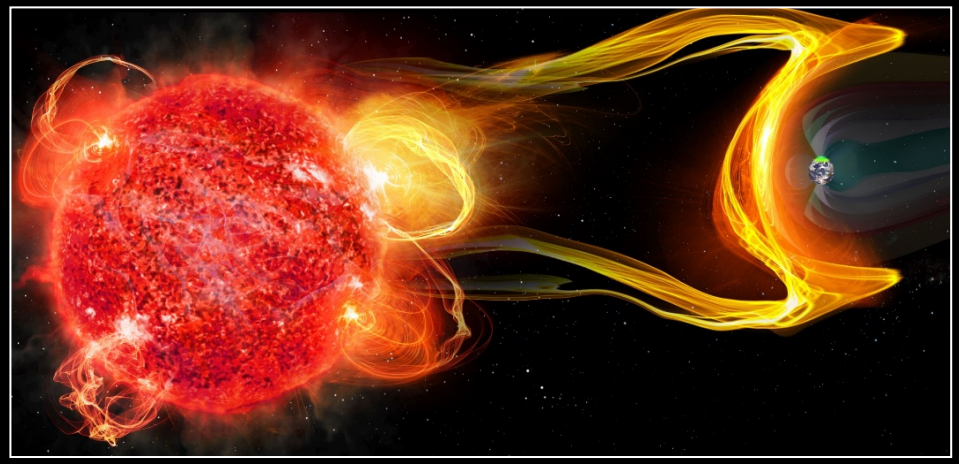
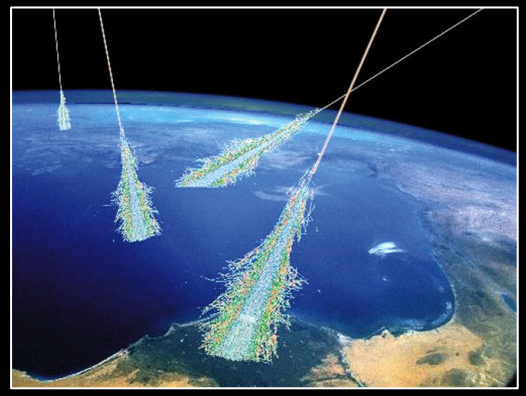
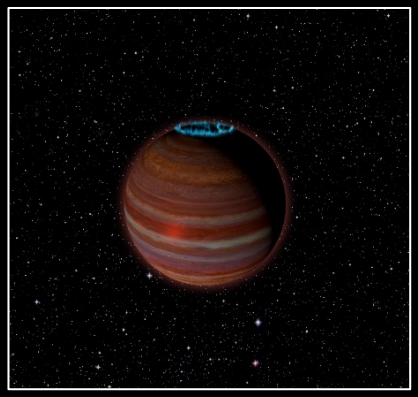
National Radio Science Meeting, Boulder, 2019

The Low Frequency Radio Transient Sky







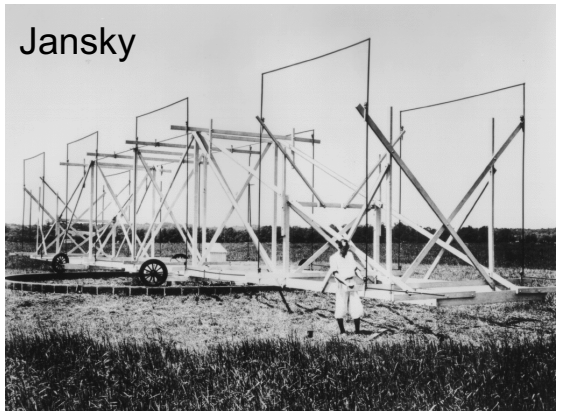
Gregg Hallinan
E-mail: *gh@astro.caltech.edu*

Caltech

Defining Low Frequencies…

JVLA

10 MHz | 100 MHz | 1 GHz | 10 GHz | 100 GHz | 1 THz



ALMA

What Can We Expect to ~~Detect~~ Identify?

Unlikely

Most classes of extragalactic explosive transients

Expected

Stellar CMEs

Radio Exoplanets

Neutron star mergers (?)

Galactic synchrotron sources

Galactic Center Radio Transients

FRBs (Thanks CHIME!)

Serendipitous

Ongoing Related Efforts

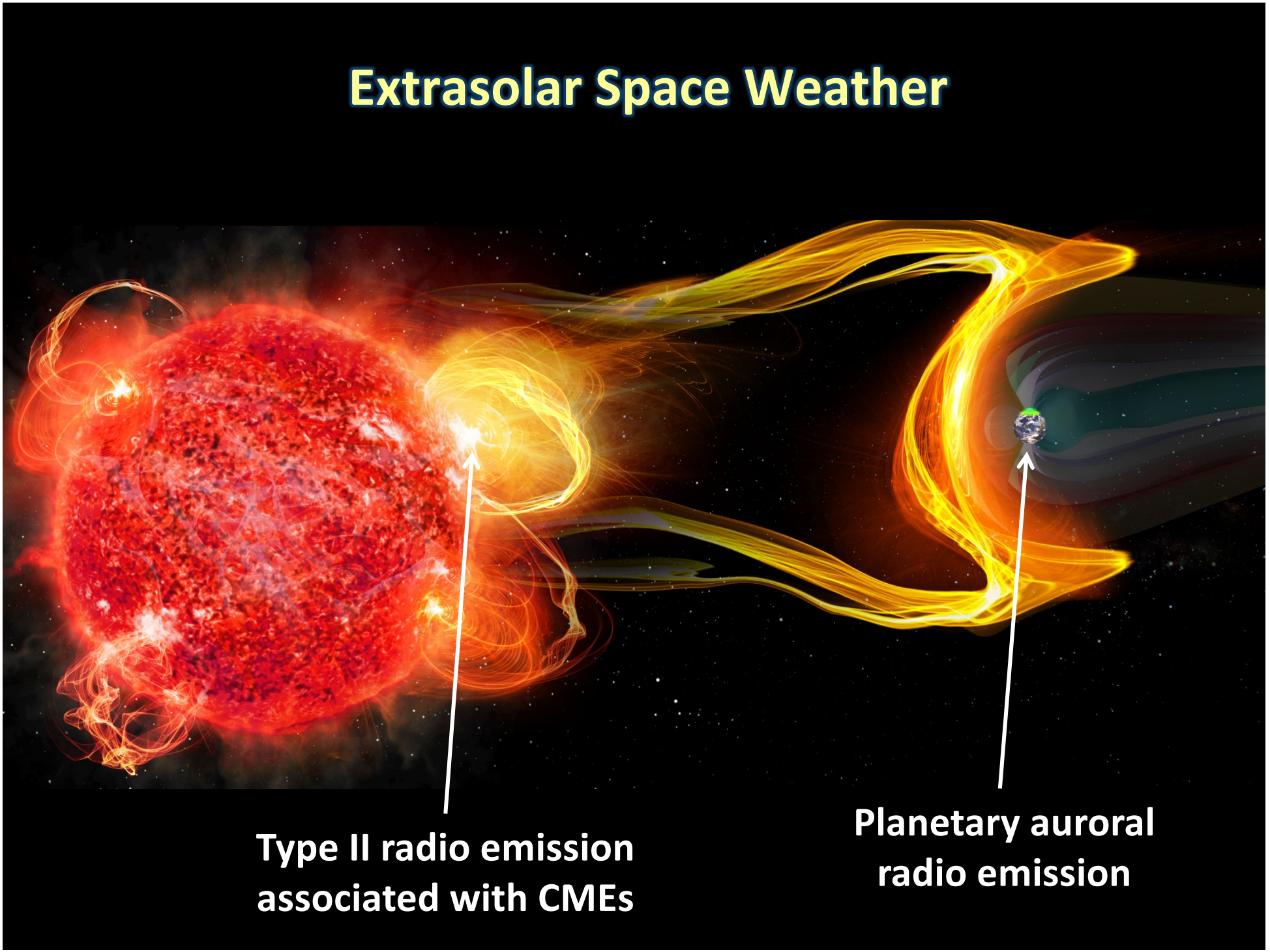
Extrinsic variability: Kaplan et al. 2015

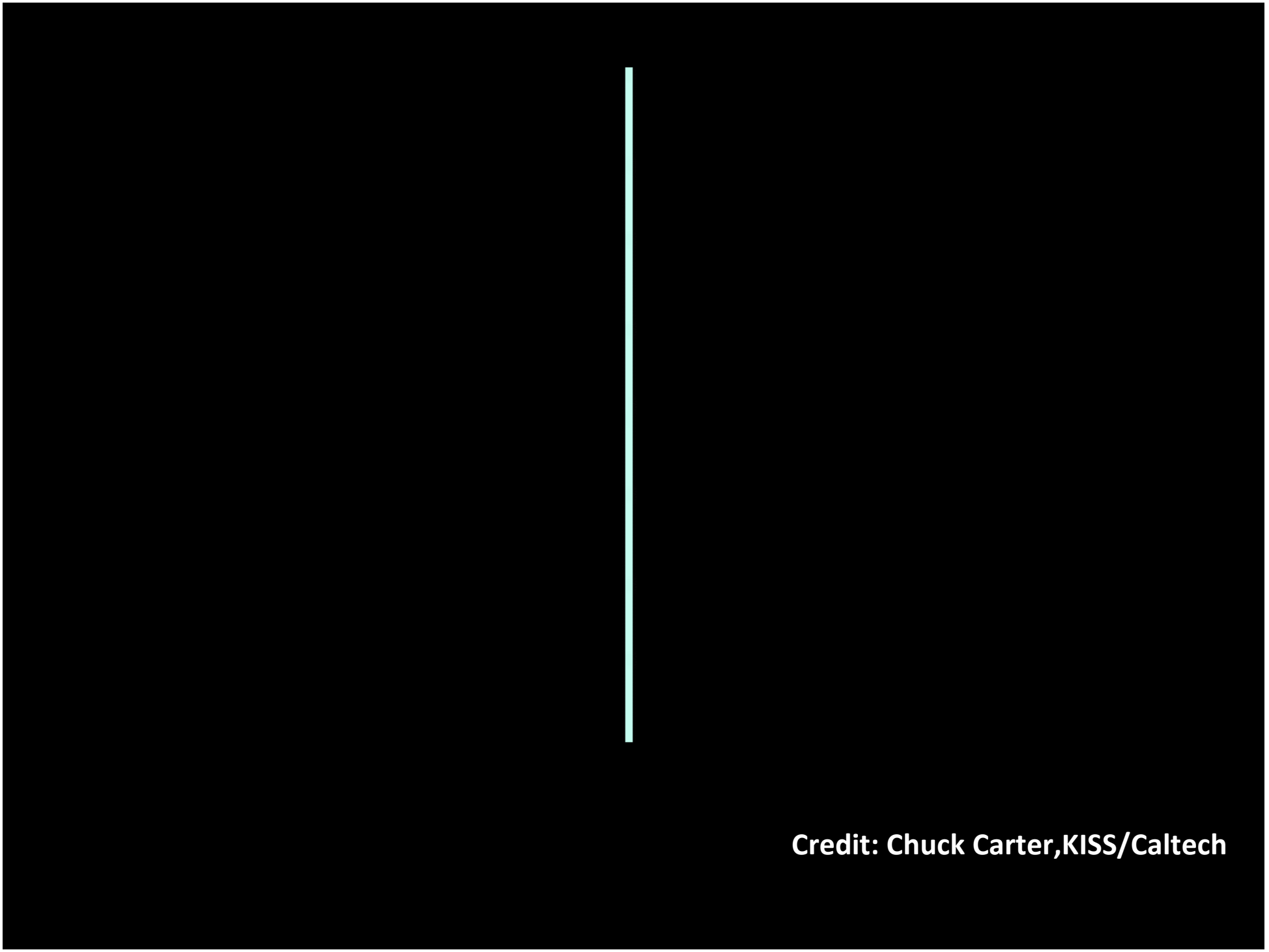
Meteor Fireballs: Obenberger et al. 2015

Cosmic Rays: Monroe et al. 2019

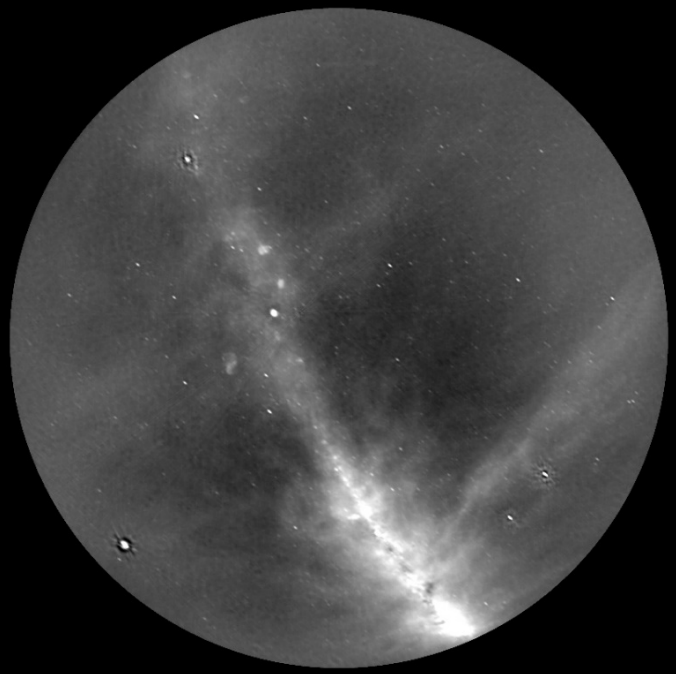
Pulsars: Pilia et al. 2016

Extrasolar Space Weather



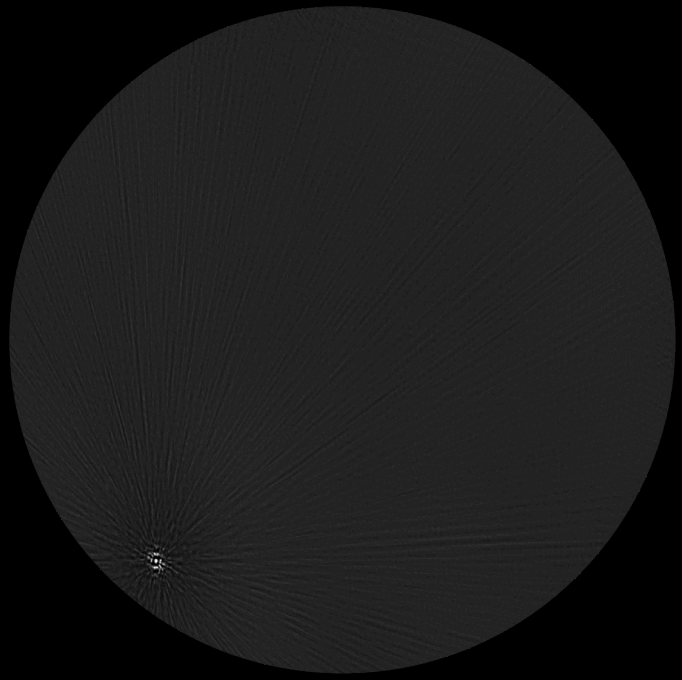


Credit: Chuck Carter,KISS/Caltech



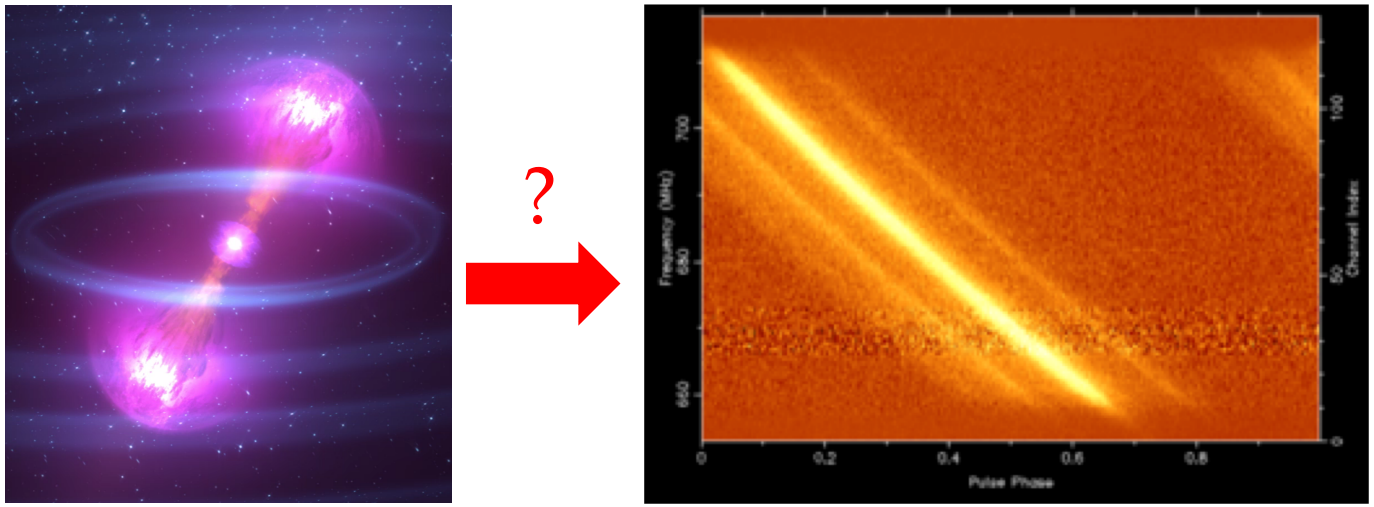
Quiescent Sun

Onset of CME



Type II Burst
Flux density increased x 1000

Low Frequency Prompt Emission from Neutron Star Mergers

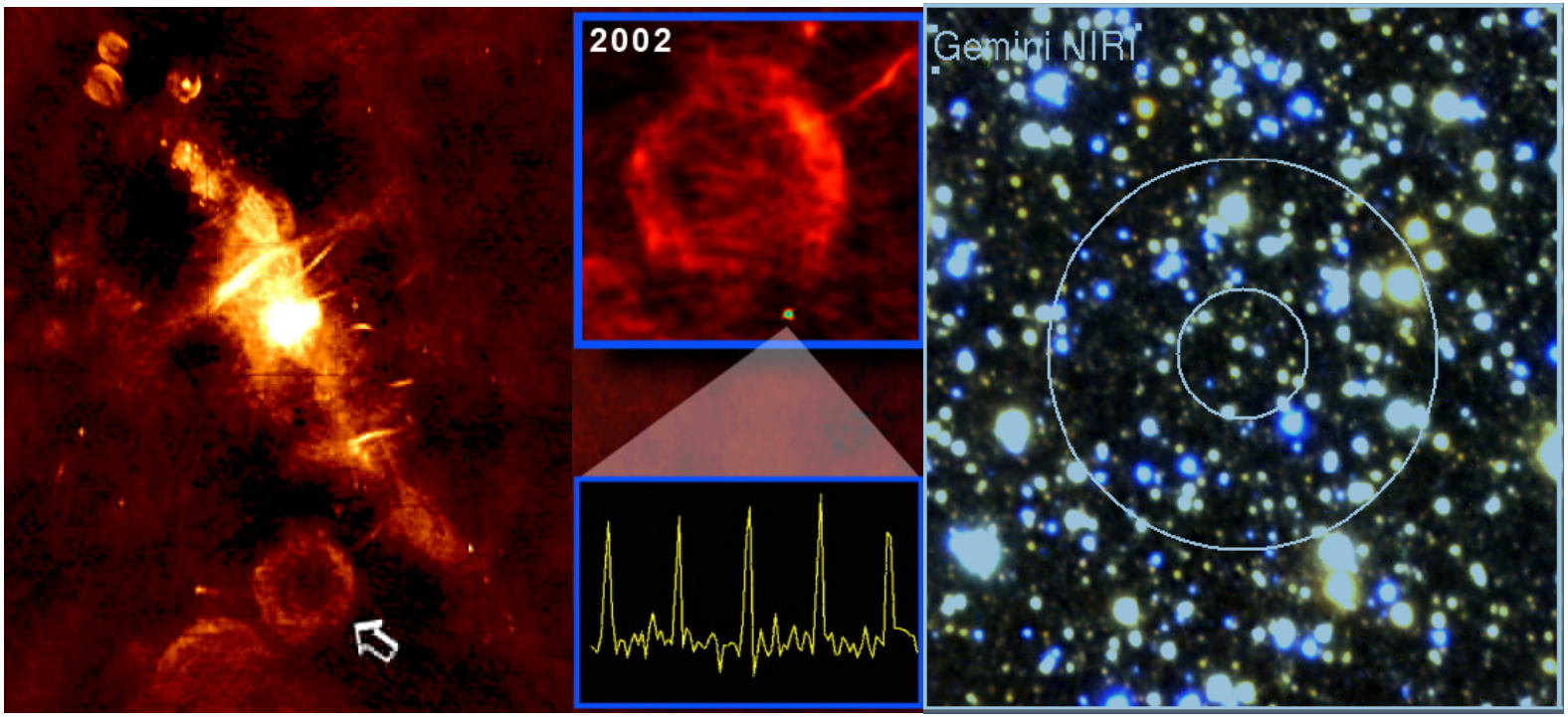


Prompt or precursor pulse to compact object mergers?
Lyutikov 2018, Lyutikov 2013, Pshirkov & Postnov 2010

See Marin's talk!

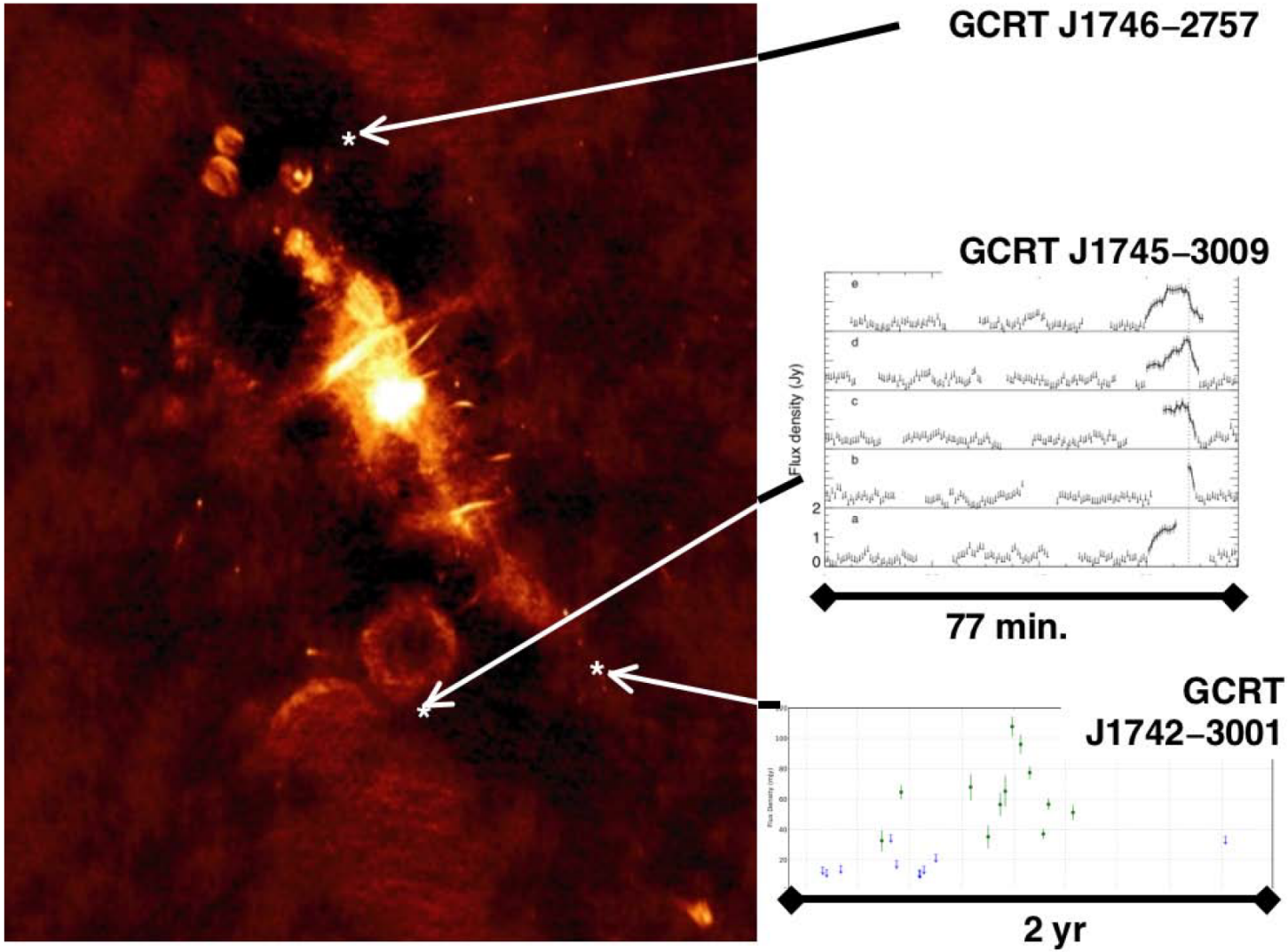
What do we see?

The Mysterious GCRT J1745-3009



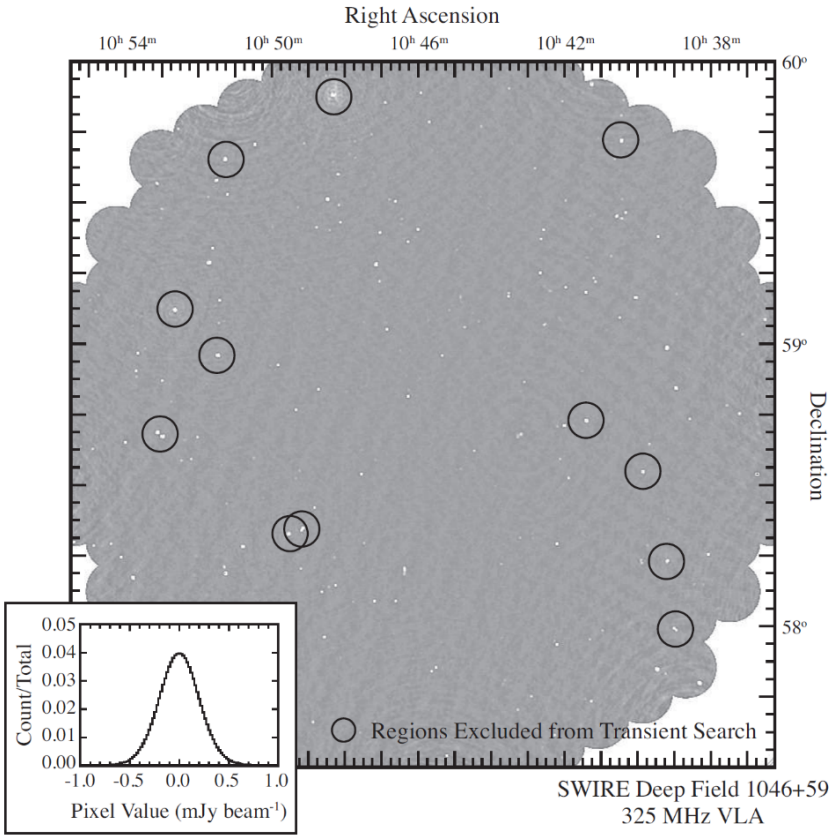
- Pulsing source (period 77 mins) discovered in archival 330 MHz VLA (1 Jy pulses) (Hyman et al 2005)
- Localization to poor to establish an optical counterpart (e.g. Kaplan et al. 2009)
- Nulling pulsar? White dwarf pulsar? Brown dwarf?
- Shown to be inconsistent with an all-sky isotropic rate (Polisensky et al. 2016)

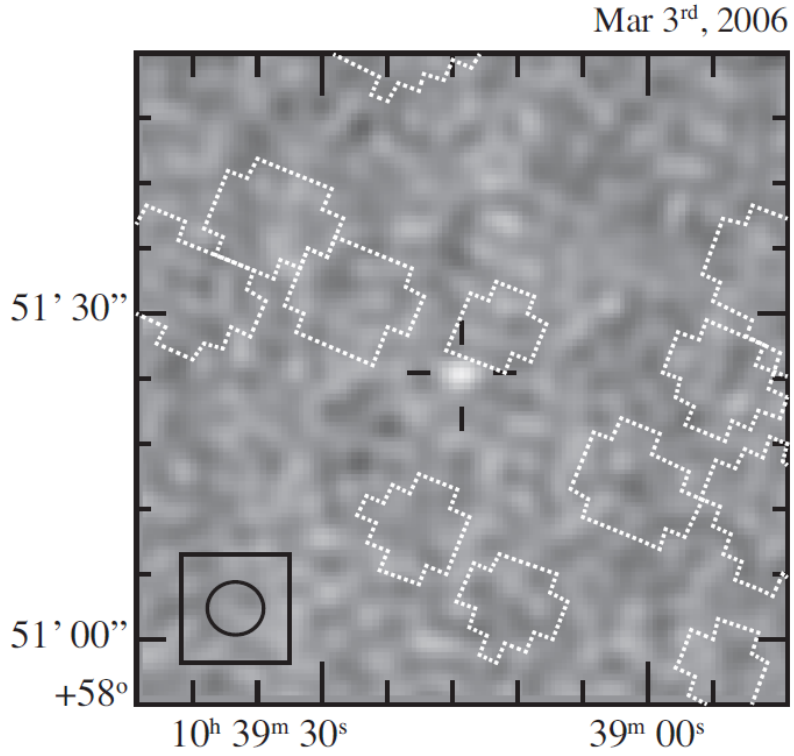
The Galactic Center Offers Rich Return



Hyman et al. 2005a, 2005b, 2009 (Figure from Lazio et al. 2009)

The SWIRE Radio Transient

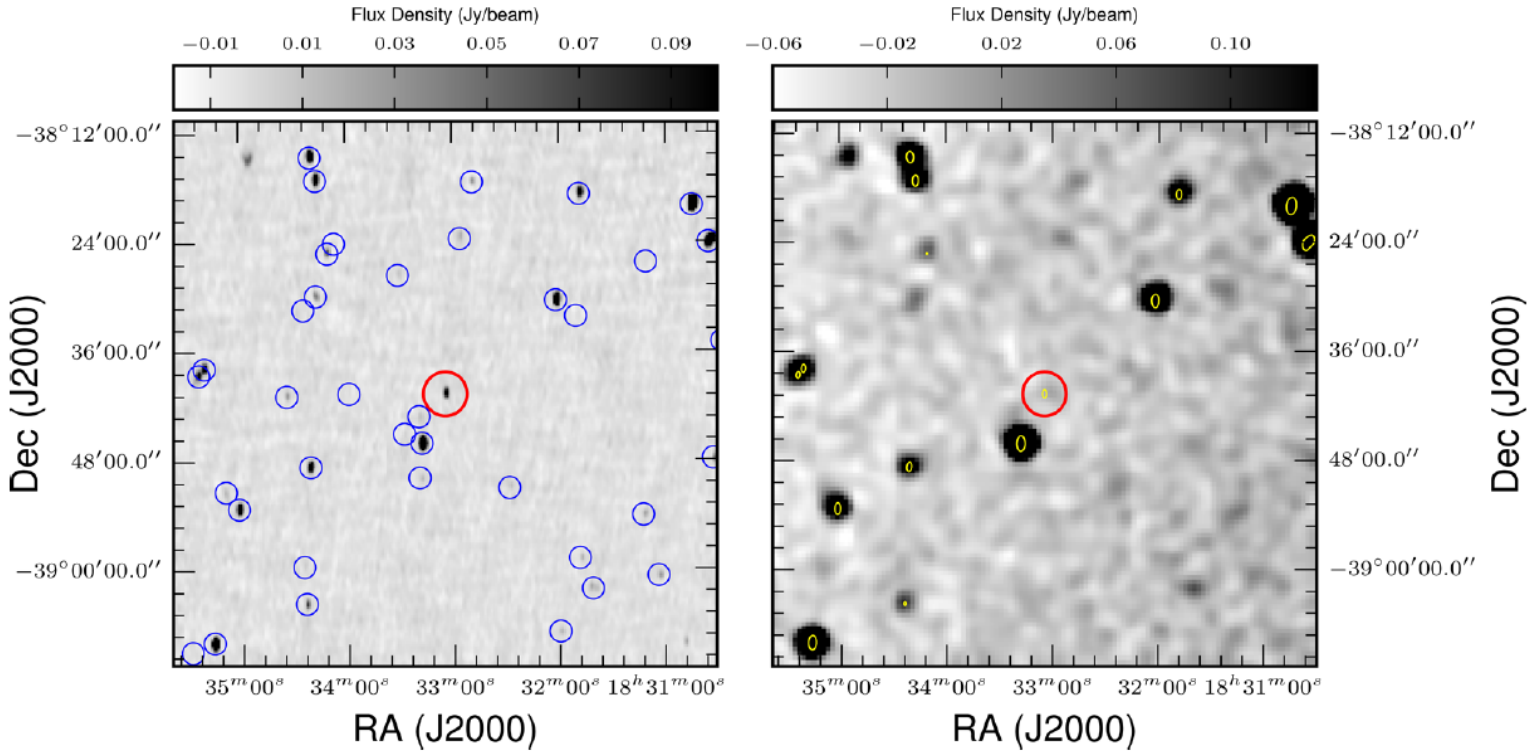




- **Transient source discovered in archival 330 MHz VLA data of the Spitzer-Space-Telescope Wide-area Infrared Extragalactic Survey (SWIRE) Deep Field (Jaeger et al. 2012)**

- **Deep observations revealed the presence of one, day-scale transient event with no apparent optical/IR counterpart.**

MWA/GMRT

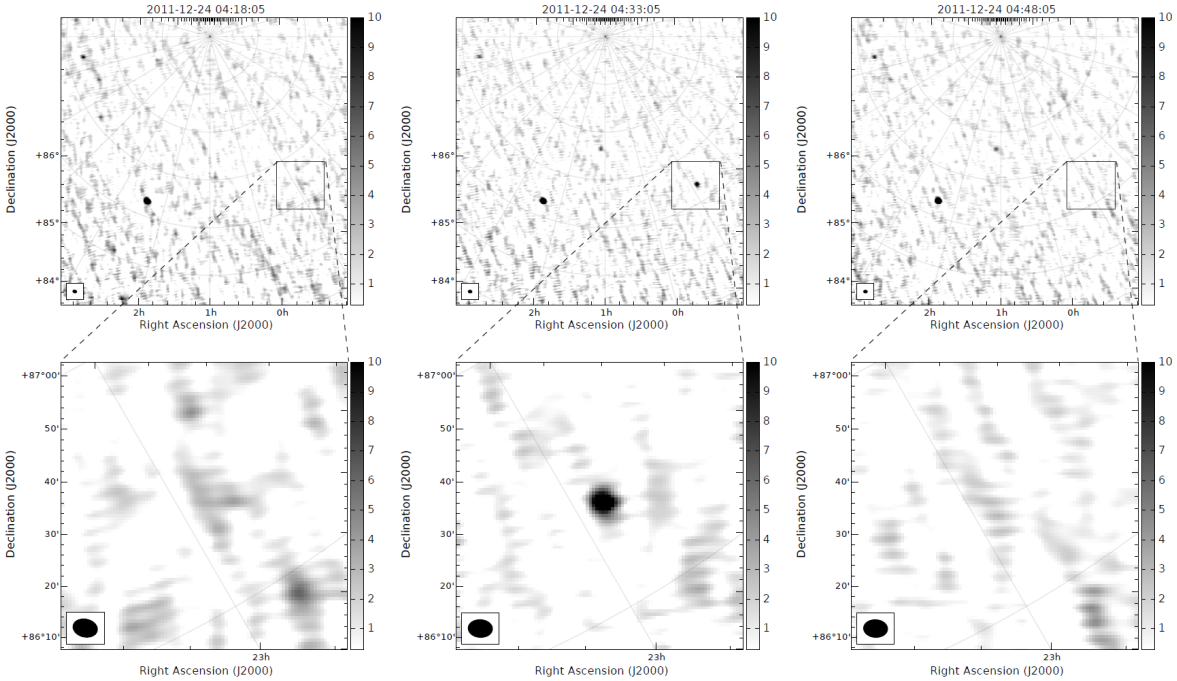


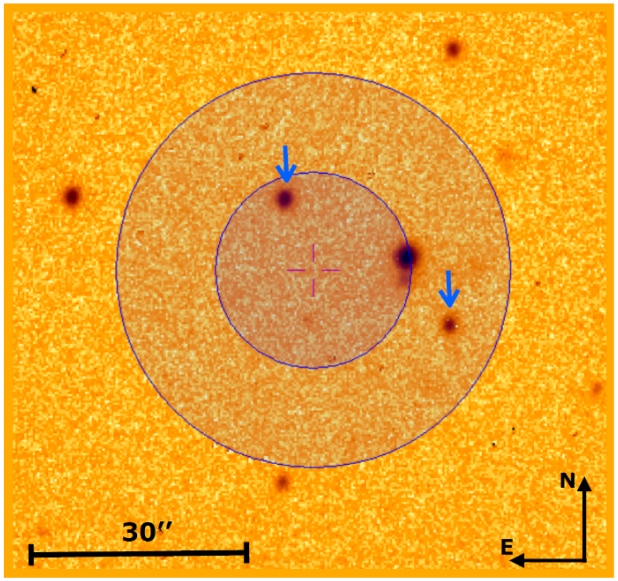
Comparison of TGSSS and GLEAM

1 transient candidate – 182 mJy at ~150 MHz

…with no apparent optical/IR counterpart

LOFAR



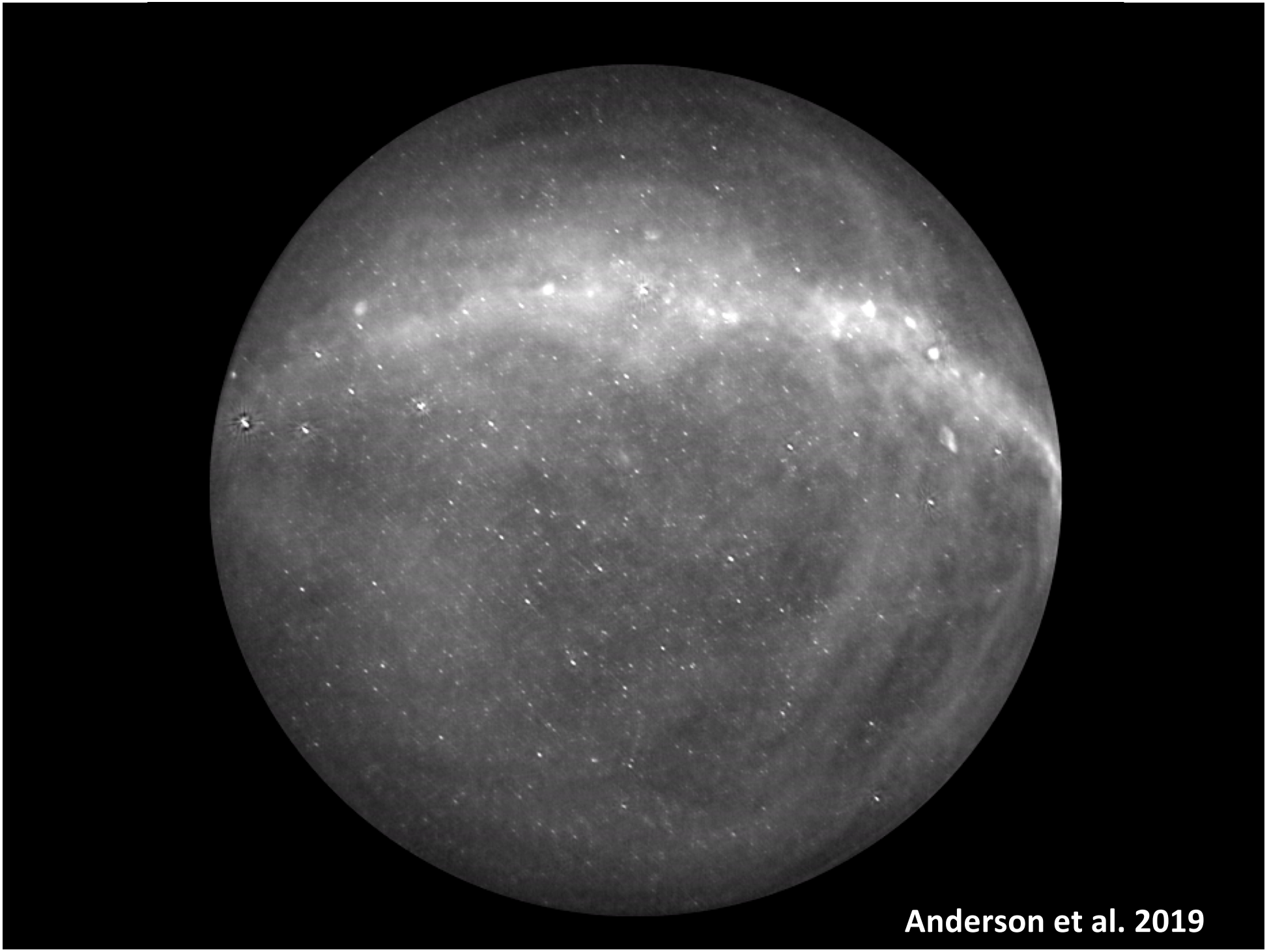


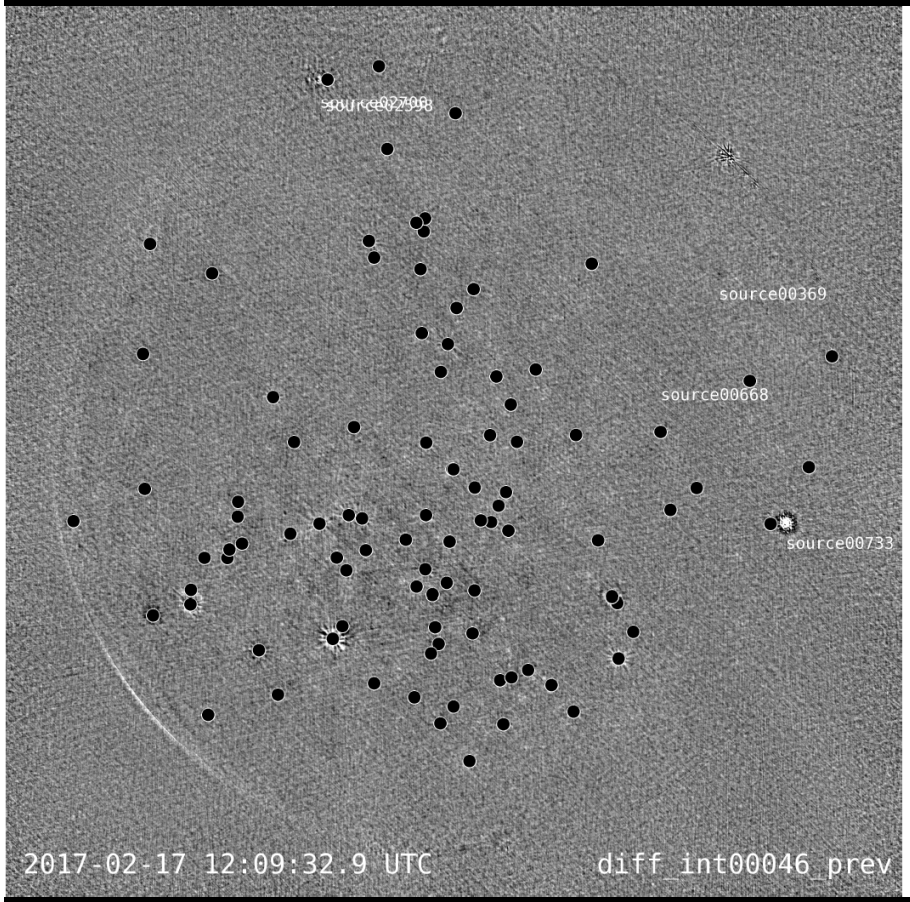
Detected at 60 MHz in 400 hours of data from the LOFAR MSSS survey (Stewart et al. 2016)

Brightness of 15-20 Jy, 11 minute timescale

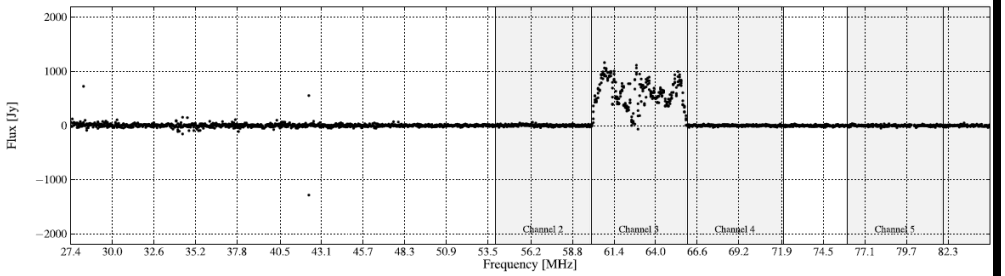
Implied rate of many per hemisphere per day…

with no apparent optical/IR counterpart


Anderson et al. 2019



(b)

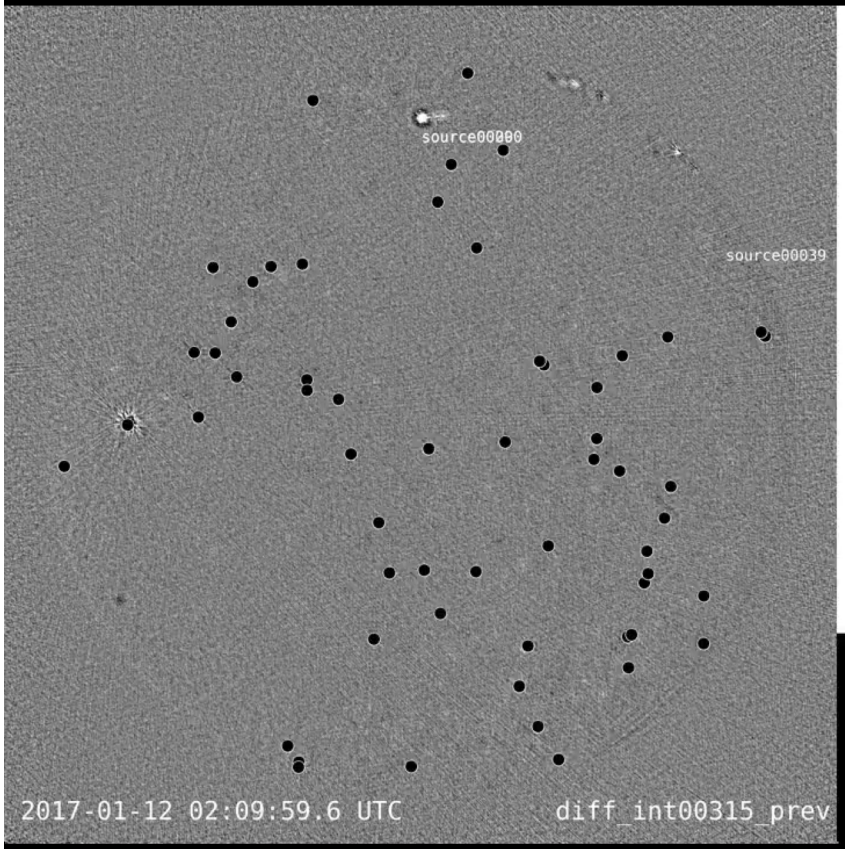


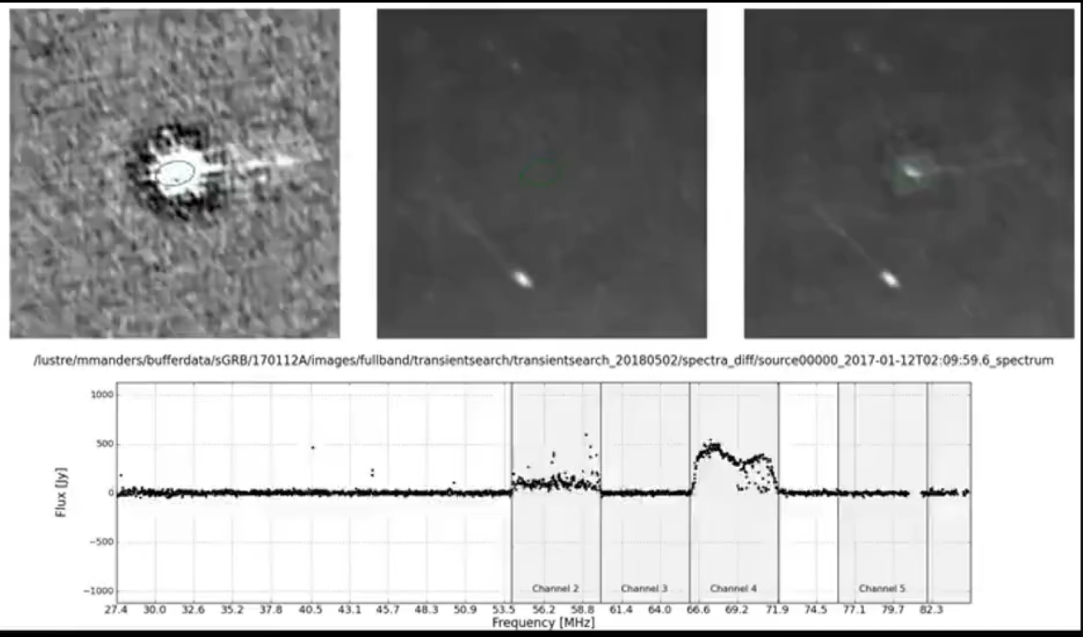
(c)

(10h17m11.0s 09d49m46.3s)
(-102.5 az 31.6 el)
(0.91deg x 0.74deg)
1.904 x unresolved
Source 00733

25.01 SNR
20.20 Jy peak flux
002 detections
Auto classification: Reflection

Anderson et al. 2019

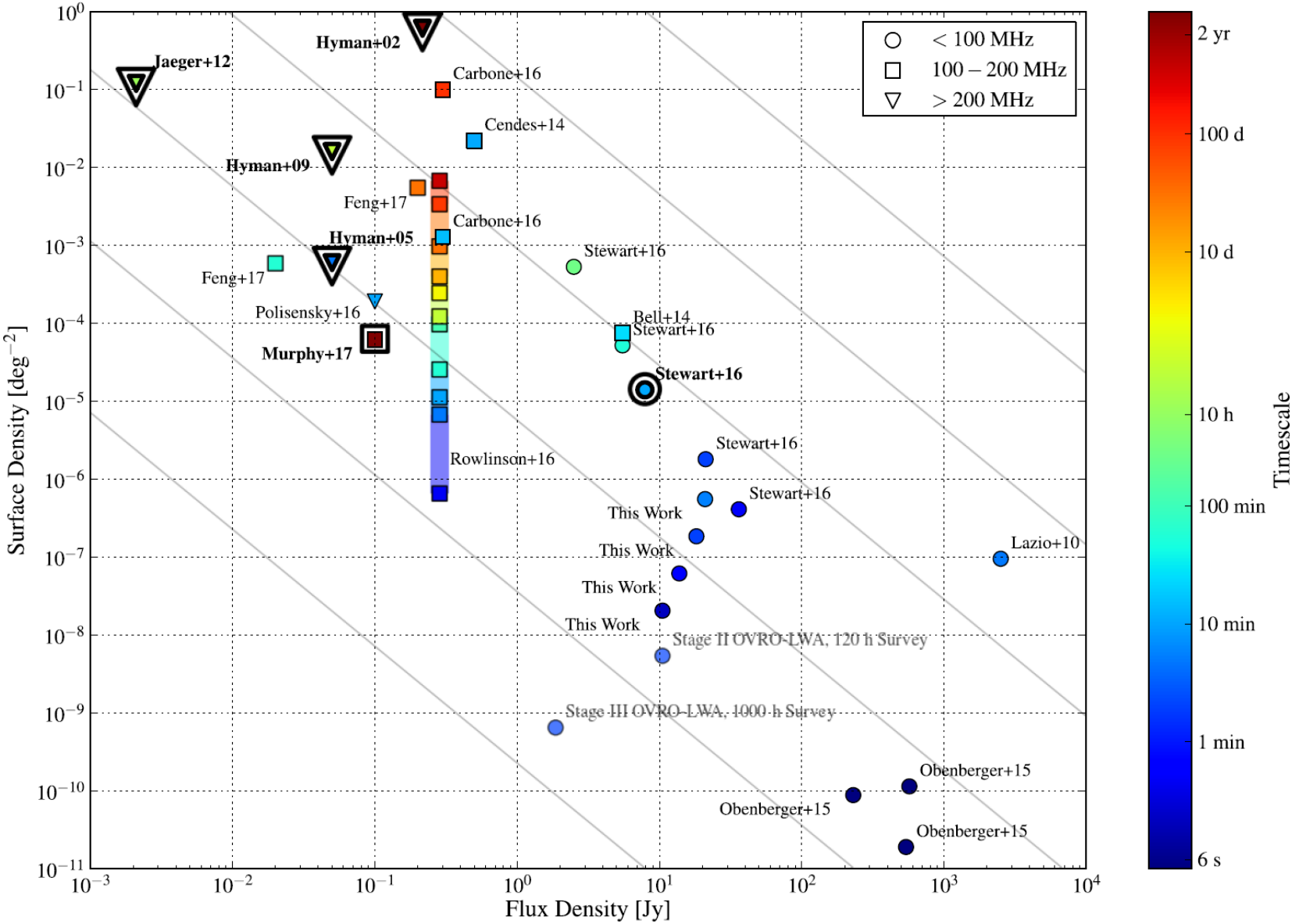




(13h42m56.7s 88d24m17.3s)
(0.0 az 35.6 el)
(0.72deg x 1.19deg)
2.478 x unresolved
Source 00000

22.41 SNR
14.80 Jy peak flux
002 detections
Auto classification: Reflection

Anderson et al. 2019

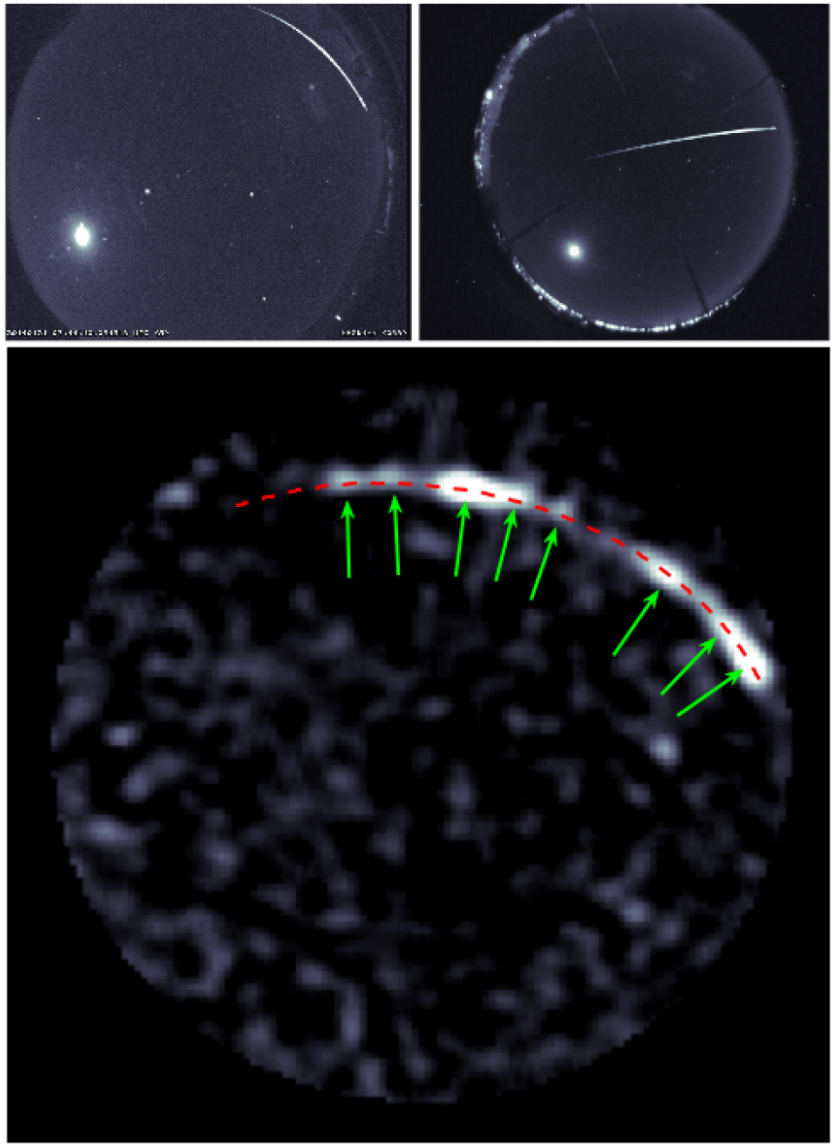


Non-detection rate from Anderson et al. 2019, implies much lower rate for the LOFAR transient, or narrow-band emission

Anderson et al. 2019

Atmospheric Phenomena

Meteors

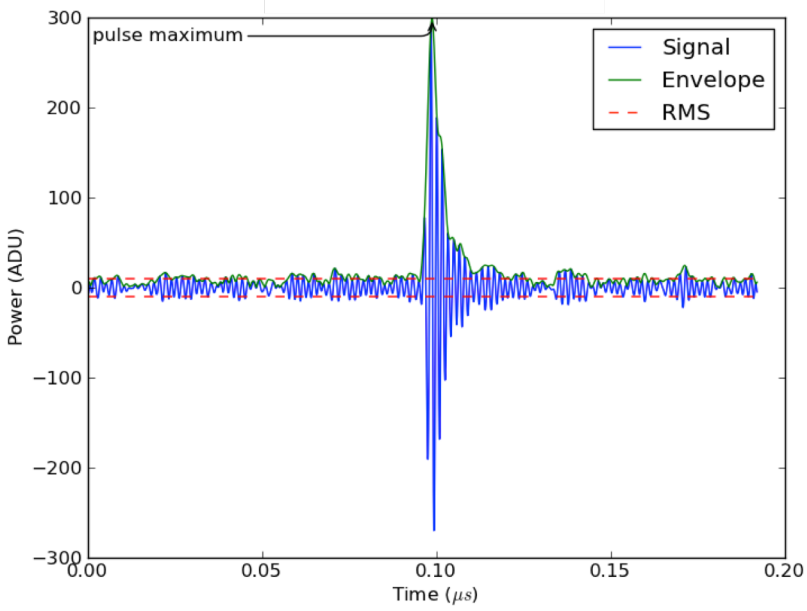


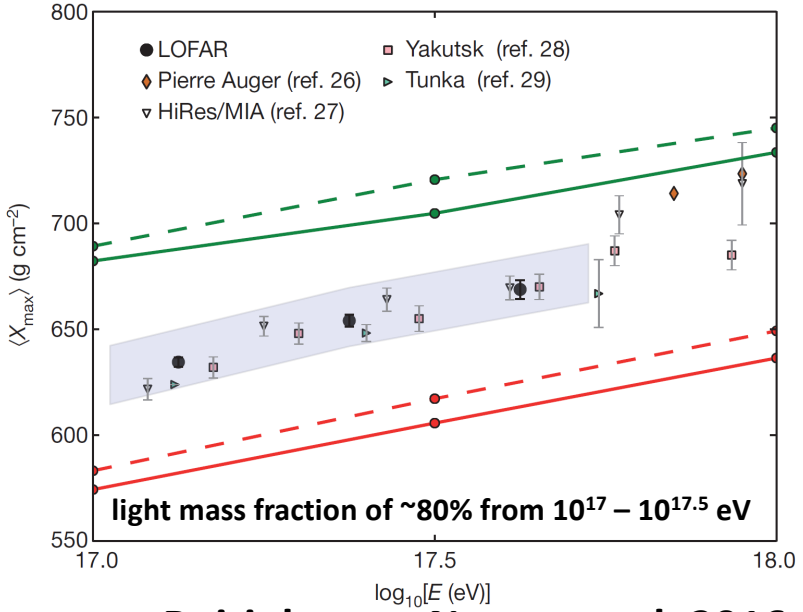
Obenberger et al. 2016, 2016a, 2016b

Mass Composition of Cosmic Rays

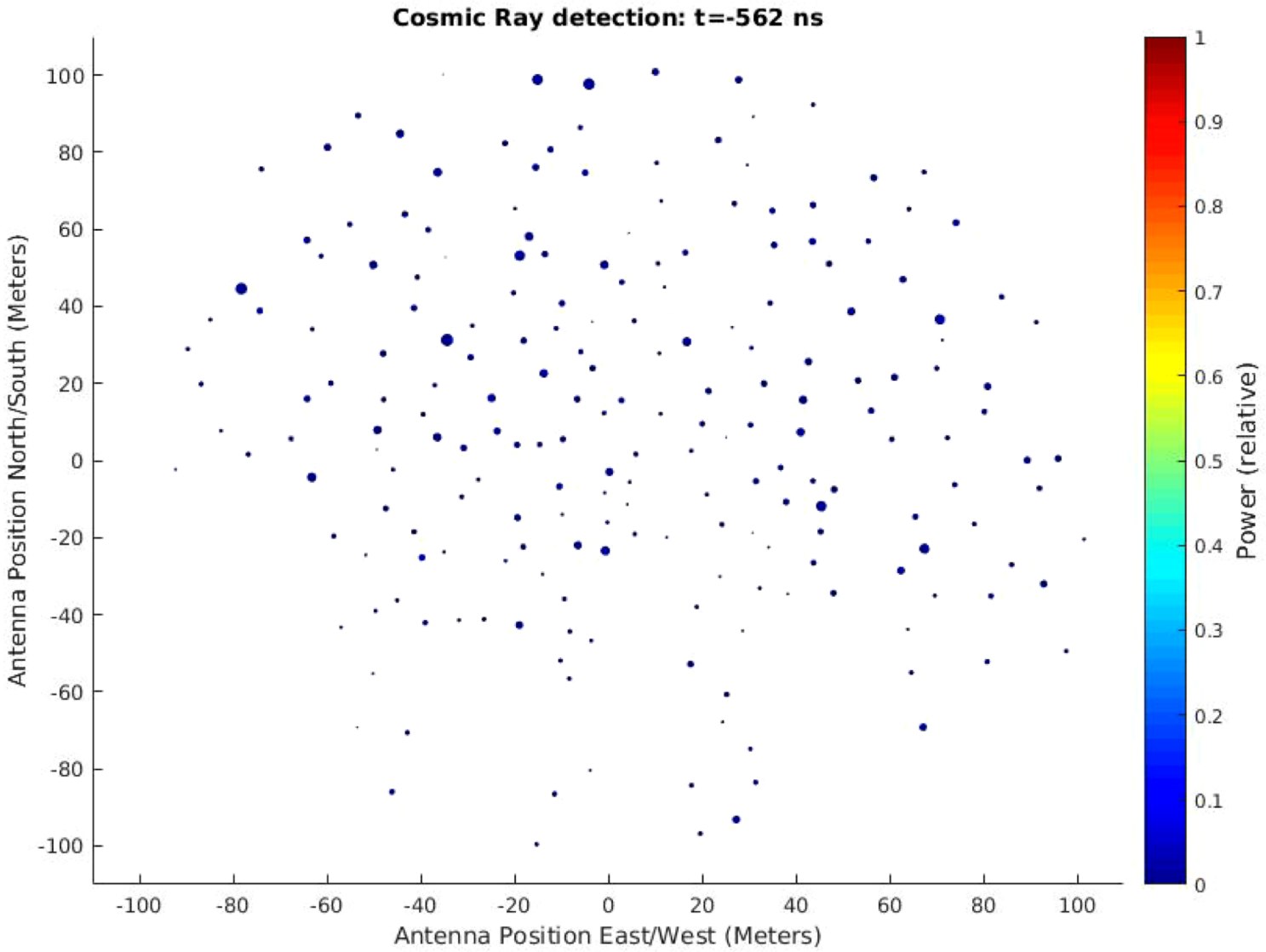
LOFAR radio telescope

LORA particle detector array





Buitink et a., Nature et al. 2016



Ryan Monroe

First RF-only detection of cosmic-rays (10 events in 40 hours)

Methodology can be applied to detection of tau neutrinos

Monroe et al. 2019

Summary

Radio transient sky starting to rumble

Data deluge has been an issue to date

Some intriguing transients without counterparts – Galactic or extragalactic?

Still in the era of boutique experiments – no one size fits all telescope

Extrasolar space weather and LIGO favor wide field

FRBs requires high time resolution (e.g. EPIC on LWA-SV)

A new population of extragalactic transients will require both survey instruments and localization instruments

e.g. LWA-OVRO + LWA-swarm

Be ready – déjà vu all over again!