AC-LGAD test setup using Infrared (IR) Laser at UIC:

Personnel : Shirsendu Nanda, Danush Shekar

Motor

Micro step size ~ 0.047625 µm

Oscilloscope

1GHz bandwidth

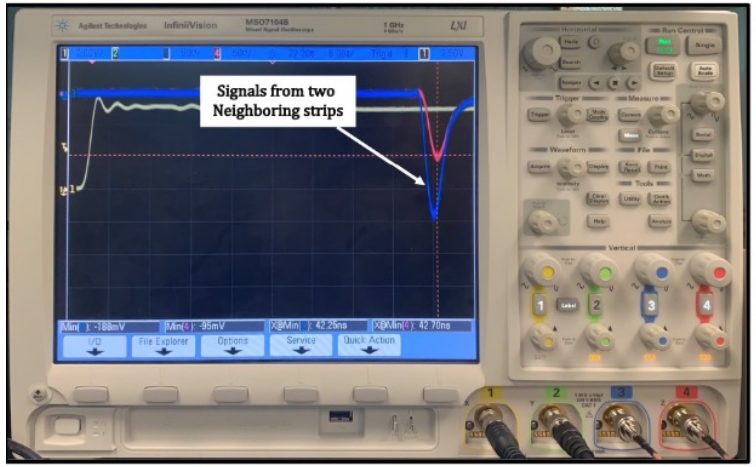
Sampling rate 4GSa/s

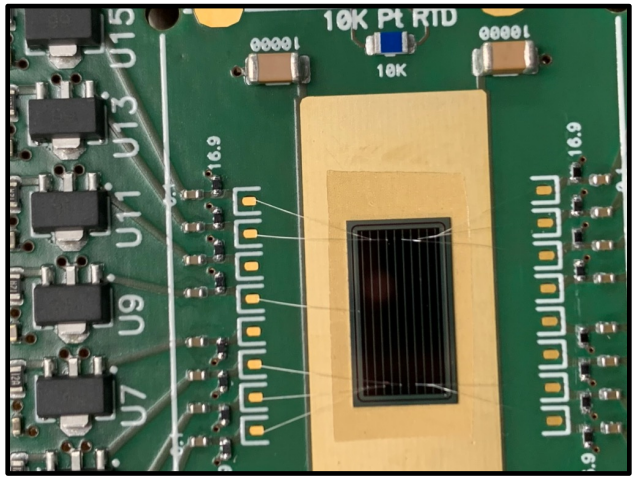
IR Laser

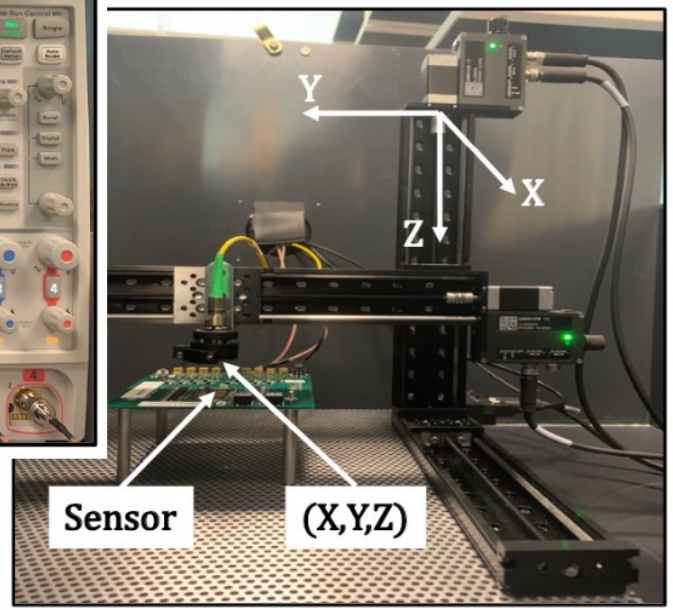
Wavelength ~ 1060 nm

Timing jitter (< 3ps rms)

- Using laser, we can study
  - signal characteristics
  - charge sharing
  - timing and position resolution
- Calibrate the laser to reach signal size comparable to MIP (120 GeV proton)
- Understand the characteristics of the HPK sensor before the upcoming test beam campaign

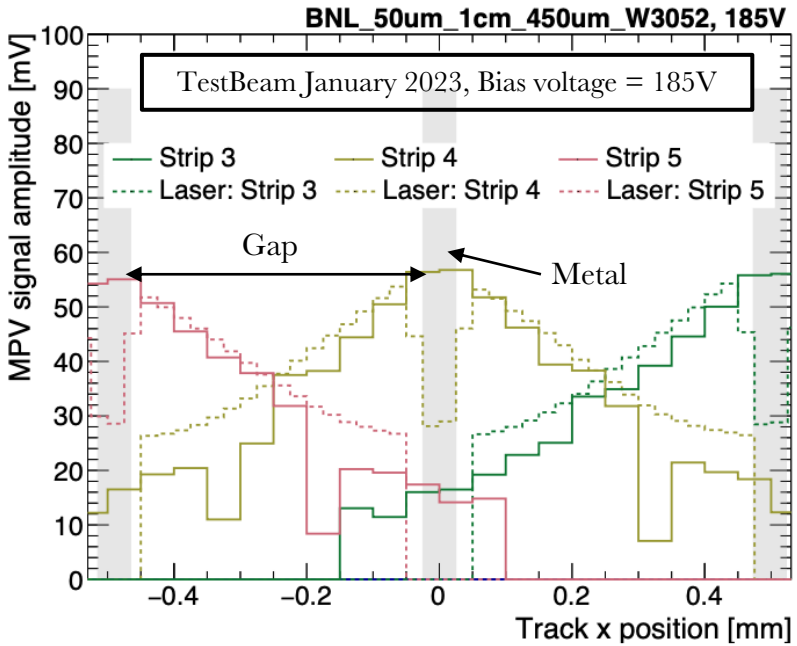






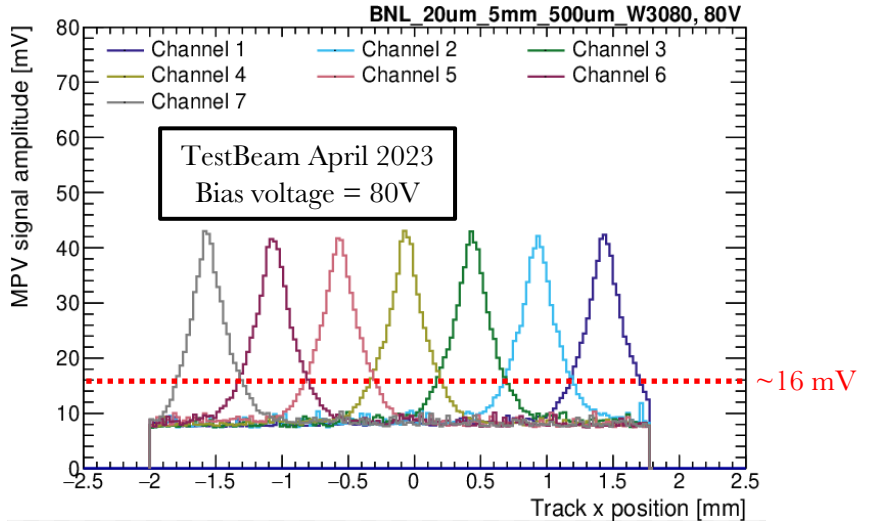
Laser calibration :

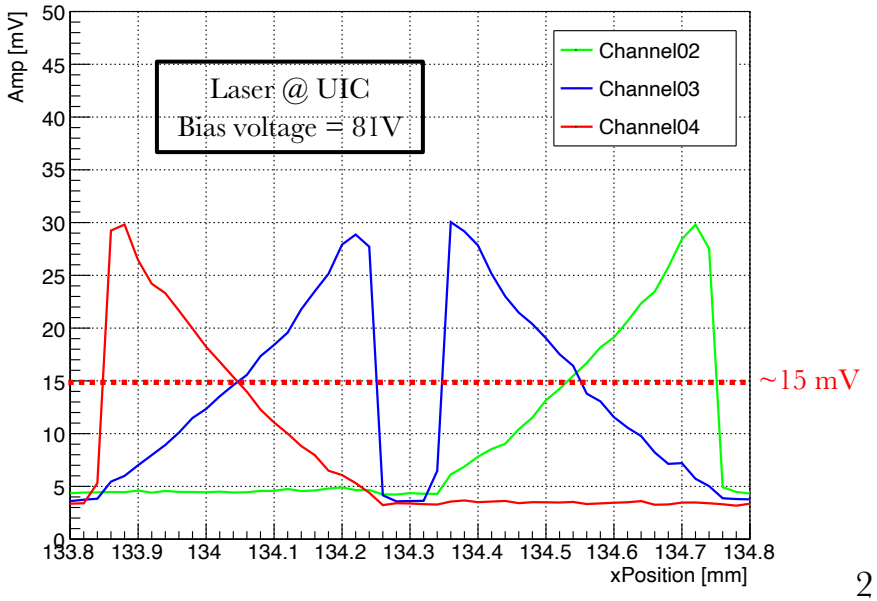
- Laser is tunned such that signal size in the middle of the gap is similar like test beam
- Compared the signal size at several position in the gap with test beam results
- BNL 50 um thick, 1 cm long with 450 um gap (50 um metal) sensor used for the calibration



independent measurement of signal size

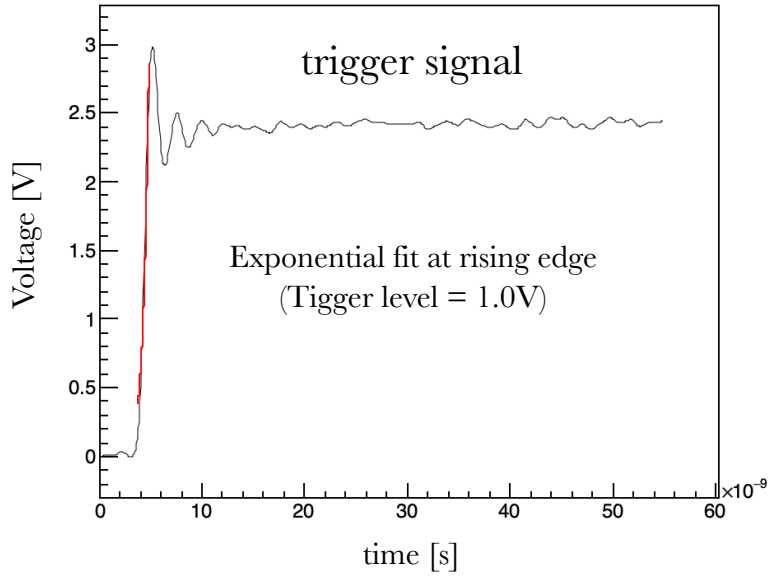
20 um thick, 5 mm length, 500 um pitch, 100 um metal

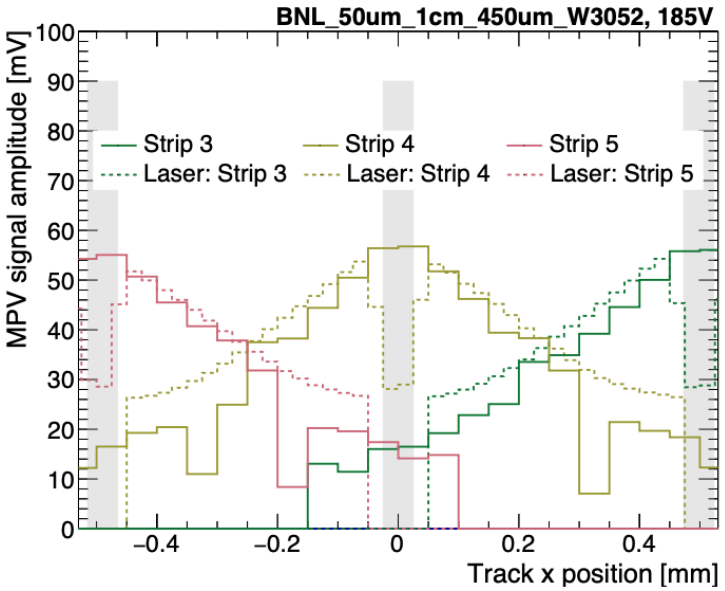


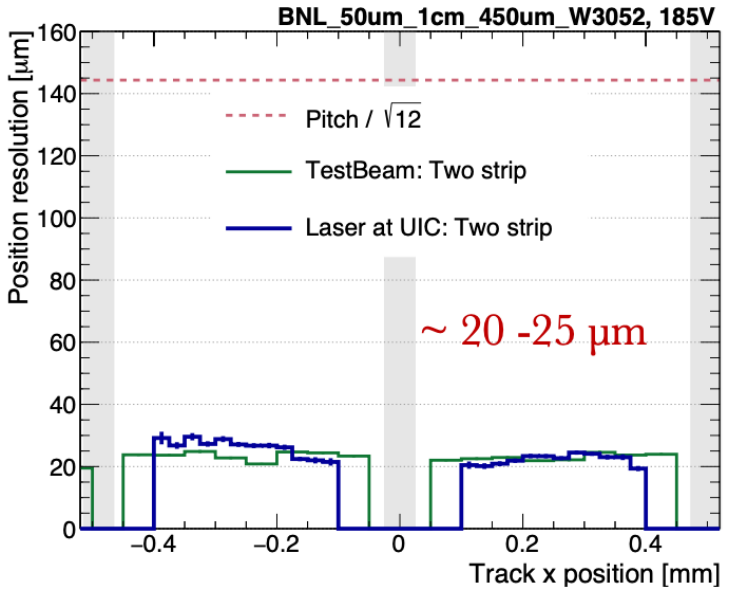


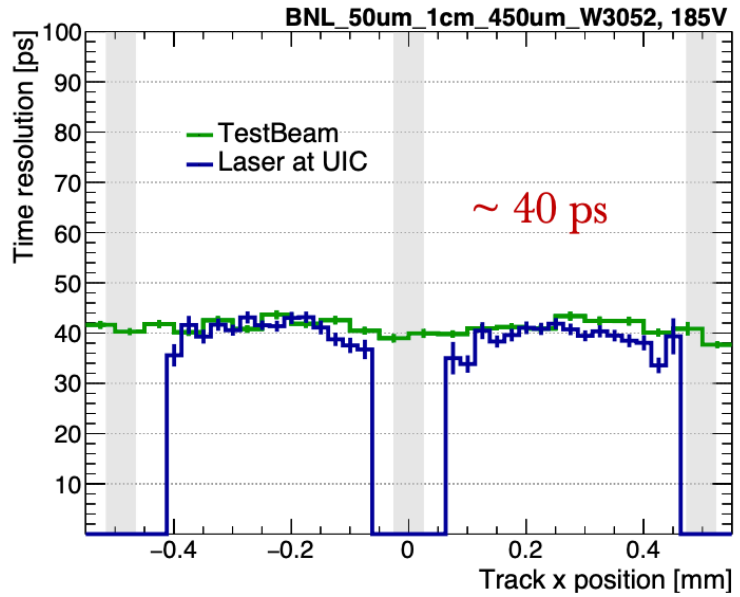
Position and timing resolution using laser:

- Analysis method is very similar like test beam data analysis for the strip sensors
- Only two-strip reconstruction at the gap region due to signal sharing
- Trigger time for a fixed trigger level used as time reference; internal trigger is being used
- time difference = CFD of 20% - Trigger time
- Position dependent time delay correction is performed
- Position and time resolution compared to test beam results
- Results shown for BNL 50 um thick, 1 cm long with 450 um gap (50 um metal) sensor





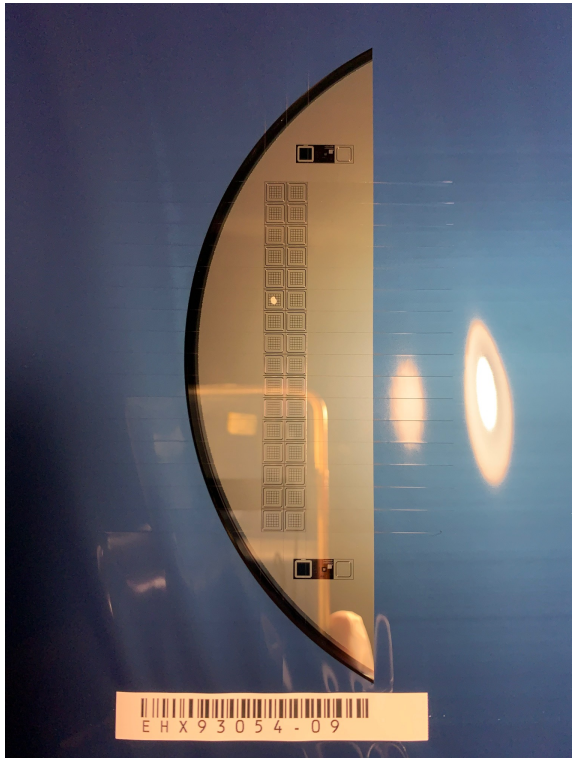


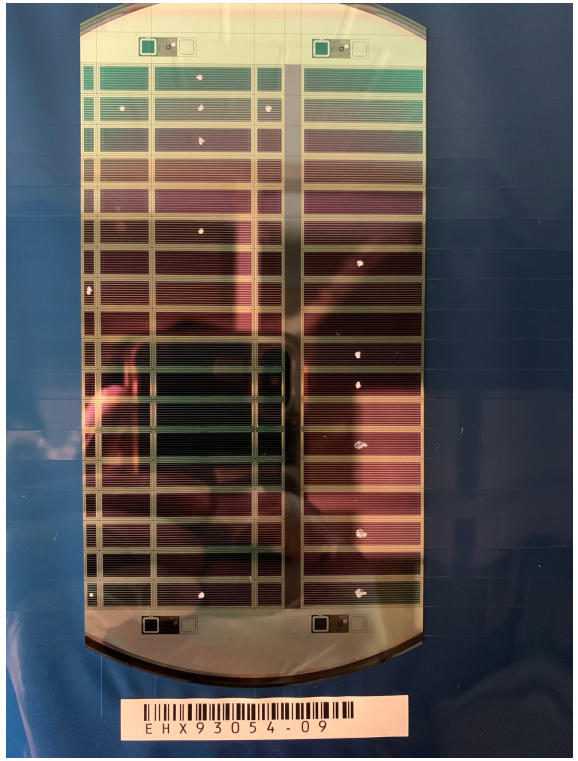


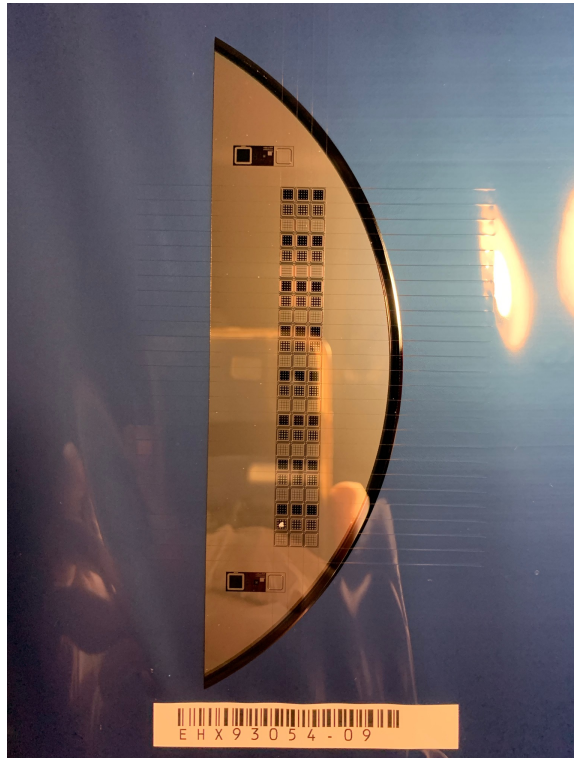
HPK sensors:

n+ resistivity	active thickness	AC capacitance
E-type	50um	240pF/mm2
C-type	50um	240pF/mm2
E-type	50um	600pF/mm2
C-type	50um	600pF/mm2
E-type	20um	600pF/mm2
C-type	20um	600pF/mm2

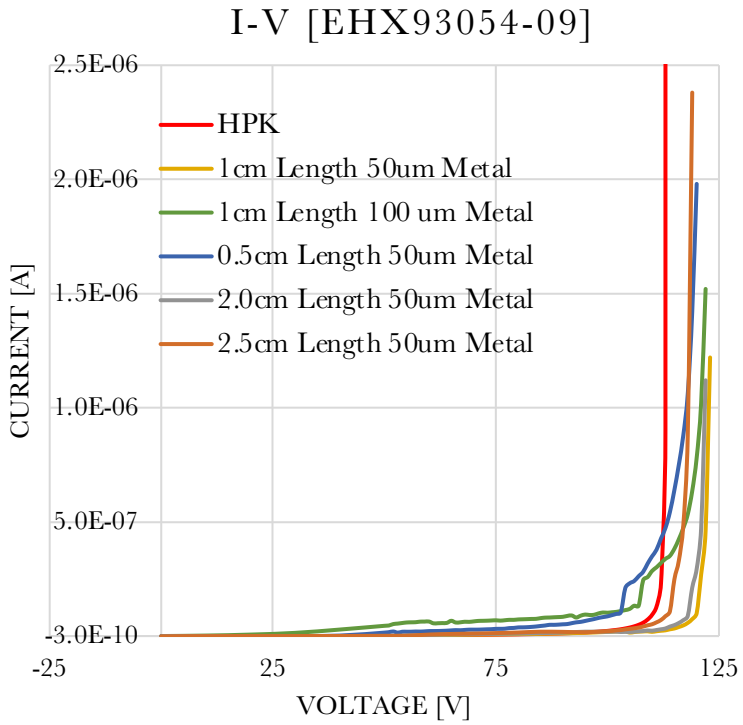
Sensor Name	Type	Electrode pitch		Electrode size	
		x [um]	y [um]	x [um]	y [um]
EIC 25mm strip wide	Strip	25000	500		100
EIC 25mm strip narrow	Strip	25000	500		50
EIC 20mm strip wide	Strip	20000	500		100
EIC 20mm strip narrow	Strip	20000	500		50
EIC 10mm strip wide	Strip	10000	500		100
EIC 10mm strip narrow	Strip	10000	500		50
EIC 5mm strip wide	Strip	5000	500		100
EIC 5mm strip narrow	Strip	5000	500		50
EIC 5x5 pixel	Pixel	500	500	450	450
EIC 4x4 pixel (450um elec)	Pixel	500	500	450	450
EIC 4x4 pixel (300um elec)	Pixel	500	500	300	300
EIC 4x4 pixel (150um elec)	Pixel	500	500	150	150

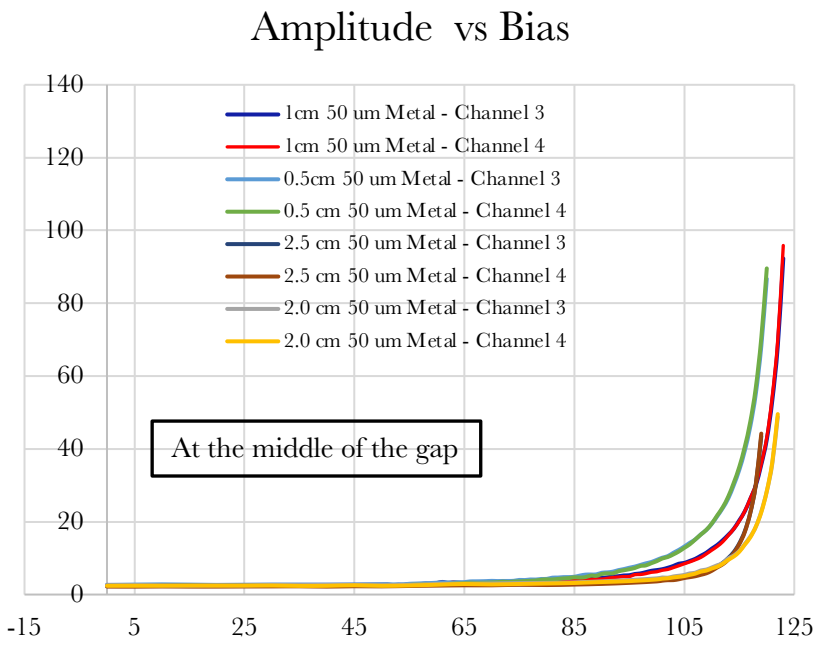


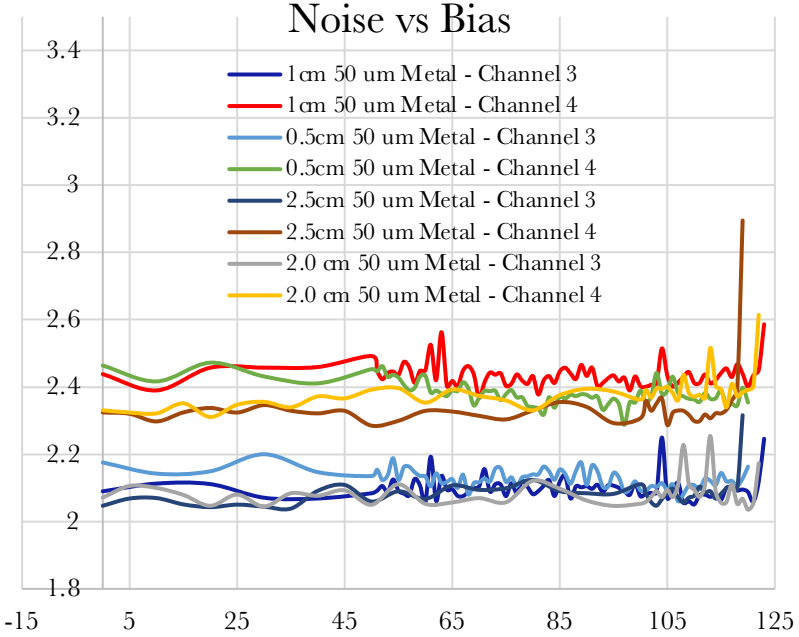




Testing HPK sensors using laser:





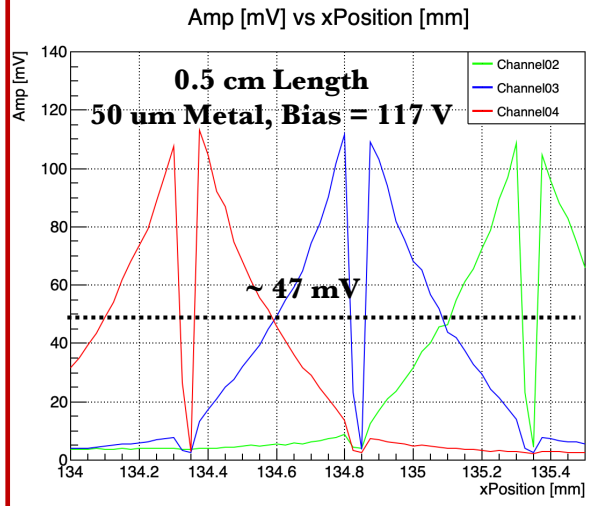


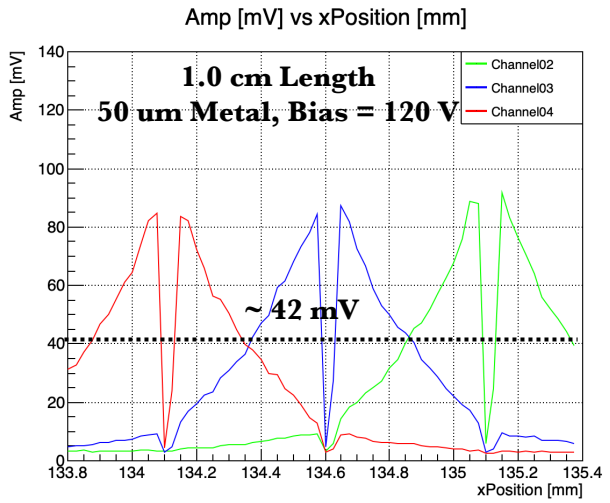
- E-type n+ resistivity, 20 um thick sensors with 600 pF/mm^2 AC-capacitance
- Four different length sensors (5mm, 10mm, 20 mm, and 25 mm) with two different metal width (50 um and 100 um)
- Operating bias voltage determination based on current and noise value
- Near breakdown noise and current value rises significantly
- Operating bias voltage 2 - 3V below breakdown

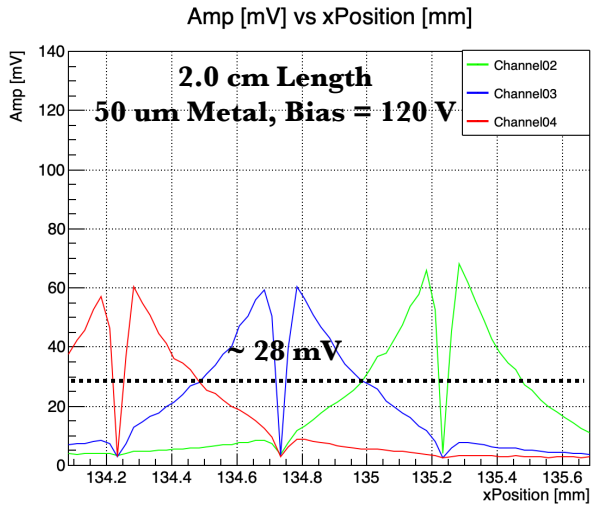
Comparing signal size for different HPK sensors (500 um pitch, 20 um thick) using laser:

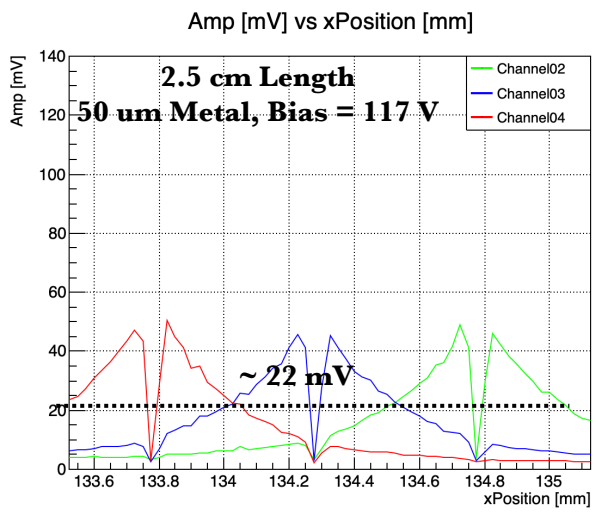
Metal width variation

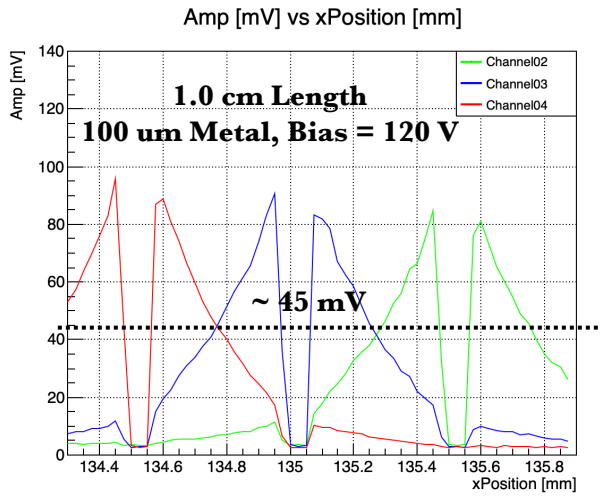
Length variation







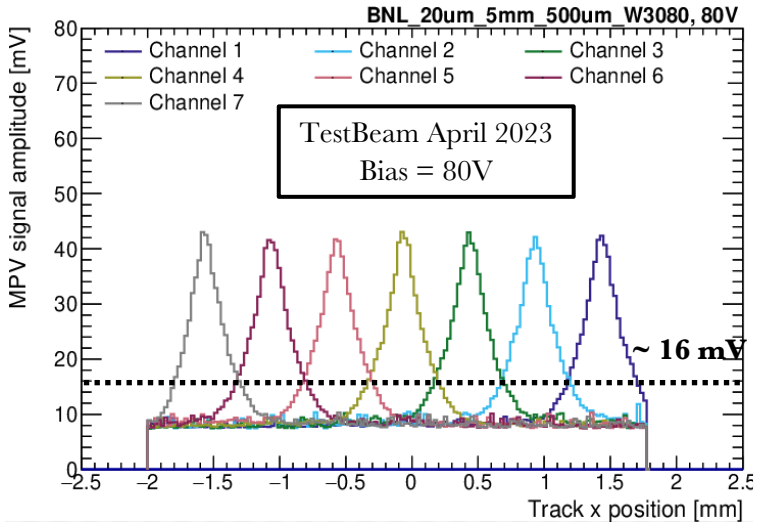


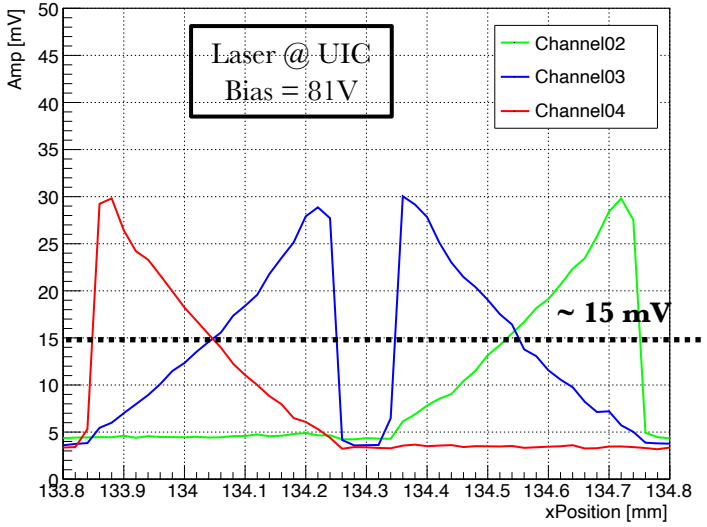


Comparing signal size for different BNL and HPK sensors:

BNL

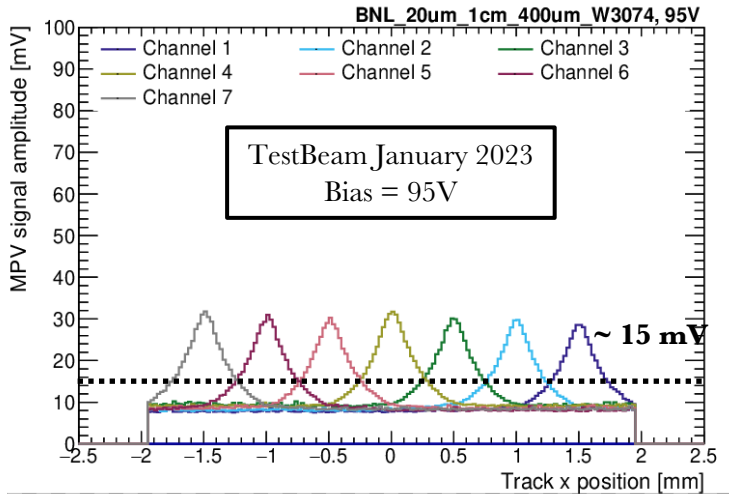
20 um thick, 5 mm length, 500 um pitch, 100 um metal





BNL

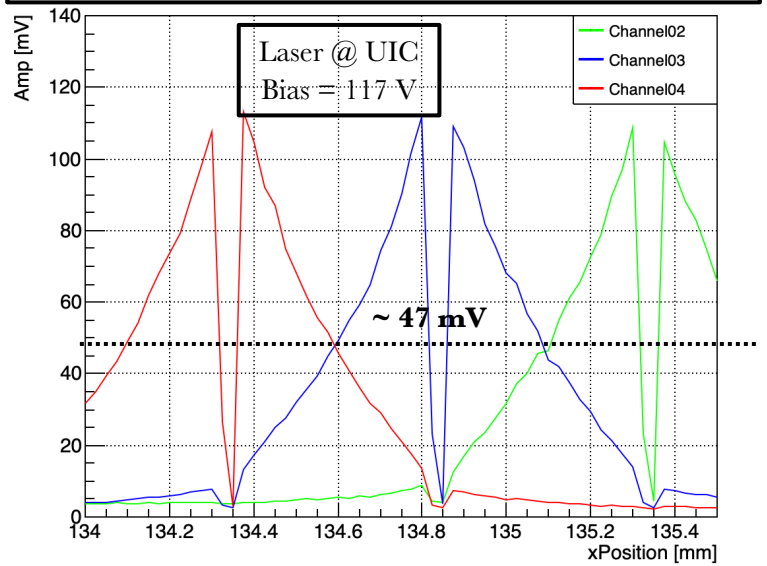
20 um thick, 10 mm length, 500 um pitch, 100 um metal



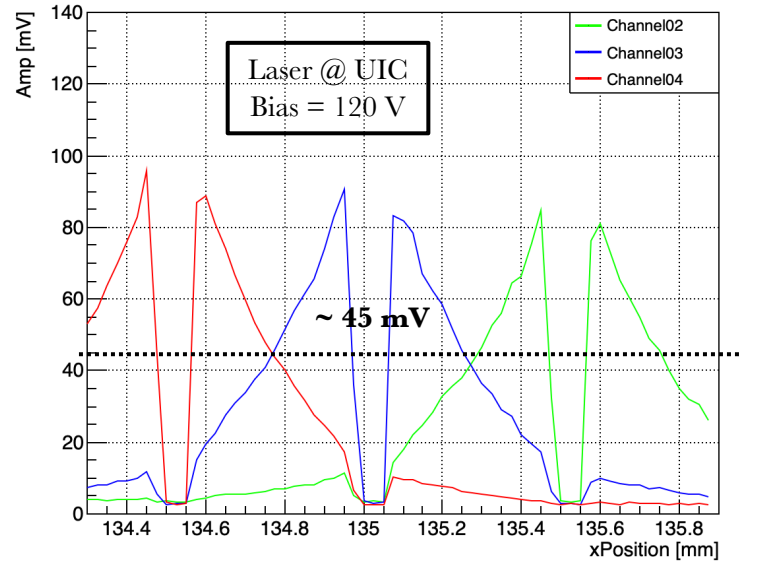
Signal size in HPK:
3X compared to BNL

HPK

20 um thick, 5 mm length, 500 um pitch, 50 um metal



20 um thick, 10 mm length, 500 um pitch, 100 um metal



Summary and outlook:

- HPK sensors with same thickness have 3X larger signal size compared to BNL
- Signal size decreases with longer strip sensor
- Same length with different metal width have similar signal size
- We will continue to characterize more HPK sensors with different resistivity, capacitance and thickness using laser at UIC
- Measure position and time resolution; compare with test beam results
- Next test beam for HPK sensor (24^{th} May – 6^{th} June)