Vertically integrated avalanche pixel sensors for charged particle detection

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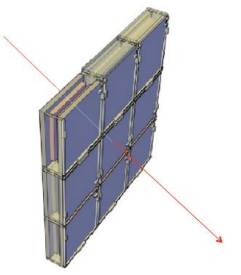
Introduction

Future HEP experiments will need tracking detectors with enhanced characteristics:

- Low material budget: small signal, amplification is needed
- Low power consumption to reduce cooling system complexity
- High timing resolution

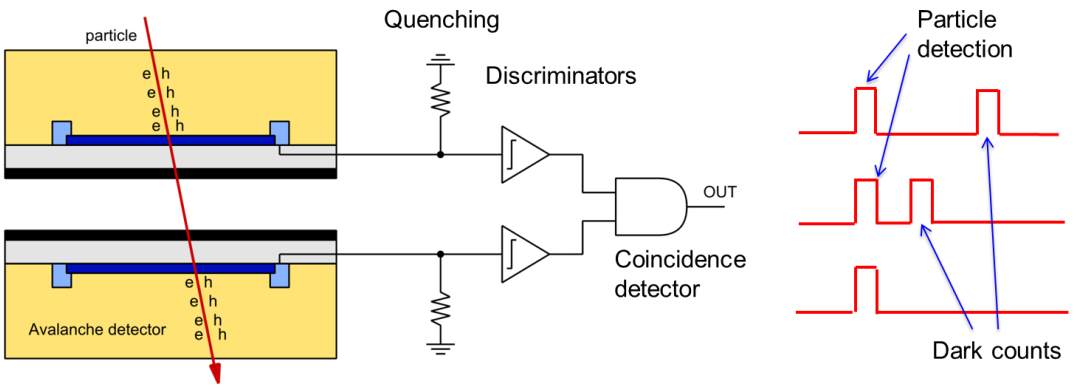


The Idea/Concept

- Two Geiger-mode avalanche detectors in **coincidence**:

$$DCR = DCR_1 \times DCR_2 \times 2\Delta T$$

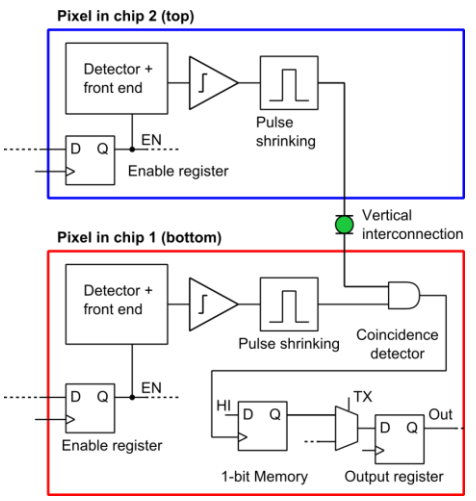
- In-pixel coincidence: integrated electronics is needed: **CMOS avalanche detectors**



Preliminary demonstration

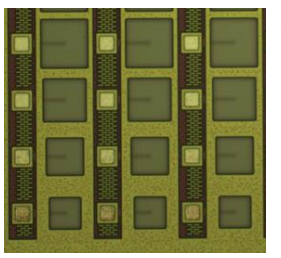
INFN APiX2 project
(coord. by P.S. Marrocchesi):

- CMOS 150nm process
- 48 x 16 pixel array
- 50um x 75um pixel size
- Max Fill Factor: 51.6%
- Vertical interconnection by bump bonding (IZM)



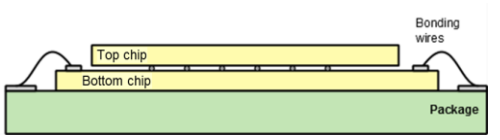
Simplified pixel schematic

Micrograph: pixels with different detector areas



Summary of experimental **coincidence measurements** (on pixels with FF = 51.6%)

	Average values per pixel	Average values per mm^2
DCR1	5 kHz	1.3 MHz
DCR2	9 kHz	2.4 MHz
Coinc	1.4 Hz	370 Hz



Sensor assembly

Potential Impact

Advantages:

- Can be thinned to a **few microns**: low material budget
- **Timing resolution** lower than 100ps potentially achievable
- Early digitization of signal: reduced system complexity and **power consumption**
- Blind to photons – **reduced background**

Opportunities:

- Progress in SPAD production and **3D integration technologies**: many major foundries active

Applications:

- **Particle tracking** in future HEP experiments
- **Biomedical applications** (proton therapy, radiotracers)