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UNIVERSITY OF GALWAY

Multi-wavelength observations of the flare star binary system: EQ Pegasi

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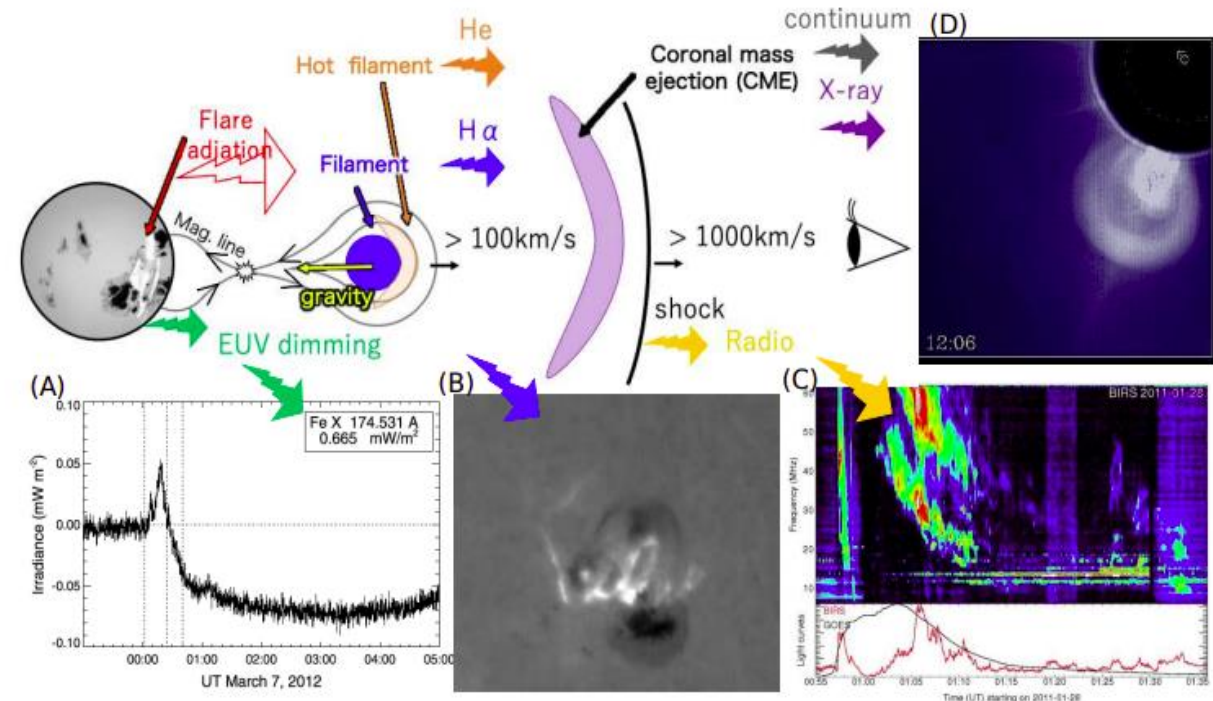
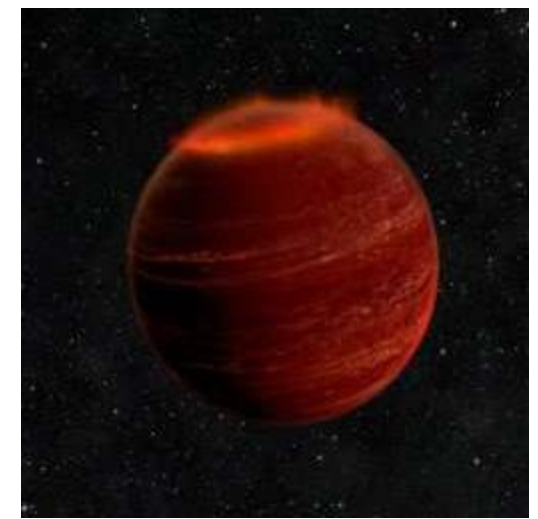
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Background / Motivation

- The detection of polarized coherent flares from the flare star UV Ceti using the MWA at 154 MHz strongly indicates the presence of auroral currents within an extensive magnetosphere, unexpected for an M5.5 dwarf (Lynch et al., 2017)
- Proposal was to observe EQ Peg in low frequency radio to
 - (i) confirm the presence of coherent emission at this passband in other M dwarf flare stars
 - (ii) confirm its origin if present is the electron cyclotron maser instability
- using high frequency radio and optical observations to
 - (iii) link radio & optical emission and so surface/coronal flare to auroral activity.

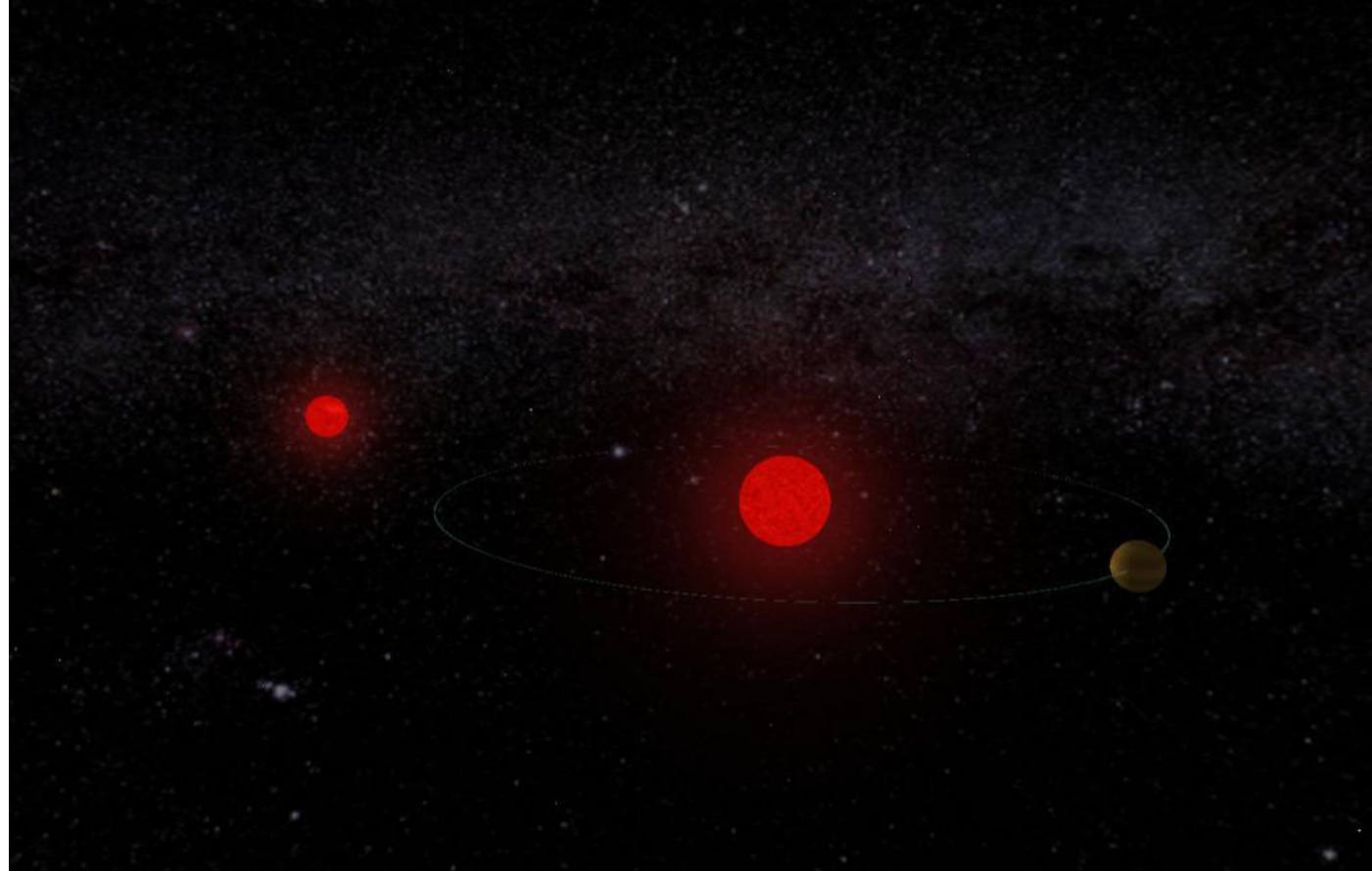


(Namekata et al, 2022)

Image Credit: <https://scx1.b-cdn.net/csz/news/800a/2022/can-fast-detect-aurora.jpg>

EQ Pegasi

- M dwarf flare star binary system
- Distance: 6.25 pc
- Period: ~ 180 years
- Separation of 5.8 arcsec
- Flare rate U': 1 flare per hour above 5×10^{31} erg
- Recently detected $2.3 M_{\text{Jup}}$ exoplanet around EQ Peg A



	Spectral Type	Rotation Period	Magnetic Field Strength
EQ Peg A	M3.5	1.061 days	480 G
EQ Peg B	M4.5	0.404 days	450 G

(Crosley & Osten, 2018; Lacy et al., 1976; Curiel et al., 2022)

Image credit: <https://www.livingfuture.cz/img/images/11184.jpg>

Hunting for CMEs from EQ Peg

Facility	Instrument/Passband	Duration	Time Resolution
Liverpool	IO:O / SDSS U'	~ 6.7 hours	20 sec
eMERLIN	C band / 4.8 – 5.33 GHz	~ 11.6 hours	1 sec
LOFAR	HBA / 110 – 190 MHz	~ 8 hours	1 sec

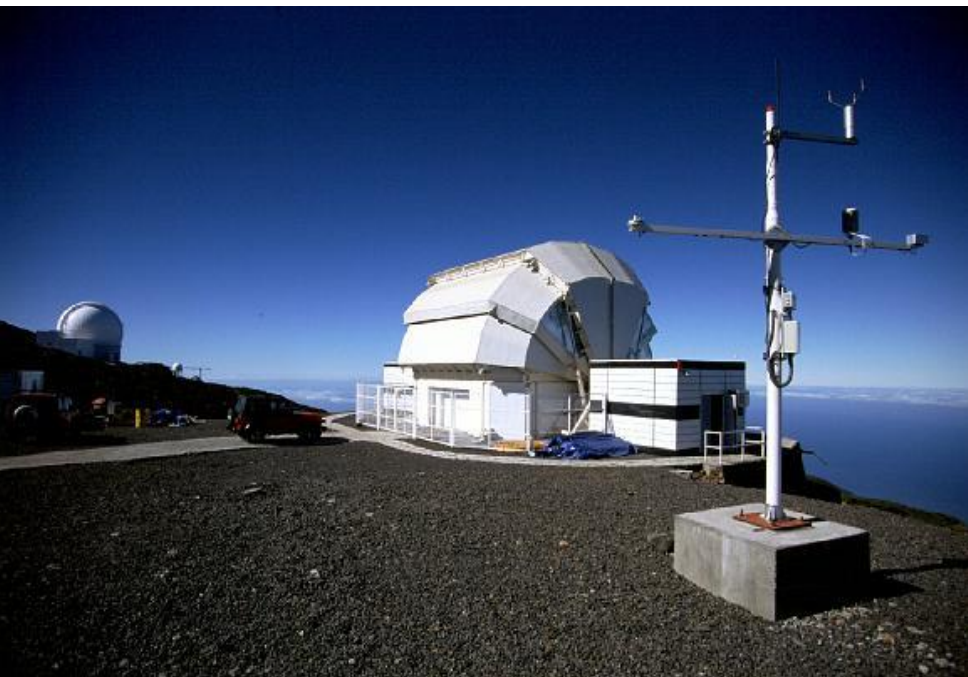


Image Credit: <https://telescope.livjm.ac.uk/>;
<https://www.e-merlin.ac.uk/>; <https://lofar.ie/>;

Every Astronomer's Nightmare...

"We regret to inform you that the LC10_018 observing run failed last night, due to faulty settings at individual stations and failure to record data on our production cluster."



What we do have...

- Provide information on the coronal environment
- Optical flares and their association with coronal radio emission at GHz bands
- Can't directly 'detect' CME but can constrain likelihood
- Study EQ Peg's magnetic activity

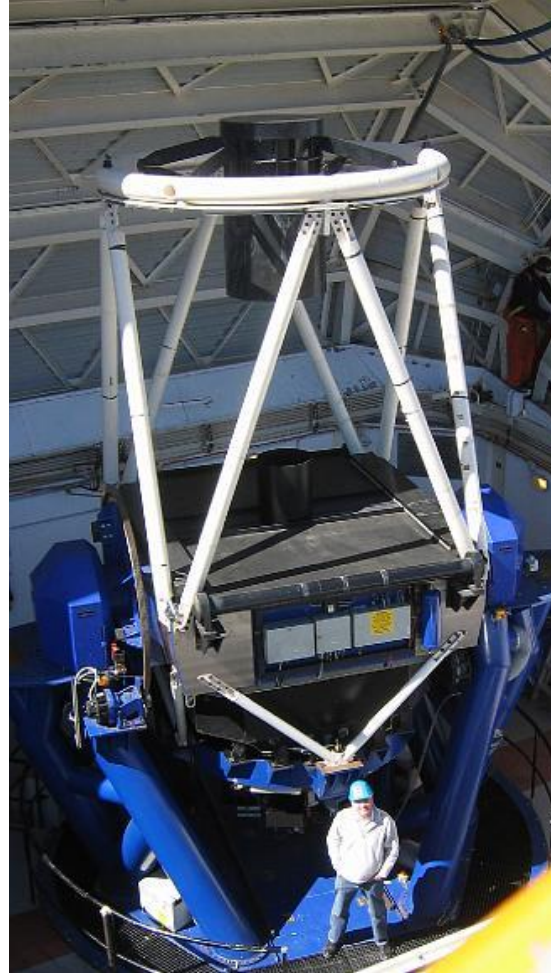
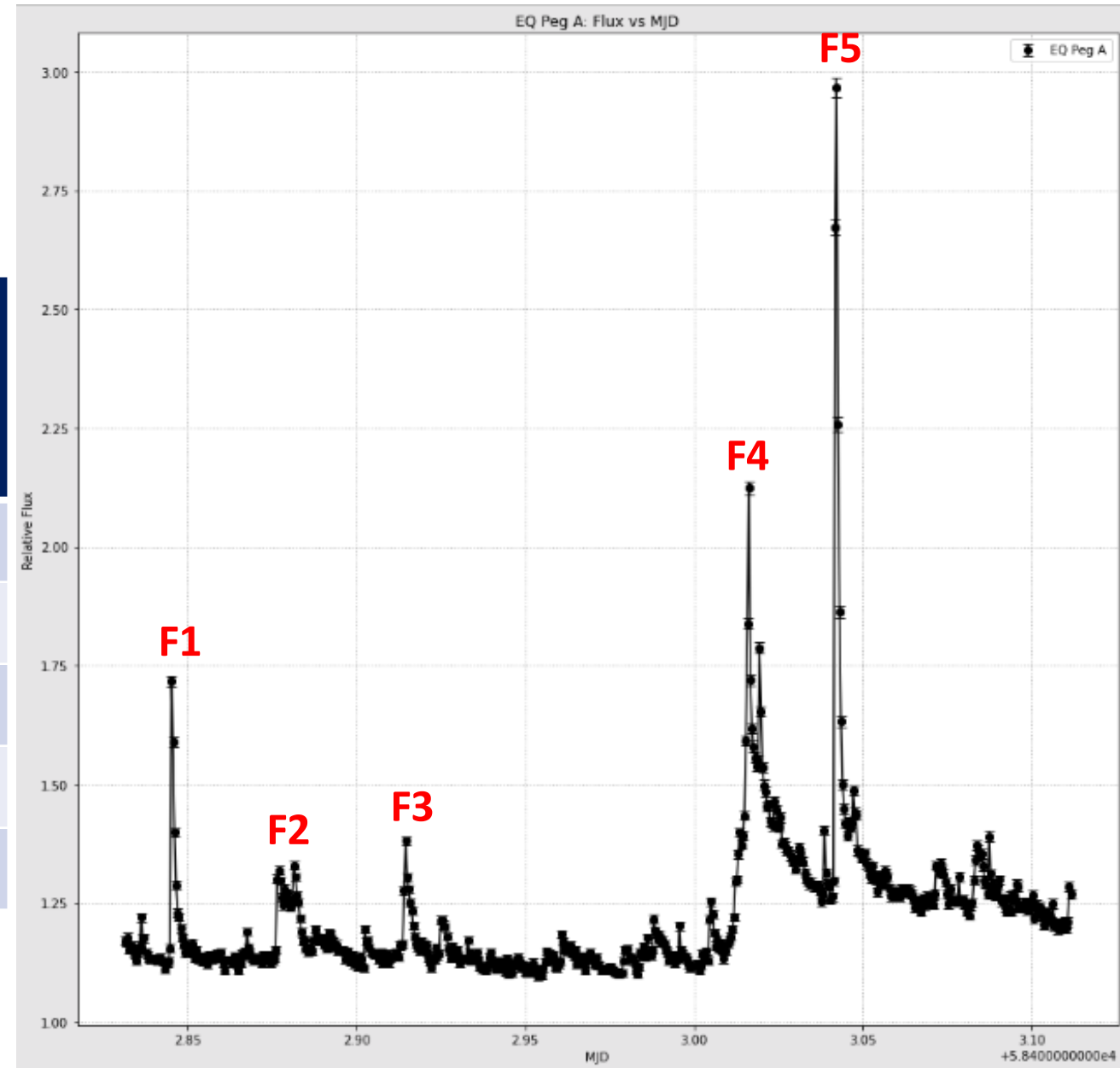


Image Credit: <https://telescope.livjm.ac.uk/>;
<https://www.e-merlin.ac.uk/>;

EQ Peg A: Flares

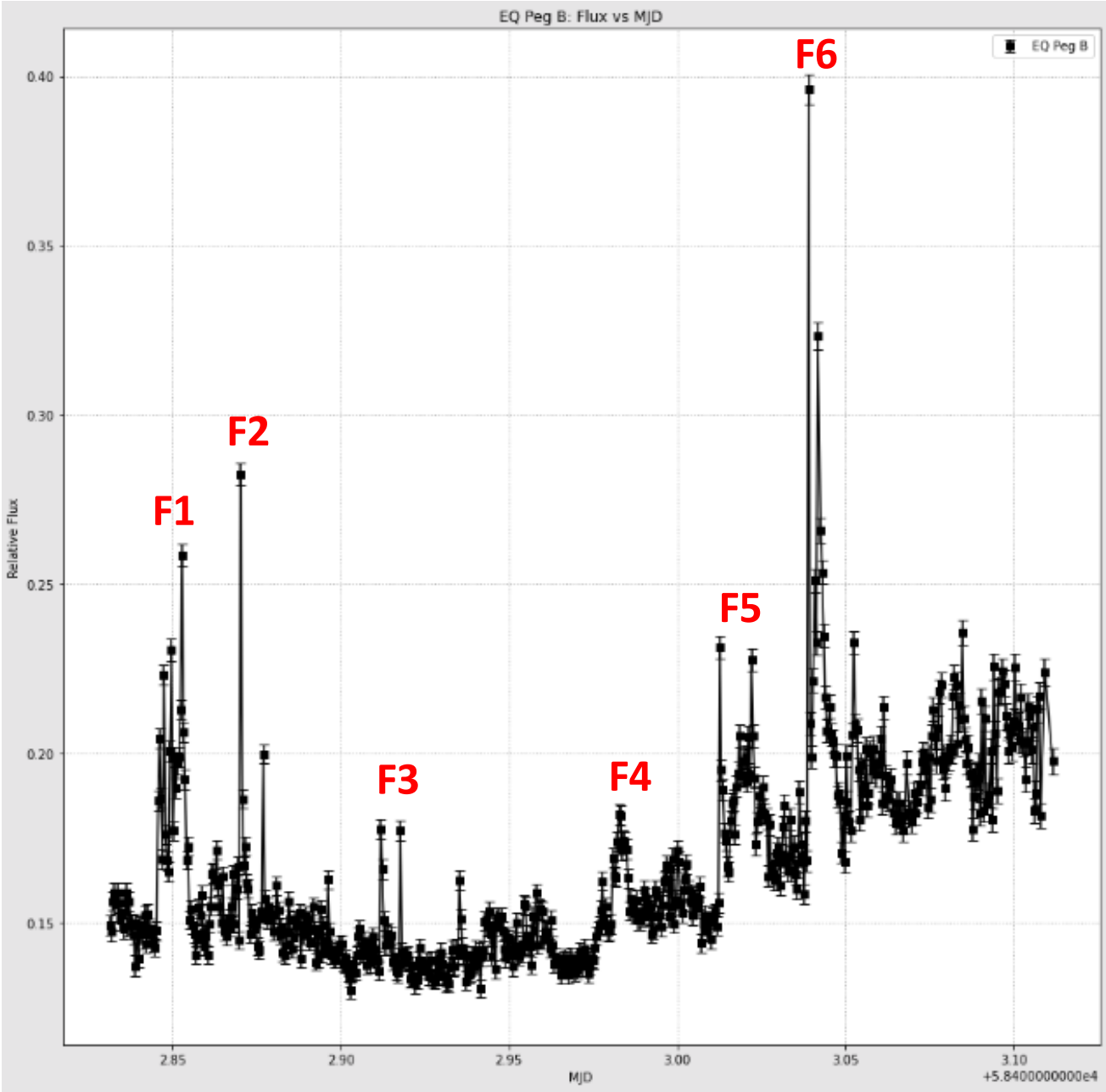
Flare	Classical / Complex	Duration (mins)	Energy U' (erg)
F1	Classical	9	4.1×10^{30}
F2	Complex	14	5.5×10^{30}
F3	Classical	9	2.7×10^{30}
F4	Complex	41	2.7×10^{31}
F5	Classical	28	1.4×10^{31}



(Ní Chonchubhair & Golden, In prep.)

EQ Peg B: Flares

Flare	Classical / Complex	Duration (mins)	Energy U' (erg)
F1	Complex	18	4.5×10^{30}
F2	Classical	12	1.6×10^{30}
F3	Complex	28	2.9×10^{30}
F4	Complex	27	4.2×10^{30}
F5	Complex	27	5.8×10^{30}
F6	Complex	17	5.3×10^{30}



(Ní Chonchubhair & Golden, In prep.)

Constraints on likely CME events

- Proposed threshold for a solar flare have an accompanying CME is 8.38×10^{29} erg in SDSS U' (Crosley & Osten, 2018)
- Our data suggests all observed flares would have passed this threshold
- How to detect CME?
- Ideally LOFAR...

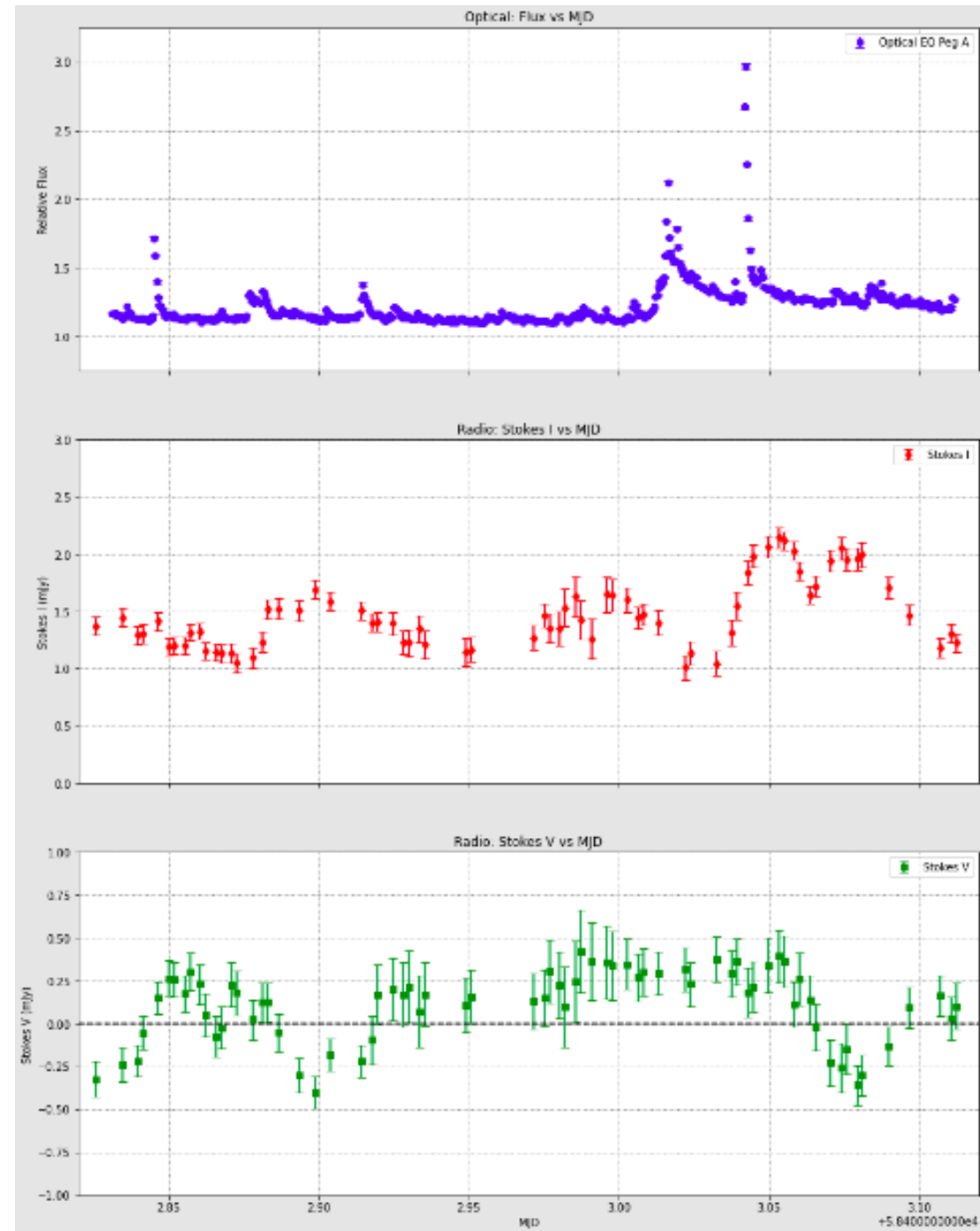
Flare	Classical / Complex	Duration (mins)	Energy U' (erg)
F1	Classical	9	4.1×10^{30}
F2	Complex	14	5.5×10^{30}
F3	Classical	9	2.7×10^{30}
F4	Complex	41	2.7×10^{31}
F5	Classical	28	1.4×10^{31}

(Table is for EQ Peg A)

EQ Peg A: Optical & Radio

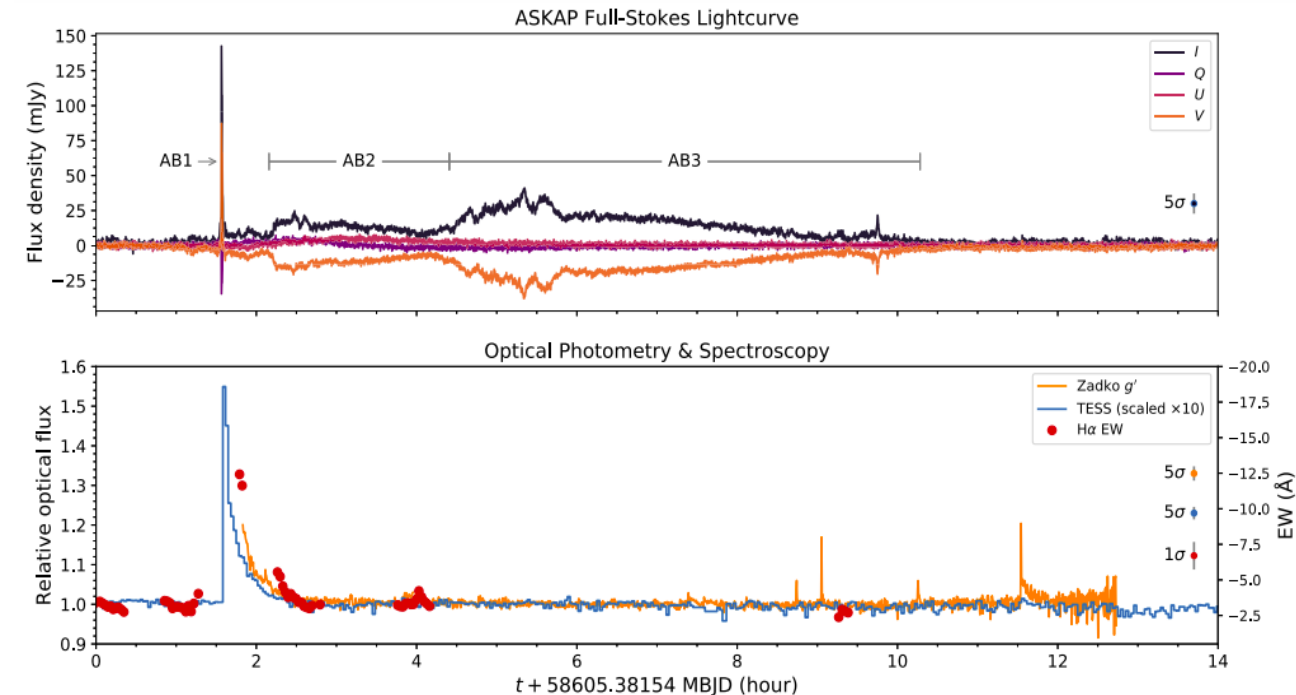
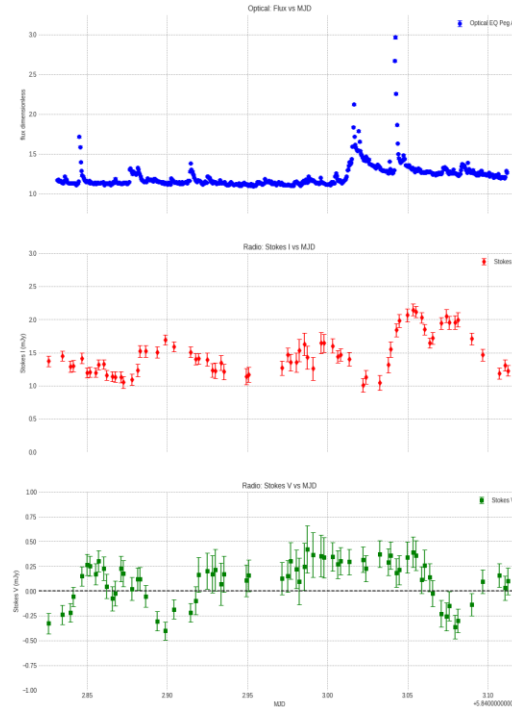
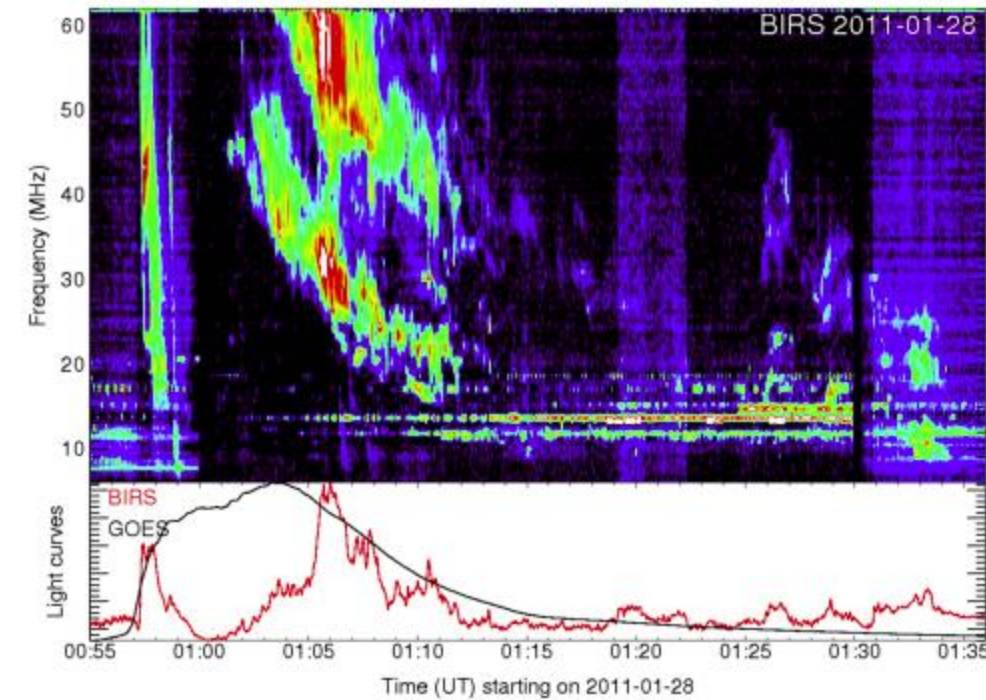
- Optical
- Radio Stokes I
- Radio Stokes V
- Delay between optical & radio
- Polarisation flip
- No detection of EQ Peg B in radio

(Ní Chonchubhair & Golden, In prep.)



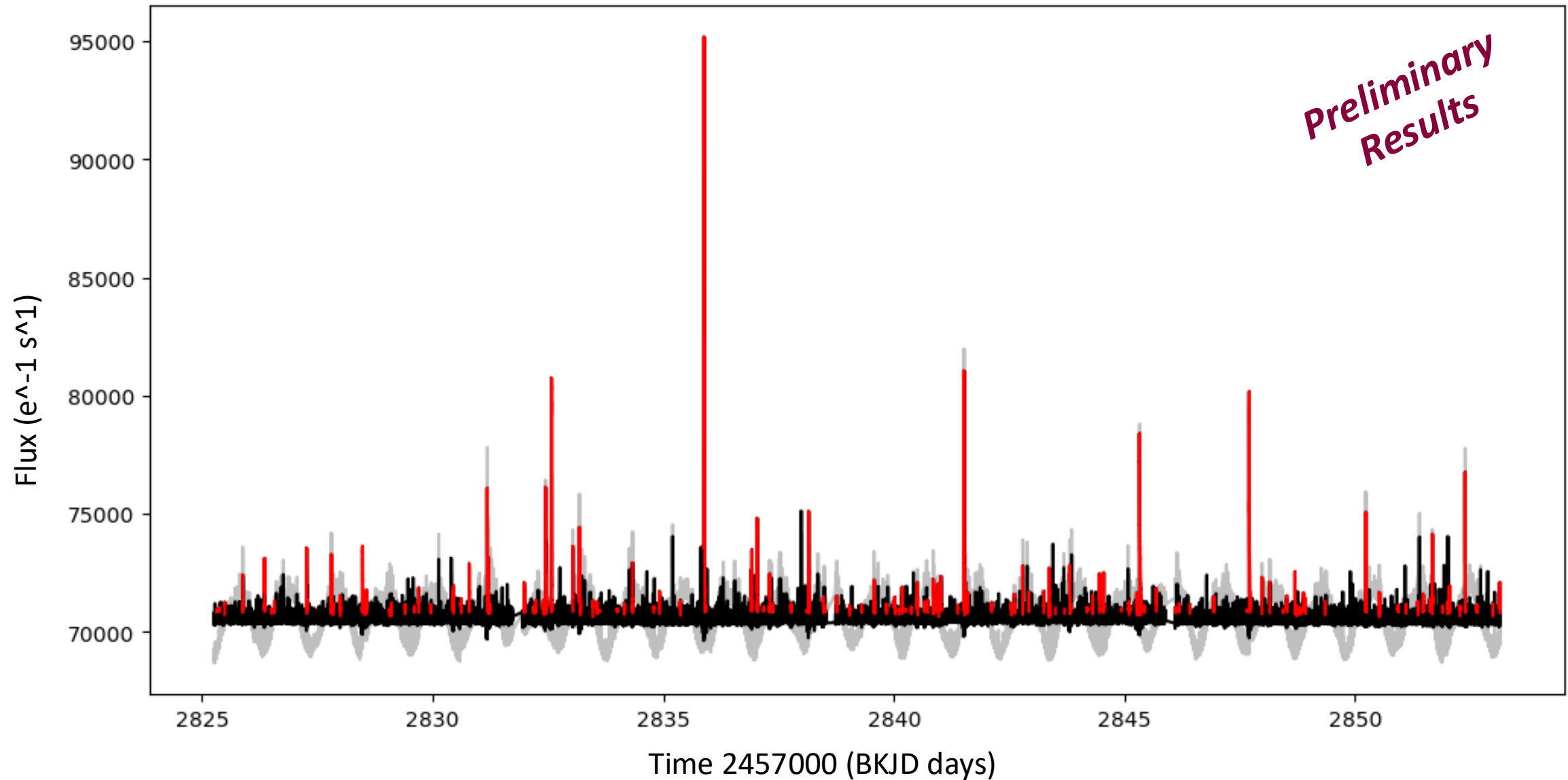
Radio Constraints on likely CME events

- For Type II burst at 10s of MHz we expect... →
- For Type IV burst at GHz passbands we expect... ↘
- We see neither of these
- Most likely gyrosynchrotron



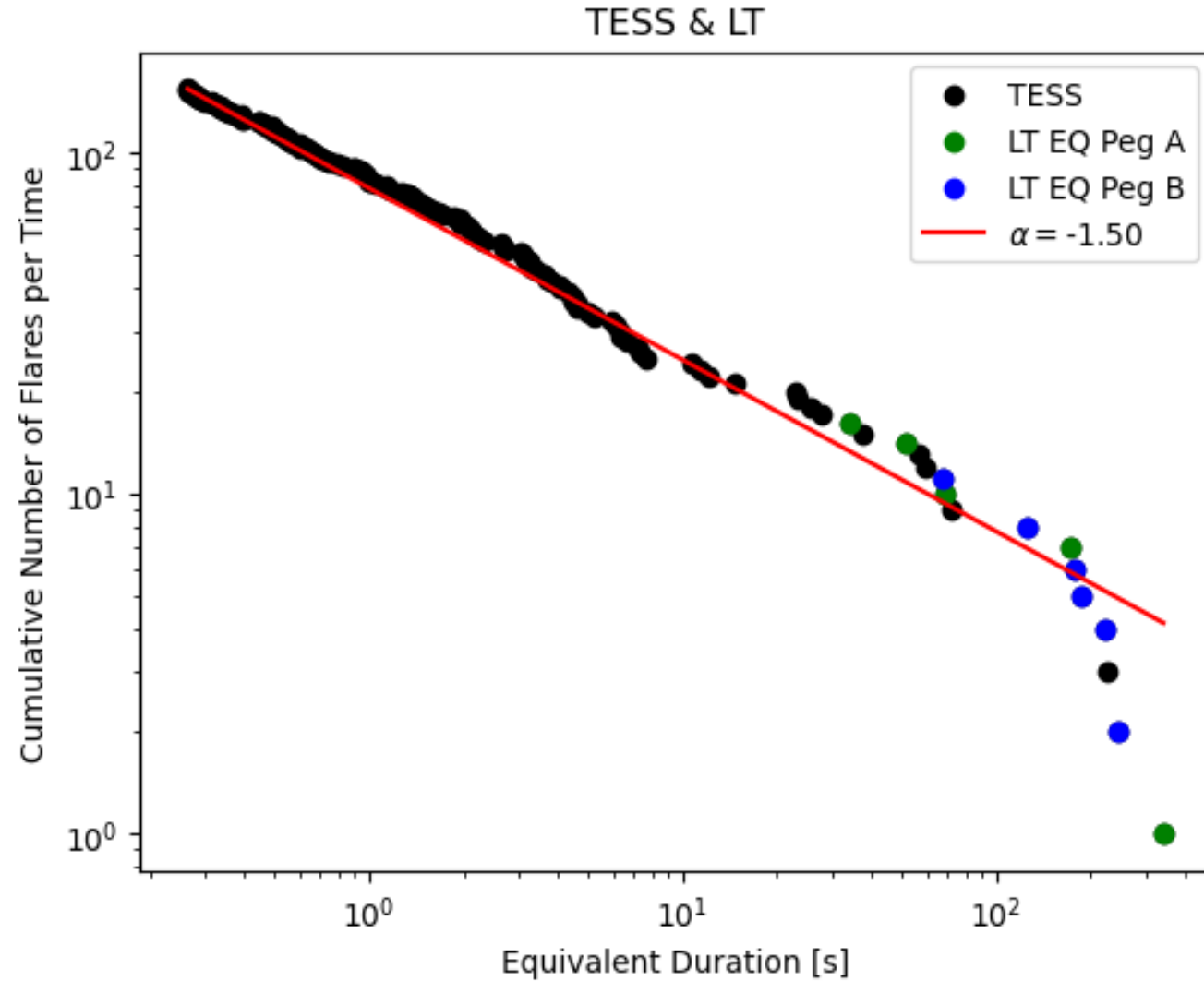
(Crosley et al., 2017;
Zic et al., 2020;
Ní Chonchubhair & Golden, In prep.)

TESS: EQ Peg



Flare Frequency Distribution TESS and LT EQ Peg A & B

Preliminary
Results



Conclusions

- From our optical data we expect to have several candidates for CMEs for both EQ Peg A & EQ Peg B
- EQ Peg A in the radio – could it be either type II or type IV?
 - > not type II (no LOFAR)
 - > not type IV (slower, no initial burst)
 - > Most likely gyrosynchrotron emission from an evolved magnetic region
- Our data consistent with the TESS data
- Need more multiwavelength simultaneous campaigns including low frequency (LOFAR, OVRO, MWA, SKA) to detect stellar CMEs



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Thank you

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