

HV-CMOS CHESS I chip testing

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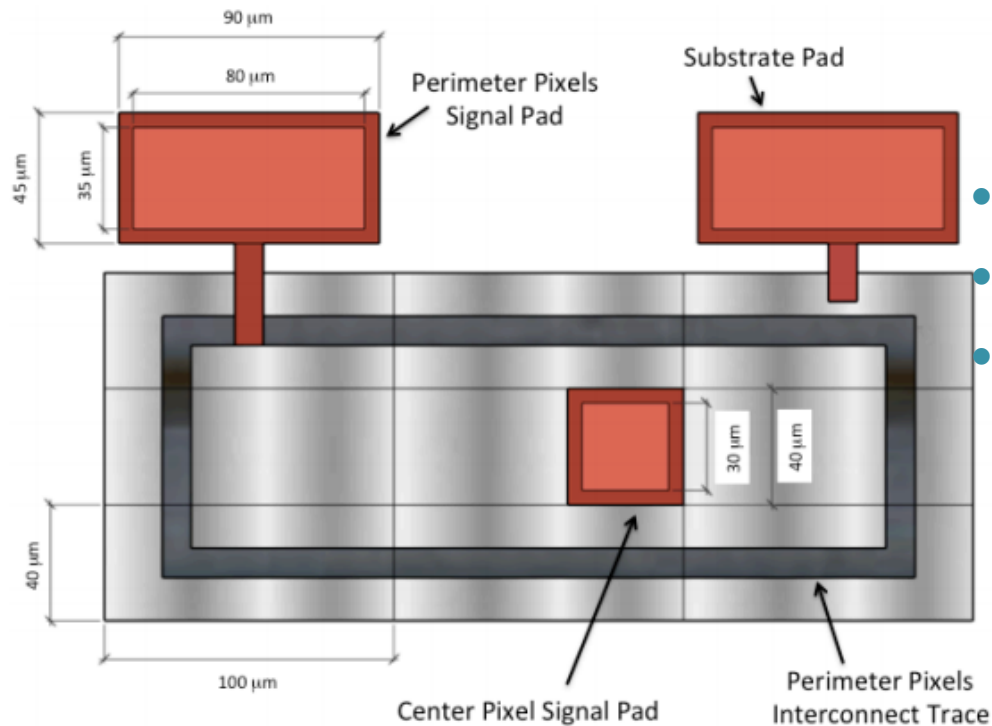
Introduction

- Gamma Irradiated CHESSI HV-CMOS chip is available for testing
- Five CHESSI chip with different dose
 - 1Mrad
 - 3Mrad
 - 10Mrad
 - 30Mrad
 - 100 Mrad
- The outline of this talk:
 - I-V measurement
 - Inter-strip measurement
 - Laser charge injection study

pixel IV measurement setup

What happens to Silicon sensor after bulk radiation damage:

- ❑ Displacements in the silicon lattice
- ❑ Creating intermediate state
- ❑ Lead to higher leakage current



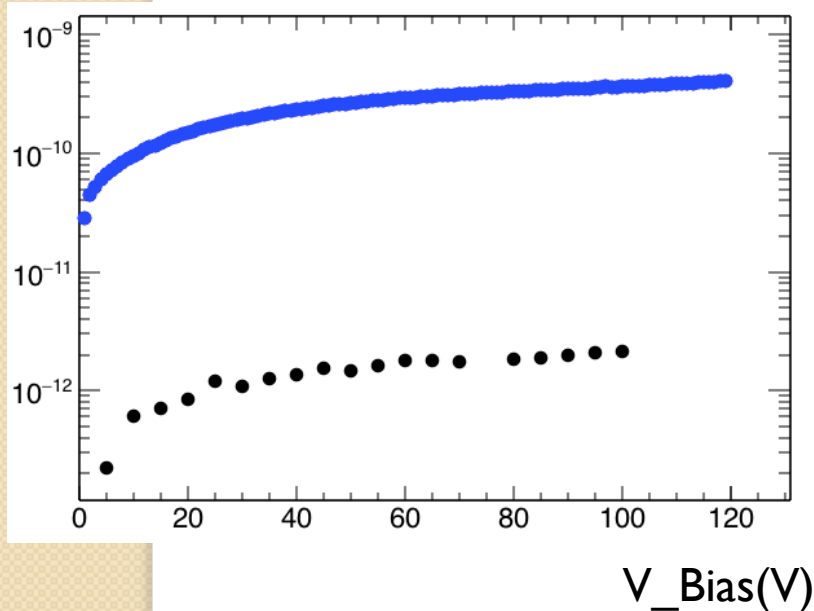
- Substrate: grounded
- Perimeter pixels: +HV
- Central pixel: +HV

I-V curve after radiation

Leakage Current @V _{Bias} =100V	PPA03	PPA07
100Mrad	0.29 nA	1.4 nA
1Mrad	-	0.25 nA
Before irradiated	2 pA	4.5 pA

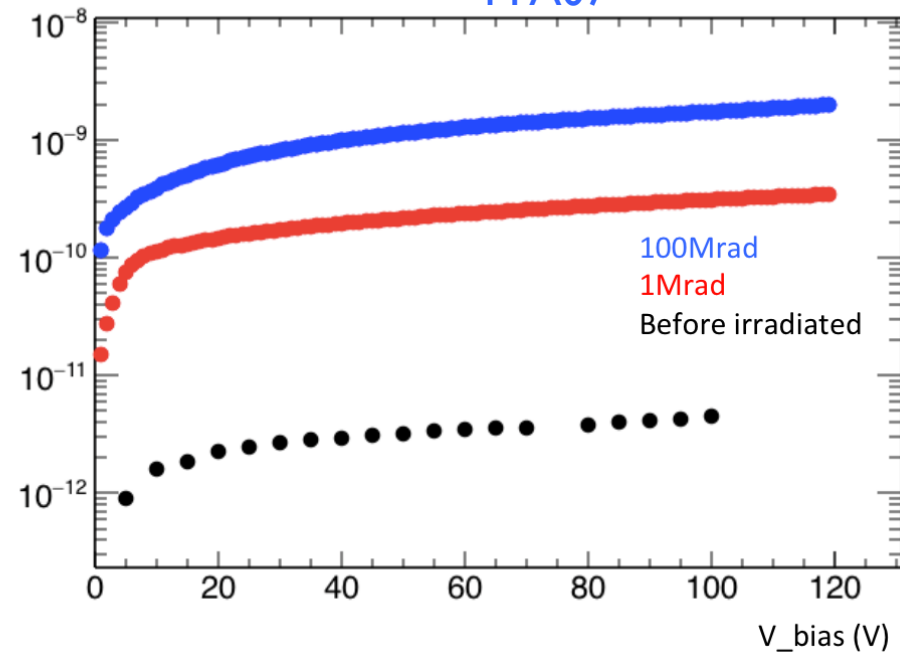
PPA #	Pixel width	Pixel length	Diode Area Fraction	Metal opening ratio
PPA03	45μm	200μm	30%	22.7%
PPA07	45μm	800μm	30%	29.8%

Leakage current(A) PPA03



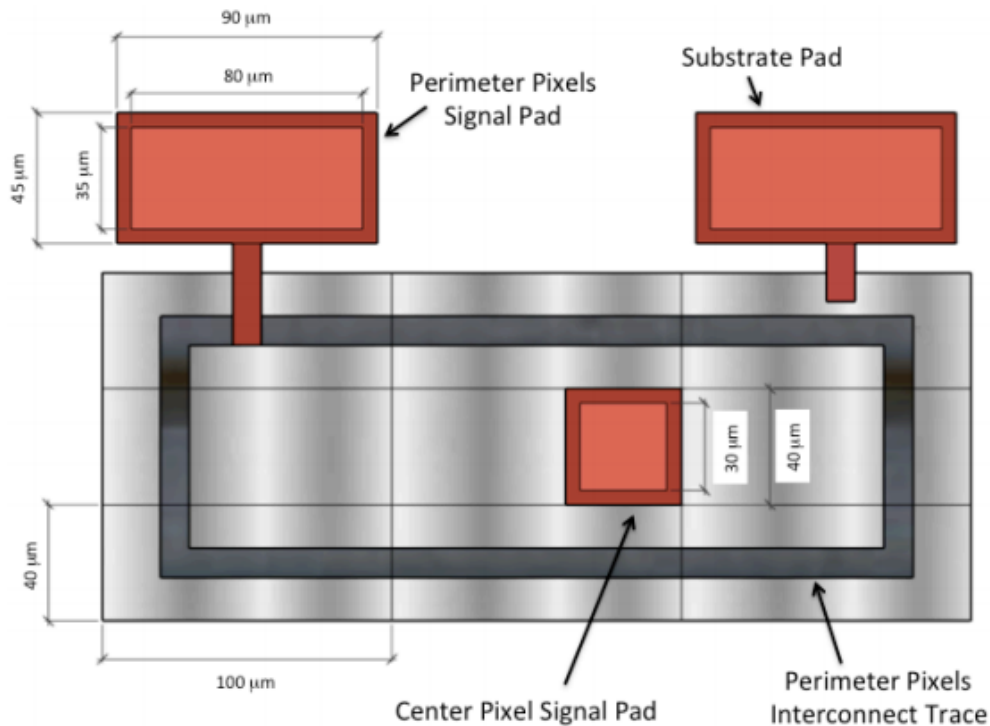
Leakage current (A)

PPA07



inter-pixel resistance

- Radiation damage will reduce the inter-pixel resistance
 - result in larger cross talk -> low position resolution
- Vary the bias voltage of the perimeter pixels by IV
 - The variation in central pixel current reflect inter-pixel resistance



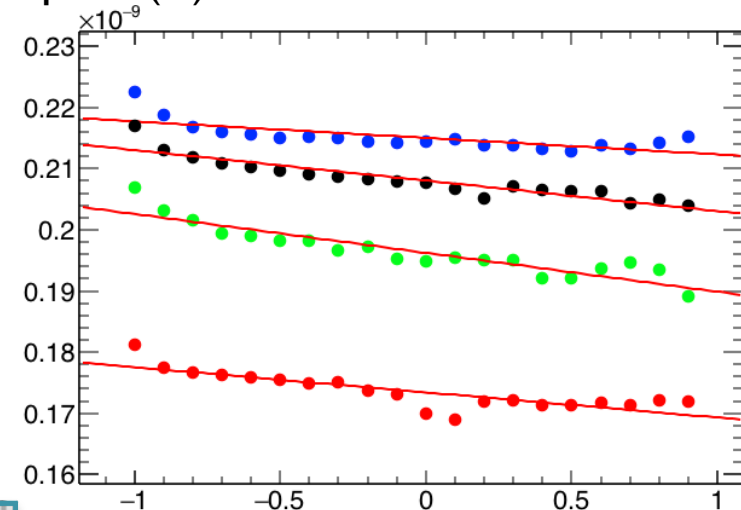
- Substrate: grounded
- Perimeter pixels: from 98V to 100V
- Central pixel: 99V

inter-pixel resistance (2)

R_int	PPA10	PPA11	PPA3	PPA04
100Mrad	370 GΩ	240 GΩ	200 GΩ	160 GΩ
Before radiation	>500 GΩ	>500 GΩ	>500 GΩ	>500 GΩ

Current in central pixel (A)

- ❑ The pixel without contact ring may lead to Low inter-pixel resistance
- ❑ It turned out that this is not a problem.

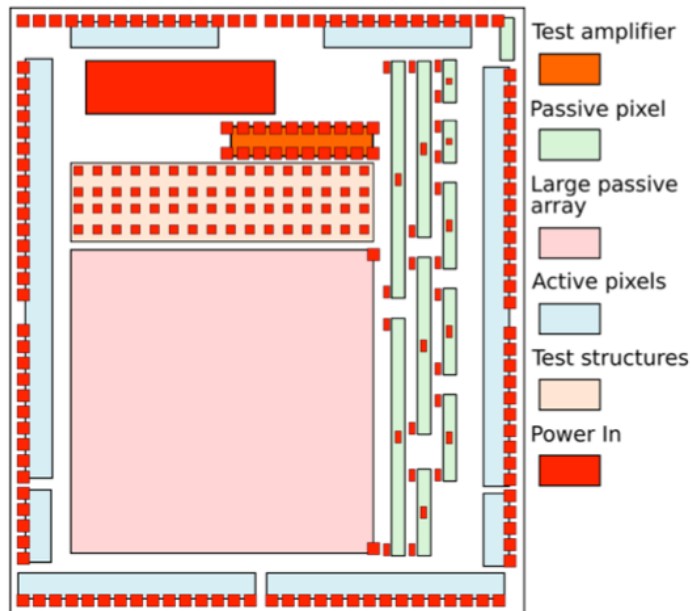


Variation in Perimeter pixels (V)

PPA #	Pixel width	Pixel length	Diode Area Fraction	Metal opening ratio	
PPA03	45μm	200μm	30%	22.7%	
PPA04	45μm	200μm	50.4%	44.0%	
PPA10	45μm	200μm	30%	22.7%	Without contact ring around each pixel, but with contact ring around the entire array having a separate pad
PPA11	45μm	200μm	30%	22.7%	With contact ring around each pixel that violates the design rules by having a symmetric width. NOTE this pixel was added twice

charge injection test using laser

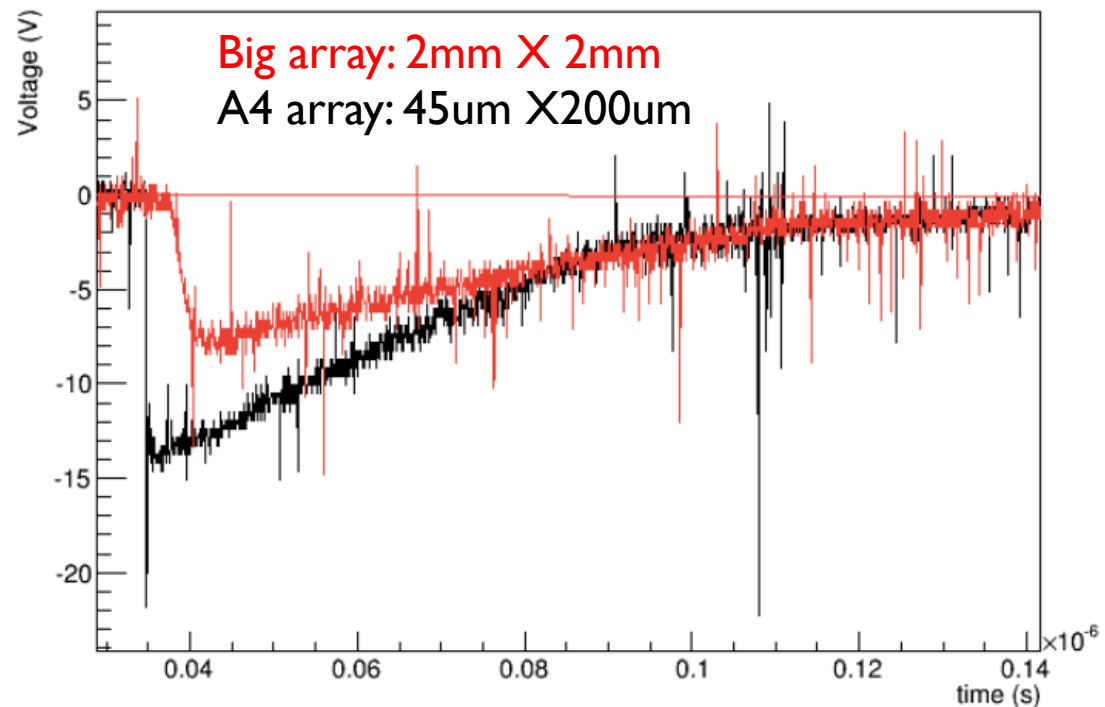
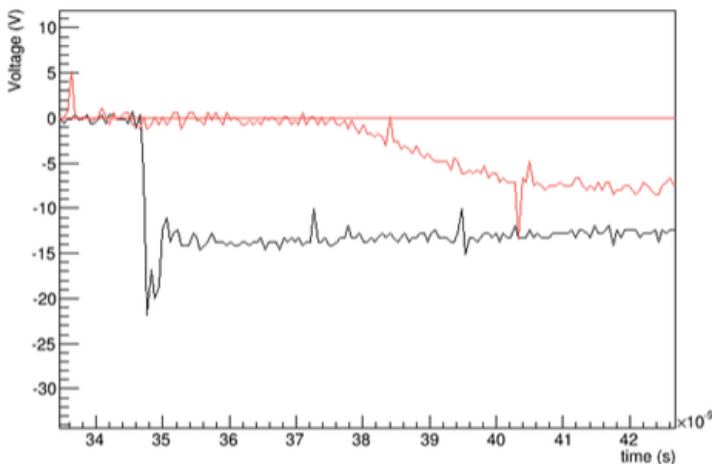
- Use high power laser to get a large signal from CHESSI chip
- Try to study the signal shape of the pixel without amplifier
 - Validate the pixel simulation
 - Study the signal raise time in different pixels
 - Diffusion VS drift contribution



Signal shape study using laser injection

- Peaking time in large array is about 4ns
 - lots of charge injected (10^6 MIP)
 - As the result, the rise time of the signal coming from the drift would be longer than in case of a MIP

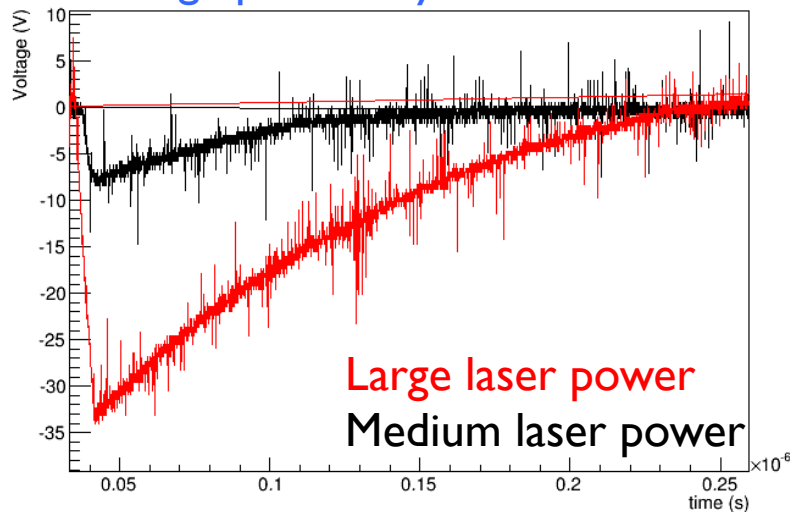
Zoom in



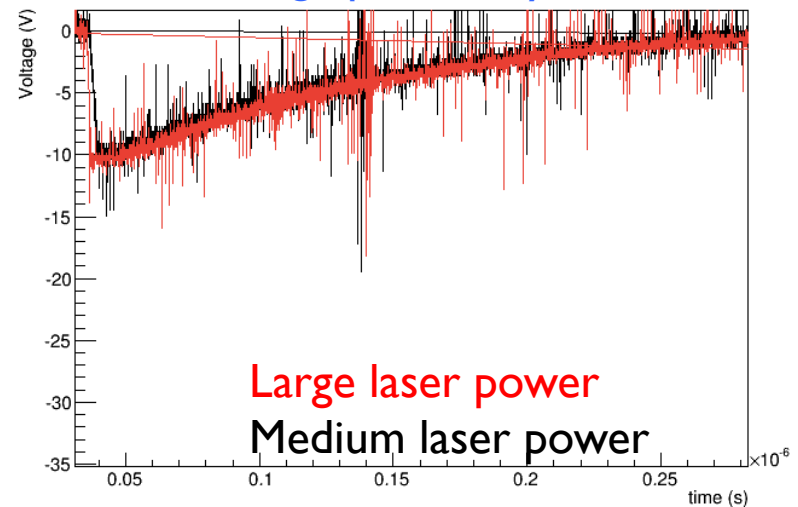
Signal size Vs laser power

- Signal shape from pixel array is similar for high and low bias voltage.

$V_{\text{bias}}=100\text{V}$
Large pixel array



$V_{\text{bias}}=10\text{V}$
Large pixel array



Proposal for talk in Trento workshop

- propose a talk in Trento workshop to cover:
 - the overview of CMOS research for ATLAS strip detector
 - CHESI chip design
 - Mainly focus on the I-V and C-V measurements on CHESI chip before and after radiation

Studies and status of CMOS-based sensors research and development for ATLAS strip detector upgrade

Content

The talk will give an overview of the studies and status of CMOS-based sensors research and development for ATLAS strip detector upgrade.

CMOS sensor can provide higher granularity, costs less in sensor fabrication compared to conventional planar sensor.

Furthermore, CMOS-based sensors collect charge from thin depleted region, and it has potential to be thinned down to 50um for reducing material the new ATLAS tracking detector.

CMOS technology been chosen for investigation for ATLAS strip detector upgrade. A test chip that comprises several pixel matrices with different geometry, as well as built-in amplifier and stand-alone amplifier arrays has been fabricated in a 0.35 μm high-voltage CMOS process.

This talk will focus on the study of the test chip characteristics.

We did a very careful measurement on the tiny leakage current from a single pixel to characterize the its basic diode properties before and after gamma radiation.

We also measured the inter-pixel resistance for different doses of gamma radiation to investigate electrode isolation in high radiation environment.

The total capacitance of a pixel diode as a function of pixel size is also measured for pixel diode size optimization.

The plan of the CMOS sensor development for ATLAS strip detector in next three years will be covered in this talk as well.

10th Anniversary "Trento" Workshop on
Advanced Silicon Radiation Detectors
FBK, Trento, Italy
February 17-19, 2015

TOPICS:

- Design and simulation
- Fabrication Technologies
- Radiation Hardness
- Read-Out
- System issues
- Applications

Organizing Committee:

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Summary

- I-V measurement and inter-strip resistances measurements are ongoing for gamma irradiated samples.
 - Low leakage current (nA level) even after 100Mrad gamma radiation
 - inter-strip resistance is still very high after gamma radiation
- Laser inject study shows that
 - The signal raising time in large array is larger than the small array