

Muon-Catalyzed Fusion **Fermilab** Erica Garcia Badaracco University of California, Berkeley Advisors: Carol Johnstone, Ara Knaian Why Muons? Previous Experimental Data Muonic vs. Thermonuclear Fusion By replacing the electron with a muon, we can λ_c , μs^{-1} Disadvantages Advantages bring nuclei closer together and facilitate fusion! 160 Smaller atomic radius Need muons Muons and Can be achieved at room (Sm 140) Electron electrons only $(2.2 \mu s)$ temperature or lower differ by mass. ent Muons are Muon No need for plasma Loss of muons due to 120 around 200 times sticking factor rate heavier. Proton Density φ cycling Proton [LHD] \times 1983-86 Los Alamos 1.2 Protium ○ 0.88–0.91 PSI PSI ▼ 0.62-0.64 Normal vs. Muonic PSI h ▲ 0.49-0.52 1.0 X-rays (%) Hydrogen ■ 0.39–0.45 PSI lons mnițiuL **60**⊢ Deuterium RIKEN-RAL X&n • 0.19–0.24 · 1997 øs 0.8 ğ Theory 100 200 300 400 500 600 700 800 900 0.6 *T*, K 1. (a) Normalized cycling rates vs. \odot Δ^{\odot} \square Hydrogen Isotopes temperature for gaseous D/T mixture at cti< 0.4 33% Tritium Concentration (C_t) and Effe different densities. 0.2 λ_c , μs^{-1} **Fusion Process** 180 1.2 0.2 0.6 0.8 1.0 0.4 A deuterium-160 Density ϕ tritium fusion Proton _____ Tritium nucleus (t) 2. Sticking probability vs. Density [LHD] (sm)¹⁴⁰ reaction produces Muon O Deuterium nucleus (d) a He^{+2} nuclei and CRYOSTAT 120 AND HEATER VACUUM CHAMBER NEUTRON a neutron. DETECTORS <u>5</u> 100 (2) Production of many tµ atoms rate 80 dtu molecules (3) Production of dtu cycling DIAMOND muonic molecules /TARGET ANVIL CELL OPTICS 60 (1) Muon injection SYSTEM ▼ T = 800 K, $C_t = 0.34 - 0.36$ Ľ 40 oduce a particle ▲ T = 550 K, $C_t = 0.33 - 0.36$ (5) Free muons nd neutrons are recycled T = 300 K, $C_t = 0.31 - 0.36$ (b) Reactivation 20 OPTICAL WINDOW • T = 158 K, $C_t = 0.31$ (6) About 1% of liberated REV FWD α particles (helium nuclei) VETO VETO 0.6 0.8 0 0 0.2 0.4 1.0 to helium nuclei COUNTER COUNTER ENTRY ELECTRON φ, LHD DETECTOR DETECTORS Sticking

Muonic Fusion Outline

αµ particles (muonic helium atoms)

1. (b) Normalized cycling rates vs. density for gaseous D/T mixture at $C_t \approx$ 33% and different temperatures.











References

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