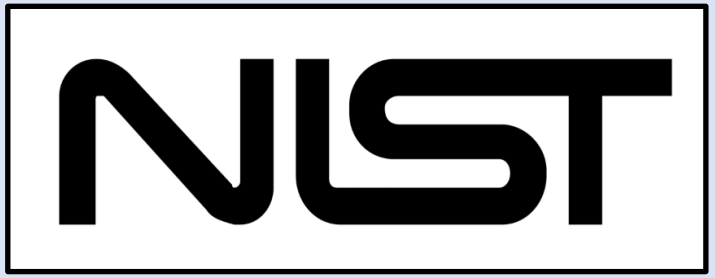


Mass Spectrometry Data Center

Mass Spectral Libraries

Breakfast Seminar

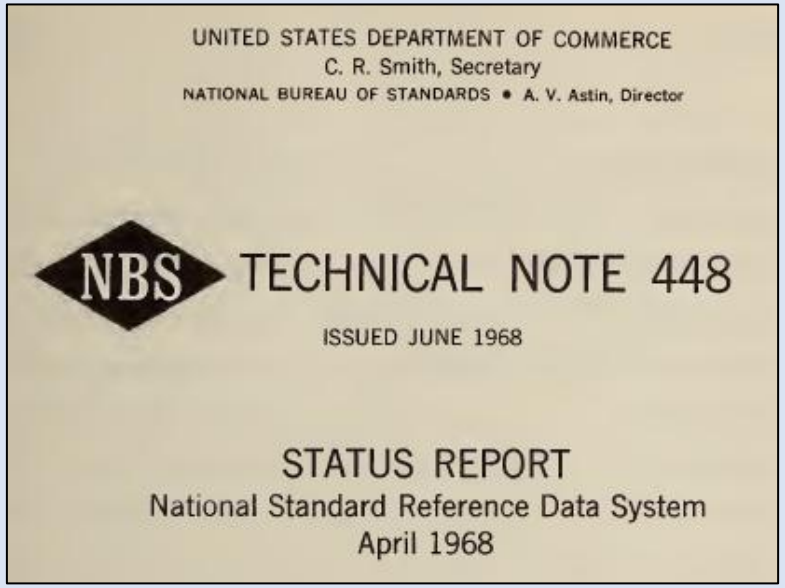
7:00 am

Room 7AB

About the National Institute of Standards and Technology

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
U.S. DEPARTMENT OF COMMERCE

- 1901: Founded as the National Bureau of Standards
- The national metrological institute (NMI) of the USA
- A non-regulatory agency of the US Department of Commerce
- Mission: To promote U.S. innovation and industrial competitiveness
- Providing Standard Reference Data (SRD) one of NIST's core functions
- 1968: Congress passed the Standard Reference Data Act
- 2026: NIST currently provides more than 100 SRD products


UNITED STATES DEPARTMENT OF COMMERCE
C. R. Smith, Secretary
NATIONAL BUREAU OF STANDARDS • A. V. Astin, Director

NBS TECHNICAL NOTE 448

ISSUED JUNE 1968

STATUS REPORT
National Standard Reference Data System
April 1968

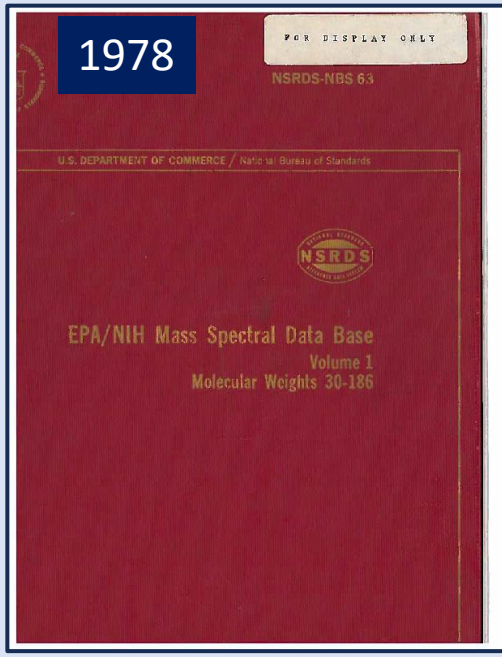
About the NIST Mass Spectrometry Data Center

NIST National Institute of Standards and Technology U.S. Department of Commerce

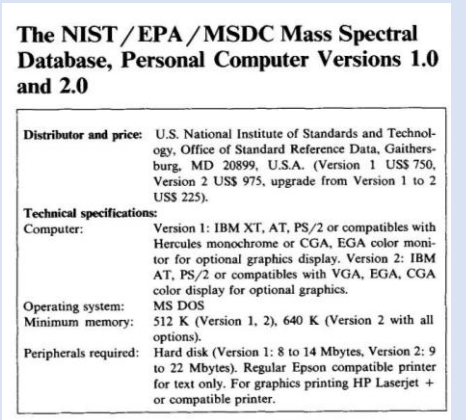
Mass Spectrometry Data Center

- 1945: NIST produced the first mass spectral reference spectra
- 1988: the NIH/EPA mass spectral library was handed over to NIST
- Since that time NIST has grown the library over seven-fold
- 2026: 13th release of the NIST/NIH/EPA library
- All measurements, evaluation, software development done in house
- Total full-time staff of 30
- Divided between chemists and computer/data scientists

1978

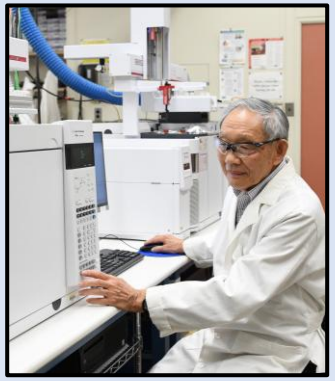


1988



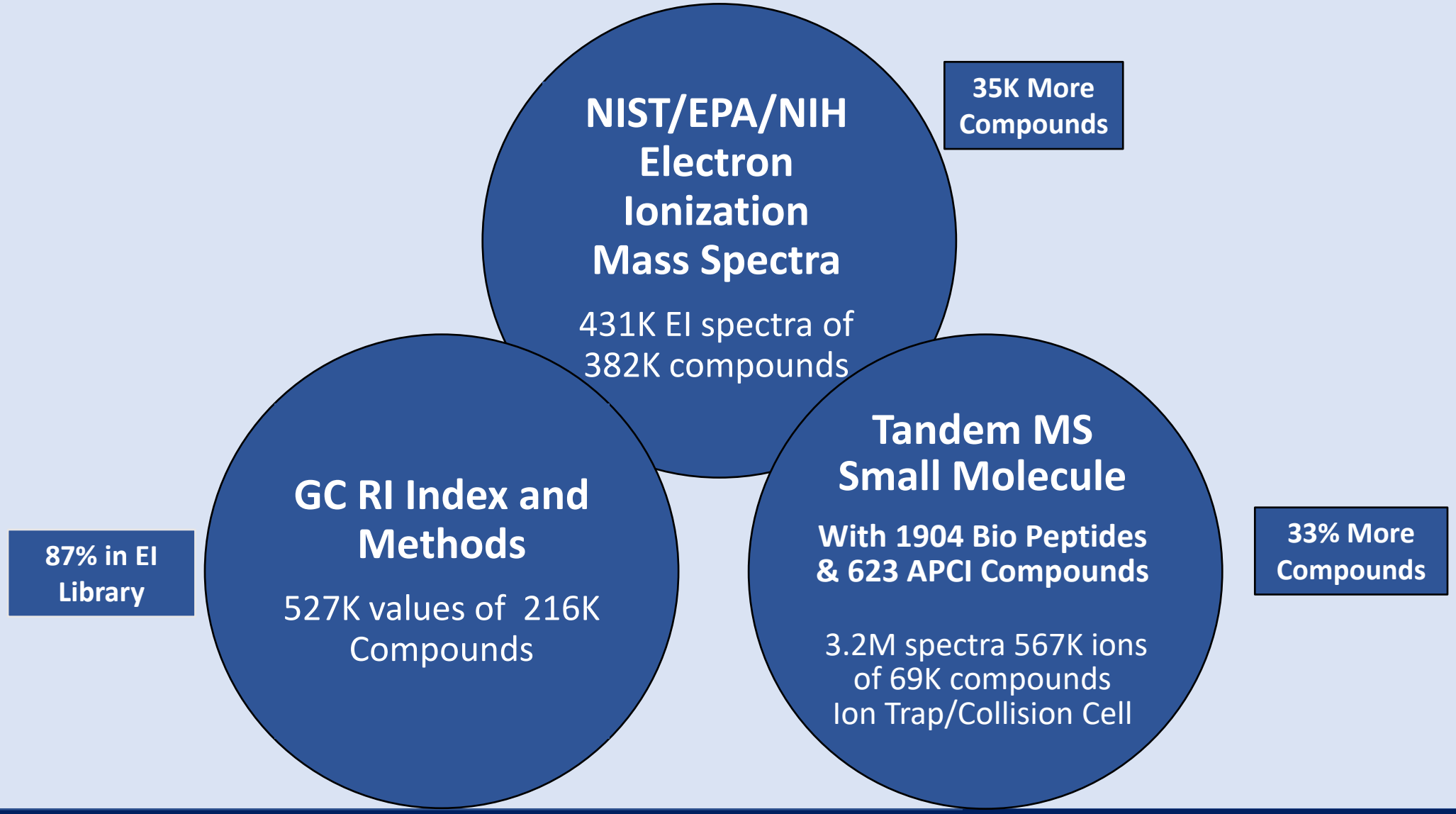
The NIST / EPA / MSDC Mass Spectral Database, Personal Computer Versions 1.0 and 2.0

Distributor and price:	U.S. National Institute of Standards and Technology, Office of Standard Reference Data, Gaithersburg, MD 20899, U.S.A. (Version 1 US$ 750, Version 2 US$ 975, upgrade from Version 1 to 2 US$ 225).
Technical specifications:	
Computer:	Version 1: IBM XT, AT, PS/2 or compatibles with Hercules monochrome or CGA, EGA color monitor for optional graphics display. Version 2: IBM AT, PS/2 or compatibles with VGA, EGA, CGA color display for optional graphics.
Operating system:	MS DOS
Minimum memory:	512 K (Version 1, 2), 640 K (Version 2 with all options).
Peripherals required:	Hard disk (Version 1: 8 to 14 Mbytes, Version 2: 9 to 22 Mbytes). Regular Epson compatible printer for text only. For graphics printing HP Laserjet + or compatible printer.

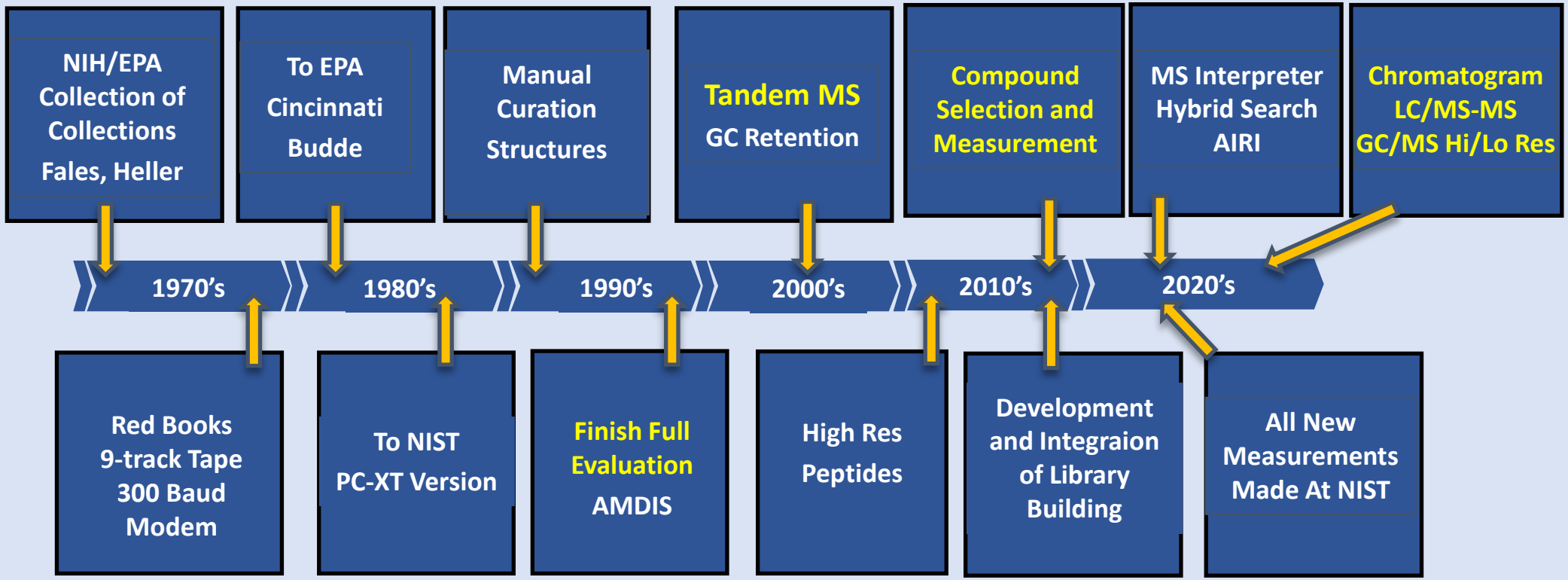


Triennial Lift Off

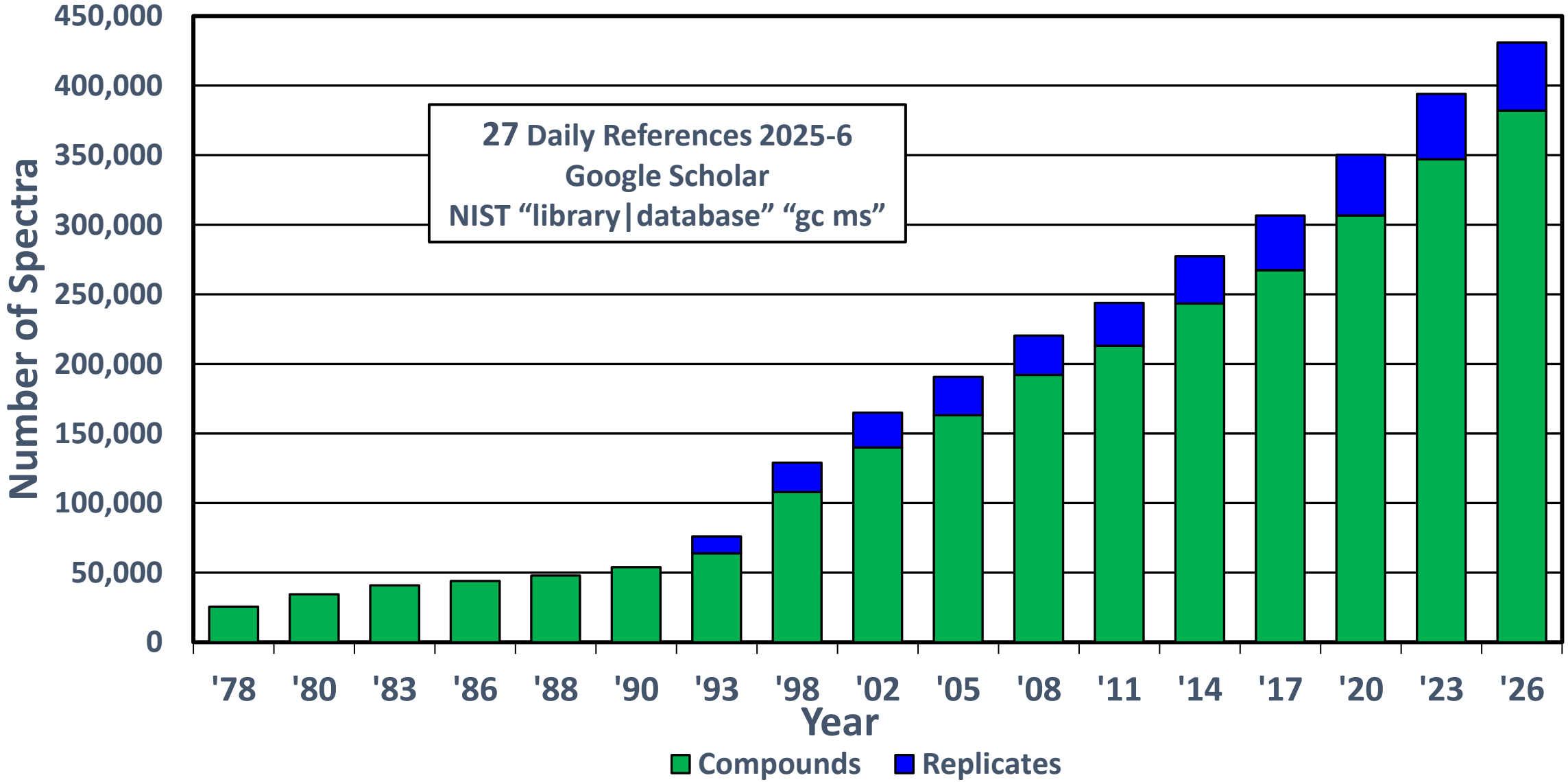
NIST 26 Mass Spectral Libraries



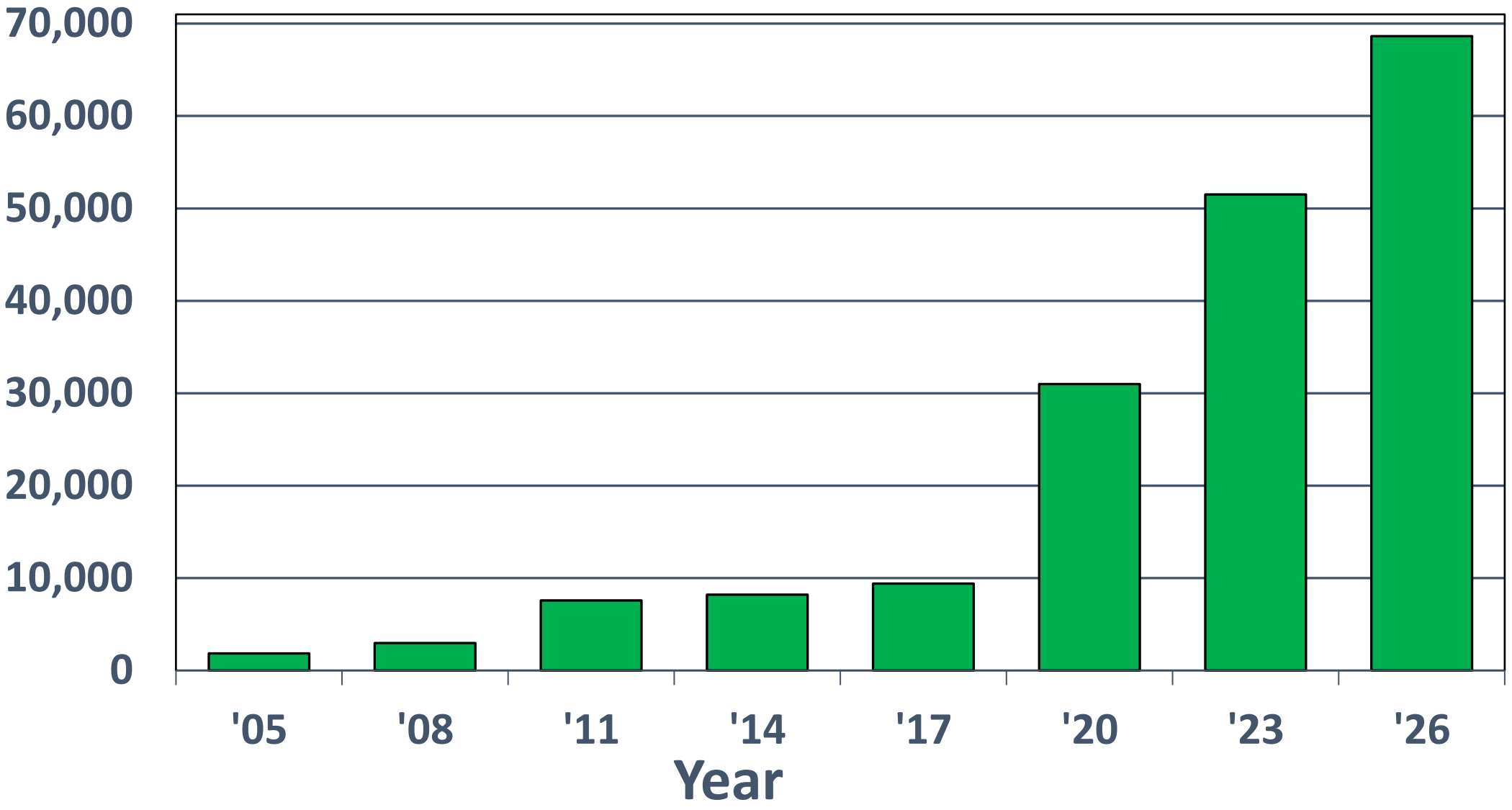
NIST MS Library Evolution



EI Spectra over Time



Compounds in Tandem Library



How do we Select Compounds to Add to Our Libraries?

Tytus Mak

~~**What** new compounds are in NIST26?~~

Why were these new compounds added to NIST26?

How were new compounds selected for NIST26?

PubChemLite EXPOSOMICS

LOTUS

LIPID MAPS

BovineDB

FOODB

FDA Substances Added To Food

DRUGBANK

ChEBI

ECOTOX KNOWLEDGEBASE

PFAS Per- and Polyfluoroalkyl Substances

EPA Hazardous Substances Databank

BitterDB Institute of Biochemistry, Food Science The Hebrew University of Jerusalem

welcome to the Toxic Exposome Database

Chemicals subject to TSCA

ORGANIC AND NATURAL COSMETICS COSMOS STANDARD

EPA PARIS III

NutriChem

DRUG DIET DISEASE

KEGG Kyoto Encyclopedia of Genes and Genomes

YMDB Yeast Metabolome Database

hmdb The Human Metabolome Database

ChEMBL

nprman

REACH COMPLIANCE

Blood Exposome Database

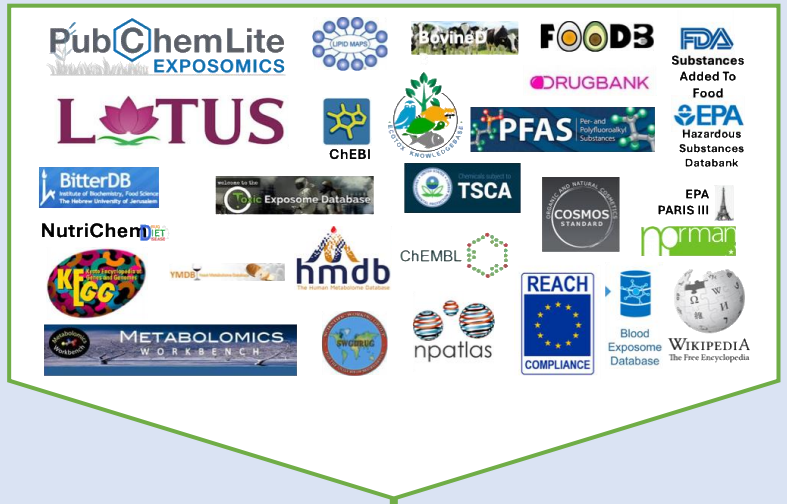
WIKIPEDIA The Free Encyclopedia

Metabolomics Workbench METABOLOMICS WORKBENCH

SCIENTIFIC WORKING GROUP SWGDRUG FOR THE ANALYSIS OF SEIZED DRUGS

npatlas

Semi-Automated Compound Selection Pipeline



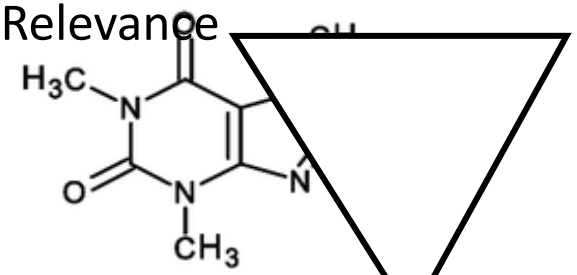
Merge via InChIKey

NIST Compound Ubiquity Index

700K+ Structures

Maximize Relevance

Most Compounds



Minimize Cost

Optimization Problem

InChI=1S/C8H10N4O2/c1-10-4-9-6-5(10)7(13)12(3)8(14)11(6)2/h4H,1-3H3 (caffeine)

InChIKey=RYYVLZVUVIJVGH-UHFFFAOYSA-N

character indicating the number of protons ('N' means neutral)

flag character for InChI version: 'A' for version 1

flag character ('S') indicates standard InChIKey (produced out of standard InChI)

First block (14 letters)

Encodes molecular skeleton (connectivity)

Second block (8 letters)

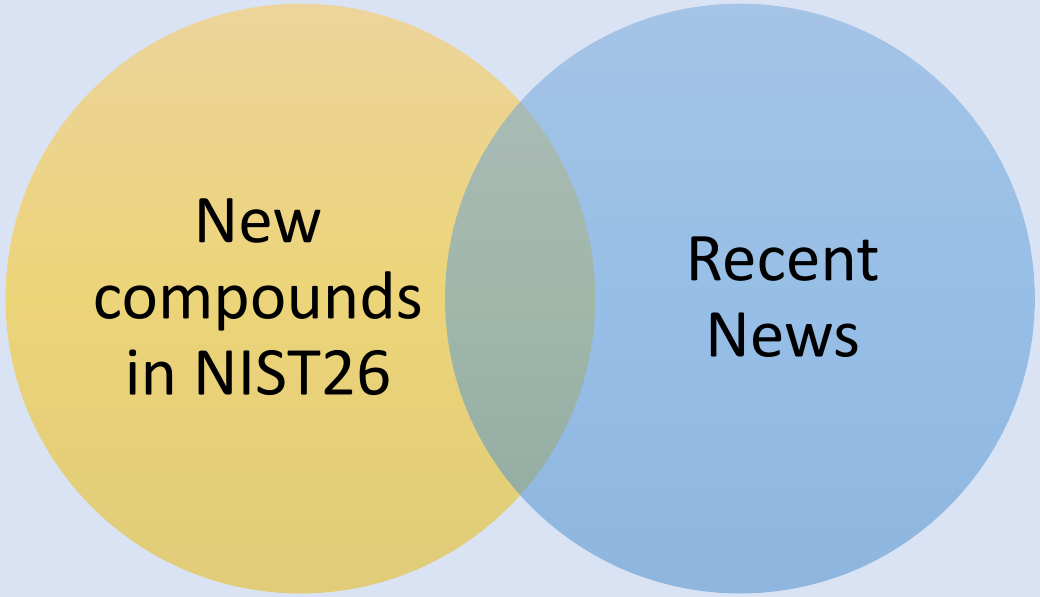
Encodes stereochemistry and isotopes

Purchasable?

Commercially Unavailable

Not Suitable

What is new + important… to me?



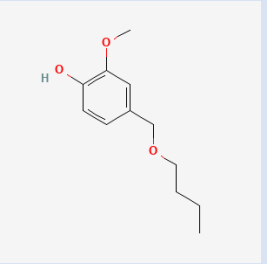
What is new + important?

Flavor/Fragrance + Cosmetics

The "Neurocosmetics" Boom: Vanillyl Butyl Ether (VBE)

New to NIST26: Vanillyl butyl ether

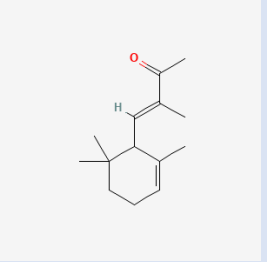
The News: Between late 2025 and early 2026, the beauty industry saw a massive surge in a trend called "Neurocosmetics"—topical products engineered to actively communicate with the nervous system to alter mood, relieve stress, or create physical sensations. As a result, the market value for Vanillyl Butyl Ether (VBE) skyrocketed.
The Science: VBE is a synthetic ether that smells faintly of vanilla. However, its primary use isn't for scent; it is a specialized sensory agent. When applied to the skin (in lip plumpers, muscle recovery creams, or warming lotions), VBE actively binds to the TRPV1 (Transient Receptor Potential Vanilloid 1) channels in human nerve endings. This creates a pleasant, long-lasting warming sensation and increases local blood microcirculation without the severe burning irritation caused by natural capsaicin (chili peppers). The addition of VBE to the NIST library allows quality control labs to accurately quantify this powerful sensory agent in the exploding neurocosmetic market.



The EU Fragrance Allergen Crackdown: α-Isomethylionone

New to NIST26: (.+/-.)-.alpha.-Isomethylionone

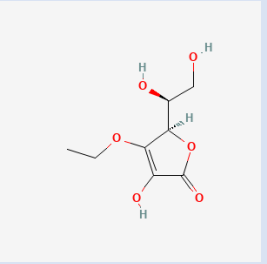
The News: In the fragrance world, 2025 and 2026 have been heavily defined by strict new European Union regulations regarding cosmetic allergens. The EU vastly expanded the list of fragrance chemicals that can no longer be hidden under the generic ingredient label "Parfum" or "Fragrance."
The Science: α-Isomethylionone is a classic synthetic aromatic compound that produces a highly desirable, powdery, "woody-violet" floral scent. However, it is also a known contact allergen. Under the newly enforced regulations, cosmetics brands are now legally required to explicitly list α-Isomethylionone on their packaging if it exceeds trace thresholds. This regulatory nightmare for perfume houses means that analytical chemistry labs desperately need updated, highly precise mass spectral libraries (like NIST26) to detect exactly how much of this molecule is hiding inside complex essential oil blends and synthetic perfumes.



Solving the Vitamin C Shelf-Life Crisis: 3-O-Ethyl-L-ascorbic acid

New to NIST26: 3-O-Ethyl-L-ascorbic acid

The News: Vitamin C serums are a multi-billion dollar market segment, but consumers have grown increasingly frustrated that their expensive serums quickly oxidize, turn orange, and lose all efficacy within weeks. In 2025 and 2026, the industry massively pivoted to a new generation of ultra-stable derivatives.
The Science: Pure Vitamin C (L-ascorbic acid) is highly unstable when exposed to light and air. By chemically attaching an ethyl group to the molecule, cosmetic chemists created 3-O-Ethyl-L-ascorbic acid. This slight modification makes the molecule highly stable and uniquely soluble in both water and oil. Once it penetrates the skin's lipid barrier, the body's natural enzymes cleave off the ethyl group, releasing the pure Vitamin C directly into the tissue. The new NIST reference allows regulators to test whether a brand's "brightening serum" actually contains active, stable Vitamin C or if it has already degraded in the bottle.



What is new + important?

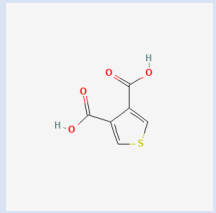
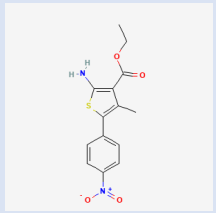
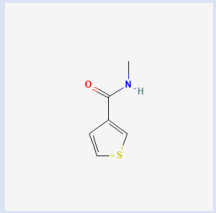
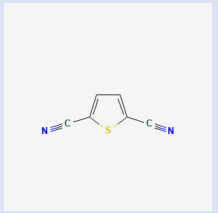
Space Exploration & Astrochemistry

Hunting for Ancient Martian Microbes: Thiophenes

New to NIST26: Over 400 specific Thiophene derivatives (e.g., 4,5,6,7-Tetrahydrobenzo[b]thiophene-3-carboxylic acid)

The News: When NASA's Curiosity rover drilled into 3-billion-year-old mudstones in Mars's Gale Crater, its onboard chemistry lab detected a surprising class of ring-shaped, sulfur-containing organic molecules called thiophenes.

The Science: On Earth, thiophenes are key biological signatures found in "extremophile" bacteria. Recent simulations proved these tough structures can survive harsh, Martian-like radiation and desiccation as chemical fossils. NASA must now determine if the Martian thiophenes came from ancient microbes or non-biological events like meteor impacts. The NIST26 catalog allows chemists to compare rover data against thousands of known thiophene structures to help solve this mystery.

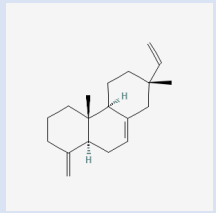
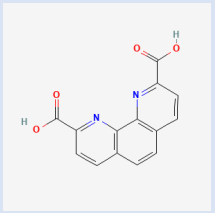
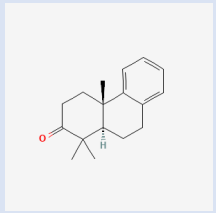






Decoding Asteroid Bennu: Alkylated PAHs

New to NIST26: Alkylated Phenanthrenes and PAHs (e.g., Phenanthrene, 7-ethenyl-1,2,3,4,4a,4b,5,6,7,8,10,10a-dodecahydro-4a,7-dimethyl-1-methylene-)

The News: In November 2025, scientists published major findings in PNAS regarding the physical samples returned from the near-Earth asteroid Bennu by NASA's OSIRIS-REx mission.

The Science: Lab analysis of Bennu's dust revealed complex organics, specifically alkylated polycyclic aromatic hydrocarbons (PAHs) like phenanthrenes. These prebiotic molecules strongly suggest that the building blocks of life formed non-biologically in the early Solar System. This discovery supports the theory that ancient asteroid impacts delivered these crucial molecules to early Earth, potentially seeding the origins of life.

What is new + important?

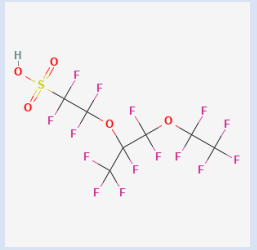
Environmental

PFAS / “Forever Chemicals”

New to NIST26: numerous PFAS (e.g., Perfluoro-4-methyl-3,6-dioxaoctanesulfonic acid and 1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-Docosafluorodecane)

The News: The ongoing environmental crisis surrounding per- and polyfluoroalkyl substances (PFAS) reached major regulatory milestones in 2025.

The Science: Strict new prohibitions are now in effect, including bans on intentionally added PFAS in consumer goods like carpets, cleaning products, and cookware. The addition of these heavily fluorinated "forever chemicals" to the NIST26 library provides environmental agencies with the essential reference data needed to rapidly detect them and rigorously enforce the new regulatory limits.



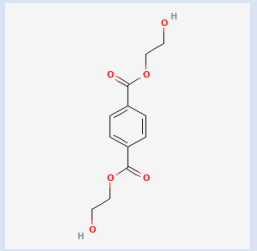
Microplastics

Bis(2-hydroxyethyl) terephthalate (BHET)

New to NIST26: Bis(2-hydroxyethyl) terephthalate, 2TMS

In the News: BHET has been highly prominent in very recent news (May 2026) surrounding advanced PET plastic recycling and bioremediation.

Context: BHET is a key intermediate produced during PET plastic breakdown. Its addition to the NIST library helps researchers track the efficiency of emerging circular-economy recycling methods, including recent breakthroughs in bacterial biodegradation and water-free chemical glycolysis.

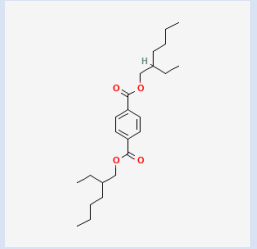


Bis(2-ethylhexyl) terephthalate (DEHT / DEHTP)

New to NIST26: Bis(2-ethylhexyl) terephthalate and 2-Ethylhexyl terephthalate

In the News: In December 2025, an extensive study published in Environmental Science & Technology highlighted DEHTP while analyzing dietary exposure to microplastics and plasticizers.

Context: As manufacturers replace restricted, highly toxic ortho-phthalates with alternatives like DEHT, these new compounds are increasingly migrating from food packaging into human diets. Tracking DEHT is vital for assessing the emerging toxicological and endocrine-disrupting risks of these alternative plasticizers.

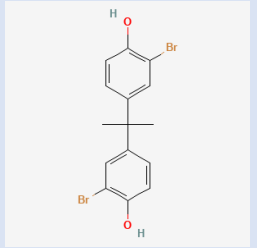


Tetrabromobisphenol A (TBBPA) derivatives

New to NIST26: Heavily brominated bisphenols like 2,2'-Dibromobisphenol A.

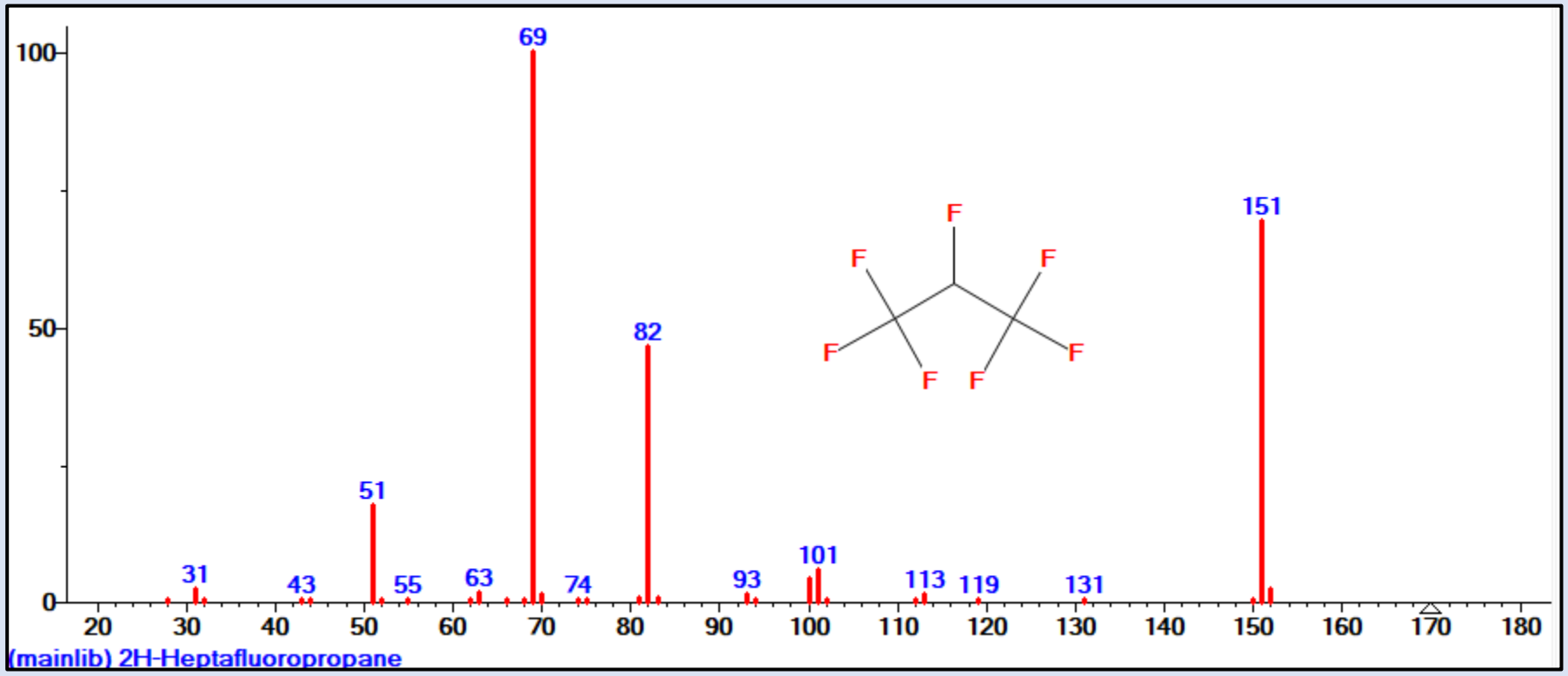
In the News: TBBPA and its derivatives, which are primarily used as reactive flame retardants in epoxy resins (such as those in printed circuit boards and electronic plastics), were the subject of an updated European Food Safety Authority (EFSA) risk assessment in early 2026.

Context: As e-waste degrades, it leaches these brominated flame retardants into the environment and food chain. Accurate mass spectra are crucial for tracking this contamination in marine ecosystems and assessing associated neurotoxicity risks highlighted in recent safety reviews.



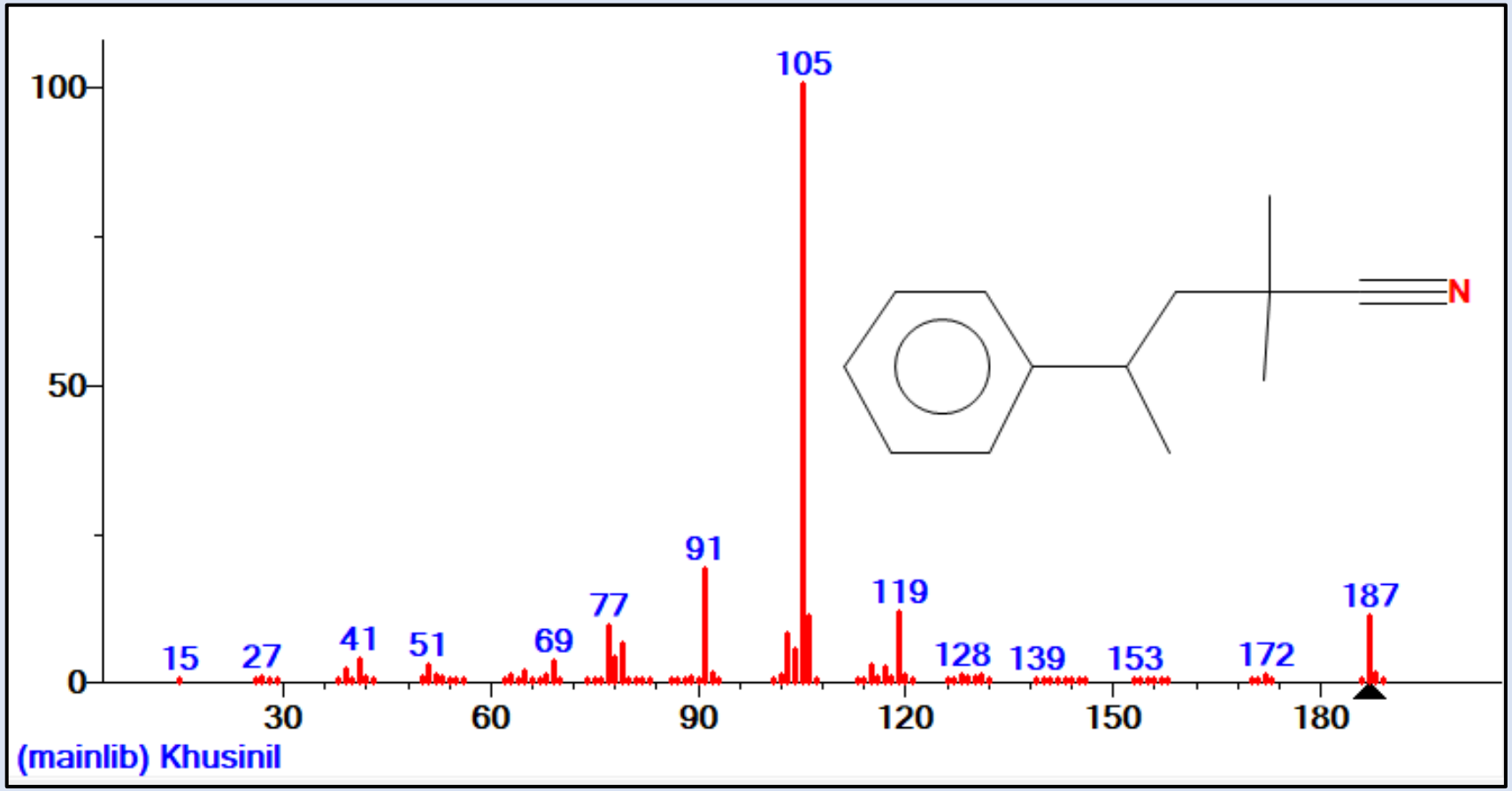
Other Sources of Compounds

Apaflurane – Fire Suppressant
> 20,000 tons/year



322 PFAS Spectra

Khusinil - Grapefruit

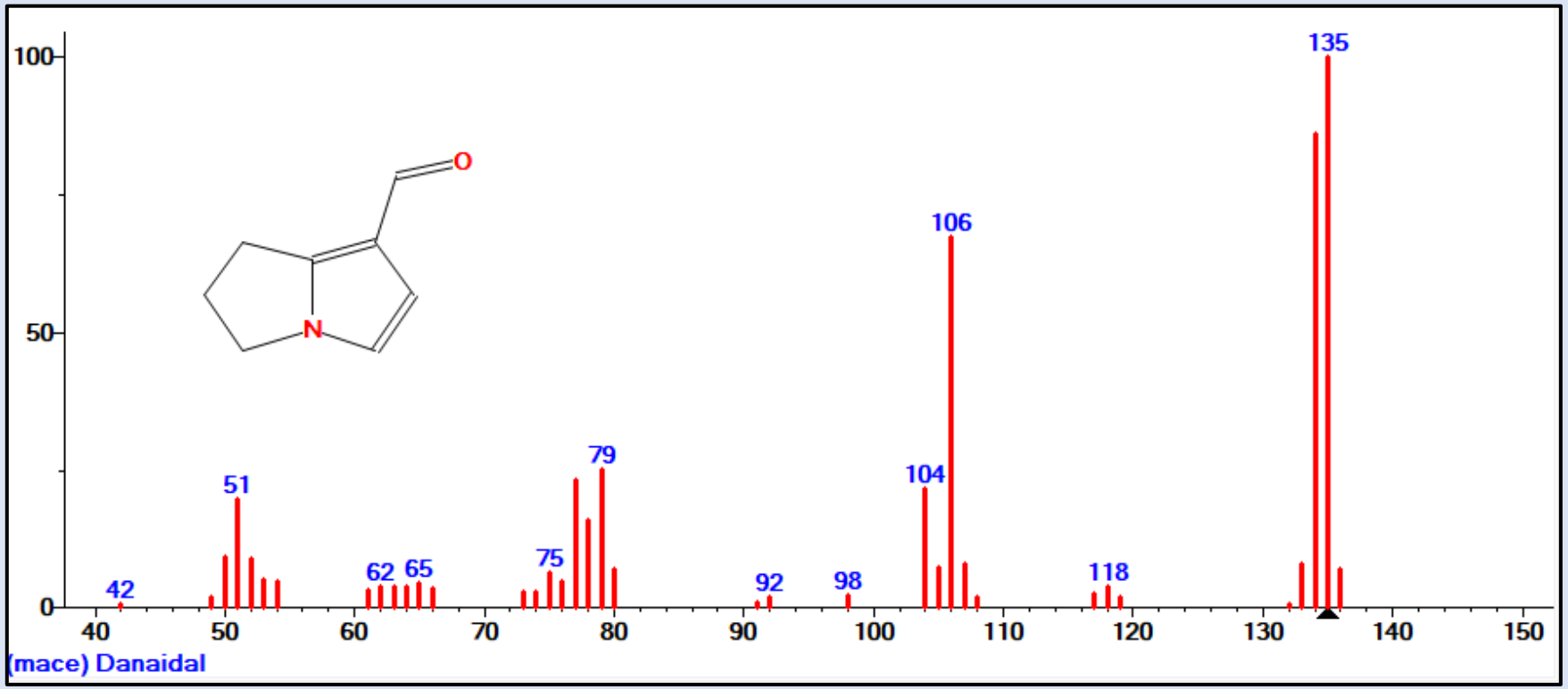


Odor Profile

- *Citrus (grapefruit)*
- *Rhubarb*
- *Burnt leaf note*

413 Compounds from Perfumer Suppliers

Danaidal - Butterfly Pheromone



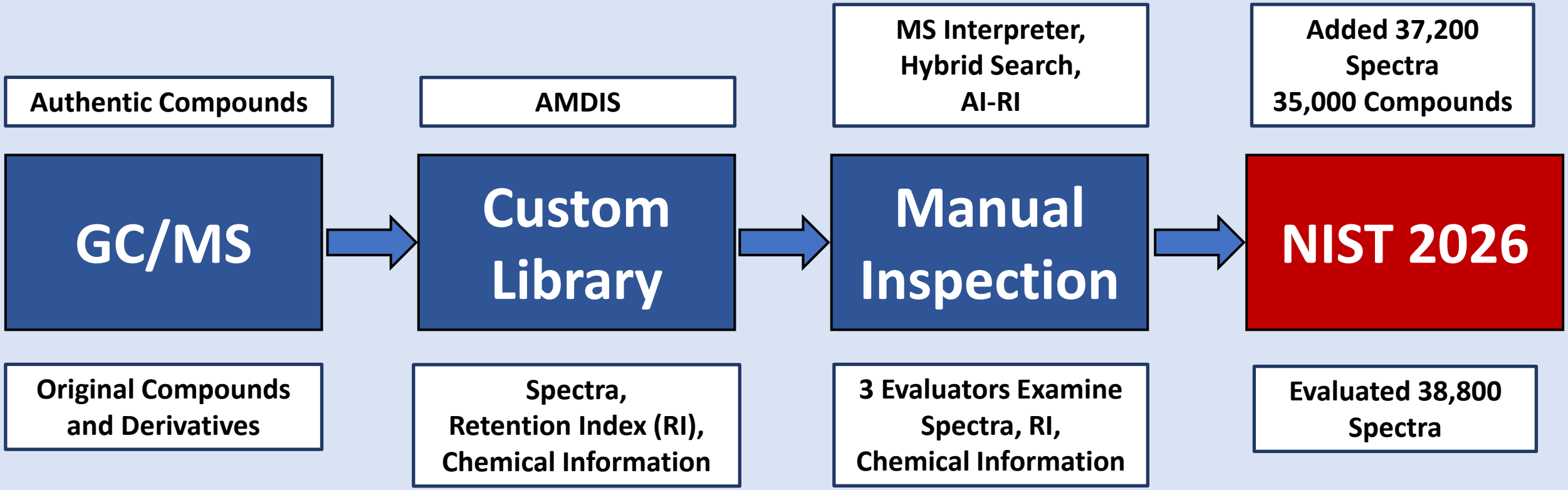
254 Chemical Ecology Spectra

MACE - S. Schultz

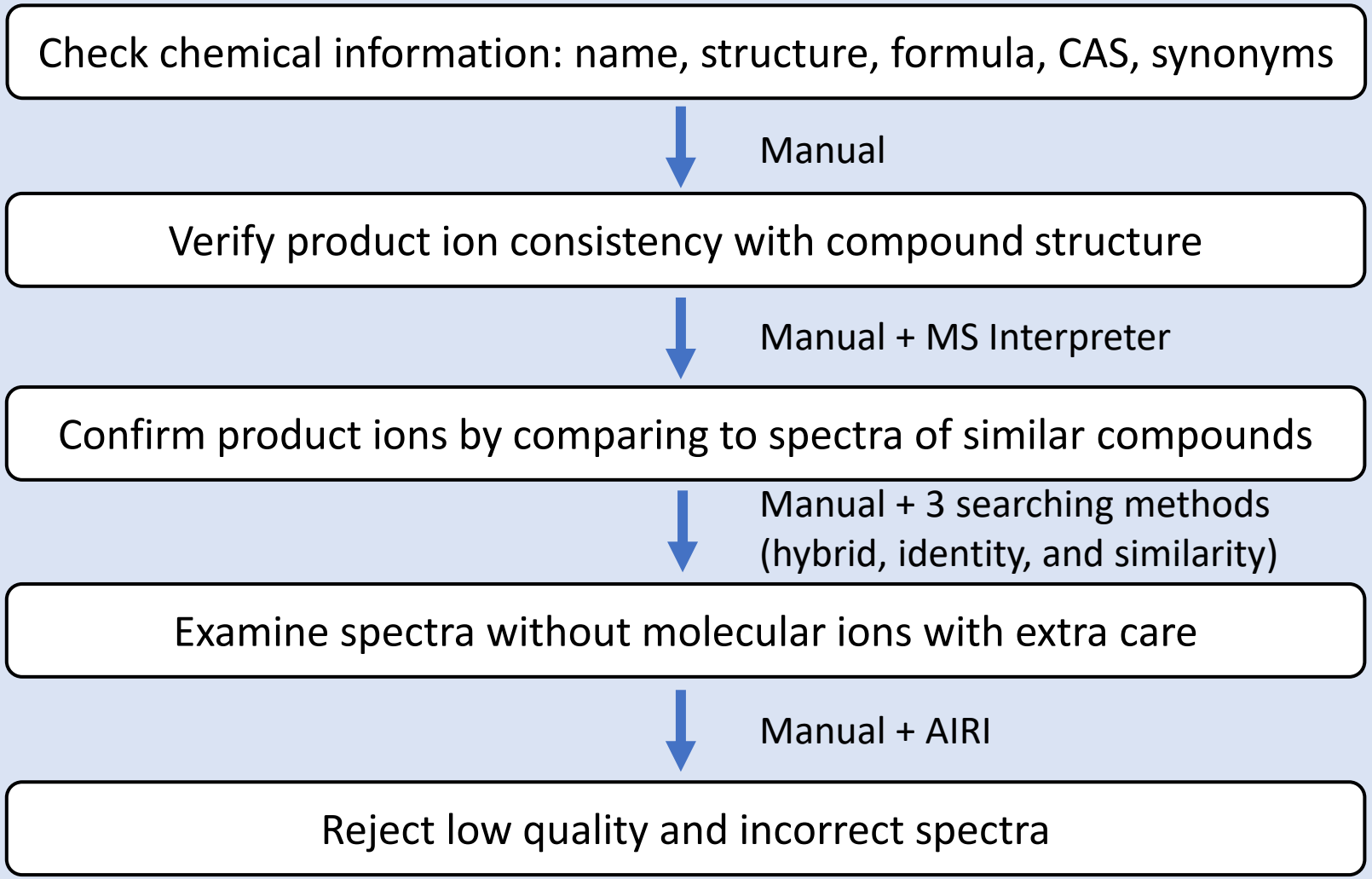
EI Library Construction

Weihua Ji

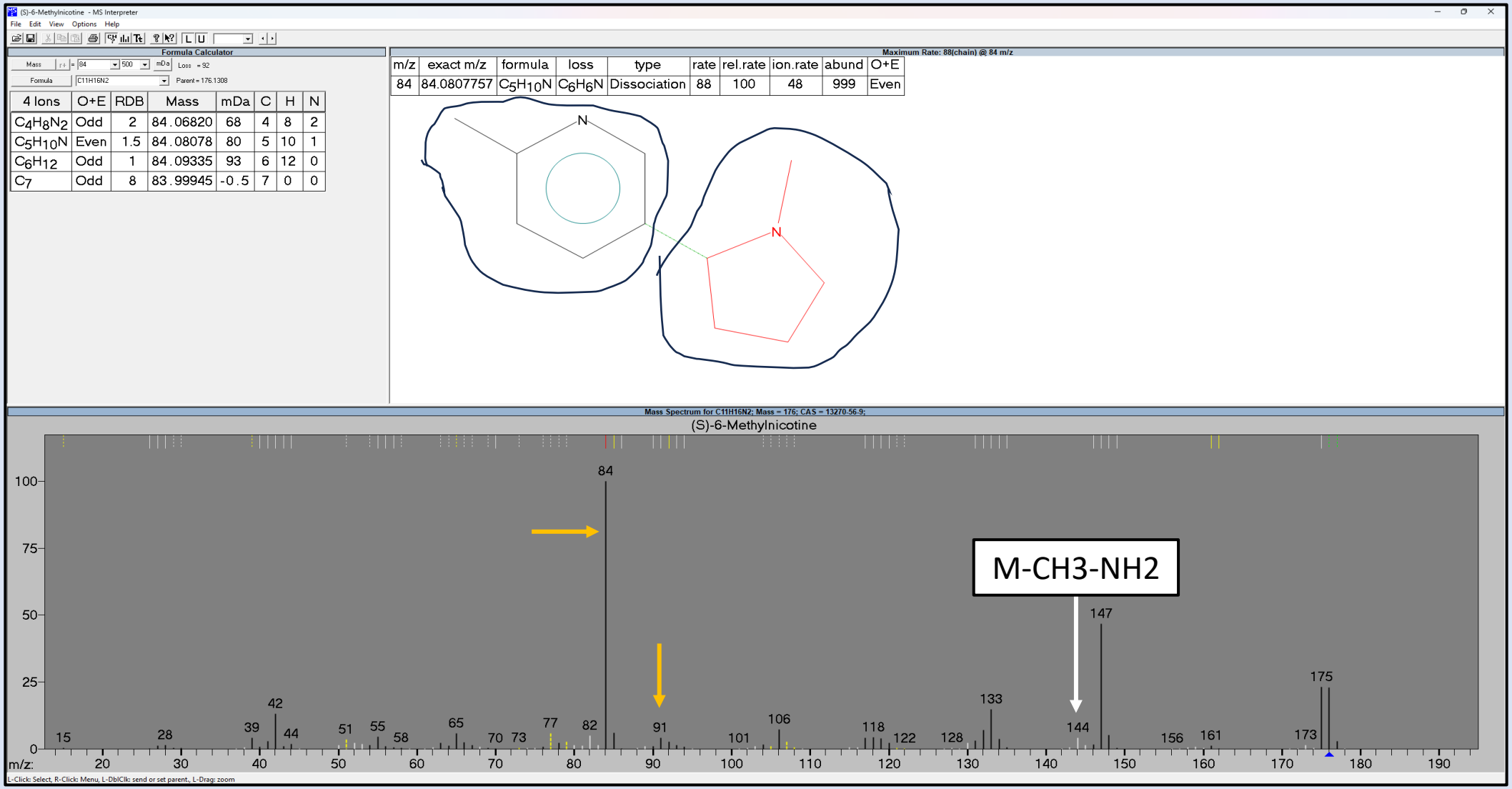
Expanding the EI MS Library



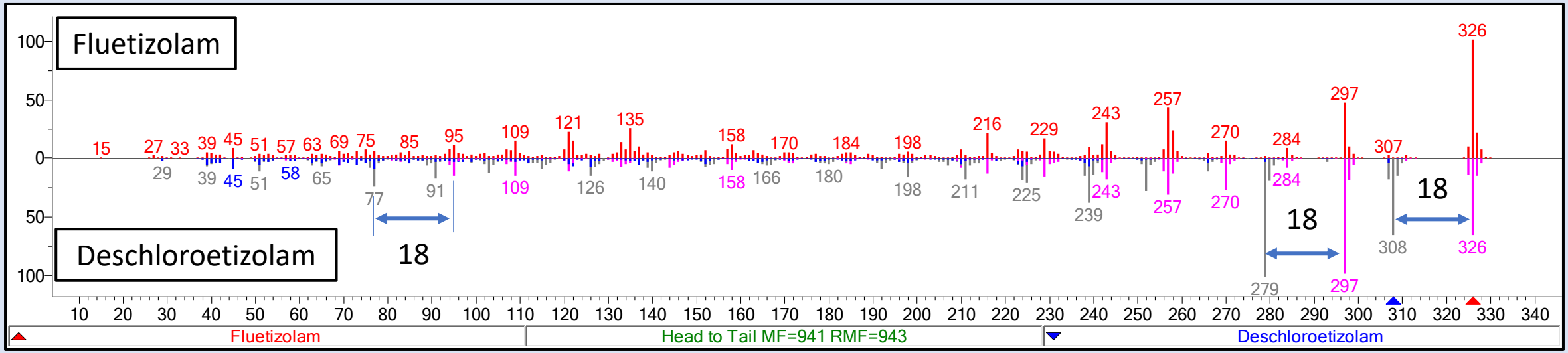
Quality Control Workflow



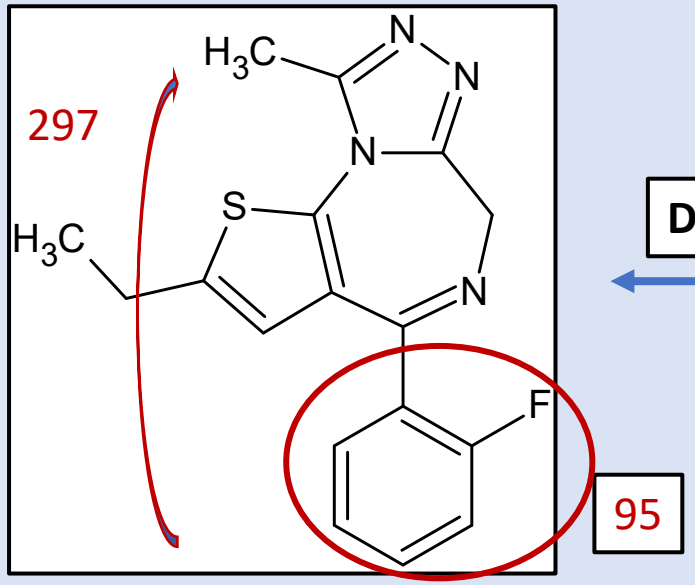
Evaluate Spectra with MS Interpreter



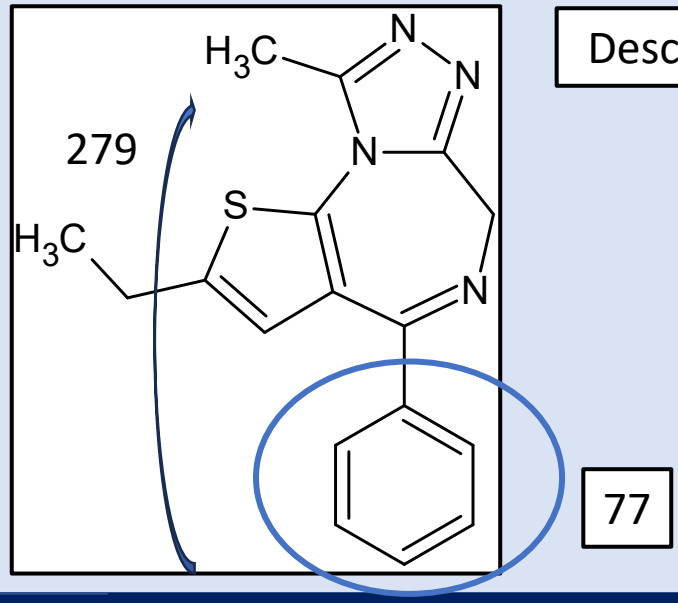
Evaluate Spectra using Hybrid Search



Fluetizolam

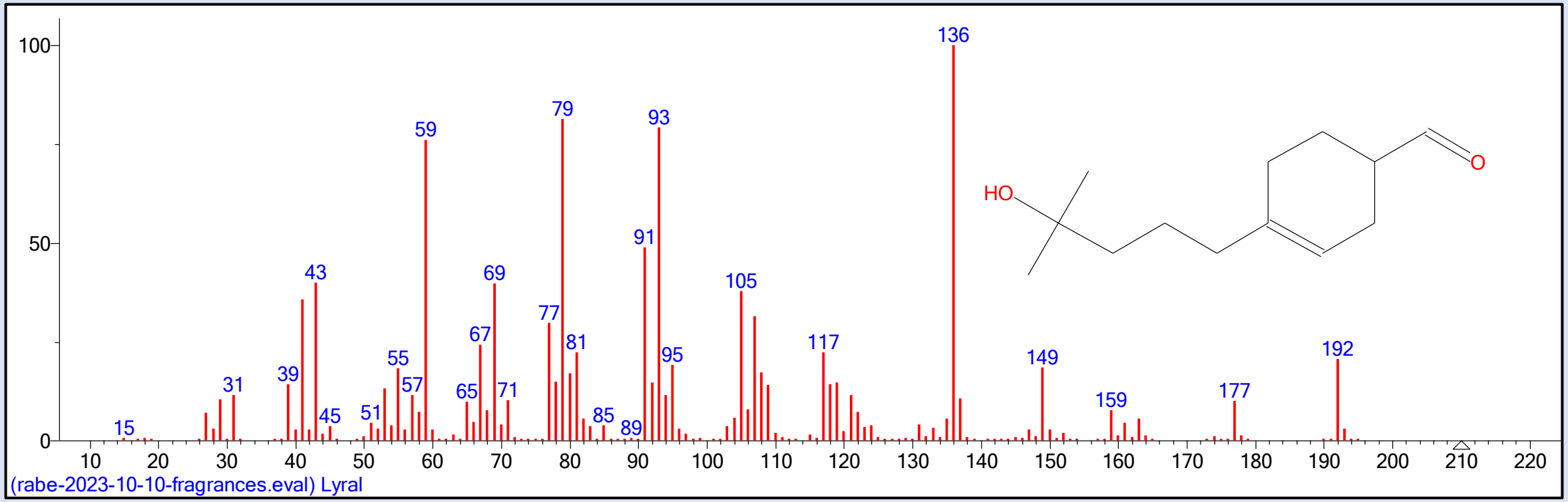


DeltaMass = 18



Deschloroetizolam

RI and AIRI Assist Spectrum Evaluation



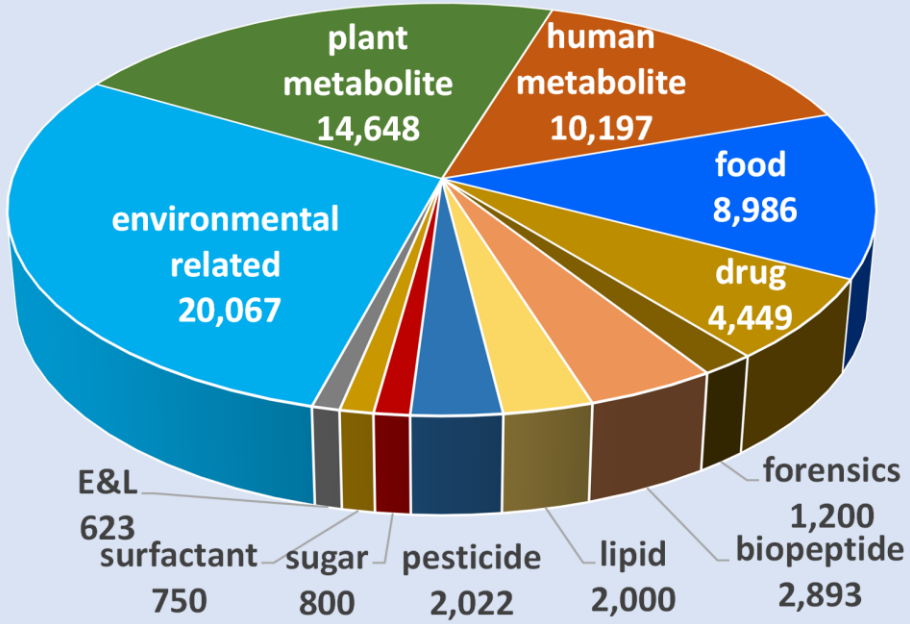
Experimental RI: 1667
AIRI: 1677

What's New in the *NIST26 Tandem* MS Library

Xiaoyu (Sara) Yang

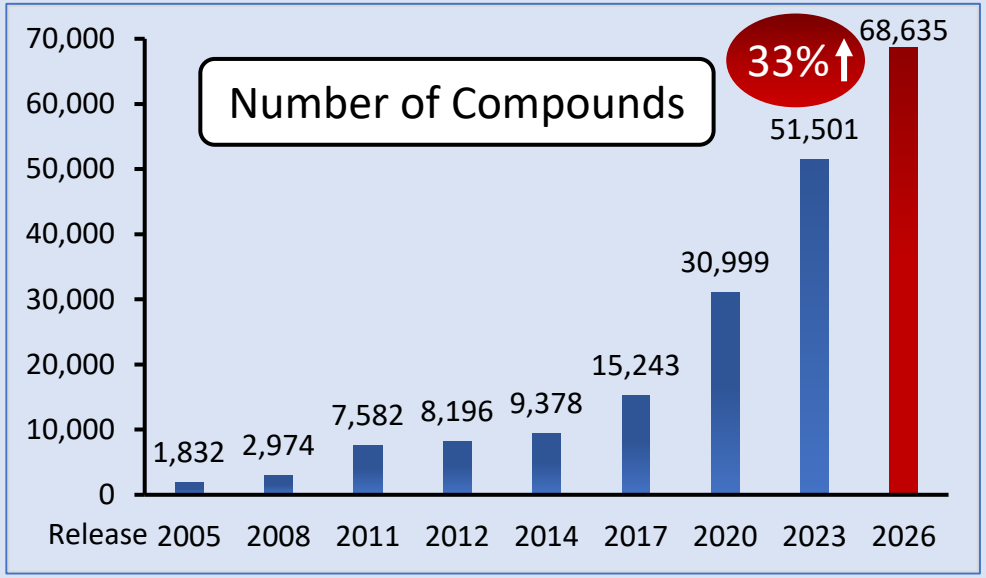
What's New in the *NIST26 Tandem* MS Library

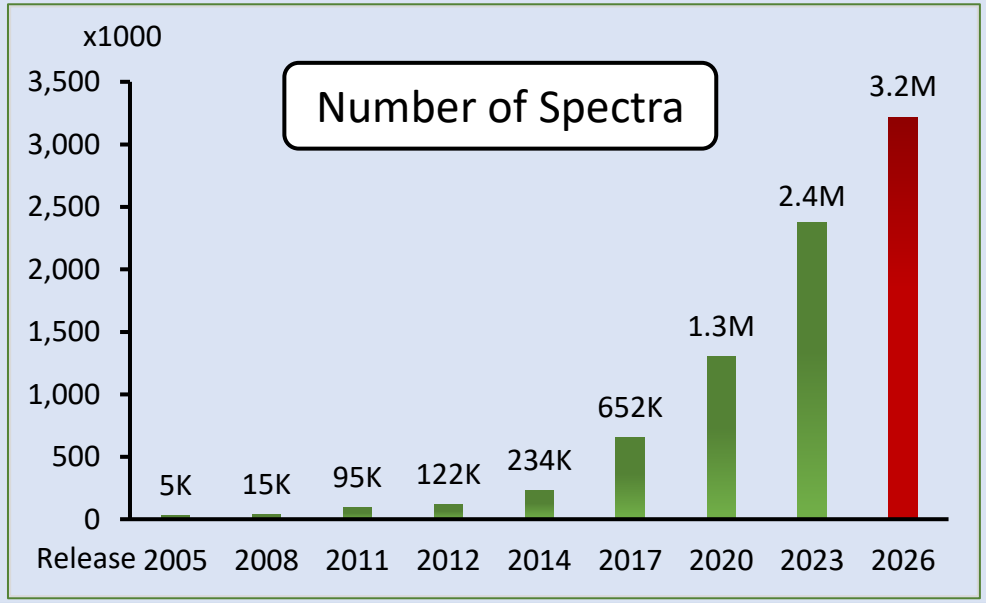
- **17,134** New Compounds
- **800K** New High- and Low-Resolution Spectra
- New software Chromatogram for LC-MS/MS



68,635 compounds
3.2 million spectra

77% positive
23% negative
50% MS^2 in-source
13% MS^3 and MS^4





Applications: metabolomics, food, health, agriculture, environmental, pharmaceutical, and forensics, etc.

Building *the NIST26 Tandem* Library
From Compounds to Annotated Spectra

Compound Analysis

- Authentic compounds
- Broad key compound diversity
- Maximum fragmentation condition coverage
- ESI: HCD, FT-IT, IT; QTOF
- APCI: QTOF, timsTOF
- 20 energy levels

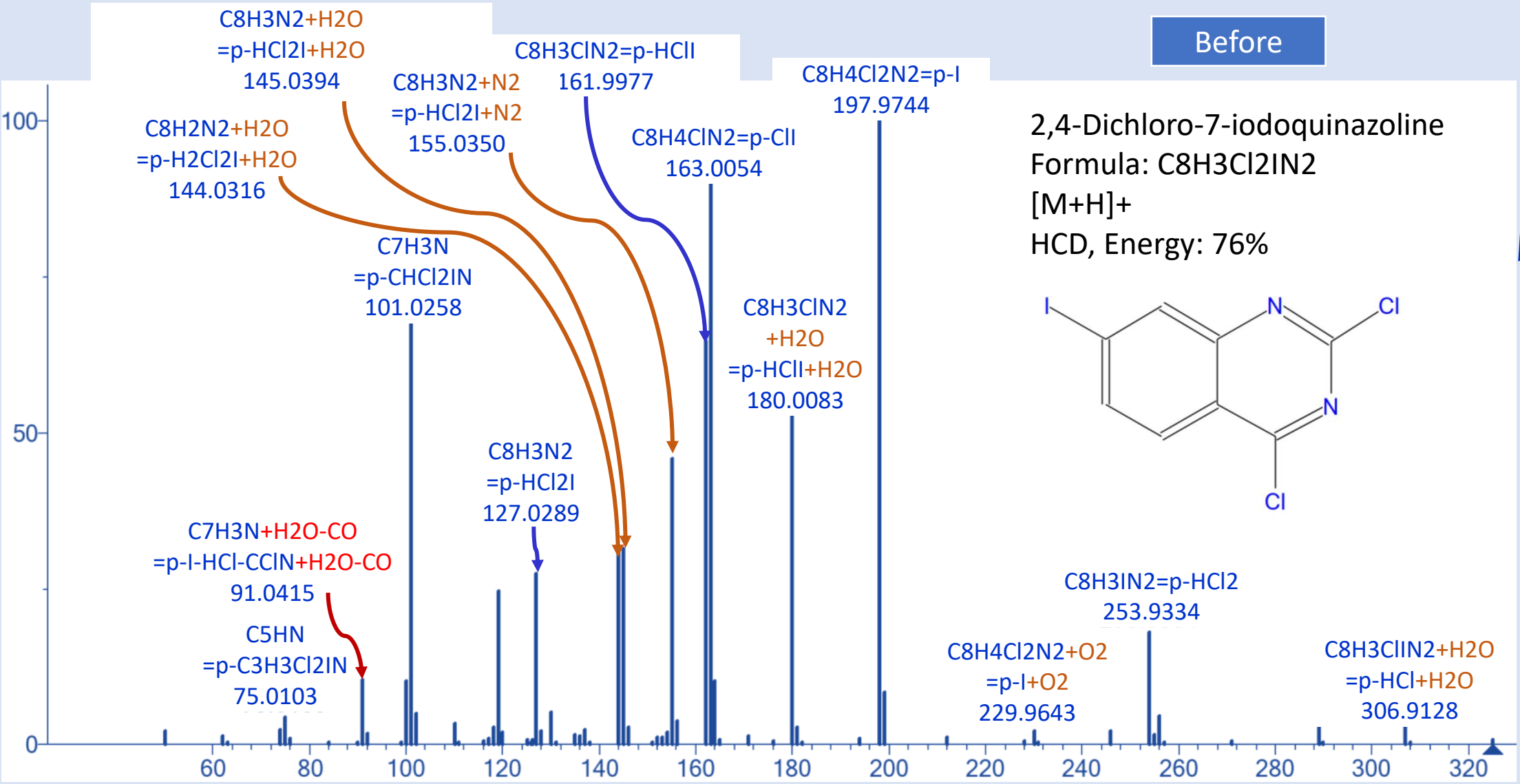
Quality Control

- Thorough evaluation
- Manual examination
- ‘Consensus spectra’
- Advanced QC procedure
- Extensive annotation
- MS Interpreter
- MS_Draw

NIST26 Tandem Library

- High quality
- Comprehensive
- Fast search
- Reliable identification
- High- and low-resolution
- Positive and negative
- MS2, MS3, MS4
- In-source ions
- Isotopic

Peak Annotation



Before

2,4-Dichloro-7-iodoquinazoline
Formula: C8H3Cl2IN2
[M+H]+
HCD, Energy: 76%

MS Interpreter

MS_Draw

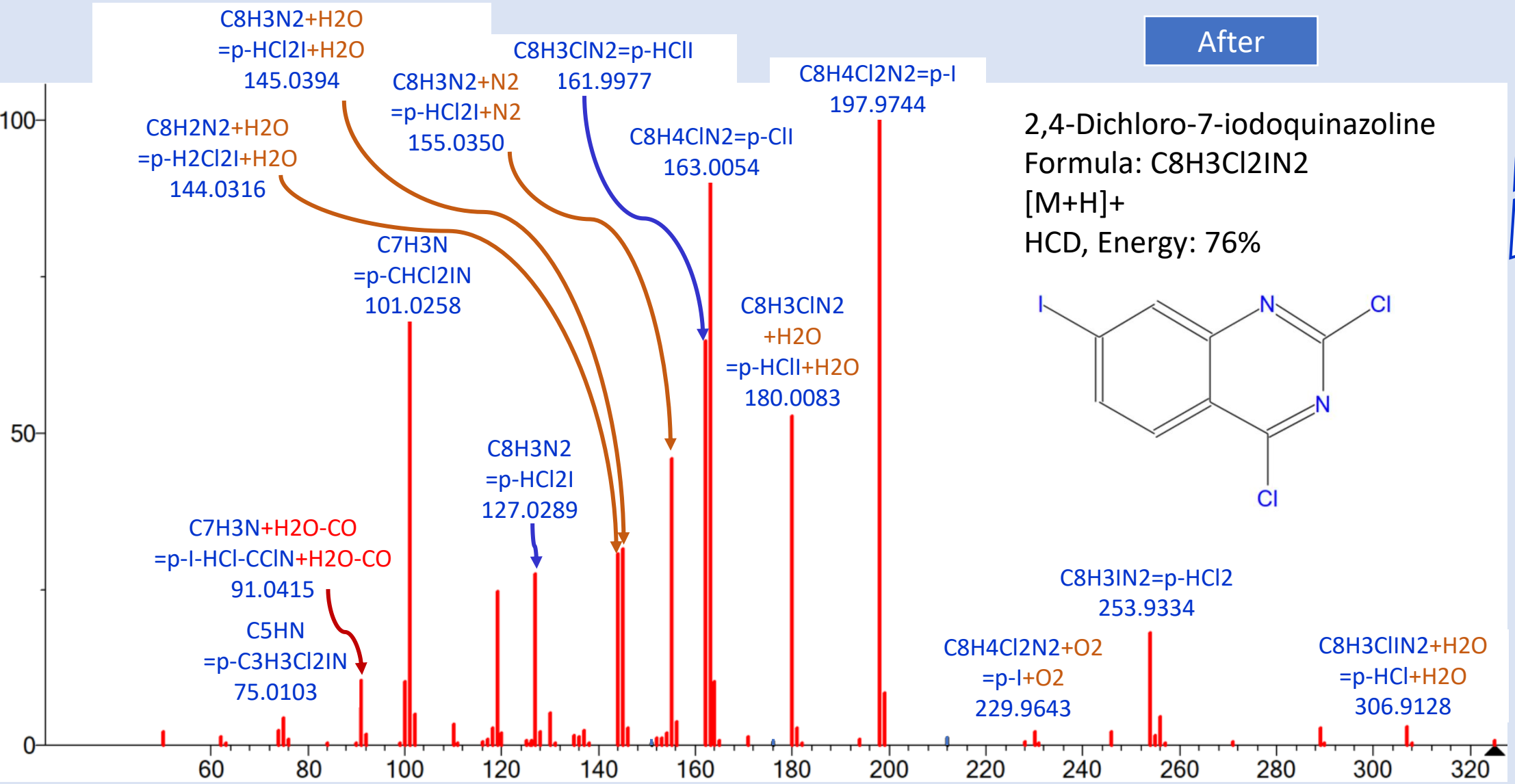
+H2O

+N2

+O2

Further fragments

Peak Annotation



After

2,4-Dichloro-7-iodoquinazoline
Formula: C8H3Cl2IN2
[M+H]+
HCD, Energy: 76%

MS Interpreter

MS_Draw

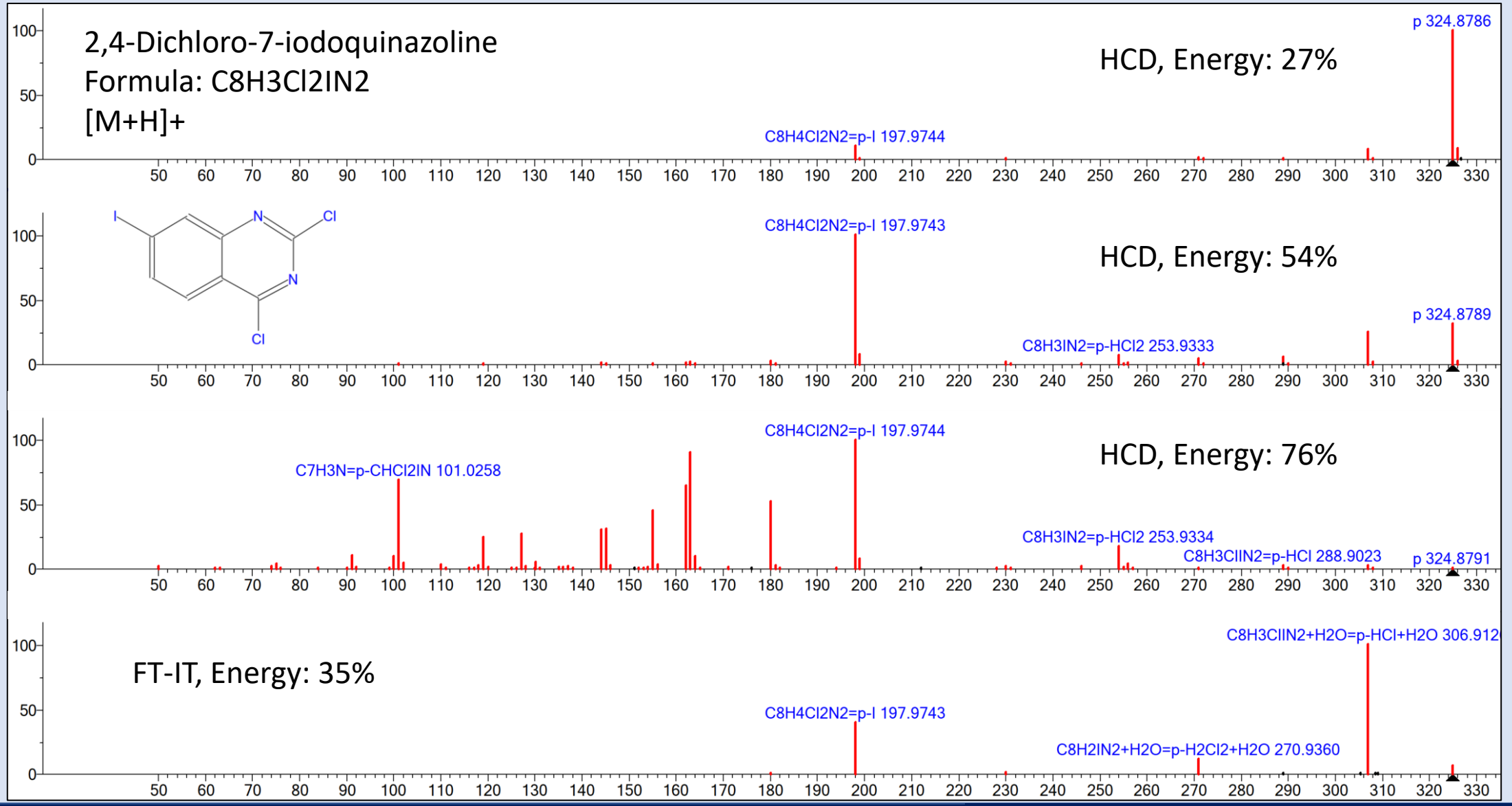
+H2O

+N2

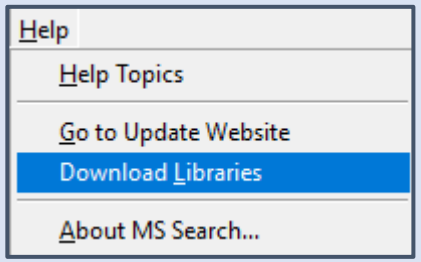
+O2

Further fragments

Spectral Examination



More NIST Libraries



NISTMS Menu

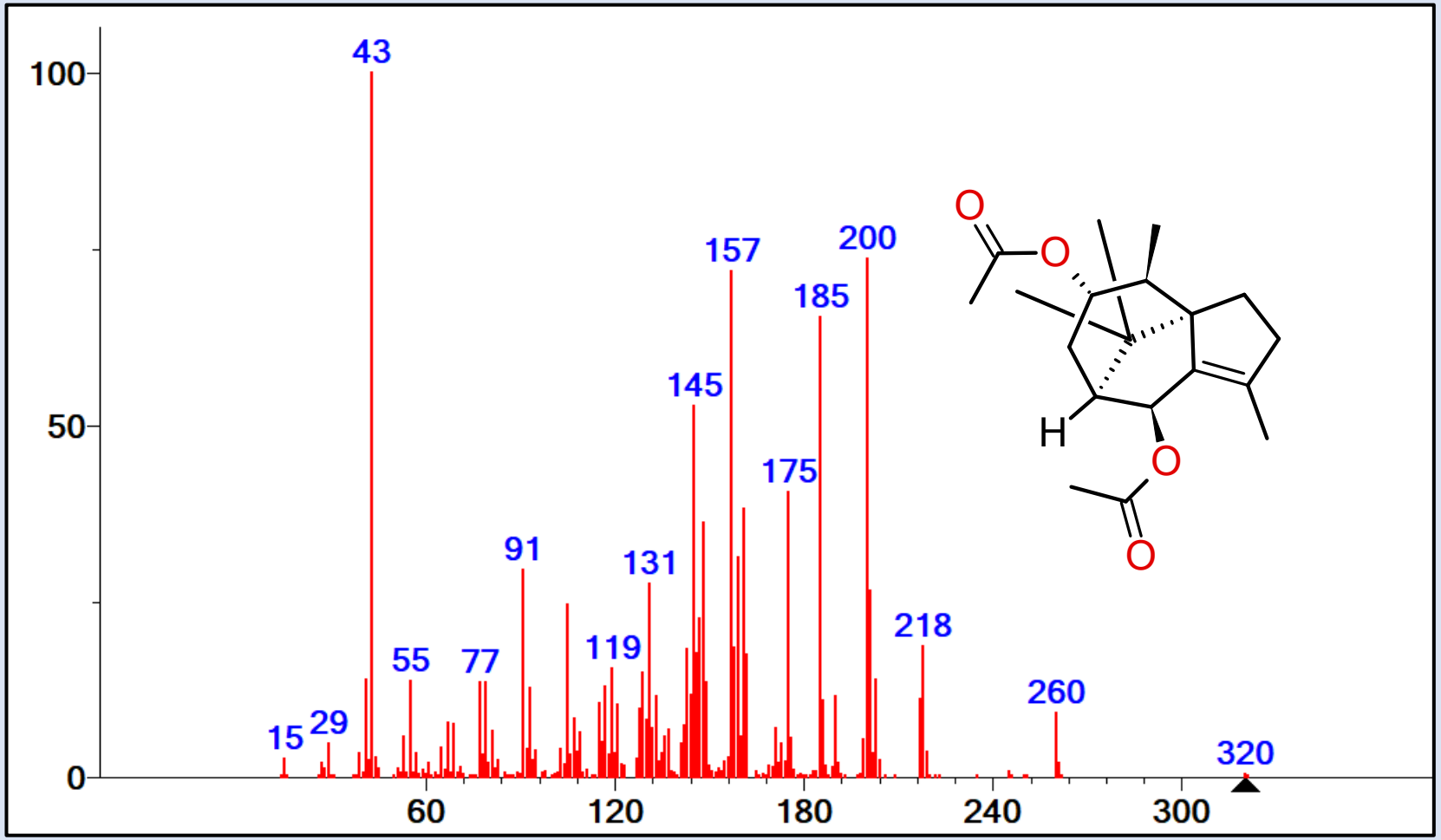
Electron Ionization

- 529 Plant Metabolites (new)– Measured at NIST, Reported in Literature
- 1019 Essential Oil – Recurring/Unidentified
- 671 Dried Food – Recurring/Unidentified
- Pediatric Urine – Recurring/Unidentified

Tandem ESI (MS/MS)

- Oligosaccharides in Milk – 2618 Compounds (published)
- Acylcarnitines – 5328 Spectra Identified by Hybrid Search in Urine (published)
- 55,371 Plasma & 216,026 Urine Hybrid Search Identified Spectra

All on NIST Website (chemdata.nist.gov)



(6S,9S)-Patchoul-4-ene-6,9-diol acetate

Not commercially available

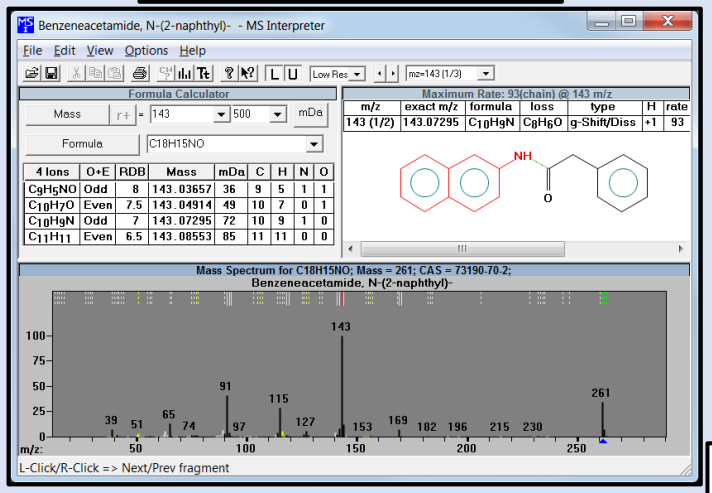
Bulletin of the Korean Chemical Society (2012), 33(9), 3115-3118; DOI: 10.5012/bkcs.2012.33.9.3115

Software

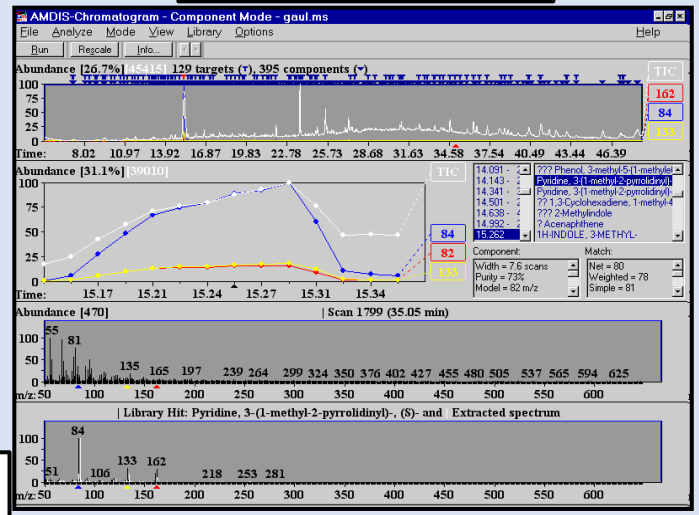
MS Search

Callable by
External Programs

MS Interpreter
EI/Tandem, Hi/Lo Res



AMDIS (gc/ms)

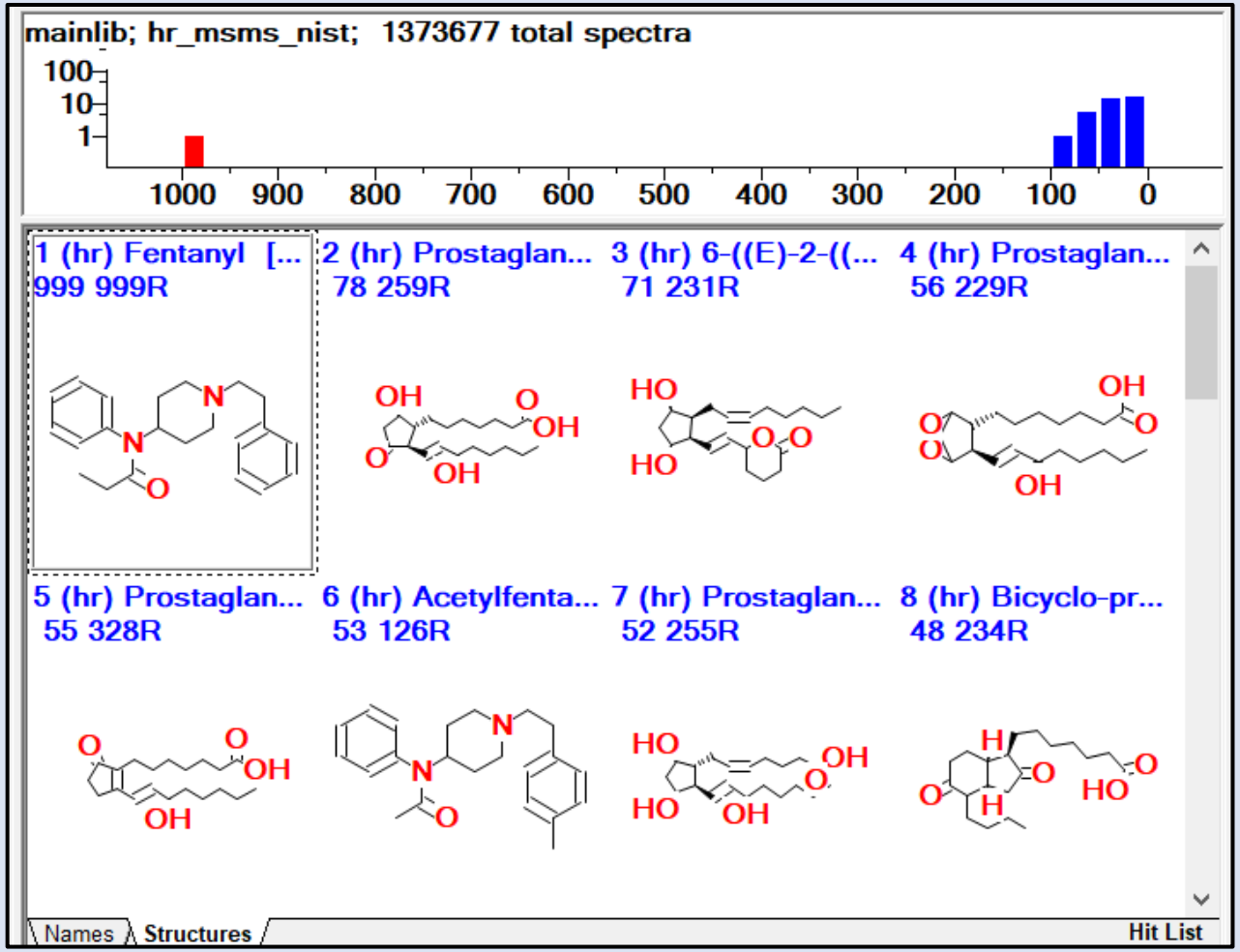


API, Lib2NIST & MSPepsearch

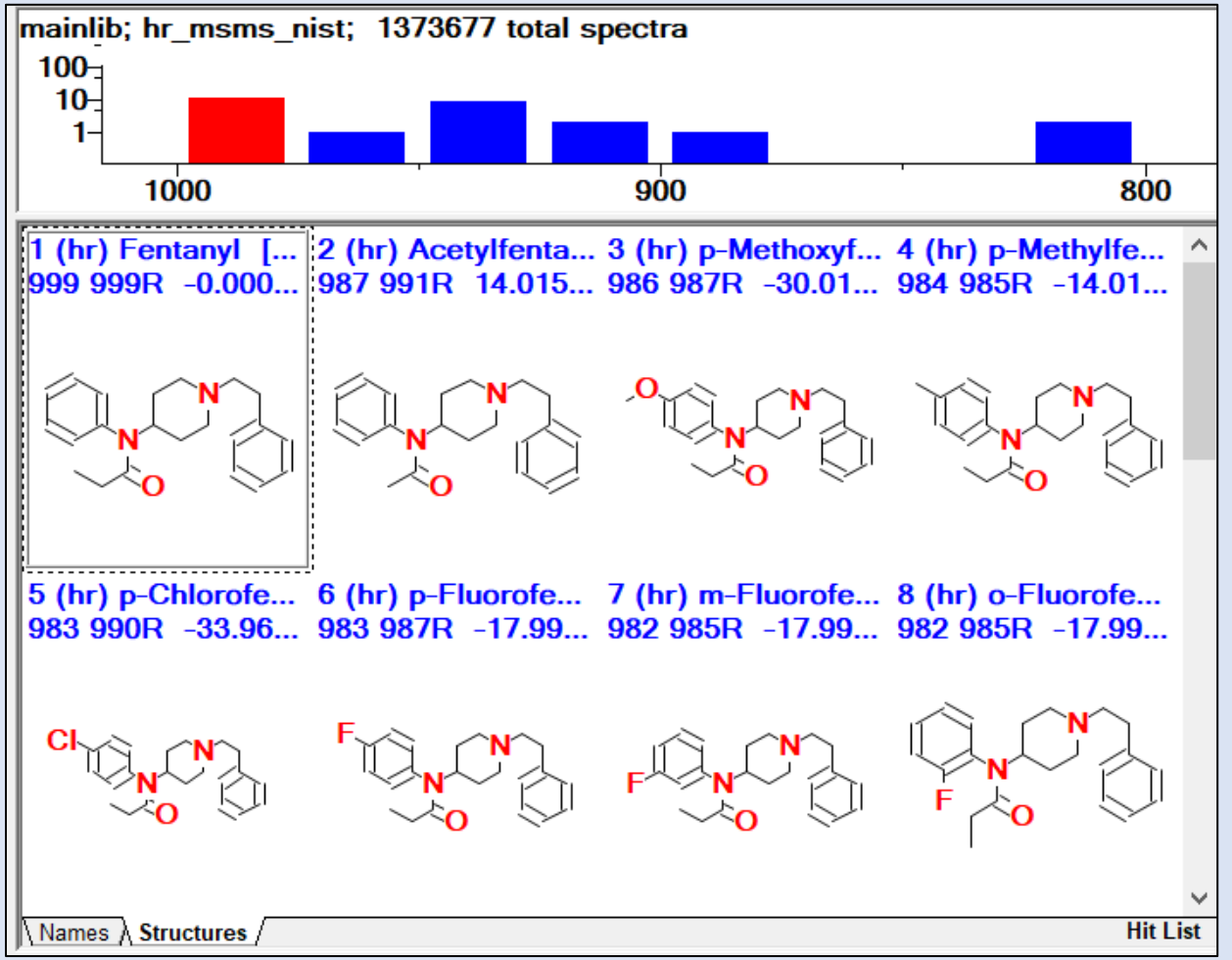
Alternate Identification Methods

- Hybrid Search for Unidentified Spectra
  - Finds Homologs
  - Compares ‘Loss’ Peaks – Requires Precursor Mass
  - Use as Default for Tandem
  - Reports deltaMass -> deltaFormula, deltaRI, …
- Prior Probability – ‘Other DBs’
- Validation by GC Retention Index (RI, AIRI)
- Multiple Search/Scoring Methods

Conventional Tandem



Hybrid Tandem



Use as Default

MS Interpreter - High or Low Res

Cortisone - MS Interpreter

File Edit View Options Help

Low Res | mz=122 (1/8)

Formula Calculator

Mass r+ = 122 500 mDa Loss = 238

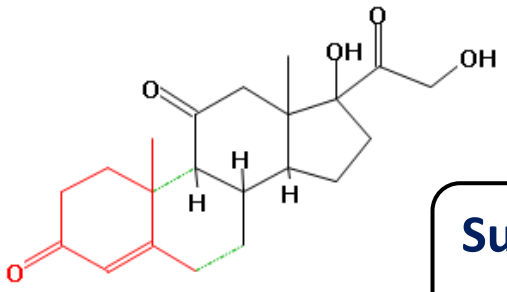
Formula C21H28O5 Parent = 360.1931

7 Ions	O+E	RDB	Mass	mDa	C	H	O
$C_3H_6O_5$	Odd	1	122.02097	20	3	6	5
$C_4H_{10}O_4$	Odd				4	10	4
$C_6H_2O_3$	Odd				6	2	3
$C_7H_6O_2$	Odd				7	6	2
$C_8H_{10}O$	Odd	4	122.07262	72	8	10	1
C_9H_{14}	Odd	3	122.10900	109	9	14	0
$C_{10}H_2$	Odd	10	122.01510	15	10	2	0

Formulas

Maximum Rate: 84(chain) @ 329 m/z

m/z	exact m/z	formula	loss	type	rate	rel.rate	ion.rate	abund	O+E
122 (1/3)	122.0726166	$C_8H_{10}O$	$C_{13}H_{18}O_4$	1,3-Ring-dissociation-OE	39	55	75	999	Odd

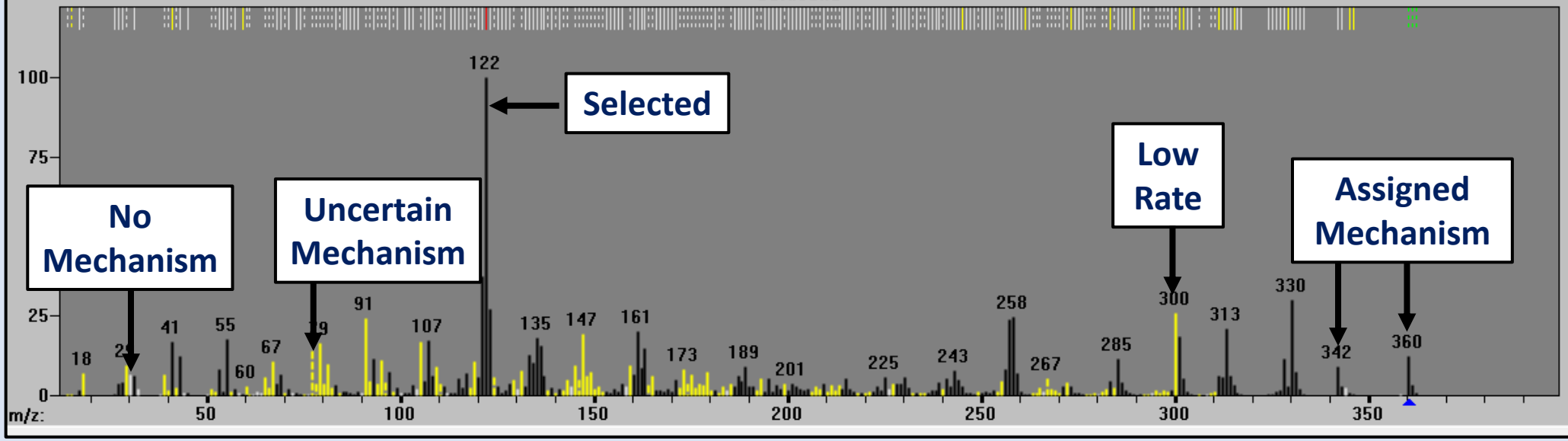


Fragmentation Info. Rates/Formulas/…

Substructure for Selected Peak Appears in Red

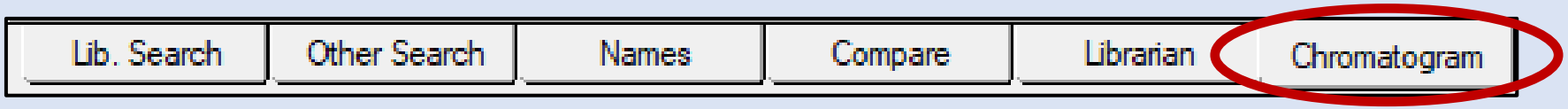
Mass Spectrum for C21H28O5; Mass = 360; CAS = 53-06-5;

Cortisone



New!

Full Chromatogram Analysis



EI (*gc/ms*)

Full AMDIS Analysis

Low/High Resolution

RI with Calibration File

Tandem (*lc/ms-ms*)

New XIC Analysis

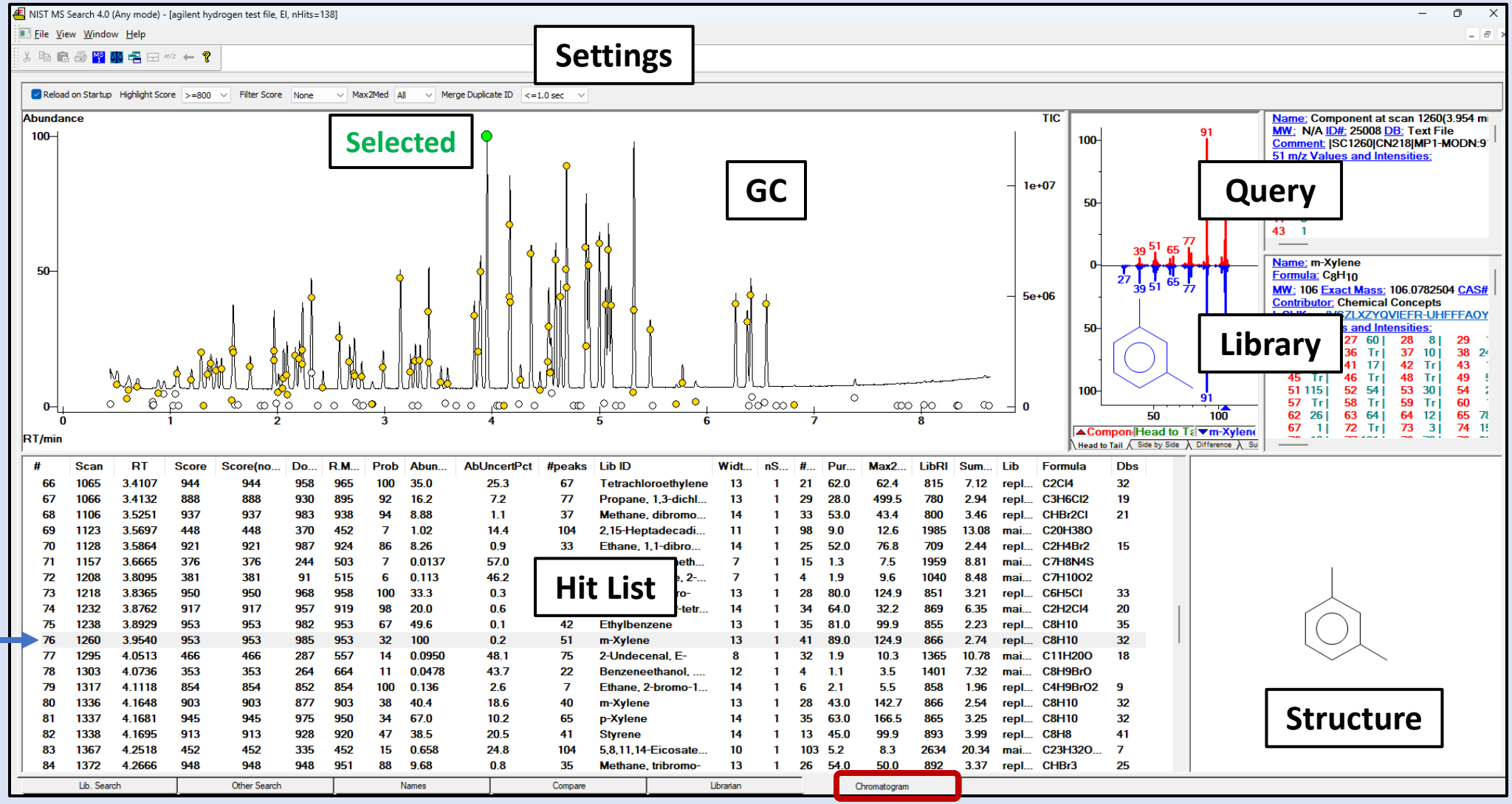
Hybrid Search Optional

Noise Filtering & Annotation

Hit List Output to Spreadsheet

Spectra analyzable by NISTMS tools

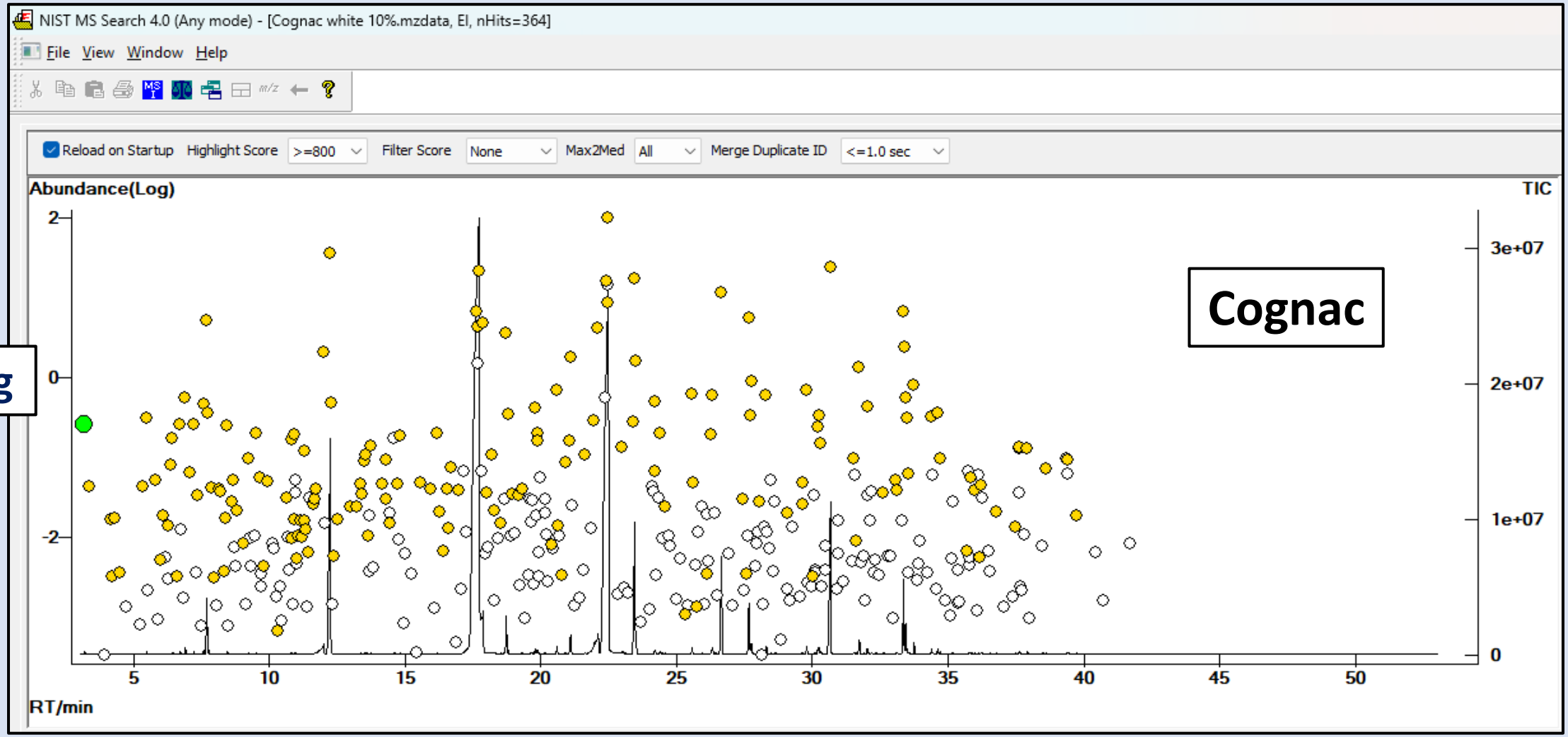
Low Resolution EI with AMDIS



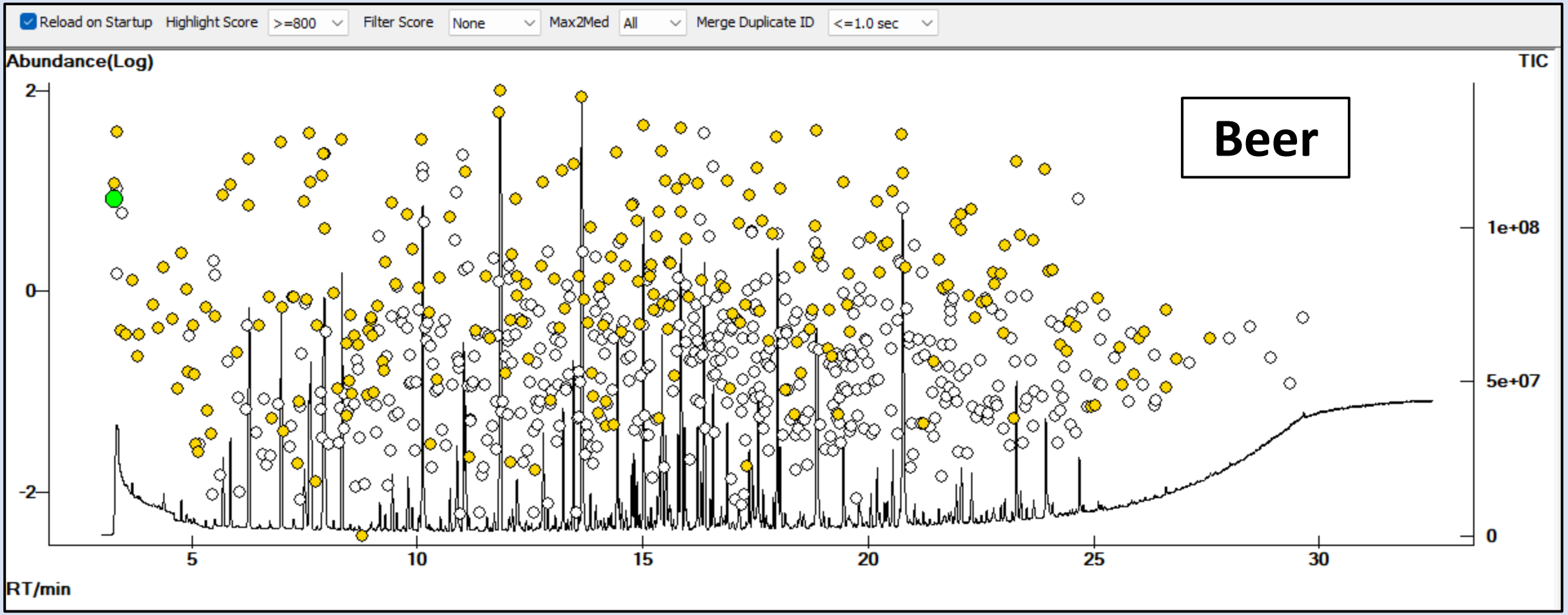
#	Scan	RT	Score	Score(no...	Do...	R.M...	Prob	Abun...	AbUncertPct	#peaks	Lib ID	Widt...	nS...	#...	Pur...	Max2...	LibRI	Sum...	Lib	Formula	Dbs
66	1065	3.4107	944	944	958	965	100	35.0	25.3	67	Tetrachloroethylene	13	1	21	62.0	62.4	815	7.12	repl...	C2Cl4	32
67	1066	3.4132	888	888	930	895	92	16.2	7.2	77	Propane, 1,3-dichl...	13	1	29	28.0	499.5	780	2.94	repl...	C3H6Cl2	19
68	1106	3.5251	937	937	983	938	94	8.88	1.1	37	Methane, dibromo...	14	1	33	53.0	43.4	800	3.46	repl...	CHBr2Cl	21
69	1123	3.5697	448	448	370	452	7	1.02	14.4	104	2,15-Heptadecadi...	11	1	98	9.0	12.6	1985	13.08	mai...	C20H38O	
70	1128	3.5864	921	921	987	924	86	8.26	0.9	33	Ethane, 1,1-dibro...	14	1	25	52.0	76.8	709	2.44	repl...	C2H4Br2	15
71	1157	3.6665	376	376	244	503	7	0.0137	57.0		eth...	7	1	15	1.3	7.5	1959	8.81	mai...	C7H8N4S	
72	1208	3.8095	381	381	91	515	6	0.113	46.2		, 2-...	7	1	4	1.9	9.6	1040	8.48	mai...	C7H10O2	
73	1218	3.8365	950	950	968	958	100	33.3	0.3		ro-	13	1	28	80.0	124.9	851	3.21	repl...	C6H5Cl	33
74	1232	3.8762	917	917	957	919	98	20.0	0.6		-tetr...	14	1	34	64.0	32.2	869	6.35	mai...	C2H2Cl4	20
75	1238	3.8929	953	953	982	953	67	49.6	0.1	42	Ethylbenzene	13	1	35	81.0	99.9	855	2.23	repl...	C8H10	35
76	1260	3.9540	953	953	985	953	32	100	0.2	51	m-Xylene	13	1	41	89.0	124.9	866	2.74	repl...	C8H10	32
77	1295	4.0513	466	466	287	557	14	0.0950	48.1	75	2-Undecenal, E-	8	1	32	1.9	10.3	1365	10.78	mai...	C11H20O	18
78	1303	4.0736	353	353	264	664	11	0.0478	43.7	22	Benzeneethanol, ...	12	1	4	1.1	3.5	1401	7.32	mai...	C8H9BrO	
79	1317	4.1118	854	854	852	854	100	0.136	2.6	7	Ethane, 2-bromo-1...	14	1	6	2.1	5.5	858	1.96	repl...	C4H9BrO2	9
80	1336	4.1648	903	903	877	903	38	40.4	18.6	40	m-Xylene	13	1	28	43.0	142.7	866	2.54	repl...	C8H10	32
81	1337	4.1681	945	945	975	950	34	67.0	10.2	65	p-Xylene	14	1	35	63.0	166.5	865	3.25	repl...	C8H10	32
82	1338	4.1695	913	913	928	920	47	38.5	20.5	41	Styrene	14	1	13	45.0	99.9	893	3.99	repl...	C8H8	41
83	1367	4.2518	452	452	335	452	15	0.658	24.8	104	5,8,11,14-Eicosate...	10	1	103	5.2	8.3	2634	20.34	mai...	C23H32O...	7
84	1372	4.2666	948	948	948	951	88	9.68	0.8	35	Methane, tribromo-	13	1	26	54.0	50.0	892	3.37	repl...	CHBr3	25

Standard mix

Low Resolution EI with AMDIS



High Resolution EI with AMDIS



High resolution improves spectrum deconvolution

LC-MS/MS Identification

Conventional Workflow

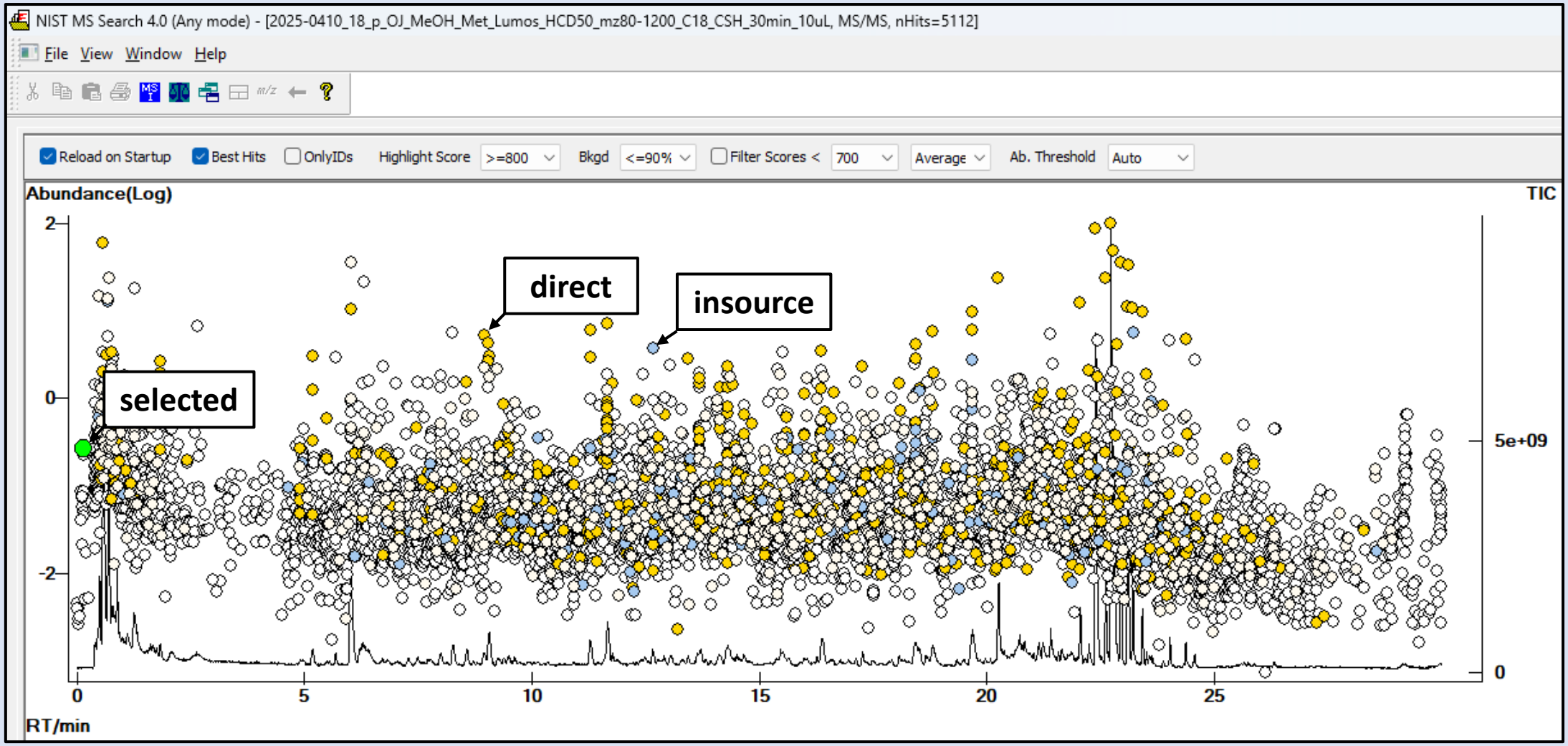
- Select Precursor *m/z* from MS1
- Fragment Ion to Create MS2
- Identify MS2 by Library Match

extend

XIC Analysis Workflow

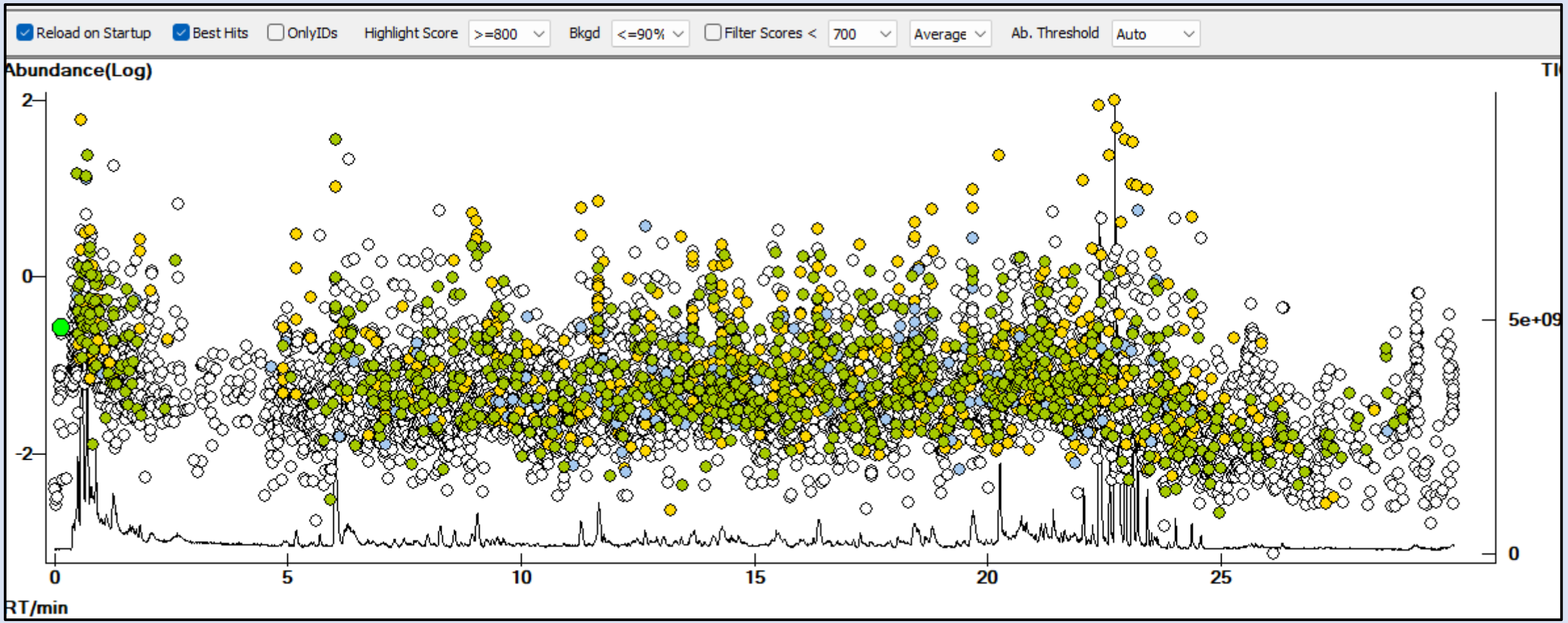
- Isolate XIC for Precursor
- From MS1: RT at Apex, Area, S/N
- Collect all MS2 for this XIC
- Identify Highest Scoring MS2
- Report Best ID, RT, Abundance,..

Orange Juice - LC/MS-MS



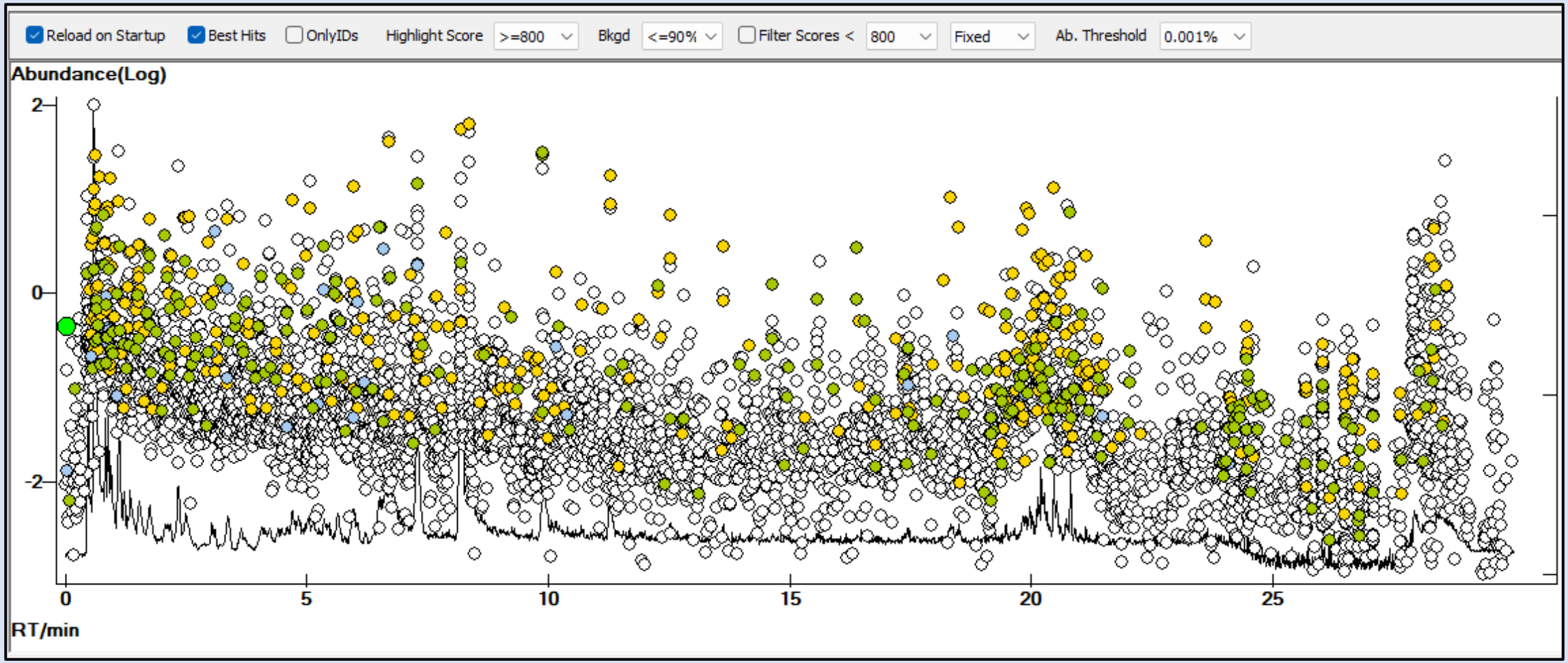
5112 XICs

Orange Juice – 2× with Hybrid IDs

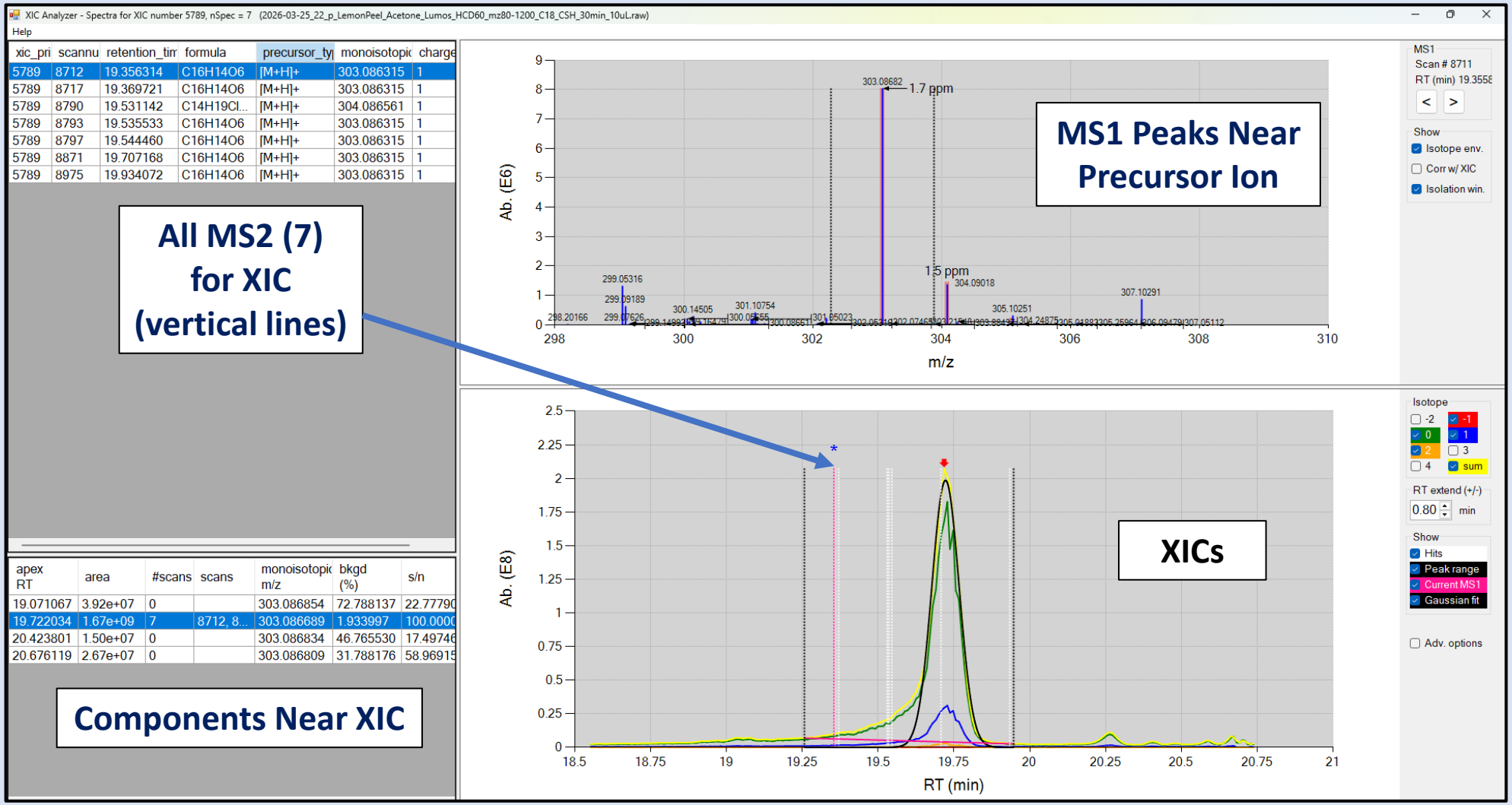


Urine SRM With Hybrid IDs

IDs > 800 increased by 66%



XIC Analyzer – Connect MS2 Spectra to MS1

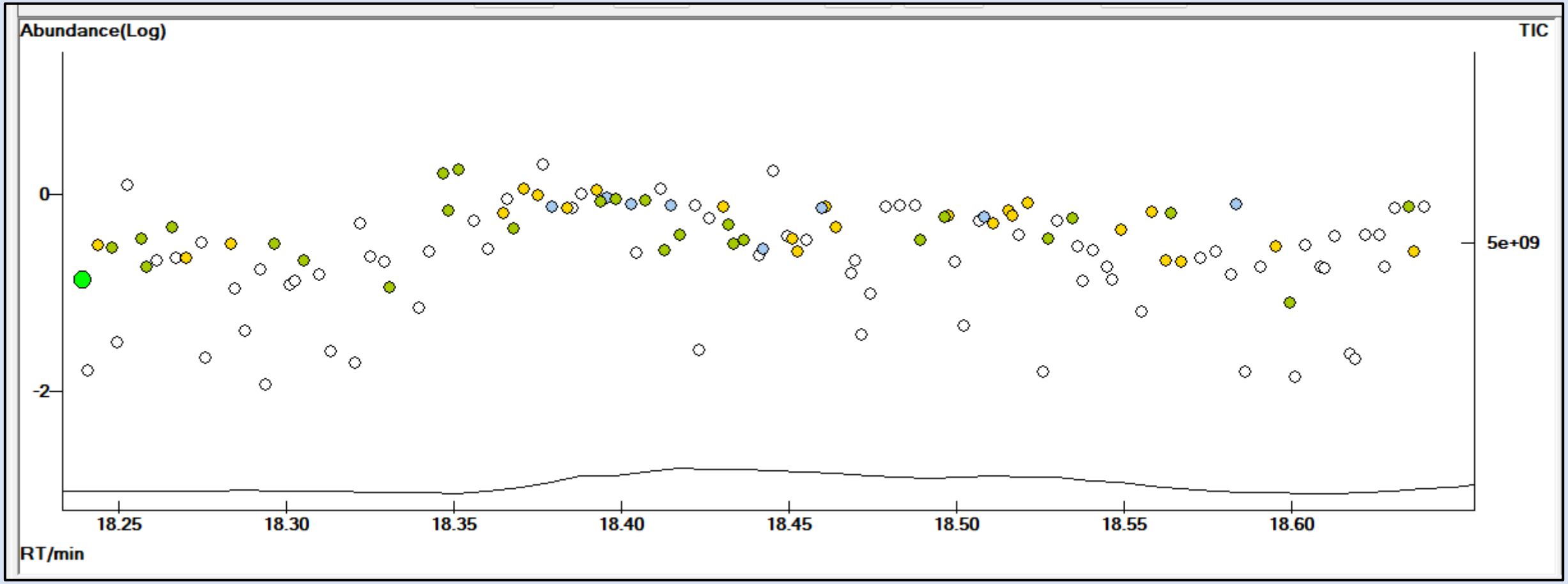


Results for One XIC

Controls

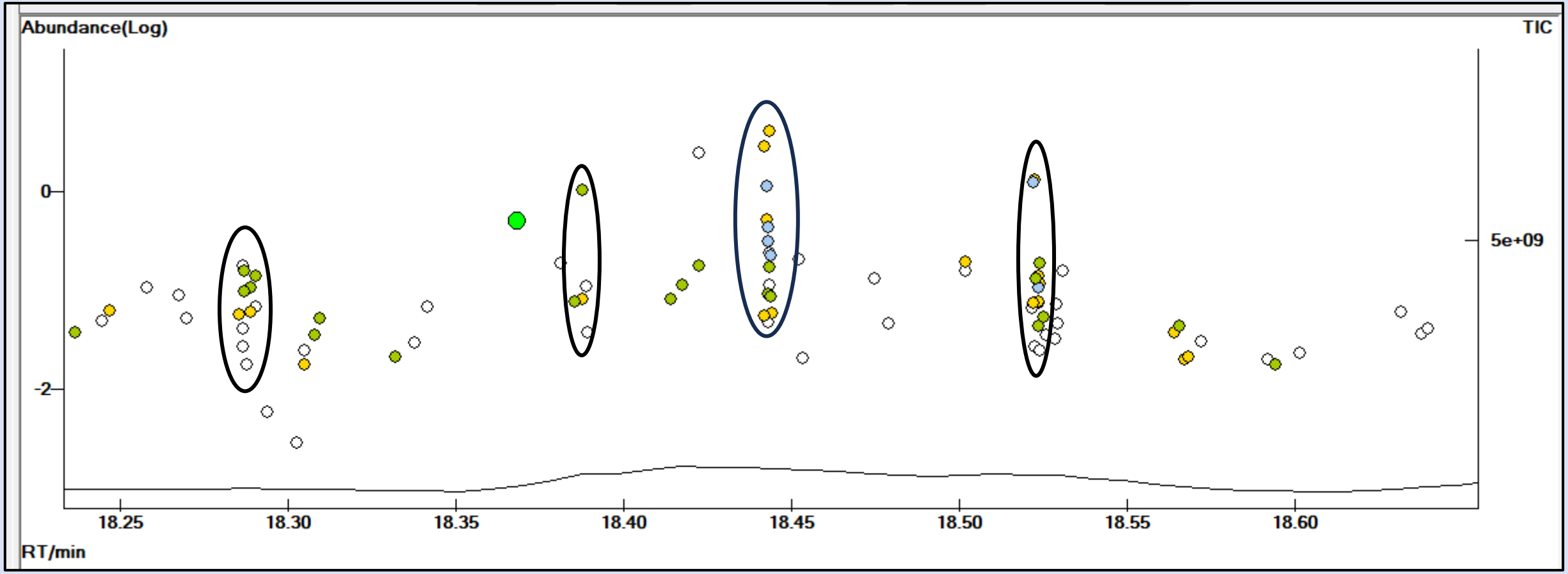
Guanghui Wang et al.
WP 430

MS/MS Spectra: 30 sec Interval

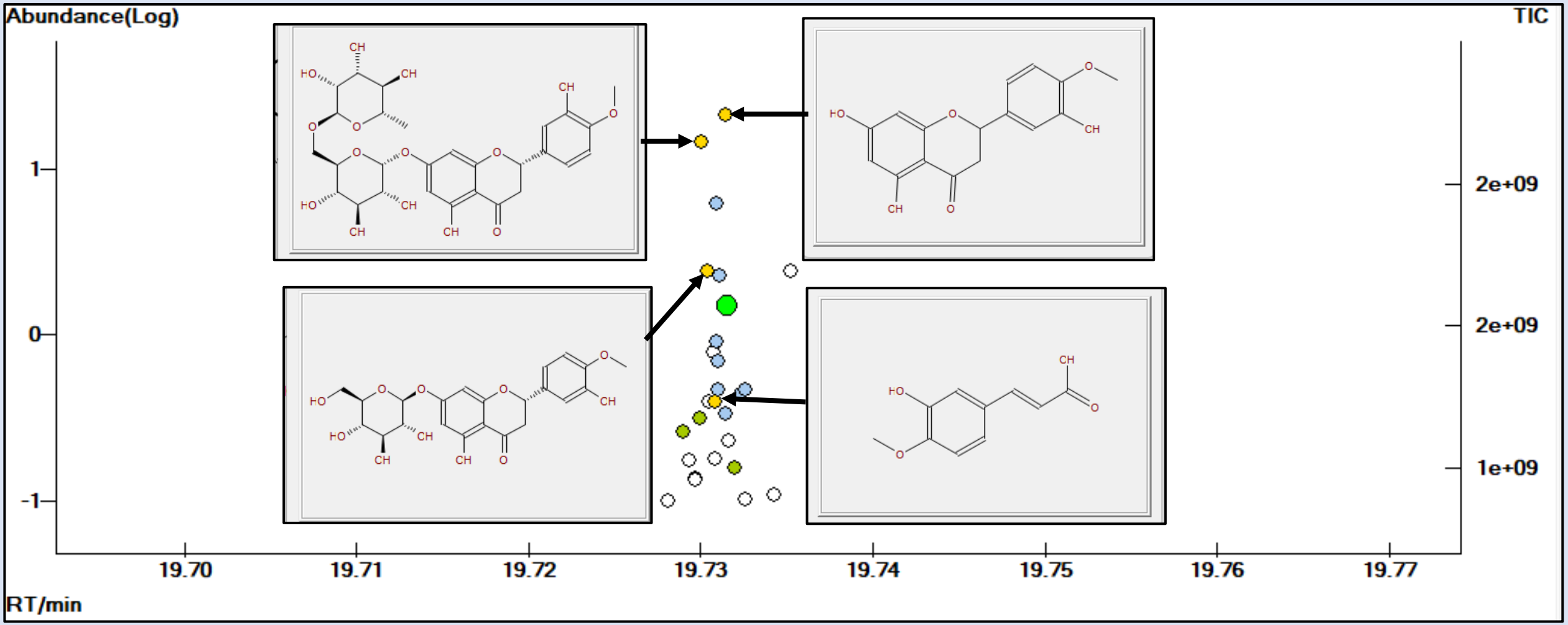


ID In-Source Hybrid

After XIC Analysis

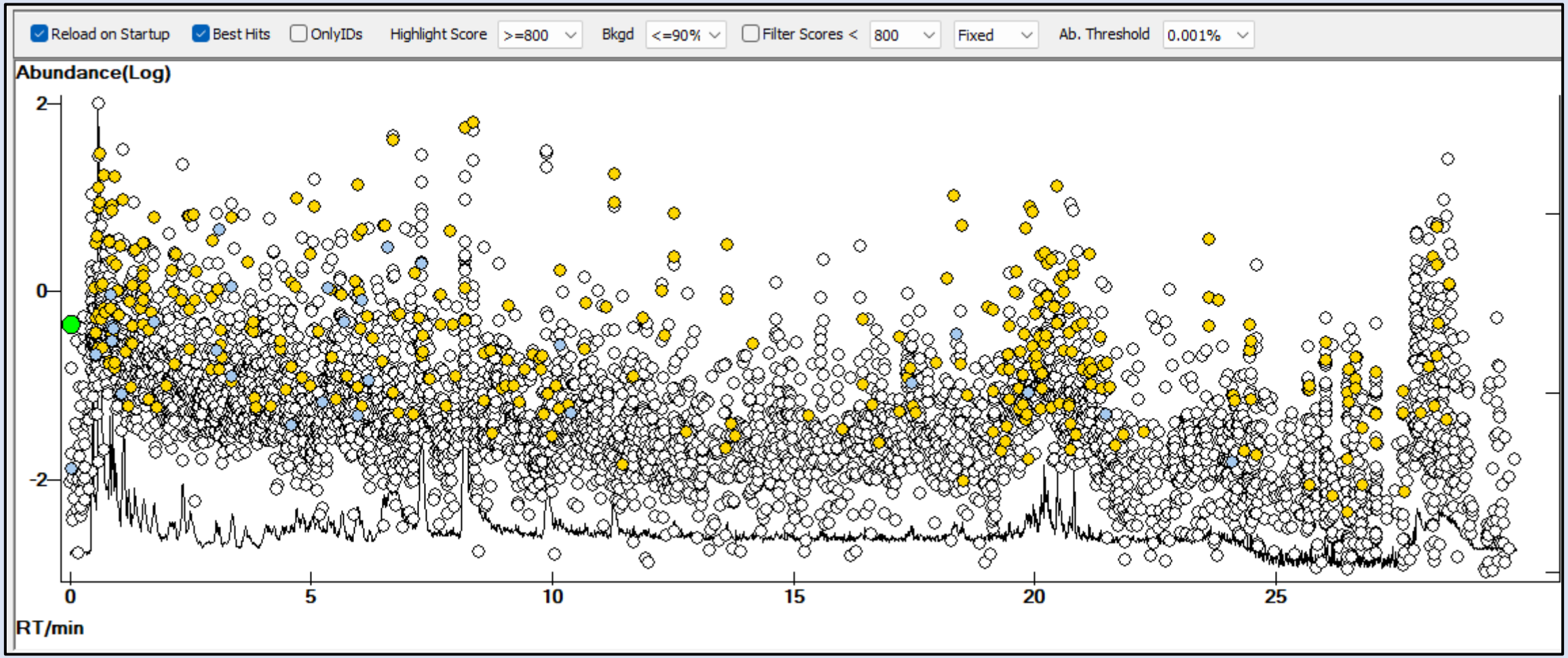


Orange Juice

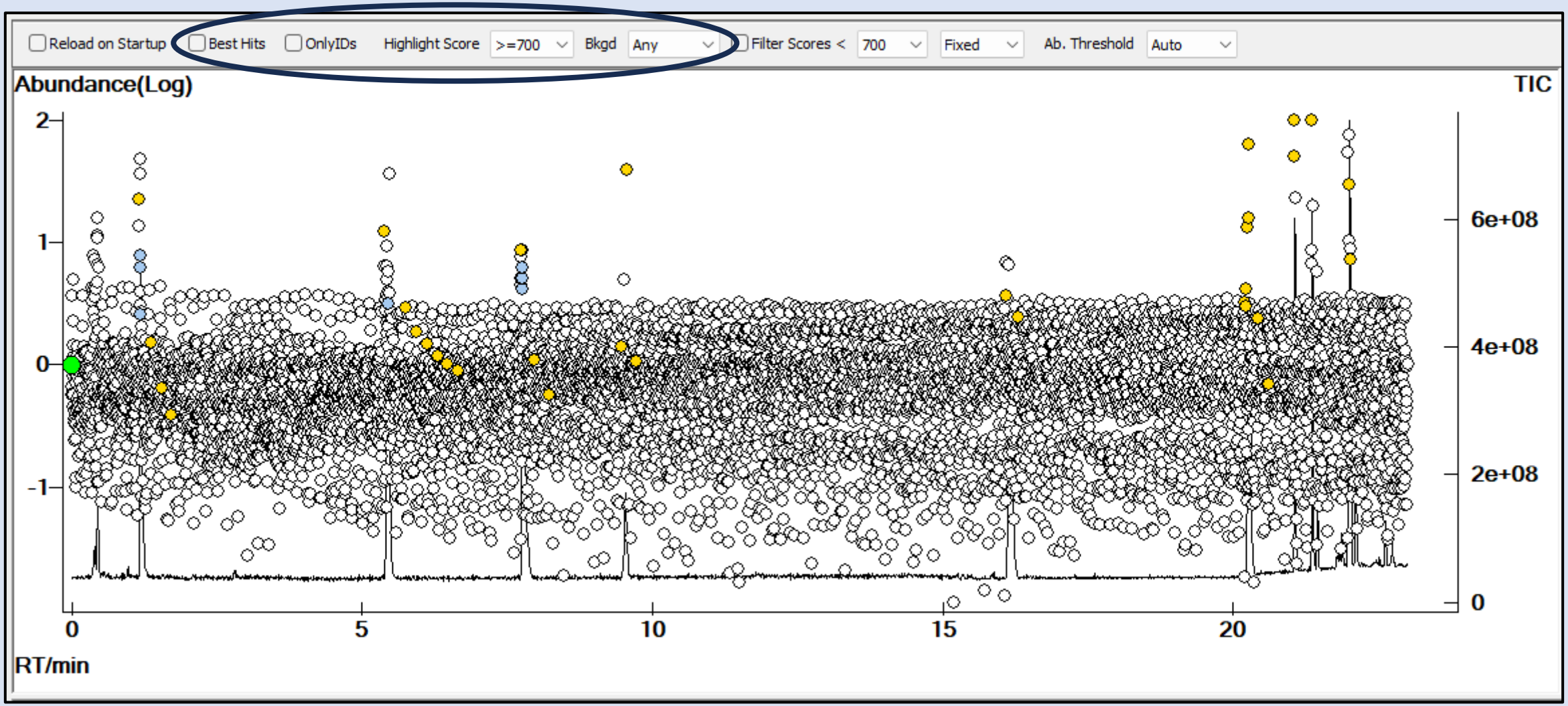


Width ~ 0.2 sec.

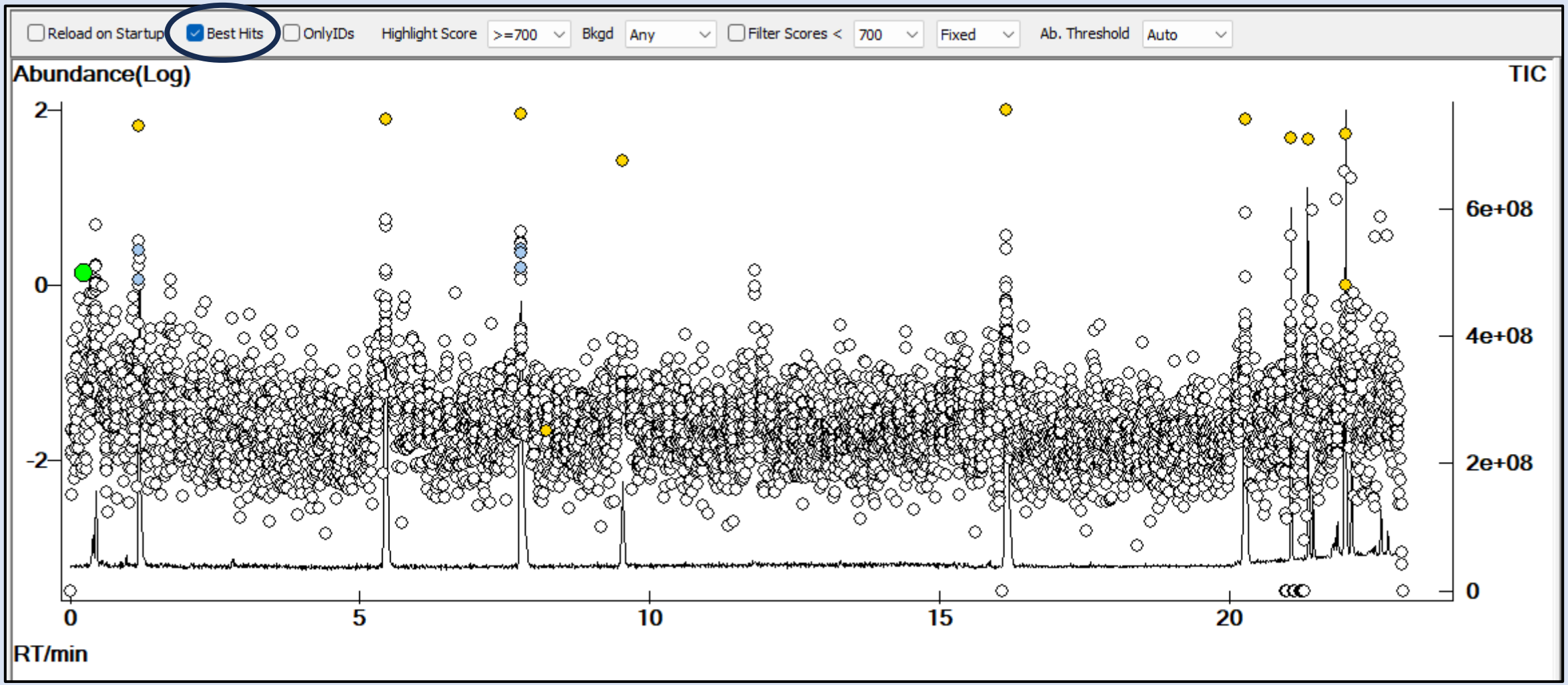
Urine Standard Reference Material (SRM 3671-1)
356 IDs > 800 Score



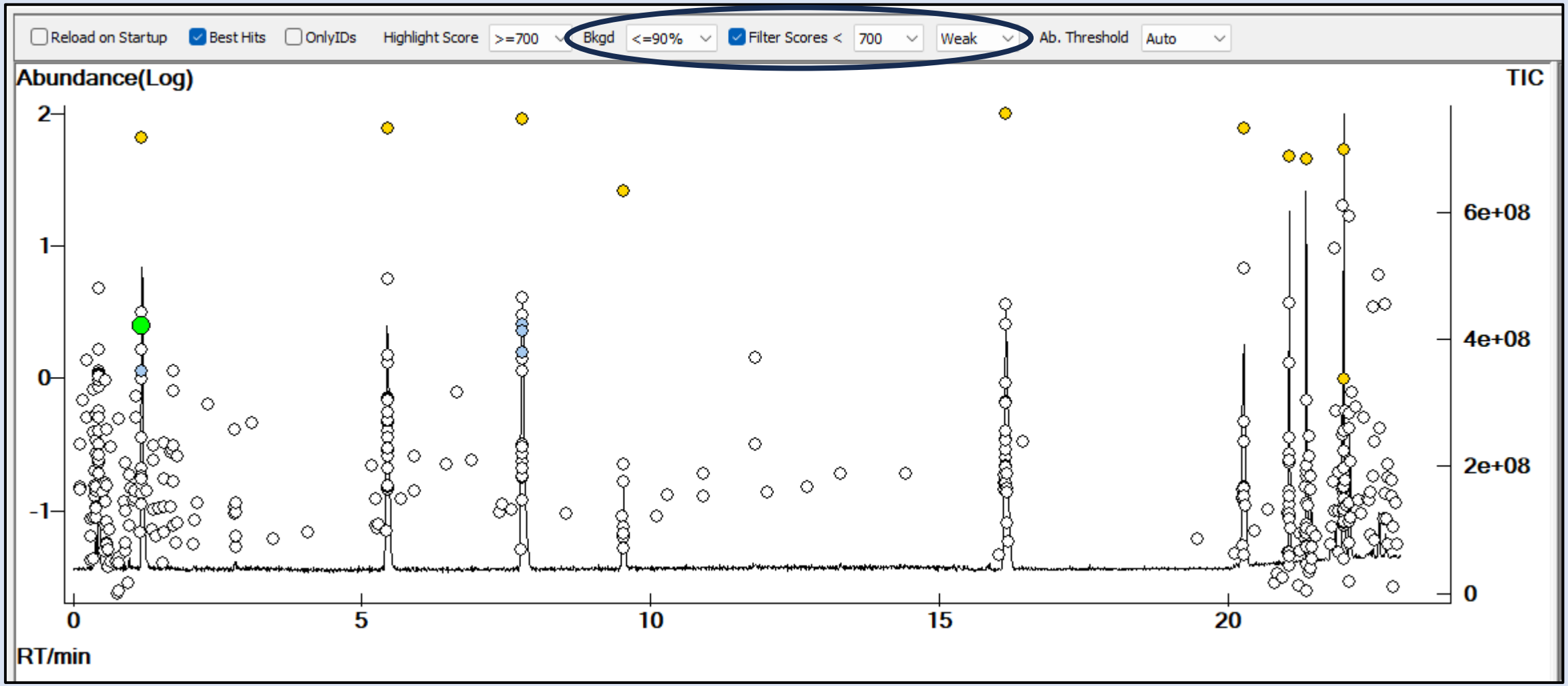
9 Compounds - 7451 Tandem Spectra



4869 XICs


Reload on Startup
Best Hits
OnlyIDs
Highlight Score
>=700
Bkgd
Any
Filter Scores <
700
Fixed
Ab. Threshold
Auto
Abundance(Log)
TIC
2
0
-2
6e+08
4e+08
2e+08
0
0
5
10
15
20
RT/min

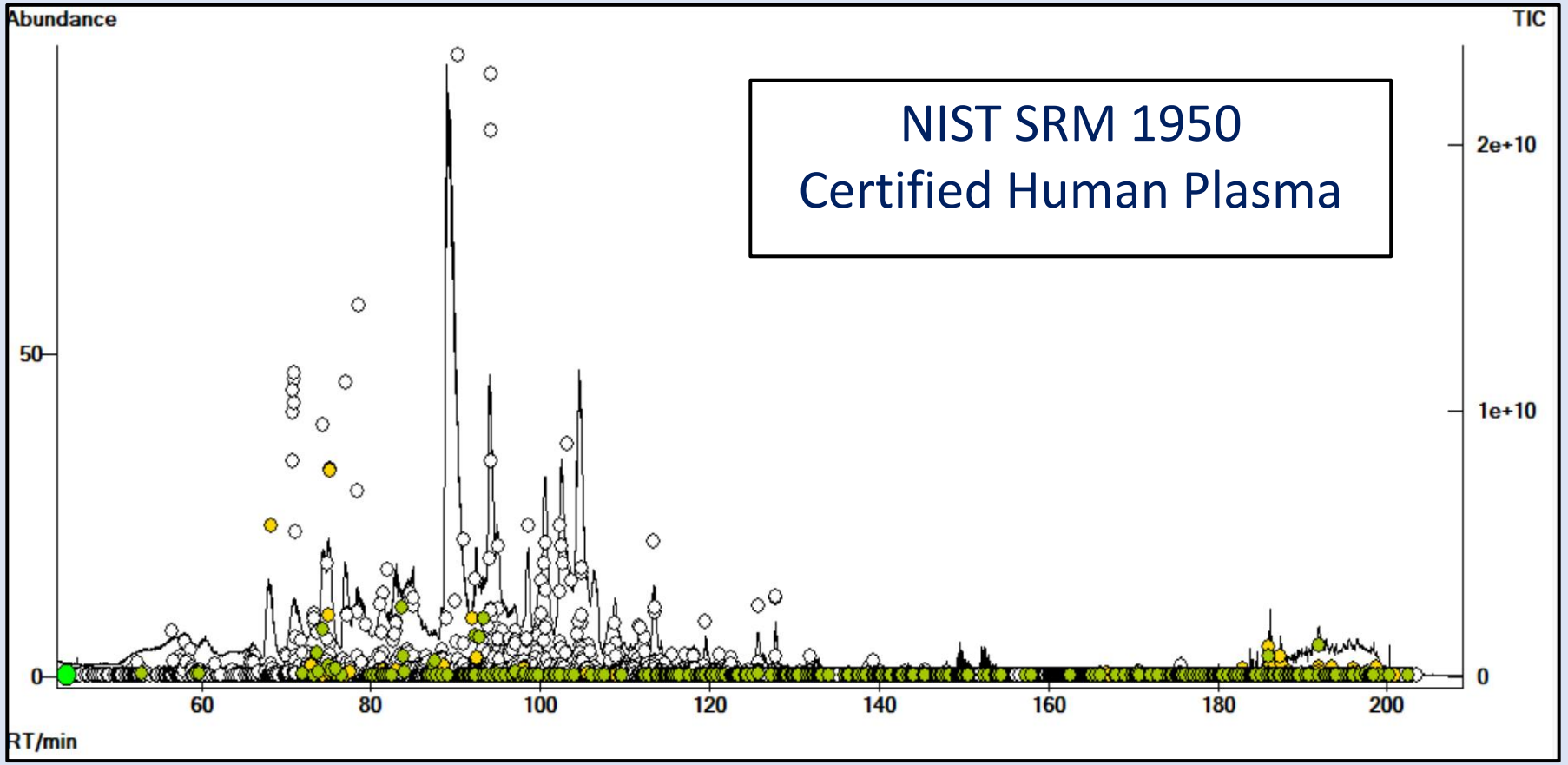
369 XICs After Background Removal



Applications to Proteomics

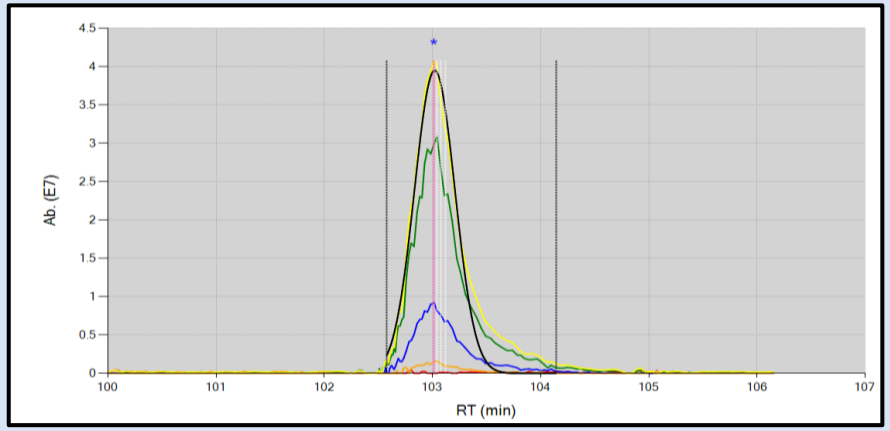
Meghan Burke

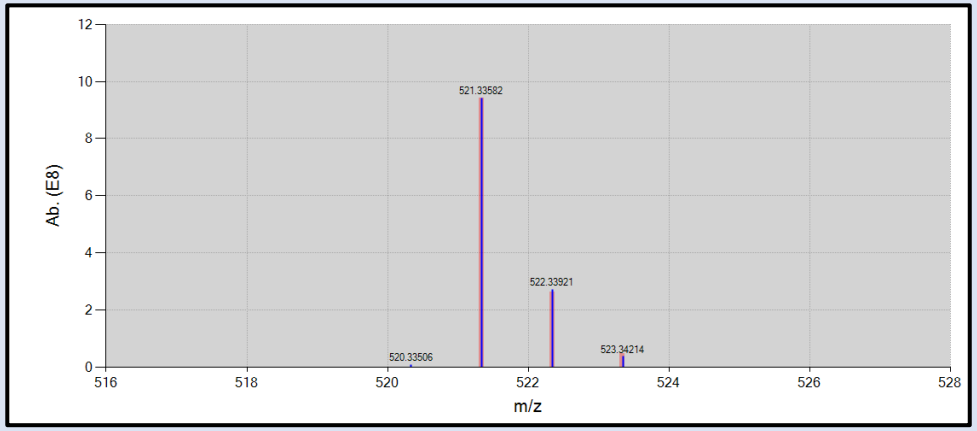
QC for Proteomics LC-MS/MS

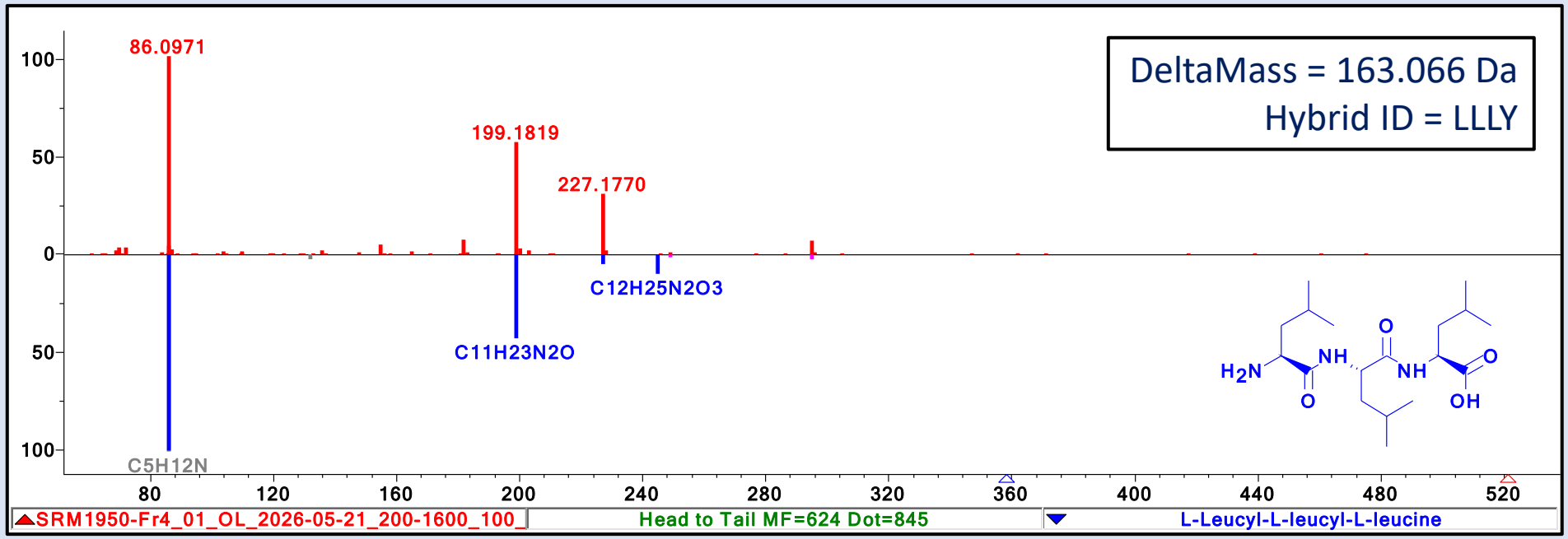


- NIST Tandem Mass Spectral Library to identify unanticipated small molecules
- Insight into sample components that would otherwise be missed

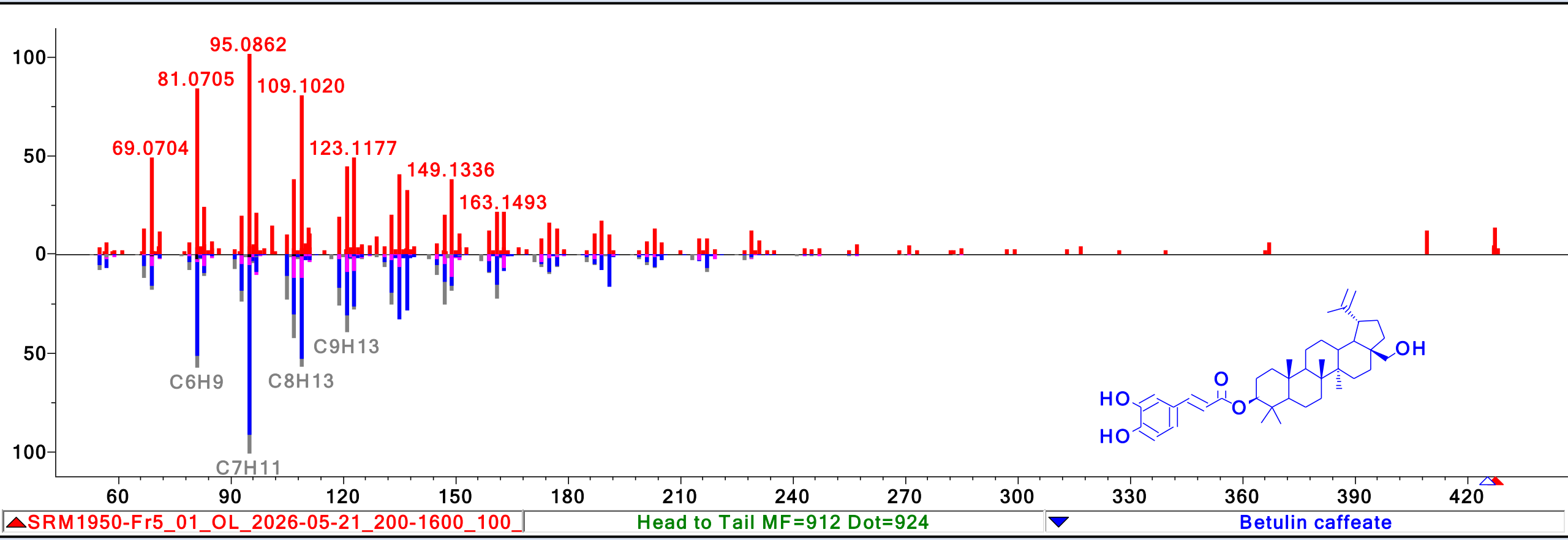
Identify Unanticipated Peptides



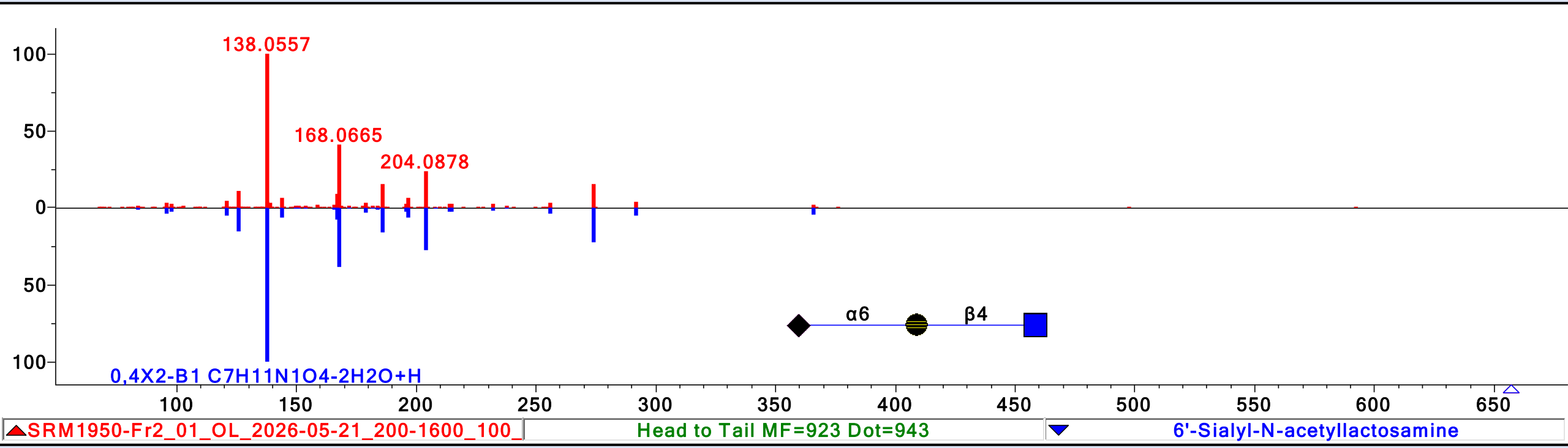




Small Molecules in Proteomic Sample



Glycans in Proteomics Sample

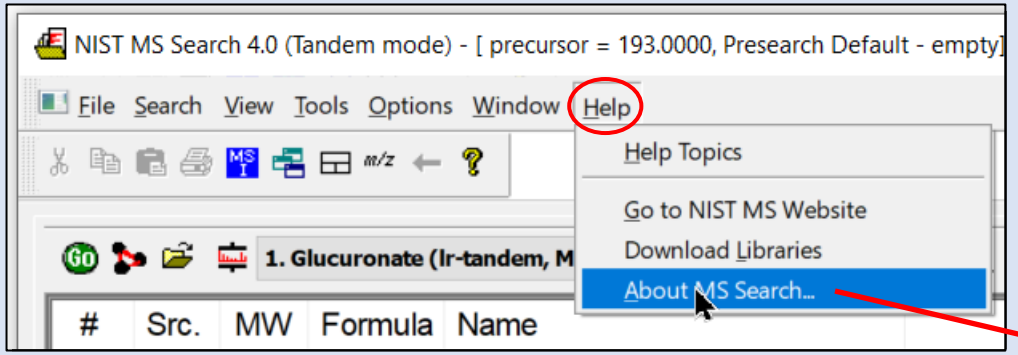


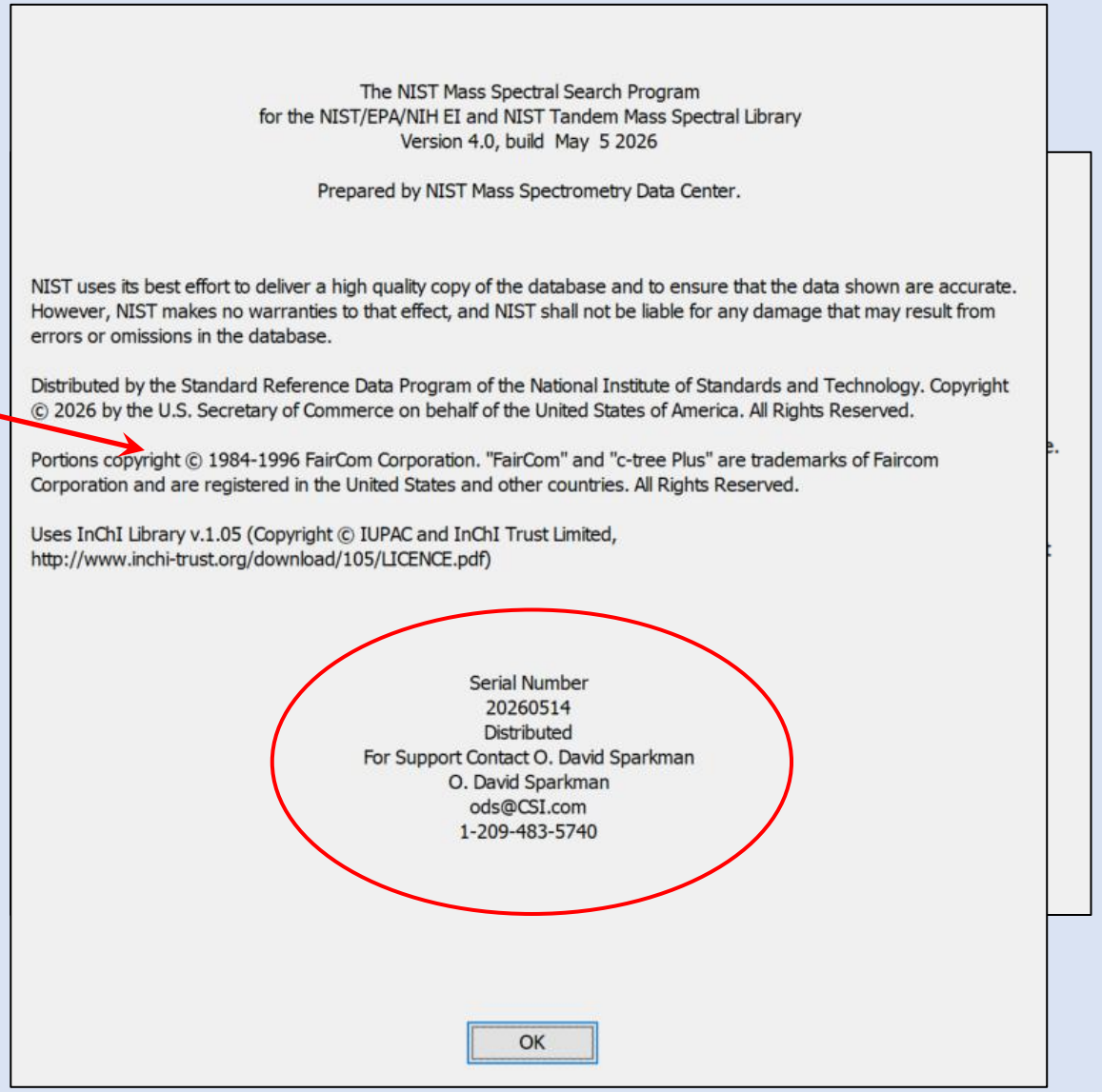
And Now
A Word For Our Distributors

from

David Sparkman

Custom Branding For Distributors



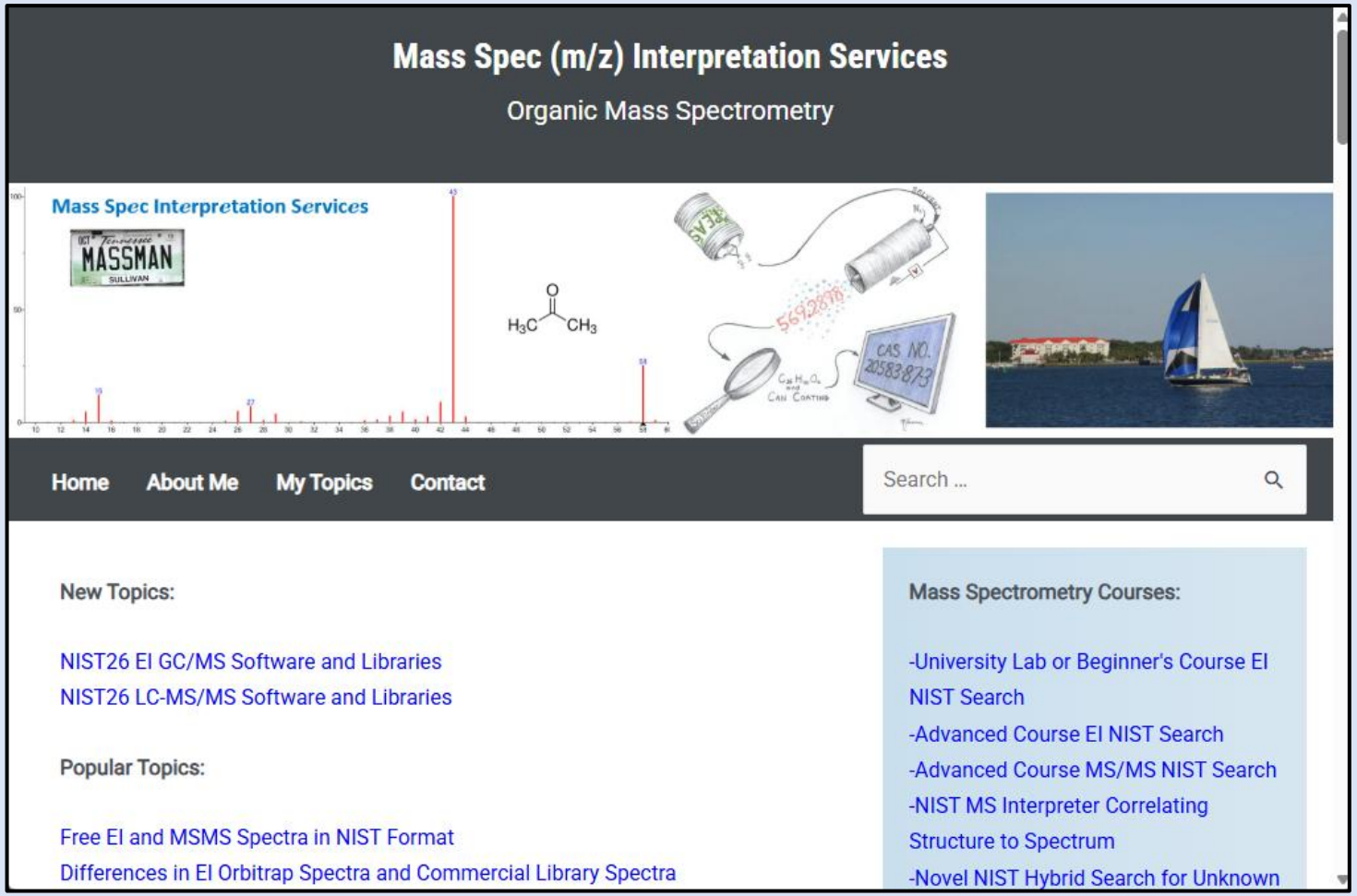


Branding Accomplished by:

- Using **NotePad**, Create a Text file with up to 5 Lines
  - First line Appears under Serial Number
  - Next 4 Lines Appear under heading **Distributed**
- Save file as **Serial.dll**
- For EI Only & GC Method/RI put file in **Setup** folder of installation device
- For NIST 23 Total & Tandem put in \Disk1 folder of the folder with the Batch setup file

Tutorial Videos for NIST 26 and More

https://mzinterpretation.com/



- **Using NIST Mass Spectral Search Programs**
- **Software & Libraries**
- **Compound Identification**
- **Videos, Data, Handouts**

by **James Little**

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
U.S. DEPARTMENT OF COMMERCE

NIST Mass Spectrometry Data

NIST Mass Spectral Data, Tools & Documentation

Coming in June! - Release of our 2026 Mass Spectral Libraries

Electron Ionization (EI), Tandem (MS/MS)

Visit our Booth (720) or Monday Breakfast (7 am, Room 7AB Convention Center) at the ASMS Meeting in San Diego

GC/MS (EI & RI)
- NIST Overview
- EI Search Program (Demo)
- GC Retention Indices
- Free EI Libraries

LC-MS/MS (Tandem)
- NIST Overview
- Tandem Search Program (Demo)
- Peptides
- Free Tandem Libraries/Utilities

MS Tools
- MS Interpreter
- AMDIS (GC/MS)
- MS Pepsearch
- Library Builder (Lib2NIST)

Other Information
- Papers/Presentations
- Distributors
- NIST Chemistry Webbook
- Dart Forensics

Our New Website

- Information
- Software
- Free data

Chemdata.nist.gov

NIST26

See you at our Booth (#720)

2023