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Continuous Multi-Metal Monitoring

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The leader in near real-time elemental speciation of particulate matter

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Presentation Outline

- Xact 625i – Description and Operation
- Accuracy – Comparison Data
- Source Identification

What is the Xact

- Continuous Metals Monitor Based On
  - X-ray Fluorescence
  - Reel to reel tape drive technology
- Able to measure up to 67 metals simultaneously including Pb, As, and Cd and give near real time analysis results

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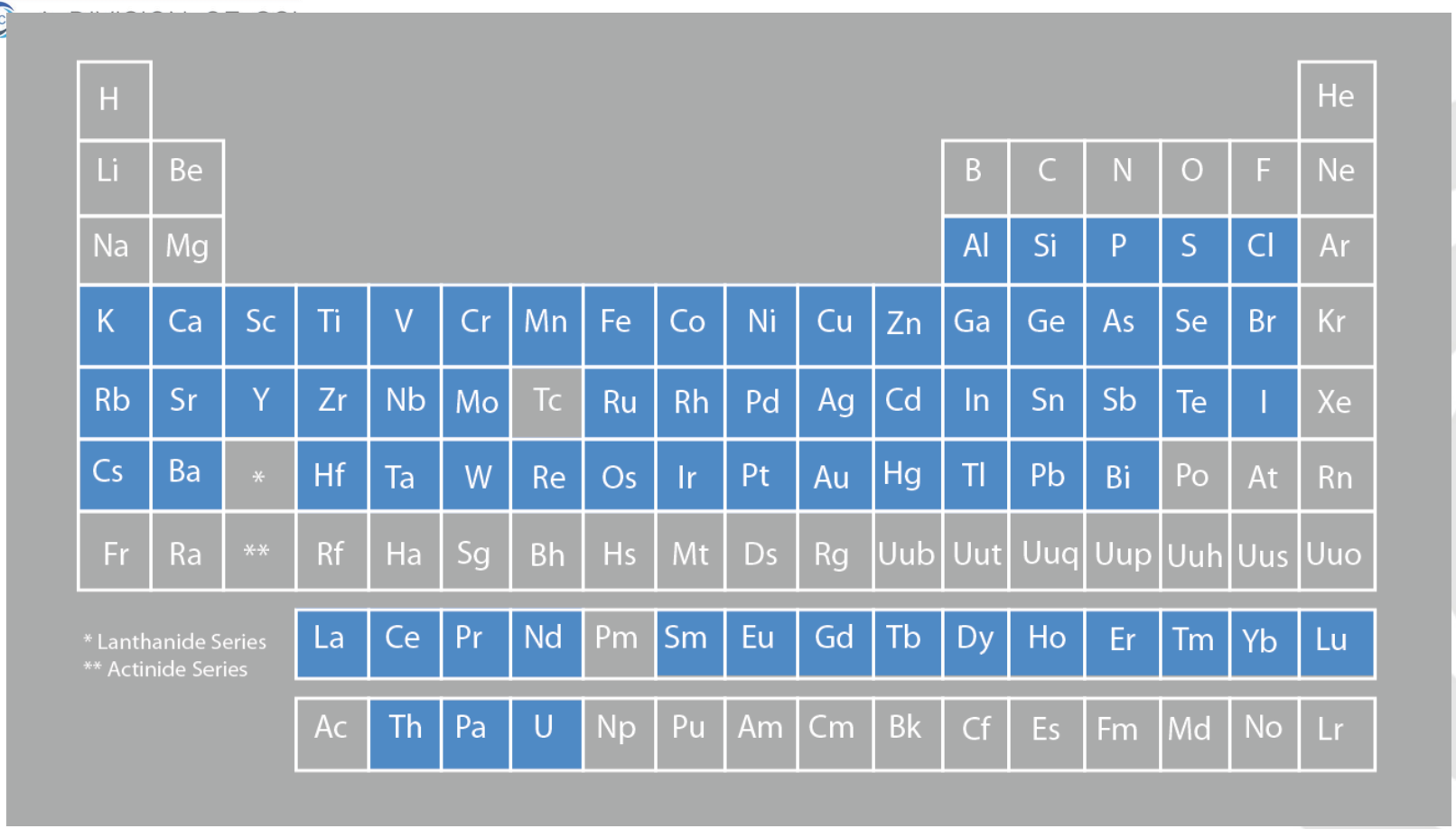
Elements Measured by Xact



- All in blue can be measured by the Xact 625i
- Standard Configuration is 44 different elements

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Measurement Capabilities

Xact 625i Minimum Detection Limits (ng/m³)
68% Confidence Level (C1σ) per US EPA IO 3.3 and Currie *

Element	Atomic Number	15	30	60	120	180	240
Al	13	840	290	100	35	19	12
Si	14	150	51	17.8	6.3	3.4	2.2
P	15	44	15	5.2	1.8	0.99	0.64
S	16	26	9.1	3.16	1.1	0.60	0.39
Cl	17	15	5.0	1.73	0.61	0.33	0.21
K	19	9.8	3.4	1.17	0.41	0.22	0.14
Ca	20	2.5	0.86	0.30	0.10	0.057	0.037
Ti	22	1.3	0.46	0.16	0.056	0.030	0.020
V	23	1.0	0.34	0.12	0.042	0.023	0.015
Cr	24	0.97	0.33	0.12	0.041	0.022	0.014
Mn	25	1.2	0.41	0.14	0.050	0.027	0.018
Fe	26	1.4	0.49	0.17	0.061	0.033	0.021
Co	27	1.1	0.39	0.14	0.049	0.026	0.017
Ni	28	0.78	0.27	0.10	0.034	0.018	0.012
Cu	29	0.65	0.23	0.079	0.028	0.015	0.010
Zn	30	0.55	0.19	0.067	0.023	0.013	0.008
As	33	0.52	0.18	0.063	0.022	0.012	0.008
Se	34	0.66	0.23	0.081	0.029	0.016	0.010
Br	35	0.85	0.30	0.10	0.037	0.020	0.013
Ag	47	16	5.5	1.9	0.68	0.37	0.24
Cd	48	21	7.2	2.5	0.89	0.48	0.31
In	49	26	8.9	3.1	1.1	0.60	0.39
Sn	50	33	12	4.1	1.4	0.78	0.51
Sb	51	42	15	5.2	1.8	0.99	0.64
Ba	56	3.3	1.1	0.39	0.14	0.074	0.048
Hg	80	0.99	0.35	0.12	0.043	0.023	0.015
Tl	81	0.95	0.33	0.12	0.041	0.022	0.014
Pb	82	1.0	0.36	0.13	0.045	0.024	0.016
Bi	83	1.1	0.37	0.13	0.046	0.025	0.016

- Detection limit is a function of sampling time – the longer the sampling and analysis time the better the detection limit
- For 1 hour sampling and analysis the detection limits are less than 1 ng/m^3
- Ultra high time resolution is now available – 5 minute sampling and analysis

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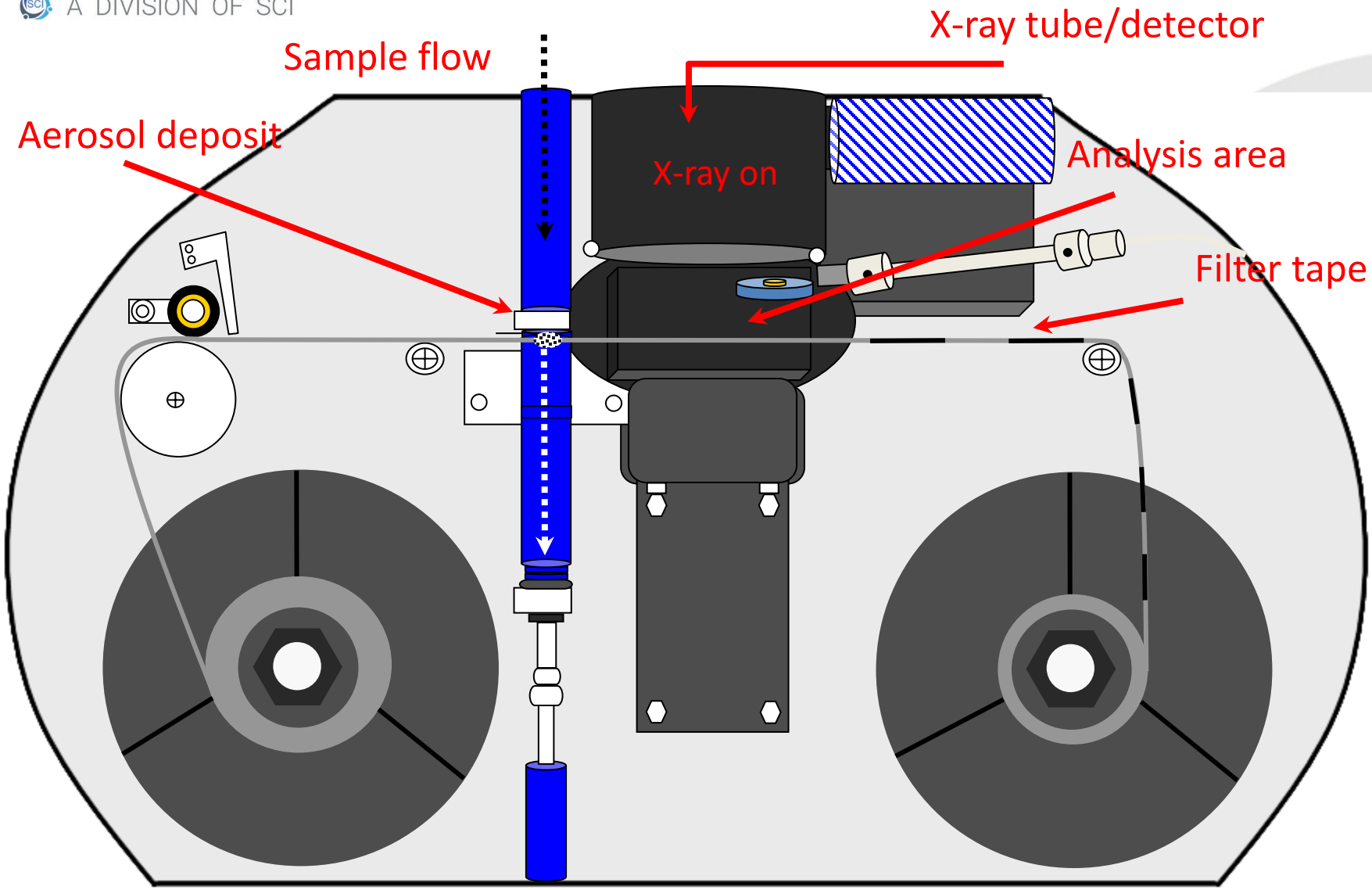
Xact® Sampling and Analysis Module



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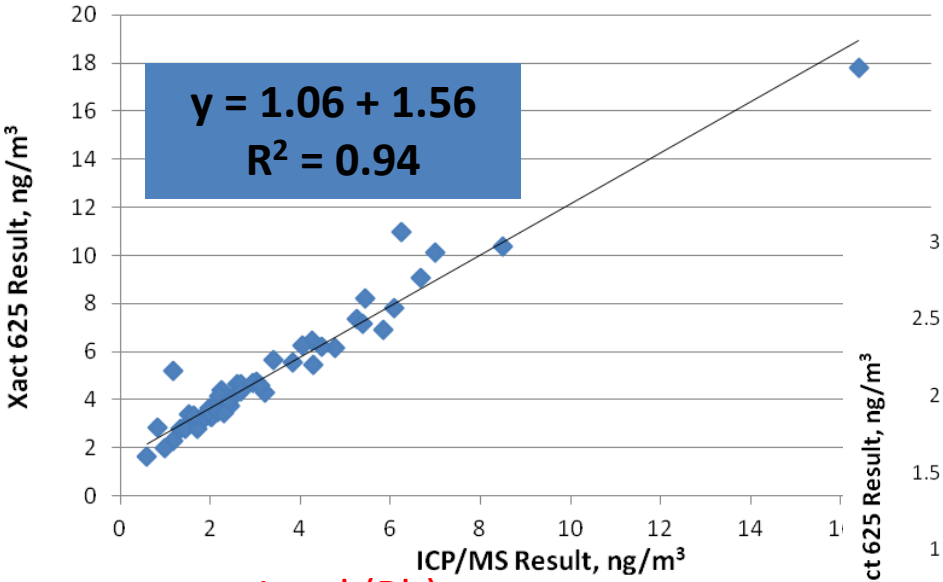
Comparability of Xact to Laboratory Analysis

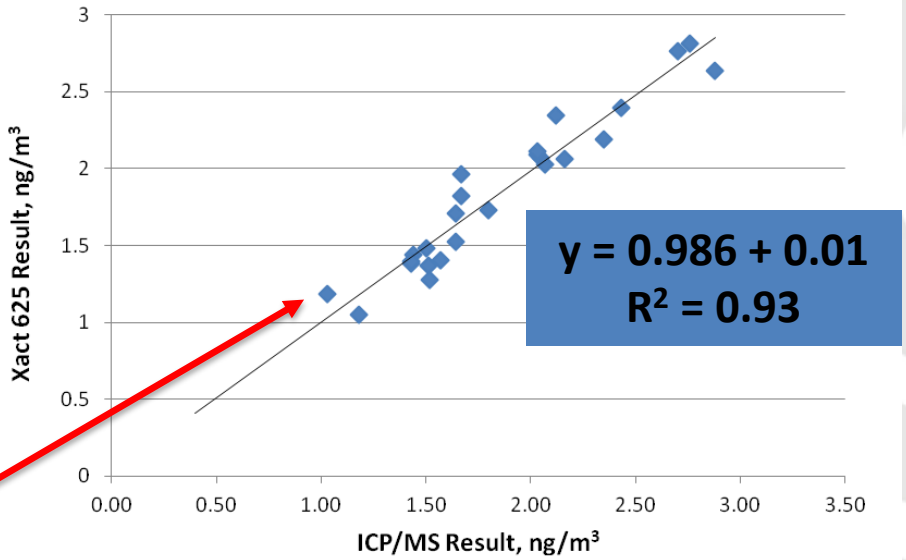
We will discuss two studies -

- U.S. EPA Environmental Technology Verification (ETV)
- King's College (London) – Atmospheric Measurement Technology Paper

ETV Accuracy Data



Lead (Pb)



Selenium (Se)

Accuracy Demonstrated Down to 1 ng/m³

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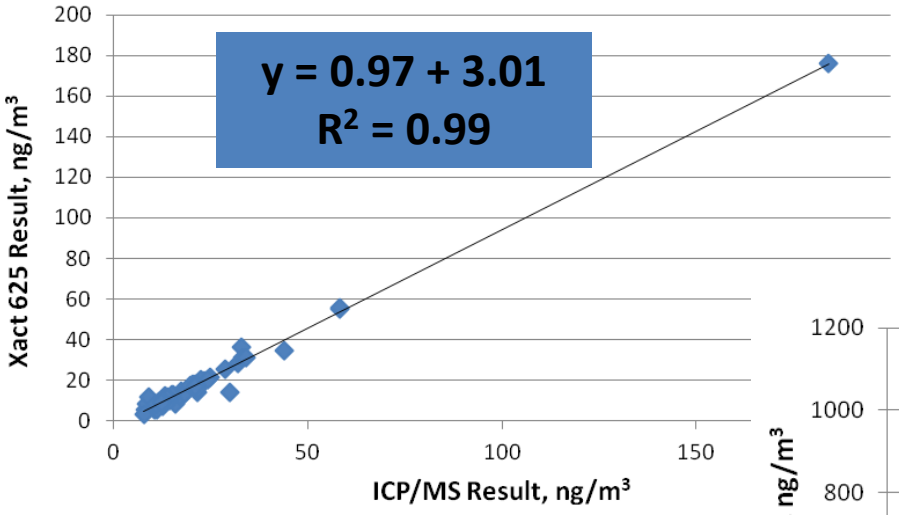
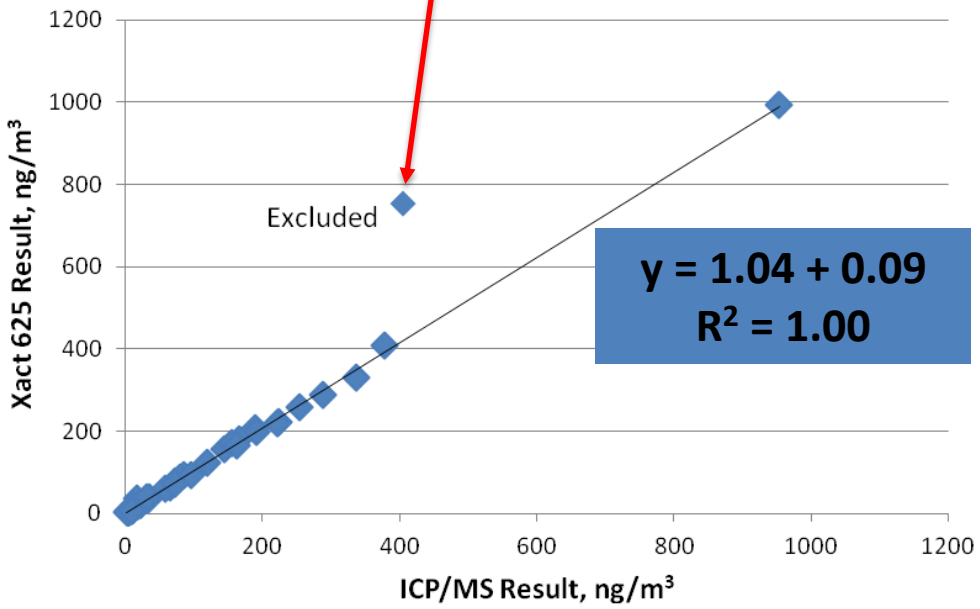
ETV Accuracy Data



Zinc (Zn)

Excluded because Xact® did not sample for 24 hours



Manganese (Mn)

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King's College Study

- Three different sampling locations
  - Roadside in downtown London
  - Industrial Area
  - Urban background
- Xact Compared ICP-MS

1. Tremper, A. H., Font, A., Priestman, M., Hamad, S. H., Chung, T., Pribadi, A., Brown, J.C., Goddard, S. L., Grassineau, N., Petterson, K. A., Kelly, F. J., Green, D. C.: Field and laboratory evaluation of a high time resolution x-ray fluorescence instrument for determining the elemental composition of ambient aerosols. Atom. Meas. Tech. *11, 3541-3557, 2018*

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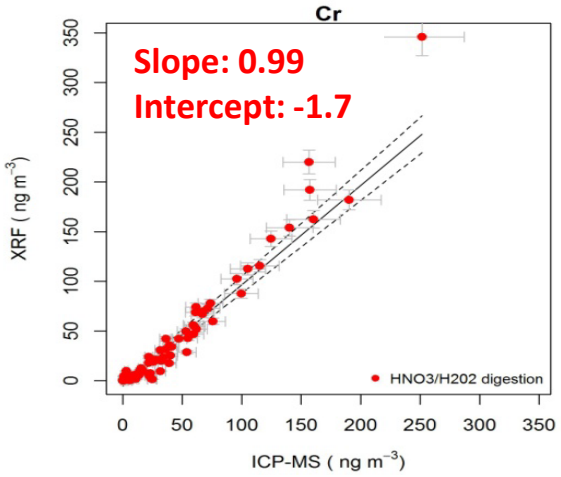
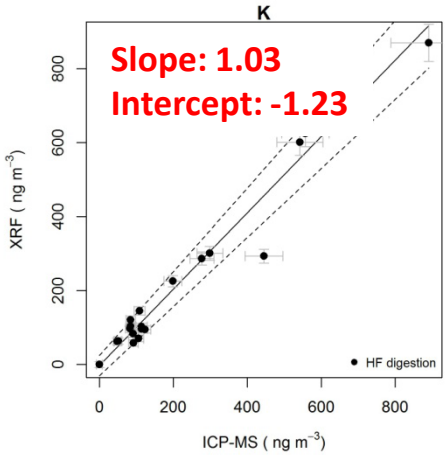
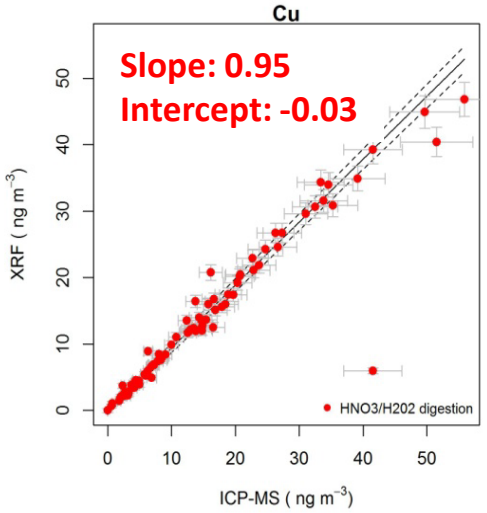
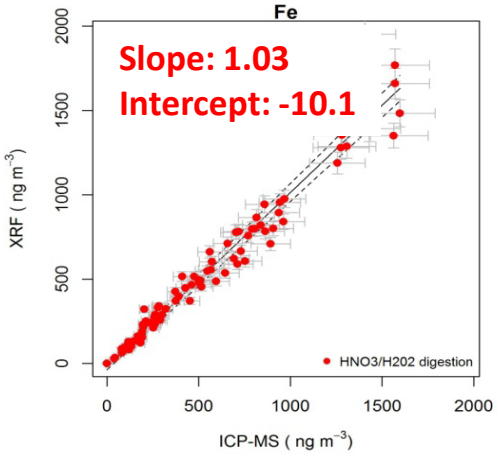
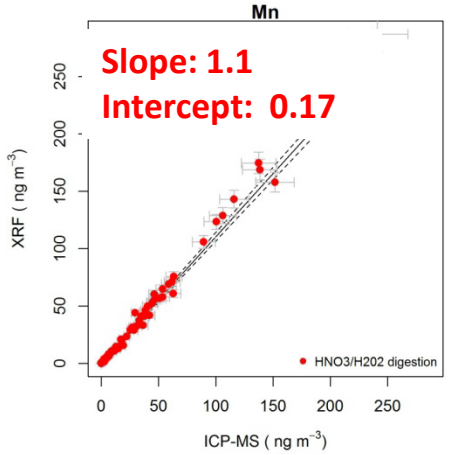
Results for Selected Elements











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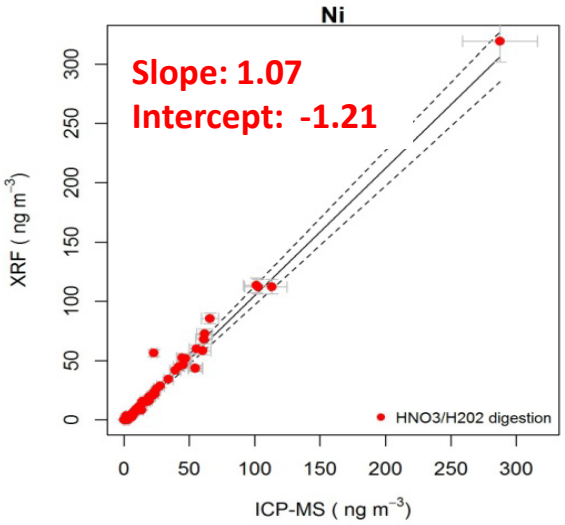
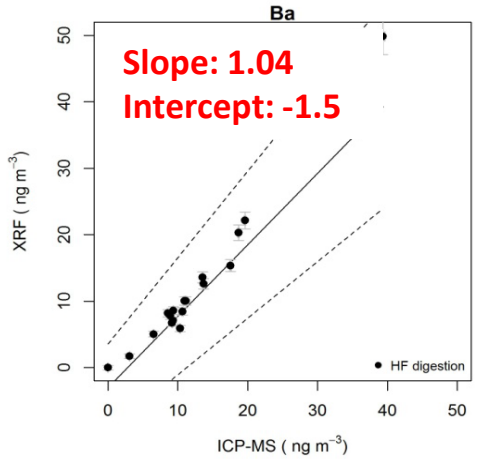
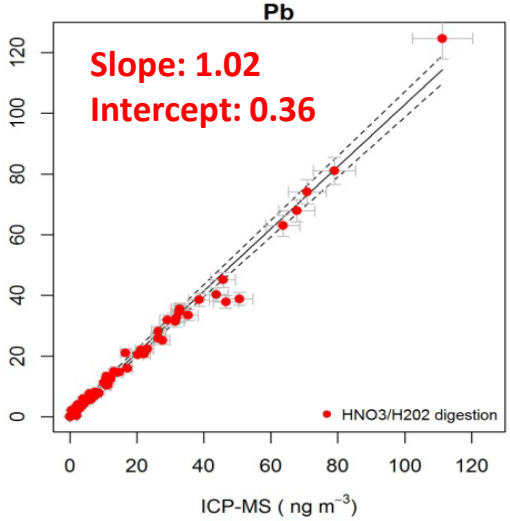
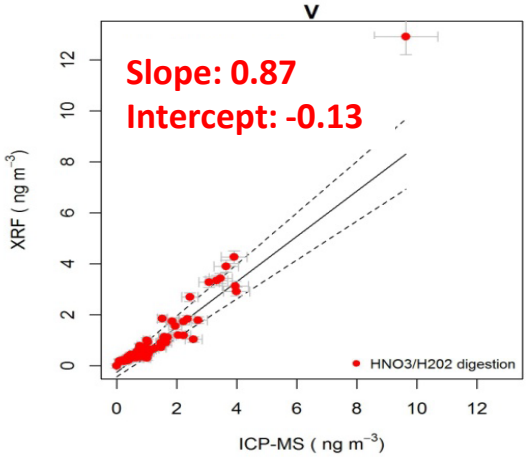
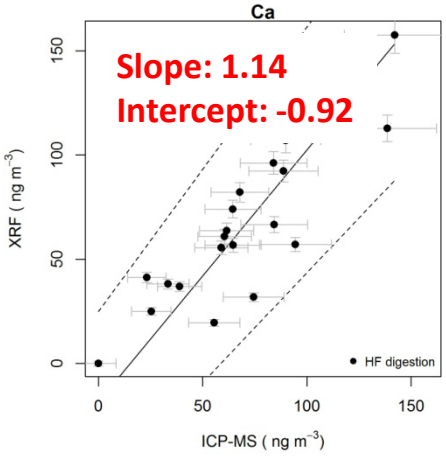
Results for Selected Elements

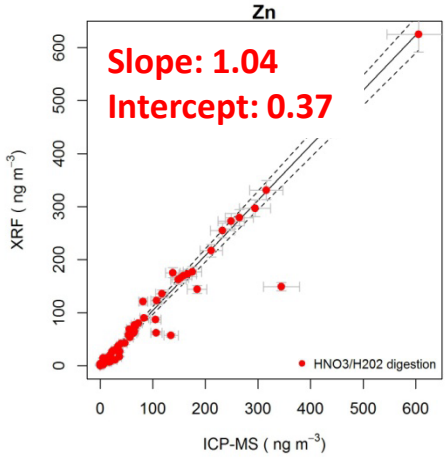












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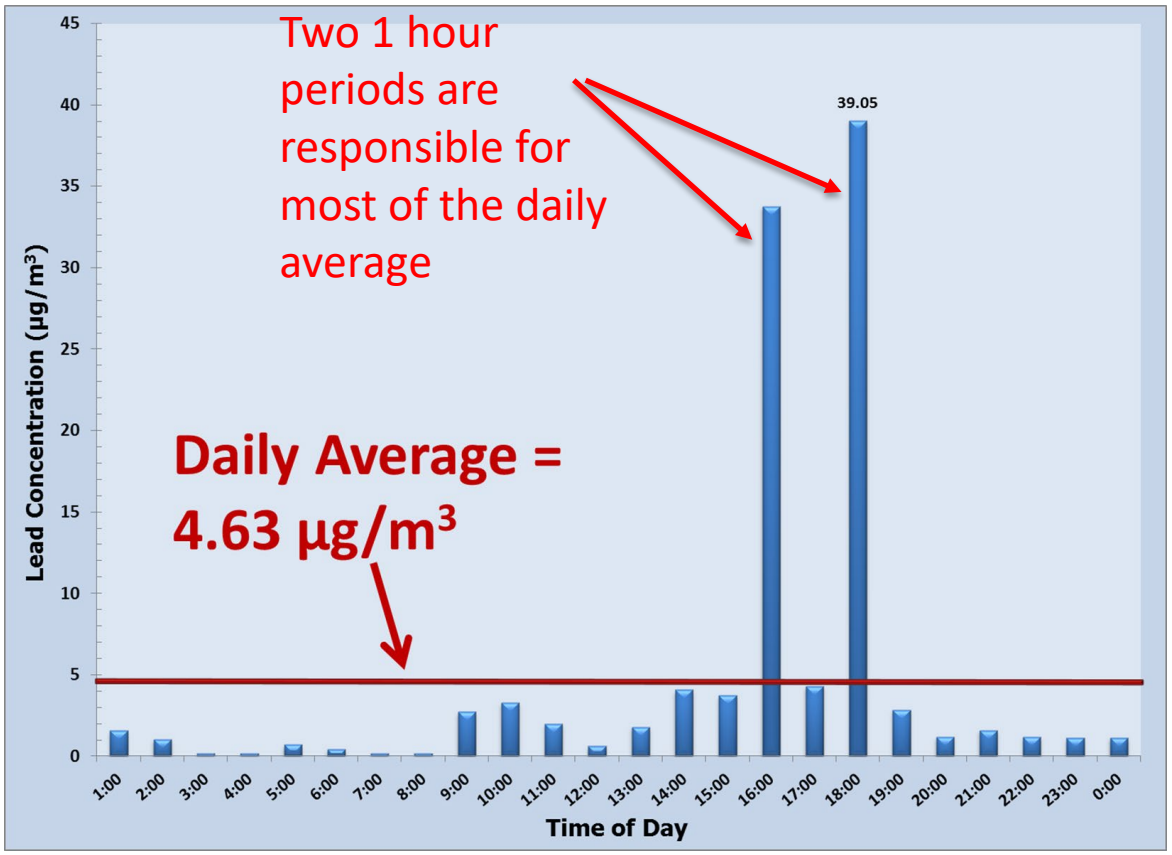
General Approaches to Source Identification

- Time Resolution
  - Correlate high concentrations with local activities
- Chemistry – compare chemistry measured with known source chemistries (particularly important in an industrial setting)
- Correlation with Wind Direction
- Highly Time Resolved Factor Analysis (e.g. PMF)

Emission Identification– Time Resolution



- Monitoring on Fenceline of a Pb Smelter
- Variability in concentration is lost when using 24 hour sampling
- Time resolution can allow for a correlation of the measurement with plant activities
- Real time feed back from the monitor may allow for process control

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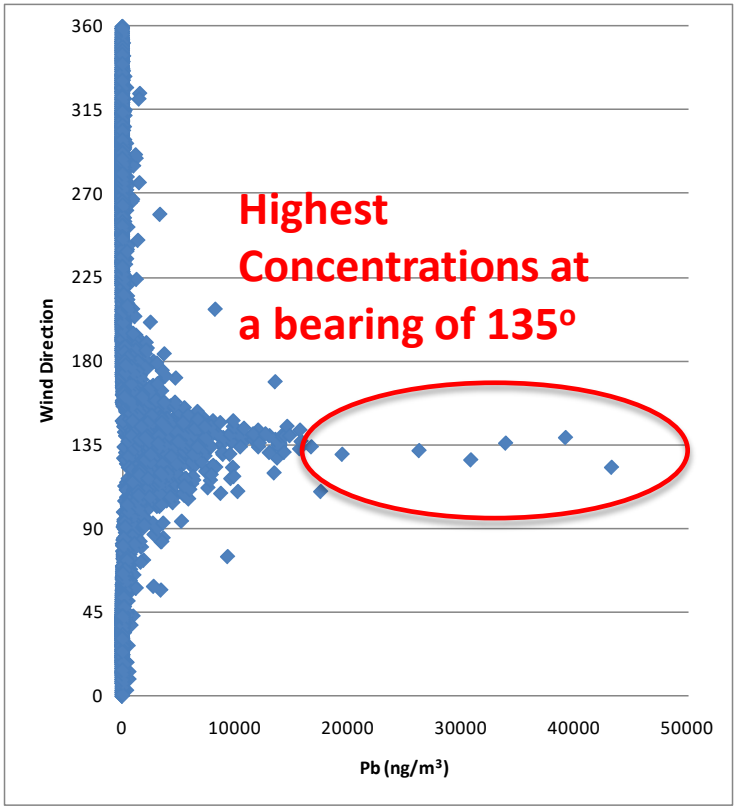
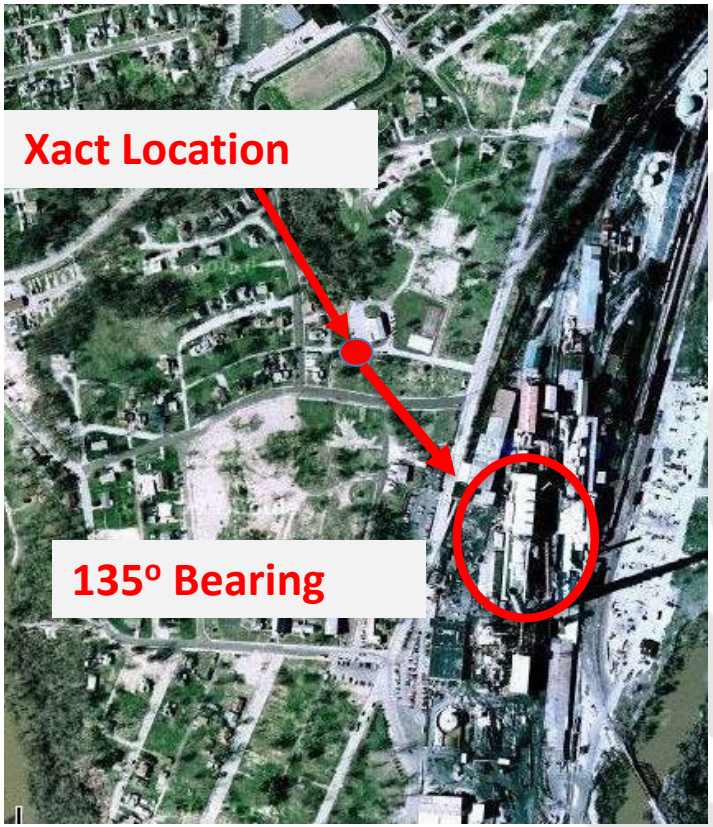
Source Identification Based on Wind Direction

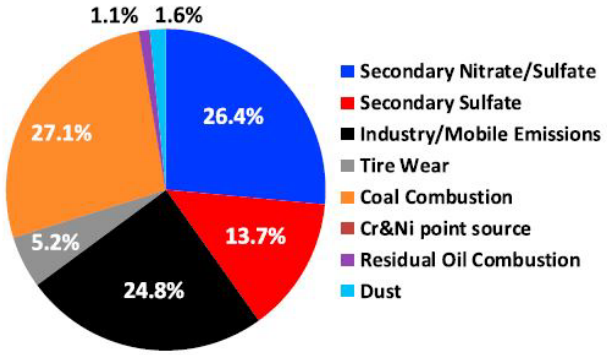




The time resolution of the data allowed for the identification of the specific part of the Pb smelter responsible for the highest concentration events

Source Apportionment

- Metals are key fingerprint for many sources
- Use of highly time resolved metals data allows for better resolution of factors than could be identified based on longer time data[2]
- Highly time resolved data allows for easy correlation of factors with specific wind directions[3]
- Even Diurnal Variability can be sources can be identified
- Xact data used in numerous peer reviewed journal articles



Example source apportionment results with Xact

2. Wang, Q., Qiao, L., Zhou, M., Zhu, S., Griffith, S., Zhen Yu, J.; Source apportionment of PM2.5 using hourly measurements of elemental tracers and major constituents in an Urban Environment: Investigation of time resolution difference; *Journal of Geophysical Research: Atmospheres,* April 25th, 2018

3. Chang, Y., Huang, K., Xie, M., Deng, C., Zou, Z., Liu, S., Zhang, Y.; First long-term and near real-time measurement of trace elements in China's urban atmosphere: Temporal variability, source apportionment and precipitation effect. *Atmoshpheric Chemistry and Physics, 18, 11793-11812, (2018)*

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Users

- Xact 625i is widely used, accepted and trusted – Over 300 installations globally

Government Agencies (Partial List)

- U.S EPA
- Environment Canada
- Ministry of Environment Ontario
- Quebec Ministry of Environment and Climate Change
- California Air Resources Board
- South Coast Air Quality Management District
- Missouri Department of Natural Resources
- National Institute of Environmental Research (Korea)
- China National EMC
- Queensland EPA
- Kansas Department of Environmental Quality

Universities and Research Centers (Partial List)

- University of Toronto
- King's College London
- University of Birmingham
- University of Manchester
- Paul Scherrer Institute
- Indian Institute of Technology Delhi
- Indian Institute of Technology Kanpur
- University of Massachusetts
- Hong Kong Institute of Science and Technology
- Tsingua University
- Peking University
- Chinese Research Academy of Environmental Science

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Summary

- Xact 625i Provides highly accurate, highly time resolved metals concentration data
- Xact is comparable to reference methods of measuring metals
- Data can be useful in source apportionment and identification

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Questions?

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