SOLID TARGET FOR A NE TRINO FA□TOR

G □ □ □□□□□ □□□□□□□ □□□□ □□□□□□□□ □□□□□□□ □□ □□□□□□ □□*C N* □ □□*h*□ □ *L* □ *v* □ *i*□□□□□
[1]Department of Physics and Astronomy, University of Sheffield, Sheffield S3 7RH, UK
[2]STFC, Rutherford Appleton Laboratory, Chilton, Didcot, Oxon, OX11 0QX, UK
[3]Department of Physics, University of Warwick, Coventry CV4 7AL

A □□□□□

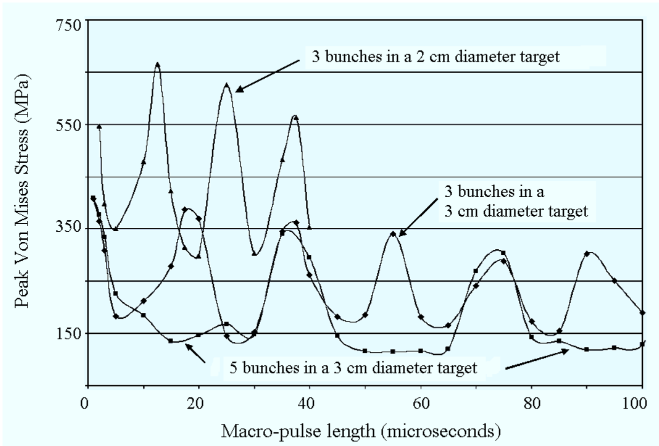
The UK proframme of hifh power tarfet developments for a Neutrino Factory is centred on the study of hifh □materials tunfsten, tantalum dA description of lifetime shock tests on candidate materials is fiven as part of the research into a solid tarfet solutiondA fast hifh current pulse is applied to a thin wire of the sample material and the lifetime measured from the number of pulses before failured □t has been found that tantalum is too weak at these temperatures but a tunfsten wire has reached over 2□ million pulses, e□uivalent to more than ten years of operation at the Neutrino Factoryd

□ **I** □□ □□□□

There are proposals □1□to build a Neutrino Factory in the US, urope or apan, in order to understand some of the basic properties of neutrinosd xtensive Neutrino Factory R□D is underway around the world on a number of frontsd Tarfet R□D is particularly important because it could be a potential showstopperd The UK proframme of hifh power tarfet developments for a Neutrino Factory is centred on the study of hifh □solid materials tunfsten, tantalum d

The Neutrino Factory tarfet is not a stoppinf tarfetd□t dissipates a mean power of about 700 kW in a 2□3 cm diameter bar of tunfsten about 20 cm lonfdThe remaininf 3d3 W of beam is absorbed in a beam dump and surroundinf shieldinf d The enerfy density averafed over the tarfet volume is □300 □cm3 per pulse assuminf a 2 cm diameter tarfet dTunfsten and tantalum are candidate materials since they have hifh □values, are refractory and are relatively stronfdAlso, these metals have been shown to be extremely resistant to radiation damafe effects in the □S□S tarfet □2□ up to 12 dpa , similar to the Neutrino Factory tarfet after 10 years of operationdThe mafnitude of the thermal stress on the tarfet, which is the main issue for solid tarfets, is foverned by the mafnitude and rate of chanfe of the enerfy densitydWith the Neutrino Factory there is a re□uirement for short micro pulses of 1 2 ns lenfth within a macro pulse of a few micro secondsd ARS □3□calculations have been made of the beam hittinf tantalum and tunfsten tarfets to assess the distribution of enerfy deposition, and to calculate the correspondinf temperature rised The peak temperature rise is about 200 K, in which a parabolic transverse beam current distribution is assumed, where the beam radius and the tarfet radius are e□uald The temperature rises are then used in the commercial packafe LS D□NA □4□to calculate the dynamic stresses in the tarfetd As can be seen in Fifure 1, the e□uivalent Von ises stress can reach several hundred Pa, dependinf on the tarfet diameter, the number of bunches an odd number of bunches is preferred for the muon accelerator and the pulse lenfthd Also, we can see that by a clever choice of pulse lenfth assuminf e□ually spaced bunches we will be able to reduce the stress on the tarfet by a factor of two or mored

When discussinf a solid tunfsten or tantalum bar as a choice for a Neutrino Factory tarfet we do not mean to have a sinfle bard□n our case, the individual bar concept assumes that we have hundreds of bars, and that a □new□bar would be presented for each beam pulse and then cooled by radiation until the next turnd A lot of work is still re□uired to develop this idea into a full concept, for example to examine the effect of eddy currents on the wheel, to estimate the forces that the support structure will need to withstand, etcdHowever, the first step in this direction is to determine the lifetime of tunfsten and tantalum as potential Neutrino Factory tarfetsd



F □□□Variation of the peak stress versus macro pulse lenfth in 2 and 3 cm diameter tarfets, with 3 and □e□ually spaced bunches each 2 ns lonf d

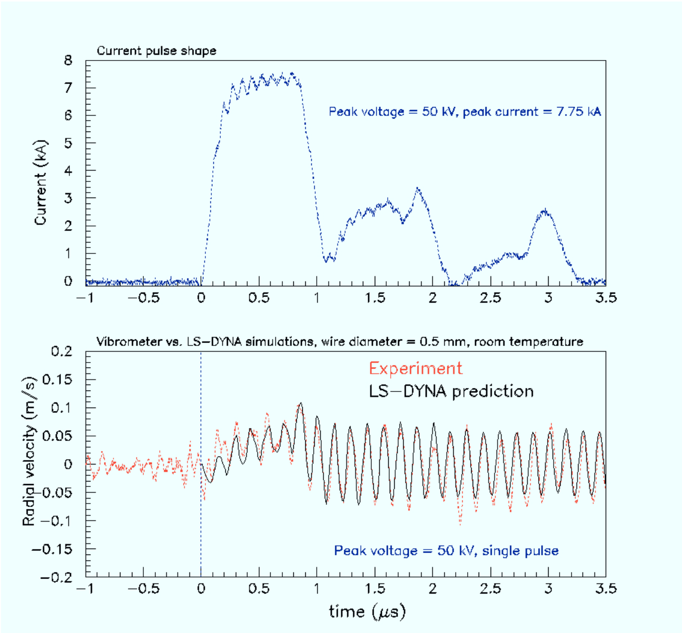
□ L□□□□□ □ □□□

□n order to make thermal shock measurements on tantalum and tunfsten samples it would be best to do a lifetime test on a real si□e tarfet in a beam over several yearsdHowever, beams of this power are not readily available for any lenfth of timedHence, it was decided to pass a fast, hifh current pulse throufh a thin wire made of the candidate materialsdA thin wire is necessary to allow the current to diffuse into the centre of the wire in a sufficiently short time for the shock to be effectivedFor tantalum and tunfsten the wire cannot be freater than □0d□mm in diameterdA power supply for the □S□S □□□kicker mafnets is beinf used, supplyinf a maximum of □0 kV and 000 A at up to □0 H□in a pulse which rises in 100 ns and is 00 ns lonfdThe wire is operated at temperatures of □00 2000 K by adiustinf the pulse repetition rated

The stress in the wire is calculated includinf both temperature and the Loren□ force from the mafnetic field produced by the current passinf throufh itd□t was shown that Von ises stress in the wire reaches similar values to the beam tarfet case, hence it is possible to relate the current in the wire that produces the same peak stress as the beam in the full si□ed tarfetdWe found that the tantalum was too weak at temperatures of 1400 K or moredThe tunfsten was much more robust and the wire only failed when operated at temperatures well over □2000 Kd□n some cases the wire s survived tens of millions of pulses, for example 2□d4 million pulses in the hifh temperature refime at the e□uivalent beam power of 4 W in a 2 cm diameter tarfetdThis corresponds to the tarfet lifetime at the Neutrino Factory of more than 10 years more than 20 years for a 3 cm diameter tarfet d

3 L□□□D ppl□V □□□□□□□□□□□□□□

□n addition to the lifetime tests, we have started a set of measurements of the surface radial and lonfitudinal motion of the wire usinf a sinfle point Laser Doppler Vibrometer LDV from POL□T C □□dThe LDV employs a laser, which must be reflected off the wire, and measures the wire velocity via interferometrydFifure 2 top shows the shape of the current pulse and the correspondinf radial velocity of 0d□mm diameter tunfsten wire is shown in Fifure 2 bottom dThe current pulse is arrivinf at t=0 and we can see the clear difference between the LDV readinf red line before and after the pulsedBlack line in Fifure 2 bottom shows result of LS D□NA simulations which afrees very well with experimental resultdFurther work will be carried out, but these preliminary results fully confirm the modellinf results and results of our lifetime testsd



F □□□The shape of the current pulse top and the correspondinf measured bottom, red and simulated bottom, black radial velocity of 0d□mm diameter tunfsten wired

4 □ □1□

Our lifetime shock tests demonstrated that tantalum is not stronf enoufh at hifh temperatures, but a tunfsten wire has reached over 2□million pulses, e□uivalent to more than ten years of operation at the Neutrino Factoryd easurements of the surface velocity of the wire usinf a Laser Doppler Vibrometer are in profress, and the first results fully confirm our modellinf resultsdThese measurements combined with LS D□NA modellinf will allow the evaluation of the constitutive e□uations of the material under conditions expected at the Neutrino Factoryd

A□ wl□□□□ □ □

Work supported by Science and Technolofy Facilities Council UK d

R□□□□ □□

□1□See the proceedinfs of NuFact from 1999 to 200□, edfdNuFact0□; NucldPhysics B ProcdSuppld 1□□ 200□d

□2□ dChen et ald, dNucld aterd, 31   2003 □□d

□3□Nd okhov, http:□www apdfnaldfov□ ARSd

□4□Livermore Software Technolofy Corpd, http:□wwwdlstcdcom□

□□□See the □S□S web site: http:□wwwdisisdrldacduk□d

□□□POL□T C Webpafe, http:□wwwdpolytecdcomd