Appendix

February 25, 2014

CONSTRUCTIVE CRITIQUE OF TFTR CLAIMS

The ITER design is based on the claimed results of the TFTR 1994 experiments, published in two letters [25, 26] and a summary article[3]. Our examination of the source data indicates no direct or indirect experimental evidence to support any of the key physics result claimed[6-8] that could pass standard reality tests of the Berkeley nuclear radiation measurement science. As shown in Table I, all 5 primary key parameters are inferences or theoretical conjectures rather than results of direct measurements. Moreover we find, in the very same published data, direct negative evidence to the TFTR claims; they are listed Table 1 next to TFTR claims. We will limit our analysis to two most striking key primary parameters claimed to have been measured:

- Production of pure thermonuclear fusion power of P_{tn} = 2.6 to 6 MW and
- Ion energy confinement time τ_E =O.26 s.

A.1 Claim of Thermonuclear fusion power production.

An injected neutral D^o/T^o beam power of Pin =39.5 MW, has produced a total fusion neutron fluence – named "emission" in TFTR papers – of

$$F = 10^{18}s^{-1}/_{4\pi} \qquad \text{(A.1)}$$

This amounts to a "total fusion neutron power" of

$$P_f = 10.7\ MW, \qquad \text{(A.2)}$$

a 26%-60% of same is the pure *thermonuclear* fusion neutron power – named "thermal" in TFTR papers,

$$P_{tn} = 2.6\ to\ 6\ MW, \qquad \text{(A.3)}$$

That yields a 'scientific power gain' of

$$Q_s = 7\% - 15\% \qquad \text{(A.4)}$$

Dual values in Eq. (A. 4) are those in 1994 Letters [25, 26] and summary article of 1995[3], respectively.

A.2 Lack of evidence for DT and DD fusion neutrons

Note that the emission Eq. (1) is 10^3 times greater than that achieved at the world's strongest neutron spallation source at Los Alamos, F_{LA}~ 10^{15} $ns^{-1}/4\pi$. From the F and τ values claimed, the neutron flux on the face of multi-fiber scintillation detector should be at least ~ 10^8 $ncm^{-2}s^{-1}$ which should generate statistical accuracy of $\pm$0.01% per shot. While "10 channel neutron collimator with 25 detectors" was used, no neutron measurement vs. energy vs. time or vs. space can be found in any of the papers. The only verbal, unpublished information on the statistical significance of the "determination of fusion energy production "is that it was done" with high accuracy, $\pm\mathbf{7}\%$ "[3] which implies 200 neutron counts in the sample[3]. The only published neutron measurement was "DT neutron emission vs. radius" with a statistical significance of $\pm$12.5%, implying a peak sample of 64 neutron counts. (Fig. 4, Ref. 3.).The incongruence between the extremely high neutron emission, F, and extreme paucity of neutrons, bring into question the former.

The key issue in measuring the pure thermonuclear fusion power is to provably distinguish thermonuclear ("TN") neutrons produced in D+T and D+D plasma-plasma impact ("signal") from the non-thermonuclear ("NTN") neutrons produced in the impacts between the beam or of plasma ions and the cold gas D^o, T^o deposits on the wall and the carbon atoms within the wall ("noise").

The best and easiest experimental proof of TN is to measure the angular correlation between α and n from D+T reaction or between ^{3}He and n or T and p from D+D reactions. The pair from TN collisions is emitted back to back (180^o), while NTN at about 90^o. Thus requires an electronic timing coincidence, as it was done with T + p, in Migma 3 experiment[13]. TFTR had no coincidence circuitry, however; only the 'singles counting' ungated method was used that has not been seen in nuclear particle labs since the early 1950's.

To observe the double peak structure, a neutron energy resolution of $\pm\mathbf{30}\ \boldsymbol{KeV}$ is required which is within the state of the art. The TFTR resolution, however, was 10^3 times less precise, capable only of "energy discrimination between D-D neutrons (2.4 MeV) and D-T neutrons (14 MeV)". Hence, the signal and noise were lumped together and defined as the "total fusion neutron emission F." Without any measurement, a 60% of F is claimed to consist of pure TN neutrons (Sect. 3)

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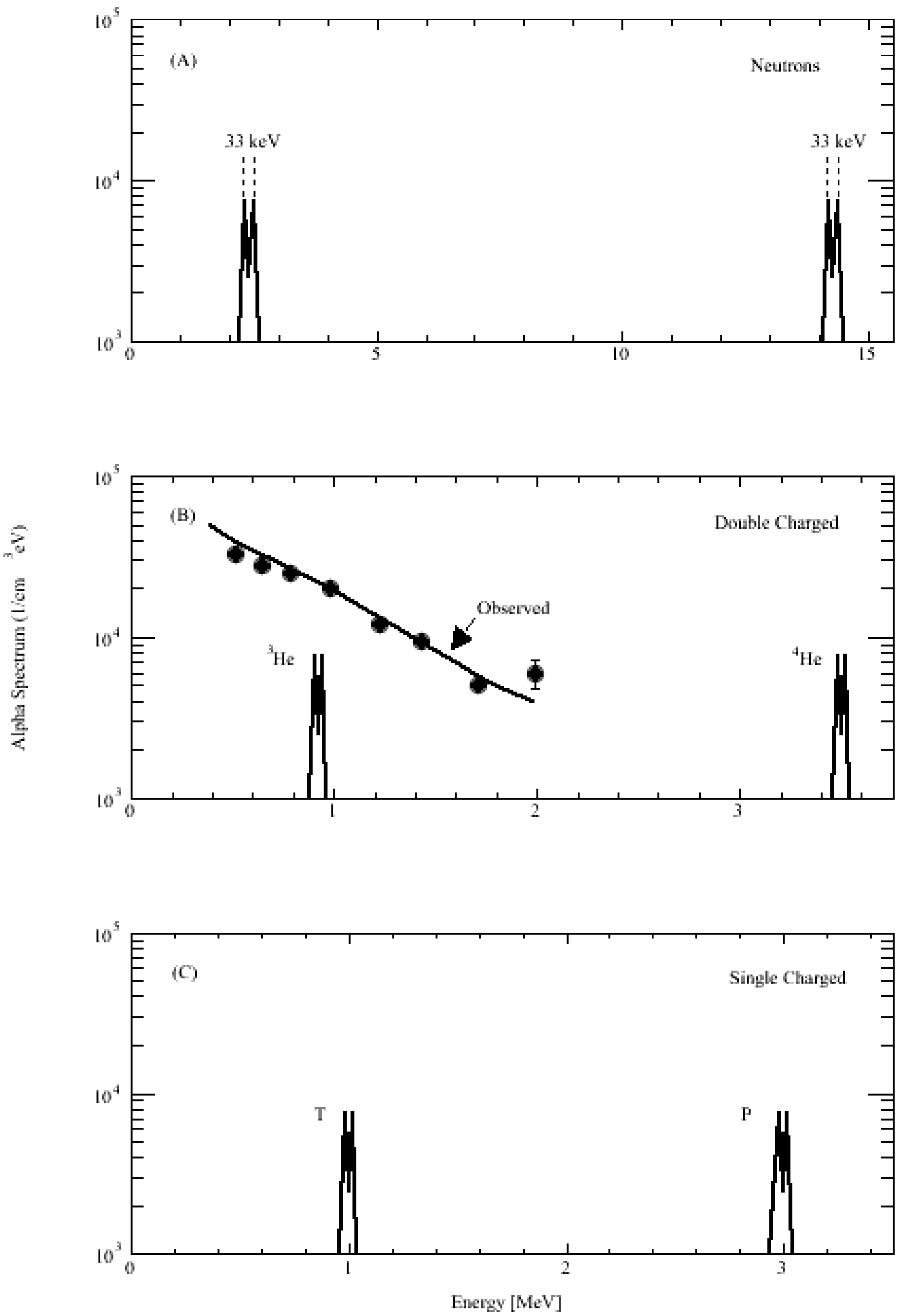

Figure 1. Four main peaks expected in neutron (A), double charged (B) and single charged (C) spectra emitted in D + T plasma; at Ti = 44 KeV. If thermonuclear fusion took place, each of the peaks should show a double-structure, the lower from plasma-gas and the higher from plasma-plasma collisions. The absence of <u>any</u> peak means no plasma was formed.

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The simplest direct poof of TN is to look for 6 double peaks in the energy spectra of the neutrons (2 peaks) ; or α and ^3He or tritons and protons from D+D all of which take place simultaneously in a D+T plasma. The lower peak are NTN neutrons and higher TN; the difference, approx. 20 to 50 KeV, coming from the two different COM energies. Observation of at least one o *double*-peak structure would consist of the proof. Referring to Fig. A1, we see the following spectral features expected from TN D+T plasma:

- neutron energy spectrum: 2.4 MeV double peak from D+D &14.1 MeV double peak from D+T;
- α energy spectrum: 0.92 MeV ^3He double peak from D+D & at 3.5 MeV α peak from D+T;
- T and p energy spectrum: at 1 MeV T & 3 MeV p both from D+D as done in Ref. 21, 23. An example of double peaks in proton spectrum is shown in Fig. A.2.

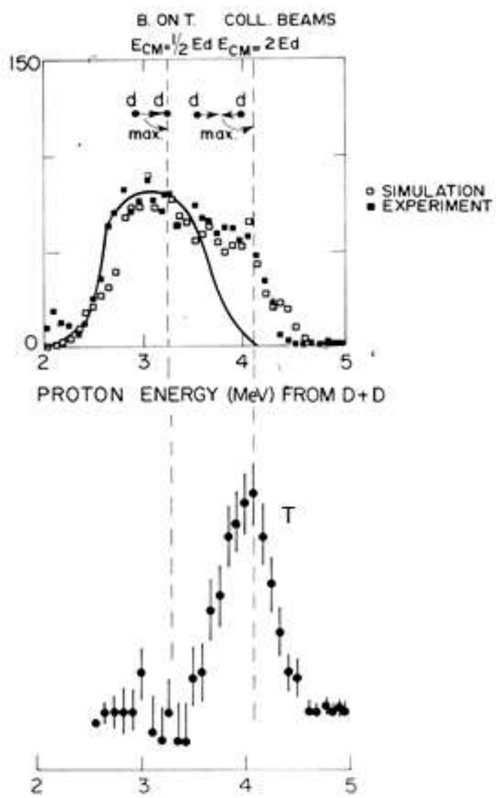

Figure 2. Two peak structure in proton spectrum from $D + D \rightarrow T + P + 4\ \mathrm{MeV}$ in self-colliding beams of $T_D^+ = 725\ \mathrm{KeV}$. TOP: Total proton spectrum as a superposition of D^++D^0 (gas) and beam-beam, D^++D^+. BOTTOM: Data in TOP after subtraction of phase-space curve for D++D0 (gas) showing proton peak position from D++D+ centered at 4 MeV <u>vs.</u> 3.2 MeV for D++D0. For D++D0, COM energy is $W = \frac{1}{2} E_D = 725\ \mathrm{KeV}$, $W = 2E_D = 1{,}450\ \mathrm{MeV}$.

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Taking plasma ion temperature at the face value of Ti=44 KeV, an energy resolution of ±30KeV is needed to resolve them. If the resolution is poorer, a broadening of the peaks must be observed and it also serves at the proof of TN. Therefore, the absence of the upper peak with the lower peak present means that all neutrons originate from collisions with T and D gas i.e. the absence of TN fusion. The absence of either peak means the absence of D+T fusion altogether. The only TFTR energy spectrum published was the α energy spectrum[3]. We have plotted the TFTR experimental points in Fig. A.1.b. In the energy band where the 0.9 MeV ^{3}He peak should appear, the spectrum is flat. Data in the energy band where α 3.5 MeV peak should appear, inexplicably, are not published. The absence of any peak at 0.9 MeV represents clear evidence that NO D+T fusion of either kind was occurring in TFTR.

The few fusion neutrons were produced on the chamber wall but since the detectors were aligned to view the center, the neutrons were hitting the opposite wall further randomly multiplying.

A.3. Questionable α particles

The absence of TN α's brings into question the validity of identification of the α particles in TFTR. There a more Carbon-12 nuclei from the wall than D and T in the chamber; since e/m of C-12 is the same as that of the α - how did the relatively simple electronics of TFTR differentiate c from C? AT these low energies, only fusion reactions can produce α's and the data in Figure eliminates fusion α's.

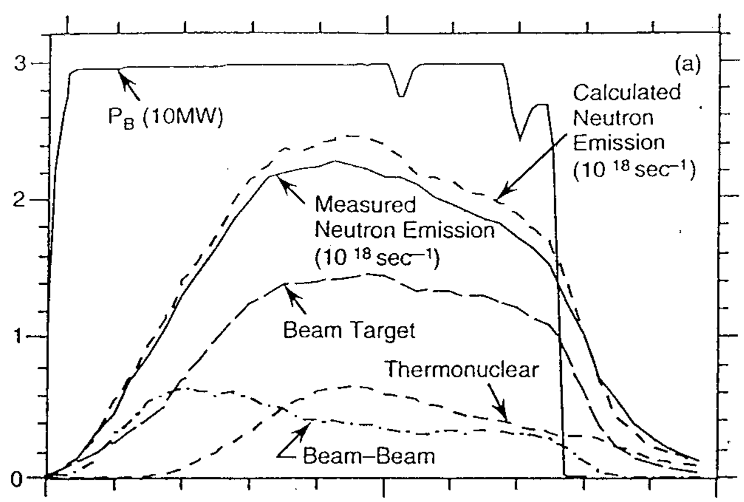

Figure 3.

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A.4 Lack of evidence for D+ T plasma.

- D+/ T+ ion temperature, claimed to be Ti = 44 KeV, was not measured.
- D+/ T+ ion *density*, claimed to be $n_i^+ = 7.6\times10^{19}$ m-3, was not measured.

The reason neither temperature nor density of D+/T+ ions cold be measured was that, although 10^{22} D^o and T^o were injected per second, “there have not been enough D+ and T+ data to establish scaling” [26] .

D/T ion temperature was inferred from the carbon ion temperature at the center by “classical beam coupling calculation from the *carbon* ion temperature”[26]. Carbon ion charge multiplicity was no known. The summary paper3 does not disclose that fact and misleadingly presents the carbon ion temperature distribution diagram [25] as that of the D/T ion temperature distribution. Moreover, the central carbon ion temperature was not measured at center but at chamber periphery, then extrapolated to center.

D/T ion density was calculated from the density of α particle in the chamber center. Central α particle density of 2.2 x 10^{17} m^{-2} was not measured but “inferred” from the peripheral density[8]. There is no mention of this fact. The summary paper that misleadingly presents the density as that of the D/T ions.

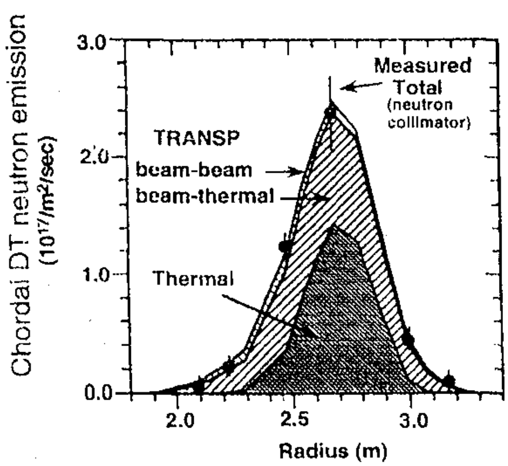

Figure 4.

A.5 Measuring neutron power without measuring neutrons.

Fusion neutron power is normally determined from the digital measurements of the neutron emission and neutron energy spectra. Direct experimental evidence, however, for the extremely high neutron emission F= 2.2 $x10^{18}$ s^{-1} or flux, ϕ= $2.2x10^{17}$ m^2s^{-1} – did not exist. What is the source data from which the total neutron fusion power of 10.7 MW have been obtained? We raised this question with the TFTR team leaders in our 'Comments to Phys. Review Letters [15,32,33] and obtain the following answer.

> "*The fusion neutron power of was not obtained from the neutron measurements, as implied in papers[6-8]. According to an official communication to us from TFTR team leaders, power was "determined by the diamagnetic response of the confining magnetic field to the plasma pressure[18]."*

A.6 Converting analog data into digital via linear extrapolation over 11 orders of magnitude

Rather than calculating neutron power from measuring the digital neutron rates and neutron kinetic energy, the neutron rates were *inferred* from an unexplained magnetic power measurement. Next, the analog data on the power were converted into the equivalent neutrons count rates that it would take to produce this magnetic power effect. Next, the data were plotted as, the equivalent neutron emission from 10^{15} to 2.2 $x10^{18}$ as the ordinate Vs. time from beam injection (abscissa). Since "equivalent " was omitted, the plot misleads the unenlightened to believe that it was the true neutron counting that was measured.

TFTR uses Campbell's mean square voltage theorem to monitor the neutron source strength. 'Campbelling' uses the large amplitude fluctuations in total current flowing thru the detector from neutron fission events in the detectors to discriminate against small amplitude gamma rays and other noise events.

The gauge was calibrated with 14 MeV neutrons and fission detector that could not measure neutron energy The absolute calibration with a "simulated neutron source" from 10^{12} to >10^{17} $ns^{-1}/4\pi$ was performed with a neutron DT generator whose emission was $5x10^7$

$ns^{-1}/4\pi$ Additional proof that the claimed τ was from the noise could not be the real tau is the fact that τ increased from by 70% to 0.27 s. to by the injection of Lithium pellet. Increasing the density of neutrals can only shorten τ. What actually took place is the noise increase.

It was determined that the response is linear over 10 orders of magnitude. Nowhere in the TFTR reports was it disclosed that the thermonuclear power can be and was determined indirectly from a diamagnetic effect.

A.7 Arbitrary estimate of thermonuclear neutron (TN) power by fiat.

The claimed thermonuclear neutron component of was not measured but estimated via an unpublished theoretical model. In the letter[26] it was stated that "26% of the plasma pressure is attributed to thermonuclear neutrons from plasma-plasma fusion". (Fig. A 3.). It was not explained how neutral particles exert plasma pressure. In the summary paper[3], TN was free hand drawn into a measured total emission vs. radius data and amounts to approx. 60 % of total emission. (Fig A. 4).

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A 8. Invention of "Global energy confinement time" when" Ion energy confinement time, τ_E" is not measurable.

τ_E requires simultaneous measurement of the evolution of plasma D+/T+ ion *energy* , Ti, and D+/T+ ion *density* , n_i , as a function of time, t, *after* the beam injection turnoff . This is routinely done by measuring CT D^o and T^o energy spectra vs. t. e.g. Ref. 21, Ref. 23.

τ_E was not possible to measure because of the following established facts:

i. D+/T+ temperature was not measured (see A.4)
ii. D+/T+ density was not measured (see A.4)
iii. Change of carbon temperature with time was not measured. What was measured was temperature of *carbon* ions *during* the D/T injection T_i and only at the chamber periphery, where T_i = 3 keV vs. and from this the D/T ion temperature in central zone of 44 keV claimed was extrapolated.
iv. Change of α density with time was never measured.
v. Since (i-iv) make it impossible to measure the real $\tau_{E,}$ it had to be redefined as "global energy confinement time (including the energy of non-thermal ions)" Fig. 1

A.9 Confinement time of charged particles noise.

The meaning of the "global τ_E "is best understood by the description of the TFTR "discharge" process as follows.

Seven neutral 105 KeV beams totaling 10^{22} s^{-1} D and T atoms and molecules were injected into the chamber and, at the same time, neutral cold (20-600 eV) hydrogenous molecules and metallic atoms from the wall surfaces, at a rate of 10^{22} s^{-1}. The walls acted both, as an internal beam dump, accumulating surface gas and also as thick target for D and T reactions producing secondary carbon nuclei (the same e/m as He 4). Using the reported surface atom density 3.45×10^{23} m^{-2} and area of 10^2 m^2, the reservoir of hydrogenous atoms on the walls was 3.45×10^{25} (assuming C: D ratio 1:1) , 10^3 times the amount injected during the discharge. As a result, the wall noise was ~10^4 times greater that the signal from the direct beam. Ref Scott Maglich

The charged particle population was a 5 component mixture, most of which is non-plasma: the beam , cold "target' atoms., molecules ,ions electrons, and solid chunks of the injected pellets of beryllium and lithium, and the equal amount of metallic particles emanating from the wall under the thermal impact of 40 MW atomic and molecular beam.. Essentially, it is the noise of charged and neutral particles and was measuring the noise, which was described to be "total fusion neutron power (see next section). The physical meaning of it is beyond the scope of this paper. The first paper on TFTR describes the mixture as the "global confinement".

Extracting meaningful physics "signal" under 10^4 times the global "noise" and particle identification – discriminating carbon nuclei from alpha from D from T from fragment and metallic ions - imposes the most state of the art radiation art and science requirements parallel to those at giant particle accelerator target area: detection logic circuitry and system made goal specific processors that combine extremely high processing rates time, space, energy and angular discrimination, the time-of-flight, double and triple coincidence and anticoincidence electronics logics. The TFTR detectors operated in single particle counting mode abandoned since the late 1940's as meaningless. In the absence of contemporary measuring tools, TFTR had no other choice but to invent surrogate techniques.

A.10 Decay *before* the beam turnoff

The published data from which one can infer the global τ from the decay slope *after the shot* – neutron fluence, alpha particle fluence, magnetic energy, electron density - all being inconsistent with energy generation. In all cases the reported amplitudes begin to begin to decay *before* the beam turnoff, *during* the shot, which implies an energy sink, rather than a source. During the beam injection Power production requires continuous growth, at least not decay, of energy contents until the end of the shot, at 3.1 s while beam turnoff was at 3.2 s. (*before* the beam cutoff *during* the shot

A.11 Doing critical test without placebo calibration

To measure half-life of even the scrambled global contents after the beam cut-off, one has to divide the observed counting rate with fusion Heavy hydrogen fuel, D and T, with the 'response function' of the system; the latter includes inertia, eddy currents and other residual effect of the system and other effects that must be separately calibrated. This is normally done by the background run analogous to placebo, by using non- fusing light hydrogen as placebo with all properties of the heavy hydrogen other than undergoing nuclear fusion. No such calibration is reported.

A 12. Counter evidence RF spectra

An alternate method to measure the plasma ion energy density, $T_i n_i$, by measuring the amplitude of the axial and radial rf spectra emitted by the circulating D+ and T+ ions like done in E.g. Ref. 18,21, 23. Although RF signals were monitored in TFTR, there was no evidence for RF signal after the beam turnoff different from during.

A.13 Direct evidence that the measured was not τ_E

Additional proof that the claimed τ was from the noise could not be the real tau is the fact that τ increased from by 70% to 0.27 s. to by the injection of Lithium pellet. Increasing the density of neutrals can only shorten τ. What actually took place is the noise increase.

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NOTES

In conclusion, all TFTR data are compatible with the neutron production solely in the collisions of 100 KeV neutral beams with carbon wall.

Since this is the proof that all injected beam ended up on the wall and the thermonuclear plasma could not be formed, it was *inferred.*

All 5 primary results reported to have been achieved in TFTR [6-8] are at least 6 orders of magnitude greater than should be expected from the classical atomic and nuclear physics

The power figures are derived from the reported b. means that 1 in 10^4 injected D^o T^0 have undergone both trapping and a fusion reaction, which is 10^6 times higher yield than plausible according to Eq. (9).

Measuring number of neutrons from neutron caused diamagnetic field.

This by itself will explain the factor of 10-6 because as I will be shown below, the ratio of all neutrons/ thermonuclear ~10^6.