Body Biasing Injection: To thin or not to thin?

Geoffrey CHANCEL

Jean-Marc GALLIERE

Philippe MAURINE

CONTEXT & STATE OF THE ART

- Fault injection techniques: VGFI, EMFI, LFI, BBI
- BBI is a recent technique
- State of the art about BBI is limited to:
  - *Philippe Maurine et al.* ***(2012)****, "Yet Another Fault Injection Technique : by Forward Body Biasing Injection" YACC'2012, lirmm-00762035*
  - *K. Tobich et al.* ***(2013)****, "Voltage Spikes on the Substrate to Obtain Timing Faults", doi: 10.1109/DSD.2013.146*
  - *Noemie Beringuier-Boher et al.* ***(2016)****, "Body Biasing Injection Attacks in Practice", doi: 10.1145/2858930.2858940*
  - *O'Flynn Colin.* ***(2021)*** *"Low-Cost Body Biasing Injection (BBI) Attacks on WLCSP Devices", doi:10.1007/978-3-030-68487-7_11*

LIRMM

OBJECTIVES

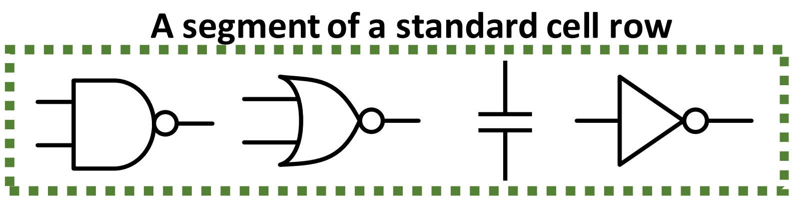
- Thinning IC's substrate?
  - Increase BBI efficiency?
  - Increase injection resolution?

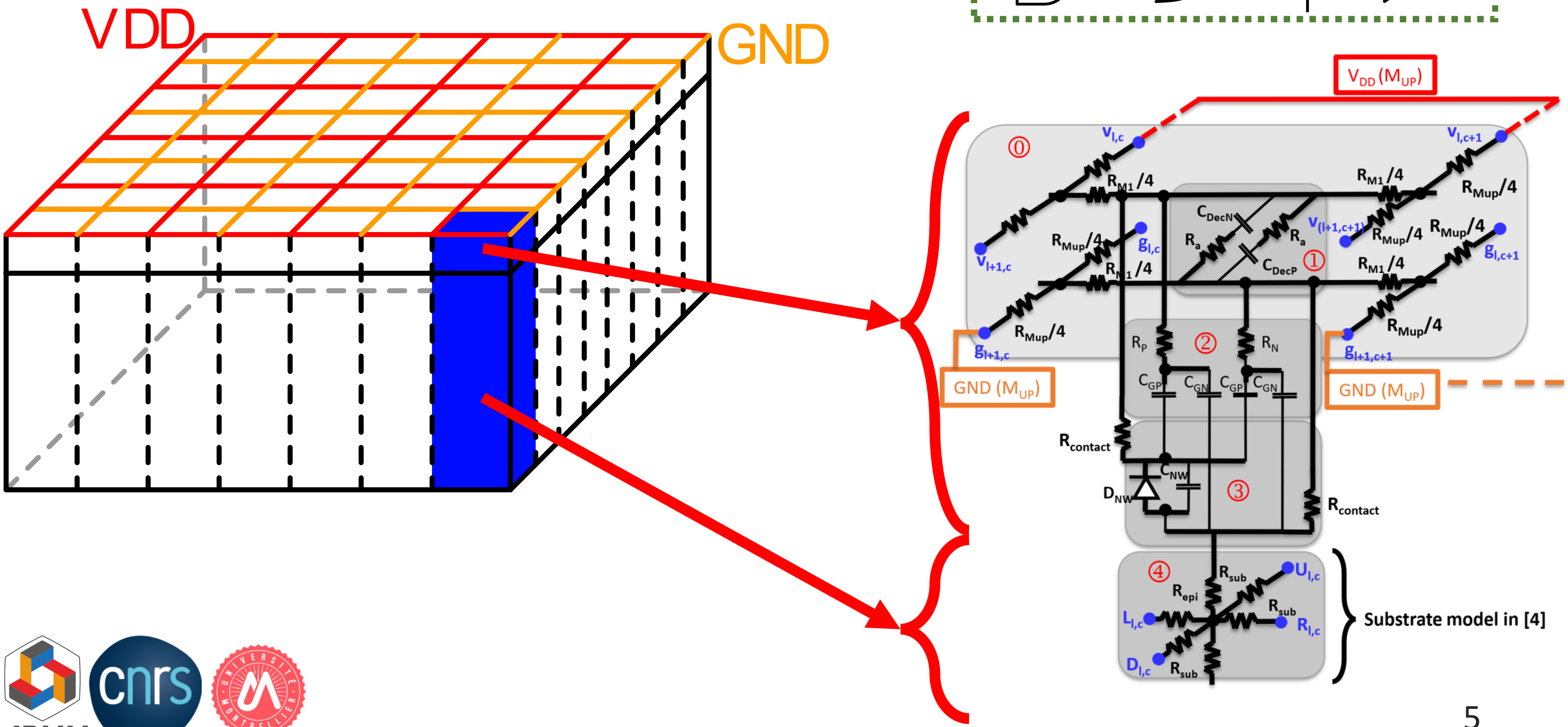
- To address these two points:
  - BBI modelling and simulation flow
  - Experimental observation

LIRMM

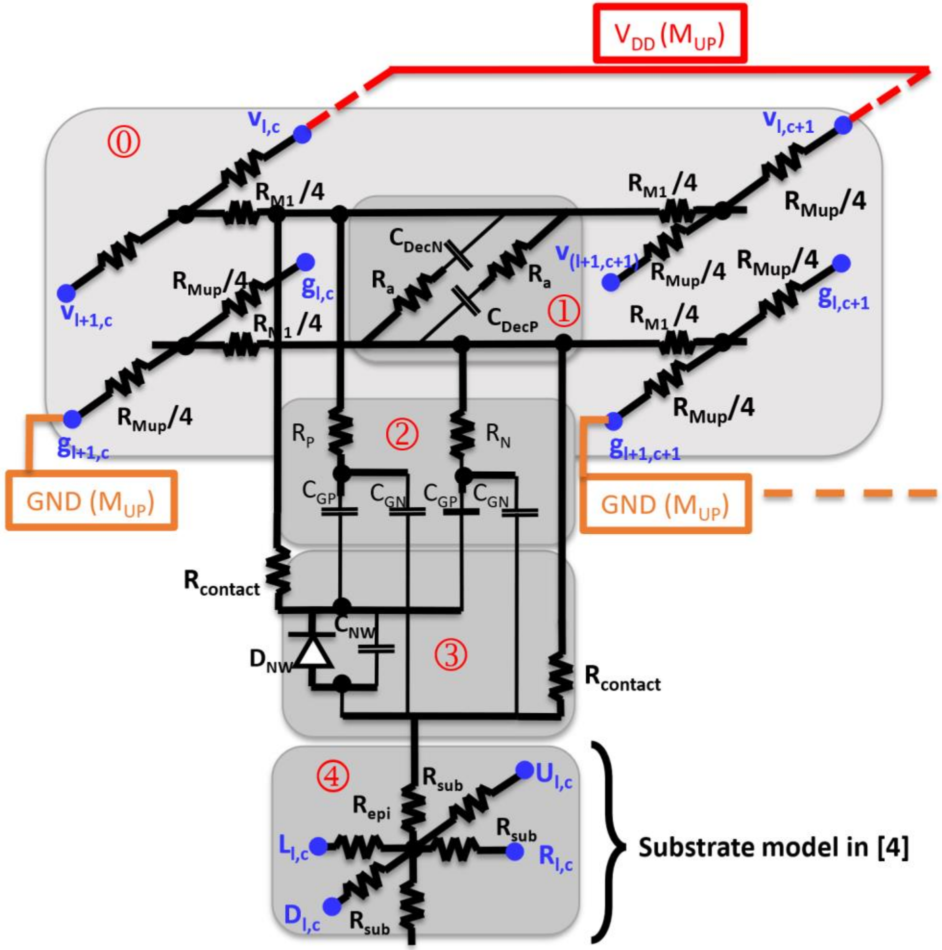
SIMULATION ANALYSIS

SIMULATION ANALYSIS

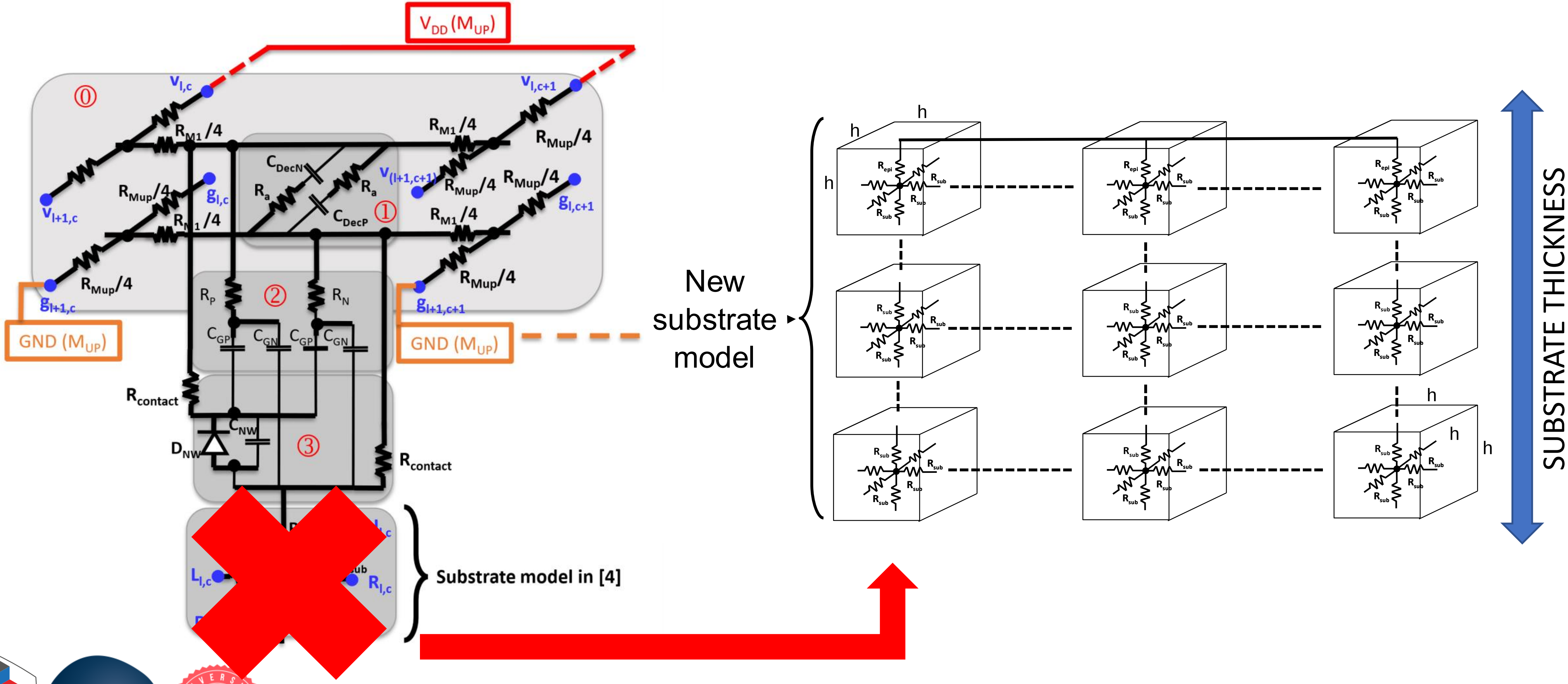




SIMULATION ANALYSIS

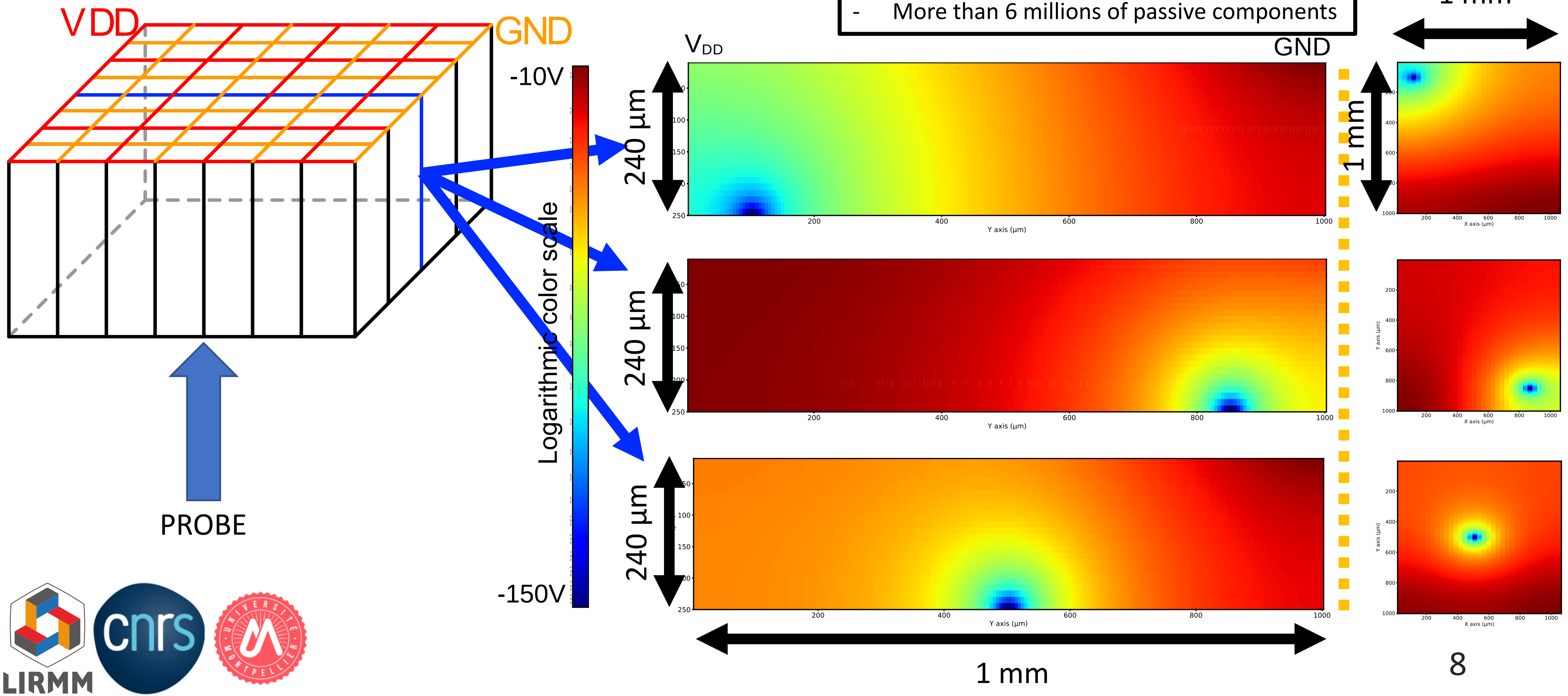


SIMULATION ANALYSIS



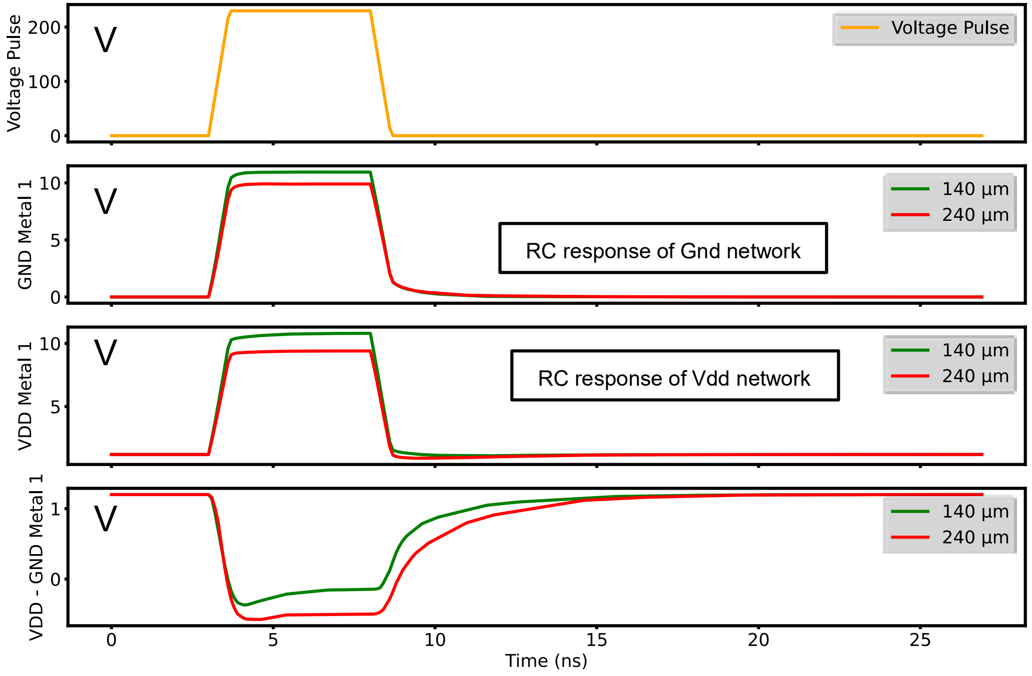
SIMULATION ANALYSIS

- Negative pulse
- 230 V
- 6 ns
- Apex of disturbance
- 7000 blocks
- More than 6 millions of passive components

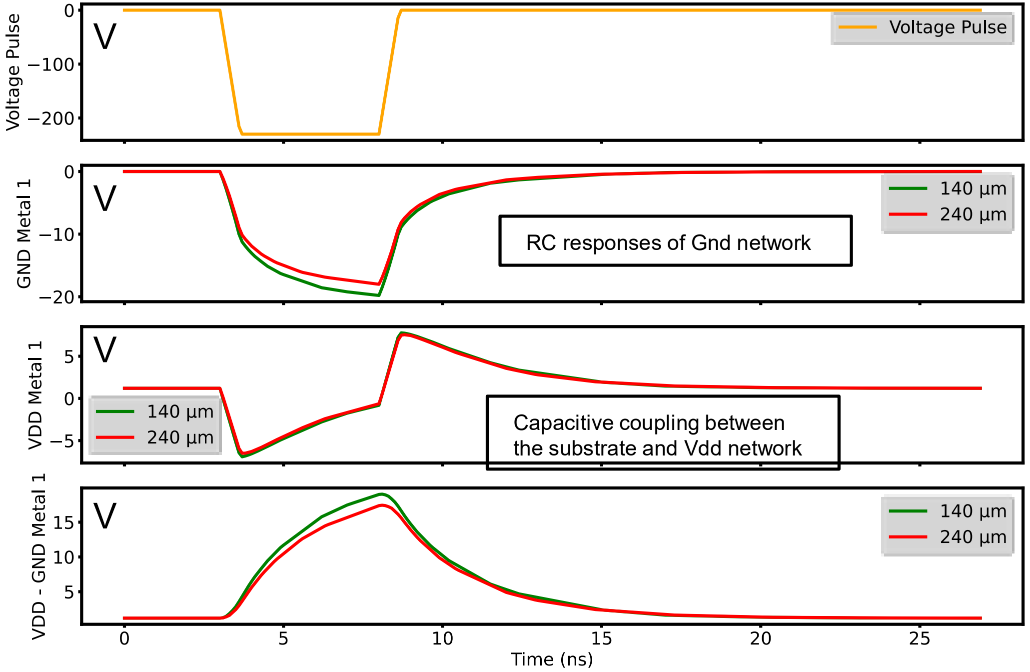


SIMULATION ANALYSIS

POSITIVE PULSE

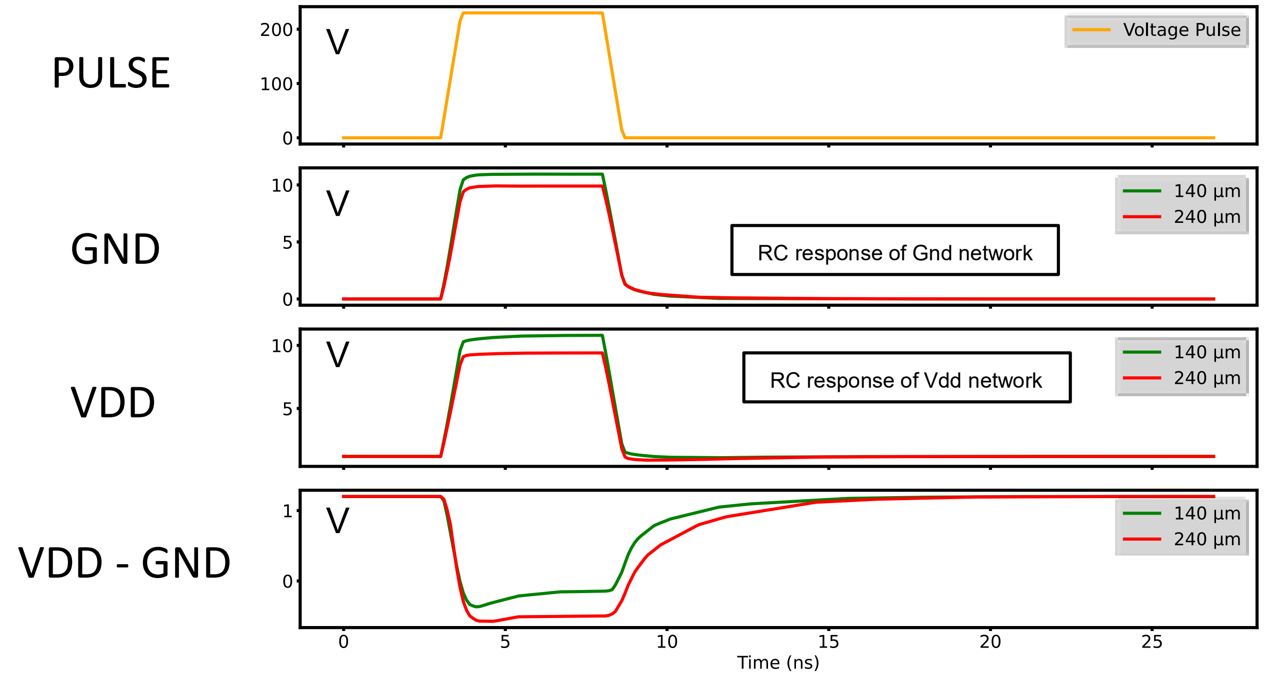


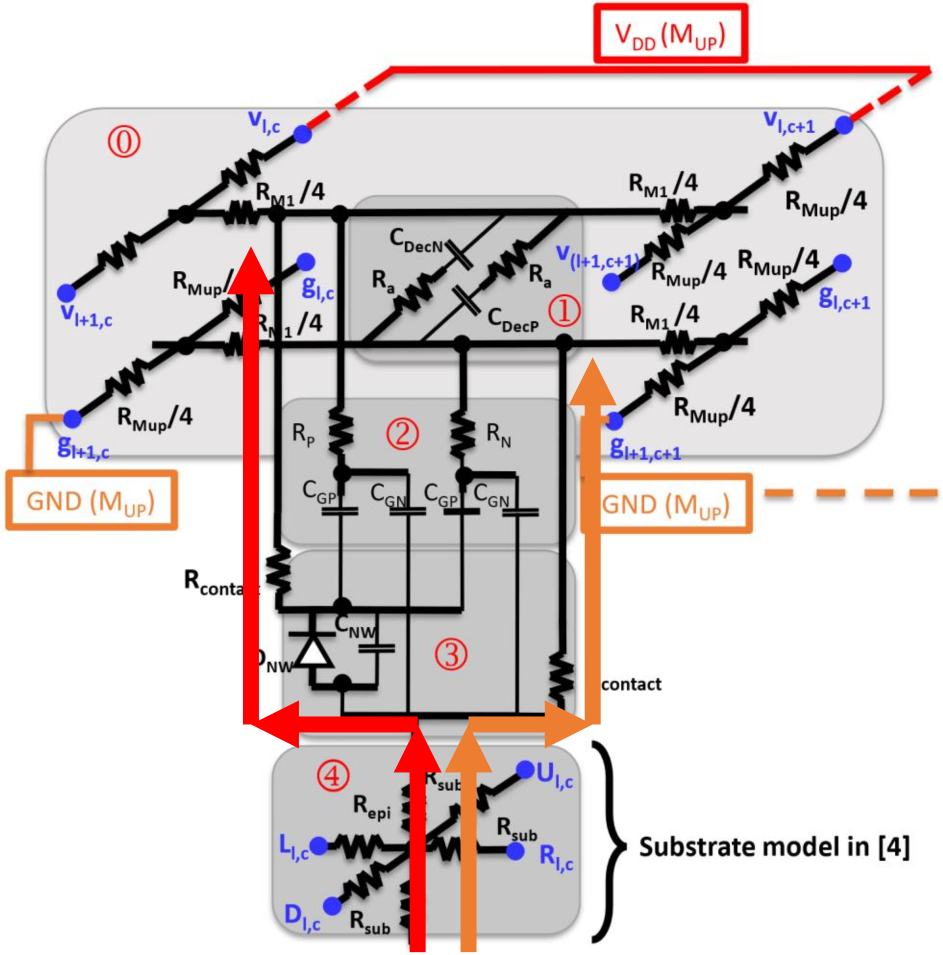
NEGATIVE PULSE



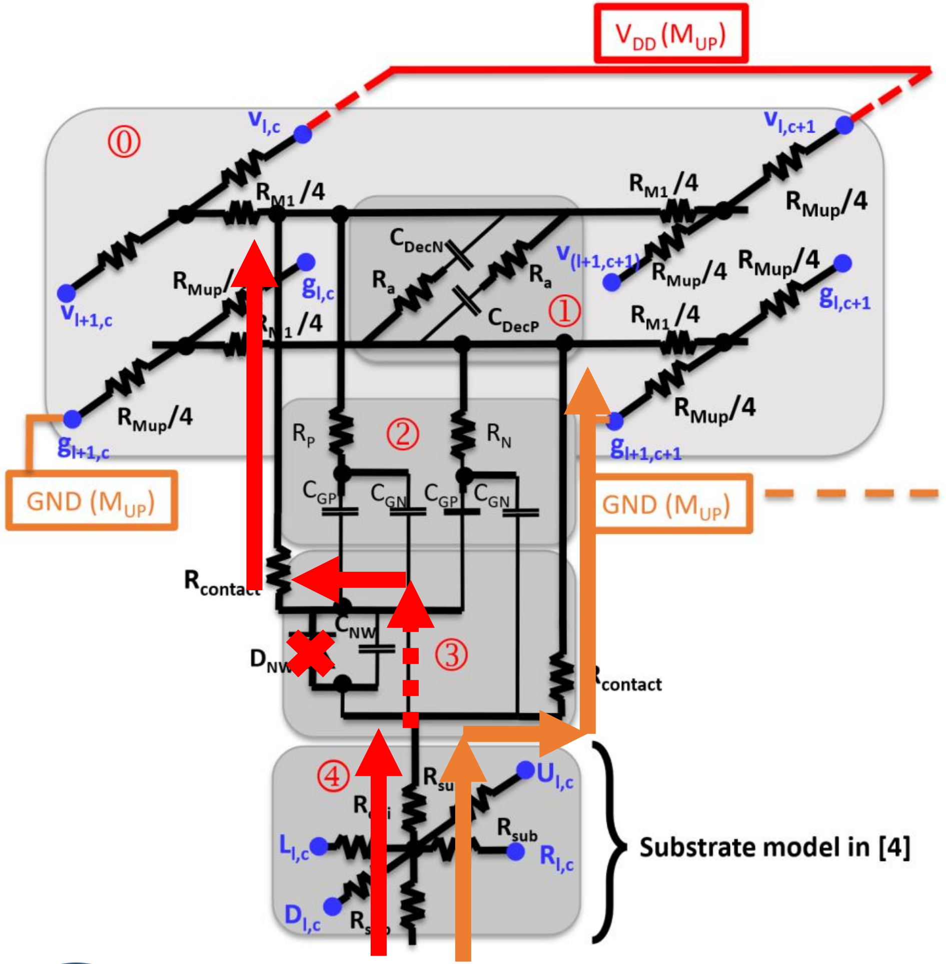
SIMULATION ANALYSIS

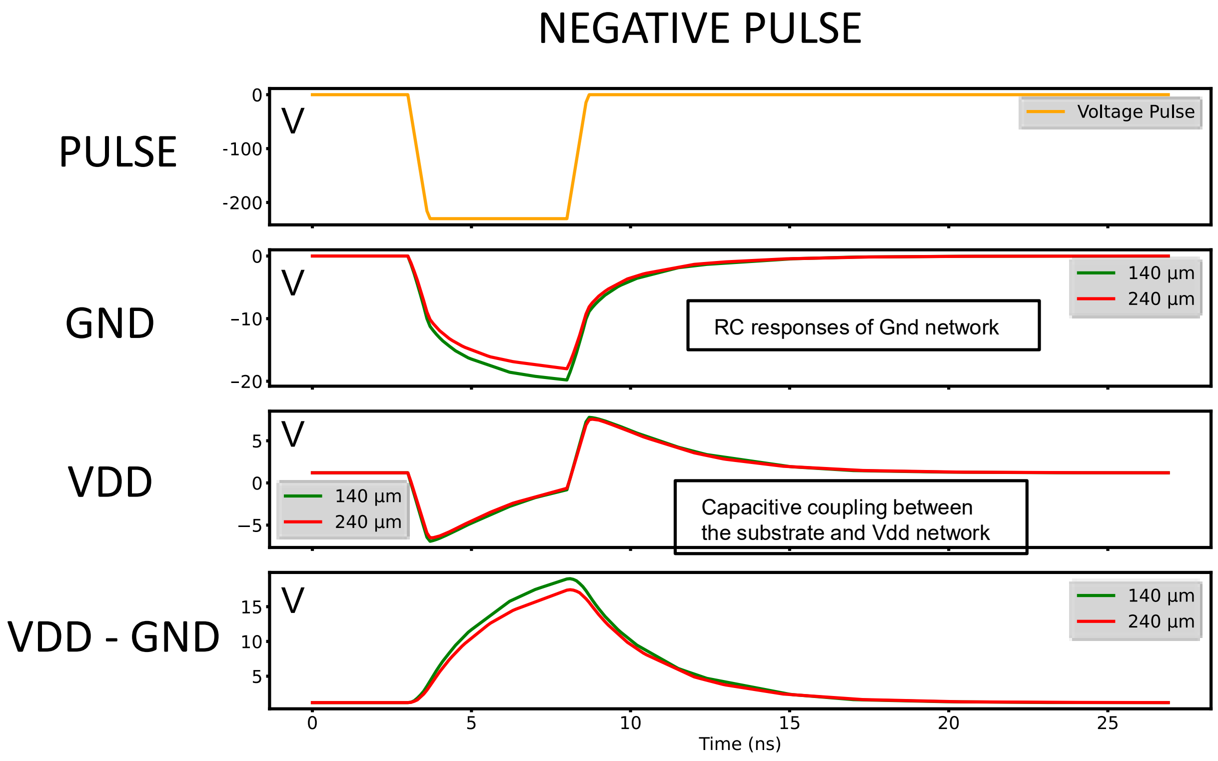
POSITIVE PULSE



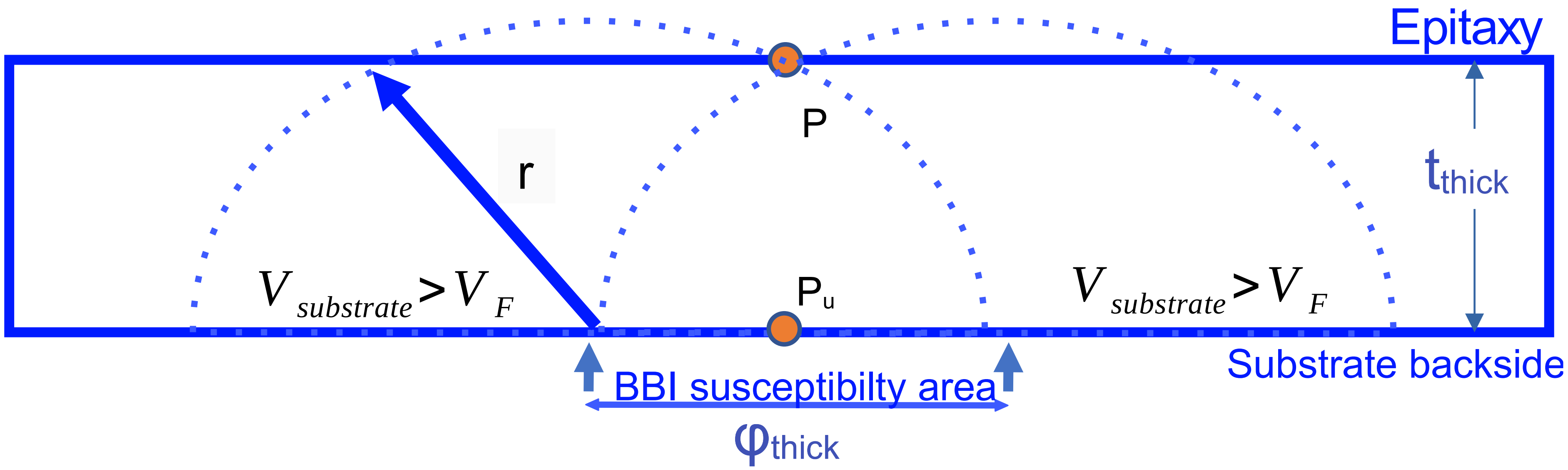


SIMULATION ANALYSIS

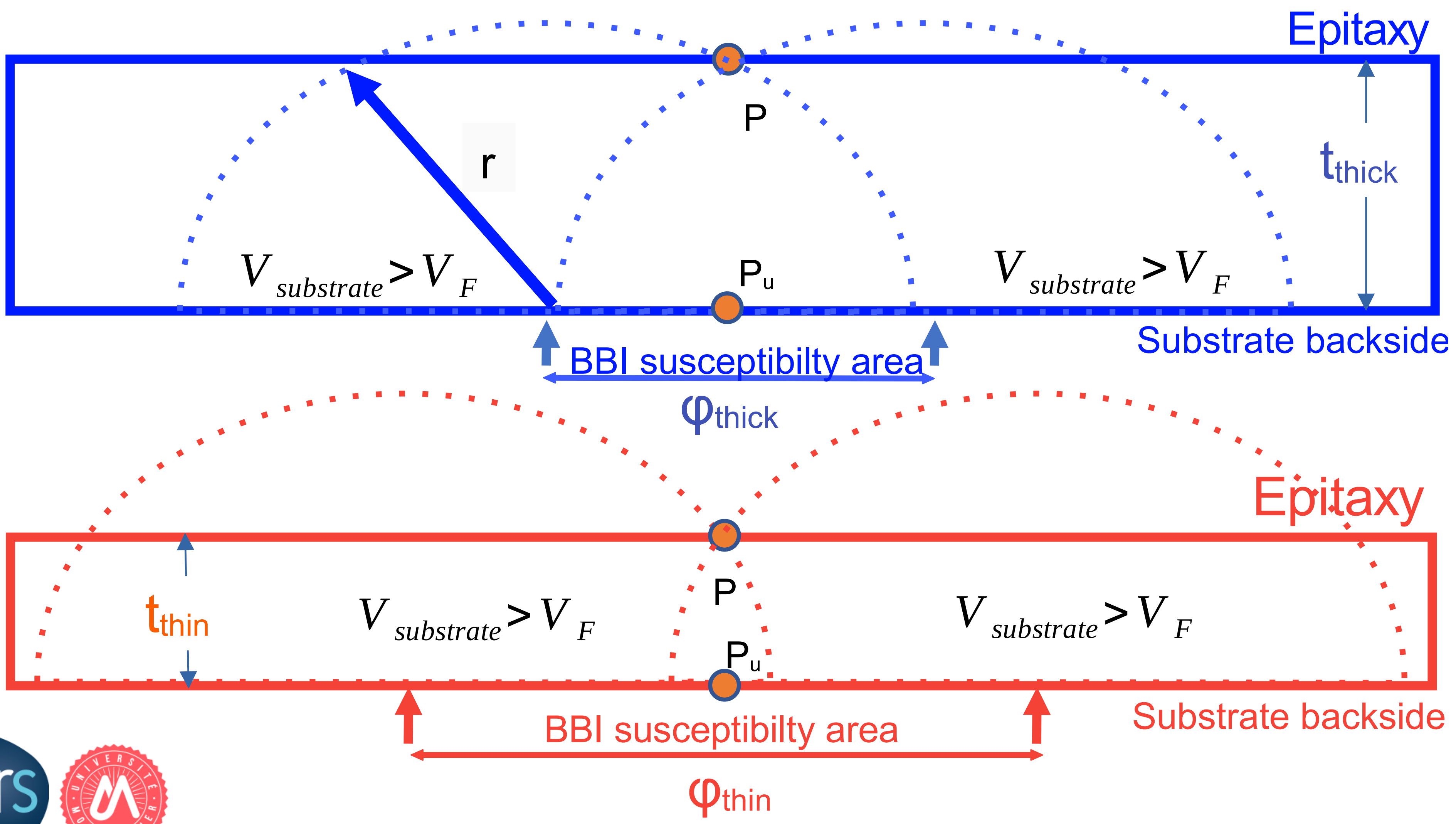




SIMULATION ANALYSIS

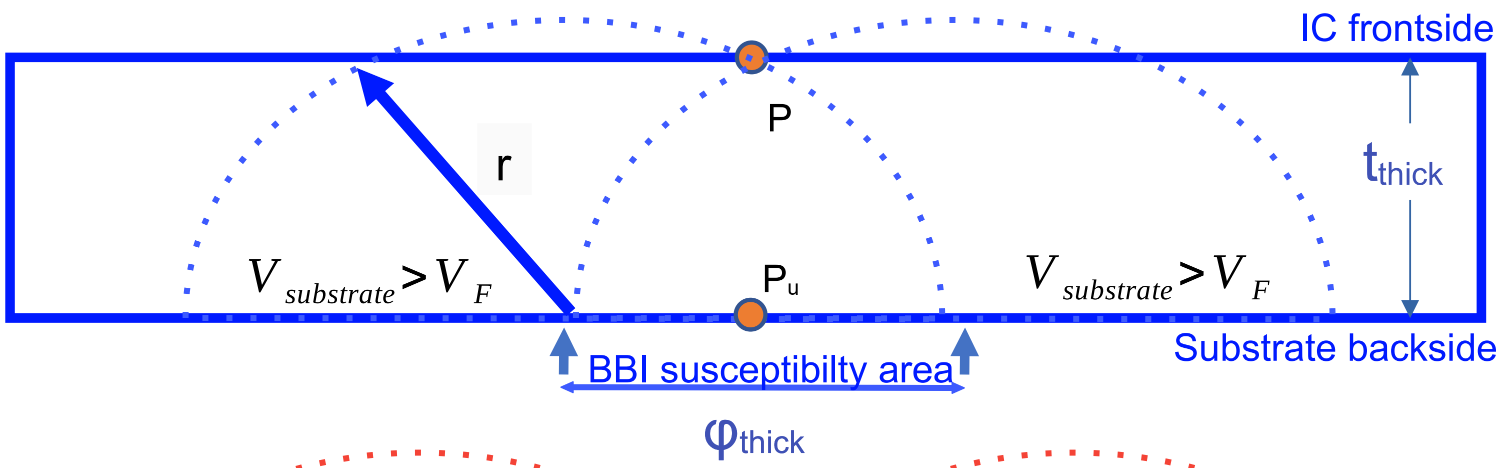


SIMULATION ANALYSIS

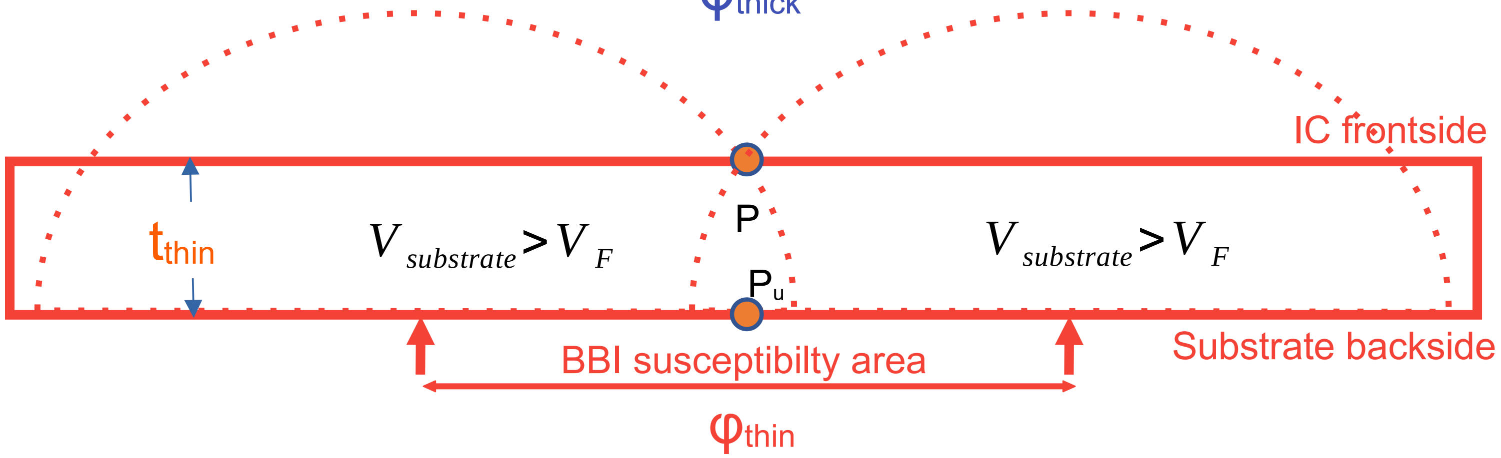


SIMULATION ANALYSIS

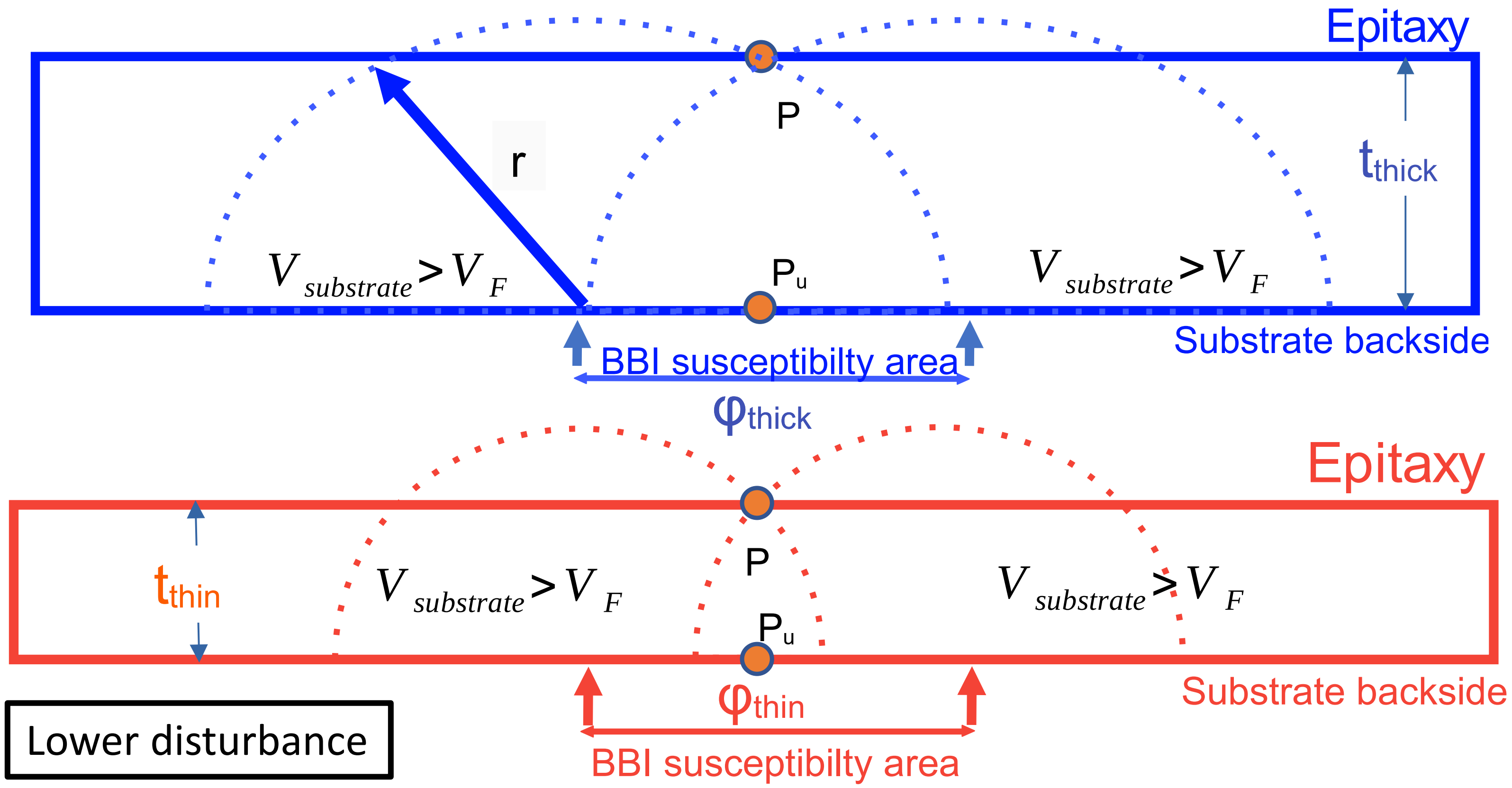
$$\frac{\phi_{thin}}{\phi_{thick}} = \sqrt{\frac{r^2 - t_{thin}^2}{r^2 - t_{thick}^2}} > 1$$



Thinning the substrate increases the susceptibility area (at equal disturbance)



SIMULATION ANALYSIS



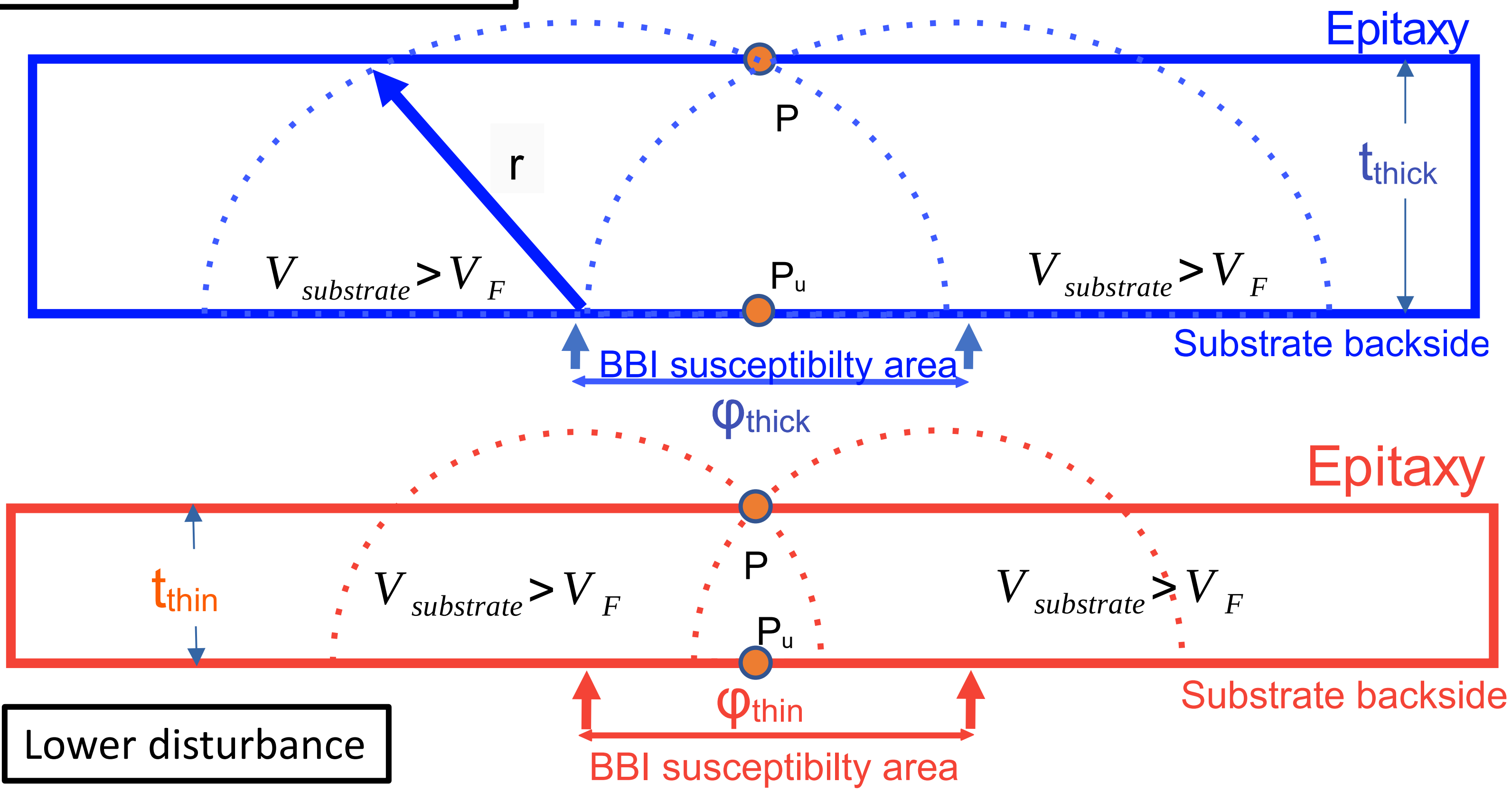
Resolution is given by the couple (t_{sub}, V_{Pu})

Lower disturbance

SIMULATION ANALYSIS

$$V_{Pu}^{*} = \frac{t_{thin}}{t_{thick}} \cdot V_{Pu} + V_F \cdot (1 - \frac{t_{thin}}{t_{thick}})$$

Resolution is given by the couple (t_{sub}, V_{Pu})



Lower disturbance

SIMULATION ANALYSIS

1. Thinning the substrate reduces the voltage required to induce faults

2. Thinning the substrate increases the susceptibility area

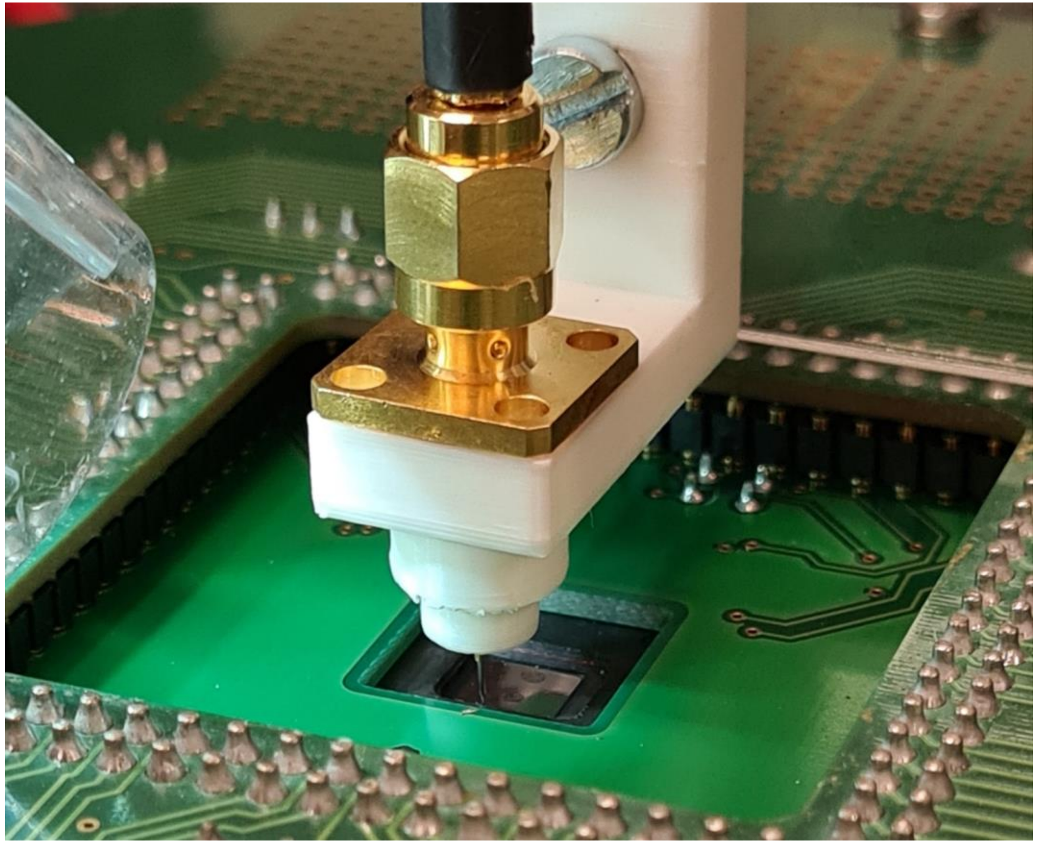
3. Resolution is given by the couple (t_{sub}, V_{Pu})

LIRMM

EXPERIMENTAL OBSERVATION

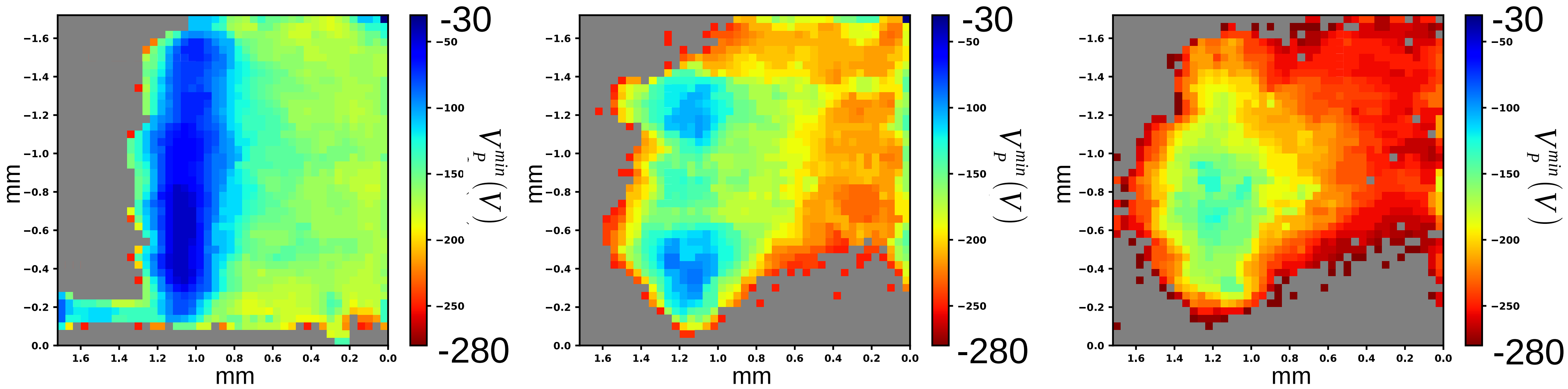
EXPERIMENTAL OBSERVATION

- Voltage pulse generator:
  - Amplitude: ±50 V to ±750 V
  - Pulse width: 6 ns to 20 ns
- Custom BBI probes:
  - 3D printed part
  - Spring-loaded pin



LIRMM

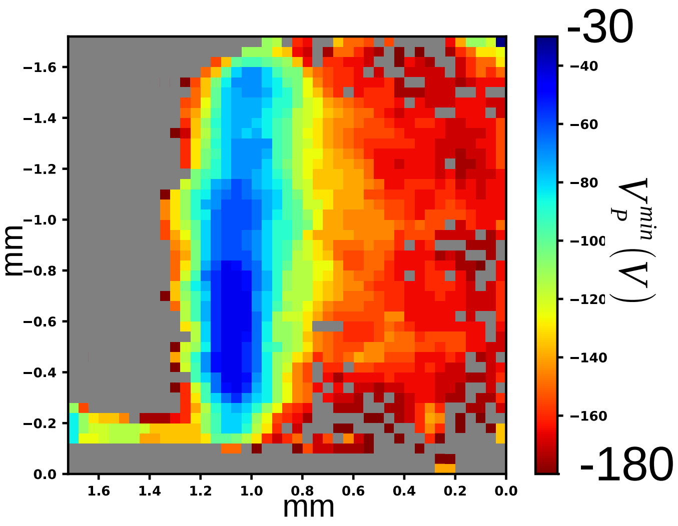
EXPERIMENTAL OBSERVATION



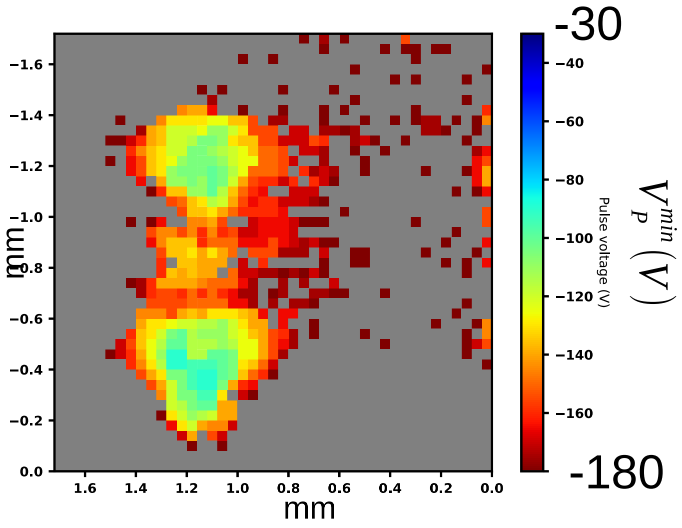
t_{sub}=50µm t_{sub}=140µm t_{sub}=200µm

Thinning → Less voltage needed

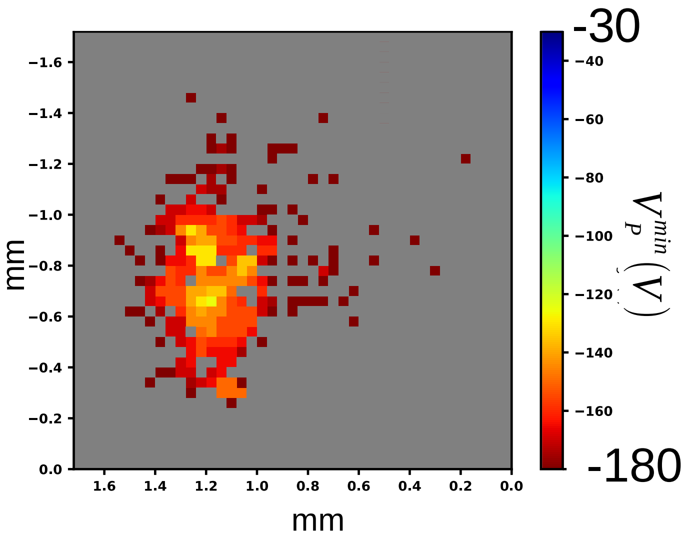
EXPERIMENTAL OBSERVATION



t_{sub}=50µm



t_{sub}=140µm

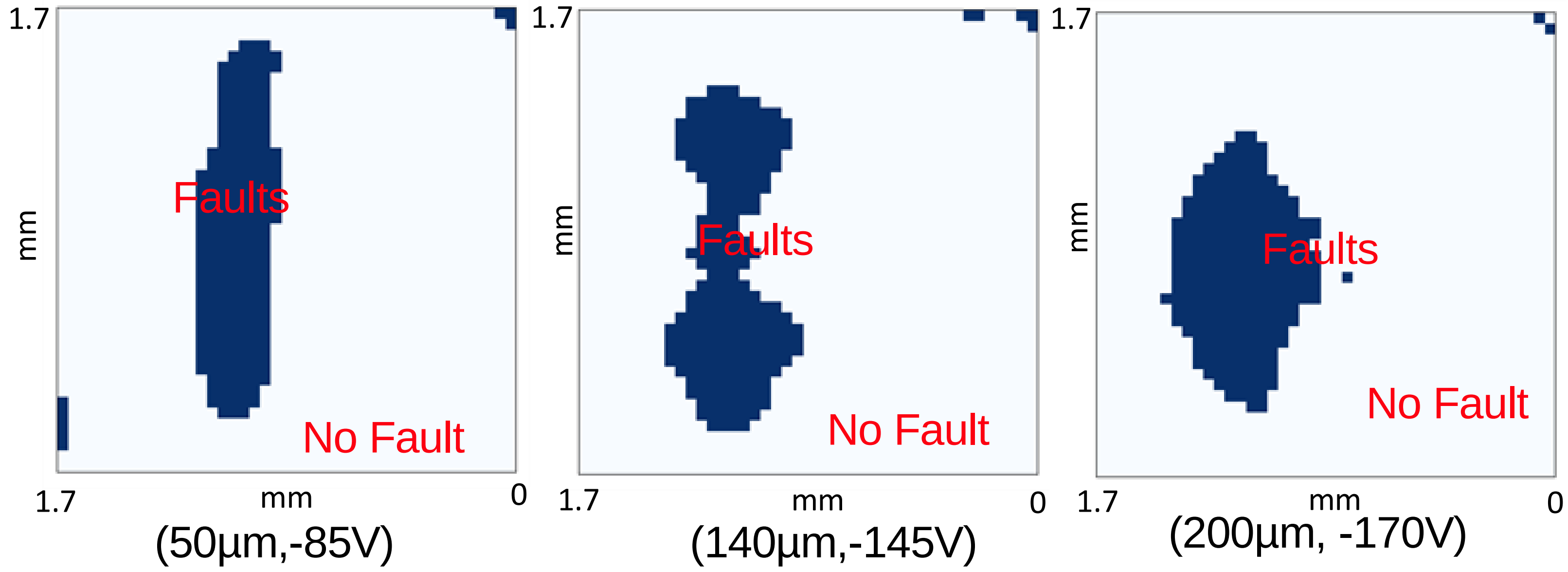


t_{sub}=200µm

Thinning → Susceptibility area grows

EXPERIMENTAL OBSERVATION

$$V_{Pu}^* = \frac{t_{thin}}{t_{thick}} \cdot V_{Pu} + V_F \cdot (1 - \frac{t_{thin}}{t_{thick}})$$



CONCLUSION

- To thin or not to thin the substrate?
- Does it increases efficiency?
- Does it improve injection resolution?
- Thinning → Lower voltage needed
- Resolution → (t_{sub}, V_{Pu})

LIRMM