# How to Go Fast and Make Your Carrier Gas Last

## Scaling GC columns to improve speed and sustainability


Agilent
Trusted Answers

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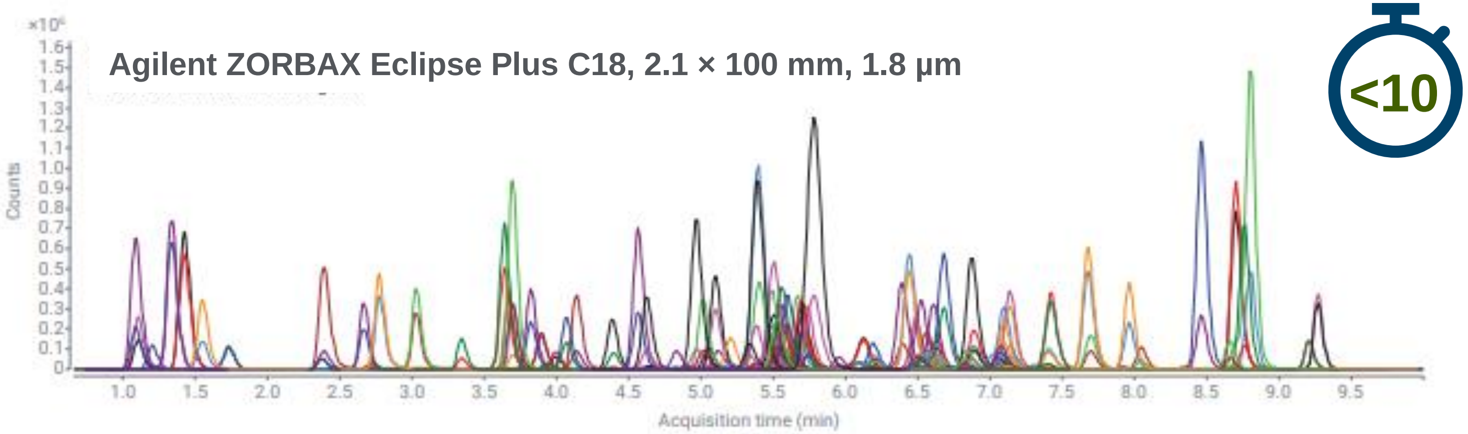
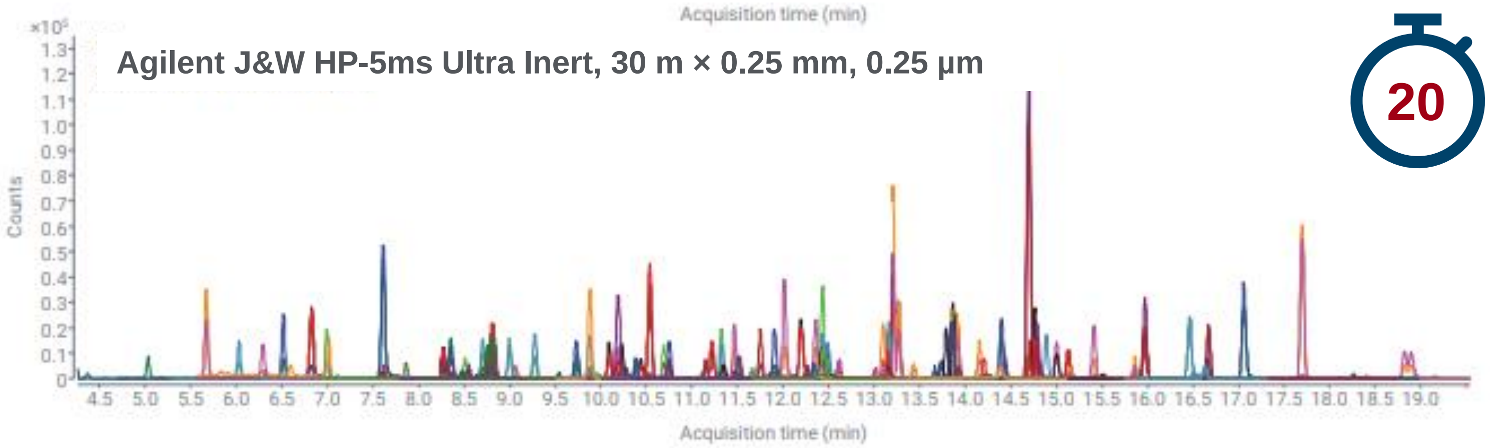
# Today's Presentation


- Review GC column parameters and choices for fast GC
- Scaling GC dimensions for speed
- Conversion to hydrogen carrier
- Five quick tips to conserve helium

# Conventional GC/MS Analysis Can Be 2x Longer UHPLC Analysis

## 240 multiresidue pesticides in bell peppers using LC/MS/MS and GC/MS/MS



# Comparing Fast LC Columns to Fast GC Columns

*Fast GC can be configured on the 8890, 7890, 6890 GC Systems and Intuvo 9000 GC System*

| Technique | Particle Diameter (dp) | Internal Diameter (id) | Length (L) |
|---|---|---|---|
| Conventional HPLC | 5 µm | 4.6 mm | 150 mm |
| Conventional LC(MS) | 3 µm | 2.1 mm | 100 mm |
| Ultra High-Performance LC | 1.9 µm | 2.1 mm | 50 mm |

- Lower particle diameter increases efficiency
- Lower particle diameter greatly increases backpressure (requires specific instrumentation)
- Internal diameter and length are scaled

| Technique | Length (L) | Internal Diameter (id) | Film Thickness (df) |
|---|---|---|---|
| Conventional GC | 30 | 0.53 mm | 0.5 µm |
| Conventional GC(MS) | 30 | 0.25 mm | 0.25 µm |
| Ultra High-Performance GC | 20 | 0.18 mm | 0.18 µm |

- Lower internal diameter increases efficiency
- Lower internal diameter increases backpressure
- Film thickness and length are scaled

# Scaling GC Columns

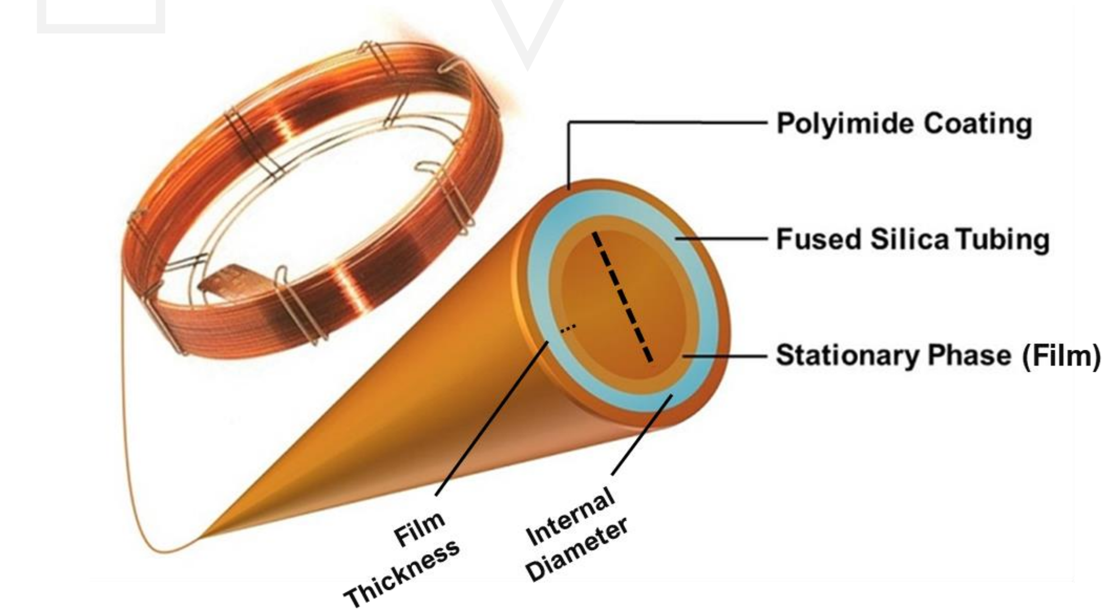
## How to maintain your chromatography when increasing your speed

# Reviewing the Parameters of a GC Column

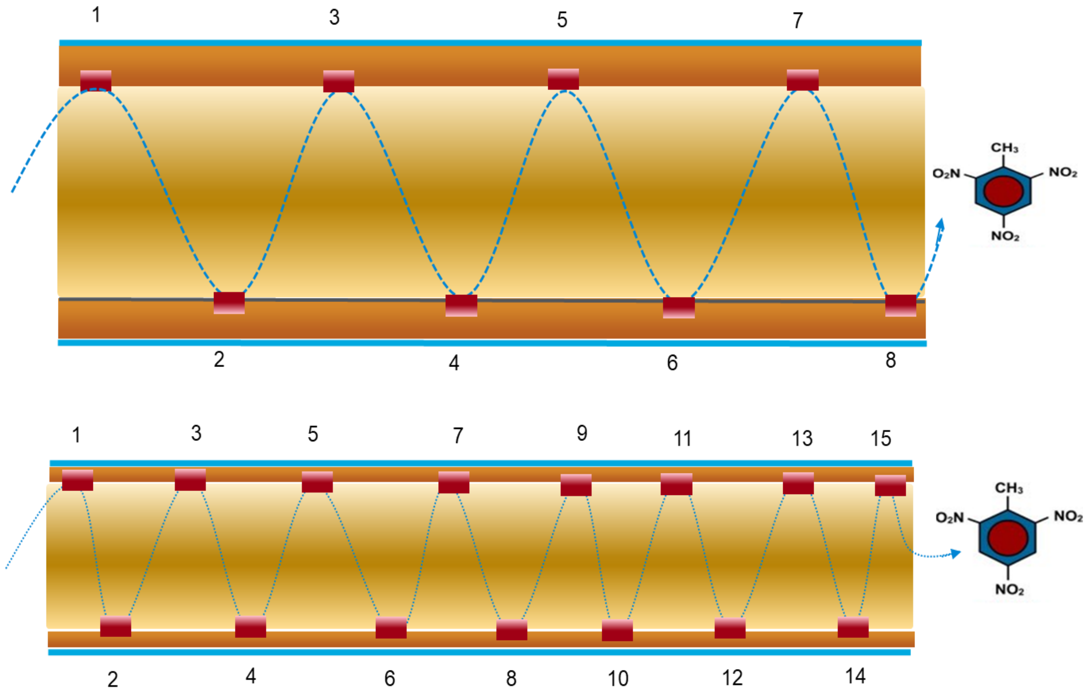
**DB-5** (Stationary Phase Type)

**30m (L) x 0.25mm (ID) x 0.25µm (df)**

Length x Internal Diameter x Film Thickness



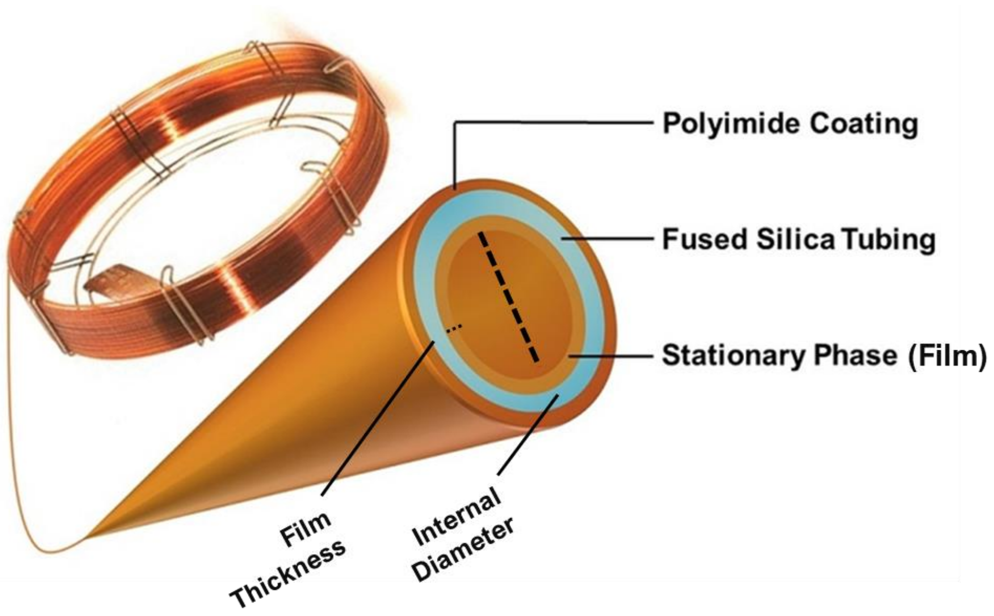

**GC column interactions (efficiency) can be increased by increasing column length or by decreasing column id**



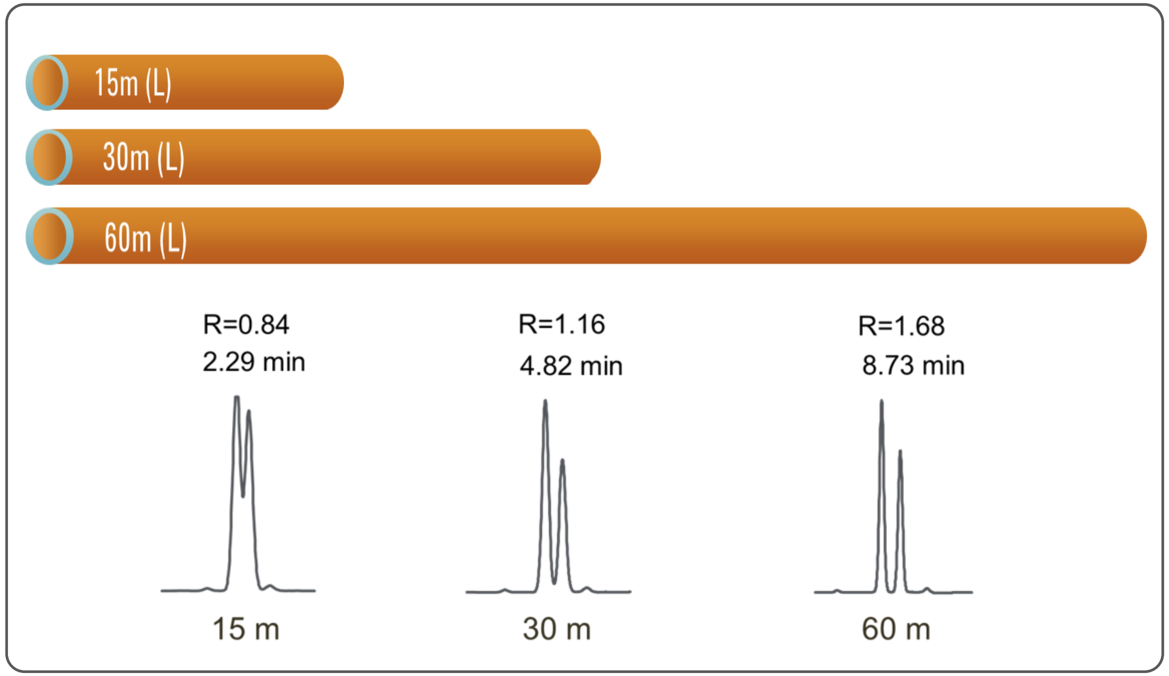
# The Impact of GC Column Length

**DB-5** (Stationary Phase Type)

**30m (L)** Length x **0.25mm (ID)** x Internal Diameter x **0.25µm (df)** x Film Thickness



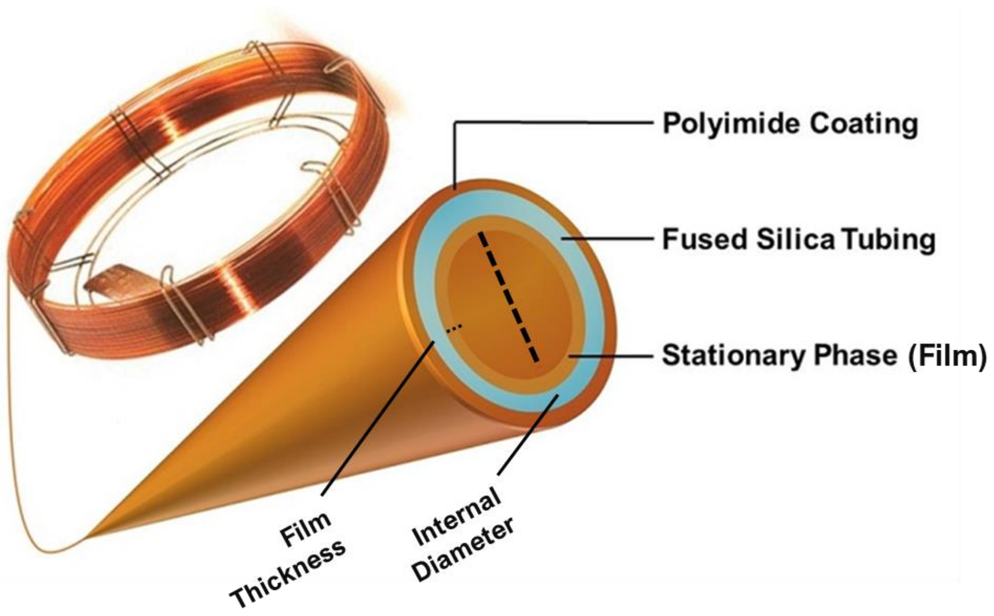

**Column length has minimal impact on resolution, but significantly increases analysis time**



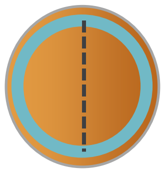

# The Impact of GC Column Internal Diameter

**DB-5** (Stationary Phase Type)

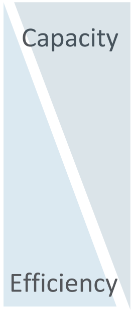
**30m (L)** Length **x 0.25mm (ID)** x Internal Diameter **x 0.25µm (df)** x Film Thickness

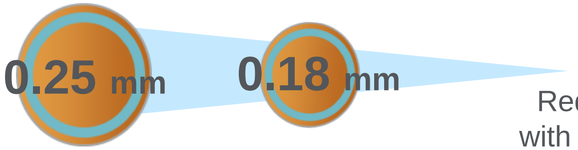



## Column internal diameter reduces analysis time, gas consumption



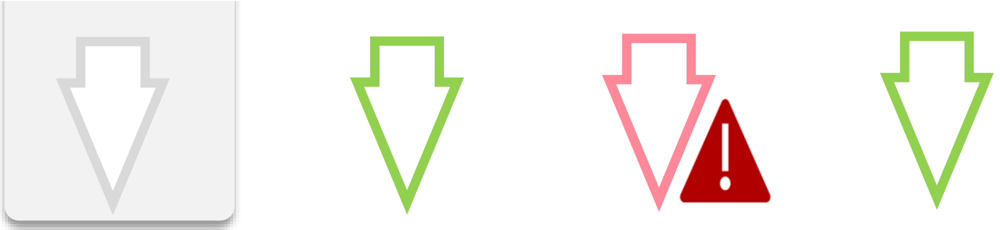
| Column Internal Diameter (ID) | Common Name |
|---|---|
| 0.53 mm | Mega-bore |
| 0.32 mm | Wide-bore |
| 0.25 mm | Narrow-bore |
| 0.18 mm | Mini-bore |
| 0.10 mm | Micro-bore |




**28%**
Reduction in flow rate with same linear velocity

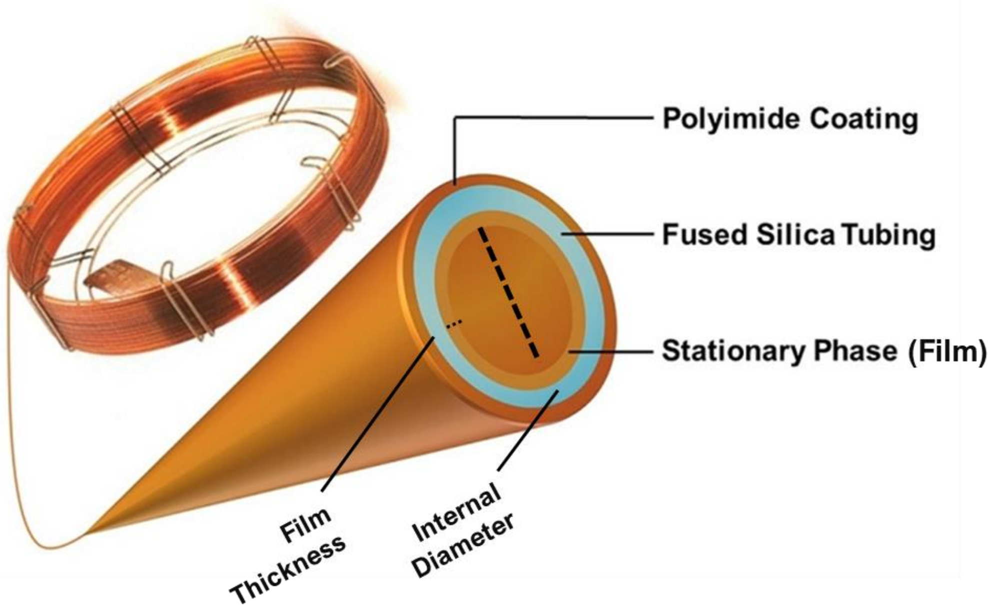
| Column id | Analysis time | Capacity | Gas consumption |
|---|---|---|---|



# The Impact of GC Column Film Thickness

**DB-5** (Stationary Phase Type)

**30**m (L) — Length
x **0.25**mm (ID) — x Internal Diameter
x **0.25**µm (df) — x Film Thickness




**Film thickness can be used to maintain retention and selectivity when adjusting column parameters**

$$\text{Phase ratio } (\beta) = \frac{\text{Column radius (mm)}}{2 \times \text{film thickness } (\mu m)}$$

$$\text{Phase ratio } (\beta) = \frac{125\ \mu m}{2 \times 0.25\ \mu m}$$

Phase ratio (β) = 250

Common scaling example for GC/MS:

**0.25 mm (id) x 0.25 µm (df)**

$$(\beta) = \frac{125\ \mu m}{2 \times 0.25\ \mu m}$$

(β) = 250

**0.18 mm (id) x 0.18 µm (df)**

$$(\beta) = \frac{90\ \mu m}{2 \times 0.25\ \mu m}$$

(β) = 250

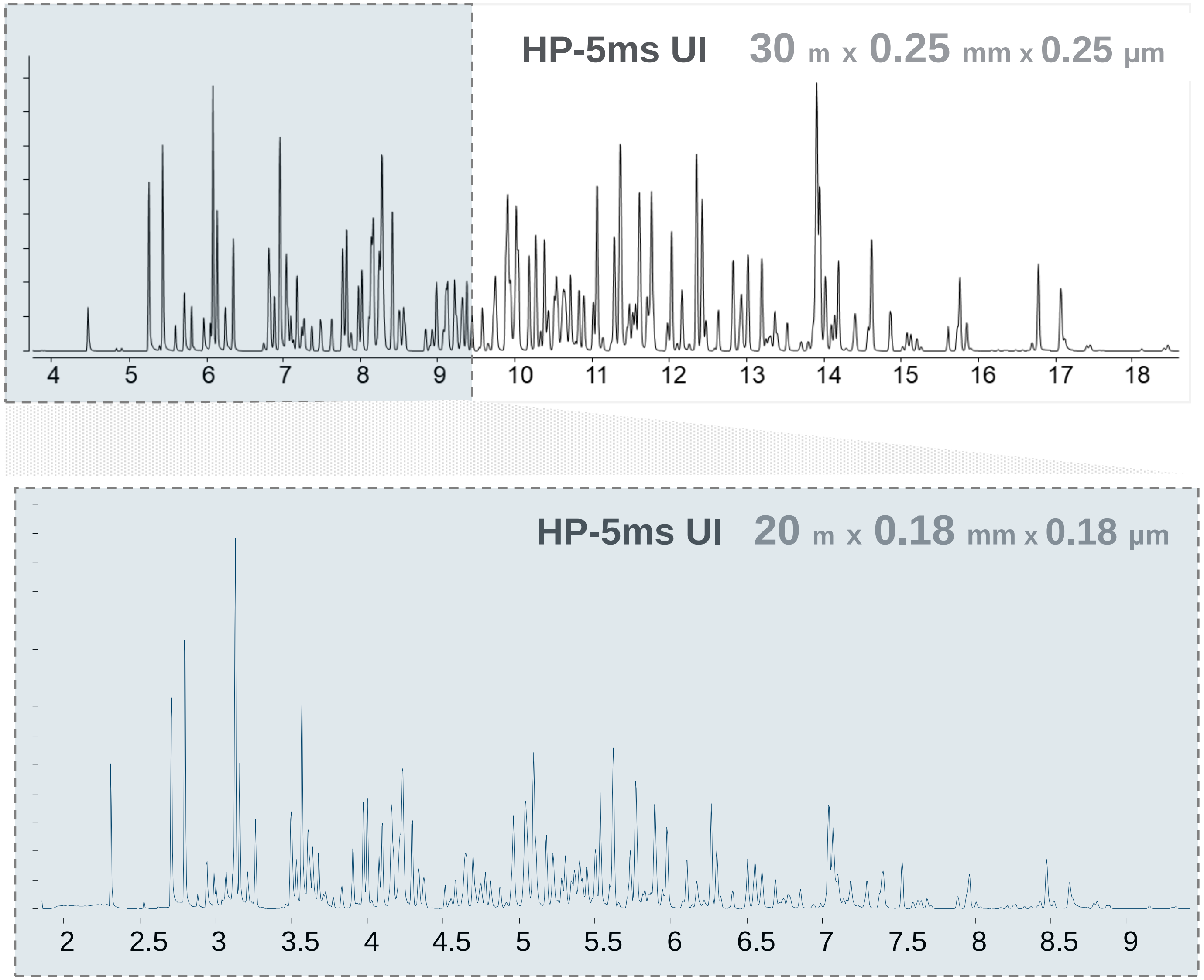
# Column Scaling Example

**When scaling GC columns:**

**Column id** | **Column length** | **Column film**

*Resulting in:*

**Analysis time** | **Gas use** | **Column capacity**

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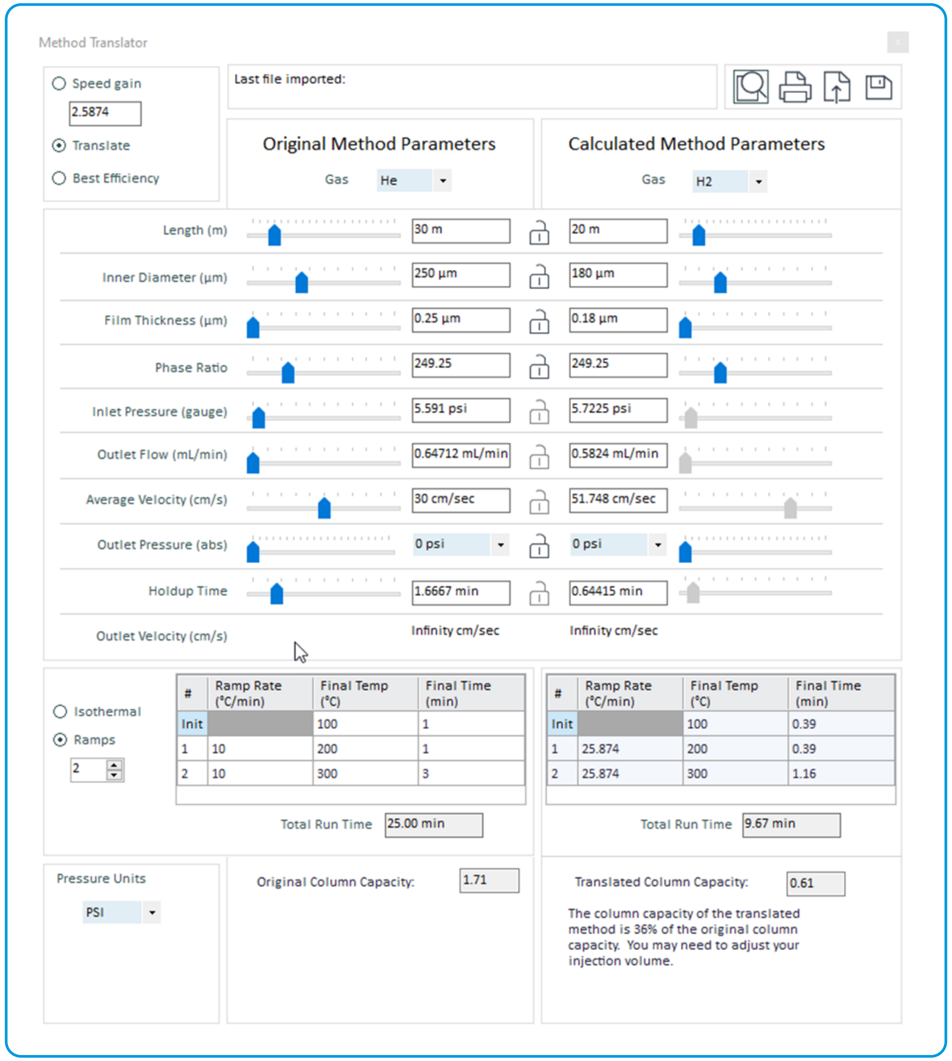
# Scaling Your GC method

## GC Method Translator Software can guide and simplify



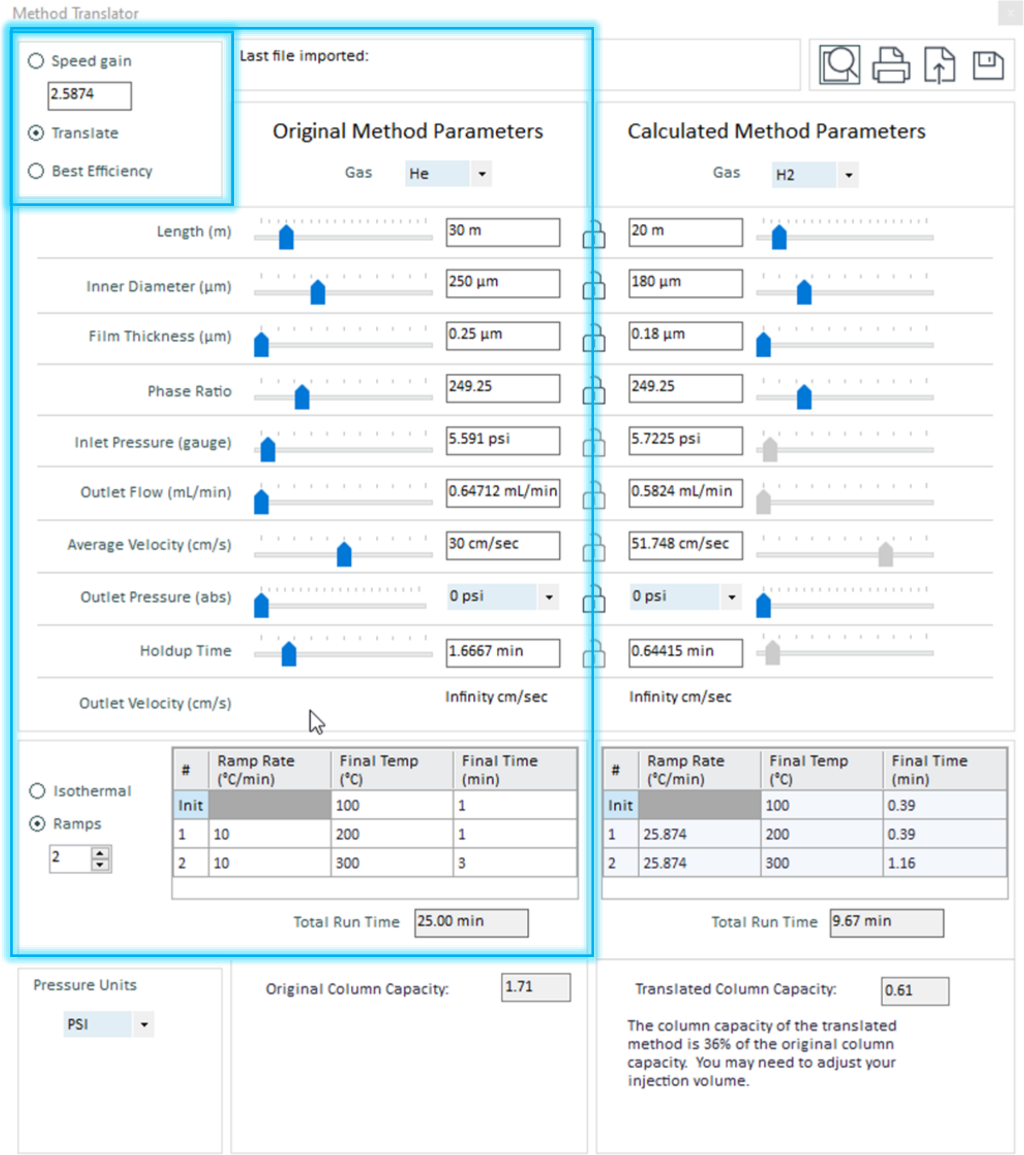

- Allows you to port a current GC method to another GC, while ensuring that relative retention order is maintained.
- This tool can used to:
  - **Speed up an analysis**
  - Change detectors (for example, from FID to MS)
  - **Change carrier gas type**
  - Adjust column dimensions

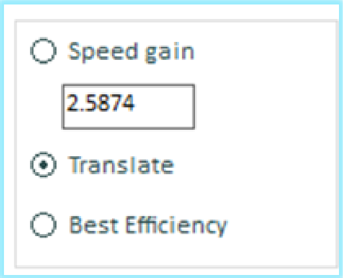
**Download GC tools**

*Free download available*

GC Calculators and Method Translator Software | Agilent

# Scaling Your GC Method Using the Method Translation Software

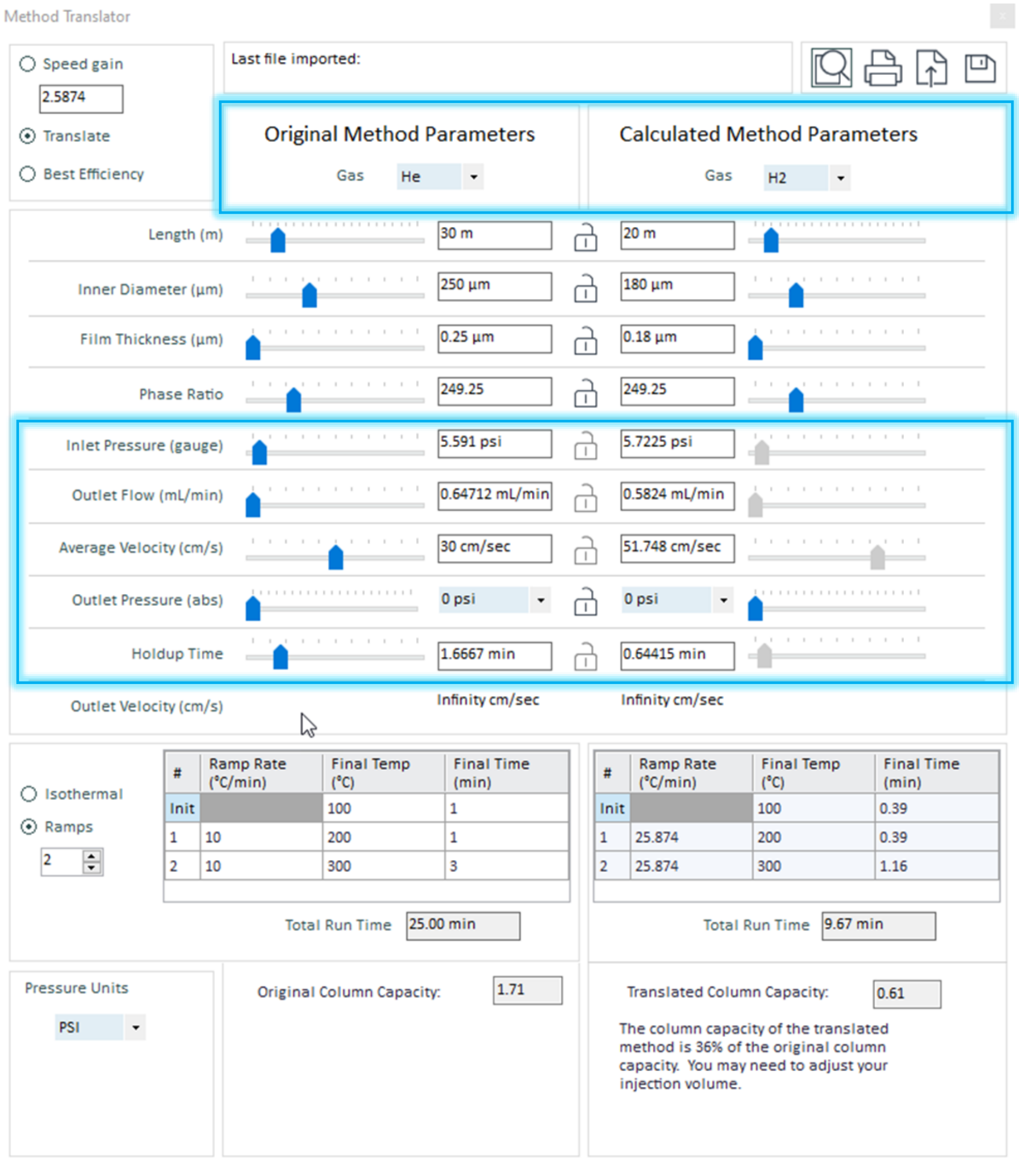


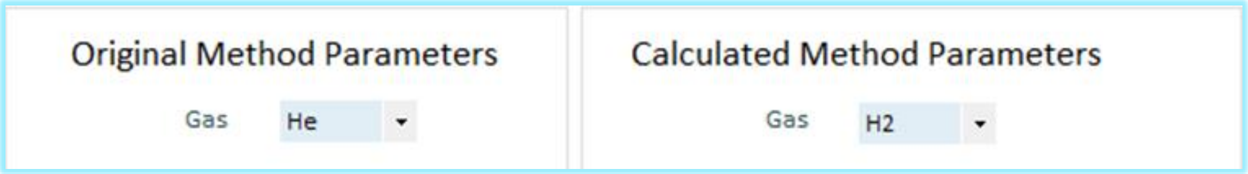

**To begin:**

- Choose translate option
- **2-3x** improvement in analysis time can be expected
- Input original method parameters

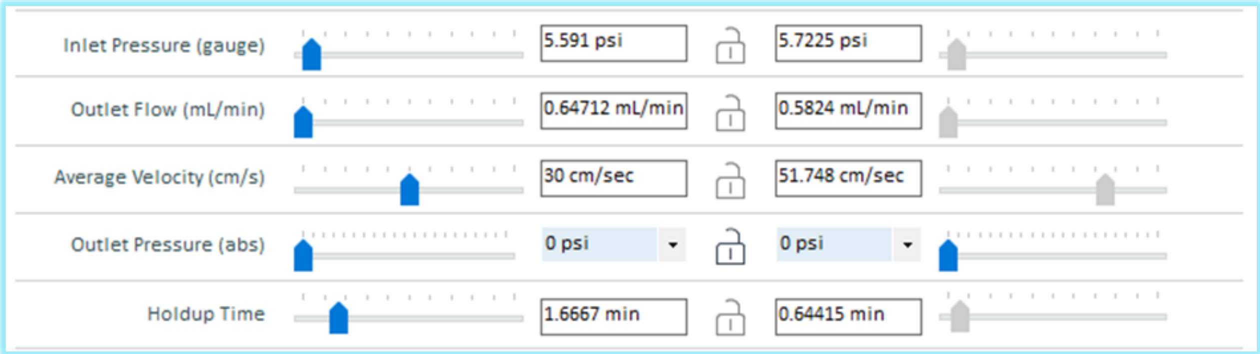
# Scaling Your GC Method Using the Method Translation Software




## Carrier gas and flows:

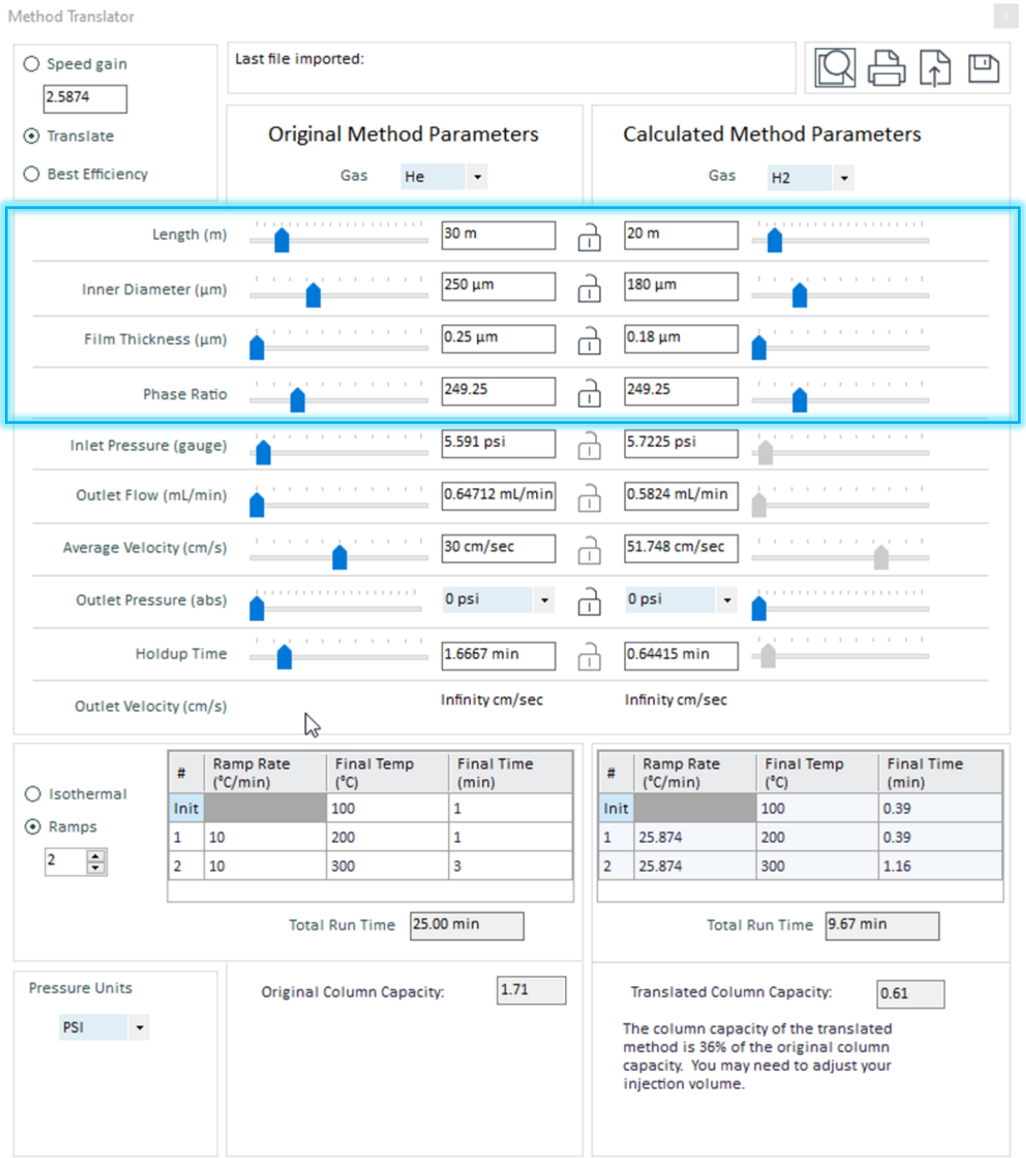



- Alternate carrier gases can be selected

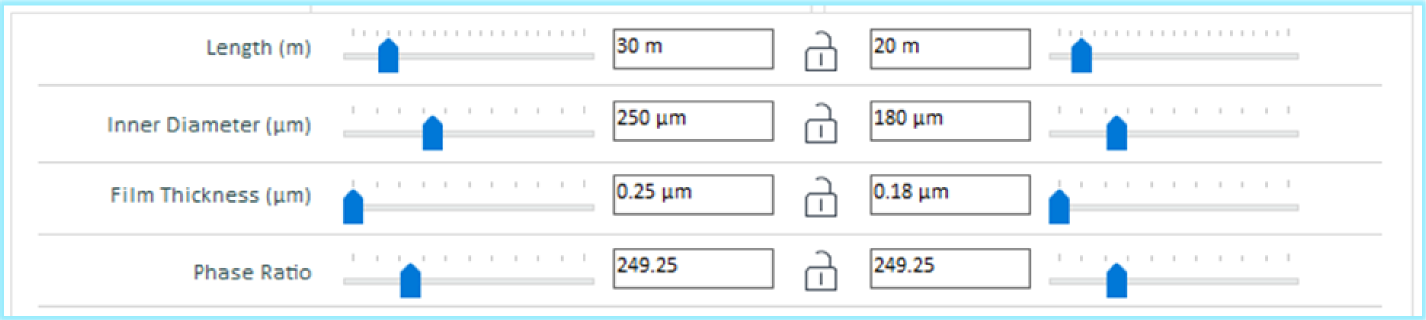



- Adjust linear velocity (reduction in gas consumption dependent on id and flow)
- Be sure to check for positive inlet pressure
- Match outlet pressure to detector
  - Atmospheric -14.696
  - Vacuum (MS) - 0

# Scaling Your GC Method Using the Method Translation Software

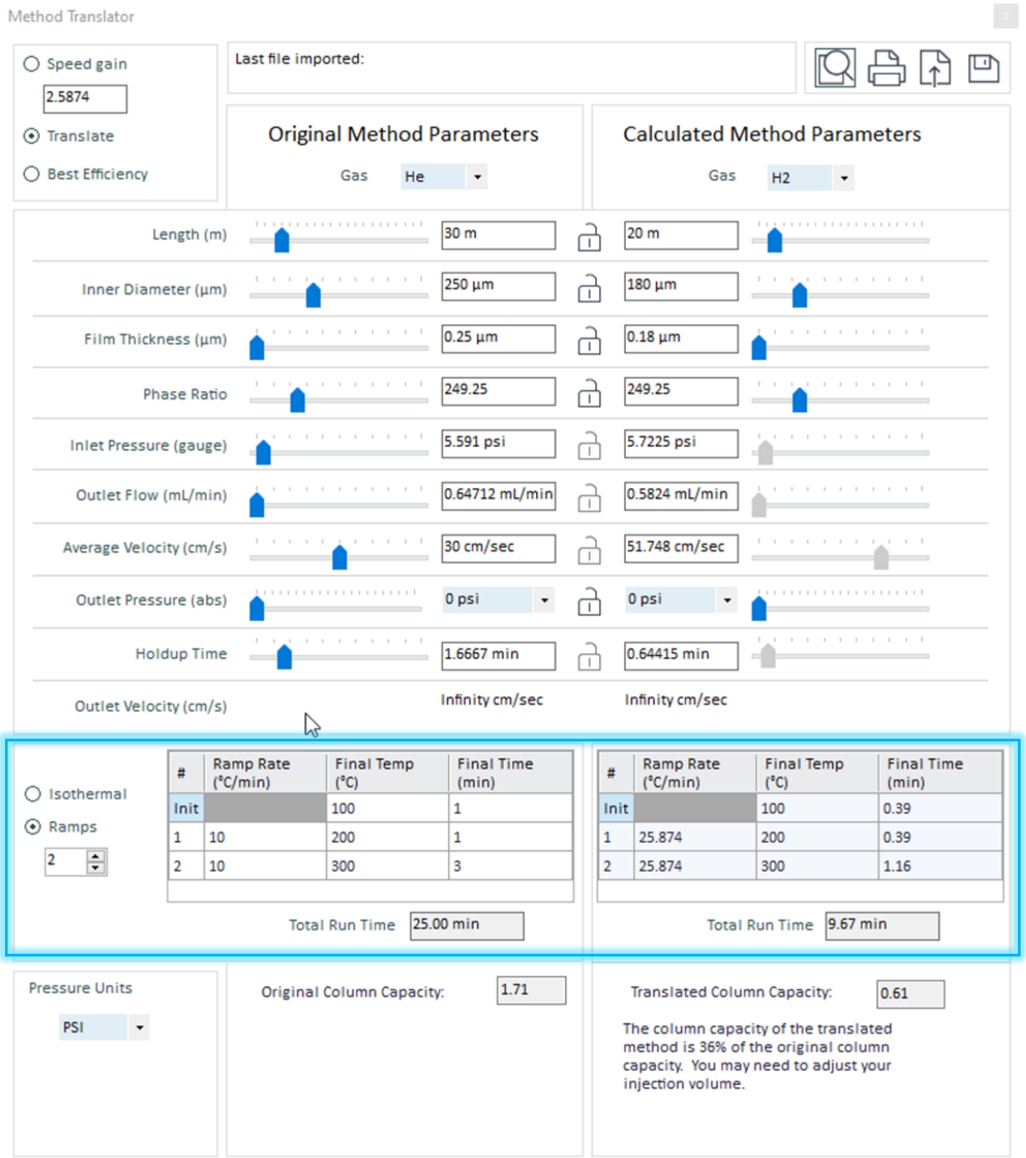



## Column parameters:

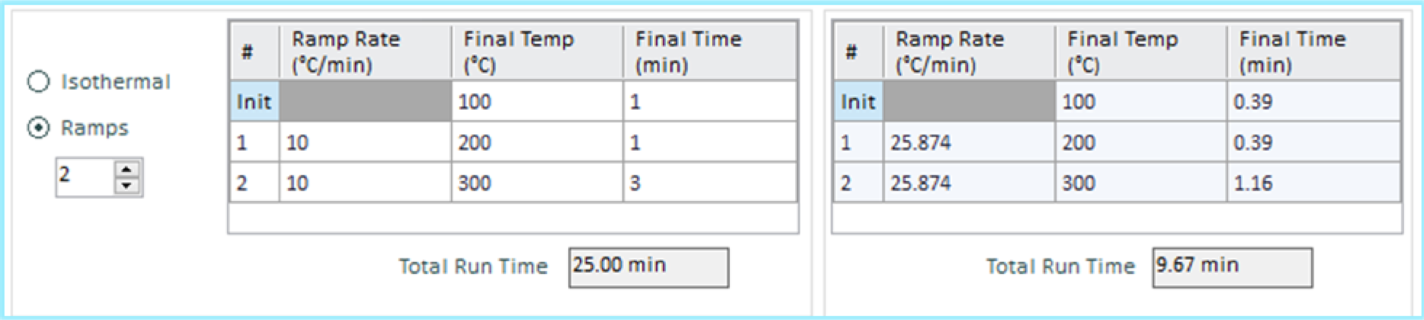



- Reduce column length
  (10 m, 20 m, 30 m, 60 m are the standard lengths)
- Reduce id
  (530 µm, 320 µm, 250 µm, 180 µm are the standard ids)
- Match phase ratios
  (to maintain retention/selectivity)

# Scaling Your GC Method Using the Method Translation Software




**Oven program:**




| # | Ramp Rate (°C/min) | Final Temp (°C) | Final Time (min) |
|---|---|---|---|
| Init | | 100 | 1 |
| 1 | 10 | 200 | 1 |
| 2 | 10 | 300 | 3 |

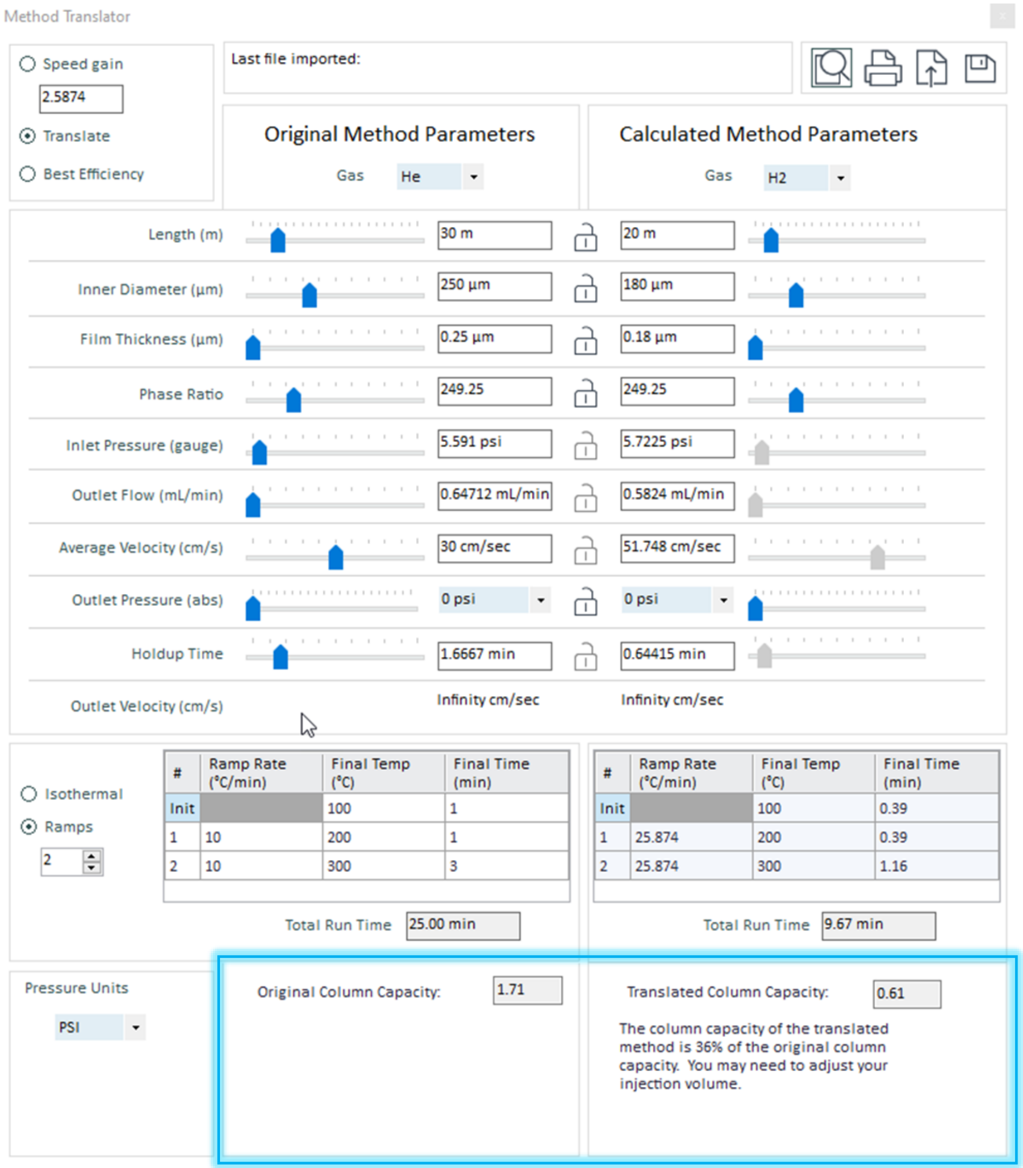
Total Run Time 25.00 min

| # | Ramp Rate (°C/min) | Final Temp (°C) | Final Time (min) |
|---|---|---|---|
| Init | | 100 | 0.39 |
| 1 | 25.874 | 200 | 0.39 |
| 2 | 25.874 | 300 | 1.16 |

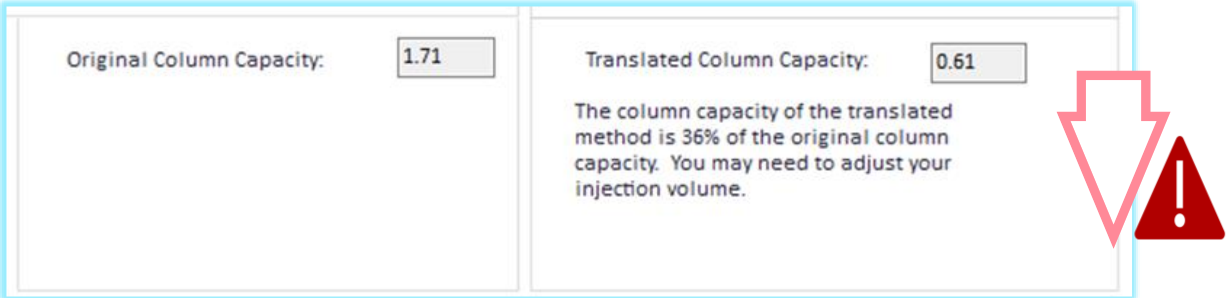
Total Run Time 9.67 min

- Adjustable and predictive
- Be sure to ramp within instrument specifications – direct heating versus air-batch
- Consider cycle times (run-time + cool-down)
- Consider backflushing instead of “bake-out” steps

# Scaling Your GC Method Using the Method Translation Software

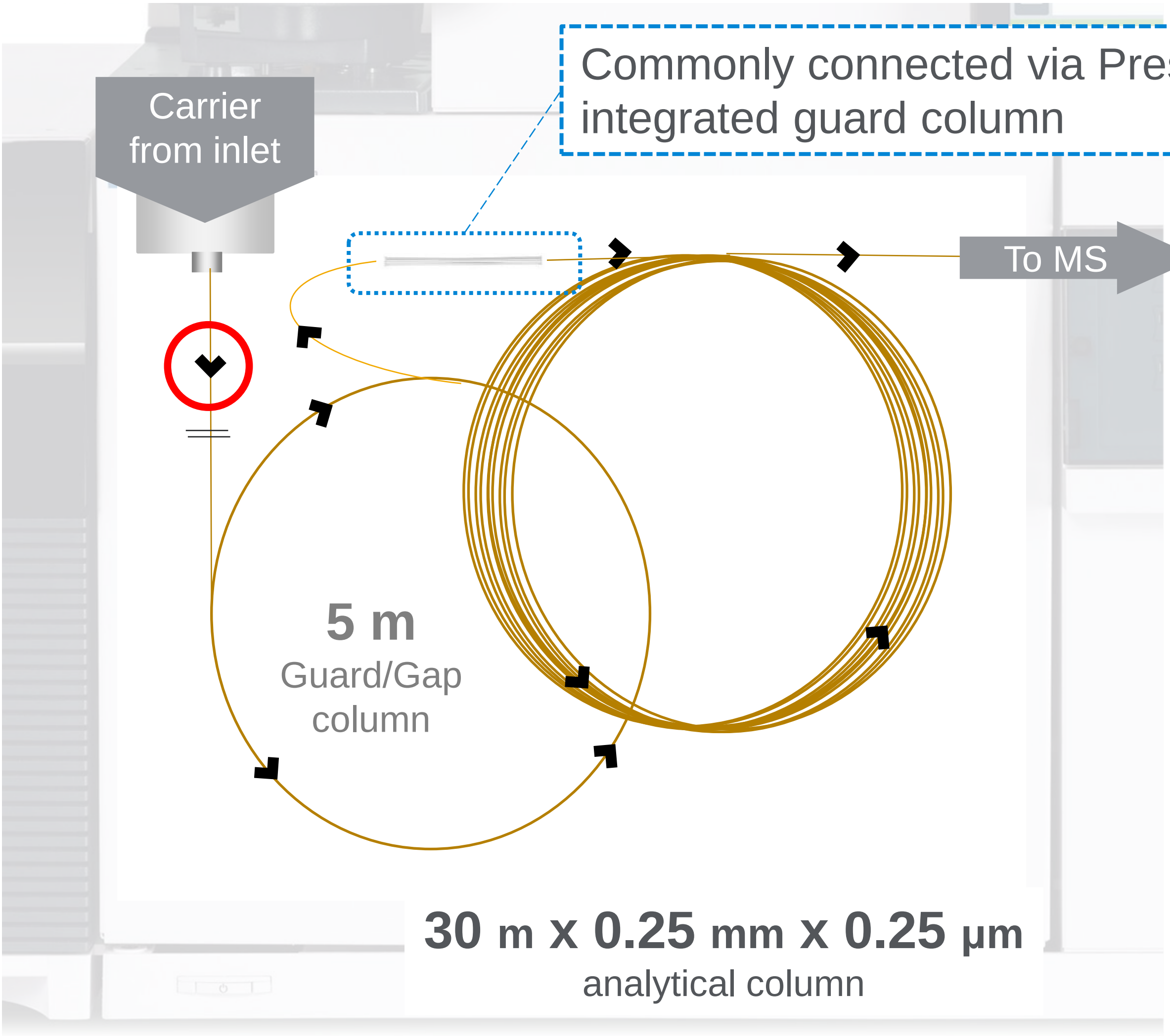


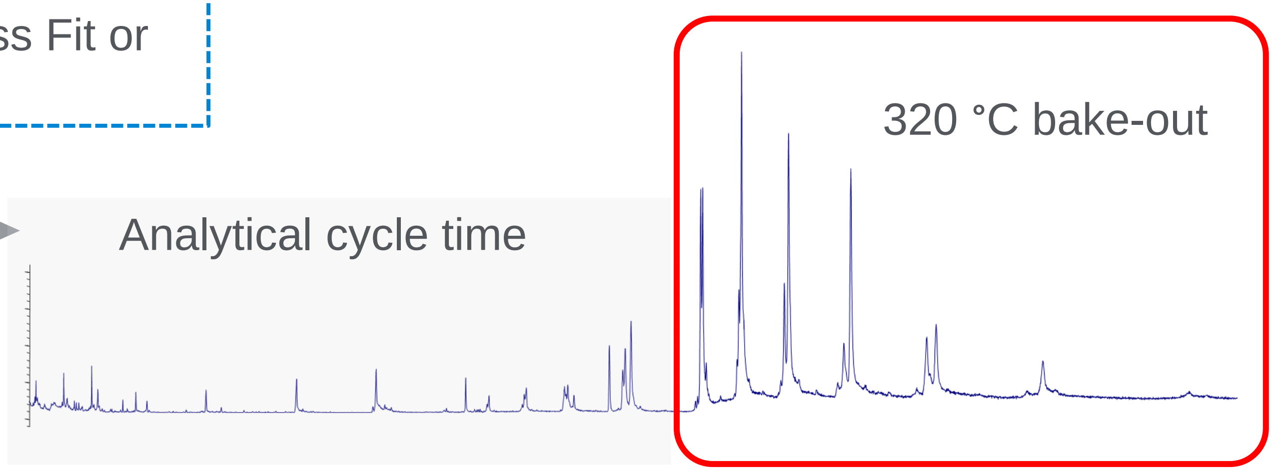

## Column capacity:




- Injection volume should be scaled proportionally
  - Trace analysis may be impacted
- Smaller column ids have been observed to increase maintenance intervals due to matrix accumulation
  - Loss of analyte response (sensitivity)
  - Loss of peak shape (integration accuracy)
  - Loss of resolution (analyte identity)

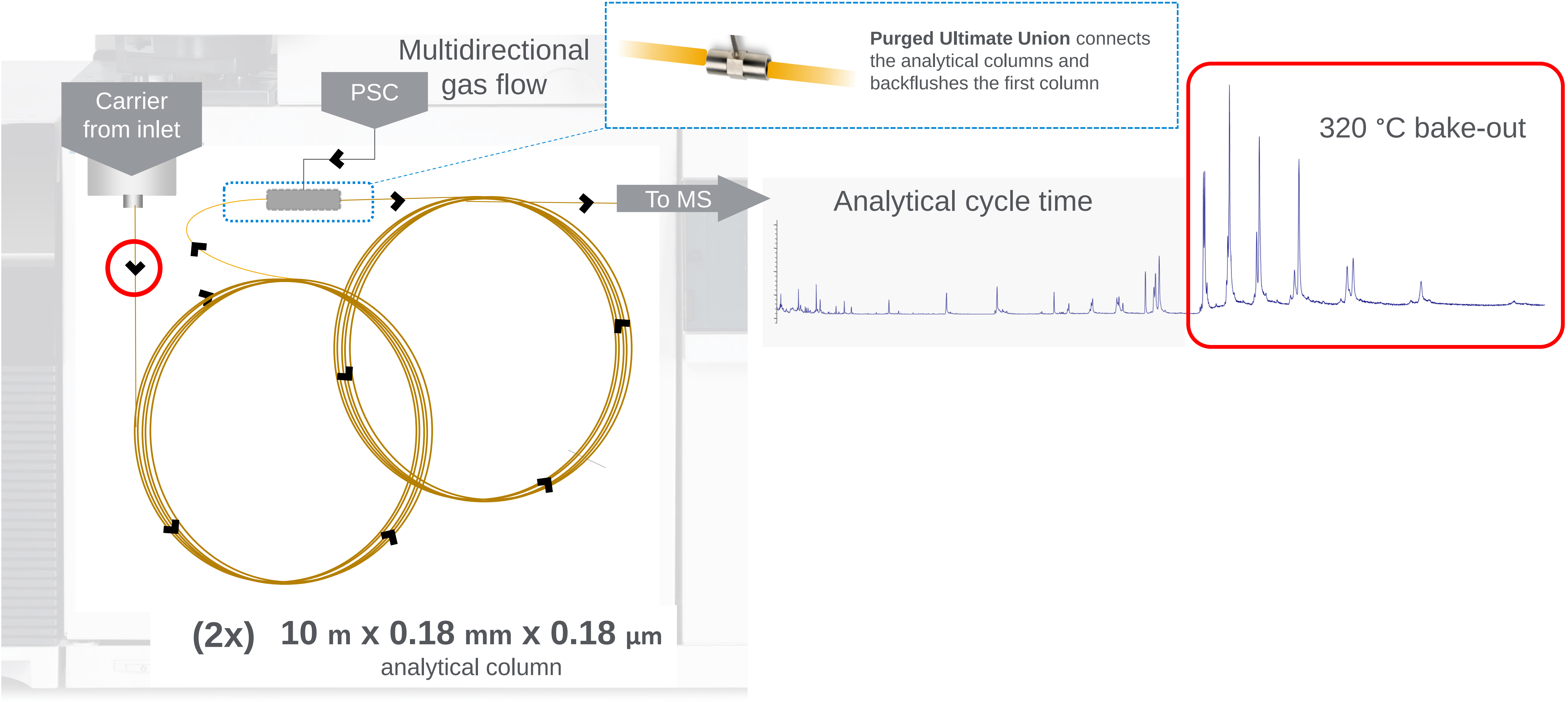
# Conventional Single-Column Analysis



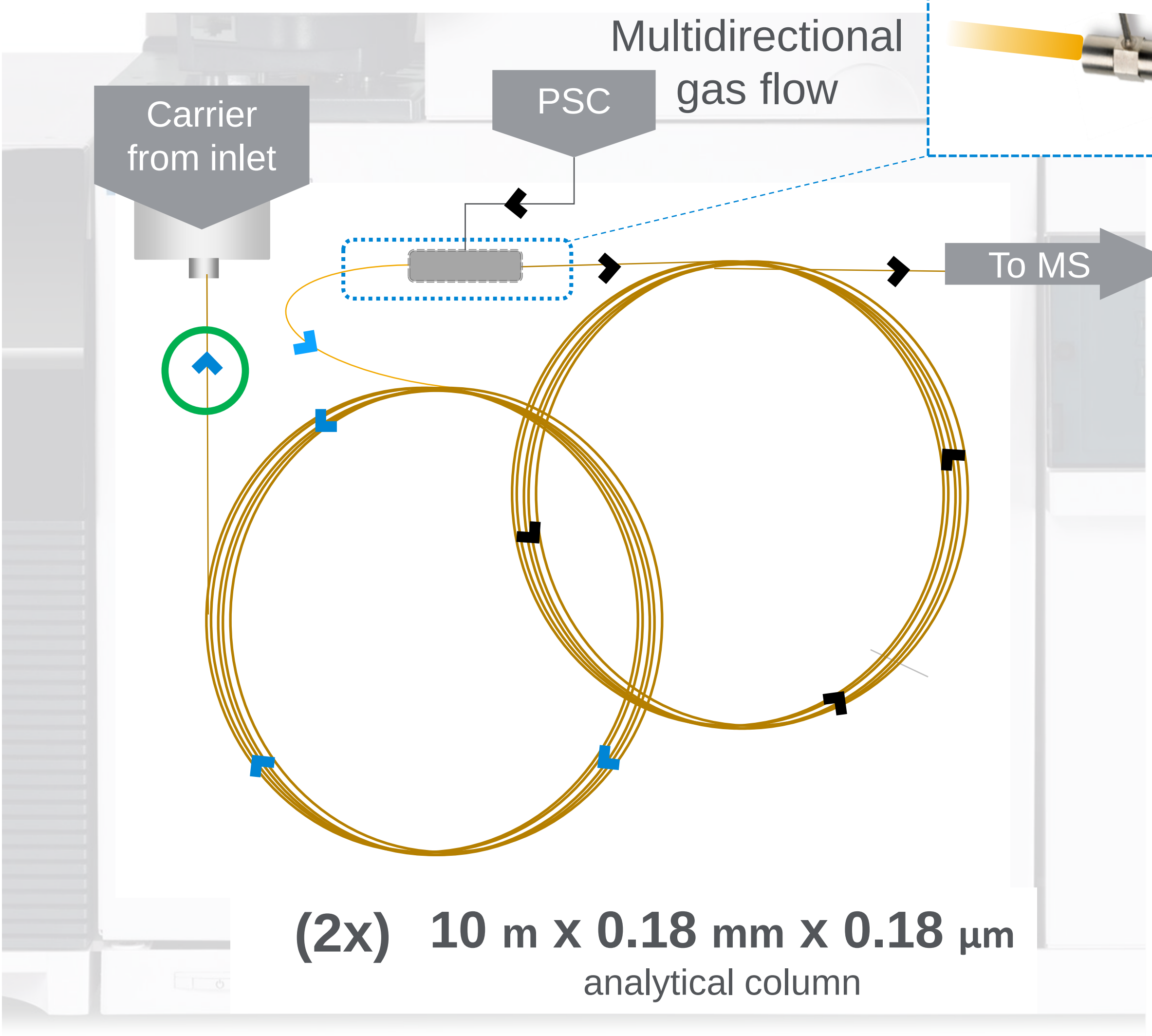



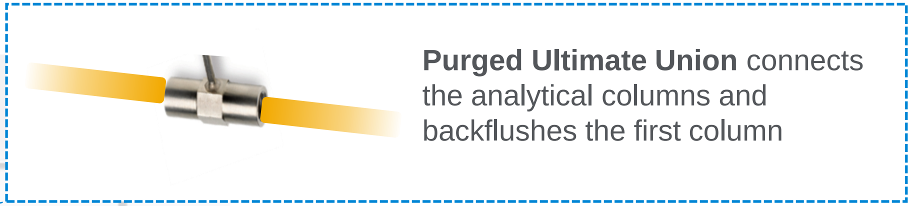

High(er) boiling matrix collects deteriorating data quality and results in a column trimming maintenance event (downtime).

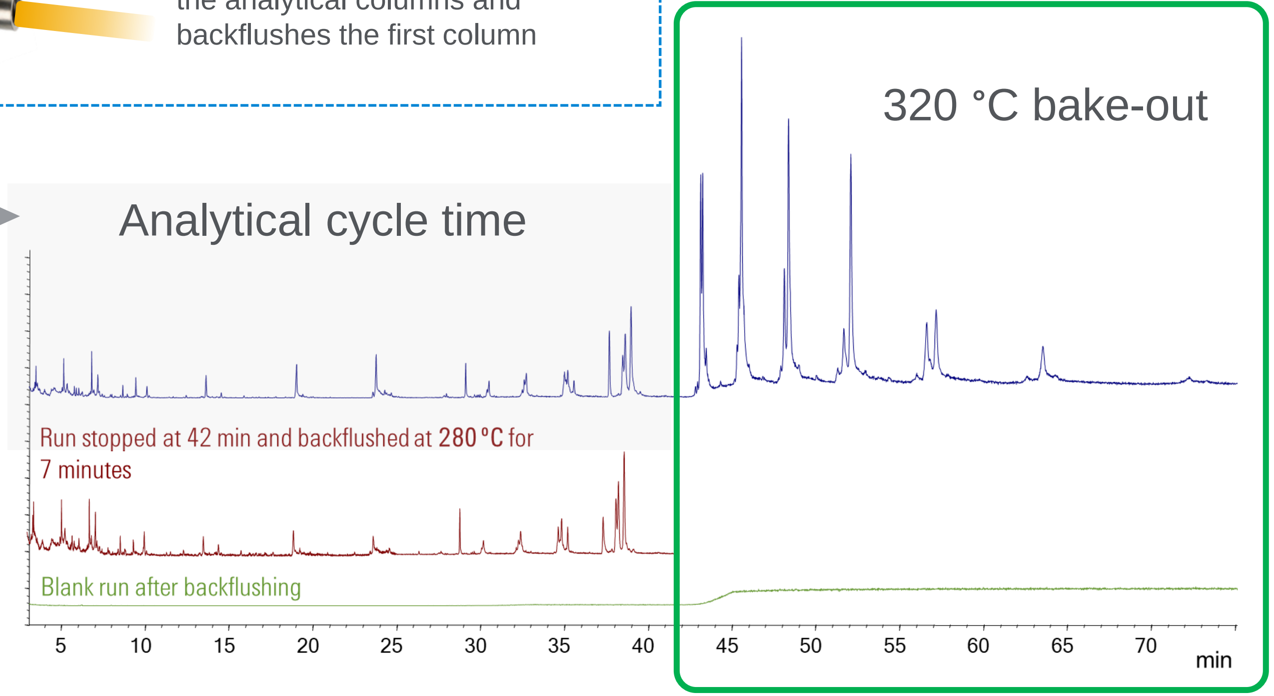
# Midcolumn Backflushing Analysis



# Midcolumn Backflushing Analysis



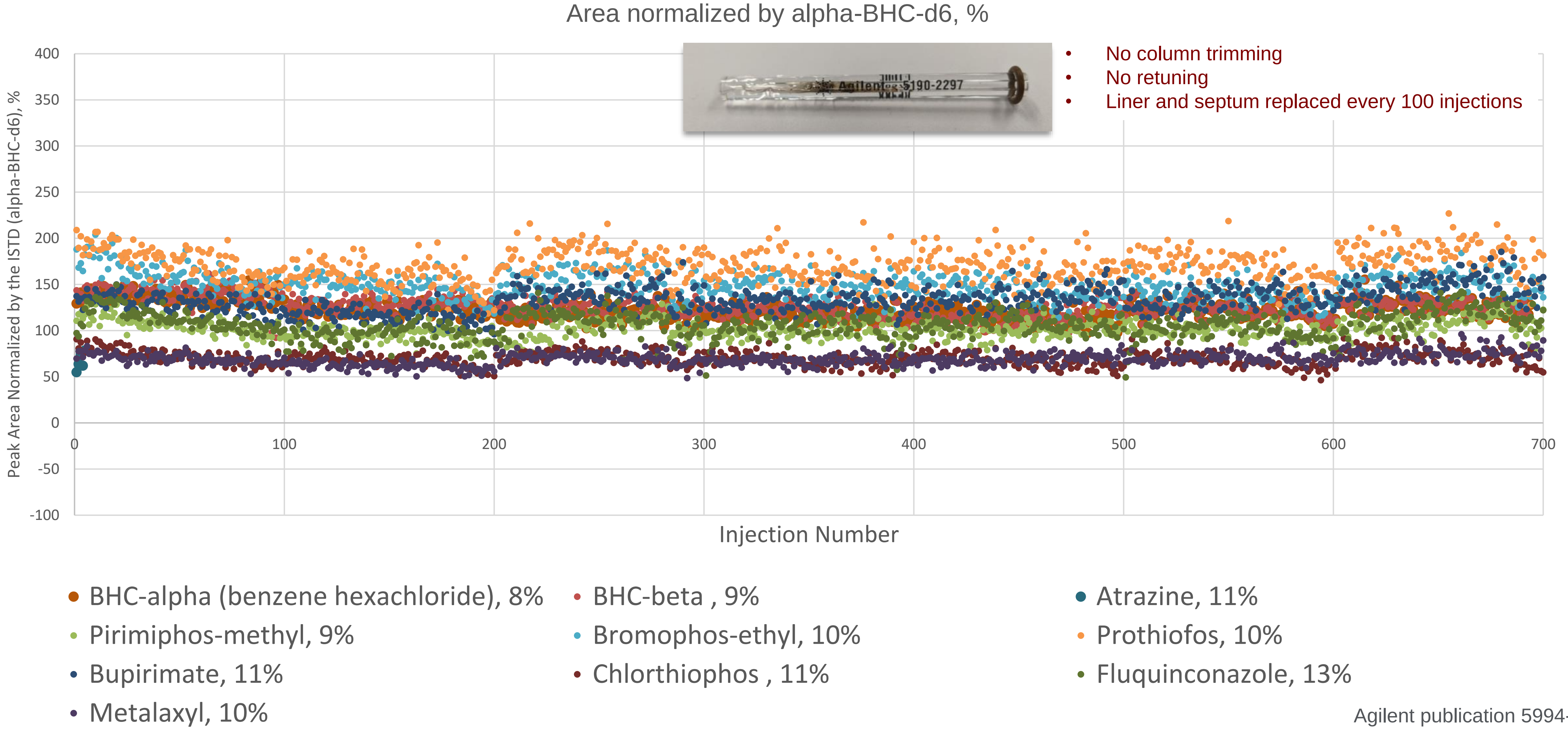




High(er) boiling matrix is backflushed out of the split vent, lessening the need for column and source maintenance events.

# Normalized Response of Pesticides - 20 ppb Spiked QuEChERS EMR-HCF Spinach

## Longevity: Area normalized by the ISTD, 20 ppb in Spinach with 7000E (10 min)

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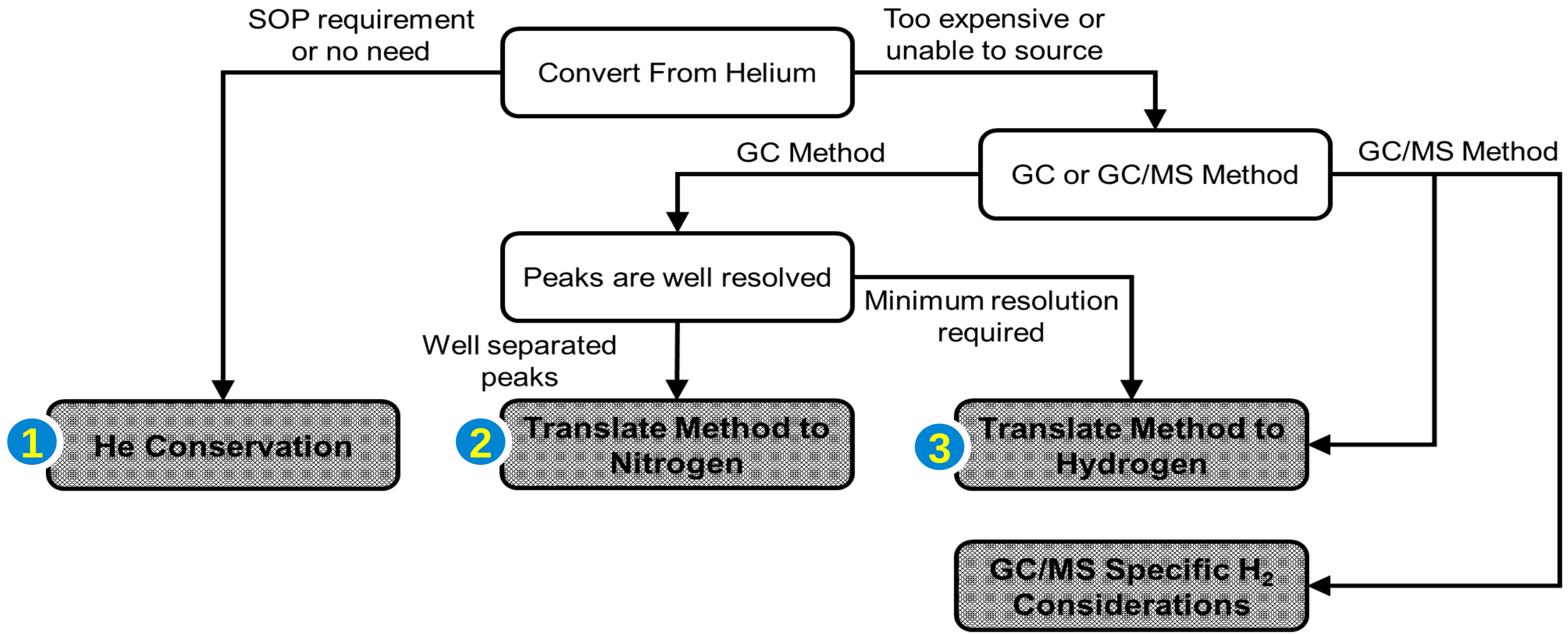
# Converting to Hydrogen Carrier

## How to maintain your chromatography and reduce speed

# Alternate Carrier Decision Tree

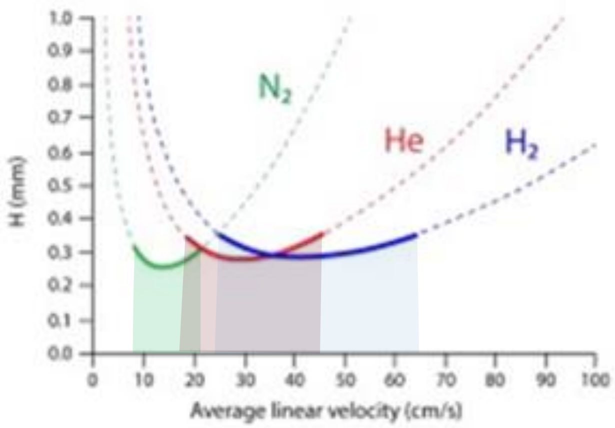



- **Helium is the best carrier gas option**
- Hydrogen and nitrogen are viable alternatives to Helium, but require special considerations
- Changes in chromatographic results and methods should be expected when converting – **not "Plug & Play"**

# Review of Alternate Carrier Gases

| | Helium Carrier | Nitrogen Carrier | Hydrogen |
|---|---|---|---|
| Pros | • Inert<br>• Excellent MS performance<br>• Reference spectra libraries available<br>• Fits common consumable dimensions | • Inexpensive and widely available<br>• No additional safety concerns<br>• Generator available | • Fast<br>• Generator available |
| Cons | • Unplanned supply disruptions<br>• Cost fluctuations | • Long run times<br>• Not recommended for MS (sensitivity) | • **Requires additional safety precautions**<br>• **Analyte activity** |
| | | **Recommended use:**<br>• Nonselective detectors<br>• Low-sample throughput<br>• Small panels, well-separated | **Recommended use:**<br>• Mass selective detectors<br>• High-sample throughput<br>• Large, multicompound methods |

**The practical linear velocity ranges of common carrier gases**



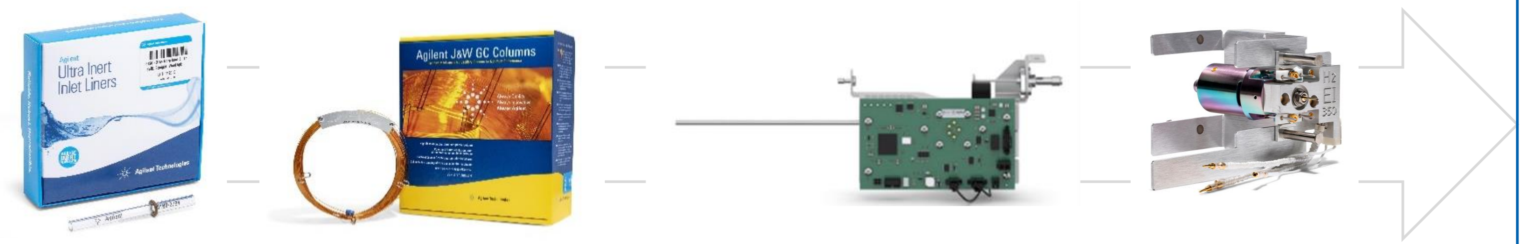

**Hydrogen is capable of high linear velocity, shortening run times**
***Additional considerations are needed for safety and analyte activity***

**Nitrogen can be used with low linear velocity, extending run times**

# Review of Alternate Carrier Market Position

| | Helium Carrier | Nitrogen Carrier | Hydrogen Carrier |
|---|---|---|---|
| Pros | • Inert<br>• Excellent MS performance<br>• Reference spectra libraries available<br>• Fits common consumable dimensions | • Inexpensive and widely available<br>• No additional safety concerns<br>• Generator available | • Fast<br>• Generator available |
| Cons | • Unplanned supply disruptions<br>• Cost fluctuations | • Long run times<br>• Not recommended for MS (sensitivity) | • Requires additional safety precautions<br>• Reactive |
| | | **Recommended use:**<br>• Nonselective detectors<br>• Low-sample throughput<br>• Small panels, well-separated | **Recommended use:**<br>• Mass selective detectors<br>• High sample throughput<br>• Large, multicompound methods |

**Be sure to use a hydrogen sensor and an Ultra Inert carrier gas flow path**




Ultra Inert liners and columns    Hydrogen sensor module    HydroInert MS source

# Carrier Gas Choice Impacts Column Internal Diameter

| Column ID Compatibility by Carrier Gas | | | | | |
|---|---|---|---|---|---|
| Column Internal Diameter (mm) | Common Name | | Helium | Nitrogen | Hydrogen |
| 0.53 mm | **Mega**-bore | Capacity | ☑ | ☑ | ☒ |
| 0.32 mm | **Wide**-bore | | ☑ | ☑ | ☒ |
| 0.25 mm | **Narrow**-bore | | ☑ | ☑ | > 40 m |
| 0.18 mm | **Mini**-bore | | ☑ | ☑ | ☑ |
| 0.10 mm | **Micro**-bore | Efficiency | ☑ | ☑ | ☑ |

| GC Conditions | Hydrogen Carrier | |
|---|---|---|
| GC Column Length (m) | **30** | **40** |
| GC Column ID (mm) | **0.25** | **0.25** |
| Inlet Pressure (psi) | -0.161 | 2.088 |
| Column Flow | 1.00 | 1.00 |

***40 m** of column length is needed to maintain positive inlet pressure for 0.25 mm id columns*

- Nitrogen carrier gas can be used with all common Helium dimensions
- **Hydrogen carrier gas use limited to smaller ids complicating conversion**

# Column Selection for Hydrogen Conversion

**1** Are you starting a new method or converting an existing method?

- New → 
  New and adjusted methods:
  **20 m x 0.18 mm** (x 0.18 µm)
- Existing → 2

**2** Are you trying to maintain your RTL from a standard 30 m x 0.25 mm?

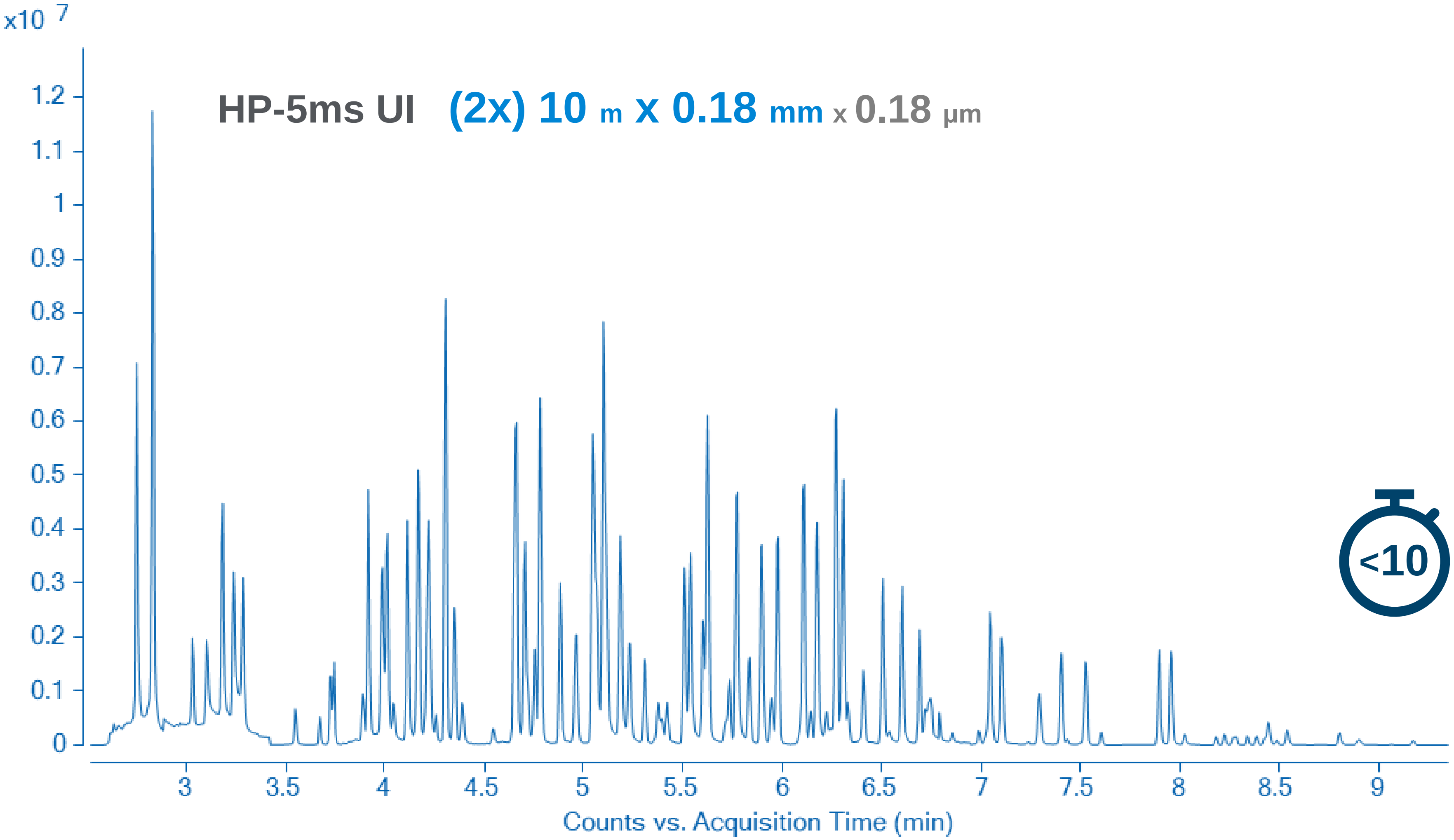
- Yes → 
  Maintain RTL:
  **40 m x 0.18 mm** (x 0.18 µm)
- No → 3

**3** Will lessening your injection volume impact your LOD/LOQ?

- Yes → 
  Extra column capacity:
  **40 m x 0.25 mm** (x 0.25 µm)
  **60 m x 0.25 mm** (x 0.25 µm)
- No → Maintain RTL: **40 m x 0.18 mm** (x 0.18 µm)

# New Hydrogen Carrier Method

## 238 pesticides analyzed with midcolumn backflushing and $H_2$ carrier

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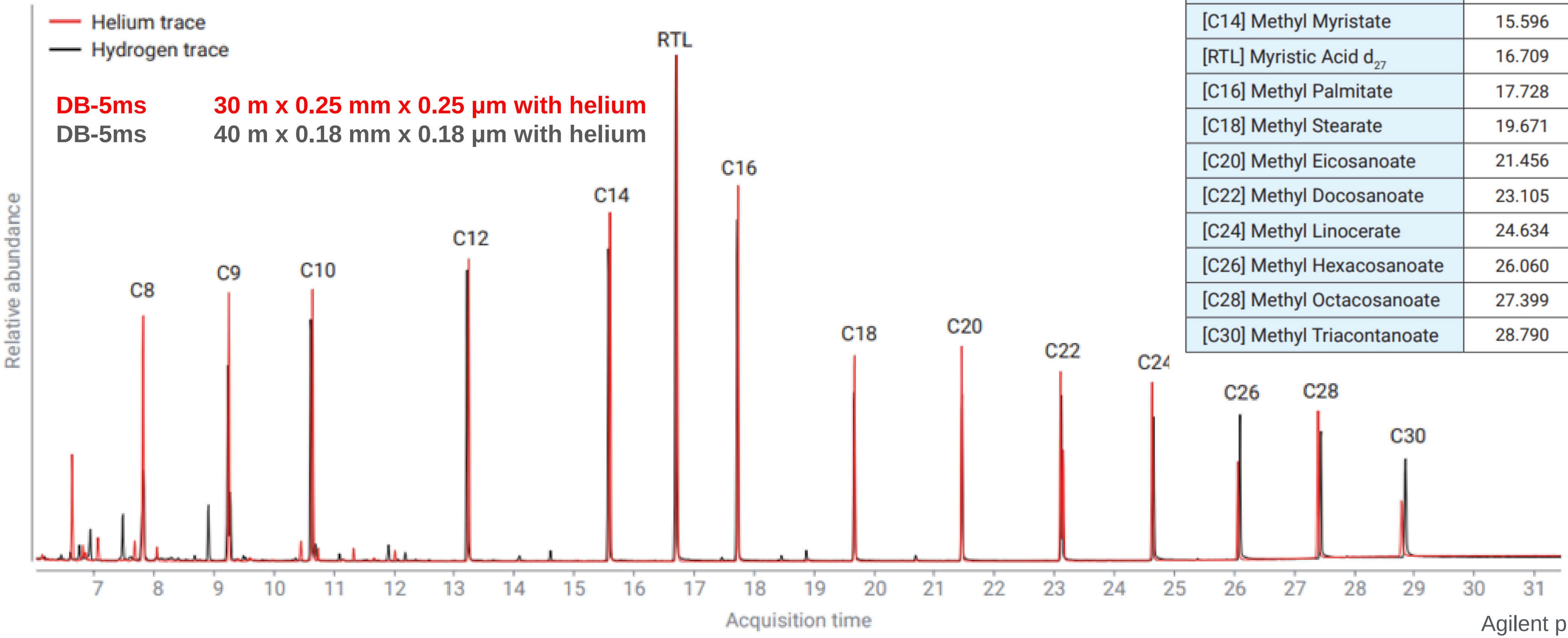
# Maintaining Retention Time Locking When Converting to Hydrogen

## Comparison of FAMEs using helium and hydrogen carrier

**A standard 30 m x 0.25 mm column will retention time lock with 40 m x 0.18 mm mini-bore columns**




| Compound Name | Helium RT (min) | Hydrogen RT (min) | RT Delta (min) |
|---|---|---|---|
| [C8] Methyl Caprylate | 7.818 | 7.82 | 0.006 |
| [C9] Methyl Pelargonate | 9.245 | 9.23 | 0.016 |
| [C10] Methyl Caprate | 10.640 | 10.61 | 0.028 |
| [C12] Methyl Laurate | 13.243 | 13.21 | 0.031 |
| [C14] Methyl Myristate | 15.596 | 15.57 | 0.024 |
| [RTL] Myristic Acid $d_{27}$ | 16.709 | 16.69 | 0.020 |
| [C16] Methyl Palmitate | 17.728 | 17.71 | 0.014 |
| [C18] Methyl Stearate | 19.671 | 19.67 | 0.005 |
| [C20] Methyl Eicosanoate | 21.456 | 21.46 | 0.006 |
| [C22] Methyl Docosanoate | 23.105 | 23.12 | 0.015 |
| [C24] Methyl Linocerate | 24.634 | 24.66 | 0.026 |
| [C26] Methyl Hexacosanoate | 26.060 | 26.10 | 0.036 |
| [C28] Methyl Octacosanoate | 27.399 | 27.44 | 0.041 |
| [C30] Methyl Triacontanoate | 28.790 | 28.85 | 0.060 |

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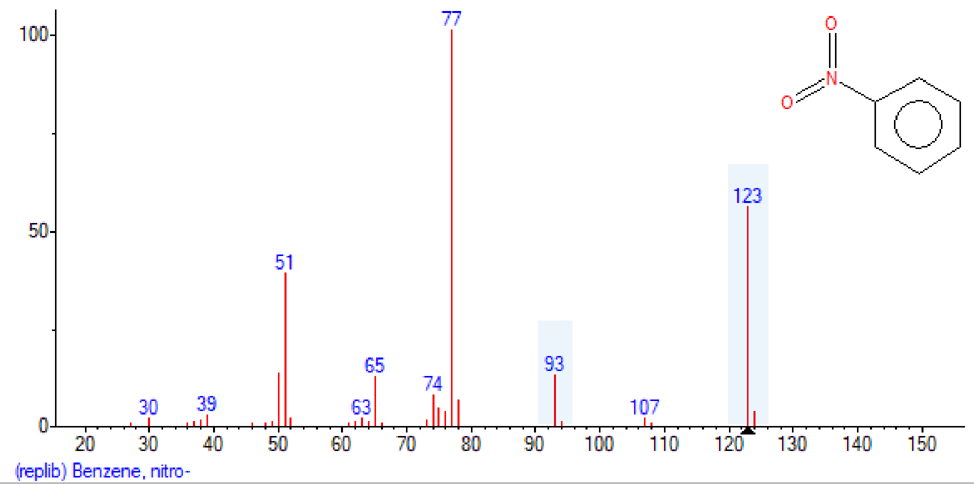
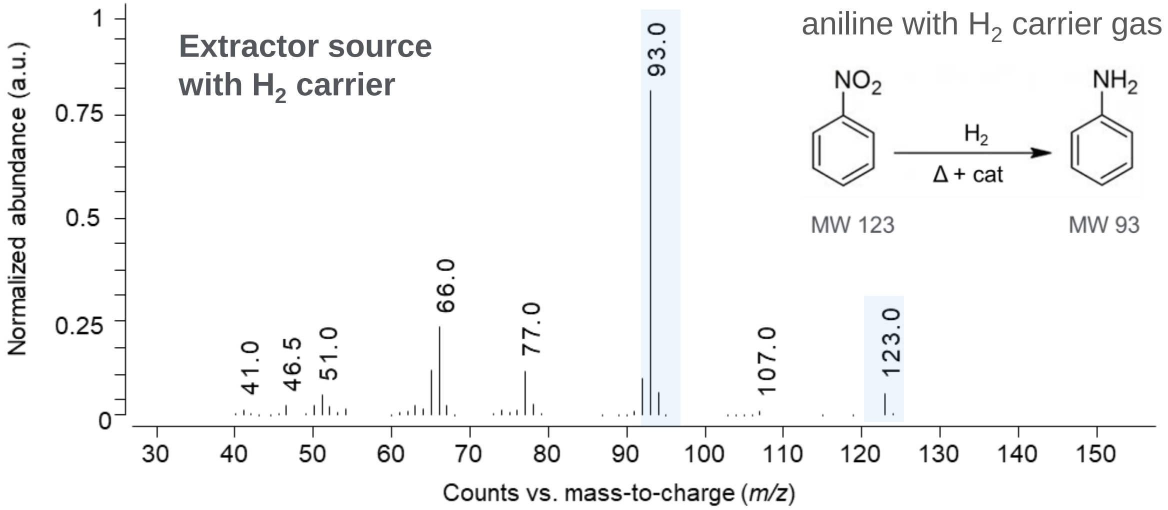
# Hydrogen Carrier Activity Can Impact Spectral Fidelity in MS

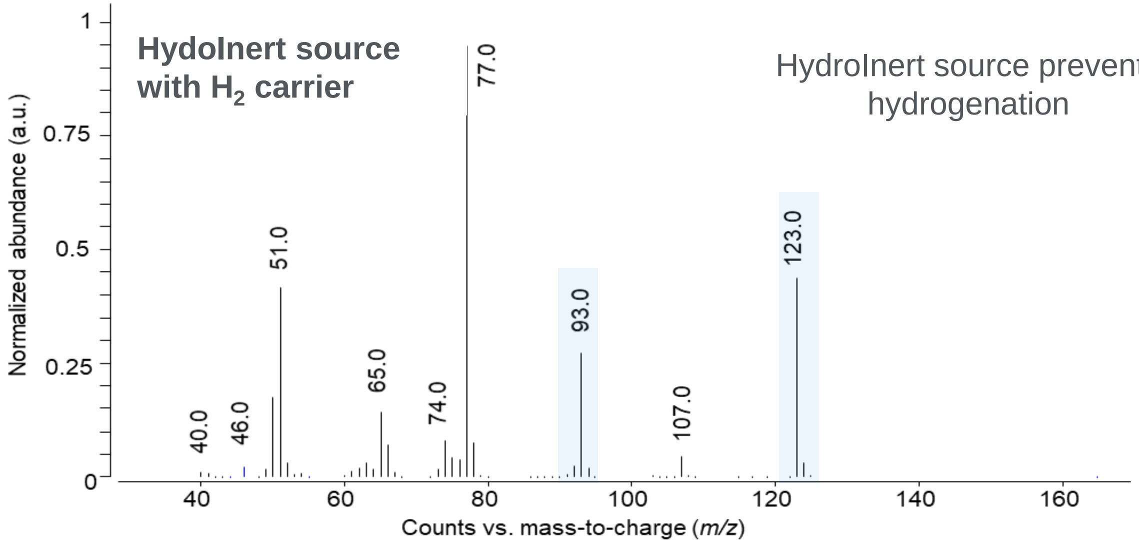
Expected mass spectrum (NIST) of nitrobenzene




Conversion of nitrobenzene to aniline with $H_2$ carrier gas

**HydoInert source**




HydroInert source prevents hydrogenation

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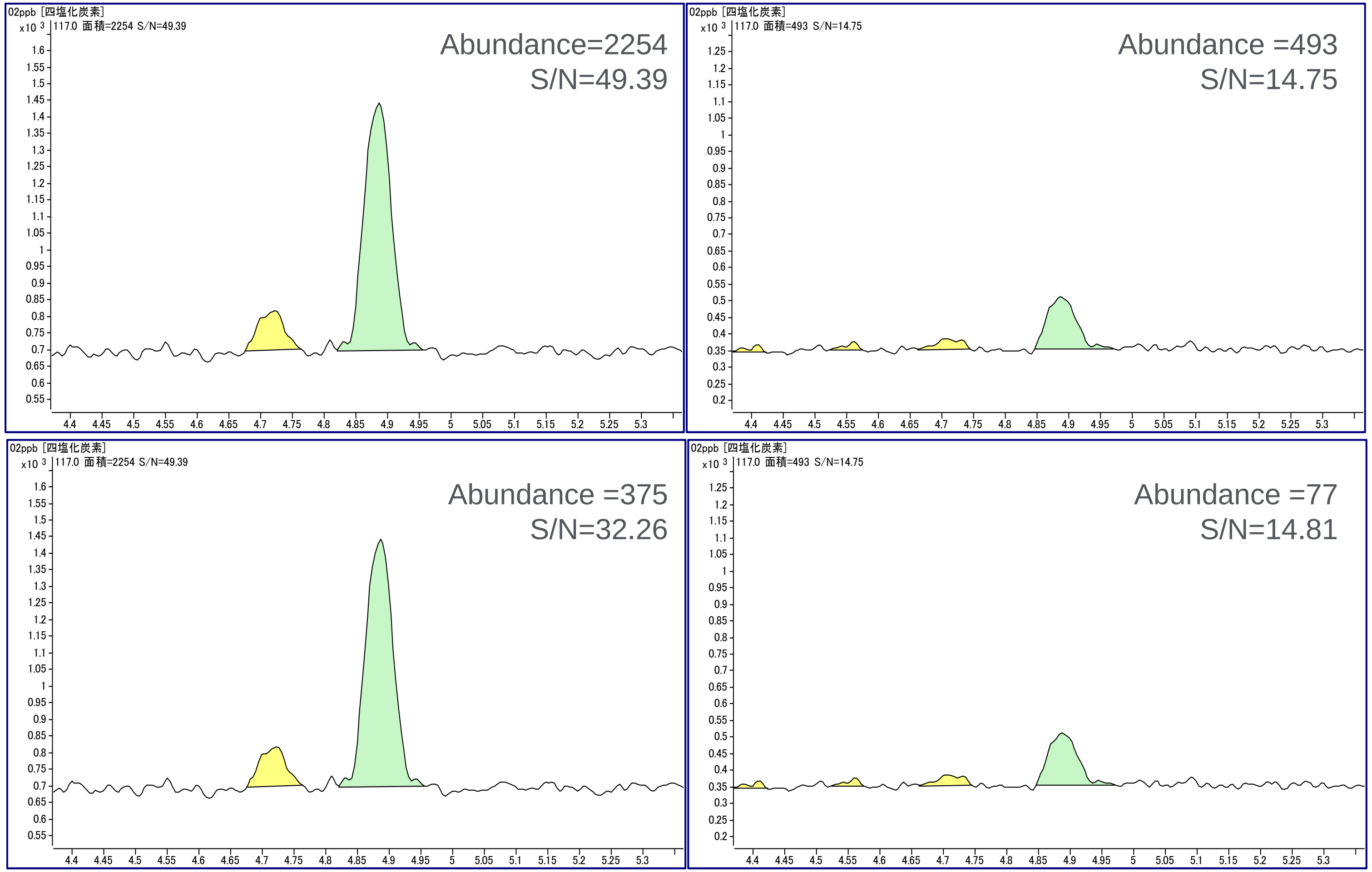
# Hydrogen Carrier Can Impact Analyte Sensitivity

HydroInert | Extractor

**Carbon tetrachloride**

**Bromoform**




Agilent publication 5994-4889EN

# Conserving Carrier Gas

## Five tips to conserve helium

# Five Tips for Conserving Carrier Gas

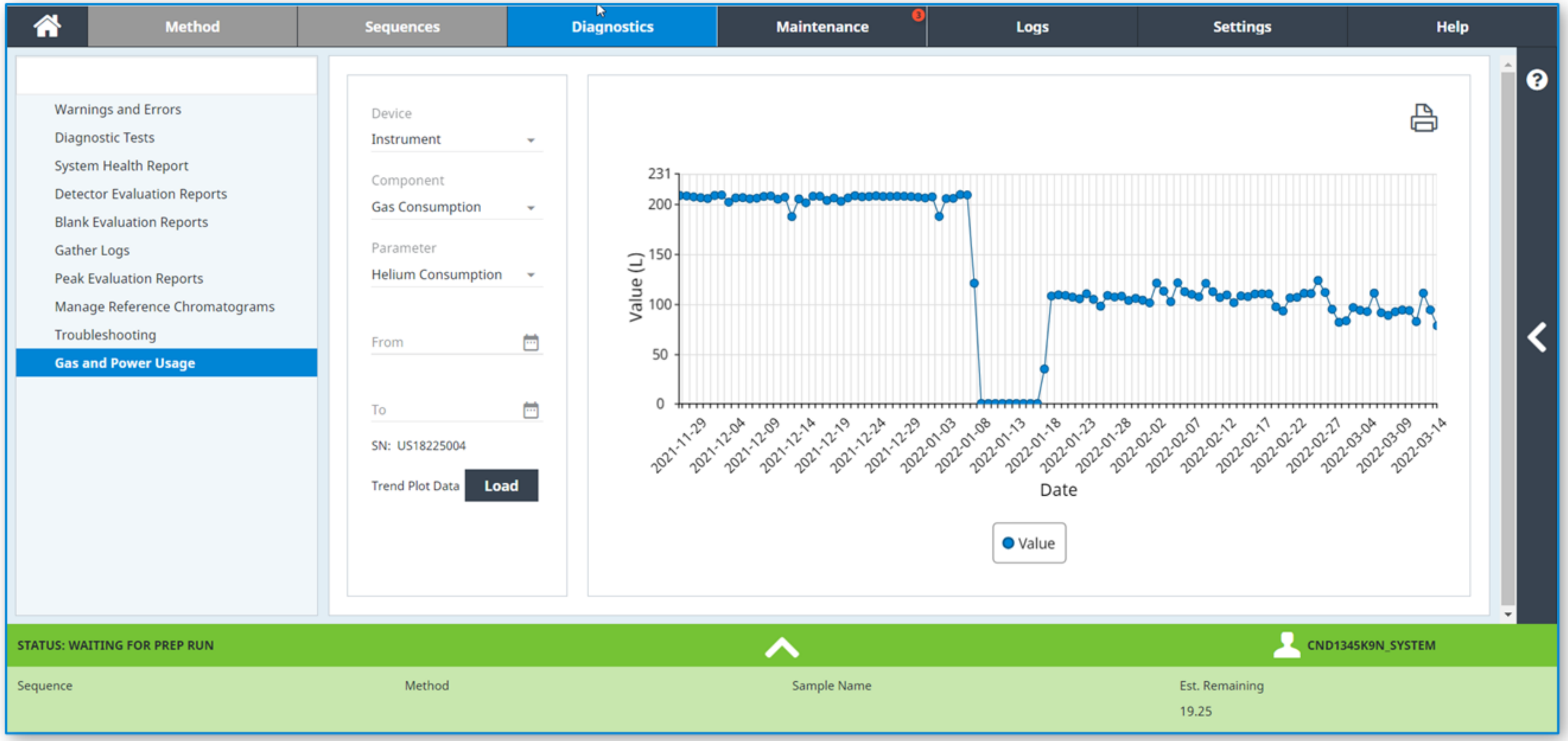
1. **Implement a leak check strategy**

- Inlet and column connections
- Valves for applicated GCs
- MS transfer lines and seals
- All gas connections to the GC
- Do not forget the rest of the lab

# Five Tips for Conserving Carrier Gas

1. **Implement a leak check strategy**
2. **Chart gas usage trends**

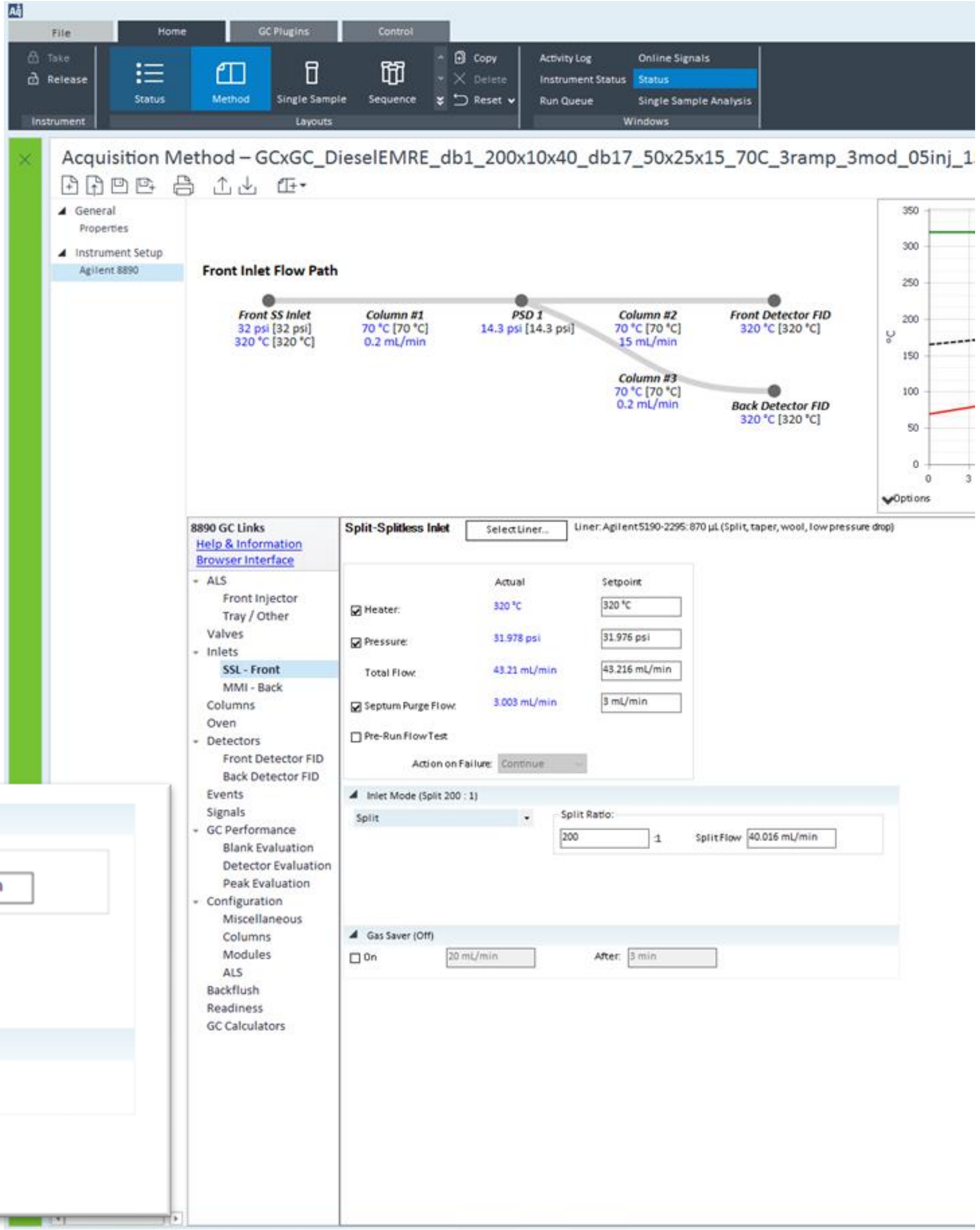
Plot gas (and power) use from touchscreen or browser interface to find anomalies and to visualize the impacts of gas usage during idle periods, sleep/wake methods, and shutdown of the system.

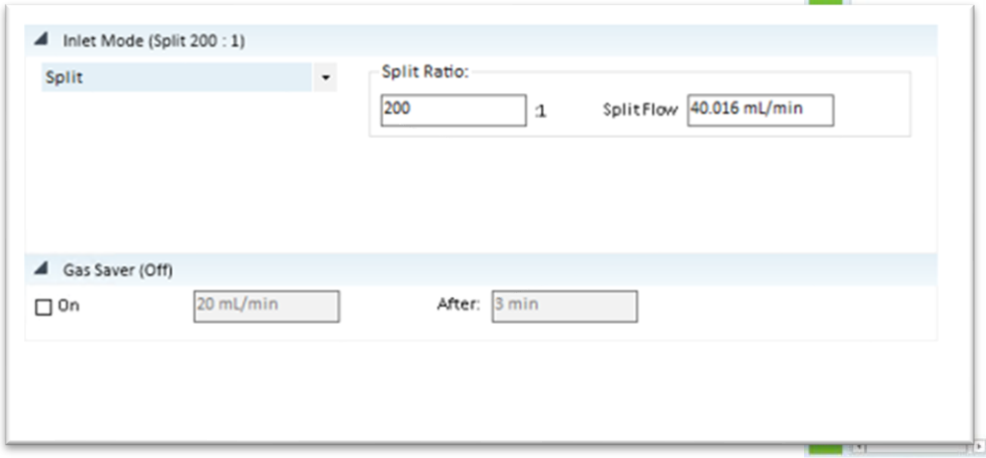


# Five Tips for Conserving Carrier Gas

1. **Implement a leak check strategy**
2. **Chart gas usage trends**
3. **Use Gas Saver**

Simple selection on the GC inlet method will decrease the split vent flow after the sample is loaded on the column.





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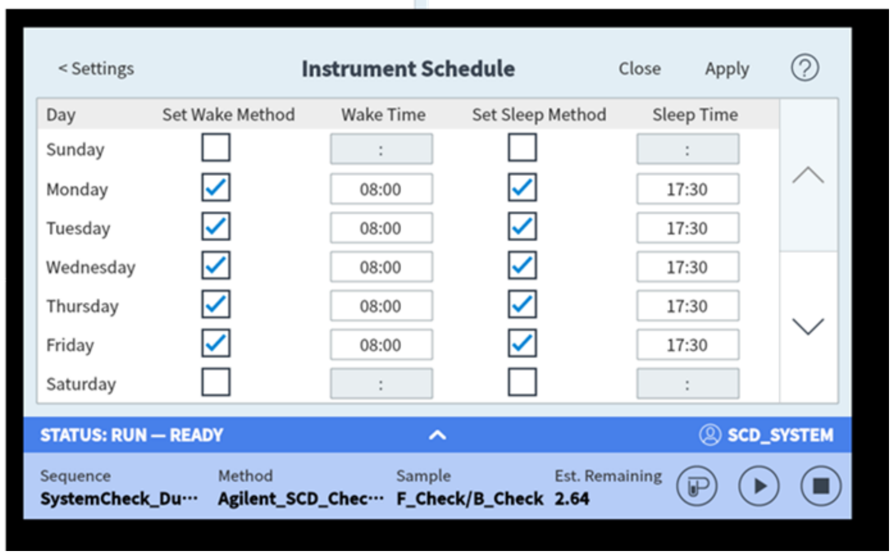
# Five Tips for Conserving Carrier Gas

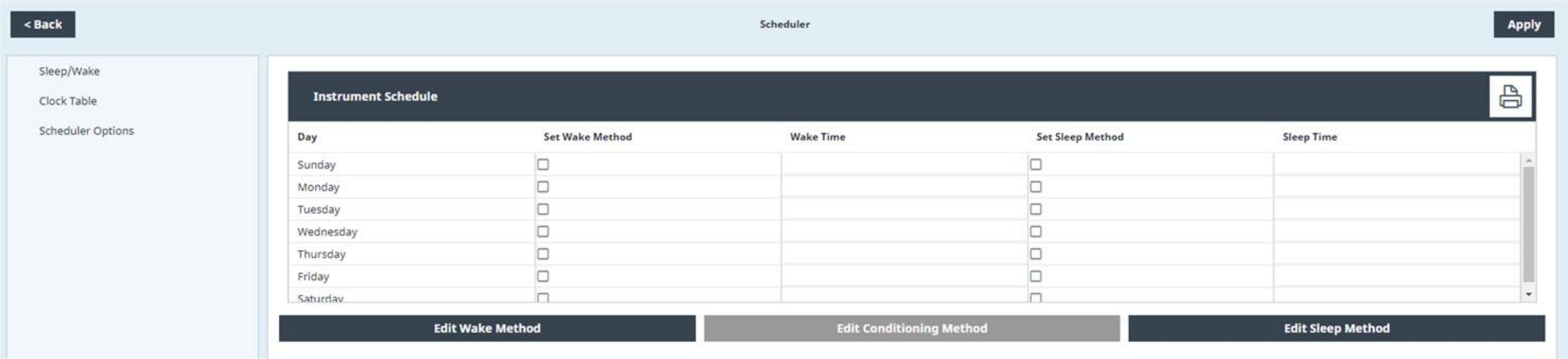
1. **Implement a leak check strategy**
2. **Chart gas usage trends**
3. **Use Gas Saver**
4. **Use a Helium Conservation Module**


- Extends the life of helium tanks by up to 30 times
- Works with any GC inlet, backflush, and dual simultaneous injection
- Carrier gas id and setpoints are part of your analytical method for easy compliance and transfer
- GC alerts you if system setpoints are not reached
- Switch from nitrogen standby to helium carrier in 15 to 30 minutes (depending on the GC detector)

# Five Tips for Conserving Carrier Gas

1. **Implement a leak check strategy**
2. **Chart gas usage trends**
3. **Use Gas Saver**
4. **Use a Helium Conservation Module**
5. **Use a Scheduler**



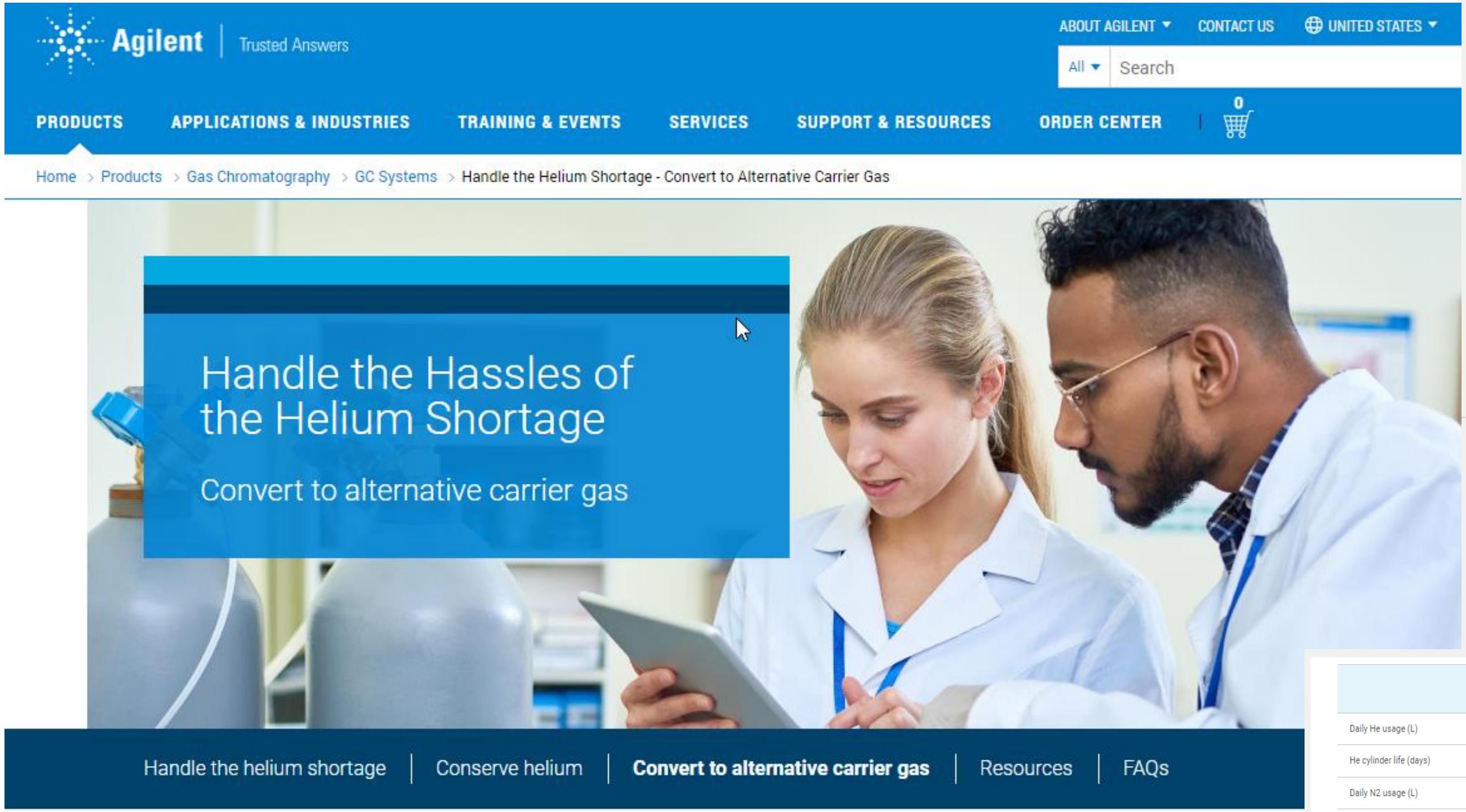



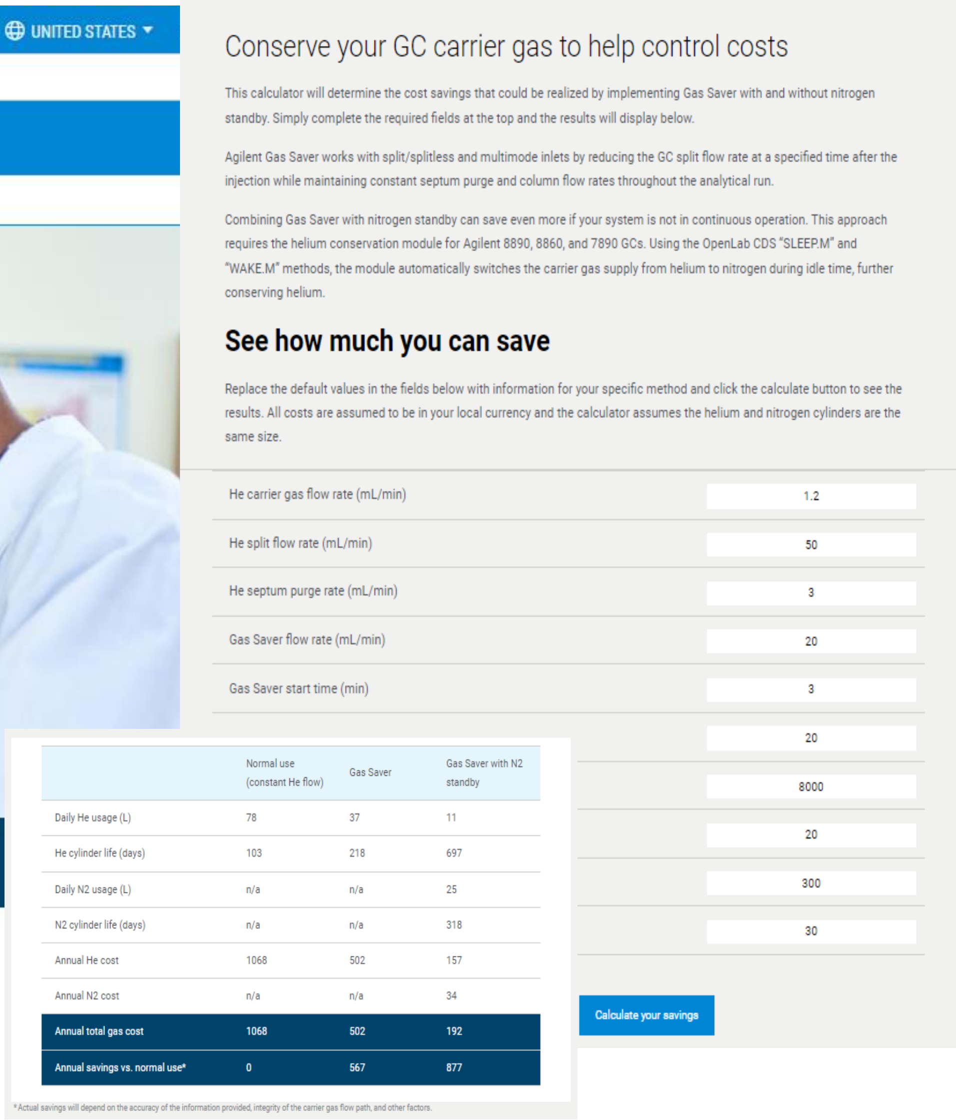
# Maintain Good Gas Hygiene

- High-quality carrier gas (four 9s or greater)
- Leak-free injector and carrier lines
  - Change septa
  - Maintain gas regulator fittings
- Appropriate impurity traps
- Check for leaks
  - Leak detector

# Additional Resources Available

[Calculating the savings](#)




| | Normal use (constant He flow) | Gas Saver | Gas Saver with N2 standby |
|---|---|---|---|
| Daily He usage (L) | 78 | 37 | 11 |
| He cylinder life (days) | 103 | 218 | 697 |
| Daily N2 usage (L) | n/a | n/a | 25 |
| N2 cylinder life (days) | n/a | n/a | 318 |
| Annual He cost | 1068 | 502 | 157 |
| Annual N2 cost | n/a | n/a | 34 |
| **Annual total gas cost** | **1068** | **502** | **192** |
| **Annual savings vs. normal use*** | **0** | **567** | **877** |

*Actual savings will depend on the accuracy of the information provided, integrity of the carrier gas flow path, and other factors.

[Switch to hydrogen or nitrogen as alternate carrier gas | Agilent](#)

# Contact Agilent Chemistries and Supplies Technical Support

1-800-227-9770 option 3, option 3:

Option 1 for GC and GC/MS columns and supplies

Option 2 for LC and LC/MS columns and supplies

Option 3 for sample preparation, filtration, and QuEChERS

Option 4 for spectroscopy supplies

Option 5 for chemical standards

Available in the U.S. and Canada, 8–5, all time zones

gc-column-support@agilent.com

lc-column-support@agilent.com

spp-support@agilent.com

spectro-supplies-support@agilent.com

chem-standards-support@agilent.com

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