# Neutrino follow-up summary

ZTF October Collaboration Meeting
21 Oct 2020 // Simeon Reusch

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**with help from our friends at GROWTH!**

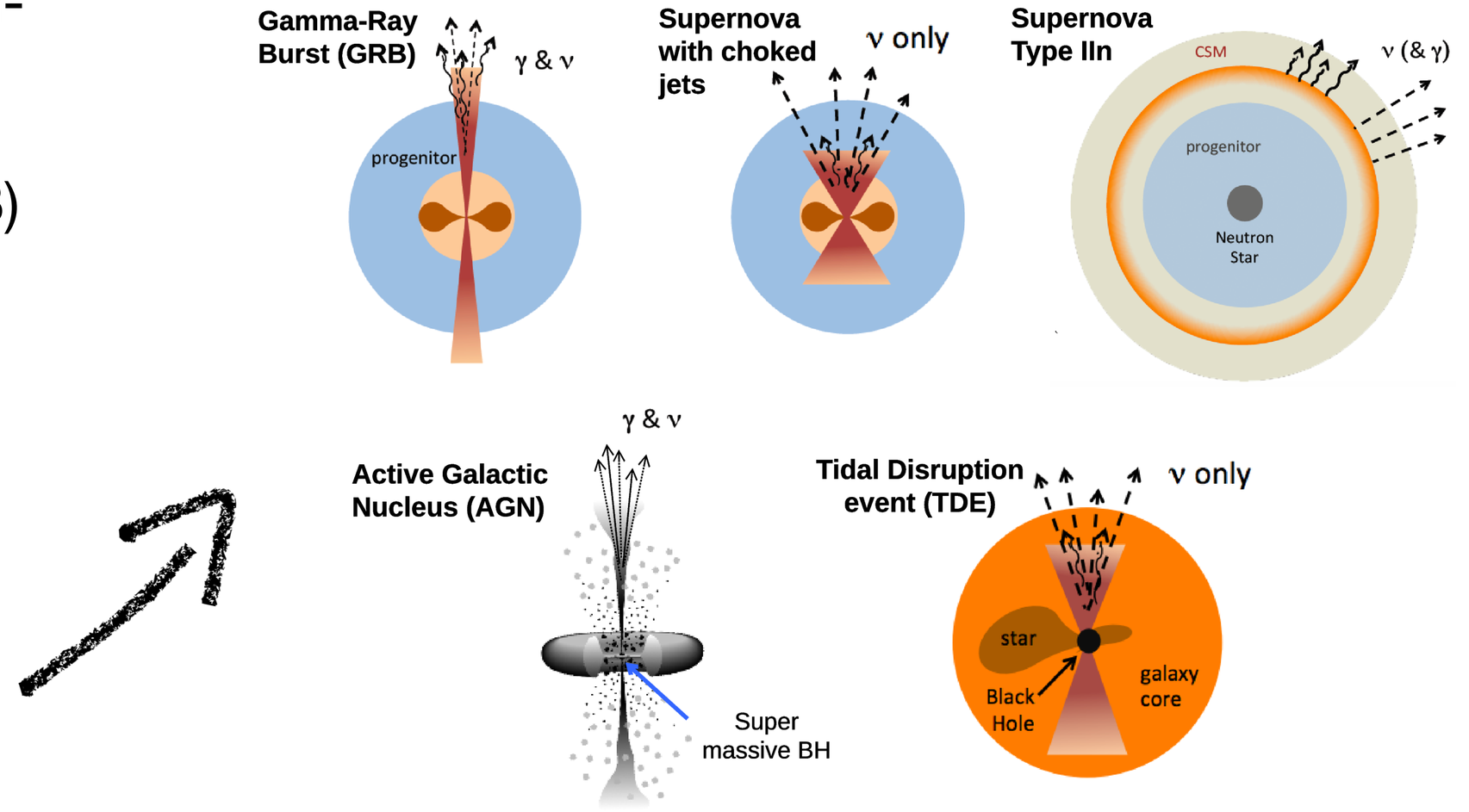
DESY.

HUMBOLDT-UNIVERSITÄT ZU BERLIN

IceCube
South Pole Neutrino Observatory

# Neutrinos as messengers

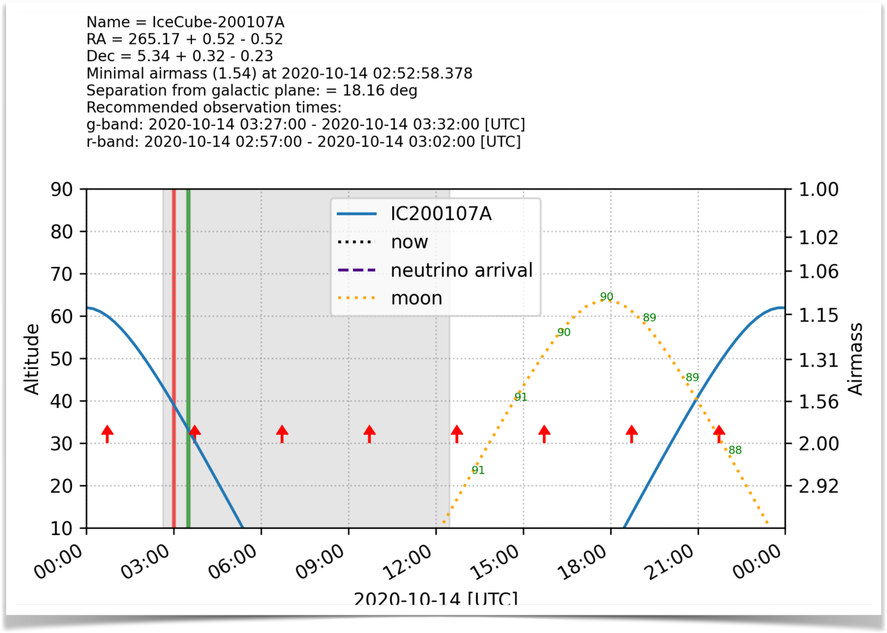
- Cosmogenic high-energy neutrino flux first detected by IceCube (2013)
- First compelling source: Gamma-ray blazar TXS 0506+056 (2017)
- At least 70% of flux: unknown origin



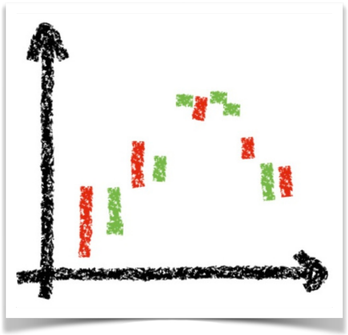
# Pipeline

IceCube @
South Pole

Slack alert




Observability check



Forced phot

AMPEL filtering

ZTF obs

# Follow-up during ZTF Phase I

- Operating since May 2019
- 15 follow-ups (39% of all 38 IceCube alerts)
- 19 GCNs/ATels issued
- Covered 119 of 137 sq. deg. total 90% uncertainty area (87%)
- 2 TDEs identified as source candidates (stay tuned)
- numerous candidates ruled out
- acquired spectroscopic resources (NOT, GTC)

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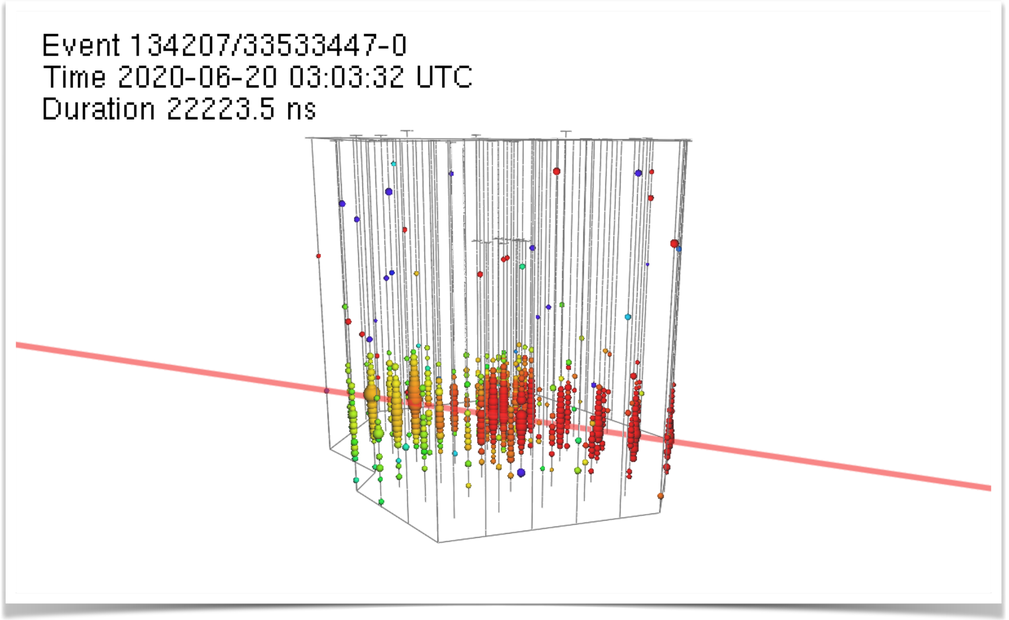
TLDR: First deep and systematic optical follow-up campaign targeting all 5 science cases. 15 campaigns done, already identified 2 probable sources in 3 years

# Follow-up since Berlin meeting

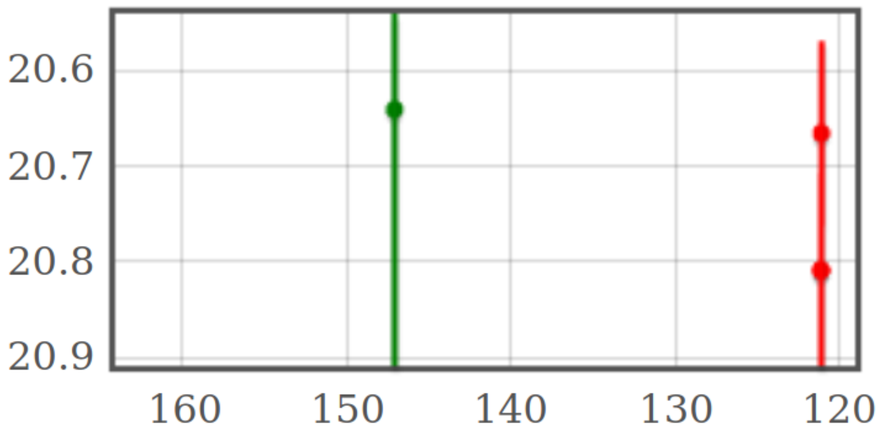
| Neutrino name | GCNed Candidates | p_astro | 90% area (sq. deg.) | Notes |
|---|---|---|---|---|
| **IC200512A** | None | 32 % | 9.4 | Close to gal. plane |
| **IC200530A** | 3 | 59 % | 22.2 | |
| **IC200620A** | 1 | 32 % | 1.2 | |
| **IC200916A** | 2 | 32 % | 3.6 | |
| **IC200926A** | None | 44 % | 1.5 | Close to gal. plane |
| **IC200929A** | None | 47 % | 1.0 | |
| **IC201007A** | None | 88 % | 0.6 | |
| **IC201021A** | ?  | 30 % | 5.5 | |

# IC200620A

- detection: June 20, 2020, 03:03 UT
- energy estimate: 113 TeV
- 32 % probability of being of astrophysical origin
- 90% region: 1.2 square deg

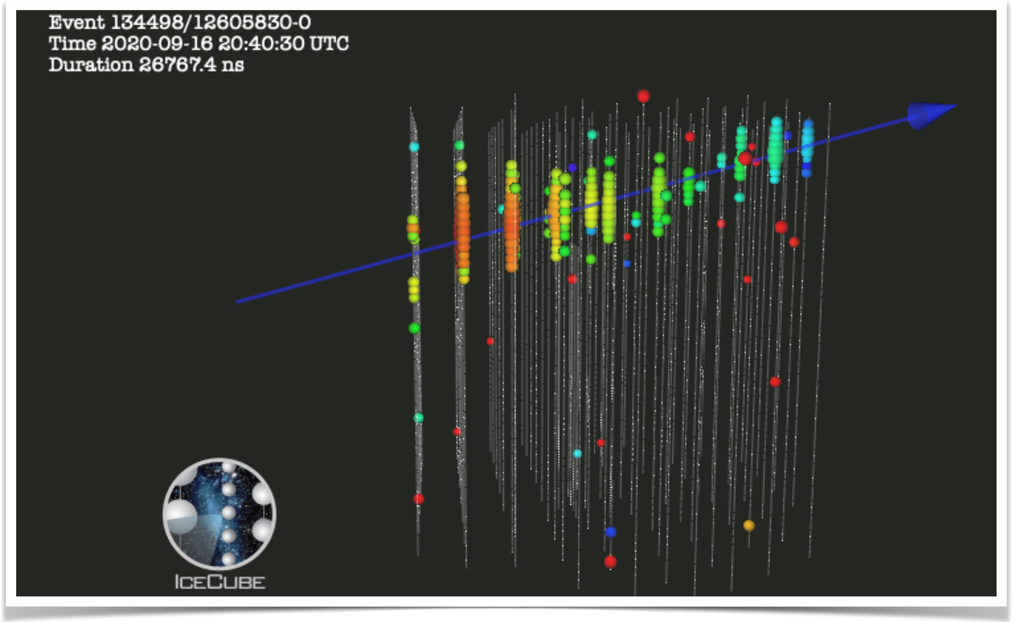



**1 candidate:**
**ZTF20abgvabi**



# IC200916A

- detection: September 20, 2020, 20:40 UT
- energy estimate: 110 TeV
- 32 % probability of being of astrophysical origin
- 90% region: 3.6 square deg

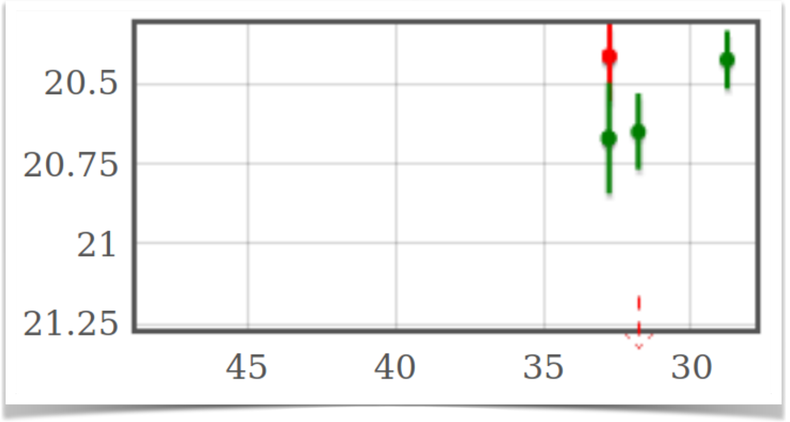



**2 candidates:**

SN Ia

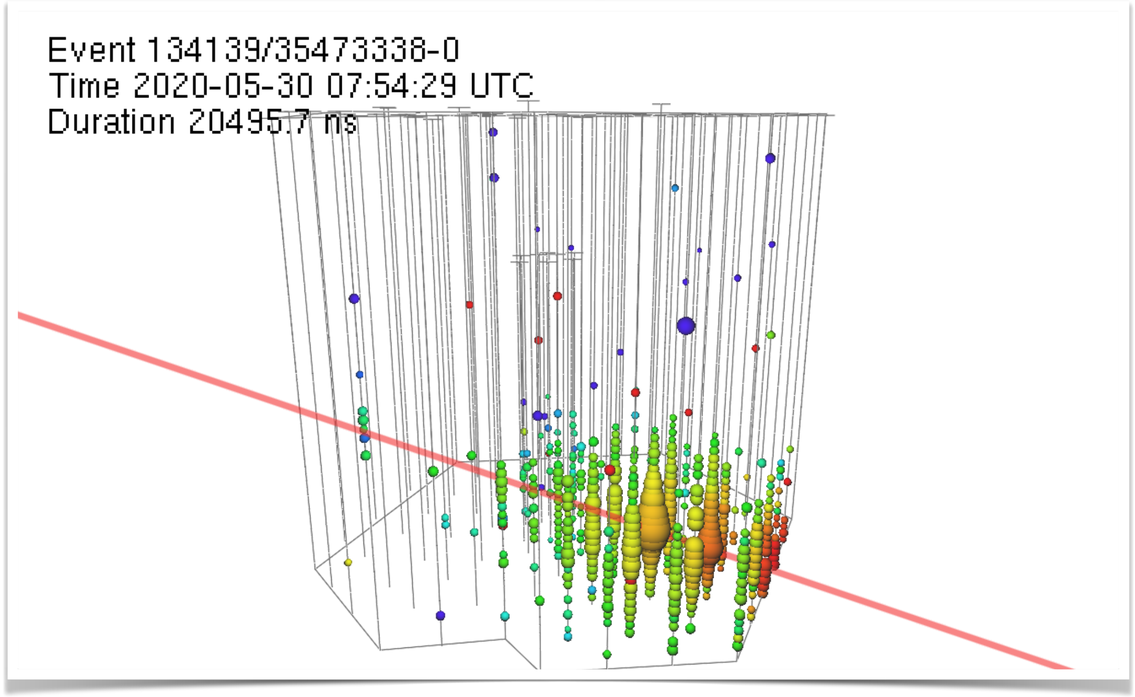
~~ZTF20acaapwk~~

**ZTF20acaapwo**



# IC200530A

- detection: May 30, 2020, 07:54 UT
- energy estimate: 82 TeV
- 59 % probability of being of astrophysical origin
- 90% region: 22.2 square deg




**3 candidates:**

SN II

~~ZTF20abbpkpa~~

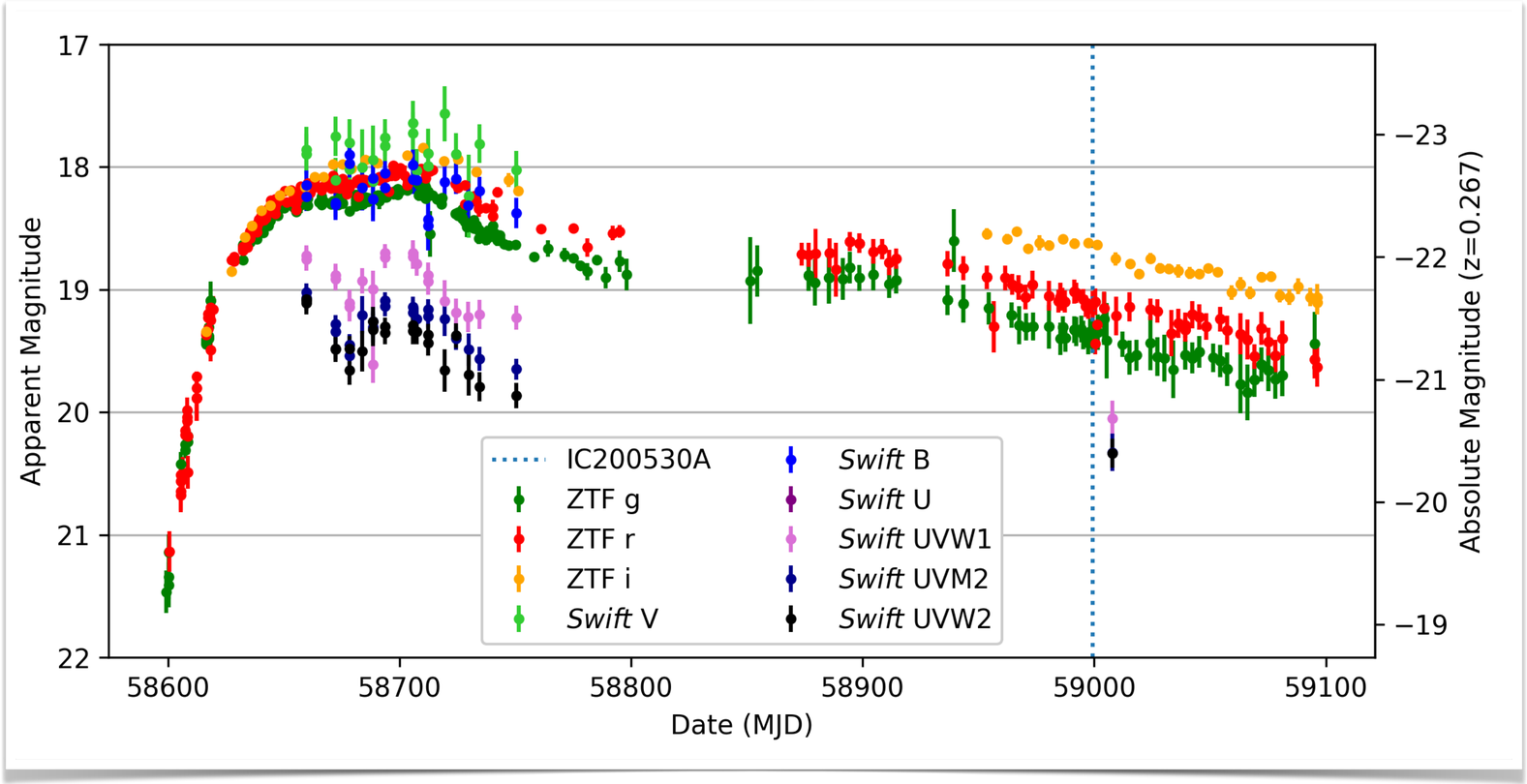
SN Ic

~~ZTF20abdnpdo~~

**ZTF19aatubsj / AT2019fdr / Tywin**

# Tywin lightcurve

- first discovered by ZTF on May 3, 2019
- first spectrum on June 8, 2019: unclear classification, but redshift = 0.267
- first classified as possible TDE or SLSN
- later tentatively classified as SN IIn

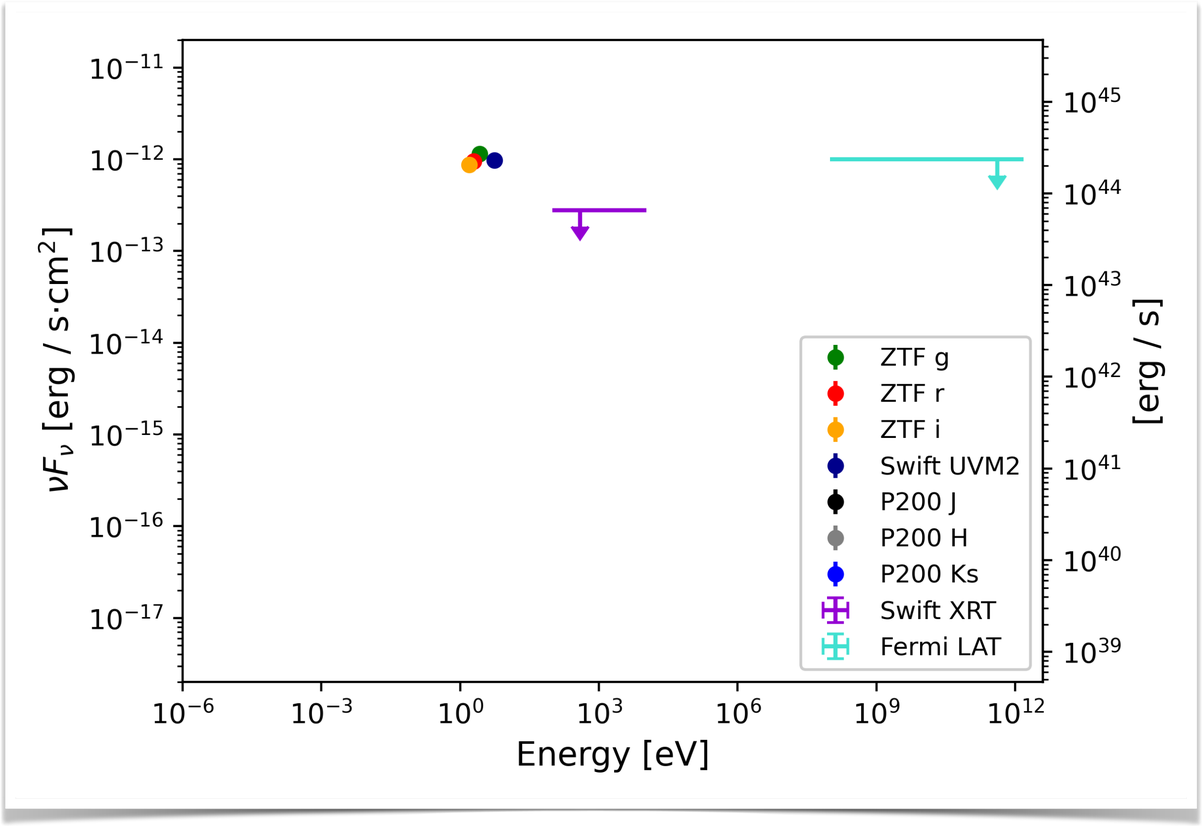



host is a narrow-line Seyfert 1 galaxy

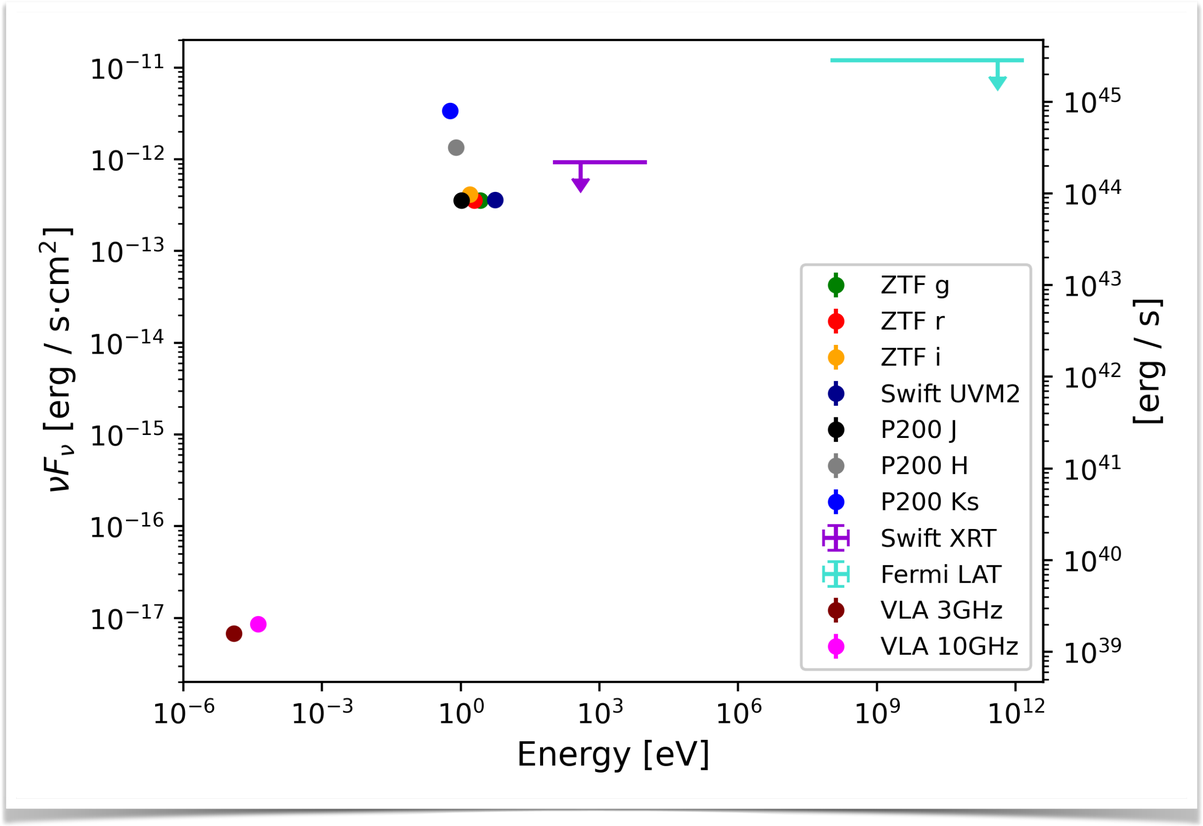
neutrino

# SED

Peak



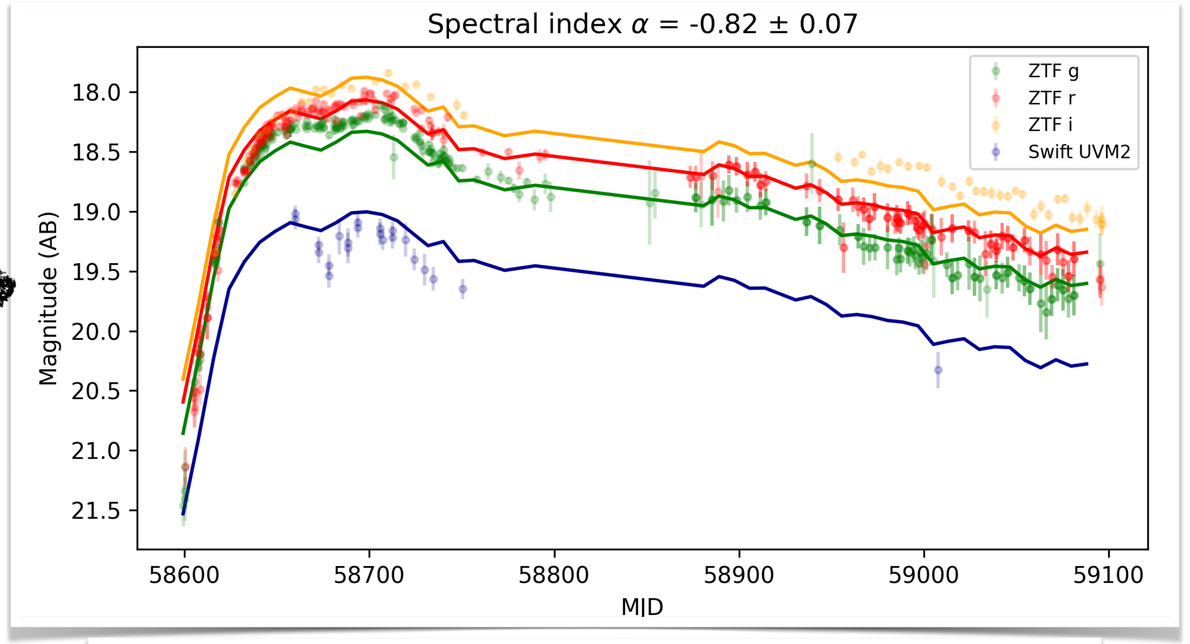

Late

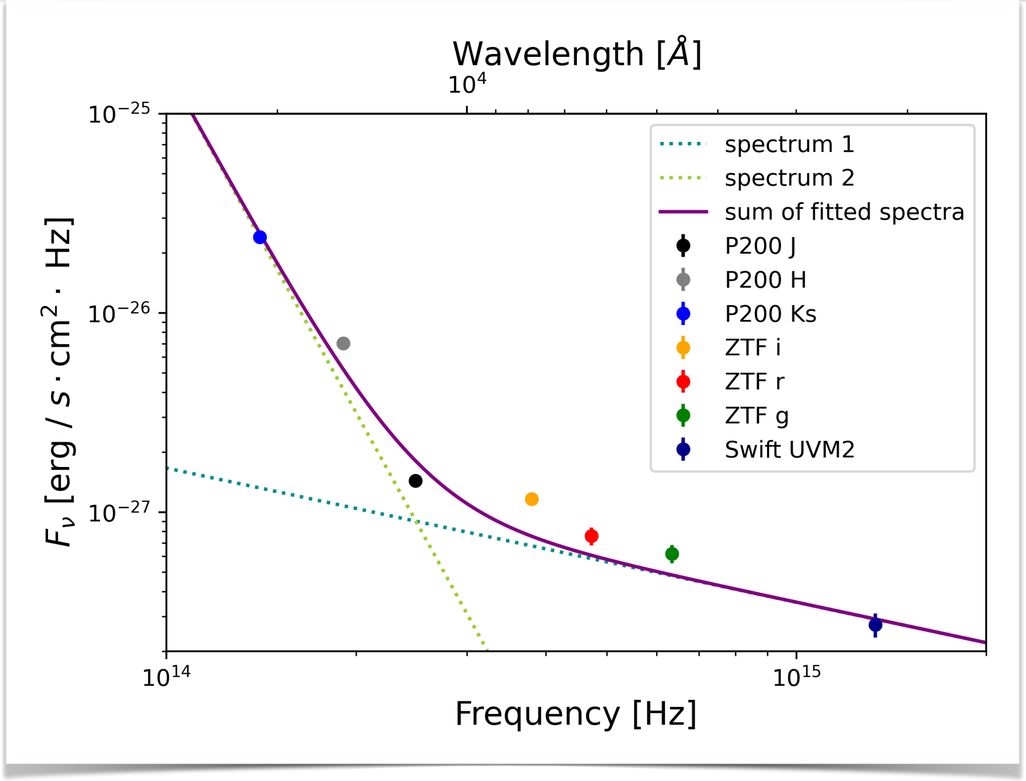



- not visible in X-Ray, Gamma-Ray
- but faint radio signal, radio spectrum incoming (226 +/- 13 uJy @ 3 GHz)

# Analysis / Modeling

- hard to model
- best global fit by powerlaw, spectral index = -0.82
- luminosity compatible with neutrino production!
- BH mass: $\log \frac{M_{BH}}{M_\odot} = 7.64 \pm 0.13$
- very bright in NIR (15 - 17.5 mag)
- NIR epochs best fit: broken powerlaw



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- E…
- ve… ma…
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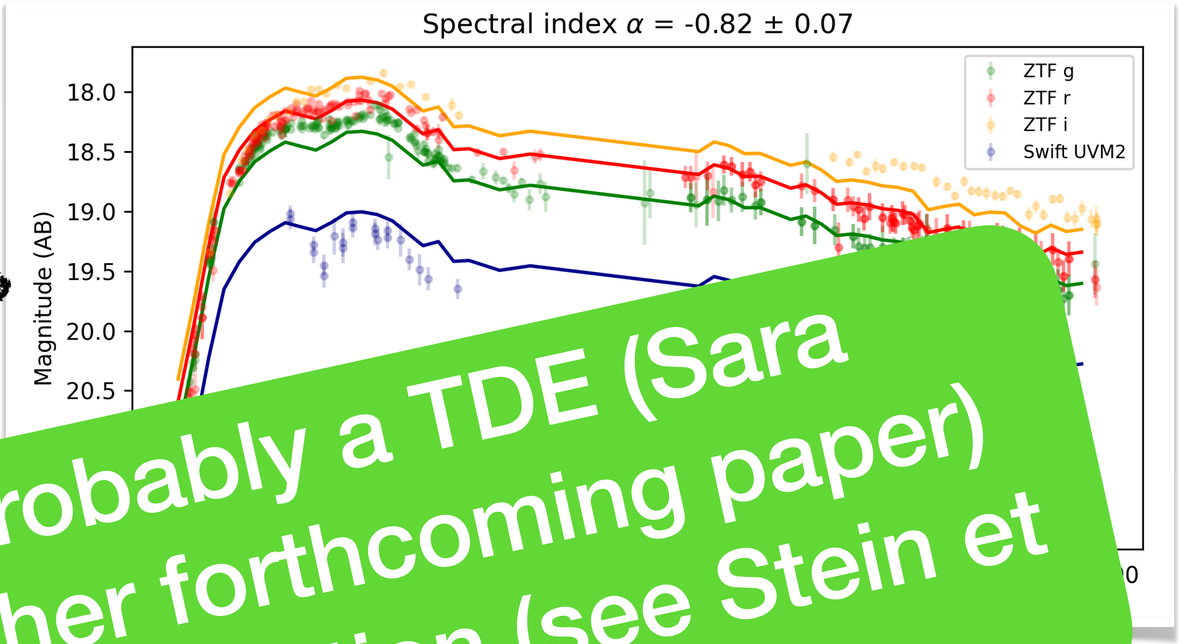
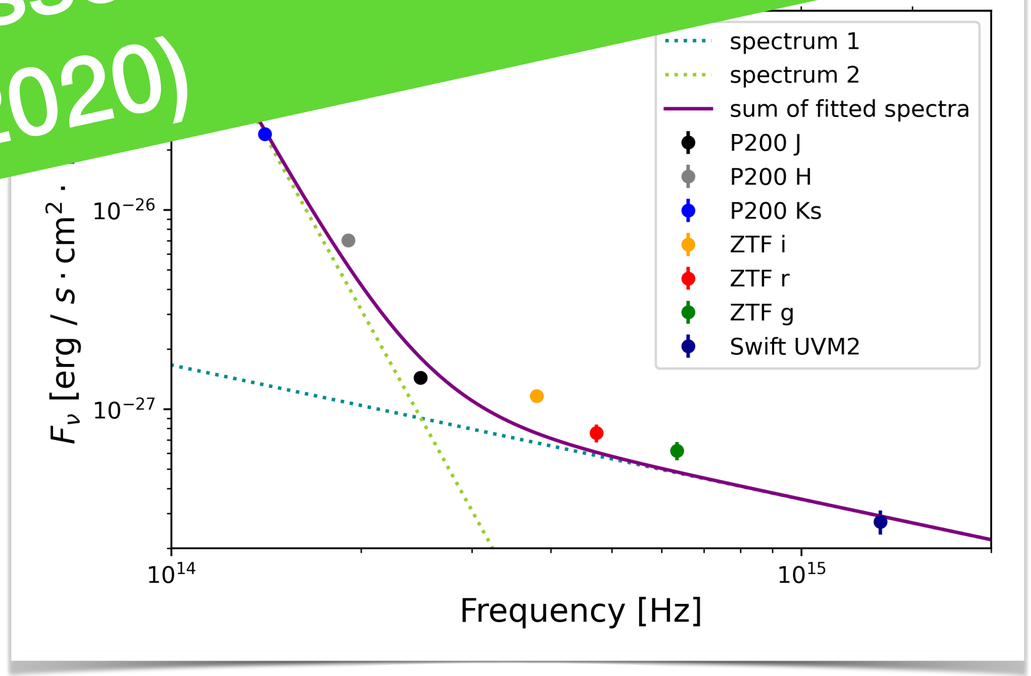
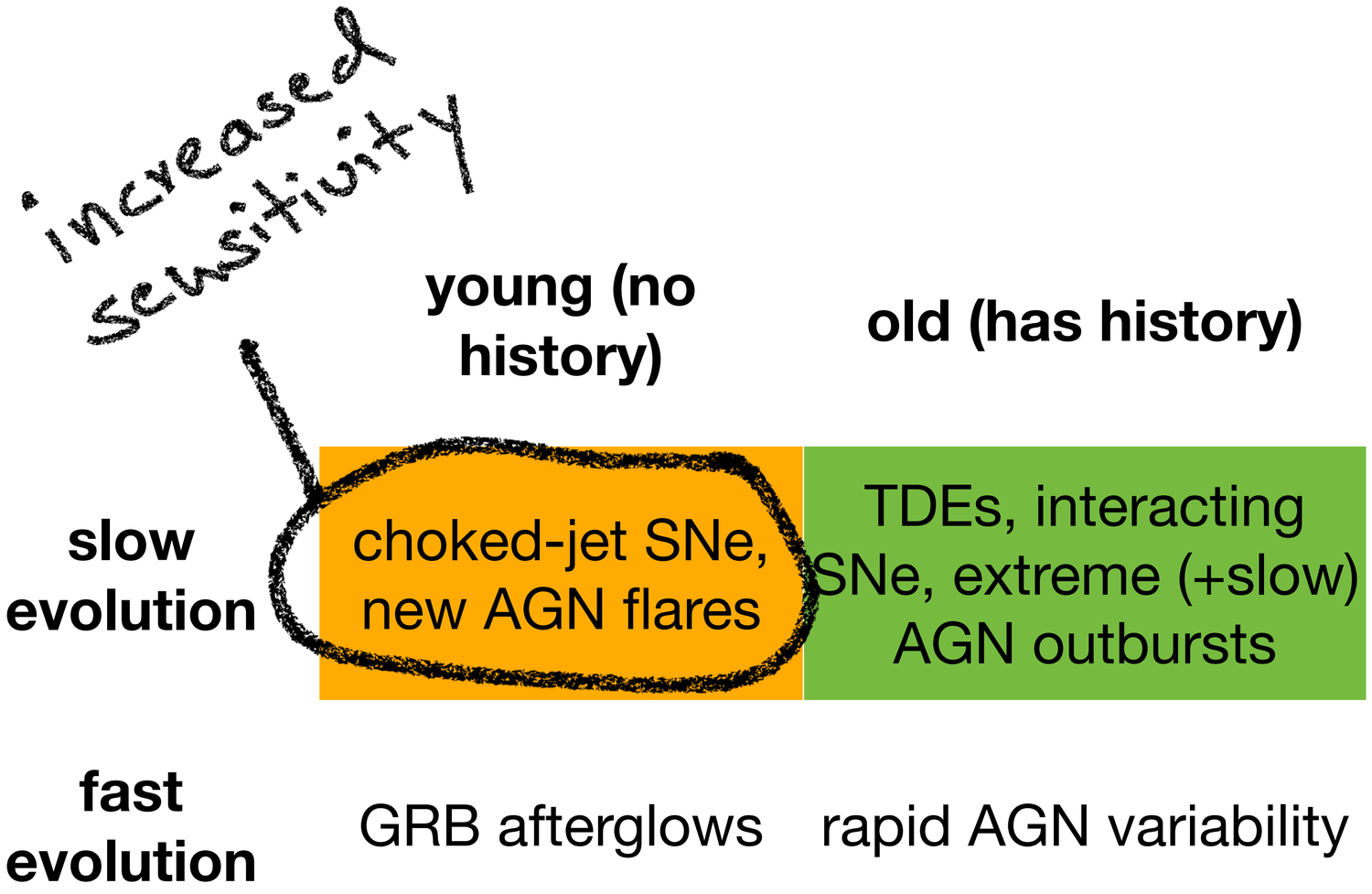



Good news: Most probably a TDE (Sara Frederick thinks so in her forthcoming paper)
Second TDE-neutrino association (see Stein et al., 2020)



# Plans for ZTF Phase II

- Change observing strategy: trade depth for more images
- Planned realtime cross-correlation study with AGN (teaming up with Matthew)
- Automated archival search



# Publication plans

## Submitted

- Stein et. al. (2020) on Bran, the first TDE in coincidence with a neutrino

## Final stages

- Reusch et. al. (2020) on Tywin

## Planned

- Pipeline paper
- Paper on limits from ZTF I phase of our neutrino program