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FSP ATLAS
Erforschung von
Universum und Materie



UNIVERSITÄT
HEIDELBERG
ZUKUNFT
SEIT 1386

IMPRS
for Precision Tests of
Fundamental Symmetries
INTERNATIONAL MAX PLANCK
RESEARCH SCHOOL



ML Pileup Rejection with Hits

(Do we need tracking anyway?)

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Kirchhoff-Institute for Physics

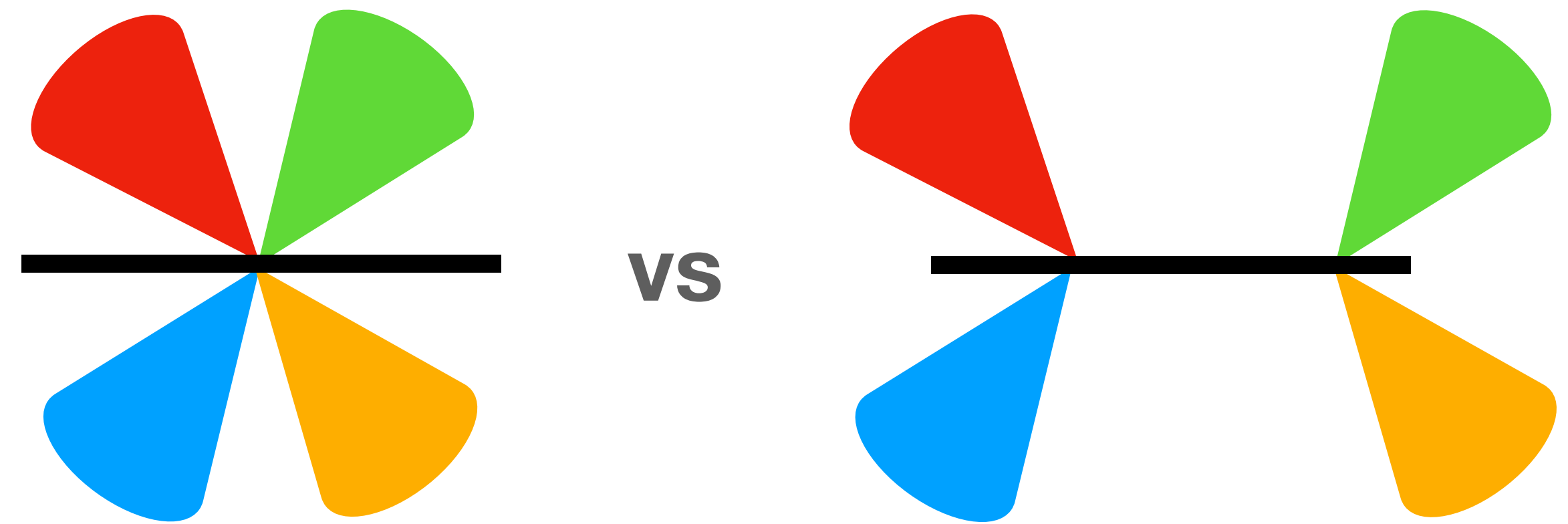
Heidelberg University

18.07.2024

ATLAS-Heidelberg Meeting @ Trifels 2024

General Idea of HitZ

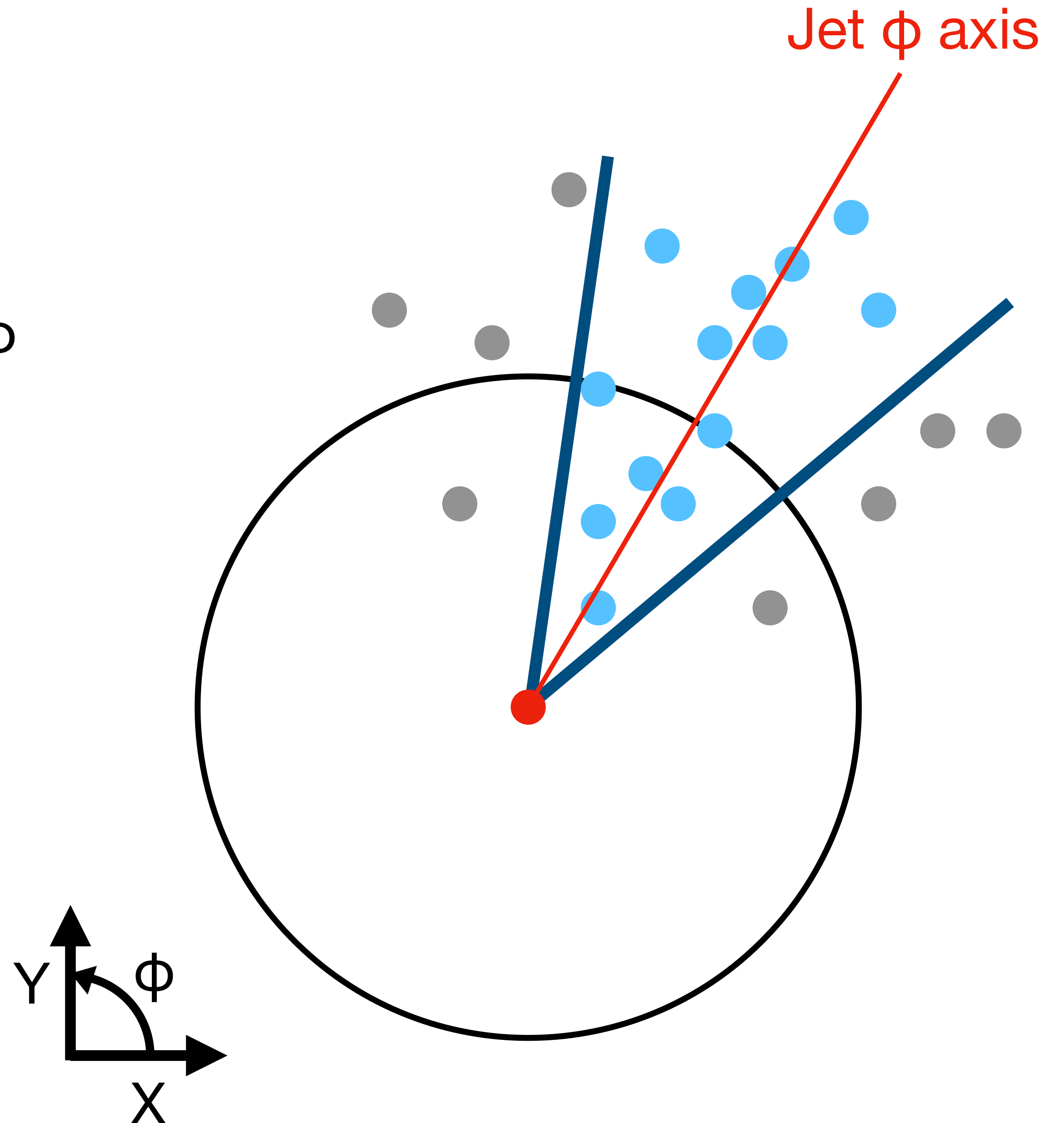
- Primary vertex \mathbf{z} reconstruction for fast online pileup rejection
- Interesting events with high jet multiplicity, e.g. Di-Higgs
- Tracking is CPU expensive
- Preferably only use hit-level information
- Predictions on a jet-by-jet basis



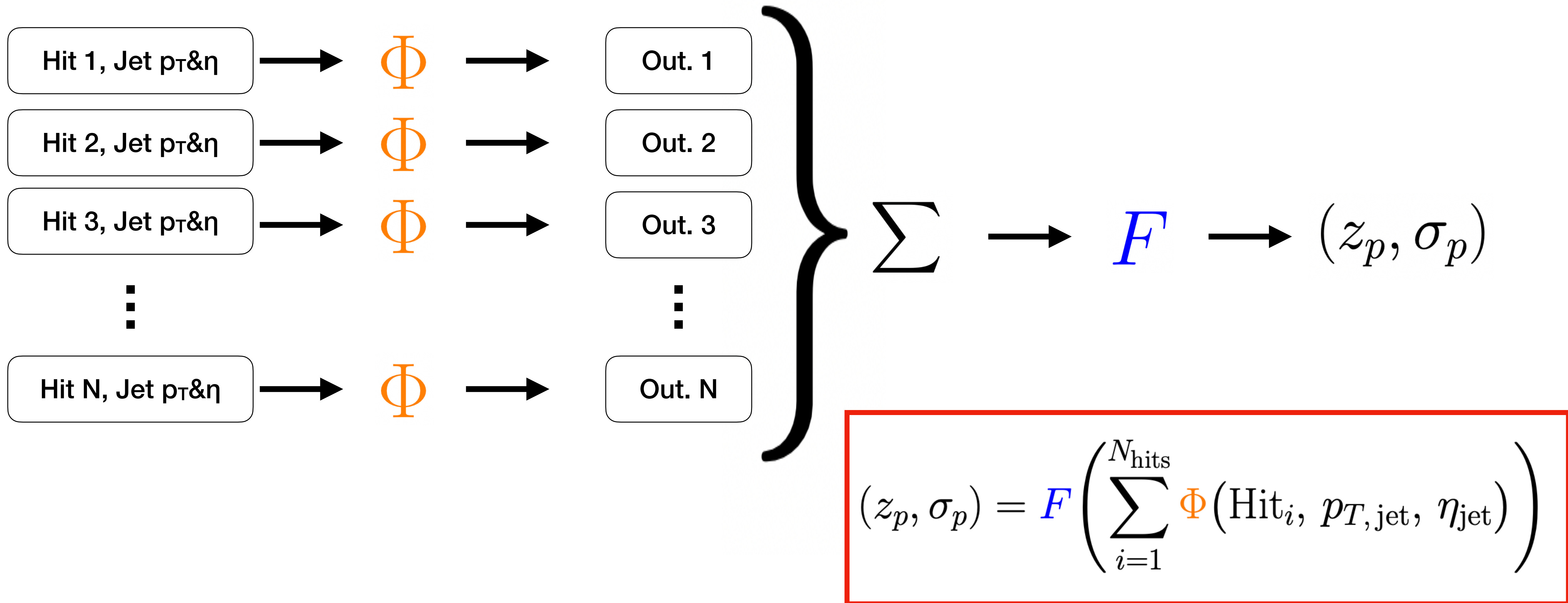
Goal: Build network with \mathbf{z} and an uncertainty σ as an output for each jet

Hit Selection

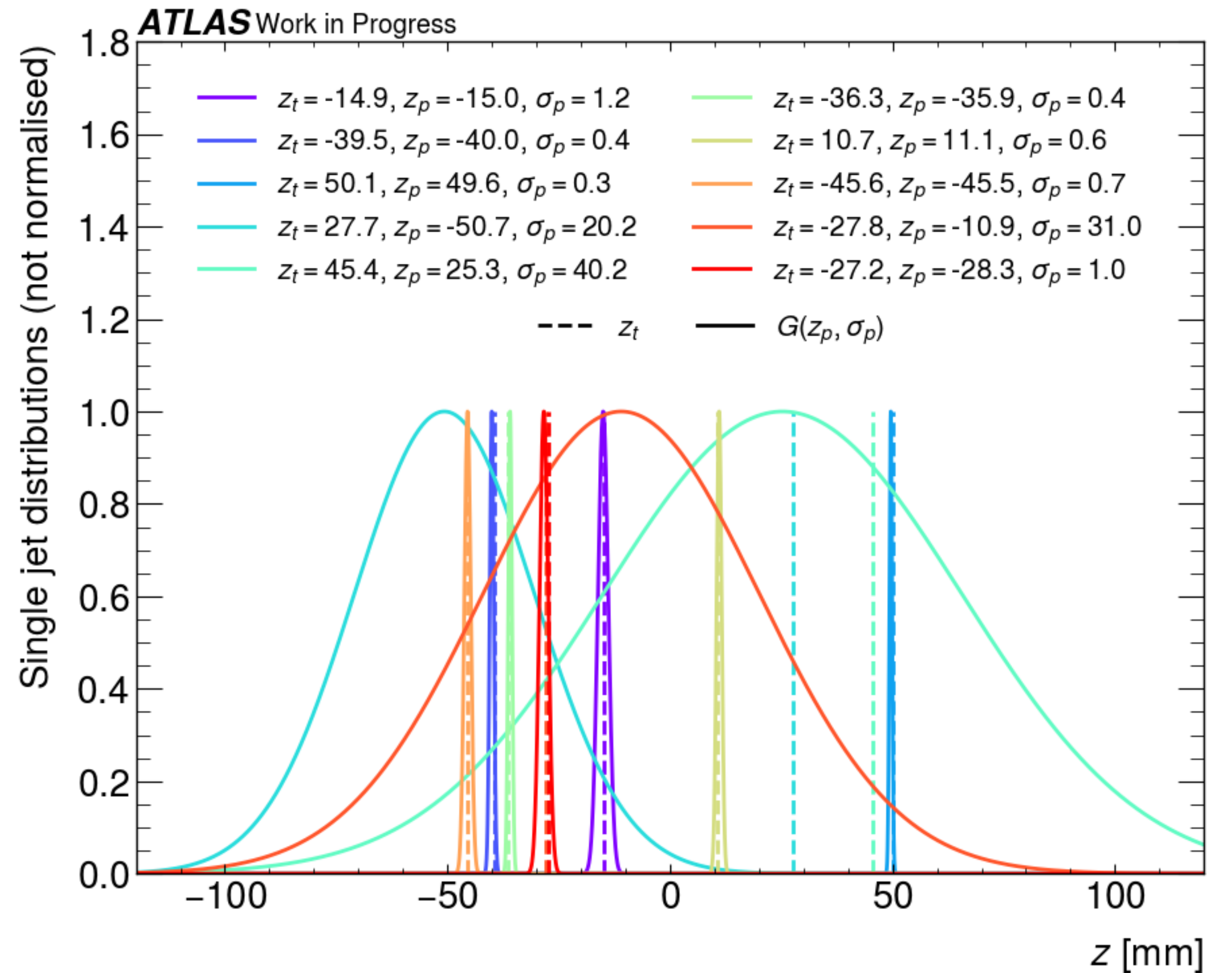
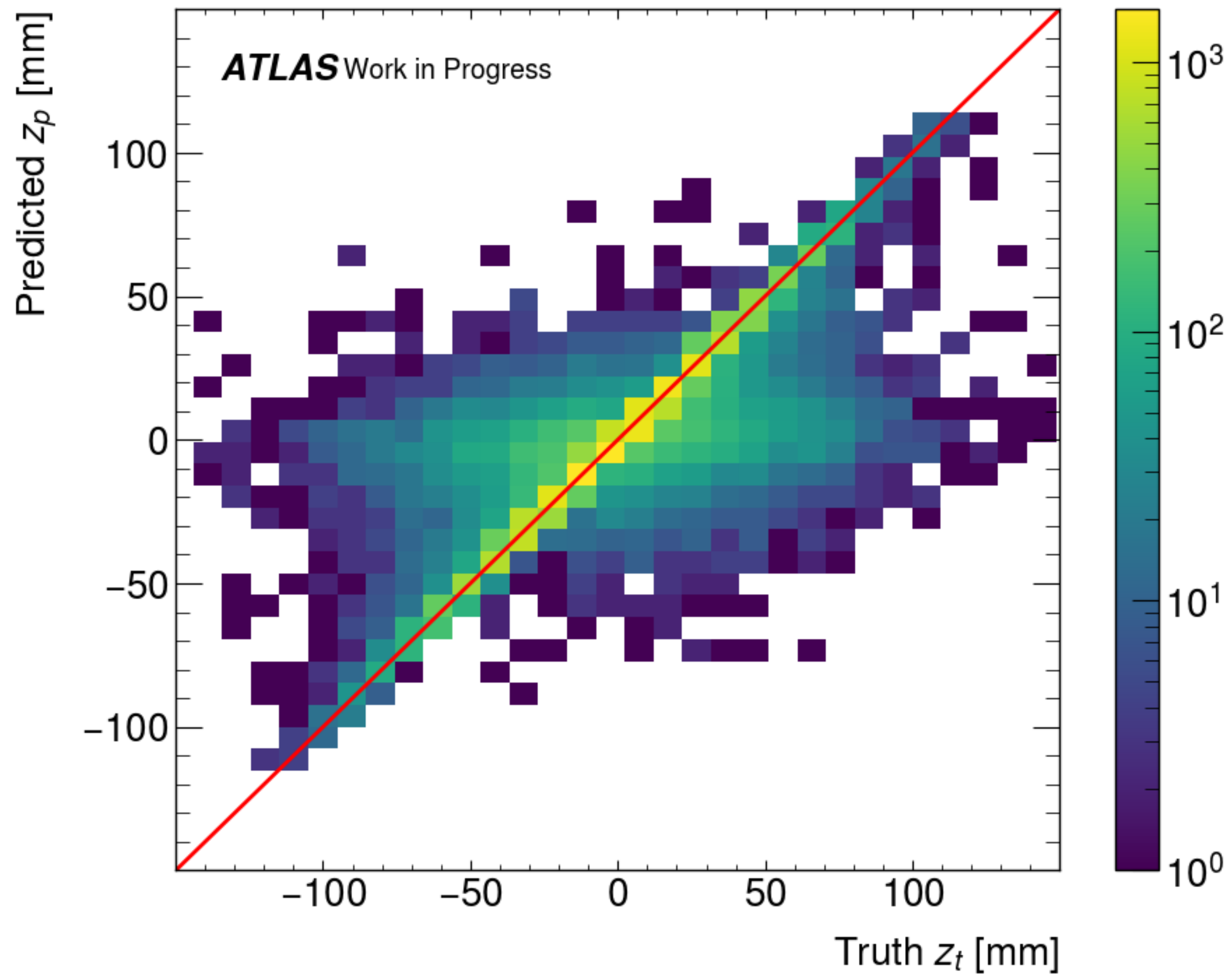
- Use jet by jet ROI (from L1 Trigger) in ϕ
- Apply cut in ϕ with fixed width to select hits
- Inputs of the network:
 - 3D position of hits
 - Jet p_T
 - Jet η



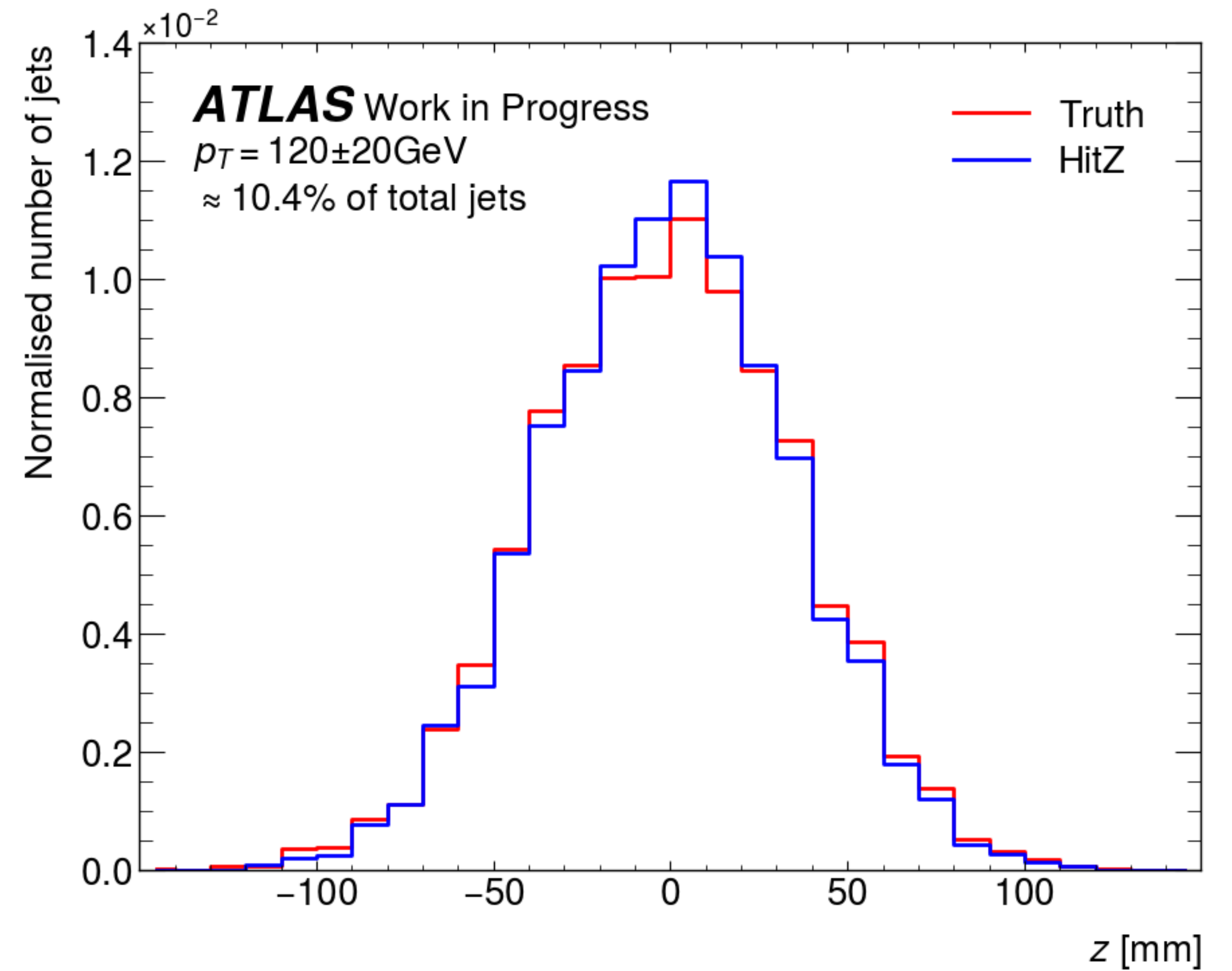
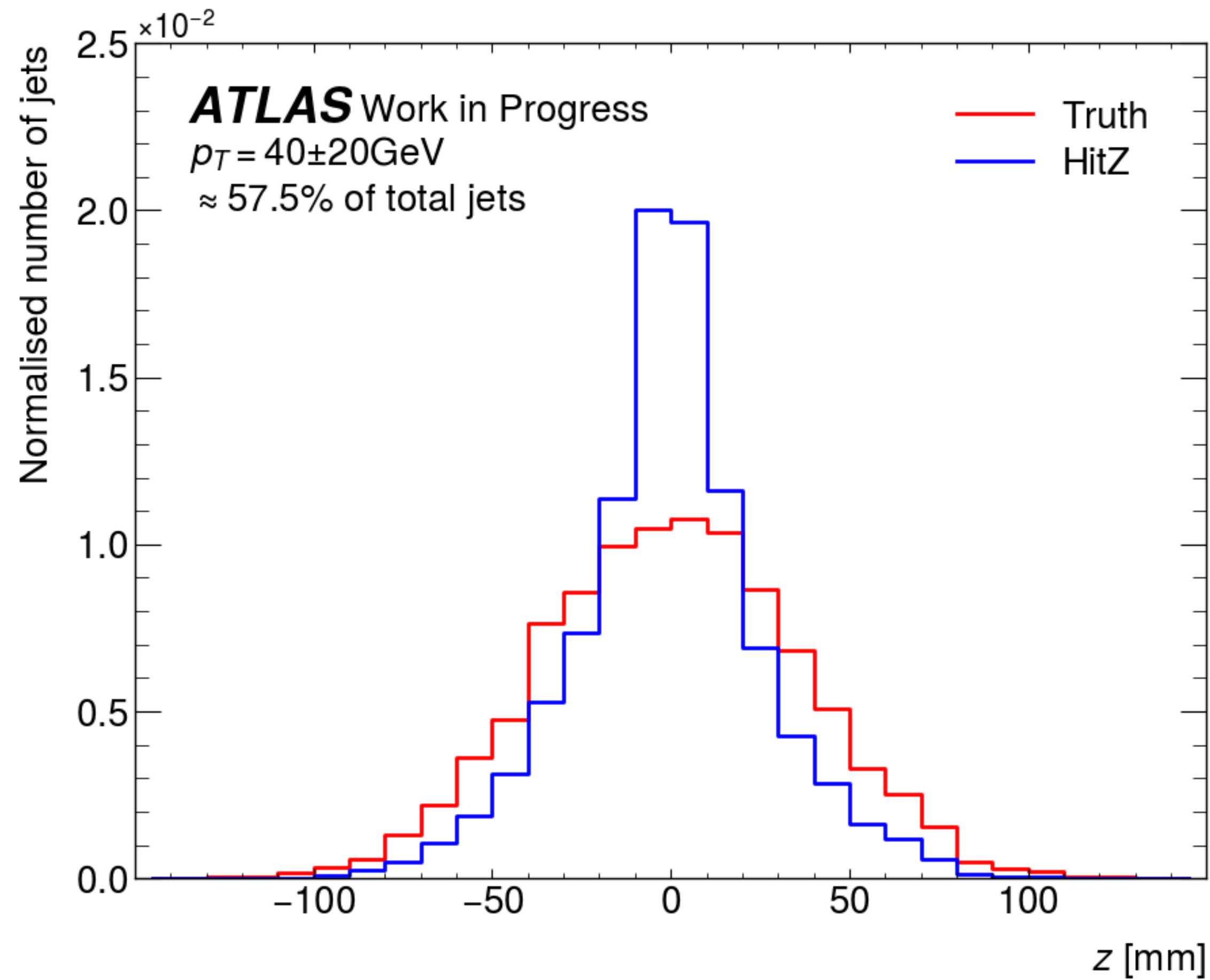
Deep Set Architecture



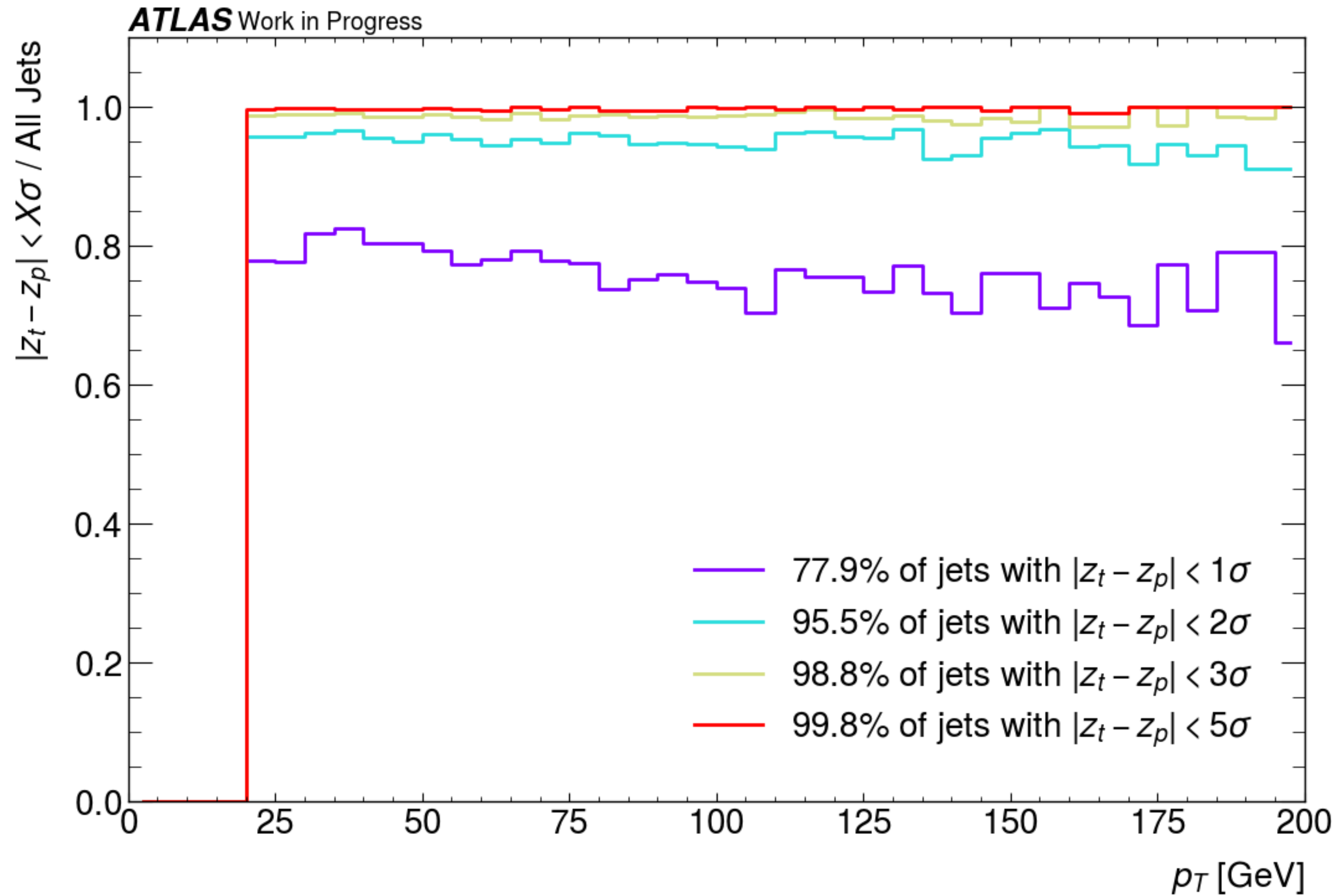
HitZ - Performance



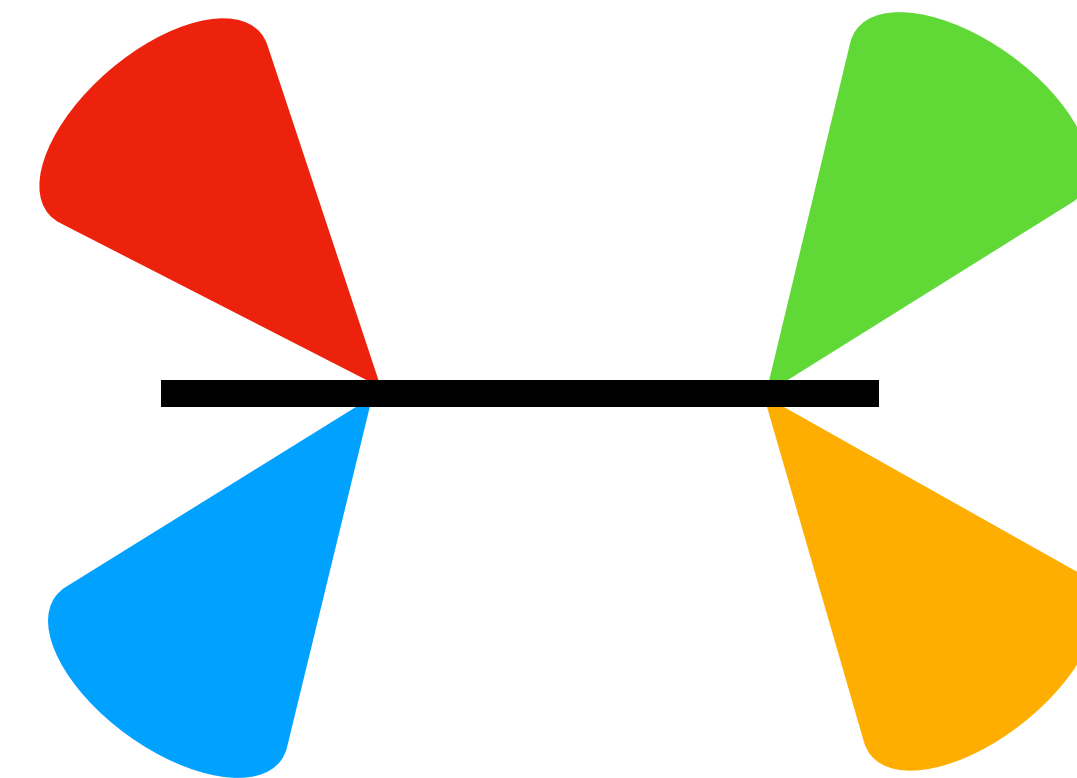
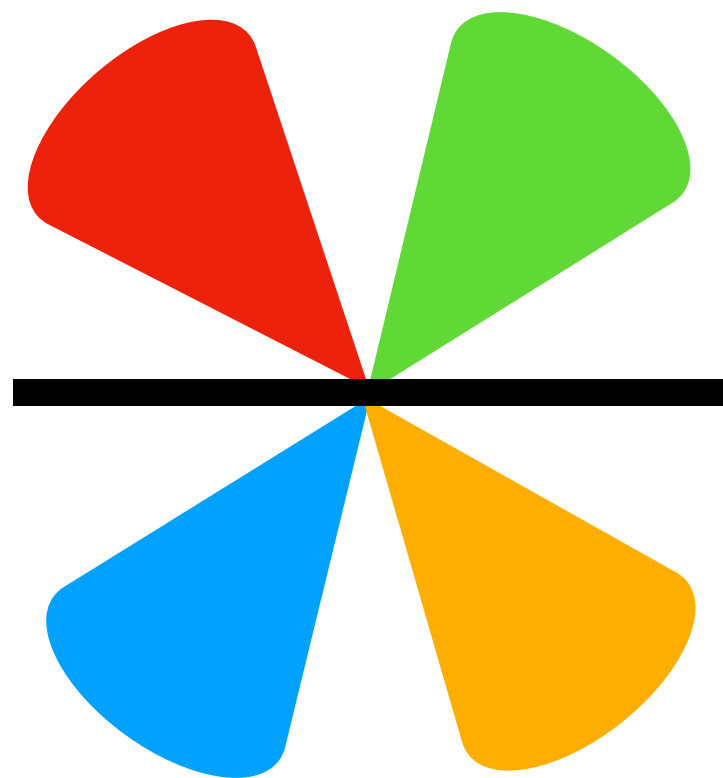
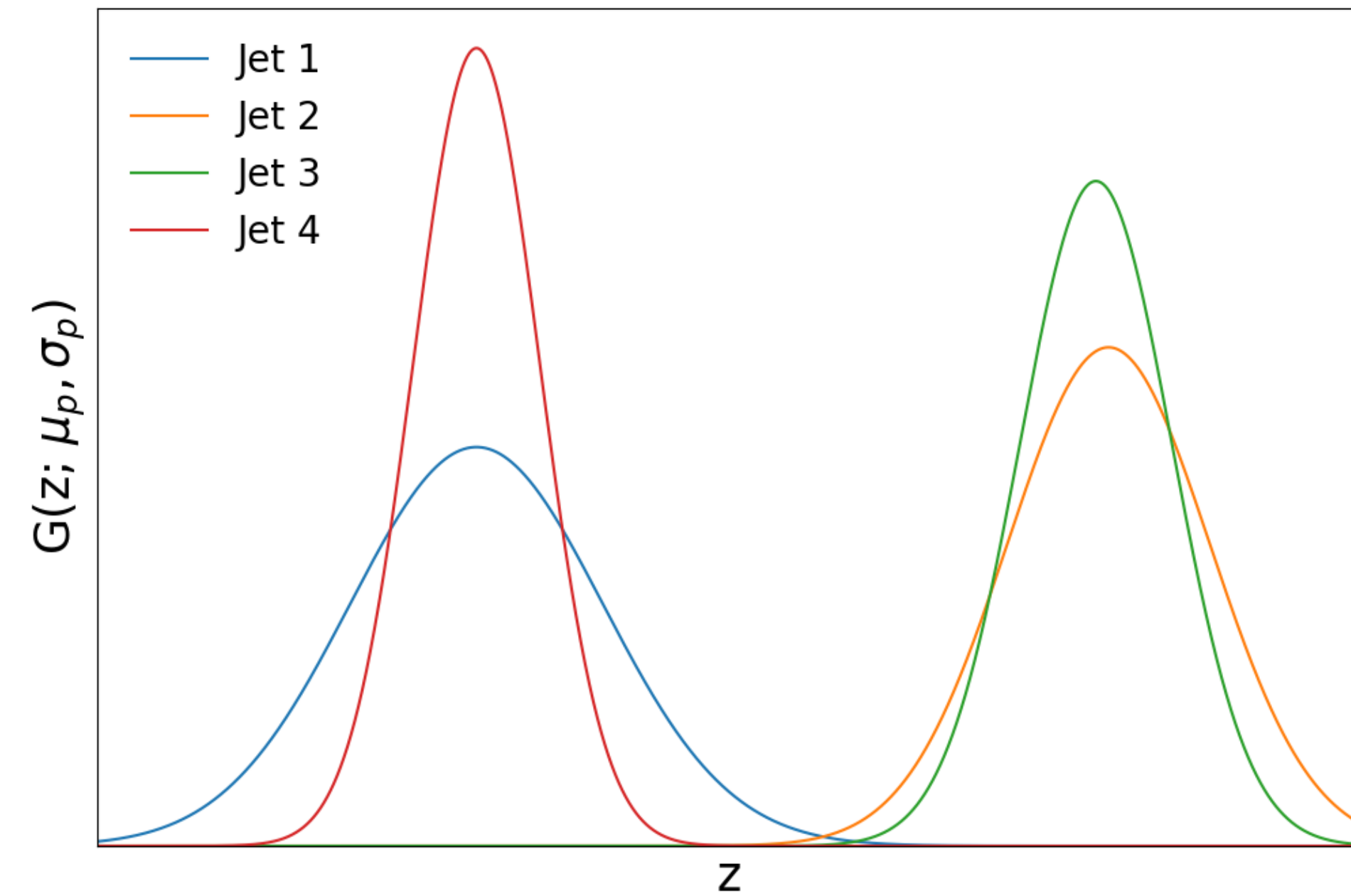
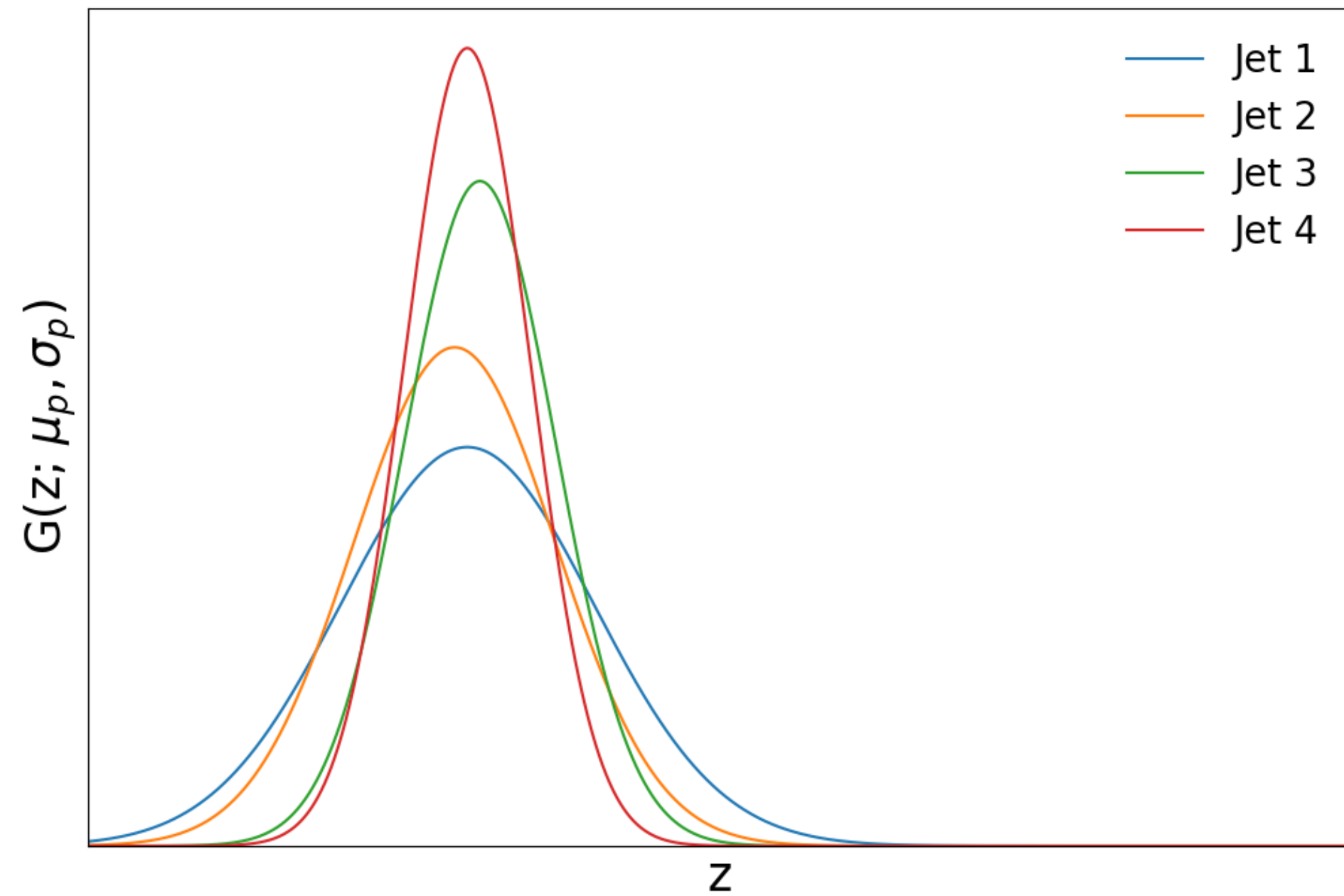
HitZ - p_T Dependency



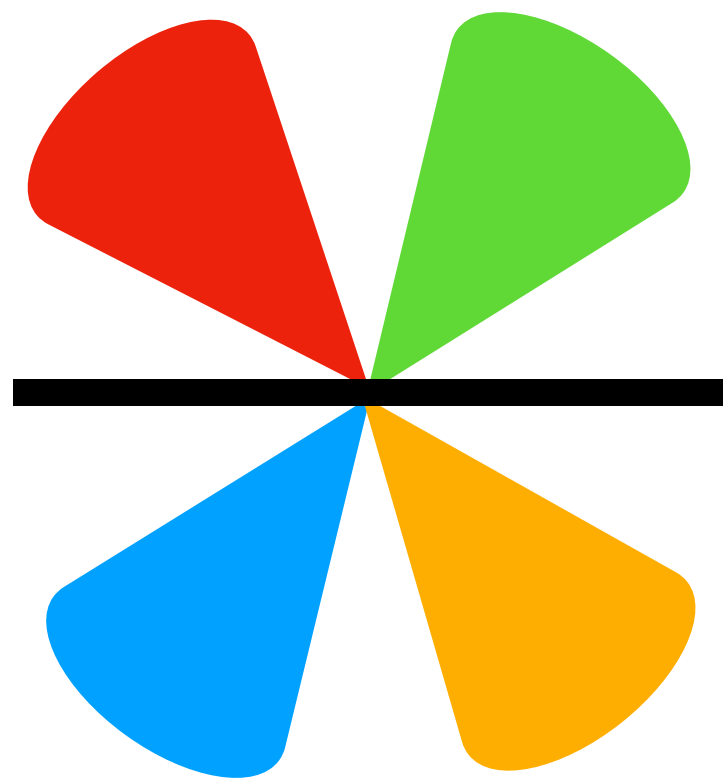
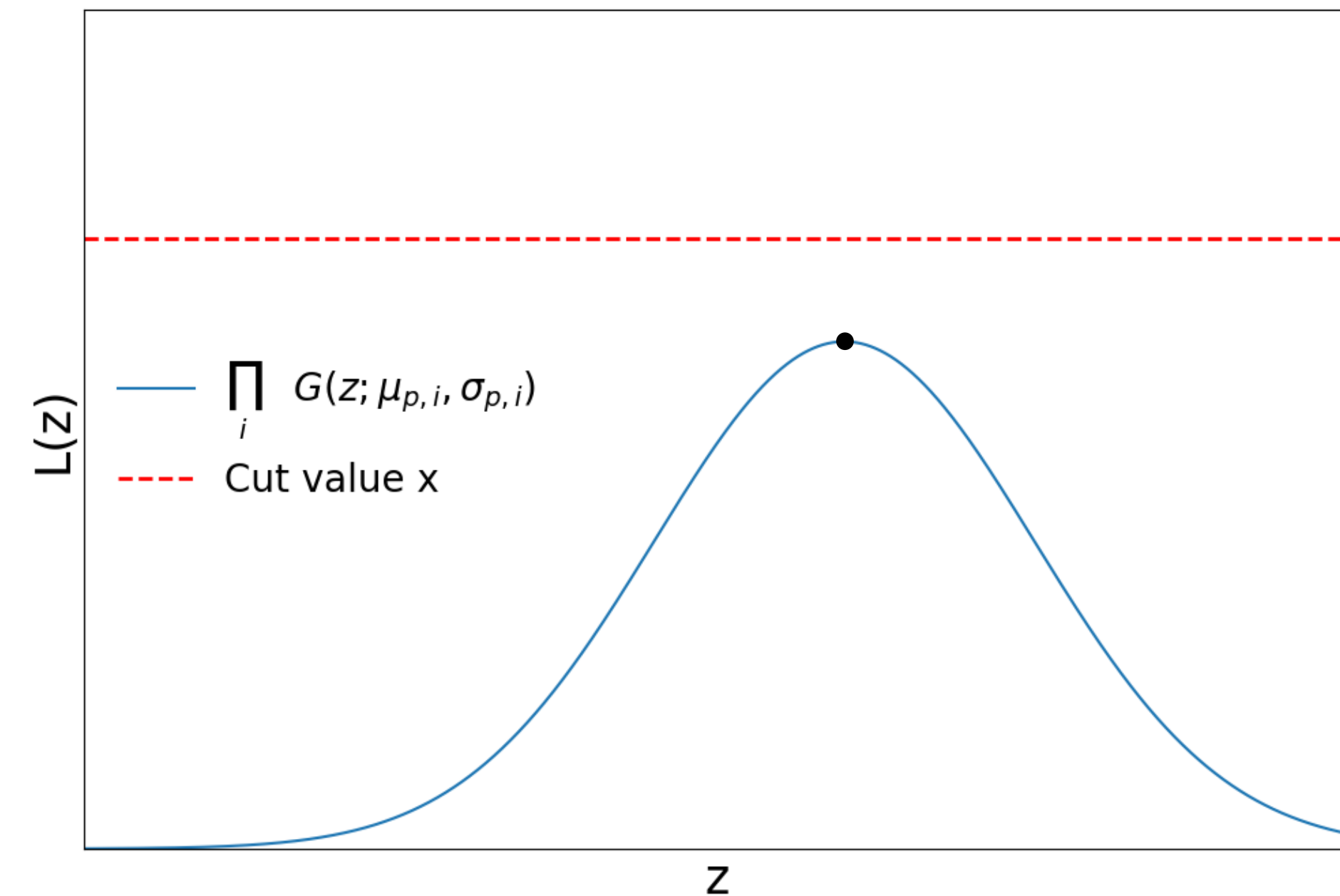
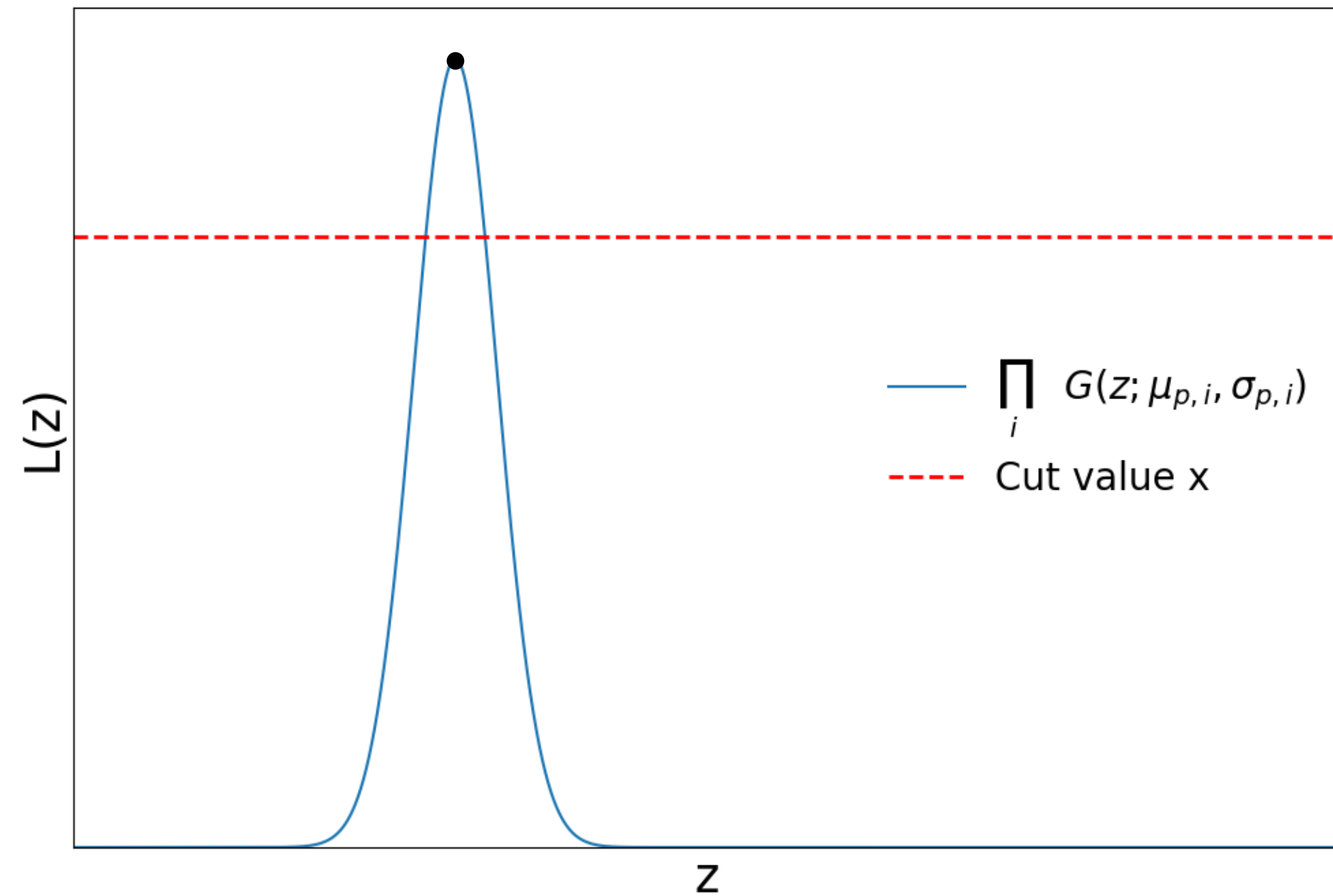
HitZ - p_T Dependency



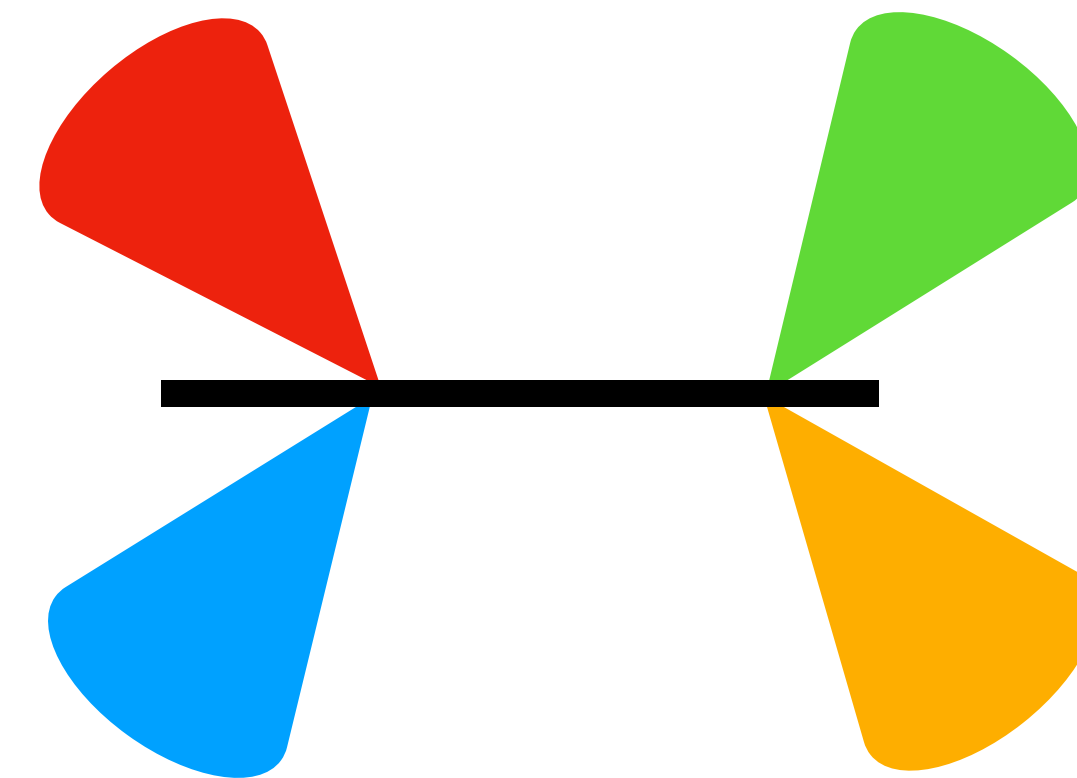
Implementing a Trigger Hypothesis



Implementing a Trigger Hypothesis

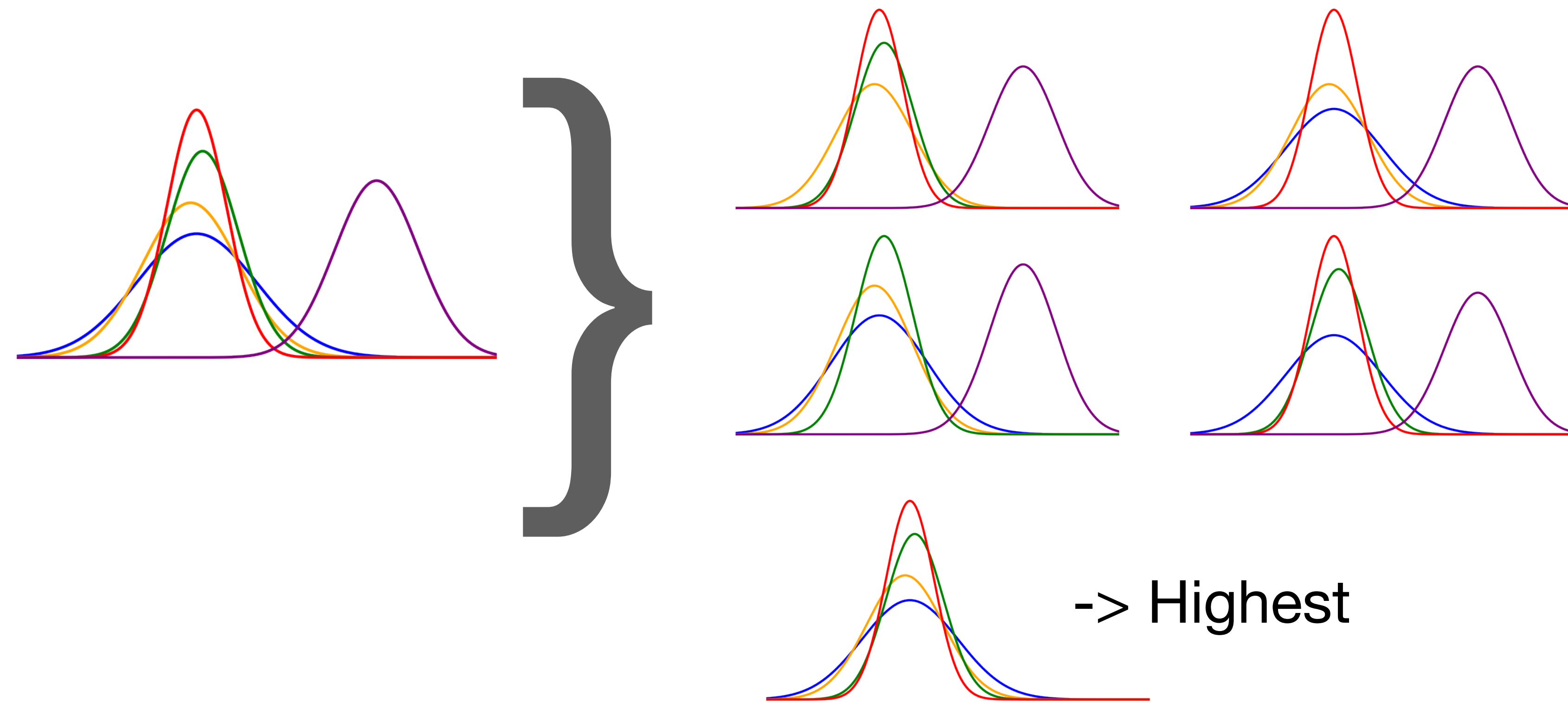


$$\mathcal{L}(z) = \prod_i G(z; \mu_{p,i}, \sigma_{p,i})$$



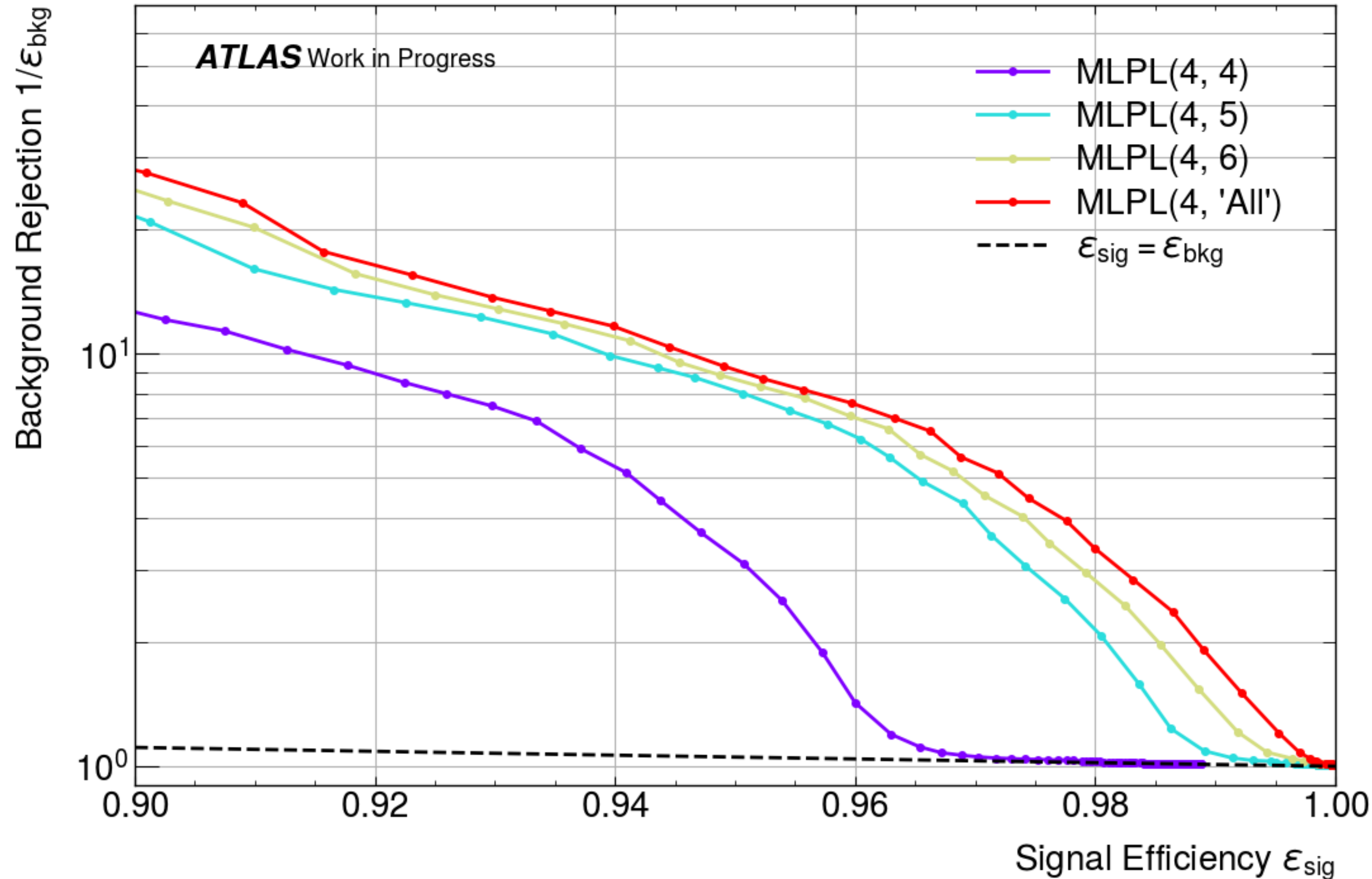
Implementing a Trigger Hypothesis

MLPL(4,5)



MLPL (n,m):
Best **n**-jet
combination out
of **m** leading p_T
jets

HitZ Performance (Signal: HH)

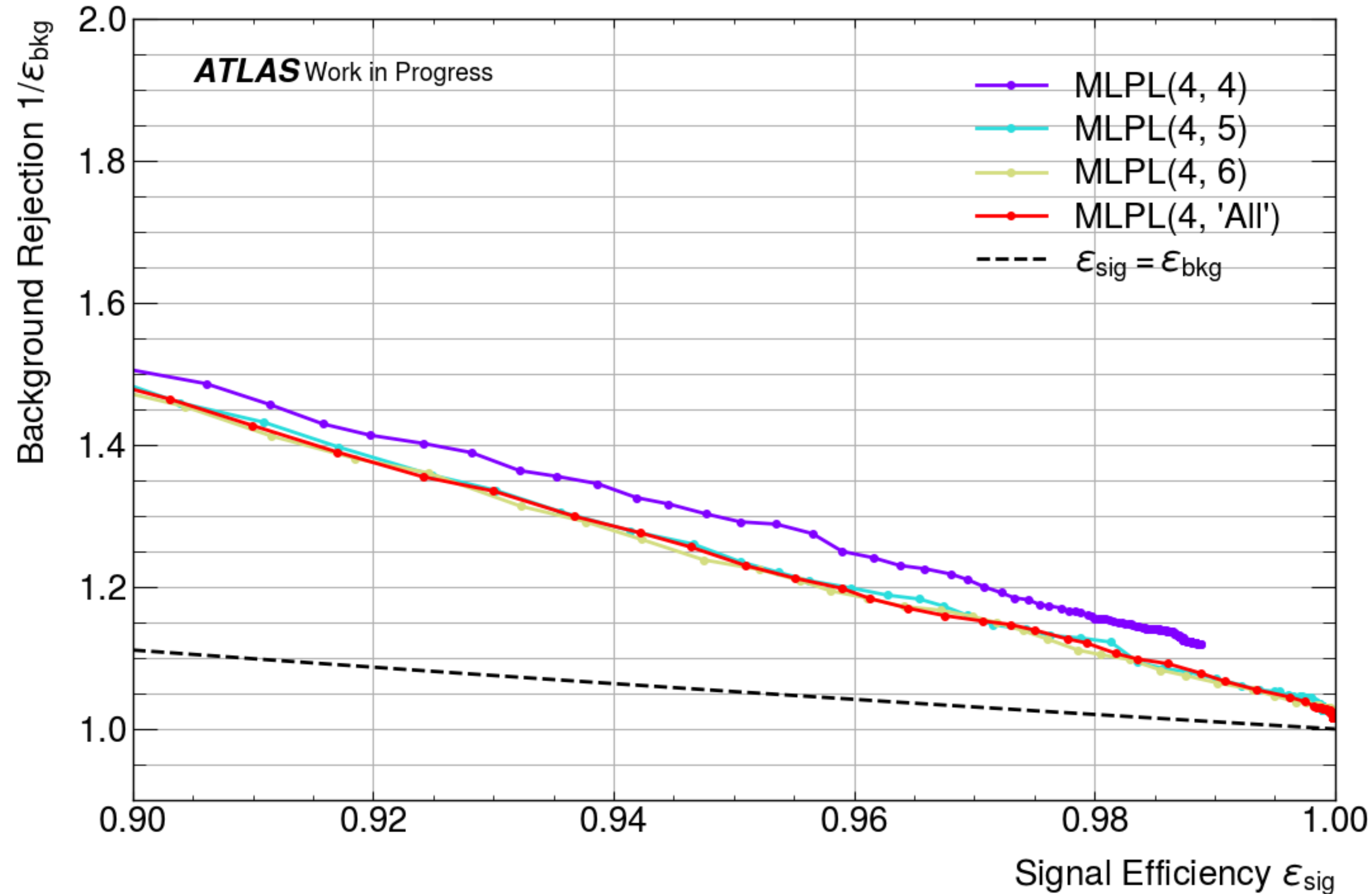


$$\epsilon_{sig} = \frac{(HH) \text{ and } (\mathcal{L}_{max} > x)}{(HH)}$$

$$\epsilon_{bkg} = \frac{(\text{dijet}) \text{ and } (\mathcal{L}_{max} > x)}{(\text{dijet})}$$

x = cut value

HitZ Performance (Signal: HH) + L1 trigger



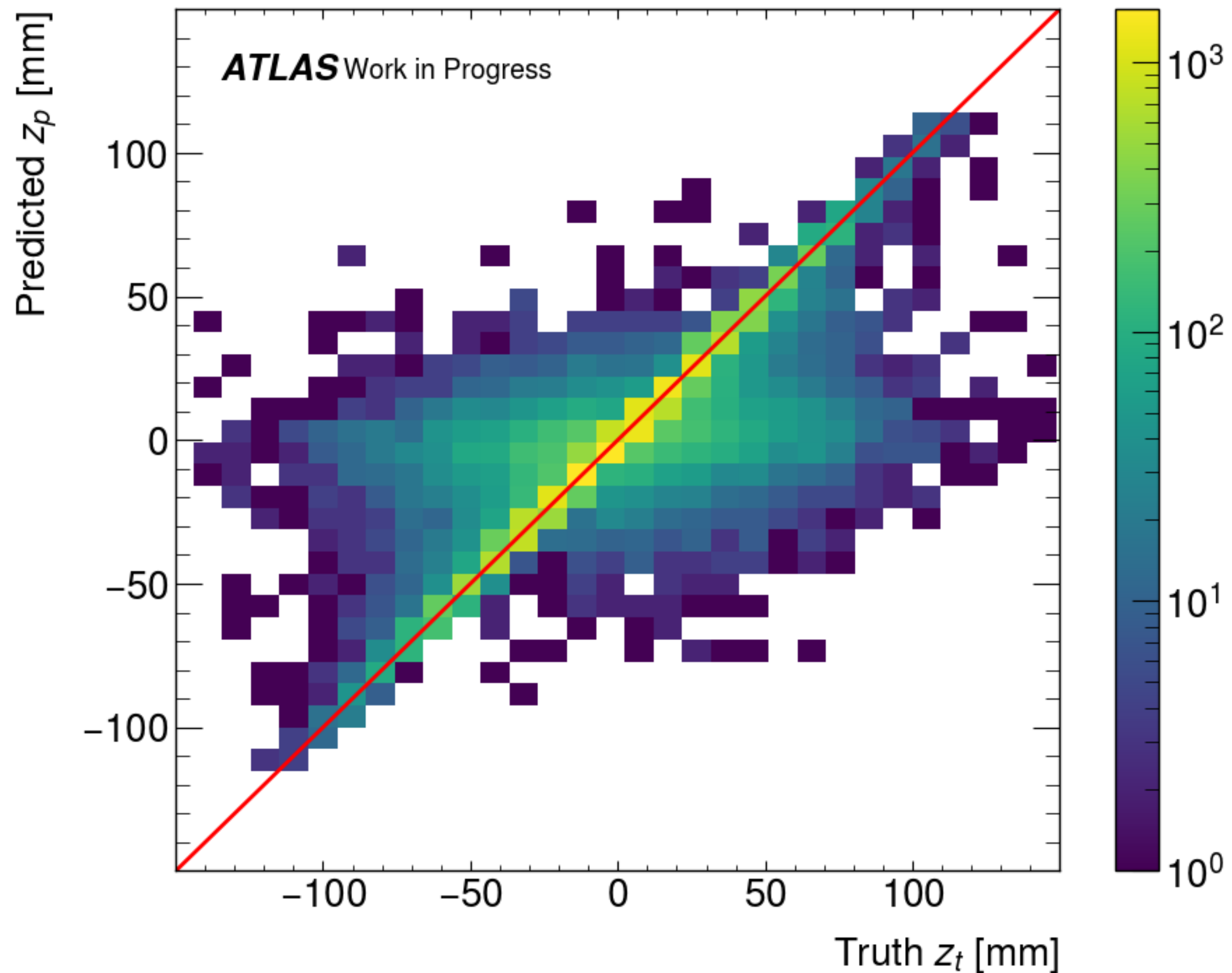
$$\epsilon_{sig} = \frac{(HH) \text{ and } (\mathcal{L}_{max} > x)}{(HH)}$$

$$\epsilon_{bkg} = \frac{(\text{dijet}) \text{ and } (\mathcal{L}_{max} > x)}{(\text{dijet})}$$

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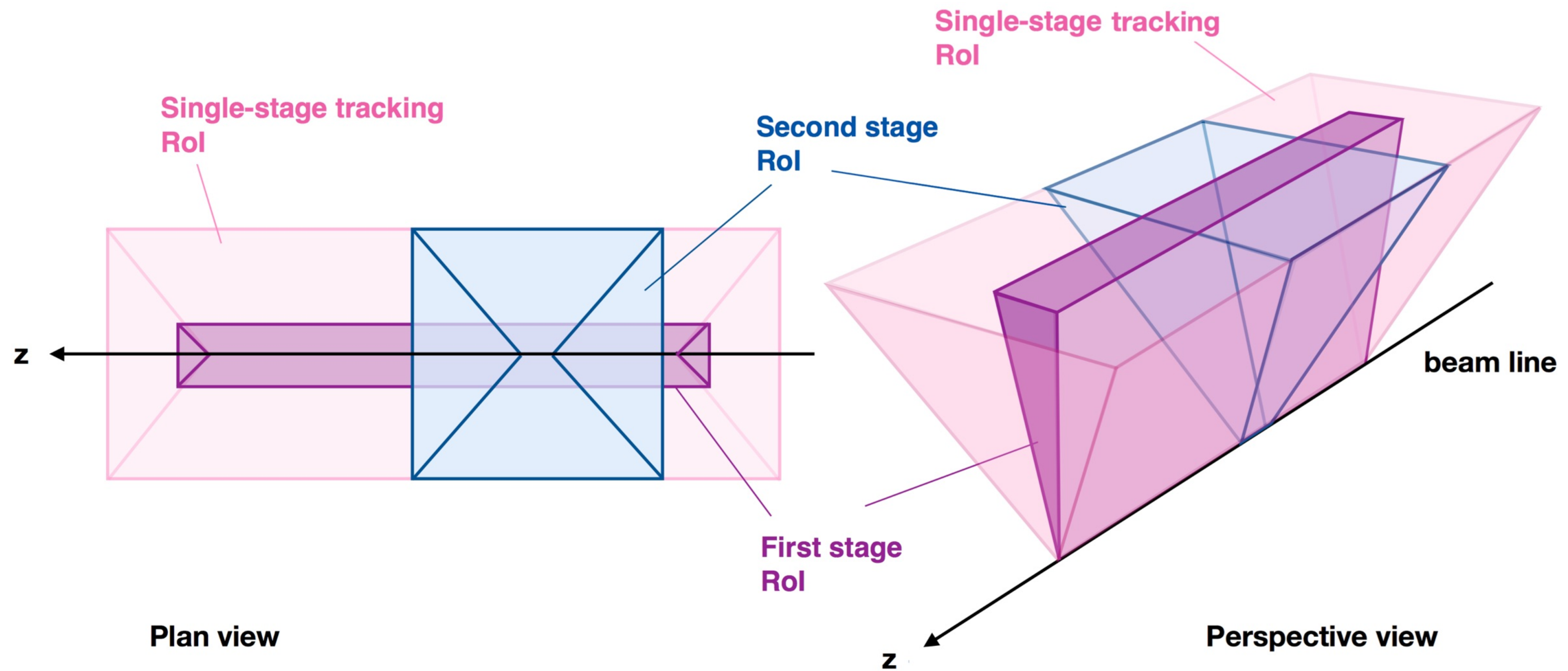
Significant Decrease!

HitZ - still a useful project?

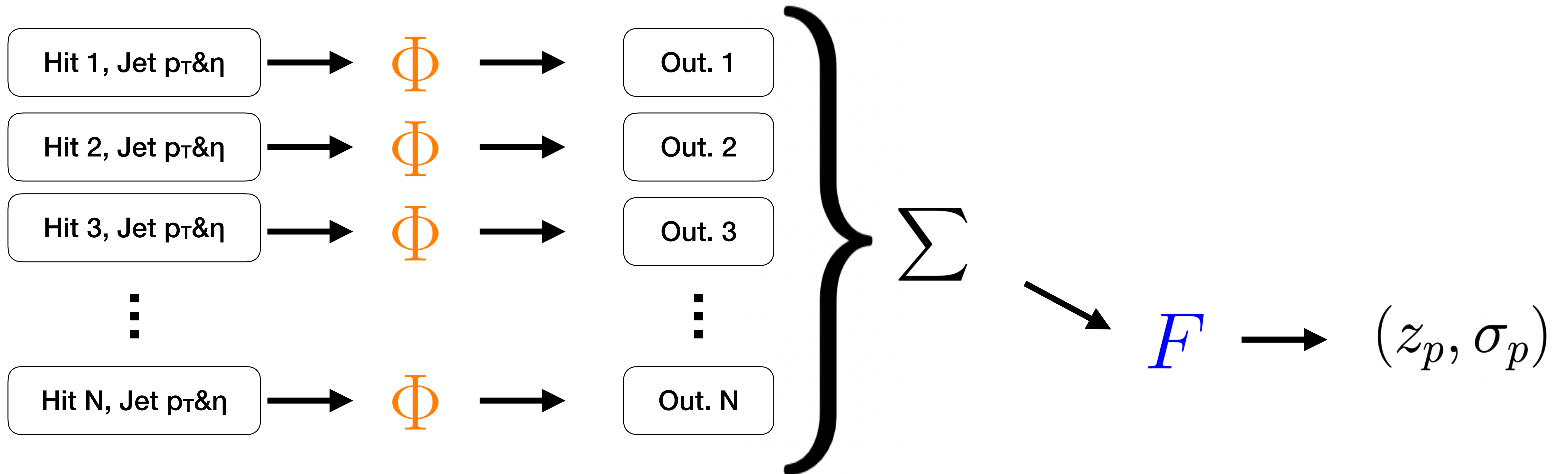


- It is still possible to make a **z** position prediction for each individual jet
- This information can be used for other applications

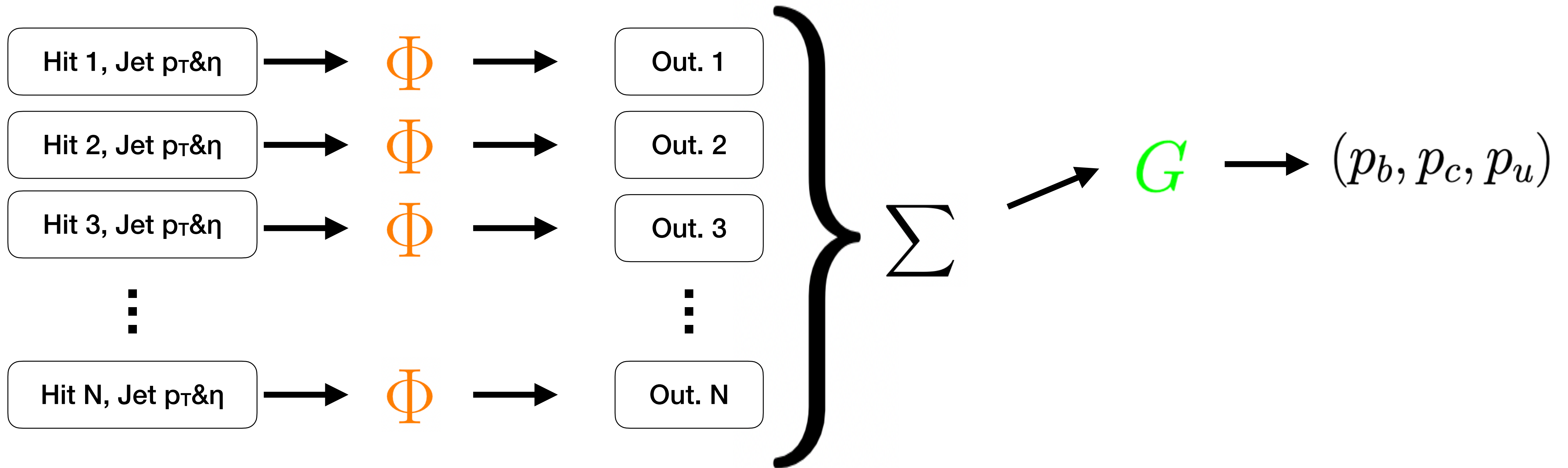
HitZ as input for ROI tracking



Further Ideas using Hit-Level Information

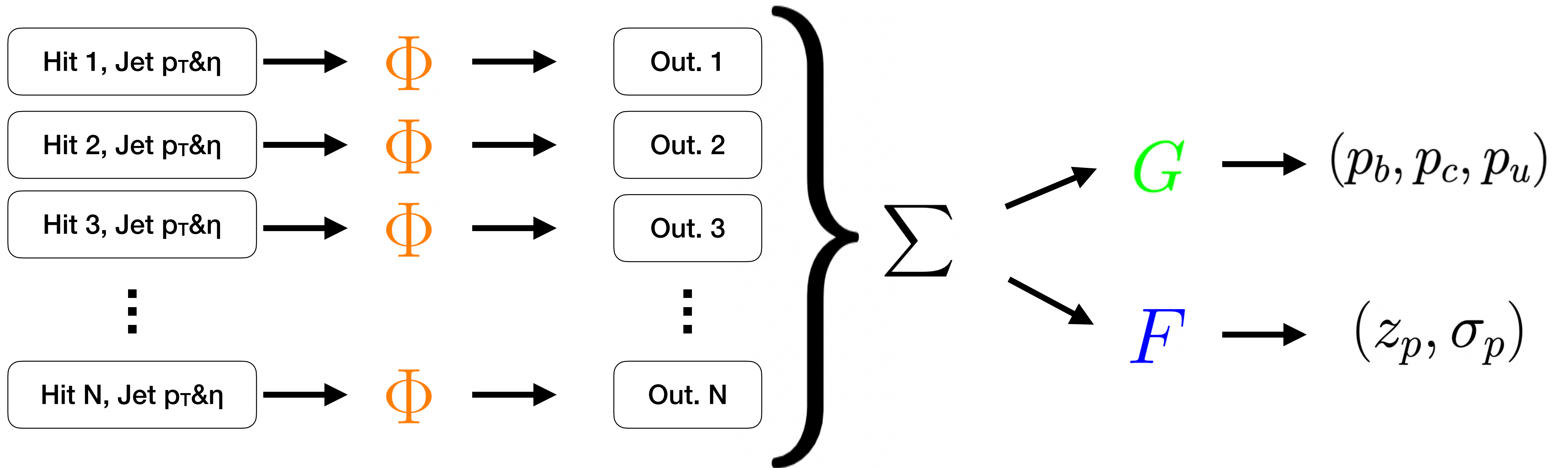


Further Ideas using Hit-Level Information



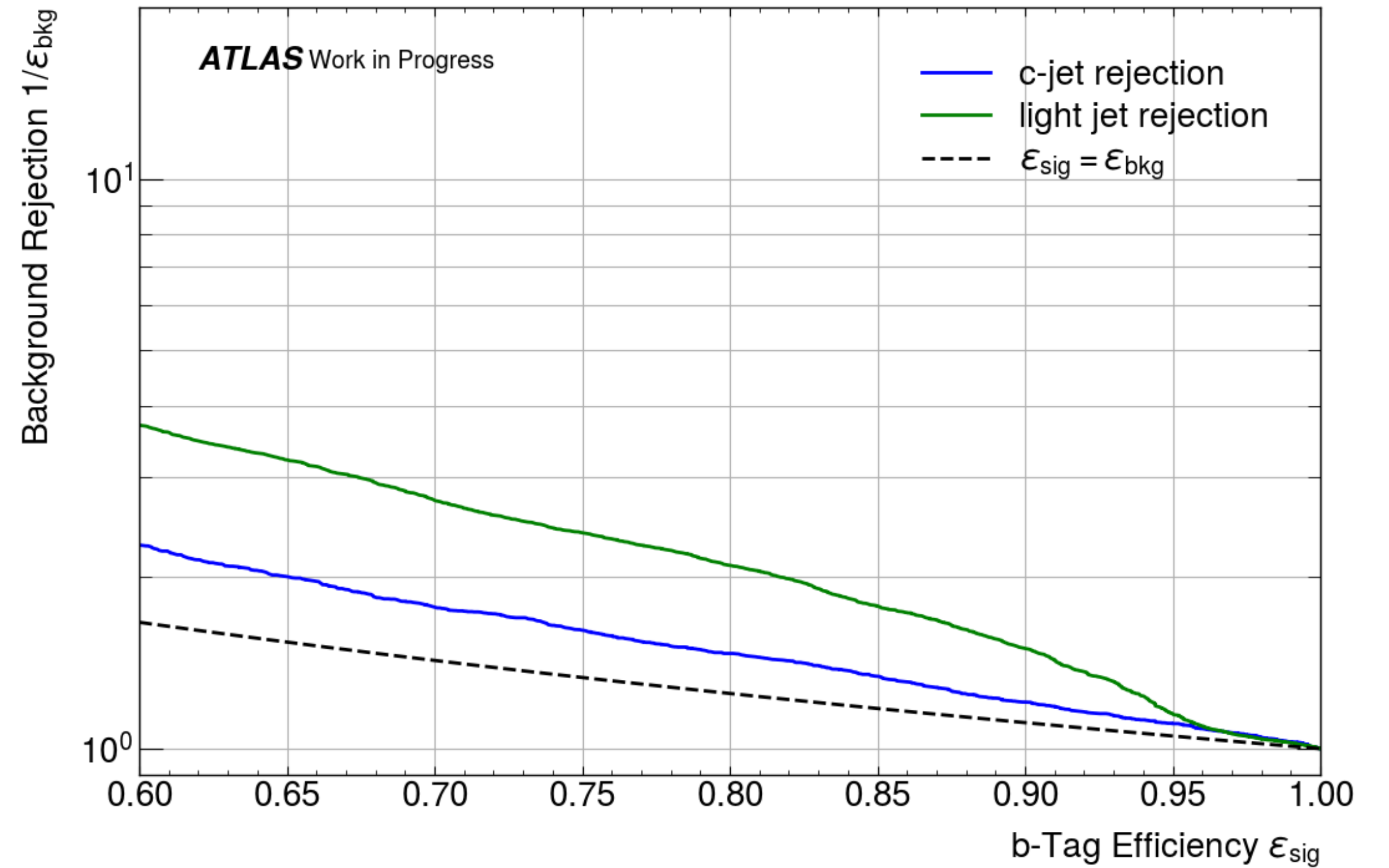
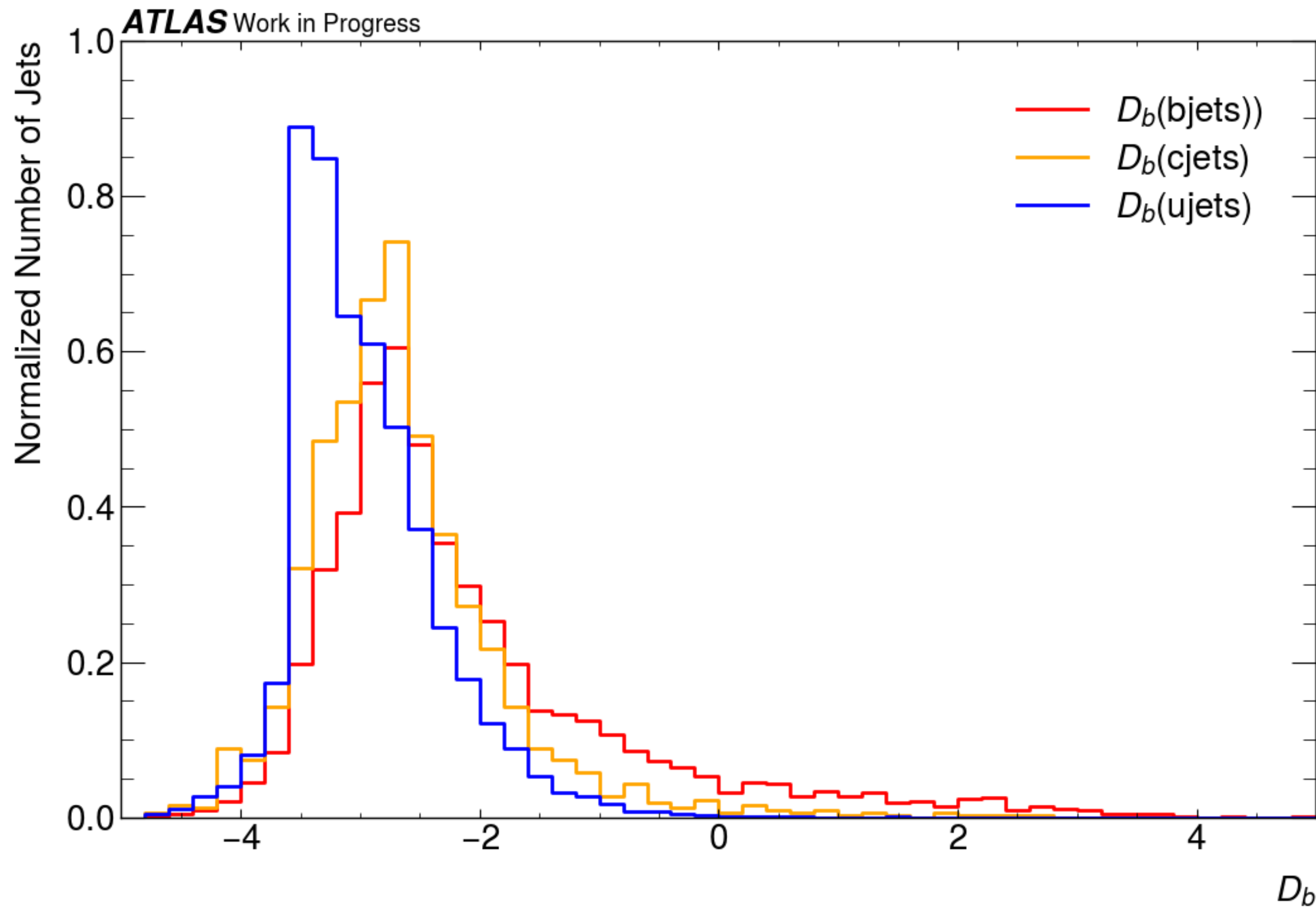
$$D_b(f_c) = \log \left(\frac{p_b}{f_c \cdot p_c + (1 - f_c) \cdot p_u} \right)$$

Further Ideas using Hit-Level Information



$$D_b(f_c) = \log \left(\frac{p_b}{f_c \cdot p_c + (1 - f_c) \cdot p_u} \right)$$

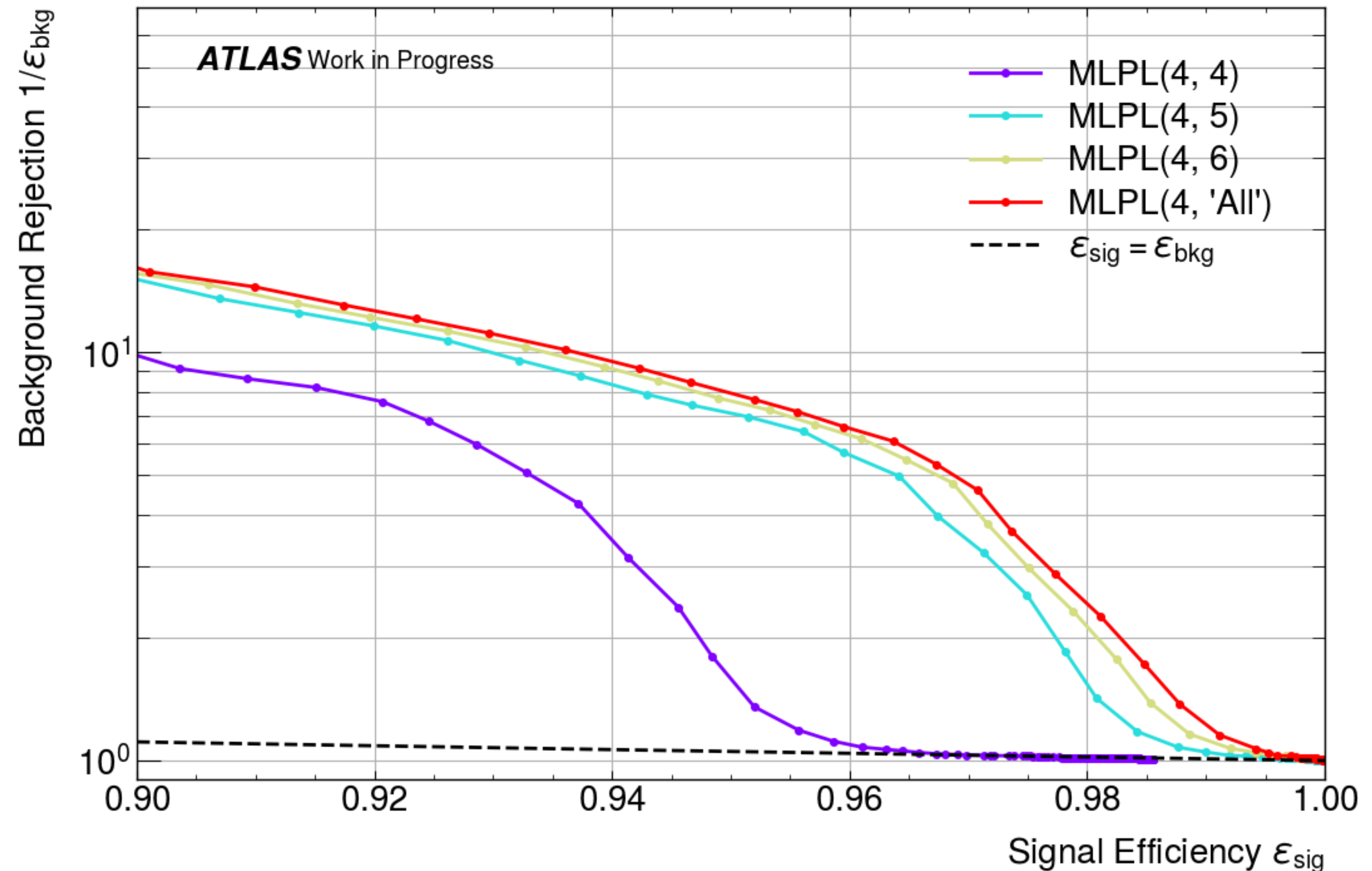
Hit-level based b-tagging



$$D_b(f_c) = \log \left(\frac{p_b}{f_c \cdot p_c + (1 - f_c) \cdot p_u} \right)$$

Conclusion

- Primary vertex prediction of jets is possible based on hit-level information
- Pile-up rejection still has to be further evaluated
- Possible Applications in fast ROI tracking and b-tagging



HitZ as input for ROI tracking

