Coronae and chromospheres - eROSITA & TIGRE

— The eROTIG program —

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The eROTIG program - What it's about?

Besancon model:
(RASS, Guillout+ 1996)

$\sim$ 0.7 million X-ray stars

$>$ 50 per deg^2 (disk), $\sim$ 6 per deg^2 (poles)

eROSITA:

L2 halo-orbit, FOV $= 1.03^\circ$ ⊘

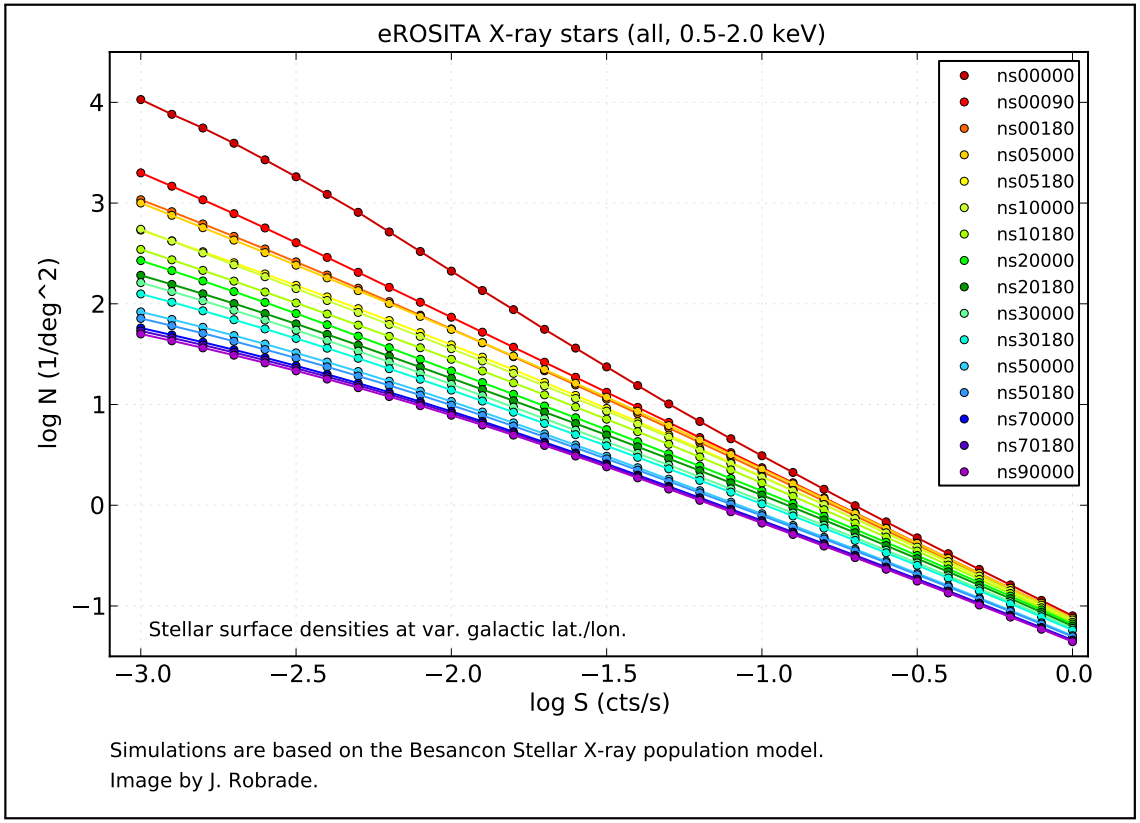
$E = 0.3 - 10.0$ keV, $\Delta E \sim 80$ eV @1 keV

$HEW = 16/26''$, on-axis/FOV @1 keV

lim. $F_X \sim 1 \times 10^{-14}$ erg cm^{-2} s^{-1}

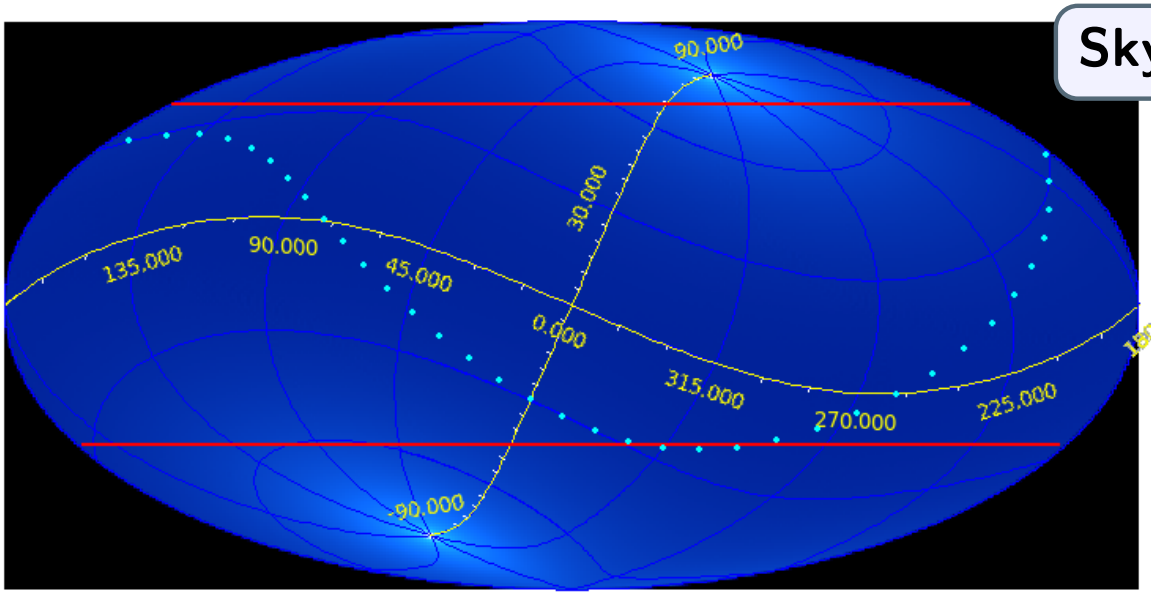
detection limit:

$L_X \approx 1 \times 10^{24} \times d^2(\mathrm{pc})$ [erg/s]



- eROSITA all-sky survey (eRASS) – 4 yr survey / 4 h scan rotation
- X-ray sampling $\Longrightarrow$ $\approx 8 \times 5 \times 40$ [s]
- largest stellar X-ray sample in human history
- use TIGRE for near-simultaneous coverage (Ca II H+K & IRT, Hα...)

eROTIG strategy Pt.I



Sky focus area

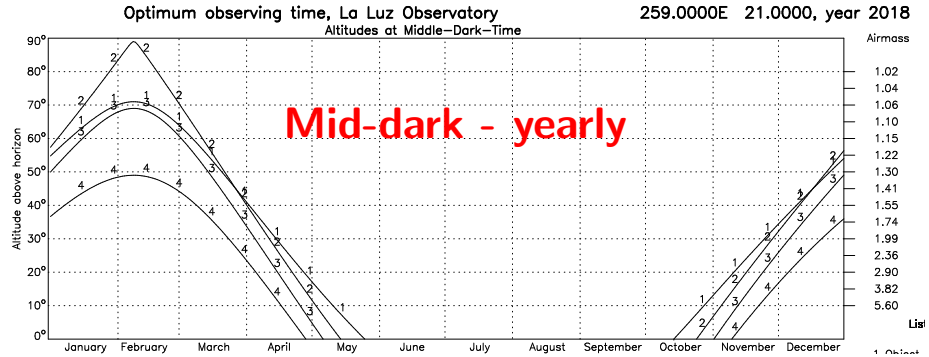
- eROSITA – German/Russian data share (50/50)
- eRO_DE (Gal. lon 180-360 deg) + La Luz visibility (Dec: $-30 \cdots +70$ deg)
- eRO_DE fits to Mexican weather
  - good coverage: Nov.-April
  - average coverage: May/June + Sept./Oct.
  - poor coverage: July/August
- MWL - visibility distribution 'dilutes' observations over the year

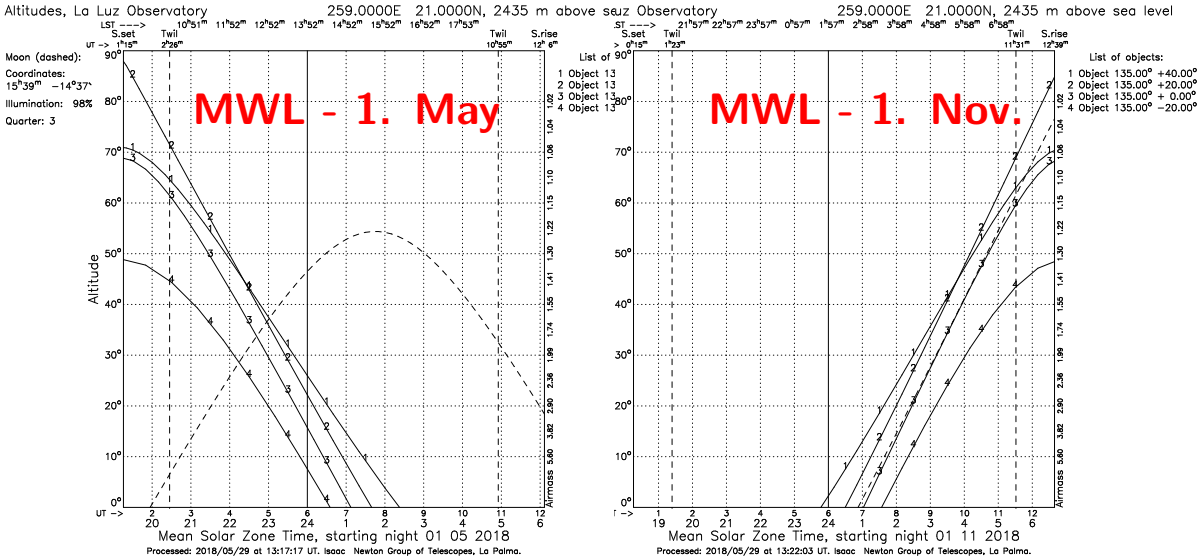
eROTIG strategy Pt.II

The 9 h strip

δ : $+40°, +20°, 0°, -20°$

obs: Nov. - May





- we think 'ecliptic' (L2 orbit)
- SRG observes at sun angles 90 ± 20 deg
- $\approx 2 \times 2$ h per day for near-simultaneous observations available
- additional monitoring easy $\Longrightarrow$ 6 months/yr coverage

eROTIG target selection Pt. I

'Our proposed eROSITA + TIGRE (eROTIG) program primarily addresses the corona-chromosphere-connection (CCC) in cool stars. The target sample is characterized by the following selection criteria and subgroups:'

- **X-ray bright stars:** RASS detection + counterpart (PSPC > 0.01 cts/s, sep. $< 30''$)
- **Nearby stars:** volume-limited samples of magnetically active stars
  - $B-V < 0.45$, sp. types early to mid F, $1.3-1.6\ M_\odot$ – *Hot*
  - $B-V = 0.45-0.58$, sp. types late F to early G, $1.1-1.3\ M_\odot$ – *Big suns*
  - $B-V = 0.58-0.77$, sp. types early to late G, $0.9-1.1\ M_\odot$ – *Solar friends*
  - $B-V = 0.77-1.25$, sp. types late G to mid K, $0.7-0.9\ M_\odot$ – *Small suns*
  - $B-V > 1.25$, sp. types late K to early M, $0.5-0.7\ M_\odot$ – *Red*
- **Joker:** Stars of particular interest and/or in eRO_RU sky

eROTIG target selection Pt. II

Aim for about 2 visits (sep. few days) at 2-3 seasons (sep. few months)

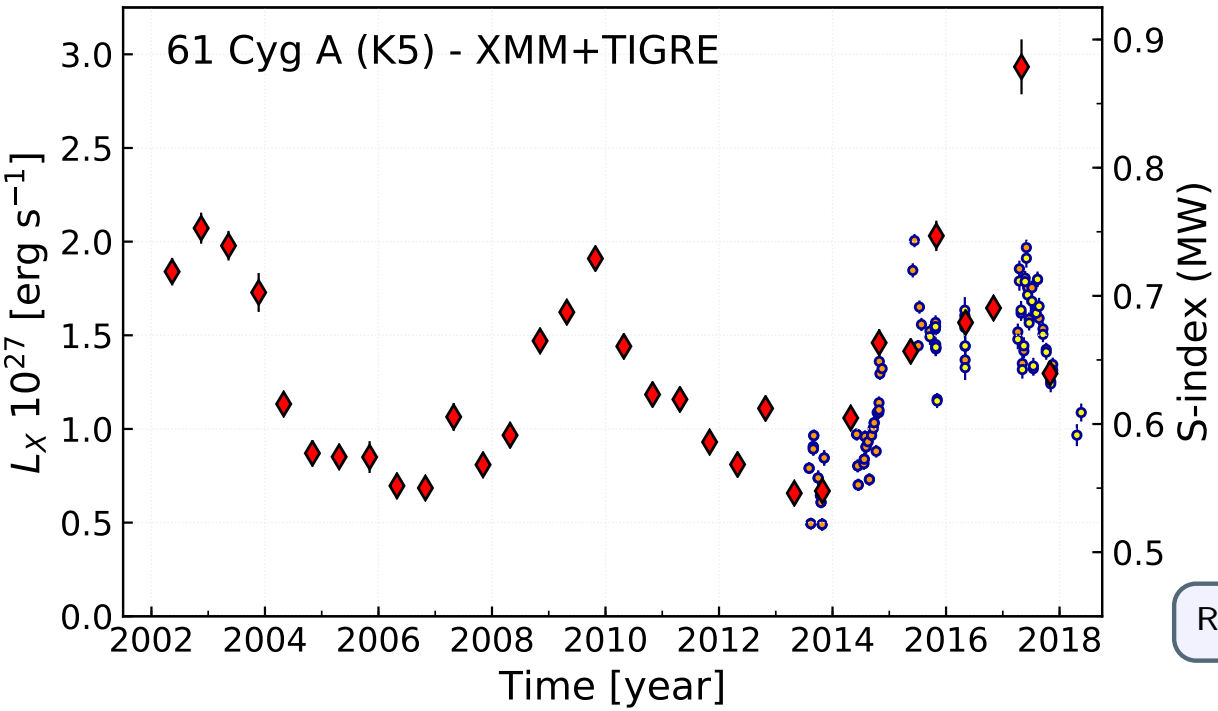
Large sample required, be realistic...

- optically bright ($V \leq 9.5$ mag), not too red ($B - V \leq 1.5$)
- Simbad database incl. cuts on binarity, luminosity class...
- $\sim$ 400 targets, semi-automatic scheduling and analysis
- test observations started 2017, pre-campaign 2018/02

	Hot	Big suns	Solar friends	Small suns	Red	Joker
Size [N]	71	79	140	89	25	ca. 25
D_limit [pc]	50/20	50/20	50/30	30/20	30/20	-
X-ray frac.	1.0	0.95	0.65	0.75	0.65	$\sim$ 1.0
T_exp [h]	0.19	0.29	0.39	0.5	0.73	typ. 0.4

Table 1: Number of stars, distance cuts (with/without RASS counterpart), RASS detection fraction and average scheduled exposure (per target and visit) for our subsamples.

Science cases



XMM-Newton
monitoring
$\log L_X/L_{bol} = -5.5$
$\log R'_{HK} = -4.78$
(Hall+2007: -4.76)

Robrade+2012 (updated)

...so far very few objects only

- corona-chromosphere-connection
  - activity-rotation-age relations
  - dynamic range: $\log L_X/L_{bol} \approx -3 \ldots -7$, $\log R'_{HK} \approx -4.2 \ldots -5.2$
- variability studies & activity cycles
  - very different periods and amplitudes

Observational statistics

Archive readout: 2018-06-06, Reduction 3.1

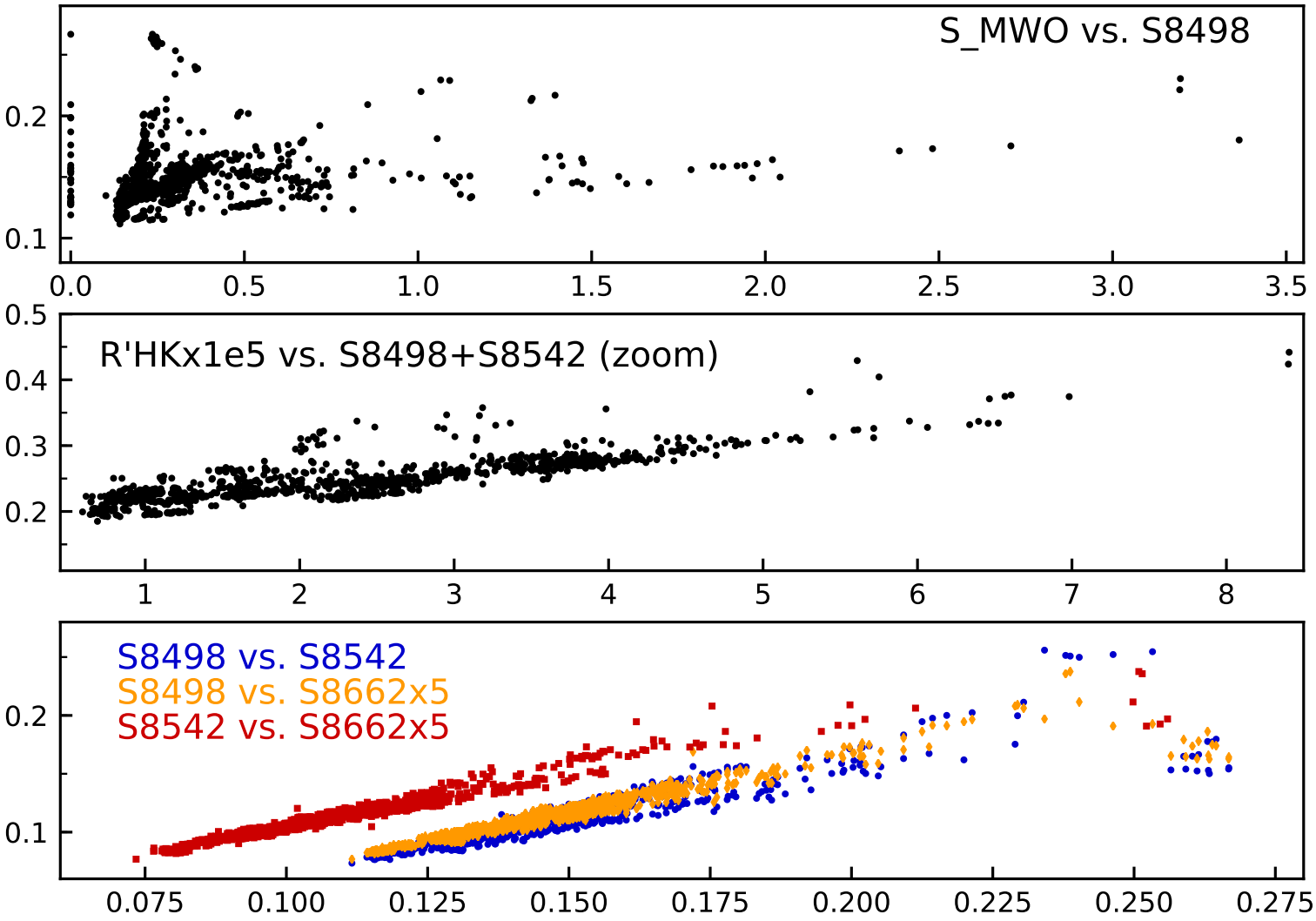
eROTIG data

- program target overlap (Act., RV,...) of 5 – 10%
  - external visit-per-target excess of factor 10 and higher
  - use for cross-checks & testing
- share to maximize science return

Performance

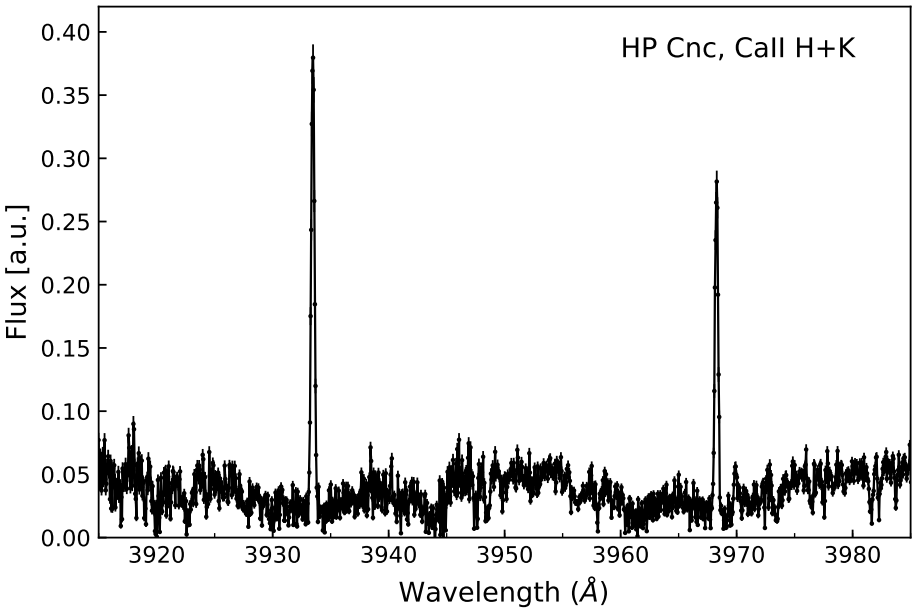
- scheduling efficiency looks ok (280 targets with 1+ spectra, $\sim$ 220 h)
- estimated exposures overall sufficient (S/N aim)
- lot's of data dropouts (TIGRE / B channel failure)
  $\gtrsim$ 100 targets affected (about 35 %)

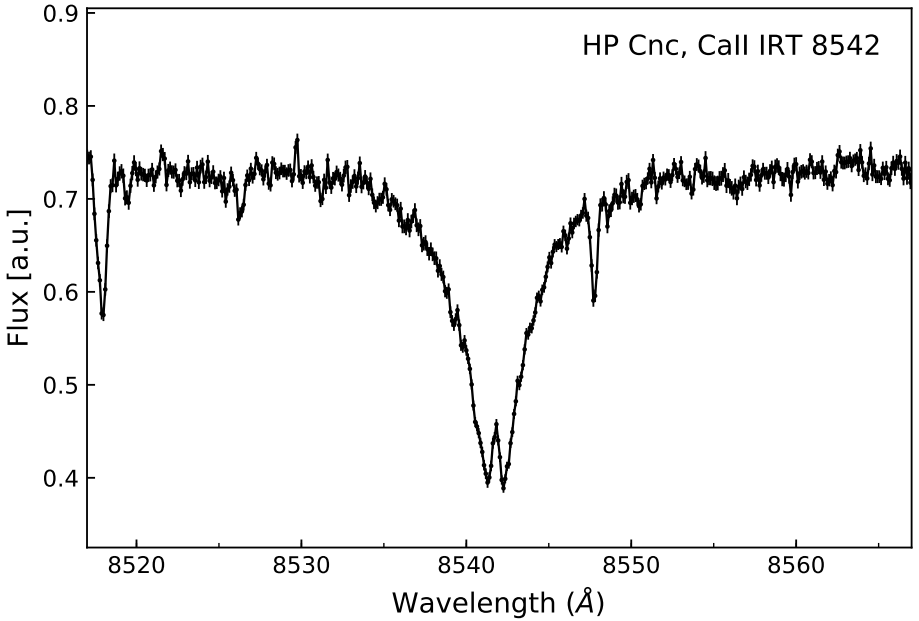
All data: CaII activity



S-index vs. R'HK vs. IRT

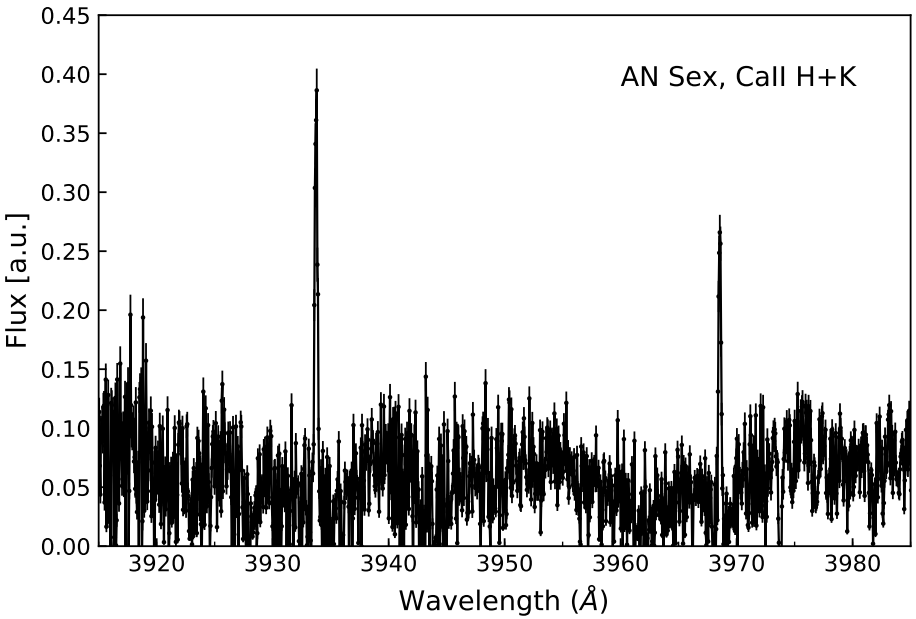
Sample data - Red

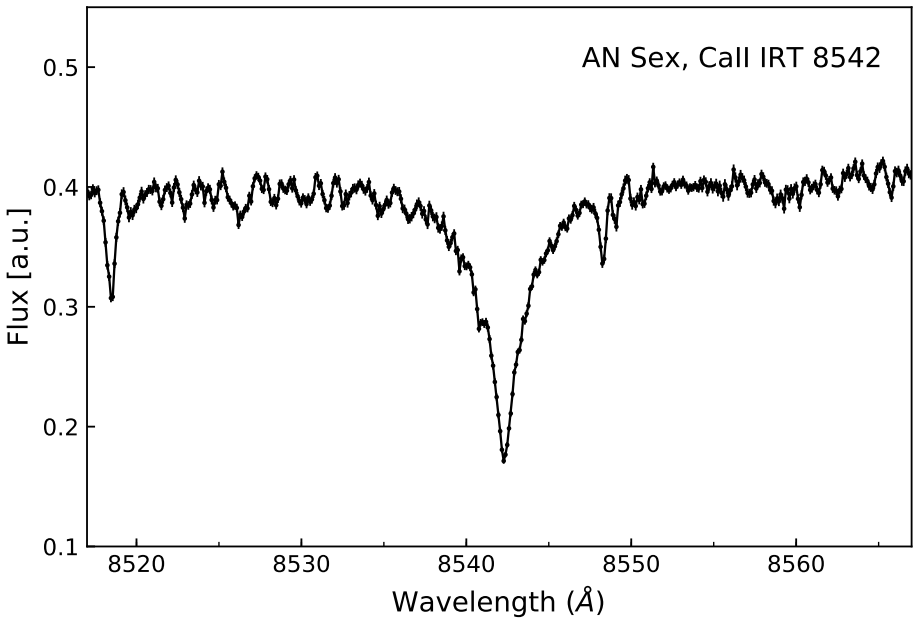




HP Cnc (GJ 323 A/B), '$V = 9.41$ mag, $B - V = 0.98$', 50 min. exp.
$\log L_{\rm X} = 28.8$ [erg/s], $\log L_{\rm X}/L_{\rm bol} = -3.7$, ($\log R'_{\rm HK} = -4.4$)

Sample data - Red

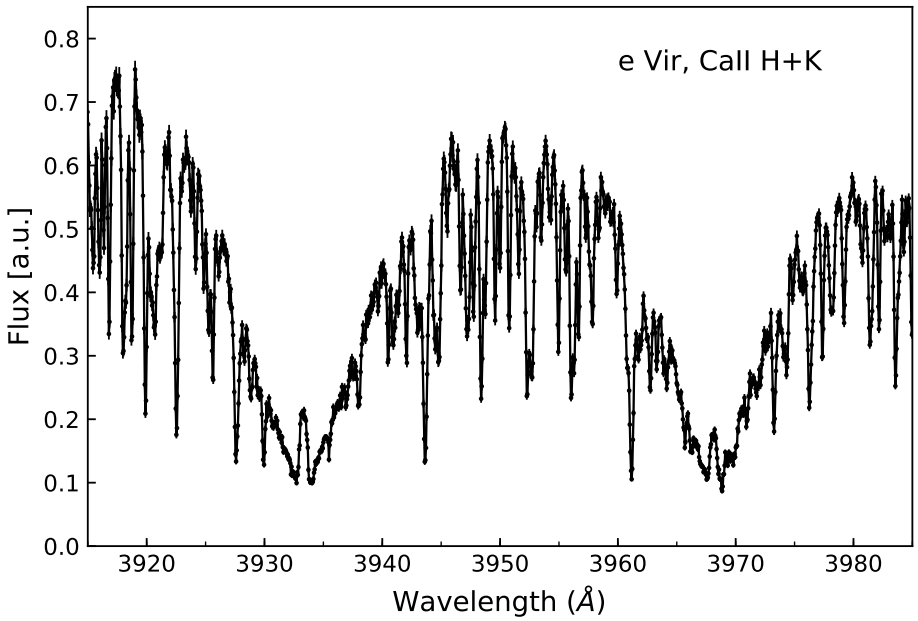


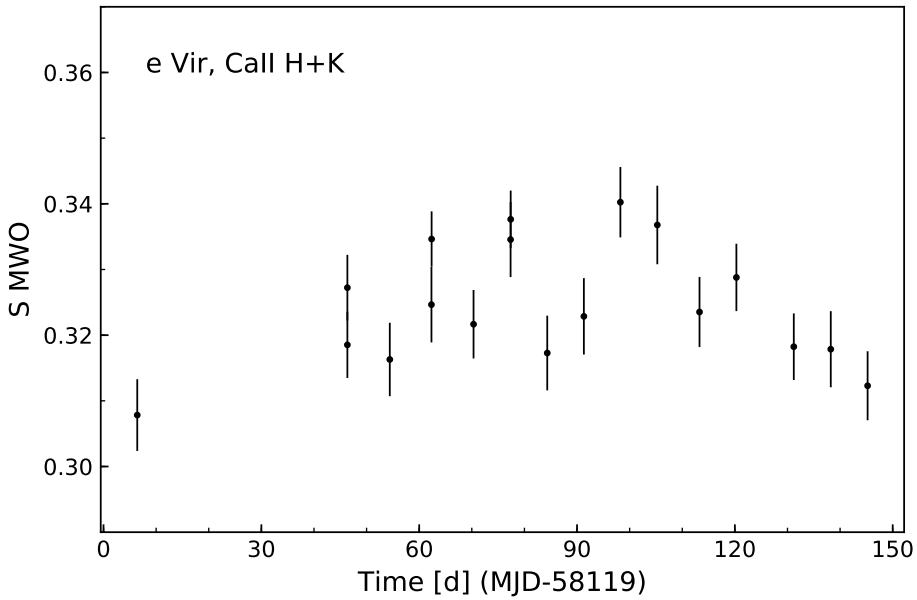


AN Sex (GJ 382), $V = 9.26$ mag, $B - V = 1.49$, 50 min. exp.

$\log L_{\rm X} = 27.4$ [erg/s], $\log L_{\rm X}/L_{\rm bol} = -4.8$, ($\log R'_{\rm HK} = -4.7$)

Sample data - Solar friends



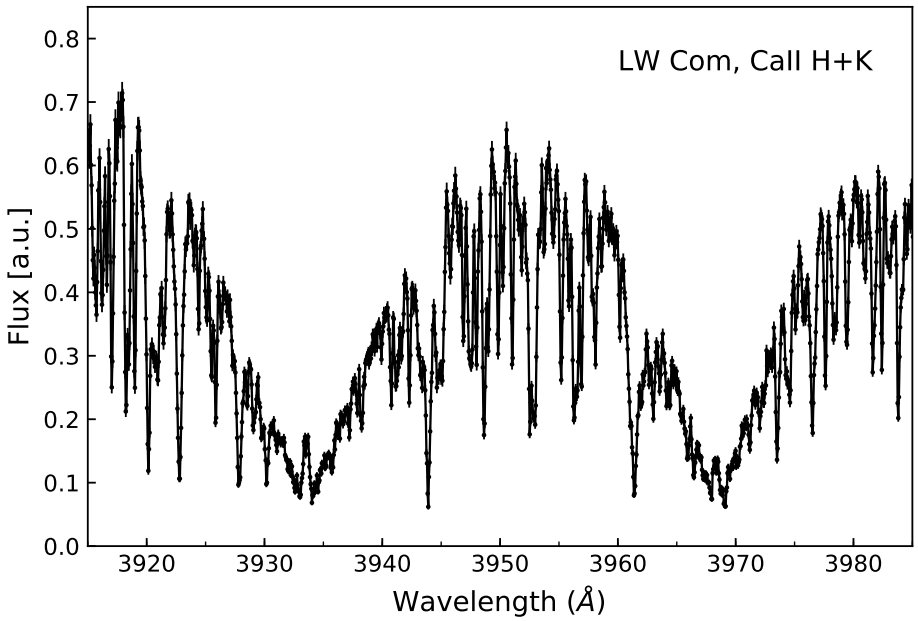


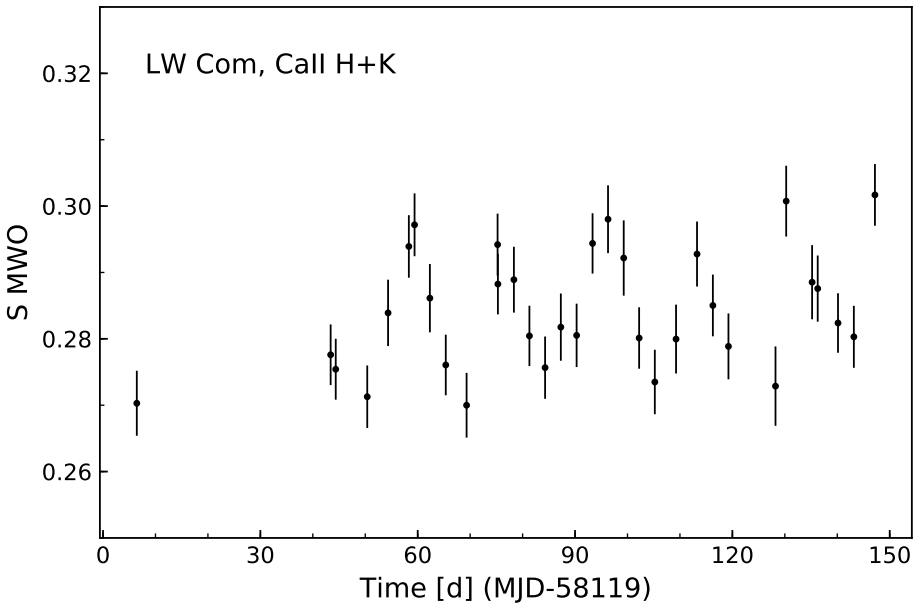
e Vir (HD 115383), $V = 5.22$ mag, $B - V = 0.59$, $T_{\rm exp} = 7.5$ min.

$\log L_{\rm X} = 29.6$ [erg/s], $\log L_{\rm X}/L_{\rm bol} = -4.3$

$\log R'_{\rm HK} = -4.43$ (Wright+2004: -4.40, Hall+2007: -4.47)

Sample data - Solar friends



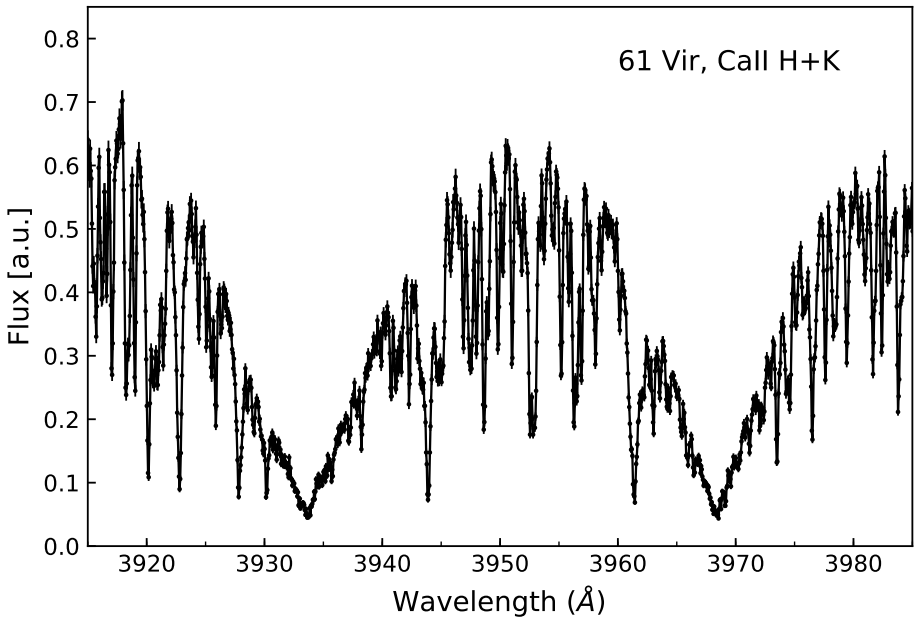


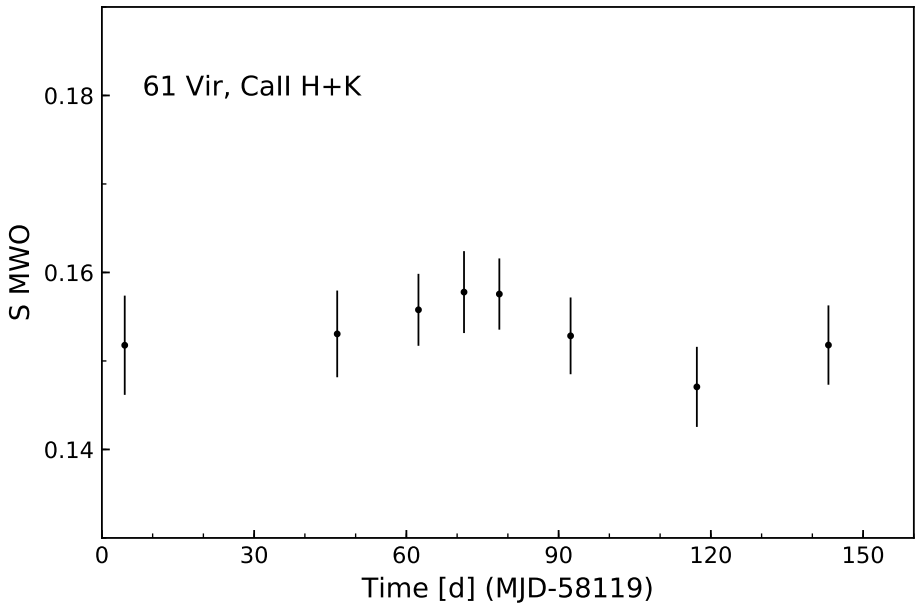
LW Com (HD 111395), $V = 6.29$ mag, $B - V = 0.69$, 15 min. exp.

$\log L_{\rm X} = 28.5$ [erg/s], $\log L_{\rm X}/L_{\rm bol} = -5.0$

$\log R'_{\rm HK} = -4.58$ (Wright+2004: -4.58)

Sample data - Solar friends





61 Vir (HD 115617), $V = 4.74$ mag, $B - V = 0.70$, 5 min. exp.

no RASS @ 9 pc, $\log L_{\rm X}/L_{\rm bol} < -6.3$

$\log R'_{\rm HK} = -5.06$ (Wright+2004: -5.04, Hall+2007: -4.93)

eROTIG future

- **Check data quality and observing success rate**
- **Review target sample**
- **Implement near-time observation software**
- **Launch SRG/eROSITA: March/April 2019**
- **Add more data + diagnostics**
- **Add more telescopes (e.g. China, Bulgaria)?**

- **Join us...**