Fast Simulation using Graph Diffusion and Graph-to-Graph Translation

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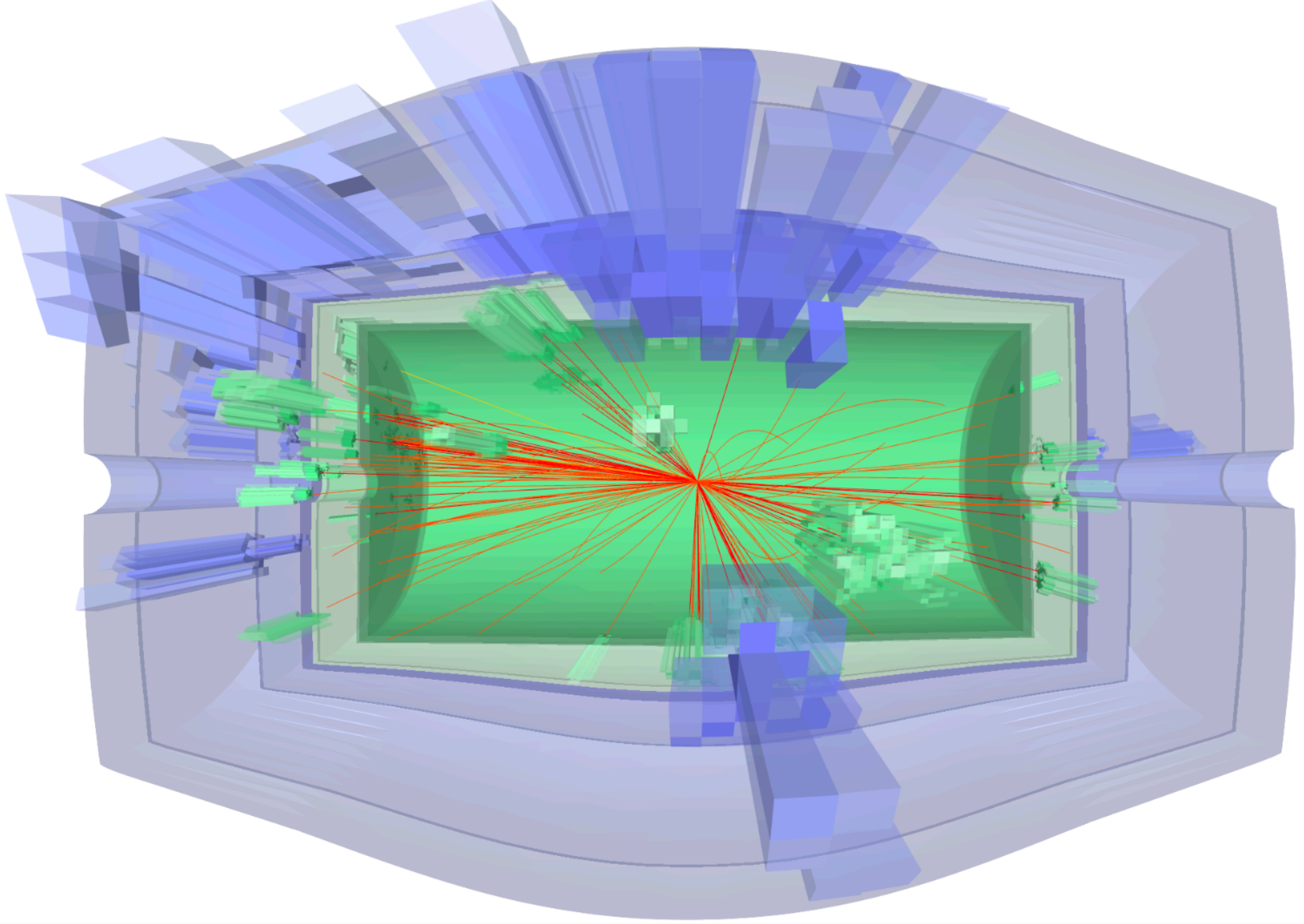
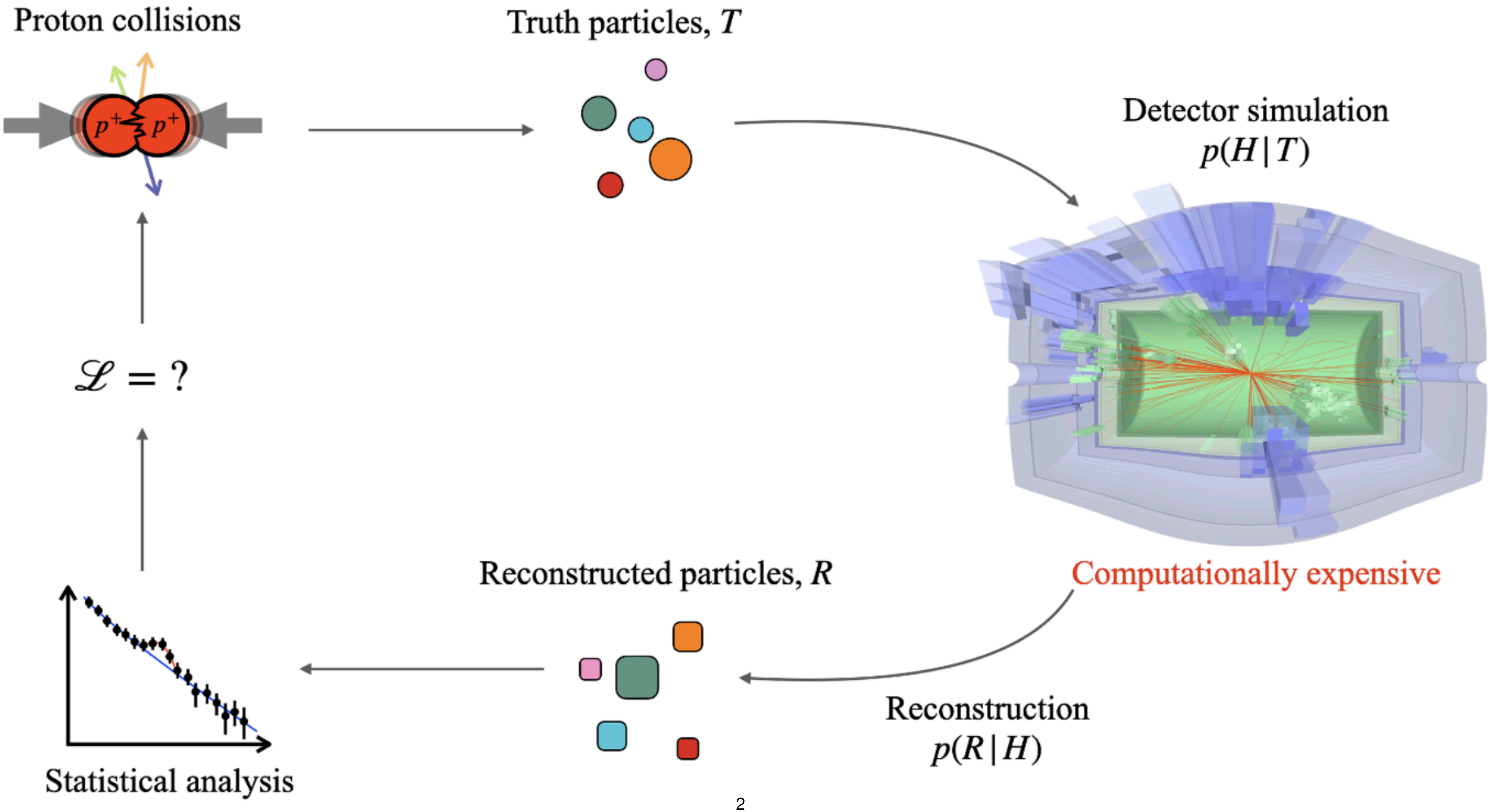
COCOA

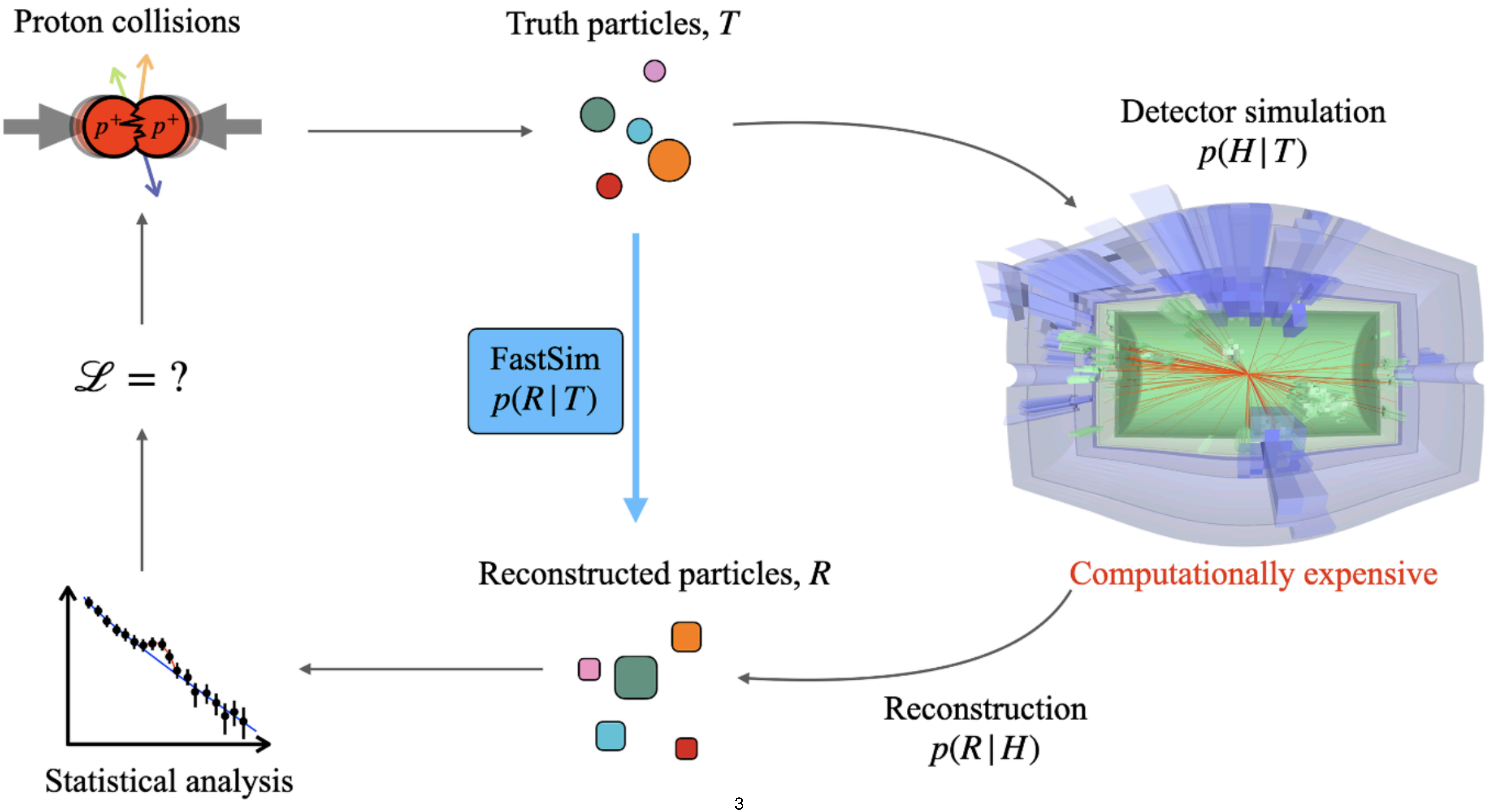


6th IML Workshop, 02.02.2024

Motivation


Proton collisions
p^+
p^+
Truth particles, T
Detector simulation
$p(H\,|\,T)$
Computationally expensive
Reconstruction
$p(R\,|\,H)$
Reconstructed particles, R
Statistical analysis
$\mathscr{L} = ?$

Motivation



Proton collisions
p^+
p^+
Truth particles, T
Detector simulation
$p(H\,|\,T)$
FastSim
$p(R\,|\,T)$
$\mathscr{L} = ?$
Computationally expensive
Reconstructed particles, R
Reconstruction
$p(R\,|\,H)$
Statistical analysis

Previous work

arXiv: 2211.06406

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ACCEPTED MANUSCRIPT • OPEN ACCESS

Set-Conditional Set Generation for Particle Physics

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Accepted Manuscript online 13 October 2023 •

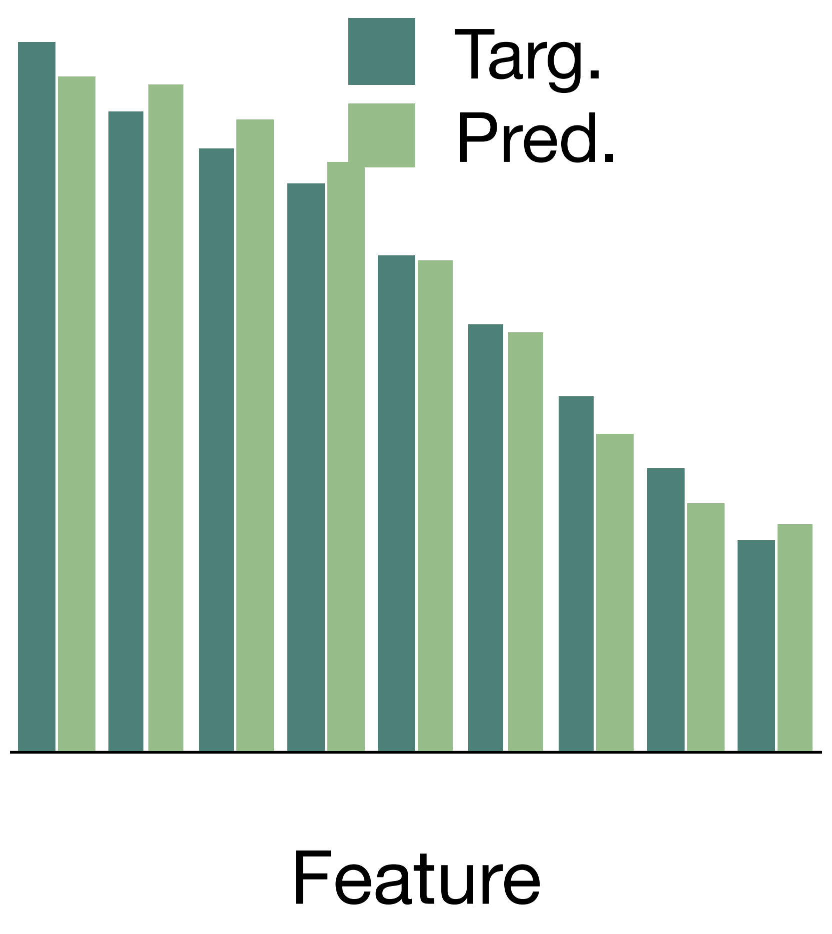
	Previously	**Now**
Dataset	Toy model — emulated tracks	Full simulation & reconstruction
Particles	charged only	charged + neutral
Architecture	GNN with Slot-Attention	Graph Diffusion Graph-to-Graph Translation

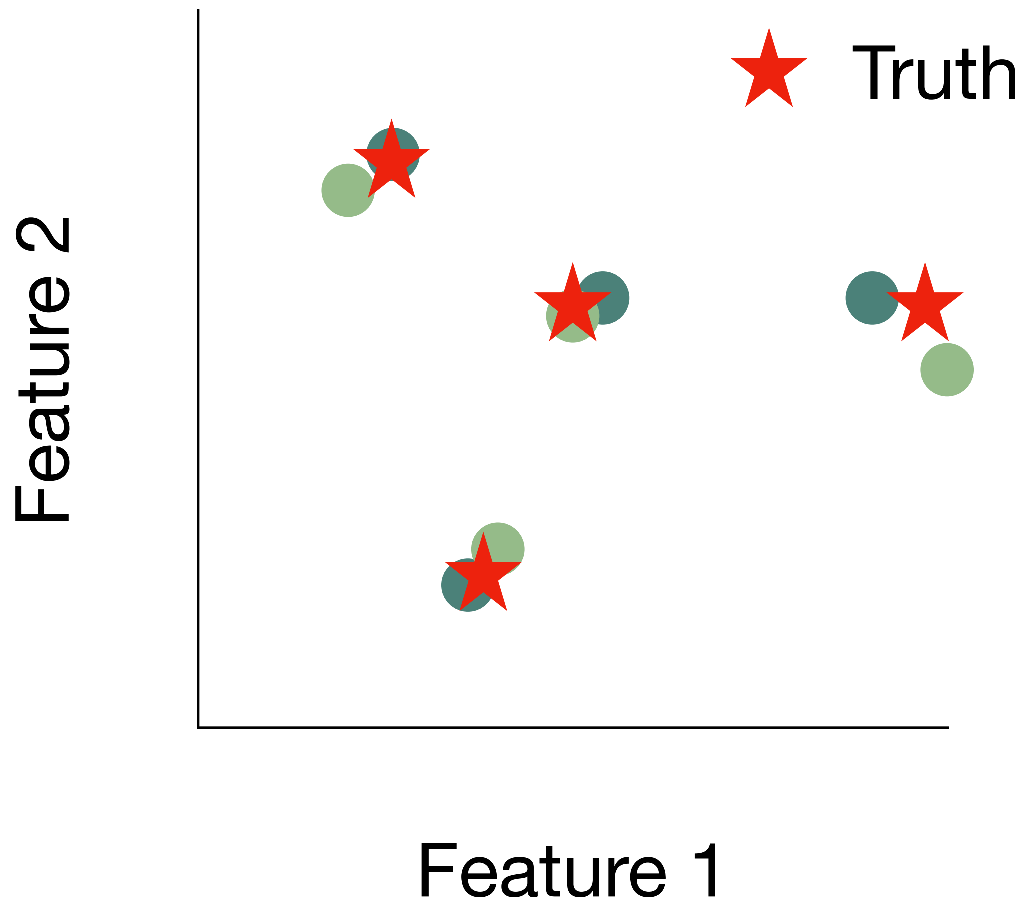
Goals

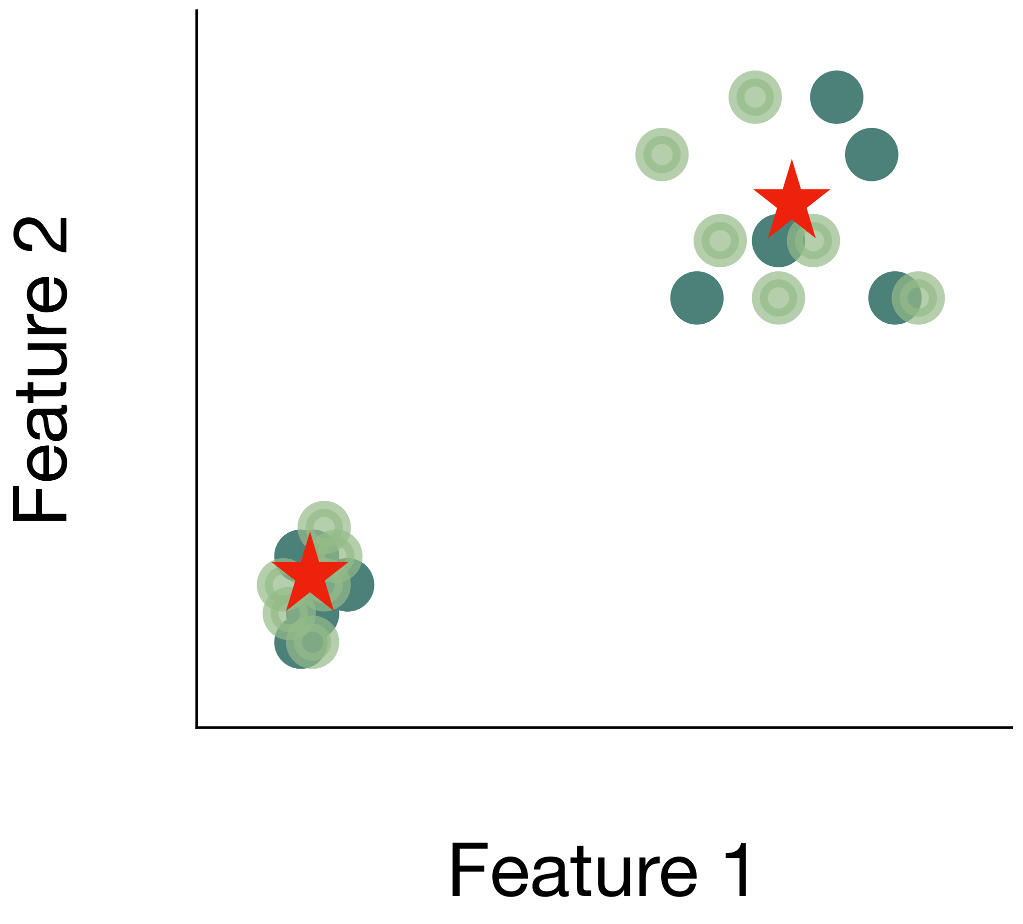
Marginal distributions

Reconstruct constituents

Resolution







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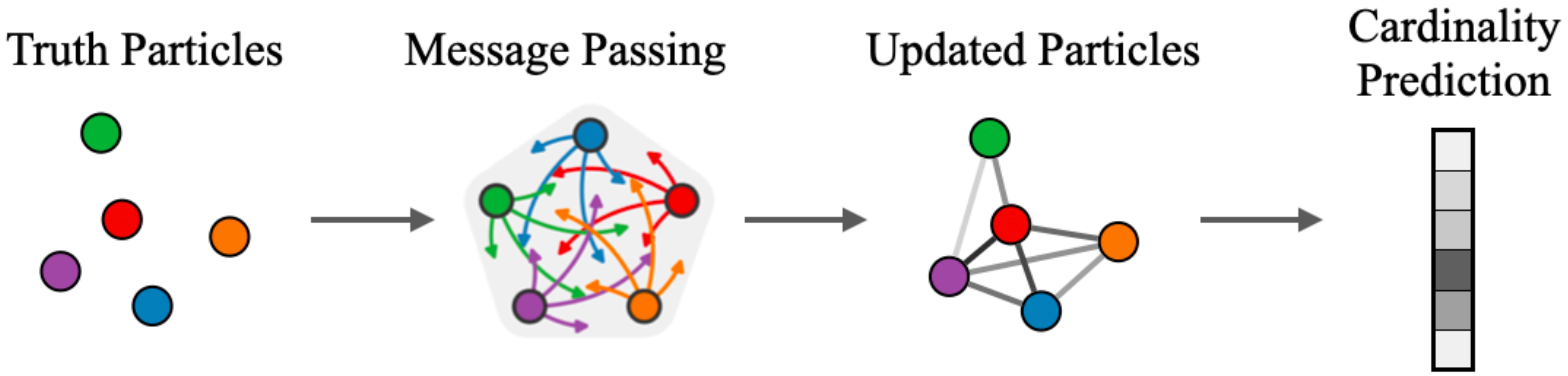
Dataset

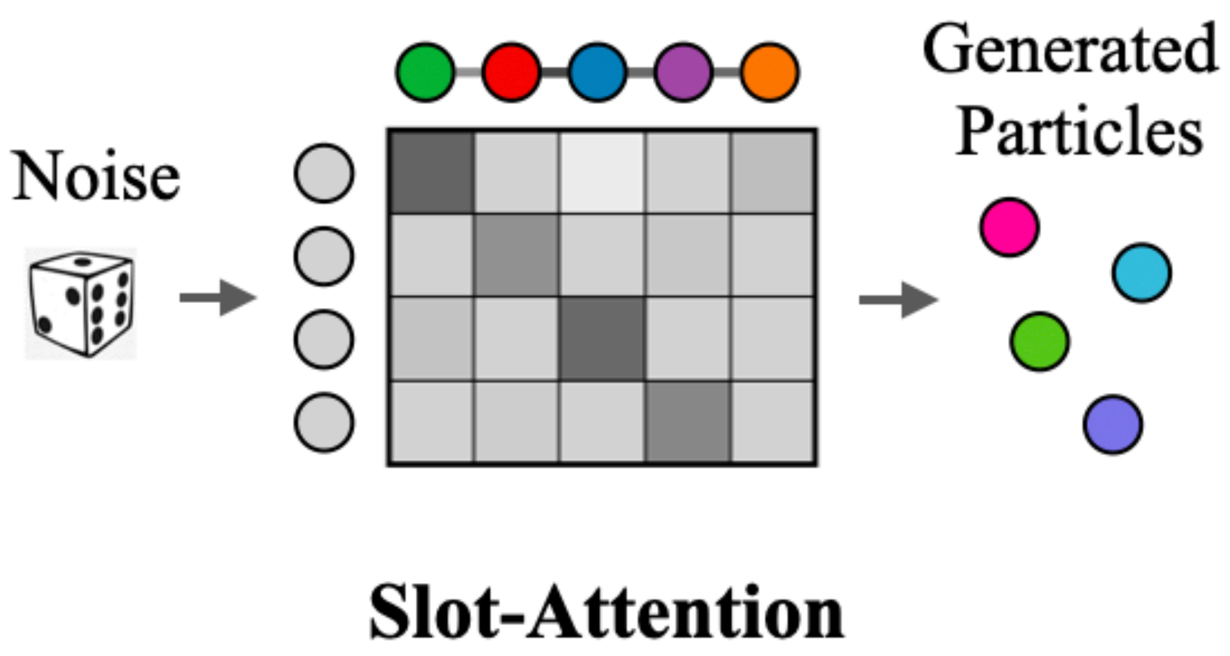
- Single jet events
- COCOA detector simulation — 2303.02101
- HGPflow reconstruction — 2212.01328
- **100 *replicas*** per event

  repeat detector simulation for the same truth event

COCOA

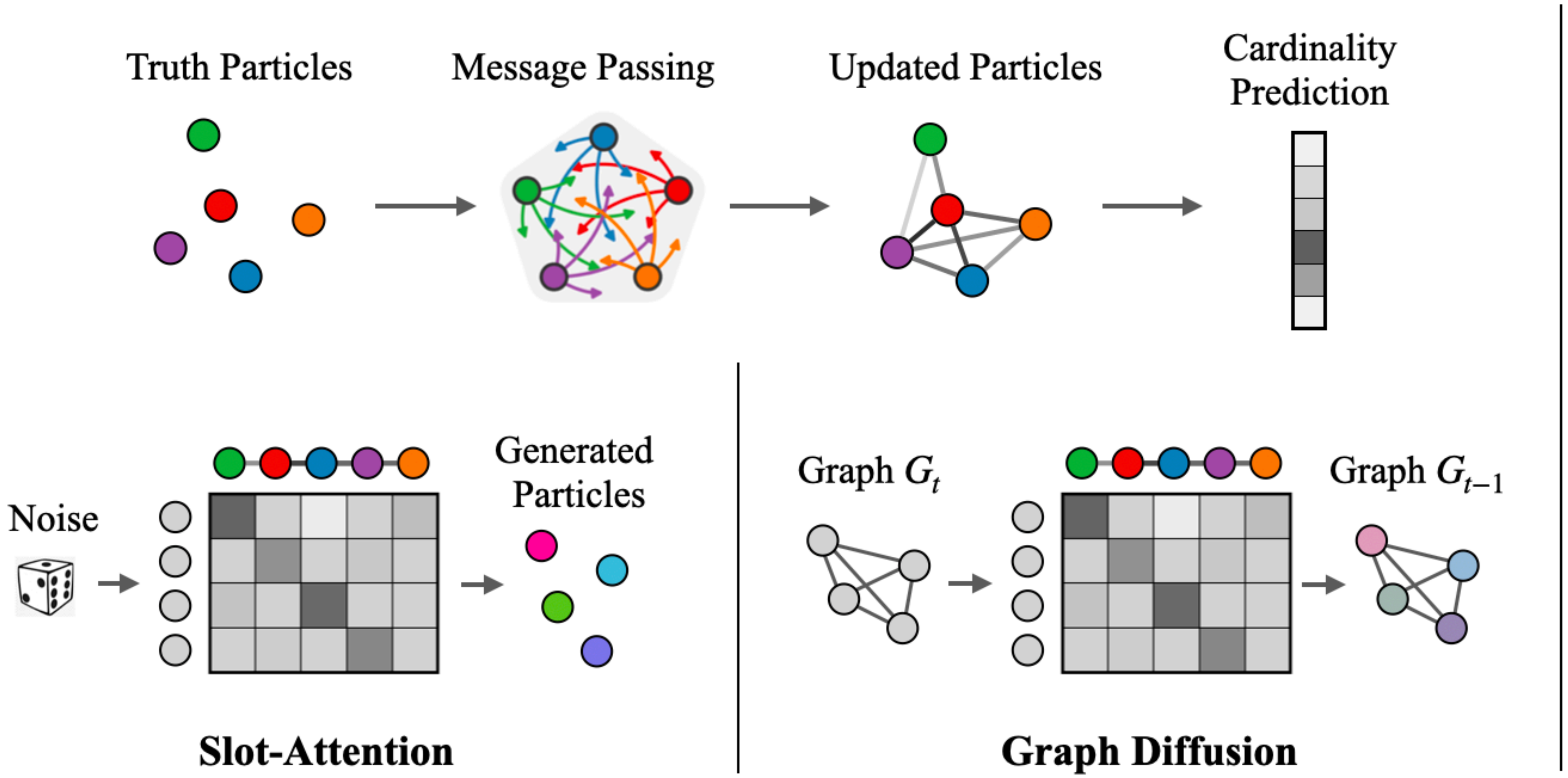
Architectures





Set-based loss through Hungarian matching (LSA) using particle features

Architectures



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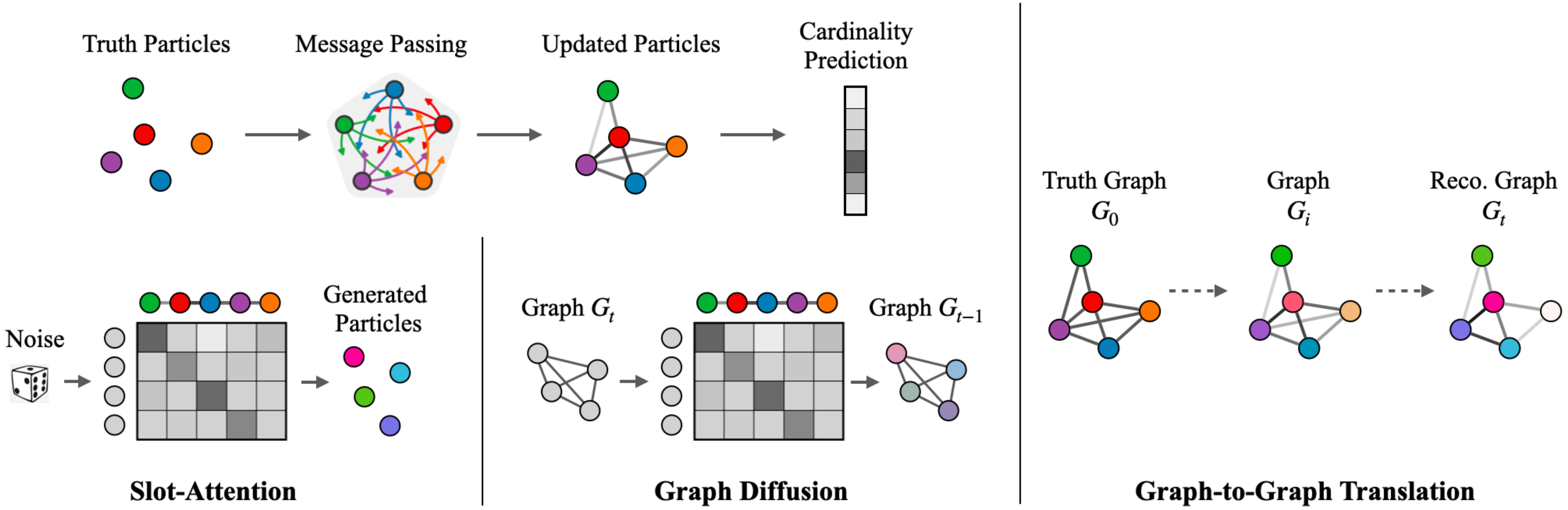

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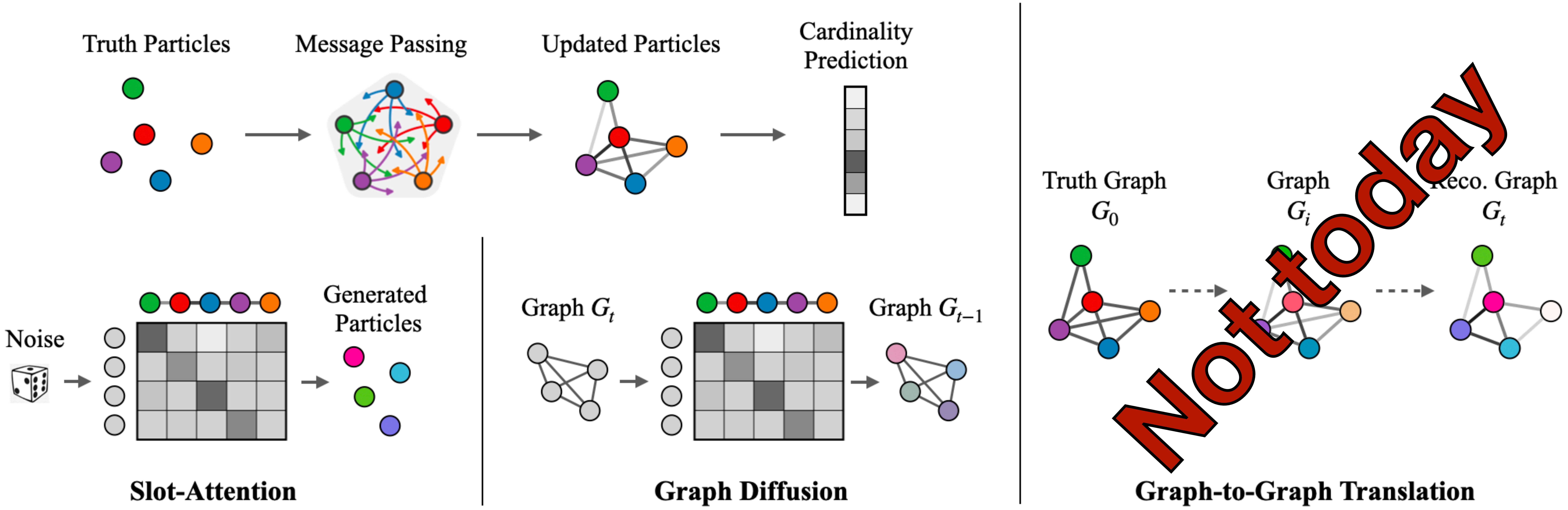
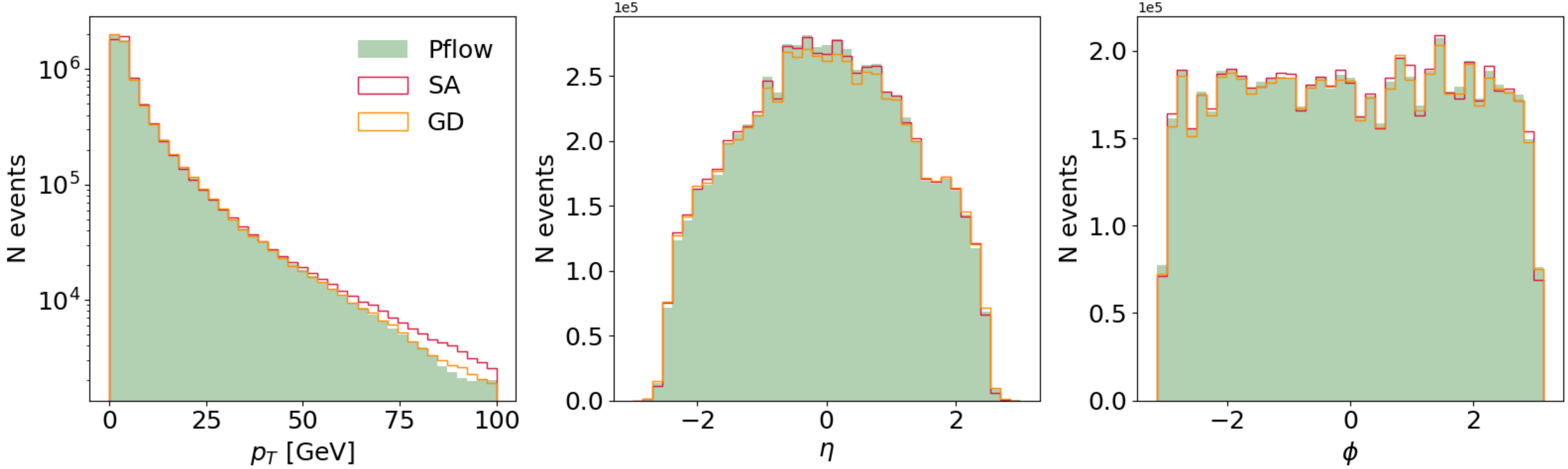


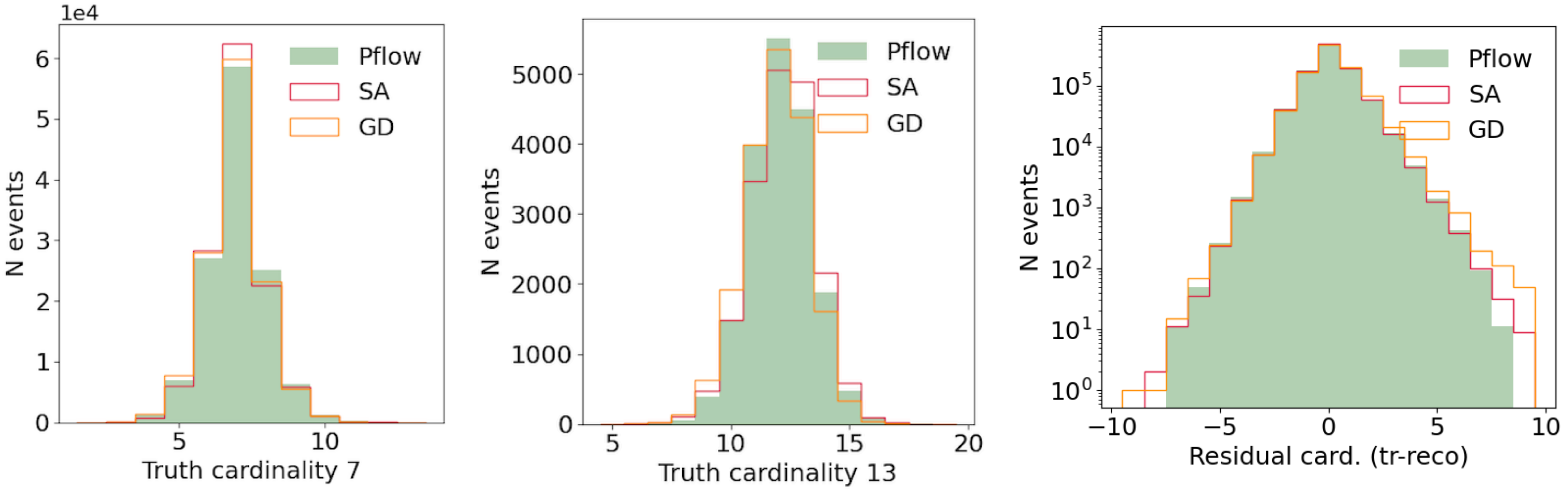
Set-based loss through Hungarian matching (LSA) using particle features

Marginal distributions



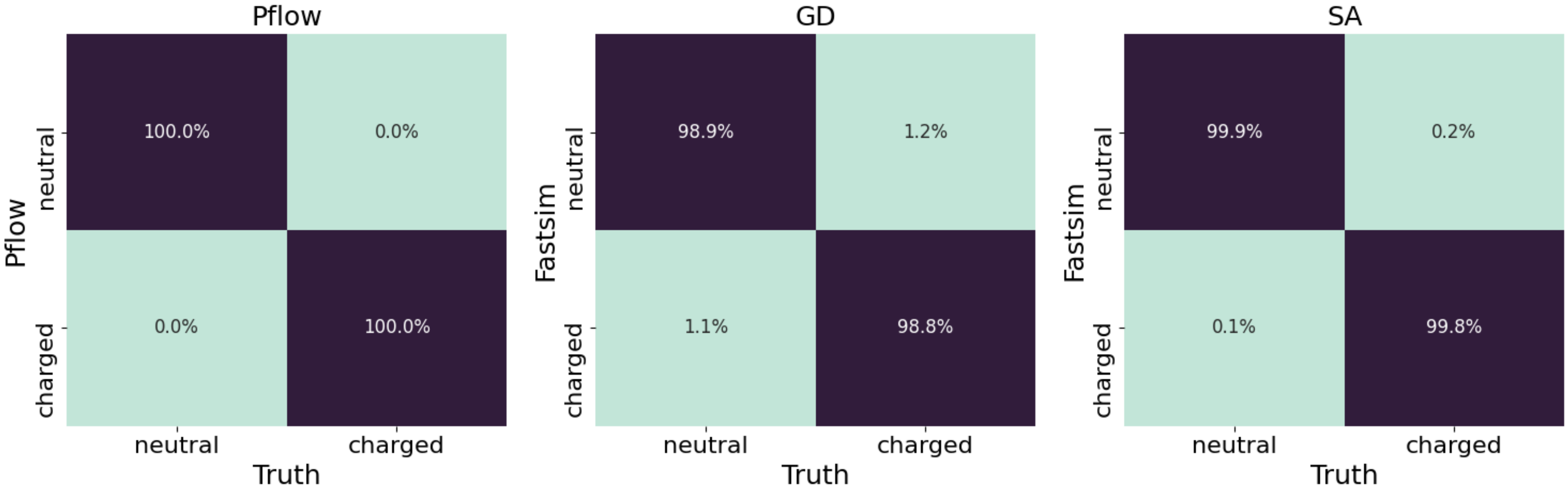
- Overall good agreement
- Some issues in p_T tail — under investigation

Cardinality



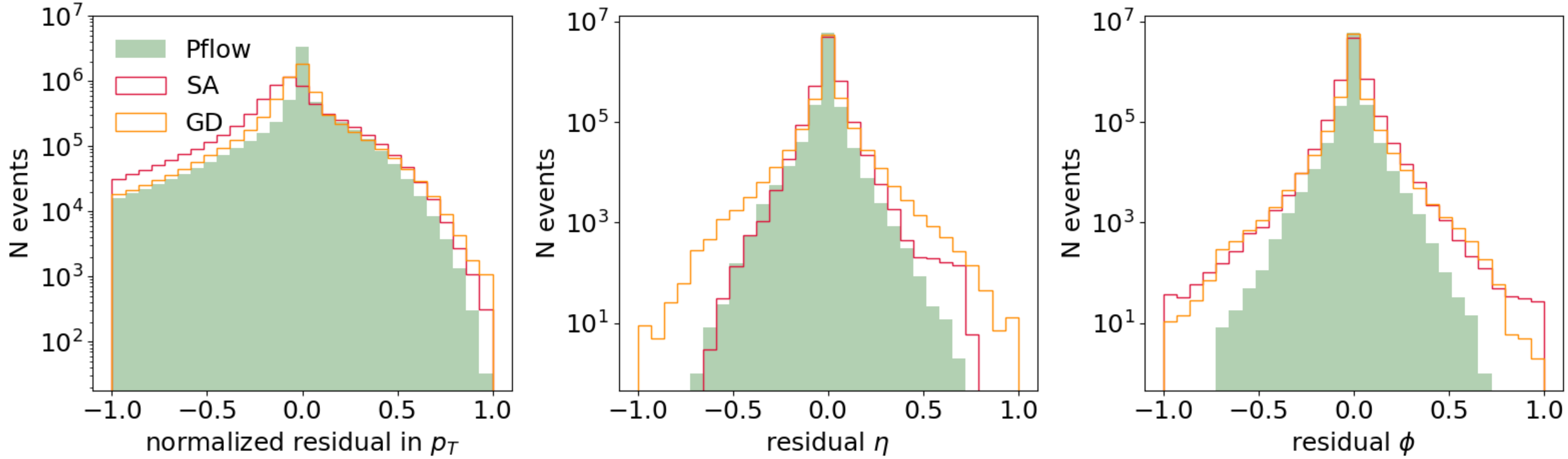
- Overall good match
- SA & GD very similar — expected since its the same network

Class prediction

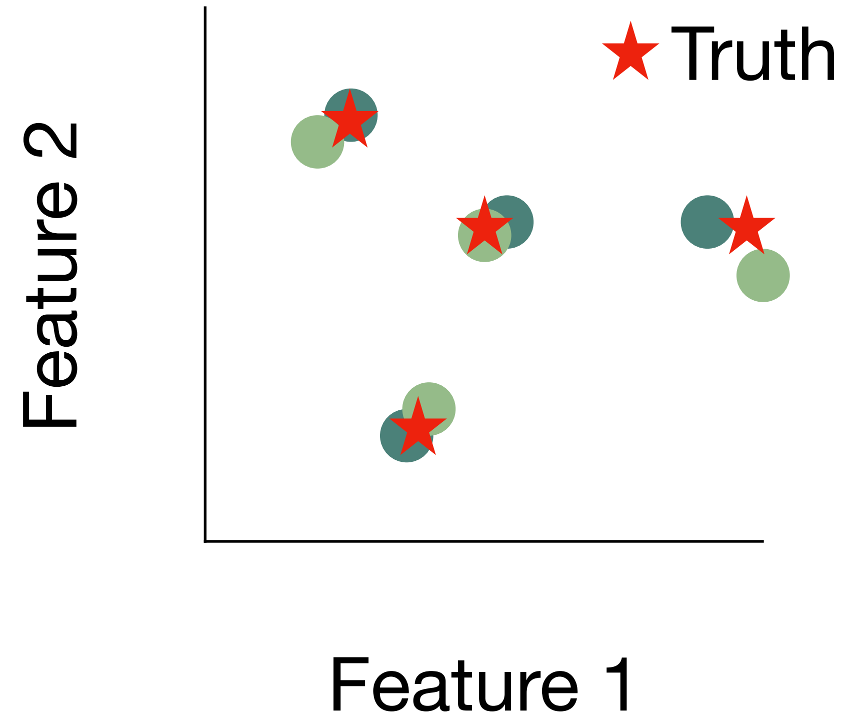


- Overall good match
- SA is better than GD

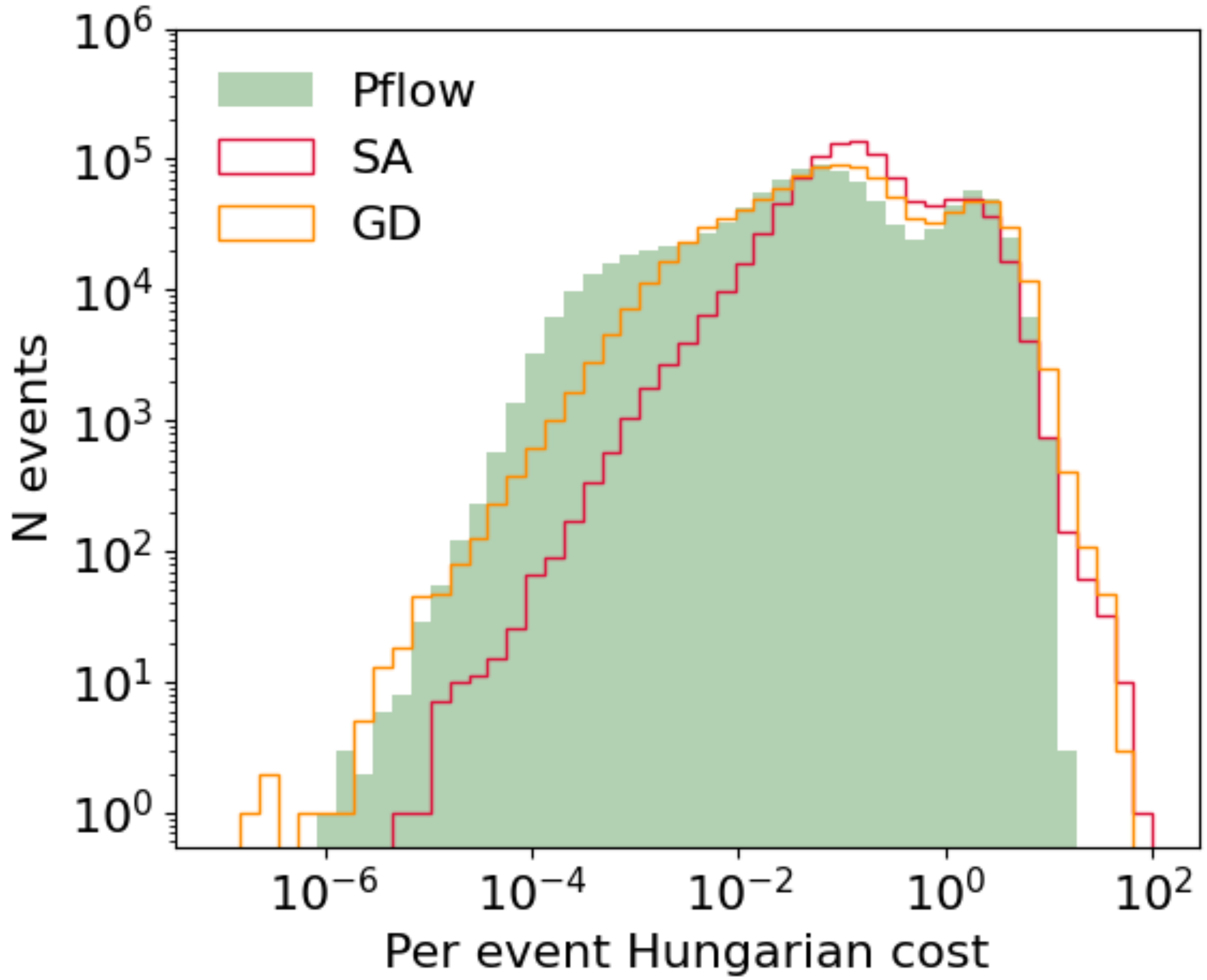
Residuals — 'Distance to Truth'



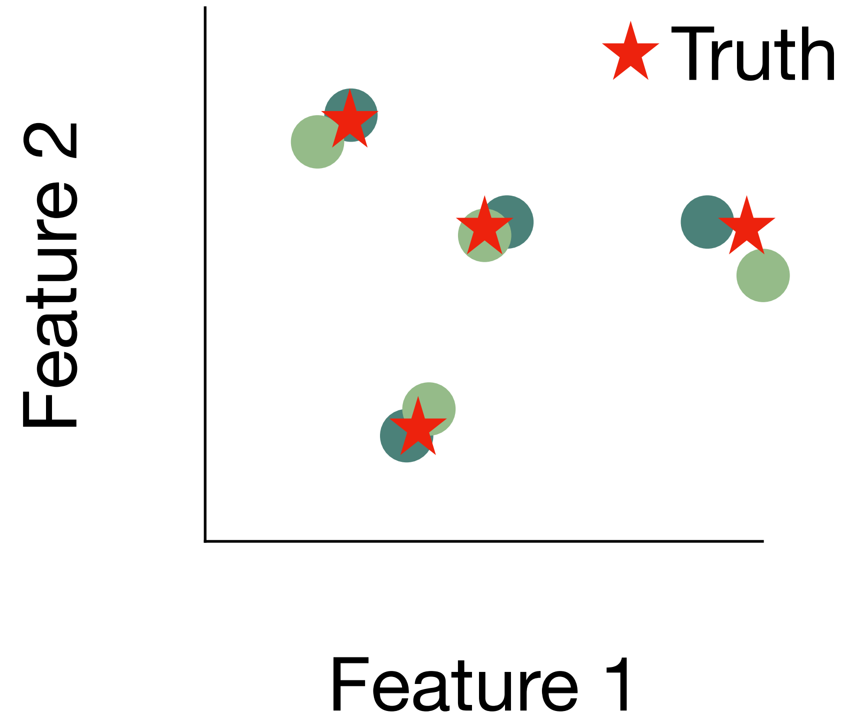
- Hungarian matching between truth and reconstruction
- GD has a good agreement in p_T
- SA is a bit better in η
- Need combined metric



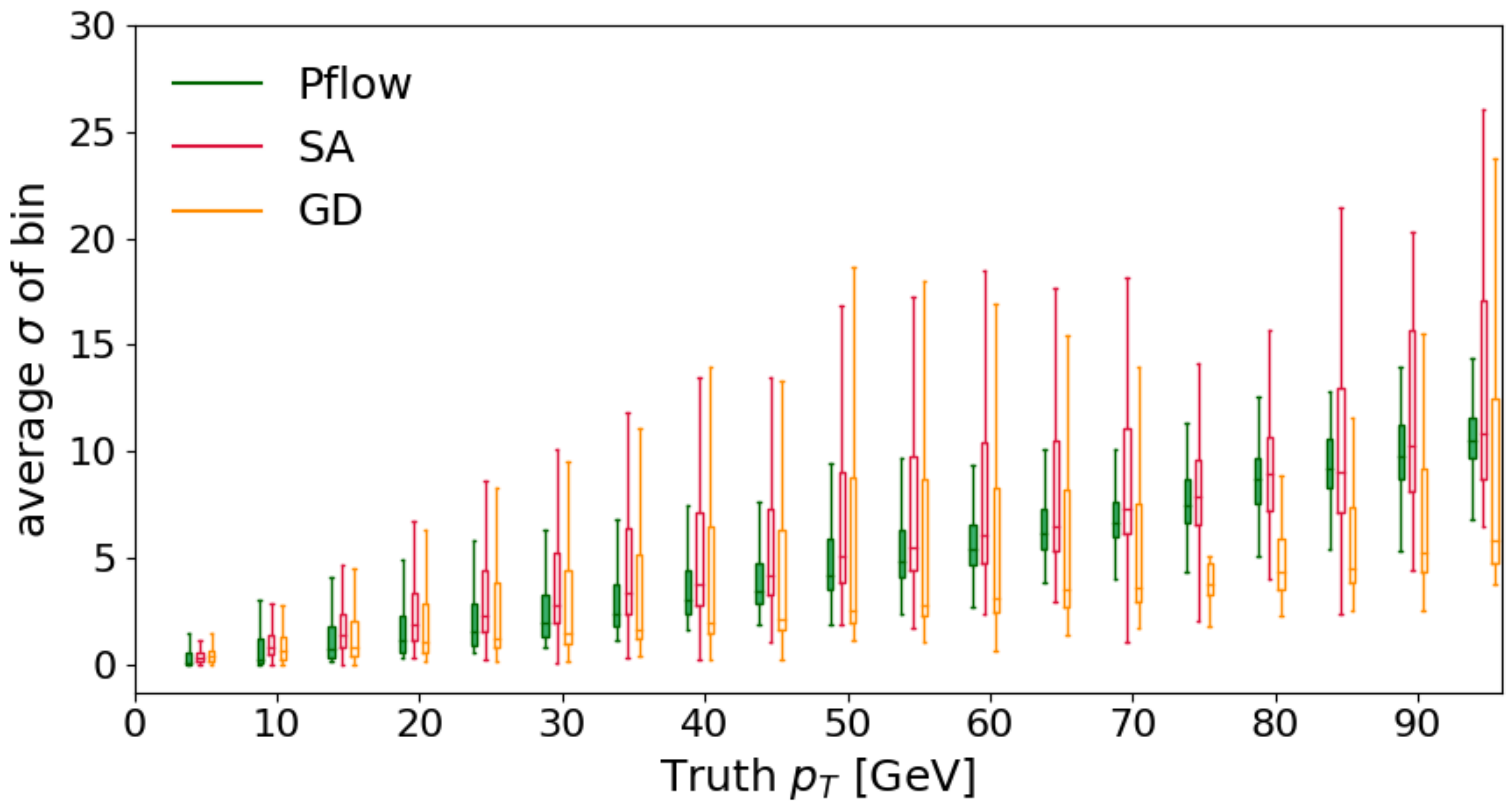
Matching with truth



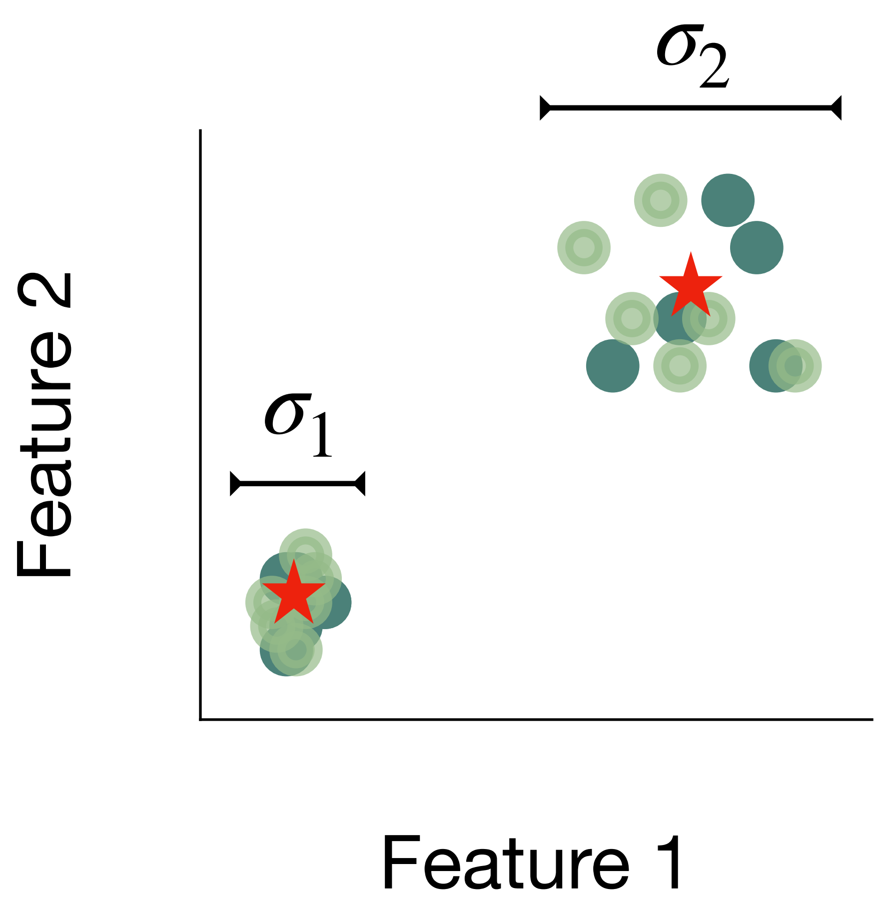
- Matching Cost —
  MSE of p_T, η, ϕ + BCE of class
- SA — to high cost
- GD — good agreement



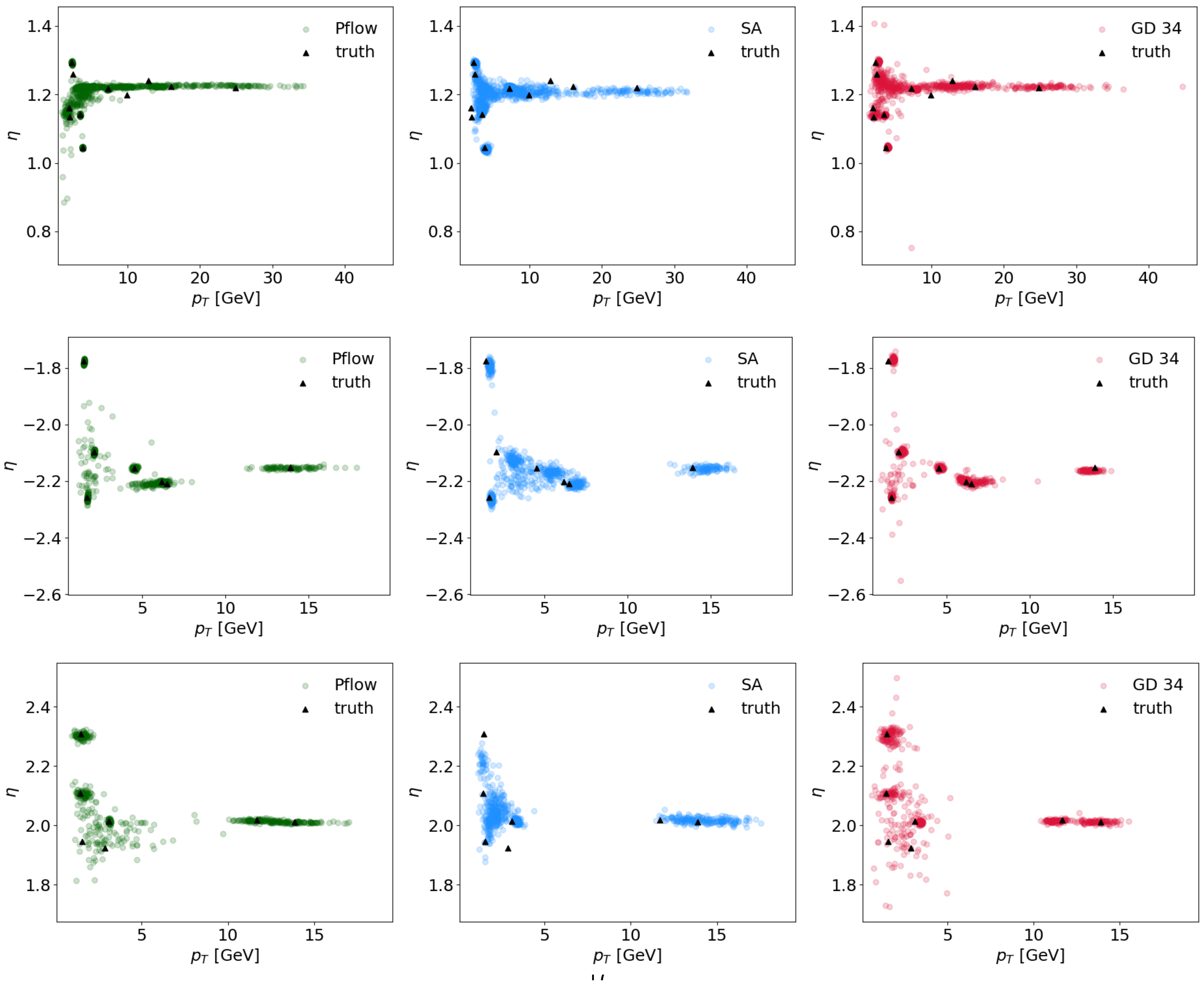
Resolution



- For each truth particle take σ of all associated replicas
- Difficulties at high p_T



Event displays



Summary

- 3 approaches for a conditional end-to-end generative model

  Slot-Attention, Graph Diffusion, Graph-to-Graph Translation

- Goal to reconstruct constituents and model detector resolution

- New models show significant improvement w.r.t. the original

- GGT trainings is in progress