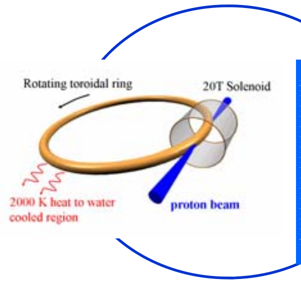


NEUTRINO FACTORY TARGET

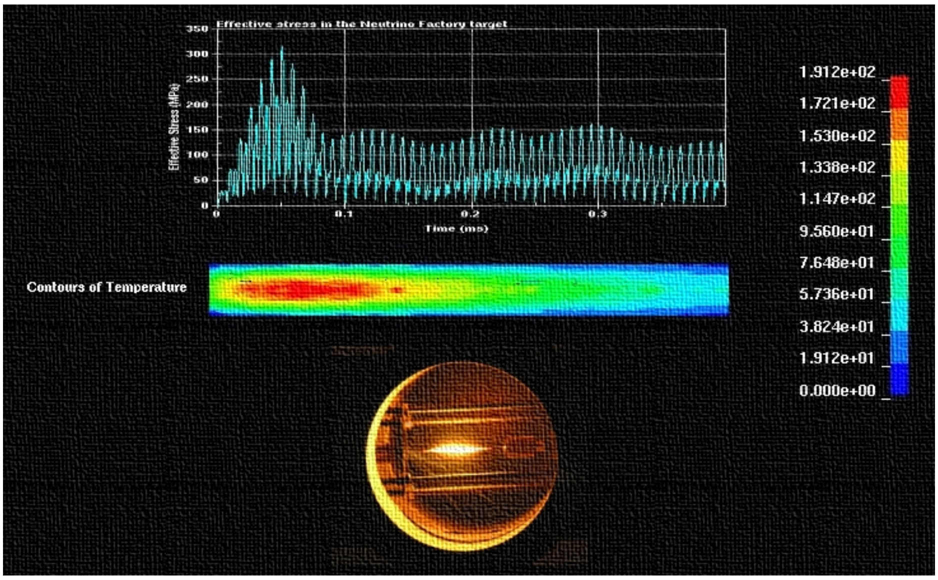
The target system at the Neutrino Factory must generate a maximal number of pions in the interactions with an intense proton beam. The target system is followed by a capture device which collects pions, so the muons resulting from their decay can be bunched, accelerated and stored in a ring.

Several designs for a Neutrino Factory target have been explored by various collaborations and laboratories in Europe, the USA, and Japan. Among them are liquid metal (mercury) jets, spheres in flowing coolant, rotating bands, bars, etc. So far, none of these ideas has been tested at full beam power or over an extended period.

The main goal is to develop a design which would have an acceptable lifetime in a situation where a 4-5 MW proton beam power is delivered in microsecond-long pulses at the repetition rate of 50 Hz. The pions and muons created in the target must be collected in a strong magnetic field which imposes additional restraints on the design of the target and collector system.

Several critical issues have to be considered in the design of a high power target:

- the beam current-density profile together with the target geometry and the pulsed or continuous nature of the beam affect the power-density distribution within the target;
- thermal and stress calculations have to be used to explore target response under extreme conditions and to study different possibilities for target cooling;
- radiation damage has to be carefully studied and hence procedures for target maintenance, replacement and disposal, remote handling and shielding have to be devised.



A particular problem exists for targets in pulsed systems. When the duration of the pulse is short the heat is deposited faster than it can be conducted away. The resulting fast temperature rise in a solid target produces high transient thermal stress waves. Modern computer codes such as LS-DYNA can be used to simulate the material response in such situations. The upper part of the picture (see above) shows the temperature rise in a 2cm diameter, 20cm long tantalum target resulting from the energy deposition of 6 GeV protons (5 MW beam power), as well as the induced thermal stress wave with an amplitude at the level of several hundreds of MPa.

In the UK, high power target studies have concentrated on a solid heavy metal target for a 4-5 MW proton beam in the 3 to 30 GeV energy range. One of the most interesting target concepts is a rotating toroidal tantalum ring operating at 2000 K, dissipating the heat by thermal radiation to water-cooled vacuum chamber walls.

An alternative to the toroid is to fire individual 20 cm long tantalum bars into the beam, catch them and then recirculate them. The radiation cooling would occur during the recirculation.

In any case, one of the important tasks is to evaluate tantalum as a possible target material, the properties of which under extreme conditions are not precisely known. Therefore, the pulsed heating of a small tantalum wire using an electric current (see lower part of the picture) was proposed as a method for measuring the properties of the material under controlled laboratory conditions. Measurements of the velocity and acceleration of the surface of the wire using modern experimental techniques will allow us to understand the behaviour of tantalum under shock conditions similar to that expected at the Neutrino Factory.

MORE DETAILS

Target web page:
http://hepunx.rl.ac.uk/uknf/wp3