# Breakfast Webinar – Analytical Quality Control

LATIS SCIENTIFIC

INFORMATION: ☐ CONFIDENTIAL ☐ RESTRICTED ☐ INTERNAL ☐ PUBLIC

LATIS SCIENTIFIC

# Breakfast Webinar

## Analytical Quality Control (AQC) – Process Control in the Analytical Laboratory

LATIS SCIENTIFIC

# QA or QC?

## Quality Assurance

Policies, procedures and other measures, e.g. audits, assuring the maintenance of satisfactory quality

## Quality Control

Practical checks performed to control laboratory processes and thus produce sound data

LATIS SCIENTIFIC

# Why apply Quality Control?

Quality Control is essential to producing analytical results that are:

- Fit for customer use – correct, reliable and accurate
- A sound basis upon which key decisions can be made
- Consistent. If determined on different batches, results should be comparable within measurement uncertainty (provided determinands are stable)
- To the expectations of ISO 17025, under which standard Latis Scientific is externally accredited by the United Kingdom Accreditation Service (UKAS).

LATIS SCIENTIFIC

# ISO 17025 & UKAS

**All of the following feature in the ISO17025 standard and are expected by (UKAS)**

## Quality Assurance (QA)

Policies & procedures, for example:

**Management Aspects:**
Quality Manual (setting policy)
Written procedures (SOPs)
Document control system
Record keeping systems
Control of data (LIMS)
Audits: Internal and External (e.g. UKAS)

**Technical Aspects:**
Qualified/skilled personnel selection
Analytical Training
Equipment selection & maintenance
Method selection & validation
Handling of samples (e.g. proper storage)
Reporting of results (result checking)

***Note: This is not an exhaustive list of ISO17025 requirements.***

## Quality Control (QC)

Practical checks to control lab processes:

**Equipment**
Calibration checks (balances, pipettes etc.)
System Suitability Checks (before analysis)

**Method**
Instrument calibration criteria
Process blanks (sample matrix blanks)

**Internal QC (AQC)**
**Reference materials (IRMs/CRMs)**
**Control charts**

**External QC (PT)**
**Inter-laboratory studies**
**IELab, LEAP, Aquacheck etc.**

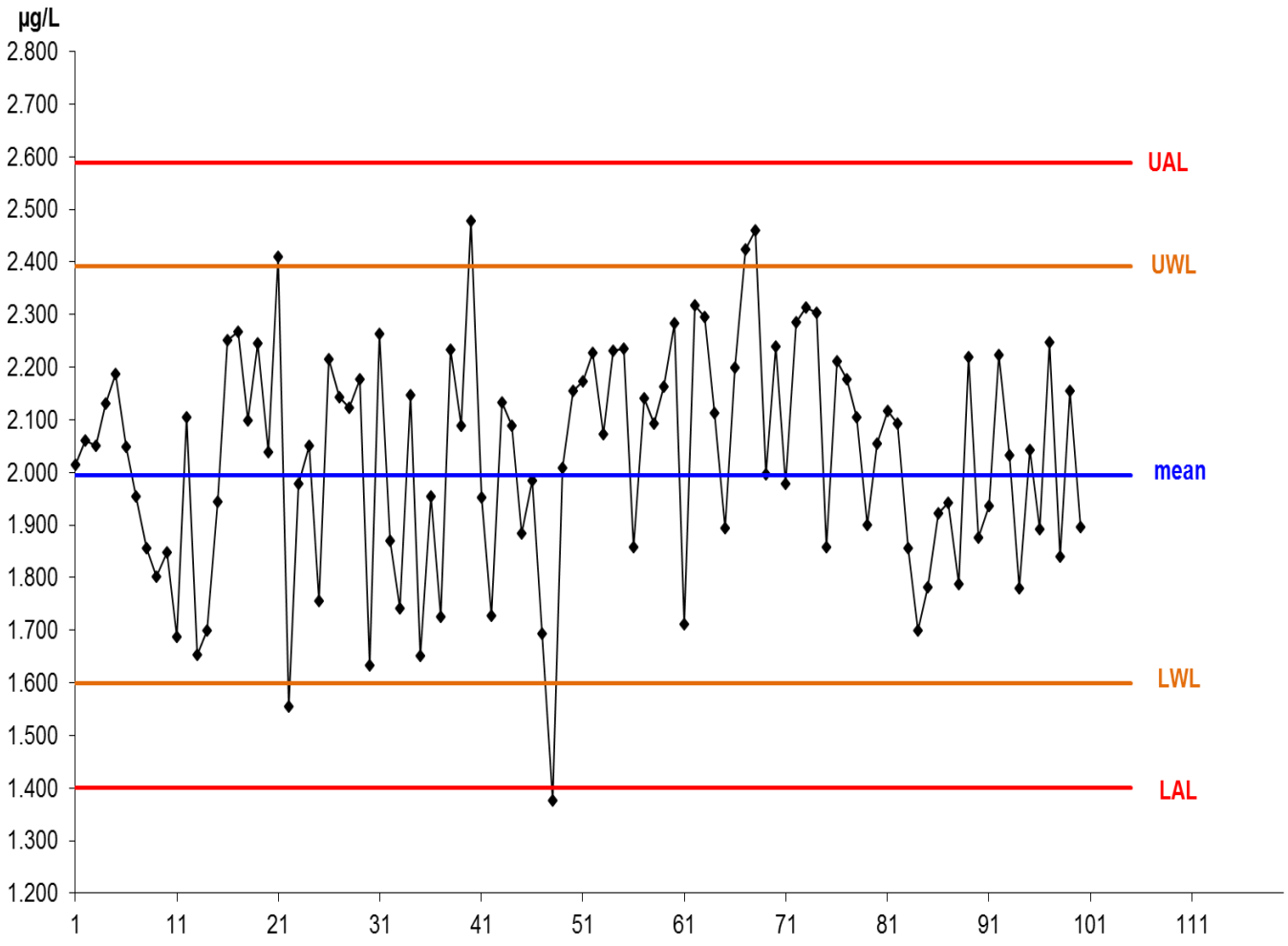
LATIS SCIENTIFIC

# The Basics of Quality Control (QC)

- The use of statistical tools to monitor process performance
- Statistical Process Control (SPC) widely used in manufacturing
- Proposed initially in 1920's USA by Dr. Walter A. Shewhart
- Shewhart introduced the concept of the process control chart
- The Shewhart chart remains the most common chart type
- Shows graphically if a process is performing within set limits
- Indicates anomalies, step changes and developing trends
- Corrective or preventative actions may then be applied

LATIS SCIENTIFIC

# Shewhart Chart



LATIS SCIENTIFIC

# Analytical Quality Control (AQC)

- AQC samples must be added to all analysis batches, to demonstrate that the method is performing satisfactorily
- Preferably matrix matched to the real customer samples
- Determinands present at known levels, preferably at concentrations to reflect levels in real customer samples
- Prepared and processed with each batch of samples
- Results are plotted on a control chart (Shewhart chart)
- Control limits statistically derived from previous real data
- This laboratory application of SPC is usually referred to as Analytical Quality Control (AQC)
- It constitutes our internal quality control for test methods

LATIS SCIENTIFIC

# AQC Samples

Determinands intrinsic to the sample are always preferred:

**Certified Reference Materials (CRM)** from external suppliers are used for method validation, but supplies may be limited and often too expensive to use in routine QC.

**In-House Reference Materials (IRM)** prepared from already characterized samples (if matrix/determinands are stable).

Alternatively standard solutions of determinands are accurately spiked onto a typical, preferably blank, sample matrix (Often used if determinands are volatile or unstable).

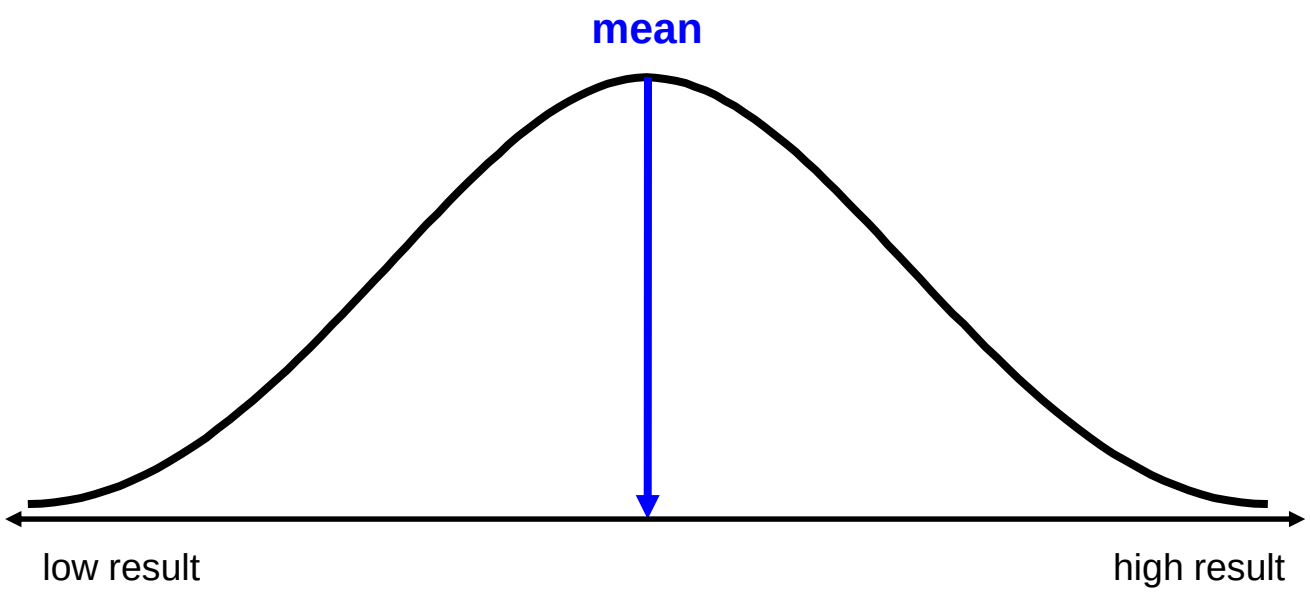
For microbiological methods, AQC samples must also be prepared fresh, using proprietary certified reference cultures of the organisms of interest.

LATIS SCIENTIFIC

# Implementing Quality Control

To implement quality control we need to apply some statistics to a data set of AQC sample replicates.

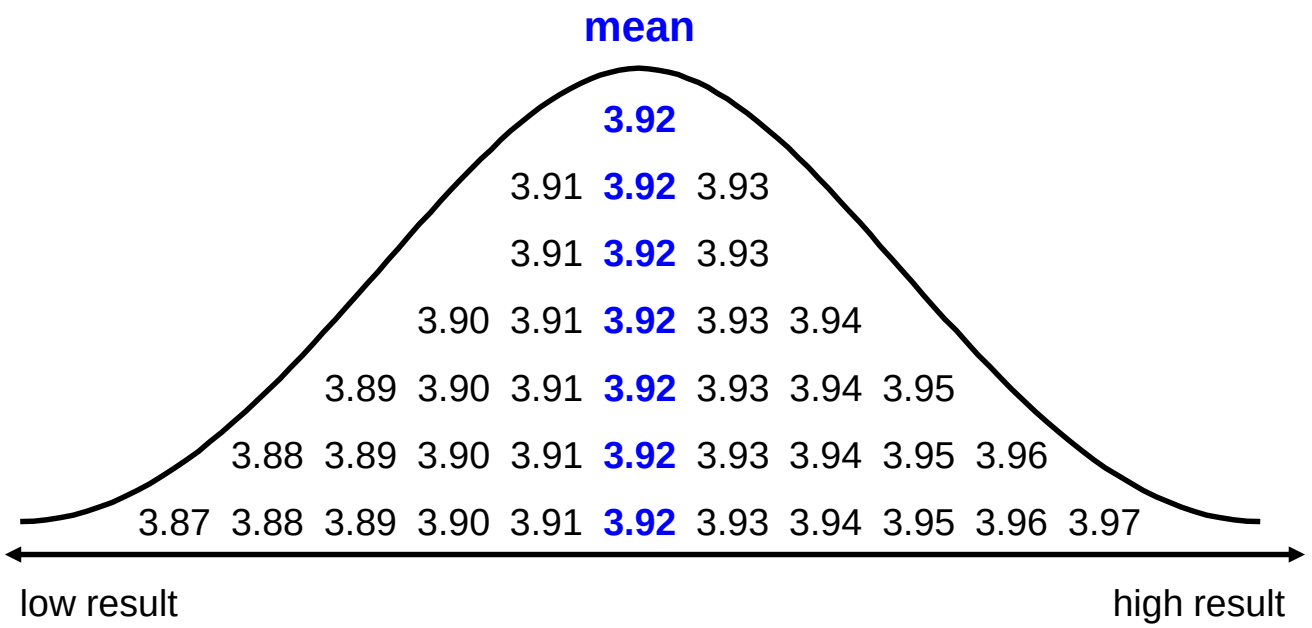
The expected spread of results around the mean average of such a data set, should look like this.



LATIS SCIENTIFIC

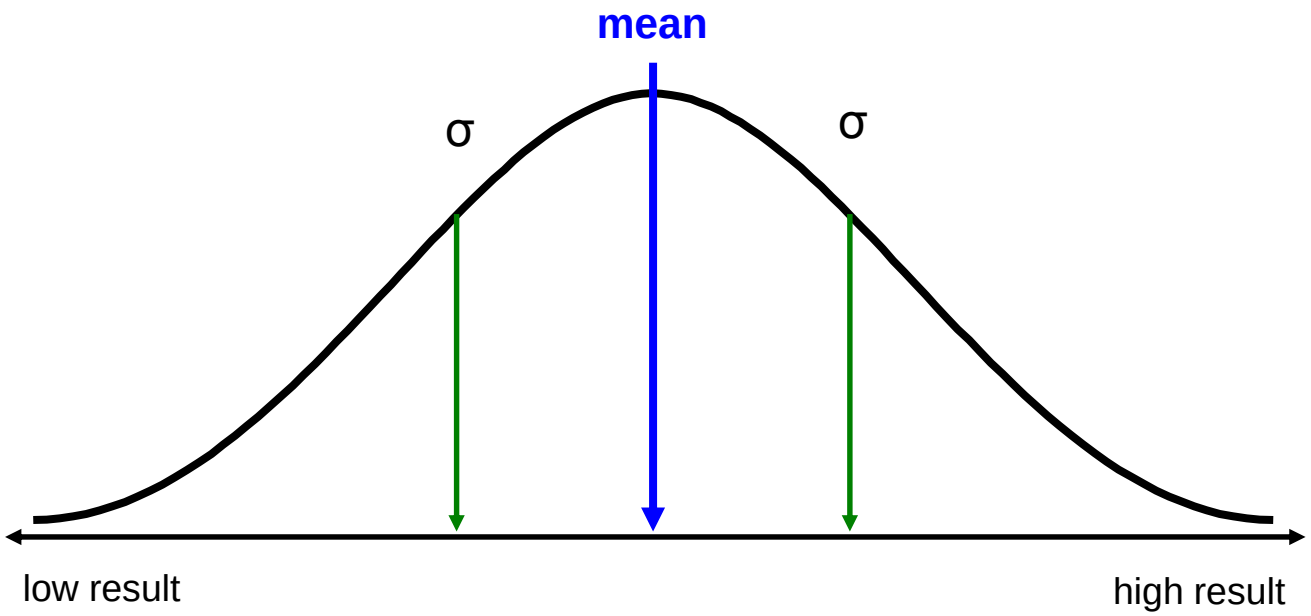
# The Normal Distribution

Put simply, more replicate results are likely to fall near to the mean of a data set. Moving away from the average, fewer results will be expected.



# The Standard Deviation (SD)

The SD or sigma (σ, or often referred to as just ‘s’ ) value indicates the degree of variation about the mean.



# Using the SD to set control limits

For a process that follows a

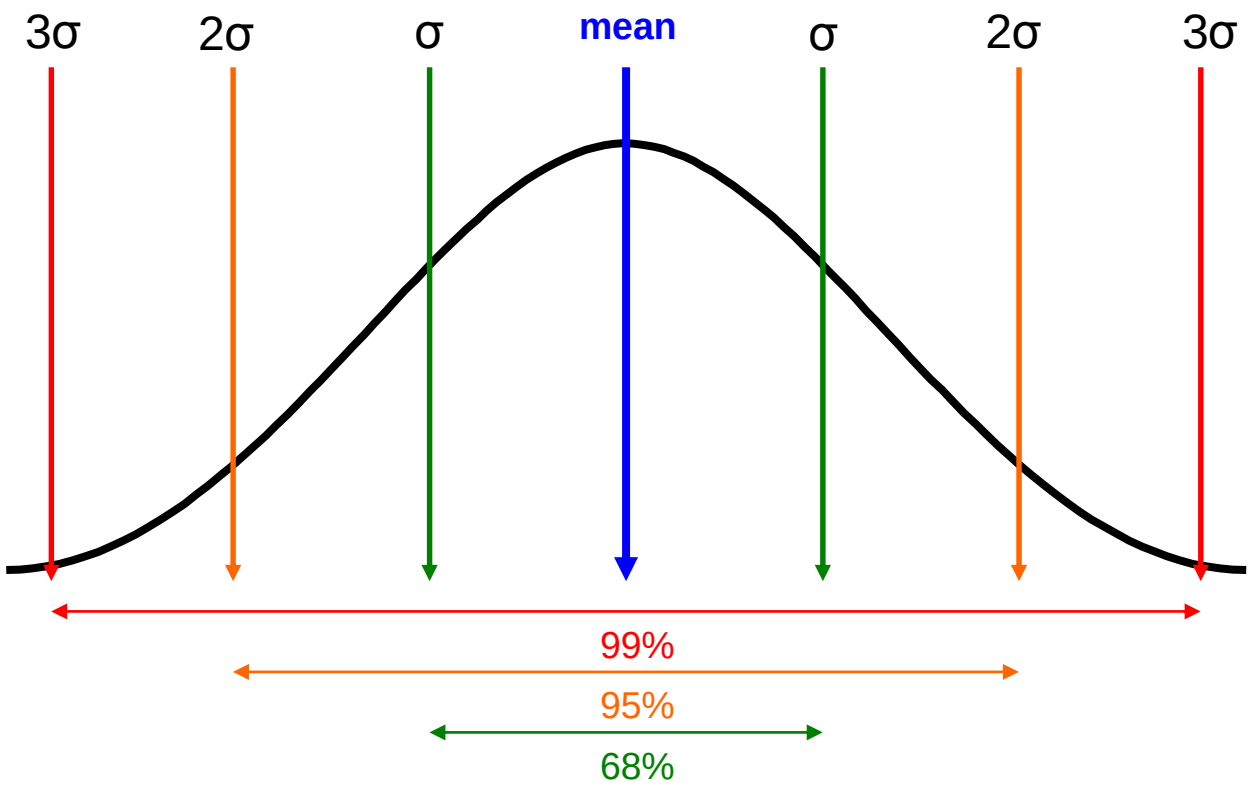
normal distribution the following is always true:

- Approx. 68% of results will fall within ±1σ
- Approx. 95% of results will fall within ±2σ
- Approx. 99% of results will fall within ±3σ

*Provided that the process in place is robust and is followed consistently.*

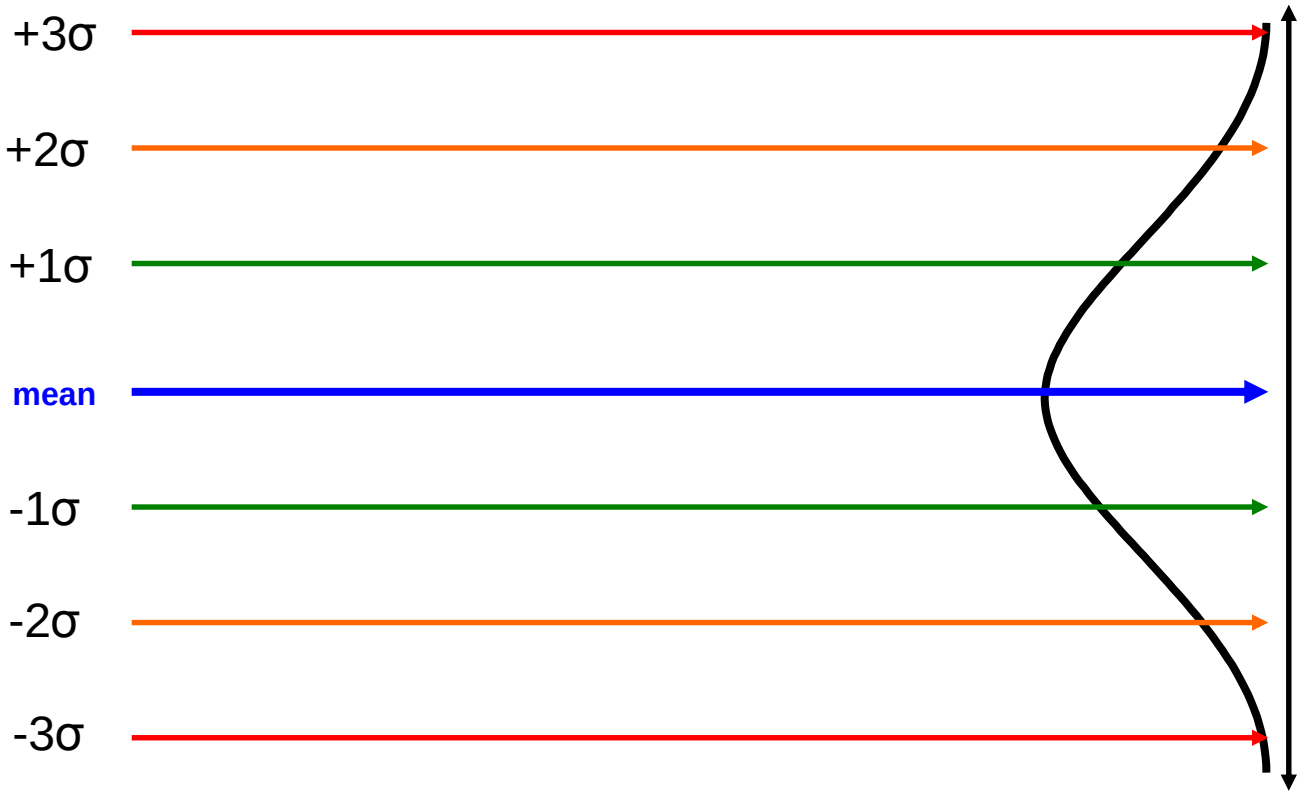
# How to make a Shewhart chart

Represented graphically, it would look like this…



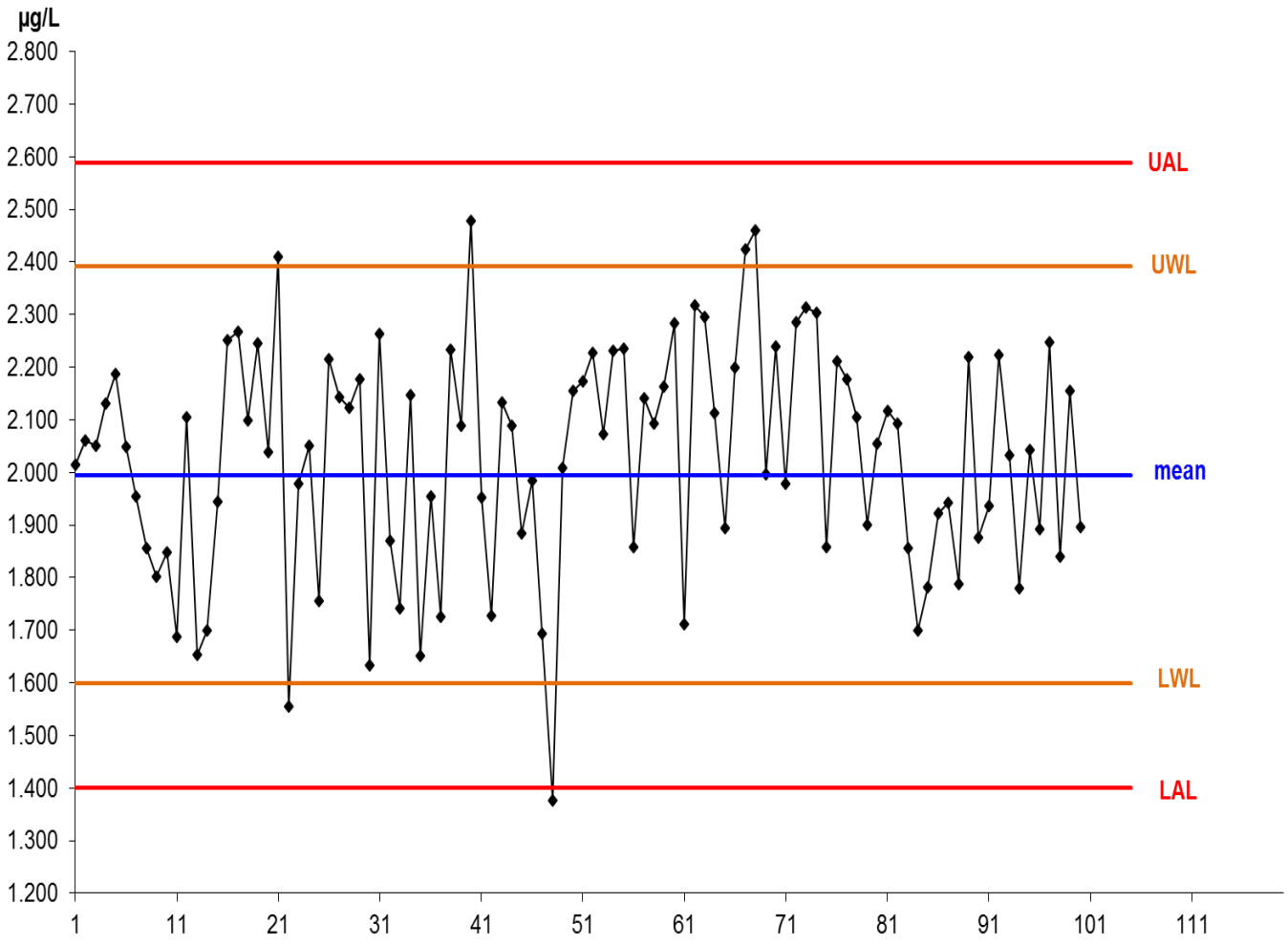
# How to make a Shewhart chart

Or, turning that through 90°, like this…



LATIS SCIENTIFIC

# Shewhart Chart



# Control Limits

- **Mean**: Mean average of dataset
- **UAL**: Upper Action Limit (**+3σ**)
- **UWL**: Upper Warning Limit (**+2σ**)
- **LWL**: Lower Warning Limit, at (**-2σ**)
- **LAL**: Lower Action Limit, at (**-3σ**)

*(Note: Some sources refer to Action Limits as Control Limits and abbreviate them UCL and LCL)*

LATIS SCIENTIFIC

# AQC Chart Rules (Basic)

**1 point outside of ±2σ** monitor next result, but no failure

**2 consecutive points outside of ±2σ** is a failure

**1 point outside of ±3σ** is a failure

- Samples associated with a failing AQC are re-tested
- All failures must be formally investigated / documented
- Investigation conducted by a specialist in the particular method and lab technique (Senior Analyst or above)
- Quality team review this and have the final sign off of the investigation and any proposed corrective actions

LATIS SCIENTIFIC

# Maintaining Shewhart Charts

- Initial chart limits set up from method validation data or AQC data from early results (at least 20 points)
- Robust limits set after 60 points, reviewed after 100-200 points and periodically thereafter
- To strive towards ‘zero defects’ is a laudable goal, but statistically a small percentage of failures will occur in fact, based on the statistical probabilities intrinsic to the Normal Distribution that we use to set the control limits:

  **1 in 100** points outside ±3σ (on average, over time)
  **5 in 100** points outside ±2σ

- Trends over time or any sudden step changes are also monitored on charts, which would result in an investigation and corrective actions as for other failures

LATIS SCIENTIFIC

# Proficiency Testing (PT)

External QC is provided by PT schemes, e.g.

IELab – Water chemistry and microbiology

LEAP (FAPAS/FERA) – waters and effluents schemes

AQUACHECK (LGC) – waters, also PT for other sectors

RTC (Sigma-Aldrich) – USEPA focussed suites

- All participants are sent identical samples by the scheme
- ‘True’ results are not published in advance
- Participants are anonymous on the reports (each lab identifies its own results by means of a code number)

LATIS SCIENTIFIC

# Calculation of ‘z-scores’

A z-score for each result reported:

$$z = \frac{\text{Lab Result} - \text{Assigned Value}}{\text{Target SD}}$$

A z-score of zero means the result is exactly the Assigned Value, i.e. the ‘true’ result (as assigned by the scheme)

**Result outside ±2z** monitor next round, but no failure

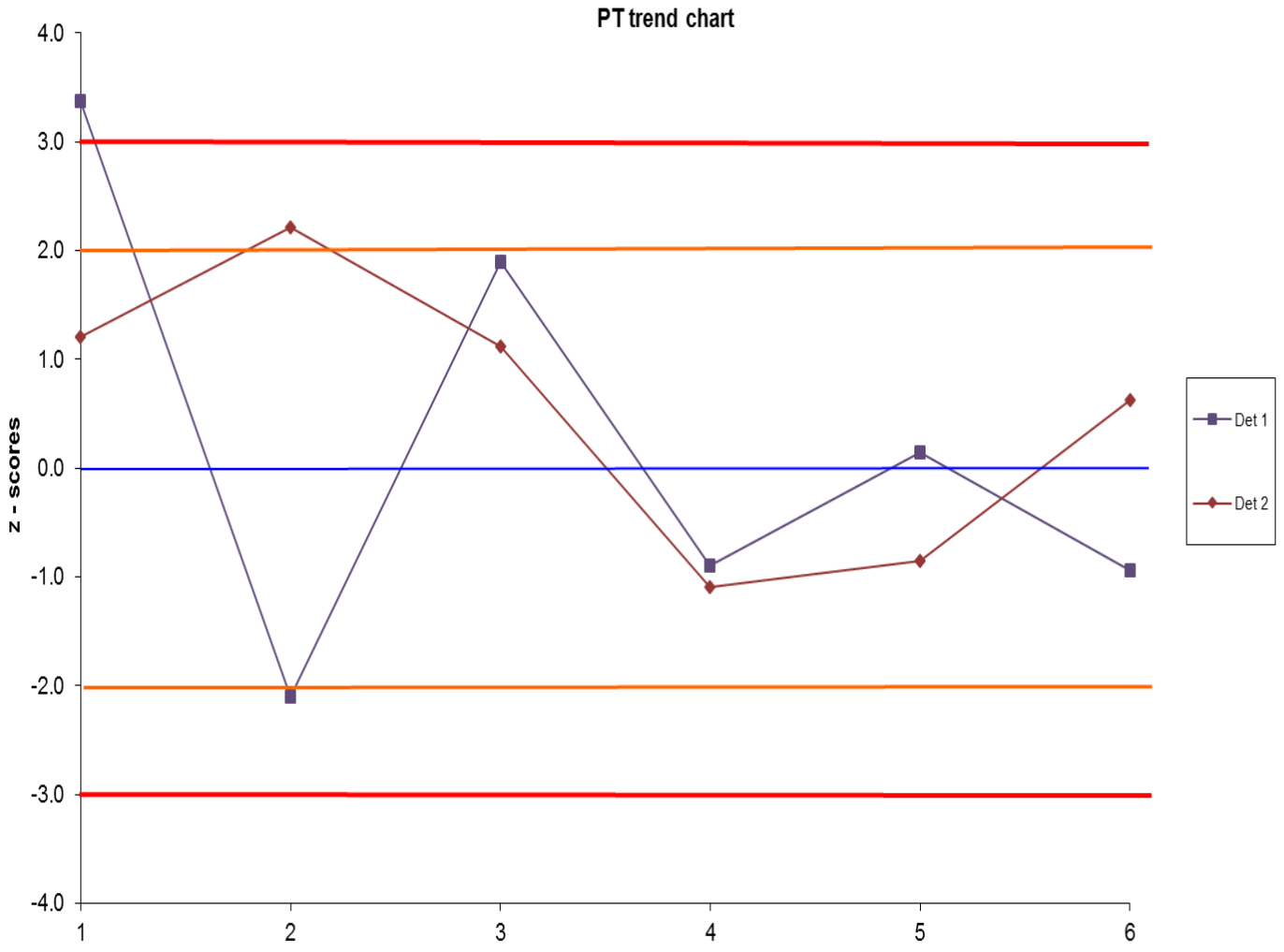
**2 consecutive results outside ±2z** is a failure

**1 result outside ±3z** is a failure

Failure investigations are conducted by a Senior Analyst and managed by the Quality team (as for AQC failures)

LATIS SCIENTIFIC

# PT Trend Analysis



LATIS SCIENTIFIC

# Limitations of PT

- If few participants, then resulting statistics are not robust
- If different labs use alternative methods, data must be segregated or the statistics may be misleading
- If labs' results differ widely, z-scores may appear sound, even if reported results are far from the assigned value
- PT sample may not be representative of real customer samples (PT rounds not available for all sample types)
- Some available PT samples are standards in a solvent
- May require non-standard dilutions or preparation, e.g. unstable determinands sent as concentrated solutions
- Volatile analytes are spiked onto a sample matrix, so additional variability is introduced through this process

LATIS SCIENTIFIC

# Benefits of PT

- Provides a means of assessing a lab's performance, compared to other labs that undertake similar testing
- Independent of the laboratory's own internal AQC
- ISO 17025 standard and UKAS advocate the use of PT
- UKAS Assessors always ask to see a lab's PT scores
- If not PT, then some other external QC is prudent, e.g. periodical CRM tests (which can be previous PT rounds)
- Good PT scores are a strong indicator of sound performance, as conducted blind and independent of the organisation

LATIS SCIENTIFIC

# Questions and Discussion

Any Questions?