Intrinsic Variability of Eclipsing Variable Beta Lyrae Measured with Digital SLR Camera

Donald F. Collins

Warren Wilson College

AAVSO November 2009

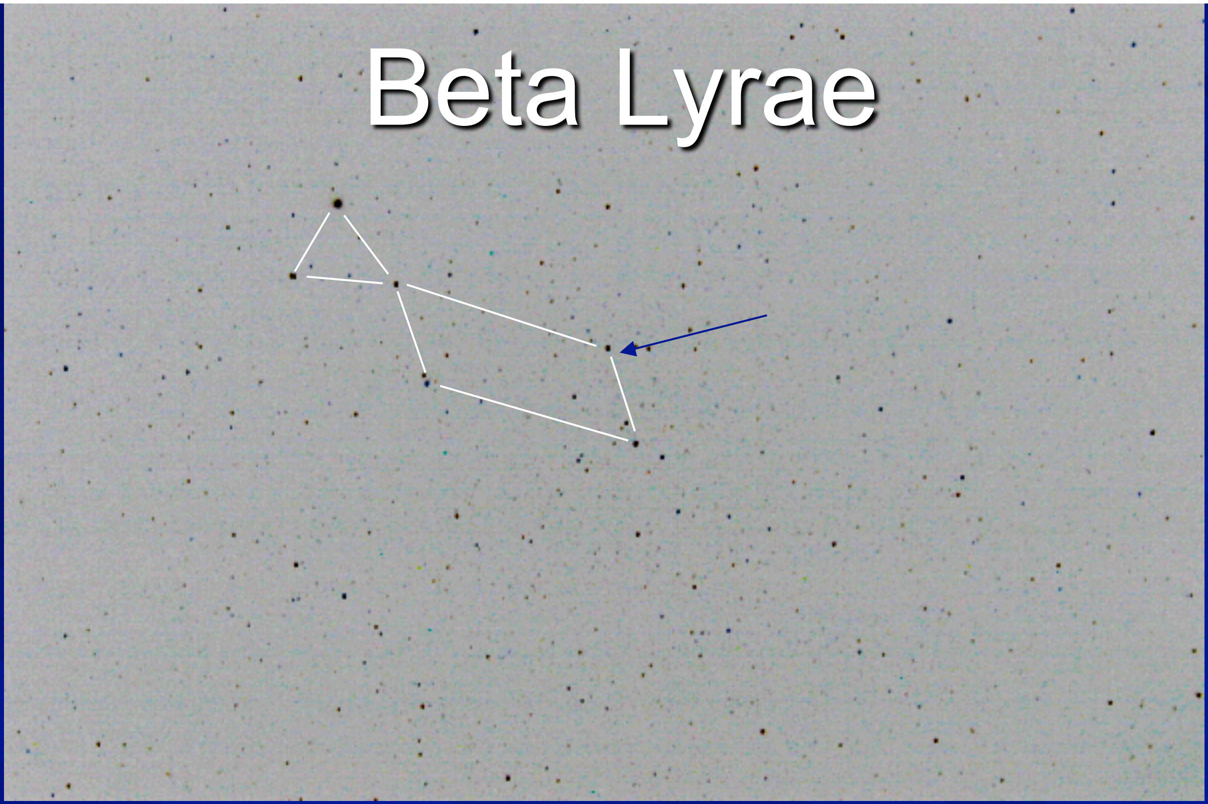
Outline

- Refer to Spring 2009
- DSLR Camera – linear, less prone to saturation than CCD, stock lens – no telescope. Parameters…
- Methods
- Results
- EL film for flat fields – characterization
- Attempt at atmos extinction measurements

Thanks to:

- WWC Student Assistants
  - Anesh Prasai
  - Sara Bacon
  - Meron Amare
- Warren Wilson College
- Petr Harmanec

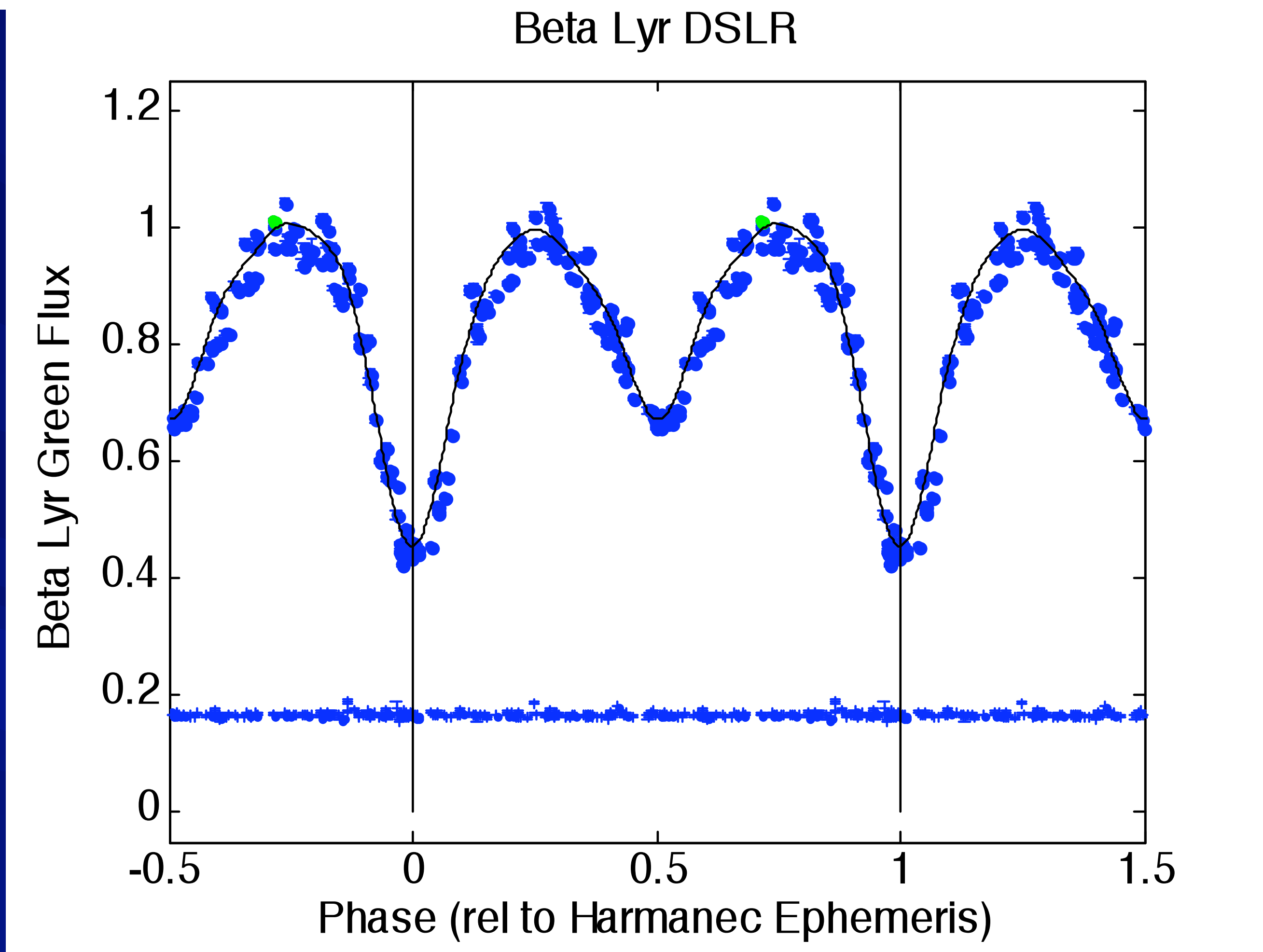
Beta Lyrae



- Well-known eclipsing binary – naked-eye
- Rapid mass exchange from donor star to receptor star
- Dense accretion torus
- Complicated system: Eclipses; Intrinsic variability; Polar jets; Rapidly evolving

No telescope

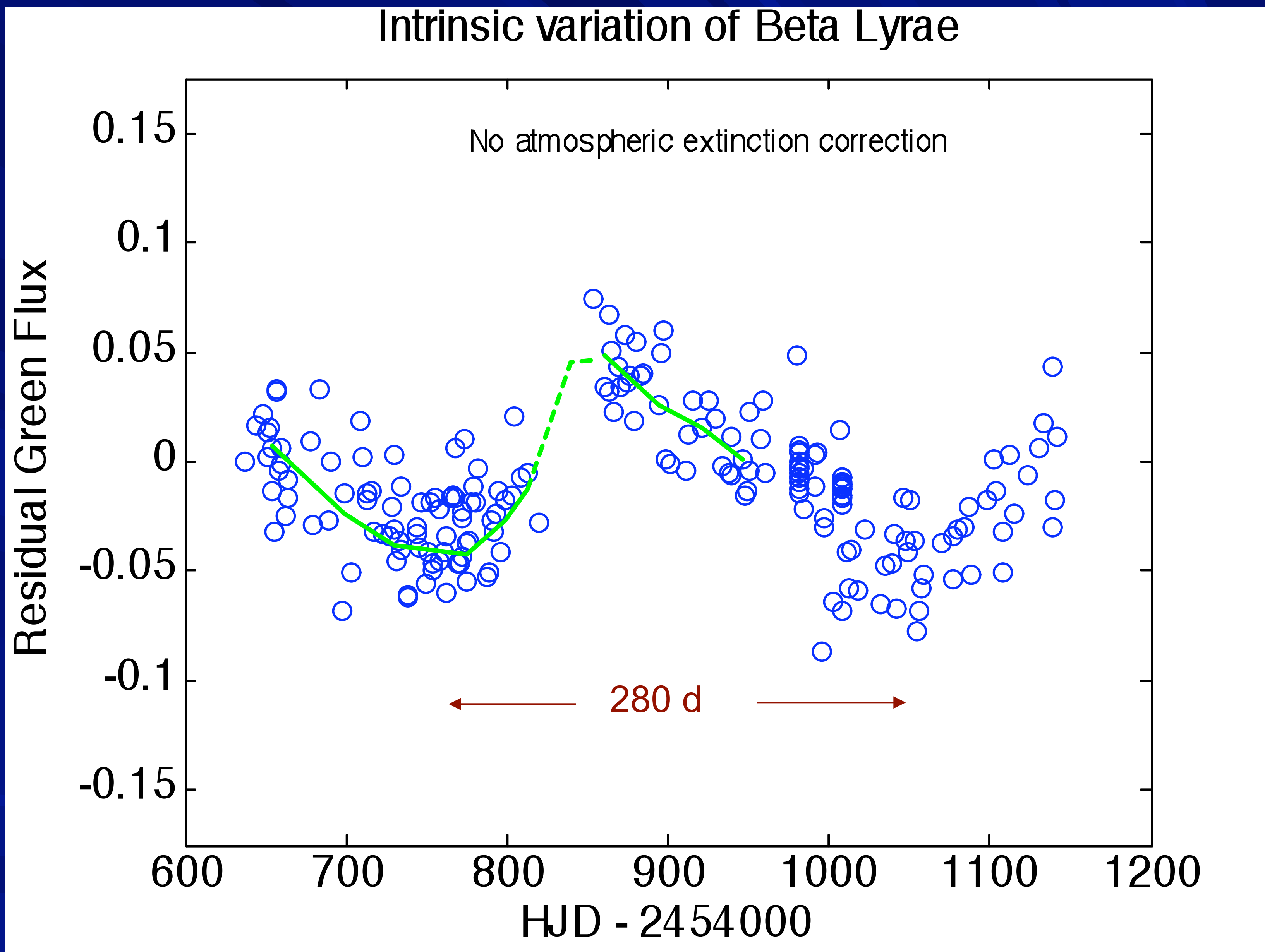
- Canon XTi (EOS 400D)
- 18mm to 55mm zoom lens – set to 55mm
- f/5.6, ISO 800, 15 sec x 11
- Dark frame and flat field compensation
- Good nights ± 0.005^m usually ± 0.01^m
- Linear response when used in “raw” mode
- Recommend 10 Mpx or less



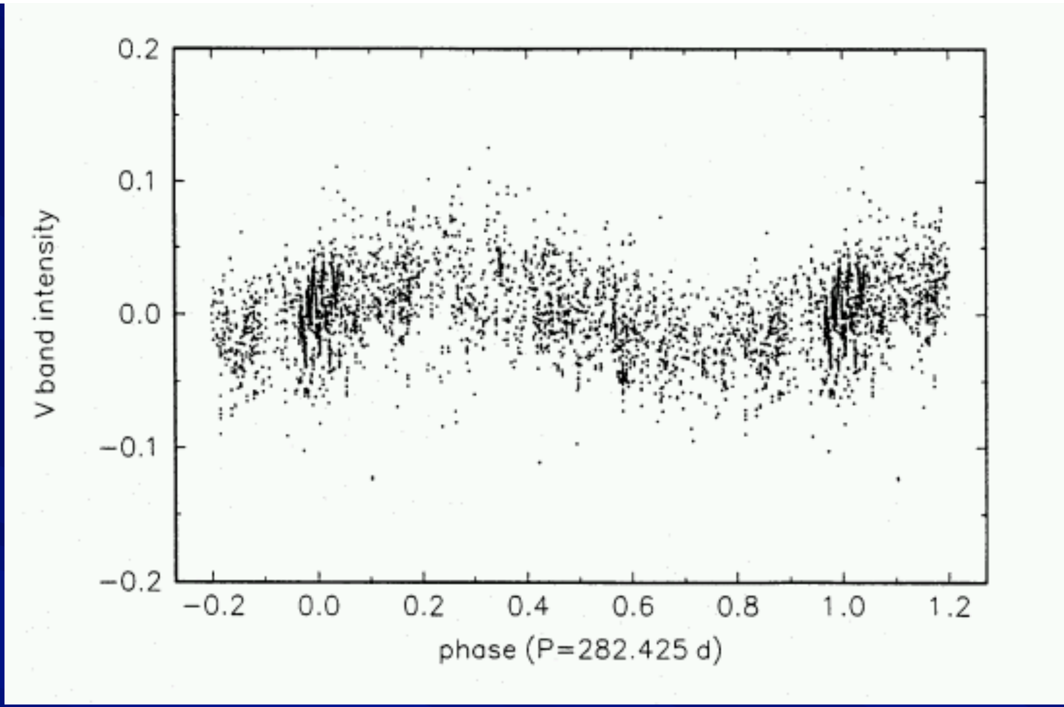
DSLR Observations from June 2008 to October 2009

Ephemeris: Harmanec and Scholz, 1993 *Astronomy and Astrophysics* **279**, 131-137

Solid line: Van Hamme, et. al., 1995, *Astron. Journal* **110**, 1350-1363

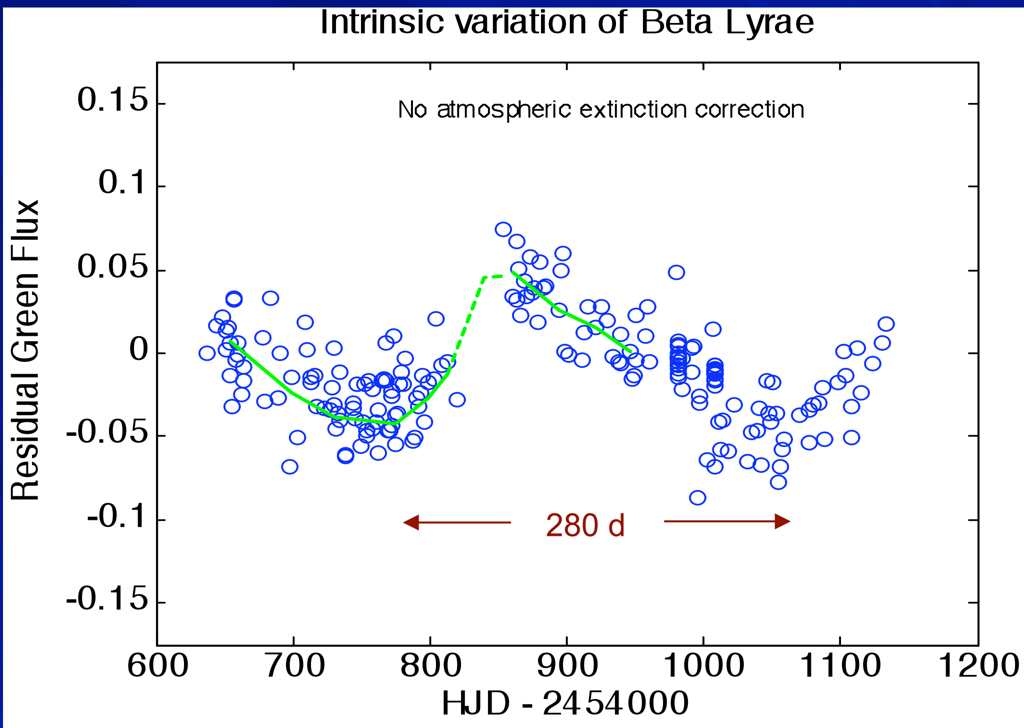

Intrinsic variation of Beta Lyrae
No atmospheric extinction correction
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
Residual Green Flux
280 d
600
700
800
900
1000
1100
1200
HJD - 2454000

- Nearly "continuous" coverage – ease of set-up
- Non-sinusoidal intrinsic variation
- Harmanec, 2002 (*Astron. Nachr. 2*, 87-98)
  - Possible beat period between orbit and a more rapid oscillation
  - Possible disk pulsations from impulsive mass transfer related to periastron passage
  - 280 day variability vanishes for orbital phases (P ~ .25, and P ~ .5)
- DSLR seems to have less scatter than many years of photoelectric data



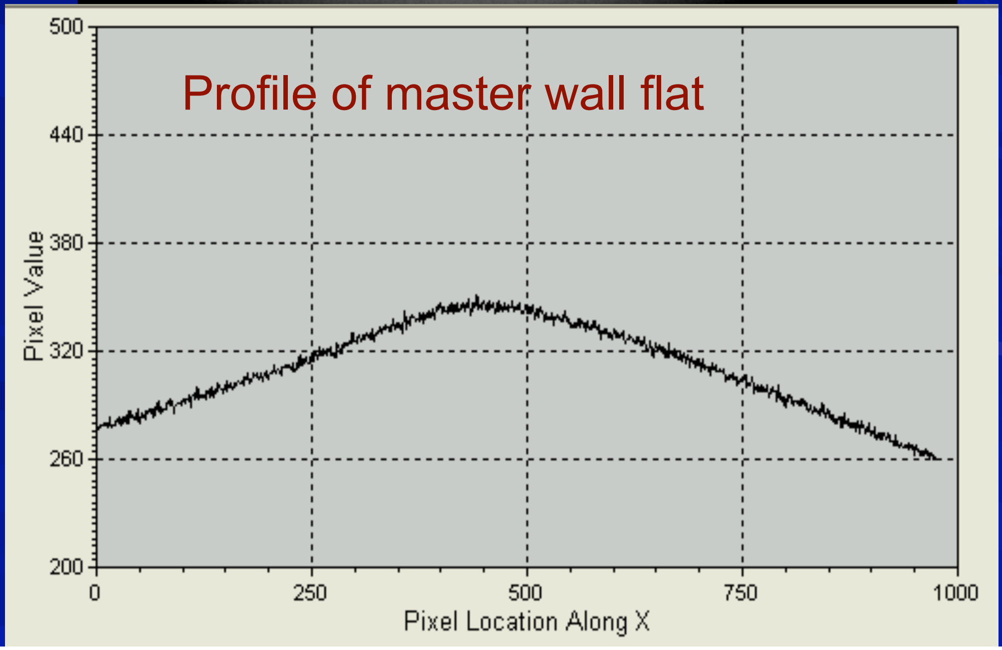
Left: Residual variability from 36 years of photoelectric and visual data. Harmanec, et. al. 1996, *Astron. Astrophys. 312,* 879-896.

Right: Secular plot of residual variability of Beta Lyrae using DSLR green flux.



Flat Field – Very Important

- Compensates for vignetting
- Obtain by photographing flat dimly-illuminated wall – same lens setting
- Make master flat from series of similar exposures



Wall Flats Difficult

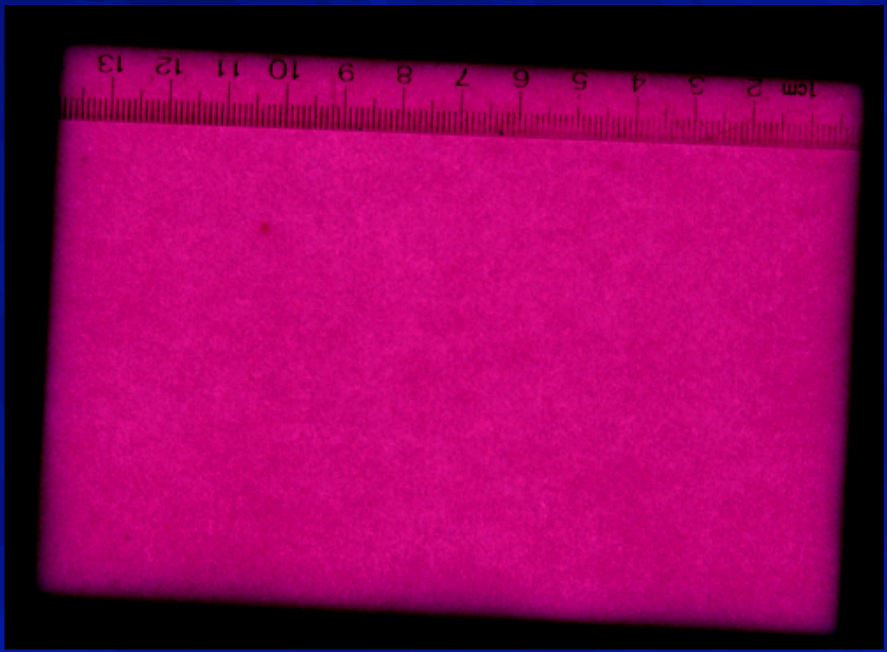
- Challenge to avoid shadowing
- Challenge to illuminate evenly
- Especially bad for wide FOV and low f/no
- Sky flats out of question for DSLR (wide FOV)

Electroluminescent Film

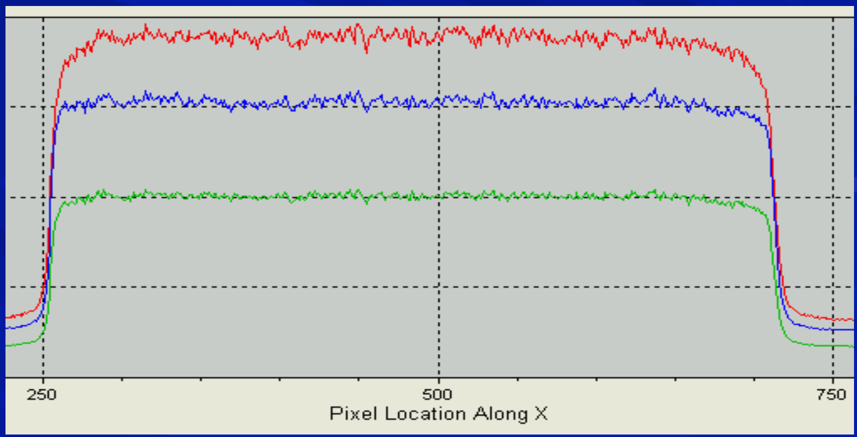
- Phosphor (ZnS) between electrodes
- Powered by 250 V-400 V, ~400 Hz
- Some observers have used these for flat-fielding telescopes – even commercial packages available
- Available in large variety of sizes – complete with power source (Luminous Film.com)
- Adjustable brightness available for more $$

Characterize EL Film

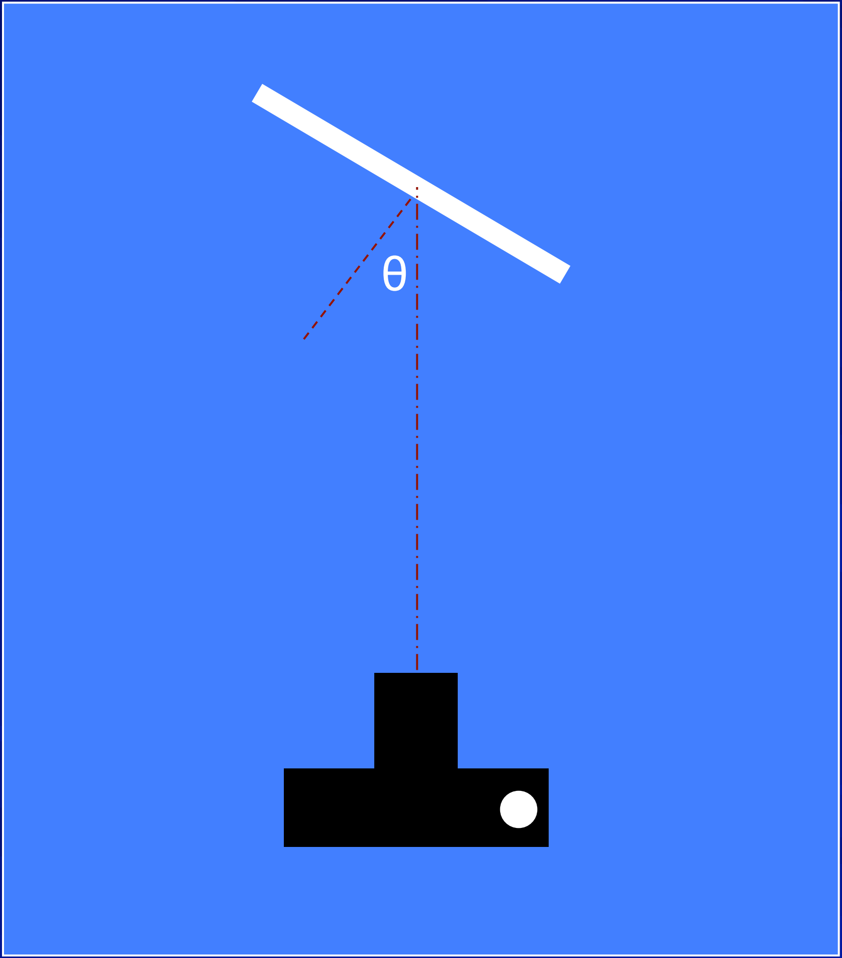
Must use “long” exposure with focal plane shutter due to AC illumination – hence Vellum

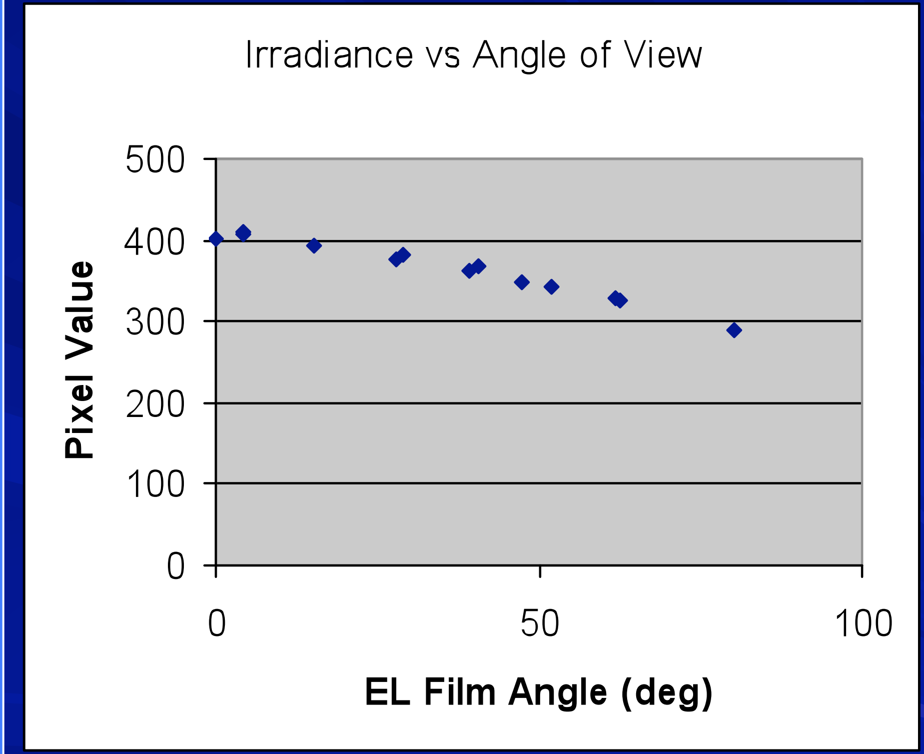


Flatness std dev ~1.5% (attenuated by 4 sheets of Vellum)

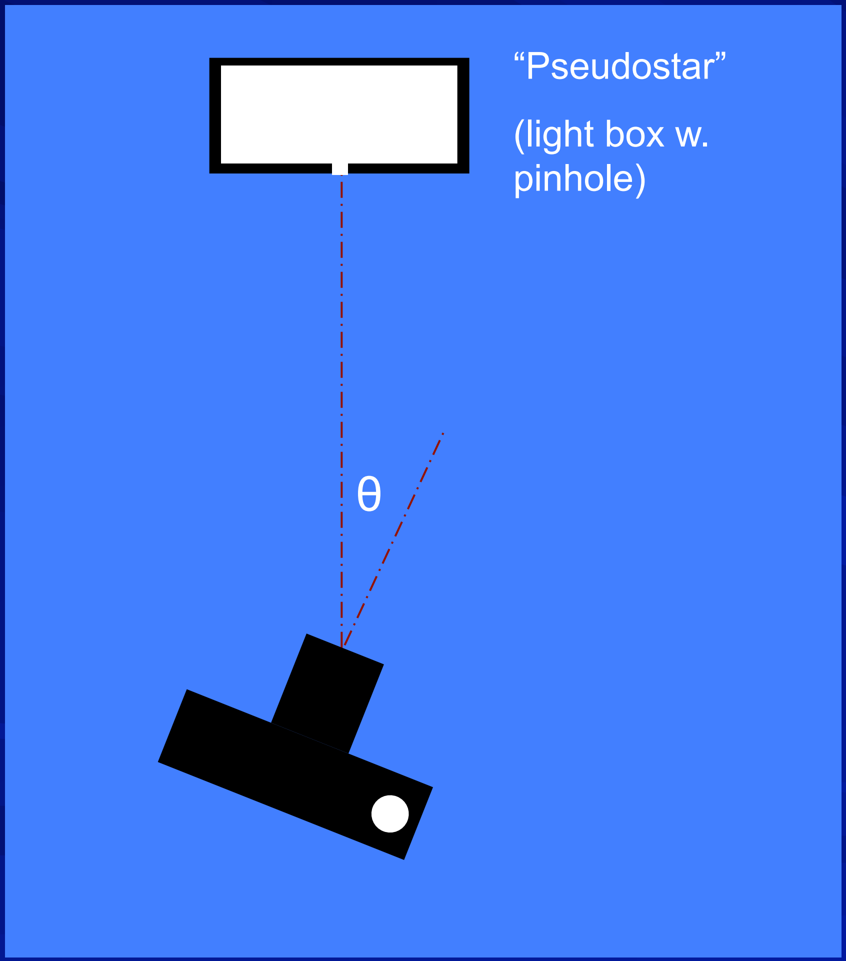


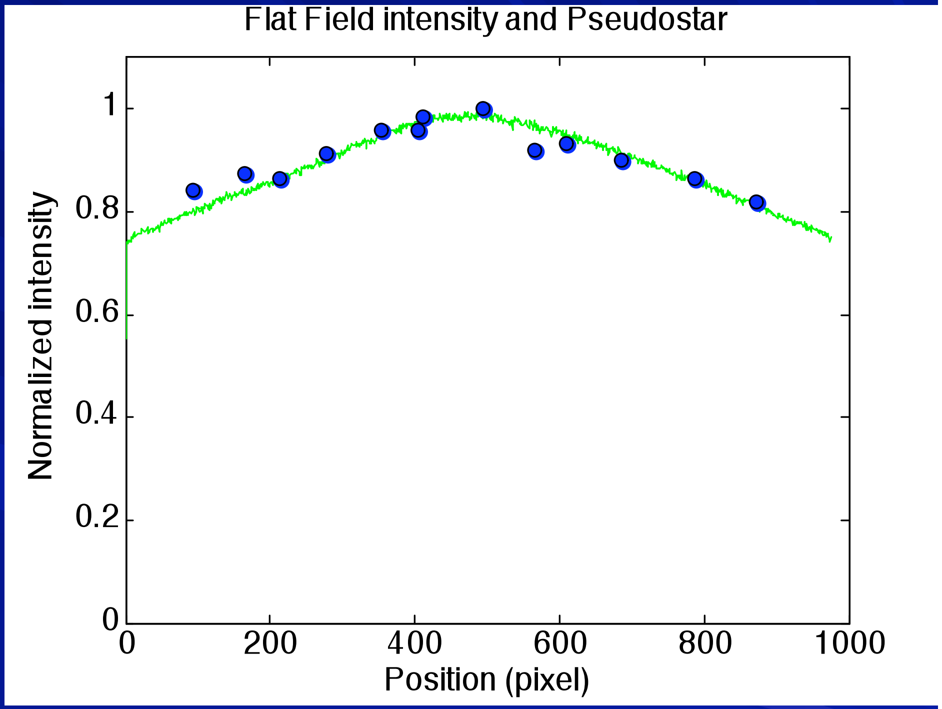
Angular dependence



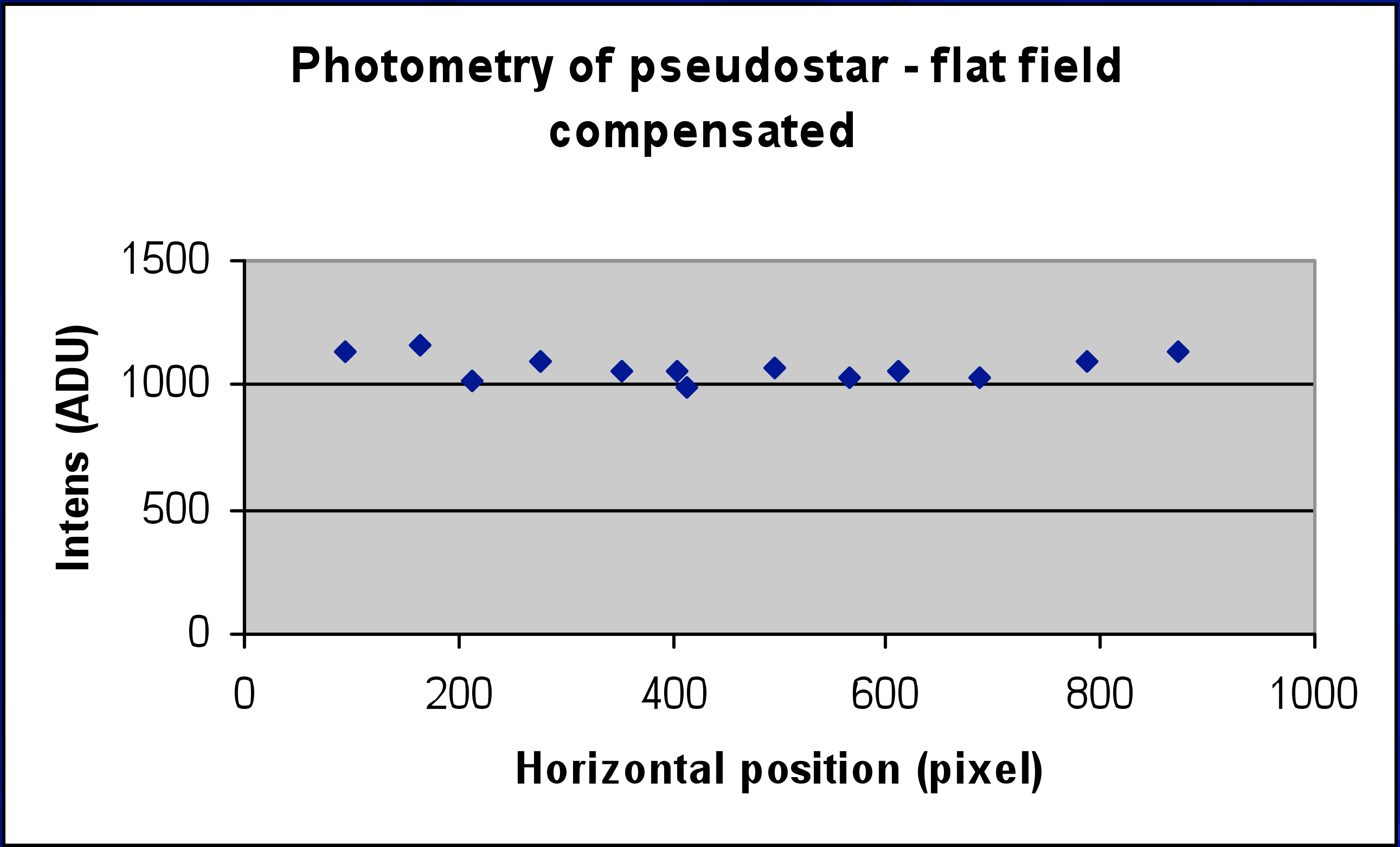


Testing Flat Field





Result of Flat Field Compensation

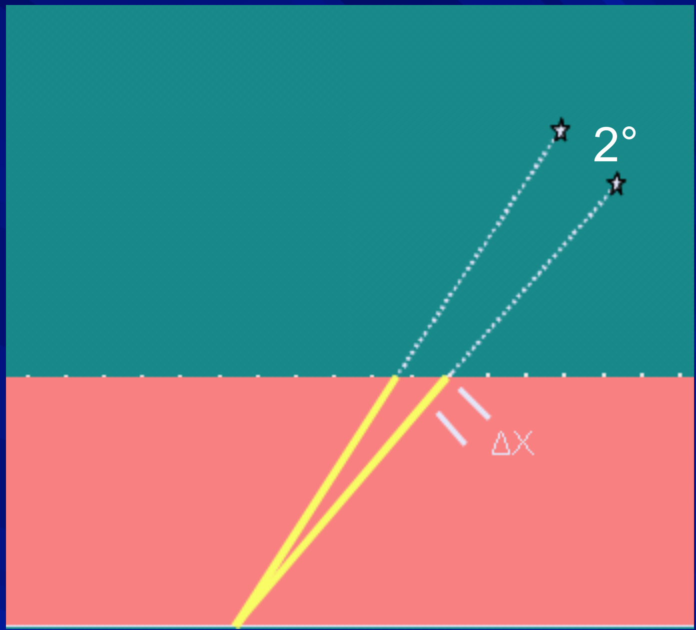


Reasonably flat in middle 2/3 of frame

Deviation at edges probably due to angular dependence of E-L irradiance

Full compensation will require photometry of standard point source over the whole FOV

Atmospheric Extinction - Problem



Elev Angle (deg)	Air Mass X	Air Mass Increment ΔX	Δmag (Kv = .2)	Δmag (Kv = 1)
90	1.0	0.00	0.00	0.00
70	1.1	0.01	0.00	0.01
50	**1.3**	**0.04**	**0.01**	**0.04**
40	1.6	0.06	0.01	0.06
30	2.0	0.12	0.02	0.12

Problems measuring atmospheric extinction

- Bright stars are rare. Bright standards even rarer.
- Tried o Her in same FOV (non-standard)
  Kv ~ .5 - .9 mag/airmass. o Her in corner.
- Bright standard stars widely separated. Tried 18 mm FL. Loses photons.
- Separate sets of images for dispersed standards – erratic results

Conclusions

- 280 day cycle for intrinsic variability for Beta Lyrae clearly seen
  - Appears non-sinusoidal
  - Good science from “backyard astronomy”
- Electroluminescent Film should be a good flat-fielding source
  - Spatial variability (about 1.5 %)
  - Angular dependence of luminance
- Atmospheric extinction non-negligible. Avoid large air mass
- Transformation coefficients – next step

Bibliography

Bruton, D., R. Linenschmidt, R. W. Schmude, "Watching Beta Lyrae Evolve". (1996), http://www.physics.sfasu.edu/astro/betalyra/index.html (submitted to IAPPP).

Bensen, Priscilla J., "CCD Transformation Coefficients". (1993), AAVSO Information Sheet. http://www.aavso.org/observing/programs/ccd/benson.pdf

Cohen, Lou, "Computing and using CCD Transformation Coefficients". (2003), AAVSO Information Sheet V. 3 (4 May 2003). http://www.aavso.org/observing/programs/ccd/ccdcoeff.pdf

Covington, Michael A., Digital SLR Astrophotography. 2007. Cambridge University Press.

Harmanec, P and G. Scholz, "Orbital Elements of βLyrae after the First 100 years of Observation". (1993). Astronomy and Astrophysics 279, 131-137.

Harmanec, P.; Morand, F.; Bonneau, D.; Jiang, Y.; Yang, S.; Guinan, E. F.; Hall, D. S.; Mourard, D.; Hadrava, P.; Bozic, H.; Sterken, C.; Tallon-Bosc, I.; Walker, G. A. H.; McCook, G. P.; Vakili, F.; Stee, P.; Le Contel, J. M. (1996). Jet-like structures in β Lyrae. Results of optical interferometry, spectroscopy and photometry. *Astronomy and Astrophysics, v.312*, p.879-896.

Harmanec, P. (2002). The ever challenging emission-line binary beta Lyrae. *Astron. Nachr. 2,* p. 87-98.

Henden, A. and R. H. Kaitchuck. (1982). *Astronomical Photometry.* Willmann-Bell, Inc.

Terrell, Dirk 2005. Variable Star of the Season, Summer 2005: Beta Lyrae, AAVSO: http://www.aavso.org/vstar/vsots/summer05.pdf

Van Hamme, W, R. E. Wilson, and E. F. Guinan. (1995). "Periodic Light Curve Changes for Beta Lyrae",. Astron. Journal 110, 1350-1363.