

Digital Active Pixel Array for LC Tracker

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Proposed Digital Active Pixel Array (DAPA) works as a system of pixelized microstrips with fast binary readout. Independent serial readout allows a particular pixel identification inside the strip and in this way two dimension particle registration with about $8\ \mu\text{m}$ space resolution. Integrated electronics includes zero suppression and memory with only one serial output for the whole $4 \times 4\ \text{cm}^2$ device.

1. INTRODUCTION

New concept of silicon sensor for Linear Collider Tracker is proposed. Essential success in Active Pixel developments is well known. Our goal is to create a simple relatively cheap device based on an advanced digital architecture adjusted to LC time structure and required 8 micron space resolution.

$4 \times 4\ \text{cm}^2$ sensor should be developed as a regular CMOS device and produced on low resistivity silicon wafers 6" or 8" diameter.

2. DAPA STRUCTURE

Basic element is about $25 \times 25\ \mu\text{m}^2$ active pixel with digital readout. It includes active sensor with or without amplifier and FF with parallel and serial outputs.

FF outputs are connected into DAP strips. Each DAP strip consists of 1,600 pixels and strip pitch is $25\ \mu\text{m}$ according to pixel size. Individual strip memory with parallel/serial switch is positioned on the end of the strip near the whole sensors edge.

3. DAPA WORKING PROCEDURE

Within each strip all FF parallel outputs are connected to one Strip Line. If a charged particle crossed ANY pixel which belongs that strip, corresponding FF turns to 1 position and a short pulse (not potential) appears on the Strip Line. This pulse coincides with a certain bunch within whole bunch train and strip memory fixes a bunch number (time) when the strip picked up a charged particle. This output can also be used to generate a fast first level trigger.

According to this architecture on the first stage (during bunch train) DAPA works as usual microstrip detector with $25\ \mu\text{m}$ pitch and binary readout. When bunch train is over the information which we call Time Map is transferred to the whole DAPA memory.

Second stage starts after bunch train. Serially connected FFs work as a shift register and the same memory fixes now what particular pixel(s) picked up a particle during the whole bunch train. This information is also transferred to the DAPA memory creating a Space Map. If occupancy is not very high the system gives exact time/space picture with 8 micron resolution in both coordinates.

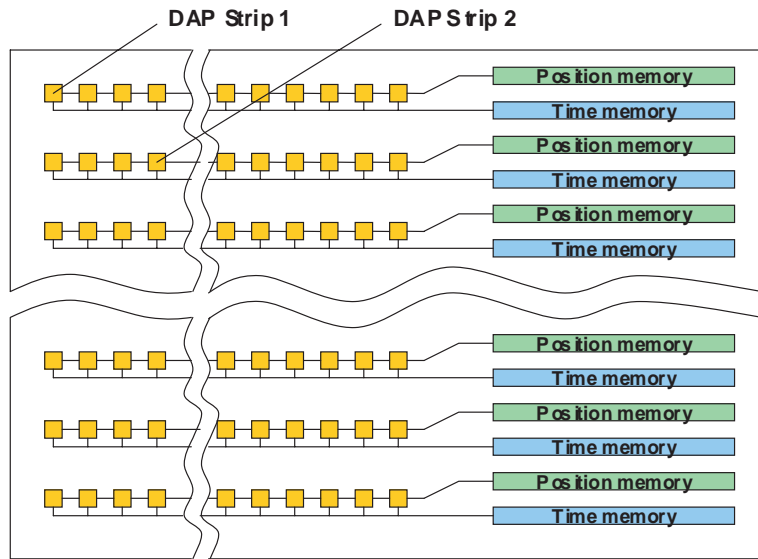


Figure 1: DAPA structure.

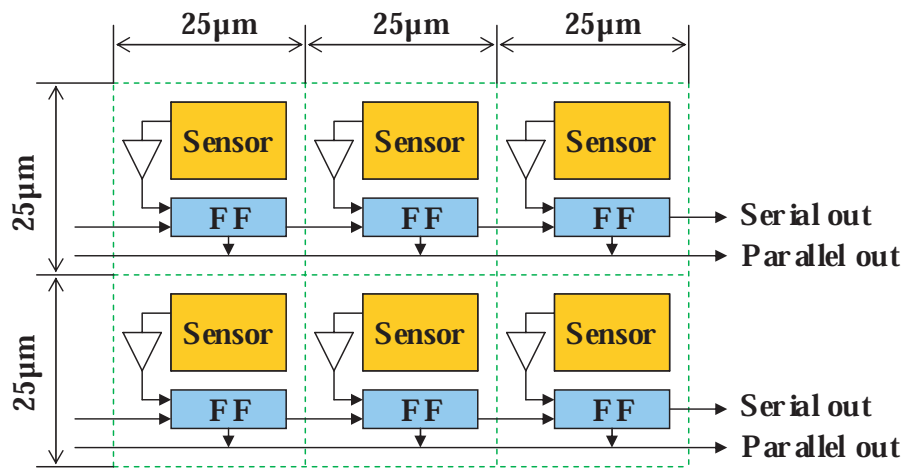


Figure 2: Pixel structure.

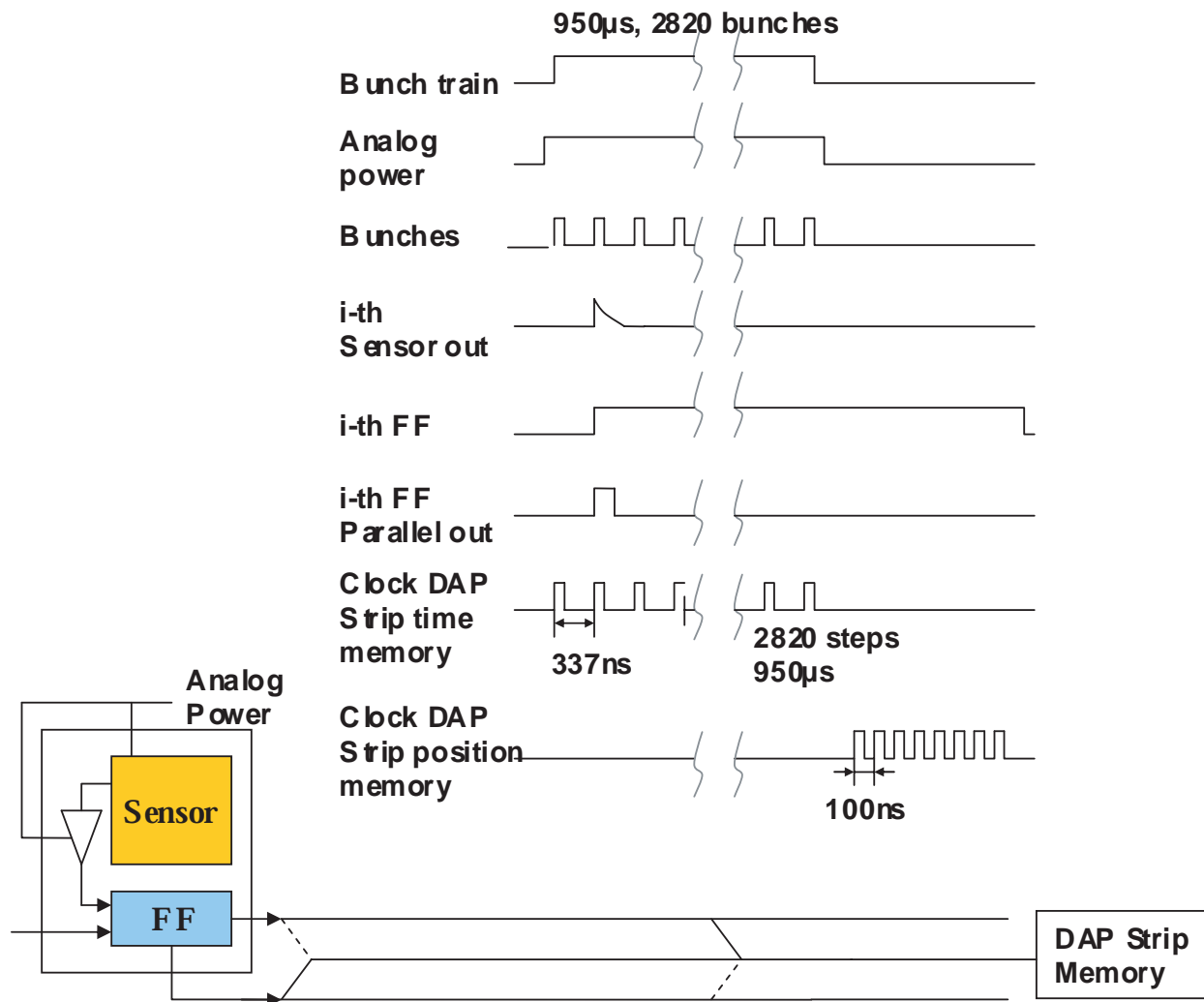


Figure 3: Timing diagram.

4. DAPA ADVANTAGES

- Completely integrated electronics.
- Completely integrated zero suppression.
- One line serial output.
- Very good space resolution on both coordinates if occupancy is not very high (not good for vertexing). Even in the worst case it works as a microstrip detector with binary readout and $8\mu\text{m}$ resolution but with the same advantages (integrated electronics and zero suppression).
- Much higher reliability because of an absence of many interconnections.
- As a single sided pixel structure it can be thinned by etching down to $50\text{-}100\mu\text{m}$. It essentially decreases multiple scattering.

Table I: Commercial Production Cost

	CMOS 0.7 μm 6 inch	CMOS 0.5 μm 6 inch	CMOS 0.35 μm 6 inch	CMOS 0.25 μm 8 inch	CMOS 0.18 μm 8 inch
Pilot run Masks + 2 wafers	\$ 54k	\$ 63k	\$ 80k		
Pilot run Masks + 6 wafers				\$ 142k	\$ 275k
25 wafers Wafer price	\$ 1.45k	\$ 1.9k	\$ 2.6k	\$ 1.8k	\$ 2.5k
500 wafers Wafer price	\$ 1.1k	\$ 1.4k	\$ 1.9k	\$ 1.7k	\$ 2.25k
Price per cm^2 .	\$ 11.0	\$ 14.0	\$ 19.0	\$ 8.95	\$ 11.85

- It is expected that DAPA system cost will be equal or even less than cost of silicon microstrip detector system which requires electronic chips, interconnections and a lot of qualified manpower for sensor/chip assembly and tests.
- If DAPA cost will be acceptable it can be successfully used in many other experiments and devices including digital calorimetry.

5. PROBLEMS / QUESTIONS

- Power dissipation. Only integrated amplifiers require noticeable power.
Pulsed power supply (only during bunch train) essentially decreases power dissipation but it still may be a real problem.
Alternative sensors (Avalanche diodes, for example) can be a good choice because they dont require additional amplification.
- Commercial production cost (Table I).
It seems to be very acceptable if yield is high enough. But yield will strongly depend on a quality of design. Sophisticated design with a doubling of schematic components can seriously increase the yield.
- R&D money.
Development of a device which is based on CMOS commercial process requires essential amount of R&D money. Collaborative efforts of a few institutions are probably needed to convert this concept into a real device.

6. CONCLUSION

- Proposed DAPA device can appear as a simple and reliable alternative to widely used silicon microstrip and pixel detectors.
- In case of high serial production yield DAPA cost will be low enough for a large area application like in LC tracker.
- Serious R&D are required to realize proposed concept.
Any intellectual, organizational and technical contribution will be very useful to initiate that R&D.