# 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

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

  $S_m$ = signal *measured* at the det. Limit

  <u>So:</u> $$\frac{S_m - S_{blank}}{\sigma_{blank}} = 3$$

***<u>REMEMBER:</u>*** It is not the *magnitude* of the blank ($S_{blank}$) that limits detection -- rather, it is the ***fluctuation*** or ***uncertainty*** of the blank ($\sigma_{blank}$) that limits detectability.



# Back to our example

| <u>Concentration</u> | <u>Signal</u> | NET <u>Signal</u> |
|---|---|---|
| 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 |

*<u>Suppose</u>* that:

$\sigma_{blank} = 0.002$

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

<u>So:</u> $S_m = S_{blank} + S = 0.136 + 0.006 = \underline{0.142}$

(0.10 ppm Pb)



# Noise

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

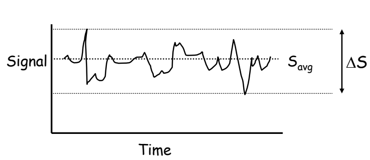


# Calculating S/N

- <u>For a set of data (replicate measurements):</u>

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

- <u>For a temporally-varying signal:</u>




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

<u>So</u>: $N \approx \Delta S/5$

<u>Thus:</u>

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



# Noise Sources

- We'll characterize by their *frequency response*

1. **<u>White Noise</u>** - *amplitude invariant with respect to frequency*

   Two types:
   - **<u>Johnson (Thermal) Noise</u>**

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

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

     k: Boltzmann's Constant; T: Absolute Temp; R: Resistance; $\Delta f$: Frequency Bandwidth