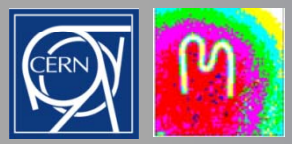


ELACCO PROJECT UPDATE

(PIXEL ELECTRONICS FOR MEDIPIX)

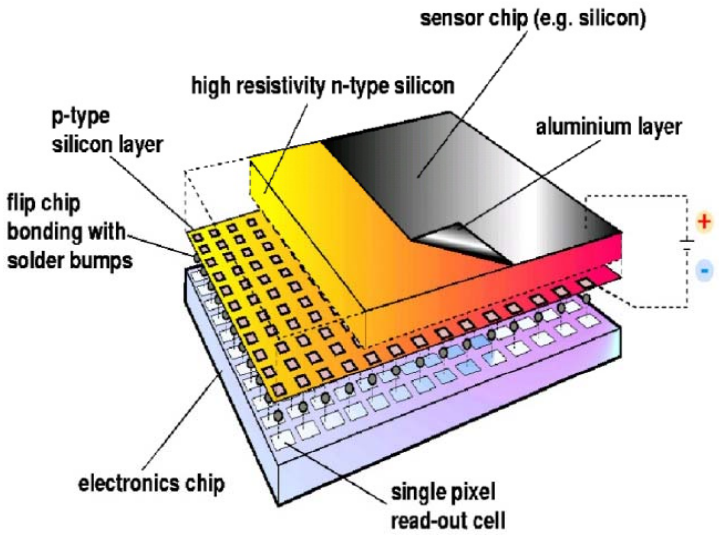
Winnie Wong

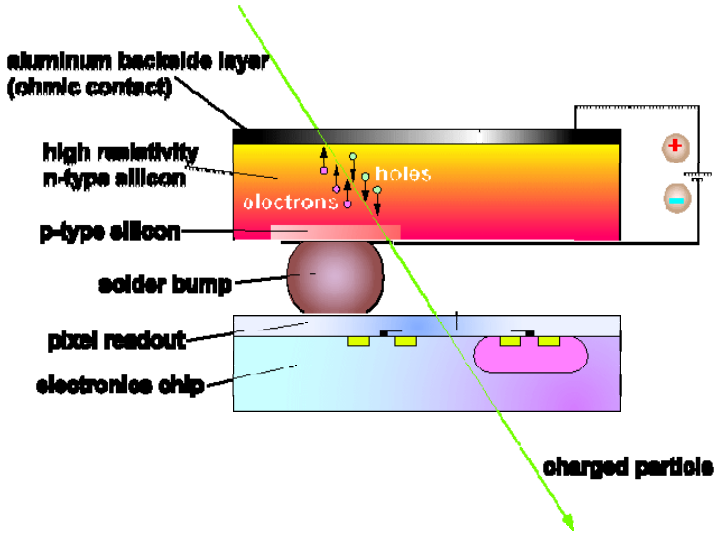
Marie Curie EST Fellow

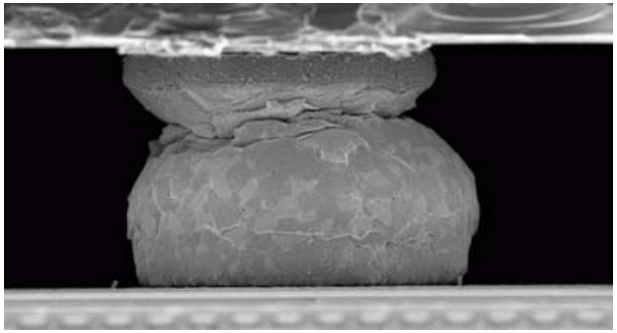
ELACCO Project

Medipix Design Team, CERN

Hybrid Photon Detectors

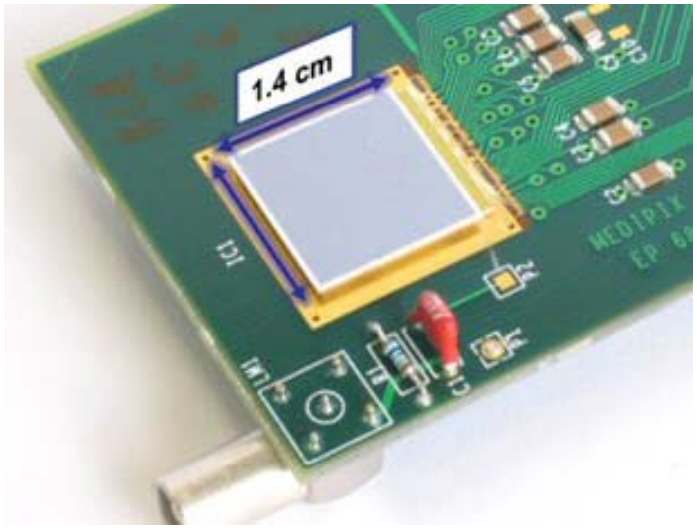






Courtesy of VTT, Finland

Medipix

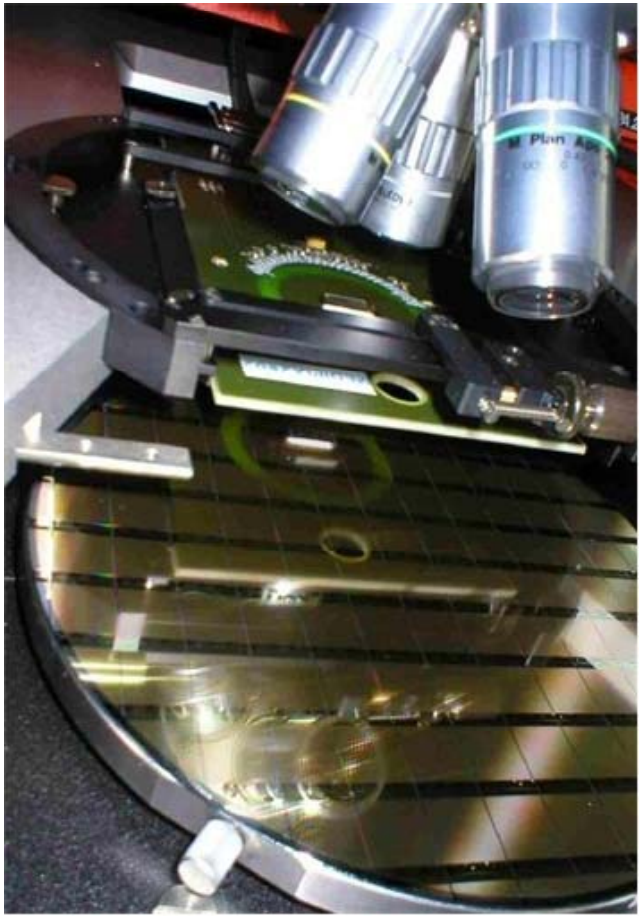


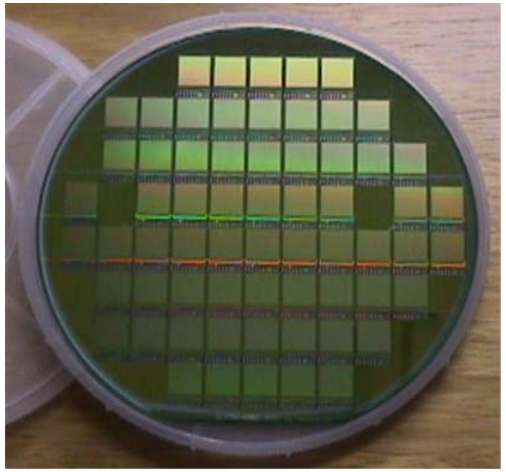
Each chip contains a matrix of 256 x 256 pixels of 55 μm pitch.

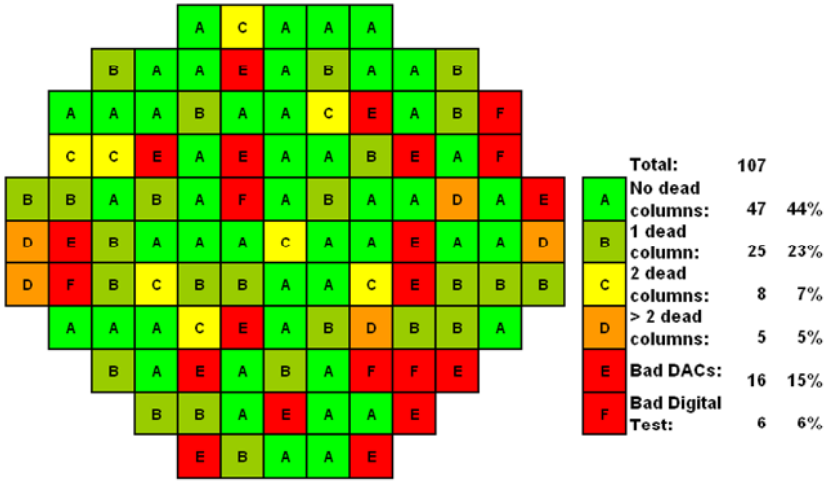
Medipix family of HPDs:

- **Medipix** } **Single Photon Counting**
- **Medipix2**
- **Timepix**
  - **Single Photon Counting**
  - **Time of Arrival**
  - **Time over Threshold**
- **Medipix3**
  - **SPC with Charge Summing**
  - **Up to 8 Energy Thresholds**
  - **Multiple readout modes**
  - **Configurable depth counters**
- **Future Medipix ASICs...**

Medipix2 and Timepix



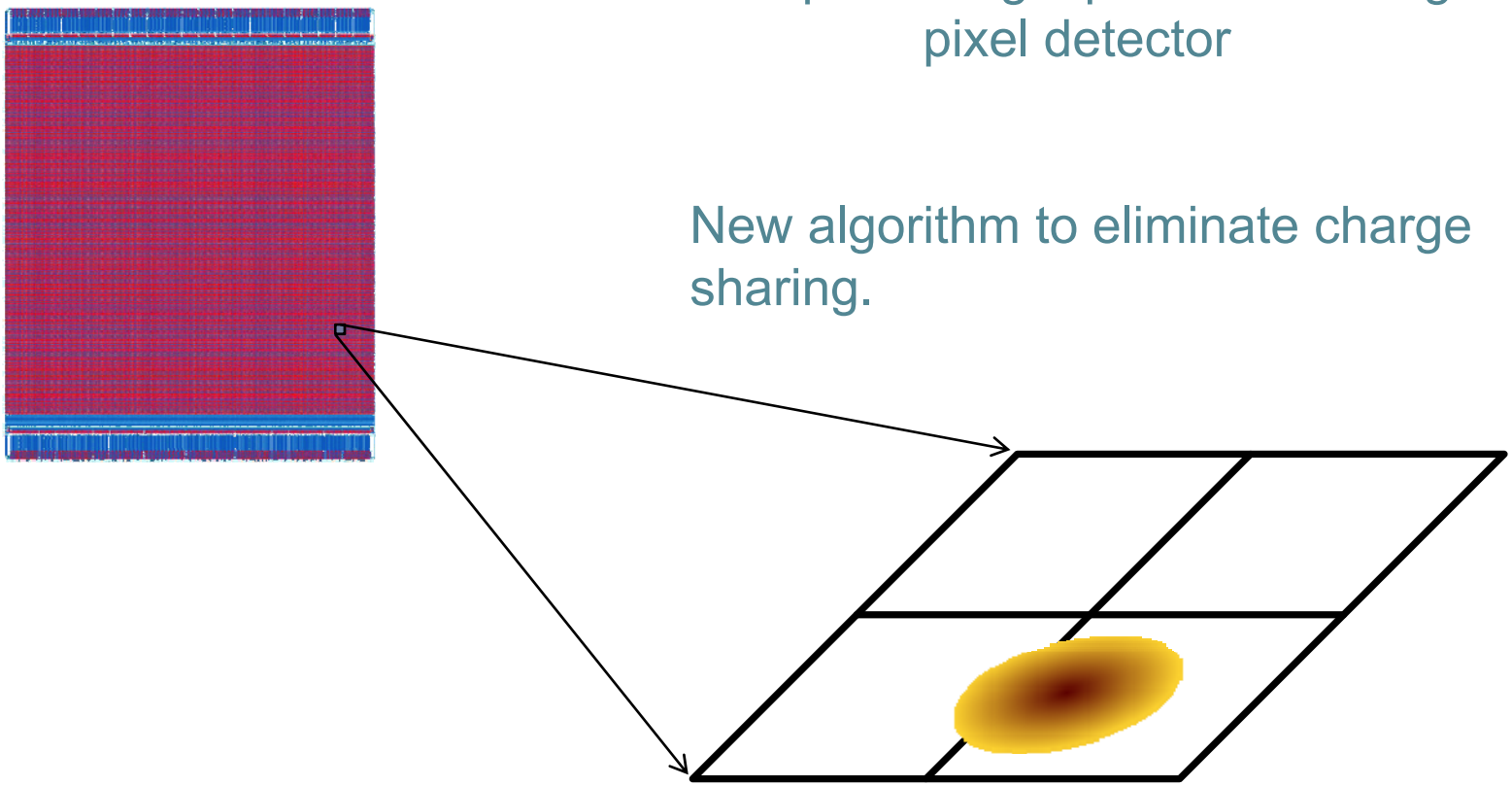




Medipix3

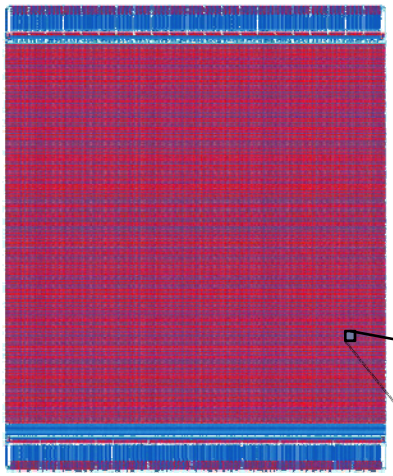
Medipix3: Single photon counting pixel detector

New algorithm to eliminate charge sharing.

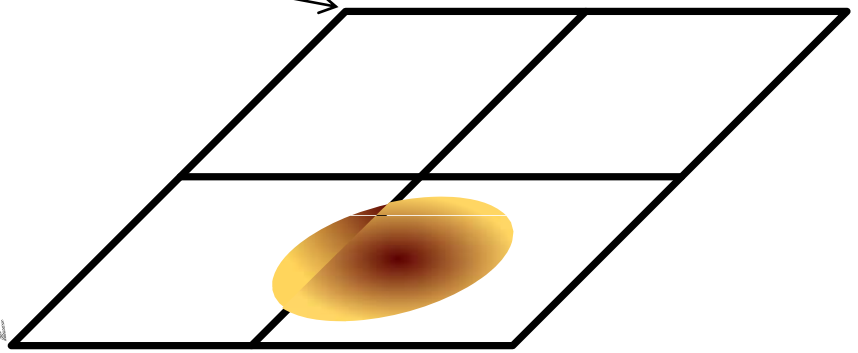


Medipix3

Medipix3: Single photon counting pixel detector



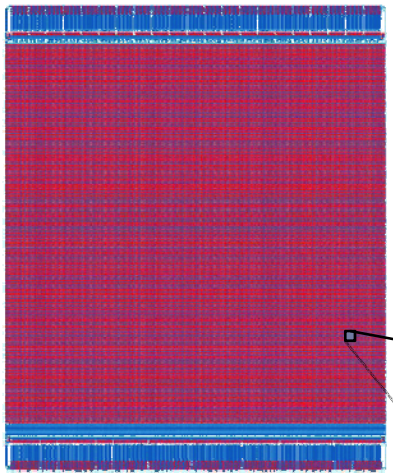
New algorithm to eliminate charge sharing.



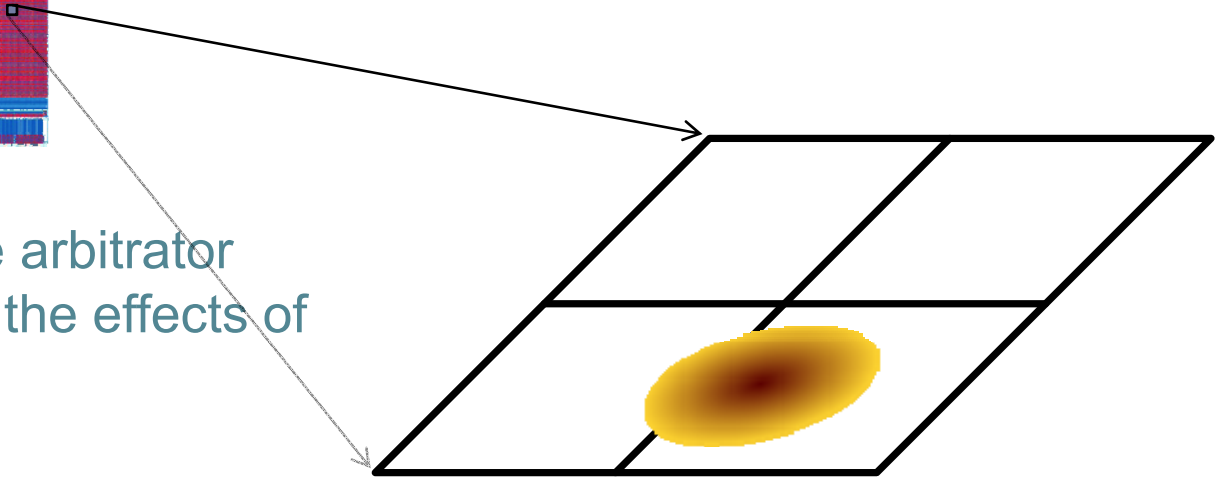
When charge sharing occurs, the photon may be doubly counted, and there may be distortion in the energy spectrum seen by the pixel.

Medipix3

Medipix3: Single photon counting pixel detector

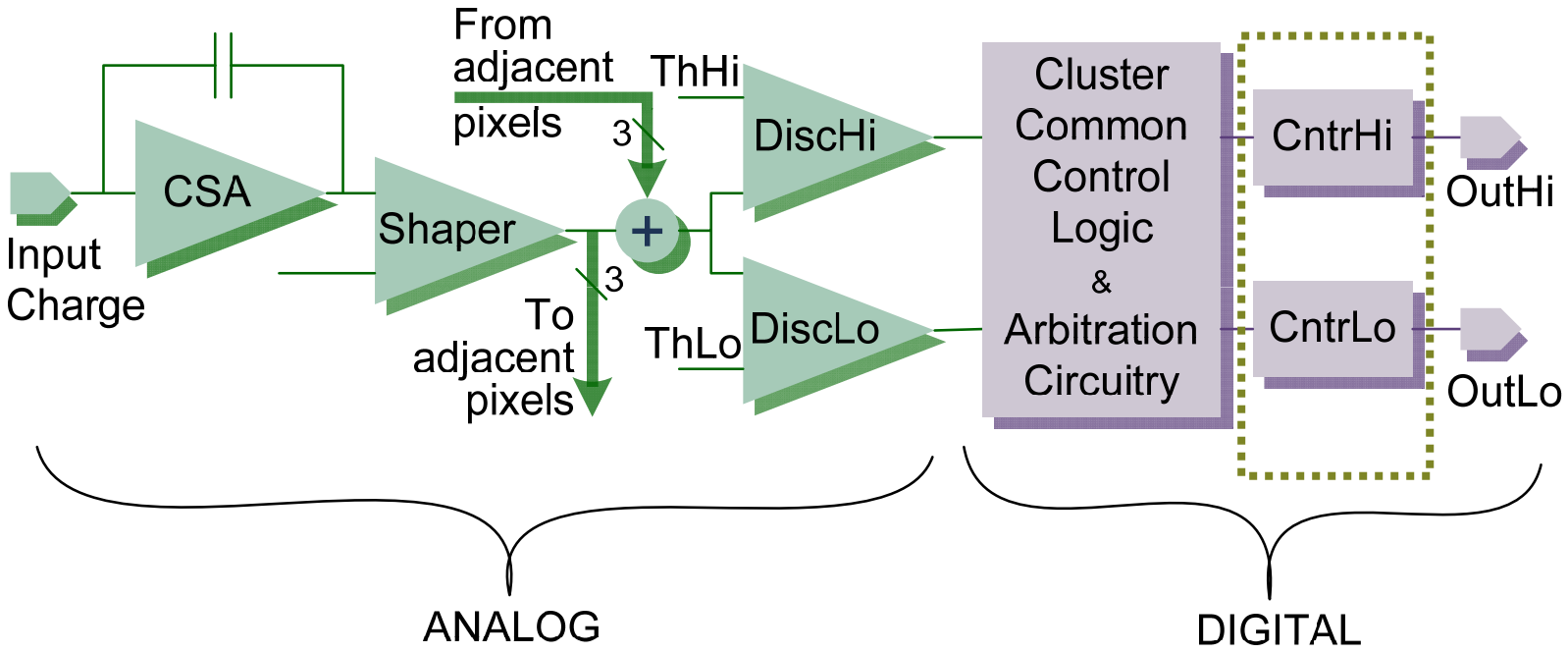


New algorithm to eliminate charge sharing.

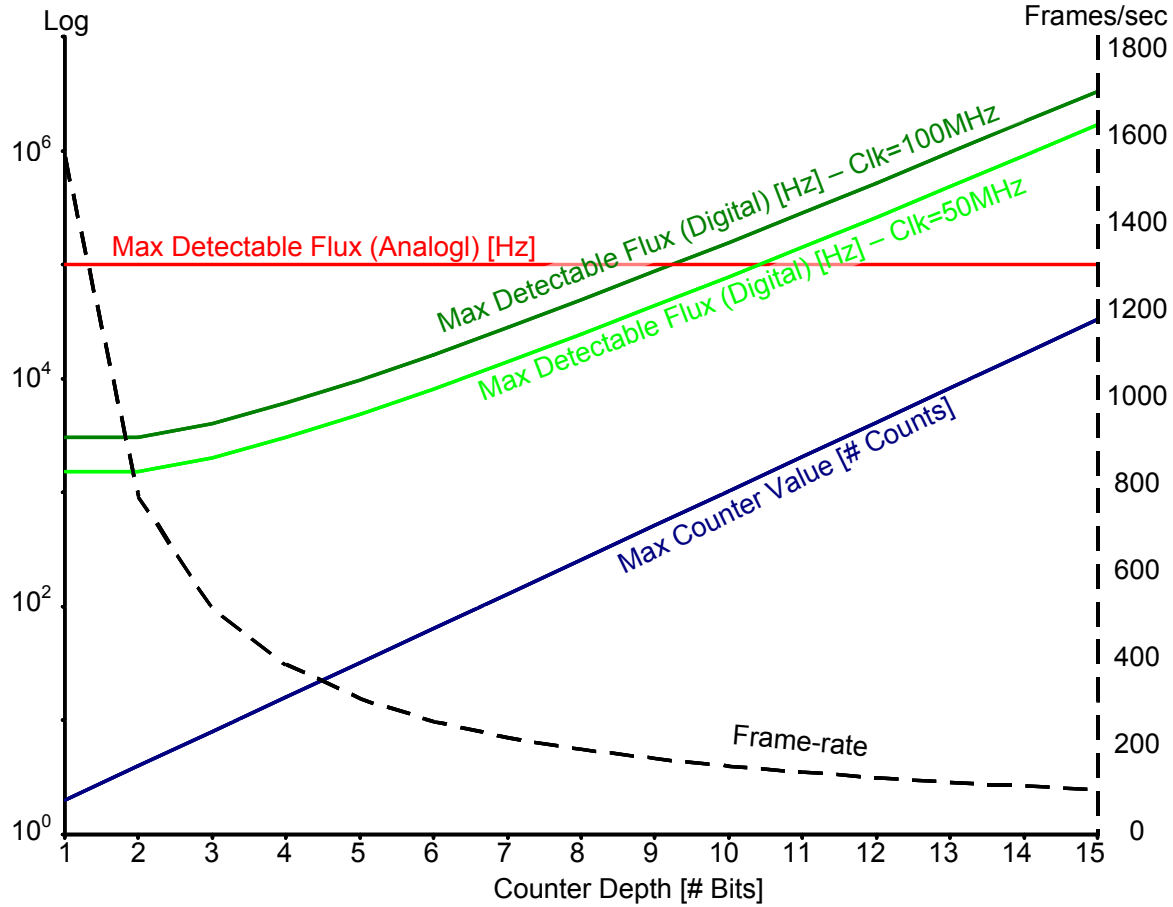


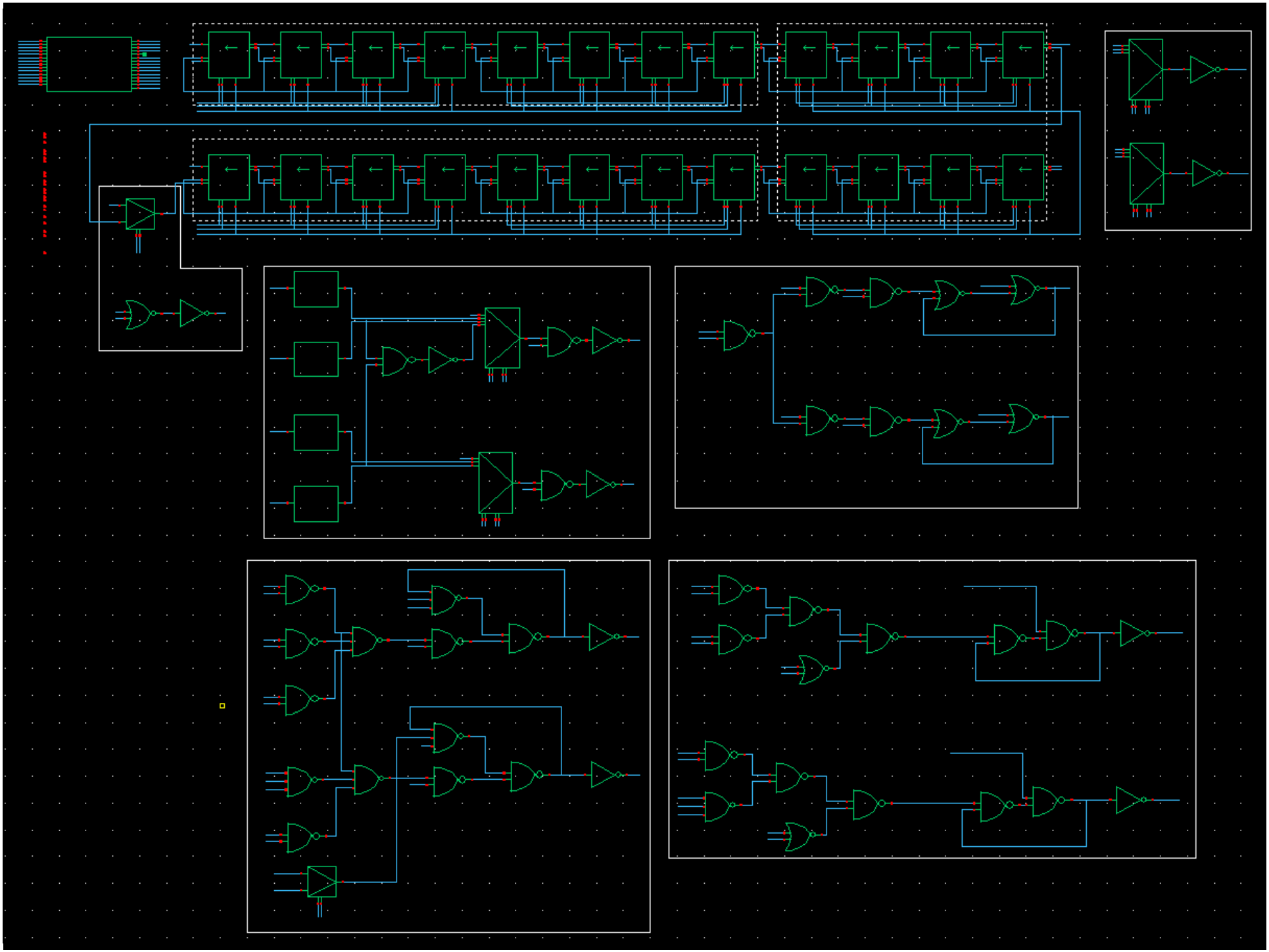
Medipix3 will have arbitrator circuits to remove the effects of charge sharing.

Medipix3


From
adjacent
pixels
3
ThHi
DiscHi
CSA
Input
Charge
Shaper
+
3
To
adjacent
pixels
ThLo
DiscLo
Cluster
Common
Control
Logic
&
Arbitration
Circuitry
CntrHi
CntrLo
OutHi
OutLo
ANALOG
DIGITAL

Limits on Counter Depth



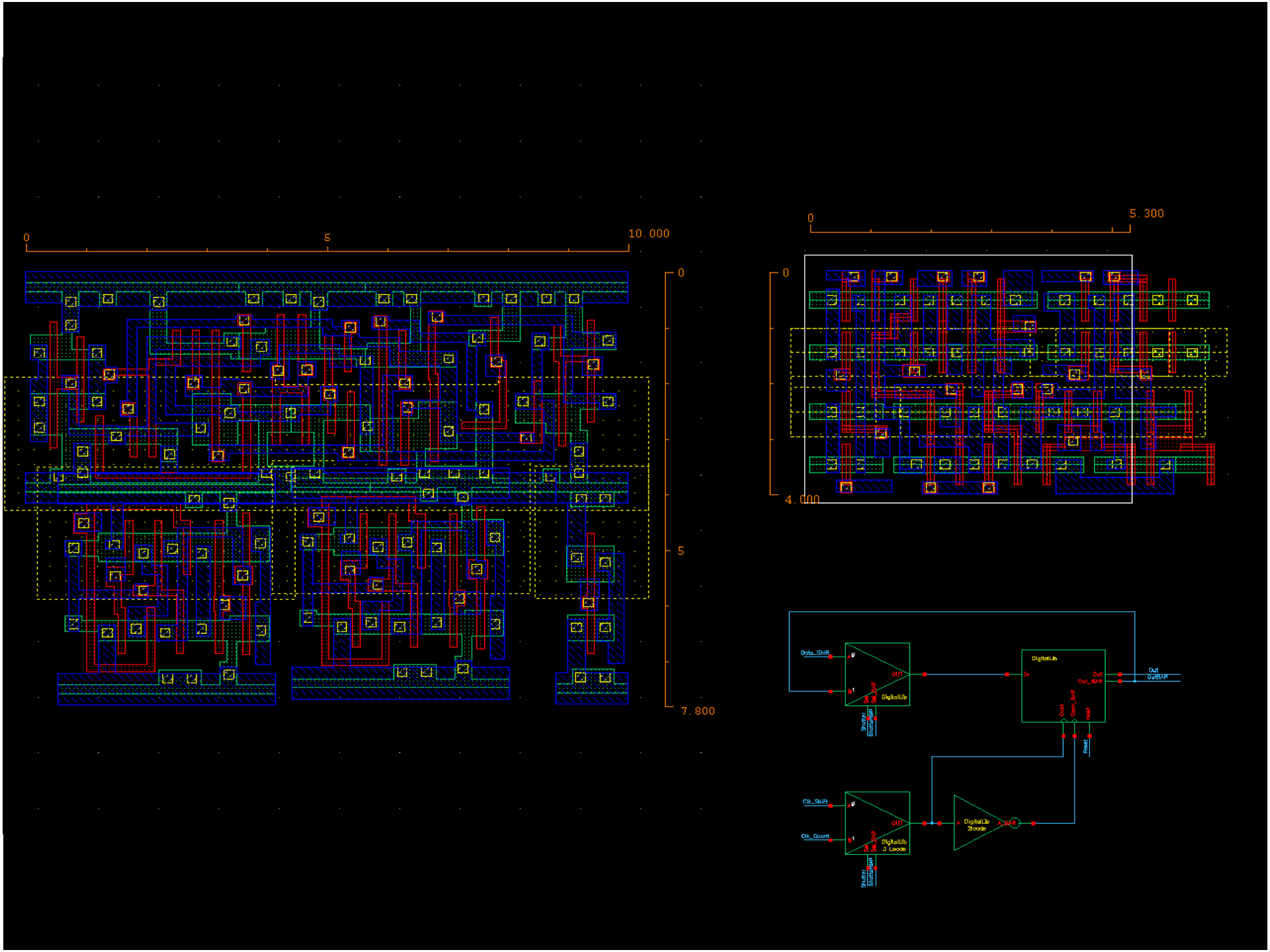


Configurable-Depth Counters/Shift Registers

Properties	Configurable-Depth			
Counter Depth	2x1	2x4	2x12	1x24
Max Counter Value	2	16	4096	16777216
$T_{Readout}$ / Frame [ms]	0.66	2.62	7.86	15.72
Max Cont. Framerate [fps]◈	1526	381	127	--
Max Sustained Framerate [fps]⌖	763	191	64	64

◈ Continuous Read/Write Mode (i.e. no deadtime)
⌖ Sequential Read/Write Mode

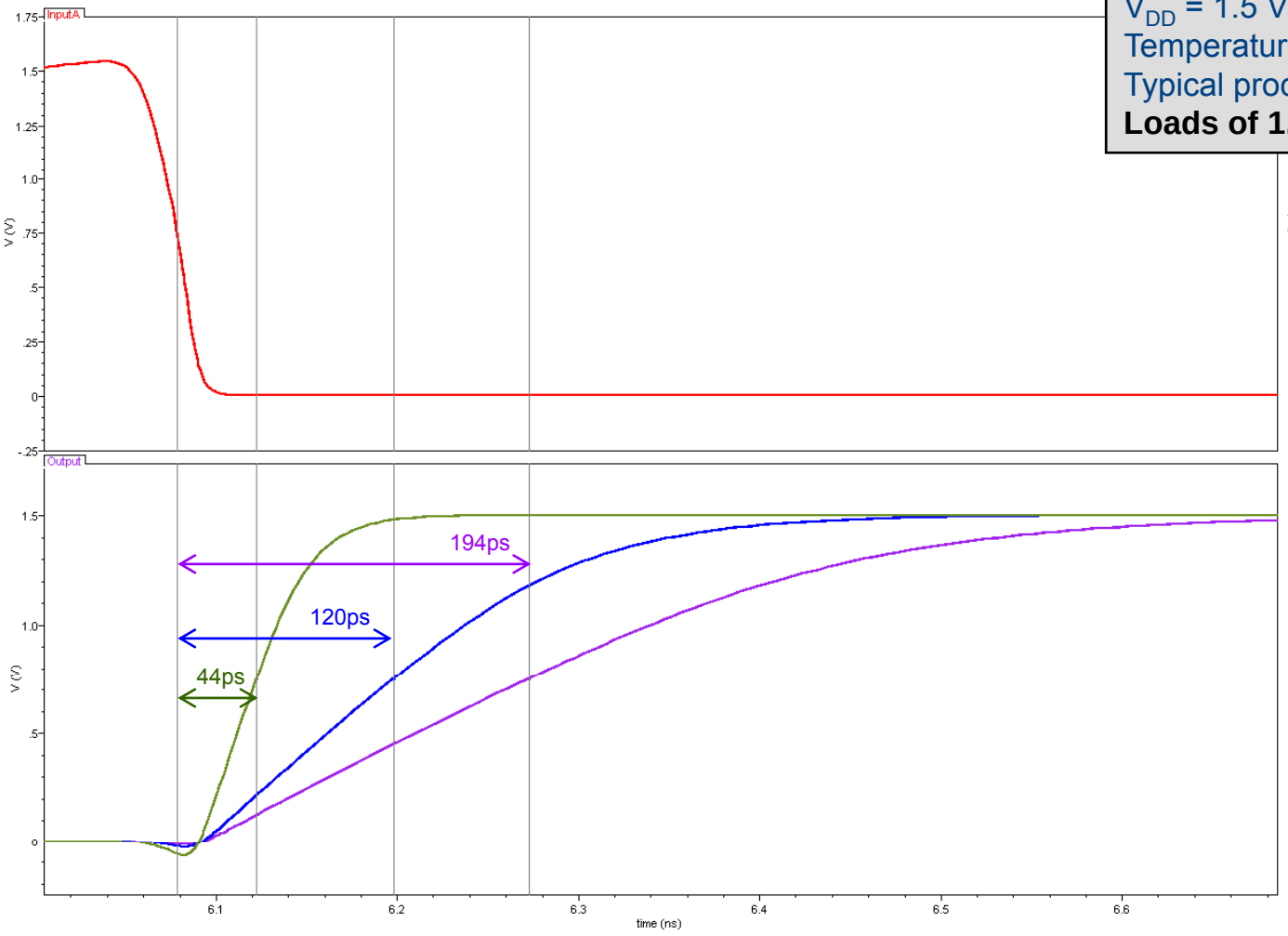
Calculations based on: ReadClk = 100MHz
Single-bit serial output

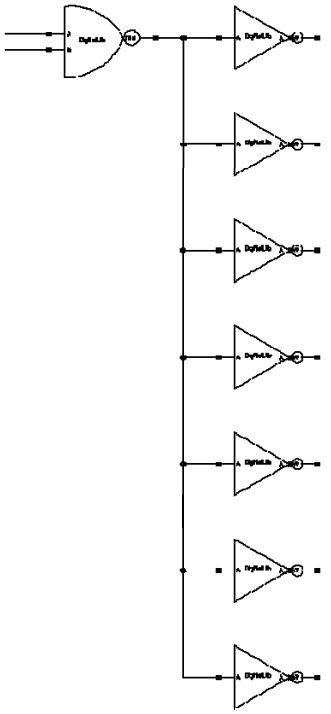


0
5
10.000
0
5
7.800
0
5.300
0
4.000
Data_Shift
DigitalLib
OUT
Shutter
Shutter/BAR
DigitalLib
In
Out
Out_BAR
Cock
Cock_BAR
Reset
Out
OutBAR
Reset
Clk_Shift
Clk_Count
DigitalLib
3 Loads
DigitalLib
2loads
A
A_BAR

Circuit Performance

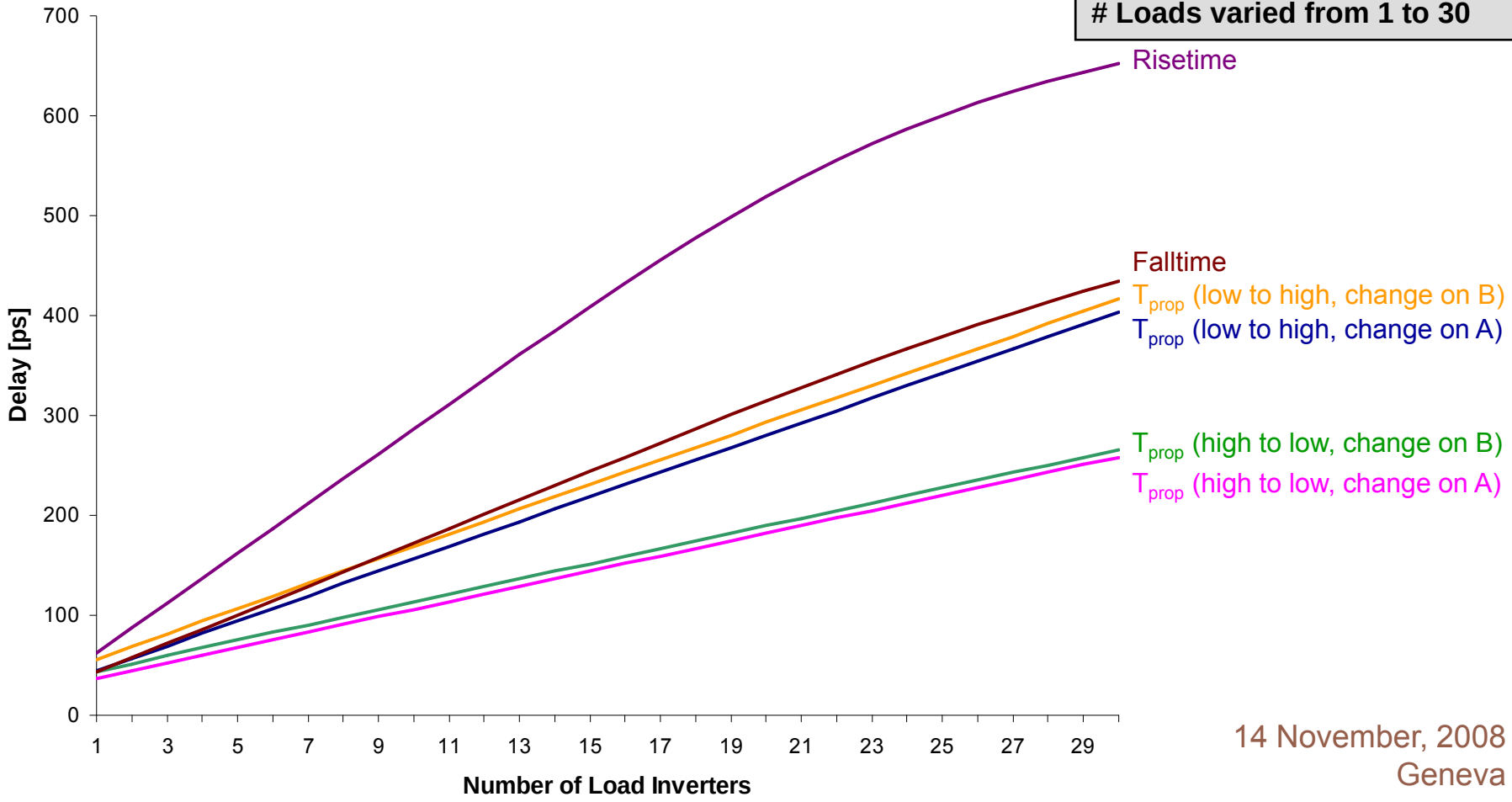
2-input min-sized NAND
V_{DD} = 1.5 V
Temperature = 25°C
Typical process conditions
Loads of 1, 7, & 13 inverters





Loading on Output

2-input min-sized NAND
V_{DD} = 1.5 V
Temperature = 25°C
Typical process conditions
 # Loads varied from 1 to 30



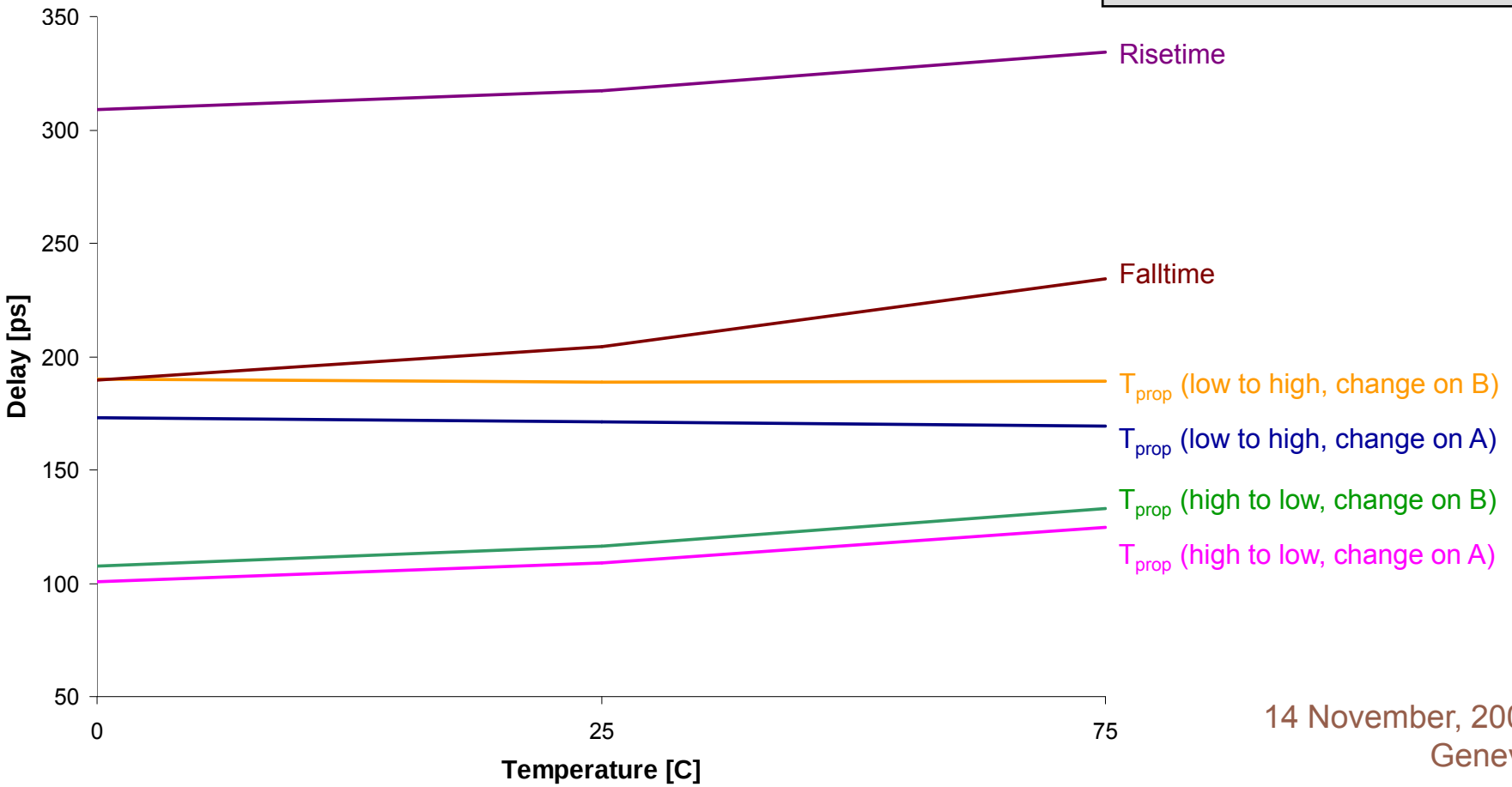
Process Variation

2-input min-sized NAND
V_{DD} = 1.5 V
Temperature = 25°C
Varied process conditions
Load: 13 min-sized inverters

The simulated process parameters can be modified by ±3σ in order to model faster (FF) or slower (SS) transistors.

Temperature

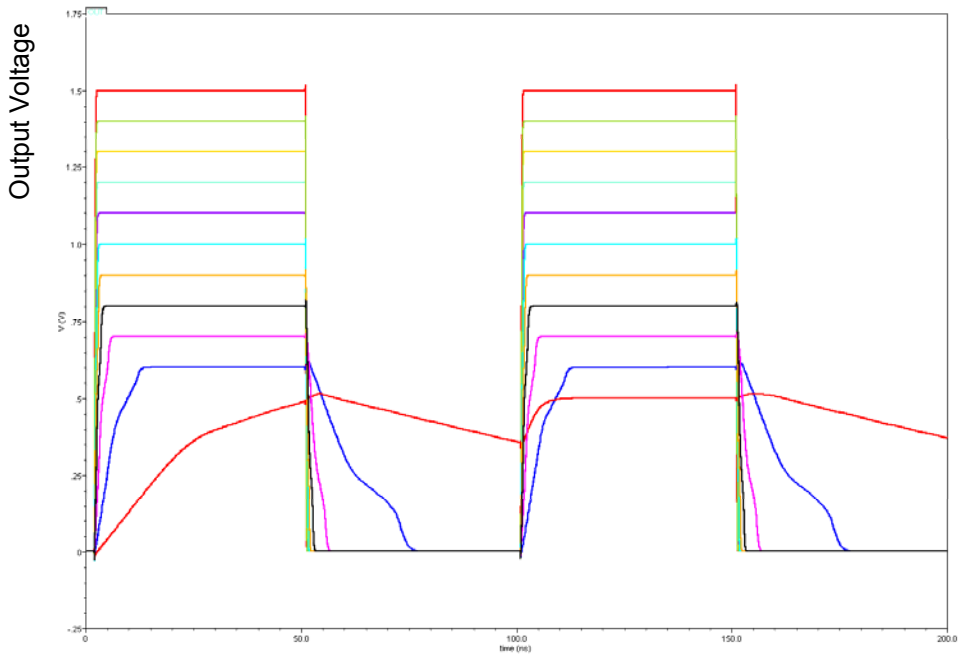
2-input min-sized NAND
V_{DD} = 1.5 V
Temp. varied from 25°C to 75°C
Typical process conditions
Load: 13 min-sized inverters

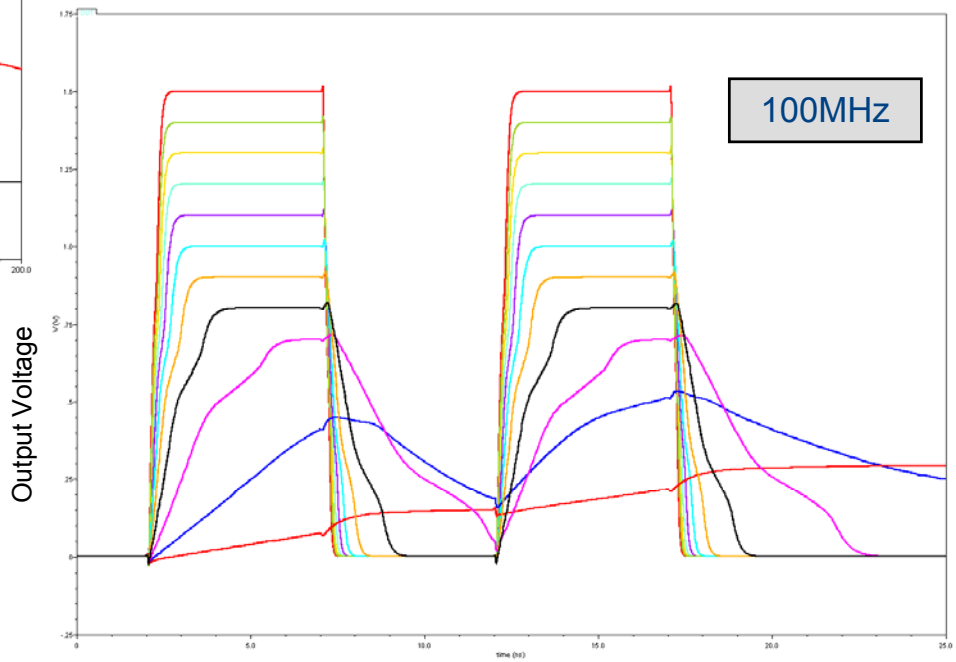


V_{DD} Drop Along a Column

2-input min-sized NAND
V_{DD} varied from 0.5V to 1.5V
Temperature = 25°C
Typical process conditions
Load: 13 min-sized inverters

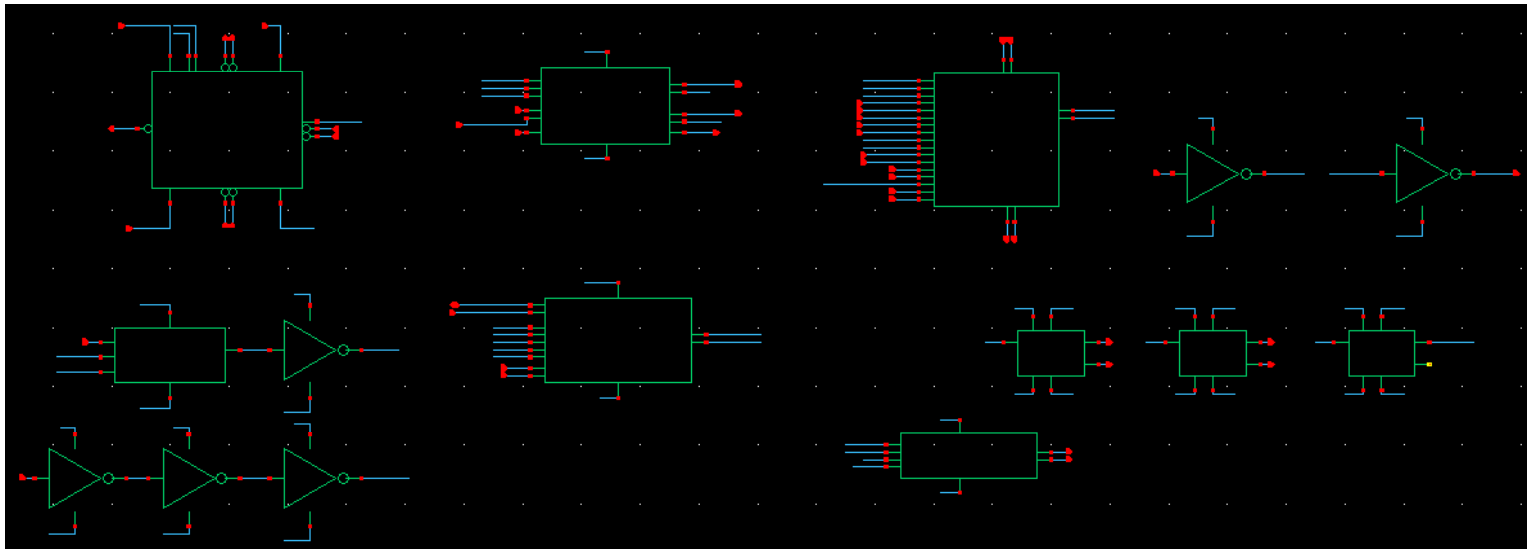
10MHz





Digital Verification

- **Arbitration, threshold synchronization, and inter-pixel communication circuits**
  1. Single Pixel Mode: Sequential RW
  2. Single Pixel Mode: Continuous RW
  3. Charge Summing Mode : Sequential RW
  4. Charge Summing Mode: CRW
  5. Colour Mode, SPM: SRW
  6. Colour Mode, SRM: CRW
  7. Colour Mode, CSM: SRW
  8. Colour Mode, CSM: CRW
- **2 configurable-depth counters/shift registers**



Medipix Collaborations

Medipix2 Collaboration

- Institut de Física d'Altes Energies IFAE
- University of Cagliari
- UC Berkeley, Space Science Laboratory
- Commissariat à l'Energie Atomique CEA
- CERN
- Czech Academy of Sciences
- Czech Technical University
- Friedrich-Alexander- Universität
- ESRF
- Albert-Ludwigs- Universität
- University of Glasgow
- University of Houston
- Medical Research Council MRC
- Mid-Sweden University (Mittuniversitetet)
- Università di Napoli Federico II
- NIKHEF
- Università di Pisa

Medipix3 Collaboration

- University of Canterbury
- CEA
- CERN
- DESY
- The Diamond Light Source
- Albert-Ludwigs-Universität
- University of Glasgow
- Institute for Synchrotron Radiation
- Leiden Institute of Chemistry
- NIKHEF
- Medical Research Council
- Mid-Sweden University (Mittuniversitetet)
- Czech Technical University
- ESRF
- Universität Erlangen-Nurnberg
- Space Sciences Laboratory, UC Berkeley
- VTT Information Technology

Training

- 2 French courses (CERN Language Training)
- Europractice courses at EPFL
  - Transistor-Level Analog IC Design
  - Low-Power, Low-Voltage IC Design
  - Advanced Digital IC Design
- International Summer School On Nuclear Physics Methods and Accelerators In Biology and Medicine
- Short course on Radiation Detection and Measurement
- IEEE NSS/MIC 2007, 2008
- TWEPP 2008
- Joint Workshop on Detector Development for Future Particle Physics and Photon Science Experiments
- Summer student lectures and CERN seminars
- Negotiating Effectively (CERN Management Training)

Presentations

- 4th International Summer School and Workshop on Nuclear Physics Methods and Accelerators in Biology and Medicine, Prague (July 2007)
  - "Counter architectures for a single photon-counting pixel detector such as Medipix3" (Oral presentation – Best Student Talk)
- Topical Workshop on Electronics for Particle Physics (TWEPP), Naxos (September 2008)
  - "Design Considerations for Area-Constrained In-Pixel Photon Counting in Medipix3" (Poster presentation)
- Medipix Open Meetings (various locations: CERN, Mid-Sweden University, Czech Technical University)
  - "Medipix2 MXR Wafer Testing Results"
  - "Circuit Modeling for Timepix"
  - "Reconfigurable Counter for Medipix3"
  - "Circuit Modeling for Medipix3"
  - "Medipix3 Digital Verification"

Publications

- **“Counter architectures for a single photon-counting pixel detector such as Medipix3”, AIP Conf Proc. 4th International Summer School on Nuclear Physics Methods and Accelerators in Biology and Medicine, 2007.**
- **“Design Considerations for Area-Constrained In-Pixel Photon Counting in Medipix3”, TWEPP, 2008.**

- **X. Llopart et al., “Timepix, a 65k programmable pixel readout chip for arrival time, energy and/or photon counting measurements”, Nuclear Instruments and Methods in Physics Research Section A, 2007.**
- **M. Campbell et al., “A Circuit Topology Suitable for the Readout of Ultra Thin Pixel Detectors at SLHC and Elsewhere”, TWEPP, 2007.**
- **L. Tlustos et al., “Simulations of the behaviour of the Medipix3 spectroscopic imaging system”, IEEE NSS/MIC/RTSD, 2008.**