How many exposures should be taken to reach a particular signal level?

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5 April 2008

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How many exposures?

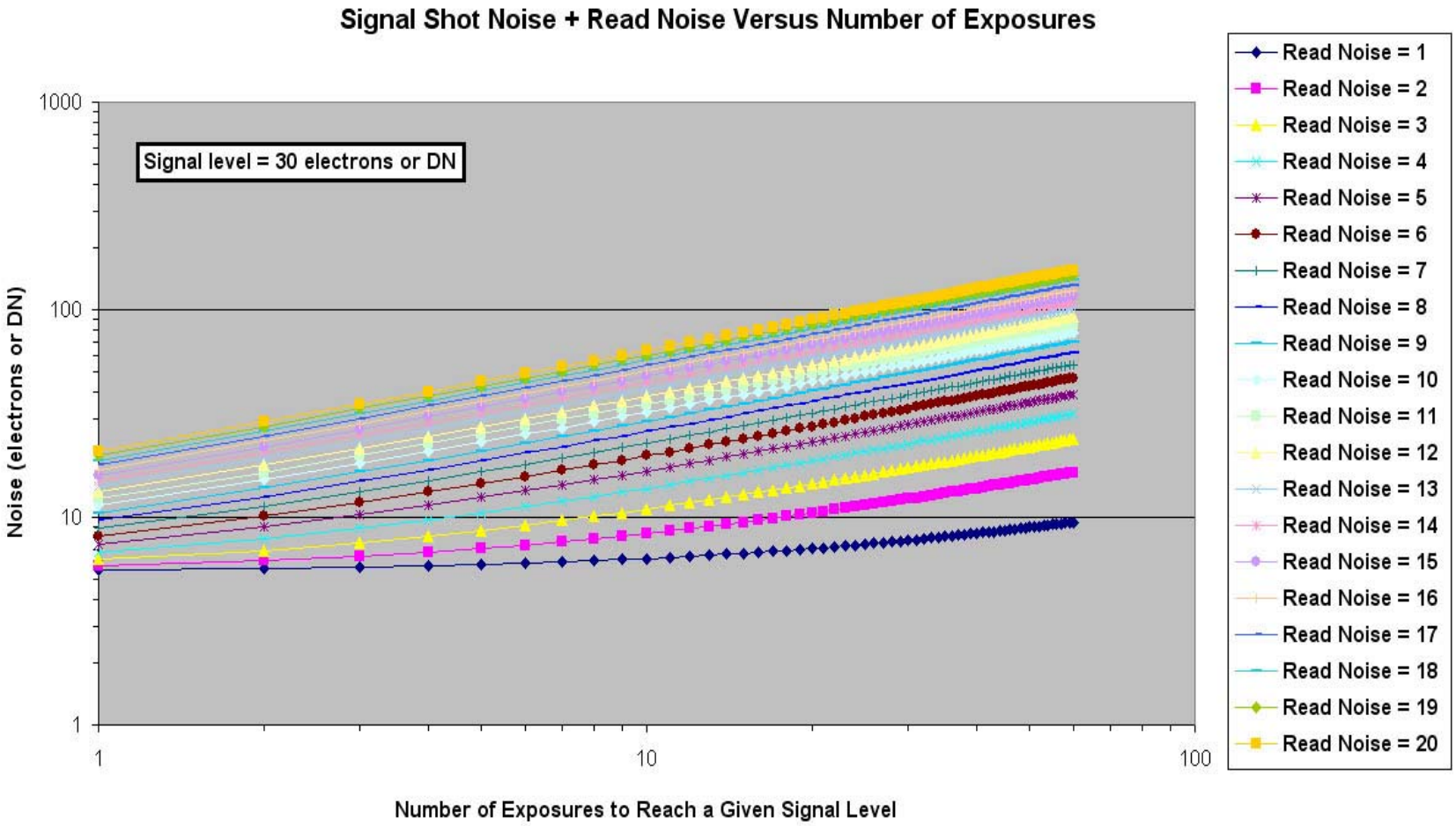
- Assume you want to take N minutes total exposure time
- How many exposures should you take to get N minutes total integration time?
  - One long exposure might be good except for saturation and blooming or excessive dark current and maybe aircraft/spacecraft trails or poor tracking
  - More exposures that are short may degrade the s/n due to cumulative read noise effects

Assumptions for this analysis

- Dark shot noise, dark fixed pattern noise, Light fixed pattern noise and sky background are all ignored
  - Dark shot and Dark fixed pattern noise addressed via cooling
  - Light fixed pattern noise addressed by flat-fielding
  - Background is suppressed by imaging in dark skies with emission line filters
- All that is considered is Signal Shot noise and Read Noise
- Noise = SQRT (signal + read_noise^2)
- S/N = signal / noise

Cases examined

- Signal level of 3000, 300 and 30 (units of electrons or DN, either is OK to use so long as you don’t mix units)
- Number of exposures ranges from 1 to 60
- Read noise ranges from 1 to 20 units (electrons or DN, your choice which way you want to interpret the units)



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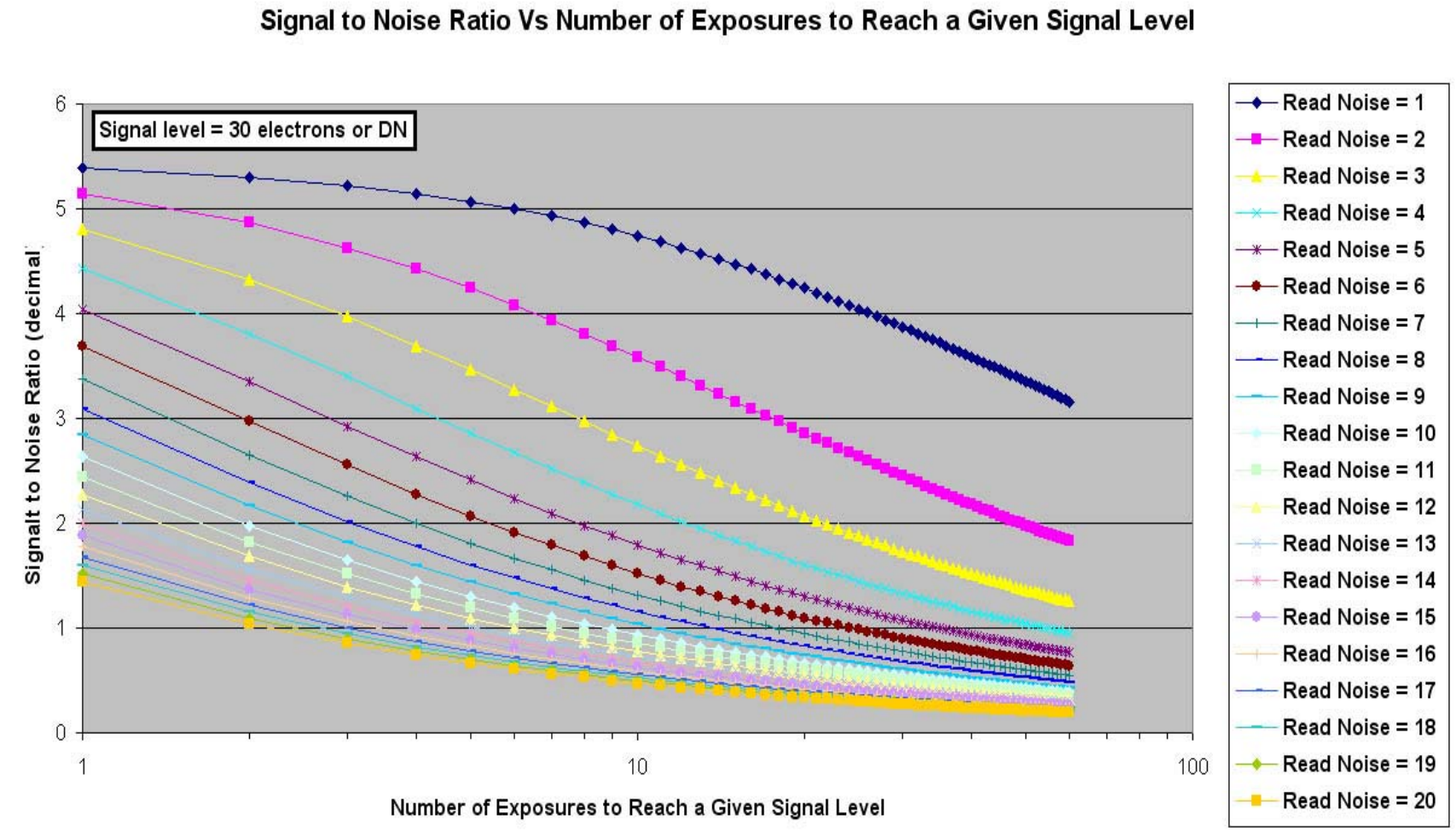

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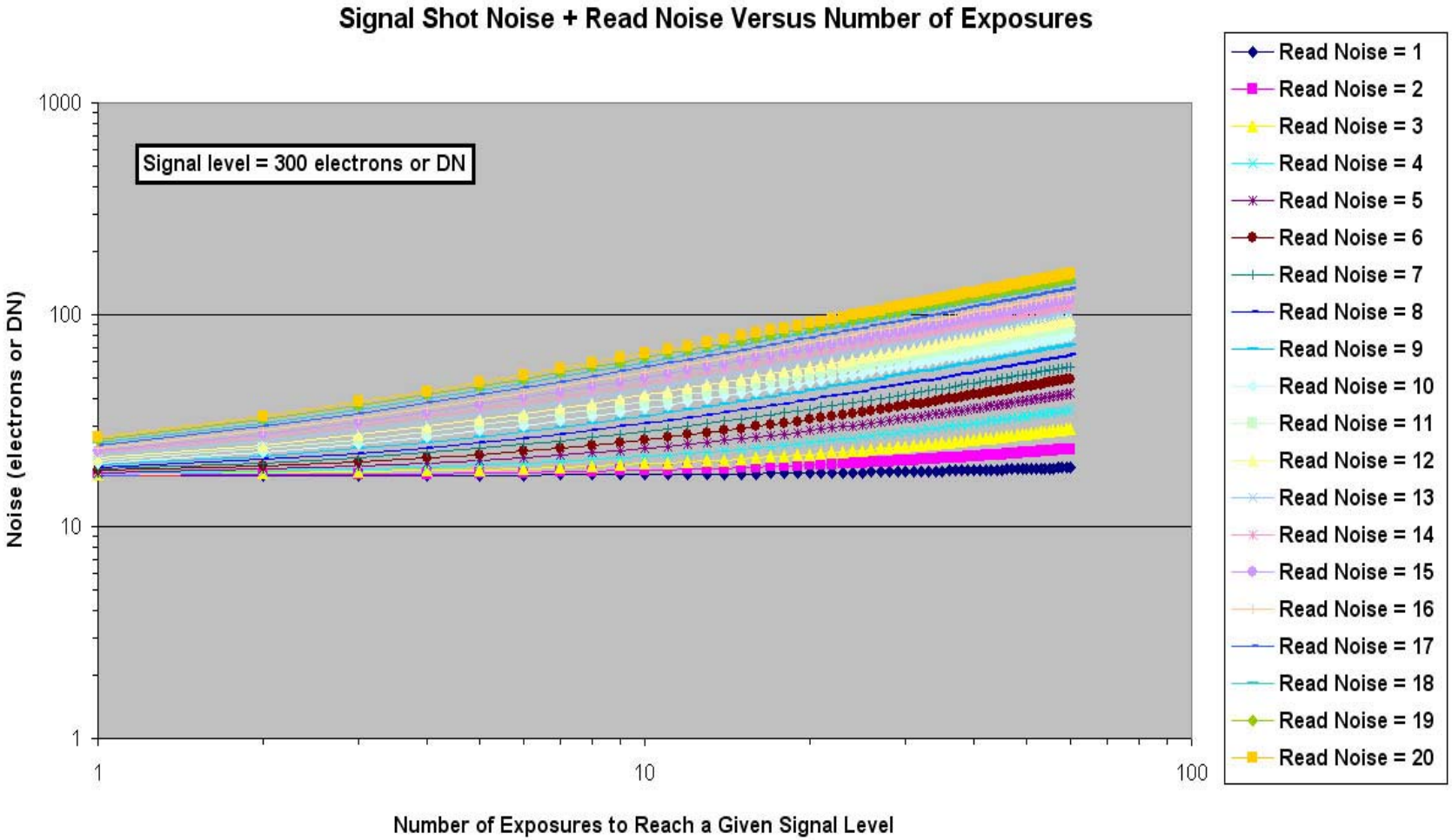

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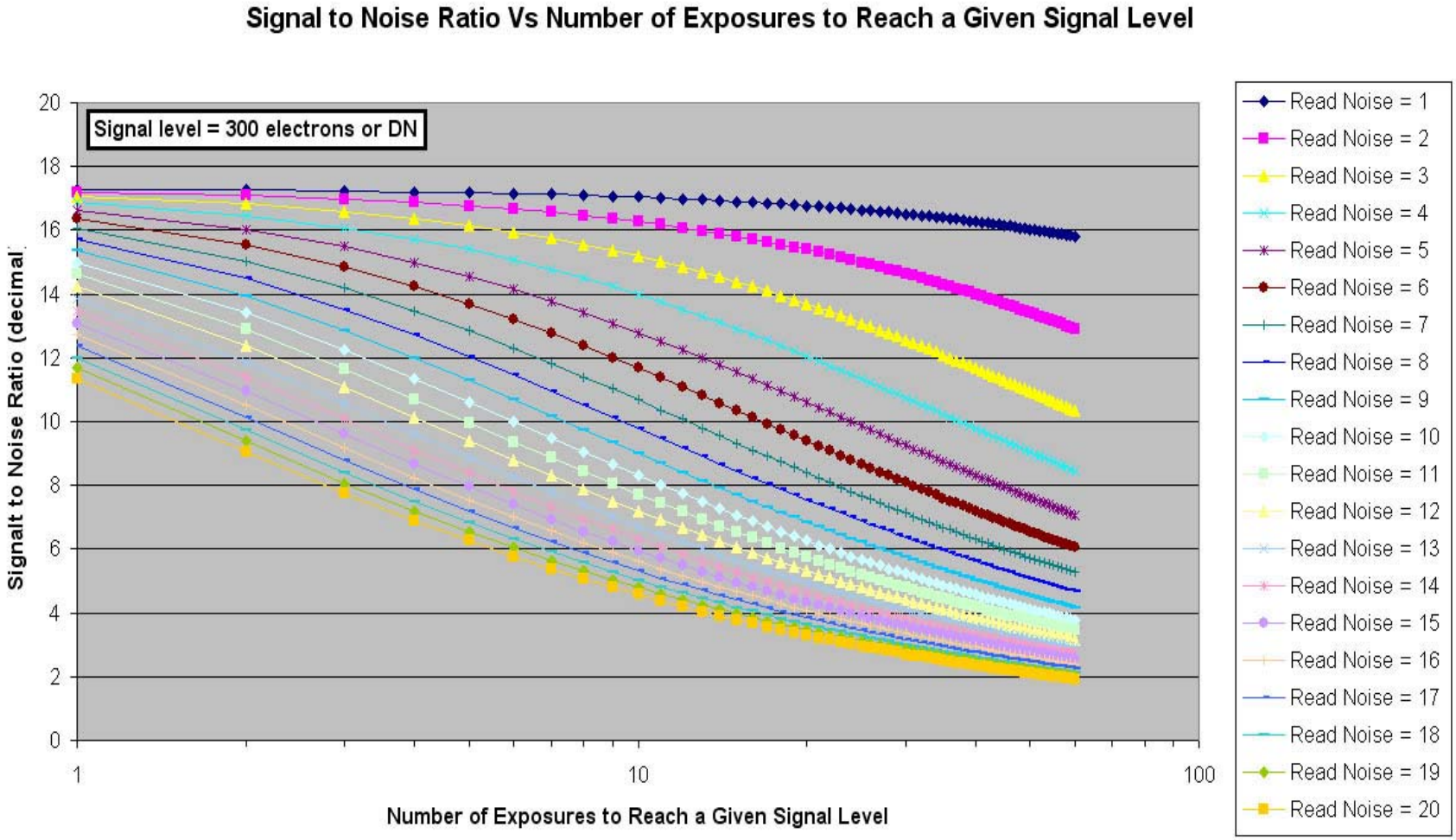

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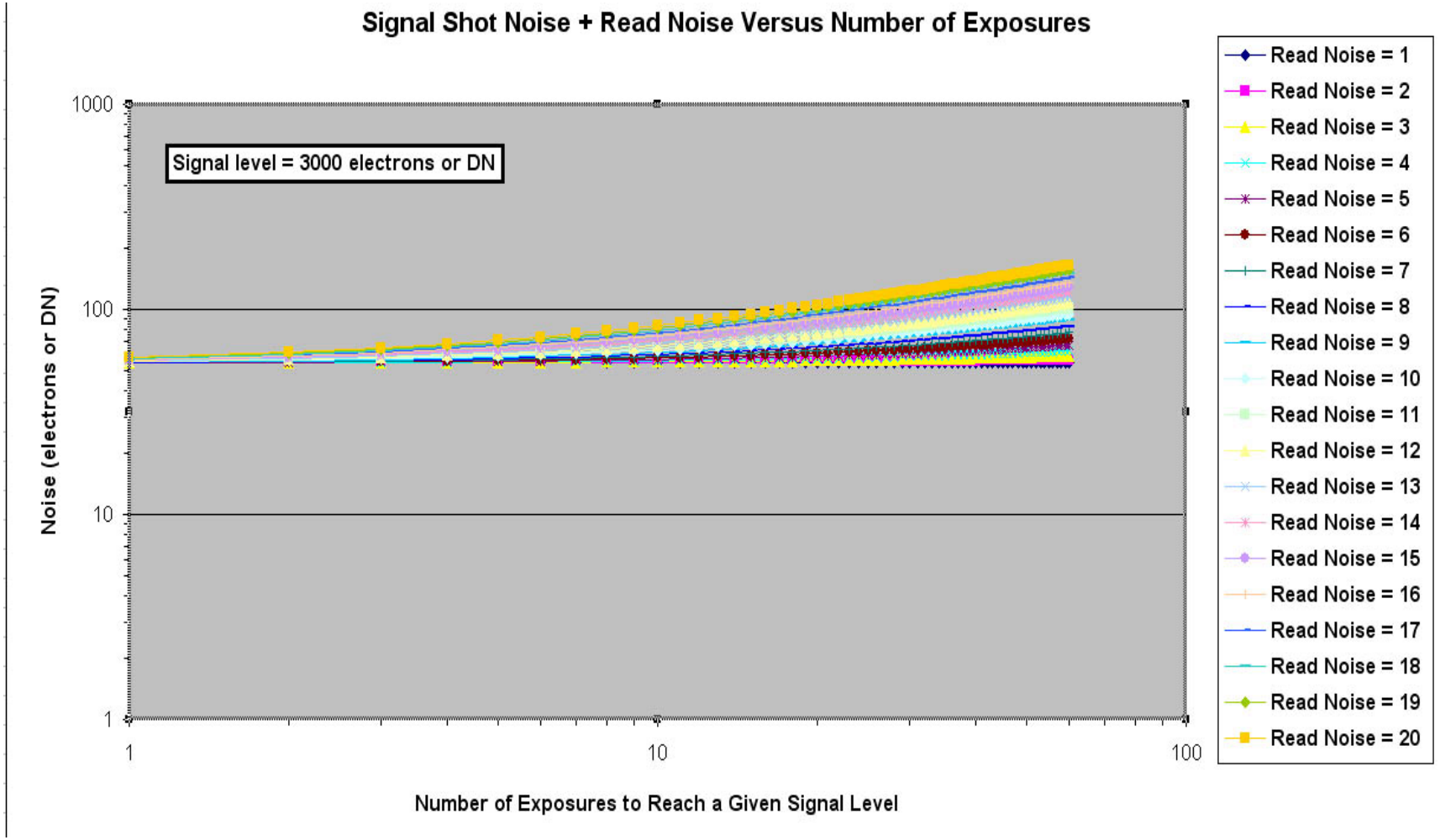

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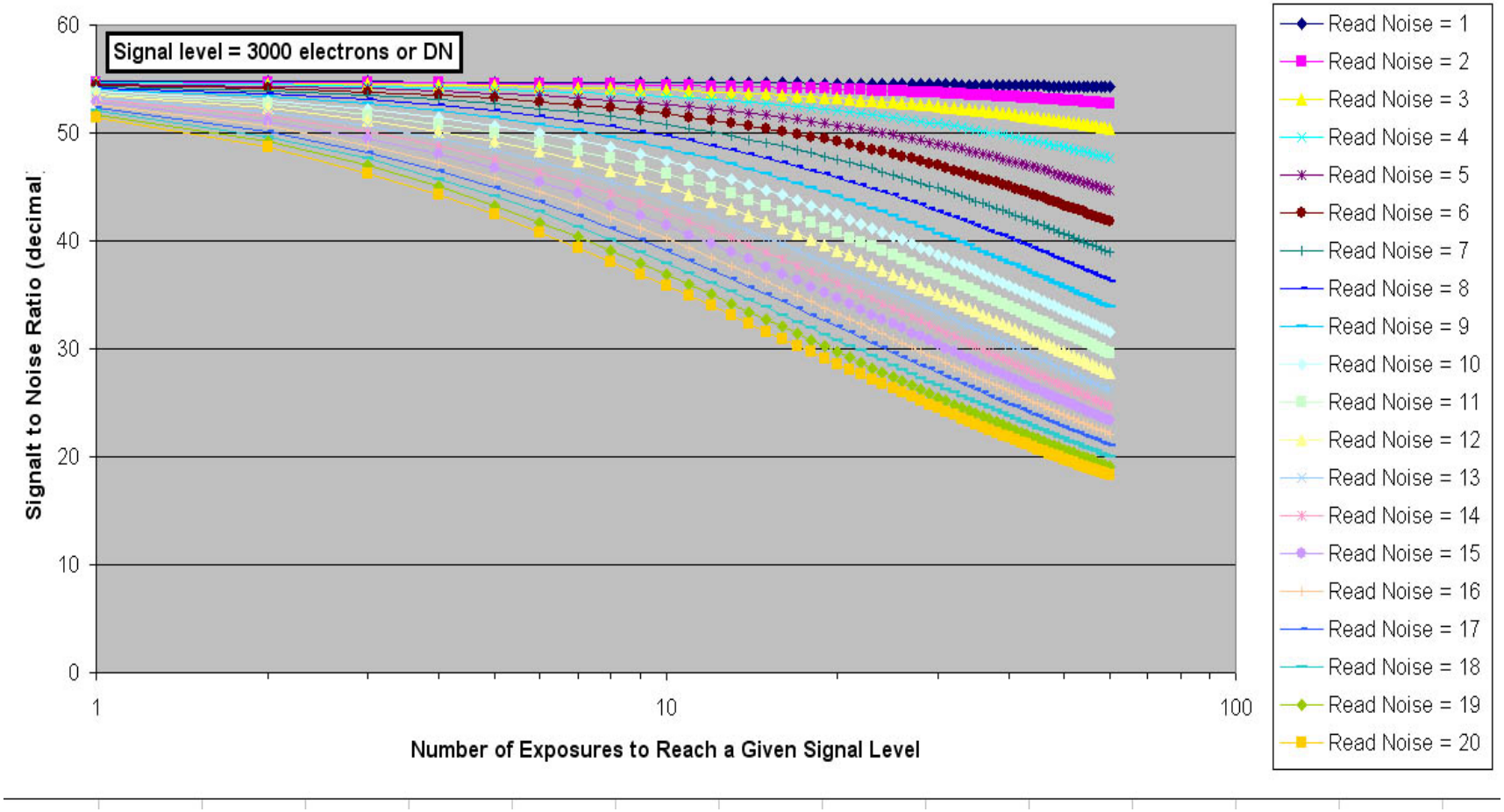
Signal to Noise Ratio Vs Number of Exposures to Reach a Given Signal Level



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Interpretation of Results

- To minimize camera-contributed noise, minimize the number of exposures and maximize their length
  - Set the exposure length based on avoiding saturating stars and on the basis of dark shot noise being less than read noise (sqrt (dark_signal) < read_noise)
- Higher object signal levels are more tolerant of larger number of exposures without degrading the S/N of the final image
  - Lower object signal levels should use fewer and longer exposures
- Higher read noise aggravates the noise problem
  - The higher the read noise the fewer exposures can be tolerated without degrading the S/N of the image for a given signal level