Recent Results of the 3D-Stripixel Si Detectors

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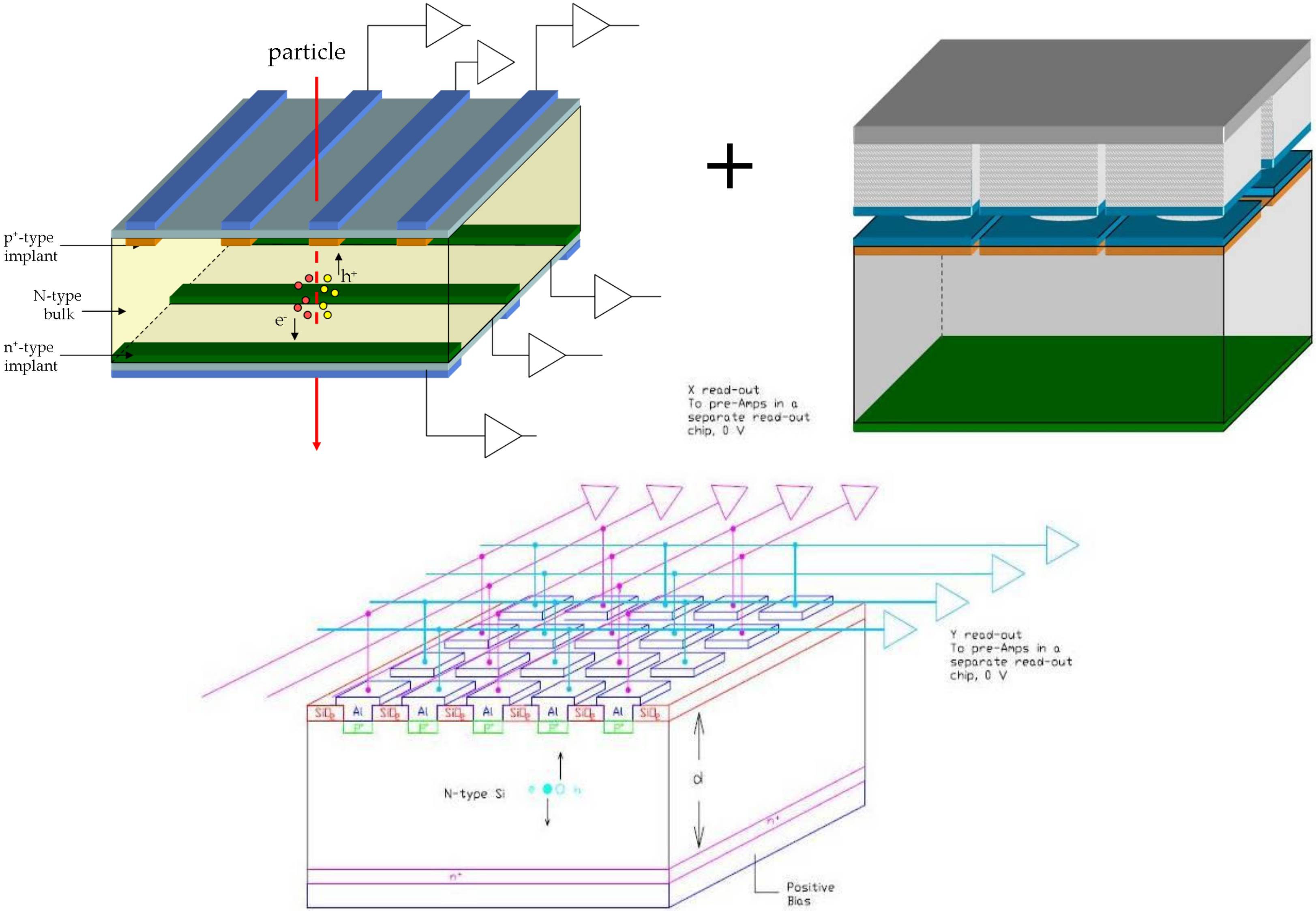
Contents

Part I:
Full 3D Stripixel Detector Designs

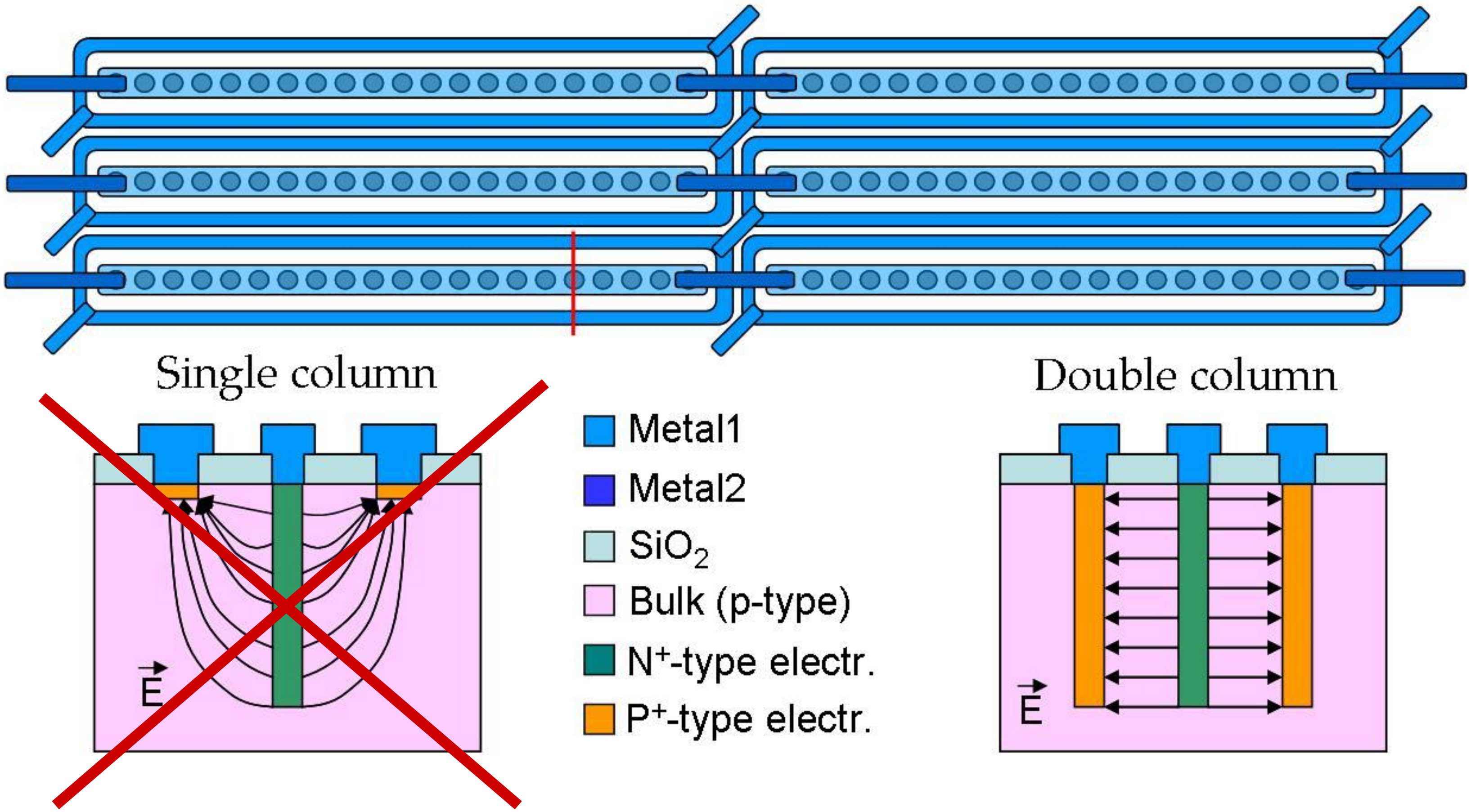
Stripixel concept: planar stripixel* at the BNL

* Z.Li, *Novel silicon stripixel detector: concept, simulation, design, and fabriction*, Nucl. Instr. and Meth. A 518 (2004) 738-753.



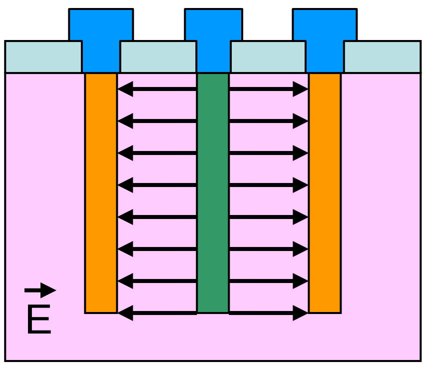
Stripixel concept: 3D stripixel* (BNL +IMB-CNM)

* Z.Li et al., *Development, simulation and processing of new 3D detectors,* Nucl. Instr. and Meth. A 583 (2007) 139-148.



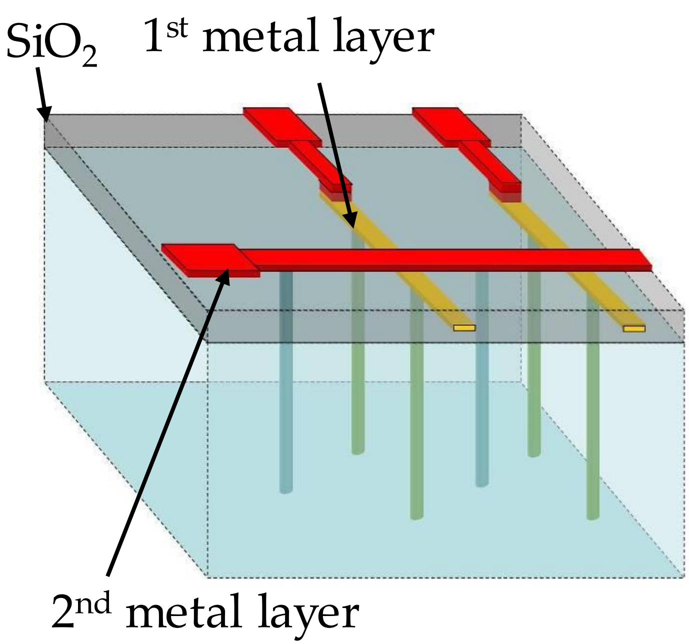
1.1 New 3D-Stripixel prototype generation: a single-side double-strip detector

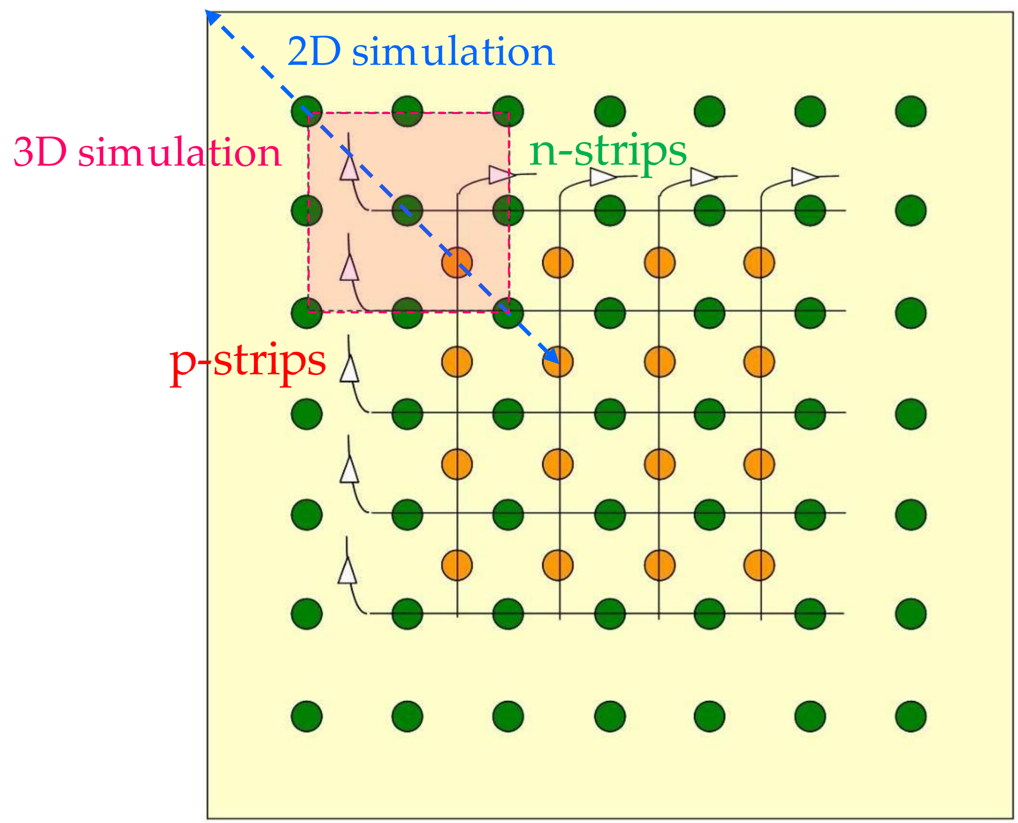
Double column



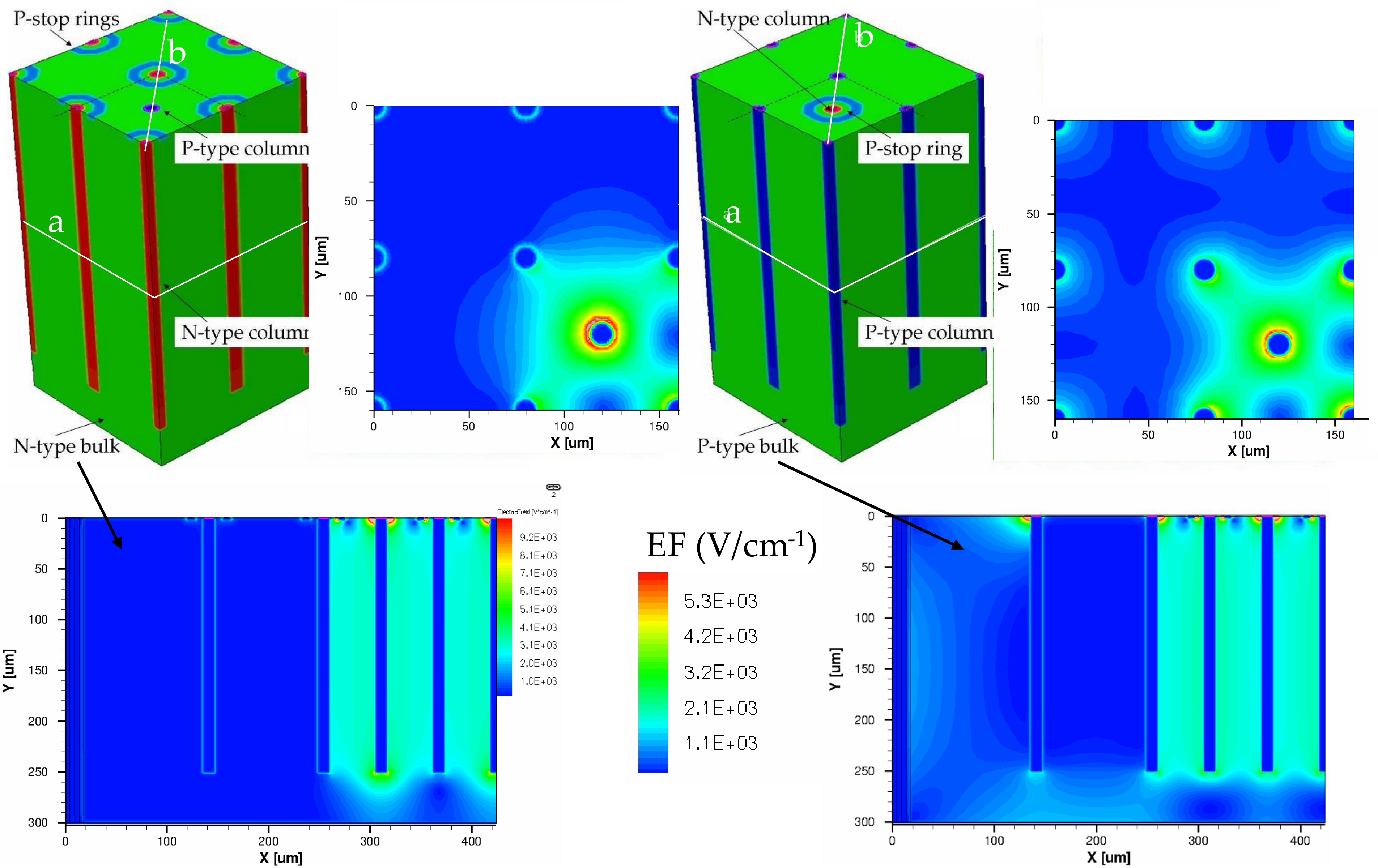
2D position sensitive

- Single sided
- Double columns (n-columns connected as n-strips p-columns connected as p-strips)
- Dual metal technology
- n-strips collect e's, p-strips collect h's





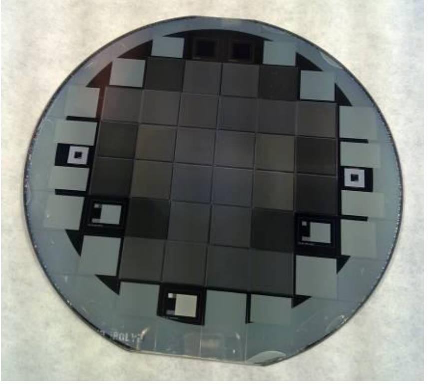
1.2 Optimization of the design: Sentaurus simulations



Edge defects model from E.P. Nochis et al., Nucl. Instr. and Meth. A 574(3) (2007) 420–424.

Real prototypes

6 wafers 300 μm thick, 1 wafer SOI 20 μm thick

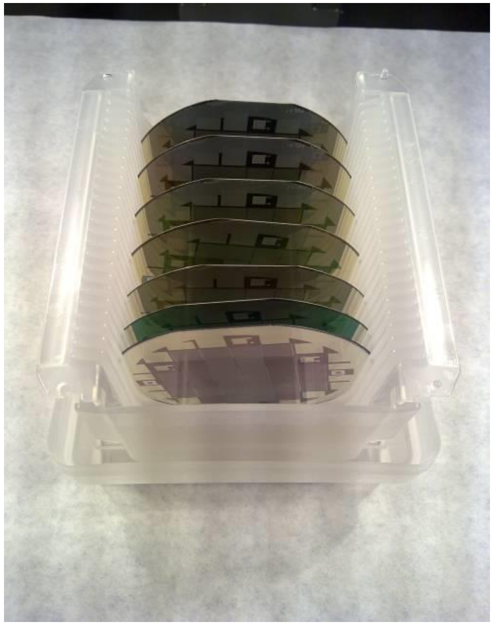


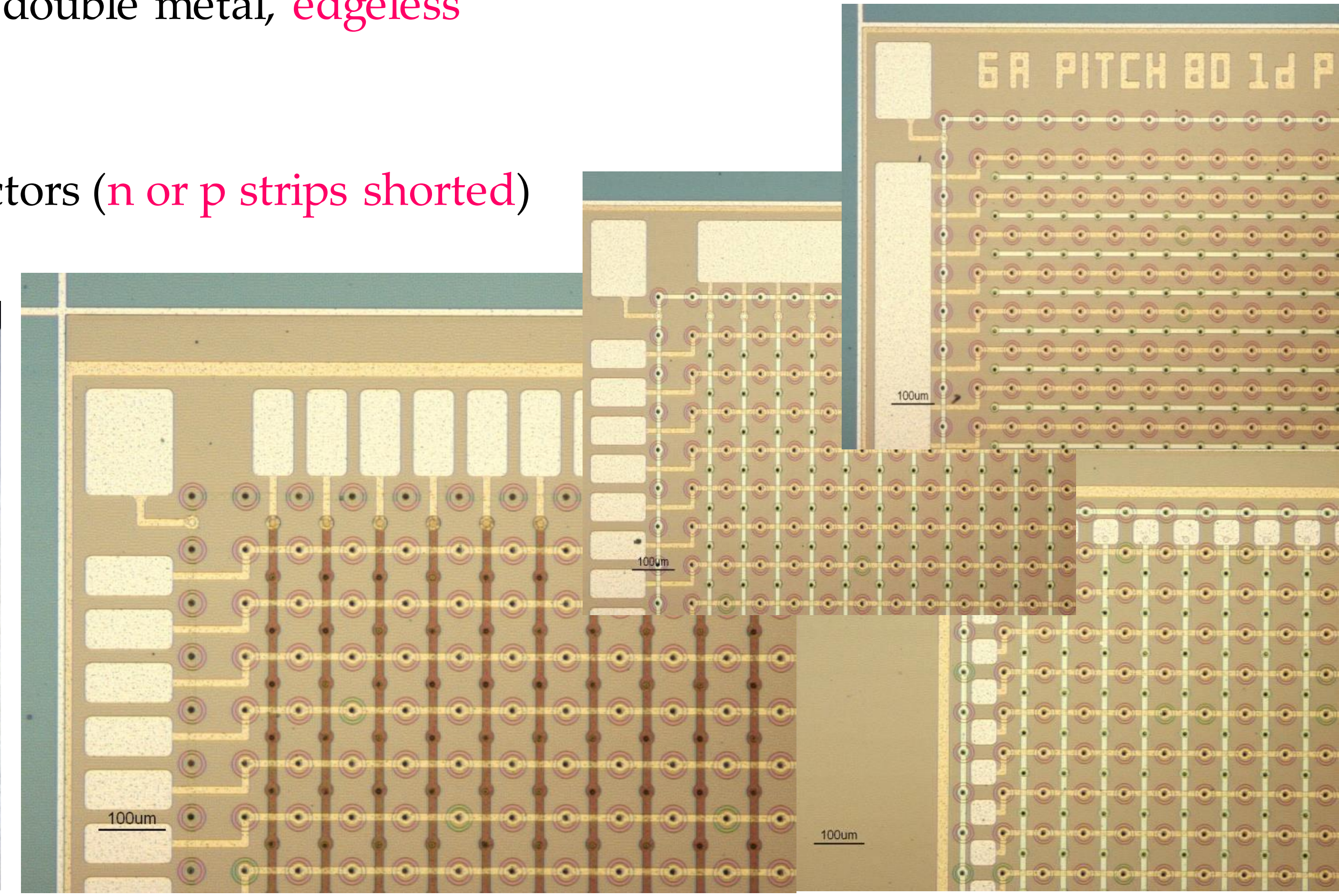
Detector structures:

- 127 p+-type strips and 128 n+-type strips
- pitch 80 or 160 μm, double metal or polysilicon
- pitch 80 or 160 μm, double metal, edgeless

Test structures:

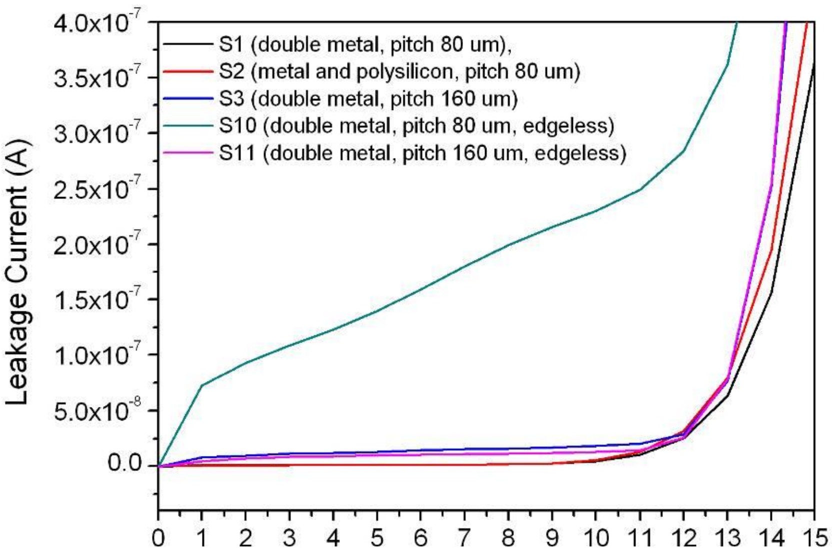
- 1D microstrip detectors (n or p strips shorted)





Part II:
Detector Characteristics Measurements

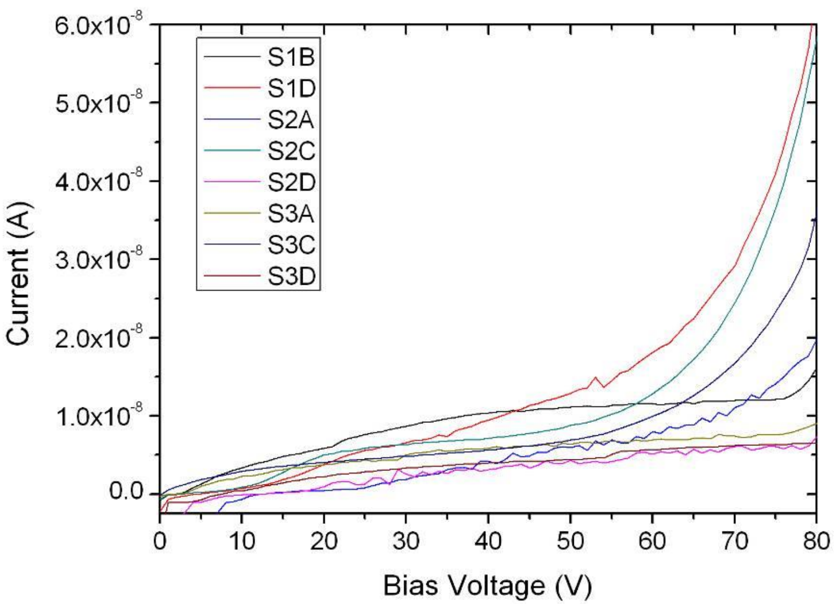
2.1 Electrical characterization



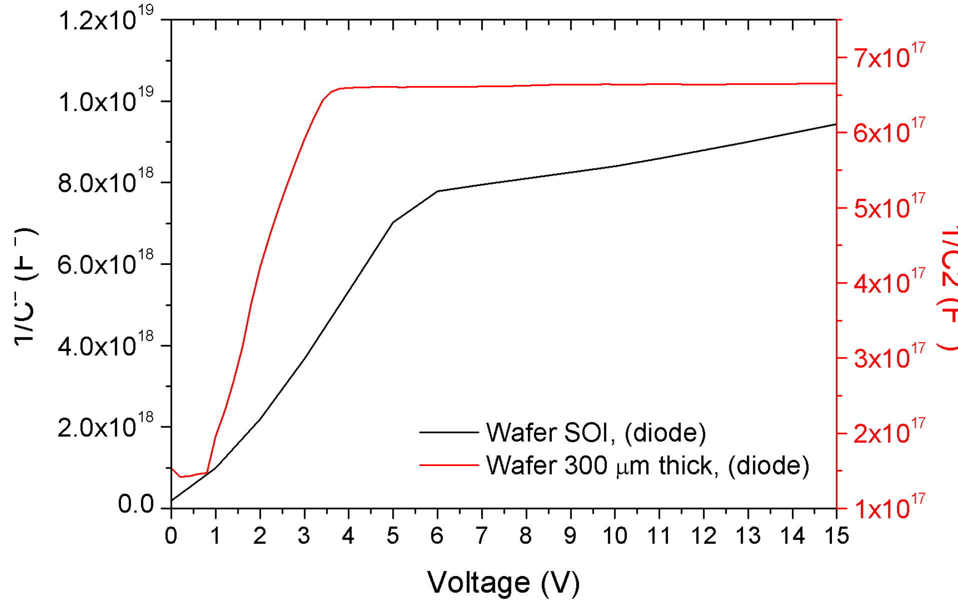
$I_{leakage}$ ~ 102 nA (wafer 300 μm)
few nA (wafer SOI)

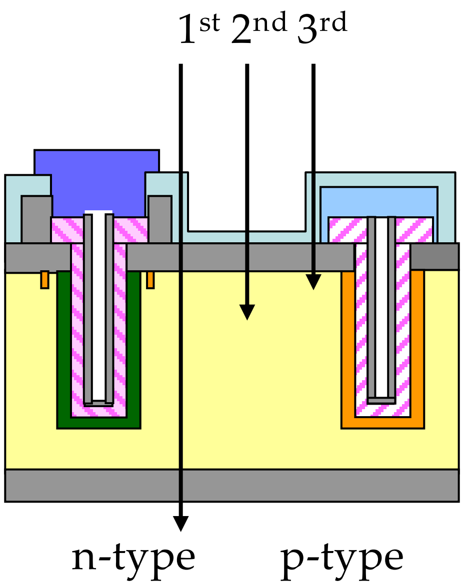
C_{bulk} ~ 8 pF (wafer 300 μm)
~ 0.4 pF (wafer SOI, 20 μm)

V_{dep} ~ 3.5V wafer 300 μm thick
~ 5.5 V wafer SOI, 20 μm thick



Diode structure





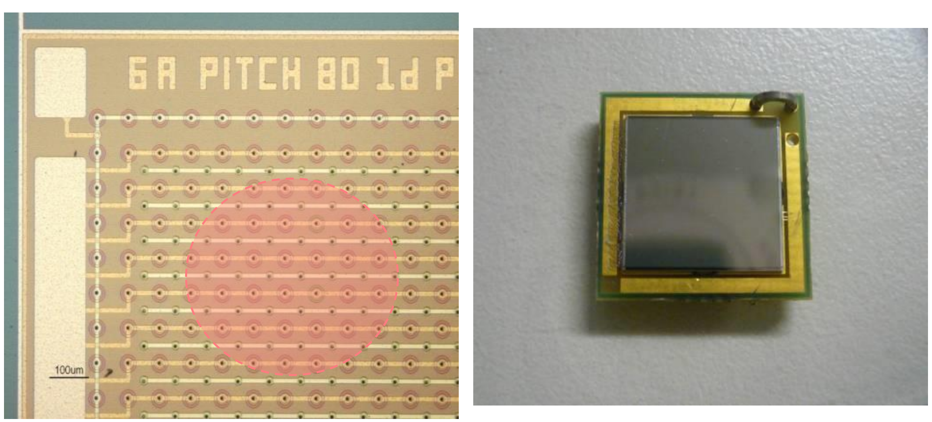
2.2 TCT measurements: setup

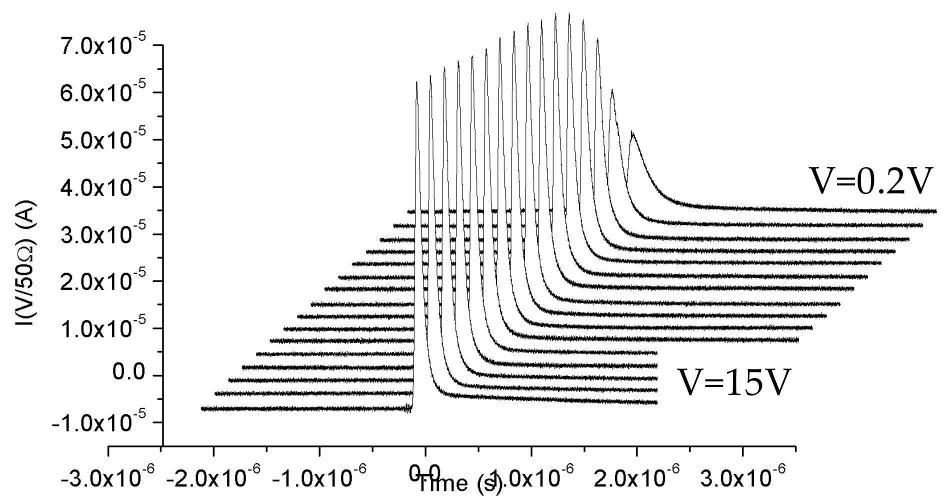
Carried out in the BNL (NY, USA) laboratories

Laser setup	Wavelength λ (nm)	Intensity (V)	Width (ns)	Period (μs)	Penetration depth (μm)
1st	1060	10	10	20	> 300 μm
2nd	830	10	10	20	15
3rd	660	10	10	20	5

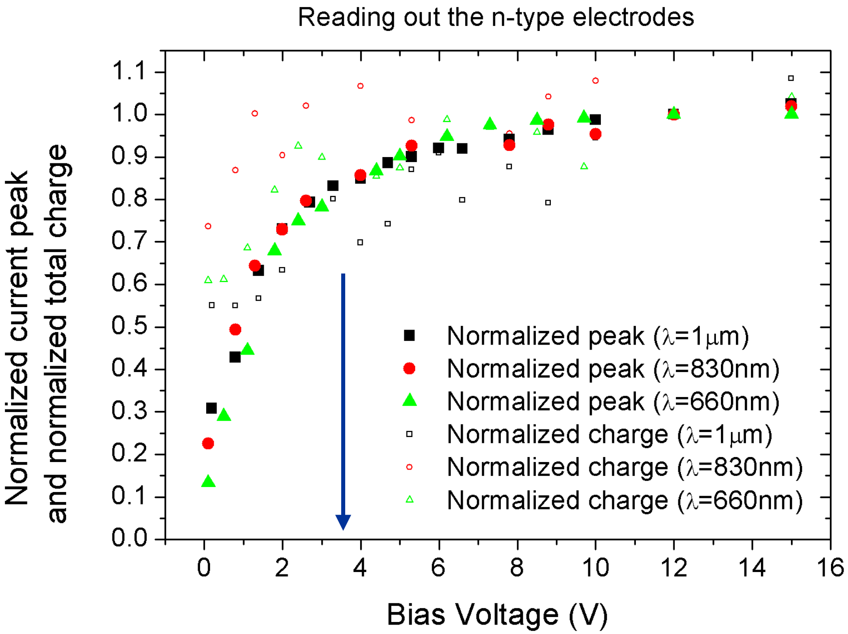
Laser beam (spot = 1mm)

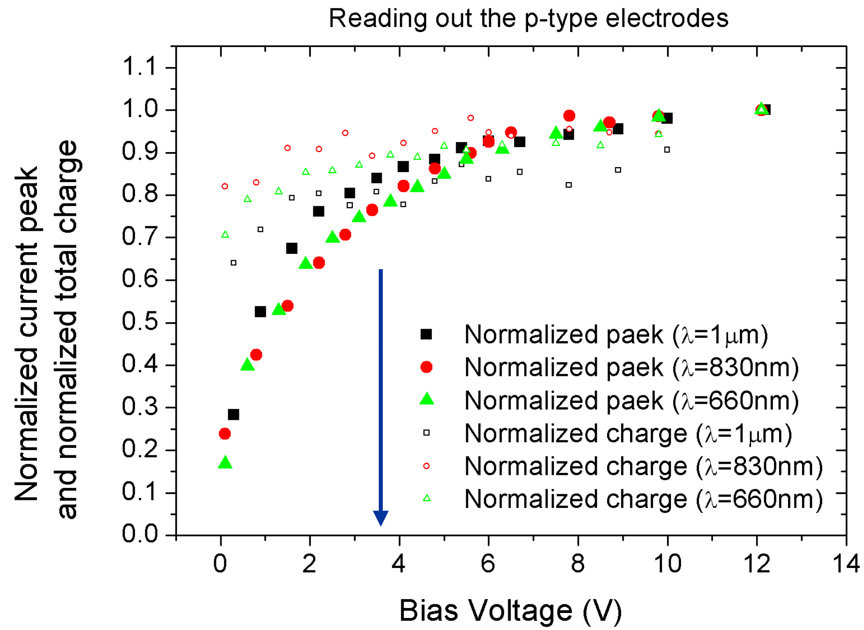
Parallel strips

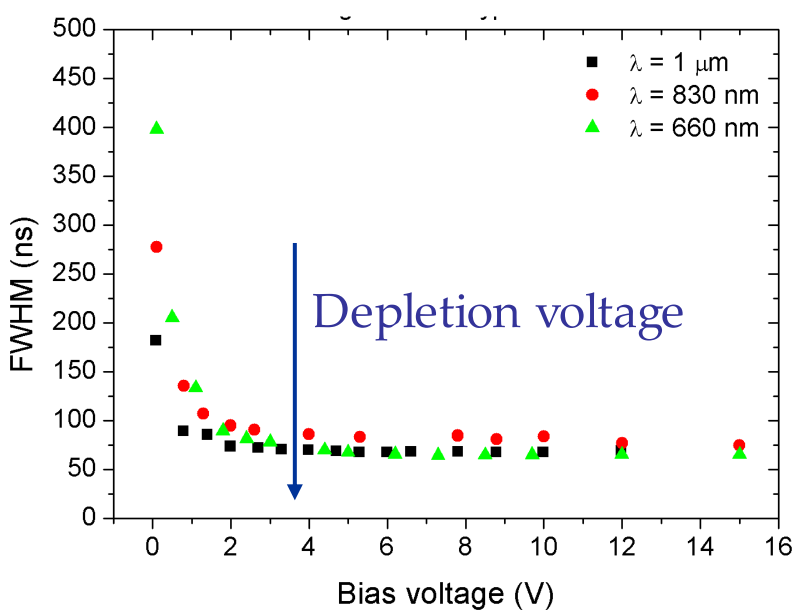


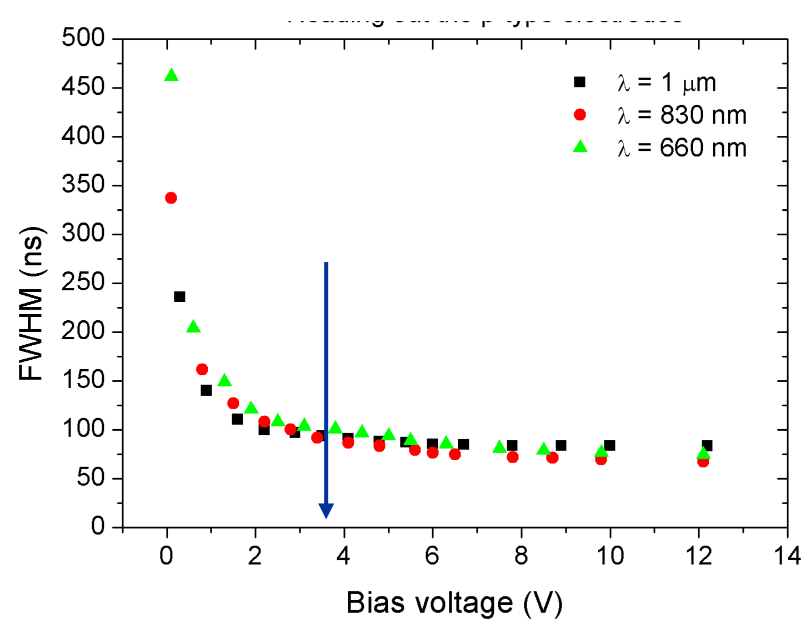


2.2 TCT measurements: laser from the front side





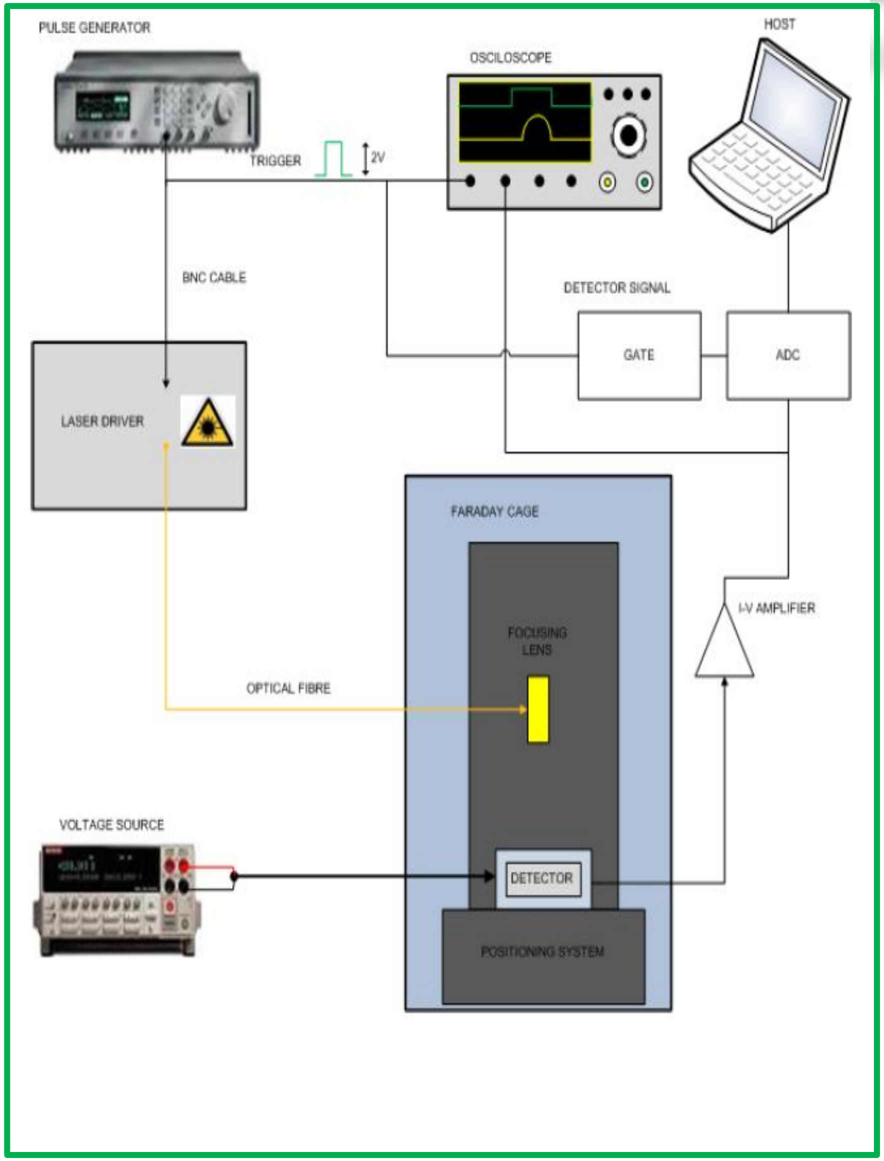


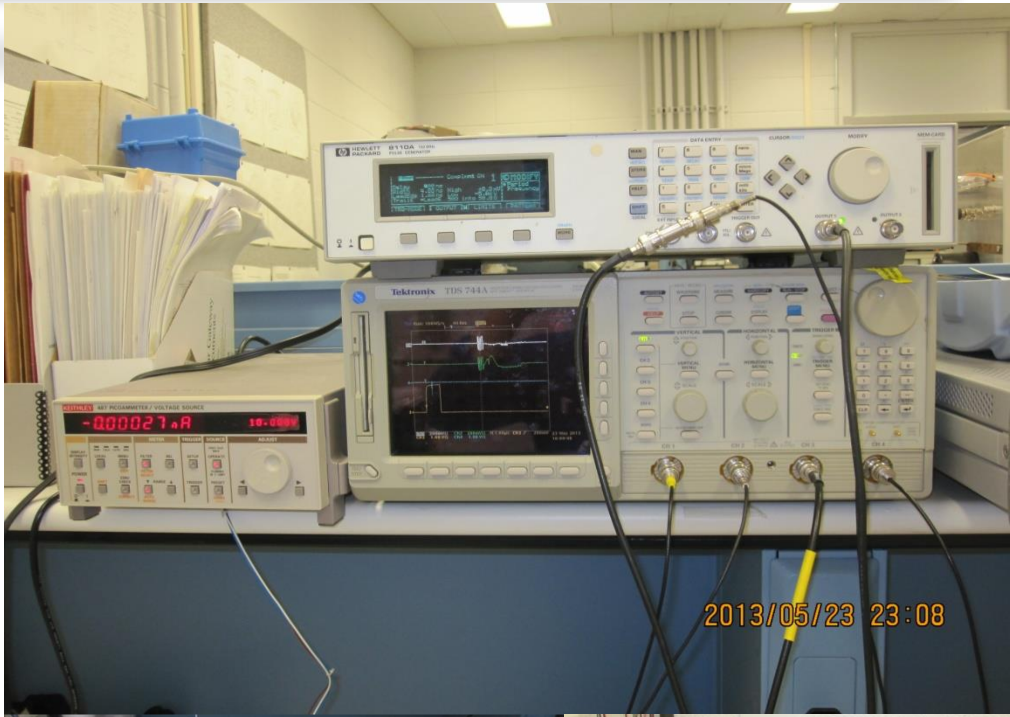


2.3 Detector Responses to Laser Measurements With Alibava DAQ System

- System Introduction
- CCE measurement
- 2D position sensitivity

System Introduction

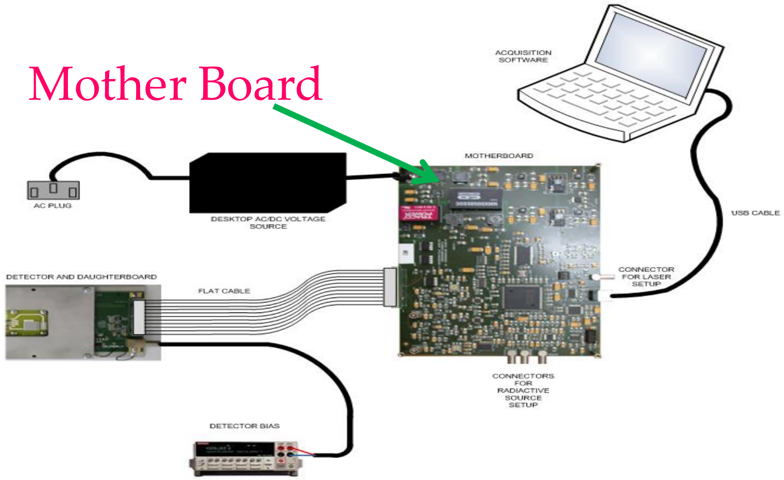


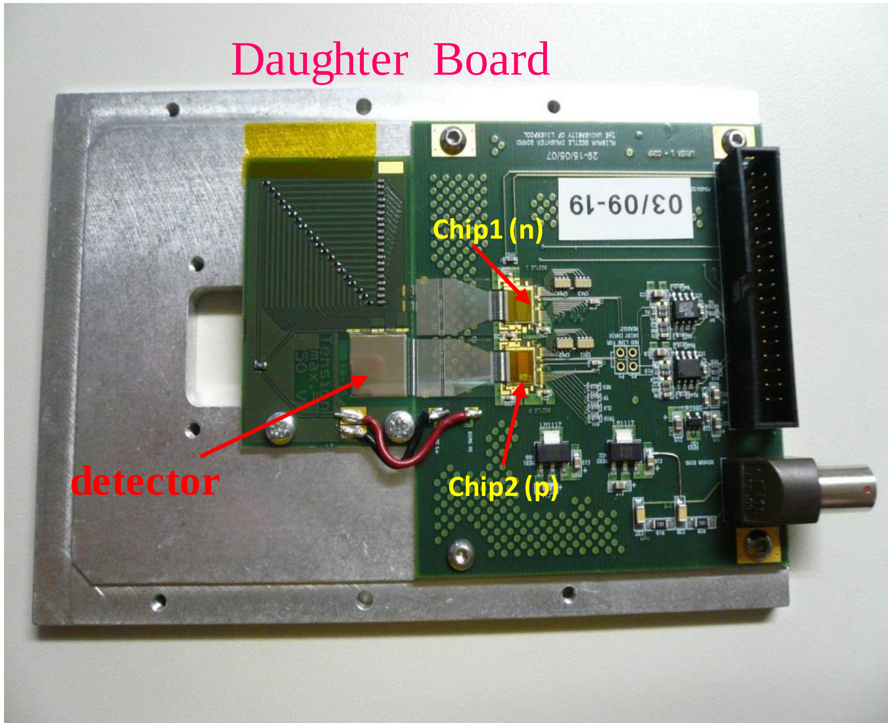


Hardware Parts-A dual board system

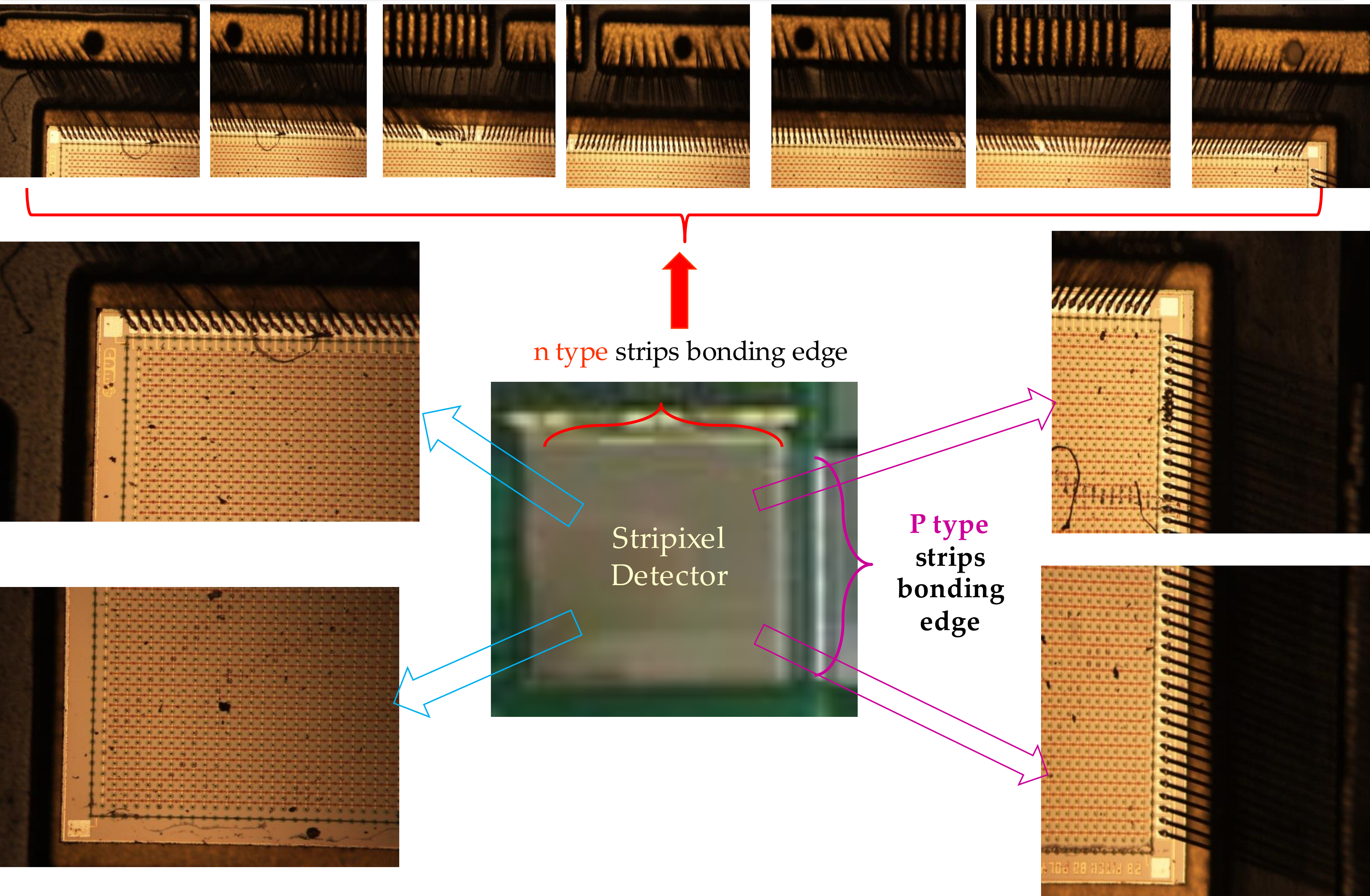
➢**Mother Board:**
- Analogue data processing
- Trigger output generation
- Hardware part control
- USB communication

➢**Daughter board**
- Two Beetle readout chips
- Fan-ins and detector support to interface the detectors



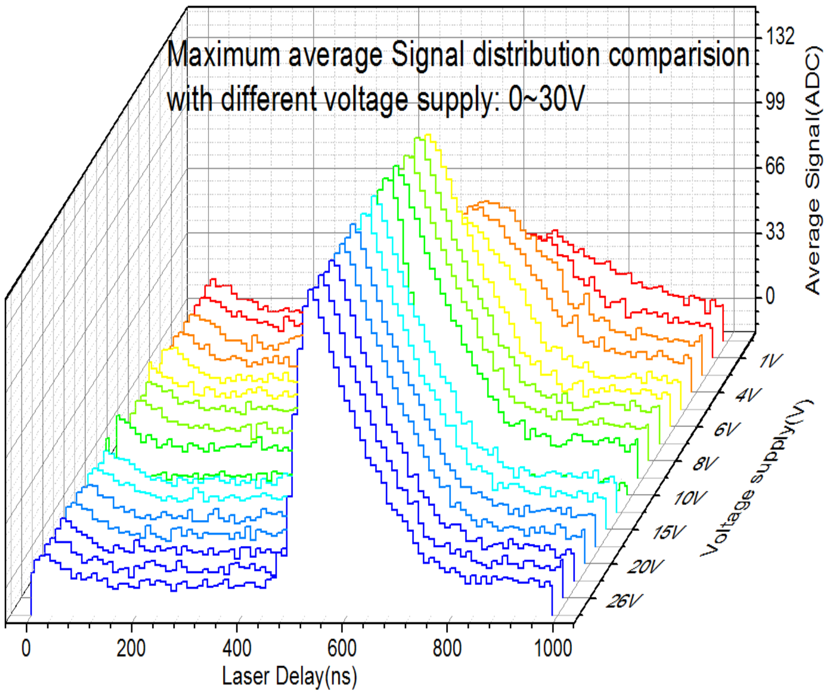


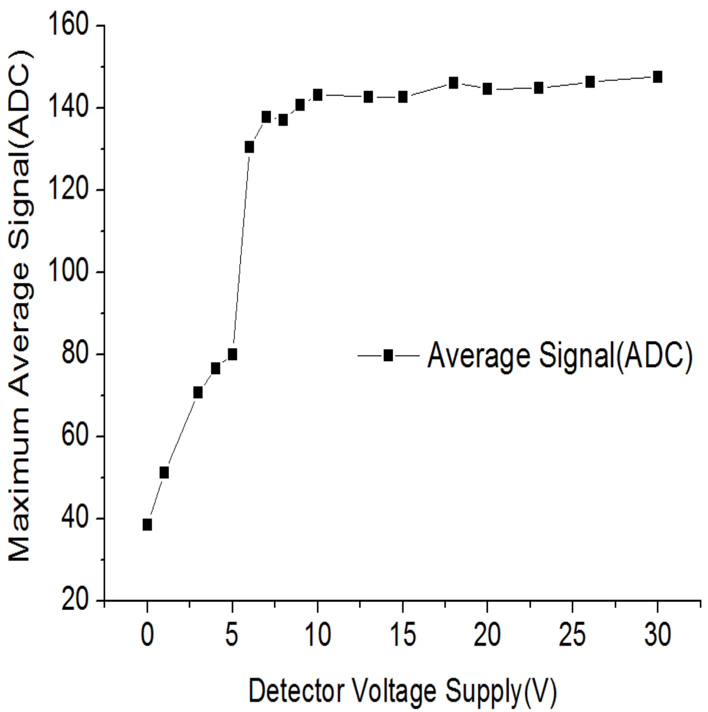
Hardware Parts-Stripixel Detector Bonding



CCE Characteristics

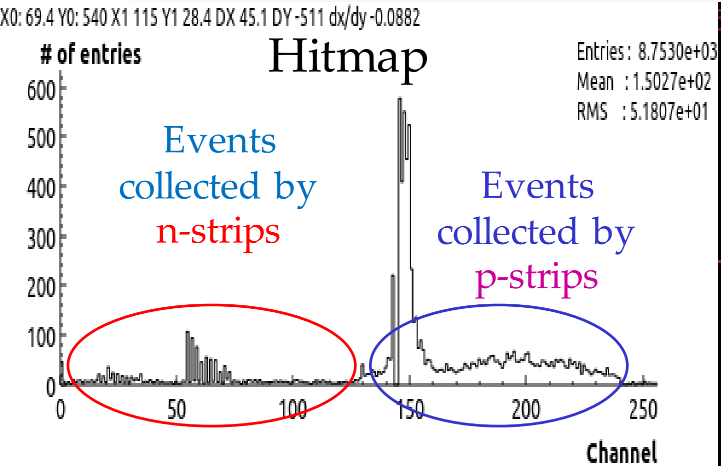
Detector CCEs distributions vis detector voltage supply

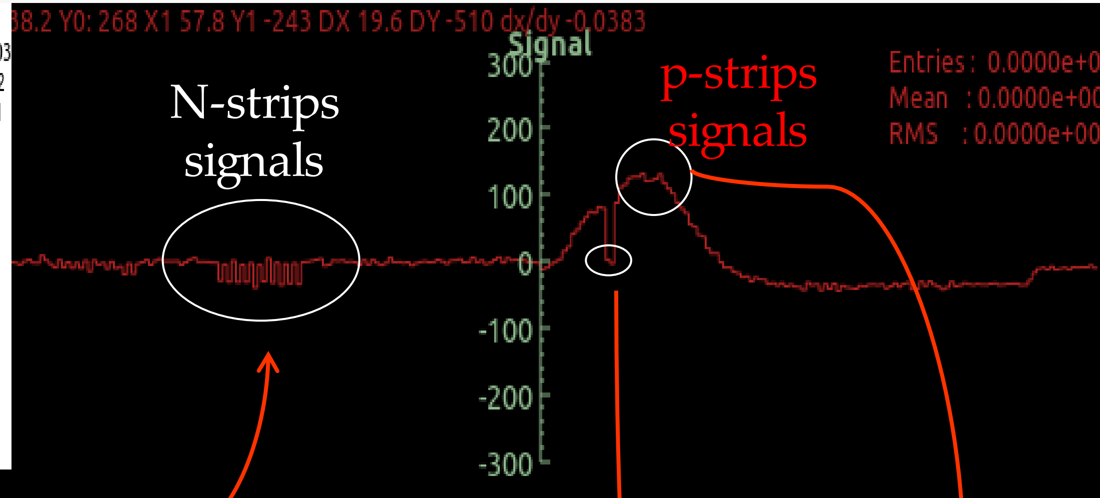




$V_{Bias} \approx 0.5 * V_{(Detector\ Voltage\ Supply)}$ → $V_{dep.} \approx 5V$

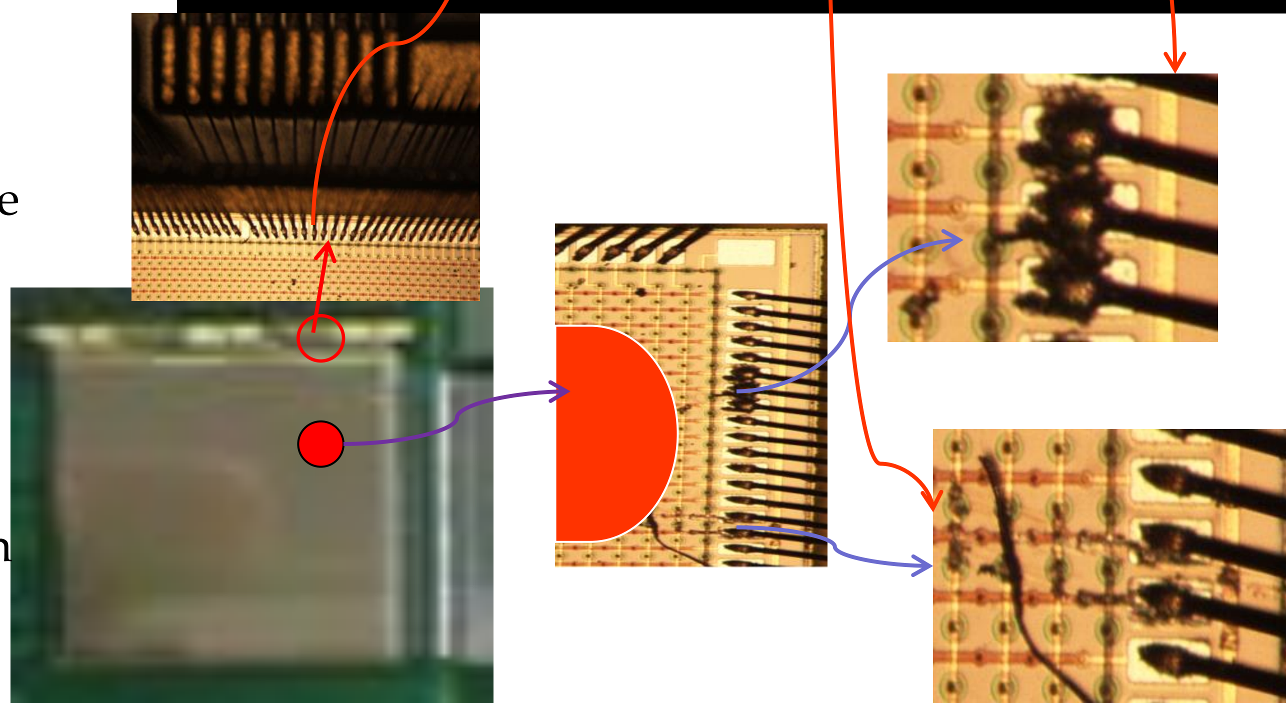
2D Position Sensitivity





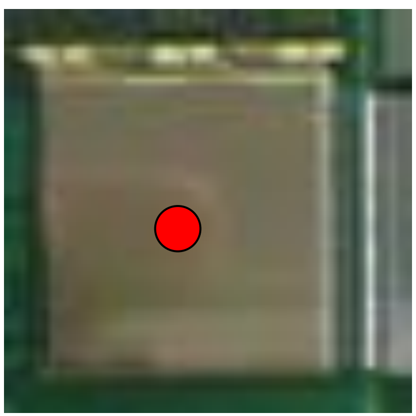
Hitmap:
distribution of laser exciting events are collected by n or p type strips detected by front-end readout chips .

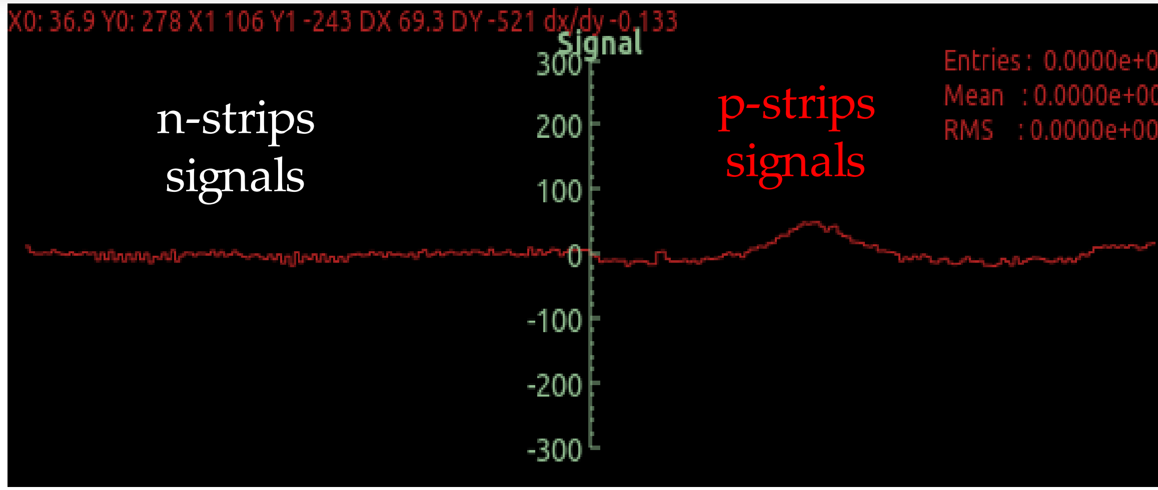
Event Signal:
Amplitude distribution of event signal(ADC) for one laser injection.

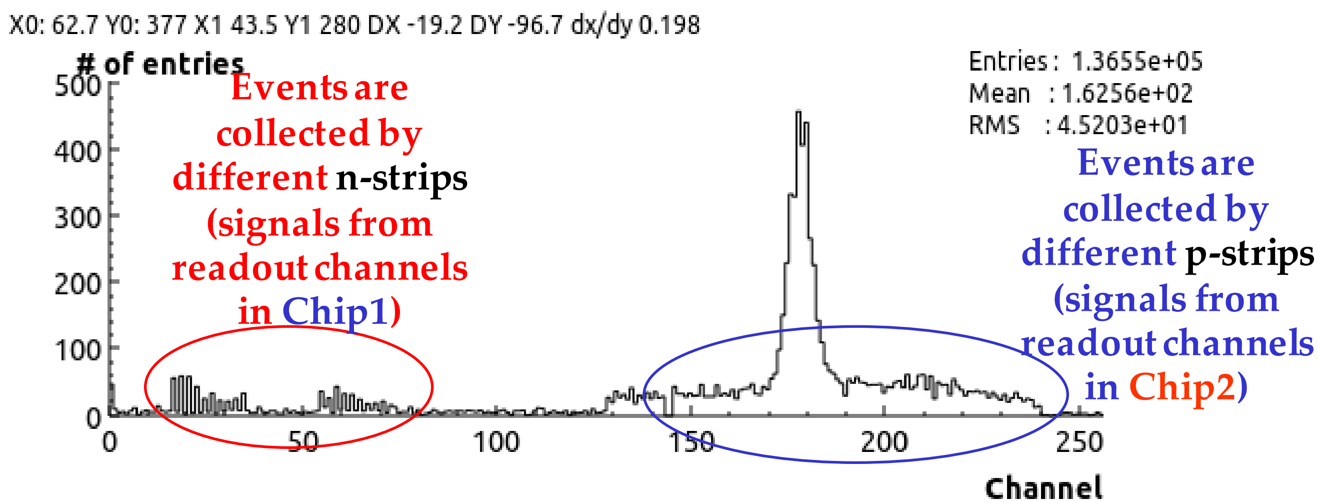


2D Position Sensitivity

Laser injection position :
near detector center

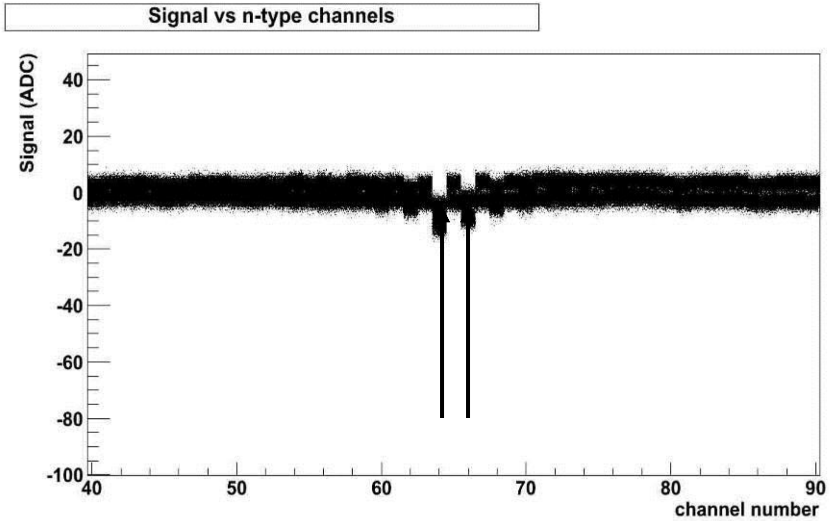


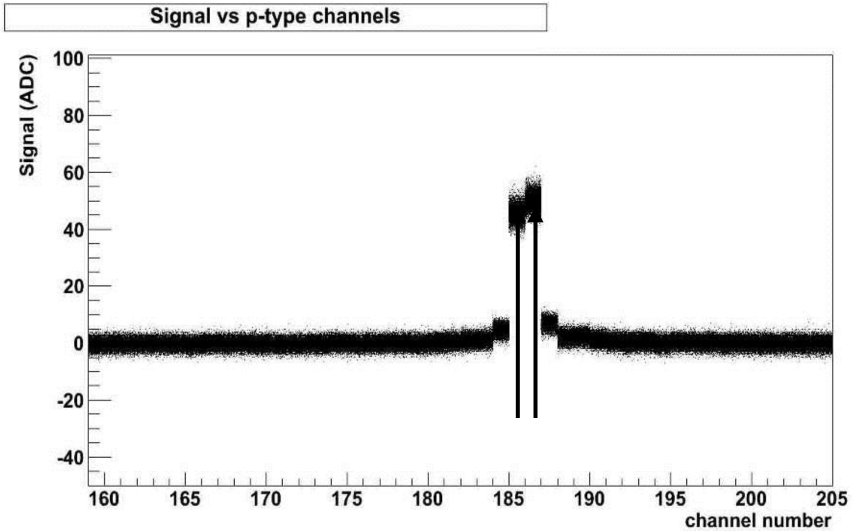


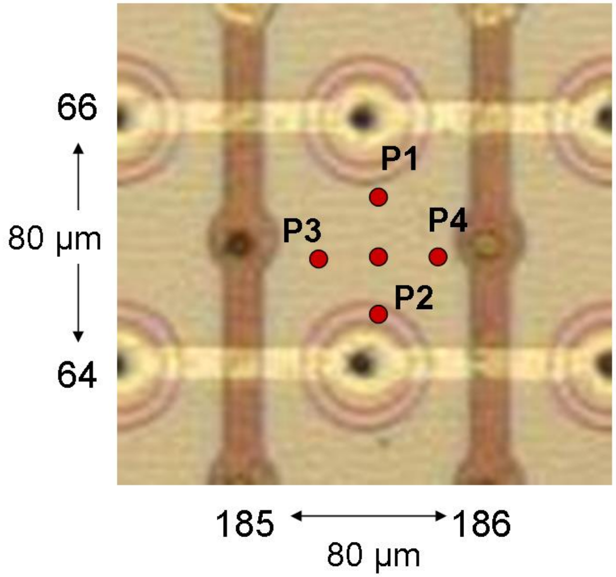


Data with more-focus laser (5 μm spot, λ=1060 nm),

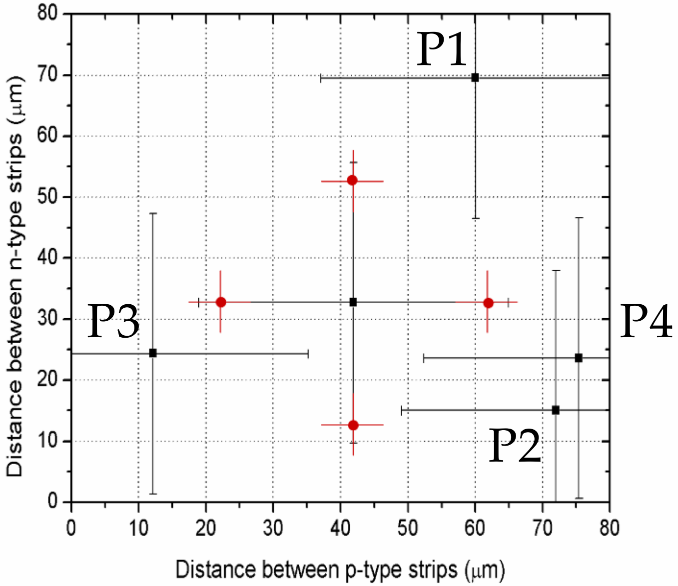
Measurements done in CNM with the same detector and daughter board







Spatial resolution
pitch/√12
~23 μm



2D sub-pixel position resolution have been seen

Part III: Summary

With BNL TCT , Alibava DAQ systems and other semiconductor detector measurement instruments, the key parameters including the depletion voltage, leakage current, and CCE characteristics of the newly designed and fabricated full 3D stripixel detectors are successfully tested.

(1) The full depletion voltage of the 3D stripixel detectors is about 3-4 volts from CV and TCT measurements, and about 5 volts from ALIBAVA CCE measurement

(2) 2D position sensitivity of laser illumination have been detected from both TCT and ALIBABA CCE measurements

(3) Measurements using a laser with a more-focused spot have shown 2D sub-pixel position resolution

1.3 Fabrication process: double metal technology

Si

Poly1

Poly2

p-type diff.

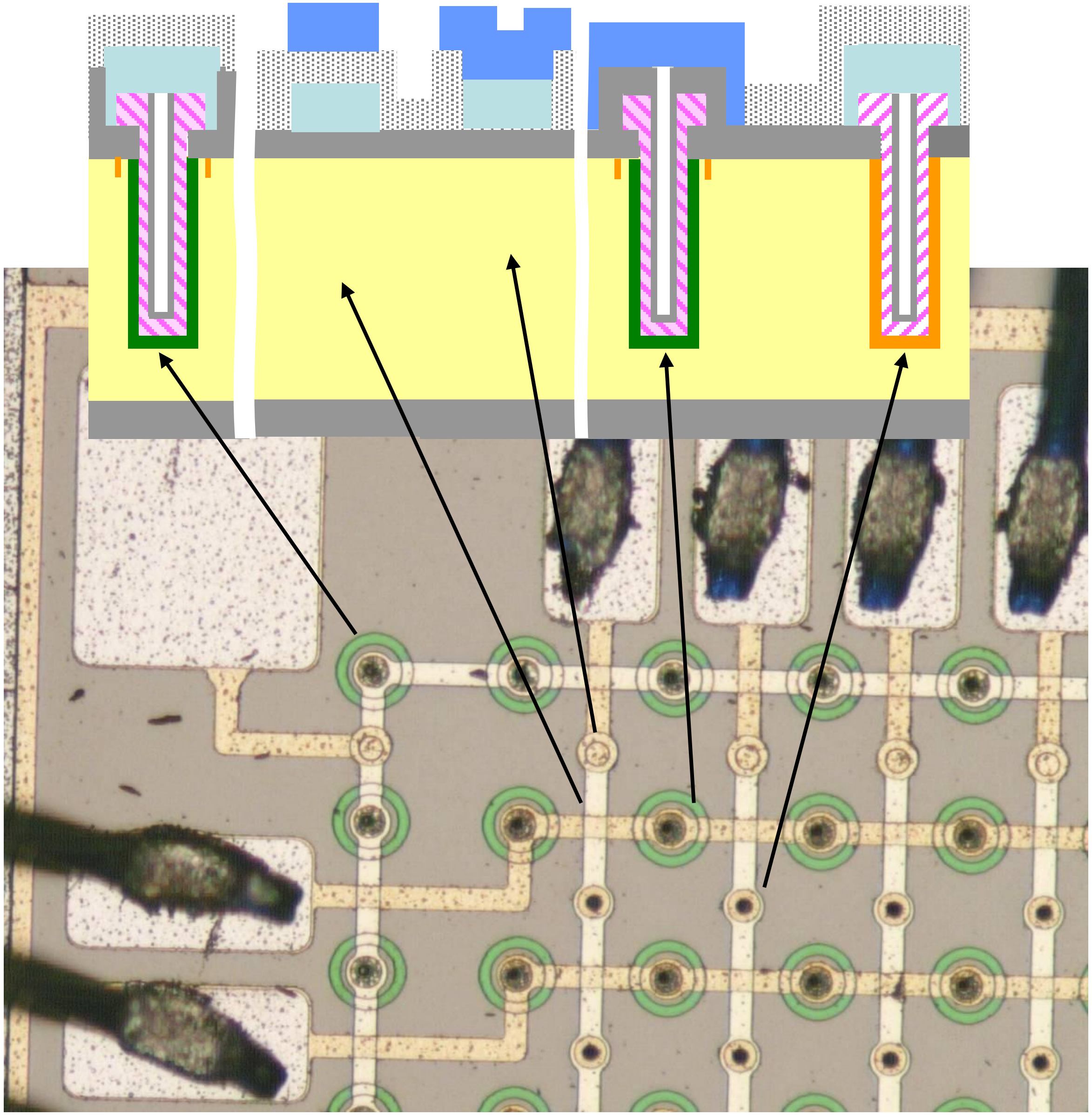
n-type diff.

SiO_2

SiO_2

Metal 1

Metal 2



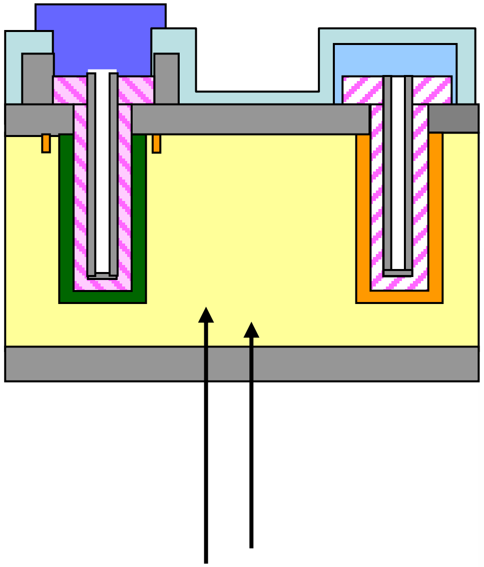
1.3 Fabrication process: the most challenging ever carried out at IMB-CNM for silicon particle detectors

100 steps, 10 photolithography process

2 deep RIE processes and 2 metallization processes on the same surface

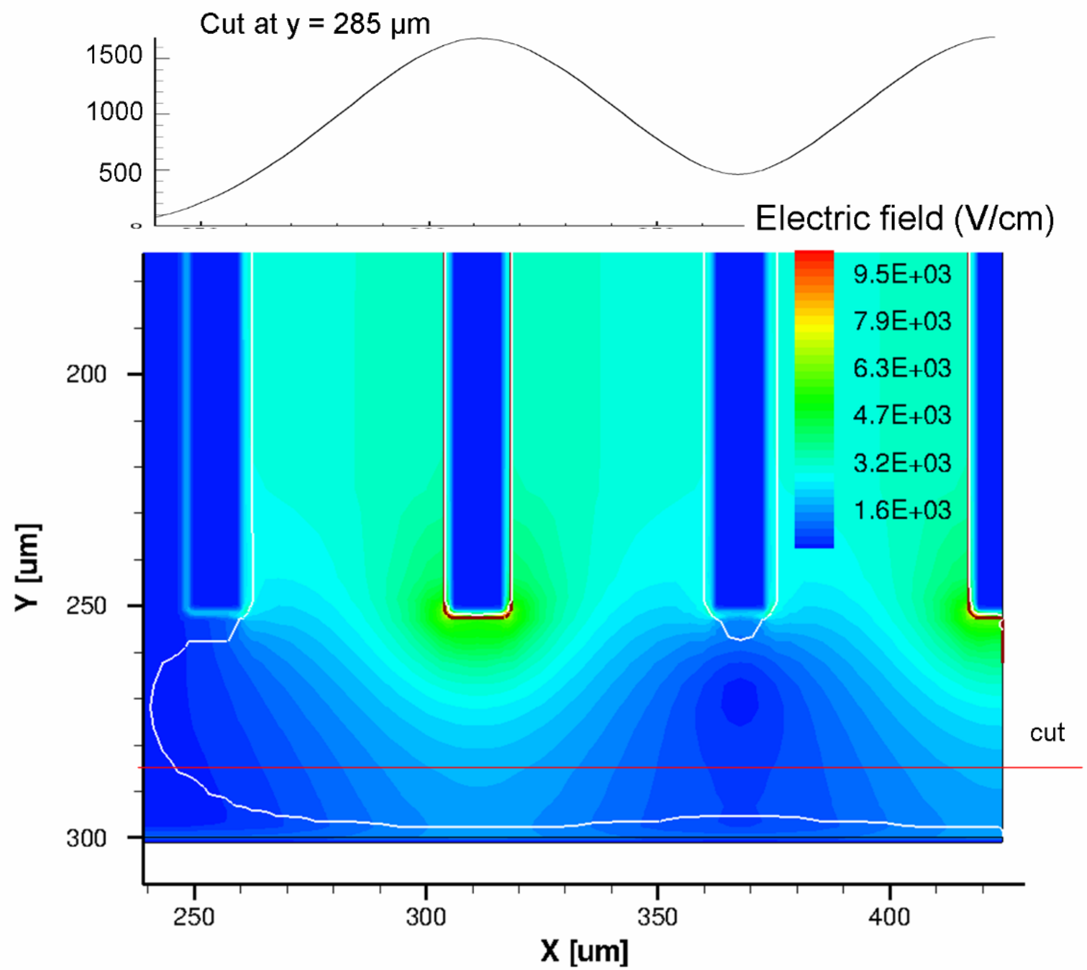
Mask level	Pattern	Comments
P-DIFF	p-stop	(p-stop rings definition around n-type columns)
N-HOLES	n+ columns	(n+ columns etching)
POLY	polysilicon	(definition of the n+ columns on the surface)
P-HOLES	p+ columns	(p+ columns etching)
POLY2	polysilicon	(definition of the p+ columns on the surface)
WINDOW	metal window	(removing SiO_2 on the guard ring columns and p-type columns to contact with the metal layer)
METAL1	metal (1st layer)	(1st metal layer pattern definition)
VIA	metal2	(window opening connection between two metal layers and removing SiO_2 on the n-type columns)
METAL2	metal (2nd layer)	(2nd metal layer pattern definition)
PASSIV	metal contacts	(opening windows on the metal connection pads)
BACK WINDOW	SOI wafer	(etching the support substrate up to SOI wafers)

2.2 TCT measurements: laser from the back side

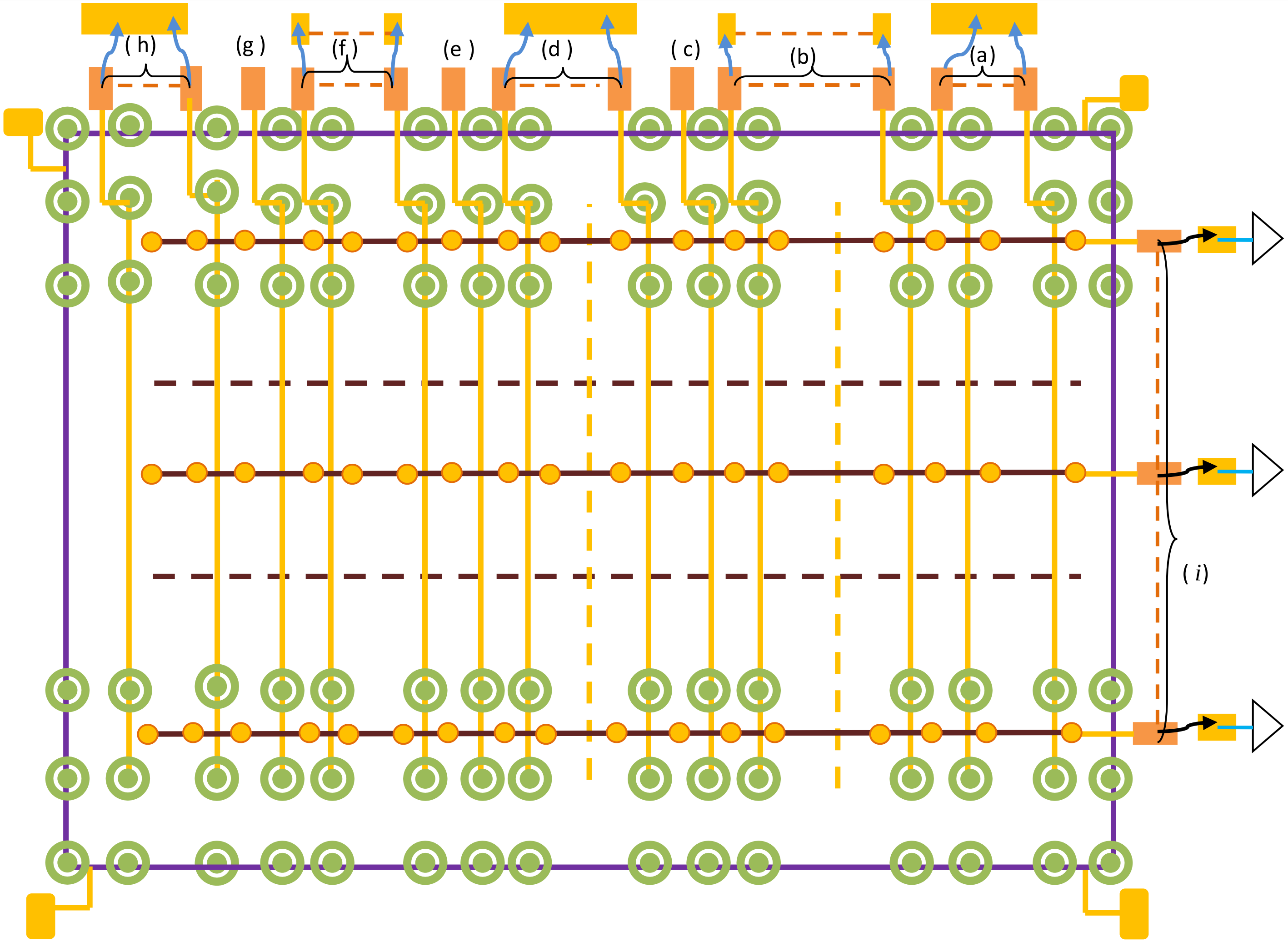


Illuminating the backside with both the lasers of shorter wavelengths (660 nm and 830 nm) no signal can be read.

Low Electric Field



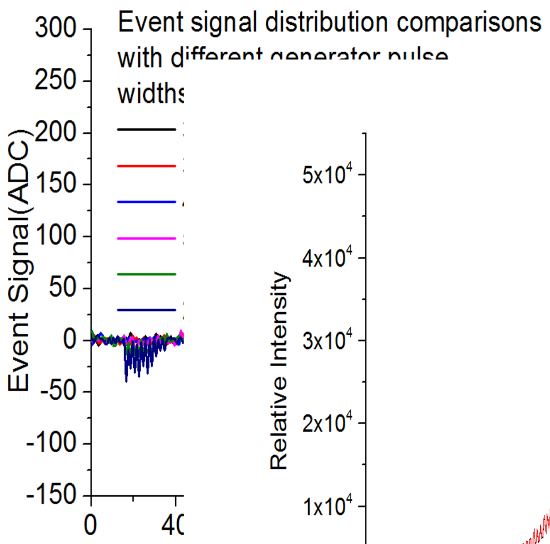
Hardware Parts-Stripixel Detector Bonding

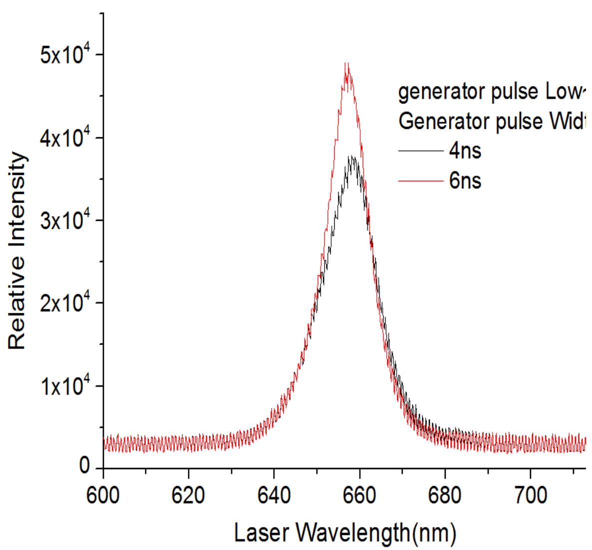


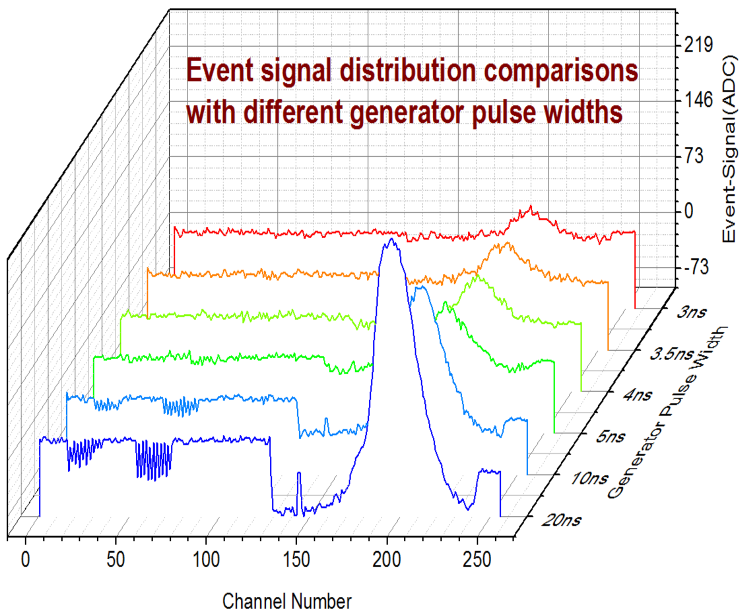
Notes: (1) Ranges of n-type strips in (a), (d) and (h) are bonded together to each one block mental respectively, every column of n-strips in other ranges((b),(d)and (f)) is respectively bonded to one metal. 3 columns of n-strips ((c),(e)and (g)) are not bonded. (2) each row of p-type strips is respectively bonded to each mental which is connected directly to each one readout channels in Chip2.

CCE Characteristics

- CCE Distributions vis generator pulse Widths



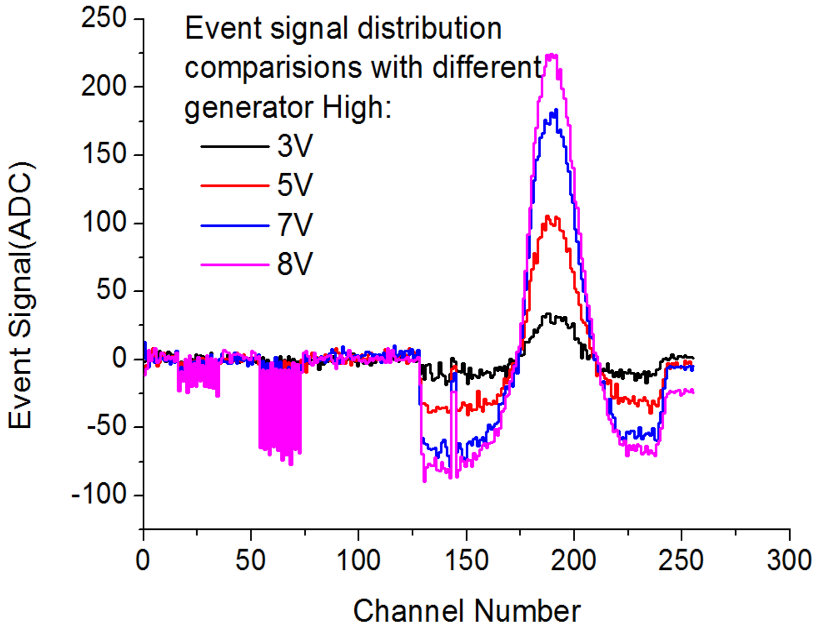


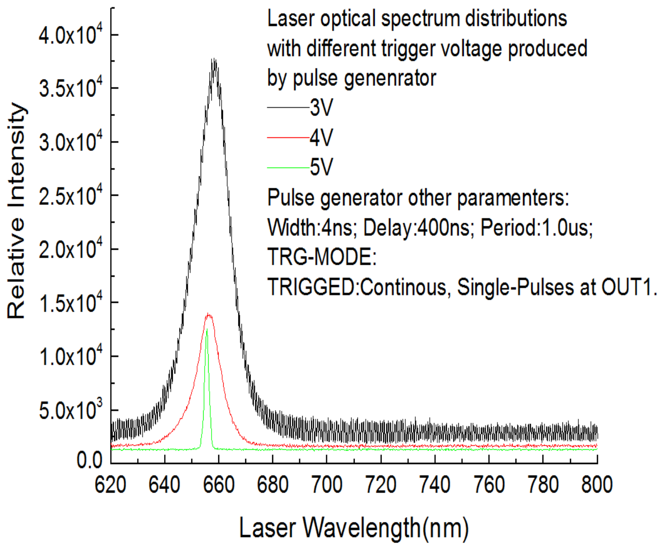


Detector Channels CCEs are increased with generator pulse signal's being Wider; As Laser Intensity is Increased with Generater Pulse signal Widths Being Wider

CCE Characteristics

- **CCE distributions via generator pulse Highs:**





Detector CCEs Changed with pulse signal ’ s High->laser spectrum distributions and intensity modification