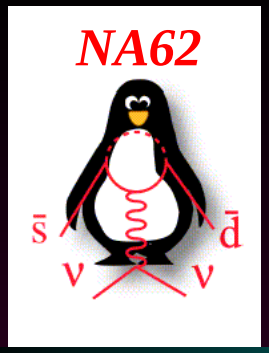
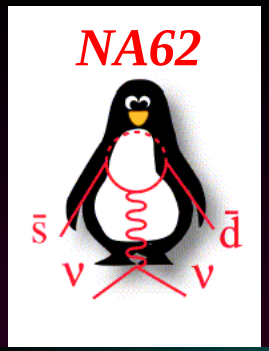


GTKpix design review

Sezione di Torino

- On chip digital circuits
- Column buses

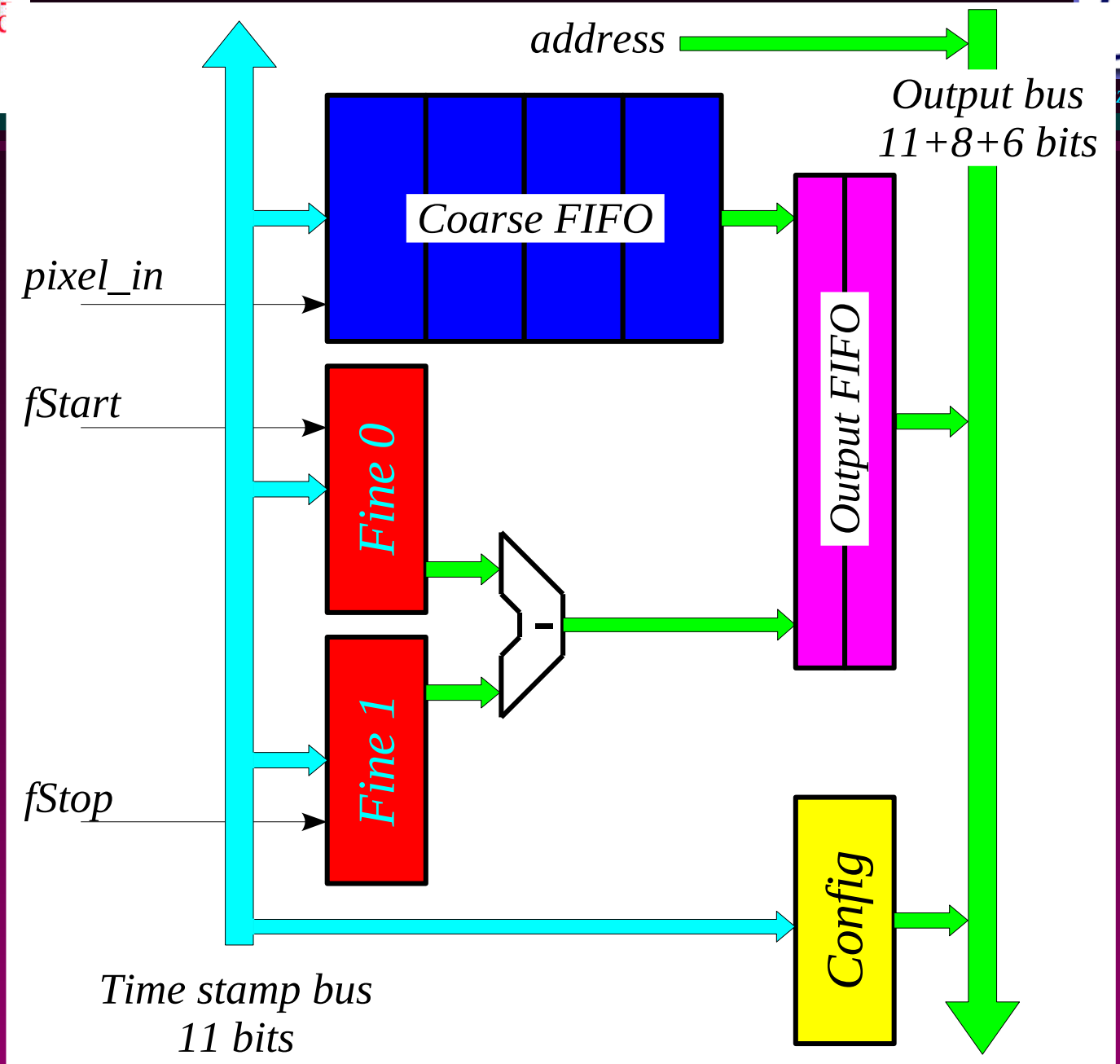


GTKpix design review

Sezione di Torino

- On chip digital circuits
- Column buses

Pixel logic


address
Output bus
11+8+6 bits
Coarse FIFO
pixel_in
fStart
Fine 0
Output FIFO
Fine 1
fStop
Config
Time stamp bus
11 bits

Registers

INFN Istituto Nazionale di Fisica Nucleare
Sezione di Torino

- Hamming-protected (SEC) registers with reload of the correct data at the next clock cycle
- Coarse time FIFO : 4x11 bits, 4x15 dFFs (15,11 encoding)
- Fine time registers : 2x8 bits, 4x12 dFFs (12,8 encoding)
- Configuration registers : 2x4 bits, 2x7 dFFs (7,4 encoding)

NA62

Control logic

INFN Istituto Nazionale di Fisica Nucleare
Sezione di Torino

- Hamming encoded state machines for SEU tolerance
- Automatic synthesis and P&R
- ARM standard cell libraries
- Estimated size :
  - 150 μm × 290 μm @ 66% occupancy
  - 130 μm × 290 μm @ 74% occupancy
  - 110 μm × 290 μm @ 88% occupancy

NA62

Hamming encoding

INFN Istituto Nazionale di Fisica Nucleare

Sezione di Torino

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	P_0	P_1	D_0	P_2	D_1	D_2	D_3	P_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	P_4	D_{11}	D_{12}	D_{13}
P_0	X		X		X		X		X		X		X		X		X		X
P_1		X	X			X	X			X	X			X	X			X	X
P_2				X	X	X	X					X	X	X	X				
P_3								X	X	X	X	X	X	X	X				
P_4																X	X	X	X

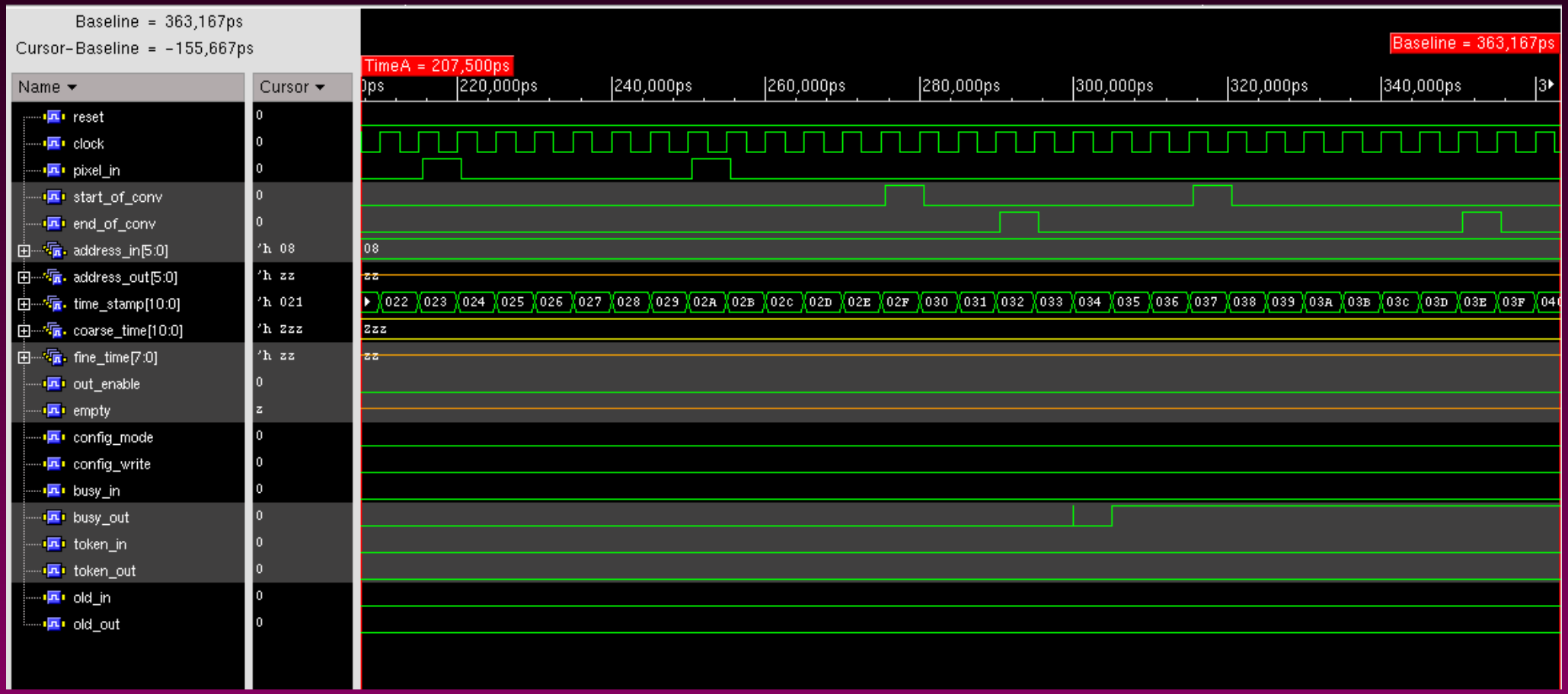
$$n \leqslant 2^k - k - 1$$

$$D_{n-1} \dots D_0$$

$$P_{k-1} \dots P_0$$

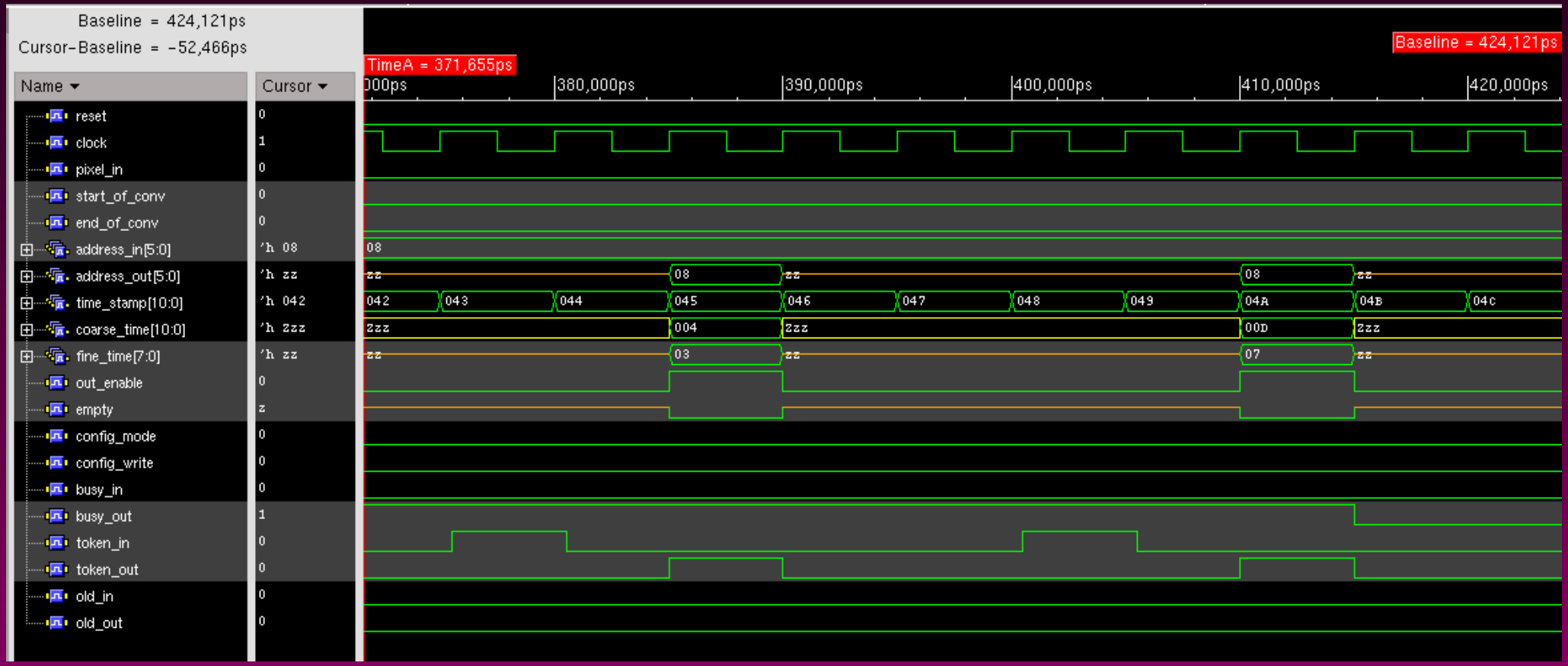
Event acquisition

Sezione di Torino



Event transmission

Sezione di Torino



Configuration mode

Sezione di Torino

- Data sent on the time stamp bus
- Two 4 bits registers
- Two control signals : *config_mode* and *config_write*
- No hit accepted when *config_mode* is high
- Packet format :

6	1	4
Address	*H/L*	*Data*

GTKpix design review

Sezione di Torino

- On chip digital circuits
- Column buses

NA62

Signal types

INFN Istituto Nazionale di Fisica Nucleare

Sezione di Torino

- Input common signals
- Local I/O signals
- Output common signals
- fastOR-chained signals

NA62

Input signals

INFN Istituto Nazionale di Fisica Nucleare

Sezione di Torino

i. reset
ii. clock ← *most critical signal !*
iii. time_stamp ← *bus, 11 bits*
iv. config_mode
v. config_write

- Transmission via pseudo differential CMOS levels
- DCVSL receivers

NA62

Clock transmission

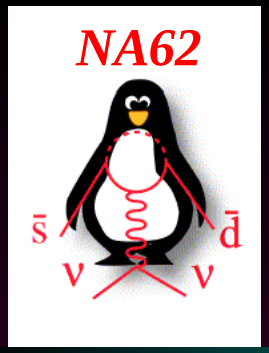
INFN Istituto Nazionale di Fisica Nucleare

Sezione di Torino

Clock is the most critical signal (jitter < 100 ps)

Clock line options :

- Current mode differential line with low impedance termination (high power)
- Clock tree with CMOS buffers (layout complexity)
- Local clock regeneration in each pixel (pixel-dependent delay can lead to syncronization problems)



Rough calculations

Sezione di Torino

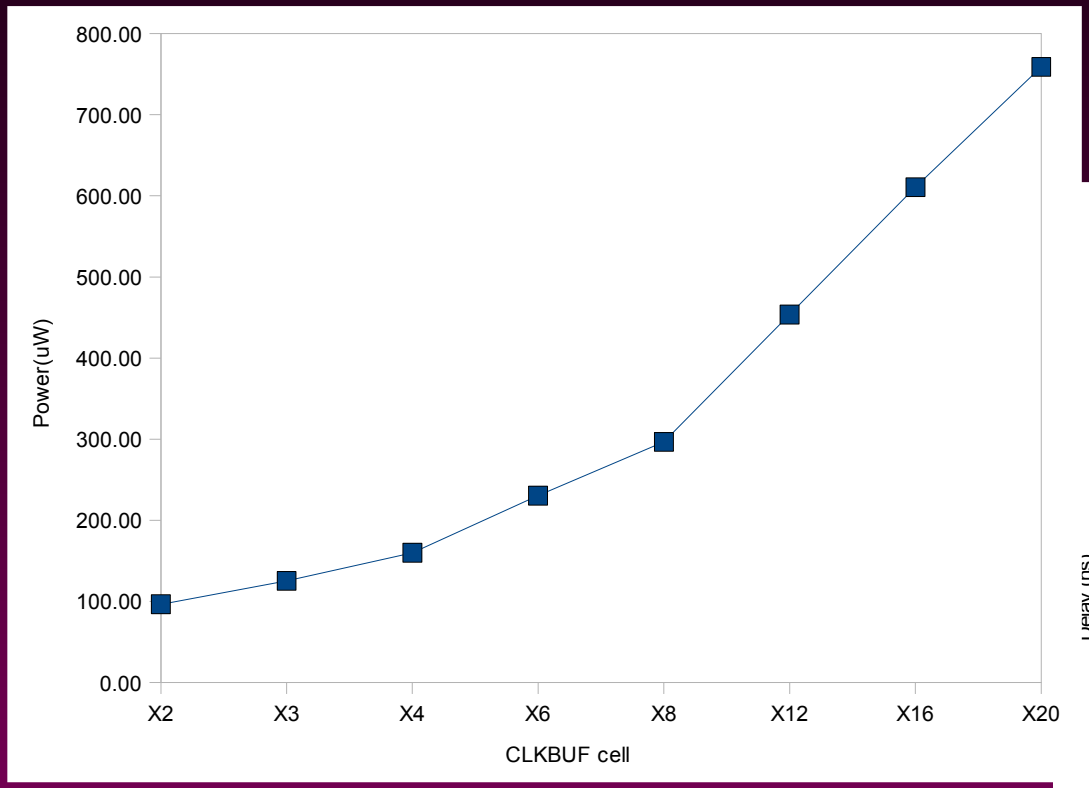
- Minimum size and space MG with MA backplane
- R=0.04 mΩ/□ · 300 μm / 0.4 μm = 30 mΩ/pixel
- C=(0.0402 + 0.0734·2) fF/μm · 300 μm = 56.1 fF/pixel
- R_{COL} = 1.35 Ω, C_{COL} = 2.5 pF
- T_{RISE} = 200 ps 0.22 · 2 · π · $R_T C_{COL}$ for 20%-80%
- Distributed RC → factor of 2 gain → R_T = 100 Ω
- I_{DRV} ≈ 5 mA every two column (67 μW/pixel)

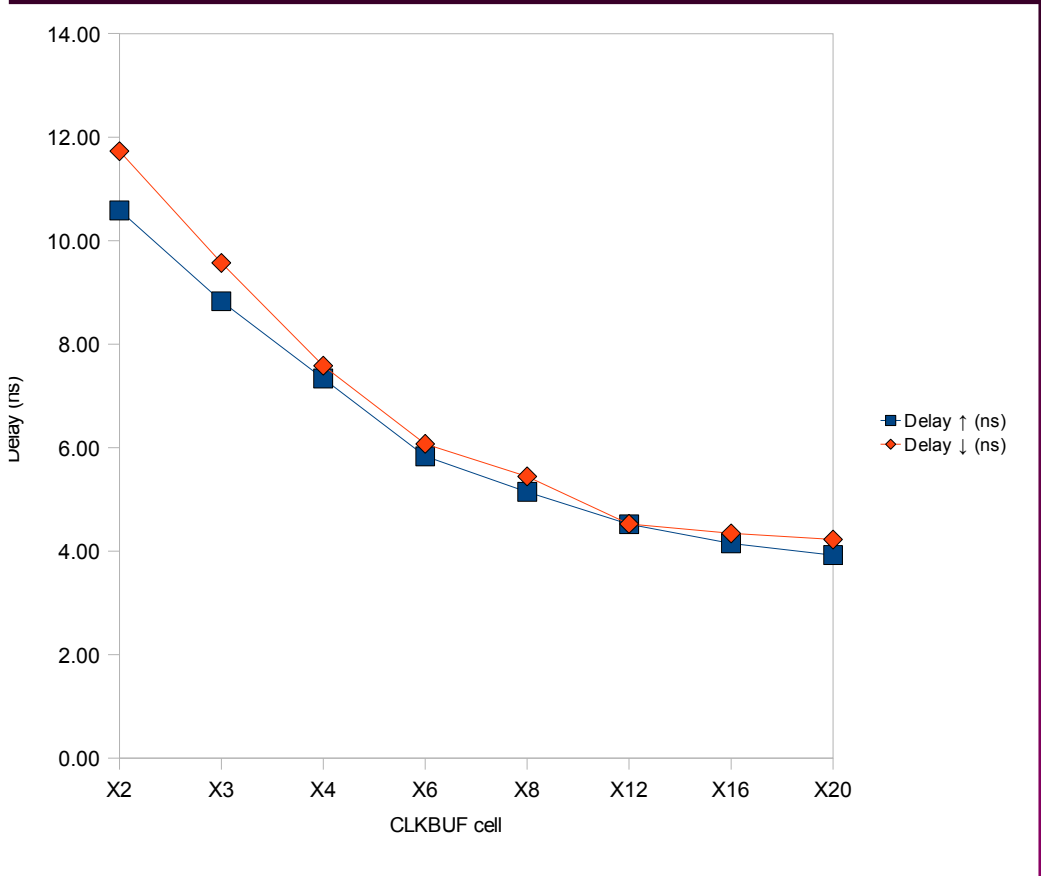
NA62

Cell delays & power

INFN Istituto Nazionale di Fisica Nucleare

Sezione di Torino



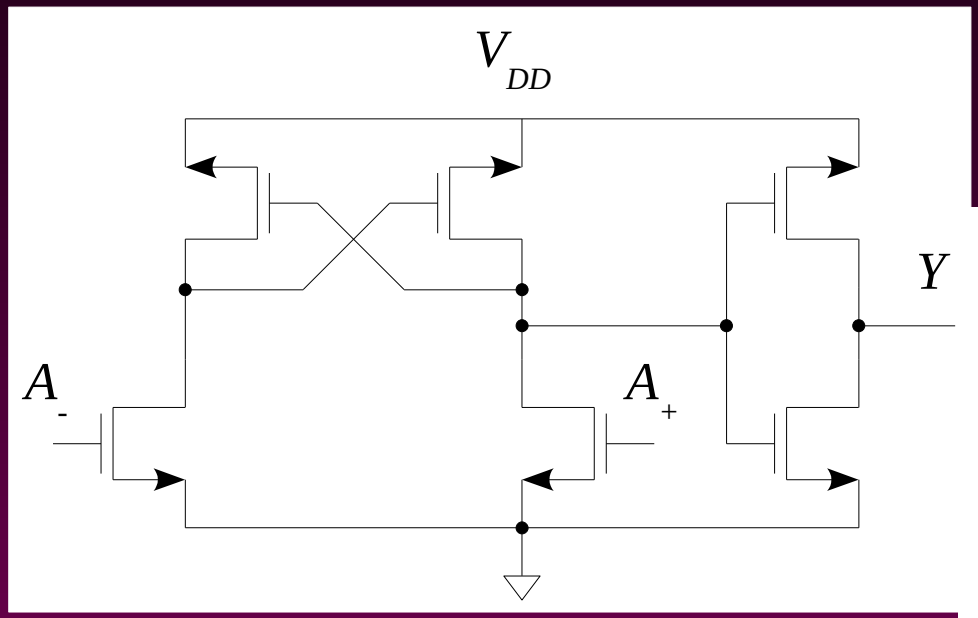


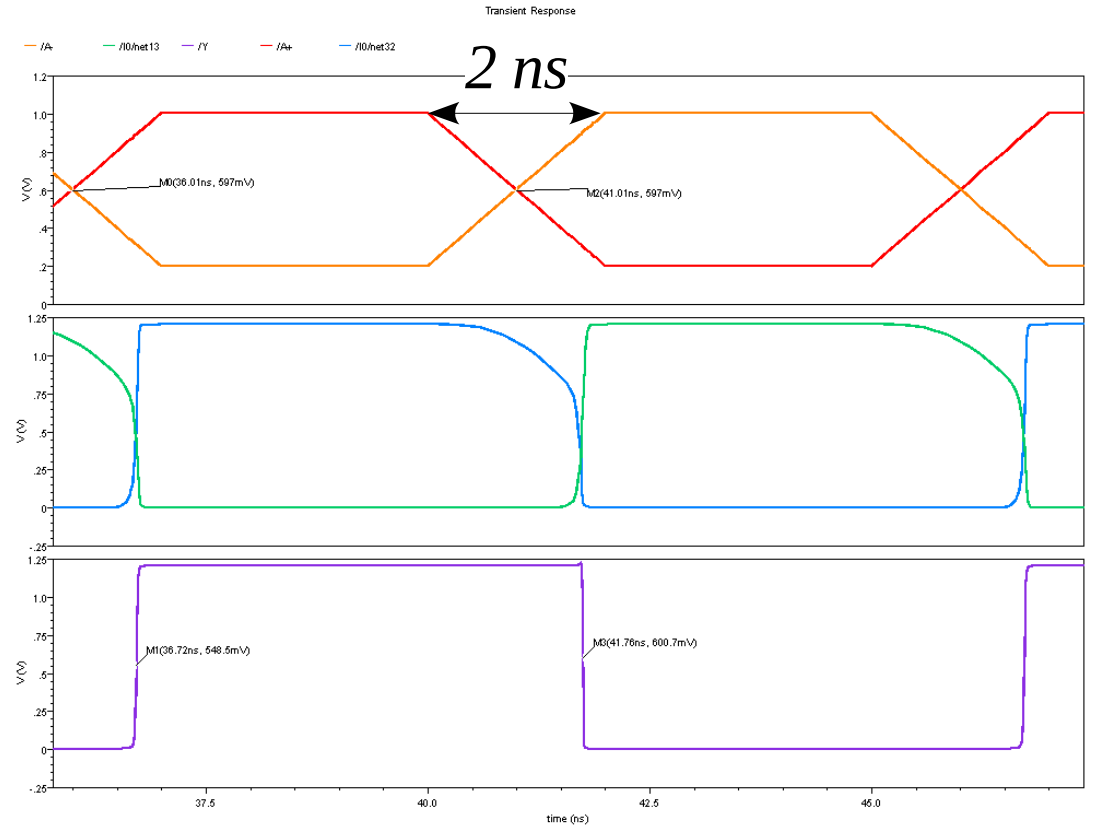
NA62

DCVSL receiver

INFN Istituto Nazionale di Fisica Nucleare

Sezione di Torino





NA62

Local I/O signals

INFN Istituto Nazionale di Fisica Nucleare

Sezione di Torino

i. pixel_in : *from CFD*

ii. start_of_conv : *capacitor discharge start*

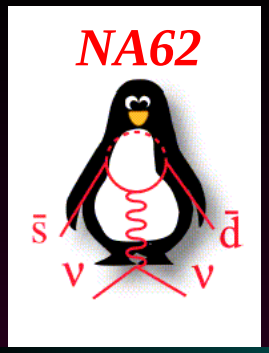
iii. end_of_conv : *capacitor discharge stop*

iv. address_in : *bus, 6 bits, hardwired*

v. write_ptr : *FIFO write pointer*

vi. read_ptr : *FIFO read pointer*

vii. out_enable : *3-state enable*

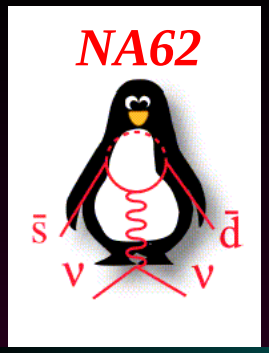


Output signals

Sezione di Torino

i. address_out ← *bus, 6 bits*
ii. coarse_time ← *bus, 11 bits*
iii. fine_time ← *bus, 8 bits*
iv. empty

- Pseudo differential lines with CMOS levels.
- End of column sense amplifier to increase the speed



OR-chained signals

Sezione di Torino

i. busy : pixel ready to be readout
ii. old : pixel with previous frame data
iii. token : token for readout enable
iv. SEU_error : SEU_error on registers or FSM

- Local signals are propagated down to the column by putting in OR the local and the previous pixel output

NA62

Sense amplifier

INFN Istituto Nazionale di Fisica Nucleare

Sezione di Torino