Changes in closure test for parameter recovery:

No sequential tuning anymore, we now have 3 tuning stages which are totally independent:

1. Muon parameters, tuned by 400k samples composed by:
   a. 200k J/ψ → μμ and Z → μμ resonance events (parent pT 1–500 GeV, QED final-state radiation off)
   b. 200k single-muon events (pT 50 GeV–5 TeV, log-uniform)

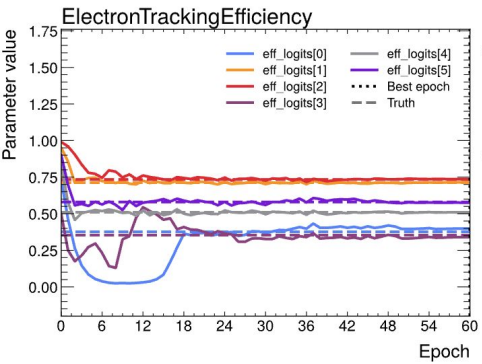
2. Electron parameters + ECal parameters, tuned by 600k samples composed by:
   a. 200k J/ψ → ee and Z → ee resonance events (parent pT 1–20 GeV for J/ψ, 1–500 GeV for Z)
   b. 200k single-electron events (pT 20–600 GeV, log-uniform)
   c. 200k single-photon events (pT 0.5–500 GeV, log-uniform, $|\eta| < 5$)
      i. Half of the photons are in the endcap to correct endcap region ECal params

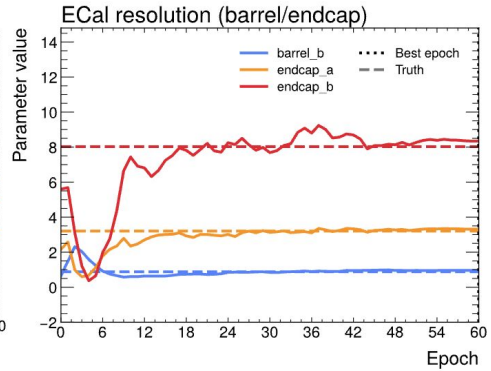
3. Chad parameters + HCal parameters, tuned by 600k samples composed by:
   a. 200k K_S → $\pi^+\pi^-$ resonance events (parent pT 1–300 GeV)
   b. 200k single-pion events (π±, pT 20 GeV–1.2 TeV, log-uniform)
   c. 200k single-K_L events (pT 1 GeV–5 TeV, log-uniform, $|\eta| < 5$)

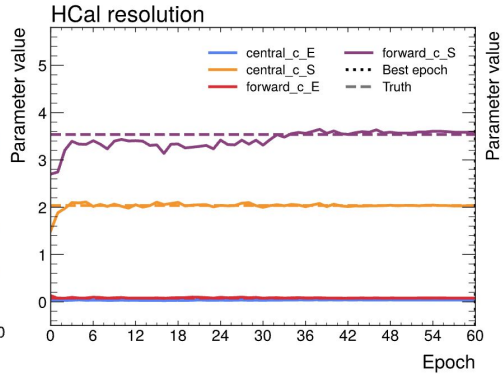
Simpler than sequential tuning: the three parameter blocks are **disjoint**, and each gun sample is sensitive to its own block only (e/γ deposit in the ECal only, π±/K_L in the HCal only, muons in neither) → **no error propagation** between stages; the three fits **run in parallel**.

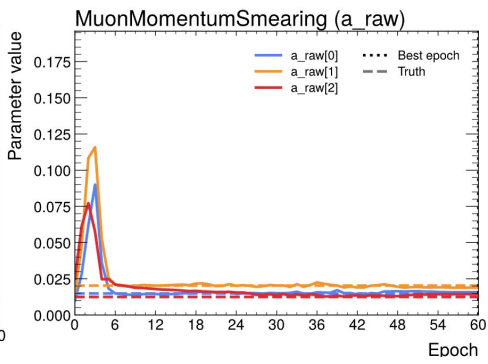
Individual parameters:

Wasserstein critics:

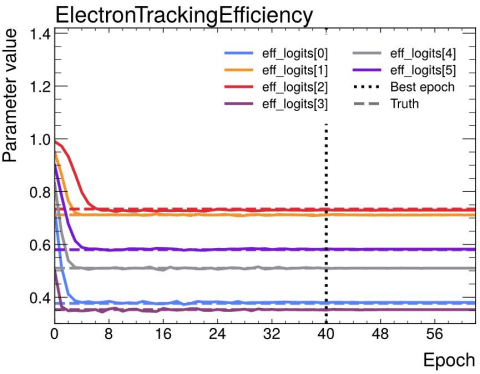


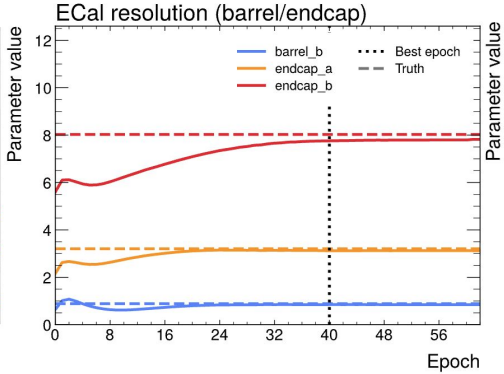


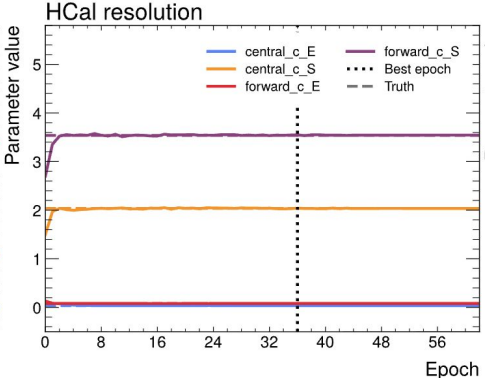


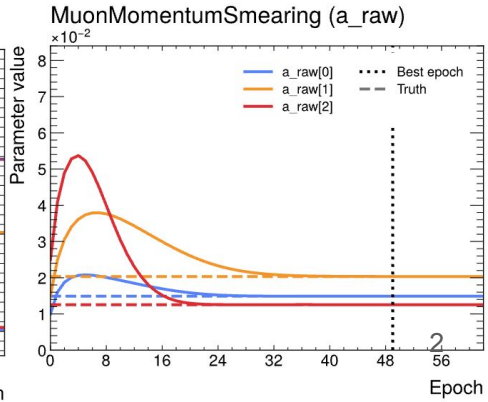


Matching + likelihood fit:



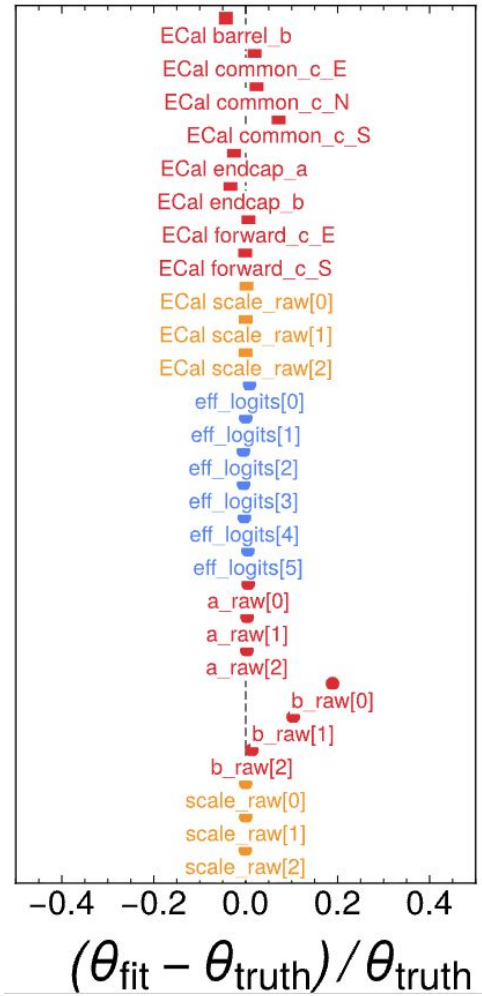




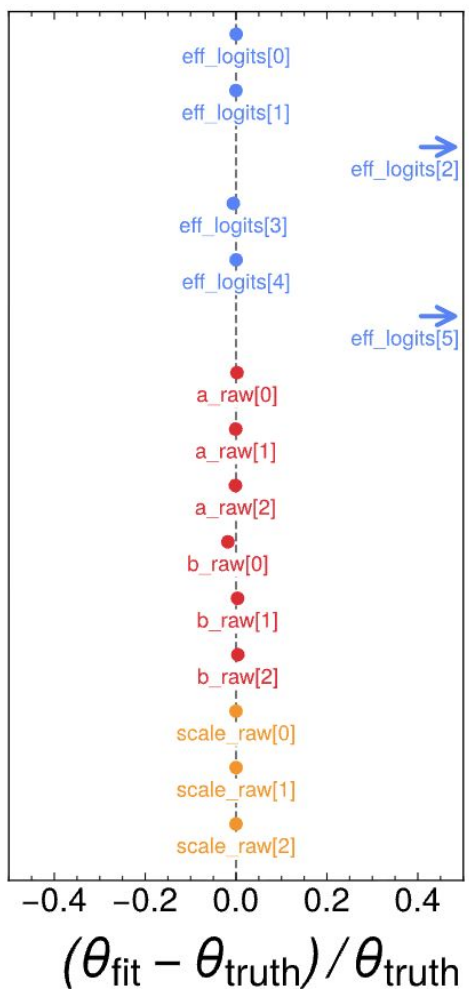


Results using **matching + likelihood loss**

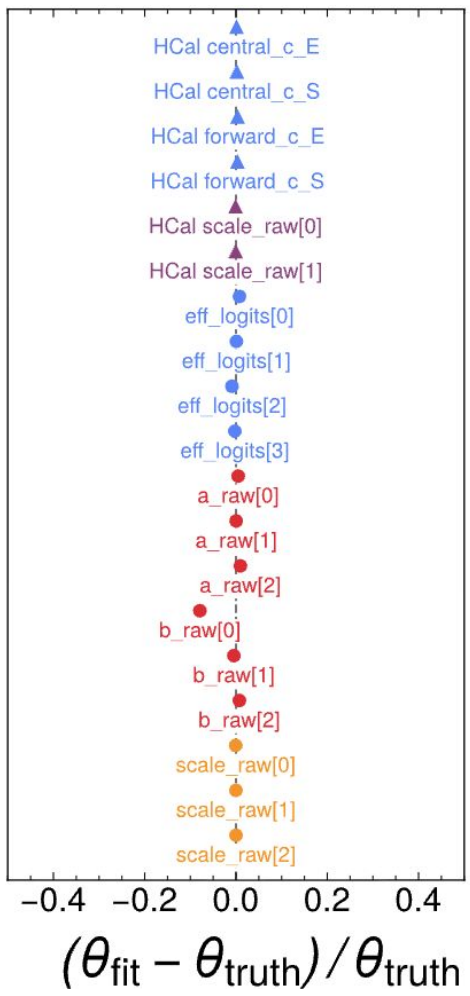
Note: to make comparison with wasserstein loss, change the lr schedule to cosine decay (keep LBFGS), and pick the best epoch



Electron + ECal



Muons



Chad + HCal

Why logits 2 and 5 fail to receive gradient?

The loss keeps a truth particle as a row of the efficiency and response terms only if

1. No harder truth particle lies inside its match window ($\Delta R < 0.005$)
2. Its 12th nearest truth particle (itself counted) is outside the window

Bug: rule 2 used k = min(12, n) for an event with n truth particles

- Single-particle event (high pt muon gun): n = 1, so k = 1 and the "1st nearest particle" is the particle
- Itself at $\Delta R = 0 \rightarrow$ always inside the window $\rightarrow$ the particle is dropped.
- Events with ≥ 12 particles (dijets, full sim) are unaffected, so it went unnoticed.

Fix: apply rule 2 only when n ≥ 12; smaller events use rule 1 alone.

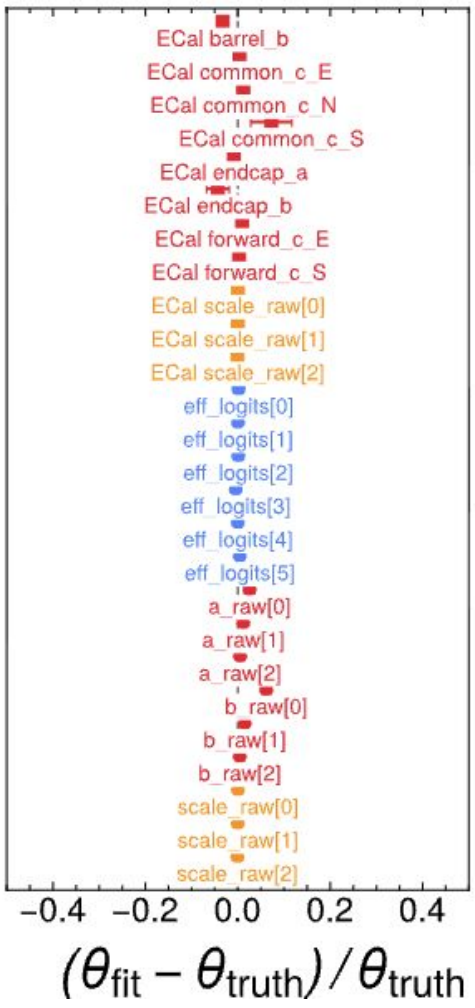
```
141     keep &= ~harder.any(axis=1)
142-    k = min(HARDEST_K, n)
143-    kth = np.partition(dr, k - 1, axis=1)[:, k - 1]
144-    keep &= ~(kth <= window[:, 0])
145     return keep
146
```

```
142     keep &= ~harder.any(axis=1)
143+    if n >= HARDEST_K:
144+        kth = np.partition(dr, HARDEST_K - 1, axis=1)[:, HARDEST_K - 1]
145+        keep &= ~(kth <= window[:, 0])
146     return keep
147
```

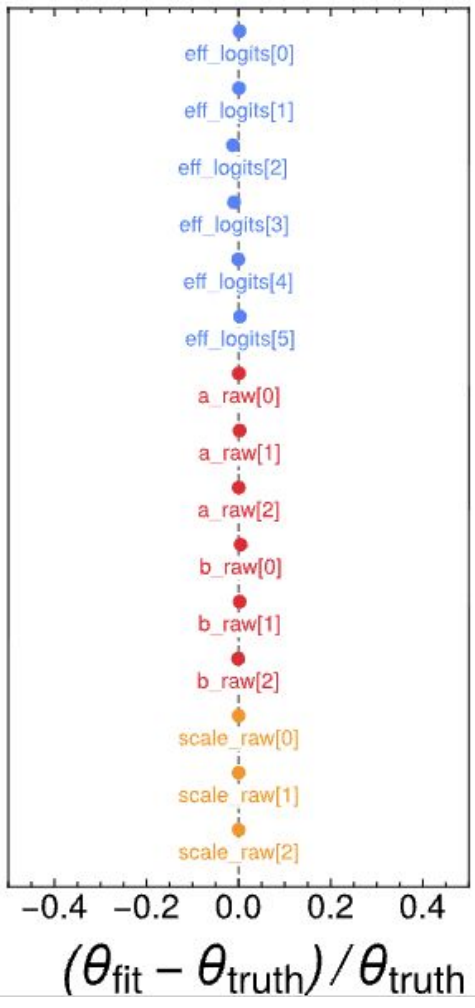
Results using **matching + likelihood loss after the fix**

5 seeds to get the error

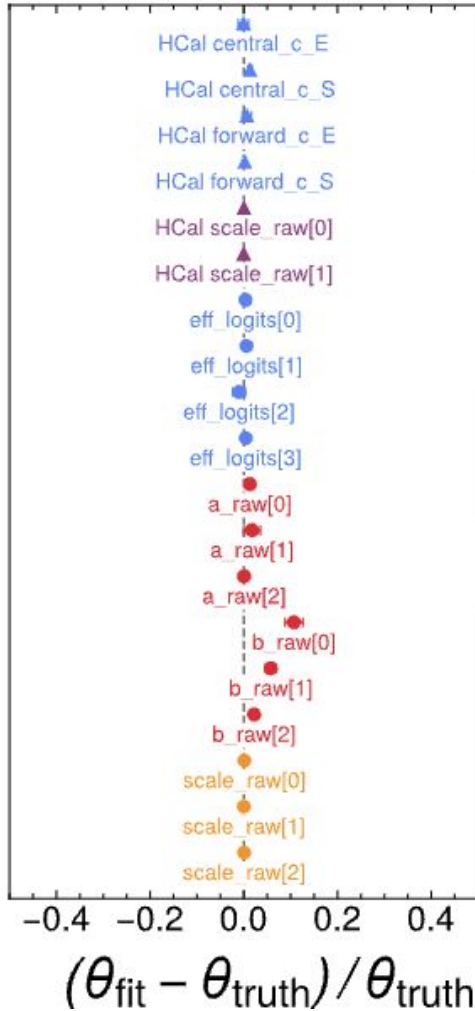
Note: to make comparison with wasserstein loss, change the lr schedule to cosine decay (keep LBFGS), and pick the best epoch



Electron + ECal



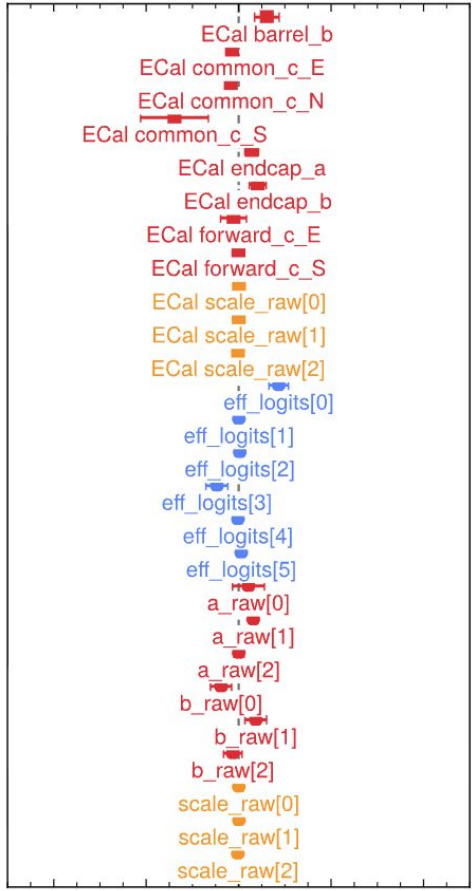
Muons



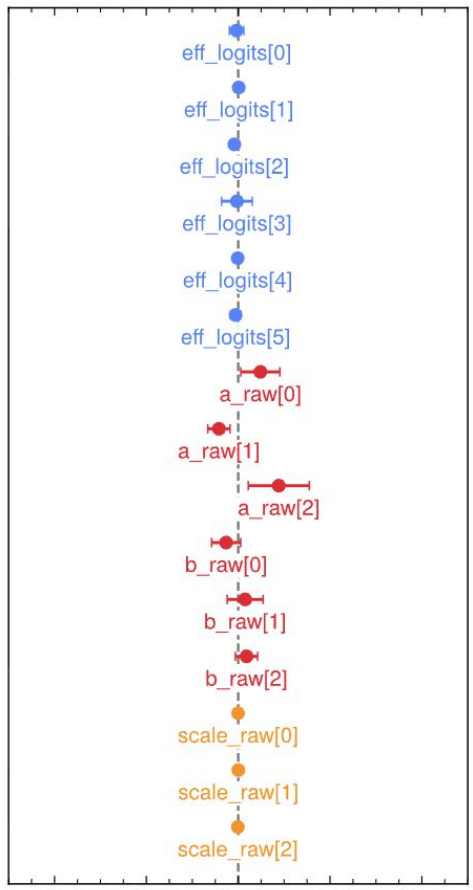
Chad + HCal

Results using
Wasserstein critic

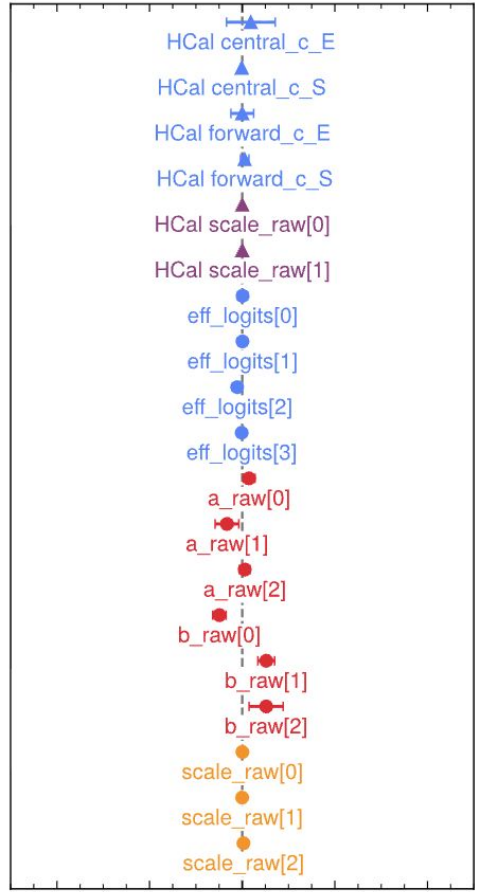
5 seeds to get the error



Electron + ECal



Muons



Chad + HCal

This design does not work for **wasserstein 1d** loss:

- For resolution related parameters, it requires a resonance sample (Z prime for b_raw) to fit properly
    - The reason is because it does not take any truth information into its loss, so there is no strong gradient coming from momentum smearing unless we define a resonance width

    - For matching + likelihood, we do have truth info from matching so smearing is read directly from reco pt - truth pt
    - For wasserstein critic, the input of critic network is F(reco, truth) so this can be learned

- In principle we can fix it by adding heavy Zprime sample or other gun samples, but for the simplicity of tuning setup I prefer we **drop this loss** (at least for now)

All changes (including two merge requests from Luigi) have been merged into master

Things to do after this:

- Closure test is mostly done for now, time to focus on full sim
  - Maybe for full sim we want to consider this tuning sample setup as well?

- Remaining discrepancy is small but seems to be real, maybe if we have time we should explore a bit more?

- Move parametric parnassus repo into omphalos-mc? (but should still be private)
- Move our own CMSSW into omphalos-mc?