

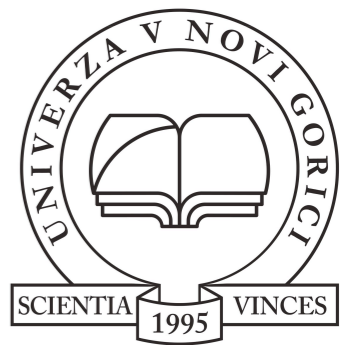


# SMASH

machine learning for science and humanities postdoctoral program



Co-funded by  
The European Union



# Characterizing the *Fermi*-LAT high-latitude sky with simulation-based inference

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$$p(Z|X) = \frac{p(X|Z)p(Z)}{p(X)}$$

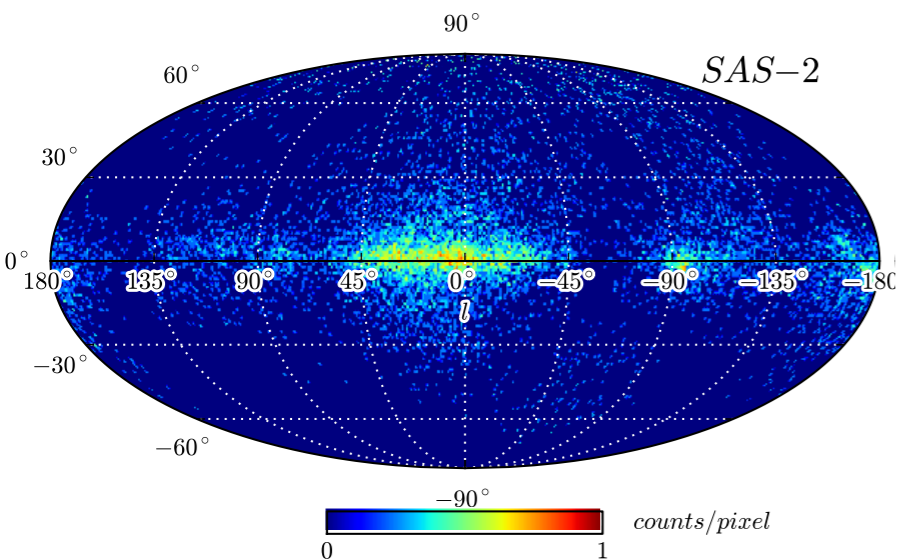
European AI for Fundamental Physics Conference (EuCAIFCon)

Amsterdam, Netherlands

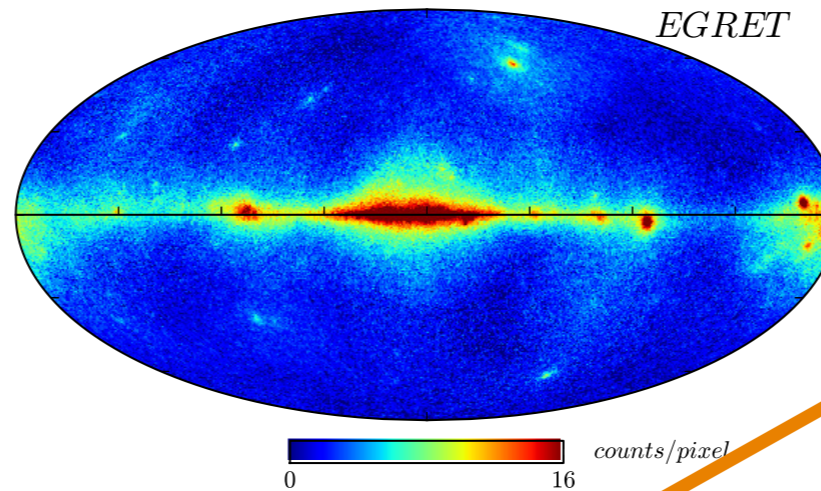
# Fundamental physics with gamma rays is hard

The high-energy gamma-ray sky seen over the decades (space-borne telescopes).

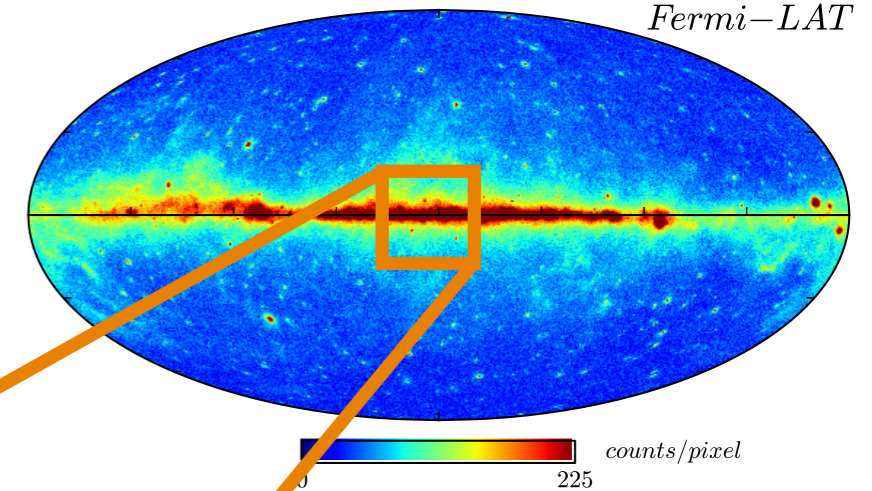
1972-73



1991-2000



2008-now



[Fermi-LAT collaboration, ApJS 223 (2016) 2]



[Bertone, Tait, *Nature* 562 (2018) 7725]

Signatures of fundamental physics are potentially hiding there!  
→ How to deal with the **complexity** of all the astrophysics?  
**There is a lot to model ...**

# Simulation-based inference brings back physics

Ratio estimation as a form of simulation-based inference (SBI):

Bayes' Theorem

posterior

Likelihood-to-evidence ratio



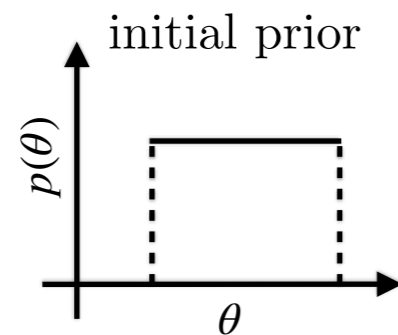
Truncated  
Marginal  
Neural  
Ratio  
Estimation

parameters  $Z$ , data  $X$

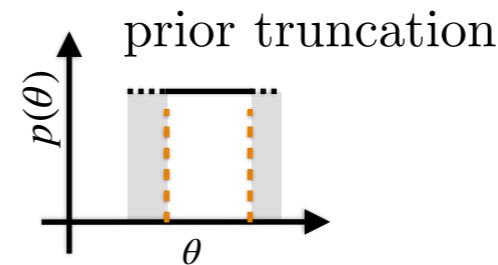
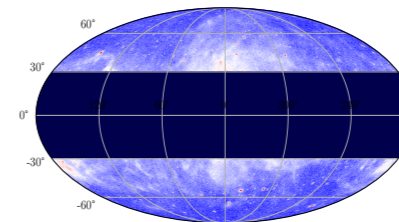
prior

$$p(Z|X) = \frac{p(X|Z)}{p(X)} = \frac{p(X, Z)}{p(X)p(Z)}$$

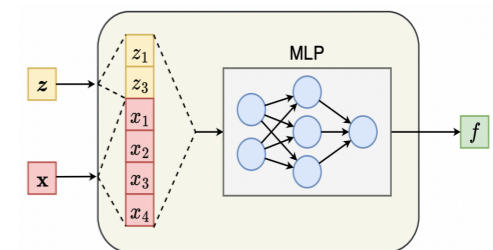
[B. Miller et al., J. Open Source Softw. 7 (2022) 75]



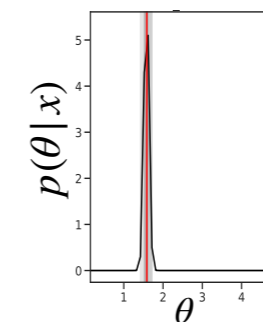
forward simulation



MNRE



parameter inference



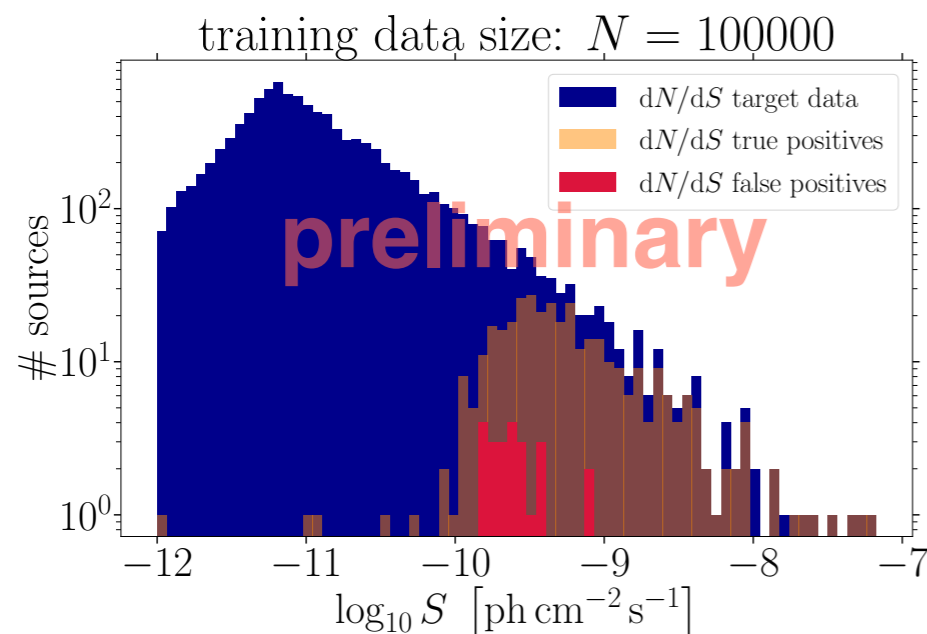
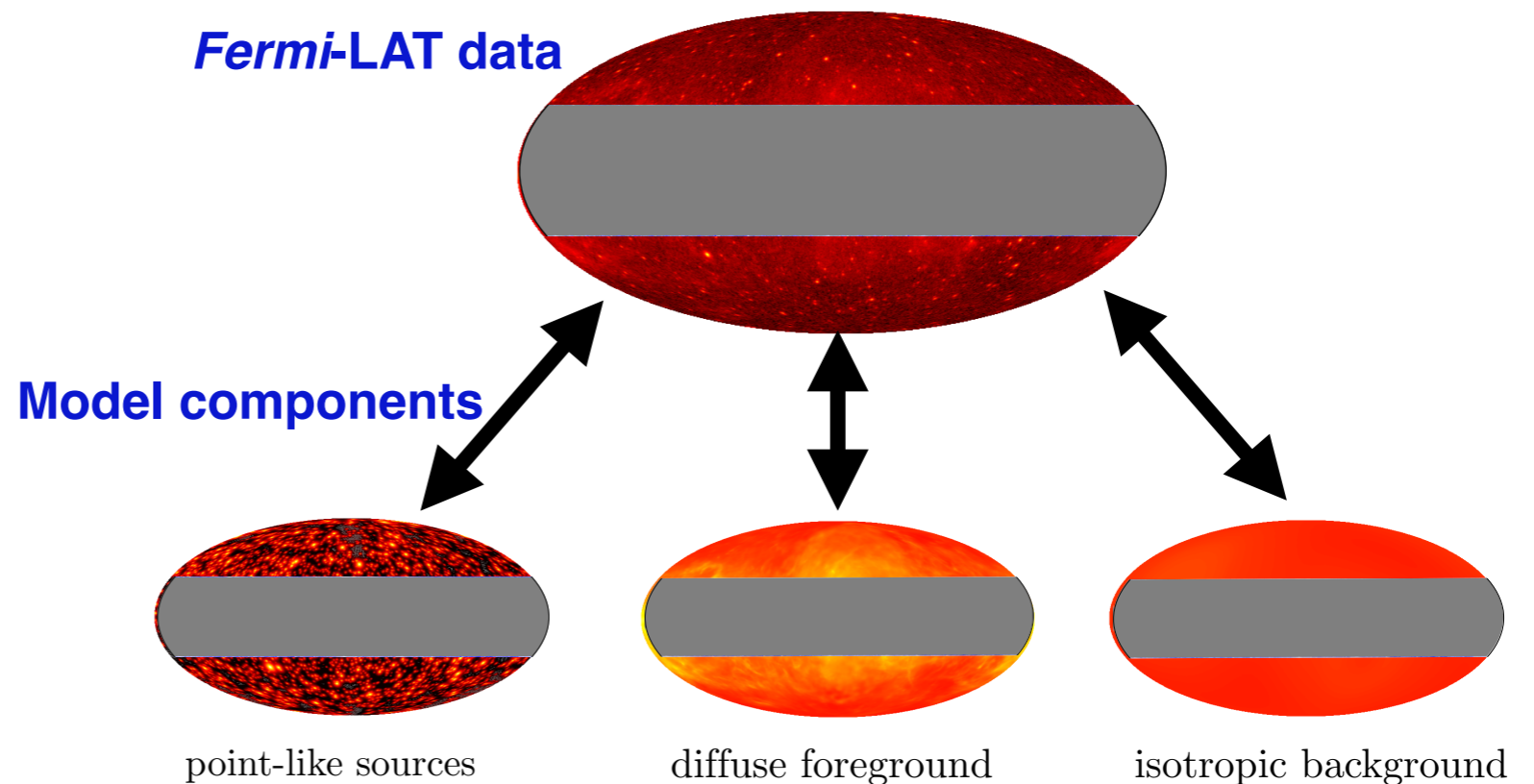
The great scheme of TMNRE:  
 → Inference on high-dimensional models using a binary classification network and an overall reduction of computation costs.

# First Application to Gamma Rays: High-Latitude Sky

We tune our SBI approach to gamma-ray data with observations of the high latitudes  
→ Less backgrounds and more opportunities to cross-check with literature results!

## Scientific Objectives:

- (1) What is the distribution of point-like gamma-ray sources as a function of their flux?
- (2) Which of them can we robustly detect?



You may wonder:

1. How does it work?
2. What does the astro model look like?
3. What are your plans?

**Let's have a chat, Wednesday 12 - 3 pm  
in poster session A!**