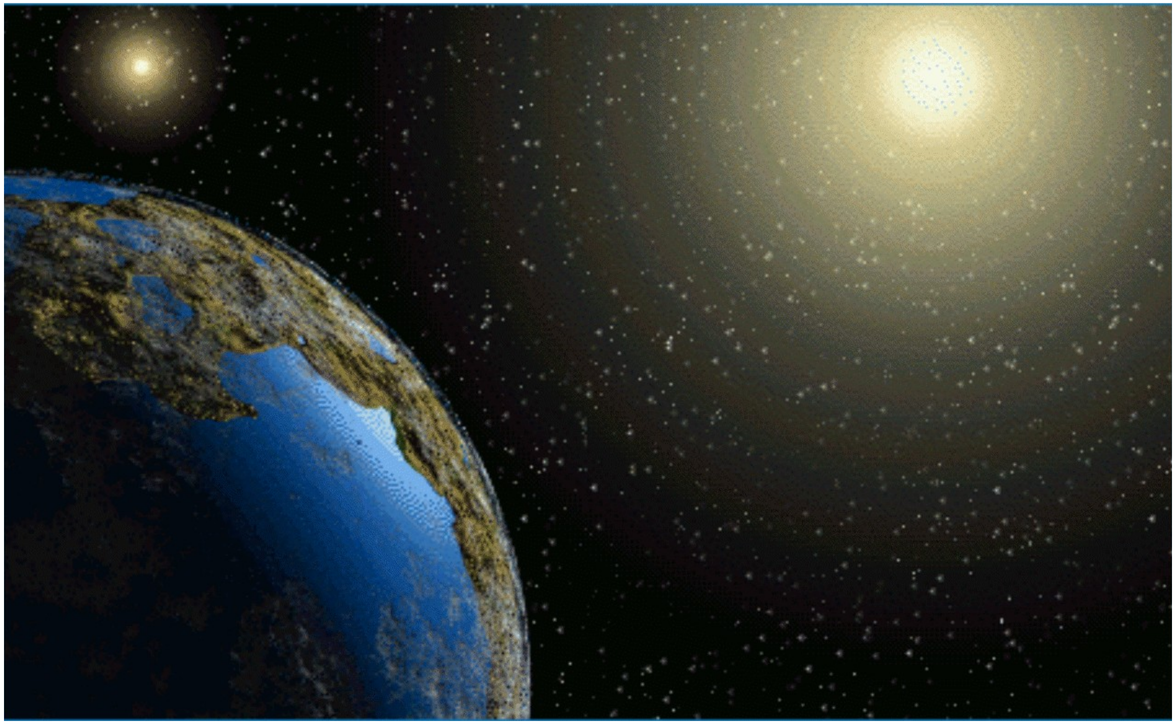
StarShot: Voyage to Alpha Centauri

Tom Ayres (Colorado)

CENTER FOR ASTROPHYSICS AND SPACE ASTRONOMY



Cambridge, MA

Aug 2016

Breakthrough *StarShot*

Announced April 2016, by Yuri Milner's

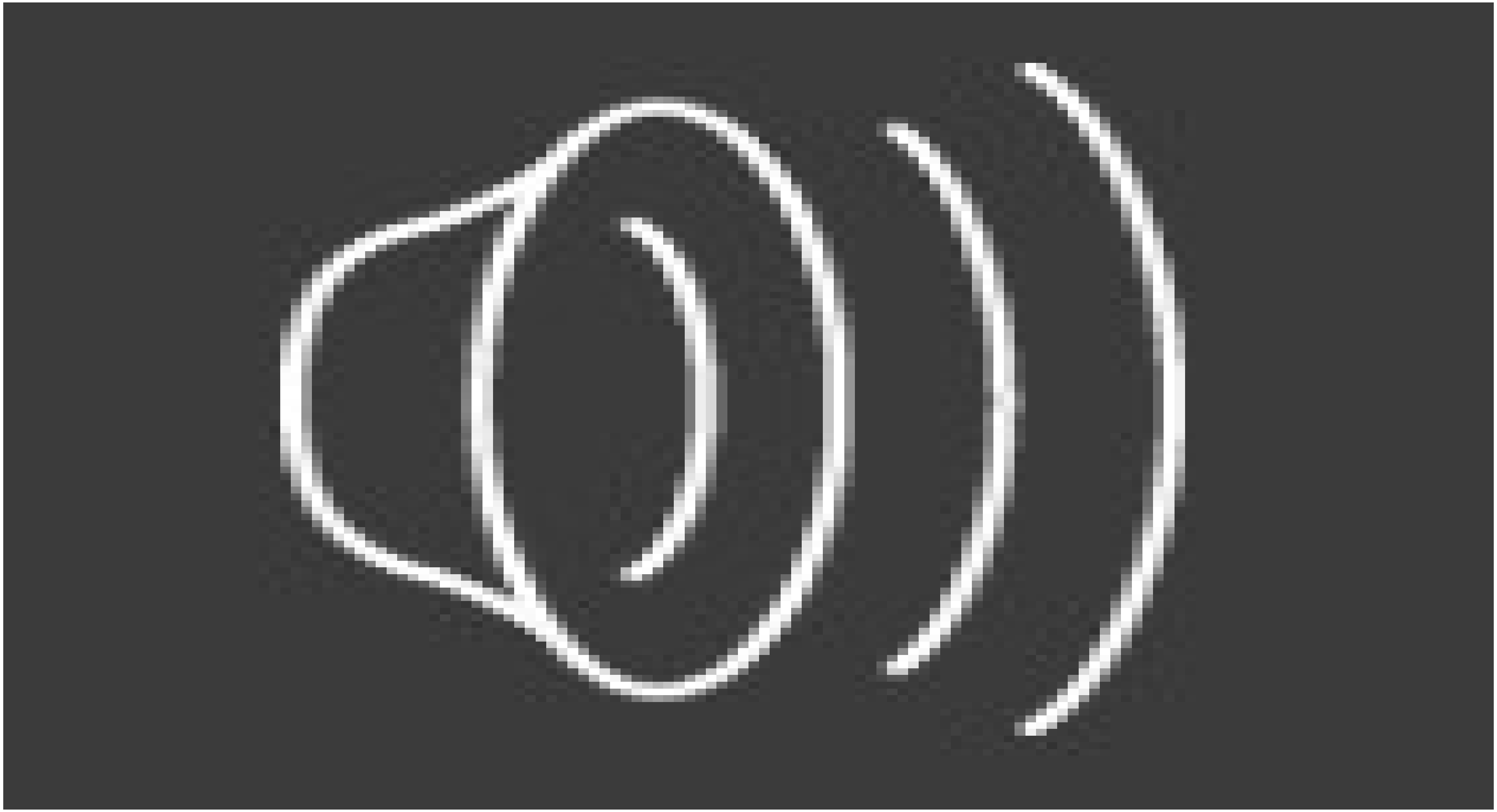
Breakthrough Initiatives Foundation

OBJECTIVE: explore habitable planets of nearest stars

INITIAL TARGET: Alpha Centauri (4.37 lyr away)

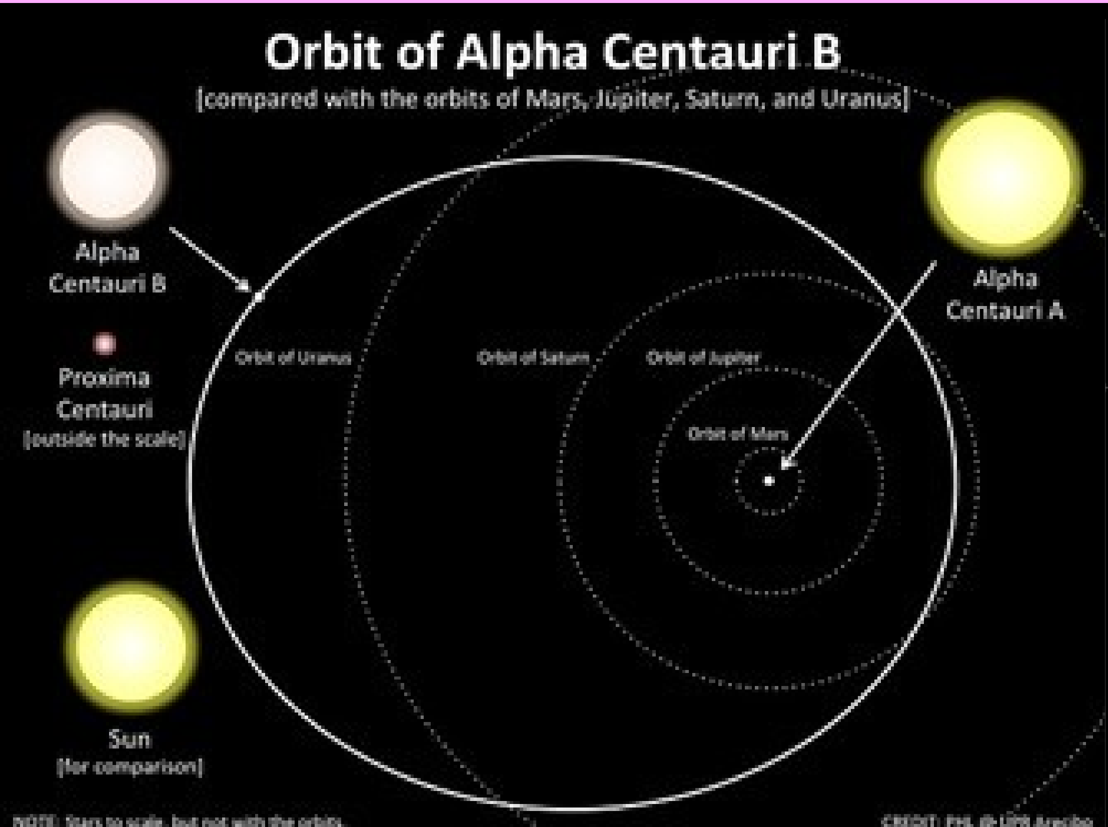
- **Identify planets in habitable zones of α Cen A & B**
- **Travel to, and photograph, these planets with swarm of nanobots on laser-propelled photon sails:**

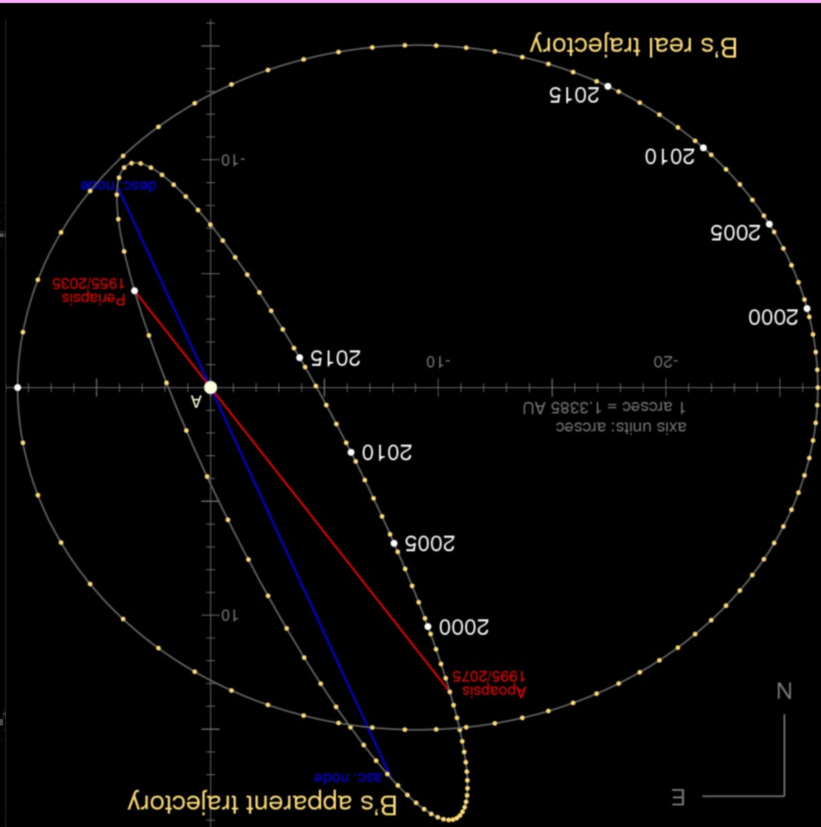
  go fast, travel light → scouts
- **Search for other civilizations in Galaxy who might be using same technology (Breakthrough Watch)**



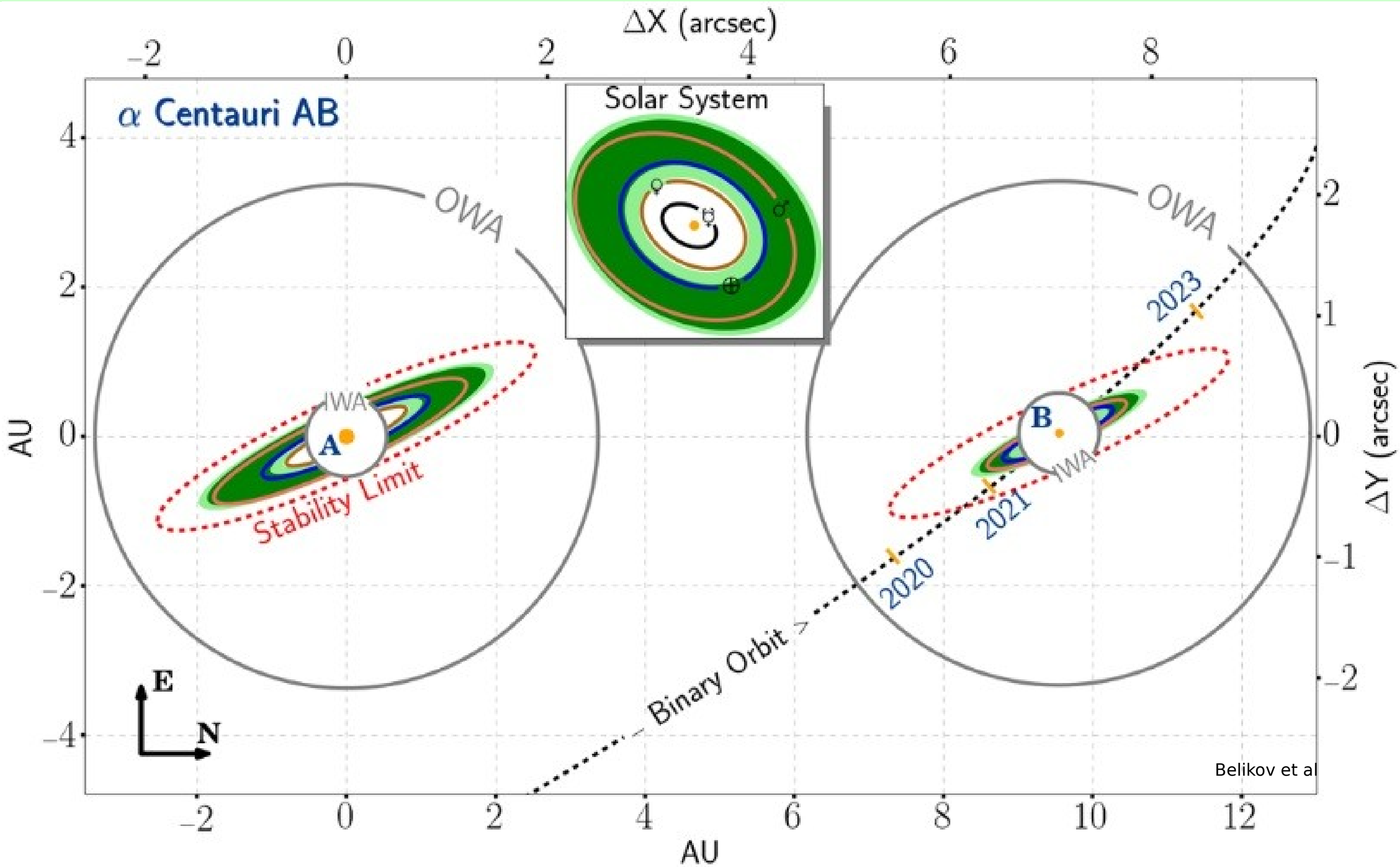
Alpha Centauri triple system:

Pair of Sun-like stars ~20 au apart (80 yr orbit); dim red dwarf (Proxima) 10^4 au away. Slightly metal rich, age ~5 Gyr. α Cen A near twin of Sun



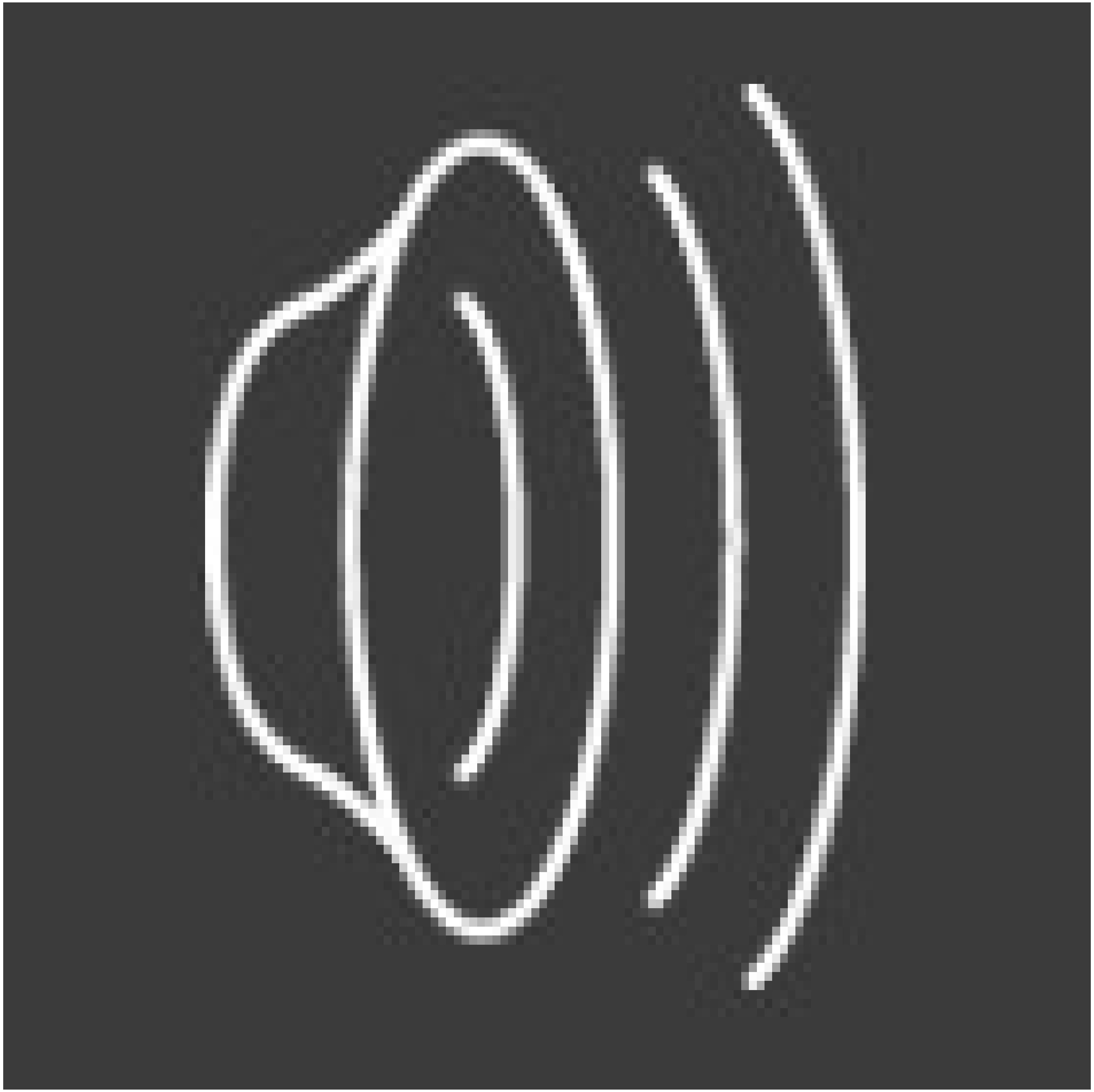


Habitable Zones of α Cen AB



Stable planetary orbits fall within the habitable zones

of both stars, arcsecond size as seen from Earth. This makes Planet Hunting easier, in some respects, but…



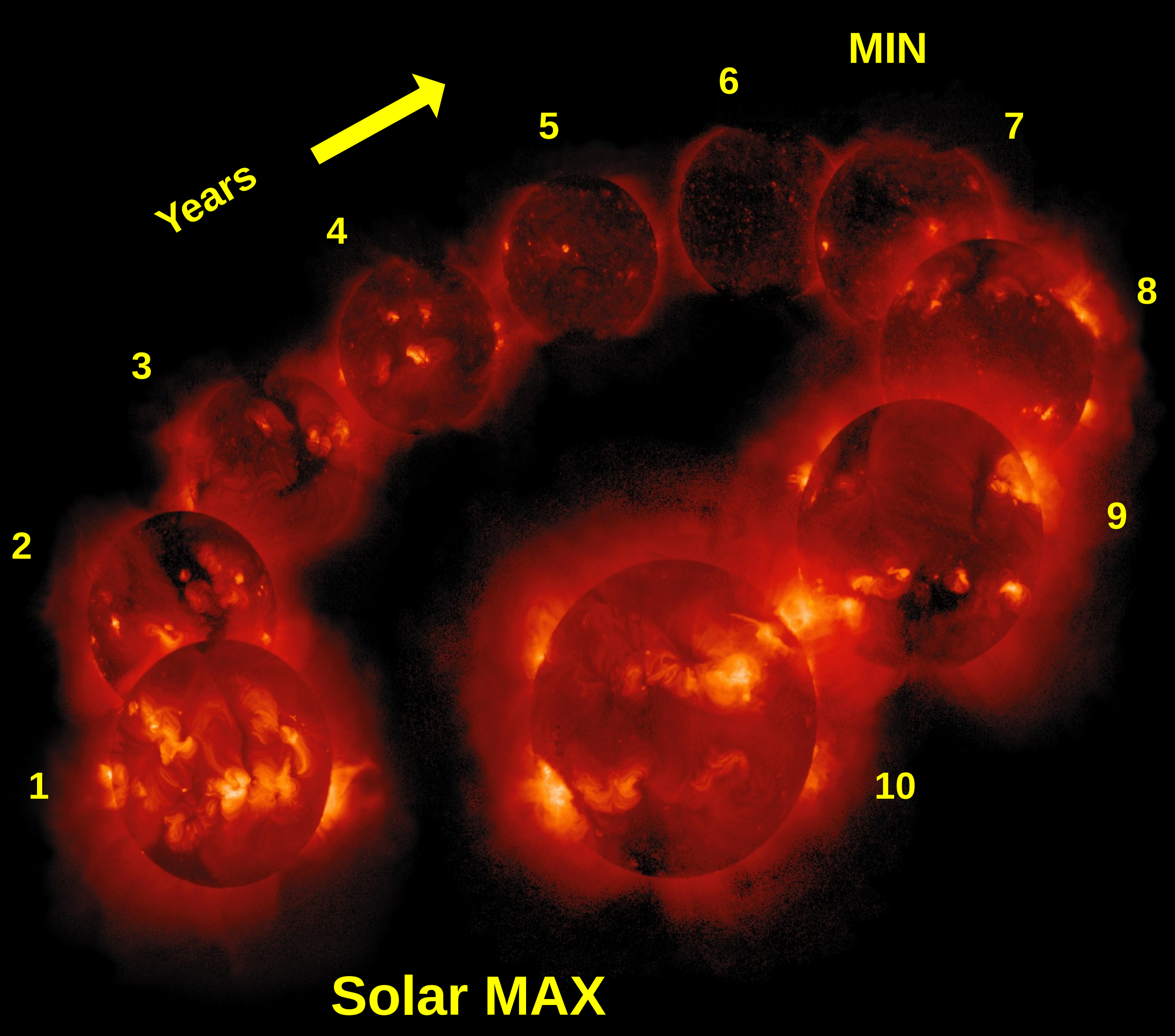
Stellar activity is bane of Planet Hunting

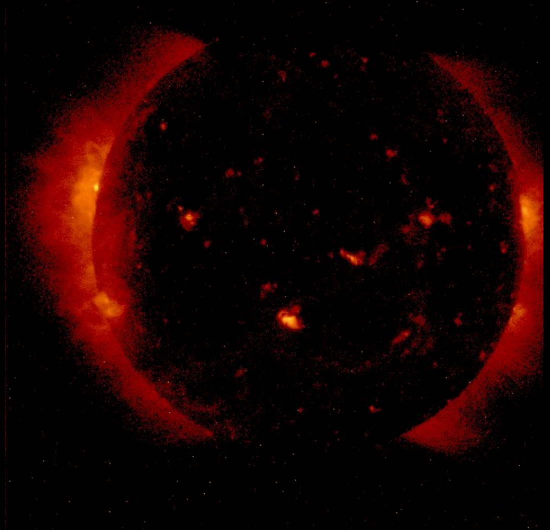
Caused by strong magnetic fields

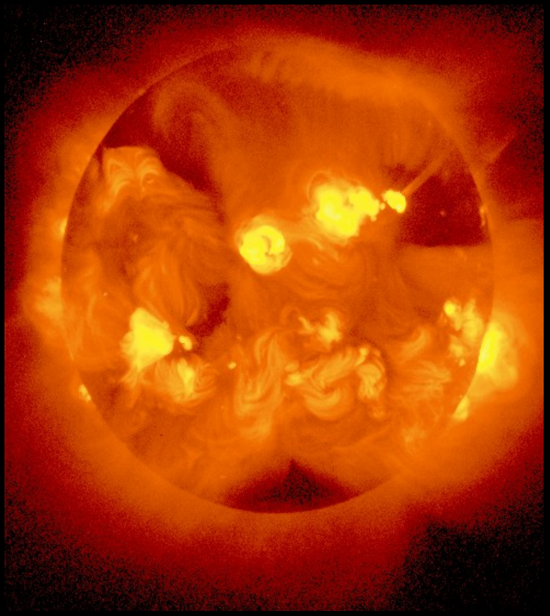
Associated dark starspots, and bright “plage” regions, affect spectral line shapes, transit photometry, and astrometric photocentroids

Active regions rotate with solar period (1 month); but also evolve on shorter timescales of hours to days

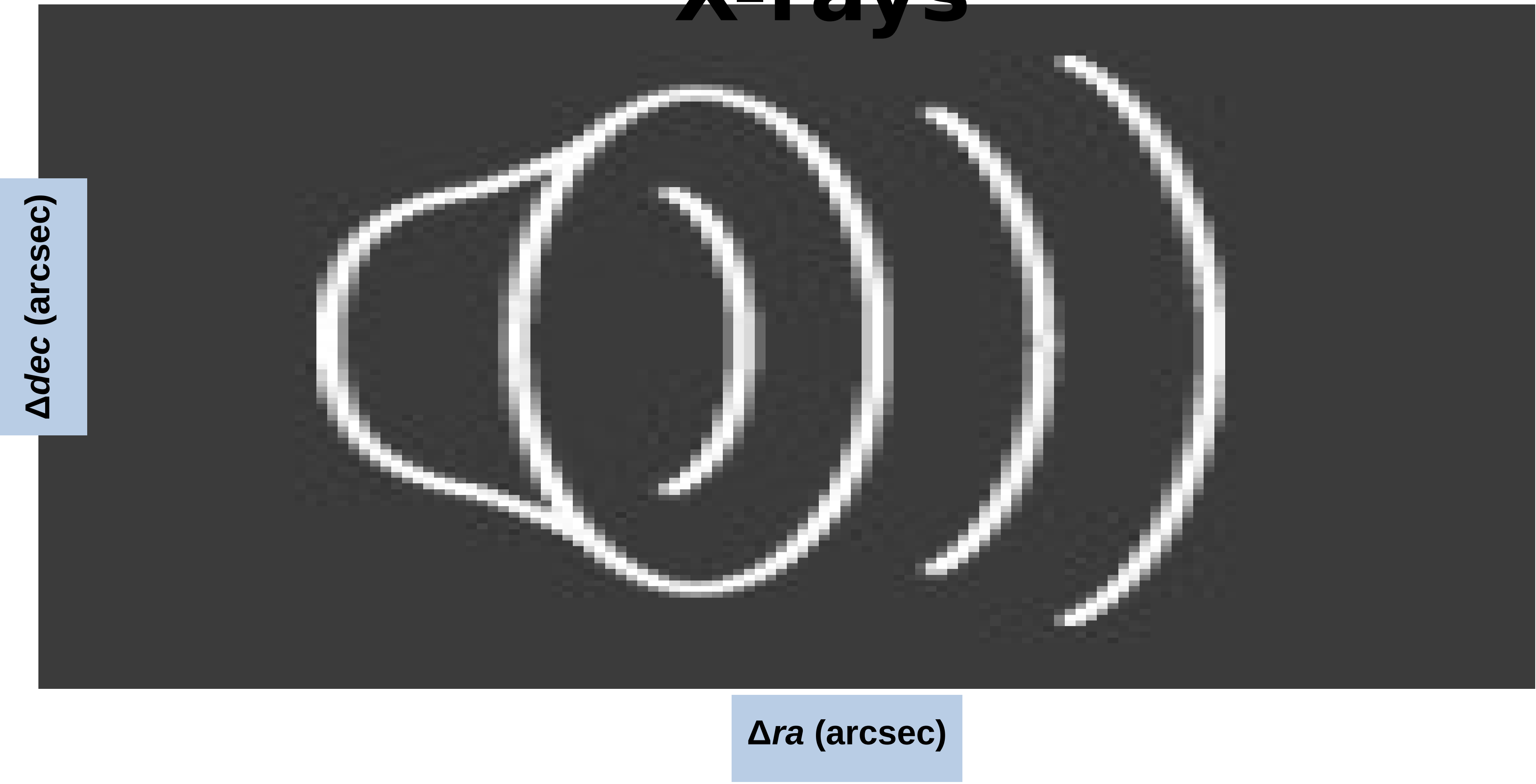
Solar activity (here in high-energy X-rays) has 11-yr cycle: deep interior magnetic “Dynamo”

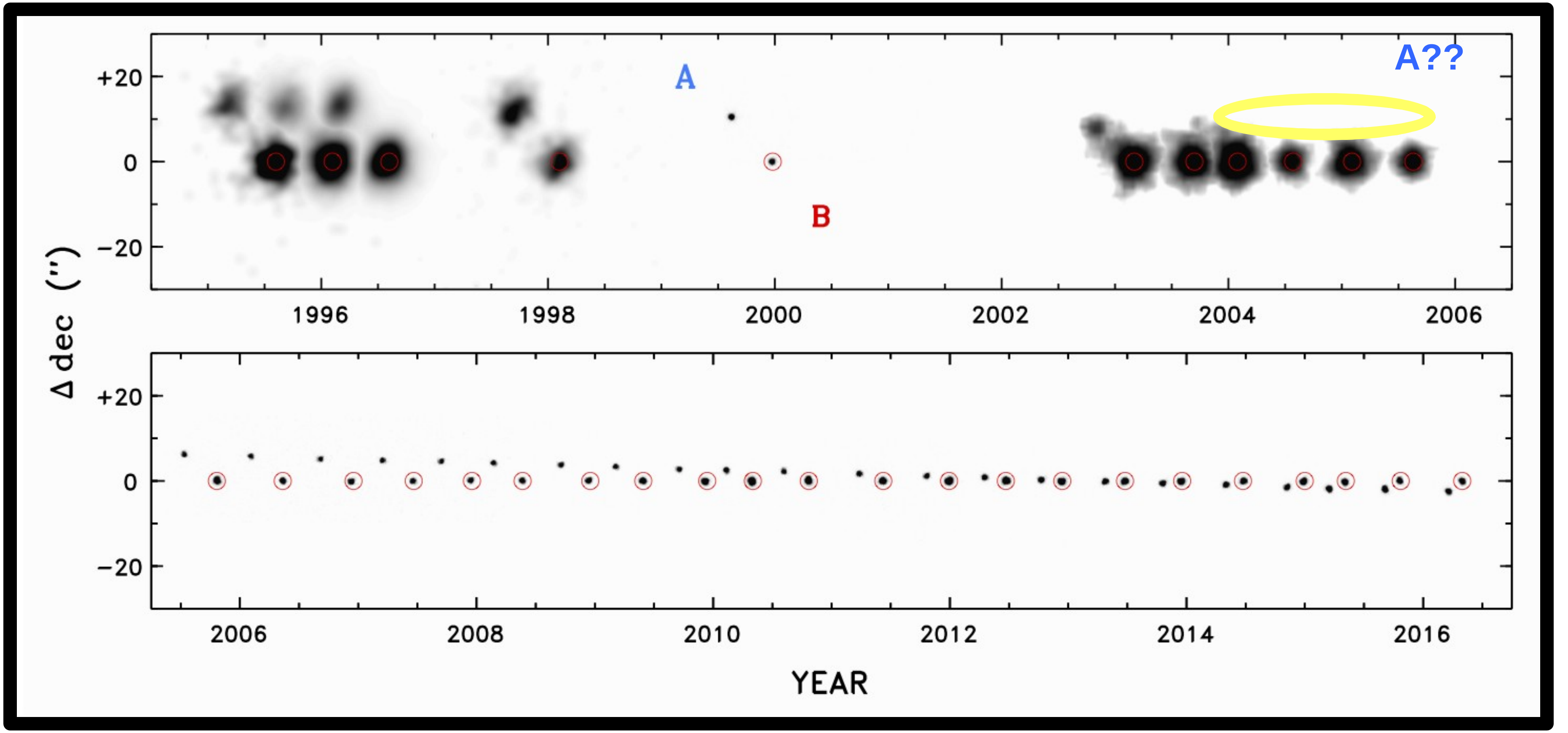






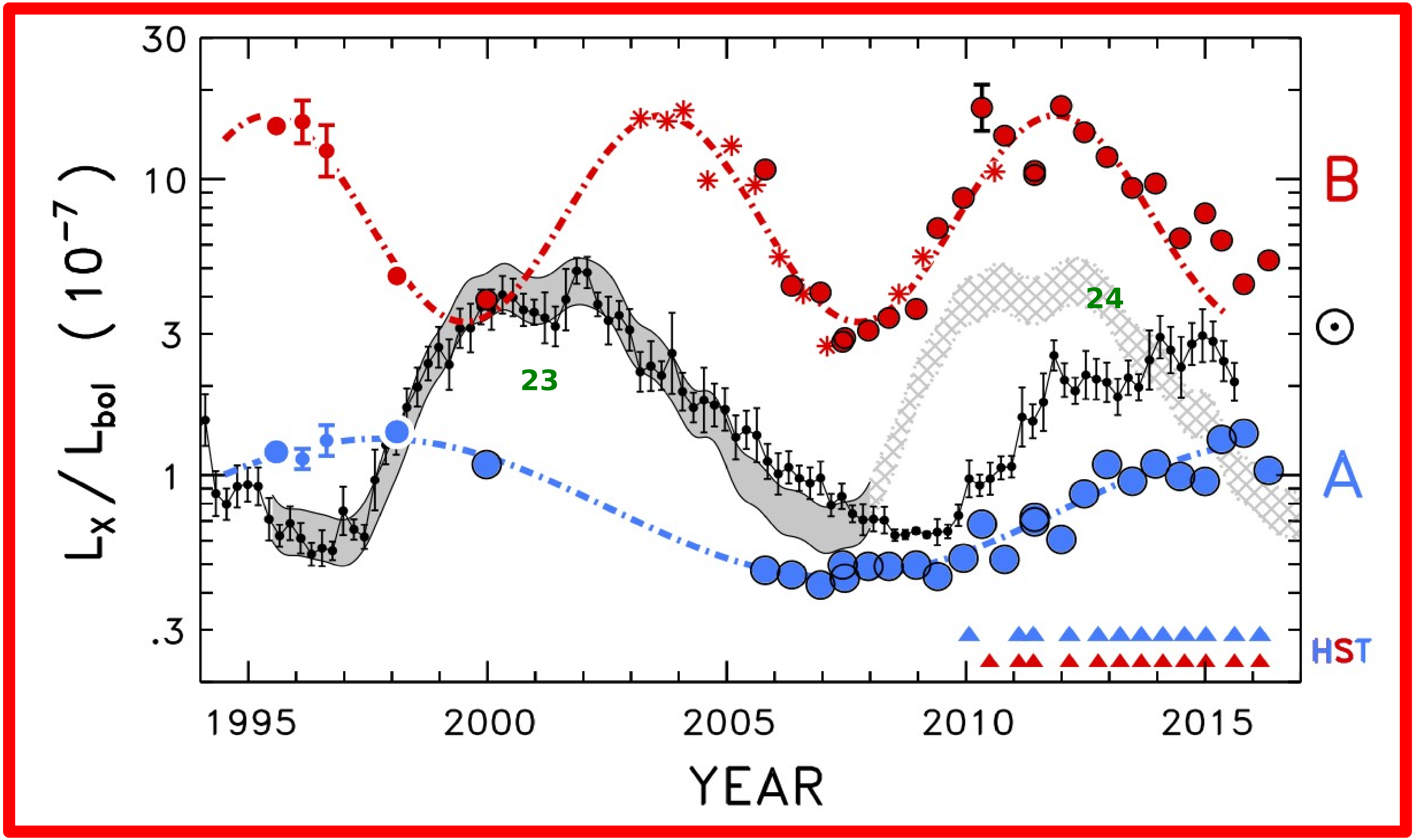
Two Decades of α Cen X-rays





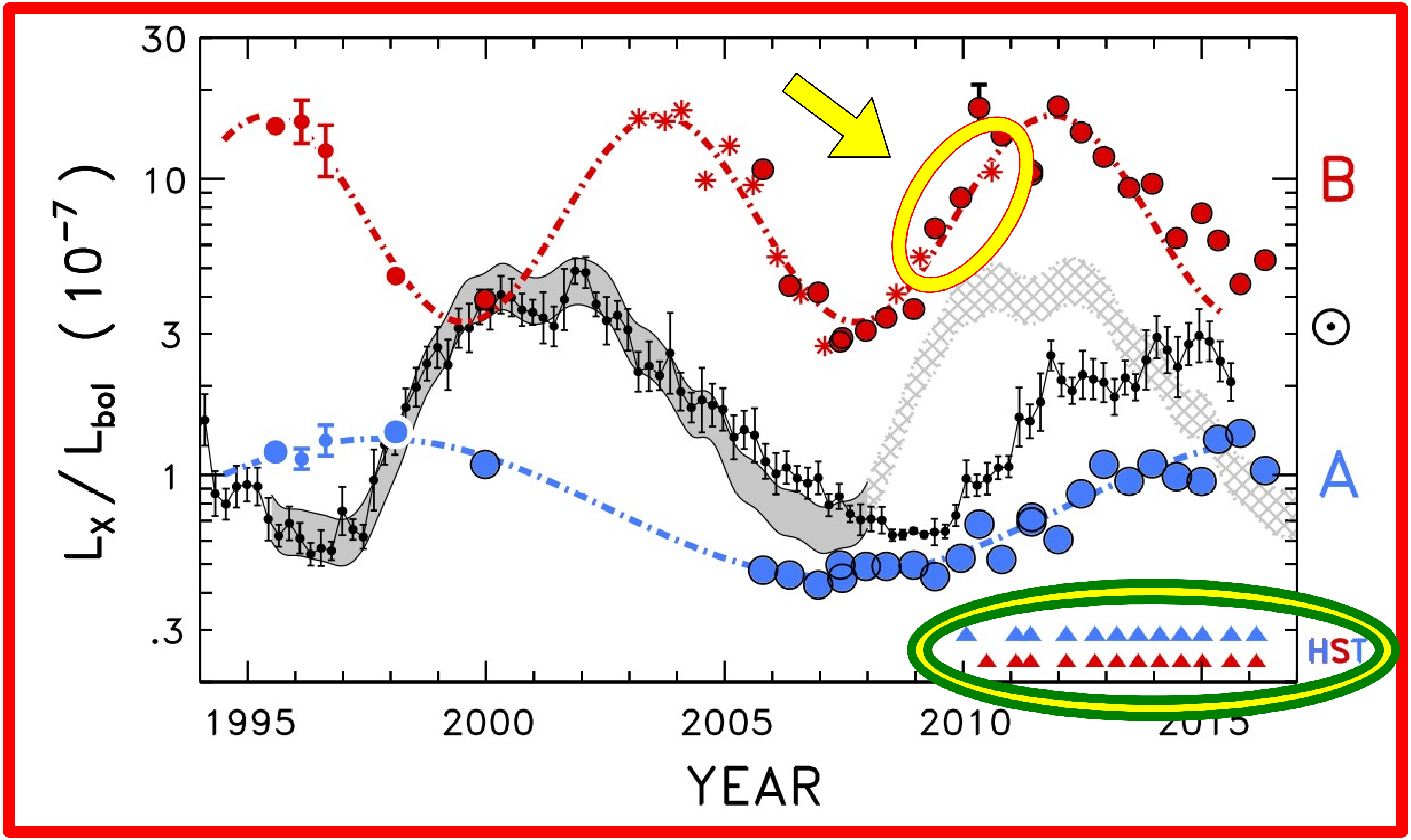
HRC-I imaging of α Cen AB in X-rays is ~50× more sensitive to activity than optical Ca II HK

Also, relative and absolute astrometry: orbit + PM



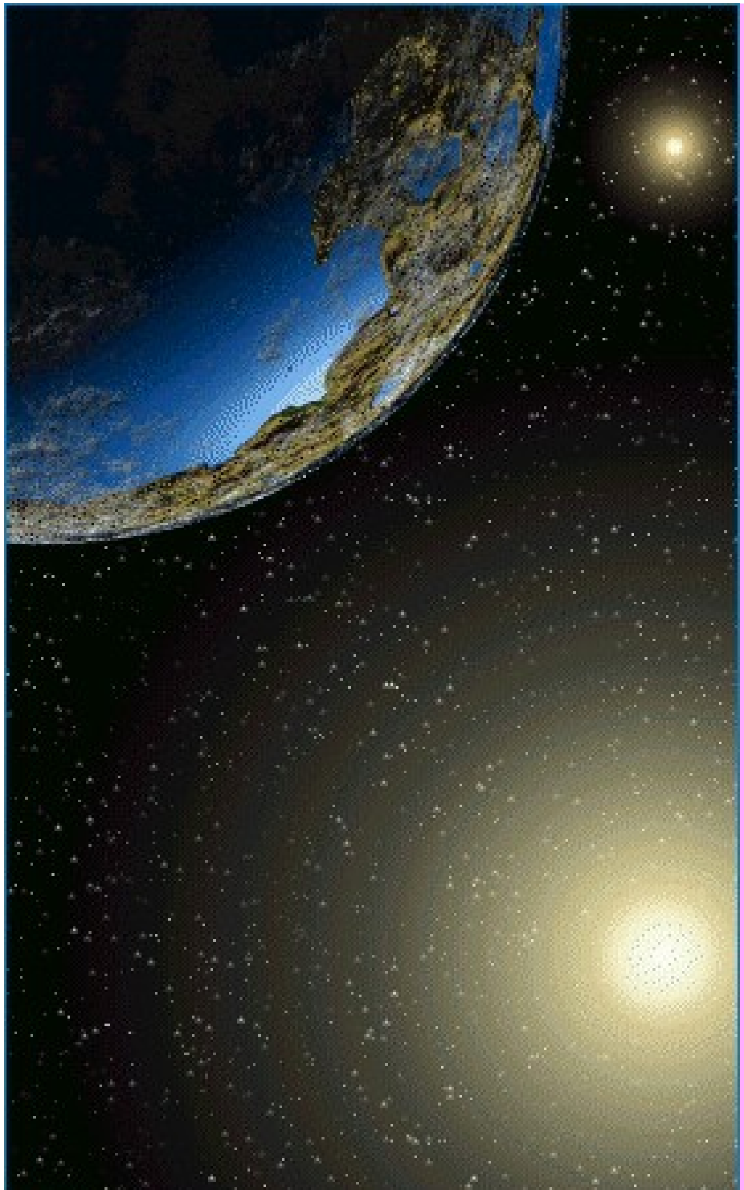
Coronal histories: *Sun* = error bars (shaded: 3 Cyc ave);

α Cen (dots: A=blue B=red): B~8 yr cycle, now falling to min; A~20 yr (?) rising to max; modest cycle depth?



Epoch when Dumusque et al. (2012) collected HARPS radial velocity data that led to report of Earth-mass planet in close (non-Hab) orbit (P=3.2 d; d=0.04 au) around α Cen B.

Summary



α Cen tempting first stop for future interstellar travelers

Finding AB's planets requires heroic effort: close separation impacts spectroscopy & imaging; activity affects Doppler reflex, transits & astrometry

Chandra contributes knowledge: fundamental properties of AB (and □-✝ Dynamos in general)

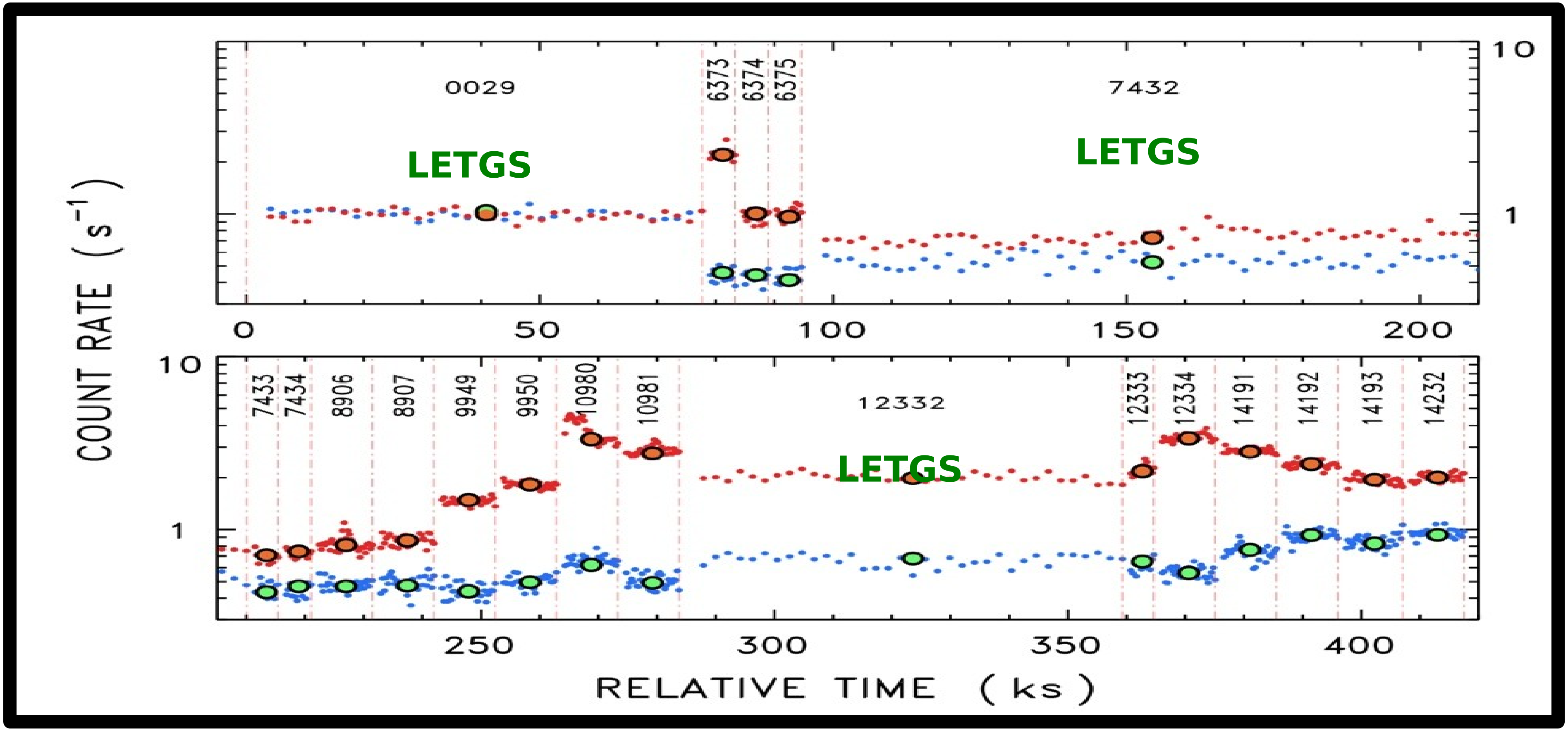
StarShot is crazy, but have to admire its vision and audacity:

"To Boldly Go Where No Starbot Has Gone Before"…

The StarShot concept – beamer-launched starchips on light sails – is an attractive approach from an energy/technology point of view. **Will require ~20 yr development, ~20 yr flight to α Cen, then 4.4 yr for signals to return.**

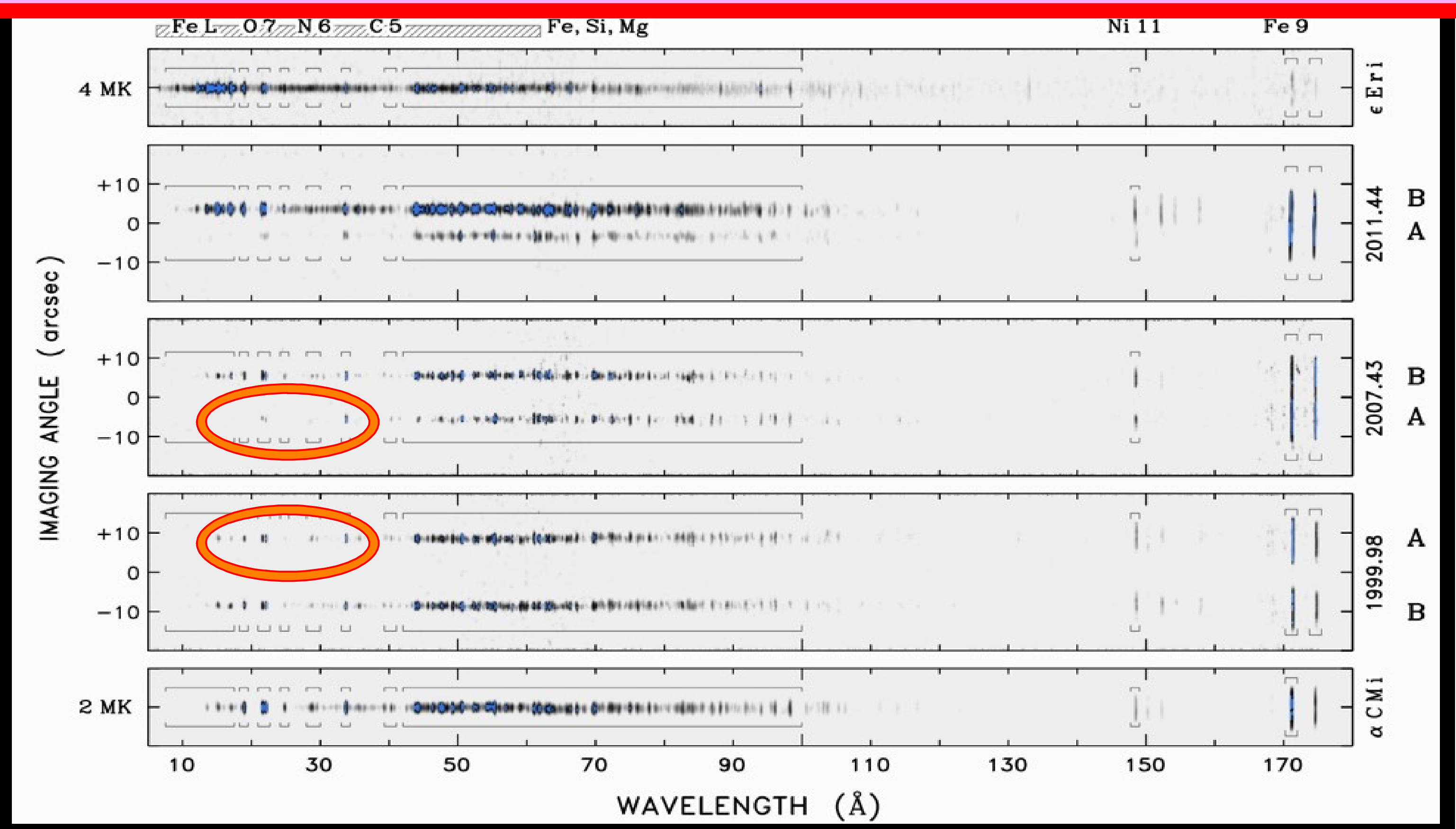
To be sure, *a few issues need to be sorted out:*

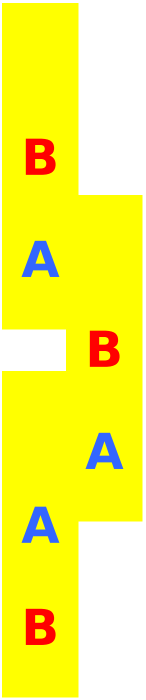
- ***Laser Beamer --*** phased optical array, laser amplifiers/combiners: **most challenging/expensive aspect of project?**
- ***Navigation –*** boost phase pointing, mid-course corrections (photon motor?)
- ***Survival –*** acceleration period, cosmic rays, interstellar/interplanet dust & gas
- ***Communication over IS distances –*** laser on chip, sail is concentrator, beamer is receiver, highly narrow-band signal
- ***Power –*** photon thrusters, thermal control, electronics (SNAP?)
- ***Imaging @ Target –*** sail is concentrator, target pointing & re-orient to Earth
- ***Total Mass –*** spacecraft on a chip, sail architecture
- ***Unwelcome Visitors?*** – each "StarShot Trooper" packs ***4 kT*** punch (EIS?)
- ***Total Cost --*** $10B, $100B, nobody knows…***all depends on Moore's Law***



Light curves for HRC-I (short) and LETGS (long) pointings, and flare-filtered averages (larger symbols); blue=A, red=B

X-ray spectra resolve the dilemma

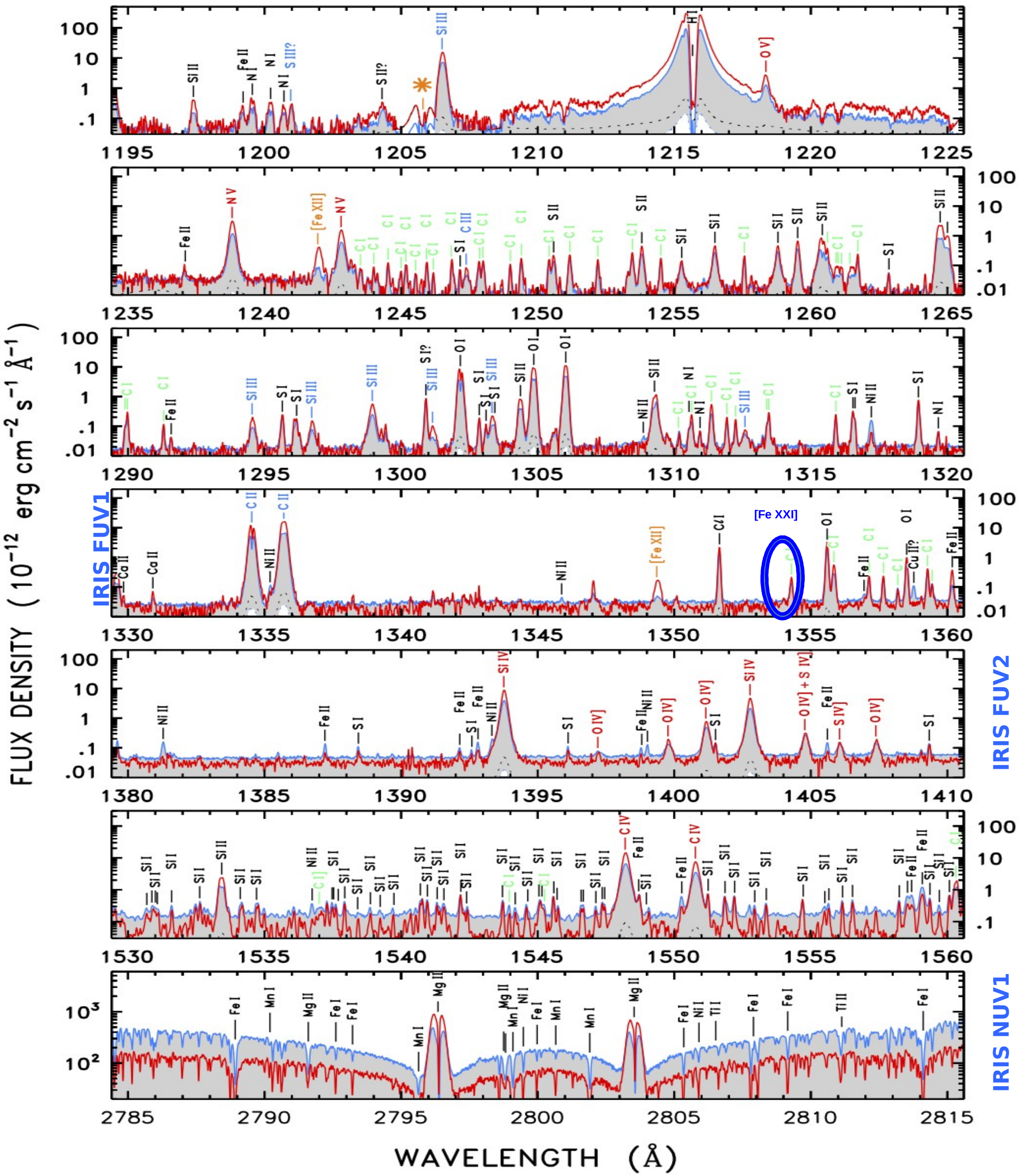




Spectrometer

α Cen AB in three epochs, + two comparison stars

(ε Eri: K2V [moderate-activity]; α CMi: F5IV



HST/STIS ultraviolet spectra of sunlike stars α Cen A [G2V] and B [K1V]

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