Σ, …
  - SIDIS Hadron: p, $p_T$, z, $\phi_h$, …
  - Jets: z, $p_T$, $q_T$, …
- Includes boost functions

```
// reconstruction methods
void CalculateDISbyElectron();
void CalculateDISbyJB();
void CalculateDISbyDA();
void CalculateDISbyMixed();
void CalculateDISbySigma();
void CalculateDISbyeSigma();
```

slide from Connor:

# Current jet implementation in AnalysisDelphes

- Jet clustering using fast jet and Delphes energy flow objects with pT > 0.1 GeV
  - EFlowTracks, EFlowPhotons, EFlowNeutralHadrons
  - four-momenta from MC particle bank also clustered to get true jets
- Currently, semi-inclusive jets using anti-kT (R=0.8) algorithm clustered, then used to calculate other variables/fill histograms
  - $z_h, j_\perp, q_T$ etc.

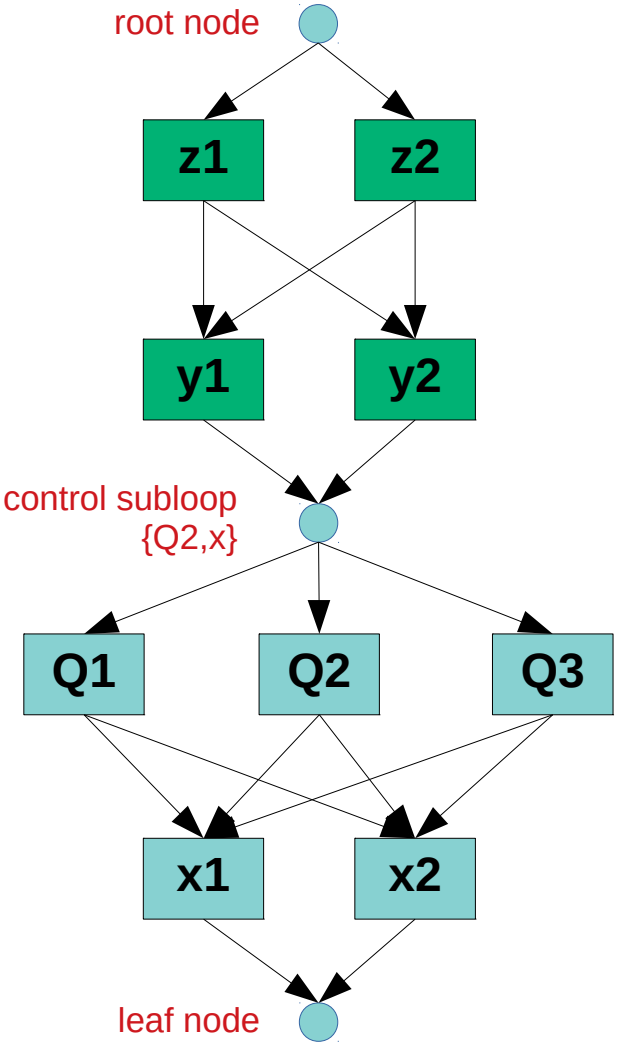
# Output Data Structures

**Adage:** Directed Acyclic Graph (DAG) that stores:

- **Data,** in arbitrary multi-dimensional bins and cuts
  - 1 “layer” of nodes = 1 variable’s bins or cuts
  - Layers are fully connected to adjacent layers
  - 1 multi-dimensional bin = 1 full graph path from root node to leaf node
    - Stores associated set histograms (**Histos, HistosDAG**)
    - TODO: generalize to store anything
- **Algorithms**, executable during graph traversal (no nested for loops!)
  - Run “payload algorithm” on every bin or on any subset of bins
  - Graph layers can be re-ordered (switches inner and outer “loops”)
  - Allows for “binning agnostic” code
- Prototype developed within SIDIS-EIC

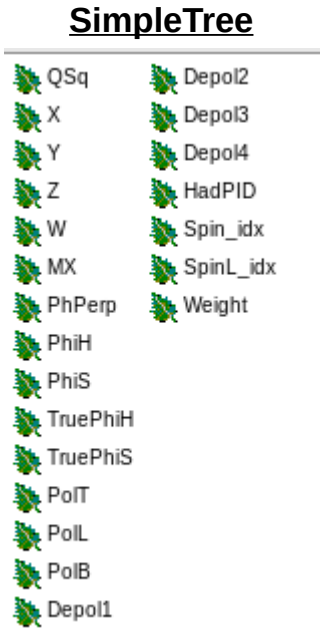
**In practice:**
1) Define your bins
2) Define your algorithms
3) Run

4D Binning in (z,y,$Q^2$,x)



# Output Data Structures

- **SimpleTree** – flat TTree, useful for quick tests etc.
  - Reconstructed SIDIS variables
  - Has been used for SIDIS single-hadron asymmetries
  - Straightforward to connect to other analysis libraries and add more variables




- ***Support for Custom Data Structures and Algorithms***
  - Existing data structures may not suit our future needs
  - Implement custom data structures
  - **TODO**: add plugin support
    - Class methods Prepare(), Fill(), Finish() = before all events, for each event, after all events
    - Support usage with Adage

# How to Add a new Analysis: Macros

- **Analysis Macro**
  - Choose **AnalysisDelphes**, **AnalysisDD4hep**, **AnalysisFun4all**
  - Configure
    - Reconstruction Method
    - Final states (single hadron, jets, … )
    - Cuts
    - Binning Schemes (construct Adage)
  - Call Execute()

- **Post-Processing Macro (if using Adage)**
  - Define algorithms (lambdas), such as:
    - Draw histograms
    - Manipulate histograms (statistics, math, ...)
    - Common algorithms available in **PostProcessor**
  - Configure Adage graph traversal
    - That is, *when* the algorithms should execute
  - Call Execute()

**Example coverage plot:** η vs. p in (x,$Q^2$) bins, with PID limits

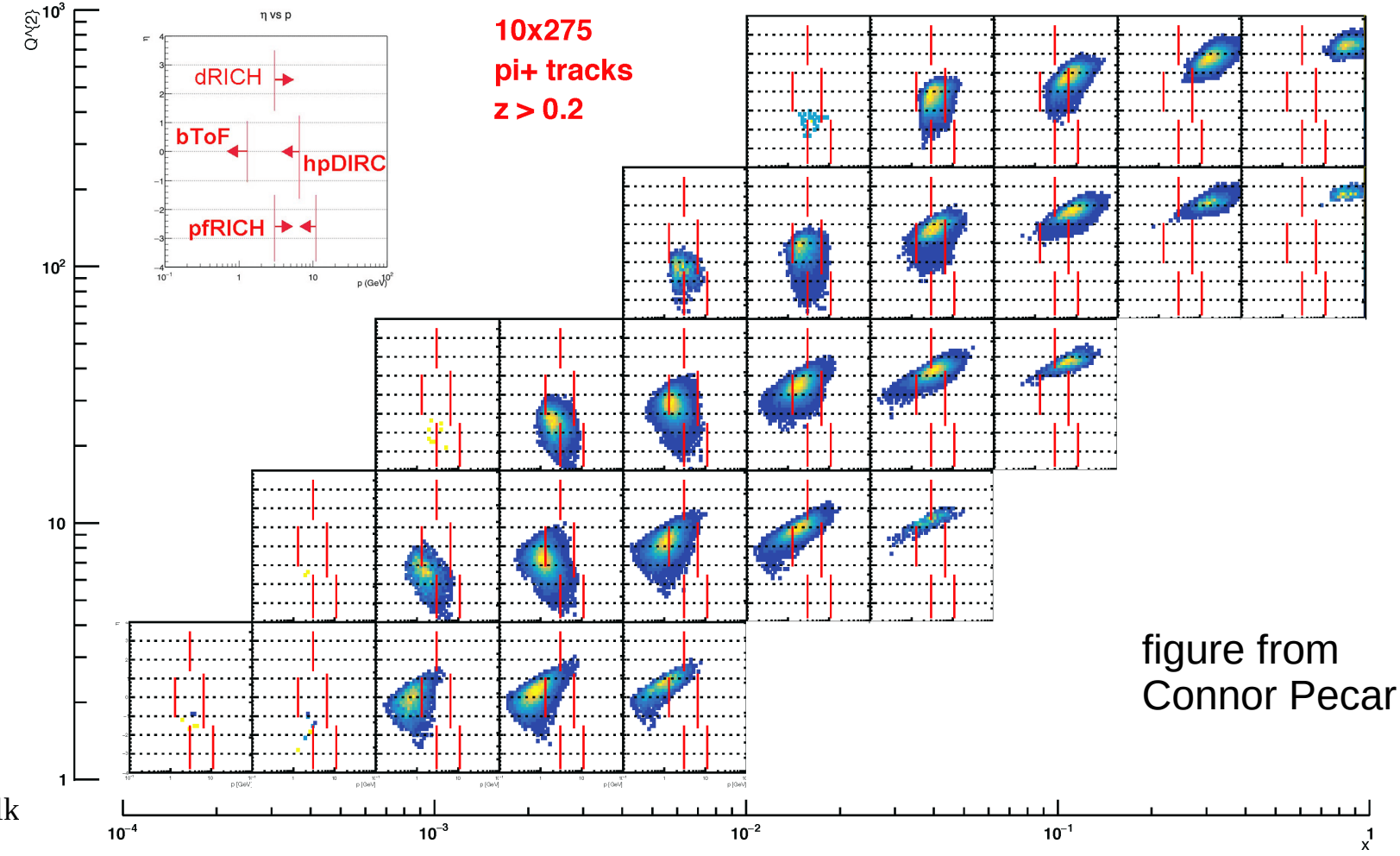



figure from Connor Pecar

**Example benchmark plot:** pion $z_{rec}$–$z_{gen}$, from fast and full simulations, in $(x,Q^2)$ bins

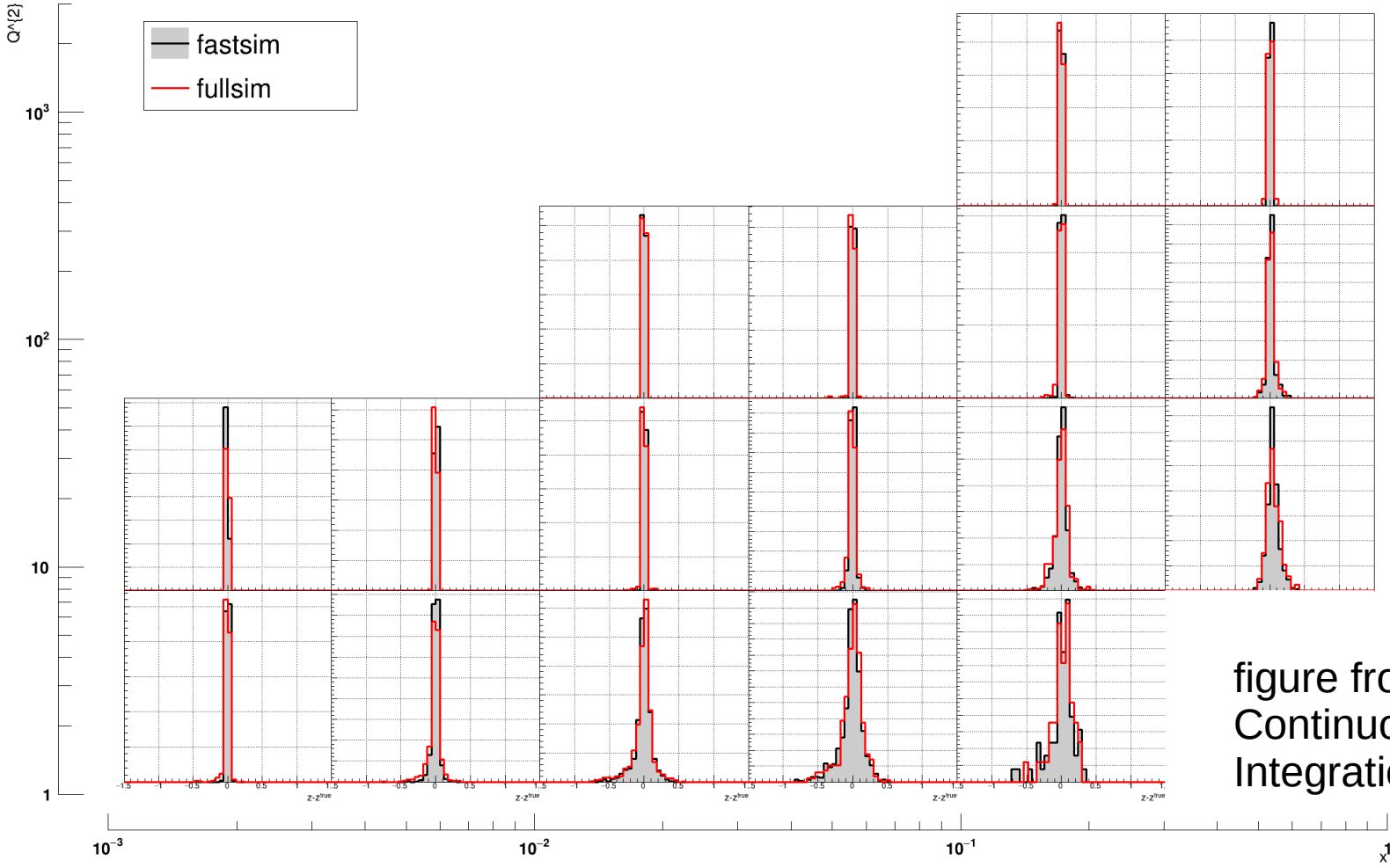



figure from Continuous Integration

**Example benchmark plot:** y, from fast and full simulations, in pion (p,η) bins

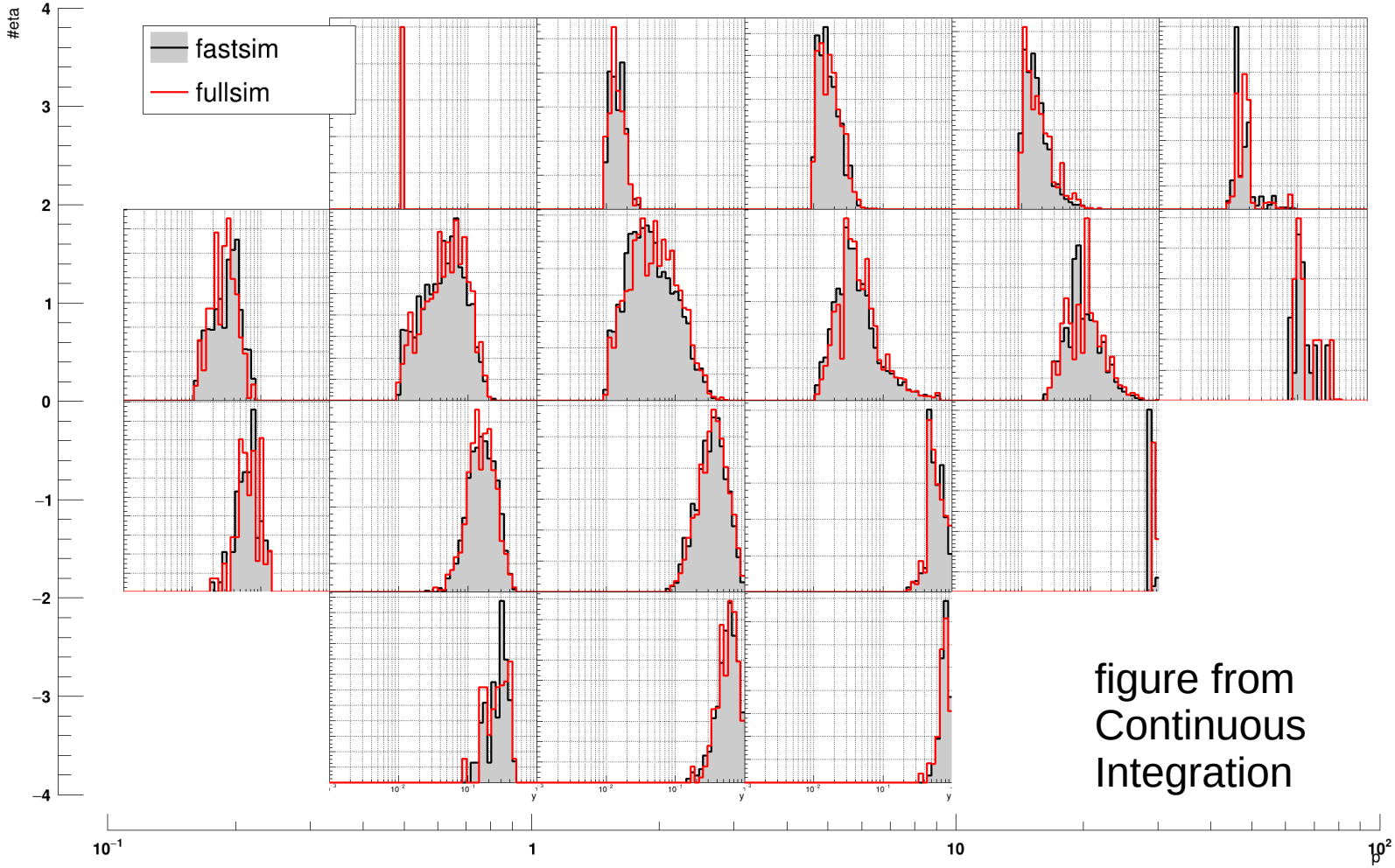


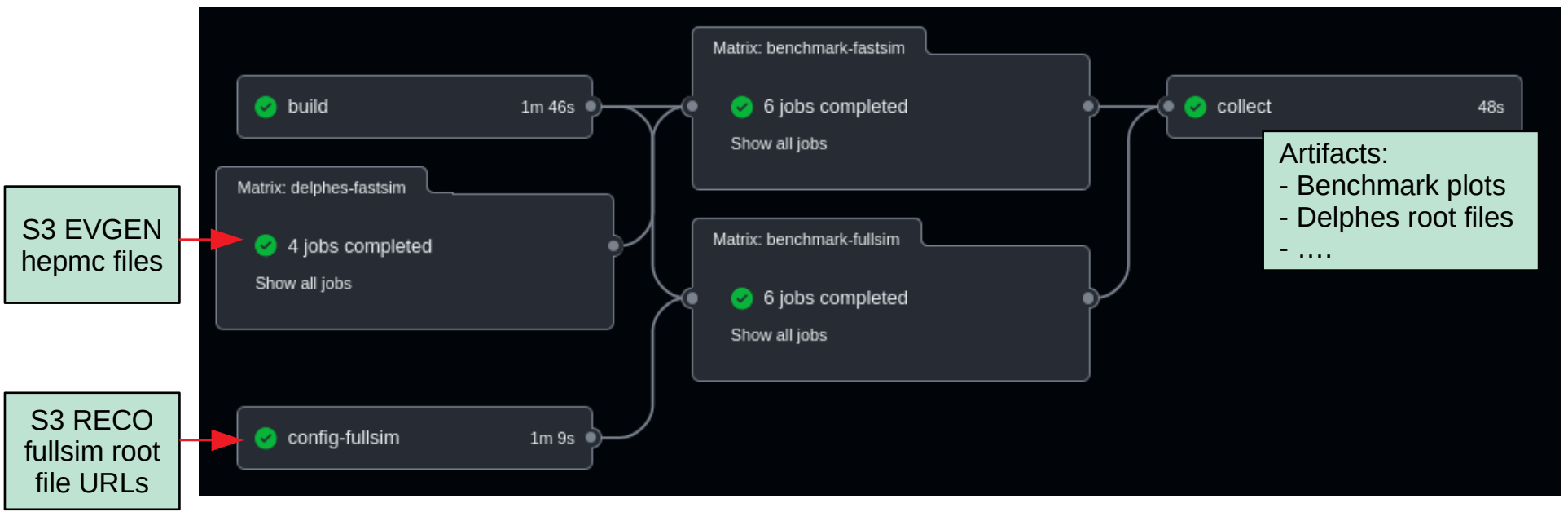

figure from Continuous Integration

# Continuous Integration (CI)

https://github.com/c-dilks/sidis-eic/actions

Executes on every Git commit (pull request):

- Compile SIDIS-EIC
- Run Delphes → AnalysisDelphes
- Stream Full Simulation Output → Analysis DD4hep
- Output (artifacts)
  - Fast vs. Full simulation comparison plots: coverage, resolution, etc.
  - Effects of varying $y_{min}$ cuts
  - Add your plots, ROOT files, … (limited to small statistics)



# Getting Started

- Setup (see README.md)
  - Use the Singularity or Docker image: based from eicweb/jug_xl
    - Includes Delphes, in addition to jug_xl software
  - Alternatively, local install (+dependencies)
- Follow README.md for documentation
- Follow Tutorials for example macros (tutorial/README.md)

**Contributions are Welcome**

- Fork SIDIS-EIC
- New branch → write code → pull request
- Github Workflow Tutorial: https://git-scm.com/book/en/v2/GitHub-Contributing-to-a-Project