January 24, 2005

- Thanks for all the fish . . . err . . . emails . . .
- **Proposed Office Hours™**
  - 1:10 – 2:10 pm, Monday, A223 Cook
    - Not today or next week (no class Monday Jan 31st!)
  - 1-2 pm, Thursday, 300 Waterman
  - 3-4 pm, Friday, 300 Waterman

Finding the Detection Limit

- BUT: recall that the signal that is measured *includes* the blank (S_{blank}), so we define:

  S_m = signal *measured* at the det. Limit

So:

$$\frac{S_m - S_{blank}}{\sigma_{blank}} = 3$$

REMEMBER: It is not the *magnitude* of the blank (S_{blank}) that limits detection -- rather, it is the ***fluctuation*** or ***uncertainty*** of the blank (σ_{blank}) that limits detectability.

Back to our example

Concentration	Signal	NET Signal
0 ppm (blank)	0.136	0.000
10. ppm	0.721	0.585
1.0 ppm	0.195	0.059
0.10 ppm	0.142	0.006
0.010 ppm	0.137	0.001

Suppose that:

$\sigma_{blank} = 0.002$

$S = 3\,\sigma_{blank} = 3\,(0.002) = \underline{0.006}$

So: $S_m = S_{blank} + S = 0.136 + 0.006 = \underline{\mathbf{0.142}}$

(0.10 ppm Pb)

Noise

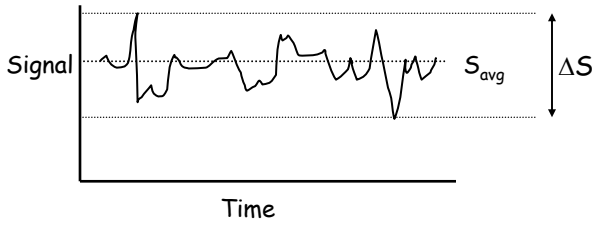
- **What is it?**
  -any "unwanted" part of the analytical signal
  -there is *always* some noise in a signal!
- **How can we *reduce* it?**
  Simple: -turn down the amplifier gain!
- **How can we *increase S/N?***
  Warning! There are *hidden costs* associated with S/N enhancement:
  -decreased resolution (selectivity)
  -increased measurement time
  -NEW sources of noise!

Calculating S/N

- For a set of data (replicate measurements):

$$S/N = \mathbf{S_{avg}} / \sigma_s = (RSD)^{-1}$$

- For a temporally-varying signal:



$\Delta S \approx 5\sigma = 5N$

So: $N \approx \Delta S/5$

Thus:

$S/N \approx 5S_{avg}/\Delta S$

Noise Sources

- We'll characterize by their *frequency response*

1. **White Noise** - *amplitude invariant with respect to frequency*

   Two types:

   - **Johnson (Thermal) Noise**

     -voltage fluctuations due to random e^- motion in resistive devices

$$V_{rms} = (4\ k\ T\ R\ \Delta f)^{1/2}$$

Boltzmann's Constant — Absolute Temp — Resistance — Frequency Bandwidth