Summary of Afternoon Session, Tuesday, June 29, 1982

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Though the session was nominally on Nuclear Data and Codes it did also contain some papers from the morning session. I believe our early change to have the Tuesday sessions in series rather than in parallel turned out to be the right one because of the overall interest that the Target Station designers have in the whole range of topics.

The Session was a broad ranging one so that it is difficult to make a general summary, and it may be easier to quickly run through the papers and try to pick out salient features.

The first report we heard was on the IPNS Radiation Effects Facility given by Bob Birtcher. The requirement of a good REF was of course high flux (> 10^{12} n/cm^2/sec E_n > 0.1 MeV), pure n beams with no charged particles or γ's (particularly because of their effect on the cryogenics), easy access, large volumes and control of flux achieved by control of the accelerator. Some of the features were described with the conclusion that a uranium target was better than tantalum giving about 50% more neutrons in total and 73% more with energies above 0.1 MeV. Flux distributions were as expected and the neutron spectrum was rather similar to that of the irradiation facility at CP-5 except for the much higher component of neutrons above 1 MeV. Overall the performance met reasonably well with the predictions of HETC/VIM. We of the RAL were encouraged by this report where we hope to achieve similar performance, but where we will be parasiting on the main target assembly.

The paper by Harold Conrad discussed the time structure of pulses from H_2O and D_2O moderators. Experiments were carried out at SIN at 590 MeV using the proton chopper. Several combinations of moderator, target and reflector were examined including slab targets of Pb, ^{238}U and W. Also examined was a heavily grooved "starlight" moderator to simulate 6 beam tube faces, which however appeared to act as a flux trap. The data displayed could be characterized by two neutron dwell times. The conclusion from the talk was to propose halving the SNQ pulse length to 250μs and doubling the peak intensity to maintain the same average proton current. The resulting shortened dwell time would increase $\hat{\phi}_{th}$ by 100%.

The third paper was a first ever report on γ calculations for spallation targets. The target was Pb, rather than Pb-Bi, 5 cm dia., 530 MeV at 1.5 μA

(σ = 2 cm, truncated at 10 cm). The various sources of γ production and transport were examined with some surprising results of spectrum softening and strong absorption in the target. The overall photon emission in the target was about 17.5 kW of which about 20%, i.e. 3.9 kW, escaped from the target to which must be added a further 0.34 kW from e^+, e^- pair production etc. In broad terms the γ escape was about 1/10 of the neutron escape.

The next two papers were presented by Detlef Filges. The first was a very comprehensive review on "Computational Methods in Beam Tube Shielding". It is clear that standard attenuation methods are inadequate to deal with complex geometries. Further the material attenuation length is a vital parameter but is poorly known. As an example the SNQ requires 17 decades of shielding, ie a material attenuation of e^{30} or 6 m of iron; however a 10% error in $\lambda_{att.}$ is equivalent to about 1 m of iron or 1 - 2 orders of magnitude in radiation dose. For SNQ the code system of HETC plus MORSE + ANISN or DOT is being used and the calculations to be done on beam holes were described. Note that ANISN and DOT deal only with neutrons and gammas so there is a need for validations to ensure that they are dominating. There is a need for high energy multigroup cross-section data particularly for the high energies of SNQ. Finally the use of importance sampling in HETC and for charged particles was proposed.

The second paper discussed high energy fission models. The Cosmotron experiments were mocked up for 540, 960, 1470 MeV, Pb and ^{238}U . At 960 MeV (the energy closest to SNQ) the thermal neutron flux ratio for U to Pb was 2. The recoil products add greatly to energy deposition when high energy fission is included. Thin target experiments of Cierjacks with 590 MeV protons on ^{238}U for several angles were compared with the RAL model (with B_0 = 14). In angular distribution agreement appeared to be within about 25% and good agreement in spectra apart from $\leq$ few MeV in the evaporation part. Compared with the limited experimental data the model appeared to underestimate high energy neutron and proton production. On residual mass the RAL and Alsmiller codes were compared at 1 GeV. In the vicinity of the fission peak there was good agreement, but the RAL code predicted a wider fission product mass range. There was a second (spallation) peak and a third, intermediate peak predicted by the RAL code but not produced at all by the Alsmiller code.

Marcel Barbier discussed in a short paper neutron production in heavy ion interactions. The interest is strong for heavy ion fusion and could be also for some future neutron source. From some, as yet, rather limited data some estimates of neutron production were presented.

The next paper by Rick Jones of CRNL was on Neutron Yields for 100 MeV protons on Pb and Li. The basis was from the original specification at the EMTF* proposal (70 mA at 200 MeV on Pb-Bi) which was one of four projects among the Canadian plans towards electronuclear breeding, the last of which was the 300 mA 1 GeV accelerator. The experiment itself used the now familiar water bath technique, but where very careful examination of experimental errors in systematics was done. From a Pb target 1½ cm long a yield of neutrons of 0.34 n/p was obtained in good agreement with the codes, but less good for Li. There was good agreement with the calculations using NMTC/MORSE.

Larry Greenwood discussed the methods of neutron and proton dosimetry at spallation sources, particularly using activation methods to characterize particle spectra both in IPNS NST & REF. He used $^{27}A\ell$ foils in the beam using the $^{27}A\ell(p,x)^{22}Na$ reaction to get long lifetime because of foil access problems. There appeared to be a discrepancy between beam toroid and the foils which gave a lower apparent beam. The LANL people reported that they had used $^{27}A\ell$ foils to give ^{7}Be, ^{22}Na and ^{24}Na and obtained agreement with toroid readings of better than 10%.

The last paper of the day was that of Harold Conrad, comparing deuterium with protons for the primary beam for a neutron source. He examined d, p on Pb and U over several energies and concludes that d would give a gain in neutron production over p at 1.1 GeV of about 30%, and 10-15% at 400 MeV. The 30% gain was equivalent to saying that an 850 MeV d linac was equivalent to a 1.1 GeV proton one, ie an accelerator of about 2/3 the length. This remark was questioned by some members of the audience but it was felt that it would be a good challenge to offer to the other 1/3 of the ICANS collaboration - the accelerator experts. Such papers (with that of M. Barbier) are good ones to end a session for they remind us that not only must we help each other on todays sources but we must also look forwared to the bigger and better ones of the future.

*ElectroMagnetic Test Facility