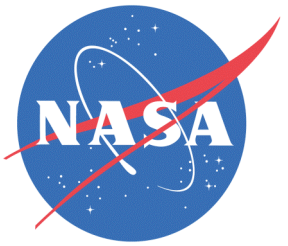
VANDERBILT School of Engineering



Moving Single-Event Mechanism Testing and Analysis into the Time-Domain

Jonathan A. Pellish, R. A. Reed, R. D. Schrimpf, R. A. Weller, N. D. Pate, A. K. Sutton, R. M. Diestelhorst, J. D. Cressler, R. Baumann, D. McMorrow, J. S. Melinger, G. Vizkelethy, and P. W. Marshall

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Sandia is a multiprogram laboratory operated by the Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

Preview

- Time-dependent *vs* time-independent methods
  - Conflict between experiment and simulation
  - Benefits to time-domain techniques

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  - Purchase of high-speed measurement equipment
  - Development of high-speed packaging
  - Initial measurement of radiation-induced transients

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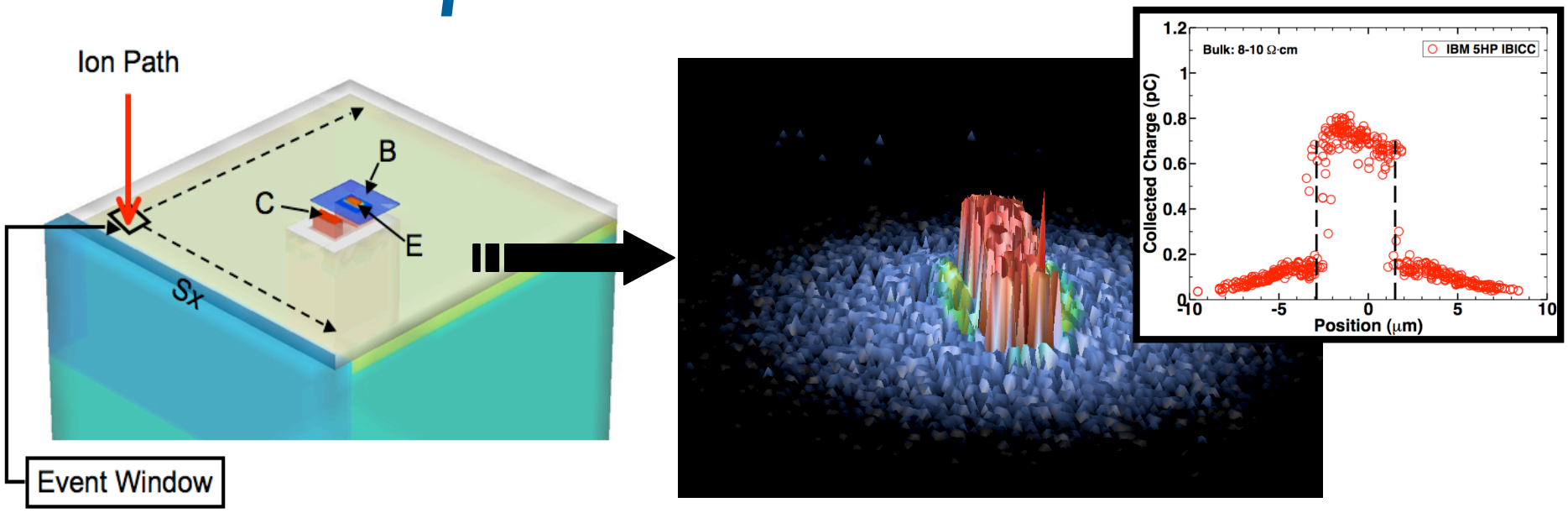
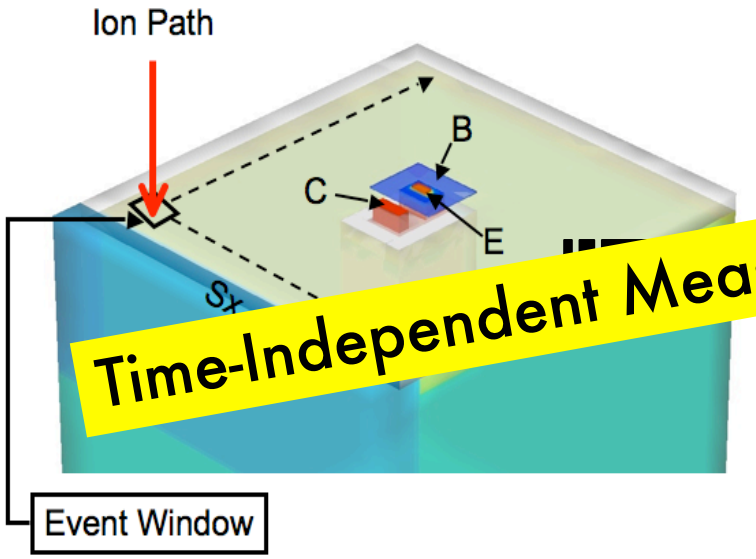
- Time-dependent *vs* time-independent methods
  - Conflict between experiment and simulation
  - Benefits to time-domain techniques
- Previous progress and present status
  - Purchase of high-speed measurement equipment
  - Development of high-speed packaging
  - Initial measurement of radiation-induced transients
- Proposed projects
  - Calibrate TCAD in the time-domain (IBM CMOS, IBM BiCMOS, TI CMOS, Jazz CMOS, Jazz BiCMOS)
  - Measure strained silicon transients (U Florida, MURI)

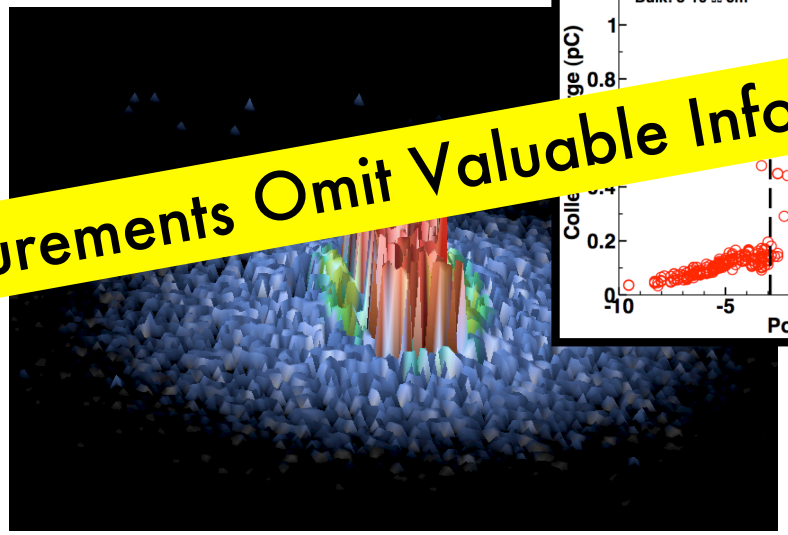
Time-Independent Measurements

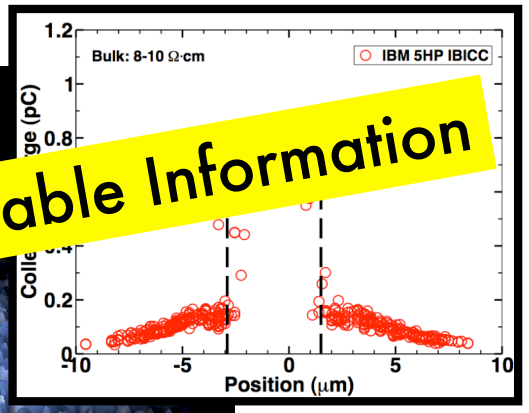


Standard Heavy Ion Microbeam and Laser Methods

Time-Independent Measurements







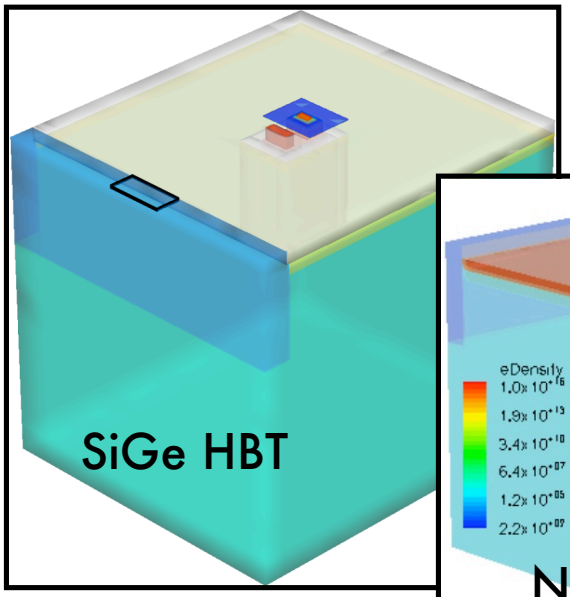
Time-Independent Measurements Omit Valuable Information

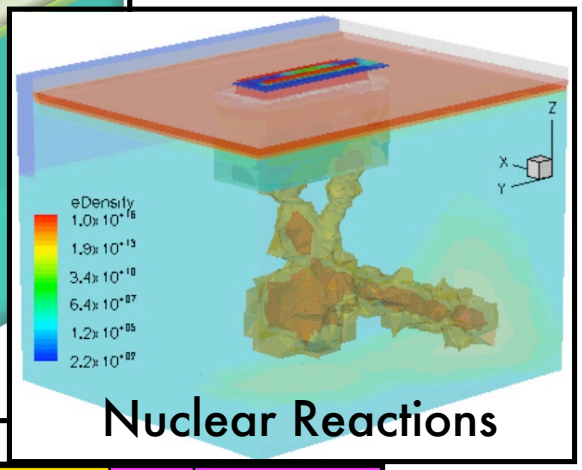
Issues with Time-Independendent Methods

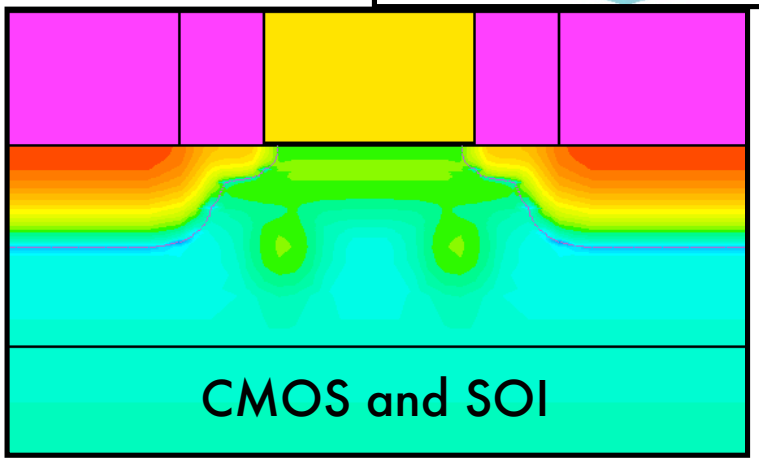
- Limited TCAD calibration
- Limited operational configurations
- Lack of transient information
- Experimental complexity

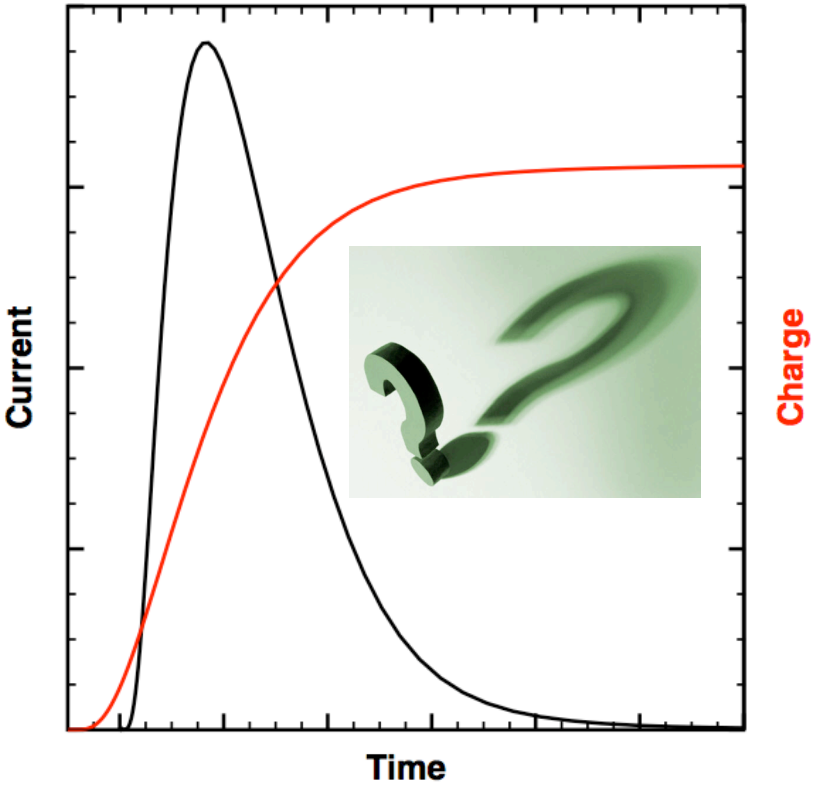
J. A. Pellish, *et al.*, "Substrate engineering concepts to mitigate charge collection in deep trench isolation technologies," *IEEE Trans. Nucl. Sci.*, vol. 53, pp. 3298-3305, Dec. 2006.

Time-Dependent Simulations





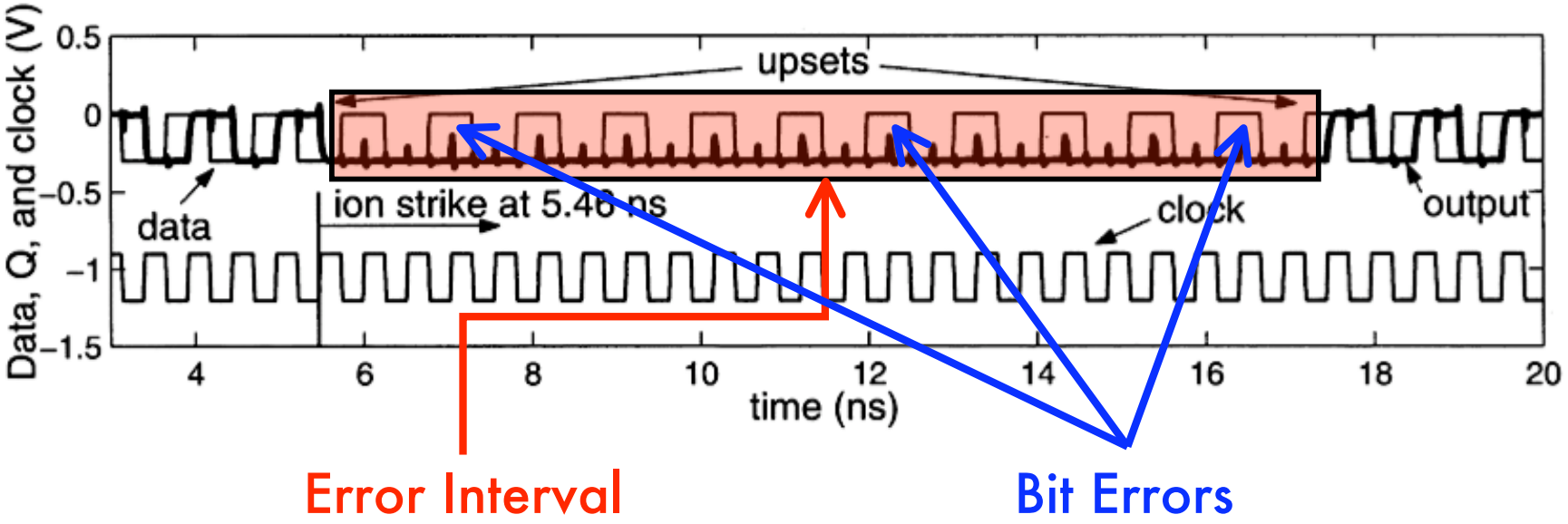




- TCAD solves time-dependent PDEs
- Calibrate to integrated values

When does this approach fail?

Serial Data At the Speed of Radiation



R. Krithivasan, *et al.*, "An SEU hardening approach for high-speed SiGe HBT digital logic," *IEEE Trans. Nucl. Sci.*, vol. 50, pp. 2126-2134, Dec. 2003.

CMOS and BiCMOS circuits now operate with time constants equal to or less than those of radiation-induced transients. ***BURST ERRORS***

Solution

- Need a predictive tool for burst error rates

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- Use mixed-mode TCAD (Synopsys, CFDRC)

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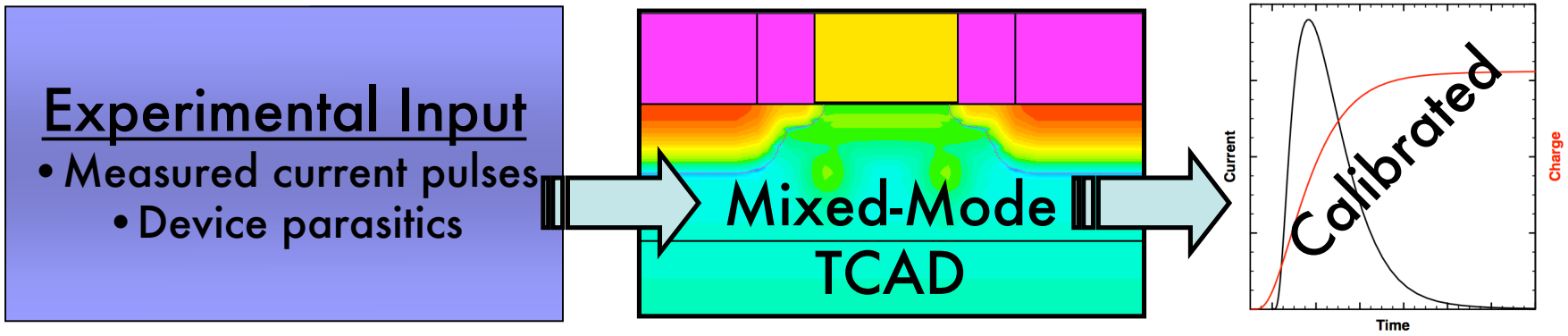
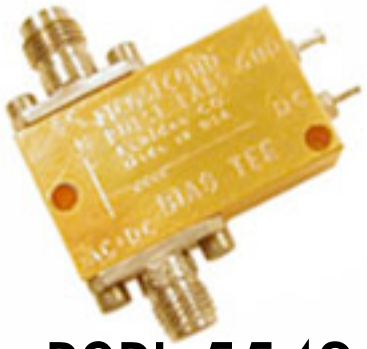
- Need a predictive tool for burst error rates
- Use mixed-mode TCAD (Synopsys, CFDRC)
- Need to calibrate TCAD to experimental time-domain data



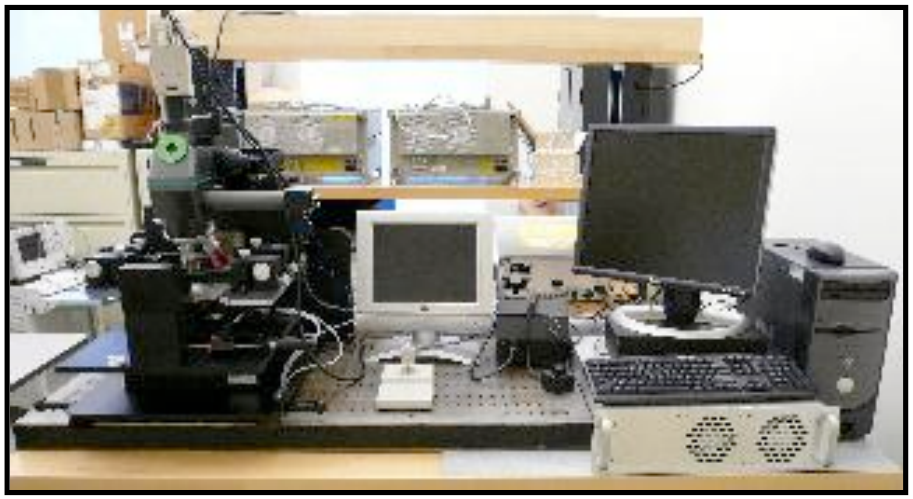
Vanderbilt Measurement System

Tektronix TDS6124C
12 GHz, 40 GS/s



PSPL 5542
50 GHz

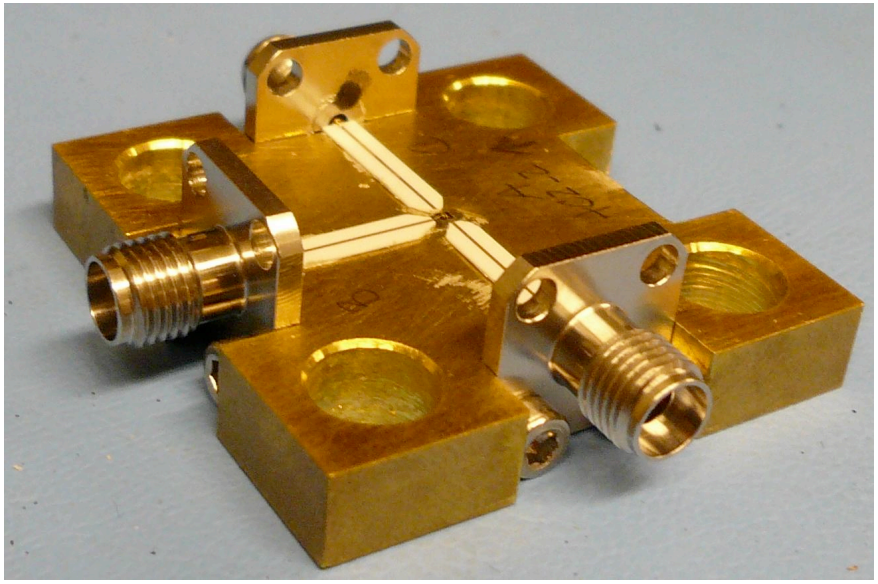
Gore 2.92 mm RF coax
40 GHz

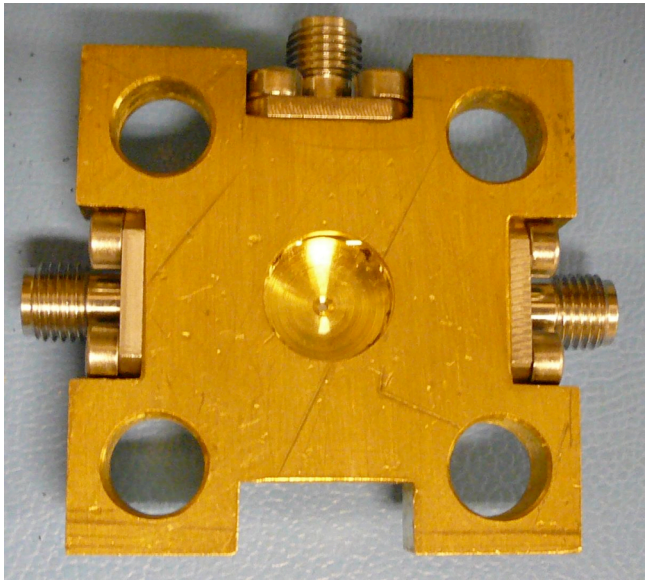


AFOSR DURIP Award

RF probe station (DC - 40 GHz)

High-Speed Package Development

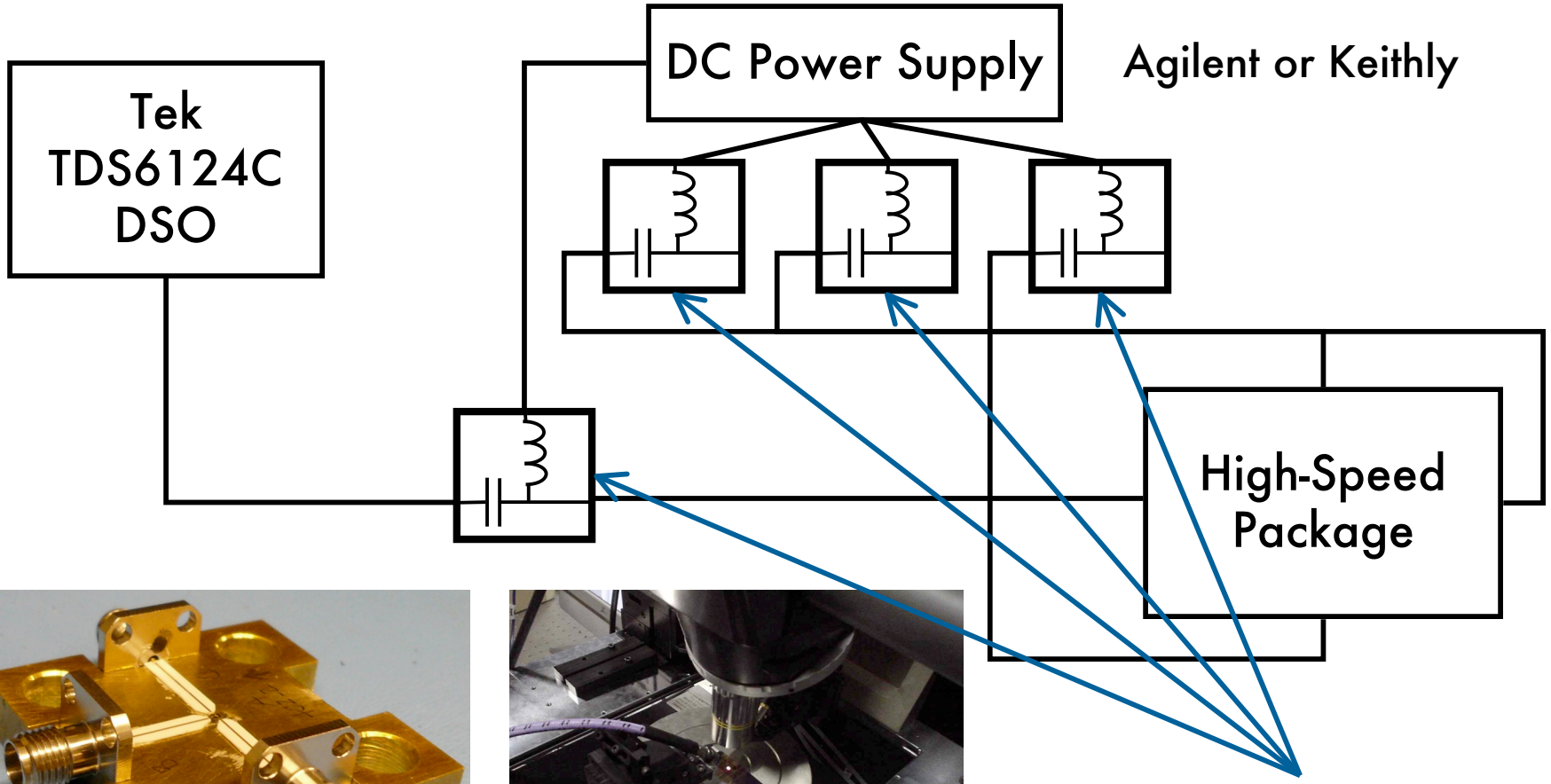




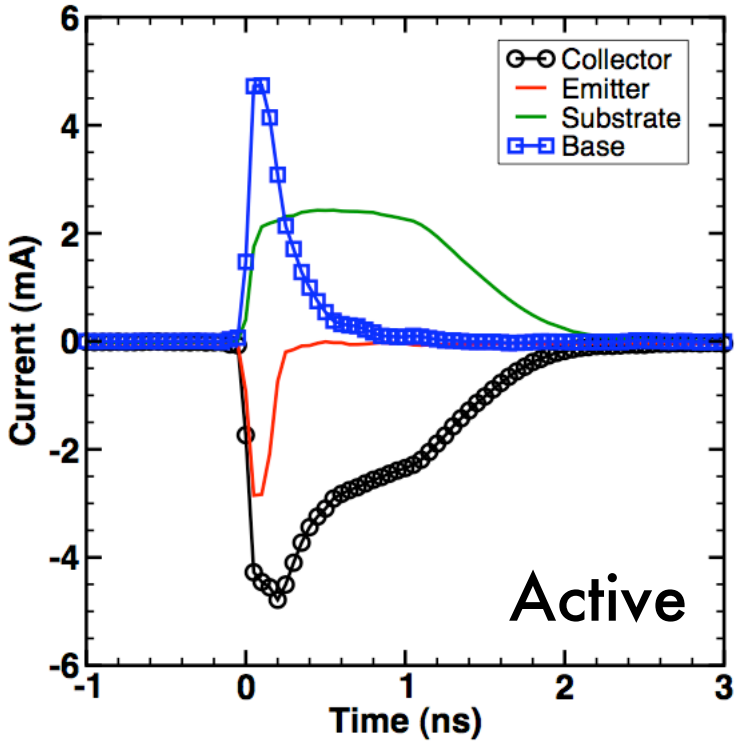
Developed in collaboration with D. McMorrow (NRL)

- Works for SPA and TPA laser testing and microbeam too
- Close attention paid to impedance matching
  - All 50 Ω to ground
- Microstrips and 2.92 mm connectors – 40 GHz
- Uses 1 mm^2 DUT tile

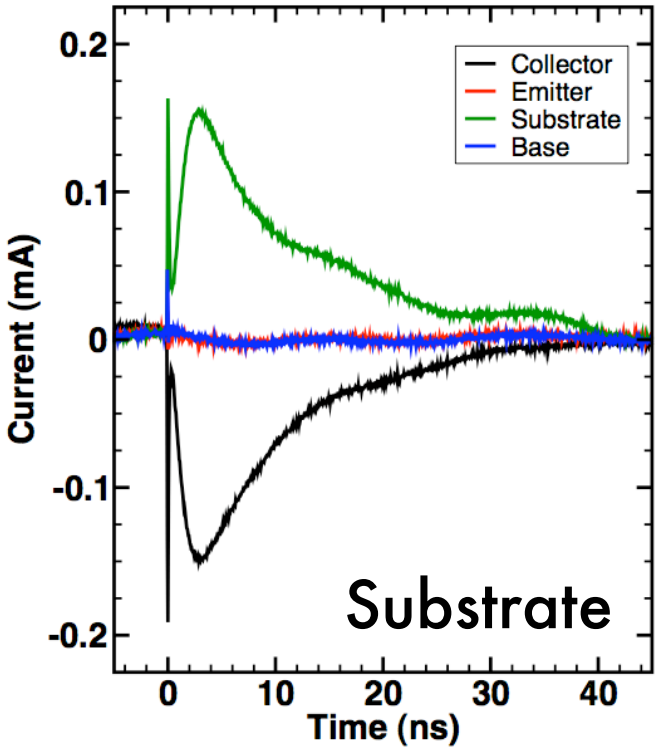
Typical Experimental Setup



Laser-Induced Transients with SiGe HBTs



NRL TPA
25 mV
1 kHz
OD-0



High-resolution: 25 ps/point Long record lengths: 5000 points

No ringing and no detectable low-pass filter effects

Planned publication in EDL

Future Work

- Ph.D. Focus
  - Use experimental transient measurements to calibrate TCAD and MRED
  - Burst error rates and frequency-dependent σ_{SEU}
    - CMOS and BiCMOS
  - Targeting fall 2008 completion
- Primary experiments
  - Laser transient generation (NRL and VU FEL)
    - TI, IBM, and possibly Jazz
  - Prove measurement system at Sandia microbeam
    - Vacuum chamber, custom RF feedthrough

Future Work

- RHESE/ETDP leverage through Georgia Tech
  - CRYO-2 substrate tap splits
    - N. Pate (Q_{total}) – SNL January 2008
    - J. Pellish (transient measurements)
  - CRYO-3a hardware (January 2008)
- U. Florida strained silicon; MURI leverage
  - Completed proof-of-concept 09/Nov/2007
- TI SET macro for scaling study
  - Down to 45 nm CMOS