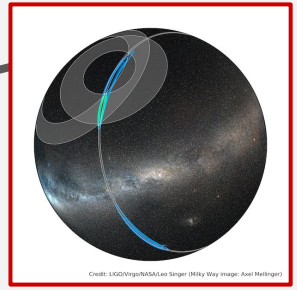
AMPEL

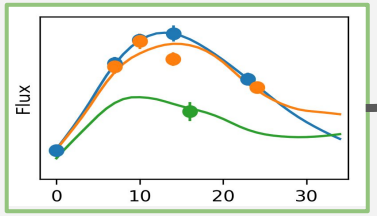
repeatable, `scalable`
modular
analysis of data streams

We did this already, right?

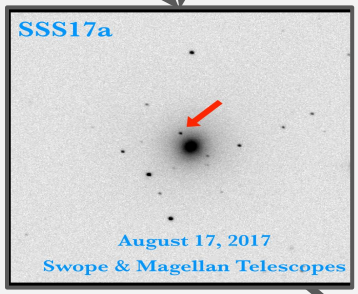
stream 2



stream 1



analysis



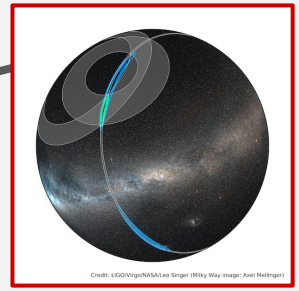
joint analysis

reaction

We did this already, right?

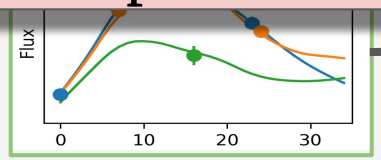
Larger rate

stream 2



ZTF

Theoretical expectations



analysis

Not as nearby

analysis

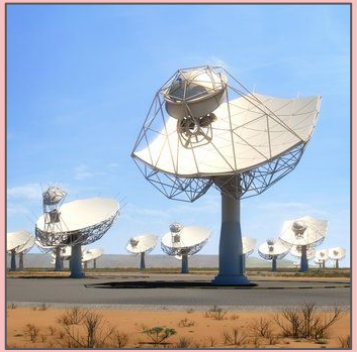
reaction

More selective

Changes seen across disciplines:

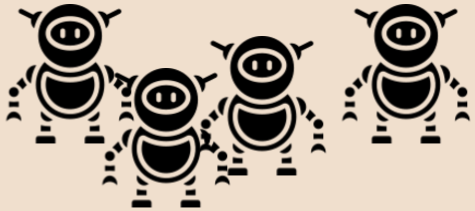
Volume

Rate explosion, detector area, connectivity, number of sensors.



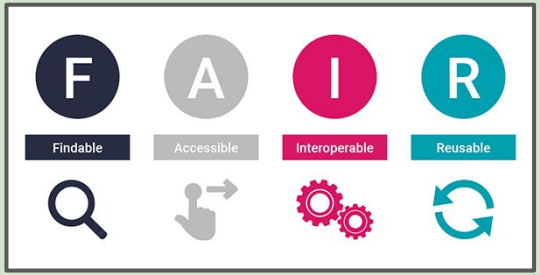
Analysis

More refined, big data, machine learning, real-time.



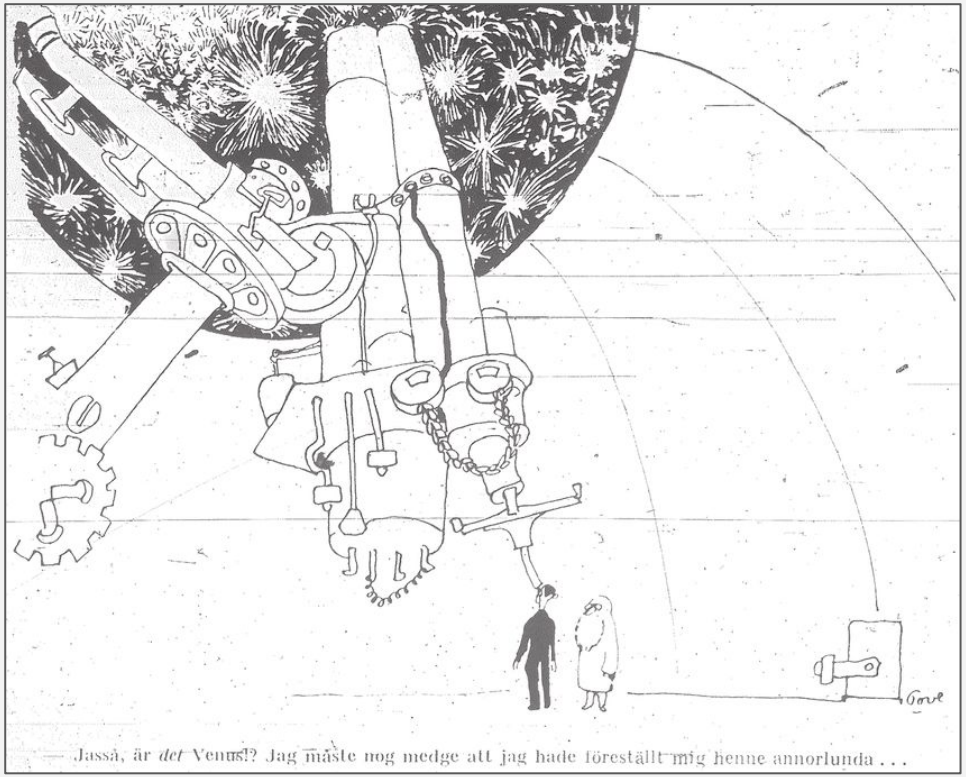
Provenance

Deduplication, FAIR, filtering, green power, irreversible data flows, one Universe.



The Scientific Process 2.0

Clone the scientist
or
scale creativity ?



Tove Jansson

Develop framework where:

- Scientists develop analysis modules using known tools and domain expertise.
- Workflows - connected analysis units - can be shared, reproduced, extended and referenced.
- Jobs can be scaled to process large data volumes.

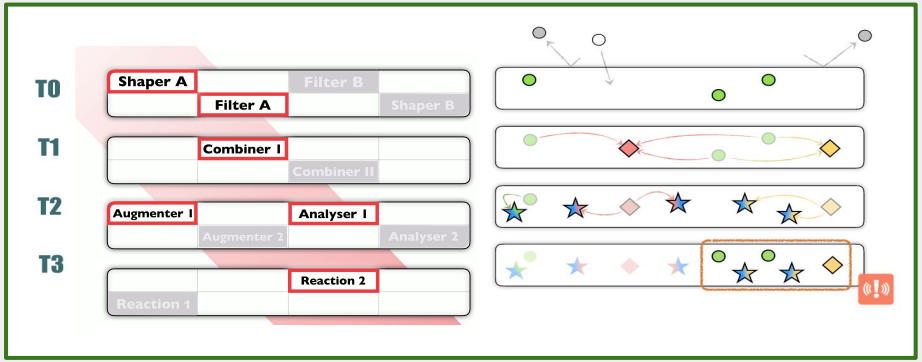
We call our version **AMPEL**
https://github.com/AmpelProject

(possibly for Alice in Modular and Provenance Enabled Land)

AMPEL x4:

2

Method for deconstructing time-domain analysis.



3

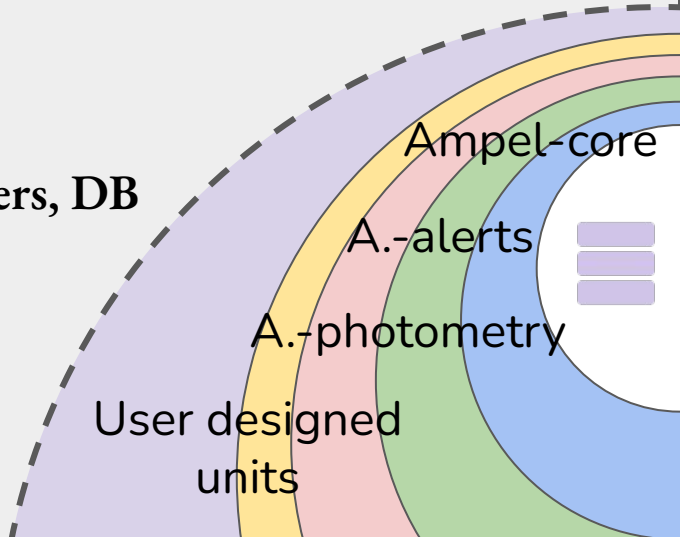
Ampel-interface

`ampel-interface` provides type-hinted abstract base classes for Ampel.

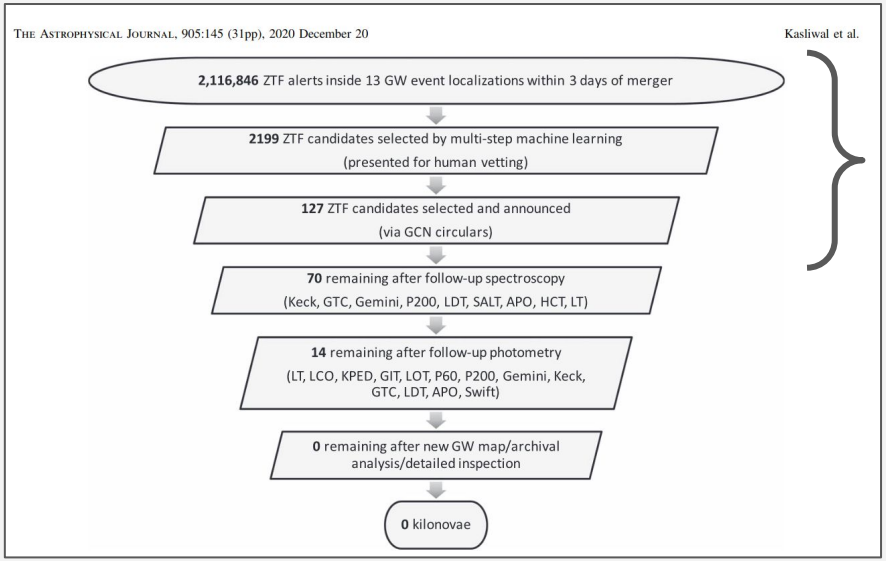
Interfaces between analysis units.

4

Execution tiers, DB and *workers*.

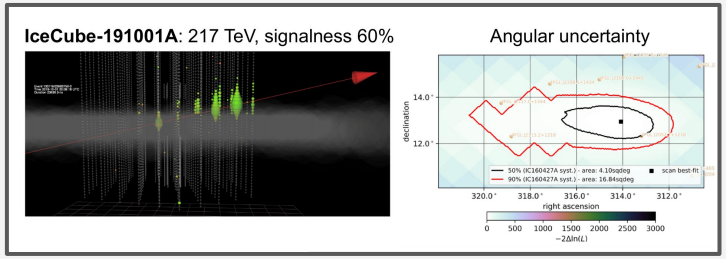


Rehearsal:
O3 ZTF KN search



Systematic, fast and flexible selection -> No KN.

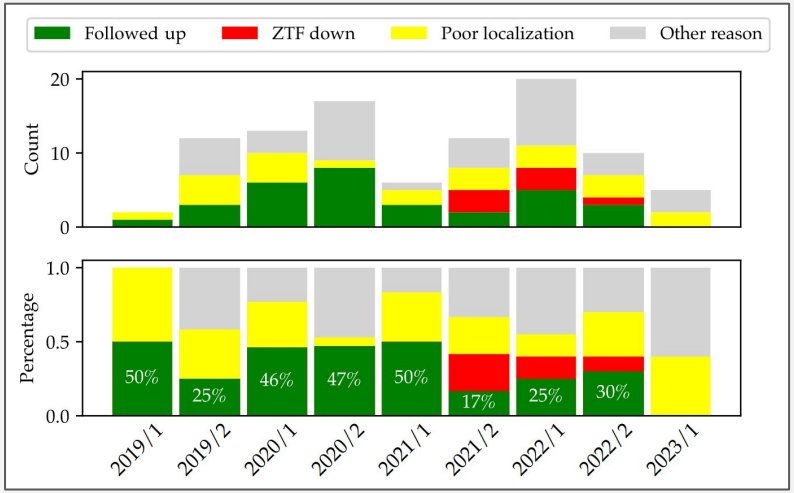
Dress rehearsal: Neutrino counterparts




```
TITLE:   GCN CIRCULAR
NUMBER:  29461
SUBJECT: IceCube-210210A: Two Candidate Counterparts from the Zwicky Transient Facility
DATE:    21/02/10 16:59:54 GMT
FROM:    Simeon Reusch at DESY  <simeon.reusch@desy.de>

Simeon Reusch (DESY), Sven Weimann (Ruhr University Bochum), Robert Stein (DESY), Micheal Coughlin (UMN) and Anna Franckowiak (DESY/Ruhr Uni

On behalf of the Zwicky Transient Facility (ZTF) and Global Relay of Observatories Watching Transients Happen (GROWTH) collaborations:

We observed the localization region of the neutrino event IceCube-210210A (Lagunas et. al, GCN 29454) with the Palomar 48-inch telescope, eq
square degree ZTF camera (Bellm et al. 2019, Graham et al. 2019). We started observations in the g- and r-band beginning at 2021-02-10 12:07
hours after event time. We covered 2.1 sq deg, corresponding to 78.6% of the reported localization region. This estimate accounts for chip g
300s with a typical depth of 21.0 mag.

The images were processed in real-time through the ZTF reduction and image subtraction pipelines at IPAC to search for potential counterpart
AMPEL (Nordin et al. 2019, Stein et al. 2020) was used to search the alerts database for candidates. We reject stellar sources (Tachibana an
moving objects, and apply machine learning algorithms (Mahabal et al. 2019). We are left with two high-significance transient candidates fro
lying within the 90.0% localization of the skymap.

+-------------------------------------------------------------------------+
| ZTF Name     | IAU Name   | RA (deg)    | DEC (deg)   | Filter | Mag   | MagErr |
+-------------------------------------------------------------------------+
| ZTF21aajxjrv | AT2021clu  | 206.9855020 | +05.3138660 | r      | 21.03 | 0.13   |
| ZTF21aajxjry | AT2021clv  | 207.3743696 | +04.9786236 | r      | 21.47 | 0.19   |
+-------------------------------------------------------------------------+

Both candidates are possible transients, with no prior detections, that have not yet been spectroscopically classified. Additional target-of
observations with ZTF are planned for 2021-02-11 as part of our neutrino follow-up program (Stein et al. 2020).

Based on observations obtained with the Samuel Oschin Telescope 48-inch and the 60-inch Telescope at the Palomar Observatory as part of the
Facility project. ZTF is supported by the National Science Foundation under Grant No. AST-2034437 and a collaboration including Caltech, IPA
Institute for Science, the Oskar Klein Center at Stockholm University, the University of Maryland, Deutsches Elektronen-Synchrotron and Humb
TANGO Consortium of Taiwan, the University of Wisconsin at Milwaukee, Trinity College Dublin, Lawrence Livermore National Laboratories, and
Operations are conducted by COO, IPAC, and UW.
GROWTH acknowledges generous support of the NSF under PIRE Grant No 1545949.
Alert distribution service provided by DIRAC@UW (Patterson et al. 2019).
Alert database searches are done by AMPEL (Nordin et al. 2019).
Alert filtering is performed with the AMPEL Follow-up Pipeline (Stein et al. 2020).
```

Dress rehearsal: Neutrino counterparts

Systematic follow-up…



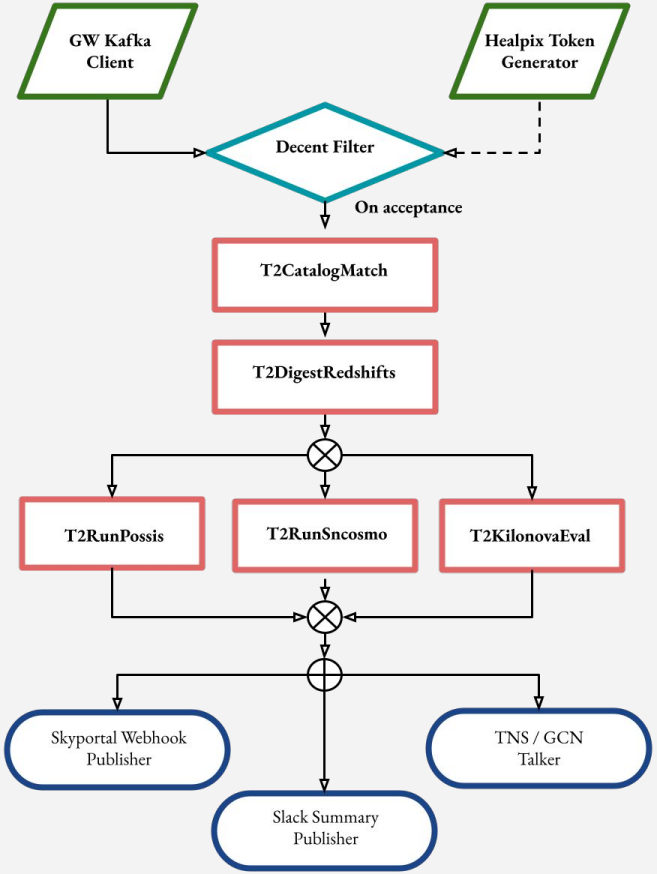
S. Reusch

… with surprises.

AMPEL in O4

AMPEL in O4

Workflow detailing LVK / ZTF crossmatch

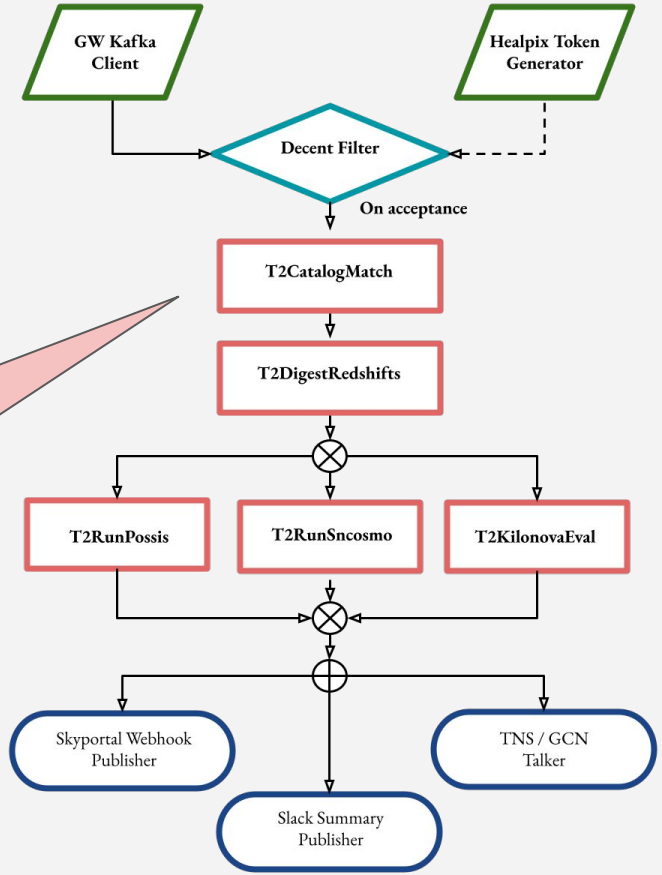


AMPEL in O4

Workflow detailing LVK / ZTF crossmatch

Each unit is a public python module:

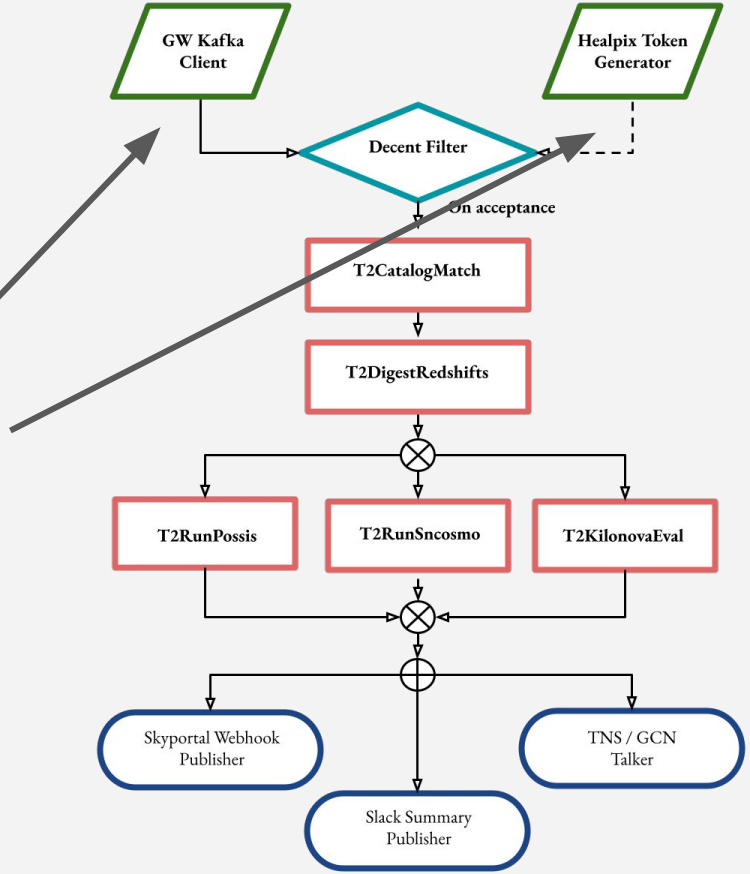
https://github.com/AmpelAstro/Ampel-ZTF/blob/master/ampel/ztf/t2/T2CatalogMatch.py



AMPEL in O4

Workflow detailing LVK / ZTF crossmatch

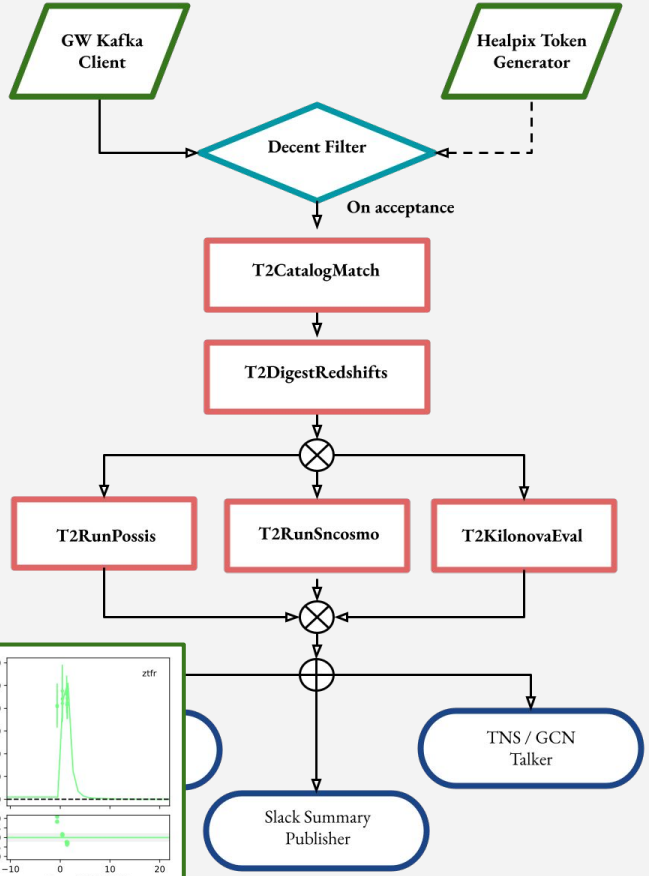
Identical structure for autonomous alert reaction, simulation studies and archive runs.



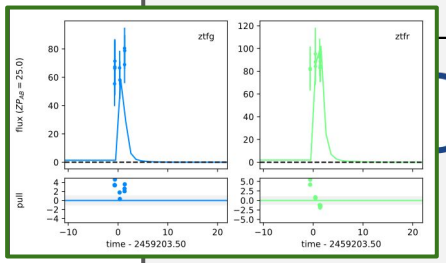
AMPEL in O4

Workflow detailing LVK / ZTF crossmatch

Consistent use of theoretical models



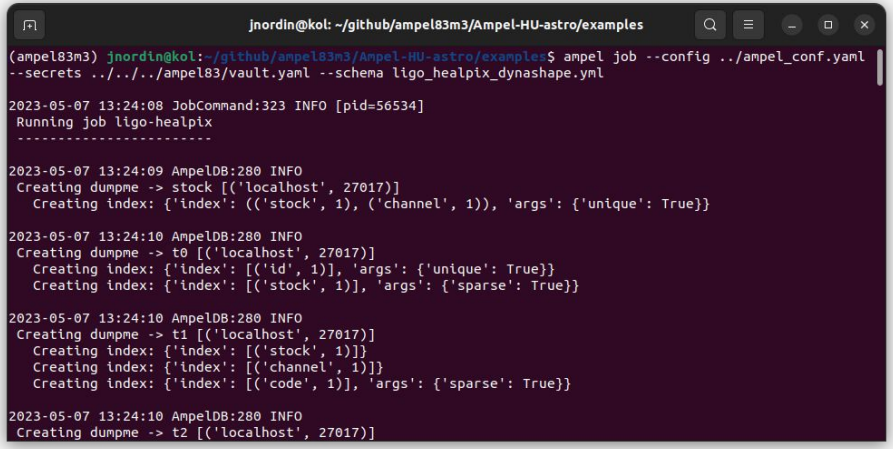

```python
class T2RunPossis(T2RunSncosmo):
    """
    Load a POSSIS kilnova model and fit to a LightCurve object as process is called.

    Load one of the POSSIS models and create an sncosmo_model
    model for fit by T2RunSncosmo.
    :param possis_base_url: str, path to (github) possis repository
    :param model_gen: str, name of model generation (subfolder)
    :mej_dyn: float, Possis parameter
    :mej_wind: float, Possis parameter
    :phi: int, Possis parameter
    :cos_theta: float, Possis parameter

    Dynamically fix model explosion time
    :param explosion_time_jd: Union[None, float, Literal['StockTriggerTime']]


    """
```

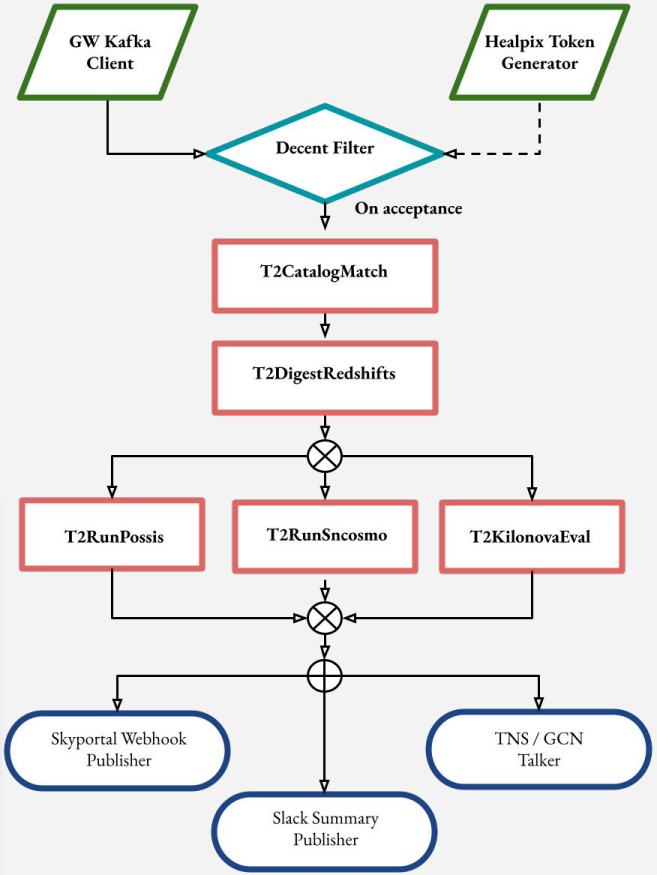


AMPEL in O4

Workflow detailing LVK / ZTF crossmatch

Reproduce locally, scale at CS, co-develop and publish.

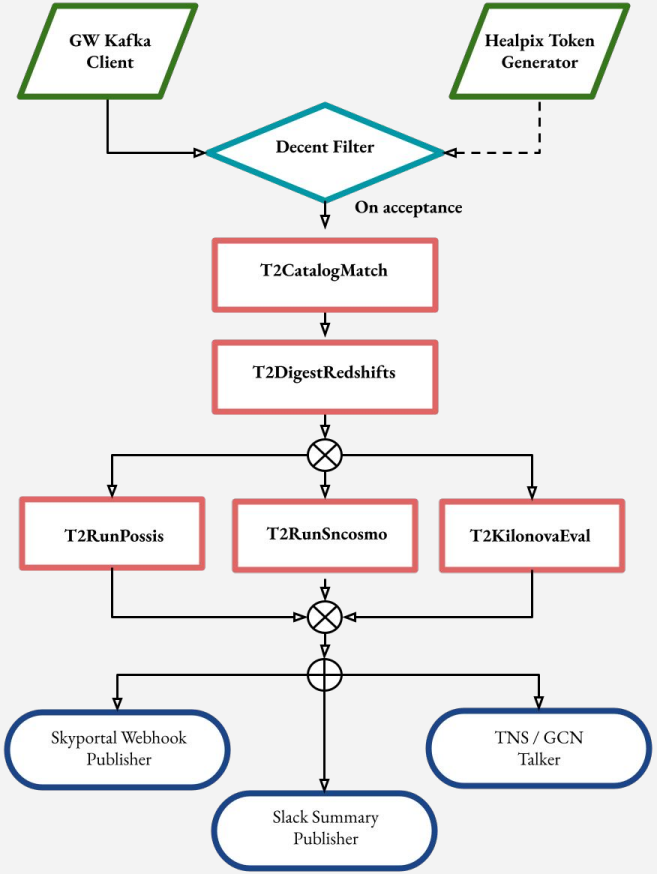




AMPEL in O4

Workflow detailing LVK / ZTF crossmatch

Full configuration at:
https://github.com/AmpelAstro/Ampel-HU-astro/blob/gwO4/examples/ligo_healpix_dynashape.yml

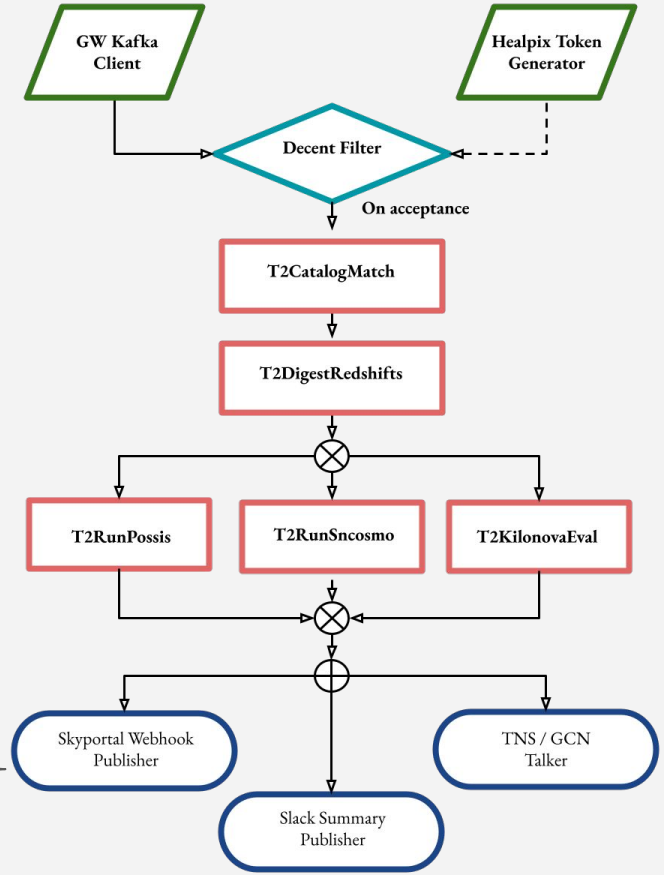


AMPEL in O4

Workflow detailing LVK / ZTF crossmatch

```python
class DevSkyportalWebhookPublisher(AbsPhotoT3Unit):
    """

    Dev unit for assembling information for publishing to the Skyportal
    webhook endpoint.

    We assume that there is a direct mapping between a t2unit config running

    See:
    https://skyportal.io/docs/analysis.html#external-analysis-services
    https://github.com/skyportal/skyportal/pull/3918

    Expected format (Feb 17)
    params={
        "show_parameters": True,     # What does this do?
        "analysis": {
                "plots": ...,
                "inference_data": ...,
                "results": {
                        "format": "json",
```

Publish results:
“Kilonovaness”
combined score



AMPEL in O4

Of interest if:

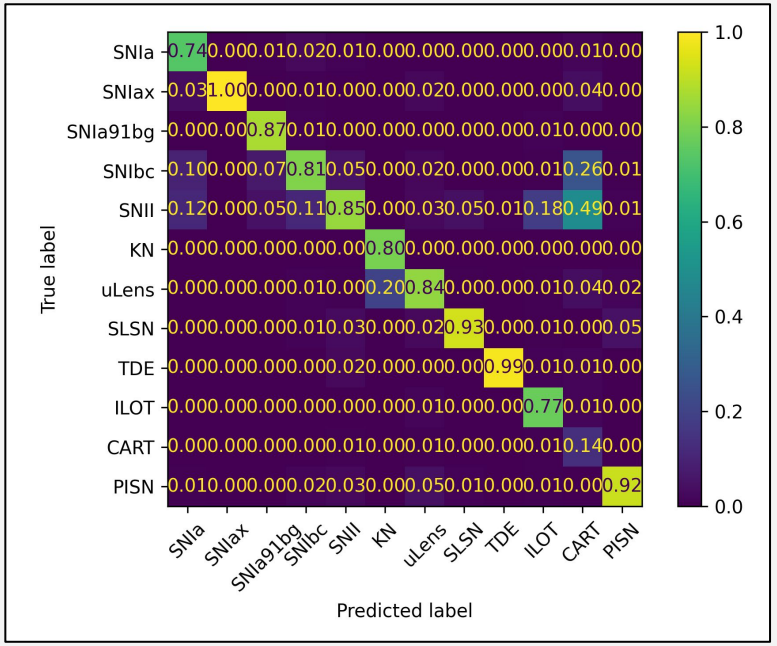
- You see GCN / Skyportal /Slack note with something like “AMPEL kilonovaness” on it.
- You wonder whether an analysis can be reproduced, or what a certain selection algorithm would have yielded for previous alerts?
- There are new and better counterpart models to use.
- Better ideas? Take job file and improve it.
- Systematically process all skymaps (any FAR, origin) .
- Rule out/confirm models.

Lessons from LSST

Working with VRO/LSST will be *hard*.

DESC-created ELAsTiCC data challenge showed AMPEL classification schema to work better than expected.

Time-domain challenging, but possible with significant preparation.



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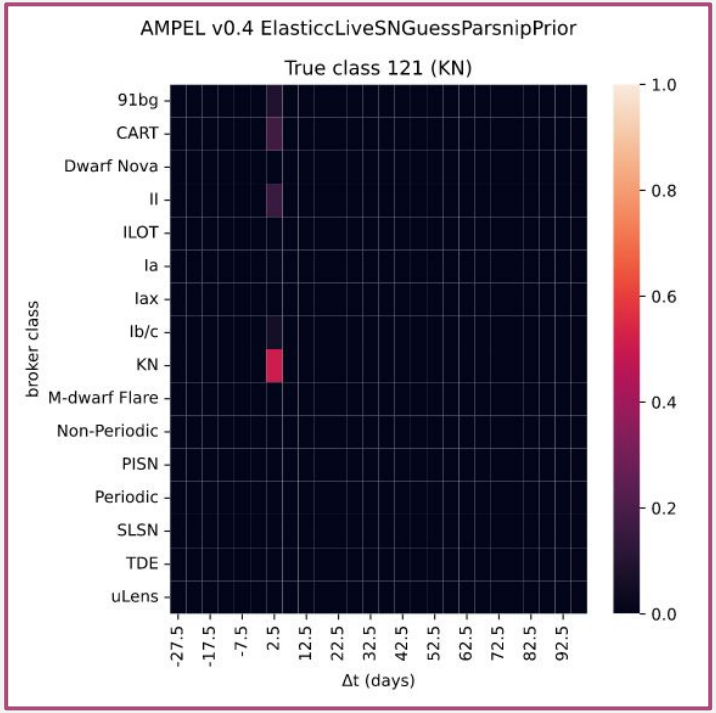

DESC external verification.

Questions for O4(b):

What if we confirm no/few counterparts?

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Either:
- Too rare / too faint to be detected?

Or:
- They will be detected (often?!) but can not systematically be followed and confirmed.

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Or:
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Enter a statistical domain where many NSBH/NSNS-KN models need to be compared with large transient samples with precise background estimates.

Questions for O4(b):

Observers: Should we at some point focus more on providing extensive, wide-field multi-band photometry rather than hunting spectroscopic confirmation of nearby objects?

Theorists: How much are the KN models biased by 170817?

A new work methodology

Inverted work order - cost up front:

1. Retrieve data
2. Run analysis software
3. Evaluate result

3. Define project goals
2. Develop and push software
1. Connect to data streams

How to run AMPEL:

Create a python 3.10 environment w. poetry and:

- `git clone https://github.com/AmpelProject/Ampel-HU-astro.git`
- `cd Ampel-HU-astro/`
- `poetry install -E "ztf sncosmo extcats notebook"`

Allows to run demo notebooks

- `cd notebooks`
- `poetry run jupyter notebook`

Summary & Take-away

- Tools such as AMPEL will be necessary to use all the data
  - Especially once we start working with “probable” KNe
- If you see results of the AMPEL O4 workflows and kilonovaness scores you know where it came from (and how to reproduce it)
- Improve it further (input streams, new models, better logic…)

Work of a lot of people:
Valery Brinnel, Jakob van Santen
Andrea Ernst, Matteo Giomi, Simeon Reusch, Robert Stein…