The mm view of TDEs:

New constraints on jets, outflows, and Supermassive Black Hole accretion

NRAO/AUI/NSF/NASA

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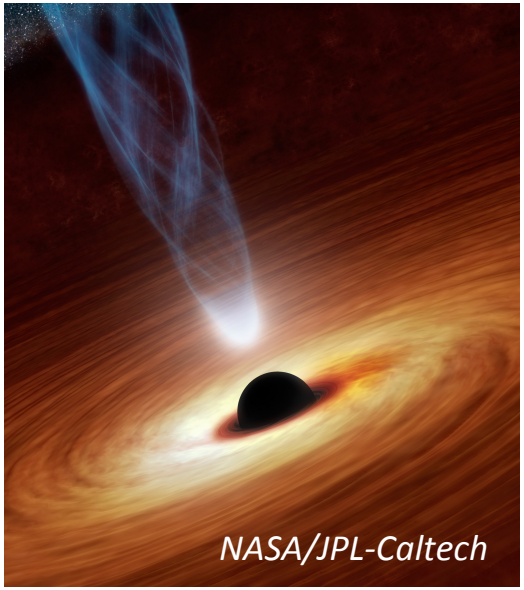
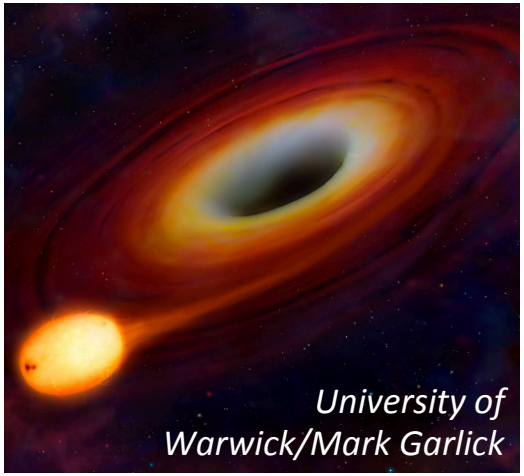
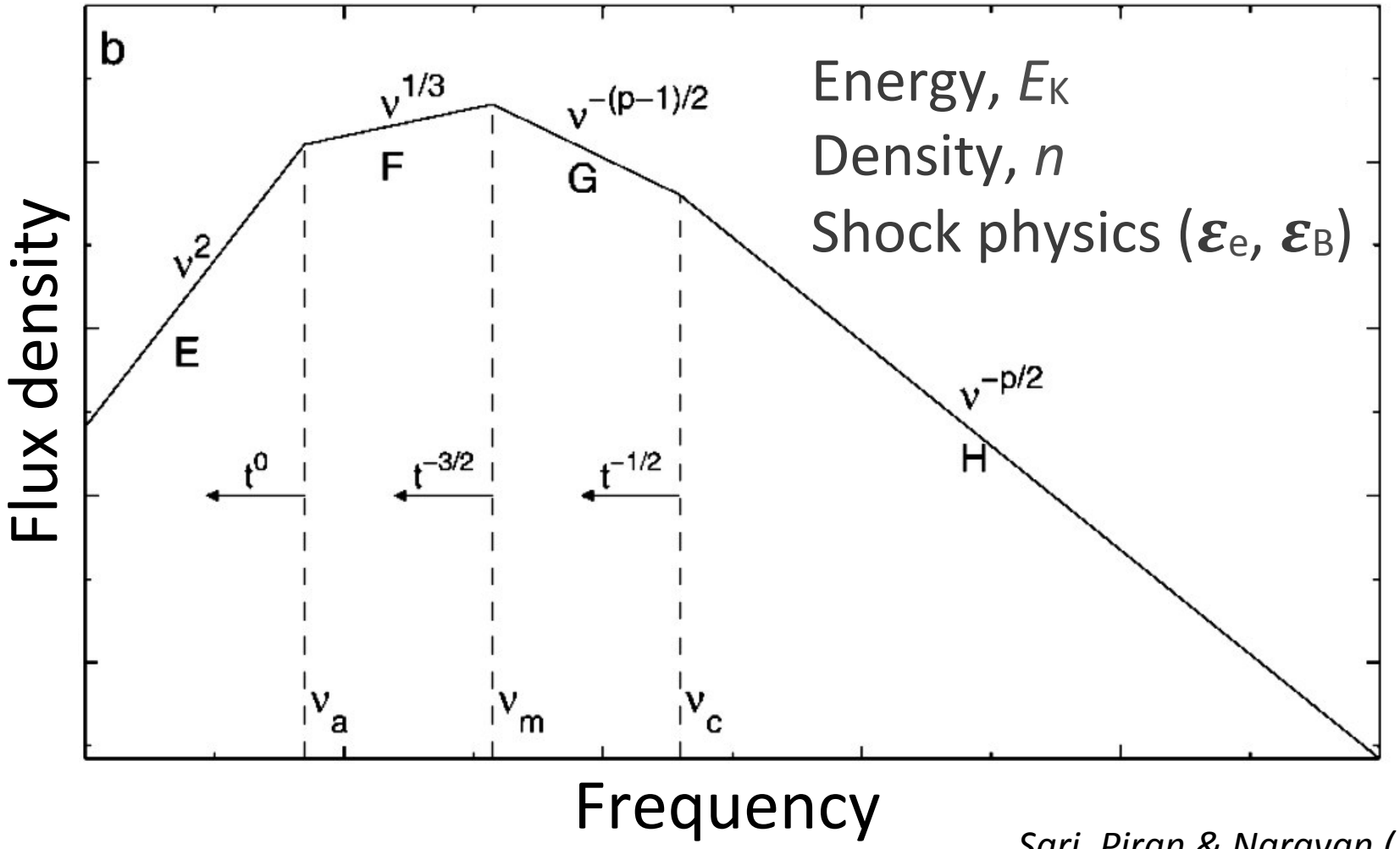
Jets & outflows probe Cosmic Extremes

- Radio TDEs reveal **jet/outflow evolution** from birth to death
- Open questions:
  - How exactly do relativistic jets and outflows form? What physical conditions are required?
  - What is the jet structure?
  - What do the environments around (recently) quiescent supermassive black holes look like?
  - How do TDEs fit into the broader picture of SMBH accretion and growth?





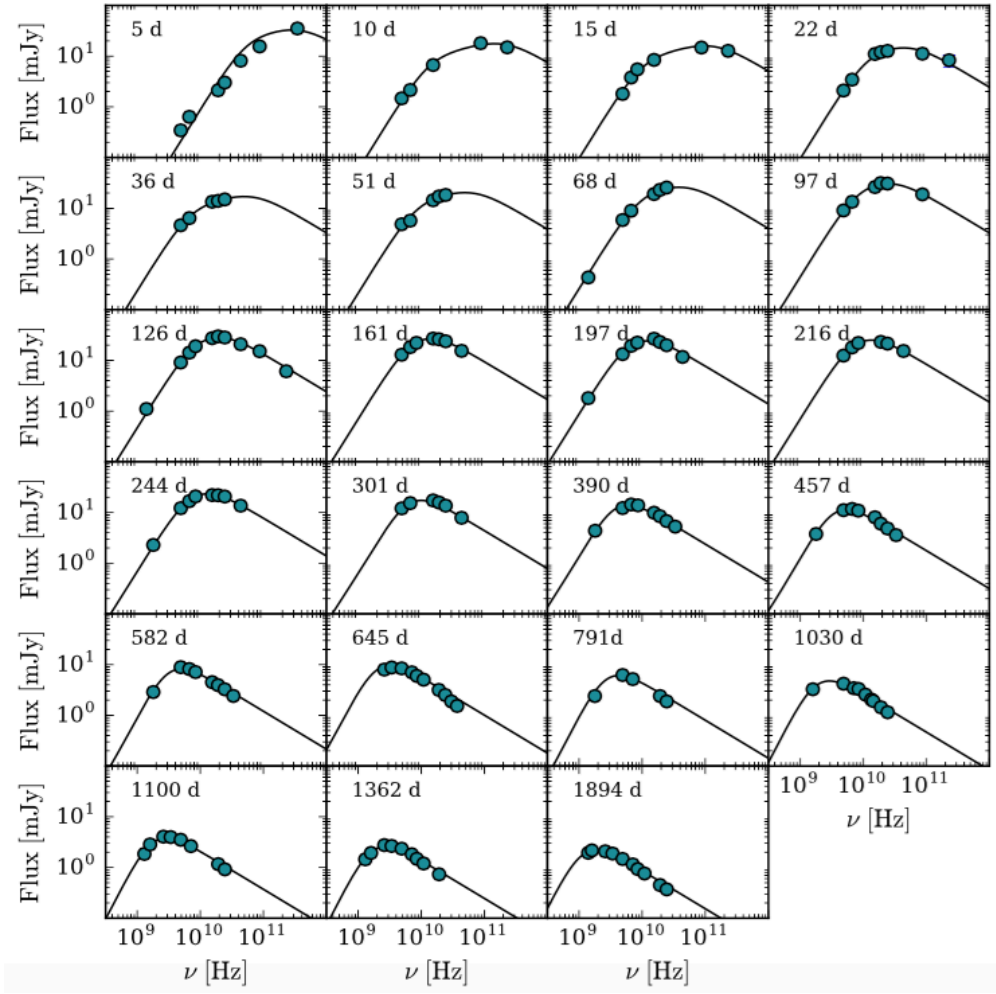
Outflows Generate Synchrotron Emission



Energy, E_K
Density, n
Shock physics (ε_e, ε_B)

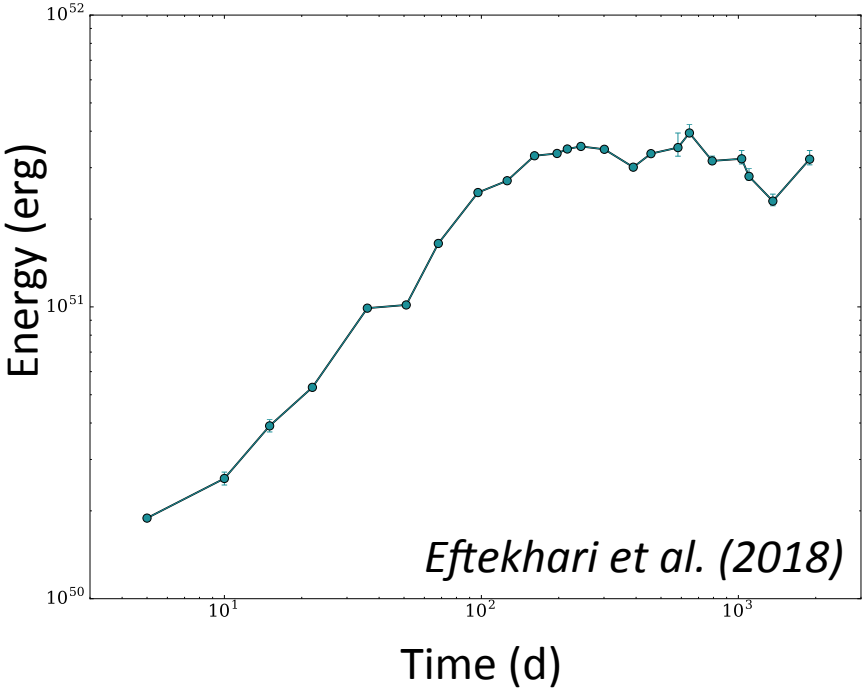
Sari, Piran & Narayan (1998)
Slide courtesy T. Laskar

Outflows Generate Synchrotron Emission

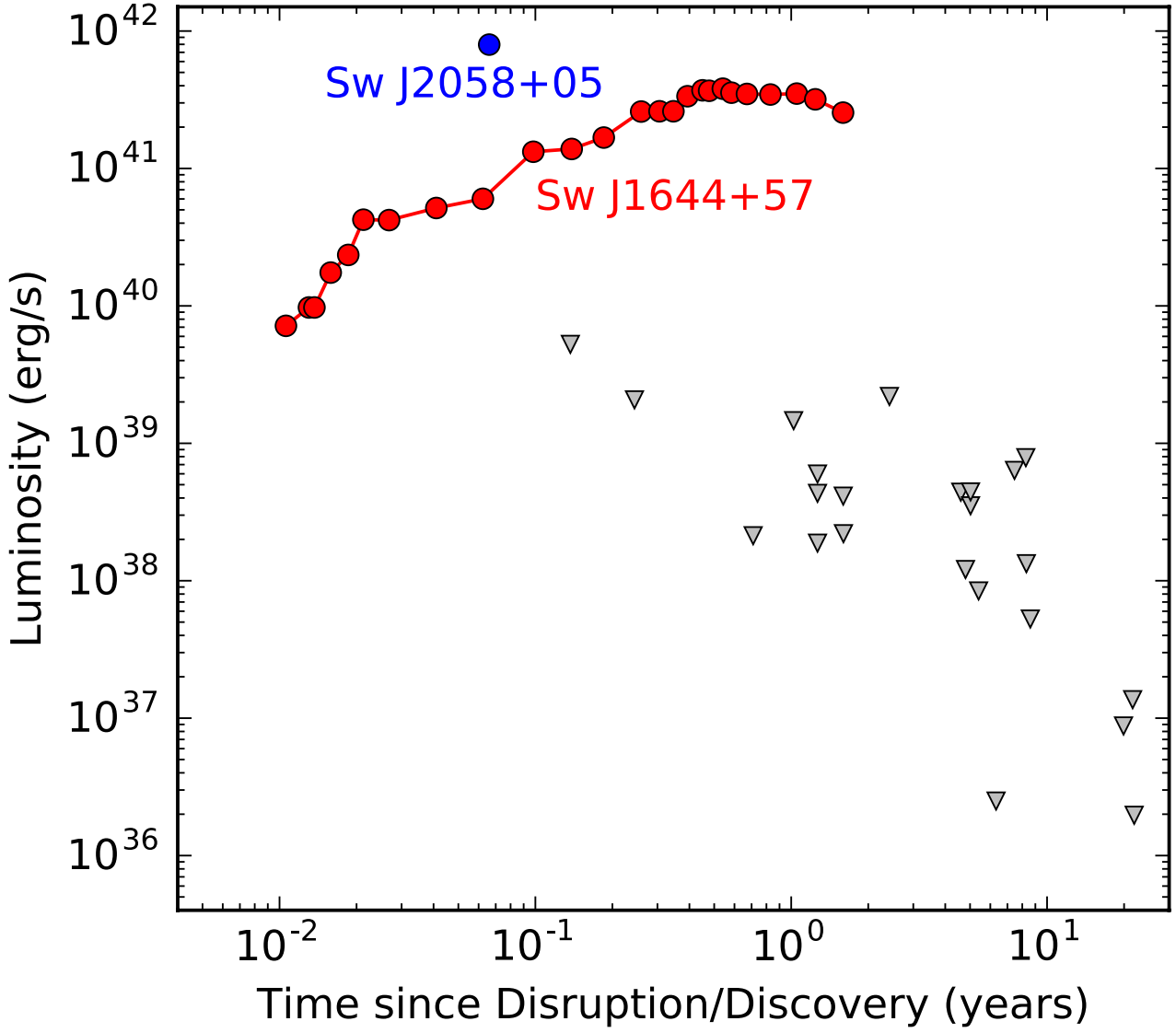


Eftekhari et al. (2018)

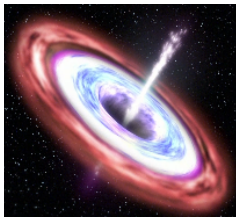
TDE Swift J1644+57



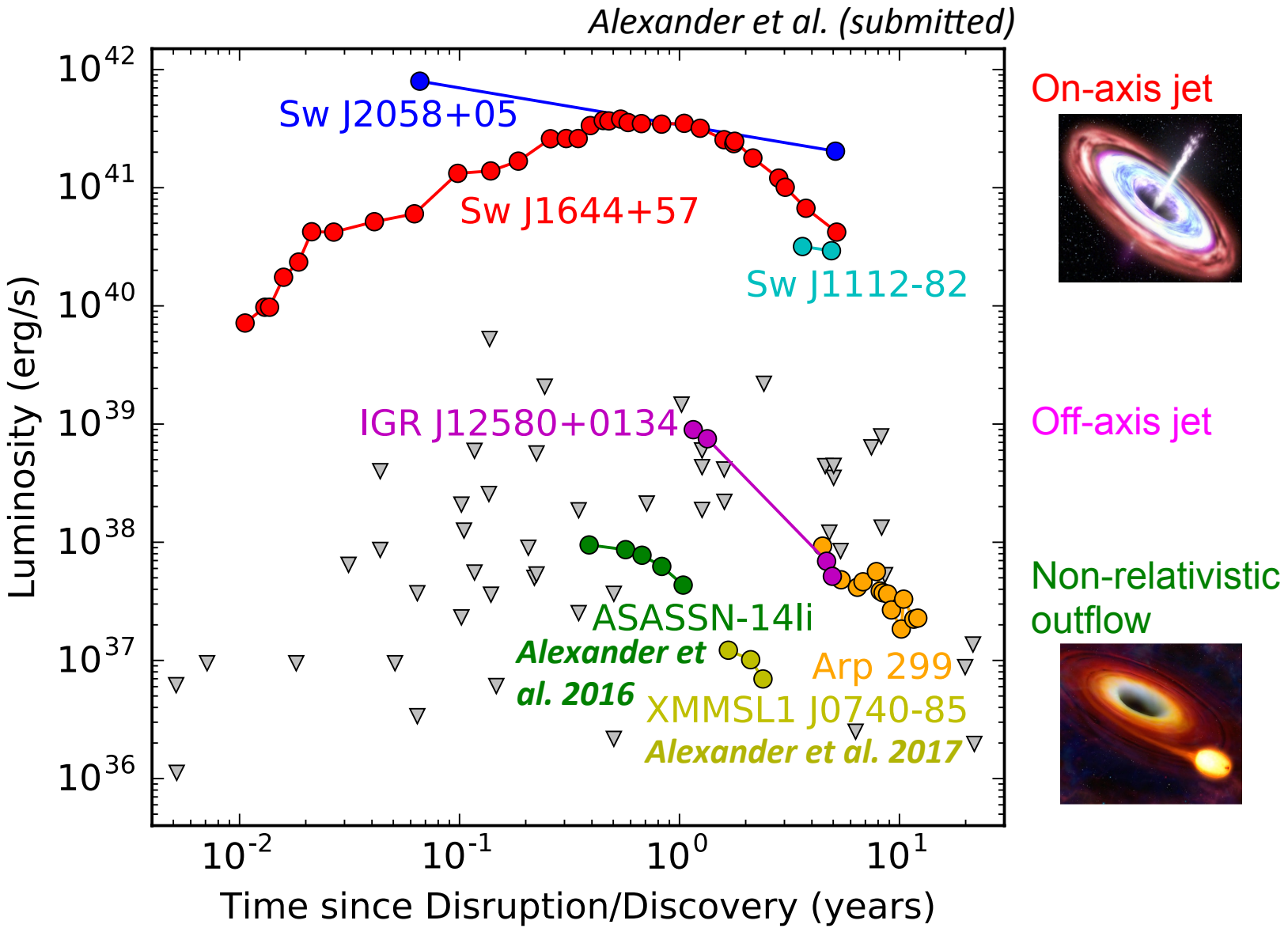
TDE Radio Observations (2014)



On-axis jet



TDE Radio Observations (2019)



On-axis jet

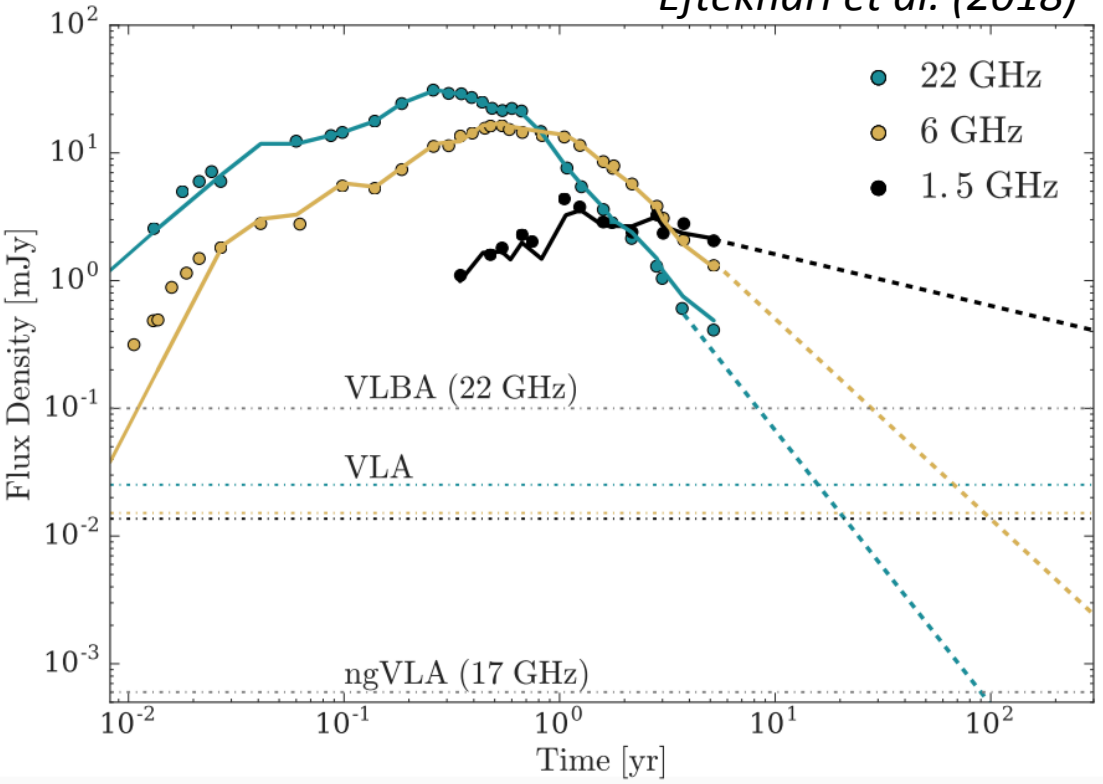
Off-axis jet

Non-relativistic outflow

High-frequency sensitivity is crucial

- TDEs peak **brighter** and **faster** at higher frequencies
  - To probe the highest densities, we must observe in the mm
  - Lower background emission from other processes in the host galaxy (e.g. star formation, AGN)
- But until recently, mm facilities lacked the sensitivity + resolution…

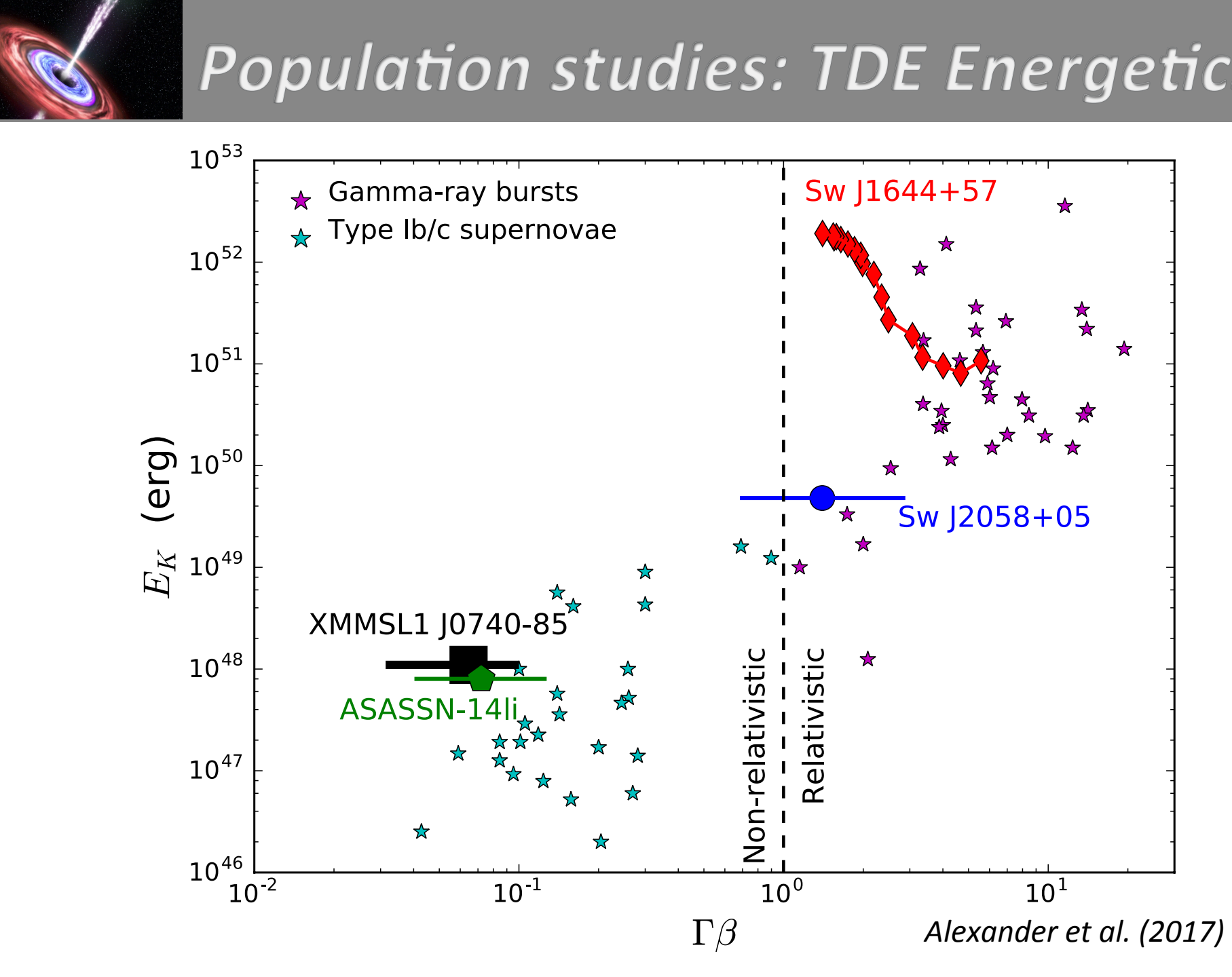
Eftekhari et al. (2018)



ALMA: A TDE Outflow Machine

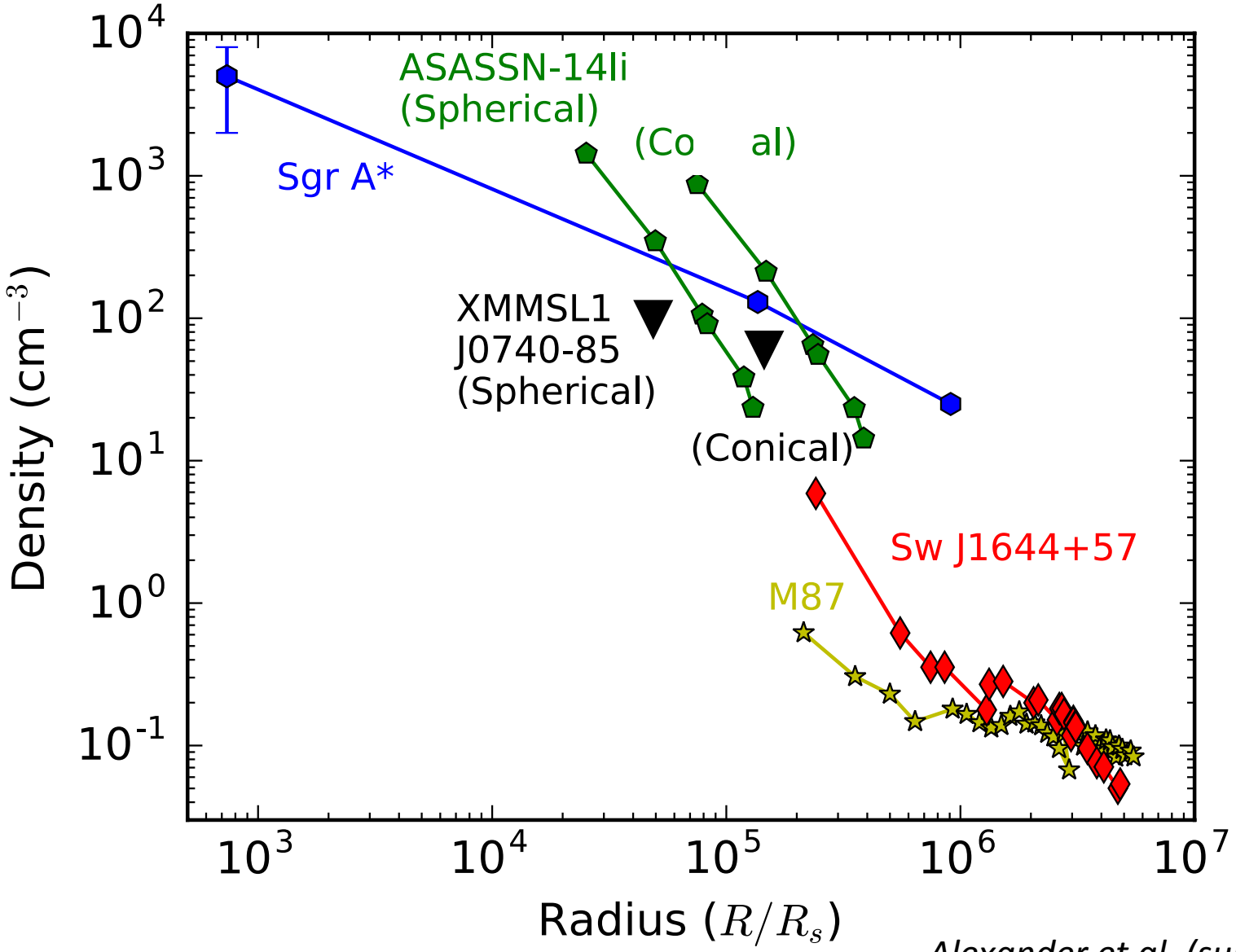
- For the past 9 months, we have been targeting new TDEs with ALMA (PI: Alexander)
  - Recently reapproved for Cycle 7

Population studies: TDE Energetics



Alexander et al. (2017)

Circumnuclear Density Profiles



Alexander et al. (submitted)

Summary

- ALMA is an ideal facility to study the faintest outflows yet seen in TDEs
  - First results from our Cycle 6 program coming soon (Alexander et al. 2019 in prep)
  - Within the next few years, we will know what fraction of TDEs produce low-energy outflows