

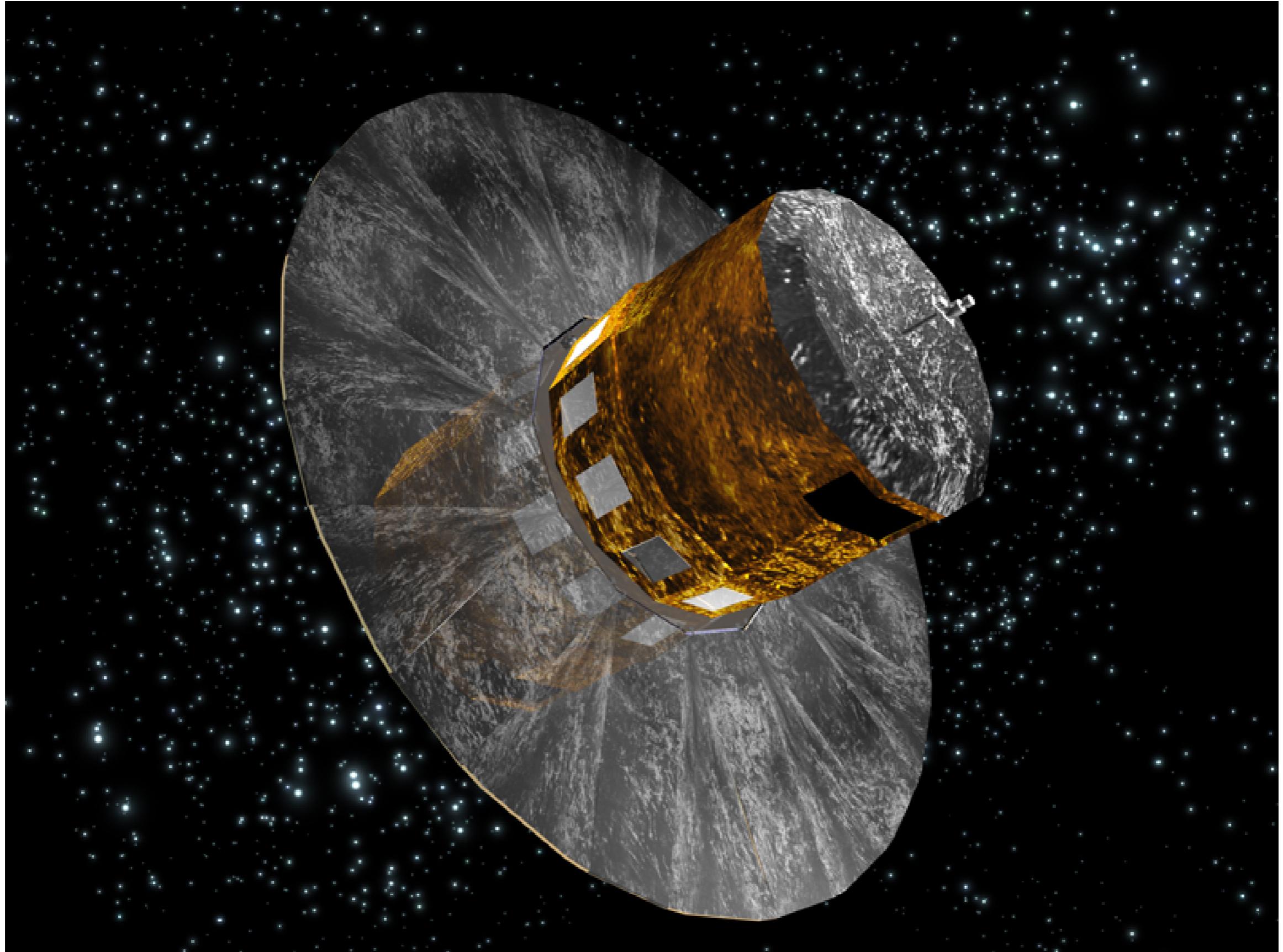
# **Efficient use of simultaneous multi-band observations for variable star analysis**

**Maria Süveges**

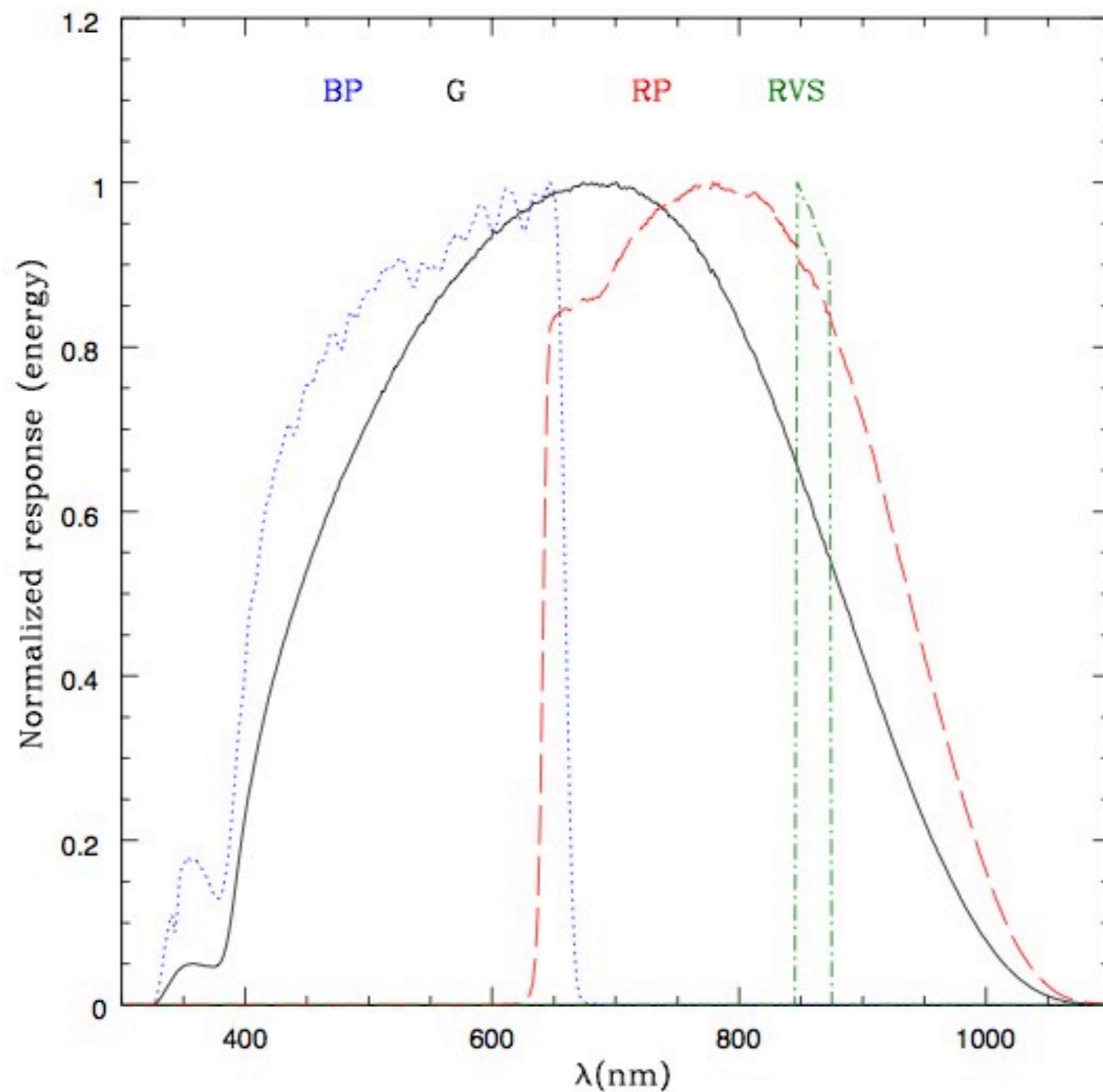
P. Bartholdi, A. Becker, Z. Ivezic, M. Beck, L. Eyer

GREAT Workshop on Astrostatistics and Data Mining  
in Astronomical Databases  
La Palma, May 30 - June 3 2011

# Large surveys

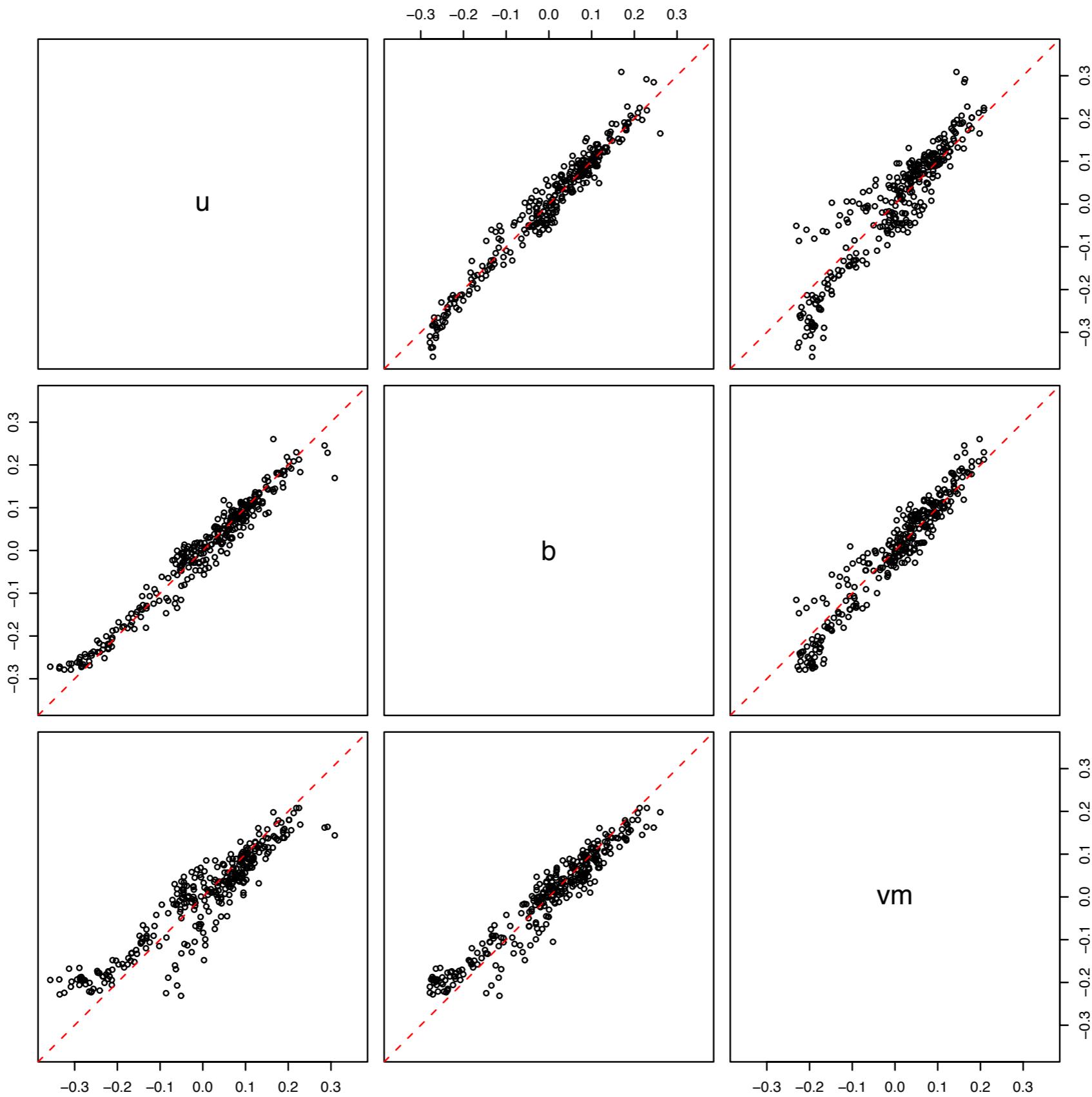


# Multi-band data



# Multi-band data

3 C 273



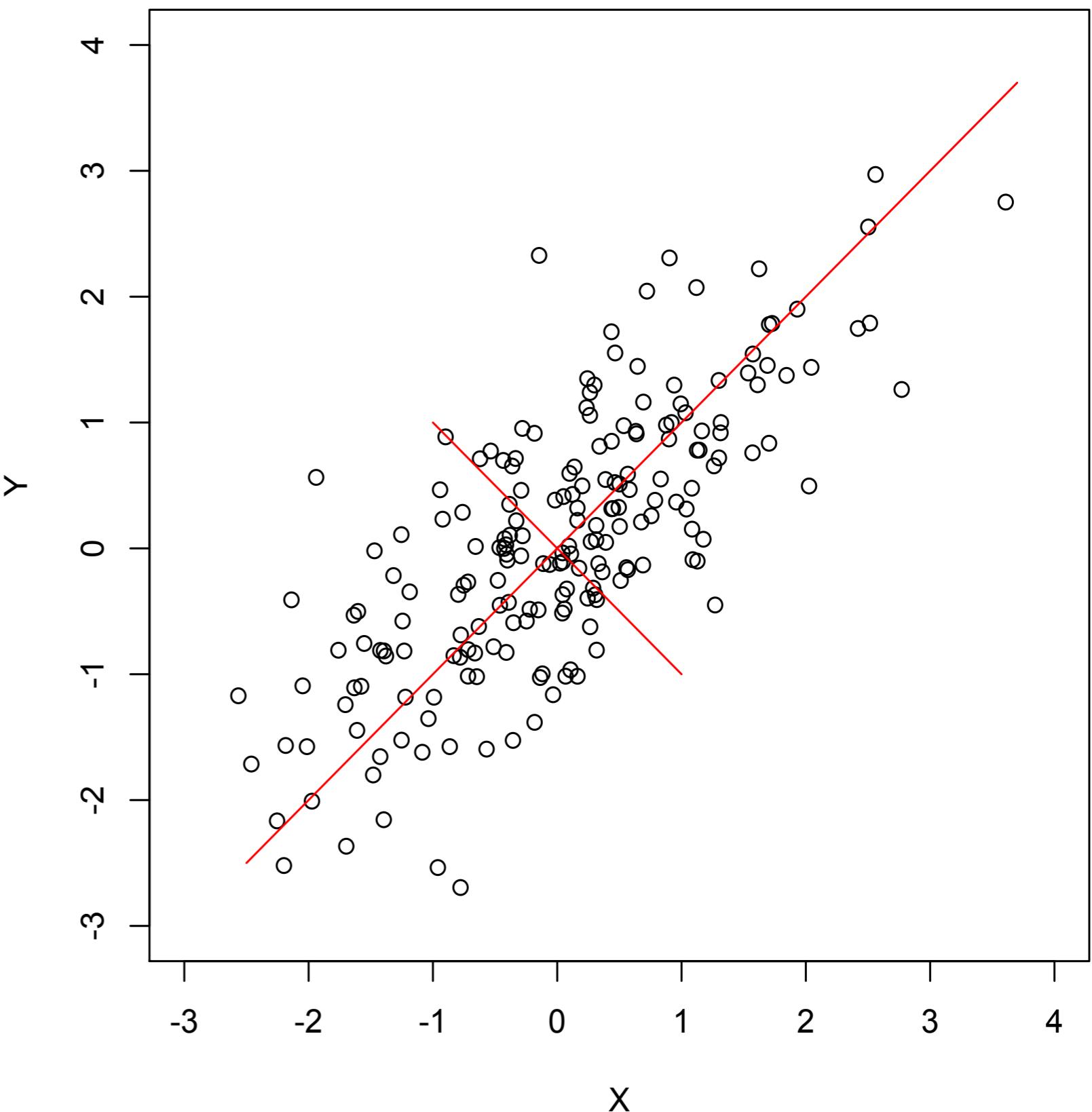
# Principal Component Analysis

## Goal of PCA:

find successive orthogonal directions with maximal variance

## Potential use:

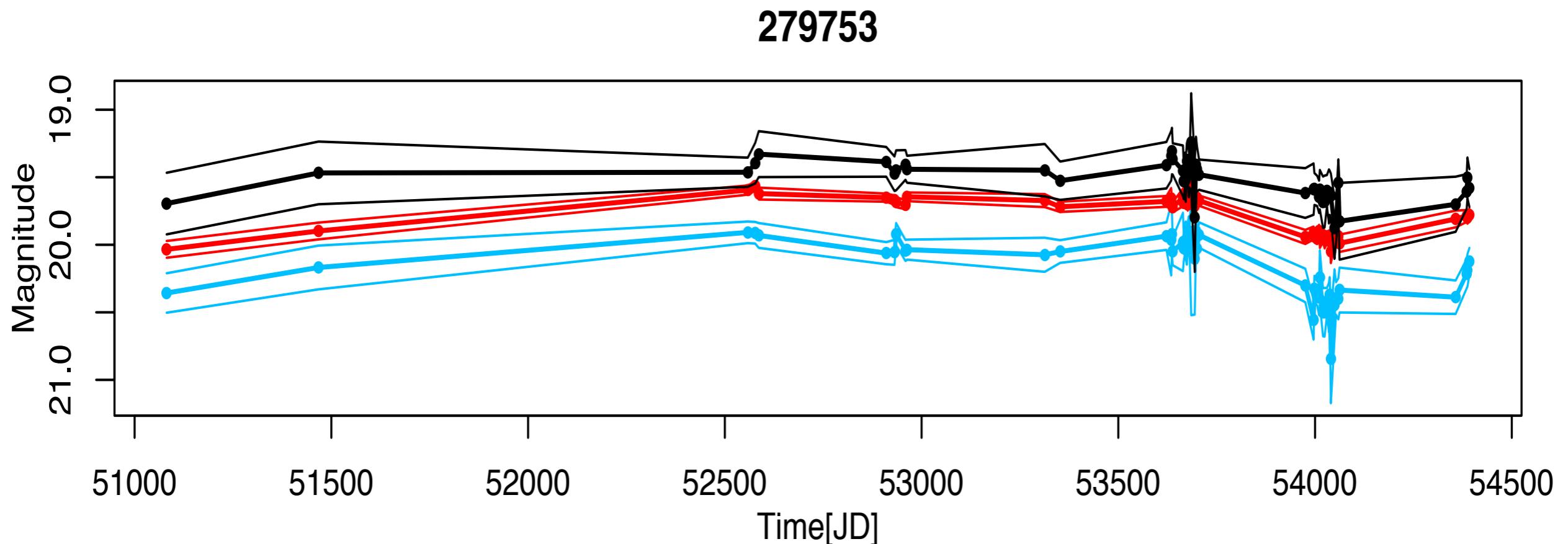
- Variability detection for small amplitudes
- Better signal-to-noise ratio for period search
- Colour information for classification



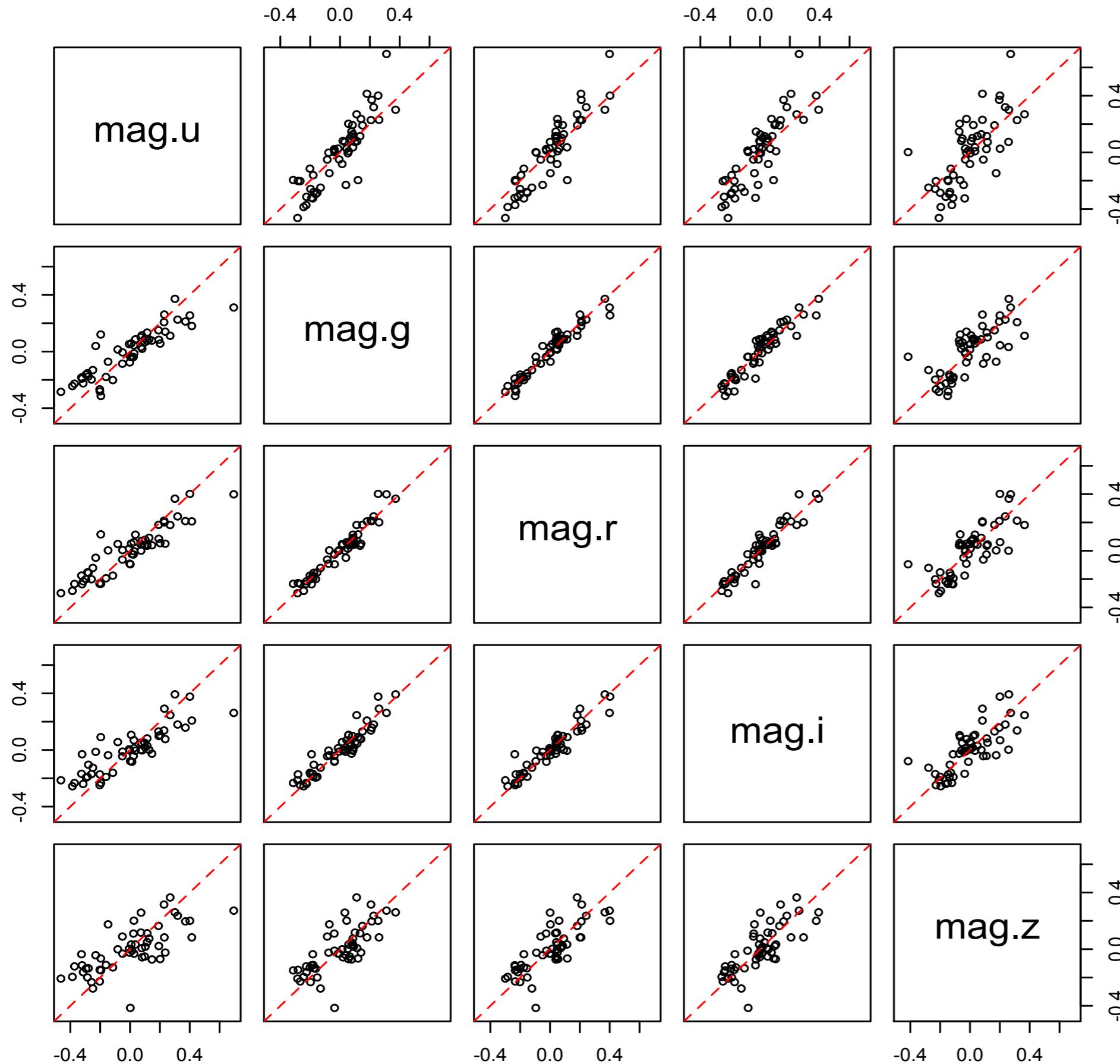
# SDSS Stripe 82



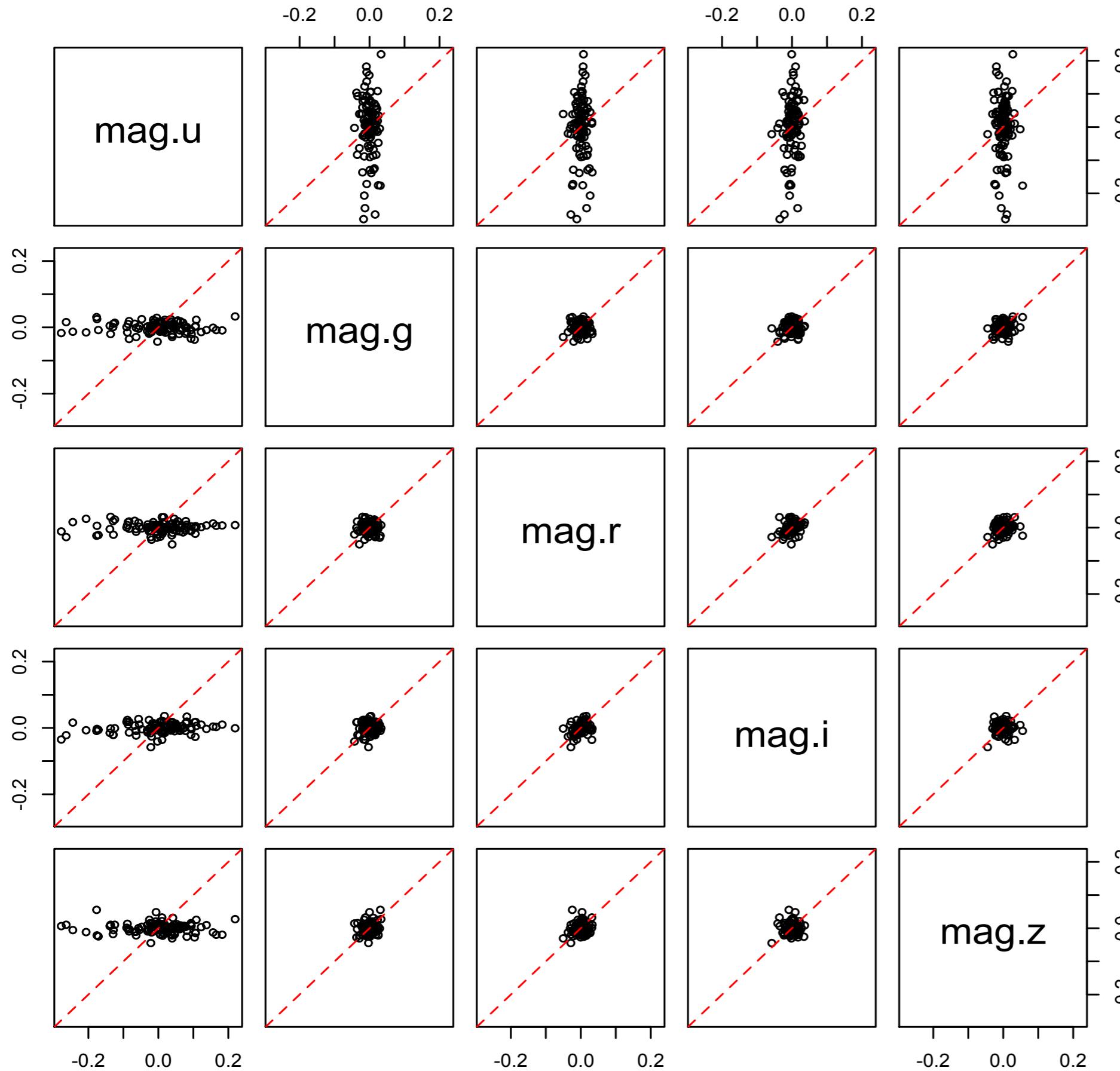
- Sloan Digital Sky Survey: ground-based five-band deep survey of the sky between 1998-2010, down to magnitude 22.5 in r-band
- Repeated imaging of a 300 square degree stripe in the southern Galactic cap: Stripe 82
- Identified RR Lyrae stars (Sesar et al., ApJ., **708**:717-741, 2010) and variable flags available
- Goal: check for more RR Lyraes and select SX Phoenicis type stars



# Variable star in Stripe 82



# Variable star in Stripe 82

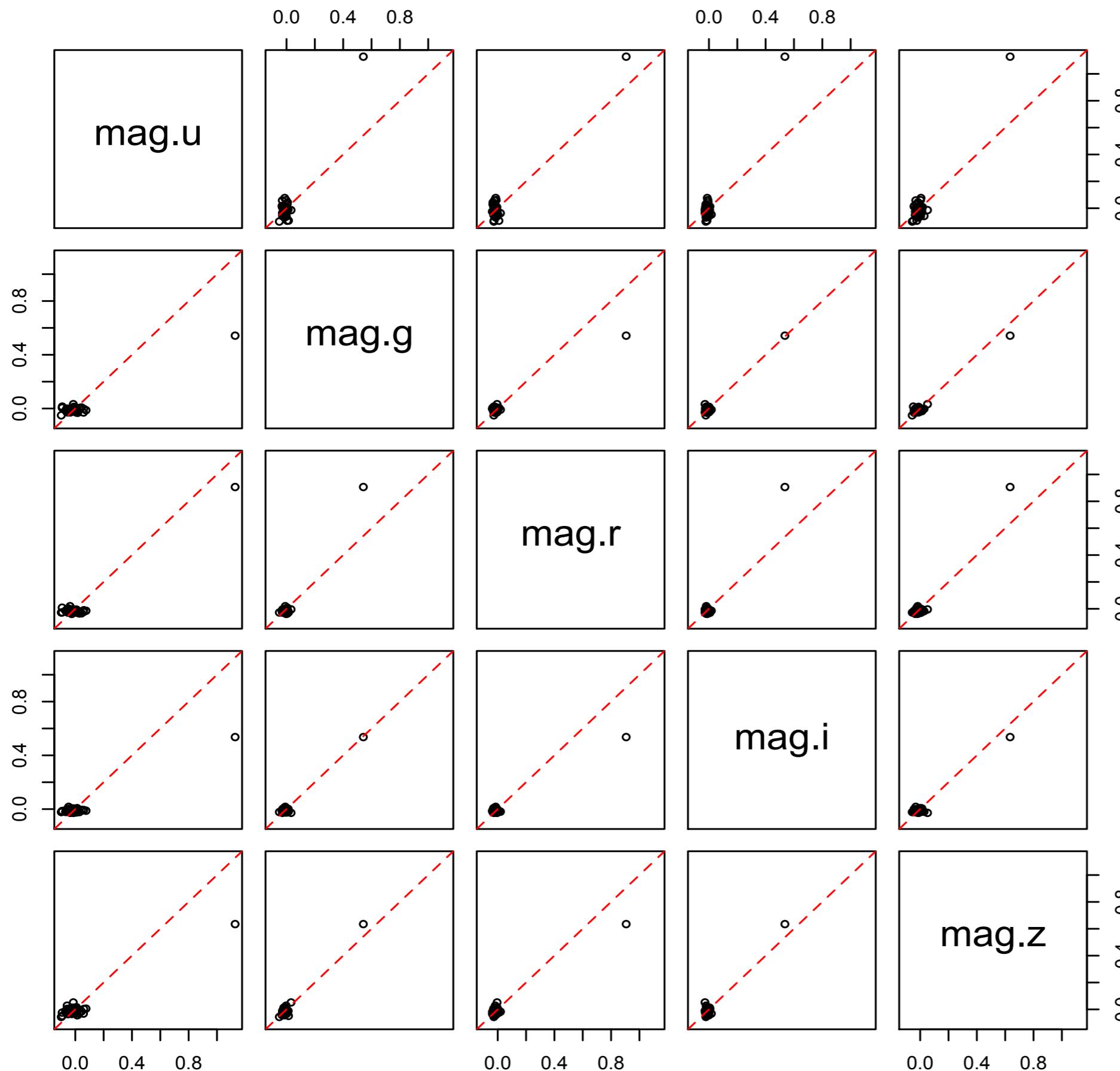


**Problems:**

Different errors in every band, error dependence on magnitudes:

Variance stabilizing tr.

# Variable star in Stripe 82



**Problems:**

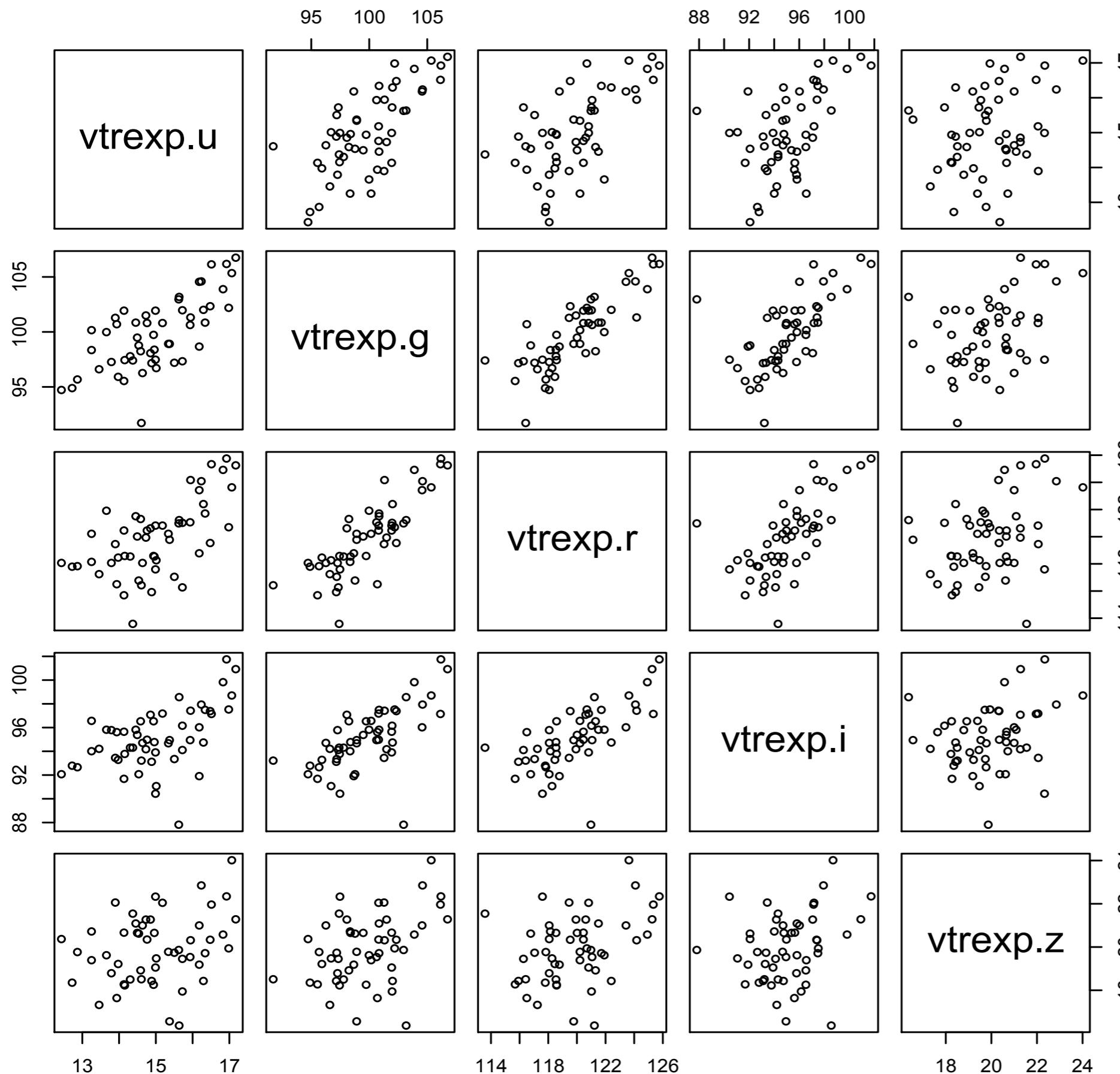
Different errors in every band, error dependence on magnitudes:

Variance stabilizing tr.

Outliers:

Robust PCA (minimum covariance determinant)

# Variable star in Stripe 82



## Problems:

Different errors in every band, error dependence on magnitudes:

Variance stabilizing tr.

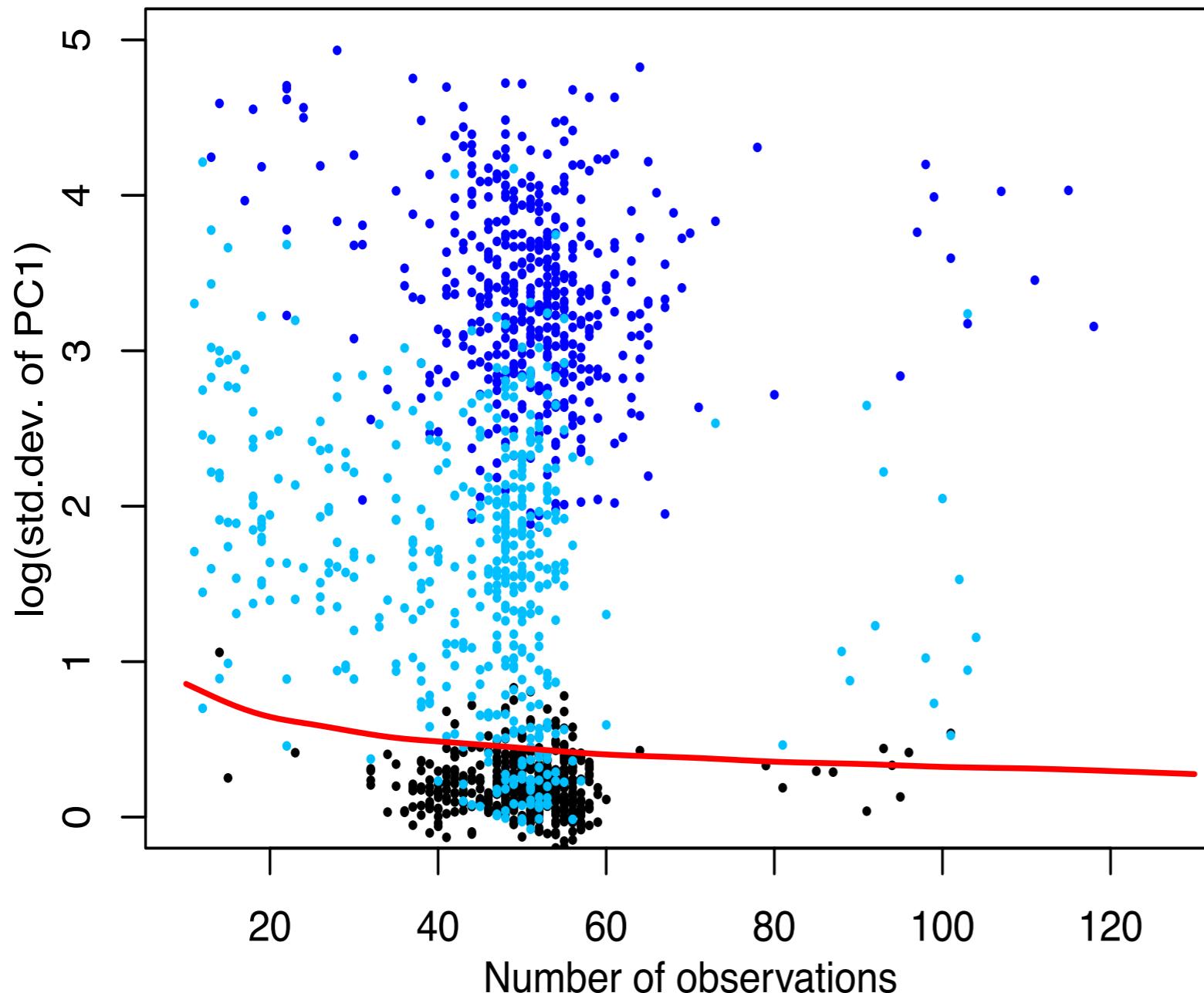
## Outliers:

Robust PCA (minimum covariance determinant)

## Questions:

- Is this star variable?
- What is its period?
- Type of variability?

# Variability detection



Dark blue: RR Lyraes (Sesar et al., 2007, 2010)

Light blue: variables based on chi-squared statistics and rms cuts

Black: nonvariables

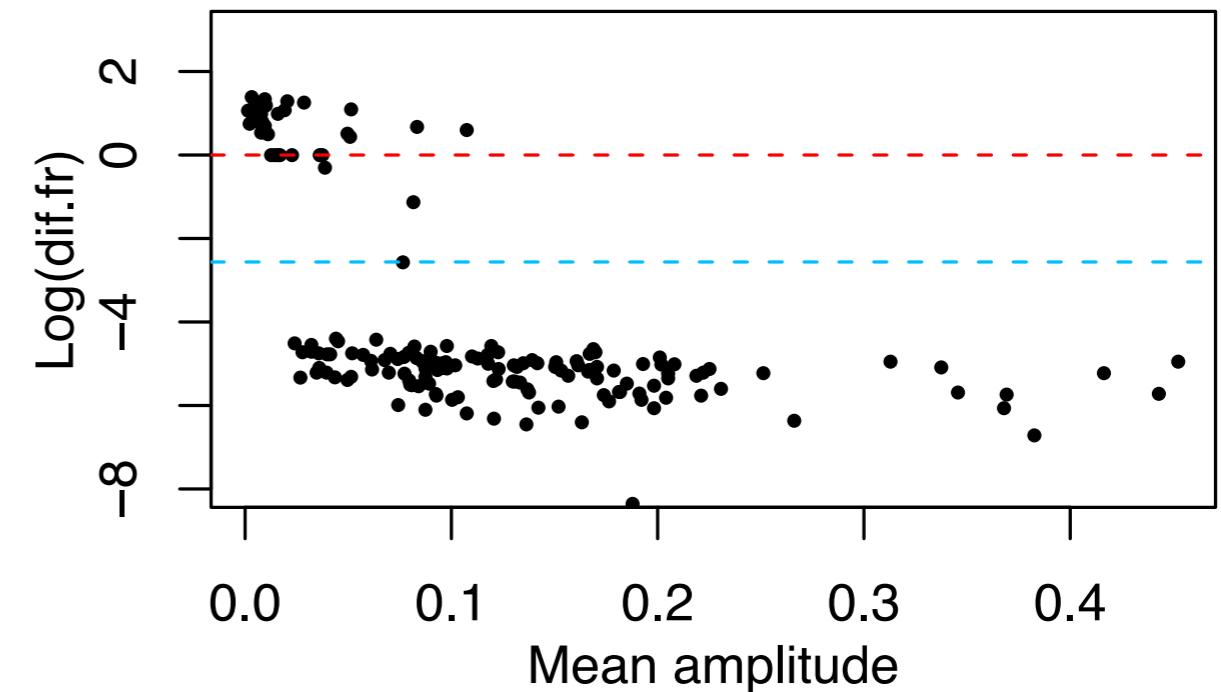
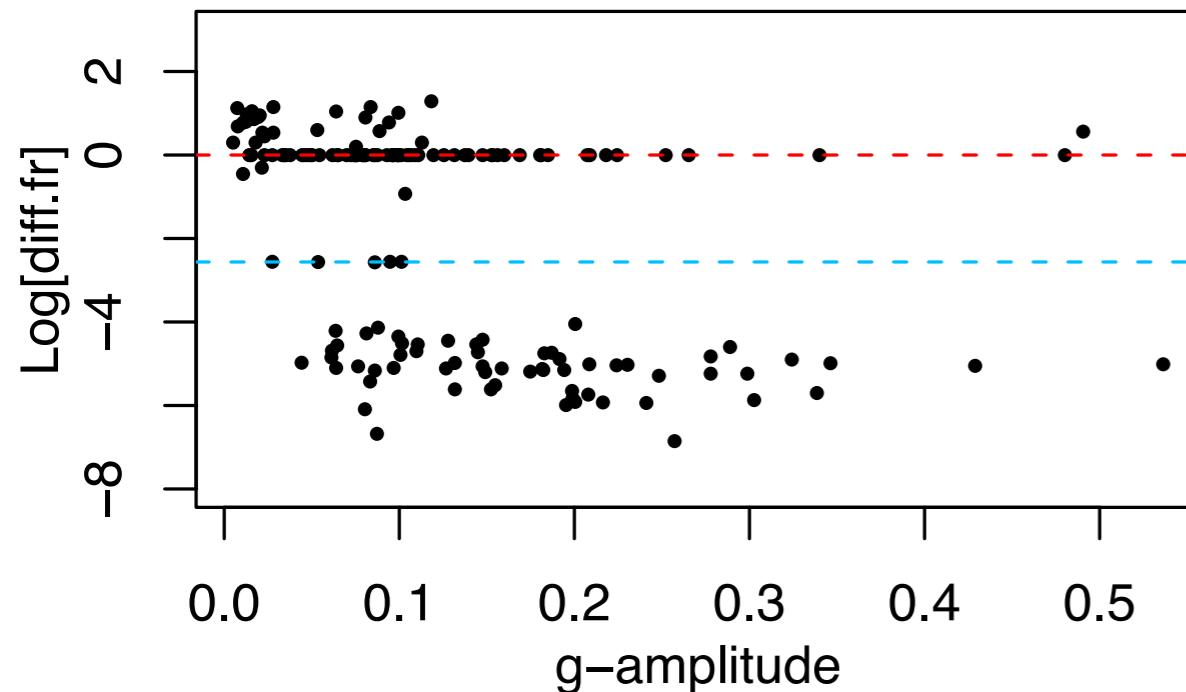
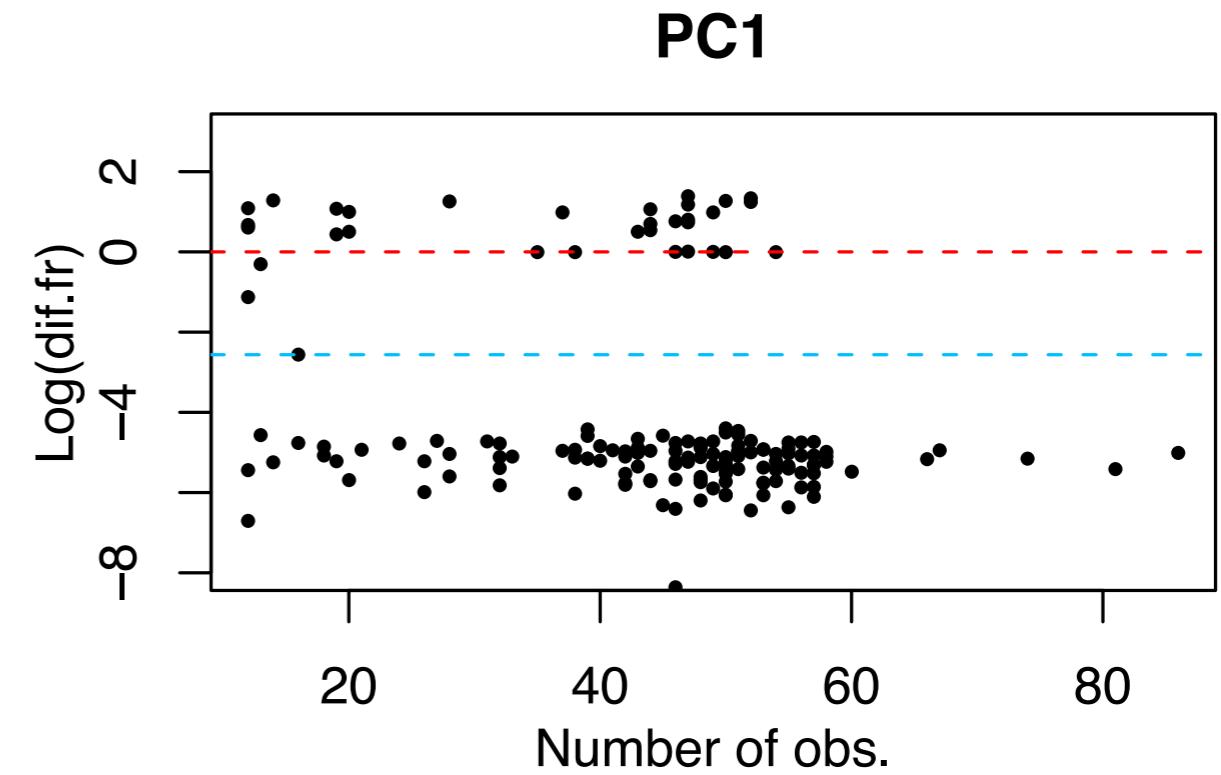
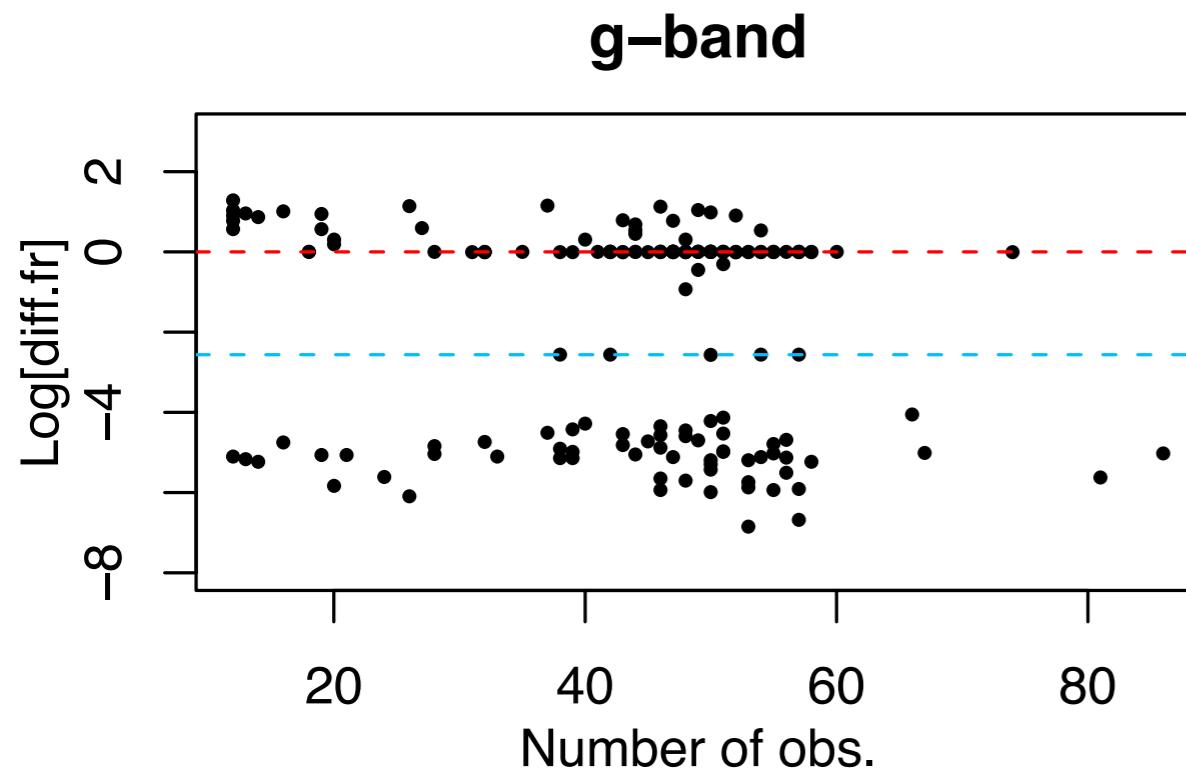
Red line: the 0.9999 quantile of log(std.dev.of PC1) in a 5-variate standard normal sample (based on simulations).

**H0** :  $\log(\text{std.dev of PC1})$  is compatible with that of a  $\mathcal{N}_5(0,1)$  sample

**H1**: not compatible

# Period search

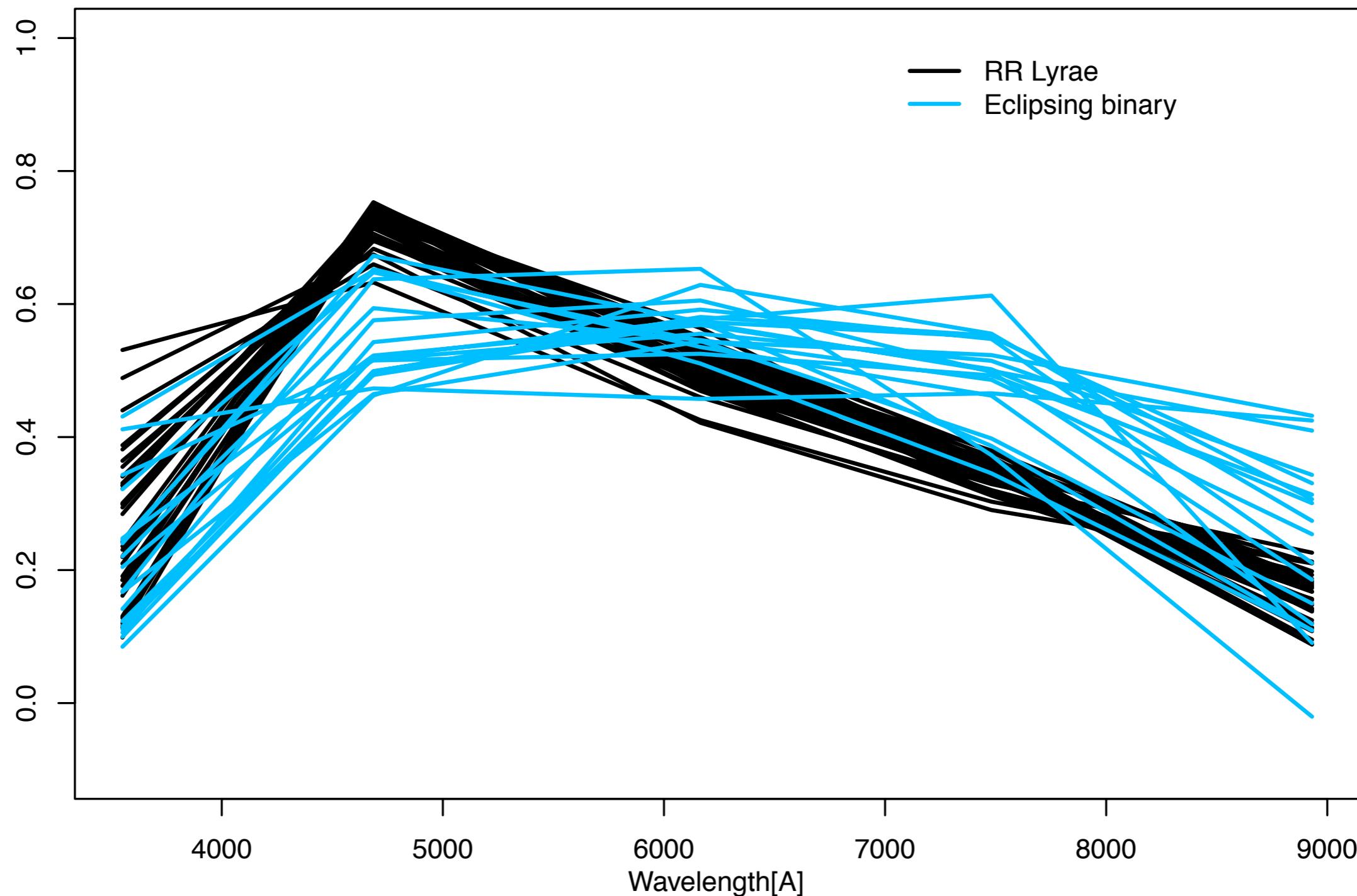
Simulations using SDSS error patterns



# PC1 spectrum

Aid in separation of pulsating variables and eclipsing binaries, based on characteristic colour variations: ~100 new RR Lyrae candidates, ~100 SXPHE/HADS candidates

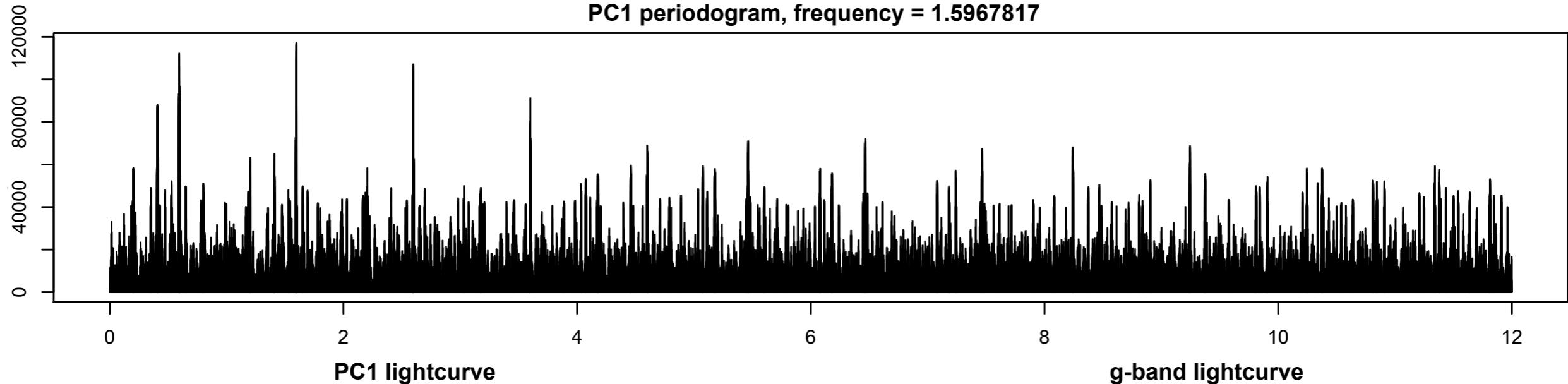
PC1 spectrum



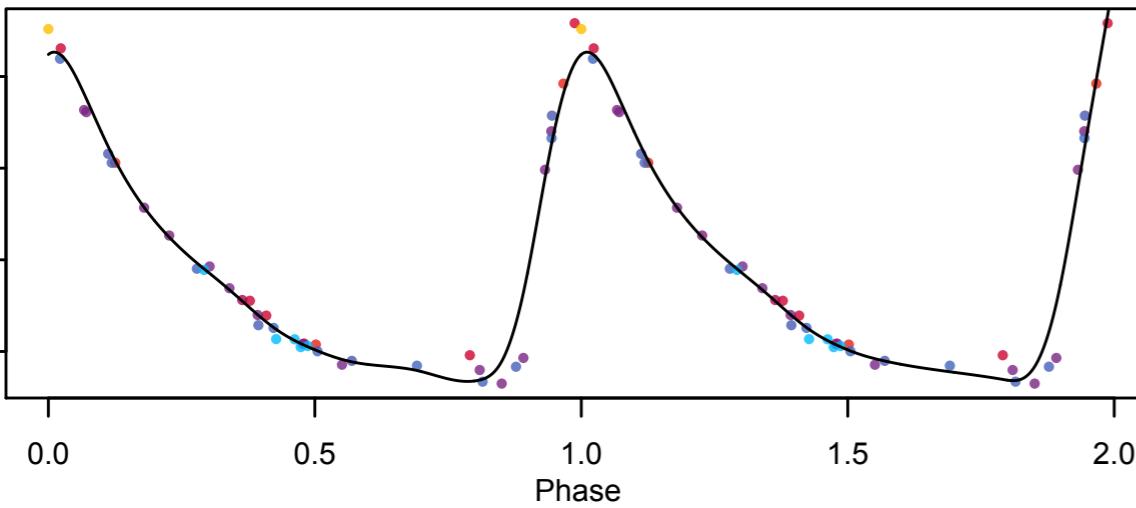
# New RR Lyrae candidates



3874813  
PC1 periodogram, frequency = 1.5967817

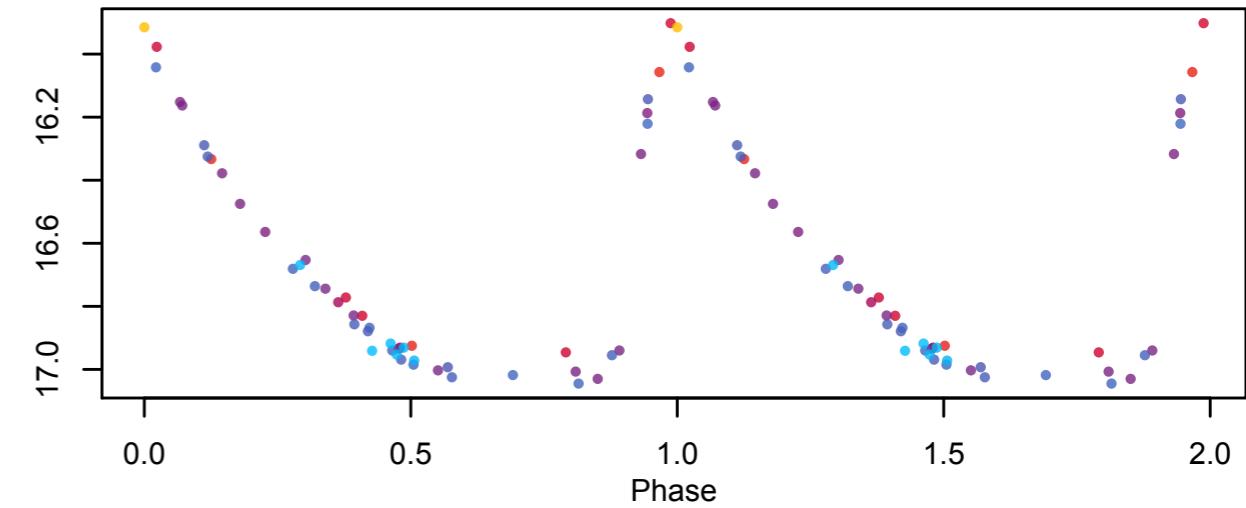


PC1 lightcurve



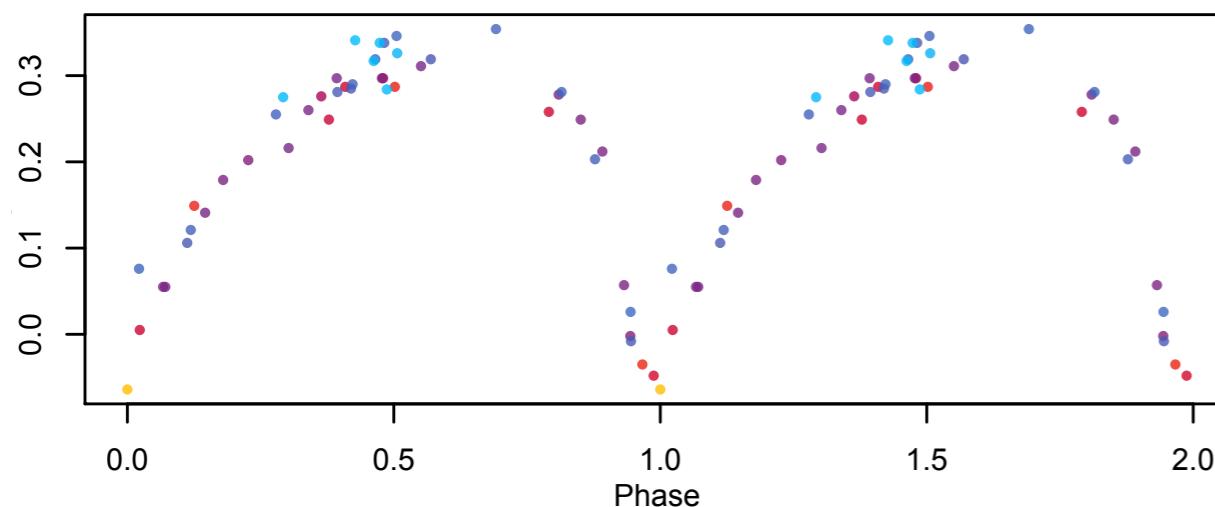
Phase

g-band lightcurve



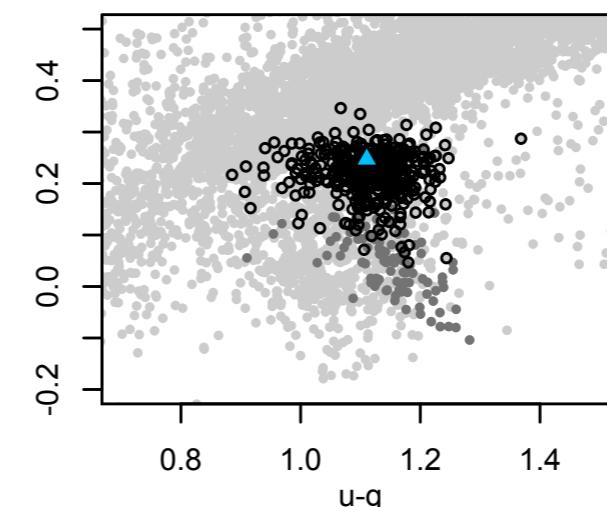
Phase

g-r lightcurve



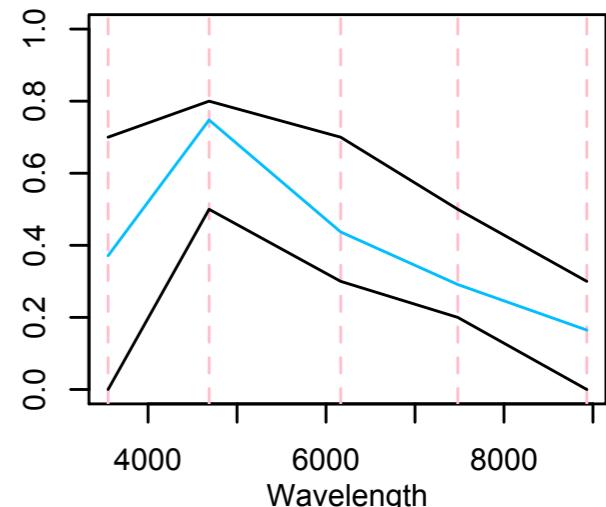
Phase

Colour-colour diagram



u-g

PC1 spectrum

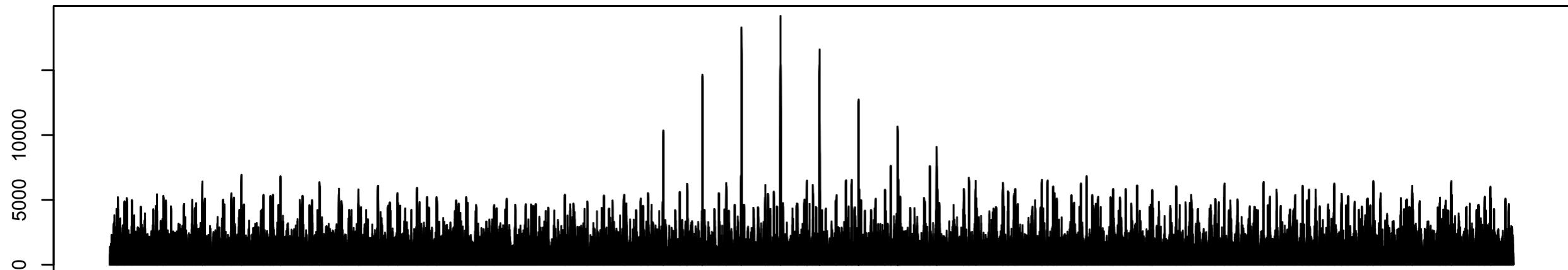


Wavelength

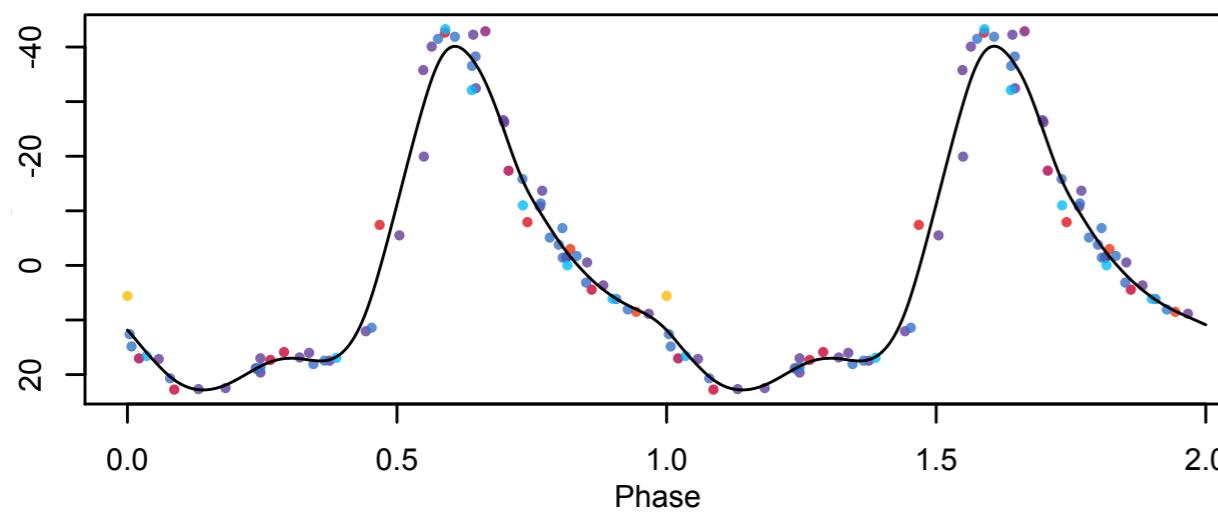
# New SX Phoenicis/HADS candidates



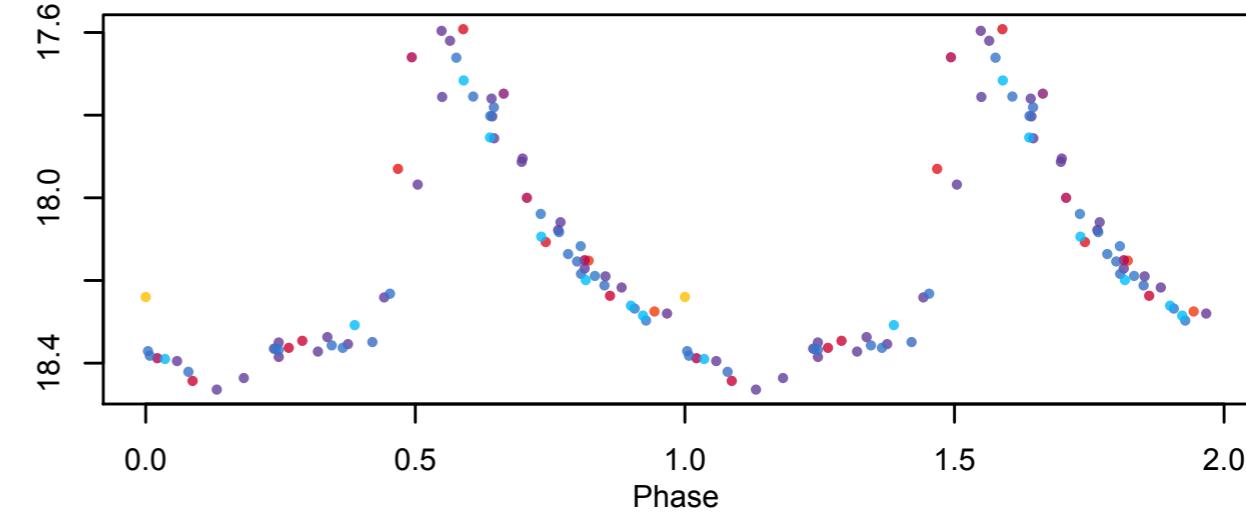
3133582  
PC1 periodogram, frequency = 17.201516



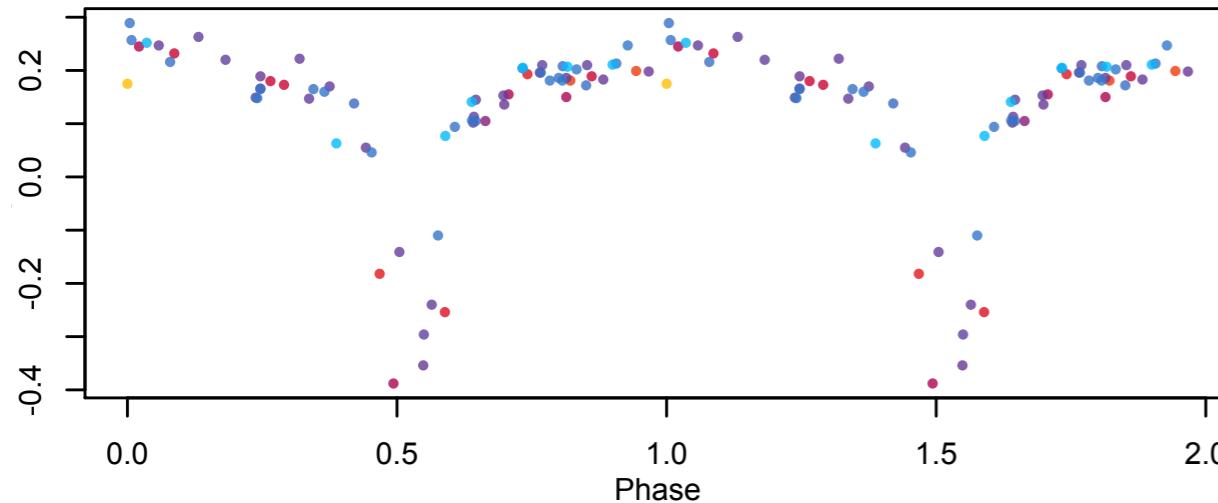
PC1 lightcurve



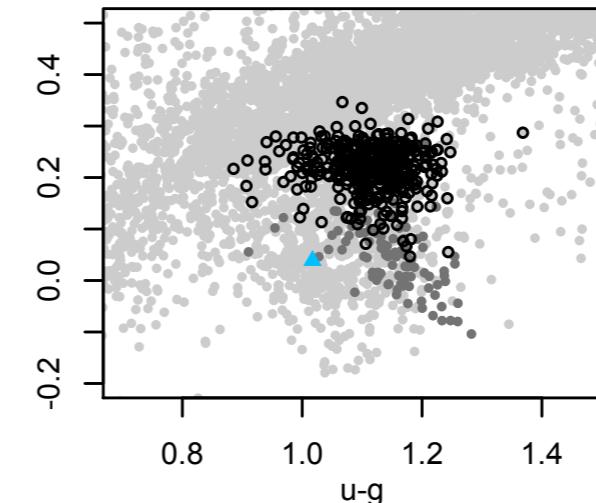
g-band lightcurve



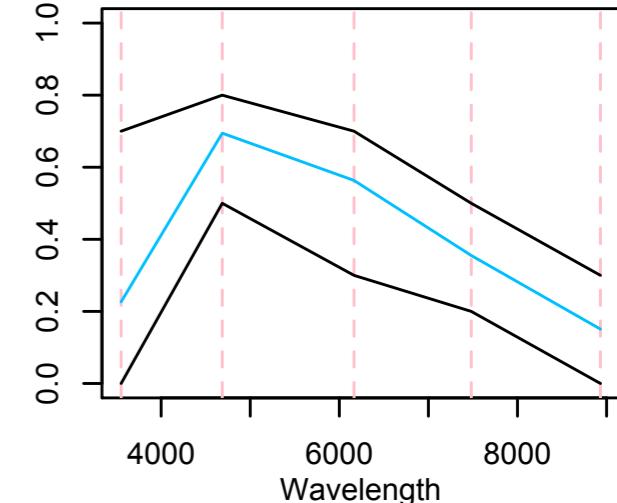
g-r lightcurve



Colour-colour diagram



PC1 spectrum



# Summary

PCA: way of dimension reduction while extracting/preserving the information

Applied to 5-variate time series of SDSS Stripe 82 data

## Results:

- A possible detection criterion
- Using PC1 time series improves period search compared to one-band error-weighted generalized least squares
- Aid in classification (separation of eclipsing binaries from types with symmetric light curves)

## Future work:

- Application to faint end
- Test it with simulated Gaia data