Read Noise impact on # exposures needed for SNR Goal

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Goals, Method

- Determine # exposures needed to stack to attain an arbitrary SNR for a given read noise and signal level
- Use noise equation to solve analytically
- Plot results for specific values

Equations

$$Noise = \sqrt{Signal + ReadNoise^2} \quad (1)$$

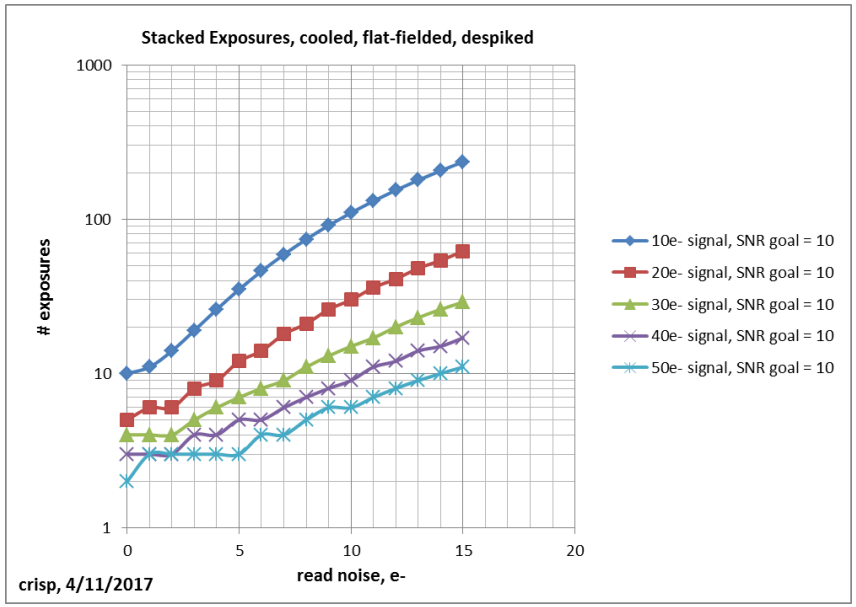
$$SNR = \frac{Signal}{\sqrt{Signal + ReadNoise^2}} \quad (2)$$

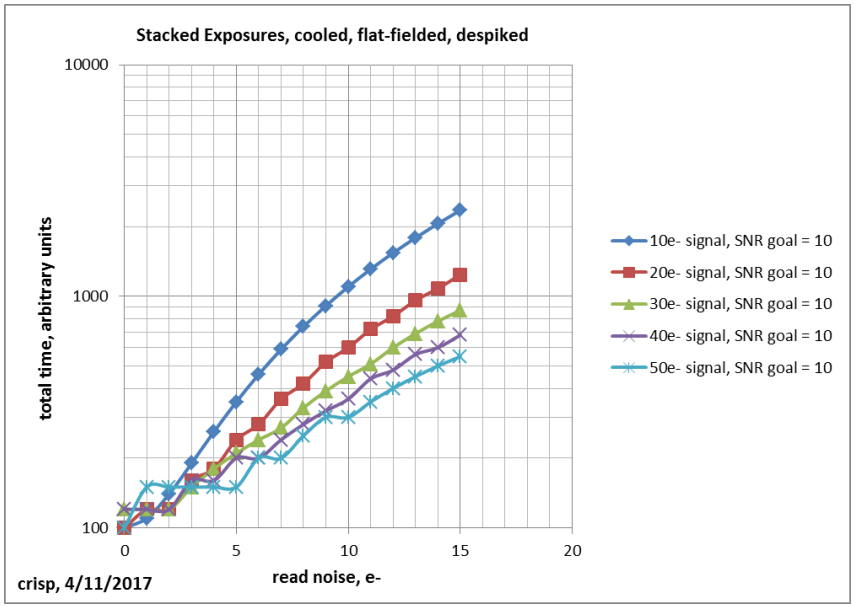
Results for Specific Cases

- Case 1 Narrowband
  - Signal levels range from 10 e- to 50 e-
  - Read noise: 0 to 15 electrons
  - SNR goal for stacked result: 10
- Case 2 broadband
  - Signal levels range from 100 e- to 500 e-
  - Read noise: 0 to 15 electrons
  - SNR goal for stacked result: 50

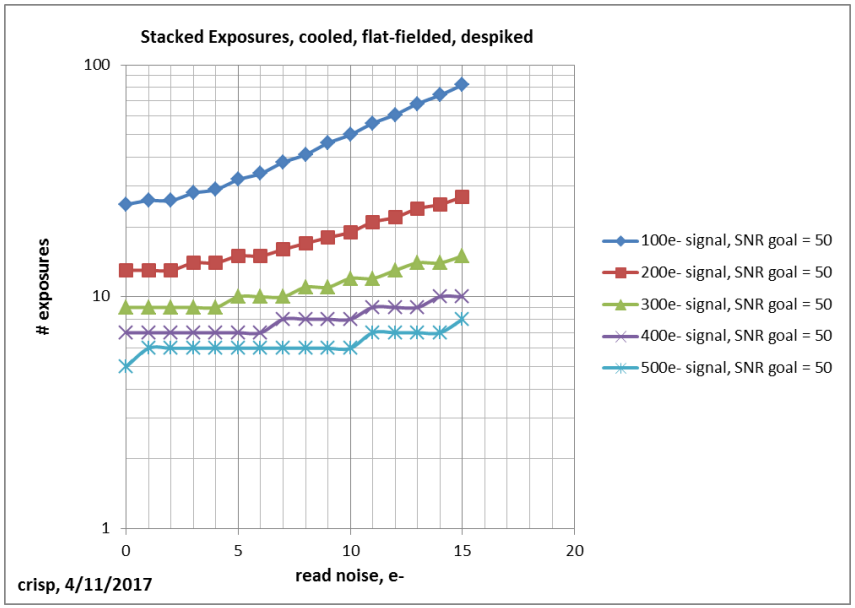
Comment on Time Units

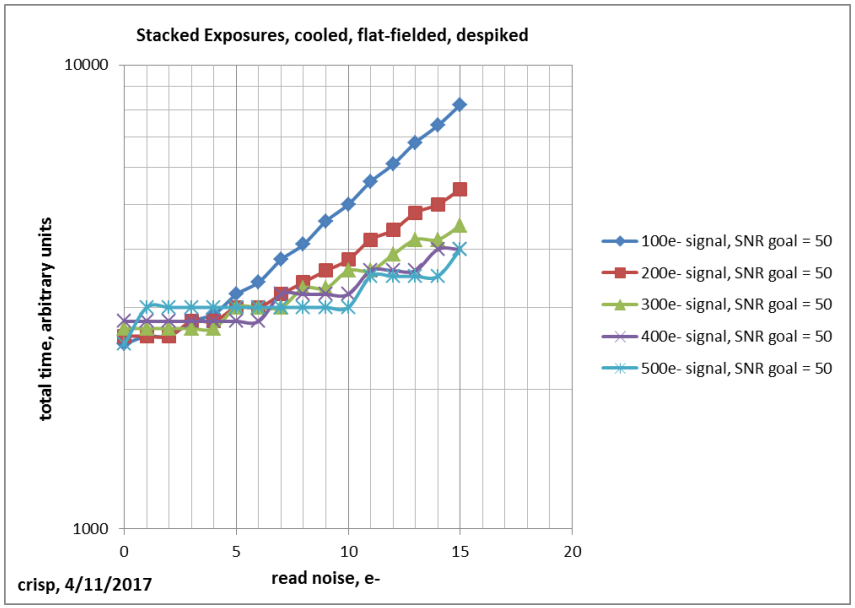
- Arbitrary units are chosen for time
- One arbitrary time unit is that amount of exposure time that results in 1 electron of signal
- Example: 10 e- takes 10 arbitrary time units



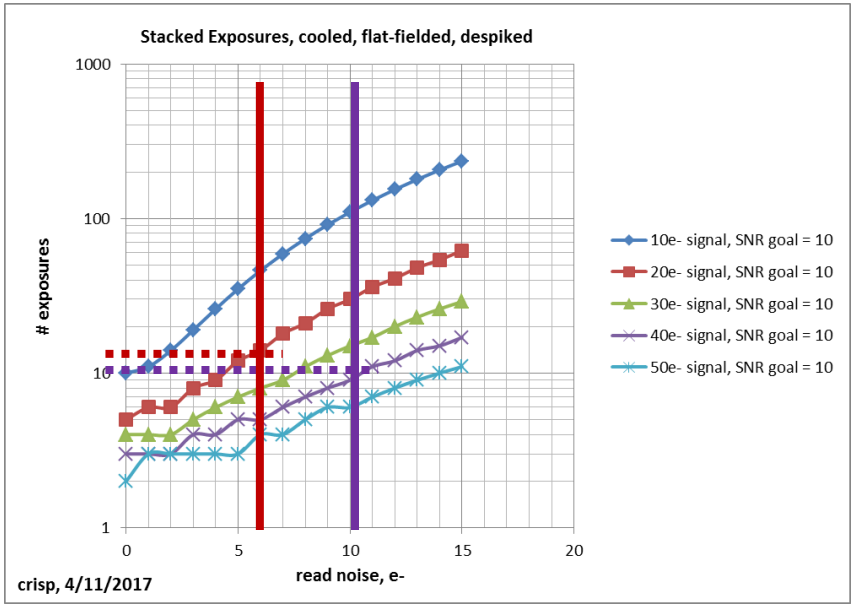


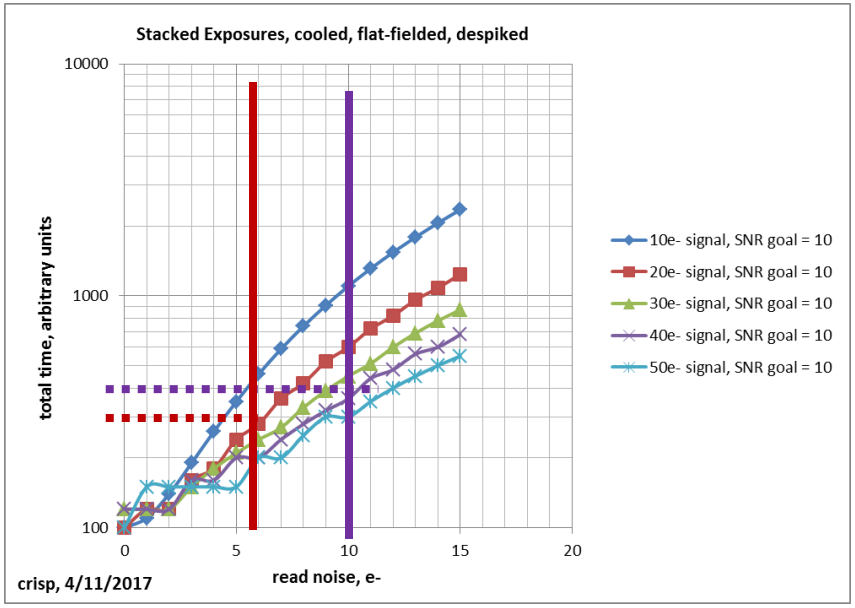
Narrowband Typical





Broadband Typical

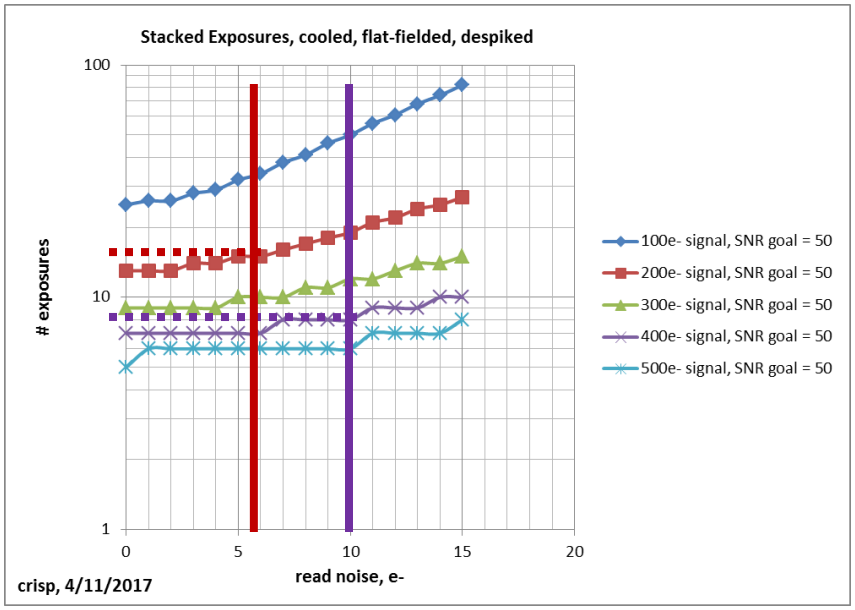


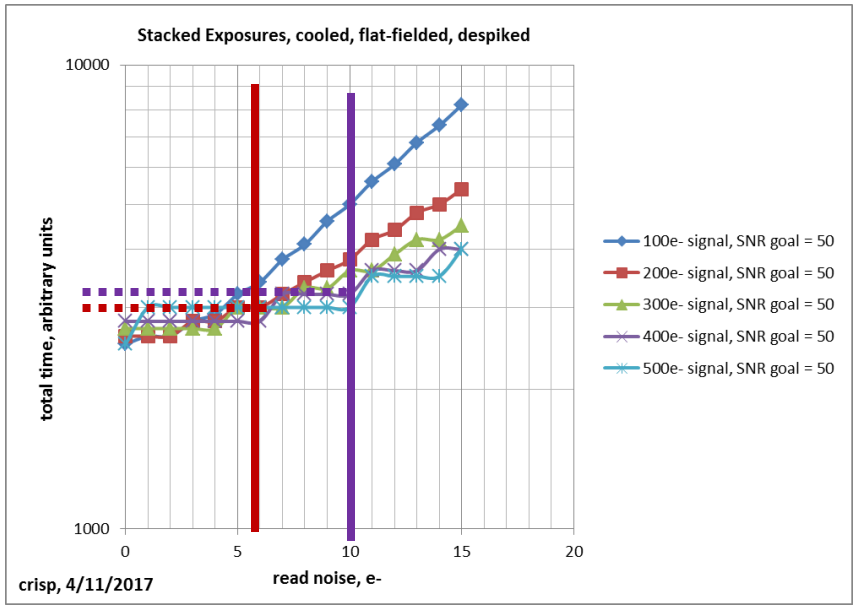


Narrowband Typical

Assume 10 e- read noise Camera 1 and 40 e- signal levels
Assume 6 e- read noise Camera 2 and 20 e- signal levels
Compare total exposure time for SNR 10

camera	Signal level (e-)	# exp	Total Time (arb units)
Camera 1	40	9	360
Camera 2	20	14	280



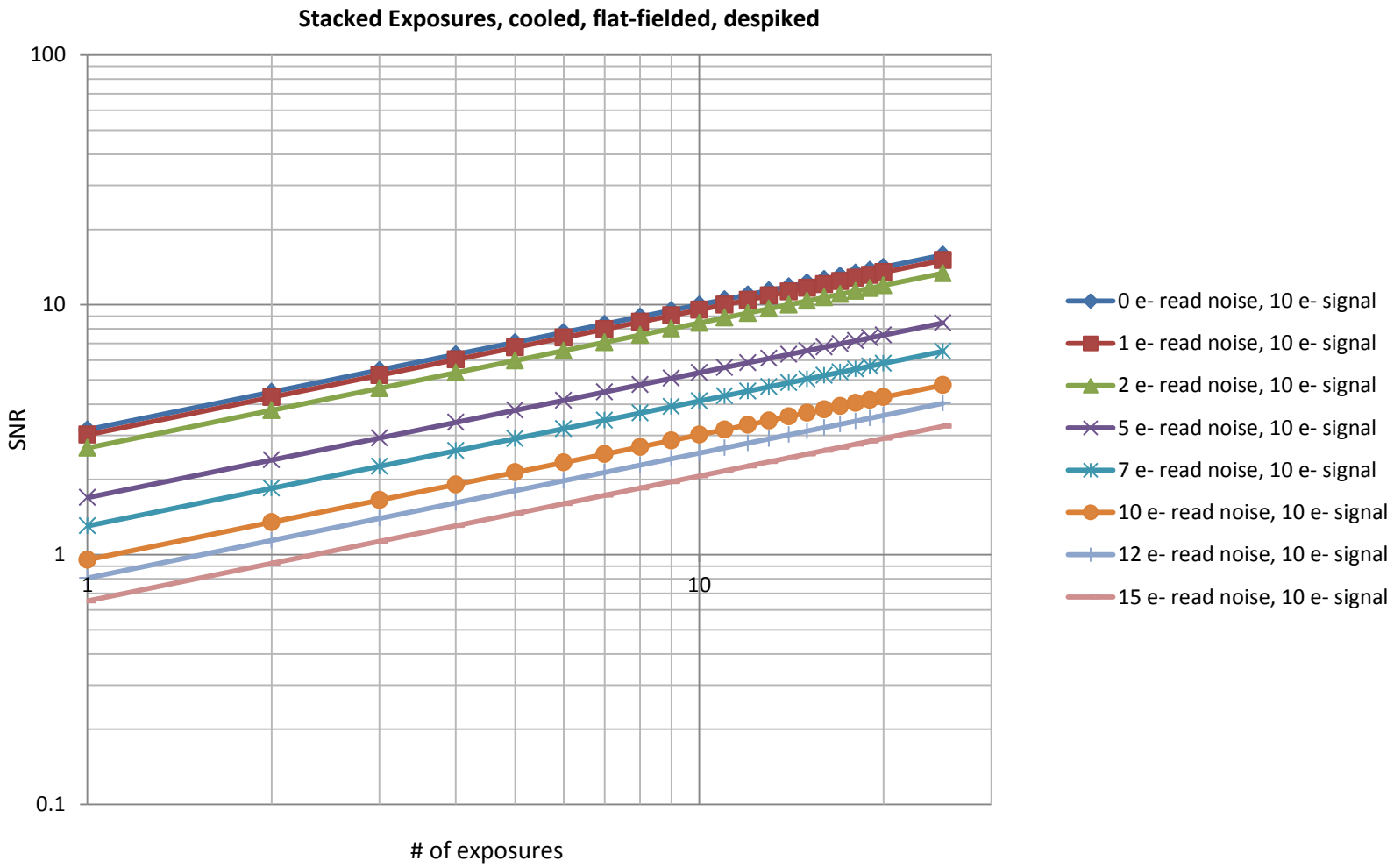


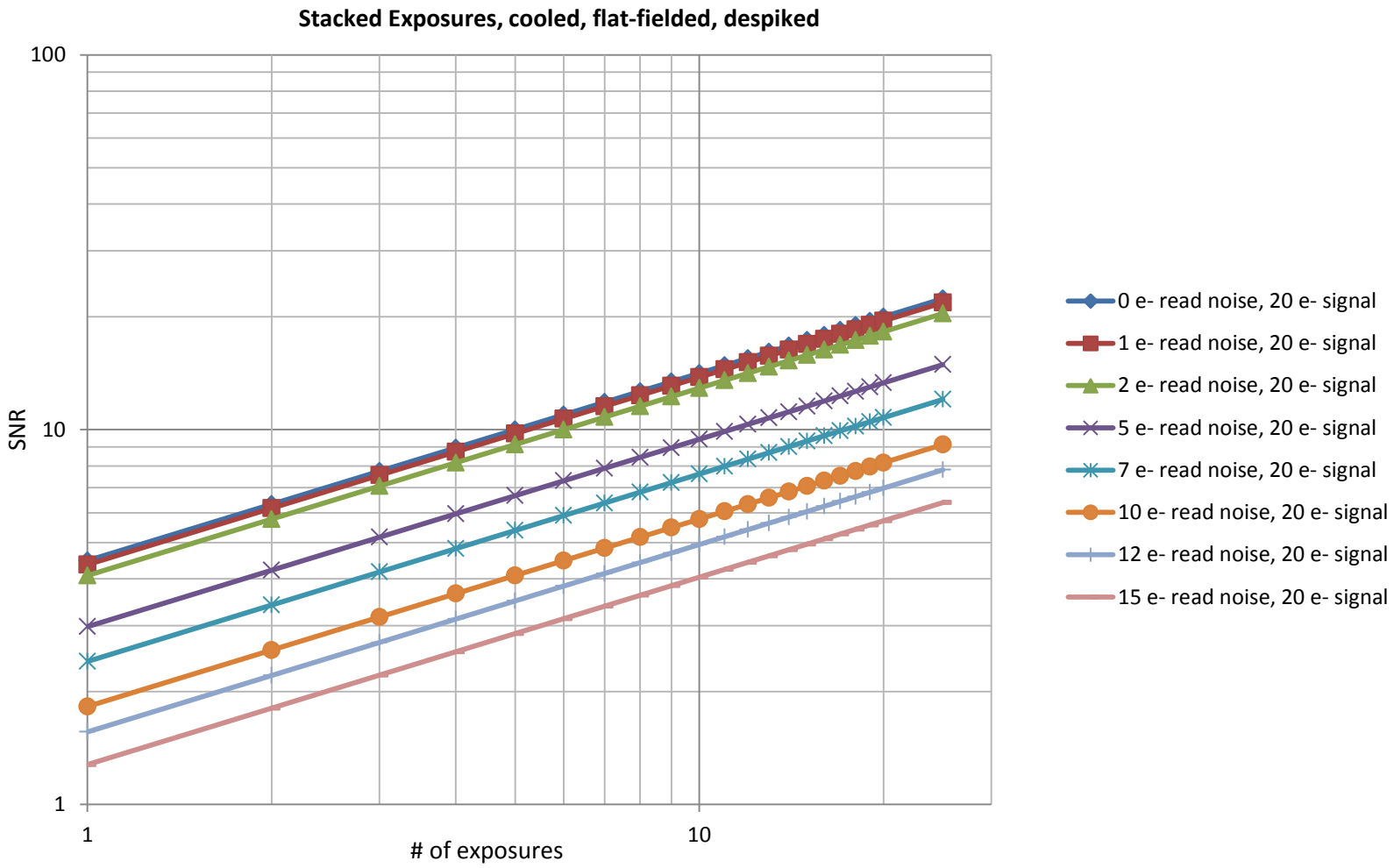
Broadband Typical

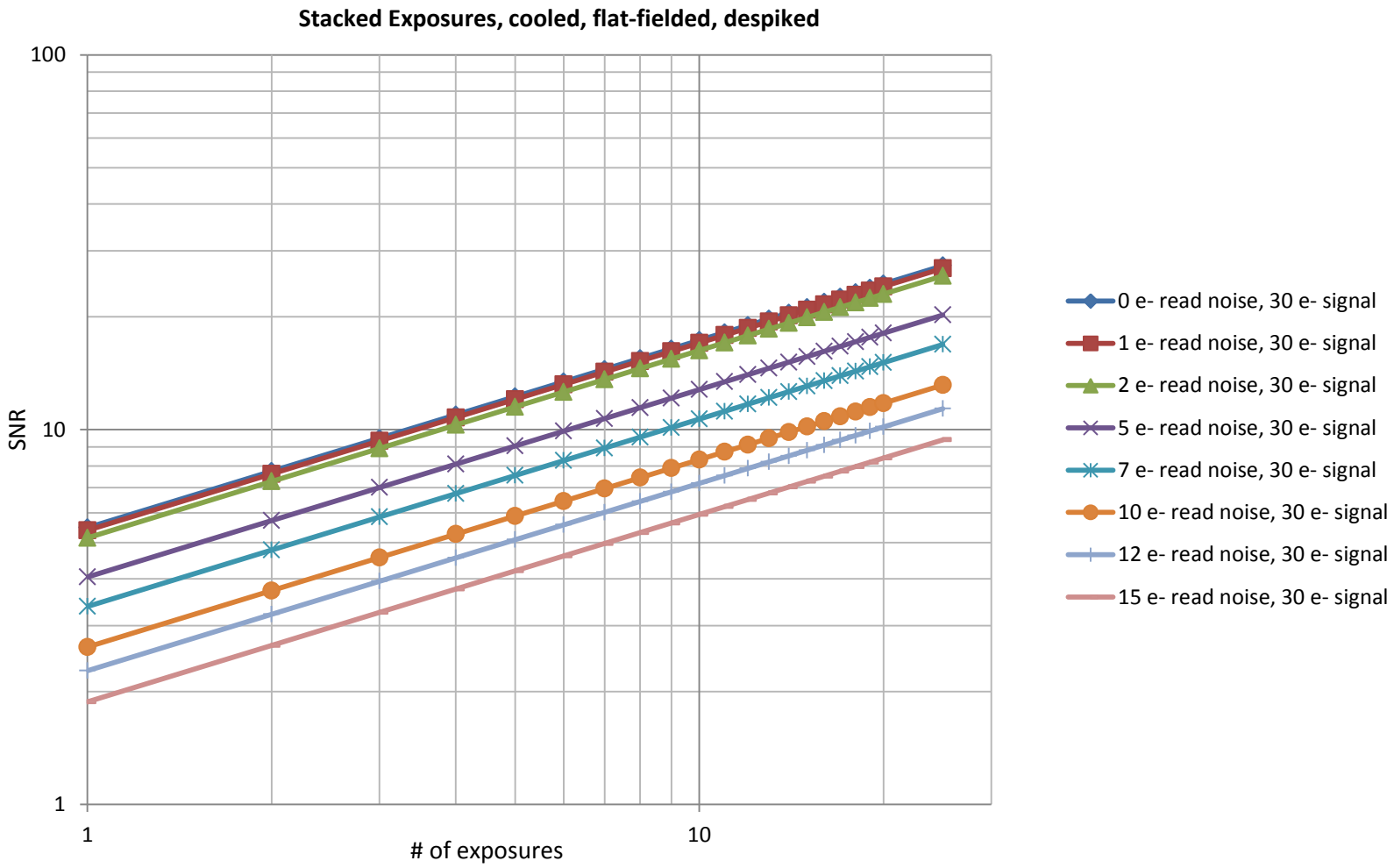
Assume 10 e- read noise Camera 1 and 400 e- signal levels
Assume 6 e- read noise Camera 2 and 200 e- signal levels
Compare total exposure time for SNR 50

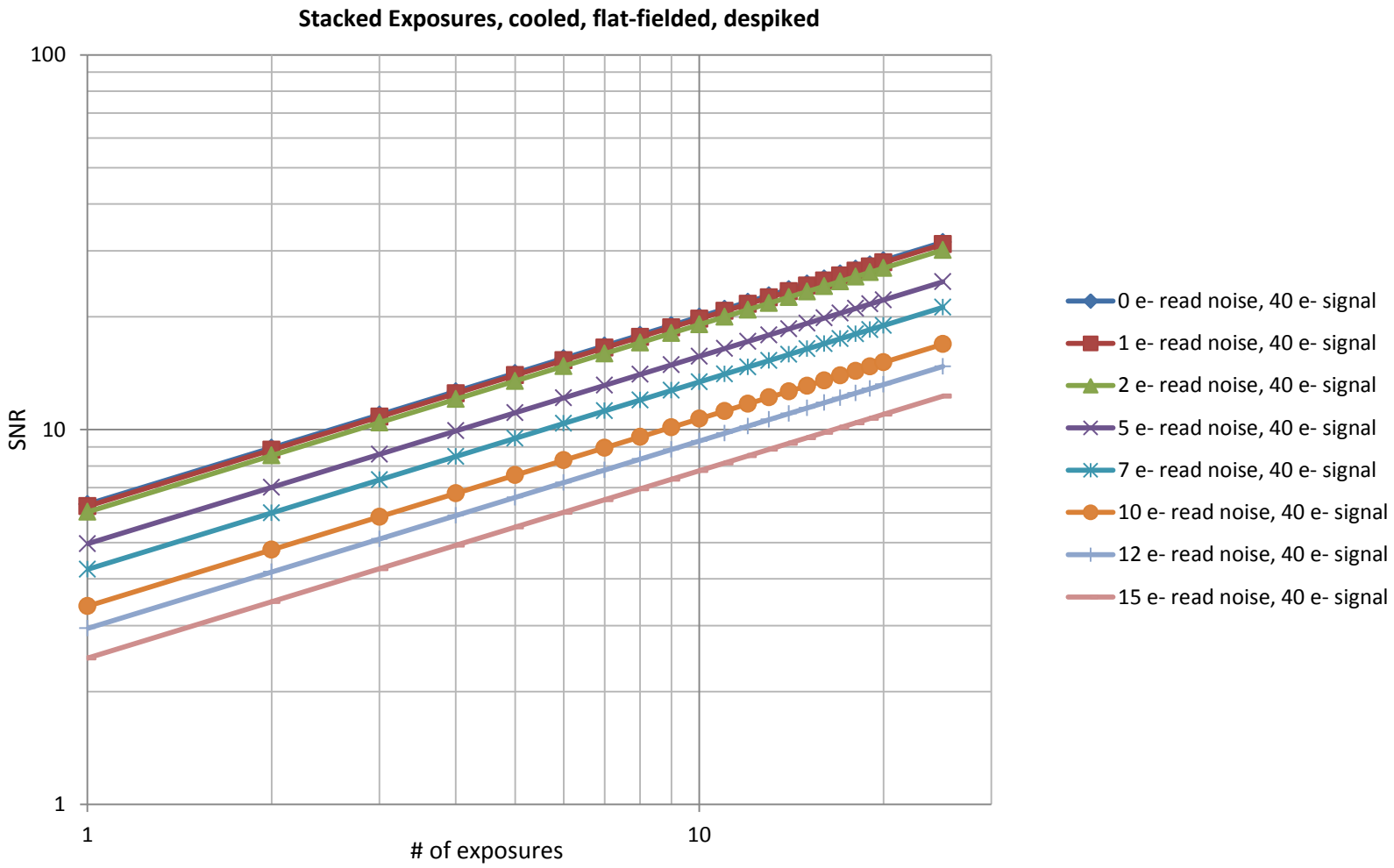
camera	Signal level (e-)	# exp	Total Time (arb units)
Camera 1	40	8	3200
Camera 2	20	15	3000

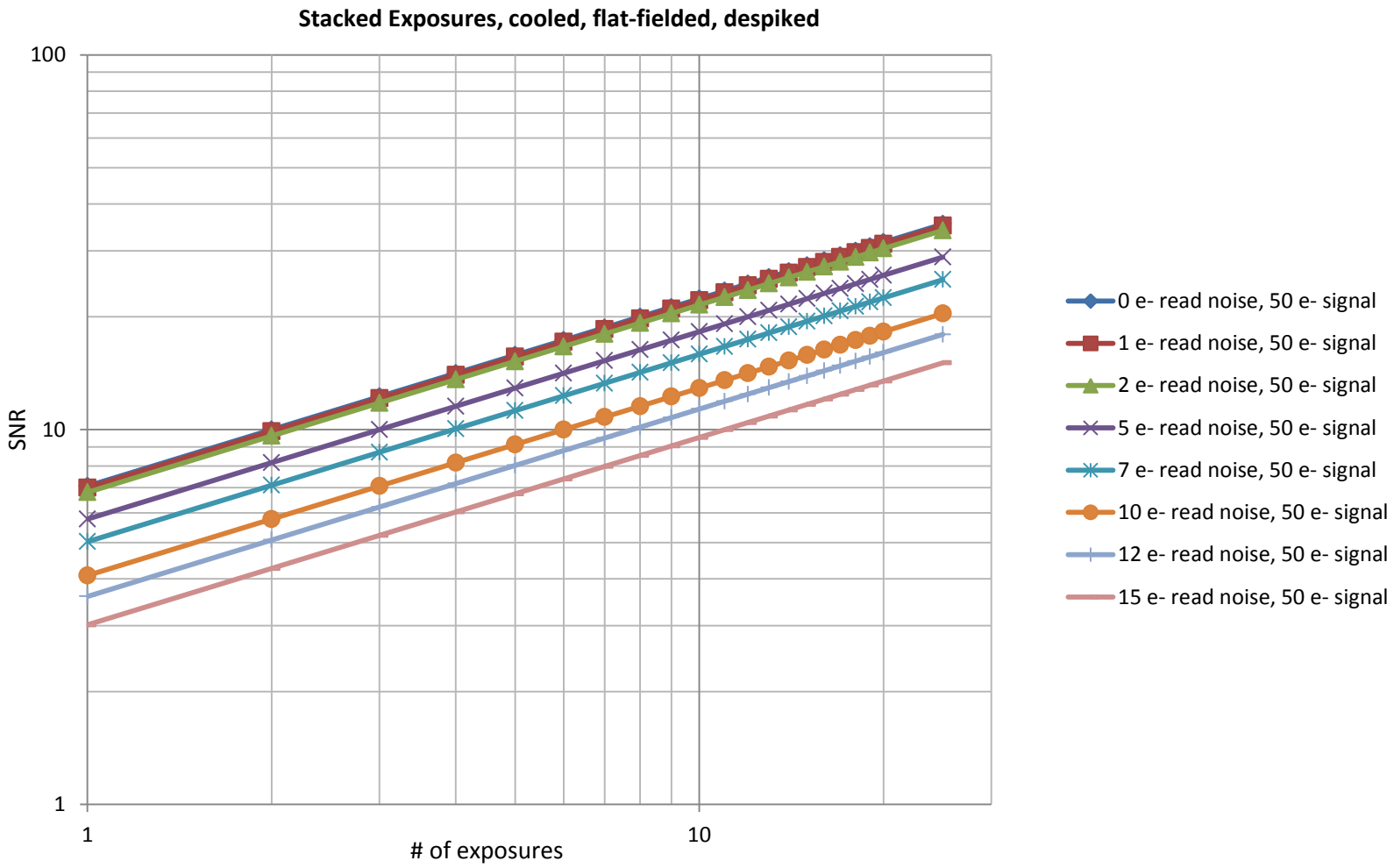
Low Signal Levels
Like in Narrowband Imaging


Stacked Exposures, cooled, flat-fielded, despiked
100
10
1
0.1
SNR
1
10
# of exposures
0 e- read noise, 10 e- signal
1 e- read noise, 10 e- signal
2 e- read noise, 10 e- signal
5 e- read noise, 10 e- signal
7 e- read noise, 10 e- signal
10 e- read noise, 10 e- signal
12 e- read noise, 10 e- signal
15 e- read noise, 10 e- signal

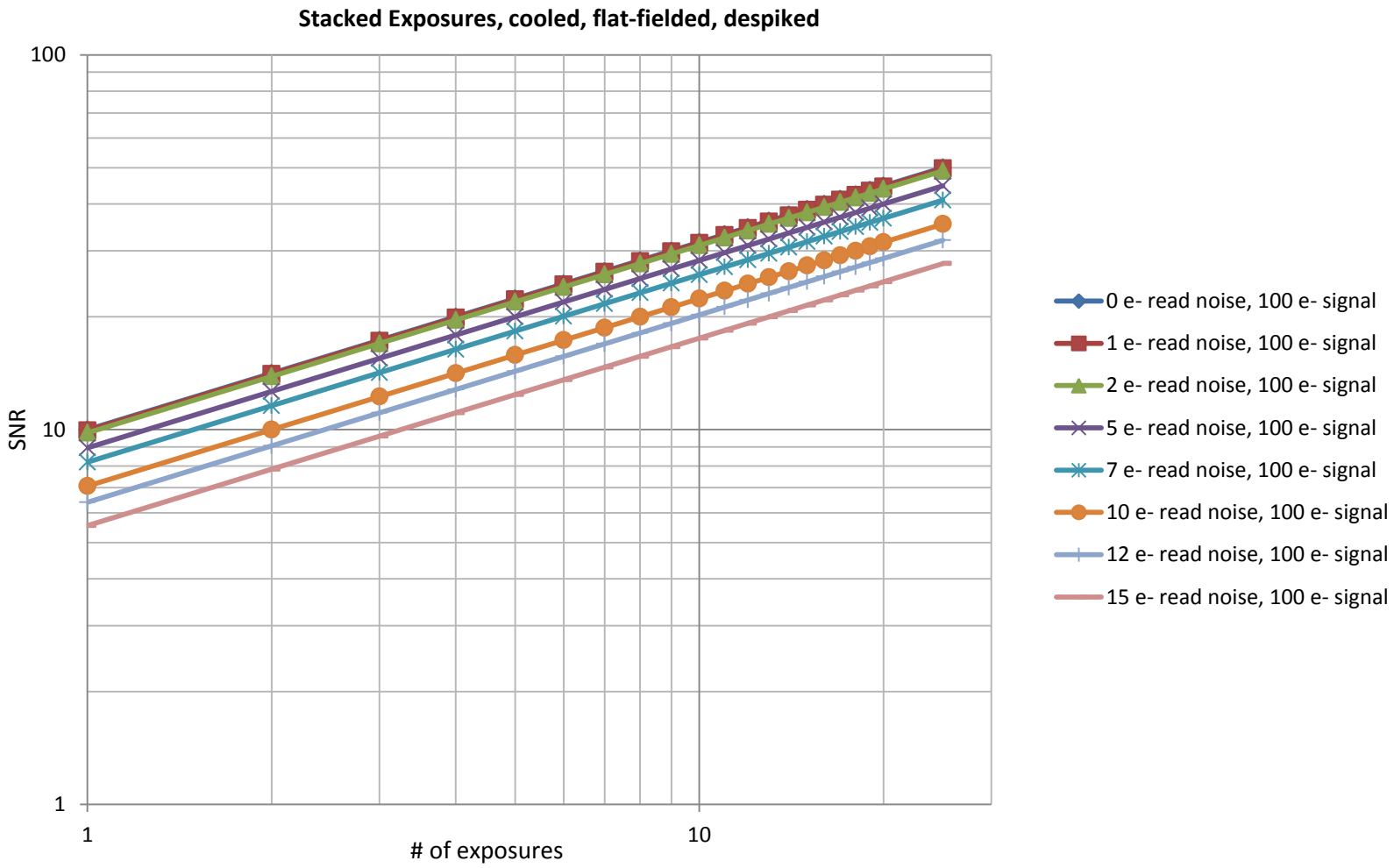

Stacked Exposures, cooled, flat-fielded, despiked
100
10
1
SNR
1
10
# of exposures
0 e- read noise, 20 e- signal
1 e- read noise, 20 e- signal
2 e- read noise, 20 e- signal
5 e- read noise, 20 e- signal
7 e- read noise, 20 e- signal
10 e- read noise, 20 e- signal
12 e- read noise, 20 e- signal
15 e- read noise, 20 e- signal

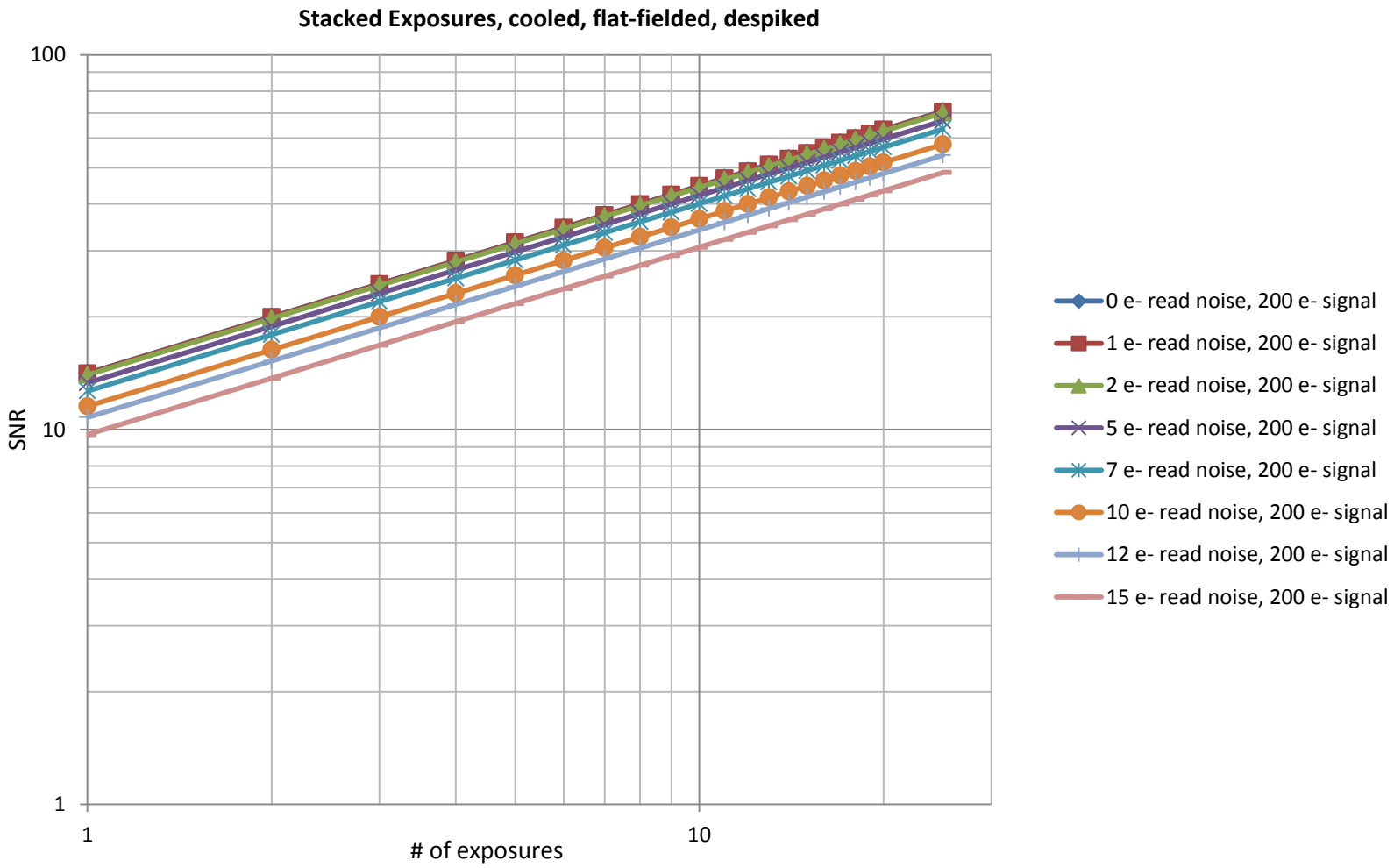

Stacked Exposures, cooled, flat-fielded, despiked
100
10
1
SNR
1
10
# of exposures
0 e- read noise, 30 e- signal
1 e- read noise, 30 e- signal
2 e- read noise, 30 e- signal
5 e- read noise, 30 e- signal
7 e- read noise, 30 e- signal
10 e- read noise, 30 e- signal
12 e- read noise, 30 e- signal
15 e- read noise, 30 e- signal

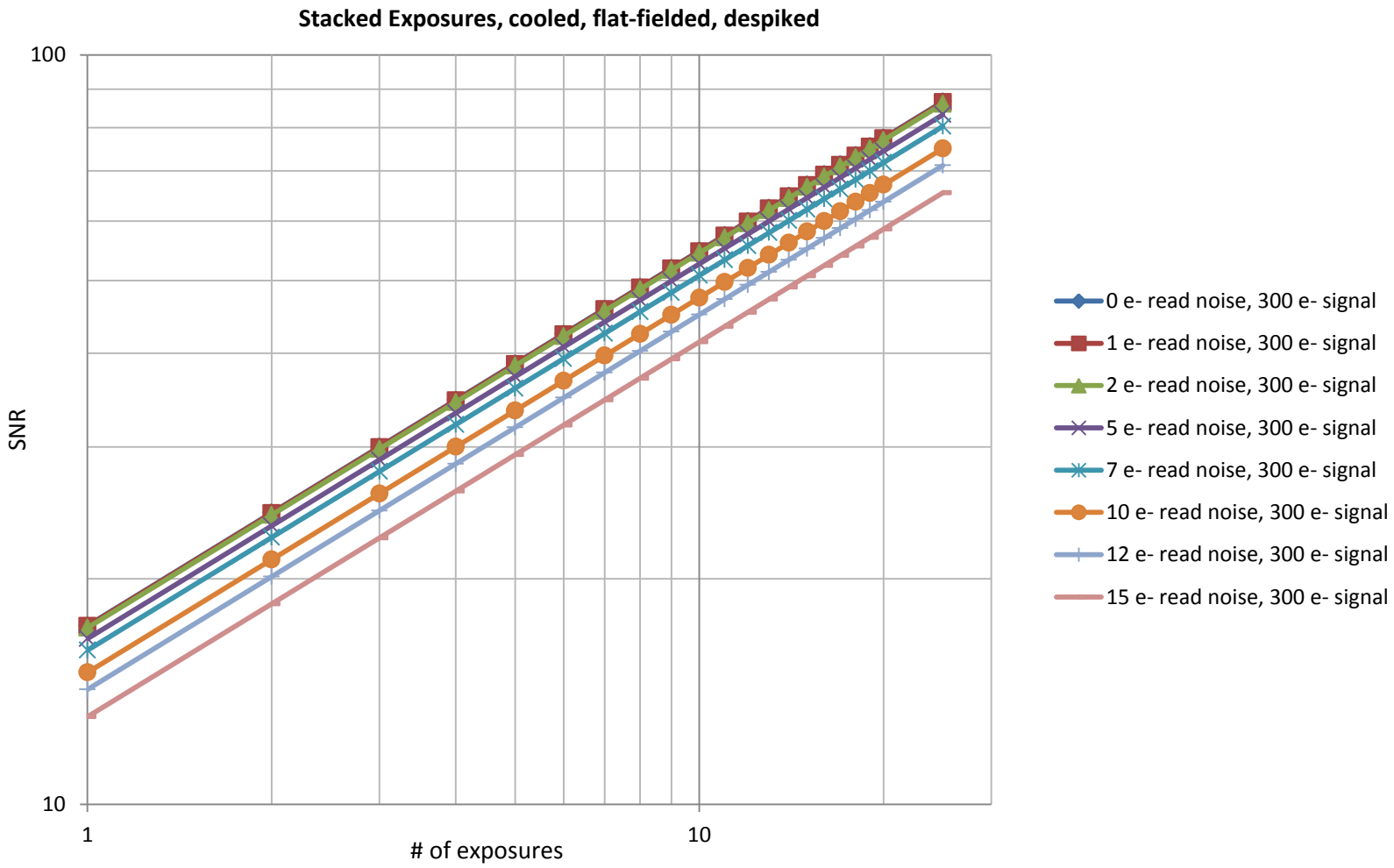

Stacked Exposures, cooled, flat-fielded, despiked
100
10
1
SNR
1
10
# of exposures
0 e- read noise, 40 e- signal
1 e- read noise, 40 e- signal
2 e- read noise, 40 e- signal
5 e- read noise, 40 e- signal
7 e- read noise, 40 e- signal
10 e- read noise, 40 e- signal
12 e- read noise, 40 e- signal
15 e- read noise, 40 e- signal

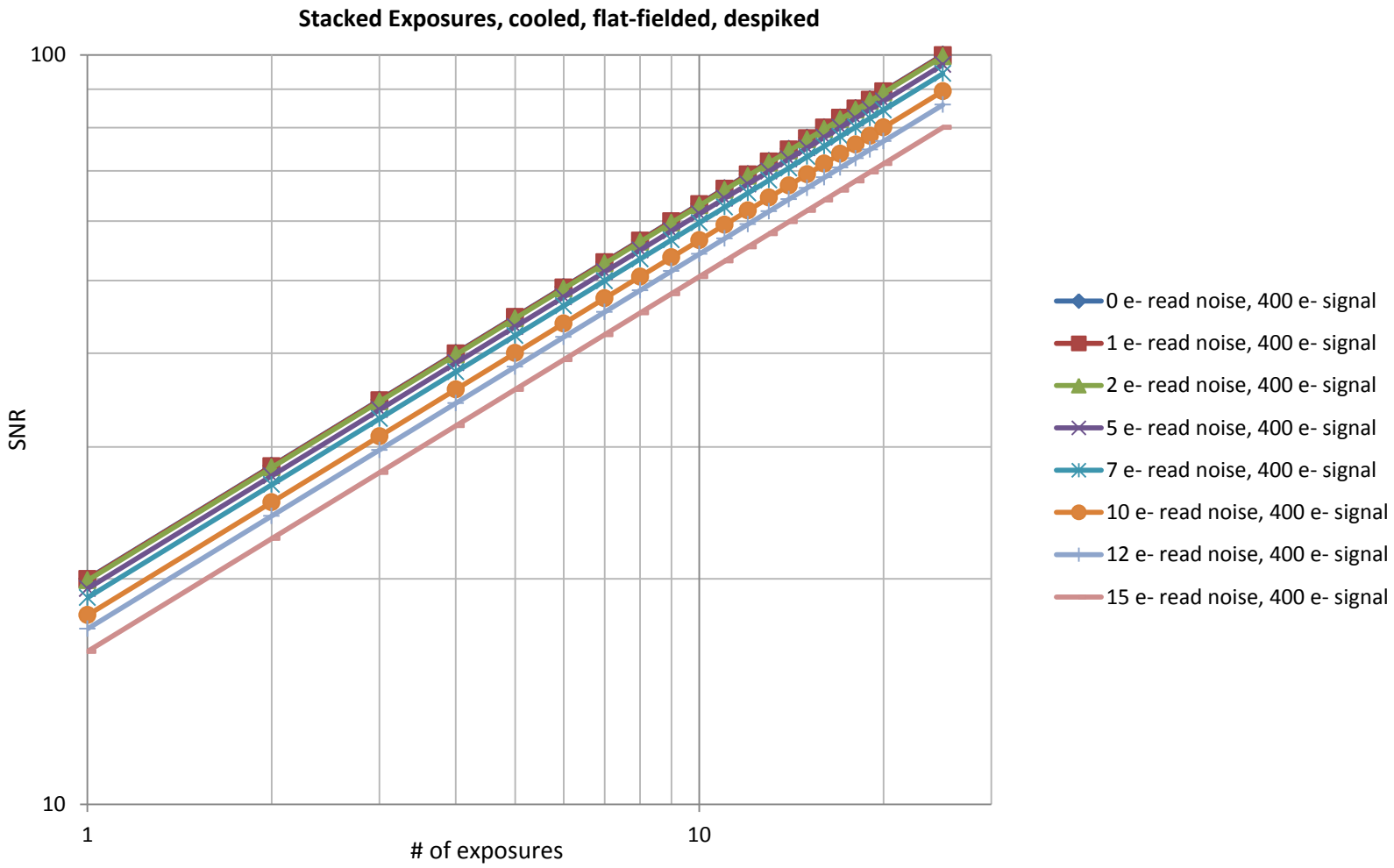

Stacked Exposures, cooled, flat-fielded, despiked
100
10
1
SNR
1
10
# of exposures
0 e- read noise, 50 e- signal
1 e- read noise, 50 e- signal
2 e- read noise, 50 e- signal
5 e- read noise, 50 e- signal
7 e- read noise, 50 e- signal
10 e- read noise, 50 e- signal
12 e- read noise, 50 e- signal
15 e- read noise, 50 e- signal

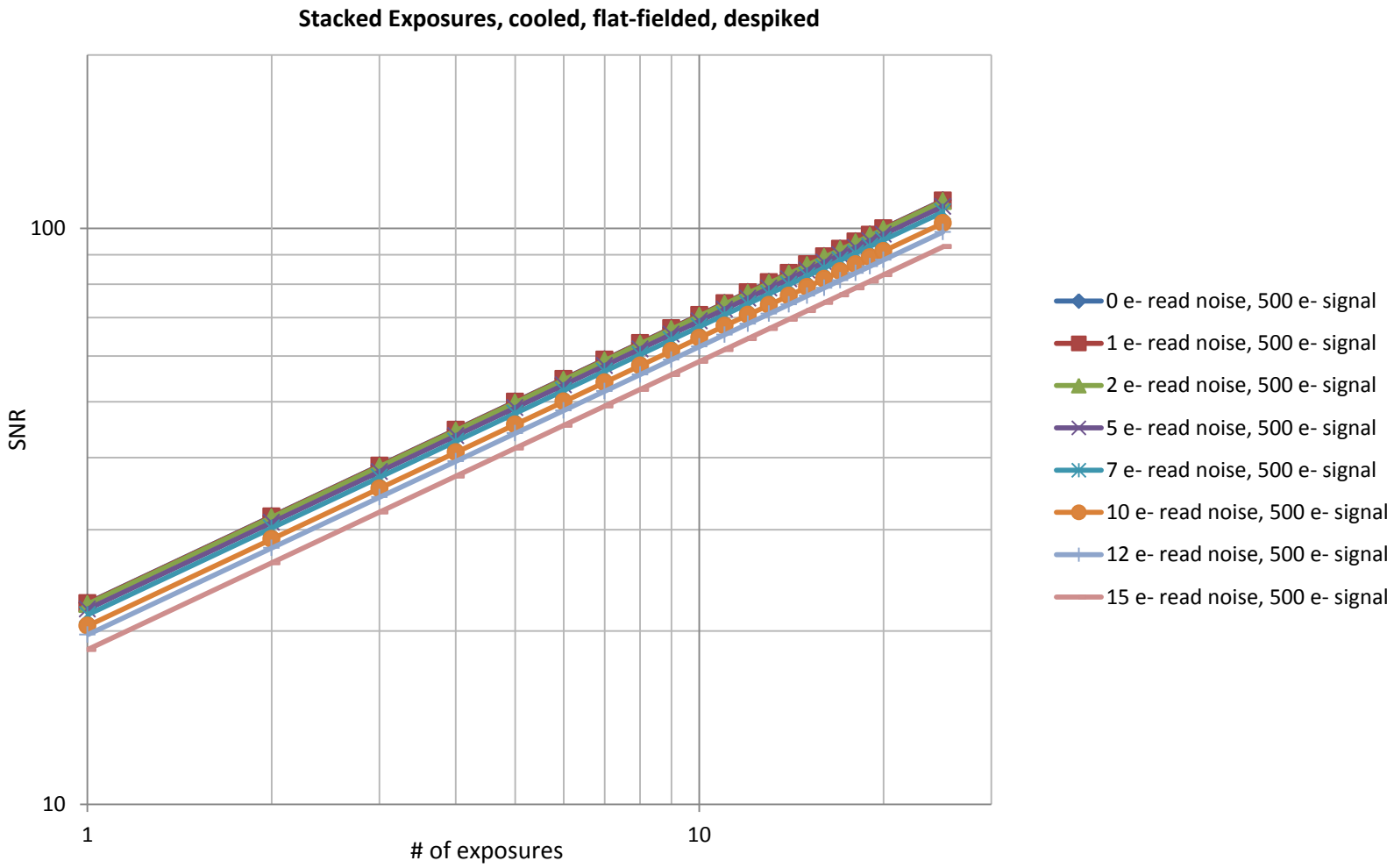
High Signal Levels
Like in Broadband / Terrestrial Imaging


Stacked Exposures, cooled, flat-fielded, despiked
100
10
1
SNR
1
10
# of exposures
0 e- read noise, 100 e- signal
1 e- read noise, 100 e- signal
2 e- read noise, 100 e- signal
5 e- read noise, 100 e- signal
7 e- read noise, 100 e- signal
10 e- read noise, 100 e- signal
12 e- read noise, 100 e- signal
15 e- read noise, 100 e- signal


Stacked Exposures, cooled, flat-fielded, despiked
100
10
1
SNR
1
10
# of exposures
0 e- read noise, 200 e- signal
1 e- read noise, 200 e- signal
2 e- read noise, 200 e- signal
5 e- read noise, 200 e- signal
7 e- read noise, 200 e- signal
10 e- read noise, 200 e- signal
12 e- read noise, 200 e- signal
15 e- read noise, 200 e- signal


Stacked Exposures, cooled, flat-fielded, despiked
100
10
SNR
1
10
# of exposures
0 e- read noise, 300 e- signal
1 e- read noise, 300 e- signal
2 e- read noise, 300 e- signal
5 e- read noise, 300 e- signal
7 e- read noise, 300 e- signal
10 e- read noise, 300 e- signal
12 e- read noise, 300 e- signal
15 e- read noise, 300 e- signal


Stacked Exposures, cooled, flat-fielded, despiked
100
10
SNR
1
10
# of exposures
0 e- read noise, 400 e- signal
1 e- read noise, 400 e- signal
2 e- read noise, 400 e- signal
5 e- read noise, 400 e- signal
7 e- read noise, 400 e- signal
10 e- read noise, 400 e- signal
12 e- read noise, 400 e- signal
15 e- read noise, 400 e- signal


Stacked Exposures, cooled, flat-fielded, despiked
100
10
SNR
1
10
# of exposures
0 e- read noise, 500 e- signal
1 e- read noise, 500 e- signal
2 e- read noise, 500 e- signal
5 e- read noise, 500 e- signal
7 e- read noise, 500 e- signal
10 e- read noise, 500 e- signal
12 e- read noise, 500 e- signal
15 e- read noise, 500 e- signal