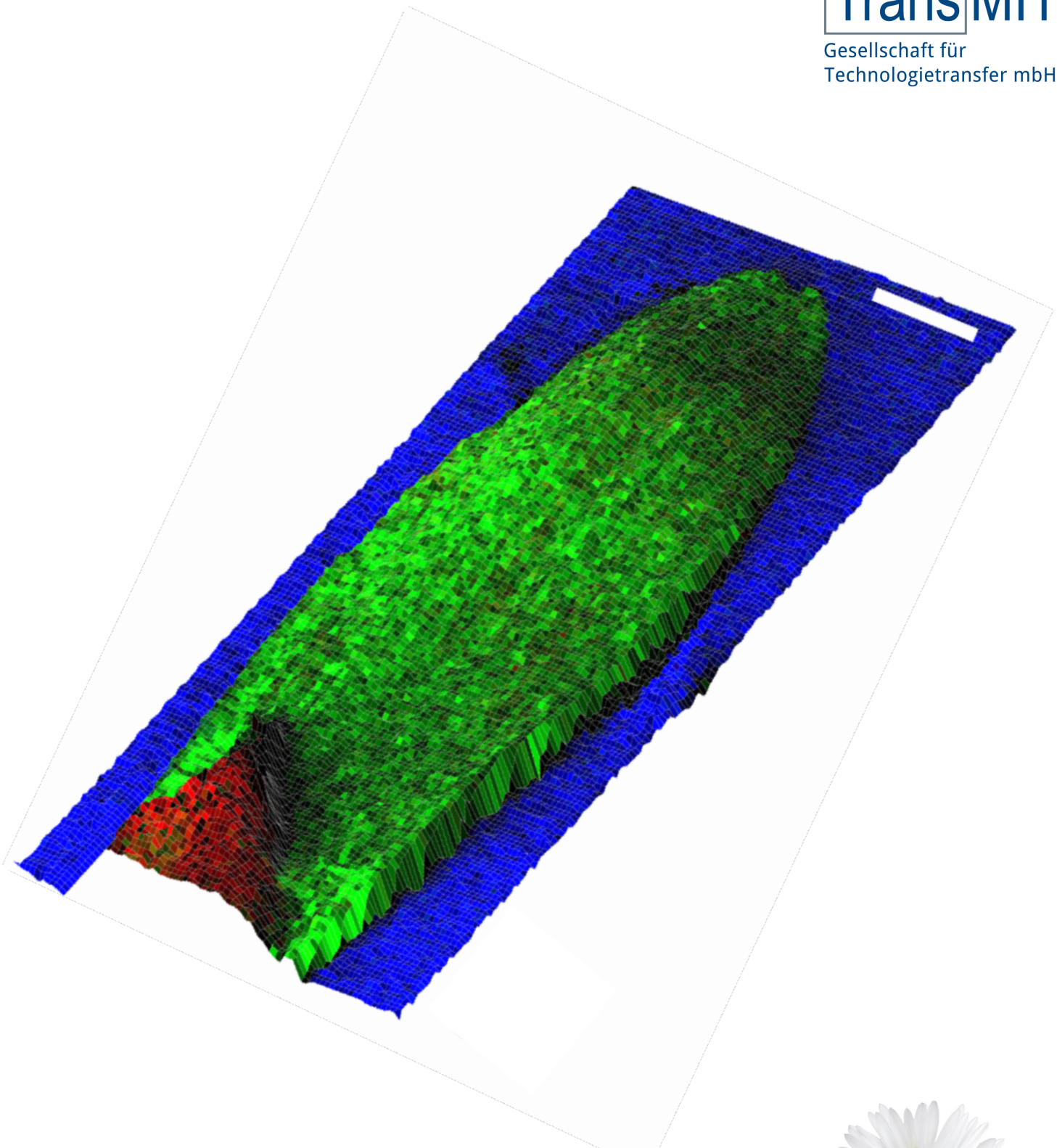
TransMIT
Gesellschaft für
Technologietransfer mbH



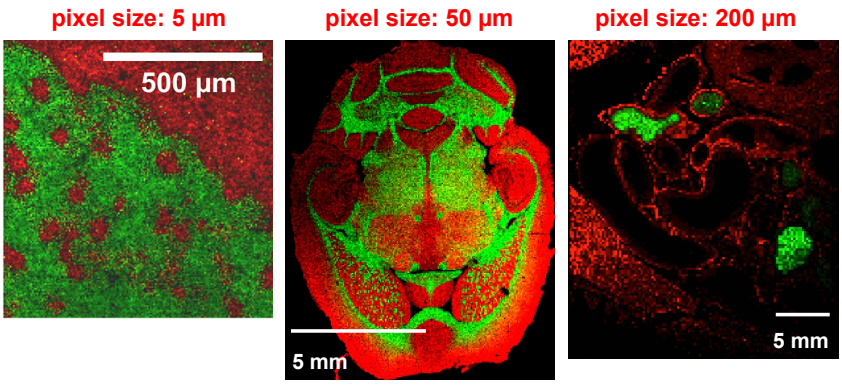
Its all about the surfaces

AP-SMALDI^5 AF

High-performance Mass Spectrometry Imaging

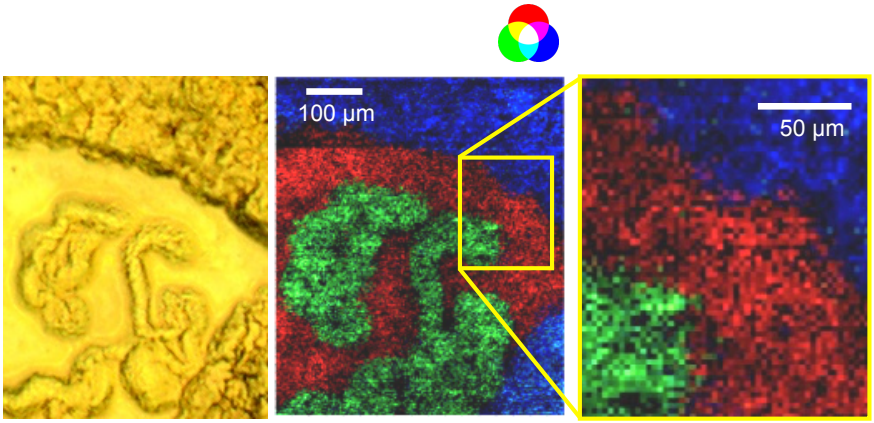
AP-SMALDI5 AF

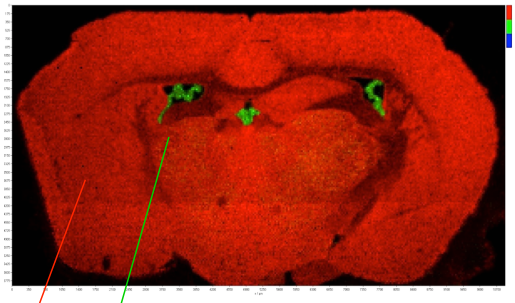
MALDI Imaging with high resolution in mass and space



Atmospheric-pressure MALDI mass spectrometry imaging at various lateral resolutions: mouse brain coronal section; mouse brain horizontal section; rat intestinal tract.

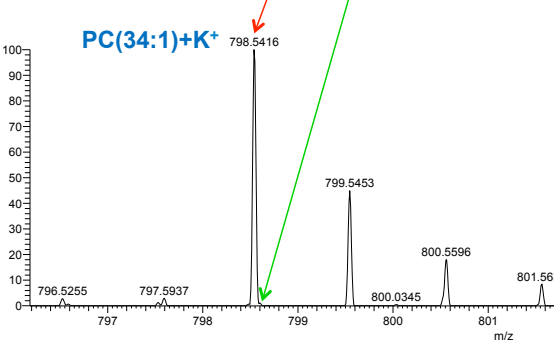
Lateral resolution (step size, pixel size) 5 µm **without oversampling**, at 5 µm ablation spot diameter. **Oversampling** analyses with smaller step sizes (pixel sizes) are also possible, with reduced quality, e.g.: mouse brain choroid plexus, **3 µm** pixel size

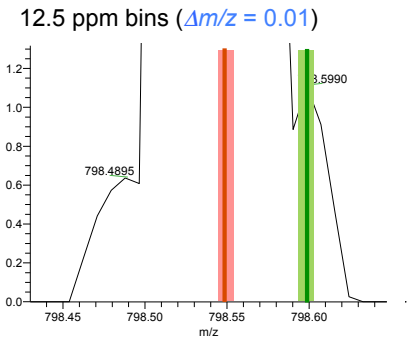




Choroid plexus

Highest imaging selectivity and dynamic range, due to orbital trapping mass analysis

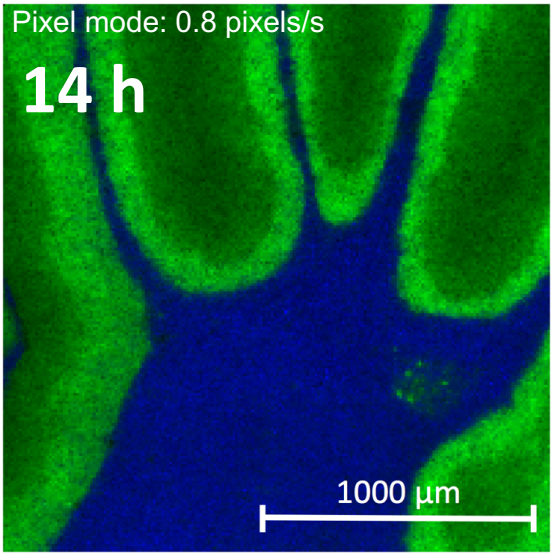


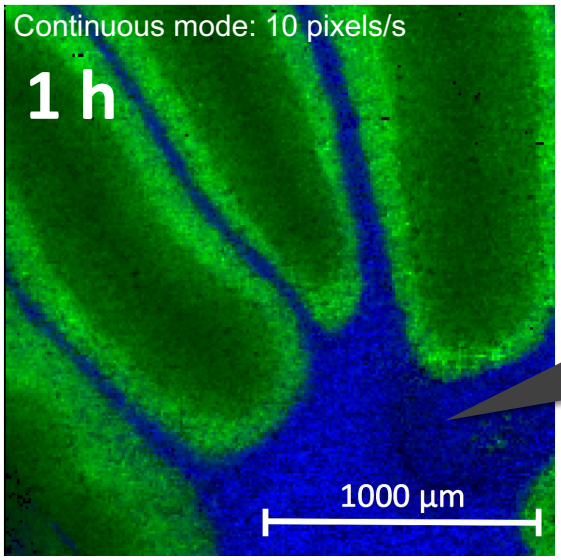


AP-SMALDI5 AF

MALDI Imaging at high laser repetition rate

High-speed mode

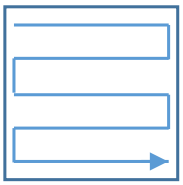


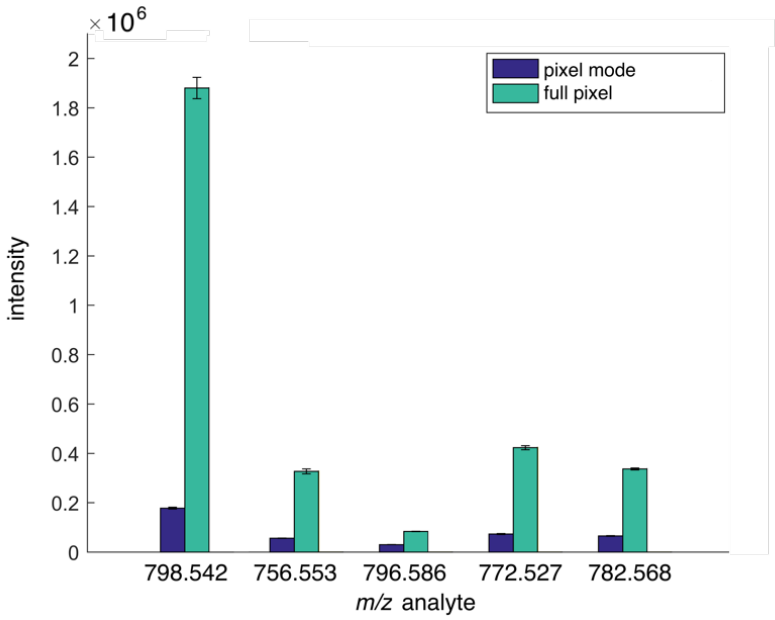


Highspeed imaging in continuous scanning mode (at reduced mass resolution; actual speed depends on Orbitrap model)

Full pixel mode

En-hanced signal inten-sities by analysis of entire sample pixel area (values depend on chosen pixel size)

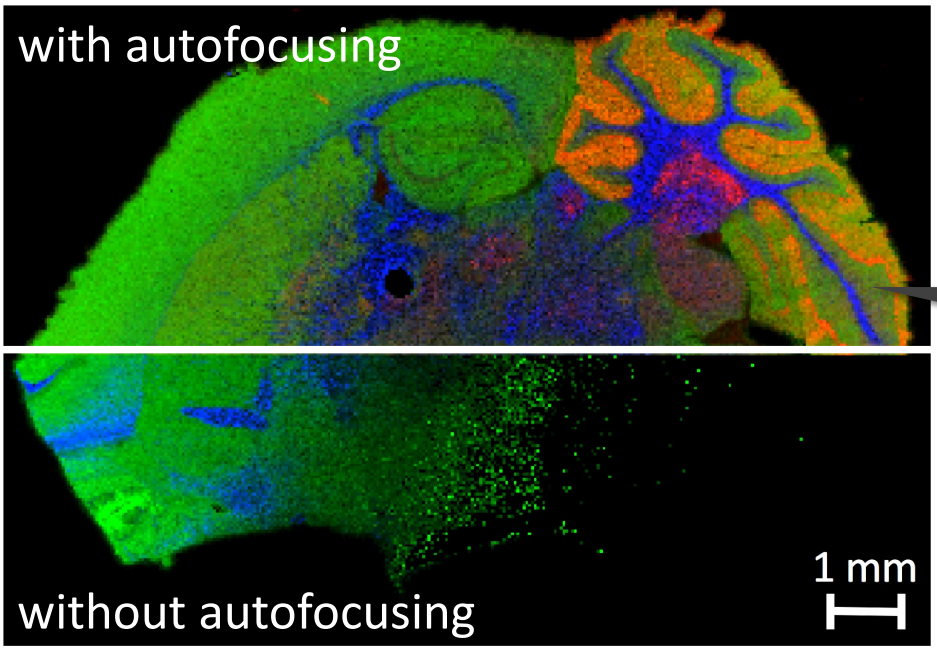




AP-SMALDI5 AF

MALDI Imaging in two and three dimensions

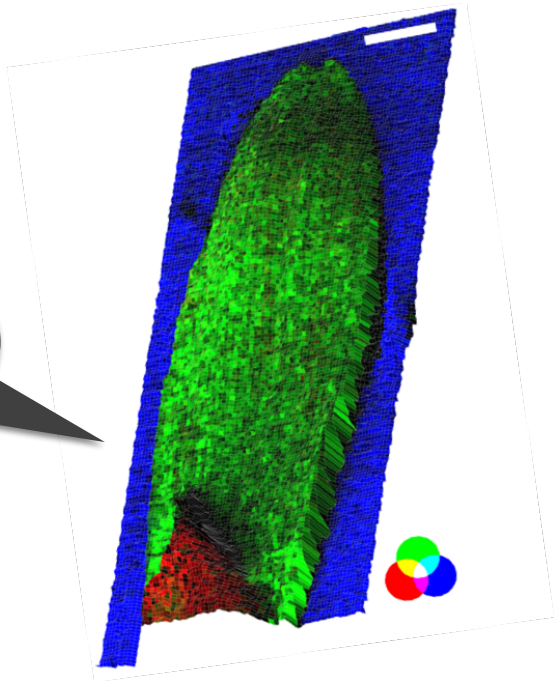
Tilt correction

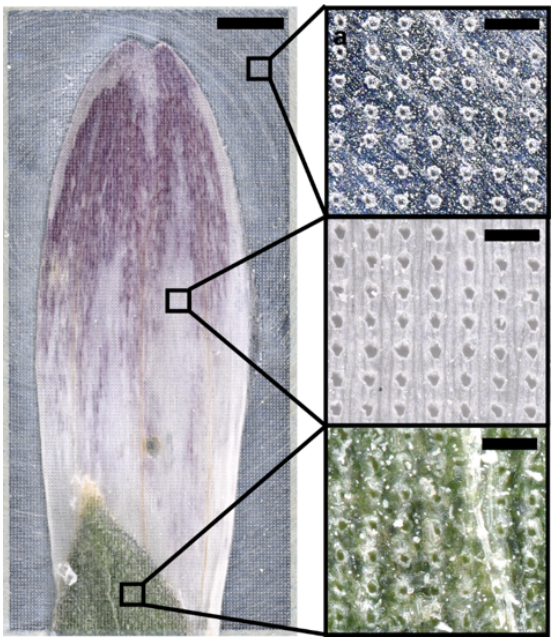


Authentic imaging of imperfect or tilted sections

3D-surface mode

3D RGB MS image of a daisy blossom

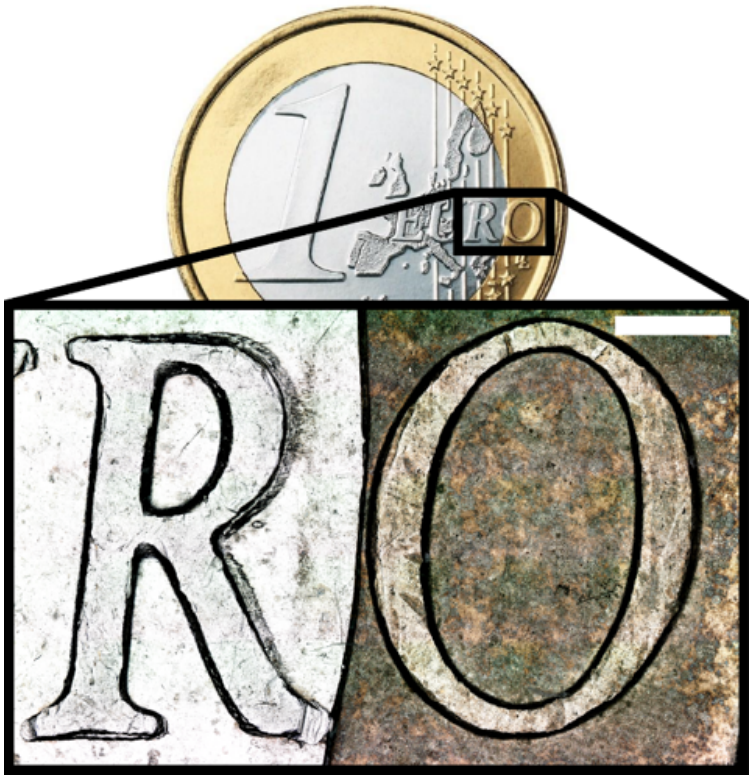


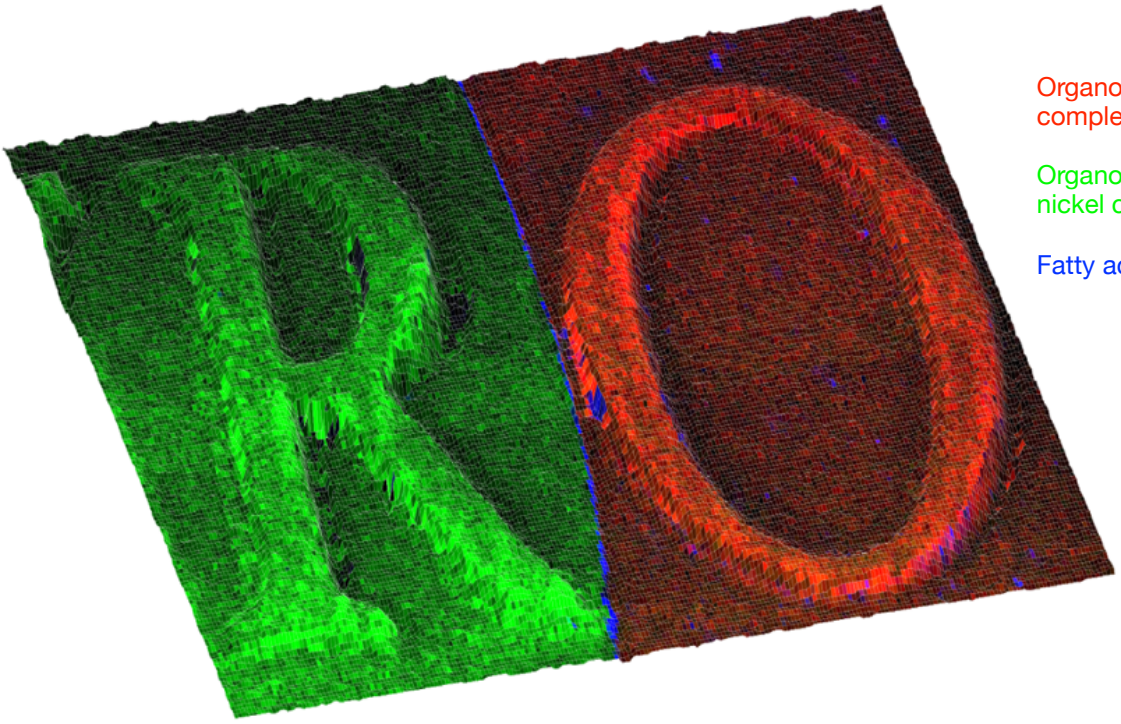


Kompauer M, Heiles S, Spengler B, Autofocusing MALDI mass spectrometry imaging of tissue sections and 3D chemical topography of nonflat surfaces. **Nature Methods** 14 (2017) 1156-1158.

AP-SMALDI5 AF

MALDI Imaging in two and three dimensions





Organometallic zinc complex

Organometallic copper/ nickel complex

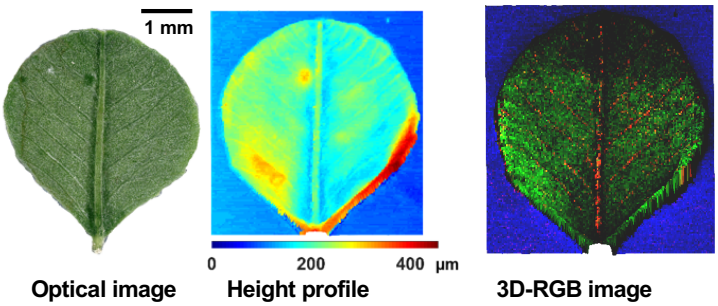
Fatty acid

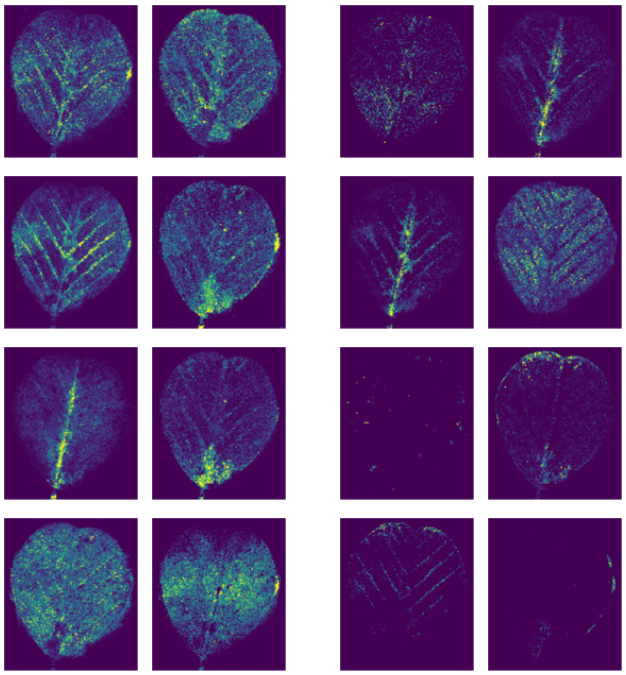
Kompauer M, Heiles S, Spengler B, Autofocusing MALDI mass spectrometry imaging of tissue sections and 3D chemical topography of nonflat surfaces. **Nature Methods** 14 (2017) 1156-1158.

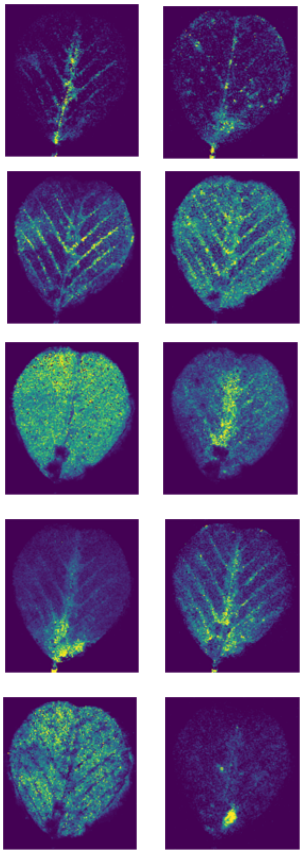
AP-SMALDI5 AF

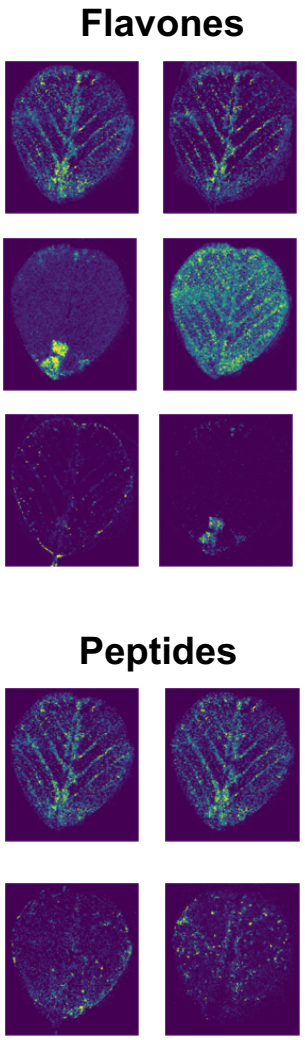
MALDI Imaging in two and three dimensions

Metabolomics imaging of non-flat samples



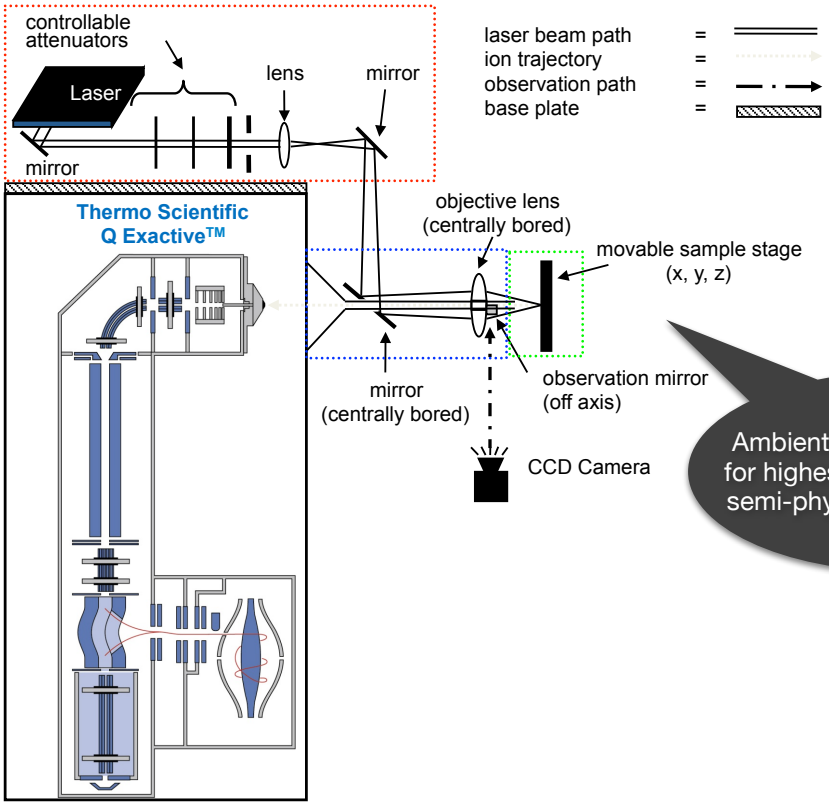


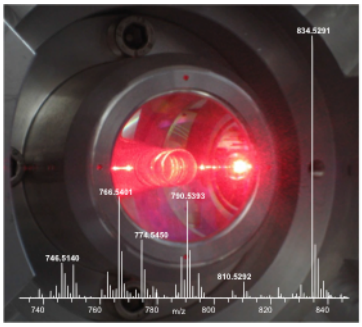




AP-SMALDI5 AF

High resolution in mass and space



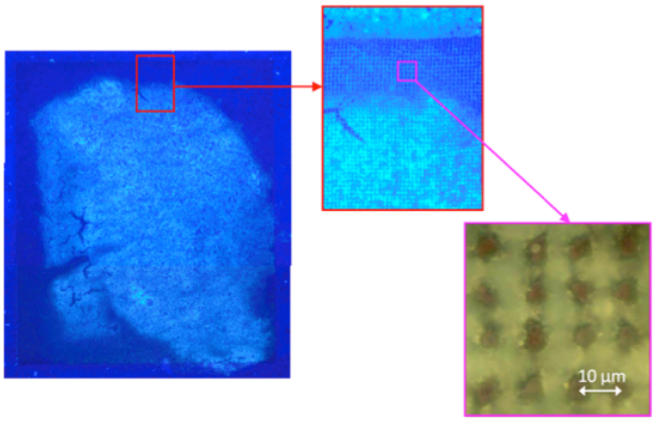


Ambient pressure ion source for highest performance under semi-physiological conditions

Unique coaxial setup for orthogonal laser irradiation, using a centrally bored objective lens

Ablation spot size is 5 µm in diameter on tissue under typical conditions. Post-measurement histochemistry is routinely possible down to 10 µm step size.

Bartels B, Svatos A. Spatially resolved in vivo plant metabolomics by laser ablation -



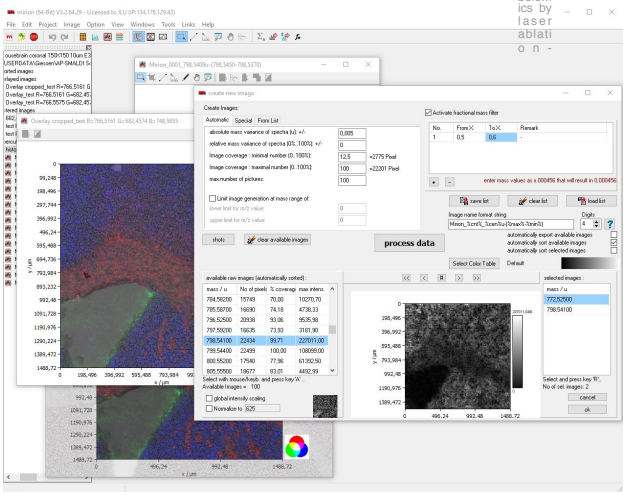
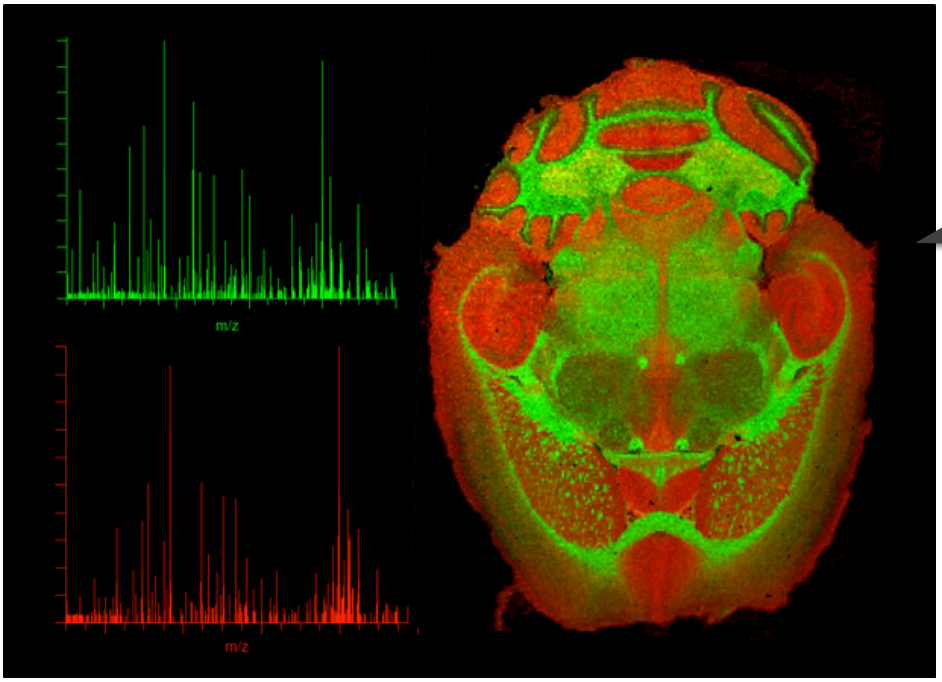


Image generation and data analysis is done with a powerful software package, including imzML integration for using open access image analysis programs.

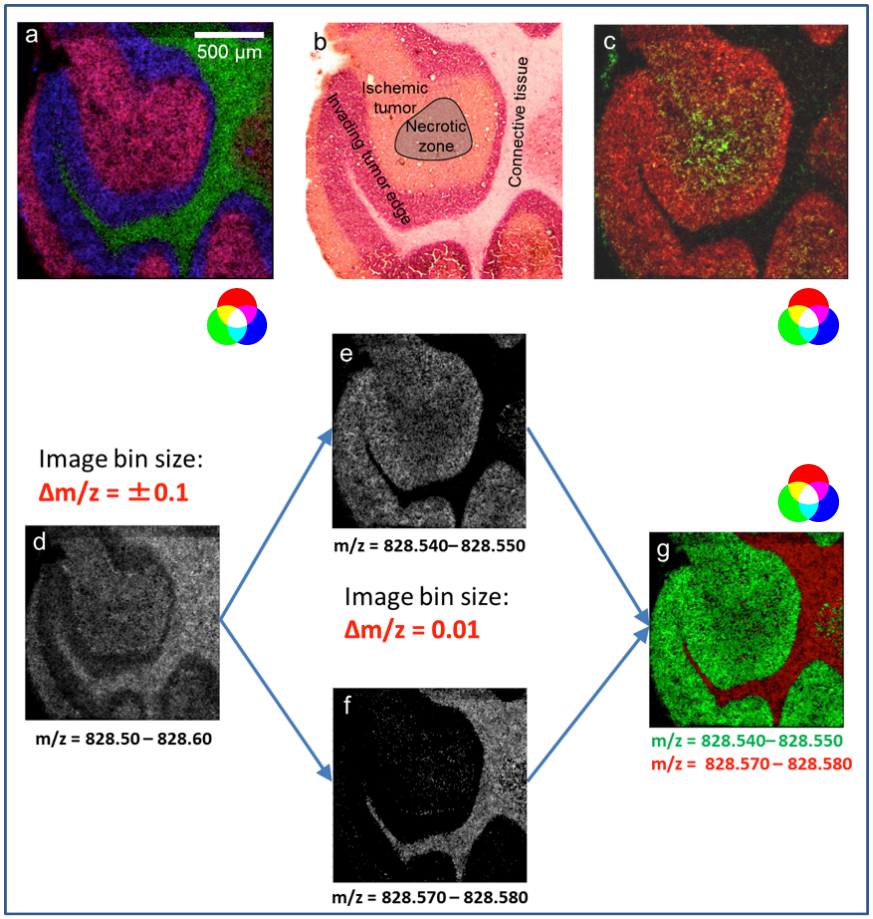
[molecular histology]



High-contrast molecular imaging of lipids, peptides, on-tissue digested proteins, small molecules, metabolites, compounds, …

… from animal and human tissue, plants, insects

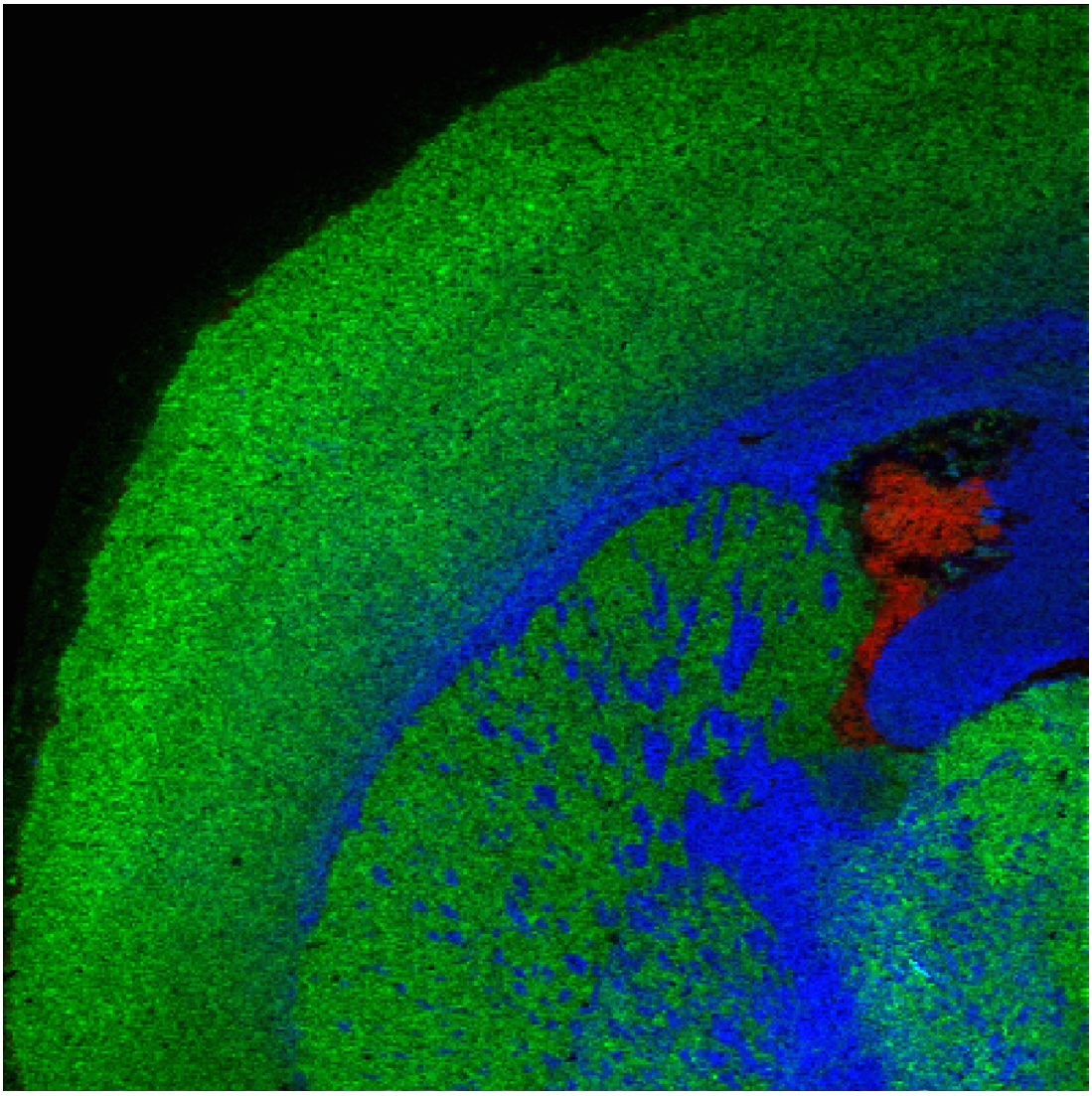
Tissue section of a human non-small-cell lung carcinoma that was induced into a severe combined immunodeficiency (SCID)) mouse model. a) MS image, 10 µm pixel size. b) Optical image after staining. c-g) MS images. The high imaging selectivity of the AP-SMALDI system of $\Delta m/z = 0.01$ (Fig. e and f) is essential for biological samples to avoid multi-compound artifacts (Fig. d).



Römpp A, Spengler B, **Histochem Cell Biol** (2013) 139:759–783.

Exploring Nature

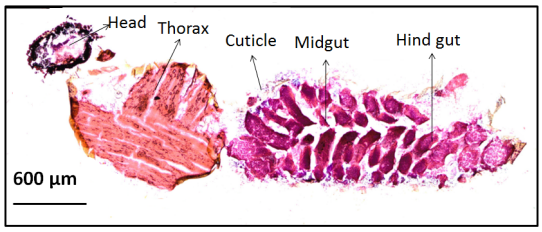
by High-Performance MALDI Mass Spectrometry Imaging



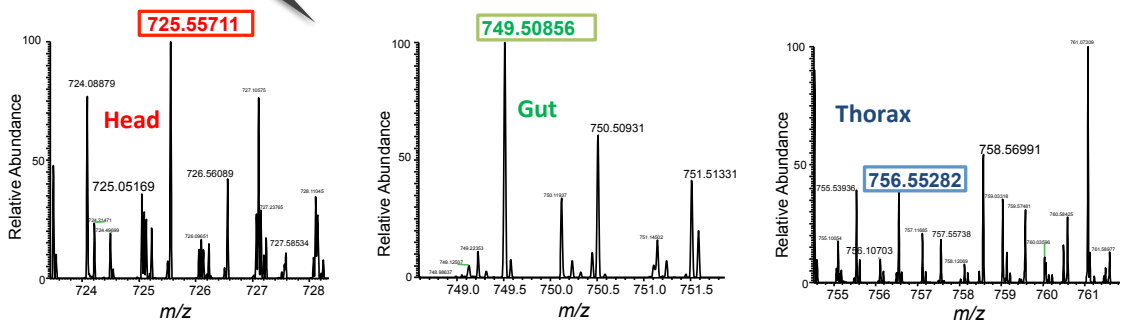
[delicate objects]

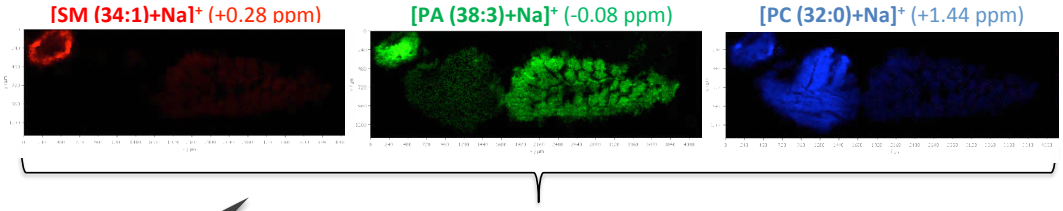
Anopheles stefensi
body weight app. 100 µg
body length app. 3 mm

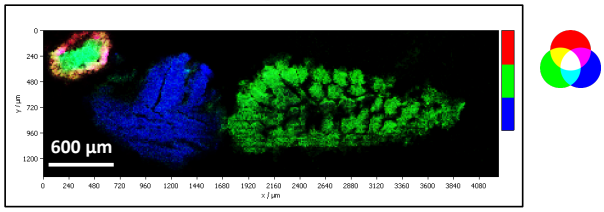
Positive-ion AP-SMALDI mass spectra averaged from head, gut, and thorax region of the mosquito section.



10 µm thick section of embedded mosquito, H&E-stained after analysis



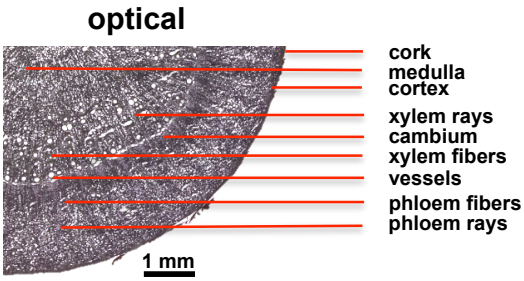




Individual phospholipid species are characteristic for tissue types, body regions or metabolic states.

Khalil SM, Romp A, Pretzel J, Becker K, Spengler B, Phospholipid topography of whole-body sections of the Anopheles stephensi mosquito, characterized by high-resolution atmospheric-pressure scanning microprobe matrix-assisted laser desorption/ionization mass spectrometry imaging. **Anal Chem** 87 (2015) 11309-16.

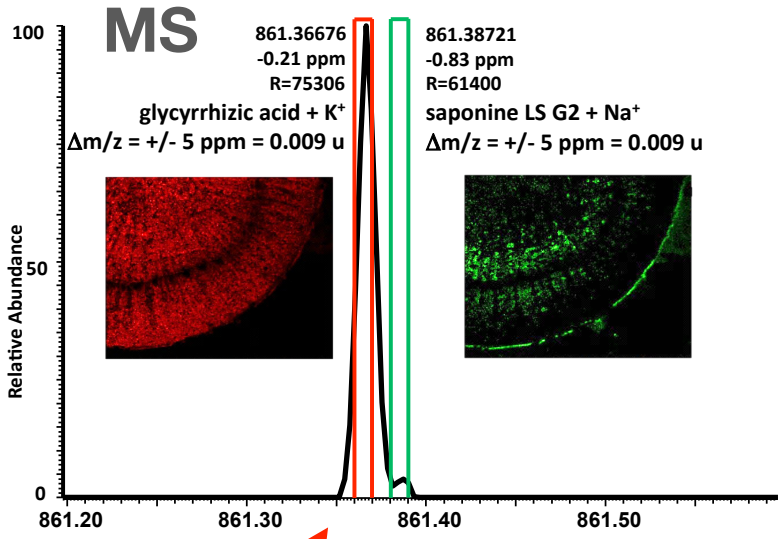
[image-assisted identification]



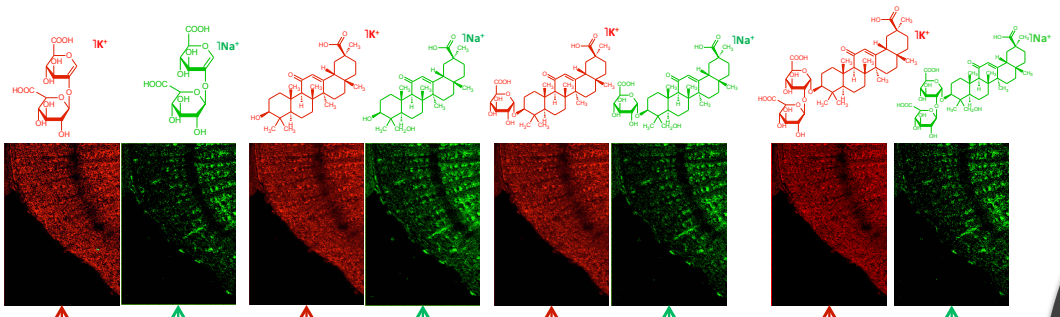
Rhizome section of licorice (*Glycyrrhiza glabra*). The plant has multiple pharmacological activities (anti-inflamatory, antimicrobial, antiviral, anti-tumor). A large number of saponines, flavonoid glycosides and free flavonoids were detected and imaged.

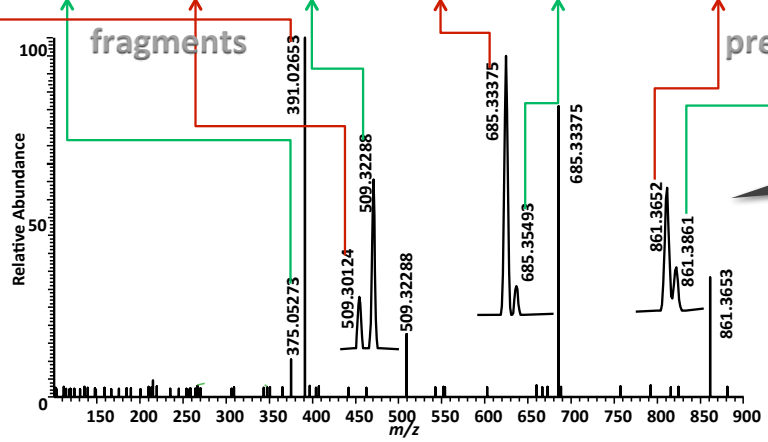
MS images and single-pixel mass spectrum of two closely neighboring natural compounds, glycyrrhizic acid (potassiated) and saponine LS G2 (sodiated), detected in the rhizome section.

The two signals differ by only 0.02 Da. The two images were generated with a *m/z* bin width of 10 ppm (green and red bars)



MS/MS





MS/MS images of glycyrrhizic acid and saponine LS G2 precursors reveal two classes of fragment ions, corresponding to the two precursor ions.

MS/MS images assist in structural characterisation and identification in complex samples. Fragment ions and their precursors have equivalent images.

The MS/MS spectrum is a single pixel spectrum selected for demonstration.

Li B, Bhandari DR, Janfelt C, Römpp A, Spengler B, **PLANT** 80 (2014) 161-171.

International publications using AP-SMALDI technology

1. Bartels B, Svatos A. Spatially resolved in vivo plant metabolomics by laser ablation-based mass spectrometry imaging (MSI) techniques: LDI-MSI and LAESI. Frontiers in Plant Science. 2015;6. DOI: 10.3389/fpls.2015.00471

2. Kusari S, Sezgin S, Nigutova K, Cellarova E, Spiteller M. Spatial chemo-profiling of hypericin and related phytochemicals in Hypericum species using MALDI-HRMS imaging. Analytical and Bioanalytical Chemistry. 2015;407(16):4779-91. DOI: 10.1007/s00216-015-8682-6

3. Wang WX, Kusari S, Sezgin S, Lamshoft M, Kusari P, Kayser O, Spiteller M. Hexacyclopeptides secreted by an endophytic fungus Fusarium solani N06 act as crosstalk molecules in Narcissus tazetta. Applied Microbiology and Biotechnology. 2015;99(18):7651-62. DOI: 10.1007/s00253-015-6653-7

4. Ait-Belkacem R, Dilillo M, Pellegrini D, Yadav A, de Graaf EL, McDonnell LA. In-Source Decay and Pseudo-MS3 of Peptide and Protein Ions Using Liquid AP-MALDI. Journal of the American Society for Mass Spectrometry. 2016;27(12):2075-9. DOI: 10.1007/s13361-016-1511-0

5. Beck S, Stengel J. Mass spectrometric imaging of flavonoid glycosides and biflavonoids in Ginkgo biloba L. Phytochemistry. 2016;130:201-6. DOI: 10.1016/j.phytochem.2016.05.005

6. Eckelmann D, Kusari S, Spiteller M. Occurrence and spatial distribution of maytansinoids in Putterlickia pyracantha, an unexplored resource of anticancer compounds. Fitoterapia. 2016;113:175-81. DOI: 10.1016/j.fitote.2016.08.006

7. Kucharikova A, Kusari S, Sezgin S, Spiteller M, Cellarova E. Occurrence and Distribution of Phytochemicals in the Leaves of 17 In vitro Cultured Hypericum spp. Adapted to Outdoor Conditions. Frontiers in Plant Science. 2016;7. DOI: 10.3389/fpls.2016.01616

8. Mascini NE, Cheng ML, Jiang L, Rizwan A, Podmore H, Bhandari DR, Rompp A, Glunde K, Heeren RMA. Mass Spectrometry Imaging of the Hypoxia Marker Pimonidazole in a Breast Tumor Model. Analytical Chemistry. 2016;88(6):3107-14. DOI: 10.1021/acs.analchem.5b04032

9. Belov ME, Ellis SR, Dilillo M, Paine MRL, Danielson WF, Anderson GA, de Graaf EL, Eijkel GB, Heeren RMA, McDonnell LA. Design and Performance of a Novel Interface for Combined Matrix-Assisted Laser Desorption Ionization at Elevated Pressure and Electrospray Ionization with Orbitrap Mass Spectrometry. Analytical Chemistry. 2017;89(14):7493-501. DOI: 10.1021/acs.analchem.7b01168

10. Breindahl T, Kimergard A, Andreasen MF, Pedersen DS. Identification of a new psychoactive substance in seized material: the synthetic opioid N-phenyl-N- 1-(2-phenethyl)piperidin-4-yl prop-2-enamide (Acrylfentanyl). Drug Testing and Analysis. 2017;9(3):415-22. DOI: 10.1002/dta.2046

11. Dilillo M, Pellegrini D, Ait-Belkacem R, de Graaf EL, Caleo M, McDonnell LA. Mass Spectrometry Imaging, Laser Capture Microdissection, and LC-MS/MS of the Same Tissue Section. Journal of Proteome Research. 2017;16(8):2993-3001. DOI: 10.1021/acs.jproteome.7b00284

12. Eckelmann D, Kusari S, Spiteller M. Spatial profiling of maytansine during the germination process of Maytenus senegalensis seeds. Fitoterapia. 2017;119:51-6. DOI: 10.1016/j.fitote.2017.03.014

13. Nishidate M, Yamamoto K, Masuda C, Aikawa H, Hayashi M, Kawanishi T, Hamada A. MALDI mass spectrometry imaging of erlotinib administered in combination with bevacizumab in xenograft mice bearing B901L, EGFR-mutated NSCLC cells. Scientific Reports. 2017;7. DOI: 10.1038/s41598-017-17211-6

14. Sorensen IS, Janfelt C, Nielsen MMB, Mortensen RW, Knudsen NO, Eriksson AH, Pedersen AJ, Nielsen KT. Combination of MALDI-MSI and cassette dosing for evaluation of drug distribution in human skin explant. Analytical and Bioanalytical Chemistry. 2017;409(21):4993-5005. DOI: 10.1007/s00216-017-0443-2

15. Wenande E, Olesen UH, Nielsen MMB, Janfelt C, Hansen SH, Anderson RR, Haedersdal M. Fractional laser-assisted topical delivery leads to enhanced, accelerated and deeper cutaneous 5-fluorouracil uptake. Expert Opin Drug Deliv. 2017;14(3):307-17. DOI: 10.1080/17425247.2017.1260119

16. Eckelmann D, Spiteller M, Kusari S. Spatial-temporal profiling of prodiginines and serratamolides produced by endophytic Serratia marcescens harbored in Maytenus serrata. Scientific Reports. 2018;8. DOI: 10.1038/s41598-018-23538-5

17. Ha-Andersen J, Kaasgaard SG, Janfelt C. MALDI imaging of enzymatic degradation of glycerides by lipase on

textile surface. Chemistry and Physics of Lipids. 2018;211:100-6. DOI: 10.1016/j.chemphyslip.2017.11.004

18. Hansen SE, Marxen E, Janfelt C, Jacobsen J. Buccal delivery of small molecules - Impact of levulinic acid, oleic acid, sodium dodecyl sulfate and hypotonicity on ex vivo permeability and spatial distribution in mucosa. European Journal of Pharmaceutics and Biopharmaceutics. 2018;133:250-7. DOI: 10.1016/j.ejpb.2018.10.016

19. Kashimura A, Tanaka K, Sato H, Kaji H, Tanaka M. Imaging mass spectrometry for toxicity assessment: a useful technique to confirm drug distribution in histologically confirmed lesions. Journal of Toxicologic Pathology. 2018;31(3):221-7. DOI: 10.1293/tox.2018-0006

20. Kohnen KL, Sezgin S, Spiteller M, Hagels H, Kayser O. Localization and Organization of Scopolamine Biosynthesis in Duboisia myoporoides R. Br. Plant and Cell Physiology. 2018;59(1):107-18. DOI: 10.1093/pcp/pcx165

21. Marxen E, Jacobsen J, Hyrup B, Janfelt C. Permeability Barriers for Nicotine and Mannitol in Porcine Buccal. Mucosa Studied by High-Resolution MALDI Mass Spectrometry Imaging. Molecular Pharmaceutics. 2018;15(2):519-26. DOI: 10.1021/acs.molpharmaceut.7b00891

22. Marxen E, Jin L, Jacobsen J, Janfelt C, Hyrup B, Nicolazzo JA. Effect of Permeation Enhancers on the Buccal Permeability of Nicotine: Ex vivo Transport Studies Complemented by MALDI MS Imaging. Pharmaceutical Research. 2018;35(3). DOI: 10.1007/s11095-017-2332-y

23. Tocci N, Gaid M, Kaftan F, Belkheir AK, Belhadj I, Liu BY, Svatos A, Hansch R, Pasqua G, Beerhues L. Exodermis and endodermis are the sites of xanthone biosynthesis in Hypericum perforatum roots. New Phytologist. 2018;217(3):1099-112. DOI: 10.1111/nph.14929

24. Yakoub K, Jung SS, Sattler C, Damerow H, Weber J, Kretzschmann A, Cankaya AS, Piel M, Rosch F, Haugaard AS, Frolund B, Schirmeister T, Luddens H. Structure Function Evaluation of Imidazopyridine Derivatives Selective for delta-Subunit-Containing gamma-Aminobutyric Acid Type A (GABA(A)) Receptors. Journal of Medicinal Chemistry. 2018;61(5):1951-68. DOI: 10.1021/acs.jmedchem.7b01484

25. Baumeister TUH, Vallet M, Kaftan F, Svatos A, Pohnert G. Live Single-Cell Metabolomics With Matrix-Free Laser/Desorption Ionization Mass Spectrometry to Address Microalgal Physiology. Frontiers in Plant Science. 2019;10. DOI: 10.3389/fpls.2019.00172

26. Clitherow KH, Murdoch C, Spain SG, Handler AM, Colley HE, Stie MB, Nielsen HM, Janfelt C, Hatton PV, Jacobsen J. Mucoadhesive Electrospun Patch Delivery of Lidocaine to the Oral Mucosa and Investigation of Spatial Distribution in a Tissue Using MALDI-Mass Spectrometry Imaging. Molecular Pharmaceutics. 2019;16(9):3948-56. DOI: 10.1021/acs.molpharmaceut.9b00535

27. Handler AM, Marxen E, Jacobsen J, Janfelt C. Visualization of the penetration modifying mechanism of laurocapram by Mass Spectrometry Imaging in buccal drug delivery. European Journal of Pharmaceutical Sciences. 2019;127:276-81. DOI: 10.1016/j.ejps.2018.11.011

28. Hendel KK, Bagger C, Olesen UH, Janfelt C, Hansen SH, Haedersdal M, Lerche CM. Fractional laser-assisted topical delivery of bleomycin quantified by LC-MS and visualized by MALDI mass spectrometry imaging. Drug Delivery. 2019;26(1):244-51. DOI: 10.1080/10717544.2019.1574937

29. Kubicki M, Lamshoft M, Lagojda A, Spiteller M. Metabolism and spatial distribution of metalaxyl in tomato plants grown under hydroponic conditions. Chemosphere. 2019;218:36-41. DOI: 10.1016/j.chemosphere.2018.11.069

30. Nishidate M, Hayashi M, Aikawa H, Tanaka K, Nakada N, Miura S, Ryu S, Higashi T, Ikarashi Y, Fujiwara Y, Hamada A. Applications of MALDI mass spectrometry imaging for pharmacokinetic studies during drug development. Drug Metab Pharmacokinet. 2019;34(4):209-16. DOI: 10.1016/j.dmpk.2019.04.006

31. Sugiyama E, Kondo T, Kuzumaki N, Honda K, Yamanaka A, Narita M, Suematsu M, Sugiura Y. Mechanical allodynia induced by optogenetic sensory nerve excitation activates dopamine signaling and metabolism in medial nucleus accumbens. Neurochem Int. 2019;129:6. DOI: 10.1016/j.neuint.2019.104494

32. Takahashi M, Miki S, Fujimoto K, Fukuoka K, Matsushita Y, Maida Y, Yasukawa M, Hayashi M, Shinkyo R, Kikuchi K, Mukasa A, Nishikawa R, Tamura K, Narita Y, Hamada A, Masutomi K, Ichimura K. Eribulin penetrates brain tumor tissue and prolongs survival of mice harboring intracerebral glioblastoma xenografts. Cancer Science. 2019;110(7):2247-57. DOI: 10.1111/cas.14067

Publications of the Giessen group using AP-SMALDI technology

1. Rompp A, Guenther S, Schober Y, Schulz O, Takats Z, Kummer W, Spengler B. Histology by Mass Spectrometry: Label-Free Tissue Characterization Obtained from High-Accuracy Bioanalytical Imaging. Angewandte Chemie-International Edition. 2010;49(22):3834-8. DOI: 10.1002/anie.200905559

2. Guenther S, Rompp A, Kummer W, Spengler B. AP-MALDI imaging of neuropeptides in mouse pituitary gland with 5 mu m spatial resolution and high mass accuracy. International Journal of Mass Spectrometry. 2011;305(2-3):228-37. DOI: 10.1016/j.ijms.2010.11.011

3. Rompp A, Guenther S, Takats Z, Spengler B. Mass spectrometry imaging with high resolution in mass and space (HR2 MSI) for reliable investigation of drug compound distributions on the cellular level. Analytical and Bioanalytical Chemistry. 2011;401(1):65-73. DOI: 10.1007/s00216-011-4990-7

4. Schober Y, Guenther S, Spengler B, Rompp A. Single Cell Matrix-Assisted Laser Desorption/Ionization Mass Spectrometry Imaging. Analytical Chemistry. 2012;84(15):6293-7. DOI: 10.1021/ac301337h

5. Schober Y, Guenther S, Spengler B, Rompp A. High-resolution matrix-assisted laser desorption/ionization imaging of tryptic peptides from tissue. Rapid Communications in Mass Spectrometry. 2012;26(9):1141-6. DOI: 10.1002/rcm.6192

6. Paschke C, Leisner A, Hester A, Maass K, Guenther S, Bouschen W, Spengler B. Mirion-A Software Package for Automatic Processing of Mass Spectrometric Images. Journal of the American Society for Mass Spectrometry. 2013;24(8):1296-306. DOI: 10.1007/s13361-013-0667-0

7. Rompp A, Spengler B. Mass spectrometry imaging with high resolution in mass and space. Histochemistry and Cell Biology. 2013;139(6):759-83. DOI: 10.1007/s00418-013-1097-6

8. Berisha A, Dold S, Guenther S, Desbenoit N, Takats Z, Spengler B, Rompp A. A comprehensive high-resolution mass spectrometry approach for characterization of metabolites by combination of ambient ionization, chromatography and imaging methods. Rapid Communications in Mass Spectrometry. 2014;28(16):1779-91. DOI: 10.1002/rcm.6960

9. Bhandari DR, Shen T, Rompp A, Zorn H, Spengler B. Analysis of cyathane-type diterpenoids from Cyathus striatus and Hericium erinaceus by high-resolution MALDI MS imaging. Analytical and Bioanalytical Chemistry. 2014;406(3):695-704. DOI: 10.1007/s00216-013-7496-7

10. Li B, Bhandari DR, Janfelt C, Rompp A, Spengler B. Natural products in Glycyrrhiza glabra (licorice) rhizome imaged at the cellular level by atmospheric pressure matrix-assisted laser desorption/ionization tandem mass spectrometry imaging. Plant Journal. 2014;80(1):161-71. DOI: 10.1111/tpj.12608

11. Bhandari DR, Schott M, Rompp A, Vilcinskas A, Spengler B. Metabolite localization by atmospheric pressure high-resolution scanning microprobe matrix-assisted laser desorption/ionization mass spectrometry imaging in whole-body sections and individual organs of the rove beetle Paederus riparius. Analytical and Bioanalytical Chemistry. 2015;407(8):2189-201. DOI: 10.1007/s00216-014-8327-1

12. Bhandari DR, Wang Q, Friedt W, Spengler B, Gottwald S, Rompp A. High resolution mass spectrometry imaging of plant tissues: towards a plant metabolite atlas. Analyst. 2015;140(22):7696-709. DOI: 10.1039/c5an01065a

13. Khalil SM, Rompp A, Pretzel J, Becker K, Spengler B. Phospholipid Topography of Whole-Body Sections of the Anopheles stephensi Mosquito, Characterized by High-Resolution Atmospheric-Pressure Scanning Microprobe Matrix-Assisted Laser Desorption/Ionization Mass Spectrometry Imaging. Analytical Chemistry. 2015;87(22):11309-16. DOI: 10.1021/acs.analchem.5602781

14. Li B, Bhandari DR, Rompp A, Spengler B. High-resolution MALDI mass spectrometry imaging of gallotannins and monoterpene glucosides in the root of Paeonia lactiflora. Scientific Reports. 2016;6. DOI: 10.1038/srep36074

15. Nielsen MMB, Lambertsen KL, Clausen BH, Meyer M, Bhandari DR, Larsen ST, Poulsen SS, Spengler B, Janfelt C, Hansen HS. Mass spectrometry imaging of biomarker lipids for phagocytosis and signalling during focal cerebral ischaemia. Scientific Reports. 2016;6. DOI: 10.1038/srep39571

16. Tsai YH, Bhandari DR, Garrett TJ, Carter CS, Spengler B, Yost RA. Skeletal muscle fiber analysis by atmospheric pressure scanning microprobe matrix-assisted laser desorption/ionization mass spectrometric imaging at high mass and high spatial resolution. Proteomics. 2016;16(11-12):1822-4. DOI: 10.1002/pmic.201500536

17. Khalil SM, Pretzel J, Becker K, Spengler B. High-resolution AP-SA/LUDT mass spectrometry imaging of Drosophila melanogaster. International Journal of Mass Spectrometry. 2017;416:1-19. DOI: 10.1016/j.ijms.2017.04.001

18. Kompauer M, Heiles S, Spengler B. Autofocusing MALDI mass spectrometry imaging of tissue sections and 3D chemical topography of nonflat surfaces. Nature Methods. 2017;14(12):1156-+. DOI: 10.1038/nmeth.4433

19. Kompauer M, Heiles S, Spengler B. Atmospheric pressure MALDI mass spectrometry imaging of tissues and cells at 1.4-mu m lateral resolution. Nature Methods. 2017;14(1):90-6. DOI: 10.1038/nmeth.4071

20. Vijayan V, Srinu T, Karnati S, Garikapati V, Linke M, Kamalyan L, Mali SR, Sudan K, Kollas A, Schmid T, Schulz S, Spengler B, Weichhart T, Immenschuh S, Baumgart-Vogt E. A New Immunomodulatory Role for Peroxisomes in Macrophages Activated by the TLR4 Ligand Lipopolysaccharide. Journal of Immunology. 2017;198(6):2414-25. DOI: 10.4049/jimmunol.1601596

21. Bhandari DR, Wang Q, Li B, Friedt W, Rompp A, Spengler B, Gottwald S. Histology-guided high-resolution AP-SMALDI mass spectrometry imaging of wheat-Fusarium graminearum interaction at the root-shoot junction. Plant Methods. 2018;14. DOI: 10.1186/s13007-018-0368-6

22. Desbenoit N, Walch A, Spengler B, Brunelle A, Rompp A. Correlative mass spectrometry imaging, applying time-of-flight secondary ion mass spectrometry and atmospheric pressure matrix-assisted laser desorption/ionization to a single tissue section. Rapid Communications in Mass Spectrometry. 2018;32(2):159-66. DOI: 10.1002/rcm.8022

23. Huber K, Khamehgir-Silz P, Schramm T, Gorshkov V, Spengler B, Rompp A. Approaching cellular resolution and reliable identification in mass spectrometry imaging of tryptic peptides. Analytical and Bioanalytical Chemistry. 2018;410(23):5825-37. DOI: 10.1007/s00216-018-1199-z

24. Khamehgir-Silz P, Schnitter F, Wagner AH, Gerbig S, Schulz S, Hecker M, Spengler B. Strategy for marker-based differentiation of pro- and anti-inflammatory macrophages using matrix-assisted laser desorption/ionization mass spectrometry imaging. Analyst. 2018;143(18):4273-82. DOI: 10.1039/c8an00659h

25. Pleik S, Spengler B, Bhandari DR, Luhn S, Schafer T, Urbach D, Kirsch D. Ambient-air ozonolysis of triglycerides in aged fingerprint residues. Analyst. 2018;143(5):1197-209. DOI: 10.1039/c7an01506b

26. Schaepe K, Bhandari DR, Werner J, Henss A, Pirkl A, Kleine-Boymann M, Rohnke M, Wenisch S, Neumann E, Janek J, Spengler B. Imaging of Lipids in Native Human Bone Sections Using TOF-Secondary Ion Mass Spectrometry, Atmospheric Pressure Scanning Microprobe Matrix-Assisted Laser Desorption/Ionization Orbitrap-Mass Spectrometry, and Orbitrap-Secondary Ion Mass Spectrometry. Analytical Chemistry. 2018;90(15):8856-64. DOI: 10.1021/acs.analchem.8b00892

27. Bader S, Gerbig S, Spengler B, Schwiertz A, Breves G, Diener M. Robustness of the non-neuronal cholinergic system in rat large intestine against luminal challenges. Pflugers Archiv-European Journal of Physiology. 2019;471(4):605-18. DOI: 10.1007/s00424-018-2236-7

28. Garikapati V, Karnati S, Bhandari DR, Baumgart-Vogt E, Spengler B. High-resolution atmospheric-pressure MALDI mass spectrometry imaging workflow for lipidomic analysis of late fetal mouse lungs. Scientific Reports. 2019;9. DOI: 10.1038/s41598-019-39452-3

29. Kadesch P, Quack T, Gerbig S, Grevelding CG, Spengler B. Lipid Topography in Schistosoma mansoni Cryosections, Revealed by Microembedding and High-Resolution Atmospheric-Pressure Matrix-Assisted Laser Desorption/Ionization (MALDI) Mass Spectrometry Imaging. Analytical Chemistry. 2019;91(7):4520-8. DOI: 10.1021/acs.analchem.8b05440

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