LFHCAL software update

Peter Steinberg, BNL / LFHCAL biweekly / 19 July 2023

Status of MC/reco associations

- **With single particle simulations, association of a specific truth particle with each cluster is not important**

- **As of April, the MC association mechanism was completely broken**
  - The link variables existed in the EICrecon output but the fields (simID and recID) were garbage

- **Nathan Brei walked me through a few fixes to the process, which I committed, but even that required changes to the algorithm model that were not ready yet**
  - Cue forward 3 months :)

- **Now when I try running single (& double) particle events, I see that the mechanism is working**

Example

- **Simple 2π particle gun (20 GeV, 2π, θ=7-37 degrees)**

```
root [22] events-
>Scan("MCParticles.momentum.z:MCParticles.momentum.x:MCParticles.momentum.y","","",1,4)
************************************************************
*    Row   * Instance * MCParticl * MCParticl * MCParticl *
************************************************************
*        4 *        0 * 19.296258 * -0.477318 * -5.237033 *
*        4 *        1 * 19.450958 * -4.626739 * -0.503520 *
************************************************************
```
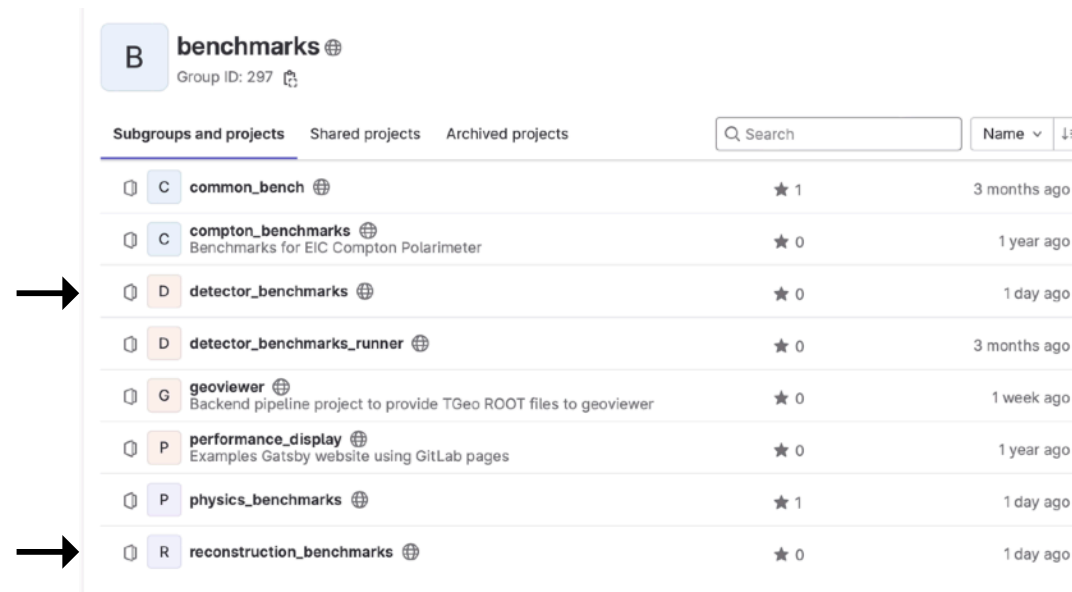   "simID"   pz   px   py

- **We now see that there are multiple clusters and each one gets associated with each truth particle**

```
root [20] events-
>Scan("LFHCALClusters.energy:LFHCALClusters.position.z:LFHCALClusters.position.x:LFHCALClusters.p
osition.y:LFHCALClusterAssociations.simID:LFHCALClusterAssociations.recID","","",1,4)
*************************************************************************************************
*    Row   * Instance * LFHCALClu * LFHCALClu * LFHCALClu * LFHCALClu * LFHCALClu * LFHCALClu *
*************************************************************************************************
*        4 *        0 * 16.337261 * 3966.3288 * -98.38687 * -1066.359 *        0 *        0 *
*        4 *        1 * 15.361476 * 4395.7490 * -1034.903 * -114.1571 *        1 *        1 *
*        4 *        2 * 0.3571598 * 3696.1523 * -873.5999 * -74.05000 *        1 *        2 *
*        4 *        3 * 0.1818682 * 4208.7998 * -769.2000 * -74.05000 *        1 *        3 *
*************************************************************************************************
```
                  E   z   x   y   simID   recID

Clear correspondence of cluster position and truth momentum 👍

Validation procedures

- **With the most basic functionality coming into focus, validation becomes crucial, ideally in the CI model**

- **Have been learning about the developments in the ePIC CI system from Dima Kalinkin**
  - I was looking in eic/epic and eic/EICrecon for this functionality and was in the 100% wrong place
  - He spoke on this last week: https://indico.bnl.gov/event/20069/

- **The system (as most of you know) is hosted on eicweb at ANL**
  - https://eicweb.phy.anl.gov/EIC/benchmarks

Detector benchmarks

- **https://eicweb.phy.anl.gov/EIC/benchmarks/ detector_benchmarks**

- **Intended as very low-level (from the README)**
  - "Detector benchmarks are meant to test for regressions in individual detector subsystems. The analysis is meant to avoid a reconstruction step. So this precludes using juggler for processing the events"

What is there for detectors?

- **Some subsystems are present, but old (and not LFHCAL)**

Name	Last commit	Last update
master ▾ detector_benchmarks / benchmarks		History Find file ⬇▾ Clone ▾
..		
📁 b0_tracker	fix: migrate from JUGGLER_DETECTOR to simply DETECTOR	11 months ago
📁 barrel_ecal	fix: emcal_barrel_pi0 fallback to stats if fit fails	6 months ago
📁 barrel_hcal	feat: rename EcalBarrelHits to EcalBarrelImagingHits	8 months ago
📁 material_maps	fix: ACTS material mapping: disable surfaces caching	9 months ago
📁 others	fix: material scan benchmarks allow_failure true	9 months ago
📁 pid	fix: migrate from JUGGLER_DETECTOR to simply DETECTOR	11 months ago
📁 timing	fix: migrate from JUGGLER_DETECTOR to simply DETECTOR	11 months ago
📁 tracking_detectors	fix: remove unmaintained benchmarks	7 months ago
📁 zdc	fix: allow_failure of zdc benchmarks	9 months ago

https://eicweb.phy.anl.gov/EIC/benchmarks/detector_benchmarks/-/tree/master/benchmarks

Structure of detector benchmarks

- **Scripts to generate samples of single particles, and to automate energy scans**

- **config.yml to run the full gamut of particle species/energies**

config.yml

📄 **config.yml** 📋 3.88 KiB   Open in Web IDE ∨ | 📋 | 📄 | ⬇

```yml
1  sim:hcal_barrel_pions:
2    extends: .det_benchmark
3    stage: simulate
4    script:
5      - bash benchmarks/barrel_hcal/run_hcal_barrel_particles.sh piplus
6      - bash benchmarks/barrel_hcal/run_hcal_barrel_particles.sh piminus
7
8  sim:hcal_barrel_kaons:
9    extends: .det_benchmark
10   stage: simulate
11   script:
12     - bash benchmarks/barrel_hcal/run_hcal_barrel_particles.sh kplus
13     - bash benchmarks/barrel_hcal/run_hcal_barrel_particles.sh kminus
14     - bash benchmarks/barrel_hcal/run_hcal_barrel_particles.sh kshort
15     - bash benchmarks/barrel_hcal/run_hcal_barrel_particles.sh klong
16
17 sim:hcal_barrel_muons:
18   extends: .det_benchmark
19   stage: simulate
20   script:
21     - bash benchmarks/barrel_hcal/run_hcal_barrel_energy_scan.sh muon
22     - bash benchmarks/barrel_hcal/run_hcal_barrel_particles.sh muon
23
24 sim:hcal_barrel_antimuons:
25   extends: .det_benchmark
26   stage: simulate
27   script:
28     - bash benchmarks/barrel_hcal/run_hcal_barrel_energy_scan.sh antimuon
29     - bash benchmarks/barrel_hcal/run_hcal_barrel_particles.sh antimuon
30
31 sim:hcal_barrel_protons:
32   extends: .det_benchmark
33   stage: simulate
34   script:
35     - bash benchmarks/barrel_hcal/run_hcal_barrel_energy_scan.sh proton
36     - bash benchmarks/barrel_hcal/run_hcal_barrel_particles.sh proton
37
38 bench:hcal_barrel_protons:
39   extends: .det_benchmark
40   stage: benchmarks
```

Reconstruction benchmarks

EIC › benchmarks › **reconstruction_benchmarks**

⚙️ **fix: use positional arguments in hepmc3.GenEvent constructor**
Wouter Deconinck authored 3 weeks ago

⚠️ | 6a7e673b | 📋

master ⌄ | reconstruction_benchmarks / benchmarks | History | Find file | ⬇️ ⌄ | **Clone** ⌄

Name	Last commit	Last update
..		
📁 clustering	fix: use positional arguments in hepmc3.GenEvent constructor	3 weeks ago
📁 ecal	fix: use positional arguments in hepmc3.GenEvent constructor	3 weeks ago
📁 far_forward	fix: far_forward:collect:allow_failure:true since needs have allo...	1 month ago
📁 imaging_ecal	fix: use positional arguments in hepmc3.GenEvent constructor	3 weeks ago
📁 imaging_shower_ML	fix: use positional arguments in hepmc3.GenEvent constructor	3 weeks ago
📁 rich	fix: use positional arguments in hepmc3.GenEvent constructor	3 weeks ago
📁 track_finding	fix: switch back to single hit collections	9 months ago
📁 track_fitting	fix: switch back to single hit collections	9 months ago
📁 tracking	fix: use positional arguments in hepmc3.GenEvent constructor	3 weeks ago

Clearly active work going on, but need to introduce forward calo.
Directories contain python scripts that generate particles, run ddsim,
and analyze podio output…but not running EICrecon AFAICT

Brookhaven National Laboratory

ePIC

Next steps: lots to do!

- **Work on the reconstruction itself**
  - Generating relevant truth samples
    - *single particle*
    - *multi particle*
    - *full DIS*
  - Standalone LFHCAL clustering, EM+HCAL, full pflow.

- **Work on the CI validation**
  - Automating important use cases
  - Developing references
  - Integrating into detector benchmarks
  - Integrating into reconstruction benchmarks