Chapter in **Advancing Astrophysics with the SKA – II**

The Astrophysics of Fast Radio Bursts

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Fast radio bursts (FRBs) provide a glimpse of high-energy astrophysical phenomena in other galaxies. They point the way to extreme conditions that are currently undetectable by any other known means. These coherent radio flashes have timescales of microseconds to milliseconds, and inferred energies that are comparable to those of the most extreme bursts seen from Galactic neutron stars. However, the nature of FRB sources remains an open question in astrophysics. Magnetically powered neutron stars known as 'magnetars' are a leading candidate for explaining the FRB phenomenon, but other plausible progenitors include magnetically interacting neutron-star binaries or accreting black holes. The diversity of FRB burst types and their galactic environments hint that multiple mechanisms and progenitor types may be responsible. Here we discuss the ways in which the SKA can uncover the nature of FRBs. In particular, we focus on the key advantages of the SKA: its Southern Hemisphere location and hence overlapping sky coverage with the Vera C. Rubin Observatory, its high sensitivity compared to existing wide-field FRB surveys, its fast search timescales down to tens of μs, and its broad spectral coverage with bands from 50 MHz to 15 GHz. With these capabilities, the SKA will excel in detecting FRB sources across new frequency ranges and timescales. This will aid in a better understanding of the fundamental astrophysics behind FRBs, which will in turn also contribute to their use as cosmological probes, as explored in companion chapters.

1 Introduction

The discovery of pulsars in 1967 by Jocelyn Bell Burnell and collaborators revealed the existence of neutron stars and provided a powerful observational tool for studying the physics of such compact objects (Hewish et al., 1968). Forty years later, the discovery of the first fast radio burst (FRB) by Lorimer et al. (2007) established an even more extreme type of impulsive radio emission, providing another laboratory for studying the extremes of the Universe.

Observationally, FRBs can be defined as roughly millisecond-duration radio flashes whose dispersion measures (DMs) imply an extragalactic origin. Broadly, there are at least two classes of FRBs: those that sporadically repeat and those that are apparent one-off events. In addition to their activity rates, systematic differences in the emission bandwidth and timescale of repeaters vs. non-repeaters also suggest that they derive from distinct mechanisms and/or progenitors (Pleunis et al., 2021a; Curtin et al., 2025).

It took over a decade to firmly establish the astrophysical origins of FRBs (as opposed to artificial interference), to collect the first small sample of signals, and to localise a few to their host galaxy (Thornton et al., 2013; Spitler et al., 2014; Chatterjee et al., 2017). In the past five years, however, progress has rapidly accelerated. Thousands of FRB sources are now known (CHIME/FRB Collaboration, 2025), over a hundred have been localised to their host galaxy (e.g., Bhandari et al. 2020; Law et al. 2024; Pastor-Marazuela et al. 2025; CHIME/FRB Collaboration et al. 2025b), and monitoring of repeating sources has revealed their dynamic local environments (e.g., Michilli et al., 2018; Xu et al., 2022; Mckinven et al., 2023; Anna-Thomas et al., 2023; Ould-Boukattine et al., 2025; Pandhi et al., 2026).

The short timescales (μs - ms) and enormous luminosities ($\sim 10^{36} - 10^{44}$ erg s^{-1}) of FRB emission necessitate a compact and high-energy-density environment. Additionally, to produce such high luminosities on such short timescales, a coherent emission mechanism is required. Theoretical models for the nature of FRBs have thus focused on white dwarfs (WDs), neutron stars (NSs), and black holes (BHs) with a variety of emission mechanism models (e.g., Kumar et al., 2017; Lu and Kumar, 2018; Metzger et al., 2019). However, the exact underlying emission mechanism, progenitor type, and energy source are still not definitively confirmed.

The discovery of an FRB-like burst from the Galactic magnetar SGR 1935+2154 suggests that at least some extragalactic FRBs arise from magnetars (Bochenek et al., 2020; CHIME/FRB Collaboration et al., 2020). However, the burst from SGR 1935+2154 was a few orders of magnitude less energetic than FRBs seen at extragalactic distances (see Figure 1; Nimmo et al., 2022) and FRBs have been seen from a range of local host galaxy environments with a diverse set of burst properties (e.g., Chatterjee et al., 2017; Bhardwaj et al., 2021; Kirsten et al., 2022; Gordon et al., 2023; Shah et al., 2024; Eftekhari et al., 2024). Thus, it remains unclear whether magnetars can explain all FRB sources. As with short- and long-gamma-ray bursts (GRBs), the observed population of FRB signals may have multiple physical origins (Berger, 2014; Gal-Yam, 2019).

Astronomers have only recently begun exploring the full parameter space for FRB discovery. While Figure 1 compares FRB luminosities and durations to certain Galactic events, it does not emphasize the different activity rates, polarization states, and spectral extents seen from FRBs. Future efforts

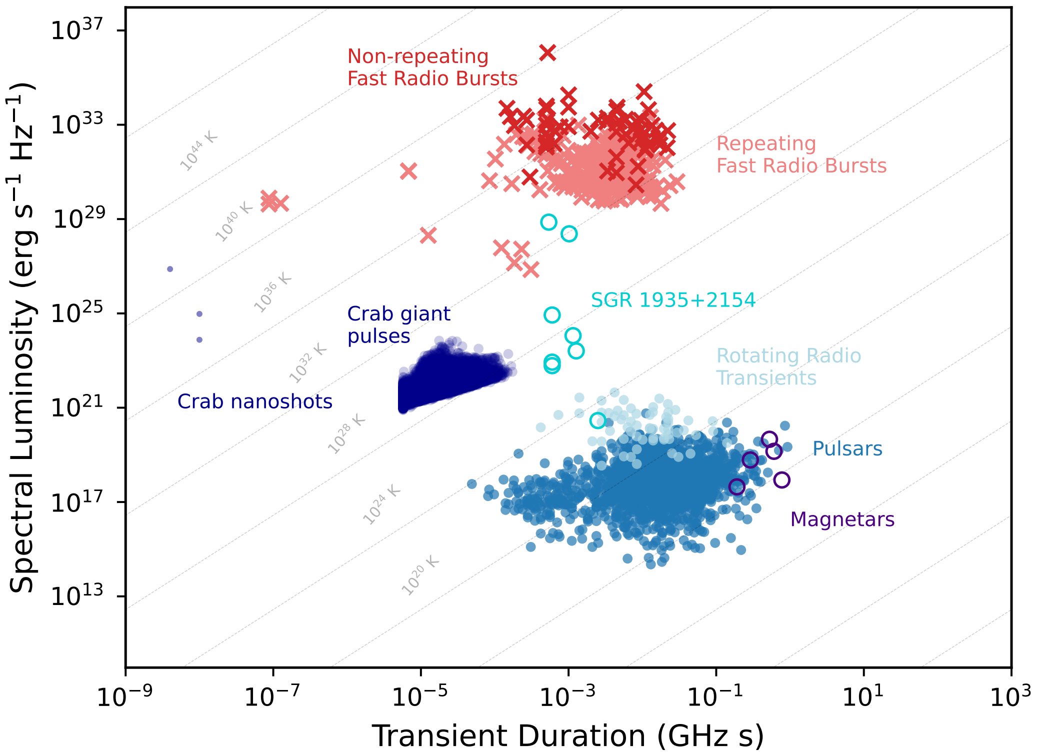

Figure 1: Spectral Luminosity vs. frequency-weighted transient duration for a sub-sample of pulsars, rotating radio transients (RRATs), Crab giant radio pulses (GRPs), Crab nanoshots, SGR 1935+2154 bursts, magnetar pulses, and FRBs. Figure adapted from that of Nimmo et al. (2022) with the additional inclusion of results from Ryder et al. (2023); Law et al. (2024); CHIME/FRB Collaboration et al. (2025b). The FRBs span over a full 10 orders of magnitude in their luminosities, with the brightest bursts from the Galactic magnetar SGR 1935+2154 consistent in luminosity with the faintest repeating FRBs detected. Burst luminosities from SGR 1935+2154 similarly span a large seven to eight orders of magnitude in range (Kirsten et al., 2021). While not demonstrated here due to showing the frequency-weighted transient duration, non-repeating FRBs tend to have shorter temporal durations but larger bandwidths than bursts from repeating sources (Pleunis et al., 2021a; Curtin et al., 2025).

to expand transient searches to a wider range of timescales, frequencies, and redshifts could be the key to revealing multiple astrophysical origins for FRBs.

In this chapter, we outline how the SKA can contribute to understanding the origin(s) and astrophysics of FRBs. Two accompanying chapters titled ‘Probing the baryon distribution with Fast Radio Bursts’ and ‘Fast Radio Bursts as Cosmological Probes’ focus on how we can use FRB signals as tools to study other topics such as the density, clumpiness, and magnetisation of the intergalactic medium (IGM) as well as the larger-scale evolution of the Universe (Caleb et al., 2026a,b). Here we focus on the following interconnected, high-level questions:

- Do all FRBs have the same astrophysical origin?

- Which astrophysical sources produce FRBs, and under what circumstances?
- Do all FRBs repeat, or are some related to cataclysmic explosions?
- What powers FRB emission and what is the mechanism?
- What can we learn about the astrophysics of WDs, NSs, and BHs using FRBs?
- How do FRBs relate to the significantly less luminous radio transients we detect from Galactic sources?
- What physical properties of FRBs are intrinsic rather than due to propagation effects? How does this impact FRBs as cosmological probes?

2 How to reveal the nature and astrophysics of FRBs

There is a rich literature describing possible FRB progenitors and emission mechanisms. We refer here to the progenitor as the astrophysical object and conditions that lead to FRB production while the emission mechanism is a physical process by which a progenitor emits an FRB. The high volumetric event rate of FRBs (Ravi, 2019) as well as their repeating nature (Spitler et al., 2016) tells us that most FRB progenitors must be relatively long-lived sources of energy, though some small fraction of FRBs could come from cataclysmic events. Platts et al. (2019) provide a catalogue of FRB theories, and describe progenitors like isolated magnetars (Lyubarsky, 2014; Beloborodov, 2020), accreting BHs (Sridhar et al., 2021), and compact binary WDs (Mottez and Zarka, 2014). Potential cataclysmic events include, e.g., binary NS, BH, or WD mergers (Kremer et al., 2021; Cooper et al., 2023). More exotic proposals involve cosmic strings (Brandenberger et al., 2017), axion interactions in NSs (Iwazaki, 2015; Van Waerbeke and Zhitnitsky, 2019), and BH 'batteries' (Mingarelli et al., 2015). Platts et al. (2019) also describe the possible emission mechanisms by which FRBs are generated, which could be common to several progenitor types. These mechanisms include, e.g., coherent curvature radiation (Kumar et al., 2017; Lu and Kumar, 2018), synchrotron masers (Metzger et al., 2019), and Dicke's super-radiance (Houde et al., 2018).

Depending on their exact origins, FRBs could provide new insights into the underlying physics of WDs, NSs, and (stellar mass) BHs, all objects that are notoriously hard to detect, especially at extragalactic distances. Understanding the intrinsic properties and nature of FRBs will thus have direct implications for our understanding of high-energy astrophysics, compact objects, and possibly even dark matter, cosmic strings, or axion physics.

As with many open topics in astronomy, several complementary strategies are needed to further extend our understanding of FRBs: (1) a larger population of known sources to identify groupings and outliers, (2) deeper characterisation of individual sources, and (3) exploration of a wider observational parameter space. Below, we outline some of the key FRB observables that are relevant for these strategies.

FRB signal properties: The spectral, temporal, and polarimetric properties of FRBs give hints to their emission mechanisms and serve as a way to quantitatively compare different sources (Hessels et al., 2019; Li et al., 2021b; Mckinven et al., 2025; Nimmo et al., 2025). The observed signals are also influenced by propagation effects incurred in the intervening magneto-ionic media along the line-of-sight, giving us direct insights into both the local environments of FRBs (Michilli et al., 2018; Feng et al., 2022; Anna-Thomas et al., 2023) as well as the intervening media (see accompanying chapters on FRBs as cosmological probes; Caleb et al., 2026a,b). These effects include dispersion (quantified by dispersion measure, DM), scattering (quantified by scattering time, $\tau_{\rm scat}$), scintillation (quantified by scintillation bandwidth, $\nu_{\rm scint}$), and Faraday rotation (quantified by rotation measure, RM). Repeating FRBs sometimes show a time-frequency drift in their emission patterns — commonly referred to as the 'sad trombone' effect — which is likely a radius-to-frequency mapping phenomenon as the burst propagates outwards from the central engine (Hessels et al., 2019). A larger sample of FRBs at different time and frequency resolutions over large spectral extents will provide further insight into both the local environments of these sources, as well as their intrinsic emission mechanisms. This will be crucial for understanding the so-far-observed differences in time and frequency structure seen between repeating and thus-far non-repeating sources.

Prompt multi-wavelength counterparts: Contemporaneous optical, X-ray, or γ-ray emission accompanying an FRB would provide strong clues about the emission mechanism and the total energetics. So far, this has only been achieved with a simultaneous FRB-like radio/X-ray burst from SGR 1935+2154 whose extreme proximity compared to extragalactic FRBs made it much easier to detect (Bochenek et al., 2020; CHIME/FRB Collaboration et al., 2020; Ridnaia et al., 2021; Mereghetti et al., 2020; Li et al., 2021a). Multi-wavelength campaigns of even relatively nearby extragalactic FRBs have so far only resulted in upper limits (Scholz et al., 2020; Trudu et al., 2023; Cook et al., 2024; Pearlman et al., 2025; Eppel et al., 2025; Hanmer et al., 2025; Tian et al., 2025). Next generation, high-energy instruments should continue multi-wavelength observations of repeating FRBs, with particular focus on local-Universe sources. Radio instruments such as the SKA can also trigger on external multi-wavelength alerts such as those from gravitational waves, gamma-ray bursts, and neutrinos. For more details on this, see the chapter on "Rapid response triggering for radio transients with the SKA" (Anderson et al., 2026).

Host galaxies: Identification of an FRB's host galaxy requires roughly arcsecond-level localisation precision, and thus is only achievable using a radio interferometer (Eftekhari and Berger, 2017). Once a host galaxy is known, its redshift provides a distance measurement and hence better constrains FRB energetics. However, obtaining arcsecond-level localizations for FRBs has been a major challenge, with the majority of sources detected so far localized to no better than arcminute precision (CHIME/FRB Collaboration et al., 2021; CHIME/FRB Collaboration, 2025). Nonetheless, if an FRB's host galaxy can be determined, the global properties of the galaxy — in terms of star-formation history, total stellar mass, etc. — can also provide hints as to the nature of the FRB, similar to how the hosts of short and long GRBs have been studied (Bhandari et al., 2020; Heintz et al., 2020; Mannings et al., 2021; Gordon et al., 2023). A better understanding of the host contribution enables a potential statistical reconstruction of the electron density profile in hosts and the distribution of FRBs within them (Ocker et al., 2022b; Leung et al., 2025). This can be very valuable when studying the cosmic distribution of baryons and the effect of feedback mechanisms in a cosmological setting. High-sensitivity observations that discover FRBs that are either under-luminous or very distant may also reveal new trends in the population.

Local environments: When an FRB can be localised to milliarcsecond precision using long-baseline interferometry, then the (tens of) parsec-level local environment can be identified (Figure 2; Tendulkar et al., 2021; Kirsten et al., 2022; CHIME/FRB Collaboration et al., 2025a). This local environment can be studied in terms of star-formation rate, metallicity, and counterparts. A small number of active repeating FRBs (between three and five claimed) are associated with compact (milliarcsecond/parsec-scale) persistent radio sources, which may represent a nebula powered by the burst engine (see Panel C of Figure 2; Marcote et al., 2017; Niu et al., 2022; Moroianu et al., 2025). Time variation of the FRB propagation effects discussed above also reveals the conditions in the local environment by constraining its density, distribution, and magnetisation. With less than ten FRBs currently localised to a few milliarcsecond precision (equivalent to roughly tens of parsec scales in the host galaxies), a larger sample is needed to identify emerging trends and groupings.

Redshift Evolution: Amongst the proposed FRB progenitor models, there is a wide variance in their expected redshift distributions. Even for models proposing a magnetar progenitor, the varying delay times between core-collapse and compact merger formation channels lead to drastically different redshift distributions for the emitted FRBs (Zhang et al., 2021; James et al., 2022; Law et al., 2024). As a result, understanding the redshift distribution of FRB sources can directly inform our understanding of their progenitors and their formation histories. To date, a vast majority of FRBs with known redshifts occur below a redshift of one where the impact of any source evolution in redshift is marginal. A sample of higher-redshift FRBs would be more sensitive to differences in source evolution and provide a direct way to distinguish between potential progenitors. They will also be crucial for work using FRBs as cosmological probes (see accompanying chapters; Caleb et al., 2026a,b).

3 The role of the SKA in understanding FRBs and their astrophysics

Many telescopes worldwide have ongoing FRB observation programs. Wide-field FRB discovery systems include ASKAP/CRAFT (Shannon et al., 2025), CHIME/FRB (CHIME/FRB Collaboration et al., 2018), DSA-110 (Law et al., 2024), and MeerKAT/MeerTRAP (Rajwade et al., 2022). Together, these are discovering several FRBs per day, many of which can now be localised to (sub)-arcsecond precision and associated with a host galaxy. Other radio telescopes — from small single dishes to large interferometers — provide valuable follow-up of repeating sources across a broad frequency range with high sensitivity, cadence, and/or localisation precision. These facilities include Effelsberg, EVN, FAST, GBT, uGMRT, LOFAR, LWA, *Murriyang* (Parkes), MWA, Nançay, NenuFAR, Onsala, Stockert, Toruń, VLA, VLBA, and Westerbork. There are also major FRB facilities on the horizon: in the 300 – 2000 MHz range, BURSTT (Lin et al., 2022), CHORD (Vanderlinde et al., 2019), and DSA (Hallinan et al., 2019) will expand the FRB discovery rate to at least dozens of sources per day while also providing (sub-)arcsecond-level positions.

We expect that the SKA's high instantaneous sensitivity, broad spectral coverage, large 'grasp' (product of field-of-view and sensitivity) together with its frequency agility and sub-arraying capabilities will give it unique and complementary capabilities for FRB science. We outline these below.

3.1 SKA-Low

Discovery Rate: SKA-Low could detect up to thousands of FRBs per year, comparable to the detection rates predicted for future Northern Hemisphere surveys such as CHORD and the DSA (see the accompanying chapters on cosmology for further details; Caleb et al., 2026a). Compared to LOFAR, which is currently the world's most sensitive wide-field telescope operating in the SKA-Low band, SKA-Low AA* will provide over an order-of-magnitude increase in sensitivity and grasp — assuming that commensal FRB searches run with high-cadence. SKA-Low AA4's increase in sensitivity could have a large effect on FRB detection rates as they scale non-linearly with fluence; some repeaters have burst fluence ($\mathcal{F}$ distributions as steep as $\mathcal{F}^{-2} - \mathcal{F}^{-3}$), meaning that even a ×2 increase in sensitivity can lead to a ×4 or ×8 increase in detection rate. However, as discussed below, factors such as scattering may play a major role in non-detections at these lower frequencies.

Population of Low-Frequency FRBs: FRB emission below the CHIME band (< 400 MHz) has been challenging to detect and hence the FRB rate in SKA-Low's spectral range is poorly understood. Despite previous searches with the GBT, uGMRT, LOFAR, LWA, MWA, and NenuFAR, only two FRB sources have been detected below 300 MHz (Pastor-Marazuela et al., 2021; Pleunis et al., 2021b, Gopinath et al. *submitted*). Additionally, these two sources are both repeaters and hence were only detected thanks to intense monitoring with LOFAR. Scattering is likely a major hindrance here – an FRB that is scattered by 1 ms at 600 MHz would be broadened by about 256 ms at 150 MHz (assuming a ν^{-4} scaling), washing it out. Furthermore, the dense plasma environments of (some) FRBs may also hinder detection at low frequencies because of free-free absorption, scaling as $\nu^{-2.1}$.

Nonetheless, FRBs are coherent radio emitters and many coherent emission mechanisms produce increasing brightness towards low radio frequencies. For example, some radio pulsars have power-law spectra scaling as steeply as $\nu^{-2} - \nu^{-3}$ and the electron cyclotron maser instability (ECMI) mechanism often operates at low radio frequencies. SKA-Low's high sensitivity and large grasp from $50 - 350$ MHz could thus enable a world-leading search and characterisation of FRBs at the bottom of the radio band through both high-cadence commensal observations as well as targeted monitoring of known FRB sources. SKA-Low also has the potential to be the first instrument to discover FRBs at low frequencies through untargeted searches.

SKA-Low will nicely bridge the gap between LOFAR (10 – 240 MHz) where scattering may dominate and the CHIME band (400 – 800 MHz), where emission is often seen to the bottom of the 400 MHz band (CHIME/FRB Collaboration et al., 2021; CHIME/FRB Collaboration, 2025). Even if FRB detectability is suppressed towards low radio frequencies, it will map how the FRB event rate decreases due to scattering and free-free absorption, giving valuable information about FRB plasma environments.

Simultaneous Observations with SKA-Mid: For sources within the joint field-of-view of SKA-Low and SKA-Mid (e.g., circumpolar FRBs), SKA-Low will be able to both shadow SKA-Mid observations through joint SKA telescope projects and trigger on SKA-Mid detections. Due to the long dispersion delay at lower frequencies, an FRB with a DM of 500 pc cm^{-3} (the median DM from a catalogue of 4500 FRBs; CHIME/FRB Collaboration et al., 2026) detected at 1.5 GHz will be detected at 300 MHz approximately 20-s later. Given SKA-Low's large transient buffer (up to ~900-s), it should be able to easily trigger on these bursts, providing an extra 300 MHz of bandwidth coverage at lower frequencies. This will provide more information on propagation effects such as scattering and Faraday rotation measures, a further understanding of the source's emission bandwidth, and possibly an improved localization.

Host Galaxies & High-Redshift Sources: Given SKA-Low's maximum baseline of 65 km, we can expect the localization capability to approach ~250 mas for a 10σ detection at 200 MHz if data from the full-array is stored within the transient buffer and calibration solutions can be applied with sufficient accuracy to limit systematic astrometric errors to below this level. With such a localization, we will be able to associate most FRBs with their host galaxies and obtain at least photometric redshifts for these sources. This is a significant benefit as the majority of discovered FRBs do not have associated host galaxies and hence redshifts (although this is changing with development of instruments such as the CHIME/FRB Outriggers; CHIME/FRB Collaboration et al., 2025c).

SKA is unique compared to CHORD and DSA in its large overlapping sky coverage with the Rubin Observatory (Ivezić et al., 2019). Indeed, the accompanying chapter on FRBs as cosmological probes predicts that $> 90\%$ of SKA-Low hosts will be visible with the Rubin Observatory Legacy Survey of Space and Time (LSST; Caleb et al., 2026b) .

FRBs successfully detected by SKA-Low will also likely reside in relatively clean plasma environments. SKA-Low can thus provide an excellent sample of FRBs with host galaxies and redshifts to be used as probes. Furthermore, given we know FRBs emit in the GHz range, SKA-Low will be a key instrument for discovering high-redshift sources, as long as they are not scattered to undetectable levels by intervening galactic halos along the line-of-sight (Ocker et al., 2022a).

Localizations of order 250 mas should also give insight into where FRBs reside *within* a given host galaxy. These offsets, as well as the broader host galaxy properties, can be compared with those of known and better-understood transients such as core-collapse supernovae, type Ia supernovae, short gamma-ray bursts, and long gamma-ray bursts to gain insight into the possible progenitors, as well as their formation channels (Heintz et al., 2020). Additionally, with at least one FRB localized to a globular cluster (Bhardwaj et al., 2021; Kirsten et al., 2022), FRB offsets can give insight into the fraction that may be associated with older stellar populations or delayed formation channels (Gordon et al., 2025). Different formation channels should also have distinct redshift distributions. For example, magnetars produced through core-collapse supernovae should follow the star formation redshift rate and peak near redshifts of $z = 2$, while merger-driven formation channels would have flatter redshift distributions for $0 < z < 2$ (Zevin et al., 2022).

Local Environment & Persistent Radio Sources: SKA-Low can provide valuable insight into the local environment of FRBs, and in particular the persistent radio emission that is associated with a rare few but highly interesting, FRBs. Higher-frequency work has shown that the spectral index of these sources is flat in the range of 745 to 1400 MHz (Rhodes et al., 2023; Bhardwaj et al., 2025). However, current instruments lack the sensitivity to probe these sources at lower frequencies (limits in the range of $\sim 200\mu$Jy at 400 MHz with uGMRT for FRB 20121102A; Bhardwaj et al., 2025). With imaging sensitivity down to the μJy-level, SKA-Low can test whether there is a spectral turnover in the persistent radio emission and hence provide insight into the astrophysical mechanisms driving them. Detections at these frequencies will also have direct implications for the density of the local environment. However, separation of the compact emission associated with the FRB from other low-frequency radio emission associated with the host galaxy will generally require higher angular resolution than can be provided by SKA-Low alone, necessitating the use of SKA-Low VLBI. For more details on SKA-Low VLBI, see the chapter on "Low-frequency VLBI with the SKA-Low" (Timmerman et al., 2026).

3.2 SKA-Mid

Discovery Rate: SKA-Mid is predicted to detect tens to hundreds of FRBs per year, on par with current FRB experiments such as CHIME/FRB (Caleb et al., 2026b). Importantly, SKA-Mid's excellent sensitivity will give it access to many high-redshift ($z > 1$) FRBs per year. The SKA-Mid precursor MeerKAT has already given us a glimpse in this direction through its real-time commensal FRB system, MeerTRAP (Rajwade et al., 2022). In particular, Caleb et al. (2025) presented the record-breaking discovery of an FRB at $z = 2.15$ using MeerKAT, doubling the redshift of the most distant FRB yet discovered.

FRB Population at GHz Frequencies: The vast majority of FRBs, now thousands of sources, have been discovered in the $400 - 800$ MHz range thanks to the unparalleled 200 deg^2 field-of-view and powerful real-time processing infrastructure of the CHIME/FRB system (CHIME/FRB Collaboration et al., 2021; CHIME/FRB Collaboration, 2025). A sizeable population of hundreds of FRBs have also been discovered in the $800 - 2400$ MHz range using ASKAP (Shannon et al., 2025), DSA-110 (Law et al., 2024), and MeerKAT (Jankowski et al., 2023; Pastor-Marazuela et al., 2025). Thus, we have a reasonably good picture of the observational properties and event rates of FRBs in the spectral ranges covered by SKA-Mid Band 1 ($350 - 1050$ MHz) and Band 2 ($950 - 1760$ MHz). In contrast, little is known about the FRB emission and event rates in the higher-frequency ranges covered by SKA-Mid Bands 5a/5b ($4600 - 8500$ MHz/$8300 - 15400$ MHz) — though targeted follow-up of repeating sources has confirmed that FRBs emit in this range (Gajjar et al., 2018; Limaye et al., 2025) and at least one thus-far one-off FRB has been detected at S-band with MeerKAT (Pastor-Marazuela et al., 2025).

SKA-Mid Bands 5a/5b have the unique potential to greatly expand our understanding of the FRB emission at high radio frequencies. FRBs are harder to discover at such frequencies because of the reduced field-of-view and potentially negative spectral index. However, propagation effects like scattering and dispersion have a negligible effect on detectability at frequencies above 5 GHz, so there is potentially a population of FRBs in high-density environments that can only be discovered using SKA-Mid Bands 5a/5b. Here too, commensal searches leveraging as many SKA-Mid observations as possible will be crucial for success.

By searching for bursts at high time resolutions and by saving voltage/complex channelised data in its transient buffer, SKA-Mid can also chart a largely unexplored parameter space of ultra-fast radio bursts with timescales of only microseconds (Snelders et al., 2023; Nimmo et al., 2022). Indeed, SKA-Mid's FRB search time resolution at $\sim 64\mu$s is approximately ×5 higher than that of MeerKAT and will be one of the highest time resolution searches for FRBs. SKA-Mid may also detect an intrinsically "not-so-fast" population of FRBs with little scattering yet wide burst widths that would be difficult to detect at lower frequencies due to the reduced peak flux from scattering.

SKA-Mid may discover a sub-class of FRBs at higher frequencies with different progenitors. While compact object merger rates cannot explain all FRBs (and their cataclysmic nature is inconsistent with repeating sources), Most and Philippov (2020, 2022, 2023) predict a population of FRBs in the 10 to 20 GHz range from interactions in the current sheets formed prior to a compact object merger. Given the expected dense ejecta from a merger or a supernova, high-frequency SKA-Mid follow-up will also offer the best opportunity for detecting pulses from a millisecond magnetar formed post merger/explosion. Such detections would provide the strongest evidence yet for FRBs formed through one of these channels. Additionally, SKA-Mid may bridge the gap between the FRB-like bursts from SGR 1935+2154 and extragalactic FRBs through targeted searches for low-luminosity, local Universe FRBs (Pelliciari et al., 2023; Paine et al., 2024). These local Universe sources will likely be the best candidates for multi-wavelength counterpart searches.

High-Redshift FRBs: With increased sensitivity and GHz frequency ranges, SKA-Mid can discover many high-redshift ($z > 1$) FRBs that are either too faint or too scattered to be detected at lower frequencies and sensitivities. A larger sample of high-redshift sources will help us track the volumetric rate of FRBs as a function of cosmic time, giving clues to their progenitors. High-redshift FRBs are also typically the most energetic. Thus, we can use them to place strong constraints on the total energy budget of FRBs, informing both the emission mechanisms and possible progenitors. It is also possible that more extreme FRB-like emitters could be discovered in the early Universe, and that they would have different progenitors than those at lower redshifts. SKA-Mid could thus expand our view of the first FRB sources to form in the Universe.

Repeating & Non-repeating FRBs: Current measurements for non-repeater bandwidths are often limited by the spectral extent of the detection instrument, with most non-repeating CHIME/FRB bursts spanning the full 400-MHz bandwidth and hence only providing a lower limit on the total emission bandwidth (Pleunis et al., 2021b; Sand et al., 2024). Pulsar pulses, on the other hand, can have spectral extents that can span over 8 GHz (Hassall et al., 2012). While the maximum transient buffer bandwidth for SKA-Mid is currently 400 MHz, simultaneous observations with SKA-Low could test the full emission bandwidth of the thus-far non-repeating FRB sources. Indeed, a significant fraction of the sky ($20 - 30\%$) should be simultaneously visible to both SKA-Low and SKA-Mid. An understanding of the intrinsic non-repeater bandwidths will have direct implications for the assumed energy budget of non-repeating sources, and may further exacerbate the difference seen between the spectral structure of repeating (narrrow-band) and non-repeating (broadband) FRBs.

Beyond discovering new sources, SKA-Mid will also be an excellent tool for follow-up observations. With increased sensitivity, the SKA will be able search for ultra-faint repeat bursts at non-repeater locations, testing the hypothesis that all FRBs eventually repeat. As the most sensitive planned radio telescope in the Southern Hemisphere, SKA will be unique in its ability to perform this follow-up. Additionally, using the pulsar timing beams with 2.5 GHz of frequency coverage, SKA-Mid can search for temporally simultaneous repeat bursts at different portions of the FRB spectrum. While searches for this at known repeater locations has been performed (Kumar et al., 2021; Bethapudi et al., 2023; Limaye et al., 2025), it has been limited to frequencies < 10 GHz, has only been done for a small number of repeaters, and has not always been continuous in frequency coverage. Observations using the sub-arraying capabilities of MeerKAT have already demonstrated the potential of SKA-Mid in this area – with a continuous frequency coverage from 544 to 1756 MHz, it found complex burst frequency shapes and evolution from a repeating FRB (Tian et al., 2025).

Host Galaxies: Thanks to the combination of a sensitive dense core and long baselines in a spiral layout, SKA-Mid will be both an FRB detection and localisation machine. With AA* we can expect a nominal localisation accuracy of ~ 75 mas for a 10σ detection at an observing frequency of 1.4 GHz, assuming diffraction-limited astrometric accuracy. Such a localization is more than sufficient to associate the FRB with a host galaxy and, in the case of nearby FRBs, can even enable the characterisation of the local environment with localizations of order tens to hundreds of parsecs. Once AA4 becomes available, the localisation precision of SKA-Mid alone will be of order 15 mas. SKA is unique in its significant field-of-view overlap with Rubin Observatory as compared to Northern Hemisphere radio instruments. The accompanying chapter on FRBs as cosmological probes predicts that for both Band 1 and Band 2 for SKA-Mid in AA*, approximately 80% of FRB hosts will be visible with LSST (Caleb et al., 2026a). Thus, for AA4, we can routinely assign host galaxies *and* study the local environment of nearby and moderately distant FRBs.

Local Environments & Persistent Radio Sources: Coupling SKA-Mid to VLBI networks like the EVN or the LBA will provide milliarcsecond localisations of repeating sources that can be compared with optical imaging from ELT, HST, and JWST (see, e.g., Figure 2). This will allow us to zoom in on FRB progenitor environments on scales comparable to the distance between stars in the host galaxy; we may even be able to associate an FRB with a specific companion star, if it is sufficiently massive and luminous. Indeed, with a 13-pc localization for FRB 20250316A (CHIME/FRB Collaboration et al., 2025a), JWST observations were able to directly search for a magnetar at the FRB location (Blanchard et al., 2025).

SKA-Mid VLBI will also probe persistent radio emission at the locations of FRBs. This emission likely serves as a calorimeter of the central engine's cumulative energy output, and can thus inform the possible FRB progenitors (Metzger et al., 2017; Margalit and Metzger, 2018). SKA-Mid VLBI can constrain the compactness of the persistent radio source and characterise its broad-band spectrum. For more details on SKA-Mid VLBI, see the chapter on "Extending the SKA Across Africa: The Case for a Continental African VLBI Network" (Bempong-Manful et al., 2026).

4 Looking forward

By the early 2030s, CHORD, the DSA, and the SKA should be finding tens of thousands of new FRB sources per year. To remain competitive in this new era, the SKA must prioritize significant commensal searches that enable high numbers of FRB detections in new parts of the transient parameter space. With its large frequency extent from 50 MHz (SKA-Low) up to 15 GHz (SKA-Mid) and its high time resolution searches (e.g., search timescales of $\sim 64\mu$s), it has the potential to greatly extend the transient phase space along the frequency and time axes. It will also nicely complement future experiments such as DSA and CHORD, offering similar sensitivity but in the Southern Hemisphere. And, with significant overlapping sky coverage with the Rubin Observatory, it will be able to provide a large sample of FRB host galaxies and hence redshifts which will be beneficial both for understanding their progenitors and formation channels, as well as for cosmology.

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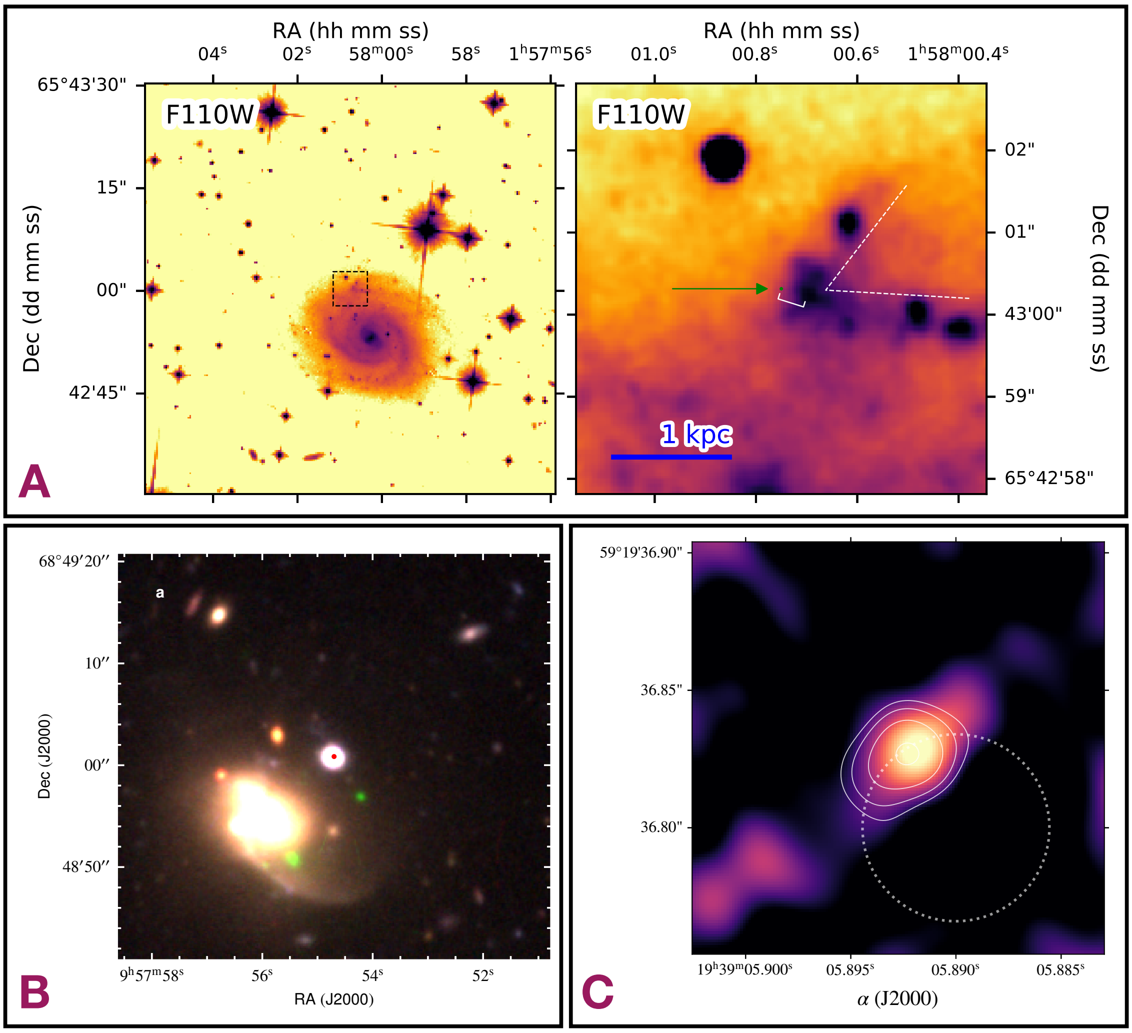

Figure 2: Three repeating FRB sources and their local environments. Panel **A**: Mas-level localisation for FRB 20180916B using the EVN overlaid on HST imaging of the field (Marcote et al., 2020; Tendulkar et al., 2021). A zoom-in of the FRB localization within the spiral galaxy is shown in the right panel, with the FRB localization indicated with a green ellipse. Using the HST imaging, the FRB is found to be offset by ∼ 200 pc from the peak of a nearby knot of star formation (separation indicated using a white bracket). Panel **B**: Localization of FRB 20200120E using the EVN in combination with Subaru imaging pinpoints the FRB to a globular cluster in the M81 galactic system (Kirsten et al., 2022).While originally discovered using CHIME/FRB (Bhardwaj et al., 2021), it was only through the mas-level localization that the globular cluster origin definitively determined. Panel **C**: A mas-level localisation of FRB 20190417A using the EVN (colour scale) and an associated compact persistent radio source (contours; Moroianu et al., 2025). EVN observations were required to confirm the compact nature of the persistent radio source ($<$ 23 parsec), as well as its co-location with the FRB ($<$ 26 parsec). For further details on these figures, see the original papers.

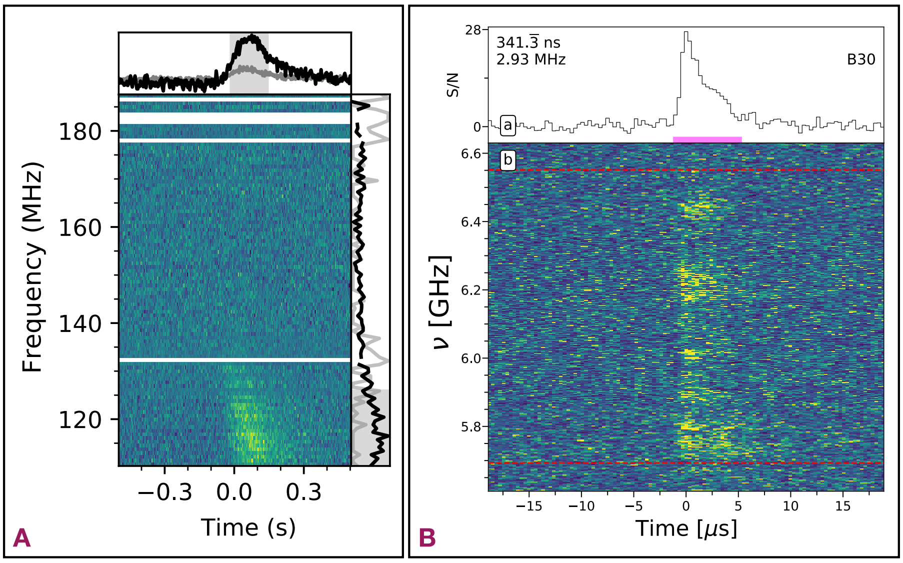

Figure 3: Panel **A**: LOFAR detection of FRB 20180916B, demonstrating emission down to the lowest-ever-detected radio frequency of 110 MHz (Pleunis et al., 2021b). Panel **B**: GBT detection of FRB 20121102A, demonstrating an isolated burst lasting only about 5 microseconds (Snelders et al., 2023). For further details on these figures, see the original papers.