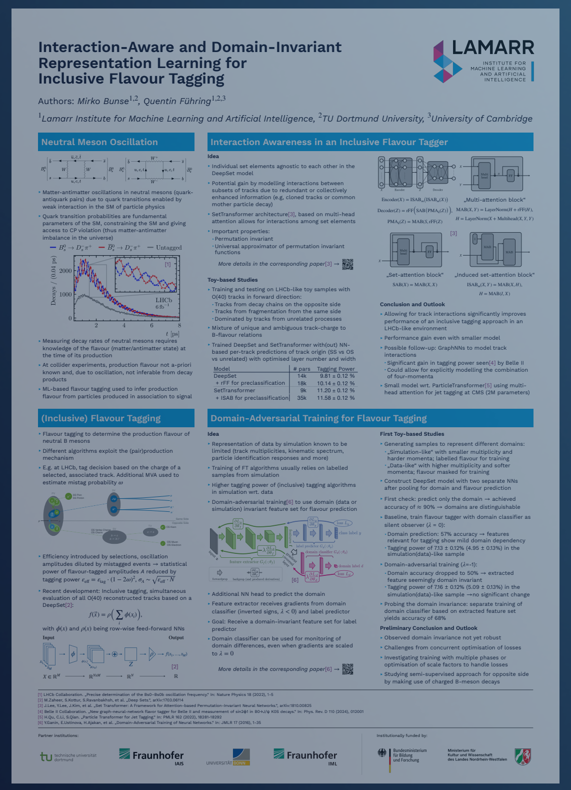
LAMARR

INSTITUTE FOR MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE

Interaction-Aware and Domain-Invariant Representation Learning for Inclusive Flavour Tagging



EuCAIFCon 2025, Cagliari

Foundations Models - Flash Talk for Poster Session B

Mirko Bunse[1,2], Quentin Führing[1,2,3]

[1]TU Dortmund University, [2]Lamarr Institute for Artificial Intelligence and Machine Learning, [3]University of Cambridge

Partner institutions:

technische universität dortmund

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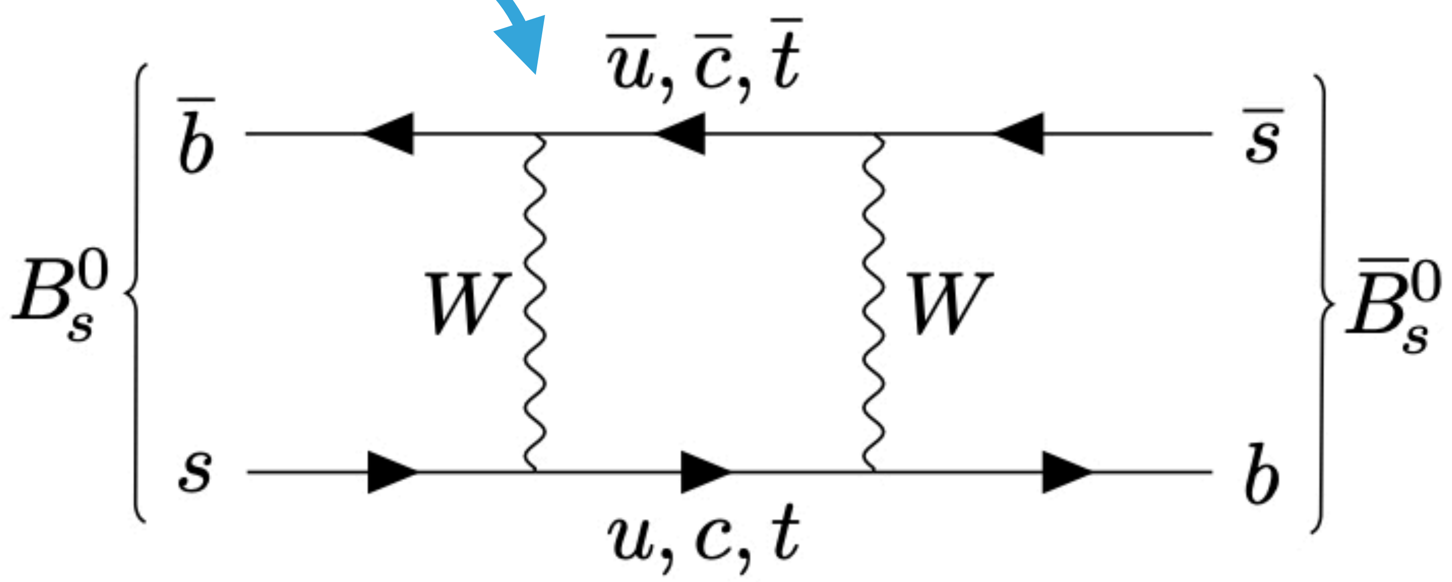
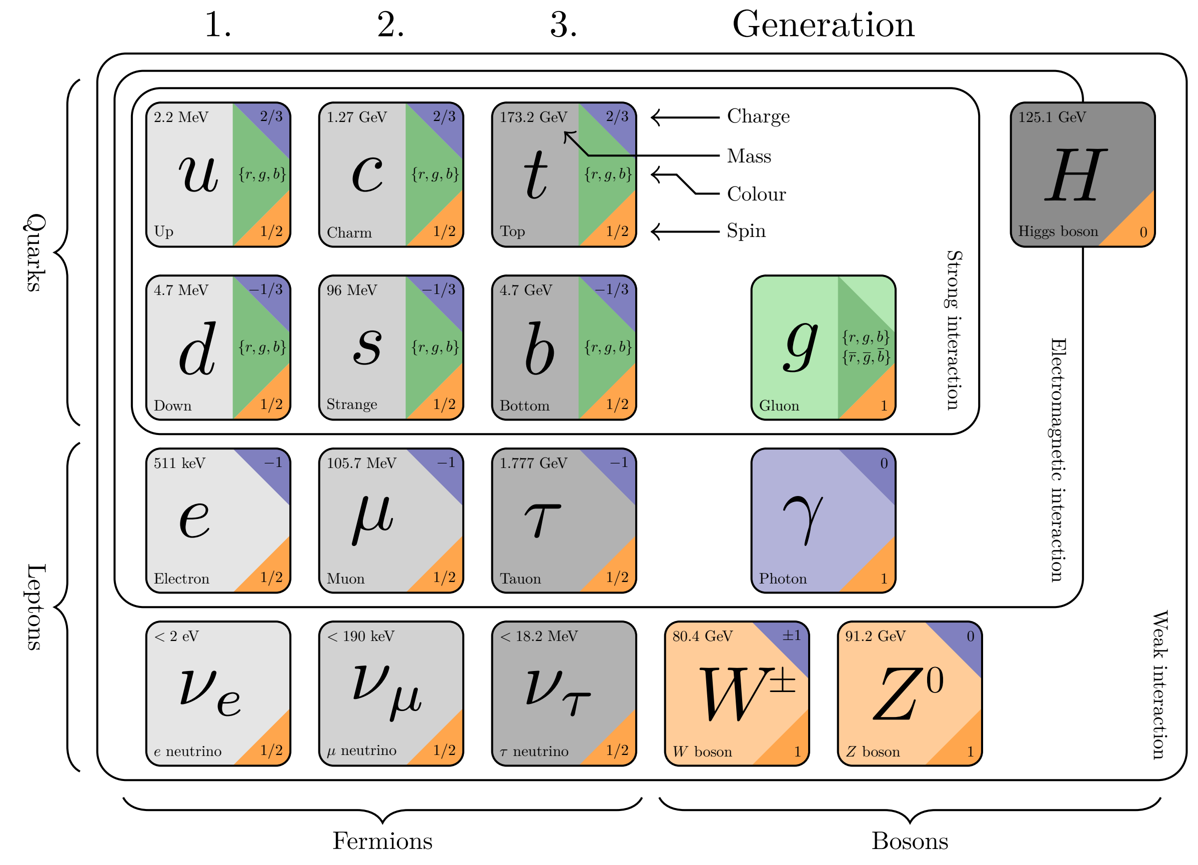
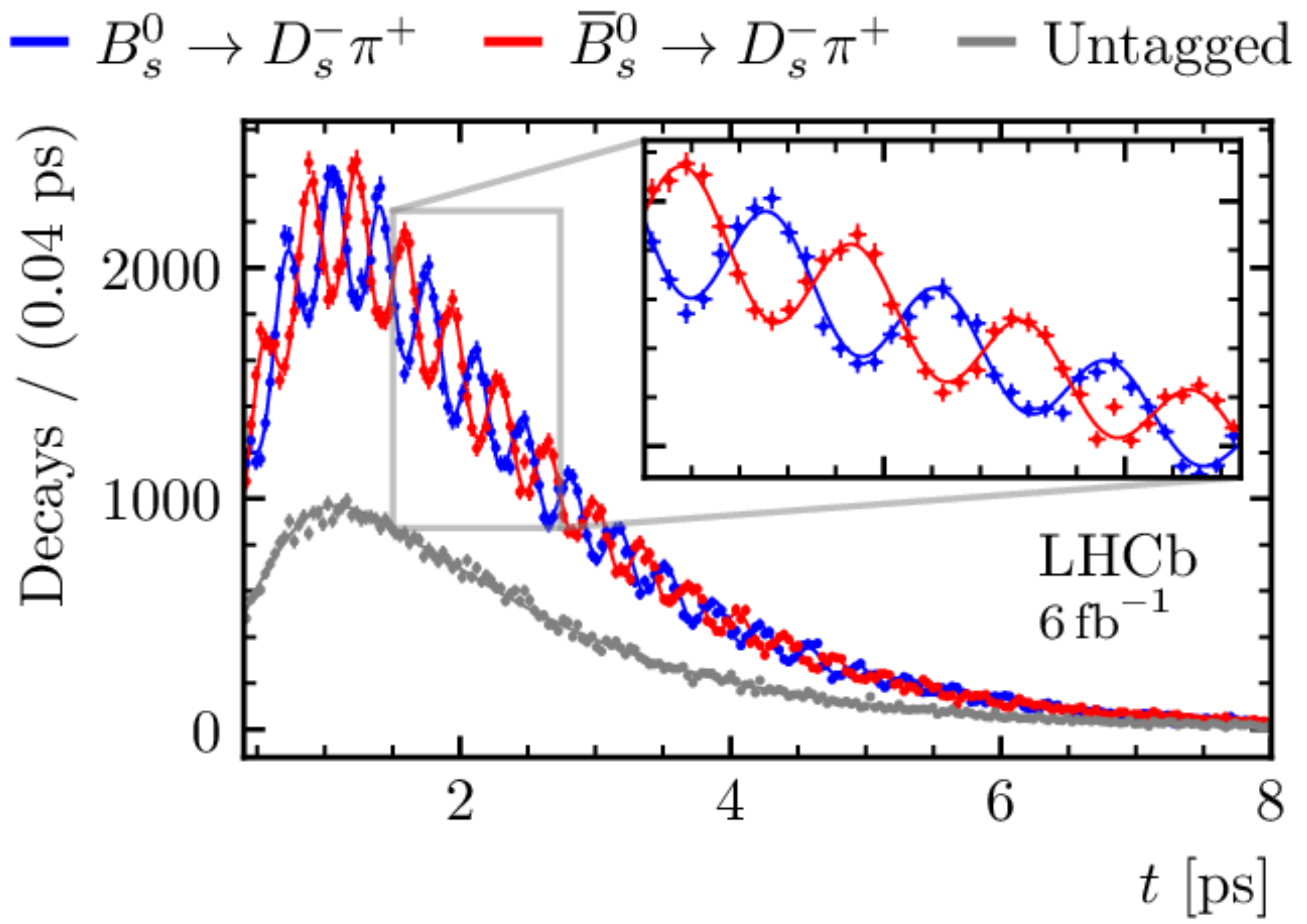
Physics Motivation: Neutral $B^0_{(s)}$-meson oscillations

Quark-mixing probabilities:
Fundamental properties of the SM

$$V_{\mathrm{CKM}} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$







[LHCb collaboration, Precise determination of the Bs-Bsb oscillation frequency, In: Nature Physics 18, 1-5 (2022)]

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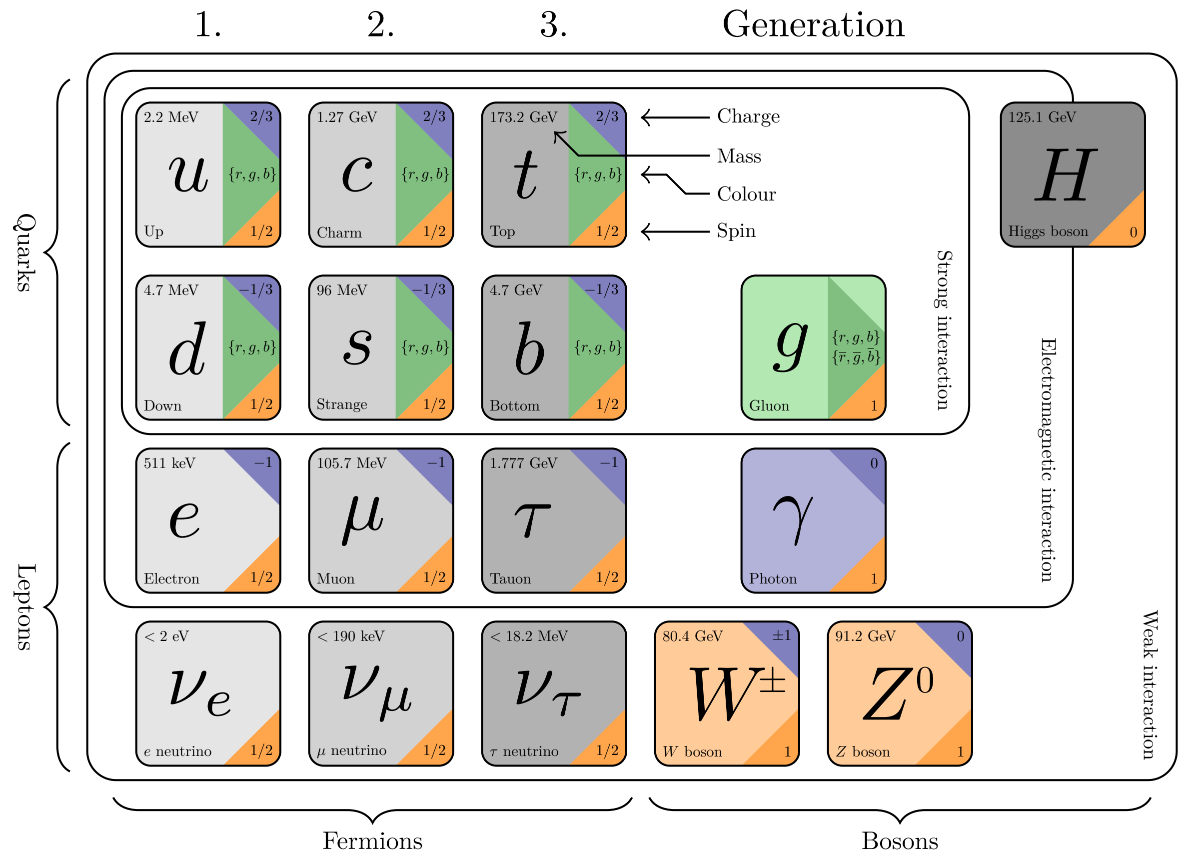
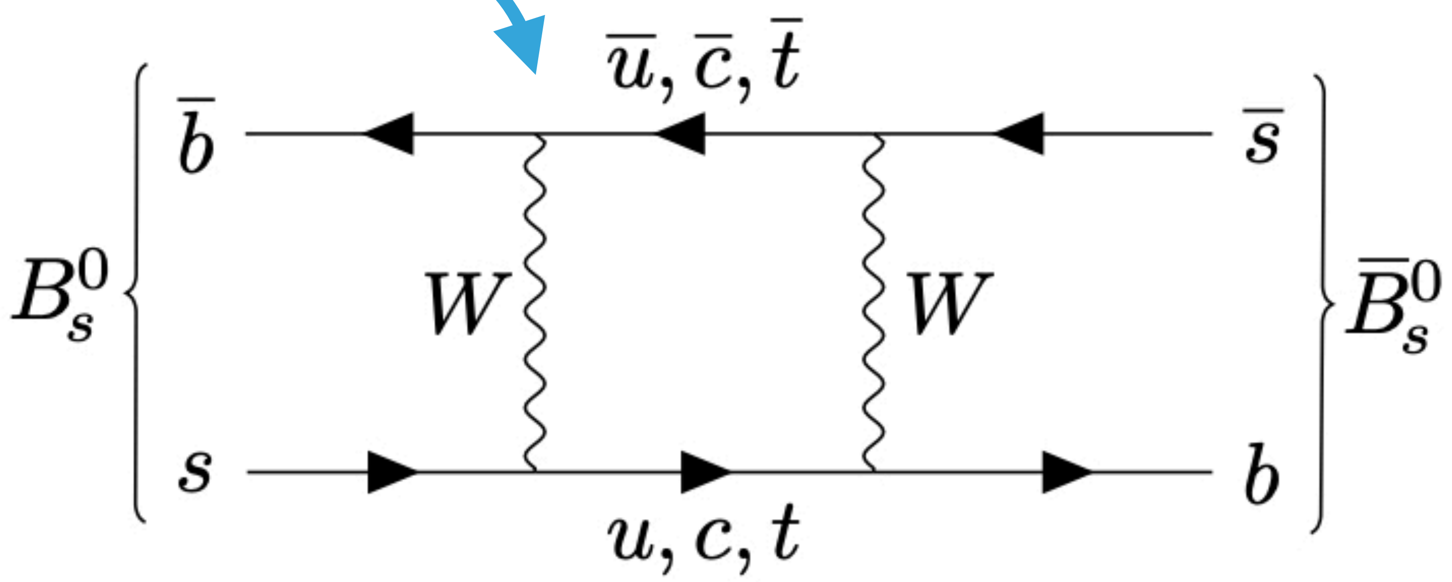
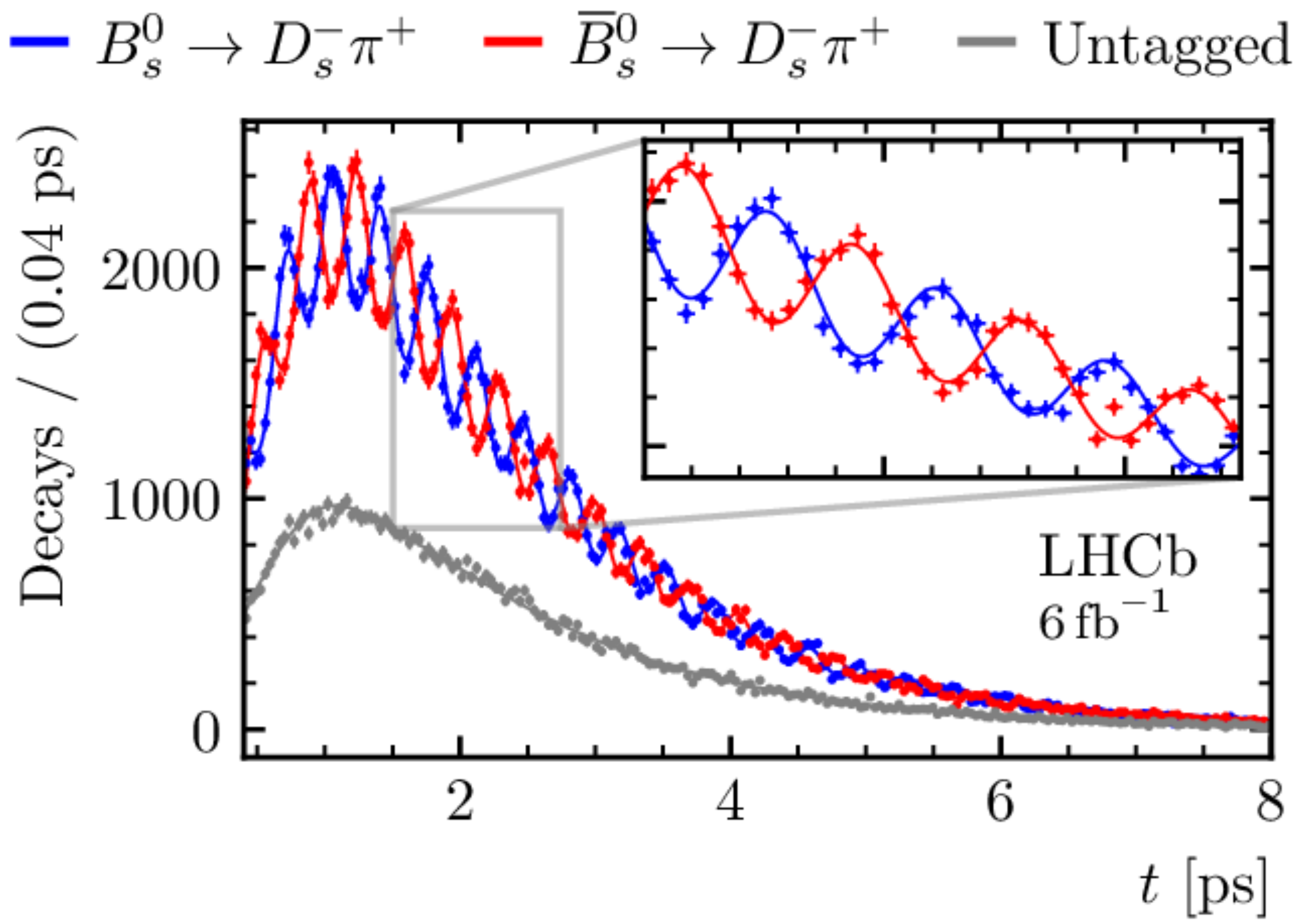




$B_s^0 \to f$

$\overline{B}_s^0 \to B_s^0 \to f$



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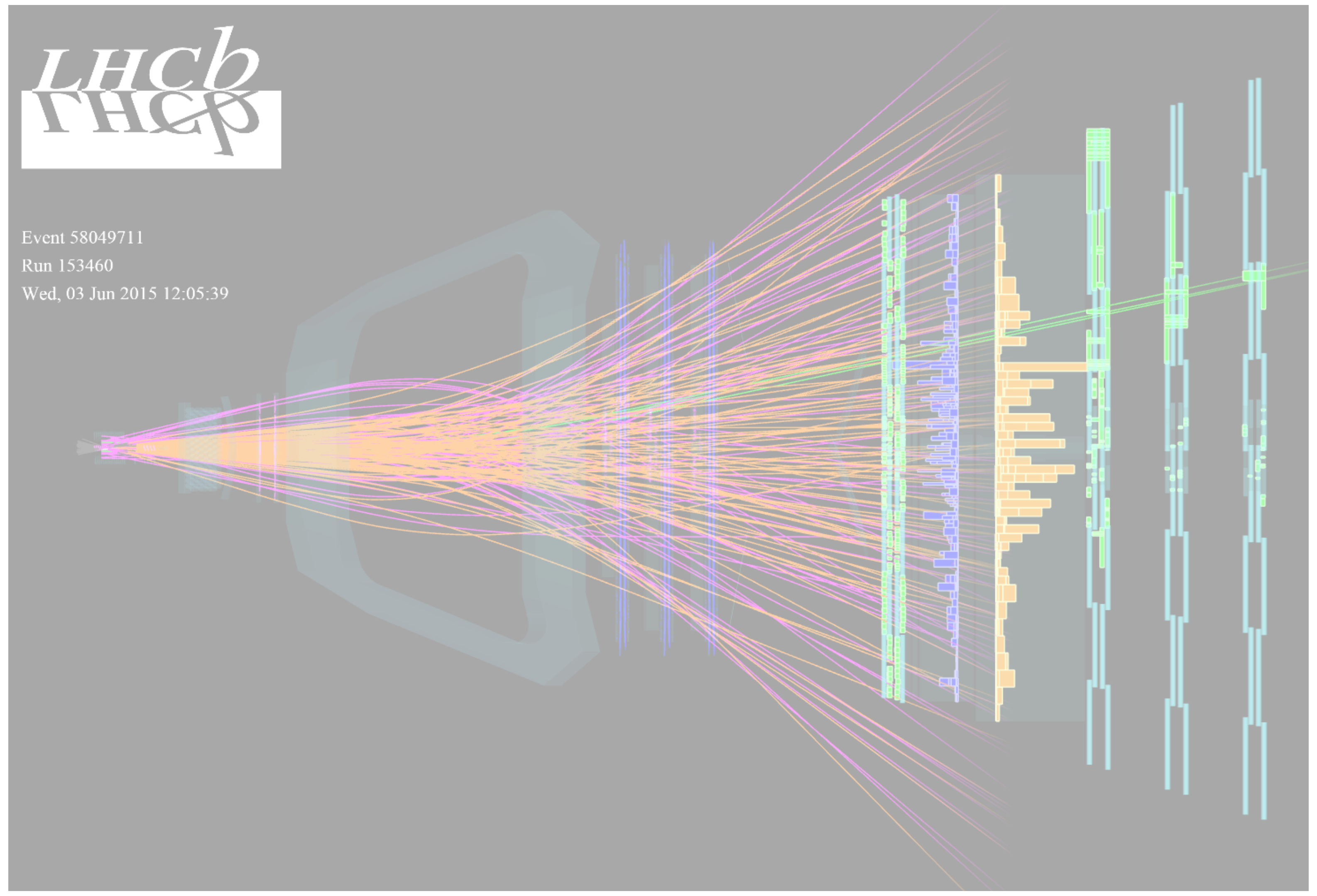
Oscillation measurements require knowledge of the initial state (B_s^0 or $\overline{B}_s^0$)

Inclusive Flavour Tagging



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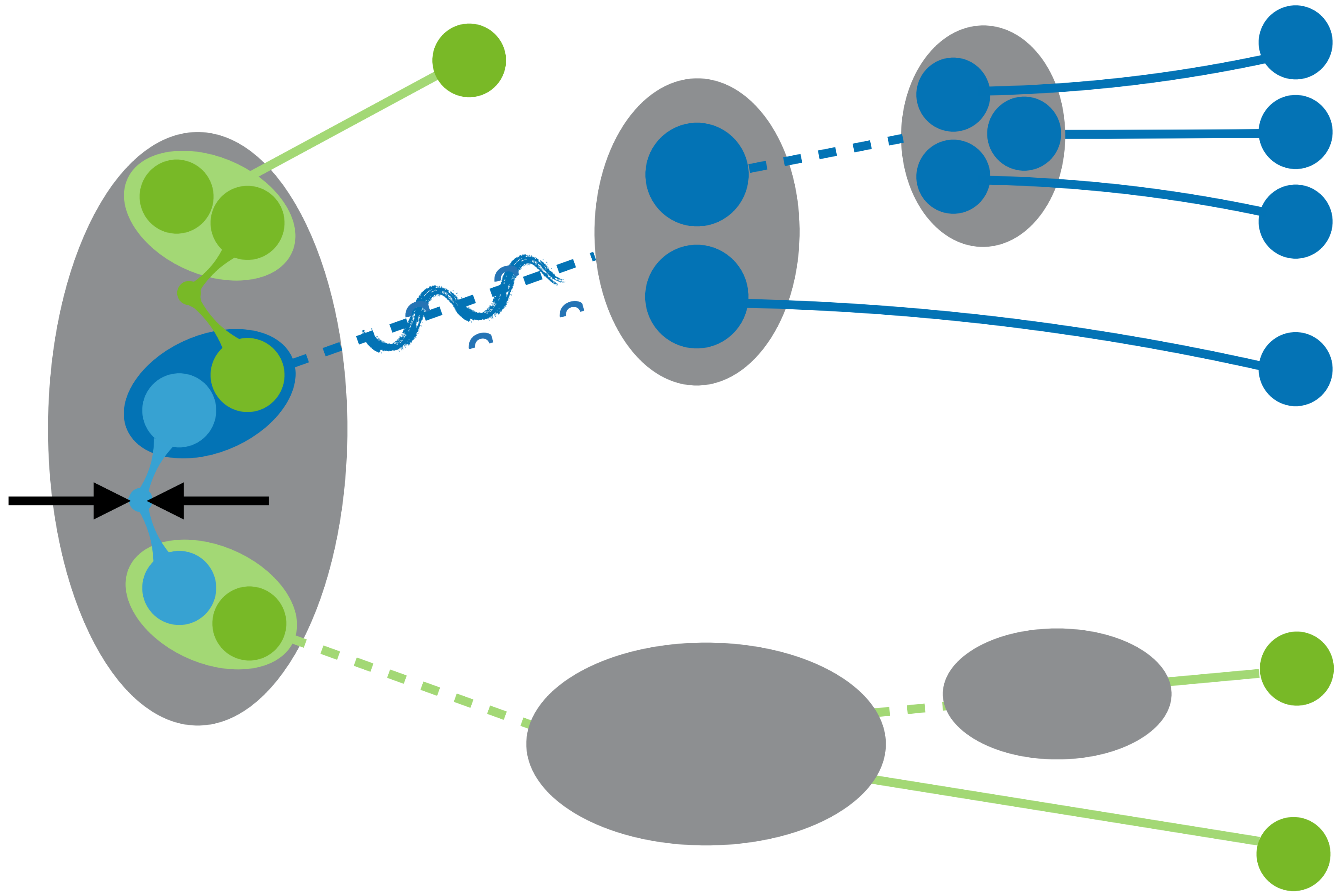
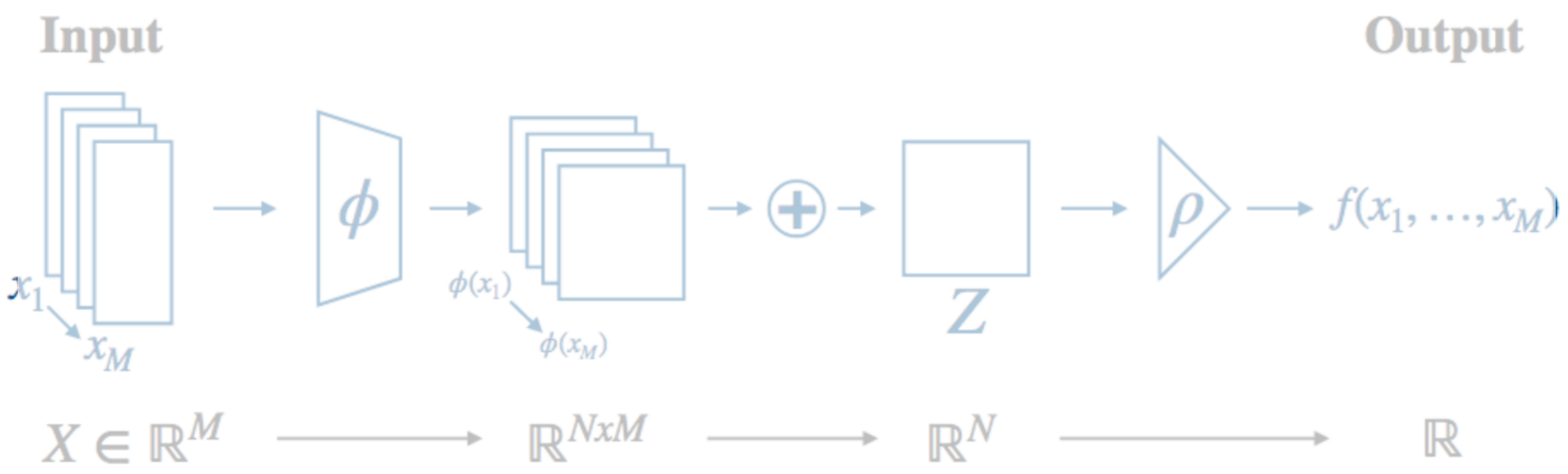
Flavour Tagging:
Algorithms exploiting specific processes

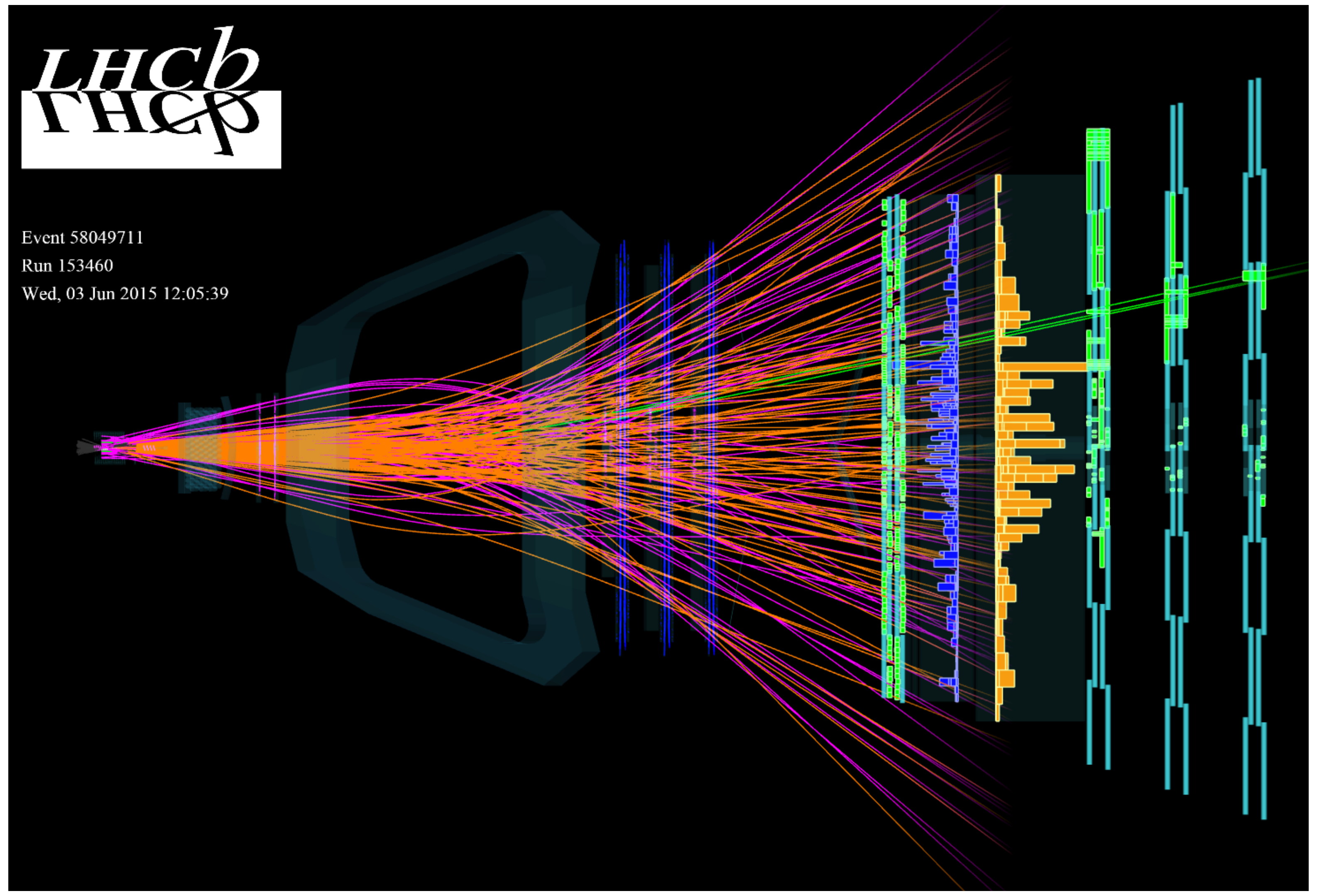


Inclusive Flavour Tagging:
Simultaneous analysis of all tracks with DeepSet NN



[Zaheer et.al., Deep Sets, arXiv:1703.06114]

Inclusive Flavour Tagging



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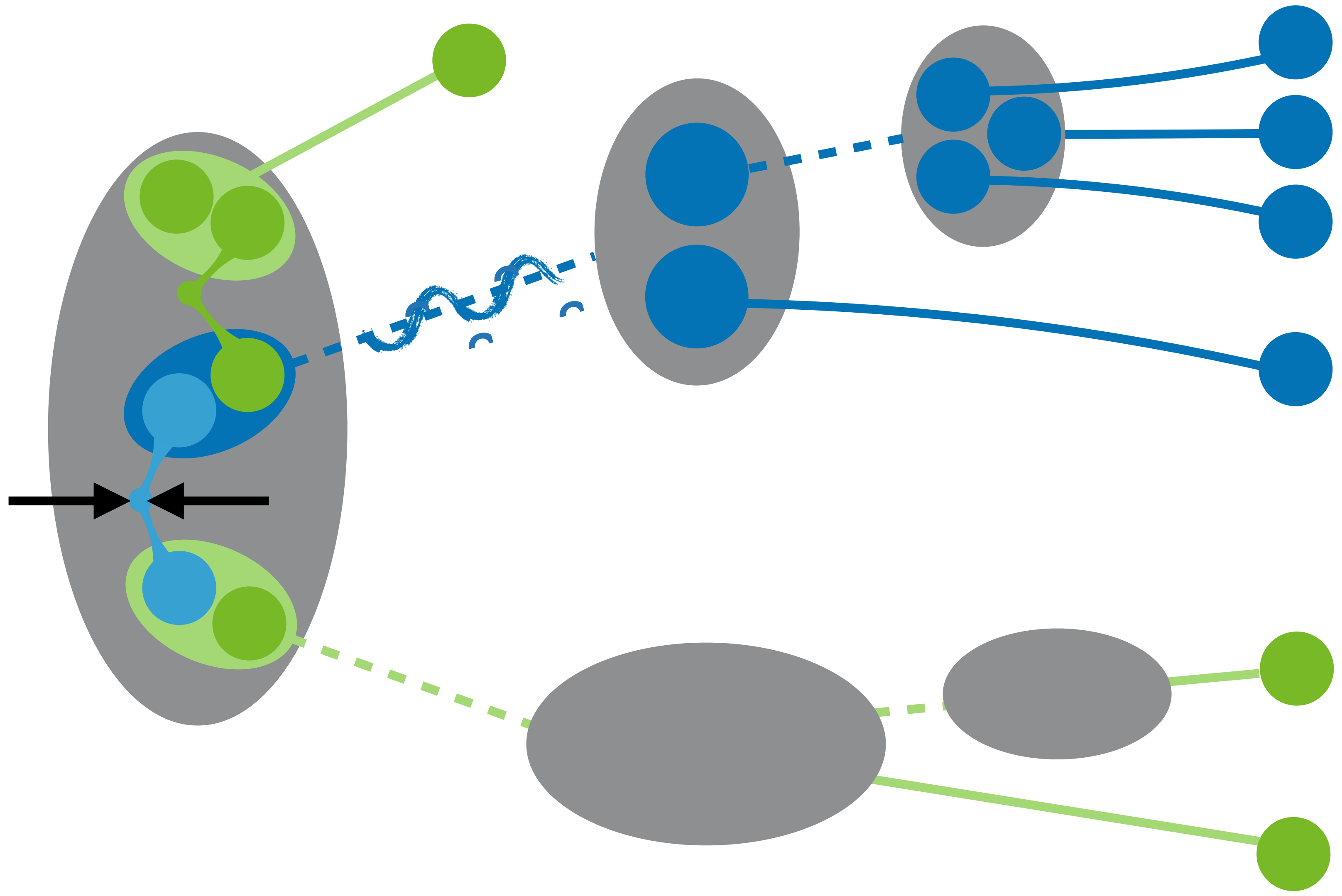
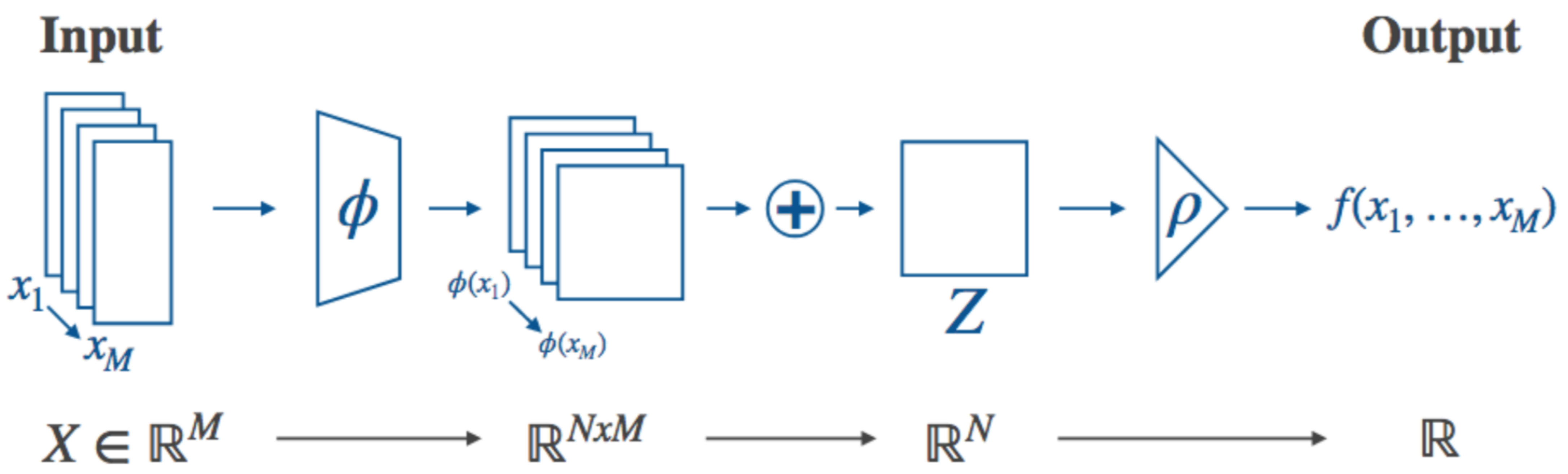


State of the Art
(at LHCb)

Inclusive Flavour Tagging:
Simultaneous analysis of all tracks with DeepSet NN



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Our work: Interaction awareness and domain invariance

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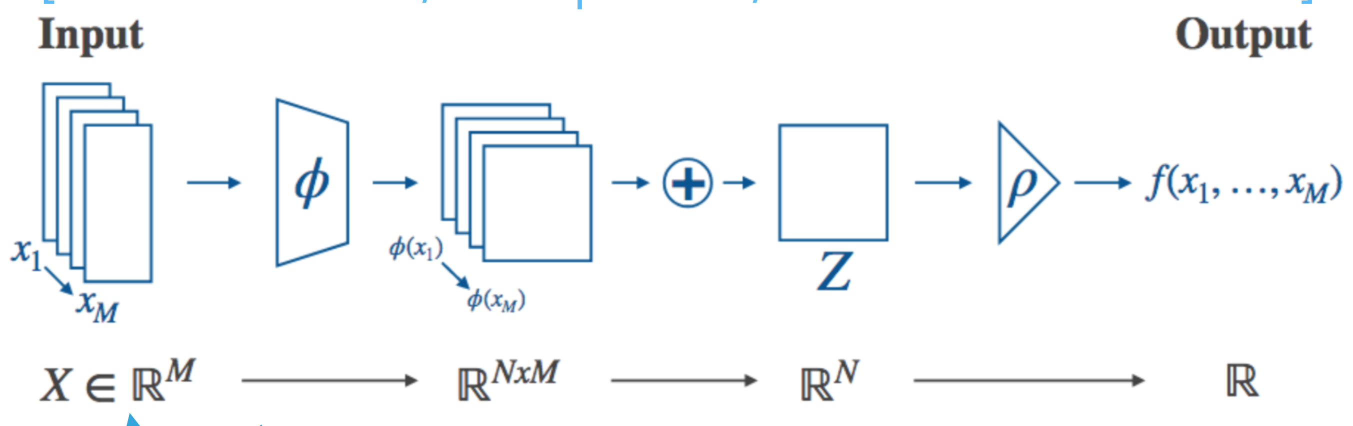
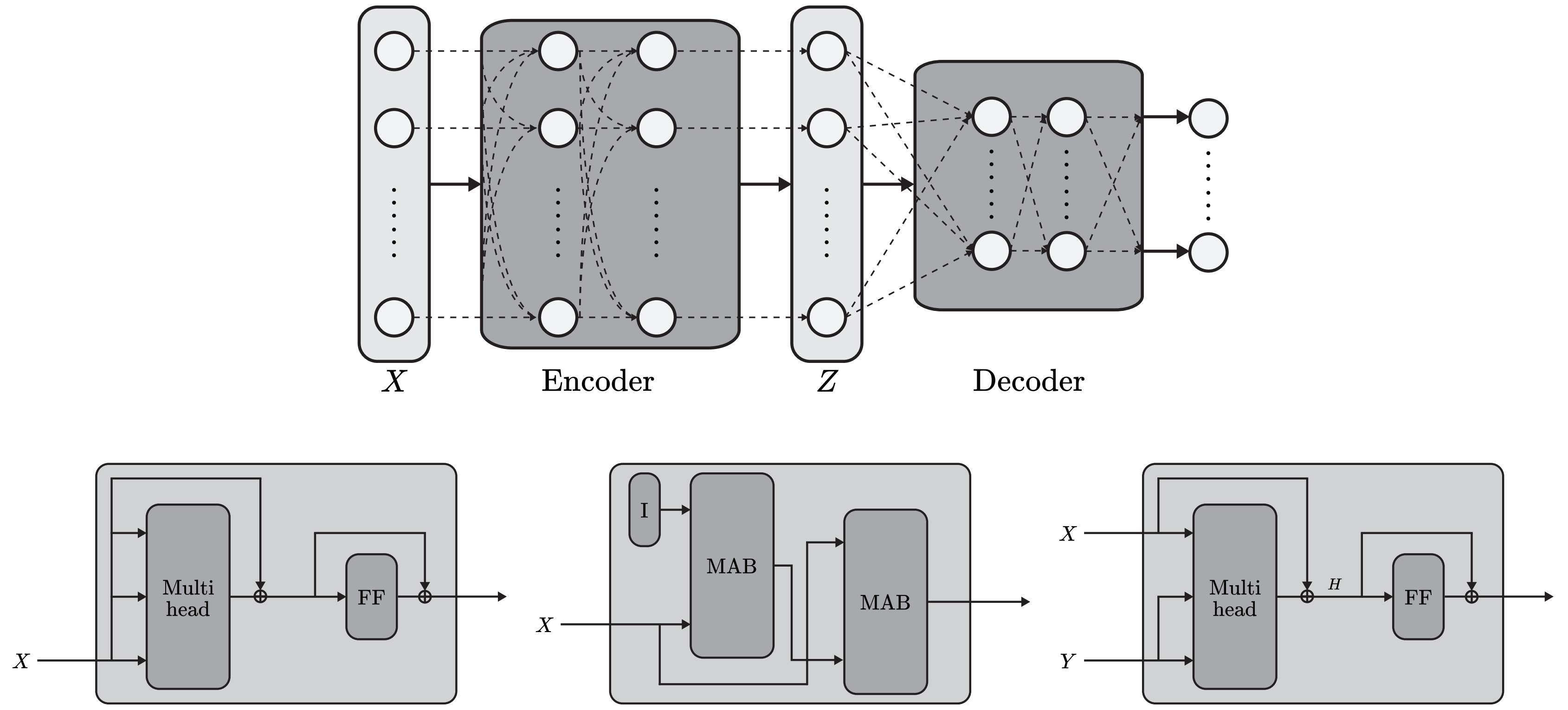


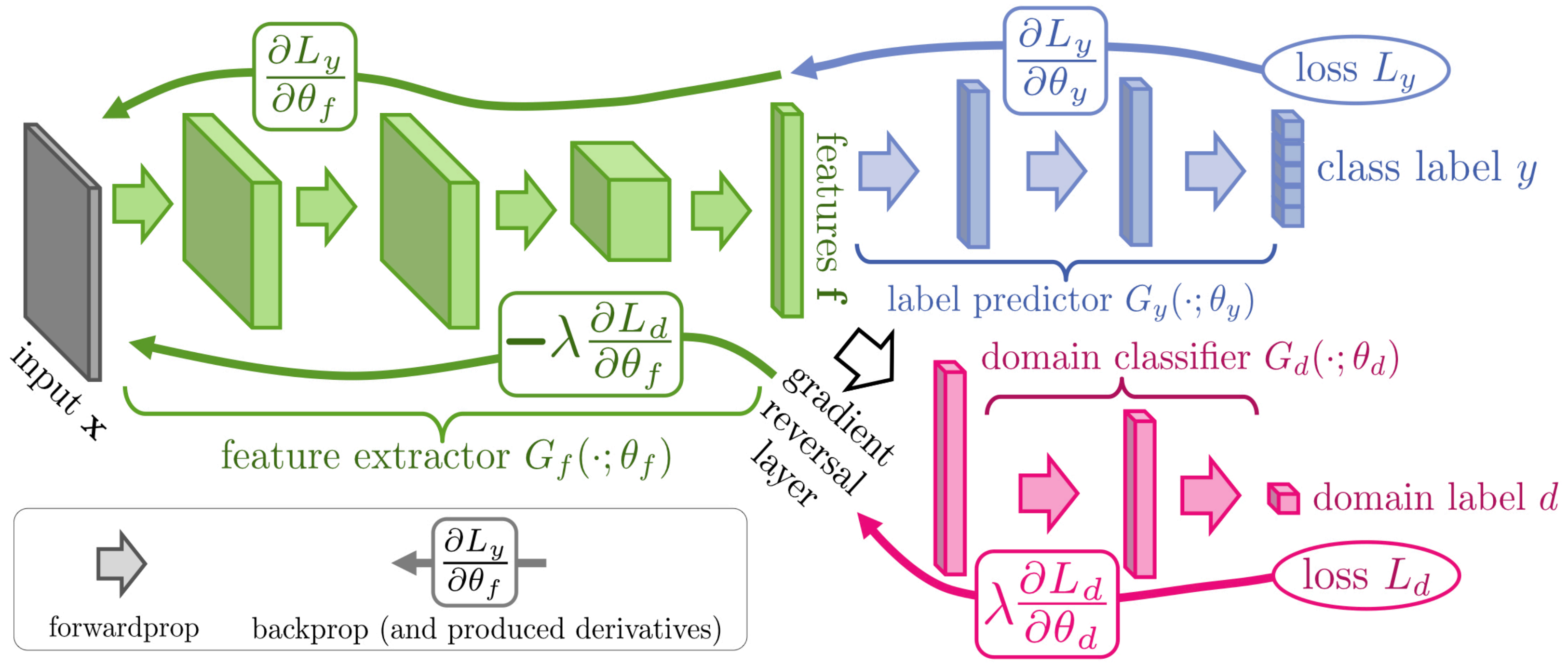
DeepSet NN
trained on simulation

Studying the SetTransformer architecture



[Lee et al., Set Transformer: A Framework for Attention-based Permutation-Invariant Neural Networks, arXiv:1810.00825]

Implementing domain-adversarial training

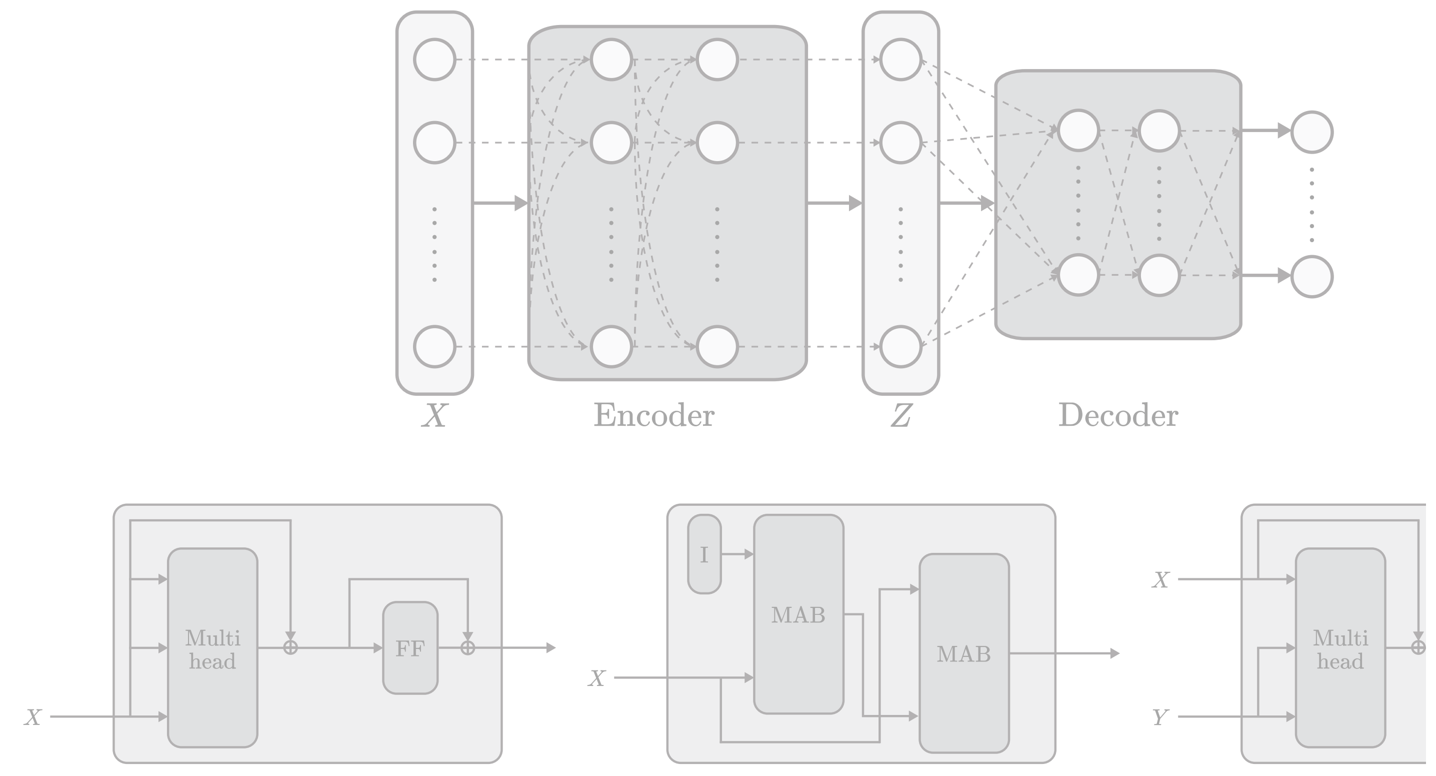


[Ganin et.al., Domain-Adversarial Training of Neural Networks, arXiv:1505.07818]

Our work: Interaction awareness and domain invariance

Studying the SetTransformer architecture

Significant improvement
in toy-based studies



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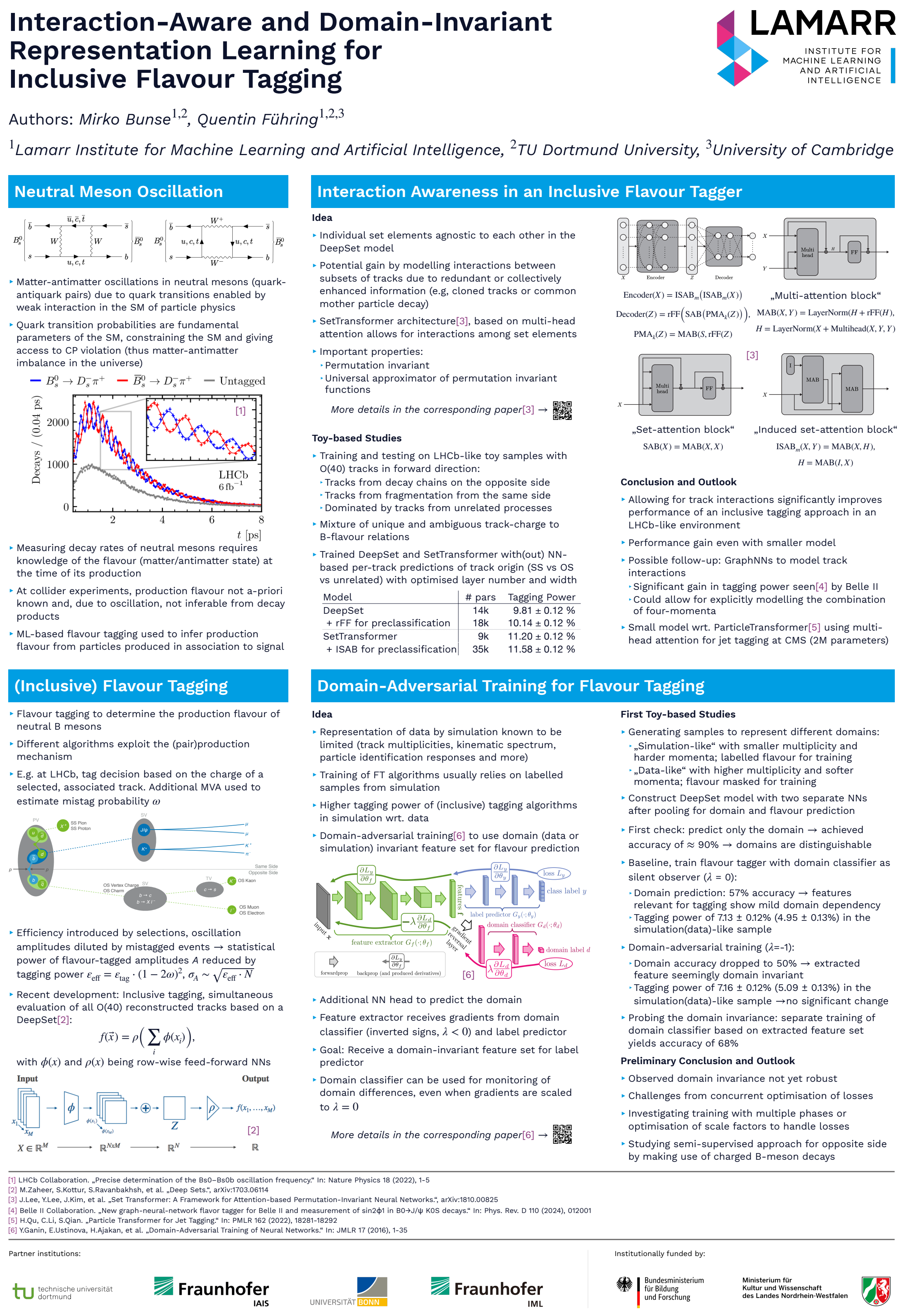
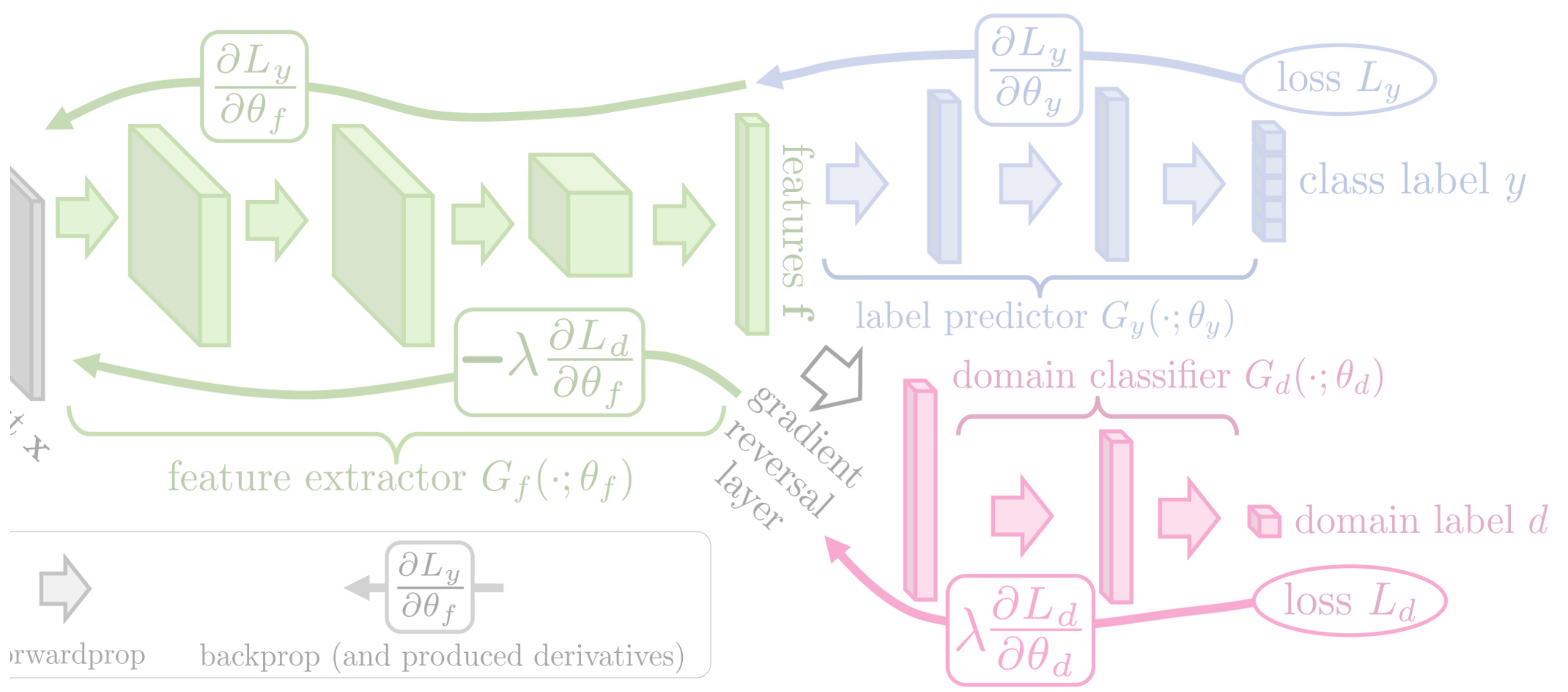


Implementing domain-adversarial training

Different challenges encountered



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