A NEW CYCLOTRON FOR BIOMEDICAL RESEARCH

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The Cancer Center has recently ordered a negative ion cyclotron model MC 21 NI from Scanditronix AB, Uppsala to replace the 20 year old AEG compact cyclotron (K=22, p, d, ^{3}He- and ^{4}He ions). Delivery is scheduled for September 1990.

THE CYCLOTRON

The machine is designed to accelerate negative hydrogen and deuterium ions from an internal dual ion source to 32 and 16 MeV, respectively. Extraction is based on the usual carbon foil stripper technique.

Rated energies and currents are:

- Protons: 15 - 32 MeV, 100 μA
- Deuterons: 8-16 MeV, 100 μA

A second beam exit port is provided.

The design is based on the proven multiparticle model MC40. Detailed data are given in the poster by R. Kjellström and J. Ahlbäck at this workshop.[1]

Facility Lay-Out

A sketch of the proposed installation is shown below. It will be located at the existing site and make use of the former beam line and water cooling components:

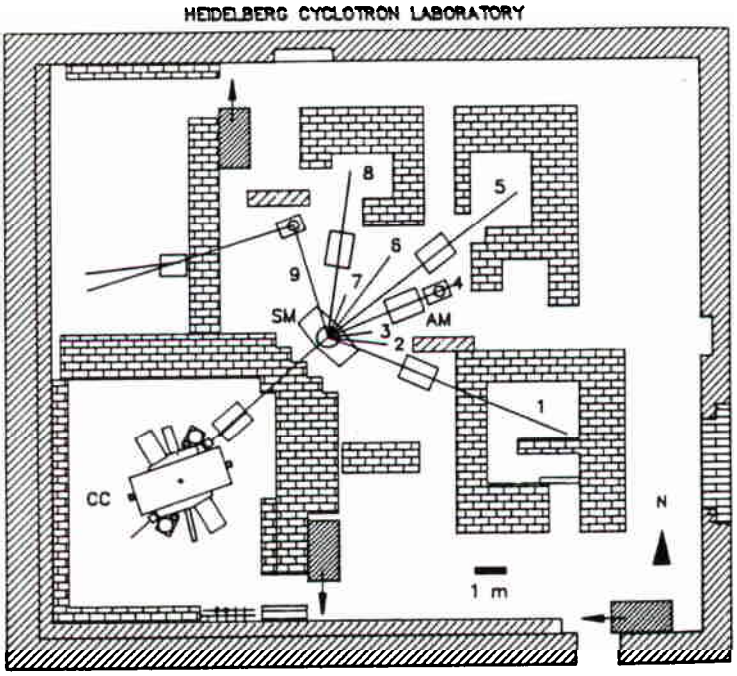

Figure 1 Proposed lay-out of the Heidelberg Cyclotron Laboratory with the new Scanditronix MC32 negative ion cyclotron. The beam line system uses the former components designed by AEG to guide K=22 particles, but still capable to handle 32 MeV protons and 16 MeV deuterons, too.

The arrangement and dedication of the targets are planned as follows:

Beam line no. (deflecting angle)	Purpose/ Nuclear Reactions
1(+65°)	experimental set-up, activations for wear measurements
2(+50°)	$^{14}N(d,n)^{15}O$
3 (+35°)	$^{14}N(p,a)^{11}C$
4 (+20°)	a) horizontal beam: multipurpose R & D b) vertical beam: meltable samples e.g. $^{10}B(d,n)^{11}C$, $^{76}Se(p,2n)^{75}Br$, $^{122}Te(p,n)^{121}I$, etc.
5 (+5°)	$^{20}Ne(d\alpha)^{18}F$-F_2 for diagnostic use (PET), 2 identical targets on revolving system
6 (-10°)	$^{20}Ne(d\alpha)^{18}F$-F2,R&D
7 (-25°)	$^{12}C(d,n)^{13}N$
8 (-50°)	$^{82}Kr(p,2n)^{81}Rb$ and other SPECT nuclides for clinical cooperative programs
9 (-65°)	$^{16}O(p\alpha)^{13}N$,$^{18}O(p,n)^{18}F$-F, etc on ladder type target changer

A second beam port will be installed when different radionuclides are needed simultaneously, for instance for the intramural PET program (e.g. ^{18}F + ^{13}N and/or ^{15}O) or to supply neighbouring radiological clinics.

THE PROGRAM

The rationale for selecting this type of accelerator with energies higher than the former AEG compact cyclotron (22 MeV p, 11 MeV d,...) is based on the expected demands of the current and the future research programs.[2] These include:

1. The routine daily production of positron emitters needed to label radiopharmaceuticals used in our PET studies as well as to support future regional PET installations.
2. We expect that more sophisticated labeling and purification procedures will increase the need of higher starting activities.
3. An increasing number of patient investigations at our Center (second PET system proposed) as well as in clinics in the area will require reliable delivery of radiopharmaceuticals. This means high reliability, especially of gas target operation which can be achieved by using thicker target foils and reducing the heat burden by higher energies (lower stopping power).
4. From basic PET studies, diagnostic procedures will be derived using single photon emitters which can be extended to clinical SPECT investigations. We like to be prepared for supplying such special nuclides (^{77}Br, ^{77}Kr, ^{81}Rb,...) to collaborating clinics.
5. Positron emitting radionuclides with longer half-lives and different chemical features (^{55}Co, ^{66}Ga, ^{75}Br, ^{121}I) will perhaps become relevant for PET studies of slow physiological processes. They have in part higher threshold energies than the usual short-lived isotopes.

CONCLUSIONS

The decision to select the Scanditronix MC 32 NI is based on the following considerations:

There is no need for very high beam currents, say > 100 μA, because we do not plan to produce huge amounts of radionuclides for commercial use. We believe that deuterons will continue to be necessary and advantageous for the production of certain chemical forms of radionuclides. It seems less complicated to us to convert a multiparticle positive ion cyclotron to a H^-/D^- machine than to redesign a pure H^- cyclotron (which we also considered seriously) in order to incorporate the D^- option.

In general, we believe that negative ion cyclotrons will be most suited to meet the demands of medical research and also commercial radionuclide production because they:

- are able to serve two simultaneous programs with two extracted ion beams (e.g. radiochemistry and fast neutron therapy) and
- reduce the risks of radiation burden to the operating staff as well as failure by not having an electrostatic deflector which is the most radioactive part in a positive ion cyclotron.

These advantages certainly outweigh the lack of Helium ions.

ACKNOWLEDGEMENTS

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REFERENCES

1. Kjellström, R., Ahlbäck, J.:MC 32 Multiparticle Negative Ion Cyclotron. This proceedings.
2. Wolber, G.:Ein neues Zyklotron für die medizinisch-biologische Forschung/A New Cyclotron for Biomedical Research. DKFZ Heidelberg, 1988.