To understand FRB emission mechanisms better and to specifically identify the astrophysical objects that produce FRBs, we need to focus on the nearest and brightest FRBs which are the ones most likely to produce detectable multi-wavelength and multi-messenger counterparts (X-/γ-rays, GW, neutrinos). I will discuss our efforts from the point of view of two main FRB origins — magnetar flares (along the lines seen from SGR 1935+2154) and compact binary coalescences (CBCs) with at least one neutron star.

Radio Counterparts to CBCs

There exists an observational gap in the transient phase space that is largely unexplored from about 0.1 s to a few minutes. Pulsars and FRBs are exquisitely studied at timescales shorter than about 50 ms and TDEs, GRB afterglows and SNe shocks are studied at hour to year timescales. By leveraging the very high survey speed of the CHIME/FRB telescope, it's multi-beam design, and stability, we propose to do the first systematic survey of the transient radio sky at timescales between 50 ms to 5 s. This is particularly relevant from the point of view of prompt radio counterparts of CBCs involving neutron stars since while a prompt radio counterpart is widely expected, the timescales at which these bursts might emerge and their properties are very poorly understood. With the CHIME/Slow Transient Search (CHIME/STS), we (mainly S. Mate, K. Luke @TIFR, Z. Pleunis, P. & Scholz @UoT) are starting a search of CHIME data at these timescales. Apart from CBC mergers, this survey will be sensitive to extremely scattered FRBs, long period magnetars, white dwarf and M-dwarf flares. We expect to do a pilot offline search by the end of 2022 and expand to a larger scale system (funded by Dunlap Institute) next year subject to resource availability.

Brightest FRBs

The need for detecting and localizing ultra-bright FRBs is well-understood. We are working on designing and building an All-Sky Transient Radio Array (ASTRA), a 400–800 MHz open dipole array with a specially designed feed (Figure 1, left panel) with a 3dB field of view (FoV) of $120^\circ \times 130^\circ$. ASTRA will have 700 dual-polarized signal chains, and most importantly, a $\approx$300 s voltage ring buffer on most (if not all) signal chains designed to respond to internal as well as external (e.g. ASKAP, OWFA, LIGO) triggers. There will be three stations separated by $\approx$ 30 km to provide an arcsecond to subarcsecond localization, sufficient for host and counterpart identification for nearby FRBs. The expected rate of FRB detection with such a system would be about 1 per two-three weeks with a sensitivity threshold of 700 Jy ms.

The current vision is to place these stations along empty GMRT pads which already have power and fiber optic lines running to them. However, Ooty Radio Telescope and Gauribidanur Radio Observatory (each with an existing maser clock and offering baselines of 200–900 km) have been identified as potential alternatives or expansion sites.

At TIFR in collaboration with RRI, we have designed (and are now testing) the ultra-wide FoV antenna (Figure 1, left panel). Though the antenna is designed to operate between 400–800 MHz, the digital systems initially would use only digitize 100 MHz of the band. The digital systems are being designed at TIFR and NCRA. We expect to set up a pilot system with 16 signal chains in Spring 2023 at the GMRT site.

Multiwavelength Counterparts — *Daksha*

The detection horizons of transient X-ray and γ-ray telescopes are significantly sensitivity limited. *Daksha* (Figure 1, right panel) is a multi-institution proposed space mission with an all-sky coverage from 1 keV to > 1 MeV at a fluence threshold of 4×10^{-8} erg cm^2 using 2 satellites in anti-podal orbits. *Daksha* consists of three separate high technological readiness level detector

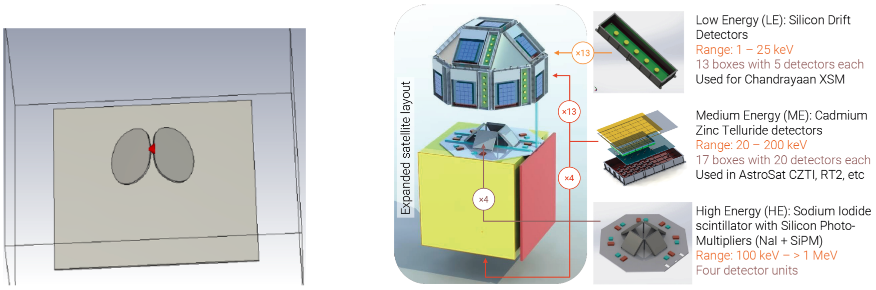

Figure 1: *Left Panel:* A 400-800 MHz ultra-wide FoV feed designed for ASTRA. The design is based on the CHIME feed, but is adapted for wider FoV and simplified for transient detection. *Right Panel:* An exploded view of one of the two *Daksha* satellites showing the three detector systems — low energy silicon drift detectors, medium energy CdZnTe detectors, and high energy NaI scintillators.

systems that have demonstrated space heritage. The effective area of the 20–200 keV CdZnTe detectors is 1300 sq. cm. (all-sky median, single satellite) is equivalent to that of Swift-BAT but with $\sim 10\times$ larger FoV. Apart from saving all received photons, *Daksha* will run optimized on-board transient detection issuing alerts with latency < 1 min.

Daksha will allow us to detect up to ∼10 EM counterparts of CBCs and $\sim$ 700 GRBs per year. It will be sensitive to magnetar giant flares (10^{47} erg) up to a distance of 140 Mpc. Fainter bursts, such as April 28 2020 burst from SGR 1935+2154 would be detectable within the entire Galaxy and its satellites. *Daksha* will be able to broadband prompt spectra of magnetar flares, microsecond timing, and Compton polarimetry above a fluence of 10^{-4} erg cm^{-2}. With improved sensitivity and higher detection rates, *Daksha* will provide a complementary view of FRBs allowing us to constrain both magnetar flare origins and binary neutron star merger origins.

Daksha has been given seed funding from the Indian Space Research Organisation, and laboratory models of the requisite systems are in a mature state of development. Once the development milestones are completed, *Daksha* will be reviewed for full mission approval.

Self Introduction — Shriharsh Tendulkar

I am a Reader (i.e. tenure track asst. professor) at the Tata Institute of Fundamental Research, Mumbai and at the National Centre for Radio Astrophysics, Pune in India. I am also a CIFAR Azrieli Global Scholar in the Gravity and Extreme Universe Program of the 2022-24 cohort. My academic arc goes like this: BTech Engineering Physics (IIT Bombay, 2008), MS Astrophysics (Caltech, 2010), PhD Astrophysics (Caltech, 2014).

My work focuses on magnetars, neutron stars, transients, and instrumentation (now in X-ray and radio) to detect and study transients. My PhD thesis (guided by SRK) was on using Keck adaptive optics to perform high-precision astrometry to conduct a kinematic survey of magnetars and to help design, build, and commission the RoboAO adaptive optics system on the Palomar 60-inch. I worked on understanding magnetar emission and accretion processes in transitional MSPs and ULXes (with newly discovered neutron stars) with NuSTAR. I then switched to radio astronomy helping design and build the CHIME/FRB and CHIME/Pulsar backends.

My group at TIFR and NCRA works on studying FRBs and X-ray transients. Apart from CHIME/FRB and CHIME Slow Pulsar Search, we are working on building the CHIME/FRB Slow Transient Search pipeline, the All Sky Transient Radio Array (ASTRA), and the Daksha X-ray mission.