LD2413 Development of µRWELL-PICOSEC Detectors

FY24 – Q3 meeting

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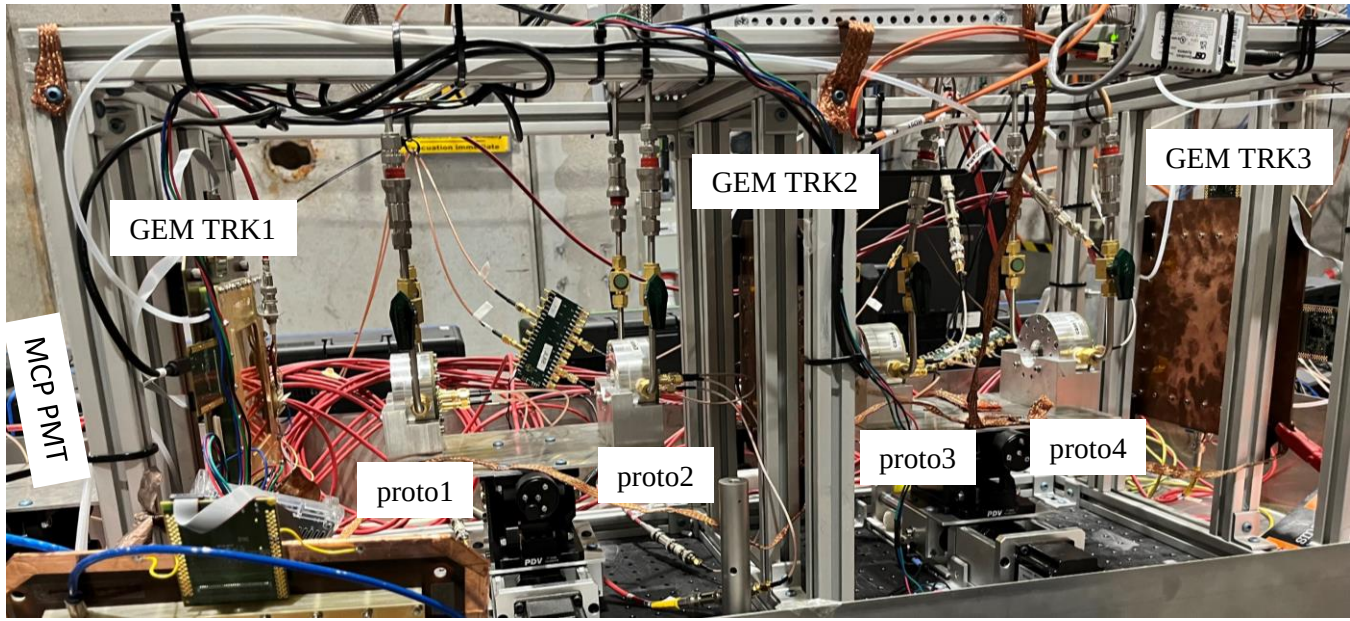
FY24 Q3 Meeting – Single-channel prototypes in April & July 2024 test beam @ CERN

Jefferson Lab

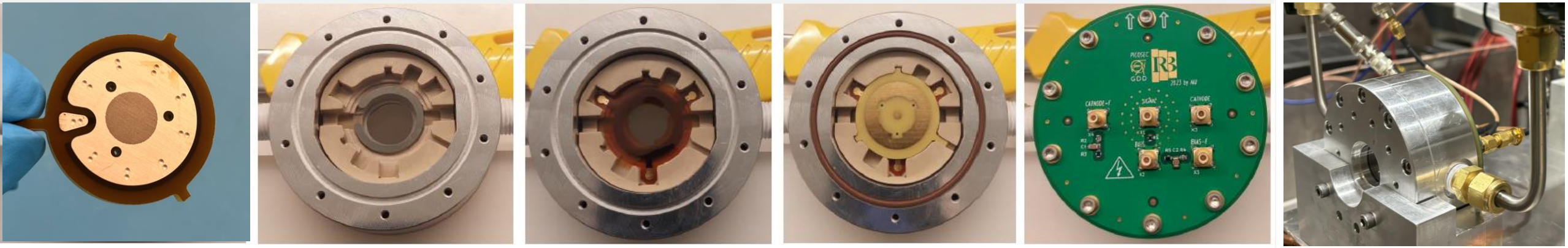
µRWELL-PICOSEC telescope

- PICOSEC telescope was operational, used in April and July test beam
- 4 × single-channel protos as well as up to 2 large prototypes
- 7 different µRWELL-PICOSEC prototypes tested in beam
- MCP-PMT & 3 × GEM trackers for timing & tracking
- DAQ: 10-ch custom preamplifier (or CIVIDEC) + Oscilloscope DAQ
- A tracking software was developed to interface with CERN MATLAB analysis tool
- More than 100 runs of 50k event each were taken ➔ analysis ongoing



µRWELL-PICOSEC telescope with 4 single-channel prototypes in July 2024 test beam

µRWELL -PICOSEC PCB | Cerenkov crystal | Cathode-spacer | µRWELL-PCB | Outer board PCB | Prototype tested in LED setup

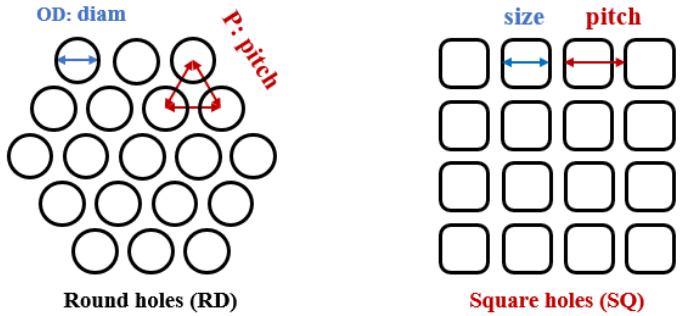


Assembly of the single-channel µRWELL-PICOSEC prototype

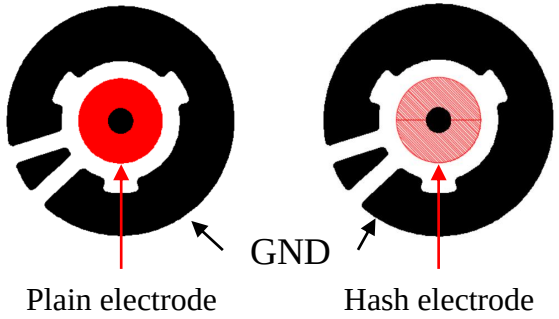
FY24 Q3 Meeting – Some preliminary results from April and July beam test

- HV scan runs with the various prototypes with different holes and pad geometries
- Tested with 2 photocathodes Cesium Iodide (CsI) and Diamond like Carbon (DLC)
- Excellent timing response with both photocathodes (23.5 for CsI and 37 for DLC)
- Data analysis ongoing

New holes geometry for µRWELL amplification

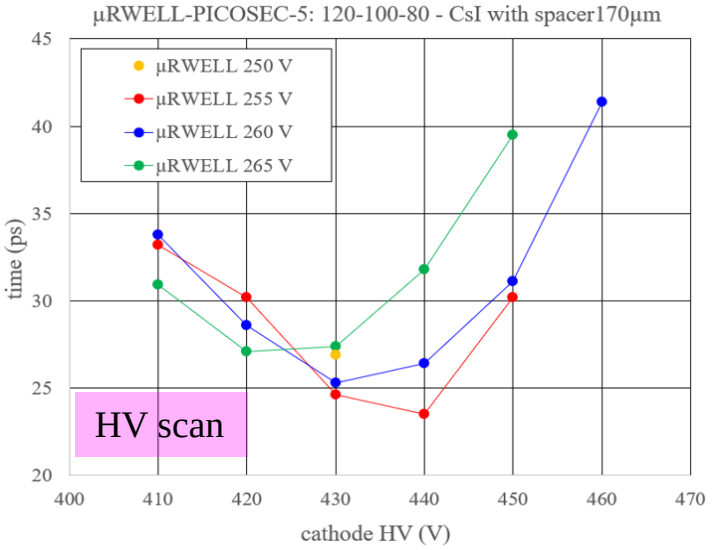


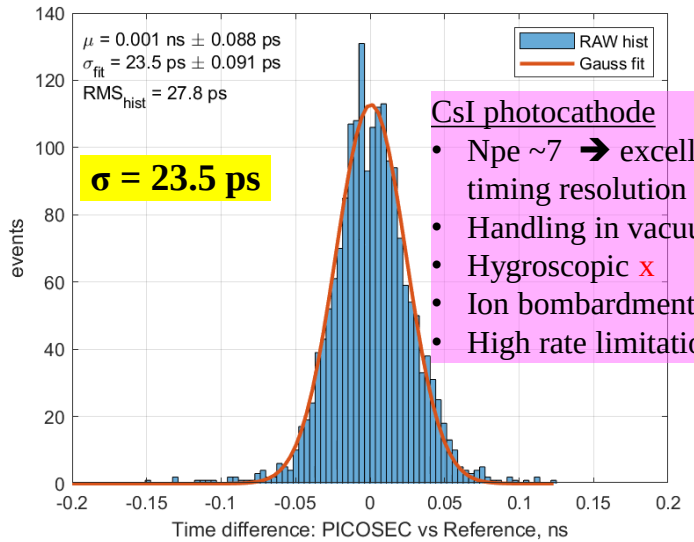
pad readout geometries



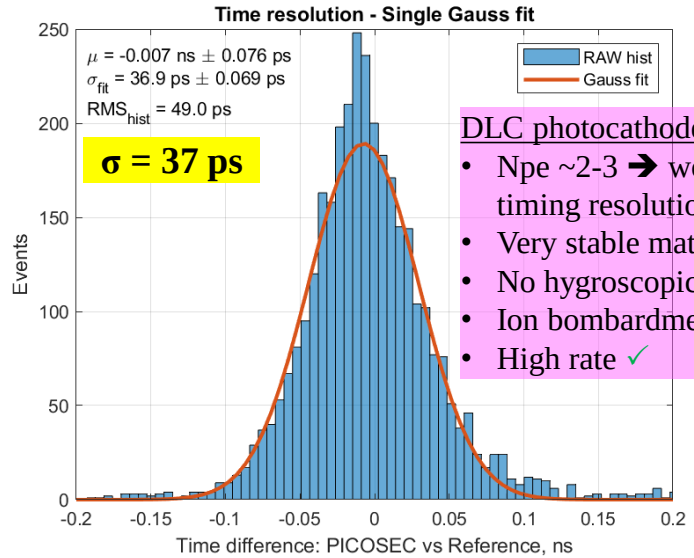
Single channel Prototypes	µRWELL hole Shape	µRWELL Pitch (µm)	µRWELL OD (µm)	µRWELL ID (µm)	Readout Pad
µRWELL 13	Round	80	60	40	**Plain**
µRWELL 11&12	Round	100	80	60	Hash
µRWELL 9&10	Round	100	80	60	**Plain**
µRWELL 7&8	round	120	100	80	Hash
µRWELL 5&6	round	120	100	80	**Plain**
µRWELL 3&4	square	120	100	80	Hash
µRWELL 1&2	square	120	100	80	**Plain**

Different single-channel µRWELL –PICOSEC prototypes fabricated



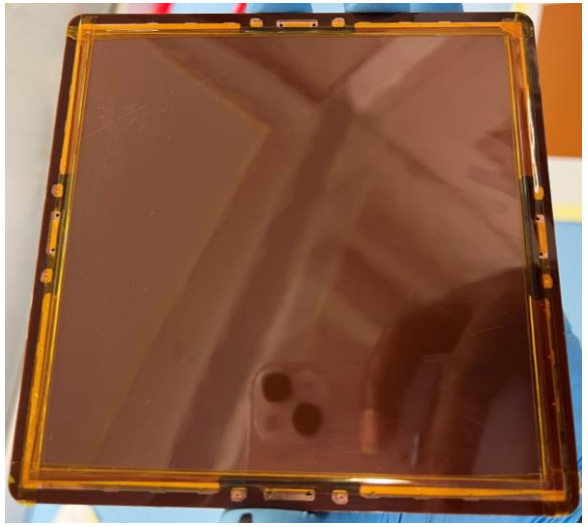


CsI photocathode
- Npe ~7 ➔ excellent timing resolution ✓
- Handling in vacuum x
- Hygroscopic x
- Ion bombardment x
- High rate limitation x

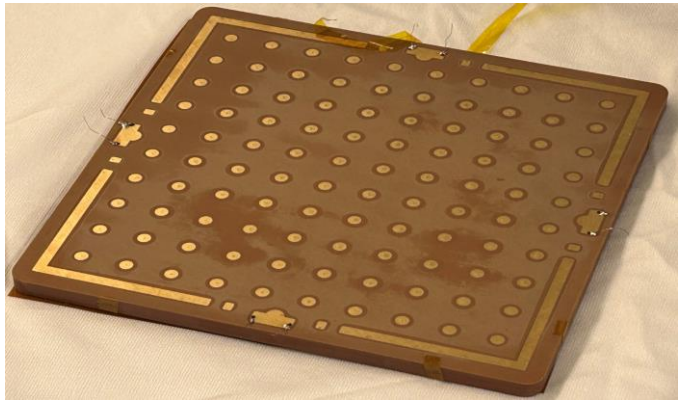


DLC photocathode
- Npe ~2-3 ➔ worse timing resolution x
- Very stable material ✓
- No hygroscopic ✓
- Ion bombardment ✓
- High rate ✓

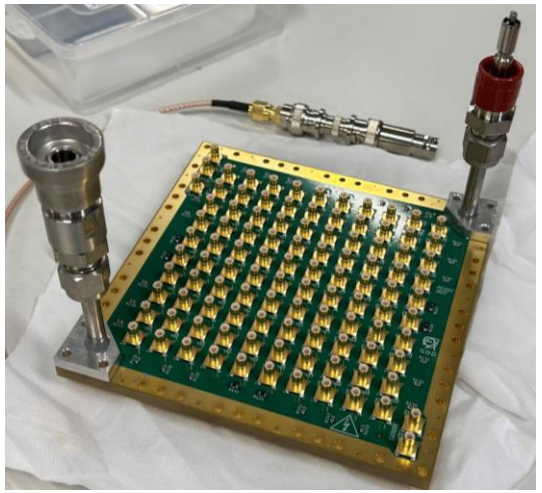
FY24 Q3 Meeting – Large (10cm × 10cm) 100-pads µRWELL-PICOSEC prototype



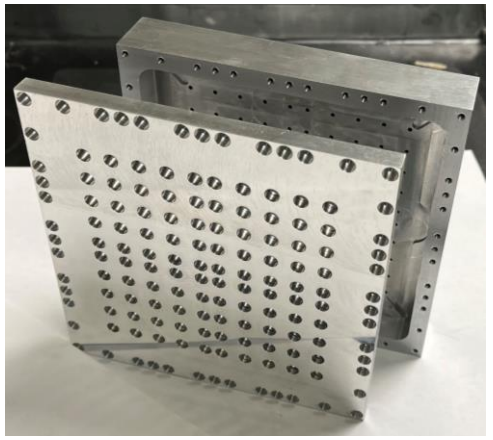
100-pads µRWELL PCB for PICOSEC



Back side of 100-pads µRWELL PCB

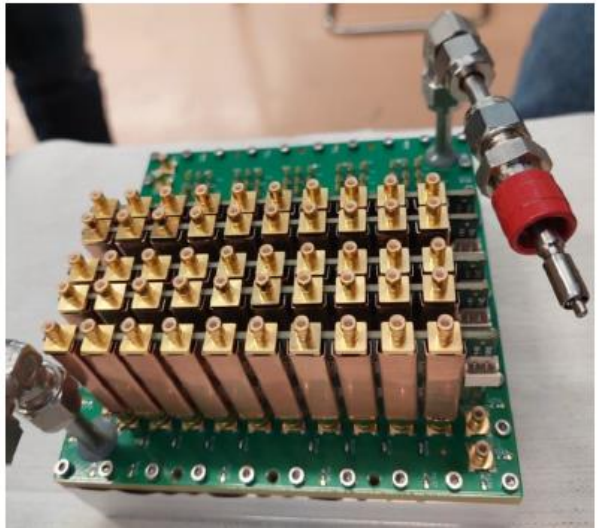


Outer PCB readout interface



Aluminum housing

- Design of large (10 cm × 10 cm) 100-pads µRWELL PCB and fabrication of the PCB at CERN workshop were completed in time for test in beam the July 2024 DRD1-PICOSEC test beam at CERN
- We procured all mechanical parts for the assembly into prototype including the outer PCB readout interface and the aluminum housing
- For the multichannel readout system, we acquire:
  - a 64-channels SAMPIC waveform digitizer (TDC) board including the powered crate and controller ➔ can be scaled to up to 256 channels
  - Six 10-channels custom preamplifier boards developed within the DRD1-PICOSEC collaboration



10-ch custom preamplifier boards

64-channels SAMPIC crate

FY24 Q3 Meeting –100-pads µRWELL-PICOSEC in July 2024 test beam@ CERN

- The large (10 cm × 10 cm) µRWELL-PICOSEC tested in beam July 2024
- Runs with all 100 pads connected to custom preamp cards + SAMPIC digitizer
- **Position scan of full area (all 100 pads) ➔ dedicated SAMPIC runs**
- HV scan on pad45 to determine optimal voltage setting
- Detector run flawlessly but planarity is poor ➔ will affect timing performance

MM1 HV Scan on Pad45

- Run316: Timing MM1-pad45 440/250
- Run317: Timing MM1-pad45 450/250
- Run318: Timing MM1-pad45 460/250
- Run319: Timing MM1-pad45 470/250

- Run360: Timing MM1-pad45 480/240
- Run361: Timing MM1-pad45 470/240
- Run362: Timing MM1-pad45 465/240

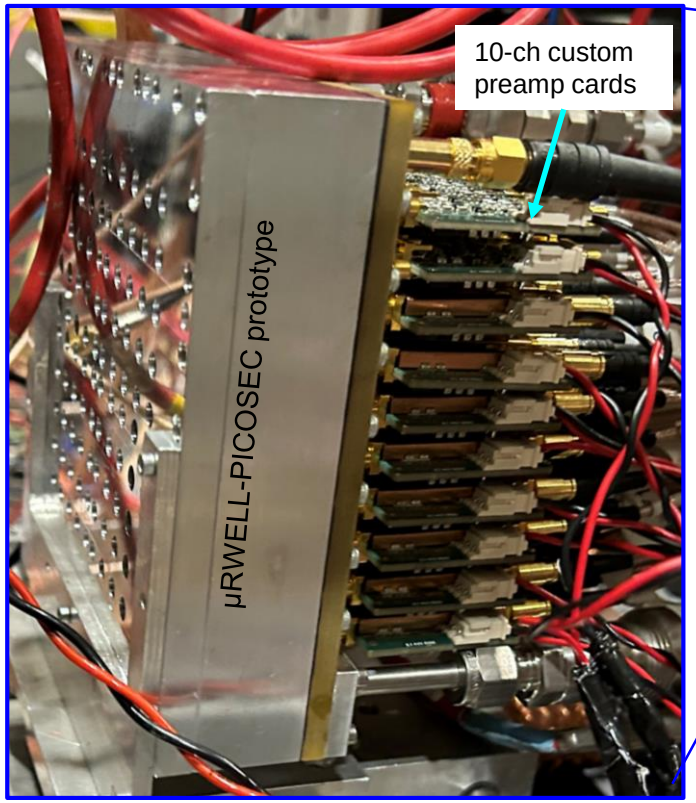
- Run363: Timing MM1-pad45 480/230
- Run364: Timing MM1-pad45 470/230
- Run367: Timing MM1-pad45 460/230

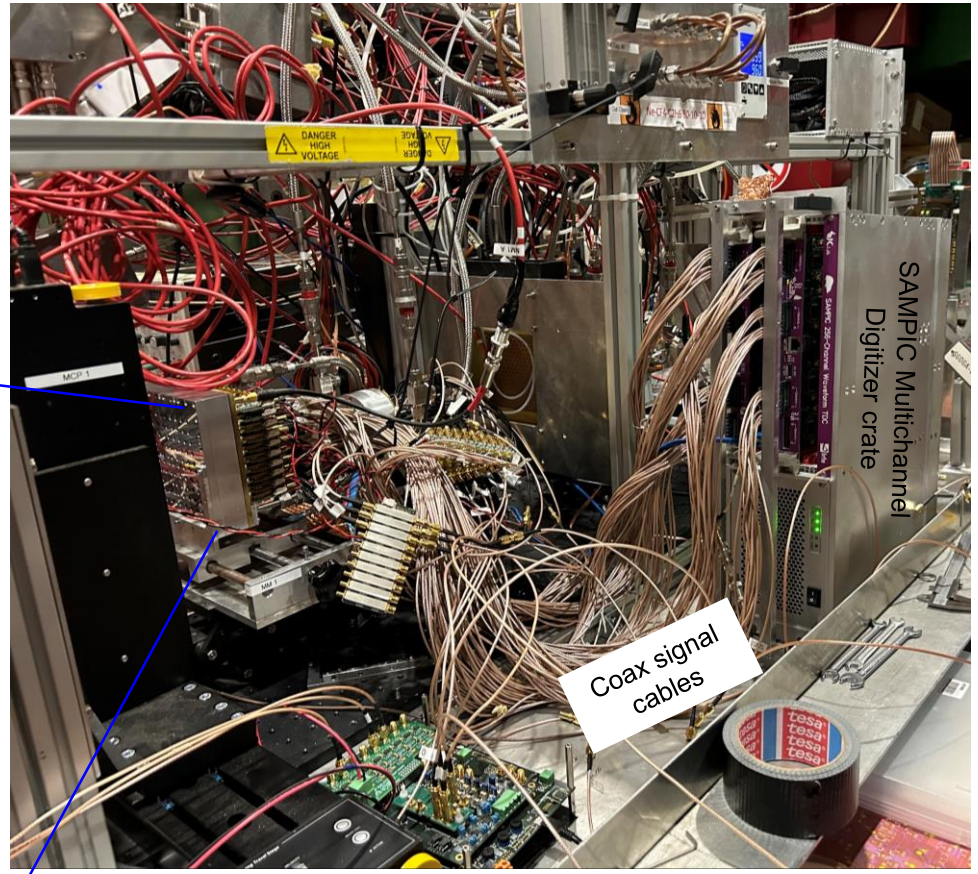
- Run 368: Timing MM1-pad45 480/220
- Run 370: Timing MM1-pad45 500/220
- Run 371: Timing MM1-pad45 520/220

- Run 372: Timing MM1-pad45 450/260

- Run 373: Timing MM1-pad45 520/220
- Run 374: Timing MM1-pad45 520/200

- Run 375: Timing MM1-pad45 525/195
- Run 376: Timing MM1-pad45 530/190





MM1 Pos Scan

- Run361:Timing MM1-**pad45** 470/240
- Run366:Timing MM1-**pad67** 470/240
- Run391:Timing MM1-**pad28** 465/250

FY24 Q3 Meeting – R&D Summary, Budget & Spending Profile, Outstanding issues

LD2413 Development of µRWELL–PICOSEC summary:

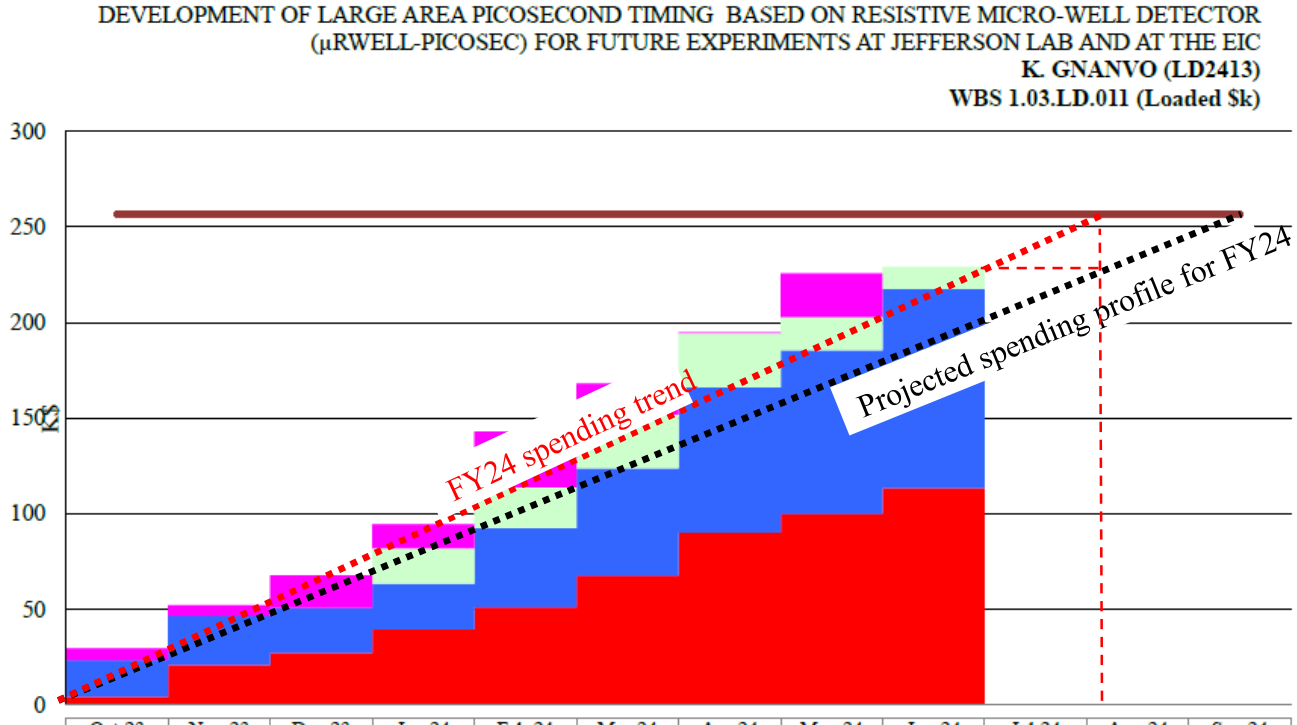
- Large (100-pads) µRWELL-PICOSEC prototype successfully tested in beam in July 2024
- Lots of R&D on single-channel prototypes with excellent timing resolution of 23.5 ps achieved in beam
- Final quarter of year II will be dedicated in test beam data analysis
  ➔ a lot of data and different configuration to explore
- Dr Akash Pandey's abstract on µRWELL PICOSEC accepted for oral presentation at the IEEE-NSS-MIC conference 2024

Budget and Spending profile - Variances anticipated:

- Our spending trend slightly diverge from the projected profile
- Material & fabrication cost higher than initially anticipated
  - all procurement is completed and no additional expense other than shipment of the material from CERN to JLab

Outstanding issues:

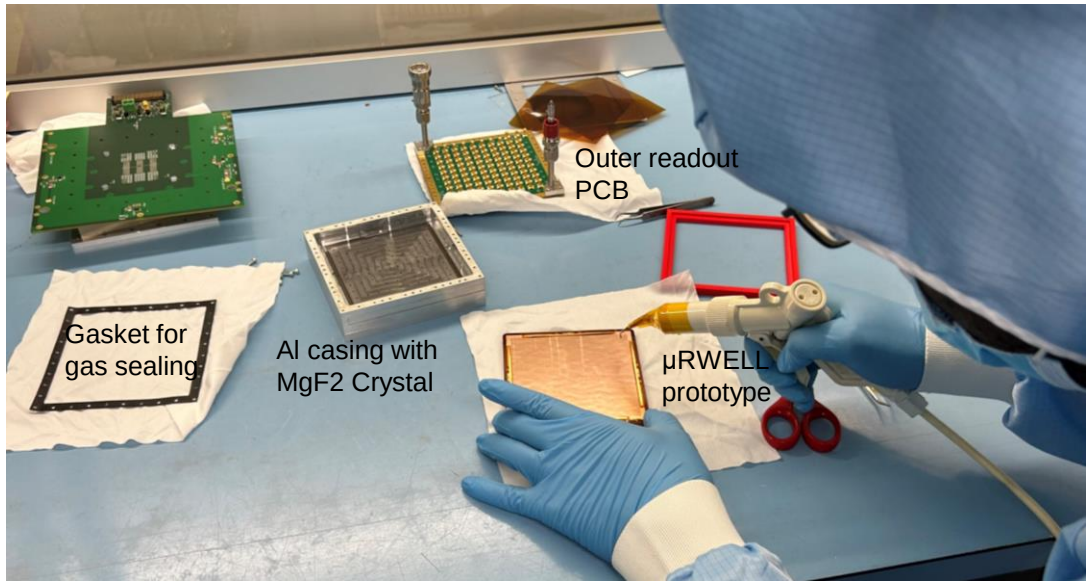
- We will request supplemental financial support for the final months (August / September) of postdoc salary
- Secure second year funding for postdoctoral Dr Akash Pandey

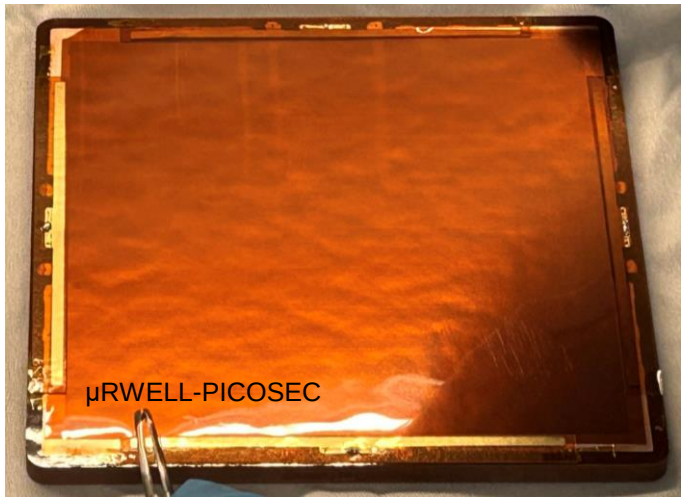


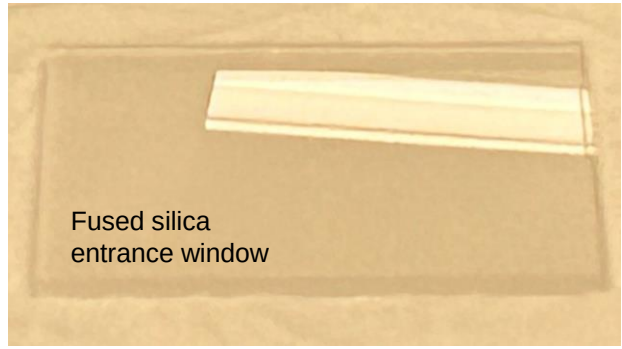
	Oct-23	Nov-23	Dec-23	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-24	Jul-24	Aug-24	Sep-24
YTD Spending	30	52	68	95	143	168	195	226	229	0	0	0
Pending	6	5	17	13	29	16	0	23	0	0	0	0
Open Obligations	0	0	0	18	21	28	28	17	11	0	0	0
Expenses	19	26	23	24	41	56	76	85	104	0	0	0
Labor	4	21	27	40	51	68	90	100	113	0	0	0
Funding	257	257	257	257	257	257	257	257	257	257	257	257
3-Mo Avg Projection												

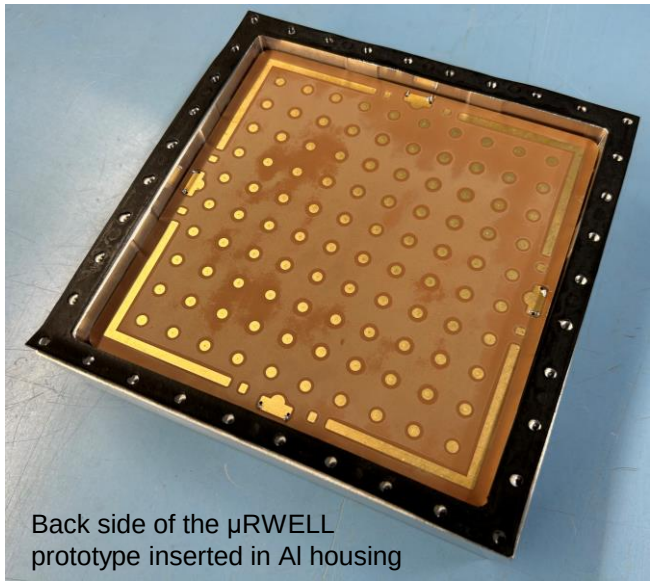
backup

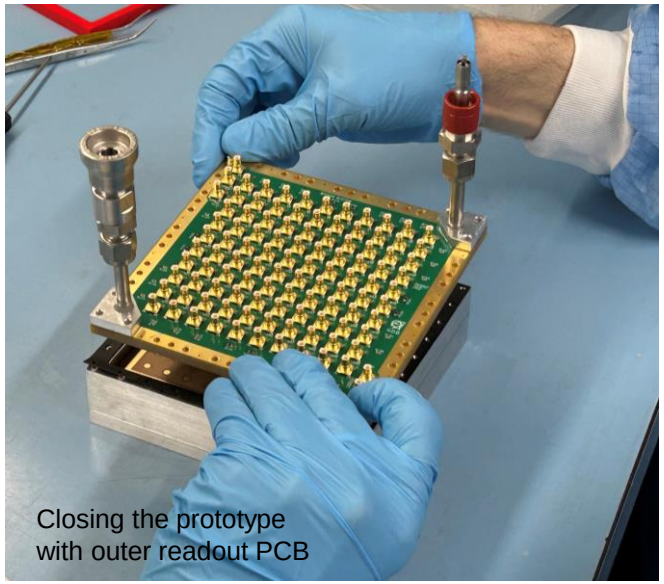
FY24 Q3 Meeting – Assembly of 100-pads µRWELL-PICOSEC

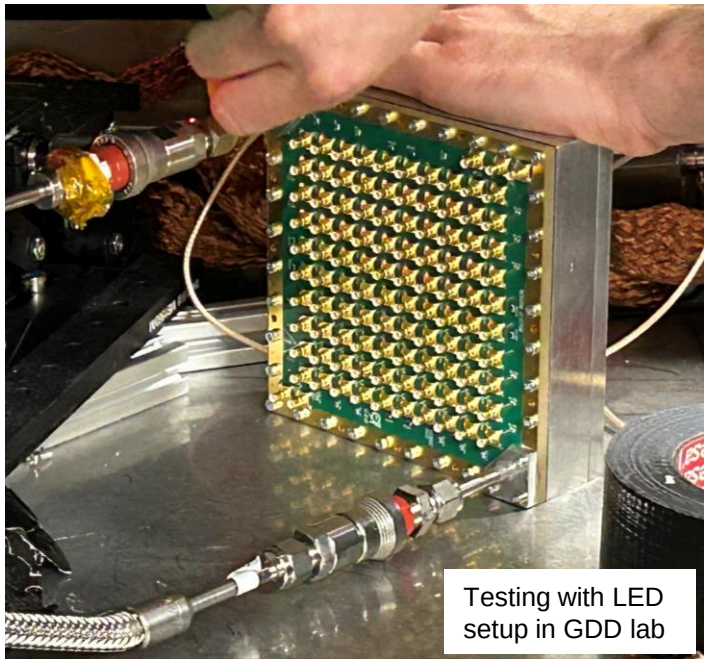







Back side of the µRWELL prototype inserted in Al housing


Closing the prototype with outer readout PCB


Testing with LED setup in GDD lab

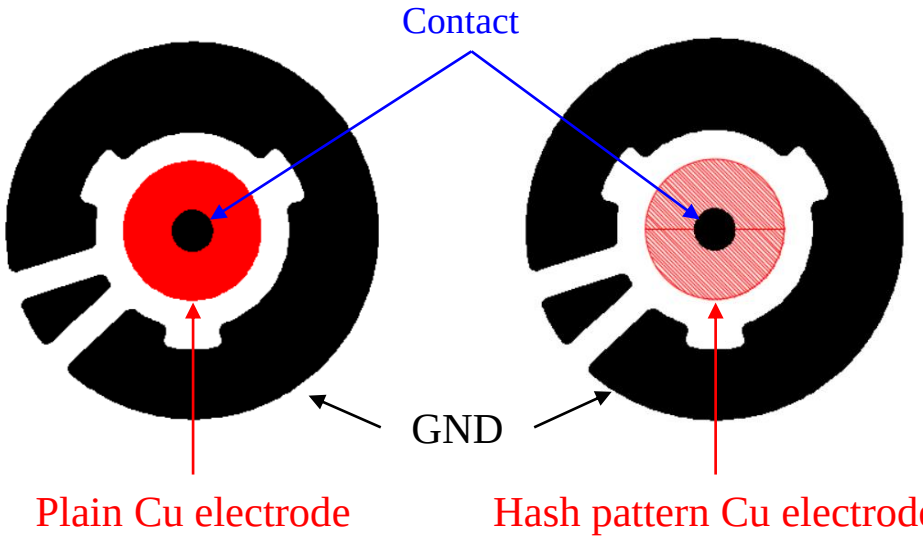
FY2413 µRWELL-PICOSEC – Q2 Progress & status

Optimization of single-channel µRWELL-PICOSEC prototypes

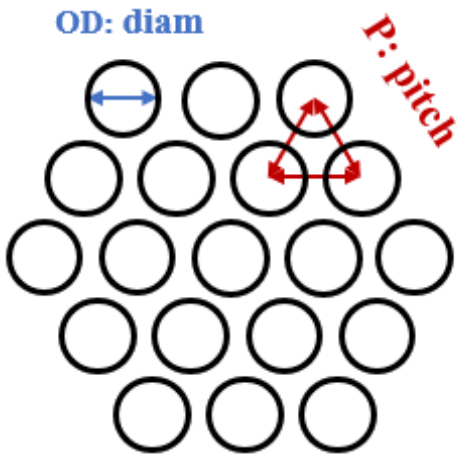
- New µRWELL hole geometries: 3 main approaches under investigation
  - Minimize pitch to outer diameter ratio ➔ reduce e-field effect
  - Increase hole density ➔ Increase gain capability
  - Standard round holes vs. square holes ➔ mimic MM mesh pattern
- Plain solid pad vs. hash pattern pad
  - Minimize detector capacitance ➔ improve S/N

Prototype	Shape	P (µm)	OD (µm)	ID (µm)
RD-T150-P80-D60	round	80	60	40
µRWELL#9	round	100	80	60
µRWELL#5	round	120	100	80
SQ-T150-P120-D100	square	120	100	80

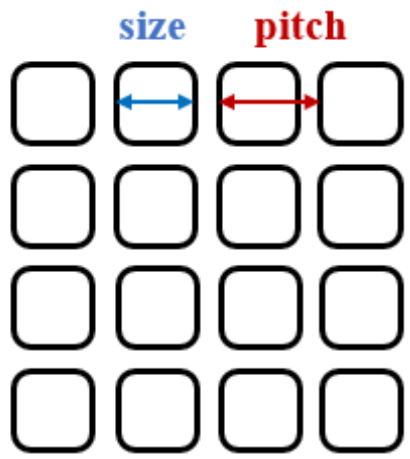
Pad readout geometry



New holes geometry for µRWELL amplification



Round holes (RD)



Square holes (SQ)