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Digital Active Pixel Array

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.

About $5x5cm^2$ sensor should be developed as regular microelectronic
device and produced on low resistivity silicon wafers 6 or 8” diameter.

Basic element is about $25x25um^2$ active pixel with digital readout.
It includes active sensor, very simple low power amplifier and FF
with parallel and serial outputs.

FF outputs are connected into DAP “strips”. Each DAP strip consists
of about 2,000 pixels and strip pitch is 25um according to pixel size.
Individual strip memory with parallel/serial switch is positioned on the
end of the strip near the whole sensor’s edge.

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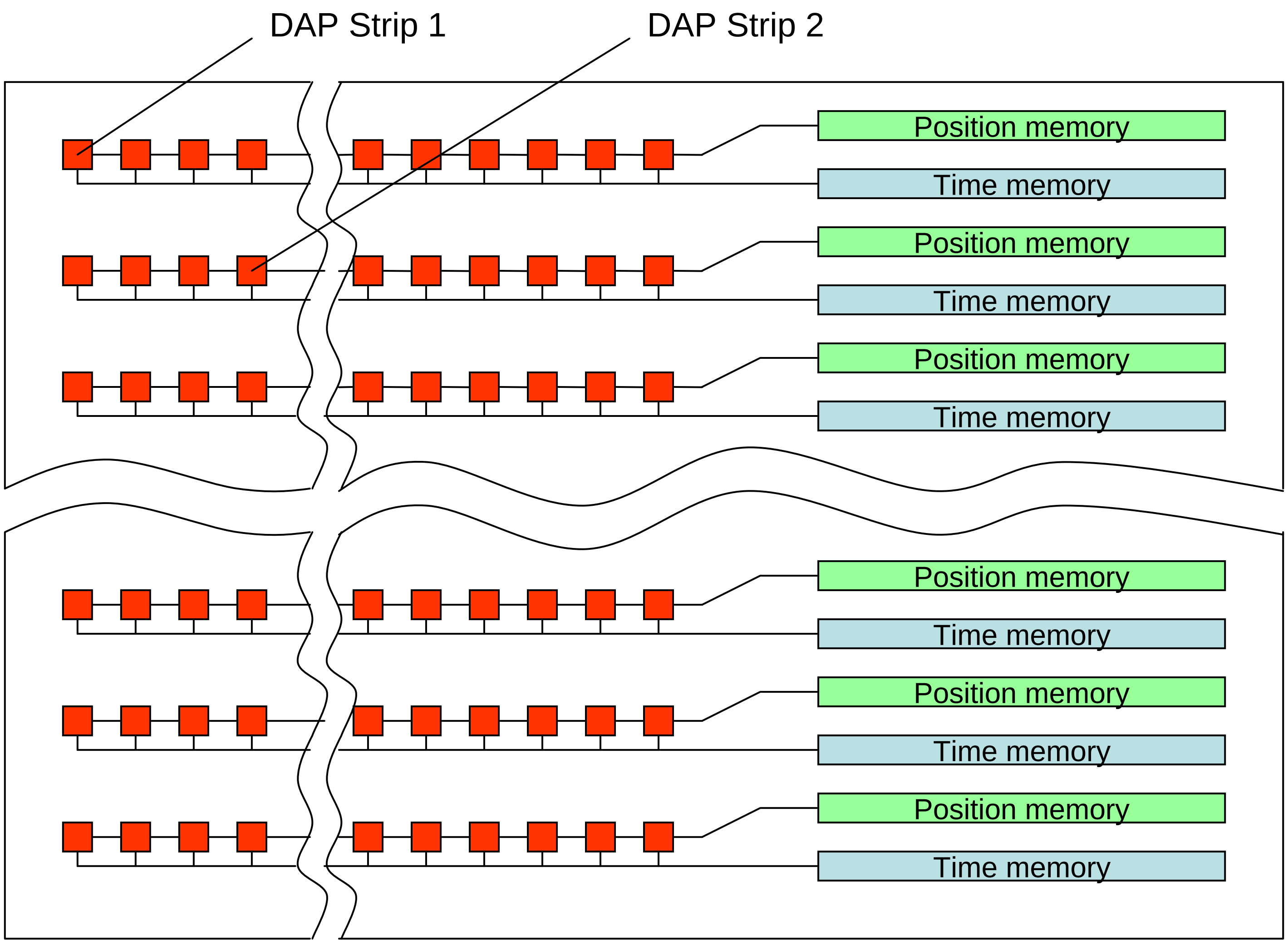

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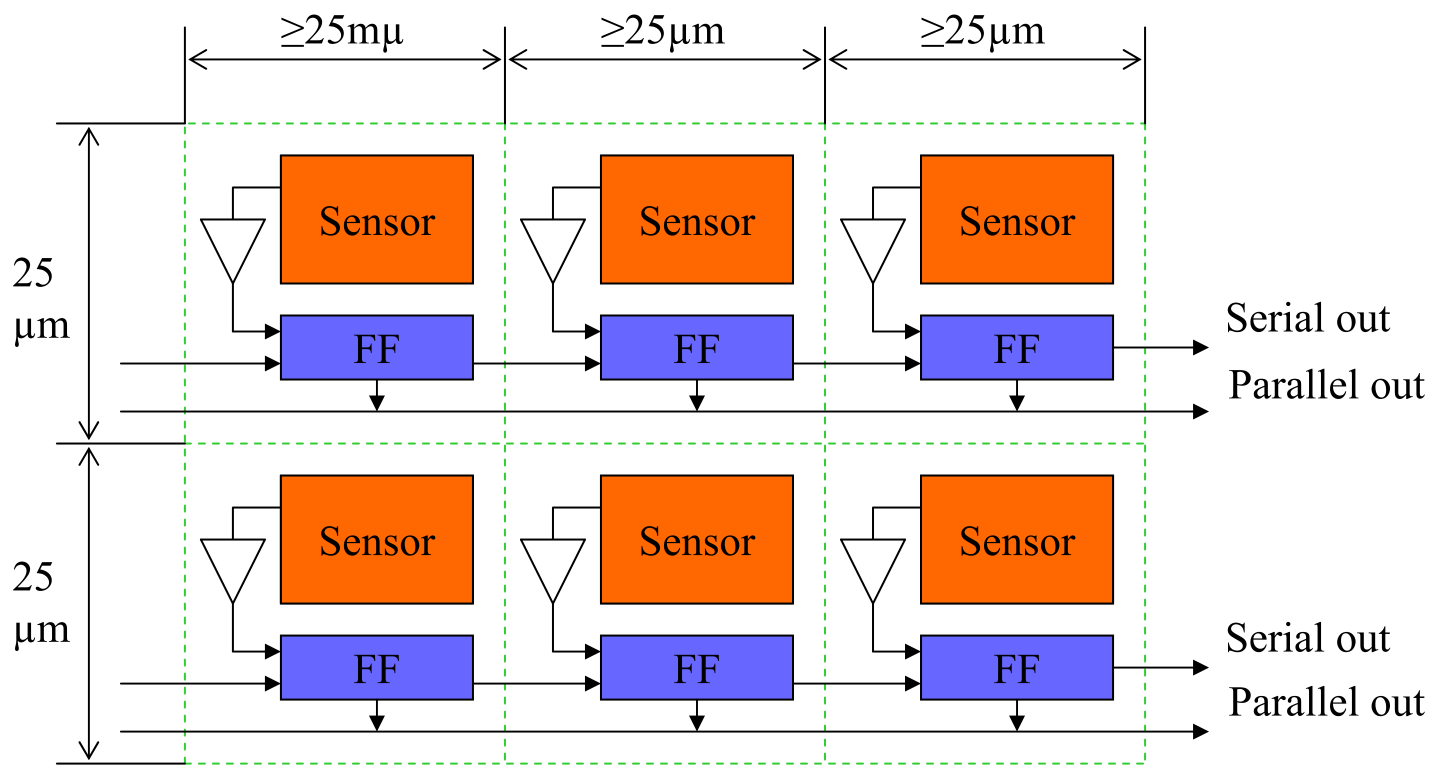
Pixel Structure



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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 when the strip picked up a charged particle.

According to this architecture on the first stage (during bunch train) DAPA works as usual microstrip detector with 25um pitch and digital 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.

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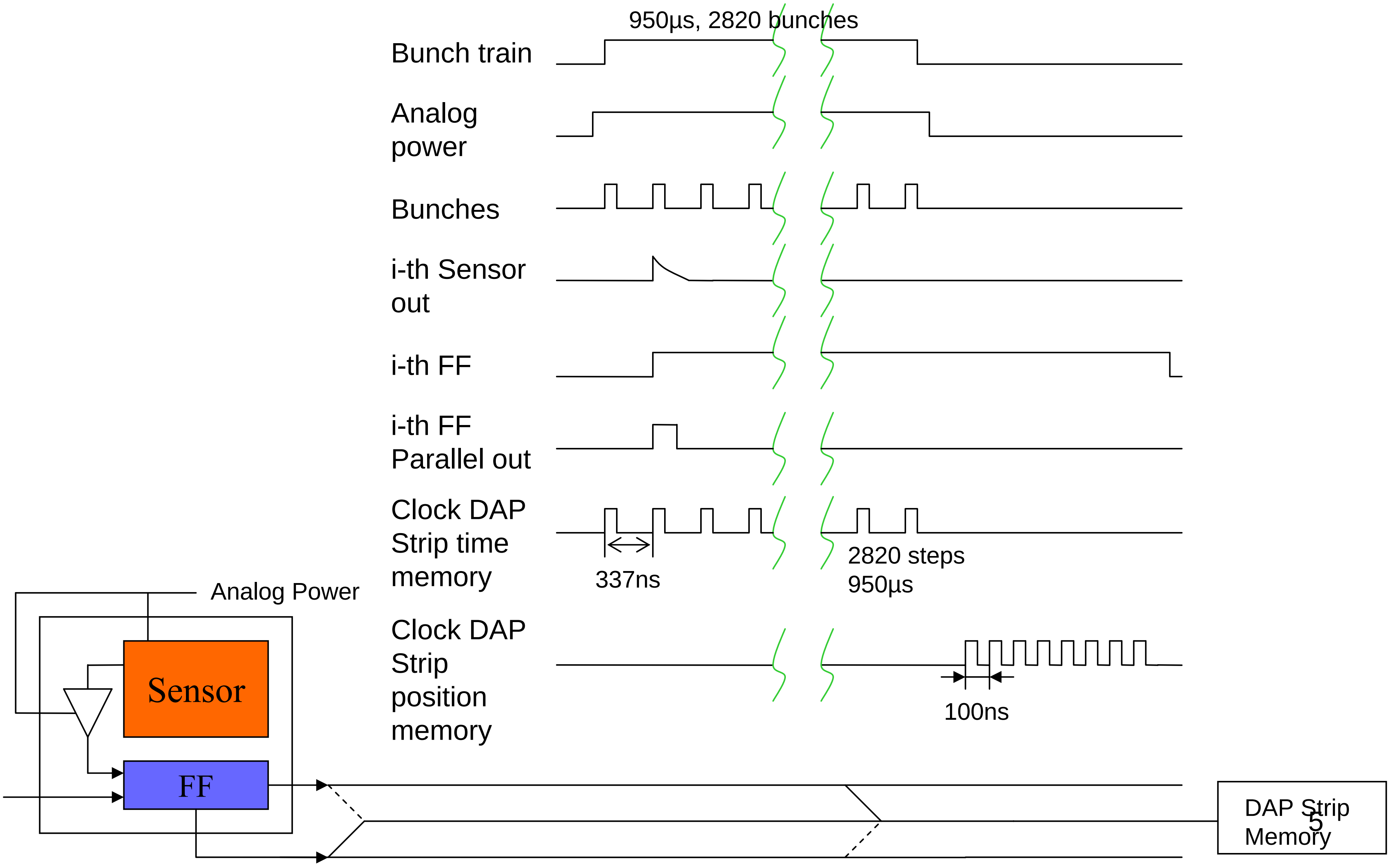
Timing Diagram



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ADVANTAGES

1. Completely integrated electronics
2. Completely integrated zero suppression
3. One line serial output
4. Very good space resolution on both coordinates if occupancy is not very high (not good for vertexing). Even for a worst scenario it works as a microstrip detector with digital readout and 8um resolution but with the same advantages (integrated electronics and zero suppression).
5. Much higher reliability because of an absence of many interconnections.
6. It is expected that DAPA system cost will be equal or even less than for silicon microstrip detector system which requires electronic chips, interconnections and a lot of qualified manpower for sensor/chip assembly and tests.
7. If DAPA cost will be really acceptable it can be successfully used for digital calorimetry.

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DISADVANTAGES

1. ……?
2. ……?
3. ……?

PROBLEMS/QUESTIONS

1. 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 don't require additional amplification.
2. Commercial production cost. 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 and minimize serial production cost.
3. 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.

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PRICE TABLE

	CMOS 0.7um 6 inch	CMOS 0.5um 6 inch	CMOS 0.35um 6 inch	CMOS 0.25um 8 inch	CMOS 0.18um 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	

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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.