Leveraging Physics-informed GNN for enhanced Combinatorial Optimization

EUCAIFCon - Amsterdam 2024

loc. 17

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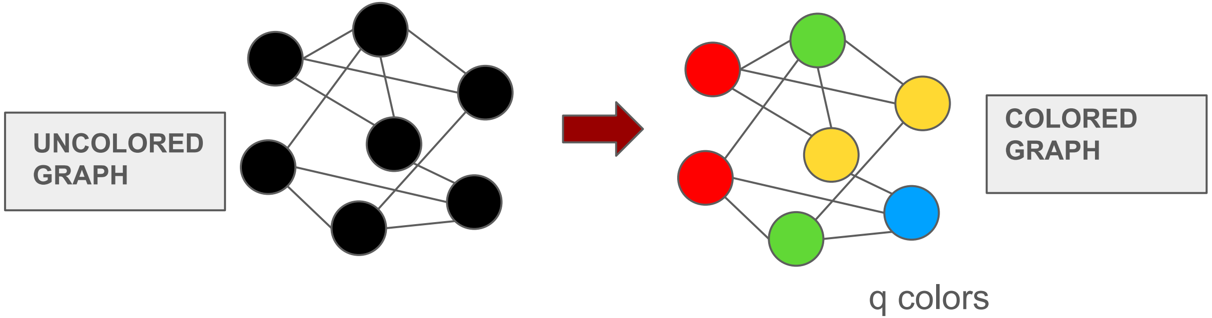
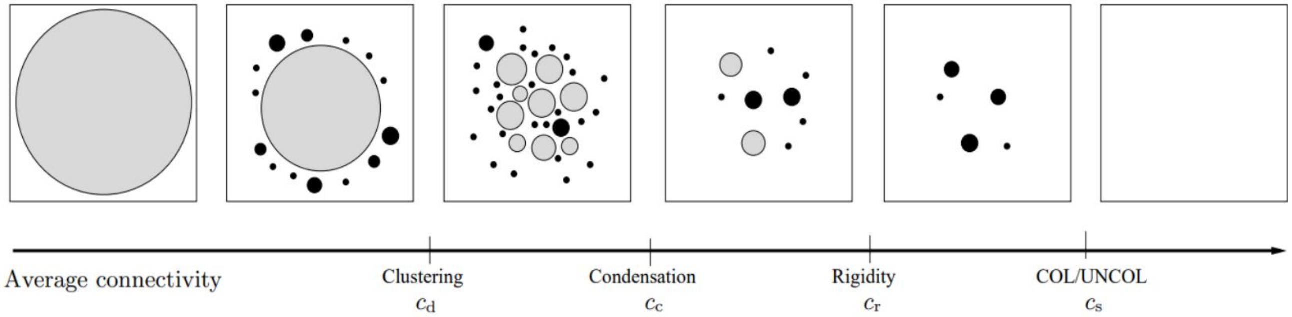
GRAPH COLORING

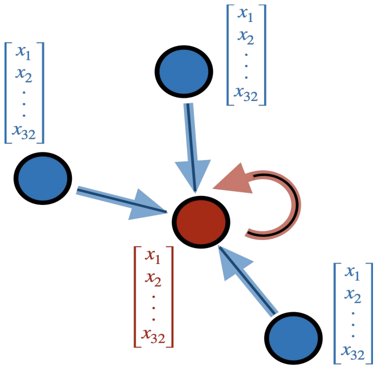


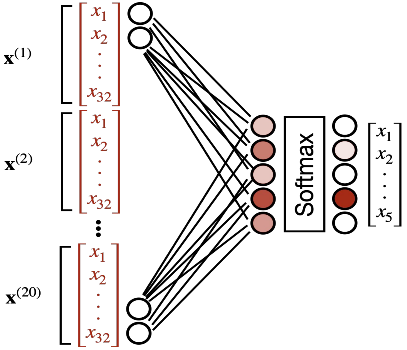
- NP-Hard problem
- Numerous applications (eg. scheduling, register allocation)
- Can be studied using statistical mechanics.

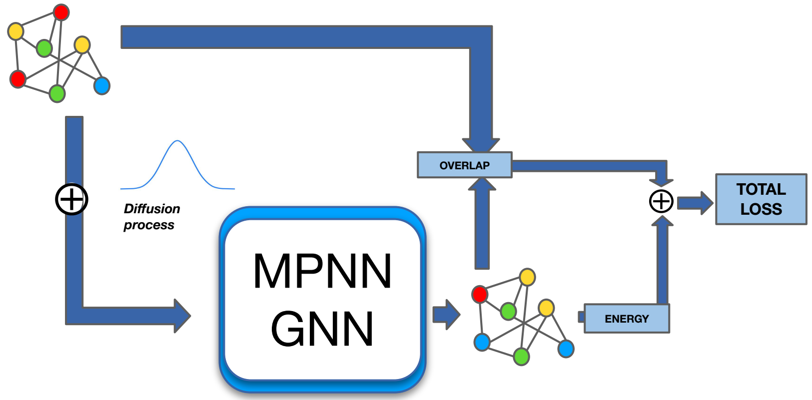
$$\mathcal{H} = \sum_{(i,j)\in E} \delta_{\sigma_i \sigma_j}$$



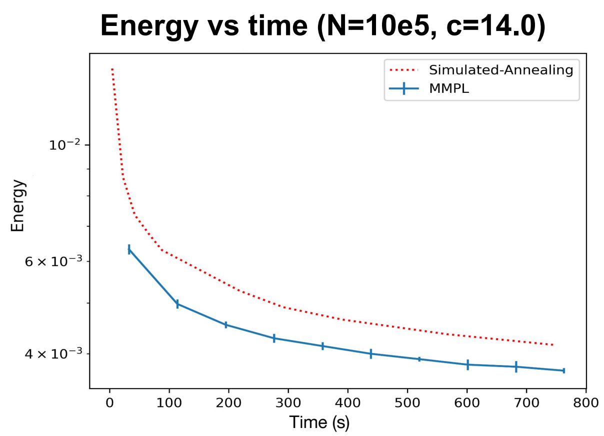
PI-GNN

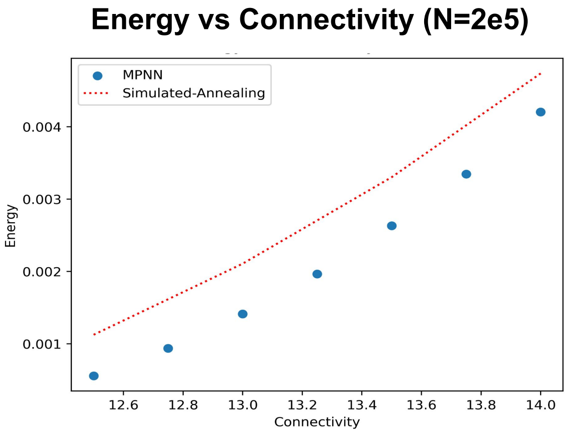




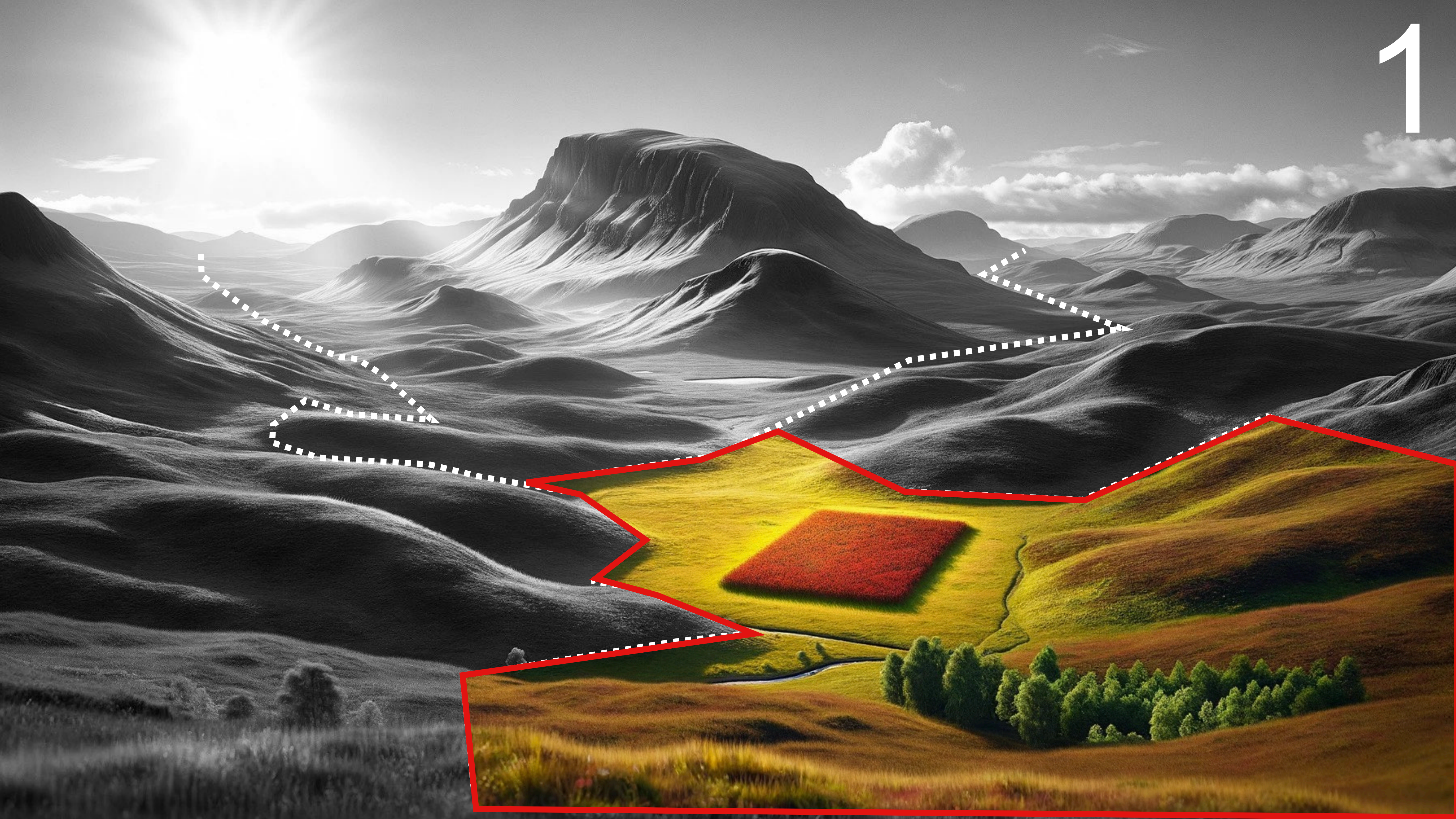


Preliminary results






1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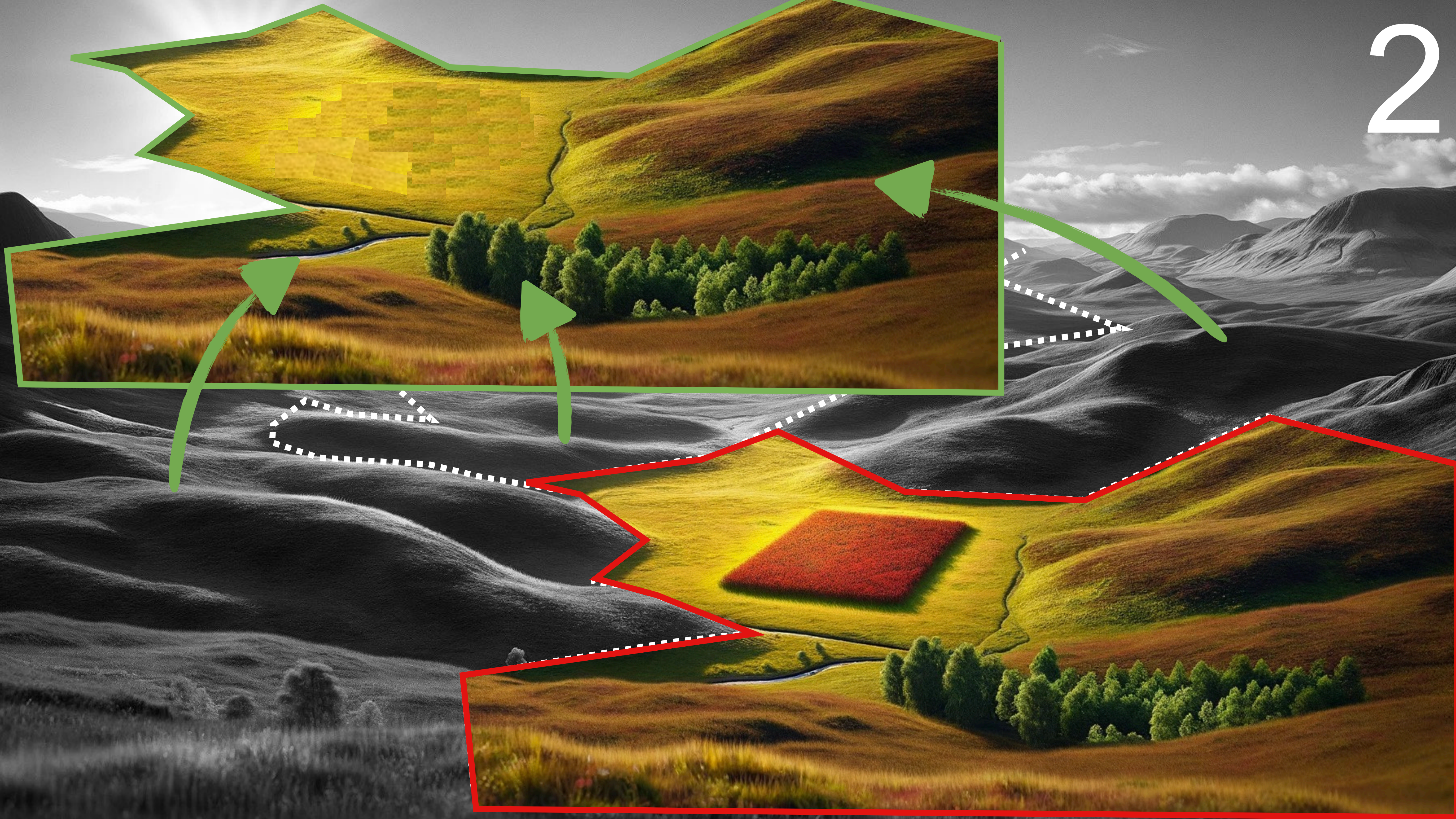
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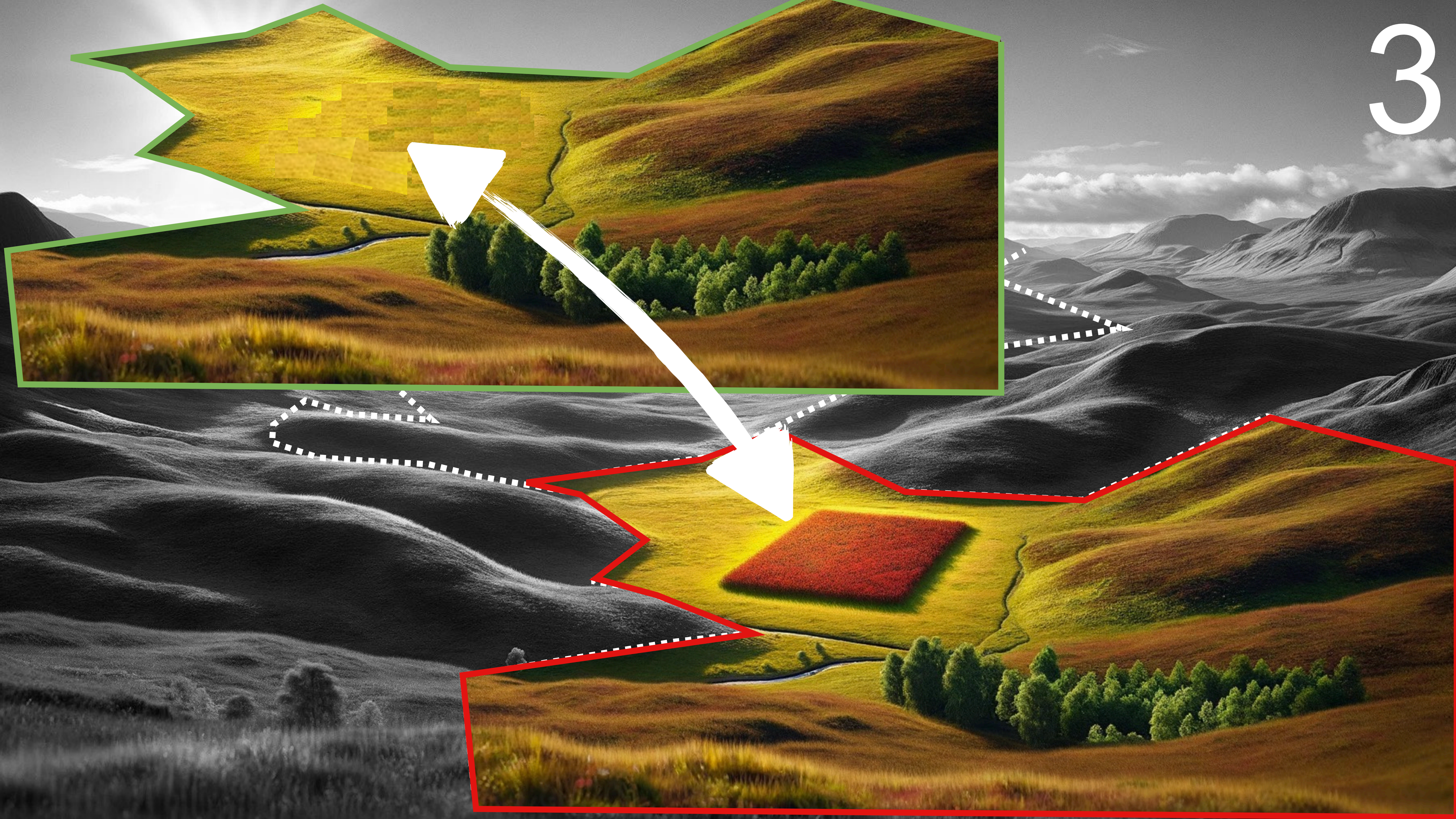
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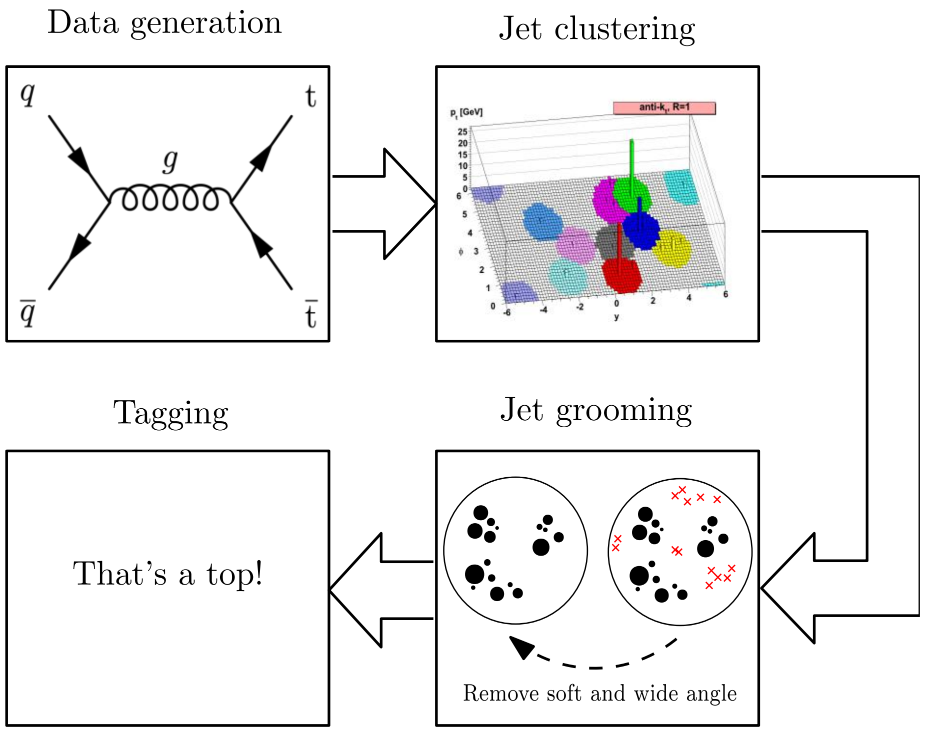
HyLAnD
Hybrid Learning for Anomaly Detection

BOOSTED PARTICLE RECONSTRUCTION WITH GRAPH NEURAL NETWORKS

Jacan Chaplais, Srinandan Dasmahapatra, Stefano Moretti

University of Southampton

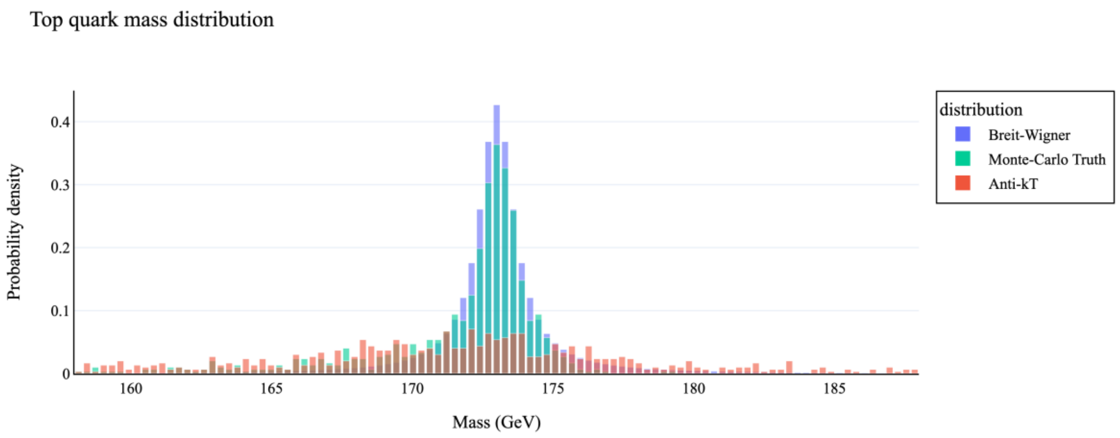
TRADITIONAL RECONSTRUCTION PIPELINES

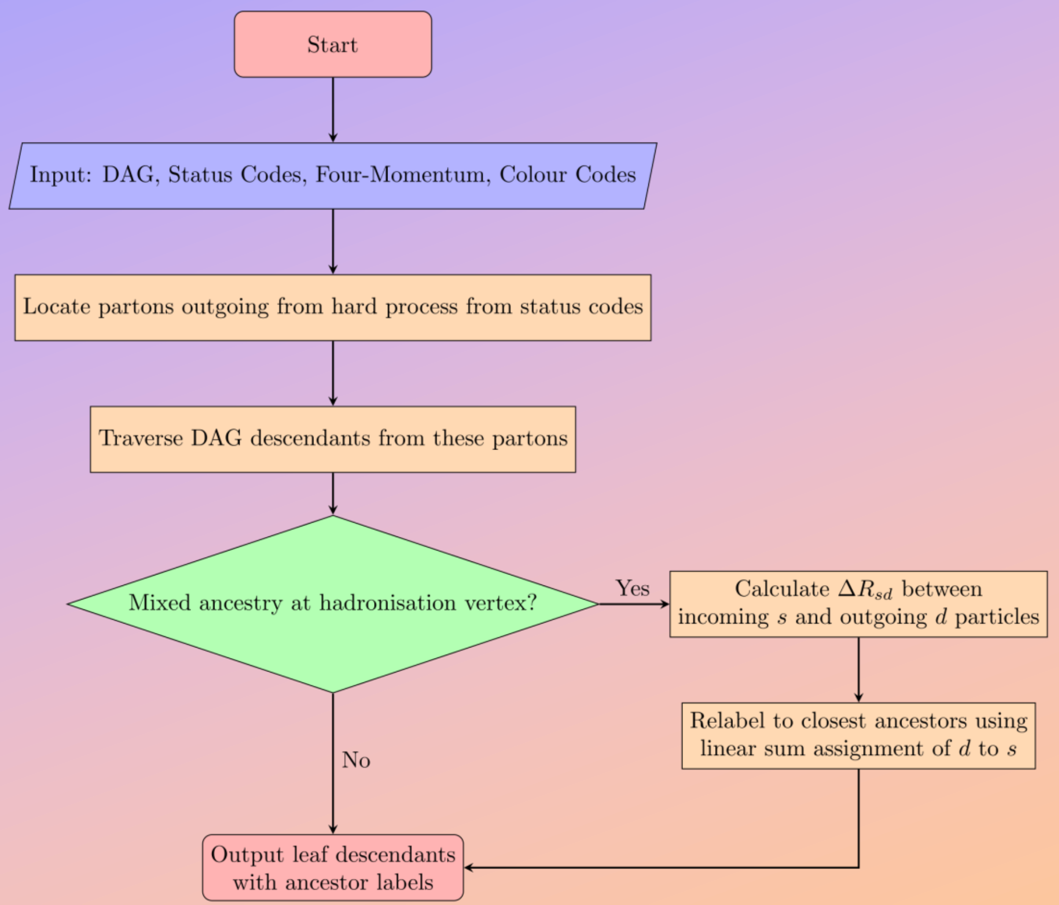


- Data is generated by simulation or experiment
- Tight, high momentum clusters (jets) of light particles form on detector walls
- Jets let us study particles which they decayed from
- Current methods based on physics theory, but only utilise momentum data

LABELS FROM SIMULATIONS

- Simulation gives us full knowledge
- Possible to track back from detected particles to original
- Challenging when colours hadronise
  - Mixed ancestry
- Our novel method (right) combines more simulation data to fix this

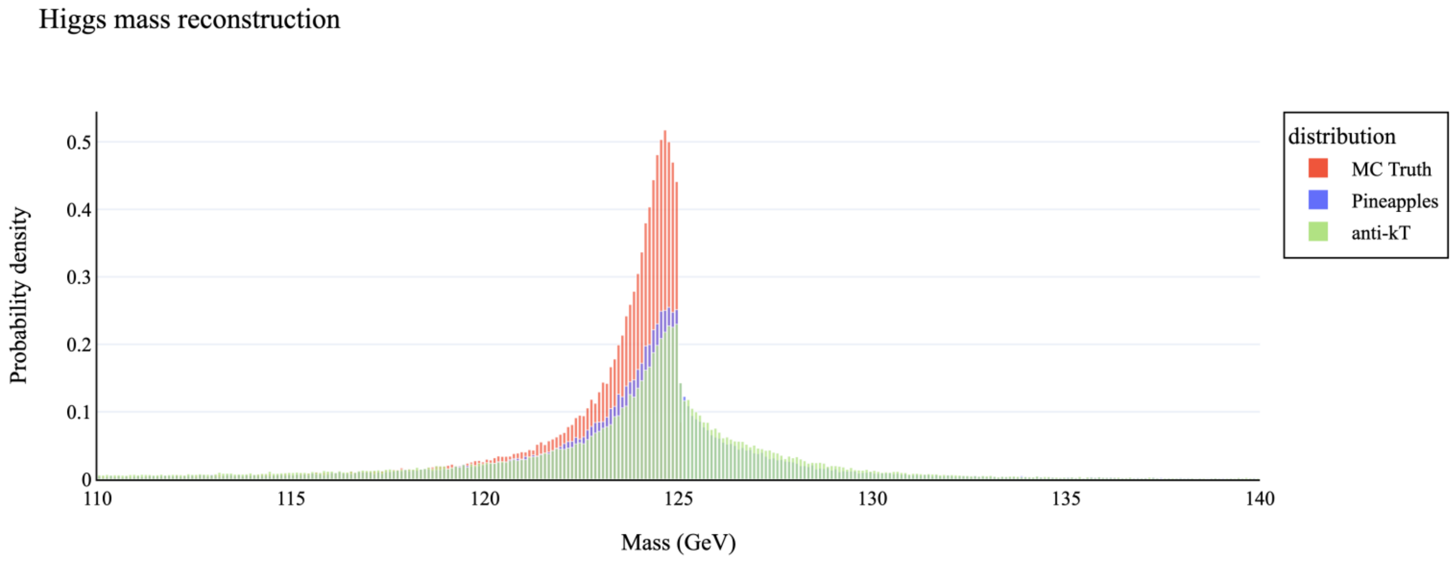




GRAPH NEURAL NETWORK PIPELINE

Feeding our GNN models simulation-informed labels for the simpler case of Higgs datasets shows improved performance over anti-k_T.

There is no need for combining, pruning, and tagging, as these are learned implicitly!



OUTLOOK

- Investigate training on top quarks
- Check performance against taggers

Get the code!

For more information, visit my poster on Wednesday, during Session A, in Location 20!

THANK YOU

Accelerating the search for mass bumps using the Data-Directed Paradigm

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Georges Azuelos
Émile Baril
Fannie Bilodeau
Bruna Pascual Dias
Muhammad Usman

Samuel Calvet
Julien Noce Donini
Eva Mayer

Shikma Bressler
Maryna Borysova
Michael Chu
Etienne Dreyer
Elad Kliger
Nilotpal Kakati
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Université de Montréal

LPC Particules pLasmas Univers applicationS
Laboratoire de Physique de Clermont

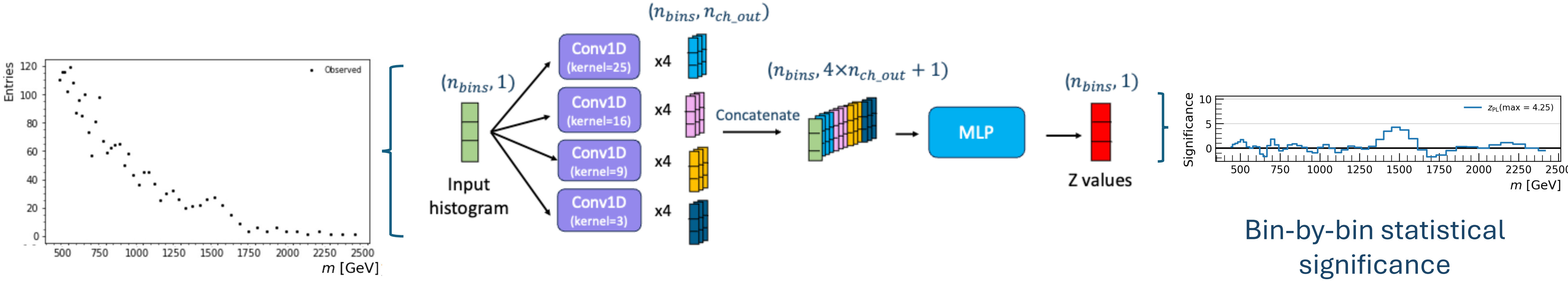
מכון ויצמן למדע
WEIZMANN INSTITUTE OF SCIENCE

EuCAIFCon 2024

What ?

- We want to maximize our chances to **find new physics** in collider data

- Train a neural network to **identify mass bumps in real data** without the need of simulation or analytical fit to estimate the background



Invariant mass histogram

Bin-by-bin statistical significance

Why ?

- Exploit the **discovery potential of the data**
  - Impossible to check all final states with a traditional analysis
  - Many possible resonances in unexplored final states → bumps

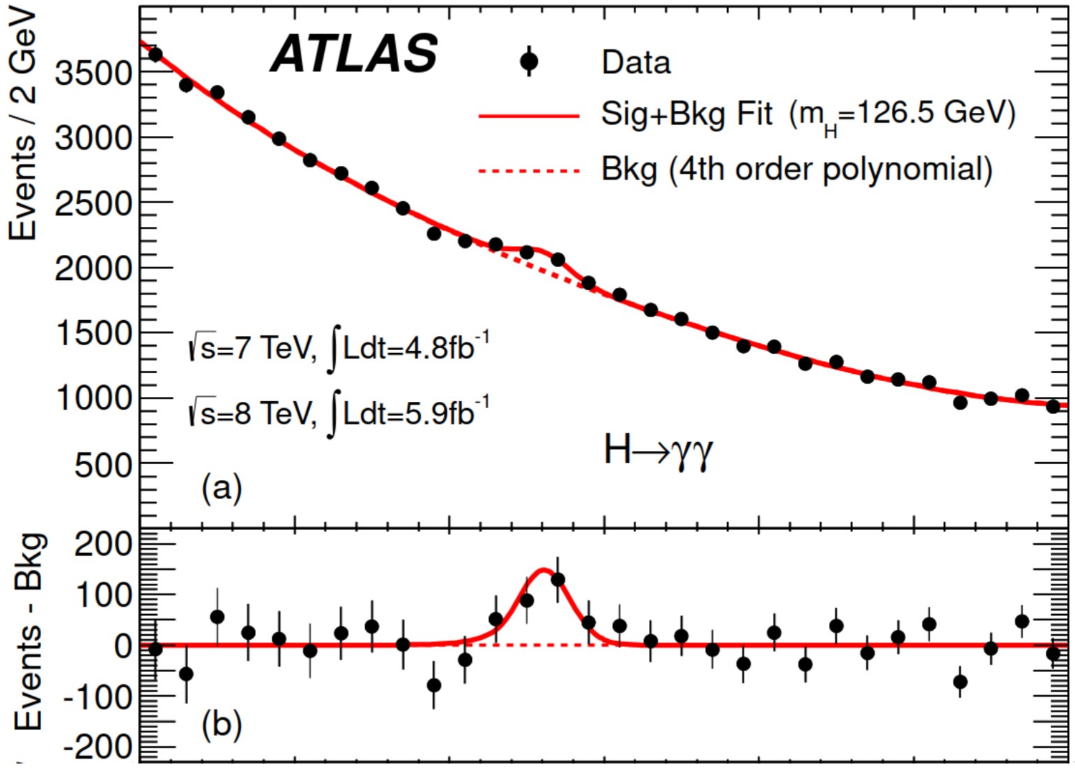
Existing searches for two-body resonances[1]

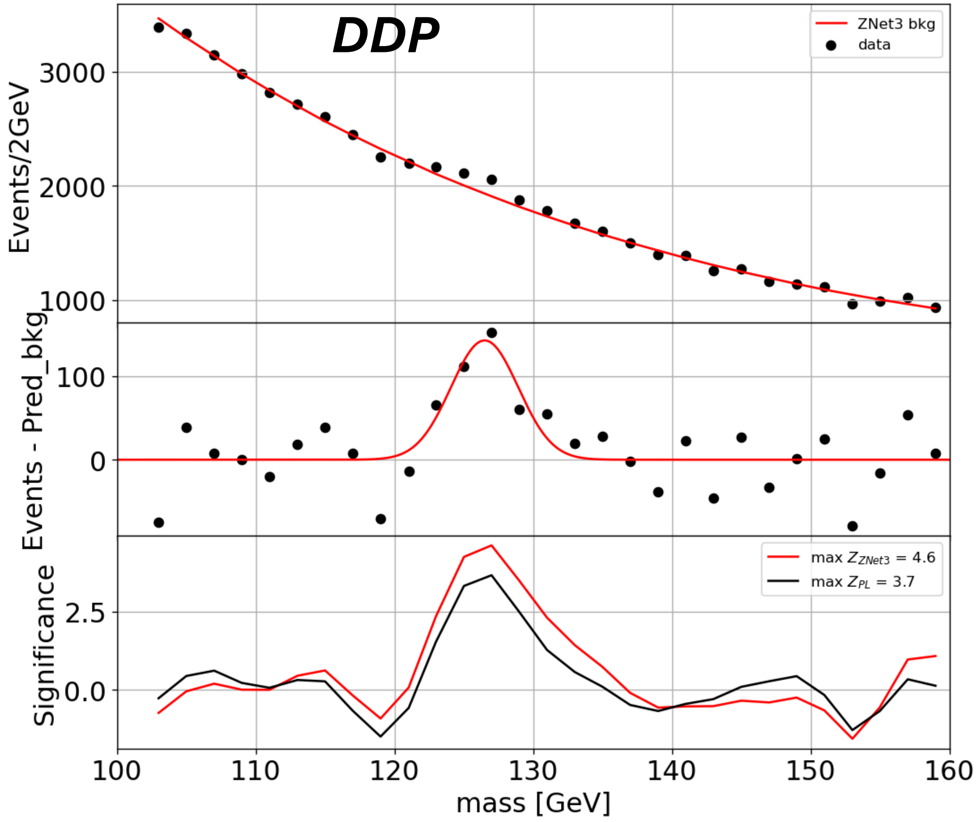
		e	μ	τ	q/g	b	t	γ	Z/W	H	$\mathrm{BSM} \to \mathrm{SM}_1 \times \mathrm{SM}_1$				$\mathrm{BSM} \to \mathrm{SM}_1 \times \mathrm{SM}_2$			$\mathrm{BSM} \to \mathrm{complex}$			
											q/g	γ/π^0's	b	$\cdots$	tZ/H	bH	$\cdots$	$\tau qq'$	eqq'	$\mu qq'$	$\cdots$
	e	[37,38]	[39,40]	[39]	∅	∅	∅	[41]	[42]	∅	∅	∅	∅		∅	∅	∅	∅	[43,44]	∅	
	μ		[37,38]	[39]	∅	∅	∅	[41]	[42]	∅	∅	∅	∅		∅	∅	∅	∅	∅	[43,44]	
	τ			[45,46]	∅	[47]	∅	∅	∅	∅	∅	∅	∅		∅	∅	∅	[48,49]	∅	∅	
	q/g				[29,30,50,51]	[52]	∅	[53,54]	[55]	∅	∅	∅	∅		∅	∅	∅	∅	∅	∅	
	b					[29,52,56]	[57]	[54]	[58]	[59]	∅	∅	∅		[60]	∅	∅	∅	∅	∅	
	t						[61]	∅	[62]	[63]	∅	∅	∅		[64]	[60]	∅	∅	∅	∅	
	γ							[65,66]	[67–69]	[68,70]	∅	∅	∅		∅	∅	∅	∅	∅	∅	
	Z/W								[71]	[71]	∅	∅	∅		∅	∅	∅	∅	∅	∅	
	H									[72,73]	[74]	∅	∅		∅	∅	∅	∅	∅	∅	
$\mathrm{BSM} \to \mathrm{SM}_1 \times \mathrm{SM}_1$	q/g										∅	∅	∅		∅	∅	∅	∅	∅	∅	
	γ/π^0's											[75]	∅		∅	∅	∅	∅	∅	∅	
	b												[76,77]		∅	∅	∅	∅	∅	∅	
	⋮																				
	⋮																				

[1] J. H. Kim et al., version 1, 10.48550/ARXIV.1907.06659 (2019), https://arxiv.org/abs/1907.06659

Promising result

- **Finding the Higgs bump**
  - Predicted significance matches the ATLAS significance within error [2]





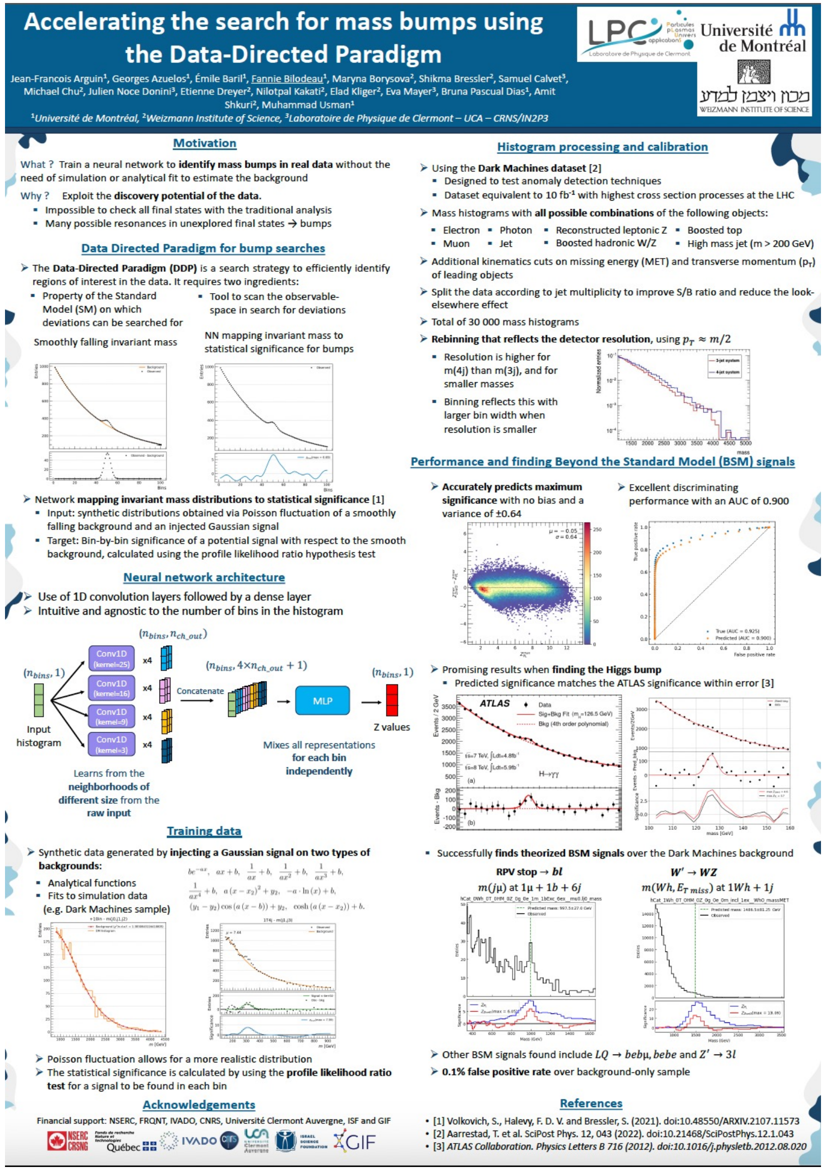
[2] *ATLAS Collaboration. Physics Letters B 716 (2012). doi:10.1016/j.physletb.2012.08.020*

Please visit our poster !

More promising results !

More on the training data !

Poster 18



More on the pre-processing of the histograms !

Come ask questions !