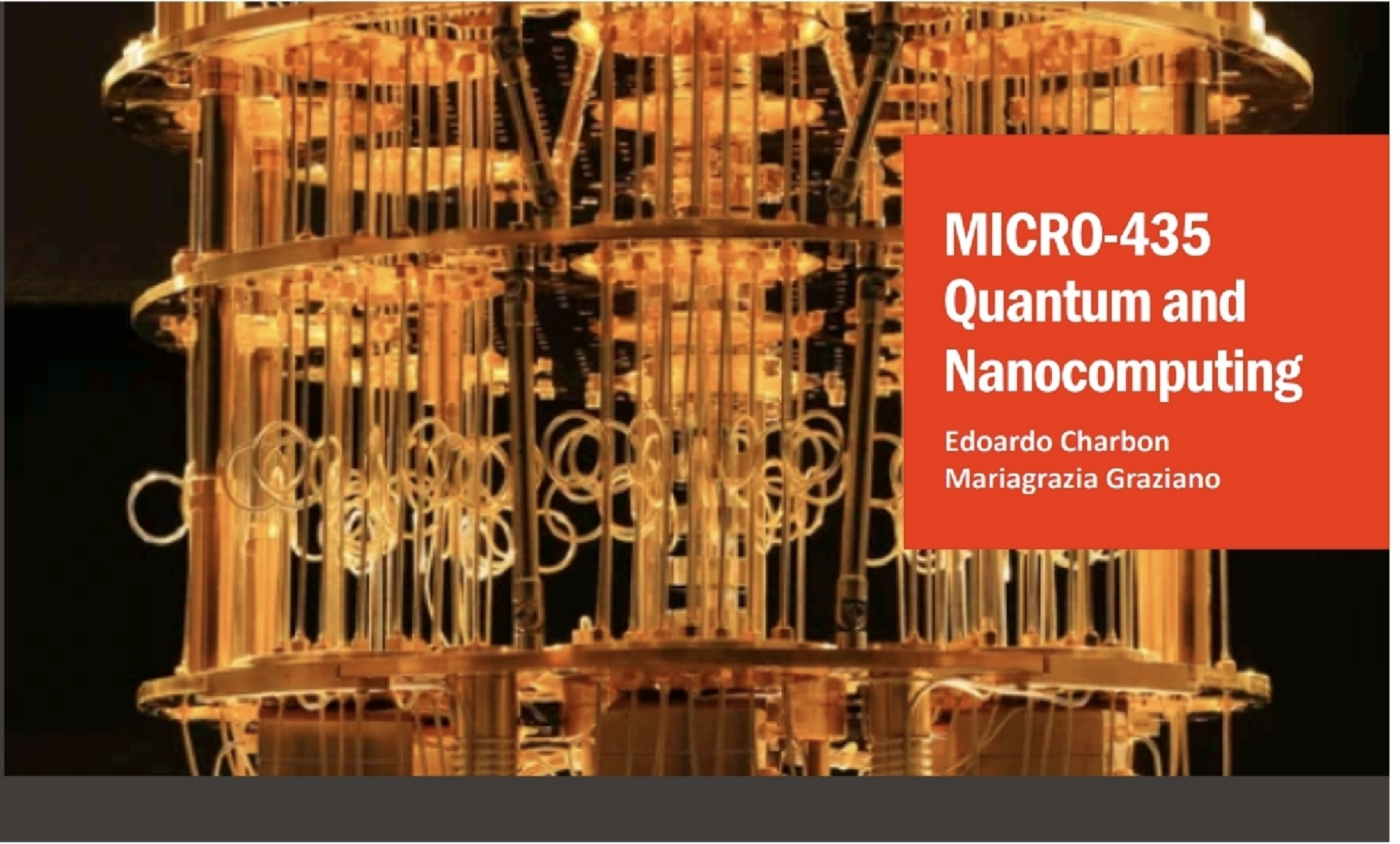


EPFL



# MICRO-435 Quantum and Nanocomputing

Edoardo Charbon  
Mariagrazia Graziano

FROM INTEL TO MORE ADVANCED  
NANOMAGNETIC STRUCTURES

- DML

# OBJECTIVES

TOWARD OTHER MAGNETIC STRUCTURES  
FOR LOGIC & MEMORY

→ DOMAIN MAGNET LOGIC

→ PML

→ RACETRACK LOGIC

→ SKYRMIONS

→ (SPIN WAVES)

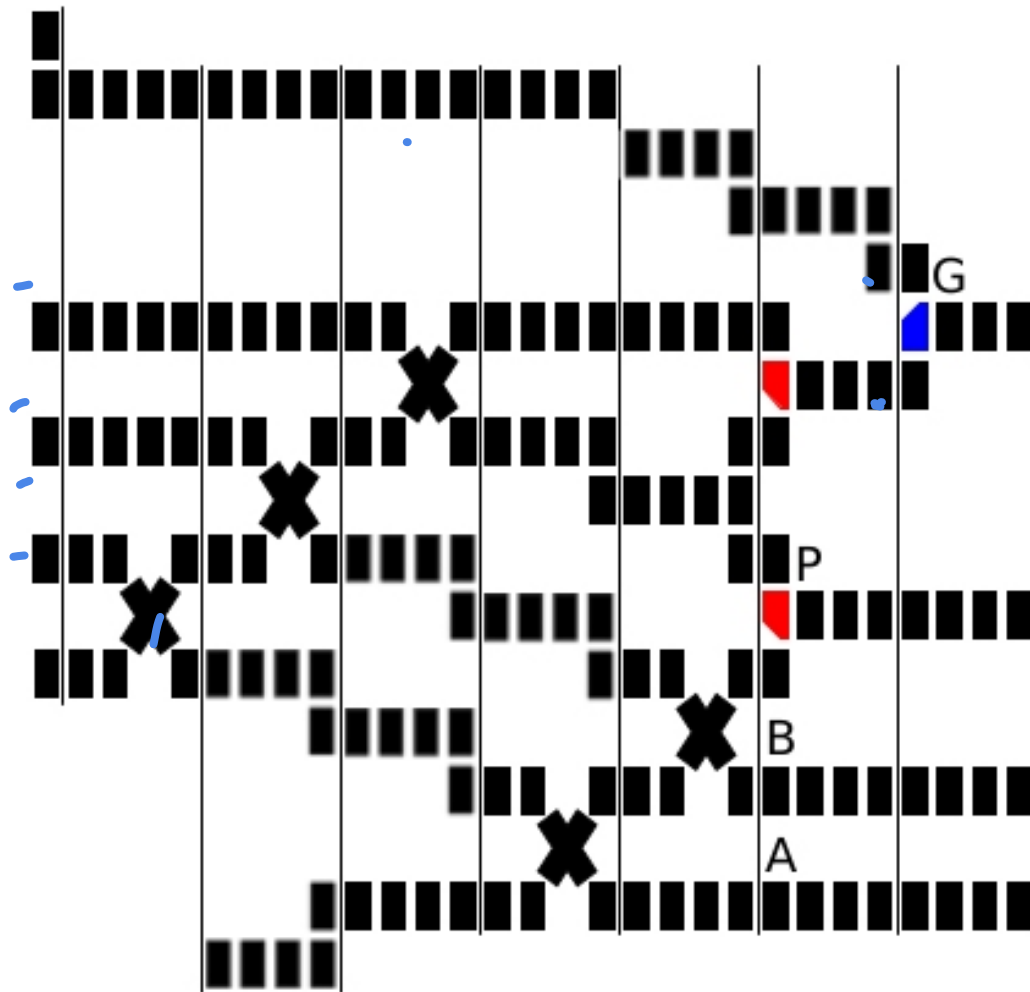
# DOMAIN MAGNET LOGIC

ONE OF THE PROBLEMS OF NML IS  
THE AREA DUE TO THE LIMITED NUMBER  
OF MAGNETS IN A CR ZONE, ESPECIALLY  
VERTICAL

↳ GOOD FOR LOGIC

↳ NOT GOOD FOR INTERCONNECT

# EXAMPLE → PROBLEM



LOGIC

CARRY  
GENERATION  
IN A CLA-LIKE  
STRUCTURE:

THE SPARSE  
TREE P4

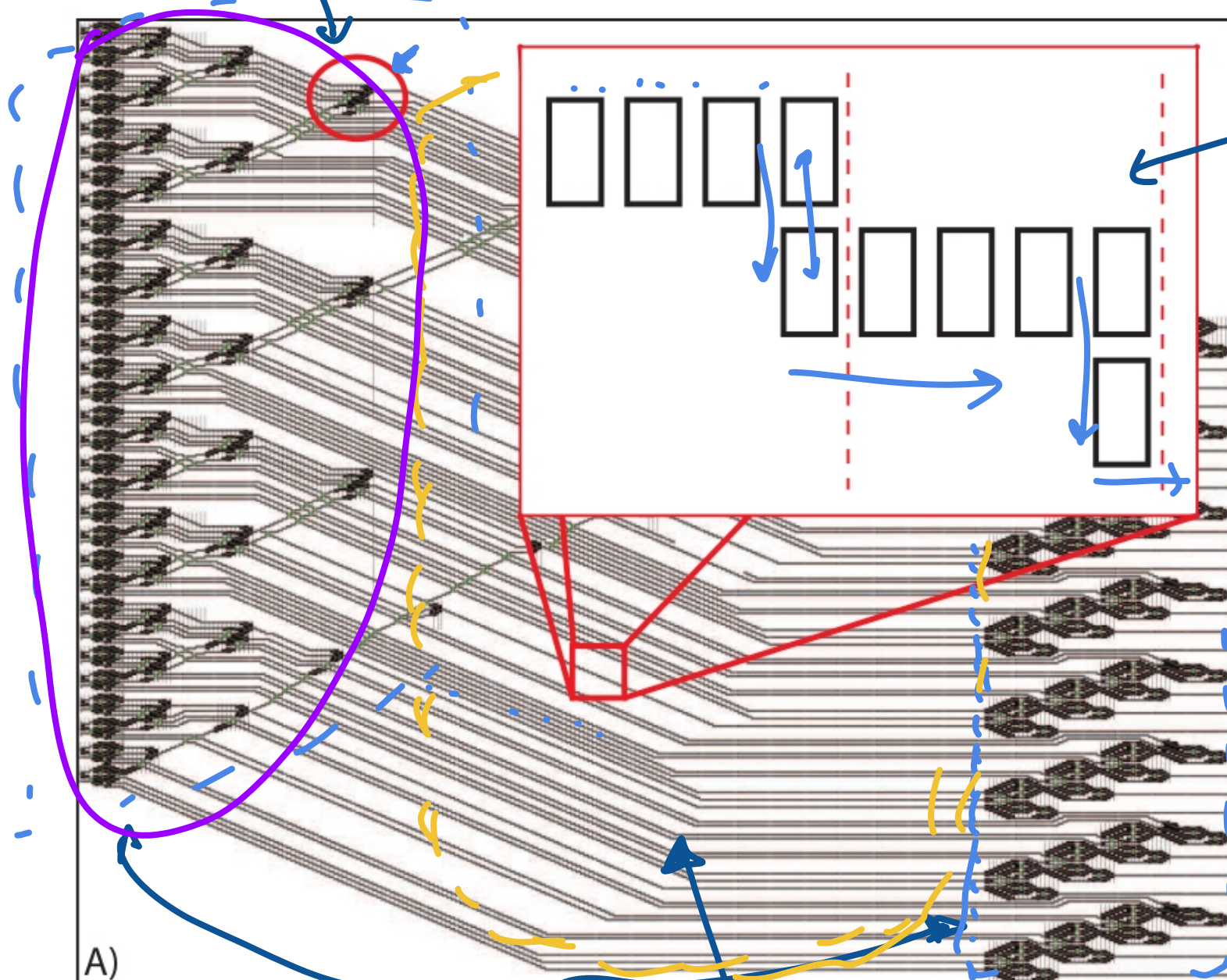
ADDER

PENTUM 4

LAYOUT = TIMING

# THE WHOLE PA ADDER

CARRY GENERATION BLOCK



STAIR WIRE NETWORK

OVERHEAD

SUM

LOGIC + INTERCONNECTS

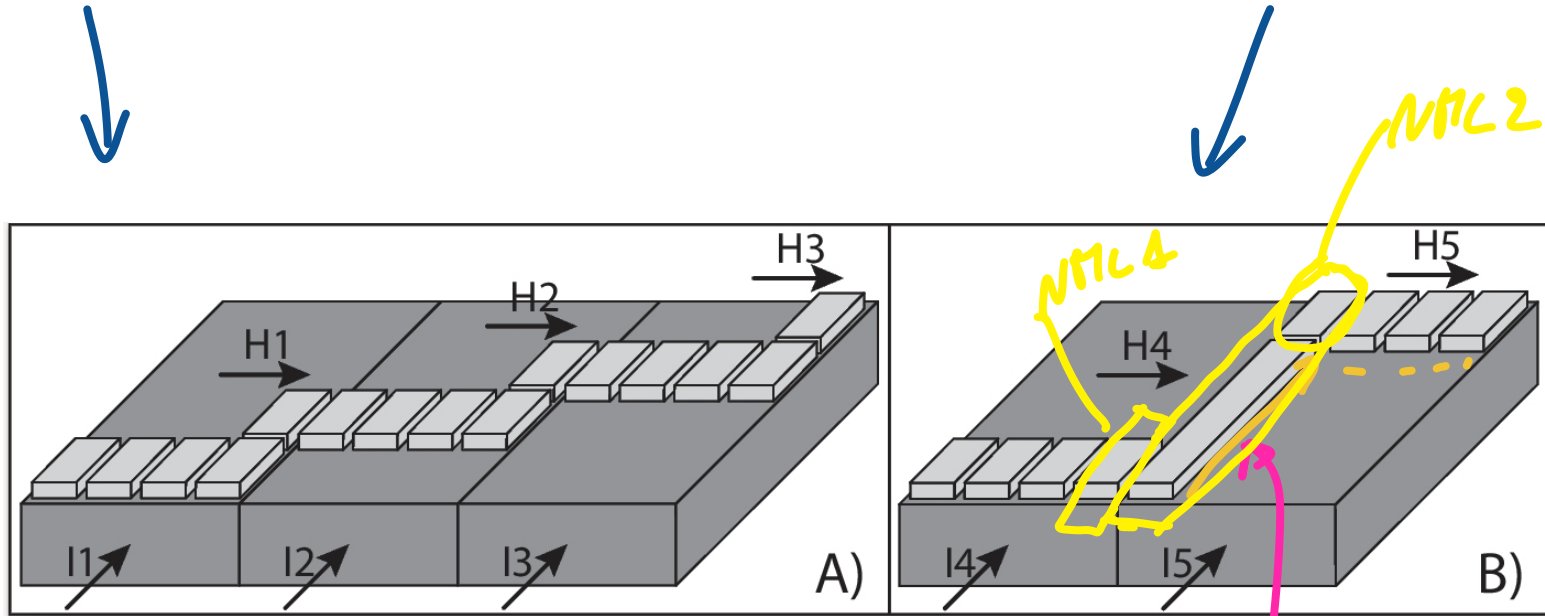


A)

# VERTICAL INTERCONNECTIONS NEEDED!

NML

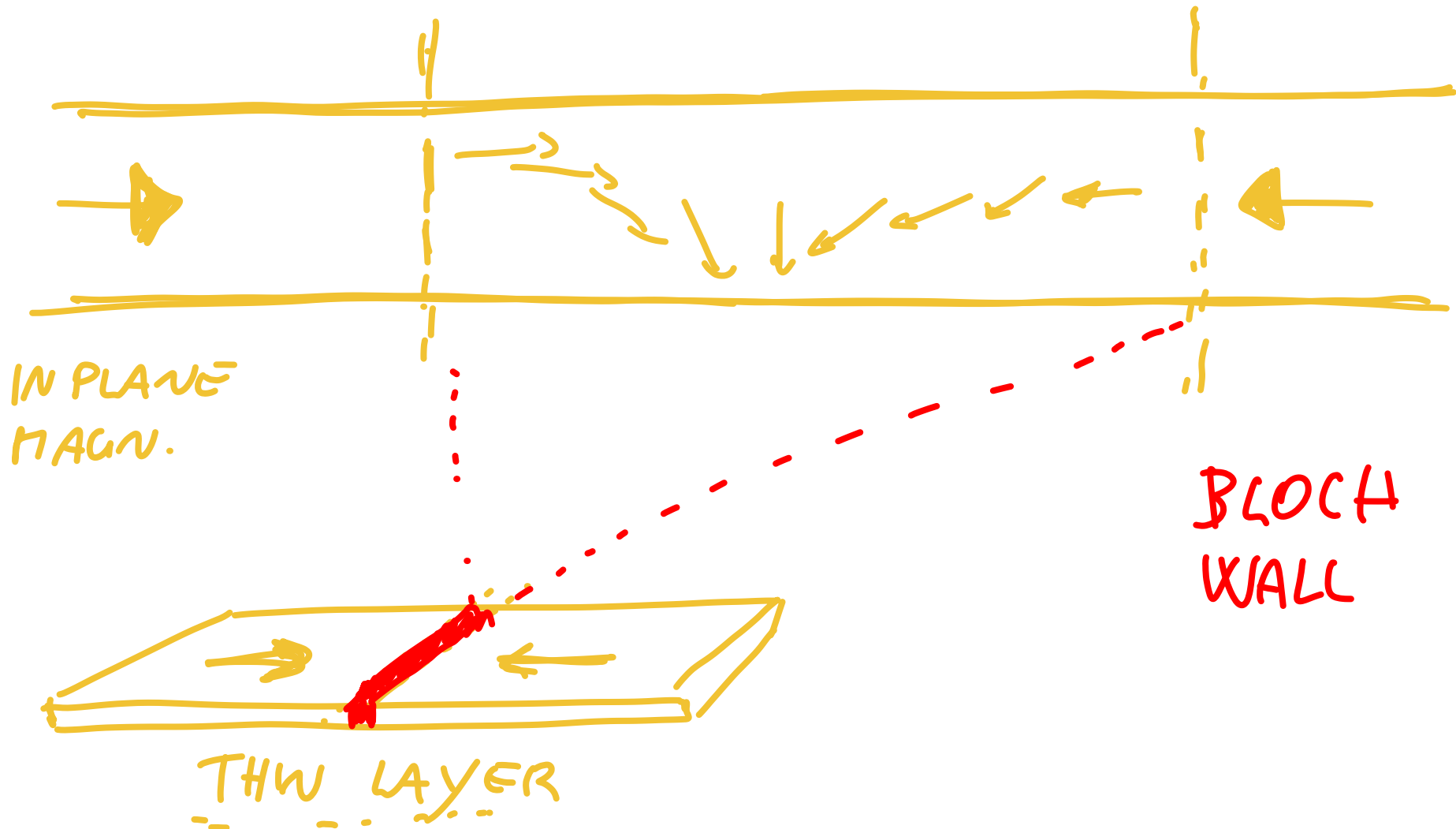
DOMAIN-MAGNET LOGIC



**D.W.** LOGIC EXISTS, BUT (COWBURN GROUP)

DW → NOT GOOD FOR LOGIC  
→ GOOD FOR INTERCONNECTS

DOMAIN WALL (see initial posts)



# DOMAIN WALL

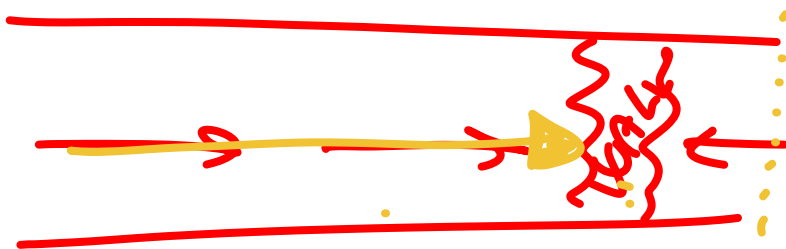
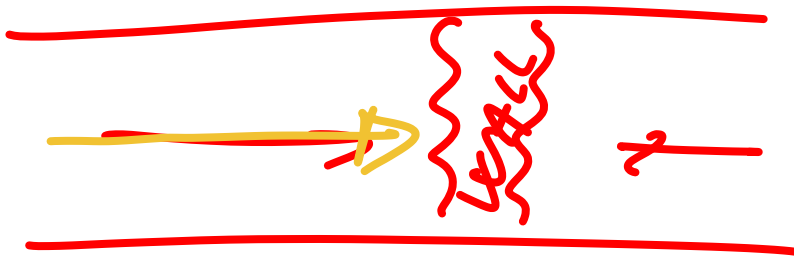
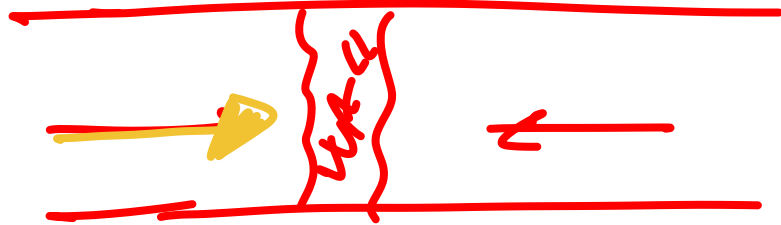
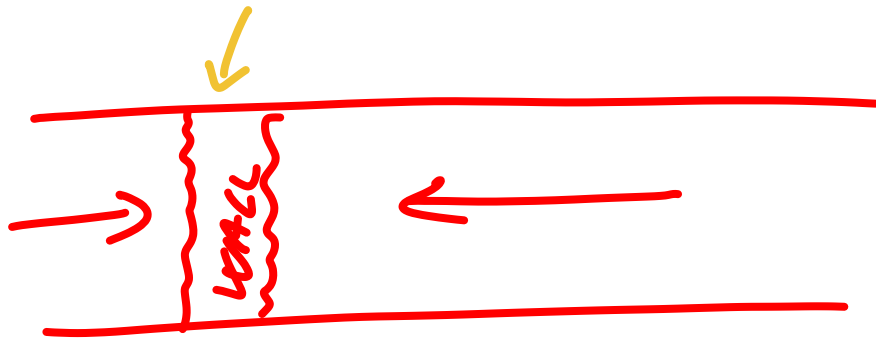
→ HAVE A PLACE IN THE STRUCTURE THAT MINIMIZES ENERGY IN A CERTAIN CONDITION

OR/AND → EXTERNAL FIELDS (H)

OR/AND → CURRENT FLOWING (SPIN POLARIZED)

OR/AND → TEMPERATURE

⇒ CHANGE THE ENERGY BUDGET AND CAN "MOVE" THE D.W.



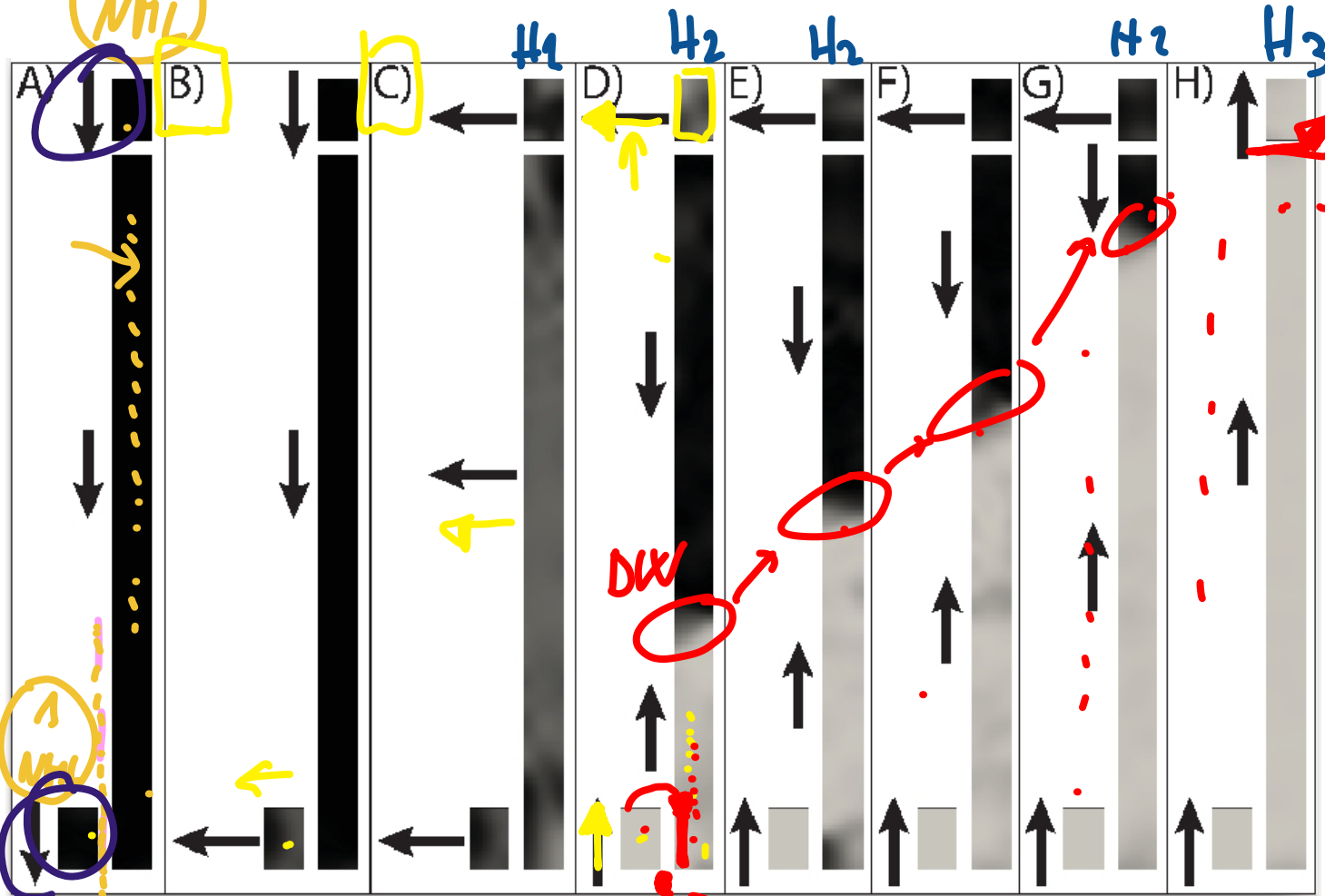
THE PROPAGATION  
IS FAST ALSO IN  
LONG WIRES



APPLY WITH  
NML



INITIAL  
MAGNETI  
ZATION

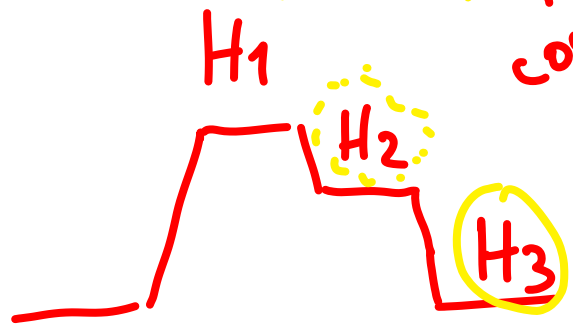


COUPLING

DW  
PROP.

CK ZONE A  
CK ZONE B

H3



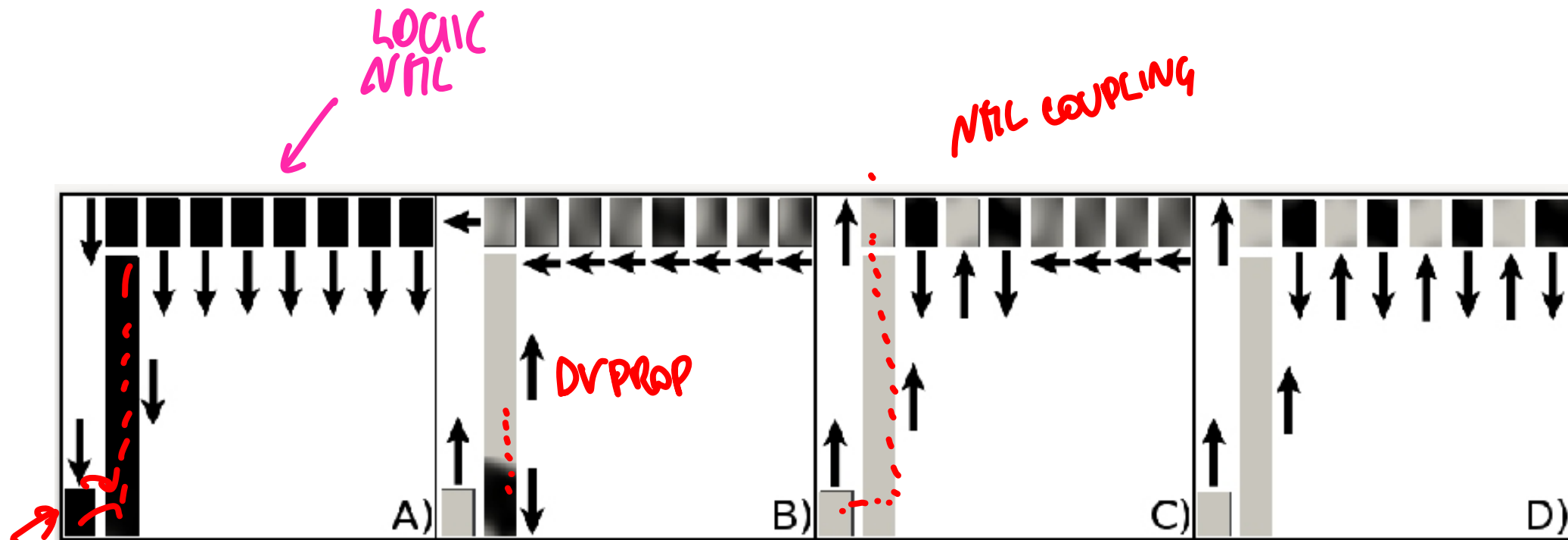
COUPLING

H1 RESET BOTH DW, NHL<sub>2</sub>

H2 RESET NHL<sub>2</sub>, NOT DW

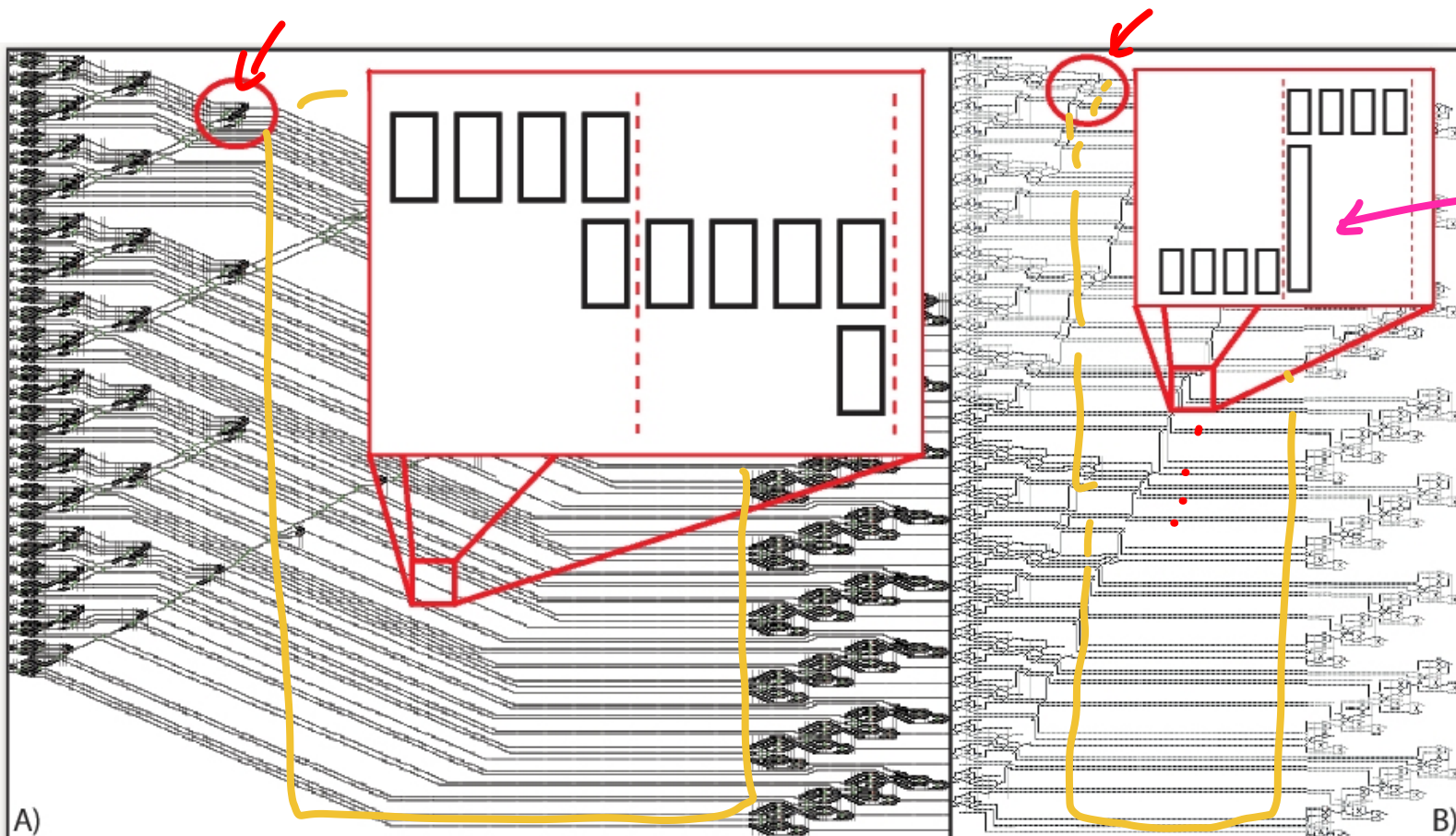
H3 NO RESET

# DW + NPL LOGIC



THERE ARE SPECIFIC RELATIONS  
ALONG

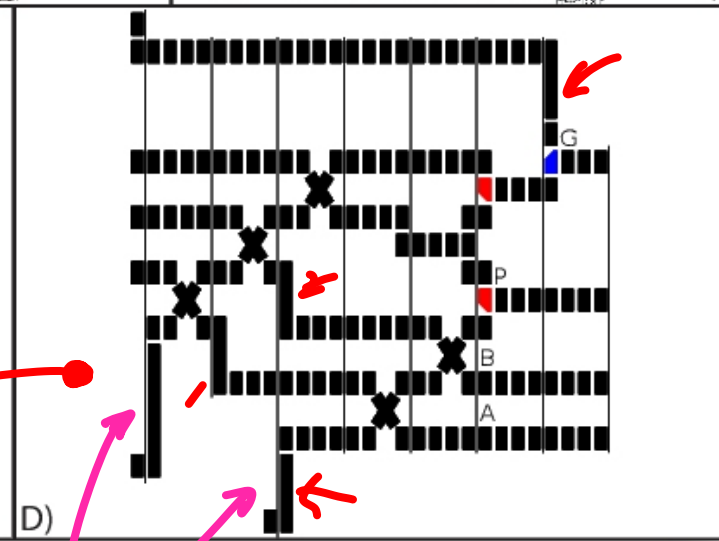
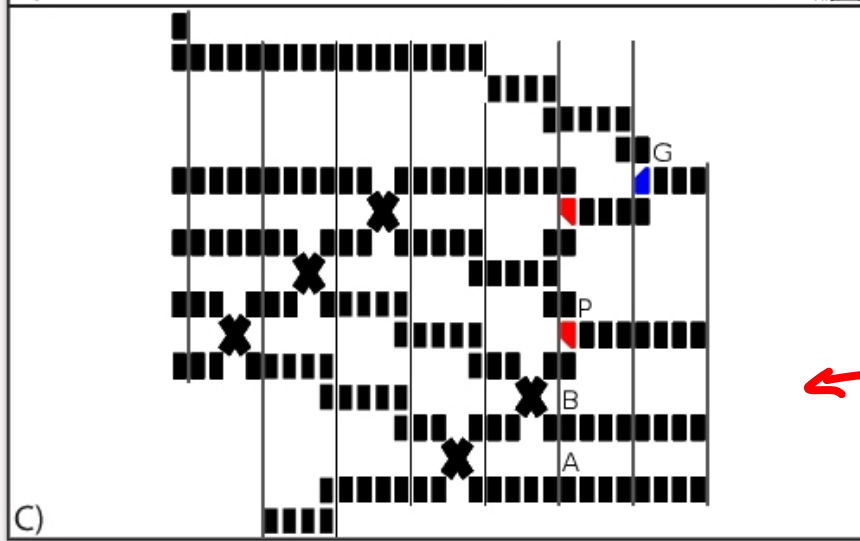
- AMPLITUDE OF FIELD
- WIDTH OF WIRE
- DISTANCE BETWEEN MAGNETS
- MATERIAL TYPE



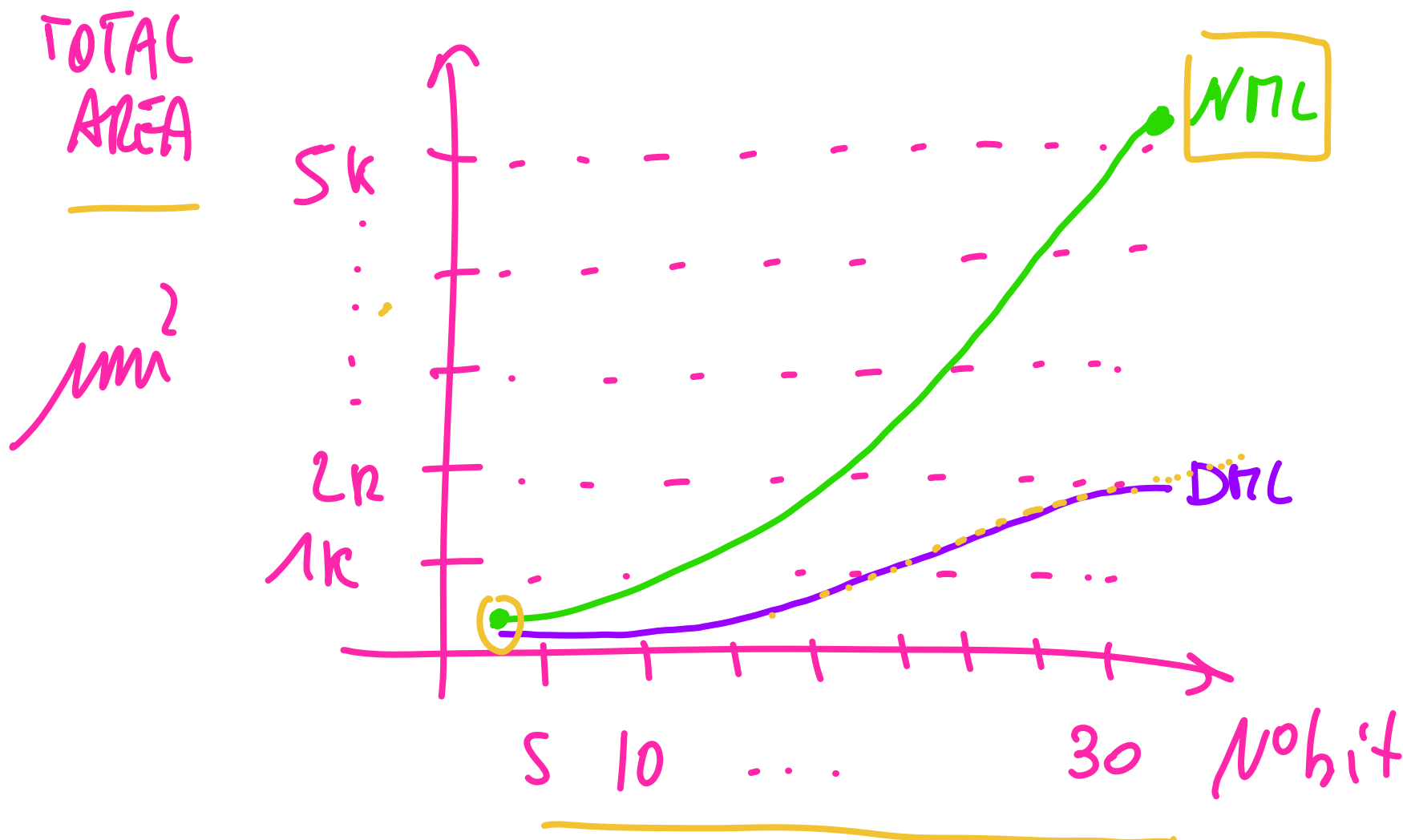
AREA REDUCED



POWER REDUCED



# ex. for the PA ADDER



AREA REDUCED ↓

SPEED ↑

↓ POWER REDUCED  
(NO CK. ZONES)