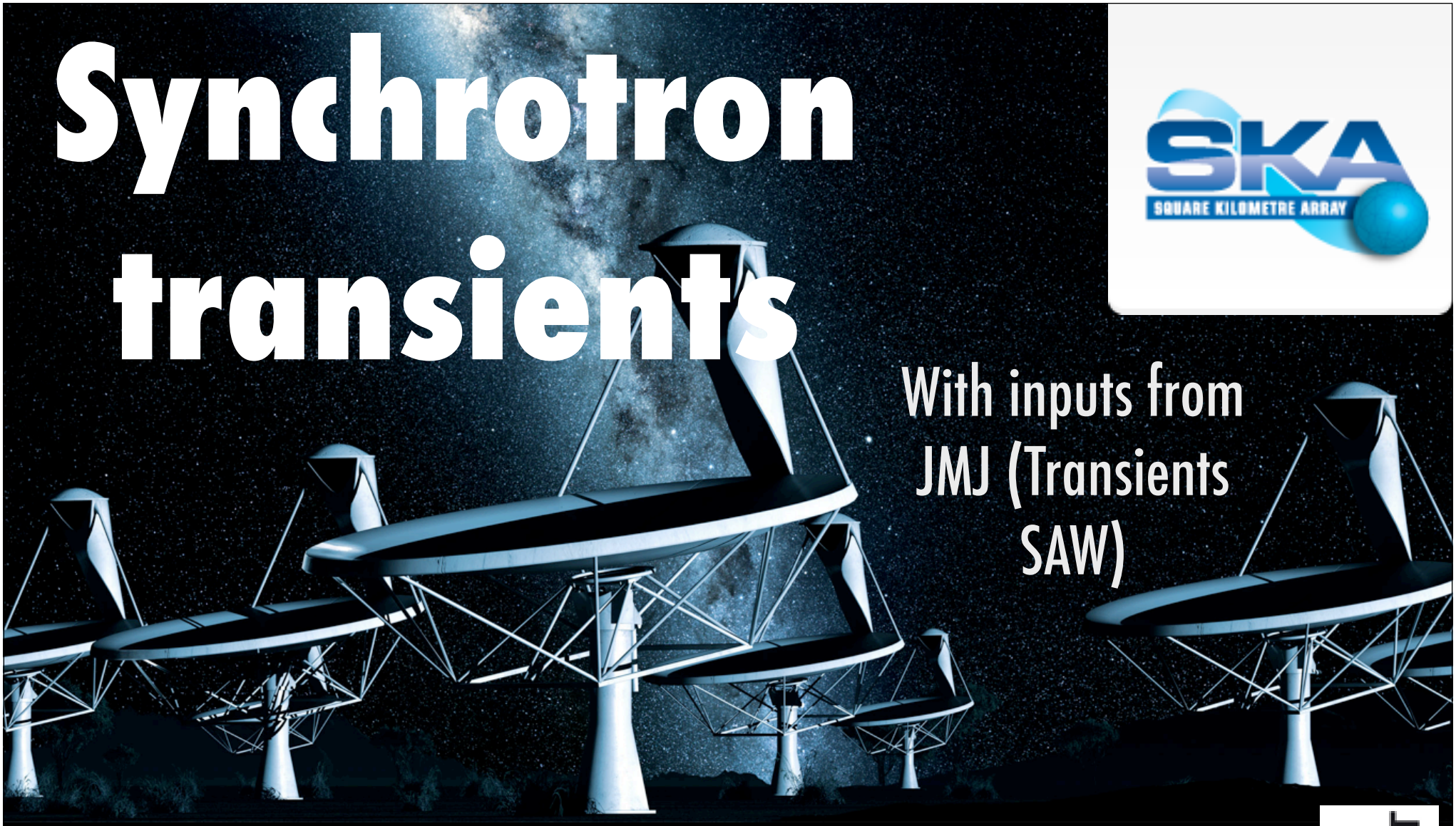
Synchrotron transients



With inputs from JMJ (Transients SAW)

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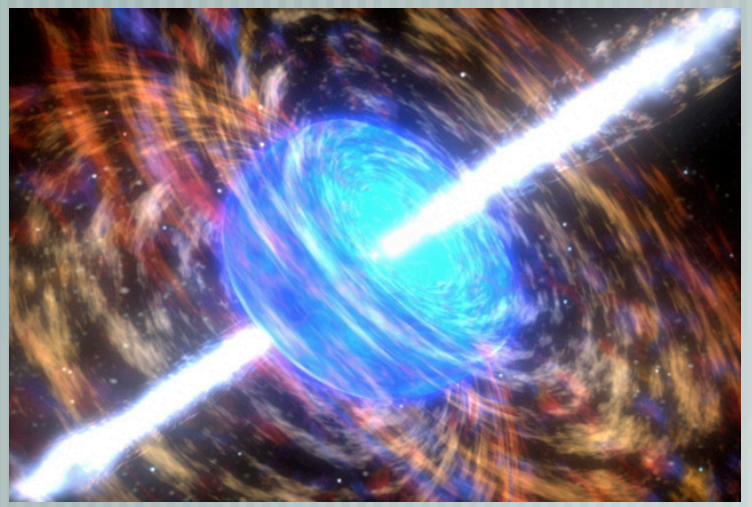
The transients radio sky

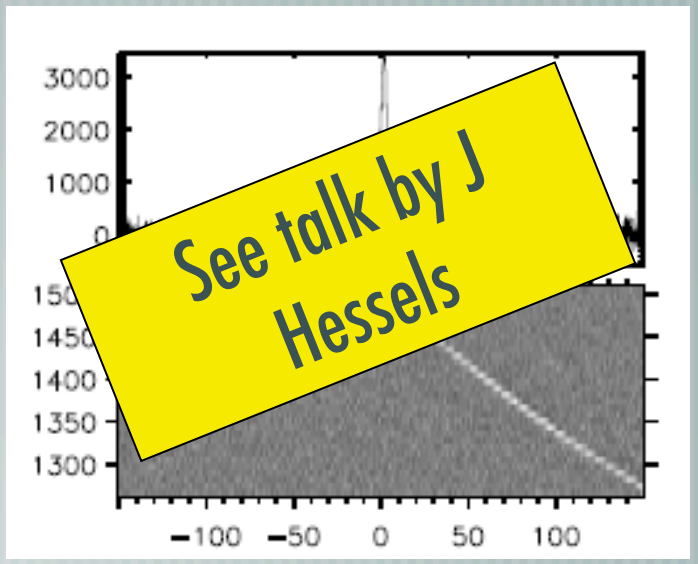
- A glimpse of physics in extreme environments.
- Time domain astronomy: a huge discovery potential, recognised in all recent prospective reports. Testing relativity. Cosmic lighthouses for probing the IGM.
- Example of unexpected transients: Discovery of pulsar by J. Bell (Nobel for Hewish), SN1a, GRB, ...
- Even now, new type of transients are still discovered nowadays: TDEs and FRBs
- A huge variety of transients on very different timescales: X-ray binaries, pulsars, black holes at cosmological distance, atmospheric γ-ray flashes, exoplanets, EM signature of GW, the unknown, ...

Two flavours of transients

- **Incoherent** synchrotron emission
  - Relatively slow variability
  - Brightness temperature limited (10^{12} K)
  - Associated with all explosive events
  - Strong potential for MW astronomy

- **Coherent** emission
  - Relatively fast variability
  - High brightness temperature
  - Often highly polarised
  - Usually associated with pulsars ?



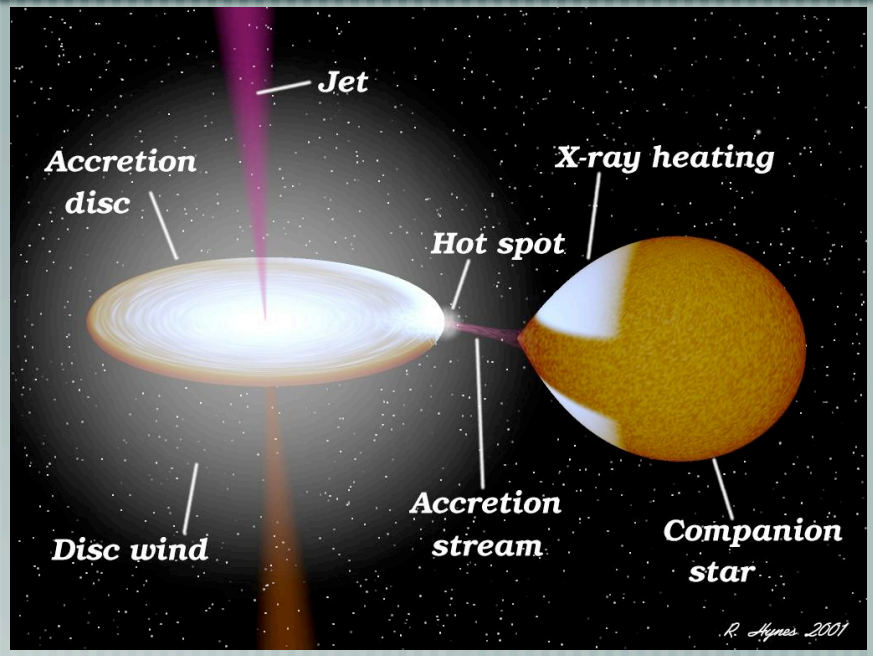


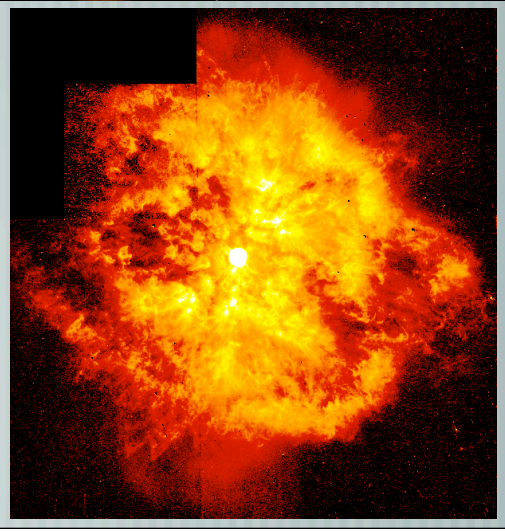
Detection: images

Detection: time series

Slow Synchrotron Transients

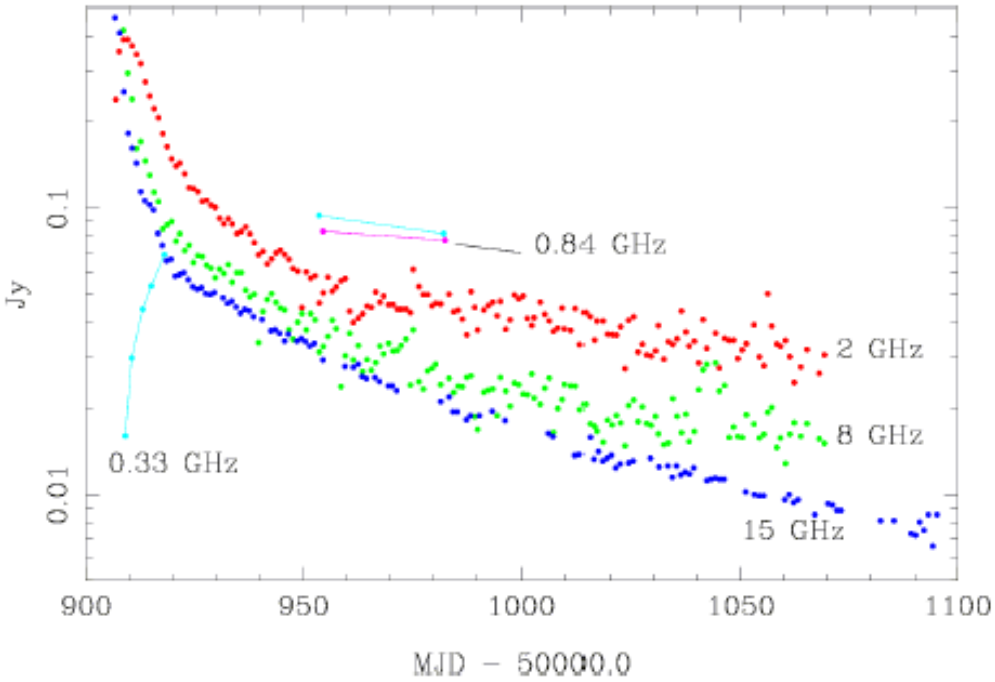
- Primarily explosive events or outflows
- Known source classes:
  - Cataclysmic Variables (CVs)
  - X-ray Binaries (XRBs)
  - Magnetar outbursts
  - Supernovae (SNe)
  - Active Galactic Nuclei (AGN)
  - Tidal disruption events (TDEs)
  - Gamma-ray bursts (GRBs)
  - Some novae (usually thermal)
  - **but do not forget the unknown !!**

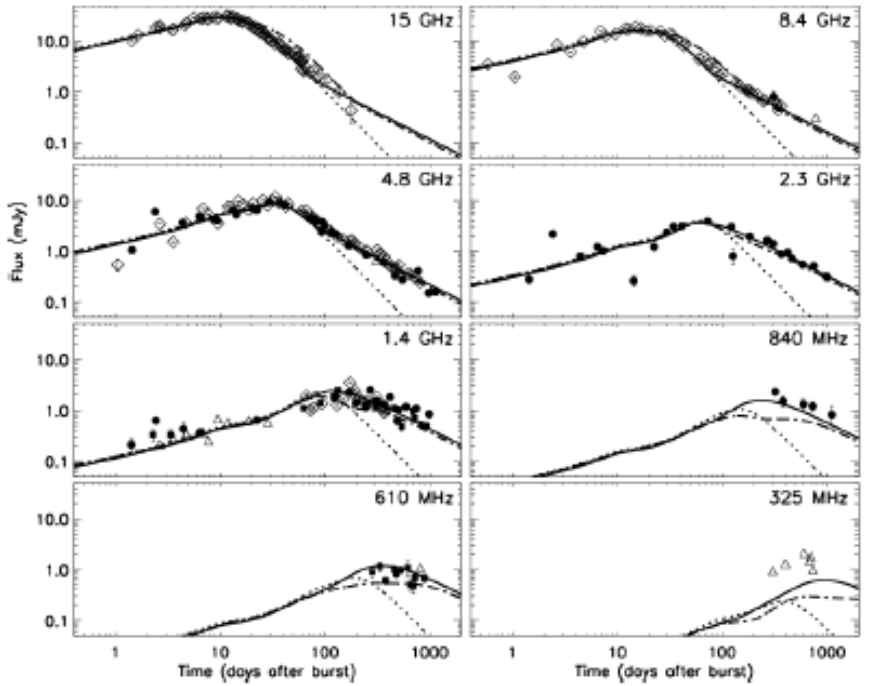




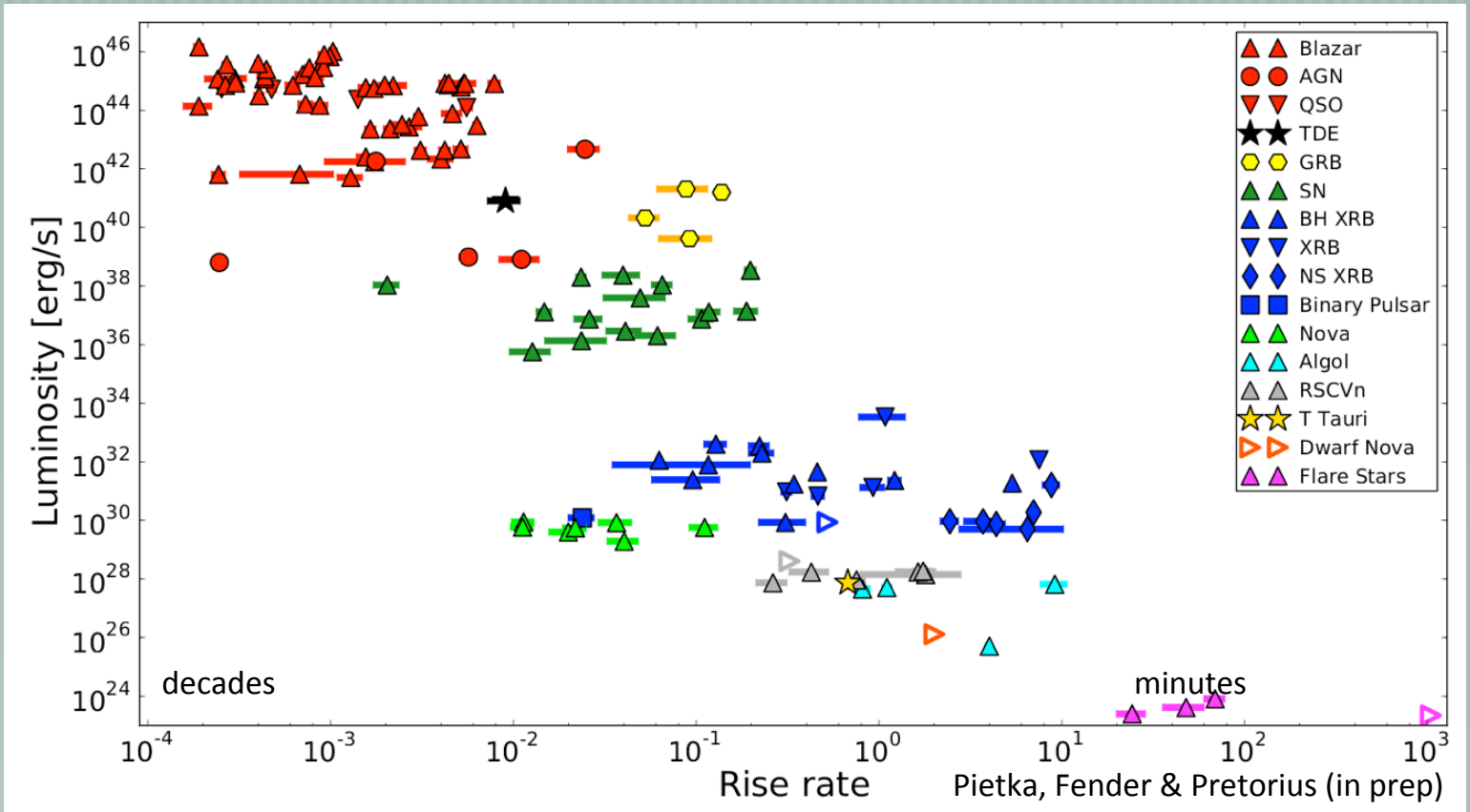
Typical evolution of a slow transient

- Shock-accelerated electrons and magnetic fields
- Important frequency evolution. Become optically thin later at lower frequencies (+lower flux also). Need high freq. SKA capabilities !!



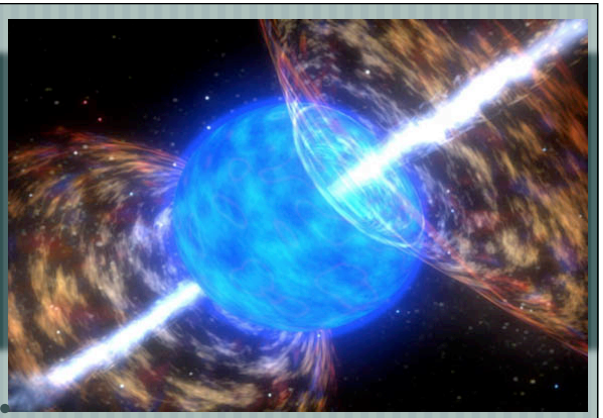


Similar physics along the mass scale

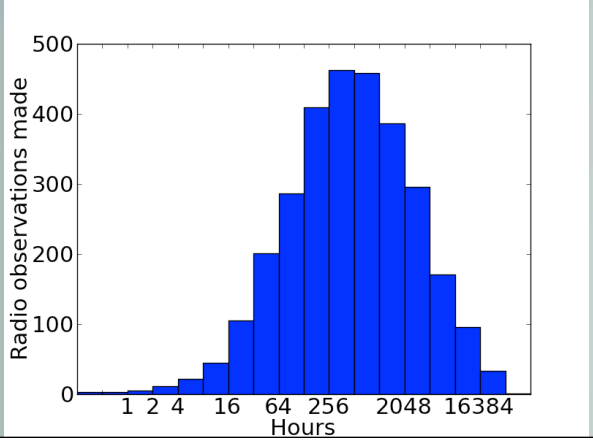


Measuring the kinetic feedback with transient cosmic explosions

Gamma-ray bursts



- Probes of distant Universe (could be seen to z~25!)
- Estimated rate 10^{-6} year^{-1} galaxy^{-1}
- Radio emission generated by afterglows
- Prompt emission likely self-absorbed at low frequencies

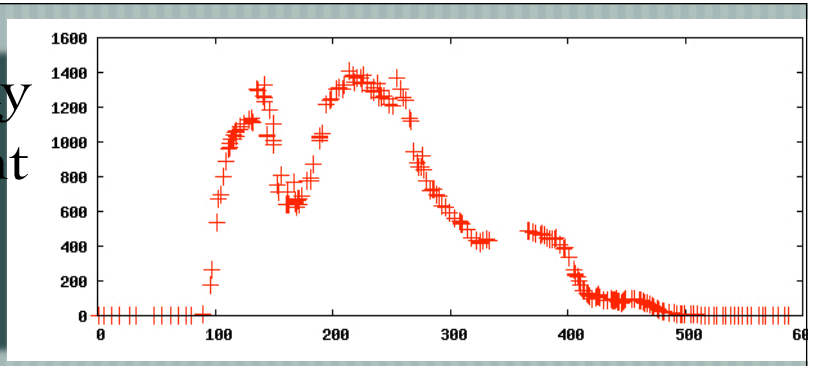


- Key questions:
  - Physical parameters
    - Kinetic energy of explosion
    - Density of circumburst medium
    - Outflow geometry
  - Orphan afterglows
    - Beaming fraction and total GRB rate
  - Radio loud vs radio quiet populations
    - 70% show radio emission, 30% do not

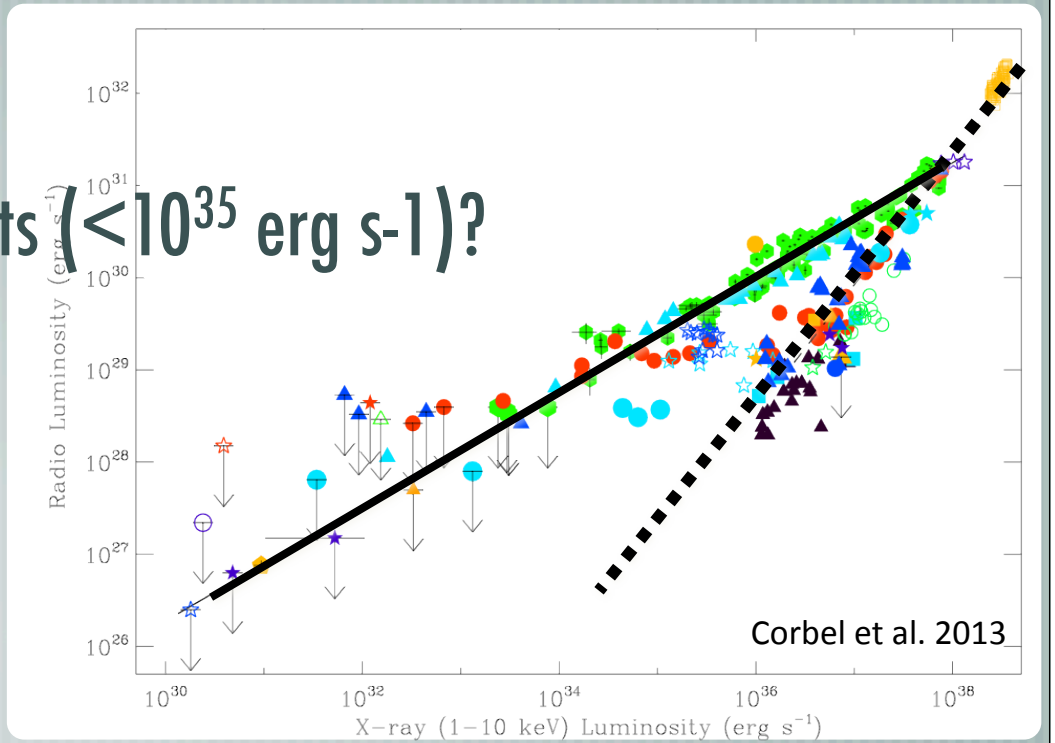
Tidal disruption events

- Star passing too close to a massive black hole
- Estimated rate 10^{-5} year^{-1} galaxy^{-1}
- Probe of jet physics
  - Launching mechanism
  - Super-Eddington accretion rates
  - Dense environments (cf AGN jets)
  - Possibly the most frequent synchr. transients (Frail et al. 2012)

X-ray binaries I



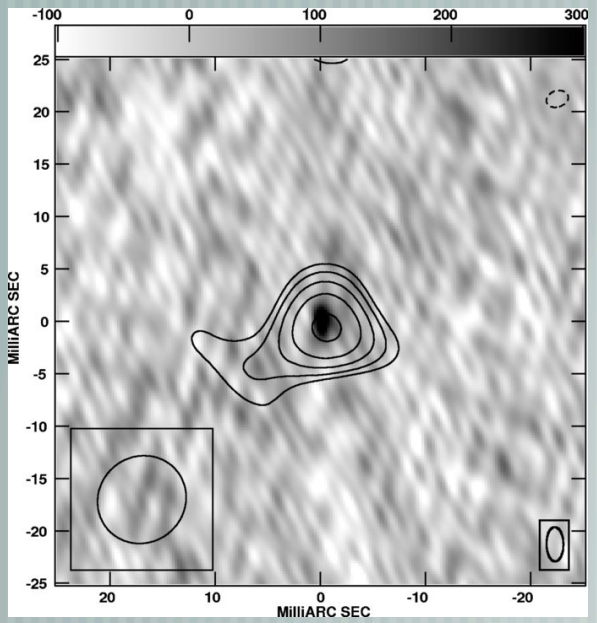
- Accreting black holes, neutron stars, white dwarfs
  - Do quiescent BHs host radio jets?
  - What fraction of the liberated accretion power do they carry away?
  - Broad-band emission ?
  - Nature of very faint outbursts ($<10^{35}$ erg s-1)?
- A few tens of outburst per year



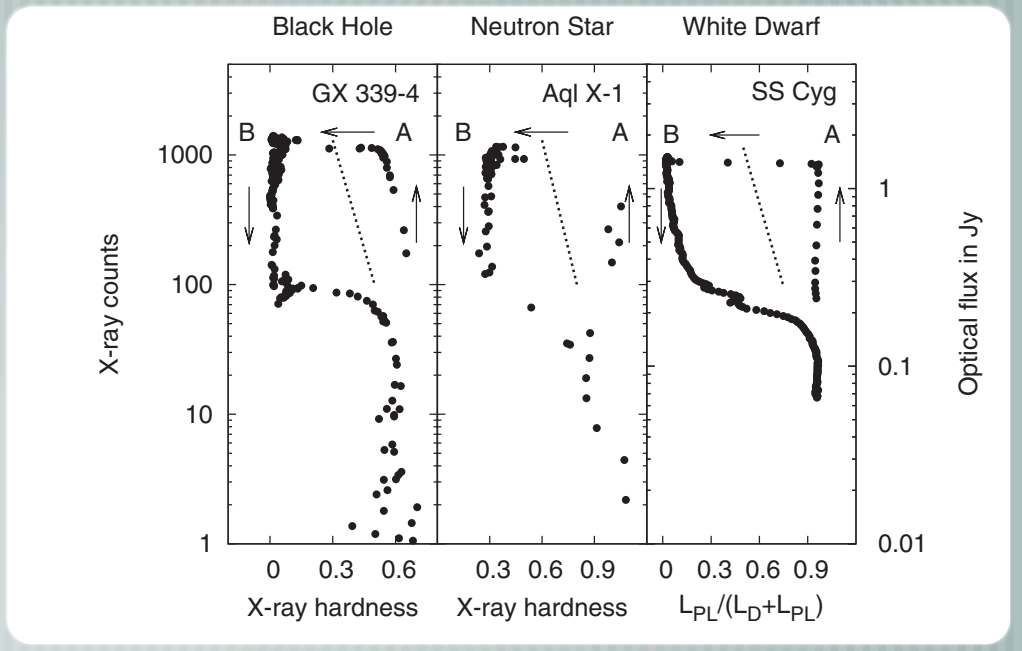
SKA: probing a significant fraction of the whole outburst duration for almost all BHs in our Galaxy. All flaring transient BHs accessible in the local Universe (possibly also up to Virgo @ 15 Mpc)

X-ray binaries II

- NSs and WDs: Is the accretion-ejection coupling universal?
- How does jet launching depend on depth of potential well, presence of a stellar surface/magnetic field?



Miller-Jones et al. 2010

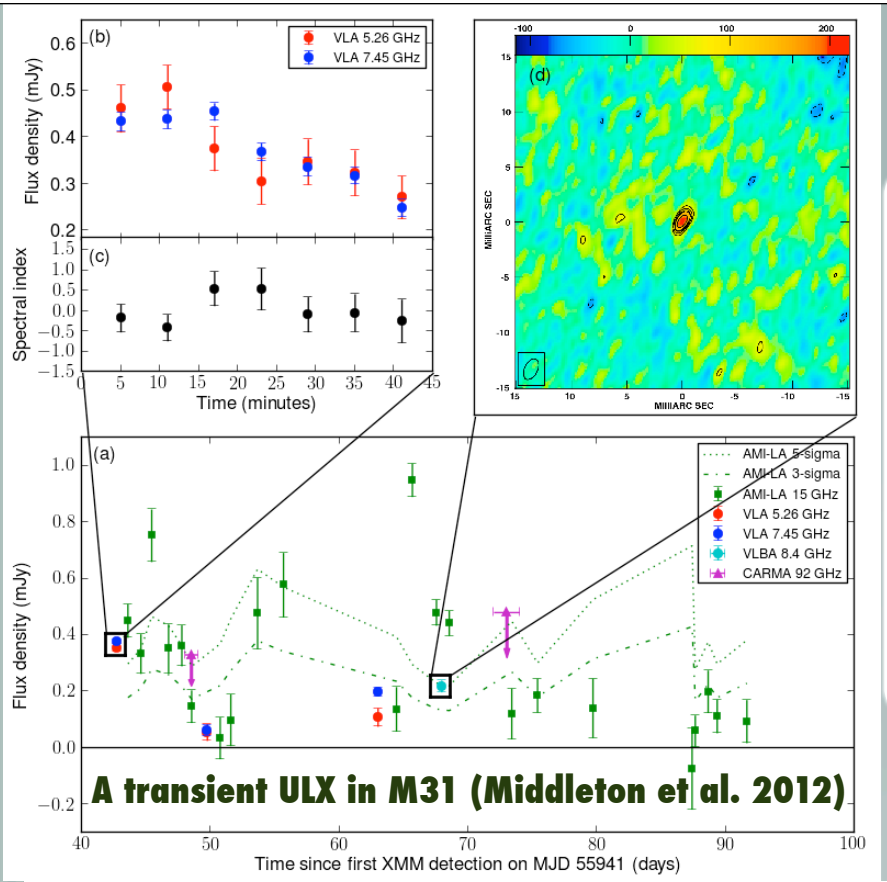


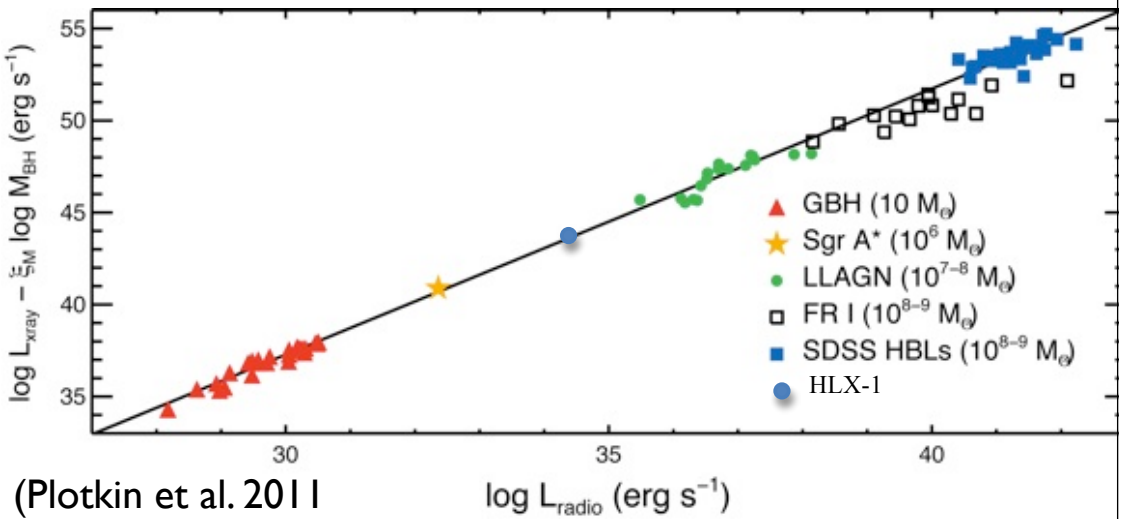
Koerding et al. 2008

Ultra-luminous X-ray sources

- X-ray Luminosities $>1.3 \times 10^{39}$ erg s^{-1} (Eddington limit for a 10 $M_\odot$ BH)
  - Are these stellar-mass BHs accreting at/above Eddington?
  - Is there evidence for massive BHs (HLX-1 with L_X Max $\sim 10^{42}$ erg s^{-1})?
  - Fundamental Plane to get BH masses
  - Probe accretion and ejection at Eddington rates
  - Growth of quasars in early Universe
  - Feedback effect on surroundings (EoR)
  - Needs sufficiently high resolution

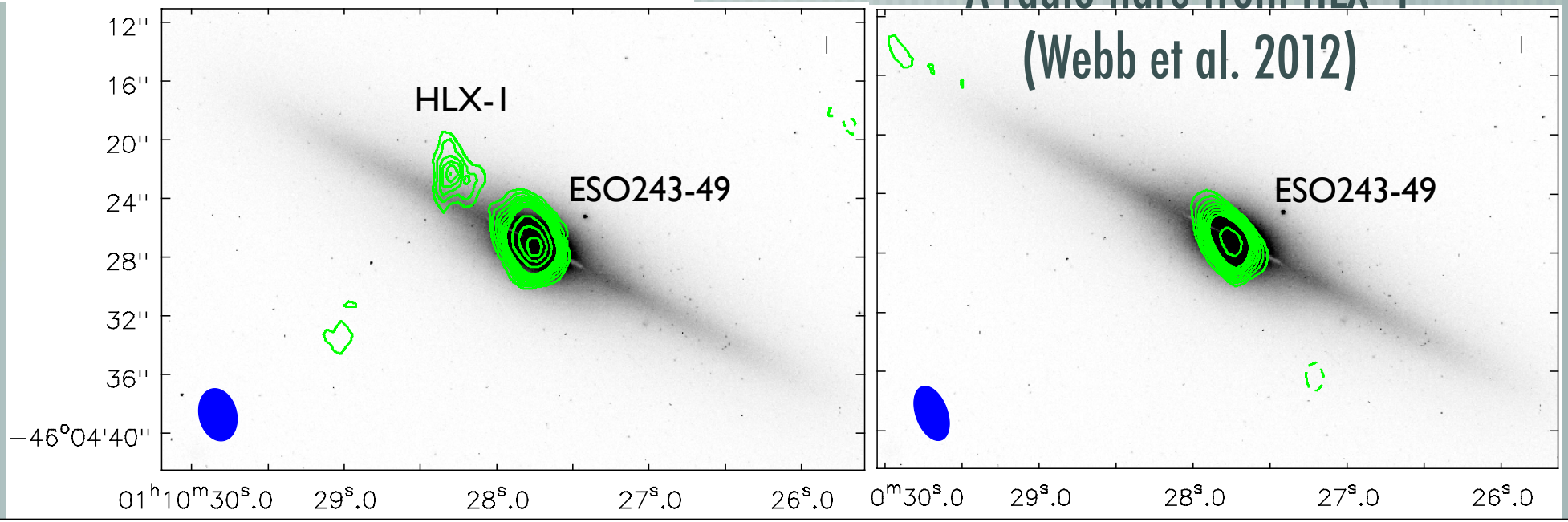
Bridging the gap in mass scale ?





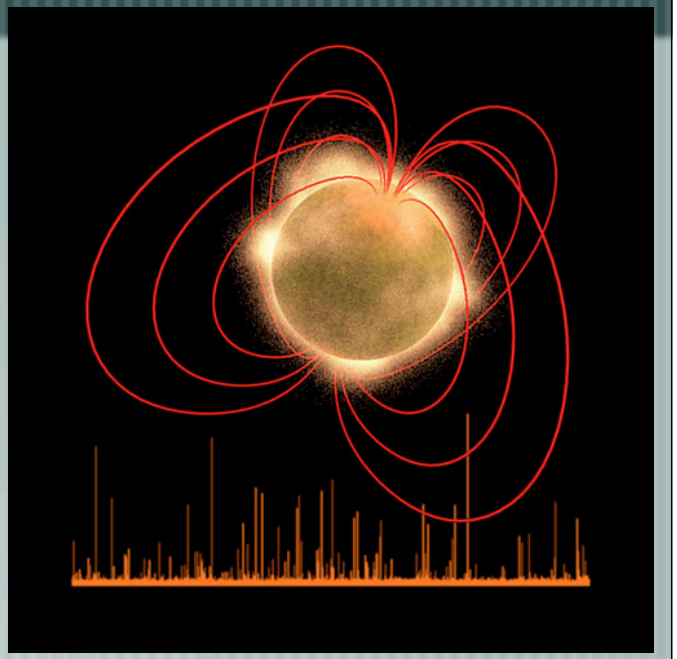
(Plotkin et al. 2011

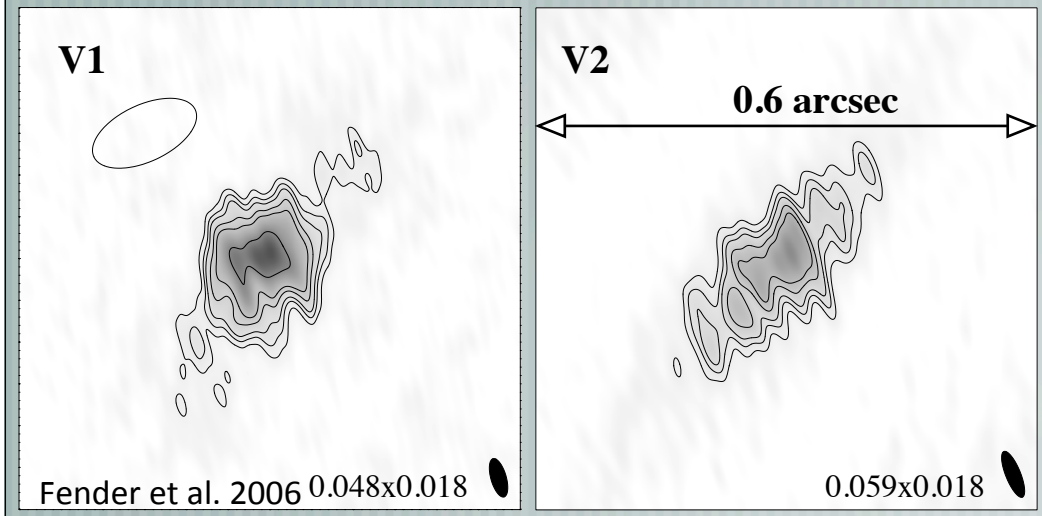
A radio flare from HLX -1 (Webb et al. 2012)



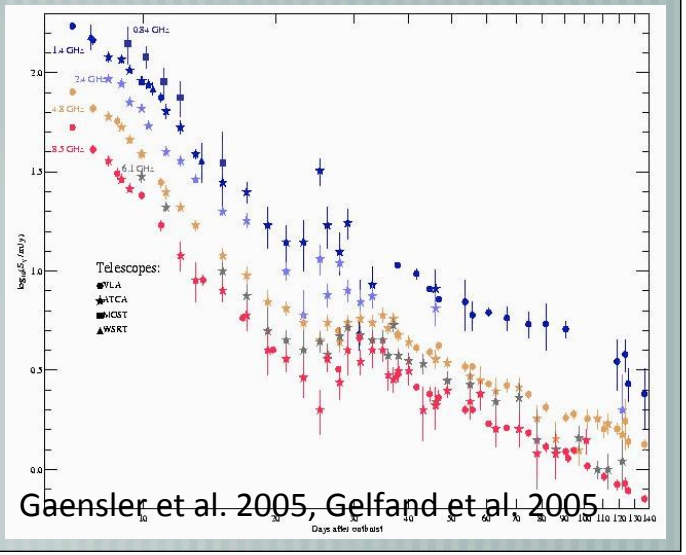
Magnetar giant outbursts

- Explosive injection of energy into ambient medium following rearrangement of B-field
  - Bright synchrotron flares (SGR1806-20)
  - Collimated outflows
  - Probing magnetar giant flare up to 300 kpc.



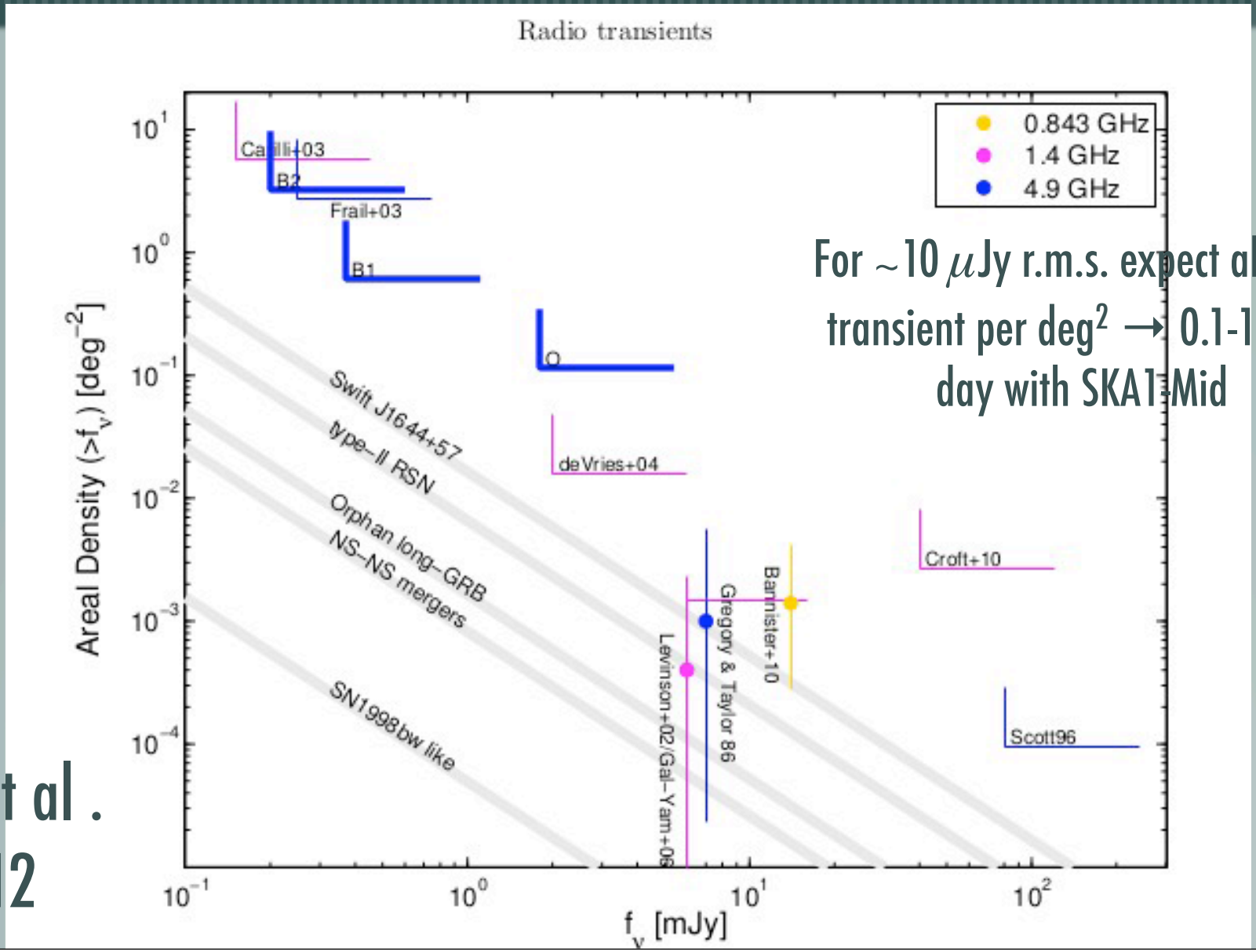


Fender et al. 2006



Gaensler et al. 2005, Gelfand et al. 2005

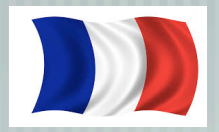
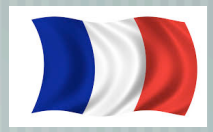
Transients in the SKA era



For ~10 μJy r.m.s. expect about 1 transient per deg^2 → 0.1-10 per day with SKA1-Mid

Frail et al . 2012

Getting involved in transients

- LOFAR Transient KP: All kind of transients: pulsars, slow transients, exoplanets, ... 
- MeerKAT: ThunderKAT  + TRAPUM 
- ASKAP: VAST  + CRAFT
- Get in touch with me if interested

Conclusions

- A variety of synchrotron transients with key questions on the extreme Universe: black holes, relativistic jets,...
- Electromagnetic counterpart of a GW event
- Probing the distant Universe
- Do not forget the unknown, i.e. unexpected discoveries by opening new parameter space in the time domain with superb sensitivity.
- A lost of synergies with forthcoming MW facilities (e.g. LSST: millions of transients per night !!)