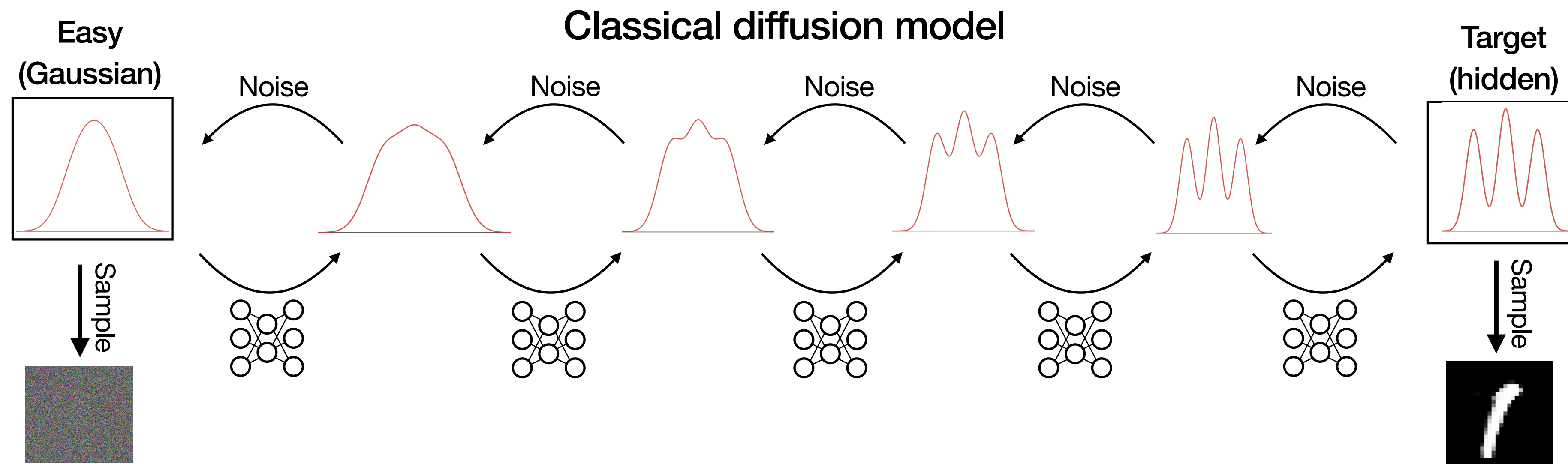
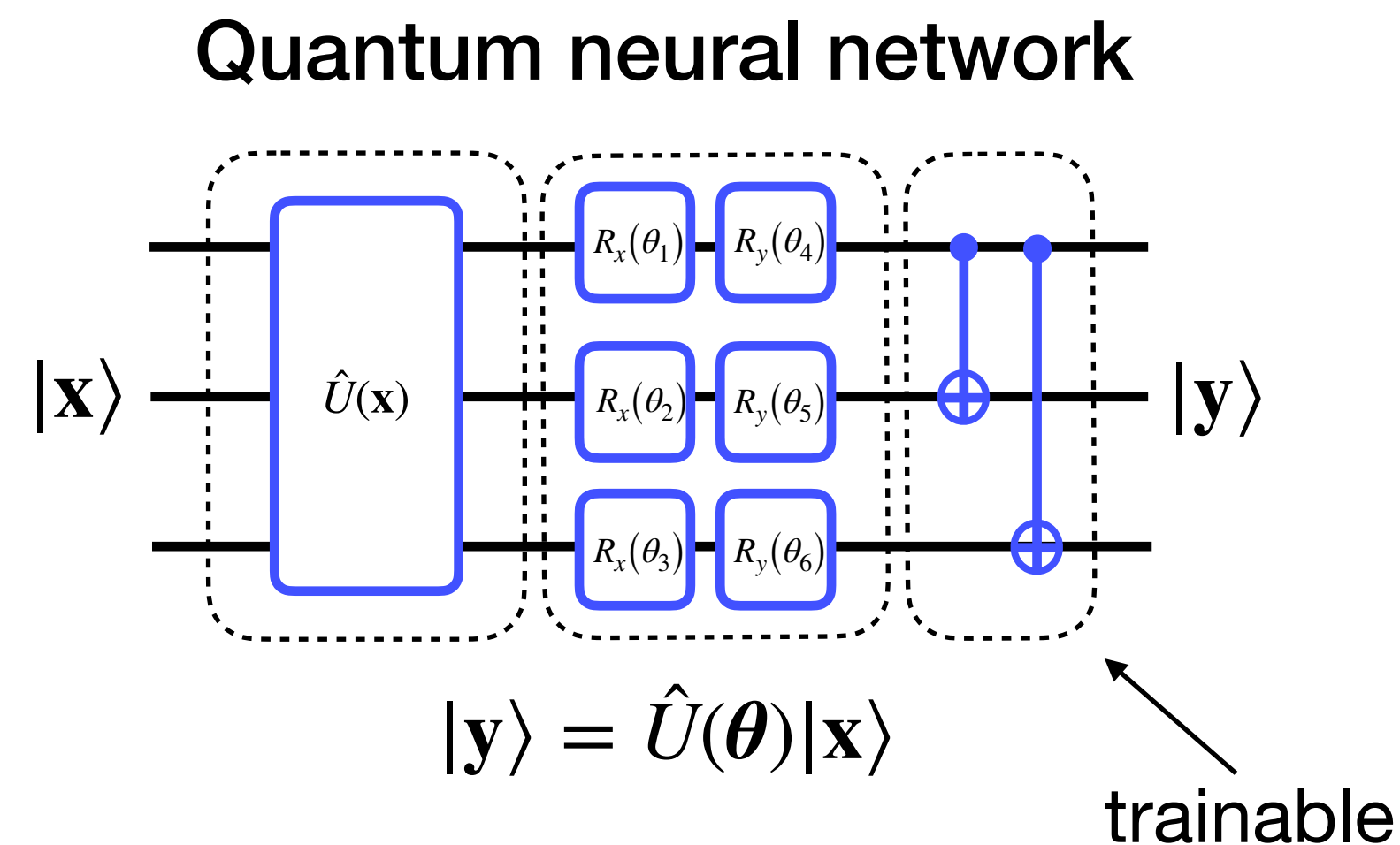


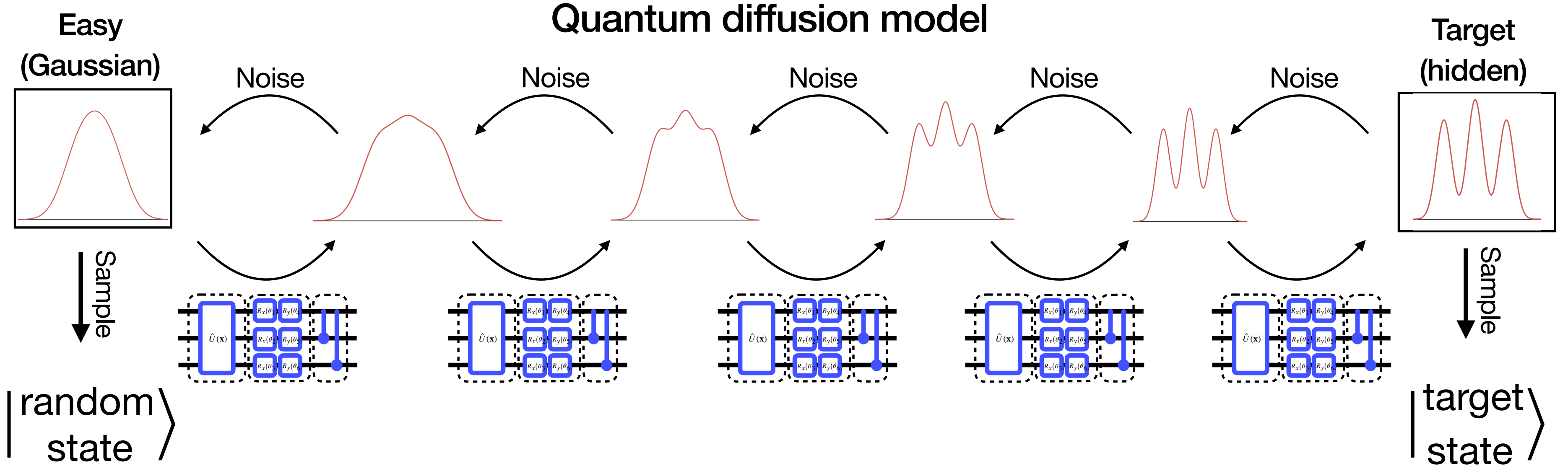
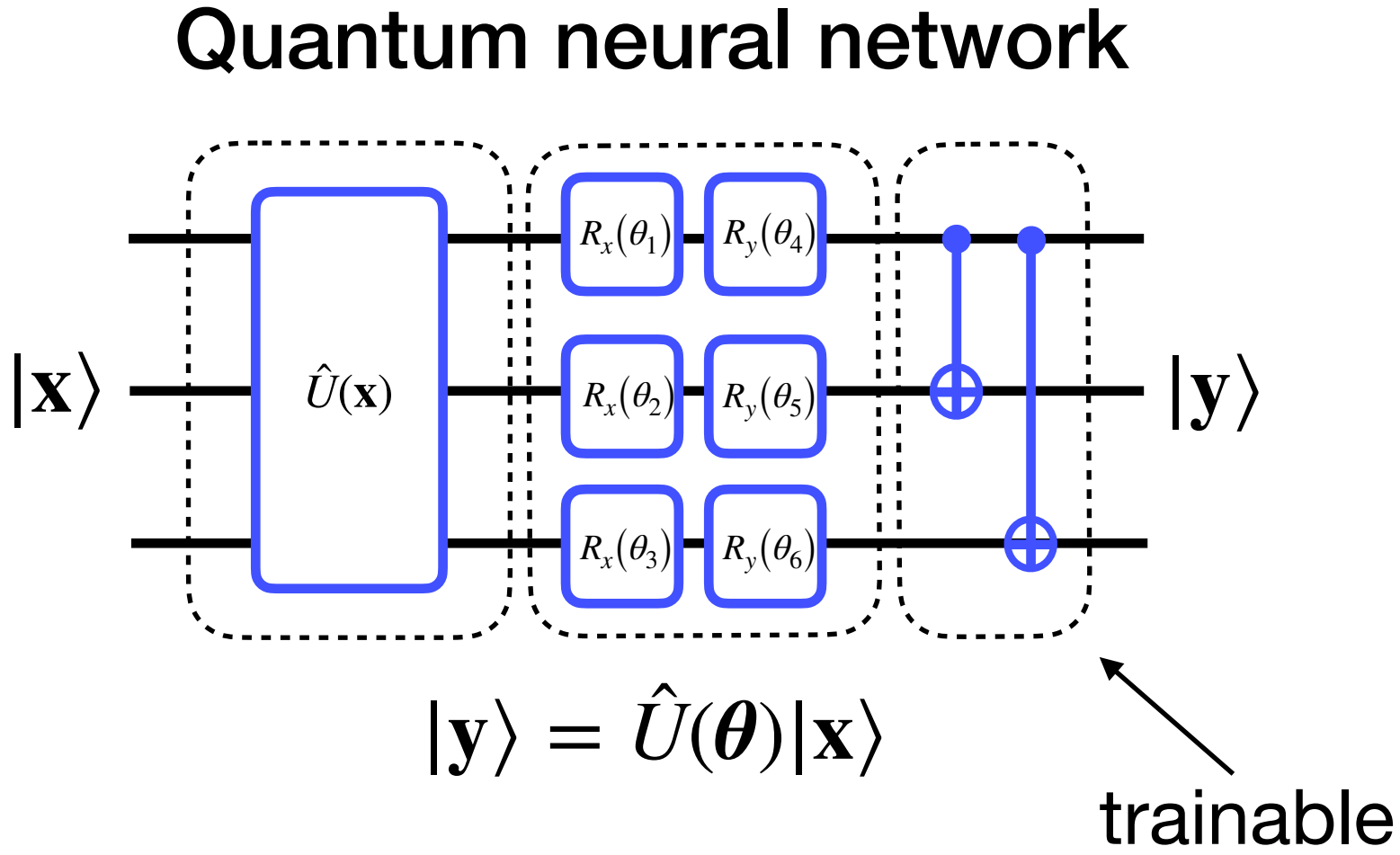
- **Generative model:** learn hidden distribution from samples
- **Diffusion model:** connect target distribution to Gaussian through Markov chain
- **Quantum neural network:** trainable transformation on quantum states



**Poster stand 33**

# Quantum diffusion model: ingredients

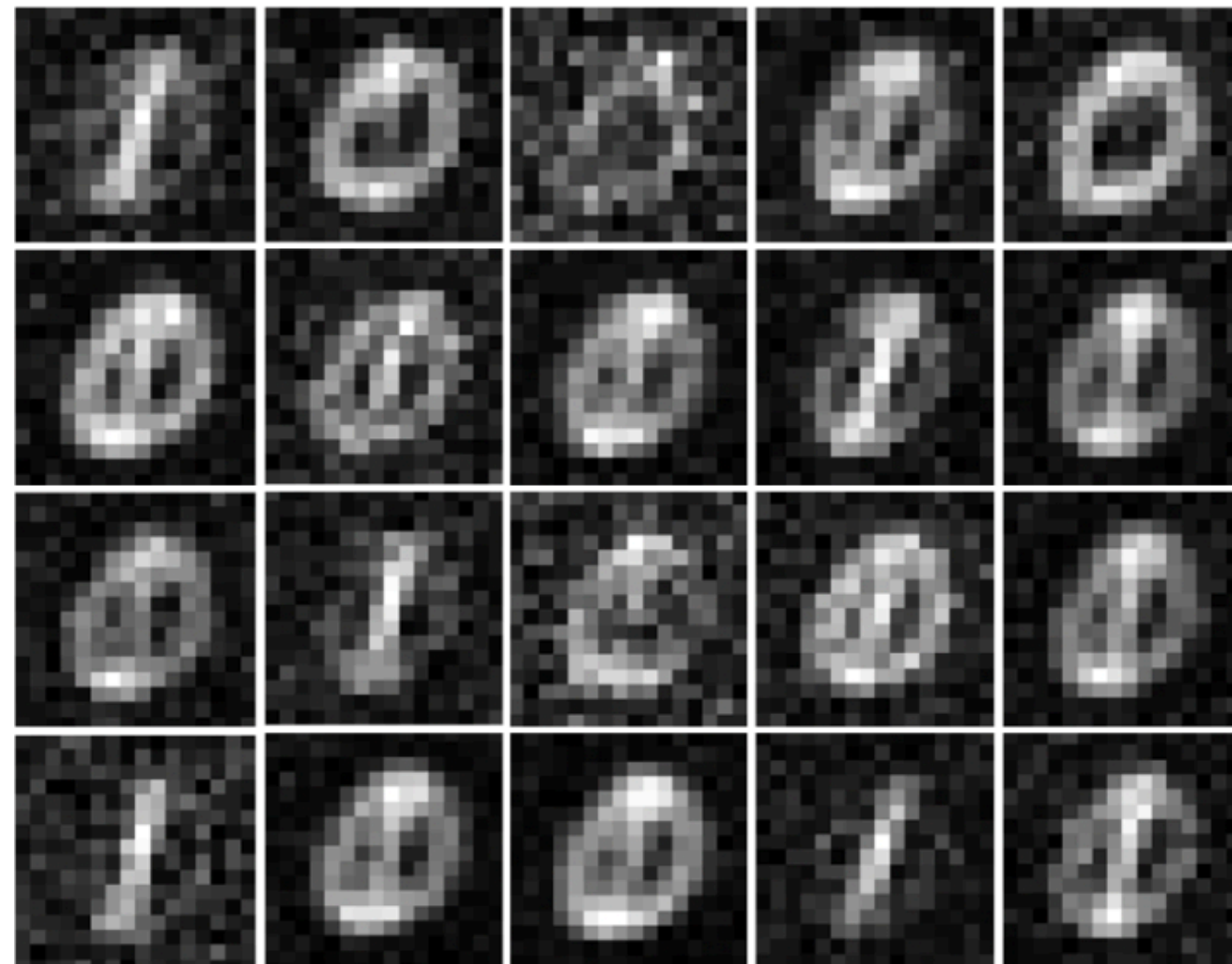
- **Generative model:** learn hidden distribution from samples
- **Diffusion model:** connect target distribution to Gaussian through Markov chain
- **Quantum neural network:** trainable transformation on quantum states



**Poster stand 33**

# Learned distributions

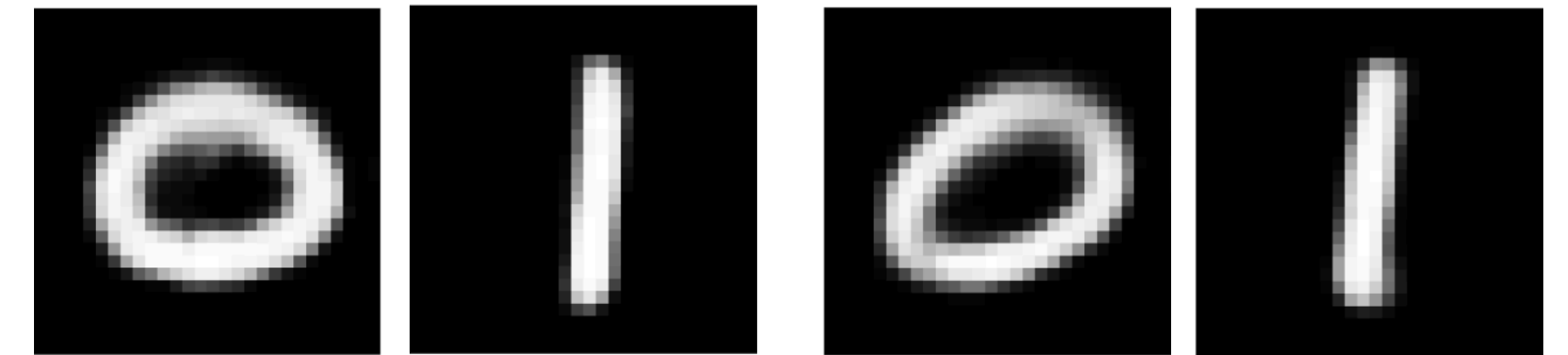
Quantum model  
(simulation)



Quantum model (simulation)  
+  
Classical autoencoder

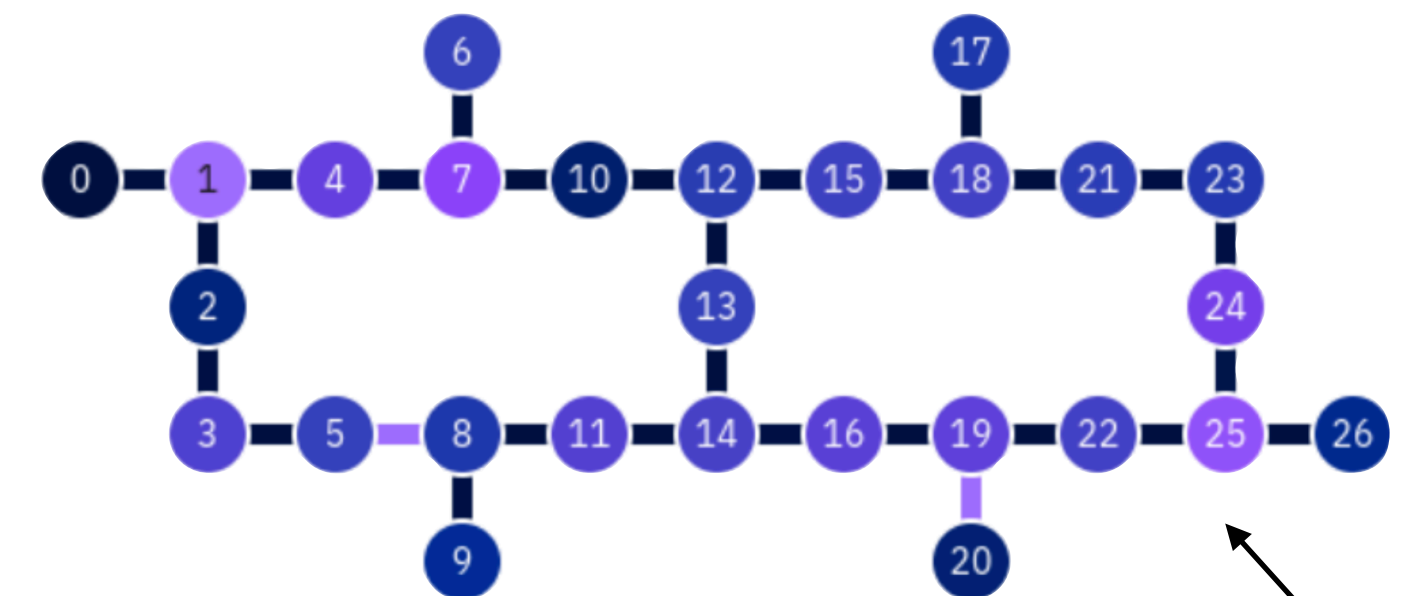


Quantum model (hardware)  
+  
Classical autoencoder



Simulated

Hardware



Quantum Chip  
(IBM Hanoi)

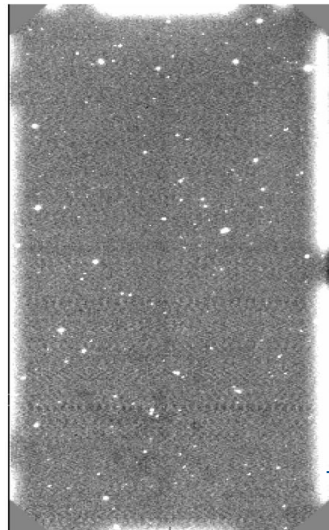
# MULTI-BAND PHOTOMETRY AND REDSHIFT ESTIMATION FROM GALAXY IMAGES WITH NORMALIZING FLOWS

Laura Cabayol-Garcia (IFAE/PIC, Barcelona)

Cosmological analysis demands precise 3D mapping of the Universe



Measuring distance to galaxies (redshift)



## Photometry

Several steps:

- Background subtraction
- Flux measurement
- Calibration
- ...

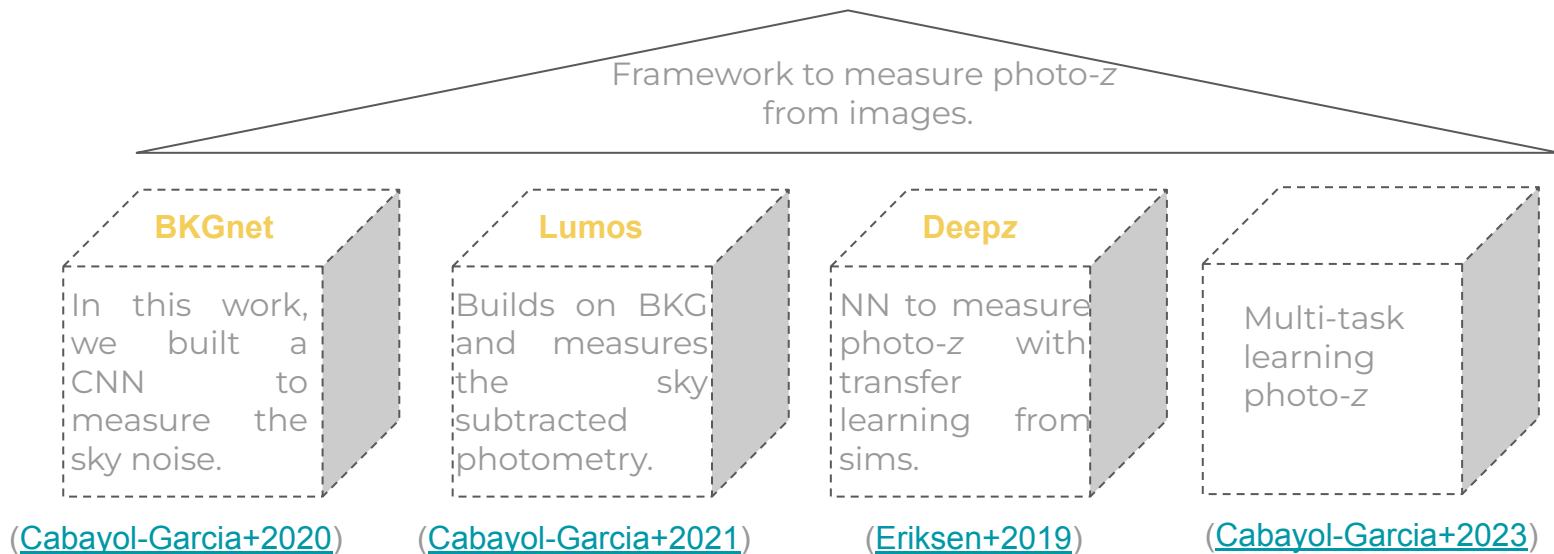
Photo-z

+photometry

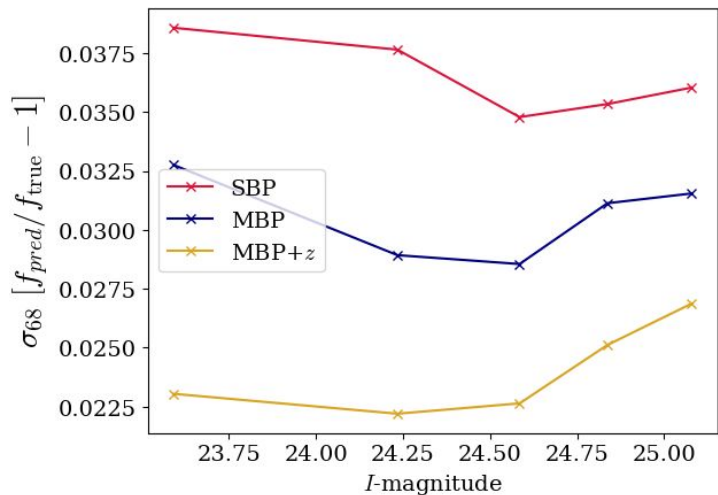
This work!

Bypassing the need for sequential measurements!!

Currently there are efforts on measuring photo-z directly from images with AI. **We are developing a normalizing flow model to concurrently measure photometry and photometric redshifts directly from the astronomical images.**



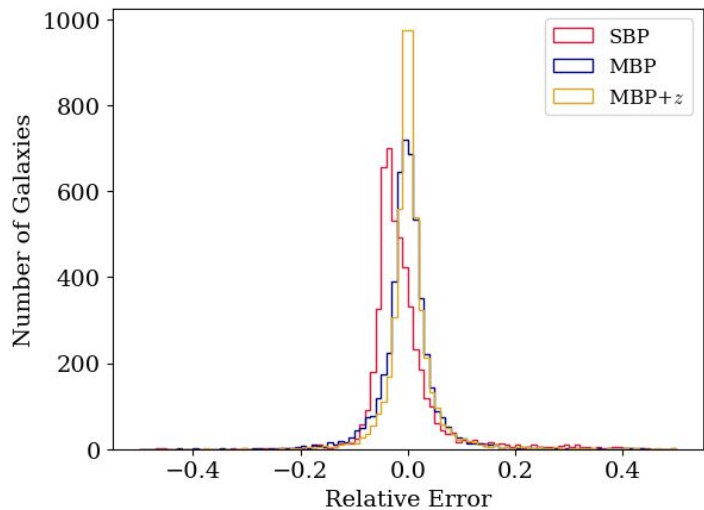
By simultaneously **measuring photometry across multiple spectral bands and photometric redshifts**, our model harnesses the full energy distribution of galaxies, which **enables cross-band constraints maximizing the use of information in the data.**



**SBP:** Single-band photometry. Each band is independent, the network does not learn from other bands to predict the flux of one band

**MBP:** Multi-band photometry. The network has information from all bands when making a prediction.

**MBP+z:** Multi-band photometry and redshift. The network has information from all bands when making a prediction. Predicts the photometry and the redshift simultaneously



The network benefits from knowing the full SED when making a prediction. It also benefits from predicting the photo-z simultaneously (MTL)

**Check poster 36 tomorrow!**

# 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

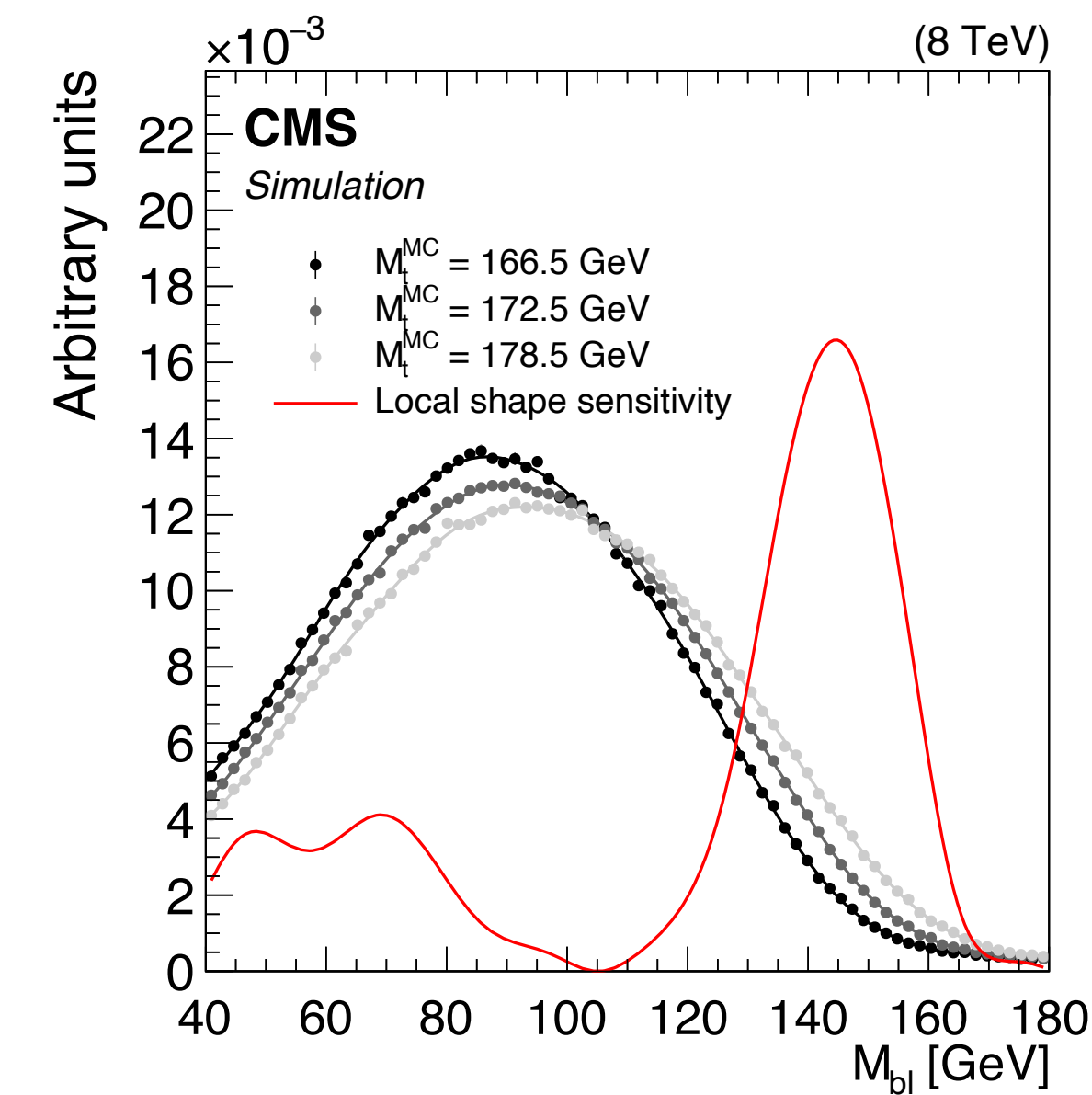
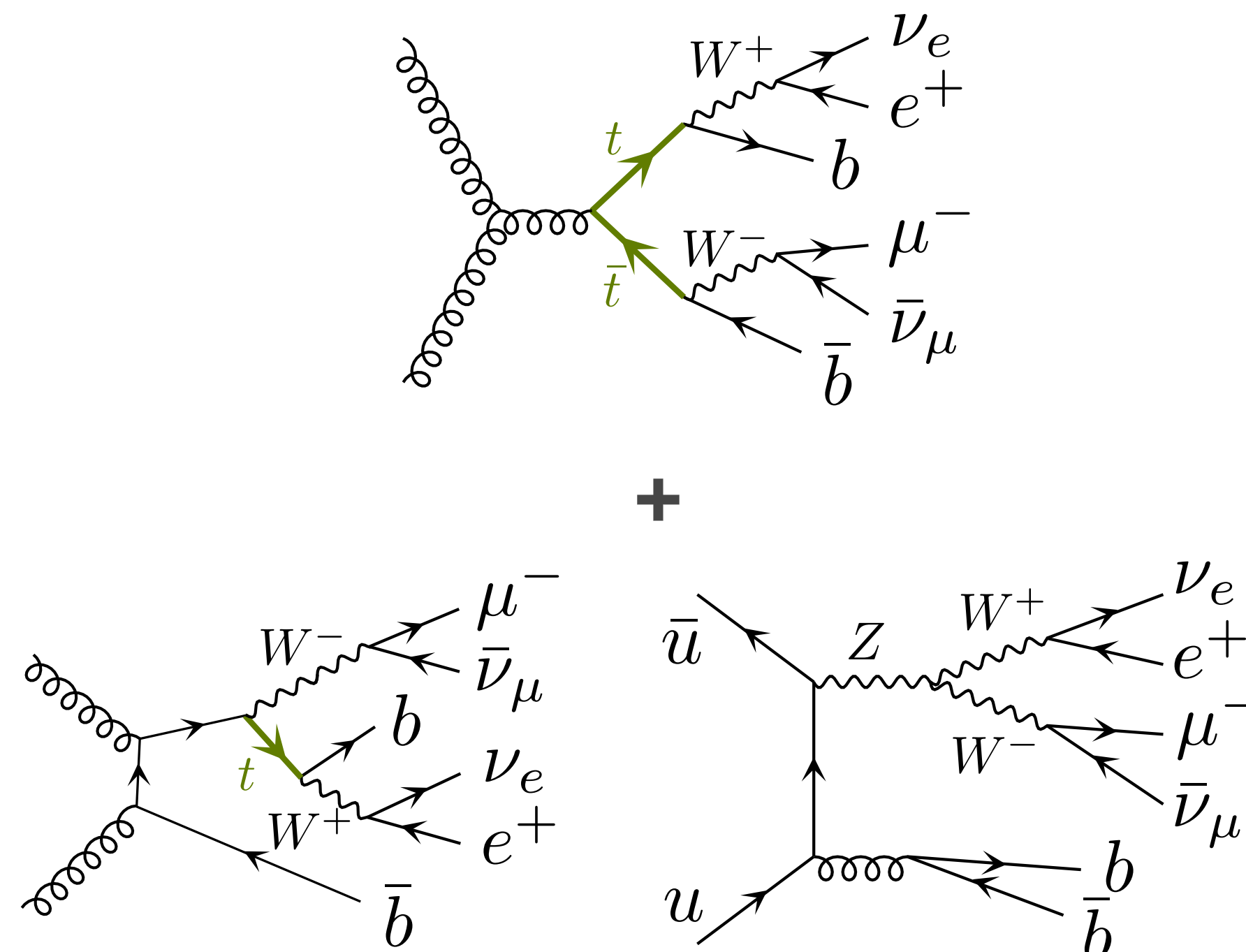


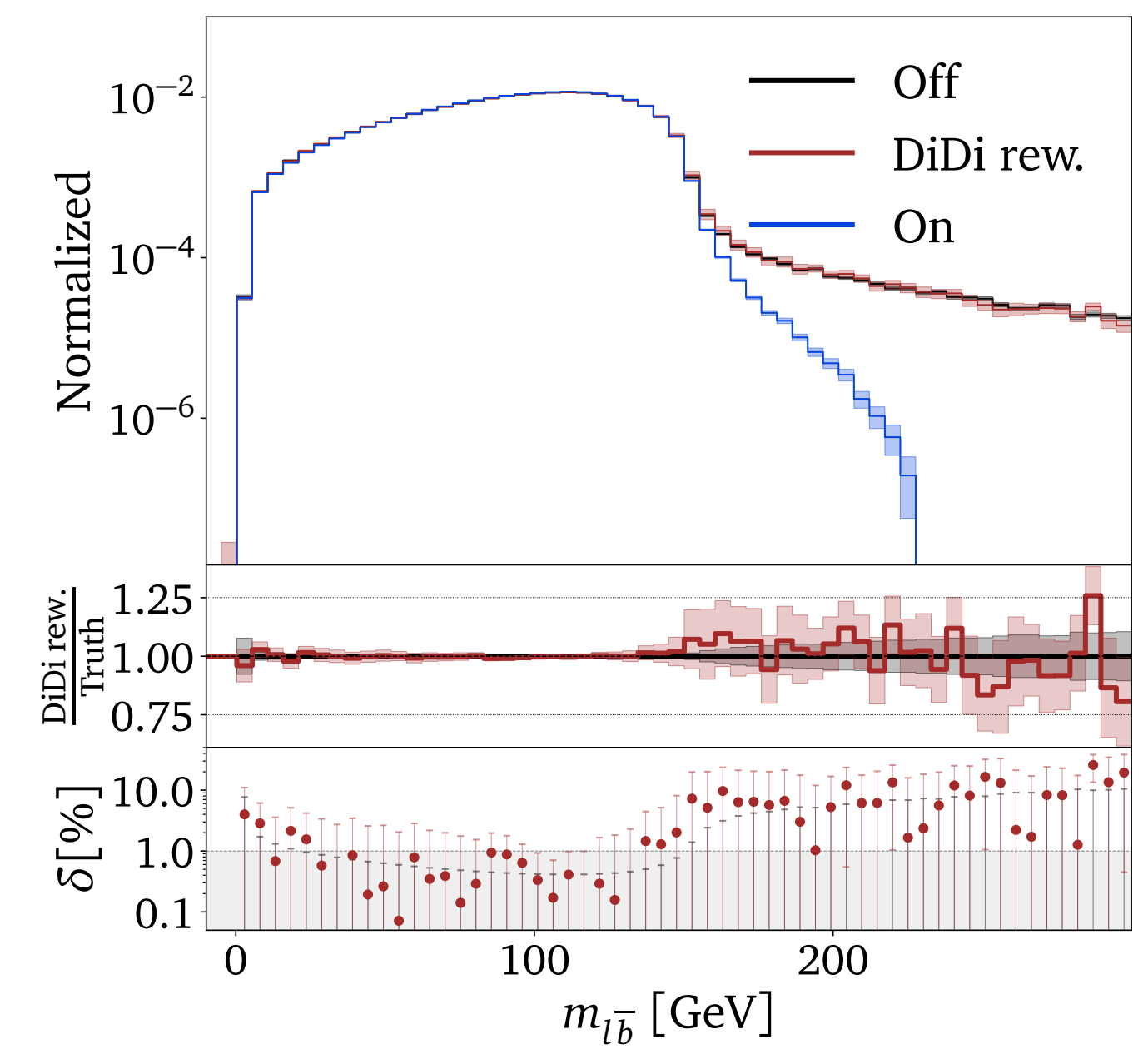
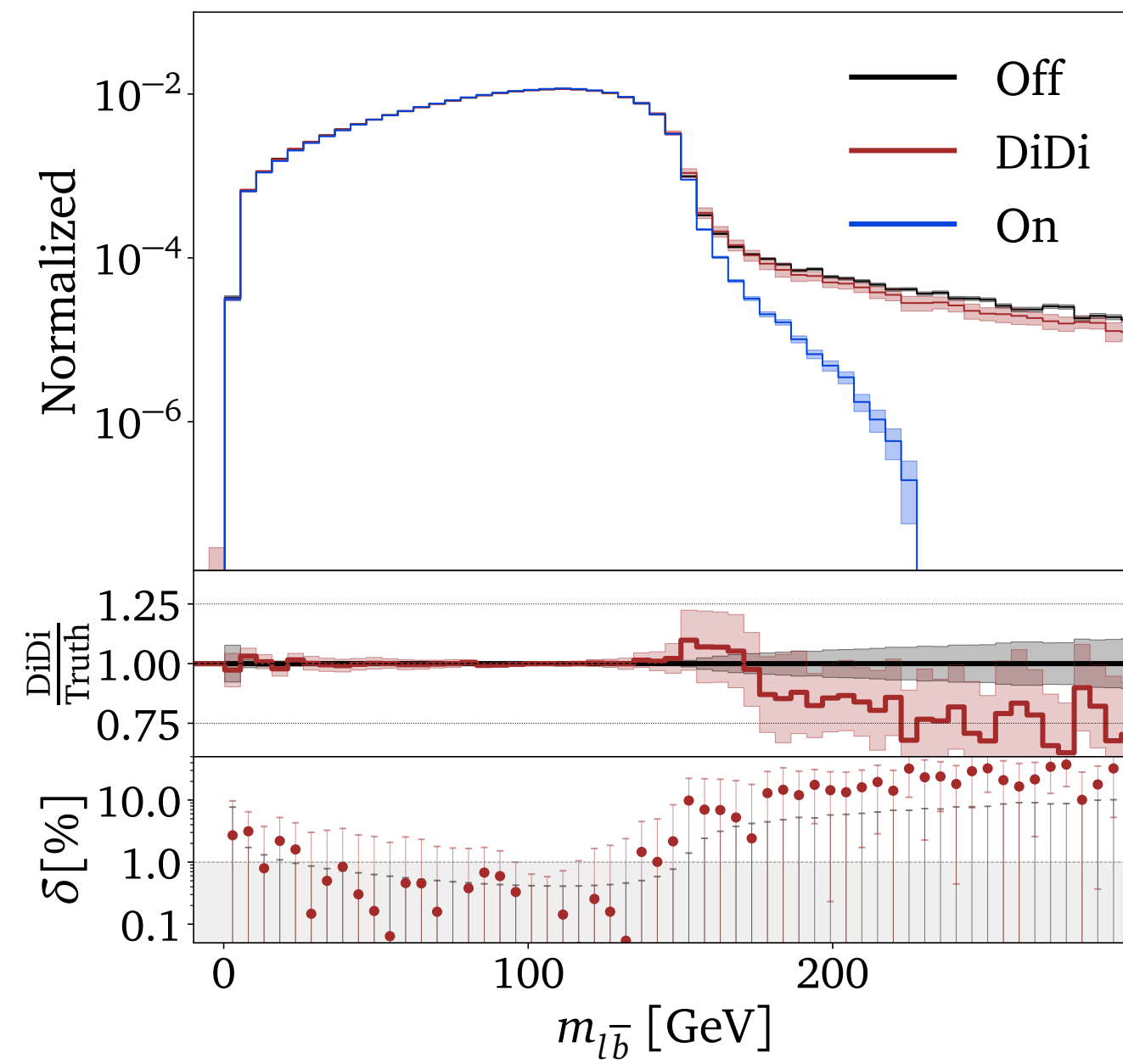
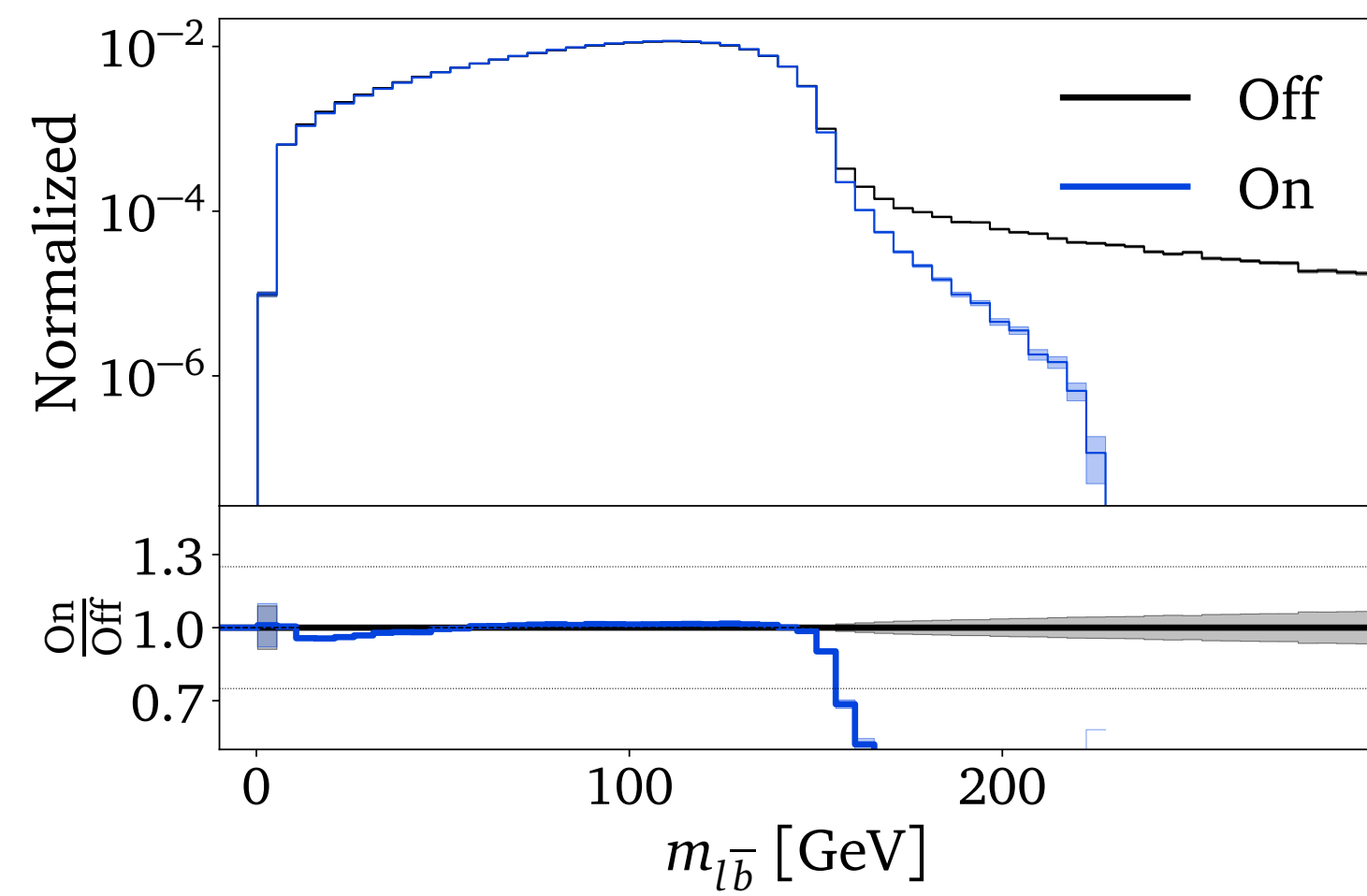
Figure from CMS arXiv:1704.06142v2



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

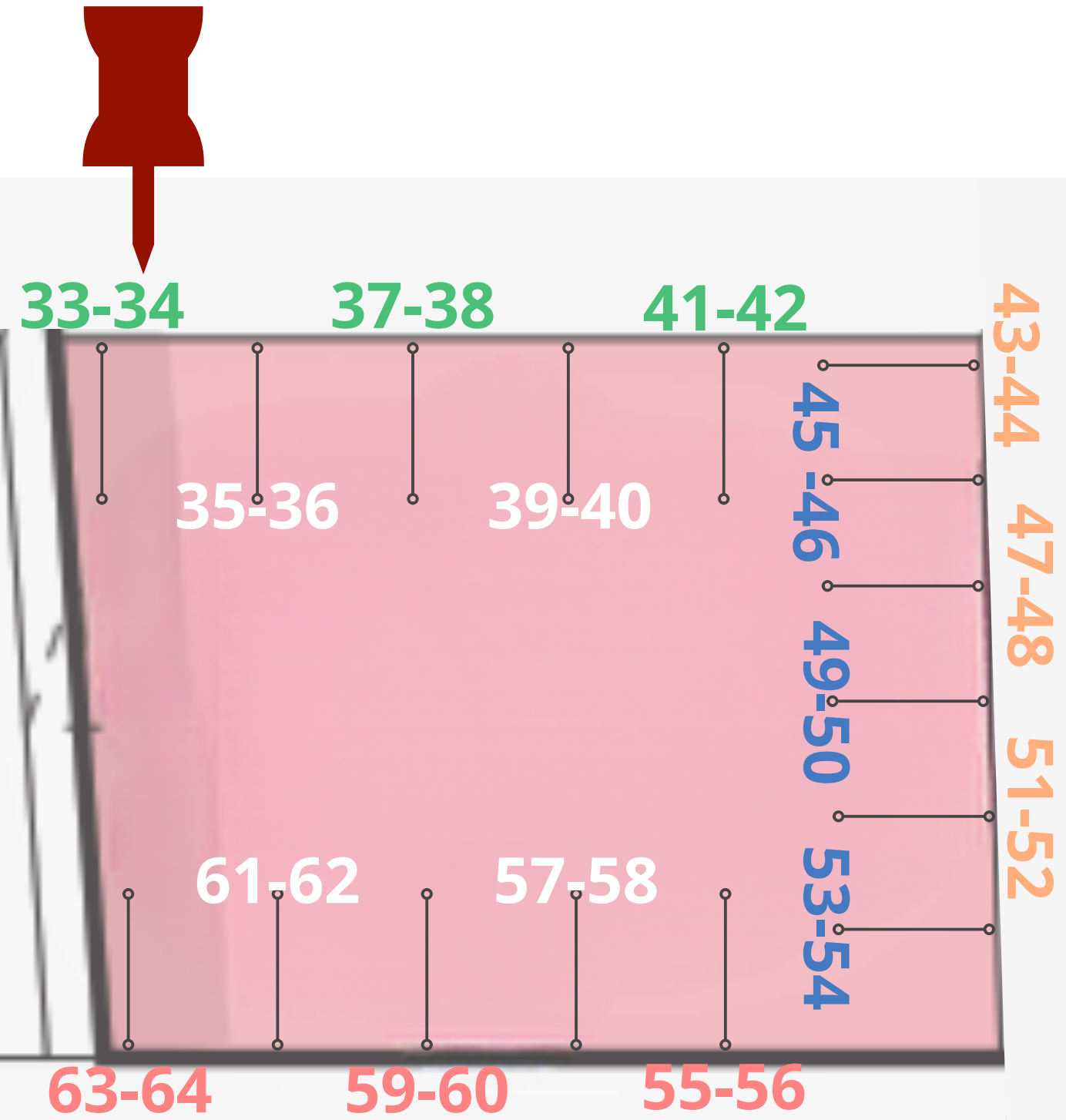
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QR code: Scan me

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

1 Institut für theoretische Physik, Universität Heidelberg, Germany  
2 Institut für theoretische Physik, Universität Münster, Germany  
3 LPNHE, Sorbonne Université, Université Paris Cité, CNRS/IN2P3, Paris, France

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# EXPLORING THE UNIVERSE WITH RADIO ASTRONOMY AND AI



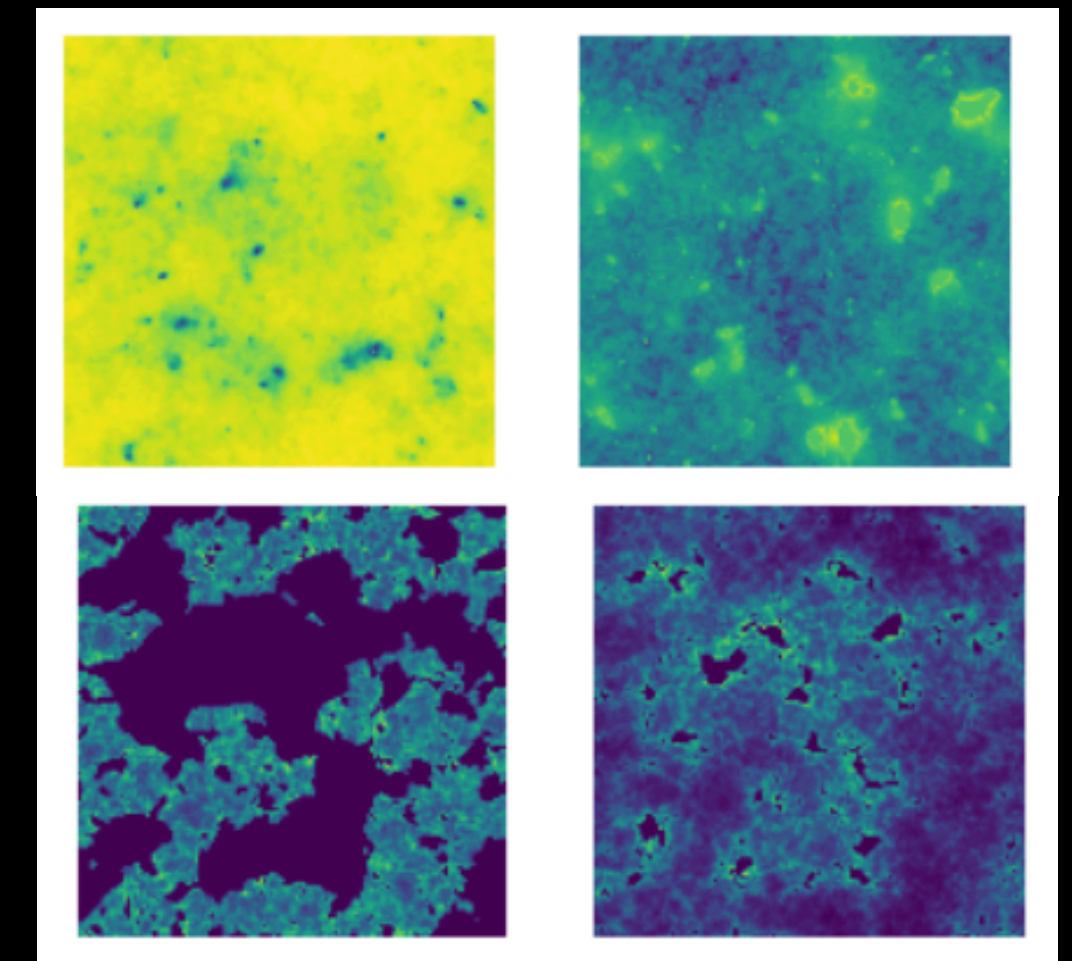
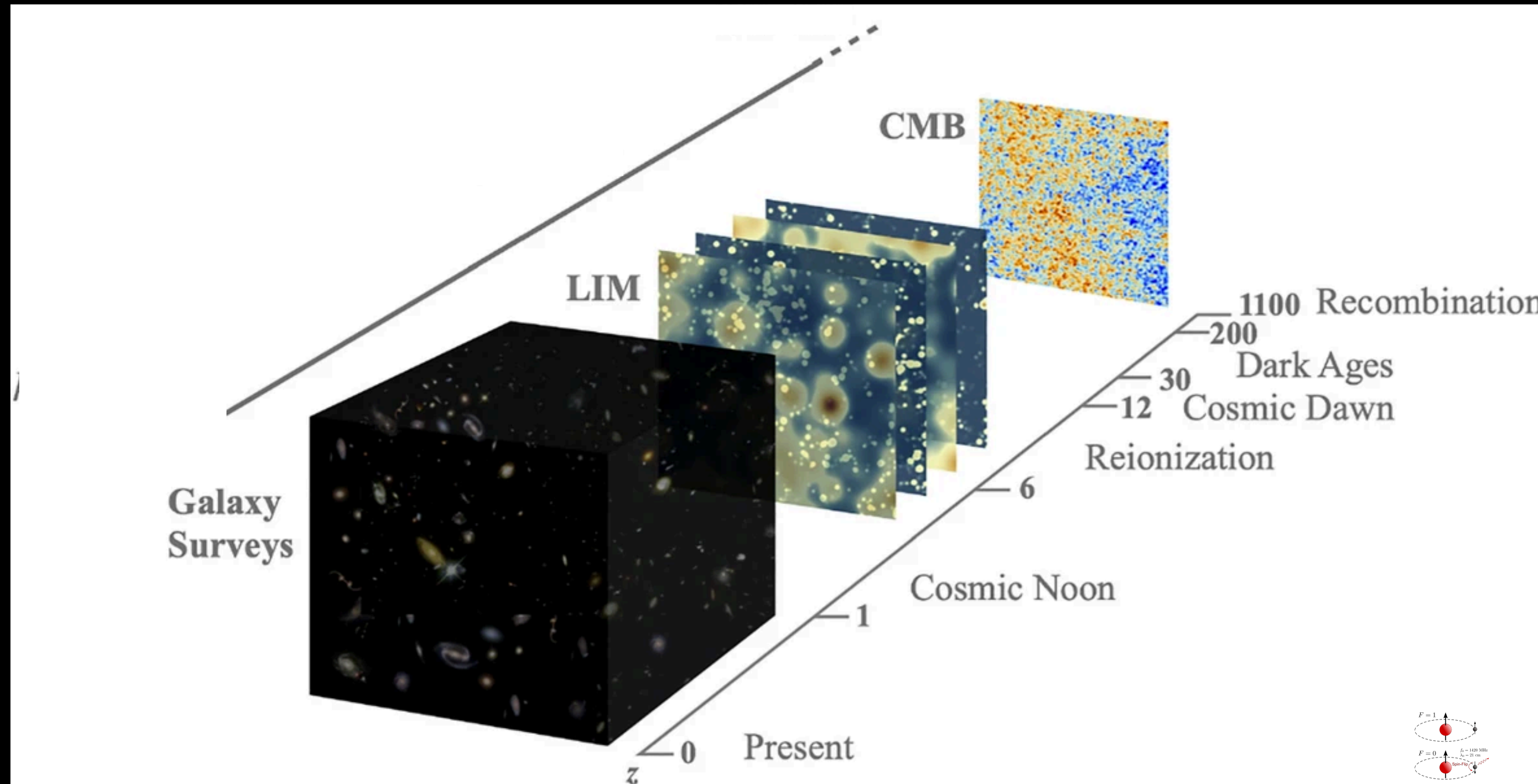
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Caroline Heneka

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