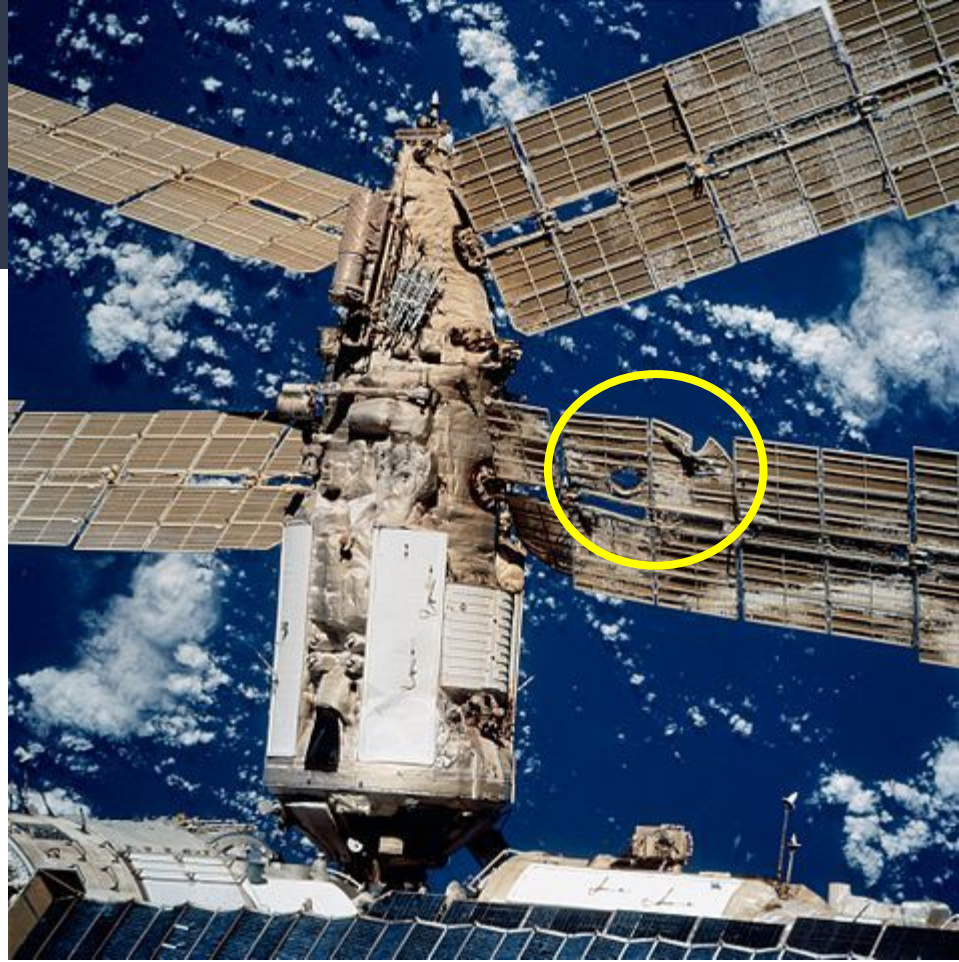
Near-field Transients: Detecting satellites and space debris with the MWA

Paul Hancock
Xiang Zhang
Randall Wayth

International Centre for Radio Astronomy Research

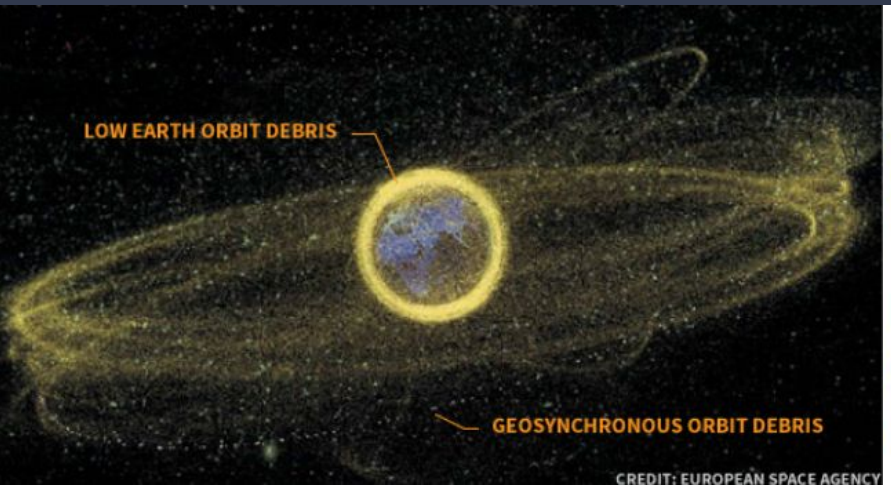
Space debris is bad

No

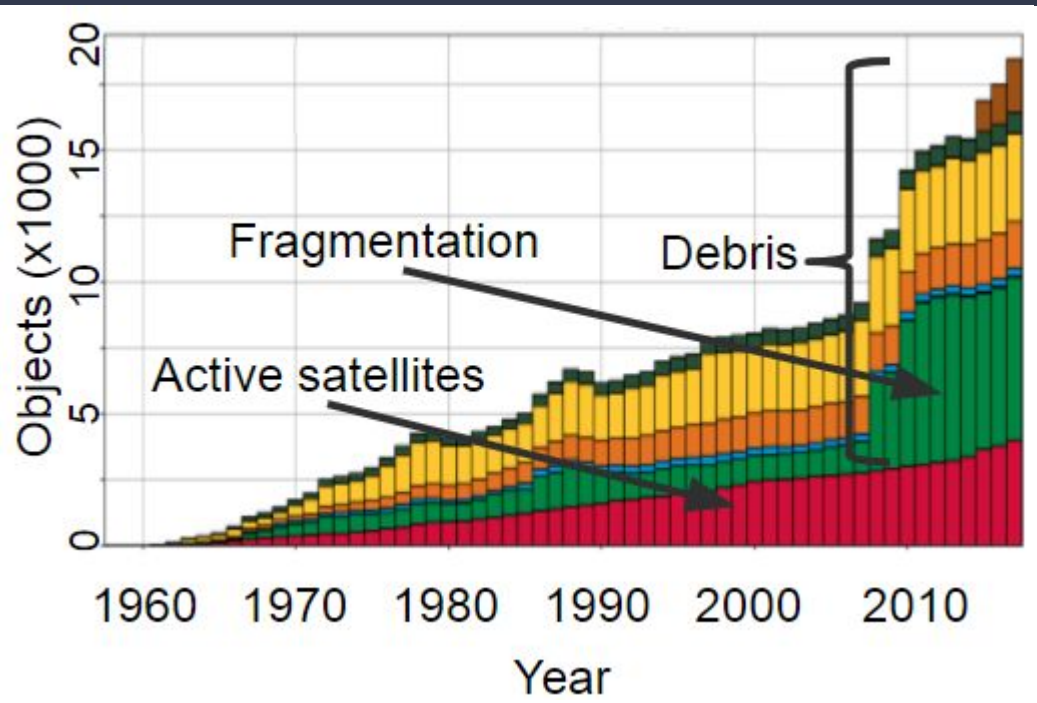


Mir + Space debris impact

Most objects in space are junk

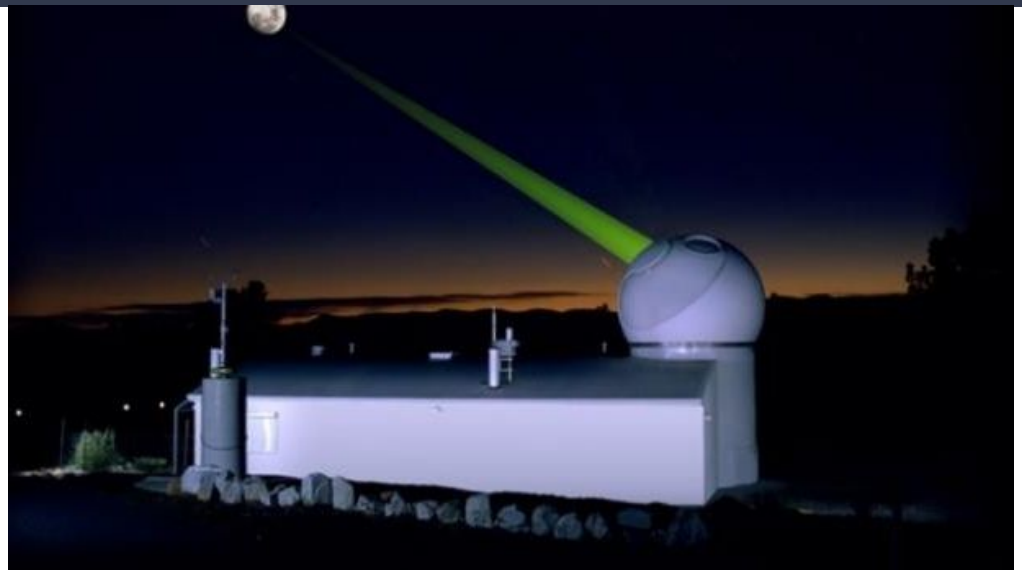


Spatial distribution



Space Situational Awareness – Global

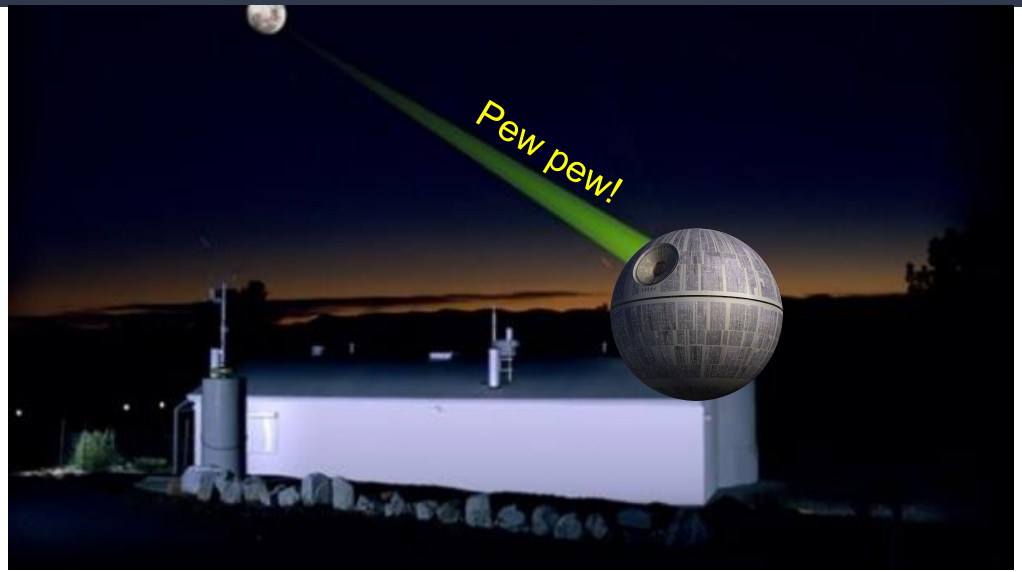
SSA in Australia



Optical LIDAR systems: Canberra + Exmouth

C-Band RADAR systems
Exmouth + Yatharagga

SSA in Australia



Optical LIDAR systems: Canberra + Exmouth

C-Band RADAR systems
Exmouth + Yatharagga

High-power laser + advanced AO ⇒ De-orbit debris!

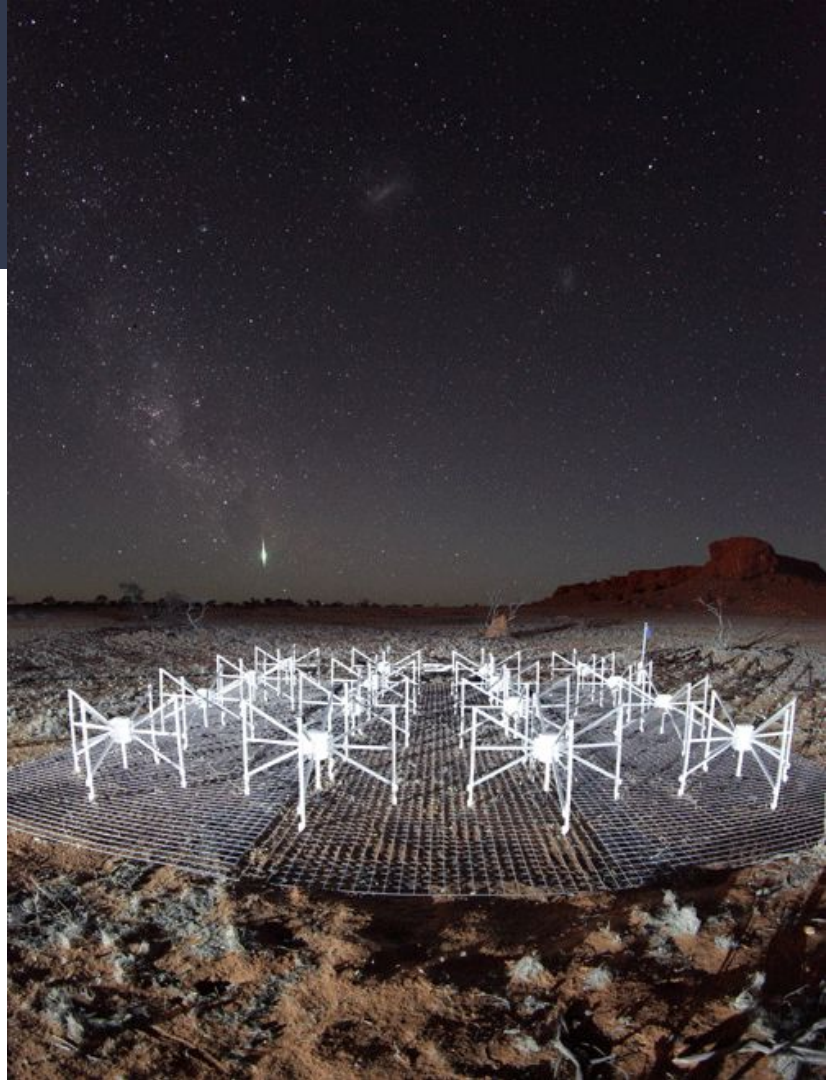
MWA to the rescue

Large FoV

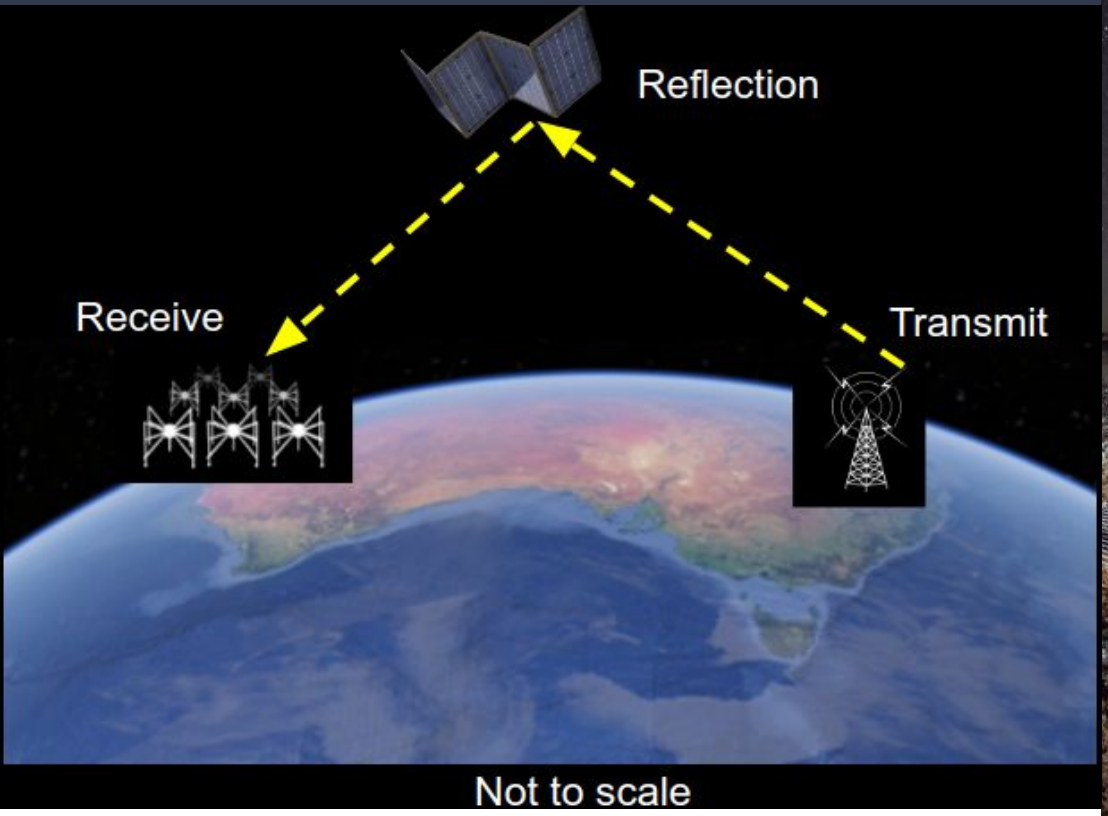
“fast scanning”

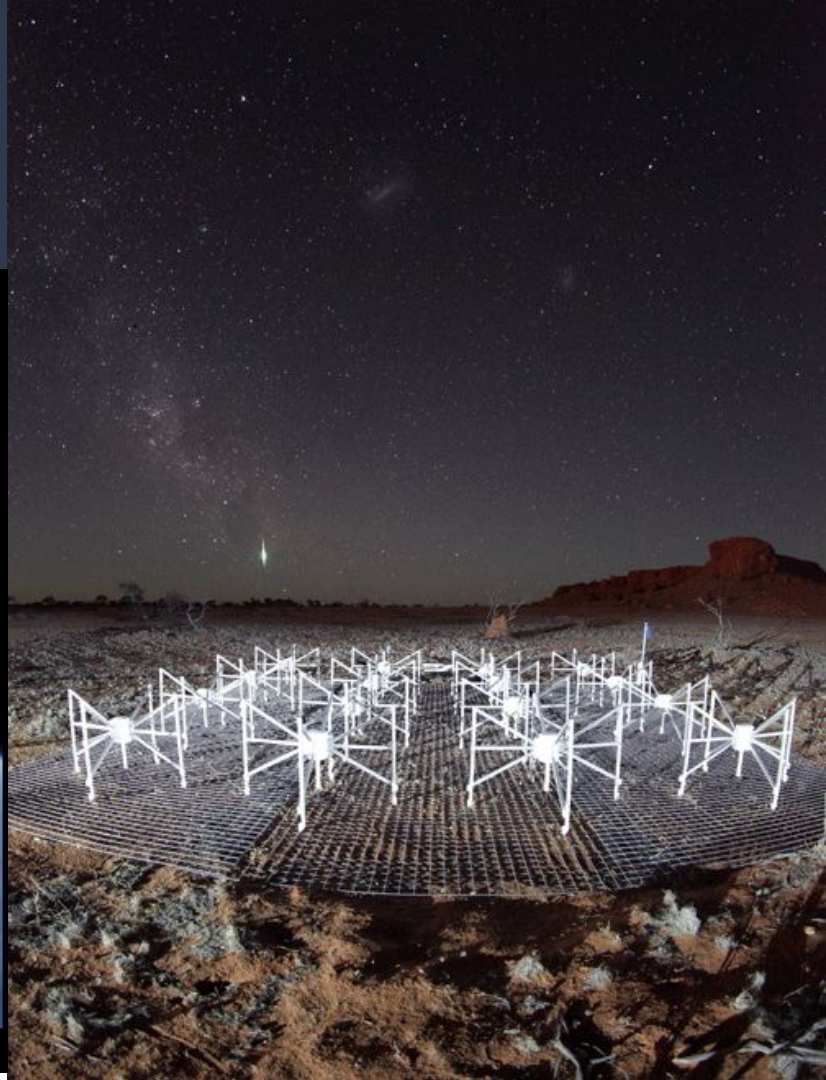
70-300MHz

But: not a radar, no local TX

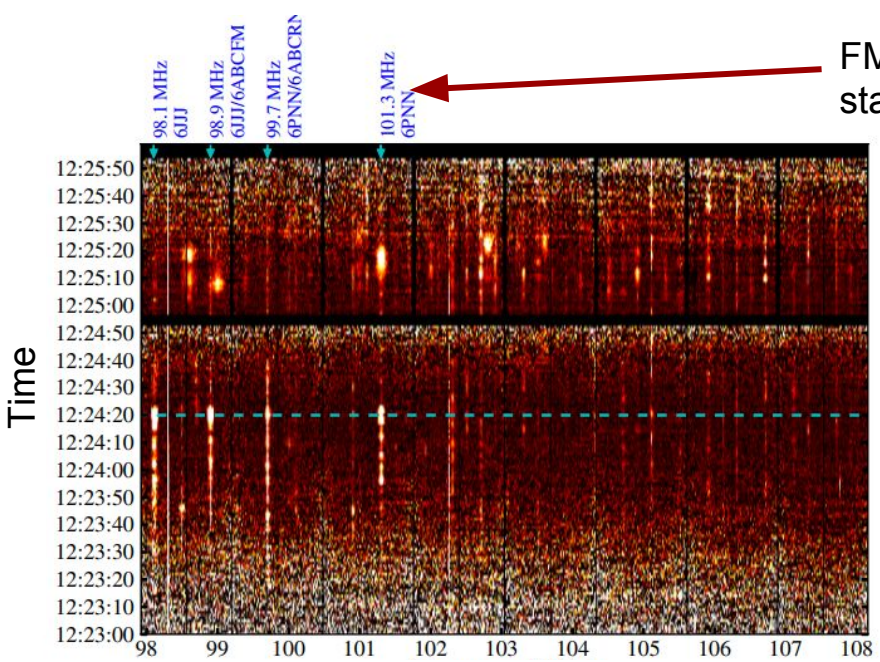


Passive radar

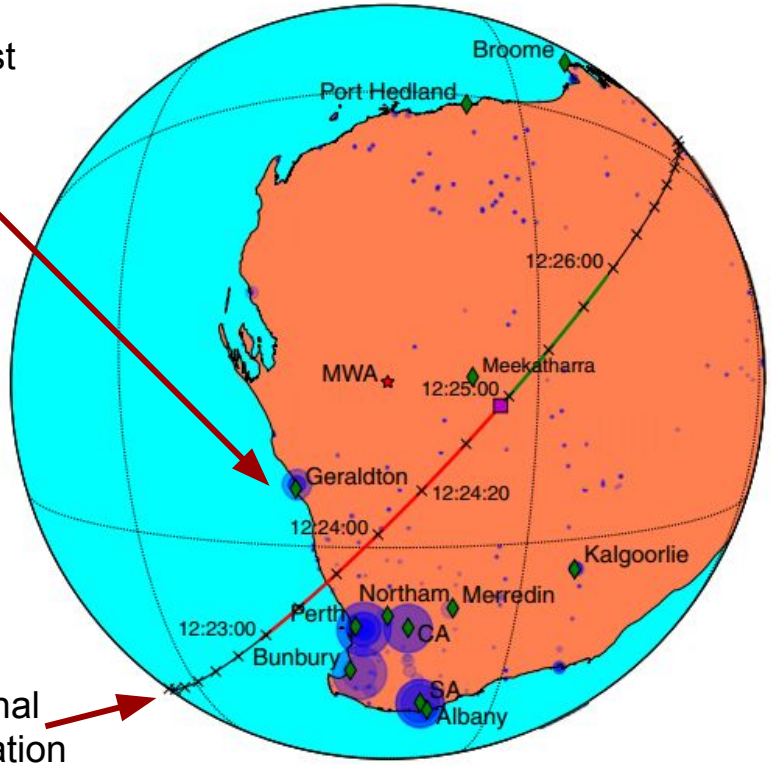




Tingay et al 2013 - With MWA 32T



FM broadcast stations



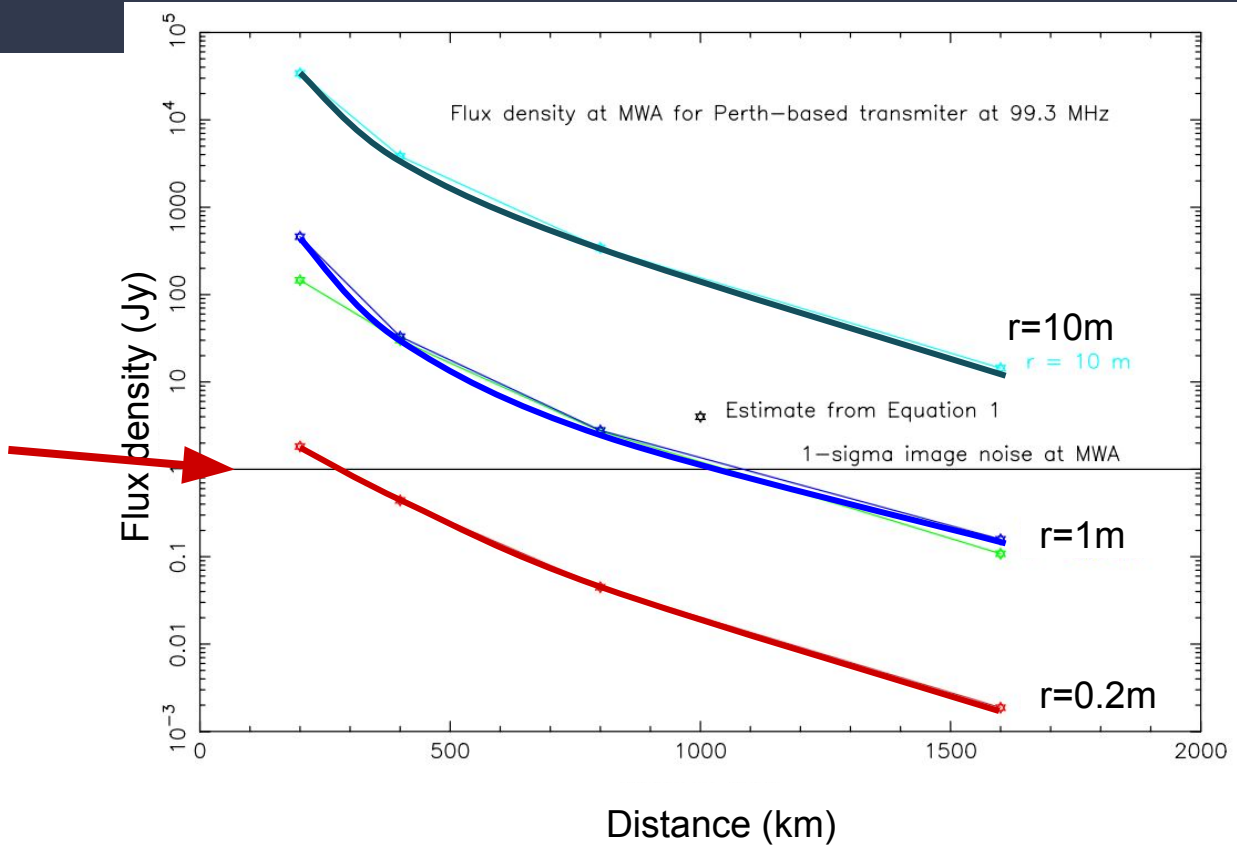
International Space Station

Tingay et al 2013 - MWA 32T

ISS easily detected

Simulations performed for smaller objects

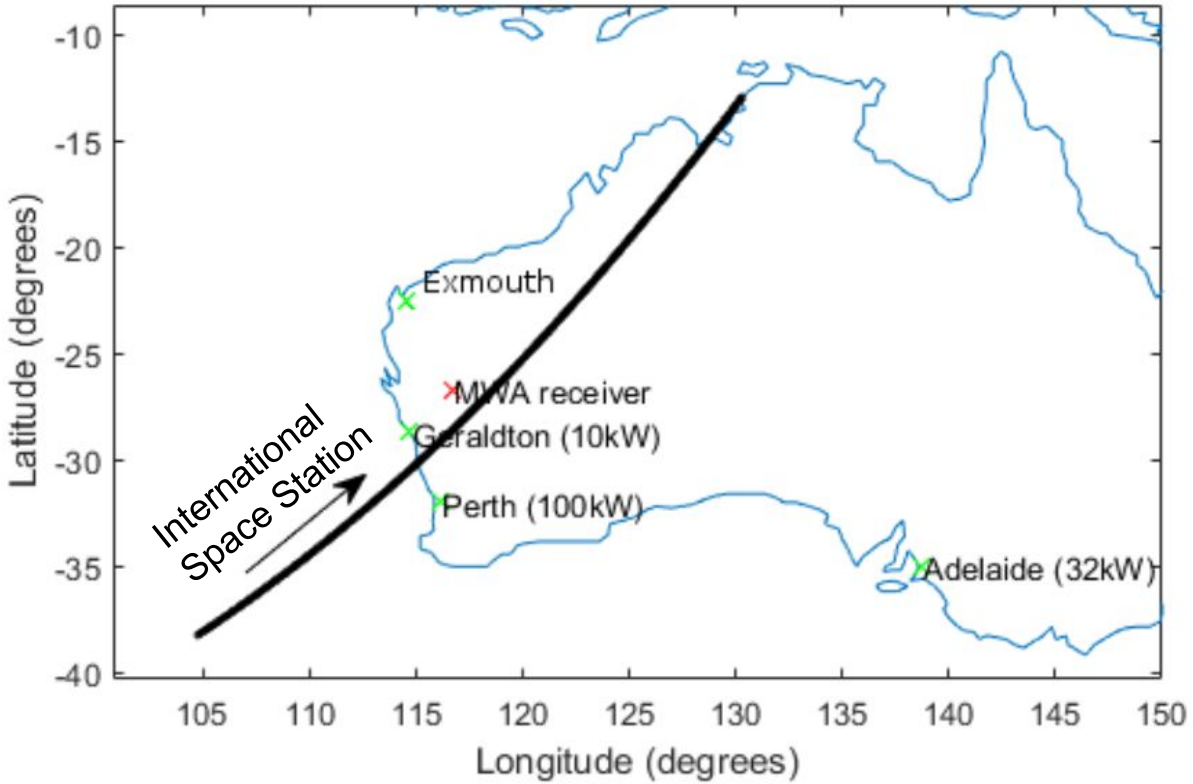
A spherical cow at 1000km would be ~1σ
(1sec x 50kHz image)



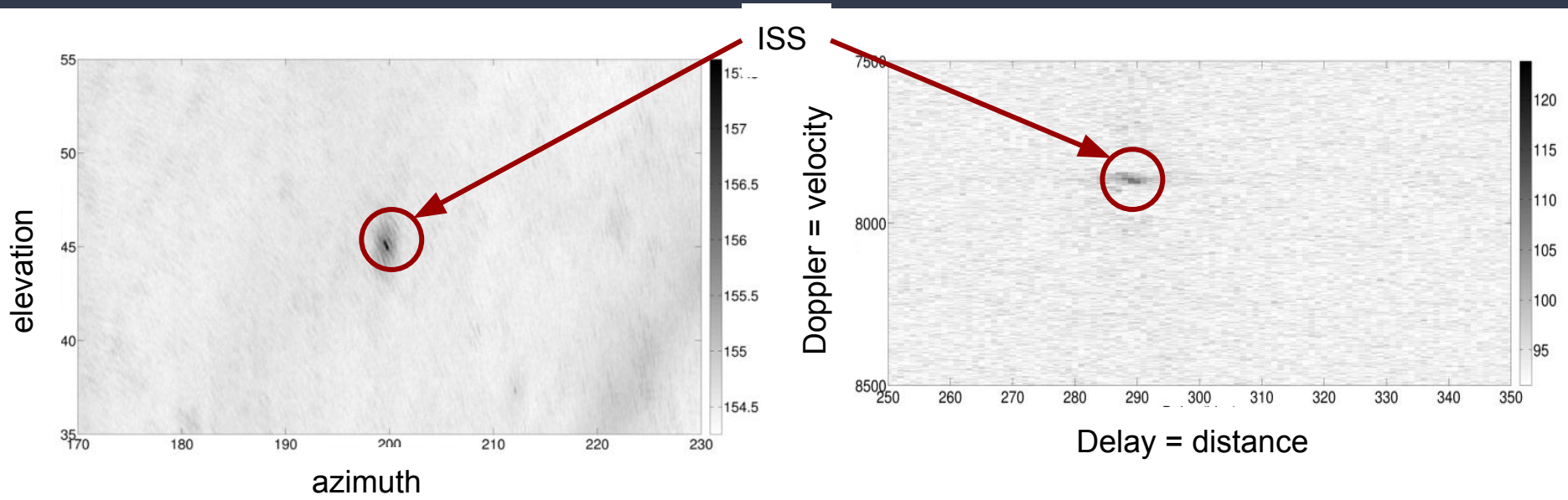
Palmer 2017 - MWA 128T

MWA in VCS mode

observe direct **and** reflected signals by forming two beams



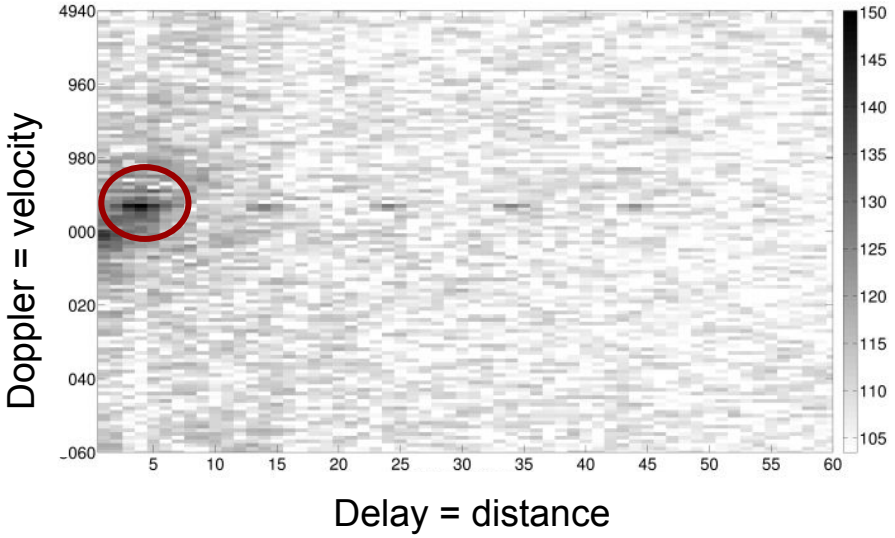
Palmer 2017 - MWA 128T



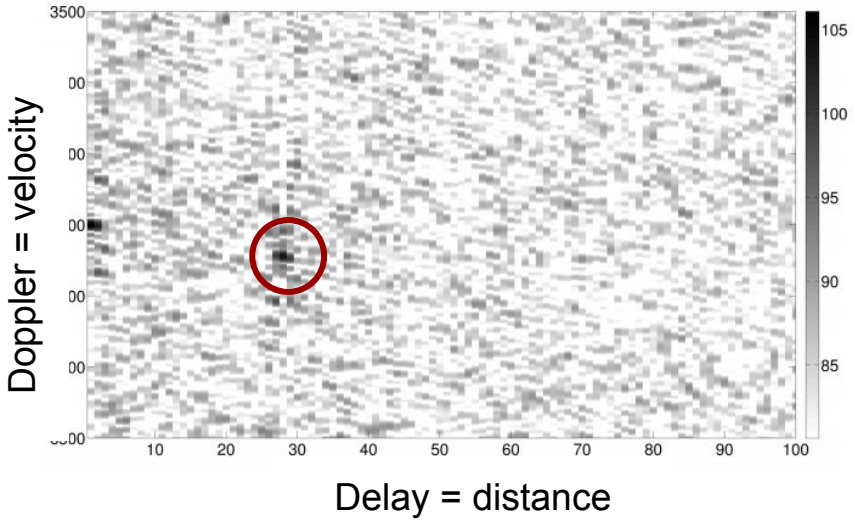
Correlate spatially ⇒ az/el images

Correlate in time/freq ⇒ d/v images

Palmer 2017 - MWA 128T



Aircraft



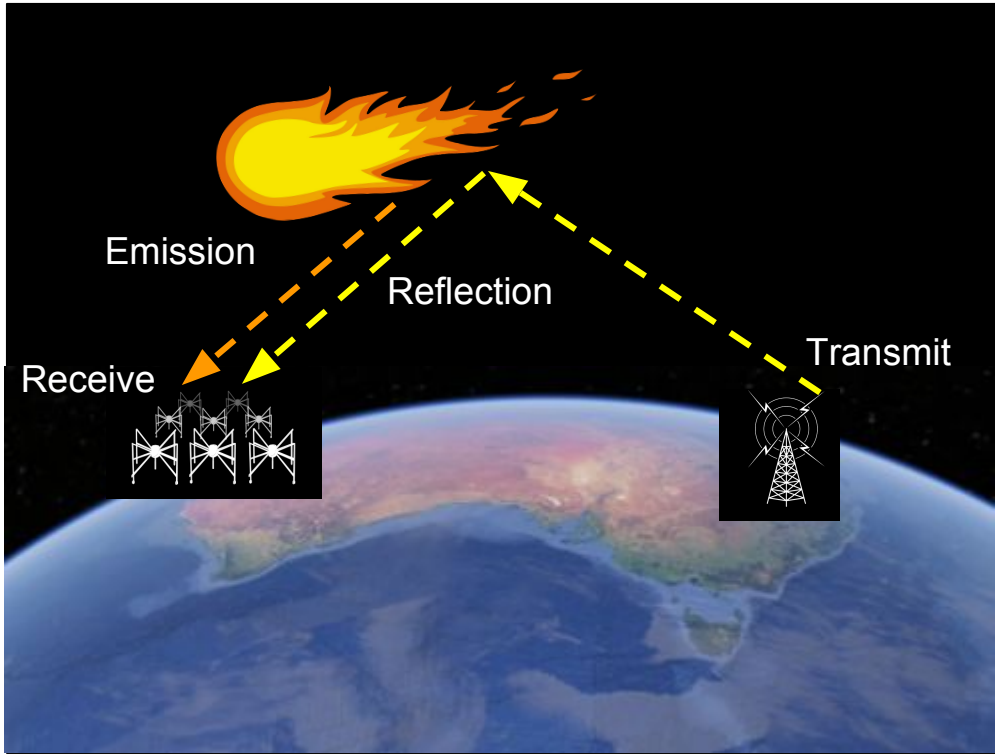
Meteor trail

Detecting Fireballs (Zhang et al. 2018)

Meteors reflect RFI

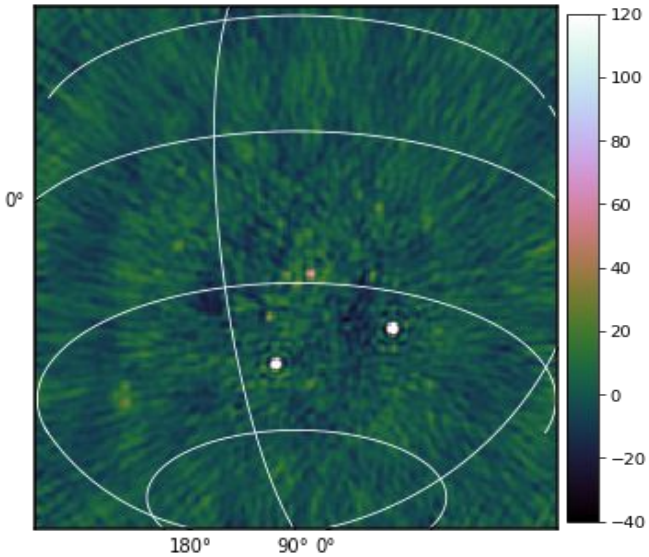
Obenberger et al. 2016 ⇒ **Emission**

Use the MWA to verify emission

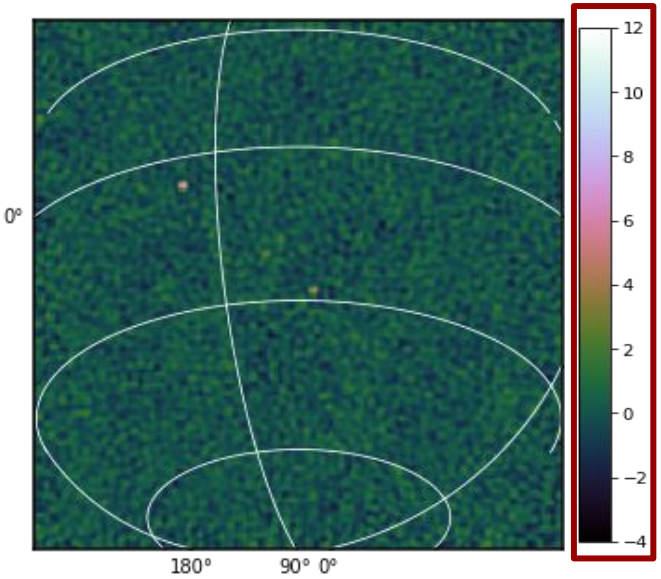


Radio difference imaging

8s snapshot image
σ = 5.5 Jy/beam

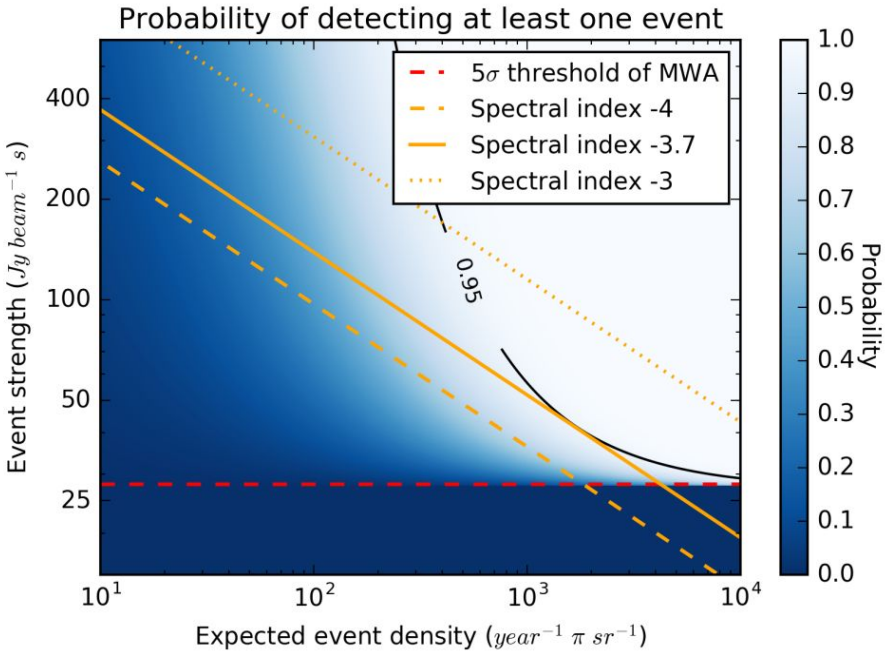


Difference image
σ = 0.46 Jy/beam



1/10
scale

Zhang 2018



Broadband emission must have a spectral index **steeper than -3.7**

Found lots of satellites (multiple times)

- DUCHIFAT 1
- UKUBE 1

] Milk carton size

- ALOUETTE 2

] Beach ball size

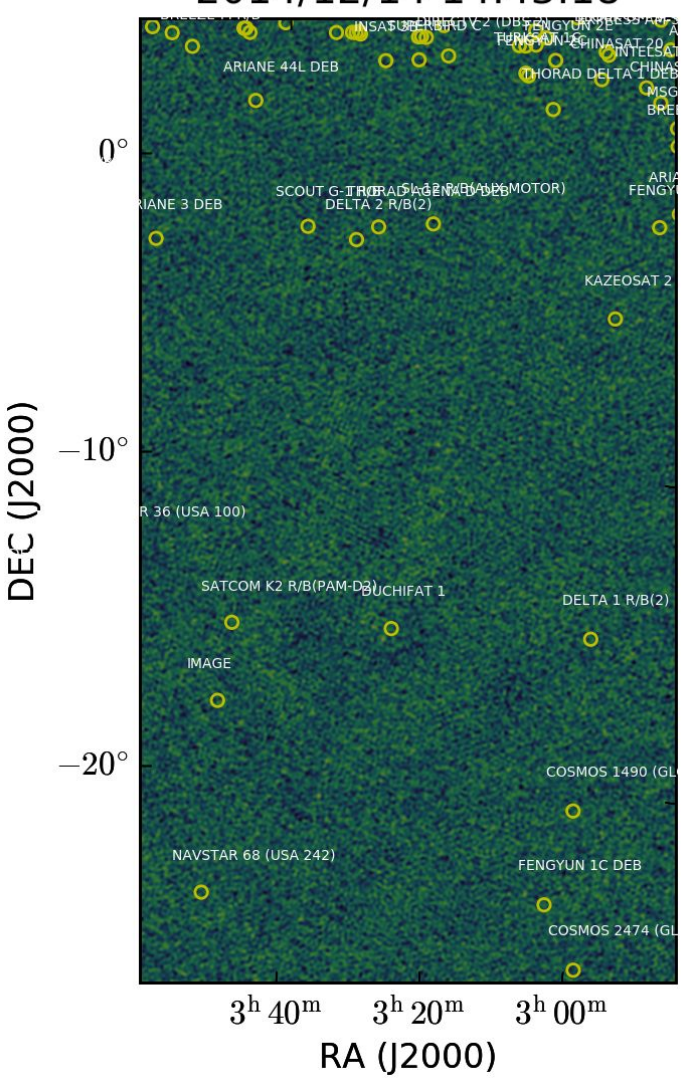
- ALOS

] Bus size

- **ISS** (ZARYA, Soyuz, Cygnus)

Satellites?

Location of known satellites in difference image



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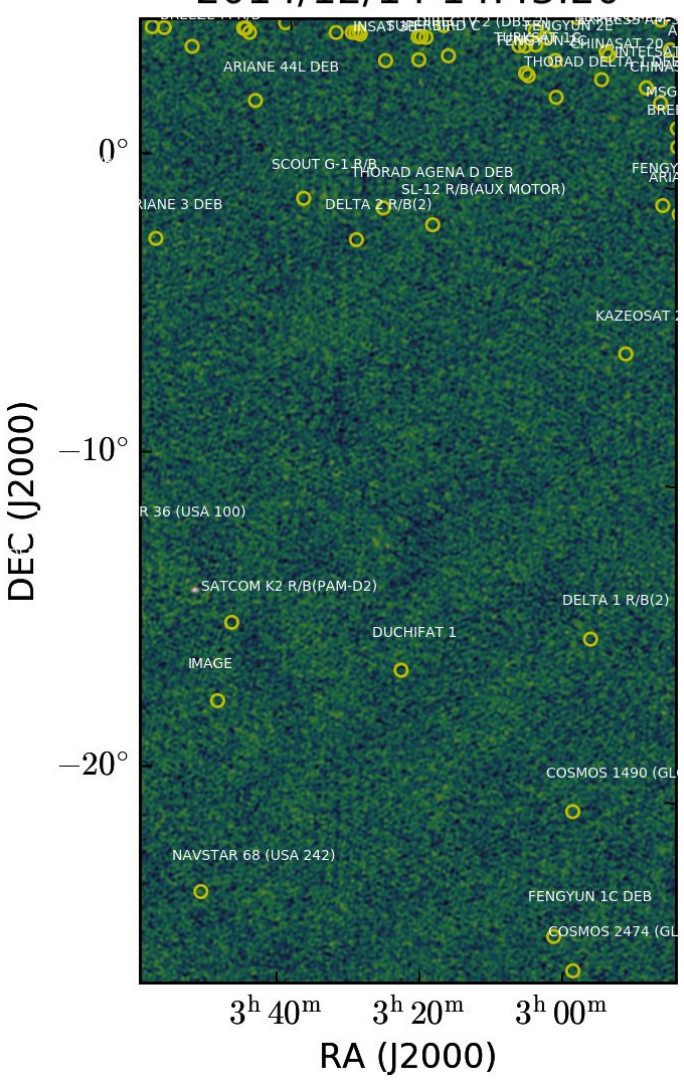

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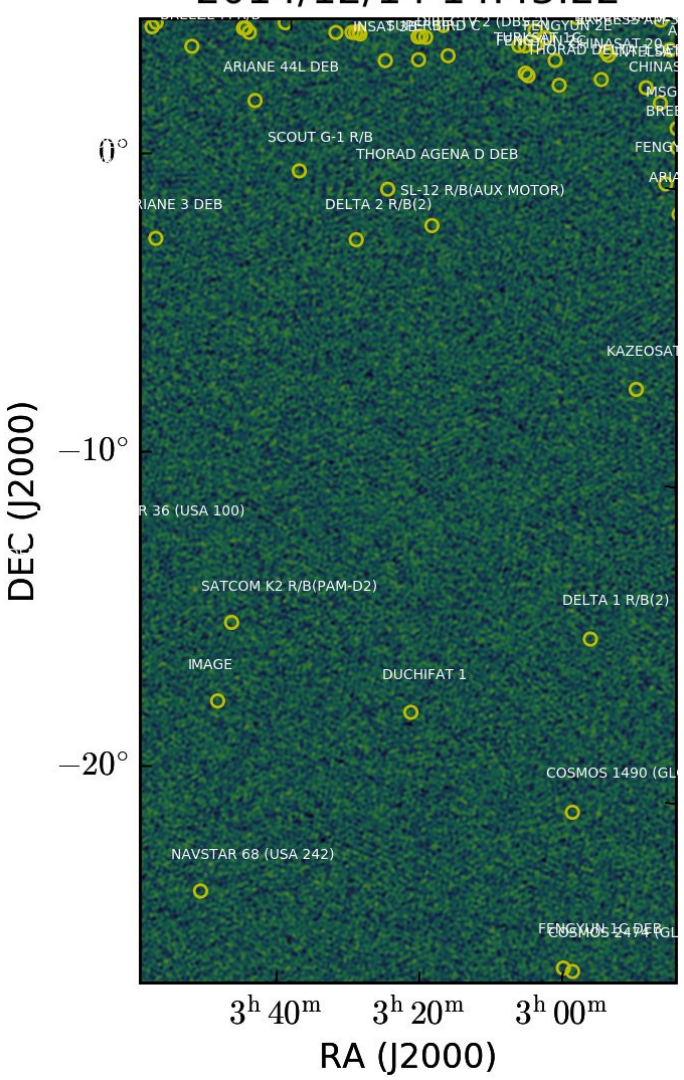

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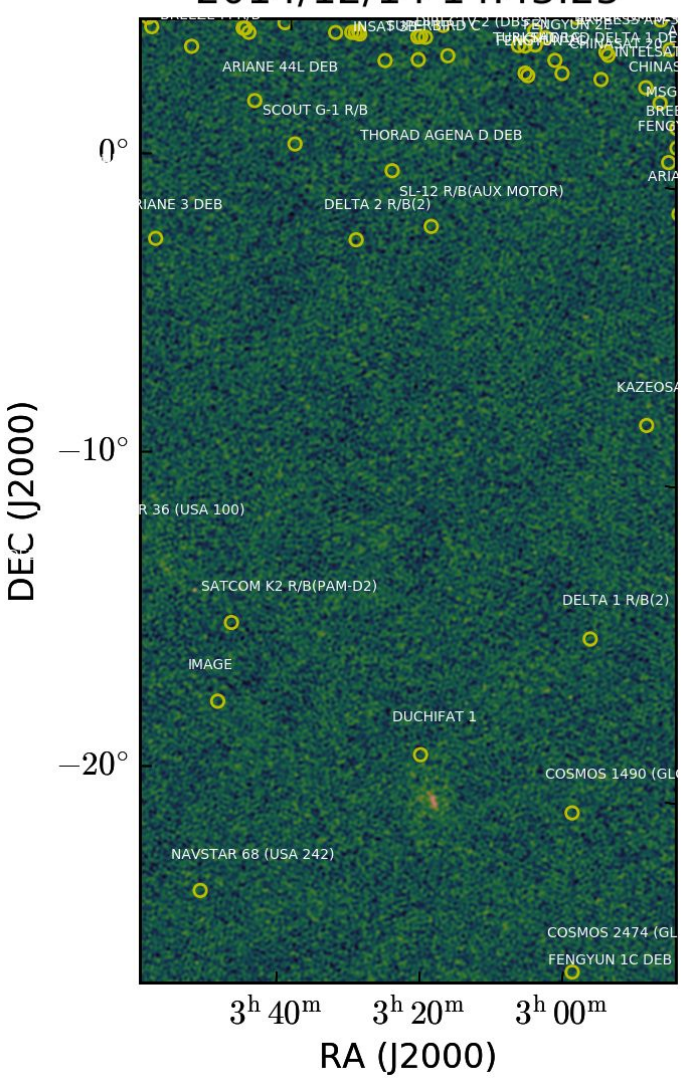

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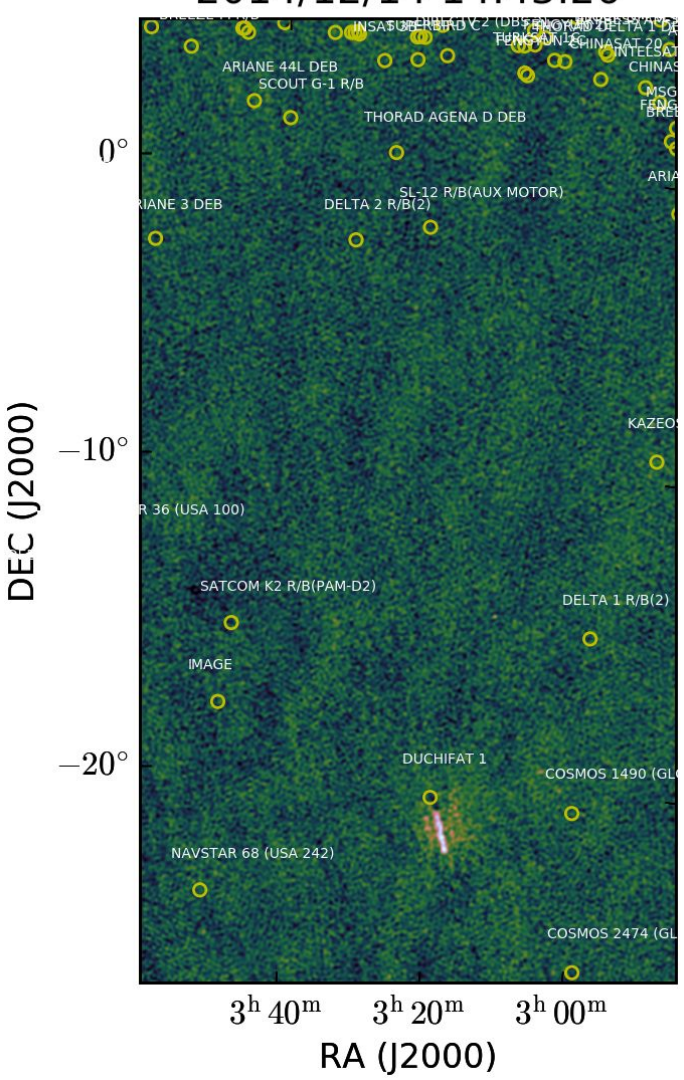

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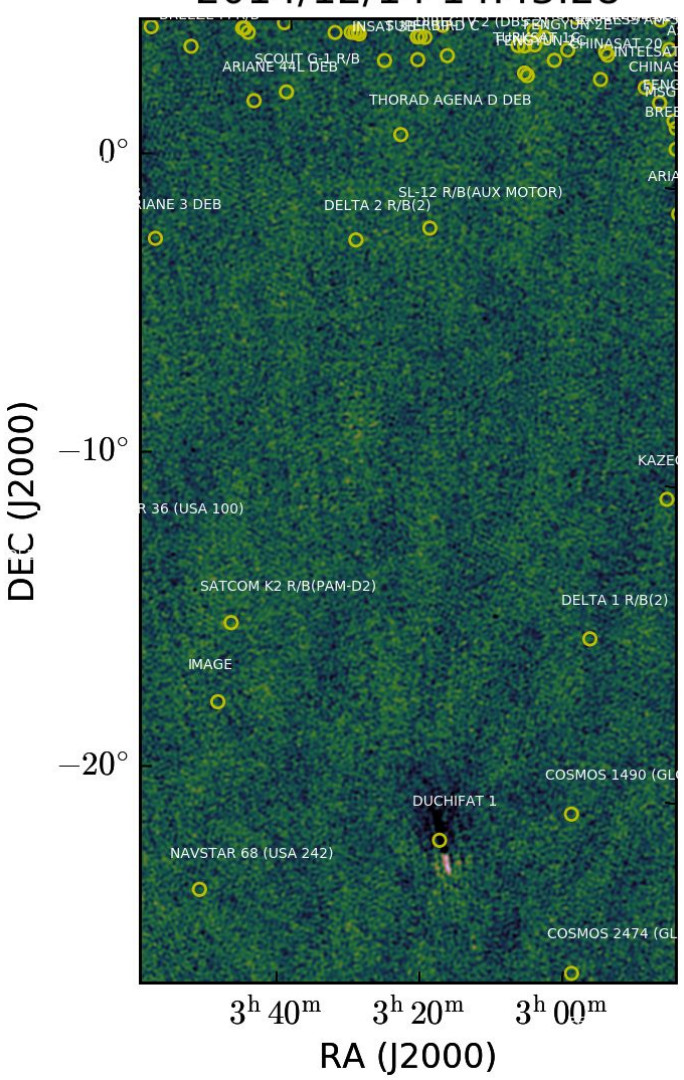
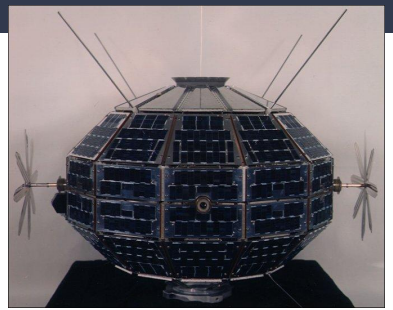


First detections

- Duchifat 1
- Cubesat launched 2014 by Israeli HS students
- Antenna for 145 MHz downlink / 435 MHz uplink
- Orbit is ~600 km altitude

Not to scale



- Alouette 2
- 1m ~~spherical cow~~ Canadian research sat.
- Launched 1965, derelict since 2013
- Orbit is 501-2638 km altitude

Future plans

1. Enhance the MWA as a **monitor** of space debris
2. Develop MWA into a **detector** of space debris
3. An ongoing monitoring program with the MWA