Prepared for submission to JINST

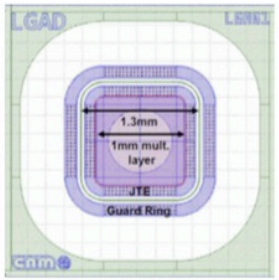
# Beam test measurements of Low Gain Avalanche Detectors single pads and arrays for the ATLAS High Granularity Timing Detector

JC107
Yuzhen Yang
2019-5-17

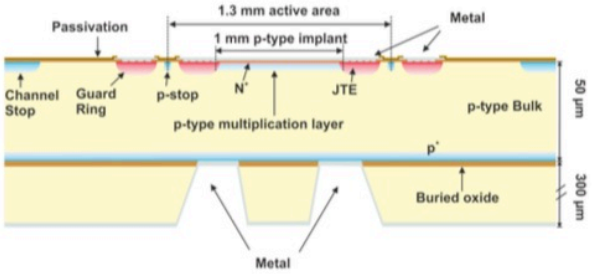
# Introduction

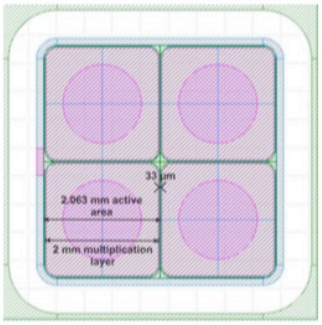
- Low Gain Avalanche Detector (LGAD): 50um
- Single pad: 1.3mm*1.3mm
- 2x2 pads: 2mm*2mm
- 3x3 pads: 3mm*3mm
- Different implant doses of the p+ multiplication layer
- Beam: pion beam of 120GeV at the CERN SPS
- Result: Time resolution
  - 40ps for a gain of 20
  - 27ps for a gain of 50
  - Fulfil the HGTD requirements

# Sensor and electronics

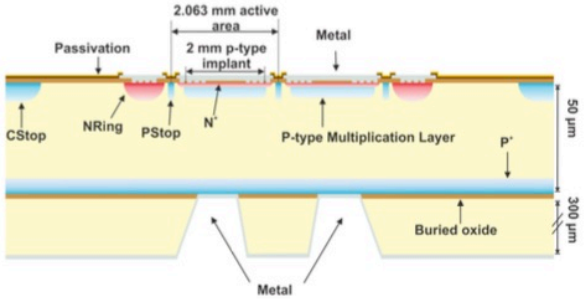


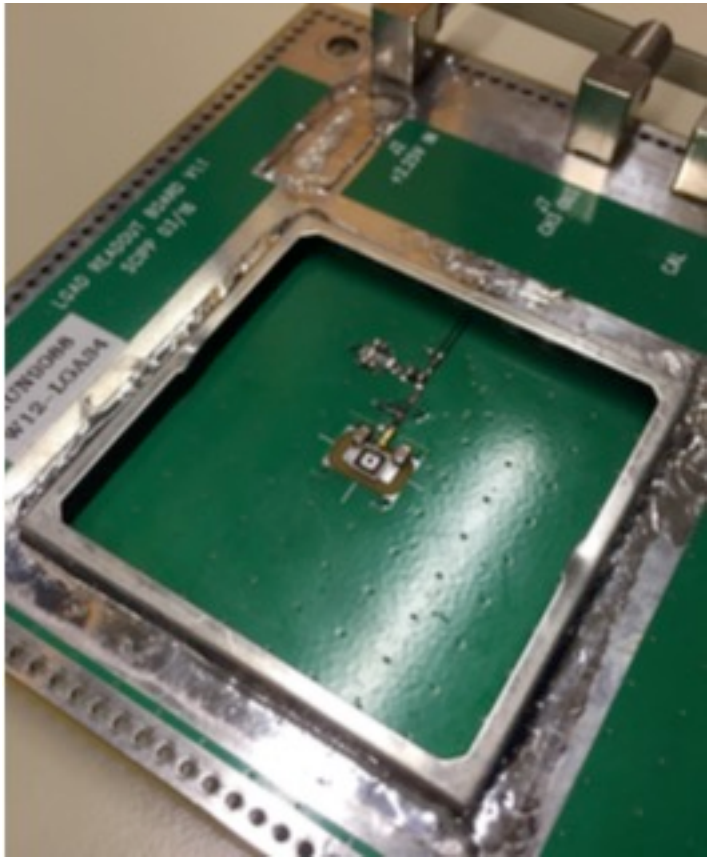

**Single Pad LGA**



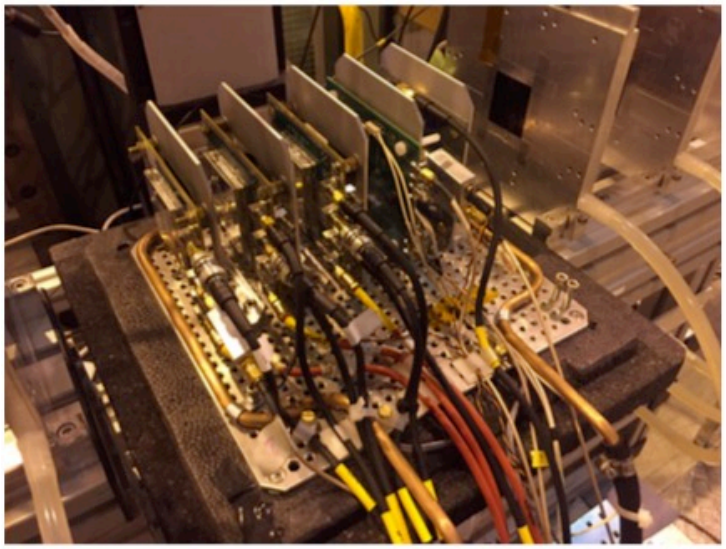




**2x2 Pad Array**

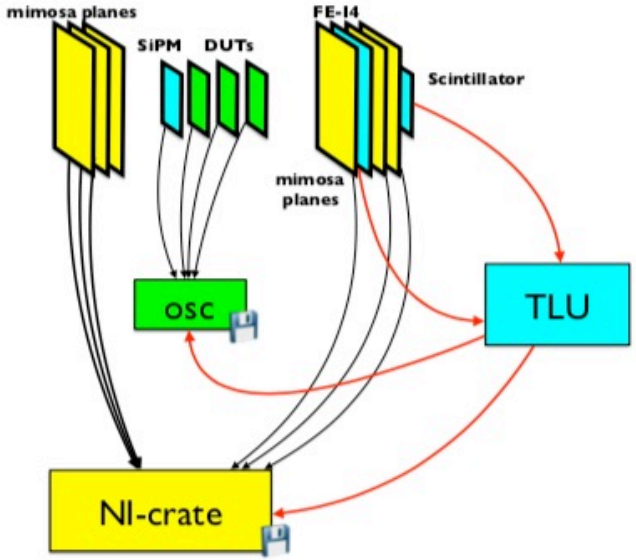


# Data reconstruction and analysis methods



(a) Sensors under test

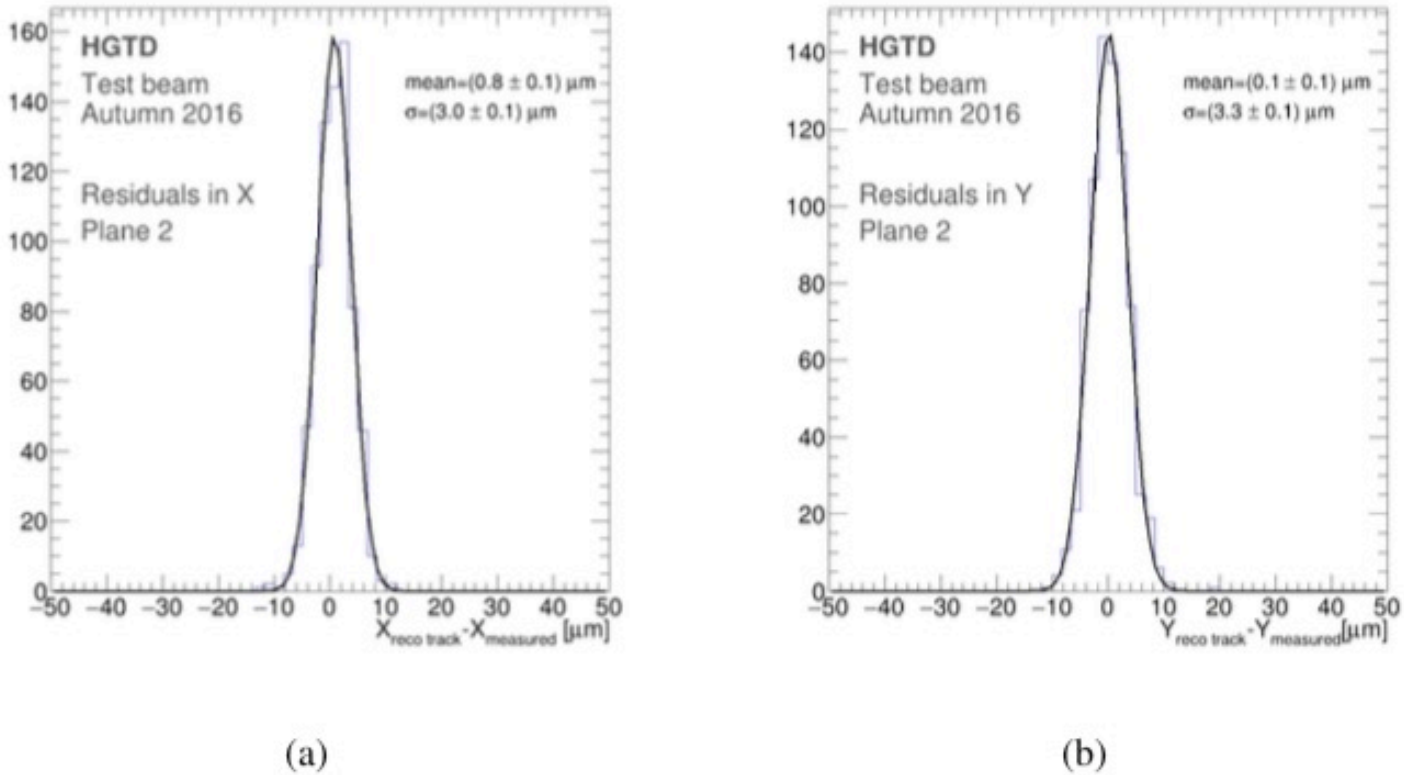



(b) Data acquisition setup

**Figure 5**: Picture (a) of the sensors under test on the movable table and drawing (b) of the beam test data acquisition setup

Agilent Infiniium DSA91204A oscilloscope with:
40 GSample/s sampling rate;
a bandwidth of 12GHz;
the bandwidth of 2GHz for data taking, in order to reduce high frequency noise contributions.
Xin: Could you explain briefly how the “Oscilloscope data” is reconstructed?

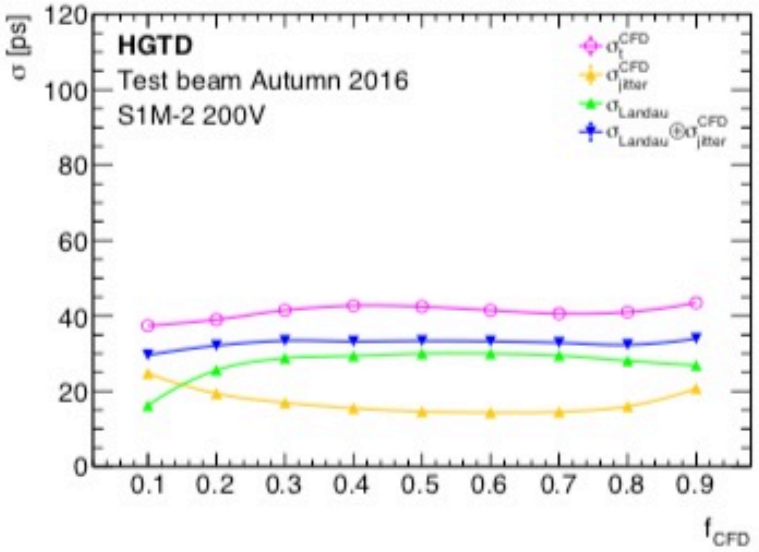
# Result



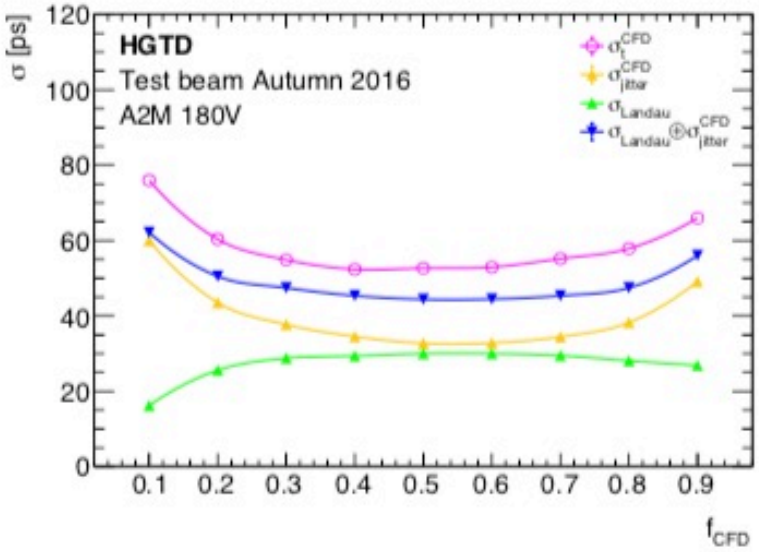

(a) (b)

**Figure 6**: The residuals after the tracking procedure in the MIMOSA plane 2 for the horizontal (a) and vertical (b) directions.

# CFD method



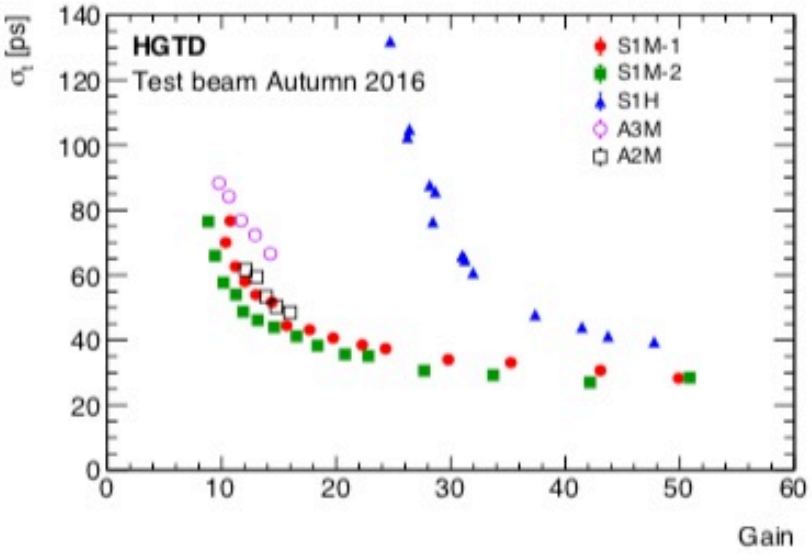

(a)



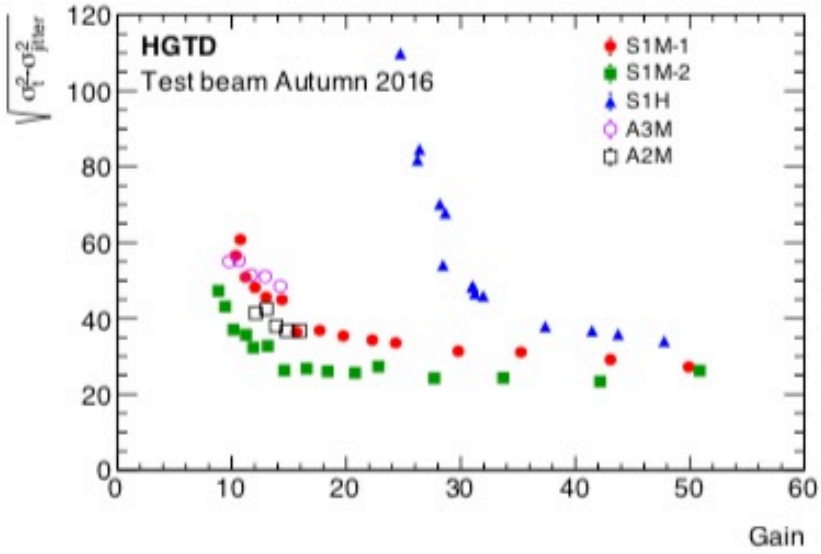

(b)

**Figure 18**: Time resolution for the CFD method $\sigma_t^{\mathrm{CFD}}$ as a function of the constant fraction parameters compared with the predictions for S1M-2 (a) and A2M (b). The term $\sigma_{\mathrm{Landau}}$ is computed with `Weightfield2` [15, 16], while $\sigma_{\mathrm{Jitter}}^{\mathrm{CFD}}$ is estimated from data (see Section 5.1.2).

# Result




(a)

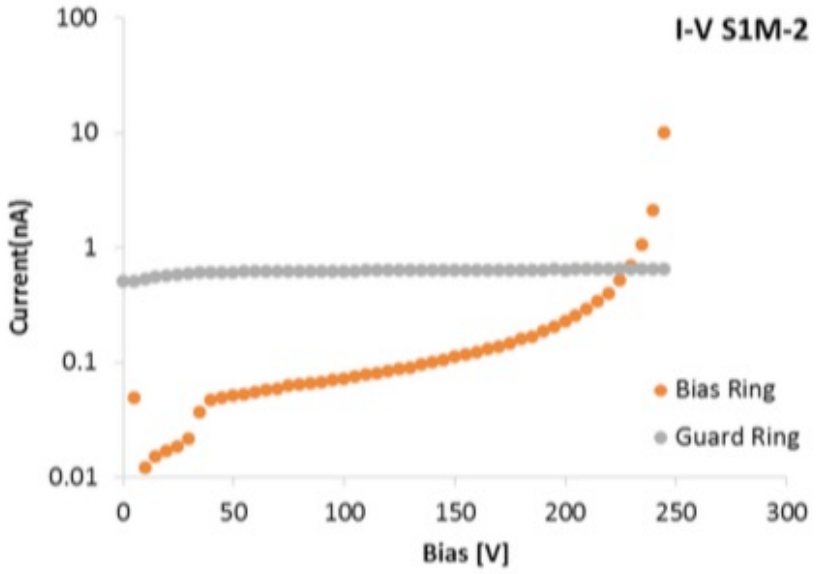



(b)

**Figure 20**: Time resolution using the ZCD method (a) and $\sigma_t^{ZCD} \ominus \sigma_{jitter}^{ZCD}$ (b) as a function of the gain for single pad sensors and arrays. Statistical uncertainties are negligible and smaller than the marker size.

# Question

Yuhang:
In Fig.2, what's the difference between bias ring and guard ring? The guard ring can avoid the collection of charges which come from the outer part of the sensor. But why the breakdown voltage will change?
A:



# Question

Kai:

1.page 3(of the document), last line, why they use neutron equivalent fluence while for the pp collision experiment, the incident particle of HGTD is dominated by proton, pion, kaon, etc?

A: Yes, Why?

2.they used pion beam to perform the test, is it enough already or in the future, we still need test it with other type beams, such as proton, electron, or even neutral source beams?

A: In my opinion, we also need to test it with other type to beams.

# Question

Amit:
My question is: What CFD method is used to reconstruct the timing?
https://en.wikipedia.org/wiki/Constant_fraction_discriminator

Is there any specific CFD method for each experiment or CFD algorithm is universal for timing resolution detector?
A: I think it is not specific.