Optimal Resolutions for Optical and IR Spectroscopy through Atmospheric Emission Lines

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Why do we want the "best" and what is it?

- Instrument design (DESpec)
- Observing proposals
- Data analysis

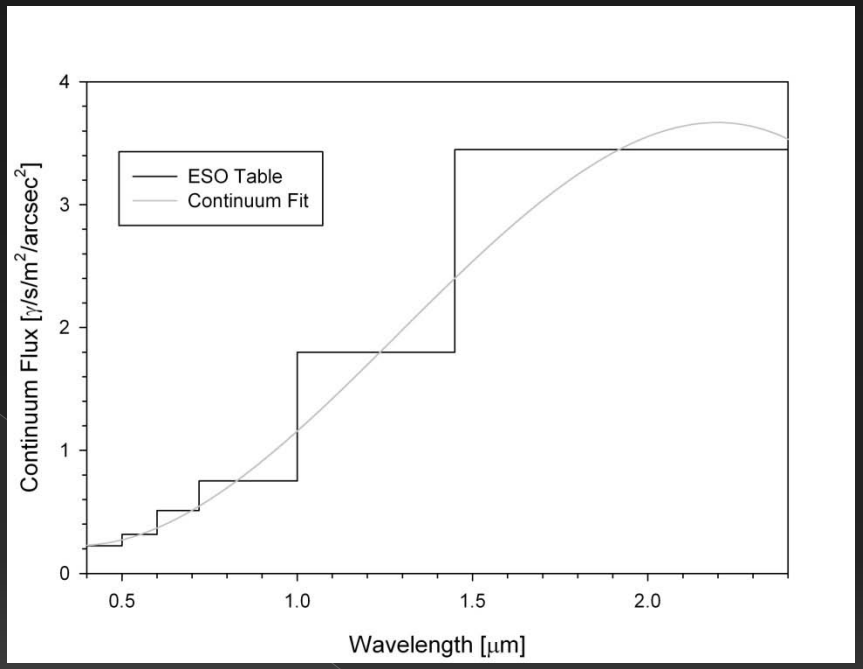
- Example: Observing a faint object in the red
- Low resolution = lots of emission lines
- High resolution = low signal

- Maximize number of pixels without emission lines?
- Maximum SNR in 1 pixel?
- Maximum SNR in all pixels?

- Quality vs Quantity

First we need a background

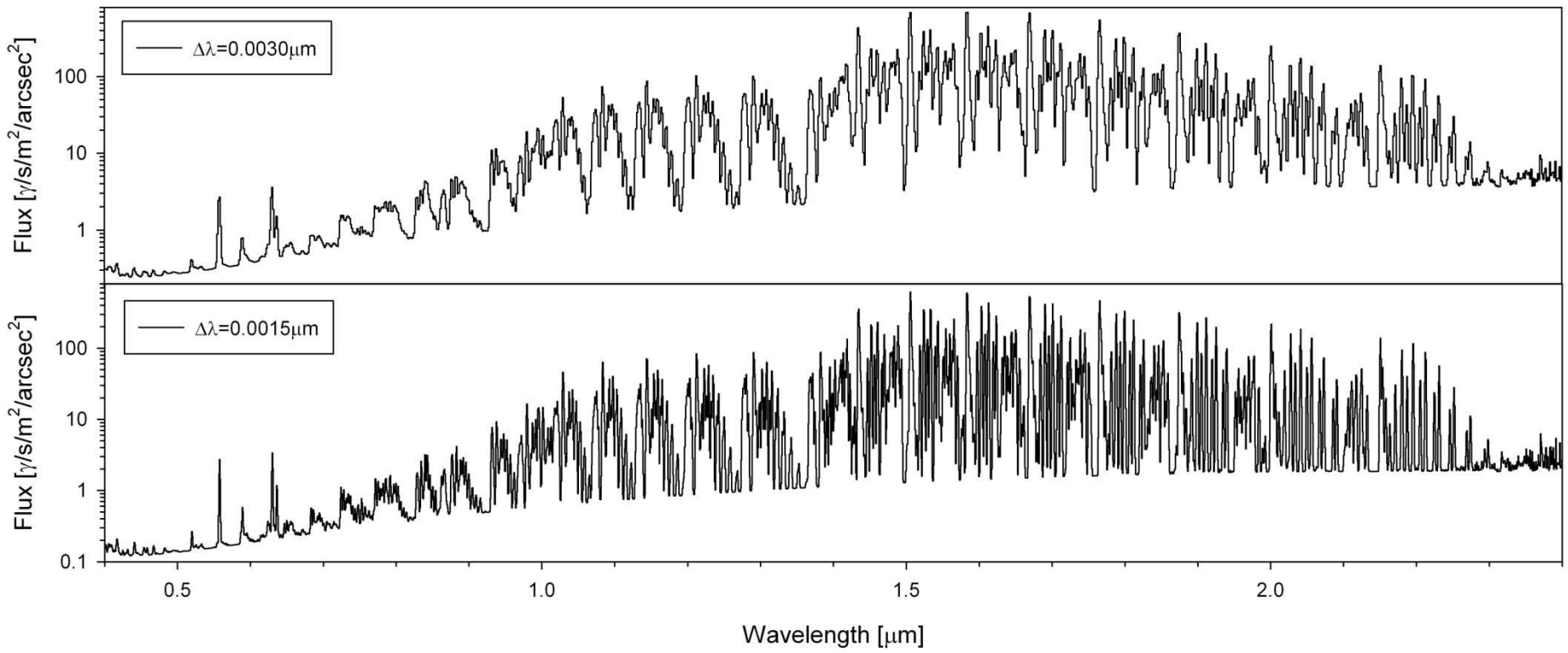
- Google: ESO atmospheric emission and download emission line and thermal emission files
- Fit a polynomial to the ESO table of continuum values
- Convert each emission line into a Gaussian at each resolution



$$f_i(\lambda) = a_i e^{\frac{-(\lambda - b_i)^2}{2c^2}}$$

First we need a background

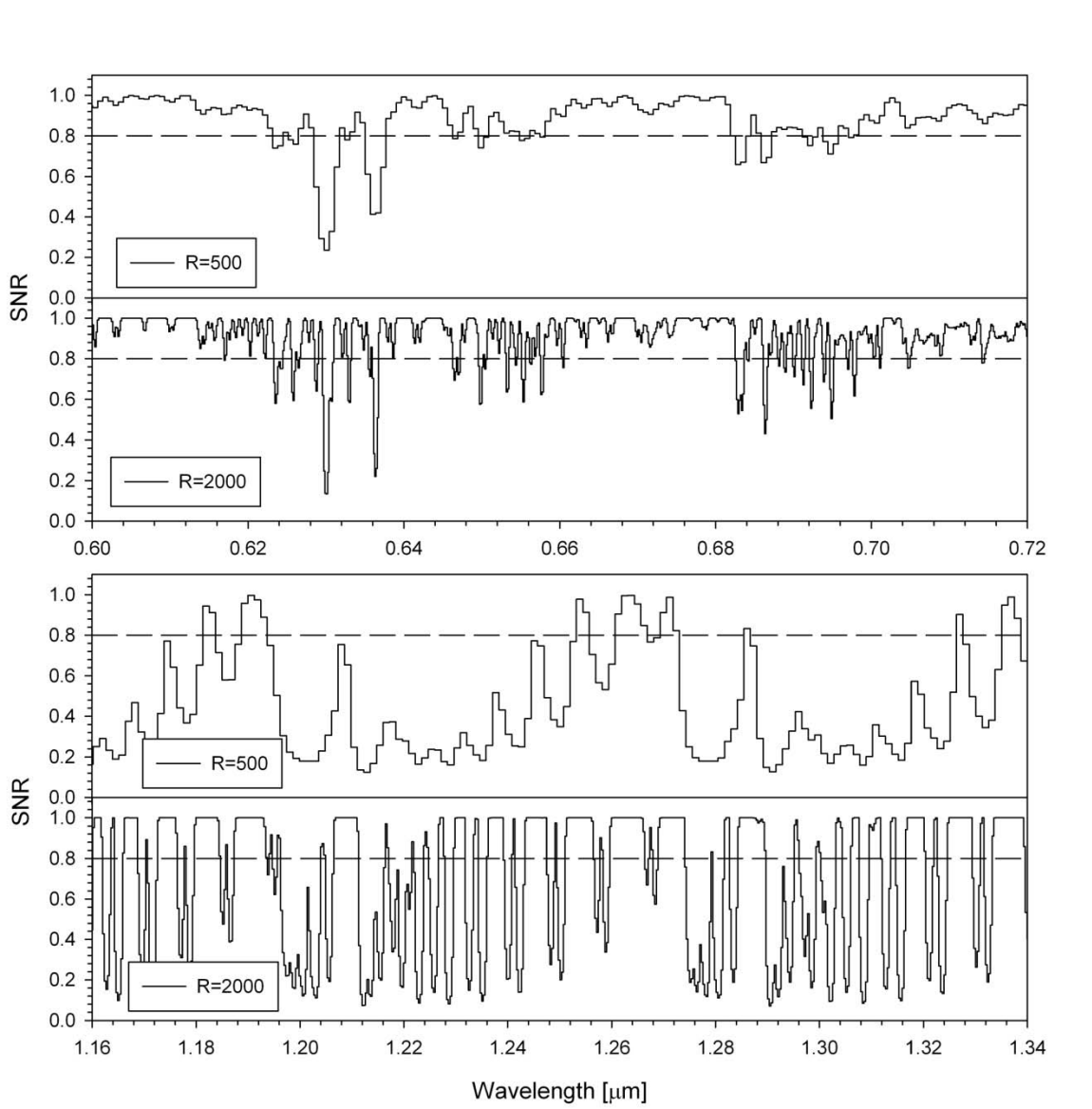
- The final spectra at each resolution is the sum of the continuum, thermal sky emission, and the Gaussian emission lines.



What is a contaminated pixel?

- We define a contaminated pixel based on the square root of the ratio of the continuum to the background

$$\frac{\sqrt{continuum}}{\sqrt{continuum + emission\ lines + thermal\ emission}} \leq 0.8$$



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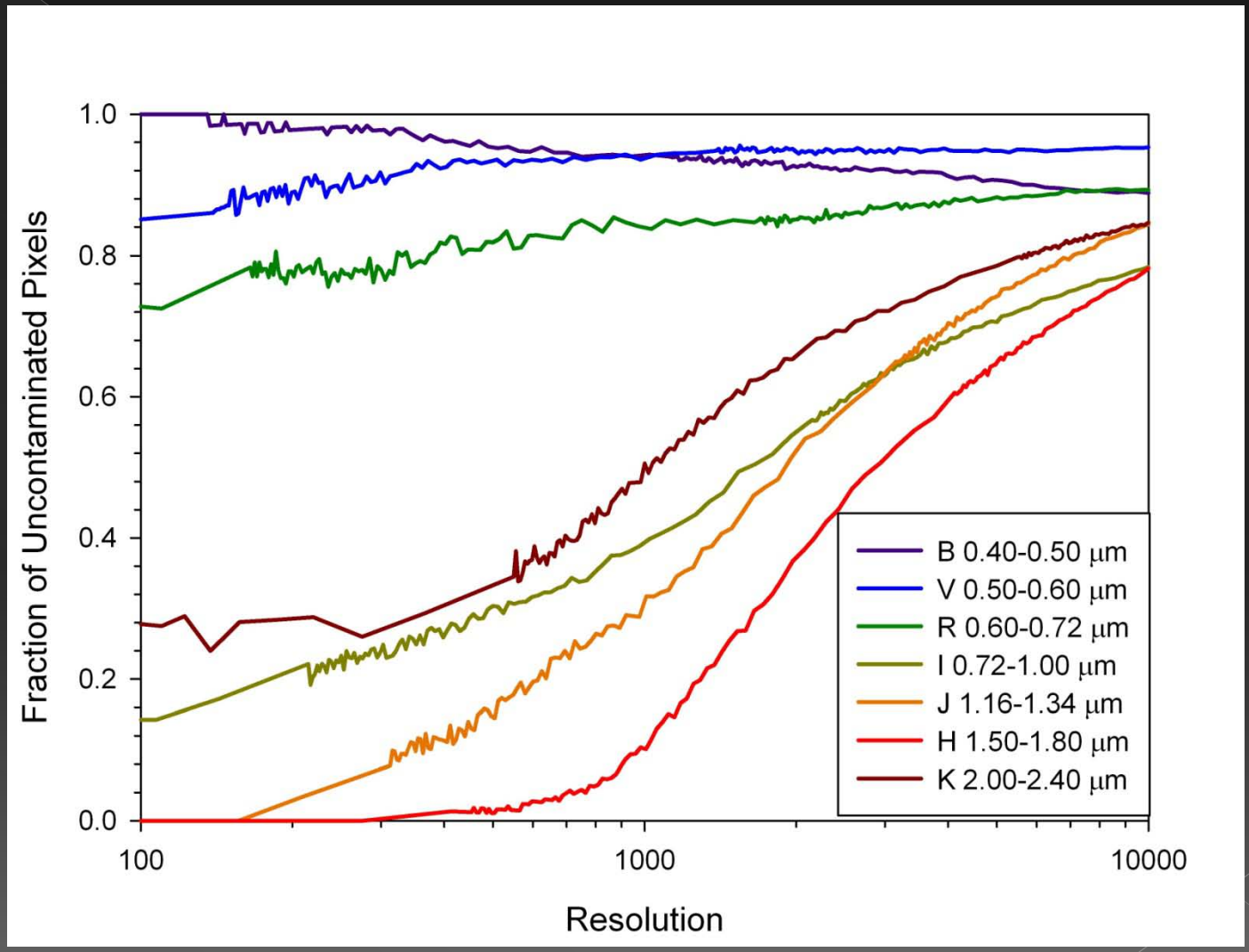
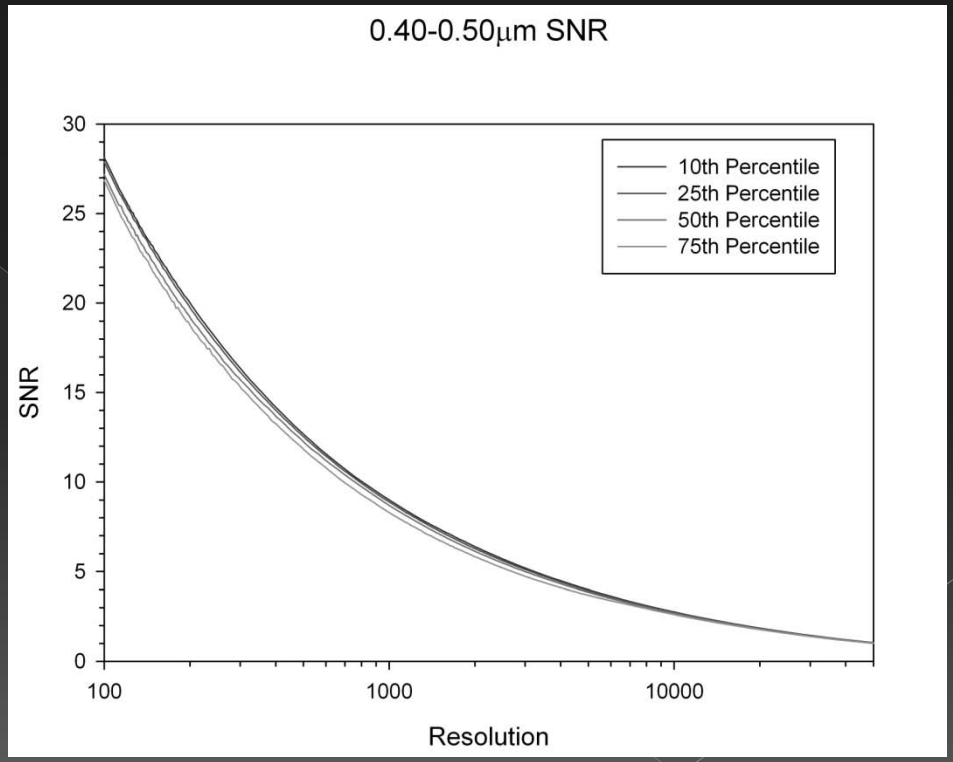


- So maximize the resolution

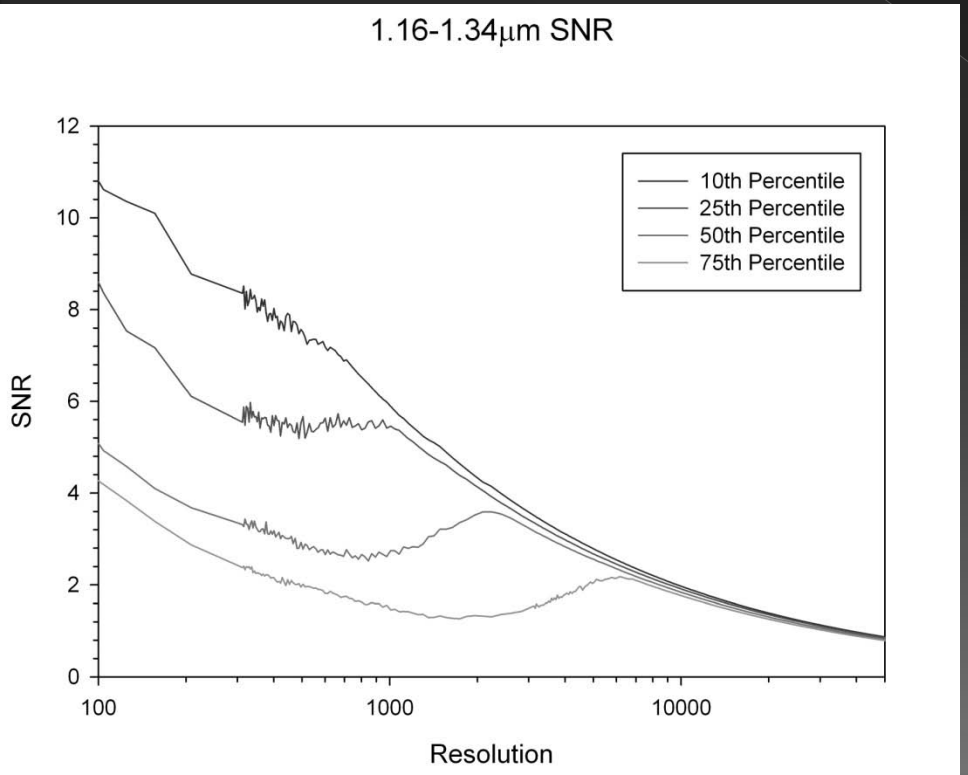
What happens to the SNR?

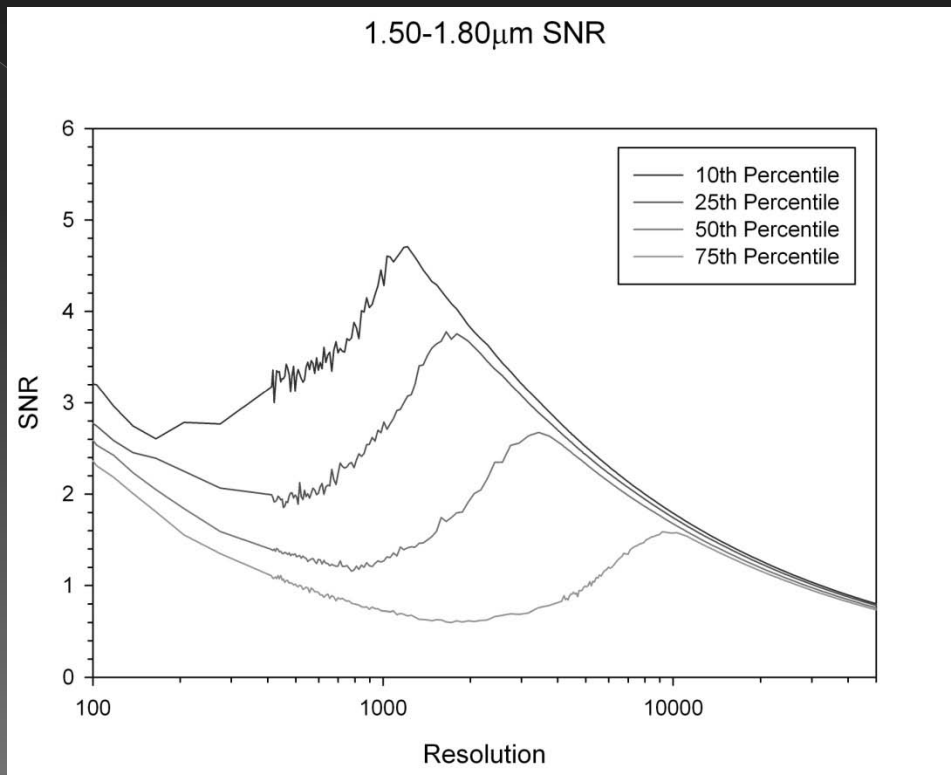
- Decreasing resolution increases SNR
- Create a target object with constant flux per wavelength and calculate the SNR in each pixel
- Rank order the pixels and evaluate the 10^{th}, 25^{th}, 50^{th} and 75^{th} percentiles



What happens to the SNR?

- As the emission lines become stronger, the SNR diverges from the expected value resulting in a maximum over some wavelength ranges





Going forward

- Find the optimal resolution to maximize SNR as a function of target magnitude
- Investigate the effects of varying line and continuum strengths and widths
- Use contaminated pixel criteria to mask bad pixels and bin to obtain greater SNR
- Questions?