# ICP:
## You CAN'T Just Push Play

A discussion and compelling argument supporting the rationale behind and critical need for proper and effective use of inter-element correction factors (IEC) –or other interference correction tools– to obtain quality ICP-OES results on environmental samples.

**Wisconsin DNR**
Bureau of Science Services
Lab Certification Program

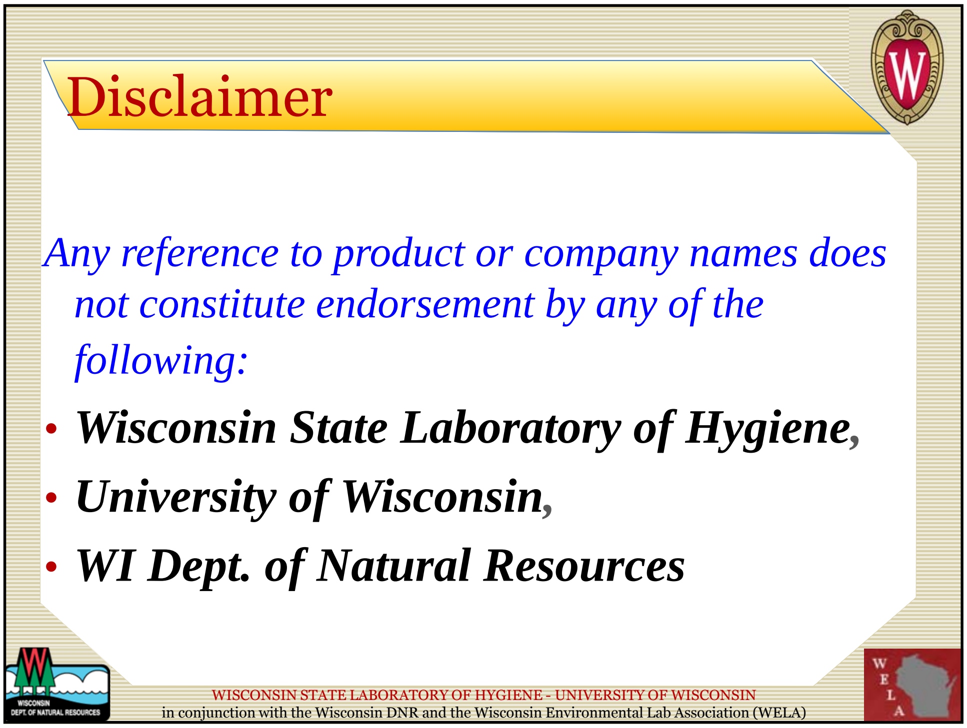
Wisconsin State
Laboratory of Hygiene
UNIVERSITY OF WISCONSIN–MADISON

**W**isconsin
**E**nvironmental
**L**aboratories
**A**ssociation

# Well, some can get away with it

Aerosmith can just push play;

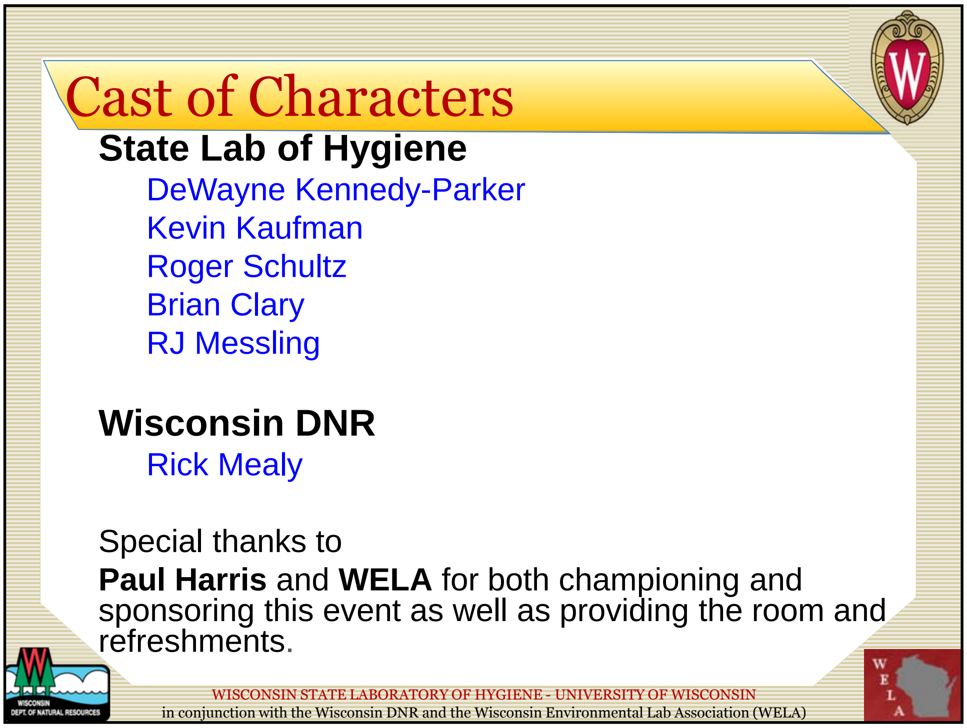
most labs, however, cannot



## Disclaimer

*Any reference to product or company names does not constitute endorsement by any of the following:*

- ***Wisconsin State Laboratory of Hygiene,***
- ***University of Wisconsin,***
- ***WI Dept. of Natural Resources***



## Cast of Characters

**State Lab of Hygiene**

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Brian Clary
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**Wisconsin DNR**

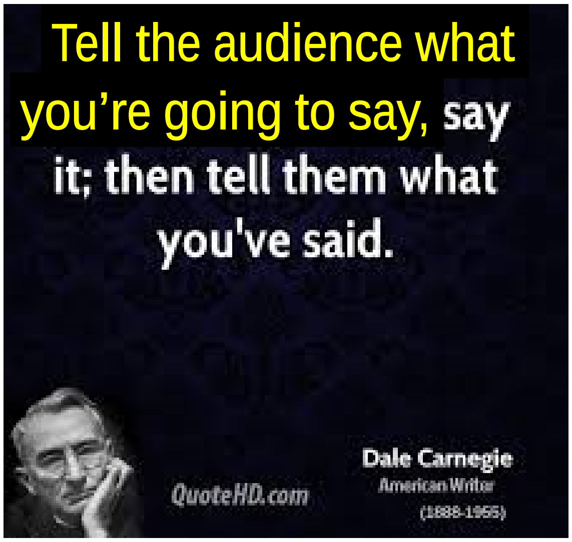
Rick Mealy

Special thanks to
**Paul Harris** and **WELA** for both championing and sponsoring this event as well as providing the room and refreshments.

# Outline

- Instruments, sample introduction, auto-samplers
- Brief instrument set-up and calibration
- Background correction (pre-loaded vs. reality)
- Inter-Element Correction factors (IECs)
- Multi-Component Spectral Fitting (MSF) and Fast Automated Curve-Fitting Technique (FACT)
- Interference check samples (ICS)
- PT sample results and examples of interference correction.
- Real World Sample Results
- Wrap-Up/ Q&A

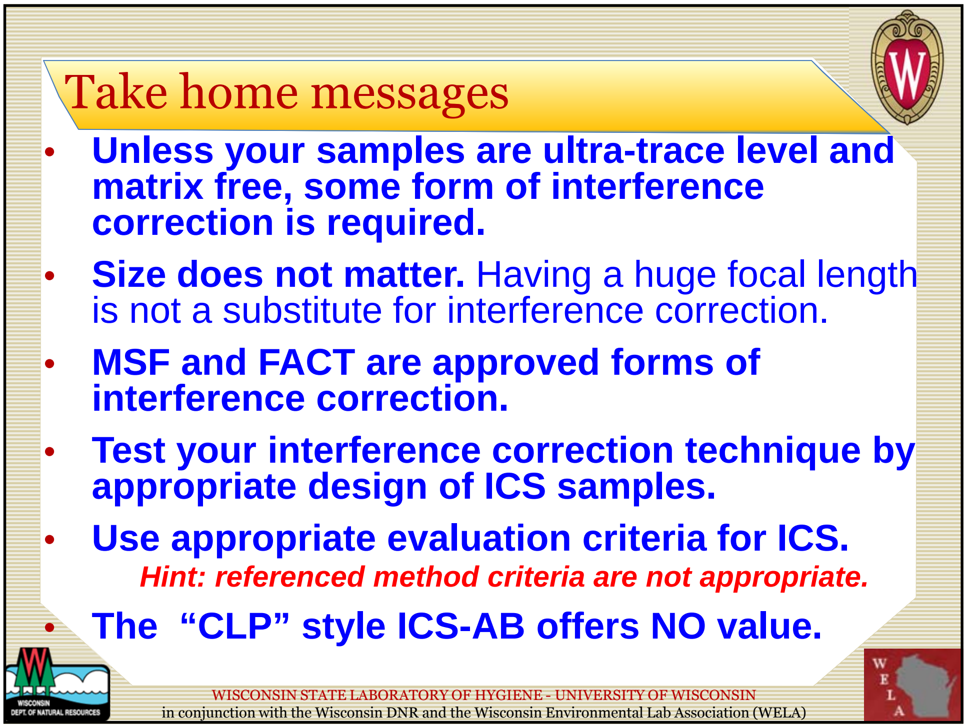
# Tell 'em What You're Going to Tell 'em



Tell the audience what you're going to say, say it; then tell them what you've said.

Dale Carnegie
American Writer
(1888-1955)

QuoteHD.com



## Take home messages

- **Unless your samples are ultra-trace level and matrix free, some form of interference correction is required.**
- **Size does not matter.** Having a huge focal length is not a substitute for interference correction.
- **MSF and FACT are approved forms of interference correction.**
- **Test your interference correction technique by appropriate design of ICS samples.**
- **Use appropriate evaluation criteria for ICS.**
  ***Hint: referenced method criteria are not appropriate.***
- **The “CLP” style ICS-AB offers NO value.**

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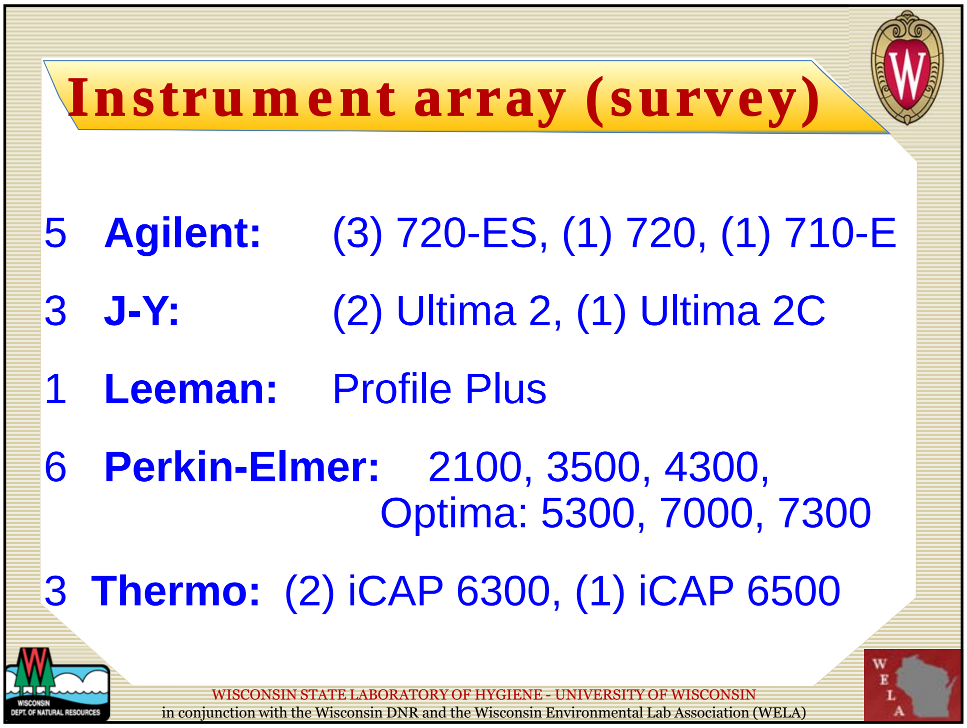

## Instrument array (survey)

5 **Agilent:** (3) 720-ES, (1) 720, (1) 710-E

3 **J-Y:** (2) Ultima 2, (1) Ultima 2C

1 **Leeman:** Profile Plus

6 **Perkin-Elmer:** 2100, 3500, 4300,
Optima: 5300, 7000, 7300

3 **Thermo:** (2) iCAP 6300, (1) iCAP 6500

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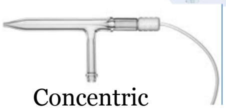
# Nebulizers based on survey

6 Sea spray
3 Meinhard
3 Gem Cone
2 Concentric
1 Gem Tip Cross-Flow
1 MiraMist
1 Hildebrand Grid
1 Micro Flow PFA-ST
1 One Neb


Seaspray


Meinhard

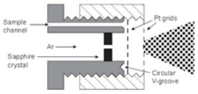

Concentric


Gemcone


Gemcone
High solids


MiraMist


gem tip cross flow




Microflow PFA


One Neb

# Nebulizers need cleaning too

There may not be an APP for that, but there IS a tool for that…

# Spray chambers (survey)

Nearly all lab use a cyclonic type spray chamber.

Also indicated:

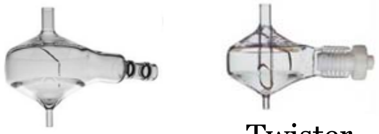
Cyclonic, single pass

(2)Cyclonic Double Pass

Double Pass

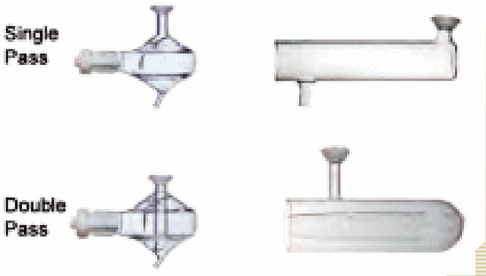
Scott-type

Twister cyclonic



Generic cyclonic

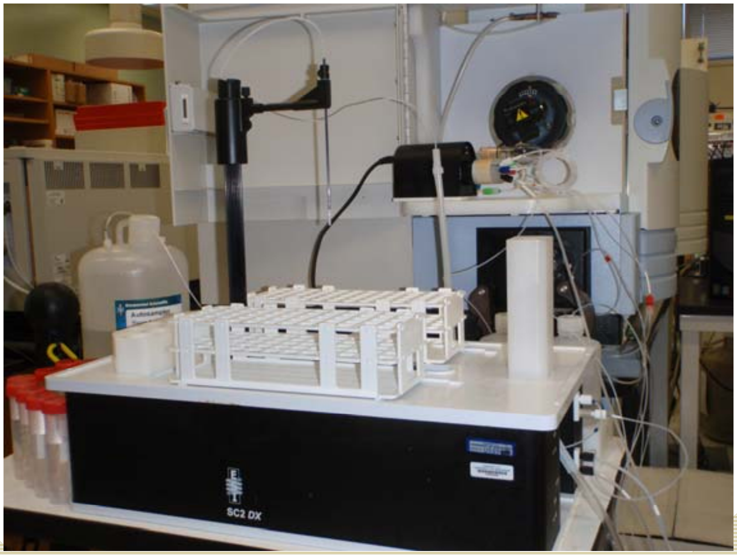
Twister double pass



Cyclonic

Scott type

# The FAST autosampler



## The FAST autosampler

## Instrument Set-up:

- Sample (and internal standard) flow check
- Spectral alignment using a single element (Mn, etc.),
- Internal instrument alignment (Hg),
- Equipment inspection
- Documentation as required by accrediting agency

## Calibration…a few words

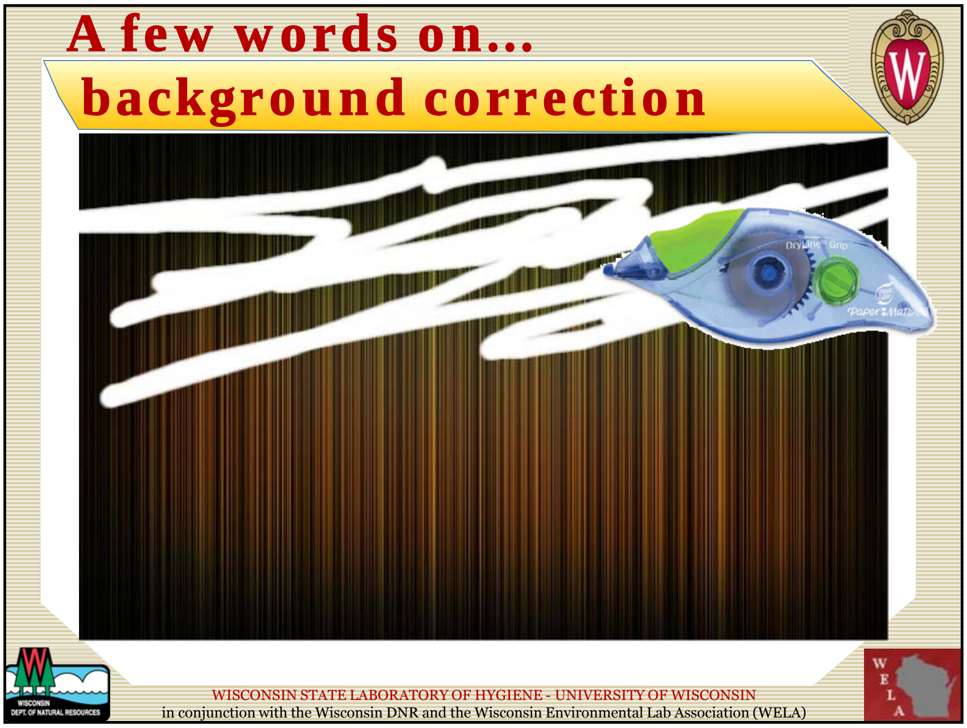
- 1pt. vs. multi pt. (ELLAP),
- element separation
- conc. levels (MDLs and linear dynamic range),
- wavelengths

## Tell 'em

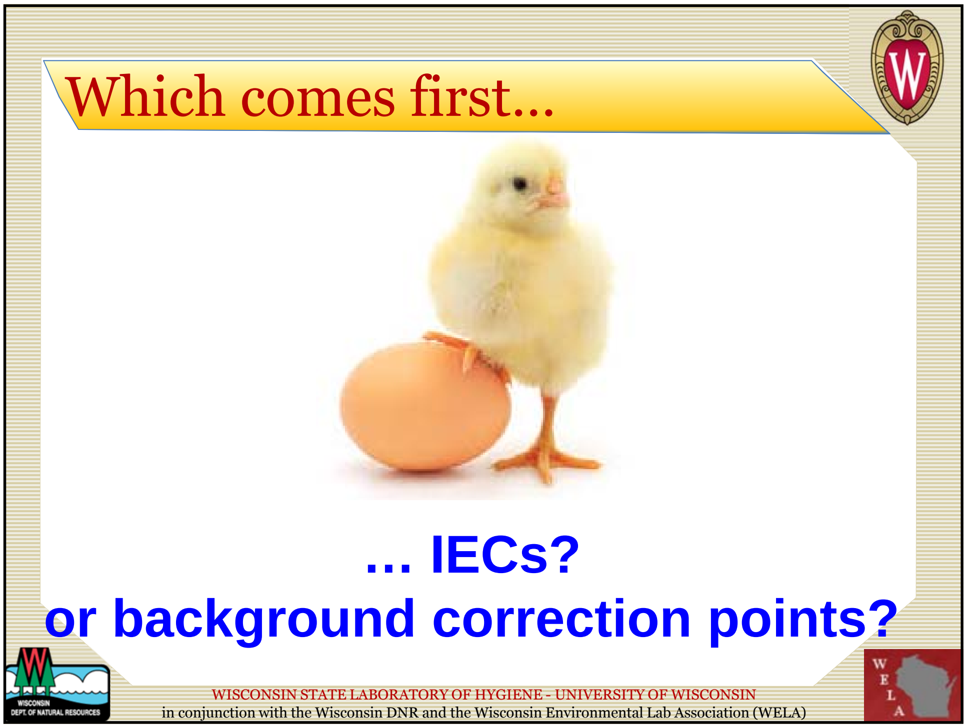
Tell the audience what you're going to say, say it ; then tell them what you've said.

Dale Carnegie
American Writer
(1888-1955)

QuoteHD.com



# A few words on… background correction



# Which comes first…

**… IECs?**
**or background correction points?**

## It’s a trick question…

**You can do these steps in either order, but because IECs have to be verified if background correction points change, it makes sense to set background points first.**

**You can update an IEC without changing background correction pts.**

**But if you change background correction (location of a point, going from 1 to 2 pts or 2 to 1 pt), you MUST re-assess any associated interference correction**

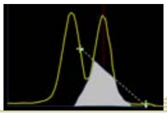
## It’s a trick question…

Background correction points and IECs work in sync.

Proper background placement or switching from 2 to 1 pts is not necessarily a substitute for IECs.

2 background points is generally reserved for areas of sloping background.

When the sloping background is a shoulder of an interferent, you will need to have an IEC to recoup the area “shaved”.



## Conclusion:

You can achieve accuracy either way.

You just have to remember that IECs are inherently linked to the background corrections points designated when then IECs were generated.

Changing background correction points requires

1. Re-standardization
2. Re-evaluation of any associated IECs.
3. Run controls (ICS) to verify

But re-evaluating IECs does not require re-setting background correction points.

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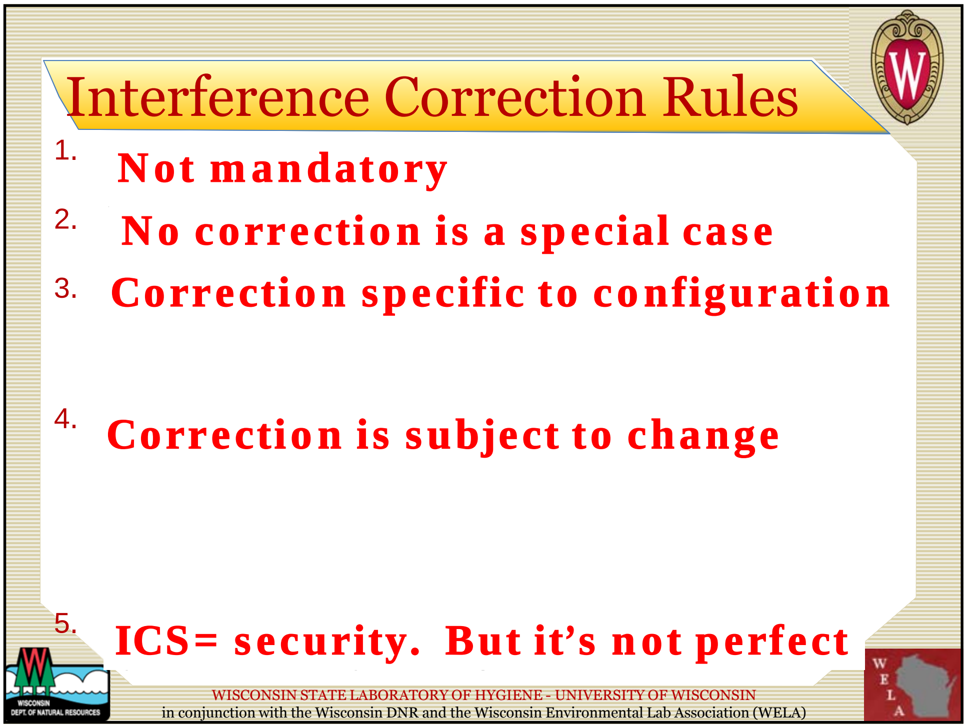
# INTERFERENCE CORRECTION



## Interference Correction Rules

1. Not mandatory
2. No correction is a special case
3. Correction specific to configuration
4. Correction is subject to change
5. ICS= security. But it's not perfect

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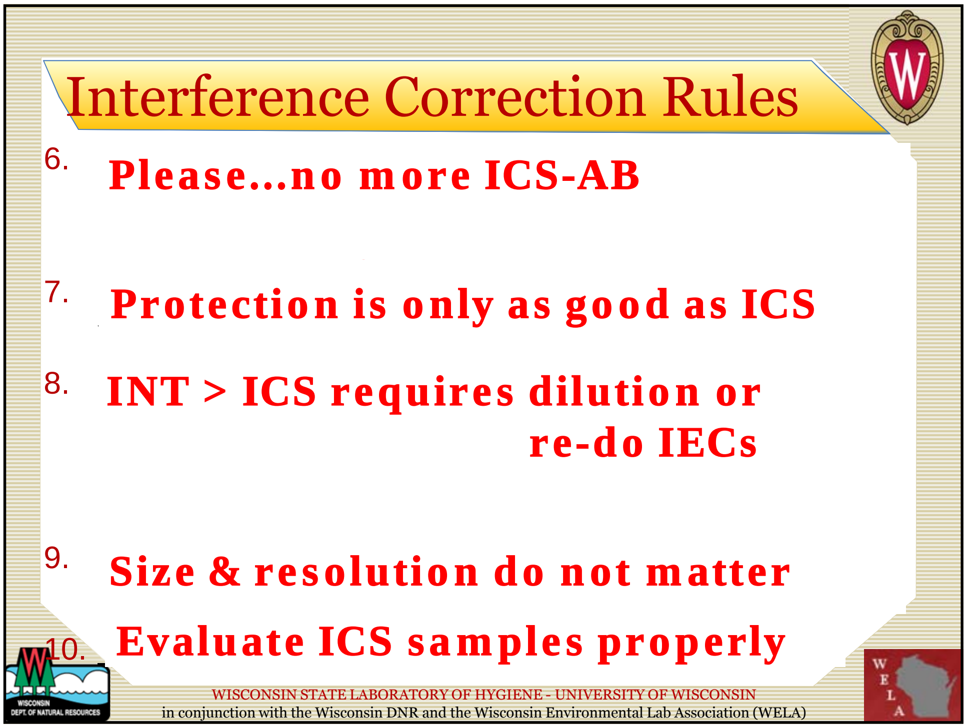

## Interference Correction Rules

6. Please…no more ICS-AB
7. Protection is only as good as ICS
8. INT > ICS requires dilution or re-do IECs
9. Size & resolution do not matter
10. Evaluate ICS samples properly

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# Which single elements? Level?

**200.7, Table 2:** Requires evaluation of interference from 17 elements: Al,Be,Ba,Cd,Ce,Co,Cr,Cu,Fe,Mn, Mo,Ni,Si,Sn,Ti,Tl,V

**6010C, Table 2:** Requires evaluation of interference from 10 elements: Al,Ca,Cr,Cu,Fe,Mg,Mn,Ni,Ti,V

1000 ppm: Al,Ca,Fe,Mg *(that seems a bit high: 250? 500 ppm?*

200 ppm: all others *(that may also be a bit high; 10 ppm will work in most cases)*

**Note that 6010 doesn't require evaluation from Mo. That wouldn't have ended well here, now would it?**

# Procedure to set IECs

1. Set background correction points.
2. Determine LODs.
3. Calibrate.
4. With IECs turned **OFF**, run single element standards for the 17 key interferents.
5. Populate an IEC table based on the results.
6. Analyze appropriate ICS standards designed to test for adequate correction of these interferences.
7. Verify that LODs are realistic (bouncing around the LOD).

## IEC Alternatives: FACT & MSF

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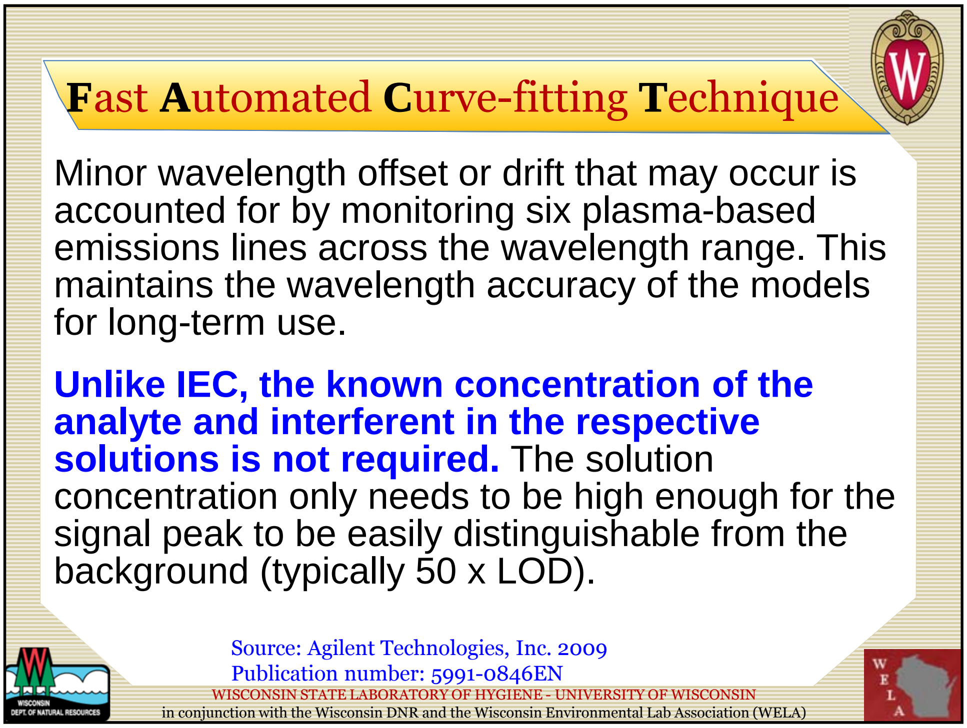

## **F**ast **A**utomated **C**urve-fitting **T**echnique

Minor wavelength offset or drift that may occur is accounted for by monitoring six plasma-based emissions lines across the wavelength range. This maintains the wavelength accuracy of the models for long-term use.

**Unlike IEC, the known concentration of the analyte and interferent in the respective solutions is not required.** The solution concentration only needs to be high enough for the signal peak to be easily distinguishable from the background (typically 50 x LOD).

Source: Agilent Technologies, Inc. 2009
Publication number: 5991-0846EN

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# How does FACT work?

Mathematically “deconvolutes” (or separate) the analyte signal from the raw spectrum.

**Models built by measuring the expected components separately and the response for each. This typically includes measuring these solutions:**

1. **A blank solution**
2. **A pure analyte solution**
3. **Pure interferent solutions.**

←Here, it’s much like MSF

Up to 7 interference models per analyte

Source: Agilent Technologies, Inc. 2009
Publication number: 5991-0846EN

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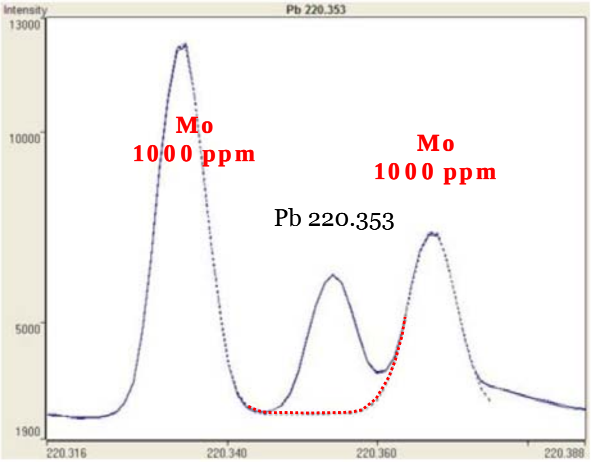
# What is Fitted Background Correction?



- Not one point,
- Not 2 points,
- but a true polynomial function solution to drawing the baseline.
- Parallel = GC peak integration.

Source: Agilent Technologies, Inc. 2012
Publication number: 5991-0841EN

## Fitted background correction

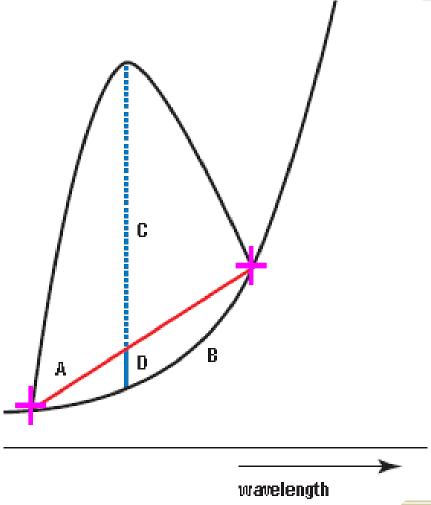
**Mathematically models the measured spectrum :**

1. Determining the **offset component** to model the unstructured continuum background.
2. Determining the **slope component to model the wings of large distant peaks.**
3. Applying three Gaussian peak components to model:
   - **a. The analyte peak.**
   - **b. Any potential interference peak left of the analyte peak.**
   - **c. Any potential interference peak right of the analyte peak.**
4. Using an iterative procedure to estimate the width and position of the peaks.
5. Using a method of least squares to determine the magnitude of the offset, slope and peak heights.

Source: Agilent Technologies, Inc. 2012. Pub. number: 5991-0841EN.
'Fitted' — Fast, accurate and fully automated background correction.

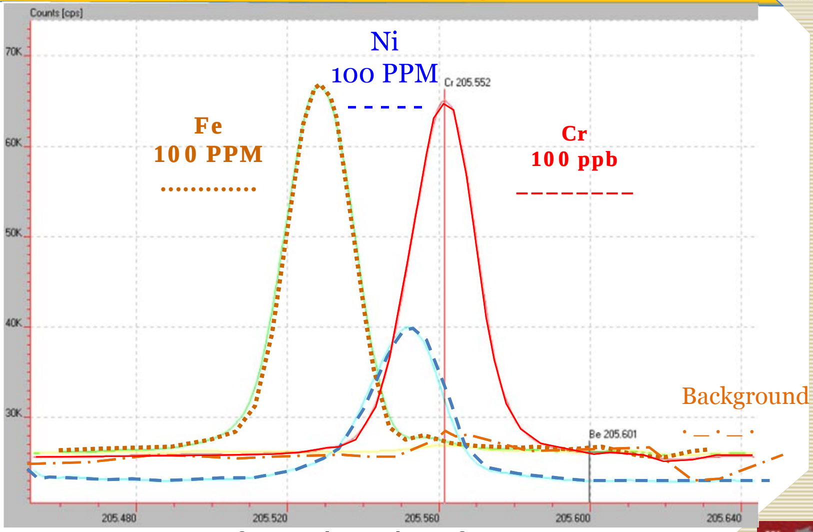
## Fitted background correction

No off-peak background correction peak searches required.



Source: Agilent Technologies, Inc. 2012
Publication number: 5991-0841EN

# Resolving Cr from high Fe, Ni…



…a perfect situation for FACT

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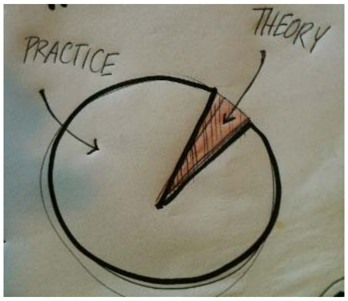
# FACT in practice for the PT sample



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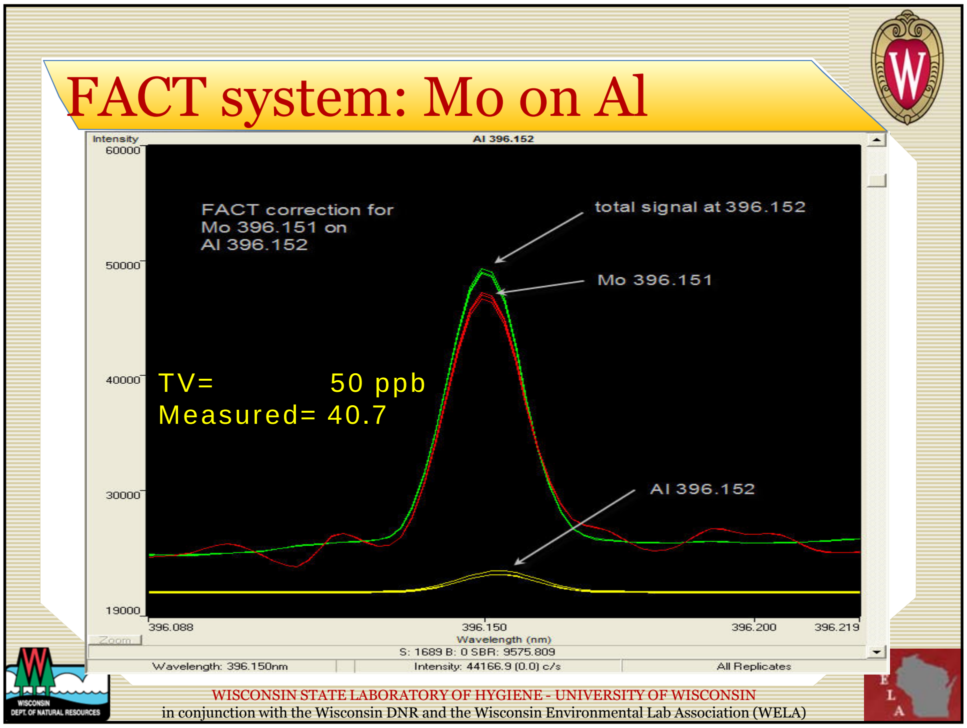

# FACT system: Mo on Al

FACT correction for
Mo 396.151 on
Al 396.152

total signal at 396.152

Mo 396.151

Al 396.152

TV= 50 ppb
Measured= 40.7

S: 1689 B: 0 SBR: 9575.809

Wavelength: 396.150nm | Intensity: 44166.9 (0.0) c/s | All Replicates

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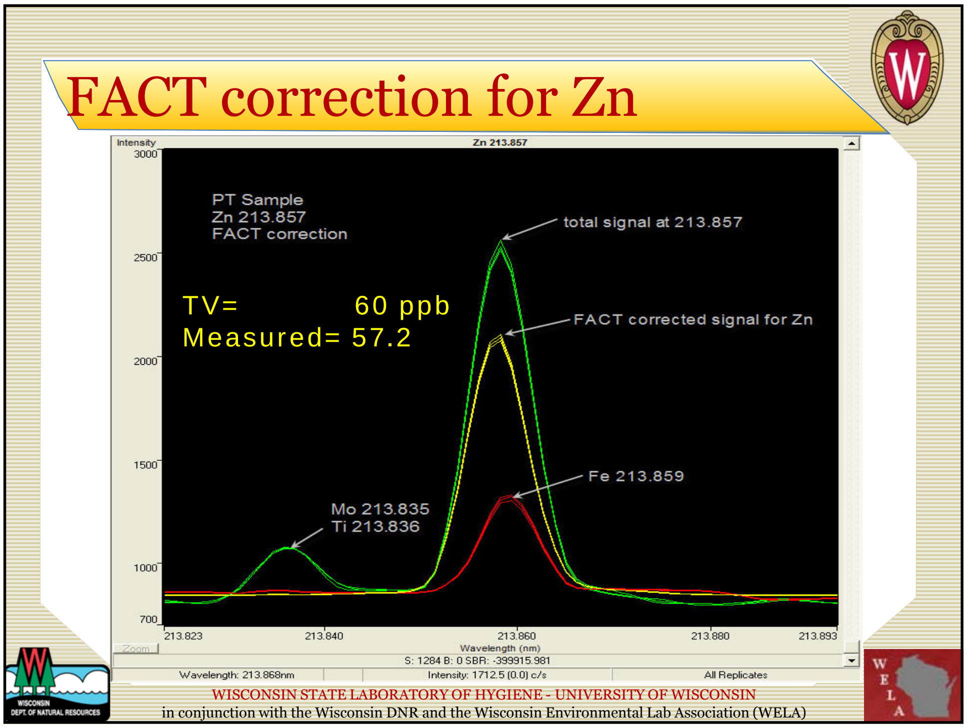

# FACT correction for Zn

PT Sample
Zn 213.857
FACT correction

total signal at 213.857

FACT corrected signal for Zn

Fe 213.859

Mo 213.835
Ti 213.836

TV= 60 ppb
Measured= 57.2

S: 1284 B: 0 SBR: -399915.981

Wavelength: 213.868nm | Intensity: 1712.5 (0.0) c/s | All Replicates

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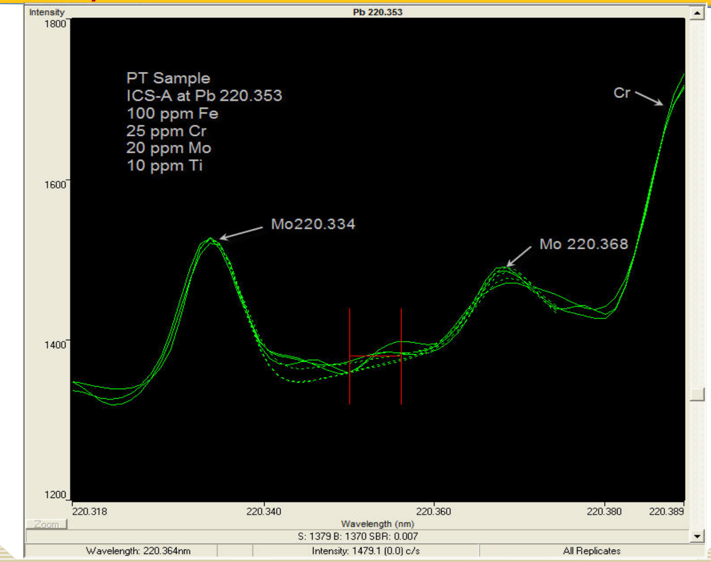
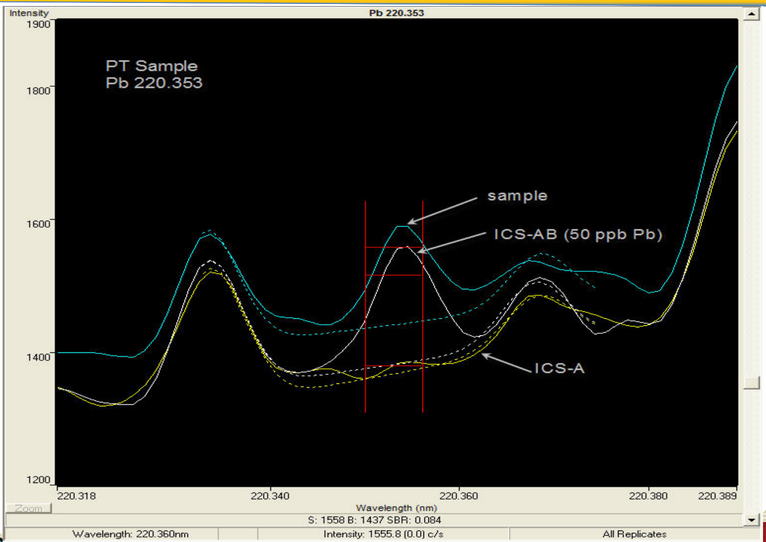
# FACT/FBC for Pb in ICS A



S: 1379 B: 1370 SBR: 0.007

Wavelength: 220.364nm | Intensity: 1479.1 (0.0) c/s | All Replicates

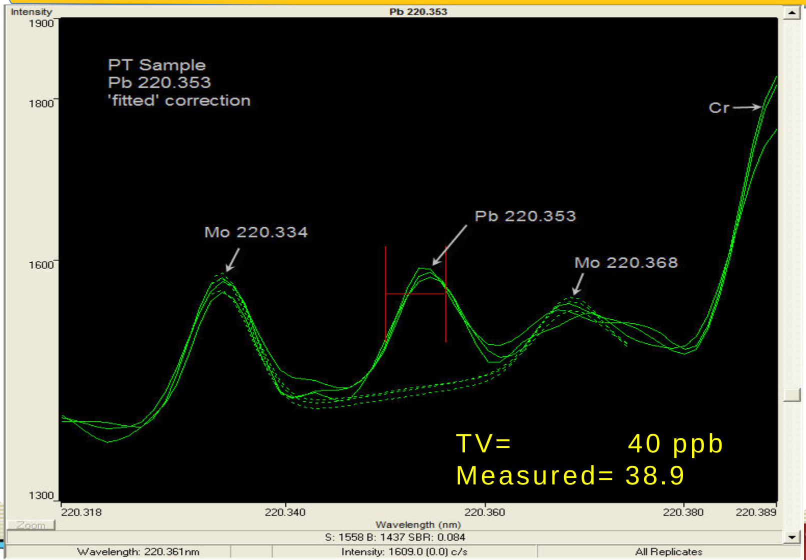
# FACT/FBC for Pb in ICS A/AB



S: 1558 B: 1437 SBR: 0.084

Wavelength: 220.360nm | Intensity: 1555.8 (0.0) c/s | All Replicates

# FACT Fitted correction for Pb



TV= 40 ppb
Measured= 38.9

S: 1558 B: 1437 SBR: 0.084
Wavelength: 220.361nm
Intensity: 1609.0 (0.0) c/s

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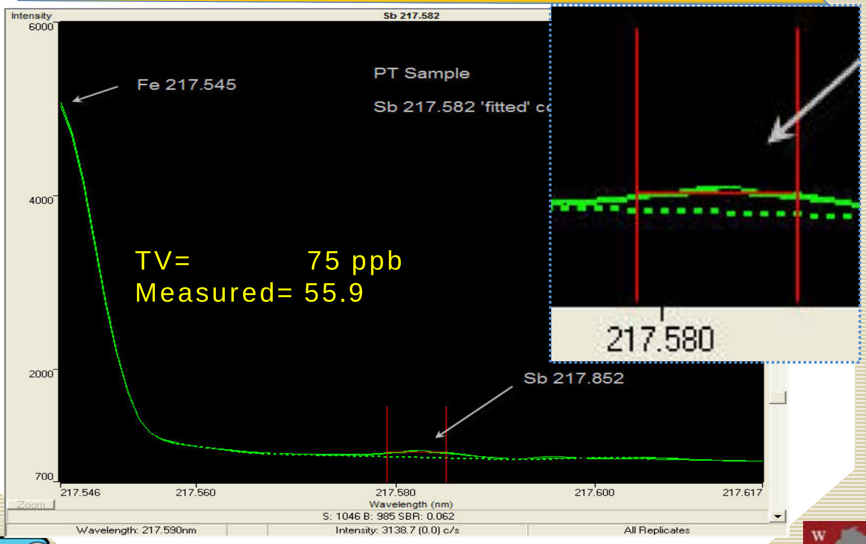
# FACT Fitted correction for Fe on Sb



TV= 75 ppb
Measured= 55.9

S: 1046 B: 985 SBR: 0.062
Wavelength: 217.590nm
Intensity: 3138.7 (0.0) c/s

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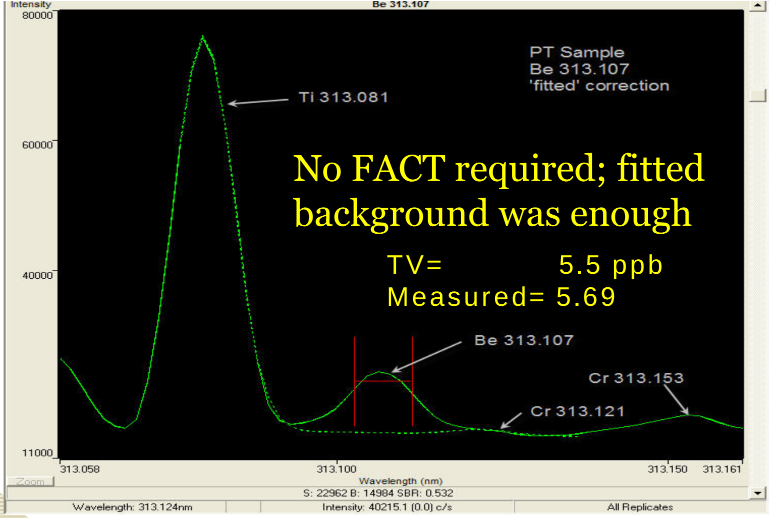
# FACT scan on Be



No FACT required; fitted background was enough

TV= 5.5 ppb
Measured= 5.69

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# LIMA on using FACT

(1) Scan the sample

(2) Make up individual single-element interferent samples & a mixed ICS-A containing all of the interferents at the concentrations in the sample.

(3) Spiked the ICS-A mix with low levels of analyte at 10 ppb and 50 ppb to run as our ICS-AB as a check against the sample spectra.

(4) Where fitted correction did not resolve the ICS-AB we employed the FACT correction and/or looked at alternate lines.

**Red H-bar** - a graphic used to indicate the pixel width at the desired λ used to adequately capture the peak for integration (default = 3 pixels wide).

MSF

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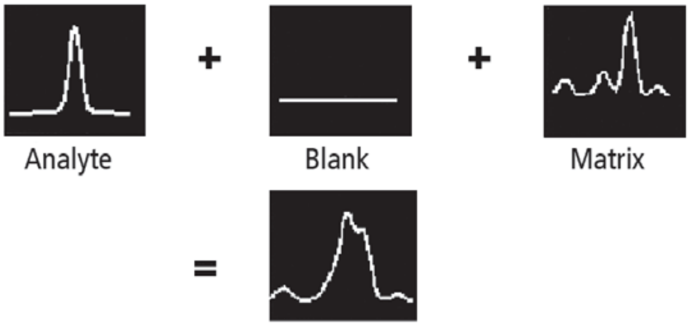
# MSF is…

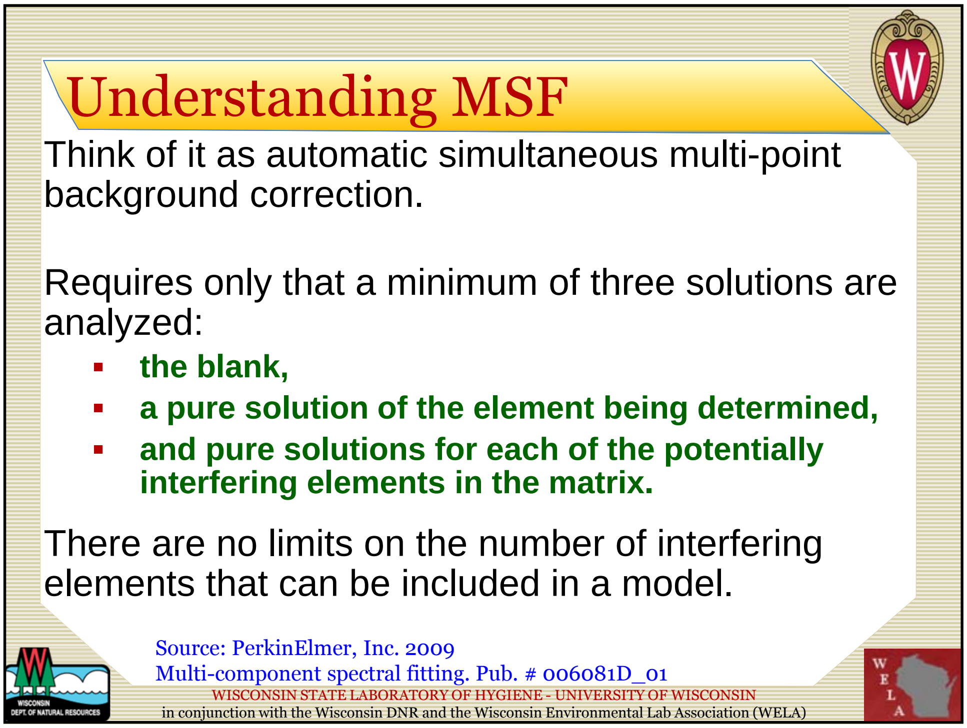
Emission spectrum = sum of $n$ contributions



Analyte + Blank + Matrix

= Measured Spectrum

**Source: PerkinElmer Inc., 2009.**
Multicomponent Spectral Fitting. Technical Note, 006081D_01.



## Understanding MSF

Think of it as automatic simultaneous multi-point background correction.

Requires only that a minimum of three solutions are analyzed:

- **the blank,**
- **a pure solution of the element being determined,**
- **and pure solutions for each of the potentially interfering elements in the matrix.**

There are no limits on the number of interfering elements that can be included in a model.

Source: PerkinElmer, Inc. 2009
Multi-component spectral fitting. Pub. # 006081D_01

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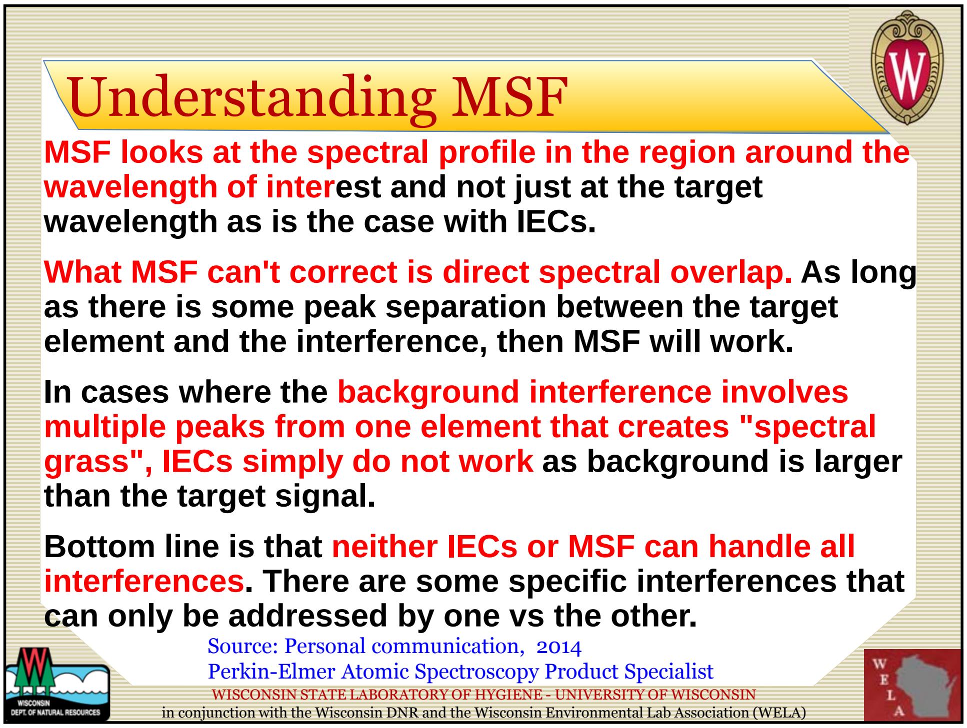

## Understanding MSF

**MSF looks at the spectral profile in the region around the wavelength of interest and not just at the target wavelength as is the case with IECs.**

**What MSF can't correct is direct spectral overlap. As long as there is some peak separation between the target element and the interference, then MSF will work.**

**In cases where the background interference involves multiple peaks from one element that creates "spectral grass", IECs simply do not work as background is larger than the target signal.**

**Bottom line is that neither IECs or MSF can handle all interferences. There are some specific interferences that can only be addressed by one vs the other.**

Source: Personal communication, 2014
Perkin-Elmer Atomic Spectroscopy Product Specialist

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# MSF in practice

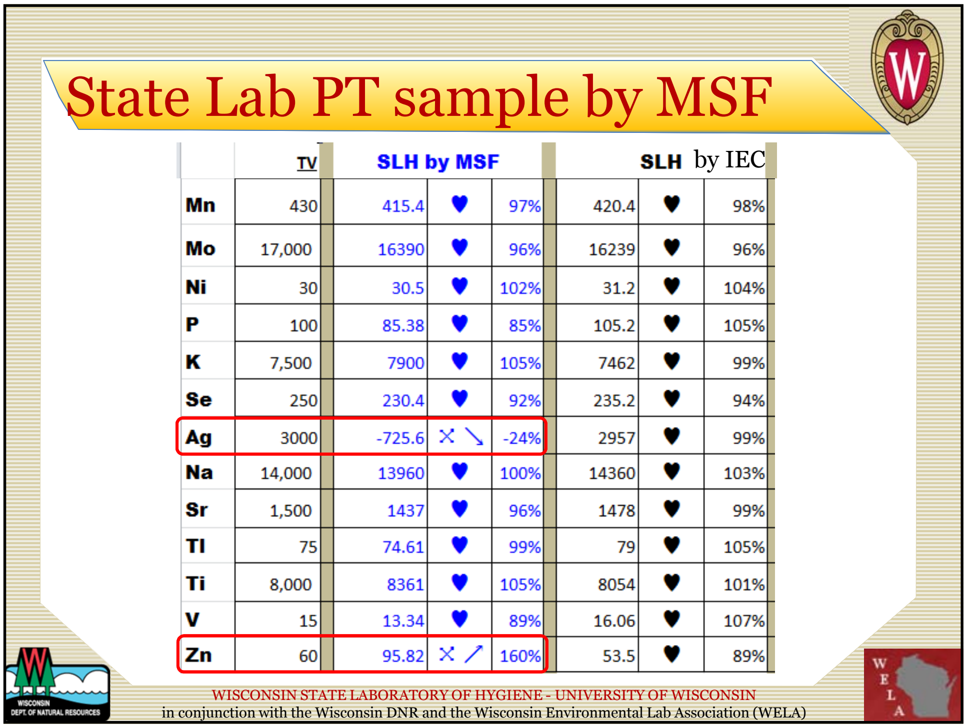
A user dialog box allows the analyst to select whether a particular line should be considered a blank, an analyte, or an interferent.

The scan appears no differently.

The SLH has MSF capability but generally does not use it because it's more sample specific.  However, an MSF routine was quickly created for the PT sample.

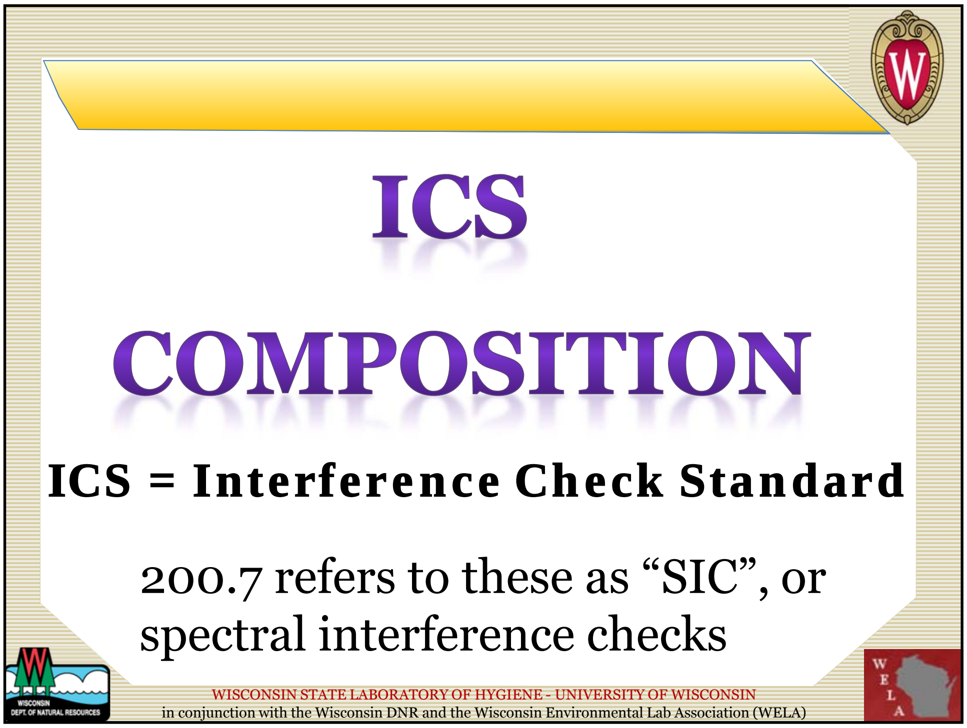
# State Lab PT sample by MSF

| | TV | SLH by MSF | | | SLH by IEC | | |
|---|---|---|---|---|---|---|---|
| **Al** | 50 | 75.96 | ♥ | 152% | 49.6 | ♥ | 99% |
| **Sb** | 75 | 58.8 | ♥ | 78% | 67.4 | ♥ | 90% |
| **As** | 100 | 109.5 | ♥ | 110% | 98 | ♥ | 98% |
| **Ba** | 880 | 860.7 | ♥ | 98% | 900 | ♥ | 102% |
| **Be** | 5.5 | 5.556 | ♥ | 101% | 5.2 | ♥ | 95% |
| **B** | 750 | 679 | ♥ | 91% | 842 | ♥ | 112% |
| **Cd** | 35 | 33.59 | ♥ | 96% | 35.2 | ♥ | 101% |
| **Ca** | 13,500 | 13460 | ♥ | 100% | 13292 | ♥ | 98% |
| **Cr** | 25,000 | 24030 | ♥ | 96% | 24610 | ♥ | 98% |
| **Co** | 240 | 230.6 | ♥ | 96% | 235.7 | ♥ | 98% |
| **Cu** | 1,300 | 1275 | ♥ | 98% | 1315 | ♥ | 101% |
| **Fe** | 110,000 | 109400 | ♥ | 99% | 112185 | ♥ | 102% |
| **Pb** | 40 | 42.23 | ♥ | 106% | 39 | ♥ | 98% |
| **Mg** | 8,750 | 9027 | ♥ | 103% | 8485 | ♥ | 97% |



# State Lab PT sample by MSF

| | TV | SLH by MSF | | | SLH by IEC | | |
|---|---|---|---|---|---|---|---|
| **Mn** | 430 | 415.4 | ♥ | 97% | 420.4 | ♥ | 98% |
| **Mo** | 17,000 | 16390 | ♥ | 96% | 16239 | ♥ | 96% |
| **Ni** | 30 | 30.5 | ♥ | 102% | 31.2 | ♥ | 104% |
| **P** | 100 | 85.38 | ♥ | 85% | 105.2 | ♥ | 105% |
| **K** | 7,500 | 7900 | ♥ | 105% | 7462 | ♥ | 99% |
| **Se** | 250 | 230.4 | ♥ | 92% | 235.2 | ♥ | 94% |
| **Ag** | 3000 | -725.6 | ✕ ↘ | -24% | 2957 | ♥ | 99% |
| **Na** | 14,000 | 13960 | ♥ | 100% | 14360 | ♥ | 103% |
| **Sr** | 1,500 | 1437 | ♥ | 96% | 1478 | ♥ | 99% |
| **Tl** | 75 | 74.61 | ♥ | 99% | 79 | ♥ | 105% |
| **Ti** | 8,000 | 8361 | ♥ | 105% | 8054 | ♥ | 101% |
| **V** | 15 | 13.34 | ♥ | 89% | 16.06 | ♥ | 107% |
| **Zn** | 60 | 95.82 | ✕ ↗ | 160% | 53.5 | ♥ | 89% |

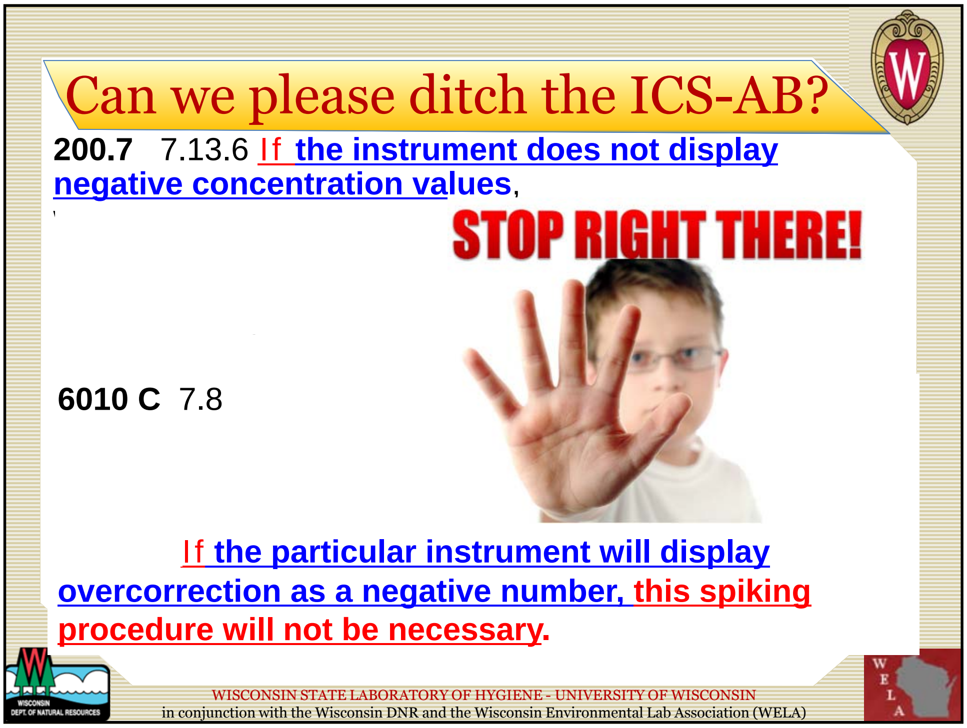


# ICS

# COMPOSITION

**ICS = Interference Check Standard**

200.7 refers to these as “SIC”, or spectral interference checks



# Can we please ditch the ICS-AB?

**200.7** 7.13.6 If the instrument does not display negative concentration values,

STOP RIGHT THERE!

**6010 C** 7.8

If the particular instrument will display overcorrection as a negative number, this spiking procedure will not be necessary.

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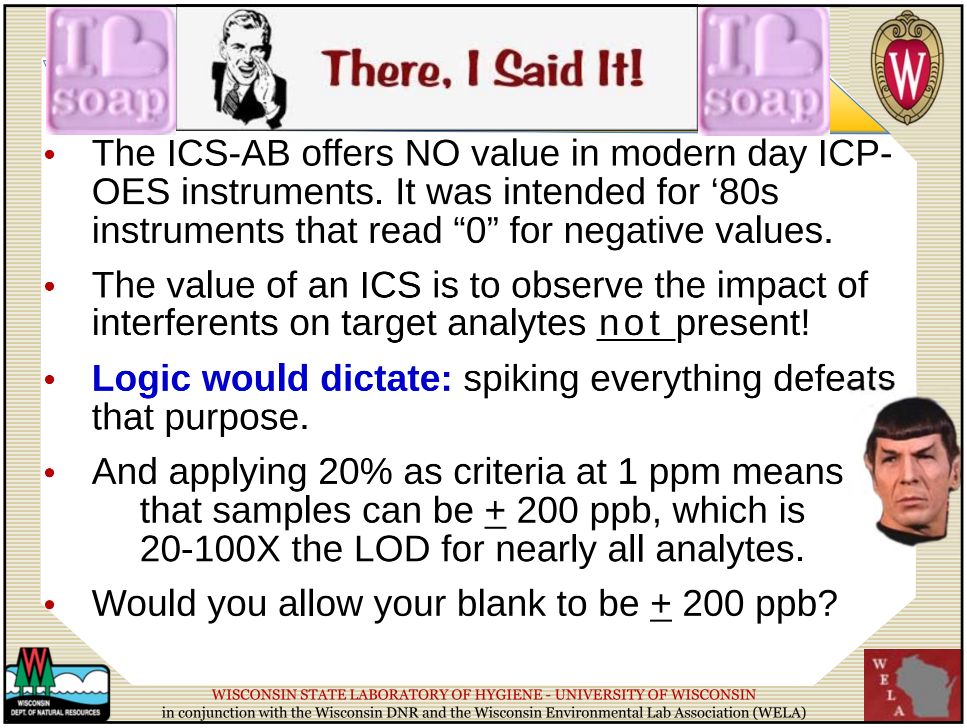

# There, I Said It!

- The ICS-AB offers NO value in modern day ICP-OES instruments. It was intended for ‘80s instruments that read “0” for negative values.
- The value of an ICS is to observe the impact of interferents on target analytes not present!
- **Logic would dictate:** spiking everything defeats that purpose.
- And applying 20% as criteria at 1 ppm means that samples can be ± 200 ppb, which is 20-100X the LOD for nearly all analytes.
- Would you allow your blank to be ± 200 ppb?

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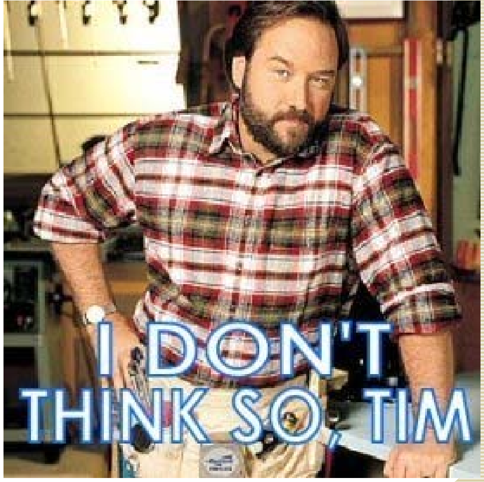
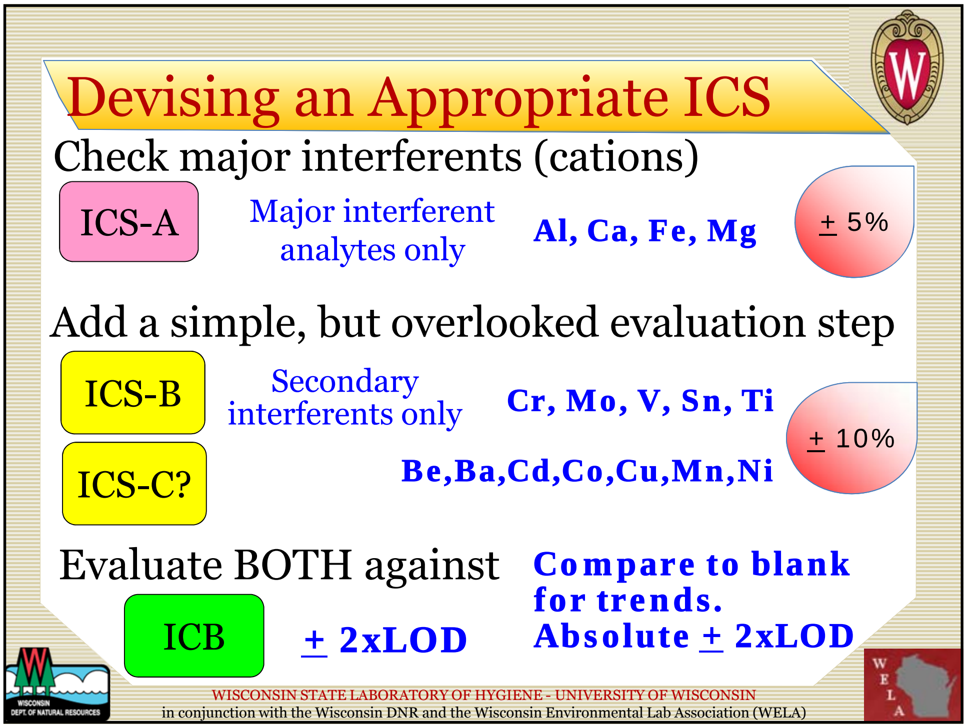
## I don't think so!

Blanks ±
200
ppb?



## ICS Evaluation Criteria

- Can we all agree that using ± 20% as acceptance criteria for ICS samples is just plain silly?
- Yes, that's what the methods suggest, **but…**
- ICV criteria are ± 5% (200,7) or ± 10% (6010)
- CCV criteria are ± 10% (200.7,6010)
- LCS criteria are ± 15% (200.7)
- At the ICS levels, shouldn't ± 5% be achievable?
- And for unspiked analytes, shouldn't they be the same as in a blank?
- **Using ± 20%? You may as well not do it at all.**



# Devising an Appropriate ICS

Check major interferents (cations)

| | | | |
|---|---|---|---|
| ICS-A | Major interferent analytes only | **Al, Ca, Fe, Mg** | ± 5% |

Add a simple, but overlooked evaluation step

| | | | |
|---|---|---|---|
| ICS-B | Secondary interferents only | **Cr, Mo, V, Sn, Ti** | ± 10% |
| ICS-C? | | **Be,Ba,Cd,Co,Cu,Mn,Ni** | |

Evaluate BOTH against

ICB **± 2xLOD**

**Compare to blank for trends.**
**Absolute ± 2xLOD**

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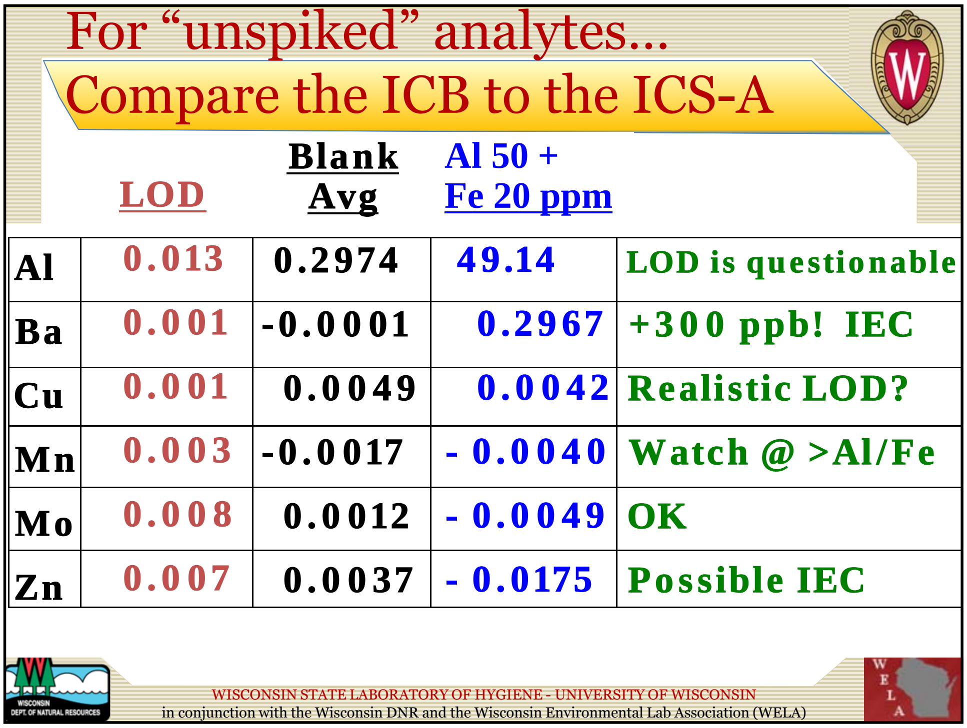

# For "unspiked" analytes…
# Compare the ICB to the ICS-A

| | LOD | **Blank Avg** | Al 50 + Fe 20 ppm | |
|---|---|---|---|---|
| **Al** | **0.013** | **0.2974** | **49.14** | **LOD is questionable** |
| **Ba** | **0.001** | **-0.0001** | **0.2967** | **+300 ppb! IEC** |
| **Cu** | **0.001** | **0.0049** | **0.0042** | **Realistic LOD?** |
| **Mn** | **0.003** | **-0.0017** | **- 0.0040** | **Watch @ >Al/Fe** |
| **Mo** | **0.008** | **0.0012** | **- 0.0049** | **OK** |
| **Zn** | **0.007** | **0.0037** | **- 0.0175** | **Possible IEC** |

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## Compare the ICB to the ICS-B

| | LOD | Blank | ICS-B* | |
|---|---|---|---|---|
| Ag | 0.0005 | 0.0009 | -0.0167 | Some interference |
| Al | 0.013 | 0.2974 | 0.7383 | Significant ↑ IEC! |
| Cd | 0.001 | -0.0021 | 0.0003 | Looks OK |
| Zn | 0.007 | 0.0037 | -0.0139 | Small IEC needed? |

*Cr,Cu,Mn,Ni,Ti,V @10ppm

## PT Sample Results

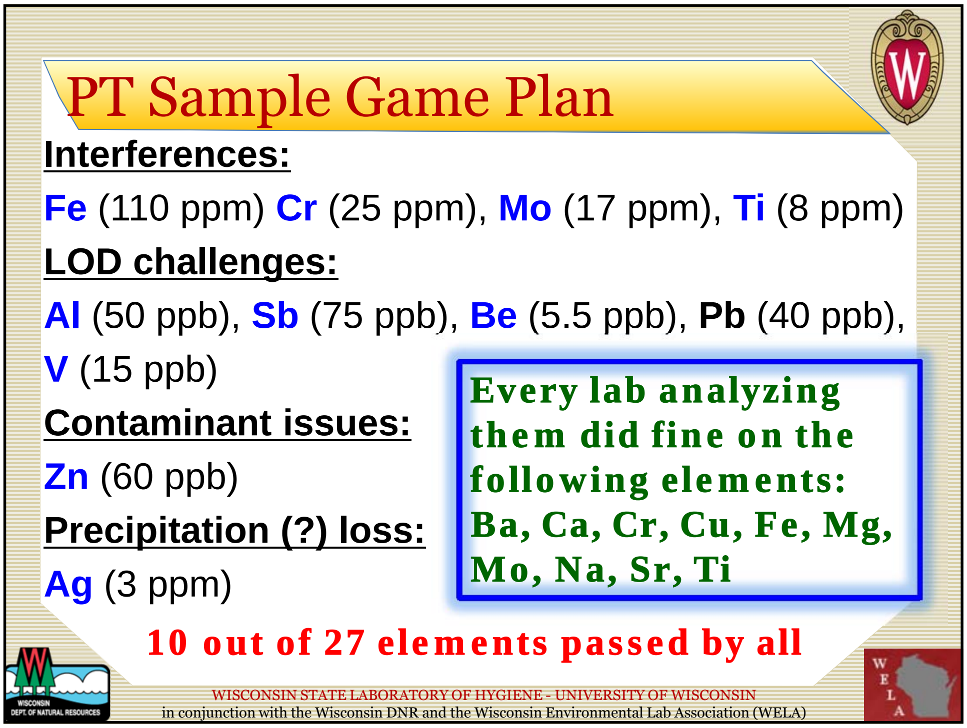
In 2005, we presented
The "Wibby"...
In 2014,
we upped the ante

## PT Sample Results

Remember…the point of these samples was analogous to an antiviral application for a computer; the sample was designed to highlight potential gaps in your interference security system. **If your lab did not fare well, please do not be discouraged**, we will be spending the majority of our time highlighting what the likely causes of these results are and how to correct them.

Please also understand that **these results are in no way reflective of any lab's day-to-day performance using ICP**. These samples, particularly the home brewed one, were specifically presented because of the challenge they pose in terms of interferents and actual levels of interferents.

Most labs will not encounter samples with such severe interferences routinely, but in the event you do, this will help you come up with a plan to upgrade your defense systems.



# PT Sample Game Plan

**Interferences:**

**Fe** (110 ppm) **Cr** (25 ppm), **Mo** (17 ppm), **Ti** (8 ppm)

**LOD challenges:**

**Al** (50 ppb), **Sb** (75 ppb), **Be** (5.5 ppb), **Pb** (40 ppb), **V** (15 ppb)

**Contaminant issues:**

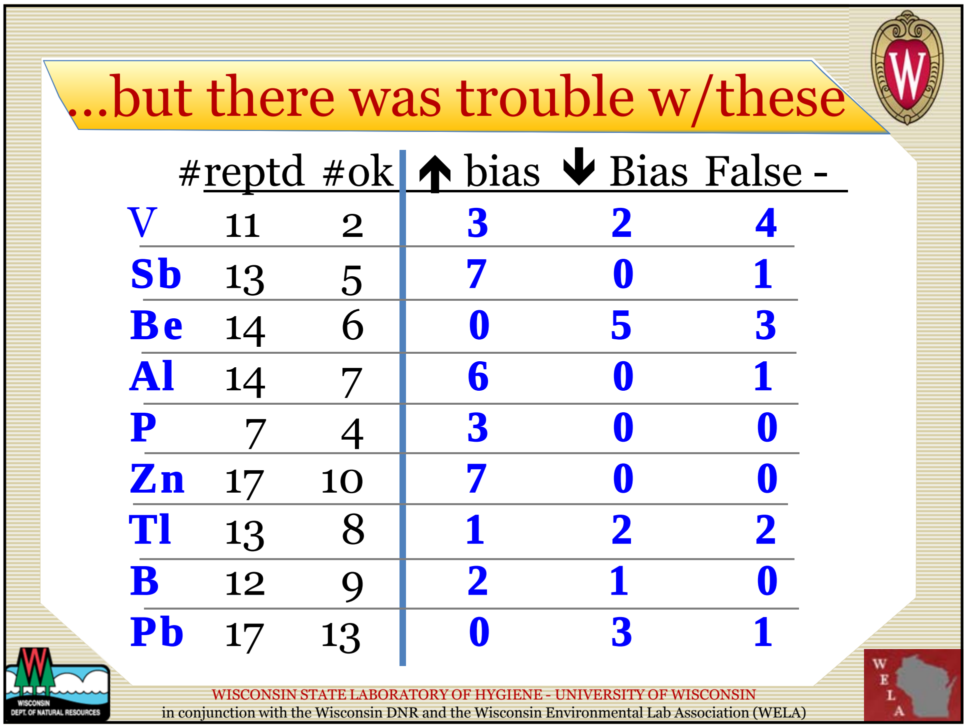
**Zn** (60 ppb)

**Precipitation (?) loss:**

**Ag** (3 ppm)

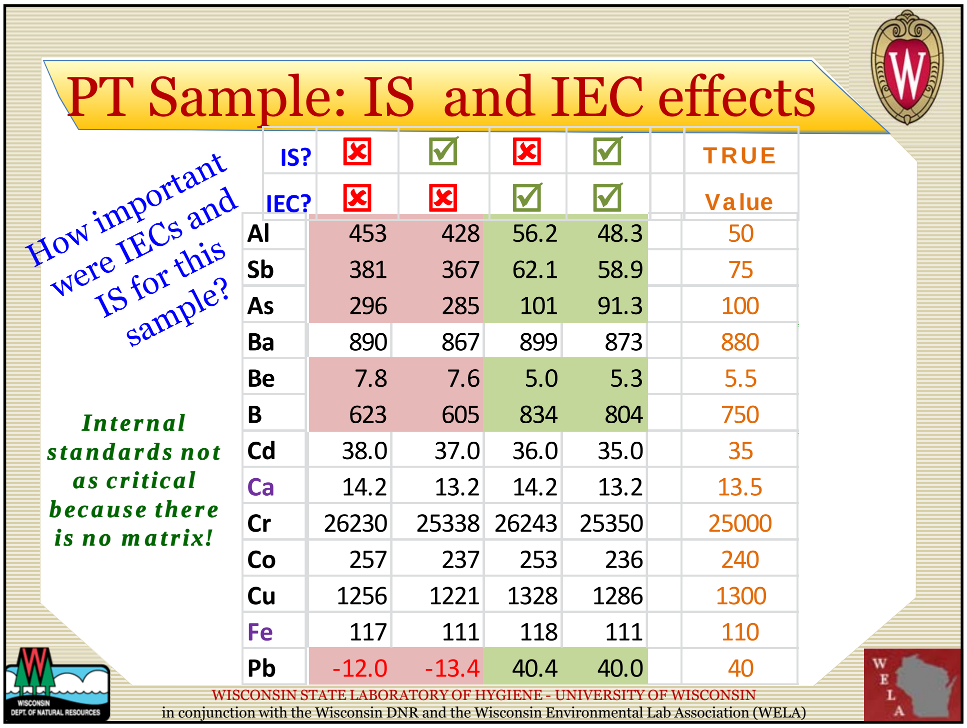
**Every lab analyzing them did fine on the following elements: Ba, Ca, Cr, Cu, Fe, Mg, Mo, Na, Sr, Ti**

**10 out of 27 elements passed by all**



# …but there was trouble w/these

| | #reptd | #ok | ↑ bias | ↓ Bias | False - |
|---|---|---|---|---|---|
| **V** | 11 | 2 | 3 | 2 | 4 |
| **Sb** | 13 | 5 | 7 | 0 | 1 |
| **Be** | 14 | 6 | 0 | 5 | 3 |
| **Al** | 14 | 7 | 6 | 0 | 1 |
| **P** | 7 | 4 | 3 | 0 | 0 |
| **Zn** | 17 | 10 | 7 | 0 | 0 |
| **Tl** | 13 | 8 | 1 | 2 | 2 |
| **B** | 12 | 9 | 2 | 1 | 0 |
| **Pb** | 17 | 13 | 0 | 3 | 1 |



# PT Sample: IS and IEC effects

How important were IECs and IS for this sample?

Internal standards not as critical because there is no matrix!

| IS? | ☒ | ☑ | ☒ | ☑ | TRUE |
|---|---|---|---|---|---|
| IEC? | ☒ | ☒ | ☑ | ☑ | Value |
| Al | 453 | 428 | 56.2 | 48.3 | 50 |
| Sb | 381 | 367 | 62.1 | 58.9 | 75 |
| As | 296 | 285 | 101 | 91.3 | 100 |
| Ba | 890 | 867 | 899 | 873 | 880 |
| Be | 7.8 | 7.6 | 5.0 | 5.3 | 5.5 |
| B | 623 | 605 | 834 | 804 | 750 |
| Cd | 38.0 | 37.0 | 36.0 | 35.0 | 35 |
| Ca | 14.2 | 13.2 | 14.2 | 13.2 | 13.5 |
| Cr | 26230 | 25338 | 26243 | 25350 | 25000 |
| Co | 257 | 237 | 253 | 236 | 240 |
| Cu | 1256 | 1221 | 1328 | 1286 | 1300 |
| Fe | 117 | 111 | 118 | 111 | 110 |
| Pb | -12.0 | -13.4 | 40.4 | 40.0 | 40 |

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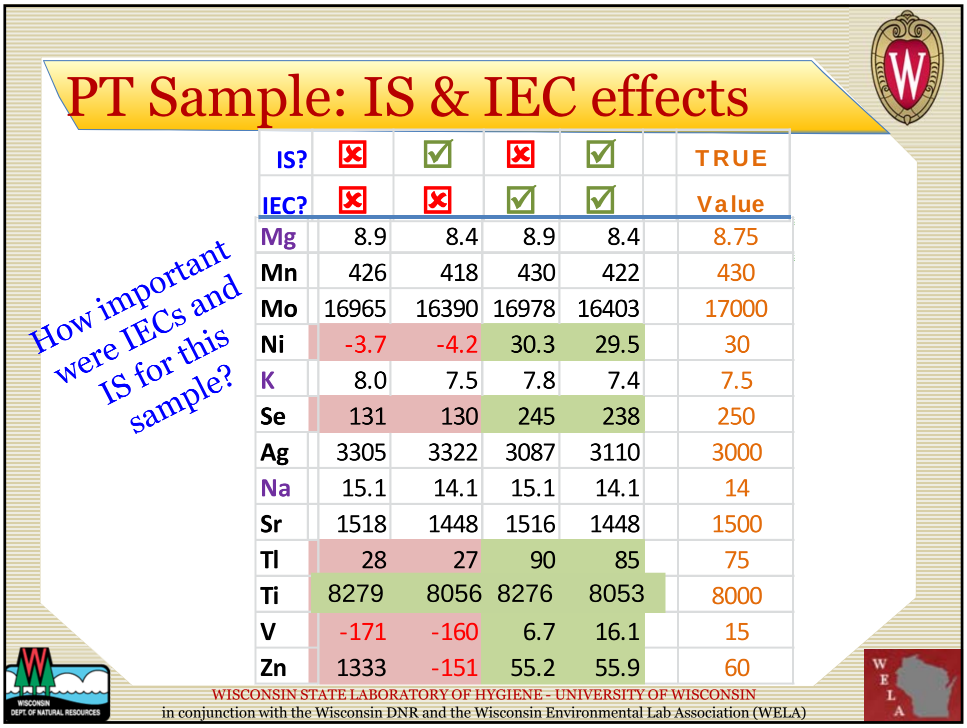

# PT Sample: IS & IEC effects

How important were IECs and IS for this sample?

| IS? | ☒ | ☑ | ☒ | ☑ | TRUE |
|---|---|---|---|---|---|
| IEC? | ☒ | ☒ | ☑ | ☑ | Value |
| Mg | 8.9 | 8.4 | 8.9 | 8.4 | 8.75 |
| Mn | 426 | 418 | 430 | 422 | 430 |
| Mo | 16965 | 16390 | 16978 | 16403 | 17000 |
| Ni | -3.7 | -4.2 | 30.3 | 29.5 | 30 |
| K | 8.0 | 7.5 | 7.8 | 7.4 | 7.5 |
| Se | 131 | 130 | 245 | 238 | 250 |
| Ag | 3305 | 3322 | 3087 | 3110 | 3000 |
| Na | 15.1 | 14.1 | 15.1 | 14.1 | 14 |
| Sr | 1518 | 1448 | 1516 | 1448 | 1500 |
| Tl | 28 | 27 | 90 | 85 | 75 |
| Ti | 8279 | 8056 | 8276 | 8053 | 8000 |
| V | -171 | -160 | 6.7 | 16.1 | 15 |
| Zn | 1333 | -151 | 55.2 | 55.9 | 60 |

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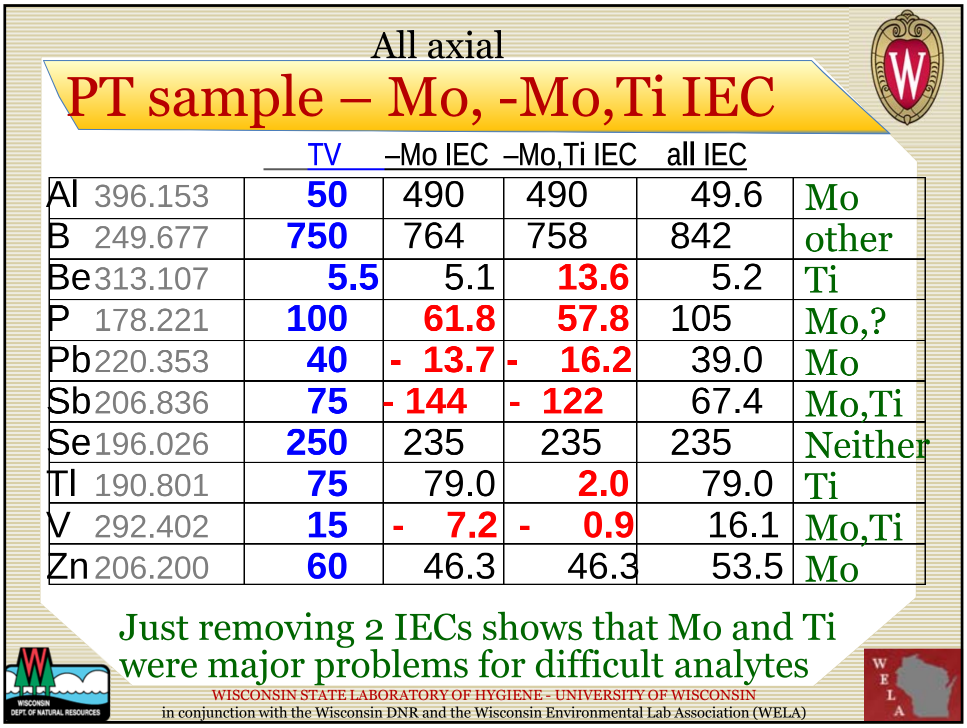

All axial

## PT sample – Mo, -Mo,Ti IEC

| | TV | –Mo IEC | –Mo,Ti IEC | all IEC | |
|---|---|---|---|---|---|
| Al 396.153 | 50 | 490 | 490 | 49.6 | Mo |
| B 249.677 | 750 | 764 | 758 | 842 | other |
| Be 313.107 | 5.5 | 5.1 | 13.6 | 5.2 | Ti |
| P 178.221 | 100 | 61.8 | 57.8 | 105 | Mo,? |
| Pb 220.353 | 40 | - 13.7 | - 16.2 | 39.0 | Mo |
| Sb 206.836 | 75 | - 144 | - 122 | 67.4 | Mo,Ti |
| Se 196.026 | 250 | 235 | 235 | 235 | Neither |
| Tl 190.801 | 75 | 79.0 | 2.0 | 79.0 | Ti |
| V 292.402 | 15 | - 7.2 | - 0.9 | 16.1 | Mo,Ti |
| Zn 206.200 | 60 | 46.3 | 46.3 | 53.5 | Mo |

Just removing 2 IECs shows that Mo and Ti were major problems for difficult analytes

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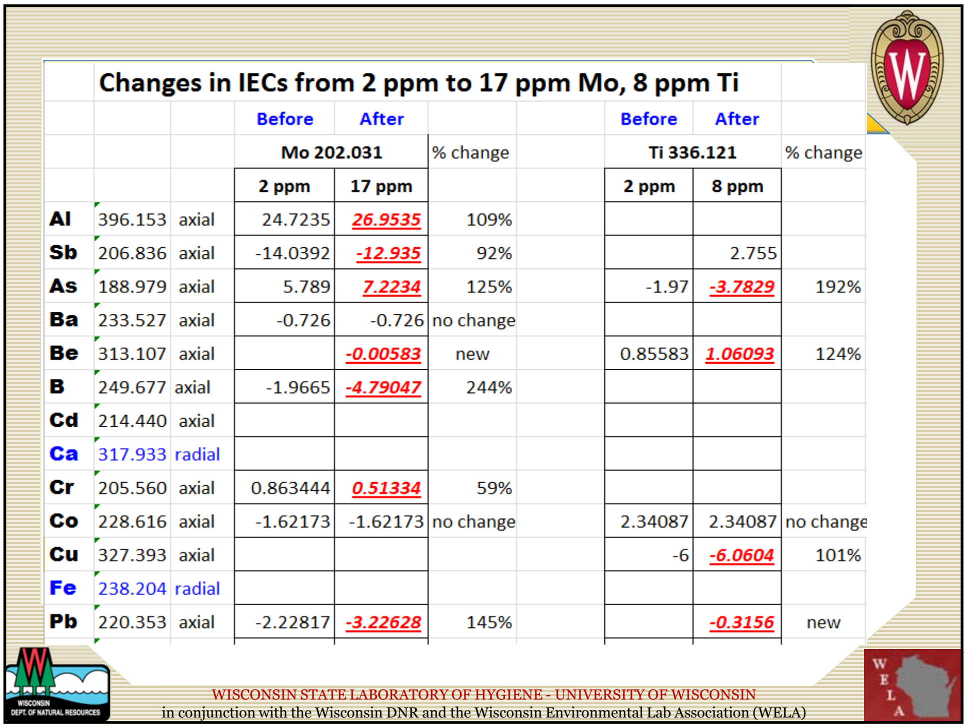

## Changes in IECs from 2 ppm to 17 ppm Mo, 8 ppm Ti

| | | | Before | After | | | Before | After | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Mo 202.031 | | % change | | Ti 336.121 | | % change |
| | | | 2 ppm | 17 ppm | | | 2 ppm | 8 ppm | |
| **Al** | 396.153 | axial | 24.7235 | 26.9535 | 109% | | | | |
| **Sb** | 206.836 | axial | -14.0392 | -12.935 | 92% | | | 2.755 | |
| **As** | 188.979 | axial | 5.789 | 7.2234 | 125% | | -1.97 | -3.7829 | 192% |
| **Ba** | 233.527 | axial | -0.726 | -0.726 | no change | | | | |
| **Be** | 313.107 | axial | | -0.00583 | new | | 0.85583 | 1.06093 | 124% |
| **B** | 249.677 | axial | -1.9665 | -4.79047 | 244% | | | | |
| **Cd** | 214.440 | axial | | | | | | | |
| **Ca** | 317.933 | radial | | | | | | | |
| **Cr** | 205.560 | axial | 0.863444 | 0.51334 | 59% | | | | |
| **Co** | 228.616 | axial | -1.62173 | -1.62173 | no change | | 2.34087 | 2.34087 | no change |
| **Cu** | 327.393 | axial | | | | | -6 | -6.0604 | 101% |
| **Fe** | 238.204 | radial | | | | | | | |
| **Pb** | 220.353 | axial | -2.22817 | -3.22628 | 145% | | | -0.3156 | new |

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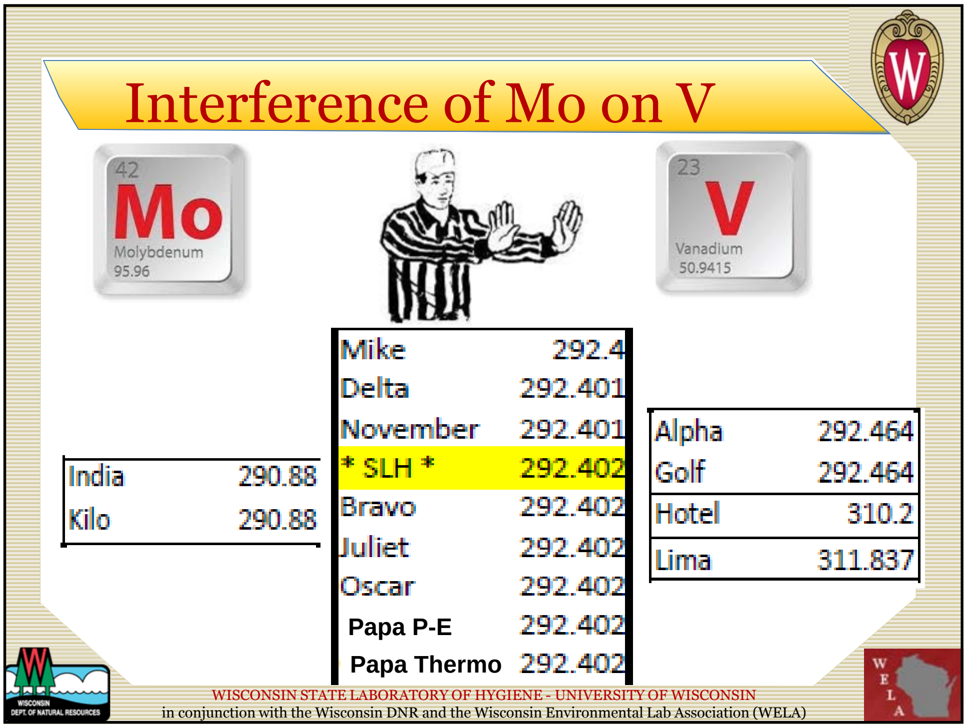
## Changes in IECs from 2 ppm to 17 ppm Mo, 8 ppm Ti

| | | | Before | After | | Before | After | |
|---|---|---|---|---|---|---|---|---|
| | | | Mo 202.031 | | % change | Ti 336.121 | | % change |
| | | | 2 ppm | 17 ppm | | 2 ppm | 8 ppm | |
| **Mg** | 279.077 | radial | | | | | | |
| **Mn** | 257.610 | axial | | | | | | |
| **Mo** | 202.031 | axial | | | | | *0.63785* | new |
| **Ni** | 231.604 | axial | -2.43243 | *-2.19289* | 90% | | | |
| **P** | 178.221 | axial | | *-2.66056* | new | | *-0.4928* | new |
| **K** | 766.490 | radial | | | | | | |
| **Se** | 196.026 | axial | | | | | | |
| **Ag** | 338.289 | axial | | | | -6.045 | *-5.8001* | 96% |
| **Na** | 589.592 | radial | | | | | | |
| **Sr** | 407.771 | radial | | | | | | |
| **Tl** | 190.801 | axial | | | | -11.6478 | *-9.5717* | 82% |
| **Ti** | 336.121 | axial | | *0.16409* | new | | | |
| **V** | 292.402 | axial | | -1.4245 | | 0.91222 | *0.77957* | 85% |
| **Zn** | 206.200 | axial | | *-0.43591* | new | | | |
| | | | 9 | 14 | # interferents | 7 | 11 | |

# Examples from the (PT) sample

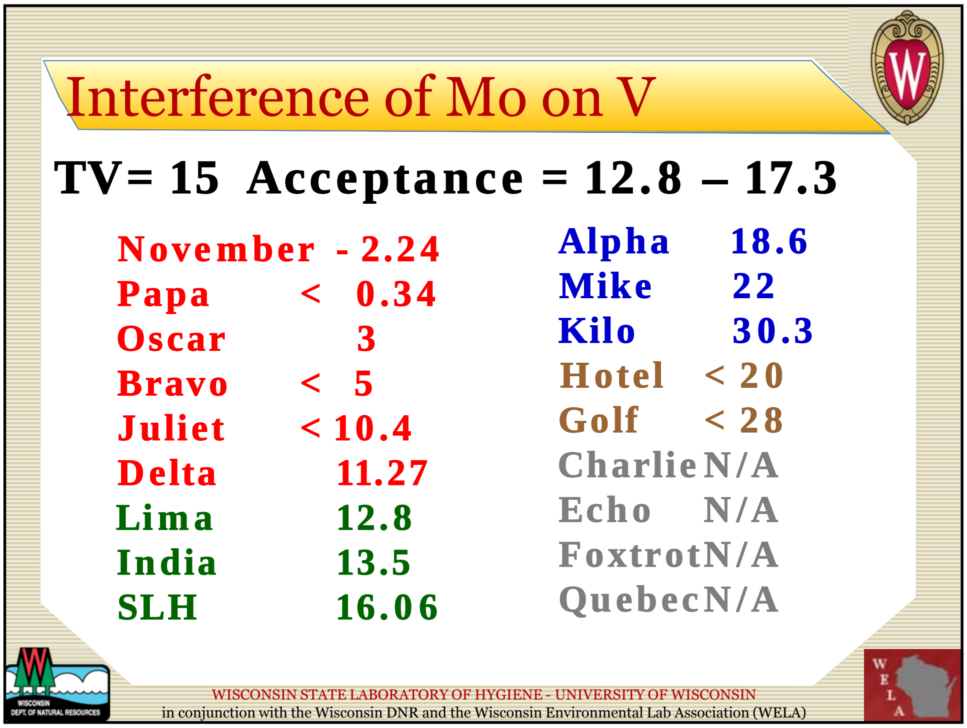


# Interference of Mo on V

| | |
|---|---|
| India | 290.88 |
| Kilo | 290.88 |

| | |
|---|---|
| Mike | 292.4 |
| Delta | 292.401 |
| November | 292.401 |
| * SLH * | 292.402 |
| Bravo | 292.402 |
| Juliet | 292.402 |
| Oscar | 292.402 |
| Papa P-E | 292.402 |
| Papa Thermo | 292.402 |

| | |
|---|---|
| Alpha | 292.464 |
| Golf | 292.464 |
| Hotel | 310.2 |
| Lima | 311.837 |



# Interference of Mo on V

**TV= 15 Acceptance = 12.8 – 17.3**

| | | |
|---|---|---|
| November | | - 2.24 |
| Papa | < | 0.34 |
| Oscar | | 3 |
| Bravo | < | 5 |
| Juliet | < | 10.4 |
| Delta | | 11.27 |
| Lima | | 12.8 |
| India | | 13.5 |
| SLH | | 16.06 |

| | |
|---|---|
| Alpha | 18.6 |
| Mike | 22 |
| Kilo | 30.3 |
| Hotel | < 20 |
| Golf | < 28 |
| Charlie | N/A |
| Echo | N/A |
| Foxtrot | N/A |
| Quebec | N/A |

# Interference of Mo on V

P-E default background correction points are at -27 and +27 pm off line from the peak maximum at 292.402 nm.

The +27 pt falls dead on top of a Mo peak (which would only be a problem at these Mo levels).

Kilo (202%) uses 290.88 line (P-E 1st recommended line). There is also a Mo peak at 290.912.

Lima passed but had low bias. They use λ 311.837 (5th recommended line). There is a Cr line at 311.865 nm.

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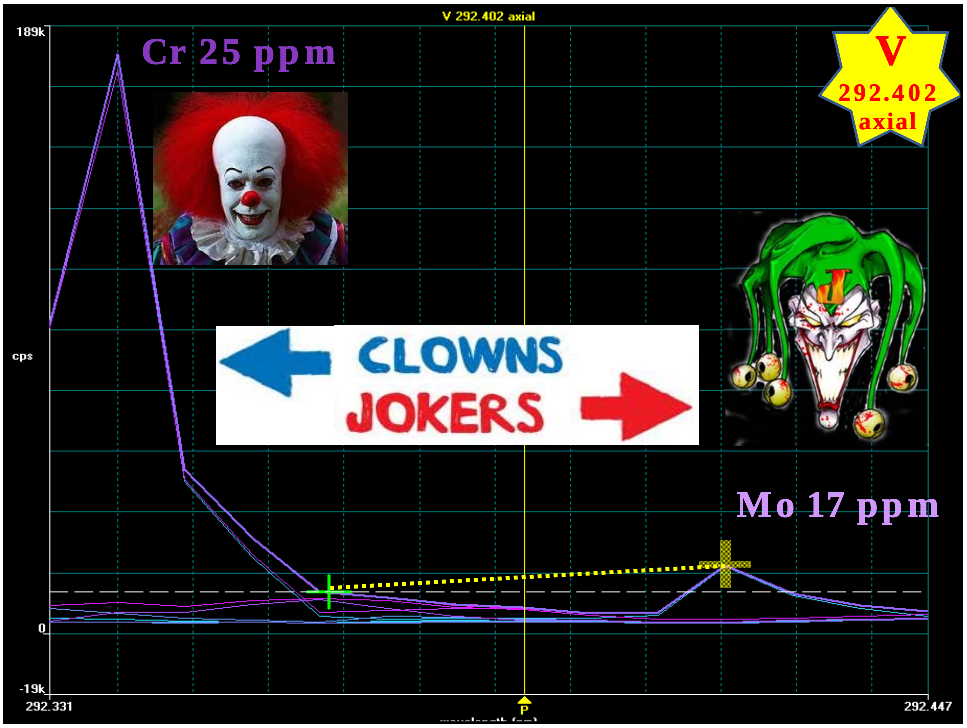

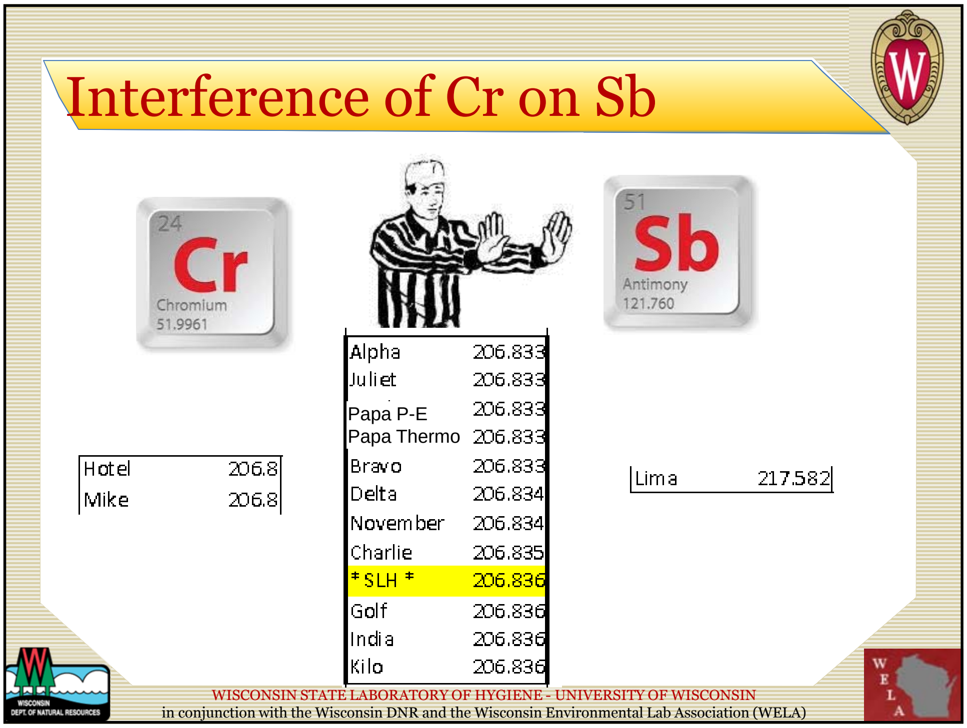

# Interference of Cr on Sb

| | |
|---|---|
| Hotel | 206.8 |
| Mike | 206.8 |

| | |
|---|---|
| Alpha | 206.833 |
| Juliet | 206.833 |
| Papa P-E | 206.833 |
| Papa Thermo | 206.833 |
| Bravo | 206.833 |
| Delta | 206.834 |
| November | 206.834 |
| Charlie | 206.835 |
| * SLH * | 206.836 |
| Golf | 206.836 |
| India | 206.836 |
| Kilo | 206.836 |

| | |
|---|---|
| Lima | 217.582 |

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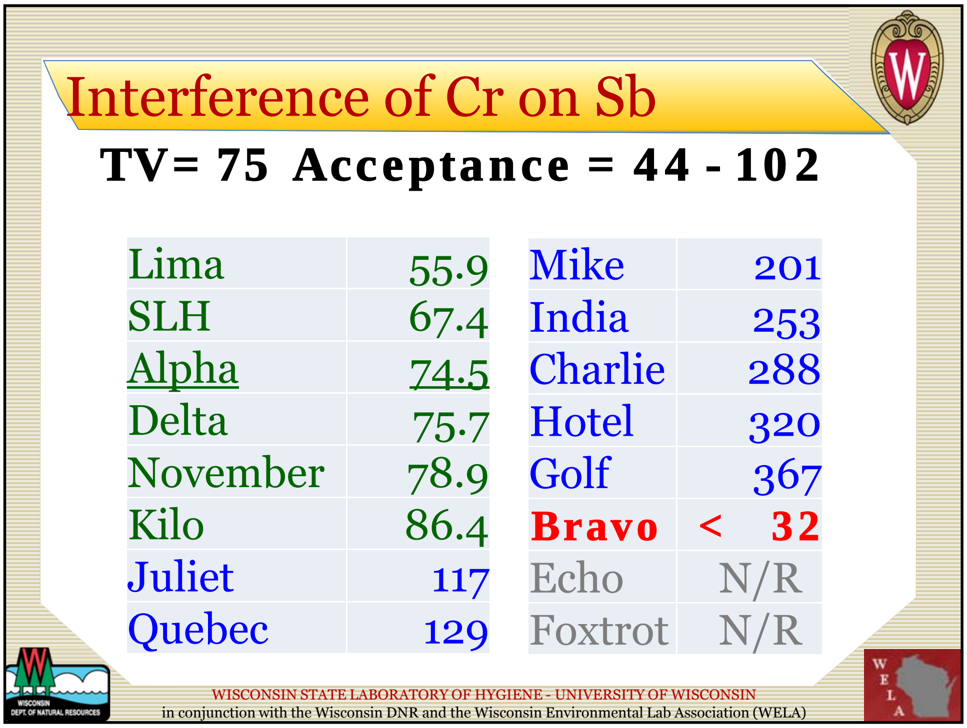

# Interference of Cr on Sb

**TV= 75 Acceptance = 44 - 102**

| | | | |
|---|---|---|---|
| Lima | 55.9 | Mike | 201 |
| SLH | 67.4 | India | 253 |
| Alpha | 74.5 | Charlie | 288 |
| Delta | 75.7 | Hotel | 320 |
| November | 78.9 | Golf | 367 |
| Kilo | 86.4 | **Bravo** | **< 32** |
| Juliet | 117 | Echo | N/R |
| Quebec | 129 | Foxtrot | N/R |

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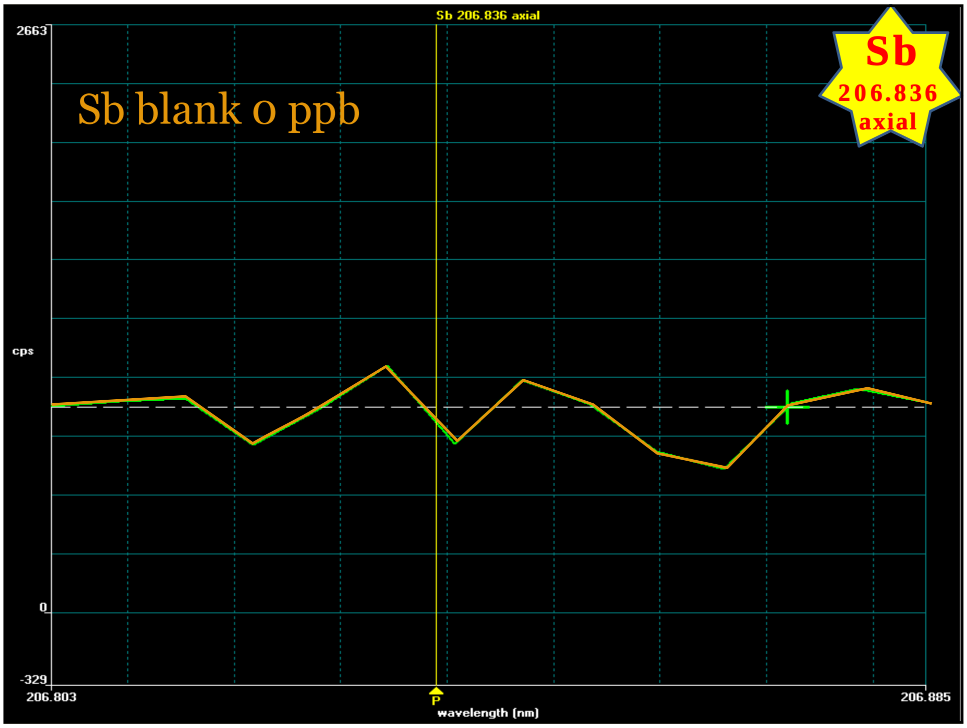
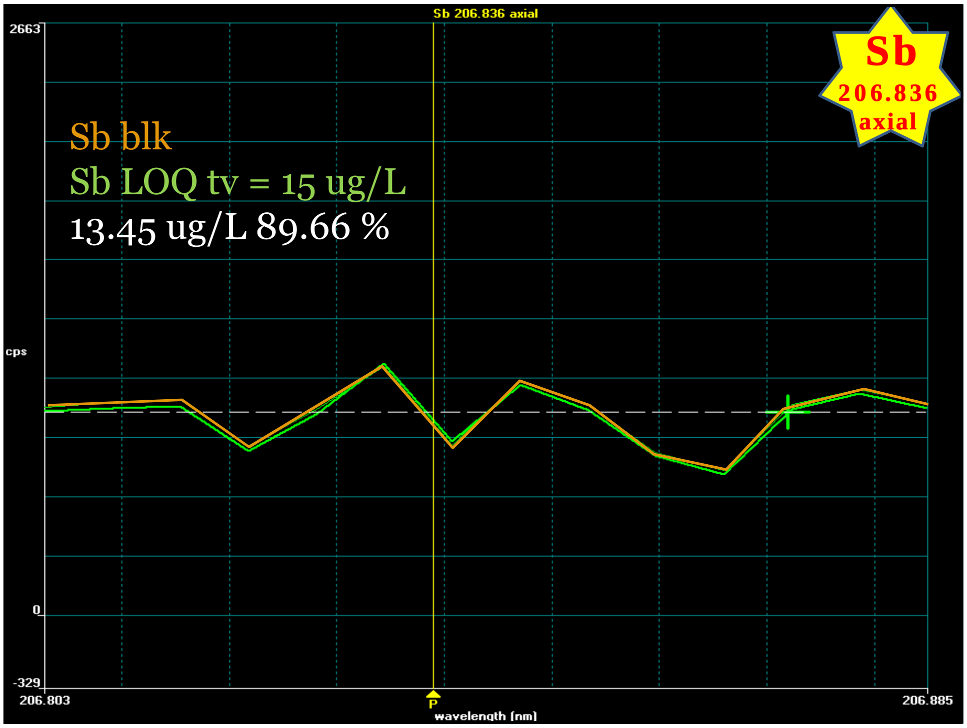
# Interference of Cr on Sb

**High bias will result (676% for SLH) if no correction was employed for interference due to Cr.**

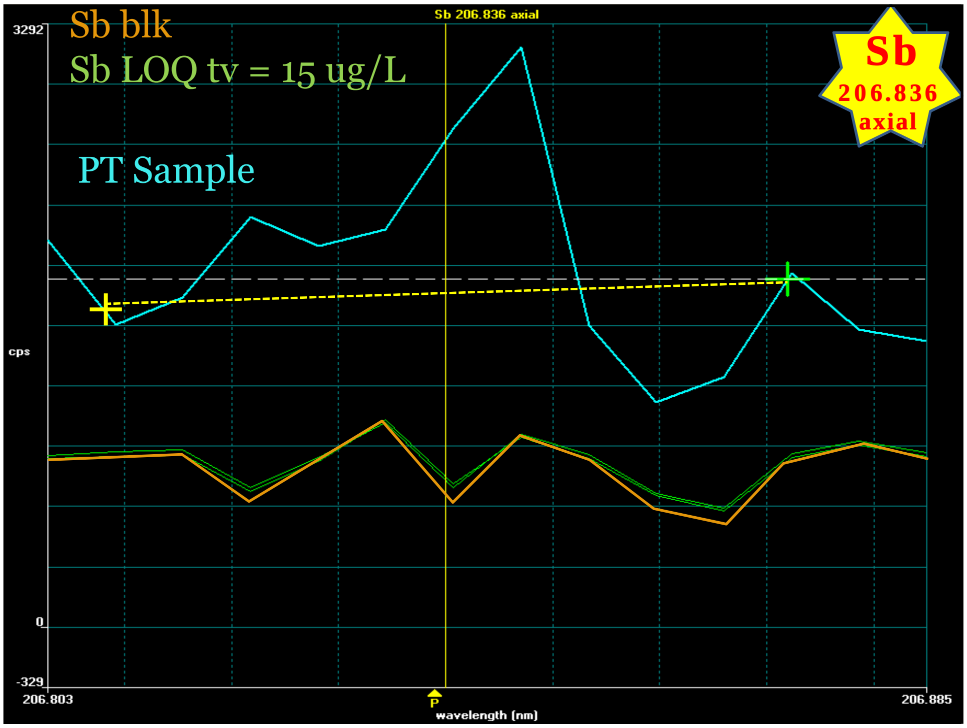
**False "-" is most likely due to use of 2 background correction points. Cr is right on top of Sb.**



Sb blank 0 ppb

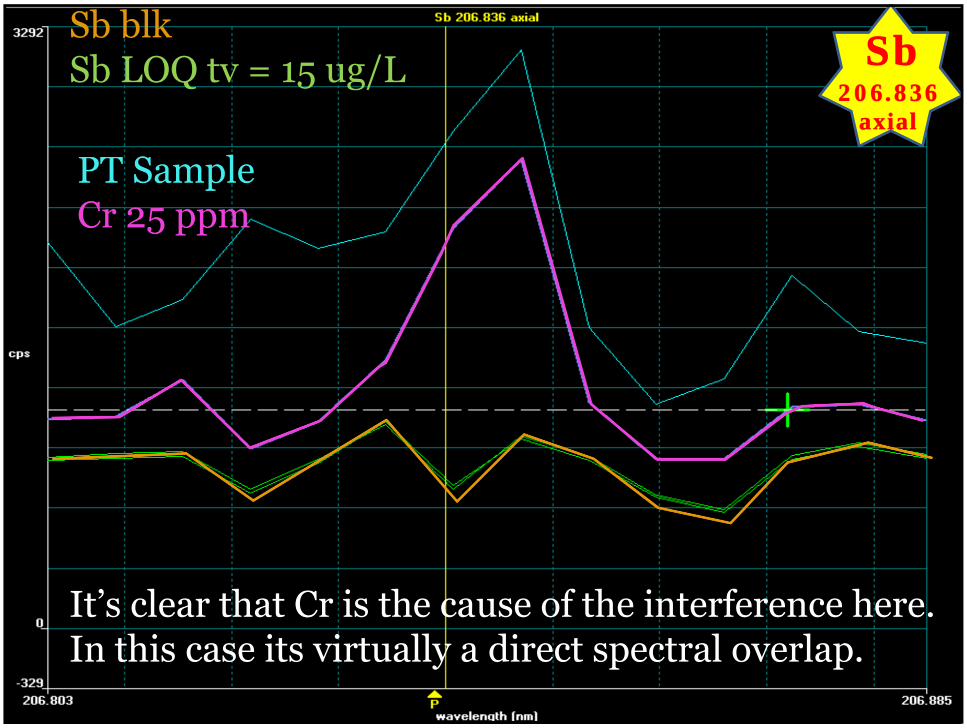


Sb blk
Sb LOQ tv = 15 ug/L
13.45 ug/L 89.66 %

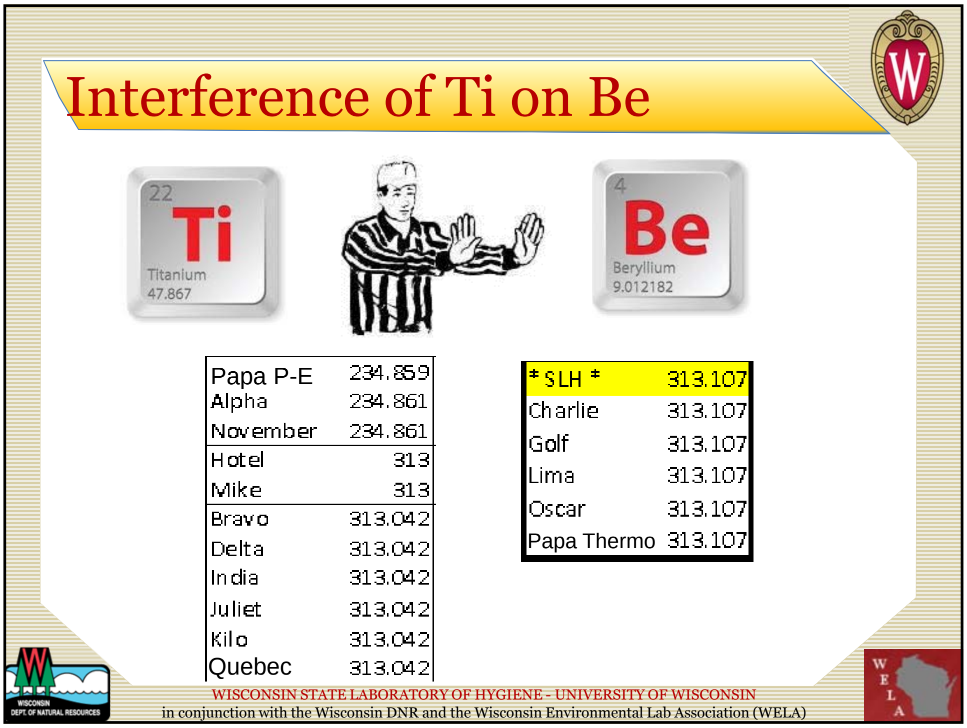


Sb blk
Sb LOQ tv = 15 ug/L

PT Sample



It's clear that Cr is the cause of the interference here. In this case its virtually a direct spectral overlap.



# Interference of Ti on Be

| | |
|---|---|
| Papa P-E | 234.859 |
| Alpha | 234.861 |
| November | 234.861 |
| Hotel | 313 |
| Mike | 313 |
| Bravo | 313.042 |
| Delta | 313.042 |
| India | 313.042 |
| Juliet | 313.042 |
| Kilo | 313.042 |
| Quebec | 313.042 |

| | |
|---|---|
| * SLH * | 313.107 |
| Charlie | 313.107 |
| Golf | 313.107 |
| Lima | 313.107 |
| Oscar | 313.107 |
| Papa Thermo | 313.107 |

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## Interference of Ti on Be

**TV= 5.5 Acceptance = 4.68 – 6.33**

| | |
|---|---|
| **Charlie** | **< 0.79** |
| **Hotel** | **< 1** |
| **Kilo** | **< 1.0** |
| **Papa** | **1.7** |
| **Oscar** | **4** |
| **November** | **4.38** |
| **Mike** | **4.4** |
| **Alpha** | **4.6** |

| | |
|---|---|
| Quebec | 5 |
| Delta | 5.069 |
| India | 5.14 |
| Juliet | 5.19 |
| SLH | 5.2 |
| Bravo | 5.26 |
| Lima | 5.69 |
| Golf | < 7 |

Echo, Foxtrot N/R

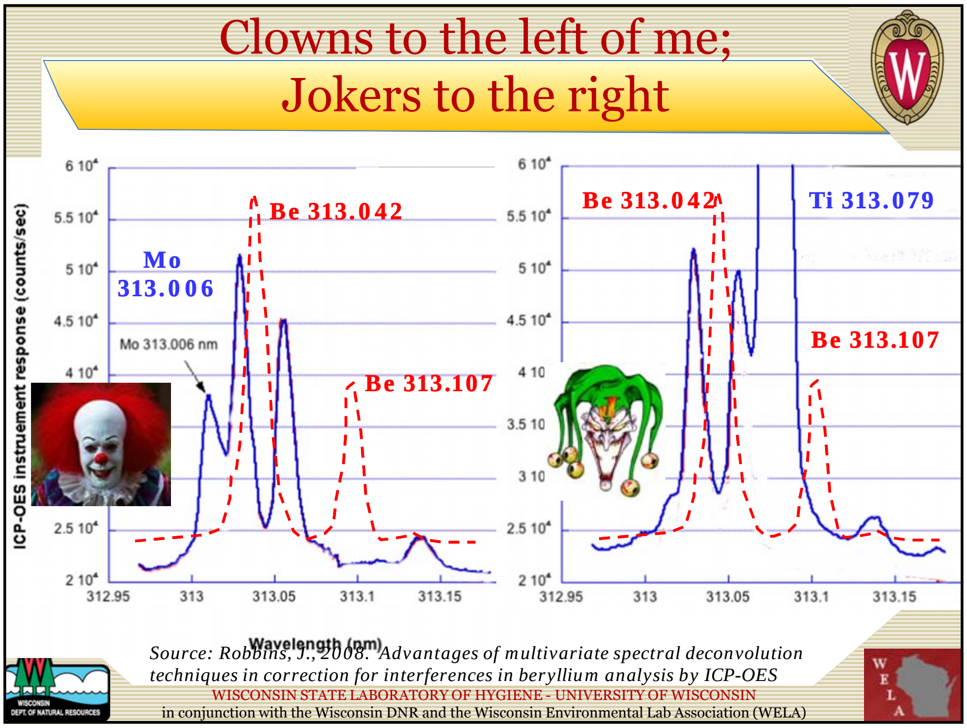
## Interference of Ti on Be

**Beryllium is a doublet peak, with two very close lines.**

**Due to Ti, even if using only 1 background correct point, low bias can result. Mo can also be an issue.**

**Will yield slight negative result if not using an IEC (or some other form of correction).**

**The false negative (Kilo) is suspected to result from using the lower wavelength. The background correction point (or one if using two points) is affected by neighboring Mo peak**



# Clowns to the left of me; Jokers to the right

*Source: Robbins, J., 2008. Advantages of multivariate spectral deconvolution techniques in correction for interferences in beryllium analysis by ICP-OES*

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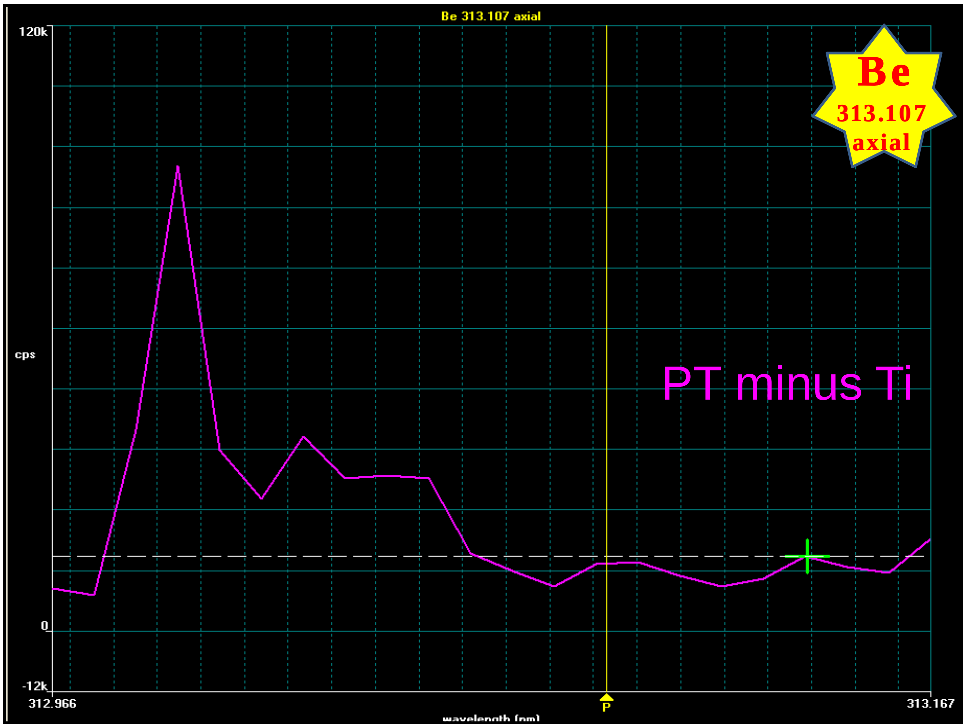
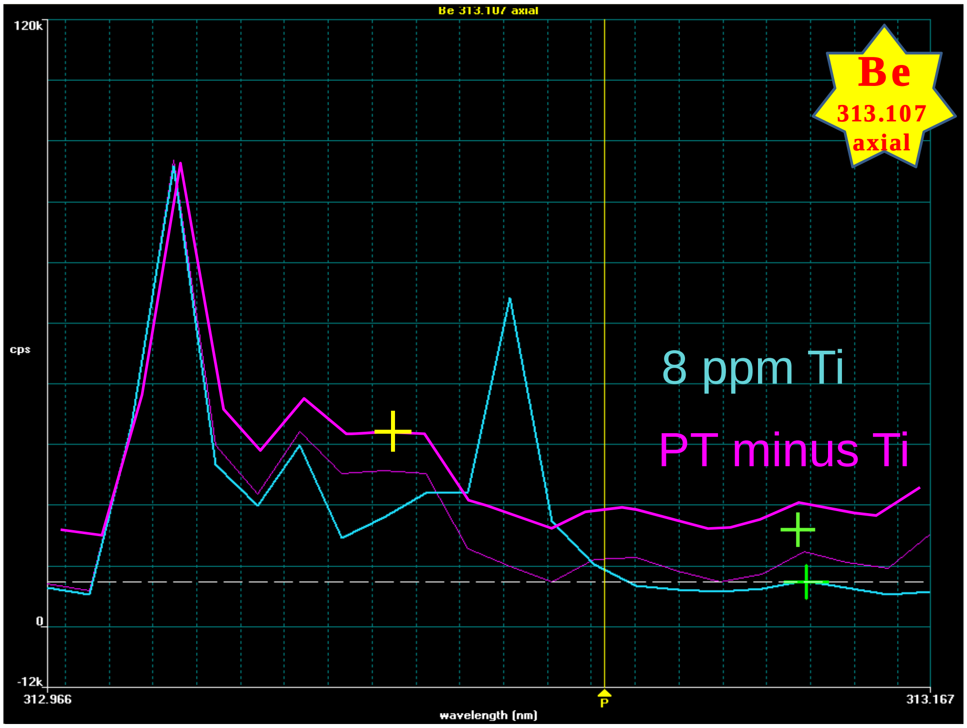
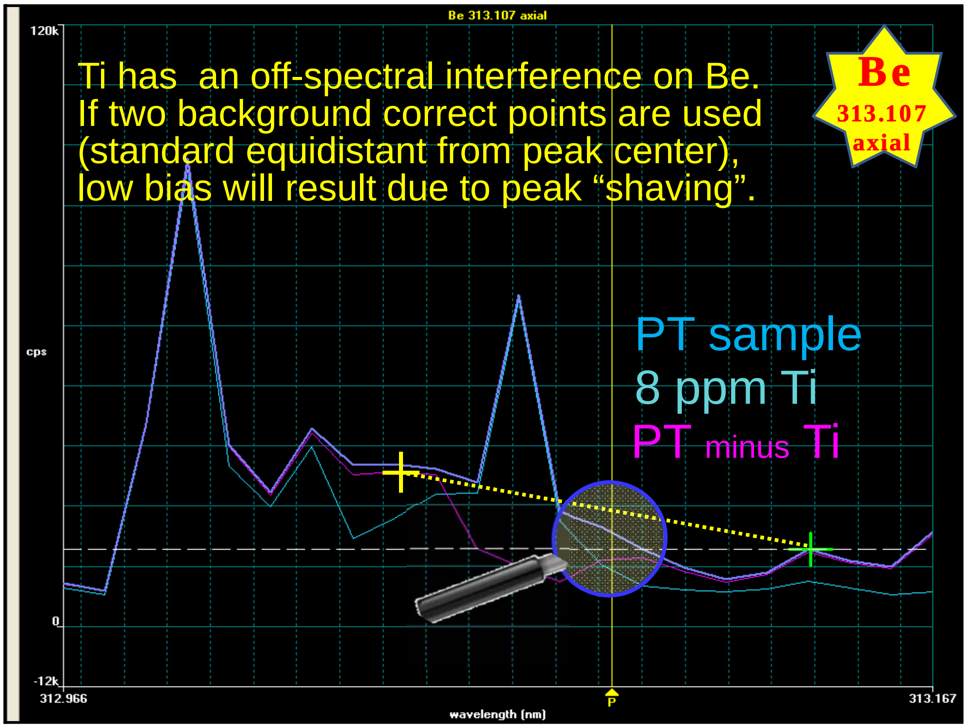
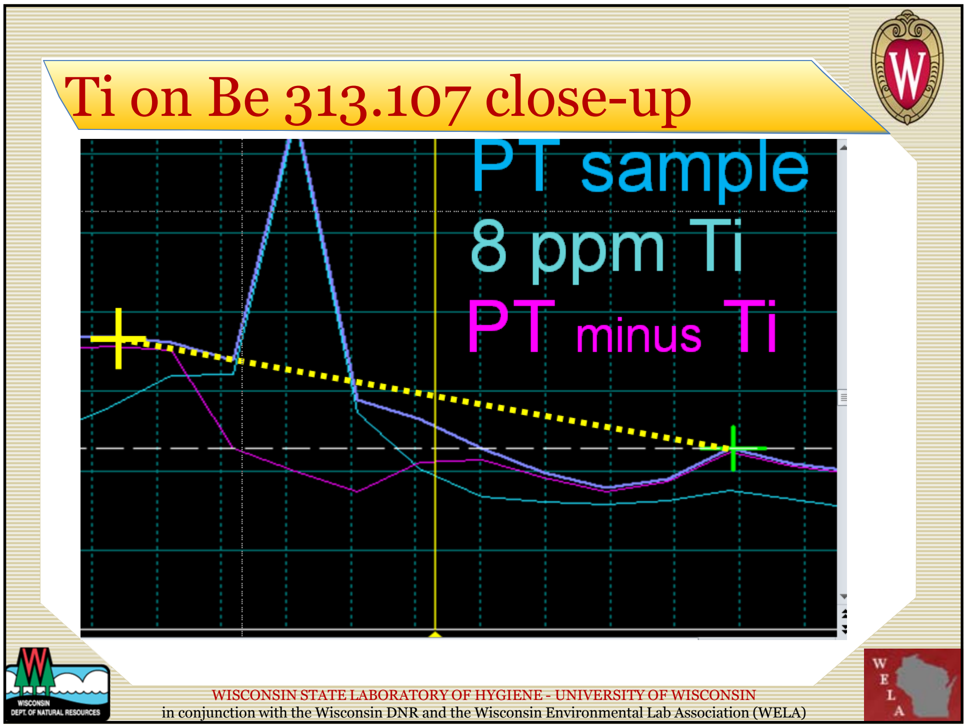


PT minus Ti




Ti has an off-spectral interference on Be.
If two background correct points are used
(standard equidistant from peak center),
low bias will result due to peak "shaving".



## Ti on Be 313.107 close-up

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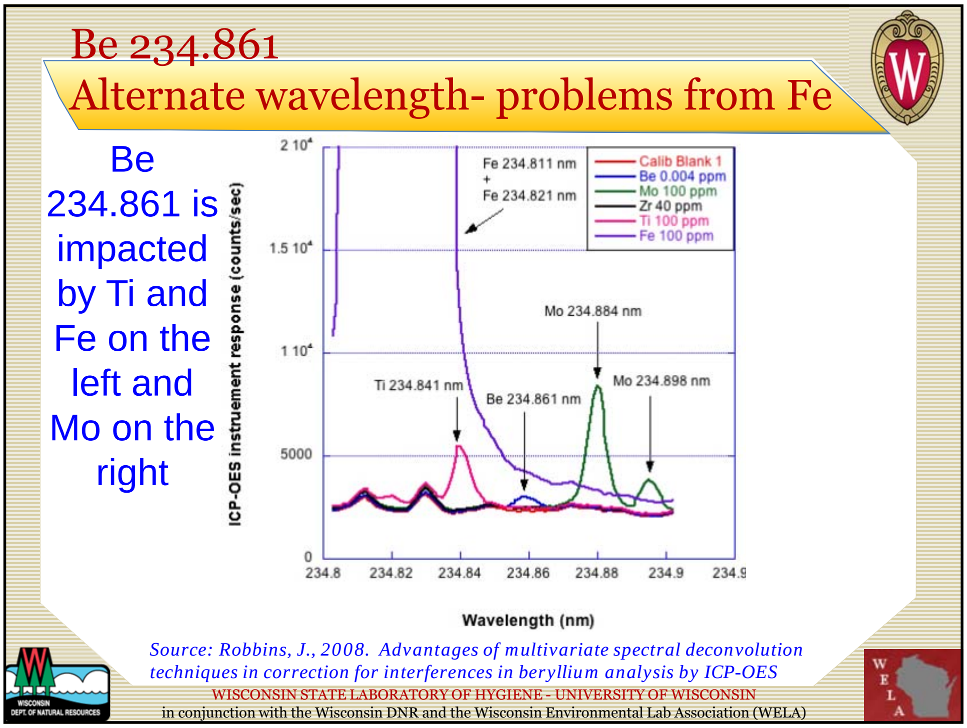

## Be 234.861
## Alternate wavelength- problems from Fe

Be 234.861 is impacted by Ti and Fe on the left and Mo on the right

*Source: Robbins, J., 2008. Advantages of multivariate spectral deconvolution techniques in correction for interferences in beryllium analysis by ICP-OES*

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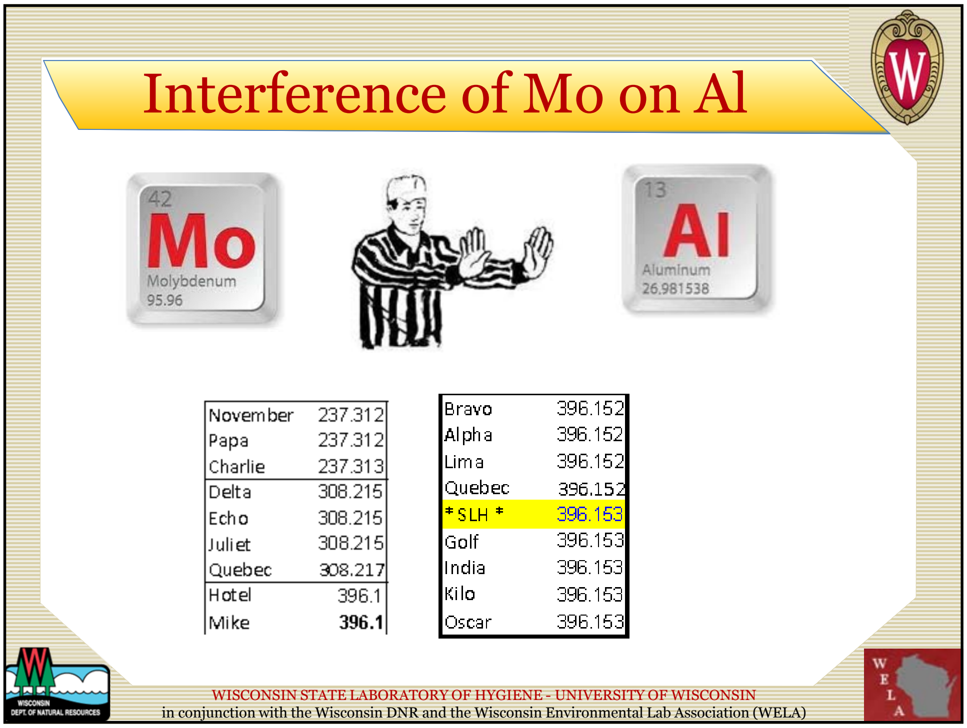
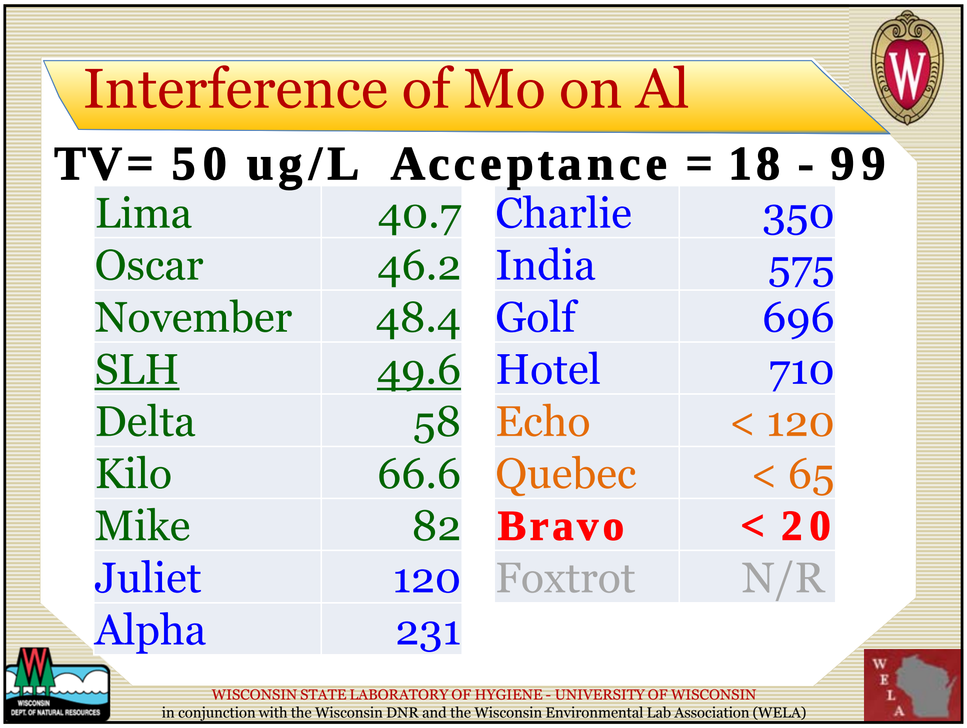


# Interference of Mo on Al

| | |
|---|---|
| November | 237.312 |
| Papa | 237.312 |
| Charlie | 237.313 |
| Delta | 308.215 |
| Echo | 308.215 |
| Juliet | 308.215 |
| Quebec | 308.217 |
| Hotel | 396.1 |
| Mike | **396.1** |

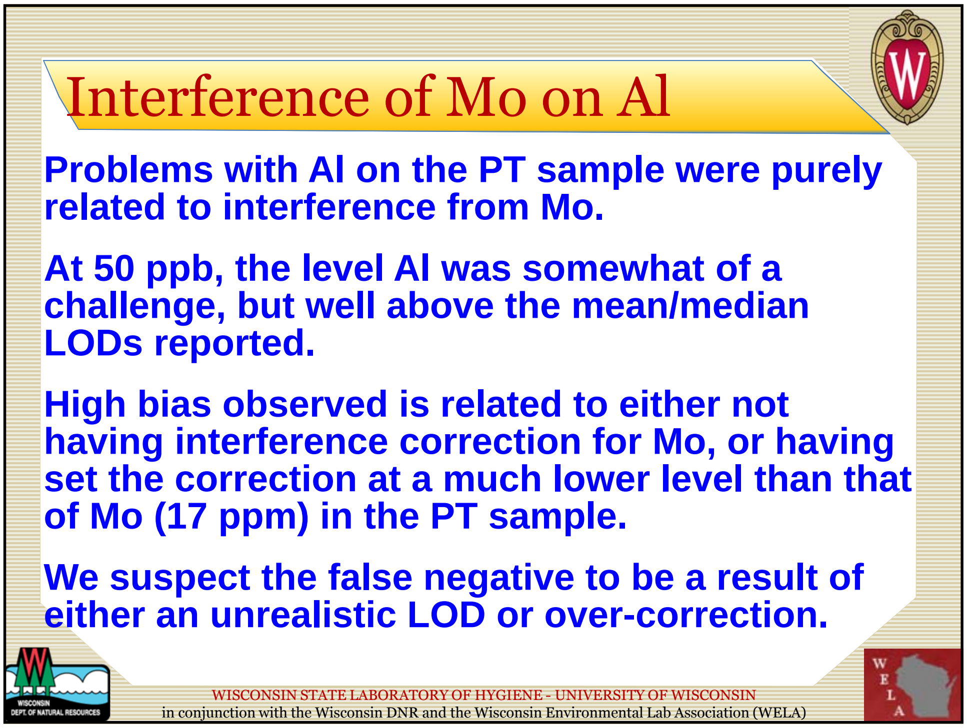
| | |
|---|---|
| Bravo | 396.152 |
| Alpha | 396.152 |
| Lima | 396.152 |
| Quebec | 396.152 |
| * SLH * | 396.153 |
| Golf | 396.153 |
| India | 396.153 |
| Kilo | 396.153 |
| Oscar | 396.153 |



# Interference of Mo on Al

**TV= 50 ug/L Acceptance = 18 - 99**

| | | | |
|---|---|---|---|
| Lima | 40.7 | Charlie | 350 |
| Oscar | 46.2 | India | 575 |
| November | 48.4 | Golf | 696 |
| SLH | 49.6 | Hotel | 710 |
| Delta | 58 | Echo | < 120 |
| Kilo | 66.6 | Quebec | < 65 |
| Mike | 82 | **Bravo** | **< 20** |
| Juliet | 120 | Foxtrot | N/R |
| Alpha | 231 | | |



# Interference of Mo on Al

Problems with Al on the PT sample were purely related to interference from Mo.

At 50 ppb, the level Al was somewhat of a challenge, but well above the mean/median LODs reported.

High bias observed is related to either not having interference correction for Mo, or having set the correction at a much lower level than that of Mo (17 ppm) in the PT sample.

We suspect the false negative to be a result of either an unrealistic LOD or over-correction.

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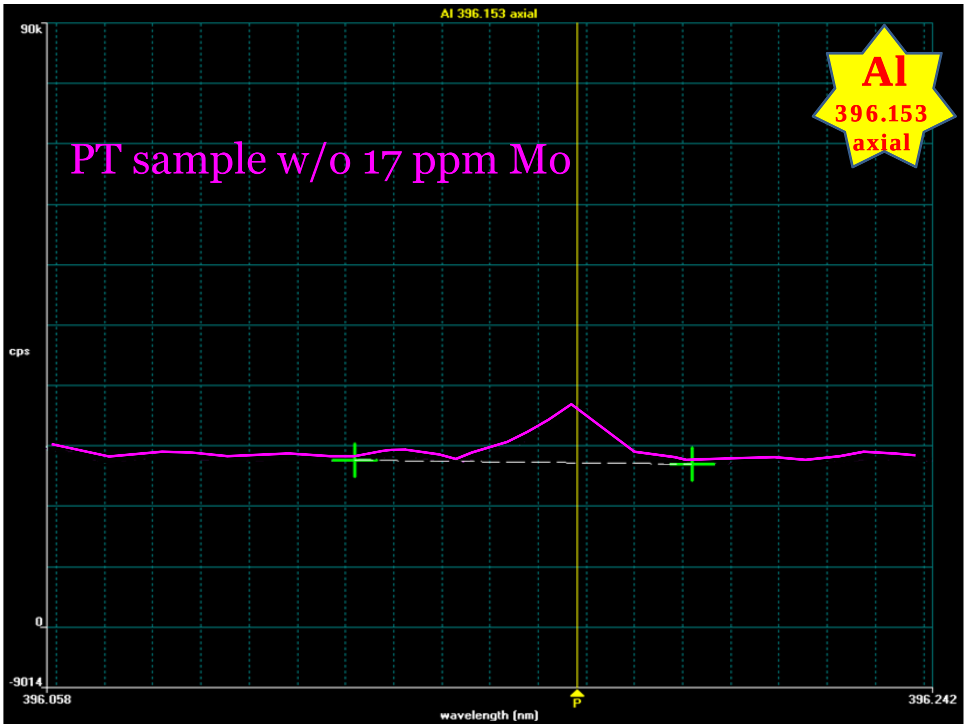
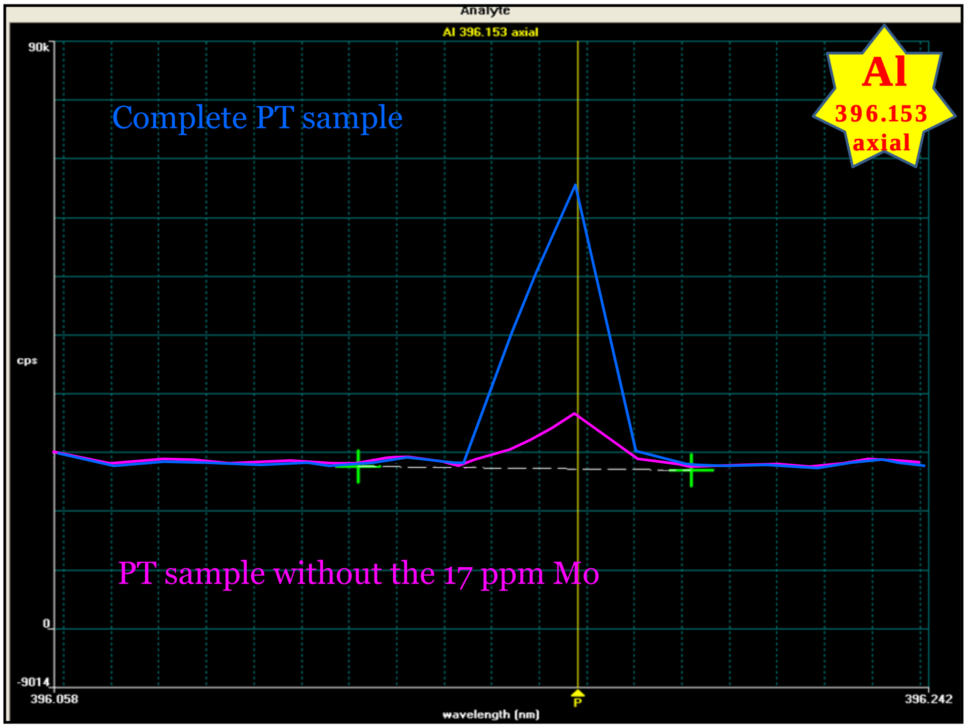


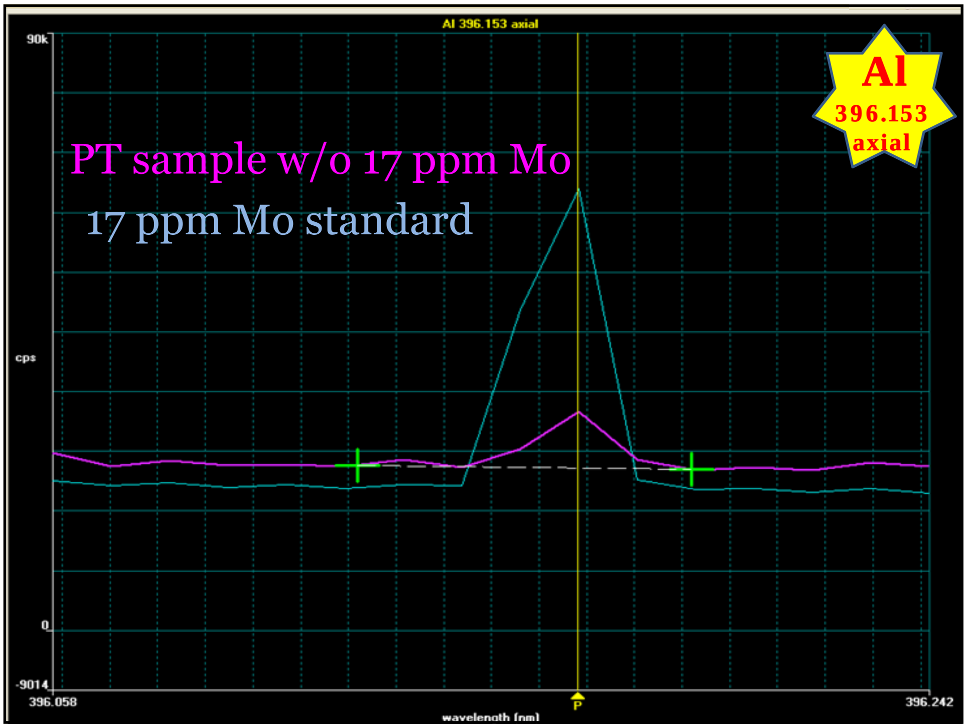
PT sample w/o 17 ppm Mo

Al 396.153 axial



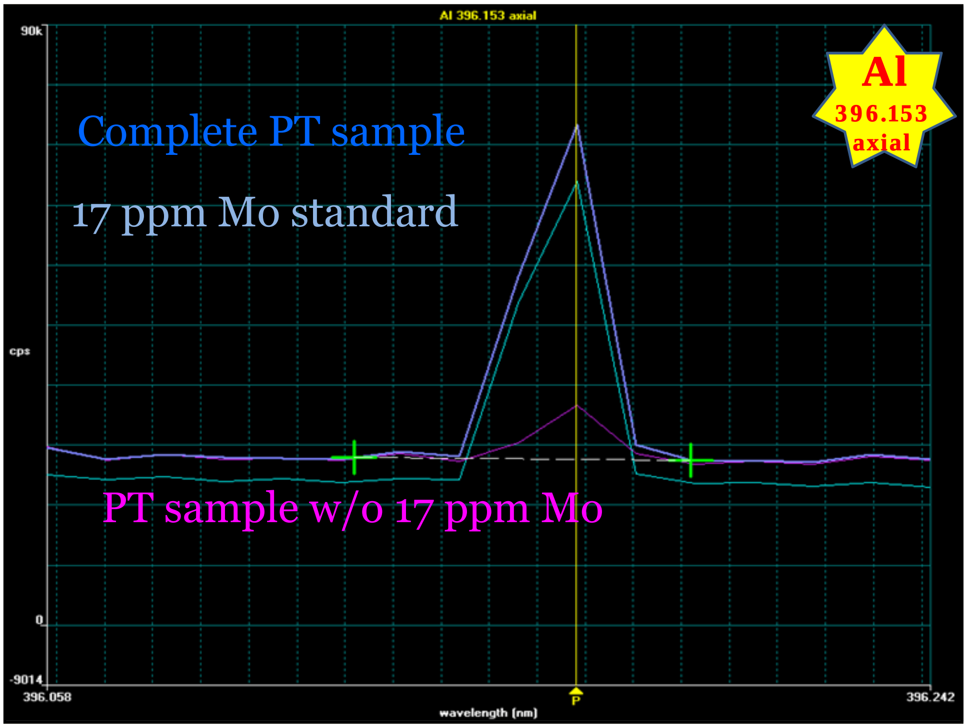
Complete PT sample

PT sample without the 17 ppm Mo



PT sample w/o 17 ppm Mo

17 ppm Mo standard

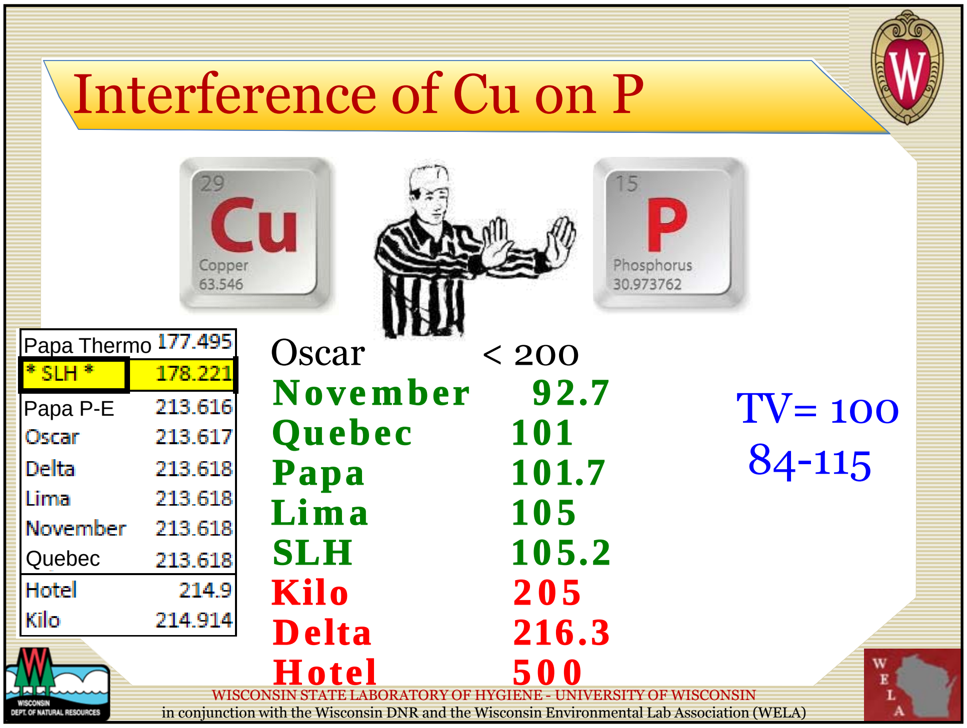


Complete PT sample

17 ppm Mo standard

PT sample w/o 17 ppm Mo

"THE TROUBLE WITH ~~TRIBBLES~~" Phosphorus



## Interference of Cu on P

| | |
|---|---|
| Papa Thermo | 177.495 |
| * SLH * | 178.221 |
| Papa P-E | 213.616 |
| Oscar | 213.617 |
| Delta | 213.618 |
| Lima | 213.618 |
| November | 213.618 |
| Quebec | 213.618 |
| Hotel | 214.9 |
| Kilo | 214.914 |

| | |
|---|---|
| Oscar | < 200 |
| **November** | **92.7** |
| **Quebec** | **101** |
| **Papa** | **101.7** |
| **Lima** | **105** |
| **SLH** | **105.2** |
| **Kilo** | **205** |
| **Delta** | **216.3** |
| **Hotel** | **500** |

TV= 100
84-115

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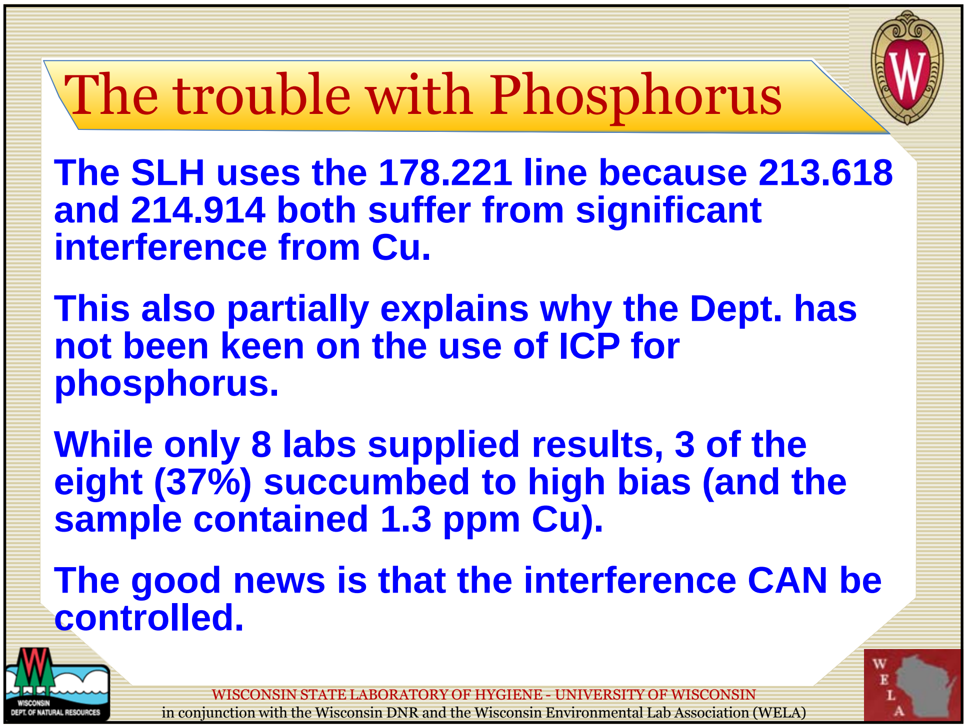

## The trouble with Phosphorus

**The SLH uses the 178.221 line because 213.618 and 214.914 both suffer from significant interference from Cu.**

**This also partially explains why the Dept. has not been keen on the use of ICP for phosphorus.**

**While only 8 labs supplied results, 3 of the eight (37%) succumbed to high bias (and the sample contained 1.3 ppm Cu).**

**The good news is that the interference CAN be controlled.**

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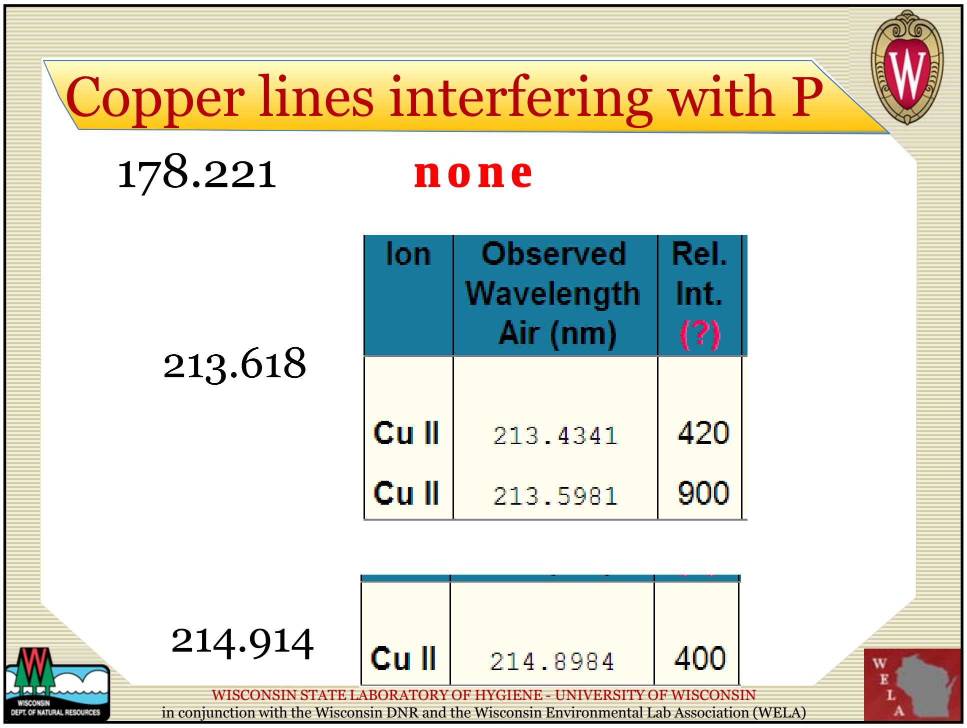

## Copper lines interfering with P

178.221 **none**

213.618

| Ion | Observed Wavelength Air (nm) | Rel. Int. (?) |
|---|---|---|
| Cu II | 213.4341 | 420 |
| Cu II | 213.5981 | 900 |

214.914

| | | |
|---|---|---|
| Cu II | 214.8984 | 400 |

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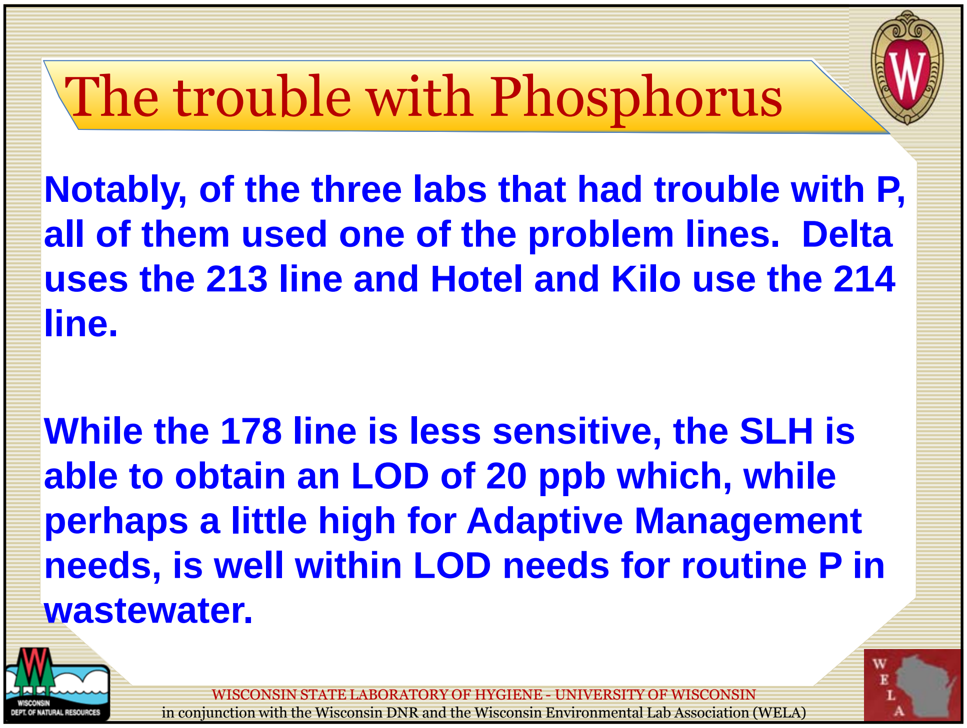

## The trouble with Phosphorus

Notably, of the three labs that had trouble with P, all of them used one of the problem lines. Delta uses the 213 line and Hotel and Kilo use the 214 line.

While the 178 line is less sensitive, the SLH is able to obtain an LOD of 20 ppb which, while perhaps a little high for Adaptive Management needs, is well within LOD needs for routine P in wastewater.

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# Interference on B

| | |
|---|---|
| Mike | 208.9 |
| Papa P-E | 208.957 |
| Papa Thermo | 208.959 |
| * SLH * | 249.677 |
| Golf | 249.677 |
| India | 249.677 |
| Bravo | 249.678 |
| Delta | 249.678 |
| Juliet | 249.678 |
| Lima | 249.678 |
| Hotel | 249.7 |
| Kilo | 249.772 |
| November | 249.772 |
| Quebec | 249.772 |
| Alpha | 249.773 |

**TV = 750 ppb**

**638 to 863**

| | |
|---|---|
| **632** | **Golf** |
| 718 | Lima |
| 729.4 | Delta |
| 737 | Bravo |
| 738 | November |
| 743 | Juliet |
| 749 | India |

| | |
|---|---|
| 764 | Quebec |
| 790 | Mike |
| 842 | SLH |
| 850 | Hotel |
| **1770** | **Kilo** |
| **2574** | **Papa** |

N/A: Alpha, Charlie , Echo, Foxtrot, Oscar

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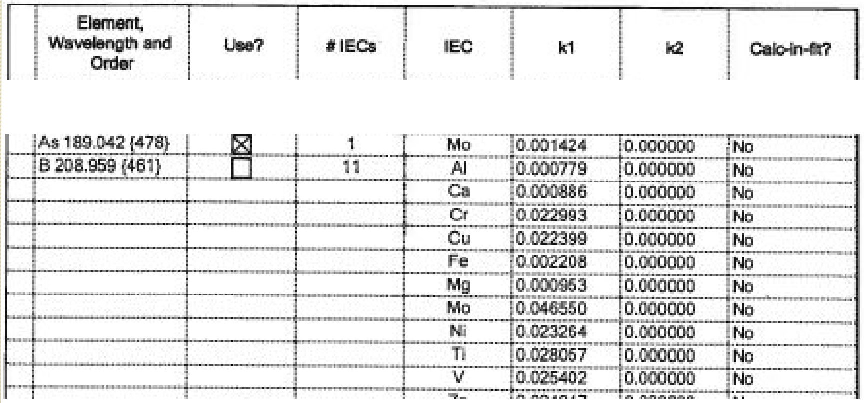
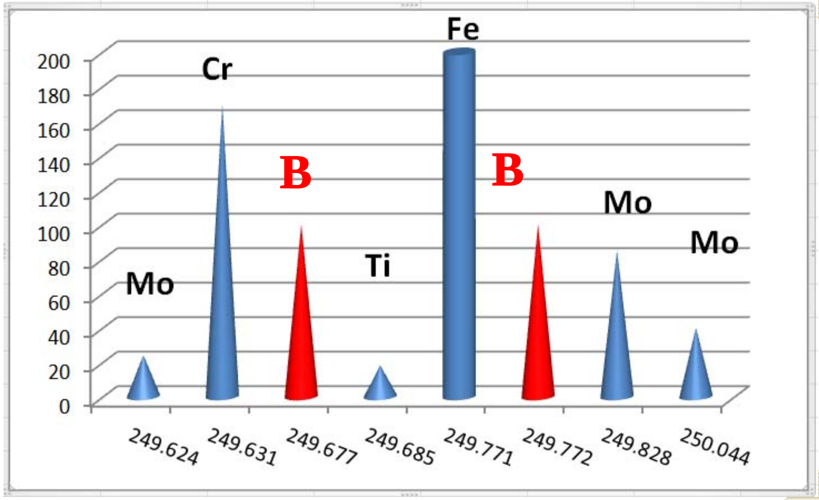
# Why Papa had high bias for B



| Element, Wavelength and Order | Use? | # IECs | IEC | k1 | k2 | Calc-in-fit? |
|---|---|---|---|---|---|---|
| As 189.042 {478} | ☒ | 1 | Mo | 0.001424 | 0.000000 | No |
| B 208.959 {461} | ☐ | 11 | Al | 0.000779 | 0.000000 | No |
| | | | Ca | 0.000886 | 0.000000 | No |
| | | | Cr | 0.022993 | 0.000000 | No |
| | | | Cu | 0.022399 | 0.000000 | No |
| | | | Fe | 0.002208 | 0.000000 | No |
| | | | Mg | 0.000953 | 0.000000 | No |
| | | | Mo | 0.046550 | 0.000000 | No |
| | | | Ni | 0.023264 | 0.000000 | No |
| | | | Ti | 0.028057 | 0.000000 | No |
| | | | V | 0.025402 | 0.000000 | No |

IECs established but “Use” being unchecked means that , while they have IECs for Boron, they did not use them!

## Interference on B



**Boron: Plenty of trouble areas**

---

## Pb and background correction

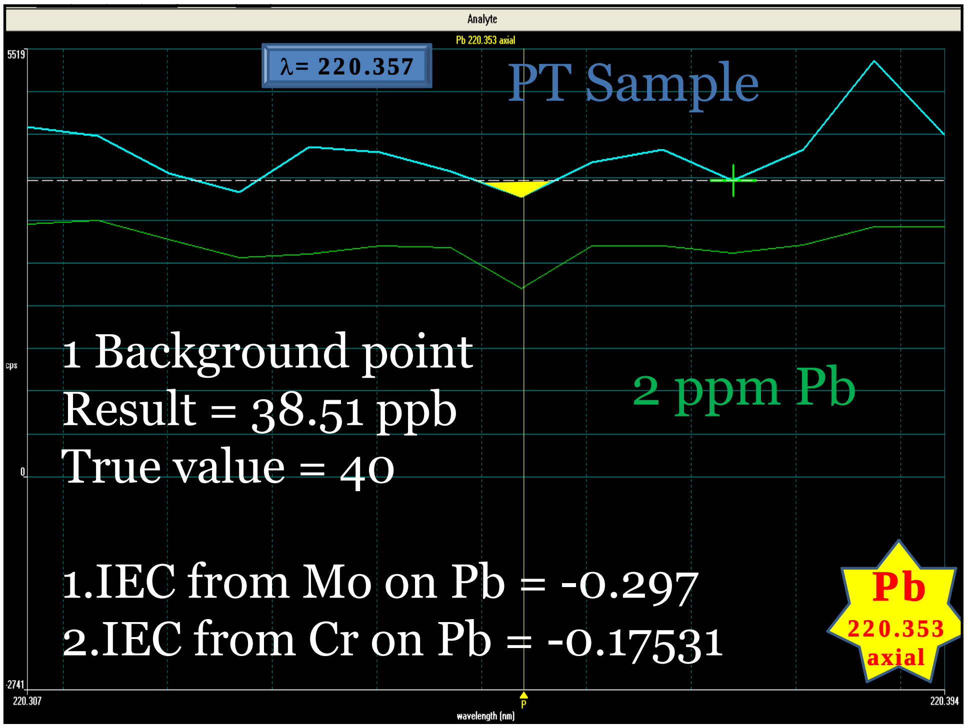
**Pb issues: intentional (back)gounding**

# Pb and background correction

P-E Out of the box defaults for Pb = λ 220.353 and 2 background correction points: -22 and + 20 pm.
All labs used the default wavelength.

| | |
|---|---|
| Papa Thermo | 182.205 |
| Hotel | 220.3 |
| Mike | 220.3 |
| Charlie | 220.351 |
| Bravo | 220.353 |
| * SLH * | 220.353 |
| Alpha | 220.353 |
| Delta | 220.353 |
| Echo | 220.353 |
| Foxtrot | 220.353 |
| Golf | 220.353 |
| India | 220.353 |
| Juliet | 220.353 |
| Kilo | 220.353 |
| Lima | 220.353 |
| November | 220.353 |
| Oscar | 220.353 |
| Quebec | 220.353 |
| Papa P-E | 220.354 |

| | | | |
|---|---|---|---|
| **< 1.2** | **Charlie** | **37** | **Quebec** |
| **22** | **Oscar** | **37.7** | **India** |
| **26** | **Golf** | **38.9** | **Lima** |
| **27.4** | **Papa** | **39** | **SLH** |
| **30** | **Bravo** | **40.1** | **November** |
| **30** | **Hotel** | **40.4** | **Alpha** |
| **30.9** | **Kilo** | **40.4** | **Echo** |
| **31** | **Foxtrot** | **46** | **Mike** |
| **33.53** | **Delta** | **49** | **Juliet** |



λ= 220.357

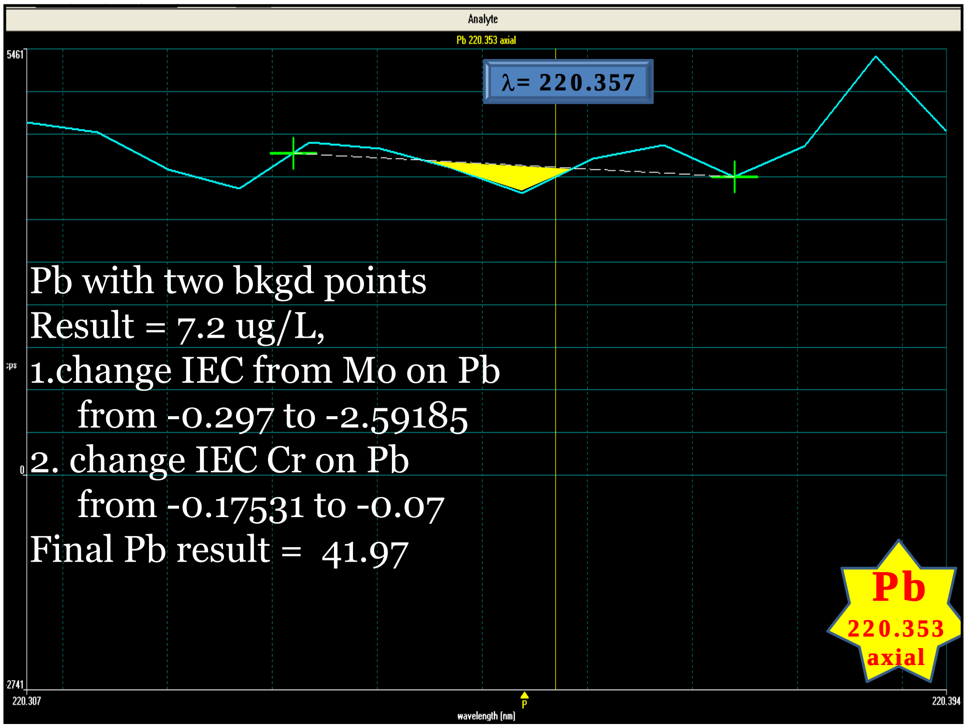
PT Sample

1 Background point
Result = 38.51 ppb
True value = 40

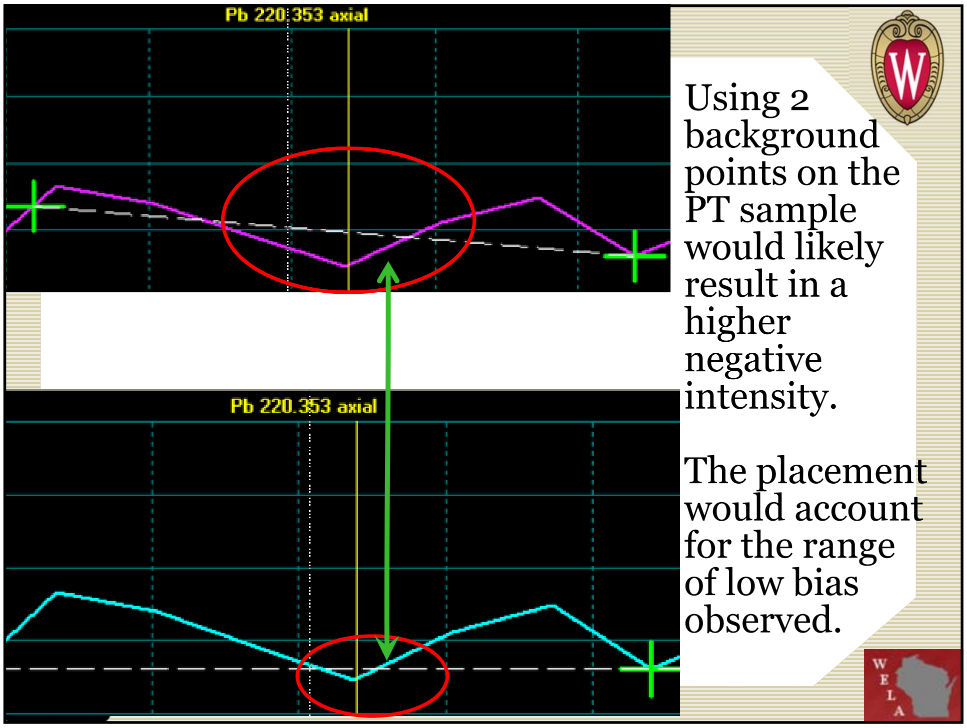
2 ppm Pb

1.IEC from Mo on Pb = -0.297
2.IEC from Cr on Pb = -0.17531

**Pb**
**220.353**
**axial**



Pb with two bkgd points
Result = 7.2 ug/L,
1.change IEC from Mo on Pb
from -0.297 to -2.59185
2. change IEC Cr on Pb
from -0.17531 to -0.07
Final Pb result = 41.97



Using 2 background points on the PT sample would likely result in a higher negative intensity.

The placement would account for the range of low bias observed.

# Special K

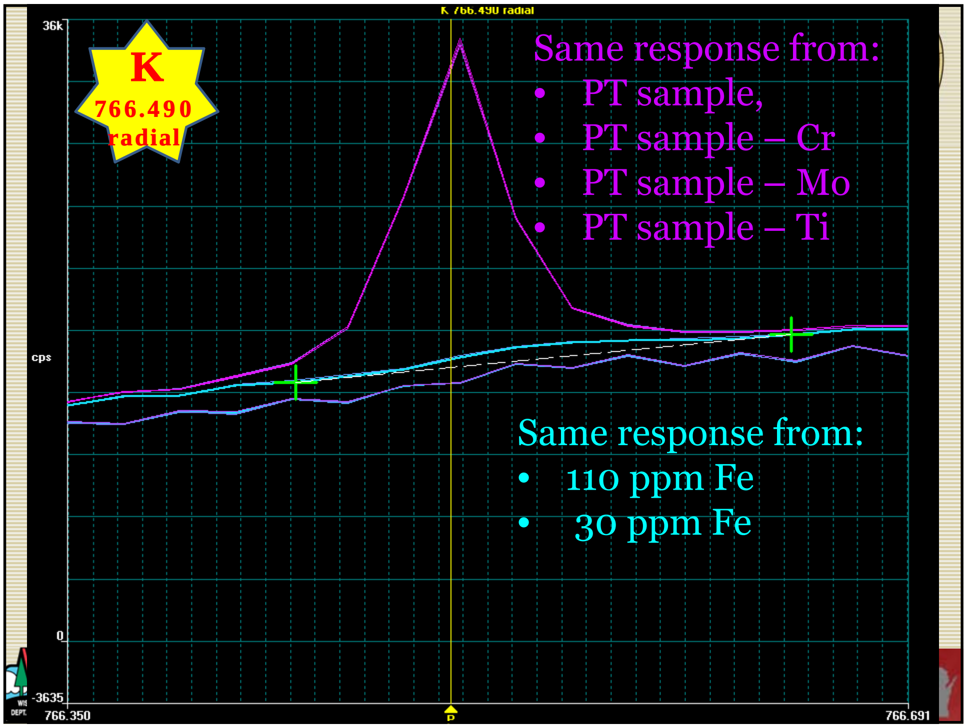
**Perfect example of a background correction rule**

# How many background correction points?

**When is using 2 background correction points a requirement?**

Whenever the background is sloping, you MUST use two background correction points (at least on a P-E system).

Potassium, at the upper end of the spectrum is a perfect example



**K**
**766.490**
**radial**

Same response from:
- PT sample,
- PT sample – Cr
- PT sample – Mo
- PT sample – Ti

Same response from:
- 110 ppm Fe
- 30 ppm Fe

# PT Sample: Ag

**Several labs expressed concern about the "trick" regarding analysis of silver.**

**Only two labs had trouble with the silver (3 ppm).**

**Both reported results around 400-450 ppb.**

**One of the two reported consecutive results of : 2171, 432, and 241 ppb. All were low, but clearly silver was dropping…why?**

# Silver and Chloride

$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$ (precipitate)

Many analysts experience low Ag recoveries when working in $HNO_3$ media. The problem is due to trace chloride contamination.

**But….I don’t see a precipitate!**

Ag has already **photo-reduced** onto the container walls. Silver is very light sensitive. You won’t see a precipitate, even though it has “fallen” out.

# Handling Ag

If Ag is prepared in just a 0.5% HNO3 solution, it will not be stable for very long.

The SLH prepares Ag standard fresh daily.

Under about 2 ppm, the presence of a small amount of HCl will actually keep the silver in solution.

We chose the 3 ppm level for Ag because at that concentration, any HCL becomes a problem and the Ag falls out of solution.

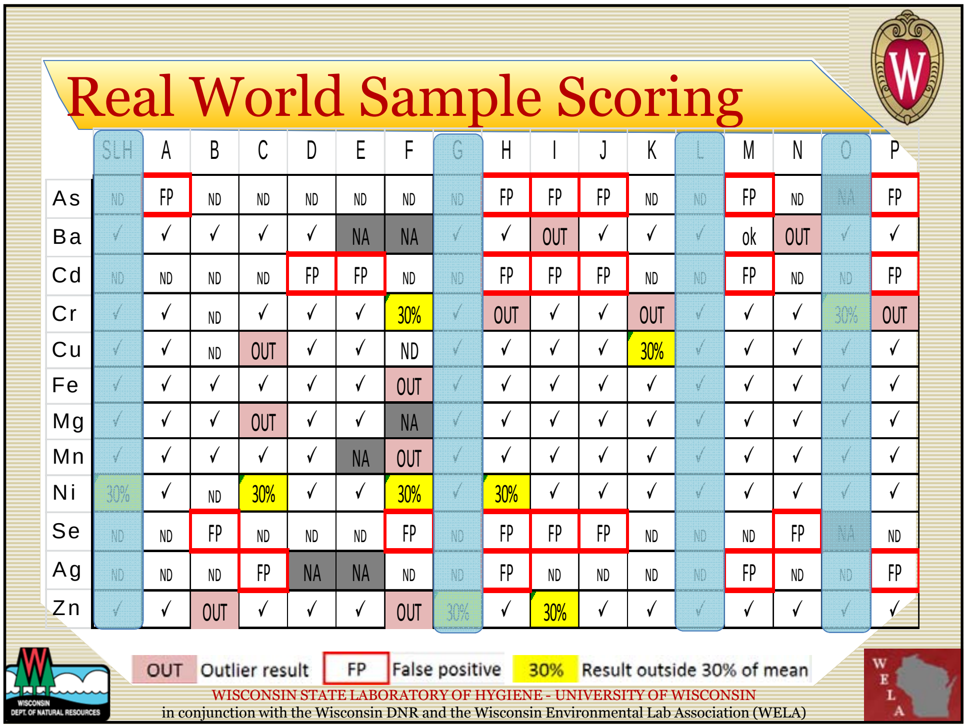
Rinse solution should have ~5% HCL (even though standards and samples are HNO3 only) to keep Ag from plating onto walls of the spray chamber

# REAL WORLD SAMPLE

## Our “Real World” sample.

As one analyst put it,

*“…a mix of milk of magnesia, Elmer’s glue, and …something else*”



# Real World Sample Scoring

| | SLH | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| As | ND | FP | ND | ND | ND | ND | ND | ND | FP | FP | FP | ND | ND | FP | ND | NA | FP |
| Ba | ✓ | ✓ | ✓ | ✓ | ✓ | NA | NA | ✓ | ✓ | OUT | ✓ | ✓ | ✓ | ok | OUT | ✓ | ✓ |
| Cd | ND | ND | ND | ND | FP | FP | ND | ND | FP | FP | FP | ND | ND | FP | ND | ND | FP |
| Cr | ✓ | ✓ | ND | ✓ | ✓ | ✓ | 30% | ✓ | OUT | ✓ | ✓ | OUT | ✓ | ✓ | ✓ | 30% | OUT |
| Cu | ✓ | ✓ | ND | OUT | ✓ | ✓ | ND | ✓ | ✓ | ✓ | ✓ | 30% | ✓ | ✓ | ✓ | ✓ | ✓ |
| Fe | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | OUT | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Mg | ✓ | ✓ | ✓ | OUT | ✓ | ✓ | NA | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Mn | ✓ | ✓ | ✓ | ✓ | ✓ | NA | OUT | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Ni | 30% | ✓ | ND | 30% | ✓ | ✓ | 30% | ✓ | 30% | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Se | ND | ND | FP | ND | ND | ND | FP | ND | FP | FP | FP | ND | ND | ND | FP | NA | ND |
| Ag | ND | ND | ND | FP | NA | NA | ND | ND | FP | ND | ND | ND | ND | FP | ND | ND | FP |
| Zn | ✓ | ✓ | OUT | ✓ | ✓ | ✓ | OUT | 30% | ✓ | 30% | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

OUT Outlier result FP False positive 30% Result outside 30% of mean

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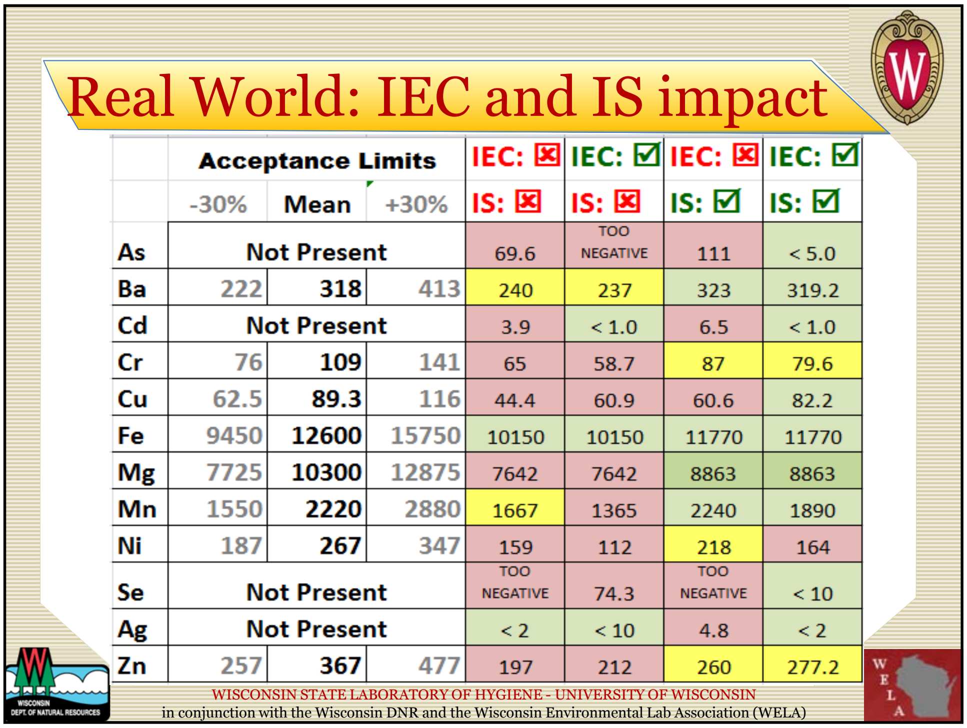

# Real World: IEC and IS impact

| | Acceptance Limits | | | IEC: ☒ | IEC: ☑ | IEC: ☒ | IEC: ☑ |
|---|---|---|---|---|---|---|---|
| | -30% | Mean | +30% | IS: ☒ | IS: ☒ | IS: ☑ | IS: ☑ |
| As | Not Present | | | 69.6 | TOO NEGATIVE | 111 | < 5.0 |
| Ba | 222 | 318 | 413 | 240 | 237 | 323 | 319.2 |
| Cd | Not Present | | | 3.9 | < 1.0 | 6.5 | < 1.0 |
| Cr | 76 | 109 | 141 | 65 | 58.7 | 87 | 79.6 |
| Cu | 62.5 | 89.3 | 116 | 44.4 | 60.9 | 60.6 | 82.2 |
| Fe | 9450 | 12600 | 15750 | 10150 | 10150 | 11770 | 11770 |
| Mg | 7725 | 10300 | 12875 | 7642 | 7642 | 8863 | 8863 |
| Mn | 1550 | 2220 | 2880 | 1667 | 1365 | 2240 | 1890 |
| Ni | 187 | 267 | 347 | 159 | 112 | 218 | 164 |
| Se | Not Present | | | TOO NEGATIVE | 74.3 | TOO NEGATIVE | < 10 |
| Ag | Not Present | | | < 2 | < 10 | 4.8 | < 2 |
| Zn | 257 | 367 | 477 | 197 | 212 | 260 | 277.2 |

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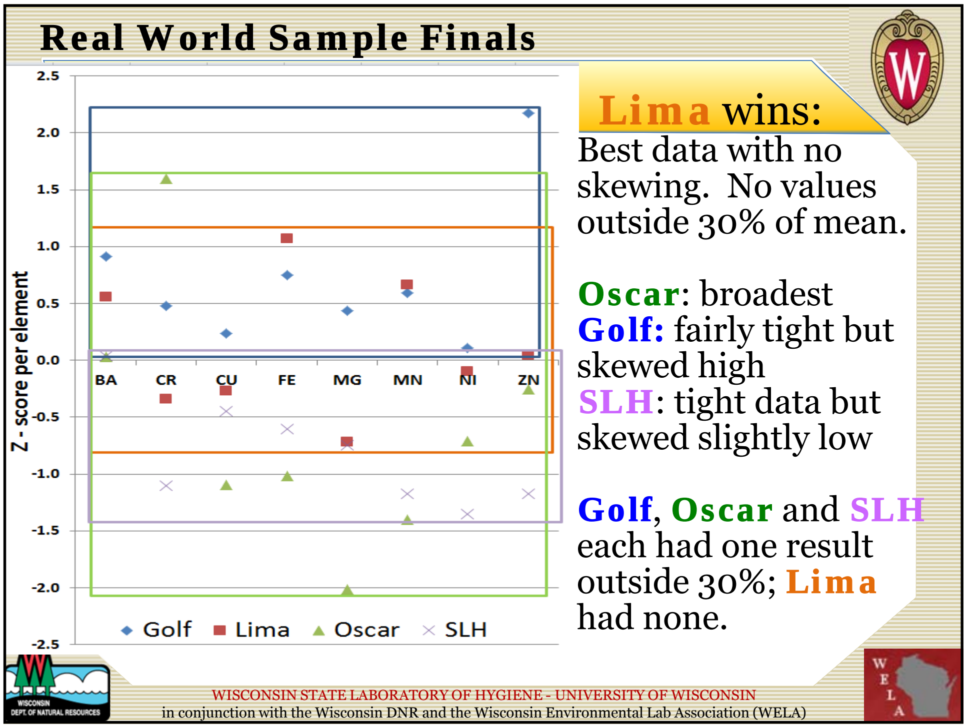
# Real World Sample Concerns

1. **False positives.** We determined that As, Cd, Ag, and Se were not present in the sample.
2. **Outliers.** We tested the data set for each element for outliers and, after identifying them, we removed them from the data set.
3. Next we calculated the mean of the remaining data.
4. We set acceptance criteria at +/- 30% of the mean.
5. Any values the fell outside of 30% were marked.

# Assessing Real World sample performance

| | outliers | False + | | > 30% | |
|---|---|---|---|---|---|
| Alpha | | As | | | |
| Bravo | Zn | Se | | | |
| Charlie | Cu,Mg | Ag | | Ni | |
| Delta | | Cd | | | |
| Echo | | Cd | | | |
| Foxtrot | Fe.Mn | Se | | Cr, Ni | |
| **Golf** | → | → | ➔Pass...on to finals | Zn | |
| Hotel | Cr | Ag,As,Cd,Se | | Ni | |
| India | Ba | As,Cd,Se | | Zn | **Lima** |
| Juliet | | As,Cd,Se | | | |
| Kilo | Cr | | | Cu | winner |
| **Lima** | → | → | ➔Pass...on to finals | → | → |
| Mike | | Ag,As,Cd | | | |
| November | Ba | Se | | | |
| **Oscar** | → | → | ➔Pass...on to finals | Cr | |
| Papa | Cr | Ag,As,Cd | | | |
| **SLH** | → | → | ➔Pass... on to finals | Ni | |



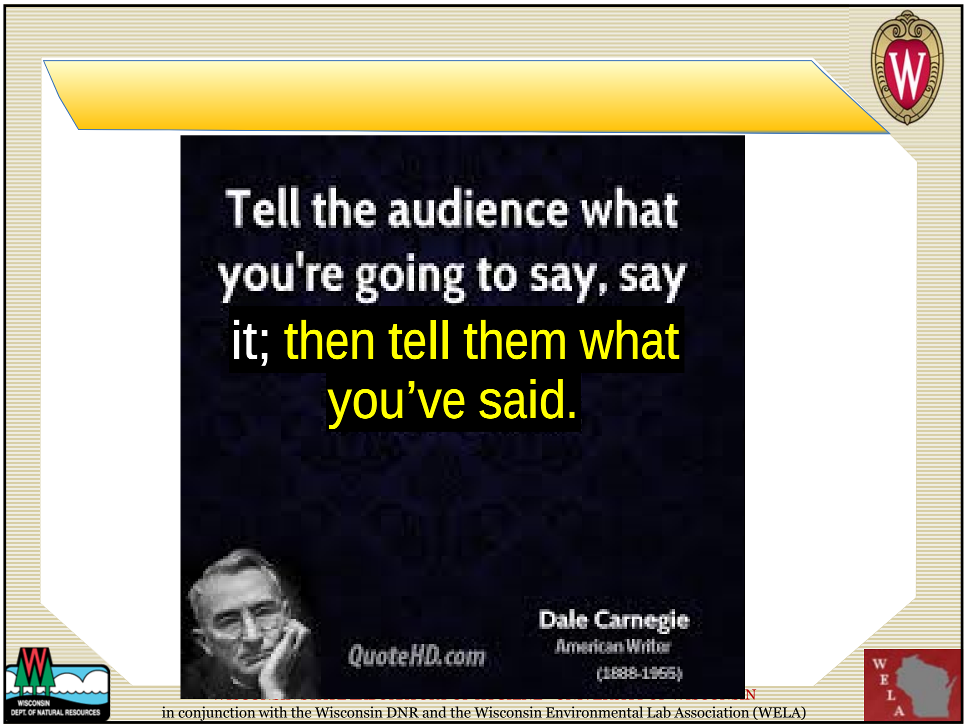
## Real World Sample Finals

**Lima** wins:
Best data with no skewing. No values outside 30% of mean.

**Oscar**: broadest
**Golf:** fairly tight but skewed high
**SLH**: tight data but skewed slightly low

**Golf**, **Oscar** and **SLH** each had one result outside 30%; **Lima** had none.

WISCONSIN STATE LABORATORY OF HYGIENE - UNIVERSITY OF WISCONSIN
in conjunction with the Wisconsin DNR and the Wisconsin Environmental Lab Association (WELA)



Tell the audience what you're going to say, say it; then tell them what you've said.

Dale Carnegie
American Writer
(1888-1955)

N
in conjunction with the Wisconsin DNR and the Wisconsin Environmental Lab Association (WELA)

## This is what we told you…

- Unless your samples are ultra-trace level and matrix free, some form of interference correction is required.
- The PT results clearly demonstrate that fact.
- Establish IECs or use FACT/MSF techniques
- The Real World sample demonstrates the importance on internal standards in the face of a matrix.
- Test your interference correction technique by appropriate design of ICS samples.
- Analyzing a “CLP” style ICS-AB offers NO value.

## Questions?

# Thanks for coming!