DE LA RECHERCHE À L'INDUSTRIE

INSPIRING INNOVATION | INNOVANTE PAR TRADITION

Ecole Nationale Supérieure des Mines SAINT-ETIENNE

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From physical stresses to timing constraints violation

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DE L'INDUSTRIE ET DE L'EMPLOI

Introduction

Research subject

- **Caracterization and analysis of common fault injection mechanism**

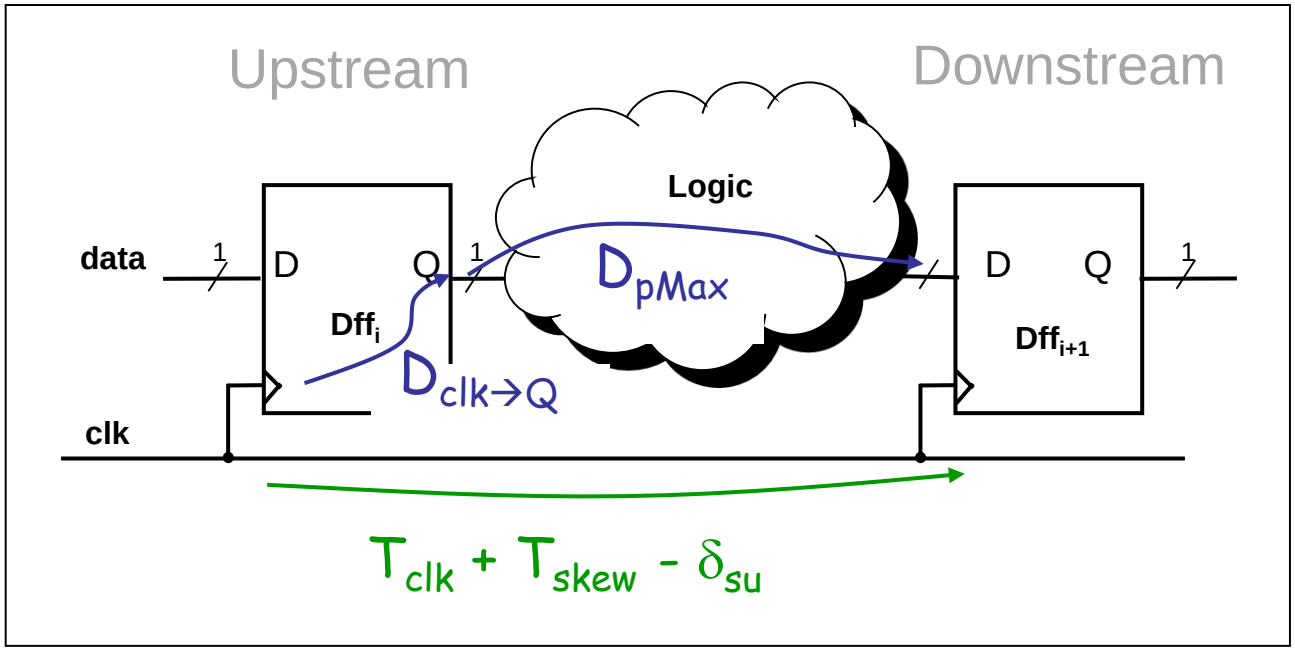
Today's subject

- **Power glitches fault injection mechanism**
  - **Analysis and practice**

Agenda

- **Timing constraints of synchronous digital IC**
- **Static stresses (global effect)**
- **Transient stresses**
- **Conclusion**

Timing constraints



data arrival time = $D_{clk \rightarrow Q} + D_{pMax}$

data required time = $T_{clk} + T_{skew} - \delta_{su}$

$\Rightarrow$ $T_{clk} > D_{clk \rightarrow Q} + D_{pMax} - T_{skew} + \delta_{su}$

How to inject faults through timing constraints violation?

- Overclocking: (Frequency increase, i.e. period decrease)

$$T_{clk} < D_{clk \rightarrow Q} + D_{pMax} - T_{skew} + \delta_{su}$$

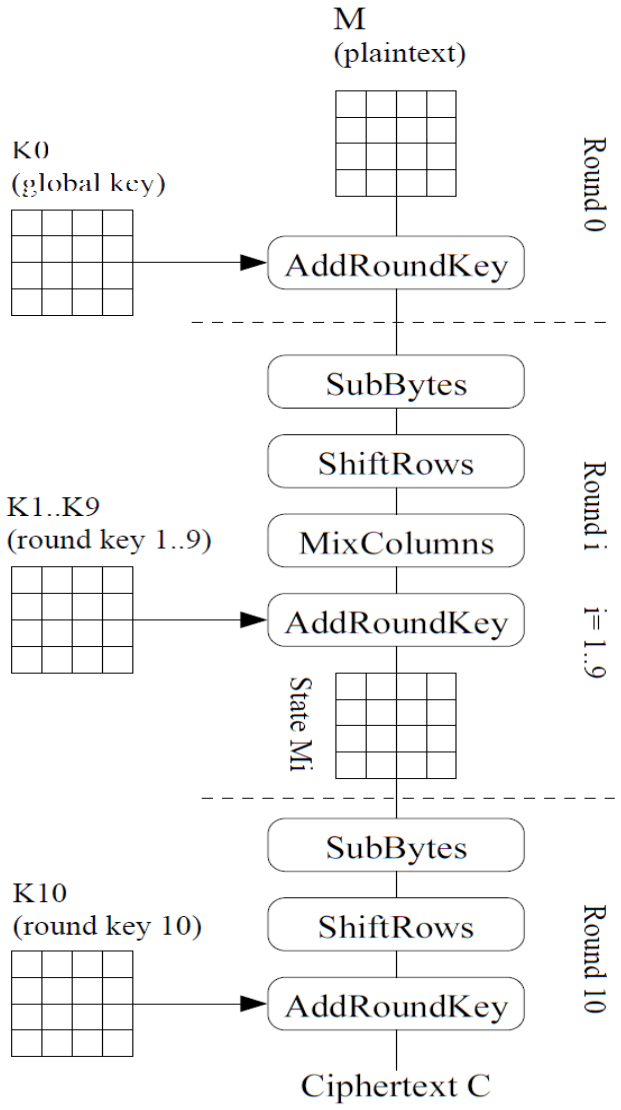
- Underpowering or overheating: (Propagation time increase)

$$T_{clk} < D_{clk \rightarrow Q} + D_{pMax} - T_{skew} + \delta_{su}$$

Experimental setup

Target

- Platform: FPGA Spartan 3A
- Algorithm: AES 128 bit
  none-secure implementation
- Frequency: 100 MHz
- Power supply: 1.2V



Previous research work

Common fault injection means

- Clock stress (overclocking)
- Power stress (underpowering)
- Overheating

A **common mechanism** !

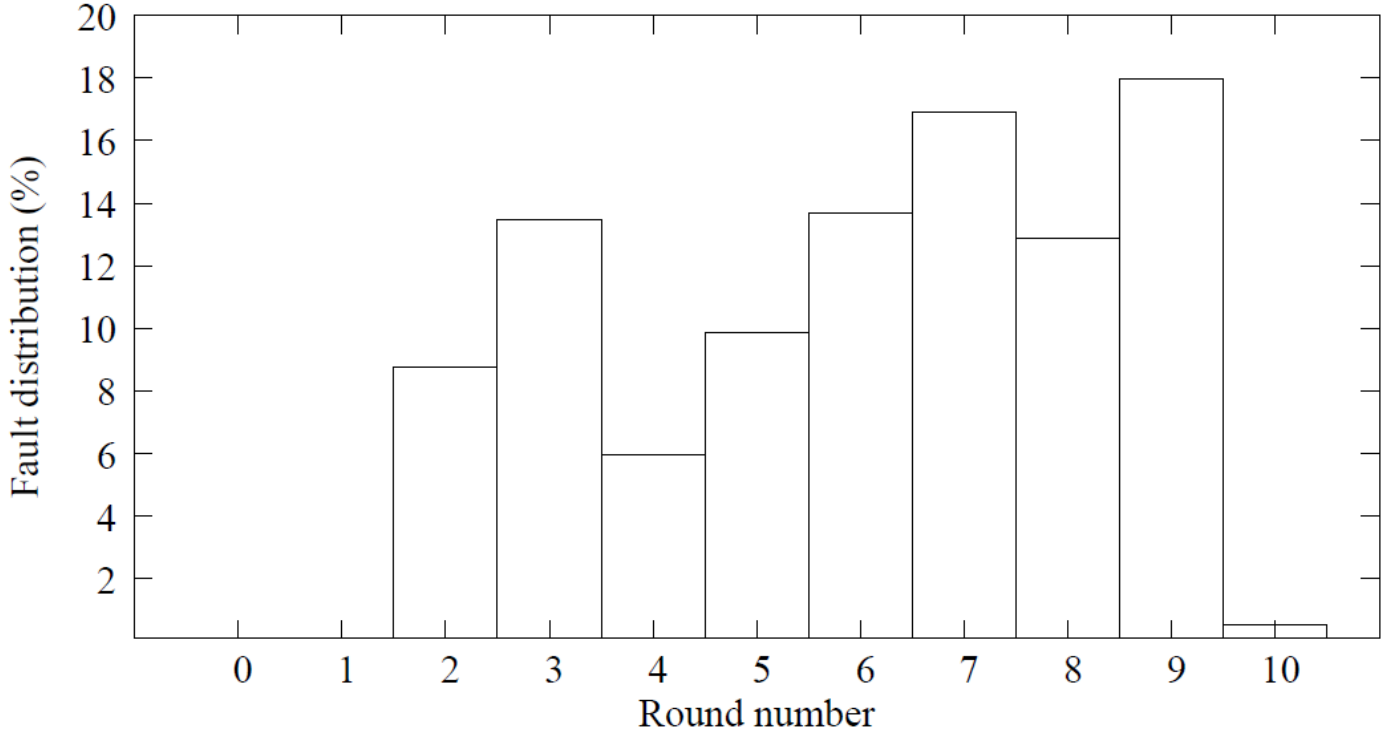
⇒ Timing constraints violations.

Experimental proof

- 10,000 input dataset
- Critical path faulted

Issues

- Low timing resolution



Transient perturbations

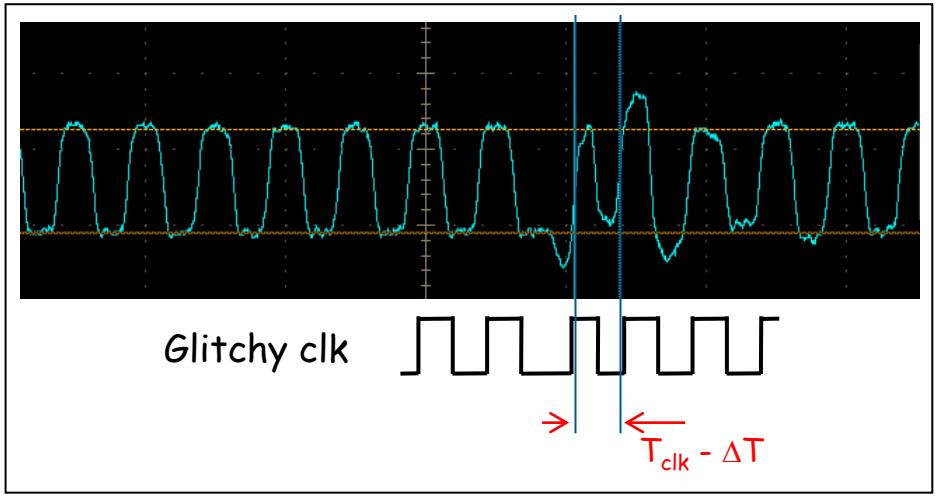
- Clock glitch
- Power supply glitch

Questions

- Injection mechanism? Timing violation?
- Achievable resolution?

Transient perturbations

Clock glitch

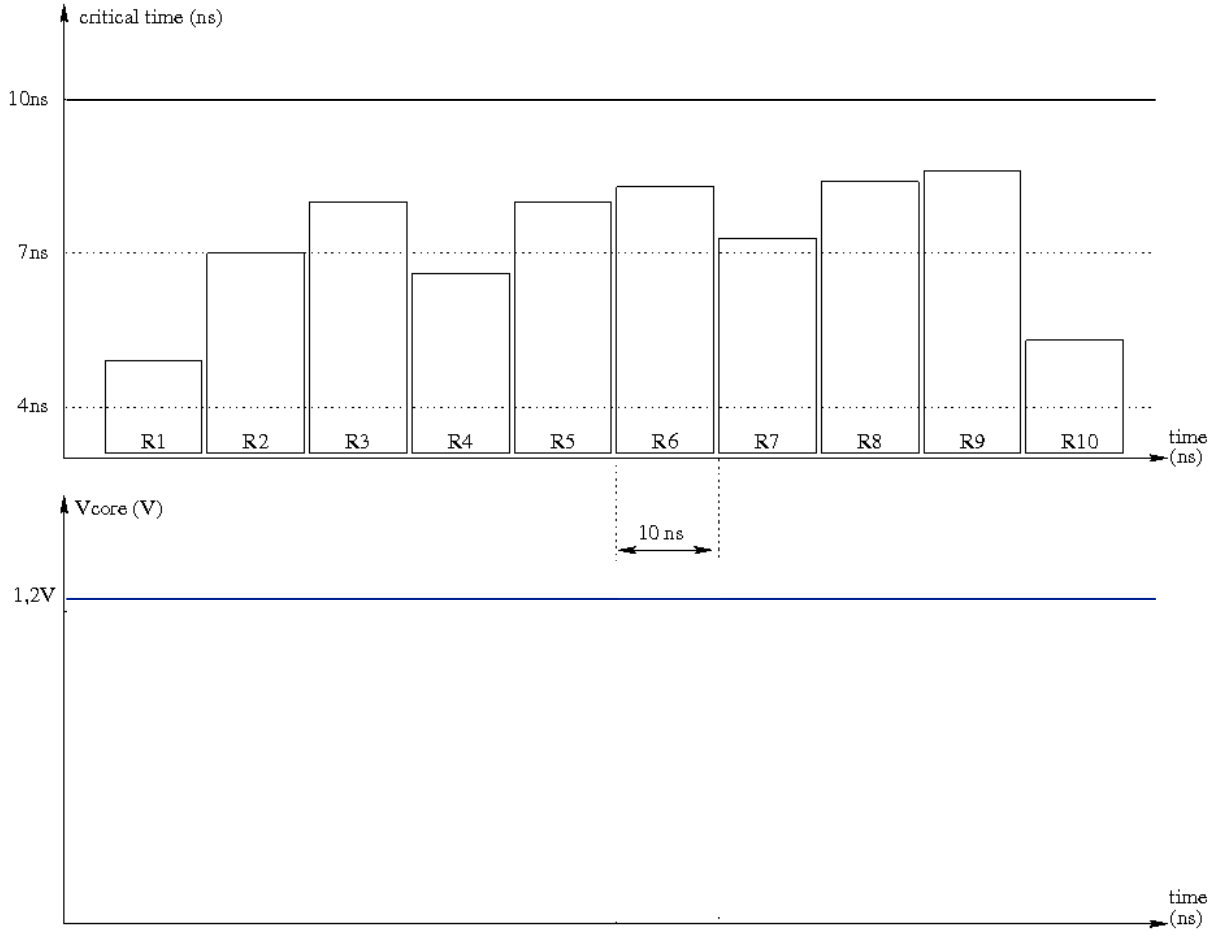


- 35ps resolution
- Global effect
- Timing constraints violation (obvious)
- A tool for critical time measurement
- Used to build a template/**reference library**

To be compared,

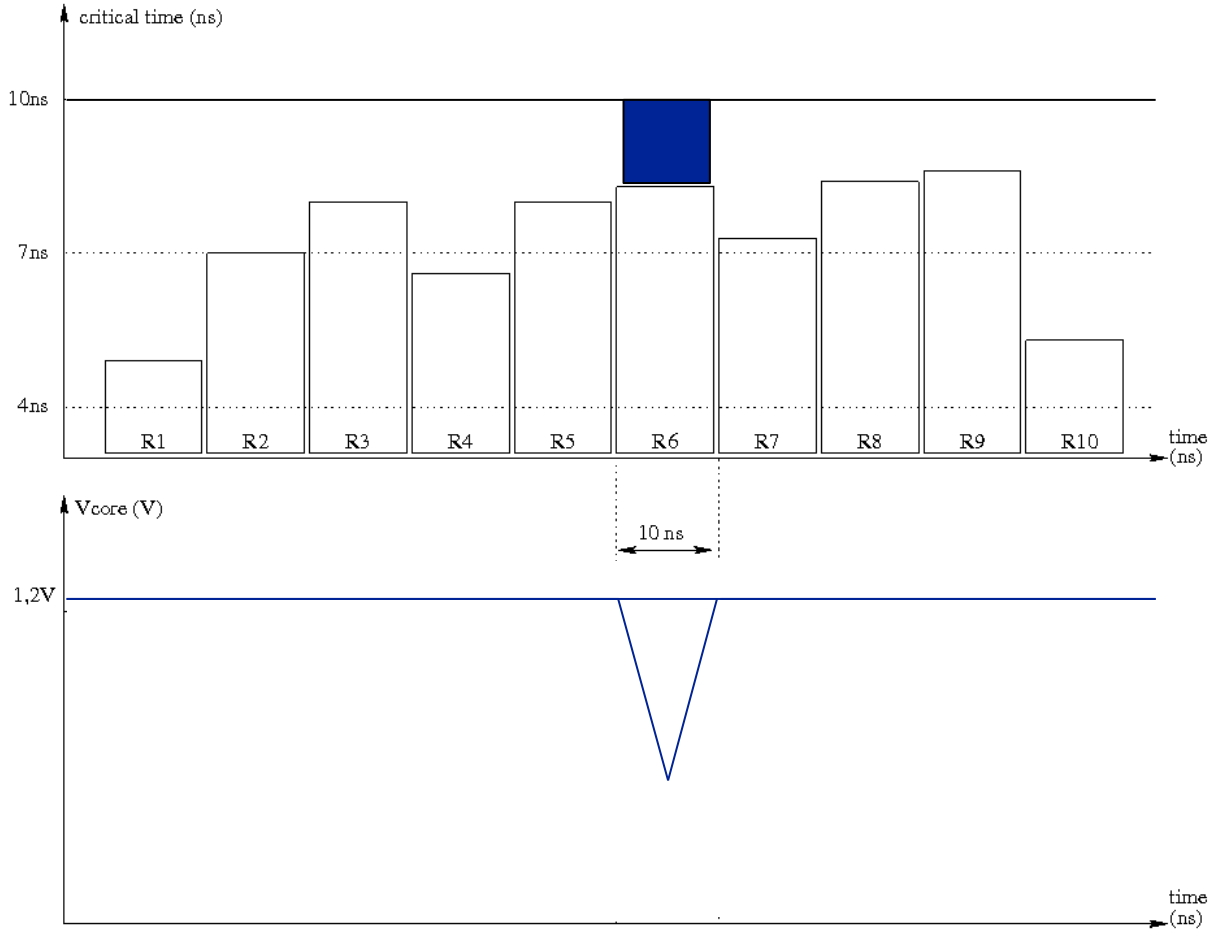
Transient perturbations

Power glitch: Ideal

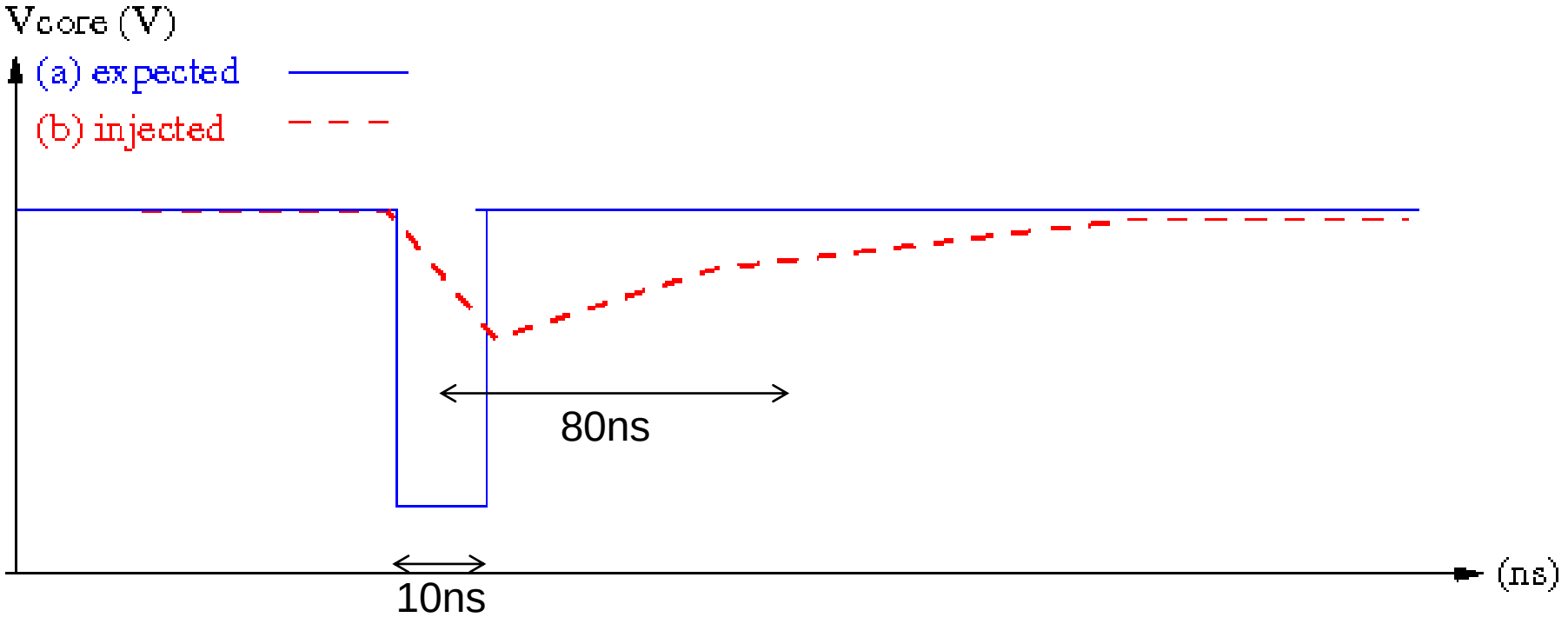


Transient perturbations

Power glitch: Ideal

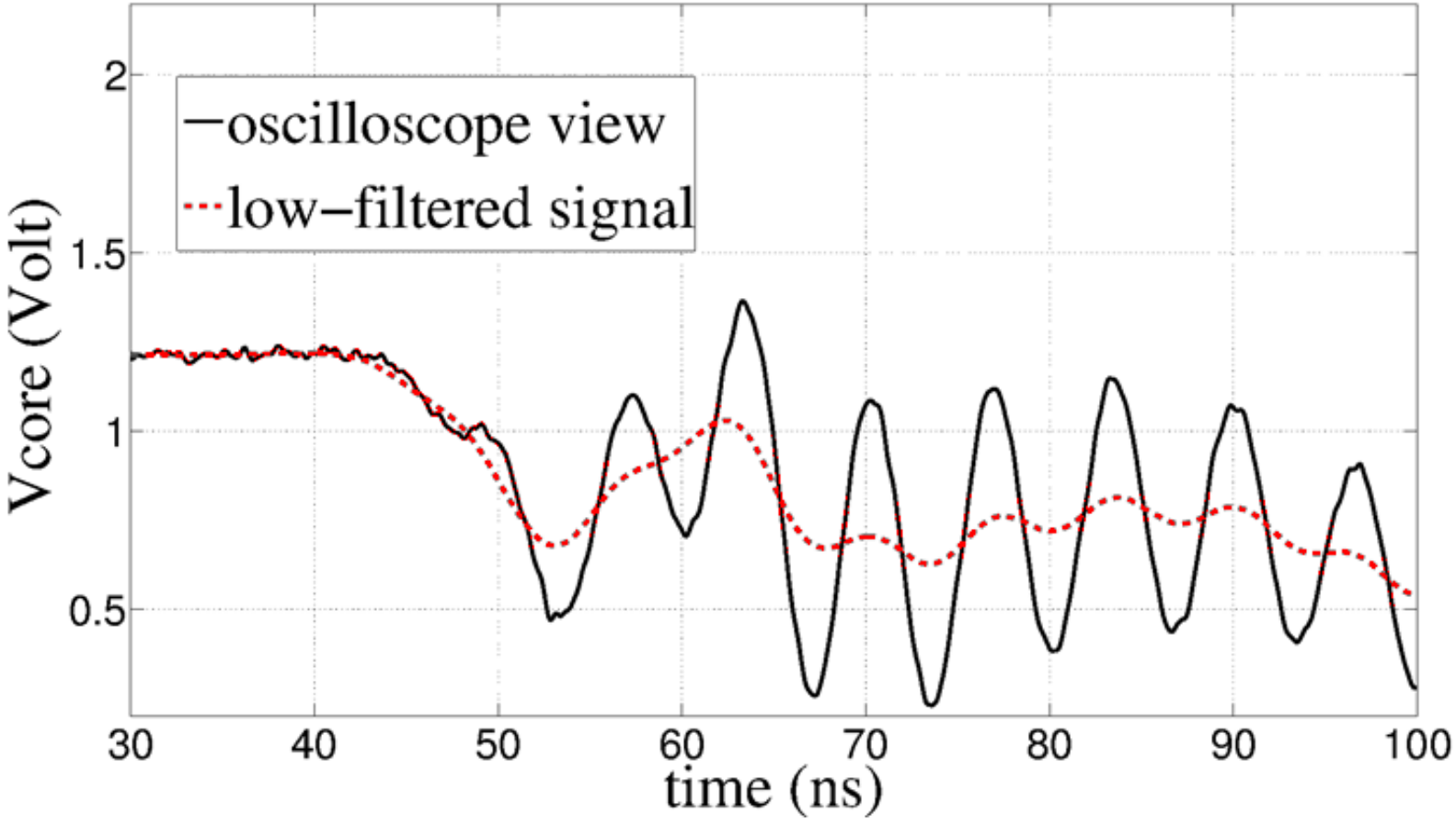


Power glitch: Input capacitance

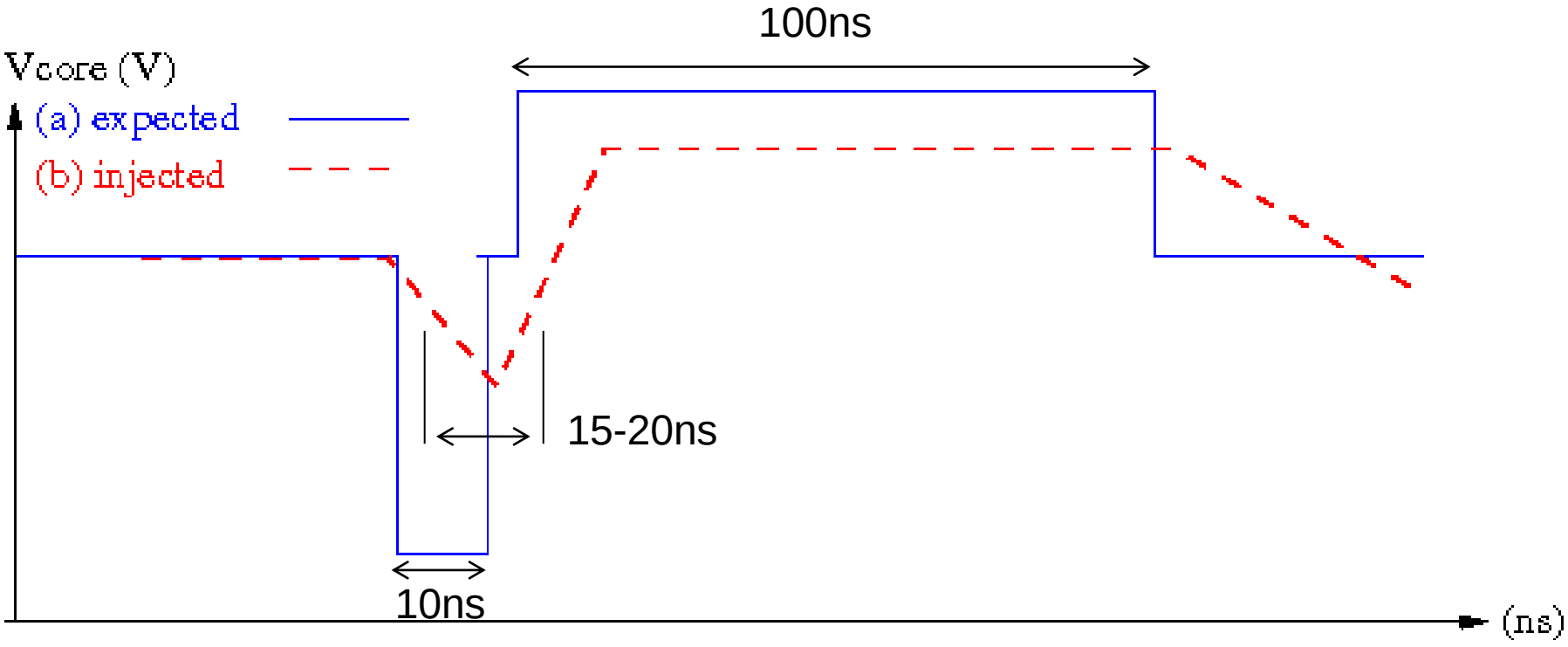


Transient perturbations

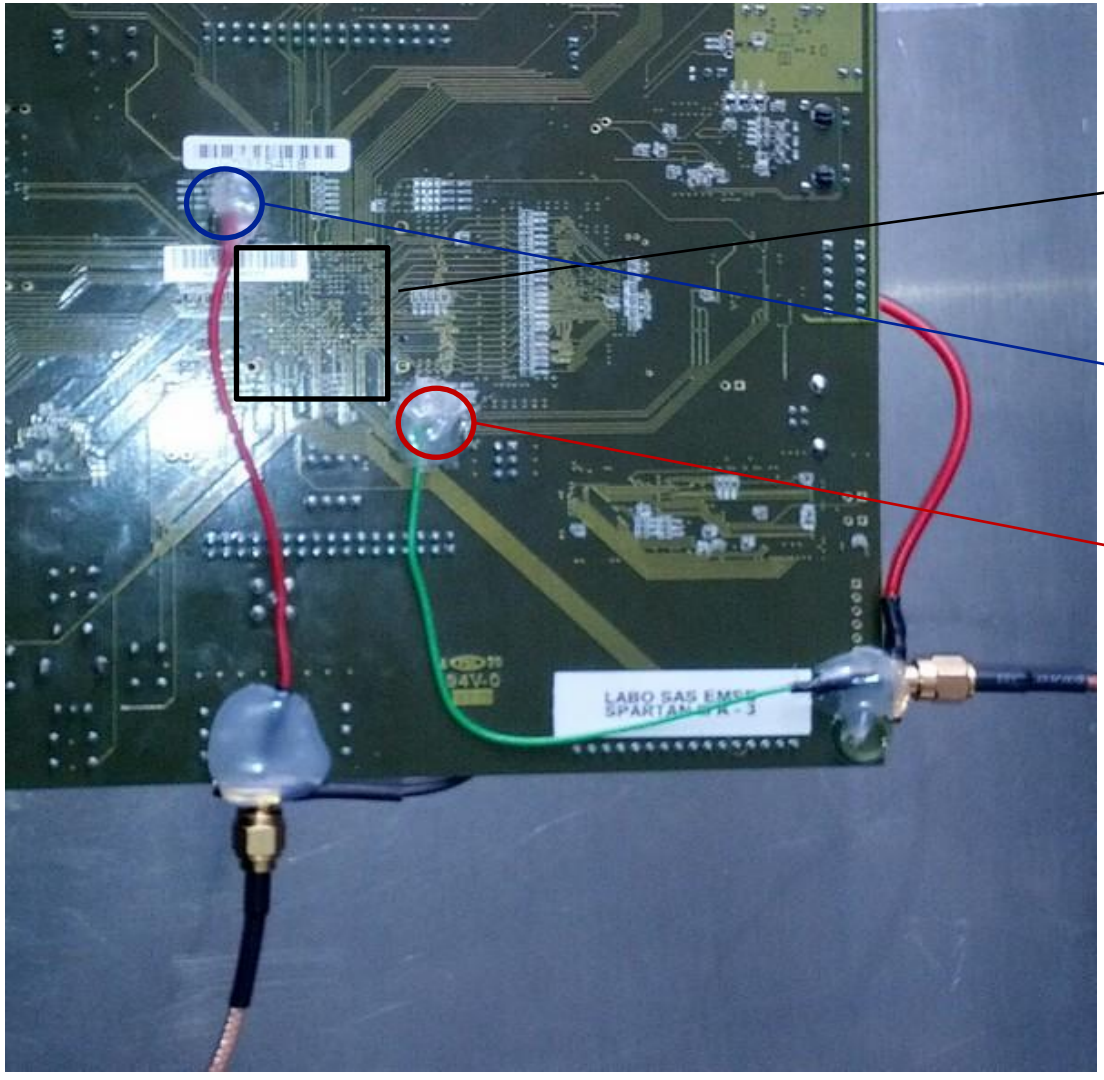
Power glitch: impedance adaptation



Power glitch: Input capacitance

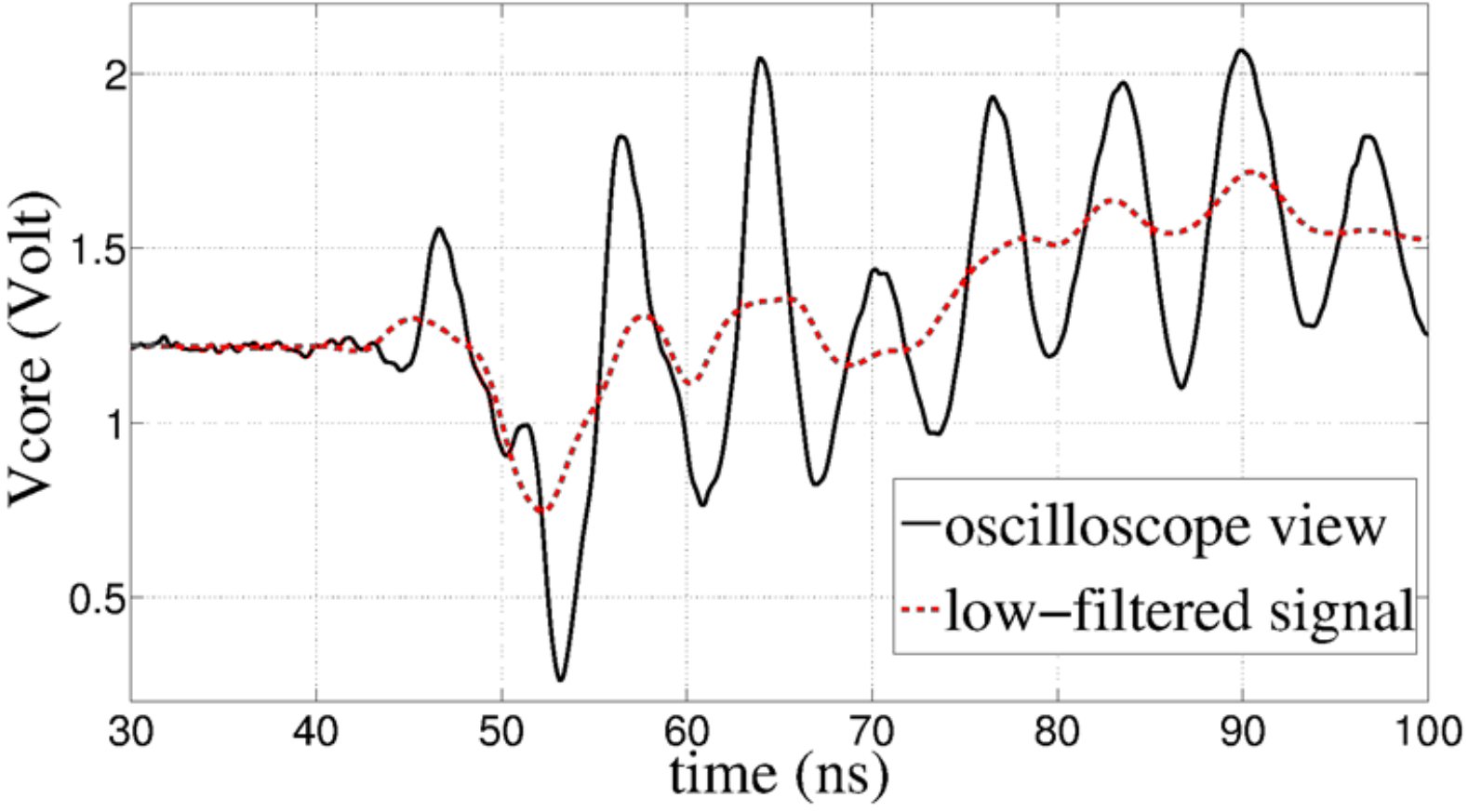


Transient perturbations



Transient perturbations

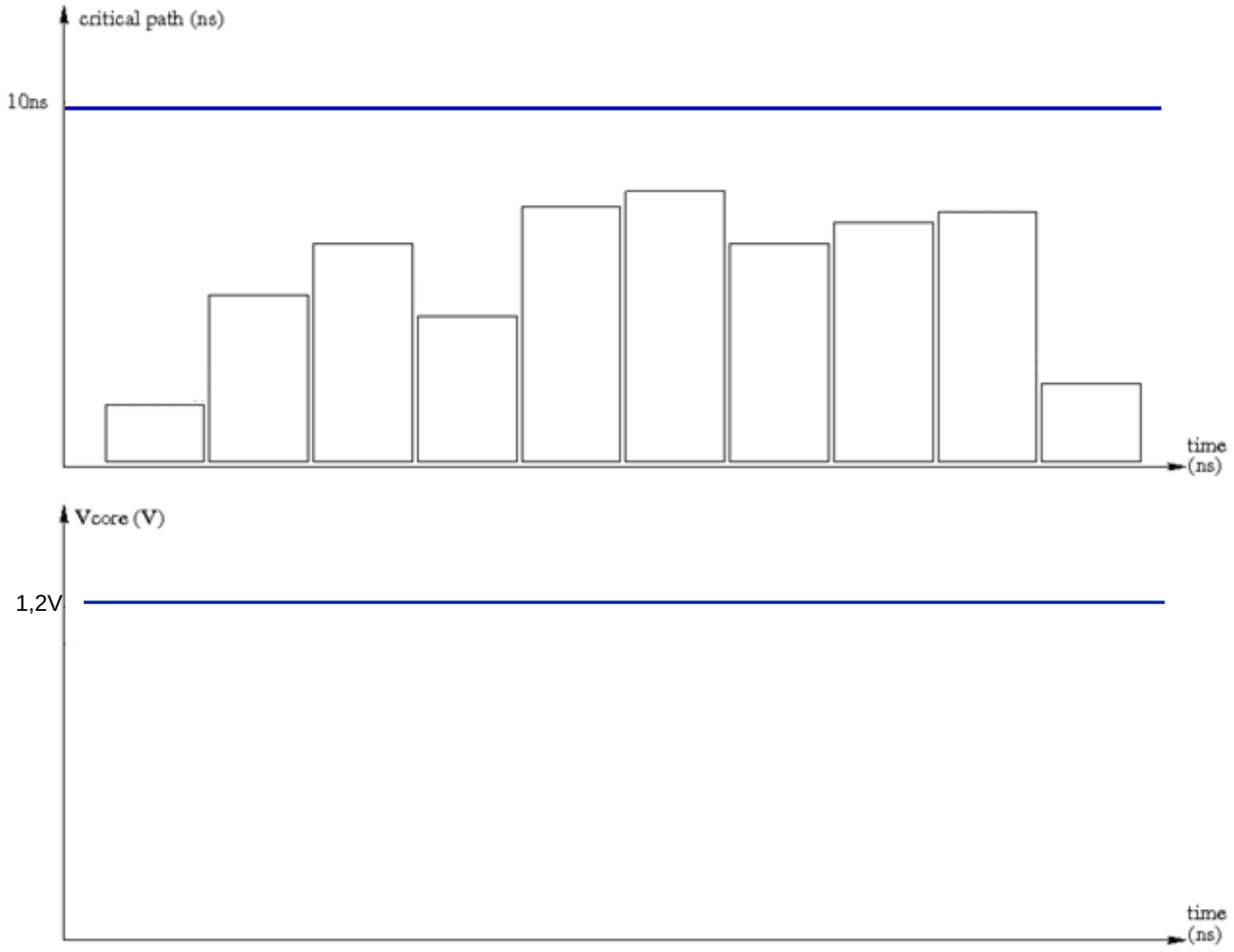
Power glitch: impedance adaptation



Transient perturbations

Power glitch

- Target a specific round but **also affect the neighboring rounds,**



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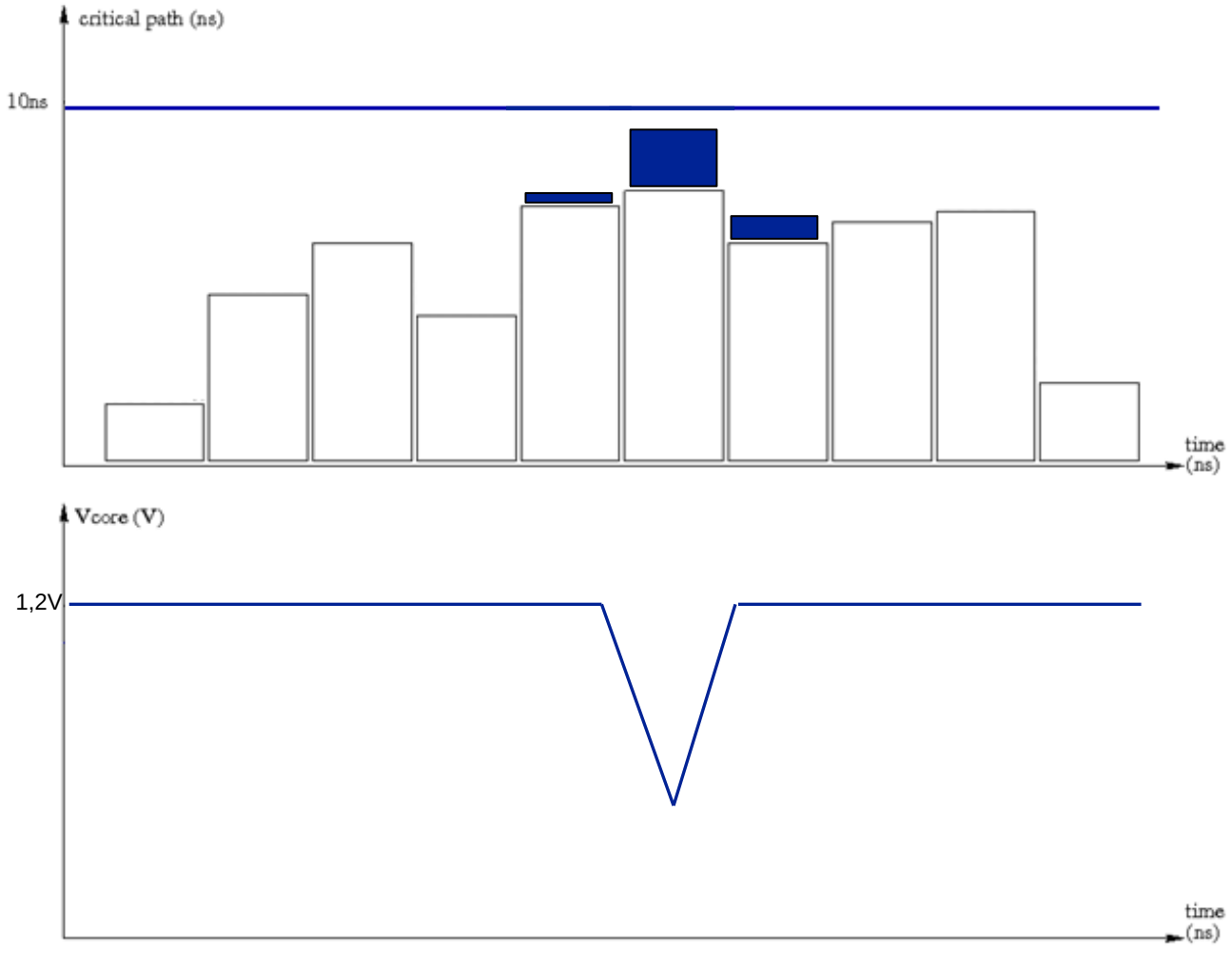
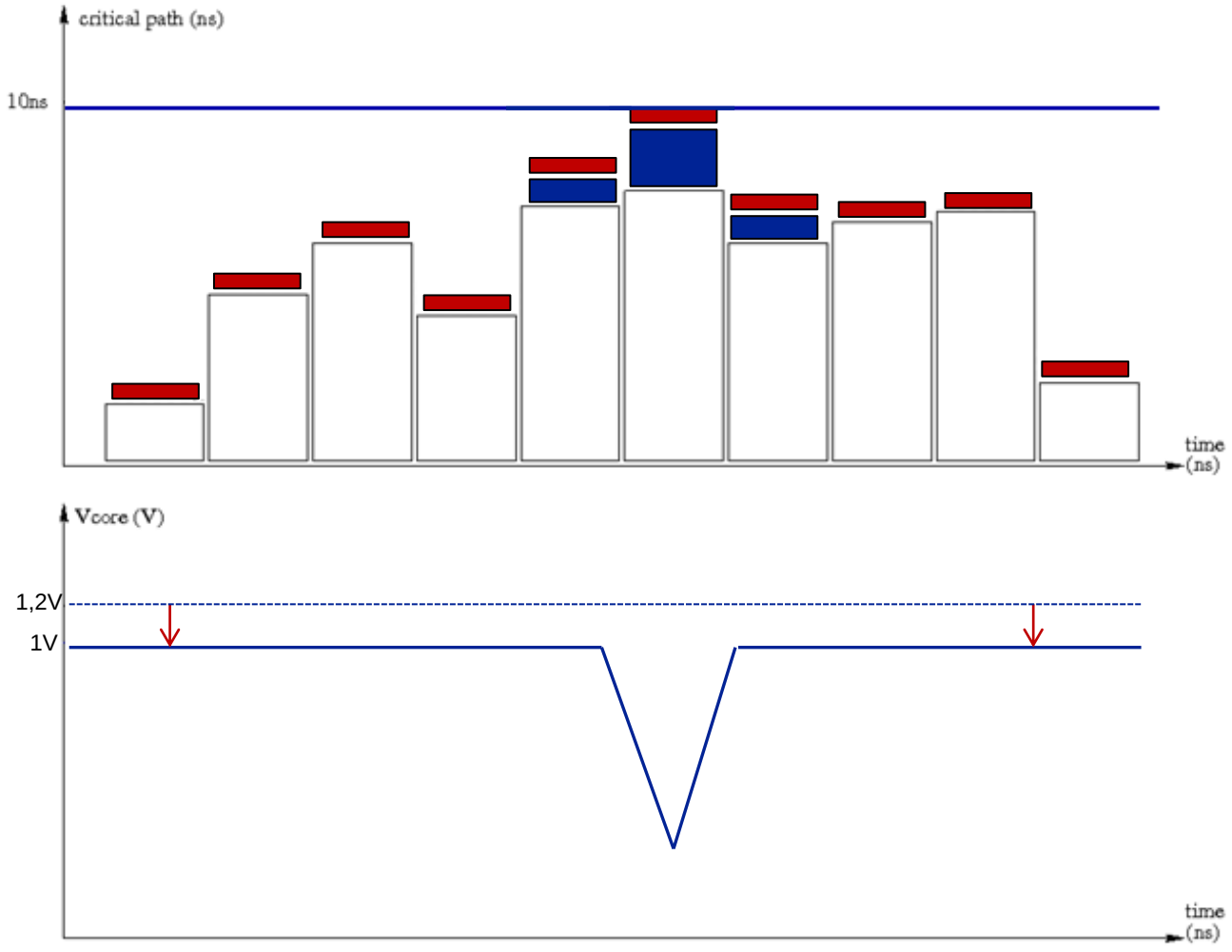


Transient perturbations

Power glitch

- Target a specific round but **also affect the neighboring rounds,**
- Global offset must be added.



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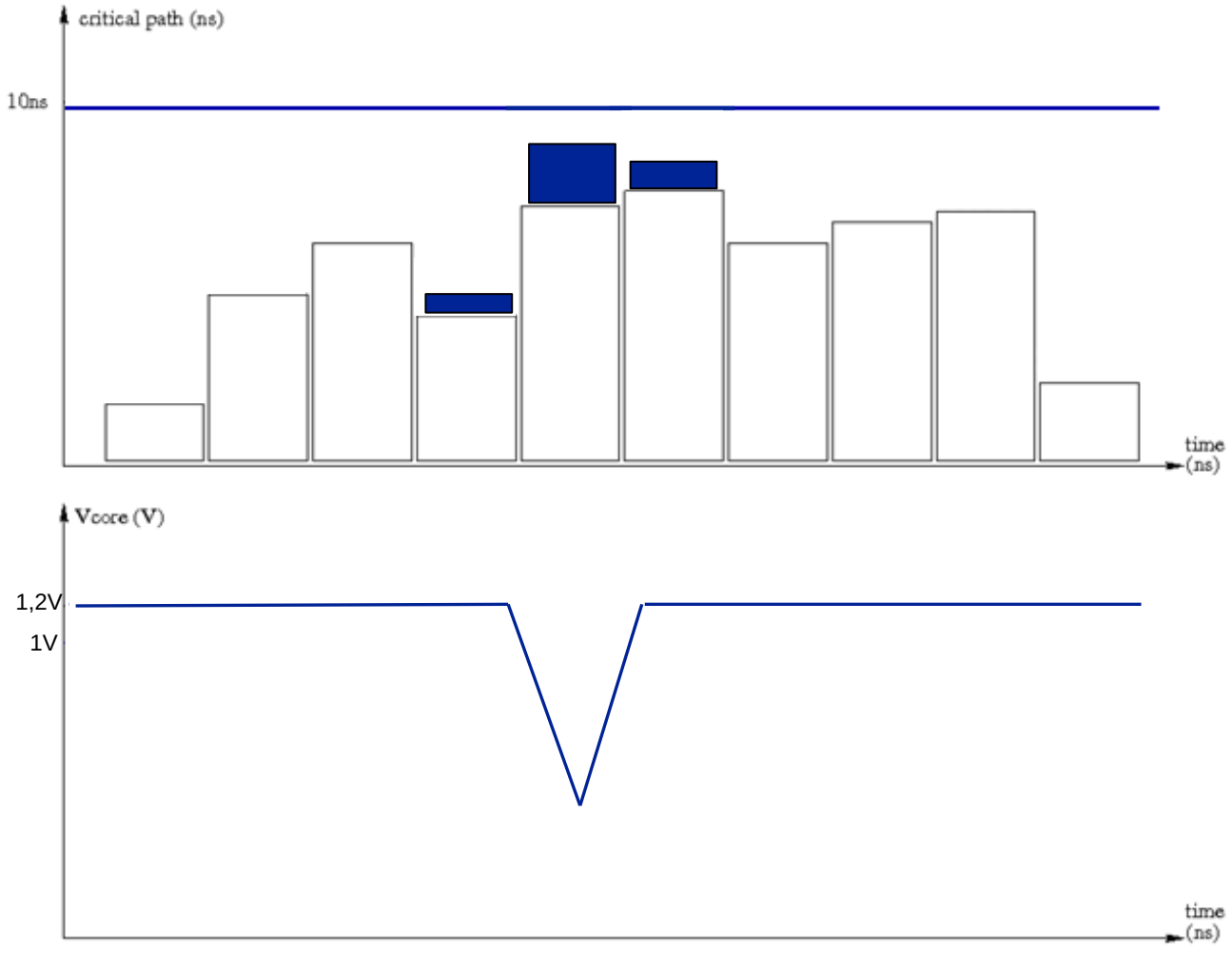

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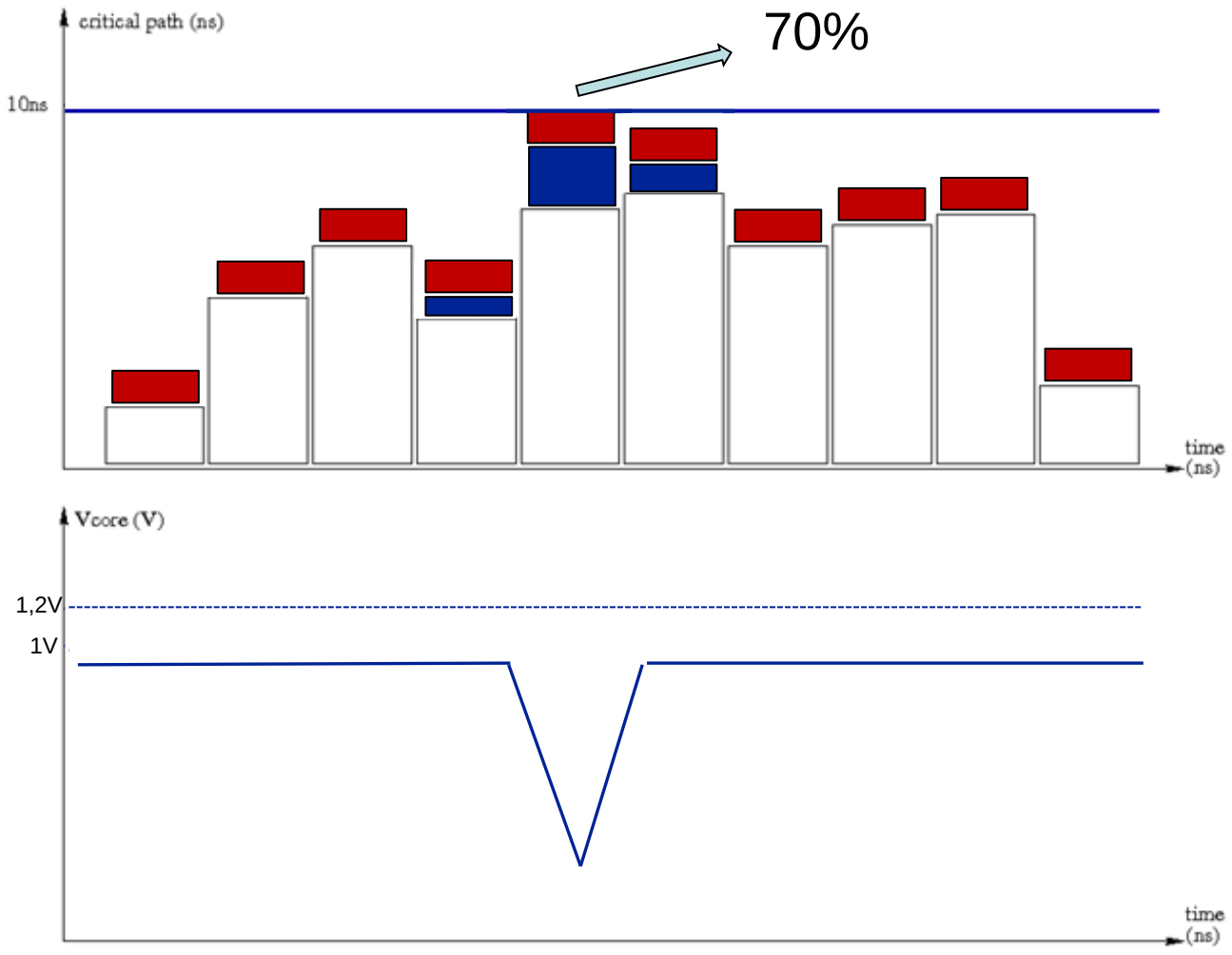

Transient perturbations

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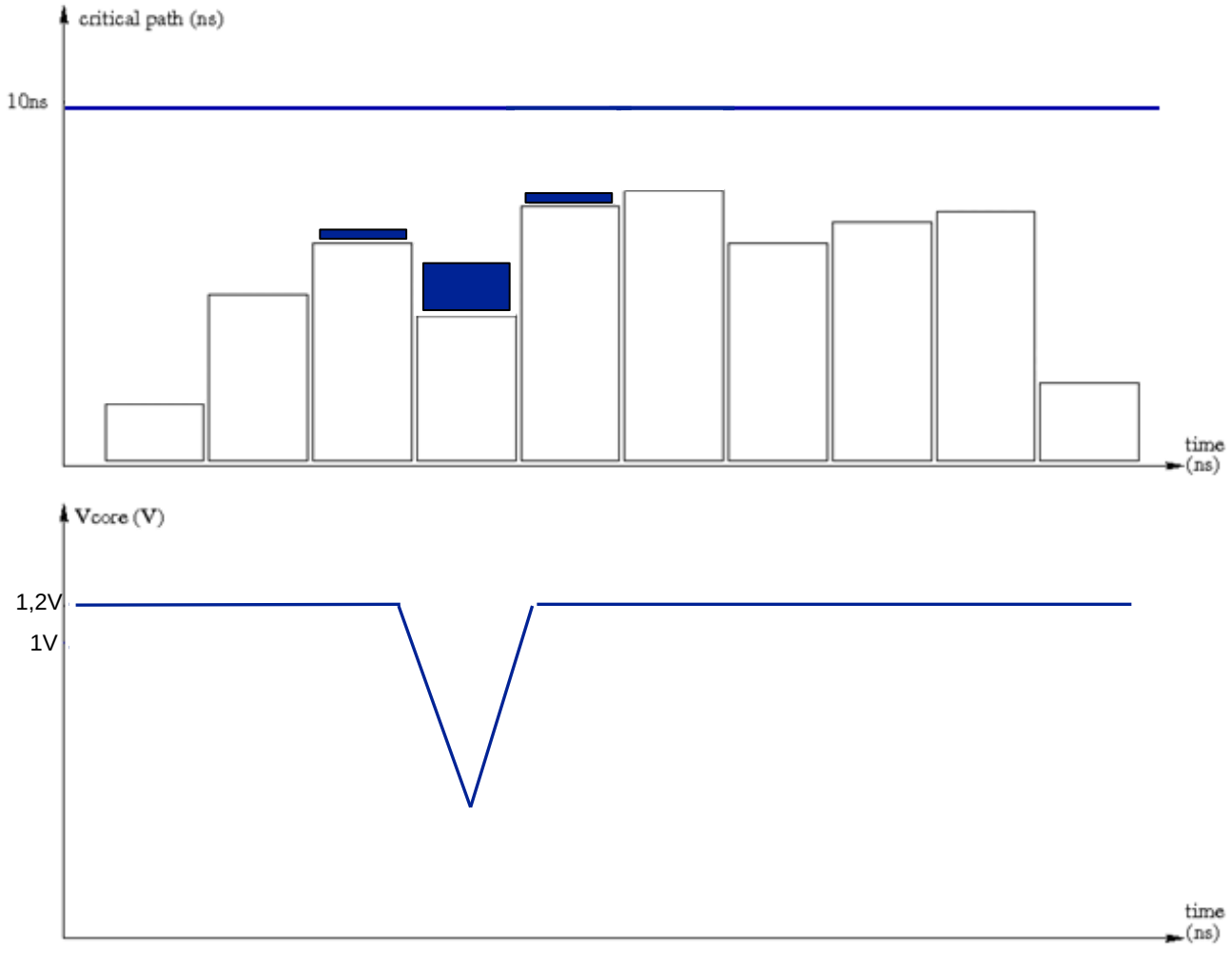

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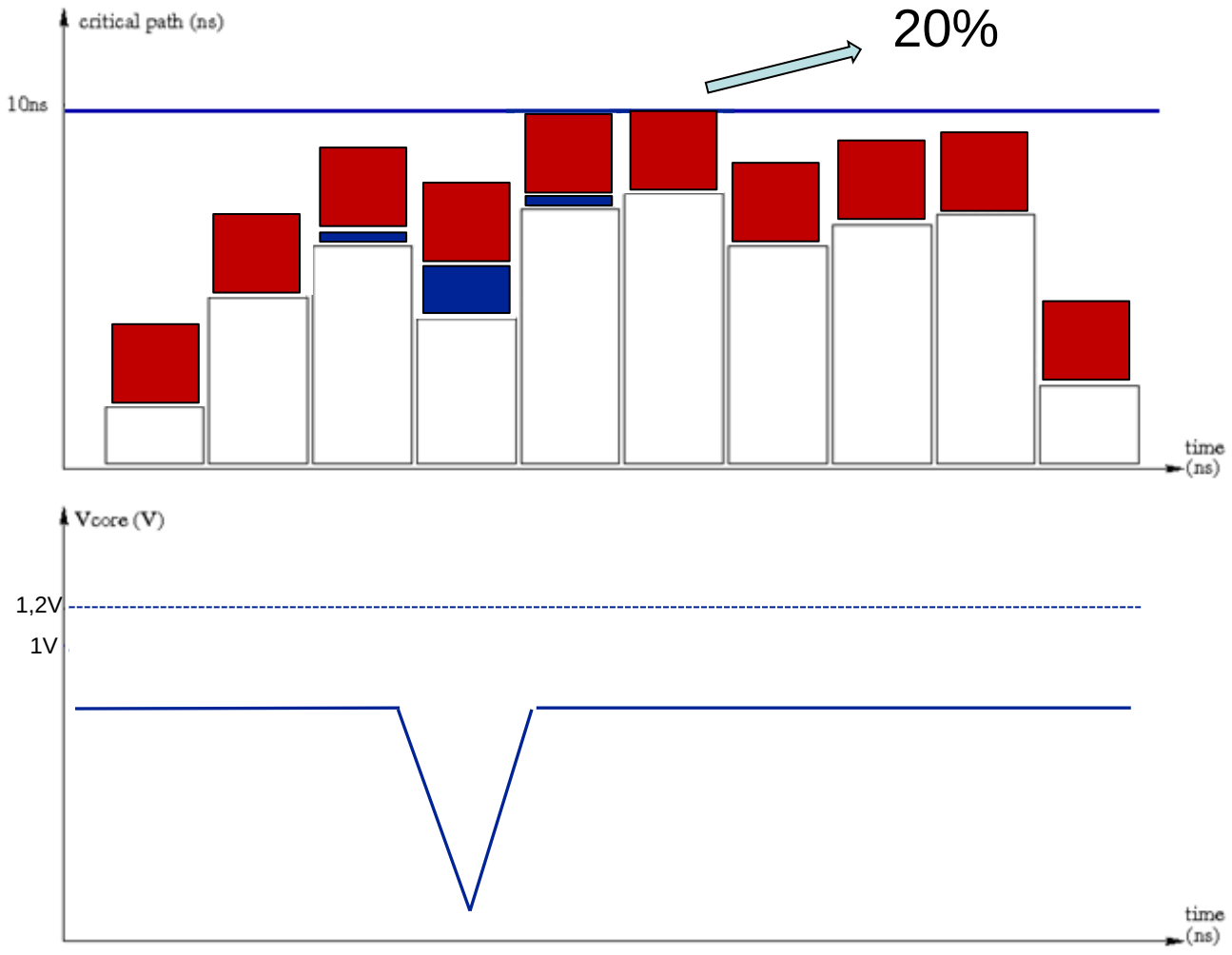

Conclusion

Power glitch

- Analysis of injected faults:
  - 70% identical to clock glitch injection
  - 20% neighboring rounds
  - 10% the second most critical path of the round
- Conclusion: Clock and power glitch induced faults are due to timing constraints violation
- >90% single-bit fault

A spatial effect component?

Linked to voltage transient propagation through the power supply grid

Questions