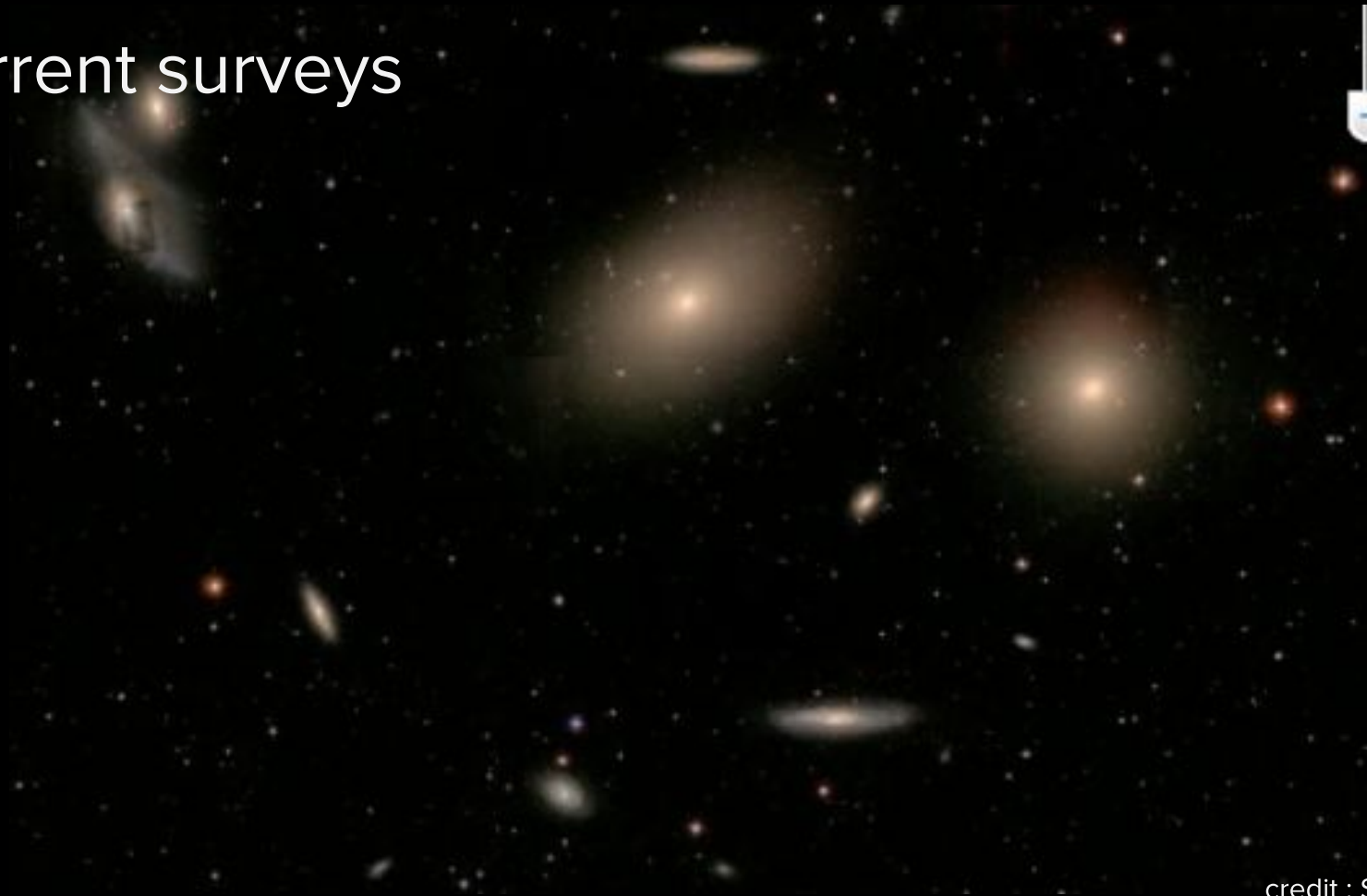


Towards probabilistic models for capturing uncertainty



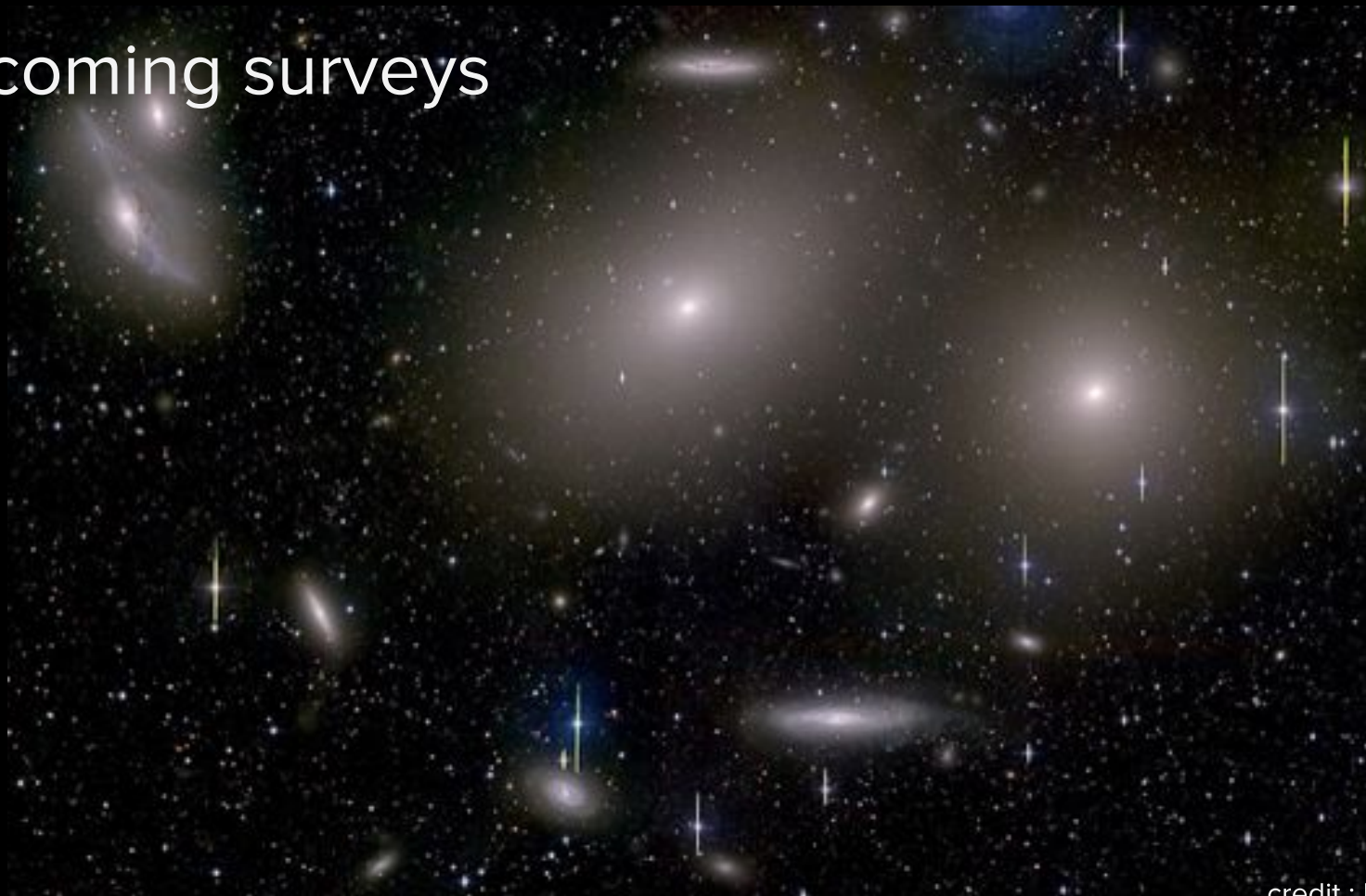
Alexandre Boucaud
CNRS/IN2P3 - France
alexandre.boucaud@apc.in2p3.fr

Current surveys



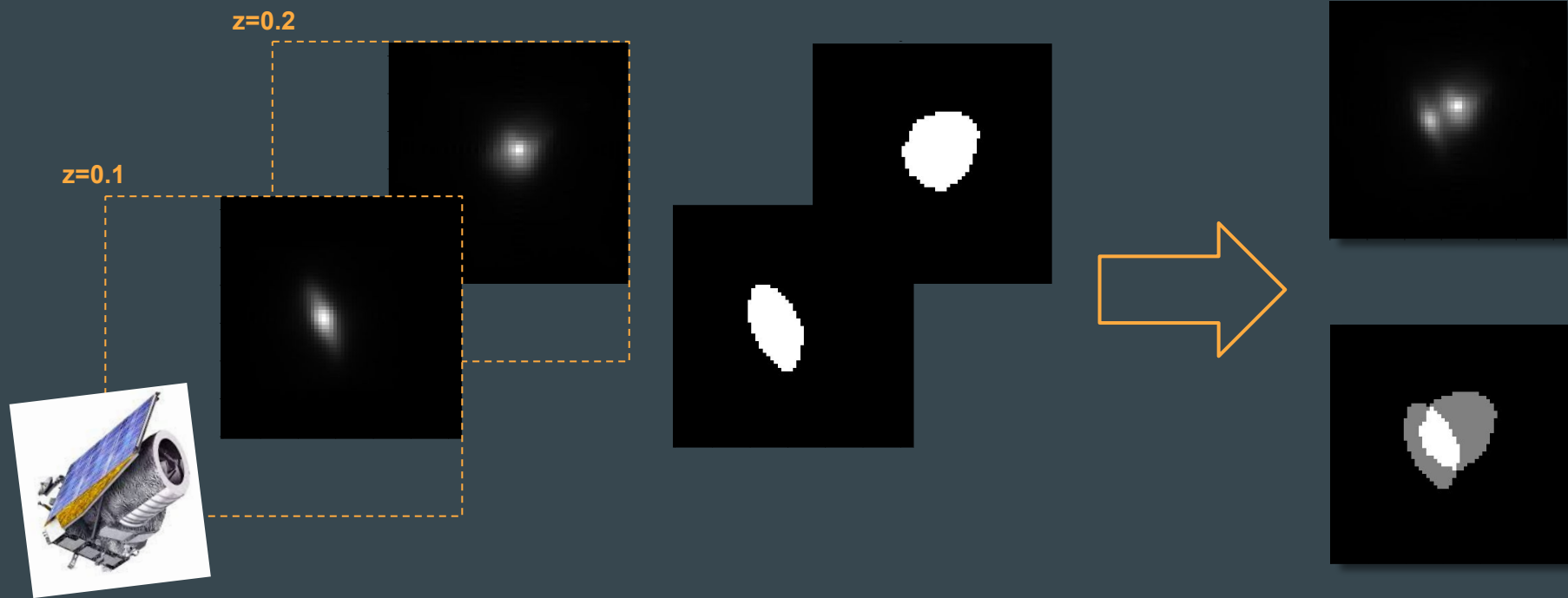
credit : SDSS

Upcoming surveys



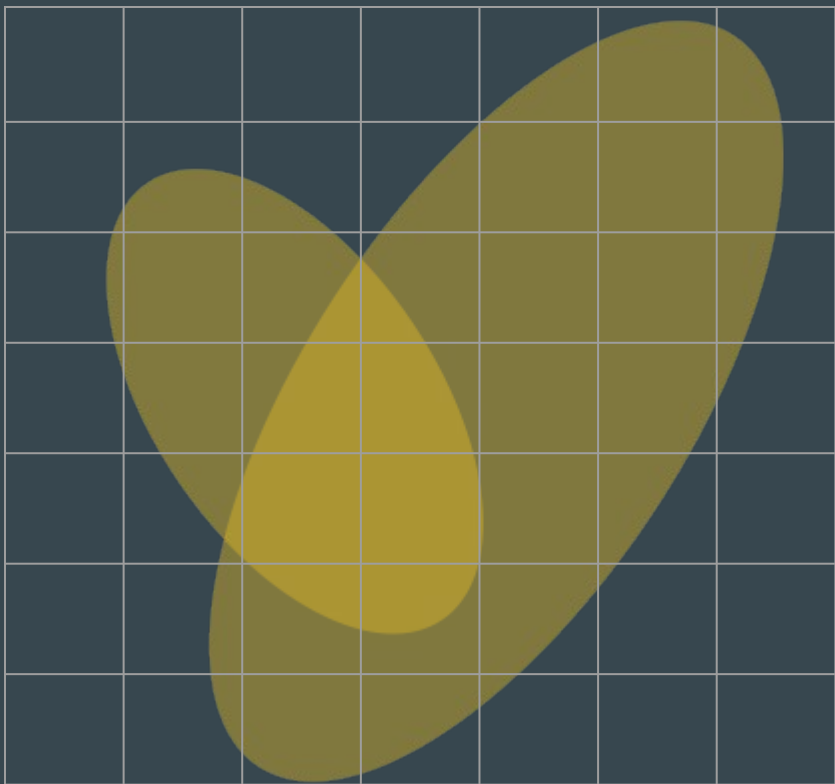
credit : NGVS

Galaxy blending



courtesy H. Bretonnière

Galaxy blending

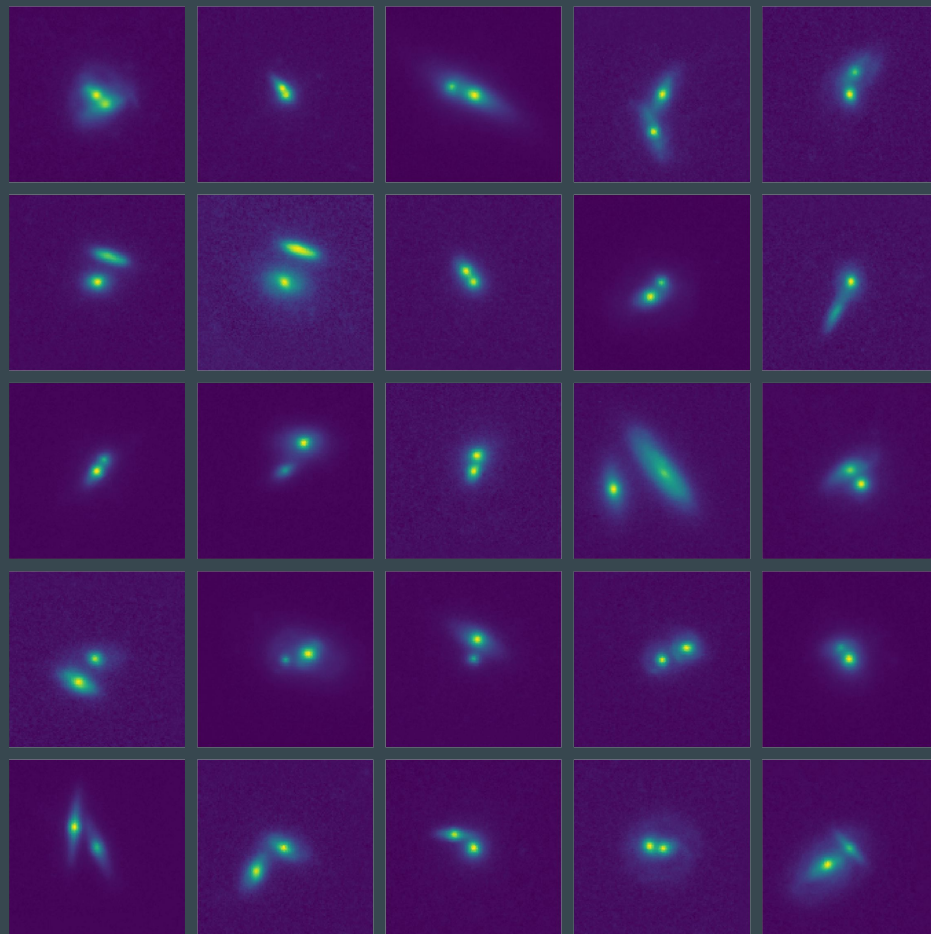


galaxies are "transparent"
=> **no obscuration**

measuring **flux** and **shape** when
galaxies overlap is tricky

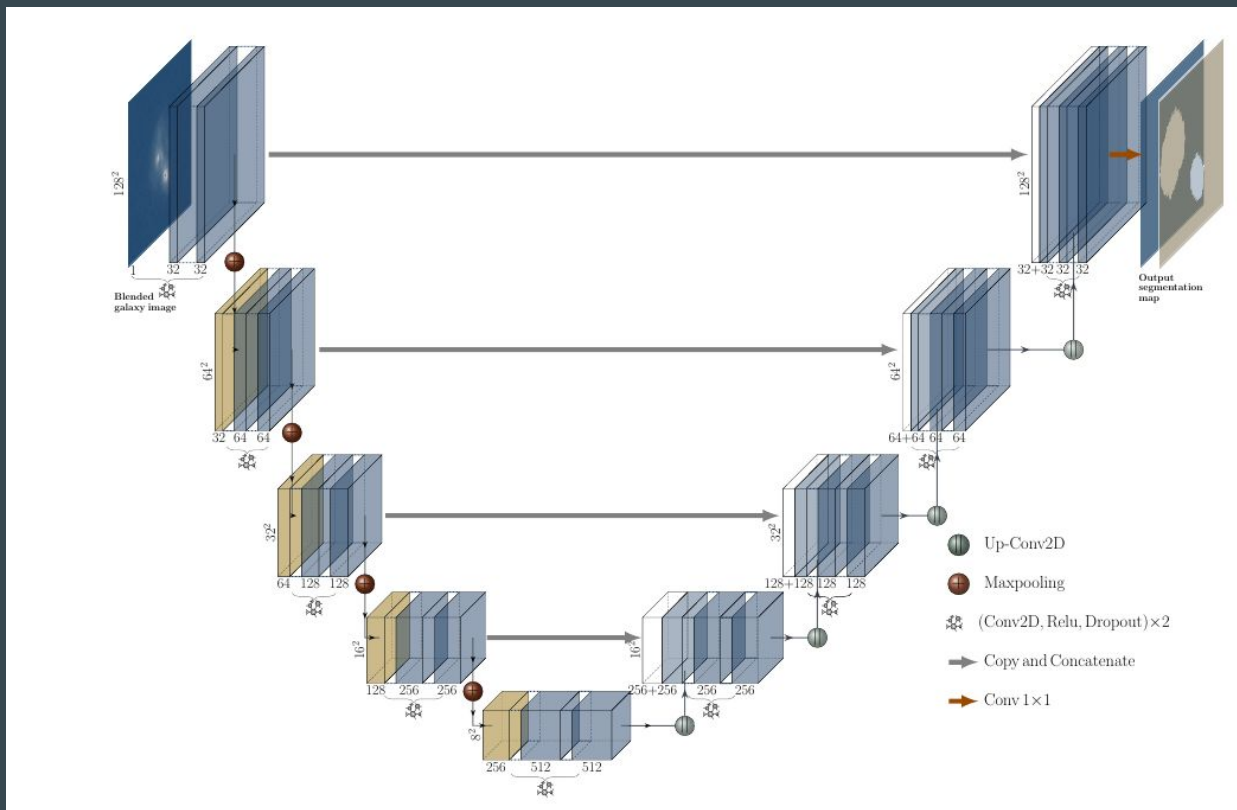
in our case a **pixel** can refer to
several objects

Galaxy blends
emulated with **real**
galaxy images



Blended galaxy segmentation

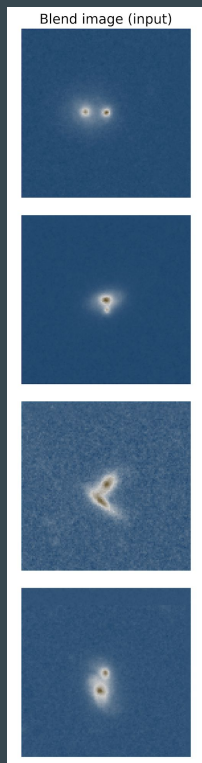
<https://arxiv.org/abs/1905.01324>



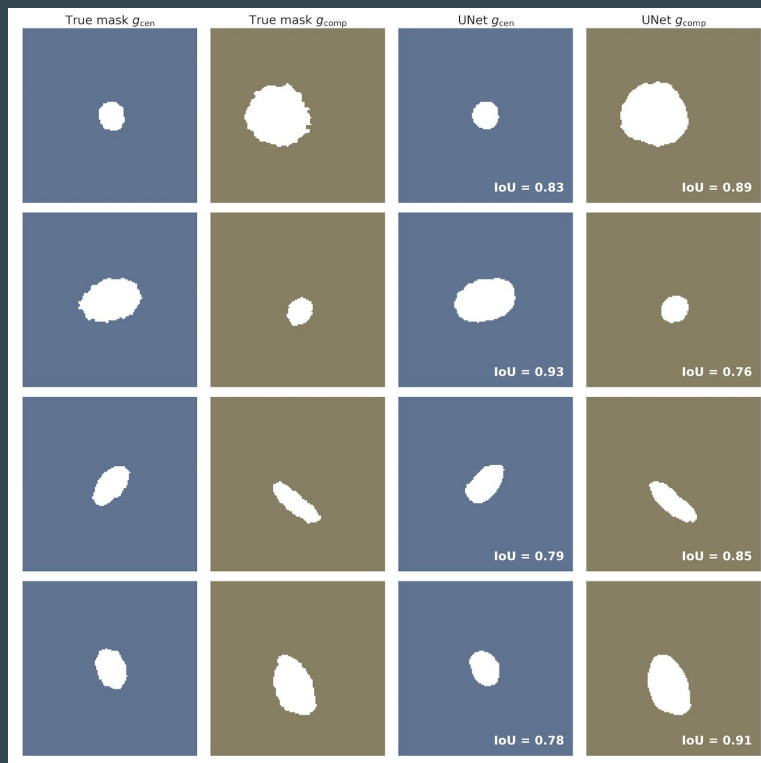
Galaxy segmentation with UNet

<https://arxiv.org/abs/1905.01324>

INPUT IMAGES
(TEST SET)



TRUE
SEGMENTATION



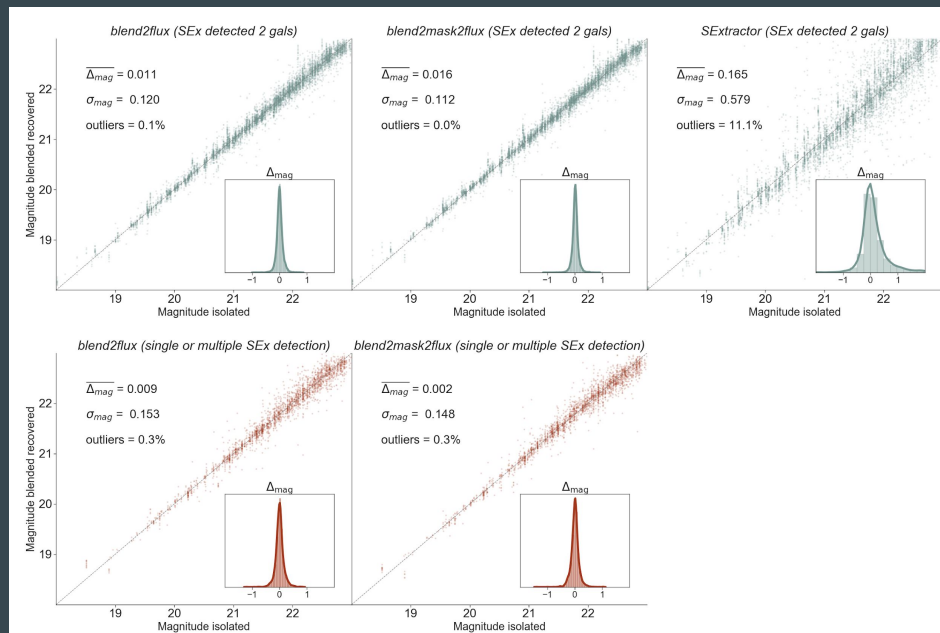
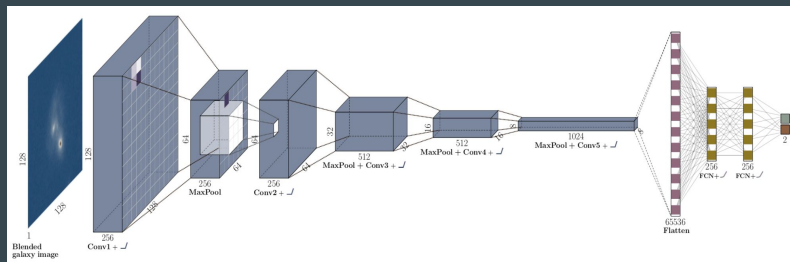
PREDICTED
SEGMENTATION

Flux estimation of blended galaxies

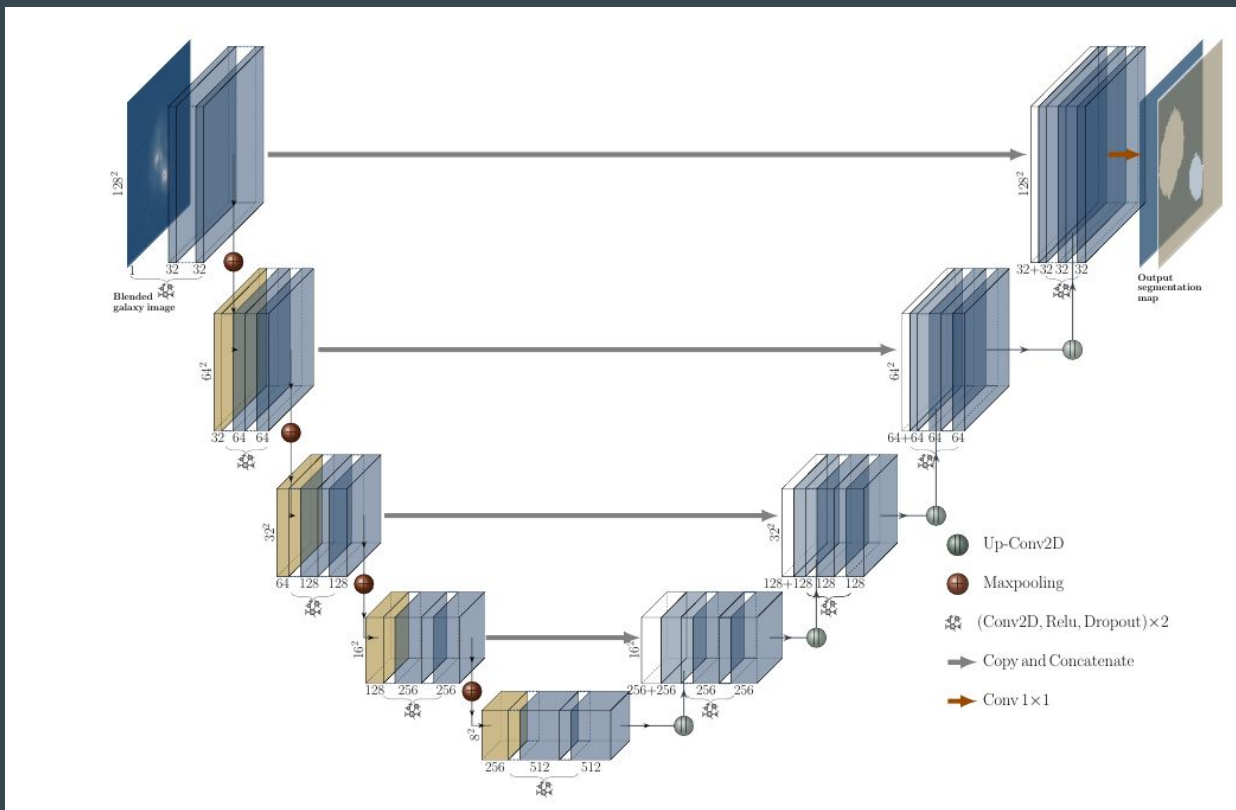
<https://arxiv.org/abs/1905.01324>

Using a classic convnet, directly on the blend galaxy images

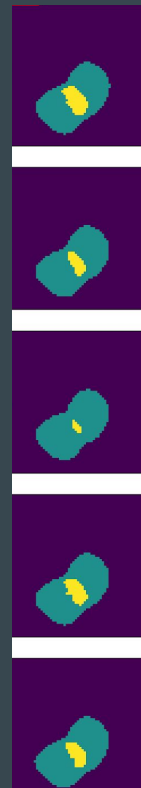
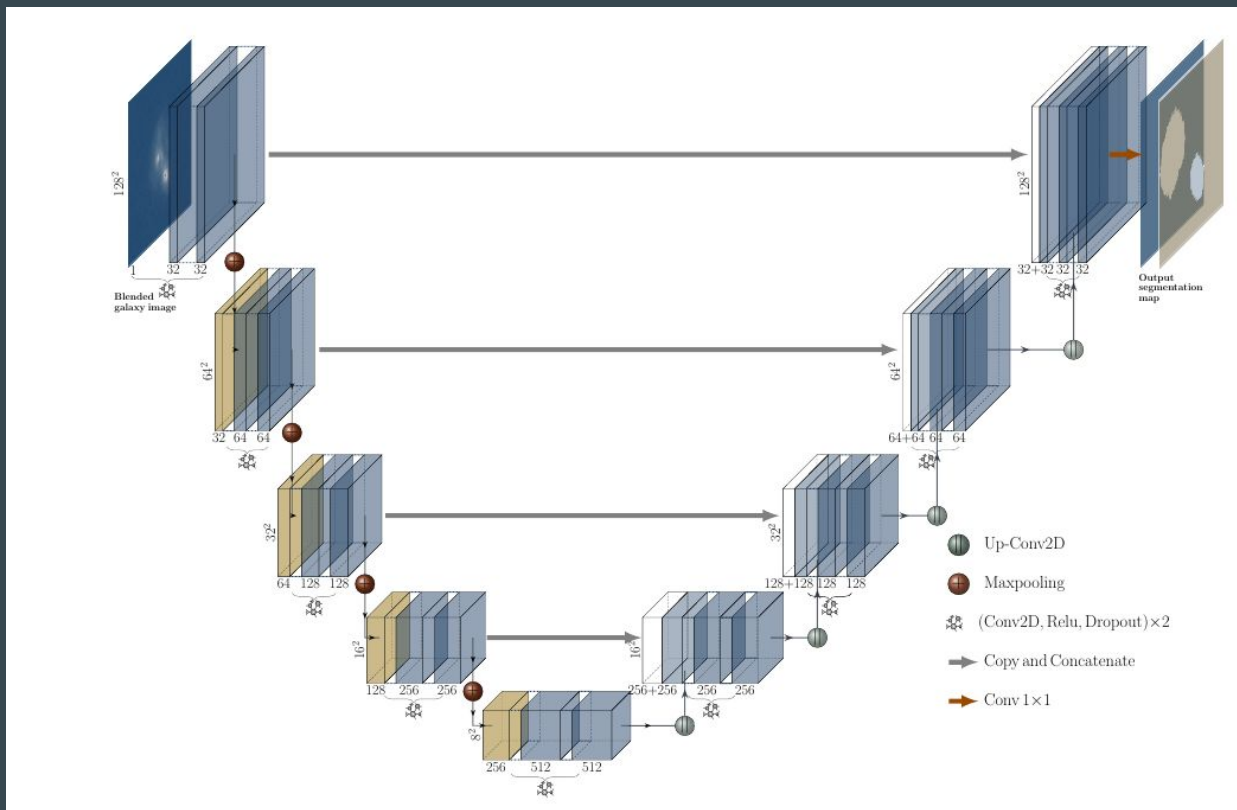
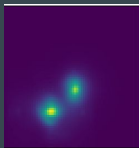
performance is much better than traditional astro detection algorithms



Could we go from a fully deterministic network..



..to a probabilistic one ?

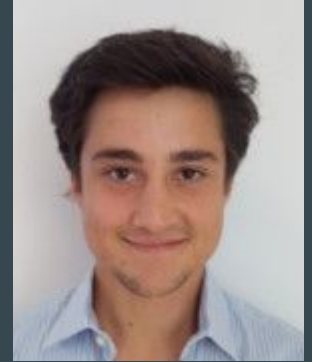


Thesis of Hubert Bretonnière

"Develop and implement deep learning-based image processing algorithms for the morphology of galaxies Euclid satellite"

co-supervision astronomer – software engineer

started last october



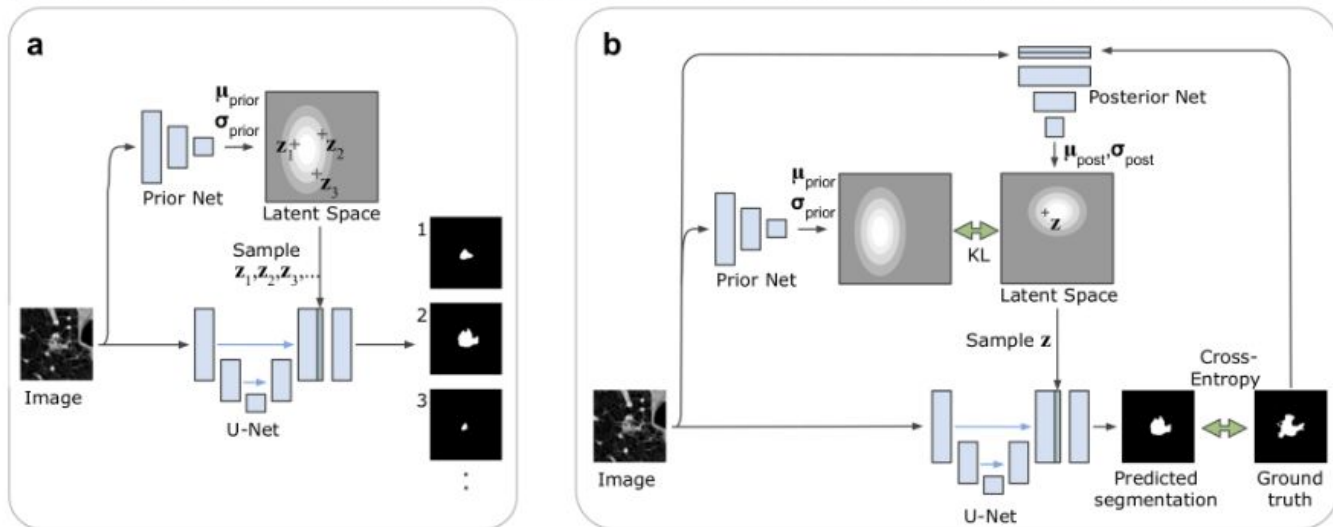
hubert.bretonniere@ias.u-psud.fr

Probabilistic U-Net

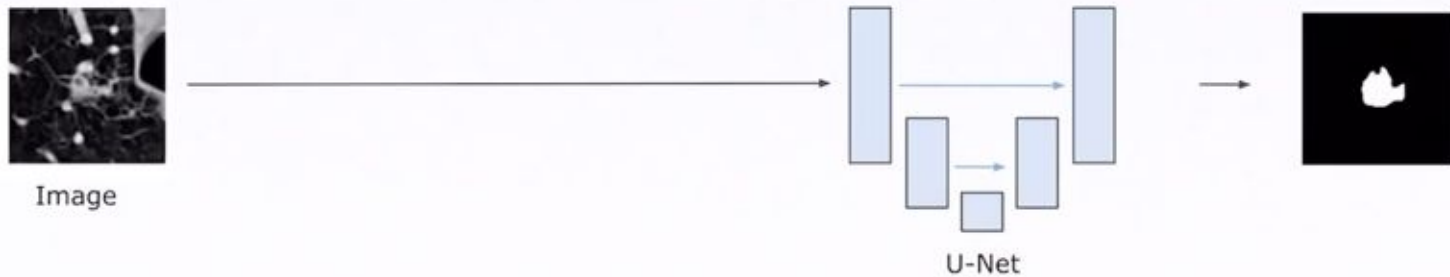
Re-implementation of the model described in 'A Probabilistic U-Net for Segmentation of Ambiguous Images' ([paper @ NeurIPS 2018](#)).

This was also a spotlight presentation at NeurIPS and a short video on the paper of similar content can be found [here](#) (4min).

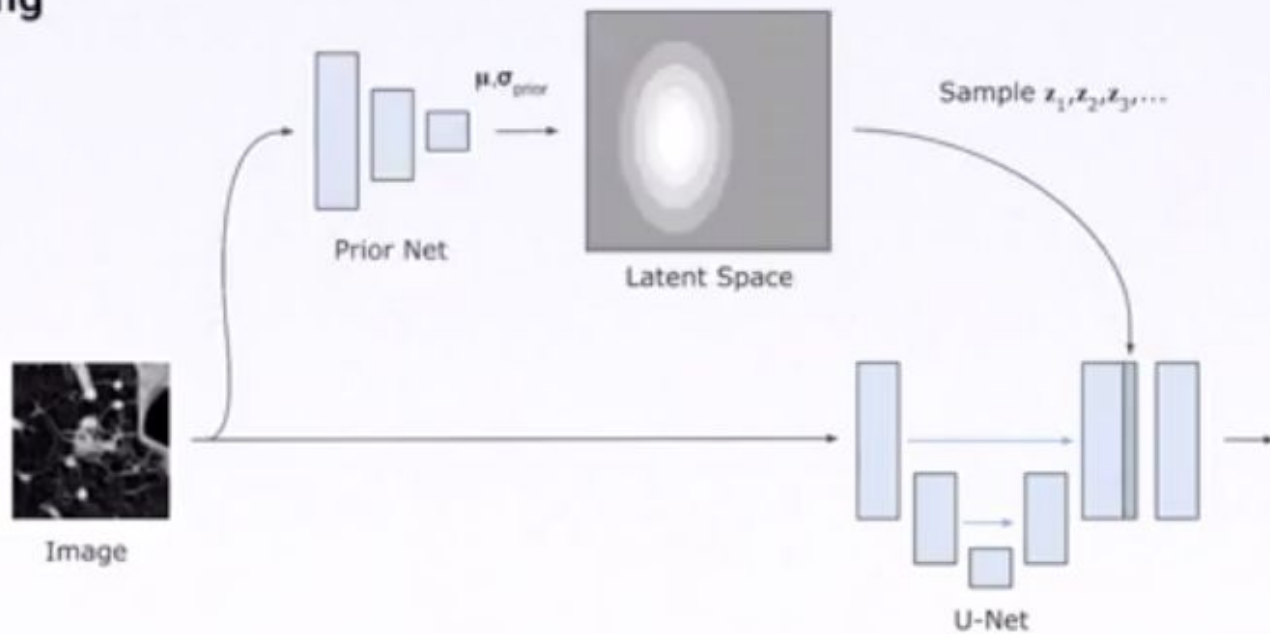
The architecture of the Probabilistic U-Net is depicted below: subfigure a) shows sampling and b) the training setup:



Deterministic U-Net

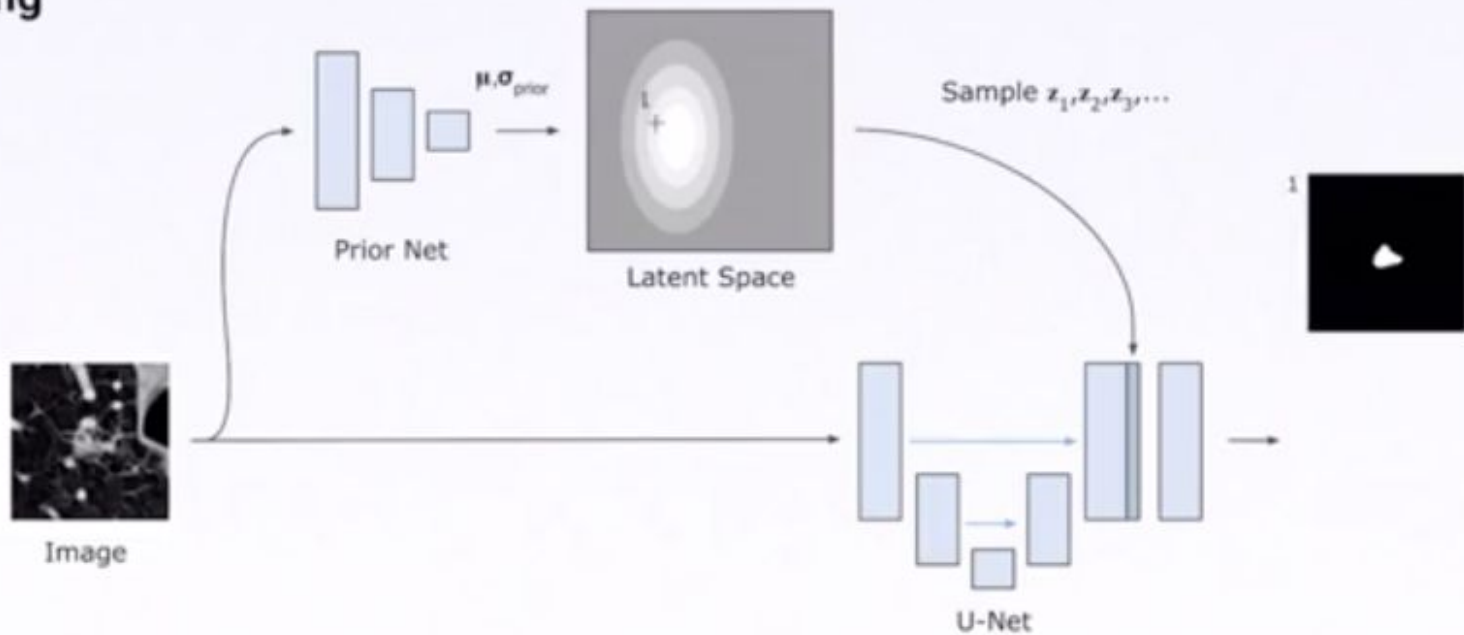


Probabilistic U-Net Sampling



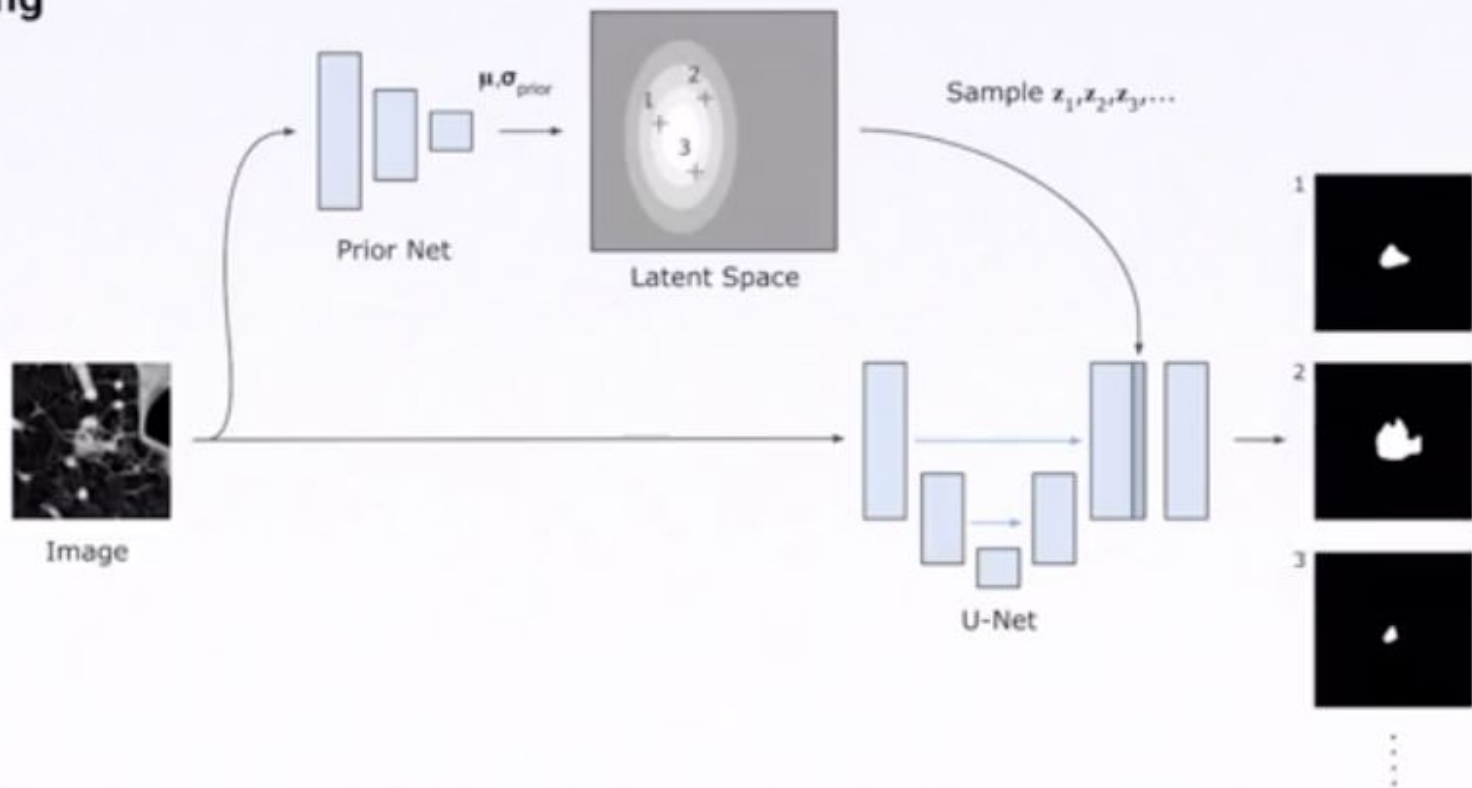
Probabilistic U-Net

Sampling



Probabilistic U-Net

Sampling



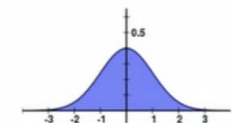
TensorFlow Probability

<https://www.tensorflow.org/probability>

Build model.

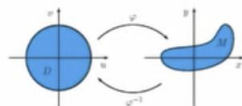
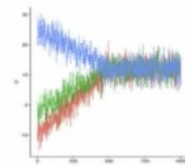


Do inference.



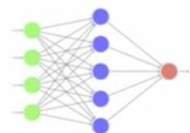
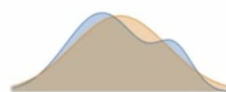
Distributions

Markov chain
Monte Carlo



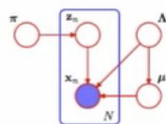
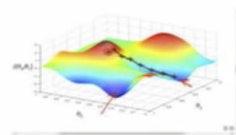
Bijectors

Variational
Inference



Layers / Losses

Optimizers



Edward2

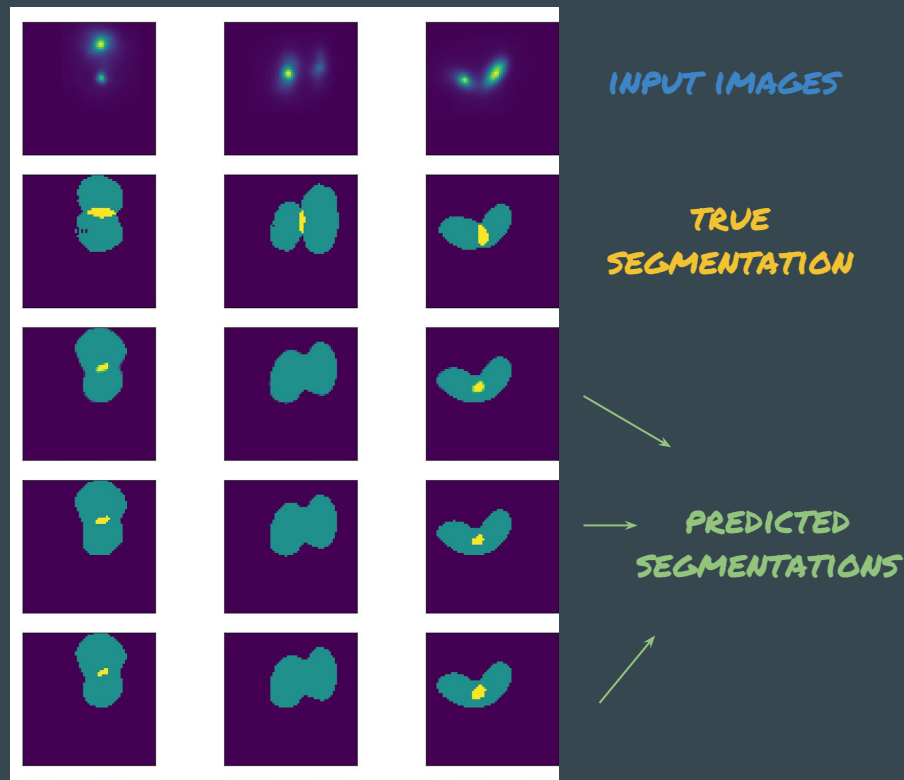
Probabilistic segmentation

aim at predicting a **probability of blending** between 2+ galaxies

can be applied to large images

ability to propose **an absence of overlap**

uses TensorFlow Probability

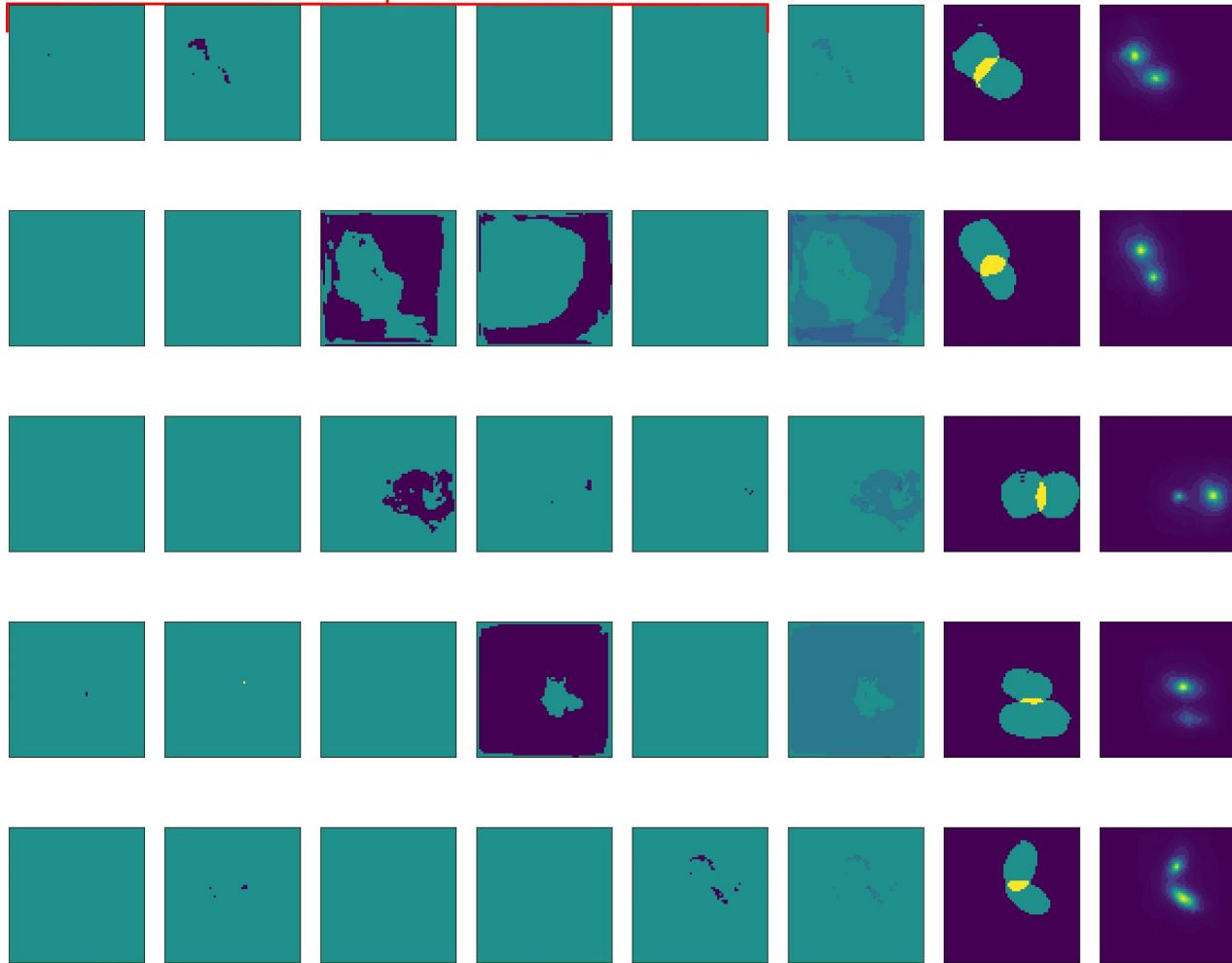


Predicted Samples

Proba SegMap

True SegMap

Blended Images



Step number 1

courtesy H. Bretonnière

Conclusions

- deterministic networks tend to **hide the model uncertainty**
- modifying your models to output **probability distributions** is quite straightforward
 - ◆ TensorFlow => TensorFlow Probability at least
 - ◆ other tools exist (Pyro w/ PyTorch, PyMC3, etc..)
- such step might be necessary in order to use your ML model to perform Bayesian inference

ANR – “AstroDeep”

Astro experts

weak lensing

signal processing

image processing
pipelines

Computer scientists

machine learning

neural networks

Markov models, random
processes, bayesian
networks...

Recently got funding
for the next 4 years

3 postdocs

1 PhD student

travel and computing

Workshop in march

- **3-day workshop** including talks, round tables and hands-on
- focus on **Bayesian inference w/ NN**
- **advanced tutorials** given by **TFProbability developers**
- deadline for application: **feb 2**

<https://indico.in2p3.fr/event/19458>



BAYESIAN DEEP LEARNING FOR COSMOLOGY AND GRAVITATIONAL WAVES

PARIS CENTRE FOR COSMOLOGICAL PHYSICS WORKSHOP SERIES
MARCH 4-6, 2020

AstroParticule & Cosmologie - Université de Paris (France)

Lectures, round tables, hands-on sessions
Bayesian neural nets, variational inference,
MCMC, TensorFlow Probability

Organisation:

Bastien Arcelin
Eric Aubourg
Matteo Barsuglia
Alexandre Boucaud
Eric Chassande-Mottin
Cécile Rouelle
Olga Szydlowska
Agata Trovato
Giulia Vannoni

Abstract submission deadline: February 2nd 2020

<https://indico.in2p3.fr/e/bayesdeep-cosmogw2020>

contact:
secretariat_pccp@apc.in2p3.fr



SCAN ME

Paris Centre for
Cosmological Physics



Formation CNRS

Fondamentaux du machine learning et du deep learning en Python

with Sylvain Caillou (LIMSI)

- **3-day** course with **tutorials** in the afternoon (50%)
- first 2 days focused on traditional machine learning (terminology, main algorithms, model comparison, etc.)
- last day focused on **neural networks** and **deep learning**

Registration starting on Feb 15, course last week of May in Villejuif (Paris)