DiffDelphes

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2026-11-11



Status

- parnassus_parametric
  - Three objectives:
    - 1-dimensional Wasserstein distance + chi-square effiency term
    - Analytical likelihood
    - Wasserstein critic
  - Re-implemented validation suite against C++ Delphes
    - Fix: angle ϕ at the propagated position (not momentum)
- Pseudodata closure tests ← Good
- Rapid fullsim sample generation: cmssw_fullsim_sample_generation
- Fullsim sequential fit ← Needs work

Benchmark process

"Pseudodata": Delphes → Delphes
"Fullsim": Delphes → CMSSW

For both pseudodata and fullsim:

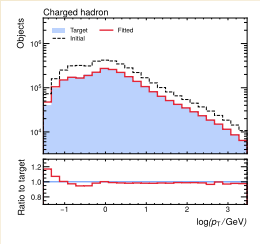
1. Muons: $J/\psi, Z \to \mu^+\mu^-$
2. Charged hadrons:
   - Pseudodata: $K^0_S \to \pi^+\pi^-$
   - Fullsim: $\rho_0 \to \pi^+\pi^-$, flattened $\pi^+\pi^-$
3. Calorimeters: QCD dijets, unflattened
4. Electrons: $J/\psi, Z \to e^+e^-$

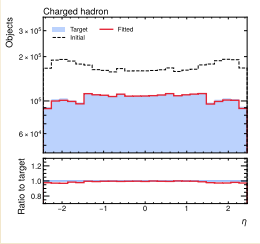
Then evaluation on held-out $H \to ZZ^* \to 4\ell$.

On fullsim: $p_T^{\text{gen}} > 0.25$ Gev, $p_T^{\text{reco}} > 1$ GeV

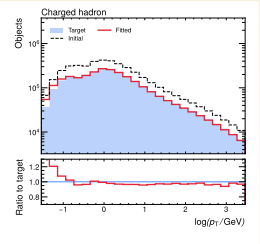
Pseudodata: charged hadrons, p_T and η

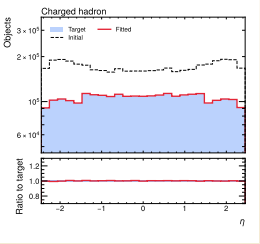
Wasserstein-1D



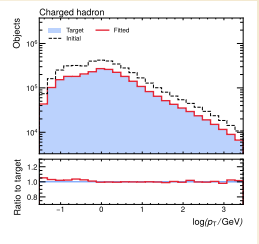


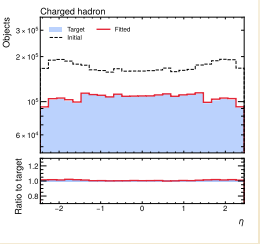
Likelihood





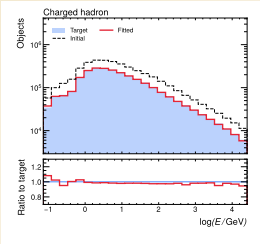
Wasserstein critic

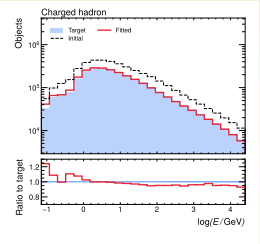


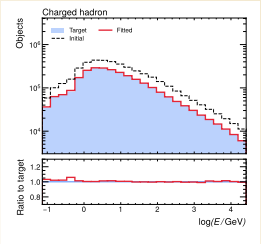


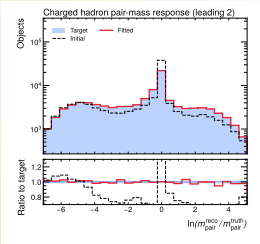
Pseudodata: charged hadrons, E and pair-mass response

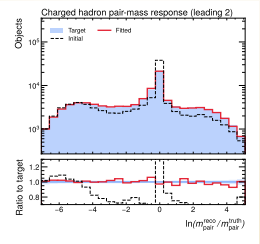
Wasserstein-1D | **Likelihood** | **Wasserstein critic**

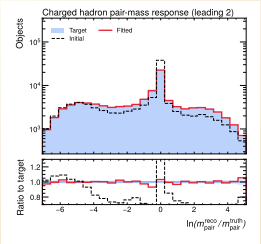






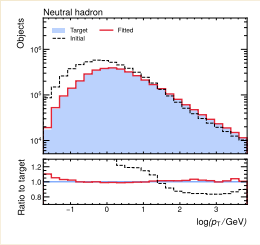


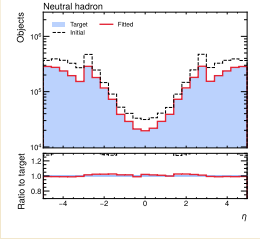




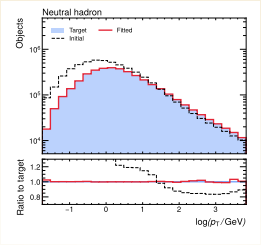
Pseudodata: neutral hadrons, p_T and η

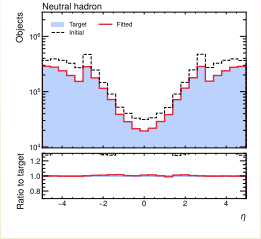
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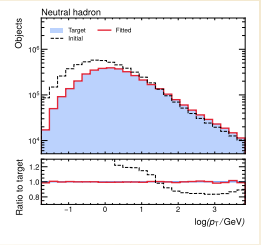


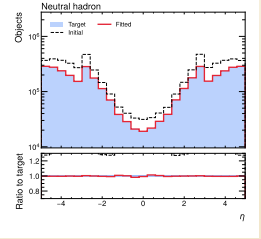
Likelihood





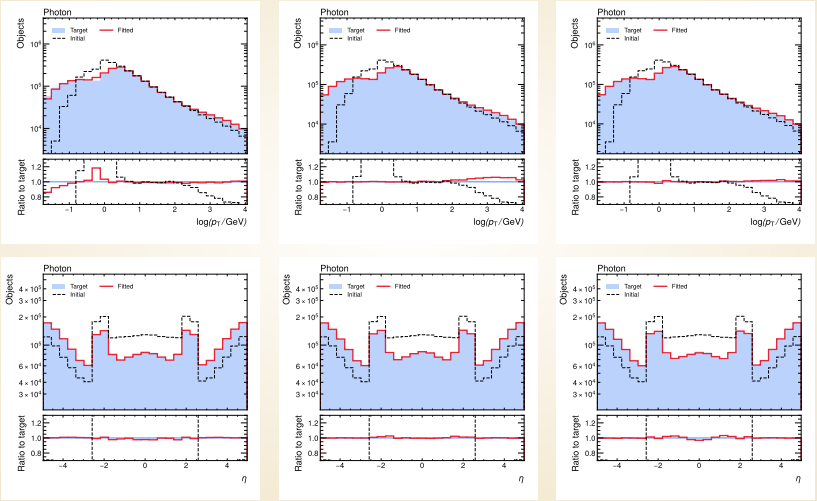
Wasserstein critic





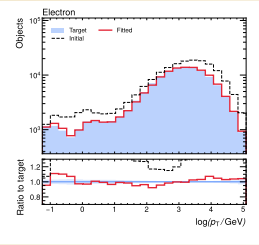
Pseudodata: photons, p_T and η

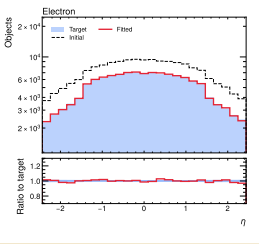
Wasserstein-1D | **Likelihood** | **Wasserstein critic**



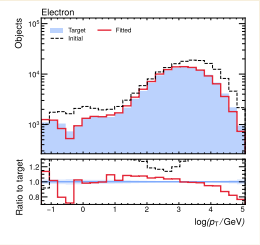
Pseudodata: electrons, p_T and η

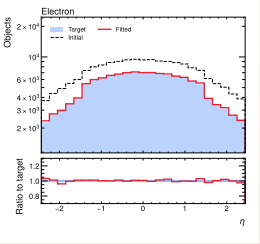
Wasserstein-1D



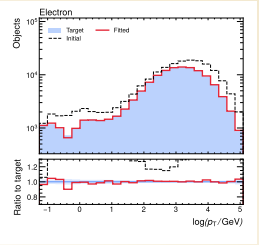


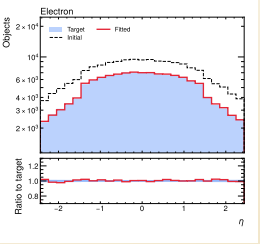
Likelihood





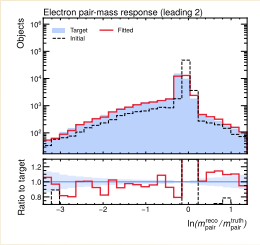
Wasserstein critic

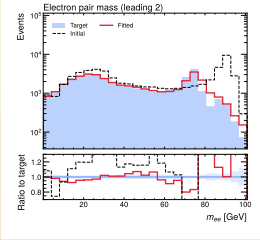




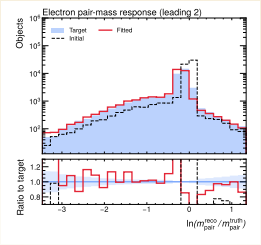
Pseudodata: electrons, pair-mass response and m_{ee}

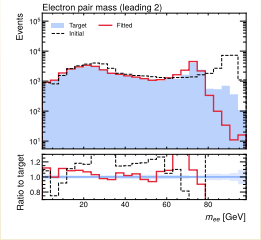
Wasserstein-1D



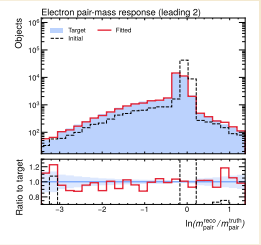


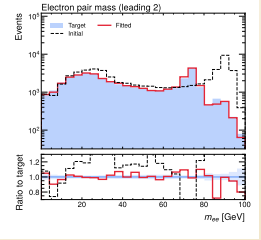
Likelihood





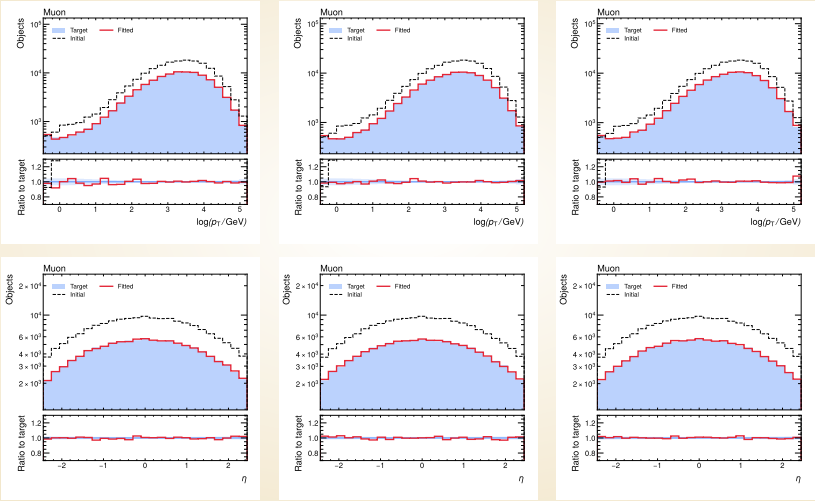
Wasserstein critic





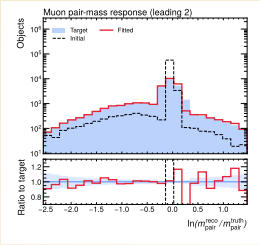
Pseudodata: muons, p_T and η

Wasserstein-1D | **Likelihood** | **Wasserstein critic**

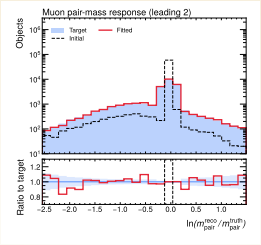


Pseudodata: muons, pair-mass response and $m_{\mu\mu}$

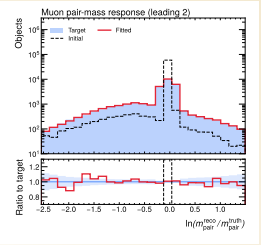
Wasserstein-1D



Likelihood

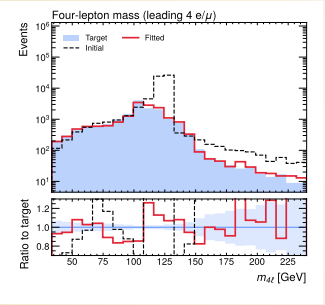


Wasserstein critic

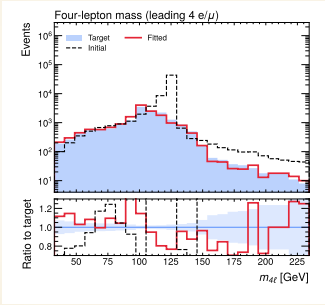


Pseudodata: four-lepton mass

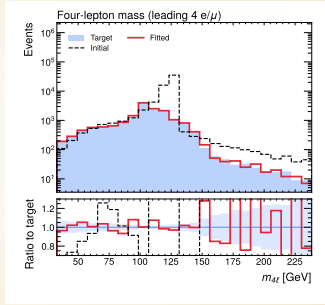
Wasserstein-1D



Likelihood

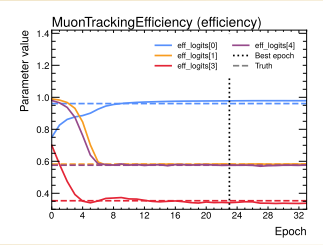


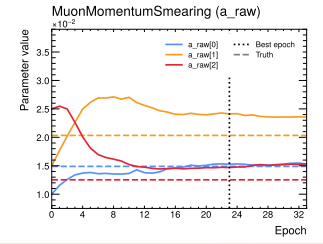
Wasserstein critic



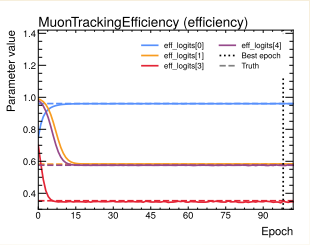
Pseudodata: muon efficiency and resolution *a*

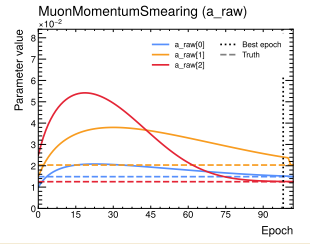
Wasserstein-1D



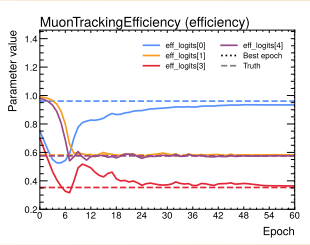


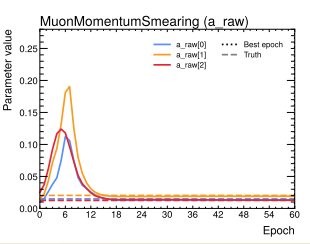
Likelihood





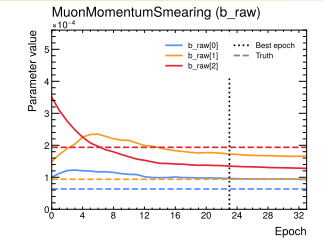
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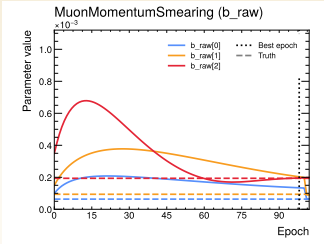


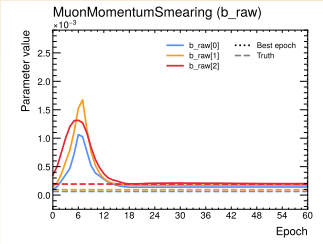


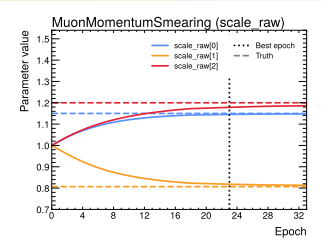
Pseudodata: muon resolution b and scale

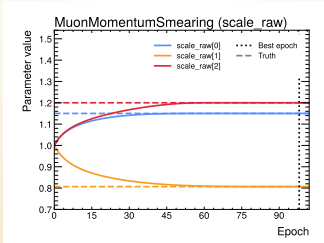
Wasserstein-1D | **Likelihood** | **Wasserstein critic**

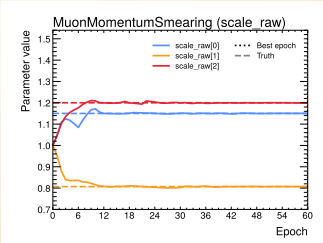






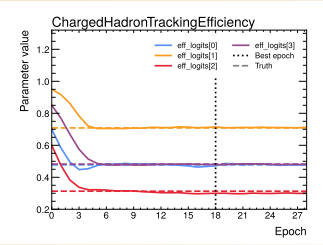


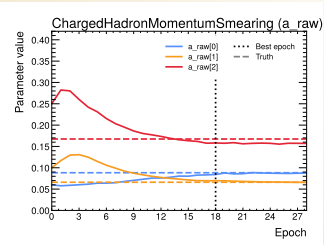




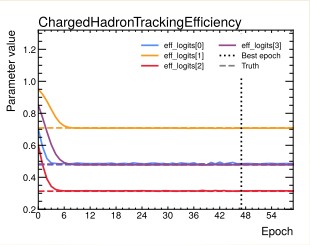
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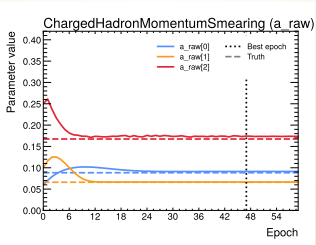
Wasserstein-1D



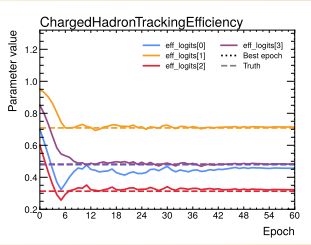


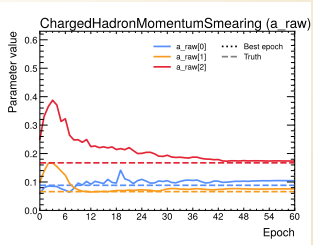
Likelihood





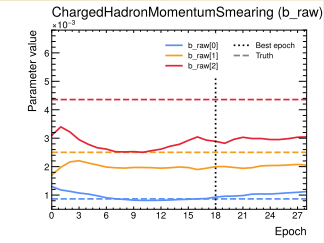
Wasserstein critic

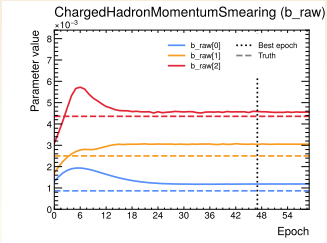


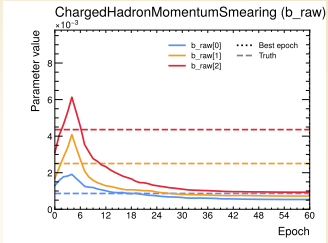


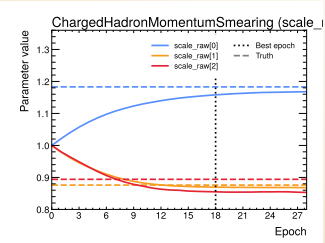
Pseudodata: charged-hadron resolution b and scale

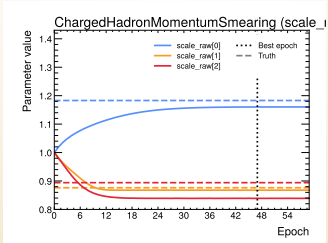
Wasserstein-1D | **Likelihood** | **Wasserstein critic**

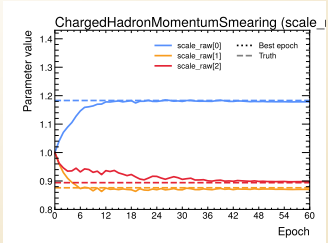






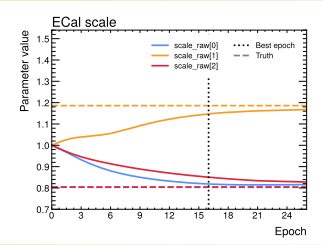


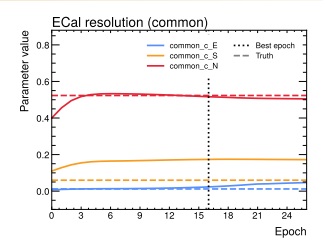




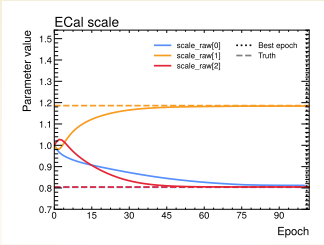
Pseudodata: ECal scale and resolution (common)

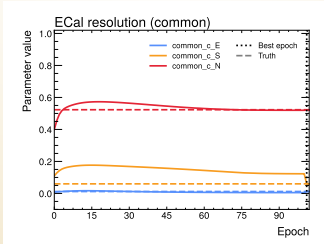
Wasserstein-1D



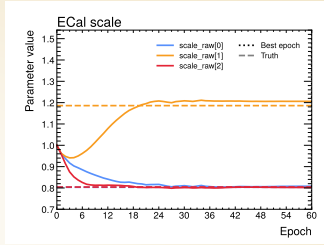


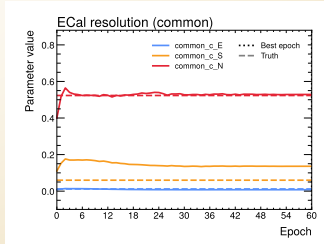
Likelihood





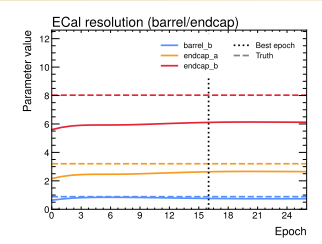
Wasserstein critic

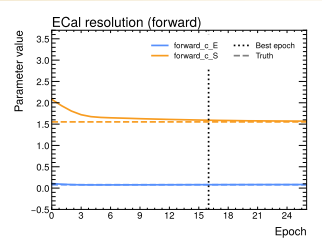




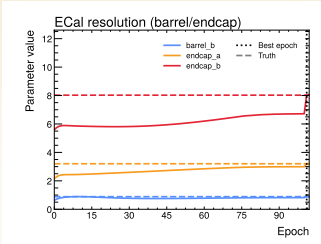
Pseudodata: ECal resolution (barrel/endcap, forward)

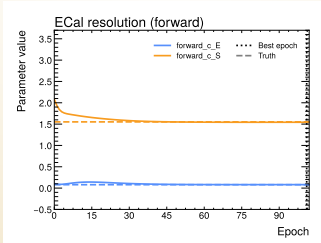
Wasserstein-1D



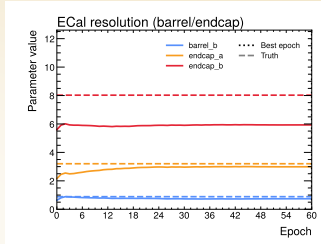


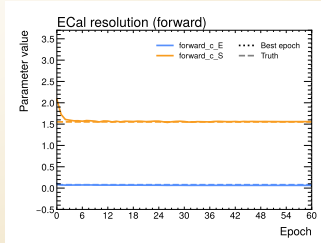
Likelihood





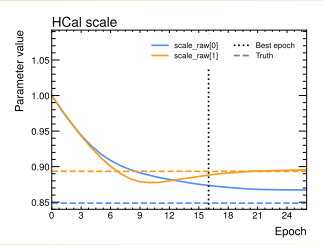
Wasserstein critic

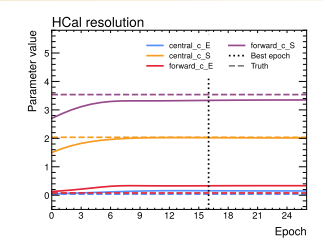




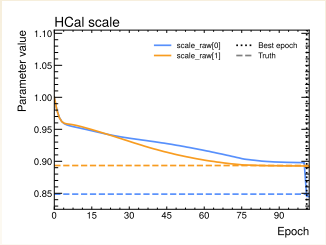
Pseudodata: HCal scale and resolution

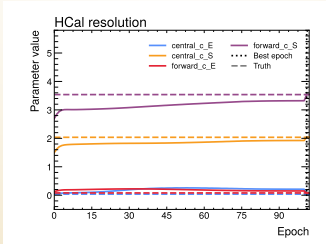
Wasserstein-1D



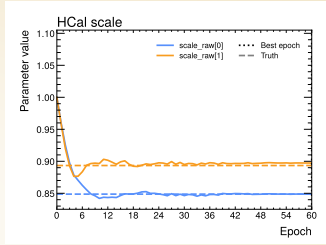


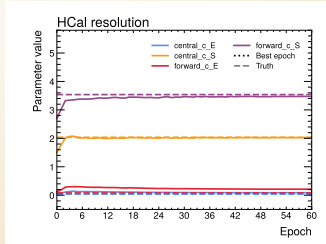
Likelihood





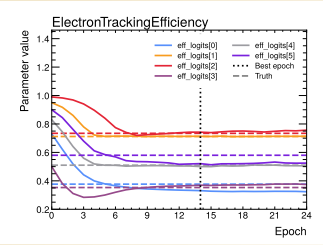
Wasserstein critic

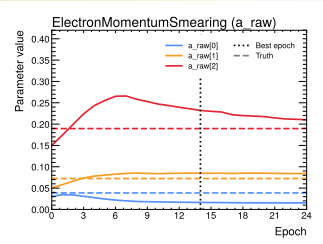




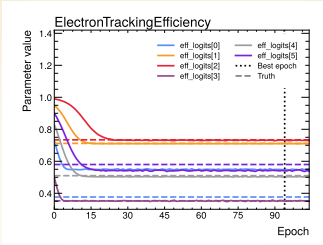
Pseudodata: electron efficiency and resolution *a*

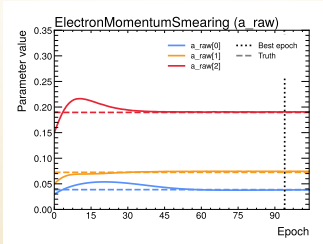
Wasserstein-1D



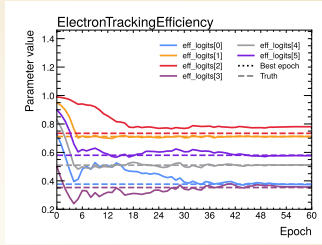


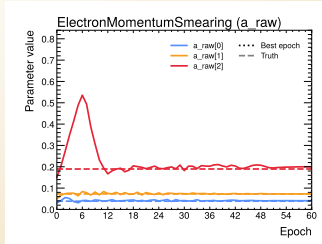
Likelihood





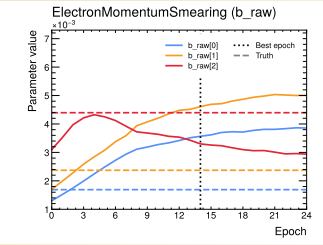
Wasserstein critic

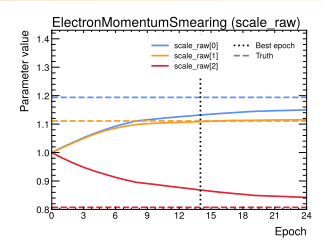




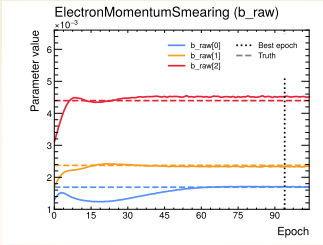
Pseudodata: electron resolution b and scale

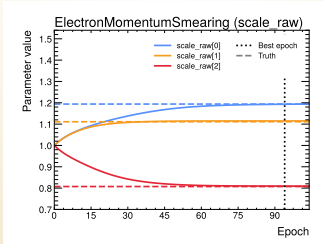
Wasserstein-1D



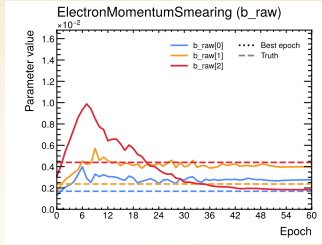


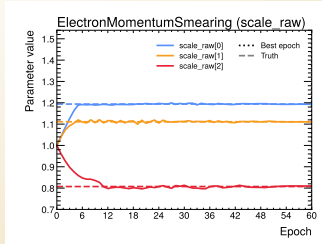
Likelihood





Wasserstein critic





Fullsim sequential tuning

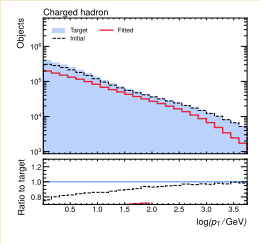
CMS approval pipeline is a bit slow for *development*.

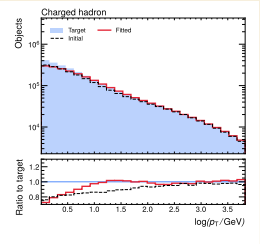
Generate our own samples using CMSSW?

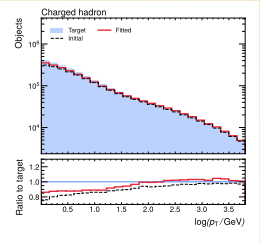
- Muons: $J/\psi, Z \to \mu^+\mu^-$
- Charged hadrons: $\rho_0 \to \pi^+\pi^-$, flattened $\pi^+\pi^-$
  - $K_S^0 \to \pi^+\pi^-$ has mid-detector decays, displaced vertices
- Calorimeters: QCD dijets, unflattened
- Electrons: $J/\psi, Z \to e^+e^-$
- Evaluation: $H \to ZZ^* \to 4\ell$

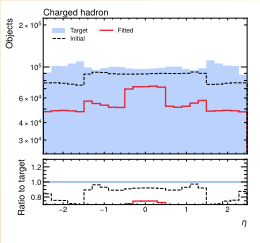
Fullsim $\pi^{\pm}$: charged hadrons, p_T and η

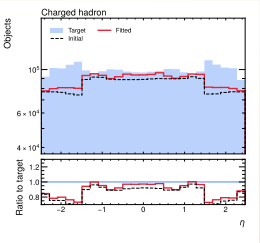
Wasserstein-1D | **Likelihood** | **Wasserstein critic**

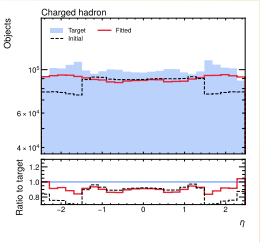






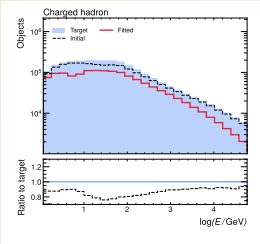


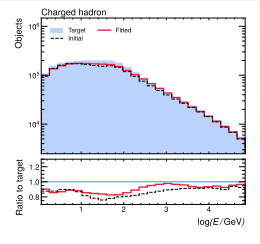


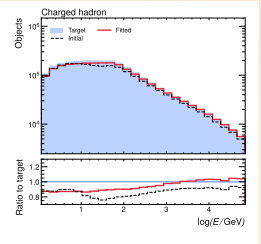


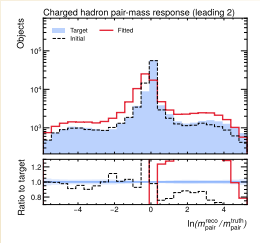
Fullsim $\pi^{\pm}$: charged hadrons, E and pair-mass response

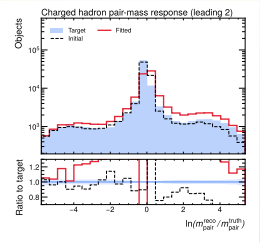
Wasserstein-1D | **Likelihood** | **Wasserstein critic**

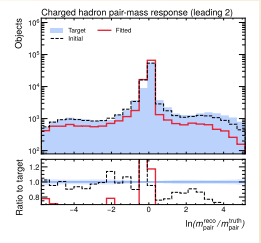






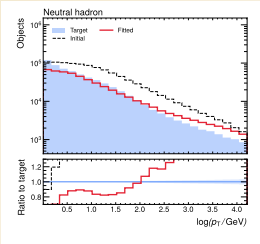


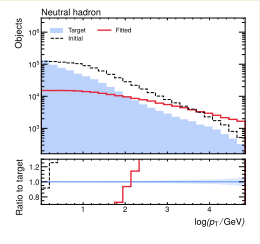


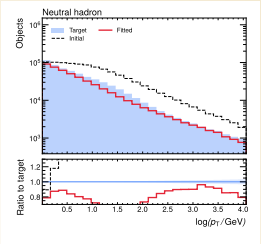


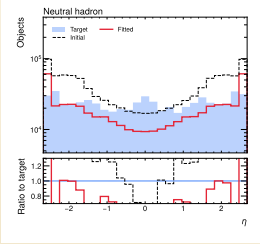
Fullsim $\pi^{\pm}$: neutral hadrons, p_T and η

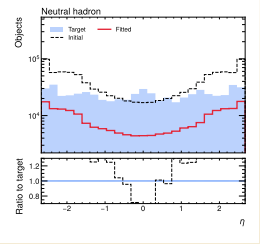
Wasserstein-1D | **Likelihood** | **Wasserstein critic**

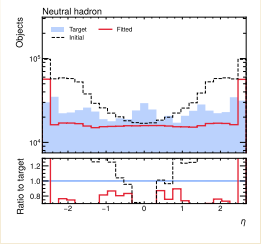






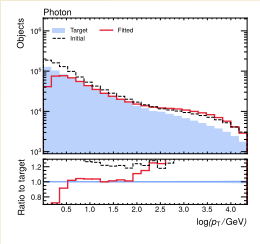


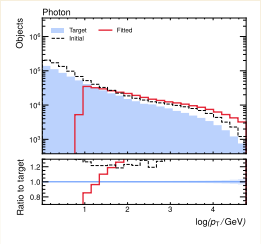


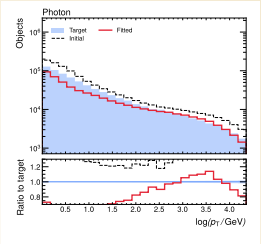


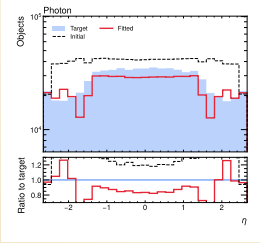
Fullsim $\pi^{\pm}$: photons, p_T and η

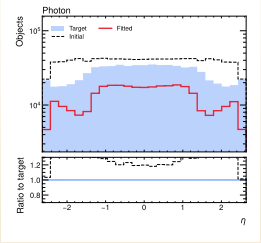
Wasserstein-1D | **Likelihood** | **Wasserstein critic**

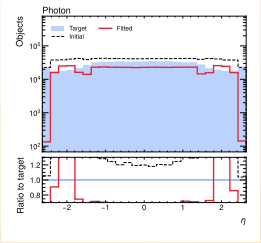






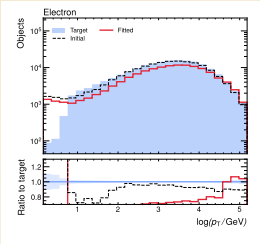


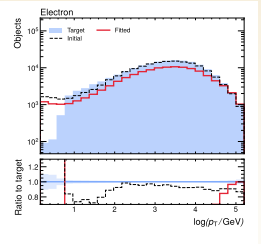


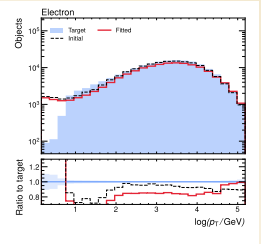


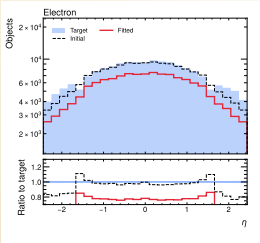
Fullsim $\pi^{\pm}$: electrons, p_T and η

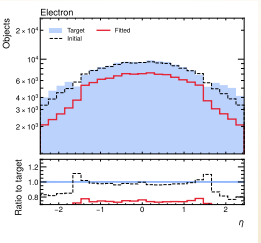
Wasserstein-1D | **Likelihood** | **Wasserstein critic**

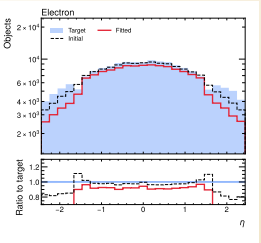






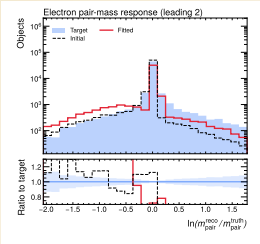


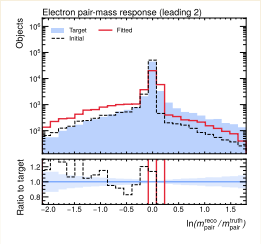


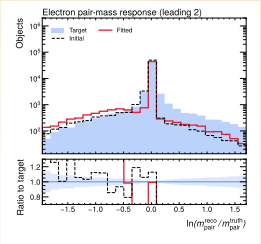


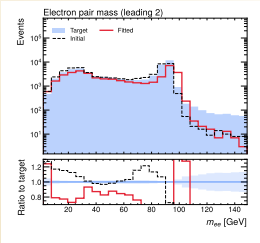
Fullsim $\pi^{\pm}$: electrons, pair-mass response and m_{ee}

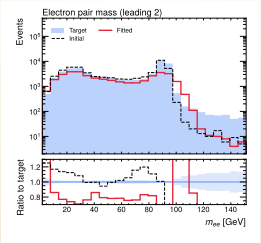
Wasserstein-1D | **Likelihood** | **Wasserstein critic**

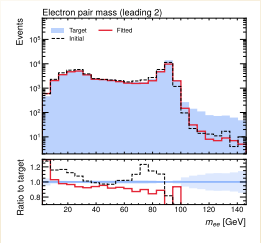






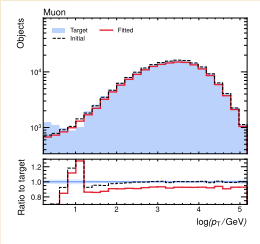


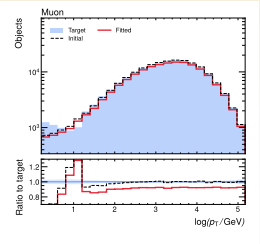


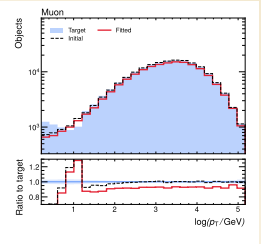


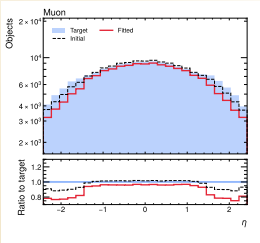
Fullsim $\pi^{\pm}$: muons, p_T and η

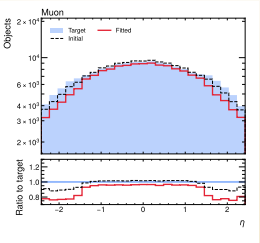
Wasserstein-1D | **Likelihood** | **Wasserstein critic**

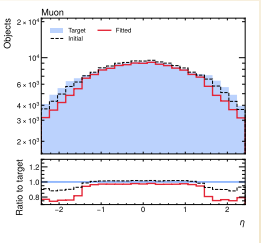






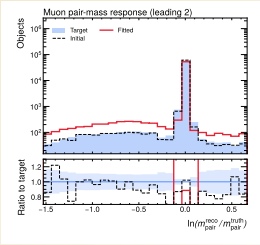


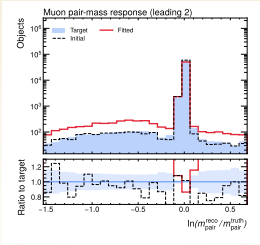


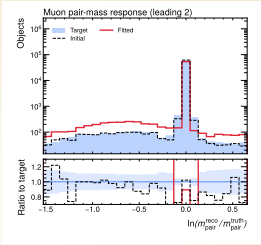


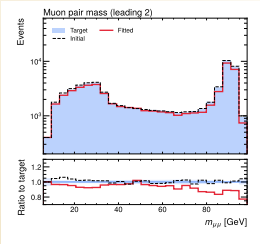
Fullsim $\pi^{\pm}$: muons, pair-mass response and $m_{\mu\mu}$

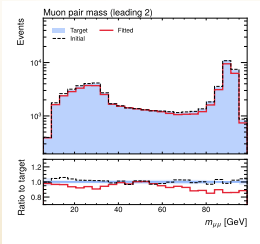
Wasserstein-1D | **Likelihood** | **Wasserstein critic**

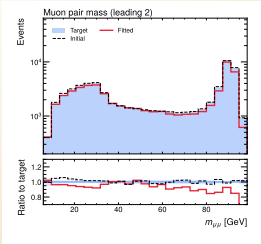






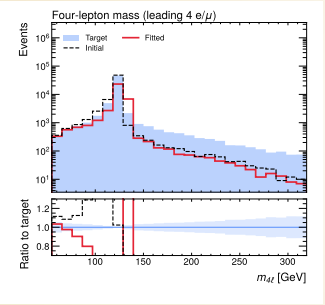




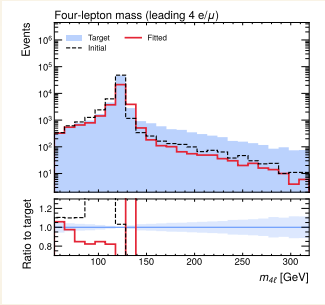


Fullsim $\pi^{\pm}$: four-lepton mass

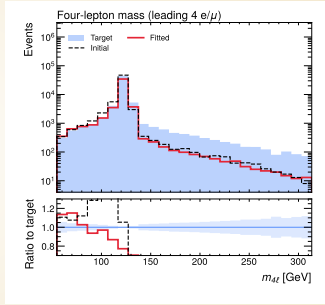
Wasserstein-1D



Likelihood

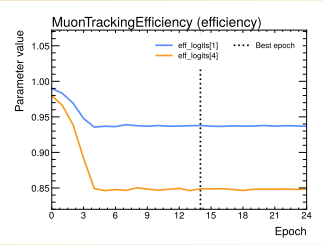


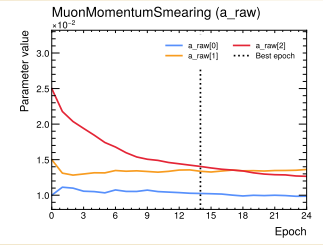
Wasserstein critic



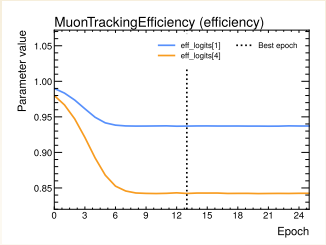
Fullsim $\pi^{\pm}$: muon efficiency and resolution *a*

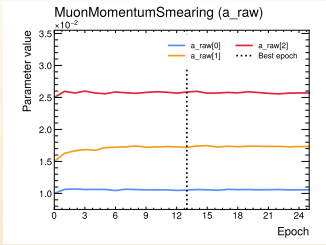
Wasserstein-1D



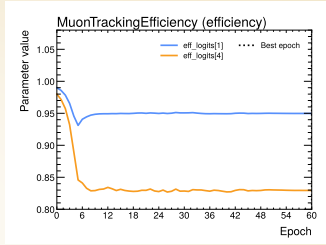


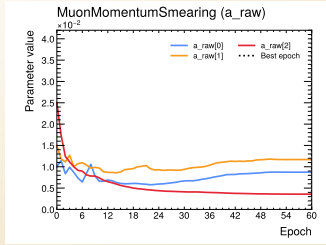
Likelihood





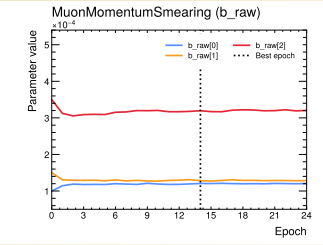
Wasserstein critic

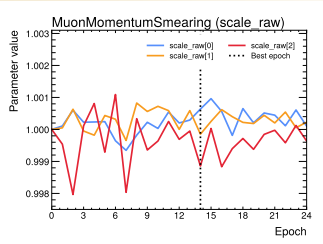




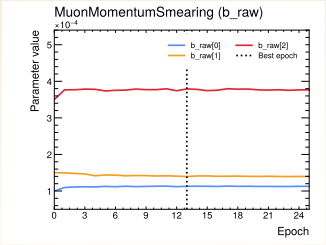
Fullsim $\pi^{\pm}$: muon resolution b and scale

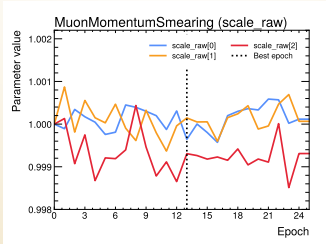
Wasserstein-1D



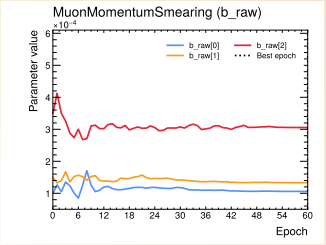


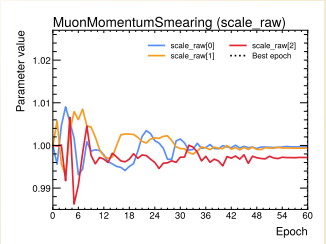
Likelihood





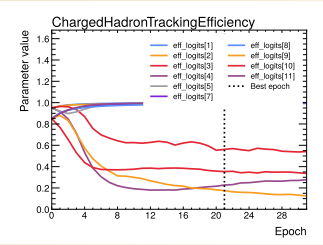
Wasserstein critic

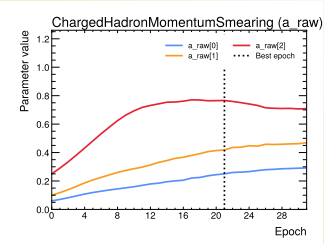




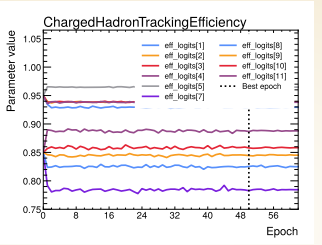
Fullsim $\pi^{\pm}$: charged-hadron efficiency and resolution *a*

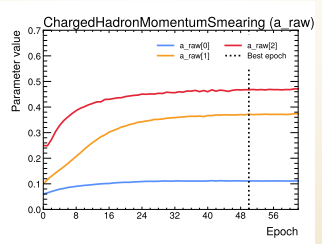
Wasserstein-1D



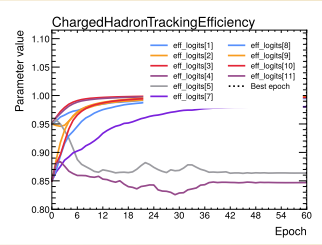


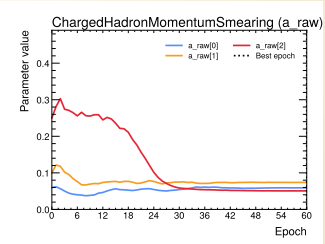
Likelihood





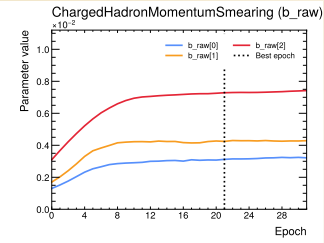
Wasserstein critic

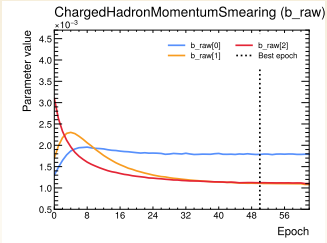


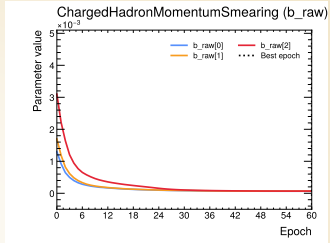


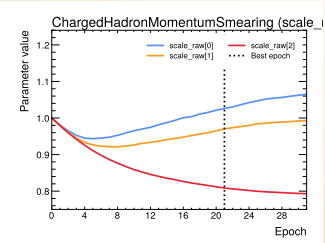
Fullsim $\pi^{\pm}$: charged-hadron resolution b and scale

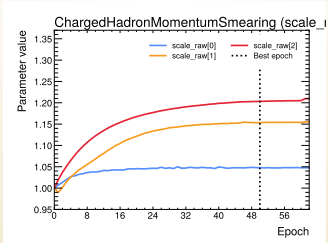
Wasserstein-1D | **Likelihood** | **Wasserstein critic**

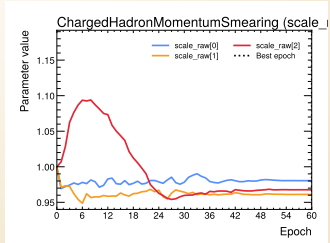






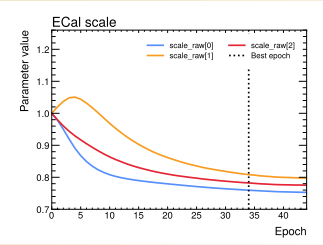


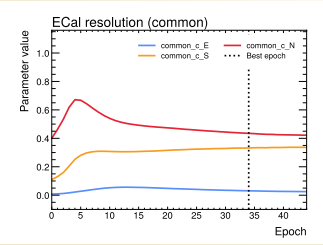




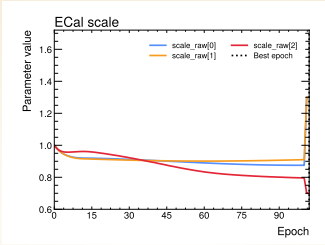
Fullsim $\pi^{\pm}$: ECal scale and resolution (common)

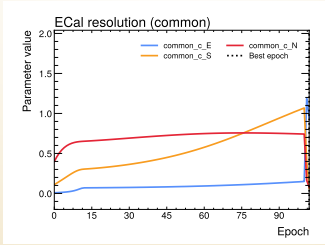
Wasserstein-1D



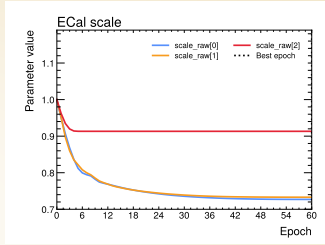


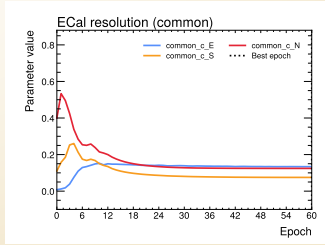
Likelihood





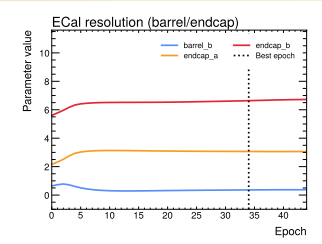
Wasserstein critic

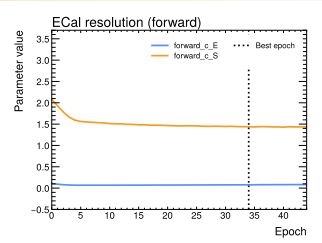




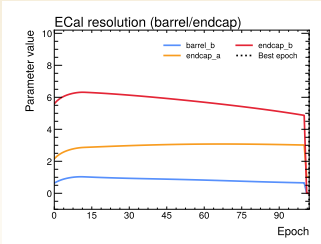
Fullsim $\pi^{\pm}$: ECal resolution (barrel/endcap, forward)

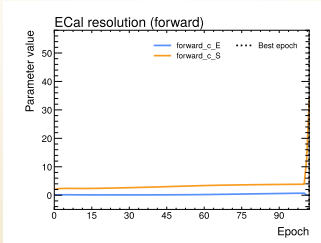
Wasserstein-1D



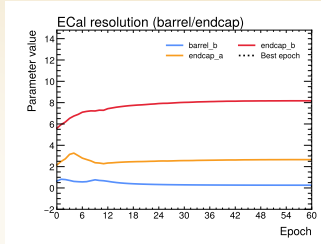


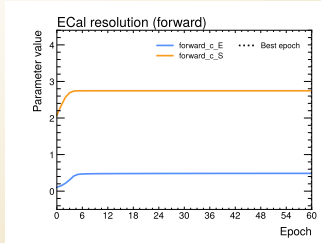
Likelihood





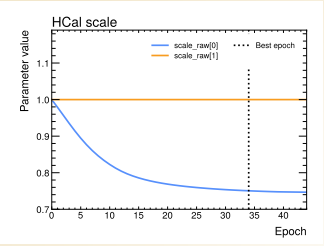
Wasserstein critic

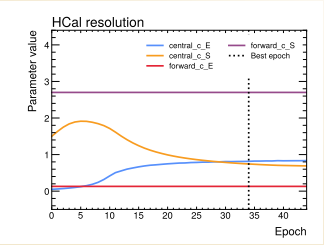




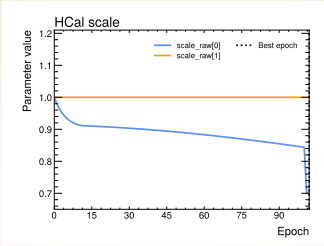
Fullsim $\pi^{\pm}$: HCal scale and resolution

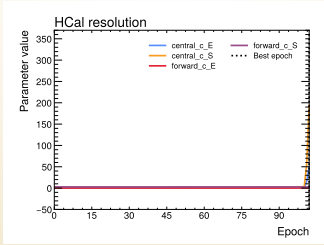
Wasserstein-1D



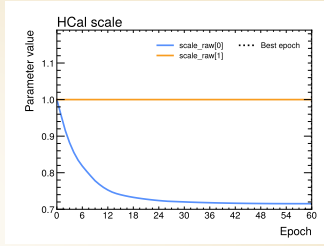


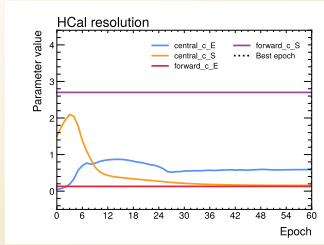
Likelihood





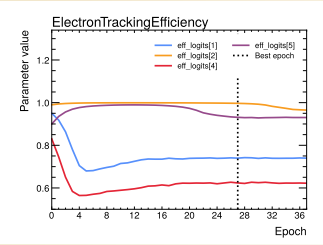
Wasserstein critic

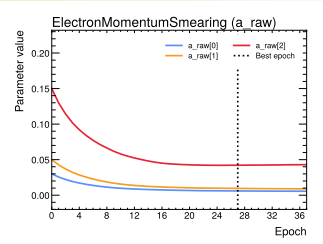




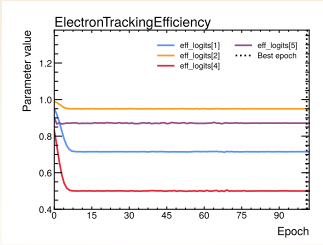
Fullsim $\pi^{\pm}$: electron efficiency and resolution *a*

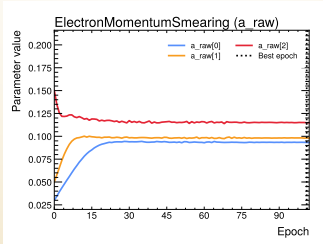
Wasserstein-1D



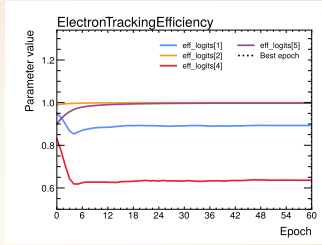


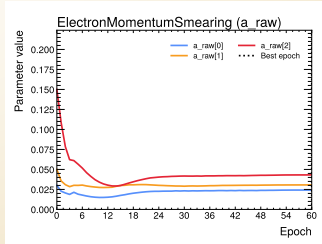
Likelihood





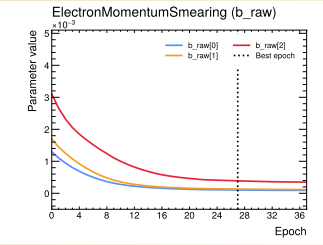
Wasserstein critic

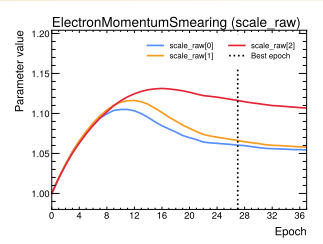




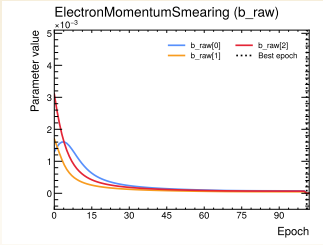
Fullsim $\pi^{\pm}$: electron resolution b and scale

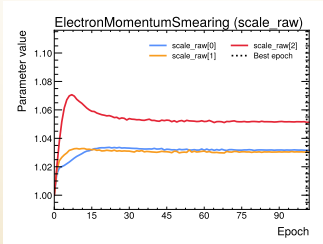
Wasserstein-1D



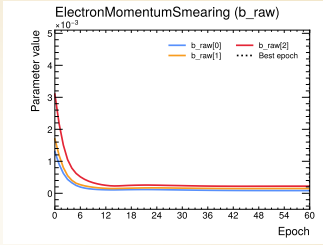


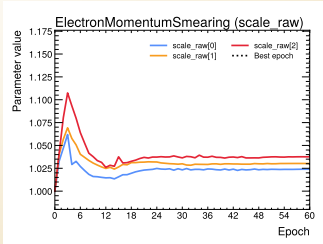
Likelihood





Wasserstein critic





Discussion

Pseudodata

- One last problem parameter! `b_raw`
  - High-pT $Z' \to \mu^+\mu^-, e^+e^-$

Fullsim

- Sometimes, Delphes already pretty good
  - E.g. muons
- Modeling discrepancies: low-hanging fruit
  - Photon-merger, calorimeter discretization ← Done
  - 2-3 weeks to explore other improvements
    - Displaced tracks
    - Tracker discretization
    - Merging collimated tracks
- Modeling discrepancies: long-term
  - Mid-detector decays
  - Detector material interactions

Discussion

Proposal storyline of the paper

1. Compare methodologies to fit Delphes parameters
   - Applied to pseudodata (closure) and CMS full simulations
2. Delphes is simplified detector simulation: misspecified
   - work out simple discrepancies to improve the full sim fit
   - have to be universal detector effects
3. Provide a detector card usable in our framework and/or Delphes

Towards the paper v2

- Start updating the draft
- What should we keep: structure, abstract, title, . . . ?

Backup