Summary of the talk

The short, high-DM FRB sky in sharp view with Apertif

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Identifying the physical nature of Fast Radio Burst (FRB) emitters arguably requires good localisation of more detections, and broadband studies enabled by real-time alerting. I will present the results, and lessons learned, from the Apertif FRB survey (ALERT) that ran 2019-2022. ALERT was powered by the Apertif Radio Transient System (ARTS), a supercomputing radio-telescope instrument that performs real-time FRB detection and localisation on the Westerbork Synthesis Radio Telescope (WSRT) interferometer. It reaches coherent-addition sensitivity over the entire field of the view of the primary-dish beam. We detected a new FRB every week of observing on average, interferometrically localised to ~0.4-10 sq.arcmin, leading to confident host associations (Fig. 1).

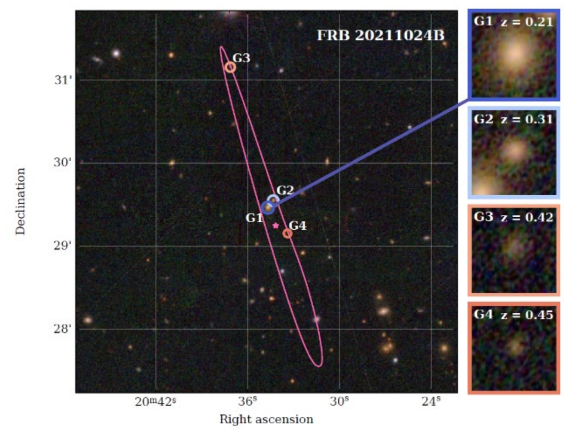

Figure 1: Localisation region and host of FRB 20211024B.

The 24 discovered FRBs broad band and very narrow, of order 1ms duration. Dispersion measures are generally high. Only through the "sharp" -- very high time and frequency resolution -- view of ARTS are these hard-to-find FRBs detected, producing an unbiased view of the intrinsic population properties. About a third of the FRBs display multiple components; a fraction much larger than the 5% found by CHIME/FRB at 600 MHz. We find this difference is not explained by increased scattering at lower frequencies alone, but is intrinsic.

Most Apertif localisation regions are small enough to rule out the presence of associated persistent radio sources. Three FRBs cut through the halos of Local Group galaxies M31 and M33 (Fig. 2).

We demonstrated that Apertif can localise one-off FRBs with an accuracy that maps magneto-ionic material along well-defined lines of sight. The solid detection rate next ensures a considerable number of new sources are detected for such study. The combination of detection rate and localisation accuracy exemplified by these ARTS FRBs thus marks a new phase in which a growing number of bursts can be used to probe our Universe.

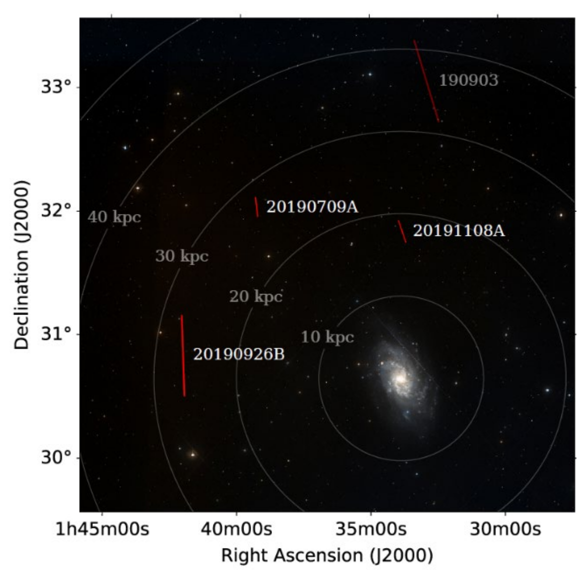

Figure 2: The location of the three FRBs + one candidate.

One of the Apertif bursts is the second most dispersed FRB known to date, and its rest frame shows FRB emission frequencies for one-offs reach 6 GHz. Repeaters had been seen up to 8 GHz before. FRB emission below 300 MHz had remained elusive, however. Using simultaneous Apertif-LOFAR radio data spanning over a factor 10 in wavelength, we show that periodically repeating FRB 20180916B emits down to 120 MHz and that its activity window is both narrower and earlier at higher frequencies. These results strongly disfavor scenarios in which absorption from strong stellar winds causes FRB periodicity. We establish that low-frequency FRB emission can escape the local medium. We thus demonstrate that some FRBs live in clean environments that do not absorb or scatter low-frequency radiation, a prerequisite for certain FRB applications to cosmology. Together, Apertif and LOFAR allow us to measure the activity in the FRB sky at multiple frequencies. For bursts of the same fluence, FRB 20180916B is more active at 150 MHz than at 1.4 GHz. We find there are 3–450 FRBs/sky/day above 50 Jy ms.

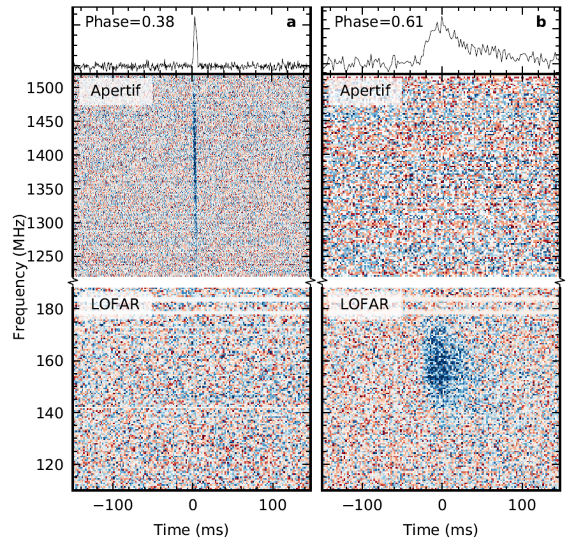

Figure 3: Two bursts at different phases. No burst was seen at both frequencies at the same time.

Self-introduction

I am Senior Astronomer at ASTRON, the Netherlands Institute for Radio Astronomy. I like to investigate transient phenomena in the Universe, through the design, execution and interpretation of dedicated radio-astronomical supercomputing experiments. My goal is to understand, a bit better, the space-time behavior plus the gargantuan densities and magnetic fields of pulsars, and perhaps the emission and explosions that occur near there.

I am (was ..?) the PI of Apertif, the wide-field high-speed radio cameras on the Westerbork Radio Telescope. Its integrated hybrid supercomputer is the largest data generator in The Netherlands.

I also lead CORTEX, a large Dutch academic-industrial consortium that makes self-learning machines faster. I am Editor for Astronomy & Computing, and an ERC Consolidator and an NWO Vici laureate. Also, winner of the triennial Willem de Graaff award for Outreach, from the Royal Netherlands Astronomical Society.

I like sports. Not watching though – only doing; especially with family or friends.