

TAOS Photometry Pipelines and Event Detection Algorithm

Speaker : Zhang, Zhi-Wei

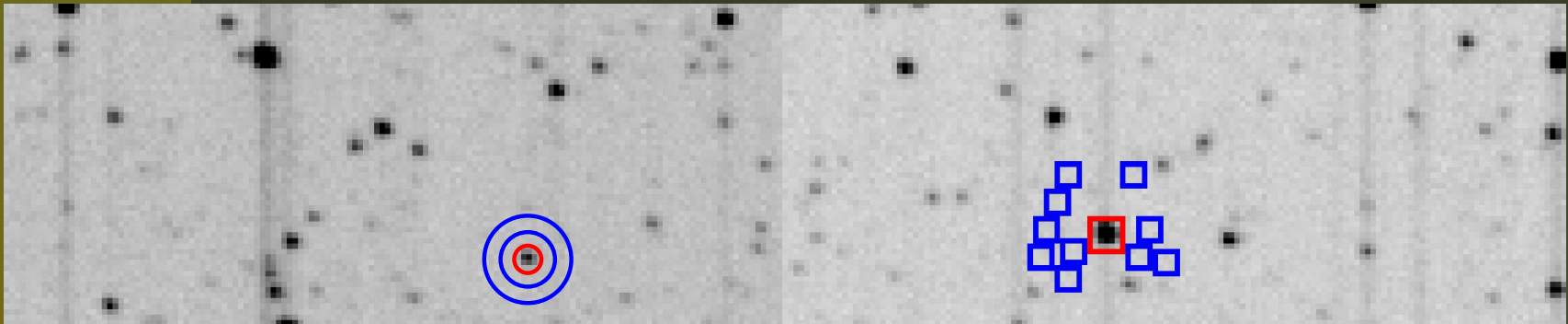
Andrew Wang, Wen-Ping Chen, and Typhoon Lee

IANCU & ASIAA

2005-06-03 CAST Meeting

PHOTOMETRY PIPELINES

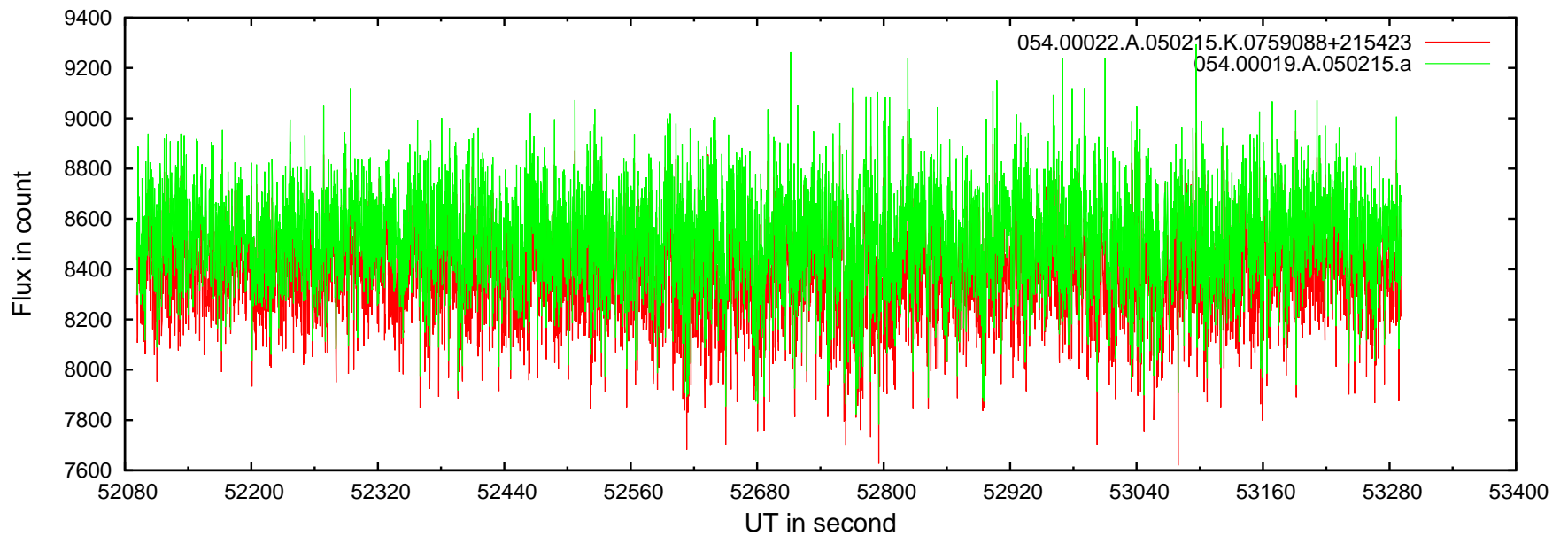
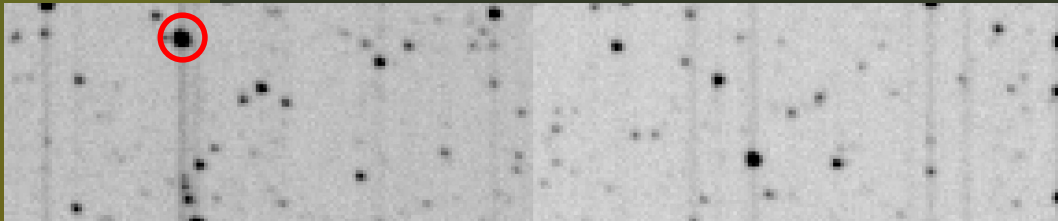
The two pipelines are on the basis of IRAF.APPHOT and Adaptive Aperture Phot respectively.



| IRAF.Apphot | AAP |
|--------------------|------------------------|
| round aperture | square aperture |
| annular sky region | individual sky patches |
| constant ap size | optimal ap size |
| time consuming | efficient |

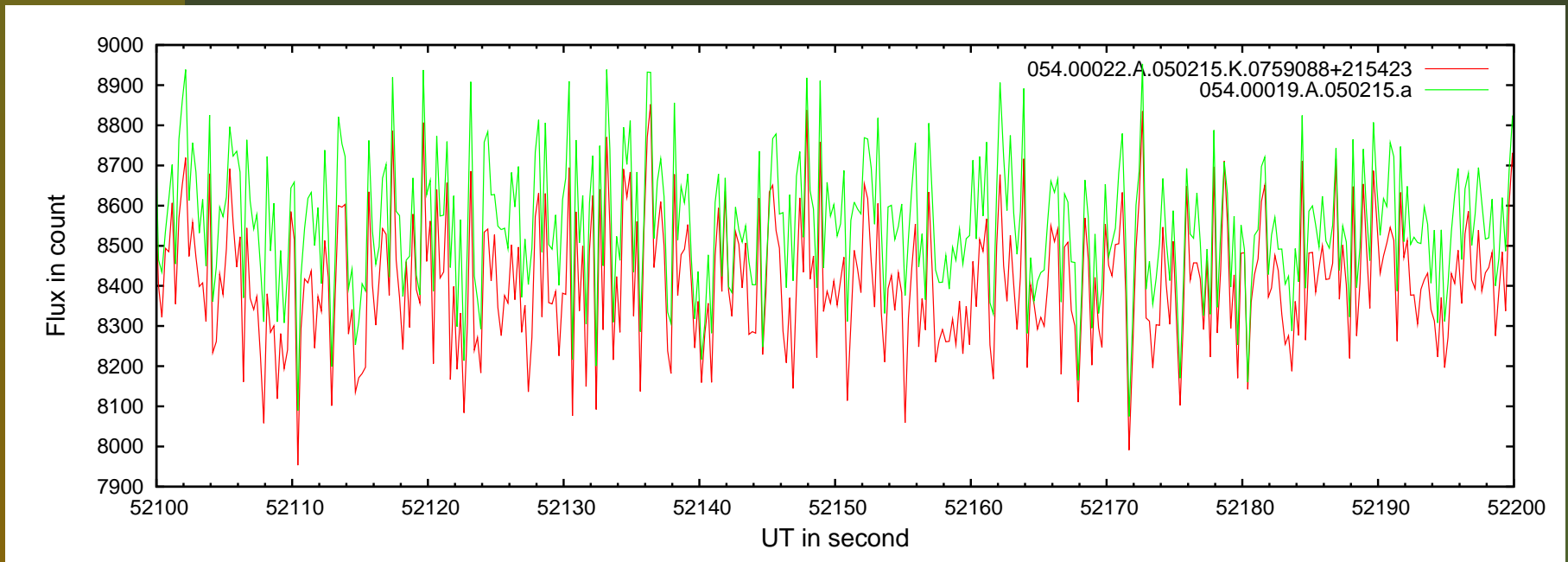
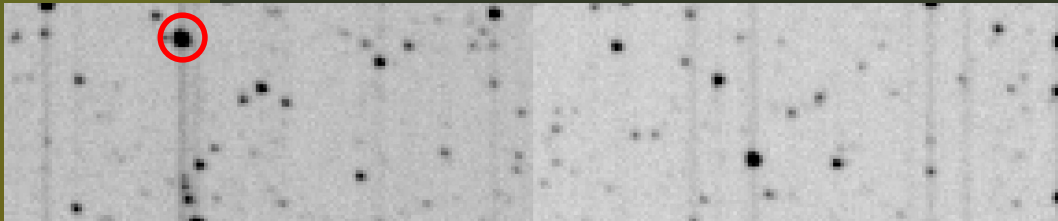
PHOTOMETRY PIPELINES

Consistency



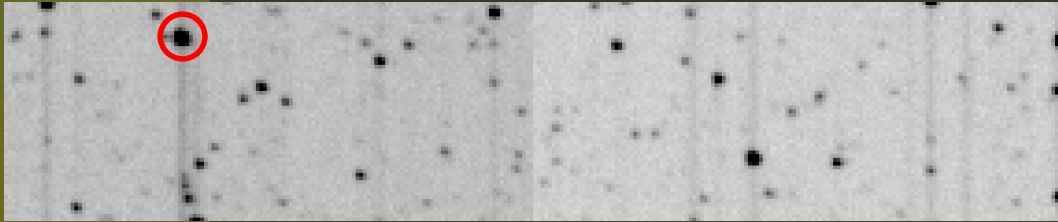
PHOTOMETRY PIPELINES

Consistency

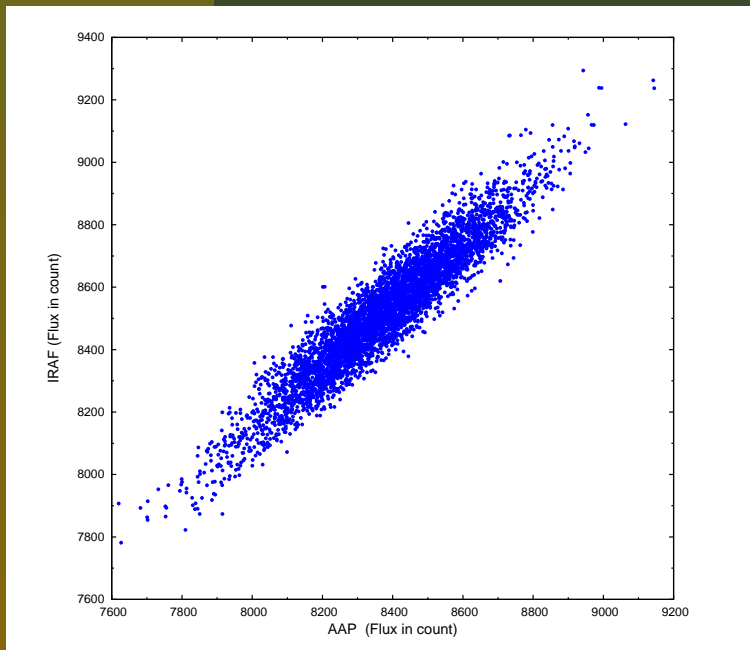


PHOTOMETRY PIPELINES

Consistency

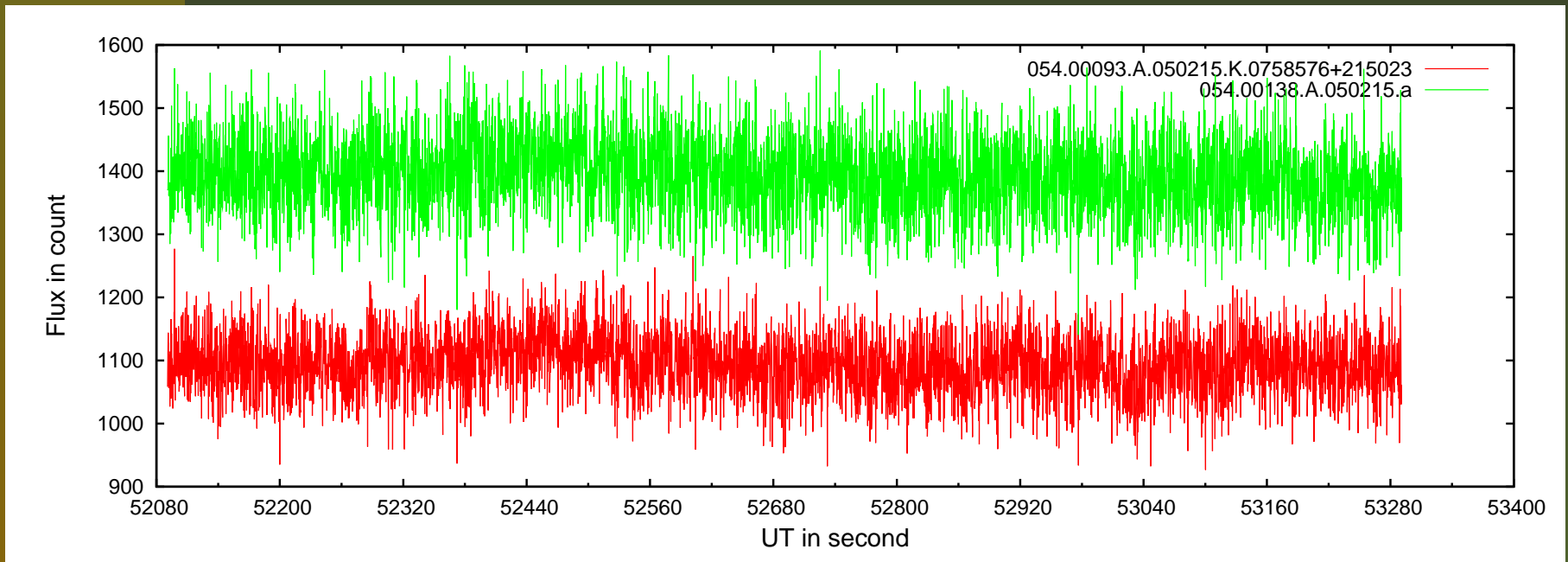
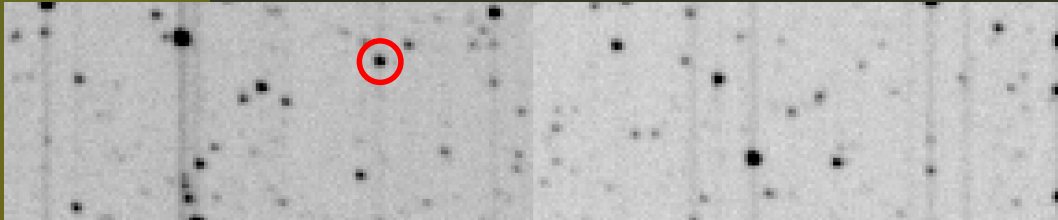


$$\rho = 0.945$$



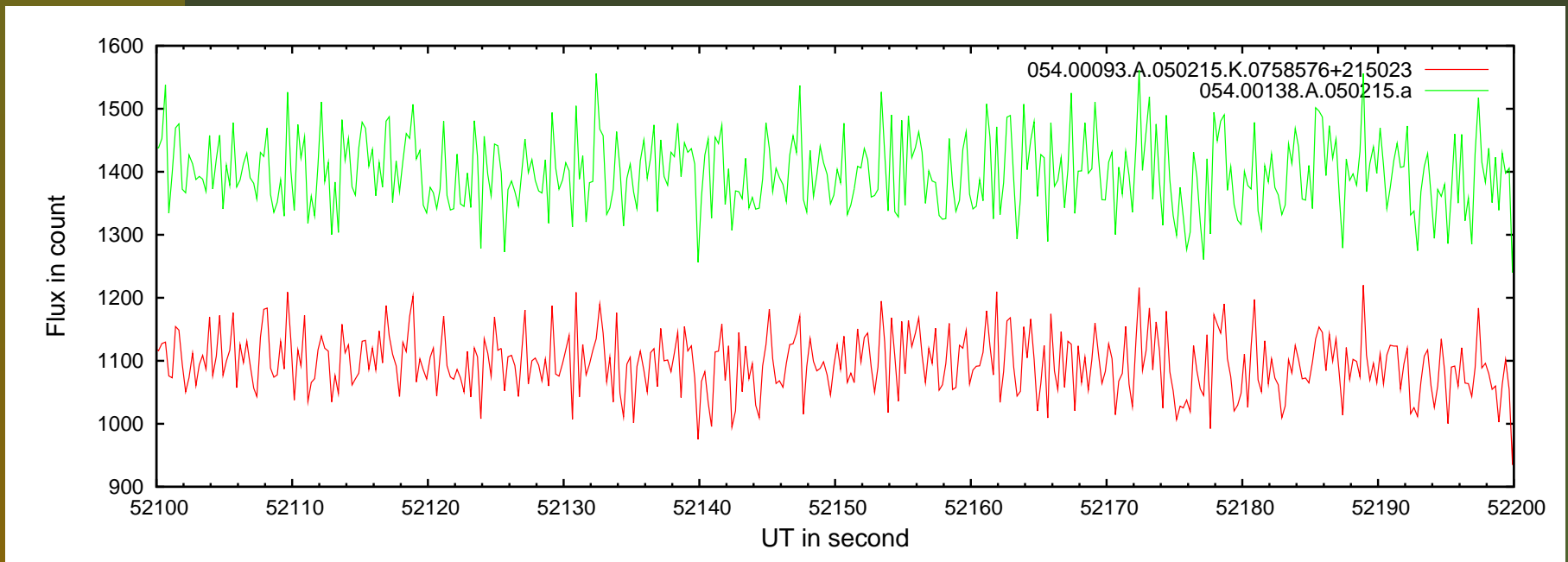
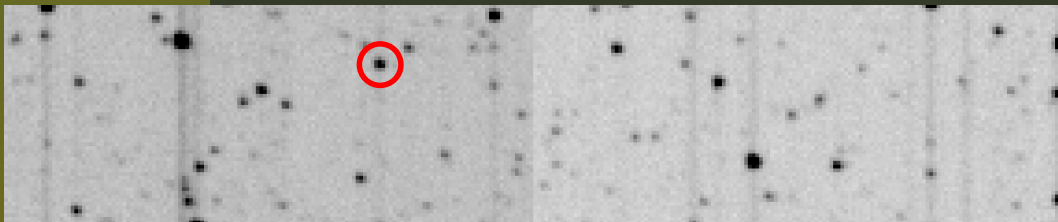
PHOTOMETRY PIPELINES

Consistency



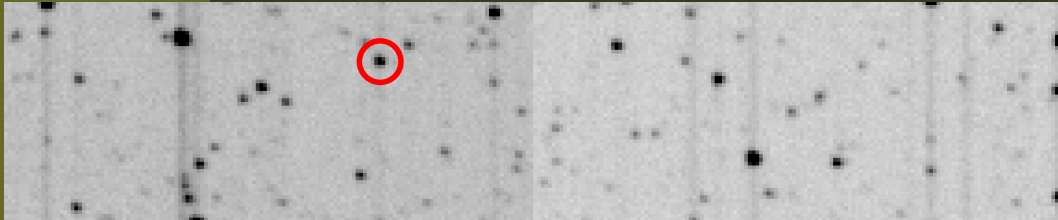
PHOTOMETRY PIPELINES

Consistency

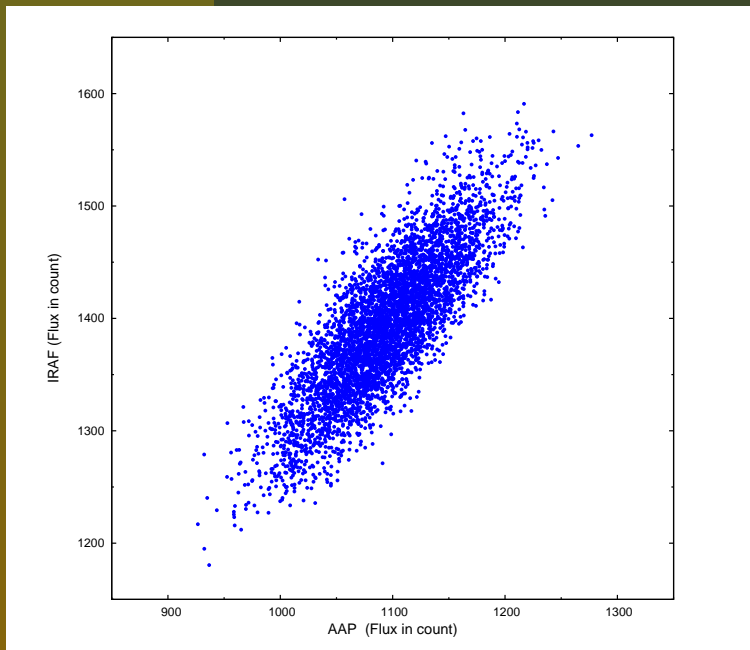


PHOTOMETRY PIPELINES

Consistency



$$\rho = 0.825$$



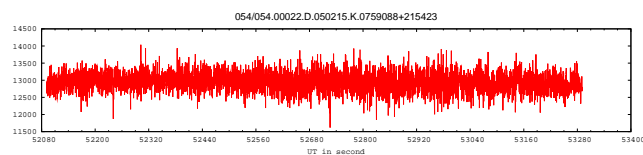
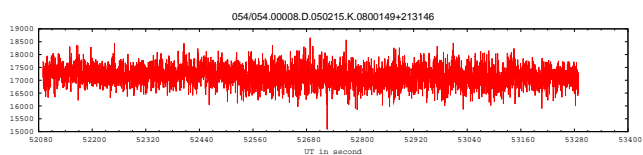
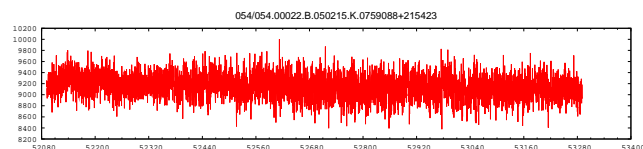
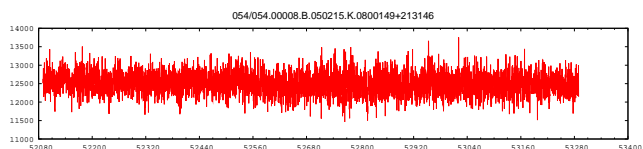
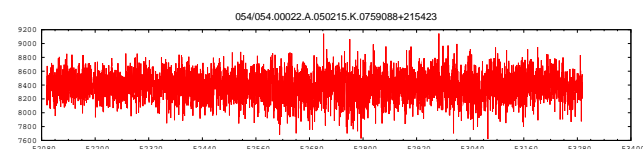
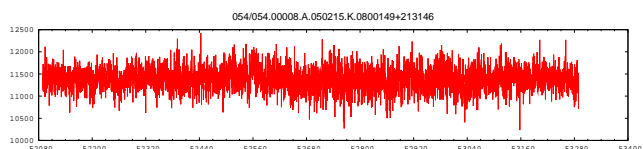
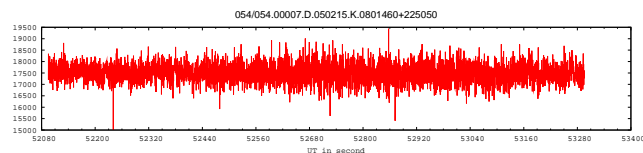
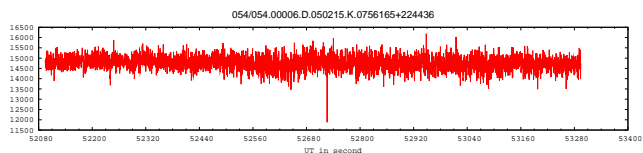
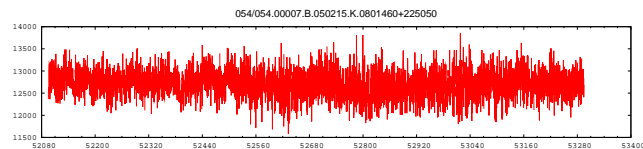
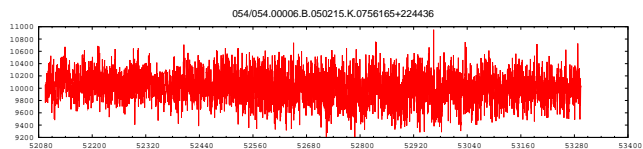
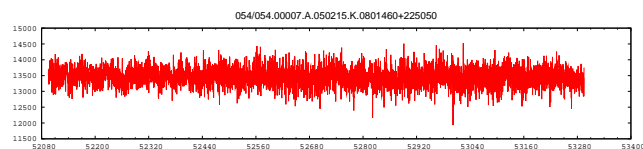
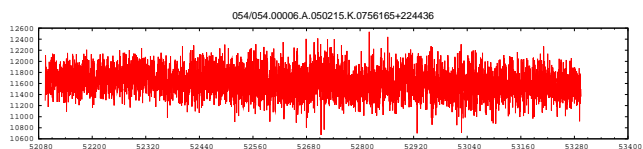
OBSERVATION

Operation routine observation of three telescopes (A, B, & D) from Jan 1st, 2005

| | Jan | Feb | Mar | Apr |
|--------|--------|-------------------------------------|---------------|---------------|
| 050116 | 16,000 | 050216 67,200 | 050316 14,400 | 050420 7,200 |
| | | 050215 57,600 | | 050419 19,200 |
| | | 050207 22,752 | | 050411 38,400 |
| | | | | 050410 33,600 |
| | | | | 050407 33,600 |
| | | | | 050404 28,800 |
| TOTAL | | $\sim 3.4 \times 10^5$ measurements | | |

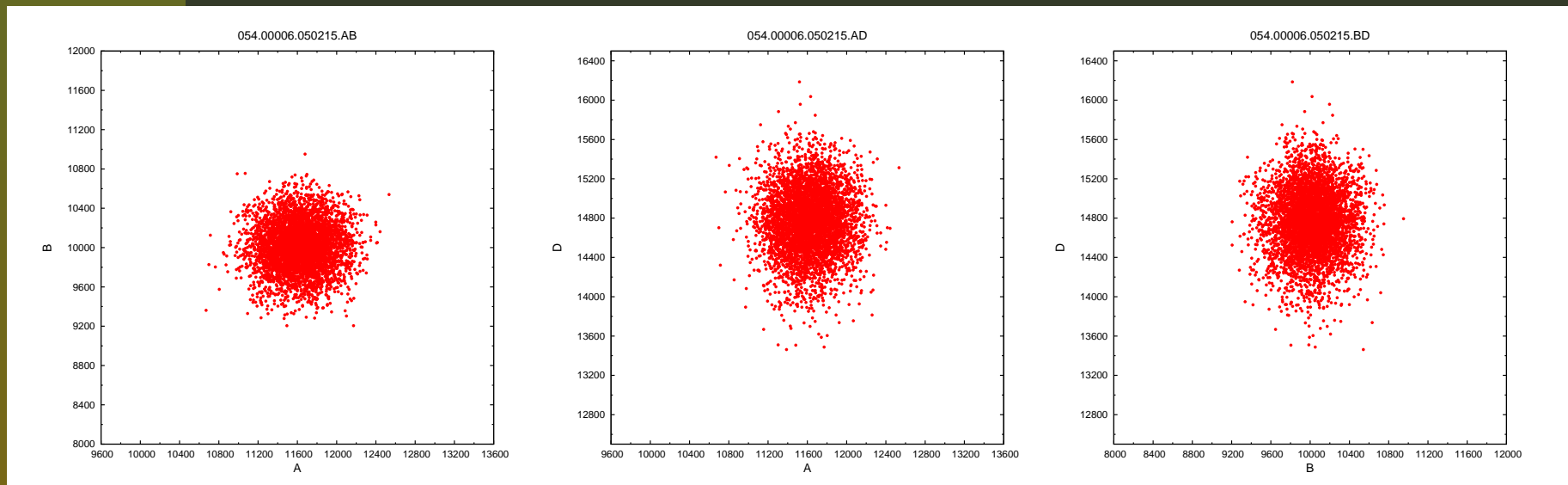
LIGHT CURVES

Under good sky condition



LIGHT CURVES

Under good sky condition



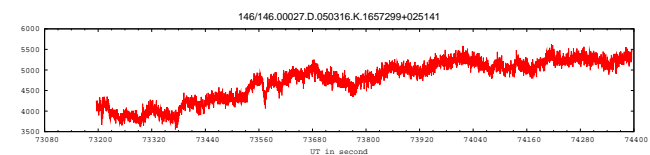
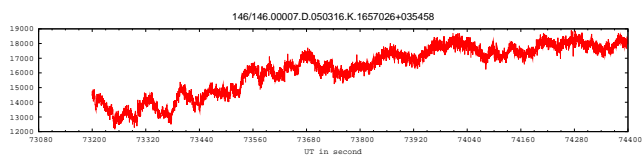
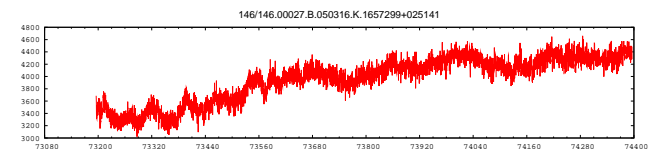
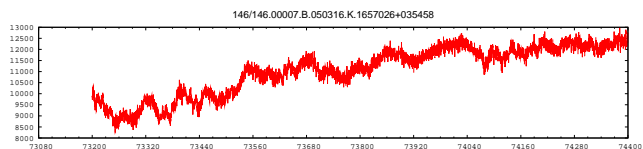
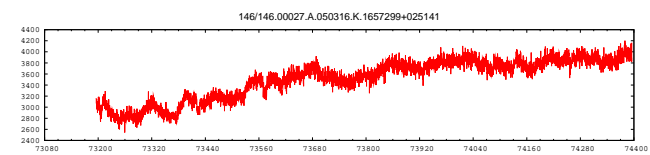
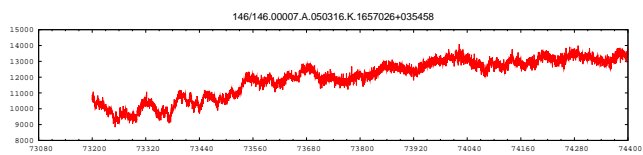
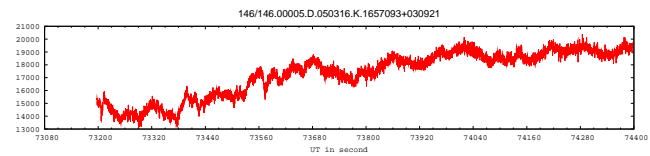
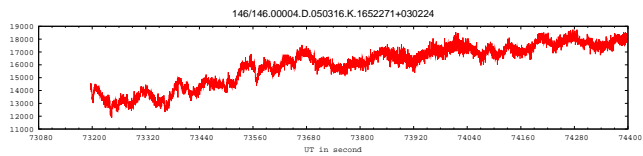
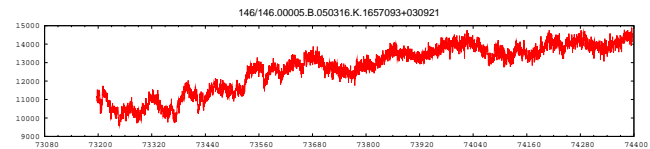
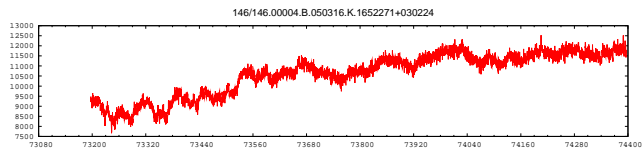
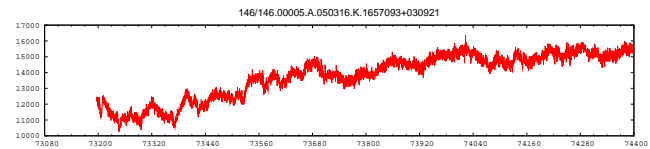
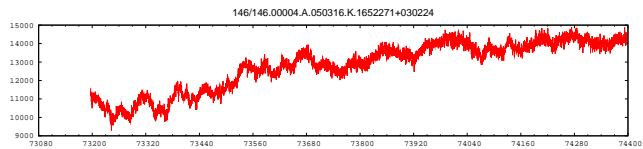
$\rho = 0.040$

$\rho = 0.020$

$\rho = 0.017$

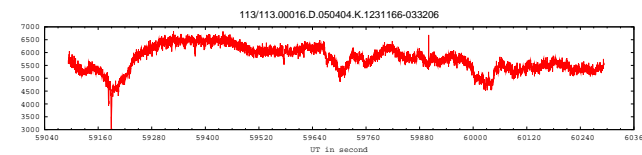
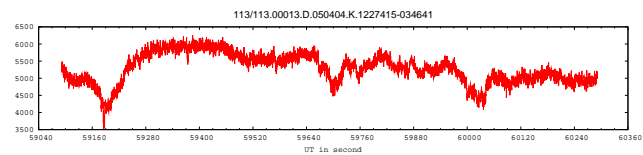
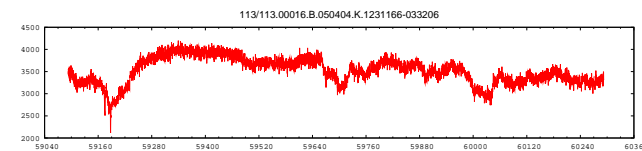
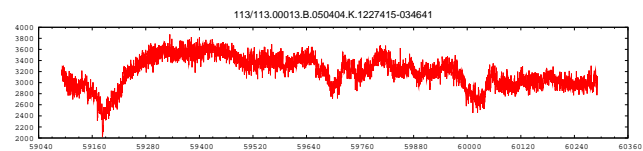
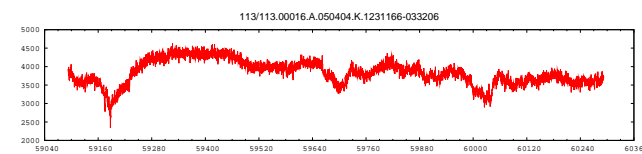
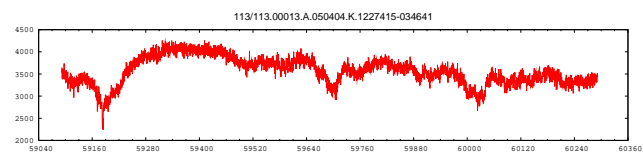
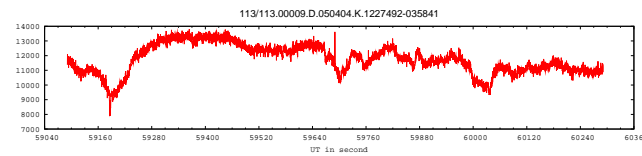
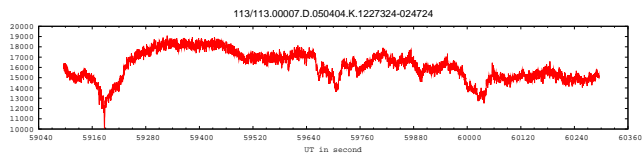
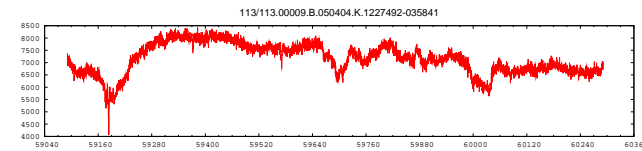
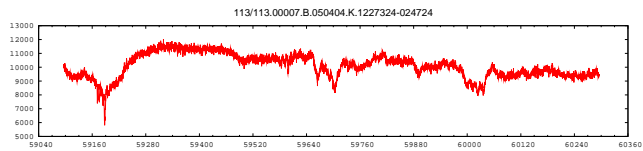
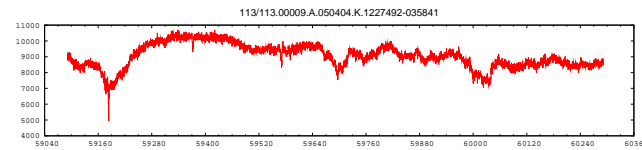
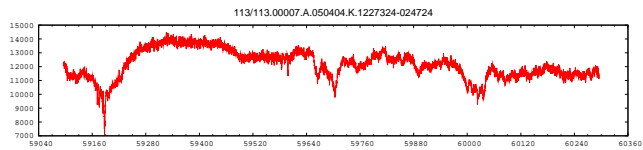
LIGHT CURVES

Under unstable sky condition



LIGHT CURVES

Under unstable sky condition



EVENT DETECTION ALGORITHM

Ranking statistics

$$\begin{aligned} R_i &= \log \left(\prod_k^3 \frac{N}{r_i^k} \right), \quad i = 1, \dots, N \\ &= \sum_k^3 \log \frac{N}{r_i^k} = -\log \frac{r_i^1}{N} - \log \frac{r_i^2}{N} - \log \frac{r_i^3}{N} \end{aligned}$$

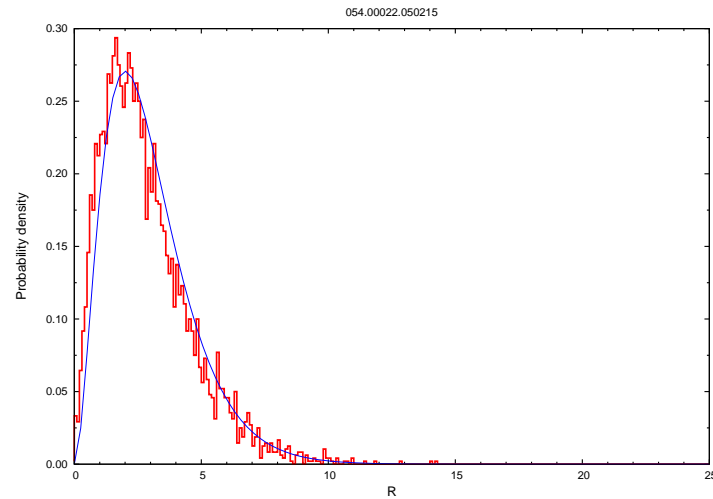
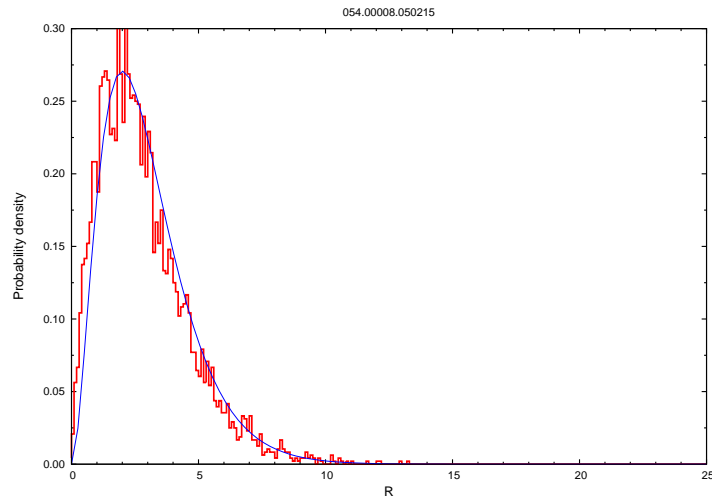
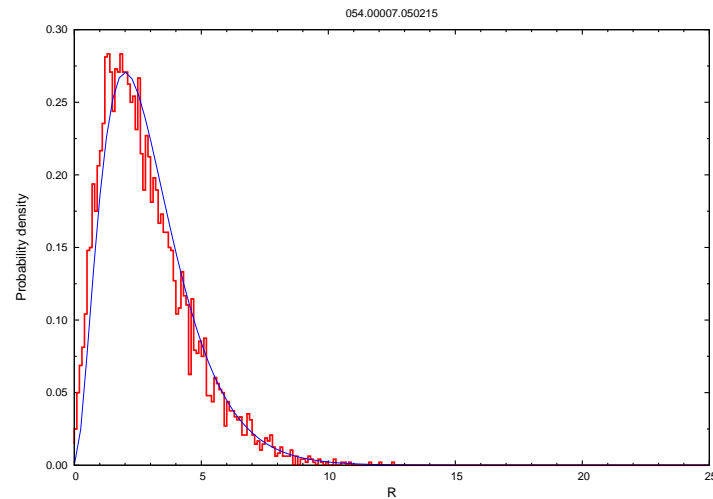
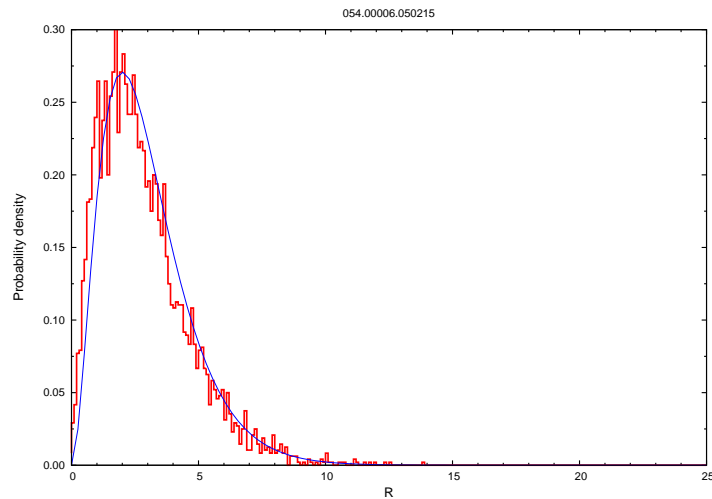
where k is the k th of telescope and i is the i th of measurement.

$$\left. \begin{array}{l} (f_1^1, \dots, f_N^1) \xrightarrow{\text{sort}} (r_1^1, \dots, r_N^1) \\ (f_1^2, \dots, f_N^2) \xrightarrow{\text{sort}} (r_1^2, \dots, r_N^2) \\ (f_1^3, \dots, f_N^3) \xrightarrow{\text{sort}} (r_1^3, \dots, r_N^3) \end{array} \right\} \implies (R_1, \dots, R_N)$$

r : uniform distribution $\xrightarrow{\text{transform}}$ R : gamma distribution $P(\alpha, R) = \frac{1}{\Gamma(\alpha)} R^{\alpha-1} e^{-R}$

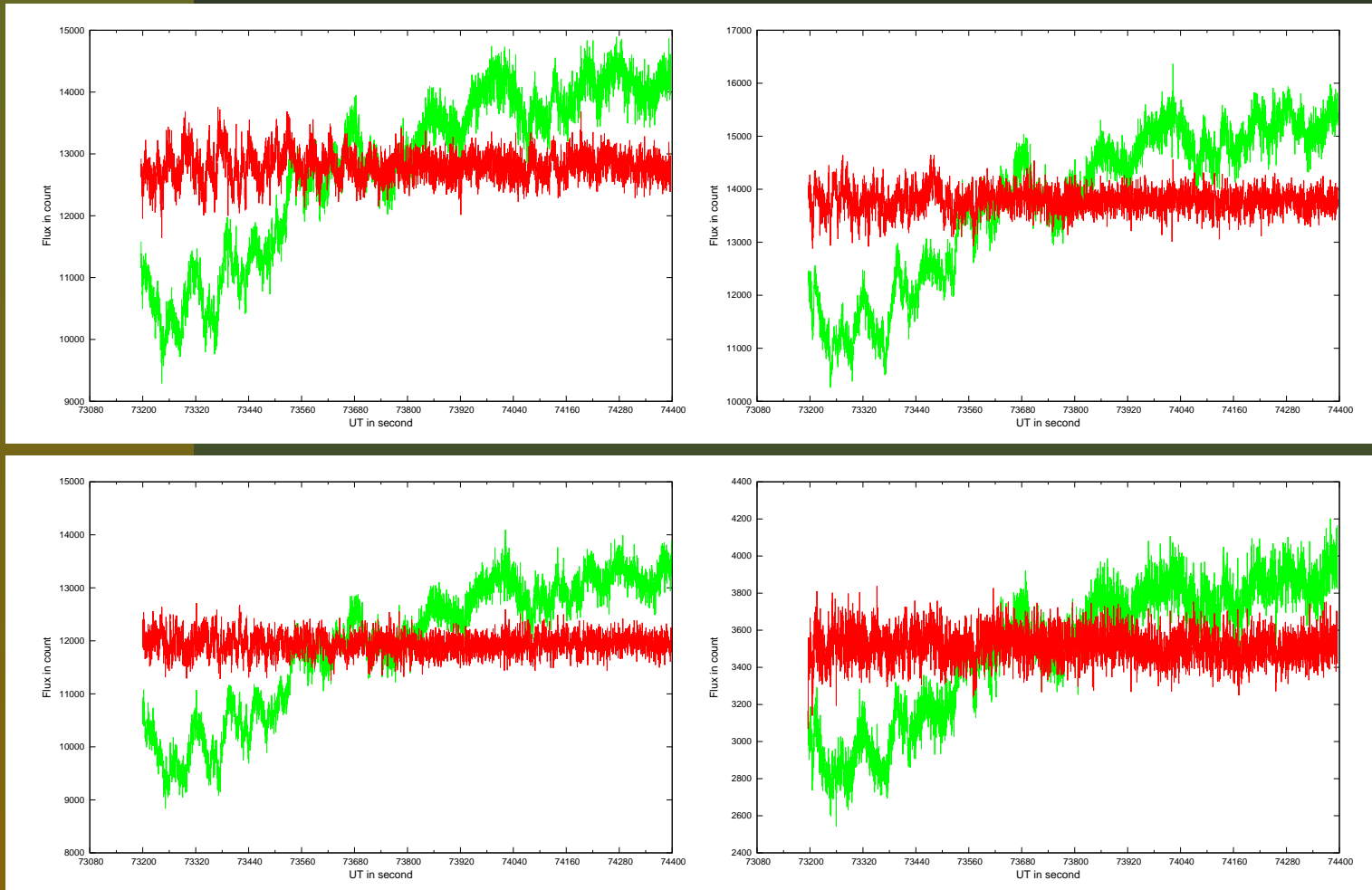
EVENT DETECTION ALGORITHM

Ranking statistics



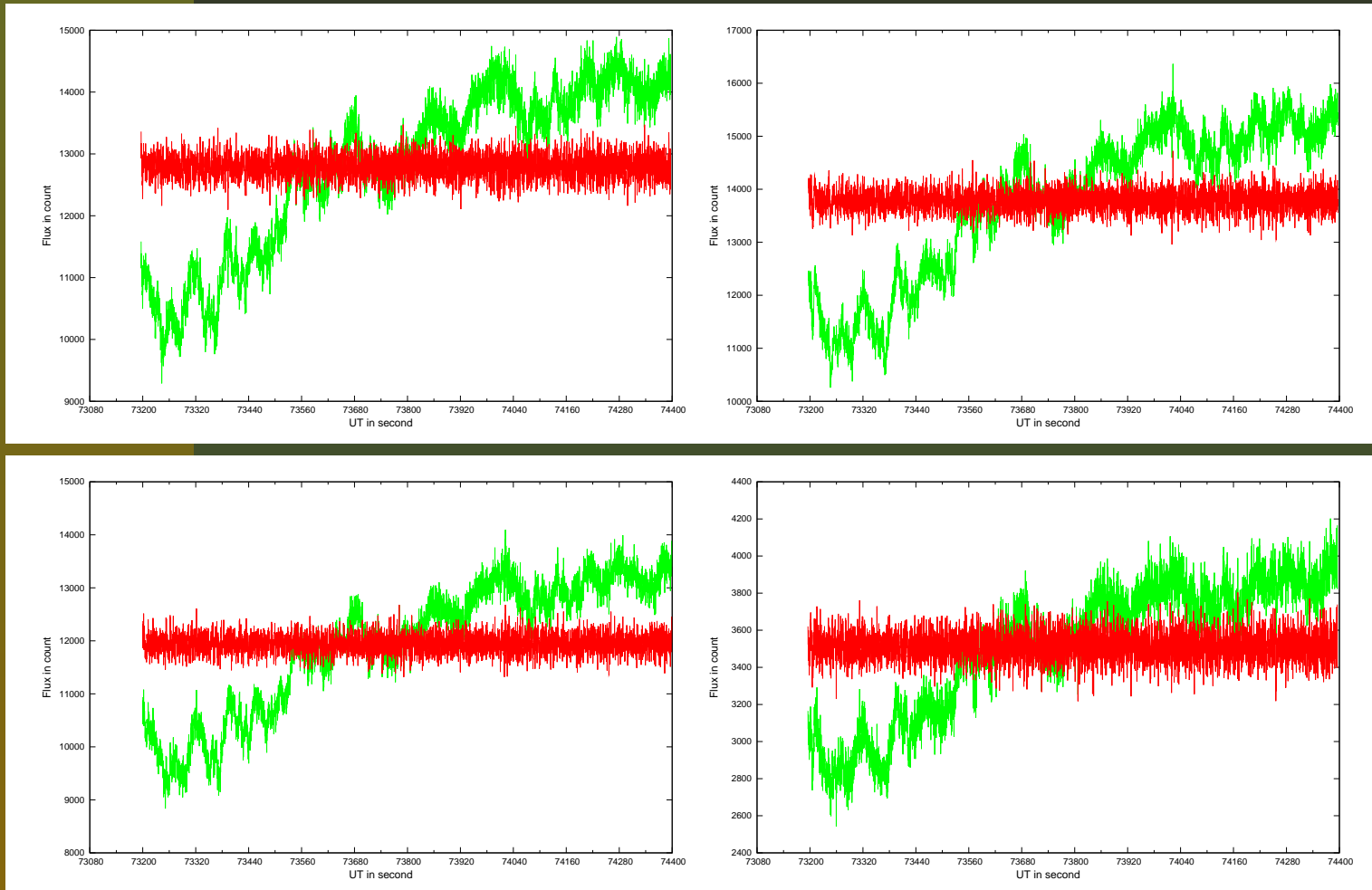
DETREND METHOD

Differential photometry (comparison stars : 13)



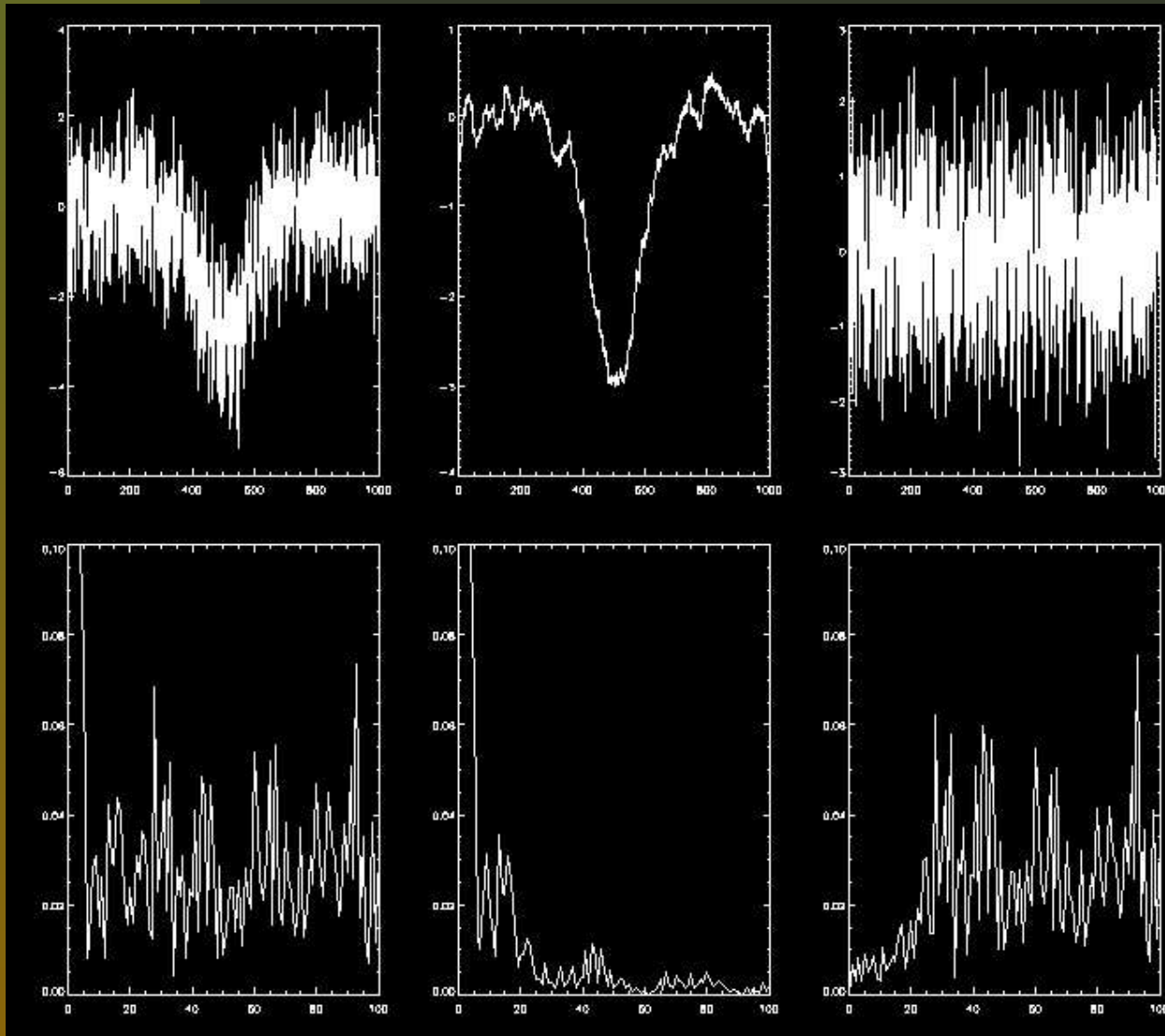
DETREND METHOD

Running smooth (window size : 33 points)



DETREND METHOD

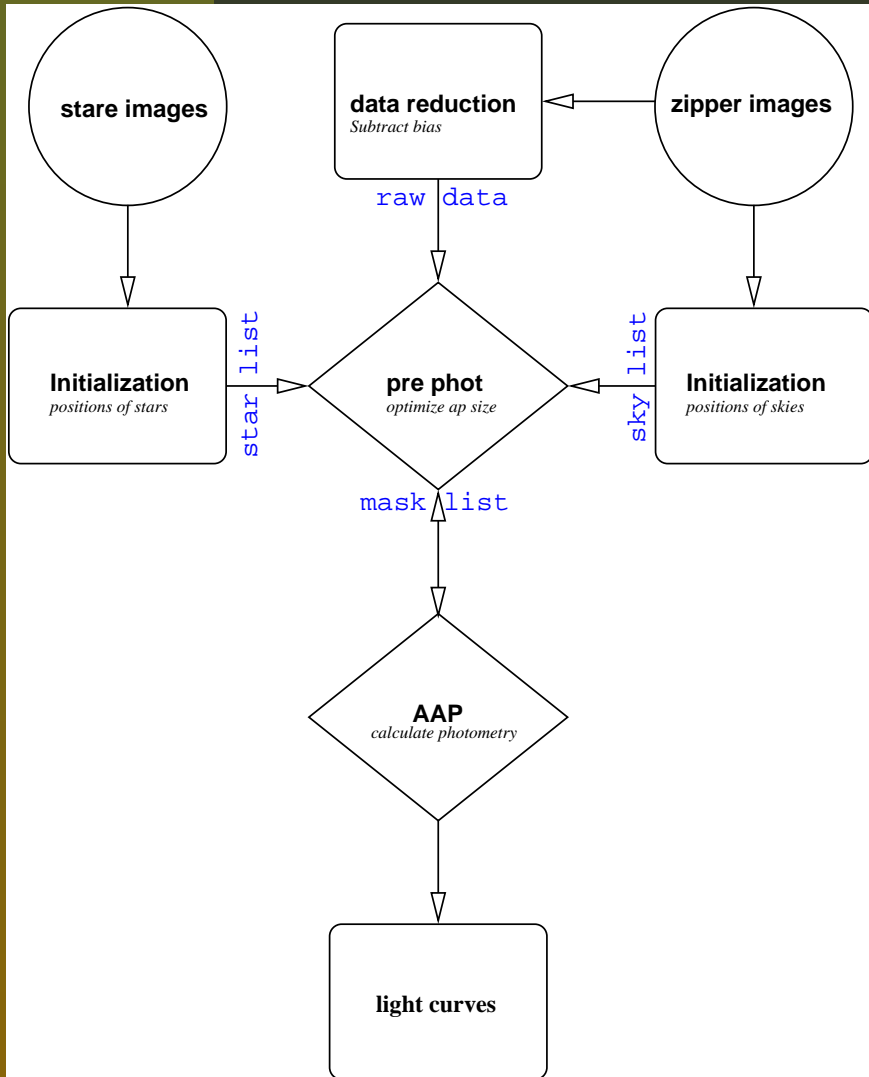
Running smooth (window size : 33 points)



by courtesy of Prof. Chen

SUMMARY

Flowchart of the automated pipeline



The photometry procedure takes ~ 0.1 sec to produce 1,000 light curves per row block (at 2.0 GHz CPU).

e.g. 1 hr zipper @ 5 Hz sampling rate

$\underbrace{20 \text{ min}}_{\text{pre-phot}} + \underbrace{30 \text{ min}}_{\text{AAP}} = 50 \text{ min}$

THE TAOS COLLABORATION

Institute of Astronomy & Astrophysics, Academia Sinica, Taiwan

Institute of Astronomy, National Central University, Taiwan

Department of Physics and Astronomy, University of Pennsylvania, USA

The Institute of Geophysics and Planetary Physics, Lawrence Livermore National Laboratory, USA

Department of Astronomy, Yonsei University, South Korea

Department of Statistics, University of California, Berkeley, USA