Measurements of neutron flux from deuterium plasmas in the MST reversed field pinch used in conjunction with ion temperature measurements indicate the presence of a fast ion population generated at magnetic reconnection events and maintained for several confinement times. During a typical event, Ti on-axis increases dramatically from ~0.1 keV to ~10 keV in less than 200 µs, and decays back to its original value in ~1ms. The subsequent neutron flux can be up to 100 times higher than from thermal plasma alone. The measured flux is consistent with, for example, a small (0.1%) non-thermal population at ~17 keV. After an event, the neutron flux decays with a time constant of ~ 3 ms. However, if an event is followed by a period of reduced magnetic fluctuations, the neutron flux decays at a much slower rate, which indicates improved fast ion confinement.

The fusion cross section is a strong function of energy, especially at the MST parameter range. A small ion population at high energy (~ 10 keV) can fuse with the thermal plasma to produce more neutrons than the thermal plasma (~ 1 keV) itself. Simultaneous neutron flux and ion temperature measurements can diagnose a fast ion population.

**Abstract**

**Fast Ion Generation**

- Large parallel electric fields (~10 V/m) are inferred to exist at the time of the reconnection event.
- The electric force is balanced by friction with electrons in a simple convection plasma, but when impurities are included, the runaway ion can occur dramatically, from ~0.5 keV to ~1 keV, in less than 200 µs, and decays back to its original value in ~1ms.

**Theory**

- The flux of ions from the plasma (~200 m/s) can be used to calculate the amount of energy deposited in the plasma.
- The reaction time of ions is given by the equation:
  \[ \tau = \frac{m_i}{eE} \]
- For example, a small (0.1%) non-thermal population at ~17 keV.

**Experiment**

- The flux of ions from the plasma (~200 m/s) can be used to calculate the amount of energy deposited in the plasma.
- The reaction time of ions is given by the equation:
  \[ \tau = \frac{m_i}{eE} \]
- For example, a small (0.1%) non-thermal population at ~17 keV.

**Fast Ion Confinement**

- The decay of neutron emission after a reconnection event is significantly longer when magnetic fluctuations are suppressed.
- In standard plasmas, the neutron emission decays with two time constants.
- The initial fast decay may be due to the disrupted confinement at the time of reconnection.

**Neutron Beam Injection**

- Fast ions from neutral beam injection are observed to be well confined in standard plasmas (no auxiliary current drive) despite field stochasticity except during diode reconnection events.

**Magnetic Mode Activity**

- A current gradient can destabilize tearing modes at resonant surfaces, resulting in large magnetic fluctuations.
- Magnetic fluctuations can be actively suppressed by inductively driving a spiral current in the edge.

**Reconnection Fast Ions**

- The decay in neutron emission after a reconnection event is significantly longer when magnetic fluctuations are suppressed.
- In standard plasmas, the neutron emission decays with two time constants.
- The initial fast decay may be due to the disrupted confinement at the time of reconnection.

**Neutron Detector**

- Organic plastic (Bicron 408) scintillator shielded by 2 in. lead.

**Charge Exchange Recombination Spectroscopy**

- 50 keV H neutral beam injected into plasma with measured electrons with plasma C+6 impurities.
- Doppler broadened CHERS spectrometer gives temperatures of C+6 impurity ions.

**Diagnastics**

- The two plots to the right show contours of constant neutron flux for runaway ion fusion (left) and thermal fusion (right) for three temperatures in MST ion temperature range.
- The measured and predicted neutron fluxes tend to agree better in these plasmas, especially at higher ion temperatures.

**Conclusion**

- The neutron flux measured from MST RFT plasma tends to be much higher (~100x) than expected away (in time) from discrete magnetic reconnection events.
- This discrepancy can be explained if there is a small population of runaway into (~0.1%) at 17 keV.
- During reconnection events, thermal fusion contributes significantly to the neutron signal, making it more difficult to diagnose a runaway event.
- By actively suppressing tearing mode activity with auxiliary current drive in the edge, the neutrons can be accounted for by thermal fusion.
- The decay of the reconnection induced neutron flux is much slower when magnetic fluctuations are reduced.