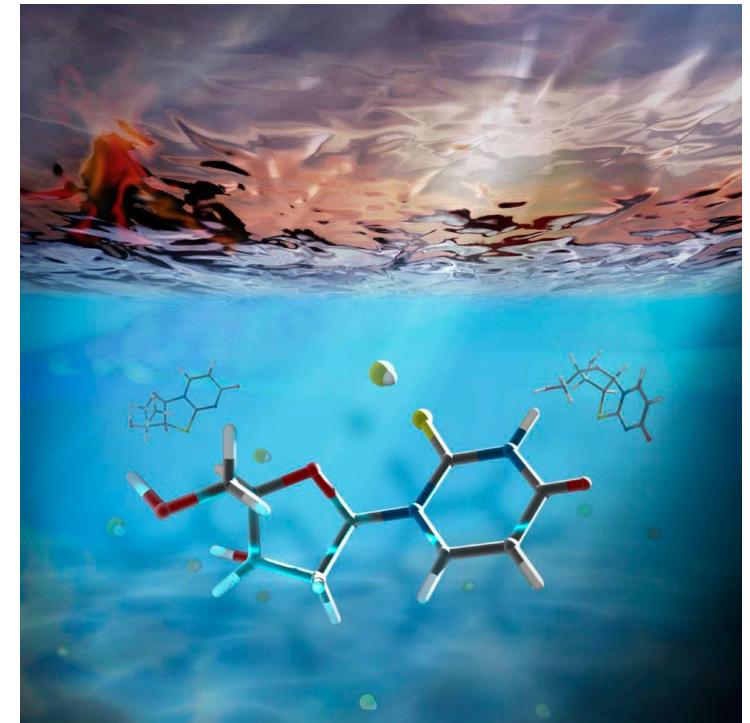


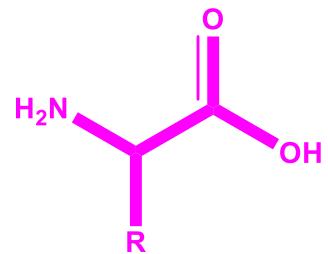
# TARGET BUILDING BLOCKS OF LIFE

- Which building blocks of life have been formed in the Space? Under which conditions?
- Did they reach structural complexity/organization?
- To what have these extraterrestrial molecules been implied in a prebiotic chemistry on the early Earth

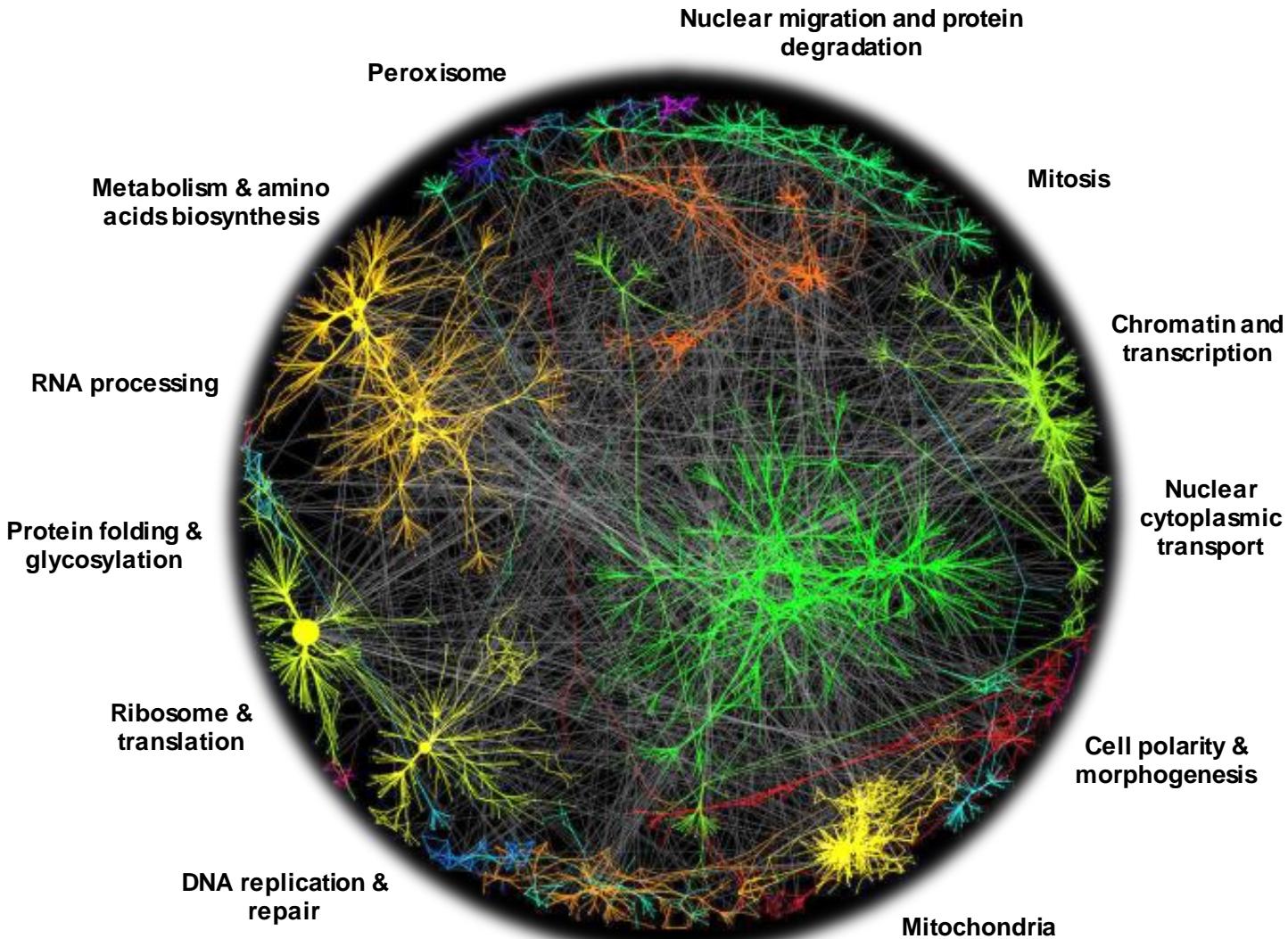
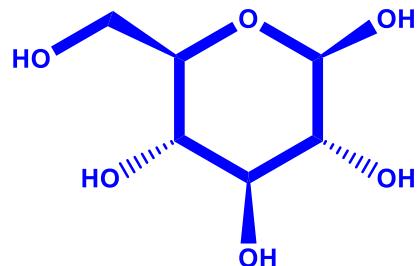


# BUILDING BLOCKS OF LIFE

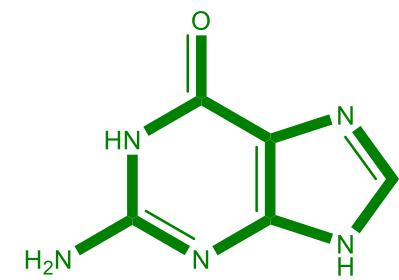
**AMINO ACIDS**  
→ *Proteins*



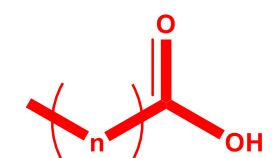
**SUGARS**  
→ *Glycans*



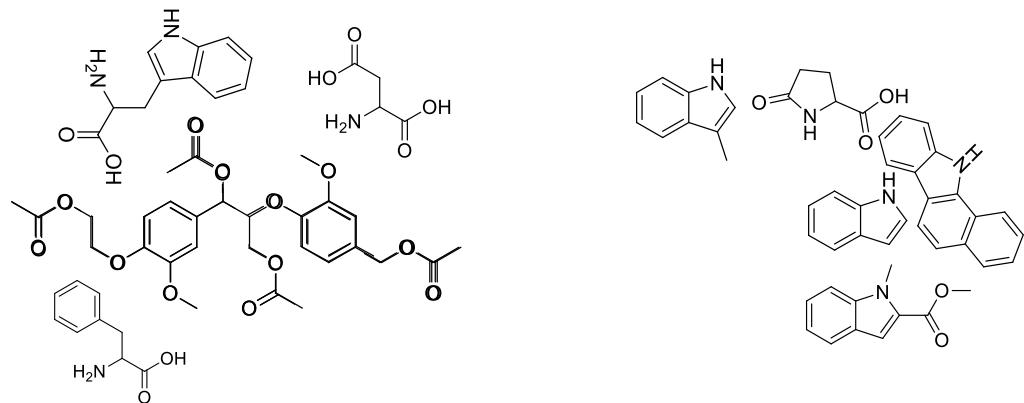
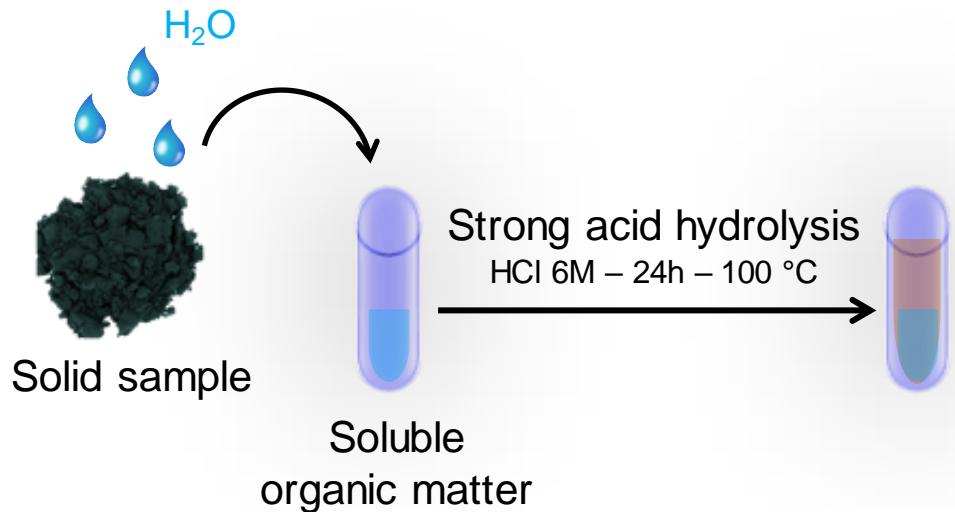
**NUCLEOBASES**  
→ *ADN / ARN*



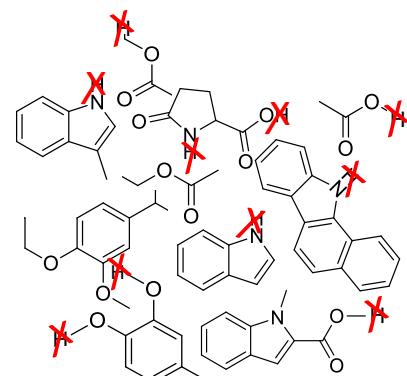
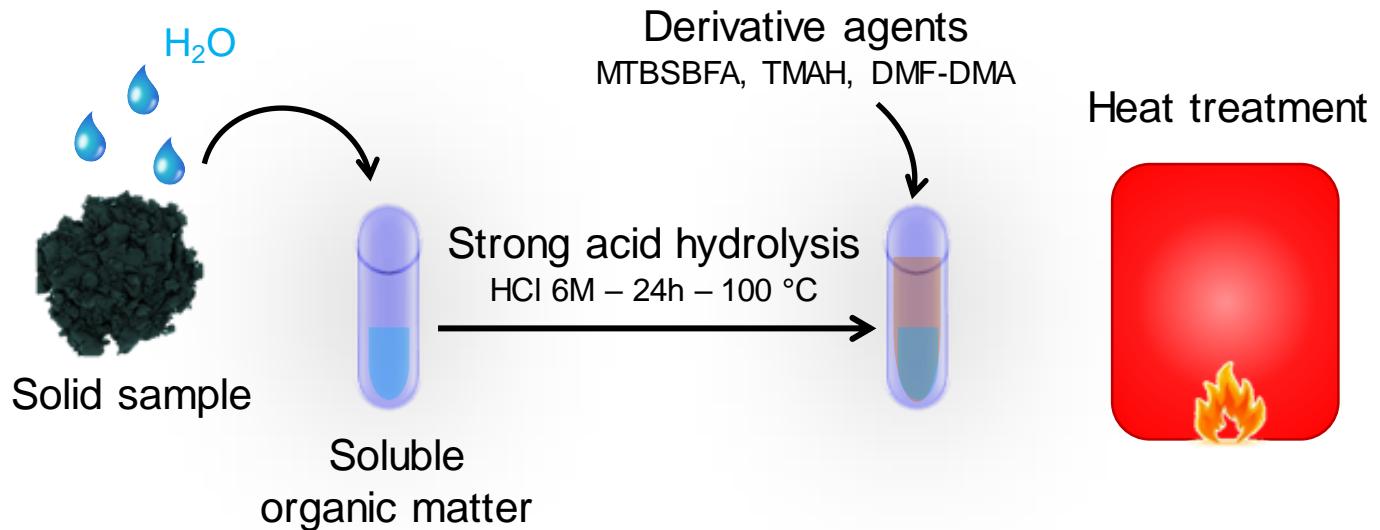
**FATTY ACIDS**  
→ *Membranes*



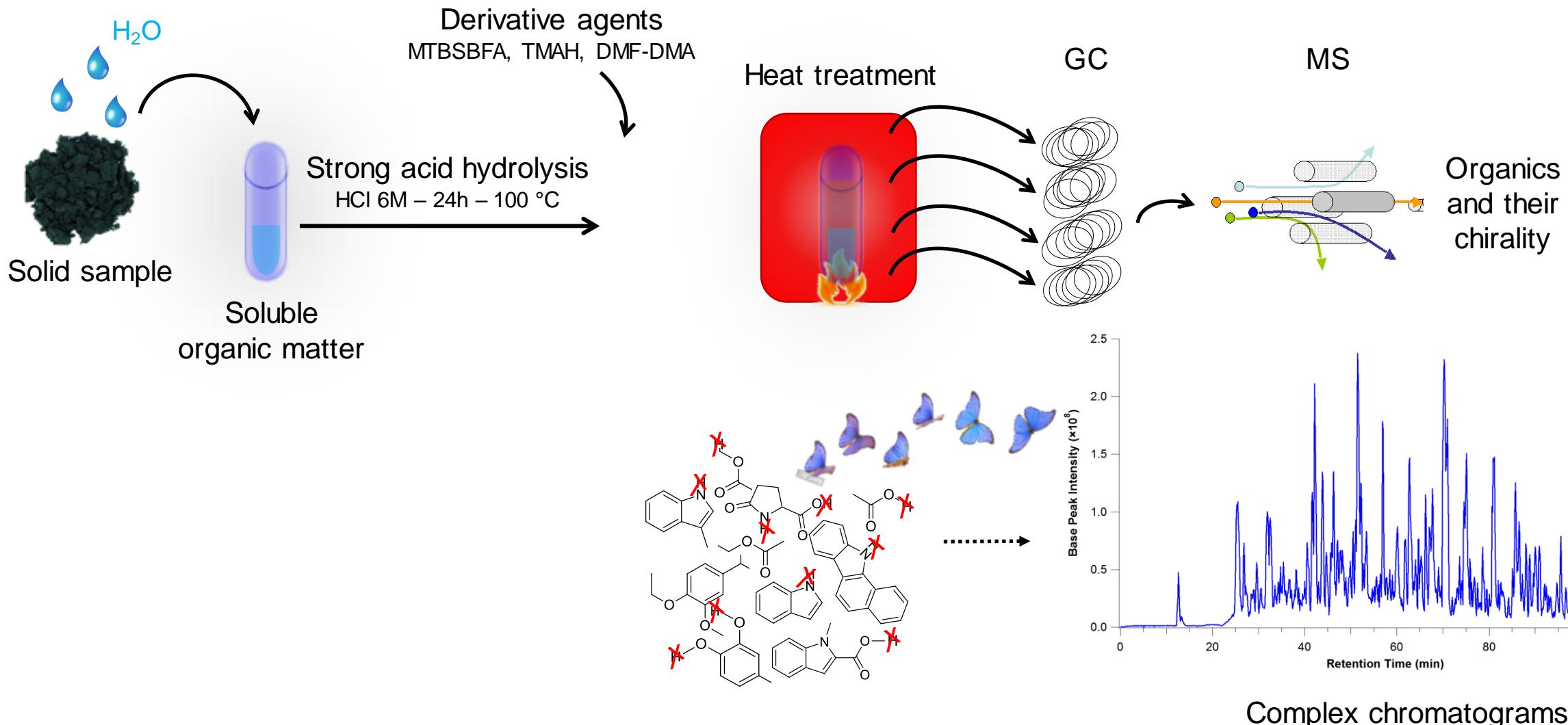
# USUAL TECHNICS: SMART GC-MS



# USUAL TECHNICS: SMART GC-MS



# USUAL TECHNICS: SMART GC-MS

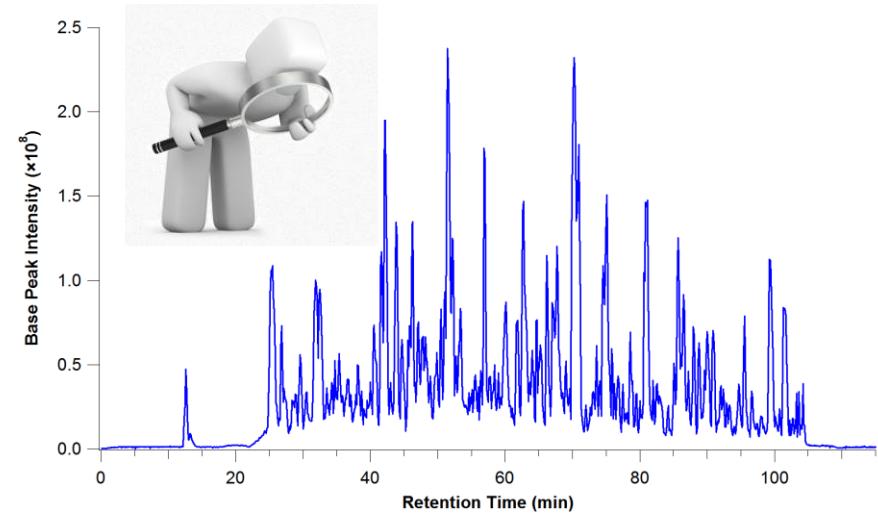


# USUAL TECHNICS: SMART GC-MS

Good recoveries of volatile organics but :

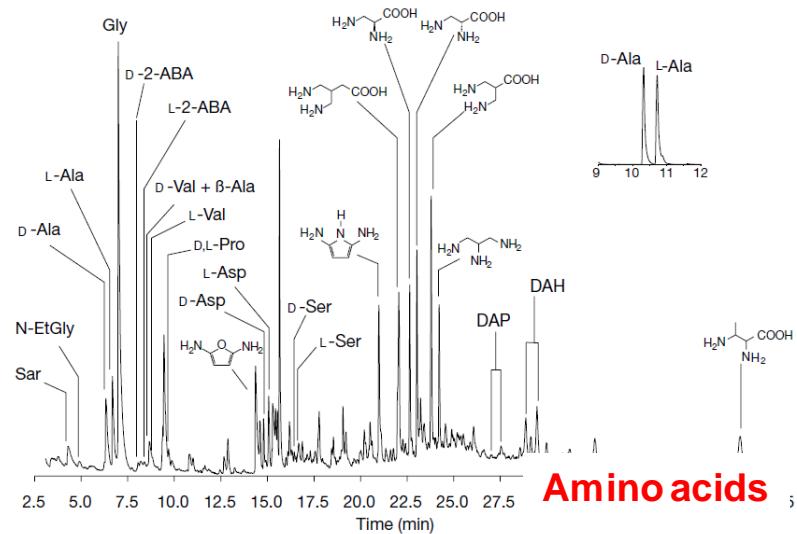
- Degradation, oxidation, rearrangement reactions
- Speculative identification
- Lack both sensitivity and versatility

*Benner et al., 2000; Glavin et al., 2001; Navarro-González et al., 2006*

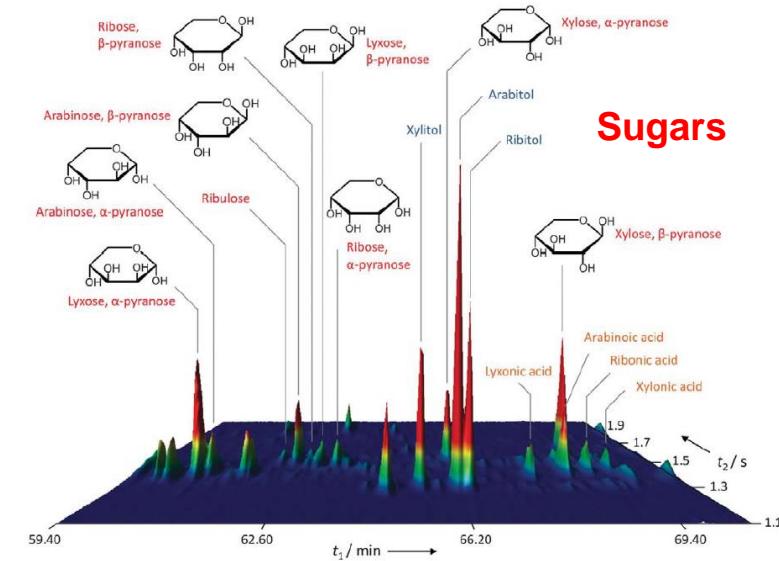


Complex chromatograms

# BUILDING BLOCKS DETECTED WITH GC-MS IN ANALOGUES

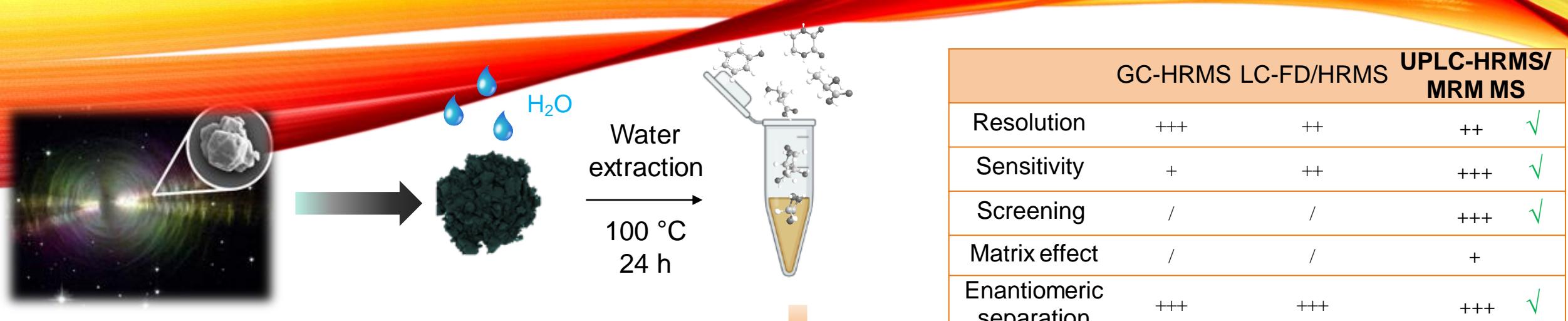


Munoz-Caro *et al.*, 2002, *Nature*, 416, 403

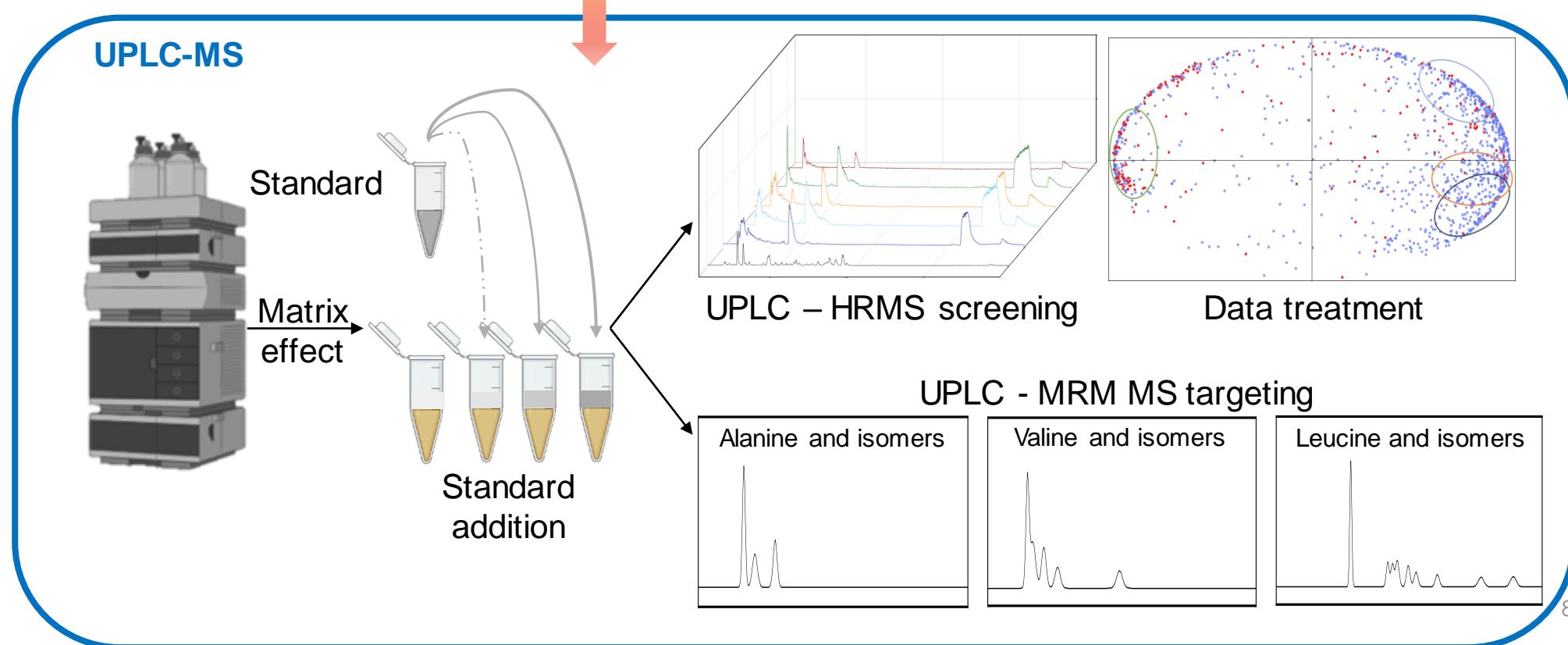


Meinert *et al.*, 2016, *Science*, 352, 208

## DEVELOP INNOVATIVE STRATEGY TO LIMIT SAMPLE DEGRADATION

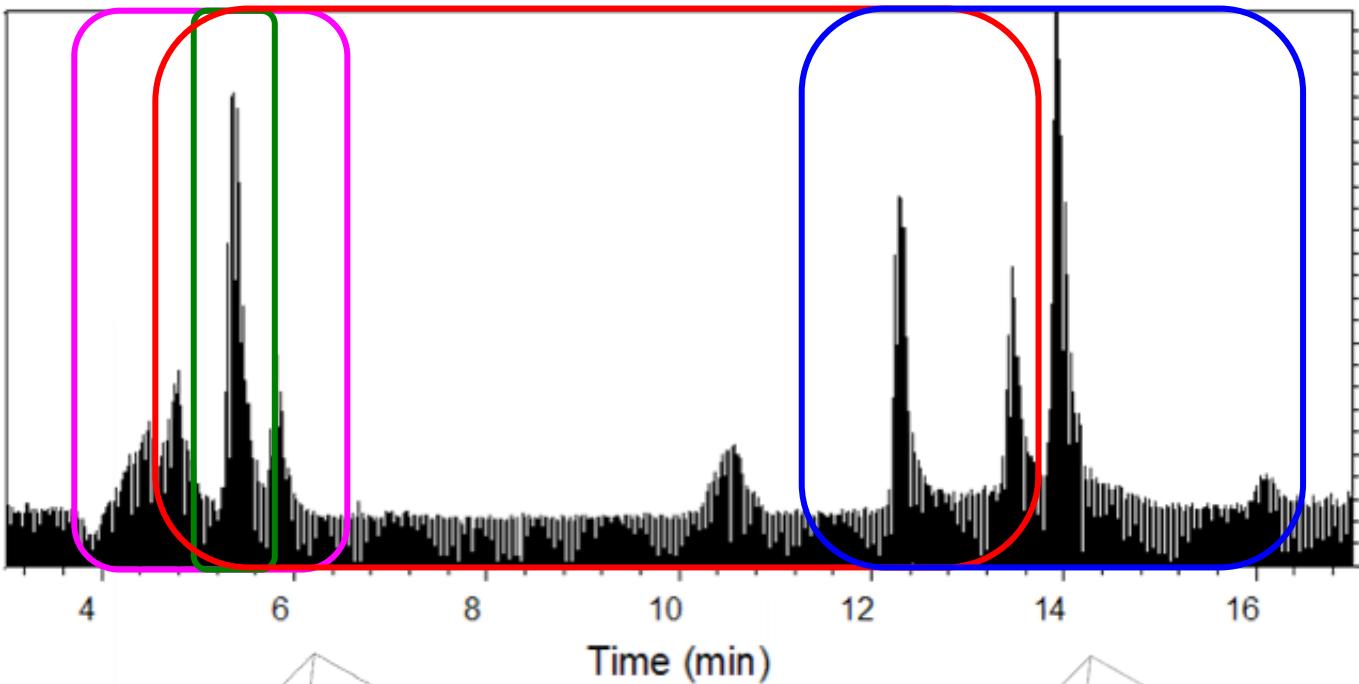
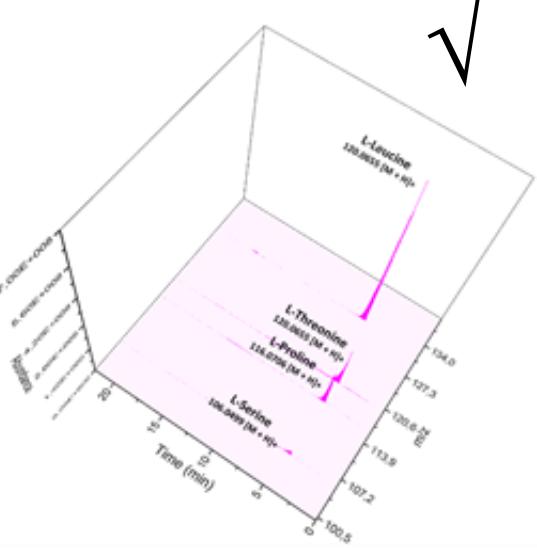


**NO SAMPLE PRETREATMENT**

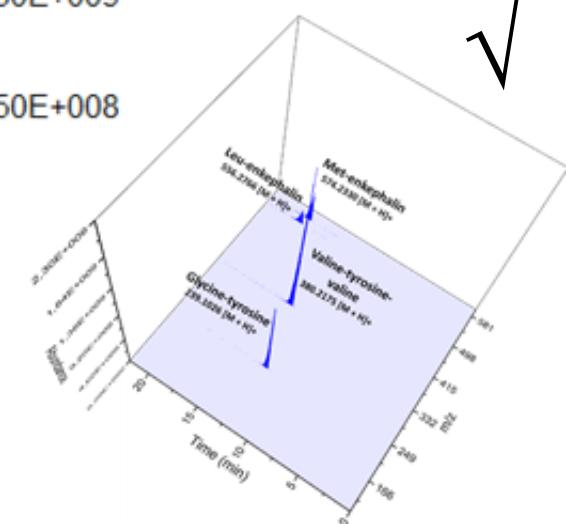


# MOLECULAR SCREENING

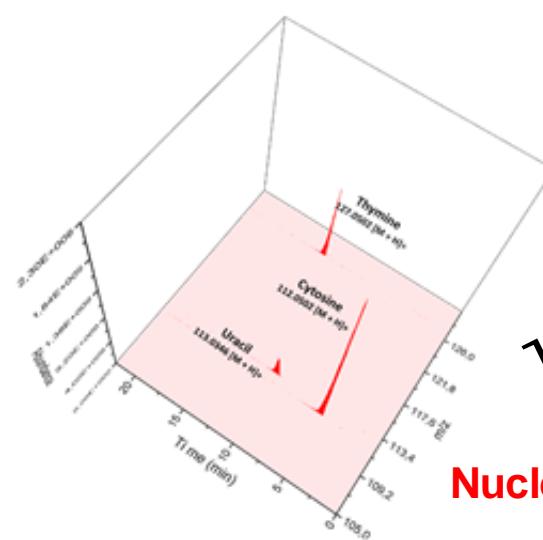
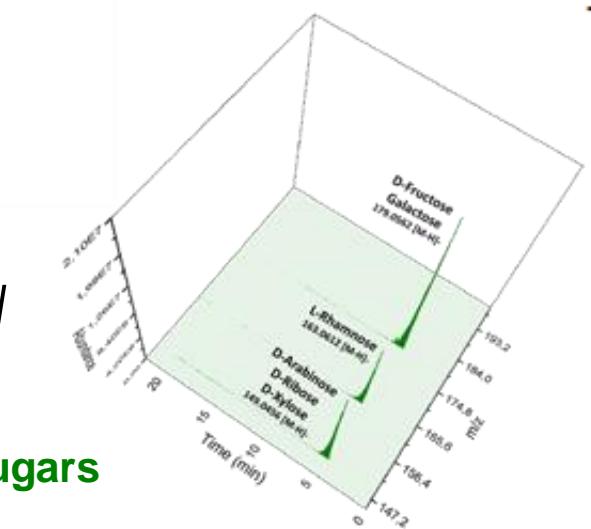
Amino acids



Peptides



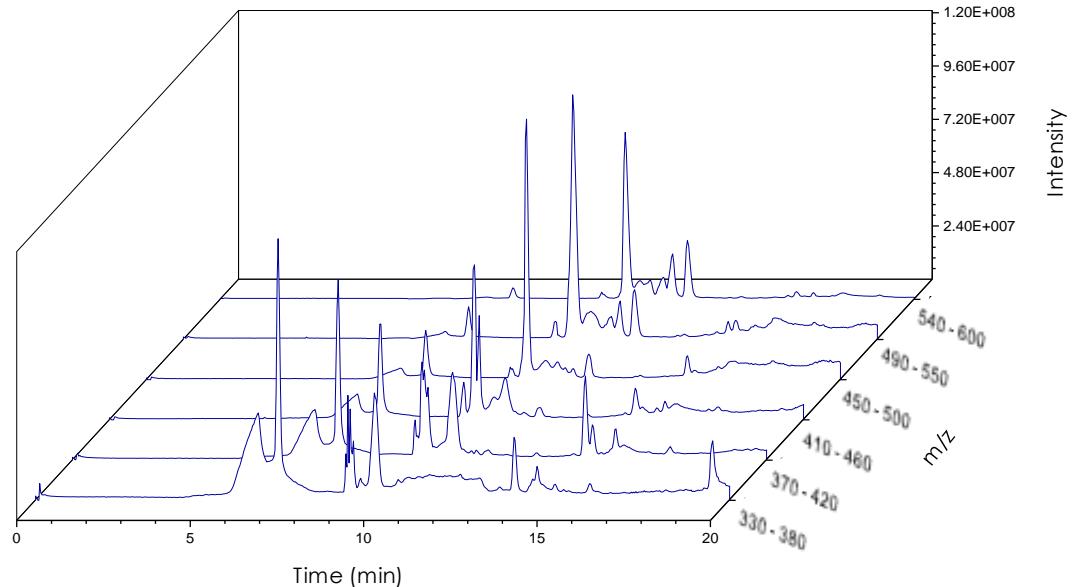
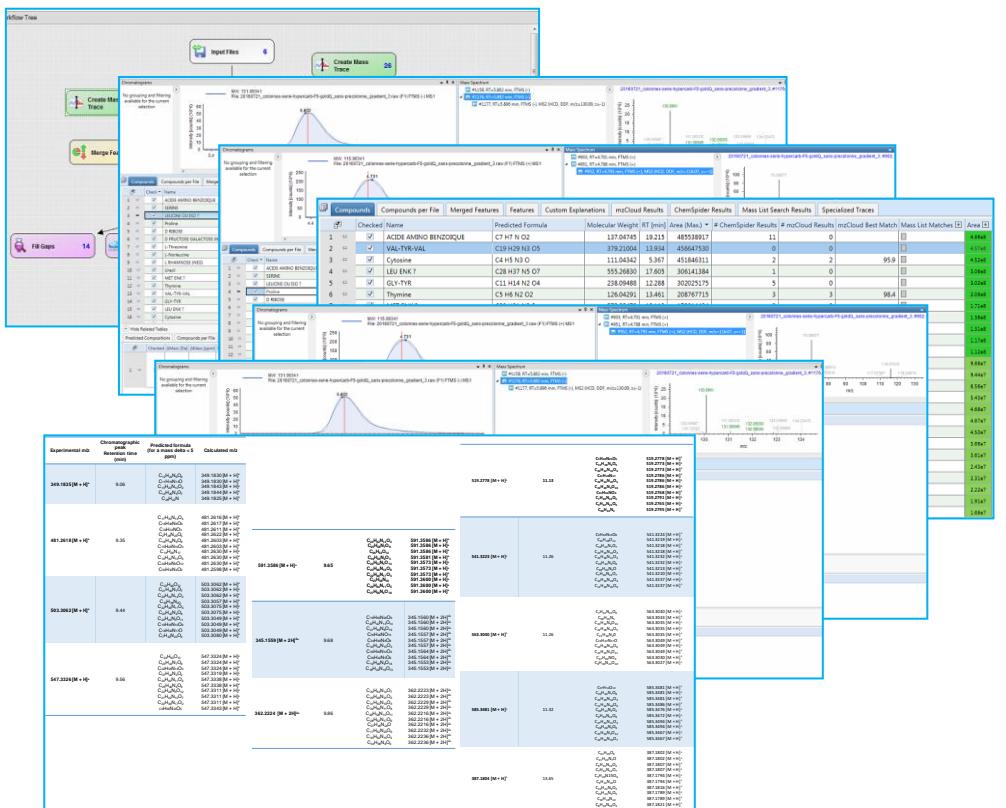
Sugars



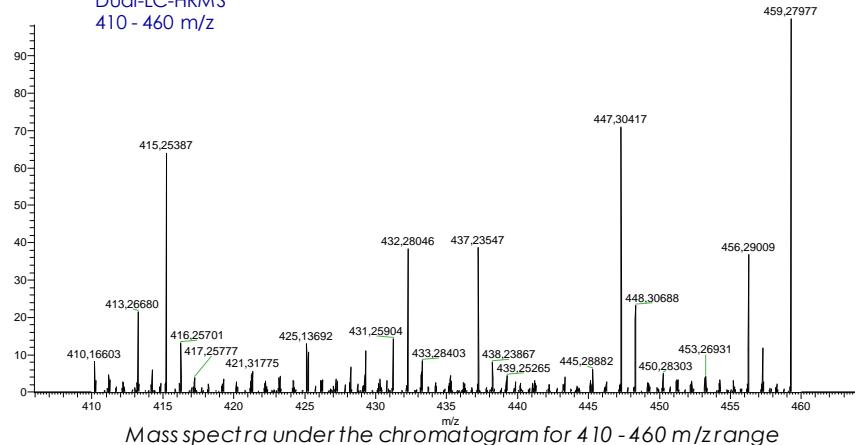
Nucleobases

# MOLECULAR SCREENING

Ice analogue

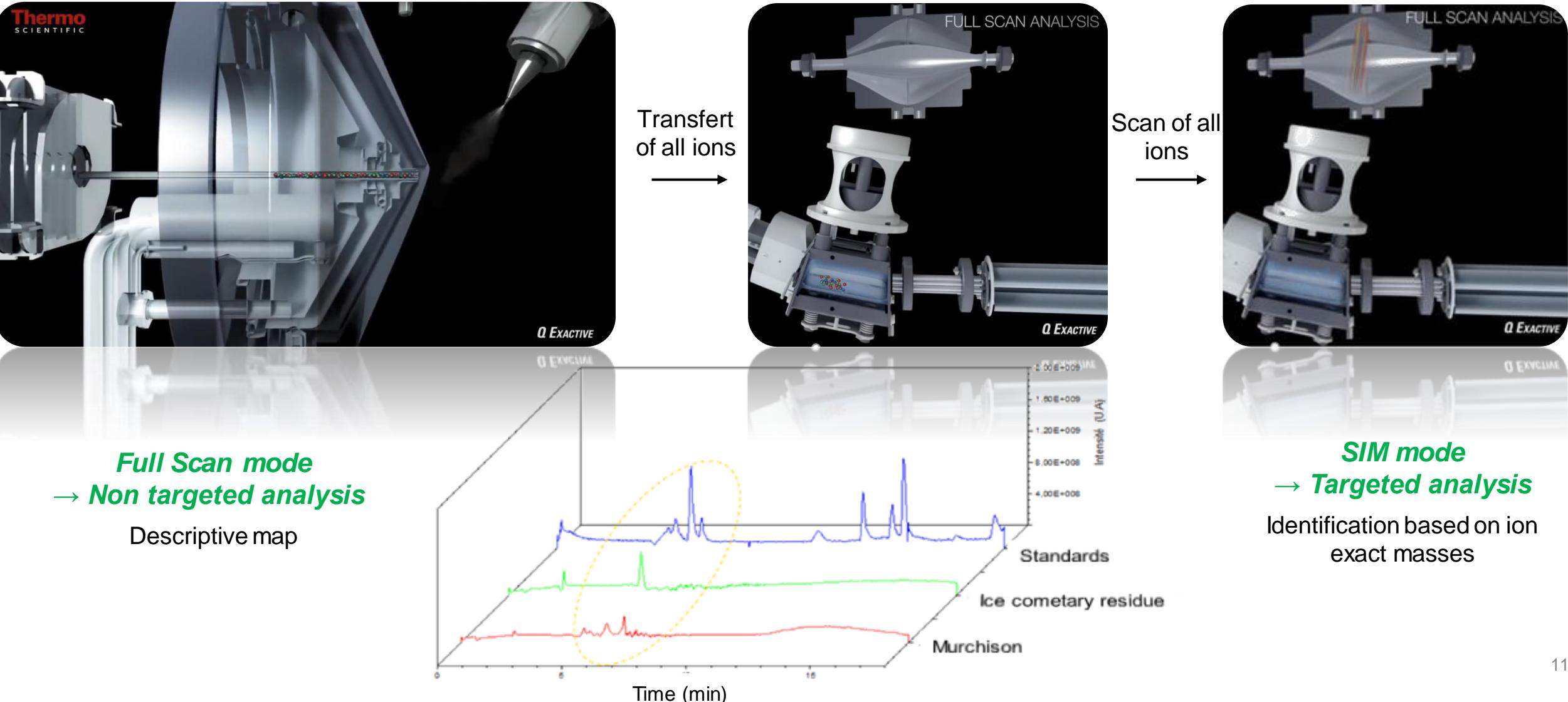


Dual-LC-HRMS  
410 - 460 m/z



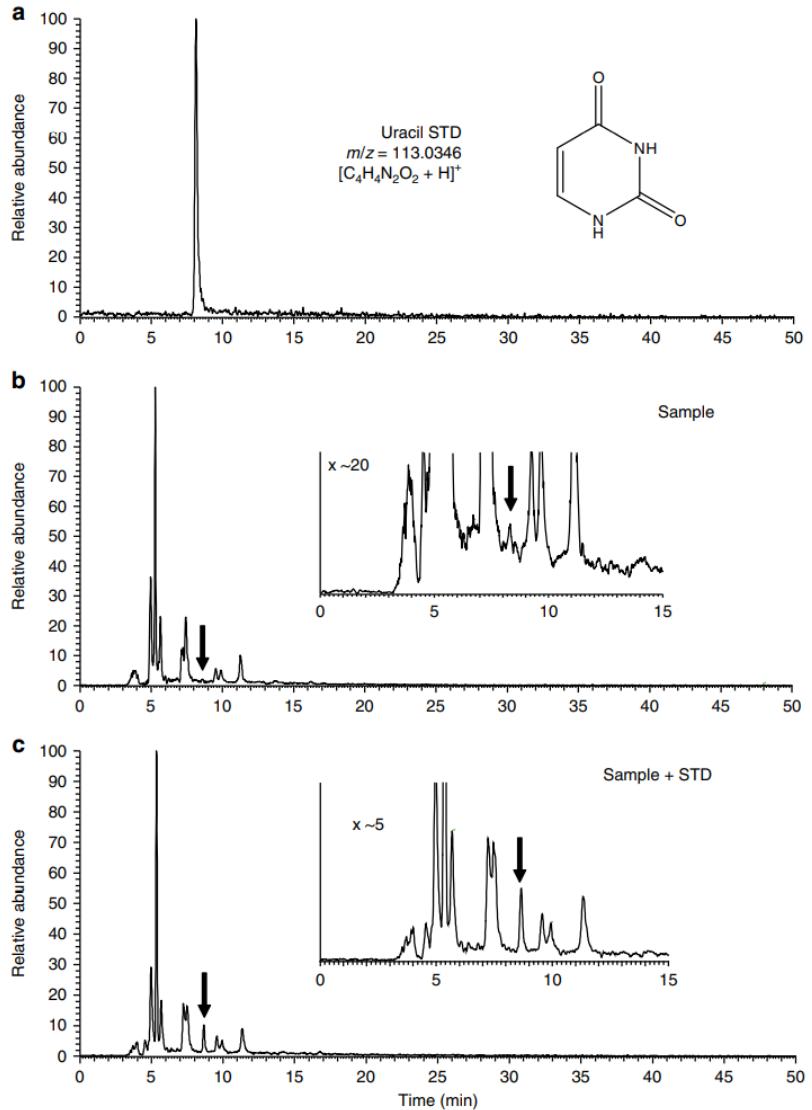
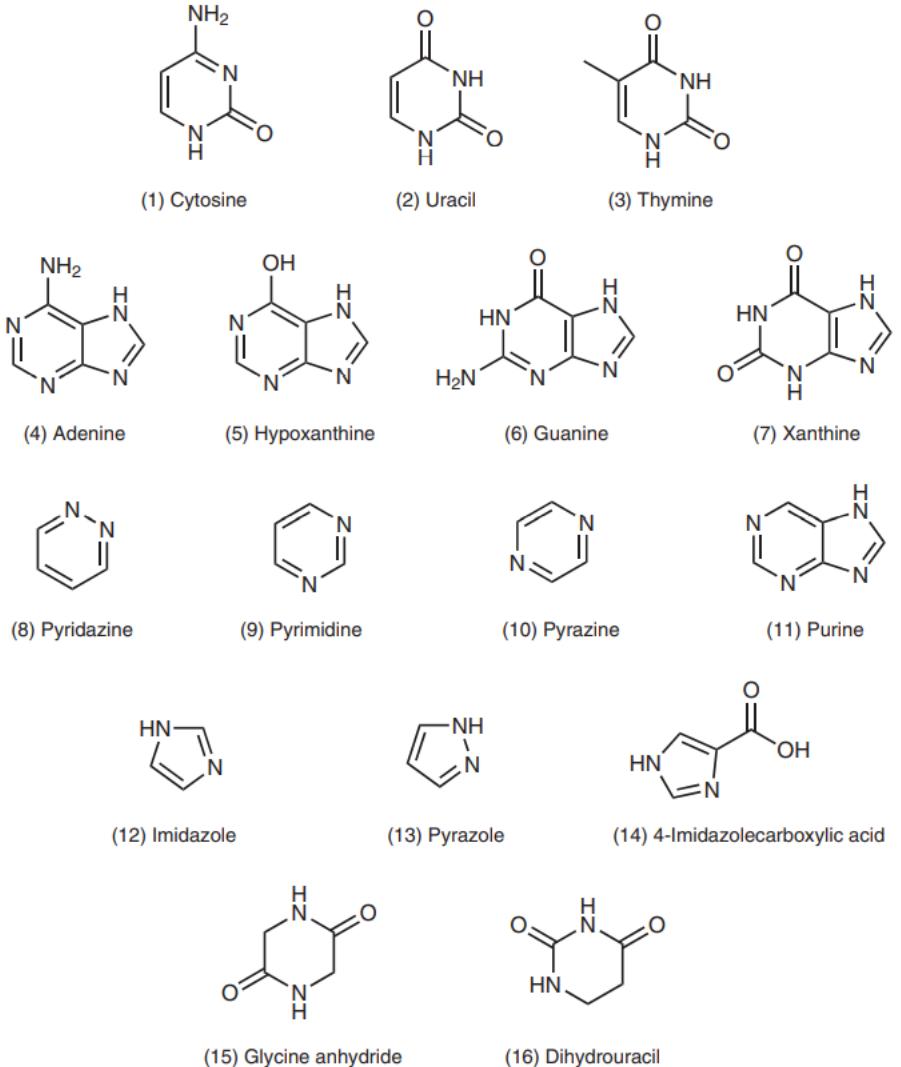
# FROM NON TARGETED TO TARGETED ANALYSIS

## UPLC-HRMS (Q-Exactive)



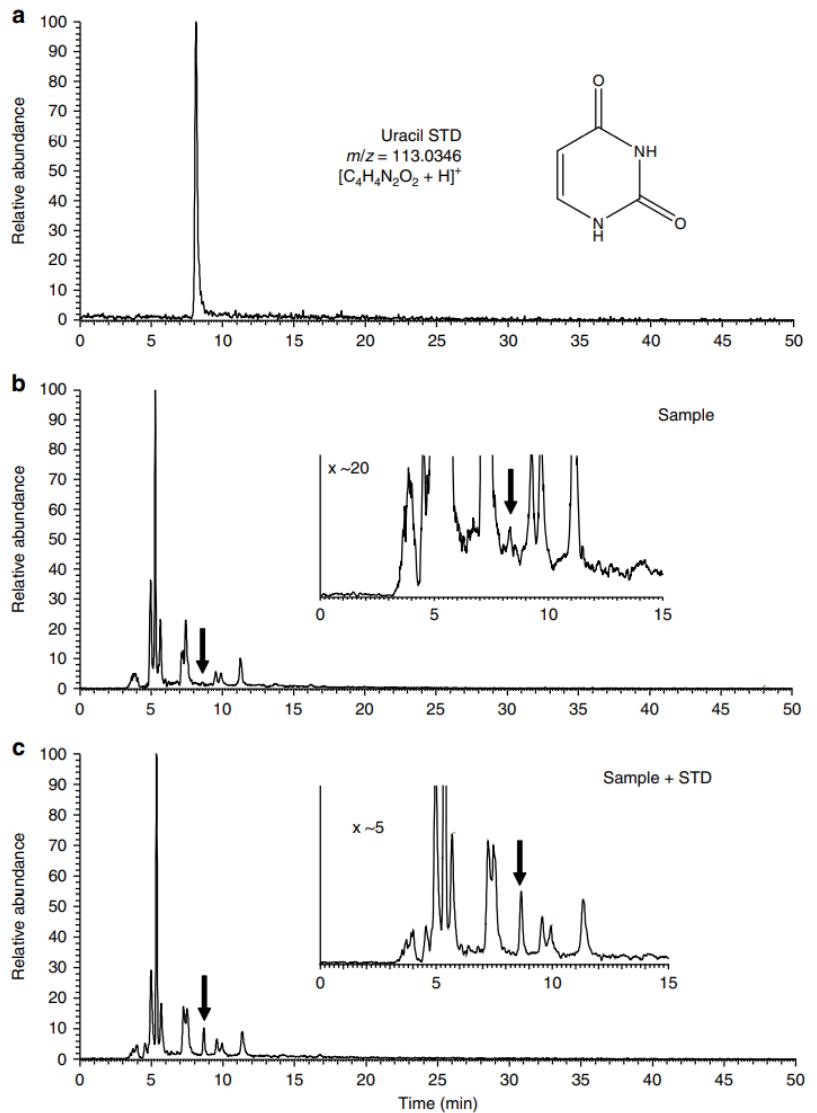
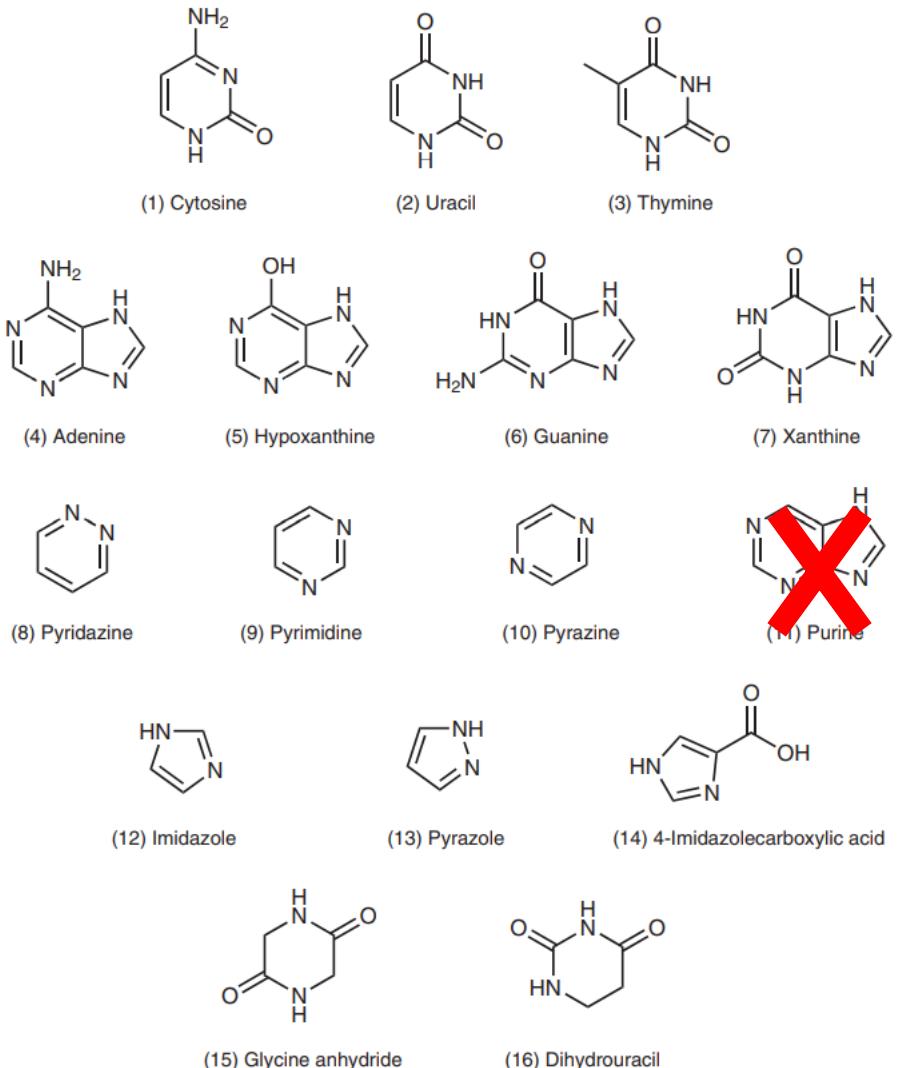
# NUCLEOBASES HRMS SIM ANALYSIS

## Astrophysical ice analogue



# NUCLEOBASES HRMS SIM ANALYSIS

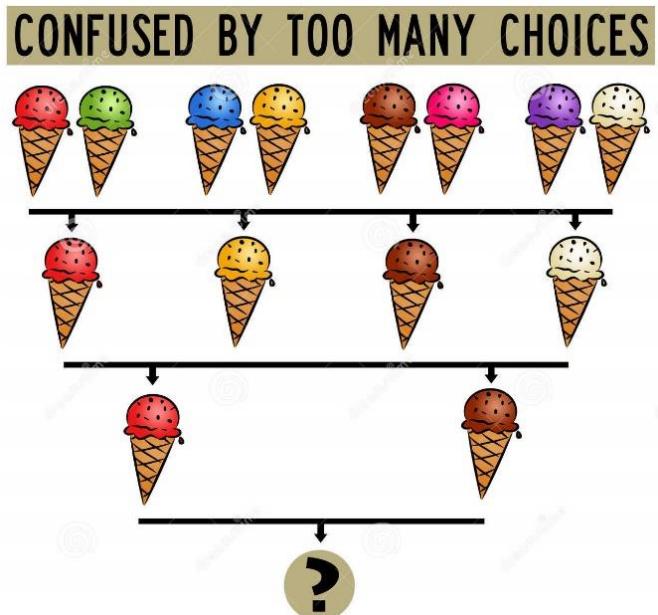
## Astrophysical ice analogue



# HRMS SIM ANALYSIS



Exact Mass Retention time Area  
161,06873      3,512      9949404,31

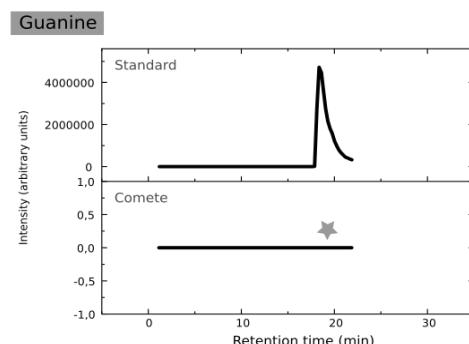
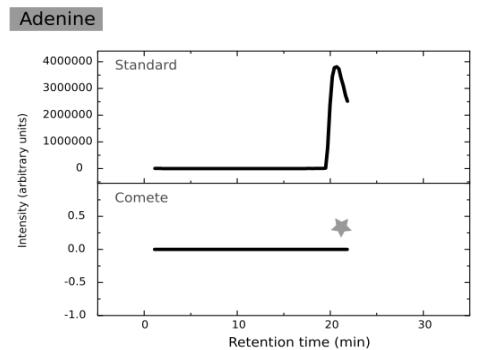
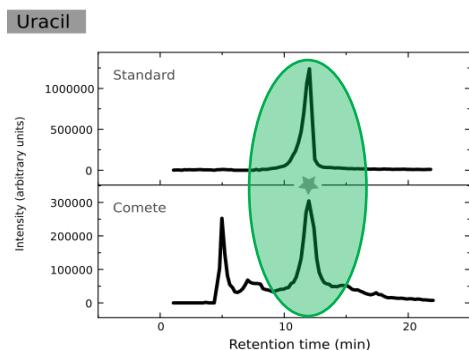
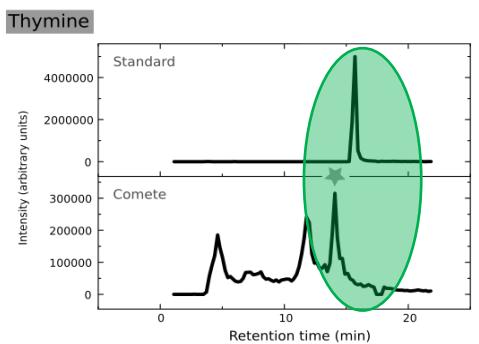
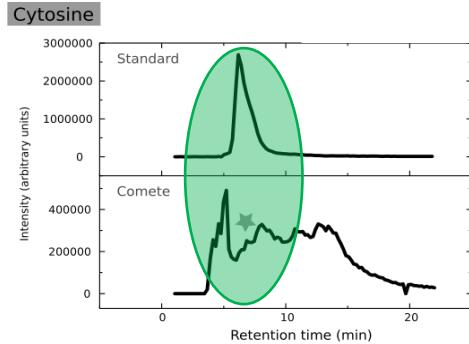


Formula	Molecular Weight	Name	DeltaMass [Da]	DeltaMass [ppm]
C6 H11 N O4	161,0688	Amino adipic acid	7,46017E-05	0,46316654
C6 H11 N O4	161,0688	α-Aminoadipate	7,46017E-05	0,46316654
C6 H11 N O4	161,0688	N-Methylglutamate	7,46017E-05	0,46316654
C6 H11 N O4	161,0688	D-2-Aminoadipic Acid	7,46017E-05	0,46316654
C6 H11 N O4	161,0688	O-Acetyl-L-homoserine	7,46017E-05	0,46316654
C6 H11 N O4	161,0688	H-Glu-OMe	7,46017E-05	0,46316654
C6 H11 N O4	161,0688	Iminodipropionic acid	7,46017E-05	0,46316654
C6 H11 N O4	161,0688	Methyl N-acetylserinate	7,46017E-05	0,46316654
C6 H11 N O4	161,0688	D-alanyl-D-lactic acid	7,46017E-05	0,46316654
C6 H11 N O4	161,0688	O-Acetylhomoserine	7,46017E-05	0,46316654
C6 H11 N O4	161,0688	4-Methyl-L-glutamic acid	7,46017E-05	0,46316654
C6 H11 N O4	161,0688	Methyl N-acetyl-D-serinate	7,46017E-05	0,46316654
C6 H11 N O4	161,0688	N-(2-Carboxyethyl)-D-alanine	7,46017E-05	0,46316654

# NUCLEOBASES HRMS SIM ANALYSIS

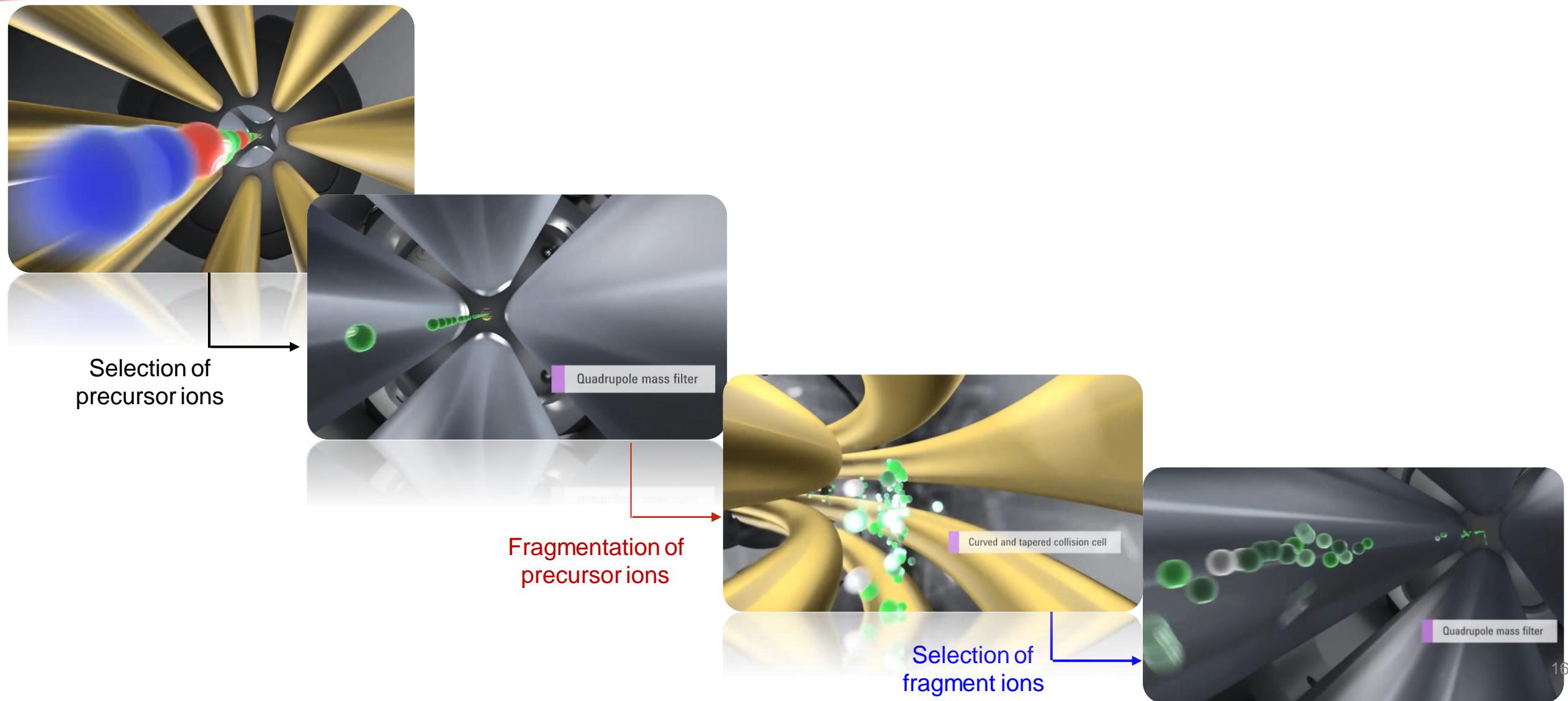
## Astrophysical ice analogue

Targeted analysis with UPLC-HRMS (SIM mode)



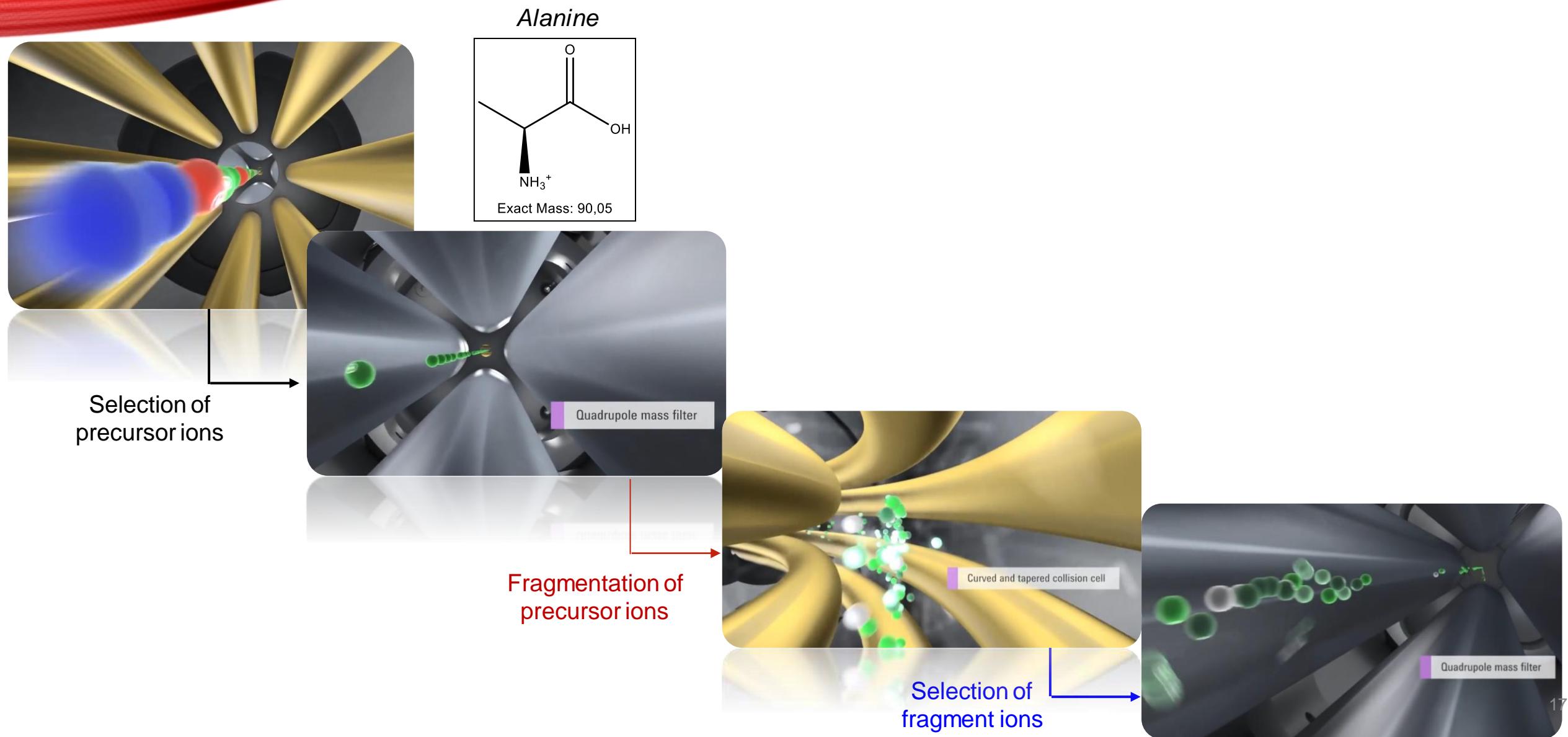
# TARGETED ANALYSIS

## UPLC-MS/MS (Triple Quadrupole)



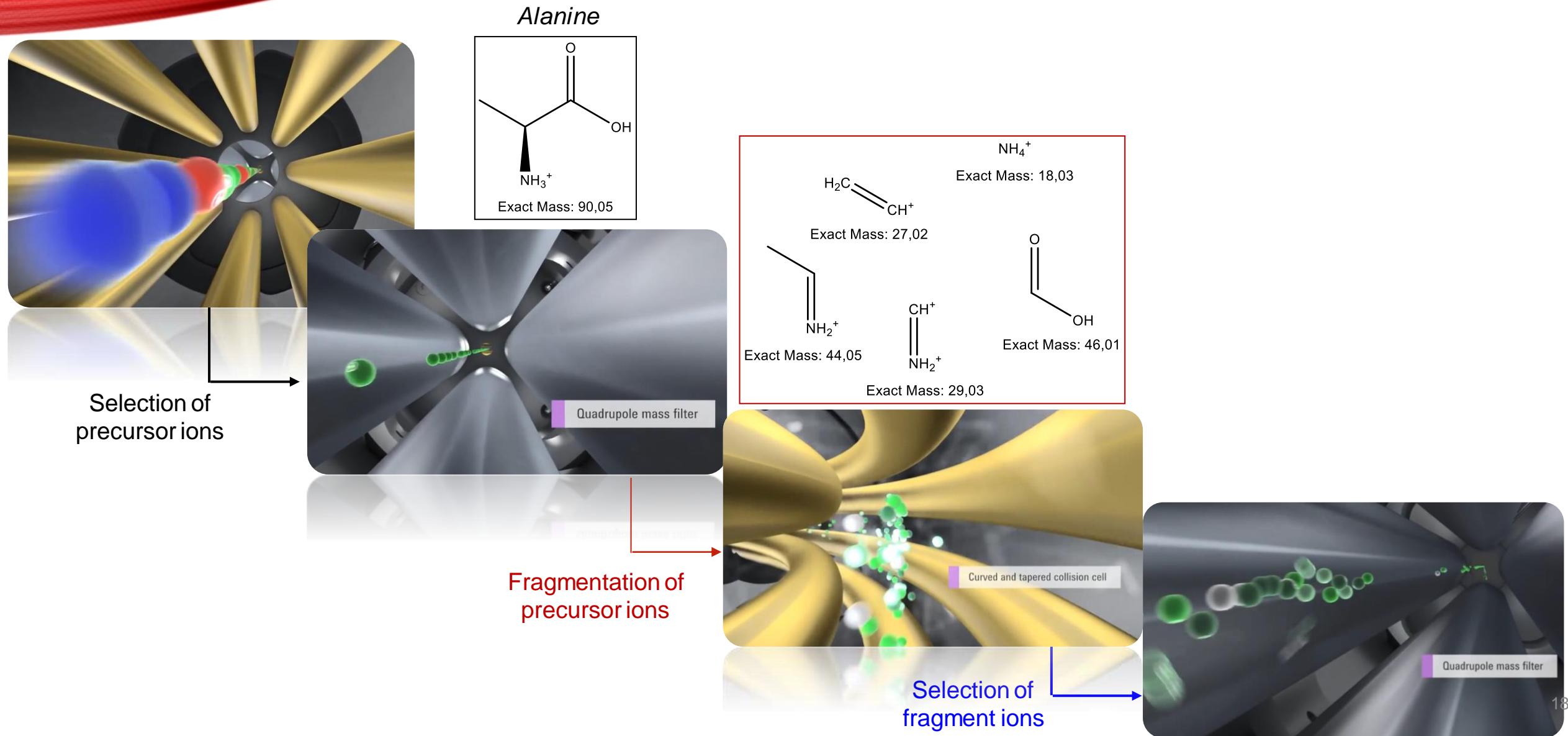
# TARGETED ANALYSIS

## UPLC-MS/MS (Triple Quadrupole)



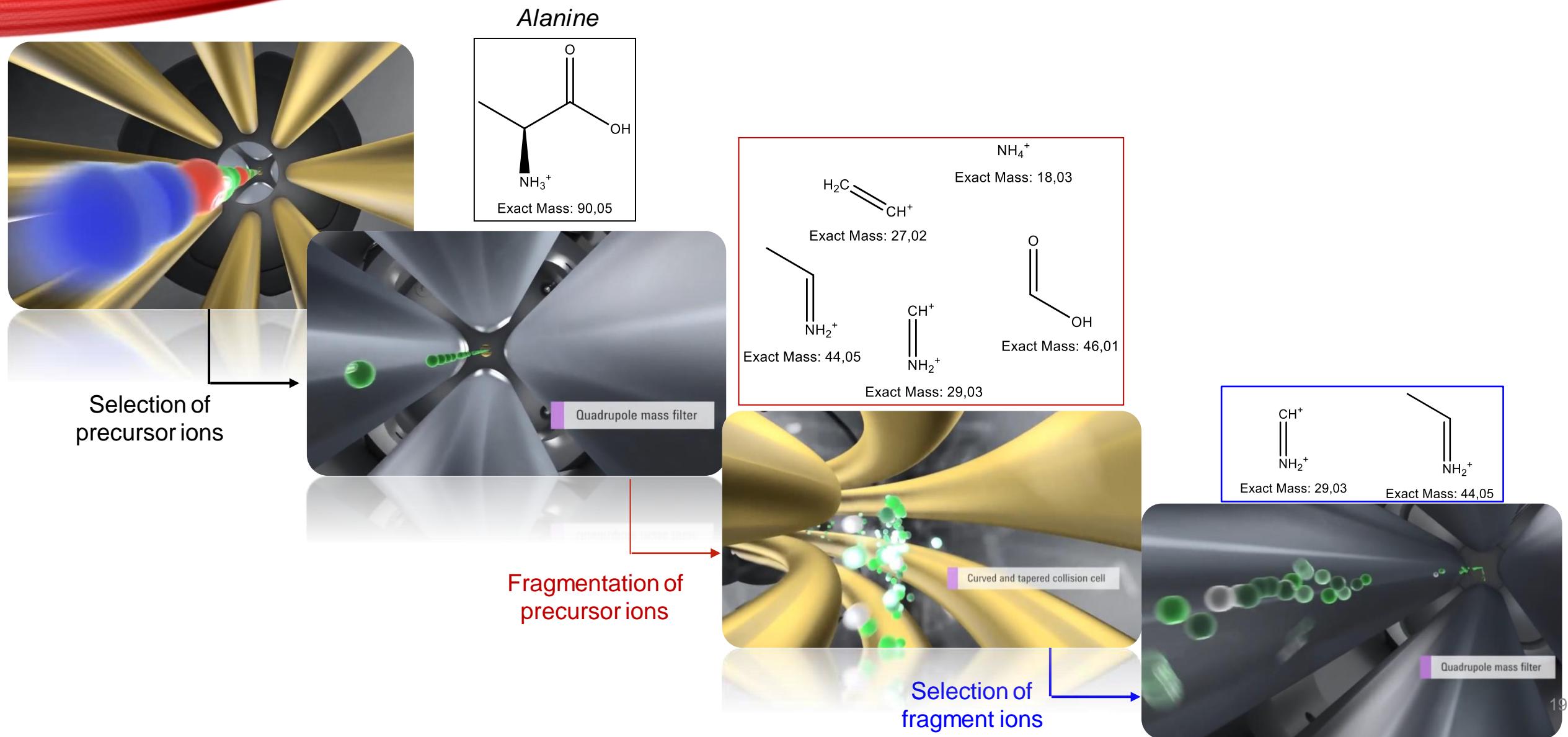
# TARGETED ANALYSIS

## UPLC-MS/MS (Triple Quadrupole)



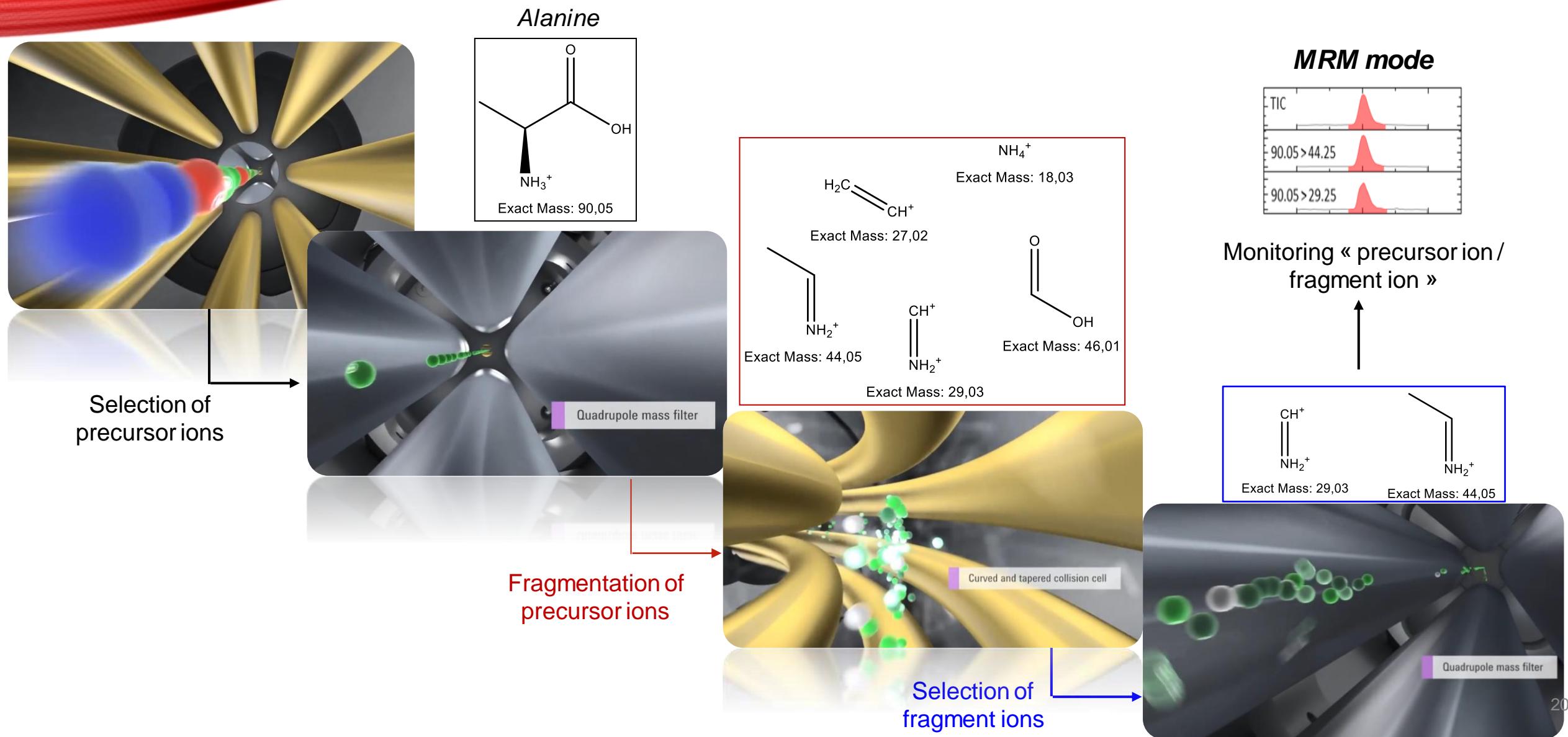
# TARGETED ANALYSIS

## UPLC-MS/MS (Triple Quadrupole)



# TARGETED ANALYSIS

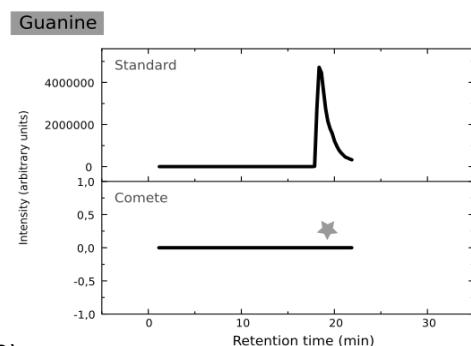
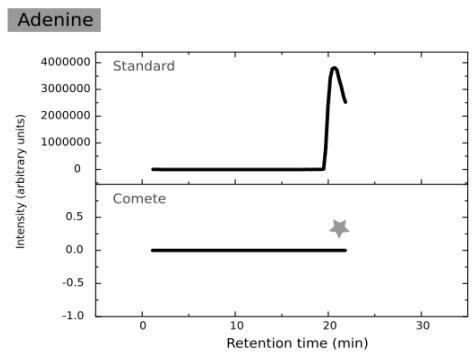
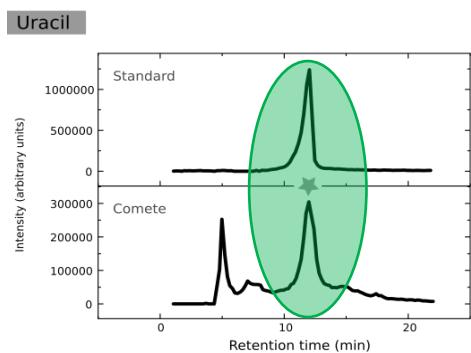
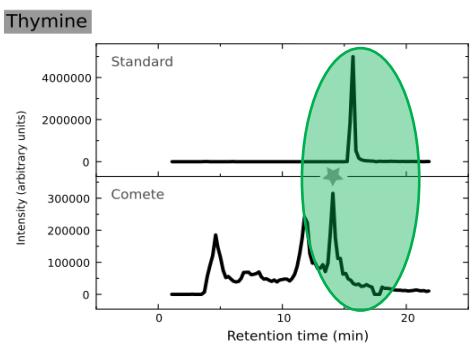
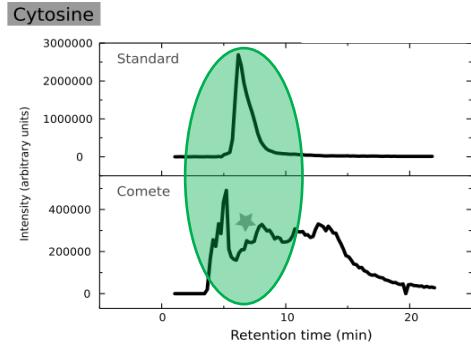
## UPLC-MS/MS (Triple Quadrupole)



# NUCLEOBASES HRMS SIM ANALYSIS

## Astrophysical ice analogue

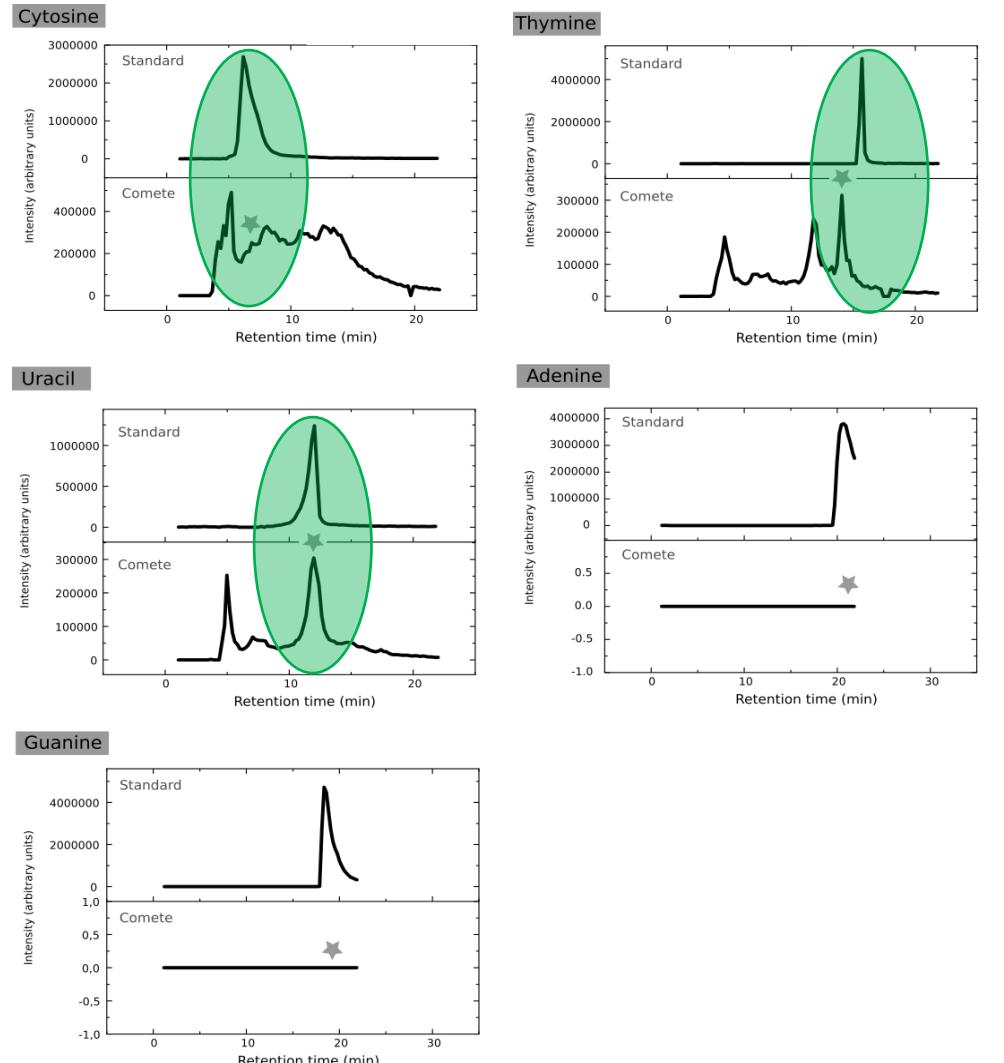
Targeted analysis with UPLC-HRMS (SIM mode)



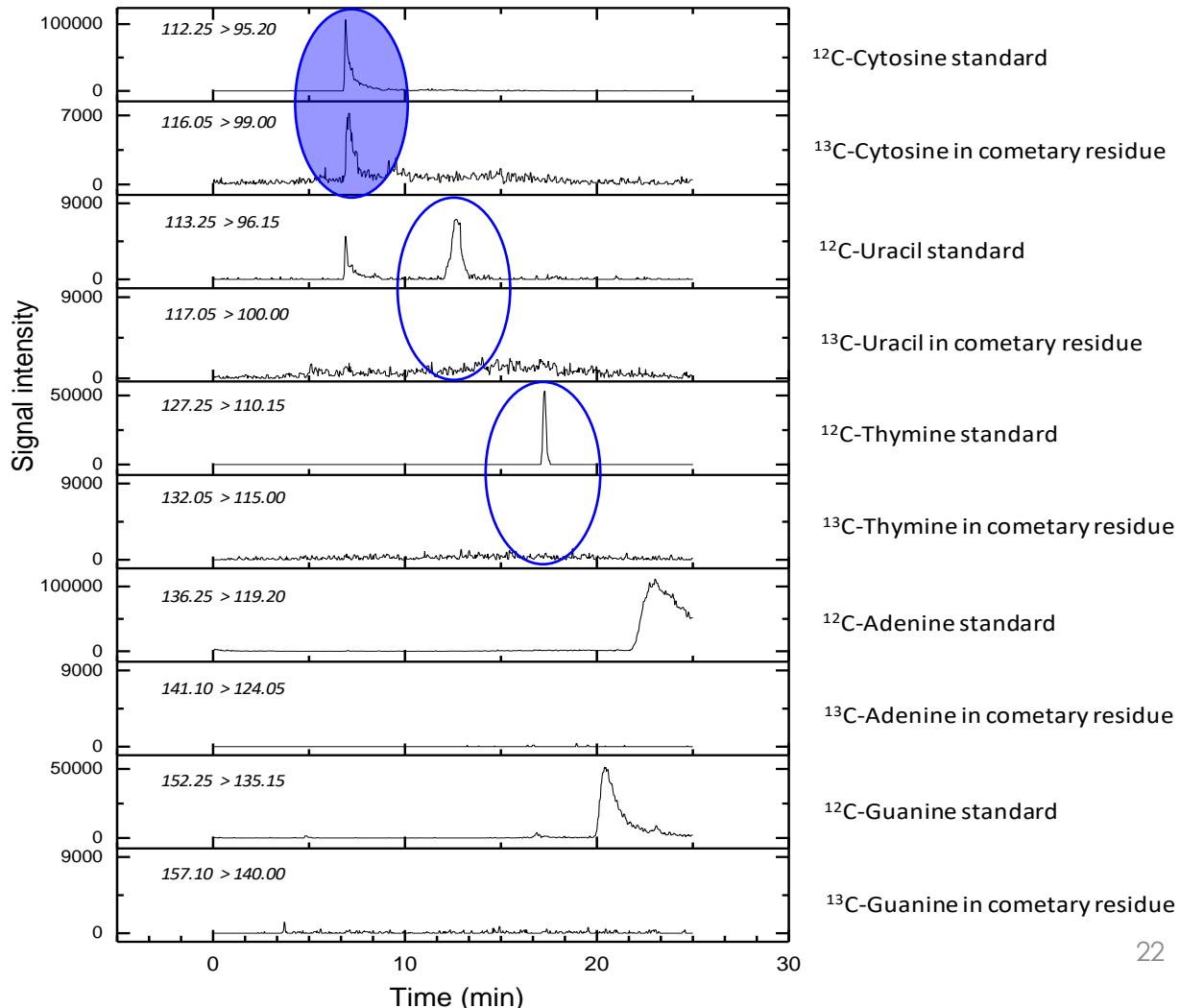
# NUCLEOBASES MRM ANALYSIS

## Astrophysical ice analogue

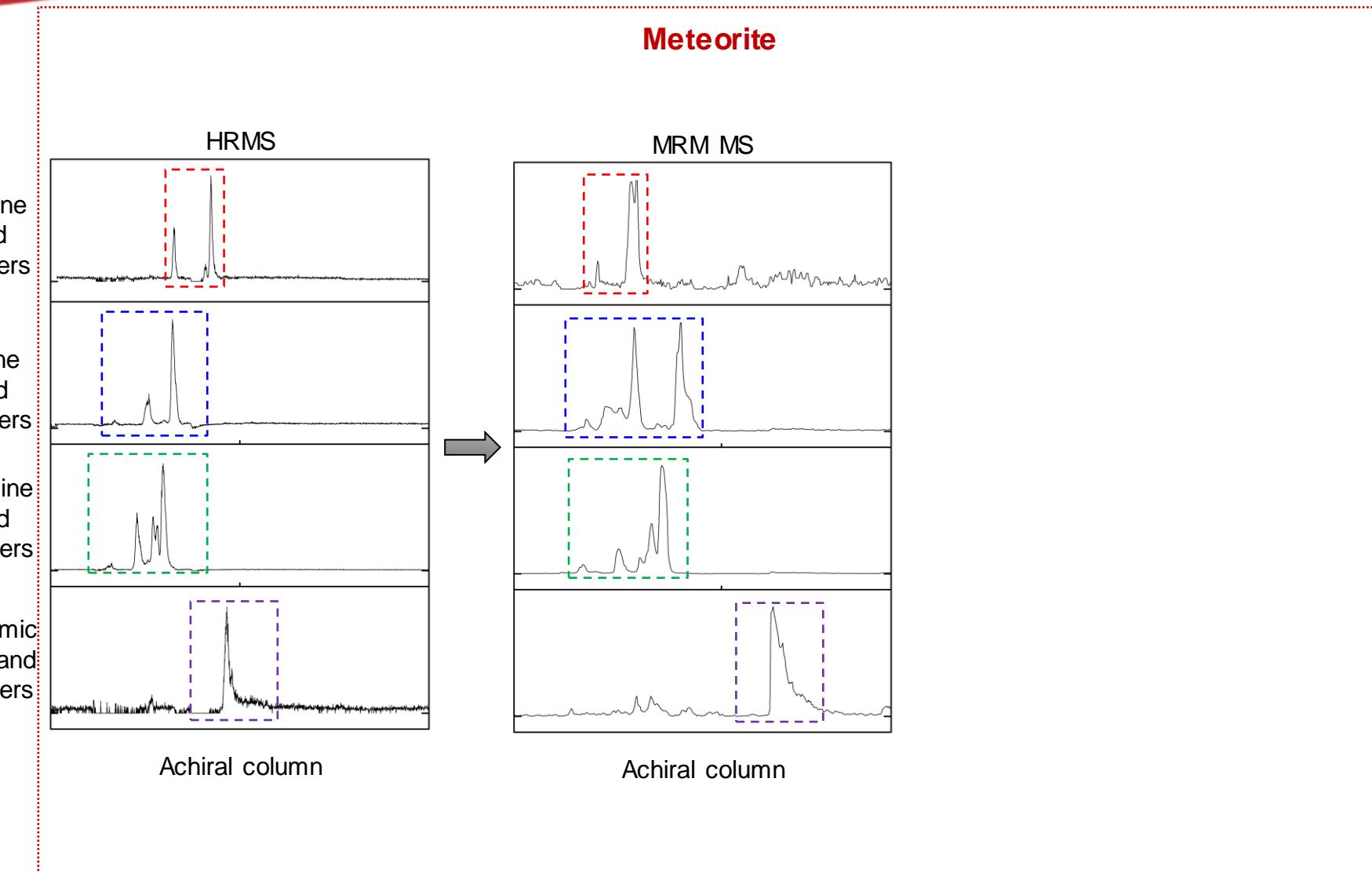
### Targeted analysis with UPLC-HRMS (SIM mode)



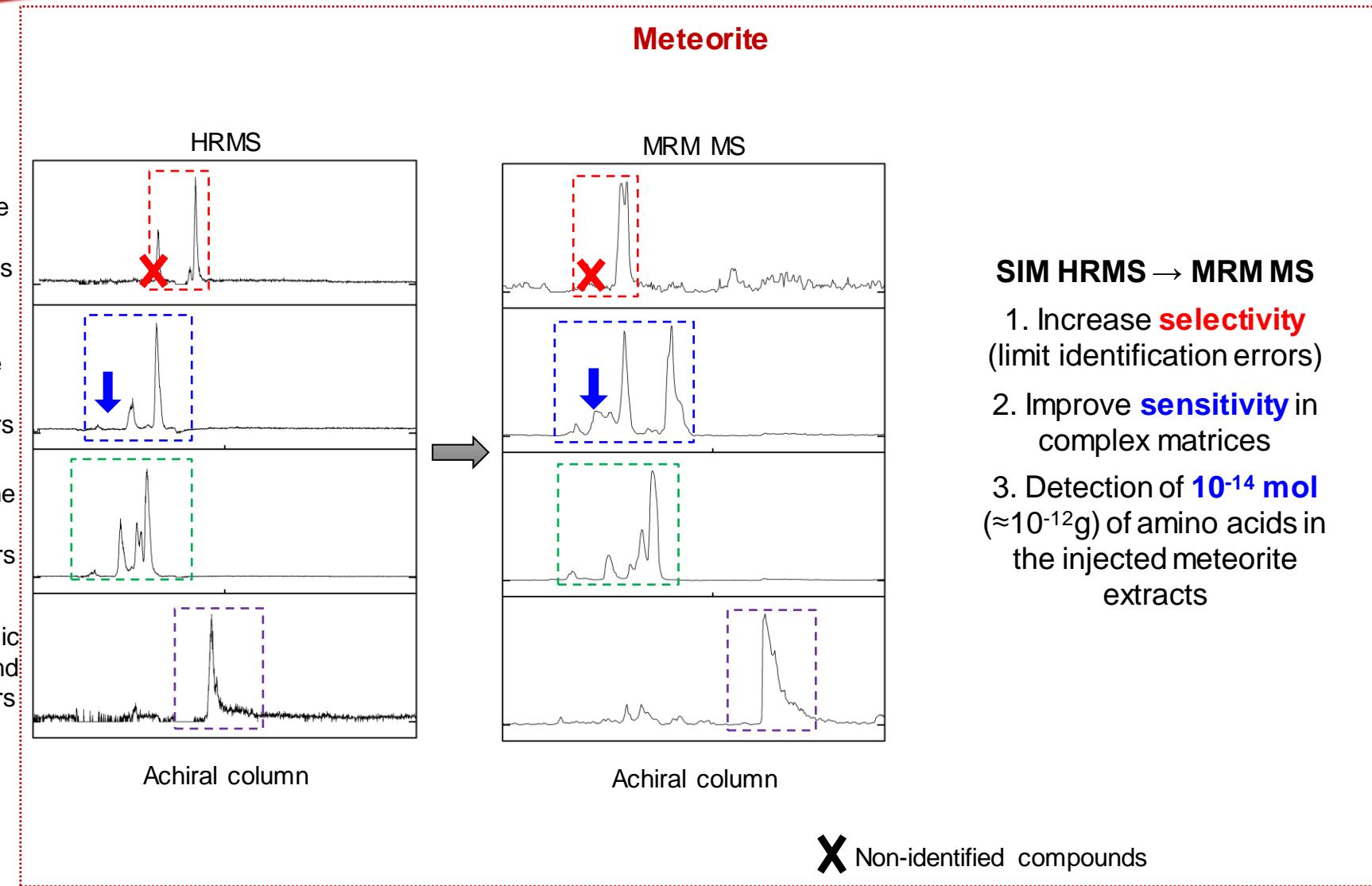
### Targeted analysis with UPLC-MS/MS (MRM mode)



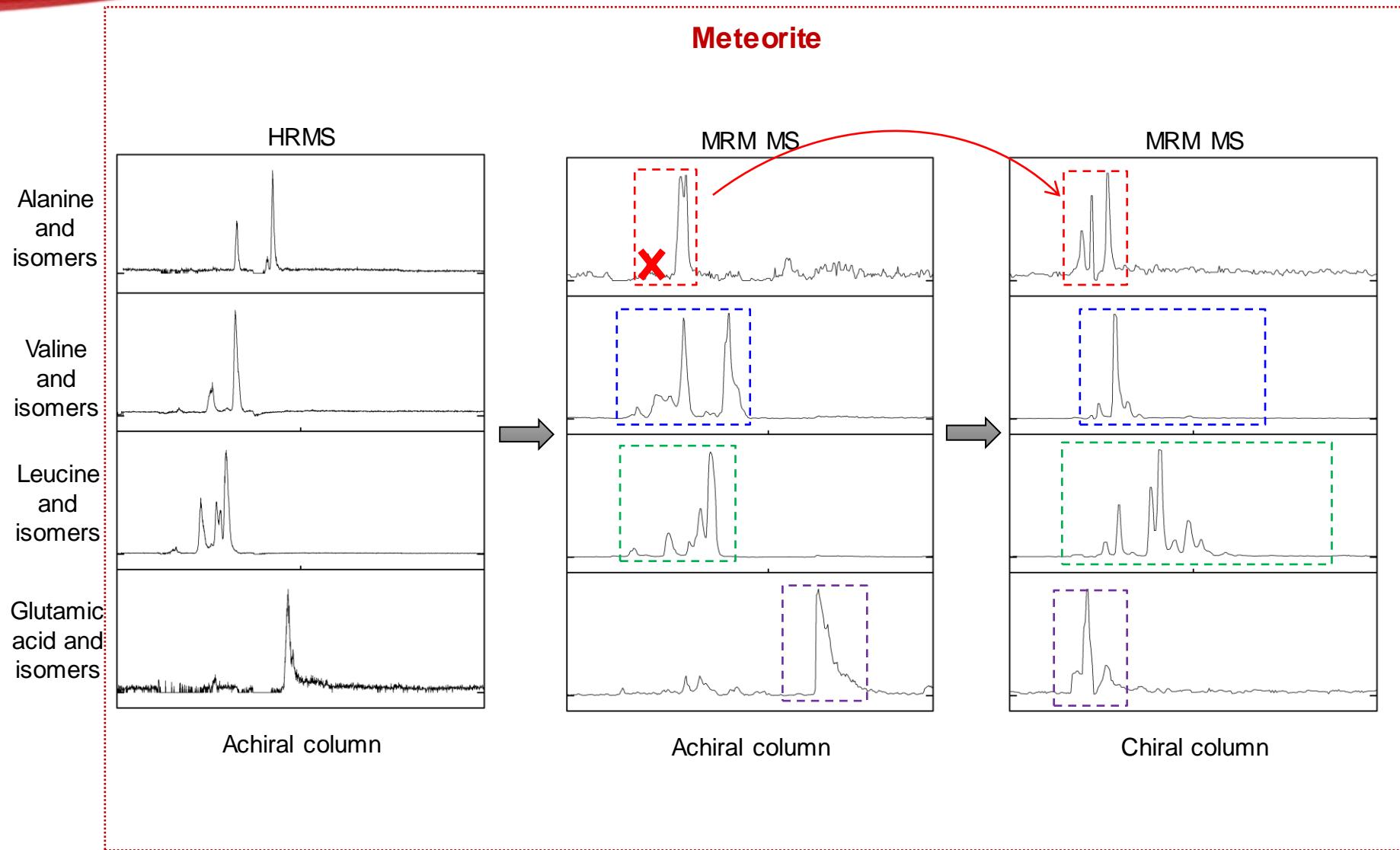
# AMINO ACIDS MRM ANALYSIS



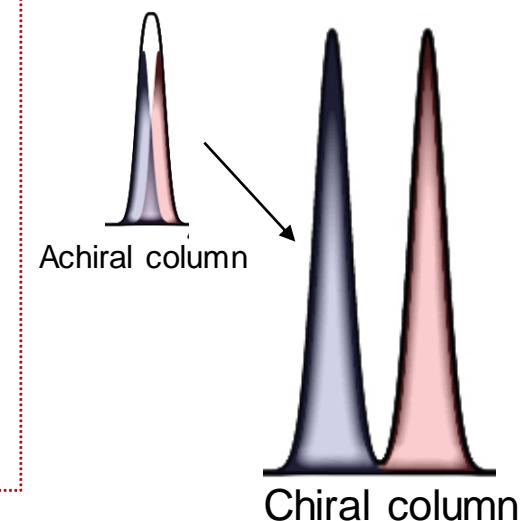
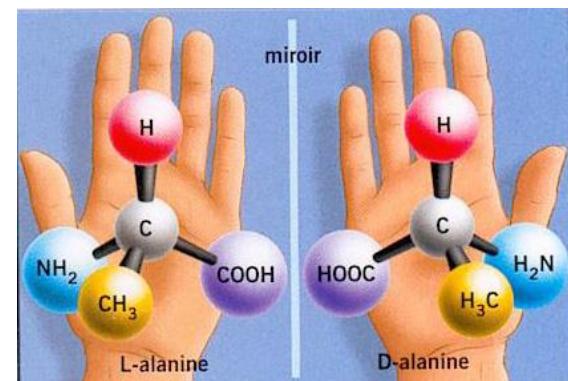
# AMINO ACIDS MRM ANALYSIS



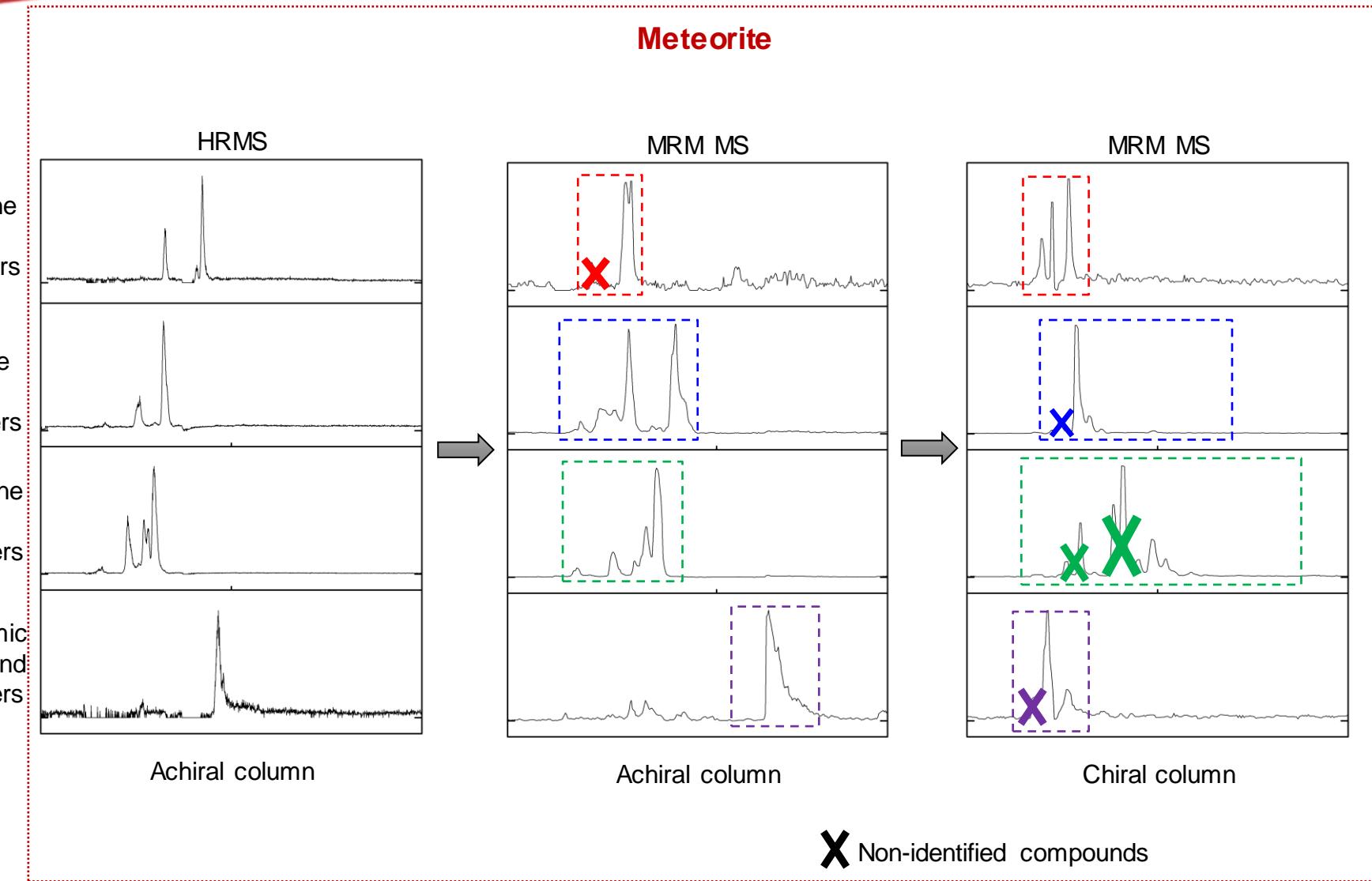
# AMINO ACIDS MRM ANALYSIS



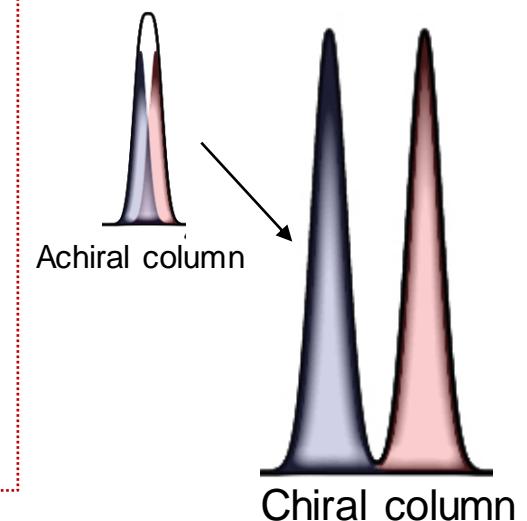
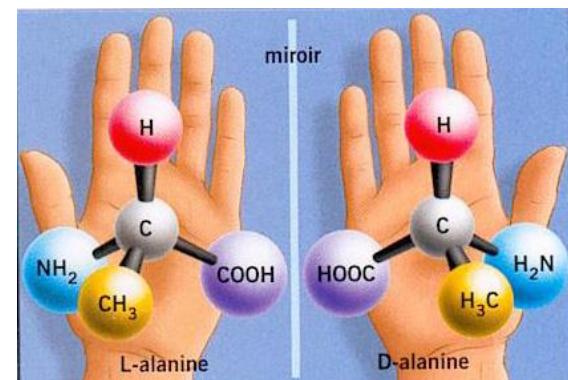
Chirality of amino acids :  
amino acids form two  
stereoisomers that are mirror  
images of each other



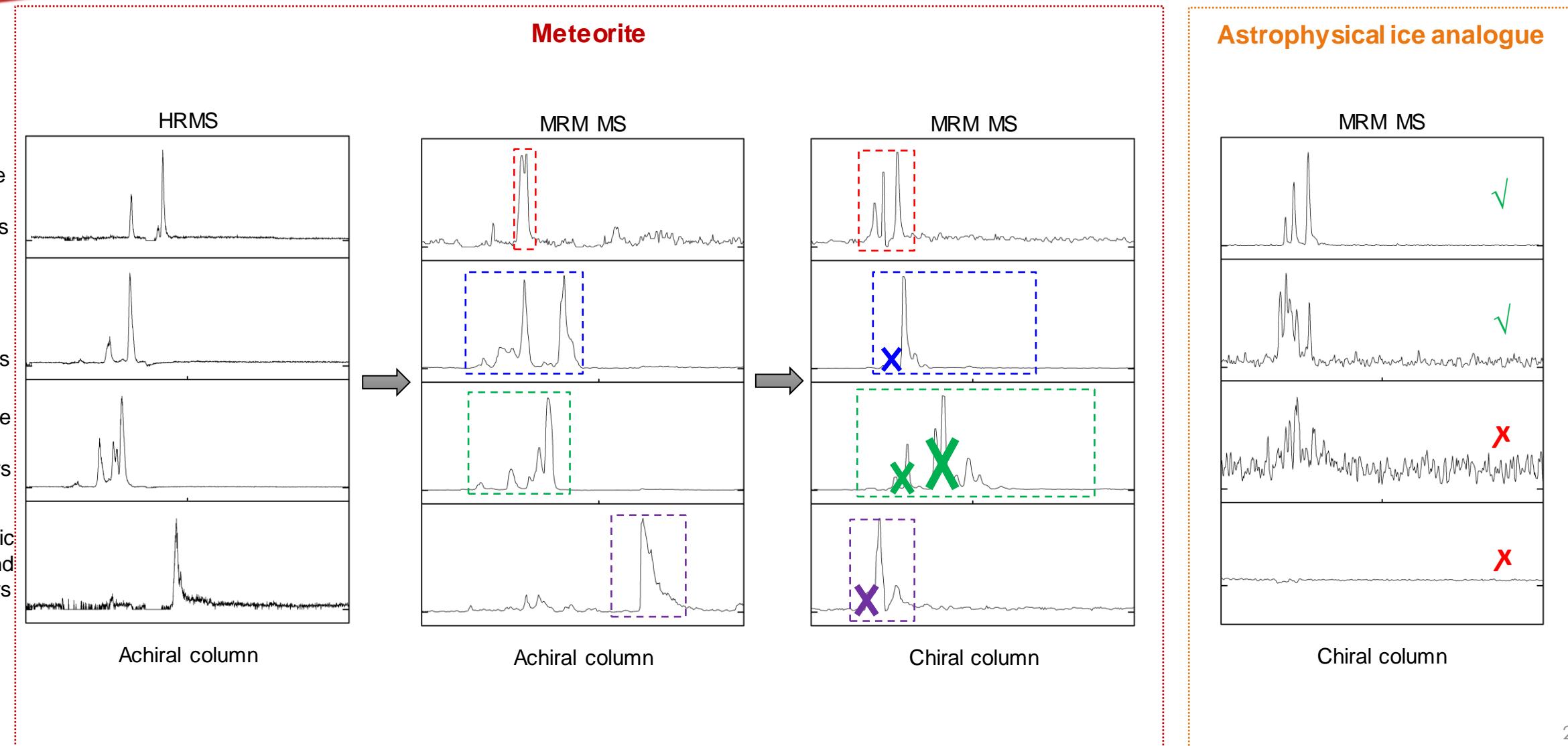
# AMINO ACIDS MRM ANALYSIS



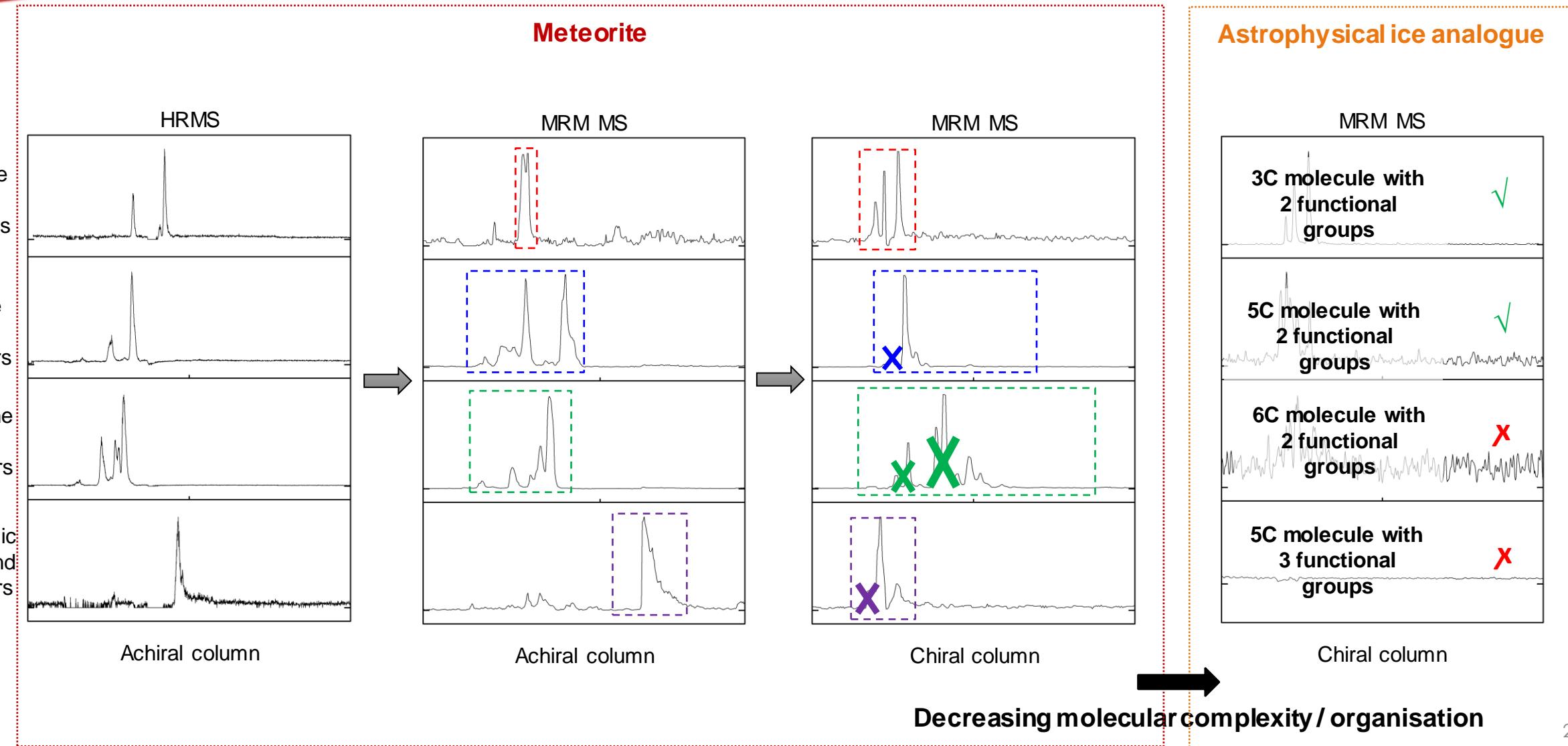
Chirality of amino acids :  
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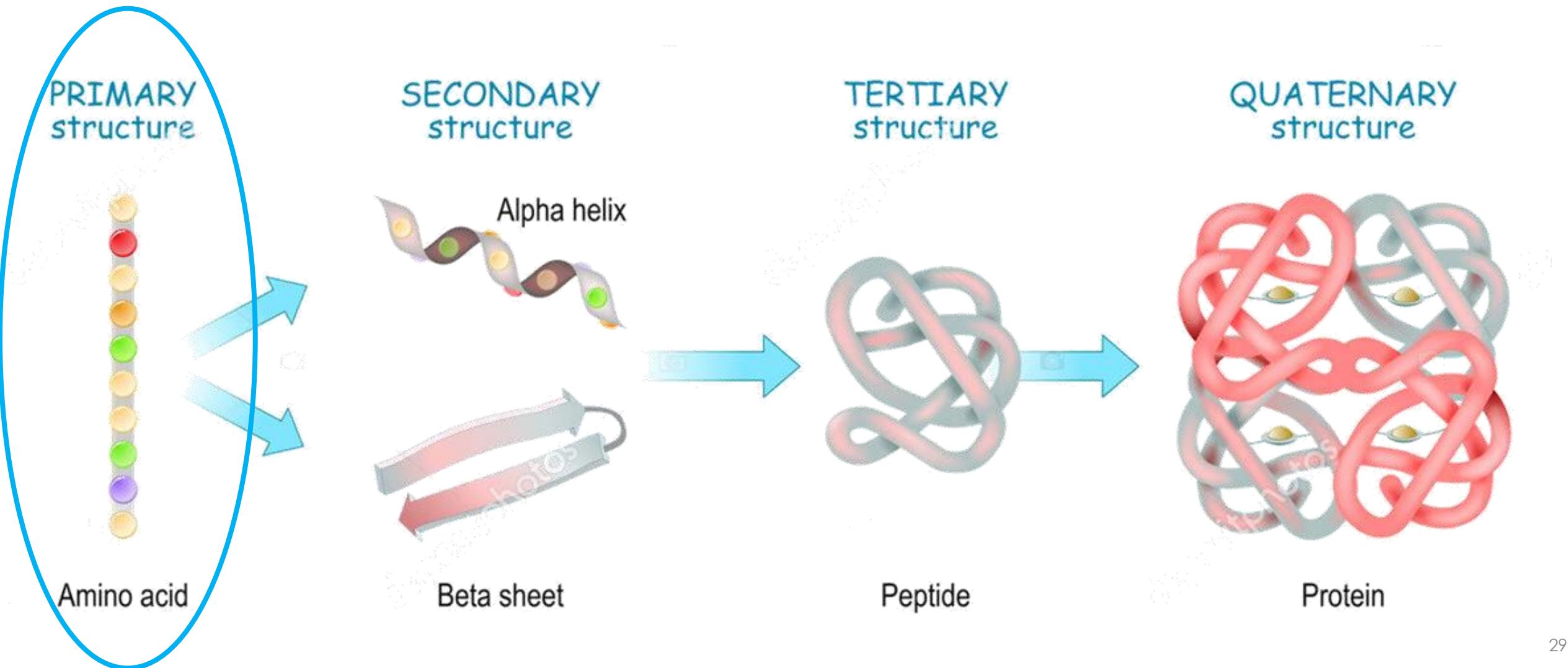
# AMINO ACIDS MRM ANALYSIS



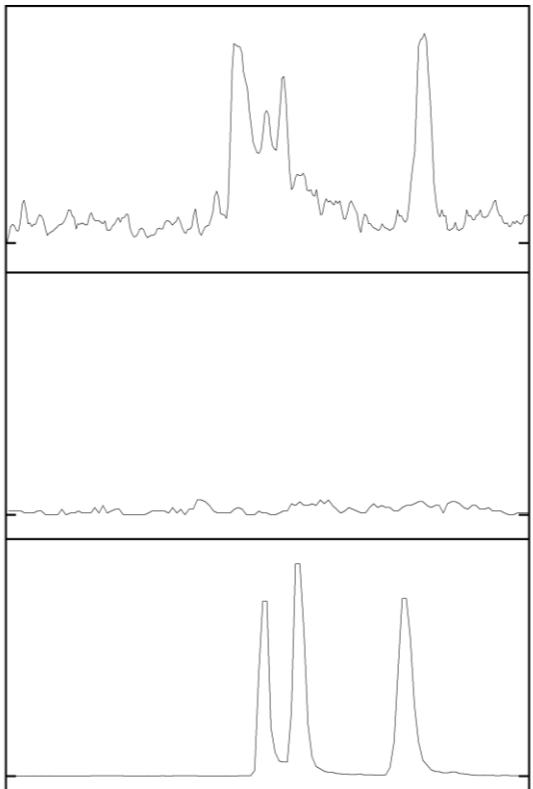
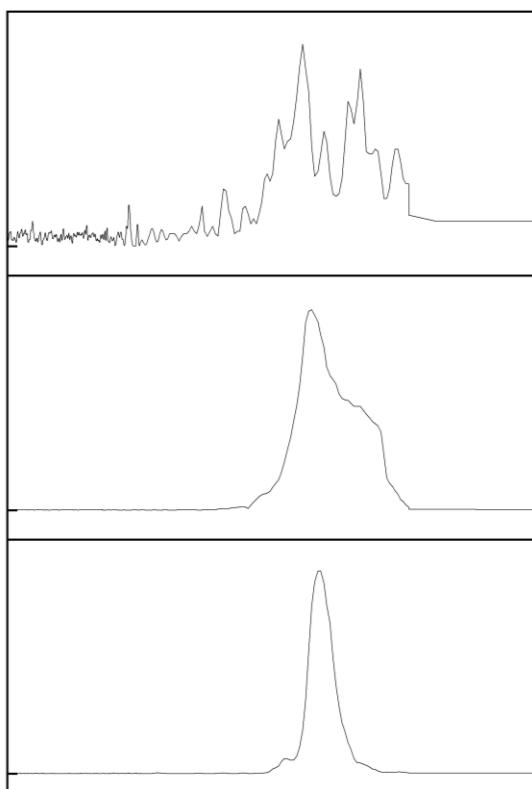
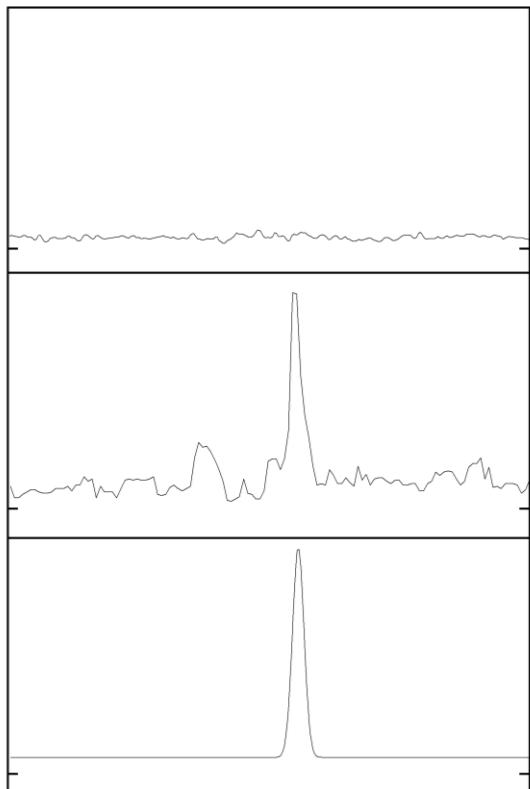
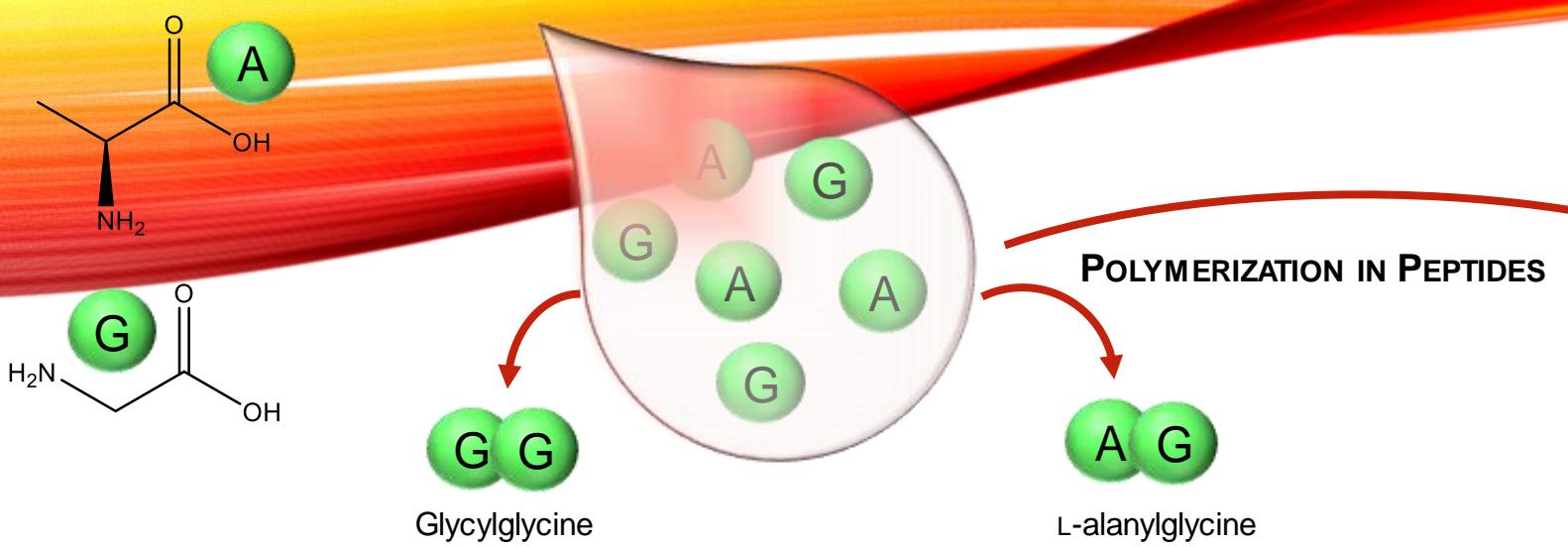
# AMINO ACIDS MRM ANALYSIS



# TOWARDS ORGANIZED MOLECULAR STRUCTURES



# TOWARDS ORGANIZED MOLECULAR STRUCTURES

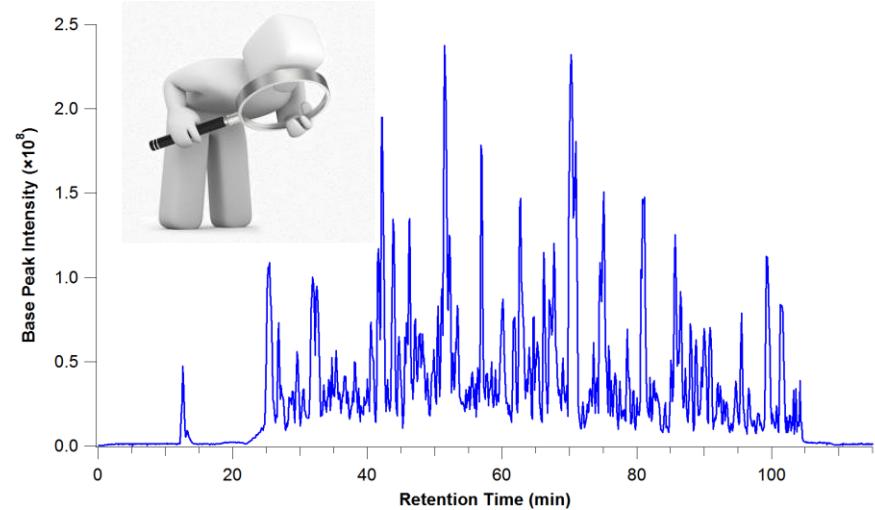
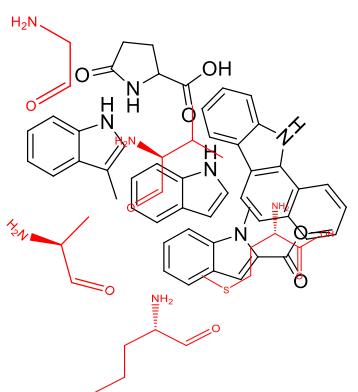
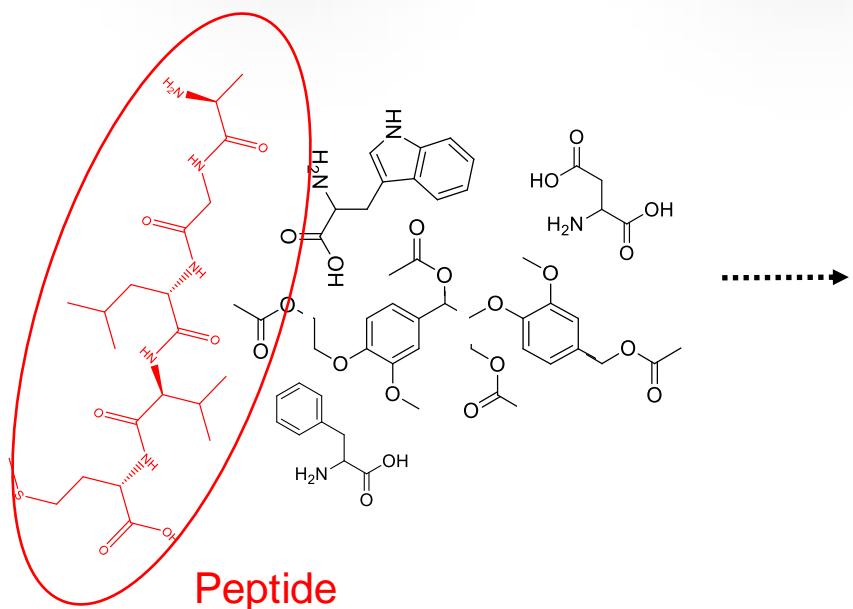
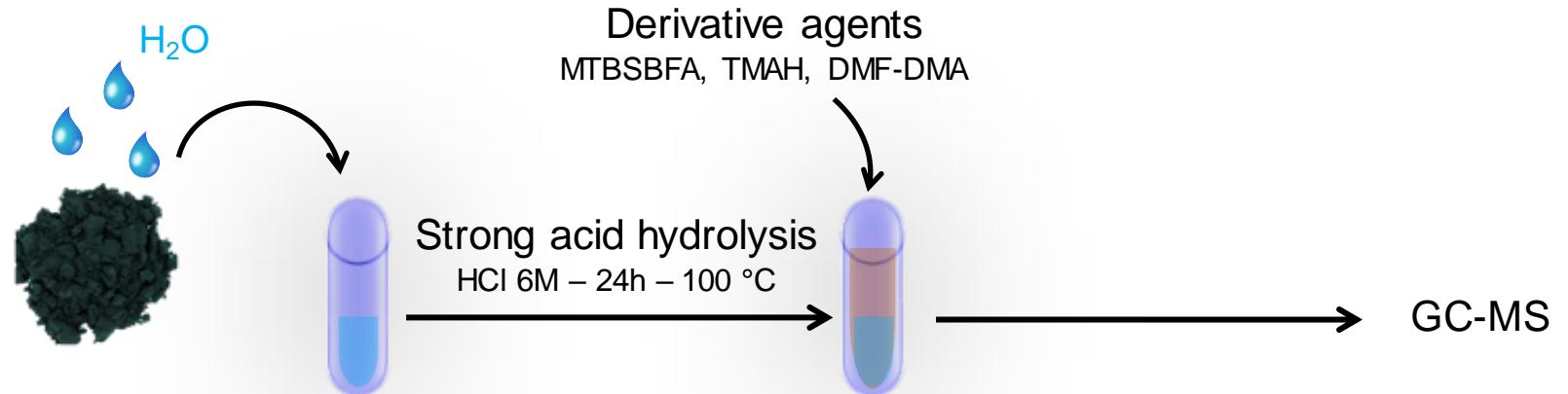


Astrophysical  
ice analogue

Meteorite

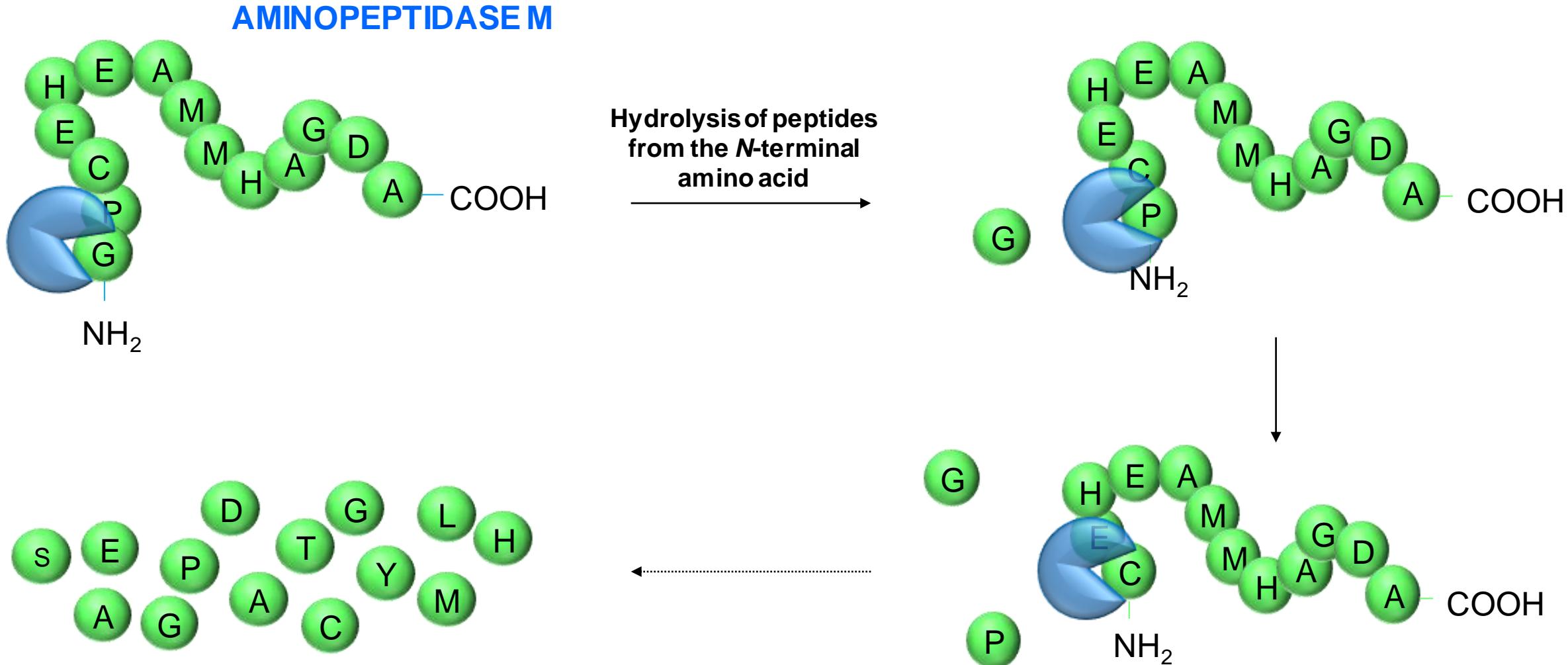
Standard

# CURRENT HYDROLYSIS METHOD UNABLE TO DETECT PEPTIDES

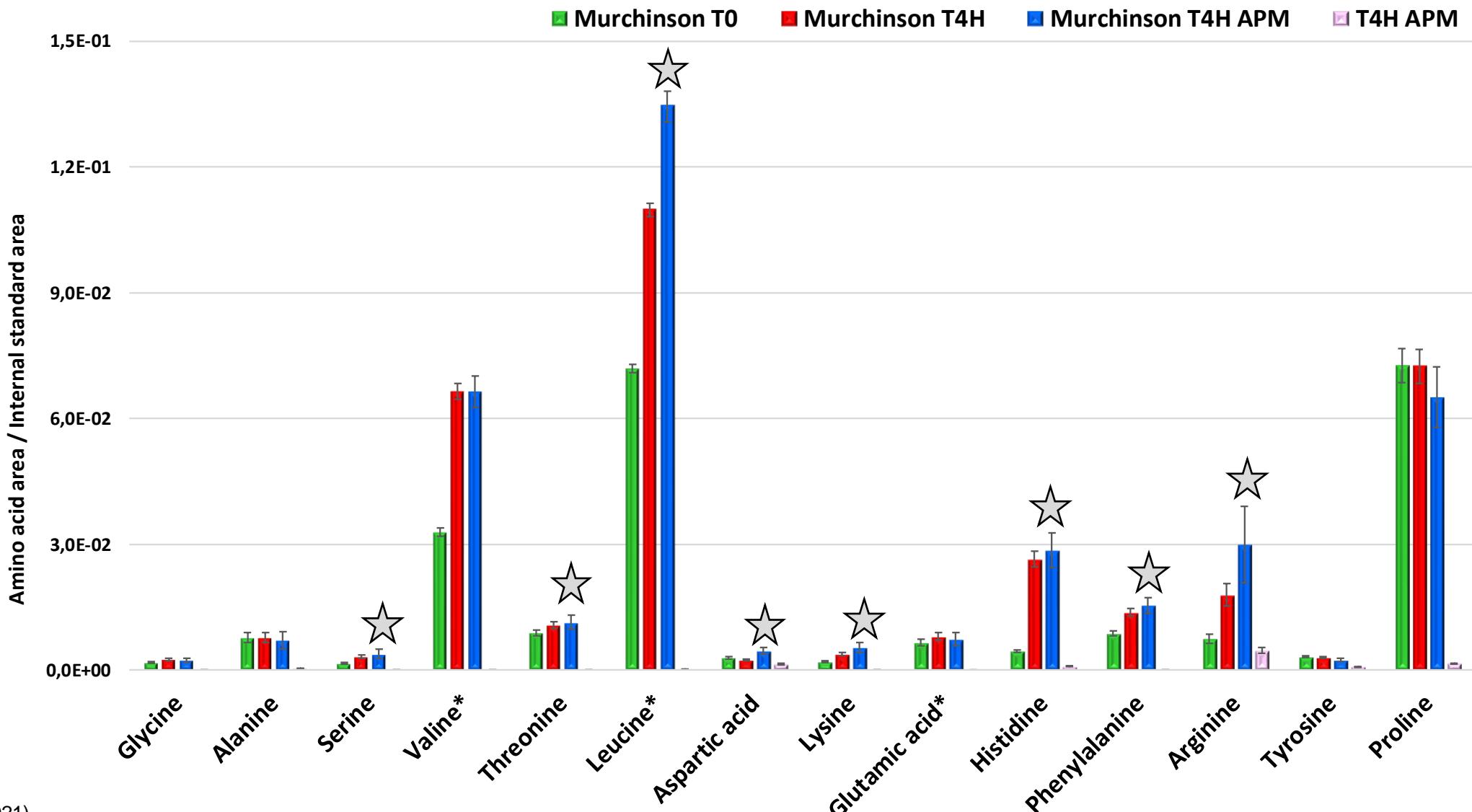


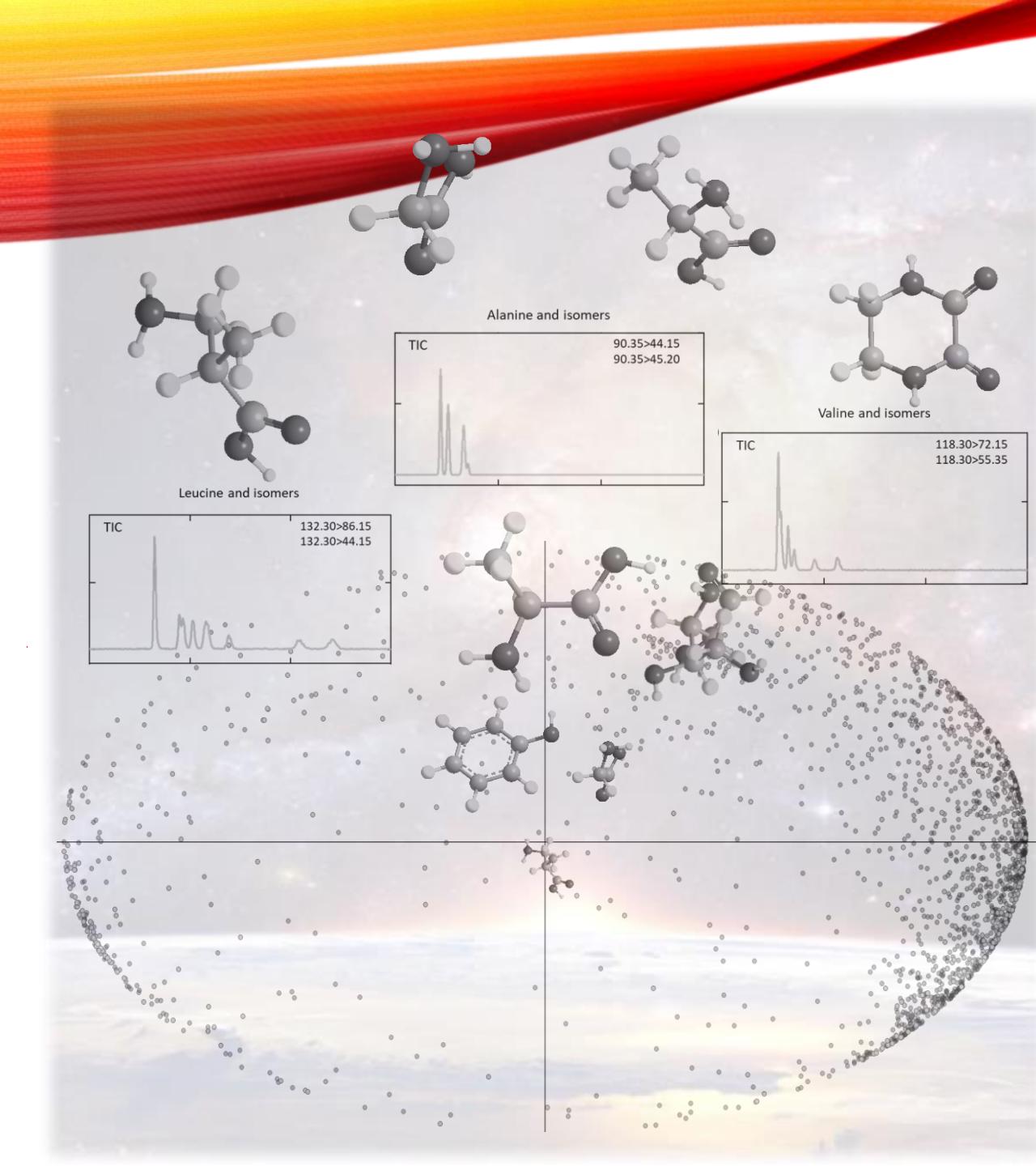
Complex chromatograms

# PROTEOMICS STRATEGY TO SEARCH FOR PEPTIDE SEQUENCES

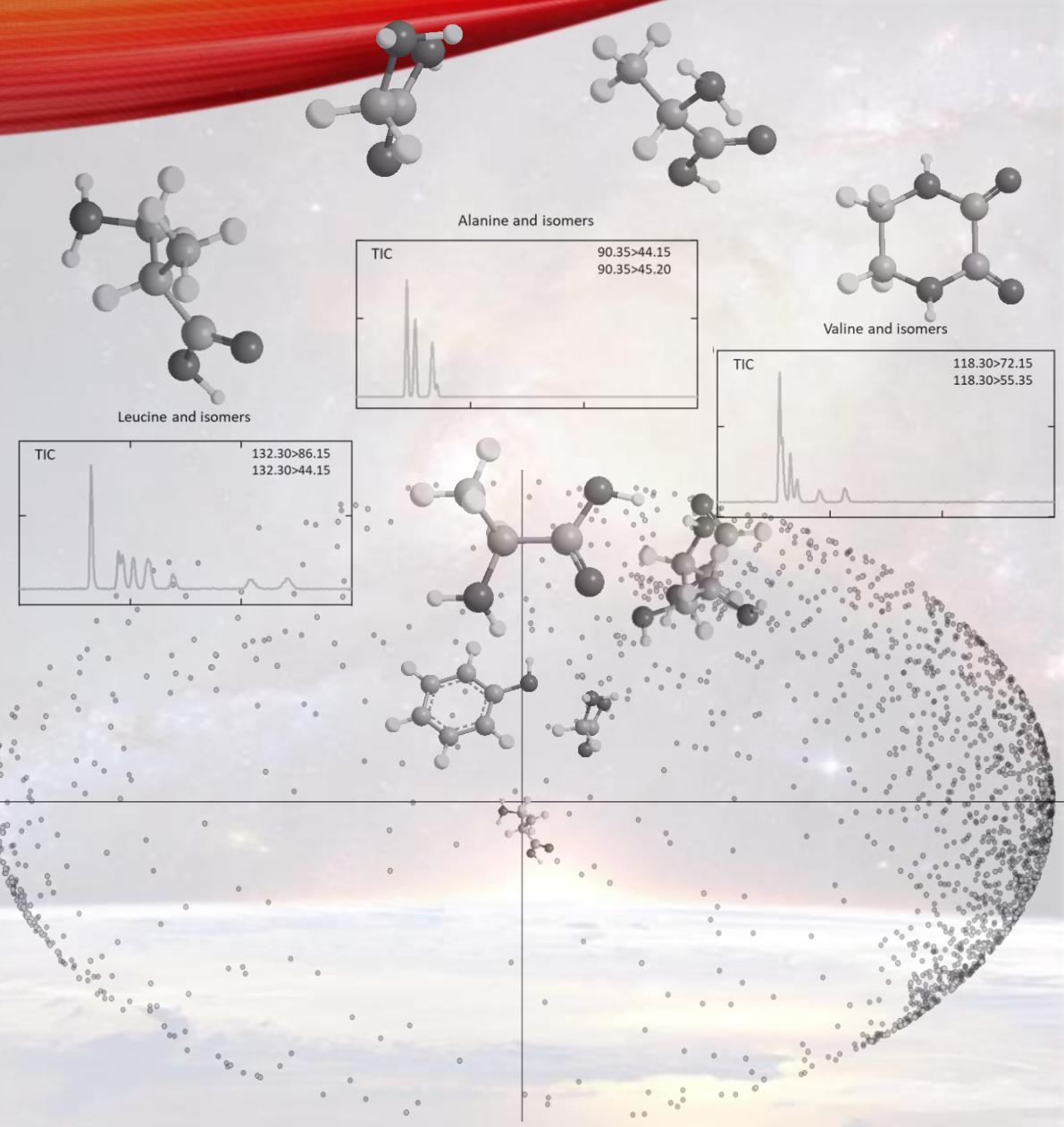


# PROOF OF CONCEPT ON MURCHISON





# They are



*Coline Serra*

*Ramzi Timouni*

*Justin Lange*

*Thomas Ribette*

*Balkis Eddhif*

*Guillaume Boulissière*

*Tiffany Bourdin*

*Audrey Allavena*

*Quentin B. Remaury*

*Claude Geffroy*

*Benjamin Riss Yaw*

*Sébastien Papot*

*Boris Laurent*

*Laurent Remusat*

