GridPix with Pasive Bipolar Grid in high Magnetic Field

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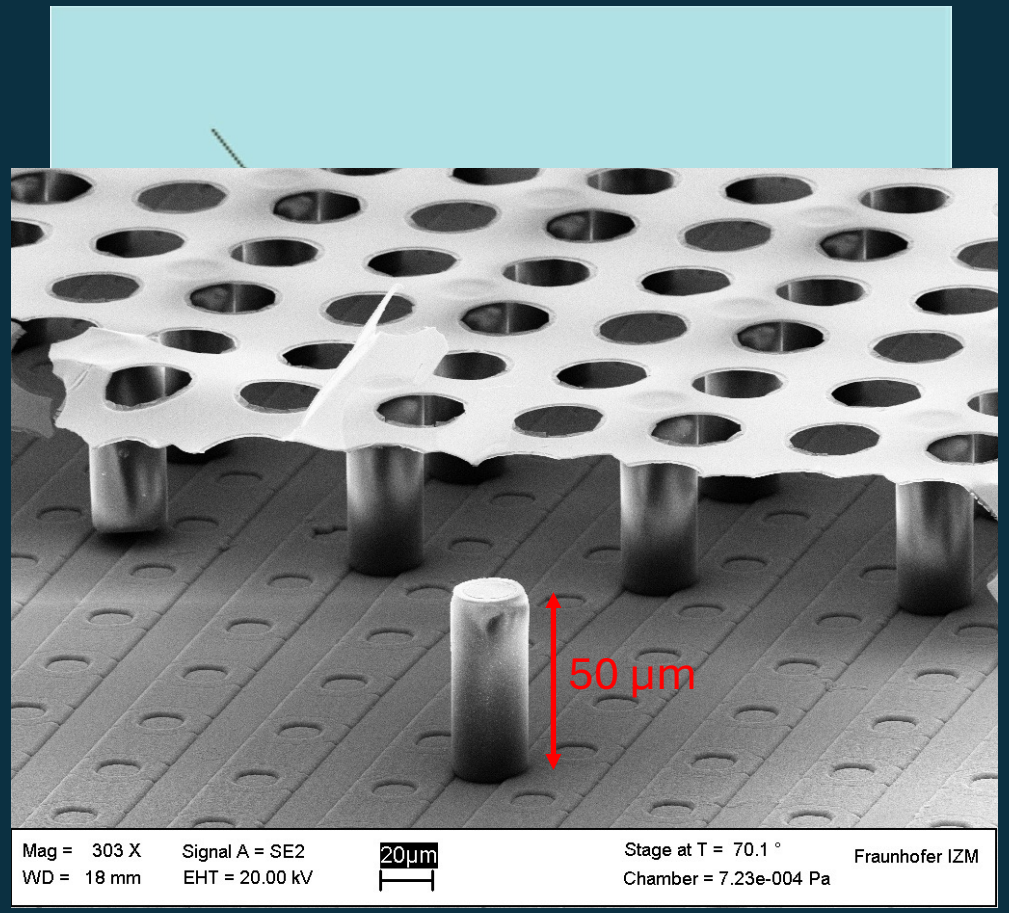
GridPix



GridPix is a miniature Time Projection Chamber (TPC) with a two-dimensional readout plane.

It consists of a gas amplification region on top of a signal-readout chip, a Timepix (CERN).

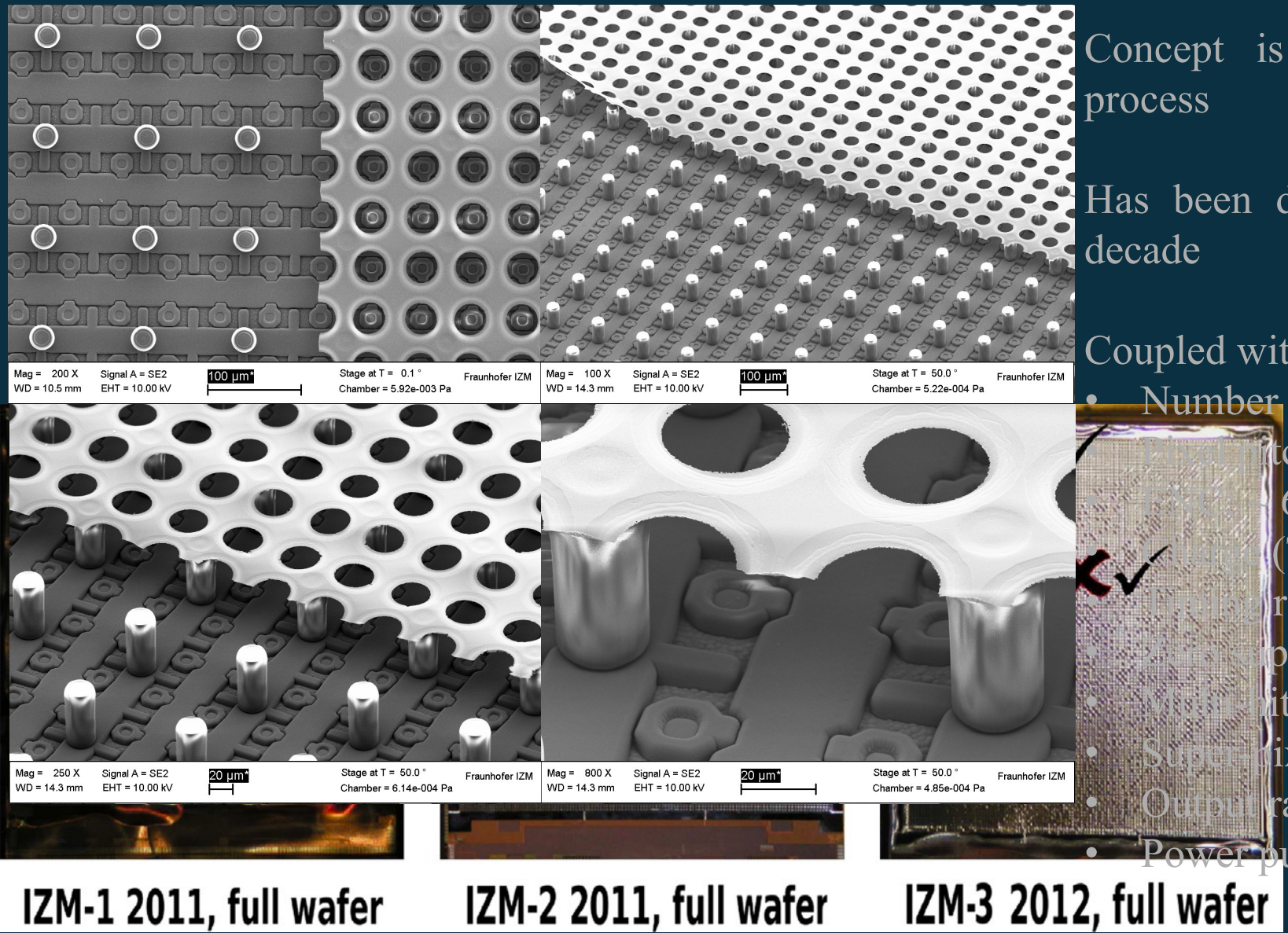
It records the arrival time and the position of electrons.

The amplification region consists of a grid supported by ~50 µm tall spacers.

Amplification field is large ~60 kV/cm to create electron induced avalanches.

A. Boldyrev & others Tracking performance of GasPixel detectors in test beam studies. NIMA 807: 47 - 55. 2016
W. Koppert & others GridPix detectors: Production and beam test results. NIMA 732: 245 - 249. 2013

GridPix



Concept is simple, production is a complicated process

Has been developing and improving over the last decade

Coupled with Timepix3 readout:

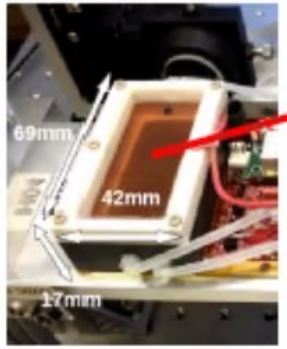
- Number of pixels: 256 × 256 pixels
- Pixel pitch: 55 × 55 µm.
- ENC: ~60 e-
- Charge (ToT) and time (ToA) available per hit
- Timing resolution: 1.56 ns for duration of ~410 µs
- Zero suppression on chip (sparse readout)
- Multi-hit capable (pixels sens. after t_{ToT}+475 ns)
- Super pixels store hits for some time
- Output rate up to 5.12 Gbps
- Power pulsing possible (800 ns for start up)

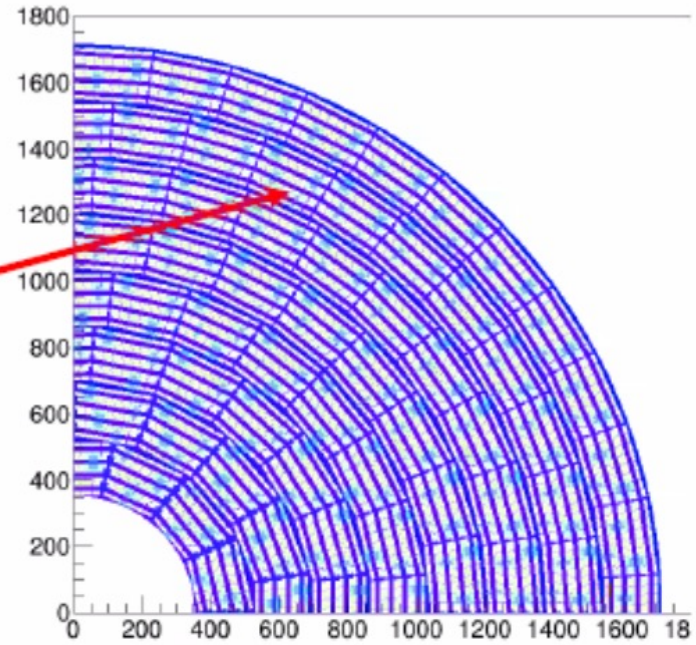
LCTPC R&D

Nikhef

Pixel TPC Test beam preparations

UNIVERSITÄT BONN





Single chip 2017

Quad 2018

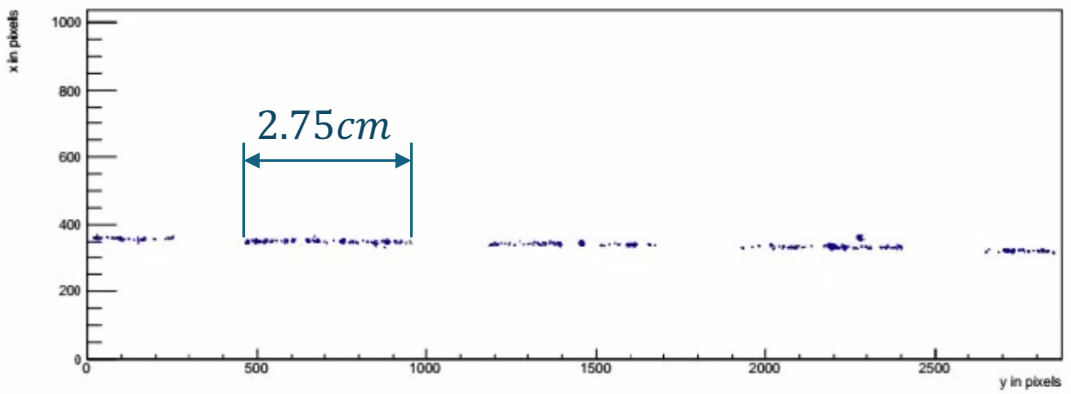
Module 2019

TPC plane

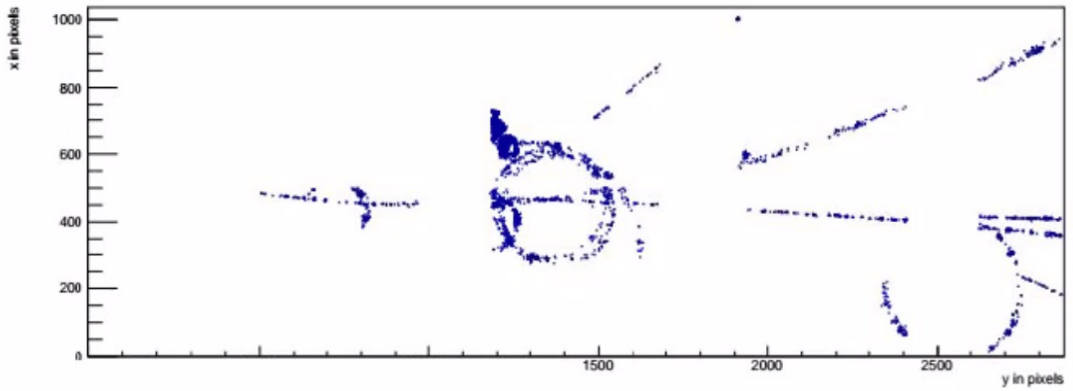
LC TPC

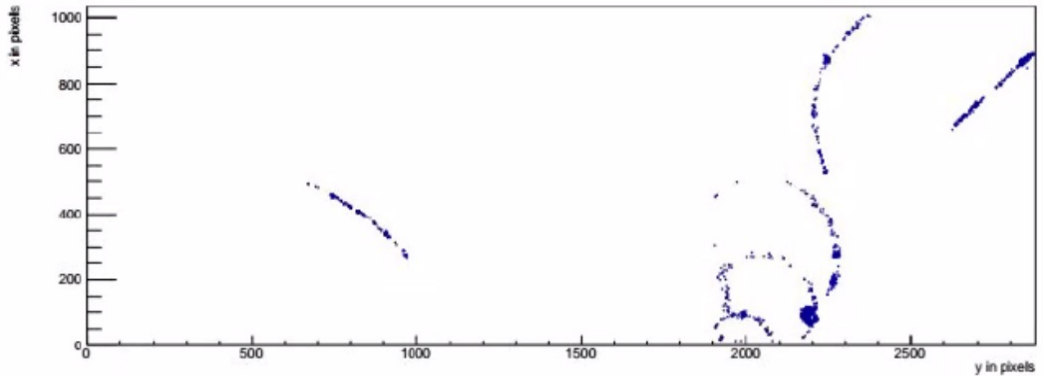
ILD

GridPix



Gas T2K ($Ar/CF_4/iC_4H_{10}$ 95:3:2)
B = 0.5 T
Drift d = 0.5-1.5 cm
P = 6 GeV/c





Segmentation: $\frac{25\ cm}{55\mu m} = 4500$

70% active area ⇒ 3150 "rows"

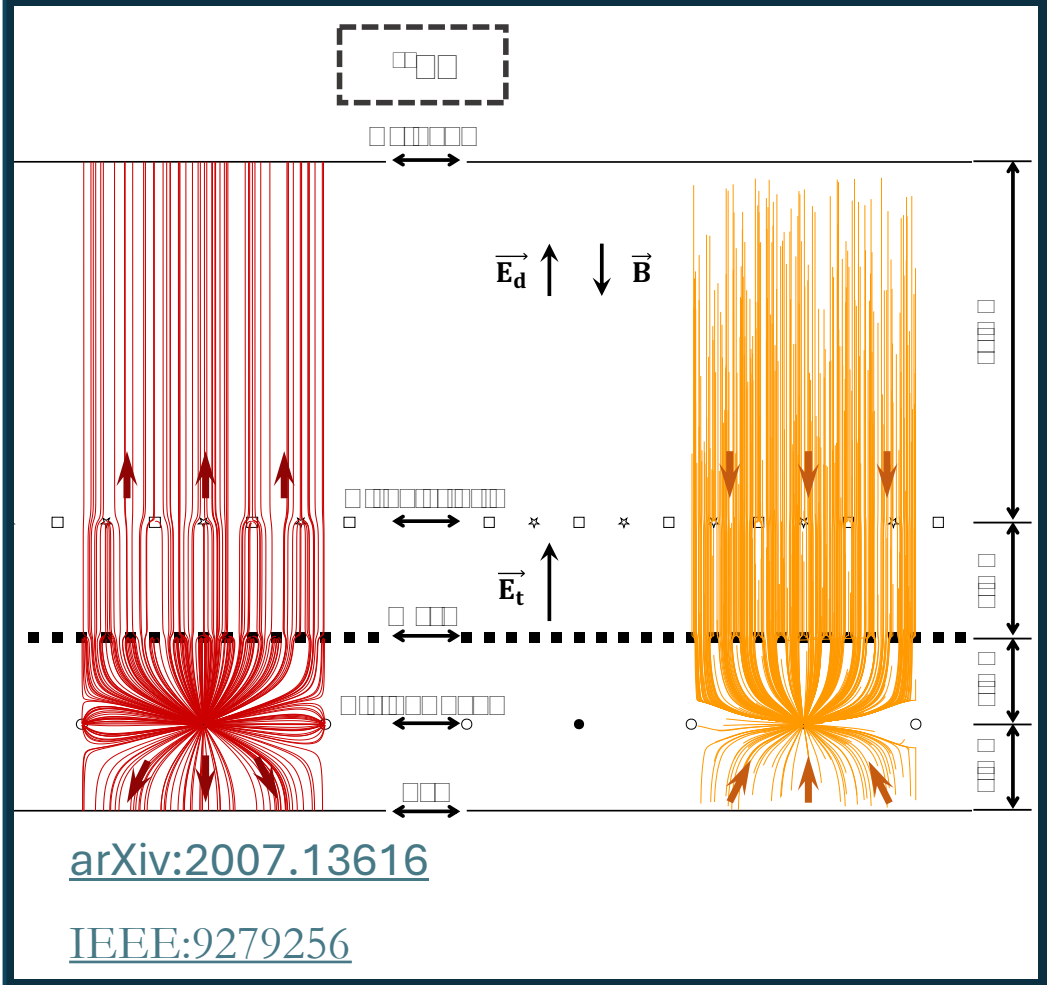
2400 primaries in 25 cm for a MIP

Thousands of hits per track

Extremely robust patterns

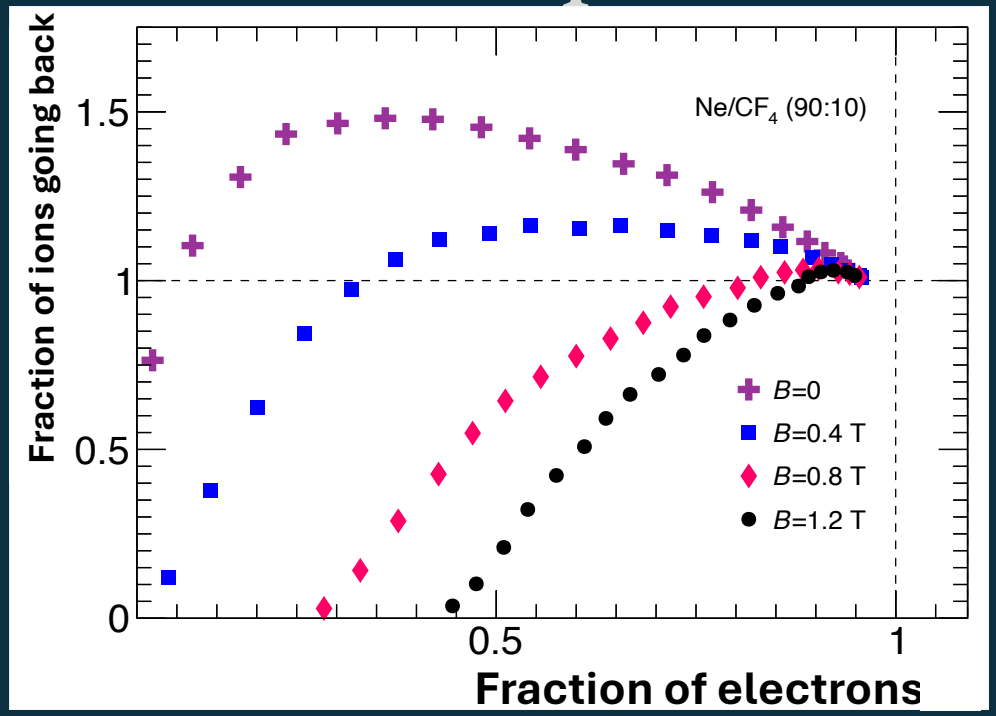
Identification/removal of δ-rays/kinks

Ion Blocking by the Passive Bipolar Grid



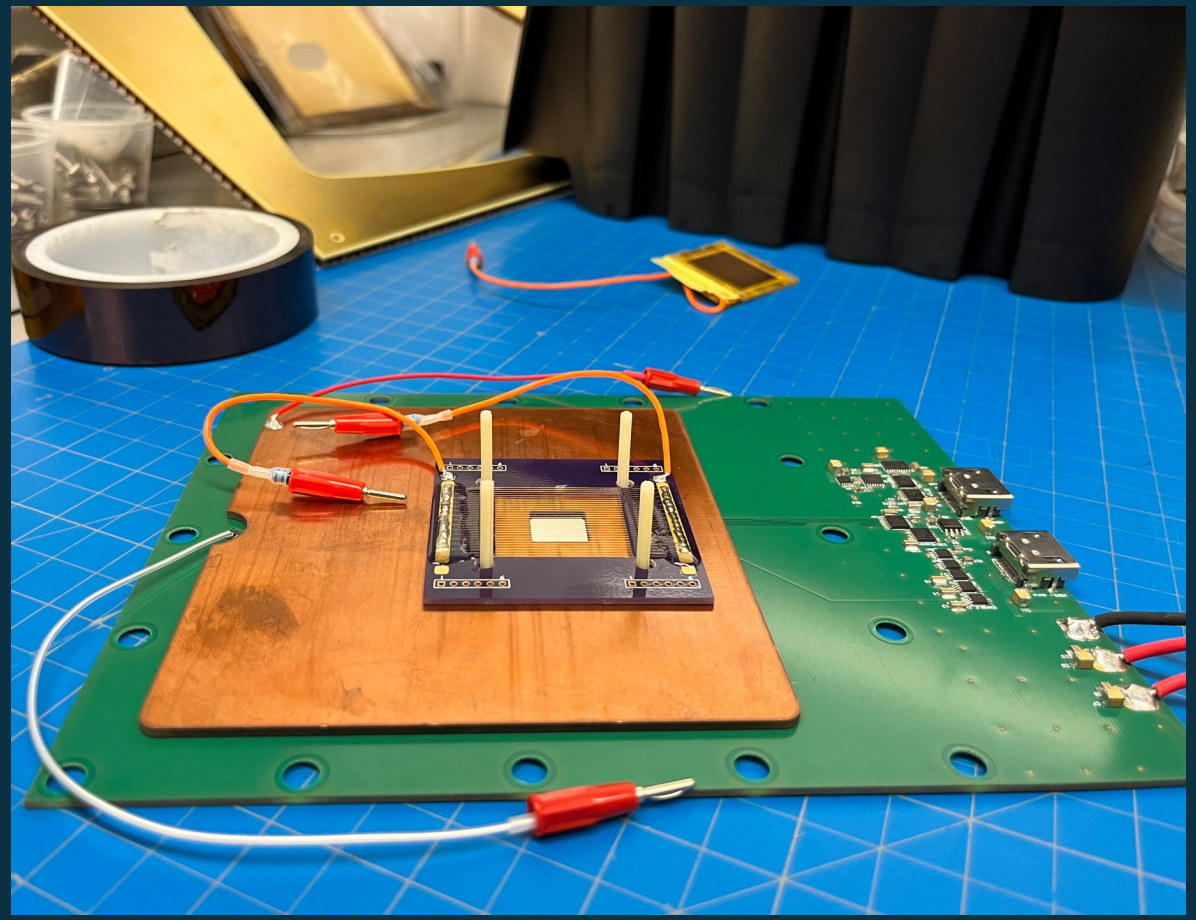
arXiv:2007.13616

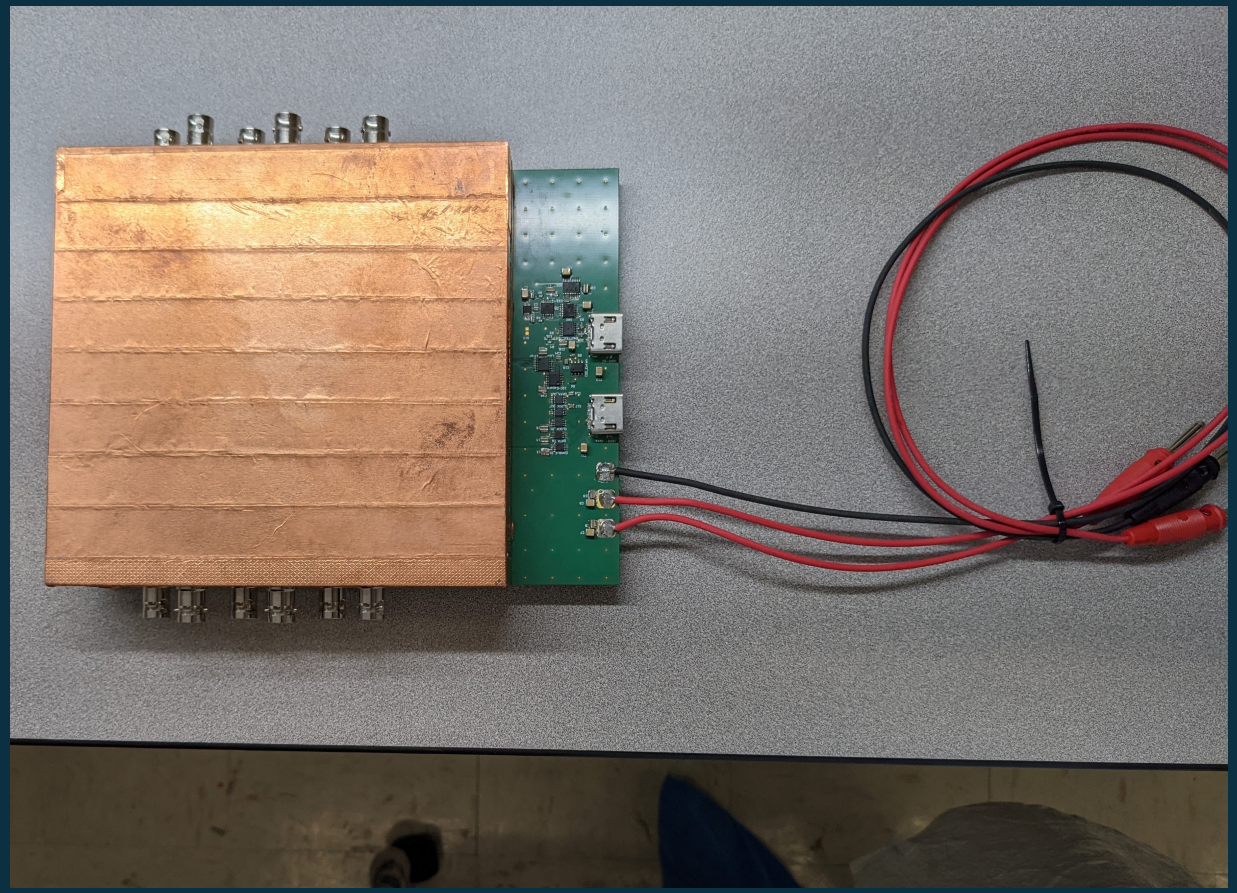
IEEE:9279256



- Results show that IBF can be suppressed down to 0 with a cost of 45% of primary electrons @ B≥1.2 T
- Comparison to simulations have been performed, better measured gases provide better results, improvement could be obtained in the future
- Beam test was performed @ the Argon National Laboratory to increase magnetic field
- Garfield++ simulations have shown good results for Ar/CH4

BPG effect on the drift of electrons



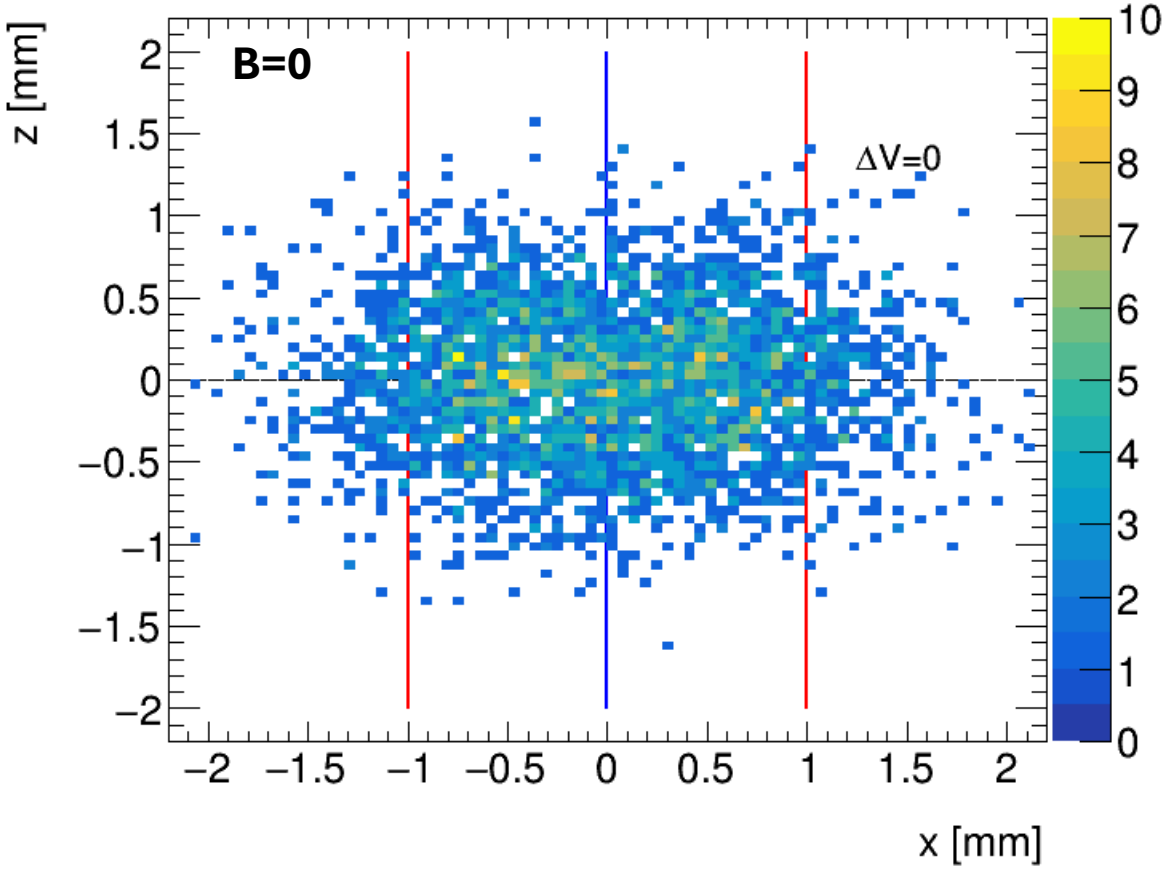


Setup is at BNL (designed by Me and J. Kaminsky produced @ Weizmann & Bonn, SRS from SBU)
In the magnetic field > 0.4T, the bi-polar wire grid (BPG) will be used to develop Zero-IBF GridPIX.
Plan to perform measurements @ BNL or ANL with >1 T magnetic field

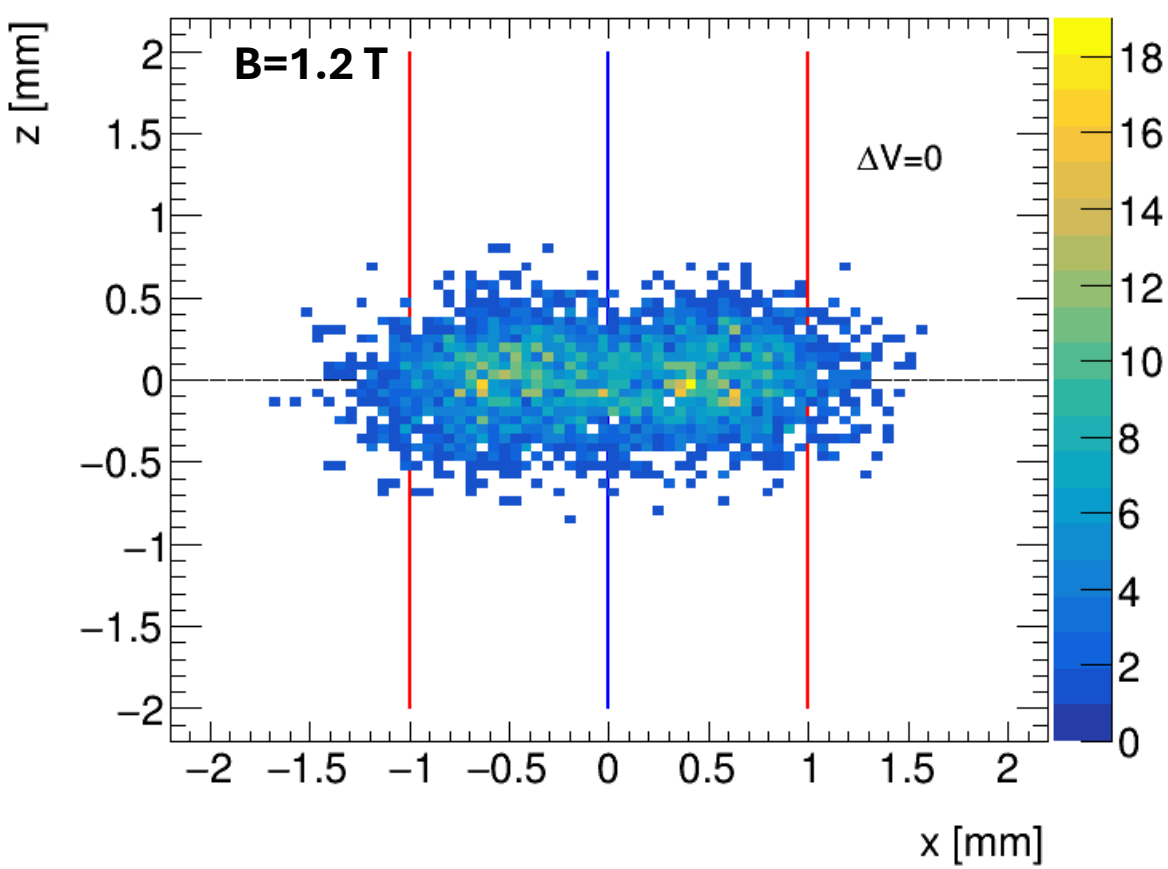
BPG effect on the drift of electrons

Garfield++ Simulations **Ar/CH_4 (90:10)**: 55 μm binning

No magnetic field



With magnetic field



Linear bias corresponding to Lorentz angle

Designed a setup with GridPix detector (from Bonn group) to measure the bias

Responsibilities

- **Bonn**: GridPix production and DAQ FW/SW

- **WIS**: BPG design and production

- **SBU**: setup production (field cage for large scale prototype tests)

- **Yale**: setup production (cooling) and simulations- BNL: assembly, tests with magnet

- **All**: data collection and analysis.

Relevant RDCs for this project are RDC1, RDC5, and RDC6.

Timeline

2025-2026: Testing BPG with first generation GridPIX at BNL with prototype from WIS and Bonn and DAQ from SBU.

2026-2027: Measurement of IBF from GridPIX. Simulations and algorithms development for cluster counting and track reconstruction.

2027-2028: Scaling with larger chip size for new generation GridPIX and precision positioning. Cluster counting and track reconstruction.

2028-2029: Testing large scale TPC with prototype from SBU and Yale with integrated BPG in the Fermilab test beam facility

Backup