HORIZONTAL BEAM TUBES IN FRM-II

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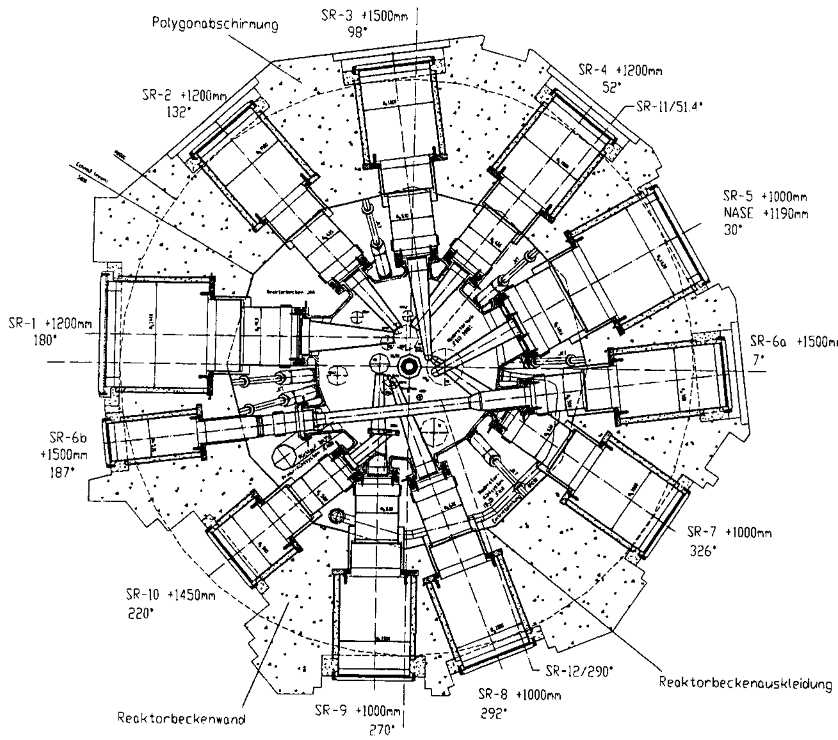
The new research reactor in Garching FRM-II is equipped with 10 leak tight horizontal beam tubes (BT1 - BT10), each of them consisting of a beam tube structure taking an insert with neutron channels (see Fig. 1). The design of all beam tube structures is similar whereas the inserts are adapted to the special requirements of the using of each beam tube.



Inside the reflector tank the beam tube structures are shaped by the inner cones which are made of Al-alloy with circular and rectangular cross sections. They are located in the region of maximum neutron flux (exception BT10), they are directly connected to the flanges of the reflector tank, their lengths are about 1.5 m (exception BT10) and their axes are directed tagentially to the core centre thus contributing to a low γ-noise at the experiments.

The beam tube structures are carried on by bellows connecting the reflector tank with the pool liner at the penetrations of the pool wall. The large diameters of the bellows allow to remove and replace the inner cones of the beam tubes towards the experimental hall with a special handling device when they are embrittled after several years of operation.

Inside the pool wall the beam tube structure comprises an inner tube being adjusted and installed inside an outer tube to achieve high precision for the inner tube alignment. The interspace between both tubes is filled with concrete. In the experimental hall the inner tubes are closed at their ends by thick plates of Al-alloy as second barrier against water loss. The plates are provided with penetrations on the axes of the neutron channels closed by thin double neutron windows, providing the second and the third barrier against water loss at these potentially weak points.

All inserts which are positioned inside the beam tube structures are equipped with the same shielding material. Concerning their function however, a difference has to be made between seven so-called standard beam tube positions on one hand and on the other hand BT 1 (directed towards the cold source, equipped with 6 neutron guides in a plug leading to the neutron guide hall) plus BT 6 (tangential through tube) plus BT 10 (fast neutron generation by a converter for medical application).

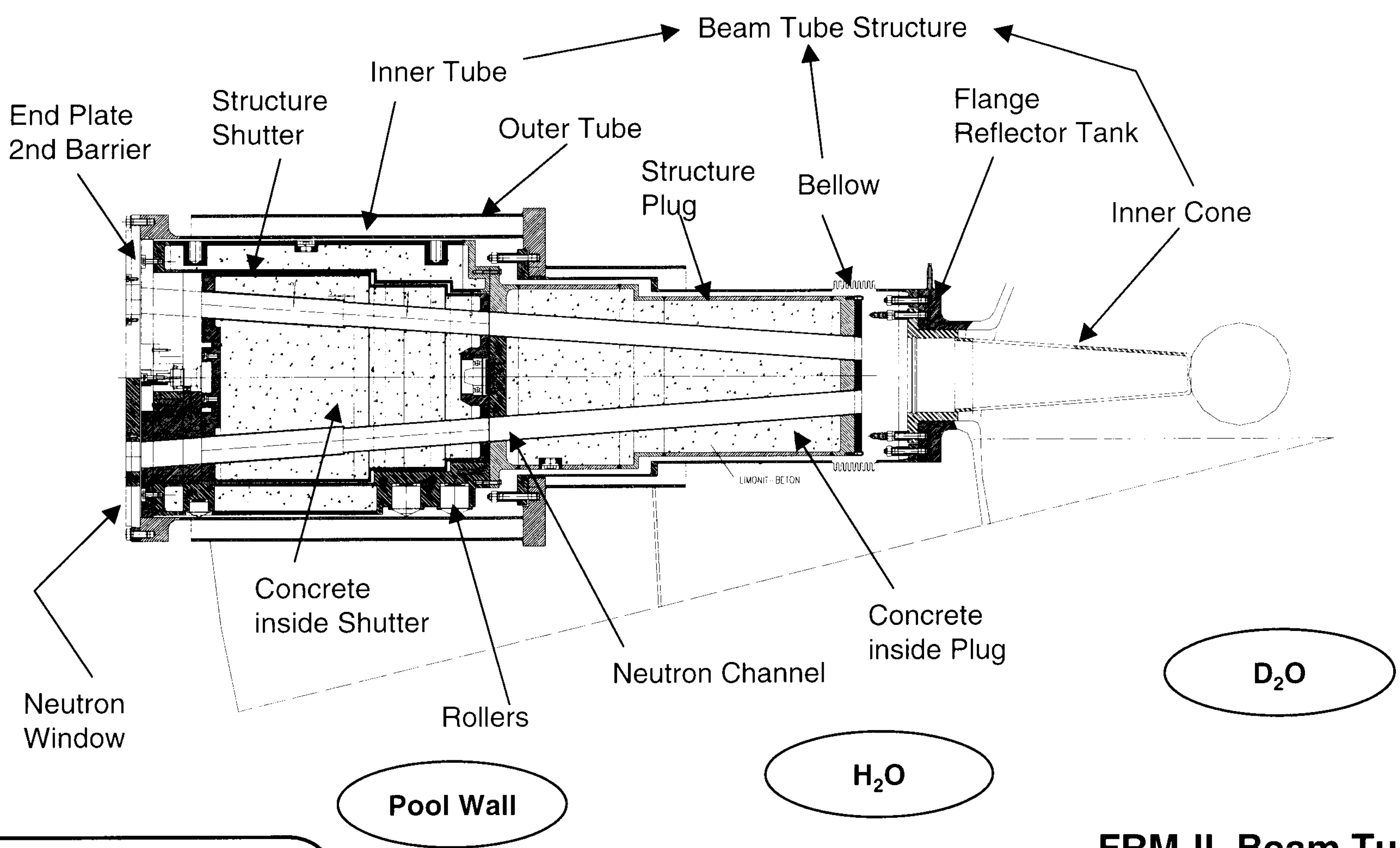
Inside each standard beam tube structure a removable plug/shutter unit is inserted on several rollers, it is clamped to the inner tube. Mostly there are two neutron channels per shielding plug each with at least 80x120 mm^2 cross section; a rotatable shutter with three neutron channels of similar cross section allows for any open/closed combination of the neutron channels. The large cross sections provide a high neutron flux at the instruments. All neutron channels are provided with features which enable the fixing of experimental inserts or a temporary plug to close a channel and thus to provide additional local radiation shielding.

Plugs, shutters and neutron channels are made of a rigid structure of stainless steel filled with a mixture of concrete with special ingredients providing a good neutronic decoupling of the neutron channels of a beam tube from each other and a good radiation shielding against neutron and gamma irradiation in case of a closed shutter. The typical weight of a plug/shutter unit is about 70 kN.

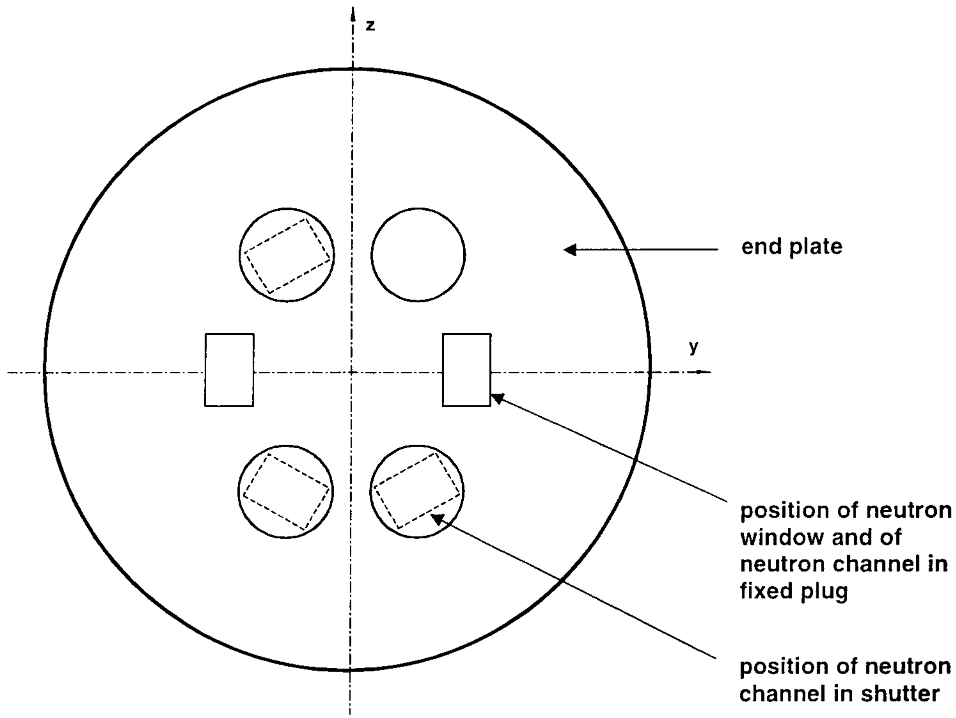
Remotely controlled drives with gears for the actuation of the rotatable shutters are installed at the outer surface of the biological shielding above the beam tube penetrations together with indications open/closed for the neutron channels of each beam tube.

The contradictive requirements for large cross sections of the neutron channels, good neutronic decoupling and good radiation shielding in case of closed shutters have finally been met by carefully modelled 3d-shielding calculations with the code MCNP4a. Suplementary 1d- and 2d-sensitivity studies contributed to determine the material arrangement for an optimised design.

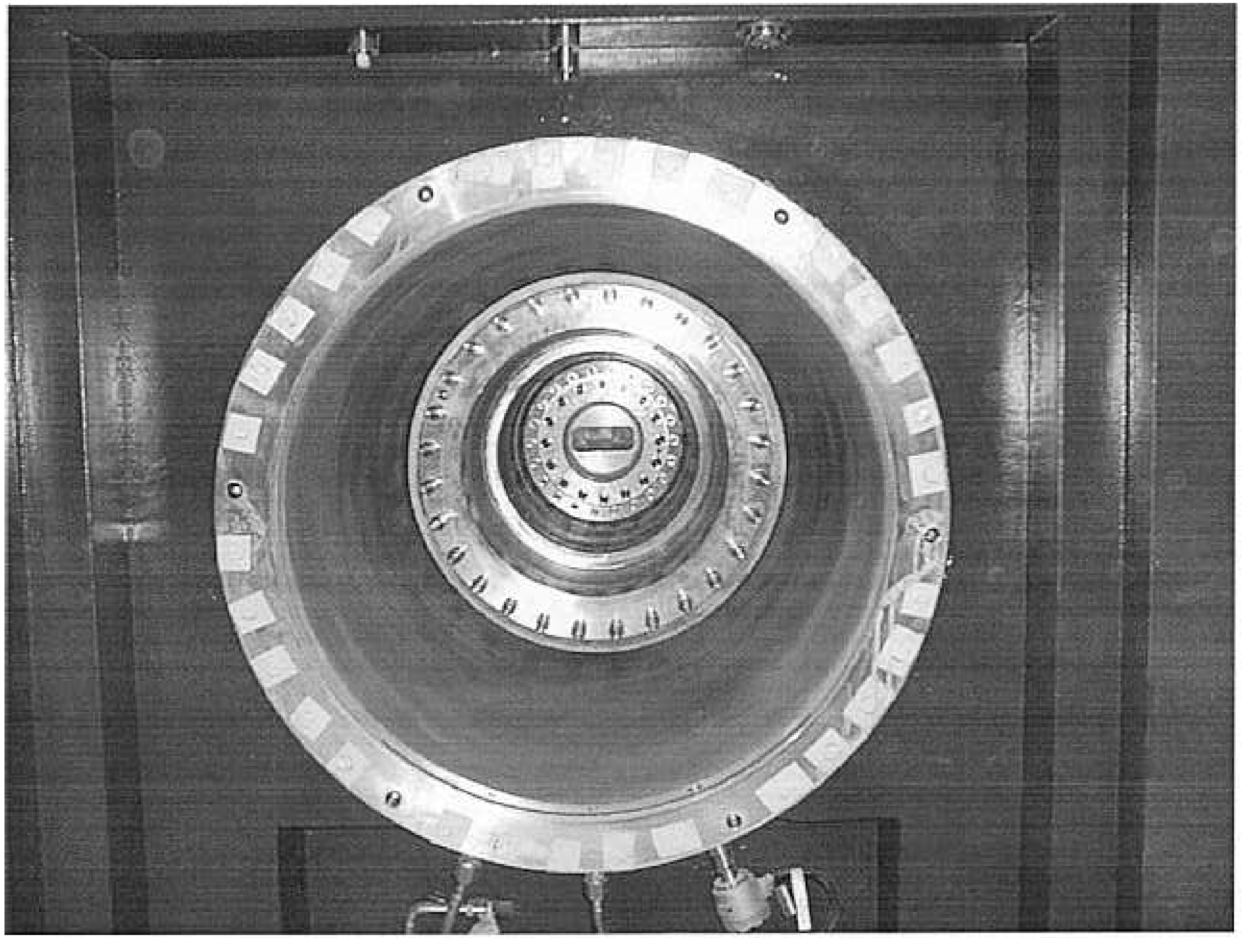
Beam Tube Design



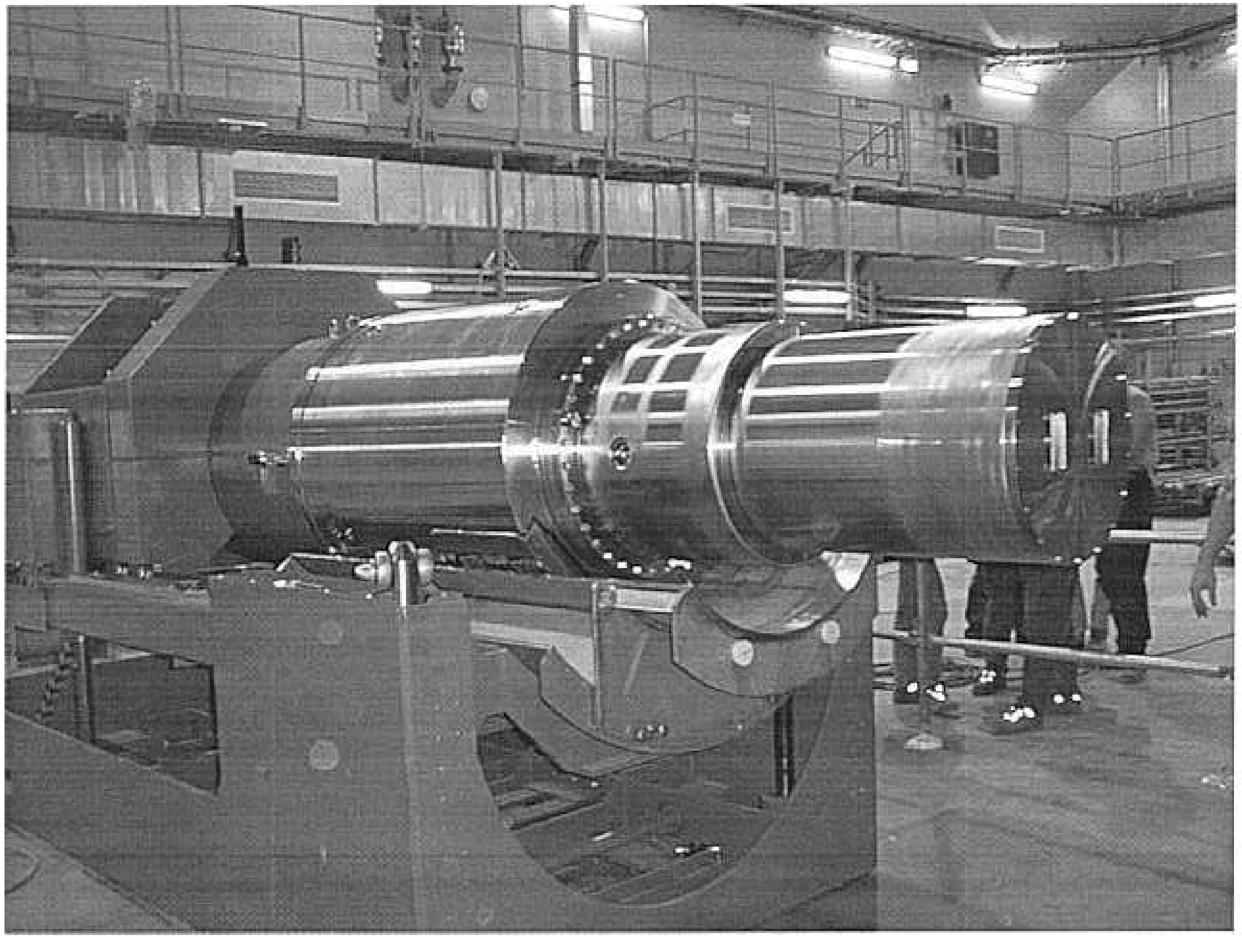
Closed Shutter
Position of Neutron Channels



View into Structure of Beam Tube 2



Beam Tube Insert on Exchange Machine



Beam Tube Cross Section, MCNP Model