Switch-Glitch

Location of Fault Injection Sweet Spots by Electro-Magnetic Emanation

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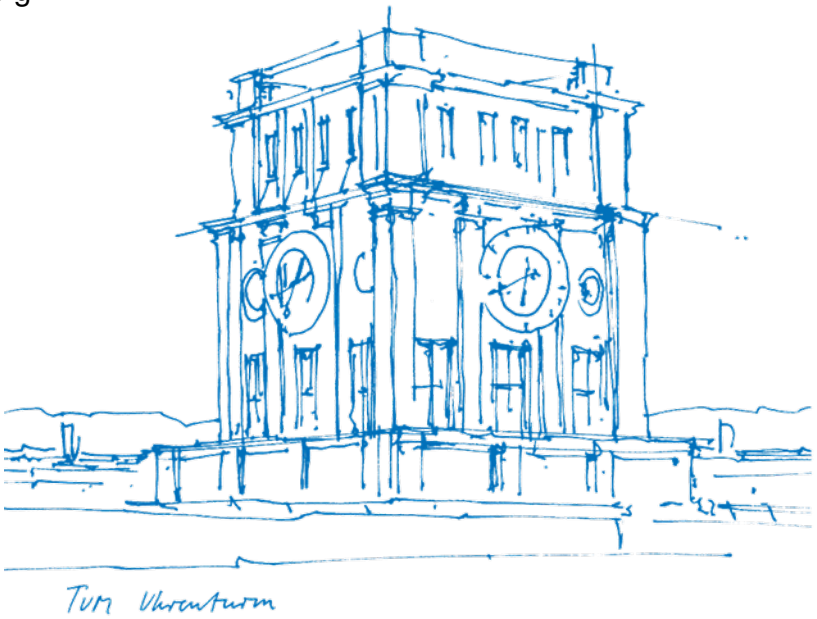


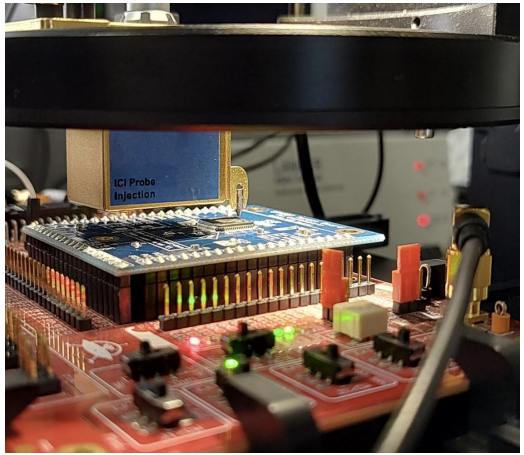
Overview

Introduction

Finding Position for EMFI means finding suitable parameters for

- x,y,z Position
- time t_{Fault}
- length Δt_{Glitch}
- strength V_{Fault}
- number of glitches
- ...

$\rightarrow$ This is takes a long time!
$\Rightarrow$ **We aim to speed up the process**



State-of-the-Art

Probe position for local Electro-Magnetic Emanation measurements:

- Statistical metrics find high SNR positions [6, 7]
- Leakage information to select positions [2, 8]
- machine learning [4]

EMFI local attacks focus on setups only:

- Breier and Jap use a laser for local fault injections [1]
- Guiellen et al. show low-cost setup to be effective for local fault injections [5]
- Ghodrati et al. inject local faults into a RISC-V core [3]

$\rightarrow$ EMFI position selection is not yet covered

$\Rightarrow$ Is there a relation between local EM positions and local EMFI positions?

$\Rightarrow$ Can we use this to our advantage?

Methodology

TVLA or SNR-test need

- multiple traces
- knowledge about processed data

EM hotspot identification with simple SNR

$$\mathrm{SNR} = \frac{\mu_T^2}{\sigma_T}$$

to collect as little data as possible.

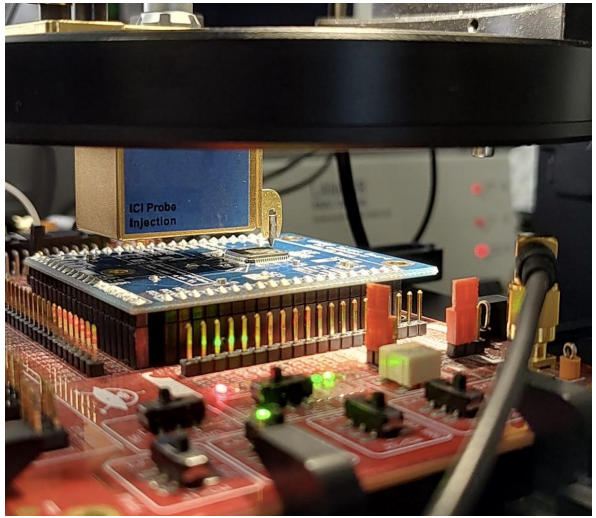
→ single trace T

→ no data-knowledge required

Testcode is used for both EMFI and SCA. For faults, we target second store of `r4` to `sp+12`.

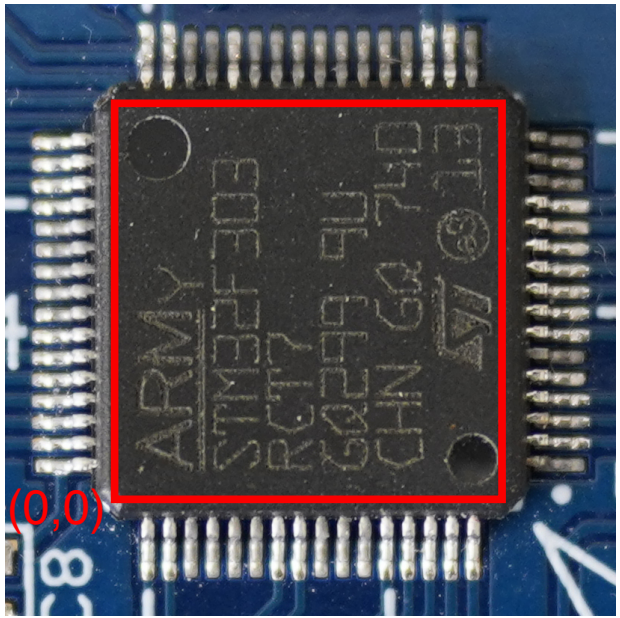
```
1   uint32_t inc, data[3] = {0,0,0};
2
3   set_trigger();
4   // function we want to glitch
5   asm("nop                         ;; 20 times
6        movs r4, #65 \n\t
7        strd r4, r4, [sp, #8]
8        nop                         ;; 20 times
9        str  r4, [sp, #16]");
10  reset_trigger();
11  send_data(data, sizeof(data));
```

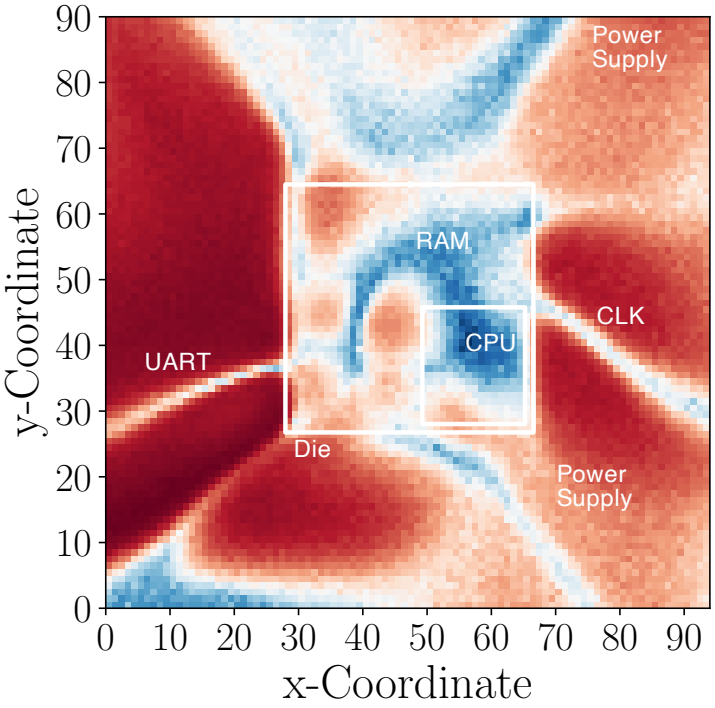
Experimental Setup



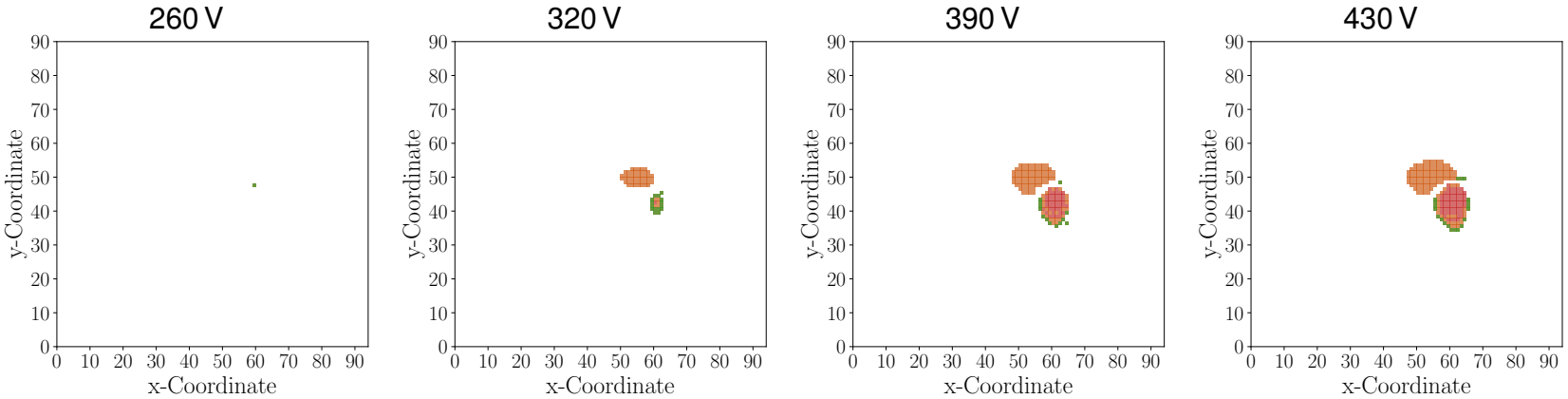
- **STM32F303** Microcontroller running at 48 MHz
- NewAE CW308 UFO Board as base PCB
- Picoscope 6402D (@ 2 GHz) with near-field EM probe with **resolution of 150 um** (Langer ICR HH250-75)
- Faults with **coil diameter of 500 um** (Langer BPS 202 and Langer ICI HH 500-15)
- **Power Cycle** during EMFI via FTDI UART bridge

Local EM emanations





Local Fault Injections I



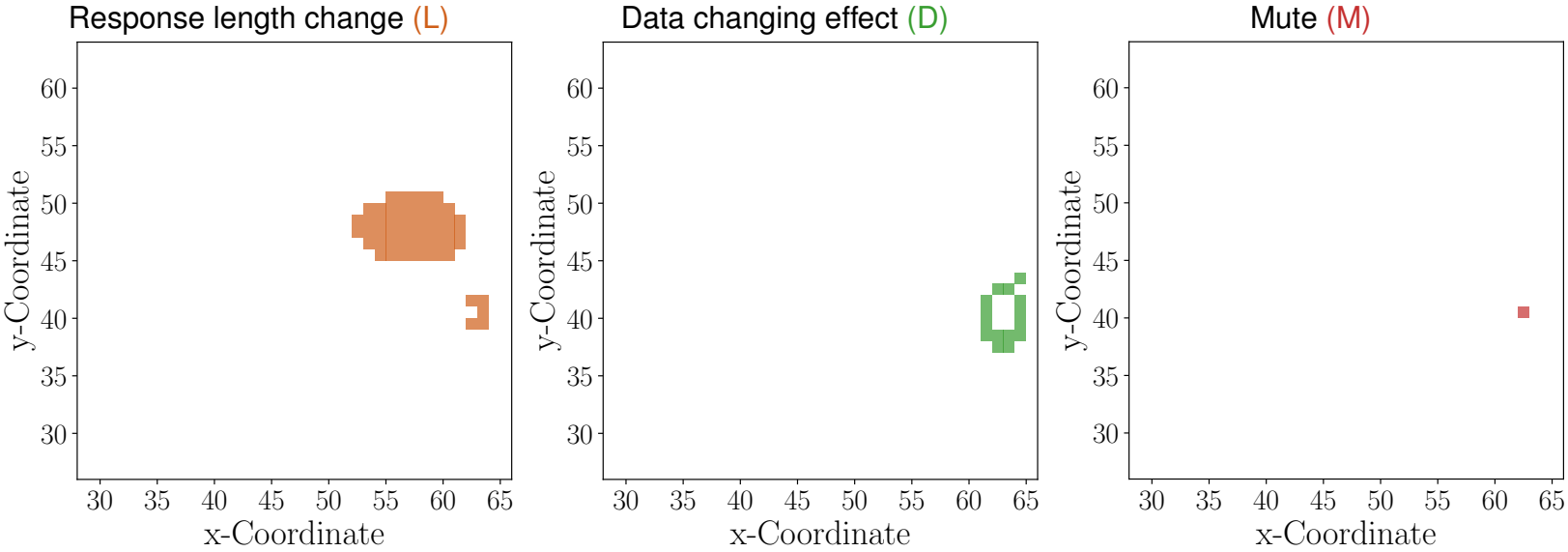
Fault parameters in addition to x- and y-direction:

- $\Delta t_{Fault} = 10\,\mu s$ (shortest possible)
- V_{Fault} from 150 V to 430 V in 10 V steps
- Offset from trigger is set to 50 ns

→ Lower voltage lead to (D) and (L) at about 320 V.

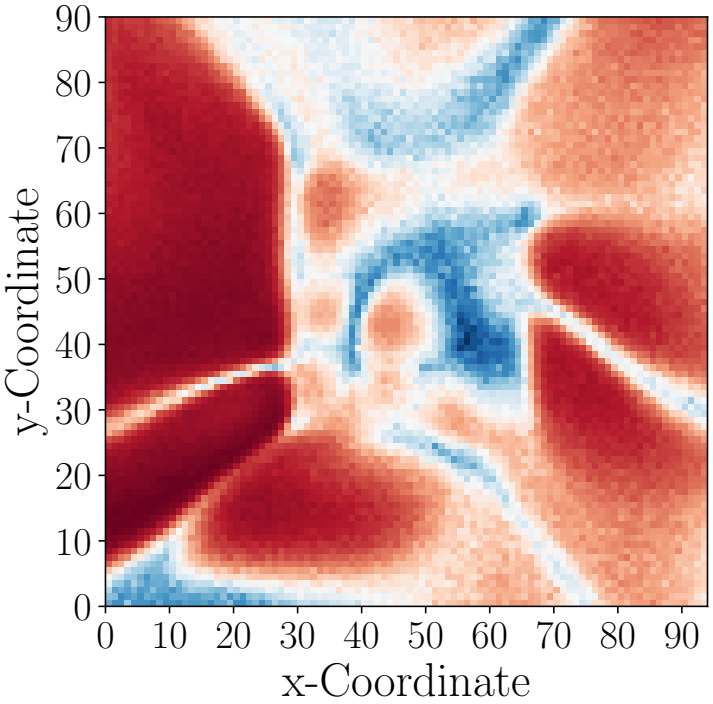
→ Increasing voltage further leads to increased (M) occurrences.

Local Fault Injections II



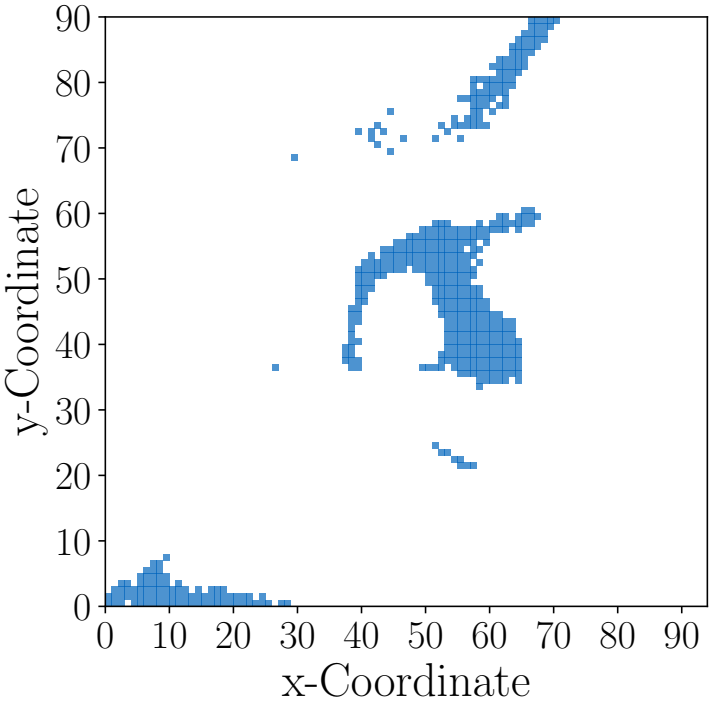
Images for $V_{Fault} = 320\,\text{V}$

Relation between EM and EMFI spots I

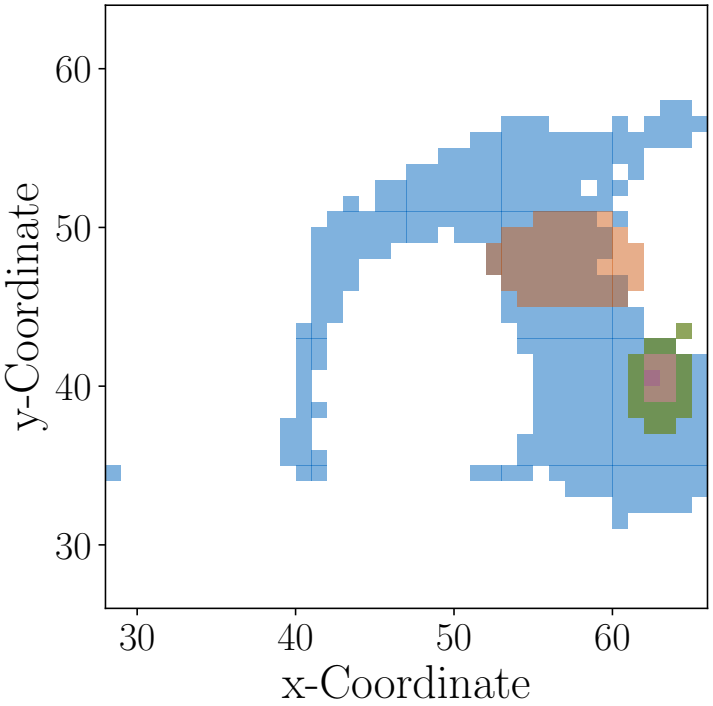


Threshold of 1.4

⇒



Relation between EM and EMFI spots II



From the figure we can see:

- (M) and most parts of (D) are included in high SNR area
- Data change area (D) is almost fully contained in the in high SNR area

This means:

→ 31% of the die area with high SNR is also prone to fault injections

→ 93% of (D) is covered by all high SNR

⇒ We can use this to speed up Sweet Spot identification

Conclusion

- ⇒ high SNR EM positions relate to fault prone positions
- ⇒ Faults only occur within the die area[1], which is 17 % of the chip area
- ⇒ We just need to inject faults at in die high SNR positions
- ⇒ By doing this, we gain a speed-up of 92.3 % (13 h instead of 168 h)

[1] in our experiments

Thank you for your attention!

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[1] J. Breier and D. Jap. “Testing feasibility of back-side laser fault injection on a microcontroller.” In: *Proceedings of the WESS’15: Workshop on Embedded Systems Security*. 2015, pp. 1–6.

[2] J. Danial et al. “SCNIFFER: Low-Cost, Automated, Efficient Electromagnetic Side-Channel Sniffing.” In: *IEEE Access* 8 (2020), pp. 173414–173427.

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[4] A. Golder, A. Bhat, and A. Raychowdhury. “Exploration into the Explainability of Neural Network Models for Power Side-Channel Analysis.” In: *Proceedings of the Great Lakes Symposium on VLSI 2022*. ACM, 2022.

[5] O. M. Guillen, M. Gruber, and F. De Santis. “Low-cost setup for localized semi-invasive optical fault injection attacks: How low can we go?” In: *Constructive Side-Channel Analysis and Secure Design: 8th International Workshop, COSADE 2017, Paris, France, April 13-14, 2017, Revised Selected Papers 8*. Springer. 2017, pp. 207–222.

[6] V. V. Iyer and A. E. Yilmaz. “An Adaptive Acquisition Approach to Localize Electromagnetic Information Leakage from Cryptographic Modules.” In: *2019 IEEE Texas Symposium on Wireless and Microwave Circuits and Systems (WMCS)*. IEEE, Mar. 2019.

[7] V. V. Iyer and A. E. Yilmaz. “Rapid Pre-Characterization of Fine-Grained EM Side-Channel (In)Vulnerability of AES Modules.” In: *2022 IEEE USNC-URSI Radio Science Meeting (Joint with AP-S Symposium)*. IEEE, July 2022.

[8] R. Specht et al. “Dividing the threshold: Multi-probe localized EM analysis on threshold implementations.” In: *2018 IEEE International Symposium on Hardware Oriented Security and Trust (HOST)*. IEEE, Apr. 2018.