LAPPD Overview: Recent performance results of Gen-II (Capacitively Coupled) LAPPDs

Shawn S. Shin

Associate Research Scientist

Incom, Inc.

Melvin J. Aviles, Stephen M. Clarke, Stefan Cwik, Michael R. Foley, Cole J. Hamel, Alexey V. Lyashenko, Derrick O. Mensah, Michael J. Minot, Mark A. Popecki, Michael E. Stochaj

Incom, Inc., Charlton, MA, USA

INCOM
BRIGHT IDEAS

Outline

- **Incom, Inc.**
- **LAPPD Features**
  - LAPPD Technical Specifications
  - LAPPD Design
  - Stripline (Gen I) vs Capacitively Coupled (Gen II)
- **Gen II LAPPD Performance**
  - Photocathode QE
  - Gain Measurement
  - Dark Count Rate
  - Timing and Position Resolution
- **Summary**

Incom, Inc.

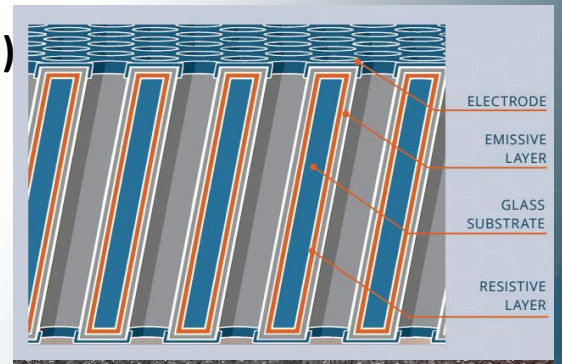
- Founded 1971
- ~200 employees
- Three facilities:
  - Incom West – Vancouver, WA
  - Incom East (2) – Charlton, MA
    - **LAPPD Pilot Production** by Detector Business Unit (**DBU**)

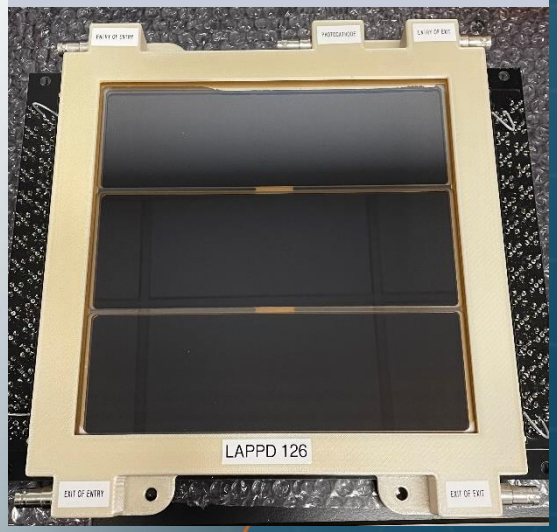
HQ Main Plant

Detector Pilot Production Facility

Large Area Picosecond Photodetector (LAPPD™) Technical Overview

- **8” x 8” MCP-PMT**
  - Chevron pair of ALD-functionalized MCPs**(10 µm or 20 µm)**
  - Glass/Ceramic package
  - **373 cm^2** effective area (97% open area)
- **High Gain (~10^7)**
- **Bialkali Photocathode**
  - Sodium-Potassium-Antimony Na_2KSb
  - **>30%** QE at 365 nm
  - **>95%** spatial uniformity
- **Timing Resolution**
  - SPE: ~48 ps (electronics limited), **~30 ps** (Vagnoni, INFN)
  - 5 GeV EM Shower: **~15 ps** (Vagnoni, INFN)
- **Position Resolution ~ *O*(mm)**





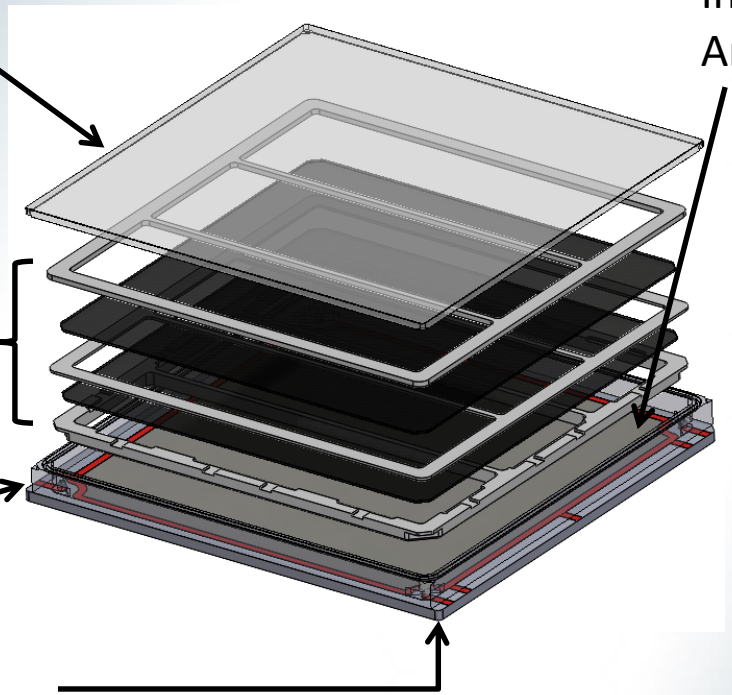
LAPPD Design

Fused Silica window (**Photocathode inside**)

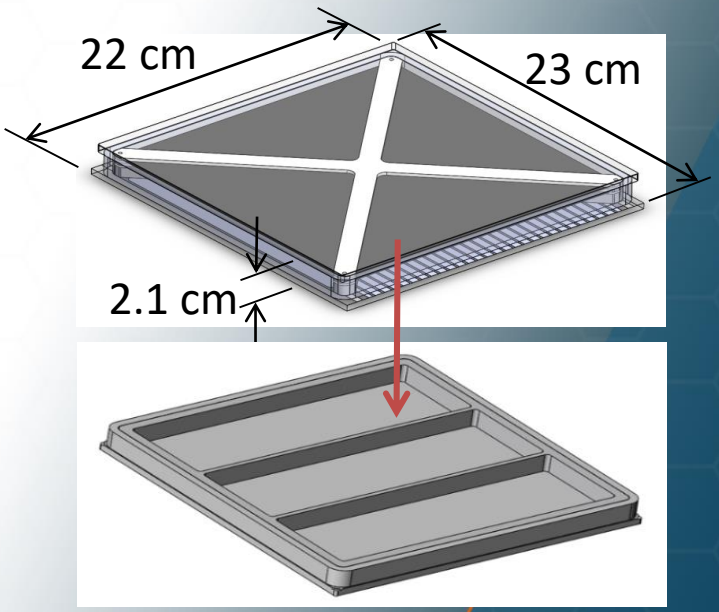
MCPs + Spacers

Sidewall frit bonded to Anode plate

HV tabs at each corner (**Independently power MCPs**)



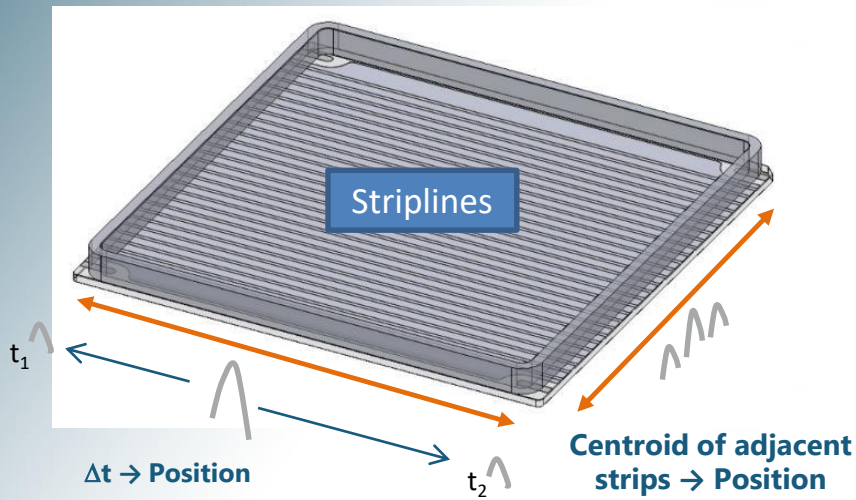
Internal Resistive Anode



- **No wall or anode penetrations**
- **Active area: 195 mm x 195 mm**
  - **X → Grid Spacer**
  - **350 cm^2 (92%) → 373 cm^2 (97%)**

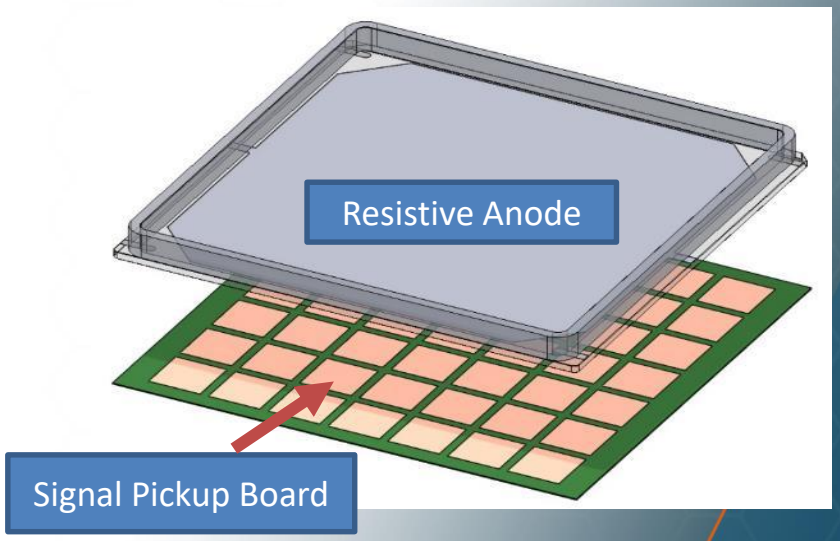
Gen-I vs Gen-II

Gen-I: Stripline Anode



- ~1 mm spatial resolution, ~50 ps TTS SPE
- Good compromise between the number of electronics channels and spatial coverage

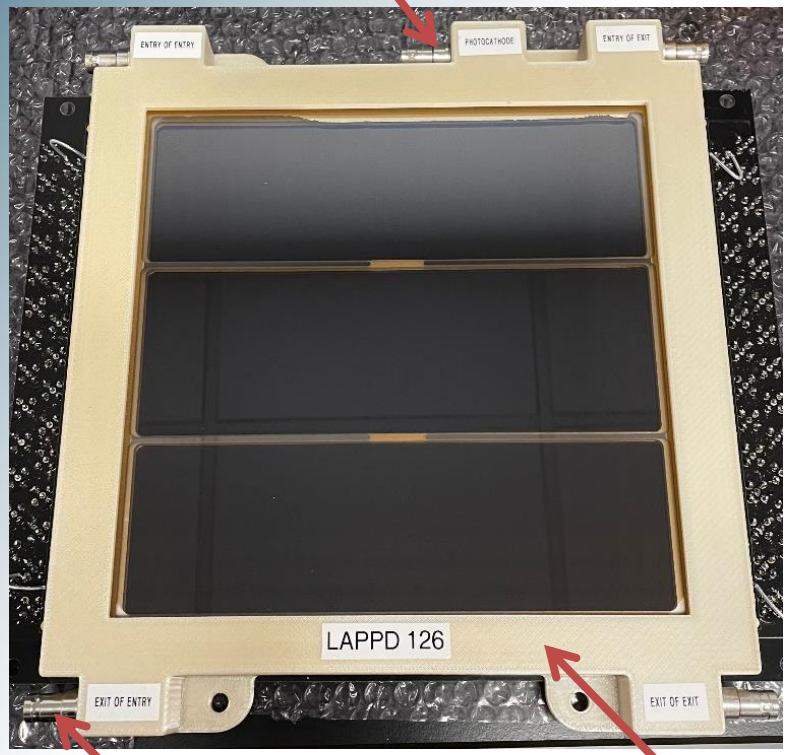
Gen-II: Capacitively Coupled Anode with External Pixelated Board

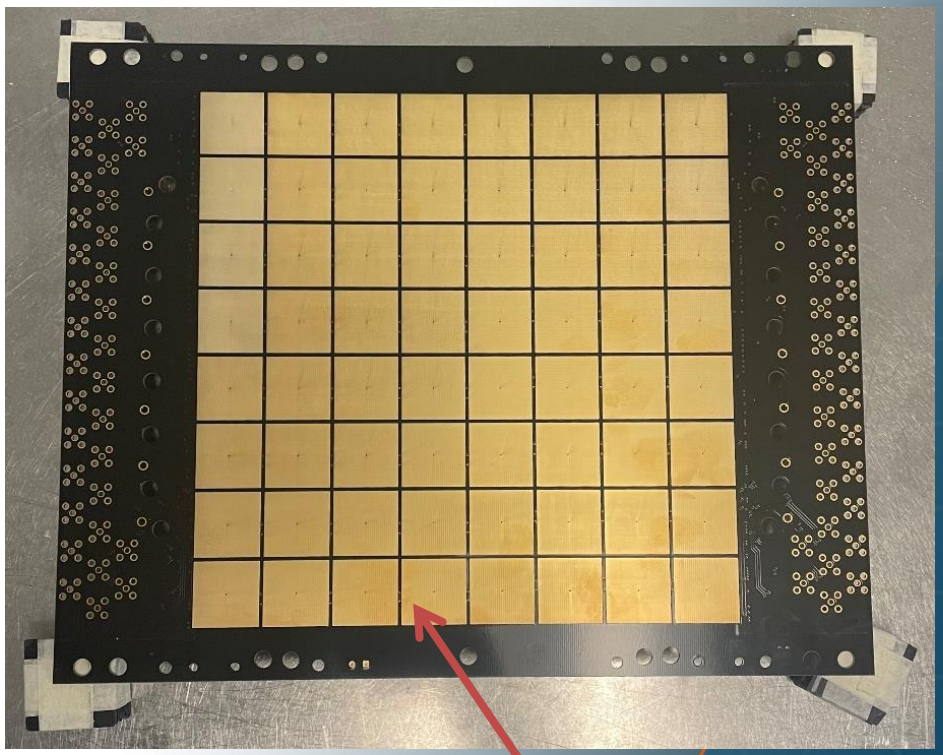


- **Fully customizable pickup pattern** (application specific)
- **Simultaneous photon detection**
- Anode physically decoupled from signal board
  - Convenient signal board swaps

Gen-II LAPPD

Photocathode HV



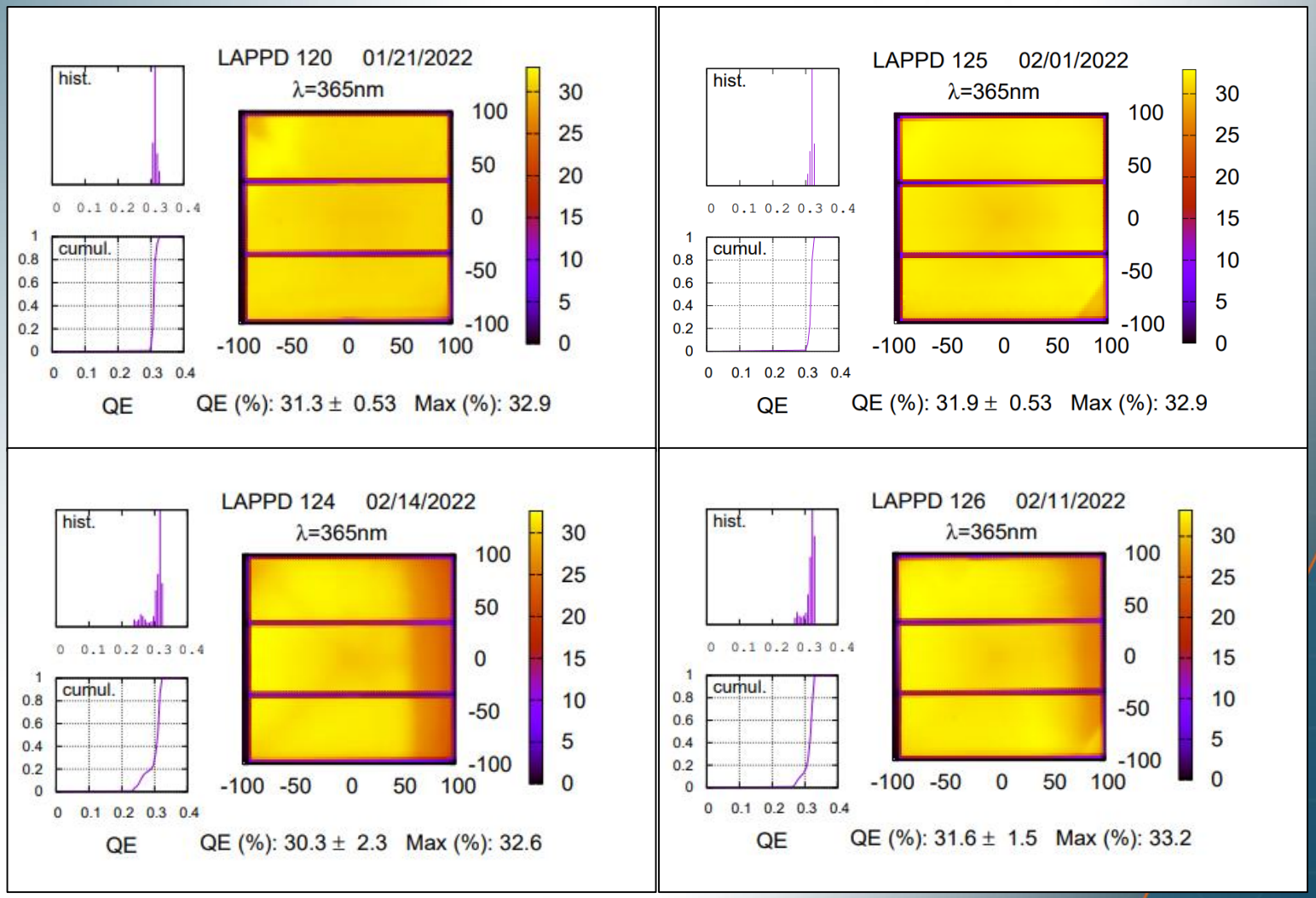


MCP HV

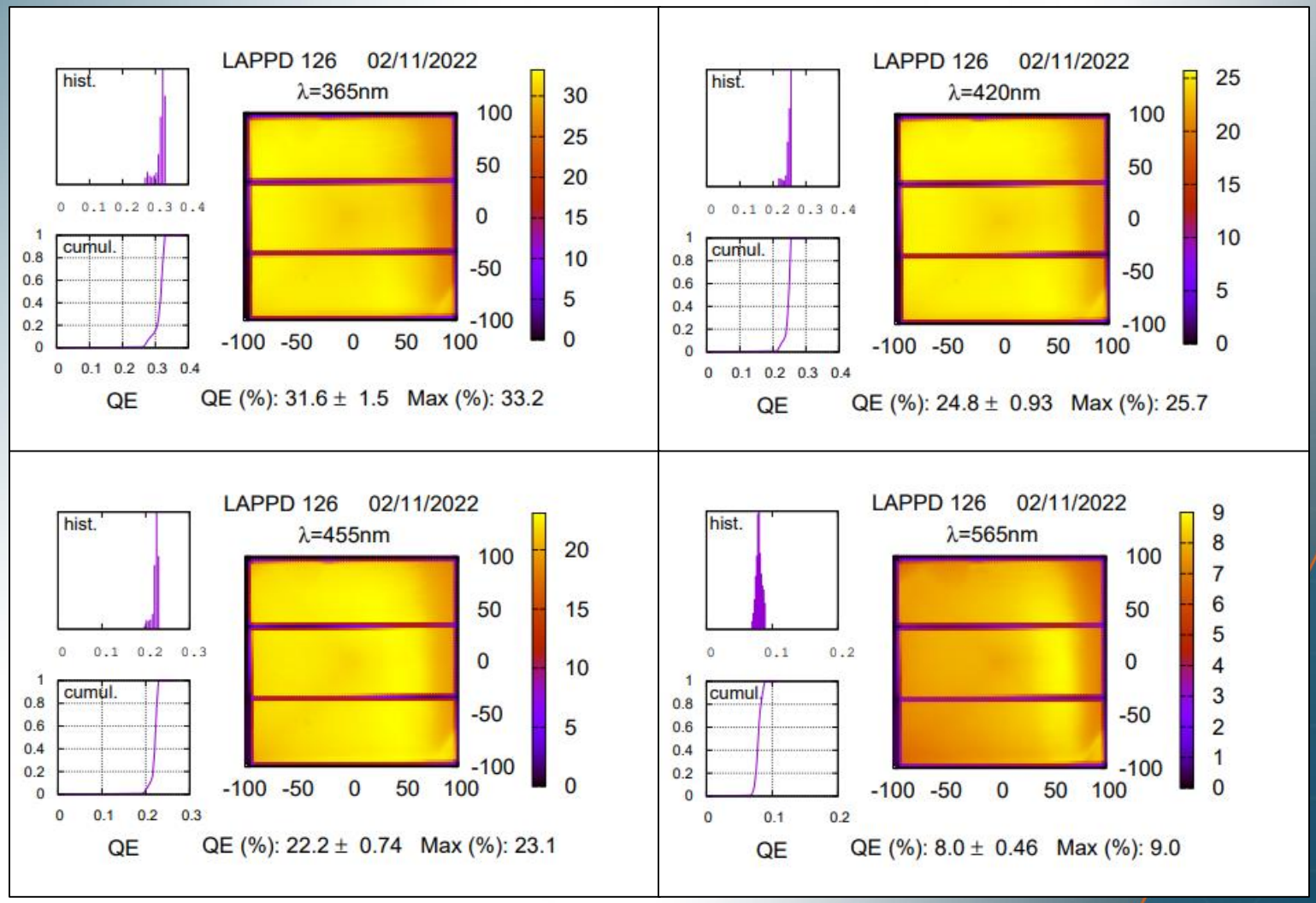
Ultem Housing

8 x 8 Pad Array
25 mm pixels

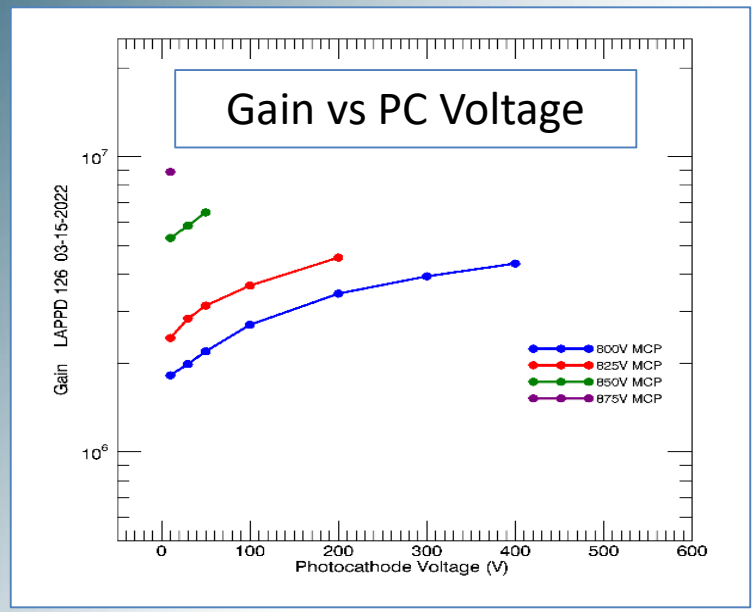
Photocathode QE at 365 nm

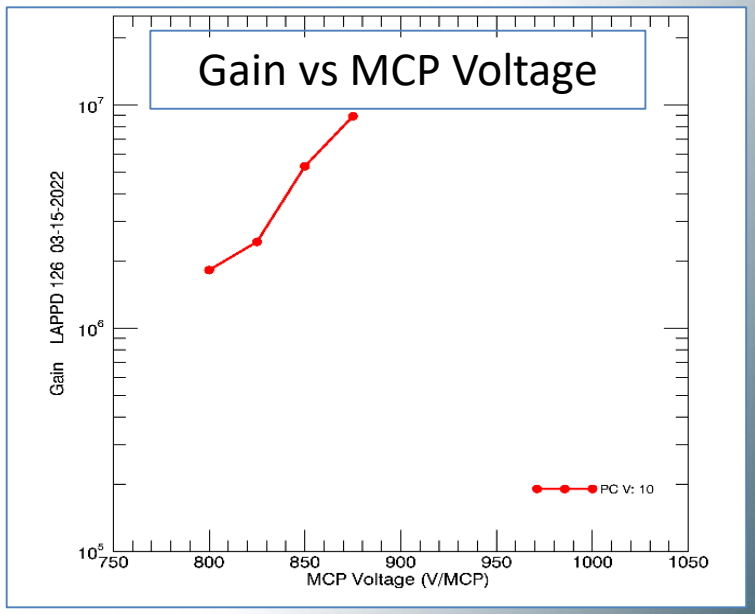


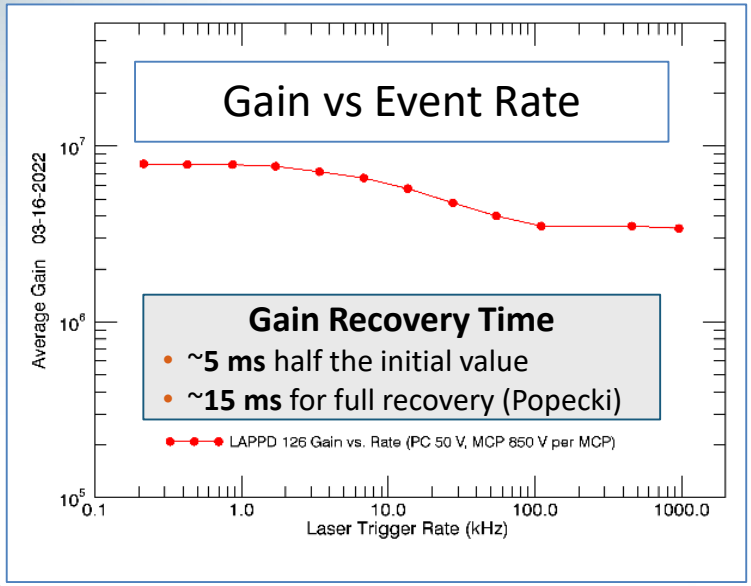
Photocathode QE

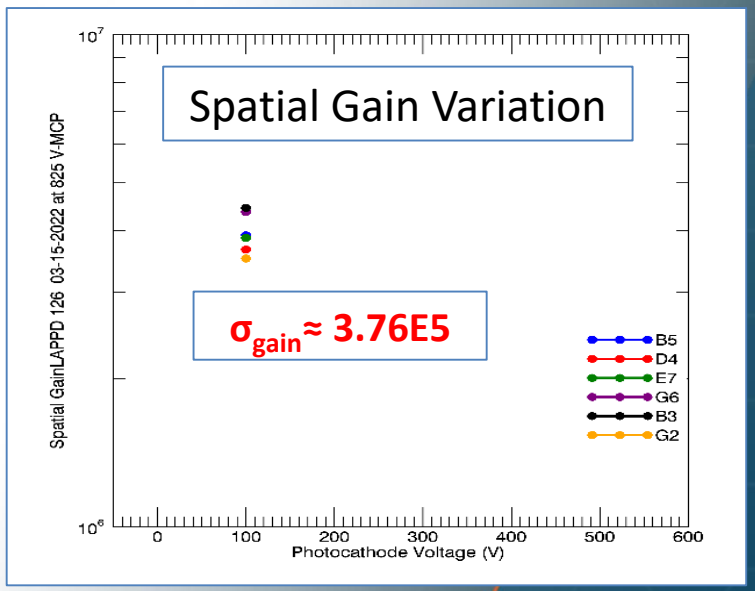


Gain Measurements



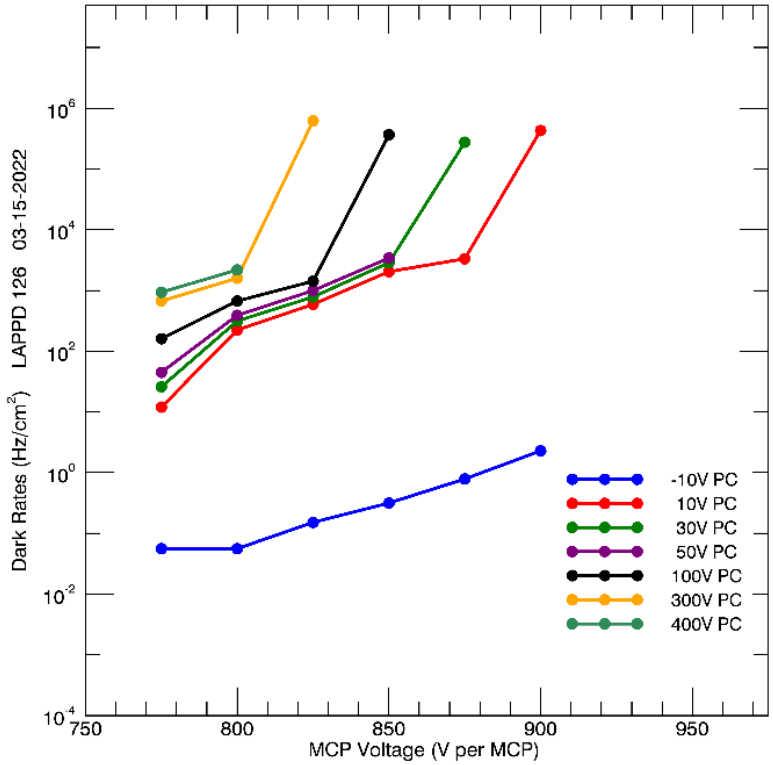




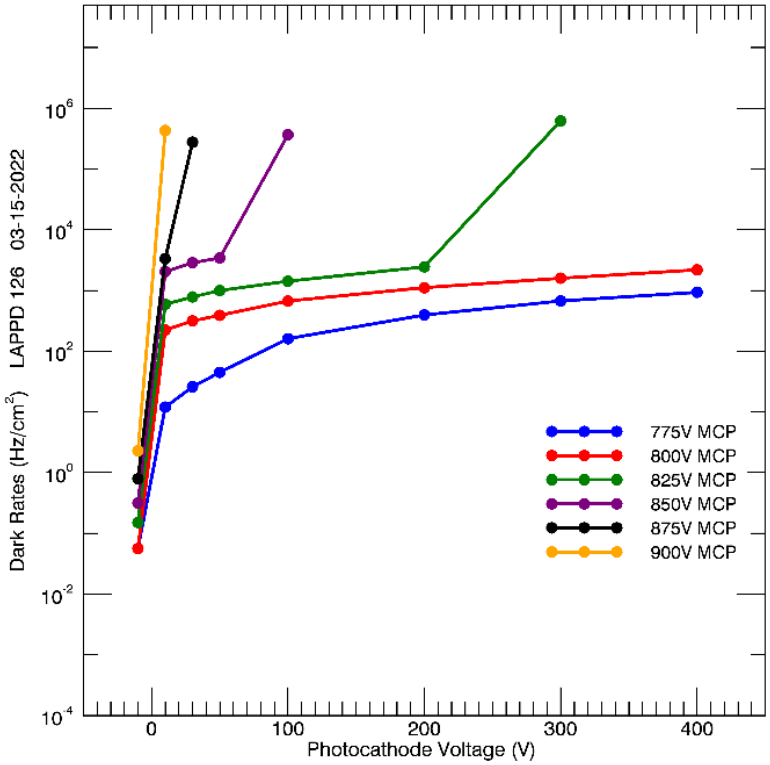


Dark Count Rate

Dark Rates vs MCP Voltage



Dark Rates vs PC Voltage

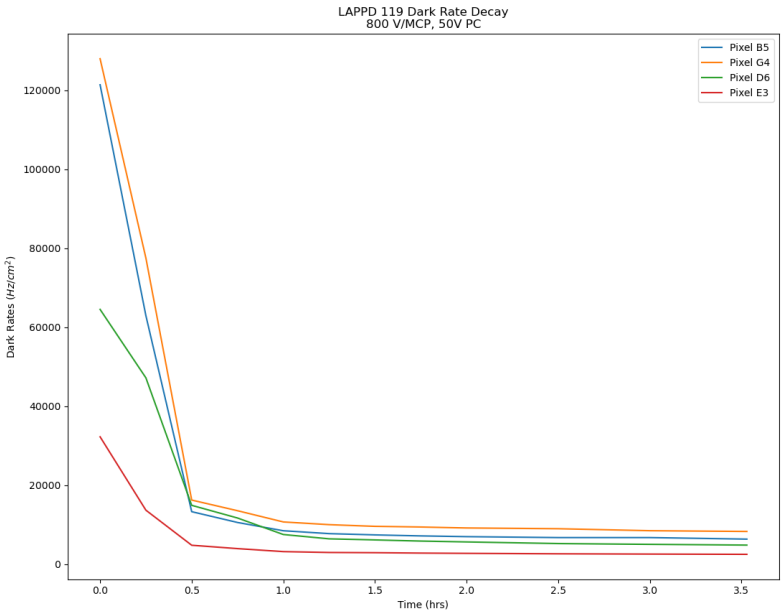


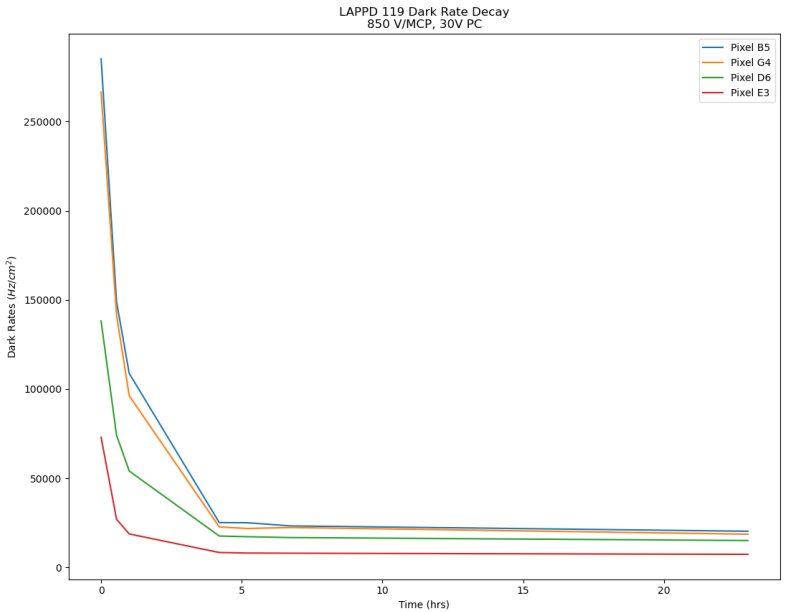
Gain ~$6 \cdot 10^6$, Dark rates ~1 kHz/cm^2

@ 850V/MCP, 30V PC

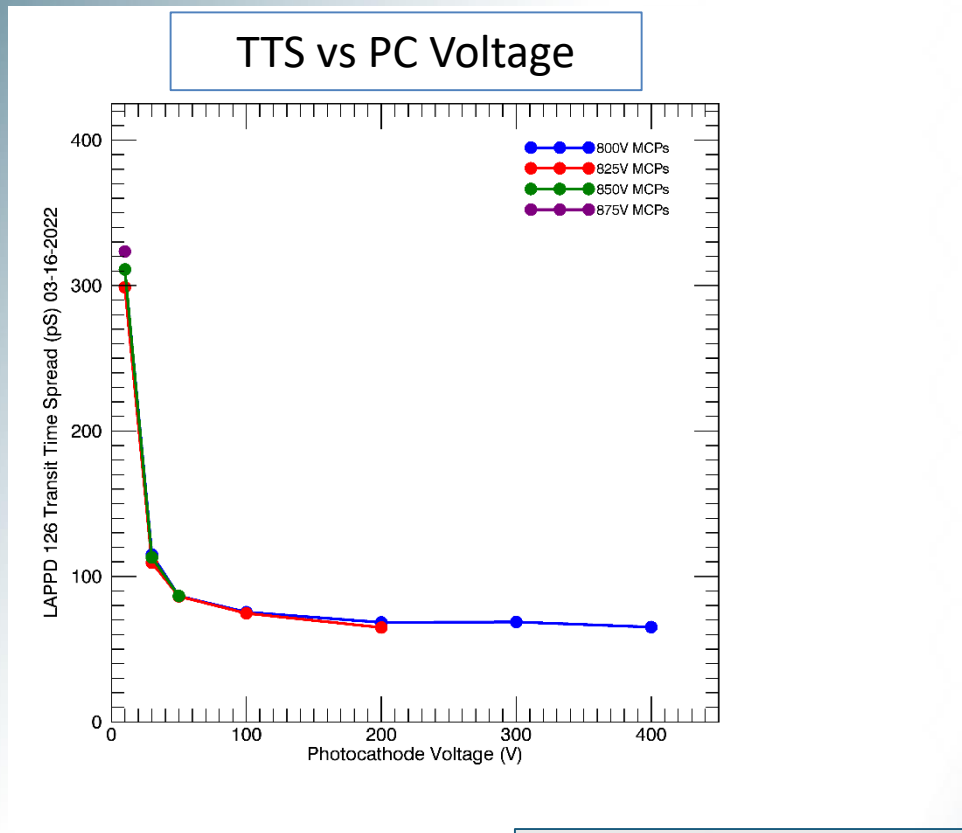
Dark Rates Decay

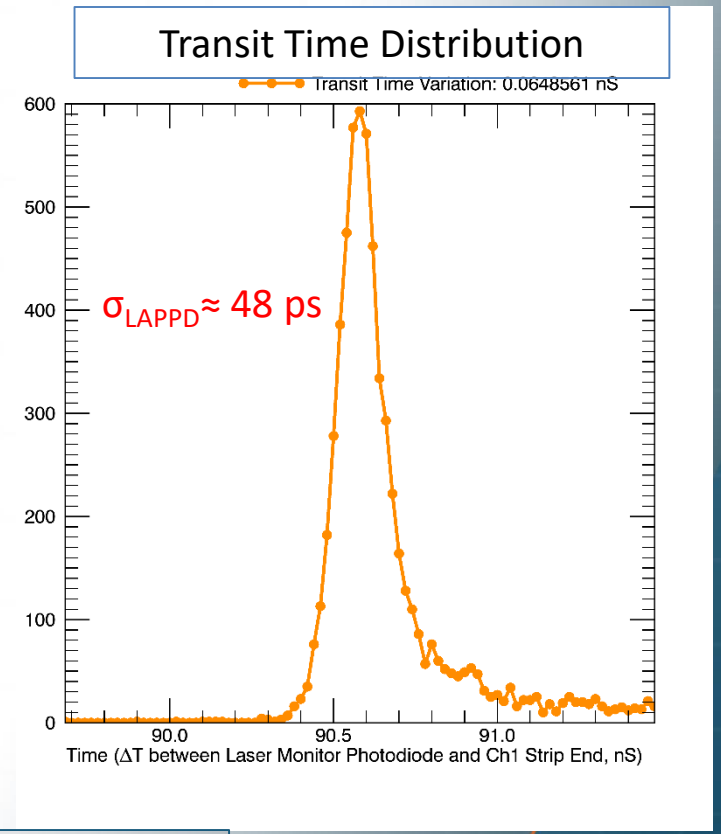
Dark Rates vs Time (hrs)





Single PE Timing Resolution



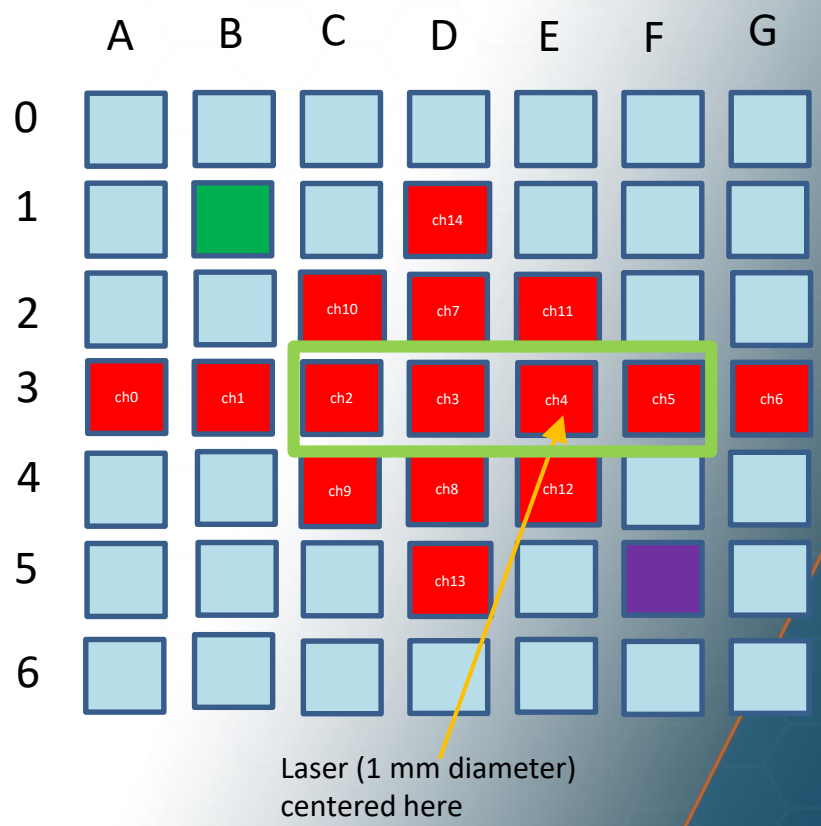


Measurements at INFN:

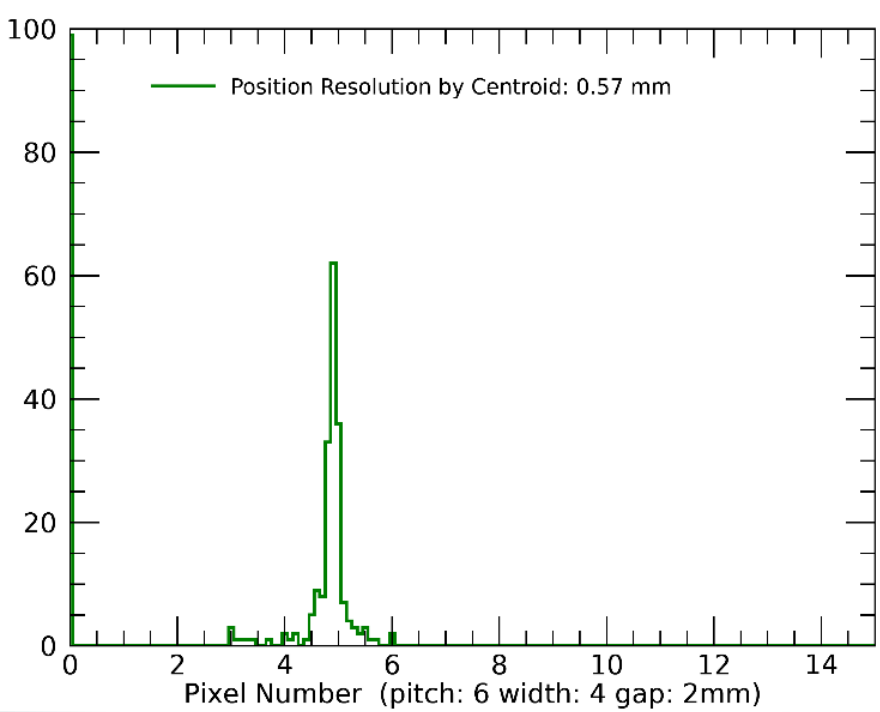
σ_{SPE} ~ **30 ps**, σ_{MPE} ~**15 ps** (Vincenzo)

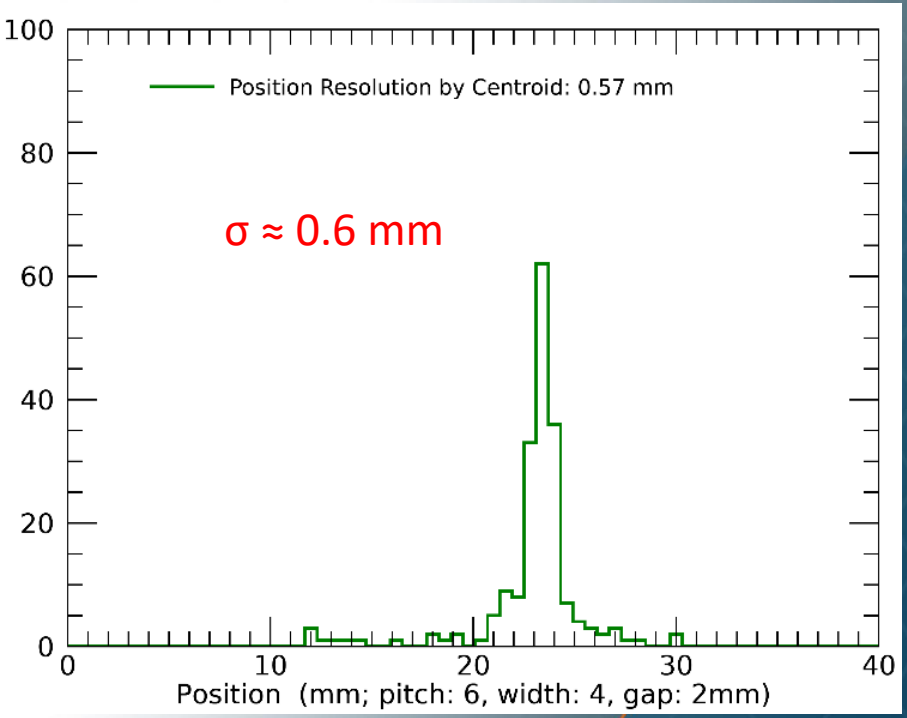
Position Resolution

- Dependent on Pixel size
- **4 mm pixel** w/ 2 mm gap (6 mm pitch)
- Position = 1D **Centroiding** of neighboring row pixels



Position Resolution





Summary

Features

- **10 µm/20 µm** MCPs
- Glass/Ceramic
- New internal support design → **373 cm²** (97% active area)
- Gen-II → flexible **pickup pattern modification**

Performance

- **High QE** (Blue-sensitive) + High uniformity
- **~1E7** Gain
- Low Dark Rates
- **~30 ps** SPE, **~15 ps** MPE
- ***O*(mm)** position resolution

Availability

- Gen I Direct readout & Gen II Capacitively Coupled readout are available today.
- High Rate Picosecond Photodetector (**HRPPD** 10 cm)