Evaluation of Proficiency Testing results

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SADCWater PT Evaluation Workshop 2016

Tanzania

Overview

- Background
- Evaluation of performance
  - Assigned value & Acceptable range
  - Performance statistics
  - Interpretation of results
    - Short term
    - Long term
  - Investigation
- Conclusion

What is Proficiency Testing?

- A regular independent assessment of the technical performance of a laboratory is necessary to assure the validity of measurements of tests and should be part of an overall quality strategy.
  - External quality assurance
    - Proficiency testing (PT)
    - Interlaboratory comparisons (ILC)
  - Complements Internal quality assurance measures
    - *Method development / validation*
    - Regular use of (certified) reference materials
    - Comparison of analysis by independent techniques
    - Control charts
    - Replicate tests
    - Intermediate checks on measuring equipment

Proficiency tests: Goals

- Compare its performance at a particular time against an external standard of performance

  How accurate is the data?

- Compare performance over a period of time

  Is it getting better or worse?

- Compare performance with that of other laboratories at a particular time

  Within peer group - how well does laboratory perform?

- Enable the organisers (regulatory authorities) to identify participants whose performance is unsatisfactory and establish whether there is a general improvement in performance in time

  Is the PT scheme doing its job of improving the quality of chemical measurements?

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Proficiency tests
Other goals

- Operated for the benefit of the participating laboratories, but data may be used from other organisations to aid understanding the capabilities and competence of the laboratories:
  - Accreditation bodies
  - Regulatory authorities
  - Customers of analytical services

Evaluation of performance

- Evaluation of performance against:
  - Assigned value
  - Acceptable range
- Determination of assigned value
  - Formulation
  - Certified reference value / Reference value
  - Consensus value:
    - Expert laboratories
    - Participants
- Determination of acceptable range / standard deviation
  - Prescribed value / Perception
  - Model, e.g. Horwitz curve
  - Precision experiment (standard method)
  - Standard deviation from participants' results

Evaluation of performance

Determination of assigned value

- Formulation
  - Spiking with known amount, concentration of an analyte to a base material containing none.
- Certified reference value (CRM)
- Reference value

For a reference value to be suitable its associated uncertainty should be 5 to 10 times better (smaller) than the uncertainties of the participants

$$u_x \leq 0.3\hat{\sigma}$$

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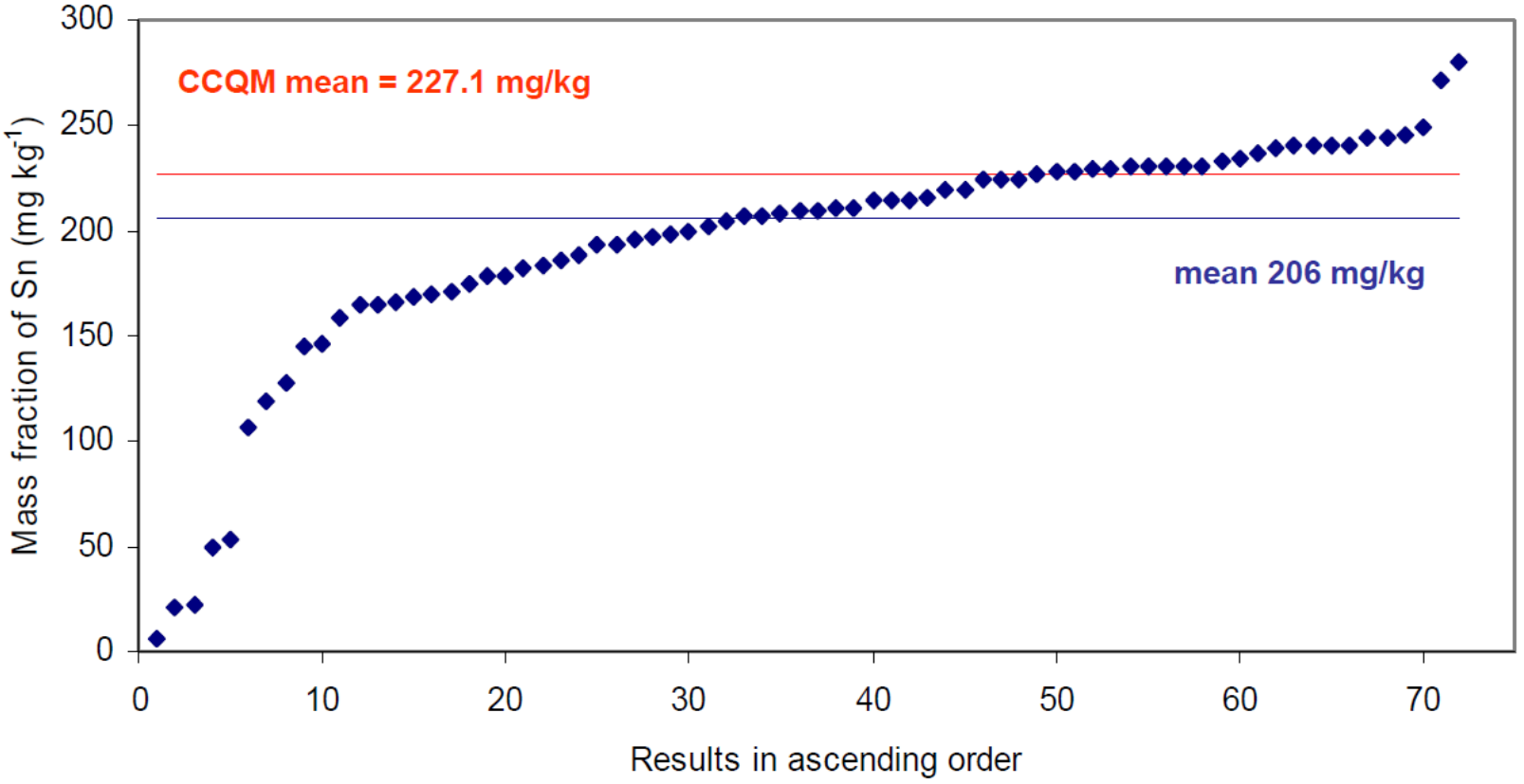
Evaluation of performance

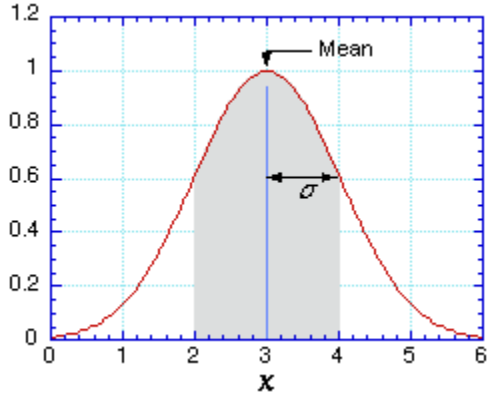
Determination of assigned value

- Consensus value:
  - Expert laboratories
    - Use of certified value of an analyte produced by group of expert or referee laboratories

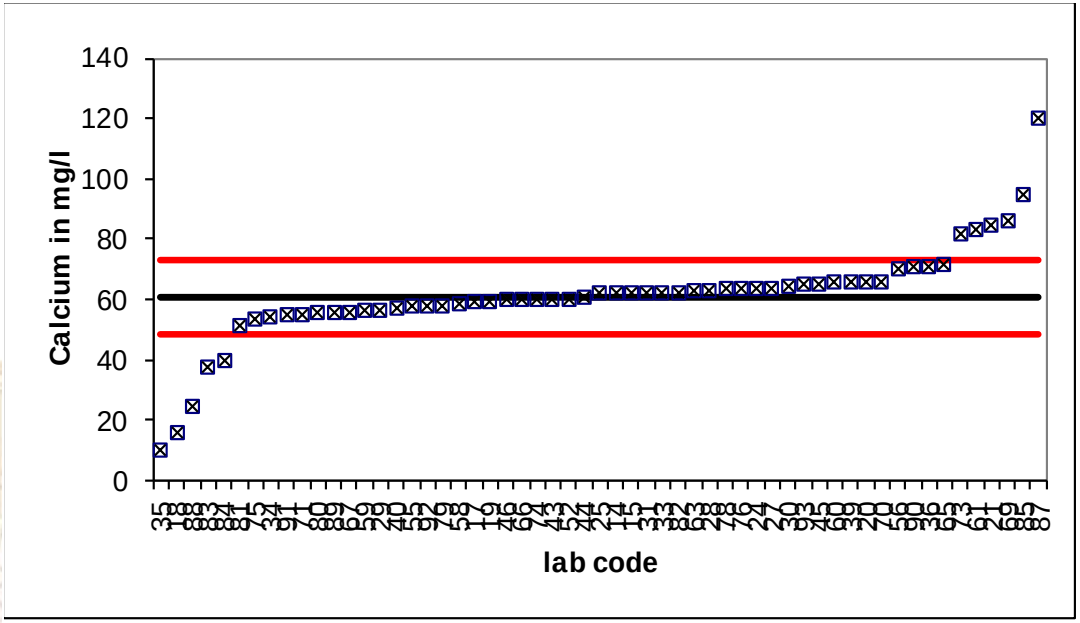


Evaluation of performance

Determination of assigned value



- Consensus value:
  - Participants
    - Parametric approach:
      - Normal distribution data
      - Arithmetic mean
      - Standard deviation - estimate of spread
      - Sensitive for deviating results, requires the use of outlier tests

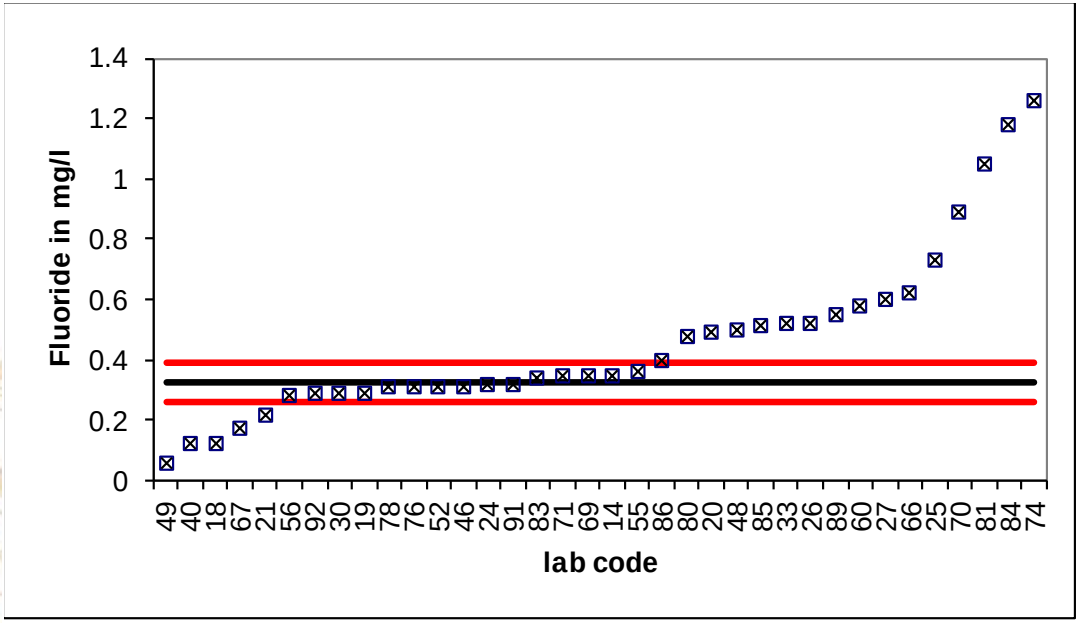


values:	59
removed:	2
mean:	61.38
ref.-value:	60.74
recovery:	101.1%
std:	7.336
rstd:	12.1%
std limit:	10%
upper limit:	72.89
lower limit:	48.59
too high:	6
too low:	7
outside limits:	13

Evaluation of performance

Determination of assigned value

- Consensus value:
  - Participants
    - Non-parametric approach:
      - Normal distribution of data is not required
      - Median
      - Median absolute deviation
      - Outlier tests are not required

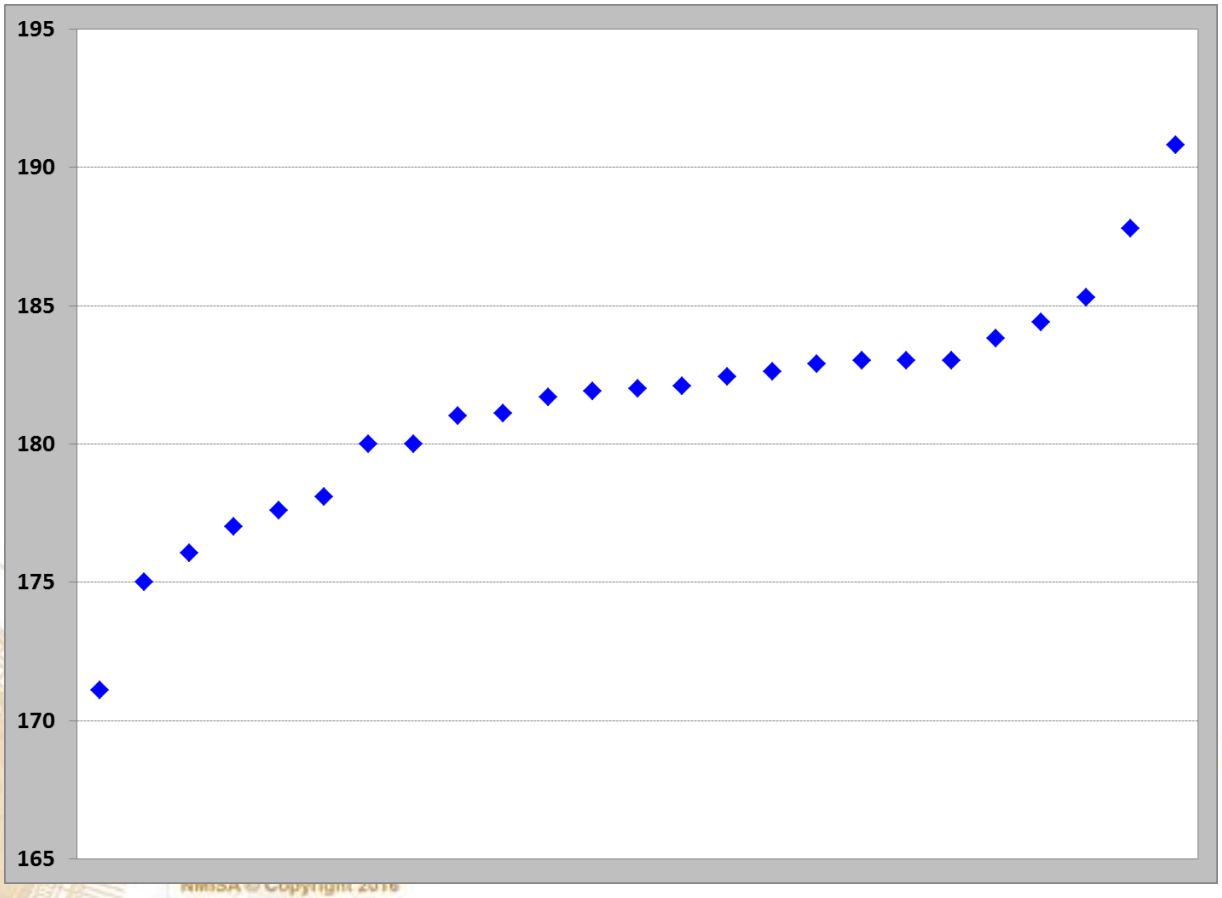


values:	**39**
removed:	**3**
mean:	**0.41**
ref.-value:	**0.33**
recovery:	**126.8%**
std:	**0.207**
rstd:	**63.5%**
std limit:	**10%**
upper limit:	**0.39**
lower limit:	**0.26**
too high:	**19**
too low:	**5**
outside limits:	**24**

Evaluation of performance

Determination of assigned value

- Consensus value:
  - Participants
    - Parametric approach: **Zn in geological material**



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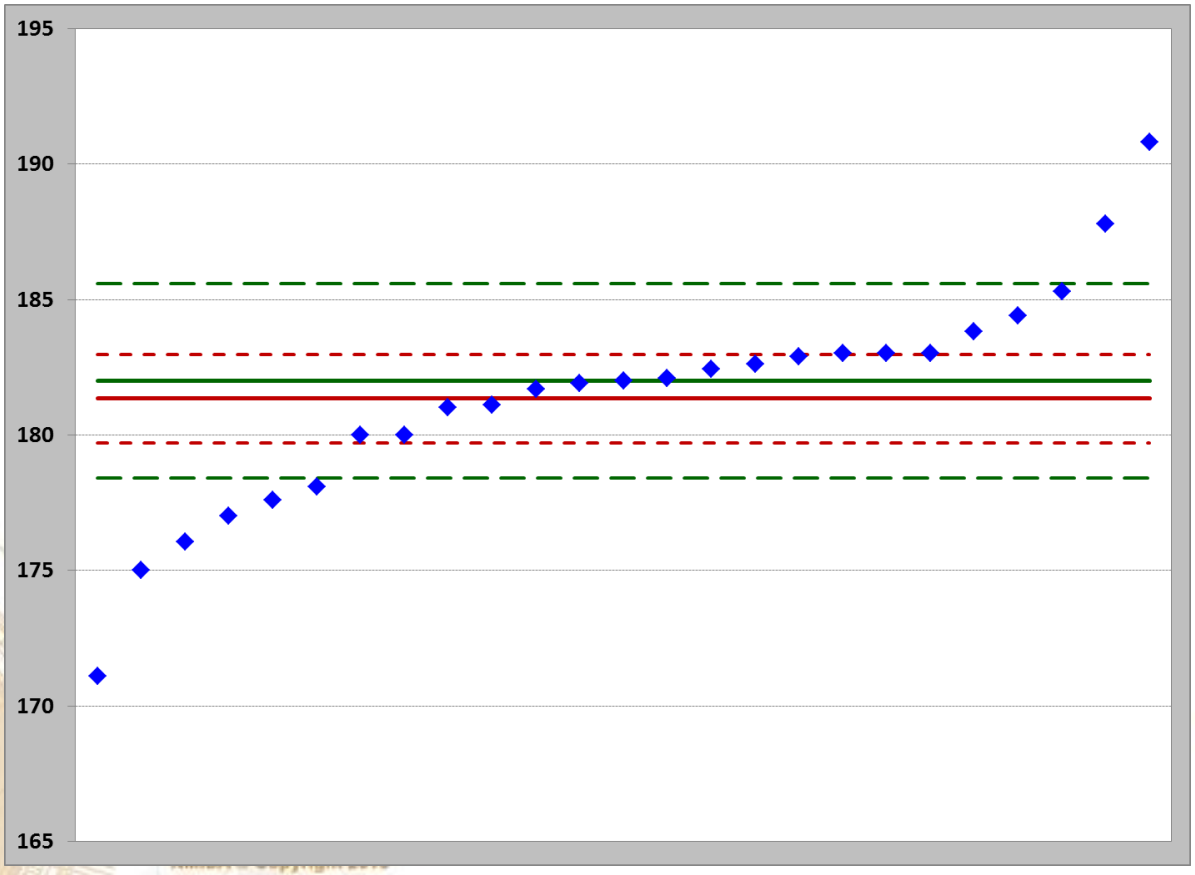
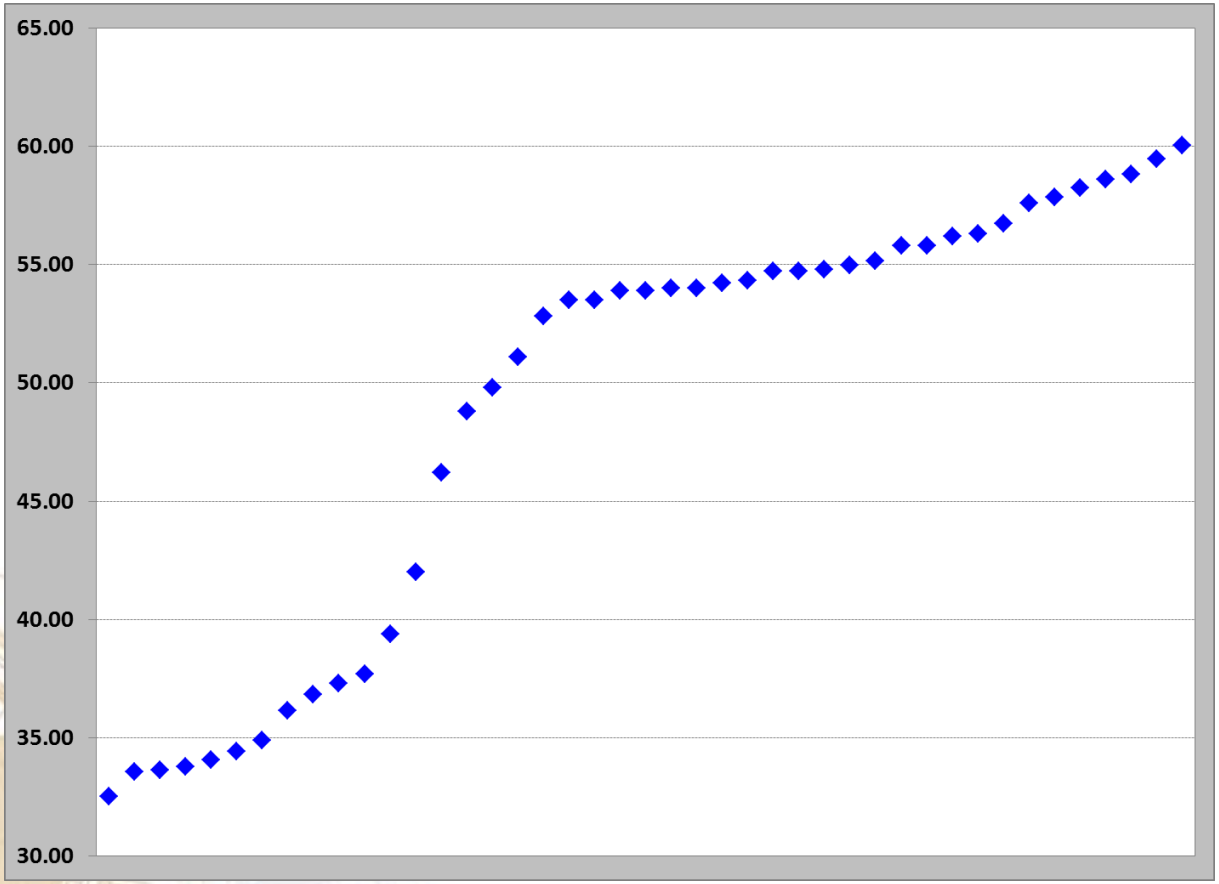


Evaluation of performance

Determination of assigned value

- Consensus value:
  - Participants
    - Non-parametric approach: **Ca in geological material**



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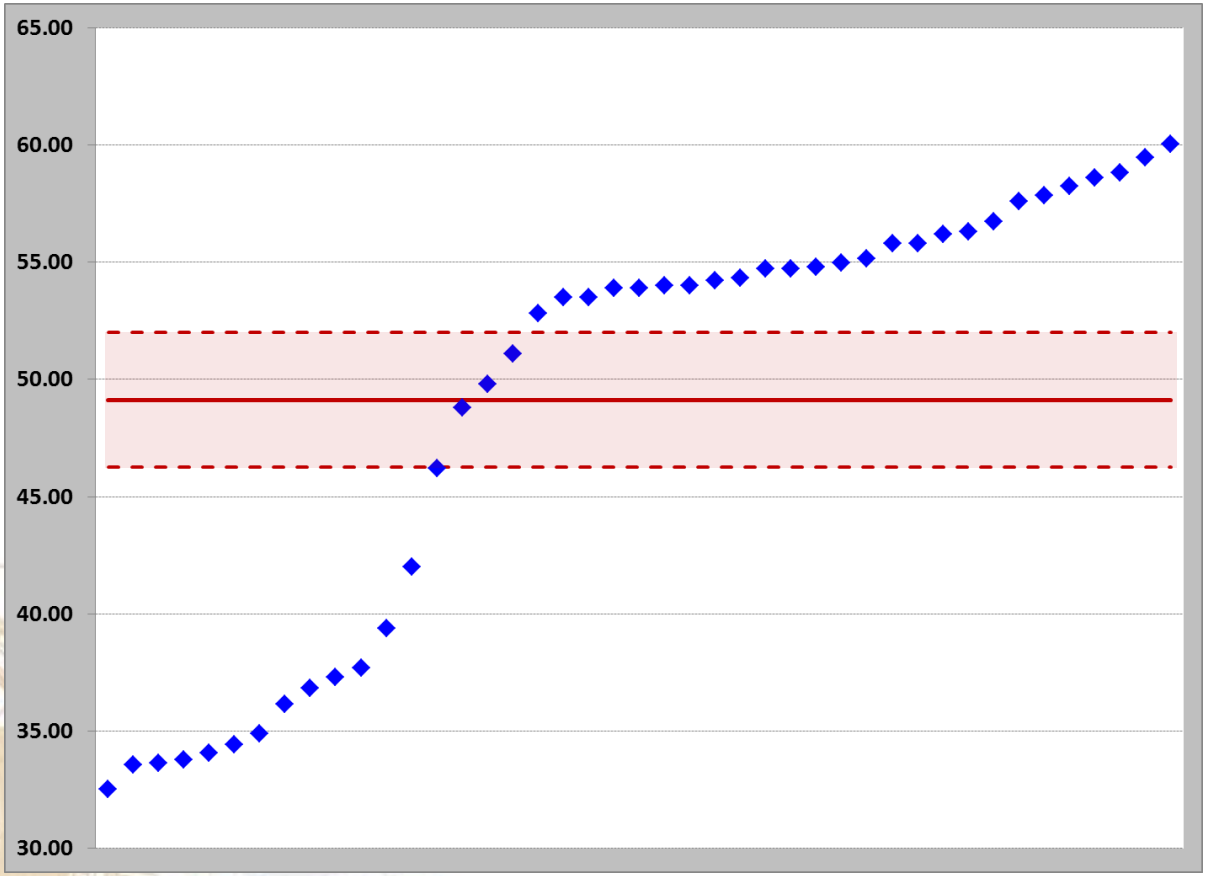

Evaluation of performance

Determination of assigned value

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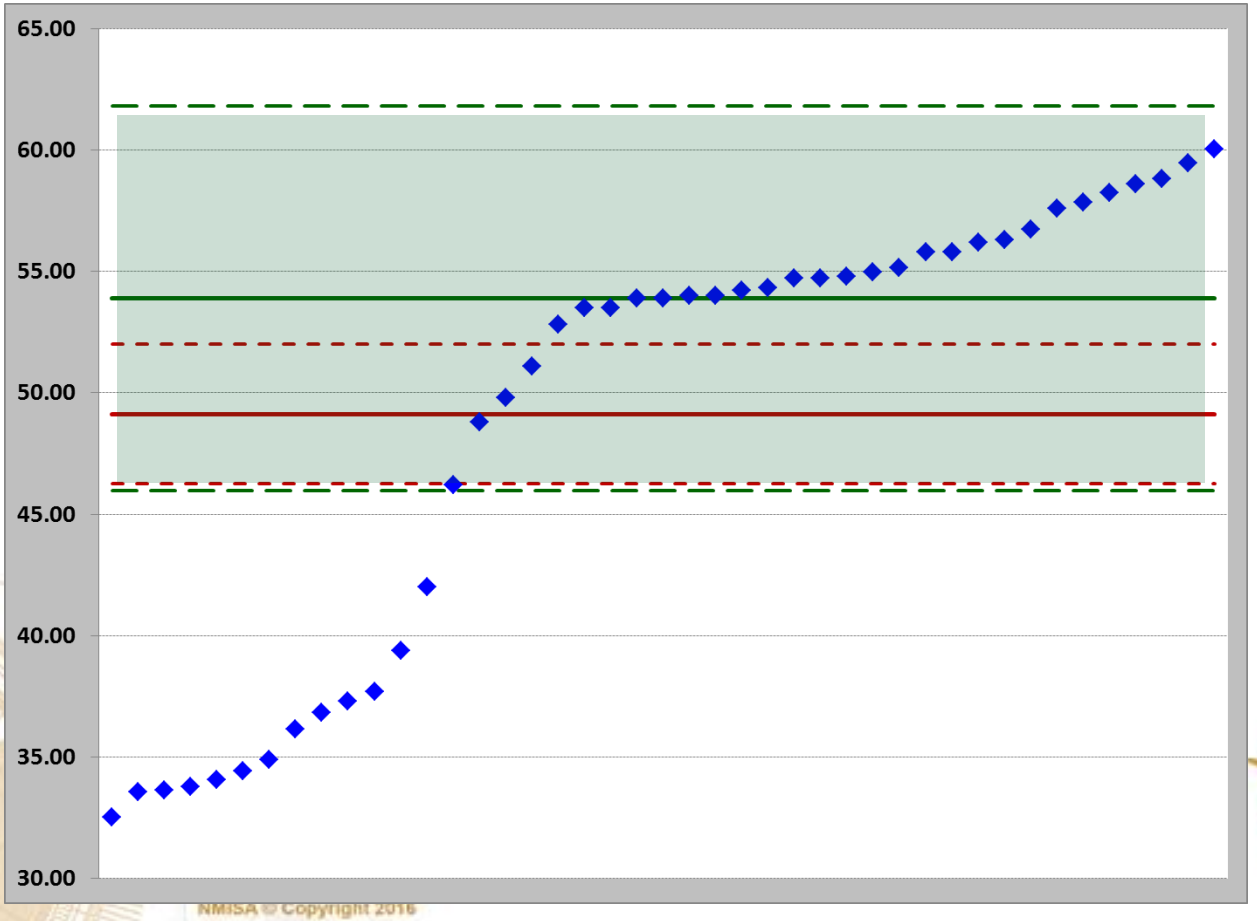
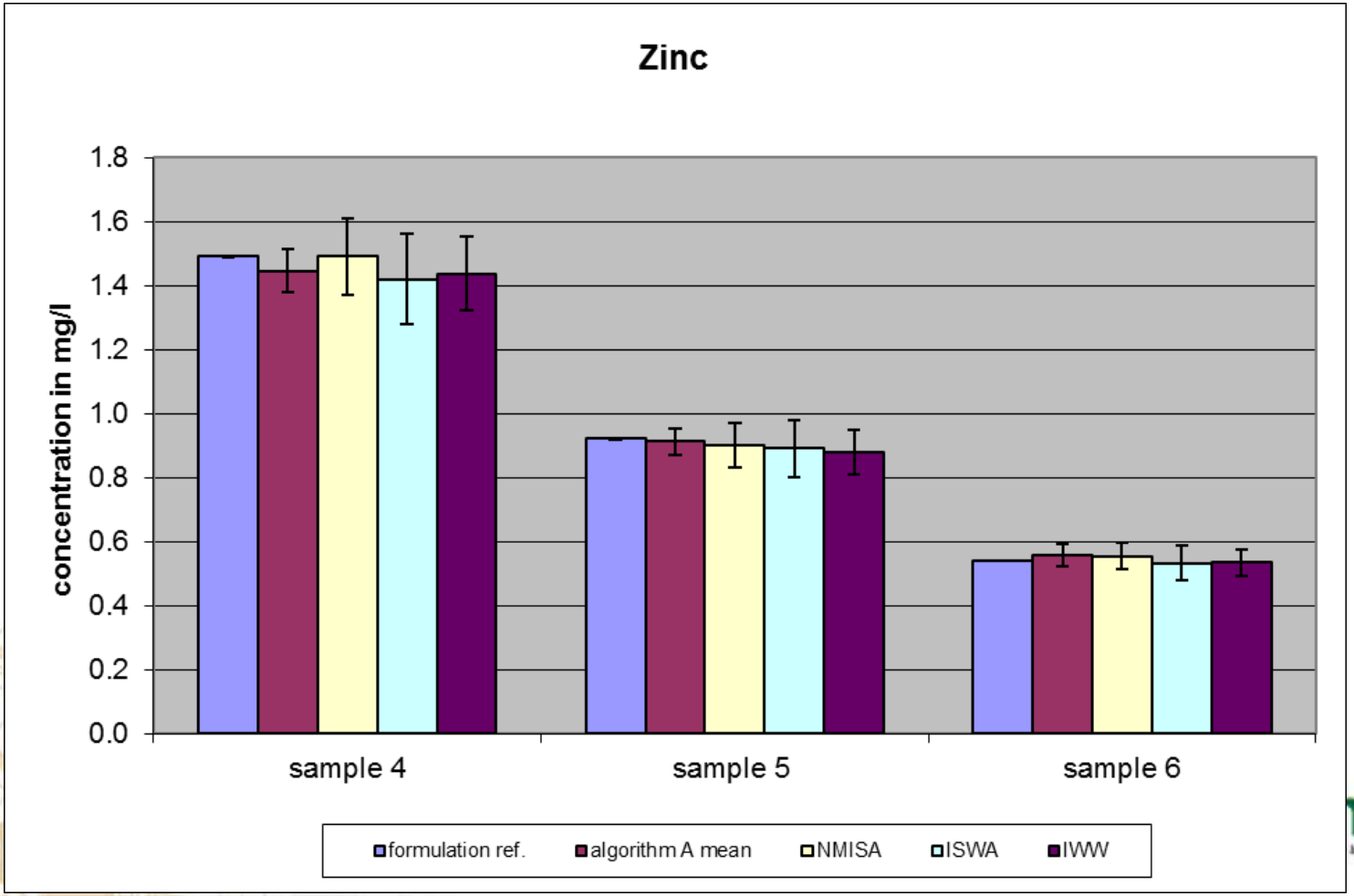


Evaluation of performance

Determination of assigned value

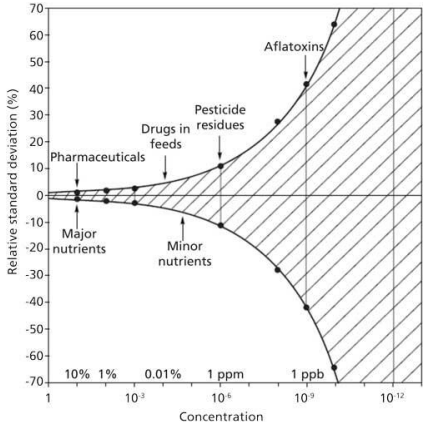
- SADCWater PT:



Evaluation of performance

Determination of acceptable range / standard deviation

- Prescribed value / Perception
  - Legislation
  - Fit for purpose (determined by coordinator / members)
- Model, e.g. Horwitz curve



- Precision experiment (standard method)
- Standard deviation from participants' results
  - Varies between rounds
  - 5% non-conforming results

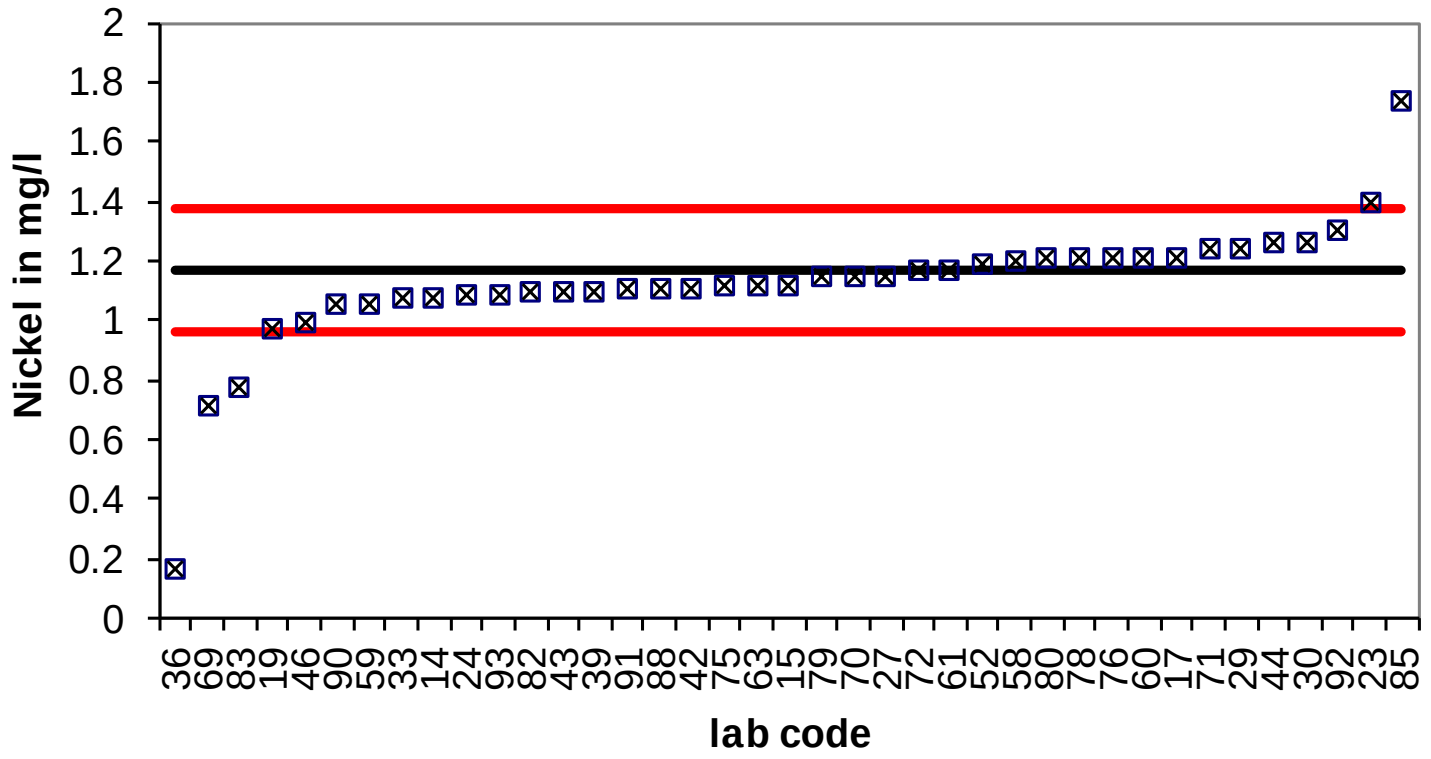
Limits for standard deviation 2015

	std limit
Sulphate	10 %
Chloride	10 %
Fluoride	10 %
Nitrate	10 %
Phosphate	10 %
TDS	10 %
Conductivity	10 %
Calcium	10 %
Magnesium	10 %
Sodium	10 %
Potassium	10 %

parameter	std limit
Iron	20 %
Manganese	20 %
Aluminium	20 %
Lead	20 %
Copper	20 %
Zinc	20 %
Chromium	20 %
Nickel	20 %
Cadmium	20 %
Arsenic	20 %
Cobalt	20 %

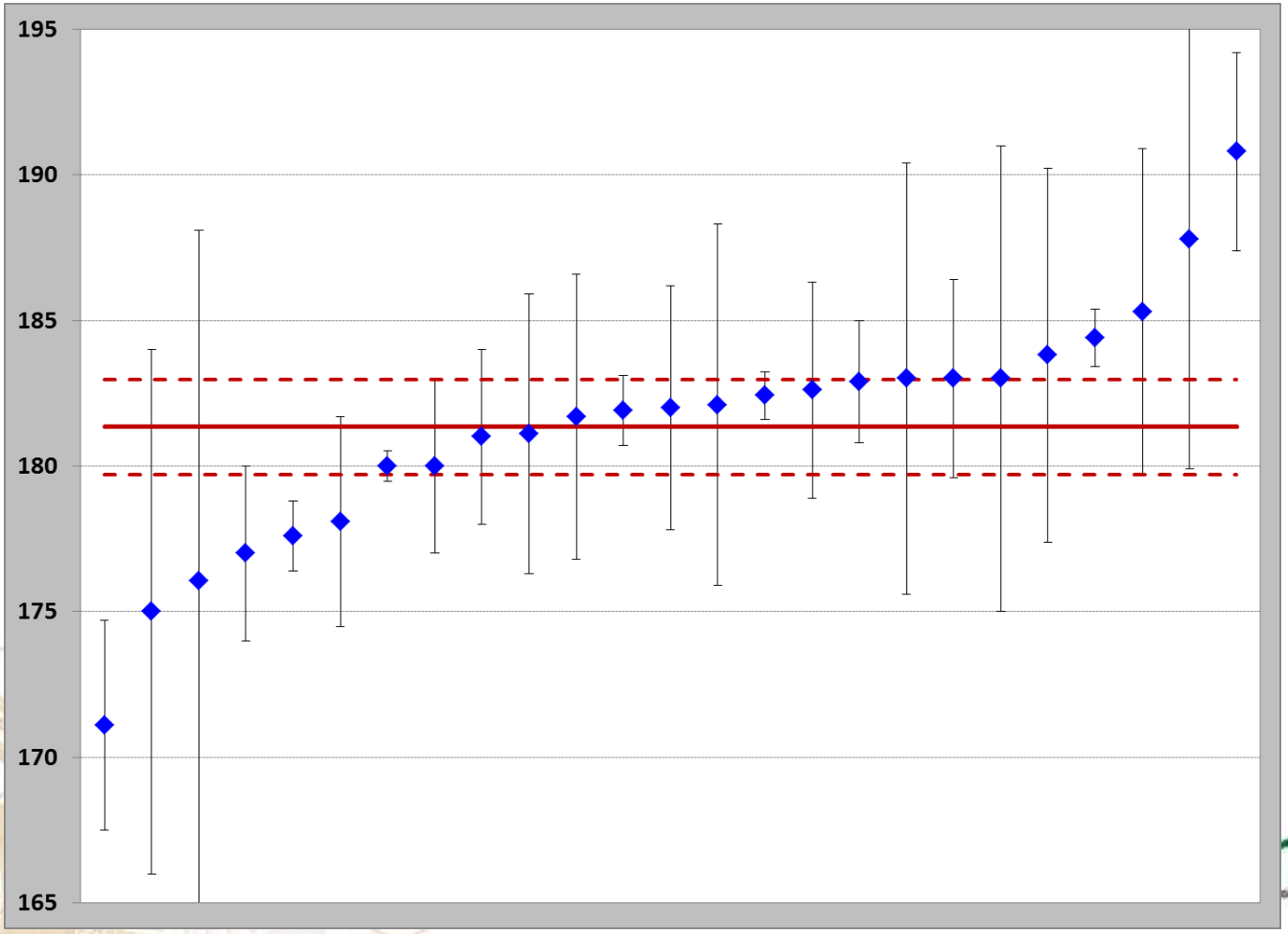
Presentation of PT/ILC results

- Normalised plot (concentration results)



Presentation of PT/ILC results

- Normalised plot (concentration results with uncertainties) _ Zn in bovine liver



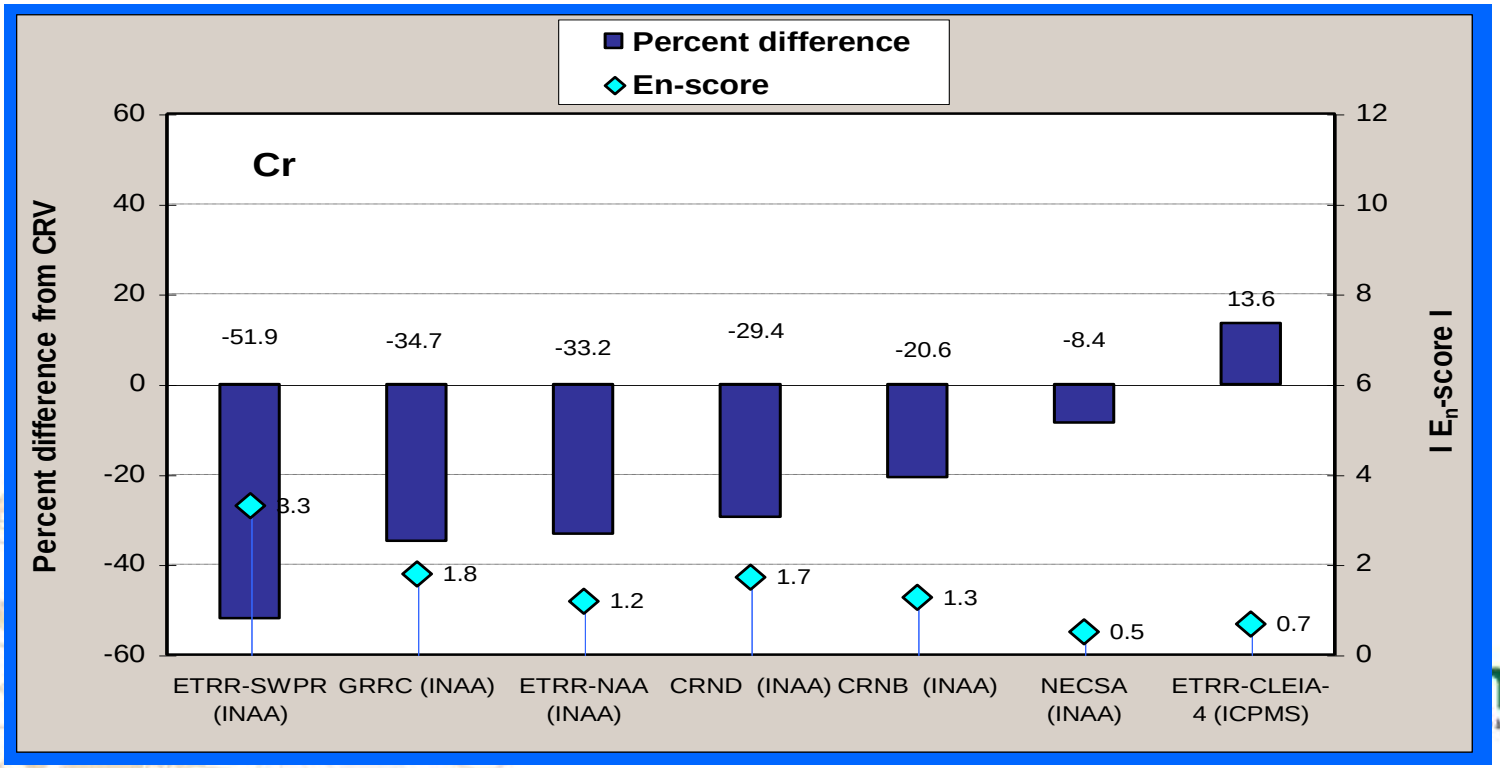
Performance evaluation / score

- Assign a normalised value that gives a score to each result, relative to the other results in the data set.
- Describes closeness of laboratory's result to consensus value
  - Bias / Percentage difference
  - z-Score
  - E_n-Score
  - ζ-score

Performance evaluation / score

- Bias / Percentage difference
  - An estimate of laboratory bias adjusted for concentration

$$\%D = \frac{x - X}{X} \times 100$$



Performance evaluation / score

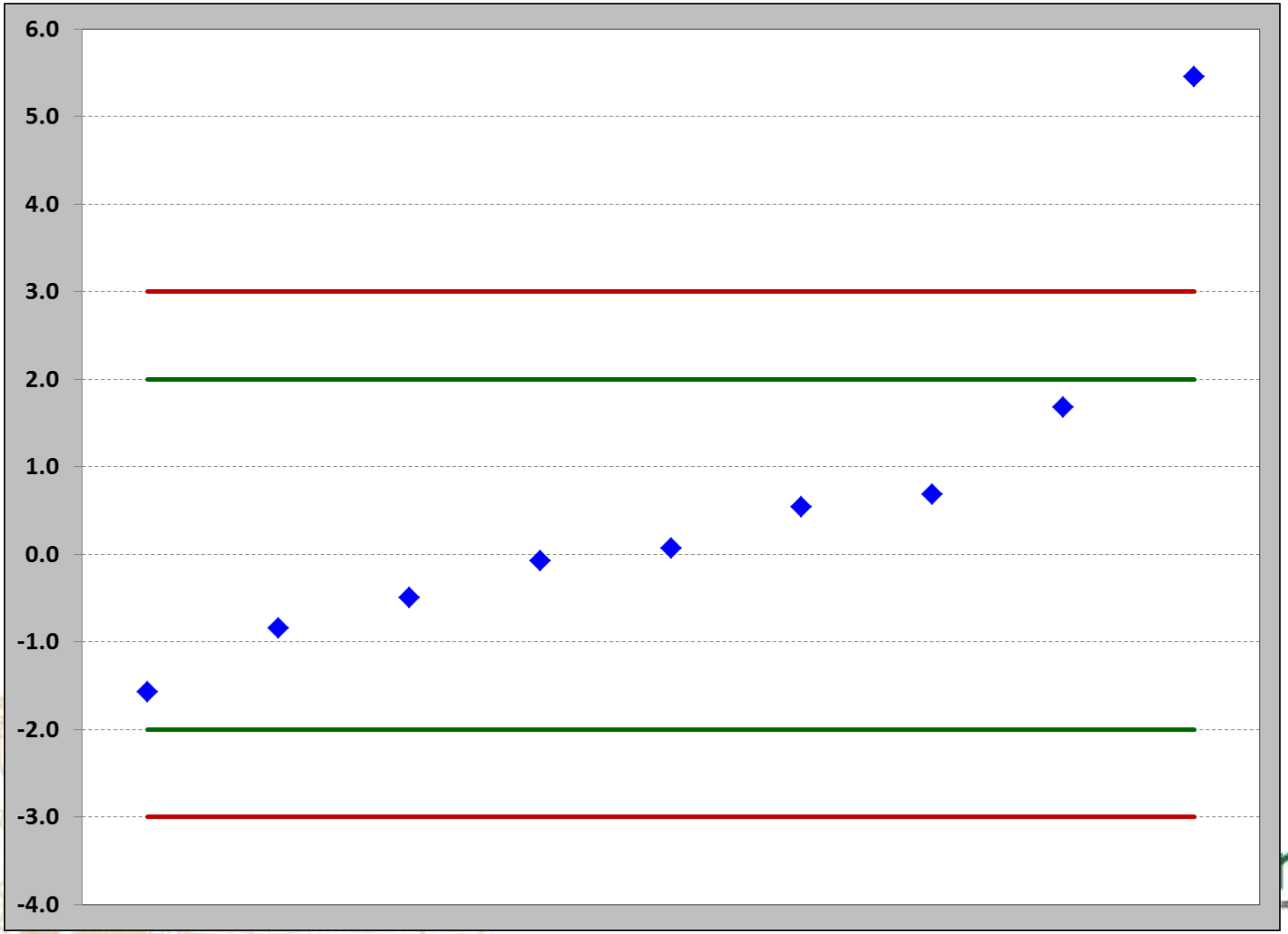
- z-Score
  - A measure of the deviation of the result from the assigned value for a particular measurand

$$z = \frac{x - X}{\hat{\sigma}} \quad \text{OR} \quad z = \frac{x - X}{s}$$

$\lvert z \rvert \leq 2$	Satisfactory	
$2 < \lvert z \rvert < 3$	Questionable	*Investigate possible causes to identify emerging or recurrent problems*
$\lvert z \rvert \geq 3$	Unsatisfactory	*Action signal indicating a need for corrective action*

Performance evaluation / score

- z-Score: **CO_2 in transformer oil**



Performance evaluation / score

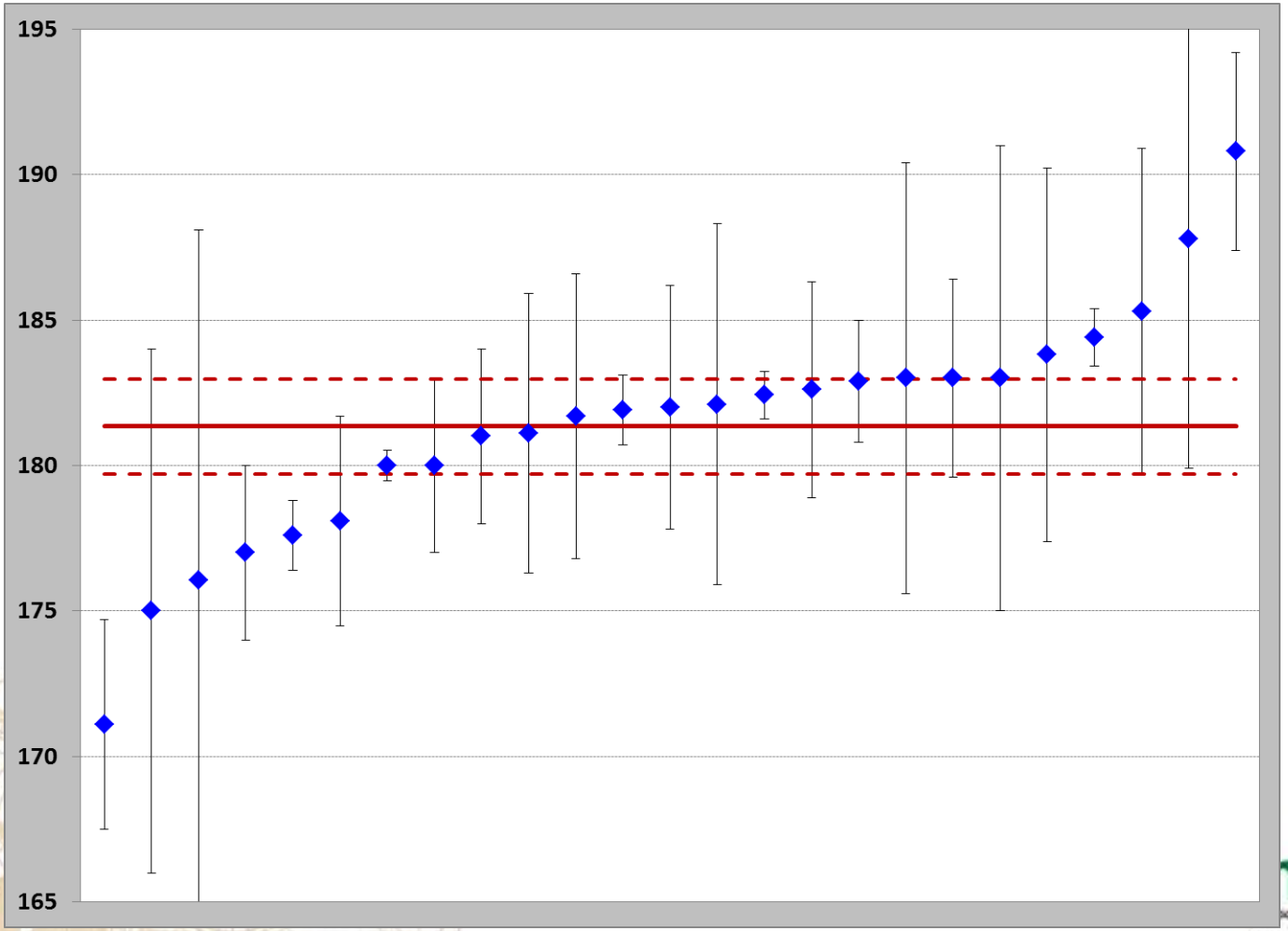
- E_n-Score
  - A measure of agreement between the assigned value and the participant's result within their respective uncertainties range

$$E_n = \frac{x - X}{\sqrt{U_x^2 + U_{ref}^2}}$$

$\lvert E_n \rvert \leq 1$	Satisfactory	
$\lvert E_n \rvert > 1$	Unsatisfactory	Action signal indicating a *need for corrective action*

Performance evaluation / score

- E_n-Score
  - Zn in Bovine liver



Performance evaluation / score

- E_n-Score
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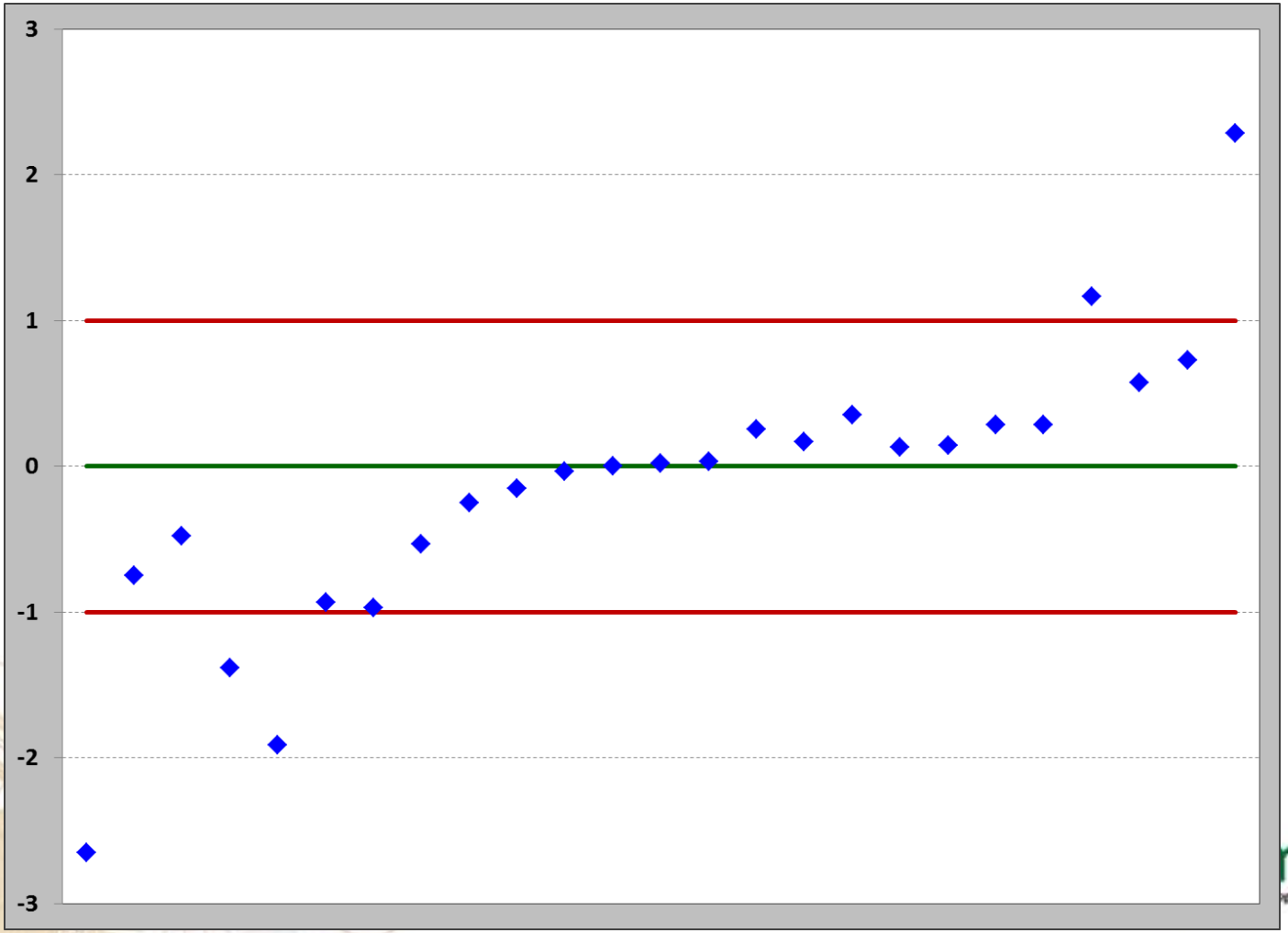


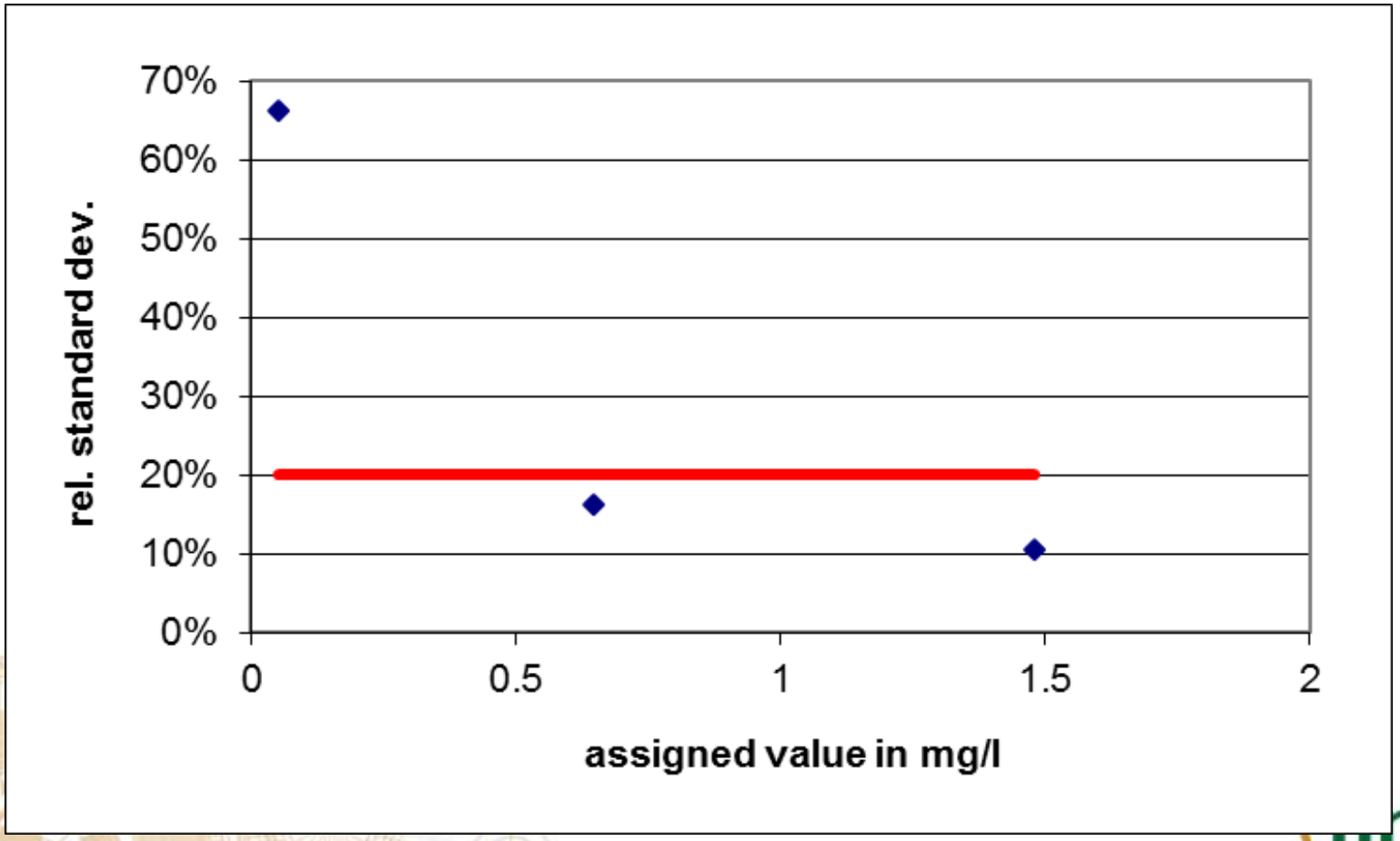
Performance evaluation / score

- ζ-score
  - Similar to En-score, using standard uncertainty instead of expanded uncertainty

$$\zeta = \frac{x - X}{\sqrt{u_x^2 + u_{ref}^2}}$$

$\lvert\zeta\rvert \leq 2$	Satisfactory	
$\lvert\zeta\rvert > 2$	Unsatisfactory	Action signal indicating a *need for corrective action*

Performance evaluation
Standard deviation vs selected limit (Pb)



How to effectively use PT results

Participating in a PT scheme is of limited value unless the laboratory takes advantage of its performance evaluation and the general information given in the PT scheme report.

- Read the PT report & review your performance:
  - How close to zero is the lab's z (or E_n) score?
  - Is the lab's result higher or lower than the consensus?
- Set own internal acceptance criteria
- Trend your performance
  - Spreadsheet
  - Graphically

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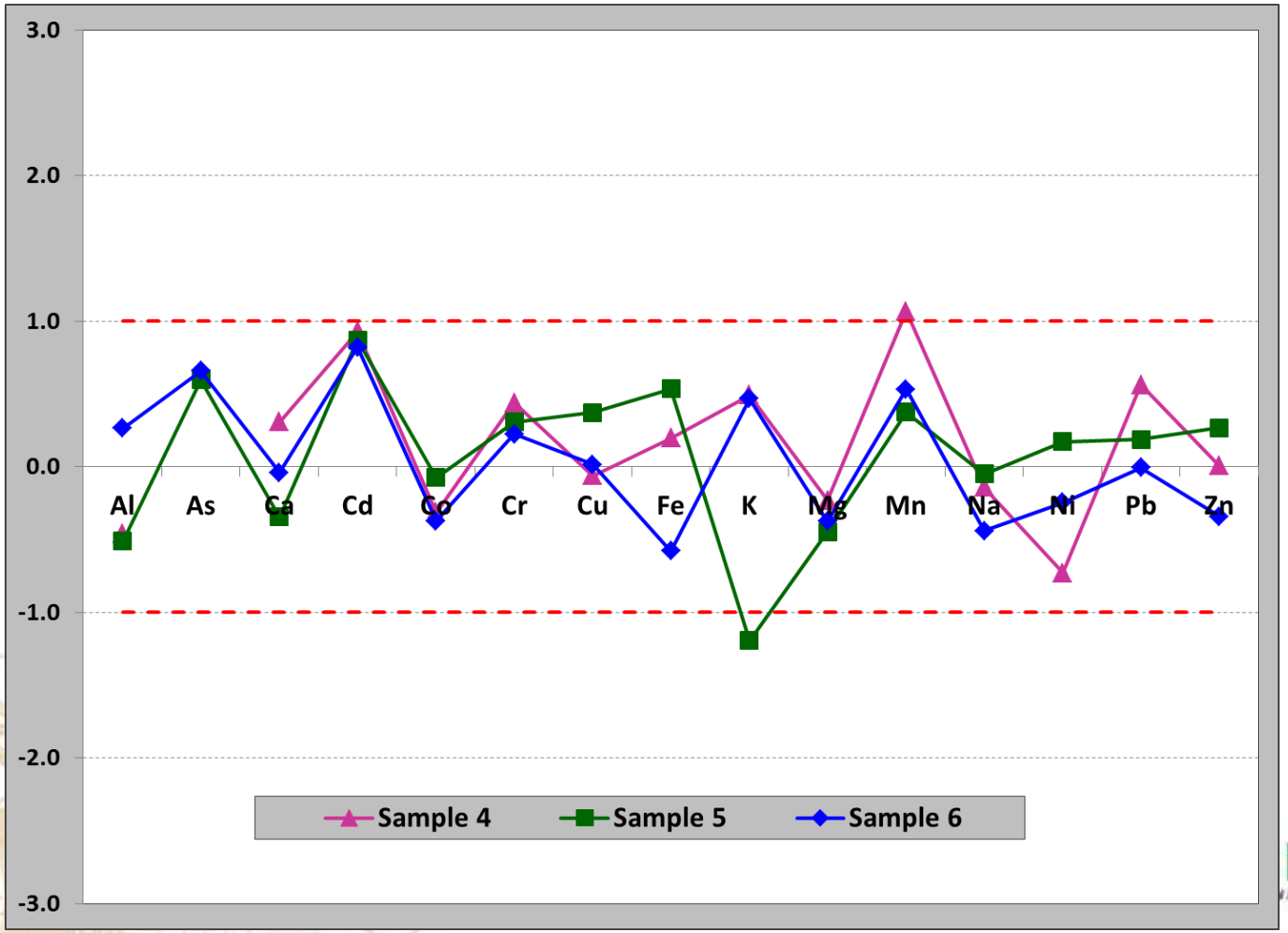
Interpretation of PT results

- Single PT round
  - Histogram of performance scores
  - Bar-plots of standardised laboratory bias
  - Standard deviation / repeatability / reproducibility
  - Normal probability plot

- Performance over time
  - Schewart control chart
  - Cusum control chart
  - Plot of standardized laboratory bias against laboratory average
  - Dot plot

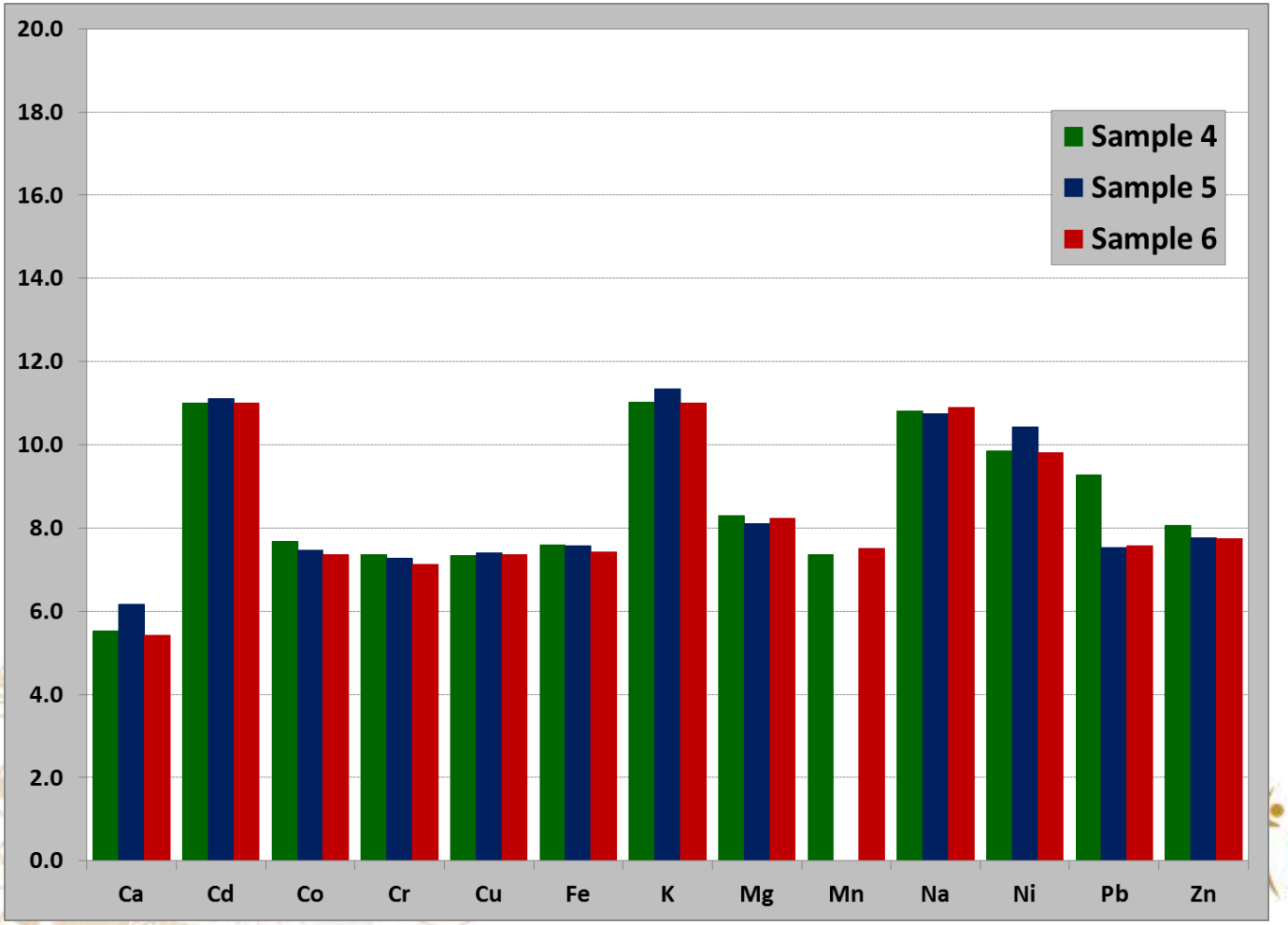
Interpretation of PT results
- Short term performance

- Schewart control chart (E_n-score)



Interpretation of PT results
- Short term performance

- Bar chart (Expanded uncertainty)



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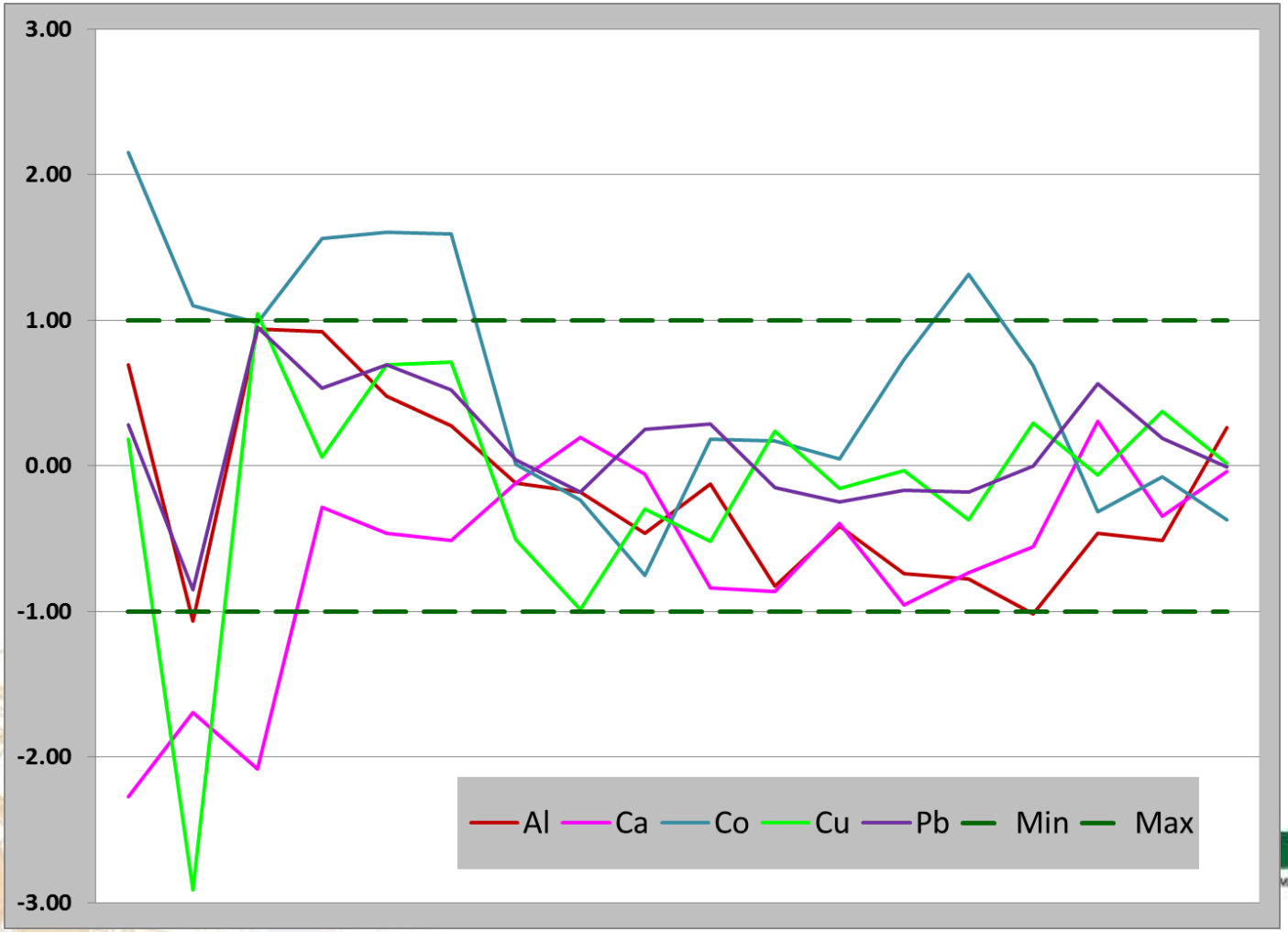
Interpretation of PT results

- Single PT round
  - Histogram of performance scores
  - Bar-plots of standardised laboratory bias
  - Standard deviation / repeatability / reproducibility
  - Normal probability plot

- Performance over time
  - Schewart control chart
  - Cusum control chart
  - Plot of standardized laboratory bias against laboratory average
  - Dot plot

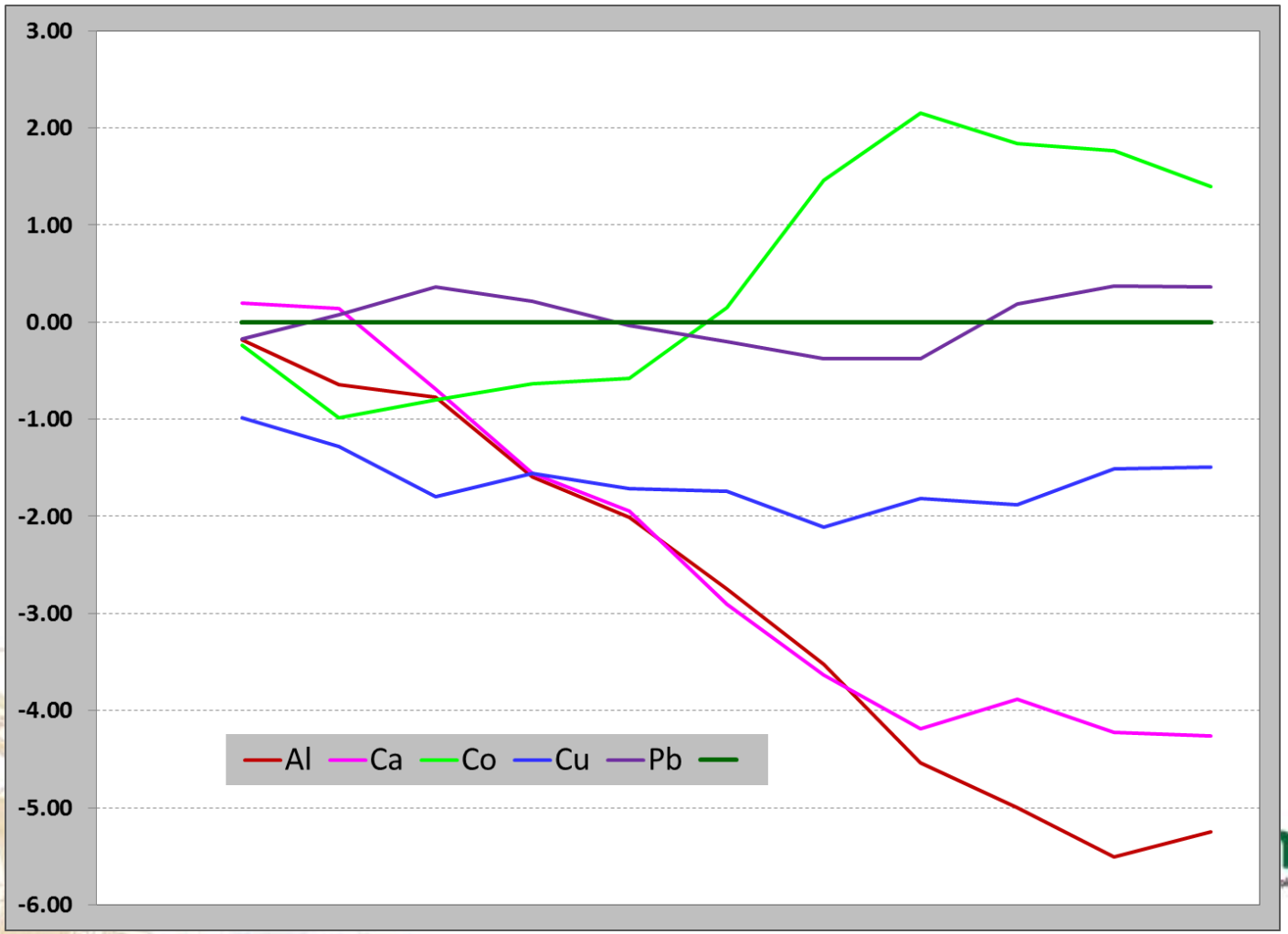
Interpretation of PT results
- Long term performance

- Schewart control chart (E_n-score)

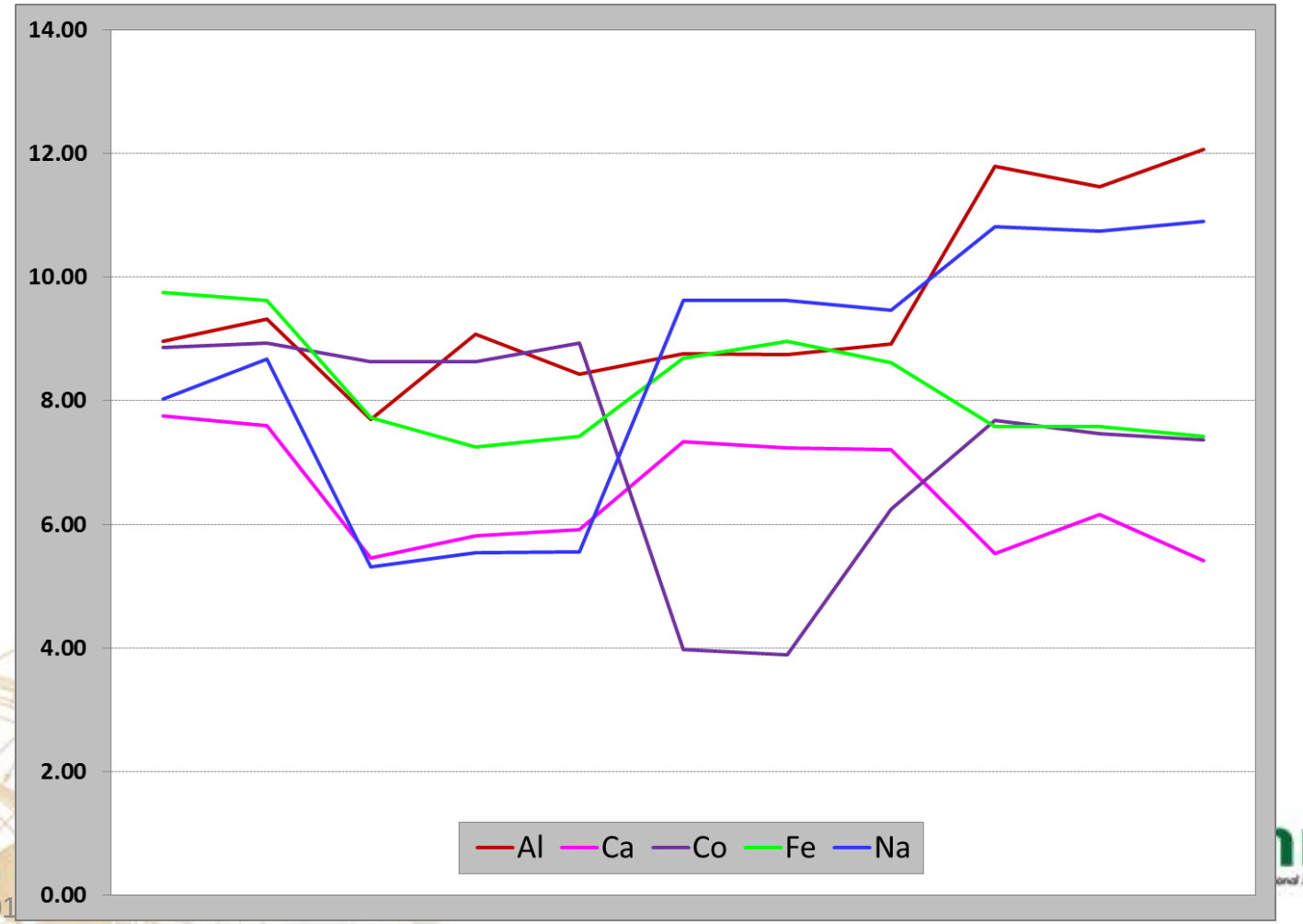


Interpretation of PT results
- Long term performance

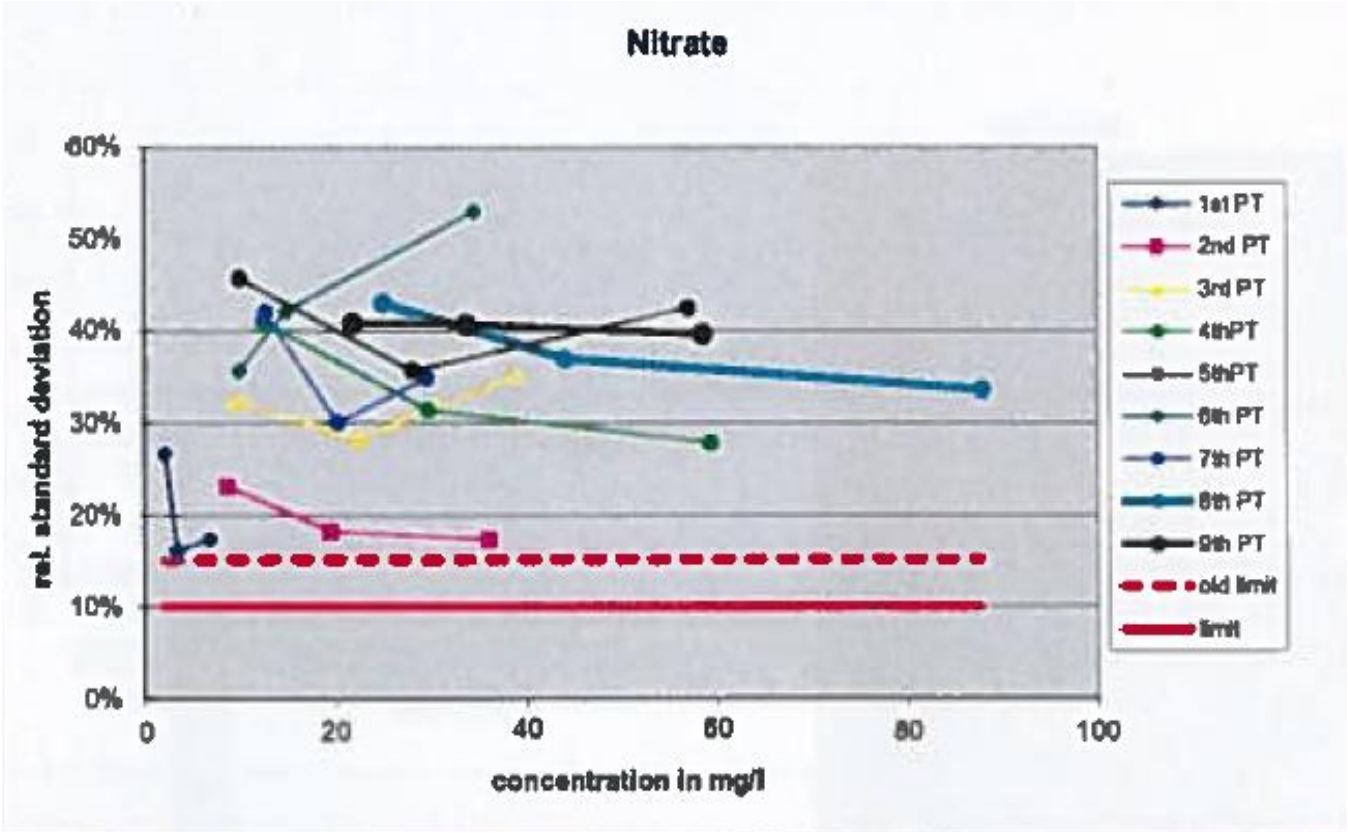
- Cusum control chart (E_n-score)



PT standard deviation:
Performance over time – Uncertainty / SD reported



PT standard deviation:
Performance over time vs limit



Interpretation of PT results
- Unsatisfactory results

- Root cause investigation
  - Raw data
  - Overall performance
  - Successive PT studies
  - Internal quality control data
- Typical causes
  - Clerical error
  - Technical problem
  - PT Scheme

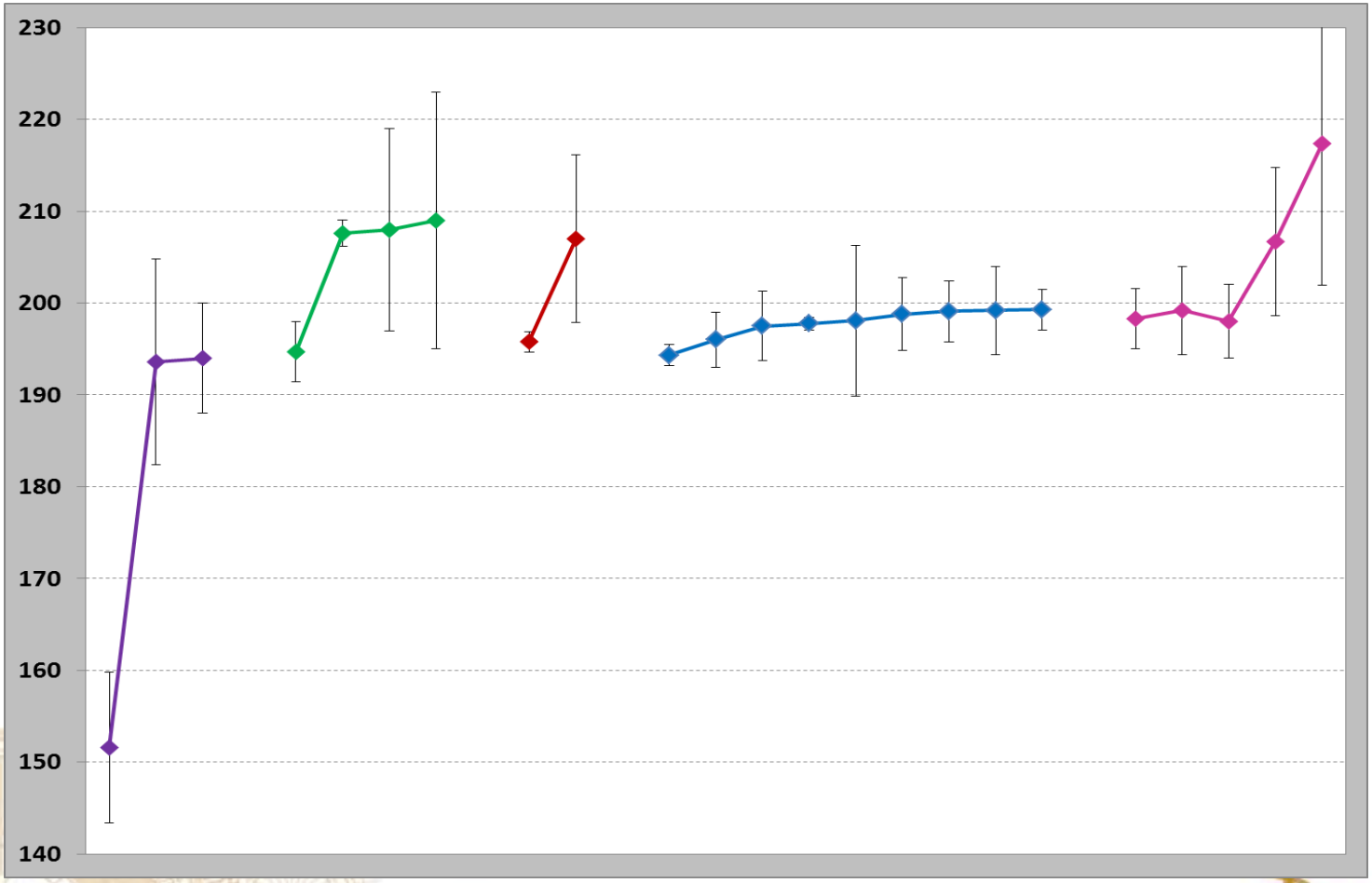
Interpretation of PT results
- Unsatisfactory results

- Typical causes
  - Clerical error
    - Transcription error
    - Labelling
    - Units
    - Decimal error

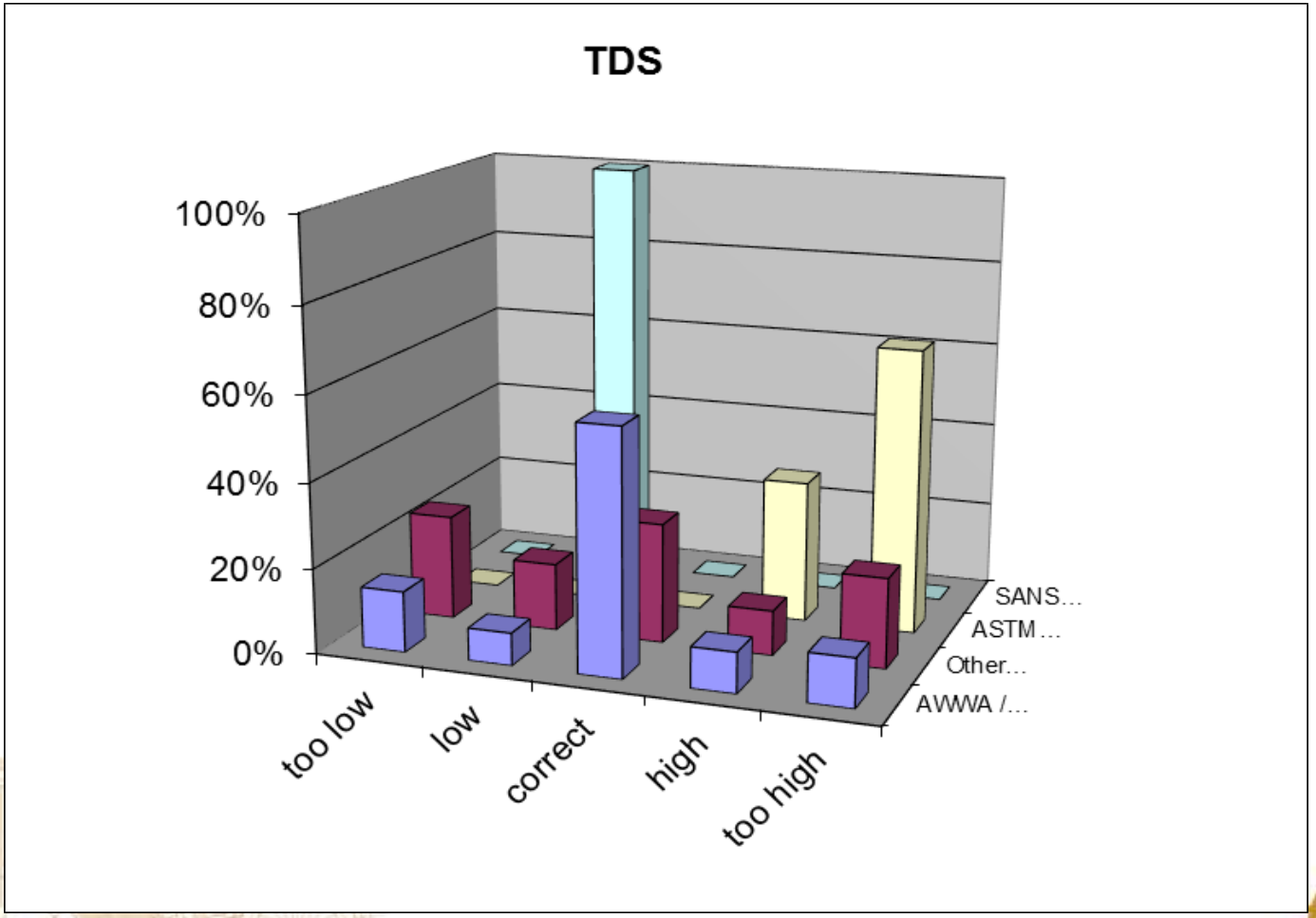
Interpretation of PT results
- Unsatisfactory results

- Typical causes
  - Technical problem
    - Storage / pre-treatment of sample
    - Method validity
    - Calibration:
      - Equipment
      - Standards
    - Reagent purity
    - Equipment
    - Environmental conditions
    - Staff competence

Interpretation of PT/ILC results
- Comparison of methods



Interpretation of PT/ILC results
- Comparison of methods



Interpretation of PT results
- Unsatisfactory results

- Typical causes
  - PT Scheme
    - Sample stability / homogeneity
    - Matrix differences
    - Concentrations outside scope of application
    - Inappropriate / inexperienced peer group
    - Incorrect assigned value / standard deviation

Investigation of PT results
- Unsatisfactory results

PT result ok?

- **No** → Long term performance ok?
  - Long term performance ok? → **Yes** → Short term problem:
    - Transcription, units, decimal error
    - Calibration standard, reagent purity (QC chart)
    - Environmental conditions
    - Staff changes?
  - Long term performance ok? → **No** → Long term problem:
    - Equipment maintenance
    - Method
    - Method validation
    - Staff competence / training
- **Yes** → Long term performance ok? → **Yes**

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Interpretation of the PT results

- PT is not about *“passing” or “failing”* a test - It is about taking part and learning from the results
- Consistent good performance is the goal.
  - One-time good performance does not necessarily make a laboratory good
  - One bad result in any round of PT does not make a laboratory bad; but it must be studied and lessons learned

Conclusion

- Proficiency Testing is a very powerful tool
  - Allows you to identify problems in testing and improve the performance of the laboratory
- A lot of information available to the laboratory. Onus is on the laboratory to use this.

Thank You

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