New Analyzing Magnet for the Tandem

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When HVEC designed the MP tandem the terminal voltage was only 10 MV, and the availability of heavy ions was limited to a few species before sputter sources were in use. For ions from this machine the mass energy product $M \cdot E/Z^2 = 200\ u \cdot MeV$ of the original analyzing system was sufficient, but with the tandem upgraded to 15 MV and with the extensive use of heavy ions the demand on beams with higher magnetic rigidity came up. An example: if we want to accelerate ^{197}Au ions to E = 180 MeV we can use 15 MV terminal voltage and the most probable charge state from the foil stripper Z = 11. With this combination the stripper yield is 17 % , but the mass energy product is 293, i.e. too much for the old magnet. With $M \cdot E/Z^2 = 200$ we had to choose charge state Z = 14 at 12 MV terminal voltage for the same energy, and then the efficiency was only 4 %.

Since long we considered to install a new magnet, but because of the high expenses the project was never carried out. However, when the Daresbury tandem accelerator was shut down we took the opportunity to acquire their analyzing magnet. Its specifications are (data of the old magnet in brackets):

Maximum Field $B_{max} = 1.6$ (1.55) T
Bending radius R = 1.65 (1.32) m
Pole gap h = 60 (41.3) mm
Mass energy product $M \cdot E/Z^2 = 336$ (200) $u \cdot MeV$

Both magnets are double focusing with 26.5° shim angles. The different sizes of the magnets and the use of the Daresbury magnet in vertical plane made some modifications of the analyzing system necessary:

First we had to construct a new support including its foundations and adjustment facilities. The beam lines on both sides of the magnet were completely reconstructed because the distance between the focus and the beam line intersection (bending radius R + focal length 2R = 3 R) has increased by 1 m. The slits are now on different positions, 1 m apart from the old ones. As shown in fig. 1 the quadrupole lens at the high energy end of the tandem and the Wien filter were moved as near as possible to the tank, nearly 1 m distant from their old positions. The devices formerly located between the tank and the quadrupole lens were removed: a valve which closes automatically in case of an accident inside the tank to prevent SF_6 escaping through the beam tube, an ion pump, a pair of slits, and a faraday cup. A 220 l/s ion pump (the same type as used in the dead sections), a faraday cup and a valve (special design, manufactured in our own workshop) were mounted inside the tank instead. The quadrupole lens between the analyzing magnet and the switching magnet in the first target room kept its old position. To fit the beam optics to the existing beam transport system we installed an additional quadrupole doublet 3.7 m downstream from the first one.

After some maintenance the power supply which came with the magnet worked properly. Unfortunately it is not one of the Danfysik series 8000, but an older type with analog voltage input/output for controlling and monitoring the output current. For the magnetic field control we purchased a Metrolab teslameter. The meter performs excellently, but we did not succeed to get the Metrolab control unit working reliably in connection with our control computer. So we assigned the control to a dedicated task in the control computer. If a new field parameter is entered the computer sets the power supply according to a table, then the control task reads the teslameter periodically and corrects for deviations from the set parameter by changing the current in the auxiliary coil of the magnet. If the auxiliary current reaches its limit (negative or positive) the main current is stepped (up or down) adequately.

We performed the installation of the magnet including the modifications of the beam line, the interfaces to the control system and the energy calibration [1] within the scheduled period. All systems work reliably. The weakest device in the high energy extension of the tandem is now the quadrupole lens with $M \cdot E/Z^2 \approx 300\ u \cdot MeV$. The mass energy product of the switching magnets is sufficient if the deflection angle is lower than 40°, and for most of the lenses in the beam transport system too. The appliance of two quadrupole lenses between the analyzing slits and the first switching magnet proved very worthwile: by splitting the focusing power in different portions one gets different magnifications, and so one can adapt the spot size and the beam divergence to the experimental necessities.

The old analyzing magnet will be used for a new experiment [2]. It is already in operation at its new destination.

References

[1] T. Faestermann *et al.*, this report, p. 4
[2] J. Besserer *et al.*, this report, p. 113