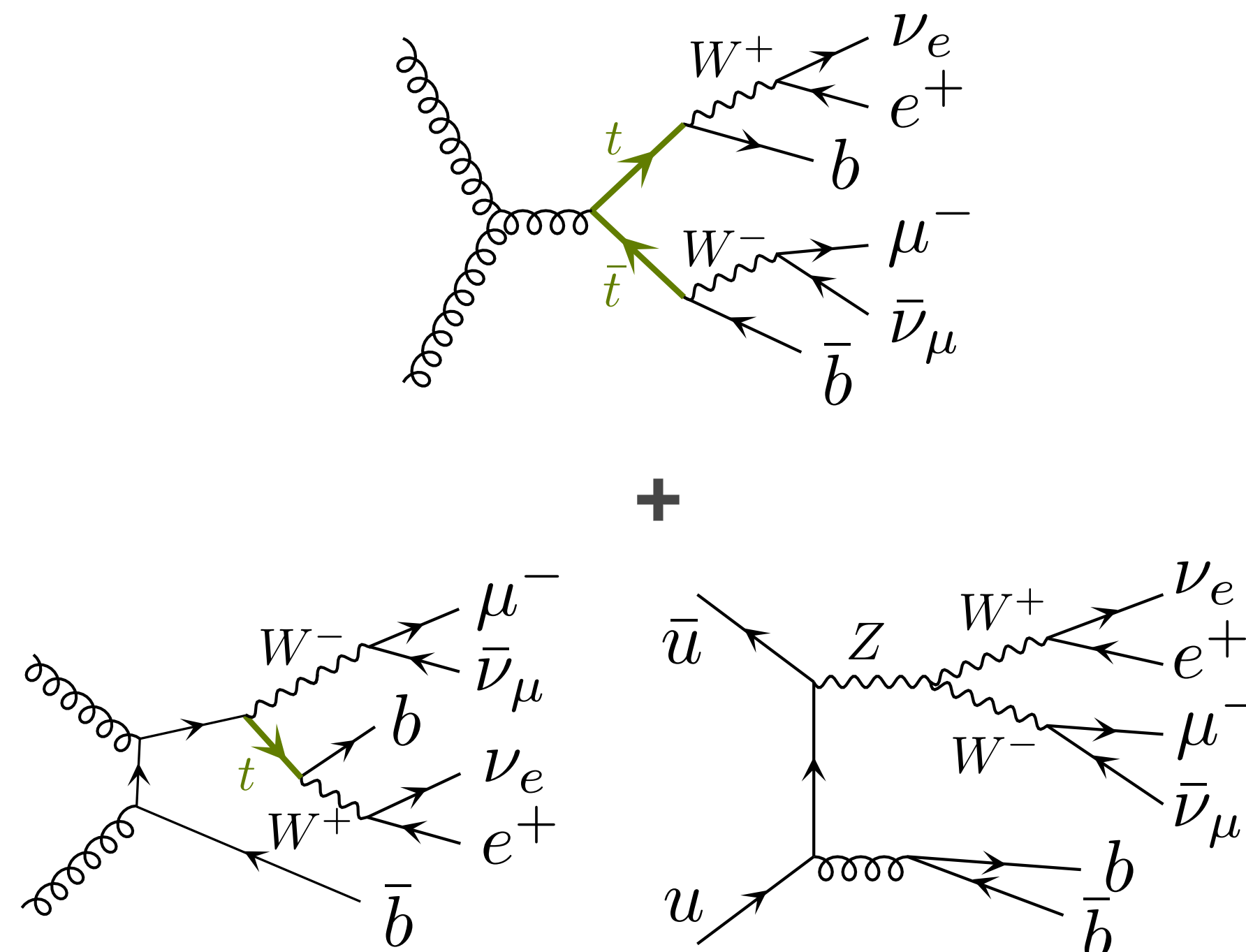
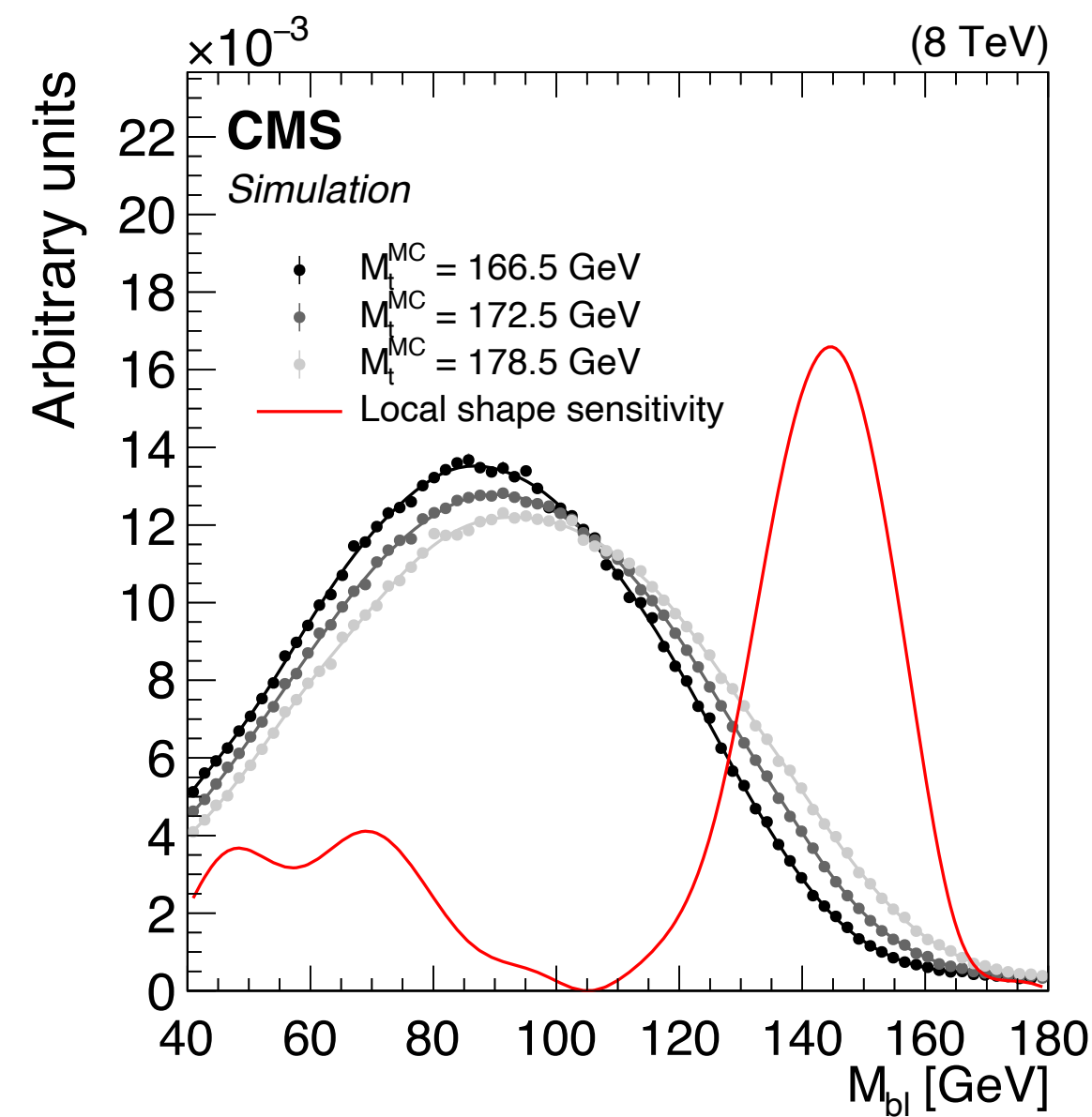


# Kicking it Off(-shell) with Direct Diffusion

Anja Butter, Tomas Jezo, Michael Klasen, Mathias Kuschick, [Sofia Palacios Schweitzer](#), Tilman Plehn  
arXiv: 2311.17175

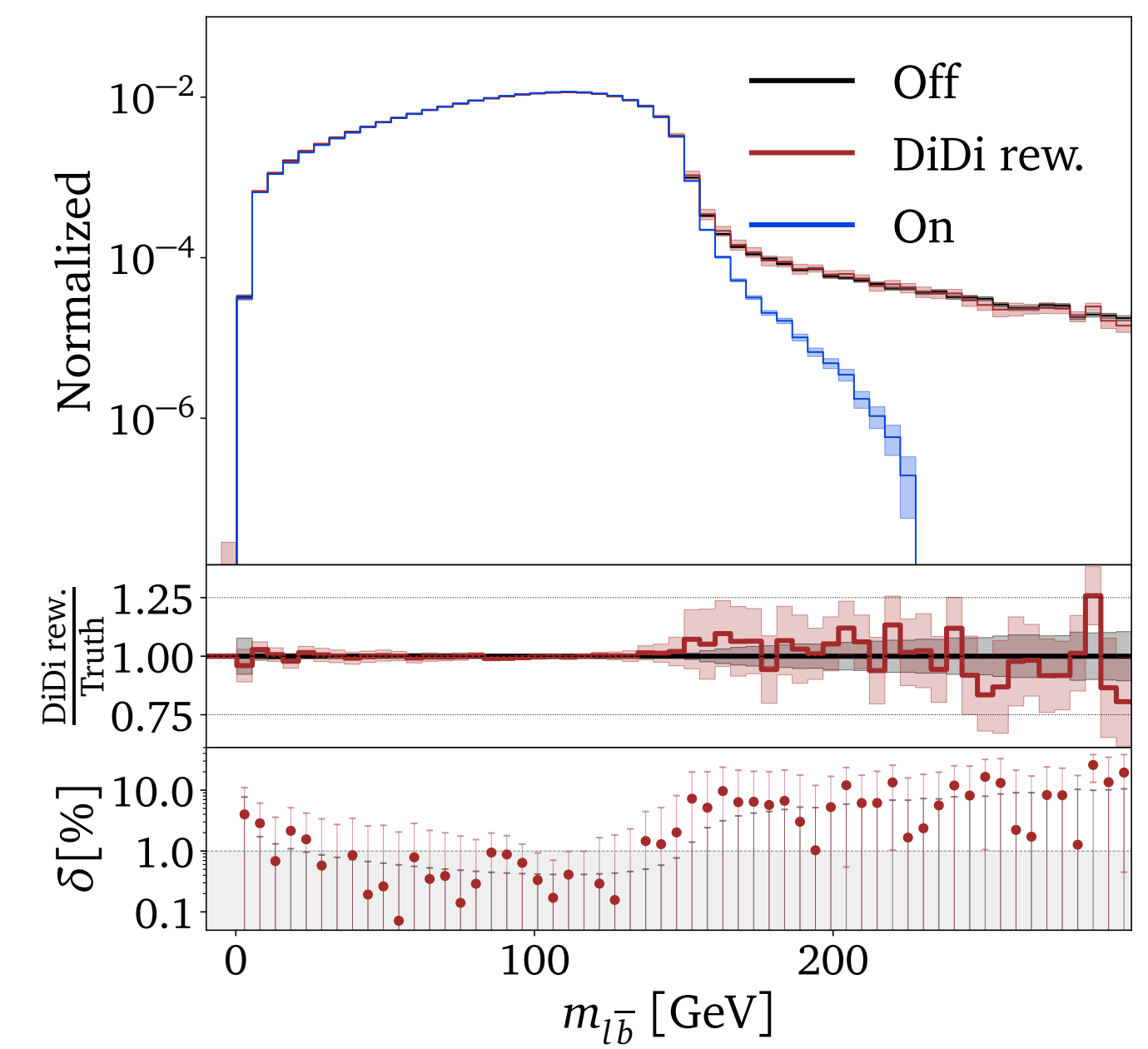
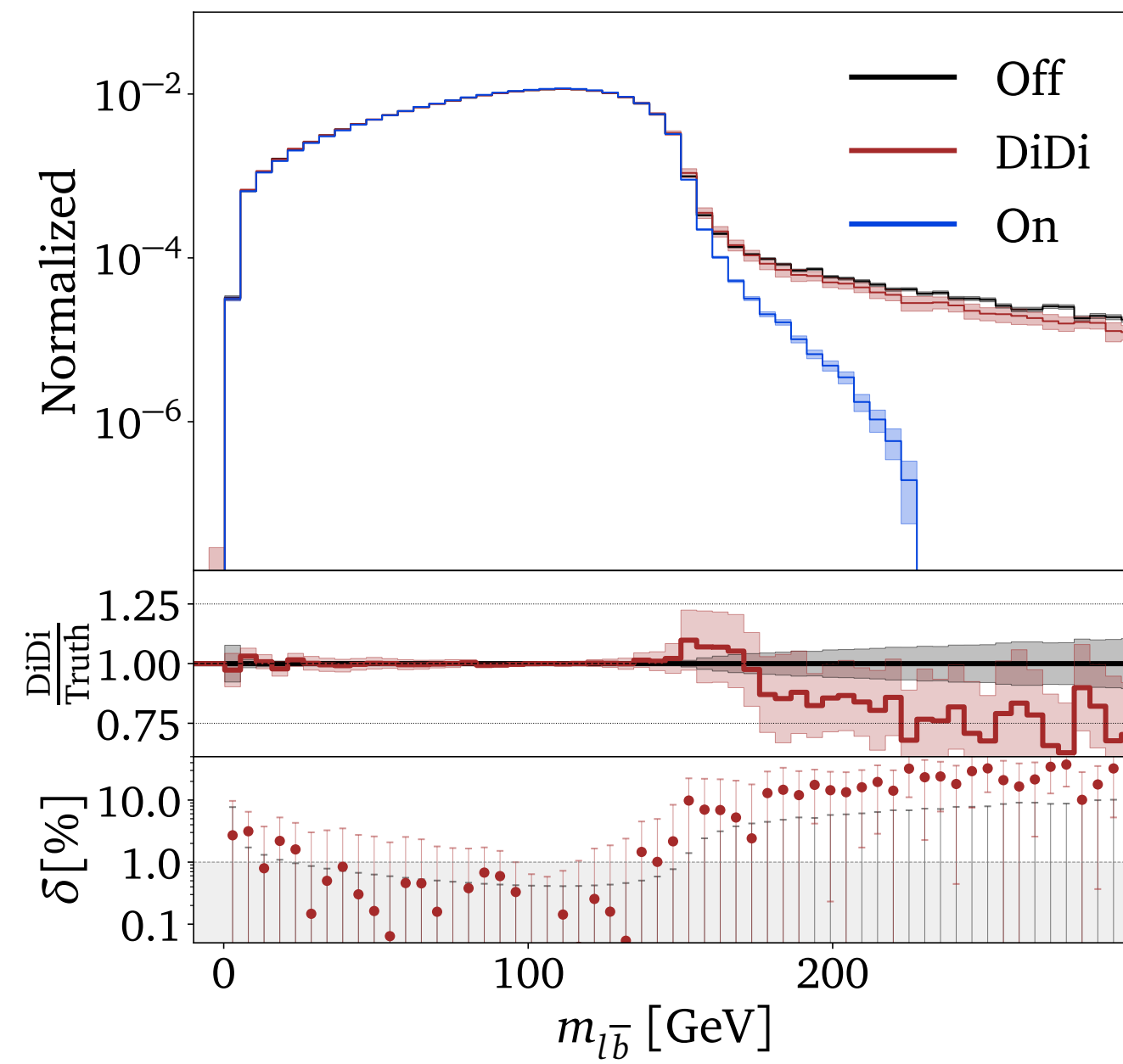
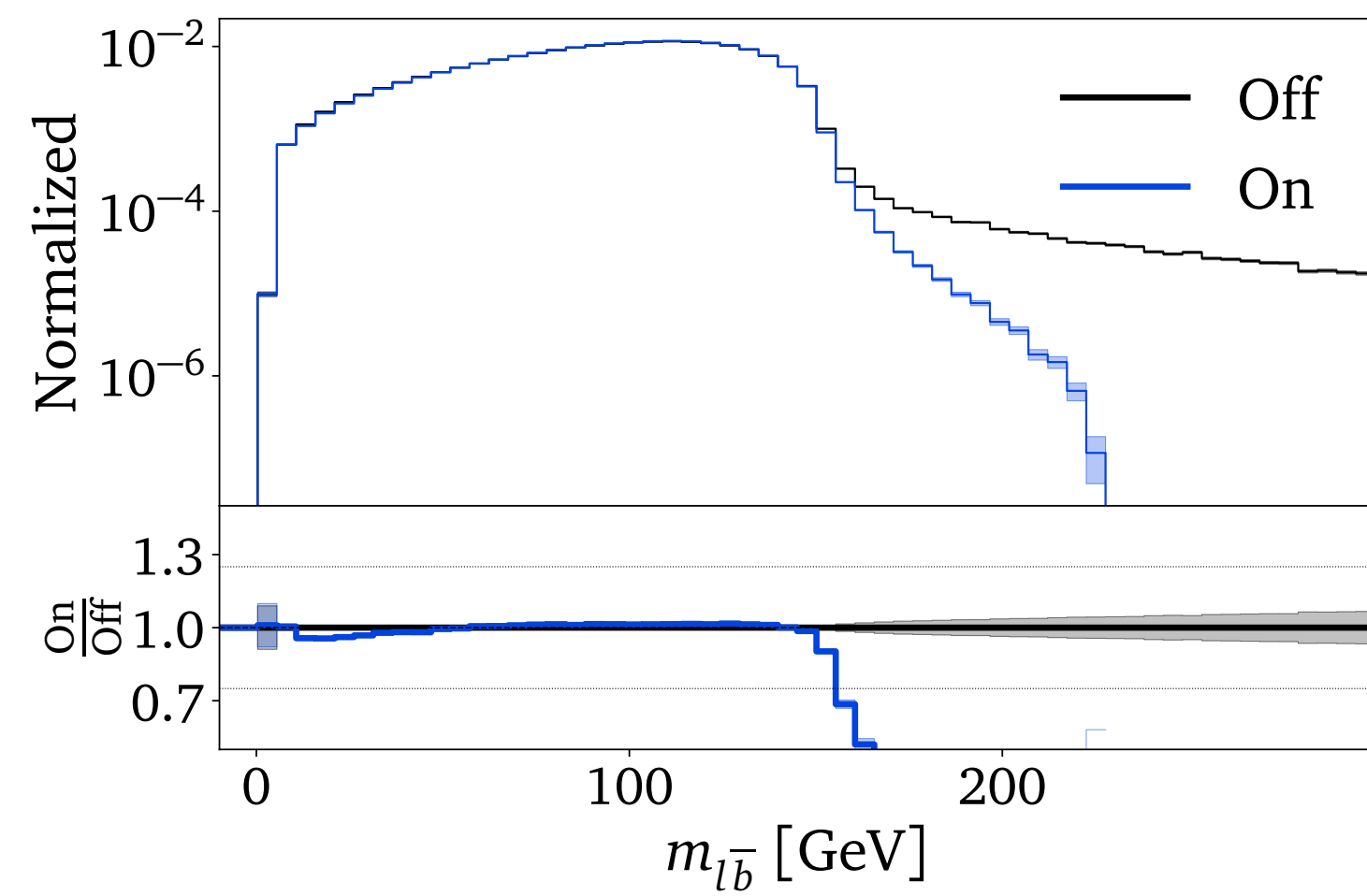
Simulating leptonic  $t\bar{t}$  decays precisely = Include off-shell processes



Need: Fast event generator

Problem: Multiresonant phase space in 24 dimensions

# Direct Diffusion (DiDi)



Check poster (34) for details

Cheaply generating  $t\bar{t}$ -events with full off-shell effects  
or  
Morphing two unknown, intractable distributions onto each other

**Physics Problem**

LHC = "Top factory"  
→ correct simulation very import  
→ crucial to include full off-shell effects

Example: leptonic  $t\bar{t}$  events

On-shell + Off-shell (examples)

Multi-resonant phase space      Extremely costly to generate

**ML Solution**

- Mapping  $p_{on}(x) \rightarrow p_{off}(x)$  with a Conditional Flow Matching (CFM) model
- Continuous time evolution governed by ODE  $v := \frac{dx}{dt}$

$t \sim \mathcal{U}([0, 1])$

$x_0 \sim p_{off}(x_0), x_1 \sim p_{on}(x_1) \rightarrow x(t|x_0) = (1-t)x_0 + tx_1$

CFM

$\mathcal{L} = (v_\theta - (x_1 - x_0))^2$

Direct Diffusion (DiDi)

**Results**

Performance:  $\mathcal{O}(1\%) - \mathcal{O}(10\%)$  precision

Mapping: optimal

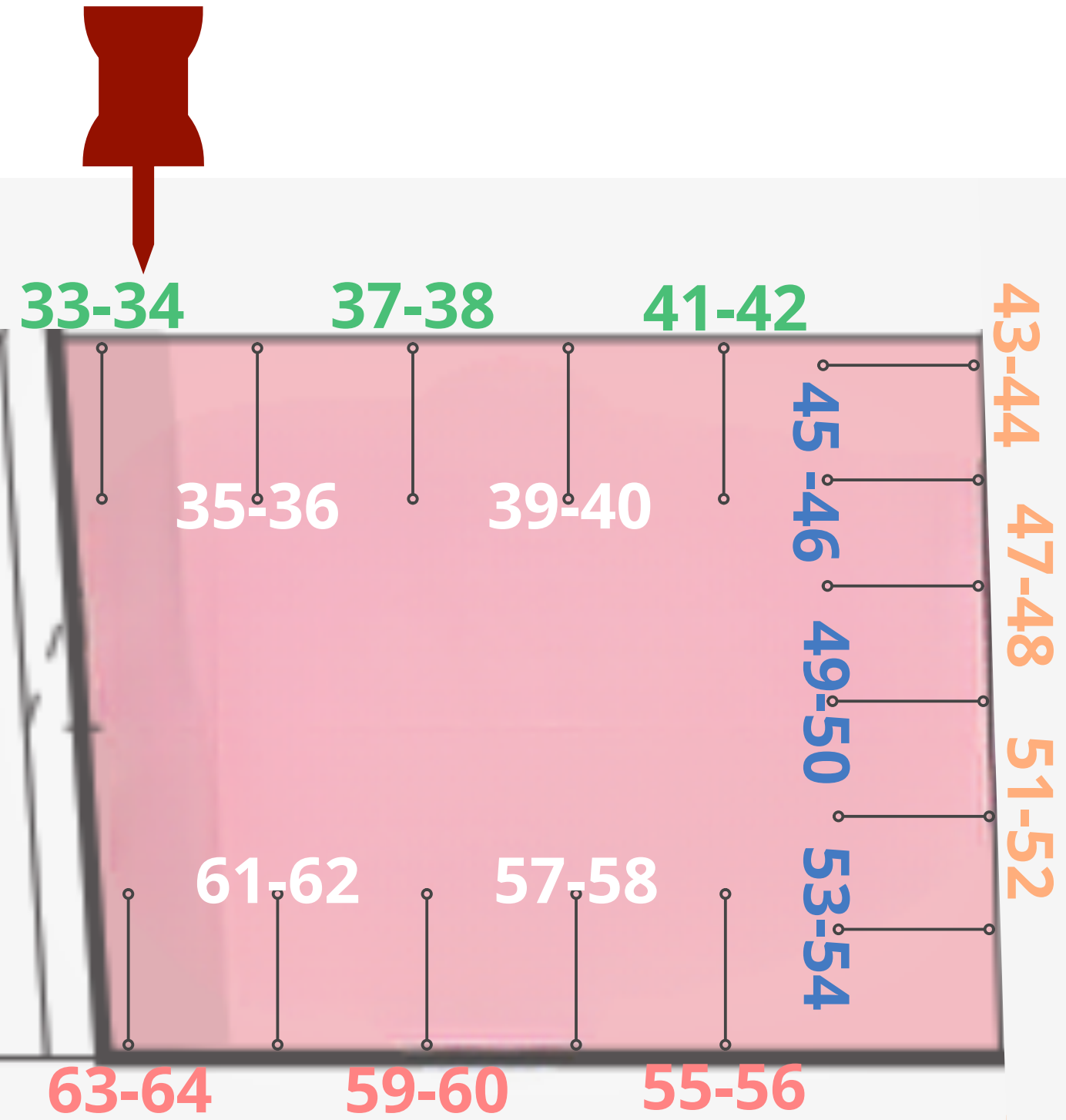
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Kicking it Off-shell with Direct Diffusion, arXiv: 2311.17175, Anja Butter<sup>1,2</sup>, Tomas Jezo<sup>3</sup>, Michael Klasen<sup>2</sup>, Mathias Kuschick<sup>2</sup>, Sofia Palacios Schweitzer<sup>1</sup>, Tilman Plehn<sup>1</sup>

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