

## PLANS FOR THE GERMAN NATIONAL NEUTRON THERAPY CENTRE WITH A HOSPITAL-BASED 70MEV PROTON CYCLOTRON AT UNIVERSITY HOSPITAL ESSEN / GERMANY

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High-LET hadrons have significant advantages in treatment of special tumour entities. 5 German neutron therapy centres of the seventies are now outdated because of deficiencies in neutron energy (tissue penetration) and technical features. Only the d(14)+Be isocentric neutron therapy facility in Essen is still working. To be comparable with the state-of-the-art in photon therapy Essen is designated to constitute the German National Neutron Therapy Centre based on a p(70)+Be cyclotron delivering neutrons with depth dose distributions comparable to 10 MV X-rays and having multi-leaf collimator and 360° rotation. Plans for this centre are presented which use existing installations as far as possible and add the capability for a proton therapy unit for eye tumours.

### 1 Introduction

Fast neutron cancer therapy has been carried out at five centres in Germany (Berlin/Dresden, Hamburg, Heidelberg, Essen, and Muenster) since 1972 using low energy cyclotrons and (d,T) neutron generators. These early attempts suffered more and more from insufficient technical properties in comparison to the continuously developing photon therapy, the most limiting factor being the rather crude target volume

mapping ability and especially the poor depth dose distribution [1]. This and a realistic evaluation of the accumulated experience of neutron therapy resulted in a clear declining but not in a vanishing of neutron treatments. At the moment only the cyclotron based d(14)+Be neutron therapy facility in Essen is still working due to its isocentric gantry, high neutron dose rate, and good reliability. However, treatment is restricted to superficial tumour sites (e.g. salivary gland tumours) because of low neutron energy.

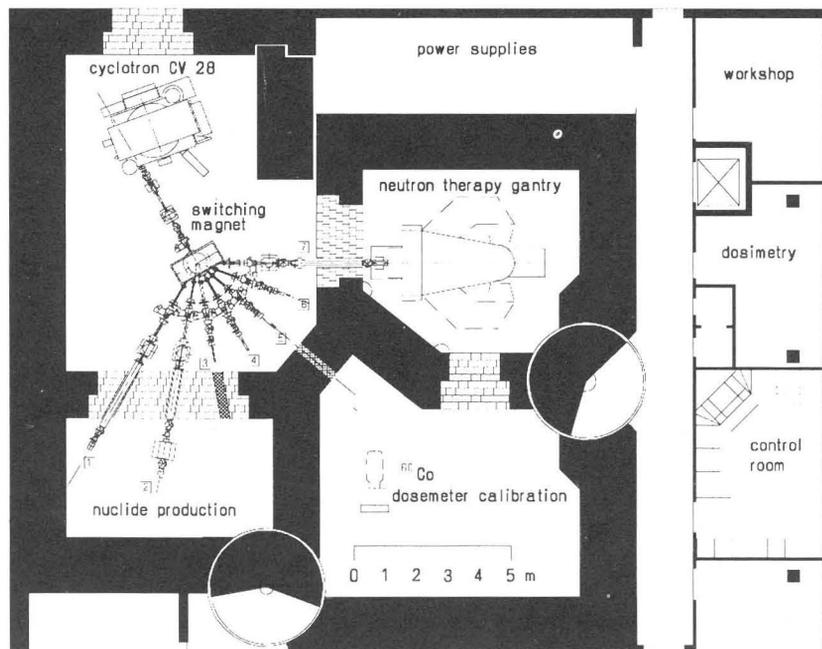


Figure 1: Present state of the Essen neutron therapy facility

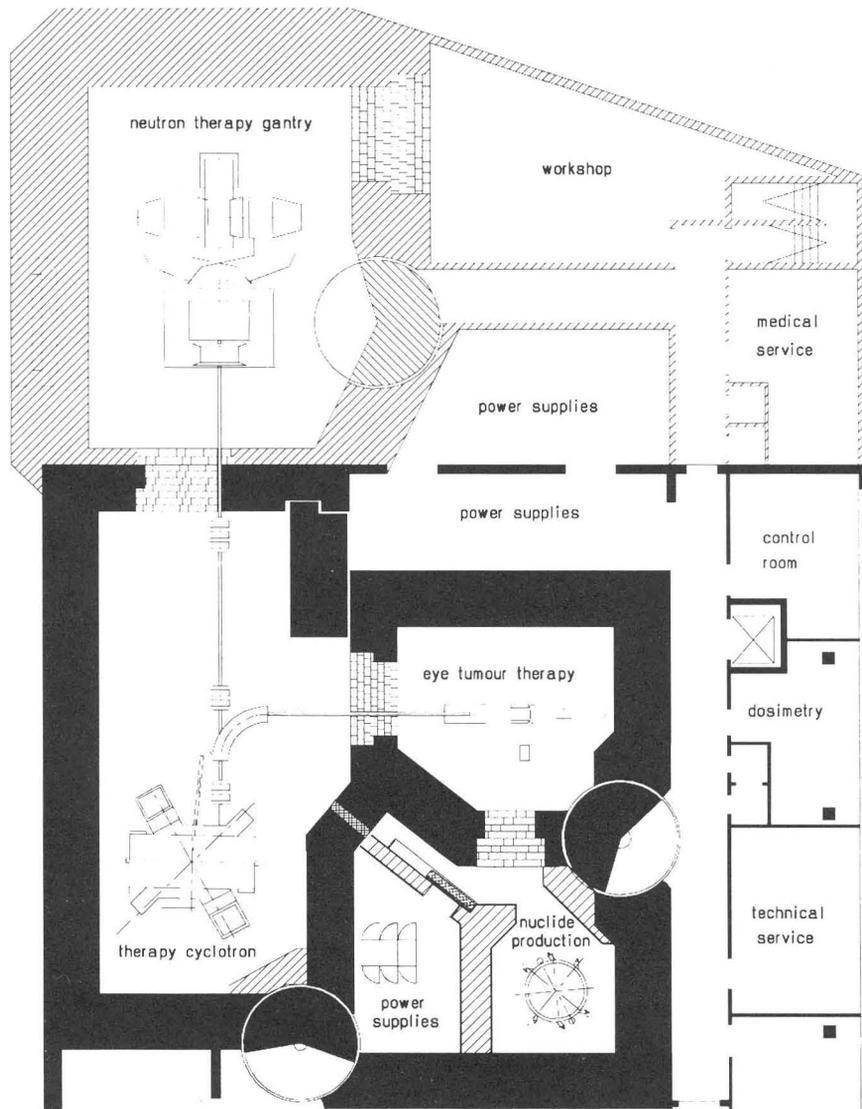


Figure 2: Proposal for a modernized neutron therapy facility

## 2 Indications for fast neutron therapy

Neutrons belong together with heavy ions to the densely ionizing (high Linear Energy Transfer) particles. Their effect in biological tissue is stronger and different from that of sparsely ionizing particles, like photons, electrons, or protons. This can be utilized for the treatment of tumours, which do not or badly respond to conventional radiotherapy. High LET particles may also be beneficial for the destruction of tumours with a high intracellular repair for radiation induced damage. Irradiation with high LET particles is advantageous in all cases where the relative biological effectiveness (RBE) for the tumour cells is greater than the RBE of the surrounding normal tissue cells which also receive the full tumour dose in the course of treatment.

In contrast to heavy ion therapy facilities which are regularly bonded to an existing big accelerator settled in a physical

research centre neutron therapy facilities have a size that allows their installation in a hospital.

Conservative evaluation of the worldwide experience, often achieved under non-optimum technical conditions, shows a secured indication for fast neutron therapy for the following specific tumour types:

- salivary gland tumours, especially adenoid-cystic carcinomas
- prostate carcinomas
- soft tissue sarcomas
- bone sarcomas like osteo- and chondrosarcomas
- pretreated recurrences.

The number of patients suffering from these diseases justifies the installation of one modern neutron therapy centre in Germany.

### 3 Technical realization

The planned neutron therapy centre should be installed in a hospital environment with both a conventional radiotherapy department and basic research institutes. The neutron therapy facility has to be compatible with the state-of-the-art of photon therapy. That means: To reach a depth dose distribution comparable to 10 MV X-rays a mean neutron energy of more than 25 MeV is needed. This can be achieved with a 70 MeV proton cyclotron which is commercially available irradiating a thin beryllium target. Moreover an isocentric gantry with 360° rotation and with multi-leaf neutron collimator and a suitable 3D treatment planning system are obligatory.

In the year 1996 the Deutsche Forschungsgemeinschaft (DFG) designated Essen to constitute the German National Neutron Therapy Centre.

Figure 1 shows the state of the Essen neutron therapy facility at the moment. Main parts of the system are a TCC cyclotron CV28 and a  $\pm 120^\circ$  isocentric gantry. Besides for neutron therapy the cyclotron is extensively used for PET radionuclide production.

Figure 2 shows a possible layout of the new facility which makes use of the existing plant as far as possible. Radionuclide production is separated from the neutron therapy facility and will be done with an IBA cyclone 18/9

cyclotron. The installation of this cyclotron is on the way.

The 360° isocentric gantry demands an extension of the building as it is not installable in the existing vault. Area for this extension is available to the necessary extent.

The therapy cyclotron may be located in the former nuclide production vault. This gives the possibility to use the former gantry vault for treatment of eye tumours using directly the proton beam. The beam is bended into this vault by a 90° double focussing magnet. As there is not enough space to have a real beam waist between cyclotron and magnet the magnet has to get a virtual object point. A big bending radius is advantageous in this respect. A quadrupole singlet or doublet between cyclotron exit port and magnet entrance matches the beam to the magnet and adjusts the image waist to the entrance aperture of the proton therapy unit.

For neutron therapy the beam is lead straight ahead. A further doublet gives enough flexibility for focussing the beam to a round real waist which is imaged to the entrance plane of the gantry by a triplet.

At the moment our activities are addressed to looking for funds.

### References

- [1] J. Rassow et al., *Rad. Prot. Dosim.* 44, 447 (1992)