The Pierce-Blitzstein Photometer – The PBPHOT

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- For most of us, our first observing experience at Penn was using PBPHOT
- Thus you are all part of the history of this instrument and in a sense coauthors
- Gene Malone was organizing a HAD meeting on dual channel photometers, and when Tony checked the website, he noticed that PBPHOT was not included

Special Session: HAD II: Photometry: Past and Present

1/5/2009 10:00 - 11:30 AM

This session is on the development of astronomical photometry. The goal is to describe and discuss the achievement of precision and accuracy since the photovisual and photographic era to the present CCD age. Both instruments and techniques are to be discussed. Thus, photoelectric photometers and photometry will be highlighted, especially the dual-beam instruments commonly referred to as two-star photometers. *The importance of photometric standardization was demonstrated in May, 2006 when a well-attended meeting on this topic was held in Blankenberge, Belgium. Although the main purpose is to discuss the historical significance of visual photometry, the UV and IR will be covered in at least one of the talks. We are trying to arrrange the following talks: 1. astronomical precision (an overview of expectation and achievement); 2. differential photometry and photometers (beginning with the Princeton polarizing photometer through the Walraven differential photometer to the Rapid Alternating Detection System); 3. astronomical standardization (both of the widely used UBVRI system, through the transition from photoelectric to the CCD regime; and. more broadly, the standardization of all other passbands from the UV through the IR); 4. spectrophotometry; and 5. polarimetry. We hope that the closely allied branches of photometry, spectrophotometry and polarimetry, also be included in the discussion, because in both cases, high precision is currently being obtained, and they are providing increasingly useful tests of astrophysical theories.*

Organizer: Eugene Milone, University of Calgary, Canada

Bob, Tony and I noticed the omission of PBPHOT, and we decided to do something about it!

- Ergo this talk, and subsequent chapter in Gene Milone's book.
- We relied heavily on Bob's notes and his scholarship, and to no small extent, this is his work.
- George Wolf recently added to the rich history of the instrument, as it matured into a true dual channel photometer. We are pleased to have this addition!

Abstract

- This report describes the inception, development and extensive use (over 50 years) of the simultaneous 2-source, pulse-counting photometer named after the two astronomers in this paper's title.
- These men are not, however, the only personalities associated with the lifetime of the photometer and the contributions of other people are explicitly recognized.
- The embellishments and upgrades over time of the original conceptions are detailed for both the optical/mechanical/ electrical hardware and the software.

Overview(1)

1. The architecture of PBPHOT was extraordinary, even visionary for its time.
2. It was an automated two channel pulse-counting photometer, a thought out system from the start

3. Product of initial collaboration between astronomy departments at Princeton & Penn, ultimately developed at Penn
4. Early collaboration with RCA to provide optimum electronics

Overview (2)

5. Ultimately optimized for productive work in problematic skies
   a. Quality data through variable extinction from cirrus clouds yet maintained better than 0.01 magnitude precision for stars ≤ 9^{th} mag.
   b. Work through cloud-modulated, light pollution background aggravated by proximity to Philadelphia

Overview (3)

5. Blitzstein incorporated calibration to match the detector and filters of each channel to each other
6. The efficiency of pulse counting electronics was exploited
7. The intent from the start was to have automated observing and this was ultimately realized.

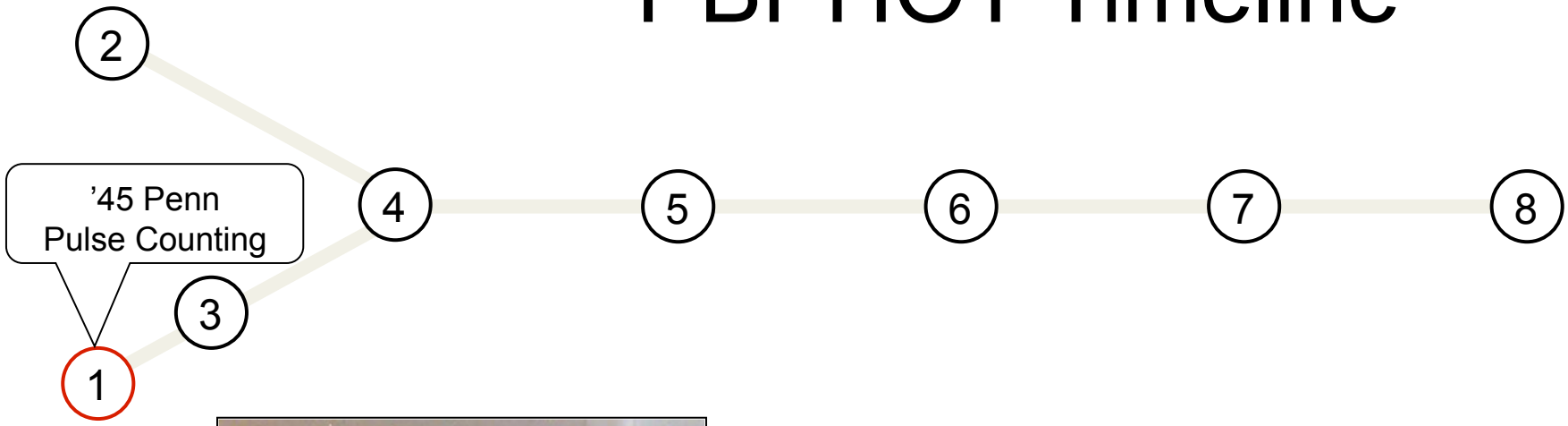
Dual Channel Heritage

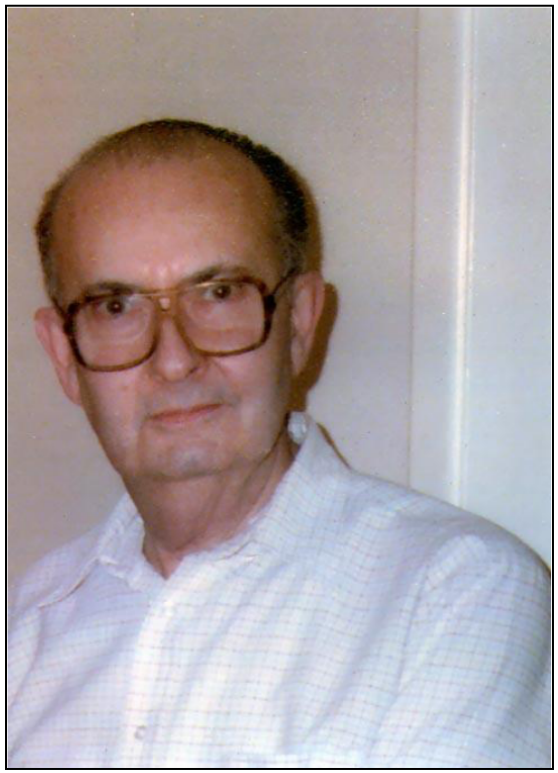
- At Princeton in the 1930s, Raymond Smith Dugan used a polarizing 2-channel photometer with the eye as a detector
- Newton Lacy Pierce and J.E. Merrill of Princeton inherited the instrumentation used by Dugan, and became dissatisfied with it due to the limitation of the eye's spectral response

Background: Dual Channel Photometry

- Pierce did not invent the concept of 2-channel photometry.
- 2-channels were used earlier with the Harvard Revised Photometry system by Edward C. Pickering (Director of Harvard College Observatory 1877-1919), Searle and Wendell and their collaborators at both Cambridge and Arequipa.
- Earlier, John Herschel invented a device and used it at the Cape to minimize an image of Moon and to present it to the observer at the same time as he was looking at a target star.

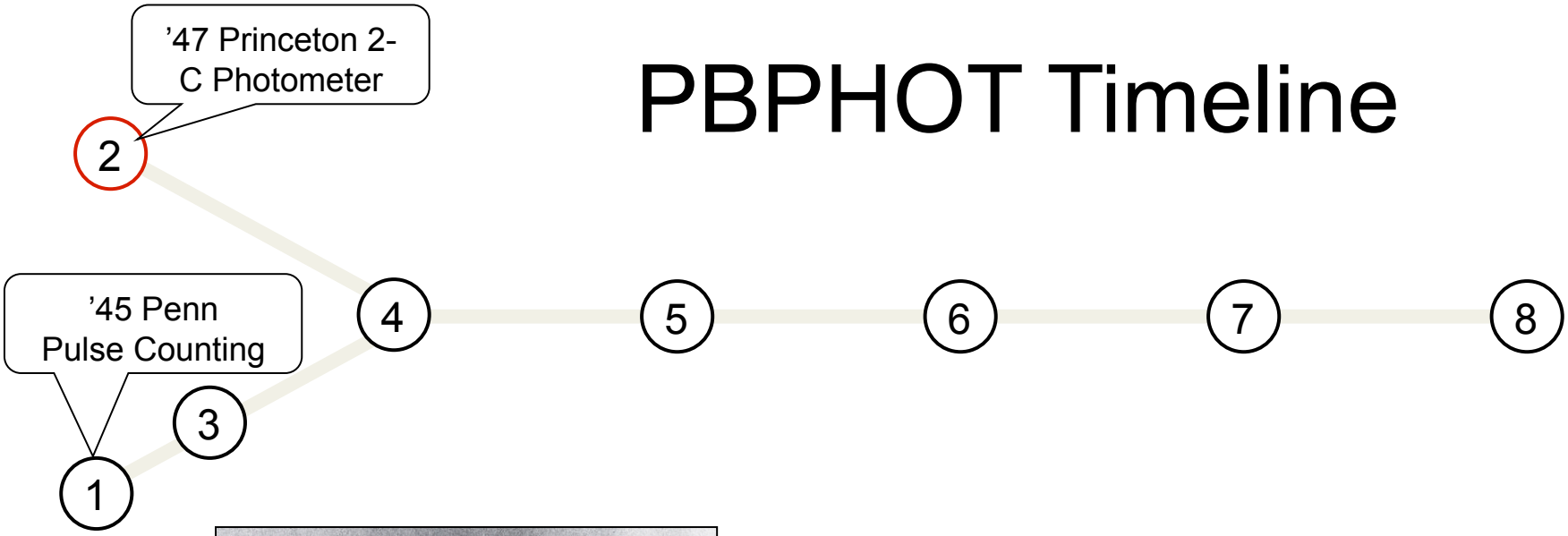
PBPHOT Timeline





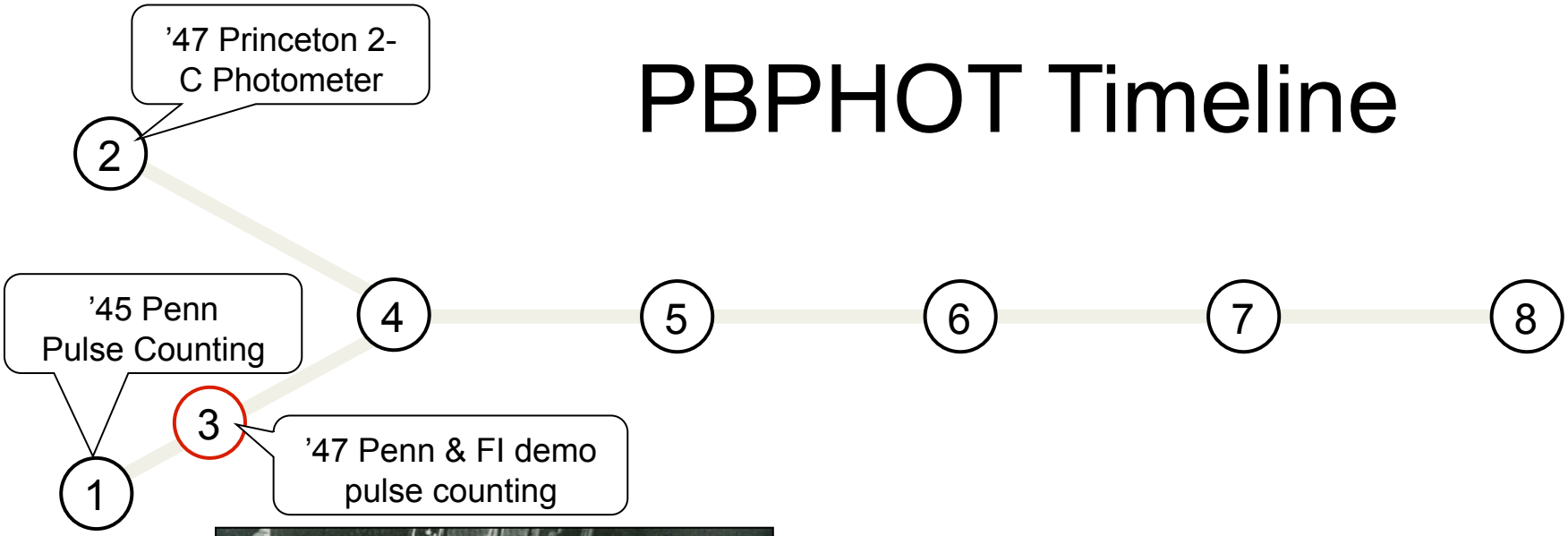
1. 1945 Penn: Grad. Student William Blitzstein developed intention to move from AC/DC amplification to pulse counting photometry

PBPHOT Timeline



2. 1947 Princeton: Newton Lacy Pierce starts to develop a 2 channel polarizing photometer

PBPHOT Timeline



3. 1947 Penn & Franklin Institute: At Flower Obs., Blitzstein & I. M. Levitt demonstrated pulse counting on stars → Paper at AAS 77

Blitzstein Light Curve of XZ And taken in late 1940s at Flower Observatory with single channel pulse counting photometer

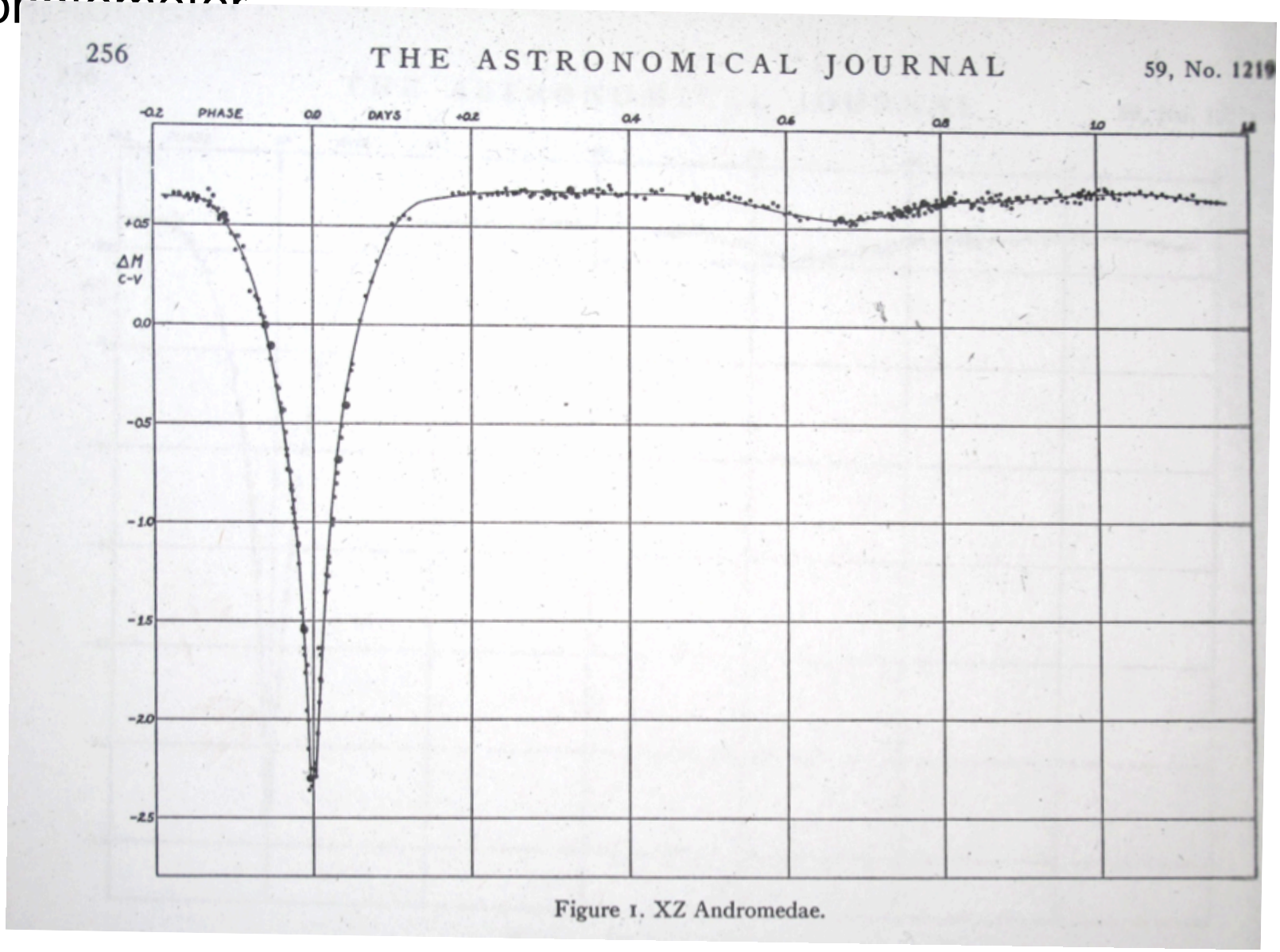
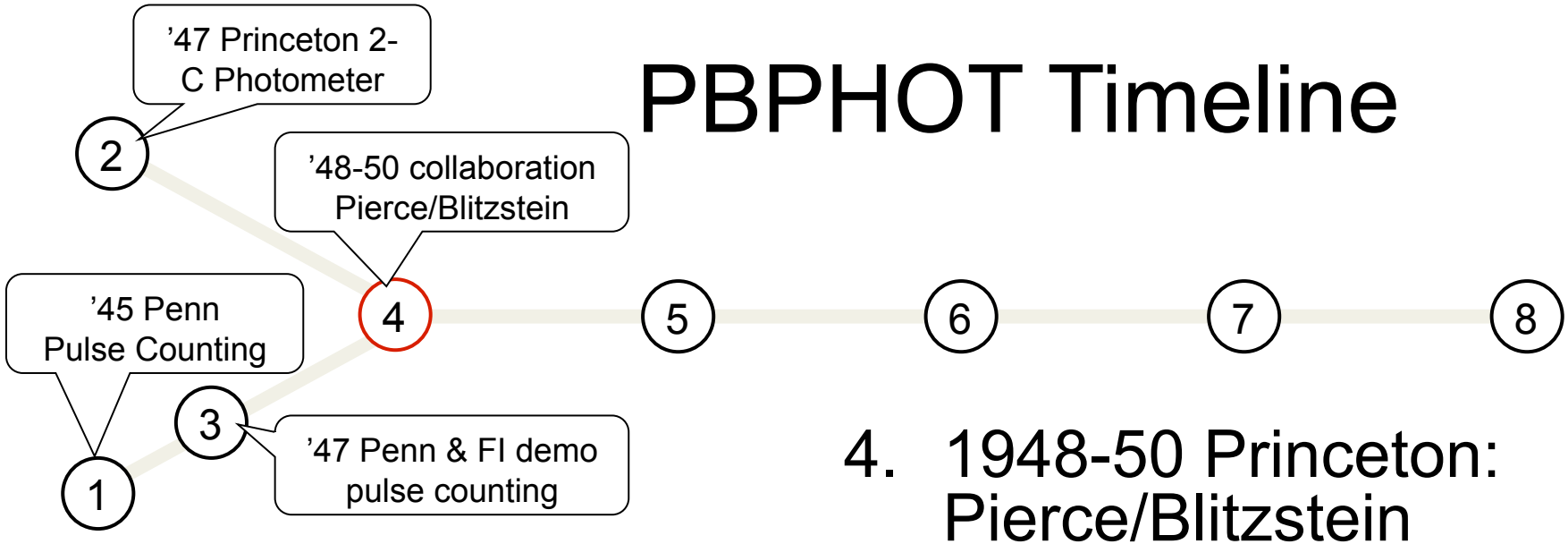


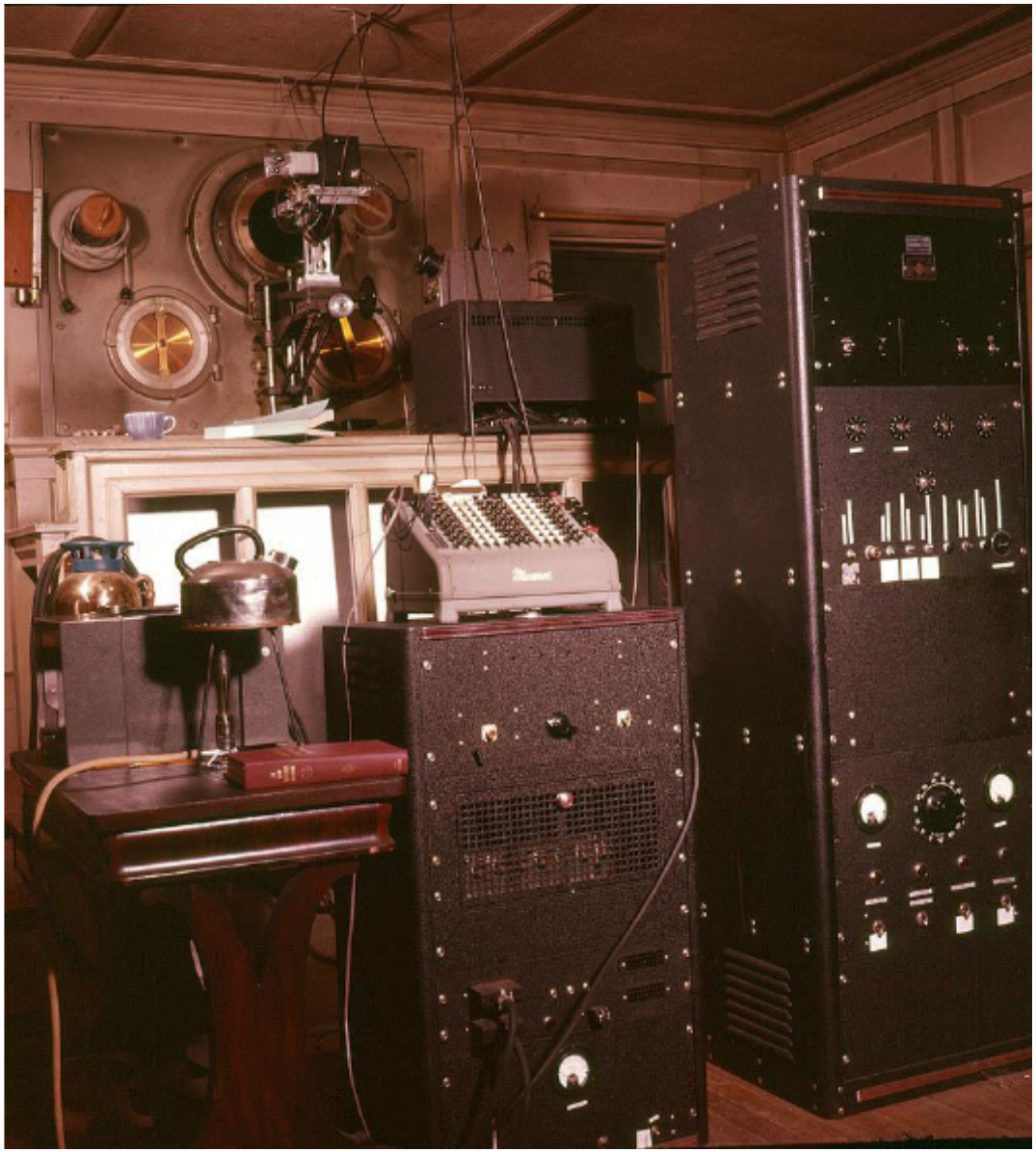
Figure 1. XZ Andromedae.

PBPHOT Timeline



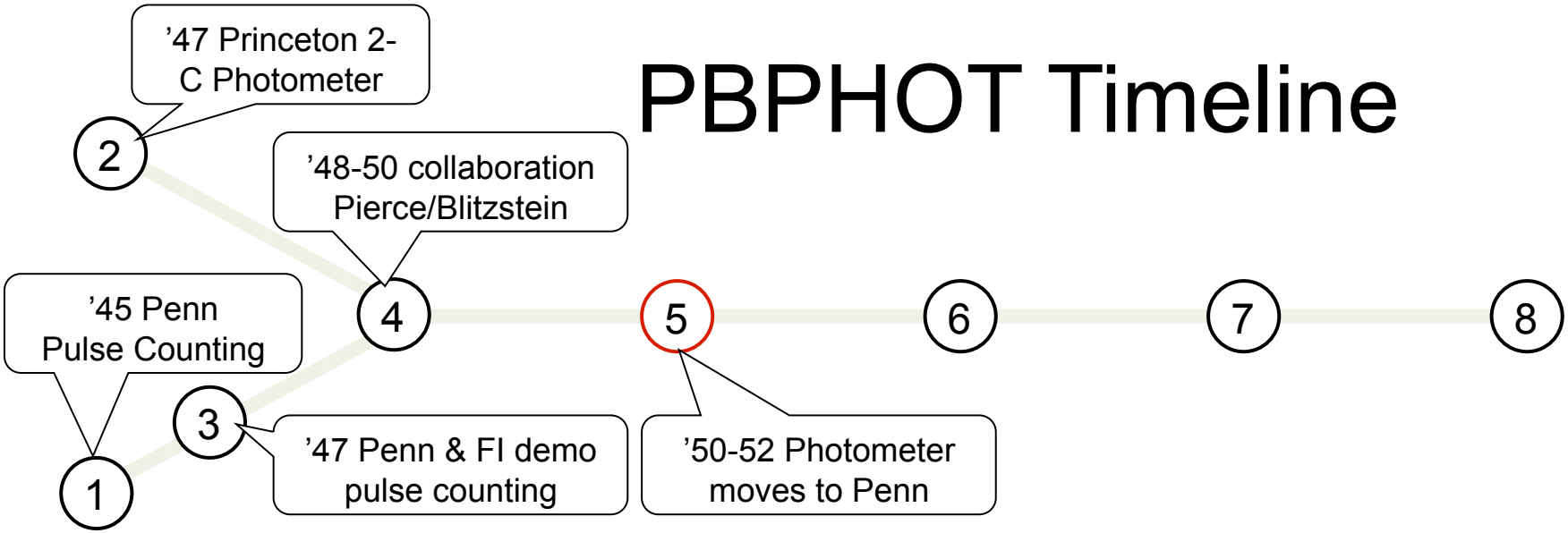
4. 1948-50 Princeton: Pierce/Blitzstein collaborate on dual channel pulse counting photometer.
- Pierce dies Aug 9, 1950 (age 45).
- Penn Chair C. P. Olivier provides financial support here, and for earlier work of Blitzstein/Levitt

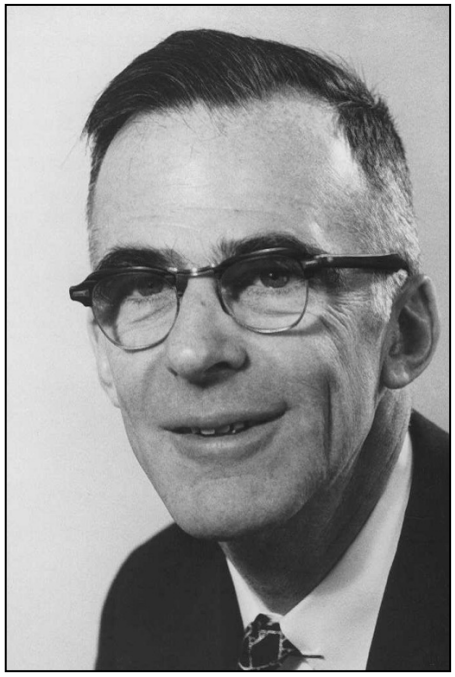
Precursor system moves to Penn



- Single Channel Photometer at Flower Observatory,
- Components acquired from Princeton for $8,600
- Incorporated Blitzstein Pulse Counting electronics

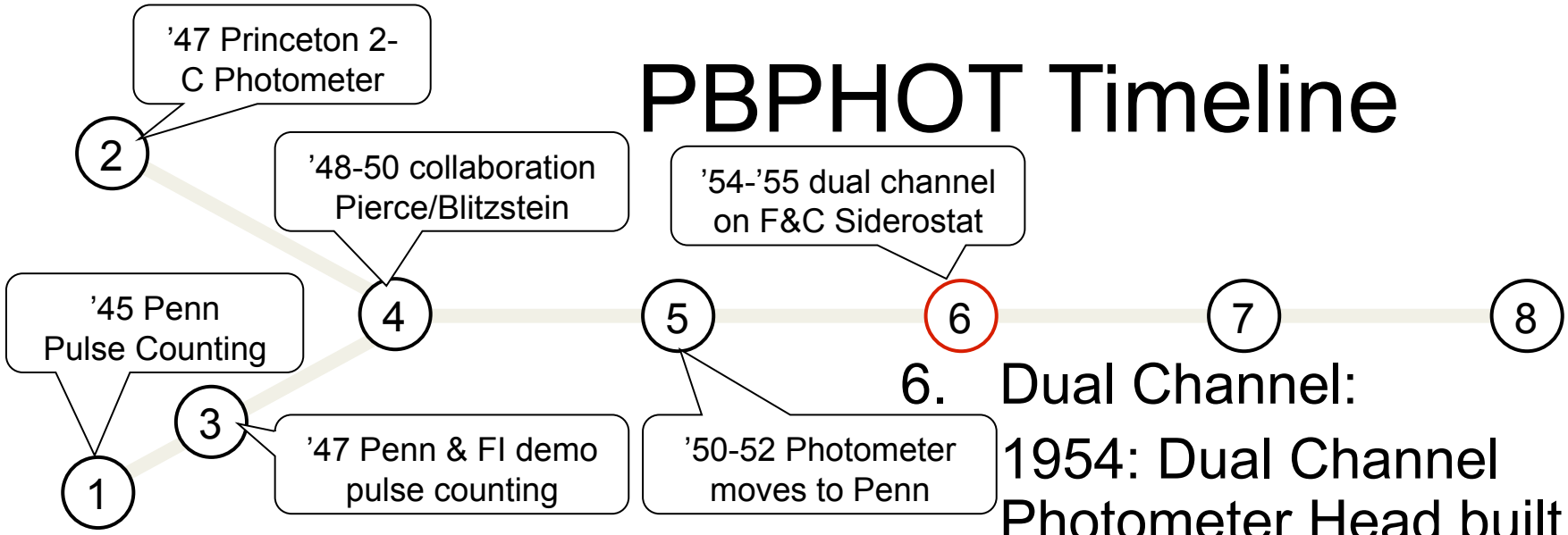
PBPHOT Timeline





5. 1950-52: Dept Chairs Frank Bradshaw Wood (Penn) and Lyman Spitzer (Princeton) facilitate moving Single Channel Photometer to Penn’s Flower Observatory

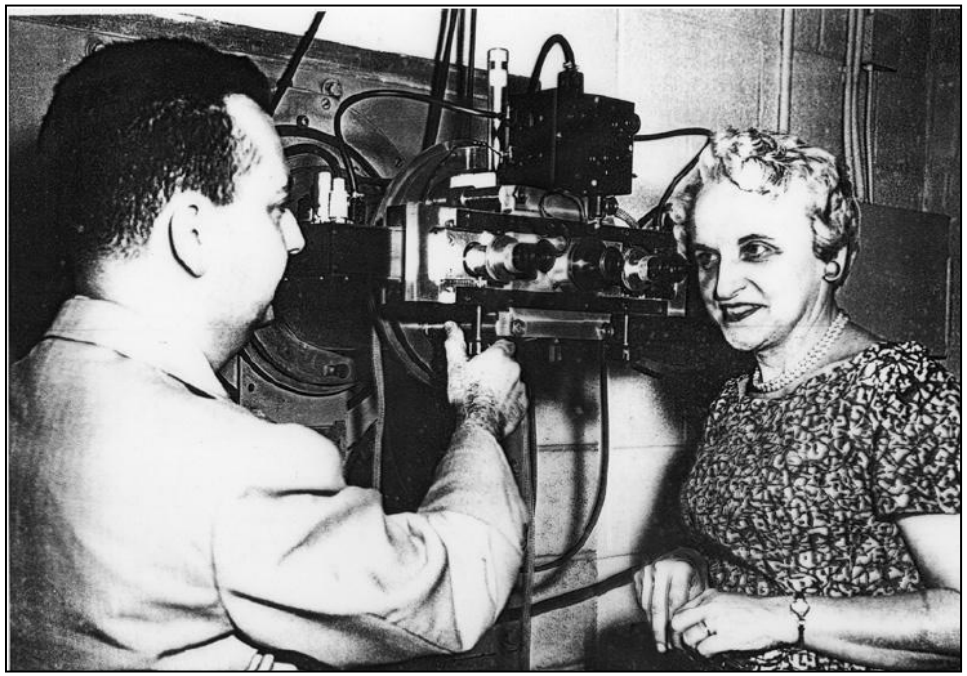
PBPHOT Timeline



6. Dual Channel:

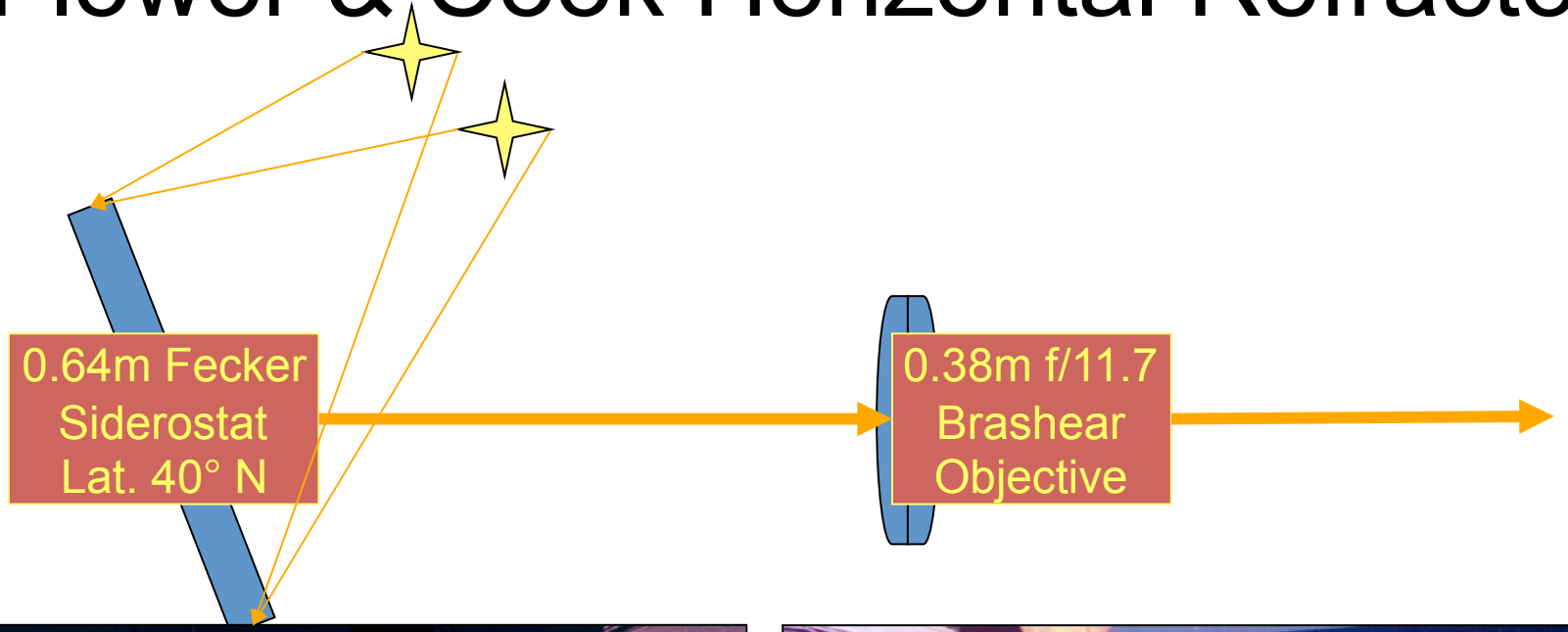
1954: Dual Channel Photometer Head built by Blitzstein at Penn

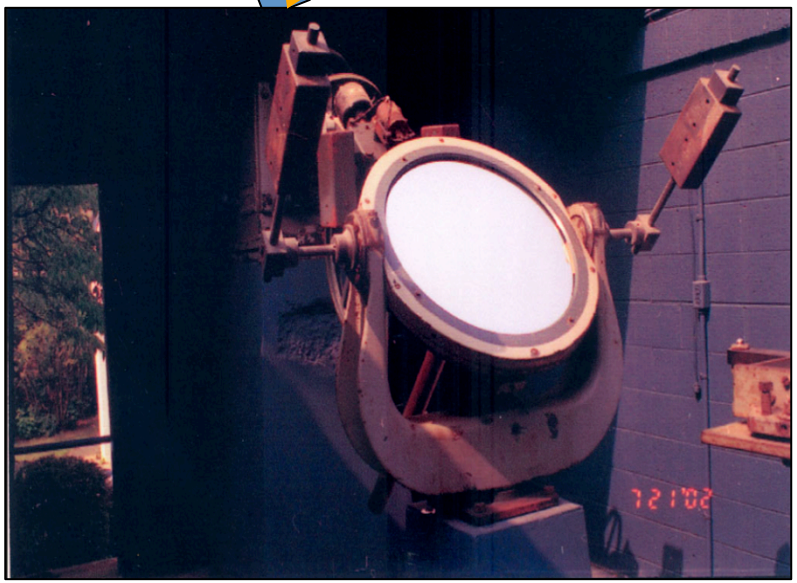
- 1955: Flower & Cook Observatory dedicated, including the 0.38m horizontal refractor fed by the 0.64m siderostat → used Dual Channel Photometer

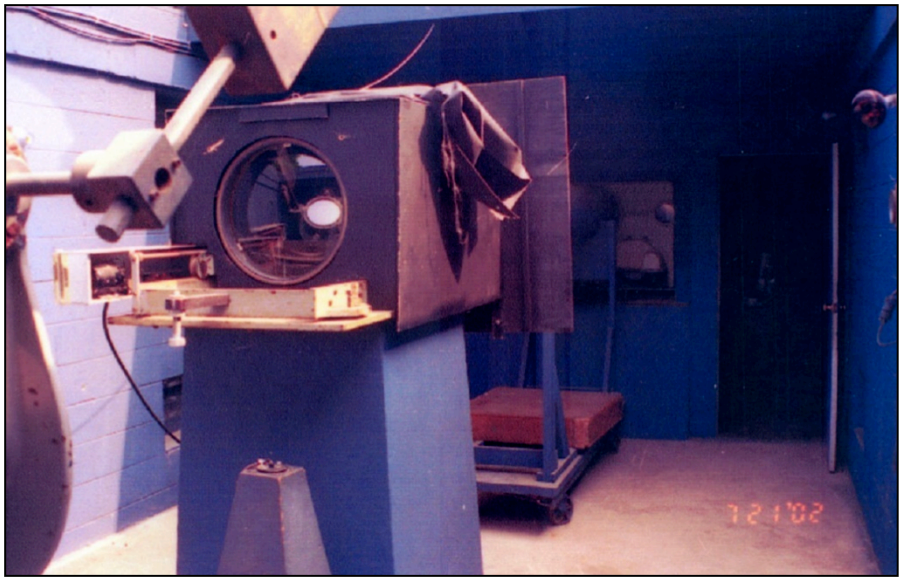


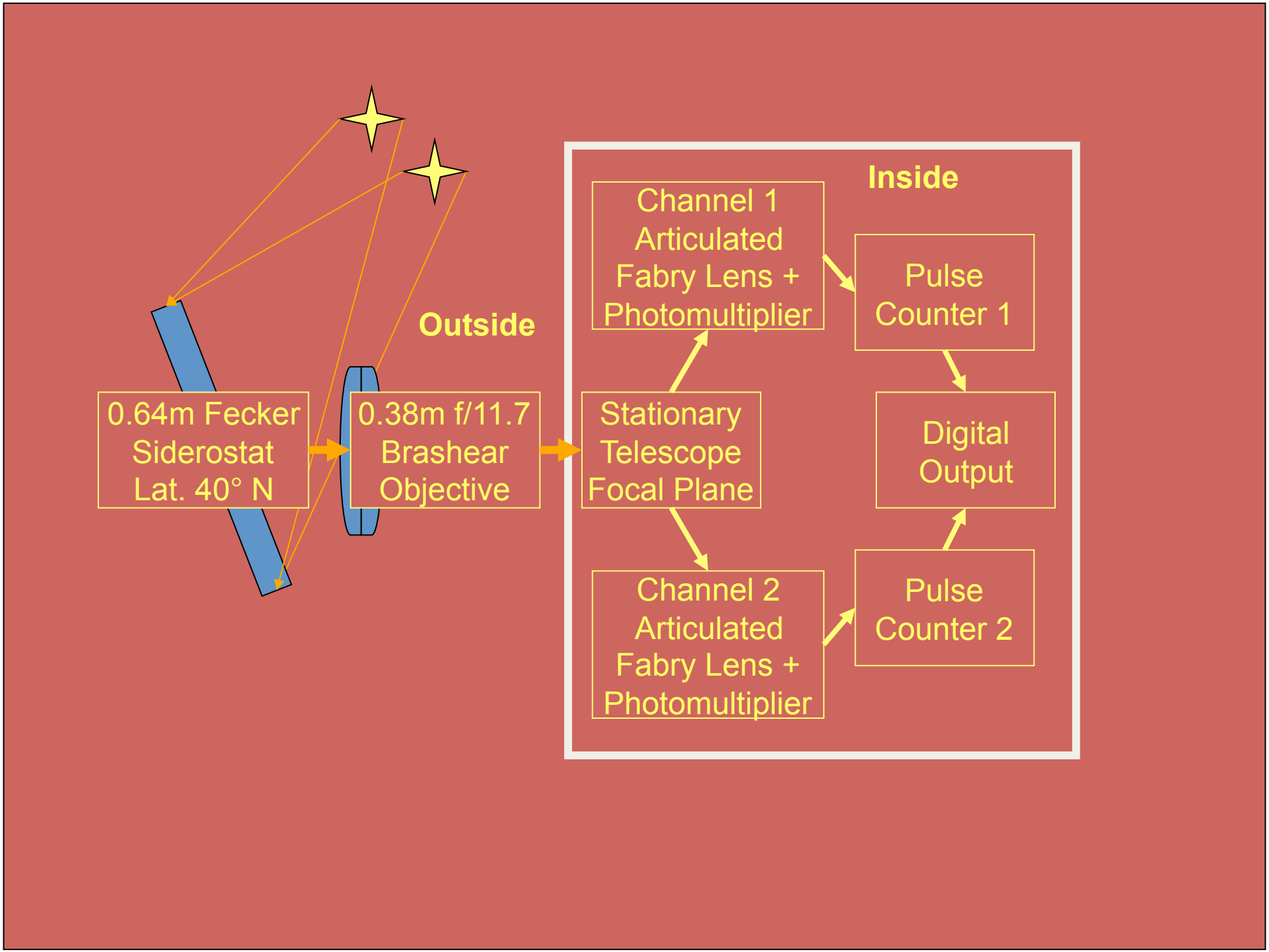
Blitzstein shows dual channel photometer To Pierce's widow at F&C dedication

Flower & Cook Horizontal Refractor

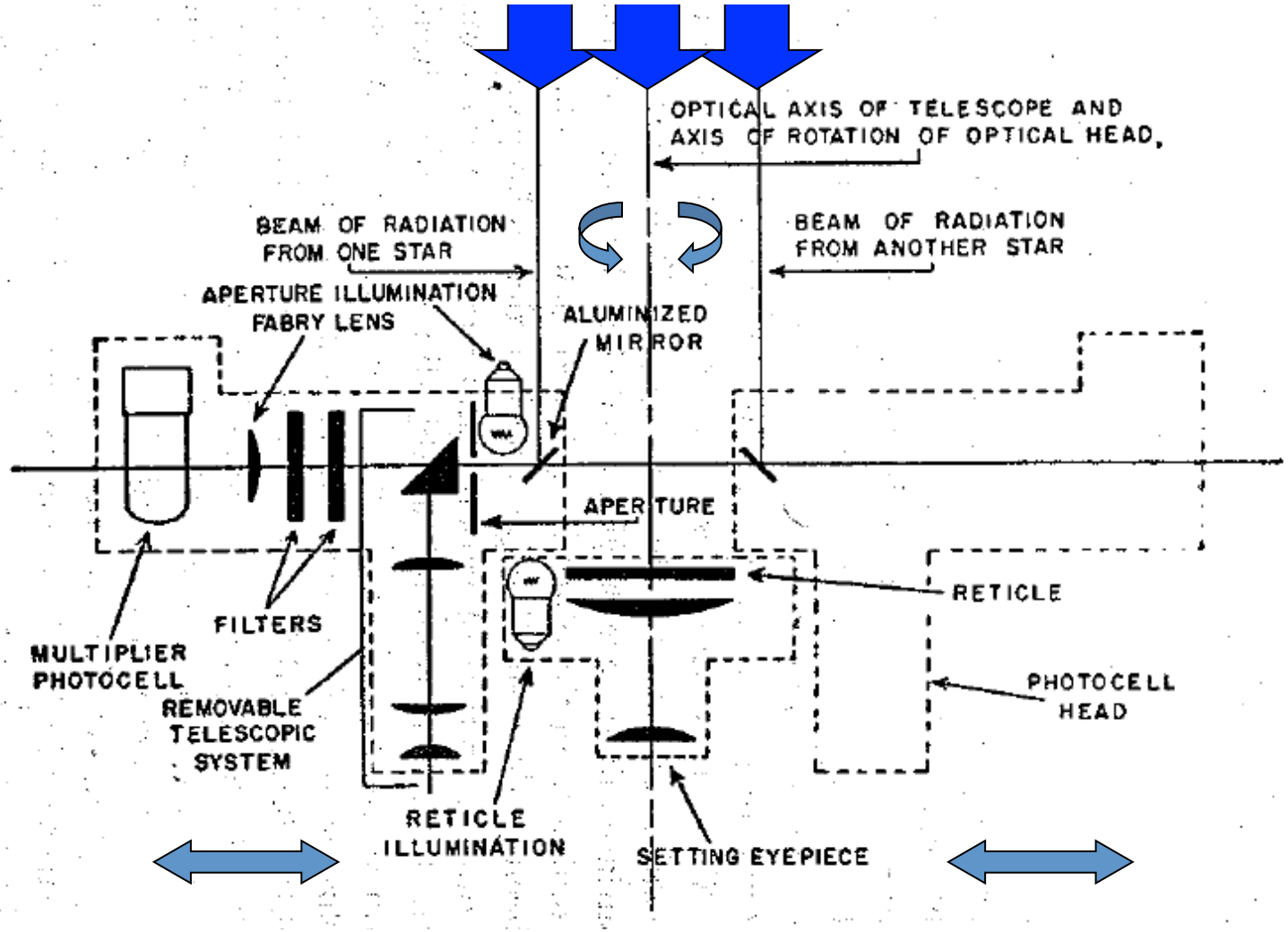




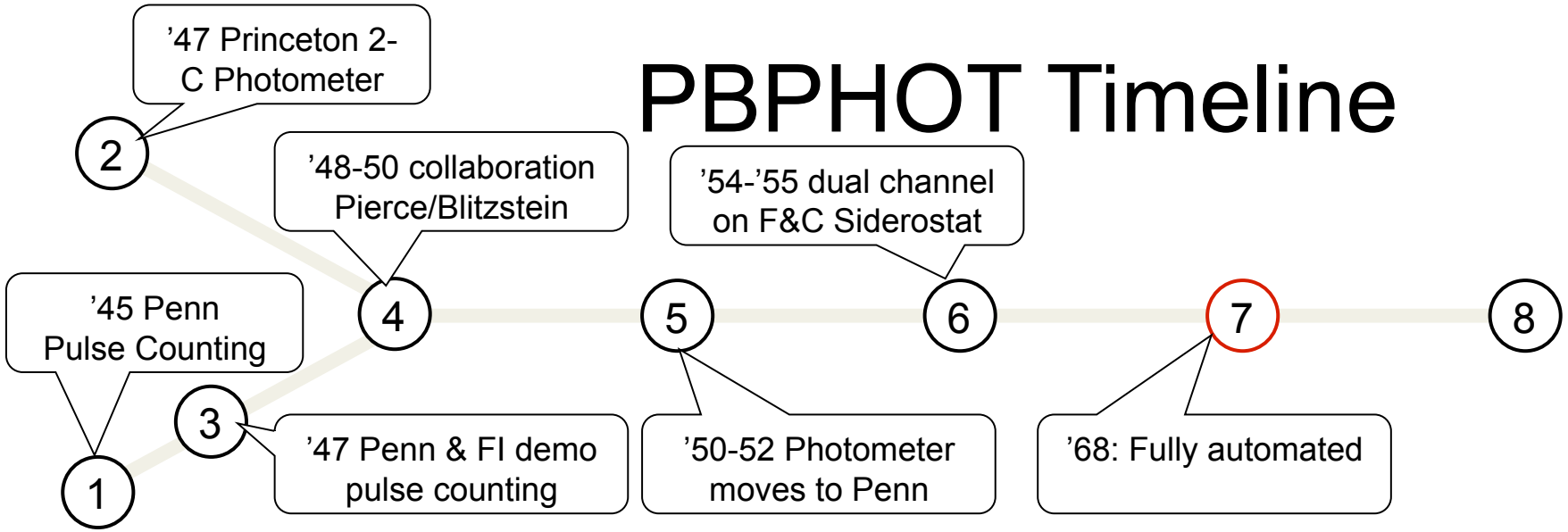


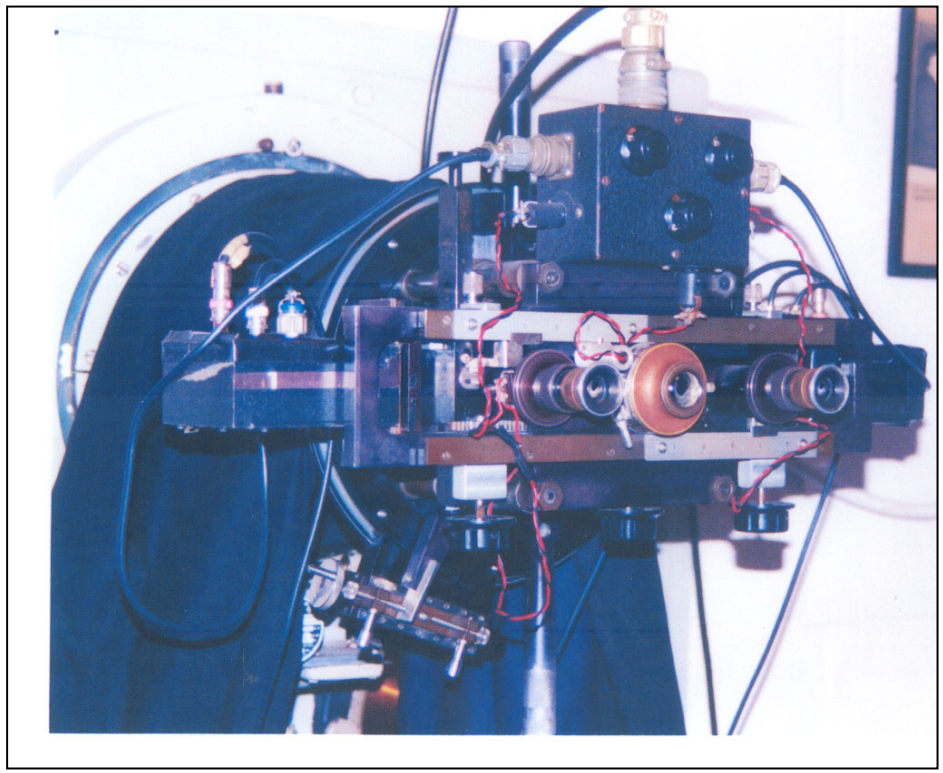

Outside
Inside
0.64m Fecker Siderostat Lat. 40° N
0.38m f/11.7 Brashear Objective
Stationary Telescope Focal Plane
Channel 1 Articulated Fabry Lens + Photomultiplier
Channel 2 Articulated Fabry Lens + Photomultiplier
Pulse Counter 1
Pulse Counter 2
Digital Output

PBPHOT Head Schematic



PBPHOT Timeline





7. 1968: Bill Blitzstein and George Wolf achieve full automation envisioned in the original design with IL/BL calibration

PBPHOT first operation in 2-channel mode

- Between 1955 and 1965 the P-B Photometer was used regularly for photometry, but only in single- channel mode.
- The systematic errors between the two channels had never been analyzed in order to calibrate and use the full two-channel capabilities of the instrument.
- In order to remedy this situation, in 1965 George Wolf began a two year Master's Thesis study of PBPHOT to characterize, calibrate and (wherever possible) eliminate all impediments to two-channel photometry.

Between 1965 & 1967, Wolf Added:

1. An incandescent light source with

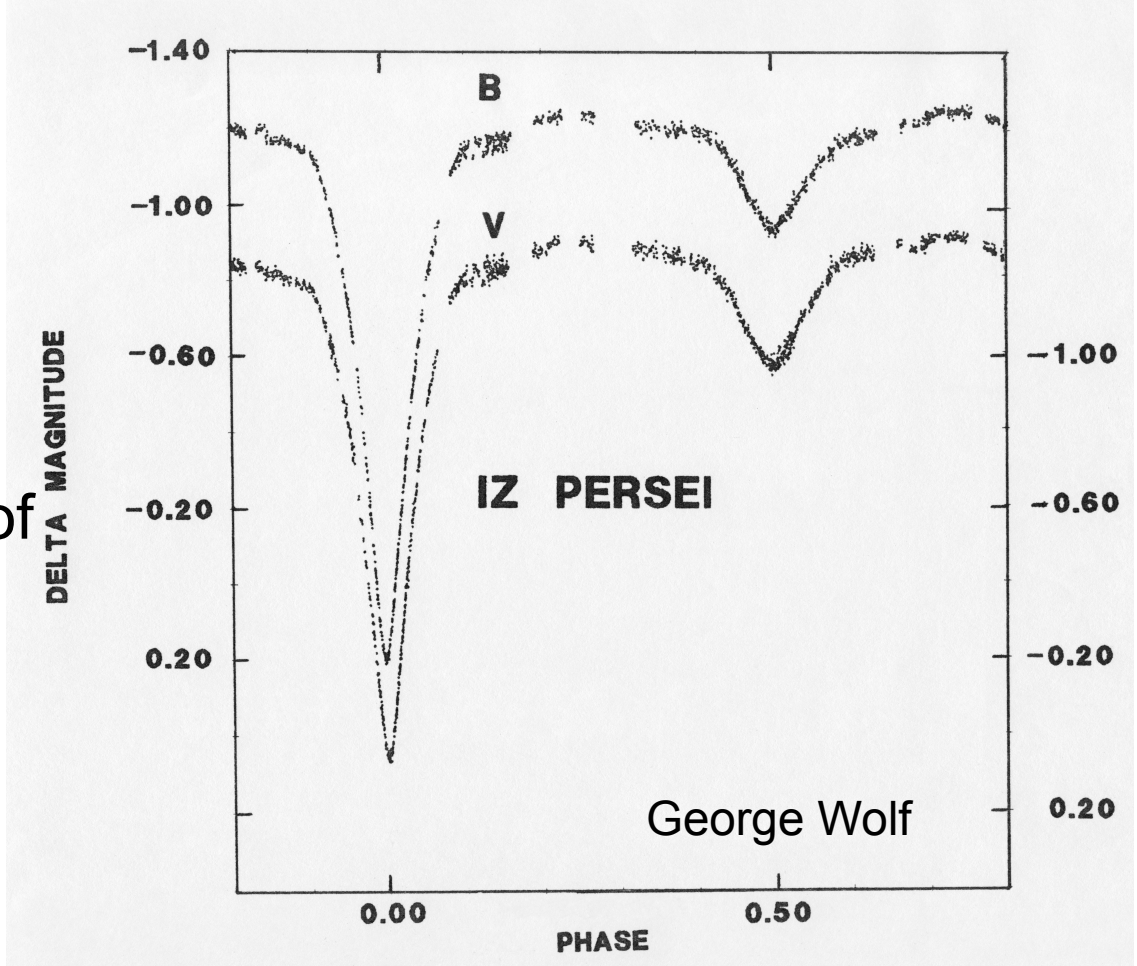
- color-temperature correction filters (which could roughly mimic black bodies from 2800K to 45,000K)
  - Opal diffuser on its front side
  - Used to illuminate the objective of the 15" siderostat.
- This light source could be put into the optical path of the telescope at the objective and observed by both channels simultaneously, as needed
  - Calibrate out any channel sensitivity differences and variations over time.
  - Similar to flat-fielding with a CCD

2. The two 1P21 multiplier photocells in the photometer heads were replaced with a new pair matched for color, absolute sensitivity, and for stability. In addition, the photocell mounts were stiffened to avoid flexure as the heads were moved and rotated.
3. The rotation axis of the entire photometer was carefully aligned with the optic axis of the telescope. This eliminated channel-ratio changes as the heads were rotated to keep up with the field-of-view rotation of the siderostat during the night.

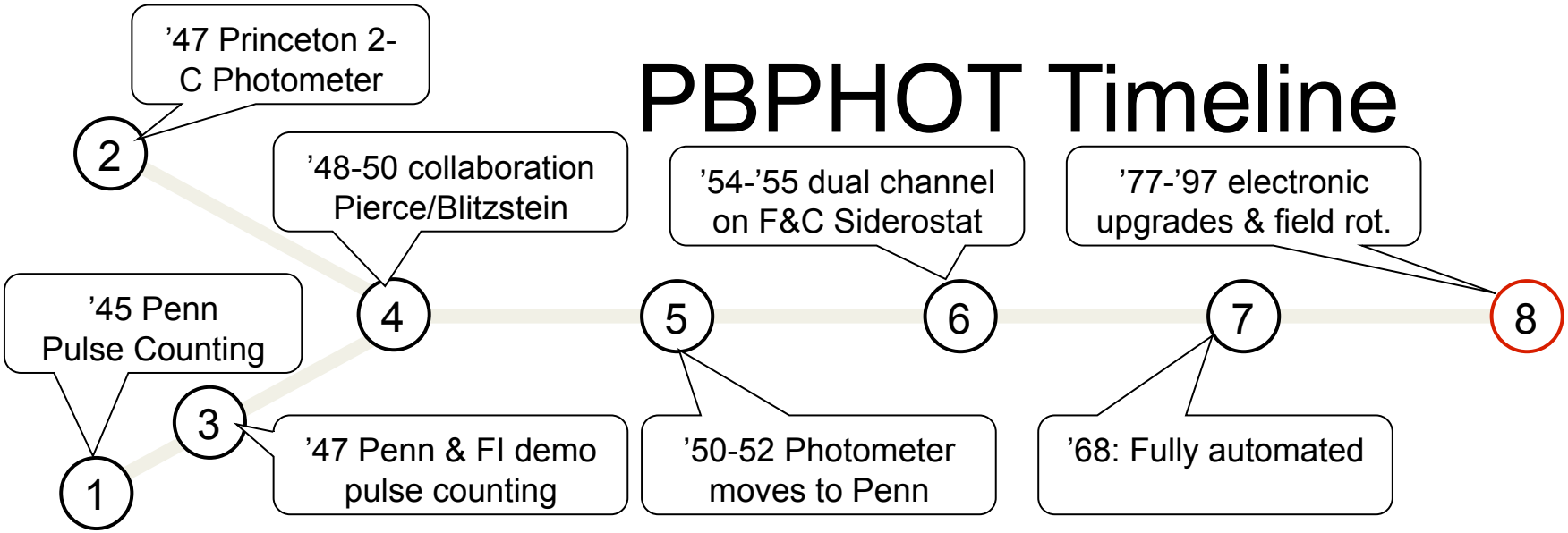
4. Filter slides with detents and matched UBV filters were added to each channel for quick and accurate filter changes.
5. The paper tape data recording was replaced with an automated IBM card punch data recording system.

These changes led to increased accuracy compared to single channel photometry, and a 100% increase in the number density of observations during a night.

- The light curve of IZ Persei (period = 3.67 days)was obtained between 1967 and 1970
- This constitutes the first long-term test of the usefulness and stability of PBPHOT in <u>two-channel</u> mode
- It is also the first light curve acquired with the two-channel method.



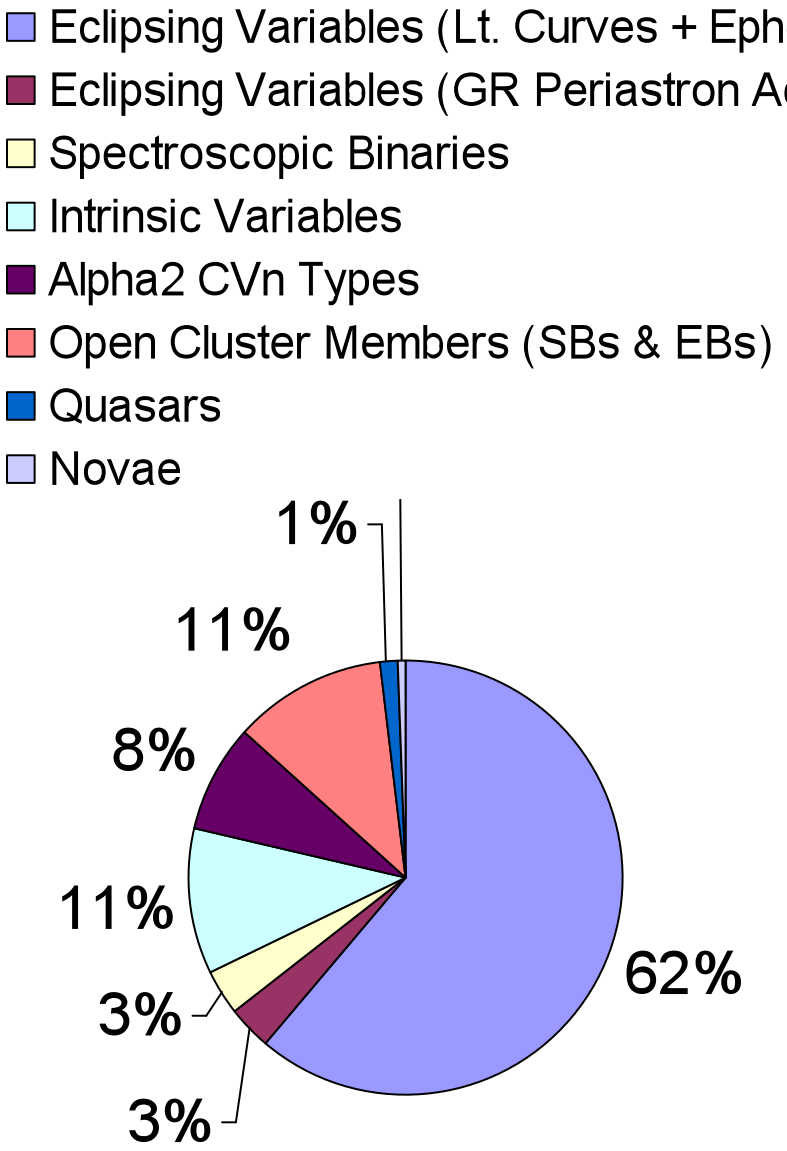
PBPHOT Timeline



8. Enhancements

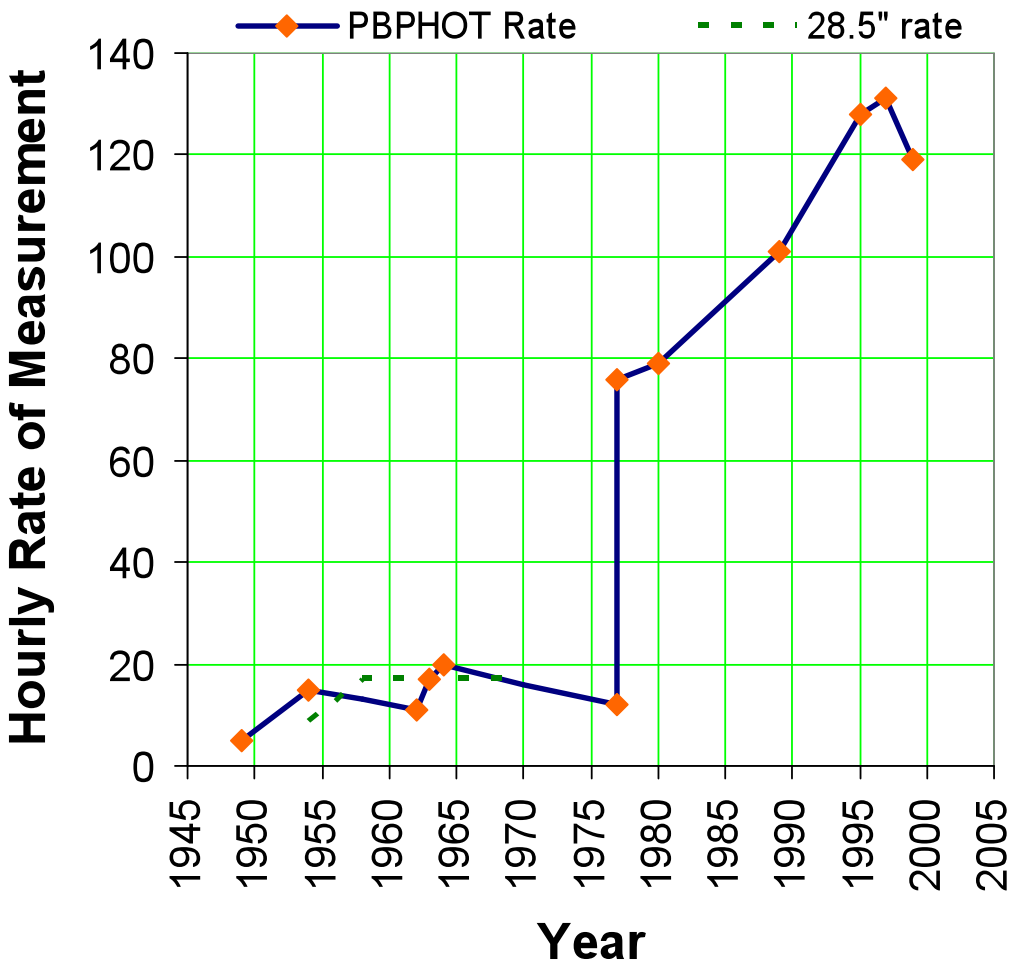
- 1977: Blitzstein upgrades to solid state electronics
- → 1997: Blitzstein, Koch & Mitchell update photomultipliers, computers, software and add compensation for siderostat field rotation

55 year Contribution to Astronomy



- Dual Channel Pulse Counting head was built in 1952
- While emphasis was 91 eclipsing variables, 35% of the effort was on other objects

PBPHOT Photometric Productivity



- Through 1977, clear night productivity was comparable to systemic and efficient observer on a single channel instrument.
- Obs. Efficiency Potential of PBPHOT began to be realized in 1977 with solid state electronics
- Further enhanced with improved computers and electronically driven correction for siderostat field rotation through 1997

Nova Cyg 1975 (V1500 Cyg)

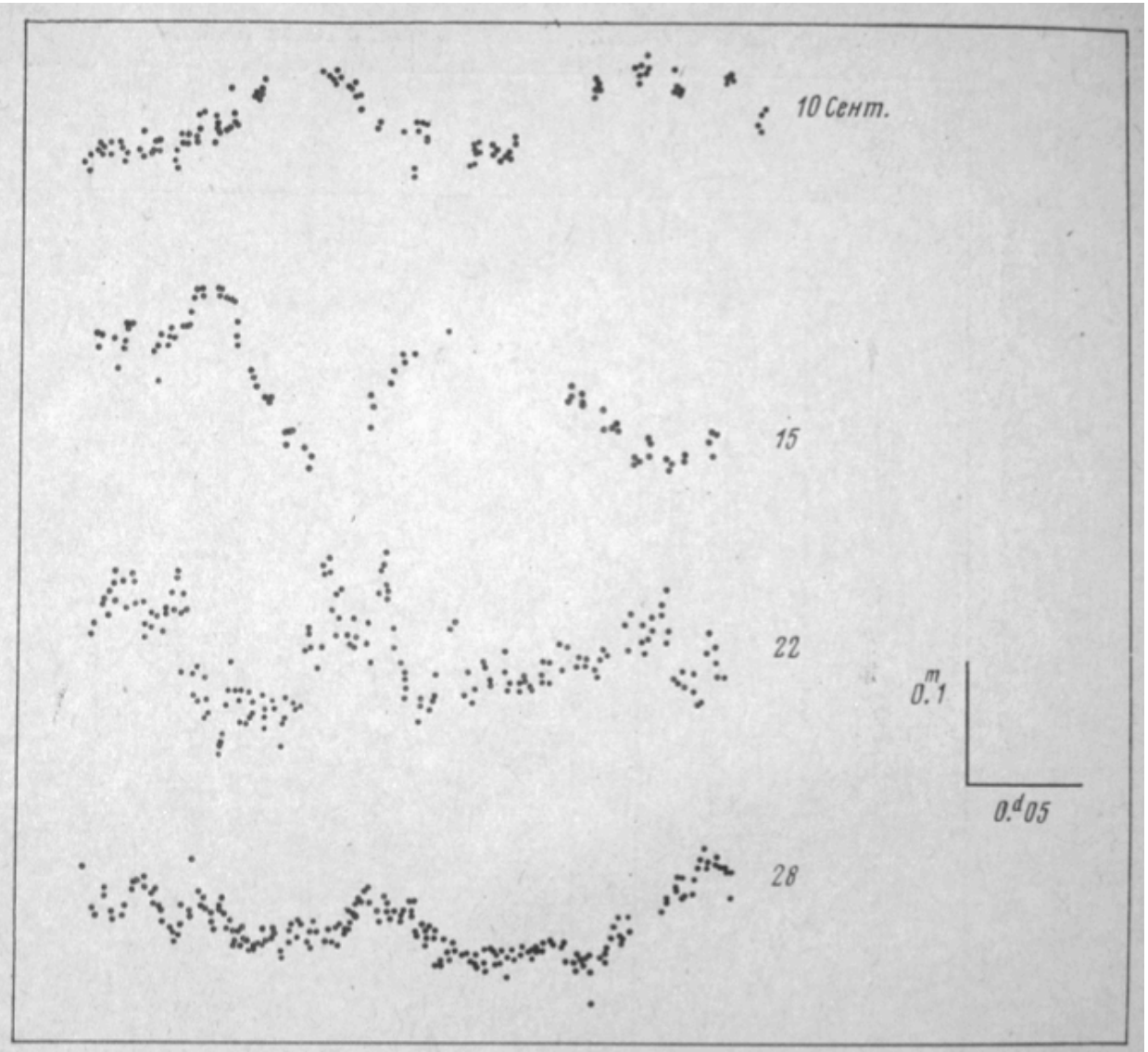
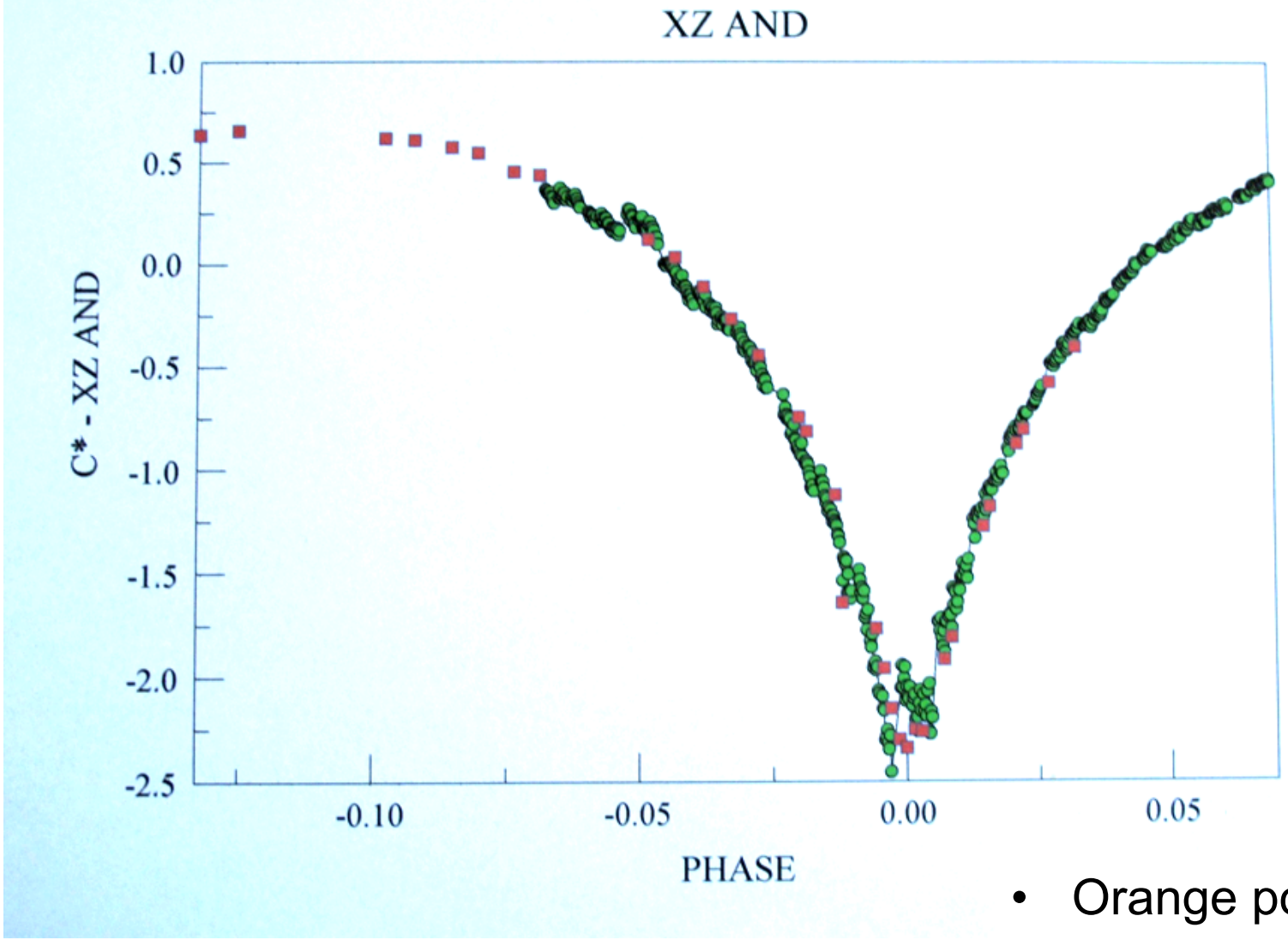


Рис. 1. Кривые блеска V 1500 Лебедя в синих лучах, наблюдавшиеся в Пенсильвании в сентябре 1975 г. Масштаб, общий для всех четырех графиков, показан в правом нижнем углу. Кривые блеска не согласованы ни по времени, ни по фазе

PBPHOT Photometric Productivity

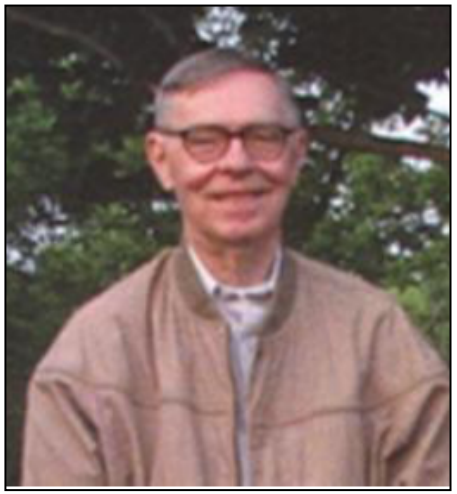


- Orange points 1948-49
- Green data taken 1998

Summary

- PBPHOT was innovative for its time
- Product of collaboration, and ultimately the perseverance of Bill Blitzstein
- Dual channel photometry, as implemented, was ideal for Eastern seaboard observatory near city lights, a difficult photometric environment!
- PBPHOT productively incorporated dual channel pulse counting methods for over 50 years → lights out in 2007!

- A landmark automated photometer!
- Bob was also its champion and his historical information made this presentation possible




We share deep
appreciation to Bob as a
champion of this great
instrument, a champion
for the field we love,
and as a teacher,
mentor and friend!