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A Brief History of Thermo Fisher (High Resolution) Mass Spectrometry in Bremen

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Bremen, Germany, and Austin, TX

Where is Bremen ?

Bremen

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Bremen, Germany – Central Location in Europe

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Bremen City

- Town Musicians – Symbol of the City

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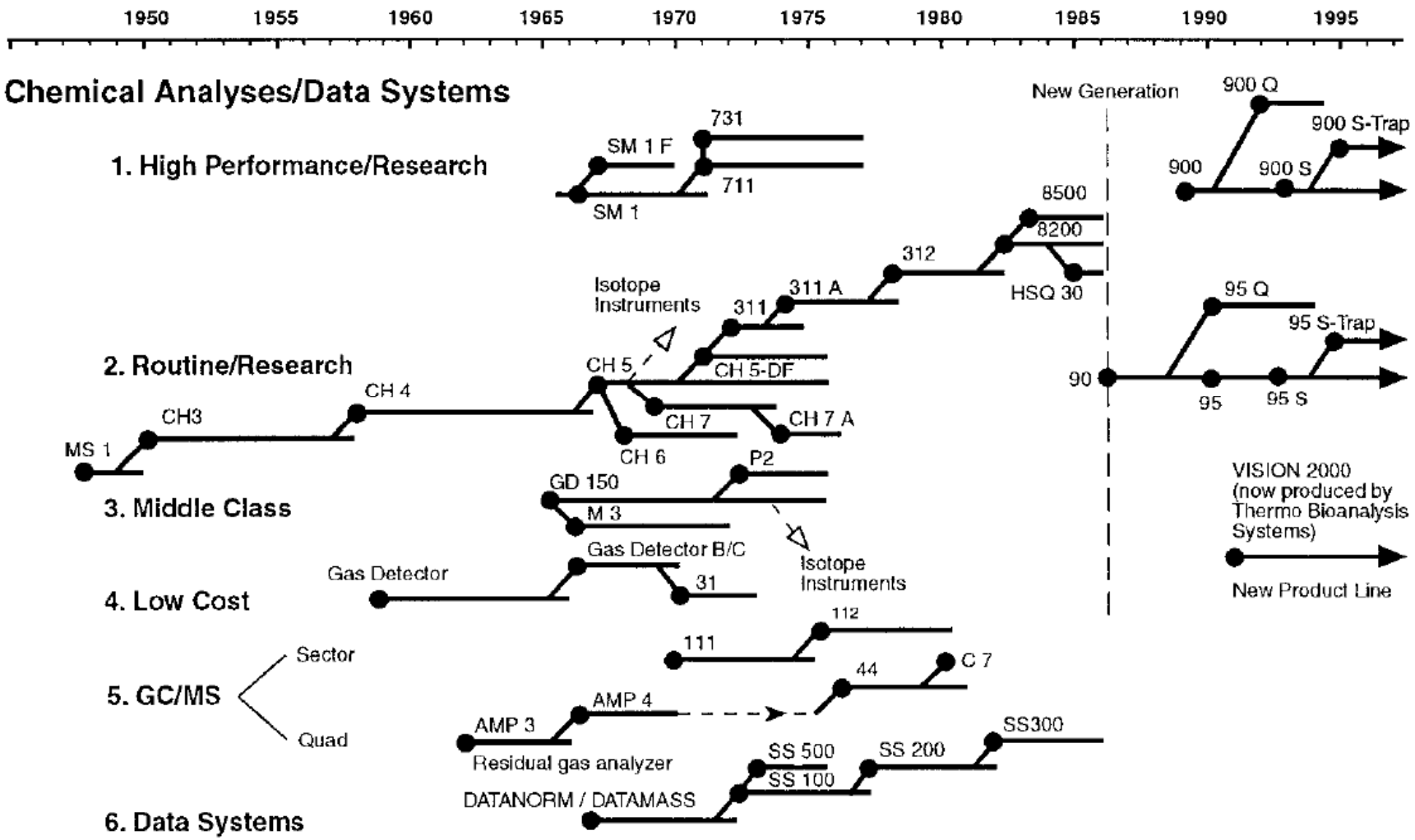
History of Thermo Fisher Mass Spectrometry in Bremen

„Organic“ MS Family Tree of MAT in Bremen



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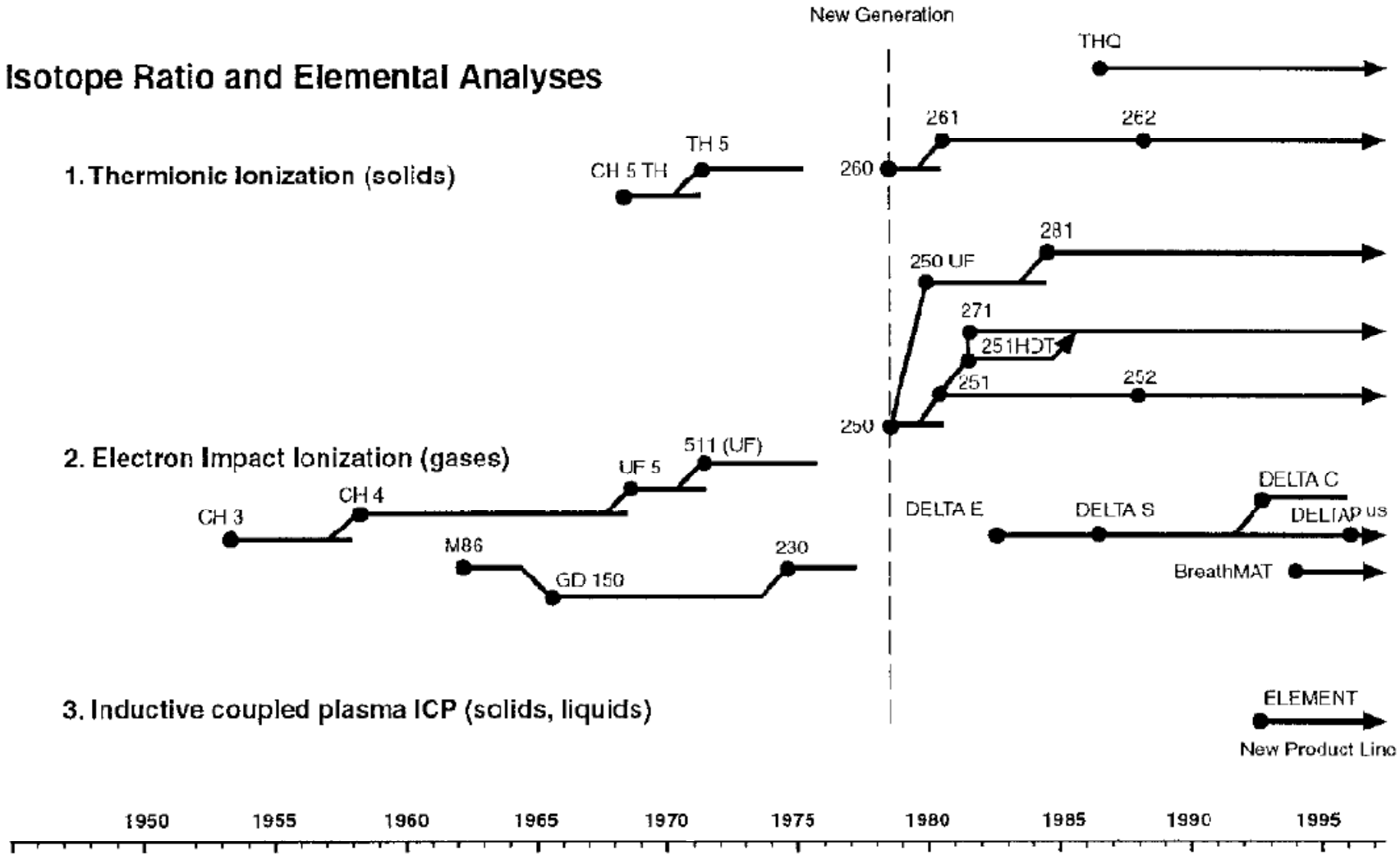
„Inorganic“ MS Family Tree



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The Roots – The Atlas Factory in Bremen

- 1902, Jan 15 founded in Bremen, Germany
  - as Norddeutsche Maschinen- und Armaturenfabrik GmbH
  - Ship yard (to 1,500 mt), aux. power units, spec devices
- 1911 Name changed to Atlas Werke AG
- 1913 2,000 employees
- 1943 3,100 employees, partialy destroyed during the war
  - Seawater treatment plants
  - Sonars und sound detectors
- 1945 Reconstruction
  - No shipbuilding, only machinery and instruments

- 1947 Atlas - MAT division (Measurement and Analysis Technique)
  - Started as a private part time initiative by Ludolf Jenkel

ATLAS MAT in Bremen

Dr. Ludolf Jenckel (Physicist, Atlas Werke AG)

- Inspired by Wilhelm Walcher, Prof of Physics, Univ Göttingen,
- Developed in 1 year together with one colleague the first MS prototype in the cellar of a hospital, called *MS1*
- Magnet came from his teacher Walcher
- Mounted on a wooden frame

After completion he persuaded Atlas AG to set up a division for MS:

1947 Atlas MAT was founded !

Measurement and **A**nalysis **T**echnique

First unit sold to the *BAYER AG* Leverkusen, Germany

Companies in England (MetroVick/AEI) and the US (CEC) already sold commercial mass specs.

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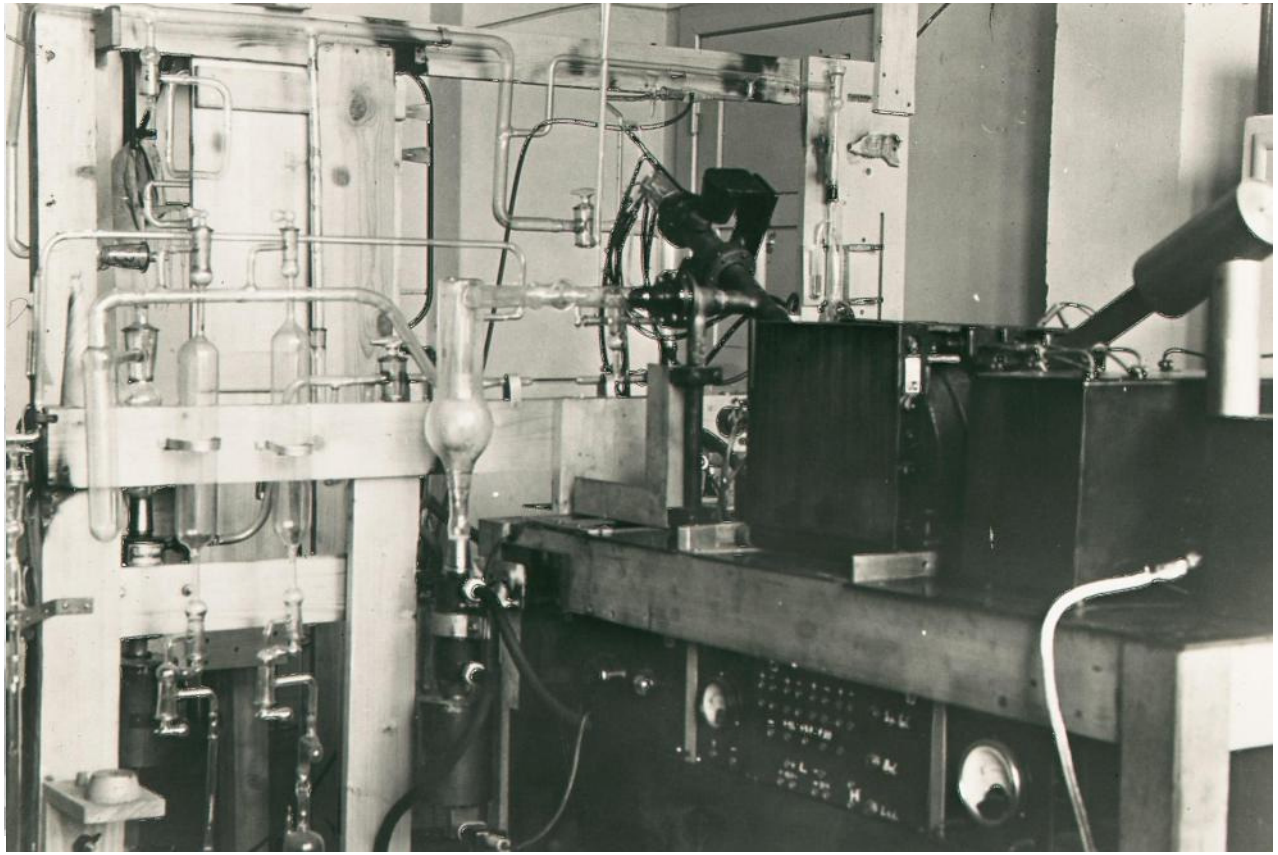
MS1 – The First MS Prototype



Inlet

- All glas
- (made biggest headaches)
- Volatile samples only

Analyzer

- Single focussing

Also called

- „The Wooden Bench“

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The Atlas MAT Upswing

- 1947 *CH1*
- 1950 *CH3*
  - First series instrument (R 300)
  - Volatile samples only
- 1958 *CH4*
  - 60° sector, 400 installations
  - Suitable for non-volatile samples
  - Curiosity: GC coupling
    - Market feedback „no use“
- 1960s *MAT 31*
  - Leak detector, smallest magnet ever

- 1947 Atlas – MAT Division
  - 1954 20 employees
  - 1956 28 employees
  - 1956 new own building
  - Competitors
    - US:CEC (RGAs),
    - UK MetroVick/AEI (Beynon, Swansea university) double focussing HRMS, accurate mass)
- 1956 Thermo Electron
  - Incorporated by George Hatsopoulos as MIT student

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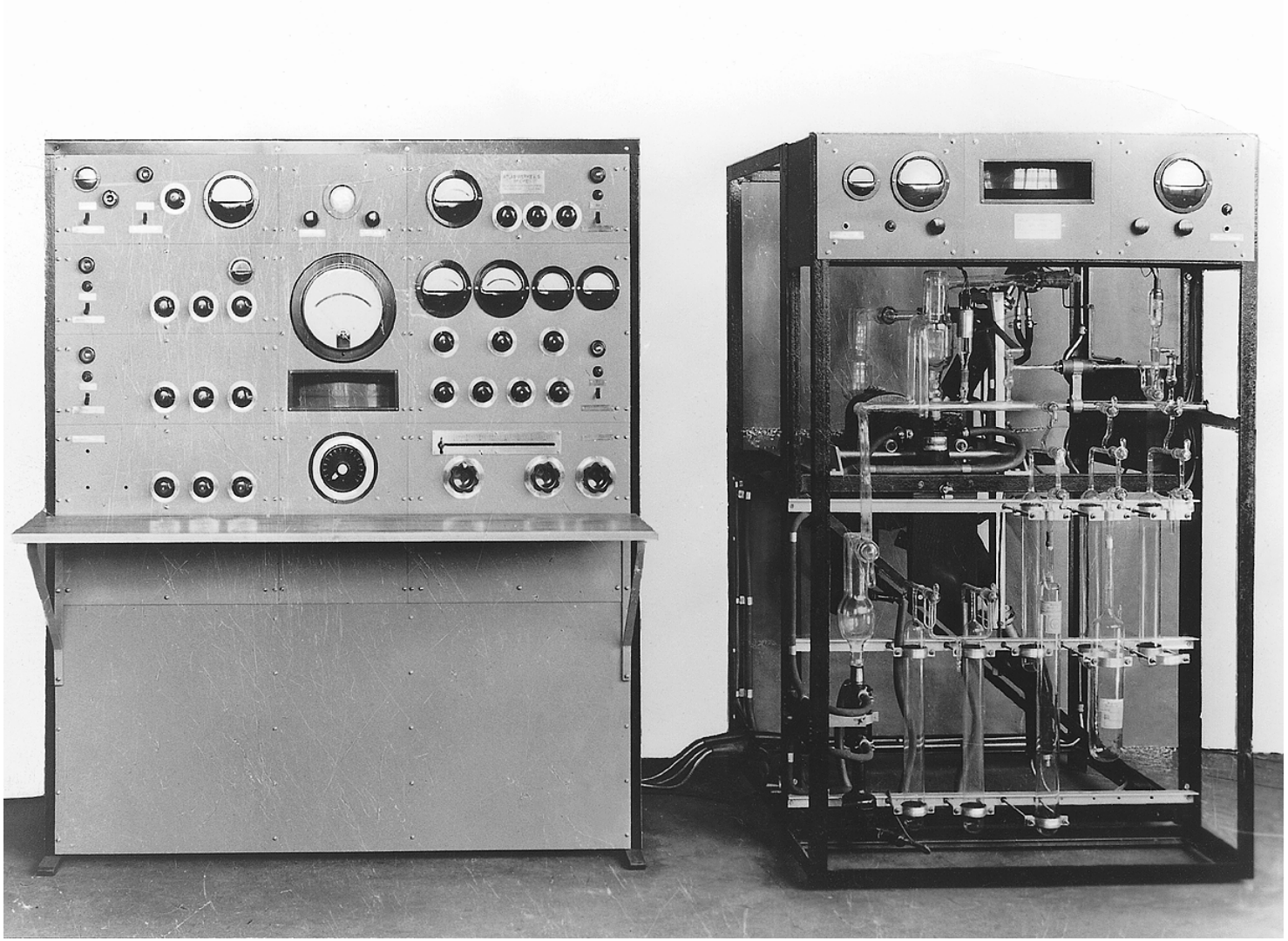
CH3 – Photo of the Prototype (1950)



1952
Exhibited at the Achema show in Frankfurt

Resolution **300**

1954
Sales volume 100.000$ per year.
Not enough for a division with 20 people

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CH4 – First Success (1958)

1967

> 400 units installed

Applications

- Coffee aroma
- Perfumes
- Cigarette smoke

MAT expanded

GC-CH4

Launch at ACHEMA as curiosity

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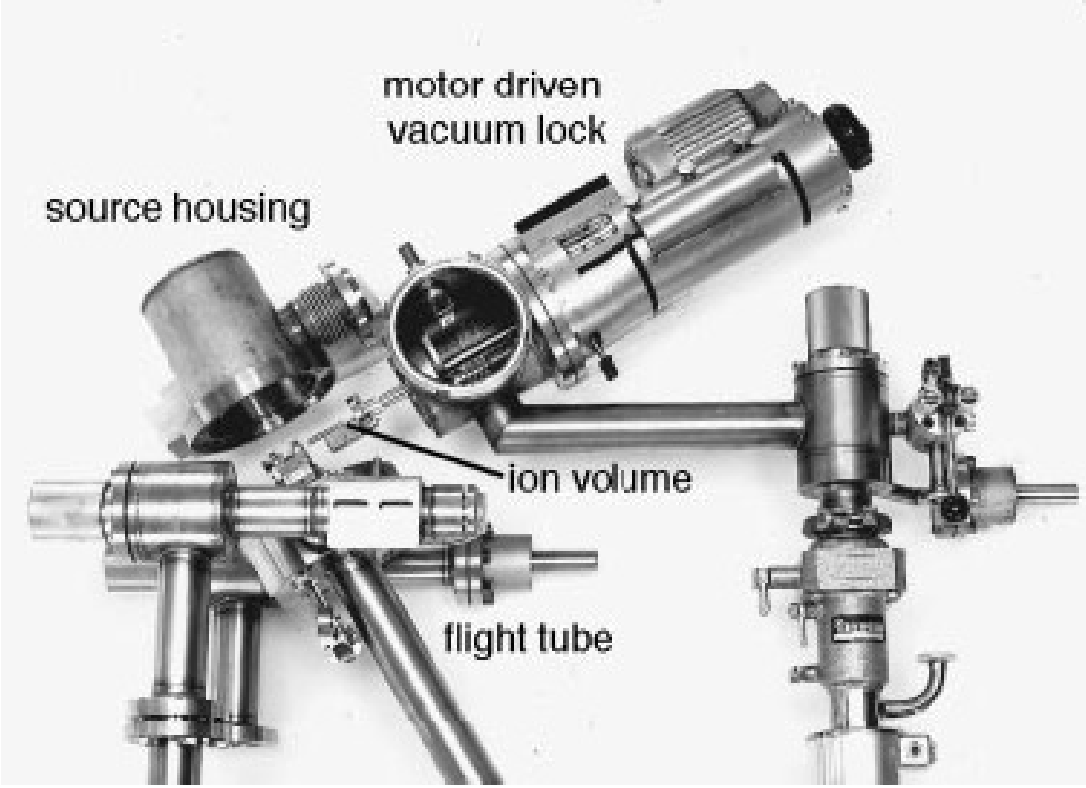
CH4 - First Vacuum Lock for Solid Sample Inlet (1960)

- Before all MS could only be used for volatile samples (all glas inlet)
- Innovation „Solid sample inlet“
  - A „boat“ with sample in mg amount was pushed into the ion source



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MAT31 – VAMS RGA Residue Gas Analyzer (1960)

Mass Range
1 – 110 Da

Resolution
44

Sensitivity
$5x10^{-12}$ Torr Ar
partial pressure

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The 60s – Varian MAT

- 1962 *AMP2*
  - First quadrupole RGA
- 1966 *SM1*
  - Double focussing (organic)
  - SM1 F (inorganic, spark source)
  - MAT 731 (photoplate recording)
  - MAT 711 (magnetic scan)
- 1967 *CH5*
  - fully transistorized circuits !
  - R 10 000 !
- 1970 *CH5-DF* > *MAT311*
  - Reverse Nier-Johnson BE config
  - MS/MS, R > 20 000

- 1962 Atlas MAT
  - Now independent from Atlas
  - 1965 $ 4m revenue
  - 400 Employees
- 1966 Krupp Atlas MAT
- 1967 Varian MAT
  - *M66* cycloidal HRMS
  - Market went for *CH5*
  - 1971 $ 10m revenue
  - 600 Employees
- 1967 Finnigan Corp founded

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SM1 - Mattauch-Herzog Geometry (1966)

1966

High End MS

The first double focussing MS

Datasystem

DATANORM

Later:

MAT 731: Photoplate

MAT 711: B Scan

SM1 F: Spark source

But:

High production cost thus high priced MS

at Hamburg University, Organic Chemsitry

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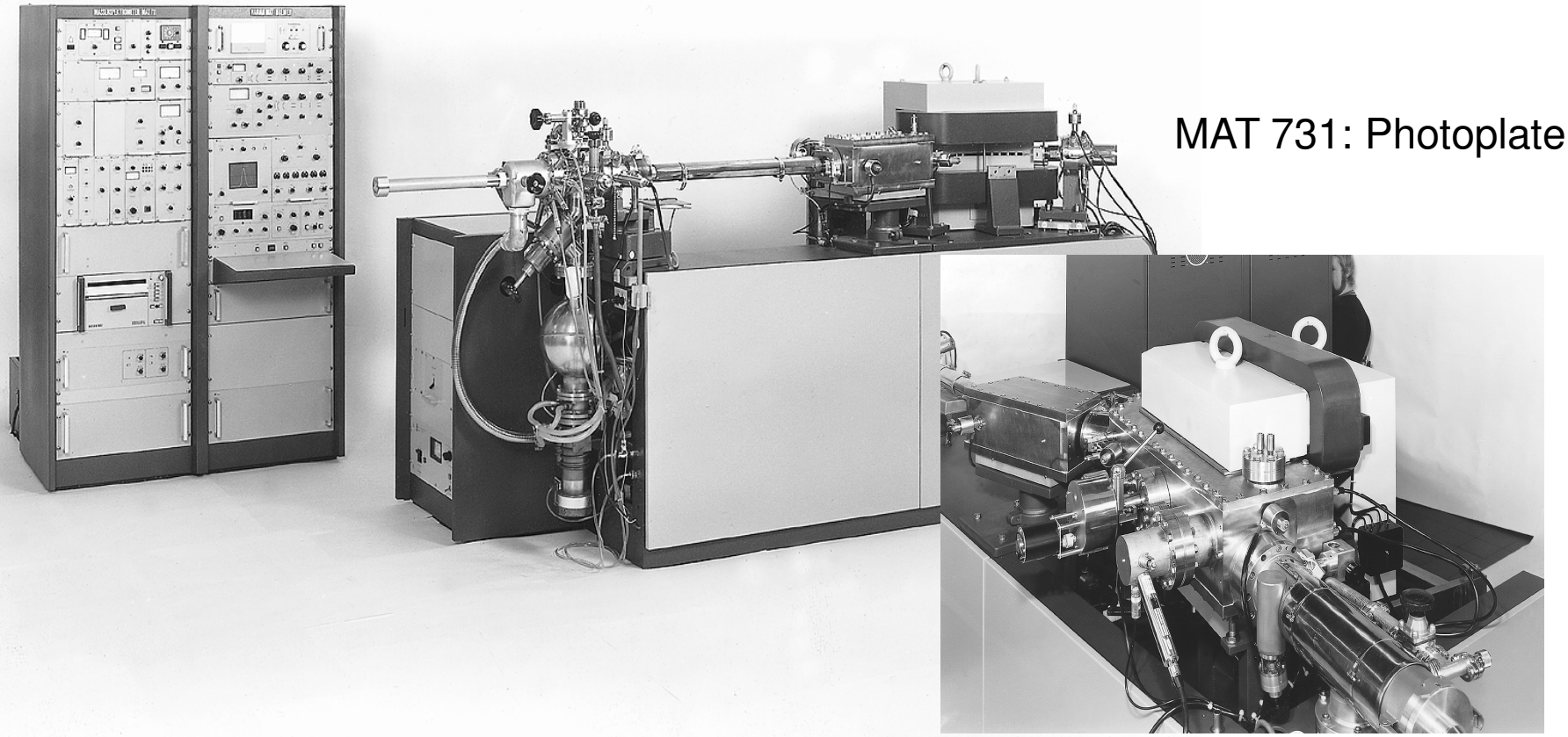
MAT 711 / 731 - Mattauch-Herzog Geometry

MAT 711: B Scan

MAT 731: Photoplate



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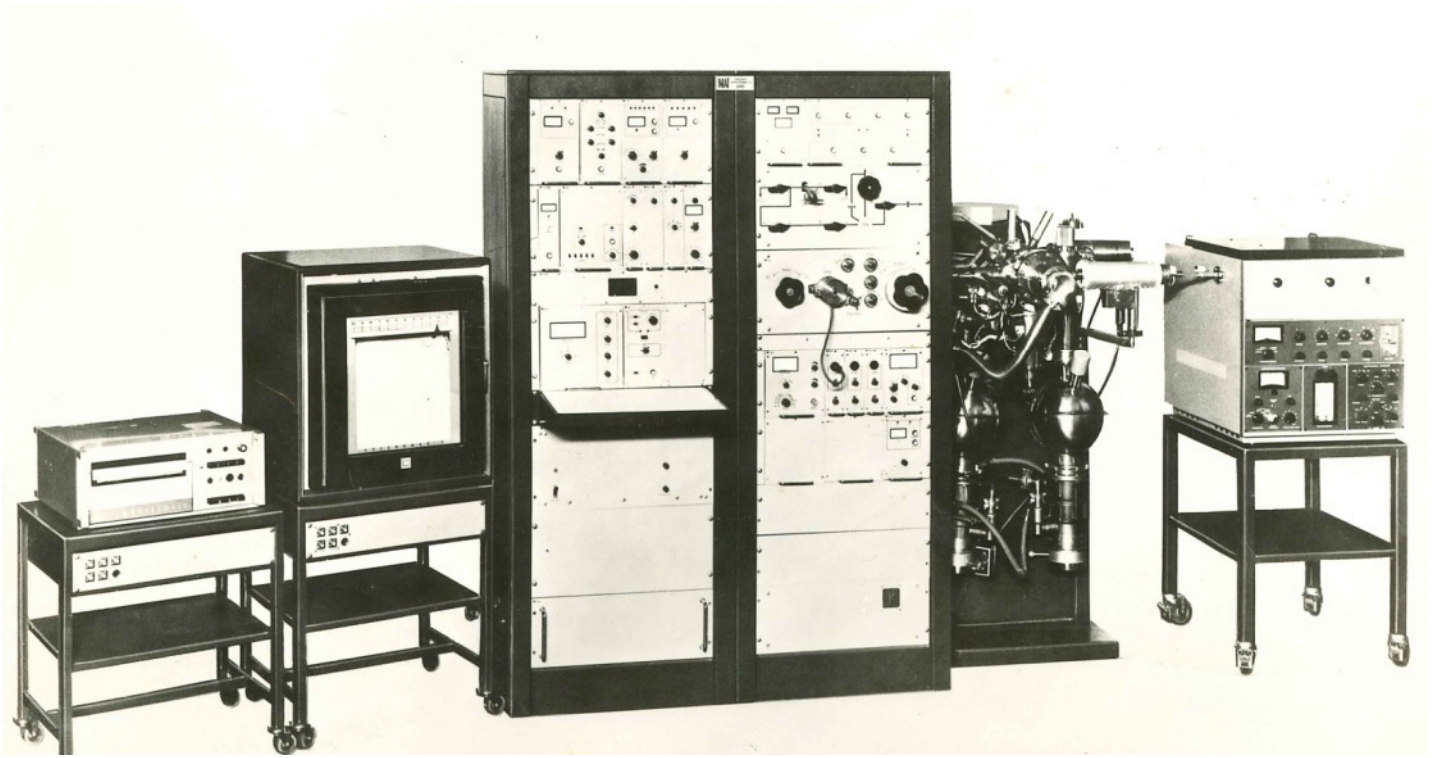
CH5 – High Resolution Routine MS (1967)



For routine analysis
- Single focussing
- GC coupling
- Double focussing optional

Resolution
- > 10 000
- > 30 000 CH5-DF

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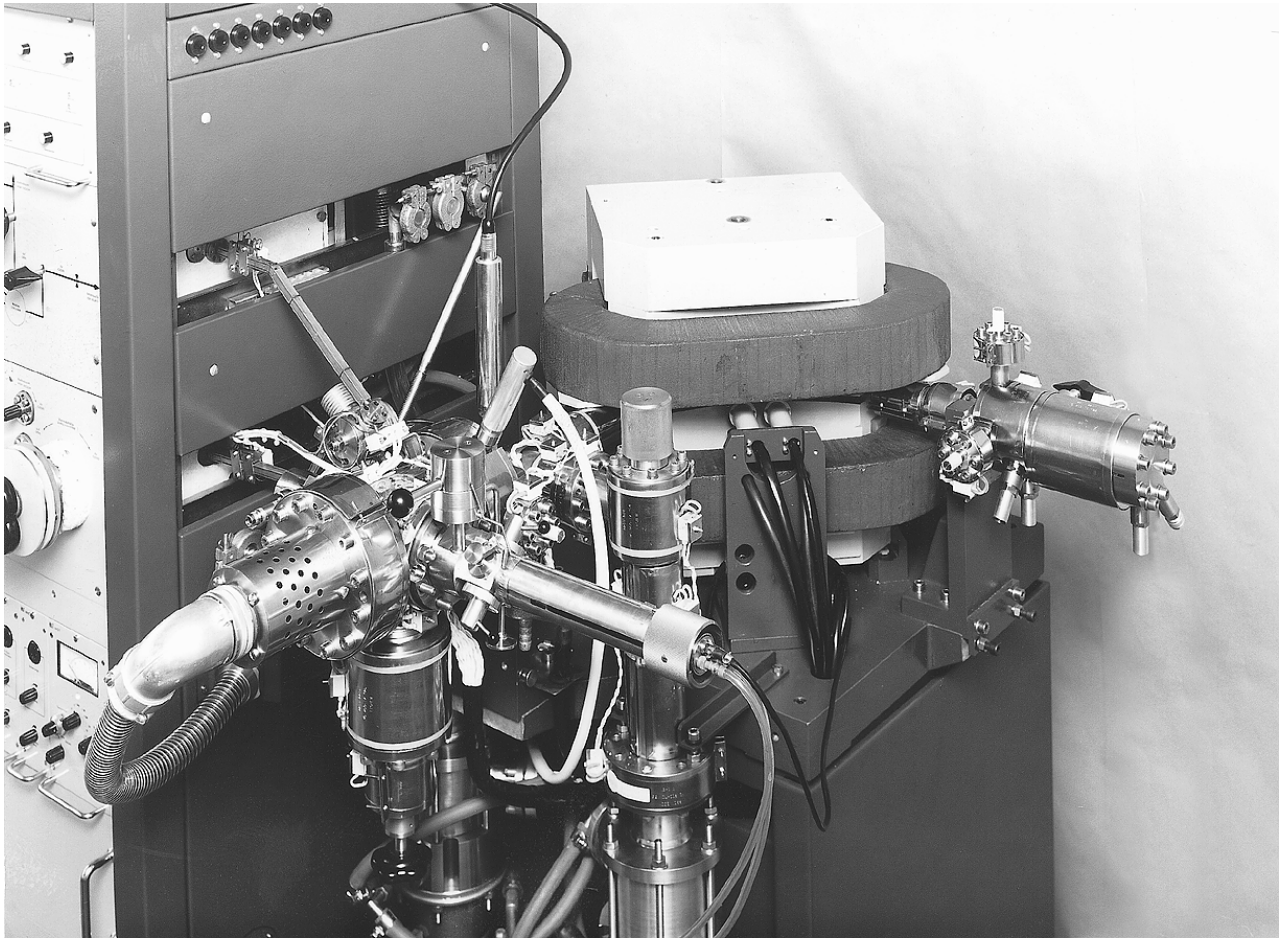
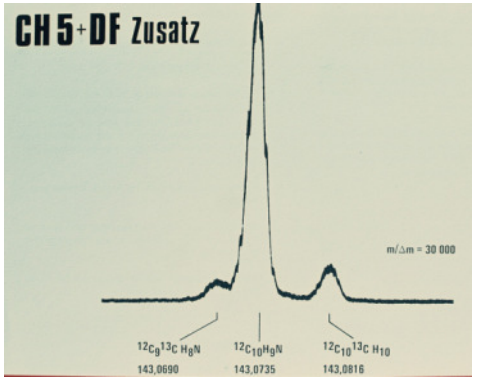
CH5 Magnet - CH5 was built until 1975



1971
CH5-DF
double focusing MS
for routine analysis
R > 30 000
143,0735
143,0816



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Growth in the 70s and 80s – Finnigan MAT

- 1971 *MAT111* „Gnome“
  - First compact GC-MS System
- 1975 *MAT112*
  - R 10 000
- 1977 *MAT44*
  - First fully computer contr. MS
  - R 12 000 (50%)
  - Hyperbolic Quads (1 µm prec.!)
- 1978 *MAT312*
- 1982 *8200*
- 1986 *MAT90*
  - First fully computer contr. HRMS
- 1990 *MAT95*
  - Competitor
    - LKB9000 GC-HRMS (Sweden)
- 1976 New building
  - 14 000 m^2
  - > 1000 MS systems shipped
- 1981 Finnigan MAT
  - Appl. lab moved from Munic to Bremen
- 1990 Thermo Electron
  - ThermoQuest

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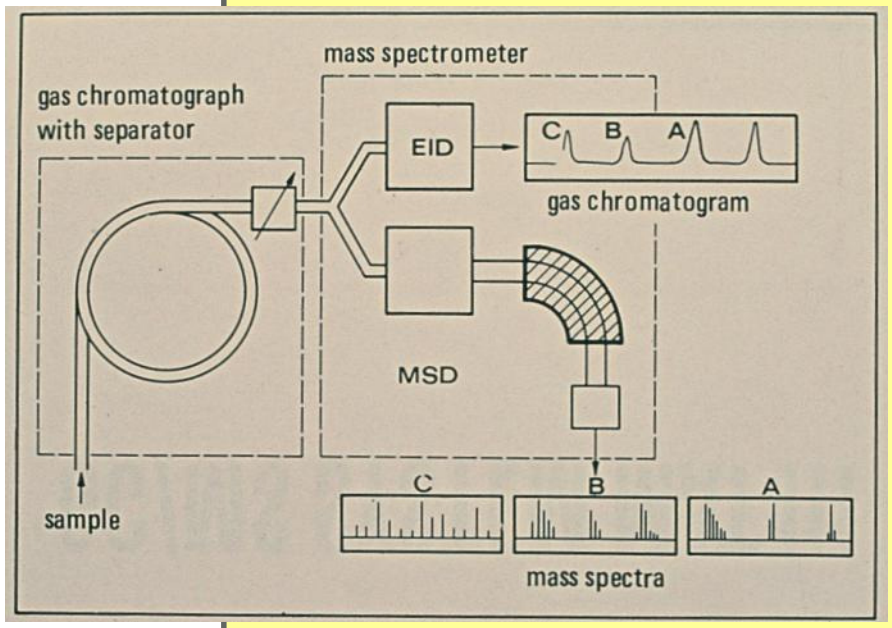
MAT 111 „Gnome“ - First Routine GC-MS (1971)



- Resolution **1 000**
  - Single focussing

- GC-MS sensitivity specs
  - **30 ng** Methylstearate for a full spectrum
  - On Varian Aerograph packed column
  - 2 detectors EID (chro) and MSD (spectra)

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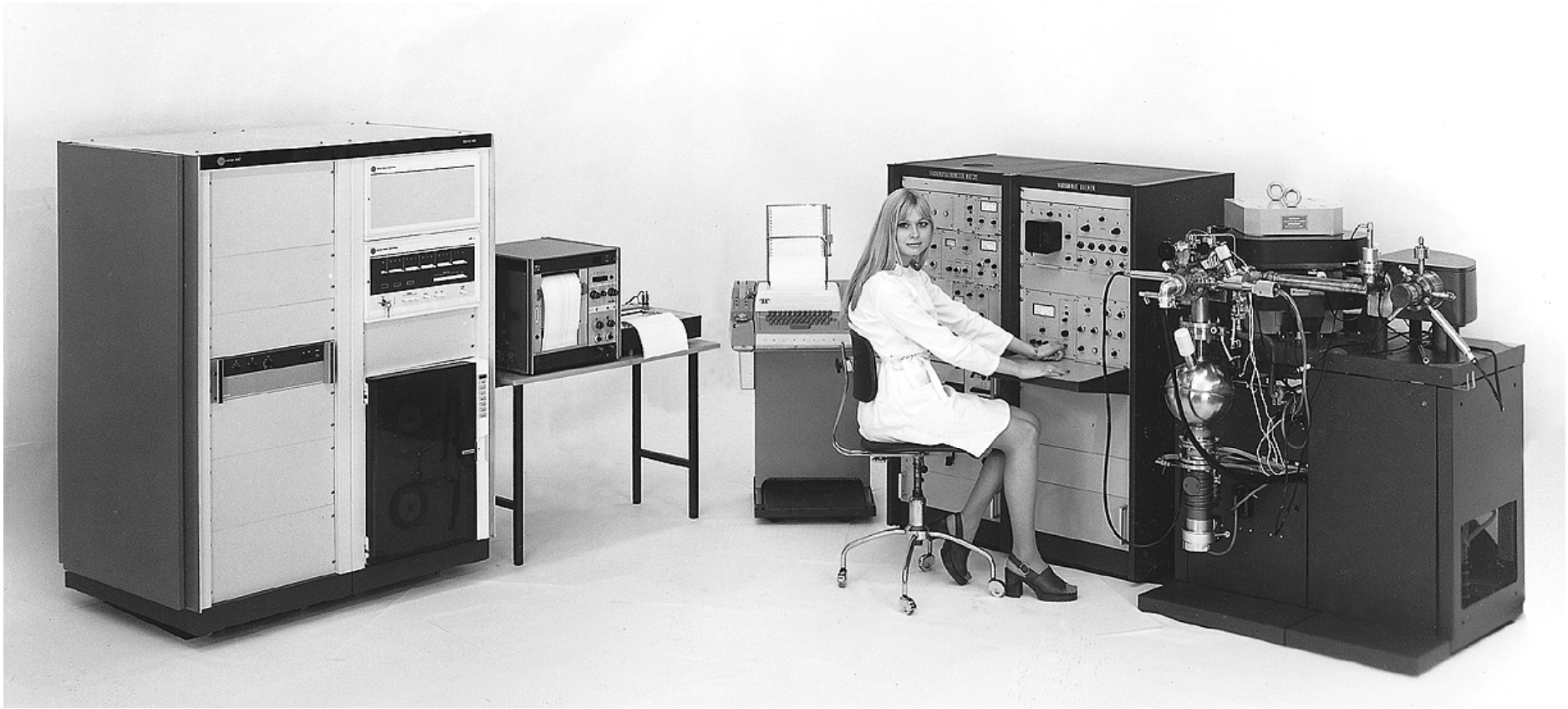
MAT 311- Double Focusing MS, BE Config. (1972)



GC? Maximum Resolution ? **No GC – But R 20,000**

With SS100 Data System - More than 1000 instruments sold by 1976
MAT became a leading MS manufacturer worldwide

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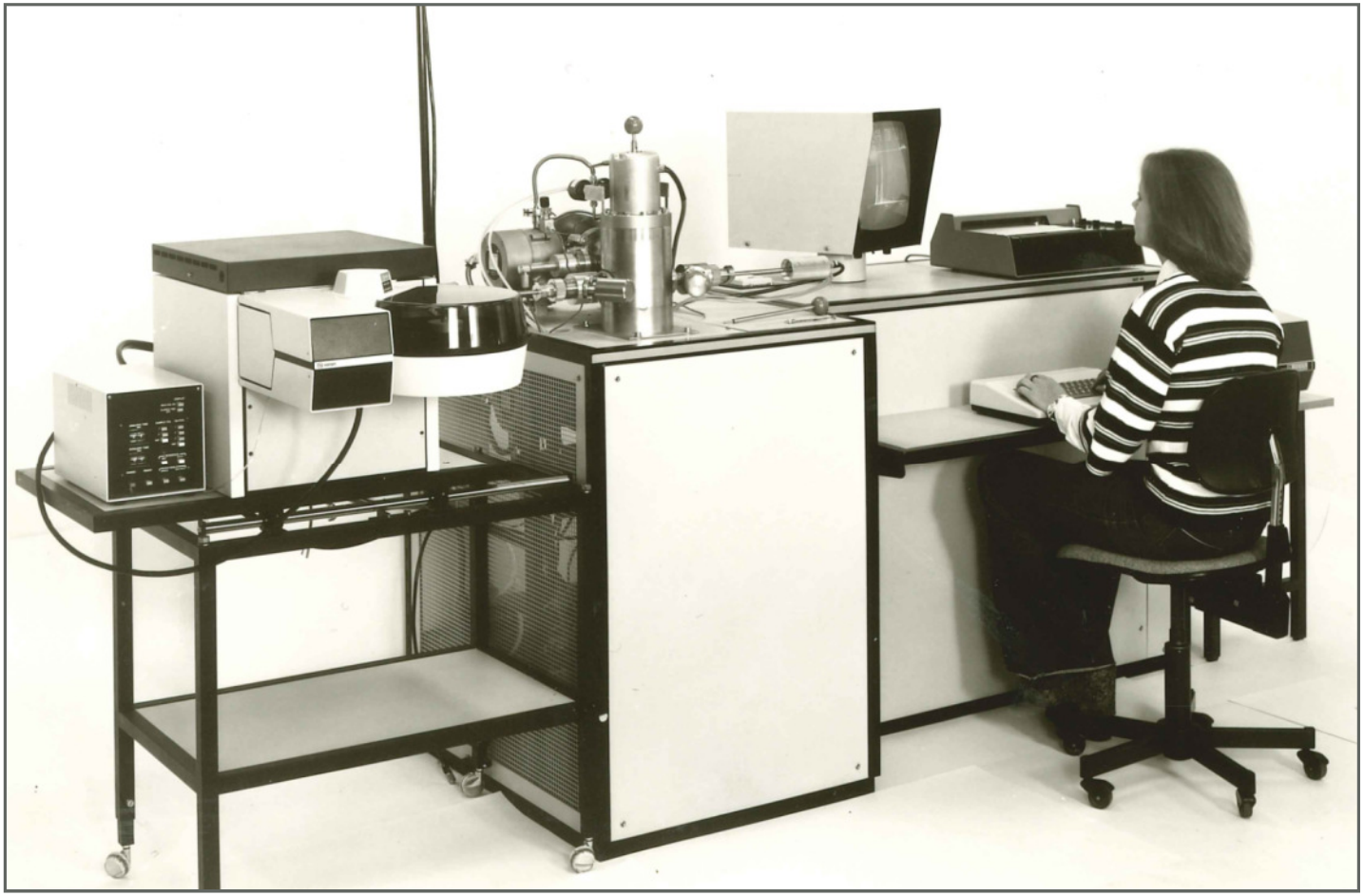
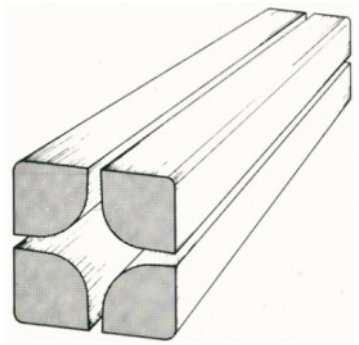
MAT 44 - First Hyperbolic Quadrupole GC-MS (1977)



Resolution
- > 4 000 (10% val.)
- @ 1166/1167 Da

Sensitivity
- 1 ng Me-Stearate
- S/N 20:1
- (CI 1 ng BZP 50:1)

Data System
- SS 200
- 64 k memory
- 4.7 Mb Dual Floppy Disk storage



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MAT 8200 – High Res GC-MS (1982 – 1986)

Routine GC-HRMS

First Dioxin measurements!

But:

Flexible GC transfer line with poor performance

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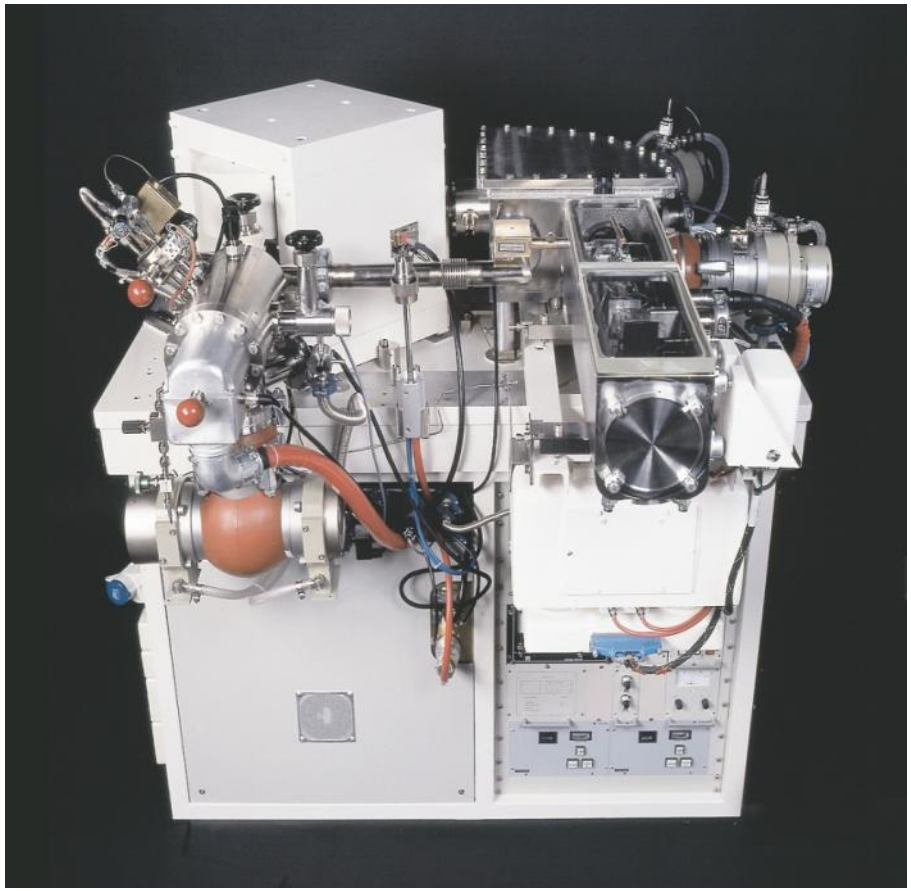
HSQ 30 (1985) – BE-QQ - The First Hybrid System



LTQ Orbitrap XL
Current Hybrid MS

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MAT 90 Series – First Digital Frame Control (1987)

- MAT90: The first completely computer controlled MS on the market
  - DEC Alpha data system
  - Electronics easily accessible in the back wall

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MAT 90 Series: Direct Predecessor of the DFS

- 1987 - MAT 90
- 1992 - MAT 95
- 1995 - MAT 95 S
- 1998 - MAT 95 XL
- 2001 - MAT 95 XP

2003

MAT95 XP

Ion optics and electronics design now dated back more than 15 years

Dual GC configuration as answer on demand for increased sample throughput

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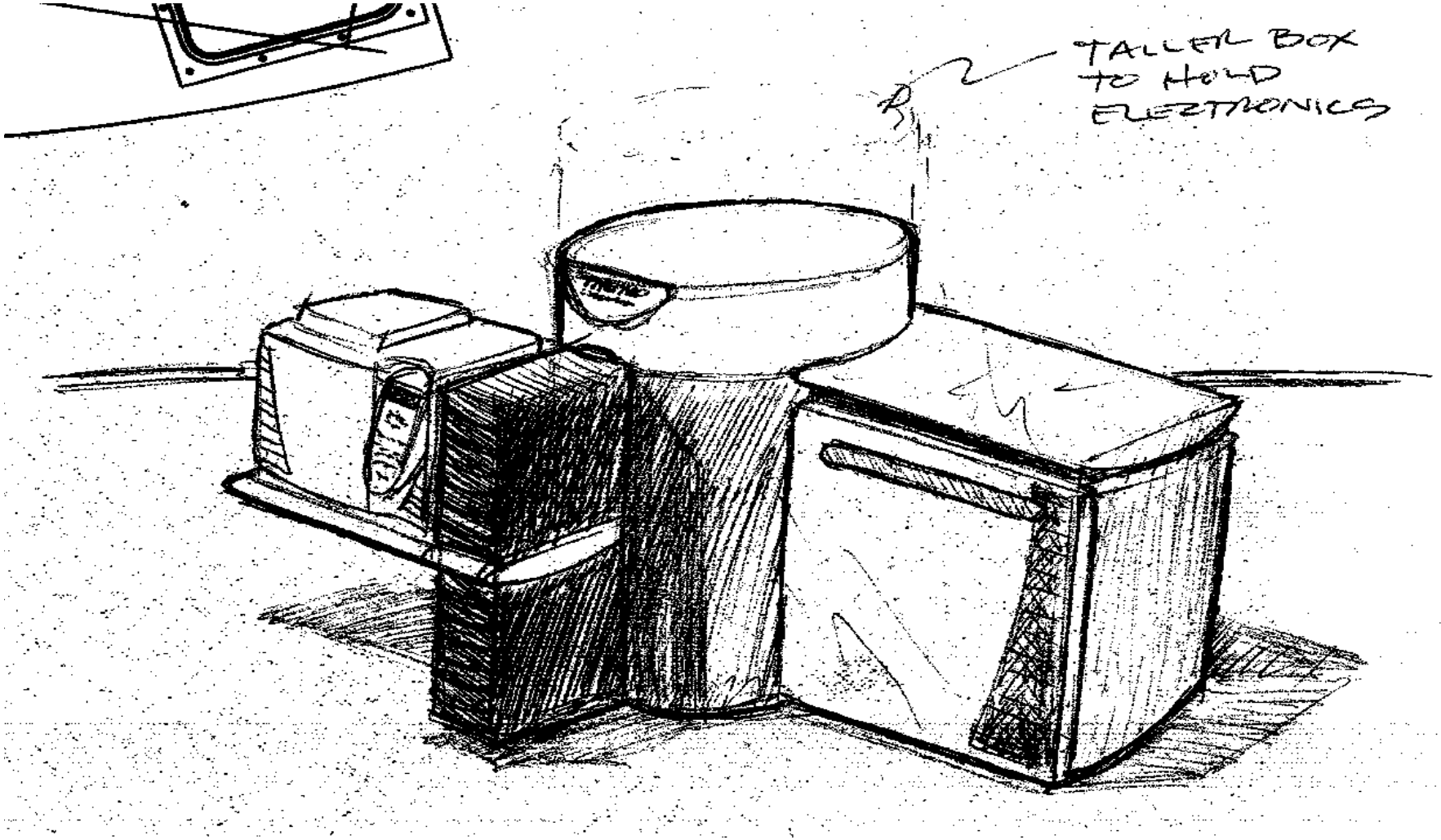
New Era – Thermo Fisher Scientific

- 2005 *DFS* GC-HRMS
  - Toronto Dioxin Conference
- 2006 *DFS Dual Data Acqu.*
  - Oslo Dioxin Conf
- 2010 *DFS* market leading
  - ships >2/3 with Dual GC config

- 2004 New Facilities Opened
  - 4 Storey Building
    - Assembly
    - Testing
    - Applications Lab
    - R&D
  - At Bremen Airport
- 2006 Thermo Fisher Scientific
- 2011 POPs
  - Center of Excellence in Bremen
- 2012 Expanded Facilities
  - Double the space

DFS – A First Design Sketch



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DFS - High Resolution GC-MS (2005)

Introduced 2005
at the Dioxin Conference in Toronto

Today 70 % used as
Dual GC-MS instrument

Resolution > **80,000**

20 fg TCDD
with S/N > 200:1

Designed for
quick installation,
low power consumption,
small footprint,
and high sample throughput

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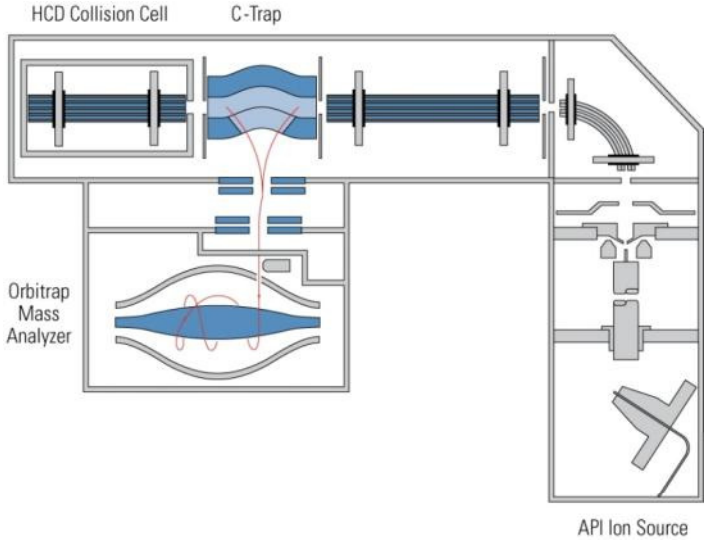
Orbitrap Innovation – FT-MS with Highest Resolution



Exactive LC-Orbitrap

- Benchtop Routine LC-HRMS^n

Resolution
100,000 at 1 scan/s
10,000 at 10 scans/s

Mass accuracy
< 2 ppm

Scan speed
Up to 10 scans/s

Mass Range
m/z 50 - 4000

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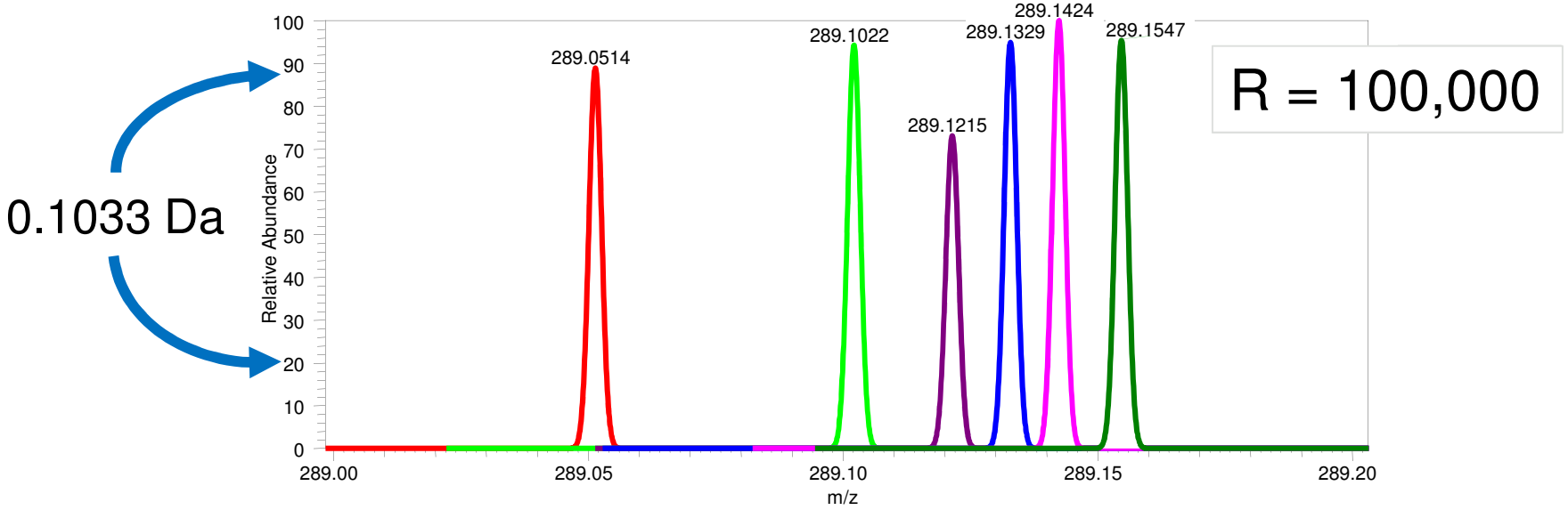
Isobaric Pesticide Compounds and Exact Mass

Element	Nominal	Exact Mass
H	1	1.007825
C	12	12.000000
N	14	14.003074
O	16	15.994915

Is a simultaneous measurement possible?



Yes, at high resolution !

Not a Fiction – Available Today.

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New Facility since December 2004

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Thermo Fisher Bremen Facility – Air View

Application Laboratory and Final Test

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Thermo Fisher Bremen Product Portfolio

Focus on Innovation – High Resolution and Magnetic Sector MS Technology

Exactive
HPLC-FT-MS

LTQ Orbitrap XL
LTQ Orbitrap Discovery
Hybrid FT-MS

DFS
High Resolution GC-MS

Delta V
Gas Isotope Ratio MS

MAT 253
Gas Isotope Ratio MS

ELEMENT 2
ELEMENT XR
High Resolution ICP-MS

ELEMENT GD
Glow Discharge MS

XSERIES 2
ICP-MS

NEPTUNE
HR MC-ICP-MS

TRITON
Thermal Ionization MS

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Thermo Scientific – GC-MS Solutions at Every Level

ITQ
Ion Trap GC-MS/MS

✓Most powerful ion trap
✓Highly economic

TSQ Quantum XLS
Triple Quadrupole GC-MS/MS

✓Highest sensitivity for matrix samples
✓Multi target compound quantitation

DFS
Magnetic Sector GC-HRMS

✓Confirmation analysis
✓The reference Gold Standard

ISQ
Single Quadrupole GC-MS

✓The Workhorse for regulated methods
✓Unstoppable productivity

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Thermo Scientific Innovations – Visit us at ASMS

Launch at ASMS
TSQ Quantum XLS Ultra

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Thank you
for your attention
Thermo
Thermo
TRACE GC ULTRA