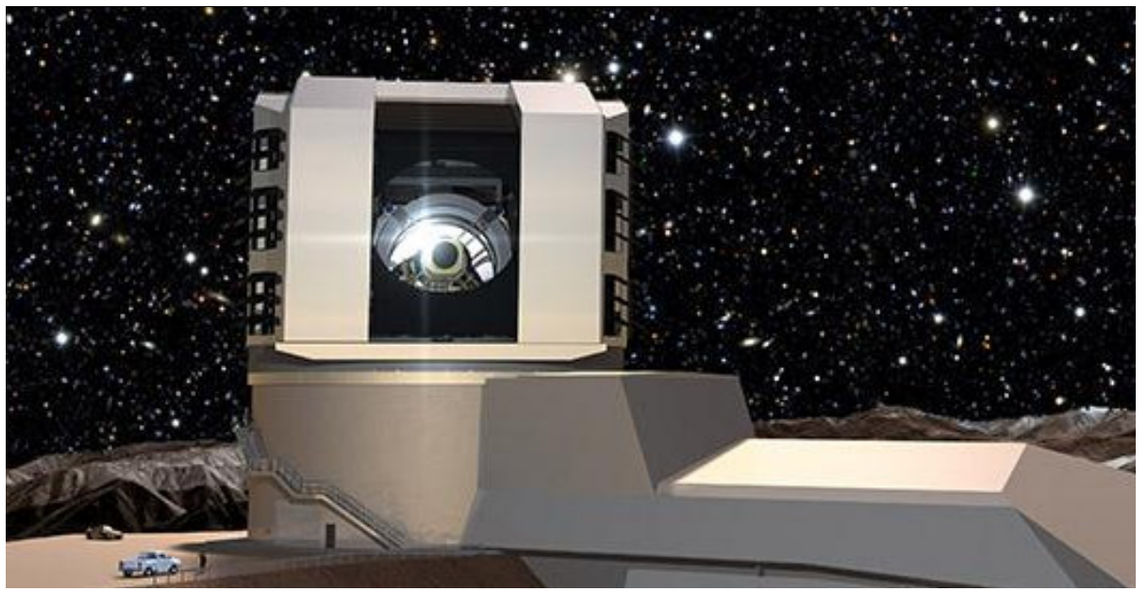
FINK

enabling supernova cosmology in the era of LSST

Anais Möller

LSST

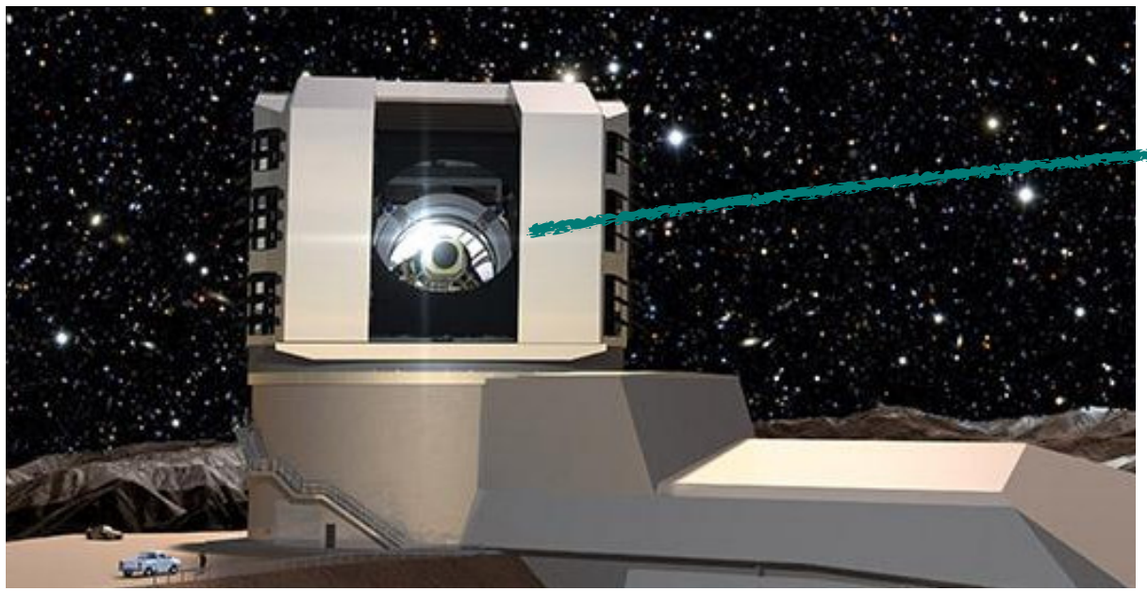


(see M. Gangler talk tomorrow)

In numbers:

* 10-year survey, starting 2022
* 1,000 images/night = 15 TB/night
* >4,000 well measured SNe Ia

LSST



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Sequential 30s image, 20TB/night

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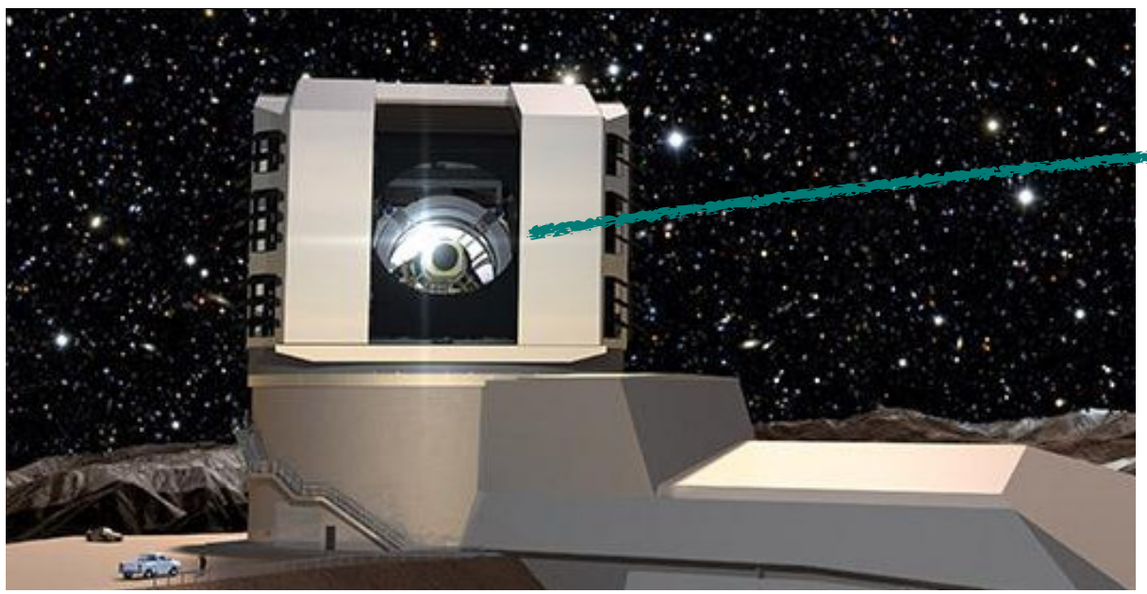

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Prompt Data Product
Difference Image Analysis
Alerts: up to 10 million per night

Public data!

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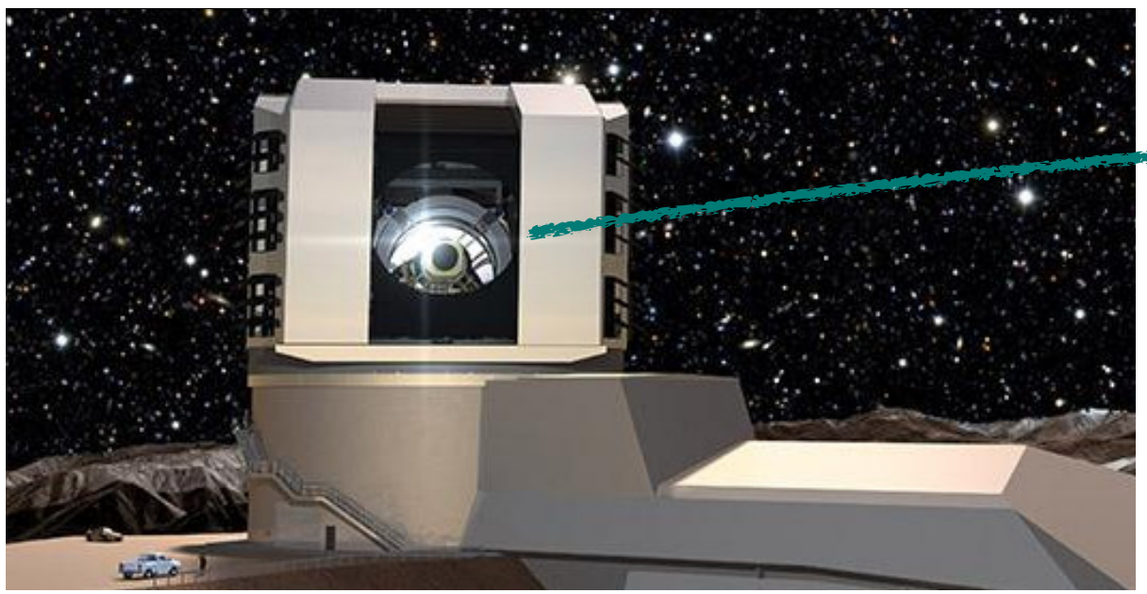

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24h

Prompt Products DataBase
Images, Object and Source catalogs from DIA
Orbit catalog for ~6 million Solar System bodies

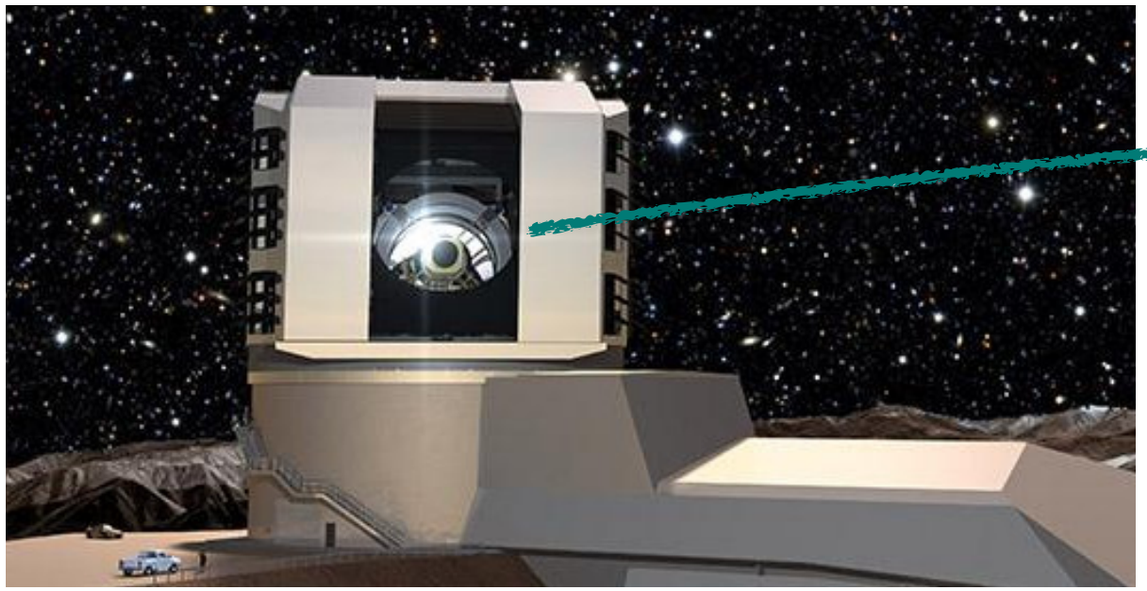
Year

Annual Data Release
Accessible via the LSST Science Platform & LSST Data Access Centers.

End

Final 10yr Data Release
Images: 5.5 million x 3.2 Gpx
Catalog: 15PB, 37 billion objects

LSST



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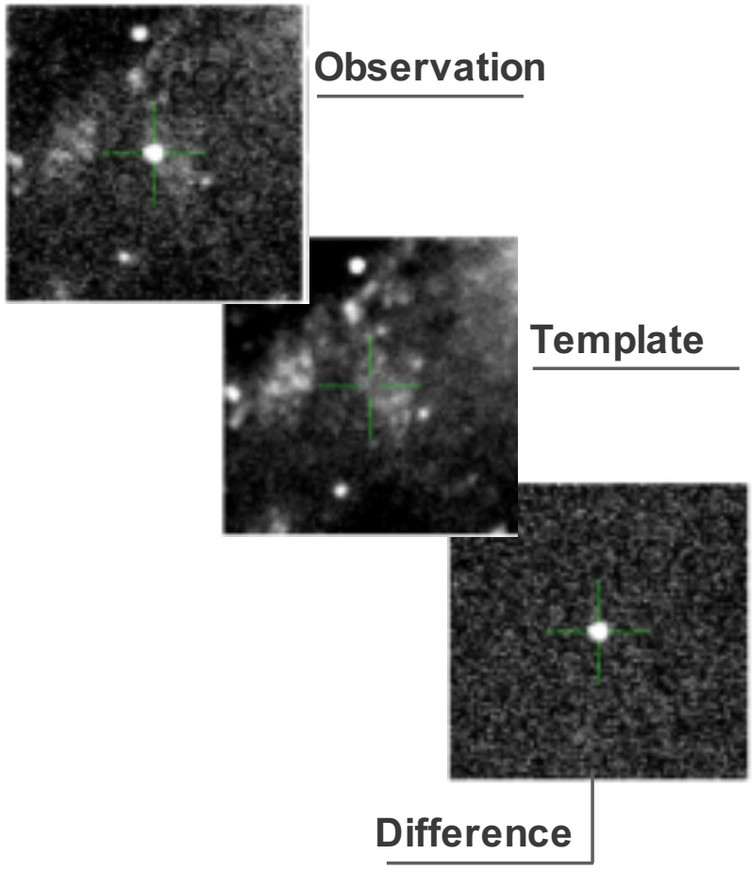
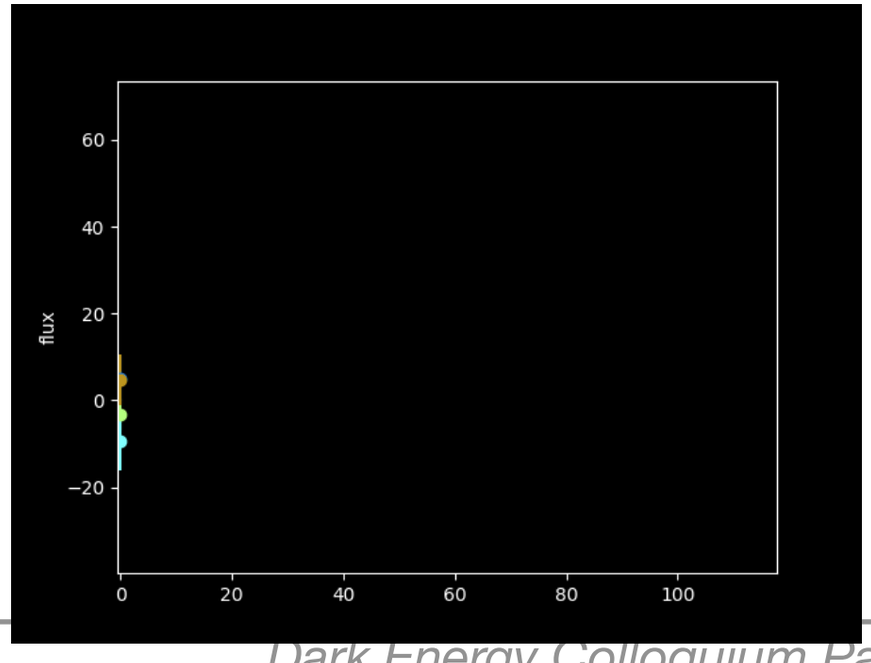
Alert Package

- Source record that triggered the alert
- Other measured source properties
- Time series features
- Crossmatches to nearby LSST detected object
- 12 months of source history
- Science and template cutouts (30x30 pixels)

Credits: E. Bellm





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10,000 alerts / 30 s

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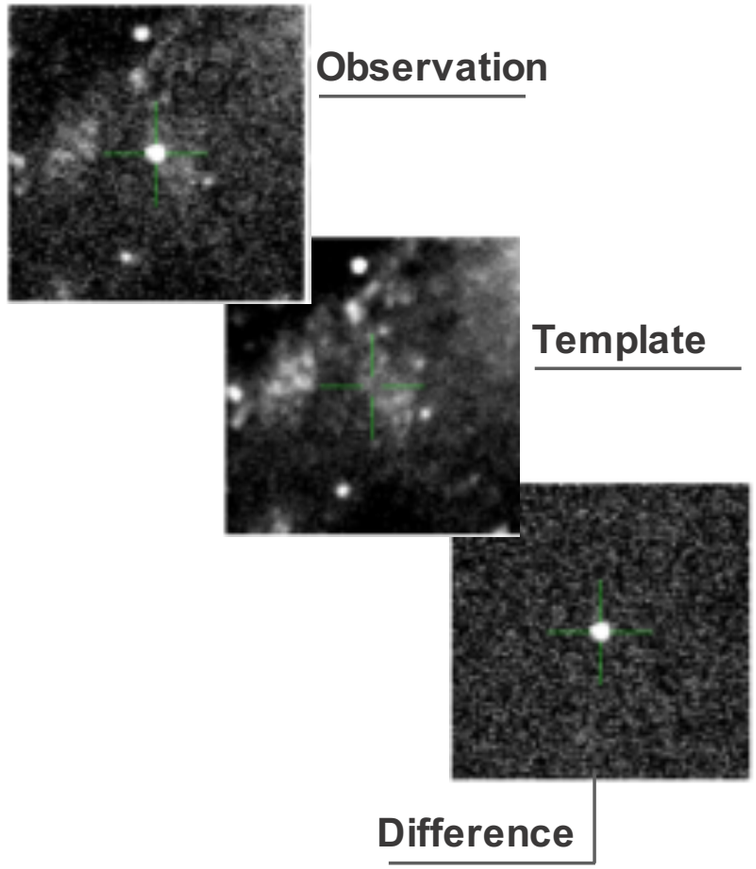
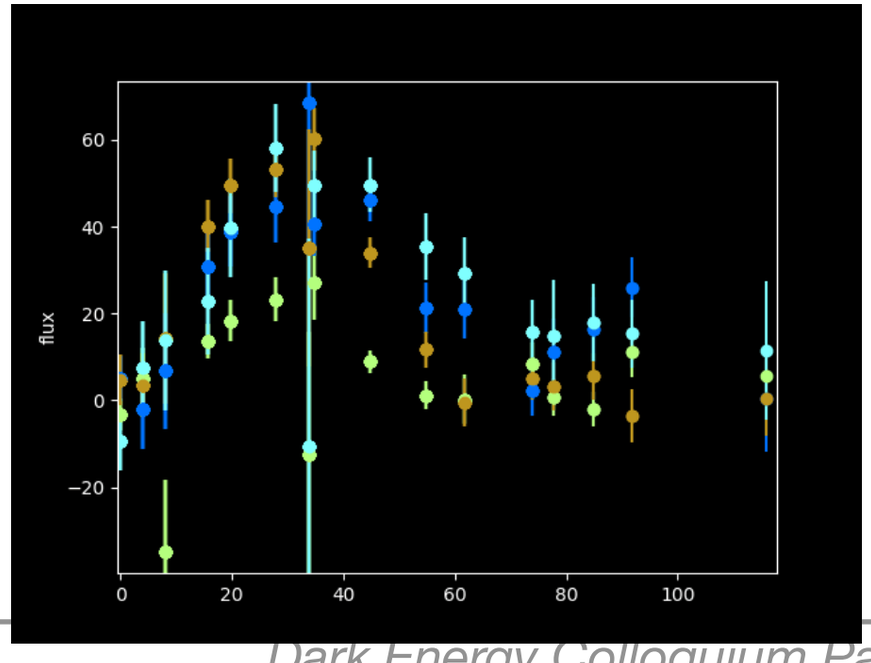




Alert Package

Alert stream

Brokers

- Collect alerts
- Preprocess them
- Add value:
  - crossmatches
  - classification / ranking
- Distribute

Broker alerts

Enabling science

FINK

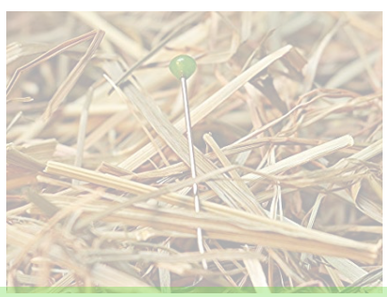
Technology & infrastructure: J. Peloton (LAL)
Science & ML: E. Ishida, A. Möller (LPC)
+ 28 signatories

Alert Package

Alert stream

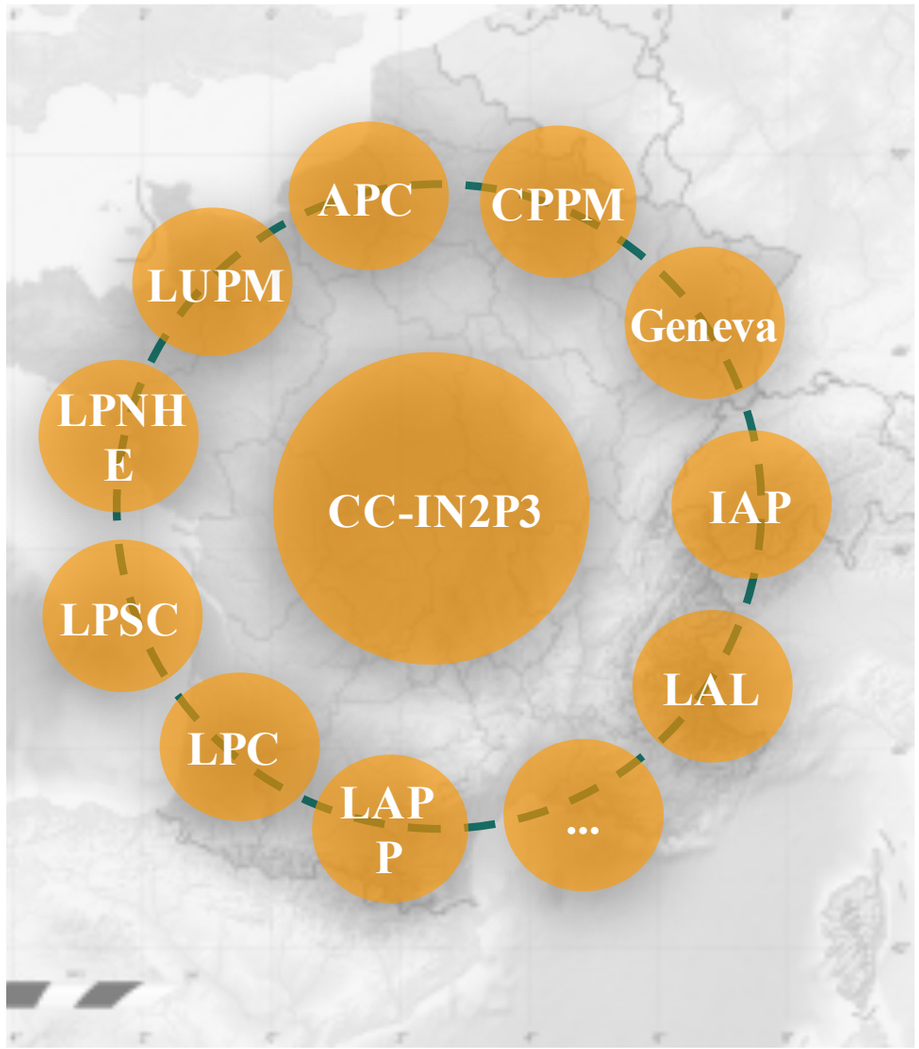
Brokers

Broker alerts



Enabling science

IN2P3 initiative to propose a broker to serve the need of LSST-France as well as the different french multi-messenger astronomy actors.



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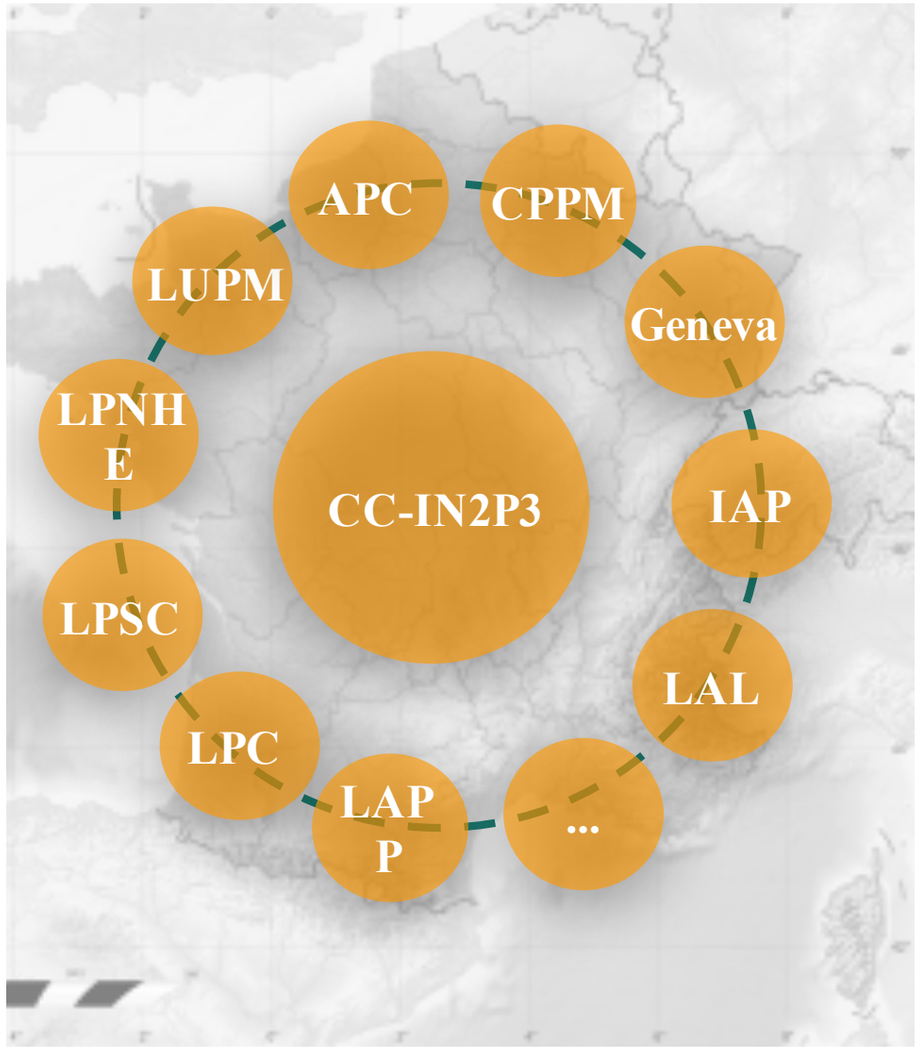


Our added values (+ std broker)

- **Science**: Supernovae, microlensing, anomaly detection, and multimessenger astronomy: GRB alerts, gamma ray, neutrinos, gravitational wave events, ….
- **Methods**: Adaptive learning, Bayesian NN.
- **Technology**: big data, cloud.

FINK & SNIa cosmology

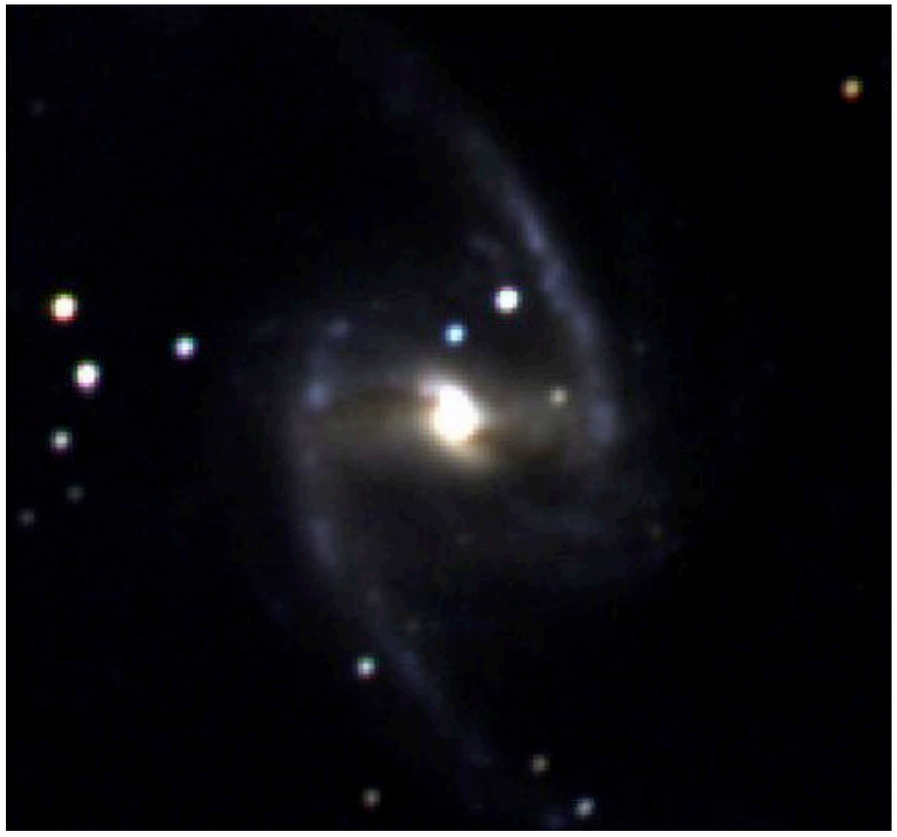
Alert Package

Alert stream

FINK

Broker alerts

Enabling science



This talk "Hubble Diagram SNIa cosmology" for other measurements
e.g peculiar velocities see R. Graziani talk tomorrow

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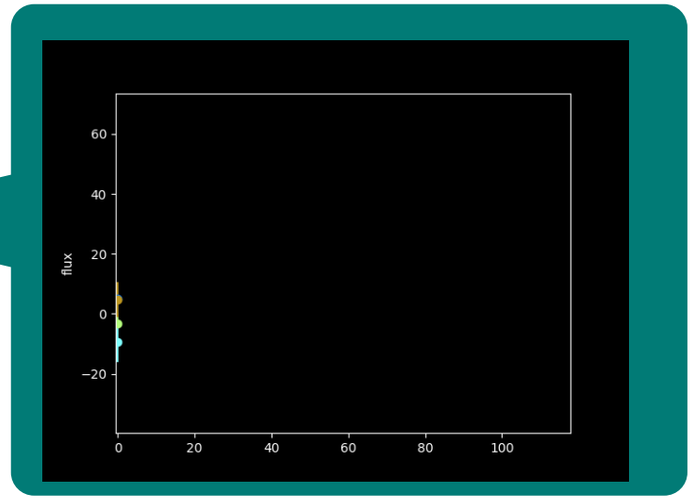
Alert Package



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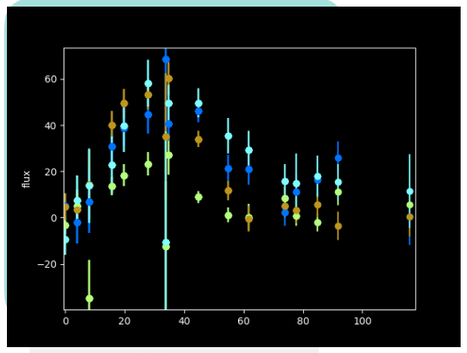

Alert stream

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Broker alerts

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- **Added value:**
  - **Catalogue crossmatches with possible host-galaxies**

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Alert stream

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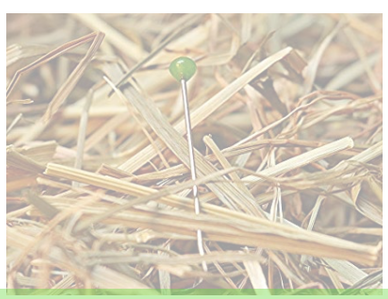
Broker alerts

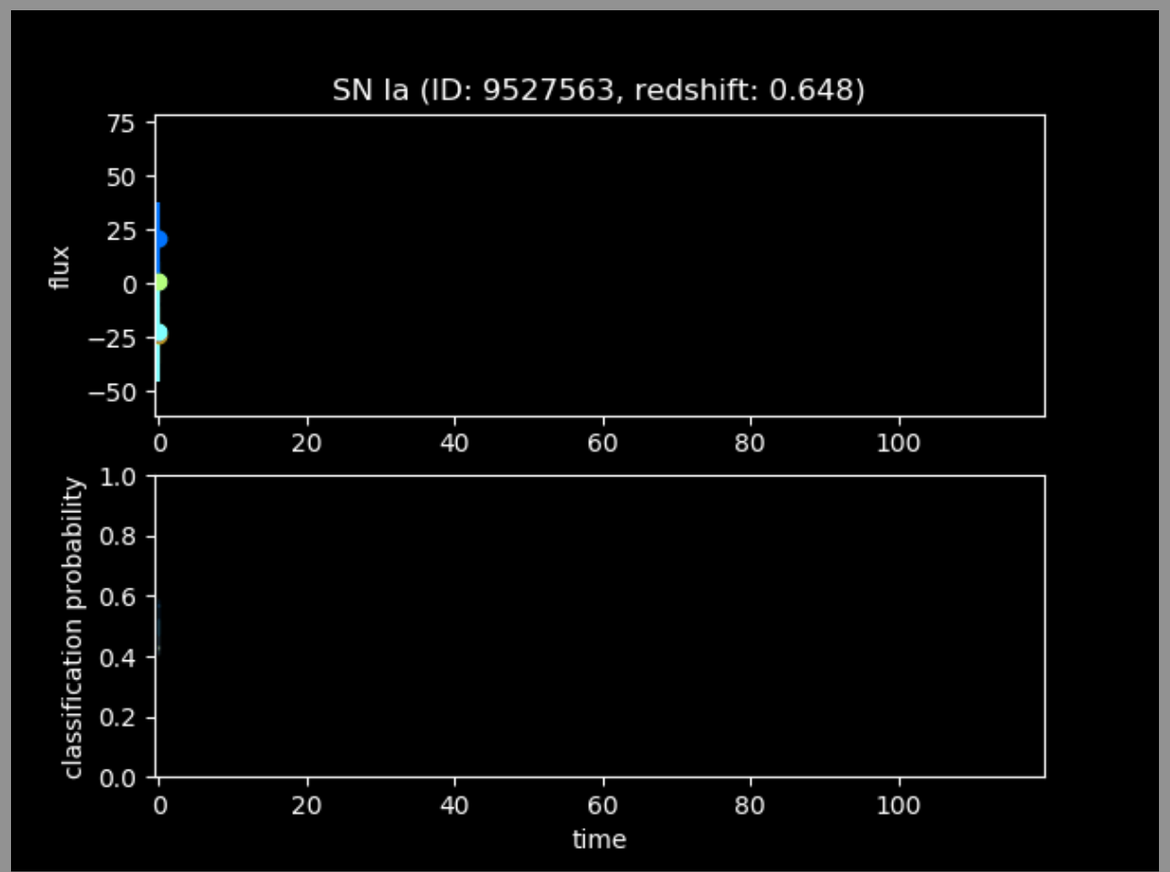


Enabling science

- **Added value:**
  - **Catalogue crossmatches with possible host-galaxies**
  - **early/complete light-curve classification**

SuperNNova
open source photometric classification

Möller+ 2019
arXiv:1901.06384



Deep learning SN classification framework

- Recurrent Neural Networks
- Bayesian NNs

Inputs:
- Flux + errors
- time
- Optional (host-z)

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Alert Package

Alert stream

FINK

Broker alerts

Enabling science

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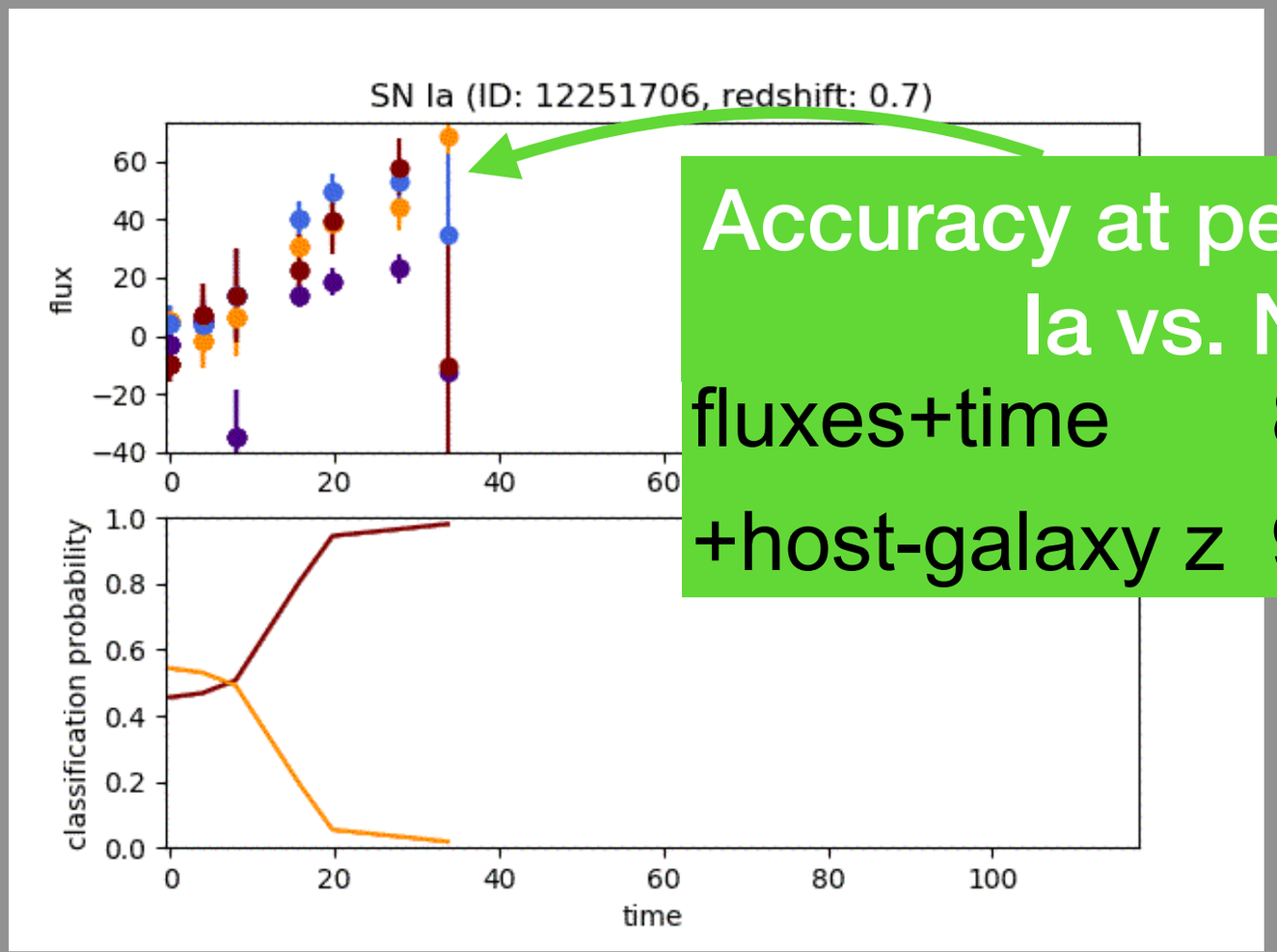

Accuracy at peak brightness
Ia vs. Non Ia

fluxes+time	**87.6 ± 0.1**
+host-galaxy z	**94.2 ± 0.1**

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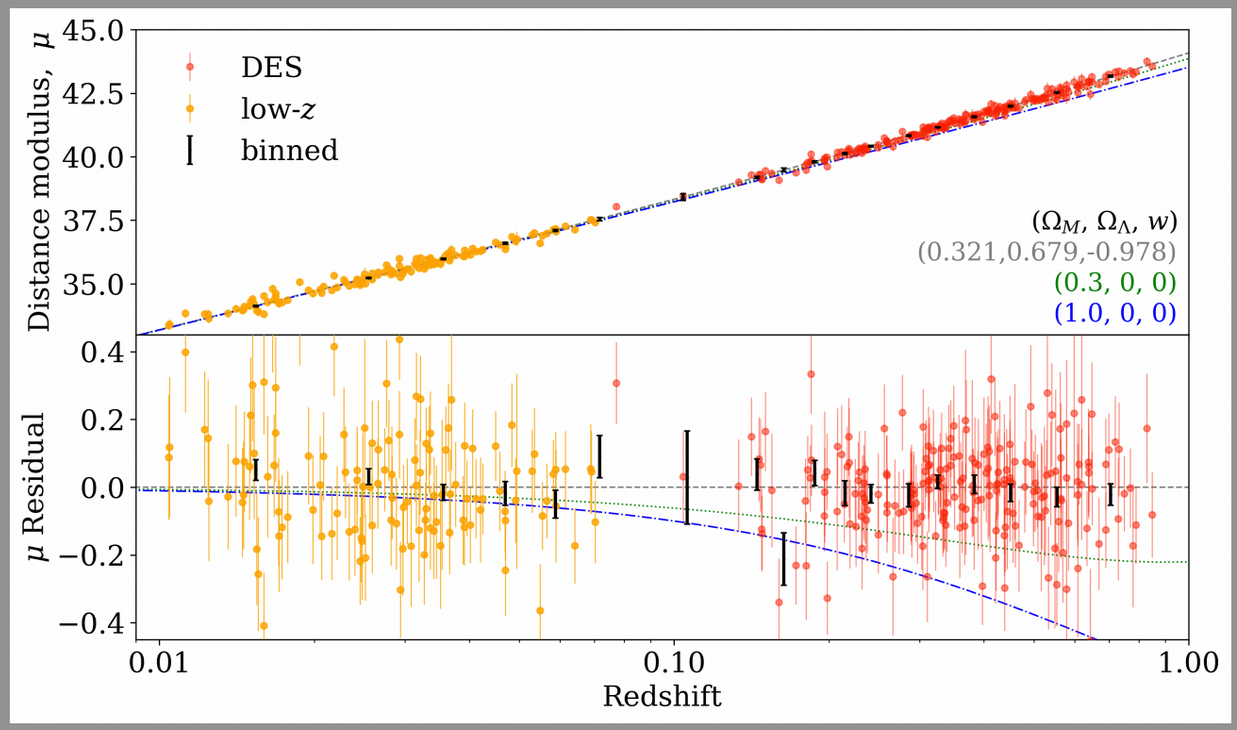
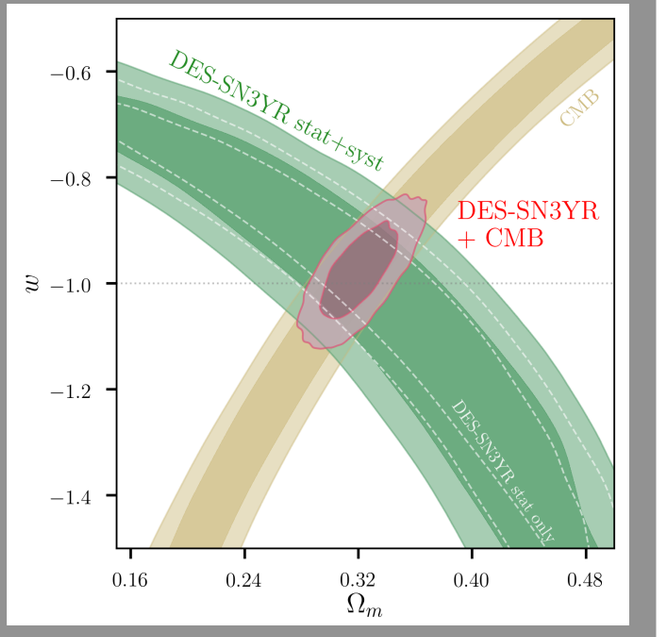
With accurate **early classification** we can do a “traditional analysis” and get **spectroscopic follow-up** to confirm those promising candidates for SNe Ia





DES collaboration 2018 (incl AM)

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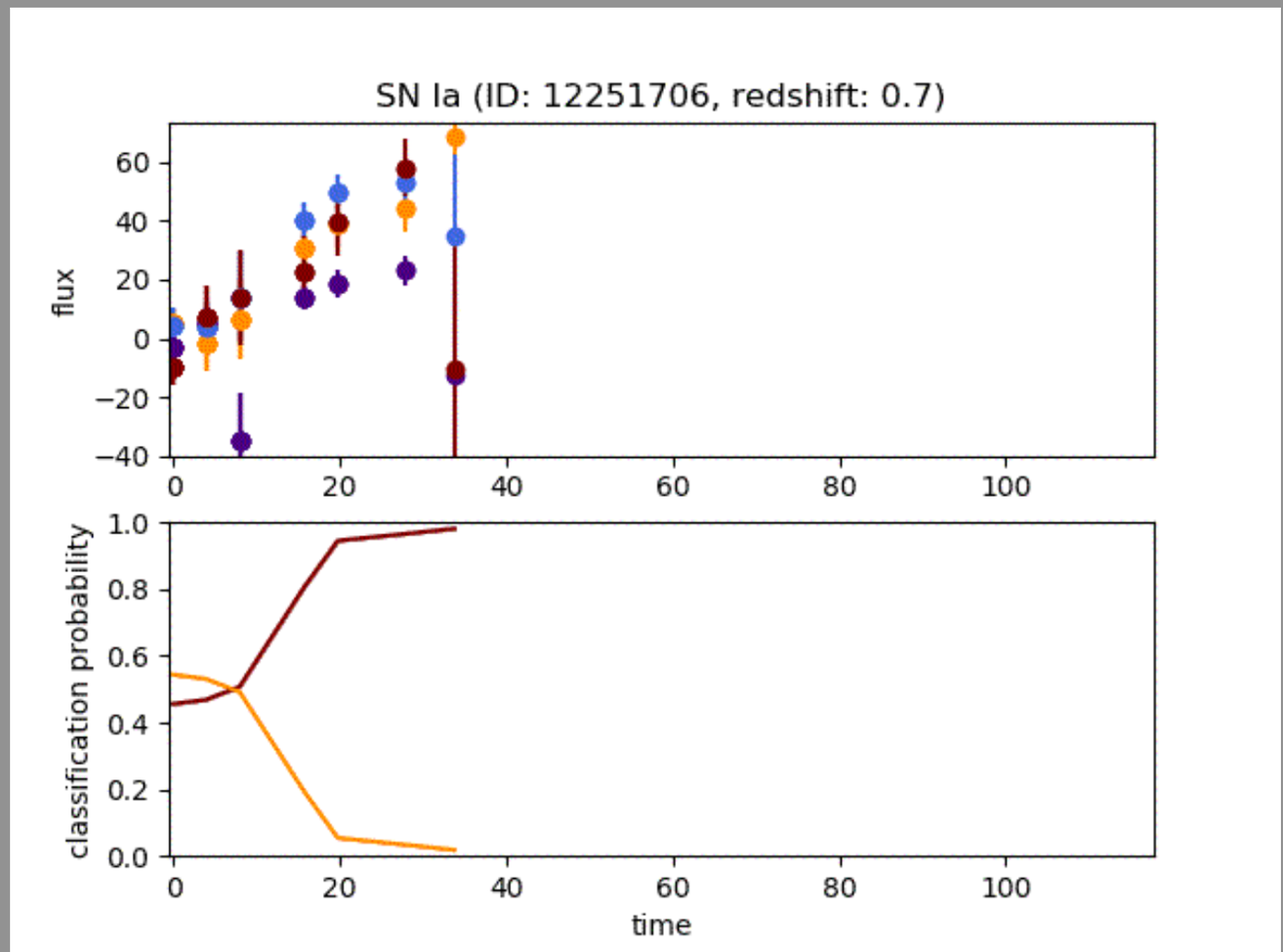
Broker alerts

Enabling science

early classification for spectroscopic follow-up



✓ Improving spectroscopic follow-up coordination
✓ Prioritization for spectrograph telescope time which is expensive/scarce

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Enabling science

early classification for spectroscopic follow-up

TABLE 1
w Uncertainty Contributions for wCDM model[a]

Description[b]	σ_w	$\sigma_w/\sigma_{w,\mathrm{stat}}$
Total Stat ($\sigma_{w,\mathrm{stat}}$)	0.042	1.00
Total Syst[c]	0.042	1.00
Total Stat+Syst	0.059	1.40
[Photometry & Calibration]	**[0.021]**	**[0.50]**
Low-z	0.014	0.33
DES	0.010	0.24
SALT2 model	0.009	0.21
HST Calspec	0.007	0.17
[μ-Bias Correction: survey]	**[0.023]**	**[0.55]**
†Low-z 3σ Cut	0.016	0.38
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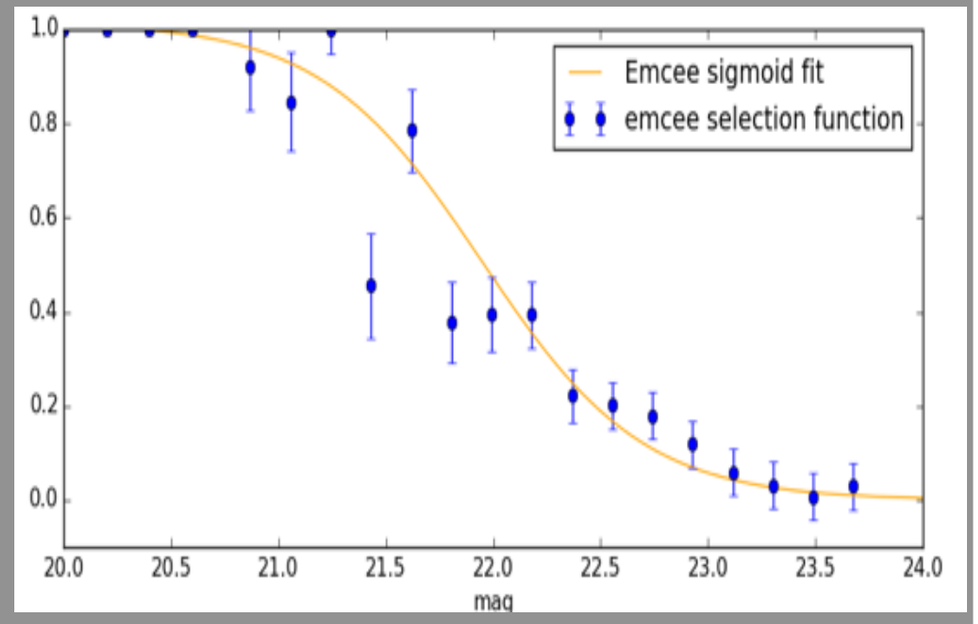

This function includes telescope time allocation but also selection of "promising candidates" often done with template fitting + human

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early classification for spectroscopic follow-up

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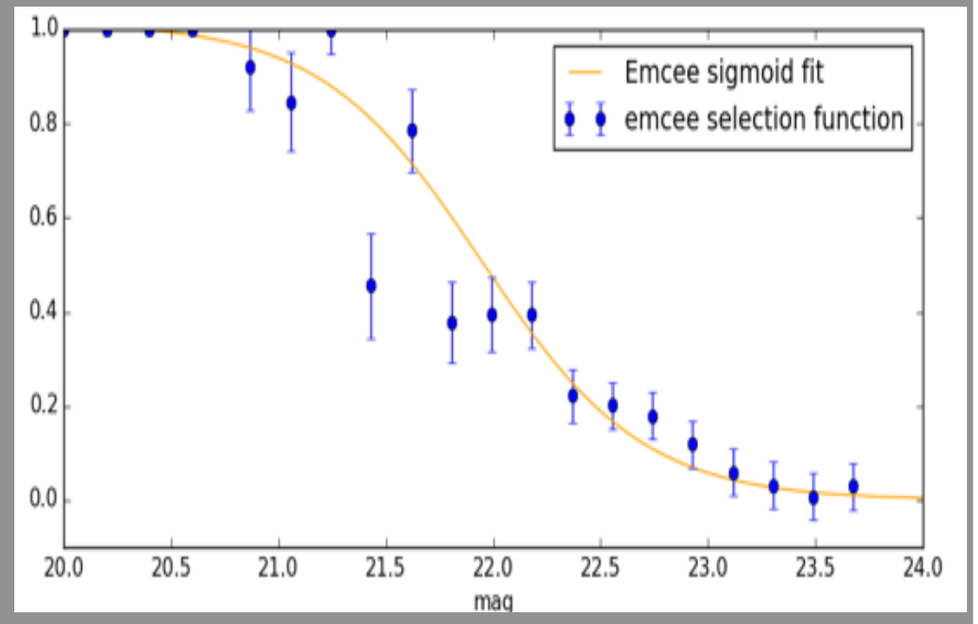

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✓ Improving modelling of selection functions

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early classification for spectroscopic follow-up

+ active learning

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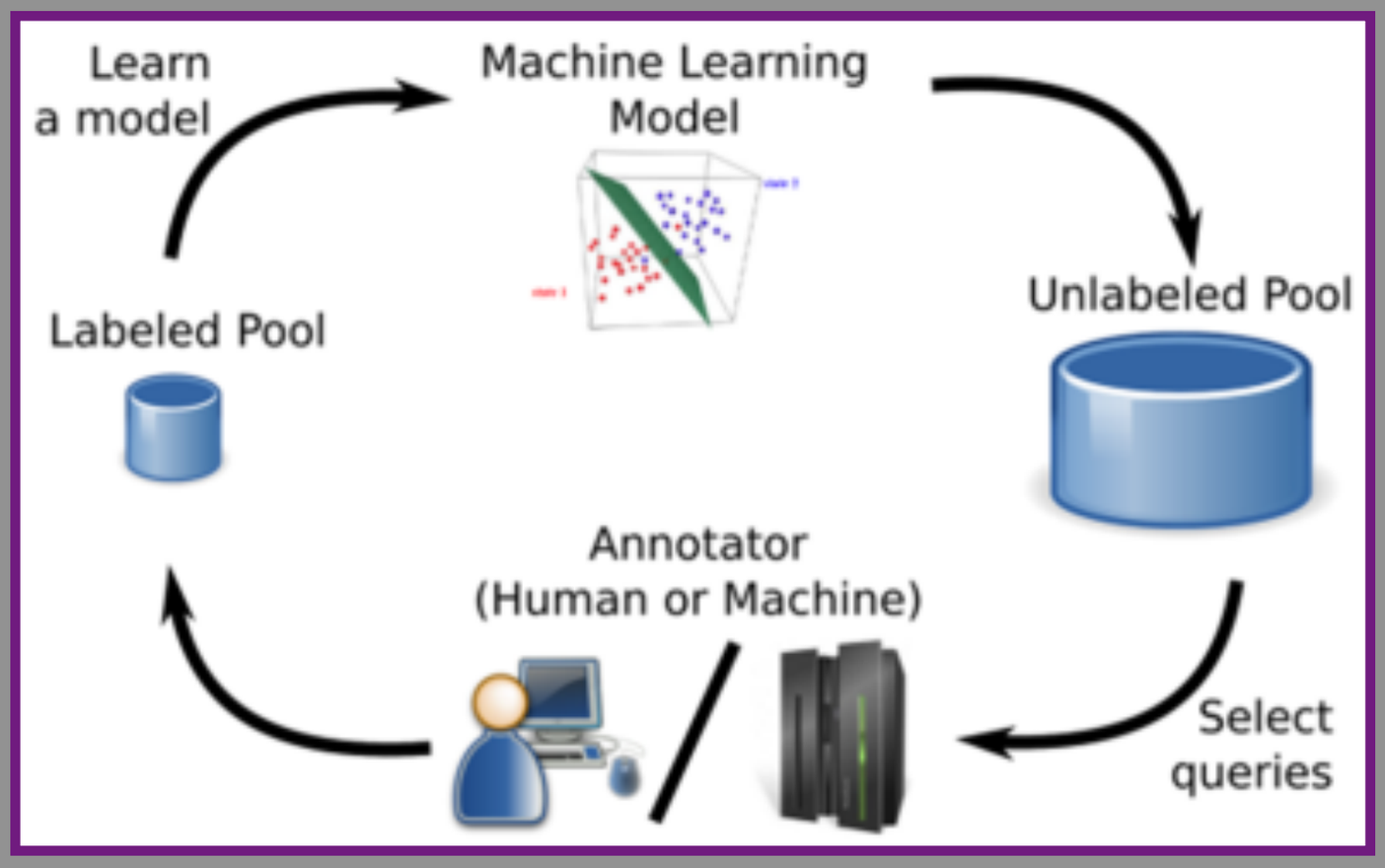
Ishida + 2019



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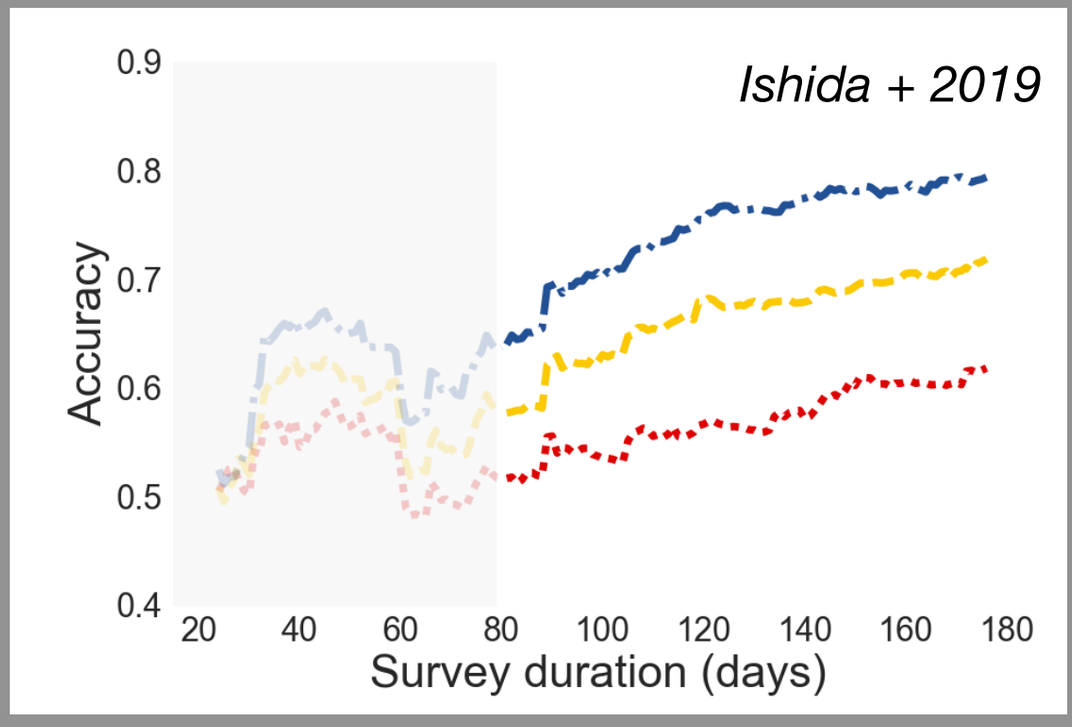

Smartly targeting objects for spectroscopic follow-up to improve your training sample (type Ia but also other types)

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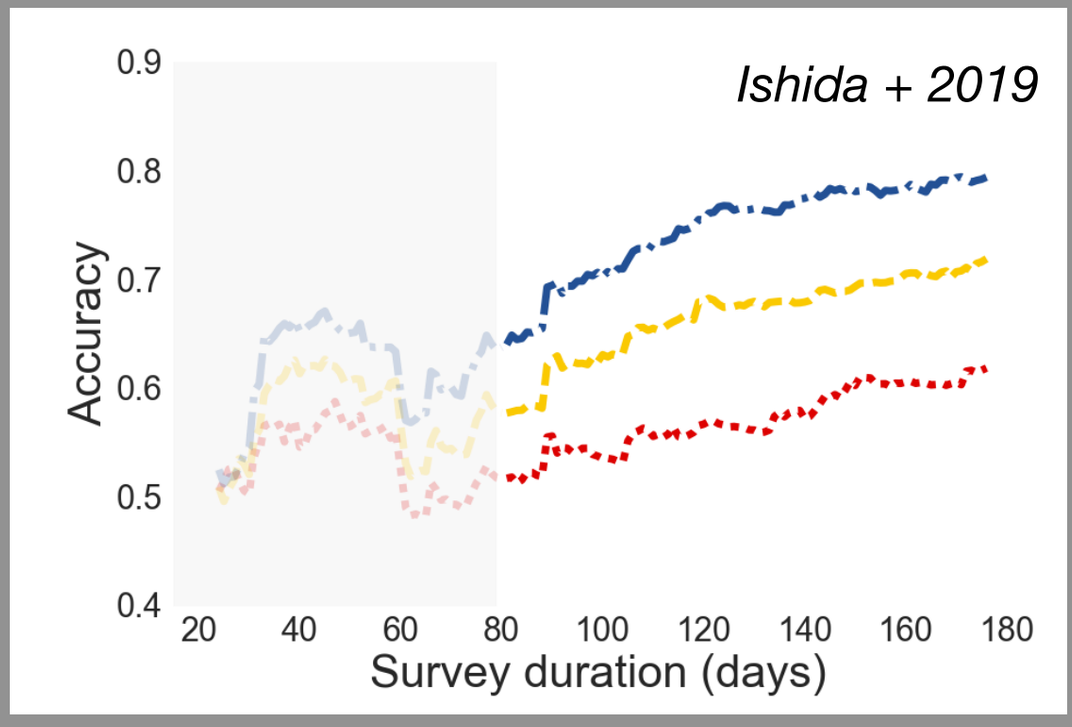
VRT will survey the sky for 10 years!

early classification for spectroscopic follow-up

+ active learning



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✓ Improve our classification models with limited spectroscopic resources

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complete light-curve classification

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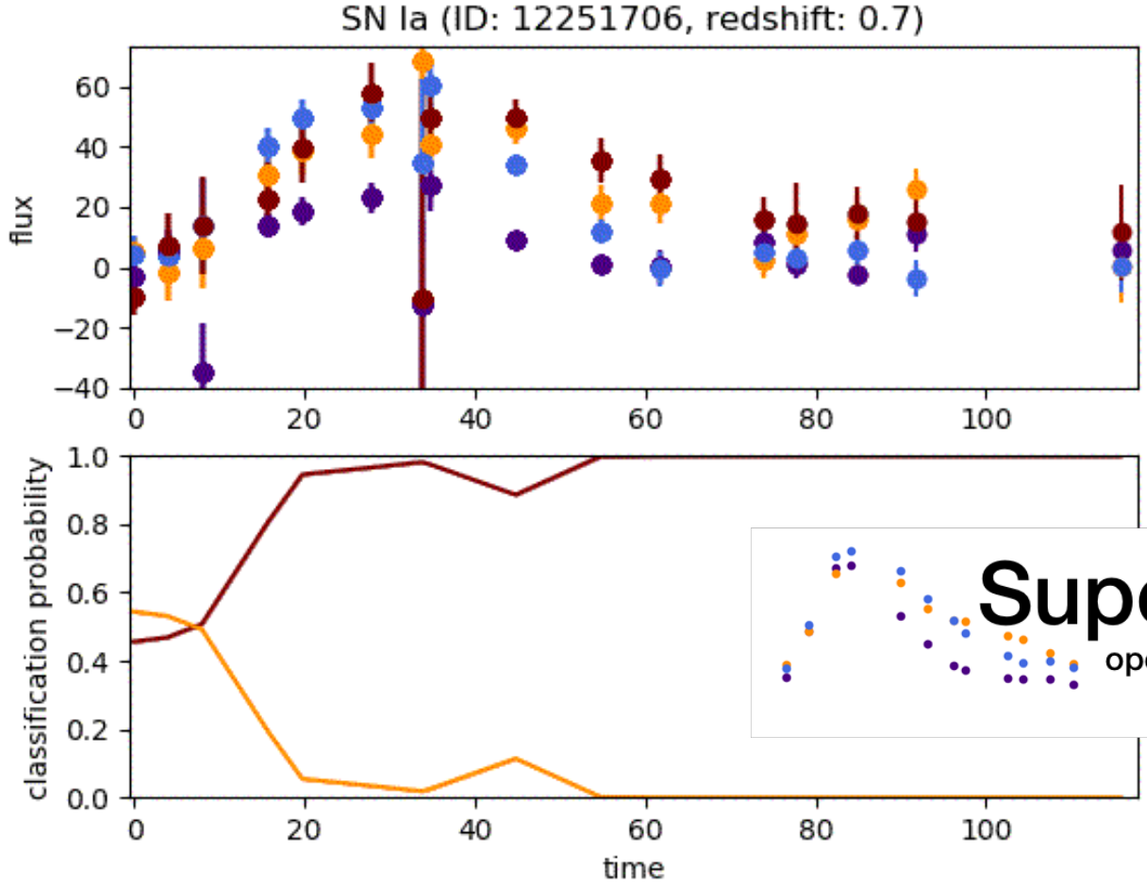

Accuracy Ia vs. Non Ia

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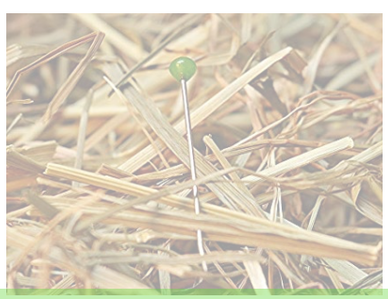

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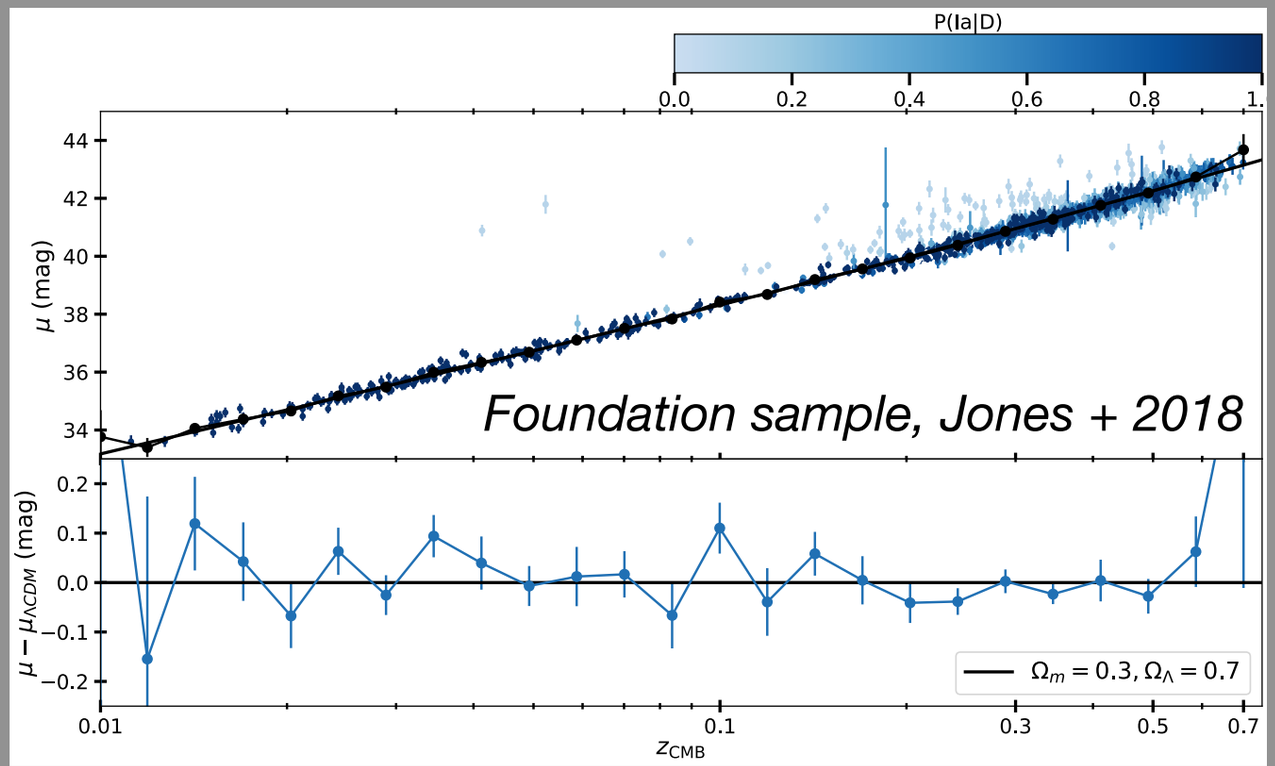
complete light-curve classification for cosmology



Dark Energy Survey 5-year analysis using SuperNNova (in prep)

Cosmology limitation:
Modelling core-collapse contamination

Current efforts include, Vincenzi + 2019, Hinton + 2018 (incl AM)

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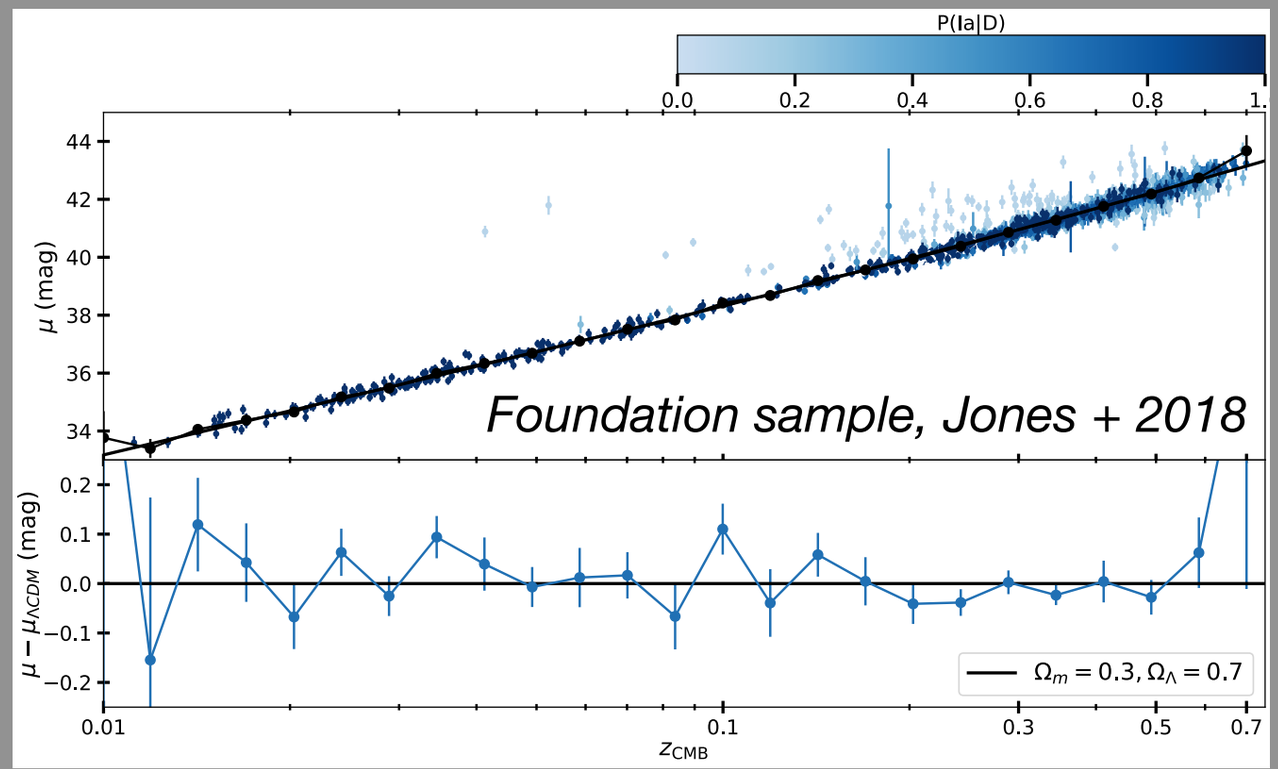
complete light-curve classification for cosmology



Dark Energy Survey 5-year analysis using SuperNNova (in prep)

✓ Photometric samples without need for spectroscopic SN follow-up

✓ More diverse samples over larger redshift range

Summary


Alert
Package
Alert
stream
FINK
Broker
alerts
Enabling science

Summary

- Vera Rubin Telescope will provide an unprecedented volume of optical data in the Southern Sky
- we must develop new methods for analysing this rich alert stream

Alert Package

Alert stream

FINK

Broker alerts

Enabling science

Summary

- LSST will provide an unprecedented volume of optical data in the Southern Sky
- we must develop new methods for analysing this rich alert stream

Alert Package

Alert stream

FINK

- in2p3 broker initiative for LSST alerts
- built on french expertise & new technologies

Broker alerts

Enabling science

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enabling SNIa cosmology

- ✓ Improving spectroscopic follow-up coordination
- ✓ Prioritization for spectrograph telescope time which is expensive/scarce
- ✓ Improving modelling of selection functions
- ✓ Improve our classification models with limited spectroscopic resources
- ✓ Photometric samples without need for spectroscopic SN follow-up
- ✓ More diverse samples over larger redshift range