LS6500 Scintillation Counting Systems

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Agenda

- LS6500 Concepts and Design
- H# Plus - The Basis of Advanced Technology
- Low Level Counting
- Alpha/Beta Discrimination

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LS6500 Concepts

- Give reproducible results regardless of the sample type
- No requirement for extensive knowledge of scintillation theory to operate the instrument
- Durable and technologically advanced enough to give a long instrument lifetime
- Interface for the storage and processing of scintillation data
    - Based on input from over 1,000 users of radio-isotopes, the above guidelines were used for the LS6500 design

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Achieving the Concept

- Electronics/Hardware Design
- Sample Handling Facilities
- Instrument Setup and Editing
- Data Storage/PC Connection

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Electronics/Hardware Design

- 32K Multichannel Analyzer
- Programmable Coincidence Gate
- Fast/Slow Pulse Analysis
- Advanced Photomultiplier Design
- Interlocking Lead Shielding
- Permanent Memory for Data/Users
- Front Panel Access
- Automatic Diagnostics and Calibration

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Sample Handling Facilities

- Versa Rack System, 336 Standard Vials, 648 Mini or Bio-vials
- Counting in microtubes
- Electrostatic Controller
- Bi-directional Sample Changer
- Automatic Batch Repeat
- Positive Sample ID
- Upward Loading into PMT Chamber

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Instrument Setup and Editing

- Easy to use menu system
- Multitasking – edit or retrieve data whilst counting
- Isotope Library – stores isotope details
- Factory Stored Quench Curve Library – quench curves available to any user
- Auto-Isoset
- Pipetting Monitor/Correlation Table
- Background Quench Curves
- Interrupt Capabilities

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LS WinConnection Suite

- LS 6500 Data Capture/ Network Software
- LS 6500 File Utility Software
- LS 6500 Instrument Performance Tracking (IPT) Software

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Quench Monitoring

- External Standard Quench Monitor
  - H Number (H# from Cs Compton Spectrum)

    Developed by Dr. Donald L. Horrocks to incorporate difference between the inflection points of the unquenched standard and the sample in the Cs Compton Spectrum

- Has become H# Plus in latest systems

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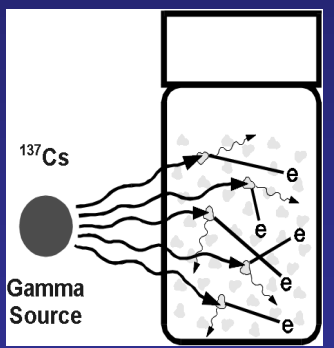
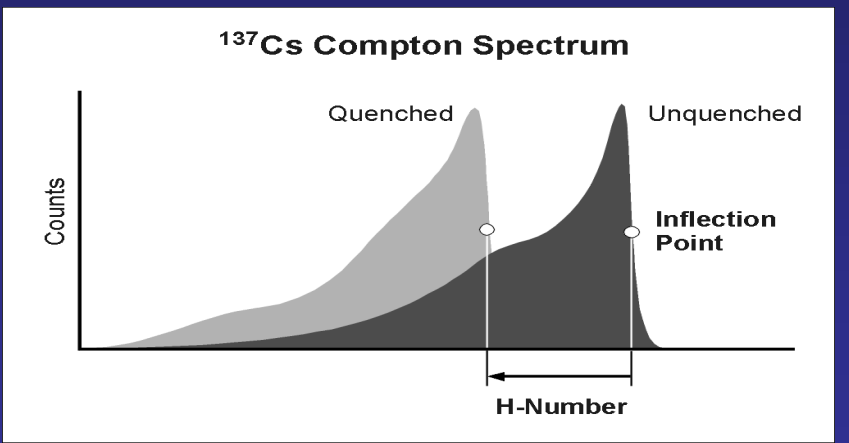
H# Plus
The Basis of Advanced Technology

- Compton spectrum is generated by positioning a gamma emitting isotope near the sample vial while it is in the counting chamber





Quench affects the Compton spectrum in a fashion analogous to the beta spectrum

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H# Plus - 1

- Proven the most precise, accurate, reliable, & reproducible quench monitor
- Allows more precise window settings
- Superior multi-label studies (3H:14C = 1:50)
- Automatic Quench Compensation (AQC) moves window settings to give more accurate results for multi-label counting

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H# Plus - 2

- Monitors both chemical, colour and background quench
- Monitors for two phase (even for samples with low or no activity)
- Independent of sample dynamics e.g. sample volume, type of cocktail
- Used to calibrate the entire system

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DPM Determination

- Auto DPM
  - SL DPM calculation on pure beta-, or alpha-emitting isotope
  - No need for a quench curve
- Single-, Dual-, Triple-Label DPM
  - Quench Curve Library
  - Factory-Stored 3H and 14C Quench Curves
  - Setting Up Quench Curves
  - Background Quench Curves

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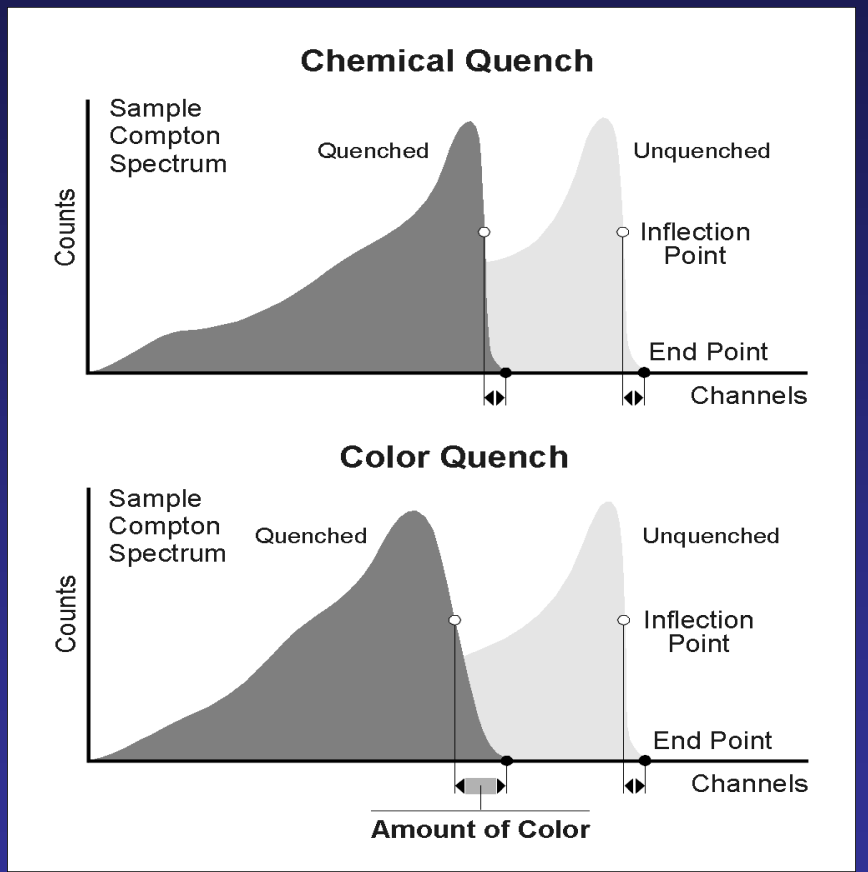
Color Detection and Correction



Common Color Quencher

Color	Type of Sample
Yellow	Urine
Green	Plant tissues
Red	Animal tissues
Brown	Faeces samples

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Two-Phase Monitor

- Monitors phase separation of the sample and the cocktail
- Allows ″Flagging ″ of the sample in the printout
- Determine the two phase condition by monitoring the number of Compton spectra

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Radioactive Waste Manager

- Easy-to-use solution to tracking and reporting radioactive waste
- Integrated into LS6500 and tracks waste for all samples counted
- Isotope usage per user can be reported

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Low Level Counting

REGULAR	LOW ACTIVITY
LS 6500 O Biological Studies, Receptors, etc. O Labeled samples O Activity > 500 CPM O Window optimization not required O Sample volumes from 100µl to 10mL (and filters)	**LS 6500 with or w/o Low Level Option** O Biological Studies, Receptors, etc. O Labeled samples O Activity from 50 to 500 CPM O Window optimization usually not required O Sample volumes from 100µl to 10mL (and filters)
LOW LEVEL	**ULTRA LOW LEVEL**
LS 6500 with Low Level Option O Environmental Monitoring, Food Control, etc. O Natural abundance samples O Activity from 2 to 20 CPM O Window optimization required O Sample volumes from 8 to 10mL	LS 6500 NOT APPLICABLE O Carbon Dating (Hydrology, Archeology, Zoology, etc) O Natural abundance samples O Activity frequently below 2 CPM O Sample volumes from 10 to 100mL

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Low Level Counting

- Scientists who work in the Low Level counting area are interested in both Accuracy and Sensitivity (or Minimum Detectable Activity, MDA)
- Accuracy is obtained by using the background subtraction feature
- To get the best sensitivity from the system, it is necessary to reduce the background level of the instrument

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Low Level Counting

- ***"What is the minimum detectable activity we can achieve with the LS6500?"***
- In order to answer this question, we need to know the following about the instrument and the samples:
- What is the true background of the instrument
- How long will the sample be counted
- How much sample will be analyzed
- What is the counting efficiency

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Low Level Counting

The MDA or Minumum Detectable Activity can be calculated with the following equation:

$$MDA = 2 \times \frac{\sqrt{\frac{2 \times B}{T}}}{V \times E}$$

where
- MDA = minimum detectable activity in DPM/mL
- V = volume of sample (without cocktail) in mL
- E = sample counting efficiency (in decimal form, e.g. 0.50 for 50%)
- B = instrument background in CPM
- T = counting time in minutes

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Low Level Counting

The following data has been obtained with an LS 6500:

Results for a "Typical" Low Level Tritium Sample

Sample: 20 mL Plastic Vial
12 mL Ready Gel
8 mL "Dead Water" as background sample

	Open ^{3}H Window		**Optimized Window**	
H# = 123	w/o LL	with LL	w/o LL	**with LL**
Background	17.3 CPM	8.6 CPM	9.8 CPM	**3.9 CPM**
Efficiency	42.8%	39.6%	36.4%	**34.6%**
E^2/B	105	182	135	**306**

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Low Level Counting

"Low Level" Counting
with Low Level option and optimized Tritium window

- O 35% counting efficiency
- O 3.9 CPM background

MDA = 0.20 DPM/mL or 3.32 Bq/L

Increasing the counting time will obviously lower the Minimum Detectable Limit, MDA:

Counting Time of 100 min:	0.20 DPM/mL	or	3.32 Bq/L
Counting Time of 300 min:	0.12 DPM/mL	or	1.91 Bq/L
Counting Time of 1000 min:	0.06 DPM/mL	or	1.05 Bq/L

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Low Level Counting

The following changes will positively affect the MDA:

- Larger sample volume
- Higher counting efficiency
- Lower background counts
- Increased counting time

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Low Level Counting LS6500 Features

- Shorter PM tubes and interlocking lead design help keep background to a minimum
- Low Level Count Feature reduces background contribution even further
- Pulse Time Analysis discriminates between true radioactive events and background events
- Background contribution reduced by 50%

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Alpha/Beta Discrimination

- Separately quantifies Alpha and Beta emitters in a single sample
- Can remove the need for chemical and/or physical separation of isotopes

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Alpha/Beta Discrimination

- Discrimination due to pulse shape (decay rate of light pulses) and intensity of light differences for alpha and beta
- Optimisation depends on several properties of the sample matrix
- Requires calibration with the radio-isotopes involved

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