Measurement of Characteristics of the Pixel Chip for ALICE-ITS Upgrade Project

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For the ALICE-ITS collaboration

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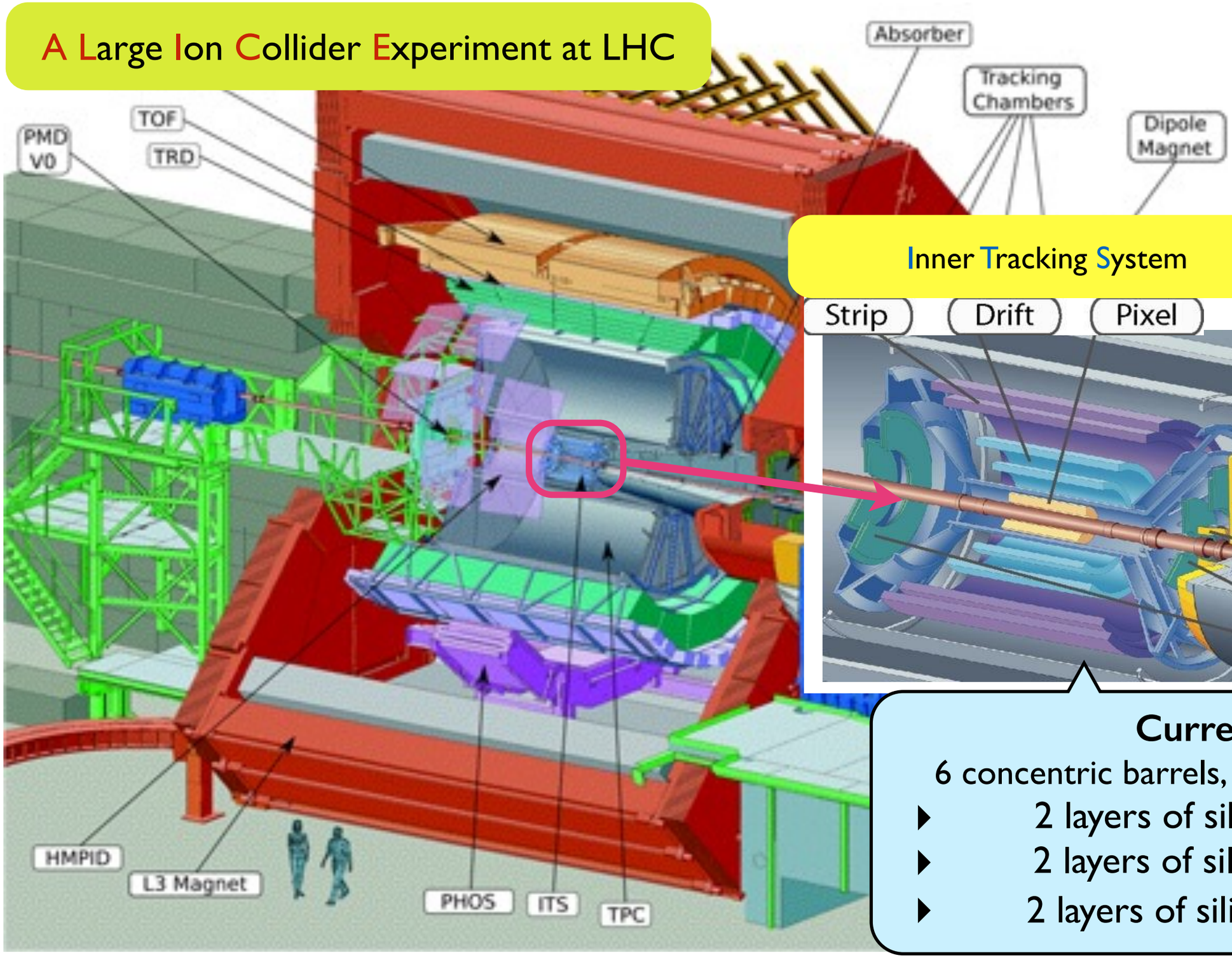
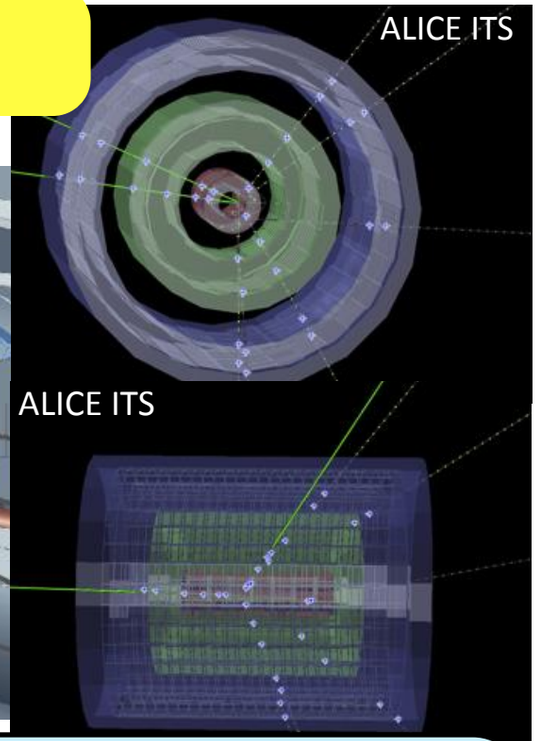
Introduction

ALICE-ITS

A Large Ion Collider Experiment at LHC



Inner Tracking System



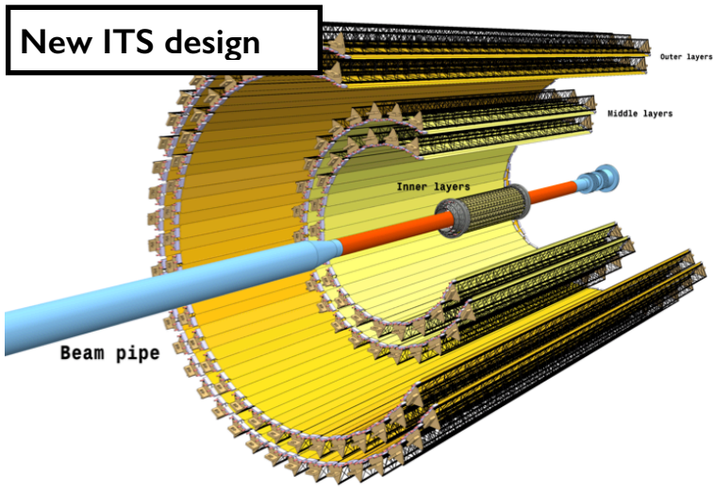
Current ITS

6 concentric barrels, 3 different technologies

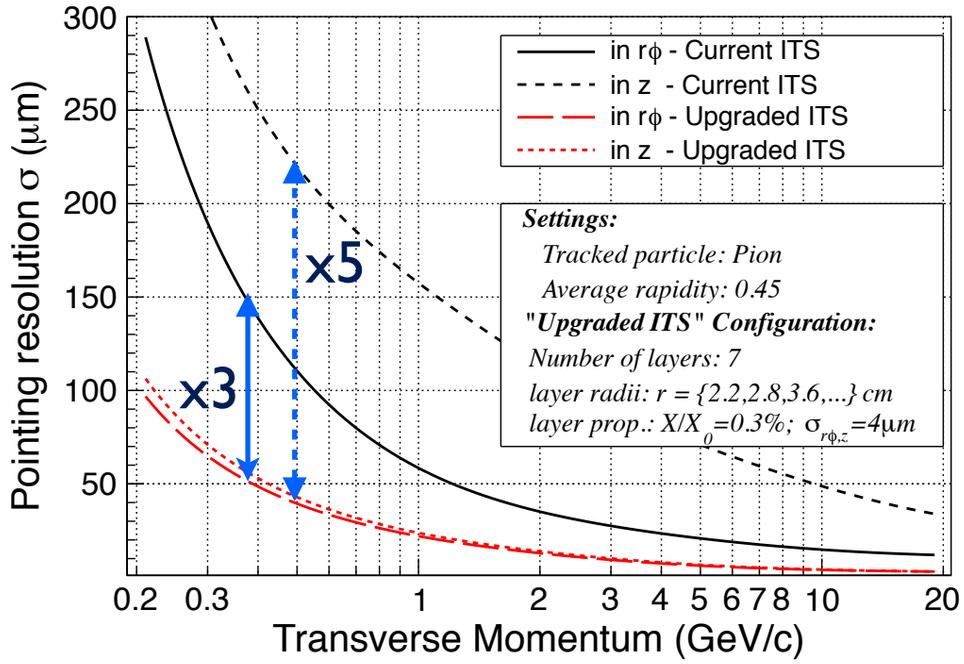
- 2 layers of silicon pixel (SPD)
- 2 layers of silicon drift (SDD)
- 2 layers of silicon strips (SSD)

ITS upgrade project

New ITS design



The Goal of ITS upgrade
- High spatial resolution
- Low-material budget
- Fast data acquisition



	Current	New ITS
# of layer	6 layer	7 layer
Pixel size	50 x 425μm^2	20x20μm^2 , 50x50μm^2
Position of 1st layer	39mm	22mm
Material budget per layer	~1.14% X_0	0.3% X_0
Data readout rate	500Hz , 1kHz	> 50kHz , > 1MHz

ITS upgrade project organization

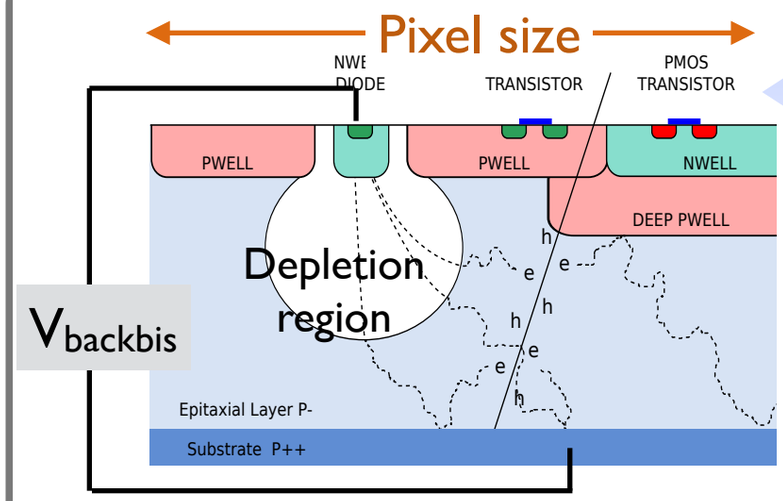
- WP1: Physics
- WP2: Simulation and reconstruction
- WP3: Pixel chip design
- WP4: Sensor post-processing and Mass test pixel
- WP5: Pixel chip characterization test
- WP6: Inner Layer Module
- WP7: Middle Layer Module
- WP8: Outer Layer Module
- WP9: Mechanics and cooling
- WP10: Readout Electronics

Main tasks of PNU
- Measurements of characteristics for the ITS prototype pixel chip
- Building up the test system in Korea
- Physics performance (with Inha Univ.)

Measurement of Characteristics of the ITS pixel chips

ITS test-system

Mono pixel Layout



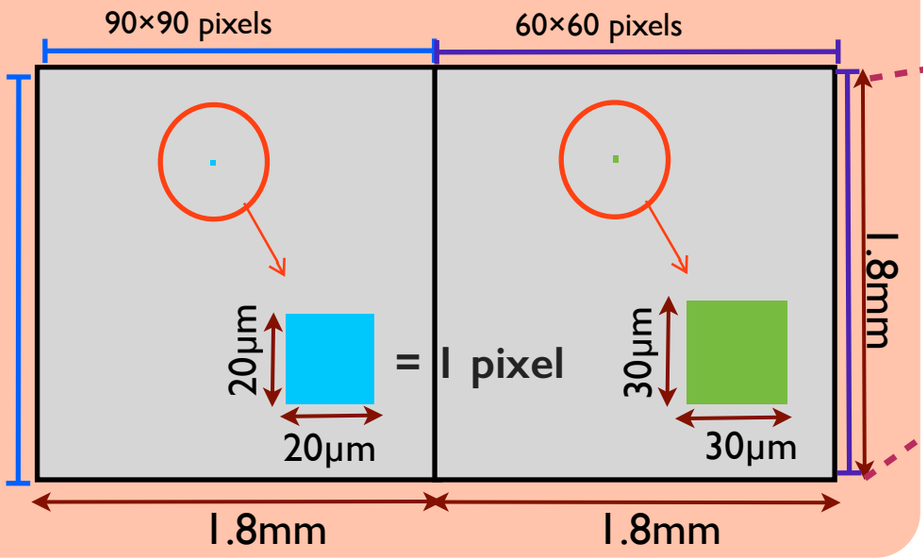
Simple principle

at the p-n junction, a fixed space charge of ionized donors and accepters is created, so called depletion region.

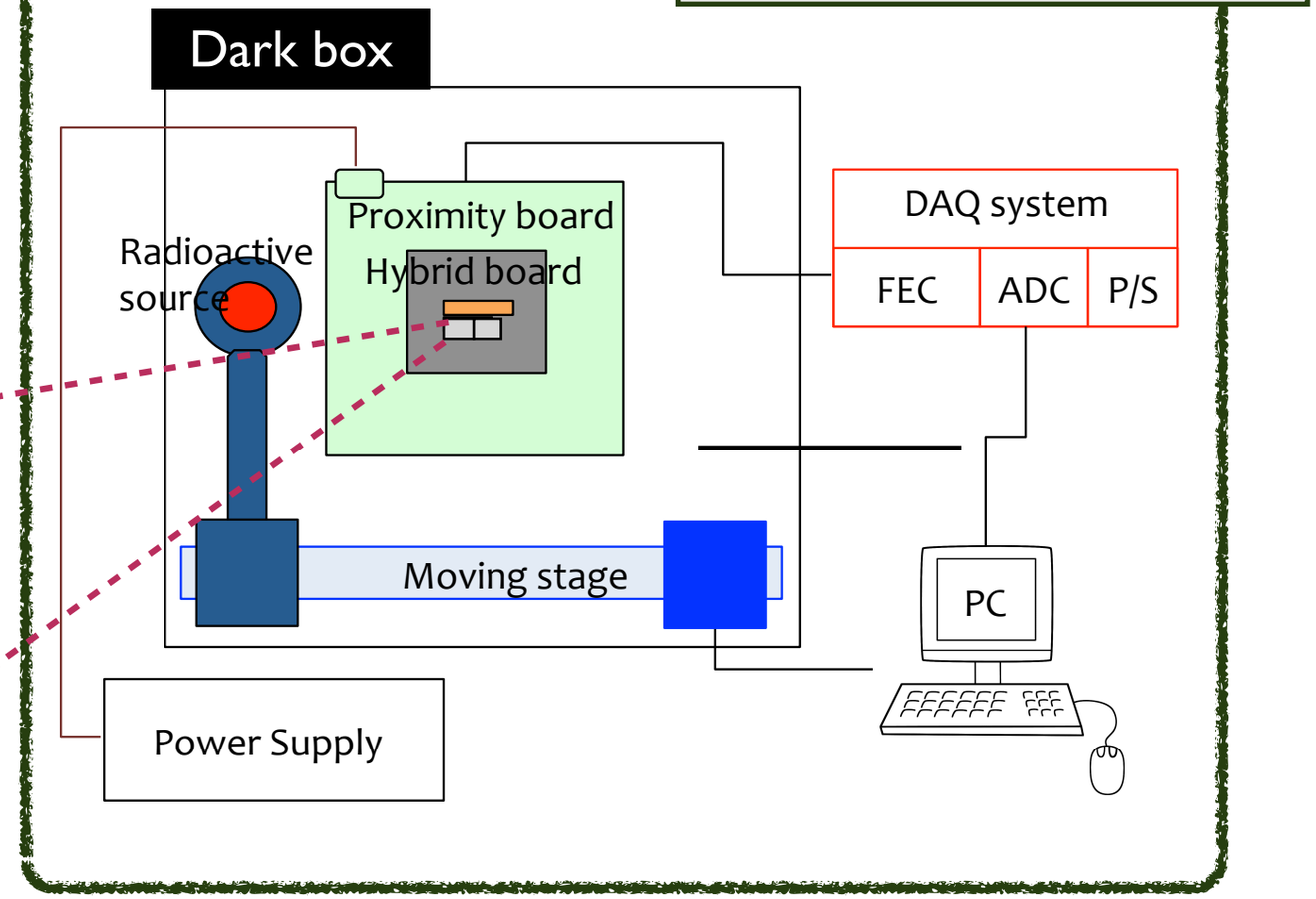
When a Ionizing particle is passing through in the detector, the particle creates electrons. the electrons near a depletion region are collected in n-well diode.
So, the particle position is detected in that way.

*Prototype: Explorer 0

(90x90) + (60x60) = 11,700 pixels in 1 chip



ITS test-system setup



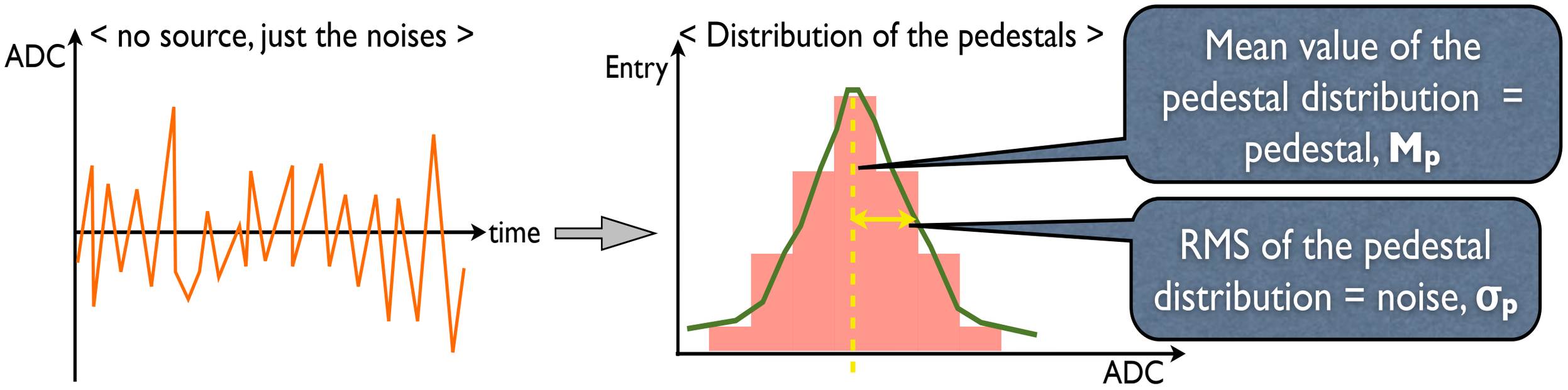
Pedestal measurement

Characterize the pixel chips

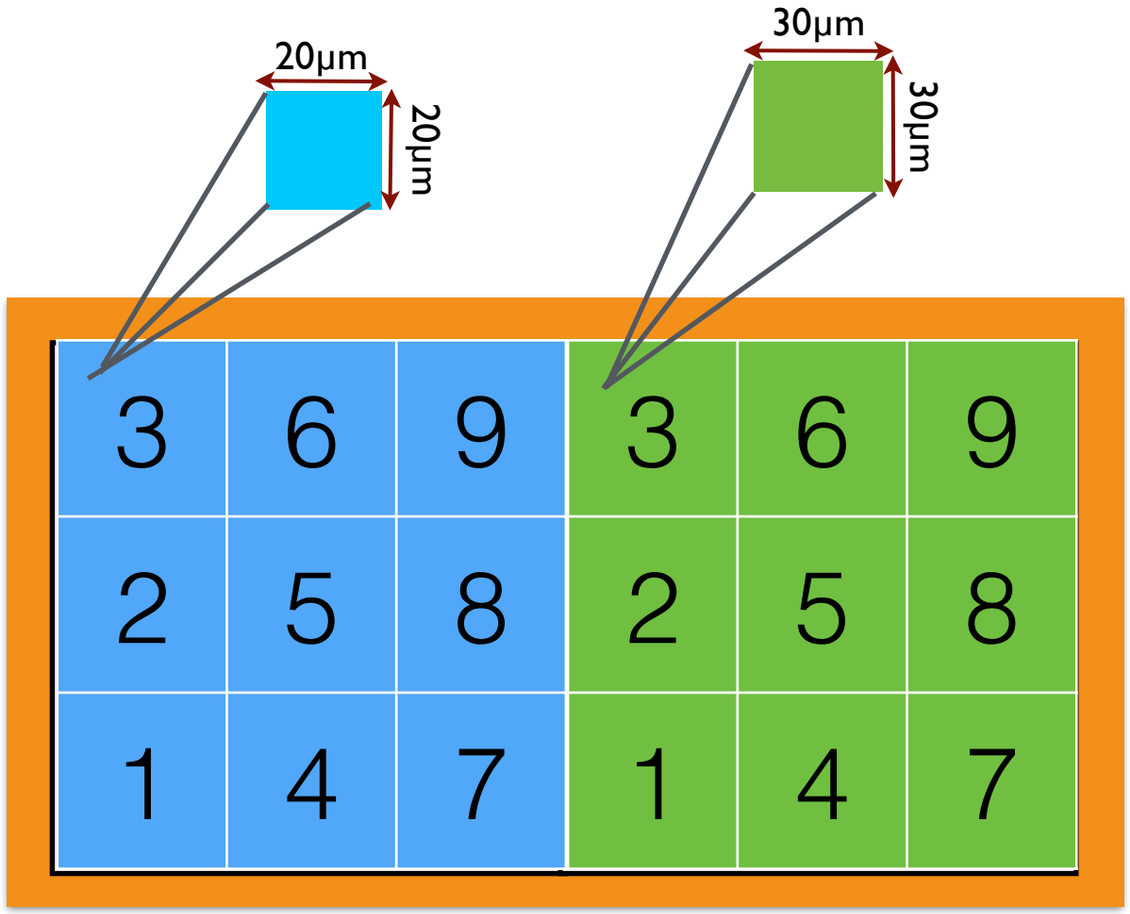
Non-irradiated vs. Irradiated*

- ✓ Noise behavior
- ✓ Charge collection efficiency
- ✓ Position resolution
- ✓ Detection efficiency

* Radiation level : 1 x 10^{13} [1MeV n_{eq} /cm^2]
- including a safety factor of 10 in the whole detector lifetime(for a collected data set corresponding to 10 nb^{-1} Pb-Pb and 6pb^{-1} pp collisions)



Anode type

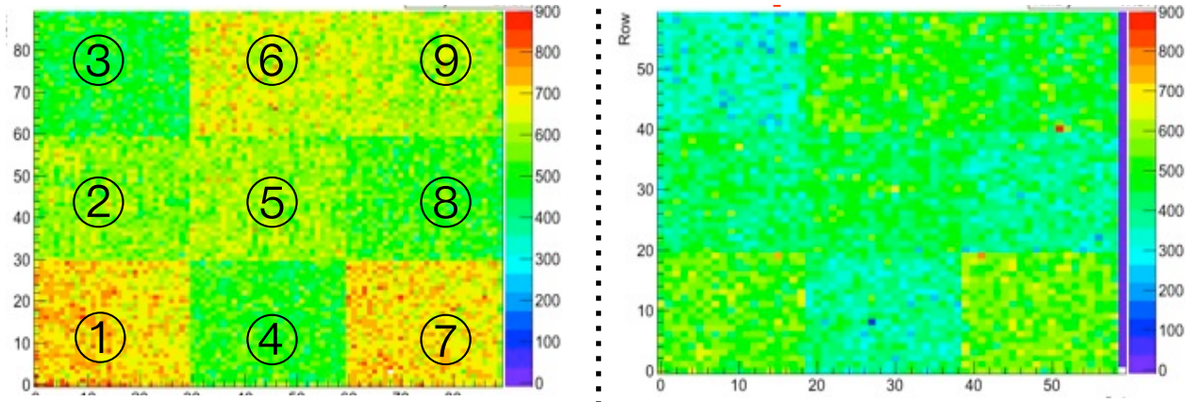
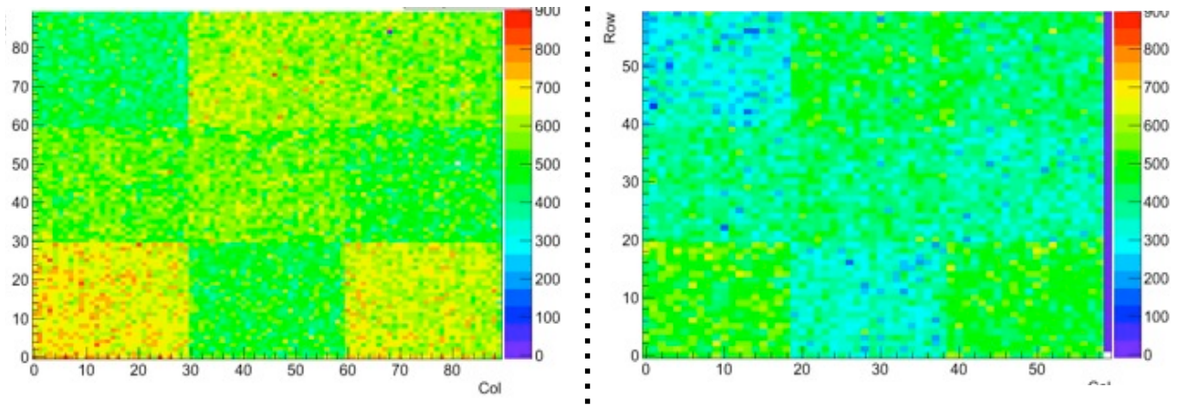


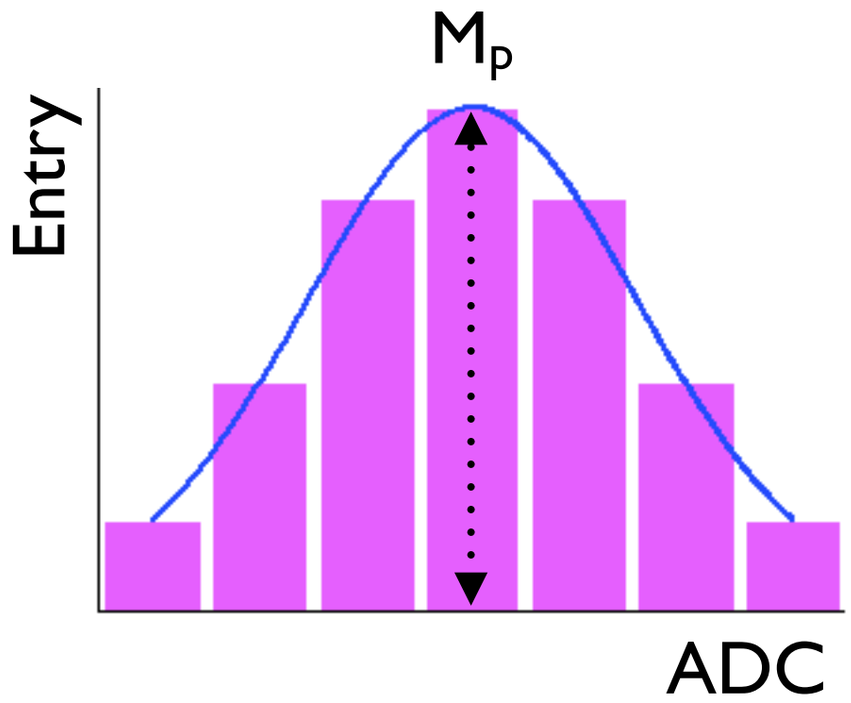
in one chip

Shape	Anode diameter [μm]	Spacing [μm]	Sectors
	2	0	1
	3	0	2, 8
	4	0	3
	3	0	4
	3	0.6	5
	3	1.04	6, 9
	2	1.54	7

Pedestal distribution

Measurement #10. in room temperature not stabilized

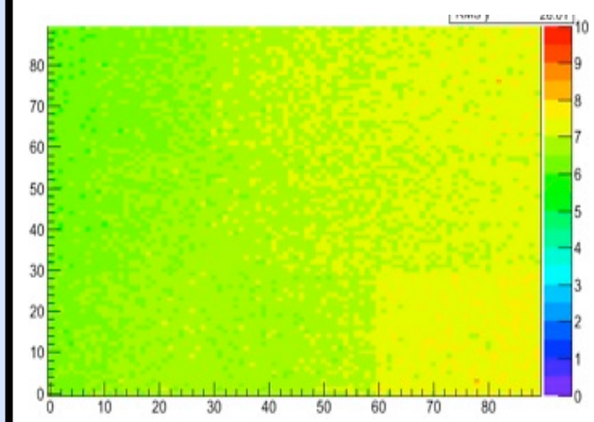
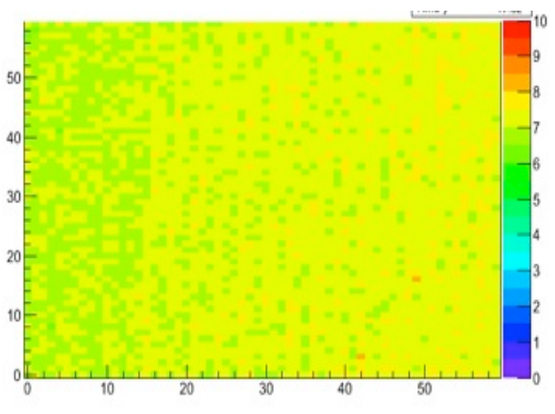
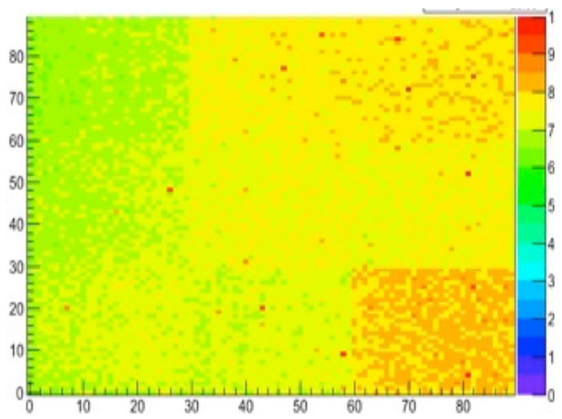
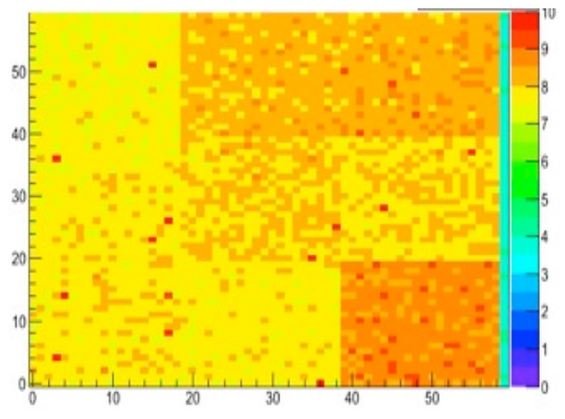
Analysis	Mp	
pixel size	20x20μm^2	30x30μm^2
Non-irradiated (not damaged)		
Irradiated (damaged)		

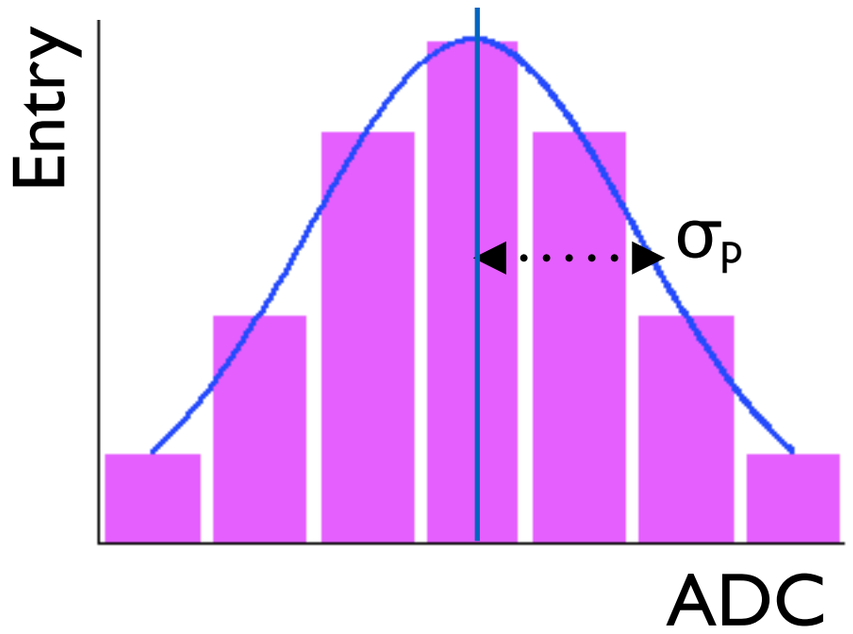


- Difference as the pixel sizes, anode types.
- No big difference of non-irradiated and irradiated pixel chip

Noise distribution

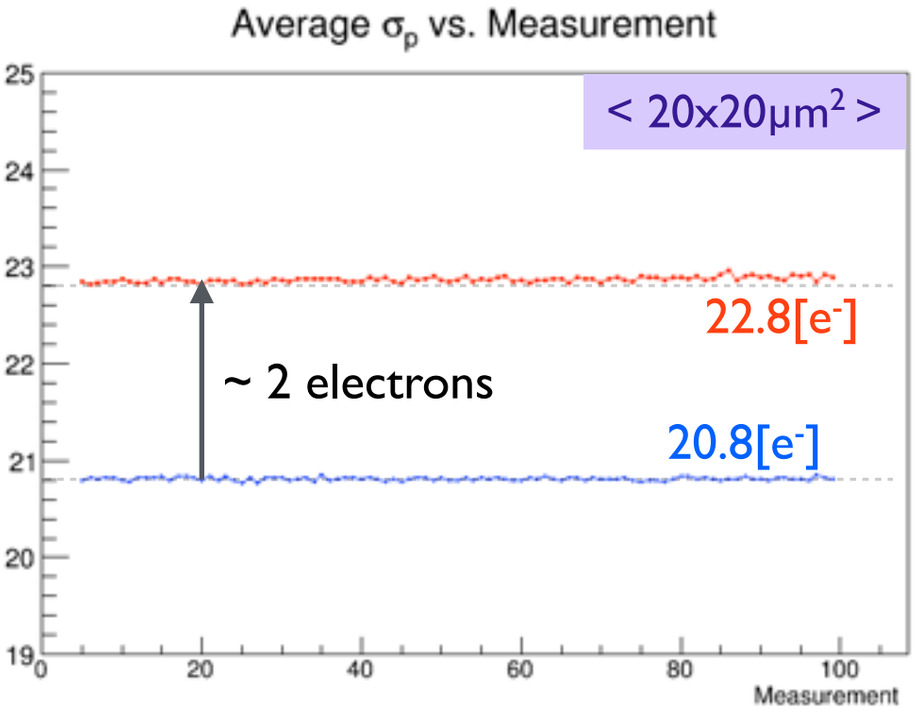
Measurement #10. in room temperature not stabilized

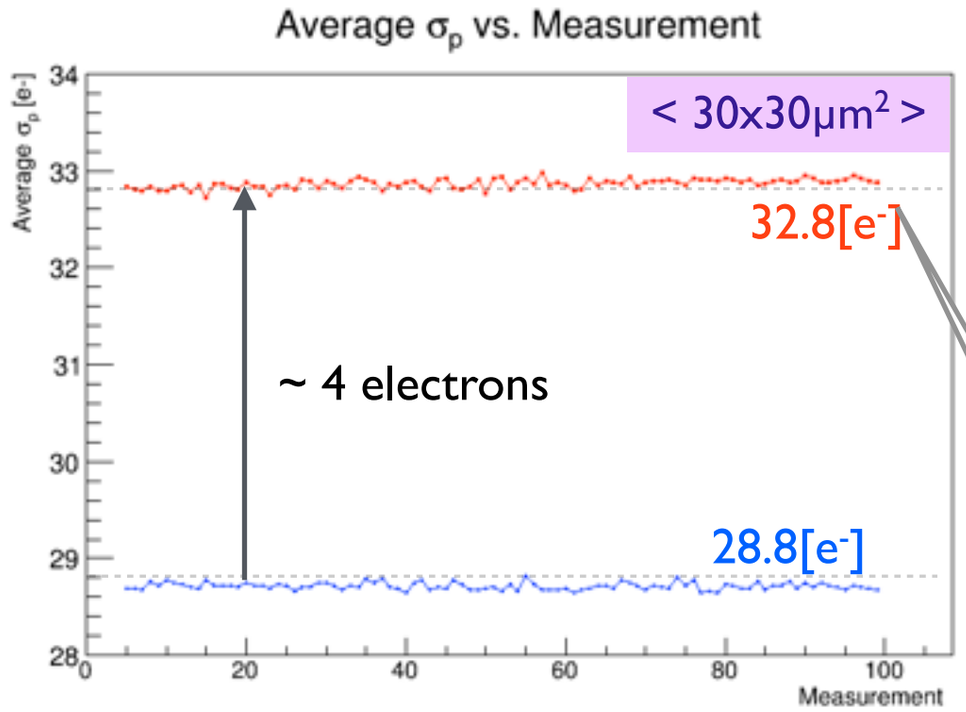
Analysis	σ_p	
pixel size	20x20μm^2	30x30μm^2
Non-irradiated (not damaged)		
Irradiated (damaged)		



- In σ_p, Visible radiation effect

Average σ_p in Sector #6



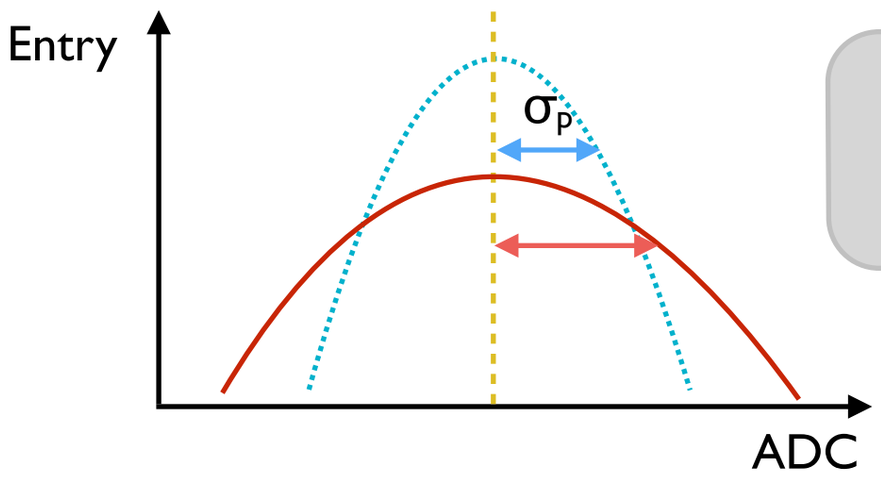


non-irradiated

irradiated

▸ Higher σ_p after Irradiation

< Distribution of pedestal >

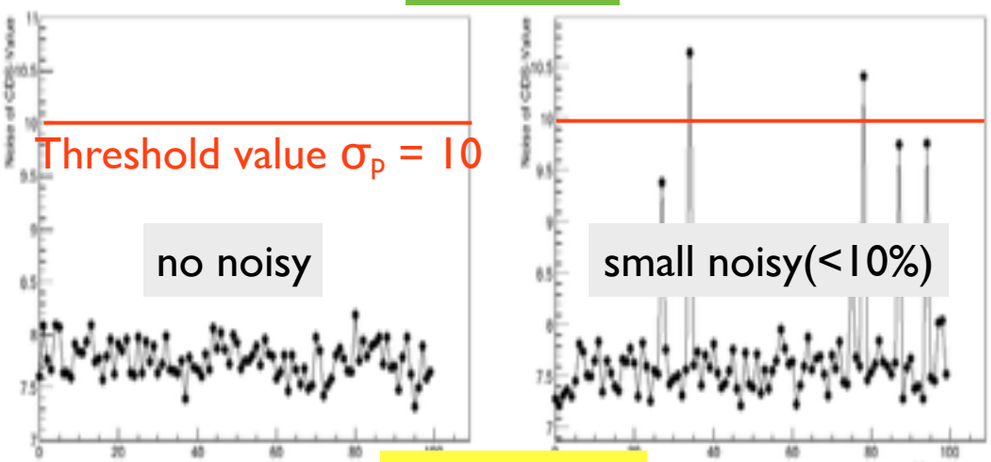


⇒ **Broadened pedestal after irradiation**

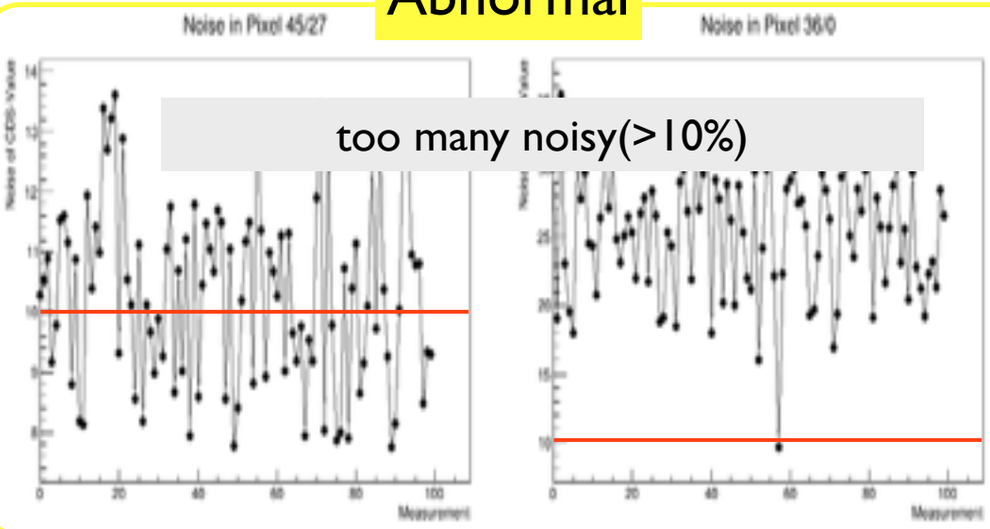
Noisy pixel Classification

✳ Noisy pixel: the Pixel with σ_p > 10 ADC, (about 40e^-)

Normal



Abnormal



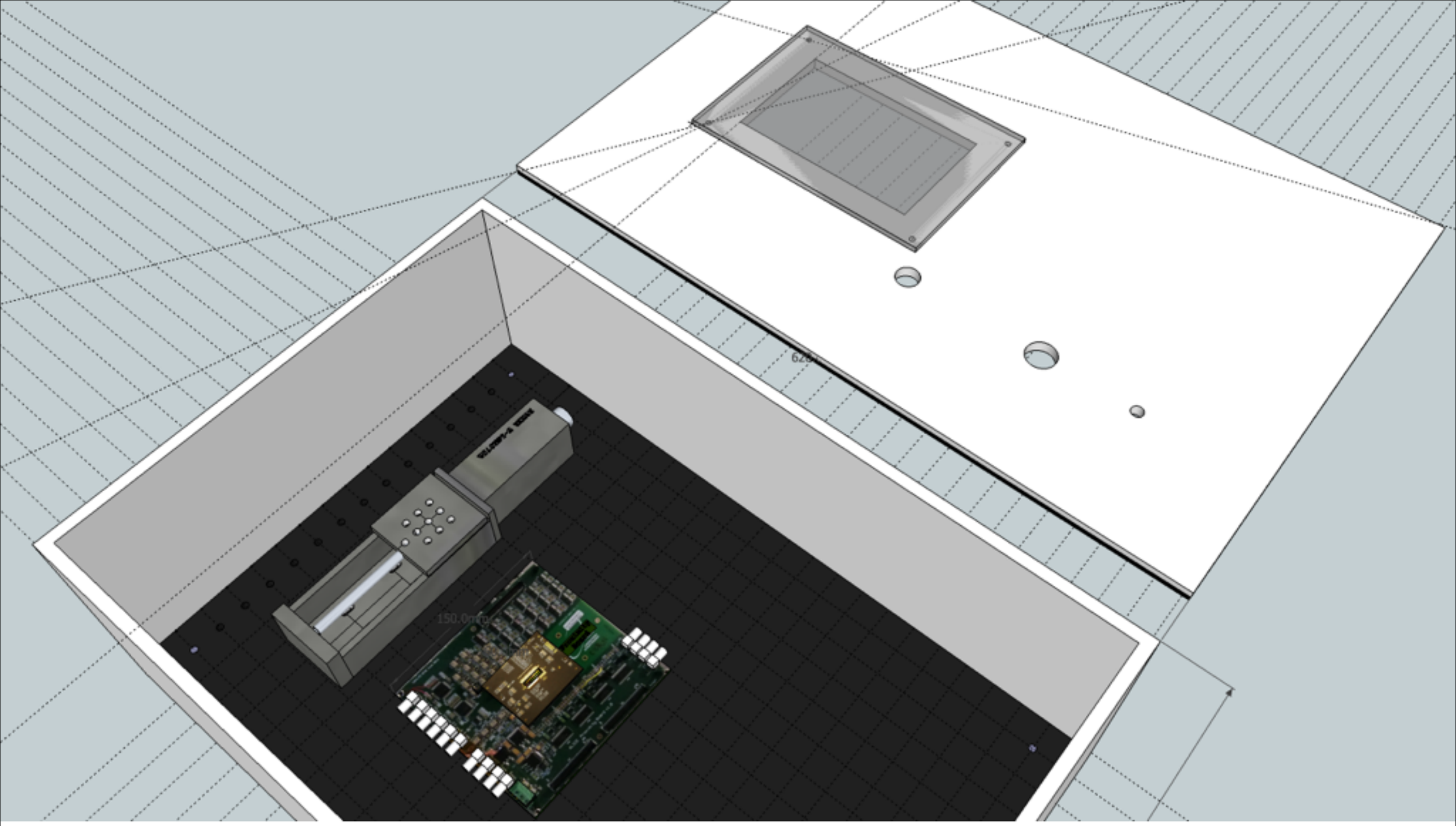
- Before irradiation
- After irradiation

Pixel size	20 x 20 μm^2		30 x 30 μm^2	
Kind	Normal	Abnormal	Normal	Abnormal
Before	99.96%	0.04%	100%	0%
After	99.91%	0.09%	99.69%	0.31%

⇒ Almost no effect after irradiation

Summary & Outlook

- Get started the R&D of the new ITS upgrade project: measurement of characteristics of the ITS prototype pixel chip.
  - Broaden pedestal after radiation
  - Abnormal pixel ratio is ignorable.
- Building up a characteristic measurement system for the pixel chips in PNU.



Thank you