90% Zeit, Lösungsmittel und Kosten einsparen

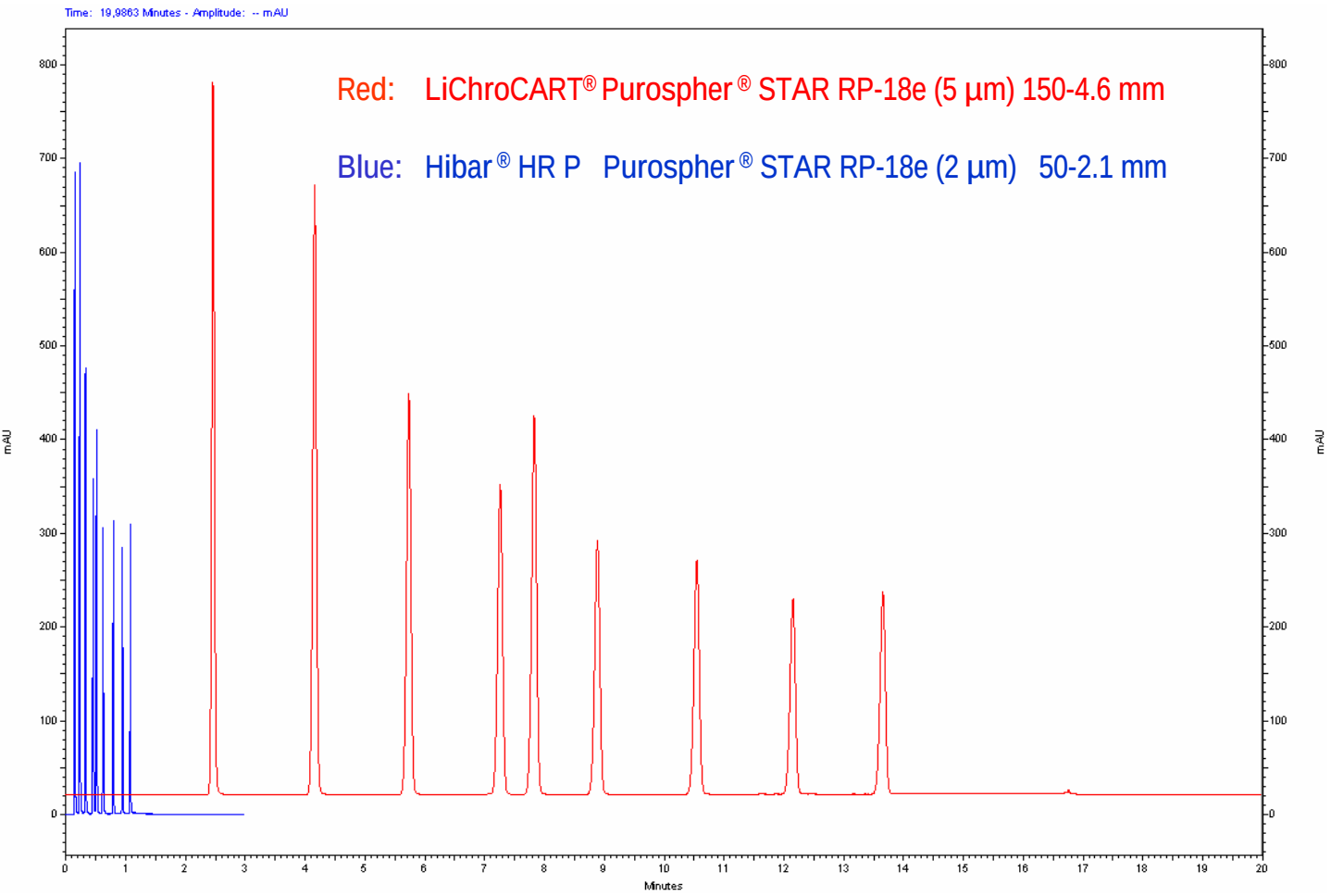
mit

„ultra“-schneller und konventioneller Chromatographie

VWR®
Supplier Partnerships for Customer Solutions

- Verwendung von Säulen mit Partikeln ≤ 2 µm
- Verwendung von Chromolith®-Säulen
- Optimierung der Methoden mit ChromSword Auto®
- Anwendungsbeispiele

Applications
Alkylphenones

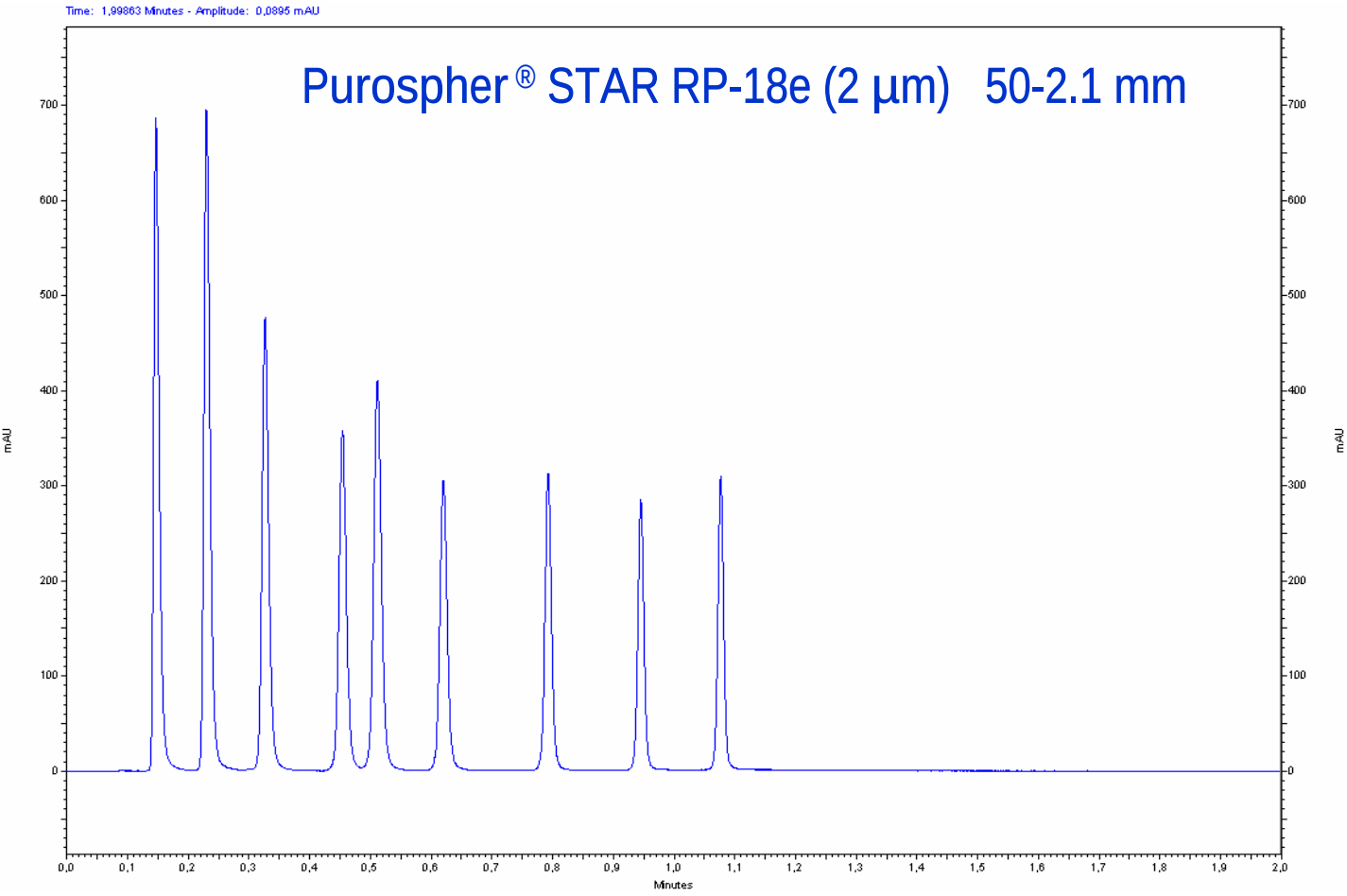


Sample: Alkylphenone standard

1. Acetanilide
2. Acetophenone
3. Propiophenone
4. Butyrophenone
5. Benzophenone
6. Valerophenone
7. Hexanophenone
8. Heptanophenone
9. Octanophenone

Column temperature: 40°C
Eluent A: Water
Eluent B: Acetonitrile
Gradient: 0 min 45% B , from 45 to 95 % B in 15 min, from 15.1 to 20 min reequilibration with 45 % B
Flow rate: 1.0 ml/min,
Pressure: 105 bar
UV: 247 nm
Injection volume: 10 µl

Applications
Alkylphenones

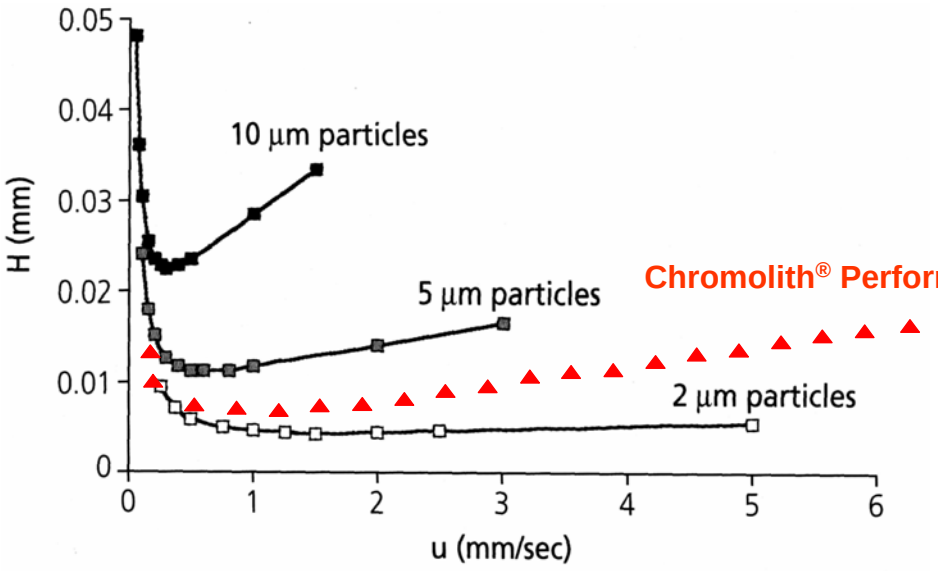


Sample: Alkylphenone standard
1. Acetanilide
2. Acetophenone
3. Propiophenone
4. Butyrophenone
5. Benzophenone
6. Valerophenone
7. Hexanophenone
8. Heptanophenone
9. Octanophenone

Column temperature: 40°C
Eluent A: Water
Eluent B: Acetonitrile
Gradient: 0 min 55% B , from 55 to 100 % B in 0.8 min, from 0.9 to 2 min reequilibration with 55 % B
Flow rate: 1.1 ml/min,
Pressure: 505 bar
UV: 247 nm
Injection volume: 1 µl

Fast Chromatography

Van Deemter Plot



H = Height Equivalent to a Theoretical Plate (HEPT)

u = Flow speed of the mobile phase

What shows this curve?

The smaller the particle diameter, the more it is possible to increase the flow rate while keeping the resolution performance (efficiency) of the column.

Van Deemter Curve

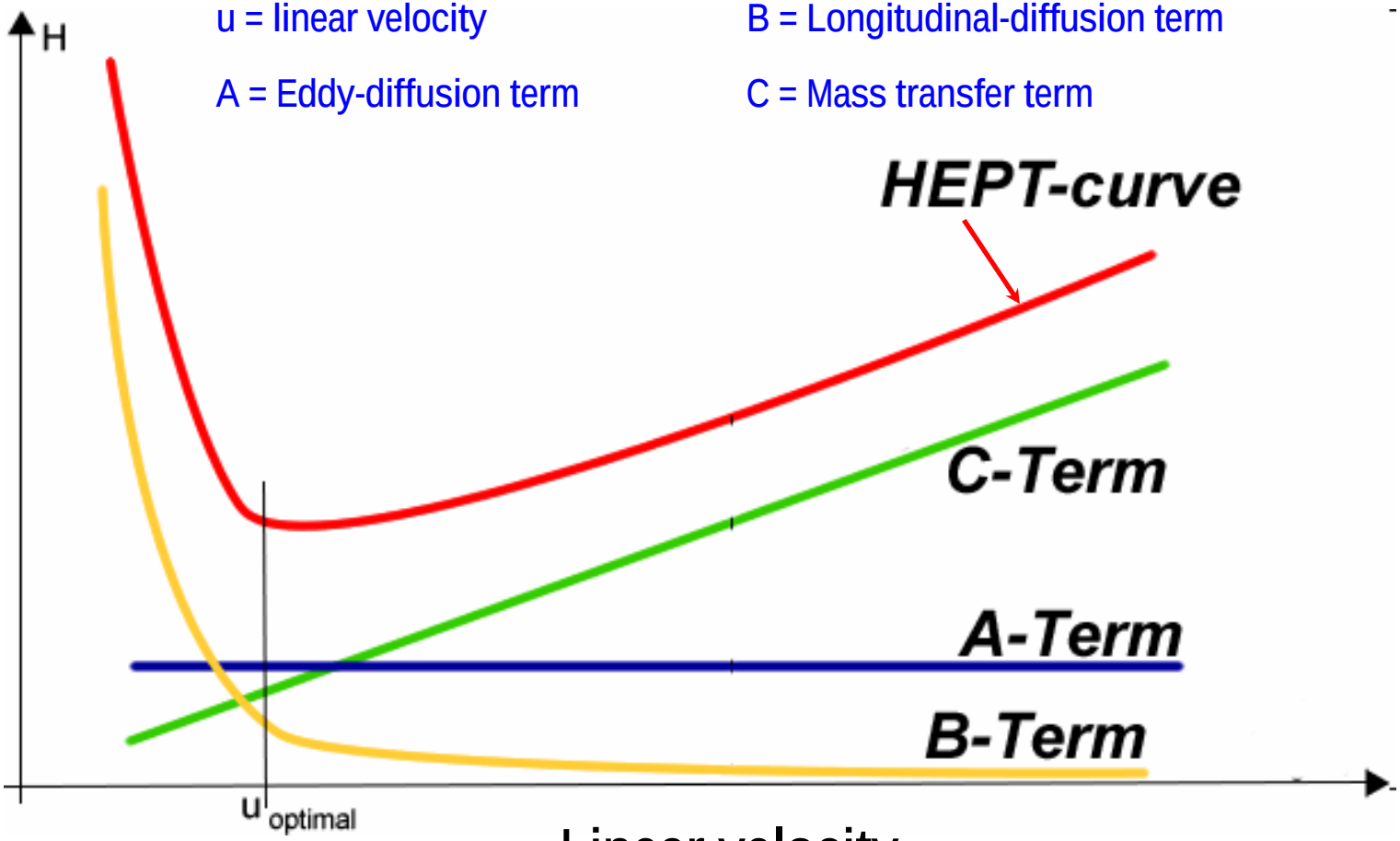
$$h = A + \frac{B}{u} + C \bullet u$$

u = linear velocity

B = Longitudinal-diffusion term

A = Eddy-diffusion term

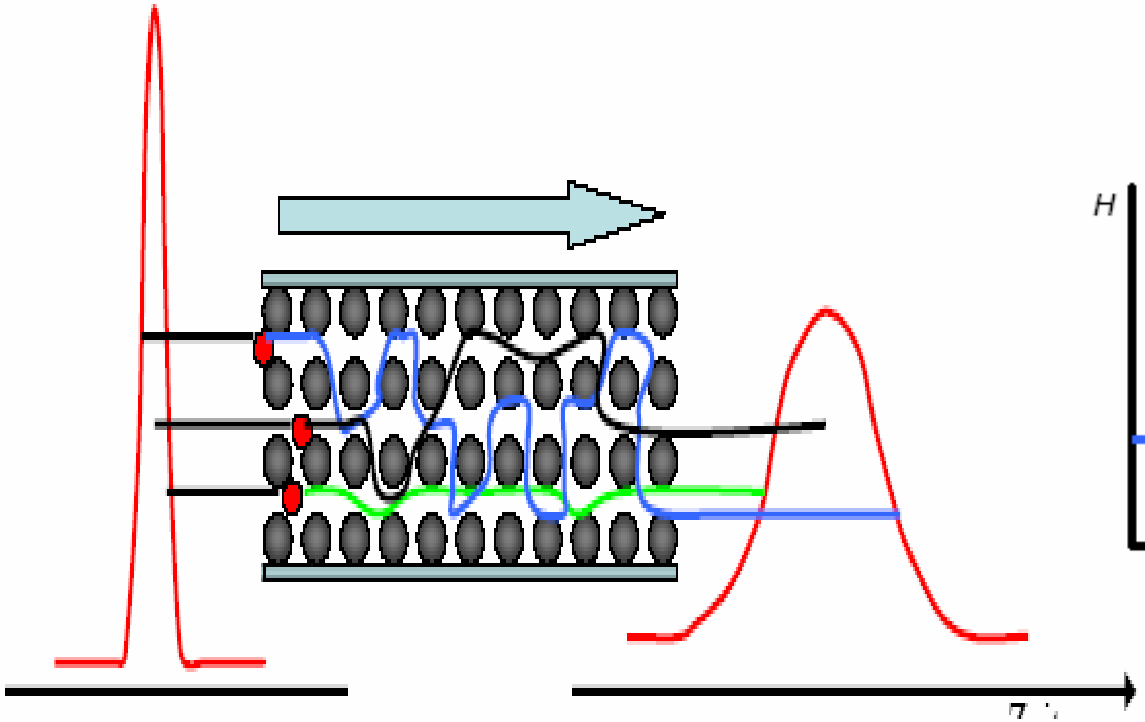
C = Mass transfer term

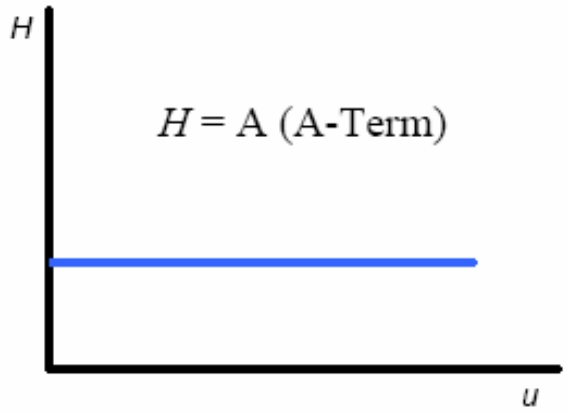


Contributions to the van Deemter Plot

Eddy-Diffusion term A : $A = 2 \cdot \lambda \cdot d_p$

λ = factor of irregulatories
dp = particle diameter

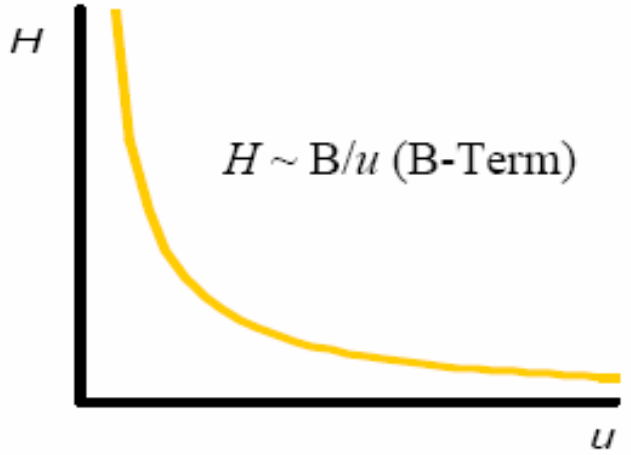


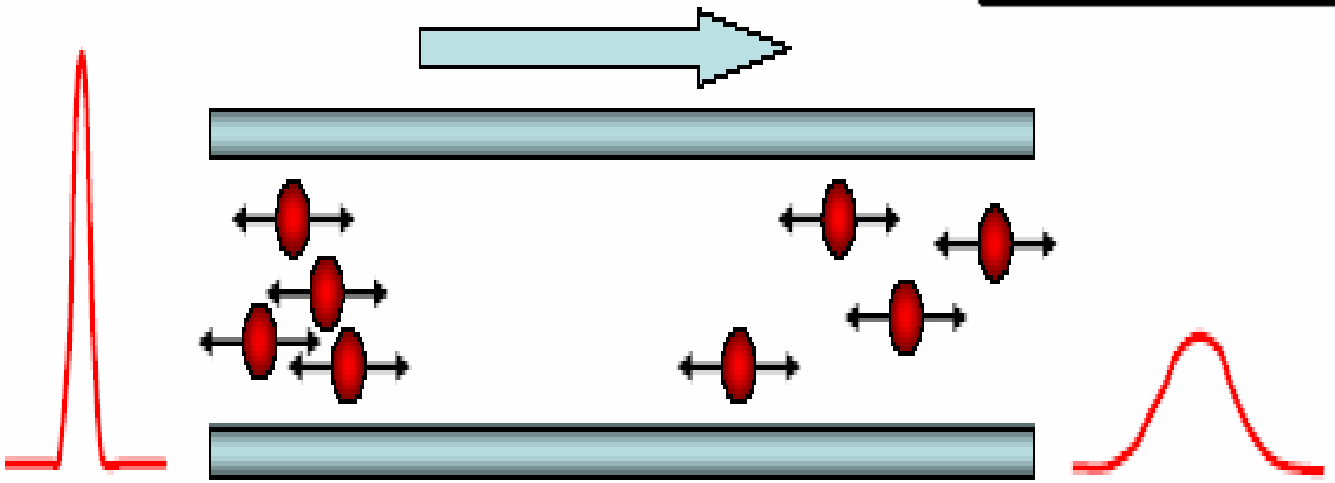


Contributions to the van Deemter Plot

Longitudinal-Diffusion term B :

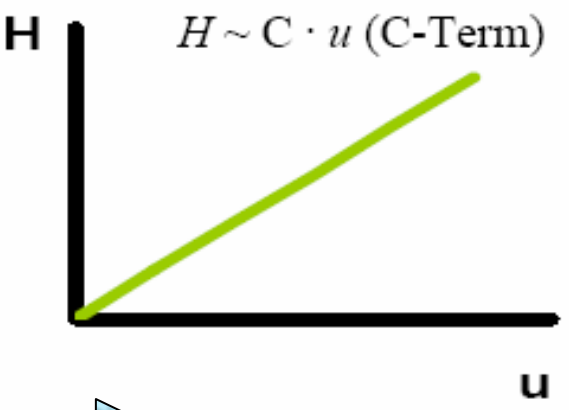
$$B = \gamma \frac{Dm}{u}$$

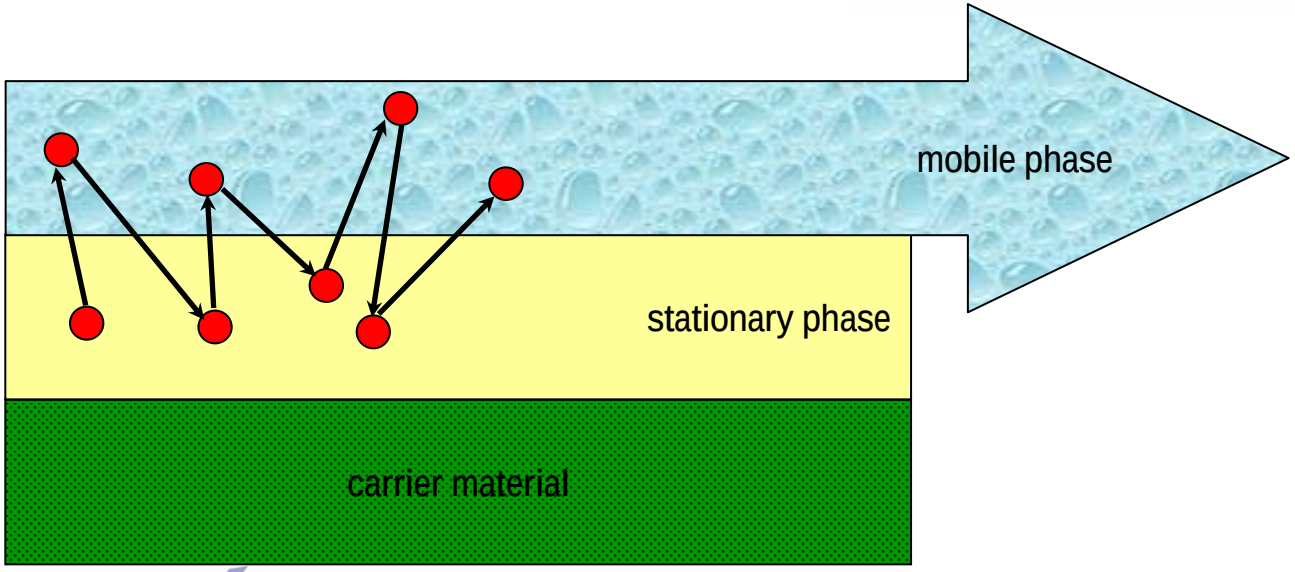




Contributions to the van Deemter Plot

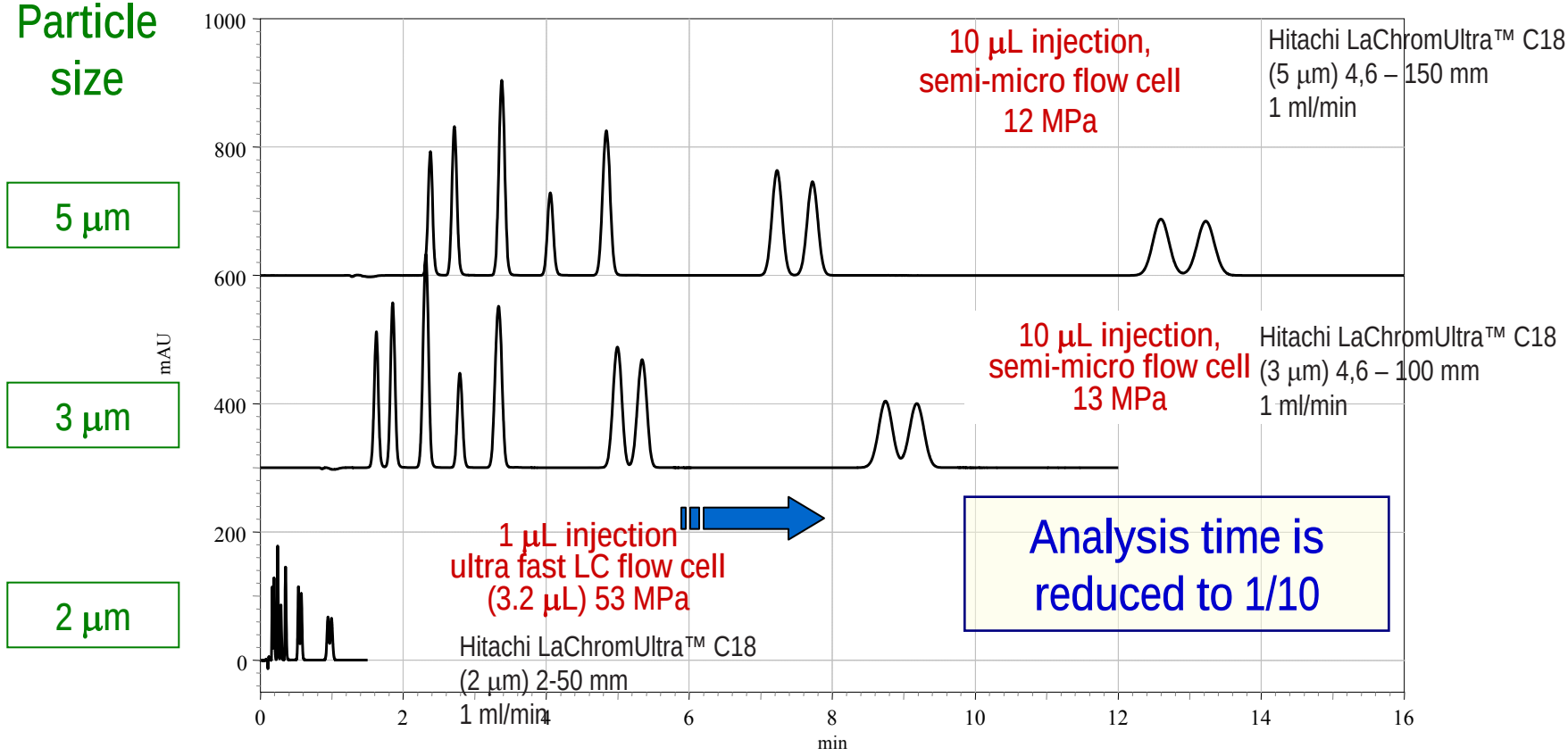
Mass transfer term C





Ultra-Fast Chromatography

Application: Preservatives



Requirements to the HPLC-System

Ultra-fast Chromatography with ≤ 2 µm Particles requires:

- High pressure resistance
- Minimised internal volumes (in order to avoid peak broadening)
- Precise and accurate gradient formation at high pressures
- Minimised sample carry-over
- Extremely fast detector reaction

The new VWR-Hitachi LaChrom Ultra HPLC System

Superior Resolution in shortest Time

Features and Benefits

The System

- General purpose HPLC system with highest performance, which allows ultra fast LC with ≤ 2 µm particle columns, fast LC using Chromolith columns as well as all standard HPLC applications.
  Max. pressure: 600 bar
  Max. flow rate: 5 ml/min

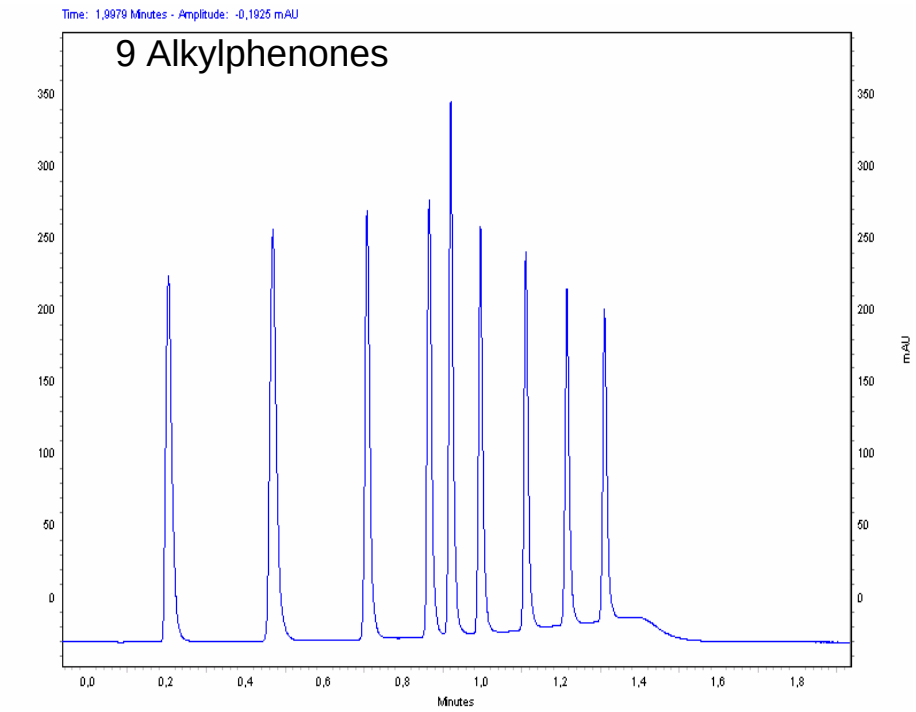
- High-pressure gradient solvent delivery system with A-EPIC control function for elimination of pulsations and compensation of solvent compressibility and with extremely low gradient dwell volume to ensure sharpest gradient steps.

- Autosampler with further reduced carry-over (0.005%) and minimised internal volume

- High performance column ovens for temperature control and reduction of solvent viscosity

- Detectors (UV, DAD, FL) with fastest response time constants (10 ms) and shortest data collection intervals (10 ms corresponds to 100 Hz) for accurately recording shortest peaks.

Gradient Performance



Linear gradient 35% B to 95% B in 1 minute

Re-equilibration in less than 1 minute

Retention Time + Injection Precision

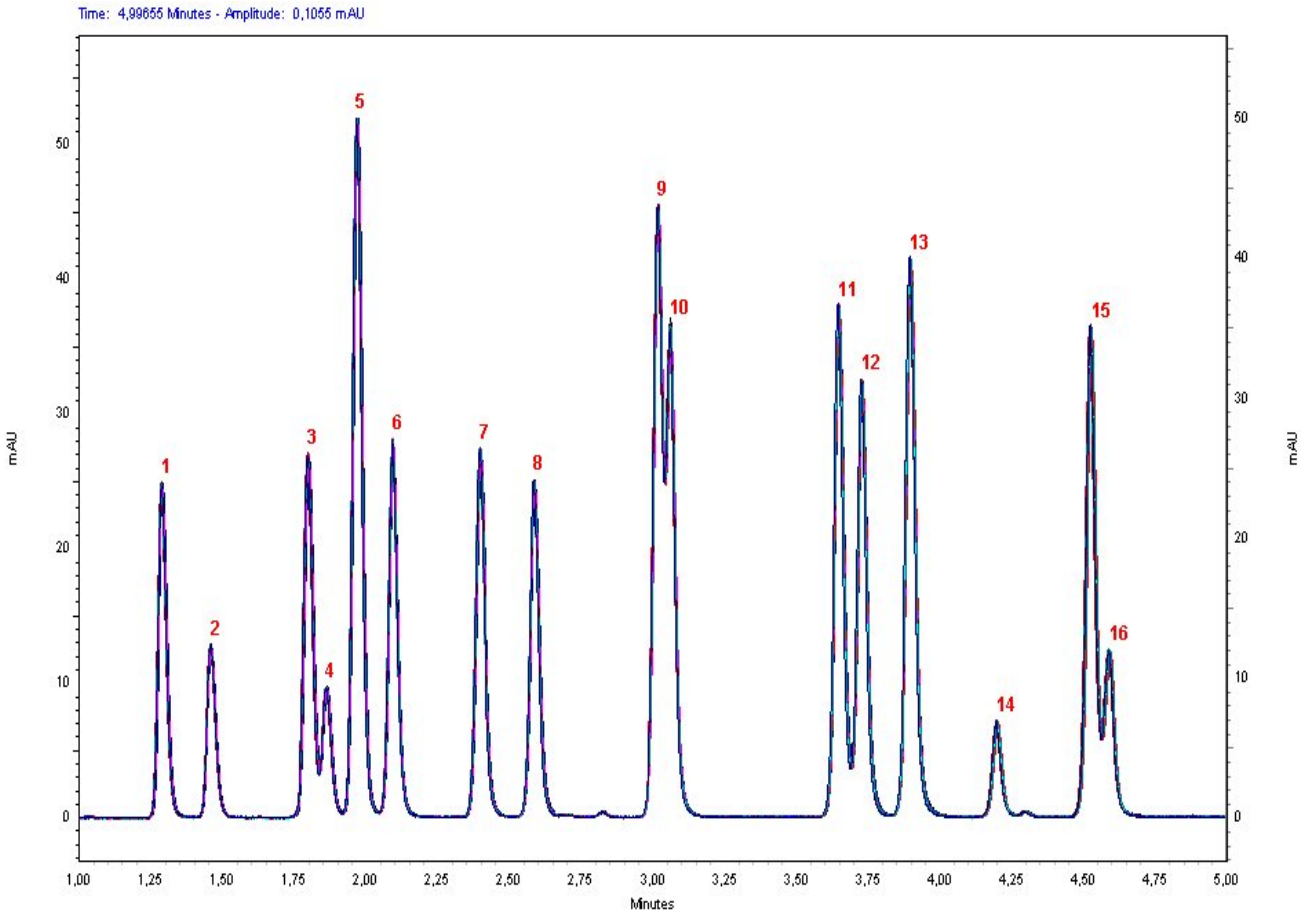
9 Alkyl phenones, inj.vol: 1 µL , n = 10 consecutive runs

Peak	Compound	RT (min)	RT RSD%	Area (µV*s)	Area RSD%
1	Acetanilide	0.255	0.10	1,105,478	0.26
2	Acetophenone	0.520	0.09	1,366,703	0.41
3	Propiophenone	0.886	0.12	1,039,794	0.47
4	Butylophenone	1.048	0.13	912,533	0.30
5	Benzophenone	1.100	0.14	1,088,765	0.45
6	Valerophenone	1.160	0.13	806,033	0.22
7	Hexanophenone	1.264	0.12	760,224	0.44
8	Heptanophenone	1.365	0.08	711,477	0.62
9	Octanophenone	1.474	0.06	694,373	0.36

Result: The LaChromUltra system has a superior flow + gradient stability of the solvent delivery system + a high injection precision

Polyaromatic Hydrocarbons

Overlay of 2 series of 10 Standard Runs



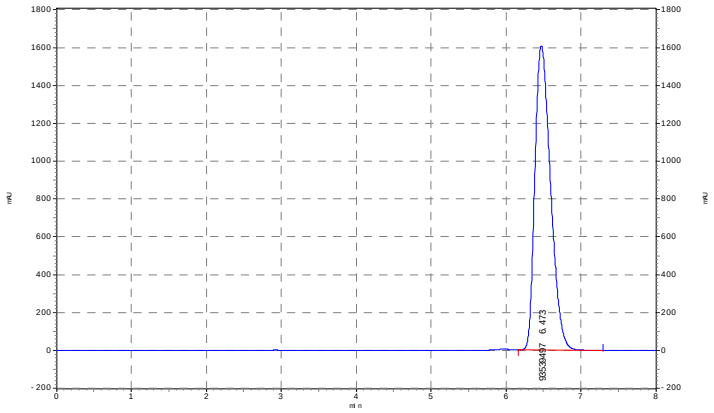
Sample: NIST-16 PAH Standard

1.Napthalene, 2.Acenapthylene, 3.Acenaphthene, 4.Fluorene, 5.Phenanthrene, 6.Anthracene, 7.Fluoranthene, 8.Pyrene, 9.Benz(a)anthracene, 10.Chrysene, 11.Benzo(b)fluoranthene, 12. Benzo(k)fluoranthene, 13. Benzo(a)pyrene, 14.Dibenz(a,h)anthracene, 15.Benzo(g,h,i,)perylene, 16.Indeno(1,2,3-cd)pyrene

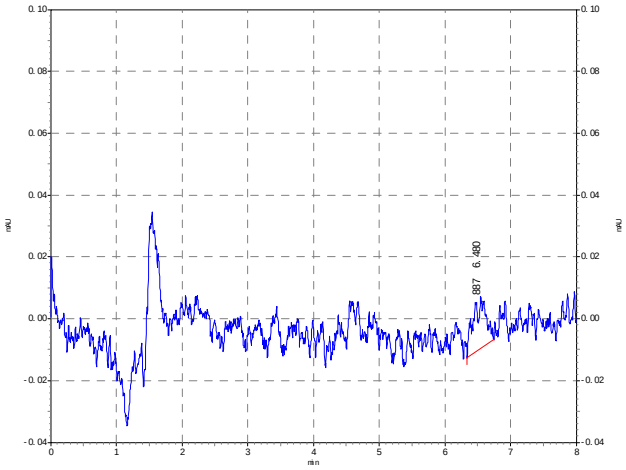
Column: Agilent Zorbax Eclispe XDB C-18 (1.8µm), 100-2.1 mm
Column temperature: 30°C
Eluent A: LiChroSolv Water
Eluent B: LiChroSolv Acetonitrile
Gradient: from 70 to 97 % acetonitrile in 4.5 min
Flow rate: 0.5 ml/min, injection volume: 2 µl
UV: 254 nm

L-2200U Autosampler
Sample carry-over

Sample data
Chlorhexidine 1000 ppm

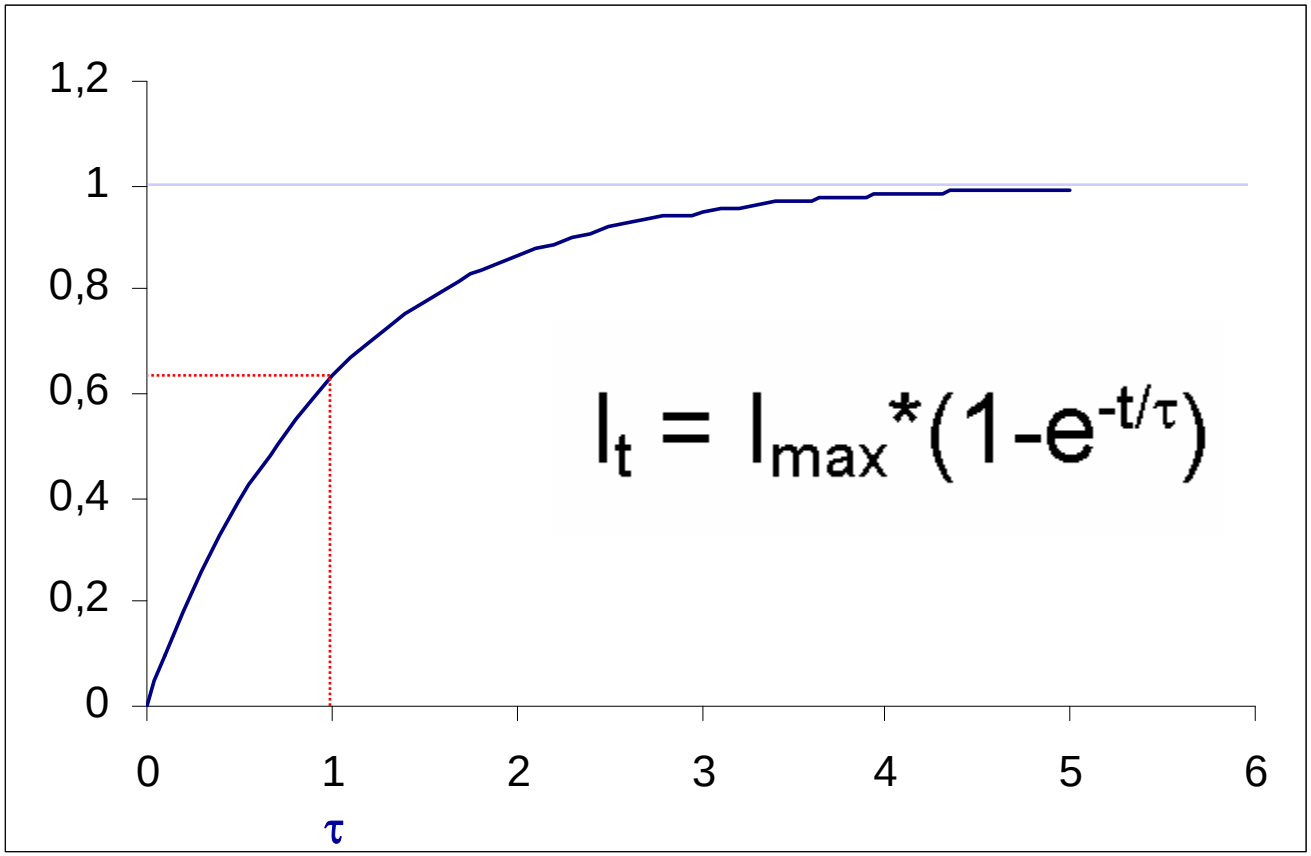


Blank data



Extremely low carry-over of
0.005% or less is realized

Response Time Constant

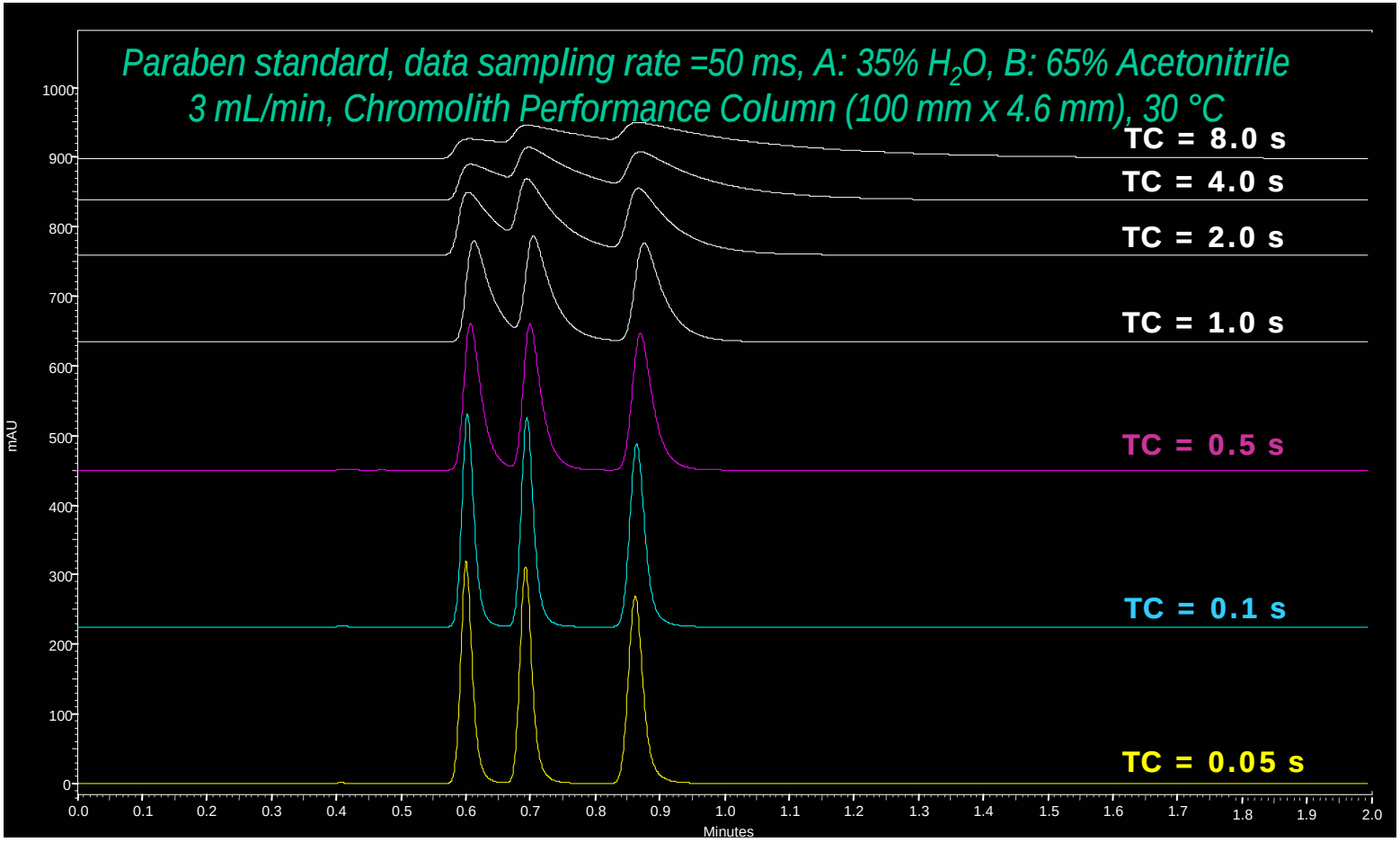


A detector reacts with a certain retardation on an incoming signal.

The response time constant τ is defined as the time where the detector outputs 63.2% (= $1-e^{-1}$) of the real signal.

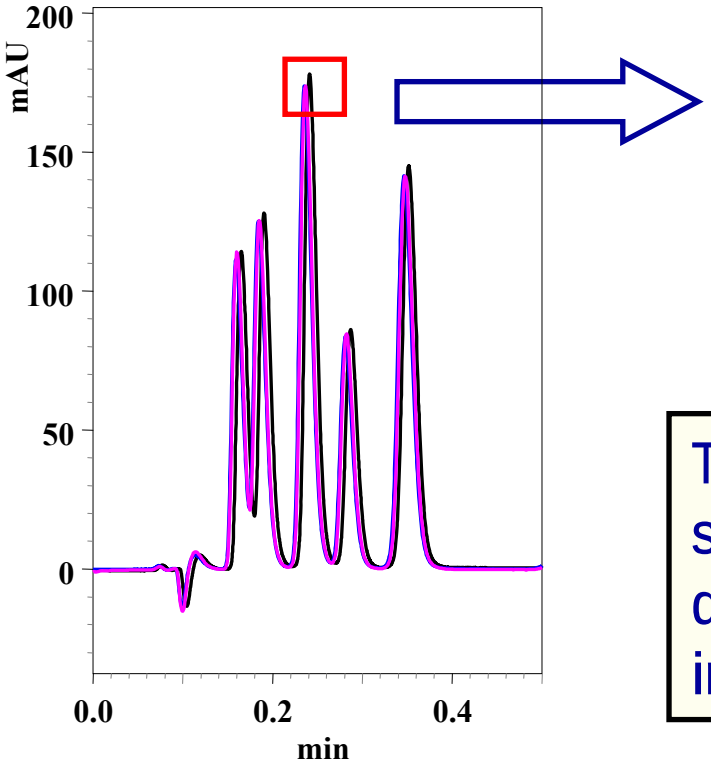
Modern detectors allow the selection of different response time constants.

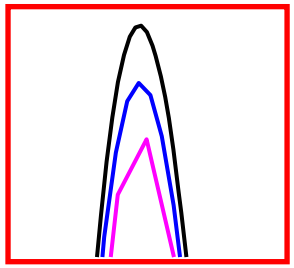
Effect of different response times



Effect of different data sampling rates

Only detectors with lowest response times and very high data sampling rates (low sampling periods) guarantee the best peak performance and separation.





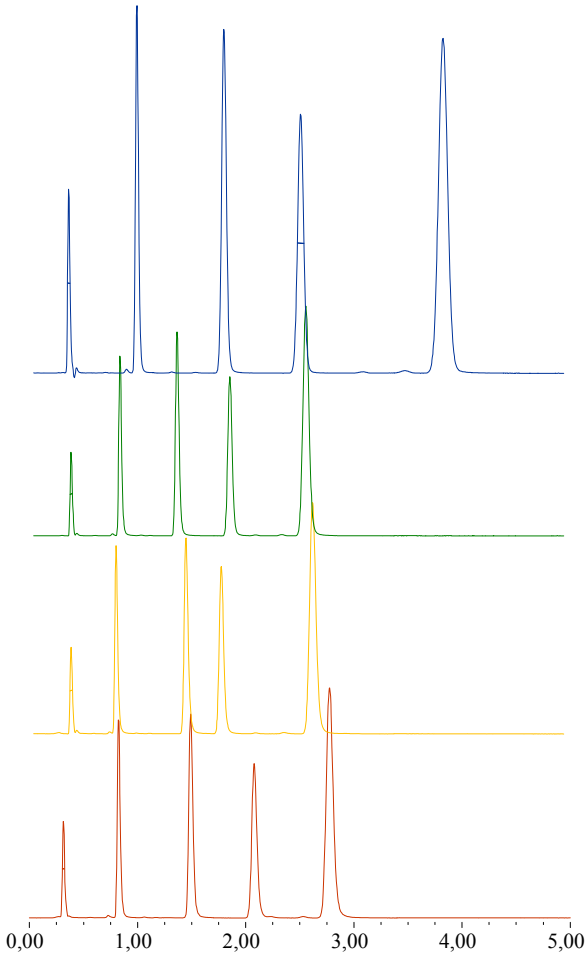
Data sampling period:

- 10 ms (100 Hz) (L-2400U)
- 20 ms (50 Hz) (L-2400U)
- 50 ms (20 Hz) (L-2400)

The theoretical plate of a column is significantly increased when using a data sampling period of 10 ms instead of 50 ms.

Ultra-fast HPLC with particular columns

Which column to select?



Purospher STAR RP-18 endcapped, 2µm
174080 N/m
130 bar

Waters, 1.7µm
187620 N/m
225 bar

Restek, 1.9µm
172840 N/m
209 bar

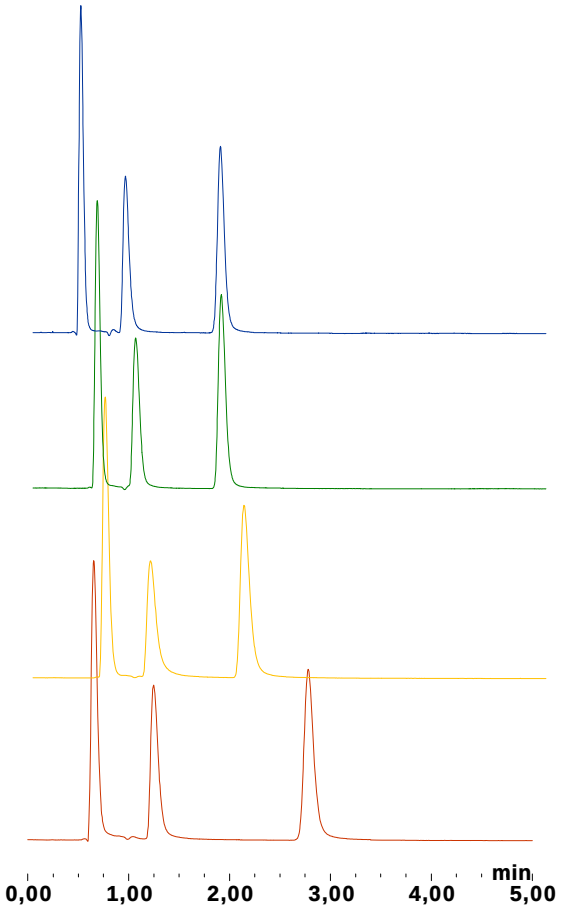
Agilent, 1.8µm
173260 N/m
175 bar

RP Test mixture

Mobile phase:	Acetonitril/Water 60/40	
Detection:	UV 254nm Response fast	
Temperature:	RT	
Flow:	0,350 mL/min	
Injection:	0,2 µL	
Sample:	Thioharnstoff	2,1 mg
	Biphenyl-2-ol	5,4 mg
	Progesteron	11,6 mg
	Hexanophenon	12,3 mg
	Anthracen	1,8 mg

Ultra-fast HPLC with particular columns

Which column to select?



Purospher STAR RP-18 endcapped, 2µm

Waters, 1.7 µm

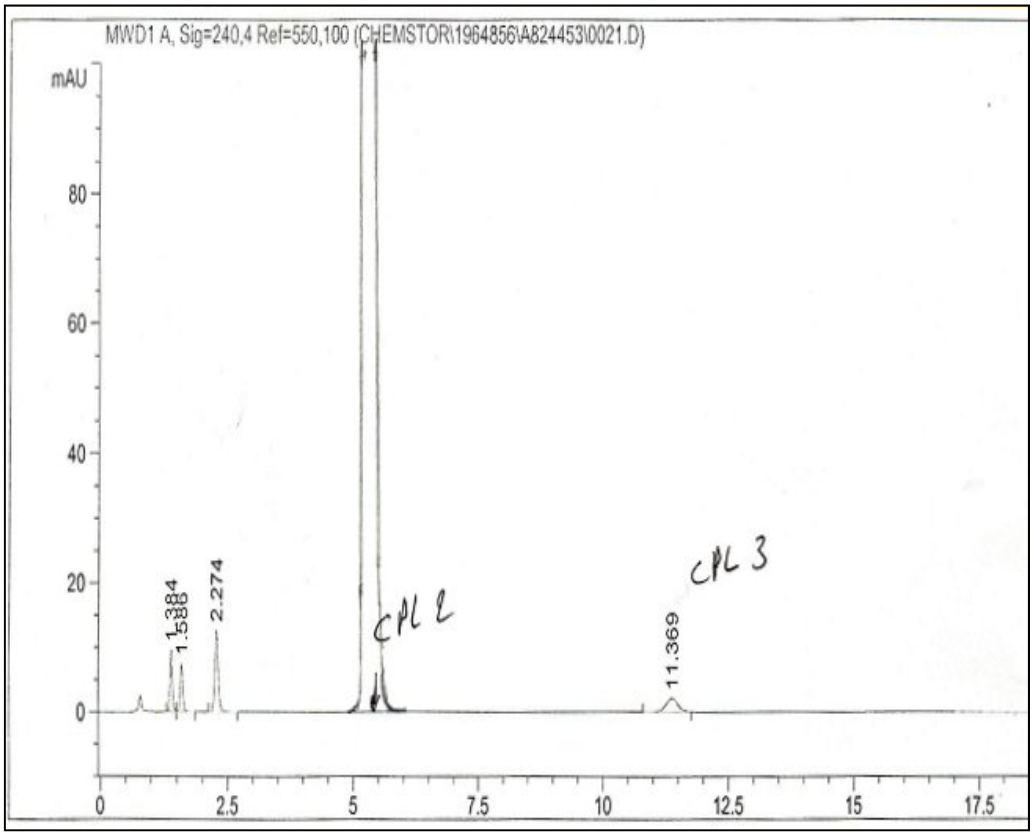
Restek, 1.9µm

Agilent, 1.8 µm

Procainamide

Mobile phase:	Methanol/0,02M NaH2PO4 pH 7,6 30/70 v/v
Detection:	UV254nm ,Res.0.1s
Temperature:	RT
Flow:	0,350 mL/min
Injection:	0,2 µL
Sample:	Uracil, Procainamide, N-Acetyl-Procainamide

Customer Application
Pharmaceutical sample



Column: Xbridge shield RP-18 (2.5 µm), 50-4.6

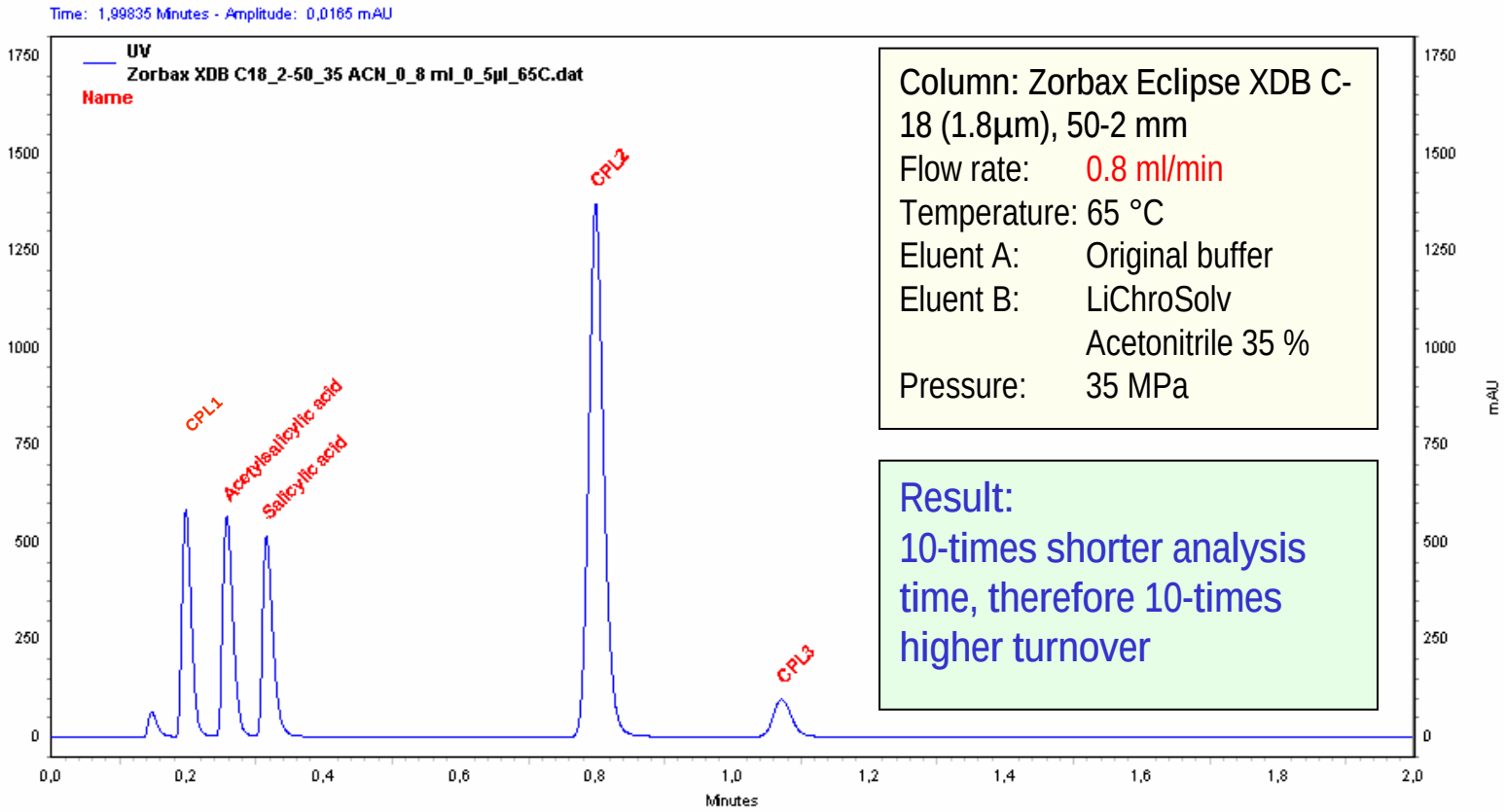
Eluent:
A: Phosphate buffer (1.77 g KH_2PO_4) + 3.08 g Hexan-sulfonic acid Na-salt per1000 ml, adjusted with 85 % phosphoric acid to pH 2.5
B: LiChroSolv Acetonitrile 37%

Isocratic Run with 63 % A and 37 % B

Flow rate: 1.0 ml/min
Temperature: 30 °C

Analysis time: 15 min

Customer Application
Pharmaceutical sample: Optimised

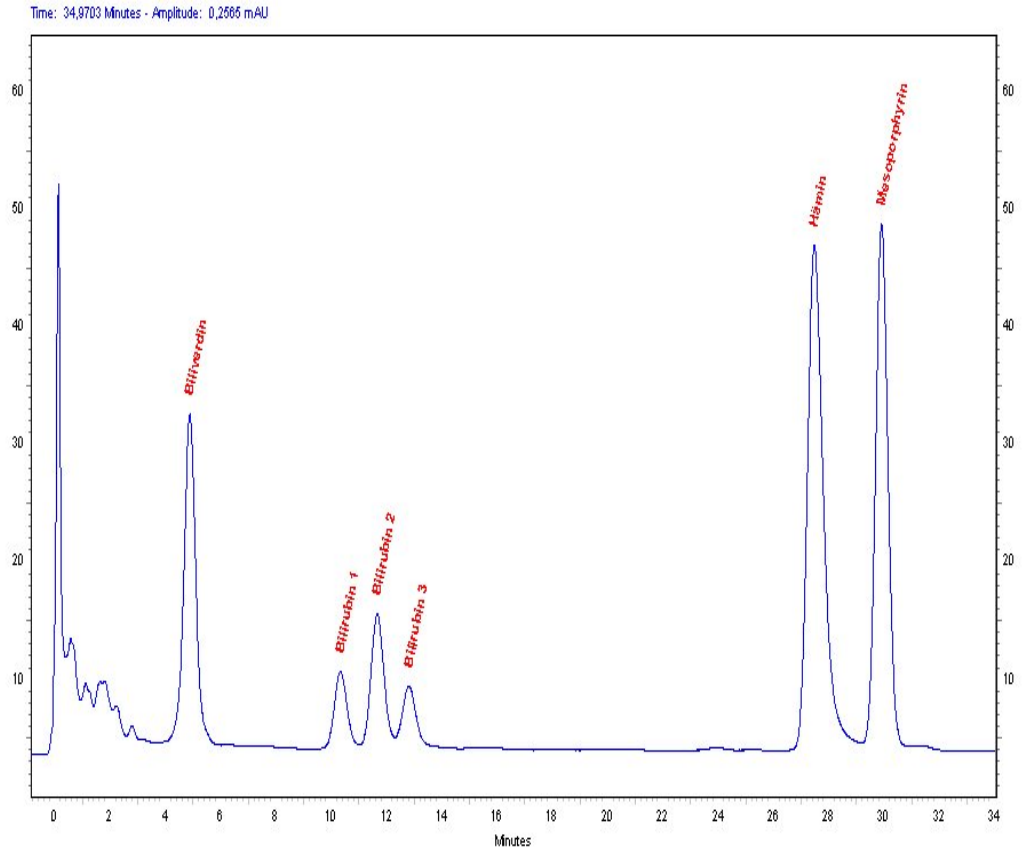


Column: Zorbax Eclipse XDB C-18 (1.8µm), 50-2 mm
Flow rate: 0.8 ml/min
Temperature: 65 °C
Eluent A: Original buffer
Eluent B: LiChroSolv Acetonitrile 35 %
Pressure: 35 MPa

Result:
10-times shorter analysis time, therefore 10-times higher turnover

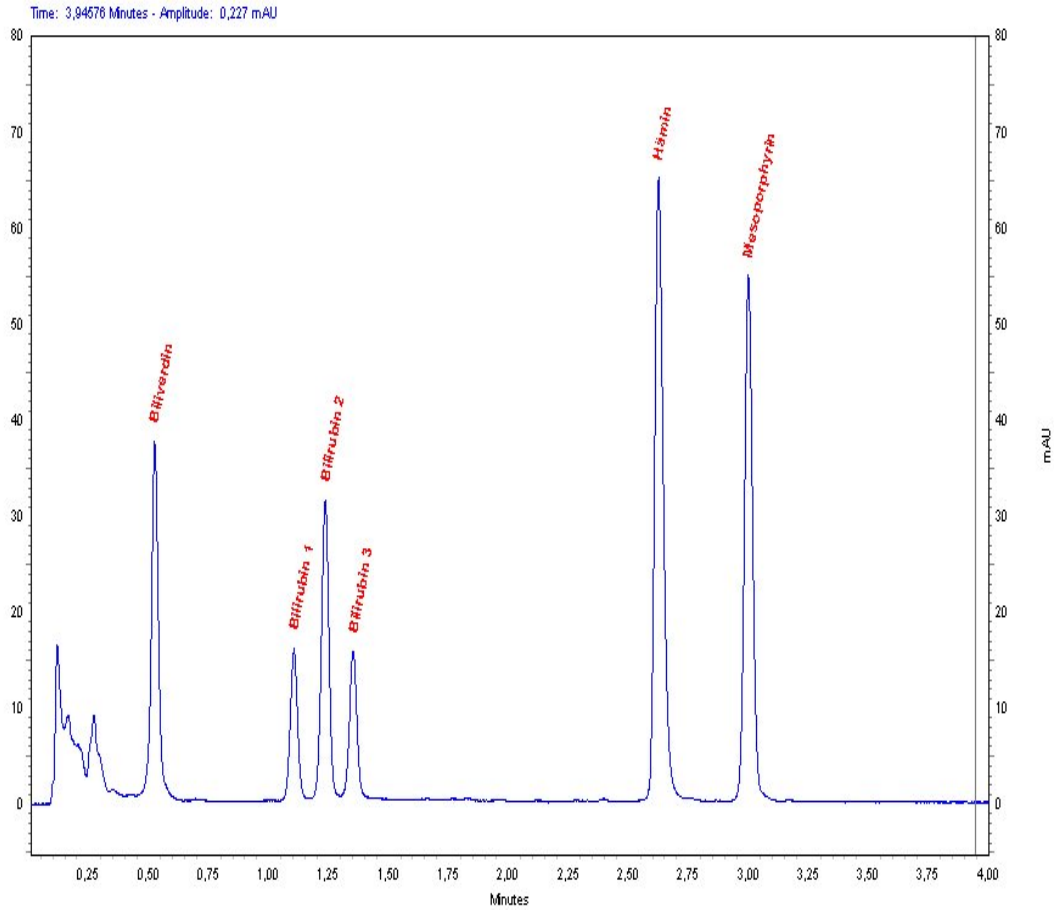
Method transfer to the Zorbax Eclipse column, 1,8 µm, 50-2 mm

Customer Application
Hemins & Porphyrins Original



Column: Purospher, C-18 (3 µm), 125-3 mm
Flow rate: 0.6 ml/min
Temperature: 40 °C
Eluent A: Ammonium acetate, 0,1 M, pH 5, 40%
Eluent B: LiChroSolv Methanol 40 %
Gradient: to 100% Methanol in 32 min
Run time: 30 min

Customer Application
Hemins & Porphyrins Optimised

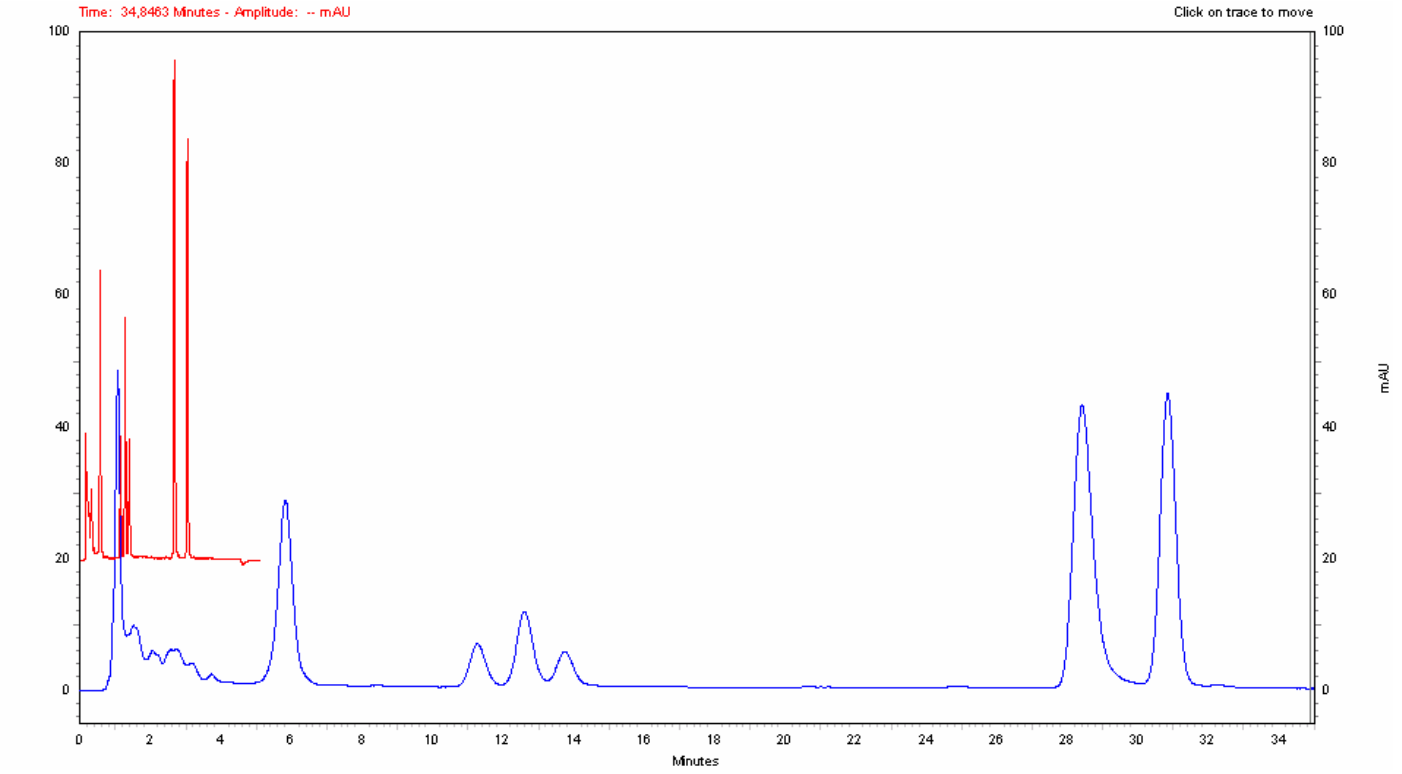


Column:	Zorbax, C-18 (1,8 µm), 30-2 mm
Flow rate:	0.7 ml/min
Temperature:	40 °C
Eluent A:	Ammonium acetate, 0,1 M, pH 5, 40%
Eluent B:	LiChroSolv Methanol 40 %
Gradient:	to 100% Methanol in 3,2 min
Run time:	3 min

Result:
10-time shorter run time, therefore about 10-times higher turnover possible

Customer Application

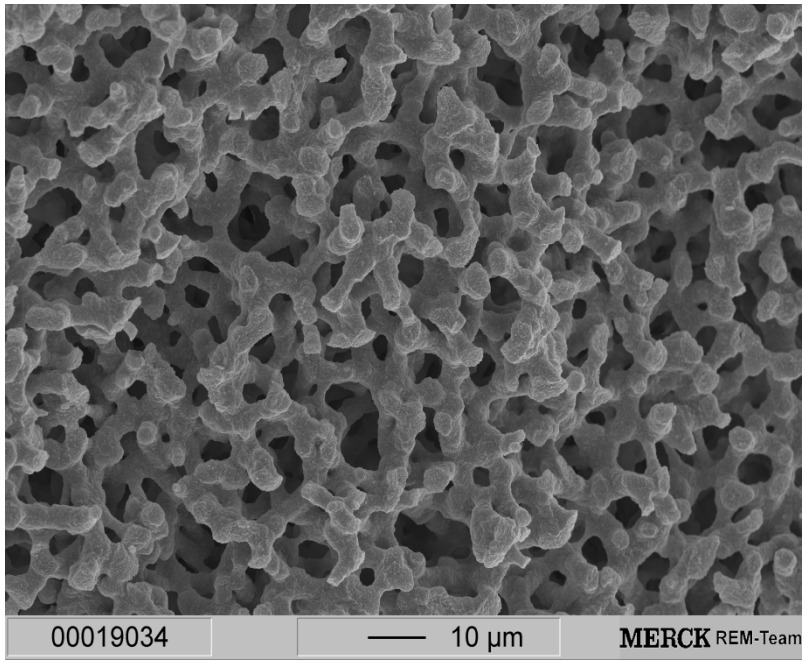
Hemins & Porphyrins Optimised

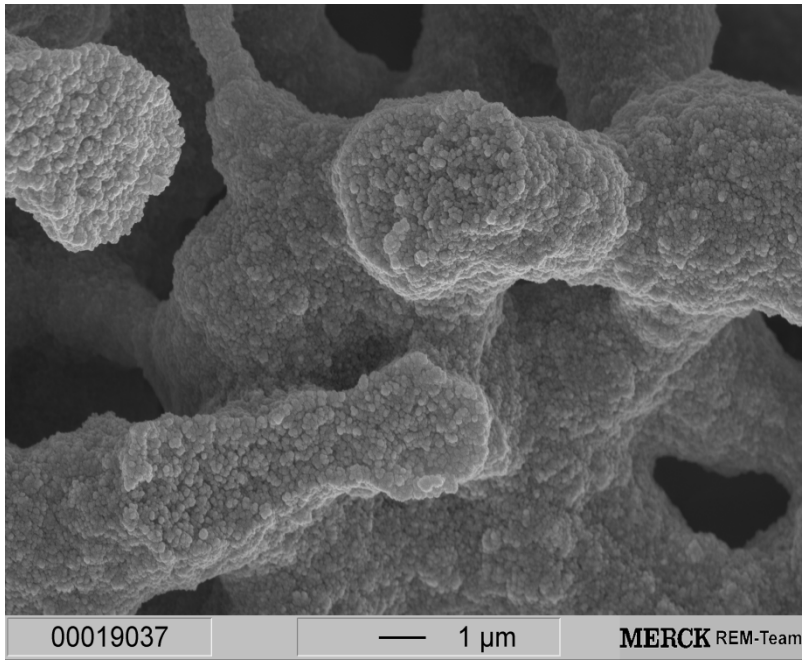


Result:
10-time shorter run time, therefore
10-times higher turnover possible

Chromolith Bimodal Pore Structure

SEM of a cross section of a monolithic silica rod





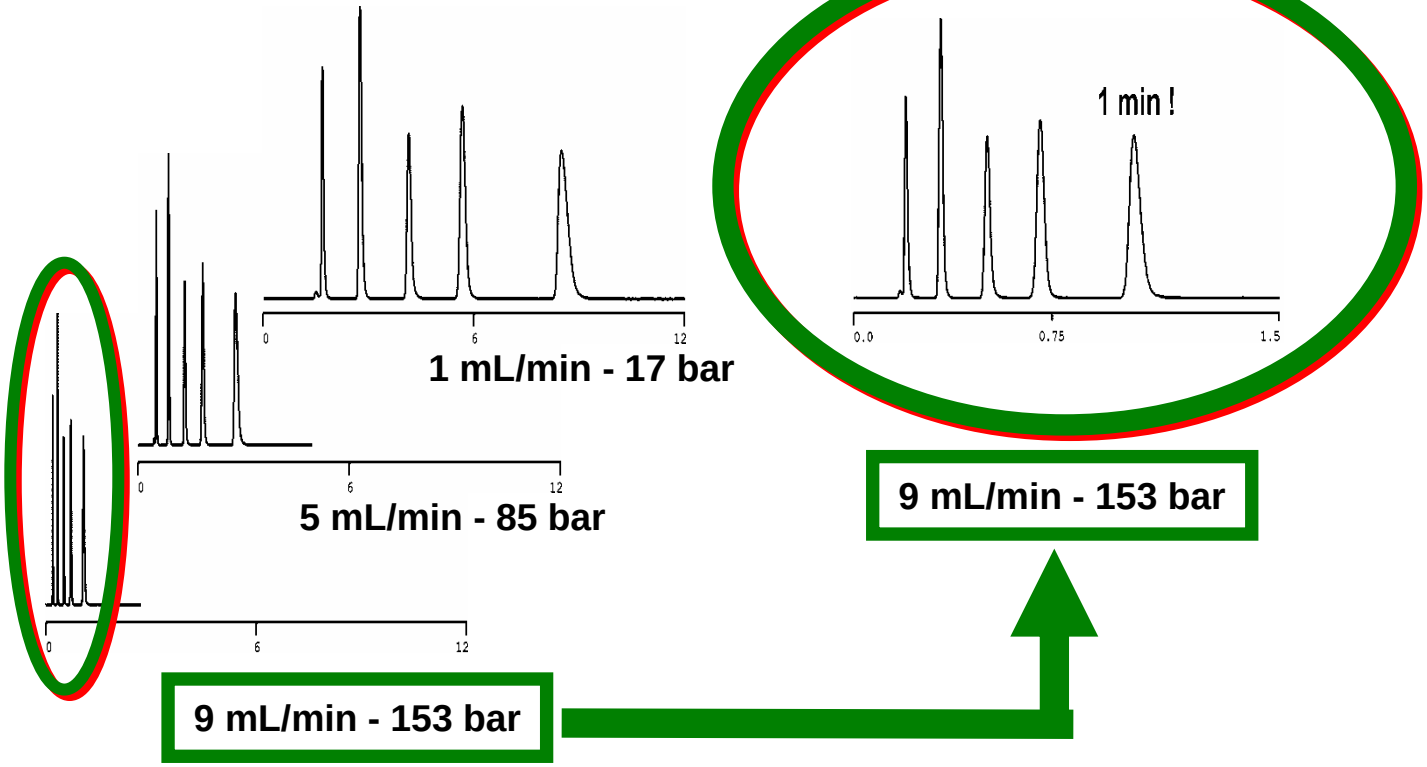
Macropores: 2 µm

Mesopores: 130 Å

Total porosity 81%

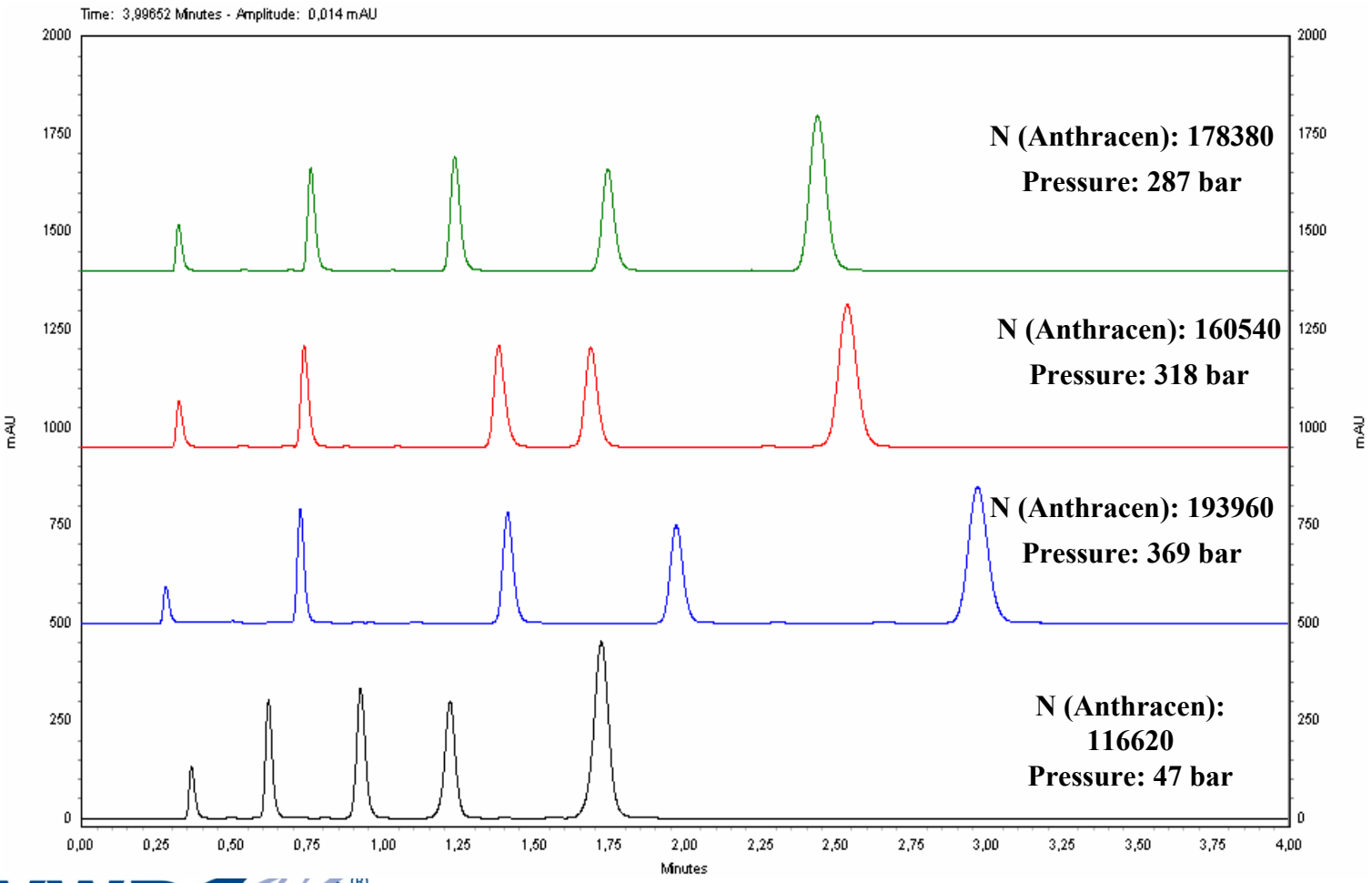
Fast Chromatography

Chromolith® Performance RP-18e (100 x 4.6 mm)



Chromolith® HPLC Columns

Comparison to sub 2µm particulate columns



Green: Waters Acquity UPLC BEH C18 1.7 µm, 50-2.1 mm

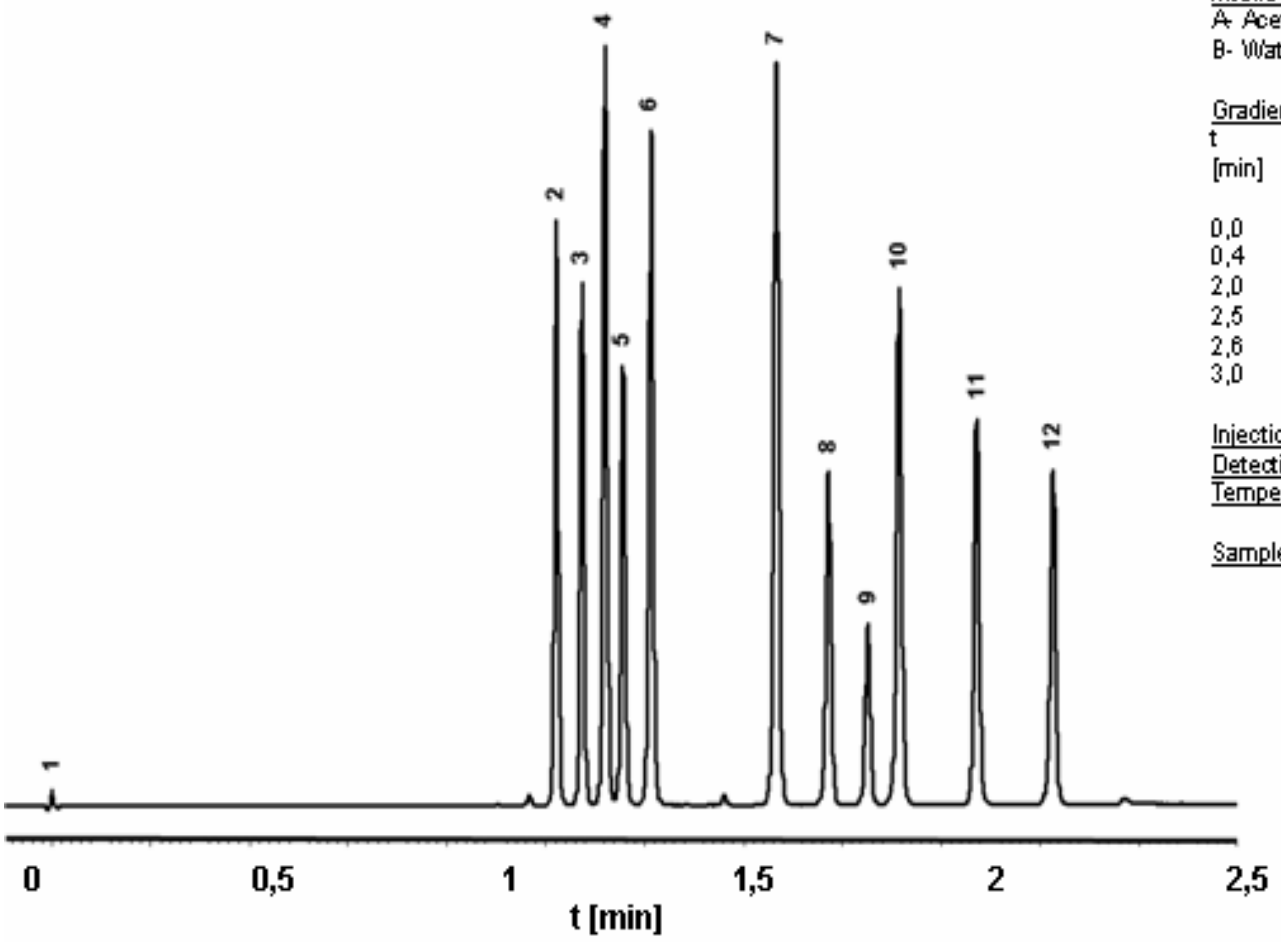
Red: Restek Pinnacle DB C18 (1.9 µm), 50-2.1 mm

Blue: Agilent Zorbax Eclipse XDB-C18 600 bar (1.8 µm) 50 x 2.1 mm

Black: Merck Chromolith FastGradient 50-2mm

Chromolith® FastGradient RP-18e

50 – 2mm



Mobile Phase:
A- Acetonitrile (LiChrosolv)
B- Water (LiChrosolv)

Gradient:

t [min]	A [%]	B [%]	flow [ml/min
0,0	15	85	1,50
0,4	15	85	1,50
2,0	100	0	1,00
2,5	100	0	1,00
2,6	15	85	1,00
3,0	15	85	1,00

Injection: 0,5µl
Detection: 240 nm UV
Temperature: 40°C

Sample:

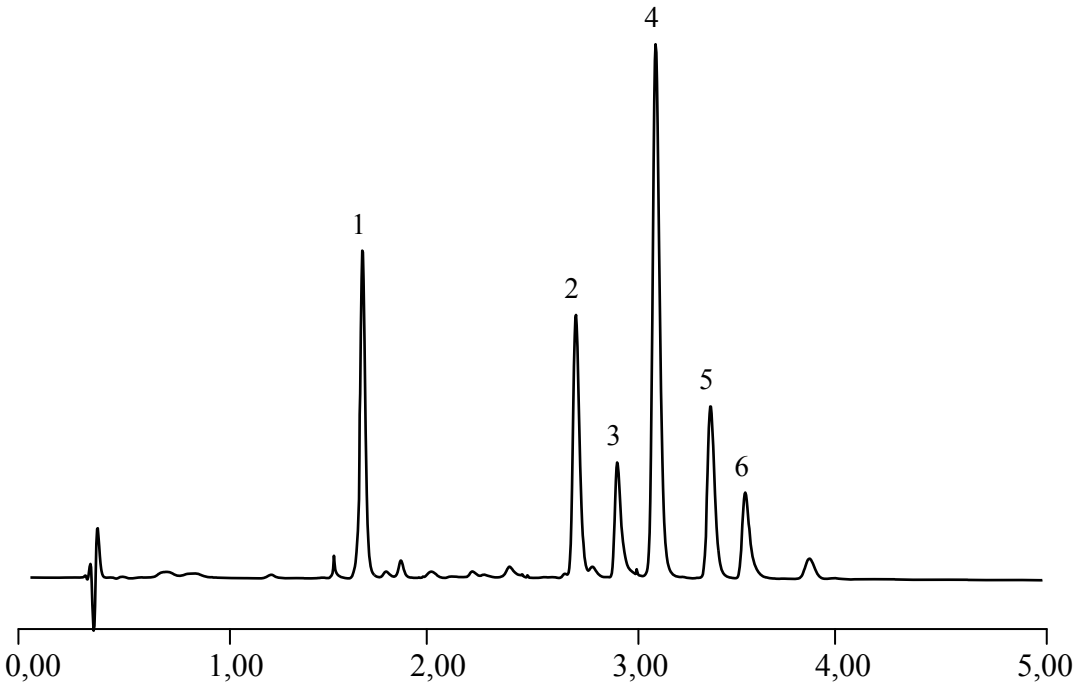
1.) Fluoxymesterone
2.) Boldenone
3.) Methandrostenolone
4.) Testosterone
5.) Methyltestosterone
6.) Boldenone acetate
7.) Testosterone acetate
8.) Nandrolone propionate
9.) Testosterone propionate
10.) Nandrolone phenylpropionate
11.) Testosterone isocaproate

Chromolith® FastGradient RP-18e

50 – 2mm

Separation of Bio-Flavonoids

on a Micro or Ultra HPLC system



Mobile Phase:
A-0,1% TFA in H2O
B- MeOH

Gradient:

t [min]	A [%]	B [%]	flow [ml/min]
0,0	85	15	0,50
2,5	50	50	0,50
5,0	50	50	0,50
5,1	85	15	0,50
8,5	85	15	0,50

Injection: 0,5µL
Detection: 220 nm UV
Temperature: ambient
Sample:
1 .) Isoquerecetin
2 .) Troxerutin
3 .) Naringin
4 .) Morin
5 .) Querecetin
6 .) Trihydroxyethylluteolin

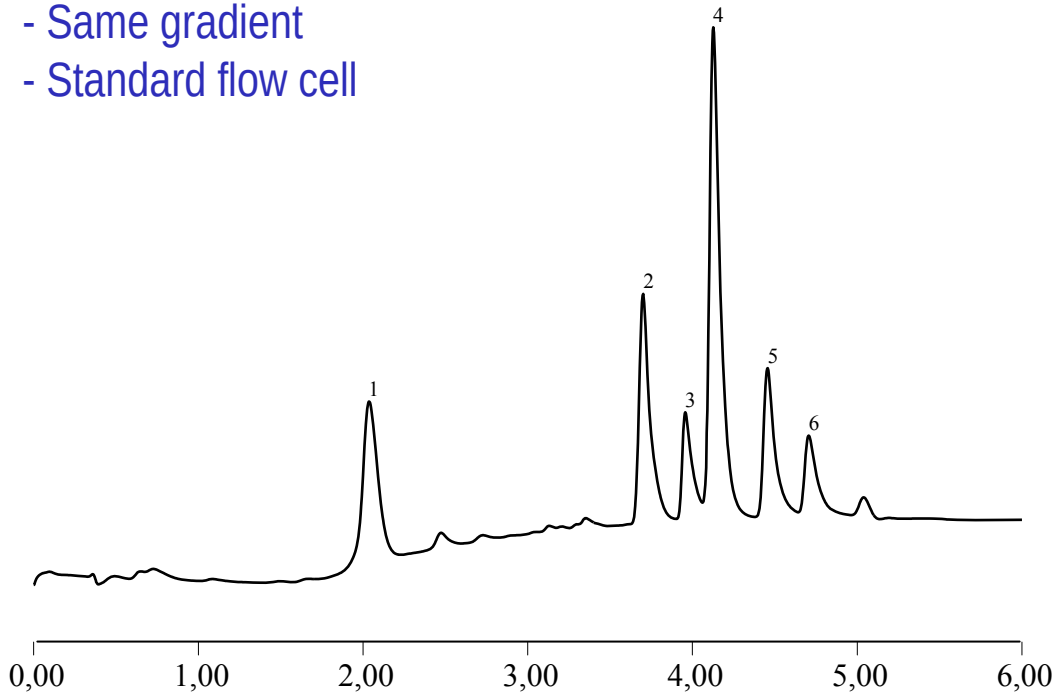
Chromolith® FastGradient RP-18e

50 – 2mm

Separation of Bio-Flavonoids

on a Conventional HPLC system

- Same gradient
- Standard flow cell



Mobile Phase:
A-0,1% TFA in H2O
B- MeOH

Gradient:

t [min]	A [%]	B [%]	flow [ml/min]
0,0	85	15	0,50
2,5	50	50	0,50
5,0	50	50	0,50
5,1	85	15	0,50
8,5	85	15	0,50

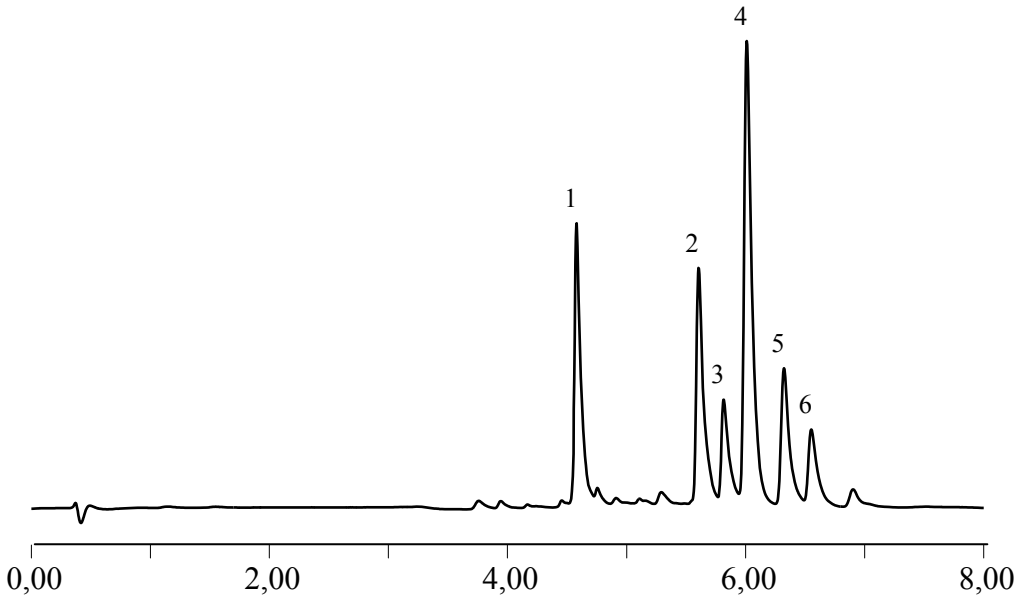
Injection: 0,5µL
Detection: 220 nm UV
Temperature: ambient
Sample:
1 .) Isoquerecetin
2 .) Troxerutin
3 .) Naringin
4 .) Morin
5 .) Querecetin
6 .) Trihydroxyethylluteolin

Chromolith® FastGradient RP-18e

50 – 2mm

Separation of Bio-Flavonoids

on a Conventional HPLC system
- Optimised gradient (due to different system dwell volume)
- Standard flow cell



Mobile Phase:
A-0,1% TFA in H2O
B- MeOH

Gradient:

t [min]	A [%]	B [%]	flow [ml/min]
0,0	95	5	0,50
1,8	95	5	0,50
4,3	50	50	0,50
6,8	50	50	0,50
6,9	95	5	0,50
10	95	5	0,50

Injection: 0,5µL
Detection: 220 nm UV
Temperature: ambient

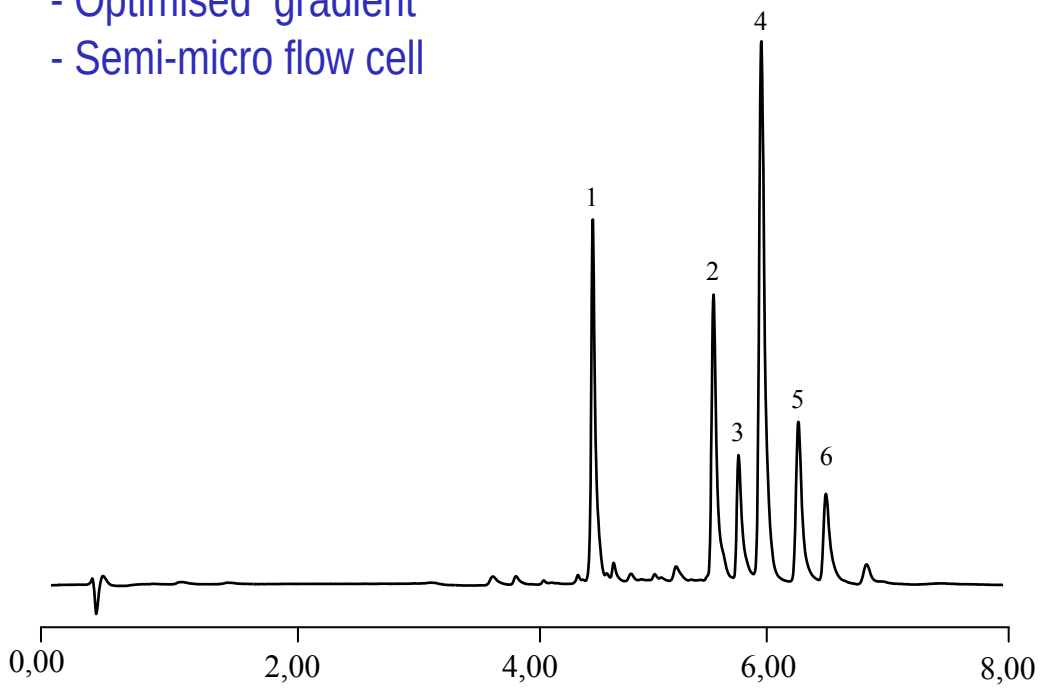
Sample:
1 .) Isoquerecetin
2 .) Troxerutin
3 .) Naringin
4 .) Morin
5 .) Querecetin
6 .) Trihydroxyethylluteolin

Chromolith® FastGradient RP-18e

50 – 2mm

Separation of Bio-Flavonoids

on a Conventional HPLC system
- Optimised gradient
- Semi-micro flow cell



Mobile Phase:
A-0,1% TFA in H2O
B- MeOH

Gradient:

t [min]	A [%]	B [%]	flow [ml/min]
0,0	95	5	0,50
1,8	95	5	0,50
4,3	50	50	0,50
6,8	50	50	0,50
6,9	95	5	0,50
10	95	5	0,50

Injection: 0,5µL
Detection: 220 nm UV
Temperature: ambient

Sample:
1 .) Isoquerecetin
2 .) Troxerutin
3 .) Naringin
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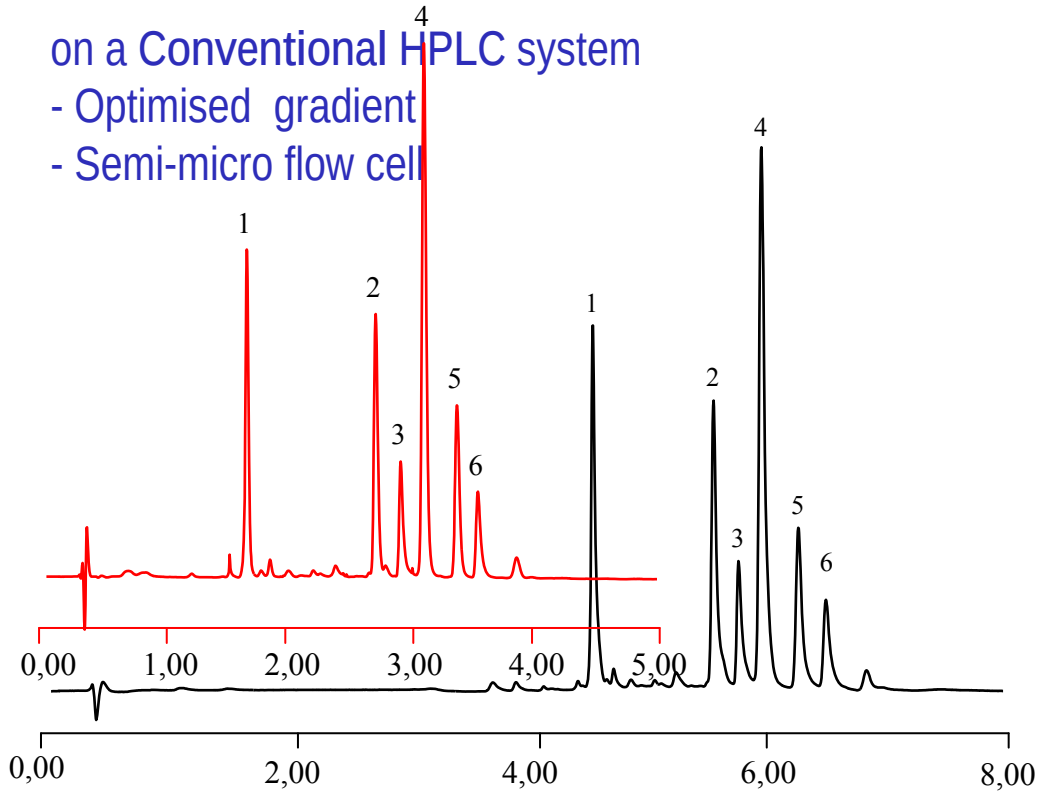
Chromolith® FastGradient RP-18e

50 – 2mm

Separation of Bio-Flavonoids

on a Conventional HPLC system
- Optimised gradient
- Semi-micro flow cell



Mobile Phase:
A-0,1% TFA in H2O
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Gradient:

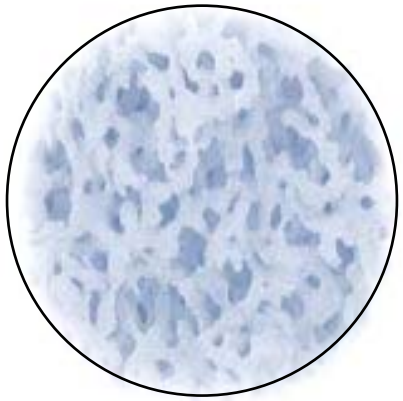
t [min]	A [%]	B [%]	flow [ml/min]
0,0	95	5	0,50
1,8	95	5	0,50
4,3	50	50	0,50
6,8	50	50	0,50
6,9	95	5	0,50
10	95	5	0,50

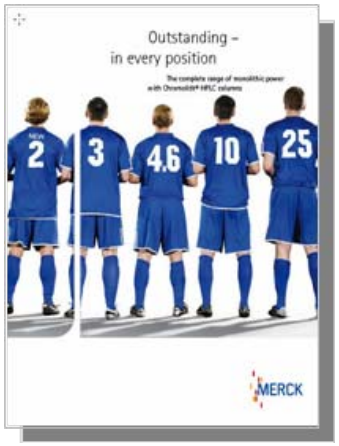
Injection: 0,5µL
Detection: 220 nm UV
Temperature: ambient

Sample:
1 .) Isoquerecetin
2 .) Troxerutin
3 .) Naringin
4 .) Morin
5 .) Querecetin
6 .) Trihydroxyethylluteolin

Supplier Partnerships for Customer Solutions

Chromolith® HPLC Columns





- Extremely **low back-pressure**
  = Shorter analysis time / higher sample throughput
- **Less sample preparation** (filtration) required
  = Ideal for real samples
- Extremely long column **lifetime** (rigid silica skeleton)
  = Significant cost savings
- **Coupling** of columns possible
  = Improved separations
- Use with **every** HPLC **or** UHPLC sytem
  = fast sparations for everyone

VWR® Supplier Partnerships for Customer Solutions

Steuert das HPLC System

verarbeitet Retentionszeiten, berechnet Retentionsmodelle

ChromSword Auto® Methodenentwicklungs- und Optimierungssoftware optimiert vollautomatisch Reversed-Phase-HPLC-Methoden. ChromSword Auto® steuert dabei den kompletten mathematischen und experimentellen Optimierungsprozess.

Die Software kann mit folgenden HPLC-Systemen kombiniert werden:

- VWR-Hitachi LaChrom, LaChrom Elite and LaChrom Ultra
- Agilent Systemen
- Waters Systemen

VWR®
Supplier Partnerships for Customer Solutions

Zwei Optimierungsmodi stehen zur Auswahl:

1. Schnelle Optimierung/ schnelles Screening:

ChromSword® Auto führt mit einer Säulen-Lösungsmittel-Kombination einen Übersichtsgradienten aus und berechnet daraus einen optimalen linearen Gradient und einen optimalen Stufengradient.

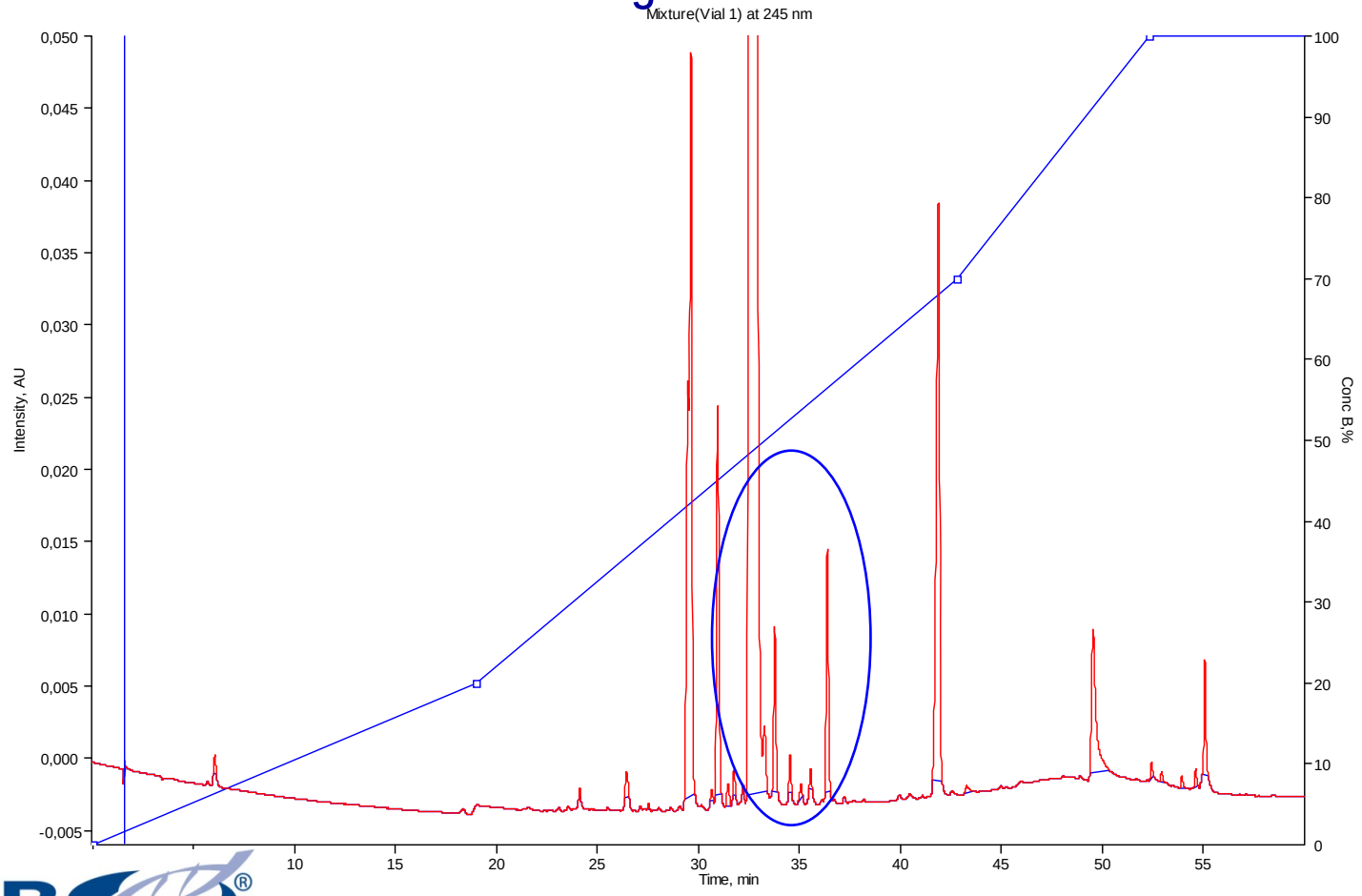
2. Fein-Optimierung

Im Verlauf der Feinoptimierung nimmt ChromSword® Auto weitere Retentionsdaten auf, um exakte Retentionsmodelle zu berechnen. Anschließend werden bis zu 10 Chromatogramme mit den berechneten optimalen Bedingungen aufgenommen.

ChromSword® Auto

Schnelle Optimierung/ Schnelles Screening: Methodenentwicklung in 3 Läufen

1. Lauf: Übersichtsgradient

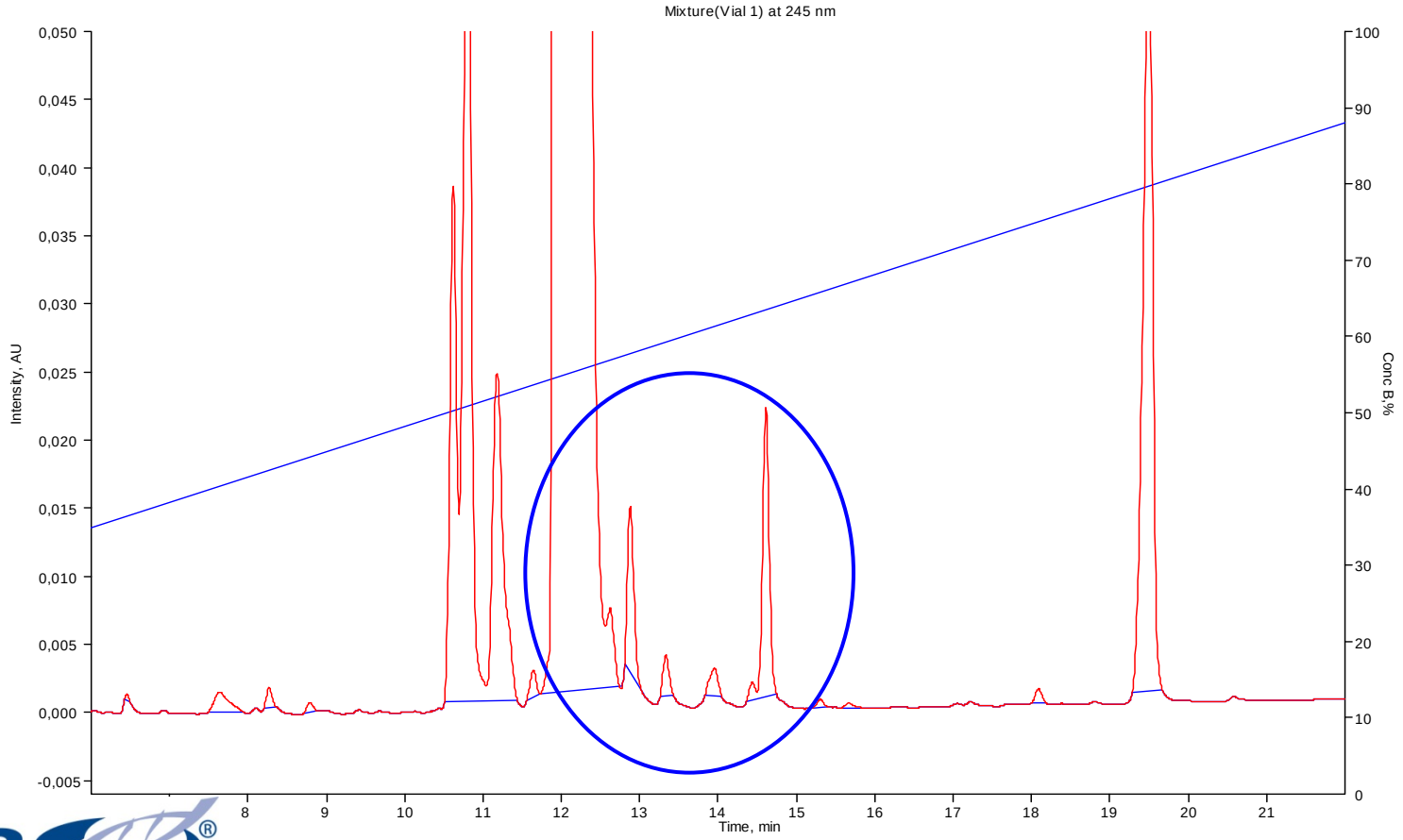


VWR®
Supplier Partnerships for Customer Solutions

ChromSword® Auto

Schnelle Optimierung/ Schnelles Screening: Methodenentwicklung in 3 Läufen

2. Lauf: optimierter linearer Gradient

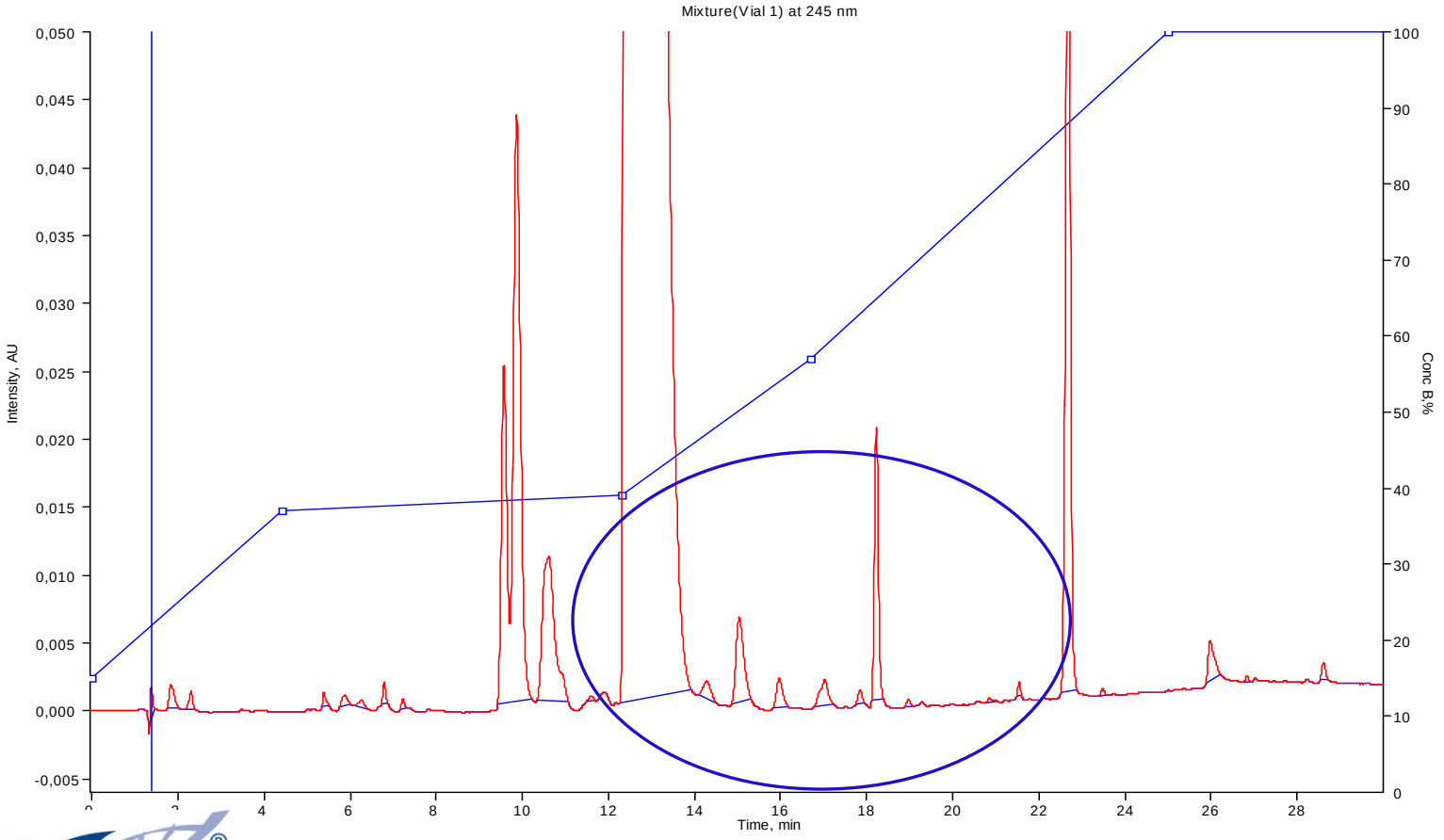


VWR®
Supplier Partnerships for Customer Solutions

ChromSword® Auto

Schnelle Optimierung/ Schnelles Screening: Methodenentwicklung in 3 Läufen

3. Lauf: optimierter Stufen-Gradient

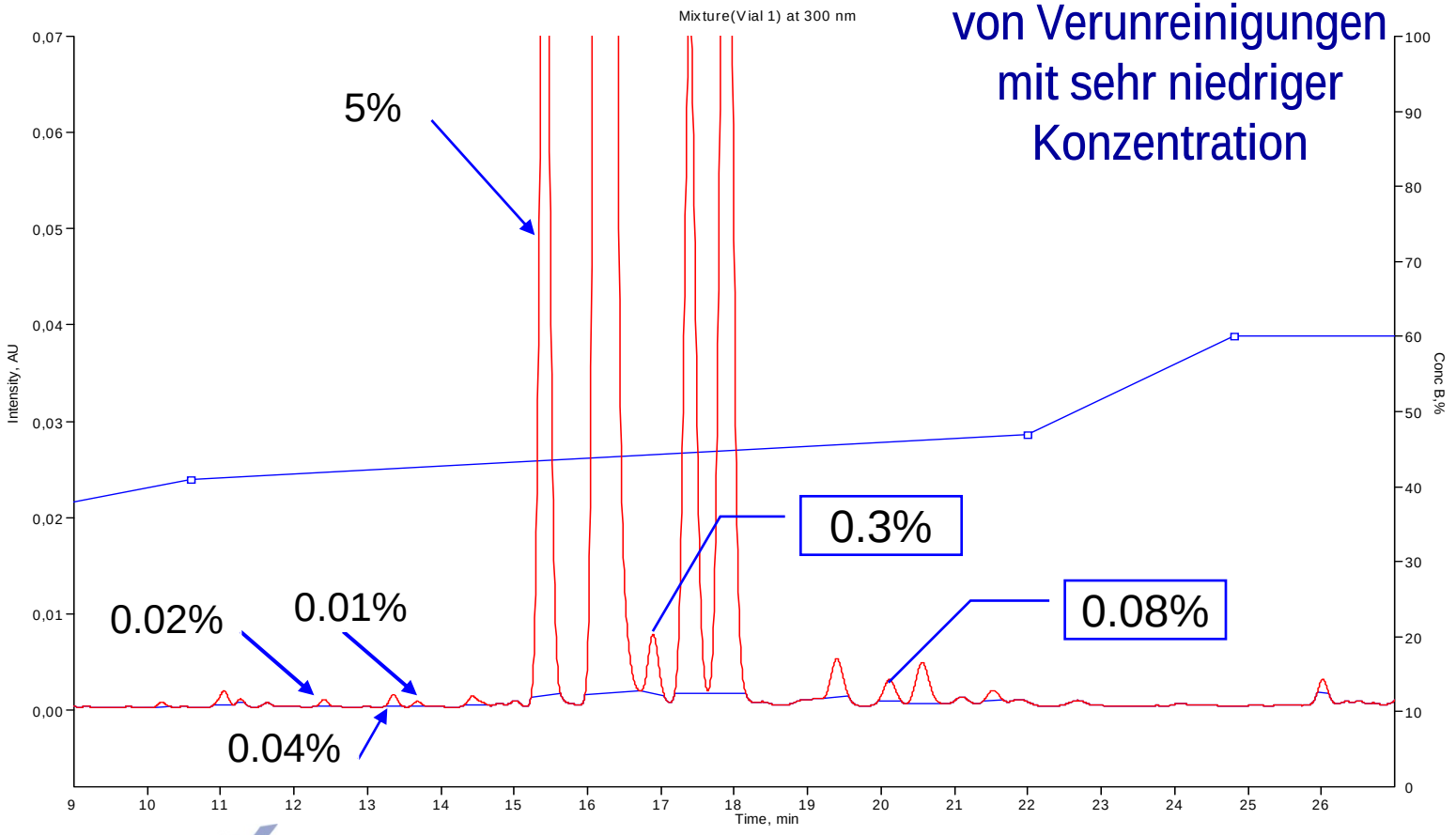


VWR®
Supplier Partnerships for Customer Solutions

ChromSword® Auto

Fein-Optimierung einer pharmazeutischen Probe

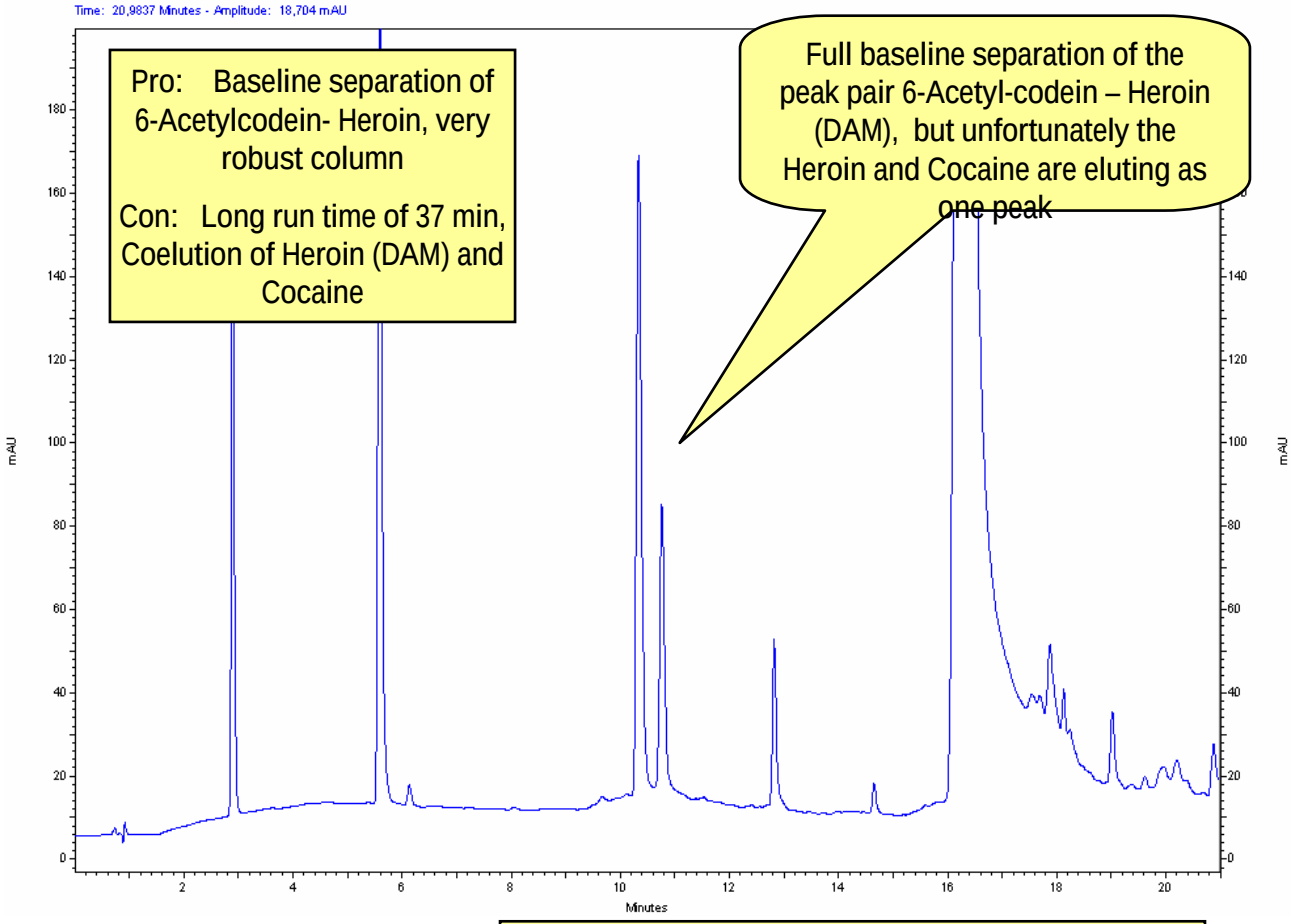
Trennoptimierung auch von Verunreinigungen mit sehr niedriger Konzentration



Supplier Partnerships for Customer Solutions

Optimisation: Drugs of Abuse
Standard mixture on LaChromUltra system

Column: Chromolith® Performance RP-18e, 100-4.6 mm



Sample: Standard mixture
1.Paracetamol, 2.Caffeine 3.6-Acetylcodeine, 4.Diacetyl-morphine (DAM, Heroin),,
Column: Chromoltih® Performance RP-18e, 100-4.6 mm
Eluent A: Phosphate buffer, pH 2.5 (2.4 g NaH_2PO_4 + 20 ml ACN ad 1000 ml > adjust with 85 % H_3PO_4 to pH 2.5
Eluent B: Acetonitrile
Column temperature: 40 °C

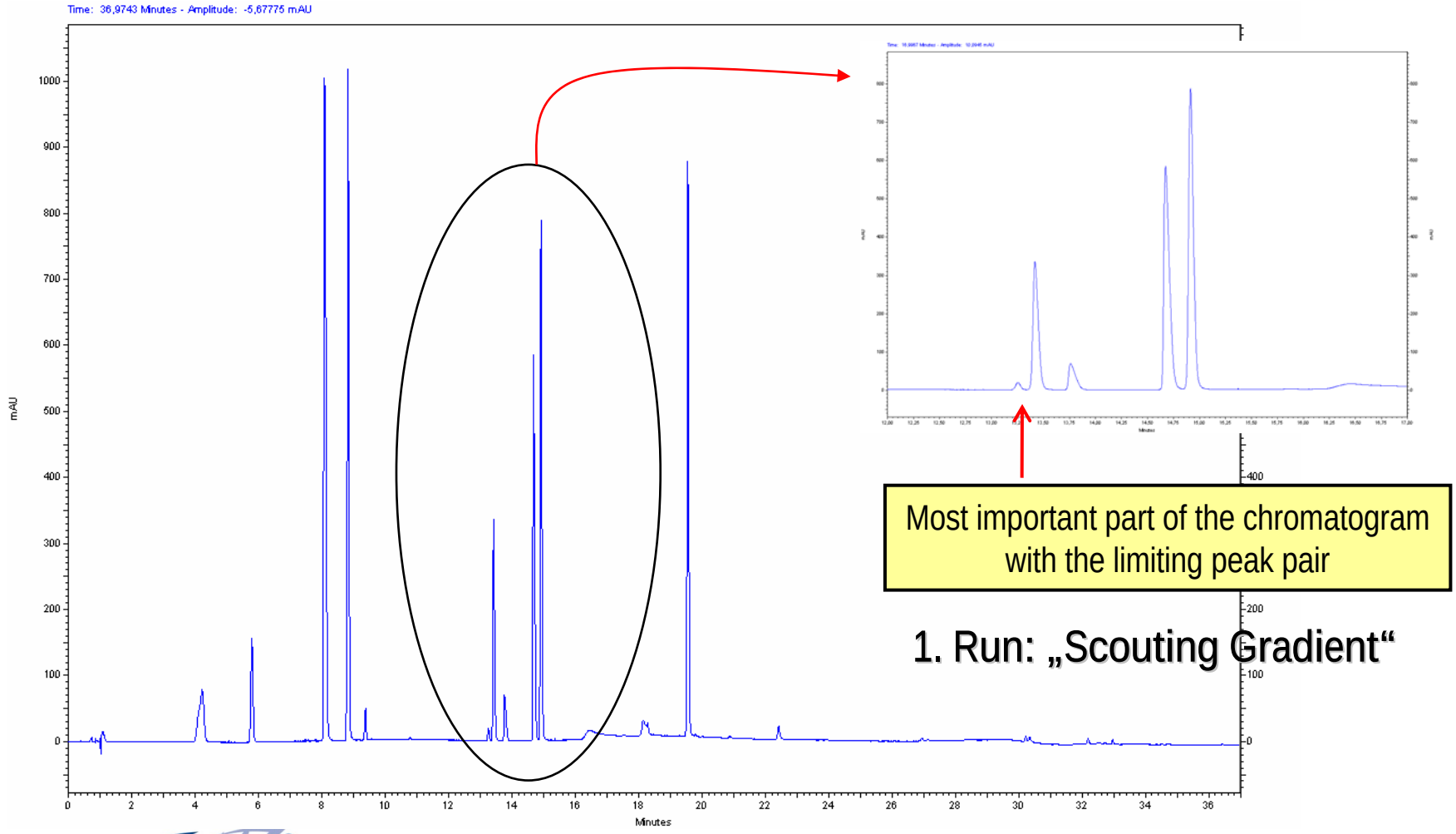
Time	A	B	Flow
0	100	0	2.0
14	79	21	2.0
20	52	48	2.0
21	22	78	2.0
23	22	78	2.0
31	100	0	2.0
37	100	0	2.0

Flow rate: 2.0 ml/min,
UV: 210 nm
Pressure: 90 bar

Original customer‘s application

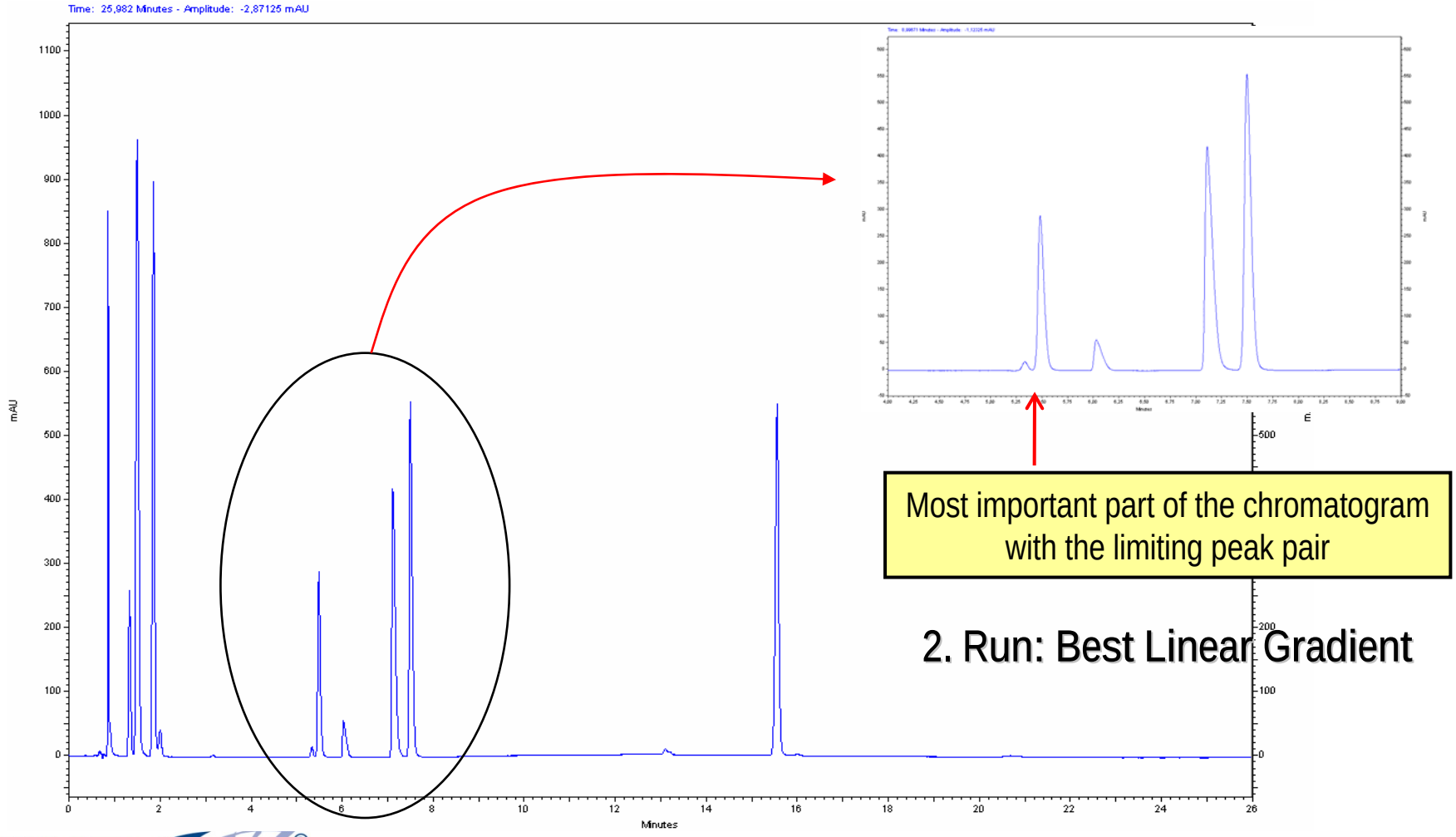
ChromSword Auto ® Optimisation: Drugs of Abuse
Standard mixture of 11 illegal drugs

Column: Purospher ® STAR RP-18e (3 µm), Hibar HR 150-2.1 mm



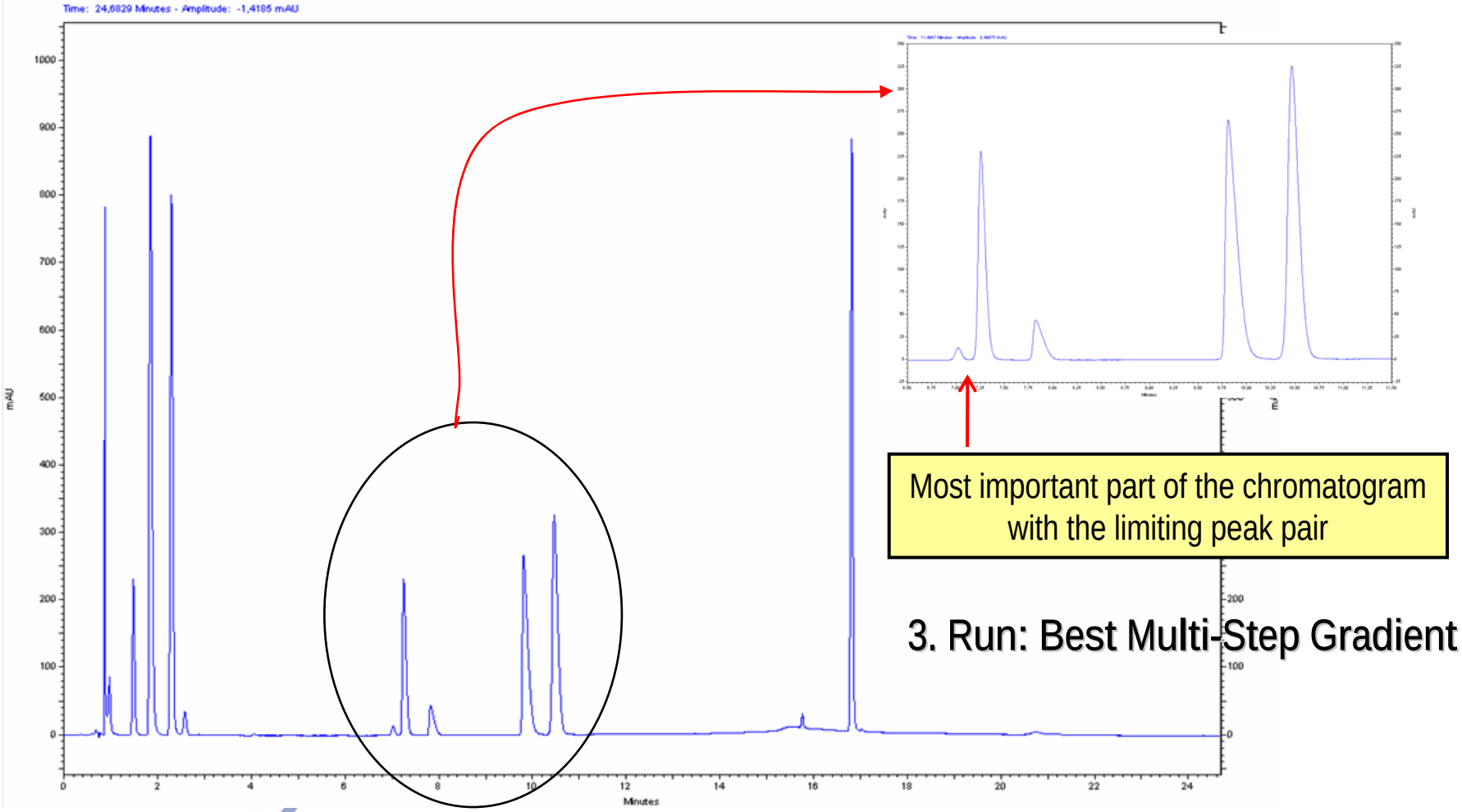
ChromSword Auto ® Optimisation: Drugs of Abuse
Standard mixture of 11 illegal drugs

Column: Purospher ® STAR RP-18e (3 µm), Hibar HR 150-2.1 mm



ChromSword Auto ® Optimisation: Drugs of Abuse
Standard mixture of 11 illegal drugs

Column: Purospher ® STAR RP-18e (3 µm), Hibar HR 150-2.1 mm

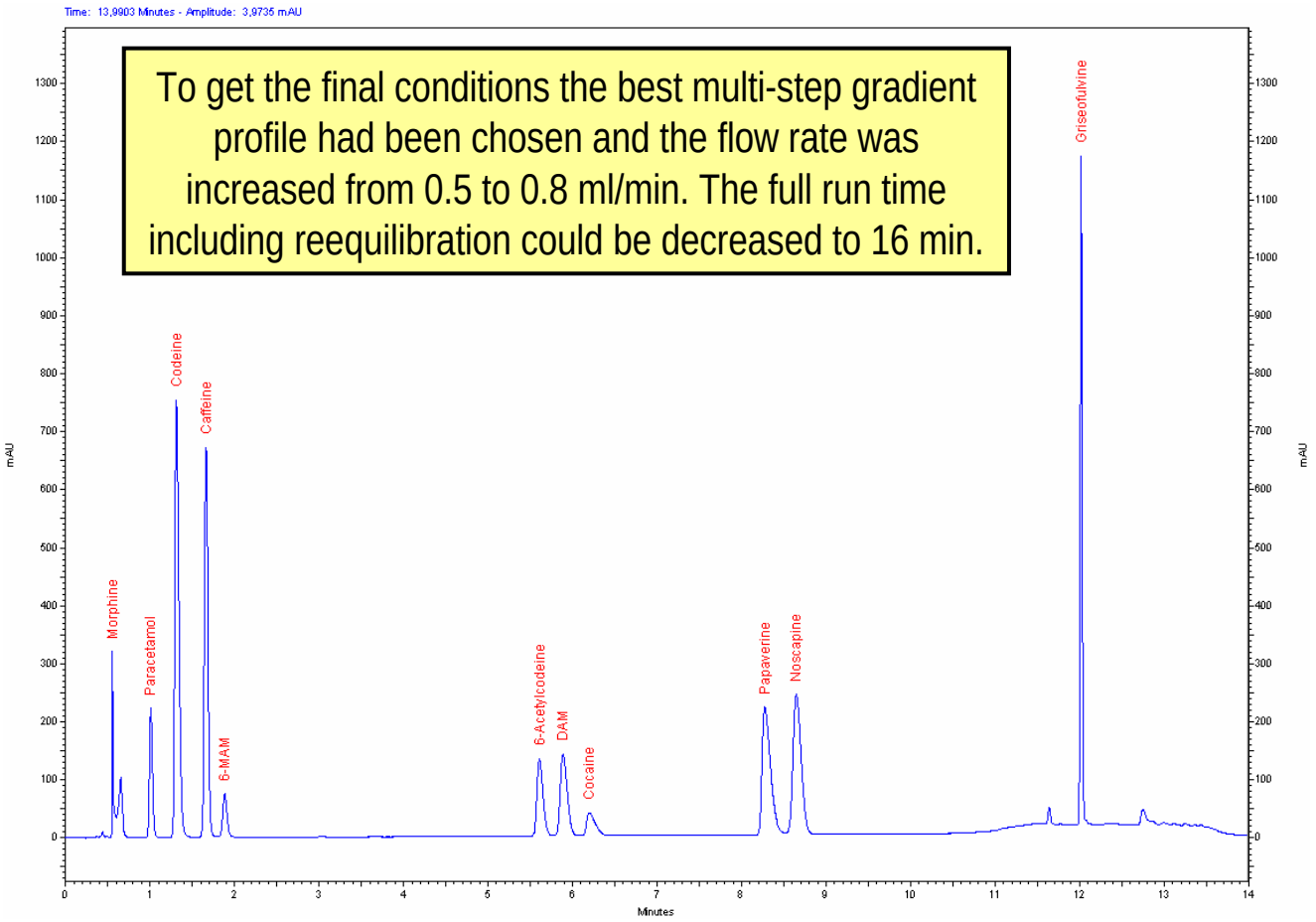


Most important part of the chromatogram with the limiting peak pair

3. Run: Best Multi-Step Gradient

ChromSword Auto ® Optimisation: Drugs of Abuse
Standard mixture of 11 illegal drugs

Column: Purospher ® STAR RP-18e (3 µm), Hibar HR 150-2.1 mm



To get the final conditions the best multi-step gradient profile had been chosen and the flow rate was increased from 0.5 to 0.8 ml/min. The full run time including reequilibration could be decreased to 16 min.

Sample: Std-Mix of 11 illegal drugs

1.Morphine, 2.Paracetamol, 3.Codein, 4.Coffeine, 5.6-Mono-acetylmorphine (MAM), 6.6-Acetyl-codeine, 7.Diacetylmorphine (DAM, Heroin), 8.Cocaine, 9.Papaverine, 10.Noscapine, 11.Griseofulvine

Column: Purospher ® STAR RP-18e (3 µm), Hibar HR 150-2.1 mm

Column temperature: 40 °C

Eluent A: Phosphate buffer, pH 2.5 (2.4 g NaH_2PO_4 + 20 ml ACN ad 1000 ml water > adjust with 85 % H_3PO_4 to pH 2.5

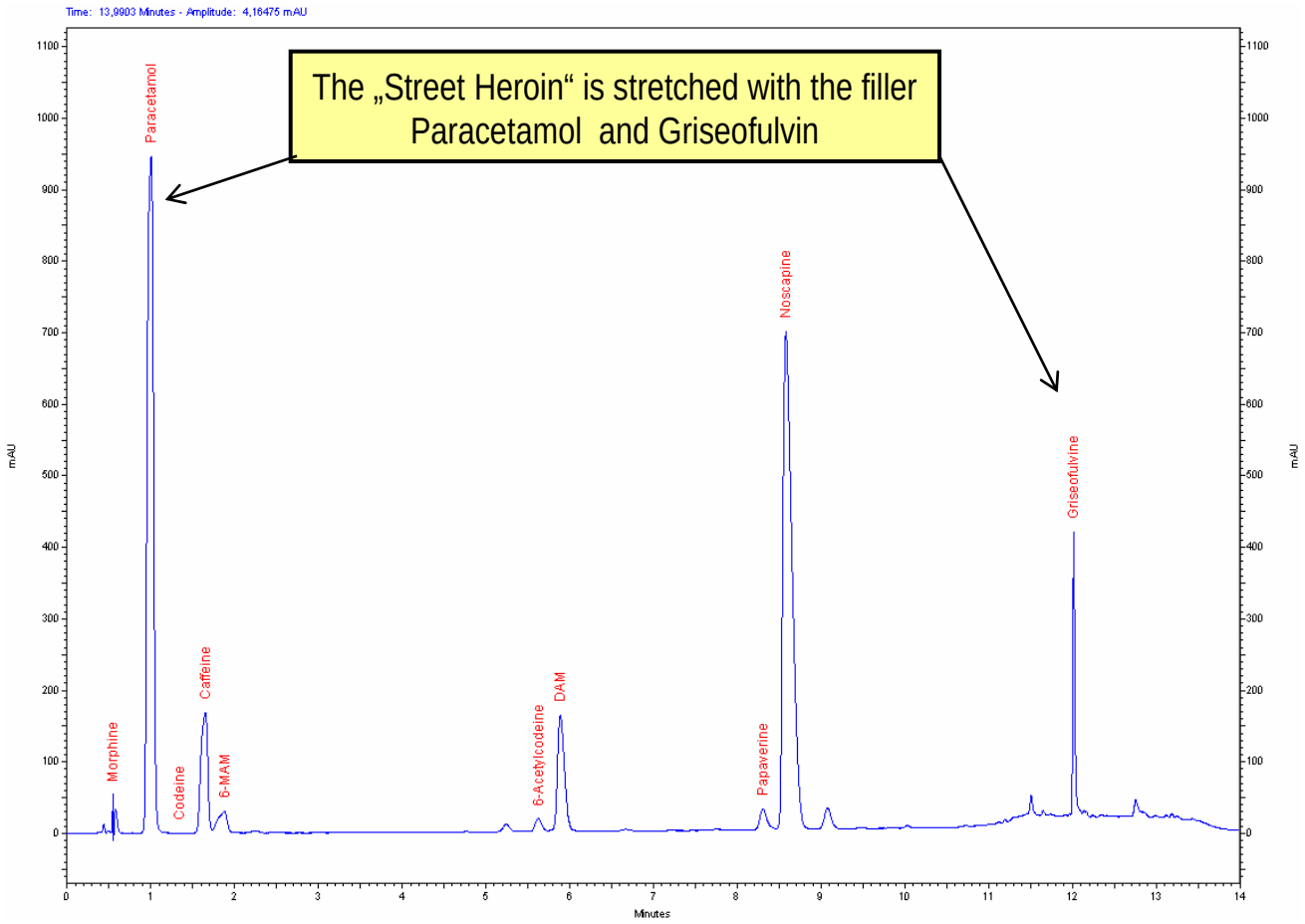
Eluent B: Acetonitrile

Time	A	B	Flow
0	89	11	0.8
5.8	82	18	0.8
7	81.5	18.5	0.8
9.5	75	25	0.8
12	30	70	0.8
13	30	70	0.8
13.1	89	11	0.8
16	89	11	0.8

Flow rate: 0.8 ml/min,
UV: 210 nm
Pressure: 520 bar

ChromSword Auto ® Optimisation: Drugs of Abuse
Real sample: „Street Heroin“

Column: Purospher ® STAR RP-18e (3 µm), Hibar HR 150-2.1 mm



Sample: “Street Heroin”

1.Morphine, 2.Paracetamol, 3.Codein, 4.Coffeine, 5.6-Mono-acetylmorphine (MAM), 6.6-Acetyl-codeine, 7.Diacetylmorphine (DAM, Heroin), 8.Cocaine, 9.Papaverine, 10.Noscapine, 11.Griseofulvine

Column: Purospher ® STAR RP-18e (3 µm), Hibar HR 150-2.1 mm

Column temperature: 40 °C

Eluent A: Phosphate buffer, pH 2.5 (2.4 g NaH_2PO_4 + 20 ml ACN ad 1000 ml water > adjust with 85 % H_3PO_4 to pH 2.5

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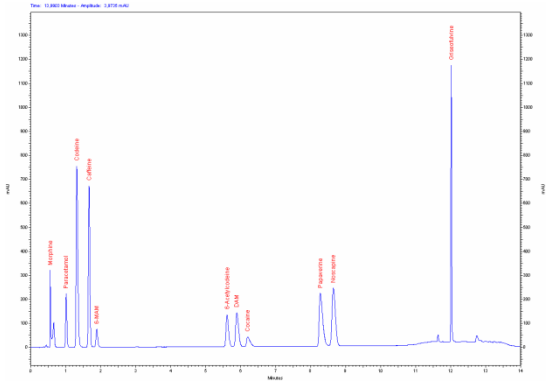
9.5	75	25	0.8
12	30	70	0.8
13	30	70	0.8
13.1	89	11	0.8
16	89	11	0.8

Flow rate: 0.8 ml/min,
UV: 210 nm
Pressure: 520 bar

ChromSword Auto ® Optimisation: Drugs of Abuse

Column: Purospher ® STAR RP-18e (3 µm), Hibar HR 150-2.1 mm



Why a 3 µm column has been selected?

Purospher ® STAR RP-18e Number of theorectical plates:

2 µm : 190 000 plates /m 50 mm column: 9 500 plates/m
3 µm : 150 000 plates /m 150 mm column: 22 500 plates/m

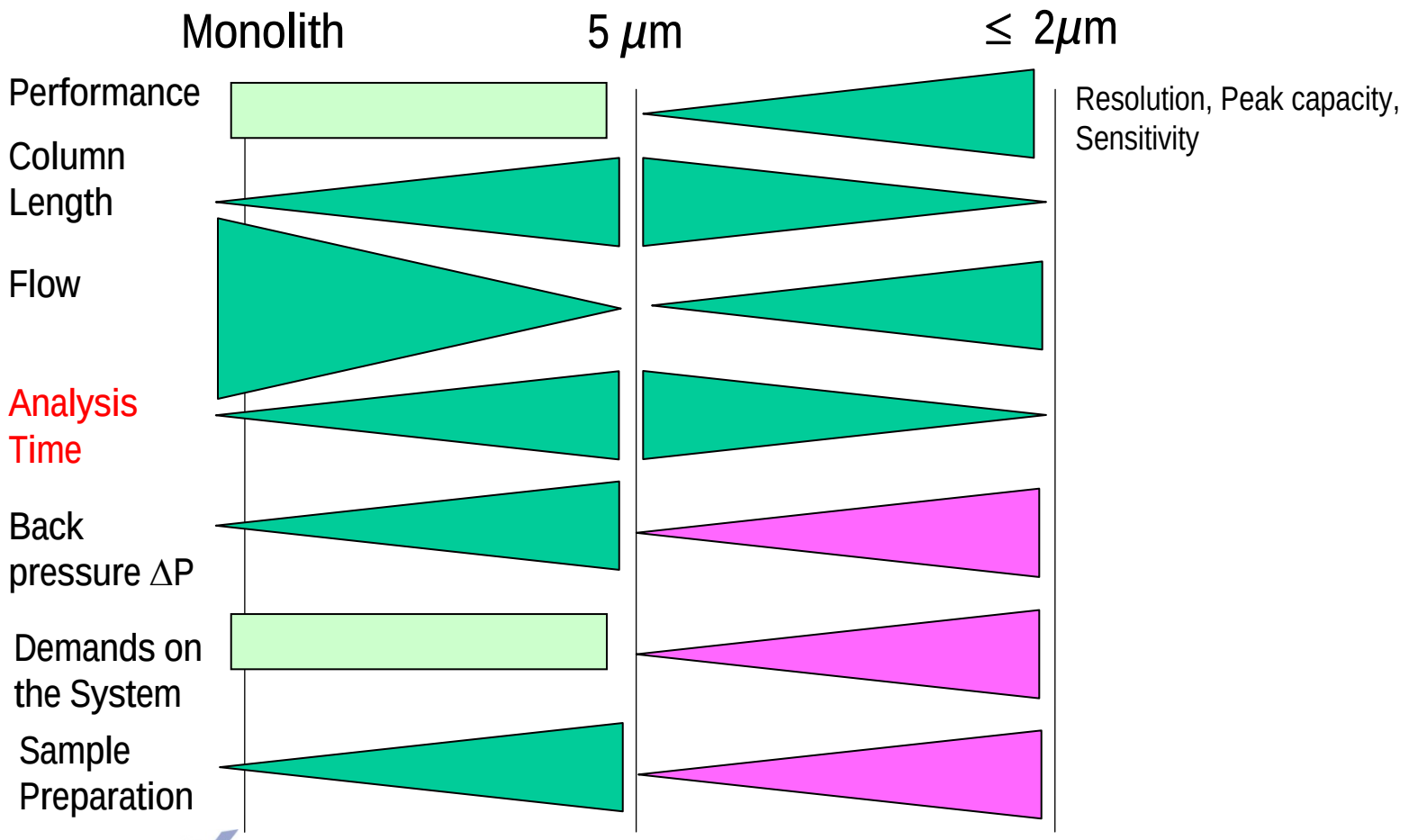
The 3 µm 15 mm column supplies a much better resolution at similar backpressure!

Sample: Std-Mix of 11 illegal drugs
1.Morphine, 2.Paracetamol, 3.Codein, 4.Coffeine, 5.6-Mono-acetylmorphine (MAM), 6.6-Acetyl-codeine, 7.Diacetylmorphine (DAM, Heroin), 8.Cocaine, 9.Papaverine, 10.Noscapine, 11.Griseofulvine
Column: Purospher ® STAR RP-18e (3 µm), Hibar HR 150-2.1 mm
Column temperature: 40 °C
Eluent A: Phosphate buffer, pH 2.5 (2.4 g NaH_2PO_4 + 20 ml ACN ad 1000 ml water > adjust with 85 % H_3PO_4 to pH 2.5
Eluent B: Acetonitrile

Time	A	B	Flow
0	89	11	0.8
5.8	82	18	0.8
7	81.5	18.5	0.8
9.5	75	25	0.8
12	30	70	0.8
13	30	70	0.8
13.1	89	11	0.8
16	89	11	0.8

Flow rate: 0.8 ml/min,
UV: 210 nm
Pressure: 520 bar

Conclusion
Chromolith vs. Particular Columns



Fazit

Bis zu 90% Zeit, Lösungsmittel und Kosten lassen sich einsparen durch „ultra“-schnelle Chromatographie

- mit partikulären Säulen ≤ 3 µm auf UHPLC-Systemen
- mit Chromolith® 50-2 mm Säulen
  auf UHPLC- und konventionellen HPLC-Systemen
- Besondere Aufmerksamkeit sollte der Methoden-Optimierung geschenkt werden - ChromSword Auto® ist dafür ein einzigartiges Werkzeug