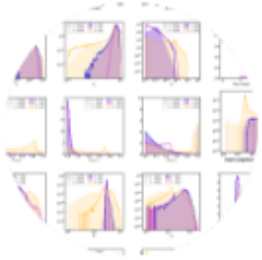
Adversarial Games for ~~Particle Physics~~ Dark Matter

Gilles Louppe

Darkmachines Kick-off
June 19, 2018

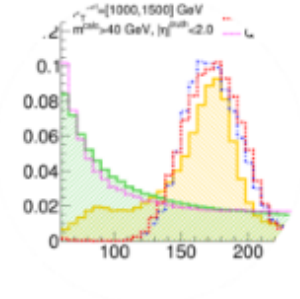
Disclaimer: Not a Darkmachines challenge in itself. Rather, an opportunity to import recent techniques from ML in one of the identified challenges.

Adversarial games for particle physics

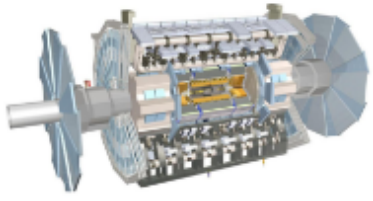


Learning to generate

Adversarial training



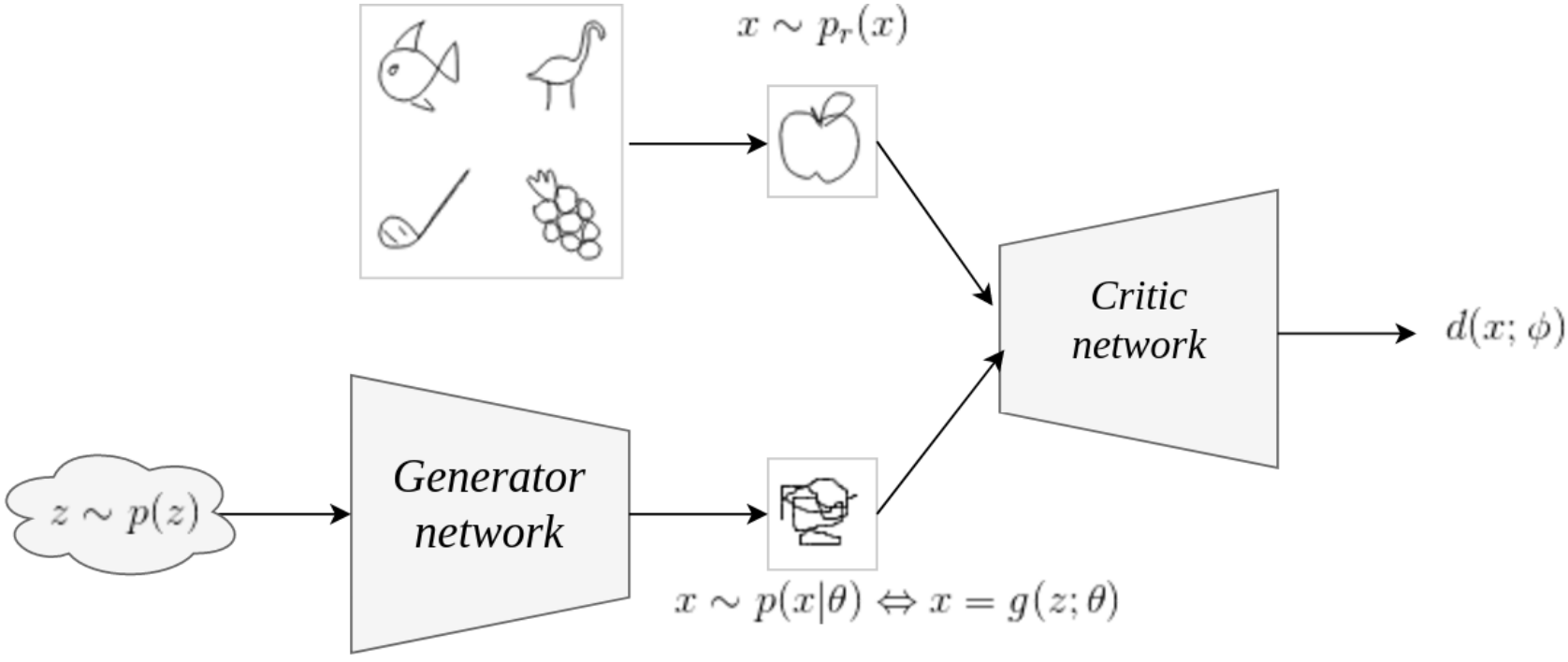
Learning to pivot



Inference

Generative adversarial networks

Goodfellow et al, 2014, arXiv:1406.2661
Arjovsky et al, 2017, arXiv:1701.07875

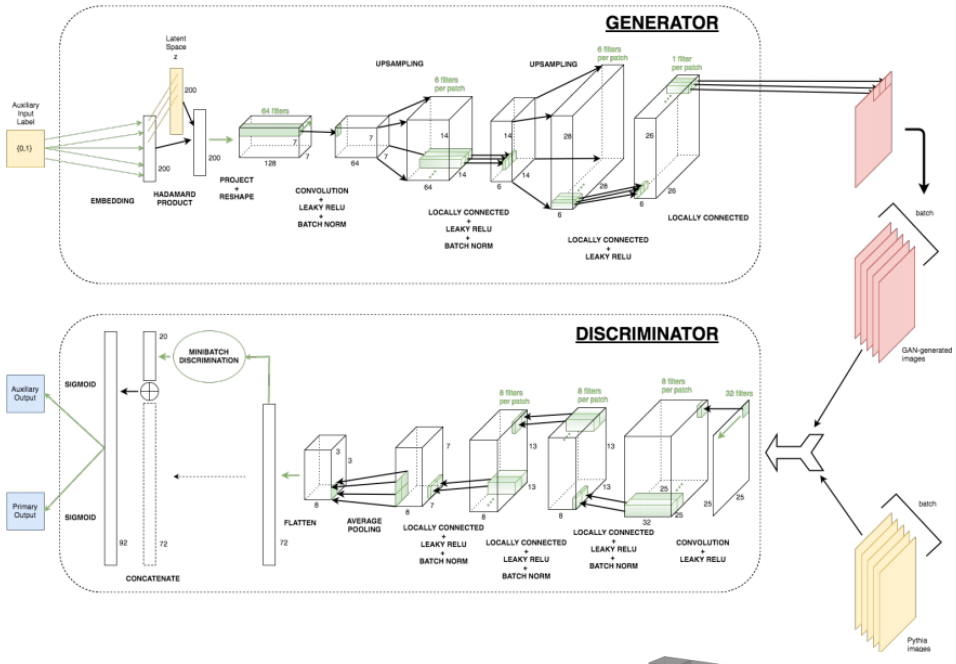


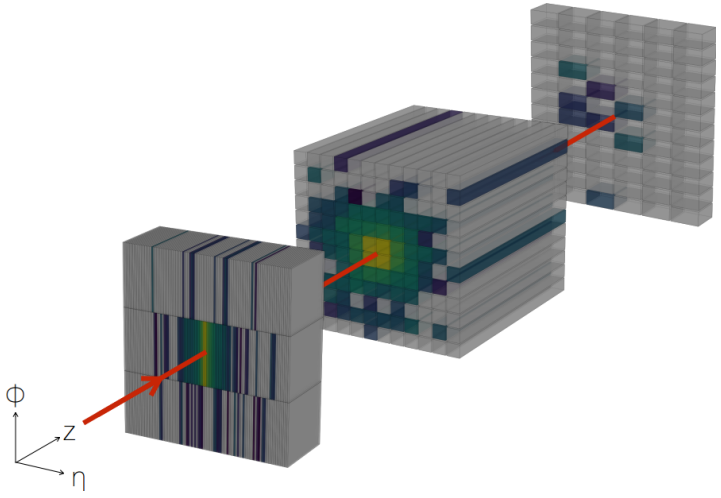
$$\mathcal{L}_d(\phi) = \mathbb{E}_{\mathbf{x}\sim p(\mathbf{x}|\theta)}[d(\mathbf{x};\phi)] - \mathbb{E}_{\mathbf{x}\sim p_r(\mathbf{x})}[d(\mathbf{x};\phi)] + \lambda\Omega(\phi)$$

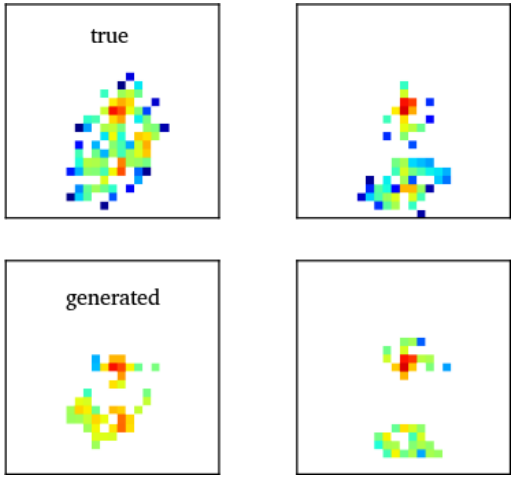
$$\mathcal{L}_g(\theta) = -\mathbb{E}_{\mathbf{x}\sim p(\mathbf{x}|\theta)}[d(\mathbf{x};\phi)]$$

(Wasserstein GAN + Gradient Penalty)

de Oliveira et al, 2017, arXiv:1701.05927; Paganini et al, 2017, arXiv:1705.02355





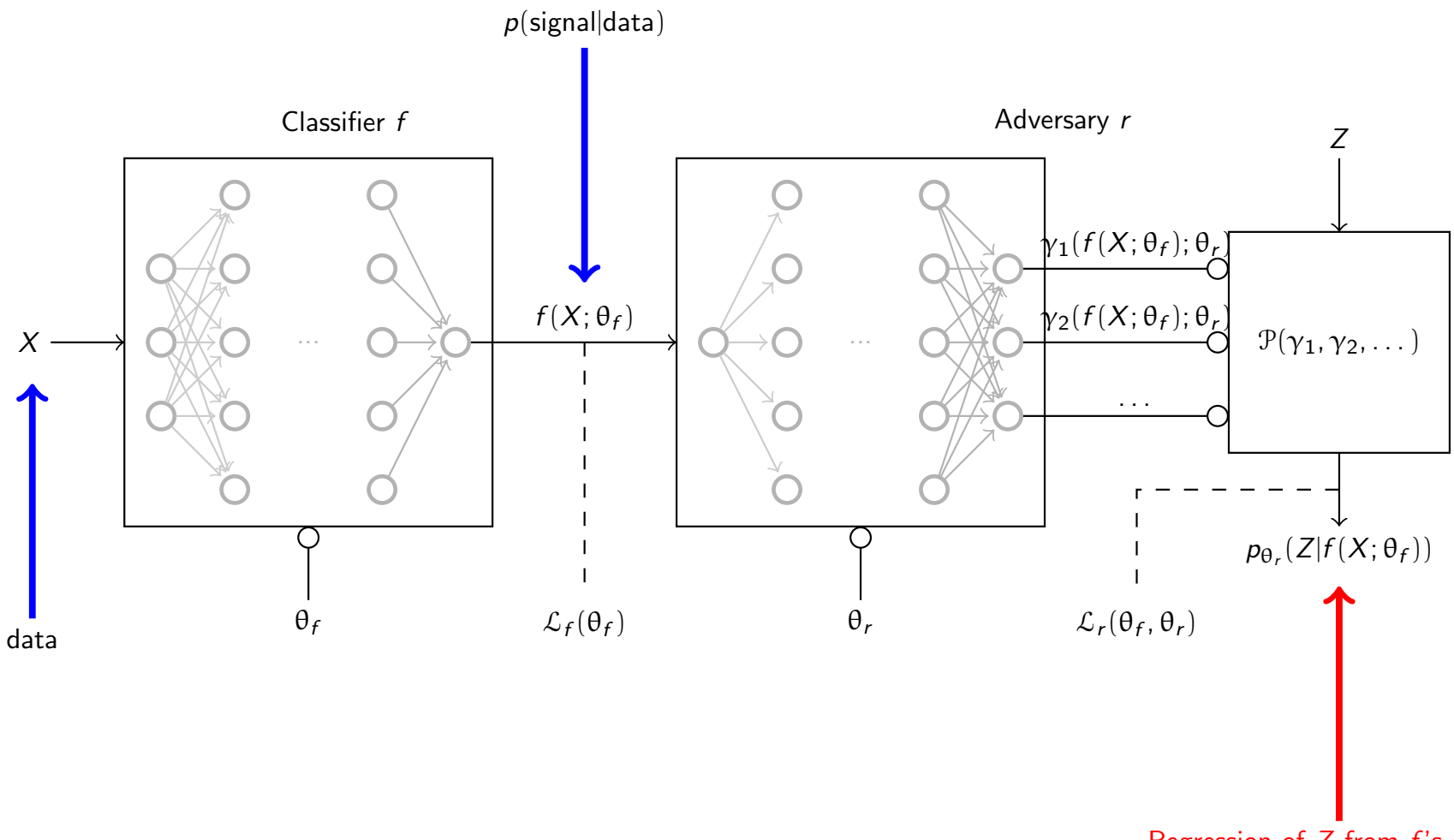


Challenges:

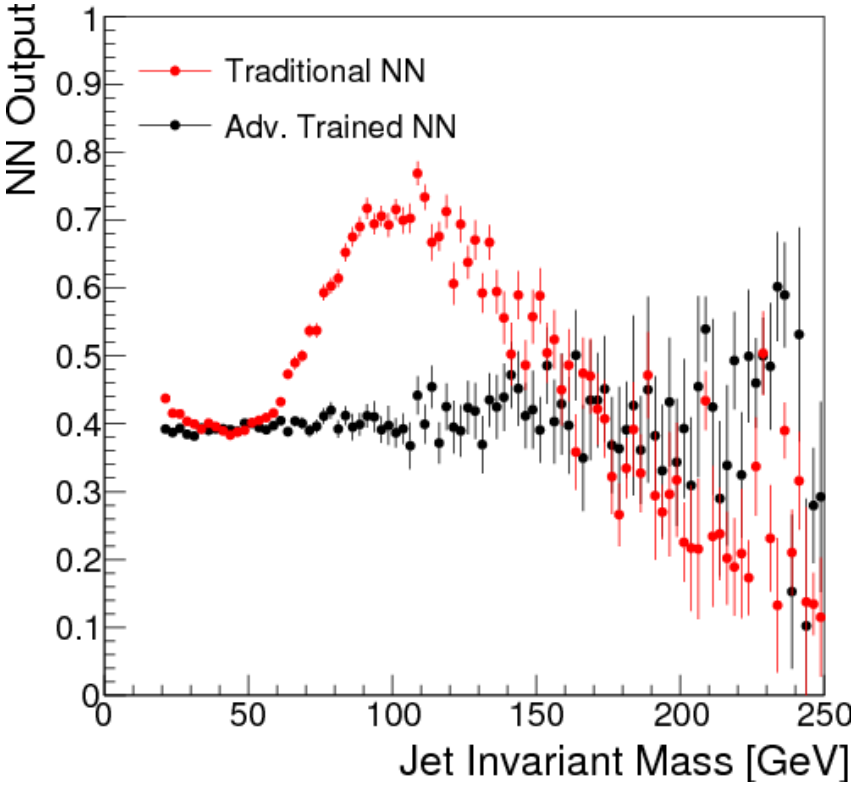
- How to ensure physical properties?
- Non-uniform geometry
- Mostly sparse
- How to scale to full resolution?

Learning to pivot

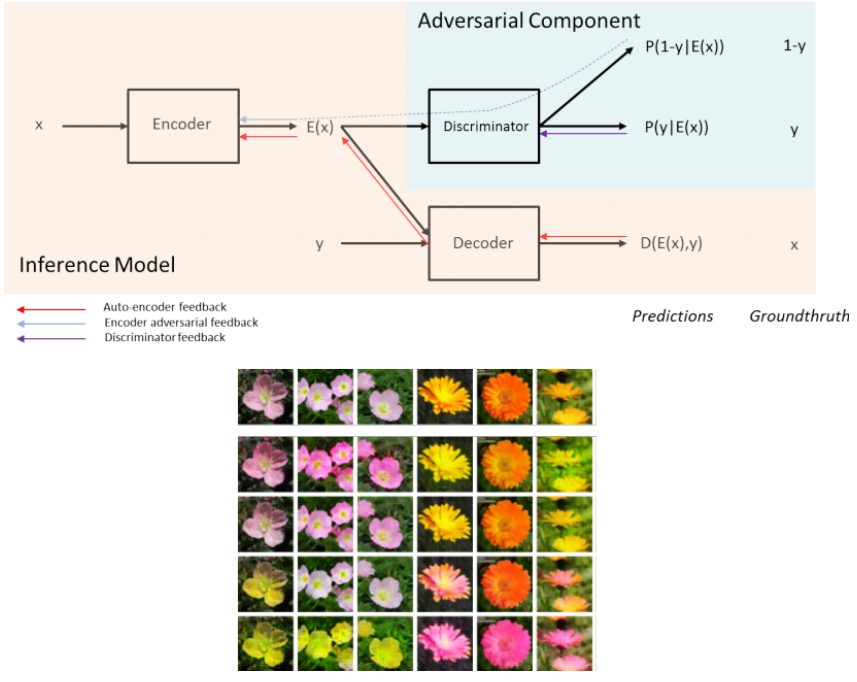
We want inference based on a classifier $f(X;\theta_f)$ to be robust to the value $z \in \mathcal{Z}$ (e.g., physics variates or nuisance parameters).



Shimmin et al, 2017, arXiv:1703.03507; Lample et al, 2017, arXiv:1706.00409



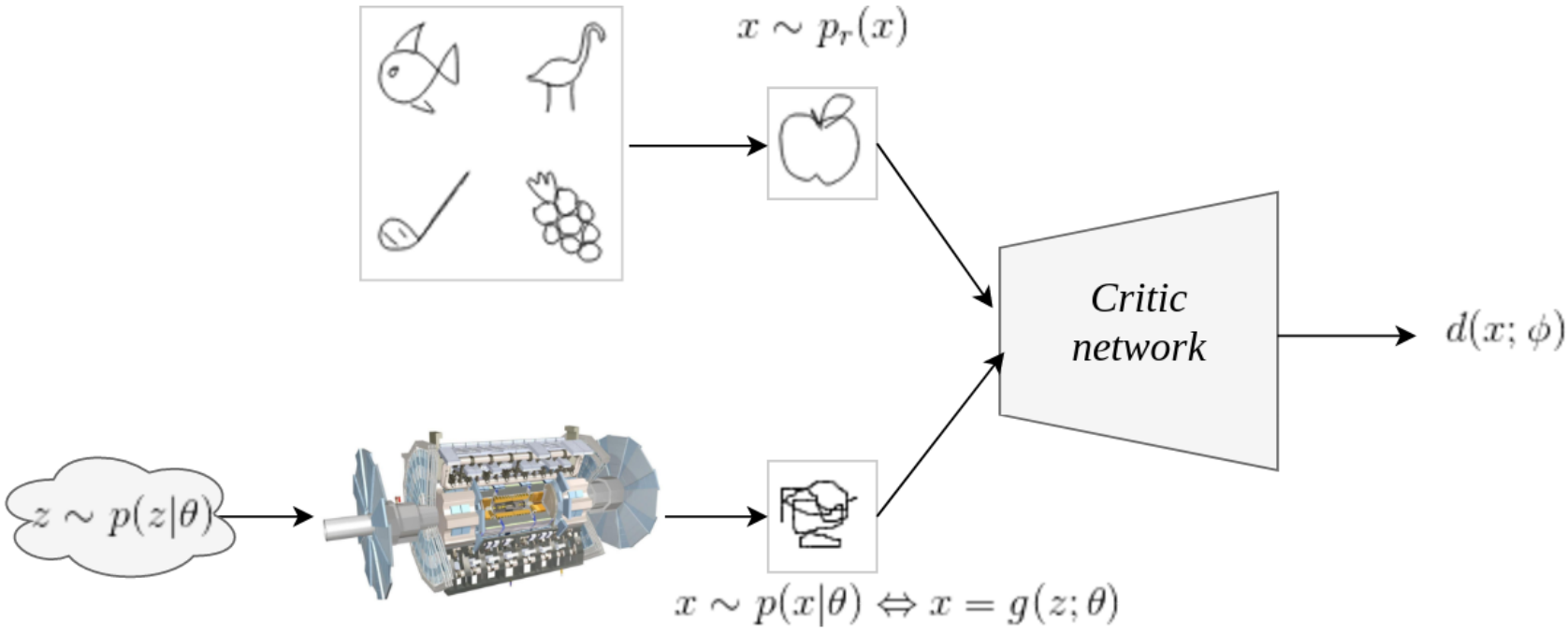
Decorrelated Jet Substructure Tagging using Adversarial Neural Networks



Fader networks

Louppe and Cranmer, 2017, arXiv:1707.07113

Likelihood-free inference

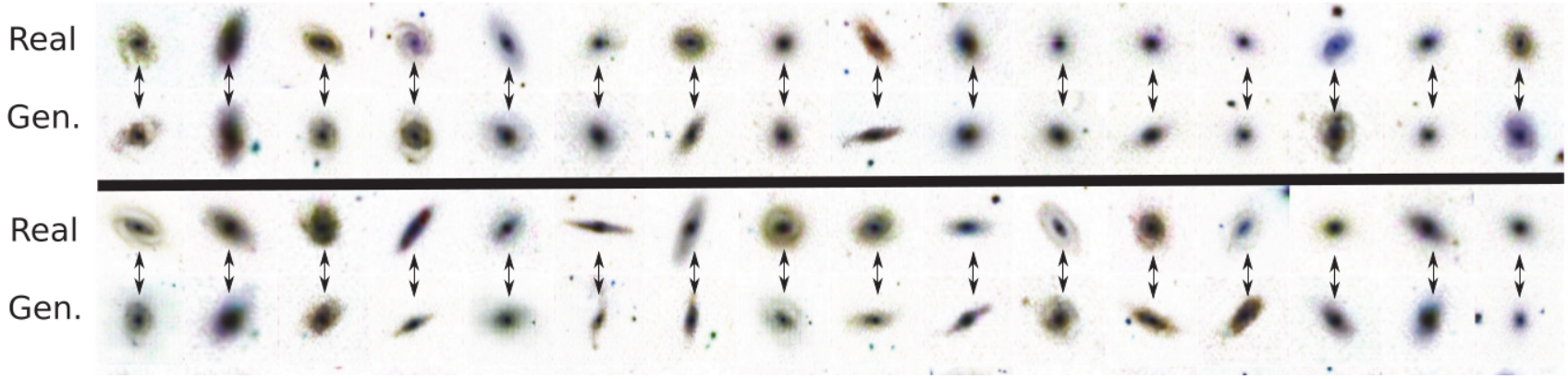


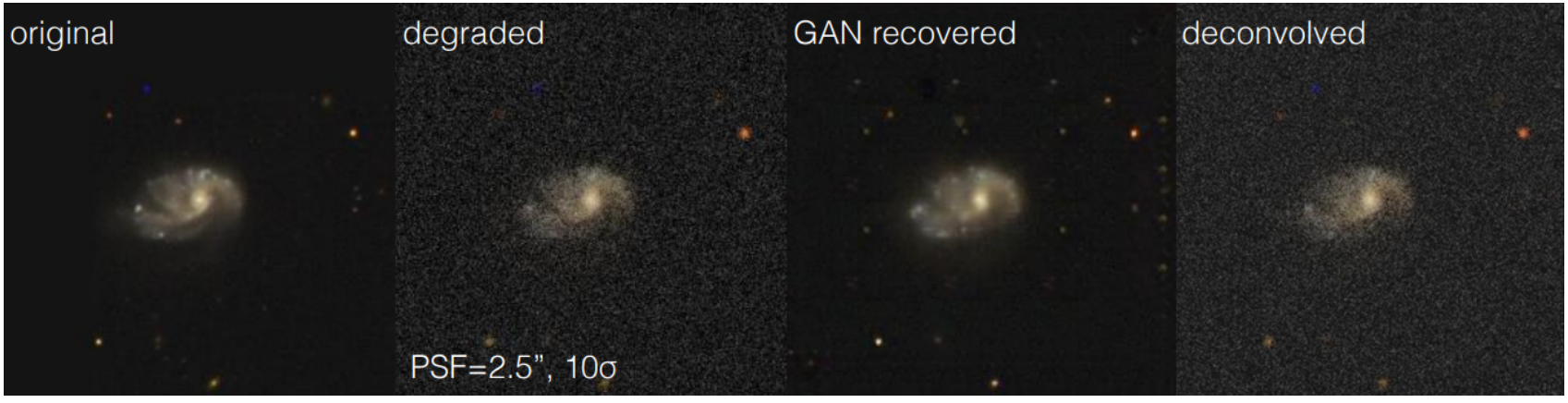
Adversarial variational optimization:

Replace g with an actual scientific simulator!

Ravanbakhsh, et al, 2016, arXiv:1609.05796; Schawinski et al, 2017, arXiv:1702.00403

GANs for galaxies





See also http://space.ml.