Addenda to Safety Report
Experiment 1031
Charged-particle exit channels from the $^{12}C+^{12}C$ fusion reaction at astrophysical energies

P. Walden

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1 Introduction

E1031 is an EEC approved experiment to investigate the role of $^{12}C+^{12}C$ fusion reactions in astrophysical settings. The experiment had one experimental run in July 2005 which attempted to run the experiment with the setup described in the first safety report produced July 5, 2005. The motivation for the experiment, the experimental technique, and safety concerns can be found in that report. In this addenda the changes to the experimental configuration and additional safety concerns as a result of the previous run are addressed.

2 Experience of the first experimental run

The E1031 experiment is the first approved EEC experiment for TUDA which uses stable beams. Up to the time of the July 2005 run no beams of intensities greater than 10^8 pps were run with the detectors activated. For the E1031 experiment, beams of 50enA (10^{11} pps) were required. All counters failed with massive leakage currents. The problem encountered was due to the electron flux emitted when the beam hit the target. The electron cloud intercepted the detectors causing the leakage current which made the detectors inoperable. The remainder of the July run was then used to solve the problem. The solution that worked was to bias the target with a positive 3kV and place shield rings around the detectors also biased positively at several kV. These measures effectively removed the electrons like a vacuum cleaner. Biasing the shield rings negatively in order to push the electrons away did not work.

A less severe experience of the July 2005 run was the observation of a high flux of protons produced by ^{12}C+p elastic scattering on H_2O which had condensed on the targets. While these protons are well separated in energy from the $^{12}C(^{12}C,p)^{23}Na$ protons of interest, the ratio of the cross sections between the rather prolific elastic scattering reaction and the rarer fusion process necessitates that the H_2O contamination on the target surfaces be removed.

3 Changes to the experimental setup

The setup up shown in the 2005 safety report has changed. The upstream S2 detector has been removed. The 2005 run experience showed that this detector was little more than a beam flux monitor and no detectable events of interest were seen. Hence it will not be present for the upcoming experimental run.

Other changes reflect the running experience in 2005. The target ladder will be electrically isolated so that it can be charged up to 3kV and guard rings will be placed around the detectors, also charged up to 3kV. In order to prevent H_2O condensation on the targets, the target ladder will be heated with a power resistor and kept at a temperature of around 75° C.

4 Additional safety concerns

4.1 Electron cloud sinks

As stated above the target ladder and detector guard rings will be charged to 3kV potential. The P/S which will do this are wire chamber supplies, Bertan 375P. The purpose for which the supplies are used is to just supply a static potential to the appropriate surfaces. There is no current demand, or very little. Thus the amperage limit on these supplies can be set to the minimum value, 0.1 μA. If this limit is reached the P/S shuts down. Thus there should be no possibility of any gross physiological damage to anyone connecting or disconnecting this system.

4.2 Heating resistors

To supply heat to the target a 25 watt resistor will be mounted to the target ladder. The specifications of this resistor is attached in the accopanying spec sheet. The resistor type is HS25 which, in air, provides a 110° C temperature rise to its casing at 25 watts. The leads of this resistor are isolated from its casing by a reportedly 10^4 MΩ, hence the target ladder, at a 3kV potential, can be heated by a resistor P/S at relatively modest potential. We have two types of these resistors which can be mounted to the target ladder, a 2KΩ and a 1Ω variety. The P/S which will be used is a 0-60V continuous variable supply that can be both limited by voltage or amperage. The P/S has meters which monitor both the output voltage and the amperage simultaneously.

While it may take 25 watts to reach a ΔT of 110° C in air, it will take much less than this to reach that temperature differential in a vacuum which is where the target ladder will be when heated. It has been made known to us that 1.3 watts was enough to melt solder. Hence we will probably run with the 2KΩ resistor as the peak wattage at 60V will be 1.8 watts. It will be possible to have fine control over the temperature with this resistor. With the 1Ω resistor the control will be somewhat coarse but manageable with the peak wattage reached at only 5 volts. Safeguards will have to be taken not to exceed this.

The temperature of the target ladder will be calibrated with the target ladder at ground potential. Two termocouples will be mounted on the ladder, one on the resistor mount itself, and the other on the a target blank furthest from the resistor. The system will be tested in both air and vacuum with thermoucouple temperature plotted as a function of P/S voltage for both the 2KΩ and 1Ω resistors. The thermocouples will be knocked off prior to the run and the temparature of the target ladder will be monitored by the voltage alone.

Damage to the experiment from over heating the resistor is a concern but poses no hazard to the personnel. Measures will be taken to monitor the resistor P/S output on a frequent basis. The knobs limiting voltage and amp output will be taped off such that they cannot be unintentionally changed. If the 1Ω resistor is used, the peak P/S output voltage will be 5V and there will be no possibility of an electric shock hazard. If the 2KΩ resistor is used the maximum voltage hazard will be 60V, enough to provide a mild discomfort perhaps, but nothing that would even remotely require first aid.

4.3 Electric Shock

From a perusal of the previous two sections there could be a concern of an electric shock hazard, but as the analysis shows it would be, at most, of the mild discomfort variety. The minimum threshold current detectable by the human body is 5mA[1] for DC voltage. The let-go current is 75 mA, meaning that the person can consciously let go of the voltage source when the electric shock is perceived. This experiment will not approach anything like these levels and maybe will not even reach the level to be consciously perceived. However when the experiment is operating a sign will be posted on the target module in brazenly bold type that HV is present and must be turned off before any cables are disconnected or the chamber opened.

4.4 Using DRAGON

The energy calibration of this experiment has to be very precise. In order to calibrate the energy, the beam will first be passed through DRAGON. In accordance with DRAGON safety procedures only a non-flammable gas, ie., Helium, will be used in the gas target.

[1] http://en.wikipedia.org/wiki/Electrical_shock