National Aeronautics and Space Administration

Heavy Ion Microbeam- and Broadbeam-Induced Current Transients in SiGe HBTs

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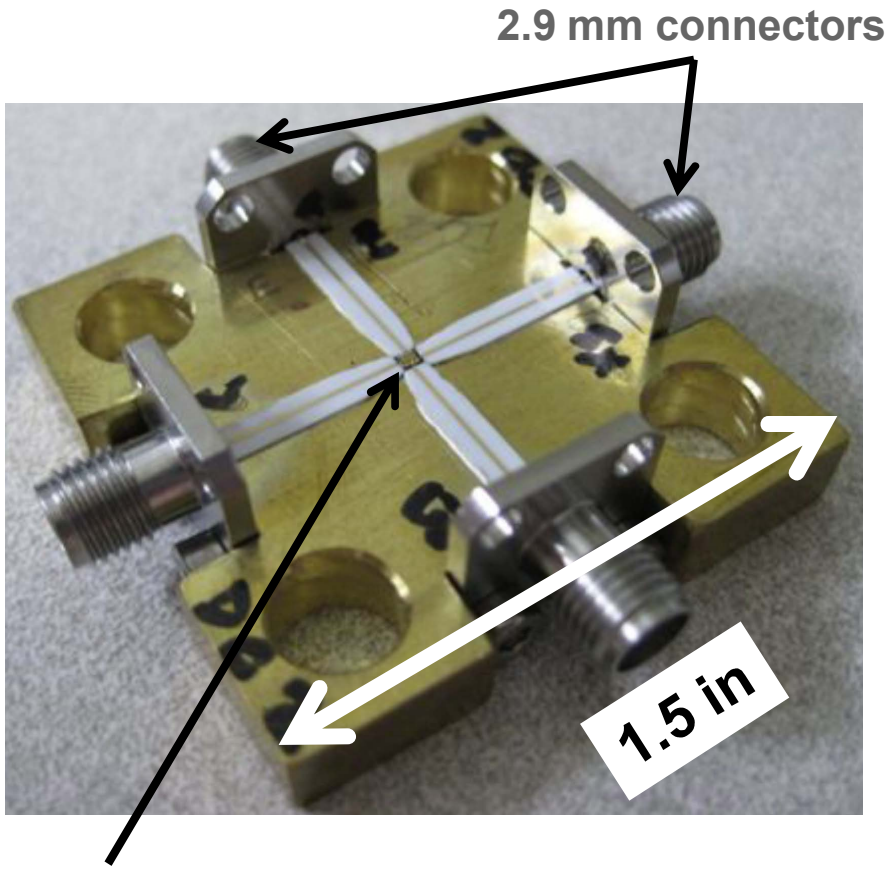
- SiGe teams at the Georgia Electronic Design Center and IBM
- Naval Research Laboratory
- CEA/DIF (Arpajon, France)
- Sandia National Laboratories **(SNL)**
- Department of Physics at the University of Jyväskylä, Finland **(JYFL)**
- Grand Accélérateur National d'Ions Lourds, France **(GANIL)**

Heavy ion transient overview

- IBM 5AM SiGe HBT is device-under-test
- High-speed measurement setup
- Low-impedance current transient measurements
  - SNL, JYFL, GANIL
- Microbeam to broadbeam position inference
- Improvement to state-of-the-art



Single SiGe HBT device under test (1 mm^2)

R. S. Wagner, *et al.*, *IEEE Trans. Nucl. Sci.*, vol. 33, no. 6, pp. 1651–1655, Dec. 1986.

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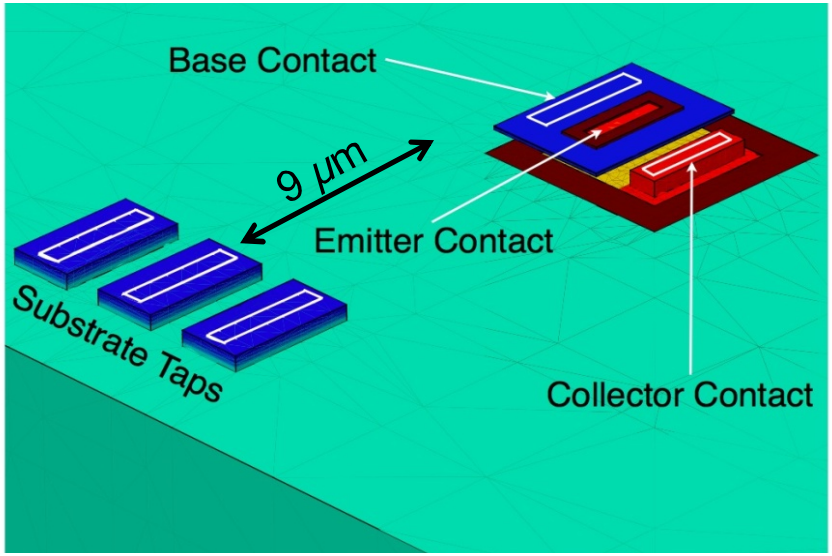
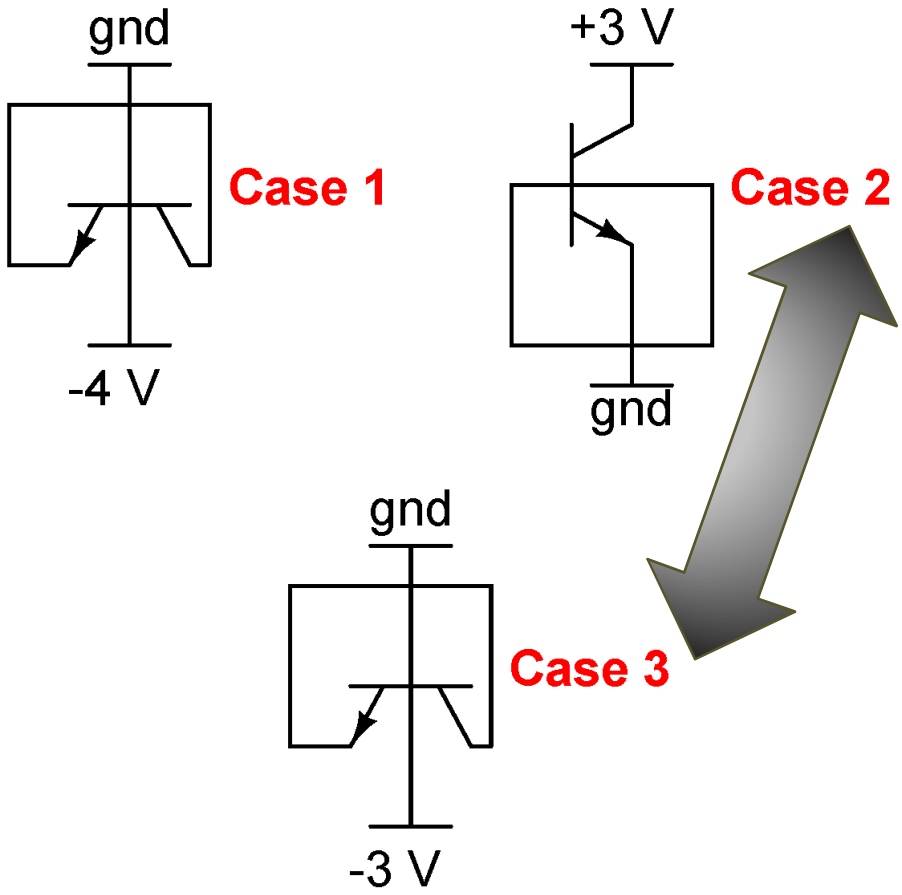
Bias conditions of interest

All biases based on device isolation



3-D TCAD from DUT GDSII
IBM 5AM npn SiGe HBT



Bias conditions chosen to represent “circuit-like” experiments

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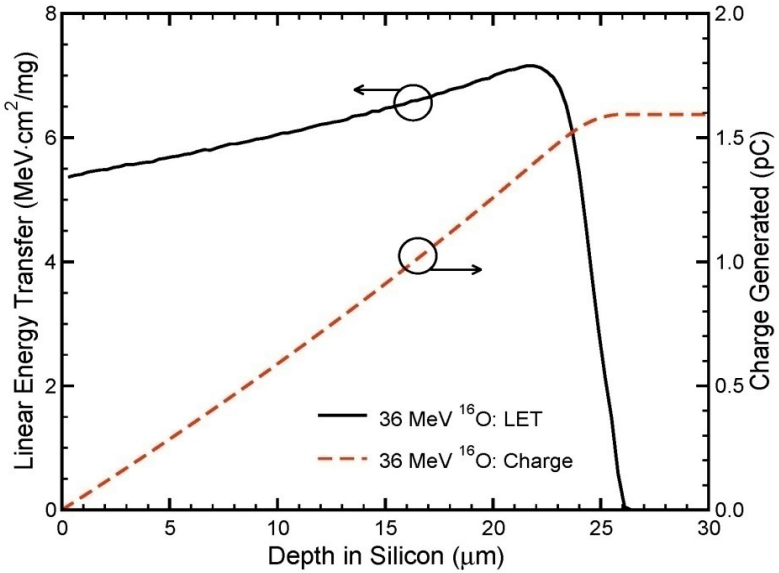
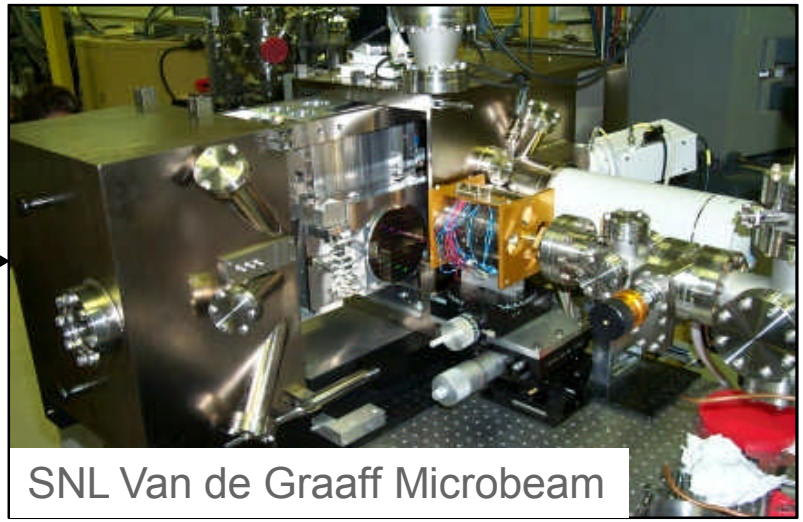
Typical experimental setup

Different than broadbeam

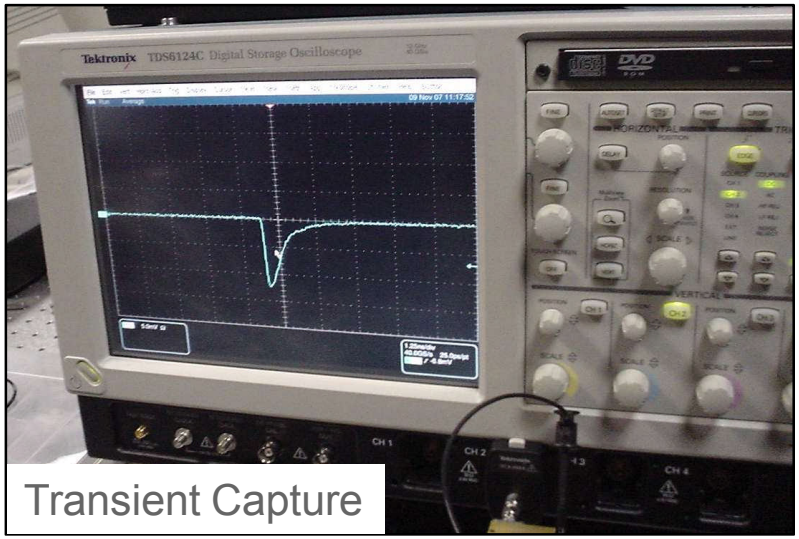


36 MeV ^{16}O d*E*/d*x* profile [SRIM-2008]

Sandia National Laboratories' Microbeam Chamber



SNL Van de Graaff Microbeam



Transient Capture

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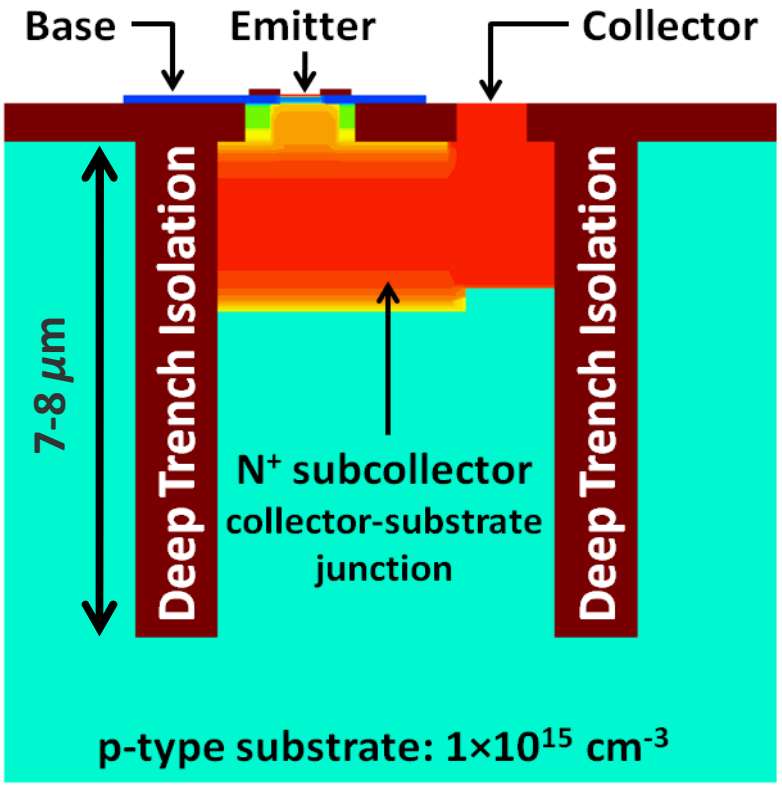
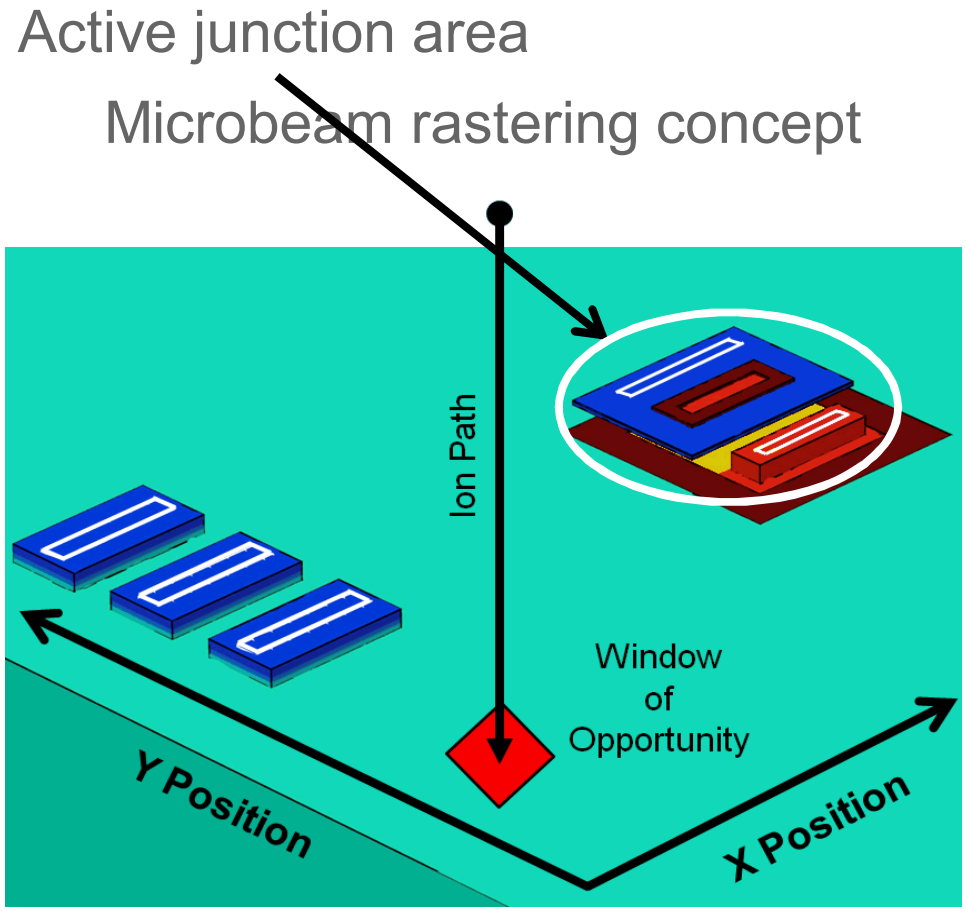
Device under test and microbeam irradiation



IBM 5AM npn SiGe HBT



Microbeam data allows position correlation

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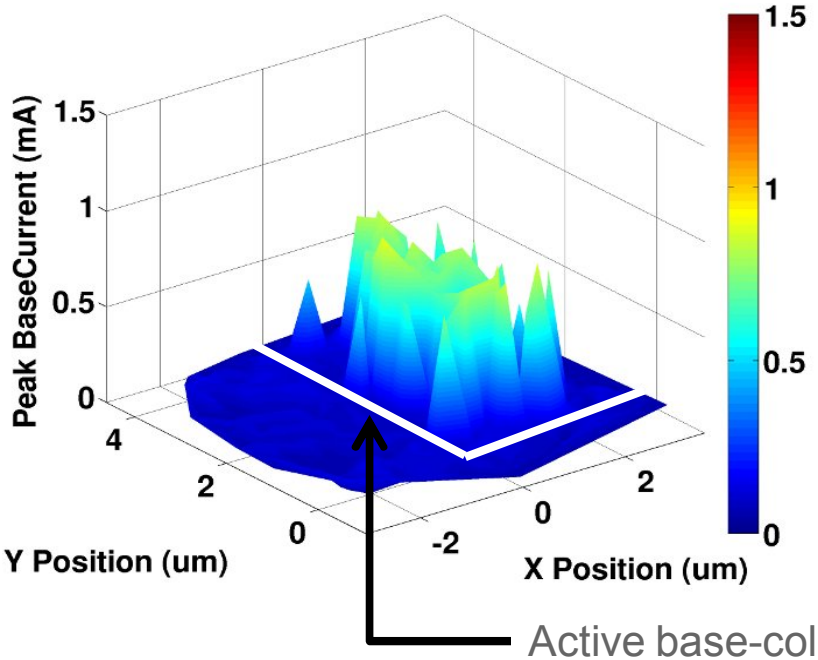
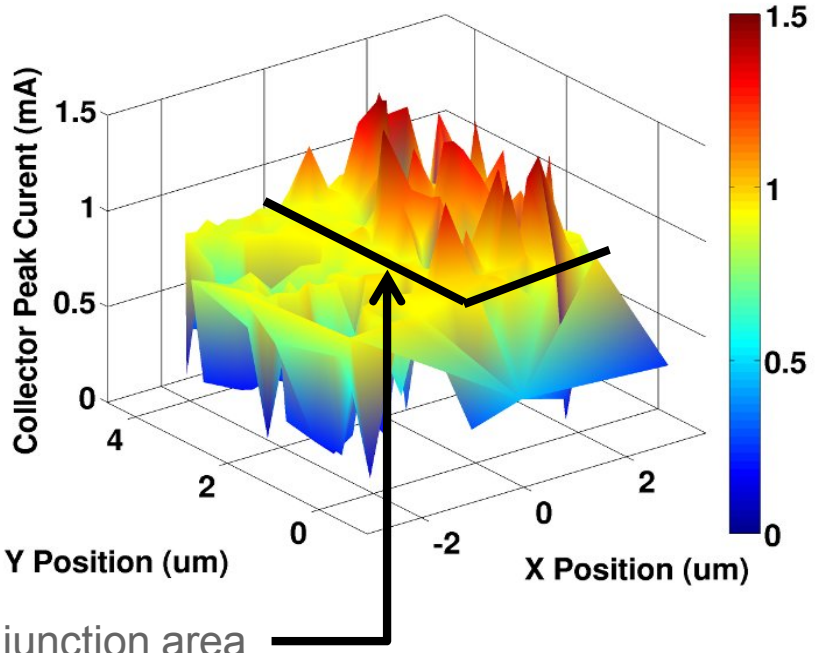
36 MeV ^{16}O SNL microbeam: Case 1

Peak current magnitude

Base



Collector



Active base-collector junction area

- V_{sub} = -4 V; all other terminals grounded
- Base terminal images base-collector junction
- Collector terminal images base-collector junction and subcollector

Imaging provides information about position and current

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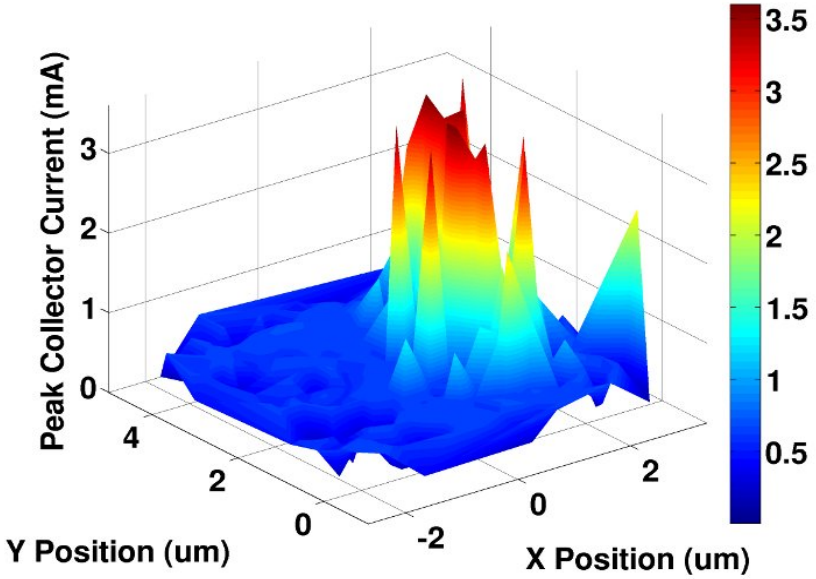
36 MeV ^{16}O SNL microbeam: Case 2 *vs.* 3

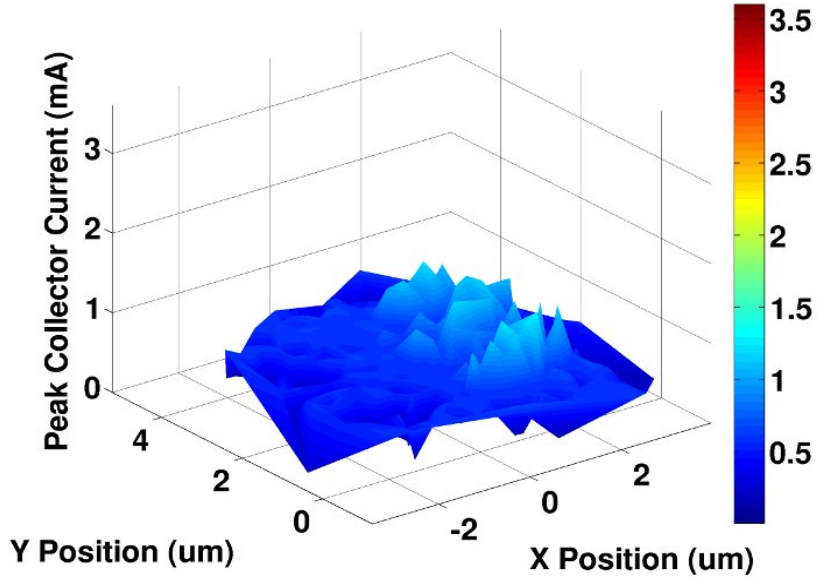
Peak current magnitude

Collector



V_C = +3 V (Case 2)

Collector



V_{sub} = -3 V (Case 3)

- Same result was observed in two-photon pulsed laser testing

J. A. Pellish *et al.*, *IEEE Trans. Nucl. Sci.*, vol. 55, no. 6, pp. 2936-2942, Dec. 2008.

Difference in peak current results from non-zero V_{CB}

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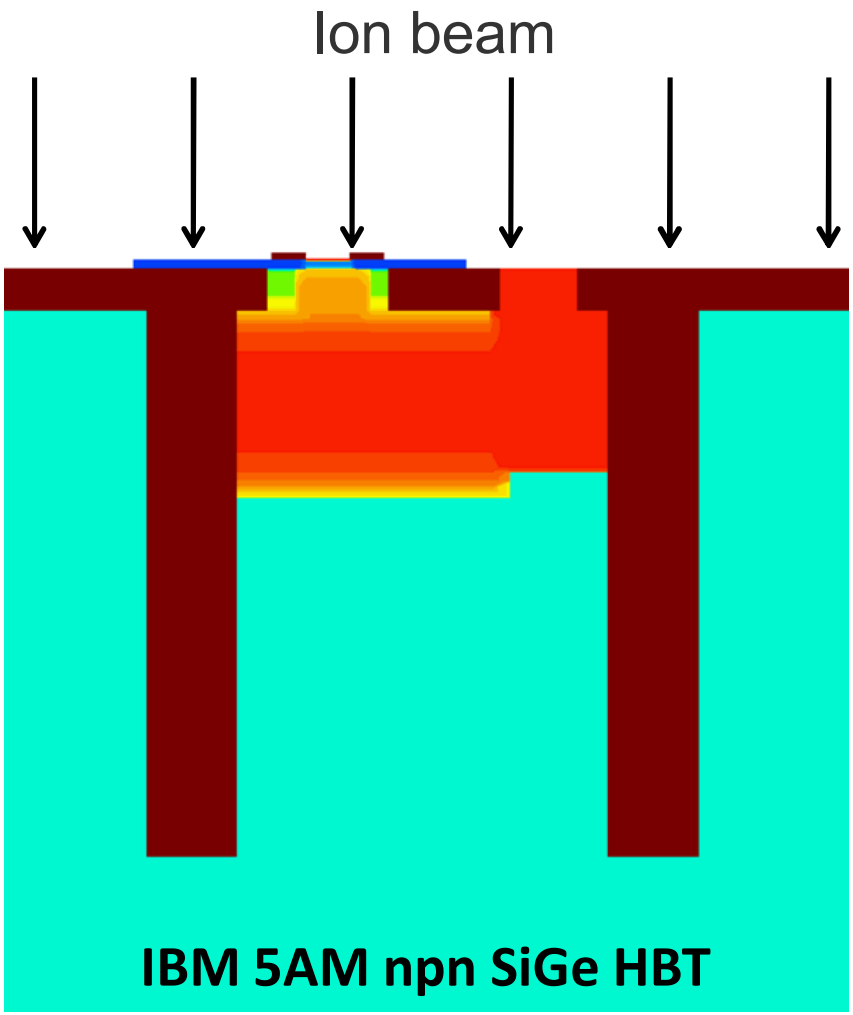
Heavy ion broadbeam transients



University of Jyväskylä
K-130 Cyclotron

No position correlation with broadbeam irradiation

- Data collection at JYFL and GANIL
- 9.3 MeV/u cocktail including ^{20}Ne, ^{40}Ar, ^{82}Kr, and ^{131}Xe and 45.5 MeV/u ^{136}Xe

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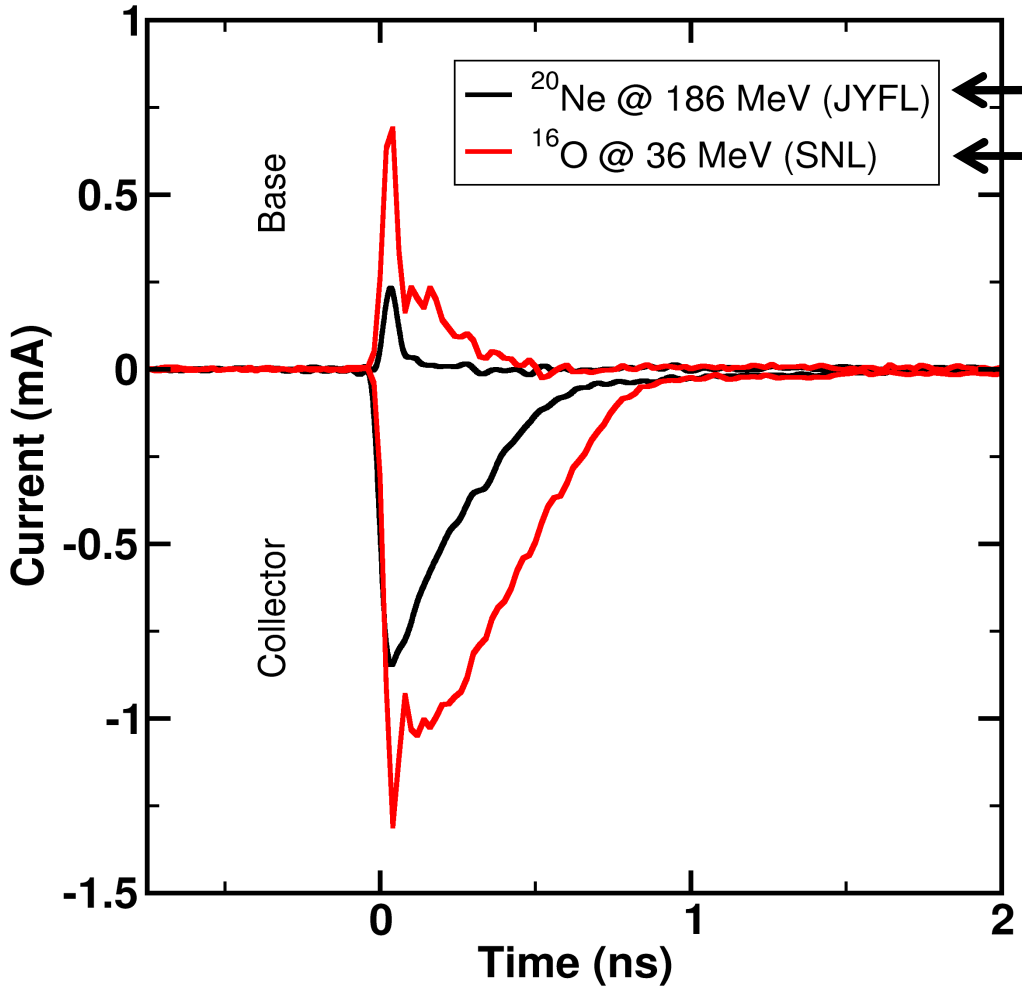
JYFL *vs.* SNL: LET scaling



A ^{20}Ne and ^{16}O transients are similar – related by LET

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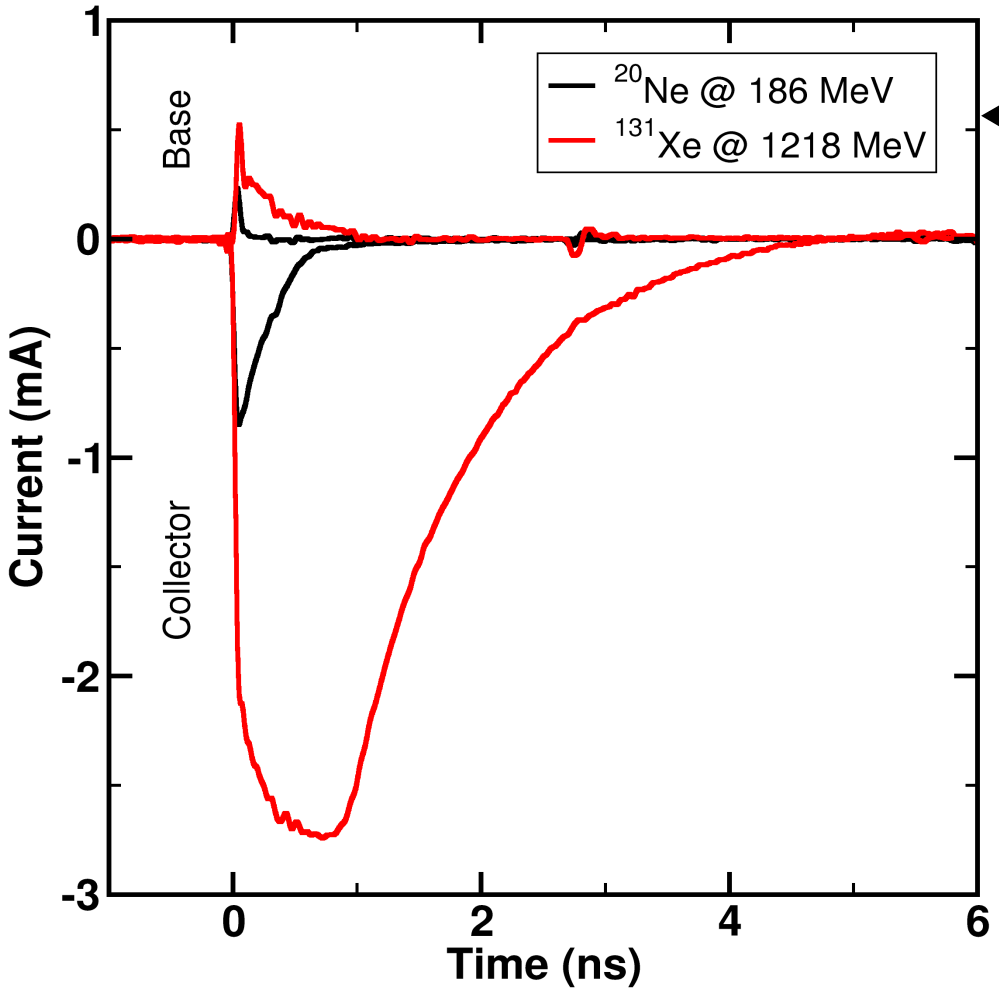
JYFL: LET extremes



9.3 MeV/u

^{20}Ne LET
3.6 (MeV·cm^2)/mg

^{131}Xe LET
60 (MeV·cm^2)/mg

Position correlation made possible with microbeam data

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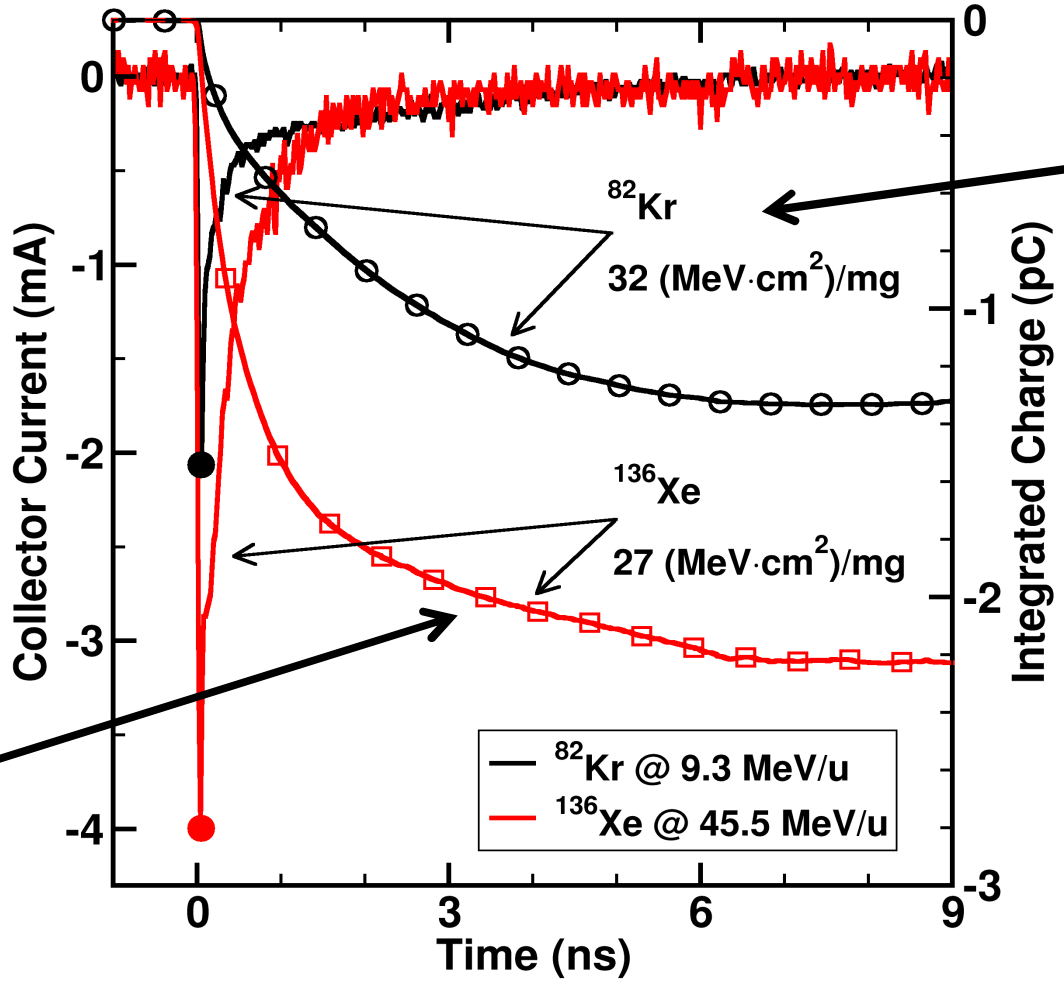
JYFL *vs.* GANIL transients



Ma Similar LET values produce different transient responses ty

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Conclusions

- Microbeam (SNL) transients reveal ***position-dependent*** heavy ion response
  - Unique response for different device regions
  - Unique response for different bias schemes
  - Similarities to TPA pulsed-laser data
- Broadbeam transients (JYFL and GANIL) provide ***realistic*** heavy ion response
  - Feedback using microbeam data
  - Overcome issues of LET and ion range with microbeam
  - **Angled ^{40}Ar data in full paper
- Data sets yield ***first-order*** results, suitable for TCAD calibration feedback

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