

## Title Page

### MassCore: Connecting Mass Spectrometry Core Facilities Across Austria

**Working subtitle:** A position paper on the mission, organisation, and value of mass spectrometry core facilities to collaboratively advance research and innovation across Austria

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## Abstract

Mass spectrometry (MS) is a cornerstone technology in modern life sciences, enabling major advances in proteomics, metabolomics, lipidomics, and related fields. As research questions increase in complexity and scale, MS provides the analytical depth, sensitivity, and versatility required to generate high-quality, reproducible, and data-driven insights.

However, growing demand for advanced instrumentation, rising operational costs, and the need for specialised expertise place increasing pressure on institutions. Fragmentation of resources, inconsistent cost models, and limited long-term funding strategies further constrain efficiency and accessibility. At the same time, the diversity of MS technologies and applications necessitates flexible, well-coordinated infrastructures that can adapt to different scientific contexts.

MS core facilities (CFs) sit at the nexus of these challenges, both contributing to their structural complexity and offering a pathway to their resolution. Their alignment with institutional frameworks is critical to improving access, sustainability, and efficiency. By combining advanced instrumentation with expert support, standardised workflows, and training, CFs translate technological capabilities into scientific output. Together with research groups, they operate along a continuum of innovation, application, and service, fostering collaboration while ensuring quality and reproducibility.

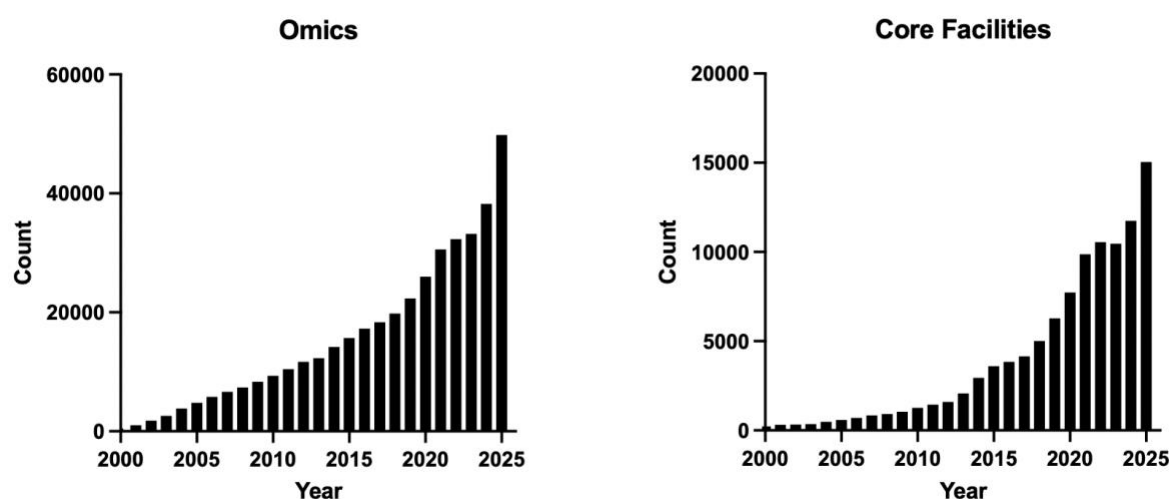
To fully realise the potential of MS-based research, clear responsibilities for instrument acquisition, maintenance, operation, and user access must be defined. Advancing the field requires sustained investment in analytical and computational infrastructure and personnel, transparent cost models, and performance metrics that balance quality, speed, and cost. Recognising these requirements, the MassCore Network was established to connect stakeholders across Austria, promoting essential knowledge exchange and strategic alignment. Strengthening such coordinated efforts provides the foundation for scientific excellence and reinforces Austria's position as a leading hub for MS-based research and innovation.

**Keywords:** instrument acquisition, infrastructure sustainability, workforce development, reproducibility, research governance, resource allocation, scientific coordination

## Main Text

### 1. Why mass spectrometry is important

Mass spectrometry (MS) has evolved from a specialised analytical technique into a cornerstone technology across modern science. Its ability to identify and quantify molecules and elements with high sensitivity, specificity, and speed enables discoveries across chemistry, biology, medicine, pharmacy, and environmental research. By providing molecular information across scales, from single atoms to entire proteomes, MS supports the elucidation of biological mechanisms, identification of drug targets, detection of environmental pollutants, and development of diagnostics and therapeutics. One of its most transformative impacts lies in the “omics” disciplines, including proteomics, metabolomics, lipidomics, glycomics, metallomics, and exposomics, which together link molecular composition to biological function and disease (see Box 1). The rapid expansion of these fields is reflected in a marked increase in annual publication output over the past two decades (**Fig. 1**), highlighting the growing reliance of modern research on MS-based analytical approaches and the increasing need for core facilities (CFs).



*Figure 1. Trends in annual publication counts for major omics-related research areas and core facilities (2000–2025). Results were retrieved from PubMed using keyword-based Boolean queries for omics-related fields (“proteomics”, “metabolomics”, “lipidomics”, “exposomics”, OR “glycomics”) AND core facilities (“core facilities” OR “research infrastructure”). All searches were restricted to the Title and Abstract fields.*

Box 1 | Mass spectrometry across omics disciplines

Mass spectrometry underpins a suite of complementary omics approaches that link molecular composition to environmental and biological function and disease. Together, these applications establish MS as a central technology in modern life-science research.

### **Proteomics**

MS-based proteomics enables high-throughput identification and quantification of thousands of proteins in complex biological samples. It is widely used to characterise signalling pathways, protein–protein interactions, and post-translational modifications, providing mechanistic insight into disease processes and enabling biomarker discovery and therapeutic target identification.

### **Metabolomics, lipidomics, glycomics**

In metabolomics, lipidomics, and glycomics, MS supports the detection and structural characterisation of both known and previously unknown small molecules. These measurements capture dynamic biochemical states and reveal subtle metabolic changes associated with physiology, disease, diet, and treatment response. Applications range from personalised medicine and clinical diagnostics to nutritional research and natural product discovery.

Glycomics could further link proteomics and metabolomics, as complex carbohydrates and glycan modifications regulate protein stability, cell–cell communication, and immune recognition. Thus, MS-enabled glycomic analyses are essential for understanding protein function, host–pathogen interactions, and therapeutic antibody activity.

### **Metallomics and speciation analysis**

MS-based metallomics enables the analysis of metal and metalloid species in biological and environmental samples. These approaches provide insight into essential and hazardous element bioavailability, homeostasis, metal–protein interactions, and trace element roles in health and disease, with applications in toxicology, environmental monitoring, and biomedical research.

### **Exposomics**

MS is increasingly central to exposomics, which aims to characterise the totality of environmental exposures across the lifespan. By detecting xenobiotics, pollutants, dietary components, and their metabolites, MS helps link environmental factors to disease risk and population health outcomes.

### **Impact of MS infrastructure**

Advanced MS platforms, which integrate multiple instruments and technologies within a single workflow, enable comprehensive multi-omics studies. Consequently, MS

infrastructure plays a critical role in scientific capability: institutions that invest strategically in MS platforms and expertise achieve greater visibility, higher publication output, and stronger competitiveness in international funding<sup>1</sup>; <sup>2</sup>.

Omics applications rely on complex analytical workflows integrating sample handling, compound separation, detection, and computational data processing and interpretation. MS measurements may be performed as targeted methods, enabling hypothesis-driven quantification of predefined analytes, or as untargeted, hypothesis-generating approaches, which comprehensively survey complex samples to reveal previously unknown compounds or molecular changes. The diversity of instrumentation, including various sample introduction systems, multiple ionisation methods, and a wide range of mass analysers, means that no single configuration can address all analytical questions. As research becomes increasingly interdisciplinary and data-intensive, the operational and analytical complexity of MS continues to increase.

The technological and analytical demands of modern MS increasingly extend beyond the capabilities of individual research groups without dedicated analytical expertise. Advanced instrumentation requires substantial financial investment, continuous maintenance, expert operation, and robust computational infrastructure to ensure data quality and reproducibility. In addition, experimental design and the interpretation of large multidimensional datasets necessitate specialised methodological knowledge and sustained bioinformatics support. Without coordinated expertise and infrastructure, efficient and equitable access to high-quality MS analysis becomes difficult to achieve.

MS CFs address these challenges by providing centralised access to state-of-the-art instrumentation, specialised expertise, and standardised analytical workflows. They support interdisciplinary collaboration, training, and method development while ensuring quality control and reproducibility across projects and user groups. By concentrating technical knowledge and operational and analytical expertise, CFs enable researchers from diverse disciplines to use advanced MS technologies reliably and efficiently, thereby amplifying scientific output and research impact across institutions.

For Austria, establishing and sustaining MS CFs represents a strategic investment in research capability and competitiveness. With a commitment to sustaining a strong educational backbone as a foundation and to supporting the development of excellent core facilities, Austria is positioned at the forefront of MS innovation. By ensuring reliable access to advanced analytical technologies and expert support, these infrastructures strengthen education, foster innovation, and enable participation in international collaborations and funding initiatives. Recent analyses<sup>3,4</sup> further highlight the translational momentum of MS technologies and the continued growth of MS-driven sectors, particularly in precision medicine, environmental health, and single-cell omics, illustrating how sustained investment in MS infrastructure contributes directly to innovation capacity and national competitiveness. Coordinated institutional support and oversight of MS infrastructure (for example, via a scientific advisory

board or user committee) not only advances scientific excellence but also supports societal and economic development through improved healthcare, environmental monitoring, and technological innovation.

## **2. Mass spectrometry core facilities – missions & values**

MS CFs are centralised research infrastructures with the mission to make complex MS technologies reliably usable across diverse disciplines by supporting users in the acquisition and interpretation of high-quality data.

Core facilities function as shared infrastructures that make advanced MS technologies accessible beyond individual research groups. By pooling instrumentation, technical expertise, and standardised workflows, they allow researchers with diverse scientific backgrounds and resources to obtain reliable analytical data without the need to independently establish and maintain specialised platforms, thereby reducing disparities in research capabilities<sup>5</sup>.

To accommodate varying institutional environments and research needs, MS CFs adopt different operational models, ranging from full-service analysis to open-access or hybrid approaches. The level of support provided depends on available staff expertise, institutional structures, and user requirements. Consequently, there is no single configuration that suits all facilities. Rather, the diversity of organizational models reflects the breadth of MS applications and allows each facility to focus on specific capabilities while maintaining structured access for its users. Ultimately, CFs put emphasis on sustainability, accessibility, transparency, and quality to provide structured access to technologies rather than primarily conducting independent research programmes.

In this respect, CFs differ from individual research laboratories, whose infrastructure is typically tailored to pursue specific scientific questions in depth rather than to provide broadly accessible analytical services. At the same time, the two operate along a continuum rather than as separate entities. Research laboratories drive exploratory method development and highly specialised applications, whereas CFs typically implement and stabilise established methodologies for wider use (further discussed in Section 2.3).

Specialised methods and workflows developed by MS-focused research groups often lay the foundation for their rollout as general and robust services provided by core facilities. Consequently, CFs and infrastructure-rich research laboratories should be regarded as highly complementary and interactive components of the research ecosystem, working hand in hand by linking technological innovation with broad scientific application.

### **2.1 Core Facilities as Technology Hubs: Institutionalising Quality and Reproducibility**

Core facilities are no longer auxiliary service units operating alongside research; they have evolved into institutional technology hubs that provide reliable access to increasingly complex analytical platforms<sup>6-8</sup>. Modern MS workflows generate large, heterogeneous datasets across diverse platforms and applications, introducing limitations related to measurement variability and reproducibility.

CFs mitigate these risks by implementing structured quality management practices, including calibration routines, quality control monitoring, and standardised data processing workflows. As emphasised by Chiva et al.<sup>9</sup>, proteomics facilities must provide robust and reproducible high-quality services while maintaining flexibility and platform diversity; similar requirements apply across metabolomics, lipidomics, and related analytical domains. Through harmonised protocols and validated procedures, CFs enable reliable comparison across studies and facilitate the translation of analytical findings into biological, clinical, and environmental interpretation. In addition, CF personnel contribute to study design, from initial experimental planning to pilot measurements, helping to match analytical strategies to biological and environmental questions and avoiding unsound study designs.

These practices are reinforced by community standards and coordinated initiatives. Global standardisation initiatives such as HUPO-PSI (Human Proteome Organization Proteomics Standards Initiative; <https://www.psidev.info>; Minimum Information About a Proteomics Experiment<sup>10,11</sup>) and broader data stewardship principles, including FAIR (Findable, Accessible, Interoperable, and Reusable<sup>12</sup>), establish reporting and data management expectations. Domain-specific efforts such as the Lipidomics Standards Initiative<sup>13</sup> (LSI) and the Metabolomics Quality Assurance and Quality Control Consortium<sup>14,15</sup> (mQACC) further promote cross-laboratory comparability. Cross-laboratory comparability also requires benchmarking inter-laboratory variability and harmonised data alignment and processing workflows to minimise batch effects and data silos. By implementing and maintaining these frameworks, CFs enable reliable comparison of datasets across projects, laboratories, and time, thereby supporting collaborative studies, long-term data reuse, and consistent interpretation, as highlighted by Restivo et al.<sup>7</sup>. Initiatives such as the European Quality In Preclinical Data (EQIPD) Memorandum of Understanding illustrate how shared standards of practice between facilities and users can strengthen accountability and data reliability. By validating and standardising emerging analytical approaches, CFs translate methodological advances into robust workflows that can be applied reproducibly by a broader research community. Implementing these principles also requires dedicated personnel and institutional computational and data-management infrastructure.

## 2.2 Core Facilities as Educational Providers and Institutional Pillars

MS CFs are not passive providers of technical capabilities; alongside MS research groups, they support the development of technical competence within the research community<sup>16</sup>.

This role depends on institutional goals and priorities and spans multiple technological layers, from sample preparation methods to MS operation and data interpretation. MS CFs can instruct users on appropriate instrument operation and critical data quality assessment. They often

integrate user engagement into routine operation by helping researchers design experiments. CF personnel assist users in troubleshooting, in interpreting analytical results, and in translating methodological knowledge into practical research competence. Such integrated training programmes and hands-on guidance have been shown to improve experimental rigour and research outcomes<sup>17,18</sup>. Through this continuous interaction, CFs disseminate methodological expertise across disciplines and support the adoption of advanced analytical approaches.

CFs, however, complement rather than replace formal academic teaching. Their primary role is technology-oriented training and consultation for active research projects, whereas university courses and research laboratories provide broader scientific education including theoretical background and in-depth discipline-specific instruction. In particular, structured teaching for large student cohorts and comprehensive curricular training typically exceeds the operational scope of CFs. MS-based research laboratories and their teaching staff, therefore, remain the backbone of education, providing the training capacity and support for the development of future specialists. That said, in many institutions CF staff are also partly affiliated with, for example, faculty departments and contribute to curricular teaching.

Over time, CFs also function as repositories of institutional knowledge. By maintaining validated workflows, documentation, and metadata across multiple research projects and staff generations, they preserve technical expertise that might otherwise be lost through personnel turnover. This continuity stabilises long-term projects, supports multi-laboratory collaborations, and enhances reproducibility in longitudinal studies<sup>7,19</sup>. In this way, CFs not only train individual users but also sustain technological competence at the institutional level.

### 2.3 Operational Models and Strategic Alignment

Modern MS research spans a continuum of scientific objectives, ranging from the development of new analytical technologies to their standardised application in large and diverse user communities. These objectives impose fundamentally different operational requirements. Method development demands unrestricted instrument access, flexibility, and tolerance for experimental failure, whereas standardised analytical services require structured workflows, defined access procedures, and quality control. Attempting to meet all these goals within a single organizational substructure often leads to conflicts over instrument availability, staffing priorities, and performance expectations.

To address these differing needs, institutions typically rely on distinct but interconnected operational models (**Table 1**). Independent methodology-oriented research groups primarily advance MS technologies and explore novel analytical approaches. Core facilities, in contrast, provide standardised, validated workflows and broad access to technologies, ensuring reliability and reproducibility across diverse projects. At the intersection, both core facilities and research groups share roles and can adapt and develop methods to address specific scientific or clinical questions, often in collaborative settings. Together, these models form a functional continuum from innovation to routine application.

The effectiveness of this structure depends on clear institutional alignment. Each model requires different evaluation criteria, staffing strategies, and access policies. Confusion between their roles can lead to inefficiencies, for example, expecting service-level throughput from research laboratories or research-level flexibility from CFs. Defining responsibilities for instrument acquisition, maintenance, operation, and user access therefore allows institutions to support scientific creativity while maintaining operational sustainability.

Establishing transparent governance and communication between these operational models enables knowledge transfer while preserving their distinct functions. When appropriately coordinated, methodological advances developed in research laboratories can be stabilised in applied platforms and subsequently implemented in core facilities as broadly accessible workflows. In this way, organizational differentiation does not fragment infrastructure but instead creates a pathway through which technological innovation becomes reproducible scientific practice.

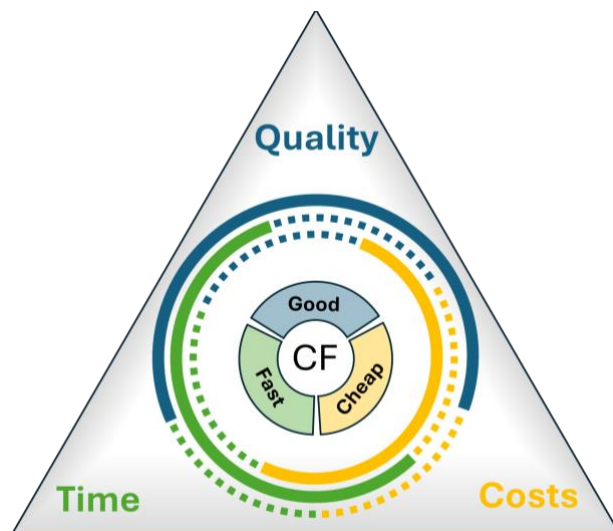
**Table 1. Distinct operational models in a mass spectrometry ecosystem.** Modern MS infrastructures span a continuum from methodological innovation to standardised service provision. Each model fulfils a specific and complementary function and therefore requires different access policies, evaluation criteria, and organizational structures.

|                               | <b>Independent<br/>methodology-oriented<br/>research groups</b>                                                                                                                                 | <b>Intersection (can<br/>be covered by<br/>both)</b>                                                                | <b>Core facilities</b>                                                                                                                            |
|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Core<br/>competence</b>    | Technology invention<br>and conceptual<br>development, innovation<br>hub                                                                                                                        | Technology<br>adaptation to<br>defined research or<br>clinical problems                                             | Standardisation and<br>broad access to<br>established technologies                                                                                |
| <b>Typical<br/>activities</b> | Development of new<br>hardware configurations,<br>acquisition strategies,<br>computational tools.<br>Optimisation according<br>to the needs of the<br>research field. Education<br>and training | Collaborative<br>projects, feasibility<br>testing, specialised<br>assays, method<br>development and<br>optimisation | Routine measurements,<br>implementation and<br>validation of workflows,<br>user training and<br>consultation, quality<br>control, data processing |

|                                          |                                                                                 |                                                             |                                                                                                                        |
|------------------------------------------|---------------------------------------------------------------------------------|-------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| <b>Instrument access model</b>           | Investigator-driven, ideally unrestricted access for continuous experimentation | Shared or project-based access, often jointly managed       | CF staff-operated, scheduled and regulated access only under defined procedures and quality control (QC) protocols     |
| <b>Primary evaluation metrics</b>        | Novel methodologies, high-impact publications, patents, trained experts         | Collaborative grants, project outcomes, technology transfer | Utilisation, throughput, turnaround time, consistent data quality, user satisfaction, and number of supported projects |
| <b>Typical funding / ownership model</b> | PI-led research grants<br><br>strategic institutional investment                | Collaborative<br><br>strategic institutional investment     | National infrastructure grants, service cost recovery<br><br>strategic institutional investment                        |

### 3. Requirements for successfully running MS CFs that support cutting-edge science

The successful operation of an MS CF requires balancing competing operational priorities. As illustrated by a modified Barnes Iron Triangle in project management<sup>20</sup> (**Fig. 2**), analytical quality, turnaround time, and cost are interdependent objectives; changing one will inevitably affect at least one of the others. High-quality analytical results require sufficient instrument availability, dedicated staff effort, and time for calibration and quality control, whereas pressure to increase throughput or minimise costs can compromise performance. The benefits associated with CFs do not arise automatically from the presence of instrumentation but depend on specific operational conditions.



*Figure 2. Modified Barnes Iron Triangle for MS core facilities illustrating the “good–fast–cheap” trade-off: prioritising analytical quality (good, blue line), turnaround time (fast, green line), or cost (cheap, yellow line) typically limits the others (corresponding dotted lines), as shown by way of example for specific CF set-ups (shown as the different layers of circles).*

Meeting these demands requires coordinated technical and organizational support. CFs must provide reliable analytical workflows, ensure appropriate allocation of resources, and operate within structures that allow planning, maintenance, and user consultation. Because MS applications span diverse methodological domains and sample types, facilities often develop areas of specialisation, and performance must be interpreted in relation to the scientific scope of each facility rather than by uniform expectations alone.

Accordingly, the effective operation of MS CFs rests on three interdependent pillars: advanced instrumentation, skilled personnel, and sustained institutional commitment. The following sections outline these requirements and describe how they jointly enable CFs to support high-quality, reproducible, and sustainable research.

### 3.1 State-of-the-Art Instrumentation: A Foundation for High-Impact Research

Regular investment in advanced MS instrumentation is essential for CFs to support cutting-edge research across universities and research institutions. MS technologies evolve rapidly, and analytical platforms require periodic renewal to maintain performance and address emerging scientific questions. Effective facilities, therefore, combine highly specialised instruments for advanced applications with robust routine platforms that serve a broad and diverse user community. CFs are highly effective at maximising instrument lifecycles by dedicating platforms to different applications. The newest systems support demanding and competitive research areas, while older instruments often remain ideal for robust routine analyses where ultimate sensitivity is less critical.

However, acquiring instruments alone does not create a functional research infrastructure. The value of MS platforms depends on skilled operation, supported by preventive maintenance, service contracts, and planned replacement cycles. Without such sustained operational support, increased downtime and delayed repairs can compromise analytical quality and restrict user access. Transparent access rules and appropriate cost structures help ensure that instruments remain available to a wide range of users, including early-career researchers. Rapid and predictable access to routine analyses is scientifically important, as many experimental workflows depend on iterative measurements and fast processing of time-sensitive samples.

Modern MS instruments also depend on surrounding technical ecosystems. Automated sample preparation systems, bioinformatics environments, high-performance computing, and data storage resources form integral components of analytical workflows rather than optional additions. Increasing data volumes and emerging AI-supported analytical approaches further increase demands on data storage, computational capacity, and data-analysis expertise. These systems also require specialised personnel to ensure reproducible workflows, e.g., data stewards, but also dedicated technical support for long-term operational repeatability. Integration with these complementary infrastructures enables standardised data processing, scalable analyses, and reproducible results across projects and users.

At the same time, access to high-end instrumentation is essential for fundamental research, and service-oriented use must be organised in a way that preserves access for research-intensive applications and laboratory-based innovation. In some cases, this requires a deliberate structural separation between academic and educational training functions and service-oriented operations, in order to balance training needs with high-performance research demands.

### 3.2 Staff Expertise: The Cornerstone of Core Facility Success

The effective operation of an MS CF depends on highly trained, dedicated personnel with specialised technical and domain-specific expertise and extensive hands-on experience. Such expertise ensures continuity of operation and reliable service provision.

MS analyses require method- and sample-specific knowledge across diverse applications and matrices. Even when using similar instrumentation, different analytical workflows demand tailored configurations, calibration strategies, and quality control procedures. Consequently, CFs often develop areas of specialisation shaped by staff expertise and sustained professional development.

CF personnel therefore perform functions extending well beyond routine instrument operation. They maintain analytical performance, develop or implement new methods, establish quality control procedures, troubleshoot technical issues, advise on experimental design, and assist in data interpretation to ensure reliable results. Beyond the scientific or technical roles, CFs carry the burden of financial responsibilities such as accounting and cost calculations, non-scientific institutional roles such as room adaptations, and organizational activities such as information

seminars. Continuous professional training and participation in scientific exchange are necessary to keep pace with evolving analytical technologies and data-processing approaches<sup>21,22</sup>. Notably, interaction with independent methodology-oriented research groups provides an excellent local environment for exchange and training of current and future CF personnel.

Because this expertise is cumulative and long-term, MS CFs depend on stable professional positions rather than short-term academic staffing. Distinct career paths, recognition of professional roles, and opportunities for ongoing development are therefore essential to retain qualified personnel and preserve institutional competence. Coordinated initiatives across facilities can further support staff development through shared training, staff exchange, and structured knowledge transfer.

CF activities extend beyond measurement throughput. Considerable effort is devoted to experimental planning and consulting meetings, method development and adaptation, data evaluation, and troubleshooting, as well as manuscript contributions and review activities – tasks that are not directly reflected in instrument booking time but are essential for producing reliable scientific results. Evaluating facility capacity solely by instrument utilisation therefore underestimates the actual workload and expertise required for MS-based research support. Formal recognition of these contributions in publications can further strengthen staff motivation and long-term retention.

### 3.3 Institutional Commitment to CFs for Sustainable Development

The sustainable operation of MS CFs depends not only on advanced instrumentation and specialised staff expertise but also on long-term institutional commitment. Universities increasingly treat CFs as research infrastructure that benefits from strategic planning rather than short-term project support. Analyses of research technology platforms across Europe indicate that stable institutional support strengthens operational reliability and contributes to the performance and attractiveness of research environments<sup>23</sup>.

From this perspective, financial planning can consider the full lifecycle of facility operation. Beyond initial acquisition, substantial recurring costs arise from staffing, maintenance and service contracts, data handling, quality assurance, and planned instrument renewal. Making these costs transparent enables realistic budgeting and reduces the risk of interruptions caused by ageing equipment or unstable personnel support. Because these obligations persist independently of individual projects, sustainable operation often depends on a degree of institutional support rather than solely on time-limited grants or service income, a consideration relevant for both core facilities and infrastructure-intensive research laboratories. User fees may contribute to operational expenses, but the extent of cost recovery can be determined strategically by each institution within its broader research and funding framework. In this context, institutions also require appropriate criteria to assess operation and guide planning; complementary performance indicators can support such evaluation (Box 2).

Institutional integration is equally important. CFs should be embedded in governance and strategic decision-making processes related to infrastructure planning and research priorities. Efficient operation of CFs further depends on strong institutional support structures, including access to expertise in finance, information technology (IT), facility management, procurement, and human resources. Recognising CF personnel as professional scientific staff rather than purely service providers enables appropriate staffing structures, career stability, and retention of expertise. Such integration also provides protected resources for method implementation, quality monitoring, and consultation activities that cannot be sustained through project funding alone.

Collaborative structures and coordinated initiatives across institutions can further facilitate sustainable operation. Participation in national and international networks enables the exchange of operational experience, development of shared standards, and coordinated professional development, all of which have been shown to strengthen the resilience of research infrastructures<sup>24</sup>. Institutional support for engagement in such initiatives allows facilities and research groups to contribute to and benefit from collective expertise, improve communication with administrative and leadership levels, and promote compatible practices across institutions. In Austria, organisations such as the Austrian Proteomics and Metabolomics Association (APMA) provide a platform for this dialogue and coordination, connecting CFs, applied research platforms, and independent methodology-oriented research groups.

Table 2. Practical institutional measures supporting the sustainable operation of MS core facilities

| Area                          | Suggested institutional actions                                                                                             |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------|
| <b>Strategic recognition</b>  | Define MS CFs as research infrastructure within institutional strategy and long-term planning.                              |
| <b>Infrastructure funding</b> | Provide recurring funding for instrument replacement, service contracts, and operational costs beyond project-based income. |
| <b>Staffing</b>               | Establish stable professional staff positions and career paths for CF personnel.                                            |

|                                         |                                                                                                                                                                                      |
|-----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Staff development</b>                | Support training, conference participation, and knowledge exchange between facilities.                                                                                               |
| <b>Governance integration</b>           | Include CF representation in infrastructure planning and research strategy discussions. Clearly define the roles and responsibilities of CF management and user steering committees. |
| <b>Access and service structure</b>     | Maintain transparent access rules, fair cost models, and support for early-career researchers.                                                                                       |
| <b>KPIs and standards</b>               | Support implementation of KPIs, standardised workflows, and community reporting standards.                                                                                           |
| <b>Data and digital infrastructure</b>  | Provide access to bioinformatics, data storage, and computational resources required for MS workflows.                                                                               |
| <b>Inter-institutional coordination</b> | Encourage collaboration and exchange of best practices across national facilities and networks.                                                                                      |

### Box 2 | Monitoring core facility performance: examples of practical indicators

Mass spectrometry core facilities differ in scientific scope, size, and operational model; consequently, no single metric adequately reflects their performance. Quantitative indicators are most informative when interpreted in the context of a facility's mission and specialisation. Rather than ranking facilities, performance monitoring should provide orientation for users, facility staff, and institutional leadership, and support informed planning and resource allocation<sup>25,26</sup>.

#### **Operational activity**

Indicators describing accessibility and utilisation of the facility:

- instrument utilisation time or booking occupancy

- number of active users and supported research groups
- number of projects processed
- turnaround times for routine analyses

### **Service quality**

Indicators reflecting reliability and user experience:

- instrument uptime and maintenance-related downtime
- adherence to standardised quality control procedures
- occurrence of remeasurements or troubleshooting runs
- analytical reproducibility across runs, batches, and time
- data quality metrics and completeness of QC documentation
- structured user feedback or satisfaction surveys

### **Scientific contribution**

Indicators describing integration into research activities:

- collaborative publications involving CF staff
- acknowledged participation in study design, data analysis and interpretation
- grant applications or collaborative projects supported by CF staff
- datasets published on open repositories
- adherence to data stewardship, repository, and documentation standards

### **Sustainability and development**

Indicators reflecting long-term operational health:

- staff training and professional development activities
- development/implementation of new analytical workflows
- technology upgrades and modernisation
- staff retention and knowledge continuity

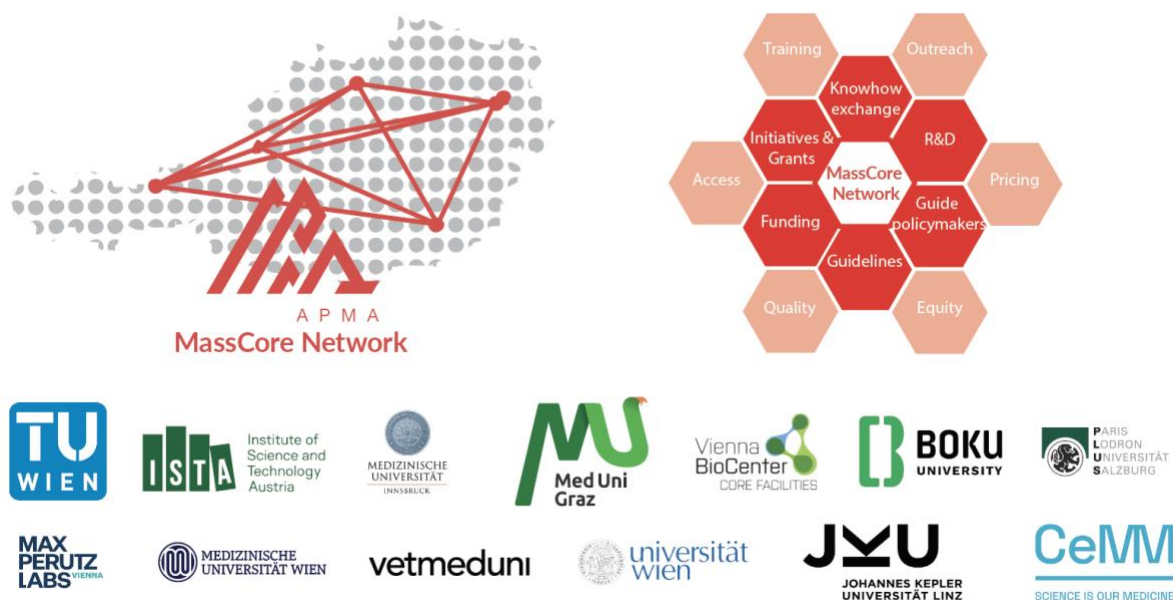
No single indicator is sufficient on its own. Meaningful evaluation requires combining operational, scientific, and developmental perspectives while considering the individual role and specialisation of each facility.

## **4. MassCore Network: Strengthening Austria's MS CFs Through Collaboration, Coordination, and Shared Expertise**

National and regional coordination networks can provide a practical framework for connecting distributed MS infrastructures while preserving local specialisation and institutional autonomy.

MassCore is Austria's national network connecting mass spectrometry core facilities located in Graz, Innsbruck, Klosterneuburg, Linz, Salzburg, Tulln, and Vienna (**Fig. 3**) within the framework of the Austrian Proteomics and Metabolomics Association (APMA). The network provides a structured platform for exchange among facilities, enabling communication between facility staff, researchers, and institutional stakeholders and offering a central point of orientation for users seeking expertise and services in MS-based research (<https://www.apma.at/apma-masscore/>).

The need for such coordination arises from the distributed nature of MS infrastructures. Individual institutions operate facilities with different capacities, specialisations, and resource constraints, while research projects frequently extend across institutional boundaries. A national network therefore does not replace local facilities but can enable system-level knowledge exchange and coordination that individual facilities and institutions cannot achieve independently, a challenge shared by many distributed research infrastructures. By coordinating information on capabilities, demand, and development needs across institutions, the network can also support evidence-based planning and investment decisions at the university and funding-agency level.



*Figure 3. The MassCore Network. Schematic of roles and participating institutions across Austria.*

Mass spectrometry facilities are not interchangeable units. Distinct analytical approaches and sample types impose distinct methodological requirements, often necessitating tailored workflows and instrument configurations even when comparable platforms are employed. As a result, facilities naturally develop areas of specialisation shaped by staff expertise, local research priorities, and accumulated experience. Far from representing redundancy, this diversity is a functional feature of the research infrastructure, fostering complementary

capabilities across institutions and ensuring that researchers can access the expertise most appropriate for their scientific questions.

Importantly, the network recognises that MS core facilities and research-based MS laboratories operate along a continuum rather than as separate or competing entities. By integrating these perspectives, MassCore can support alignment between service-oriented facilities and investigator-driven research laboratories and can facilitate the transfer of emerging methodologies into routine analytical pipelines.

One central contribution of the network is the exchange of expertise. Joint training initiatives, shared workshops, staff knowledge exchange, and communication on emerging technologies can help maintain high levels of competence across sites and reduce disparities between institutions. Such an exchange allows facilities to benefit from distributed expertise and shared experience while avoiding unnecessary duplication of specialised knowledge.

The network can also facilitate informed infrastructure planning. Because MS technologies evolve rapidly and require substantial investment, isolated procurement decisions may lead to gaps in capability in some areas and overlap in others. By sharing information on existing capacities, methodological developments, and user needs, the network can provide orientation for institutional planning and help institutions assess where local accessibility is important and where complementary capabilities may already exist elsewhere. Decisions on procurement and resource allocation remain with the respective institutions.

Administrative practices represent another area where dialogue is beneficial. Differences in cost accounting and pricing models can hinder cross-institutional collaboration and shared access. The MassCore Network can provide a forum for discussion of access rules, service structures, and financial approaches in exchange with institutional leadership and administrative departments. Such communication supports transparency and mutual understanding while respecting institutional autonomy.

Through these activities, the network functions as a professional platform for communication and consultation. Its advisory role could be important for decision-makers within universities as well as for bodies beyond them. By linking facilities, sharing operational experience, and providing a point of contact for stakeholders, MassCore supports institutions in developing compatible practices where appropriate while preserving local scientific priorities. In this way, the network contributes to maintaining advanced analytical capabilities and facilitating cooperation without replacing institutional responsibilities, providing a potentially transferable model for coordination across distributed MS infrastructures.

## **5. Conclusion**

MS CFs are increasingly central to modern life-science research, providing access to advanced technologies, specialised expertise, and reproducible analytical workflows. Their long-term effectiveness depends not only on instrumentation but also on appropriate governance, sustainable funding, skilled personnel, and institutional integration.

As MS-based research becomes more data-intensive, computational infrastructure, data storage, and data-analysis expertise are becoming increasingly important components of these environments. At the same time, coordination between facilities, research groups, and institutions can support the exchange of expertise, informed infrastructure development, and the complementary use of specialised capabilities without imposing uniform operational models.

Continued investment in personnel, analytical and computational infrastructure, training, and coordination will be important to sustain high-quality MS research and maintain competitiveness in a rapidly evolving technological landscape.

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