Warsaw University of Technology

ALICE

# How to generate all possible simulations with GANs?

*Selectively enhacing the diveristy of GAN-generated samples*

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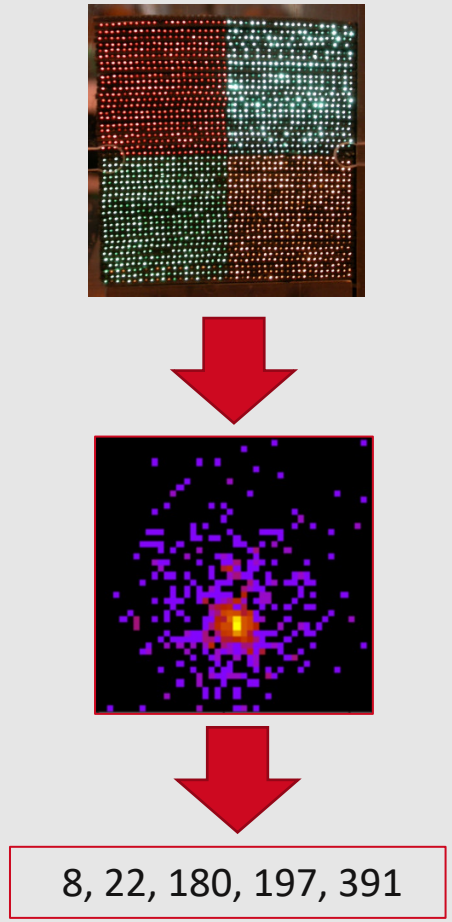
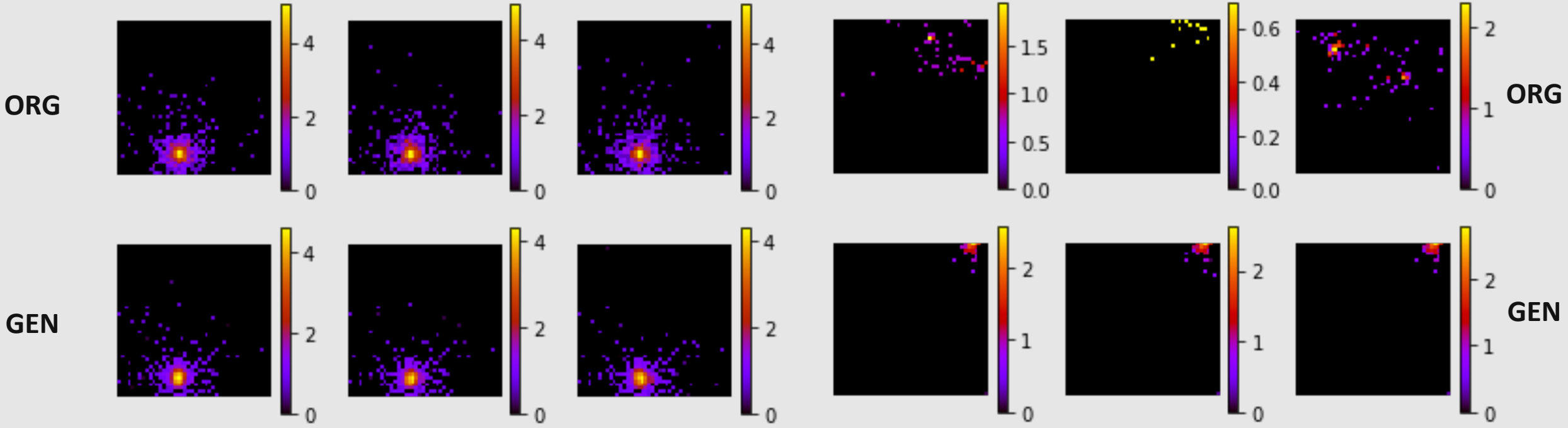
# Fast simulation of the Zero Degree Calorimeter

- We treat the response of the ZDC as a 44x44 1-channel image
- The image is produced in reponse to a particle described by 9 conditonal variables (Energy, mass, charge, Pxyz, Vxyz)
- We have run the simulation multiple times for each set of particle properties



# GANs work well for “consistent” showers …

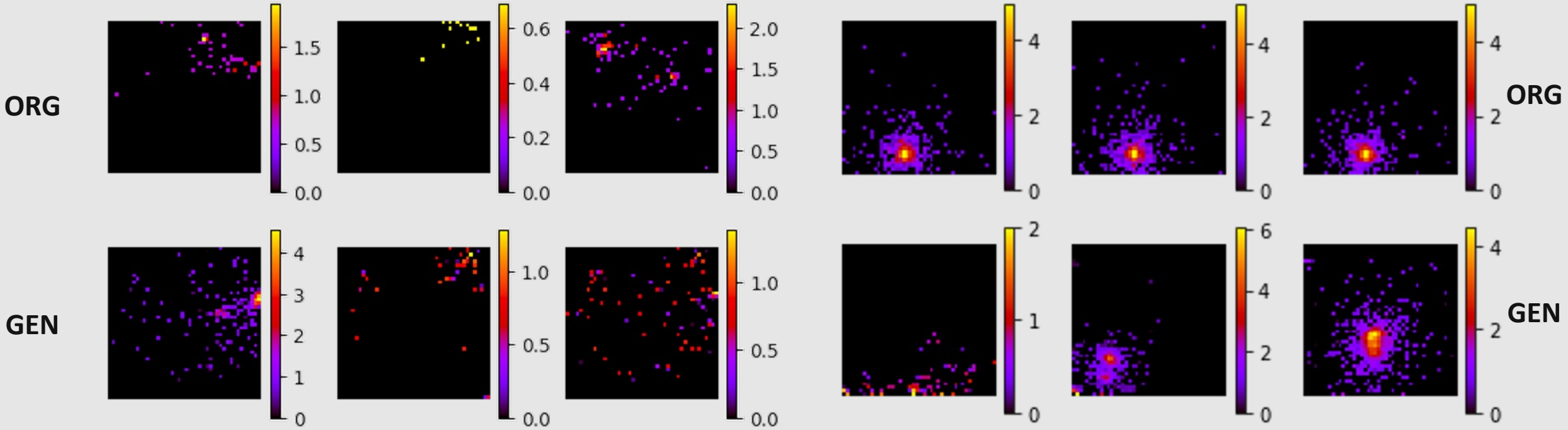
# … but fail to simulate possible diverse outcomes




*3 ZDC responses generated for the same particle (same input conditonal data)*

# Methods to increase diversity of GAN samples exist …

# … but introduce problems for "consistent" showers




*3 ZDC responses generated for the same particle (same input conditonal data)*

# Selective increase of diversity

$\propto_c$ - measure of training samples diversity for this particular set of conditonals $c$

We use mean standard deviation of pixels normalized from 0 to 1

$d_g$ - measure of distance between 2 images generated from different noise vectors $z_1, z_2$

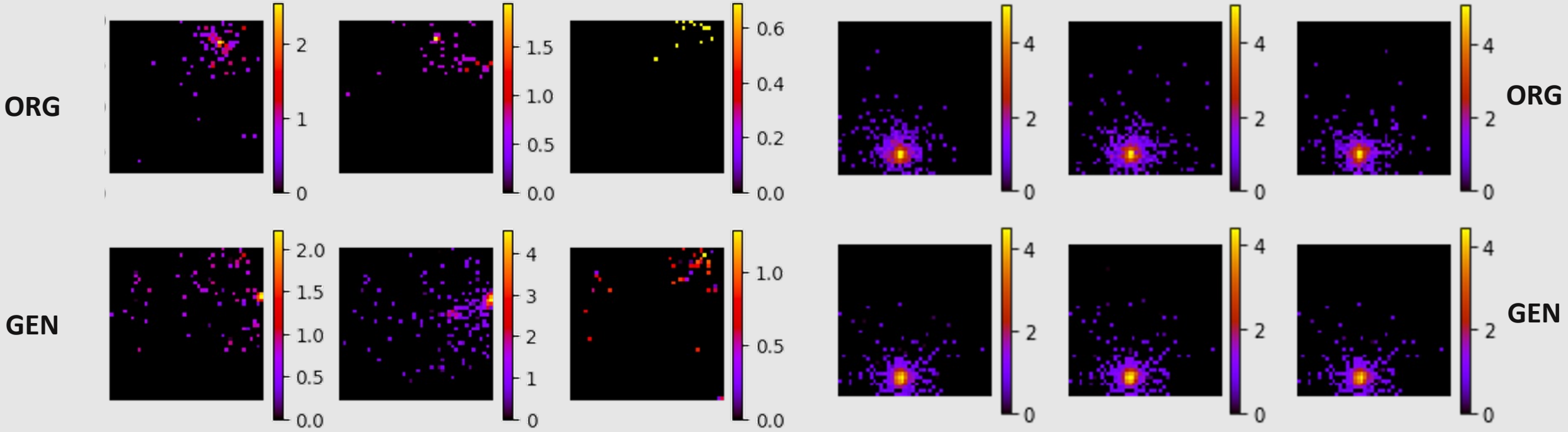
We use $L_1$ norm between features extracted from the discrimiantor penultimate layer

$$L = L_{gen} + \lambda L_{div} \qquad div = \propto_c \times \left( \frac{d_g\left(G((z_1, c)), G((z_2, c))\right)}{d_z(z_1, z_2)} \right)^{-1}$$

$d_z$ - measure of distance between 2 input noise vectors
We use $L_1(z_1, z_2)$

# GAN generates diverse results …

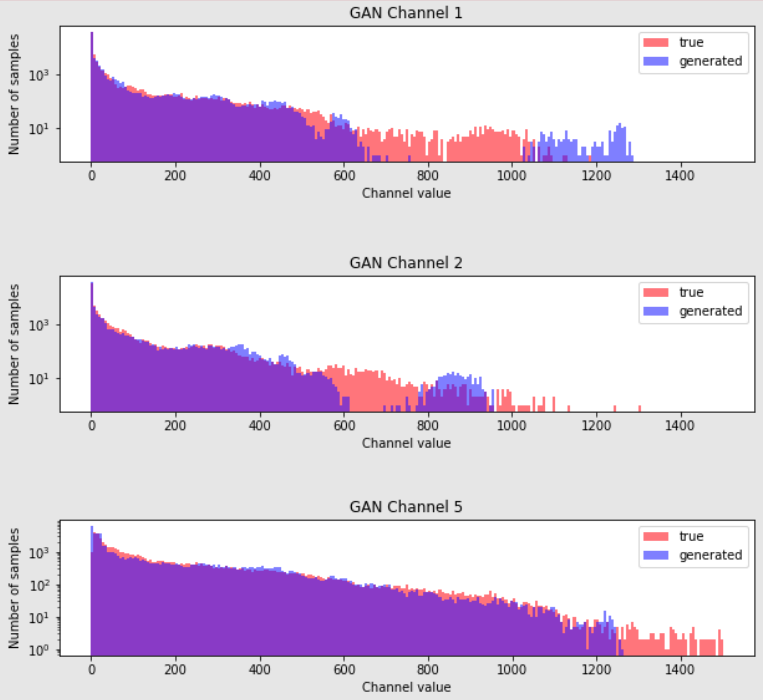
# … and keeps consistency where needed

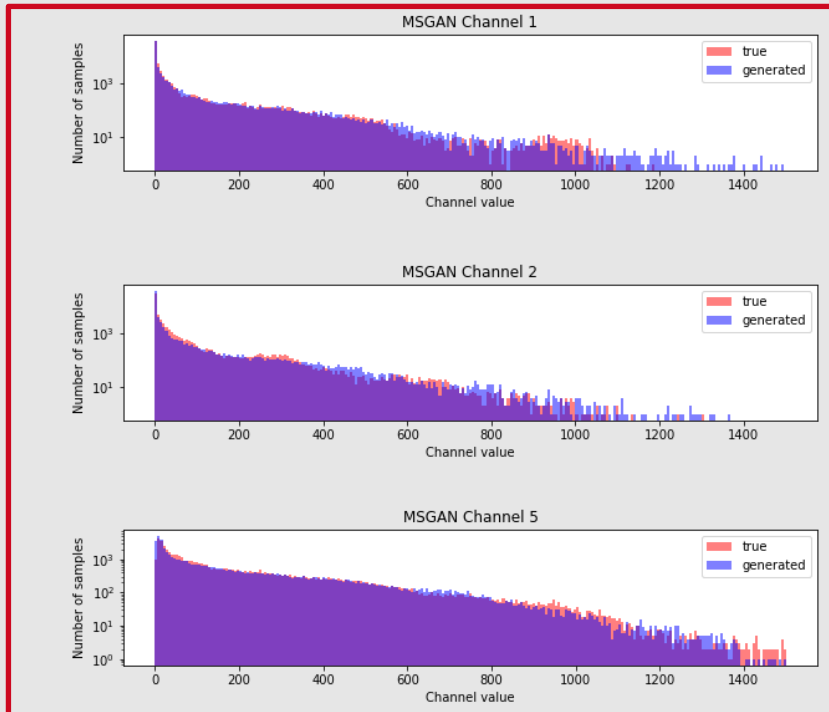



*3 ZDC responses generated for the same particle (same input conditonal data)*

# Improvement of simulation quality

GAN




GAN with selective diversity increase

Our method:

- increases the diversity of generated samples for a selected subset of input data
- leads to higher simulation fidelity by:
  - decreasing the differences between the distribution of original and fast simulation
  - smoothing the distribution of the generated results.