Monitoring nearly 4000 nearby stellar systems with the OVRO-LWA in search of radio exoplanets

Marin M Anderson

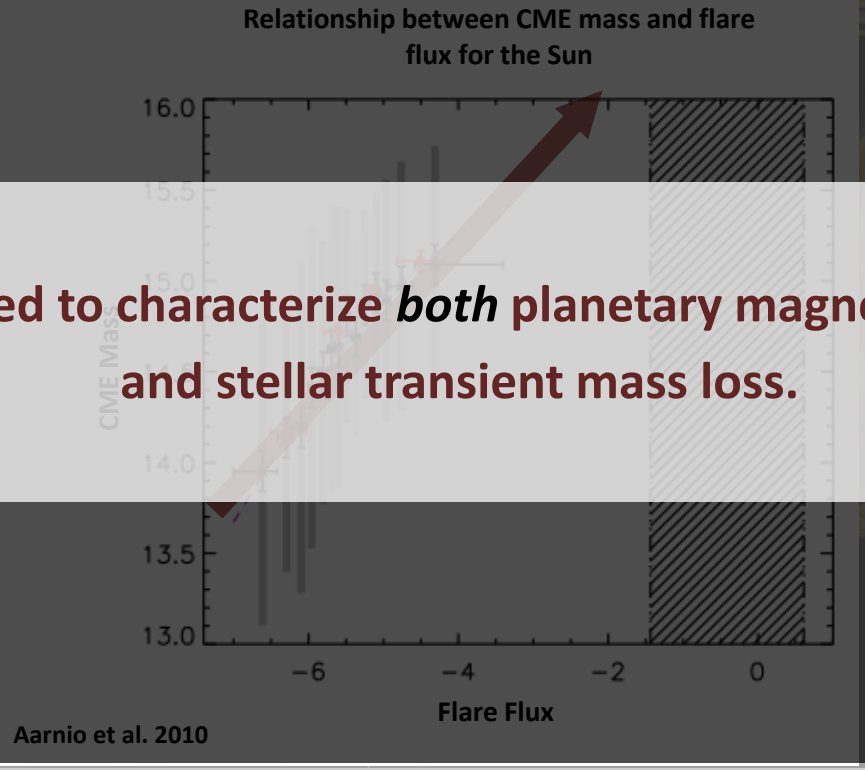
Caltech

AASTCS 5: Radio Habitability

May 11, 2017


A fertility company that defies the textbooks p. 620
Multigenerational effects on development pp. 634 & 651
Microbial ecology and evolution pp. 649 & 663
Science
$10
6 NOVEMBER 2015
sciencemag.org
AAAS
MAVEN at Mars
Probing a dynamic upper atmosphere p. 643

Understanding how CMEs scale with flare energy and frequency is critical to diagnosing habitable environments around magnetically active stars.



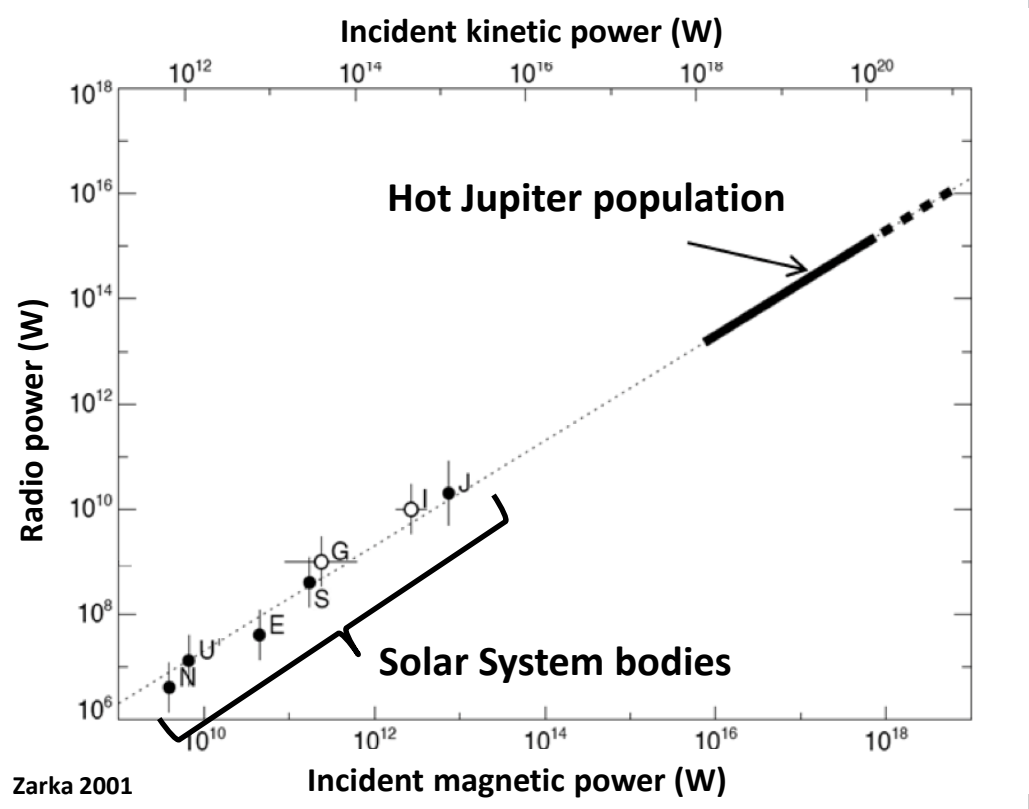
We need to characterize *both* planetary magnetic fields and stellar transient mass loss.

Characterizing stellar magnetic activity, planetary magnetic fields, and their interaction for a wide range of host mass and age.

- How can we optimize the search for extrasolar space weather, and begin detecting and characterizing systems en masse?
  - Low frequency (< 100 MHz)
  - Large-FoV instruments
  - Capitalize on characteristics of emission mechanisms (Stokes V)

Image credit: **C. Carter & G. Hallinan**

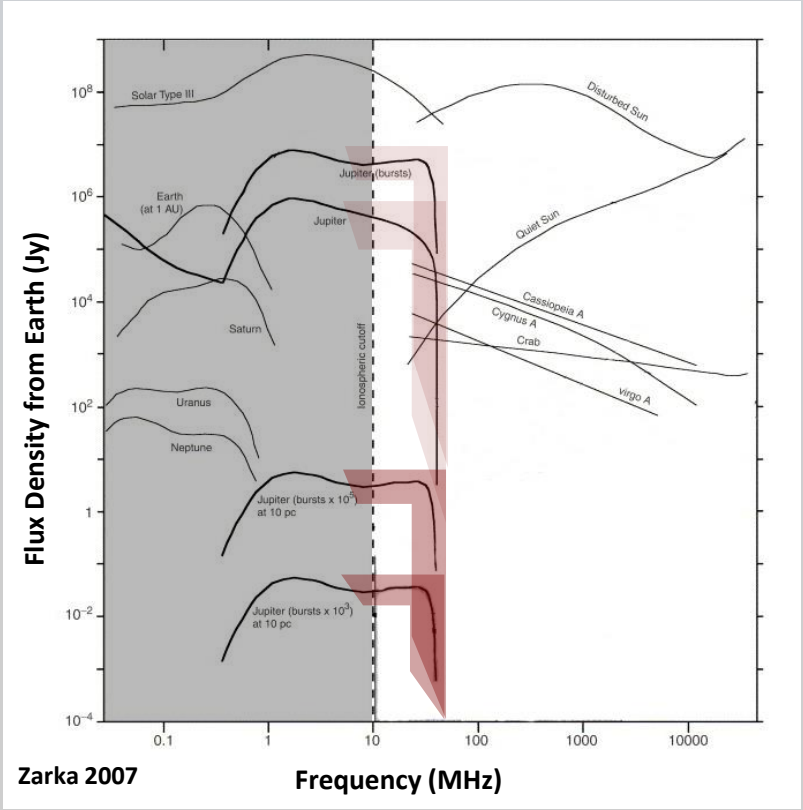
Low frequency (< 100 MHz)



Zarka 2001

Low frequency (< 100 MHz)

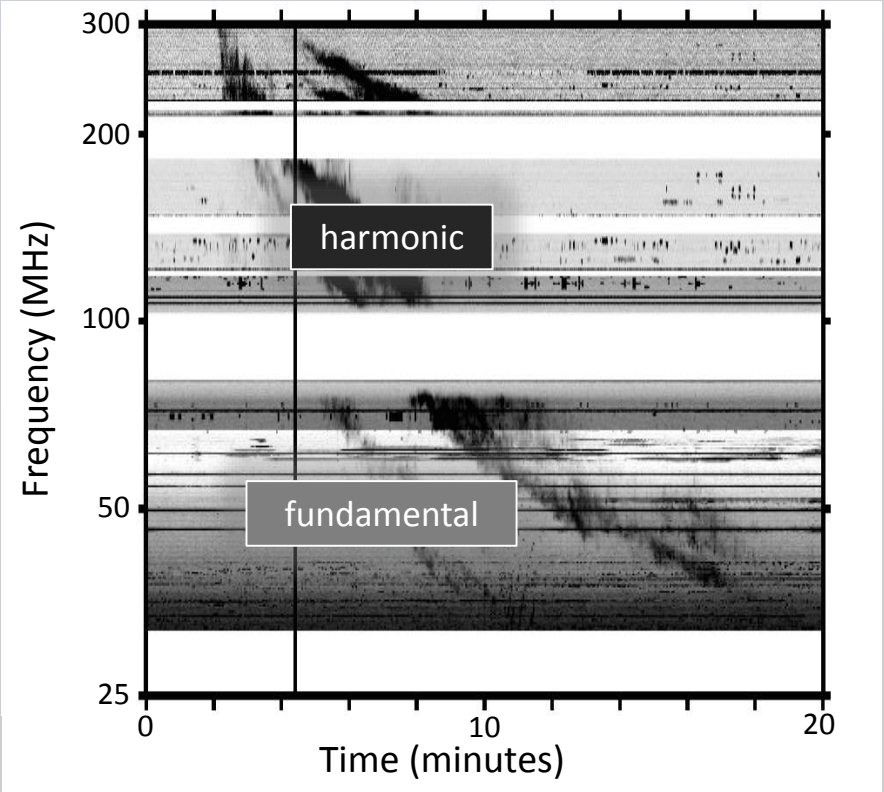
- Extrapolation from our own SS suggests it is necessary to go below 100 MHz to directly detect exoplanetary radio emission.



Low frequency (< 100 MHz)

- Extrapolation from our own SS suggests it is necessary to go below 100 MHz to directly detect exoplanetary radio emission.

- Solar Type II radio bursts are associated with CMEs, and frequently occur in the sub-100 MHz regime.

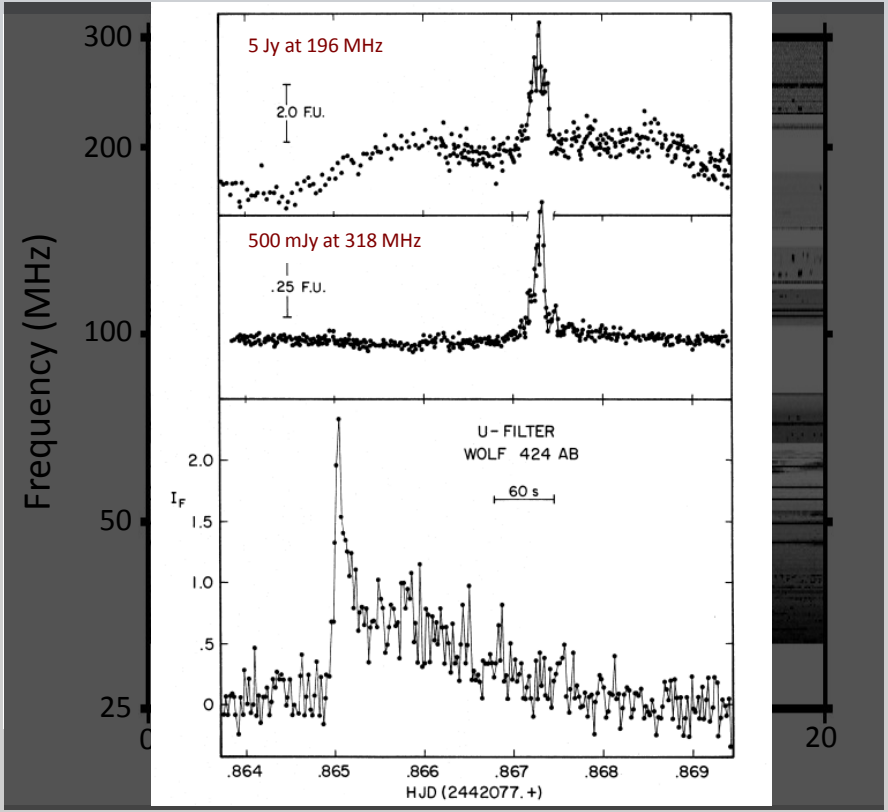


Kouloumvakos et al. 2014
Figure c/o J. Villadsen

Low frequency (< 100 MHz)

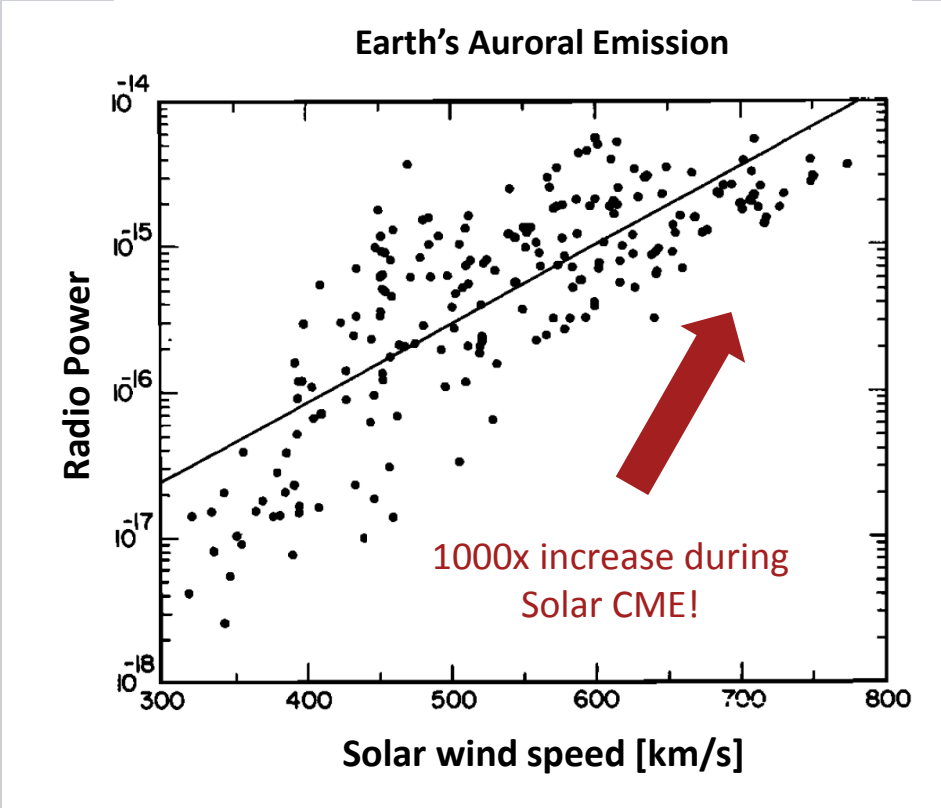
- Extrapolation from our own SS suggests it is necessary to go below 100 MHz to directly detect exoplanetary radio emission.
- Solar Type II radio bursts are frequently associated with CMEs, and peak in the sub-100 MHz regime.
- Previous detections of flare star radio emission indicate flux increases at low frequencies.

Spangler & Moffett 1976



Large-FoV Instruments

- Capture a large fraction of sky in order to monitor a large sample of objects.
- Sensitive to rare events associated with extreme flares / CMEs that may induce significant increase in exoplanetary radio power.



Gallagher and D'Angelo 1981

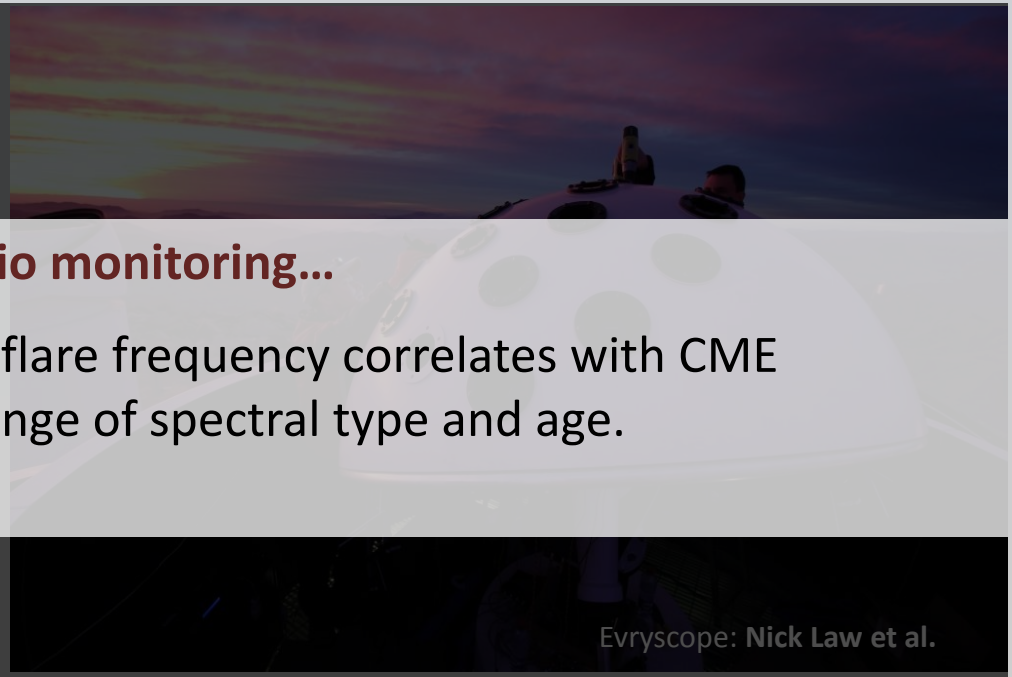
Current mode of operation with the Stage 2 OVRO-LWA

- Continuously observing as of November 2016, in order to respond to external event triggers (including GW events from aLIGO, X-ray flares from *Swift*).

- Initial 24-hour dataset monitoring 4000 objects out to 25 pc.
- 27-84 MHz with 24 kHz resolution
- 13-second integrations

Simultaneous optical monitoring with Evryscope

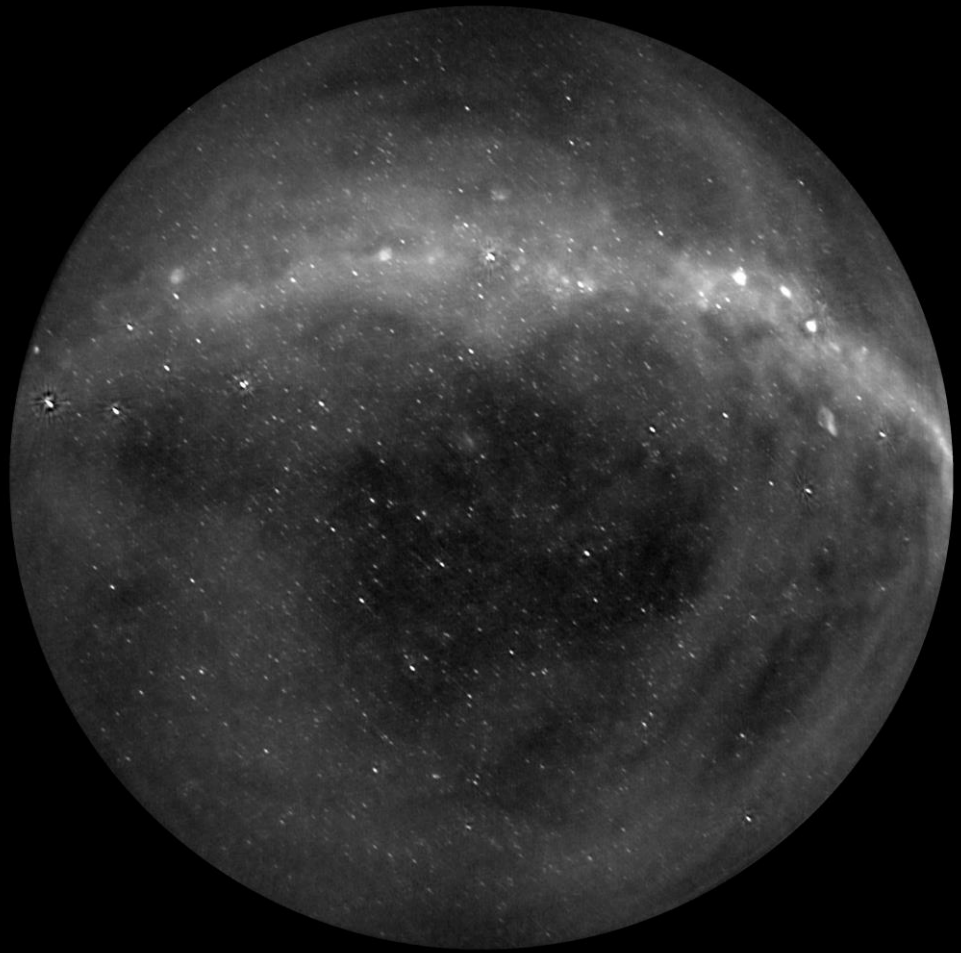
- Evryscope is an 8,600 sq. deg. FoV telescope at CTIO, that has 1.5 year-long coverage at
- 45%+ SV overlap between Evryscope and OVRO-LWA.

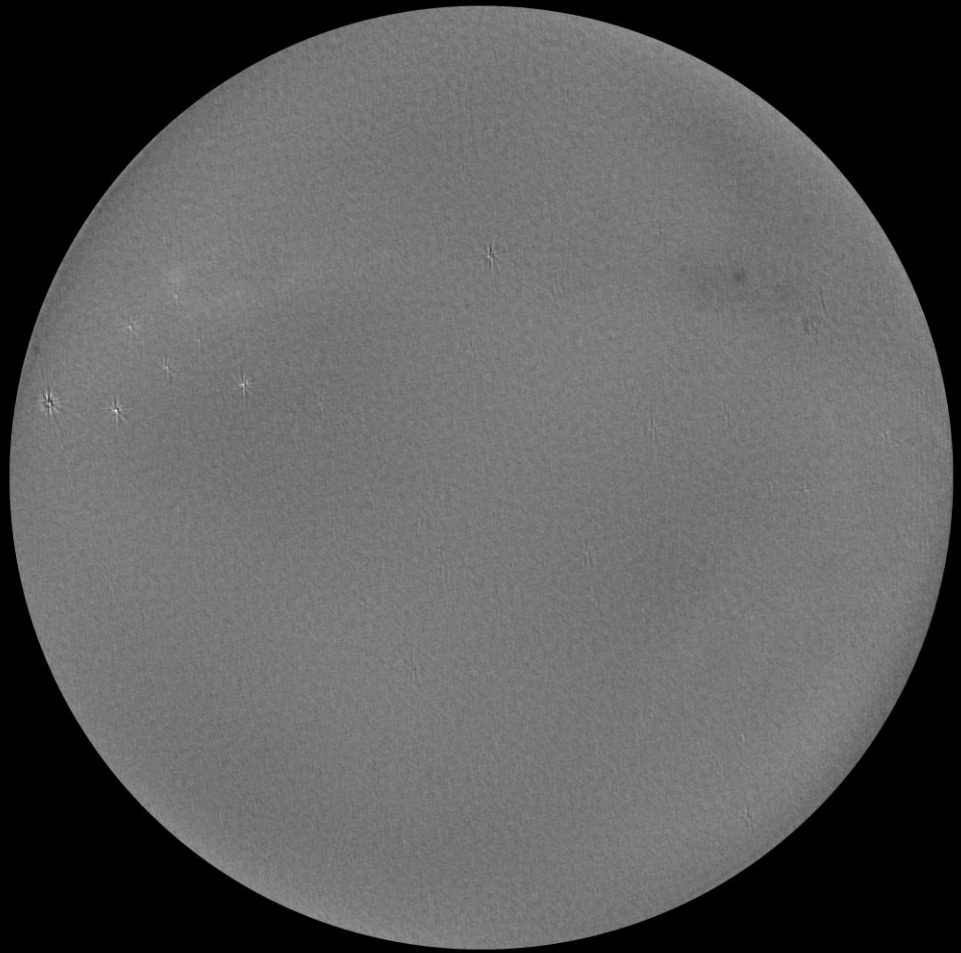


Simultaneous optical and radio monitoring…

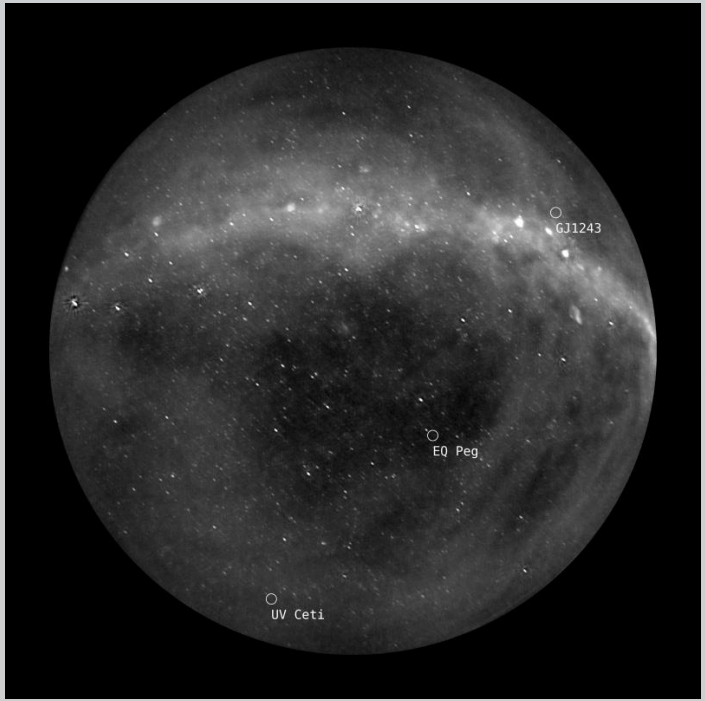
- Can begin to establish how flare frequency correlates with CME occurrence-rate for large range of spectral type and age.

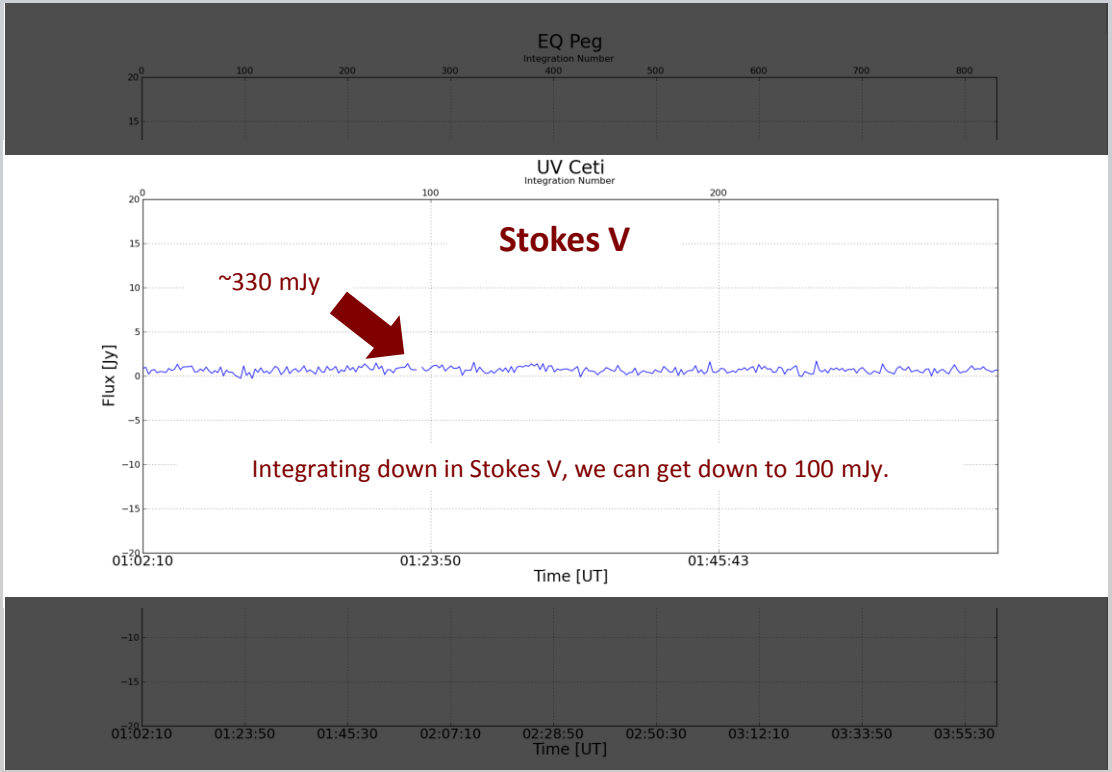
See Ward Howard's Poster 202.05 – EvryFlare: Flare rates and intensities for every 10 < g' < 15 solar-type and red dwarf star in the Southern sky



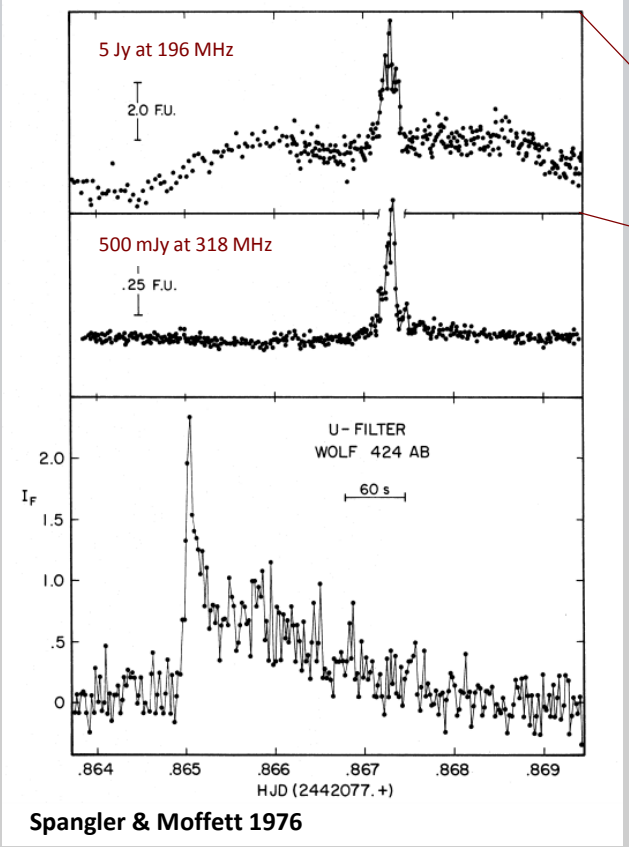


Initial results from a sample subset of flare stars.

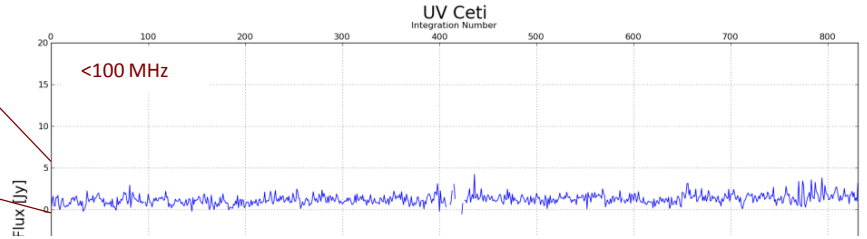


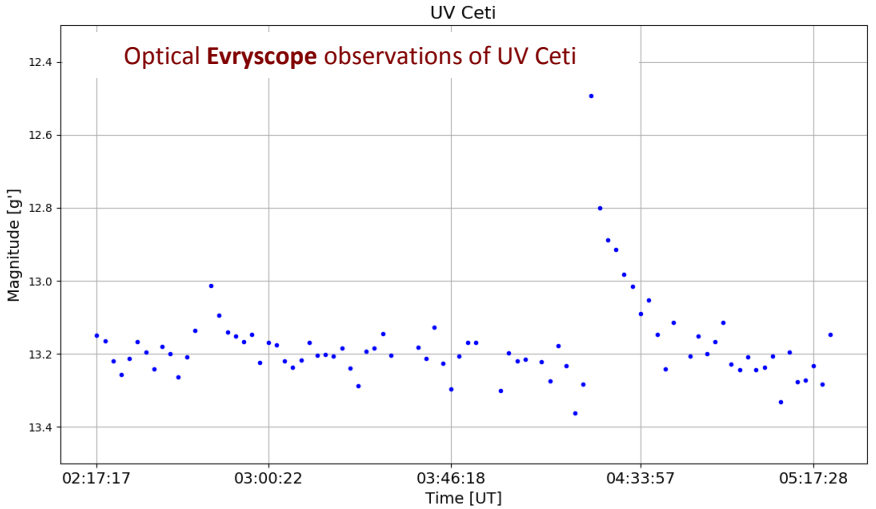


OVRO-LWA light curves for the usual flare star suspects.

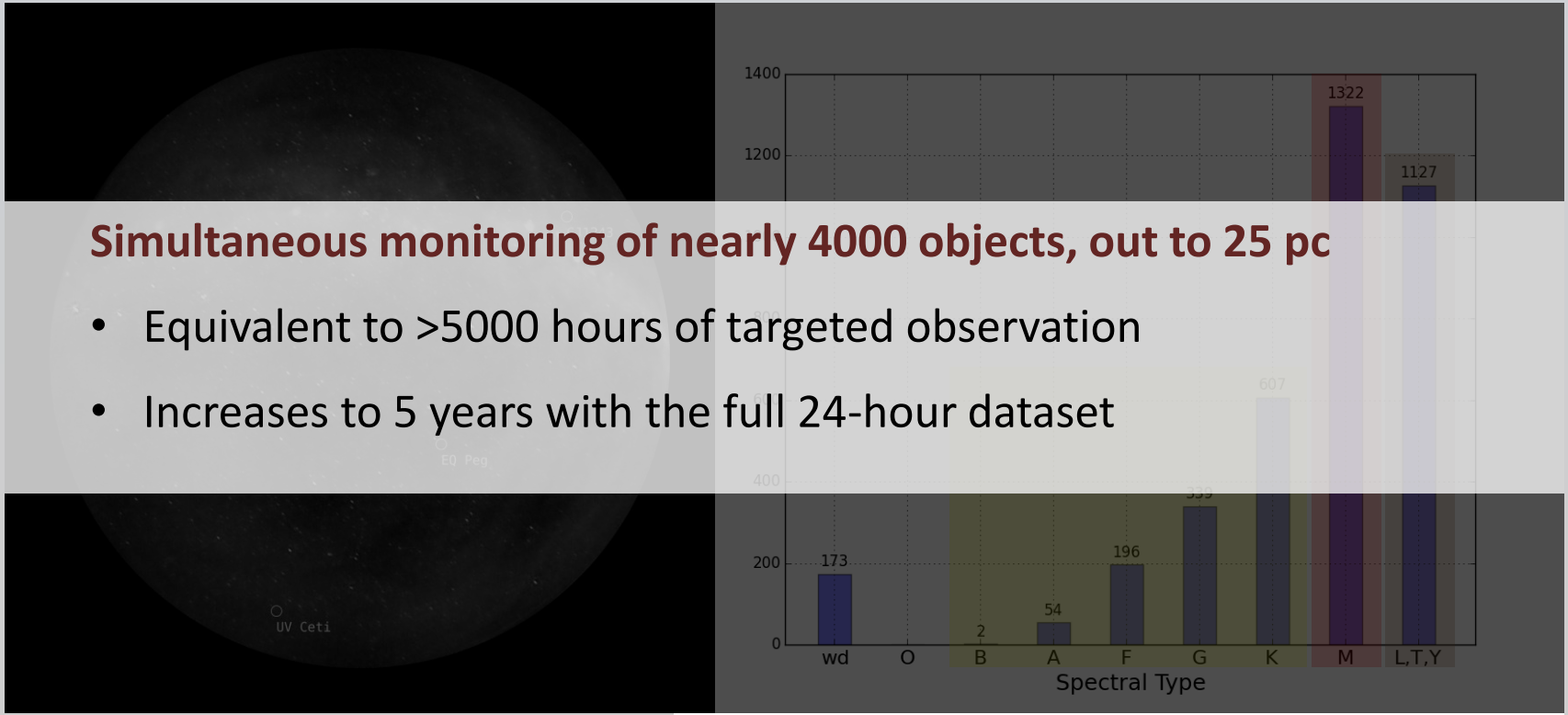


Spangler & Moffett 1976





Searching for signatures of magnetic activity in a volume-limited sample of systems.

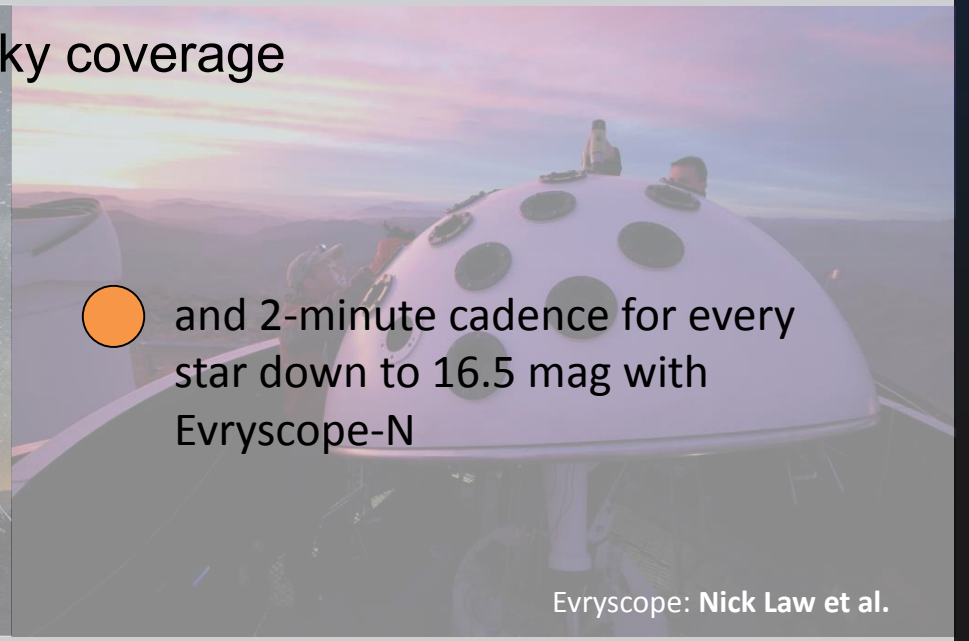


Simultaneous monitoring of nearly 4000 objects, out to 25 pc

- Equivalent to >5000 hours of targeted observation
- Increases to 5 years with the full 24-hour dataset

The completed stage-III OVRO-LWA, in coordination with Evryscope-North…

- …will provide unprecedented statistics on flare and CME activity
- …with nearly 100% overlap in sky coverage
- Planned 1000-hour survey
  - with few-seconds cadence and ~100 mJy snapshot sensitivity with OVRO-LWA
  - and 2-minute cadence for every star down to 16.5 mag with Evryscope-N



Evryscope: **Nick Law et al.**

Scientific goals of the OVRO-LWA

- Establish flare and CME rates across a wide range of mass and age.
- Investigate the relationship between flare energy and CME kinetic energies for low mass stars.
- Inform the community of extreme events.
- Receive triggers for highest energy events (e.g. *Swift* super-flares)
- Provide the most meaningful constraints (or detections) of radio exoplanets!