SuperNNova

open source photometric classification

Möller & de Boissière 2019 arXiv : 1901.06384

Anais Möller

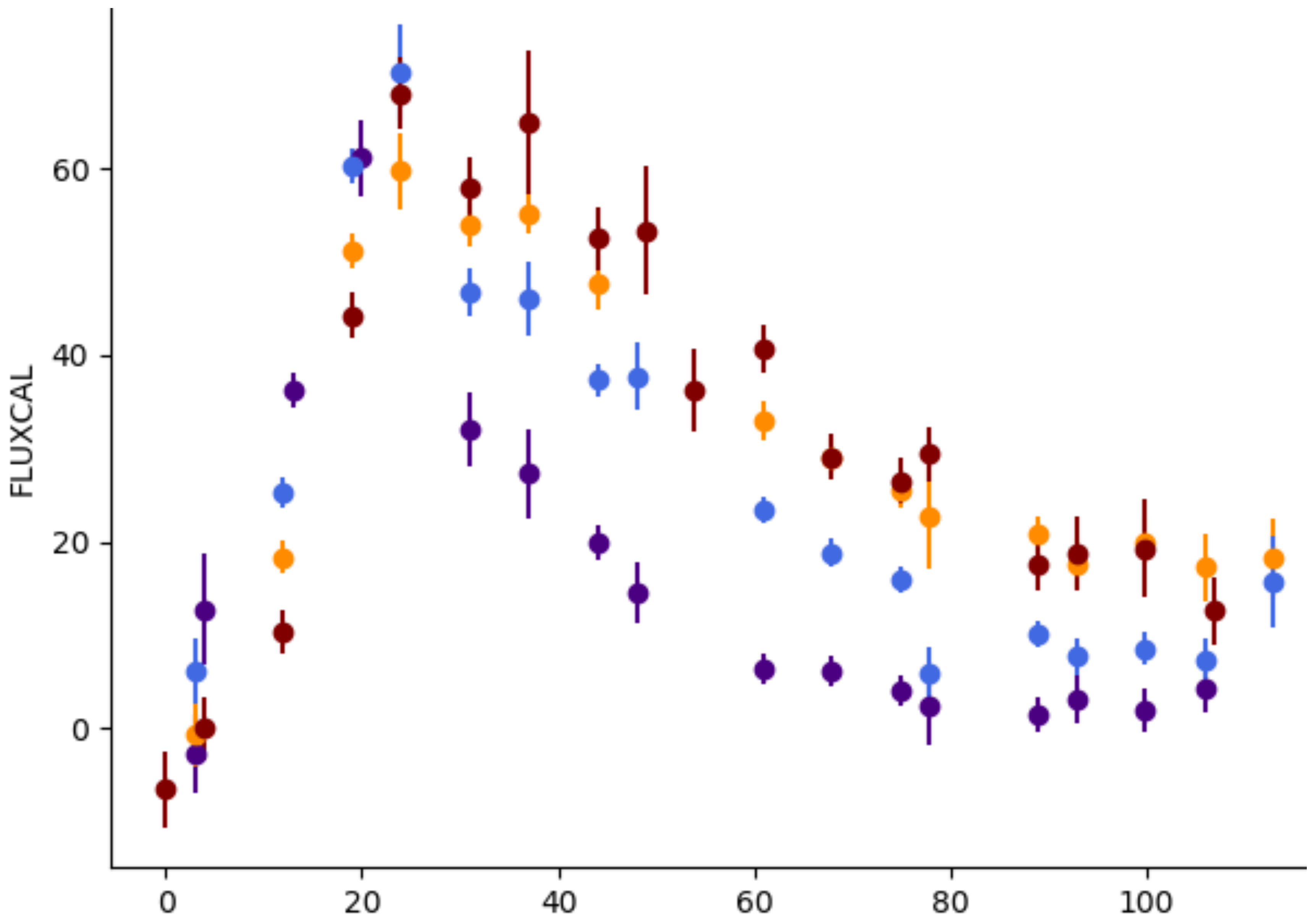
TransiXplore 2019

LPC Particules pLasmas Univers applicationS

Laboratoire de Physique de Clermont

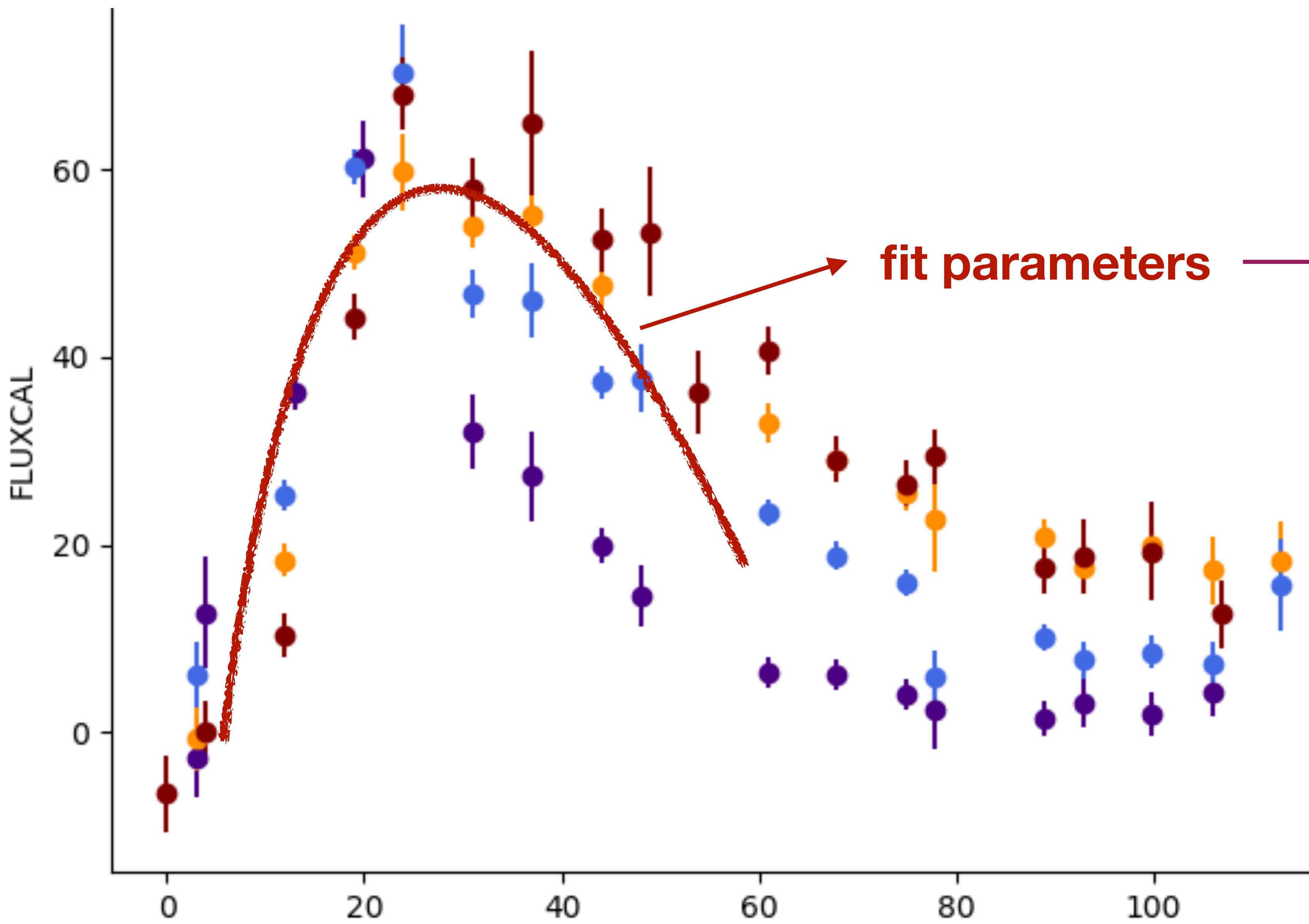
cnrs

photometric classification



photometric classification

most approaches

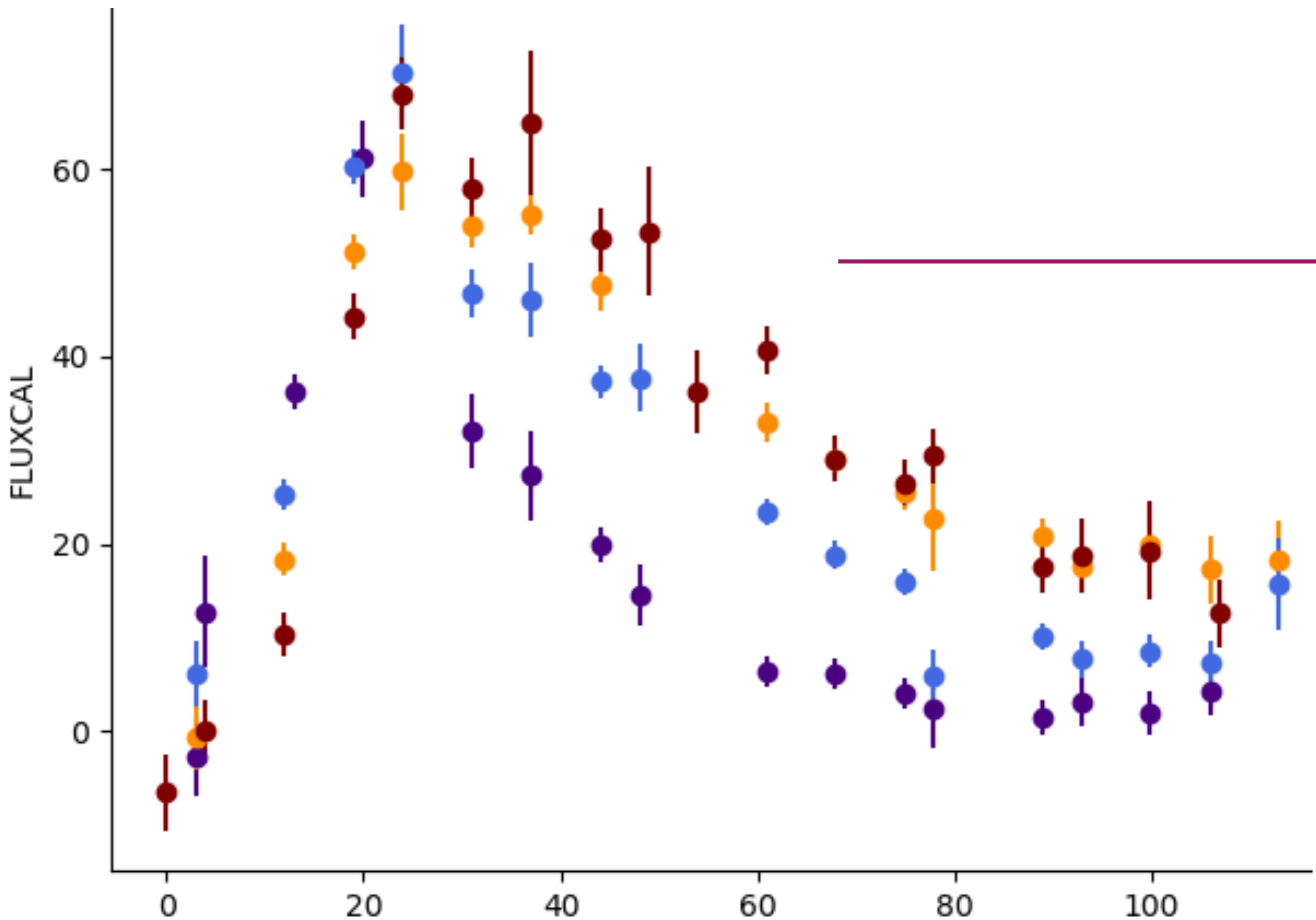


fit parameters → - sequential cuts
- machine learning

+ other cuts

science sample

photometric classification

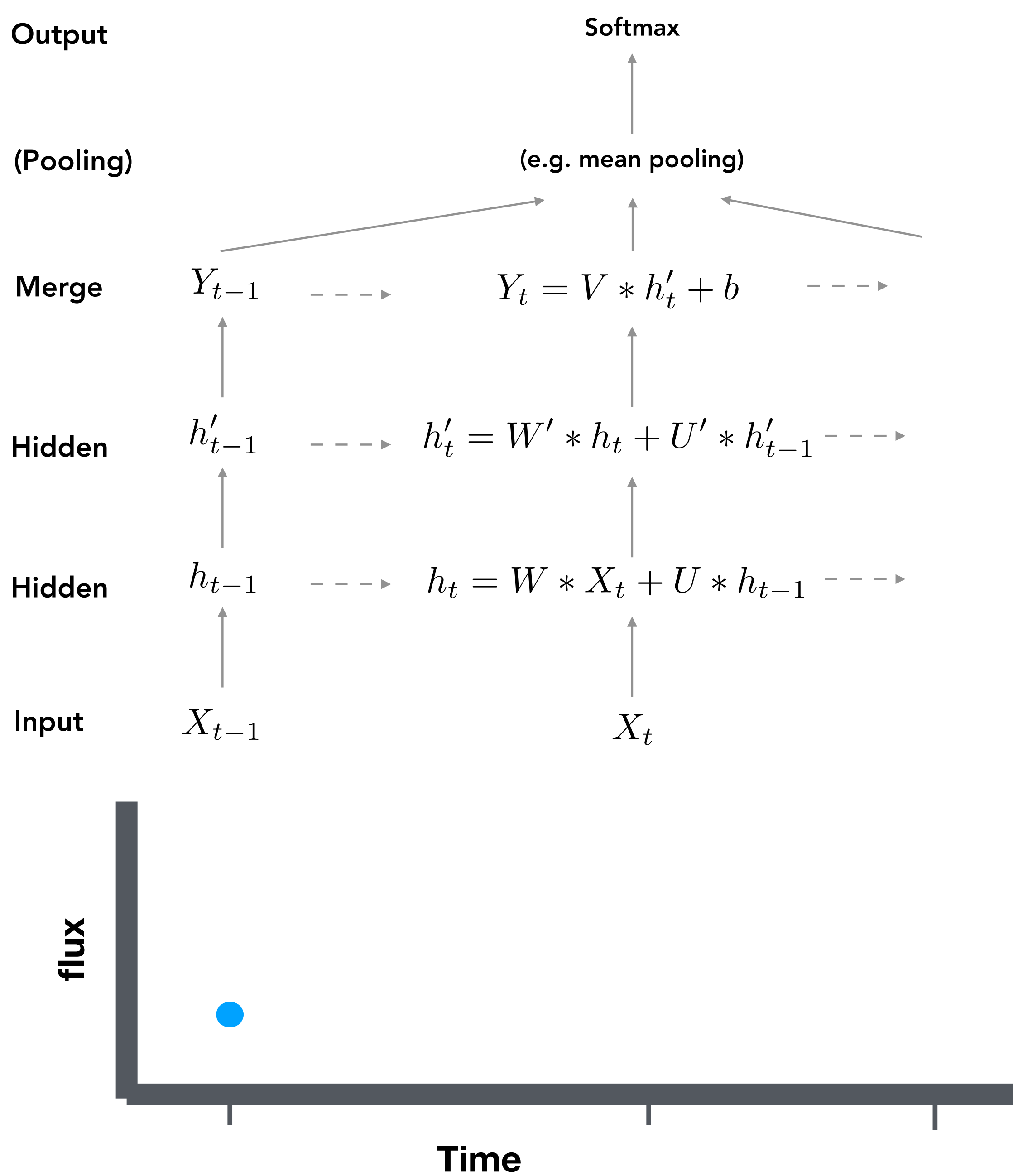


machine learning

science sample

SuperNNova is deep learning

open source photometric classification



classifiers:

- Recurrent Neural Networks (RNNs):
  - LSTM
  - GRU
- Bayesian RNNs
  - MC dropout (Gal+2016)
  - Bayes by Backprop (Fortunato+2017)
- Convolutional Neural Networks
- (Random Forest w. SALT2 fit parameters)

SuperNNova is deep learning

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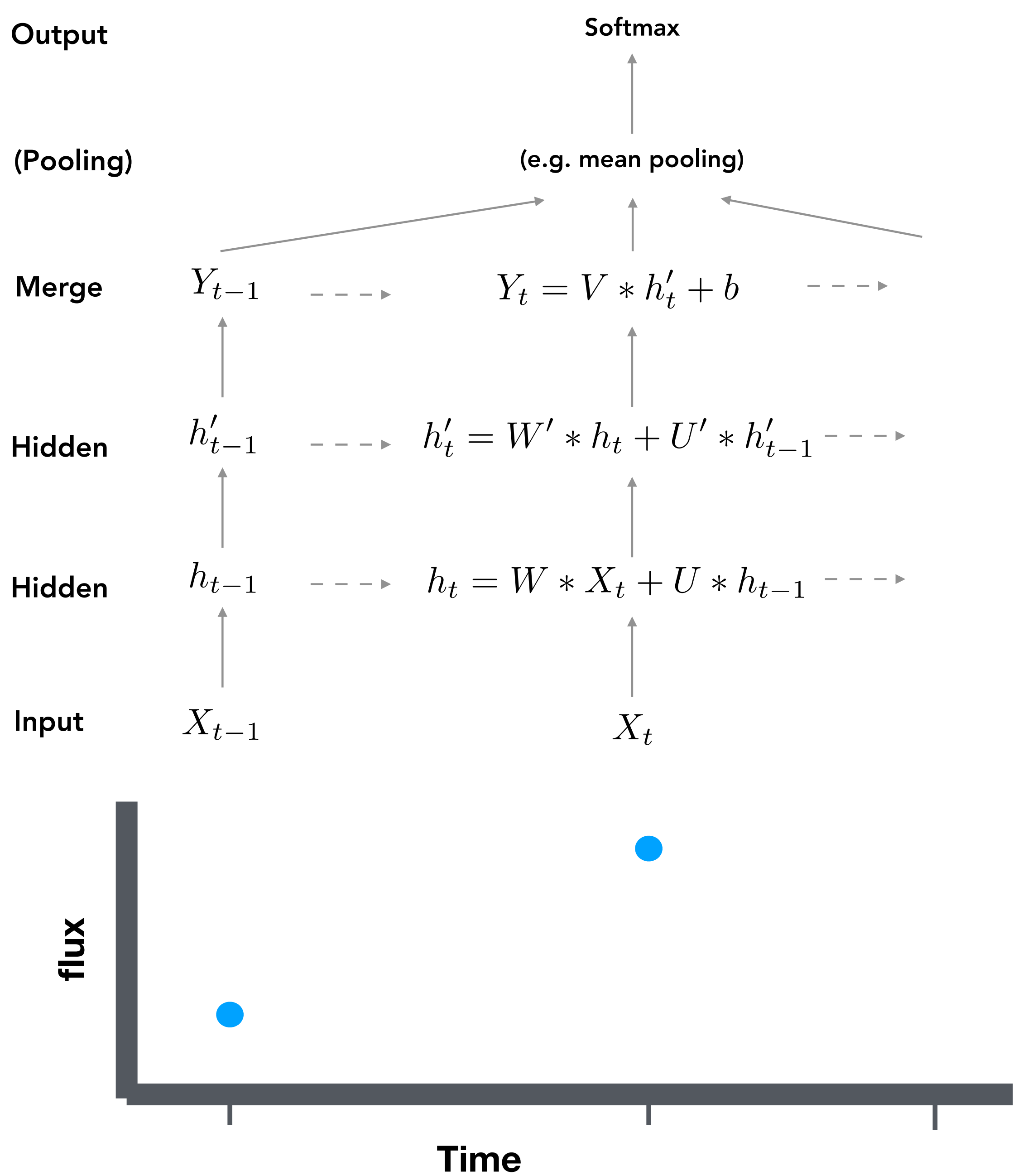

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SuperNNova uses observed data

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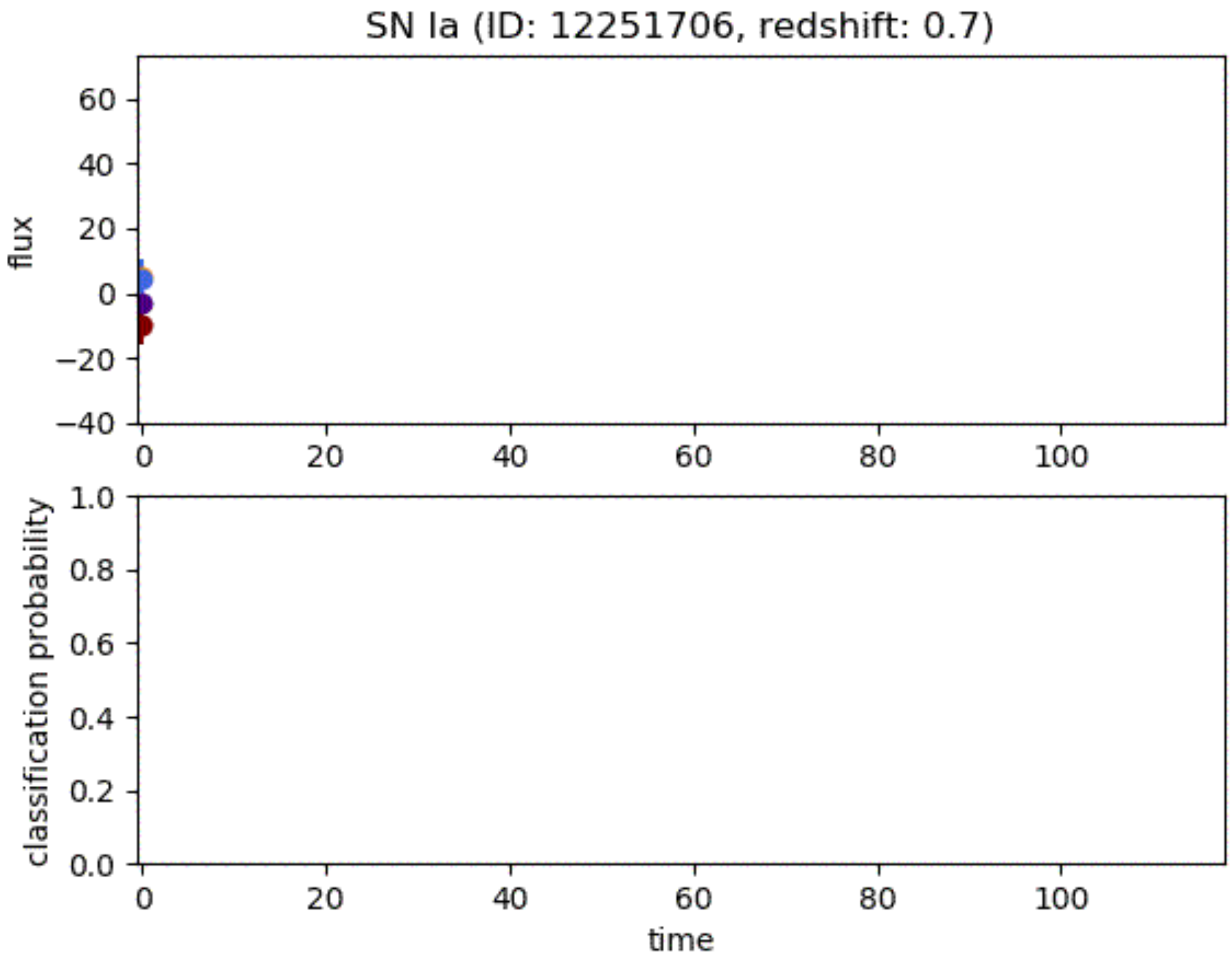

inputs:

- observed fluxes + errors
- time
- optional: host galaxy redshifts

no rest-frame, dust, … corrections

No feature engineering necessary!
Handles irregular sampled time series!

SuperNNova is deep learning

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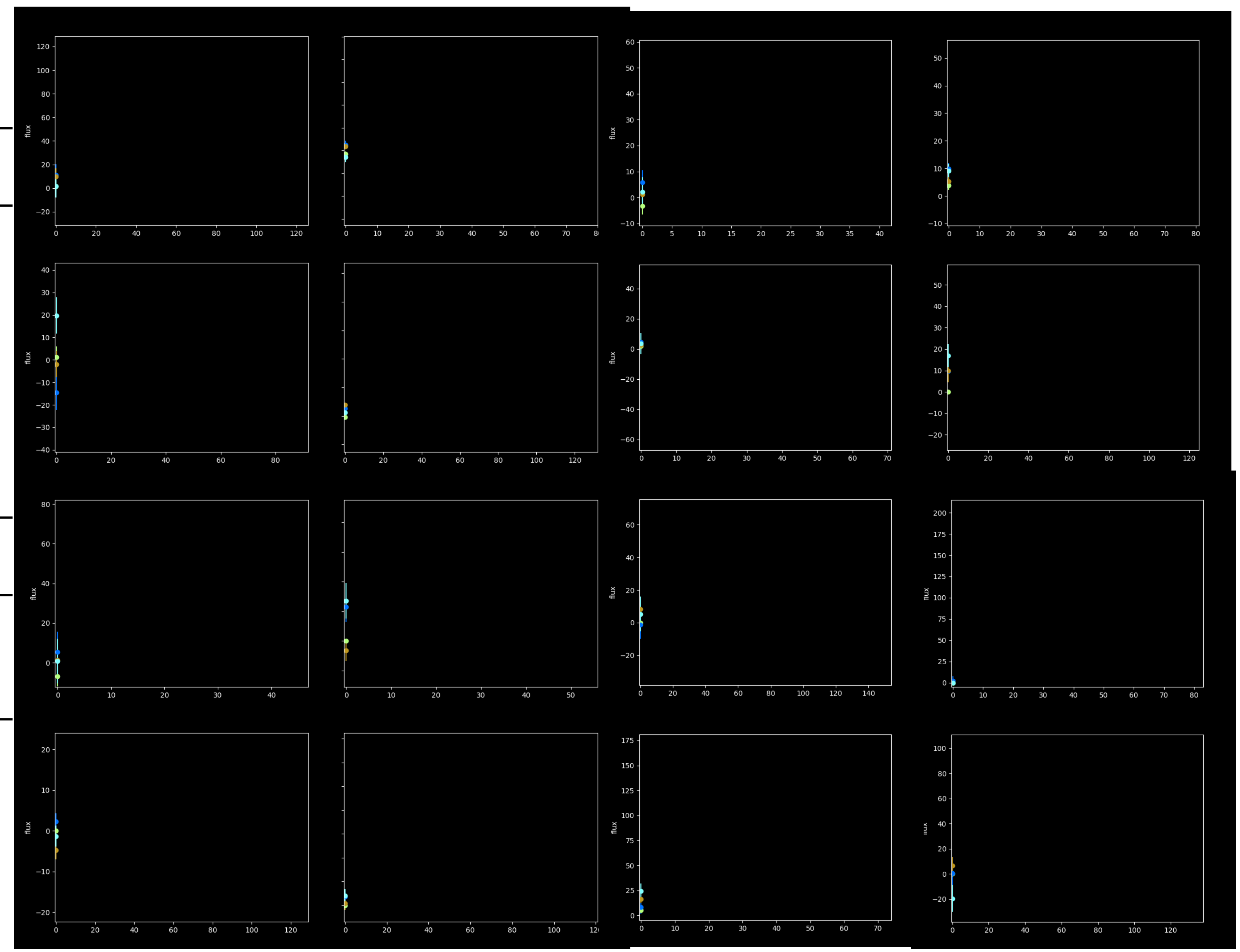
Simulated supernovae		
SN type	SALT2 fitted	complete dataset
Ia	402,786	912,691
Ib	140,197	181,454
Ic	70,811	90,485
IIP	94,994	296,523
IIn	3,249	154,614
IIL	93,535	189,615
IILs by template		
IIL1	26,717	100,827
IIL2	66,818	88,788

Möller + 2019



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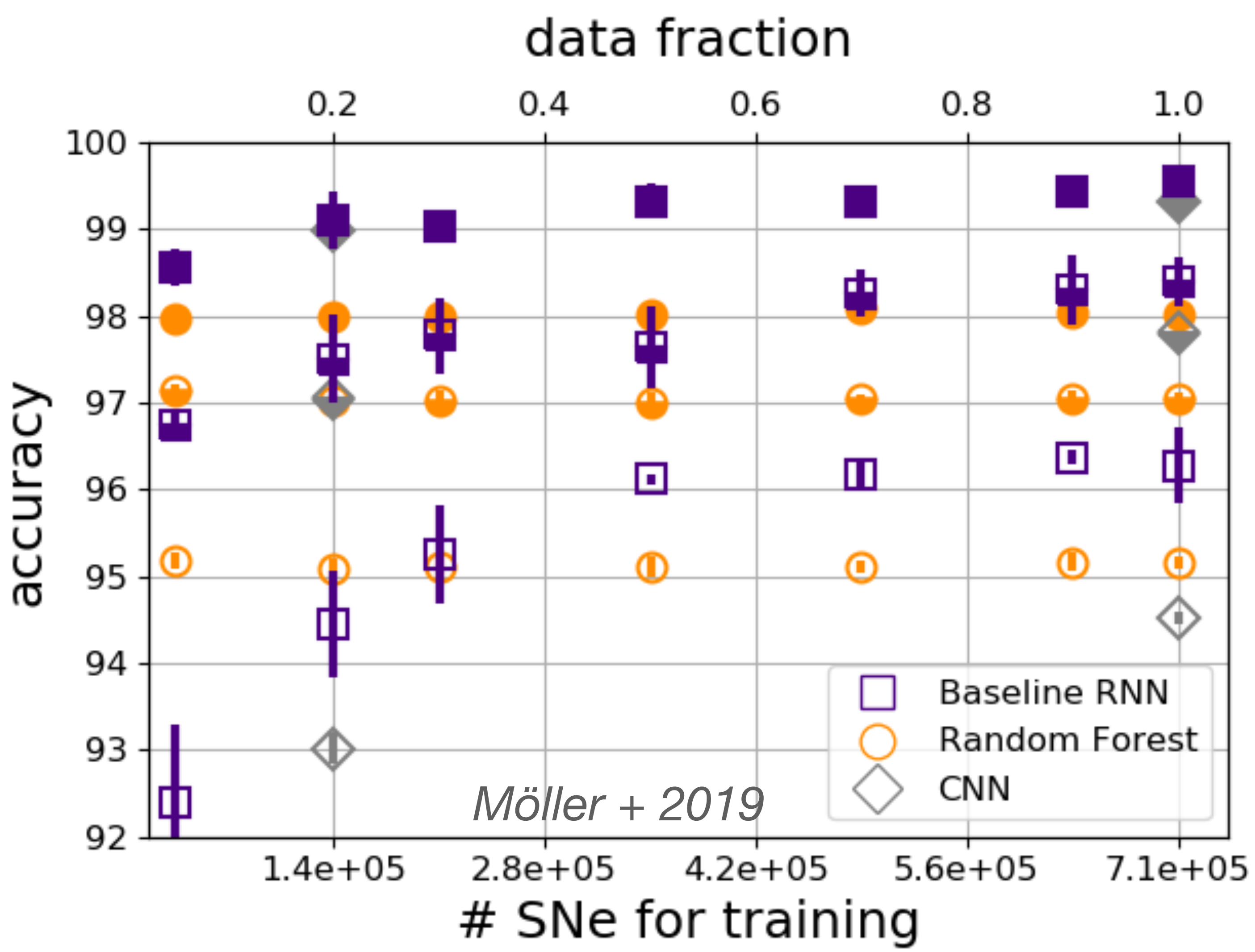
is deep learning

Needs large training samples to achieve peak performance



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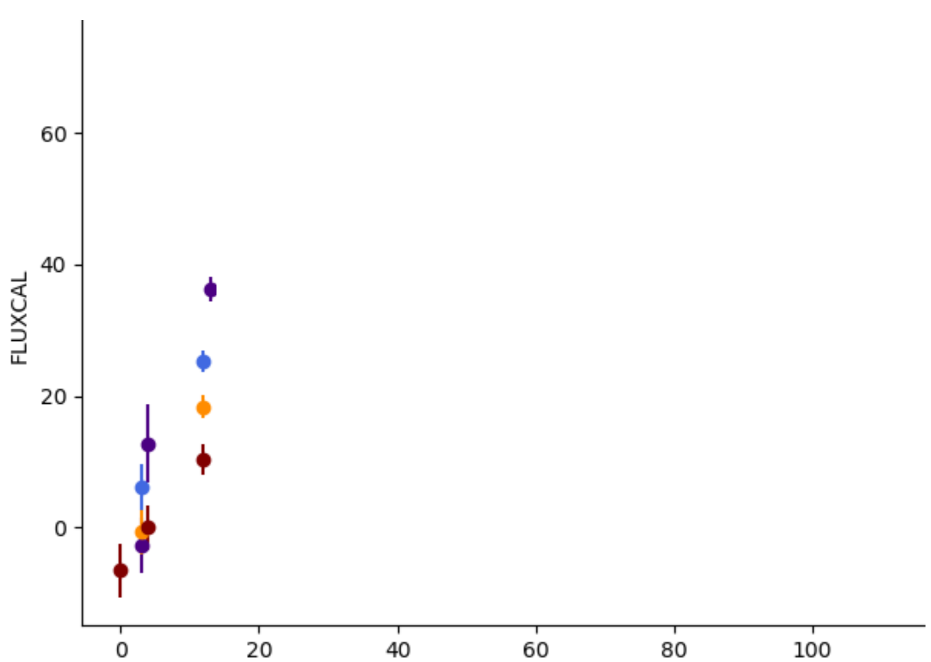
Early light curves



for spectroscopic / photometric follow-up?

- to optimise spectroscopic resources
- to select SNe to improve photometric classification?
- for brokers

SuperNNova for follow-up

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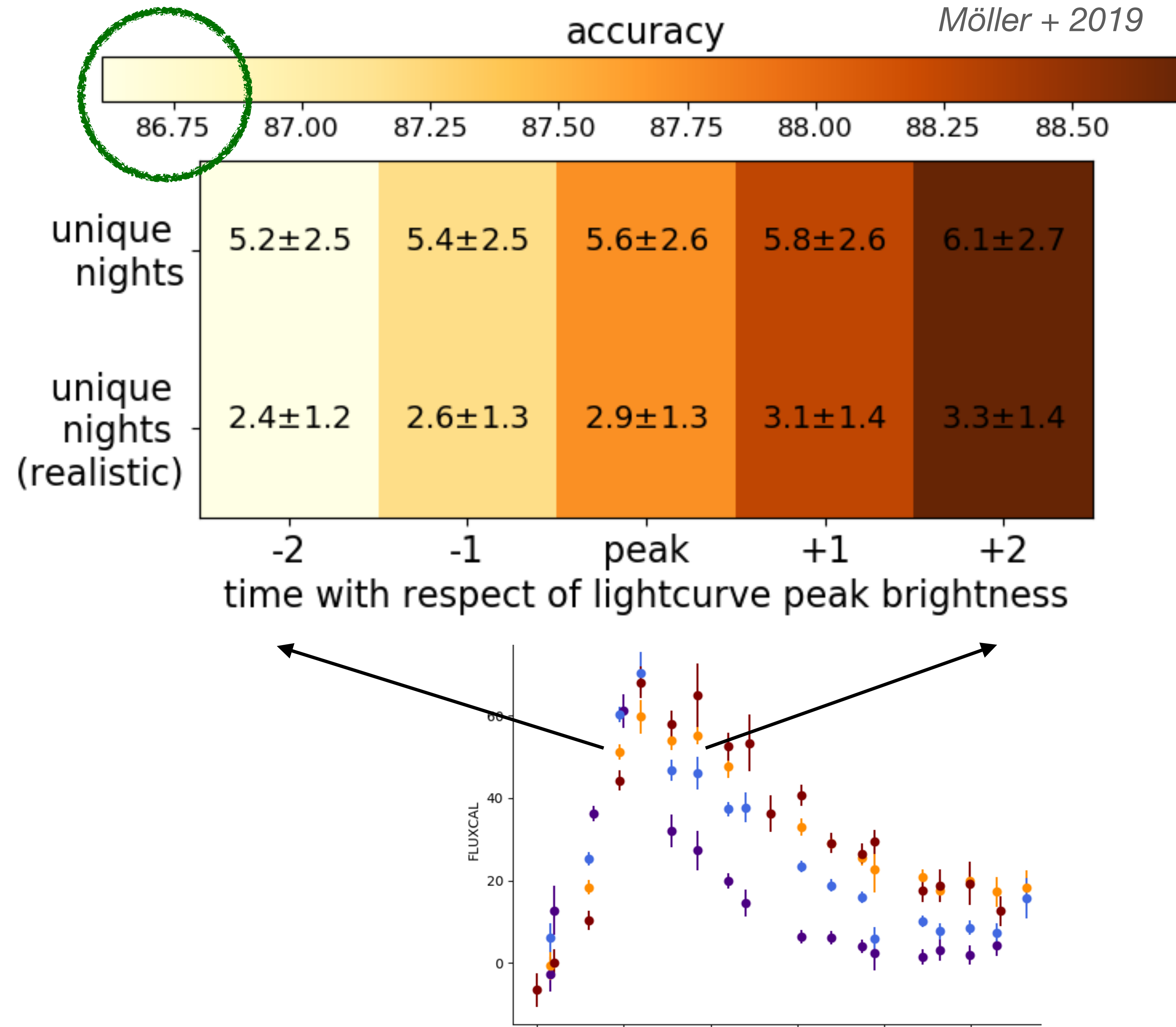
SNe Ia vs. Non Ia, no host-redshift information



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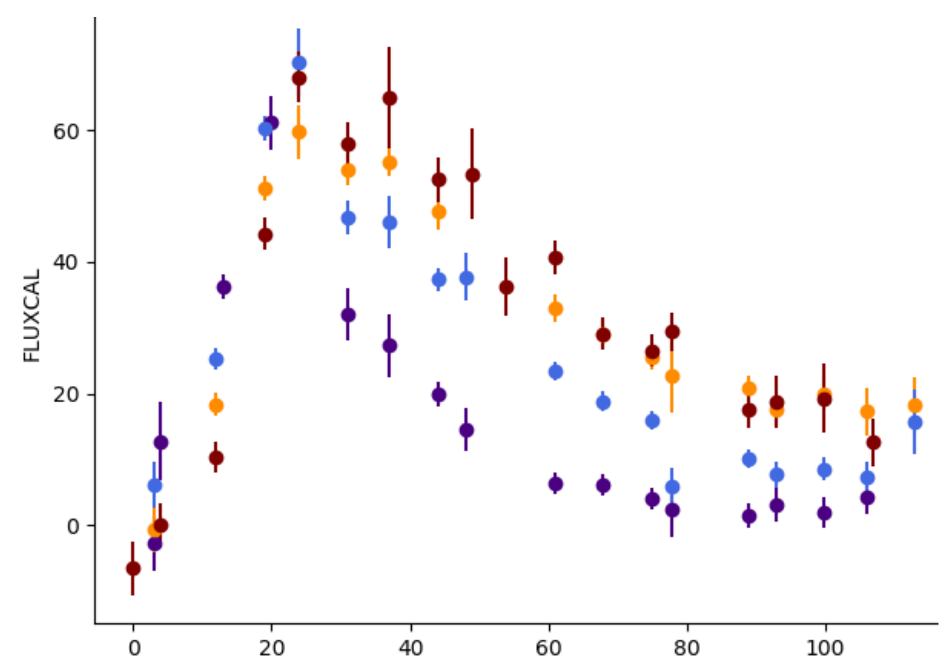
Complete light curves

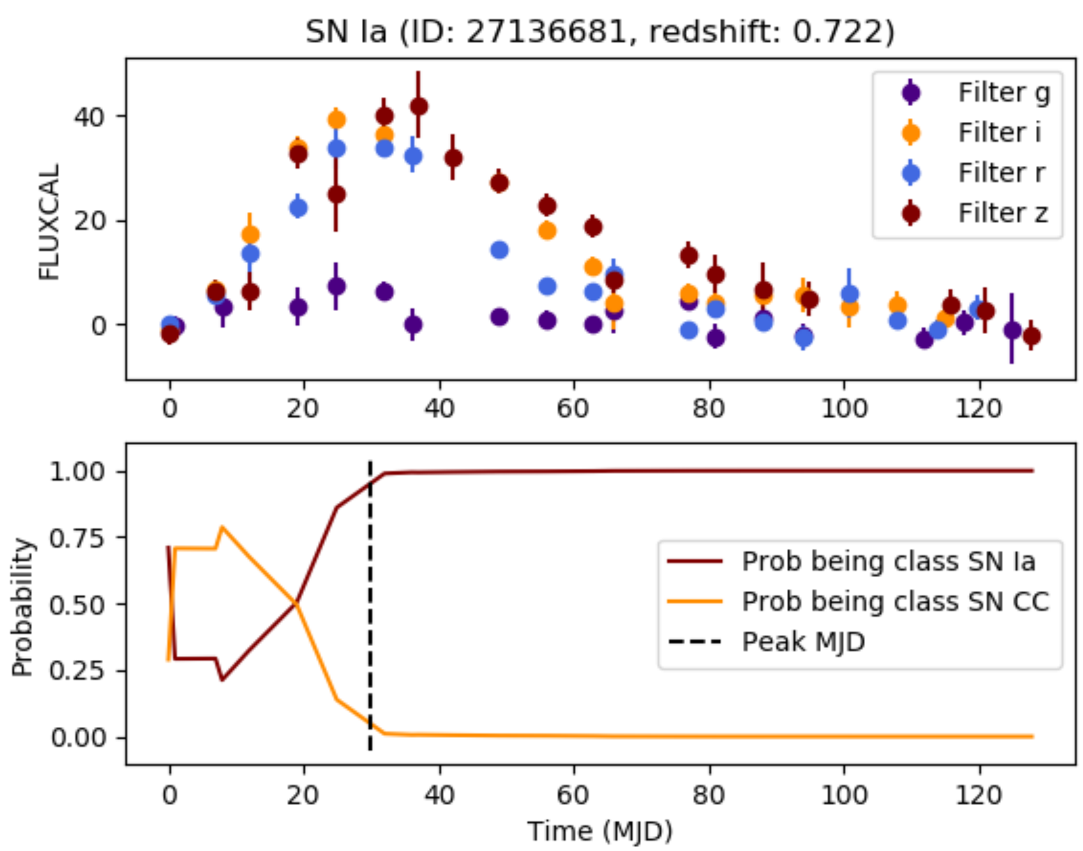


SuperNNova is accurate

open source photometric classification

trained & tested with supernovae simulations: SNe type Ia vs. Non Ia

2 classes



	complete lc
fluxes+ errors	96.92 ± 0.09
fluxes+ errors + host z	**98.85 ± 0.04**

SuperNNova is accurate

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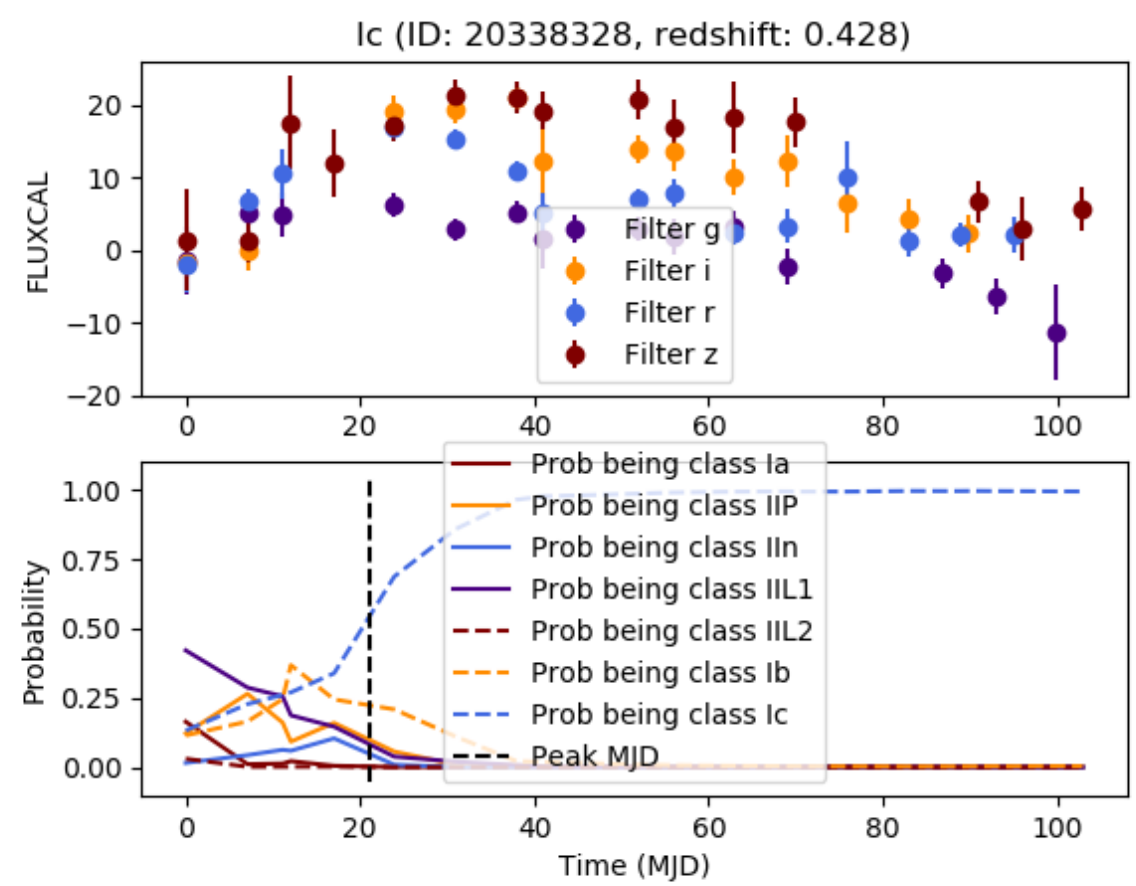
trained & tested with supernovae simulations: SNe Ia, Ic, Ib, IIn, IIL1,IIL2

7 classes

[complete lc]()

	complete lc
fluxes+ errors	86.8 ± 0.3
fluxes+ errors + host z	**90.4 ± 0.4**



photometric classifiers & common pitfalls

photometric classifiers & common pitfalls

limitations

I. **Training sets** are:

1. not representative
2. incomplete (we don't know/can't simulate)

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bayesian RNNs

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bayesian RNNs

Bayesian Neural Networks

$$\mathcal{P}\left(\mathbf{y}|\mathbf{X}, \mathbf{w}\right)$$

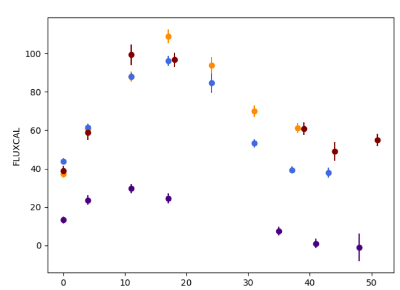
Categorical distribution

Target
(SN type)

data
(lightcurves)

Network weights

Ia vs. Non Ia



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bayesian RNNs

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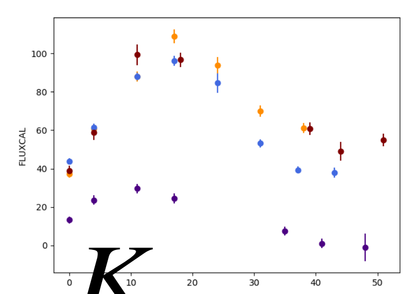

data $\mathcal{D} = (\mathbf{X}_k, \mathbf{y}_k)_{k=1\ldots K}$

Training minimisation $NLL = \min_{\mathbf{w}} \sum_{k=1}^{K} -\log \mathcal{P}(\mathbf{y_k}|\mathbf{X}_k, \mathbf{w})$

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bayesian RNNs

Bayesian Neural Networks

$$\mathscr{P}(\hat{\mathbf{y}}\,|\,\mathbf{x}) = \int \mathscr{P}(\hat{\mathbf{y}}\,|\,\mathbf{x},\mathbf{w})\mathscr{P}\left(\mathbf{w}\,|\,\mathscr{D}\right) d\mathbf{w}$$

Bayesian: distribution of weights

posterior is intractable for deep neural networks

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bayesian RNNs

Bayesian Neural Networks

$$\mathscr{P}(\hat{\mathbf{y}}\,|\,\mathbf{x}) = \int \mathscr{P}(\hat{\mathbf{y}}\,|\,\mathbf{x}, \mathbf{w})\mathscr{P}\left(\mathbf{w}\,|\,\mathscr{D}\right) d\mathbf{w}$$

Bayesian: distribution of weights

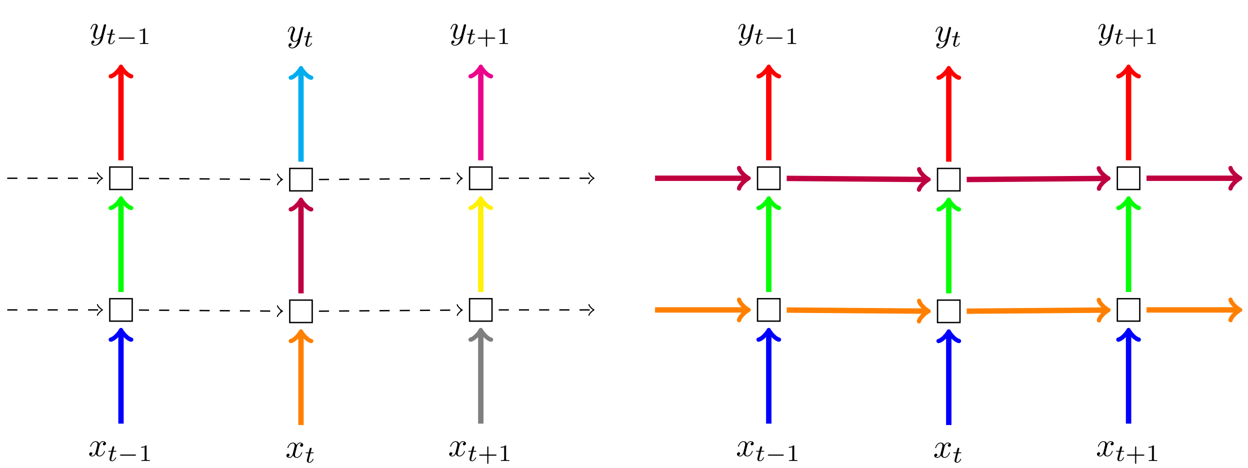
posterior is intractable for deep neural networks

$$\mathscr{P}(\mathbf{w}\,|\,\mathscr{D}) \approx q(\mathbf{w}\,|\,\theta)$$ variational distribution

Approximating the variational distribution

1. **MC dropout**

Gal & Ghahramani 2016



(a) Naive dropout RNN (b) Variational RNN

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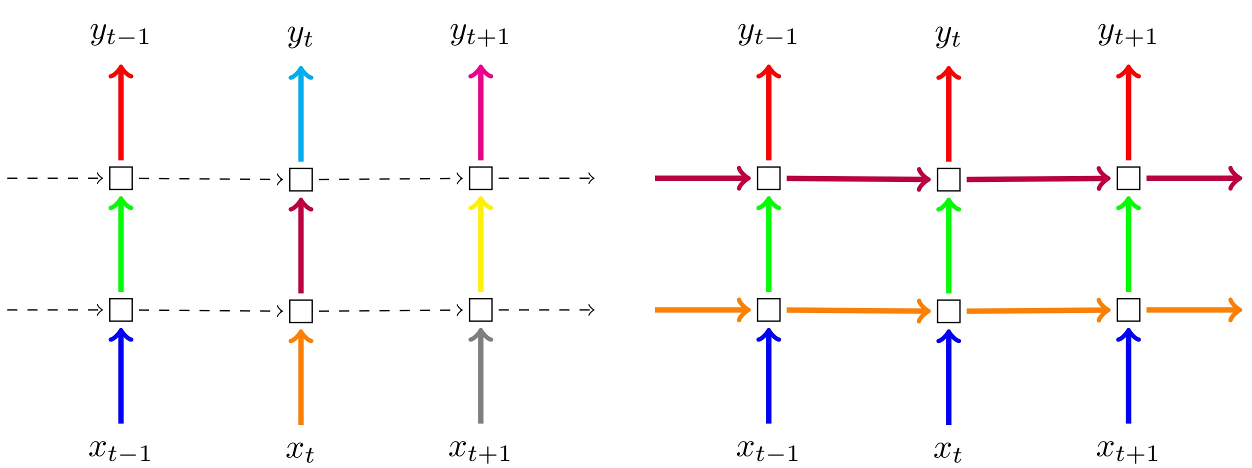
bayesian RNNs

Approximating the variational distribution

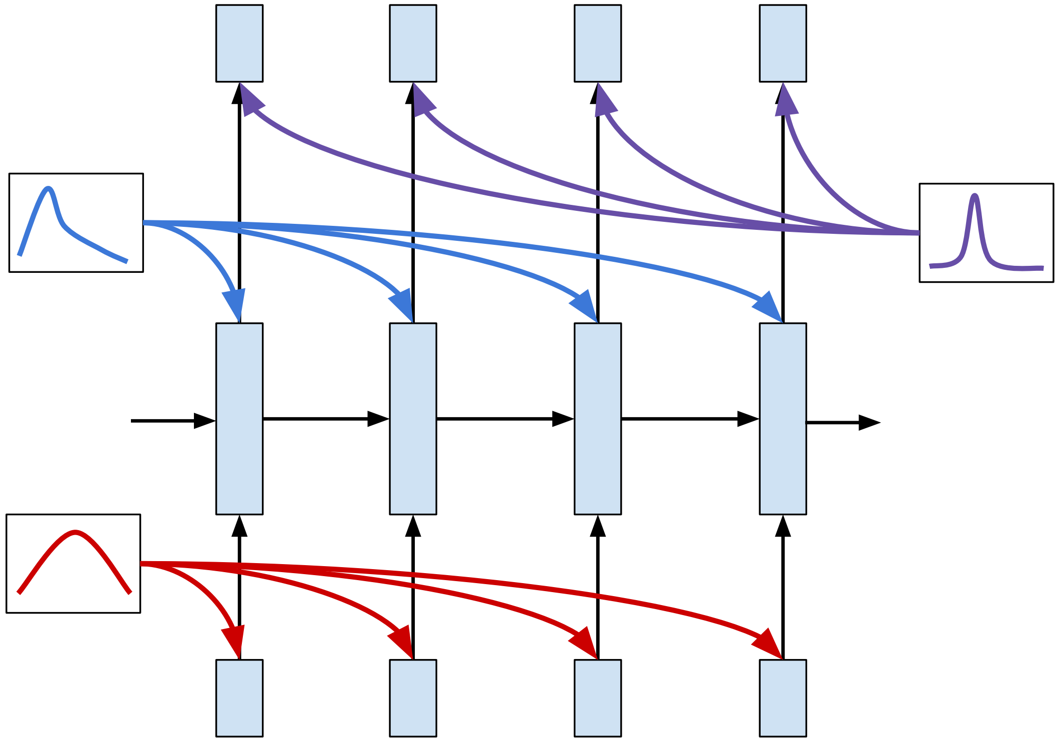
1. MC dropout
Gal & Ghahramani 2016

2. Bayes by Backprop
Fortunato+ 2017



(a) Naive dropout RNN

(b) Variational RNN



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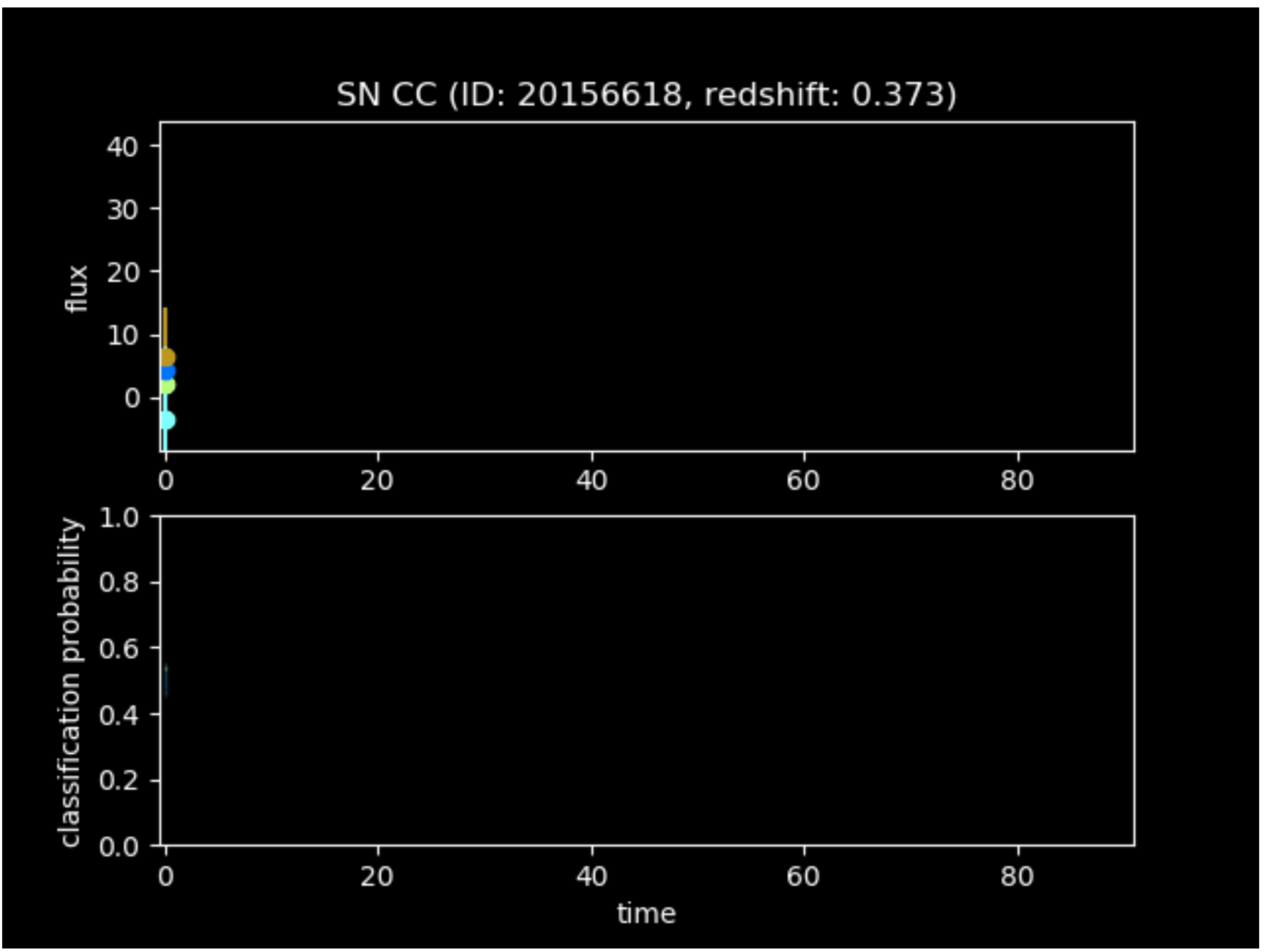
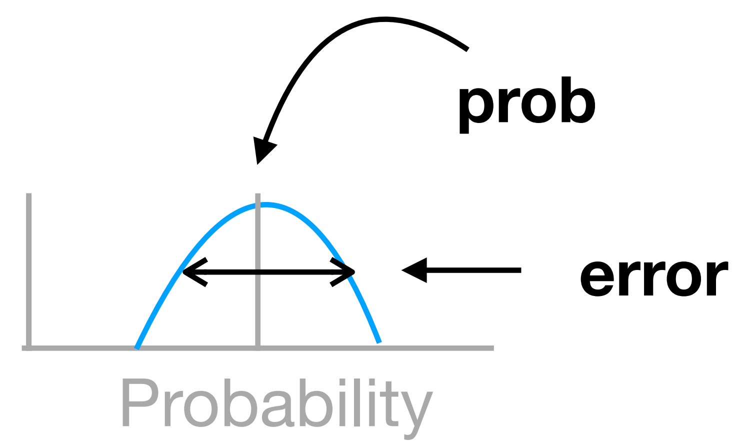
bayesian RNNs



Posterior that provides epistemic uncertainties

Epistemic uncertainties:

express our <u>ignorance about the model</u>



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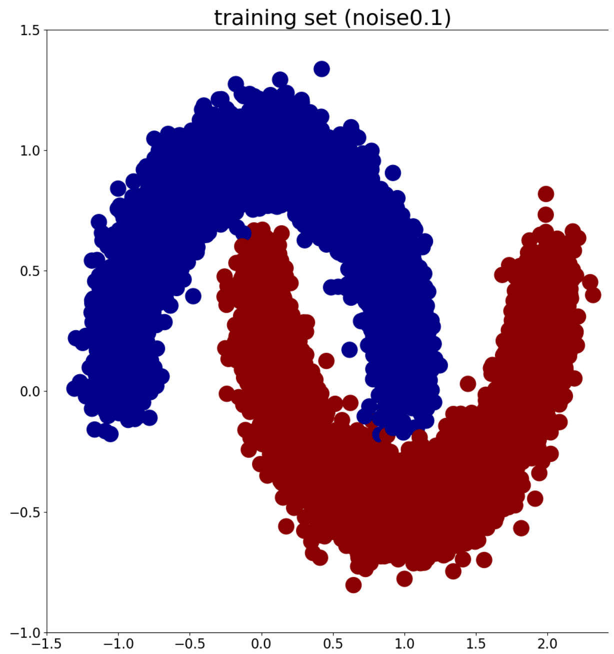
bayesian NNs

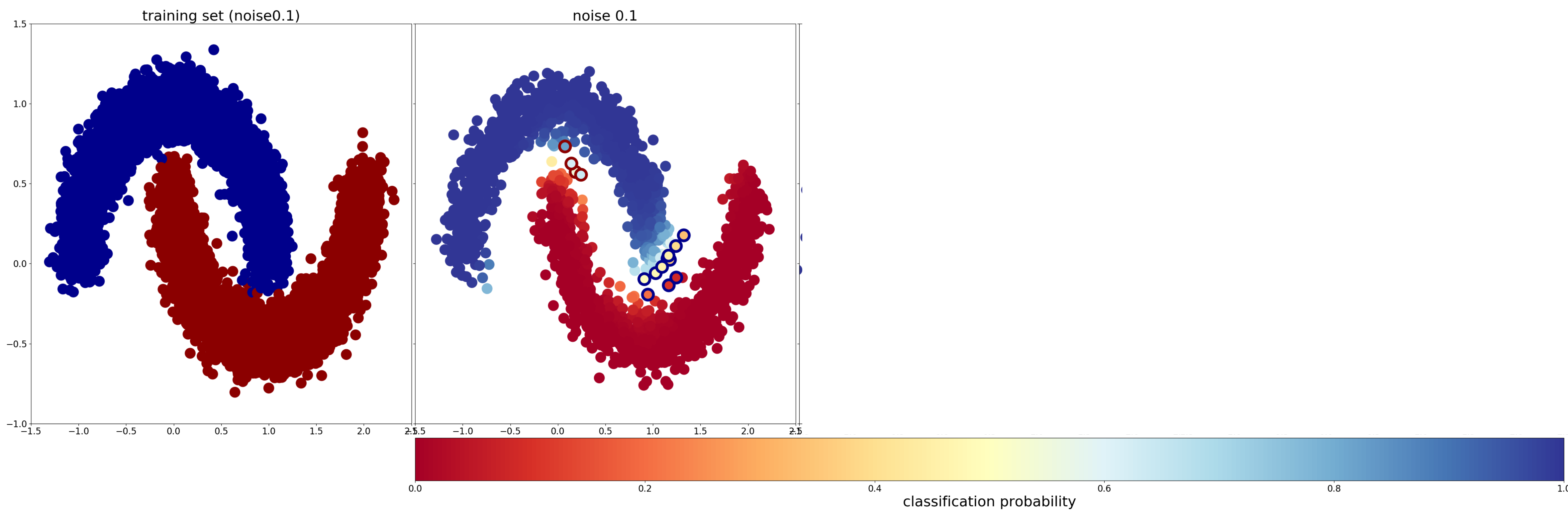


SuperNNova

open source photometric classification

bayesian NNs

classification probability

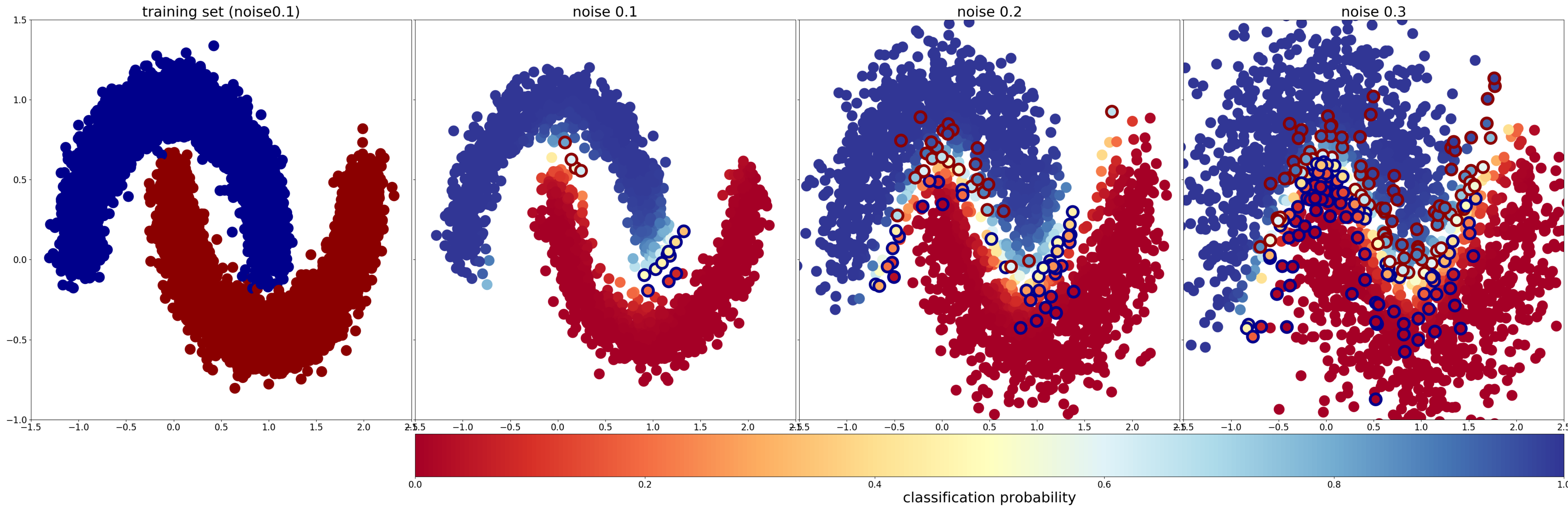


SuperNNova

open source photometric classification

bayesian NNs

classification probability



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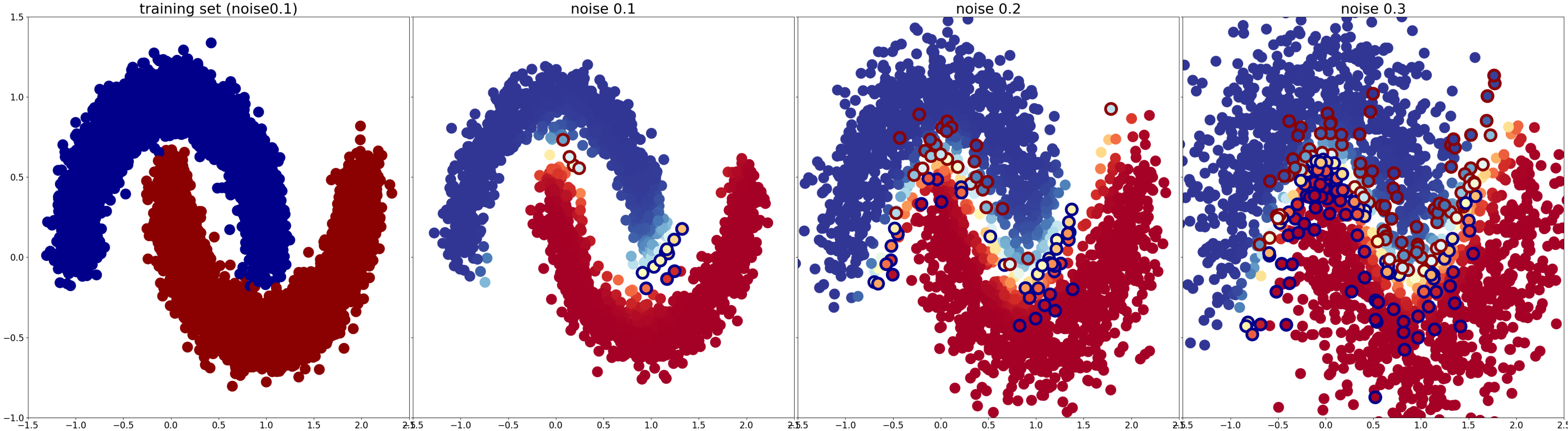
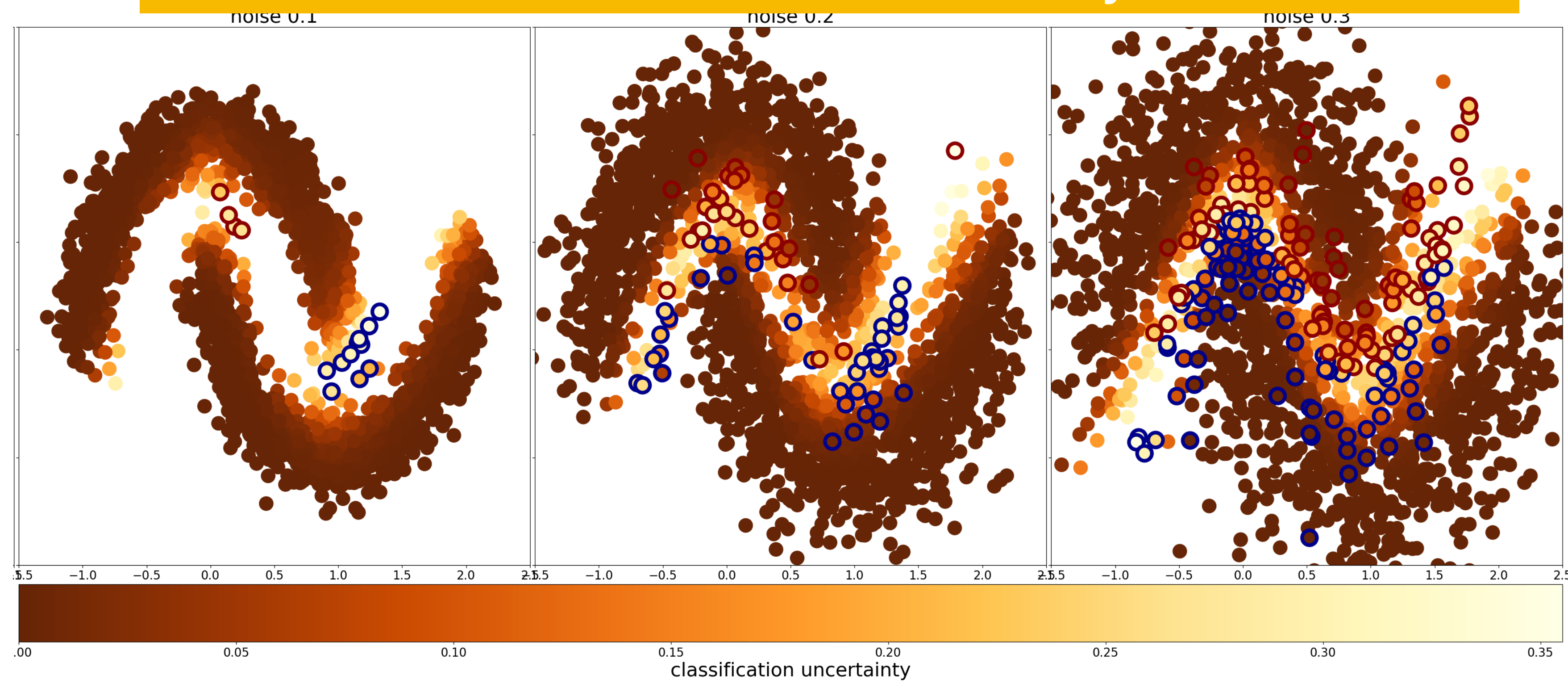
bayesian NNs

classification probability



classification uncertainty



photometric classifiers & common pitfalls

training sets are:

1. not representative

Model 1: representative model

Model 2: train non-representative model

photometric classifiers & common pitfalls

training sets are:

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Model 1: representative model

classify representative sample

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photometric classifiers & common pitfalls

training sets are:

1. not representative

<u>Model 1:</u> representative model

classify representative sample

<u>Model 2</u>: train non-representative model

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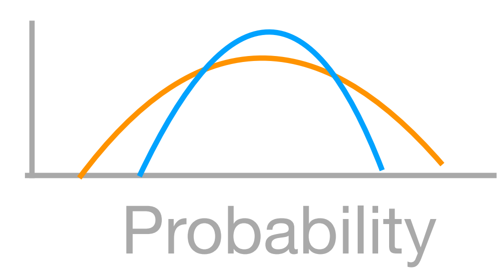
classification

accuracy changes slightly (<prob> are not the most indicative)

non-representative models give larger uncertainties!



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photometric classifiers & common pitfalls

training sets are:

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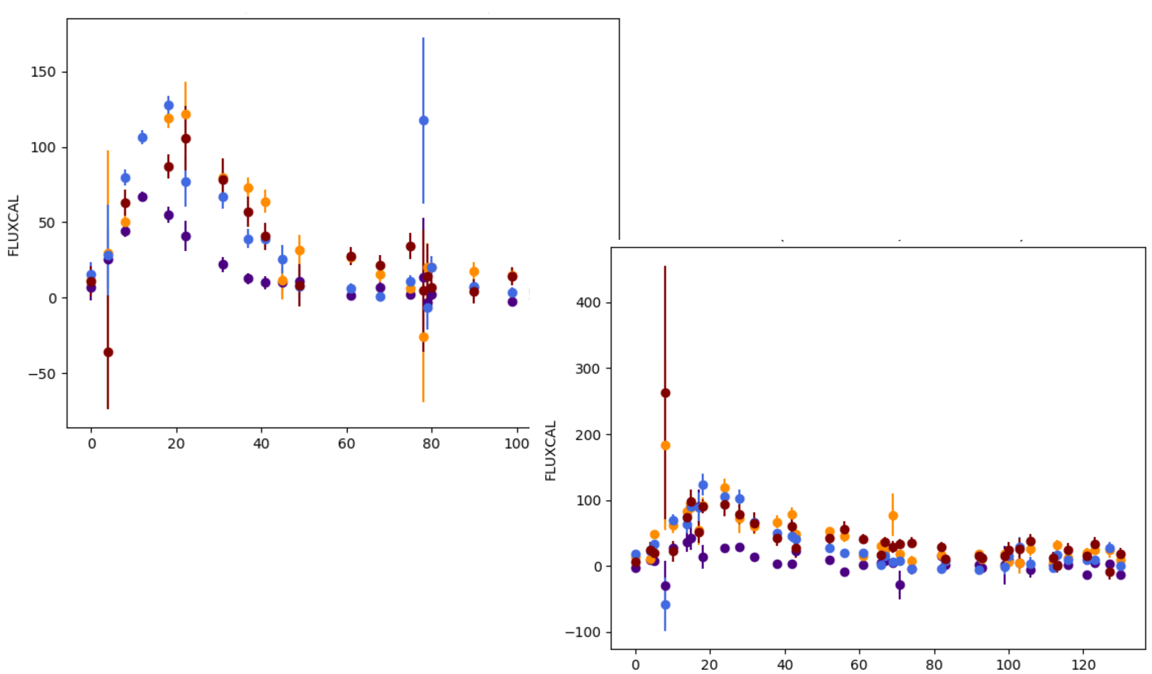
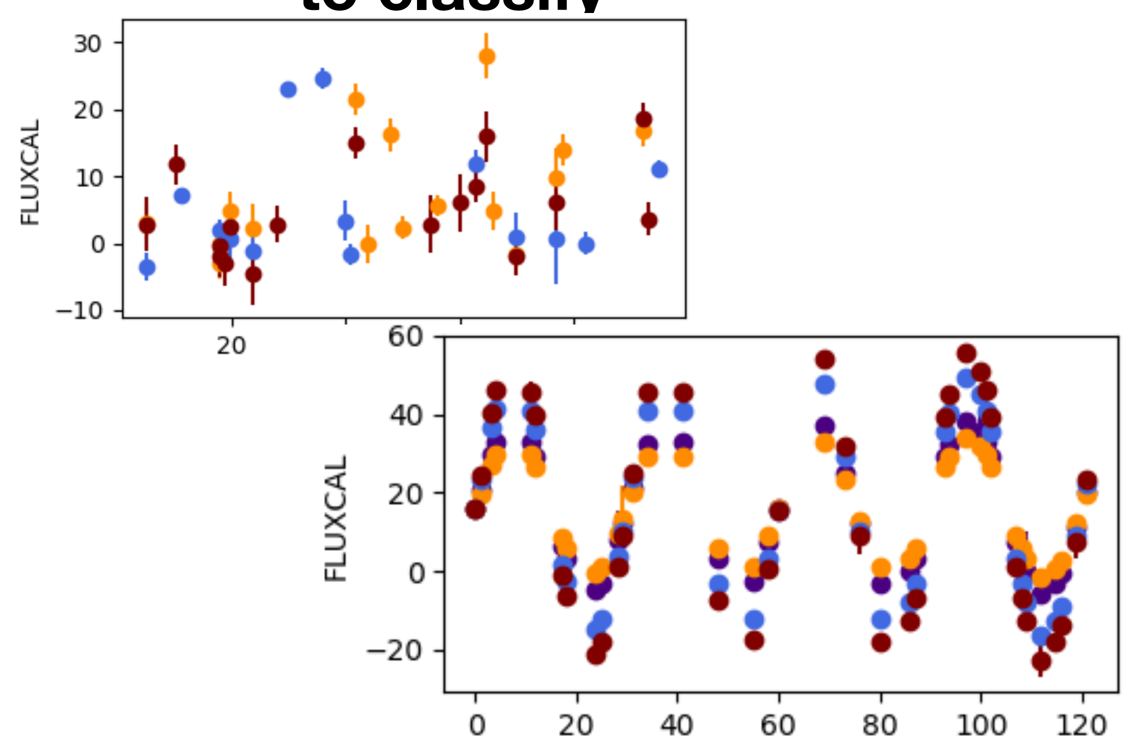
training set

to classify





SuperNNova & anomalies

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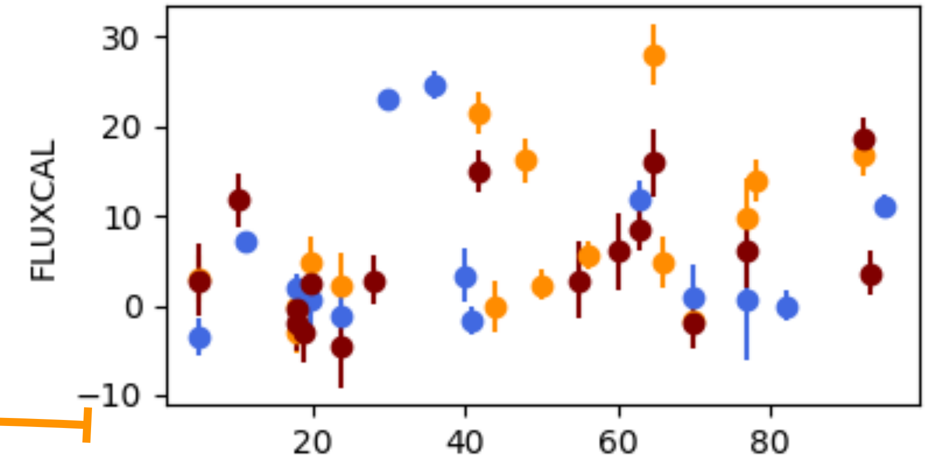
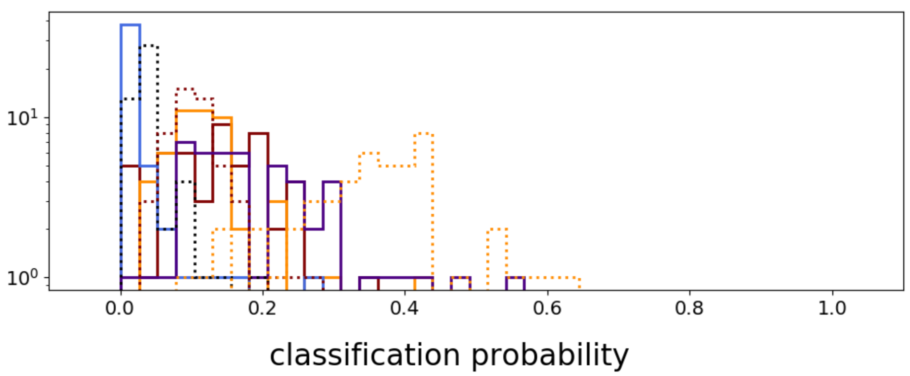
7-way classification
Ia, Ib, Ic, IIn, II-P, IIL1, III2



low probability for any class



SuperNNova & anomalies

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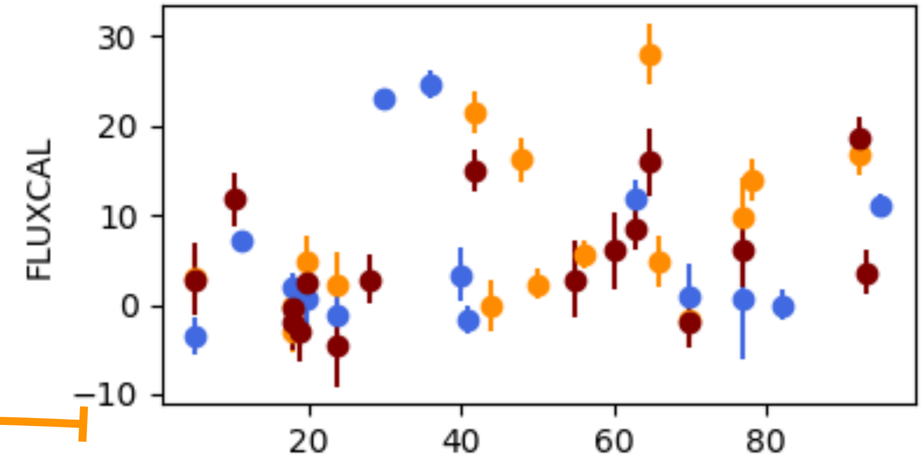

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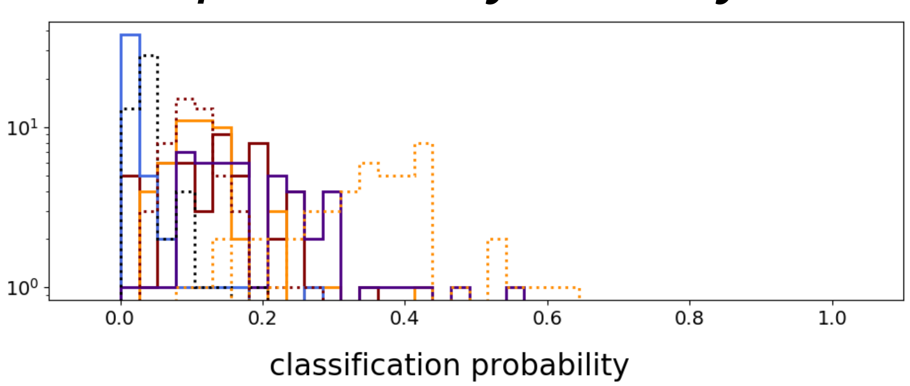
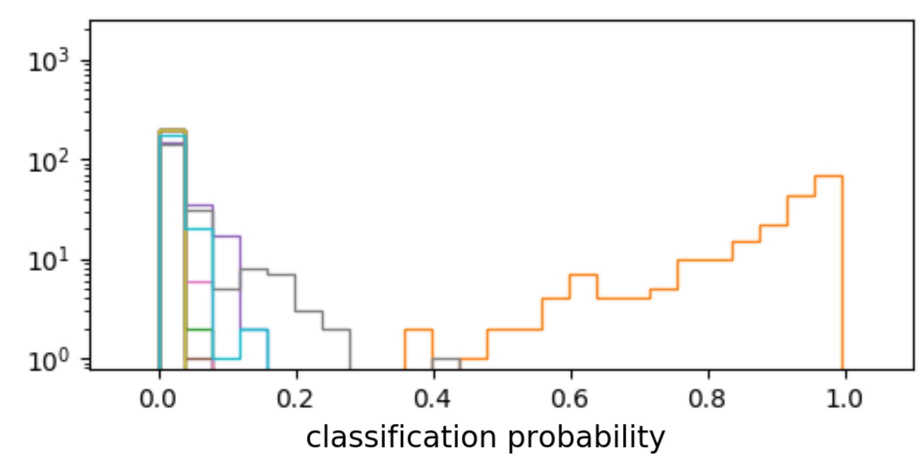


high probability for "less-known" class



but… BNNs can give us high-probability but large uncertainty

"an increase in average classification uncertainties for these anomalies" Möller + 2019

SuperNNova summary

open source photometric classification

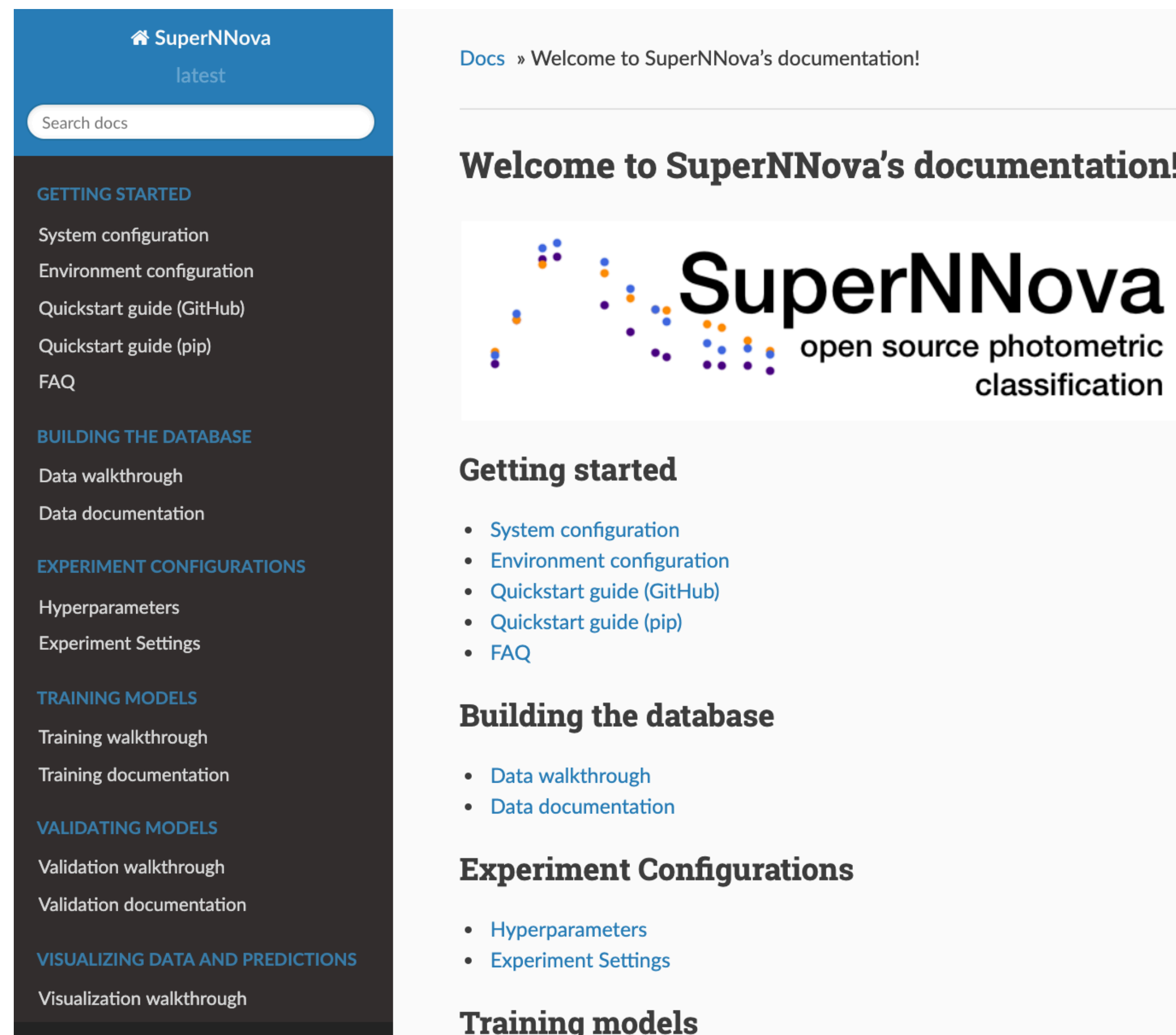
Möller + 2019

- ingests “observed data”: **no interpolation necessary**
- High accuracy for complete and partial light-curves
- Exploring the use BNNs as meaningful probabilities
- **fast:** can classify up to 2,000 lcs/s

- reproducible: data available 10.5281/zenodo.3265189
- Open source
- Documented!

supernnova/SuperNNova

https://supernnova.readthedocs.io


SuperNNova
latest
Search docs

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Environment configuration
Quickstart guide (GitHub)
Quickstart guide (pip)
FAQ

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Data walkthrough
Data documentation

EXPERIMENT CONFIGURATIONS
Hyperparameters
Experiment Settings

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Training documentation

VALIDATING MODELS
Validation walkthrough
Validation documentation

VISUALIZING DATA AND PREDICTIONS
Visualization walkthrough

Docs » Welcome to SuperNNova’s documentation!

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open source photometric classification

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Training models