Previous lecture:

"real" maximum likelihood method: Poissonian data

Finding periodicities in data

- Lomb-Scarle diagrams
- Phase dispersion minimisation
- Fourier techniques

OAF2 chapter 6.1 & 6.2

Num Res chapter 13.8, 14.3,14.5 & 14.7

Today

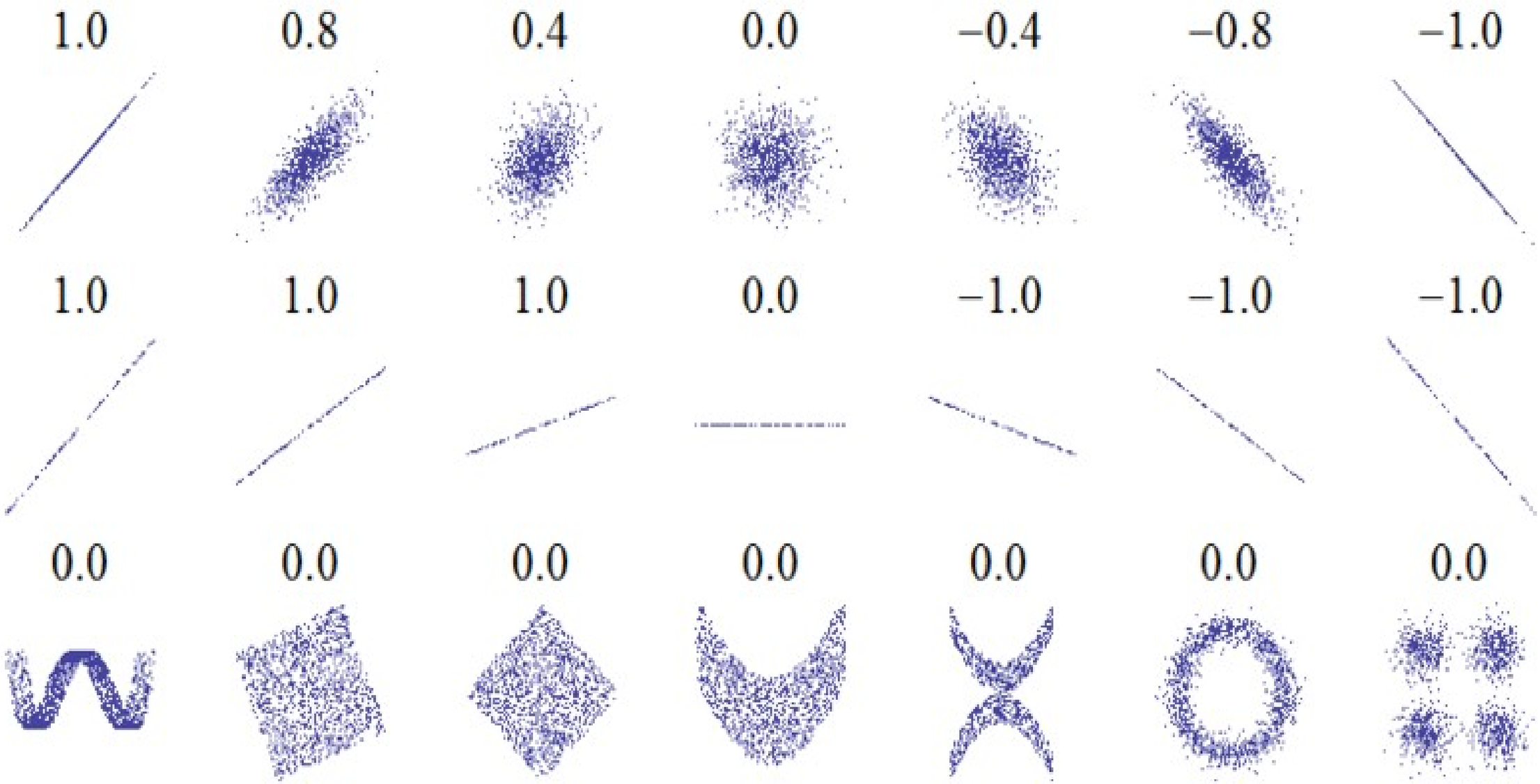
Correlations

Kolmogorov-Smirnov test

- Data is variable but not necessary periodic
- Example: compare cumulative distribution fie with model of a constant

Pearson's *r*

$$r = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2} \sqrt{\sum_i (y_i - \bar{y})^2}}$$



Examples from Wikipedia

Another way of looking at Pearson's *r*

$$\rho_{X,Y} = \frac{\operatorname{cov}(X,Y)}{\sigma_X \sigma_Y} = \frac{E((X-\mu_X)(Y-\mu_Y))}{\sigma_X \sigma_Y},$$

A simple special case (if each value in x and y is unique): Spearman's rank

$$\rho = 1 - \frac{6 \sum d_i^2}{n(n^2-1)}$$

Significance? Monte Carlo (scramble data)

Example Spearman's rank (from Wikipedia)

IQ Hours of TV per week

X_i	Y_i	$rankx_i$	$ranky_i$	d_i	d_i^2
86	0	1	1	0	0
97	20	2	6	-4	16
99	28	3	8	-5	25
100	27	4	7	-3	9
101	50	5	10	-5	25
103	29	6	9	-3	9
106	7	7	3	4	16
110	17	8	5	3	9
112	6	9	2	7	49
113	12	10	4	6	36

Sum over d_i^2 = 194, n=10, rho =-0.176

Comparing a distribution with a theoretical distri or two distributions

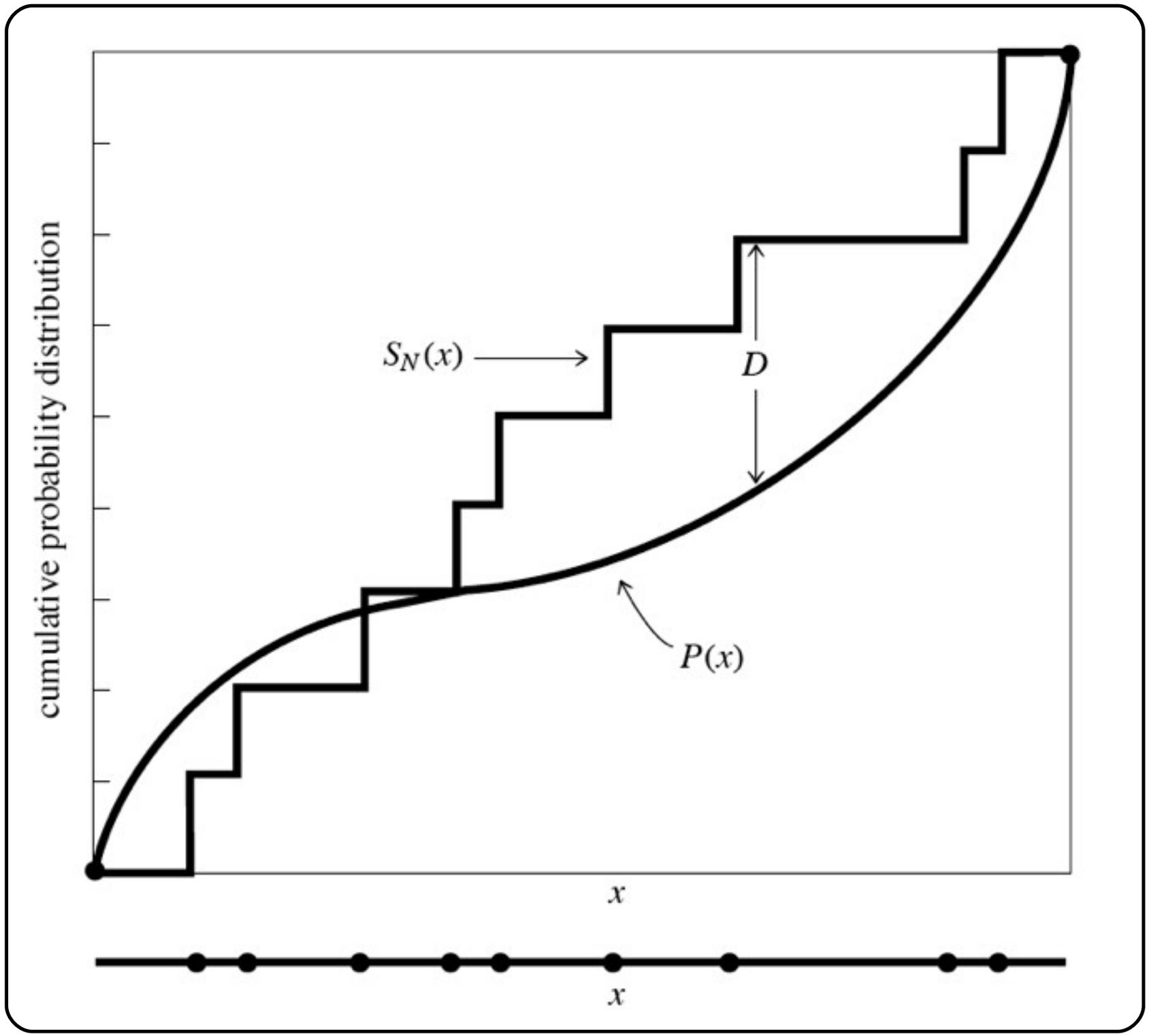
Kolmogorov-Smirnov test:

compare two cumulative distribution functions

e.g. 1 observed and 1 theoretical

or

e.g. 2 observed



K-S test

an advantage of using
K-S statistic

the distribution can be calculated in
the case of the null-hypothesis
(data sets from same distri/data
drawn from theoretical curve)

$$Q_{KS}(x) = 2\sum_{j=1}^{\infty}(-1)^{j-1}e^{-2j^2x^2}$$

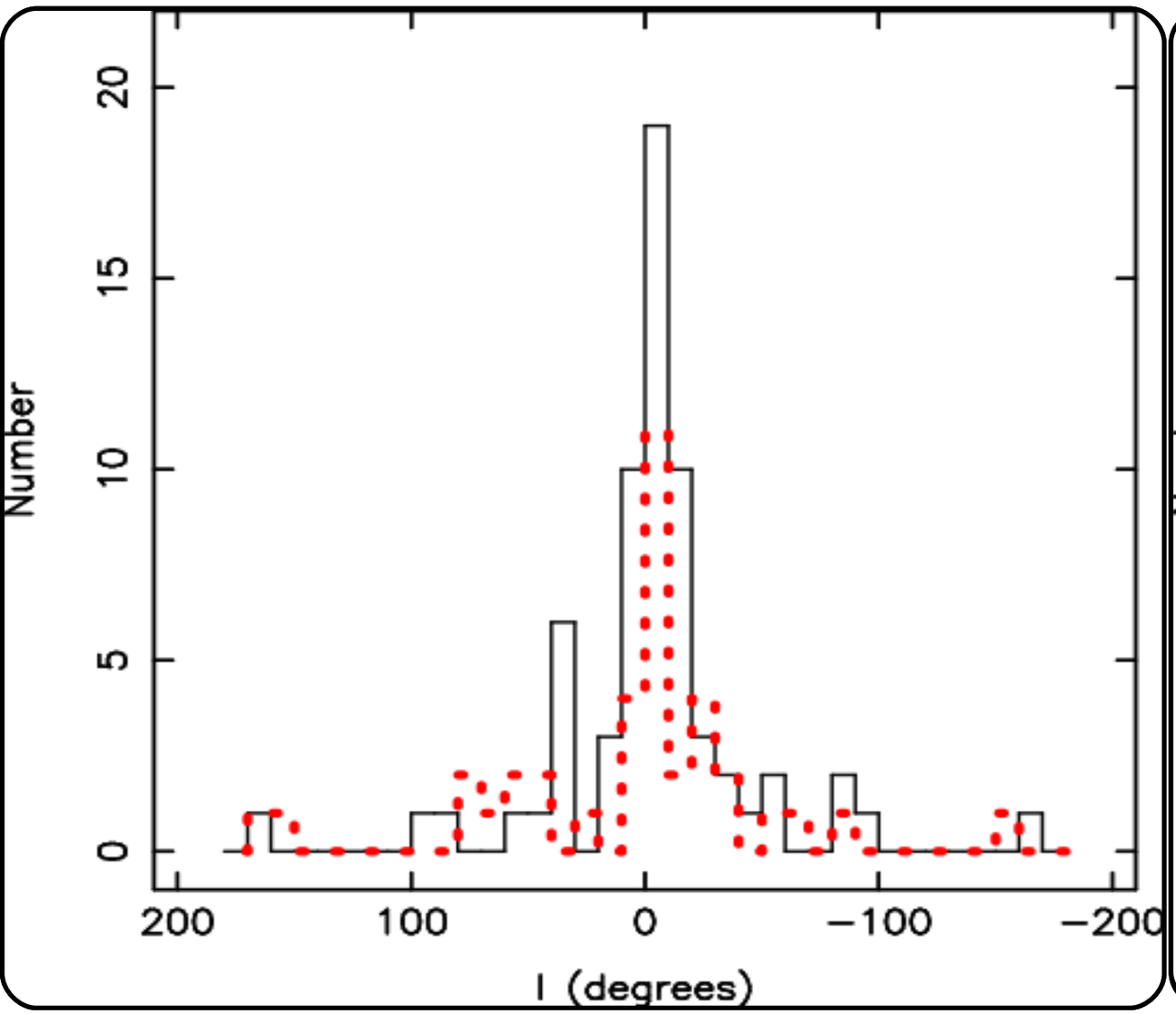
$$\text{Probability } (D > D_{obs}) = Q_{KS}([\sqrt{N_e} + 0.12 + \frac{0.11}{\sqrt{N_e}}D])$$

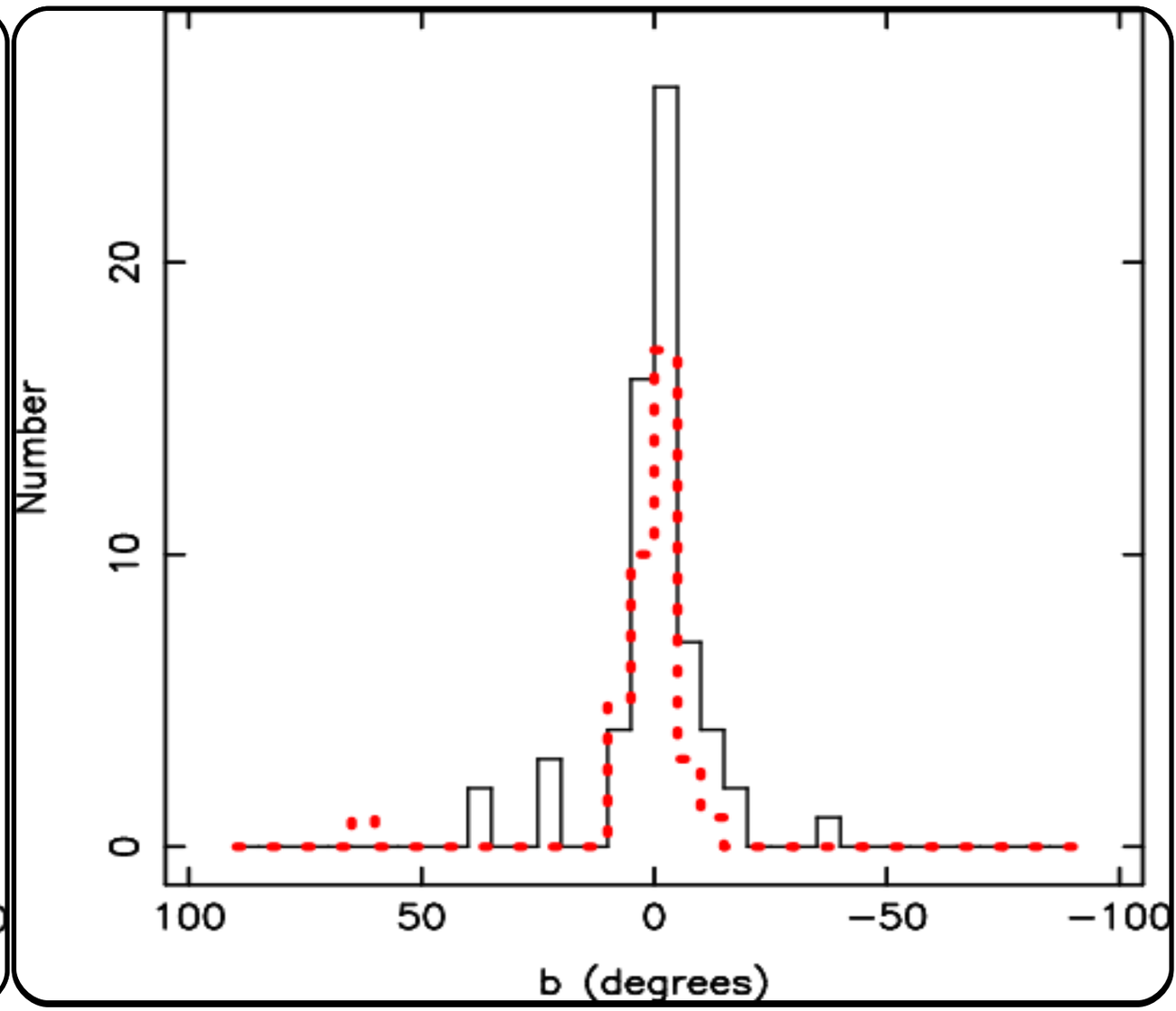
with $N_e = N$ number of data pnts or $N_e = \frac{N_1 N_2}{N_1 + N_2}$

1 distribution 2 distributions

Example K-S test

distribution of neutron stars and black hole X-ray binaries in our Galaxy





Jonker & Nelemans 2004

Probability that BHs and NSs from the same distribution

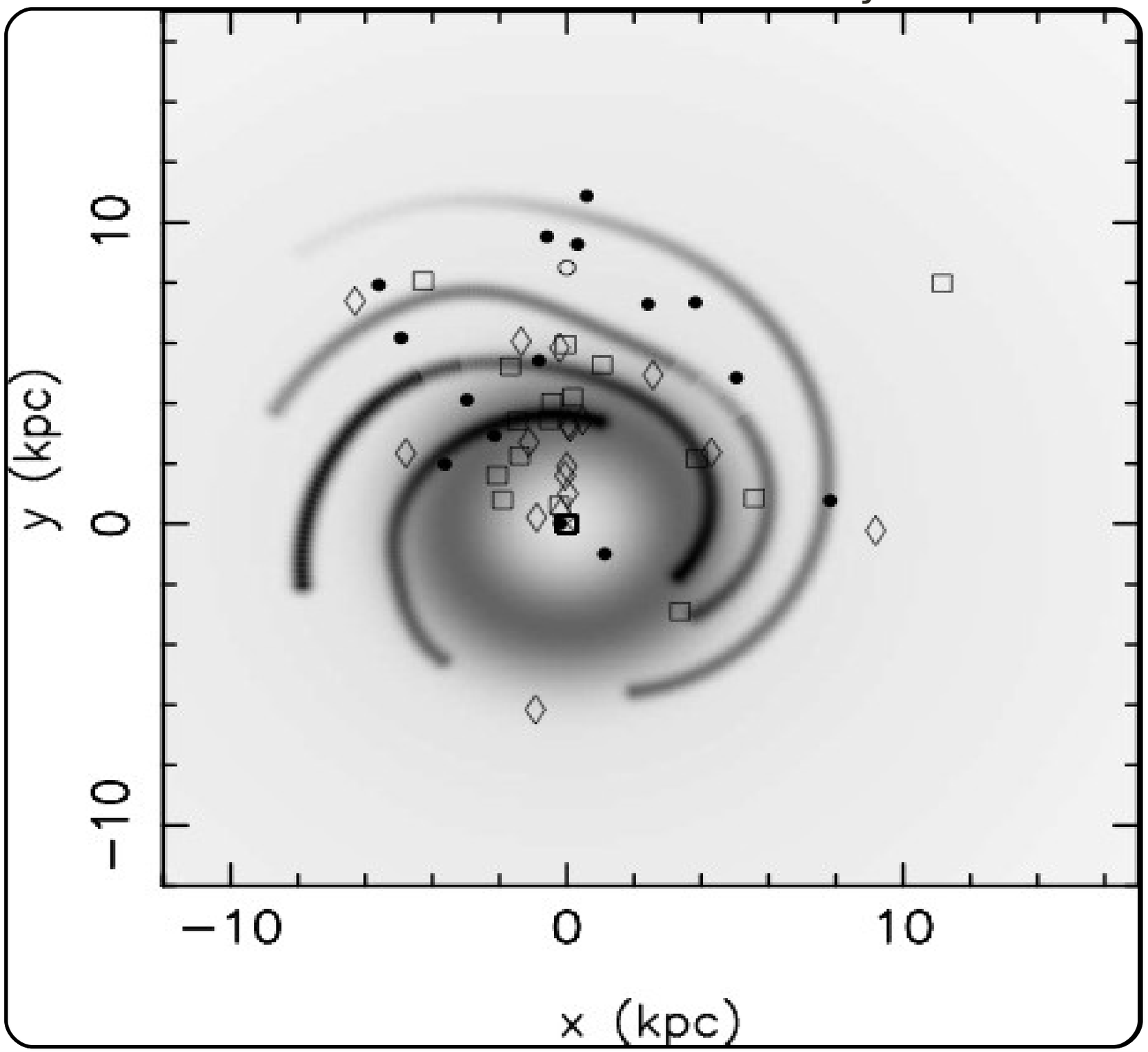
37%, D=0.19

90%, D=0.12

M101 HST image

2D K-S test

distribution of neutron stars and black hole X-ray binaries in our Galaxy

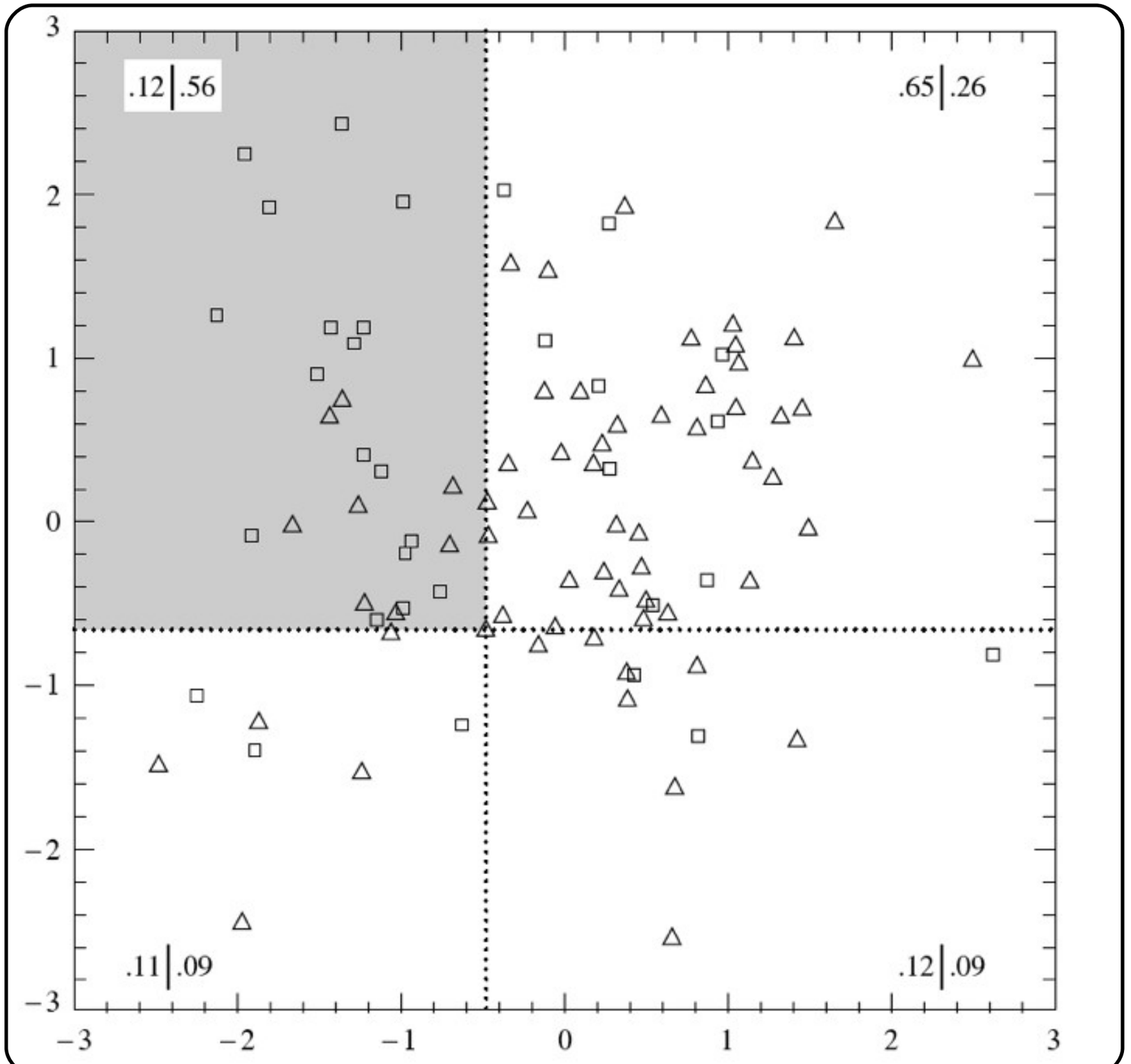


5.2%

D=0.45

Jonker & Nelemans 2004 Spiral structure Taylor & Cordess 1993

2D K-S test



$$P(D > D_{obs}) = Q_{KS}\left(\frac{\sqrt{N}D}{1+\sqrt{1-r^2(0.25-0.75/\sqrt{N})}}\right)$$

2D K-S test

$$r = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2} \sqrt{\sum_i (y_i - \bar{y})^2}}$$

r=correlation coefficient

Science at SRON staff members

Wim Hermsen: pulsars, INTEGRAL

Jean in 't Zand: type I X-ray bursts

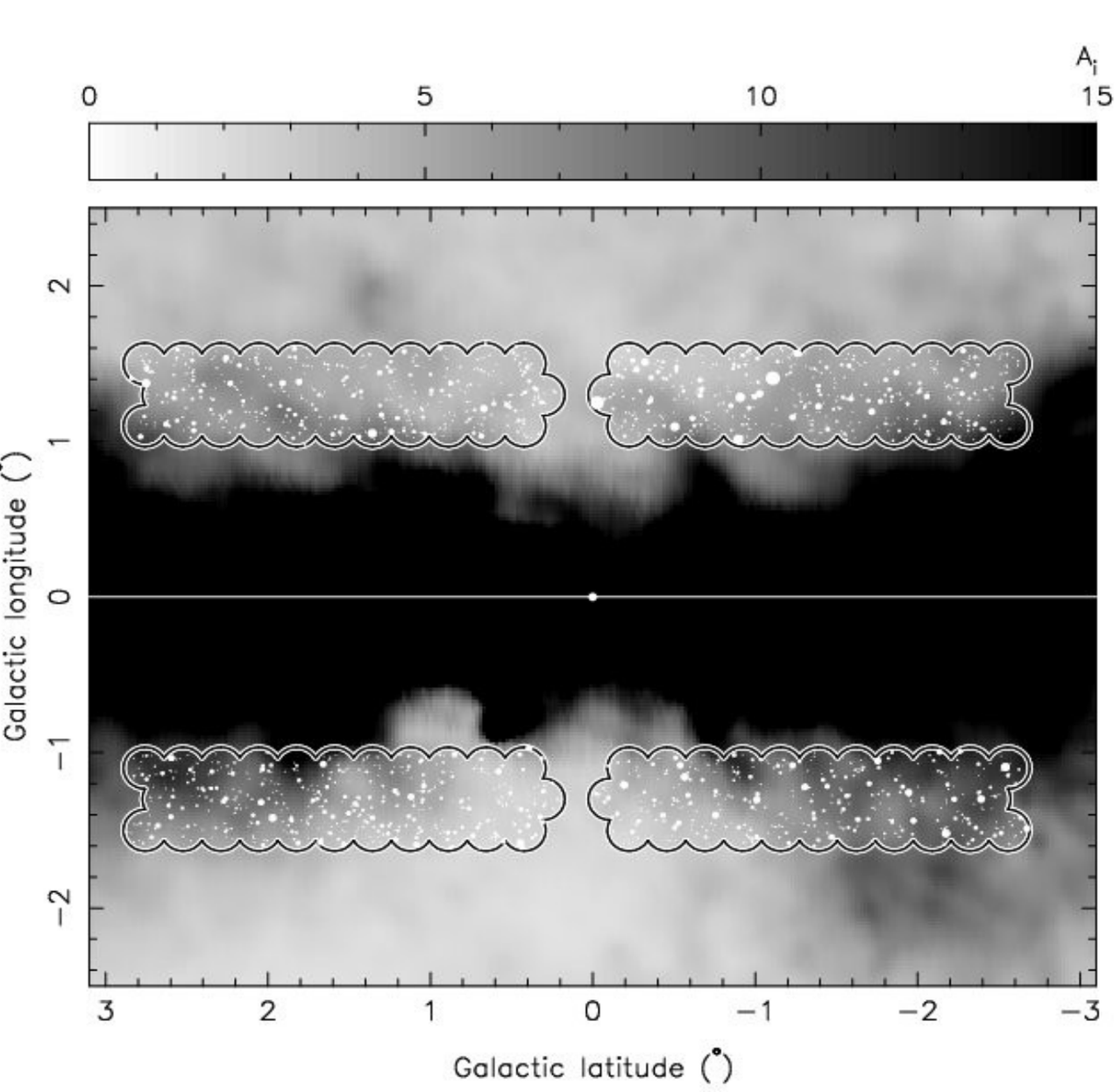
Jelle Kaastra: Clusters of galaxies, ISM studies

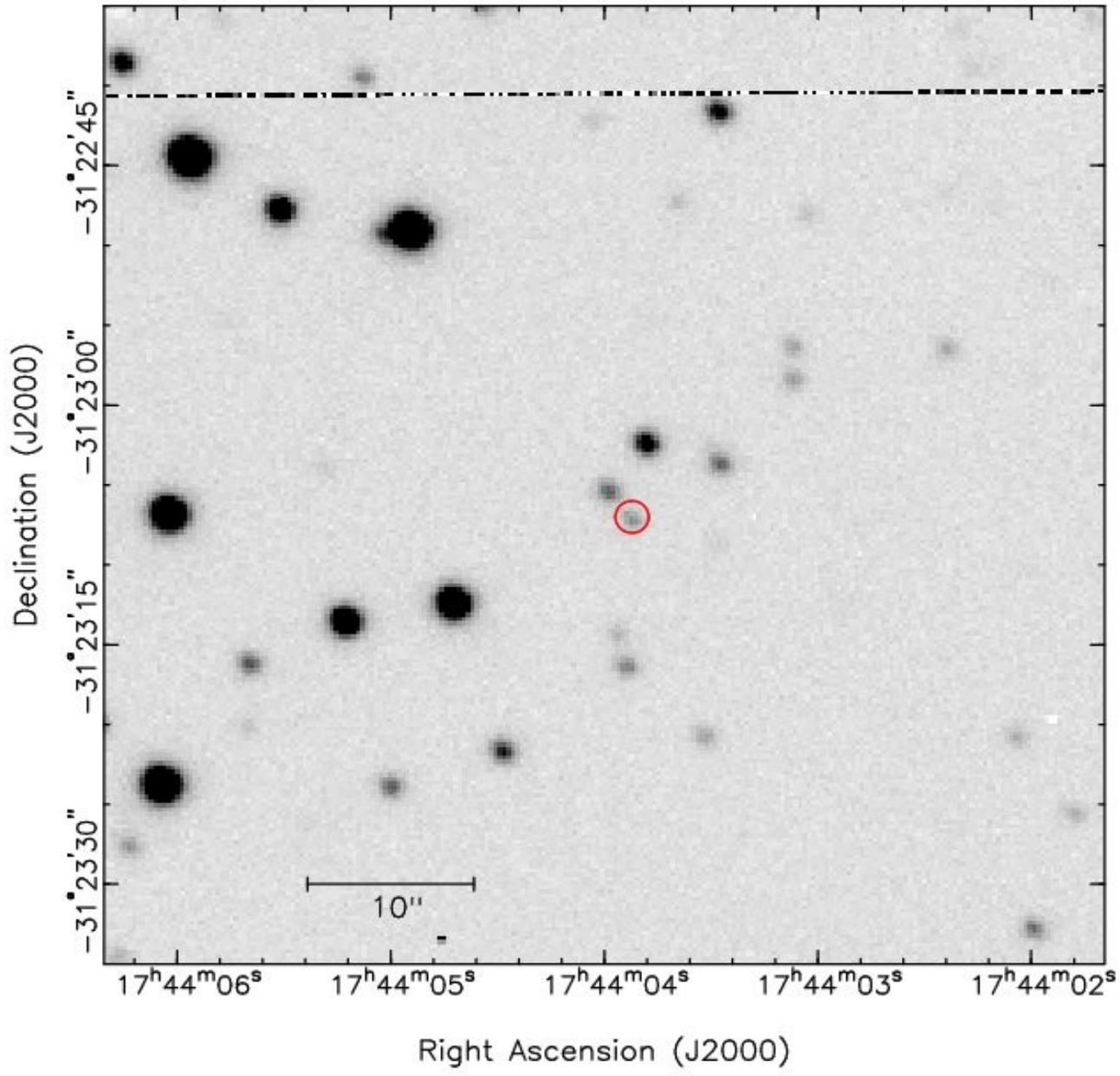
Elisa Costantini: ISM studies, AGN

Lucien Kuiper: pulsars, INTEGRAL sources

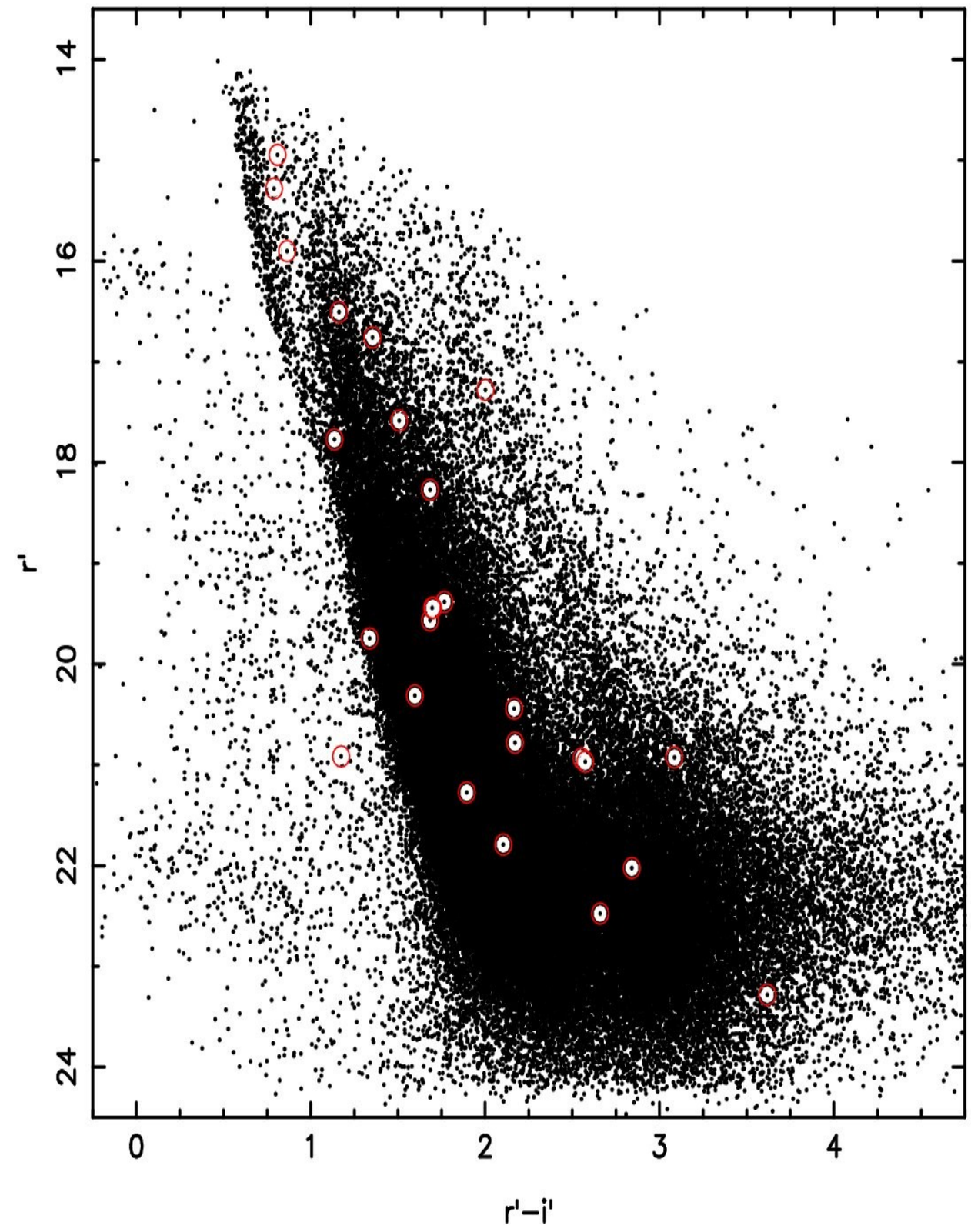
Peter Jonker: low-mass X-ray binaries, neutron stars & black holes

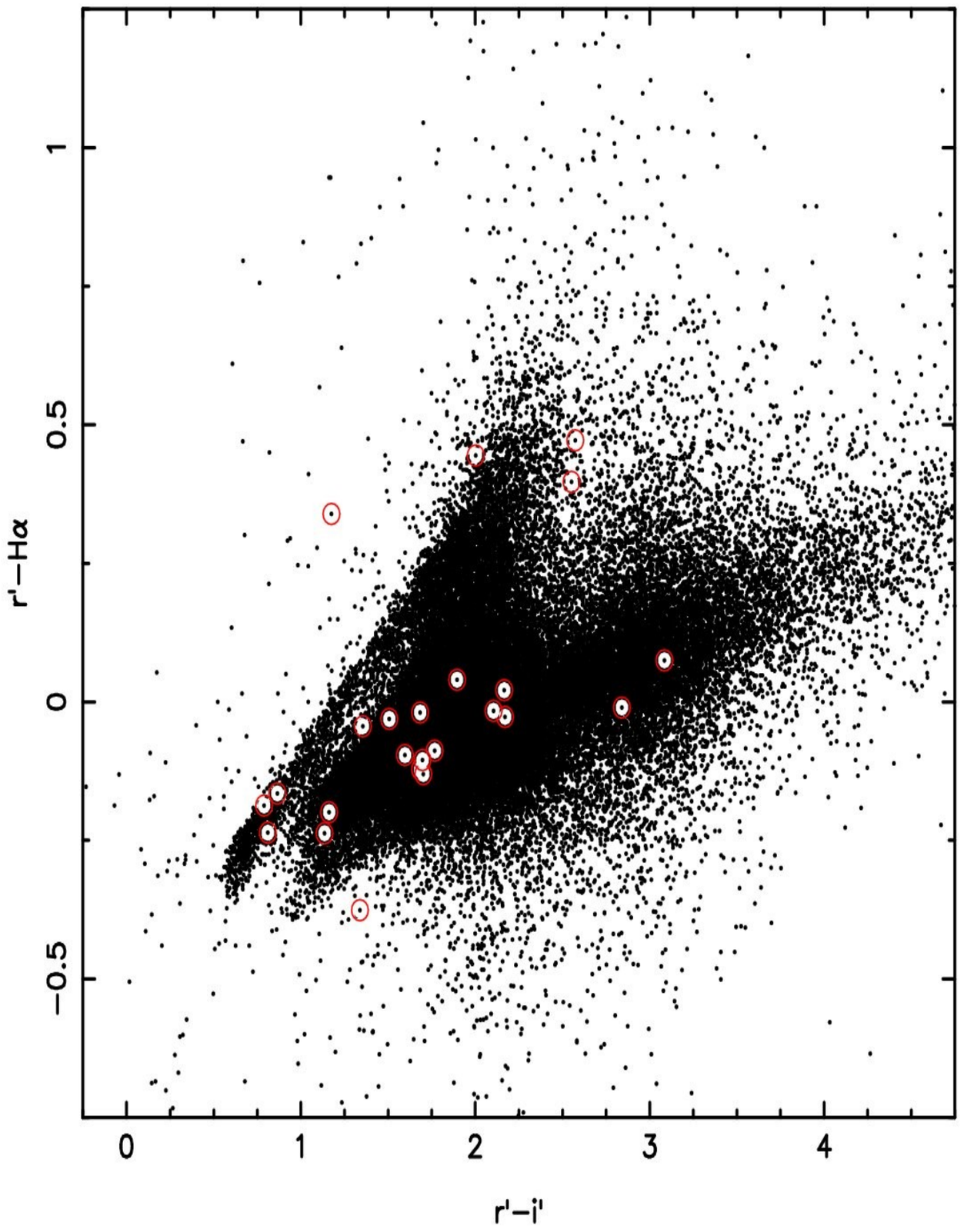
Galactic Bulge Survey





Galactic Bulge Survey





Core group of people working on the GBS:
me (PI)
Cees Bassa (post-doc)
Eva Ratti (new PhD student)

Gijs Nelemans (Nijmegen Univ)
PhD student

Danny Steeghs (Warwick Univ, UK)

Manuel Torres (Harvard-Smithsonian CfA)

Several student projects, including Bachelor student projects