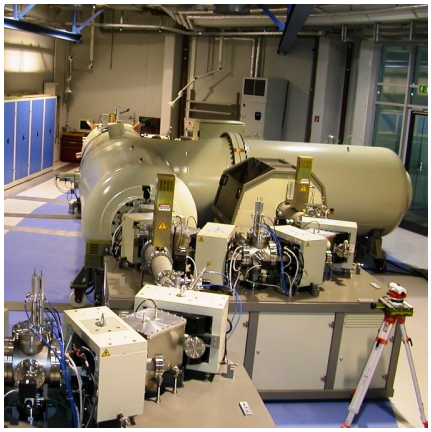
CologneAMS Newsletter special

Three Million Volt



The Institute for Nuclear Physics of the University of Cologne has purchased the Tandetron model 4130 from Max-Planck Institute for Biogeochemistry Jena (MPI). With the new 3 MV AMS system new isotopic ratio measurements can be enabled and it provide access to state of the art developments. The system could be used for Nuclear Waste Management measurements of isotopes, which are difficult to measure with liquid scintillation counting, e.g. ^{3}H, ^{14}C, ^{36}Cl, ^{41}Ca and ^{55}Fe, and for the novel ion beam cooler isobar suppression technique, to detect ^{90}Sr in the sub-Bq range.
Picture: 3 MV accelerator Jena[1].

— Markus Schiffer

A new 3 MV AMS System for CologneAMS

The Max-Planck Institute for Biogeochemistry Jena (Germany) had used a 3 MV HVEE (High Voltage Engineering Europe) AMS system for ^{14}C measurements, since 2003 [2]. In 2017 they have installed a new MICADAS AMS system to increase the efficiency of radiocarbon measurements with the same isotopic background as at the 3 MV machine [3].

The complete 3 MV AMS System was sold on October 18th in two separated units at the electronic vendue platform of the federal government of Germany, VEBEG GmbH. The Institute for Nuclear Physics (IKP) of the University of Cologne has purchased the Tandetron model 4130 including the main components of the high energy mass spectrometer; the quadrupole doubled lens, the 110° analyzing magnet and the 33° electrostatic analyzer, for 1570.92 €. The SF_6 gas system was purchased beforehand and will allow an independent installation of the accelerator in the IKP. The Institute for Ion Beam Physics and Material Research of the Helmholtz Center Dresden Rossendorf (HZDR) has purchased the components of the injector and the last 90° magnet. The complete setup at the Max-Planck Institute for Biogeochemistry Jena is shown in figure 1.

The Recombinator

The principal of simultaneous isotope injection by the use of a recombinator was developed to measure the stable ion beam and the radionuclide with the same influences of the entire accelerator system. A first-generation recombinator became operational in 1984[4] and sophisticated versions of these devices are still in use today[5].

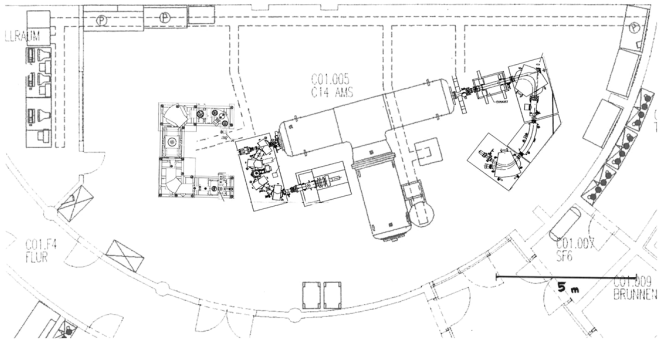


Figure 1: *Jena AMS system: recombinator: 4×45° magnets, Tandetron model 4130: terminal voltage 3 MV, high energy mass spectrometer: 110° analyzing magnet, 33° electrostatic analyzer, 90° magnet, two anode gas ionization counter[6, 7, 8]. Shown is also the new MICADAS AMS system [3].*

The Accelerator

The HVEE 3 MV Tandetron 4130 accelerator is furthermore used at the National Ocean Sciences AMS Facility at Woods Hole, Massachusetts, USA[6] and the Leibniz-Laboratory for Radiometric Dating and Stable Isotope Research, Christian-Albrechts-University Kiel, Germany[5]. The accelerator is designed in a T-shaped geometry with a SF_6 isolated pressure tank. Operation conditions are 700 kPa of SF_6 for 2.5 MV terminal voltage for the measurement of C^{3+} ion beams.

The system was designed for high current ion beams for implantations, activations and other ion beam techniques. A parallel-fed Cockkroft-Walton power supply, driven by 50 kHz, is used for the high voltage generation. The terminal voltage is stabilized by a generating volt meter or by slit feedback signals from the stable iso-

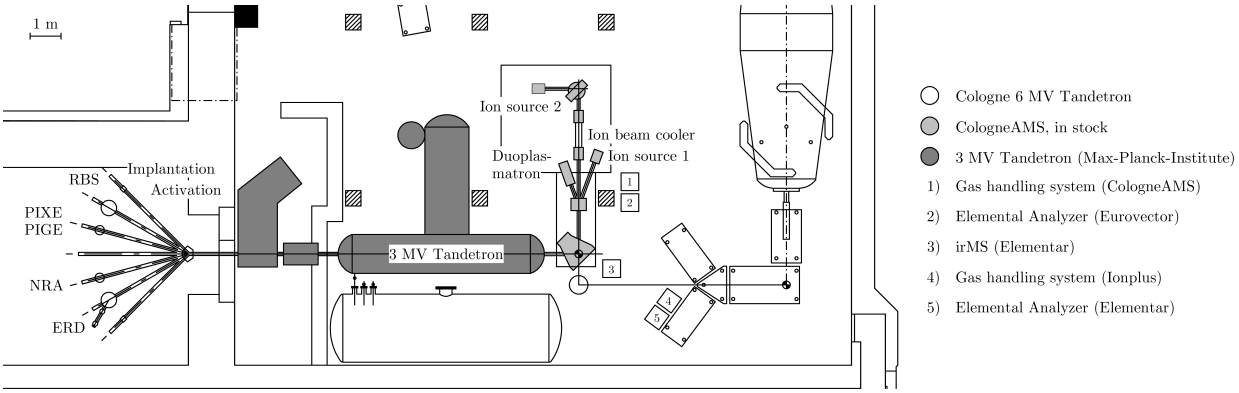


Figure 2: *One possible opportunity for the set-up of the new 3 MV Tandetron accelerator in the second basement of the accelerator building (Institute for Nuclear Physics, University of Cologne). Shown are the new components from the MPI (dark gray), the available components of the IKP (light gray) and ion beam lines for future applications; e.g. RBS, PIXE, PIGE, NRA and ERD.*

tope ^{13}C ion beam. The voltage ripple is reported to be lower 40 V[9].

For the stripping process an Ar gas stripper is used with a circulation pumping unit and differential pumping units at each end of the stripper baffle[9]. Electrons and particles from charge changing processes or collisions with electrode surfaces are suppressed by the inclined electrostatic field structure of the acceleration tubes and by magnetic suppressors[6, 7].

The High Energy Mass Spectrometer

On the high energy side an electrostatic quadrupole doublet focus the ion beam to the object slits in front of the double focusing 110° magnet. Two offset Faraday-cups for the measurement of ^{12}C and ^{13}C are mounted at the focal plane, as well as image slits for ME/q^2 selection. For E/q selection a 33° electrostatic analyzer is used to select a M/q value. The last double focusing 90° magnet is used to suppress particles, which are scattered from the surface of the electrostatic analyzer and to suppress the background by charge changing processes. This magnet is essential for the use of simultaneous isotope injection with the recombinator, because of background generated by stable isotopes[6]. For the sequential injection with a fast switching injector this can be overcome by synchronize the data acquisition with the injection process.

Opportunities for CologneAMS

The installation of the new 3 MV AMS system at the IKP could open up a wide range of applications. A large part of the beamtime could be used for nuclear waste management measurement, as the FORKA C14-AMS project for quantification of ^{14}C content in reactor graphite by use of the CologneAMS gas-handling system.

One possibility for the set-up of the new 3 MV Tandetron accelerator is parallel to the SF_6 storage tank in the second basement of the accelerator building, see figure 2. This opens two opportunities: (i) to couple the new injection system additionally to the 6 MV AMS System and (ii) to build up new beamlines for future applications in the neighboring hall, e.g. Rutherford backscattering (RBS), proton induced x-ray emission (PIXE), proton induced gamma emission (PIGE), nuclear reaction analysis (NRA) and elastic recoil detection (ERD), where high intense medium energy ion beams are needed. An attractive arrangement of components available at the IKP uses the 90° double focusing magnet from the new 100 kV accelerator and the 20° switching magnet of the duoplasmatron test bench. With this magnet different ion injection sources can be used: (a) one standard cesium sputtering ion source for solid and gaseous samples, (b) one duoplasmatron for He^- ions and (c) an ion beam cooler, for the development of chemical reaction suppression of isobars like ^{90}Zr for ^{90}Sr measurement [10] and for photo laser detachment of $^{26}MgO^-$ for $^{26}AlO^-$ injection[11].

by MARKUS SCHIFFER

Acknowledgement

We thank Dr. Axel Steinhof for his personal commitment to enable the purchase of the accelerator.

References

[1] Broschüre über das Max-Planck-Institut für Biogeochemie (2019)

[2] A. Steinhof, *Analysis of the background of the Jena ^{14}C-AMS facility*, Nucl. Inst. and Meth. B 331 (2014) 238-242.

[3] H.-A. Synal, M. Stocker, M. Suter, *MICADAS: A new compact radiocarbon AMS system* Nucl. Inst. and Meth. B 259 (2007) 7-13.

[4] J. R. Southon, D. E. Nelson, J. S. Vogel, *Injection systems for AMS: simultaneous versus sequential* Nucl. Inst. and Meth. B 52 (1990) 370-374.

[5] M.-J. Nadeau, A. E. Litherland, A. Rieck, P. M. Grootes, *Isotopic fractionation in recombinator based ^{14}C AMS measurements: how can we live with it?*, Nucl. Inst. and Meth. B 223-224 (2004) 346-352.

[6] K. H. Purser, T. H. Stick, R. K. Purser, *A precision ^{14}C accelerator mass spectrometer*, Nucl. Inst. and Meth. B 52 (1990) 263-268.

[7] K. H. Purser, *A high troughput ^{14}C accelerator mass spectrometer*, Radiocarbon 34 (1992) 458-467.

[8] S. Wijma, J. van der Plicht, *The Groningen AMS tandetron* Nucl. Inst. and Meth. B 123 (1997) 87-92.

[9] K. H. Purser, T. Smick, A. E. Litherland, R. P. Beukenes, W. E. Kieser, L. R. Kilius, *A third generation ^{14}C accelerator mass spectrometer*, Nucl. Inst. and Meth. B 35 (1988) 284-291.

[10] M. Martschini, Talk: "AMS of ^{90}Sr with ILIAMS", DPG spring meeting, Rostock, Germany.

[11] M. Martschini, J. Pitters, T. Moreau, P. Andersson, O. Forstner, D. Hanstorp, J. Lachner, Y. Liu, A. Priller, P. Steier, R. Golser, *Selective laser photodetachment of intense atomic and molecular negative ion beams with the ILIAS RFQ ion beam cooler*, Nucl. Inst. and Meth. B 415 (2017) 9-17.