First look from April 2023 AC-LGAD test beam a FNAL

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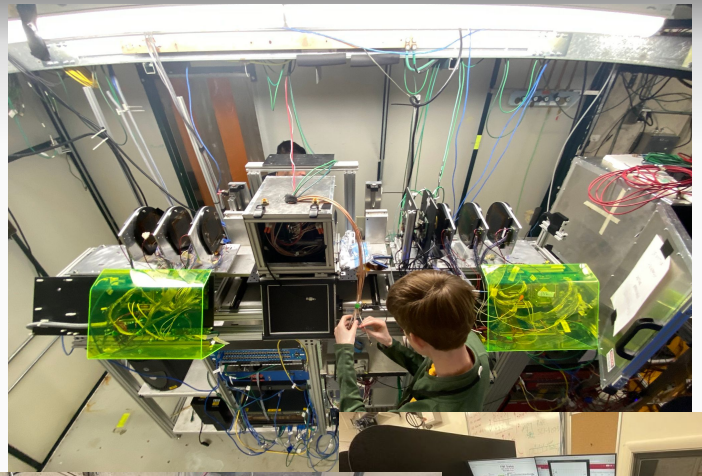
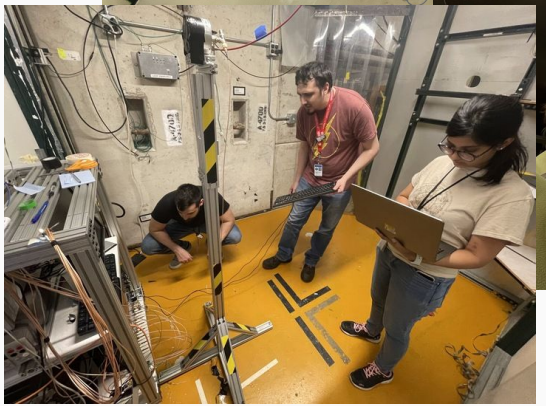
EIC meeting

16th May 2023

Introduction

- April 20-25th : 24 hour beam time
  - 120 GeV protons
- Personnel
  - Students - Ohannes, Shirsendu, Hakseong
  - Chris, Irene, Geonhee
- Measurement goals
  - Study impact of 30 μm vs. 20 μm active thickness for BNL sensors
  - Study various electrode geometries for pixel sensors





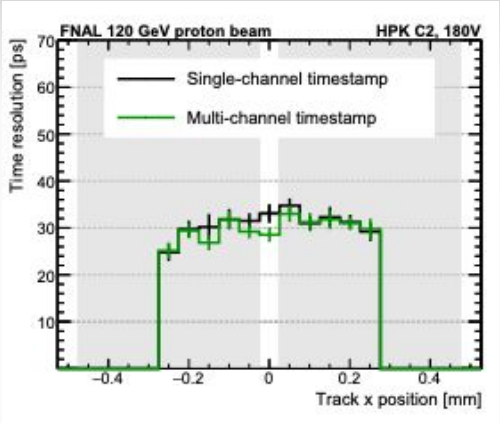
Sensors tested

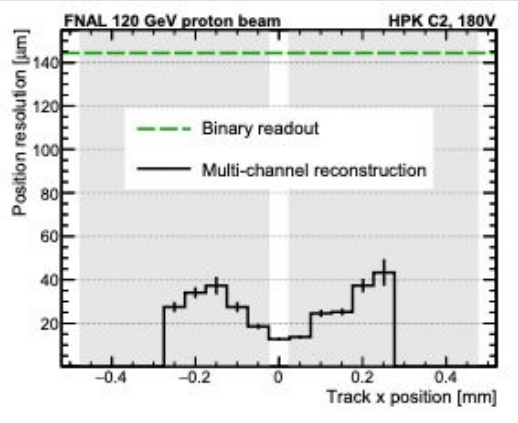
- 12 BNL sensors
  - **Strips**: 0.5 cm size, 700/500 μm pitch, 100 μm width metal electrodes - 30 μm vs 20 μm
  - **Pixels**: different electrode geometries, 30 μm vs 20 μm active thickness - Will focus on these

Geometry	Active thickness	Length	Wafer	Pitch	Electrode Geometry
Strip	30	0.5cm	W3104	700 um	
				500 um	
	20	0.5 cm	W3080	700 um	
				500 um	
Pixels	30	500 x 500 um	W3104		Large Square
					Small Square
					Cross
					Squared Circle
	20	500 x 500 um	W3080		Large Square
					Small Square
					Cross
					Squared Circle

Recap from previous HPK pixel sensors

arXiv:2201.07772

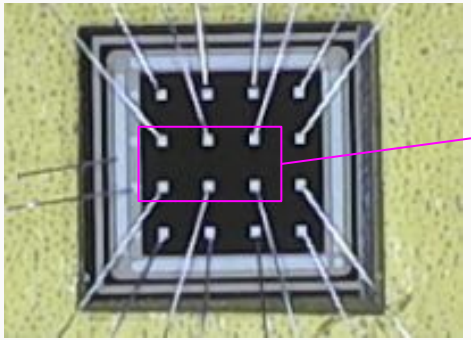




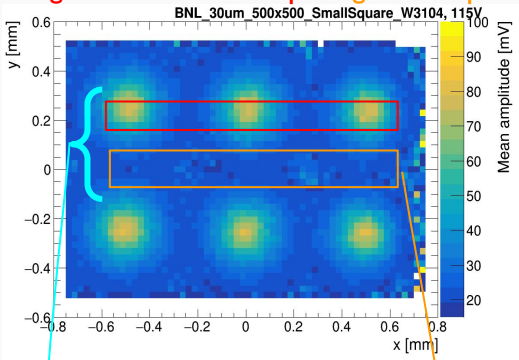
- Previous HPK 500x500 um^2 pixel sensors have shown 30 ps time resolution and 20um spatial resolution - fully metallized pads (very small gaps)
- For larger charge sharing and better spatial reconstruction efficiency, check if different metal electrode designs are useful
- This presentation - R&D on the performance of BNL pixel sensors with various metal electrode designs

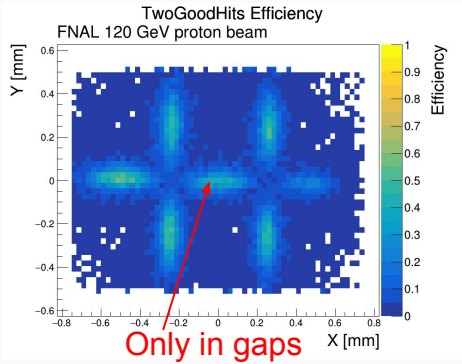
BNL 500x500um^2 Small Square

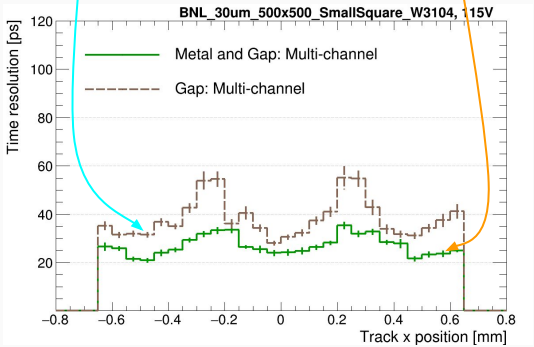
30 um (W3104); Bias voltage - 115 V



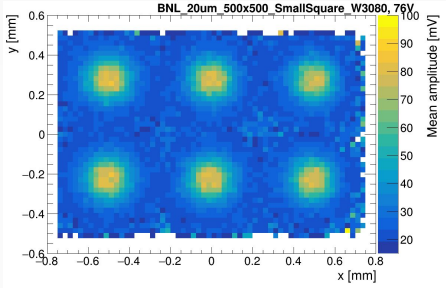
Region 1 : Metal and Gap Region 2: Gap

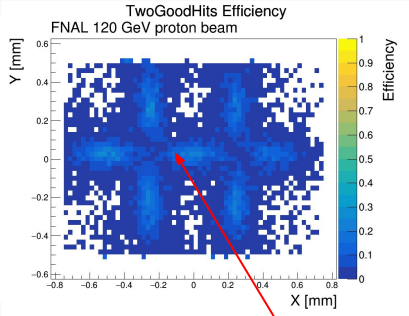




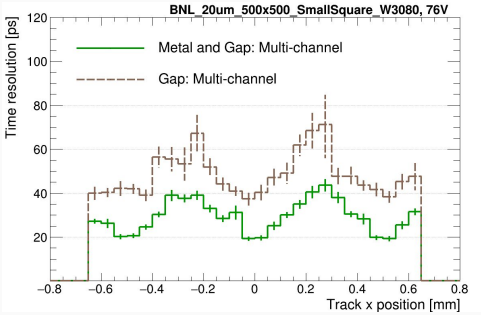


20 um (W3080); Bias voltage - 76 V



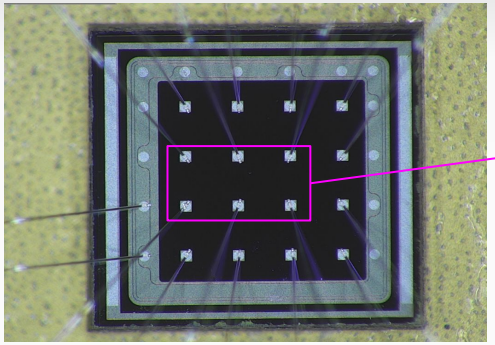


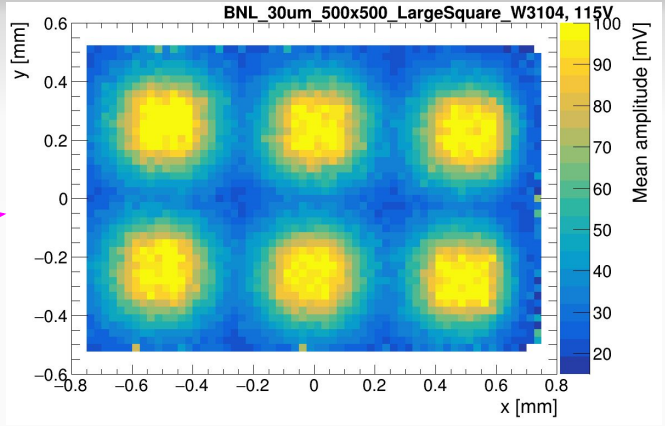
Only in gap



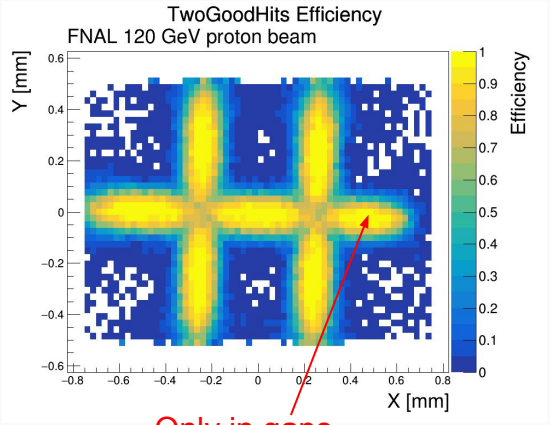
20 um has lesser ionization/ smaller gain layer (similar conclusion for all other pixels → will focus only on 30 um from now on)

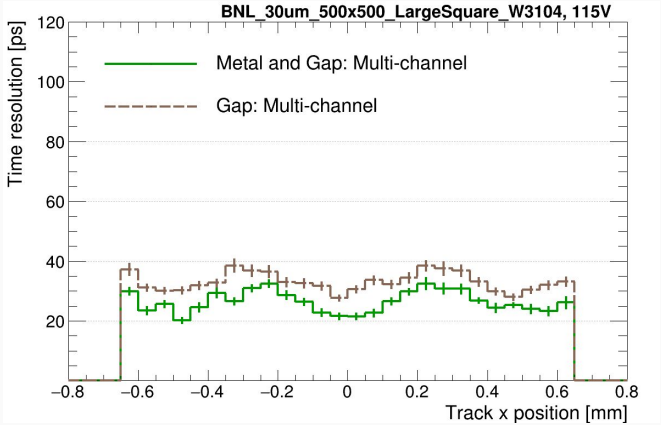
BNL 30um 500x500 um^2 Large Square



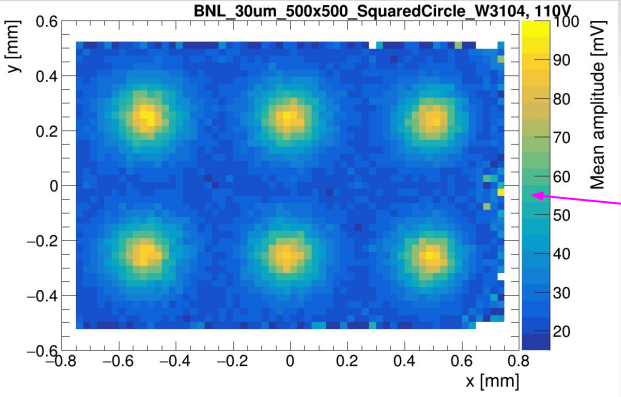


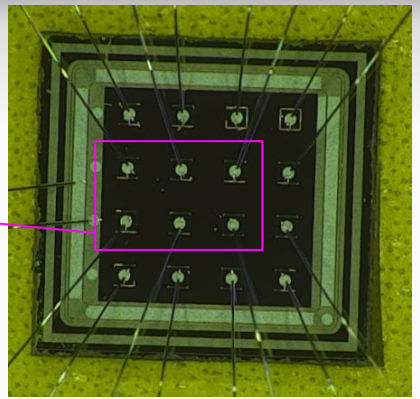
Bias voltage - 115 V

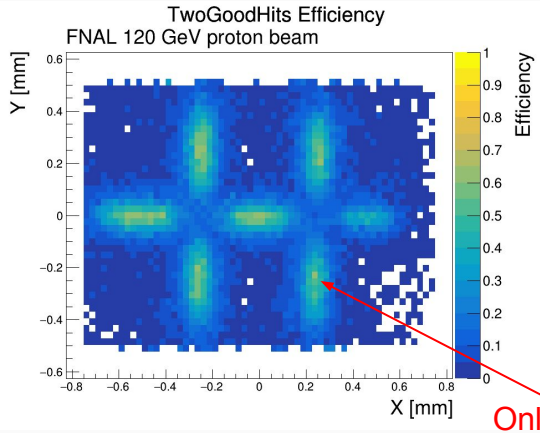


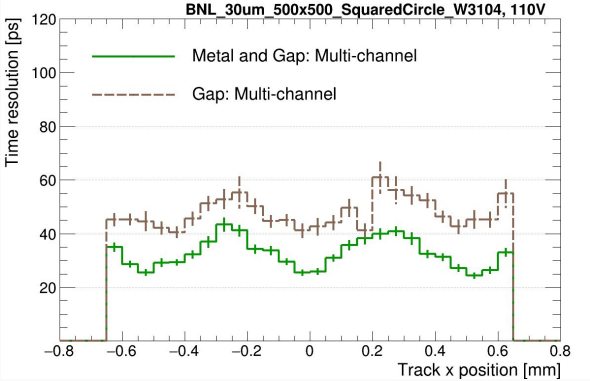


BNL 30um 500x500um^2 Squared Circle





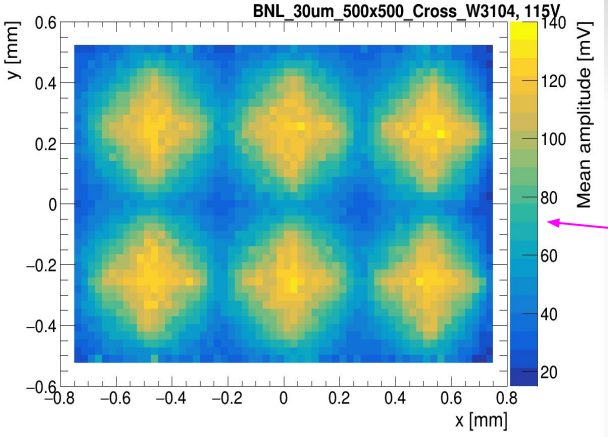


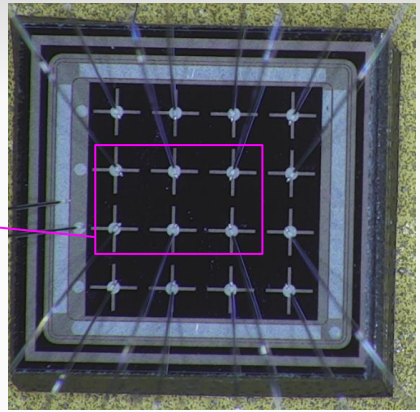


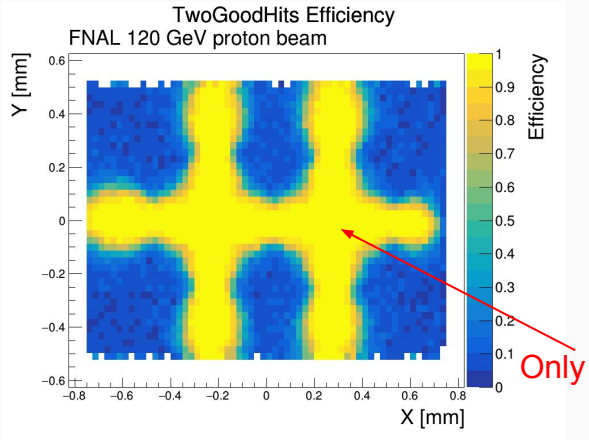
Only in gaps

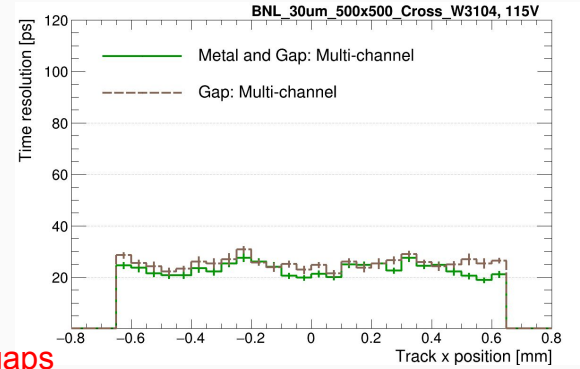
Bias voltage - 110 V

BNL 30um 500x500um^2 Cross pixel sensor







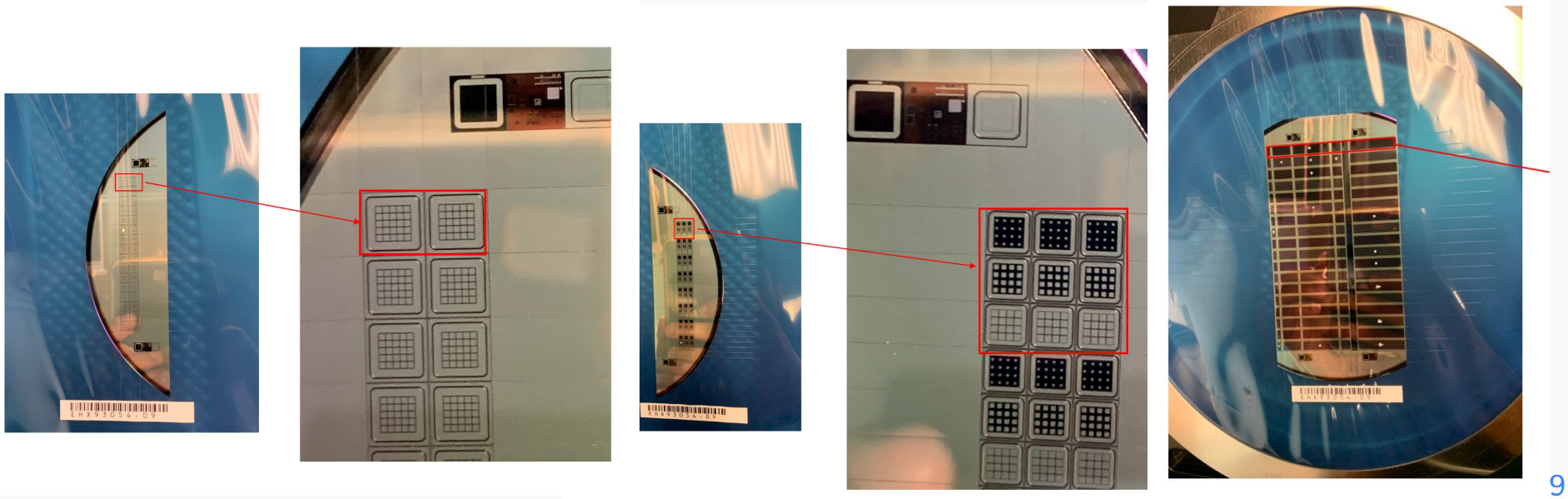


Only in gaps

Bias voltage - 115 V

Upcoming test beam campaign at FNAL

- May 24-June 6: 120 GeV protons
- Targeting various EIC-like AC-LGADs from HPK: strips and pixels



Conclusions

We had a successful beam time

- Detailed analysis of the performance of the BNL pixel sensors are now underway
  - The BNL pixels can achieve time resolution performances of ~30 ps
  - The two pad reconstruction for these BNL pixels is only possible in the gaps
  - The 20um sensors could benefit from a deeper gain layer in future productions
- We plan to **test more sensors from HPK in a test beam starting next week**
  - Explore different resistivity/ active thickness/metal electrode design etc

Backup