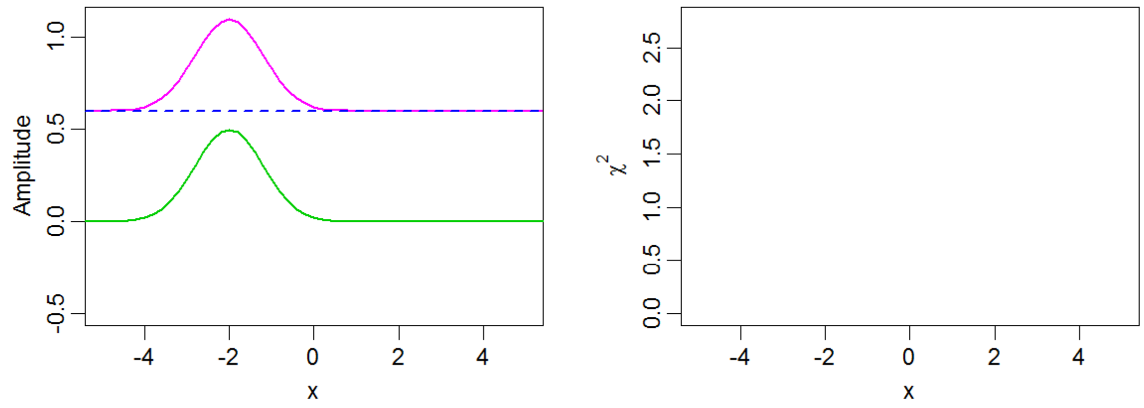
Simple example with no noise

$$\chi^2 = \sum_{i=1}^{N} \left(\frac{x_i - \text{model}_i}{\sigma_i} \right)^2$$ The full definition

$$\chi^2 \propto \sum_{i=1}^{N} \left(x_i - \text{model}_i \right)^2$$ An unscaled but appealing version



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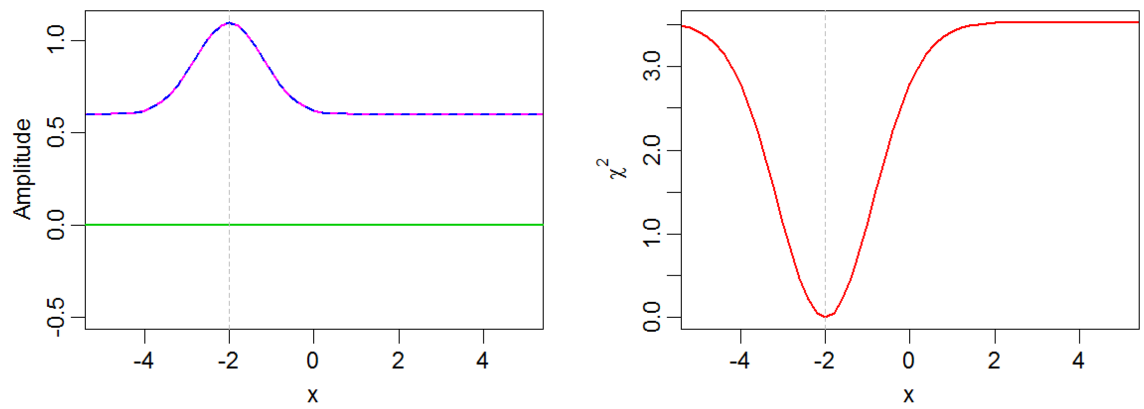

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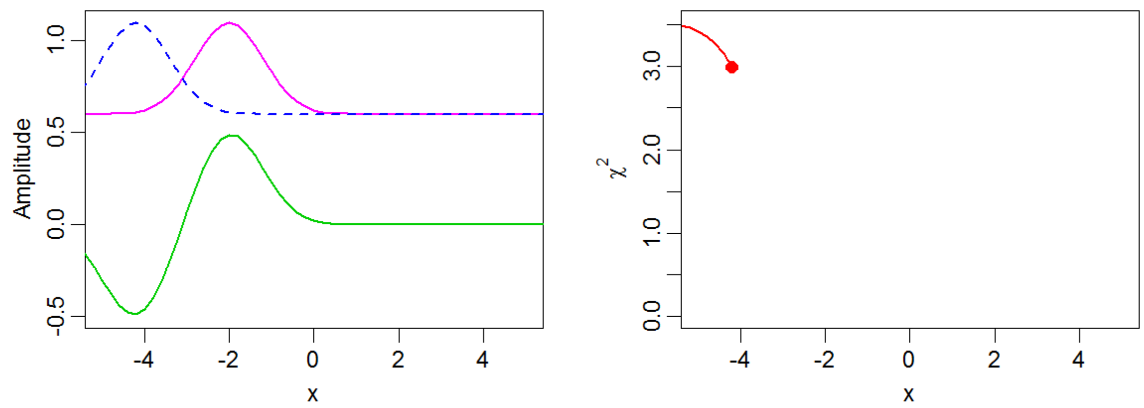

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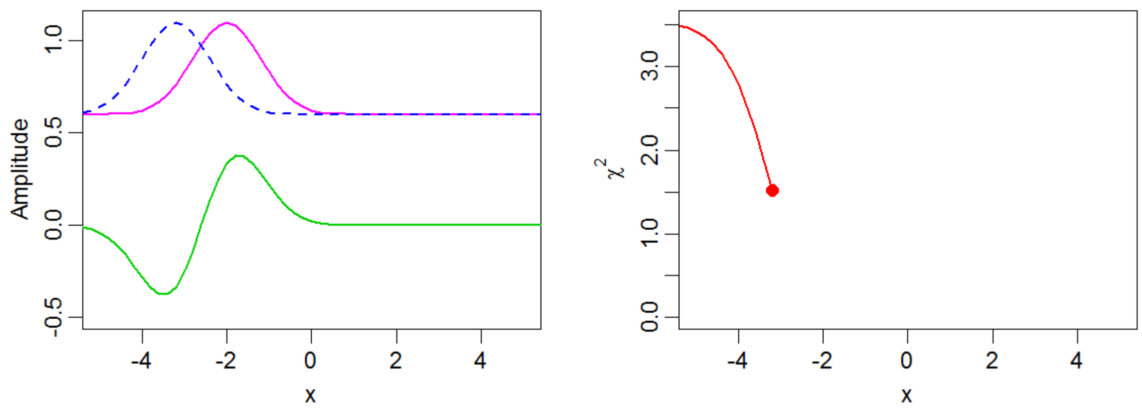

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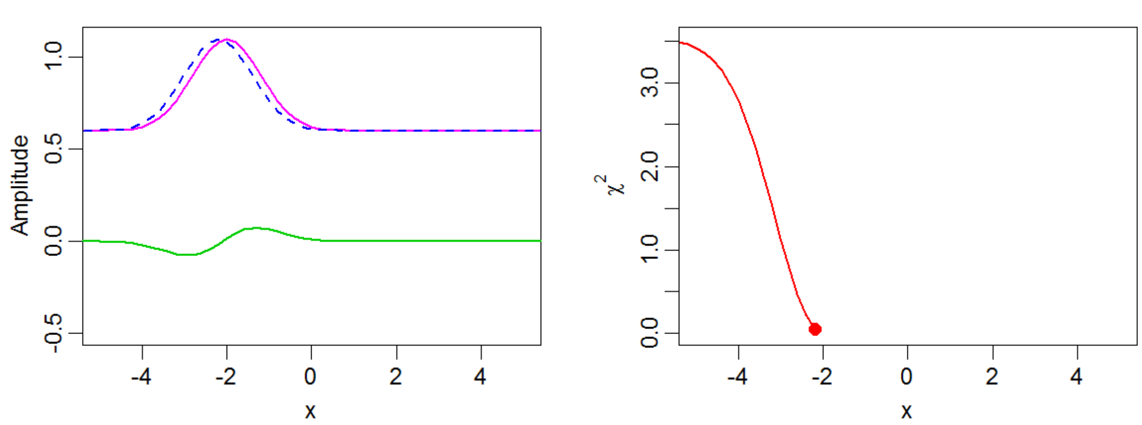

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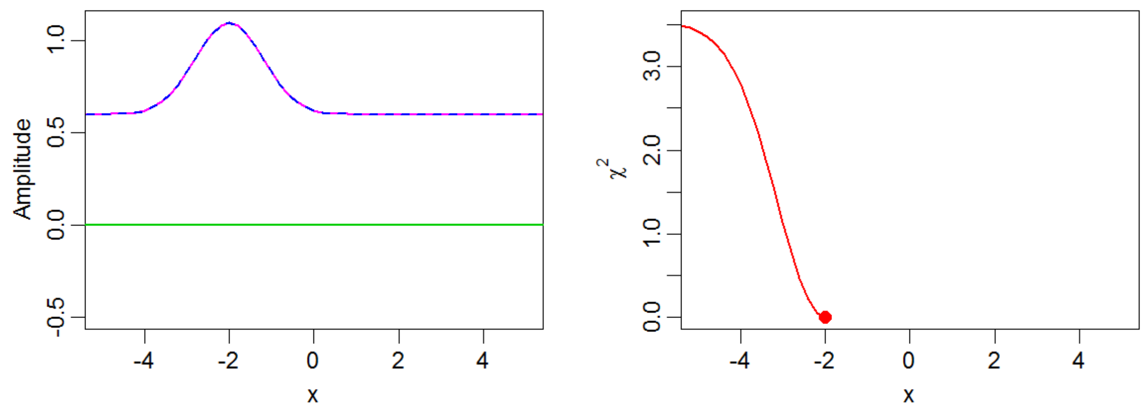

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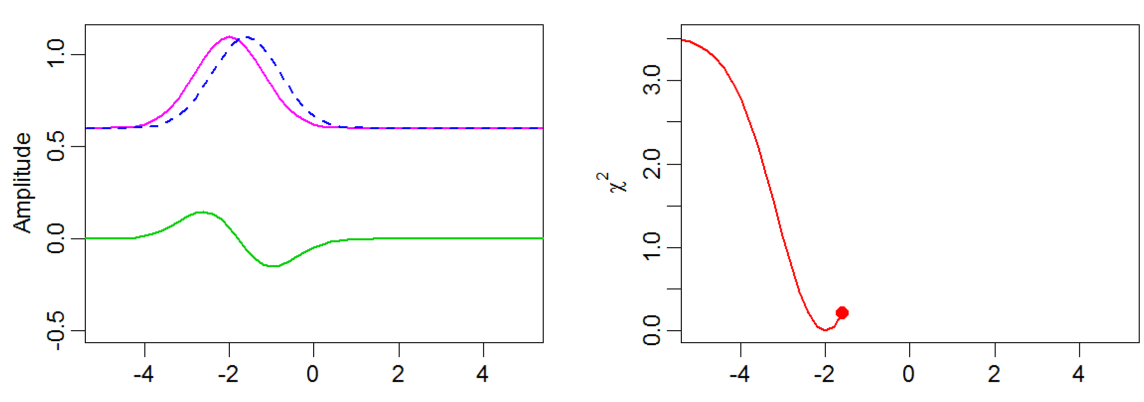

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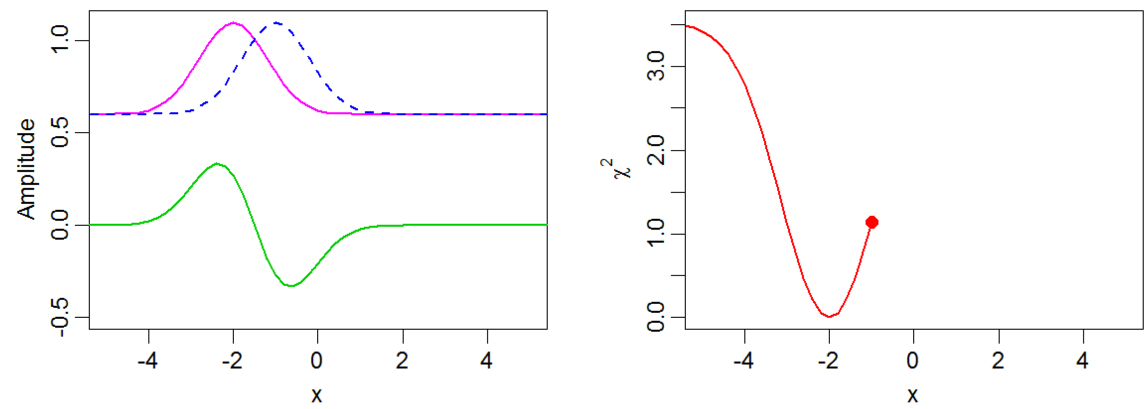

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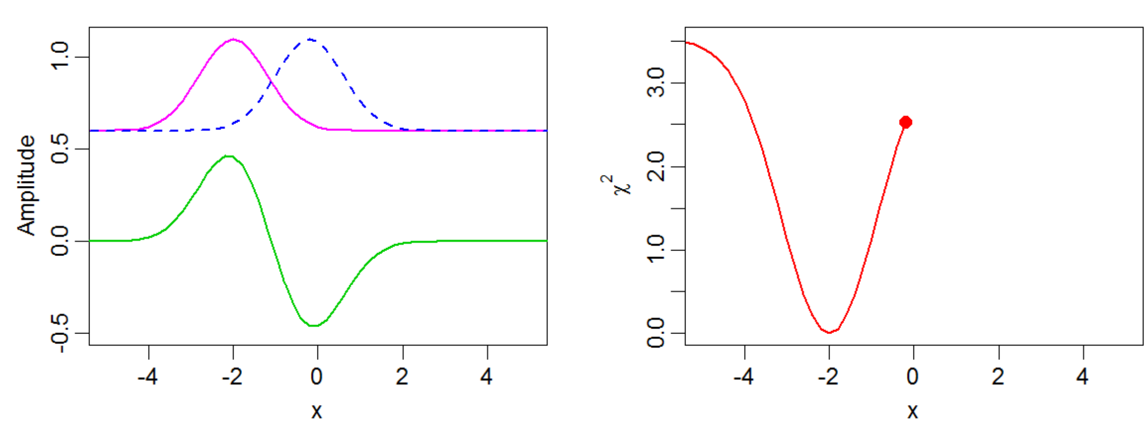

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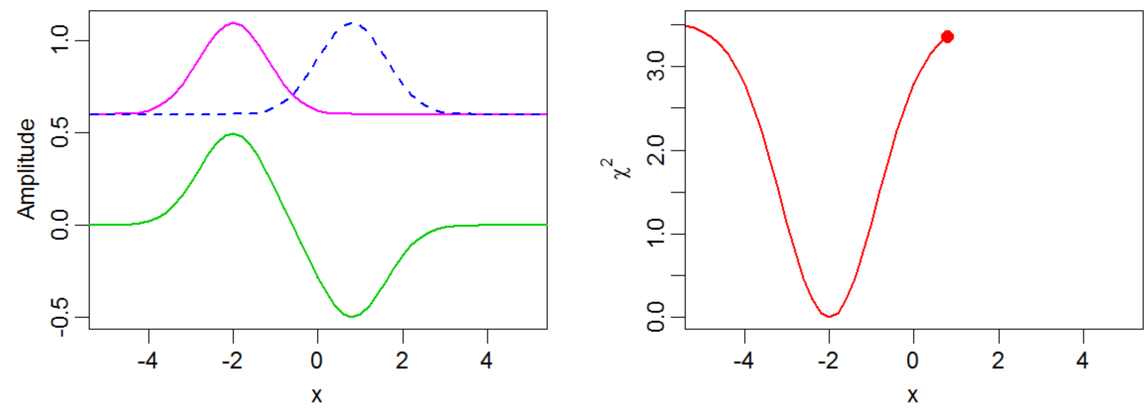

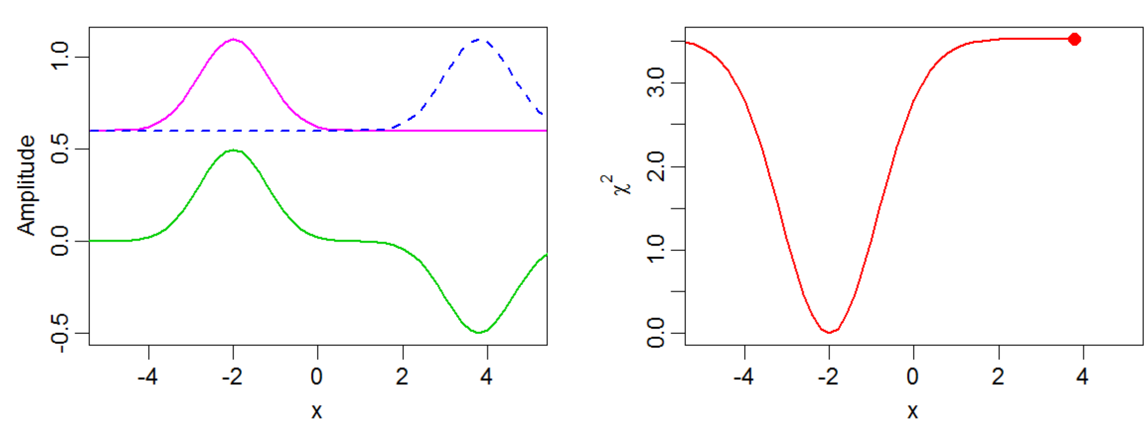

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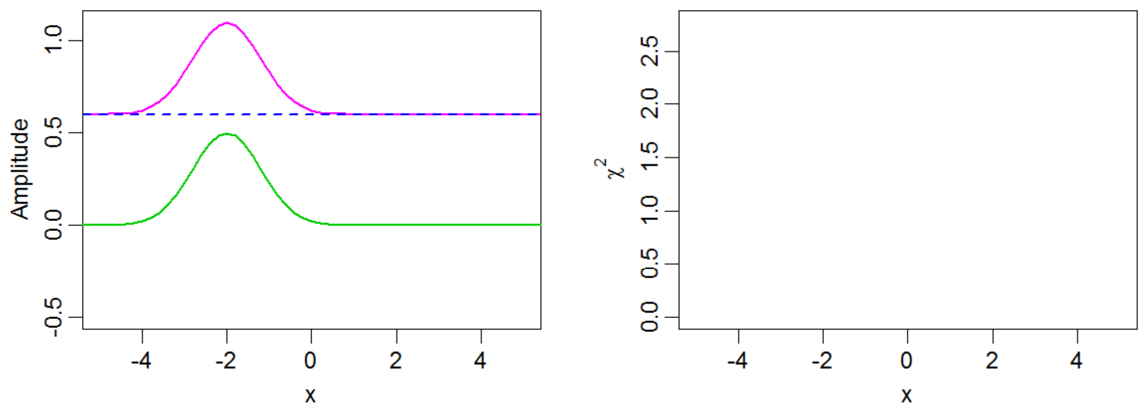

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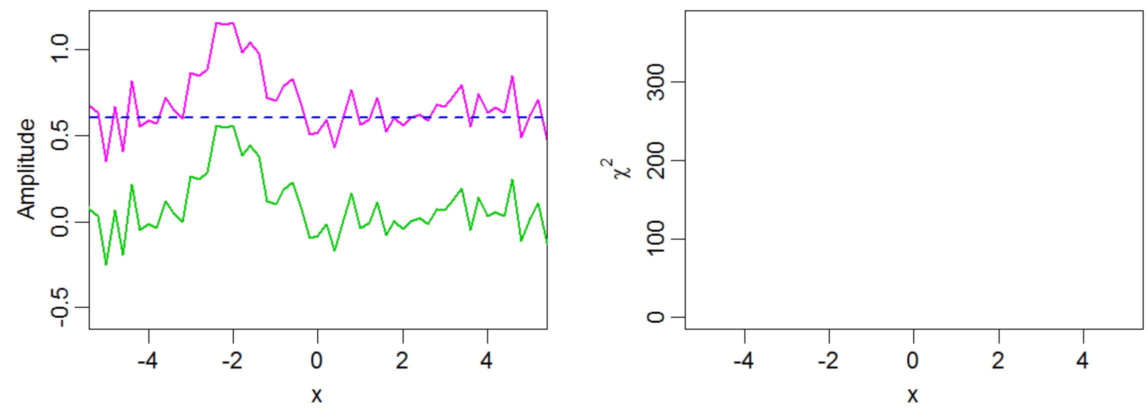
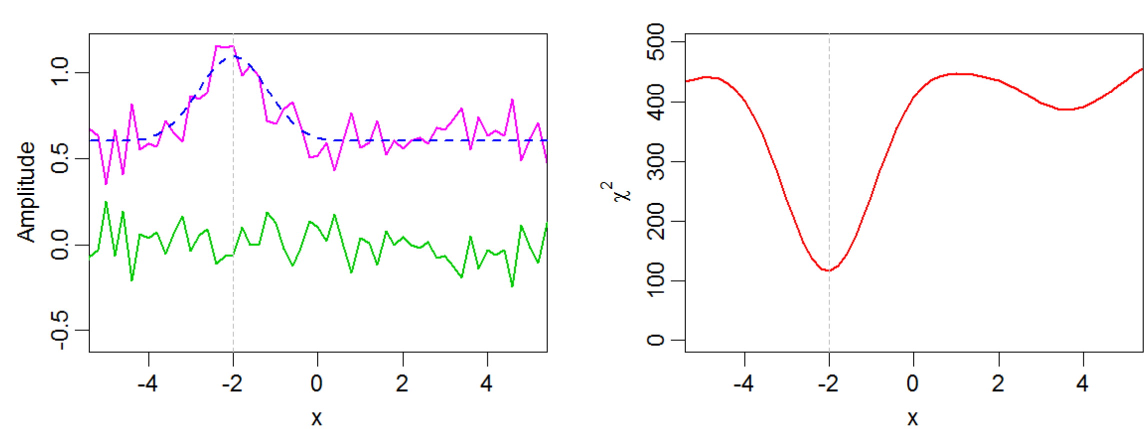
Add noise to calculation

$$\chi^2 = \sum_{i=1}^{N} \left(\frac{x_i - \text{model}_i}{\sigma_i} \right)^2$$



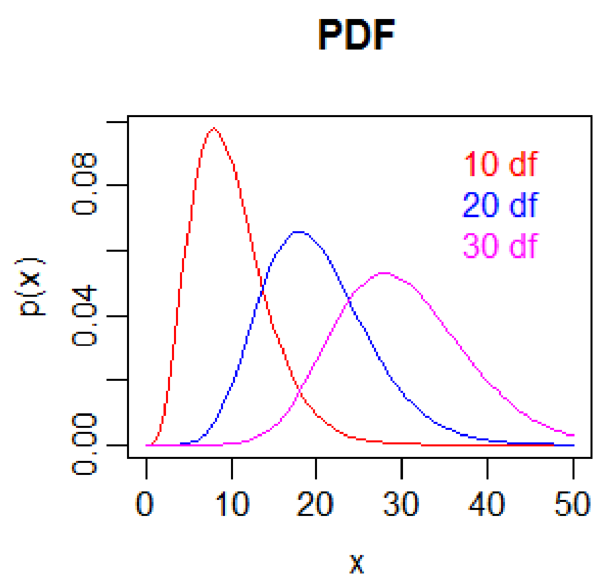
$$\chi^2 = \sum_{i=1}^{N} \left(\frac{x_i - \text{model}_i}{\sigma_i} \right)^2$$

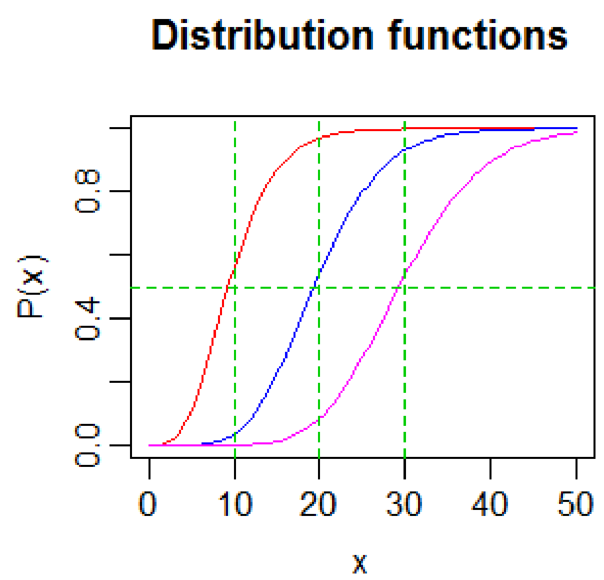


$$\chi^2 = \sum_{i=1}^{N} \left(\frac{x_i - \text{model}_i}{\sigma_i} \right)^2$$

Can’t we get more information that just the location of a minimum?

χ² PDF and CDF

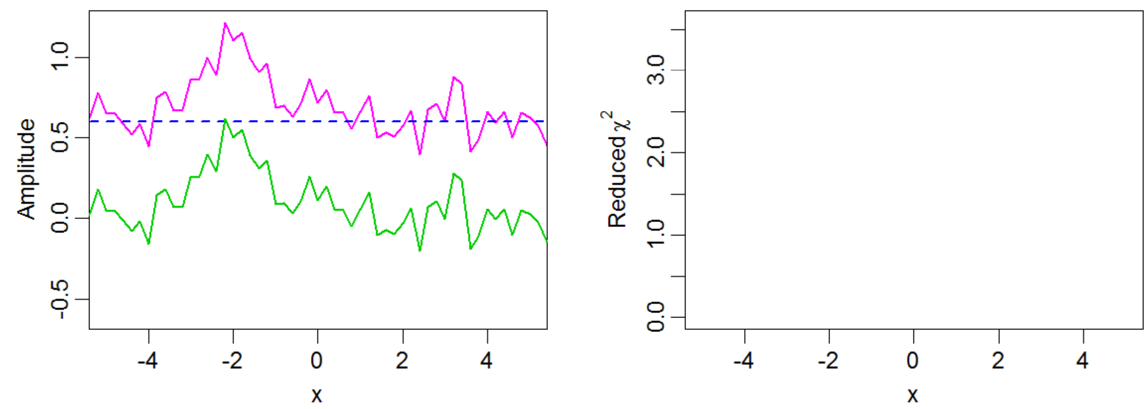




Reduced χ² with noise

Divide by degrees of freedom for "reduced χ²"

$$\chi_r^2 = \frac{1}{df}\sum_{i=1}^{N}\left(\frac{x_i - \text{model}_i}{\sigma_i}\right)^2, \quad df \le N$$



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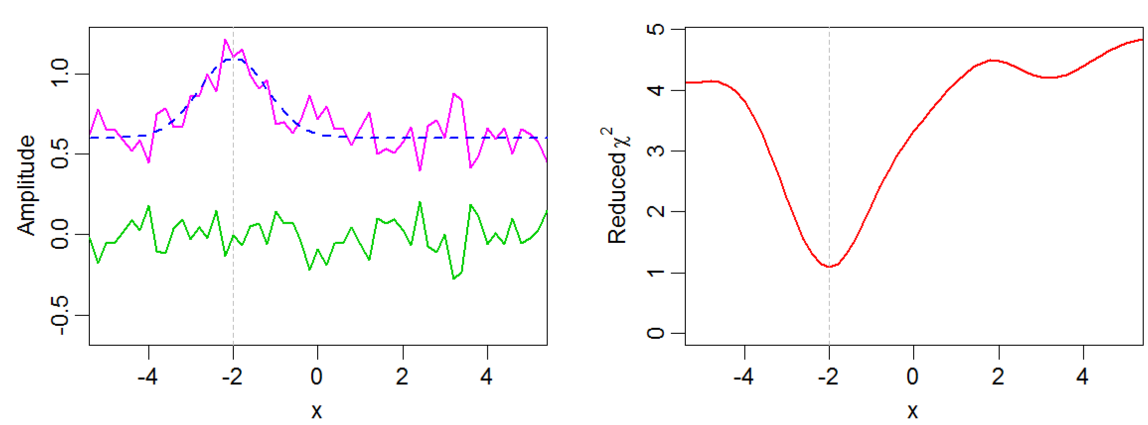

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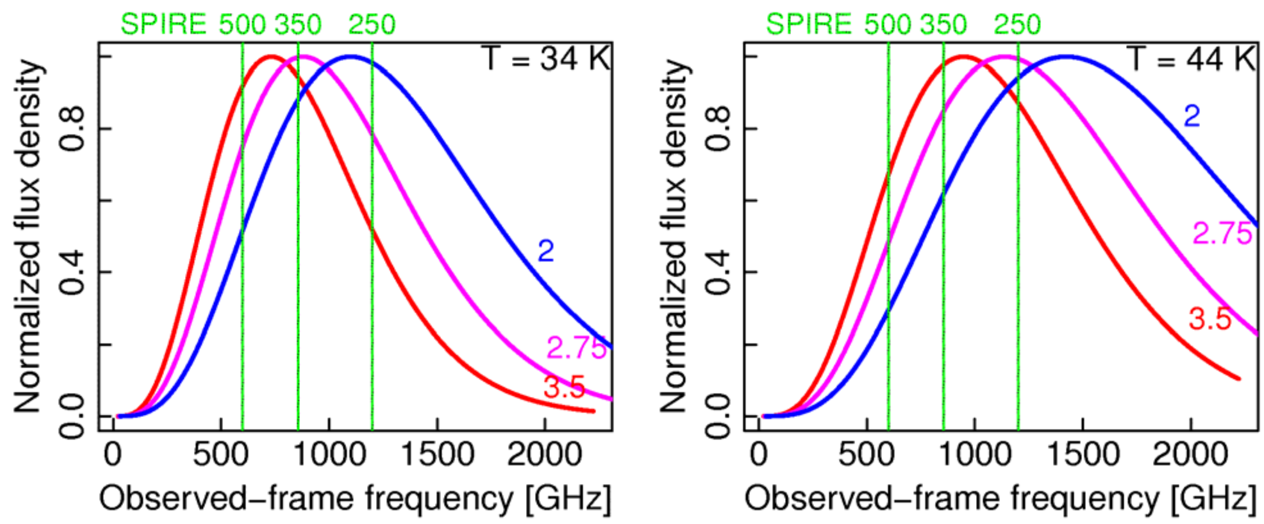
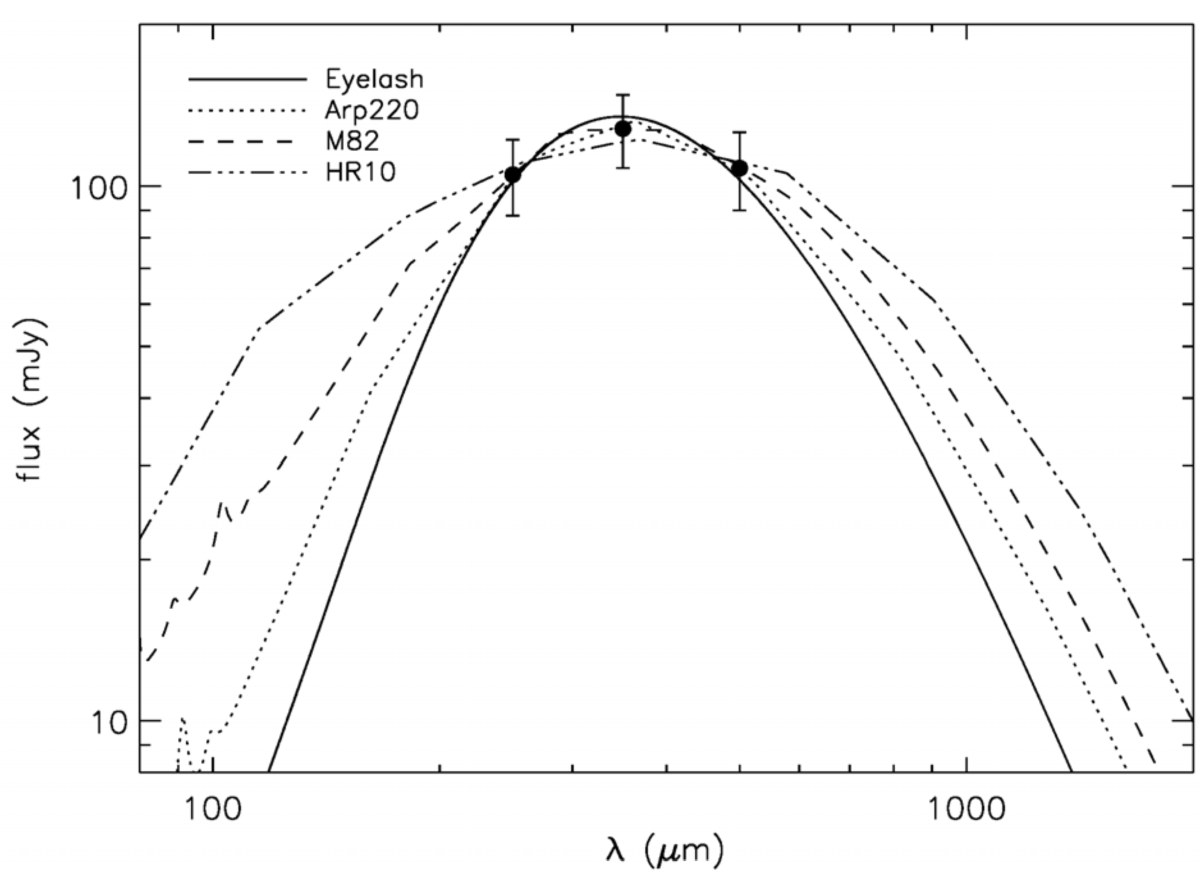
Photometric redshifts and the T-*z* degeneracy

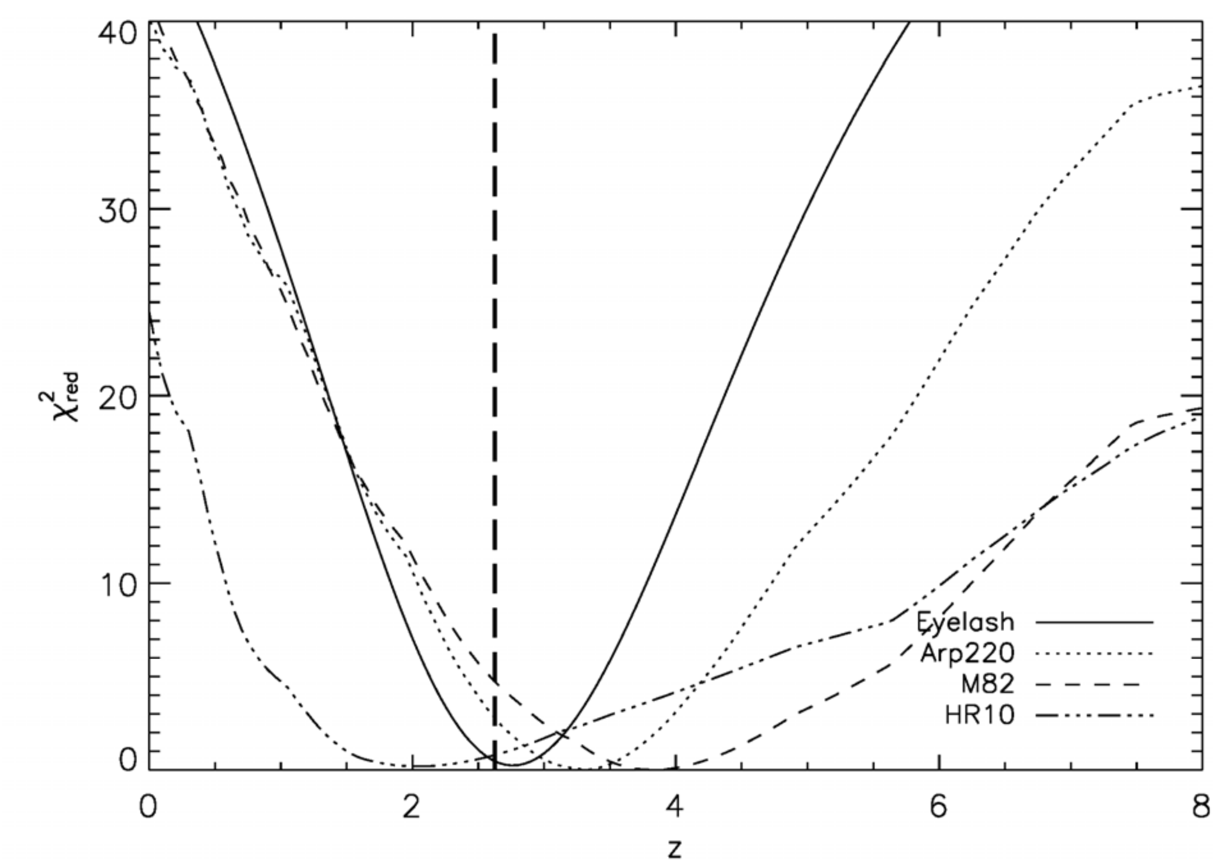


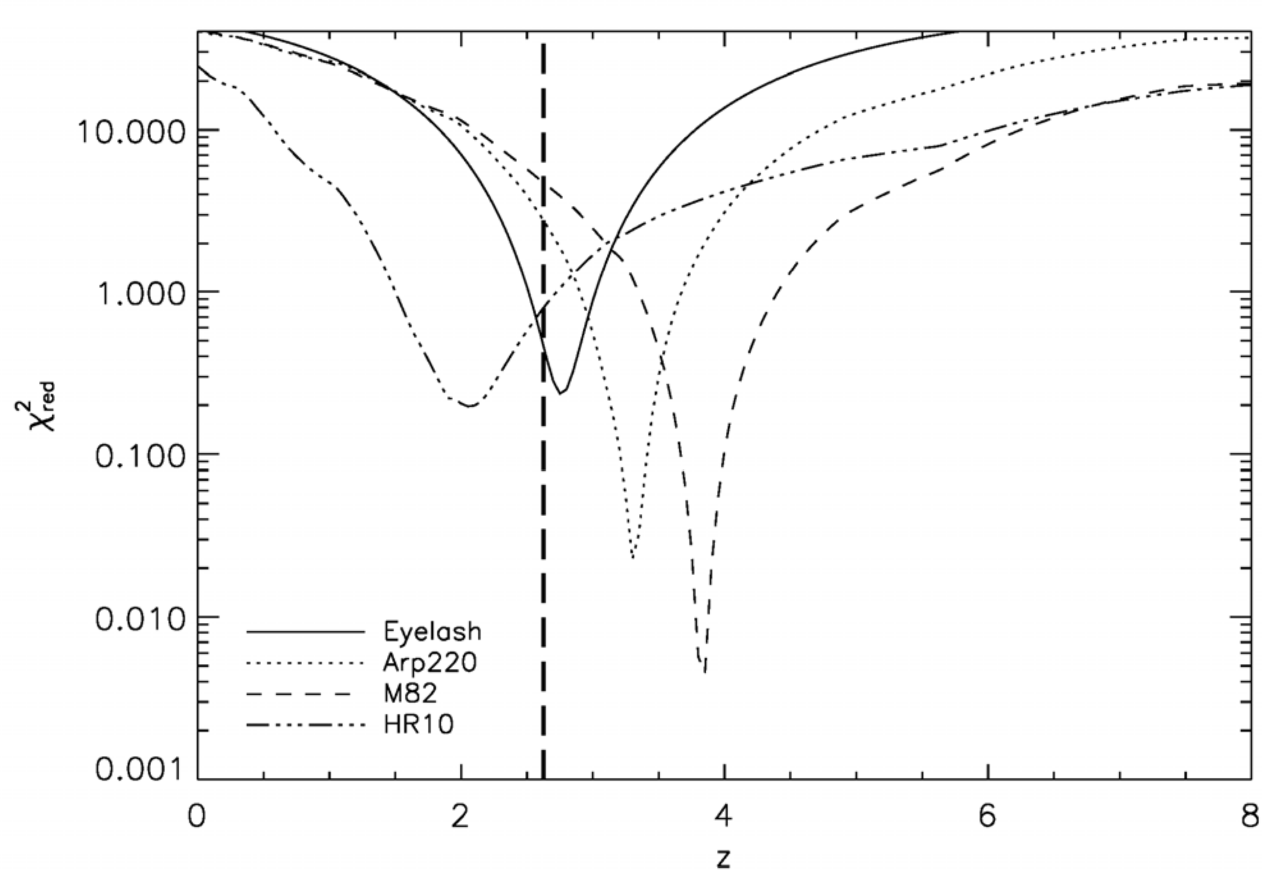
$$\lambda_{\max} T = \text{constant}$$ Wien's displacement law

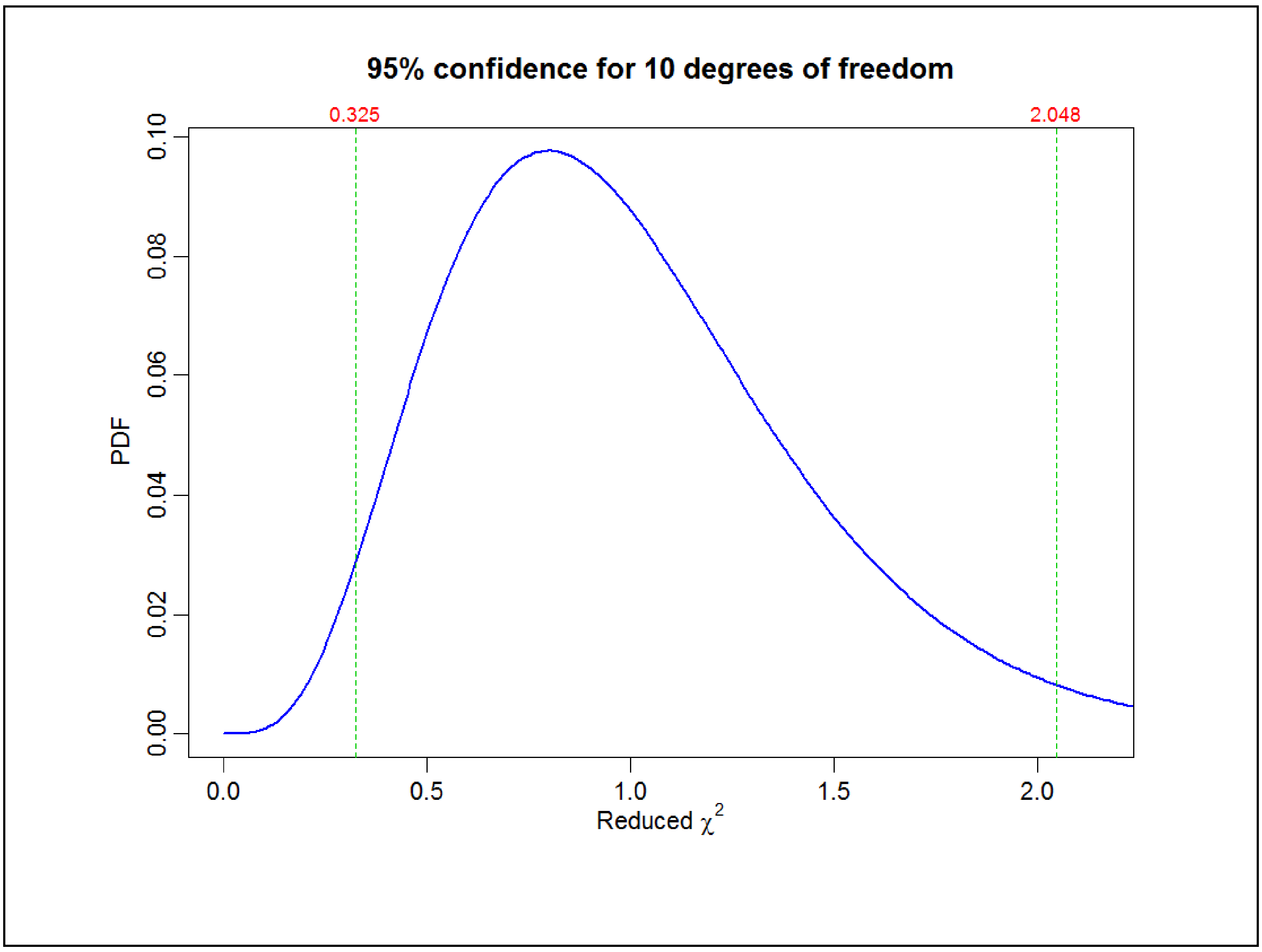
$$\lambda_{\text{max, observed}} = \frac{\lambda_{\text{max, rest}}}{1+z} \Rightarrow \lambda_{\text{max, observed}} (1+z) T = \text{constant}$$

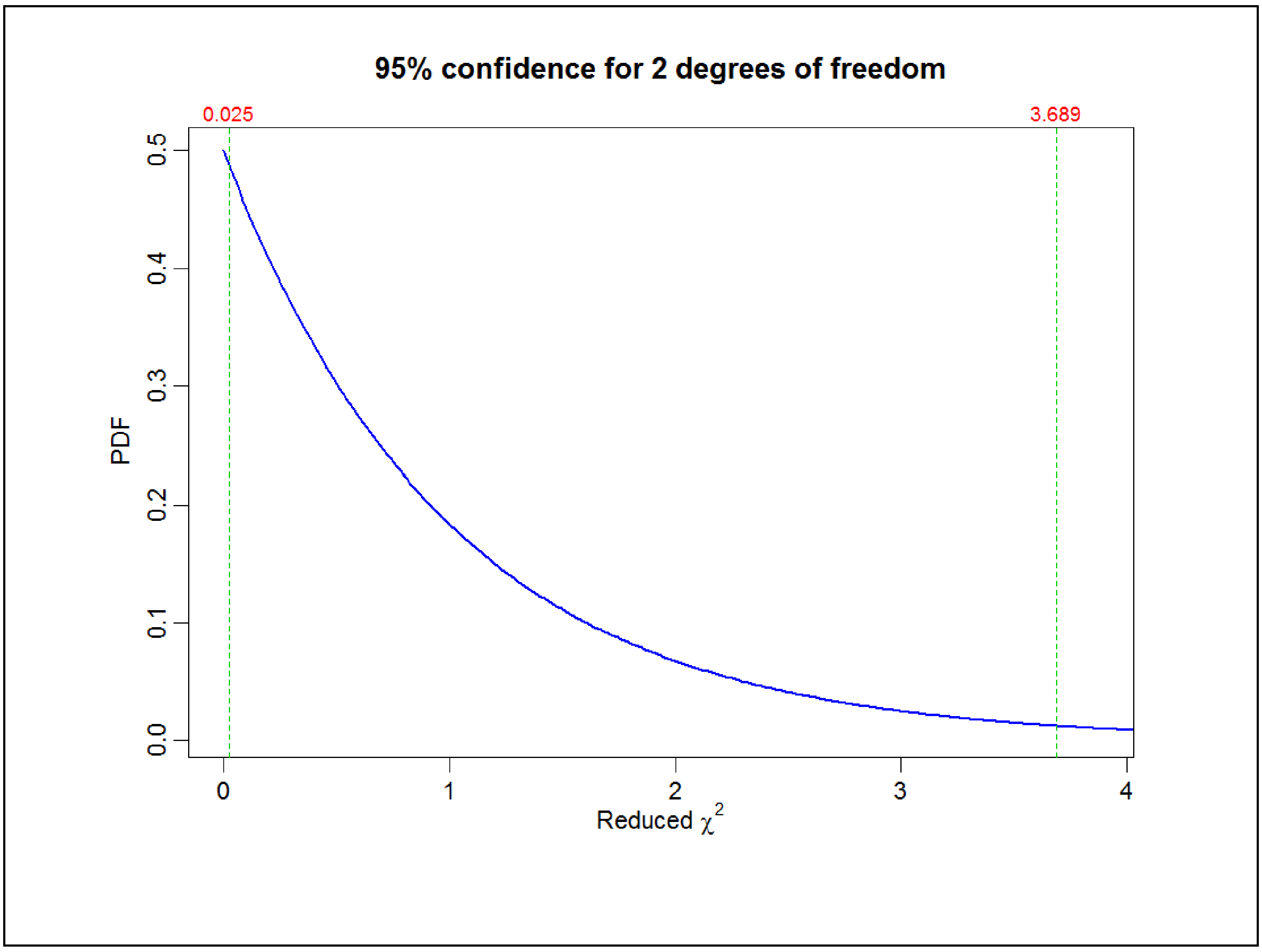
Modified for redshift

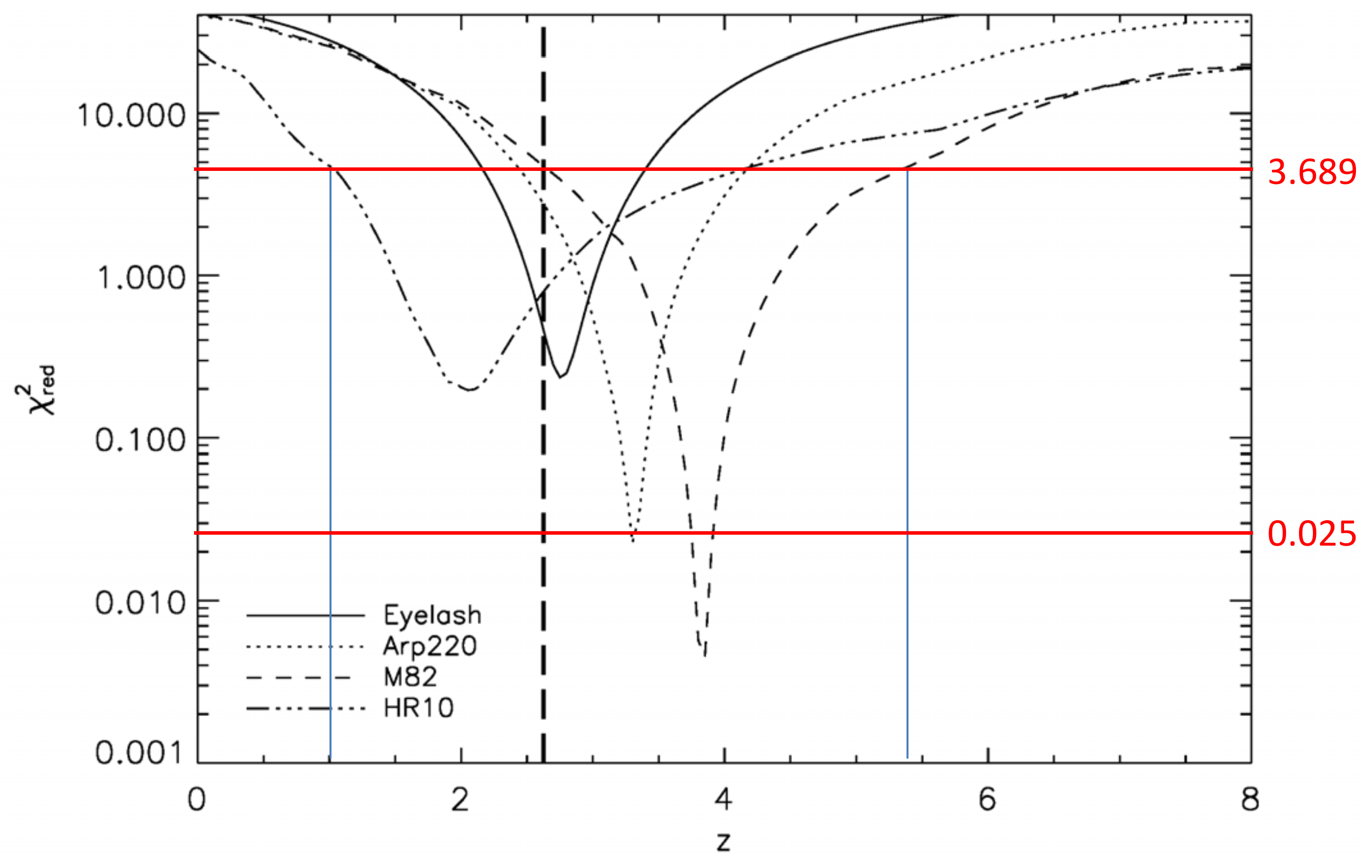


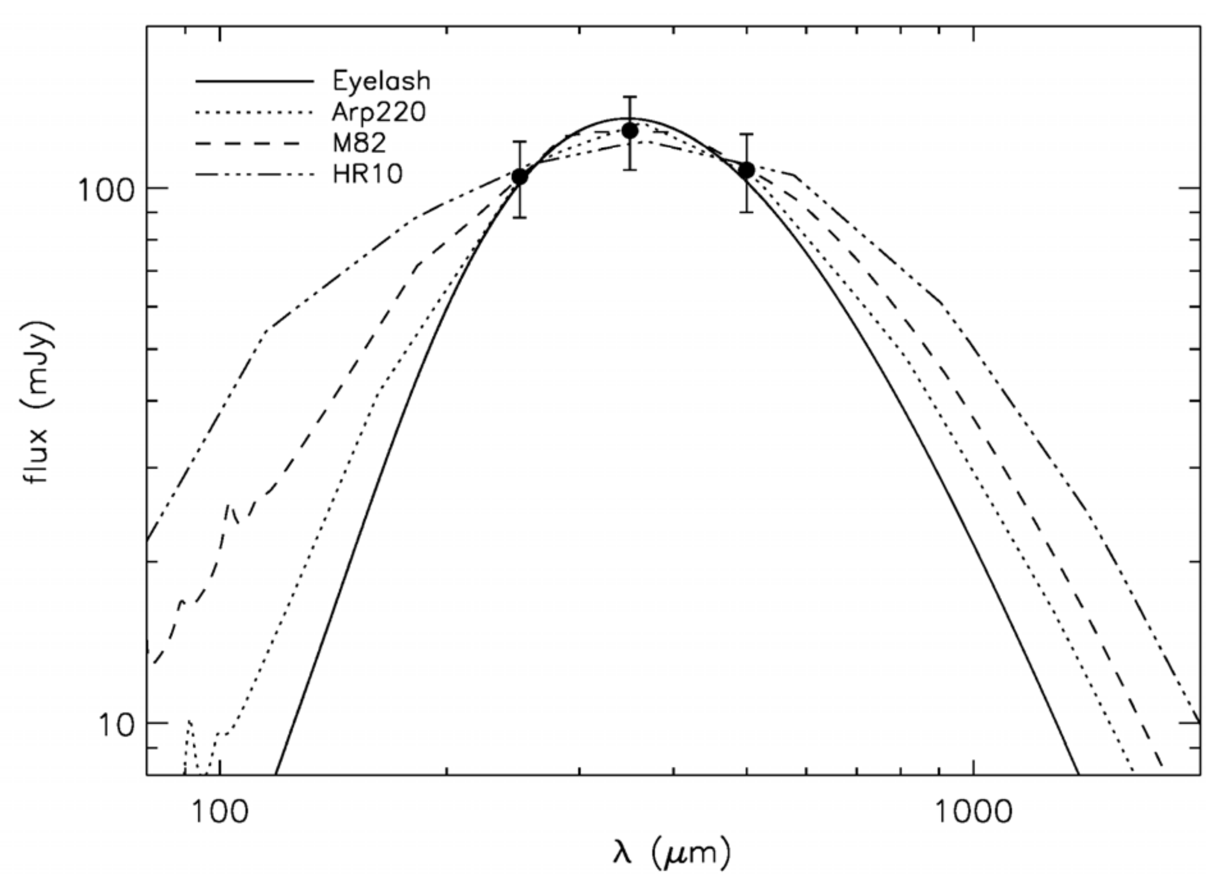

40
30
20
10
0
χ^2_{red}
0
2
4
6
8
z
Eyelash
Arp220
M82
HR10


10.000
1.000
0.100
0.010
0.001
χ^2_{red}
0
2
4
6
8
z
Eyelash
Arp220
M82
HR10


95% confidence for 10 degrees of freedom
0.325
2.048
PDF
0.00
0.02
0.04
0.06
0.08
0.10
0.0
0.5
1.0
1.5
2.0
Reduced χ2

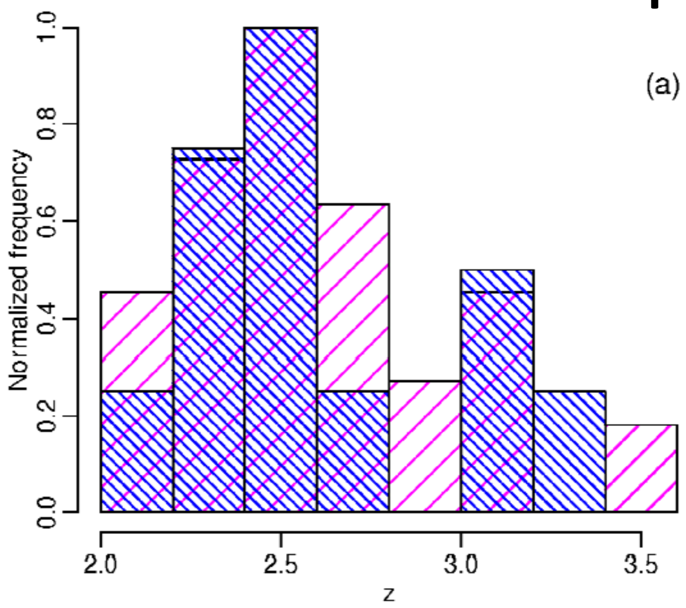

95% confidence for 2 degrees of freedom
0.025
3.689
PDF
0.0
0.1
0.2
0.3
0.4
0.5
0
1
2
3
4
Reduced χ2





Moral: it's hard to pin down the center of a peak with only values near the peak itself!

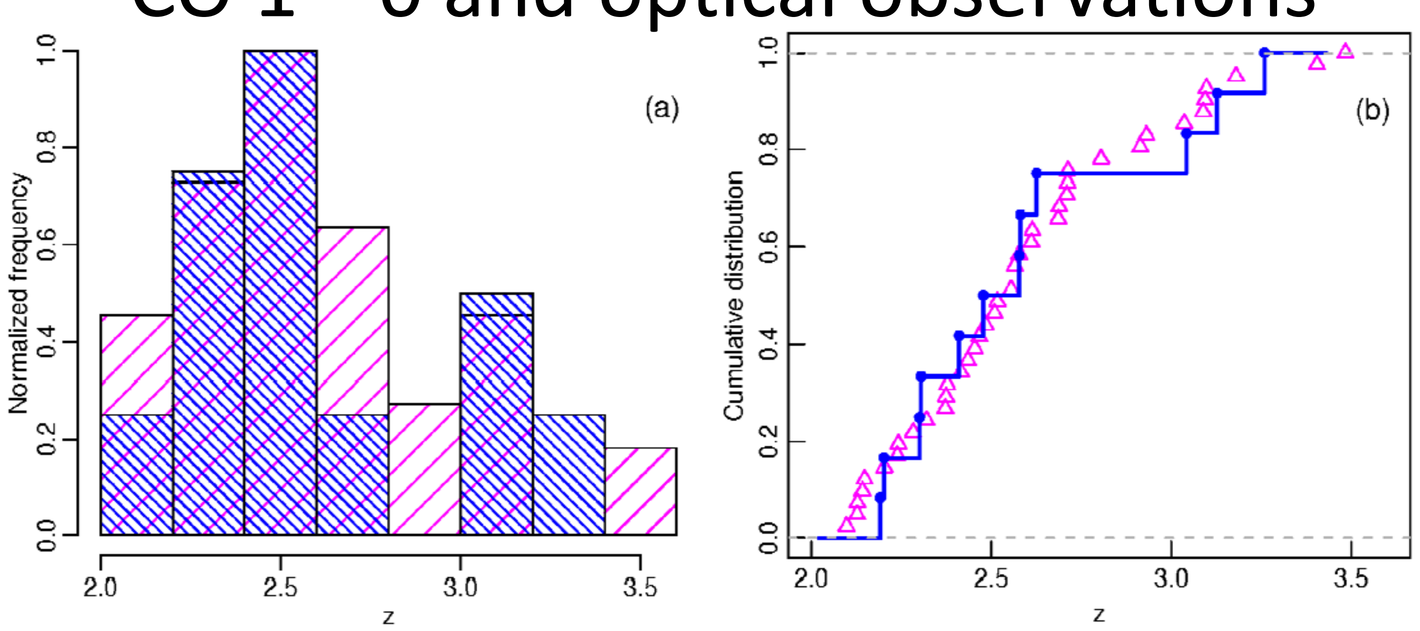
Redshift distributions from CO 1—0 and optical observations



Blue: CO, Harris et al. 2012
Magenta: Optical, Chapman et al. 2005

Harris et al. 2012

Redshift distributions from CO 1—0 and optical observations



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Harris et al. 2012

Poisson and Normal PDFs