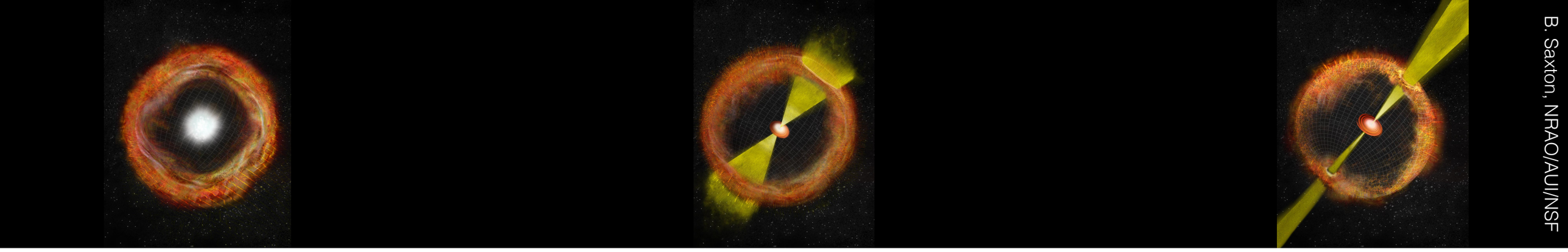
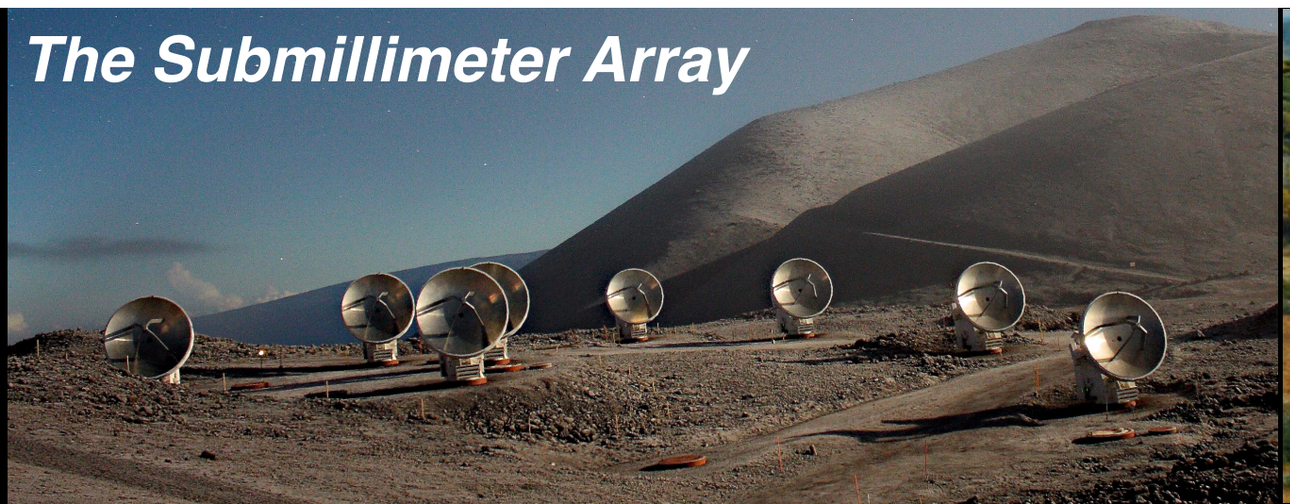


Update on Relativistic Stellar Explosions

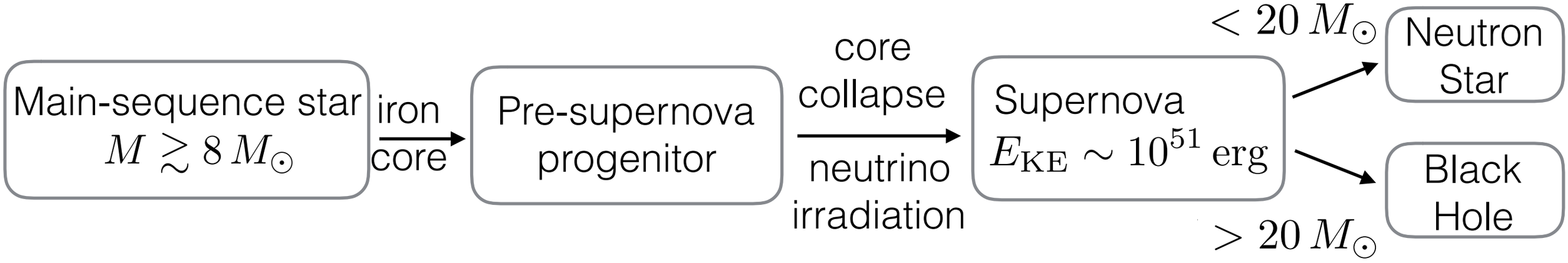
Anna Y. Q. Ho (Miller Fellow, UC Berkeley)

with D. Perley, Y. Yao, A. Corsi, S. Kulkarni, and many others



“Extreme” Physically: Unusual Stellar Endpoints

Traditional story of stellar evolution:



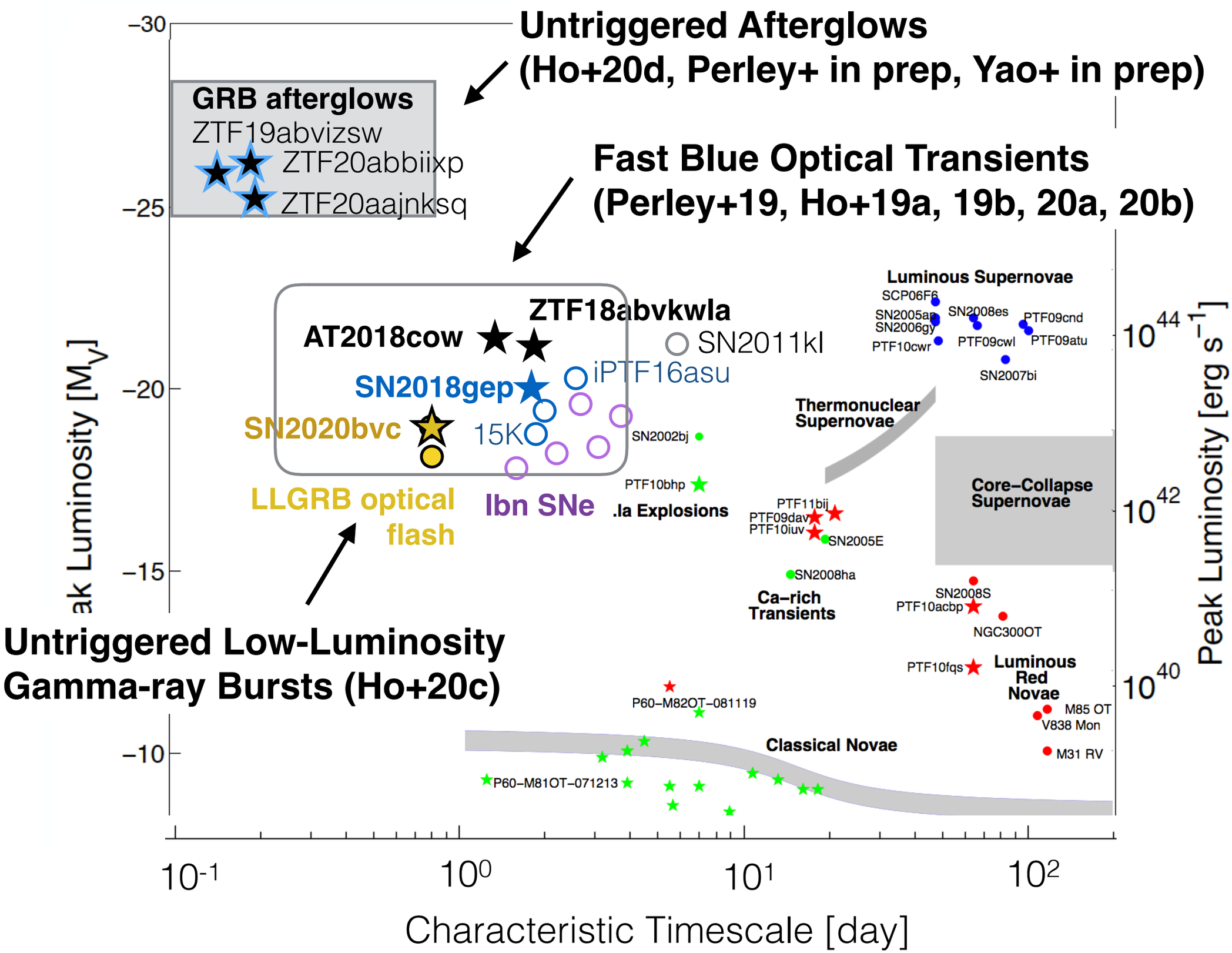
Phenomena: relativistic jets (compact object accretion/rotation; “central engine”), circumstellar interaction (recent intense mass-loss; “death omens”)

Scientific Motivation: stellar evolution (rotation, metallicity, binarity, mass-loss), explosion physics, jet physics

Relativistic jet in collapsing star: Long-duration gamma-ray burst + supernova
Spectroscopic Type Ic-BL (no H/He), “broad-lined” (high velocities)

Video credit: NASA’s Goddard Space Flight Center

“Extreme” Observationally: The Landscape of Optical Transients



modified from Kasliwal (2011)

1) Untriggered Afterglows

Motivation *Status* *Future*

Conditions to produce a GRB (break-out, hyper-relativistic velocities) are contrived: perhaps GRBs are the extreme of a continuum?

"Dirty fireball" (Dermer+99): low Lorentz factor jet, afterglow lacking GRB

Challenge: detect (and confirm!) an optical afterglow without a GRB trigger

Prior to ZTF, only three optical afterglows had been found in this way

(1) PTF11agg (Cenko+ 2013): no GRB, $0.5 < z < 3$

Rate >> classical GRB rate?

(2) iPTF14yb (Cenko+ 2015): classical GRB, z=1.9733

Rate ~ classical GRB rate

(3) ATLAS17aeu (Stalder+2017, Bhalerao+2017): true GRB, no redshift

Ho+ (2018): iPTF archival search to develop search strategy, confirmed that rate ~ classical GRB rate

1) Untriggered Afterglows

Motivation ***Status*** *Future*

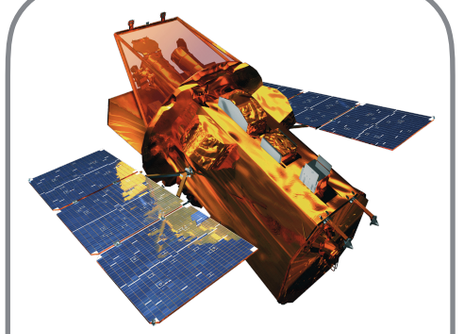
Since the last team meeting, have uncovered 2 more, bringing the total to 4

- 2 had no detected GRB
- 1 found by kilonova/fast transient searches, see Igor Andreoni's talk

1) Untriggered Afterglows

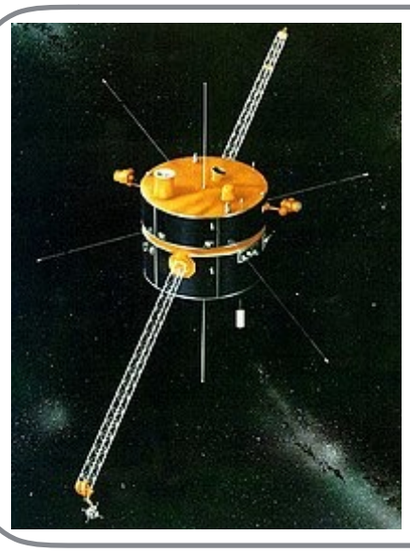
Motivation *Status* ***Future***

For a single event, very difficult to rule out GRB. e.g., AT2020blt (z=2.9):



Swift:
not in FOV

Fermi:
65% in FoV



Konus-*Wind*:
100% in FoV

Difficult to distinguish dirty fireball from slightly off-axis jet

No evidence that dirty fireballs exist (if they look the same as classical afterglows)

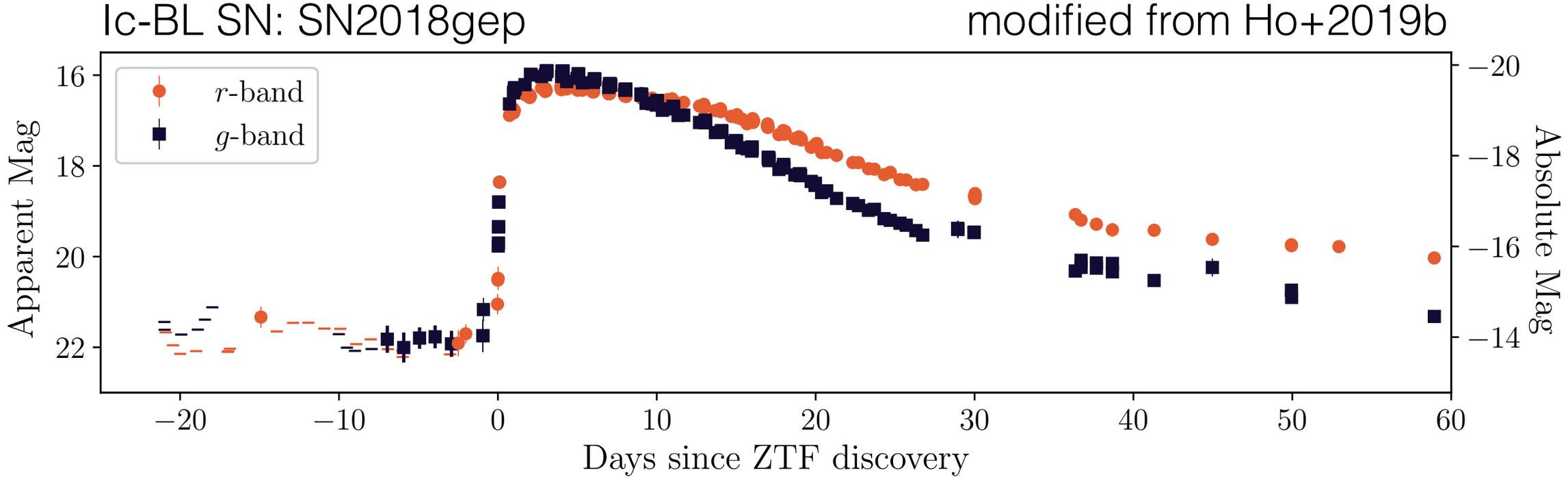
Population: could use
- luminosity function,
- probabilistic statements about coverage by GRB satellites,
- shape of the optical light curve

2) Fast Blue Optical Transients (FBOTs)

Motivation *Status* *Future*

- Fleeting ($t_{1/2}$ < 12d) common (4-7% CC SN rate) explosions with -16 < M < -21
- Originally identified via light curves in Pan-STARRS data (Drout+2014)
- Origin unknown, but starforming host galaxies suggest massive-star origin
- From handful of individual events: CSM interaction is key and progenitors are diverse

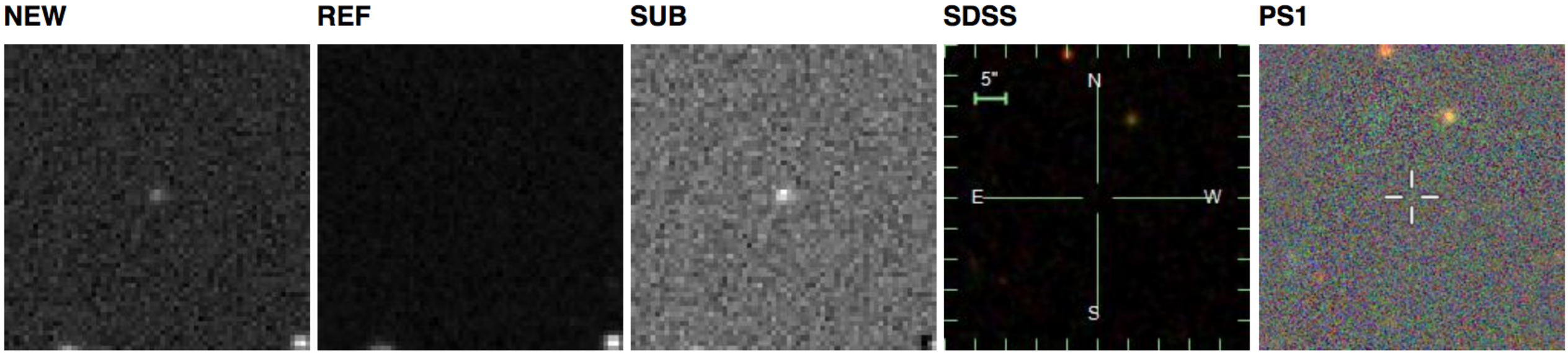
Ic-BL SN: SN2018gep modified from Ho+2019b

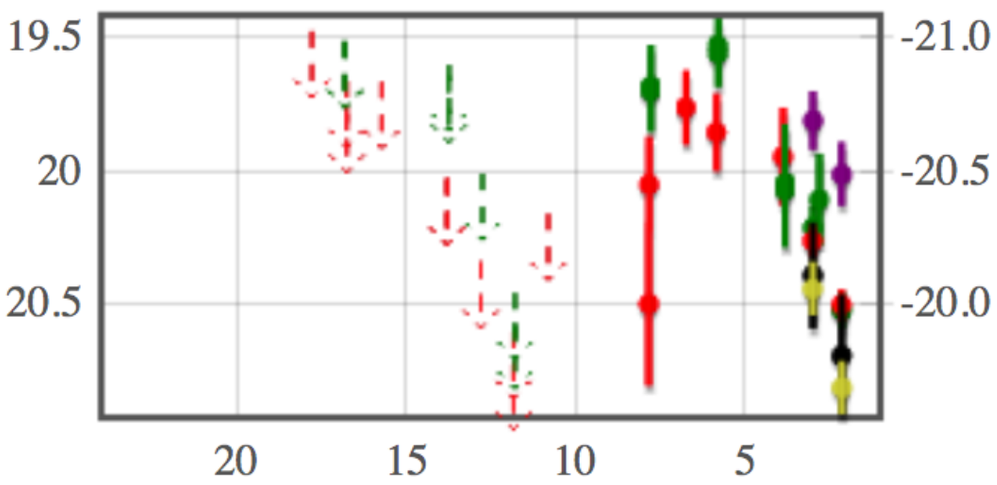


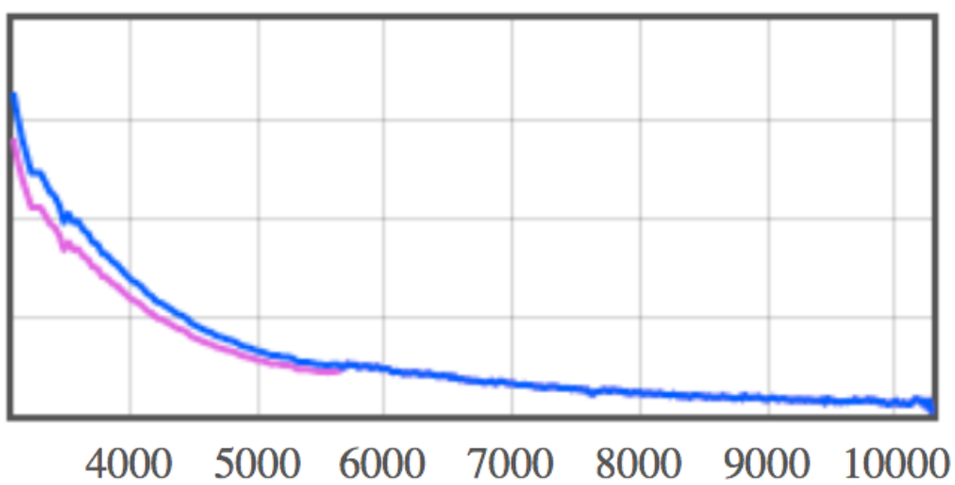
2) Fast Blue Optical Transients (FBOTs)

Motivation ***Status*** *Future*

- Last team meeting, had two well-studied FBOTs in ZTF: SN2018gep (Ic-BL; Ho+19a) and The Koala (engine-powered explosion in a dwarf galaxy; Ho+20b)
- Since then, published ultra-stripped SN2019dge (Yao+2020) and **this week** confirmed a new event resembling AT2018cow! (stay tuned…)







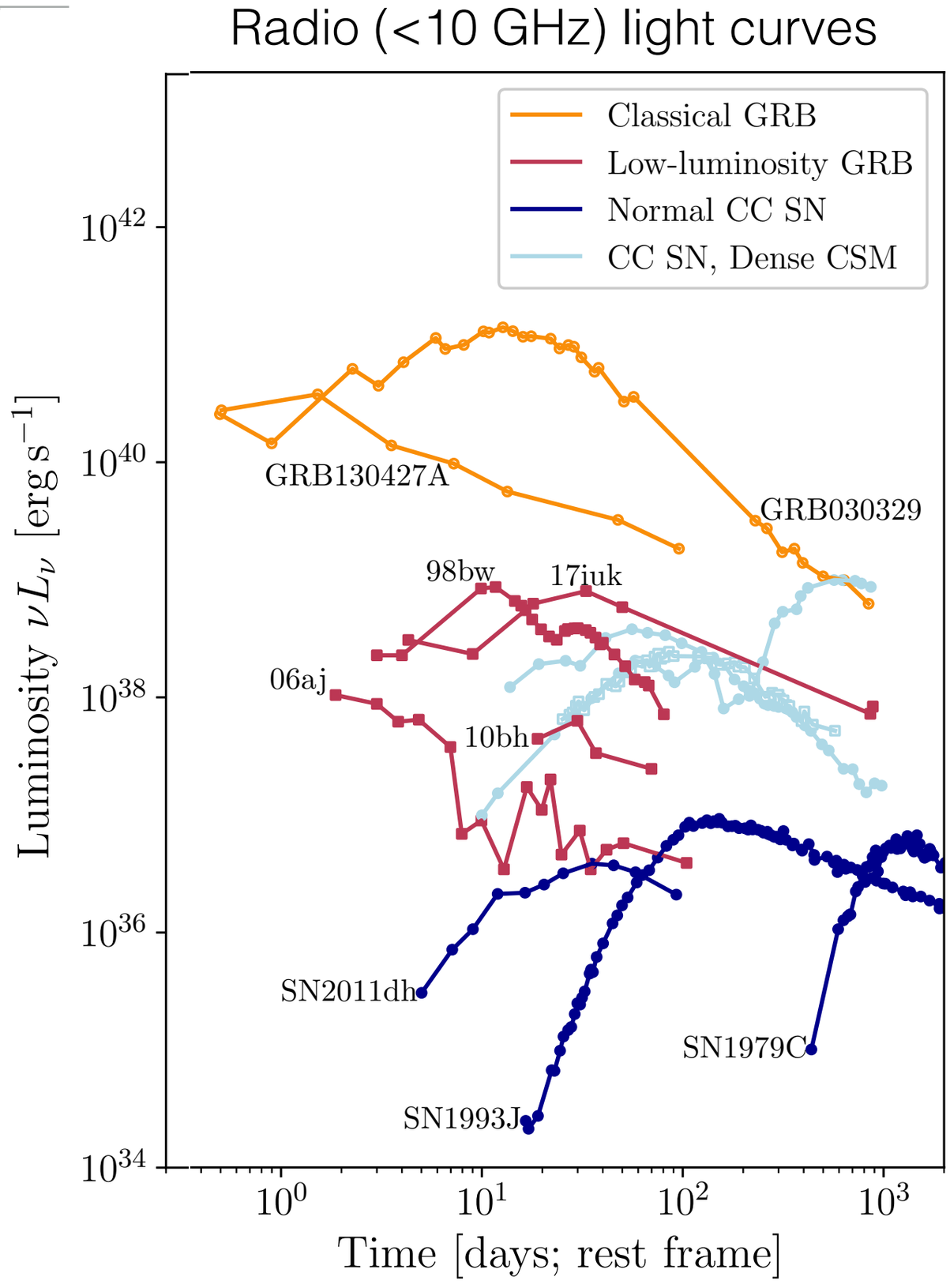
g = 20.1 (2.8 d) | Upload New Photometry

z = 0.2442 | Upload New Spectroscopy

3) Signs of Central Engines in Ic-BL SNe

Motivation *Status* *Future*

- Almost all GRBs accompanied by Ic-BL SN, but most Ic-BL SNe lack GRB
  - Jets off-axis? Choked?
  - To find out, search for:
    - luminous radio emission (VLA; PI: Corsi)
    - double peaked optical light curves (Ho+20c)



3) Signs of Central Engines in Ic-BL SNe

Motivation ***Status*** ***Future***

- Last team meeting, had two radio det.
- Now have several more (stay tuned…)
- Plan is to publish sample of radio properties (Corsi+) and study of optical/radio correlations (Ho+) next year