



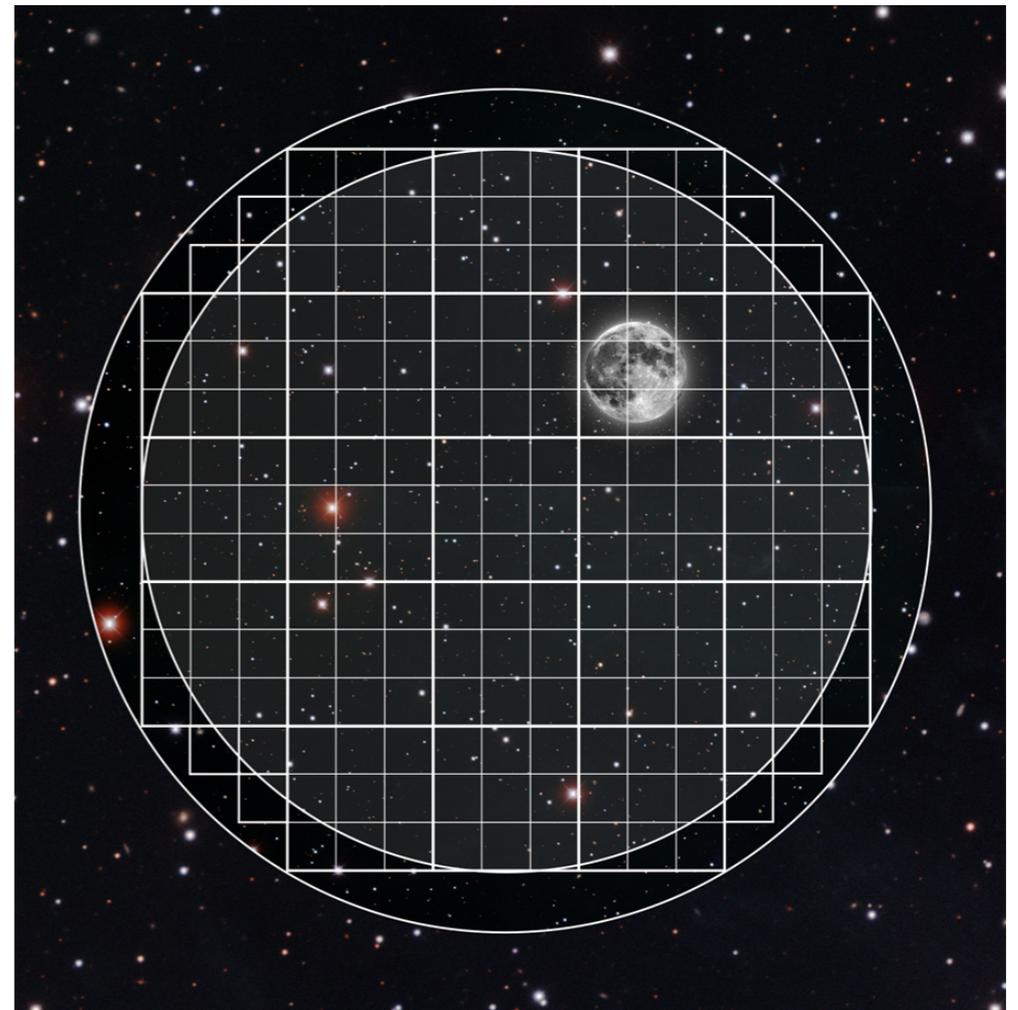
enabling time-domain
science with LSST



Anais Möller
for the Fink team



The Rubin Observatory Legacy Survey of Space and Time



in a nutshell:

- telescope: 6.7-m equivalent
- world's largest CCD camera: $3.2 * 10^9$ pixels

in numbers:

- 10-year survey, starting 2022
- 1,000 images/night = 15 TB/night



LSST + transients alerts



Now

Raw Data

Sequential 30s image, 20TB/night

60s

Prompt Data Product

Difference Image Analysis
Alerts: up to 10 million per night

Public data!

24h

Prompt Products DataBase

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

Year

Annual Data Release

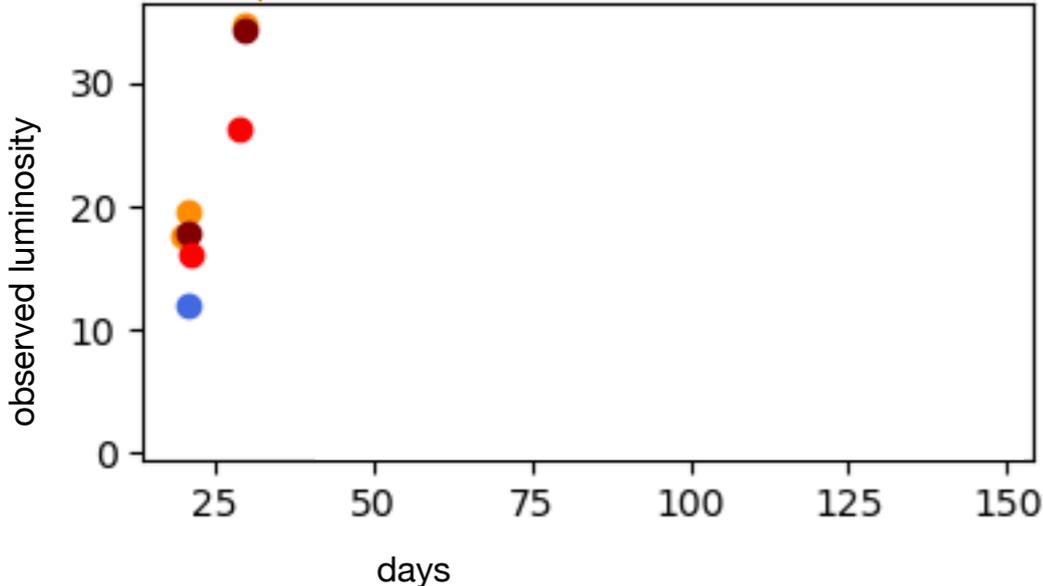
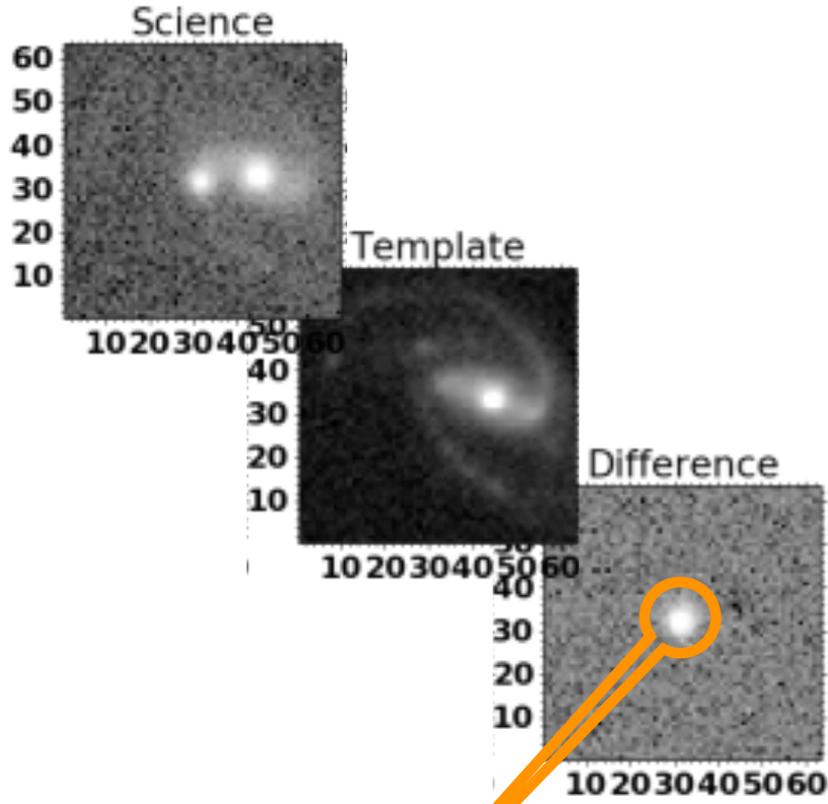
Accessible via the LSST Science Platform & LSST Data Access Centers.

End

Final 10yr Data Release

Images: 5.5 million x 3.2 Gpx
Catalog: 15PB, 37 billion objects

LSST + transients alerts

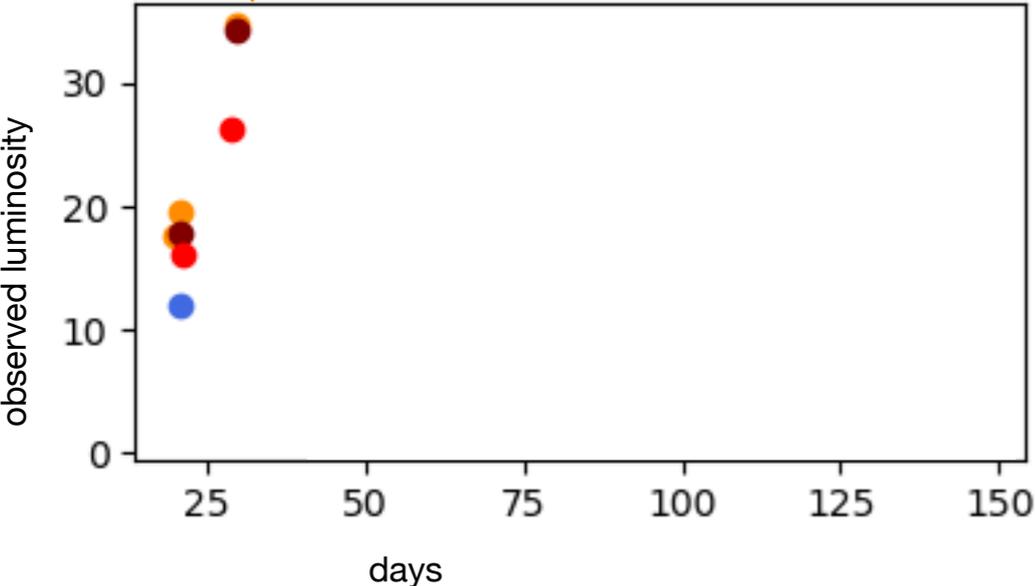
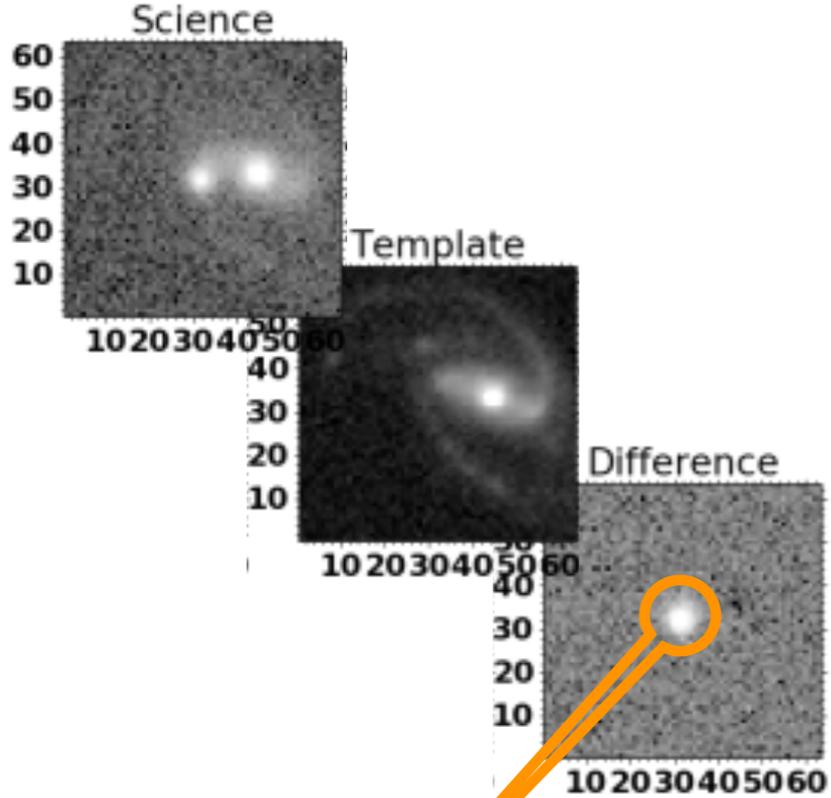


60s

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

Public data!

LSST + transients + dark energy



60s

Prompt Data Product

Difference Image Analysis

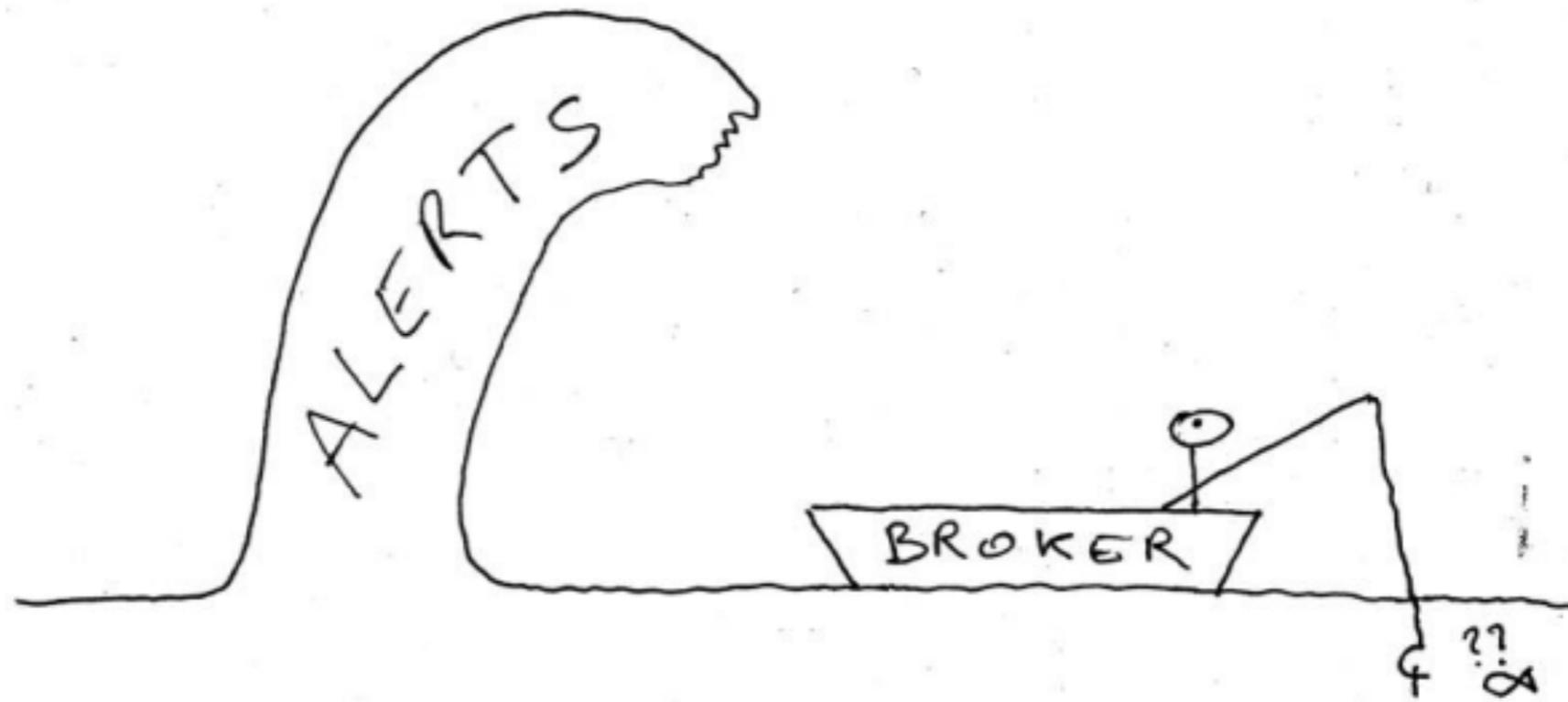
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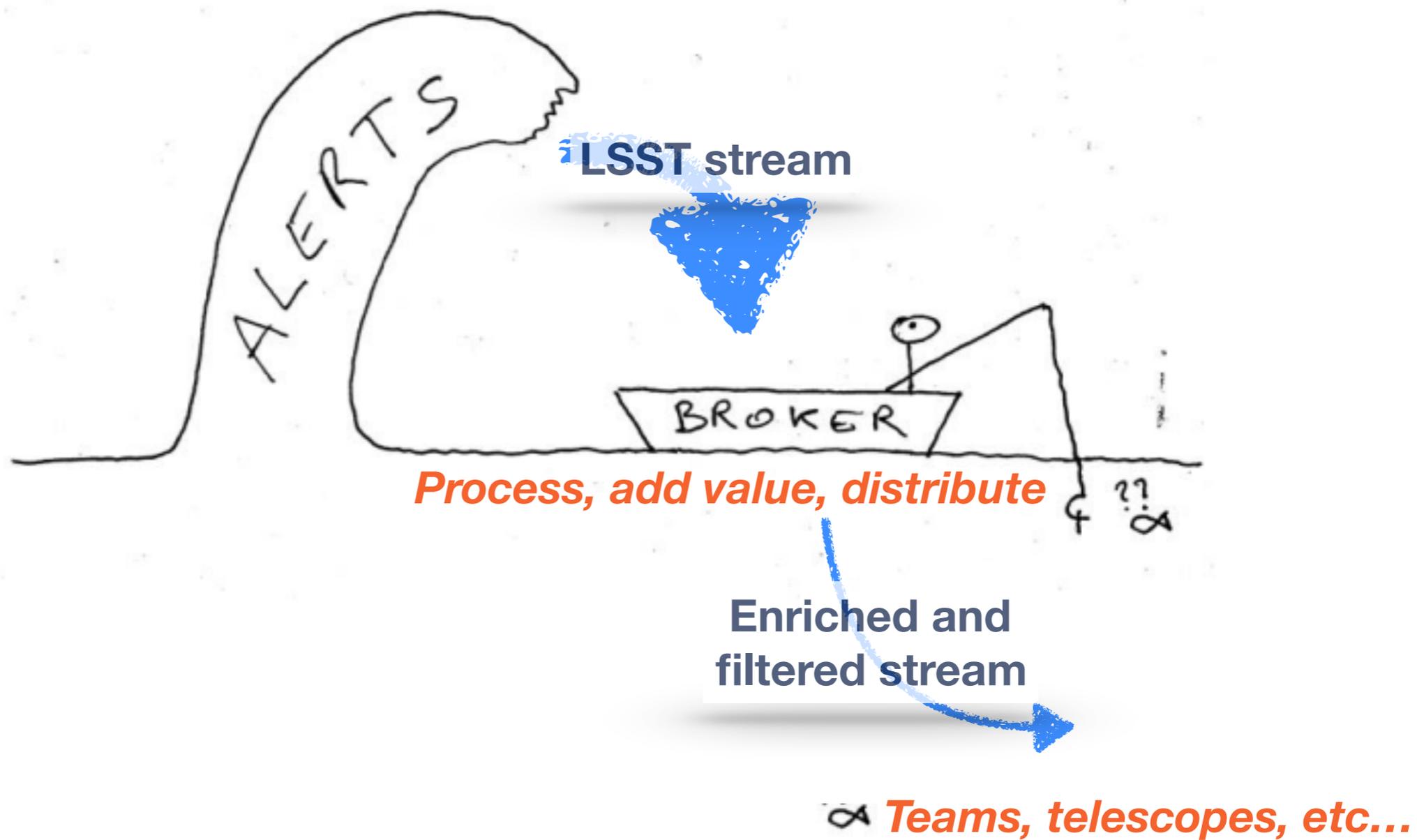
Public data!

Up to ~300,000 SNe Ia
for cosmology in a
decade!

(observing strategy dependent)

to constrain the
equation-of-state of
Dark Energy







FINK, a new generation of broker for the LSST community

Anais Möller¹★, Julien Peloton²†, Emille E. O. Ishida¹‡,
Chris Arnault², Etienne Bachelet³, Tristan Blaineau², Dominique Boutigny⁴,
Abhishek Chauhan⁵, Emmanuel Gangler¹, Fabio Hernandez⁶, Julius Hrivnac²,
Marco Leoni^{2,7}, Nicolas Leroy², Marc Moniez², Sacha Pateyron², Adrien Ramparison²,
Damien Turpin⁸, Réza Ansari², Tarek Allam Jr.^{9,10}, Armelle Bajat¹², Biswajit Biswas^{1,13},
Alexandre Boucaud¹⁴, Johan Bregeon¹⁵, Jean-Eric Campagne², Johann Cohen-Tanugi^{16,1},
Alexis Coleiro¹⁴, Damien Dornic¹⁷, Dominique Fouchez¹⁷, Olivier Godet¹⁸, Philippe Gris¹,
Sergey Karpov¹², Ada Nebot Gomez-Moran¹⁹, Jérémy Neveu²,
Stephane Plaszczyński², Volodymyr Savchenko²⁰, Natalie Webb¹⁸

20 different affiliations (13 in France, 7 abroad)

arXiv: 2009.10185





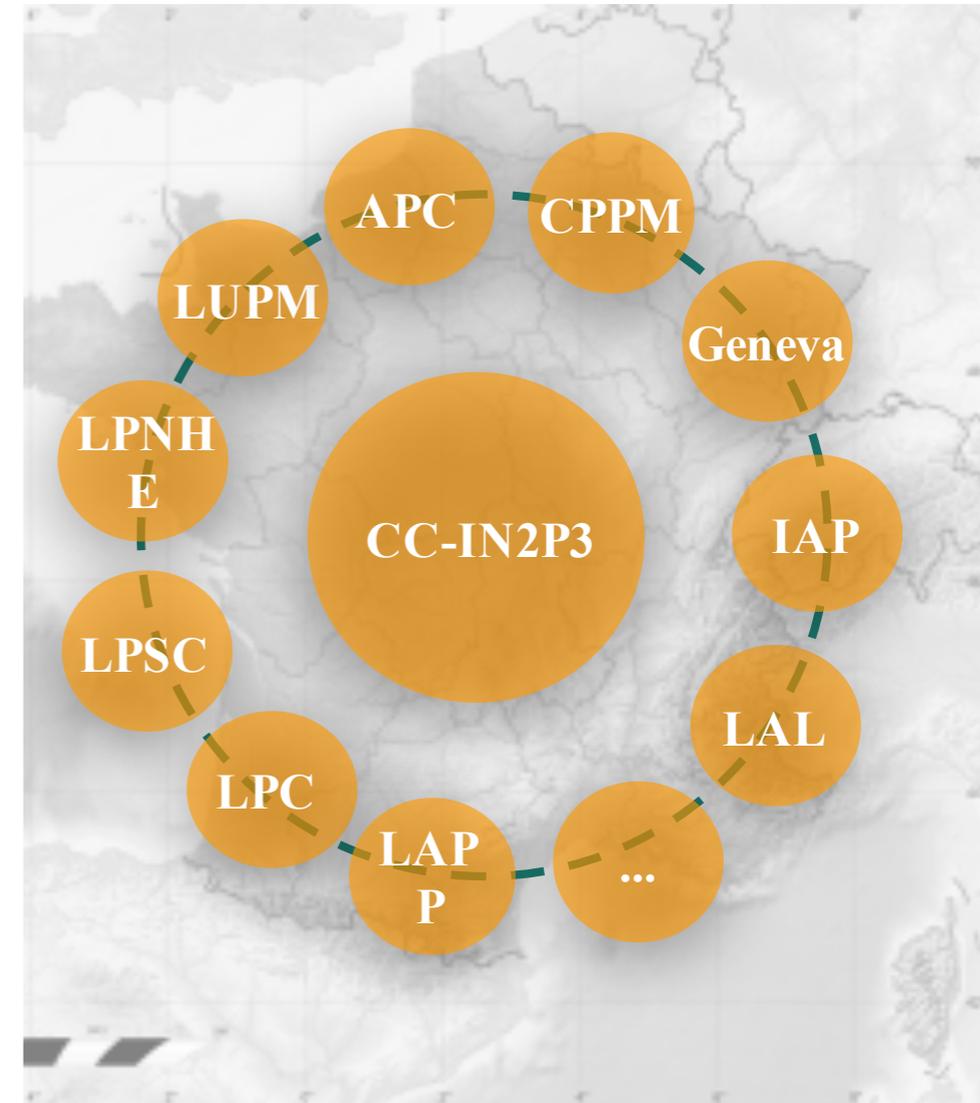
IN2P3 initiative to propose a broker to serve the need of LSST-France as well as the different french multi-messenger astronomy actors.

Our added values (+ std broker)

- **Science:** Supernovae, microlensing, anomaly detection, and multimessenger astronomy: GRB alerts, gamma ray, neutrinos, gravitational wave events,

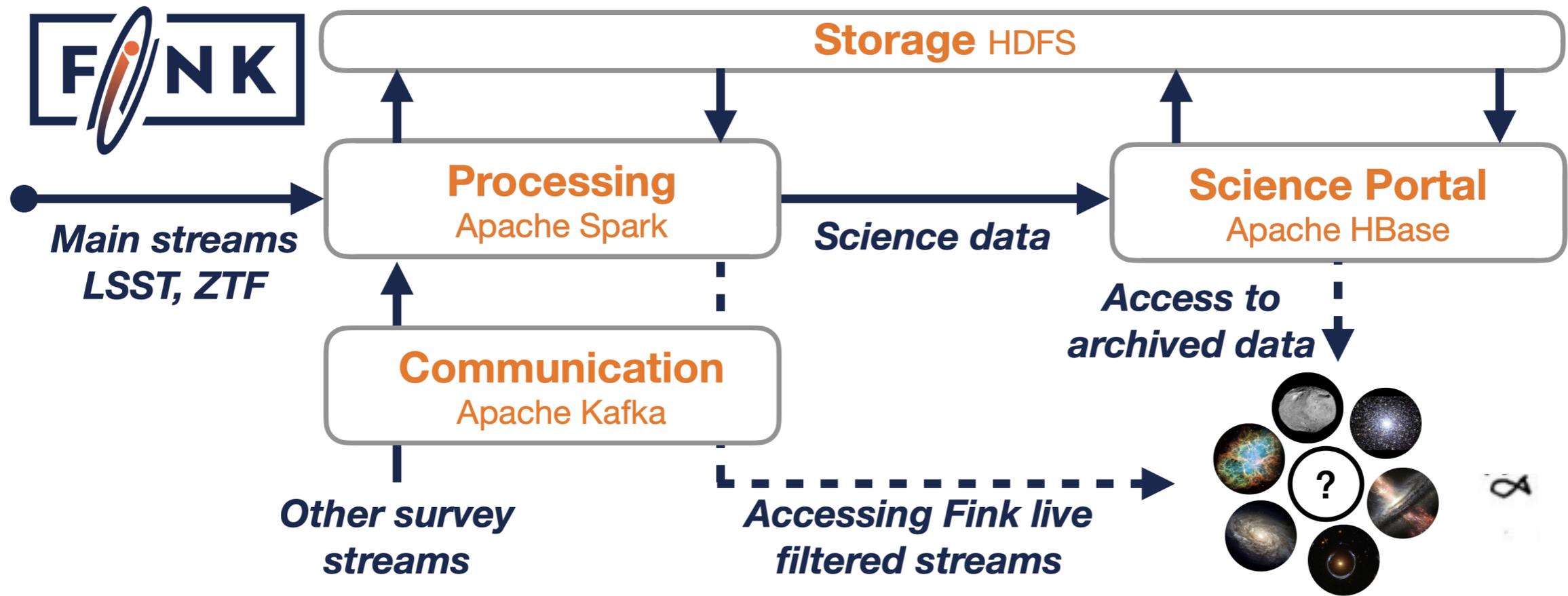
- **Methods:** Adaptive learning, Bayesian NN.

- **Technology:** big data, cloud.



Technology & infrastructure: J. Peloton (IJCLab)
Science & ML: E. Ishida, A. Möller (LPC)
+ 33 co-authors





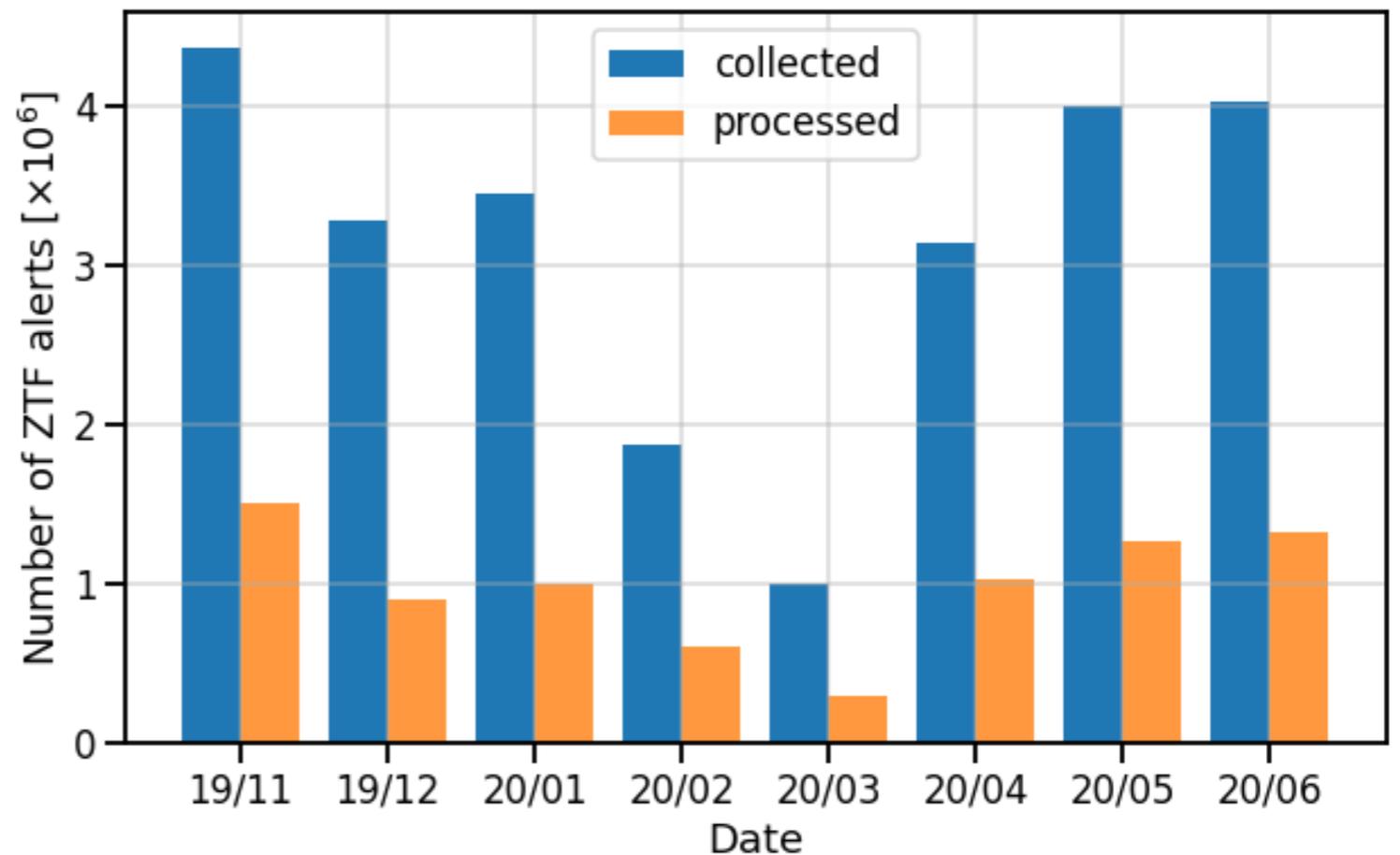
Big data & cloud technology
Diverse science goals & community





Deployment & science verification with ZTF

- MoU with Zwicky Transient Facility (ZTF), “pathfinder” for LSST.
- ~100,000 alerts per night (~10GB/night)



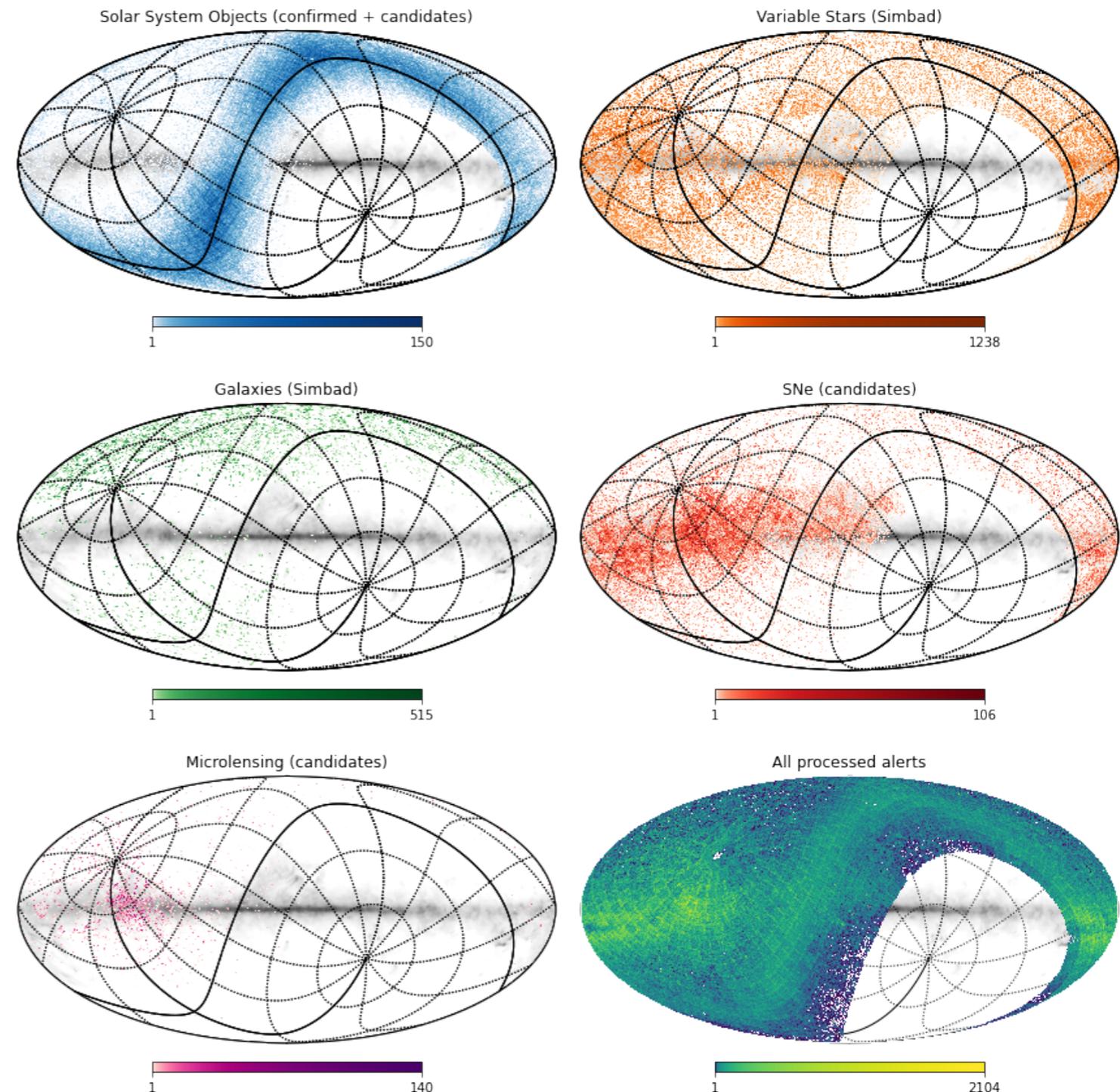


SV with ZTF

More than 30 million alerts collected from ZTF, and 8 million alerts processed in 1 year.

Cross-matching (e.g. with CDS xmatch service)

+
classification (machine learning based algorithms)



Supernovae & Fink



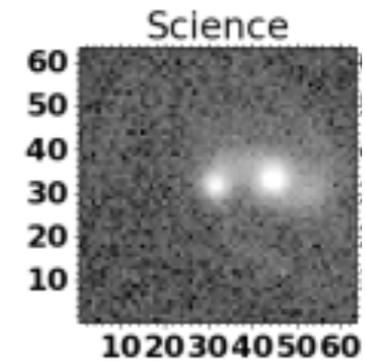
Supernovae & Fink

1. Select promising candidates for spectroscopic follow-up:



Supernovae & Fink

1. Select promising candidates for spectroscopic follow-up:
 - Identify known transients
 - Cross-matching: catalogues, alert services



Supernovae & Fink

- 1. Select promising candidates for spectroscopic follow-up:
 - Early classification

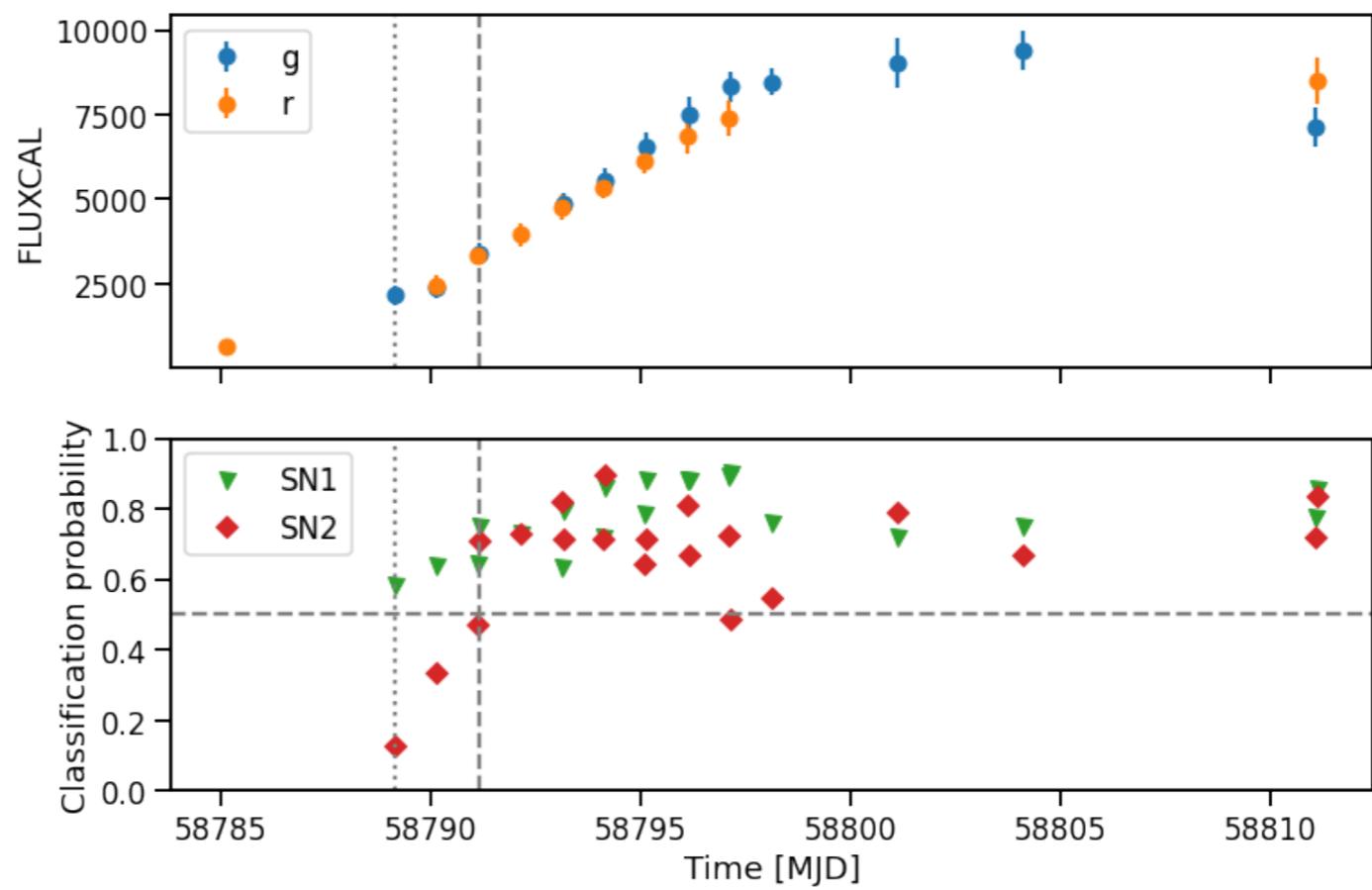
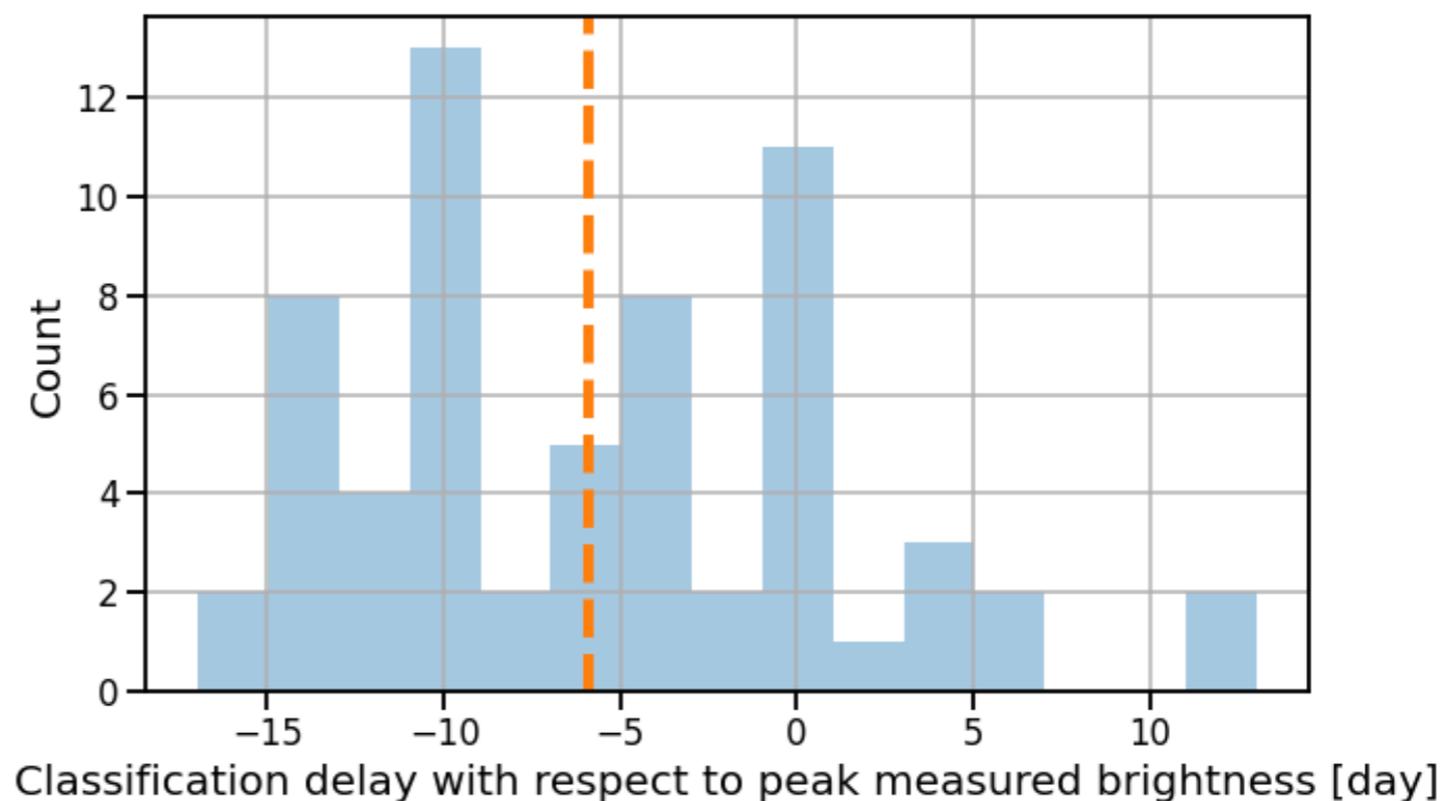


Figure 8. *Top:* Lightcurve of a supernova type Ia event classified by FINK (ZTF object ID: ZTF19acmdpyr, IAU Designation: SN 2019ugu). Blue circle markers and orange circle markers indicate

Supernovae & Fink

1. Select promising candidates for spectroscopic follow-up:
 - Early classification



ZTF alert stream November-December 2019

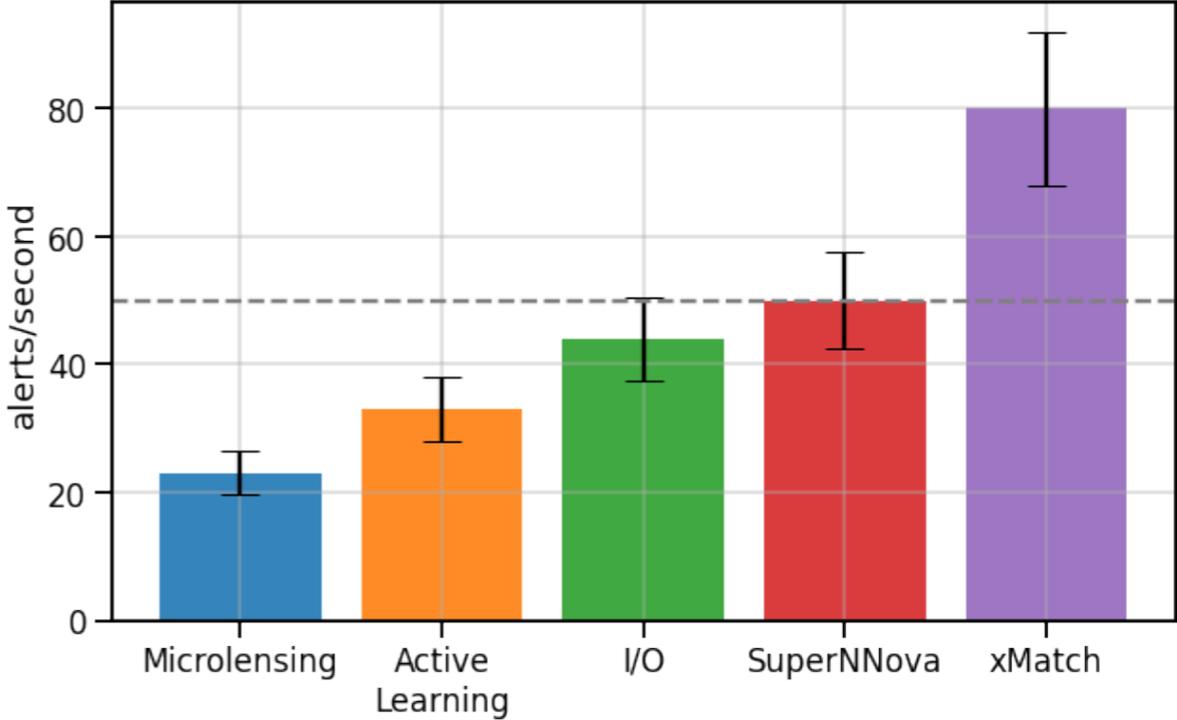


Supernovae & Fink

1. Select promising candidates for spectroscopic follow-up:
 - Reduce number of alerts swiftly

sample	# alerts	% alerts
quality cuts	2,417,284	100%
selection cuts	576,190	23.84%
SN1 > 0.5	365,228	15.11%
SN2 > 0.5	208,978	8.65%
SN1 > 0.6	308,822	12.78%
SN2 > 0.6	145,736	6.03 %

ZTF alert stream November-December 2019



Supernovae & Fink

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*Can be further reduced to achieve:
high-purity SNIa samples,
SNe Ia/galaxy properties*

ZTF alert stream November-December 2019

Supernovae & Fink

2. Improve training sets for photometric classification



Supernovae & Fink

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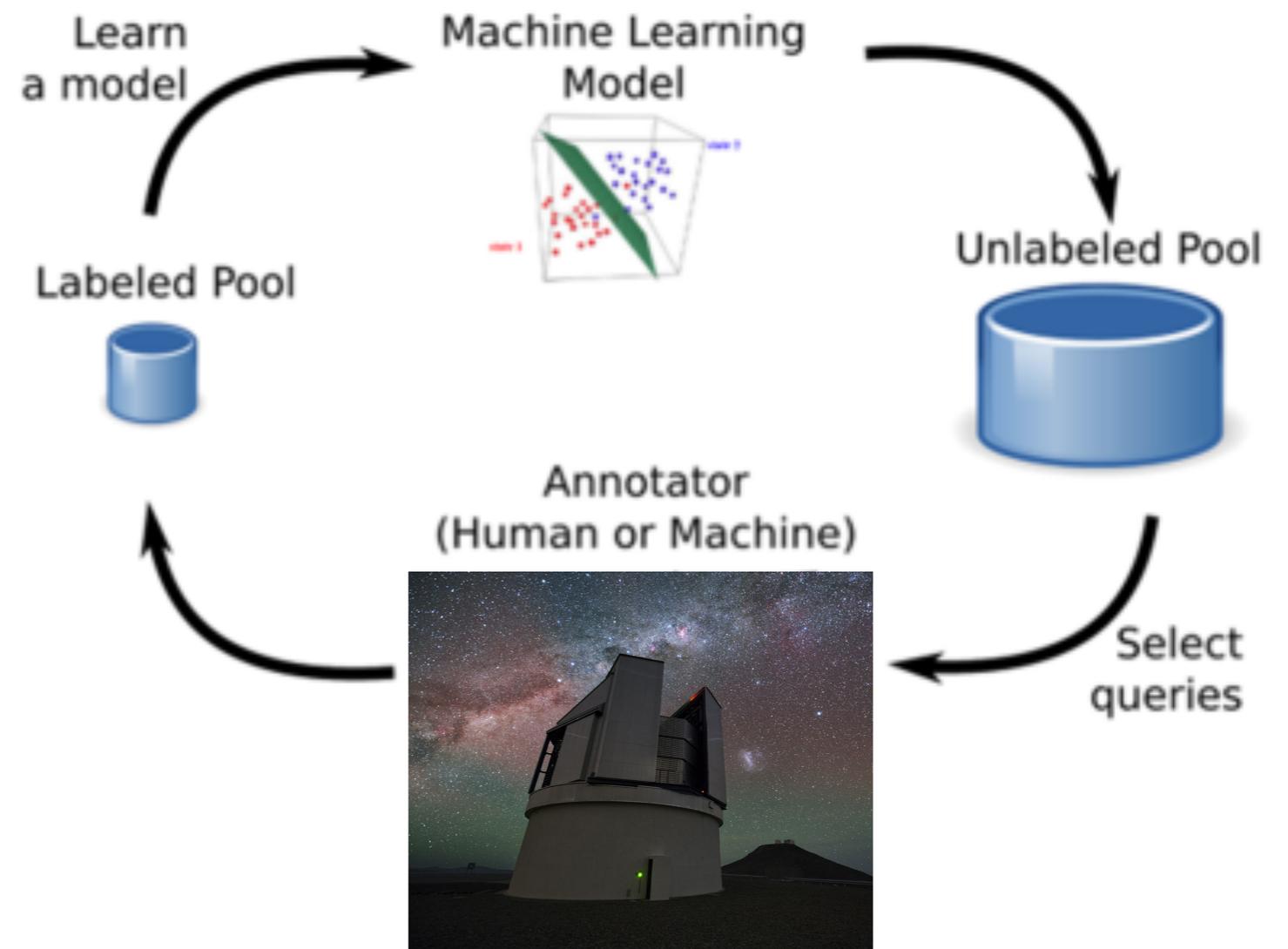
- Select SNe or transients not well characterised for follow-up



Supernovae & Fink

2. Improve training sets for photometric classification

- Active Learning approach

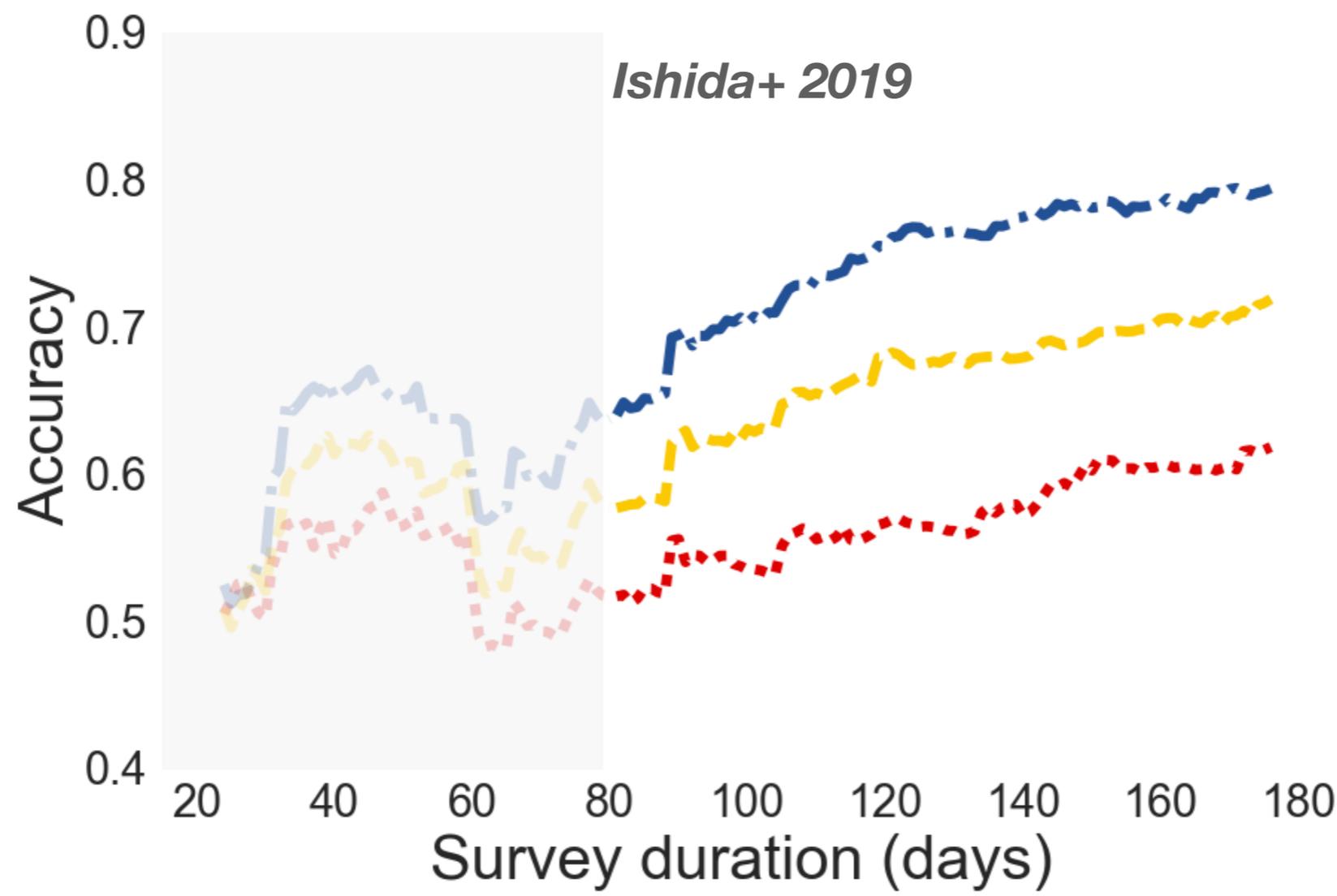


VISTA telescope Y. Beletsky (LCO)/ESO

Supernovae & Fink

2. Improve training sets for photometric classification

- Active Learning approach



Strategies: Canonical - - - Passive Learning - · - AL: Uncertainty sampling
Randomly drawn (canonical=similar to training distribution, passive=all possible)

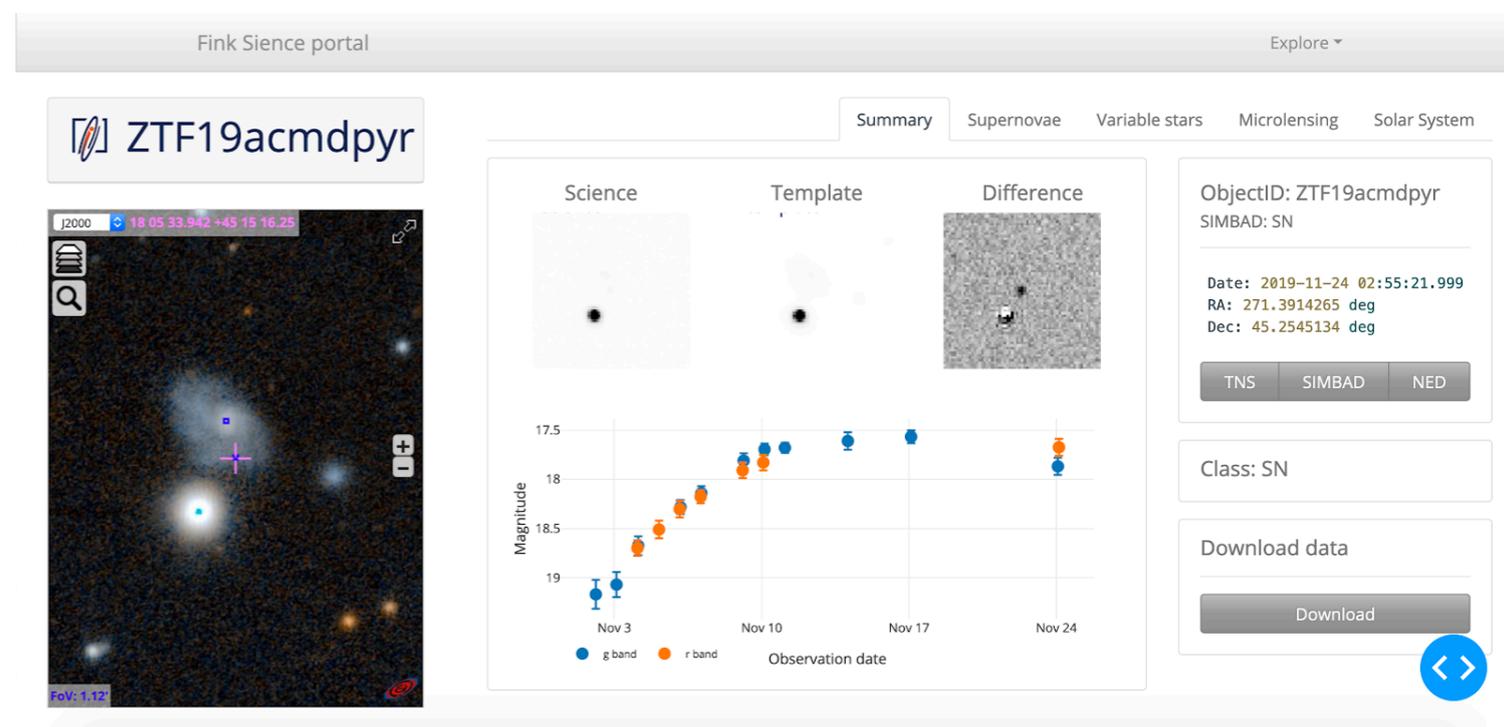
Supernovae & Fink

Already promising results with ZTF supernova selection.

Fink will be **crucial to select the SNe Ia in LSST** to constrain the cosmic expansion & Dark Energy equation-of-state.

- With and without spectroscopic follow-up
- Key for coordinating resources

Currently building the interface with teams and follow-up facilities





<https://fink-broker.org>

arXiv:2009.10185

Identifying interesting alerts is only part of the story: we need coordination with other facilities, follow-up resources and existing networks.

- Your expertise is important to us!
- Discussions and work with teams from: SVOM, GRANDMA, CTA, Integral, KM3NET, ...

We need you!

- Full broker proposal (end 2020).
- Join us! <https://fink-broker.org/joining.html>

