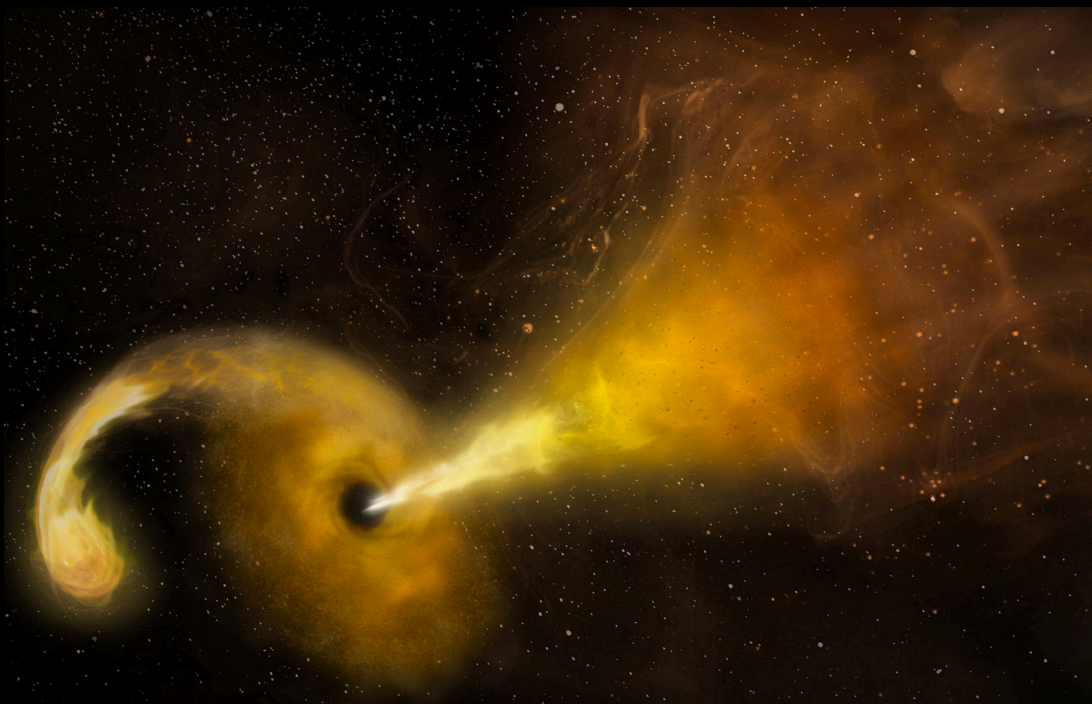


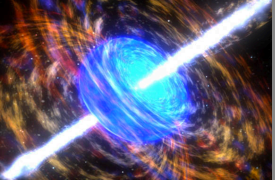
TIDAL DISRUPTION EVENTS WITH CMB-S4



Dr. Kate D. Alexander

NASA Einstein Postdoctoral Fellow, Northwestern University

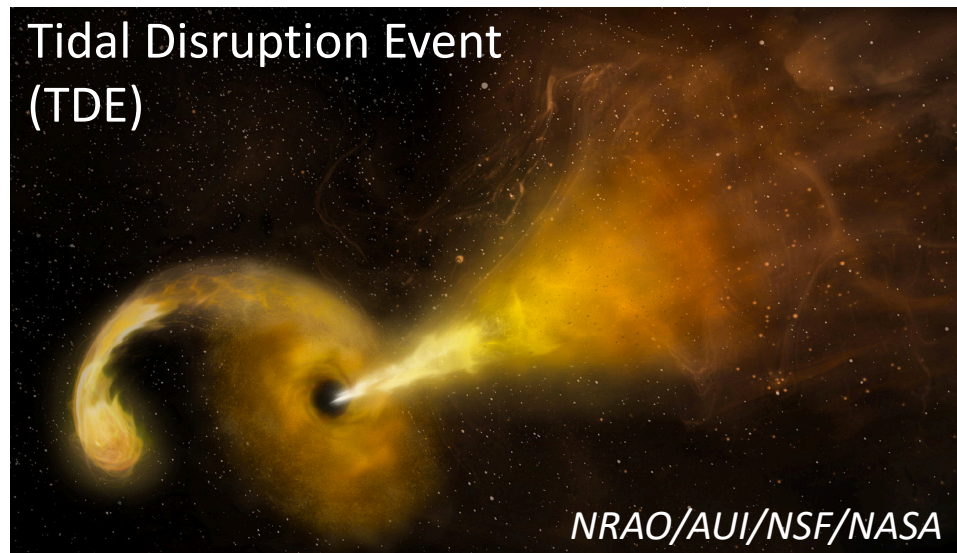
March 9, 2021



Cosmic Extremes: Collisions, Explosions

- Energetic transients let us probe extreme physical processes:
 - The deaths of massive stars (compact objects = extremely dense matter)
 - Black hole formation and growth
 - Particle acceleration (to extremely high energies)
- Open questions:
 - How do relativistic jets form?
 - How do black holes shape their environments?

Tidal Disruption Event
(TDE)

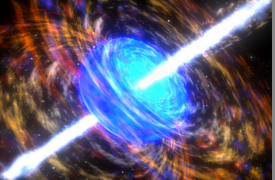


NRAO/AUI/NSF/NASA

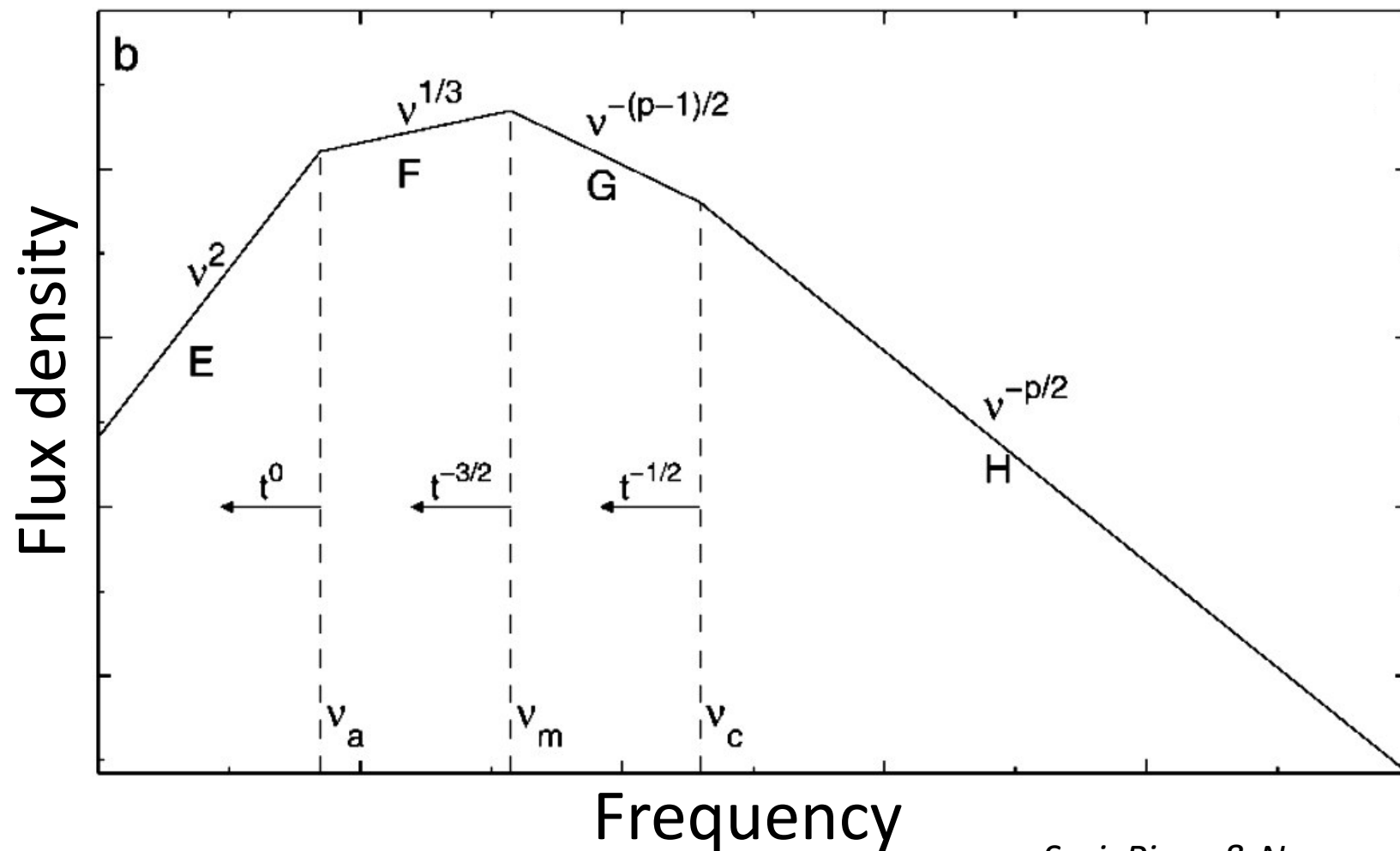
Gamma-ray Burst
(GRB)



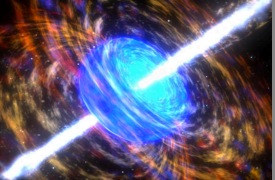
NASA/SkyWorks Digital



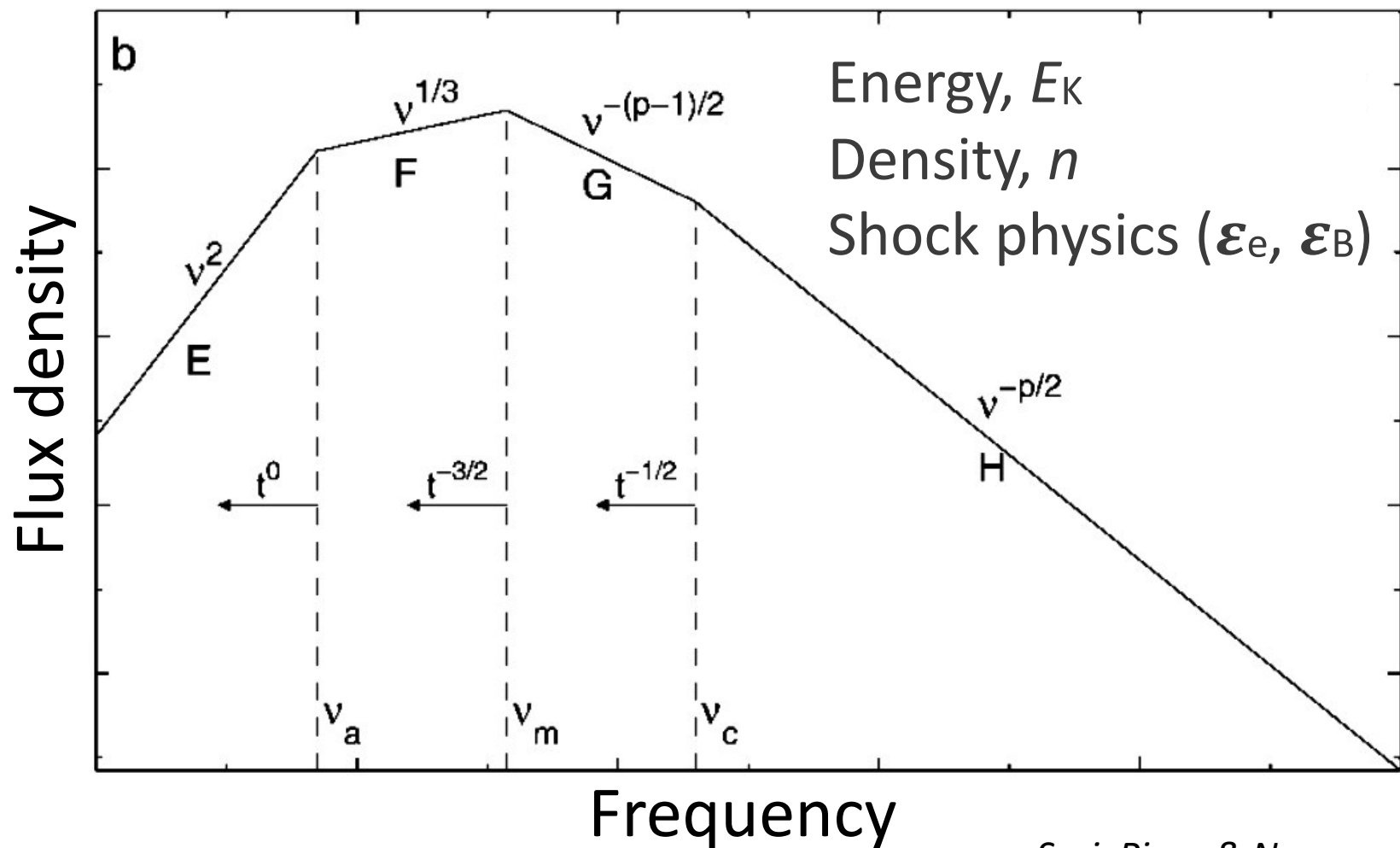
Outflows Generate Synchrotron Emission



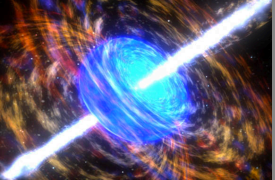
Sari, Piran & Narayan (1998)
Slide courtesy T. Laskar



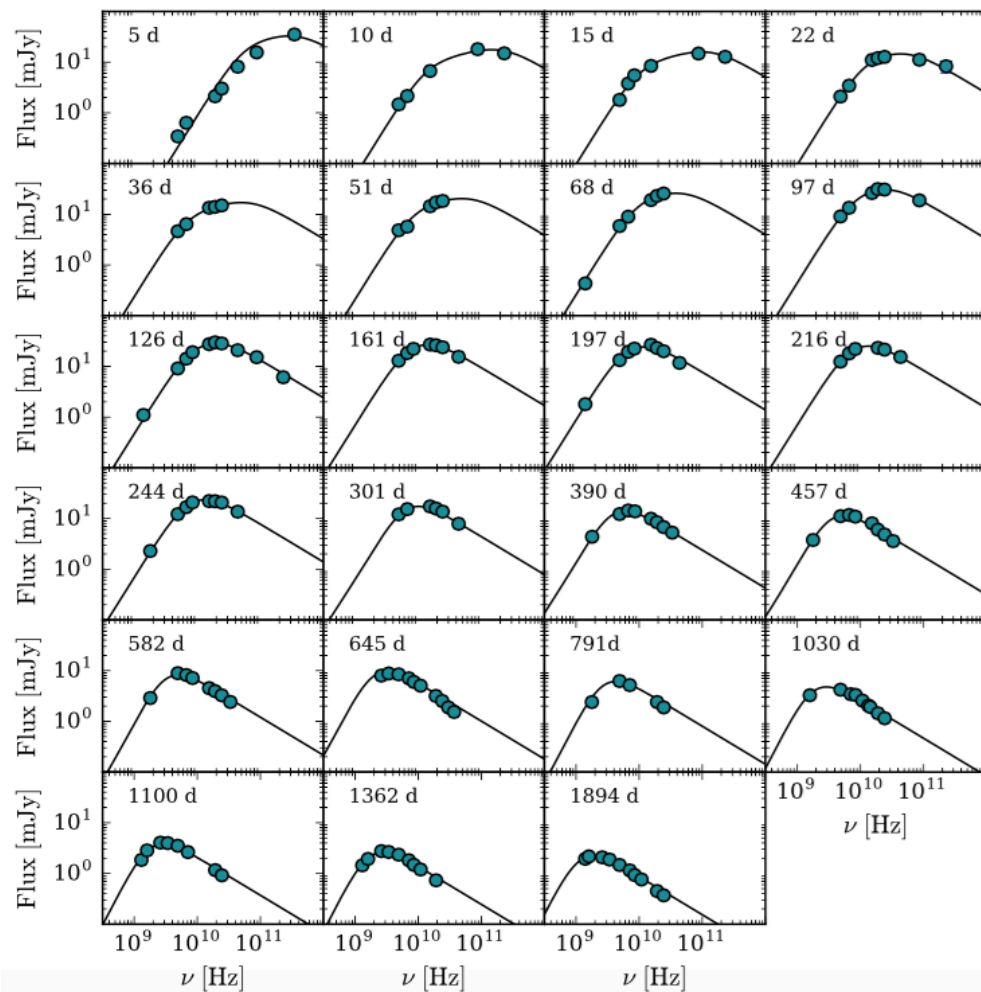
Outflows Generate Synchrotron Emission



Sari, Piran & Narayan (1998)
Slide courtesy T. Laskar



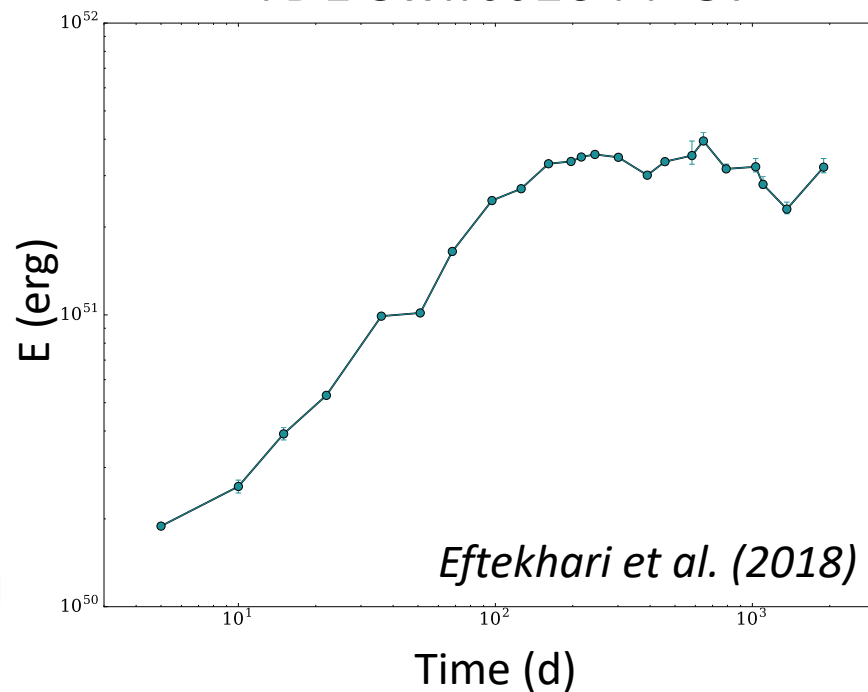
Multi-frequency observations are key



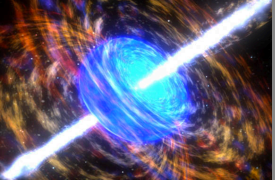
Eftekhari et al. (2018)



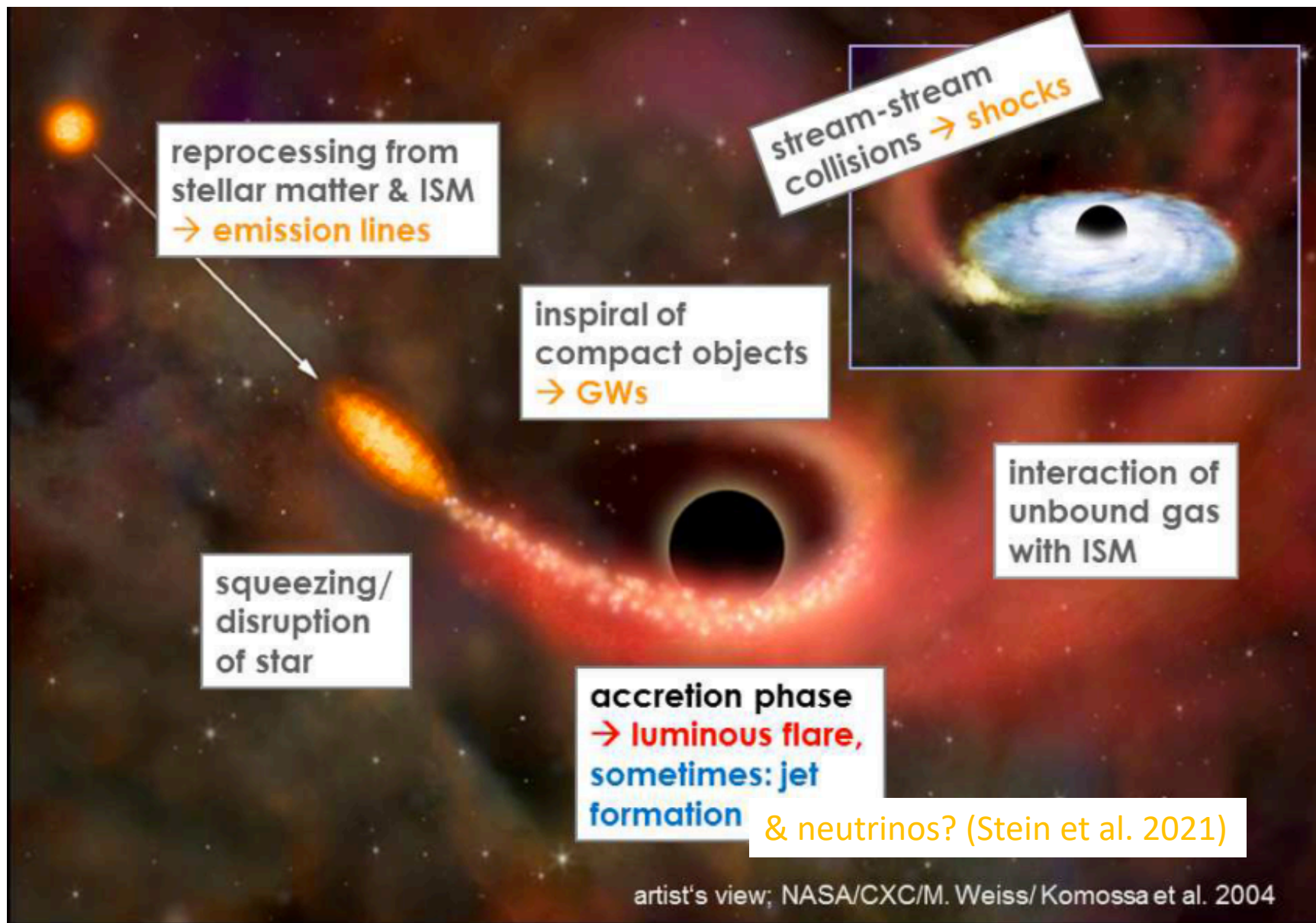
TDE Swift J1644+57

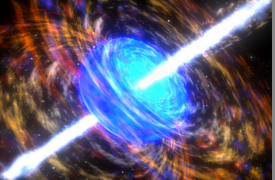


Eftekhari et al. (2018)



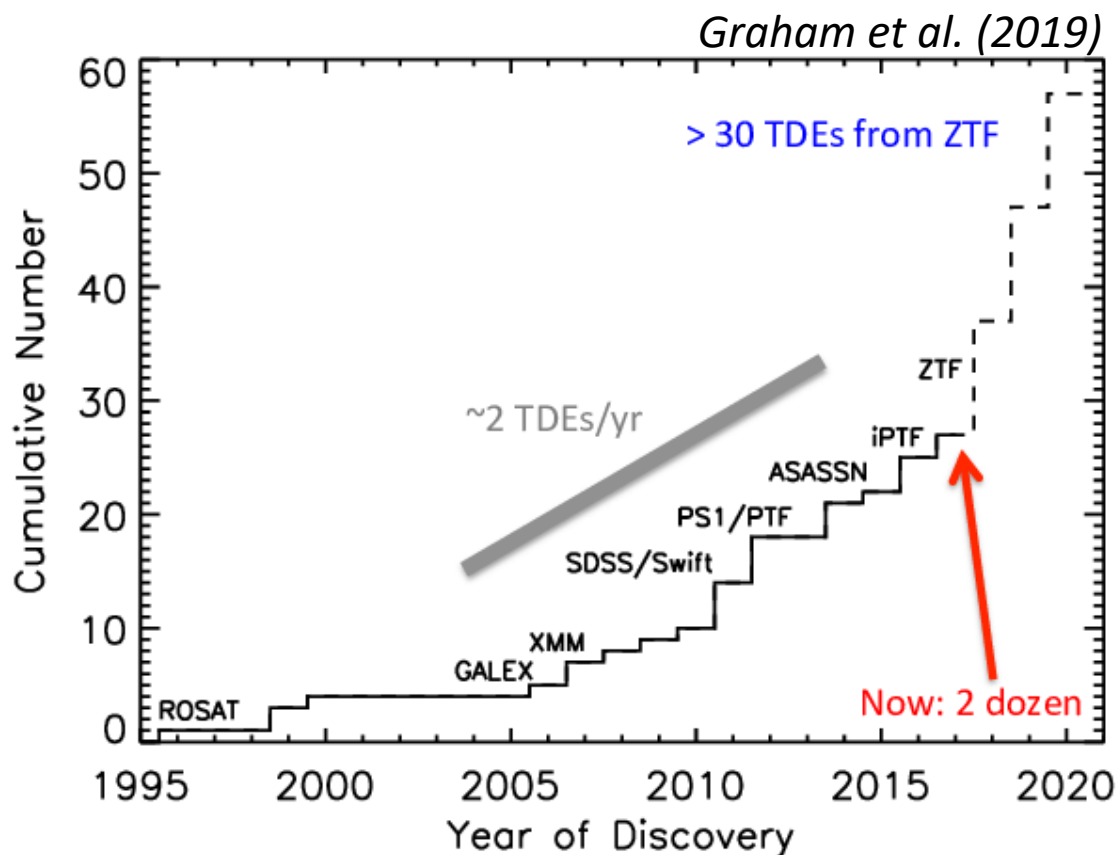
Tidal Disruption Events (TDEs)

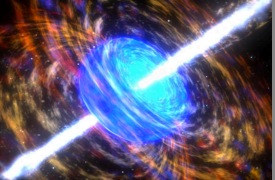




The TDE discovery rate is accelerating

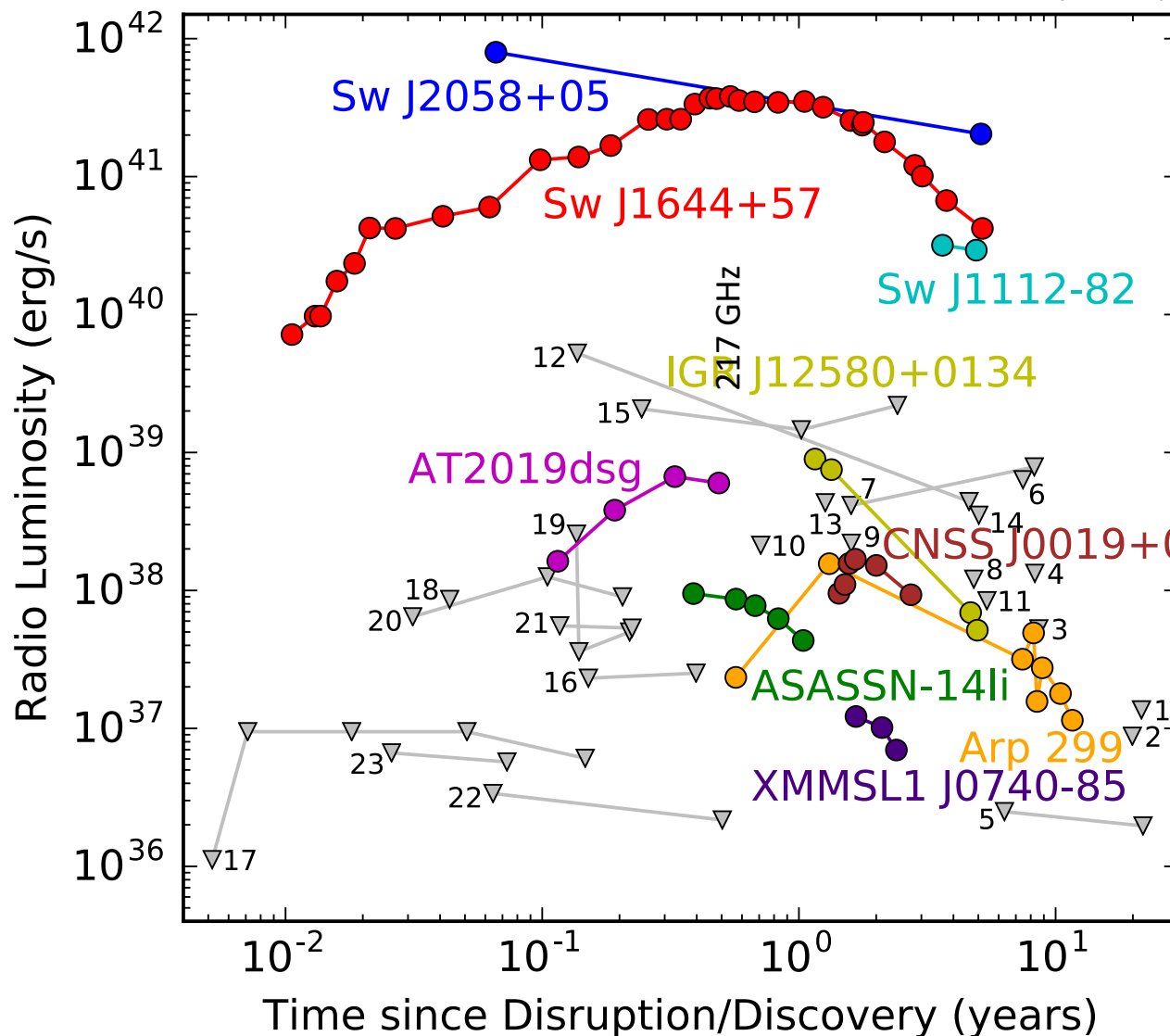
- Optical surveys continue to dominate transient discovery
 - ASAS-SN, DES, YSE, ZTF,...
- High-energy surveys also key (Fermi, Swift, eROSITA, ...)
- Looking ahead: **Rubin Observatory** (LSST)
 - Thousands of TDEs, many at high redshift (deep follow-up will be needed with e.g. ALMA, ngVLA)





TDE Radio Observations (2020)

Alexander et al. (2020)



On-axis jet

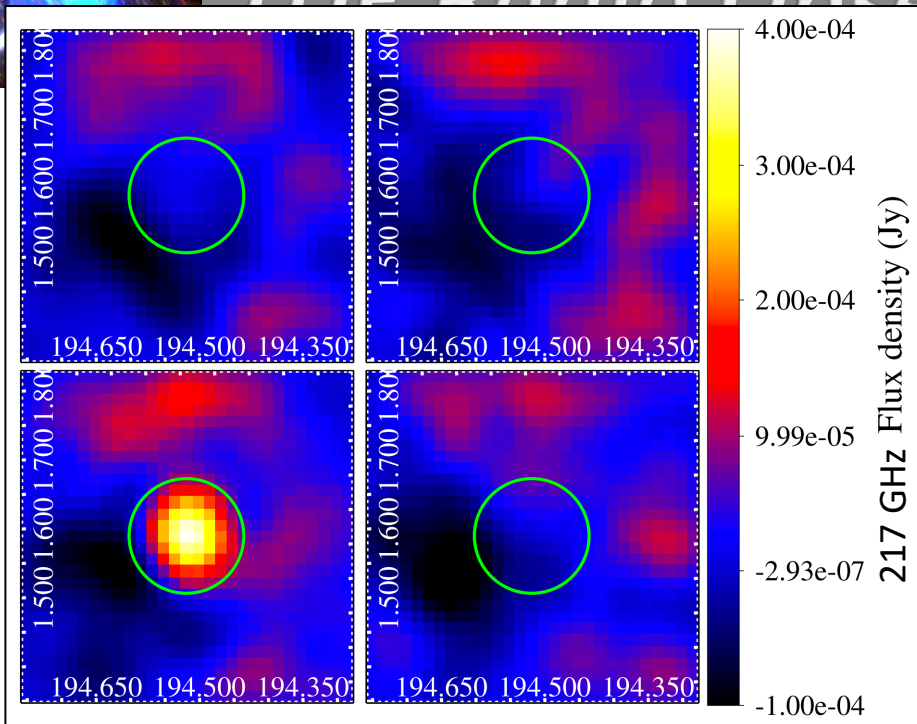


Off-axis jet

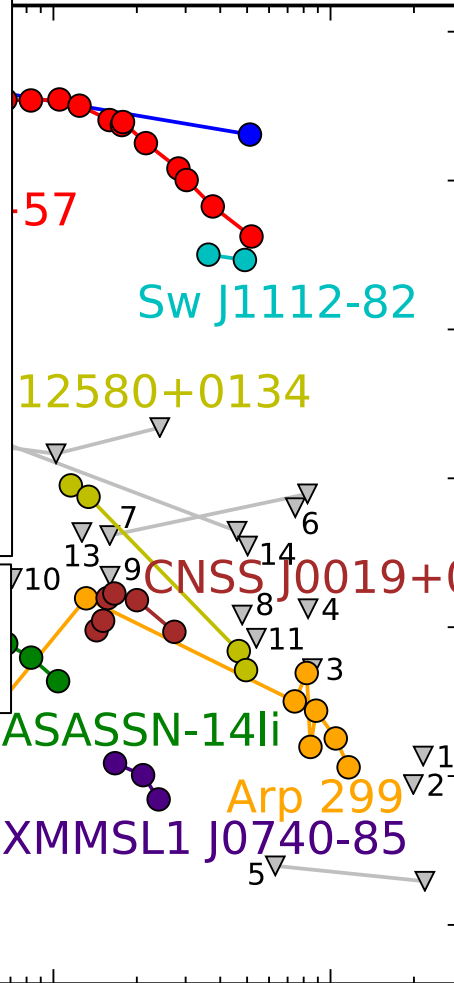
Non-relativistic outflow



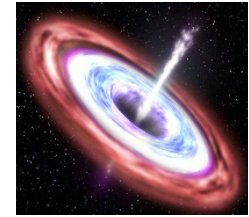
TDE Radio Observations (2020)



Alexander et al. (2020)



On-axis jet

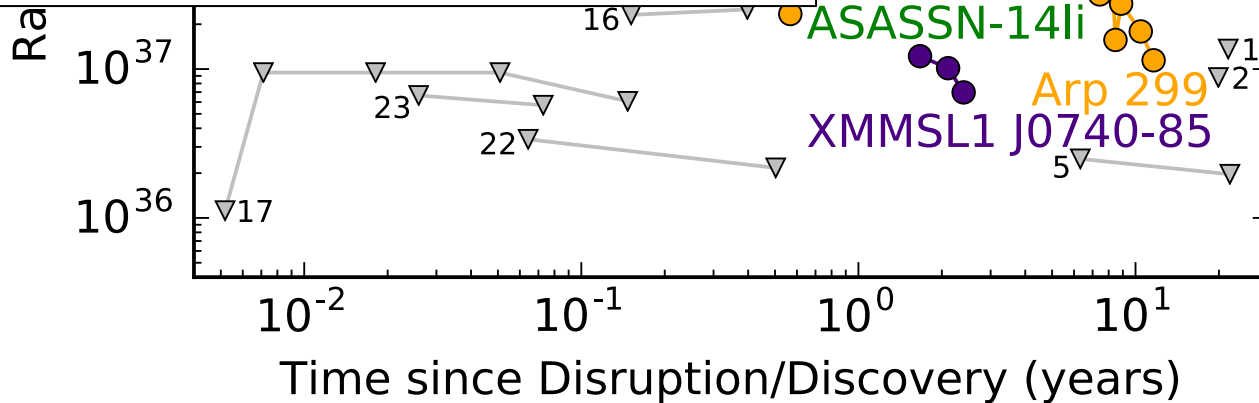


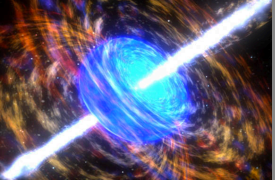
Off-axis jet

Non-relativistic outflow

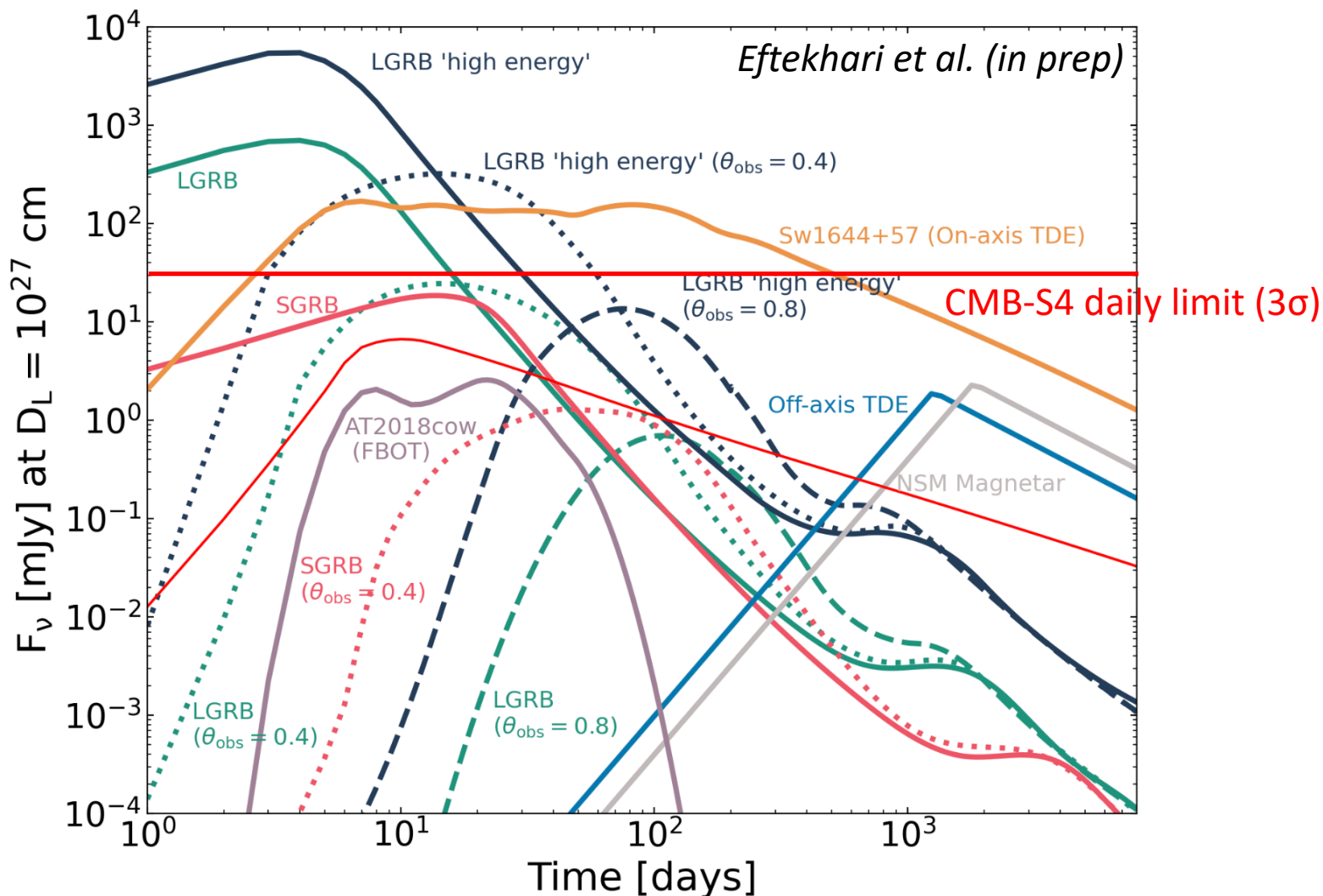


Detected in Planck all-sky survey data!
(Yuan et al 2016)

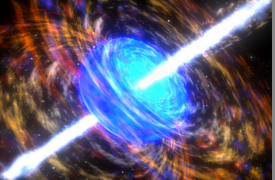




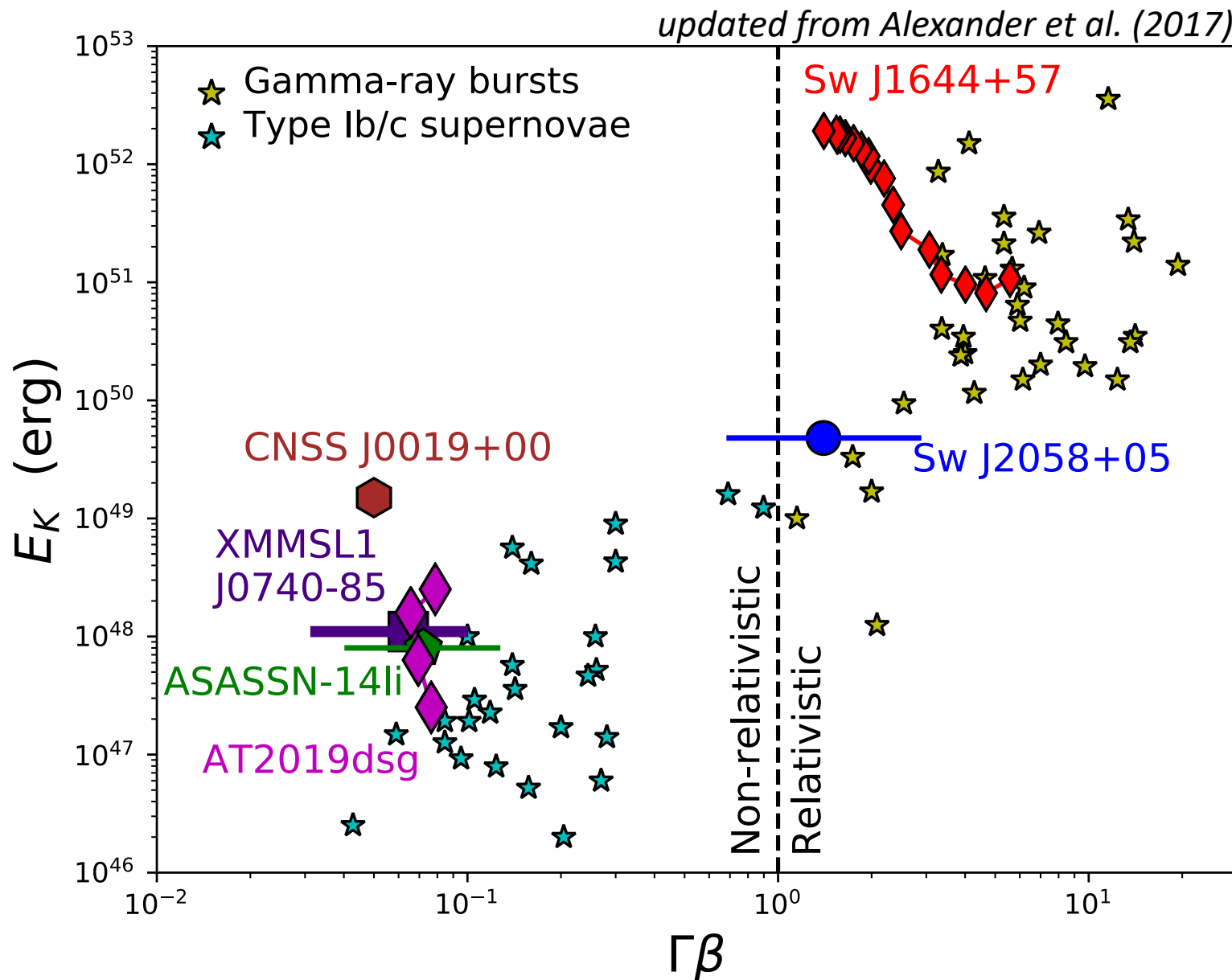
Jetted TDEs: luminous mm transients

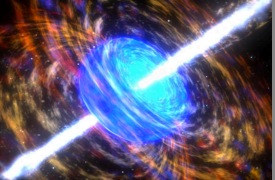


Peak flux ~ 10 s of mJy, duration \sim weeks to months



Population studies: Jets are rare

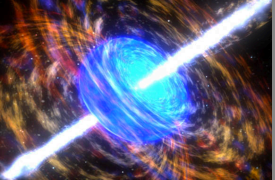




Characterizing local TDEs

- ALMA provides the best constraints on TDE outflows at early times
 - 4 TDEs observed in Cycles 6 and 7
 - no new data since March 2020 (covid-19)
- New **VLA Large Program** (PI: Alexander)
 - 300 hours over 3 yr to observe **all** new TDEs at $z < 0.1$, new jetted TDEs at all redshifts
 - Program started November 2020, first Atels out! Stay tuned.
 - <https://sites.northwestern.edu/radiotdes/>





Summary

- TDEs are exciting targets for CMB-S4 because they can produce luminous mm emission, lasting weeks-months
 - Current work will better constrain rates, radio+mm luminosity function within next few years
- CMB-S4 has great potential for transient science:
 - **Follow up/recovery** of transients discovered by contemporaneous surveys (LSST, eROSITA, Fermi, SKA...)
 - **Blind discovery** of new transients in the mm band (e.g. TDEs in dusty galaxies, obscured AGN, orphan GRB afterglows, ???)
 - **Deep template images** of the mm sky (context for new transient discoveries)
 - See Tarraneh Eftekhari's talk on Thursday for more!