Liam Connor

1 Allow myself to introduce...myself

I am a Richard C. Tolman postdoctoral fellow at Caltech, beginning my third and final year in October. I did undergrad at McGill, grad at CITA/UofT, and a postdoc at ASTRON/Amsterdam.

My early Ph.D. work focused on 21 cm cosmology and commissioning the CHIME Pathfinder instrument. This was just before the Thornton paper was published and before anybody had proposed using CHIME to find FRBs. But by 2015, I was spending most of my time on FRB progenitor models, FRB statistics, and building a precursor time-domain pipeline on CHIME Pathfinder. I used the pipeline for an incoherent experiment to test the claim that the brightness distribution was significantly more flat than Euclidean, finding that it probably wasn't. This was all done in close collaboration with my PhD advisor at CITA, Ue-Li Pen. In 2016 and 2017, I spent some time in what I call "logN-logS Purgatory", where a number of us were attempting to extract knowledge from a small set of FRB population data, to little avail.

In the mean time, I have helped build/run Apertif and DSA-110, and I am currently working on the FRB and pulsar survey design for DSA-2000. My pipeline work has included building machine learning classifiers, beamformers, single-pulse injections and completeness, and analyzing the trade-space of FRB search parameters.

I am less interested in FRB emission physics, progenitor models, and population statistics than I once was. I am now more excited by FRB applications (baryon cosmology and, to a slightly lesser extent, gravitational lensing) and survey design (GReX & DSA-2000). Here are a few of statements about FRBs that illustrate my biases:

- Localization is paramount, 0.5–3 arcseconds is often good enough.
- Large numbers of unlocalized FRBs are not inherently valuable; their usefulness is largely in offering a better chance to find outliers (R3, M81, 190520, etc.).
- The baryon cosmology stuff is inevitable and also super cool.
- Coherent gravitational lensing is very exciting but will be hard to detect and *very* difficult to apply to H_0.
- The utility of efficient algorithms and clever survey design is tough to overstate.

2 GReX and future ChASMs

My talk will be on radio all-sky monitors and the search for FRBs in the Milky Way and local Universe. I will first describe our progress on the Galactic Radio eXplorer (GReX) and then offer a path forward for coherent all-sky monitors, or "ChASMs". For the foreseeable future, there will be a significant sensitivity gap between ultra-widefield surveys and traditional telescopes such as CHIME, DSA, and ASKAP. I will argue that GReX and ChASMs will fill an important niche in nearby FRB science.

When I heard Chris Bochenek give his talk on STARE2 at FRB 2018 in Melbourne, I was pleased that he and Shri were doing this experiment. And I was glad it wasn't me doing it. I thought that they would not find anything, but that the upper limits would be useful for constraining the FRB luminosity function. Fortunately, I was wrong. This was partly due to a too-clever-by-half argument about FRB repetition statistics (see Section 4.1 of Connor & Petroff (2018)) and partly because I didn't think the luminosity function would just carry on rising down to such small L. Turns out there was plenty of room at the bottom.

The co-detection of an FRB from SGR 1935+2154 by CHIME/FRB and STARE2 was the most significant FRB discovery to date. It unified an unexplained phenomenon (extragalactic radio pulses) with a known source class (magnetars) and opened up a window to studying FRB-like emission from within the Milky Way–including multiwavelength emission that is hard to detect for extragalactic events. Maybe the discovery was lucky, but consider that STARE2 could only see about 10 % of the sky at any given time, and due to its latitude ($\sim$+40 deg) STARE2 had limited exposure to the Galactic plane where most magnetars reside. It also had a system temperature of 65 K and limited radio bandwidth. Galactic FRBs must not be all that rare.

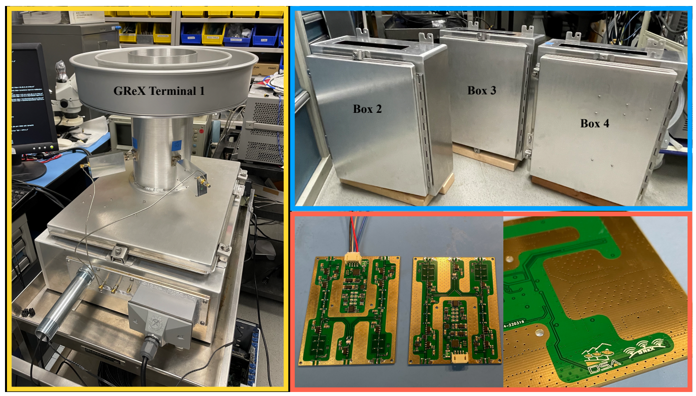

Figure 1: The first GReX terminal (yellow box). The next three GReX boxes, which house a front-end module, SNAPs, and timing (blue box). These will likely go to Australia. The custom front-end module, which performs the analog signal processing before the ADCs (red box).

For these reasons, it would be foolish to not expand our efforts to search for Galactic FRBs. We have proposed GReX as the first true radio all-sky monitor. Our plan is to deploy clusters of antennas around the world to build up to $4\,\pi$ steradians of continuous sky coverage. Each terminal will have roughly twice the sensitivity of STARE2 and will search down to 10 microsecond time resolution. With the increased sky coverage and improved sensitivity, we expect $\mathcal{O}(10)$ Galactic FRBs per year.

We are currently building the first 9 GReX terminals, amounting to three clusters that can be sent to different locations around the world. Our first non-US cluster will be sent to Australia in order to build up sensitivity to the Galactic plane. We will then deploy stations at Pierre Auger Observatory in Argentina, New York state near Ithaca, as well as Ireland and India eventually. The first terminal is now complete and is shown in Figure 1.

Despite the improvements in T_{sys} over STARE2, GReX is still an insensitive instrument. It will be able to find Galactic FRBs and, thanks to its high time resolution, supergiant pulses from pulsars. It will likely *not* find anything outside of our galaxy. The natural next step in ultra-widefield FRB surveys is a coherent all-sky monitor (ChASM), which would combine the signals from a large number of tightly-packed antennas and FFT beamform to fill the full $10^4\,\mathrm{deg}^2$ FoV. Thanks to cheap beamforming and cheap GPUs, such a system would not be dominated by N^2 correlation costs. Instead, the costs would come from digitizing, channelizing, and searching a large number of antennas. In my talk I will go into greater detail on a ChASM successor to GReX, and I will discuss other efforts in this domain.