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Sandia National Laboratories

High-Energy Neutron Platform Development

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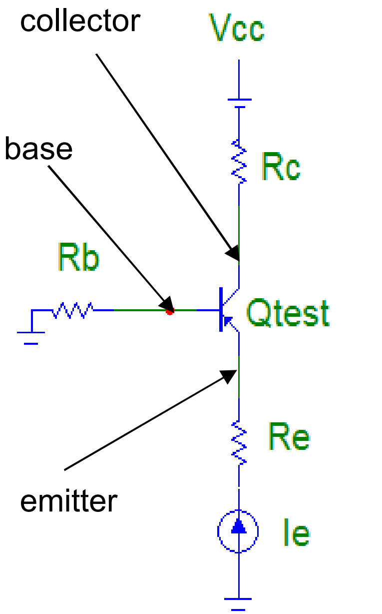
Development Campaign Goals

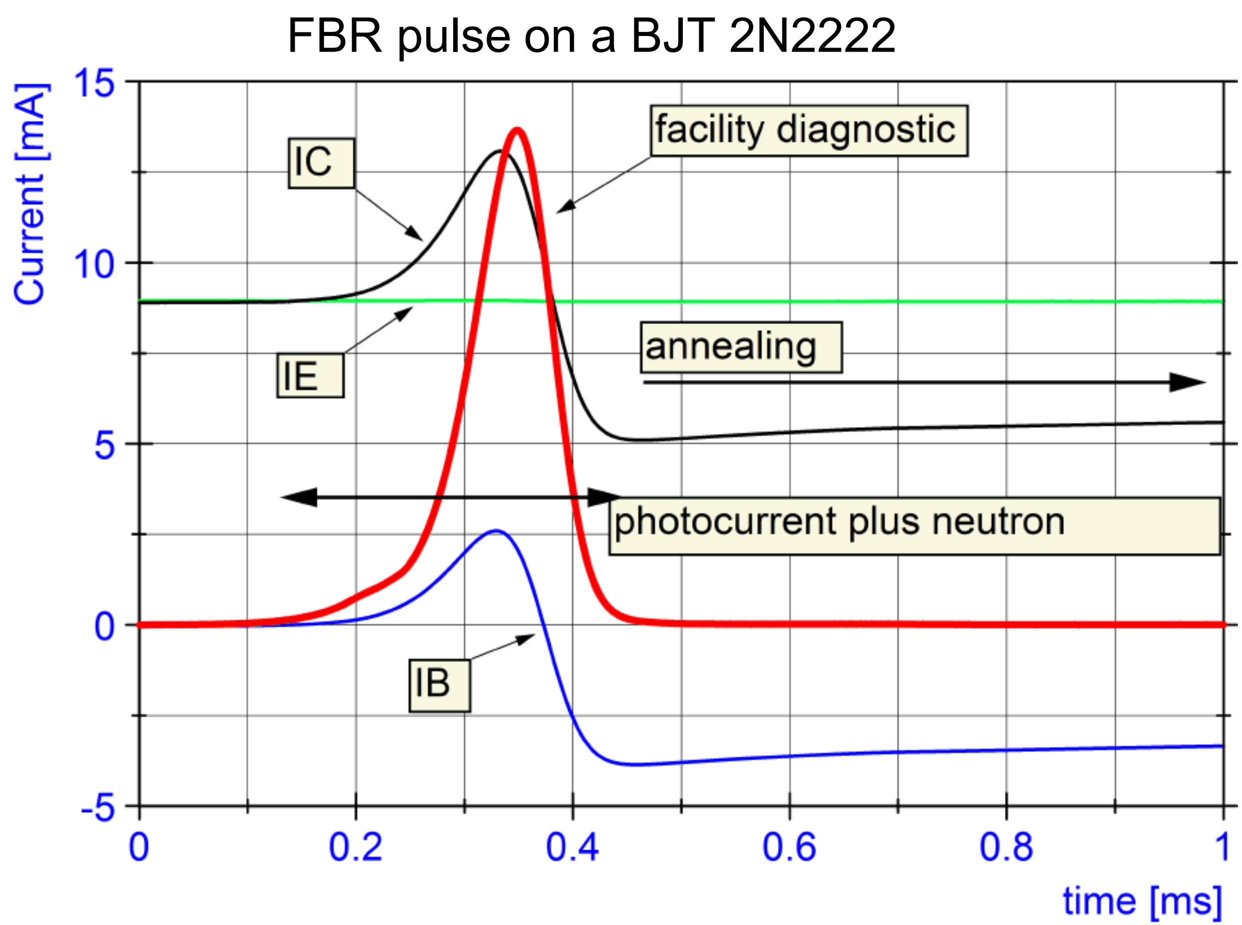
- Observe high yield D-T pulsed neutron damage to electronic components and circuits
  - Current rapid pulse test environments are limited to fission neutron energies
    - SNL's ACRR, White Sands Missile Range FBR, us-ms wide pulses
  - Desire for higher energy neutron pulses to investigate different damage mechanisms at higher energies
    - Currently limited to slow D-T neutron generator or surrogate ion irradiations
  - Time-frame for:
    - damage observation after pulse is microseconds to milliseconds
    - initial anneal and defect evolution is milliseconds to seconds
- Platform development at Z
  - Develop a testing platform with this capability as close as possible to the Z target
  - Engineer out the harsh mechanical, radiation, and electrical environment
  - In preparation for high yield D-T shots
  - Currently in FY2 of 3 in Grand Challenge LDRD
- Currently exercising this capability using discrete transistors to measure neutron levels and damage

Background on Transistors

- The transistor gain is a traditional metric.
- Transistor current response to radiation is measured



Test circuit uses ASTM Standard F 980M-961 techniques



Gain = IC/IB Inverse Gain = IB/IC

Why OMEGA and NIF

- OMEGA has a very clean D-T neutron environment with low mechanical, radiation, and electrical shock/noise
  - D-T yields at ~1E14 neutrons
    - Devices subjected to nearly 1E11 n/cm^2
  - Test capability of measuring D-T neutron fluence on soft 2N1486 power transistor
    - Gains were degraded by >85% after pulse
    - Fluence too low to see impact on harder Si components or III-Vs
  - Highly successful testing campaign with no fielding or operational issues
- NIF has the potential to have much larger impact than OMEGA
  - D-T yields at ~1E16 neutrons
  - Assuming similar fielding locations, radiation-soft devices are not necessary
    - Potential fluences of 1E13 n/cm^2
  - Damage in non-rad soft electrical components can be evaluated in real time
    - Evaluate the impact of high-energy neutrons in these components vs. fission spectrum neutrons
  - Potential near-term tests to determine if a viable neutron platform

Z is our project goal, but all fusion sources have a role

OMEGA Setup Pictures

Very simple measurement system and setup

"NED" bullet with transistor and passive dosimetry

OMEGA Results and Feedback

- Significant gain degradation and device response with low noise
- D-T target yield of 9-9.8x10^{13}
  - D-T fluence on device ~4-8x10^{10}
    - Confirmed by:
      - LLE reported yield + distance
      - SNL sulfur tablet dosimetry
      - Device gain degradation w/preliminary results of ASTM standard extended to 2N1486
- No significant issues fielding device at OMEGA
  - "NED" Nuclear Effects Diagnostic
  - No mechanical shock issues like Z
  - Device recovered to usable signal in 4-10 microseconds
- Nuances
  - Current limiting diode (CLD) vs direct power supply bias controlled emitter
    - "Circuit" response to pulse
  - Device junction shuts off for ~1 microsecond
    - Due to photocurrent