# Gas Chromatography

## Fundamentals & Cannabis Applications

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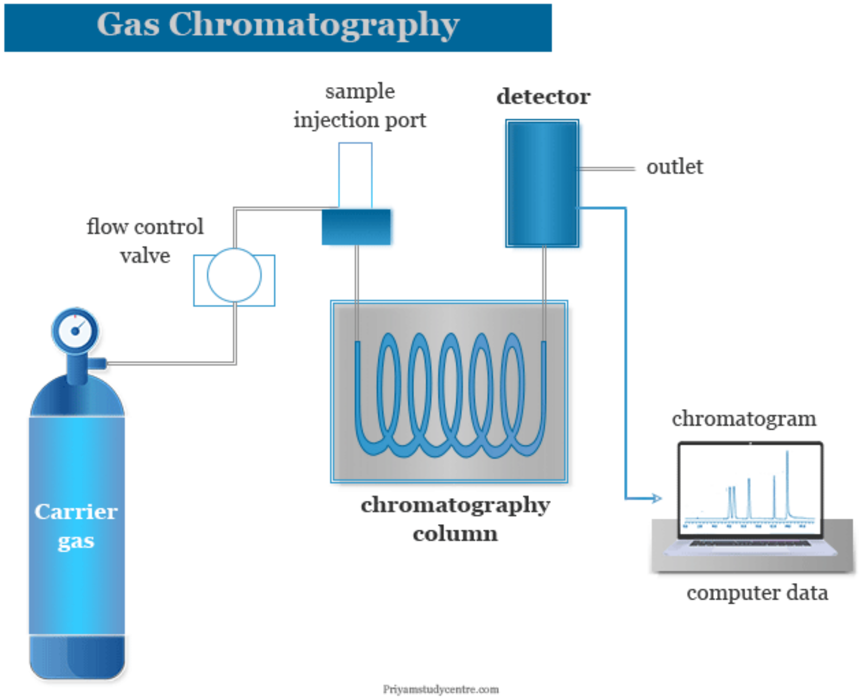
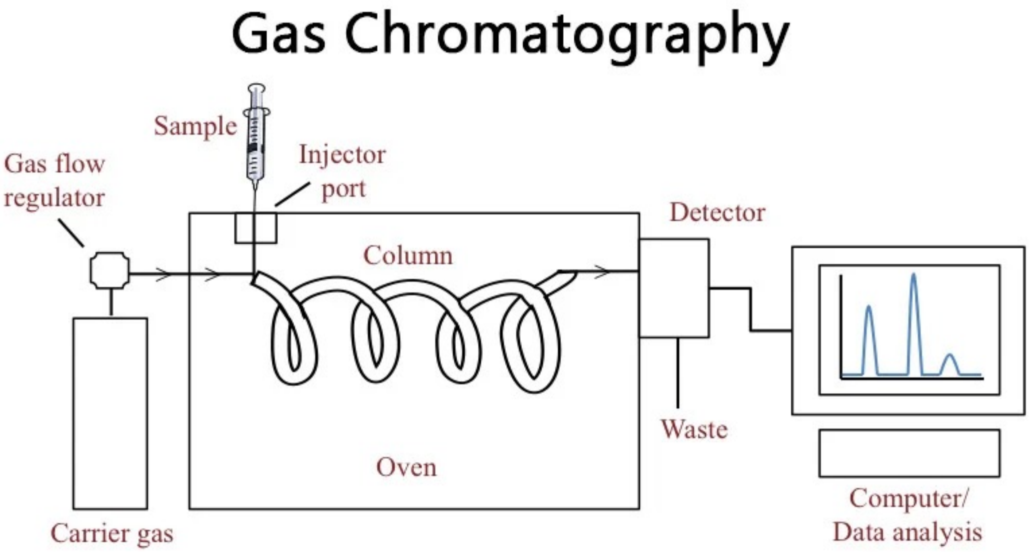
Department of Chemistry
Colorado State University
Fort Collins, CO USA

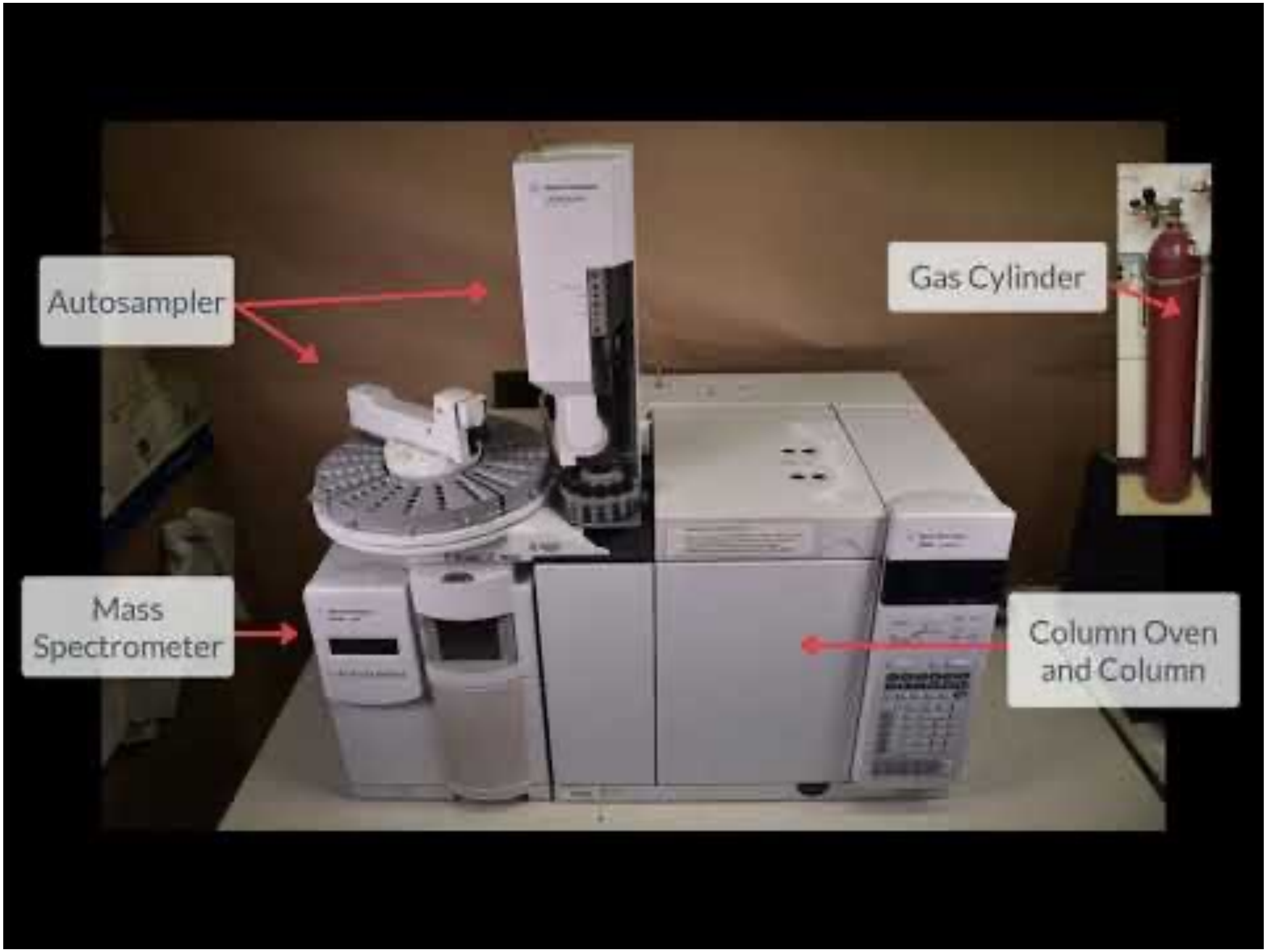
January 2023

# GC – Block Diagram

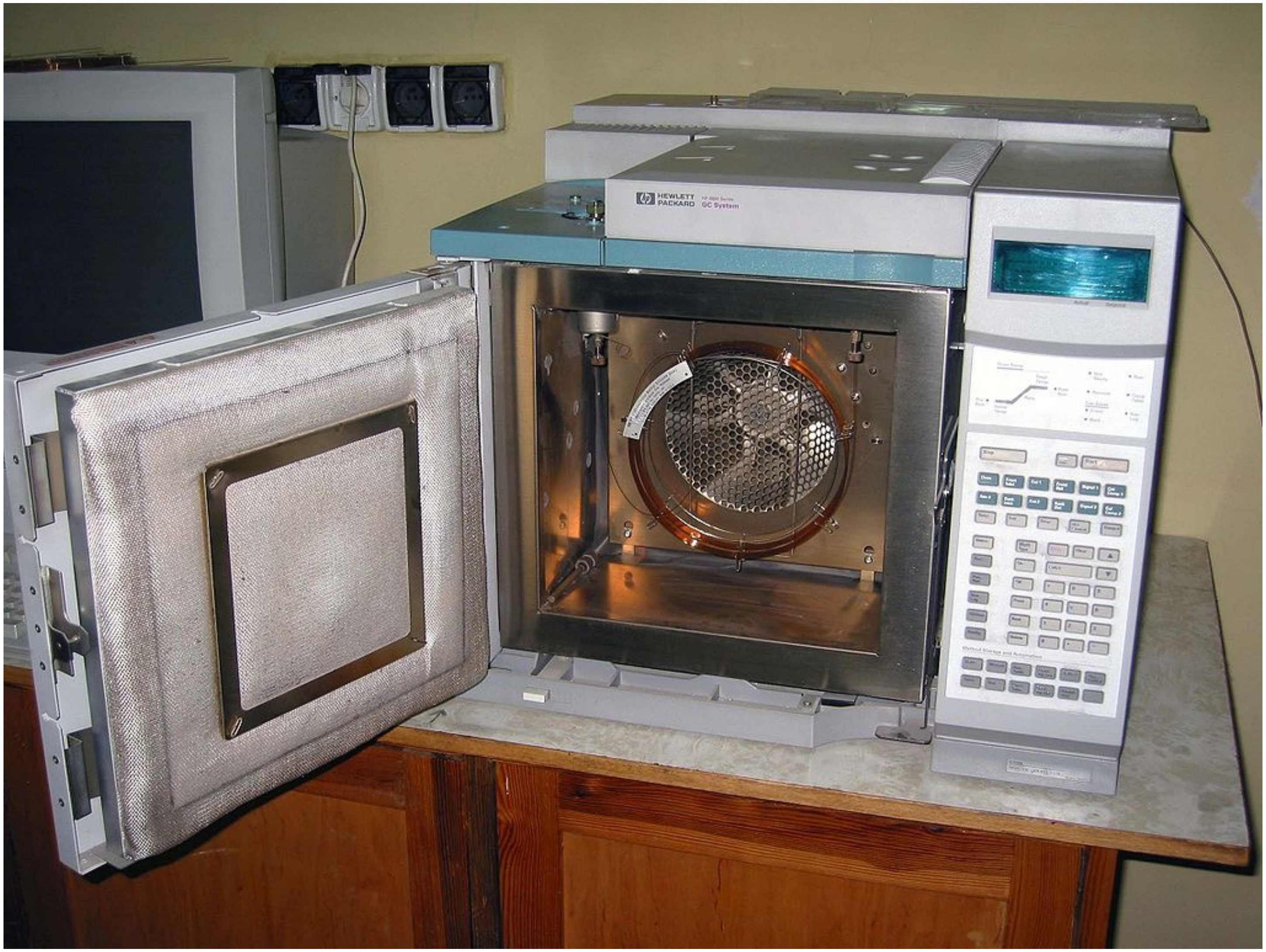

Gas Chromatography
sample injection port
detector
outlet
flow control valve
Carrier gas
chromatography column
chromatogram
computer data
Priyamstudycentre.com


Gas Chromatography
Sample
Gas flow regulator
Injector port
Detector
Column
Waste
Oven
Carrier gas
Computer/ Data analysis

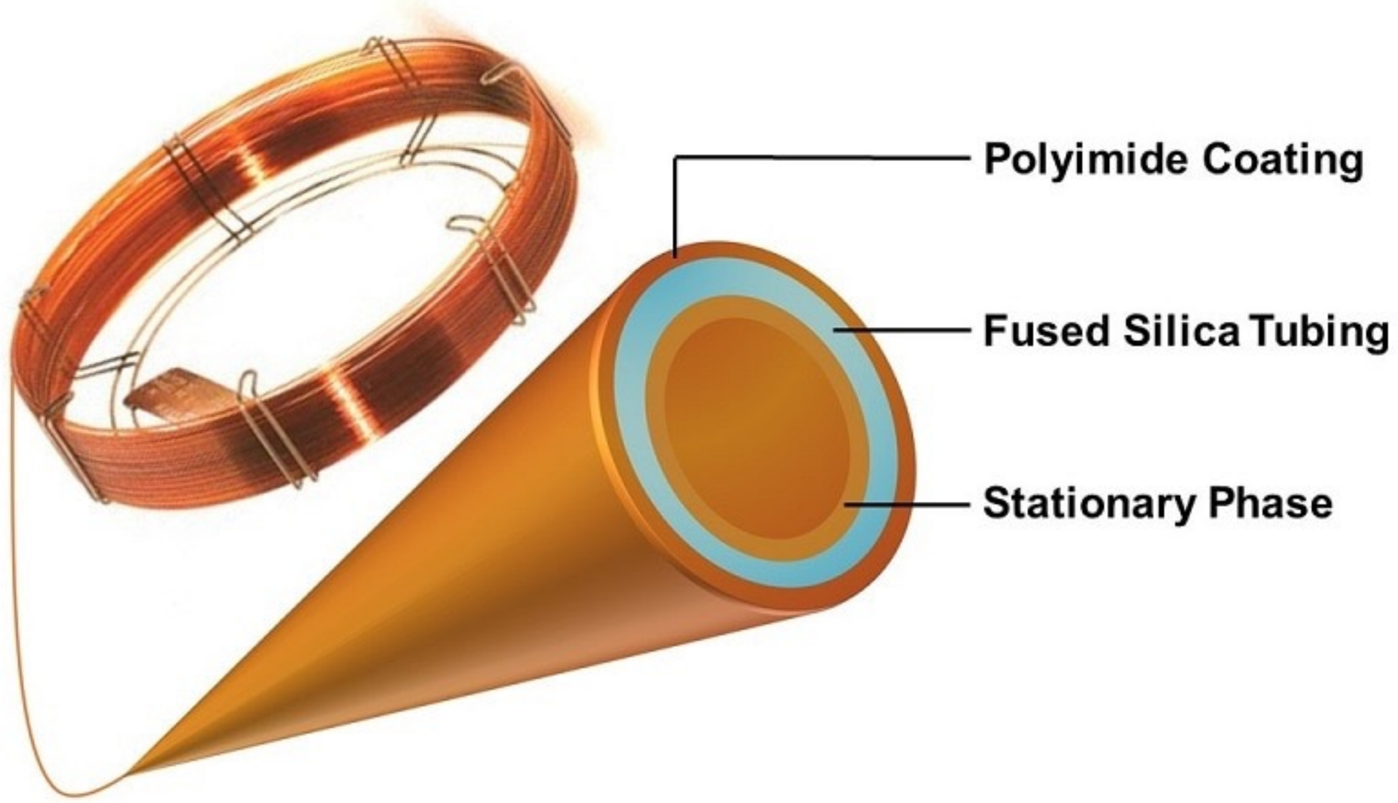
# GC – Pictorial Layout


Autosampler
Gas Cylinder
Mass Spectrometer
Column Oven and Column

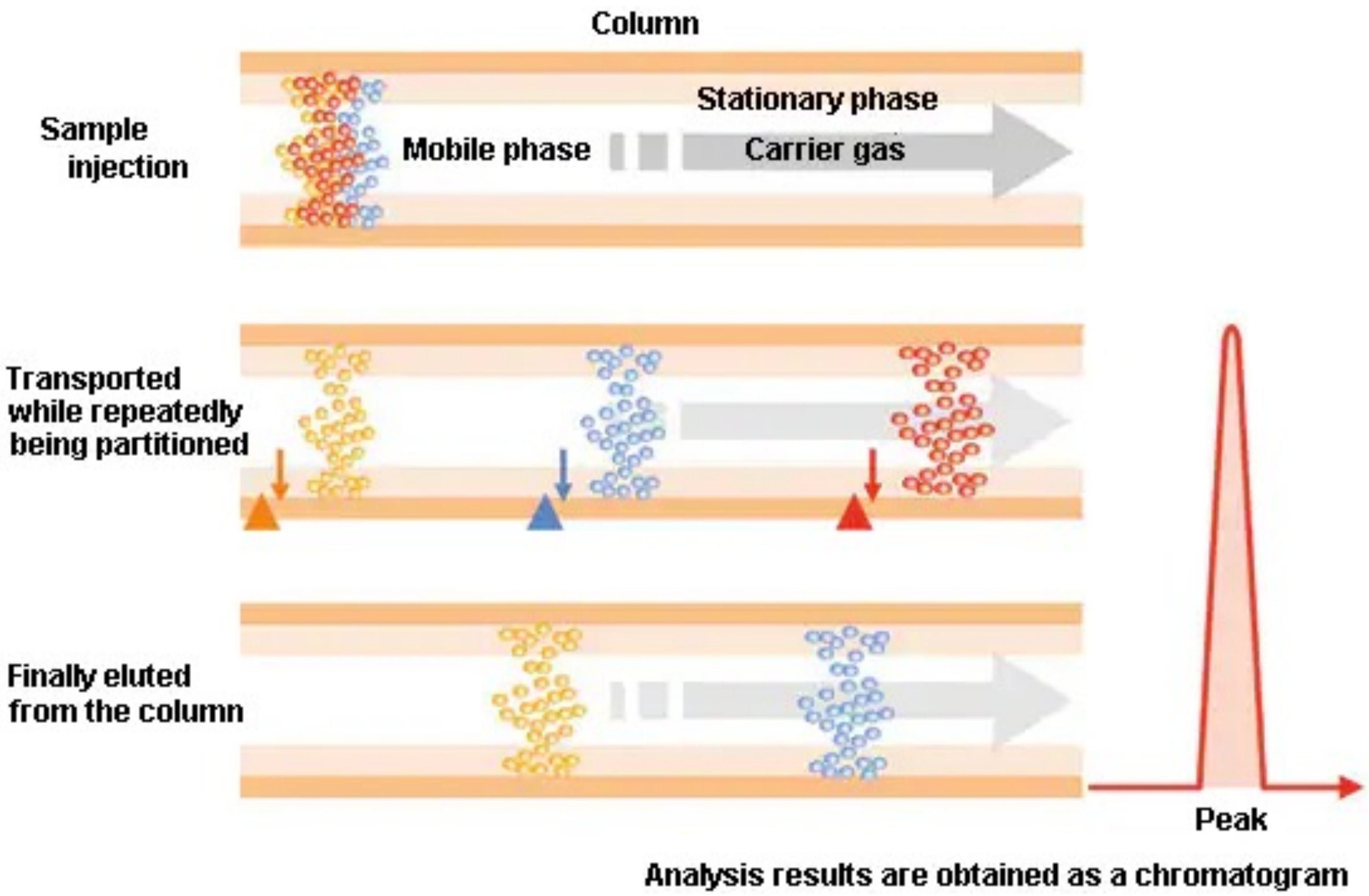
# Column Oven – Where the Magic Happens


HEWLETT PACKARD
GC System

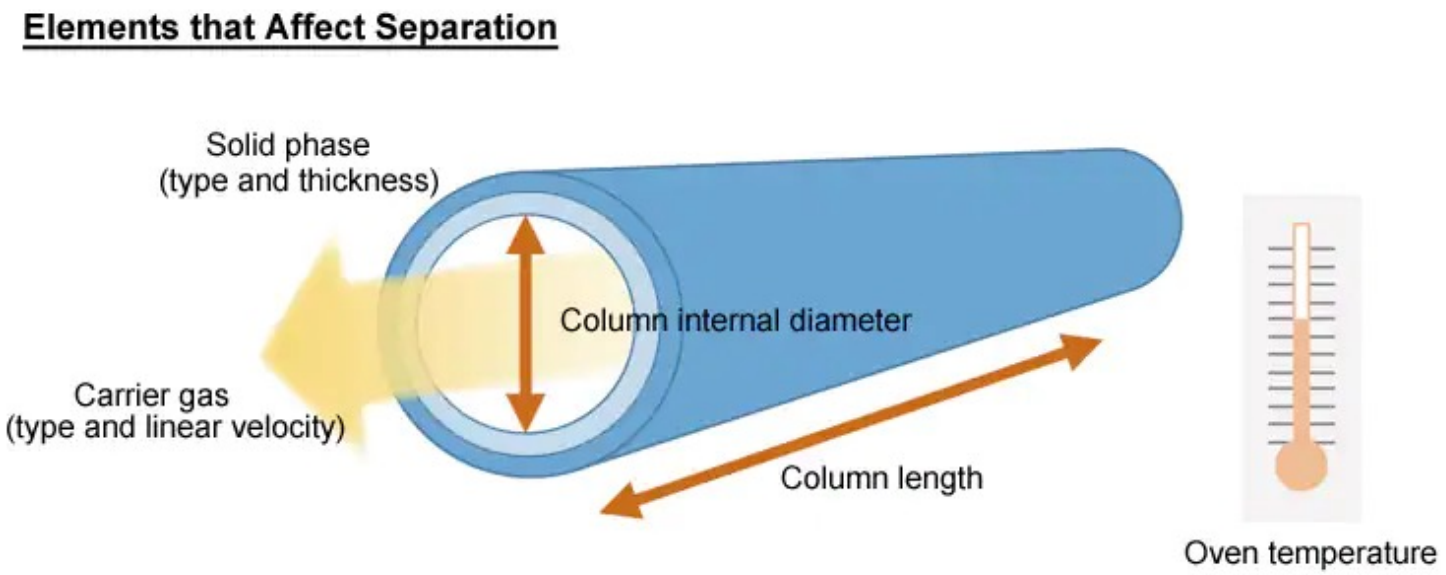
# Column Overall Geometry

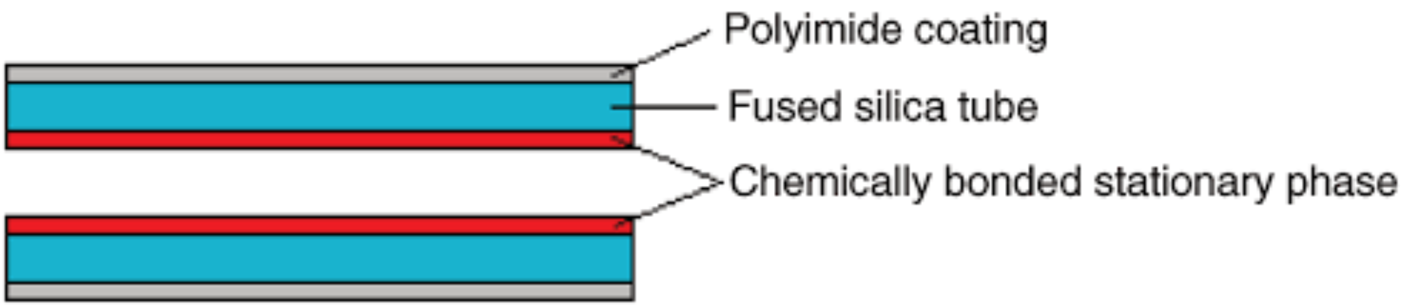

Polyimide Coating
Fused Silica Tubing
Stationary Phase

# Separation Mechanism

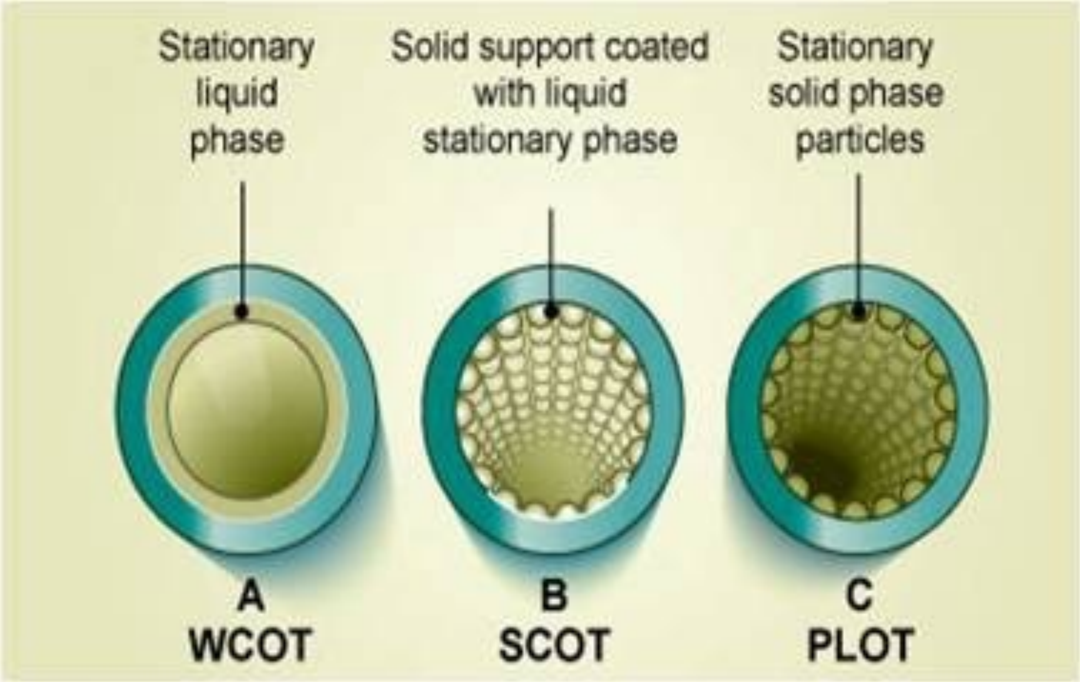

Column
Sample injection
Stationary phase
Mobile phase
Carrier gas
Transported while repeatedly being partitioned
Finally eluted from the column
Peak
Analysis results are obtained as a chromatogram

# Column Internal Details

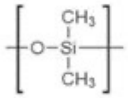

Elements that Affect Separation
Solid phase
(type and thickness)
Column internal diameter
Carrier gas
(type and linear velocity)
Column length
Oven temperature


Polyimide coating
Fused silica tube
Chemically bonded stationary phase

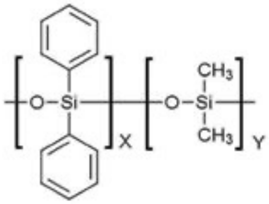
# text


Stationary liquid phase
Solid support coated with liquid stationary phase
Stationary solid phase particles
A
WCOT
B
SCOT
C
PLOT

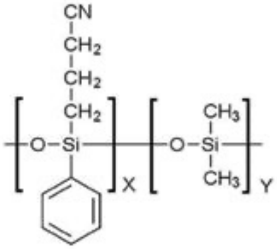
# Varying Column Chemistry



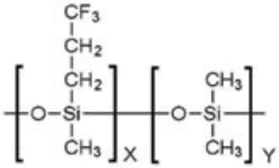
100%
Dimethylpolysiloxane



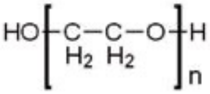
Diphenyl
dimethylpolysiloxane



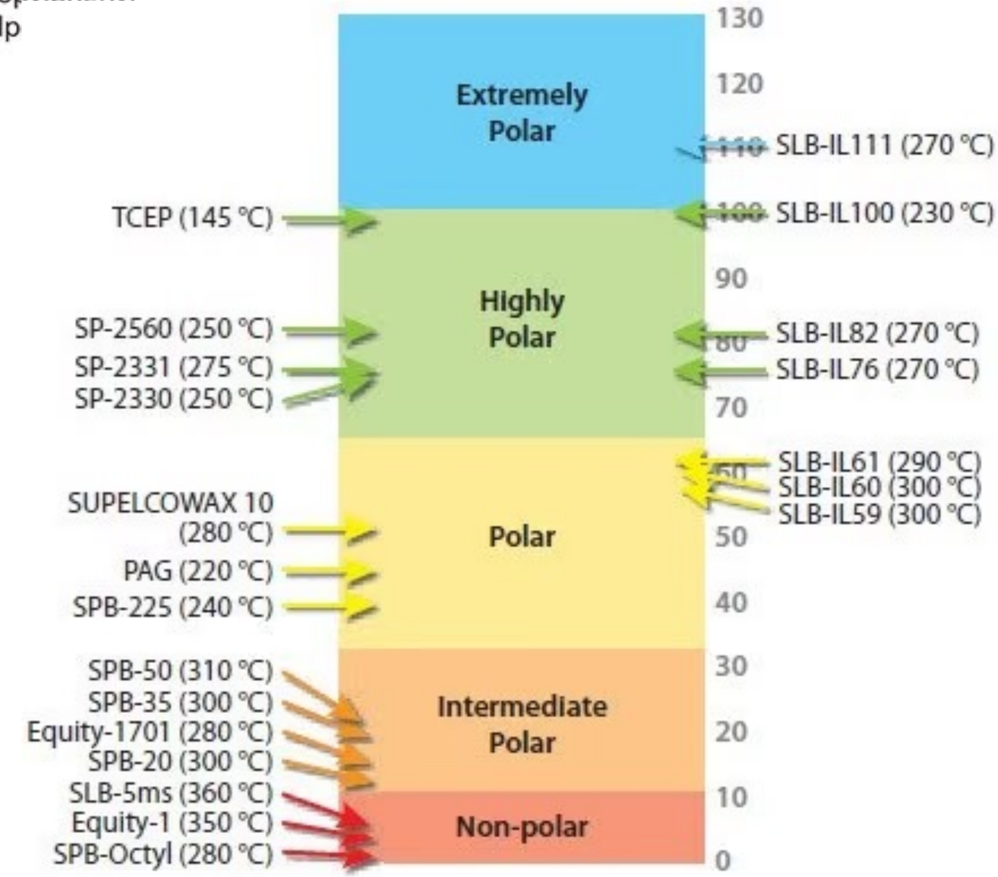
Cyanopropylphenyl
dimethylp



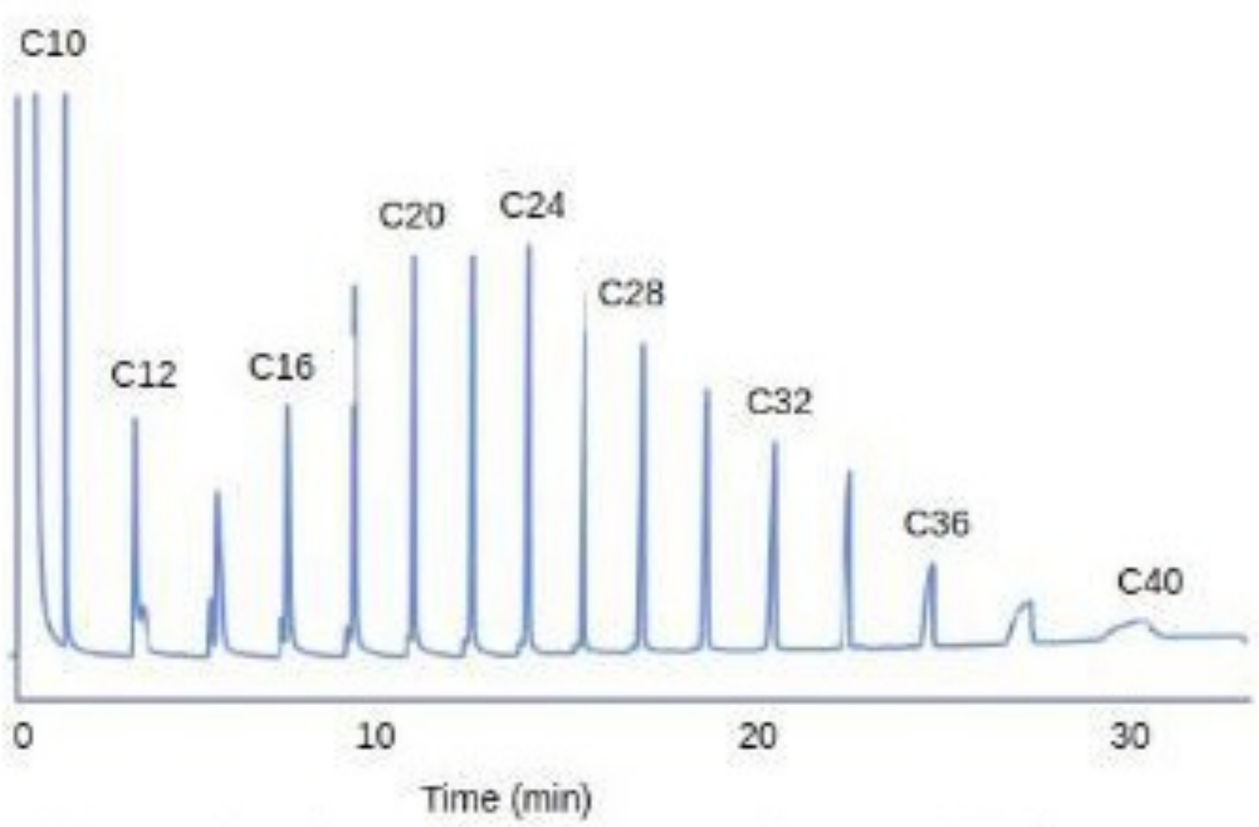
Trifluoropropyl
dimethylpolysiloxane



Polyethylene glycol (PEG) or
wax

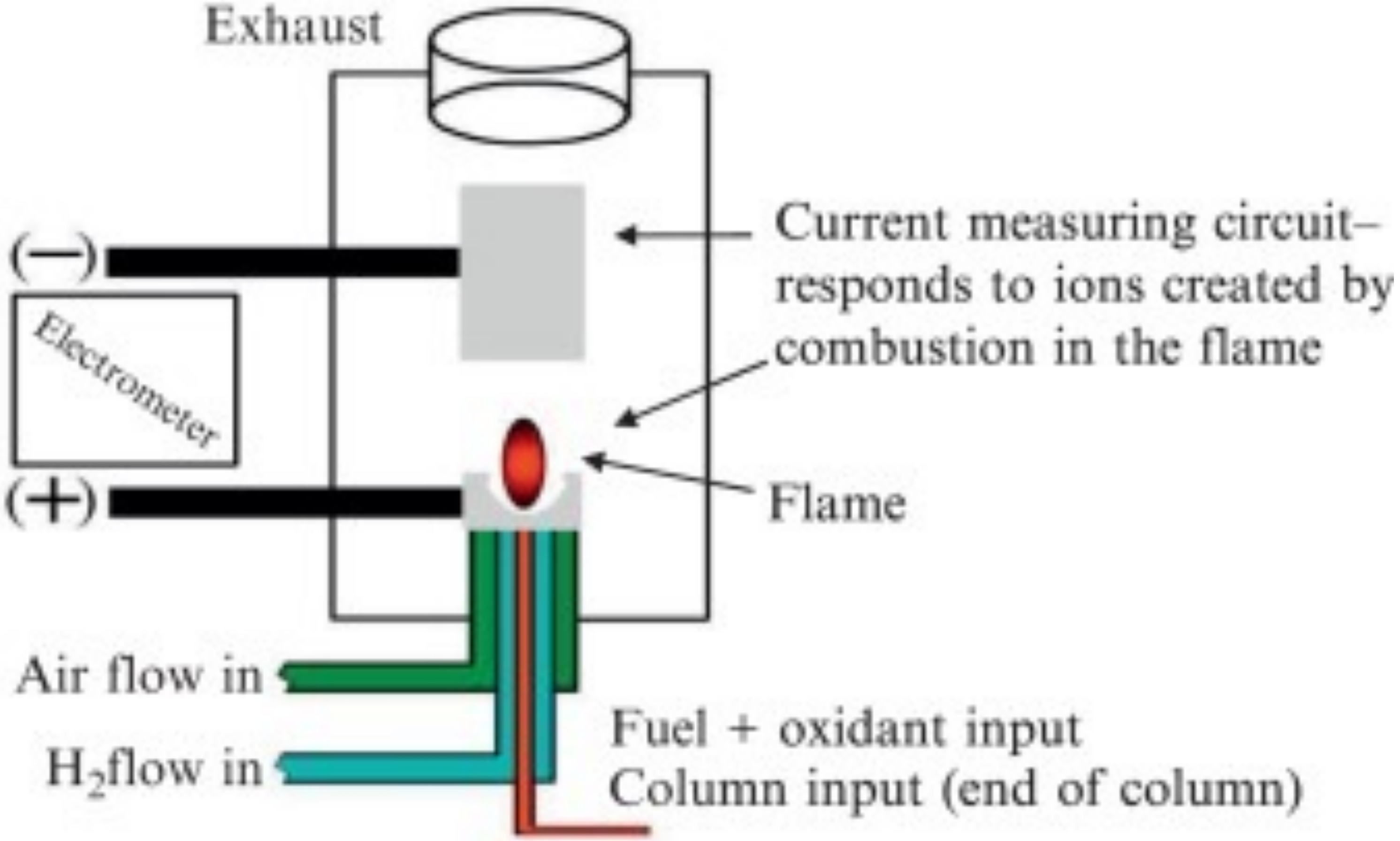


# Example Chromatogram



# Flame Ionization Detector - FID

**Colorado State University**
**Fort Collins, CO**


Exhaust
Current measuring circuit–
responds to ions created by
combustion in the flame
(−)
Electrometer
(+)
Flame
Air flow in
$H_2$flow in
Fuel + oxidant input
Column input (end of column)

# GC–MS

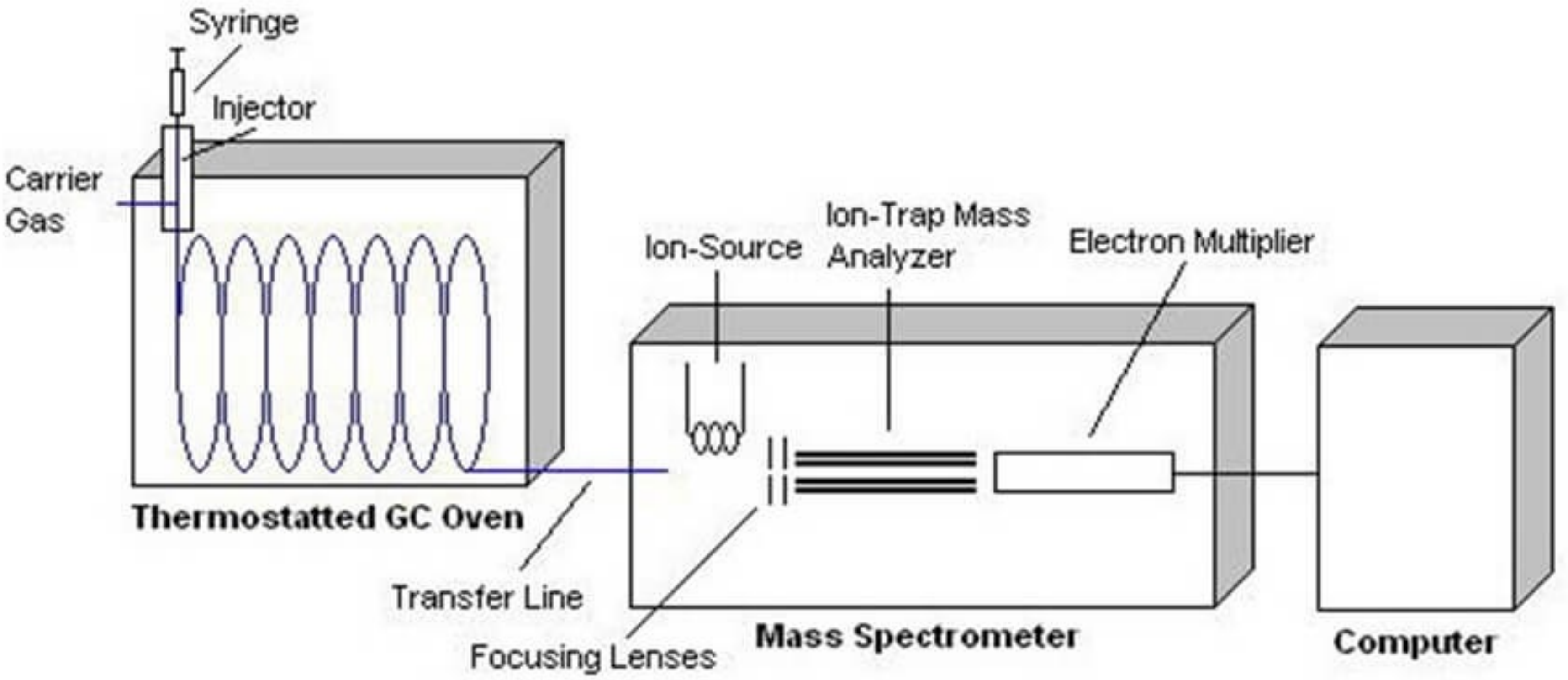
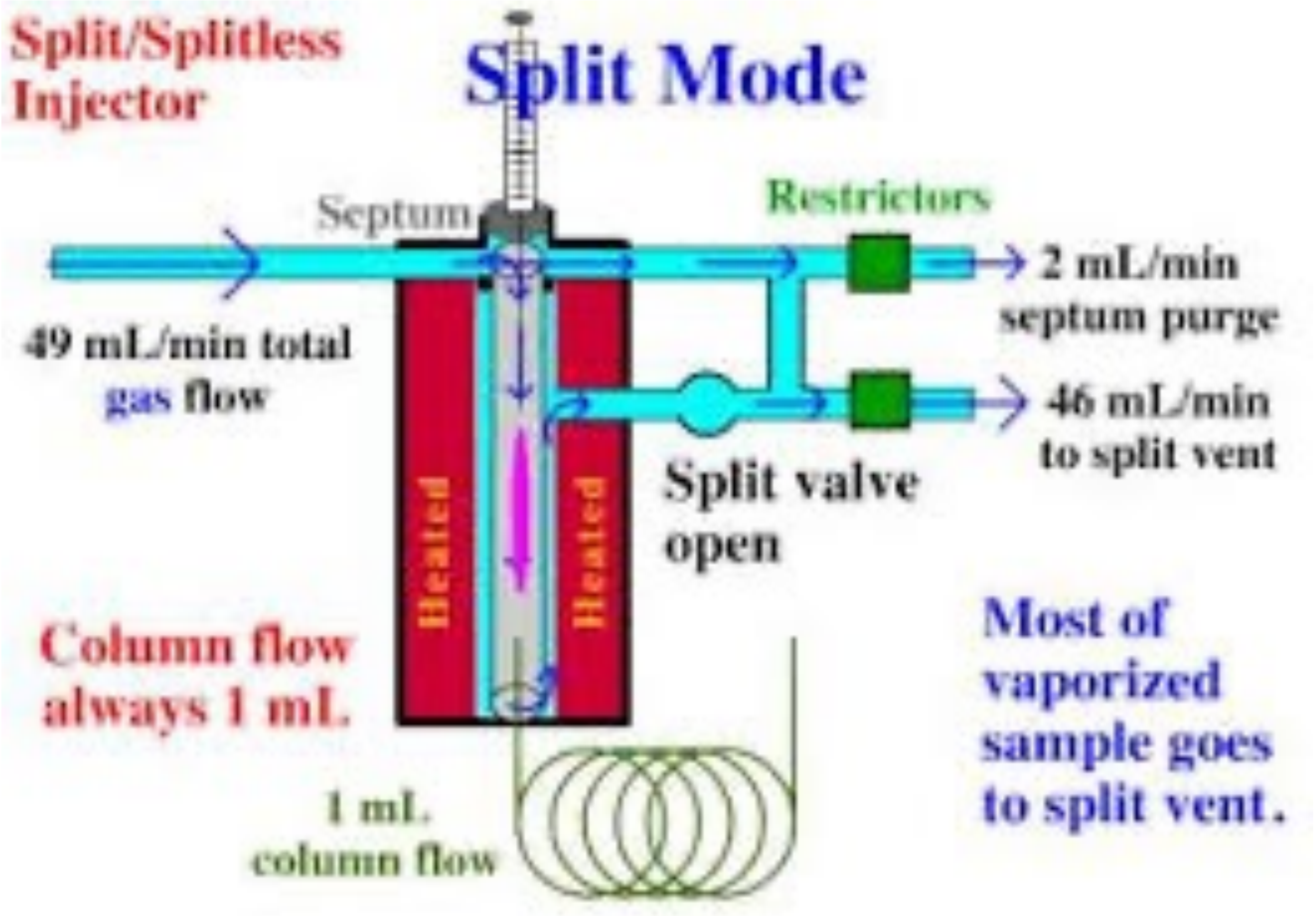
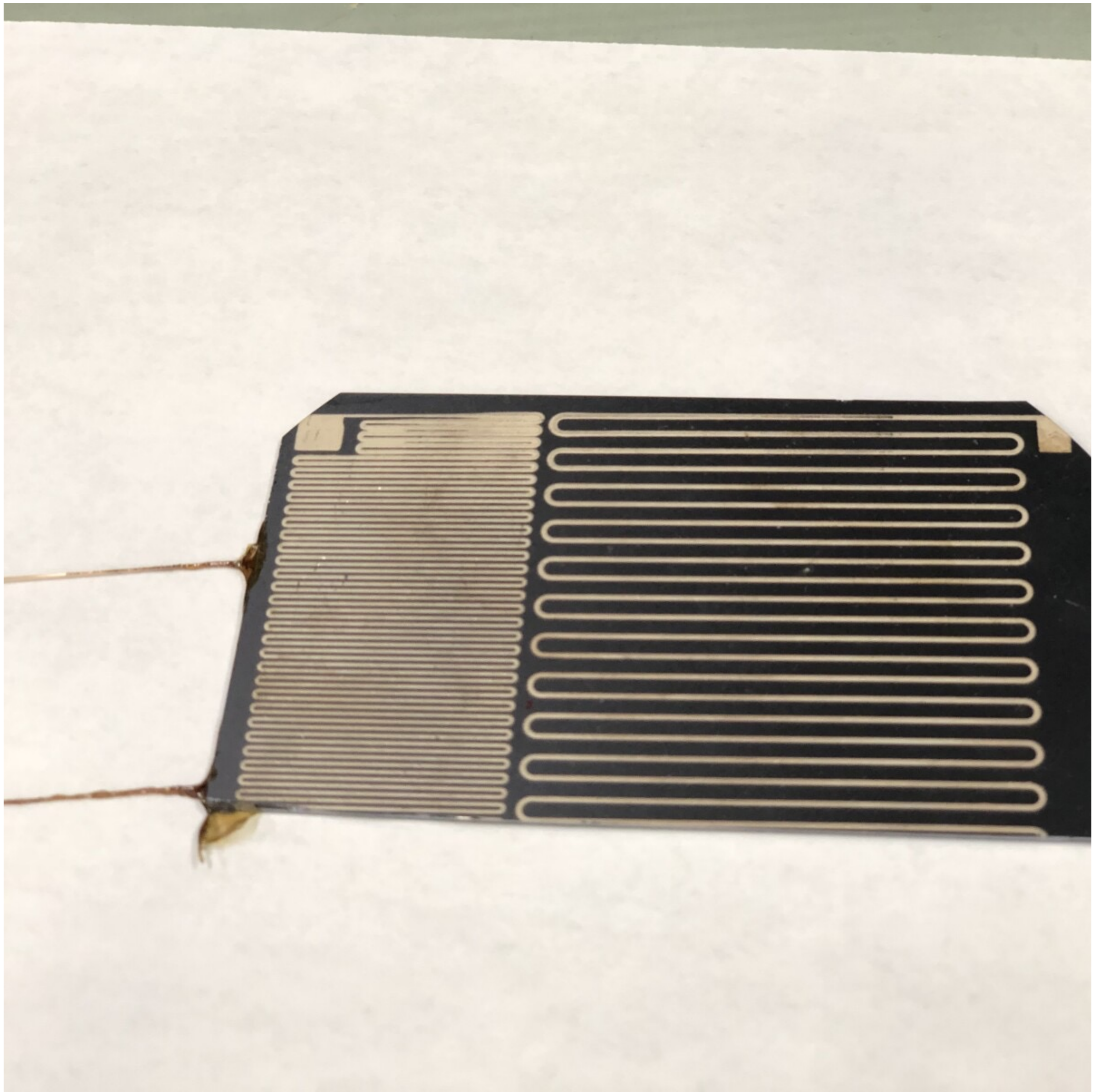

Syringe
Injector
Carrier Gas
Ion-Source
Ion-Trap Mass Analyzer
Electron Multiplier
Thermostatted GC Oven
Transfer Line
Focusing Lenses
Mass Spectrometer
Computer

Figure 1 – Diagram of Gas Chromatograph with Mass Spectrometer attached

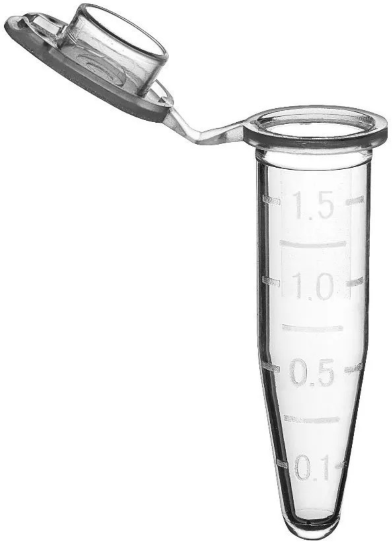
# Split Mode Injection


Split/Splitless Injector
Split Mode
Septum
Restrictors
2 mL/min septum purge
49 mL/min total gas flow
46 mL/min to split vent
Split valve open
Heated
Heated
Column flow always 1 mL.
Most of vaporized sample goes to split vent.
1 mL column flow

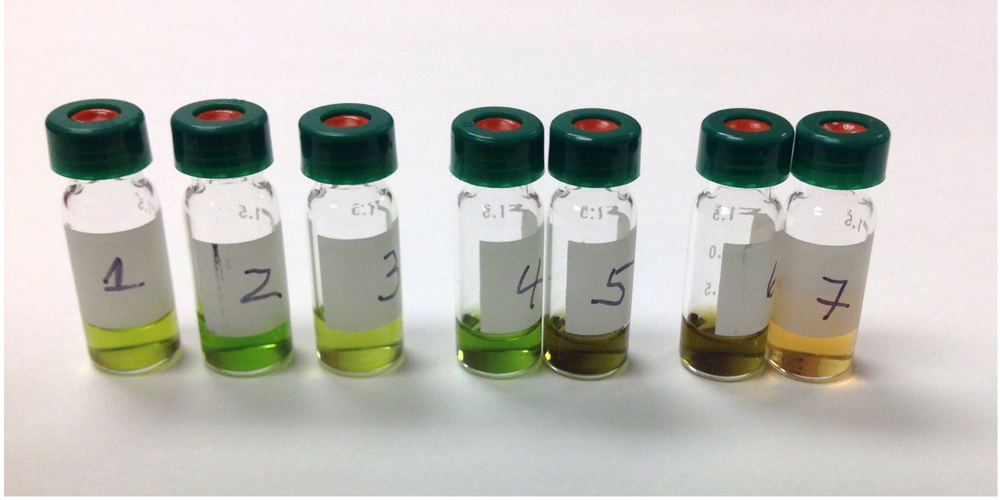
# Crazy Column Configuration



# Sample Prep – Vials and Injection Vials

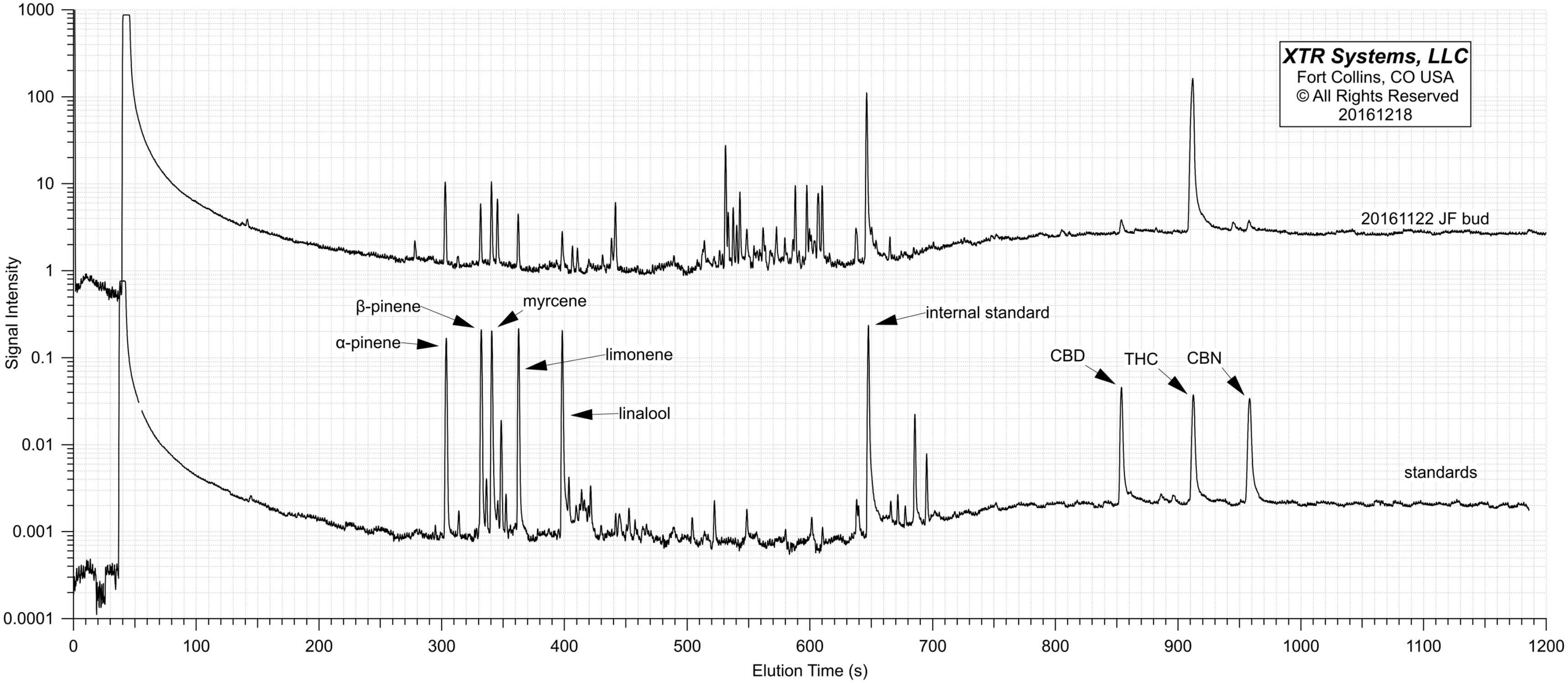


A
B
C
D
1.5
1.0
0.5ml



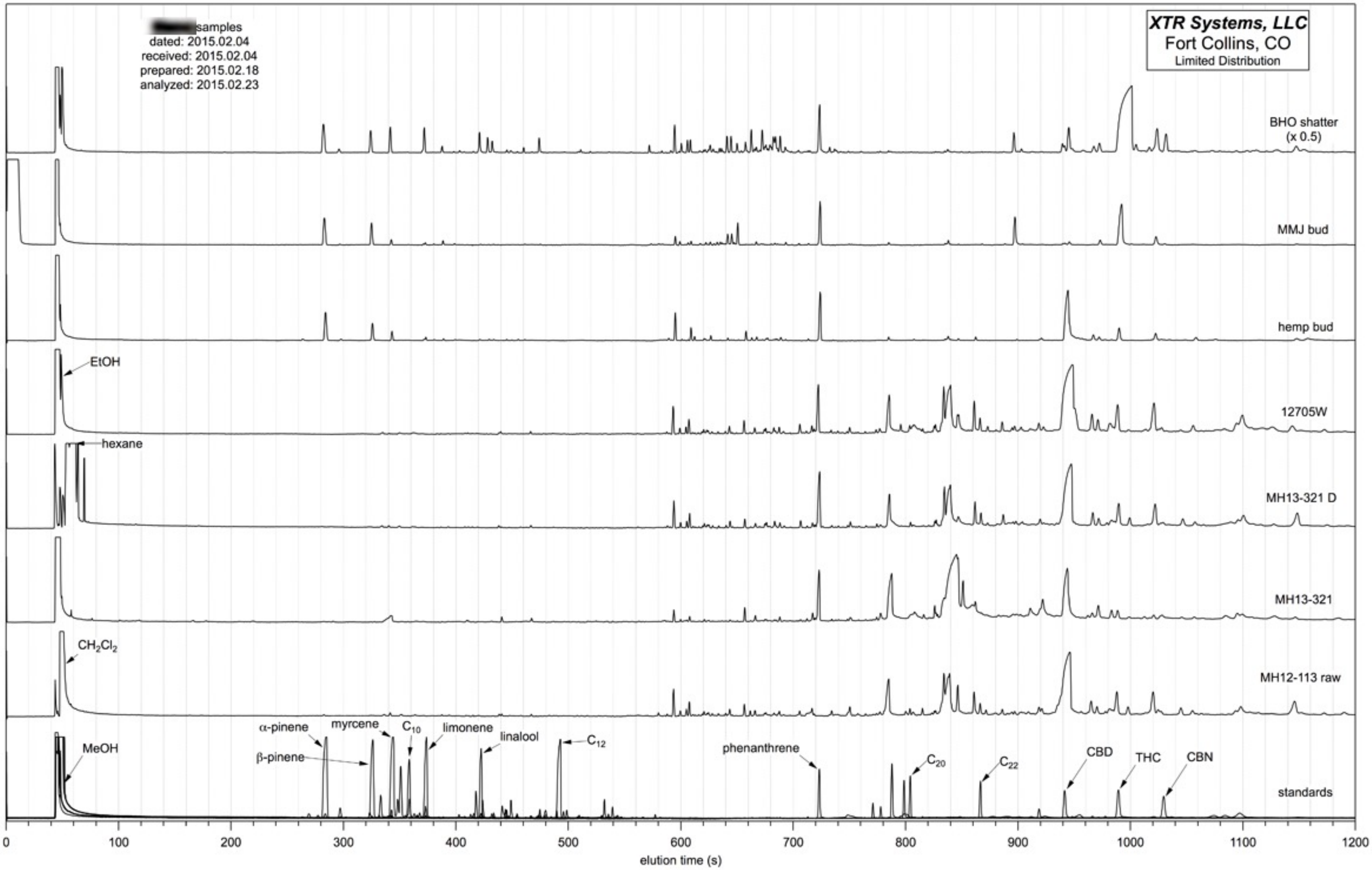
# Standards and Sample

**Colorado State University**
**Fort Collins, CO**



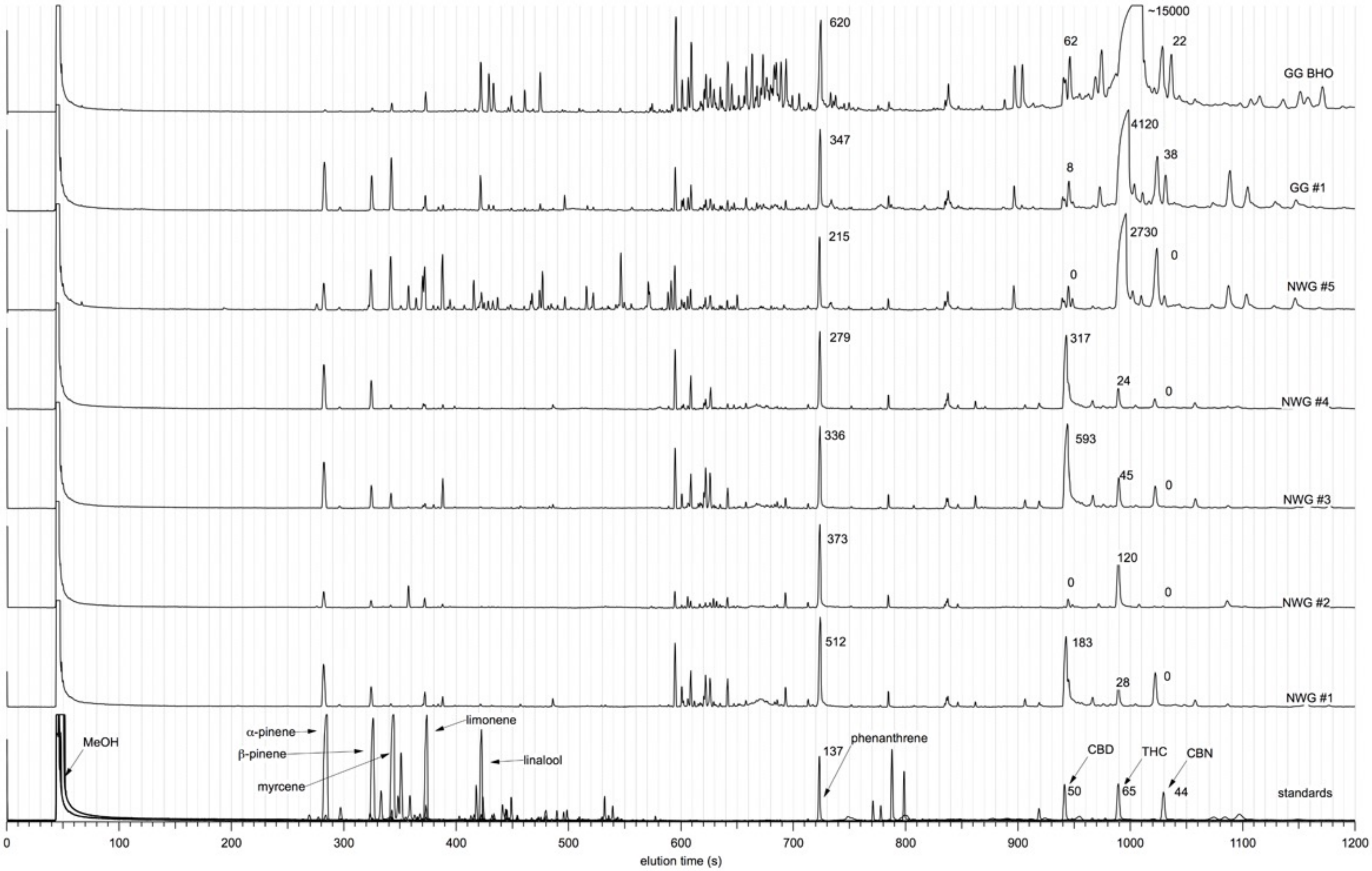
# More Samples

**Colorado State University**
**Fort Collins, CO**



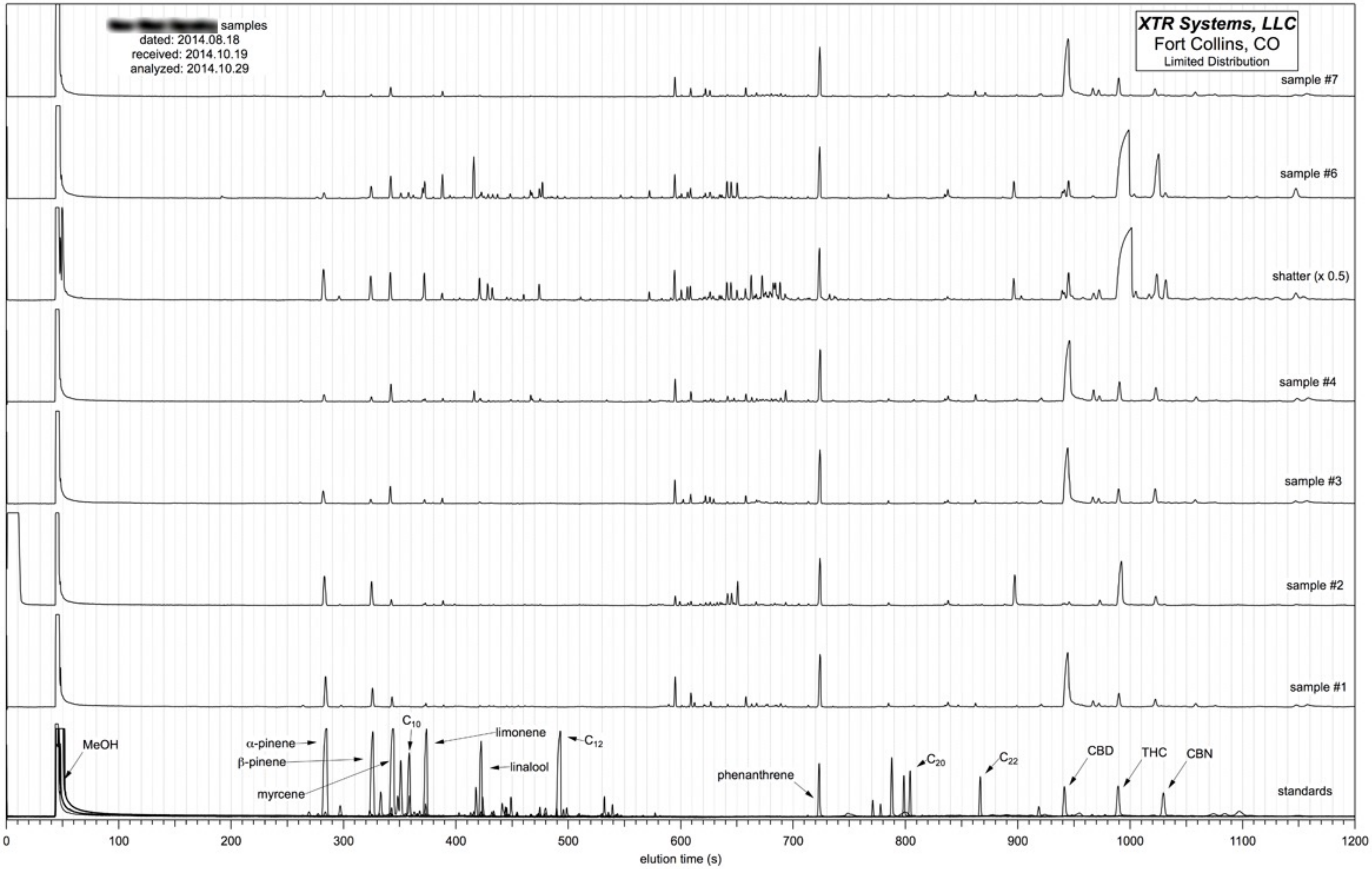
# Even More Samples

**Colorado State University**
**Fort Collins, CO**



# Even More Samples

**Colorado State University**
**Fort Collins, CO**



# Summary Results Table

**Colorado State University**
**Fort Collins, CO**

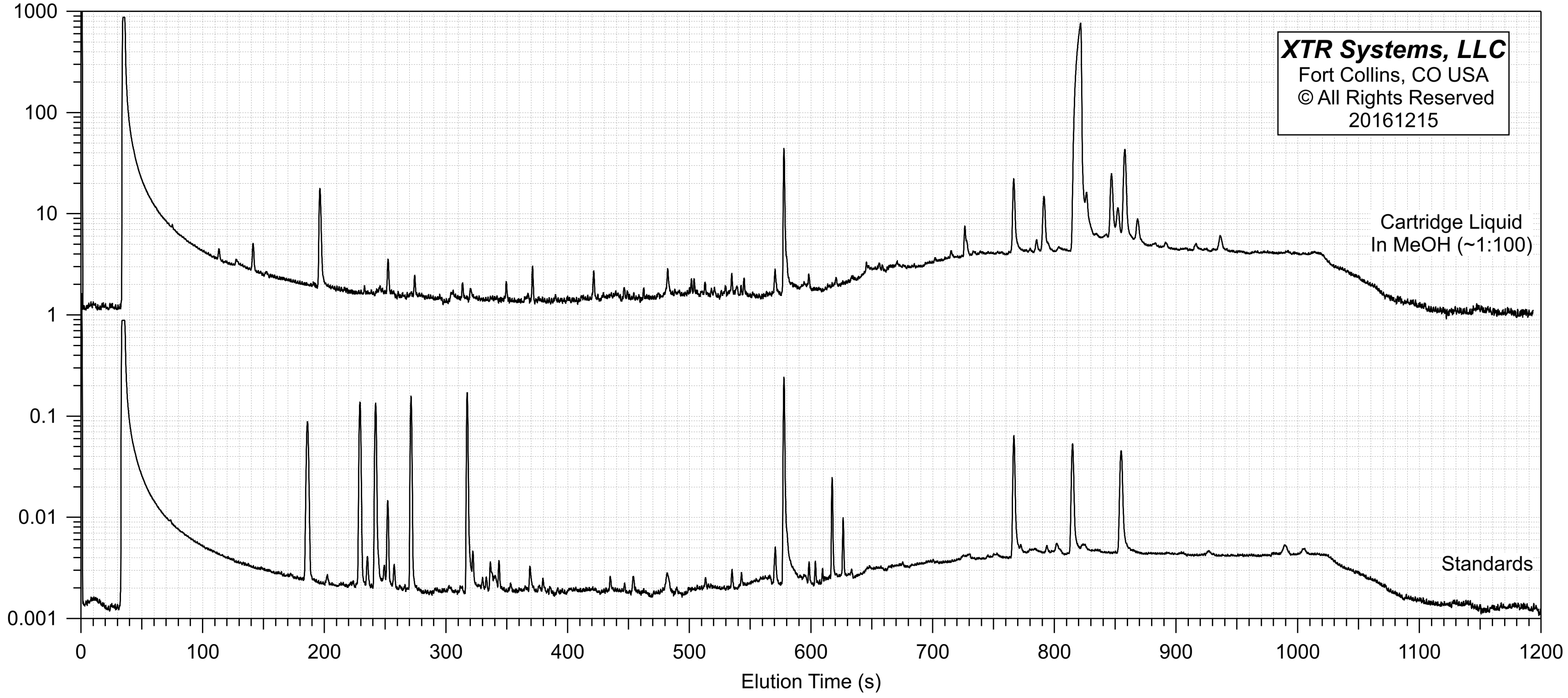
[redacted] samples
dated: 2014.08.18
received: 2014.10.19
analyzed: 2014.10.29

**XTR Systems, LLC**
Fort Collins, CO
Limited Distribution

| | a-pinene | b-pinene | myrcene | limonene | linalool | CBD | THC | CBN | moisture |
|---|---|---|---|---|---|---|---|---|---|
| sample #7 | 0.04% | 0.01% | 0.05% | 0.00% | 0.00% | 3.95% | 0.22% | 0.07% | n/a |
| sample #6 | 0.03% | 0.08% | 0.16% | 0.07% | 0.05% | 0.05% | 13.80% | 1.63% | n/a |
| sample #4 | 0.04% | 0.02% | 0.11% | 0.02% | 0.02% | 4.44% | 0.20% | 0.13% | n/a |
| sample #3 | 0.08% | 0.02% | 0.10% | 0.02% | 0.01% | 2.58% | 0.11% | 0.13% | n/a |
| sample #2 | 0.49% | 0.27% | 0.04% | 0.01% | 0.01% | 0.03% | 1.84% | 0.10% | n/a |
| sample #1 | 0.37% | 0.13% | 0.05% | 0.01% | 0.01% | 2.33% | 0.11% | 0.05% | n/a |
| BHO - shatter | 0.85% | 0.42% | 0.48% | 0.42% | 0.24% | 0.08% | 42.06% | 0.79% | 0.0% |

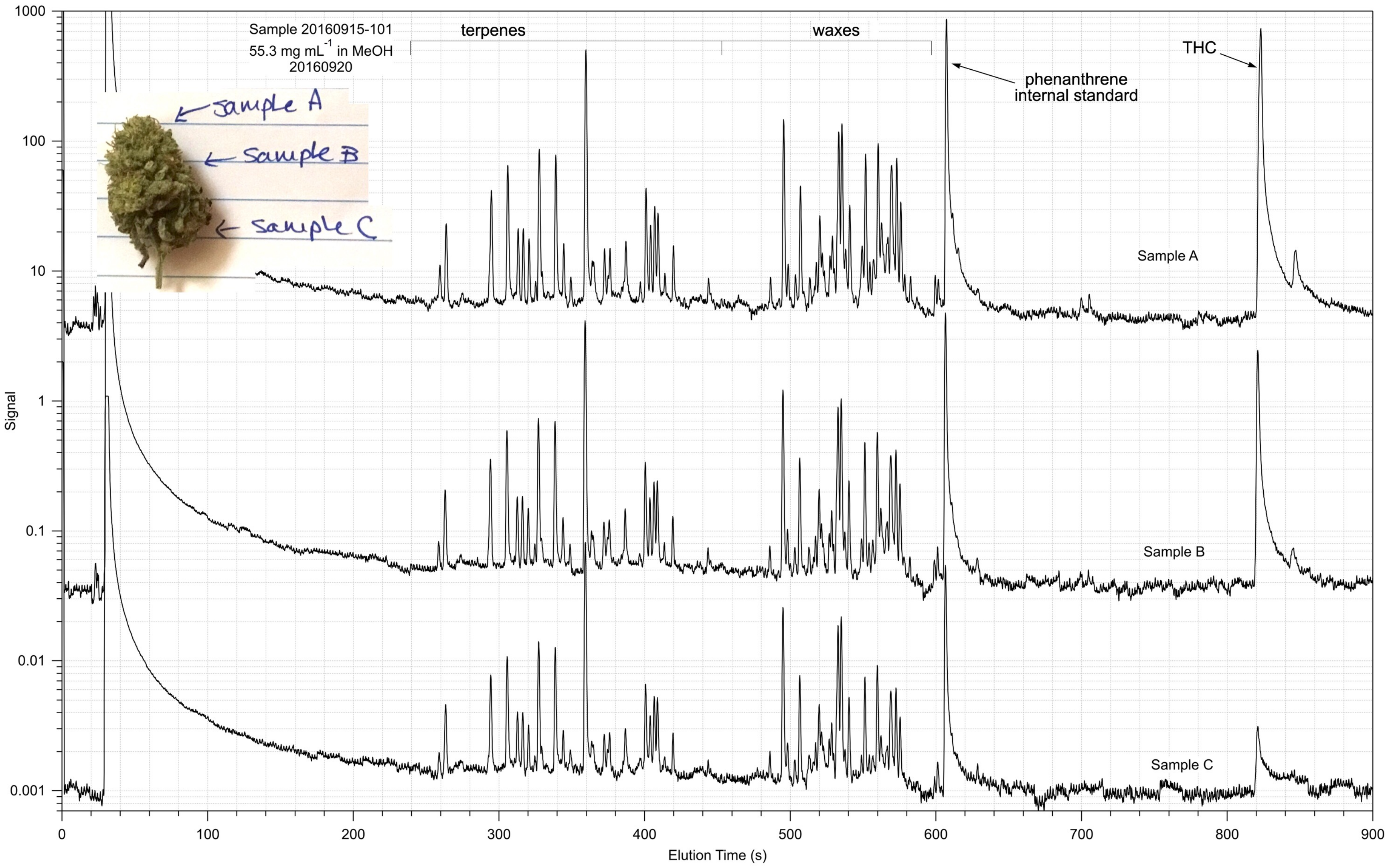
# Vape Cartridge Analysis

**Colorado State University**
**Fort Collins, CO**



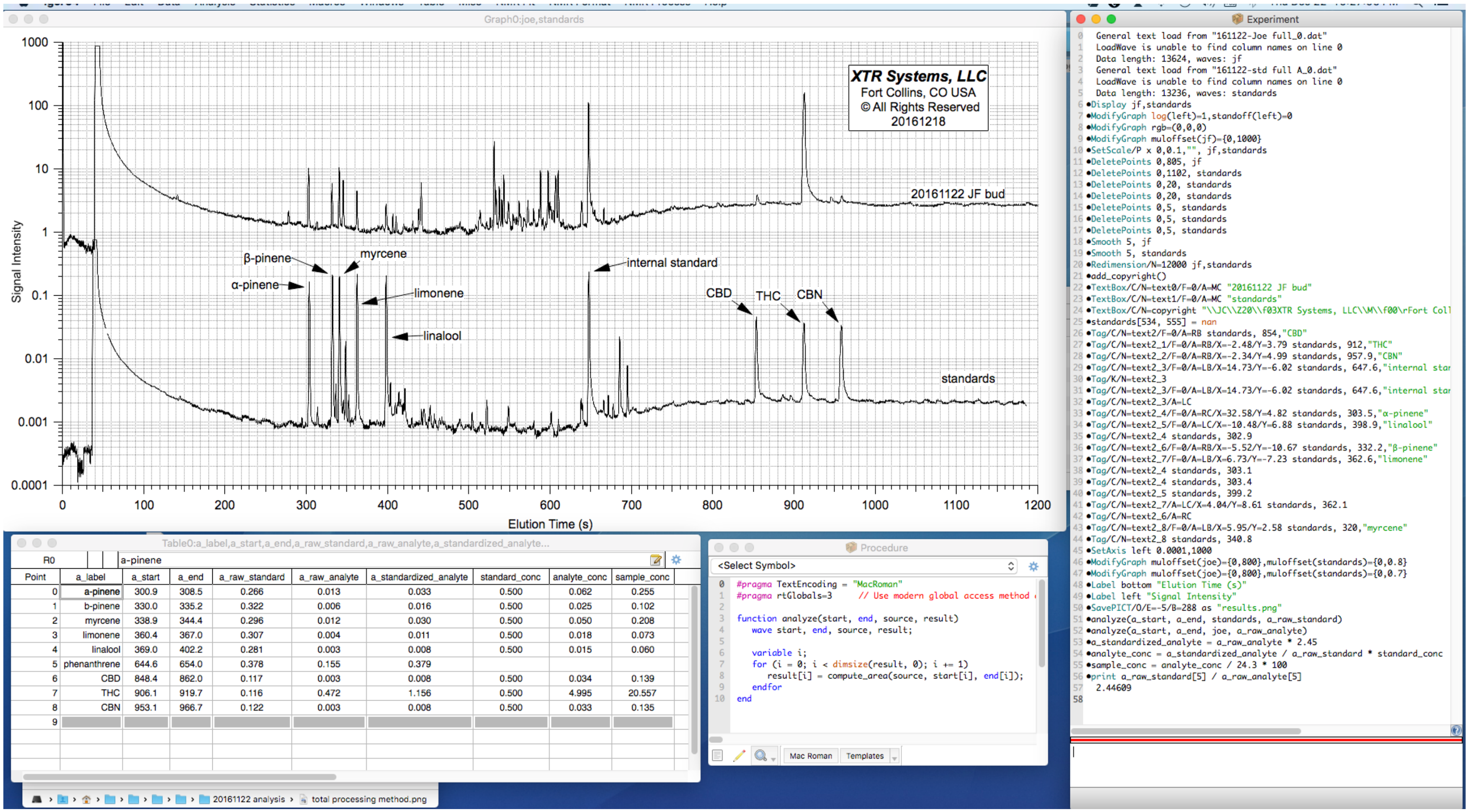
# Spatial Distribution in Flower/Bud

**Colorado State University**
**Fort Collins, CO**



# Example Rigorous Analysis

**Colorado State University**
**Fort Collins, CO**


Graph0:joe,standards
1000
100
10
1
0.1
0.01
0.001
0.0001
Signal Intensity
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
Elution Time (s)
XTR Systems, LLC
Fort Collins, CO USA
© All Rights Reserved
20161218
20161122 JF bud
standards
β-pinene
myrcene
α-pinene
limonene
linalool
internal standard
CBD
THC
CBN
Table0:a_label,a_start,a_end,a_raw_standard,a_raw_analyte,a_standardized_analyte...
R0
a-pinene
Procedure
<Select Symbol>
Mac Roman
Templates
Experiment
20161122 analysis
total processing method.png

| Point | a_label | a_start | a_end | a_raw_standard | a_raw_analyte | a_standardized_analyte | standard_conc | analyte_conc | sample_conc |
|---|---|---|---|---|---|---|---|---|---|
| 0 | a-pinene | 300.9 | 308.5 | 0.266 | 0.013 | 0.033 | 0.500 | 0.062 | 0.255 |
| 1 | b-pinene | 330.0 | 335.2 | 0.322 | 0.006 | 0.016 | 0.500 | 0.025 | 0.102 |
| 2 | myrcene | 338.9 | 344.4 | 0.296 | 0.012 | 0.030 | 0.500 | 0.050 | 0.208 |
| 3 | limonene | 360.4 | 367.0 | 0.307 | 0.004 | 0.011 | 0.500 | 0.018 | 0.073 |
| 4 | linalool | 369.0 | 402.2 | 0.281 | 0.003 | 0.008 | 0.500 | 0.015 | 0.060 |
| 5 | phenanthrene | 644.6 | 654.0 | 0.378 | 0.155 | 0.379 | | | |
| 6 | CBD | 848.4 | 862.0 | 0.117 | 0.003 | 0.008 | 0.500 | 0.034 | 0.139 |
| 7 | THC | 906.1 | 919.7 | 0.116 | 0.472 | 1.156 | 0.500 | 4.995 | 20.557 |
| 8 | CBN | 953.1 | 966.7 | 0.122 | 0.003 | 0.008 | 0.500 | 0.033 | 0.135 |
| 9 | | | | | | | | | |

```
#pragma TextEncoding = "MacRoman"
#pragma rtGlobals=3      // Use modern global access method 

function analyze(start, end, source, result)
   wave start, end, source, result;

   variable i;
   for (i = 0; i < dimsize(result, 0); i += 1)
      result[i] = compute_area(source, start[i], end[i]);
   endfor
end
```

```
  General text load from "161122-Joe full_0.dat"
  LoadWave is unable to find column names on line 0
  Data length: 13624, waves: jf
  General text load from "161122-std full A_0.dat"
  LoadWave is unable to find column names on line 0
  Data length: 13236, waves: standards
•Display jf,standards
•ModifyGraph log(left)=1,standoff(left)=0
•ModifyGraph rgb=(0,0,0)
•ModifyGraph muloffset(jf)={0,1000}
•SetScale/P x 0,0.1,"", jf,standards
•DeletePoints 0,805, jf
•DeletePoints 0,1102, standards
•DeletePoints 0,20, standards
•DeletePoints 0,20, standards
•DeletePoints 0,5, standards
•DeletePoints 0,5, standards
•DeletePoints 0,5, standards
•Smooth 5, jf
•Smooth 5, standards
•Redimension/N=12000 jf,standards
•add_copyright()
•TextBox/C/N=text0/F=0/A=MC "20161122 JF bud"
•TextBox/C/N=text1/F=0/A=MC "standards"
•TextBox/C/N=copyright "\\JC\\Z20\\f03XTR Systems, LLC\\M\\f00\rFort Coll
•standards[534, 555] = nan
•Tag/C/N=text2/F=0/A=RB standards, 854,"CBD"
•Tag/C/N=text2_1/F=0/A=RB/X=-2.48/Y=3.79 standards, 912,"THC"
•Tag/C/N=text2_2/F=0/A=RB/X=-2.34/Y=4.99 standards, 957.9,"CBN"
•Tag/C/N=text2_3/F=0/A=LB/X=14.73/Y=-6.02 standards, 647.6,"internal star
•Tag/K/N=text2_3
•Tag/C/N=text2_3/F=0/A=LB/X=14.73/Y=-6.02 standards, 647.6,"internal star
•Tag/C/N=text2_3/A=LC
•Tag/C/N=text2_4/F=0/A=RC/X=32.58/Y=4.82 standards, 303.5,"α-pinene"
•Tag/C/N=text2_5/F=0/A=LC/X=-10.48/Y=6.88 standards, 398.9,"linalool"
•Tag/C/N=text2_4 standards, 302.9
•Tag/C/N=text2_6/F=0/A=RB/X=-5.52/Y=-10.67 standards, 332.2,"β-pinene"
•Tag/C/N=text2_7/F=0/A=LB/X=6.73/Y=-7.23 standards, 362.6,"limonene"
•Tag/C/N=text2_4 standards, 303.1
•Tag/C/N=text2_4 standards, 303.4
•Tag/C/N=text2_5 standards, 399.2
•Tag/C/N=text2_7/A=LC/X=4.04/Y=8.61 standards, 362.1
•Tag/C/N=text2_6/A=RC
•Tag/C/N=text2_8/F=0/A=LB/X=5.95/Y=2.58 standards, 320,"myrcene"
•Tag/C/N=text2_8 standards, 340.8
•SetAxis left 0.0001,1000
•ModifyGraph muloffset(joe)={0,800},muloffset(standards)={0,0.8}
•ModifyGraph muloffset(joe)={0,800},muloffset(standards)={0,0.7}
•Label bottom "Elution Time (s)"
•Label left "Signal Intensity"
•SavePICT/O/E=-5/B=288 as "results.png"
•analyze(a_start, a_end, standards, a_raw_standard)
•analyze(a_start, a_end, joe, a_raw_analyte)
•a_standardized_analyte = a_raw_analyte * 2.45
•analyte_conc = a_standardized_analyte / a_raw_standard * standard_conc
•sample_conc = analyte_conc / 24.3 * 100
•print a_raw_standard[5] / a_raw_analyte[5]
  2.44609
```