DLC-uRWELL Detector R&D Progress from USTC

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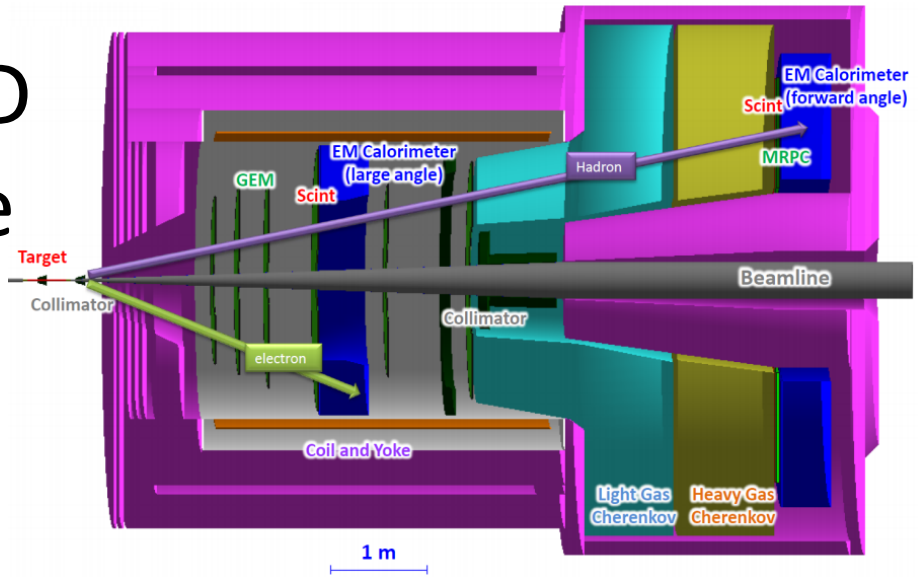
Outline

- Introduction
- DLC coating
- uRWELL with 2d readout
- High-rate uRWELL
- VMM readout
- Summary

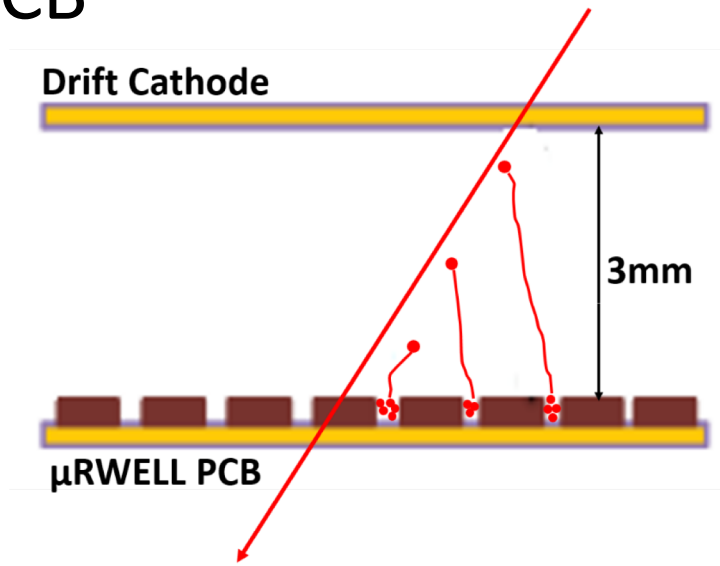
Introduction

- GEM is the baseline option of the tracker for the SoLID experiment.
  - High rate capability
  - Good spatial resolution
  - Large area and low mass
- uRWELL as a novel MPGD is a promising alternative to GEM as a detector option for the SoLID tracker

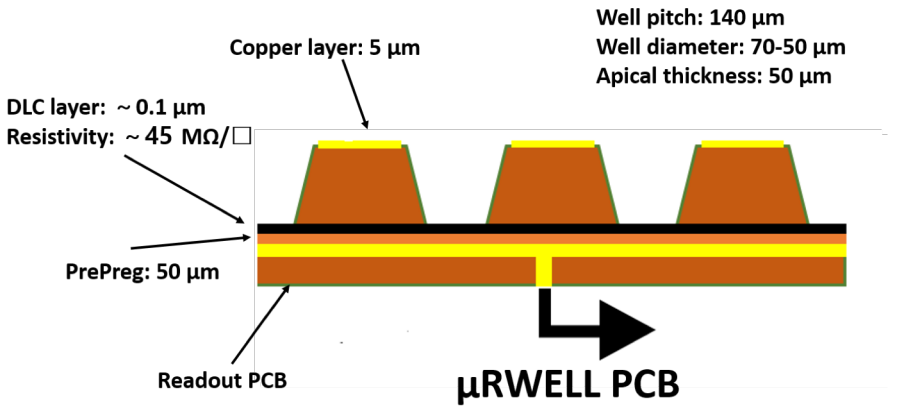


uRWELL: Micro-Resistive WELL

- uRWELL = Drift board + uRWELL PCB
  - simple and compact structure
  - low mass and good gain uniformity
  - no gluing, no spacers, no stretching, no rigid frames
  - fast assembling
  - cost effective



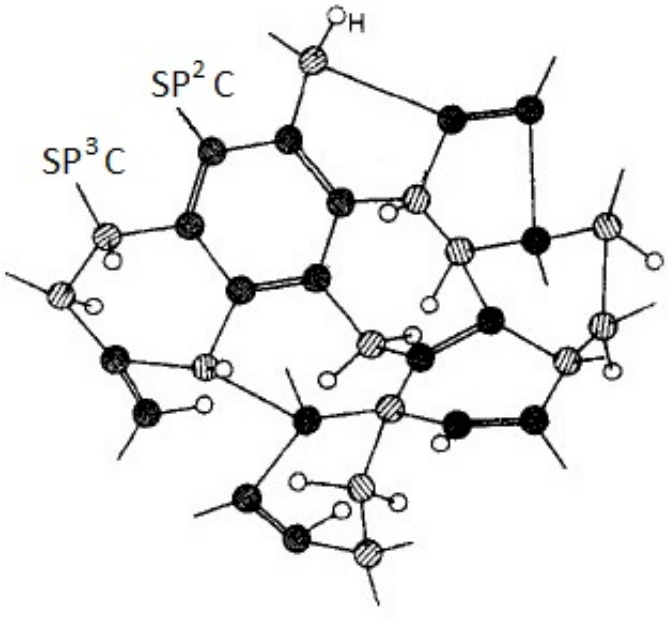
- uRWELL PCB = A stack of "readout PCB / insulating pre-preg / resistive DLC / well-type holes"
  - DLC is a critical component



Spark-protected single well-type amplification stage

DLC: Diamond-Like Carbon

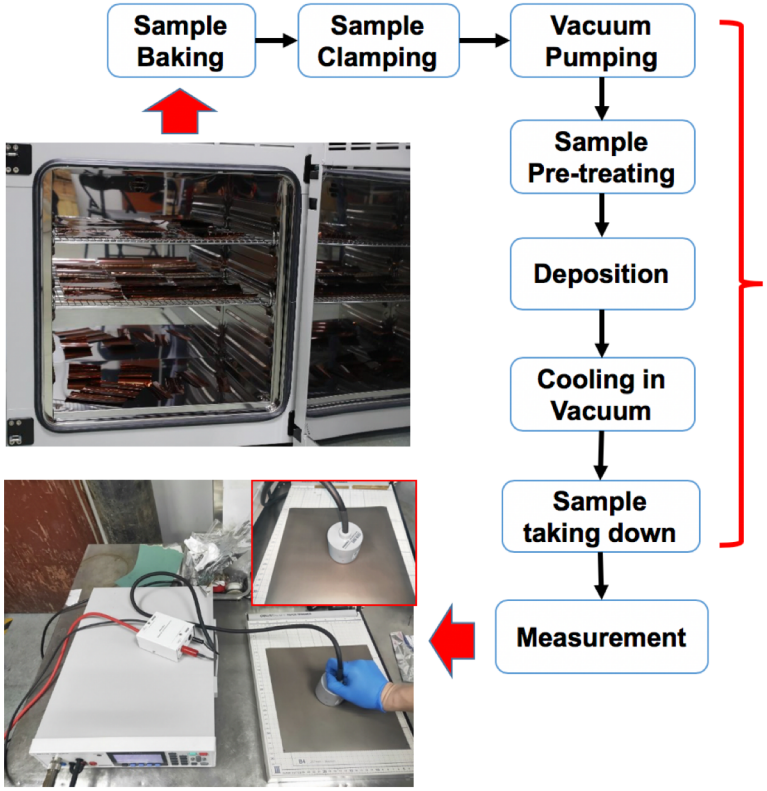
- DLC: metastable amorphous carbon material containing both diamond-structure and graphite-structure
- A new big star rapidly rising in the MPGD field
  - resistive electrodes by DLC coating

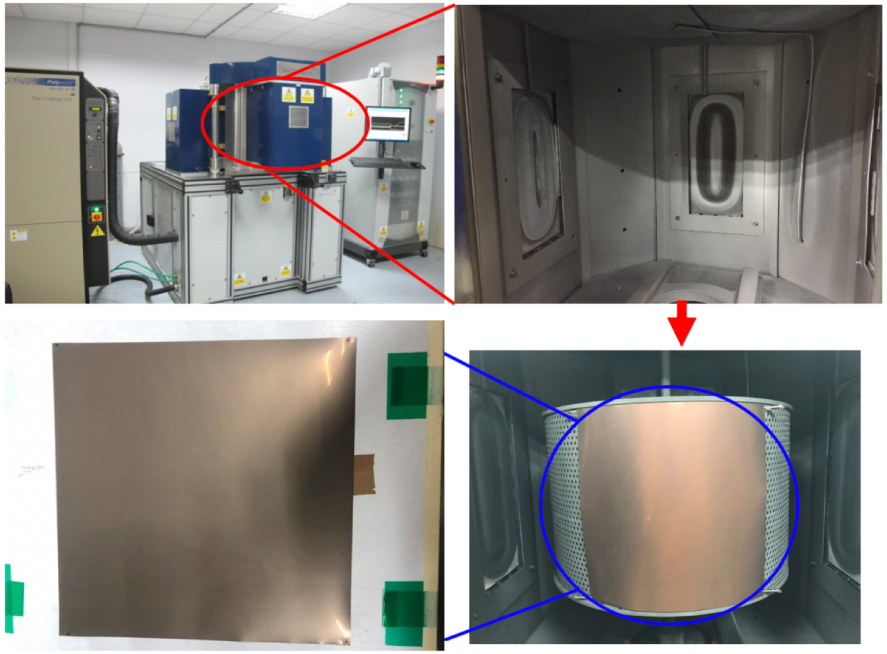


- ✓ *Stable surface resistivity which can be precisely adjusted*
- ✓ *Robust and stable both chemically and physically*
- ✓ *Sub-micrometer level coating for fine resistive structures*
- ✓ *Precise pattern can be made by using photolithography*
- ✓ *Available for large area*

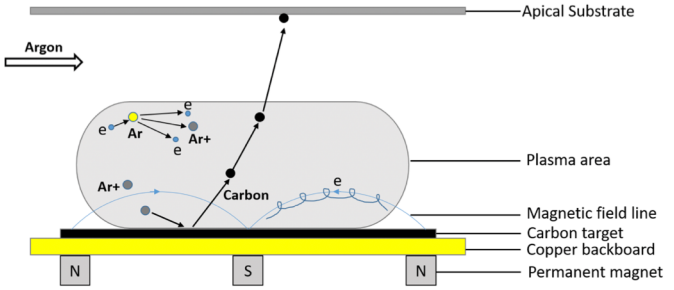
DLC with Magnetron Sputtering

Depositing DLC on a substrate with magnetron sputtering technique to form a high-quality resistive electrode





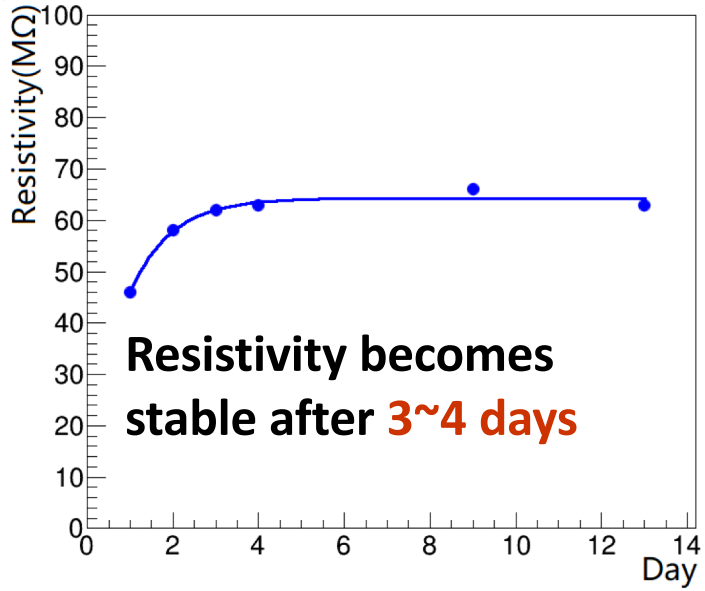
Magnetron sputtering technique

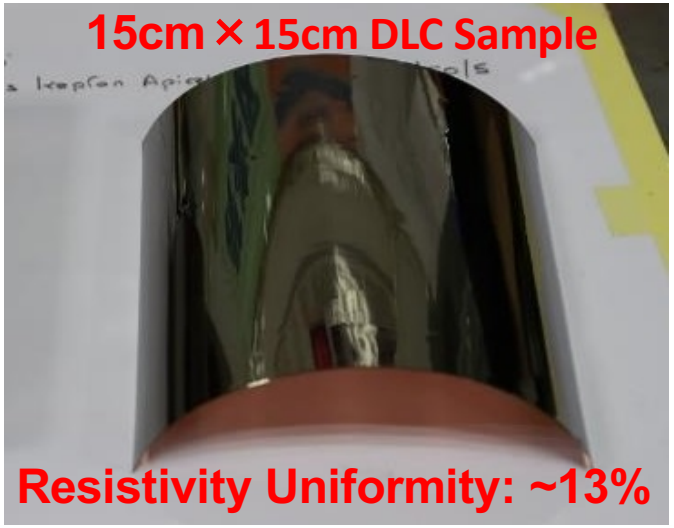


In close collaboration with State Key Laboratory of Solid Lubrication, Lanzhou Institute of Chemical Physics

DLC Resistive Electrode Samples

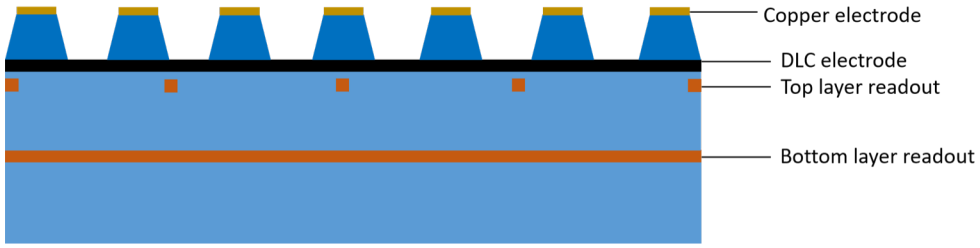
- Thickness from tens to hundreds nanometers
- A large range in surface resistivity available: 1MΩ/☐ ~ 500MΩ/☐, which can be controlled by adjusting target power, deposition time, vacuum degree and doping.
- Good resistivity uniformity achieved

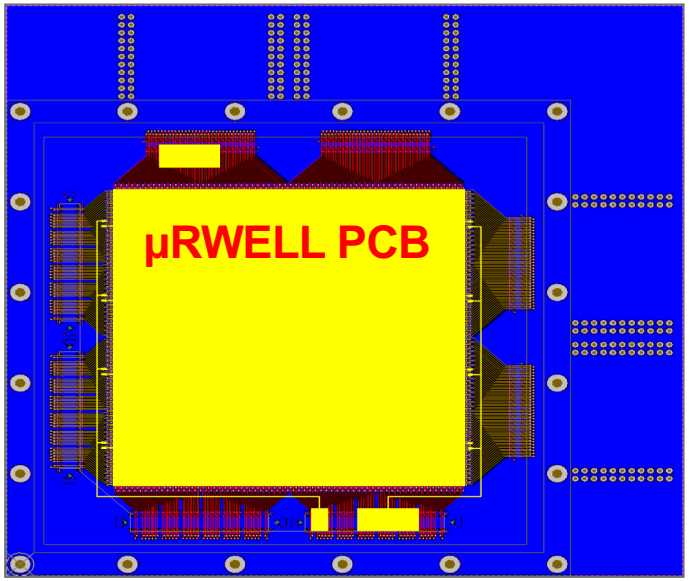




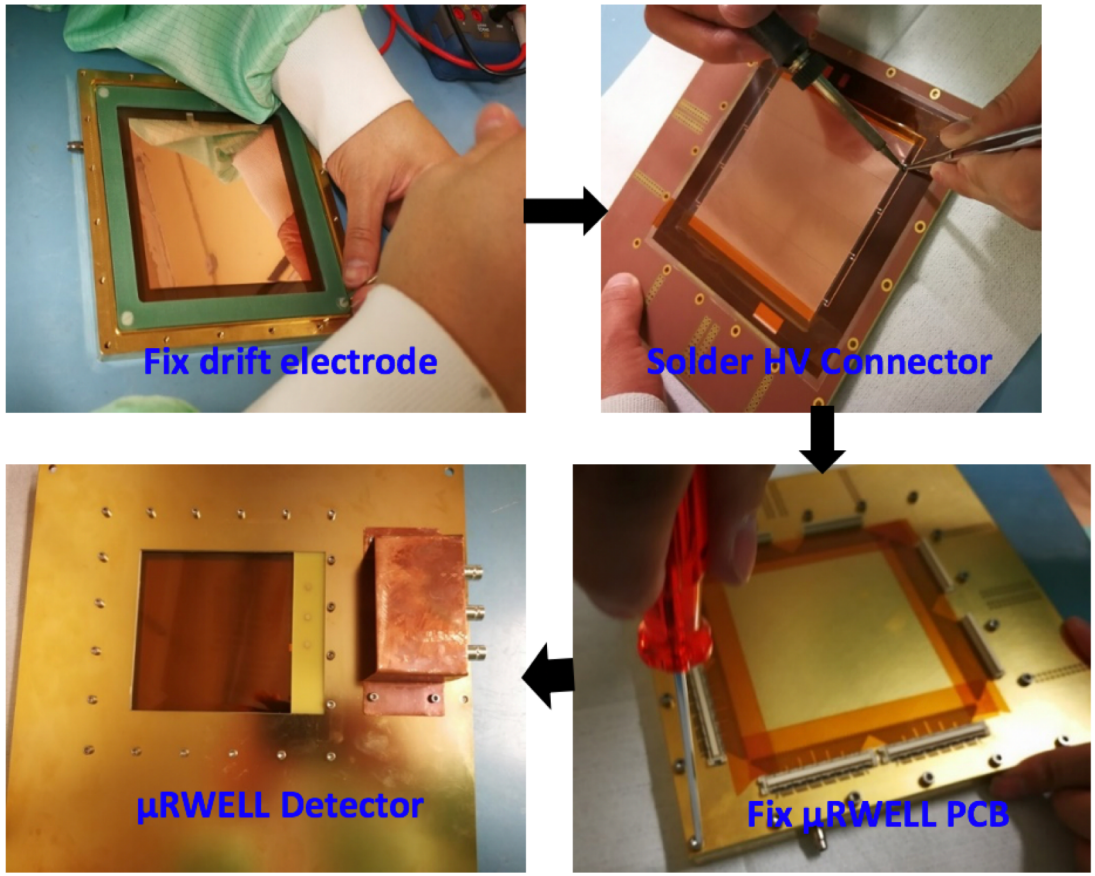
Design of a 2D uRWELL PCB

- 2 layers of readout strips in orthogonal configuration for 2-D position measurement
- An active area of 10cm*10cm into 4 sectors
- Strip pitch: 400um
- Larger strips at bottom to compensate weaker signals induced at bottom strips





Detector Fabrication



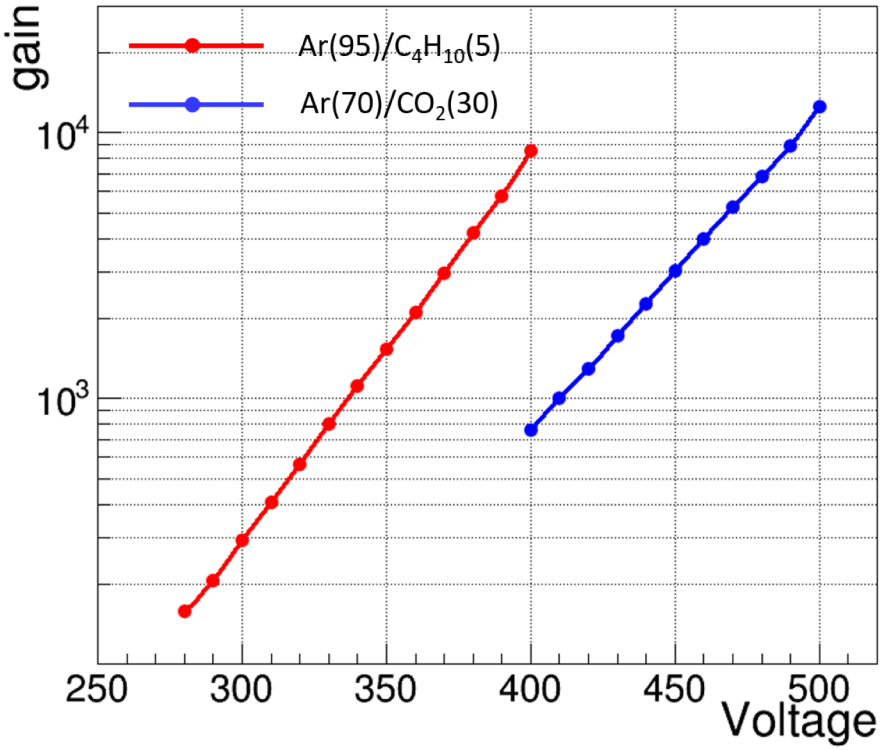
- Drift electrode: 50μm APICAL foil coated with copper
- DLC Electrode resistivity : 40MΩ
- Active area : 10cm × 10cm
- Drift gap : 3 mm
- 4 Hirose connector + 4 Panasonic connector

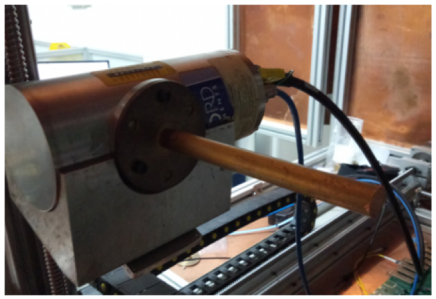
A 2D uRWELL detector with Chinese DLC !

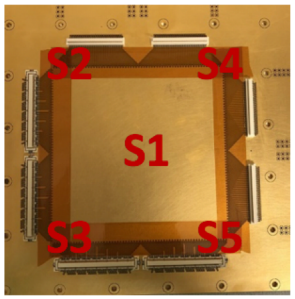
Special thanks to Antonio Teixeira and Rui De Oliveira for technical help.

Gas Gain and Rate Capability

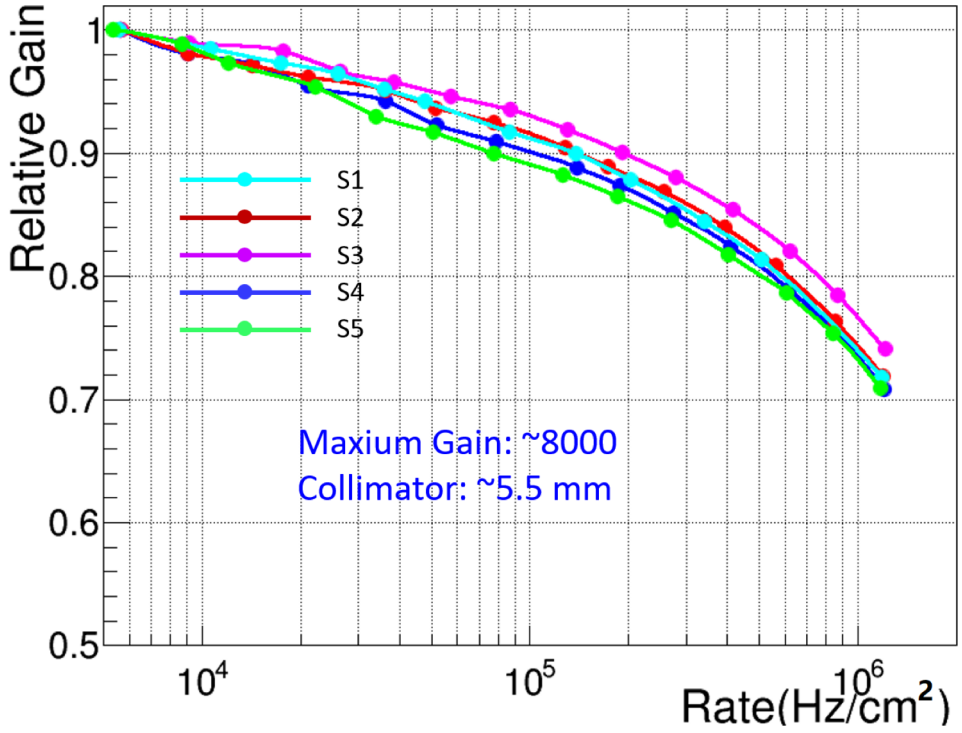
Gas gain can reach 10^4, very high for single stage amplification.





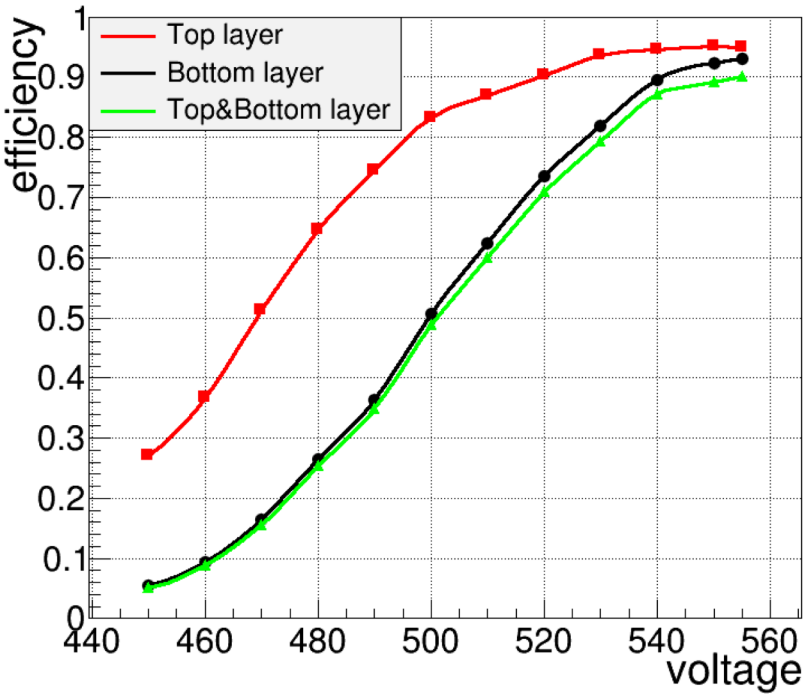


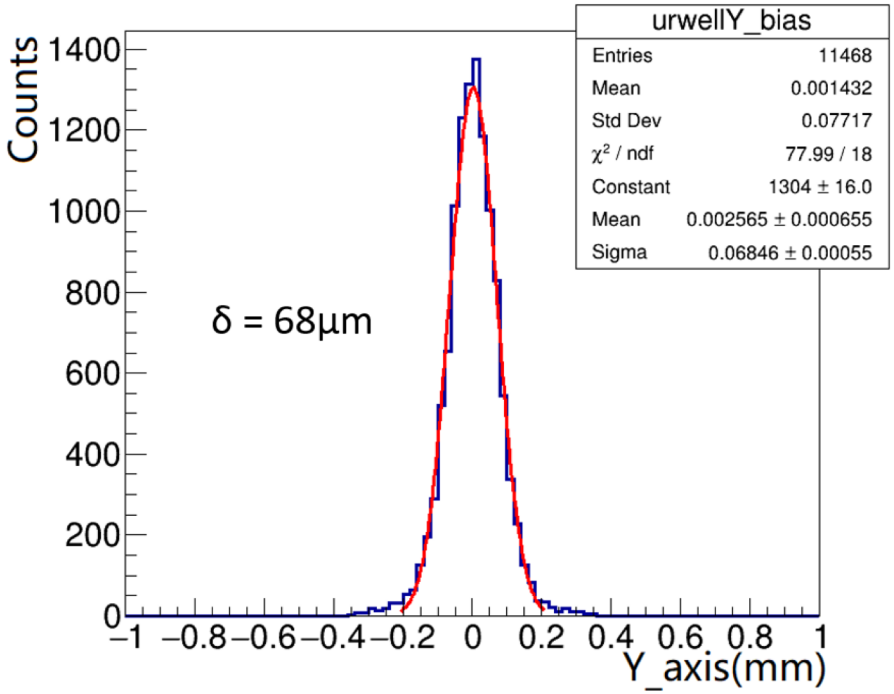
- Ar(70)/CO_2(30) gas mixture
- Source: 8keV copper X-rays
- Collimator: 5.5mm-diameter



Gas gain drops about **30% @1MHz/cm²**

Efficiency and Spatial Resolution

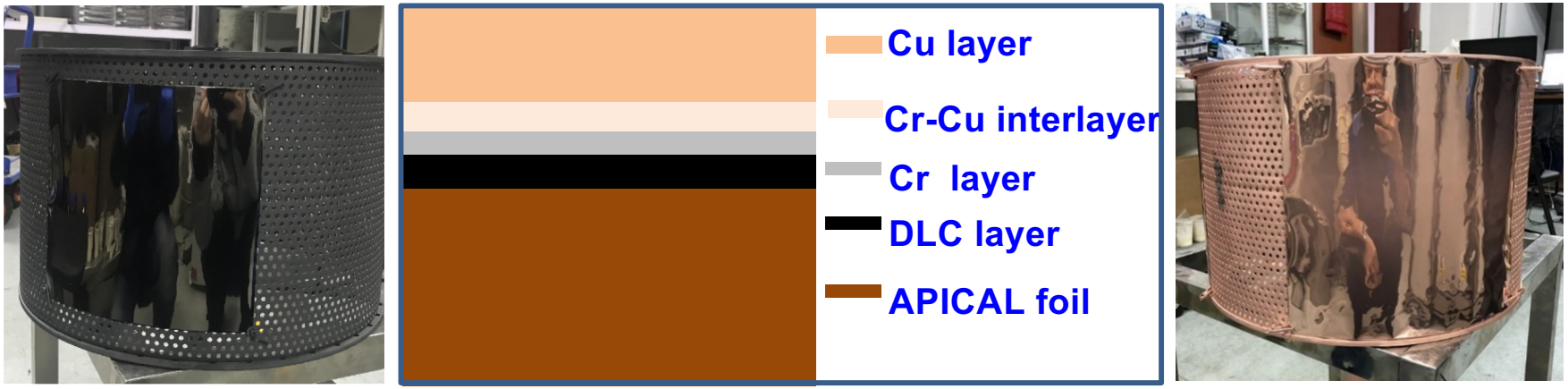




- Efficiency of top layer: ~95%, bottom layer: ~92%
- Signal induced on top layer ~2 times larger than that on bottom layer, strip layout needs to be optimized
- A position resolution better than 70 um is achieved in both dimensions

DLC+Cu Deposition

DLC coating on substrate → Copper coating on DLC



- Simplifying manufacturing process of resistive MPGDs and improving the quality.
- Allowing to create precise printed circuits on a DLC resistive electrode hence realizing complex functions
- opening ways for making new MPGD architectures

A critical element in making high-rate uRWELL structures

RD51 Common Project

- DLC based electrodes for future resistive MPGDs
- DLC+Cu is a central subject in this project

Title of project: *DLC based electrodes for future resistive MPGDs*

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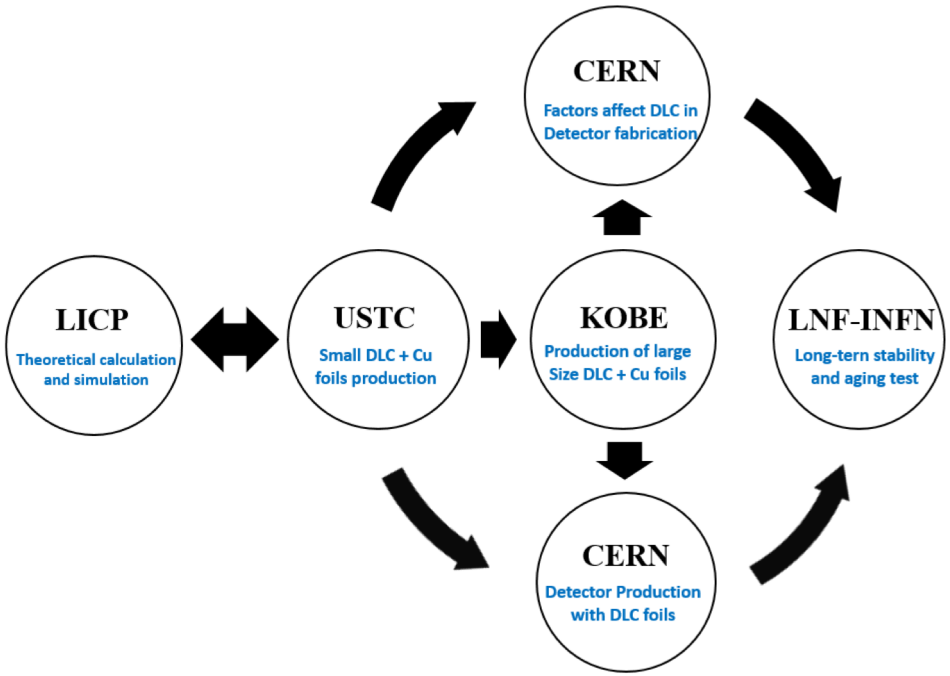
Ext. Collaborators:

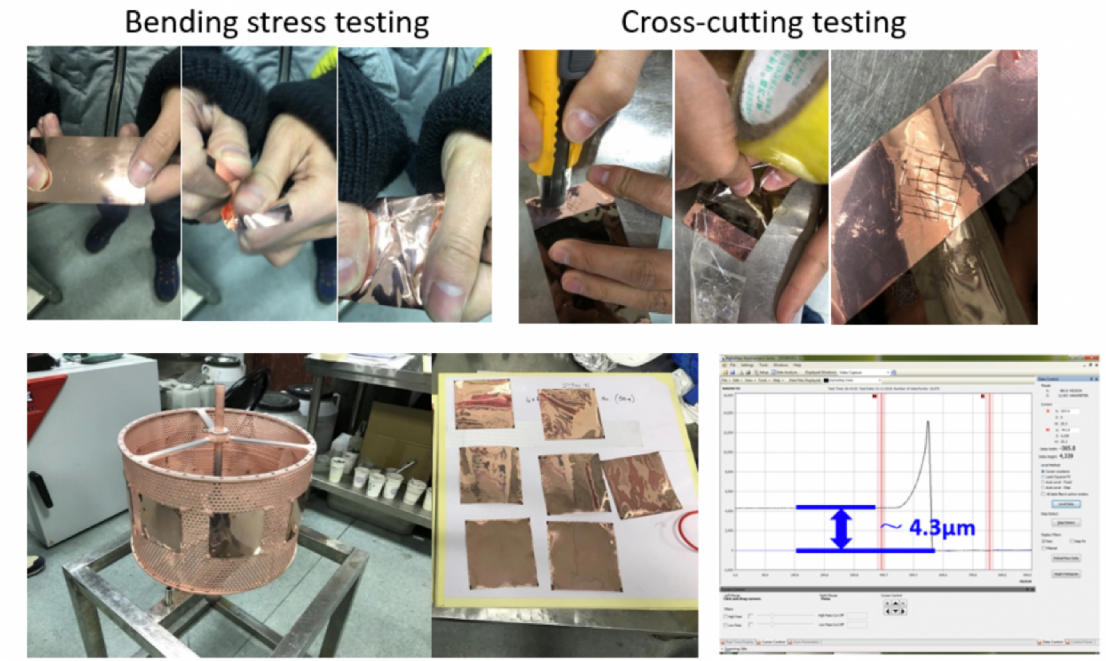
1. *State Key Laboratory of Solid Lubrication, Lanzhou Institute of Chemical Physics, Chinese Academy of Science contact person: Lunlin Shang e-mail: shangll@licp.cas.cn*



USTC is leading this project.

Big Progress on DLC+Cu

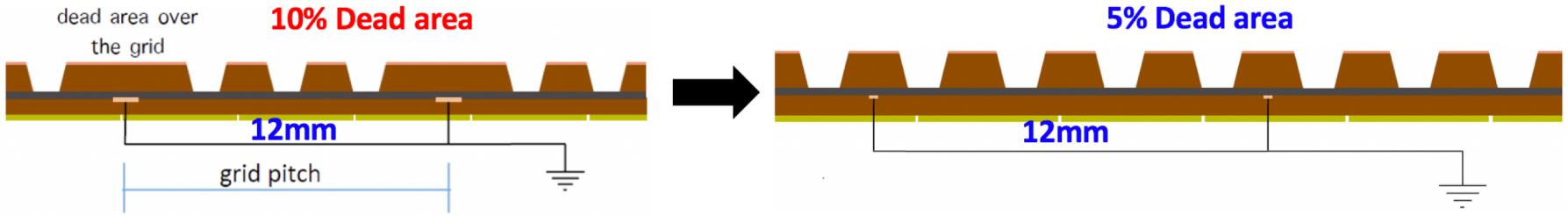
- Good adhesion has been achieved between DLC and copper by introducing a Cr transition layer.
- Cu coating thickness can be adjusted from 1-5 um
- Many DLC+Cu samples have been produced for the MPGD community



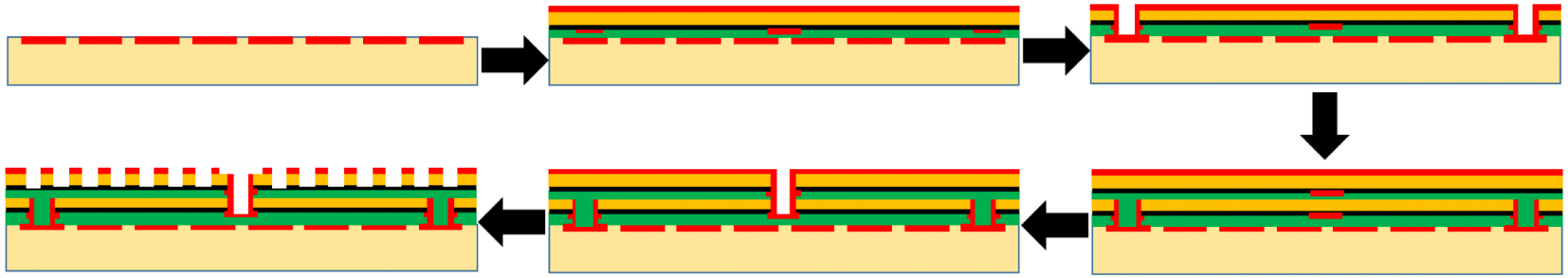
High-rate uRWELL Concepts

- Approach to high-rate: fast grounding
- Two structures being explored, which are only made possible with DLC+Cu

Single-DLC layer uRWELL with fast grounding lines



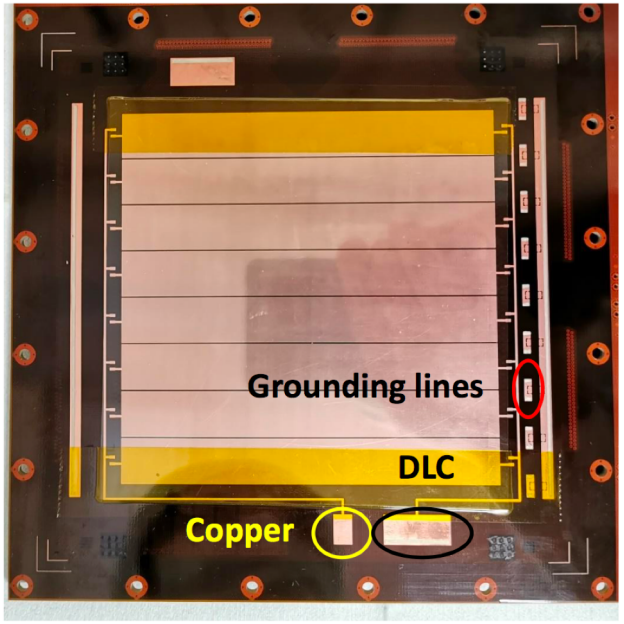
Double-DLC layer uRWELL with Sequential Build Up (SBU) technology : more promising for large area production



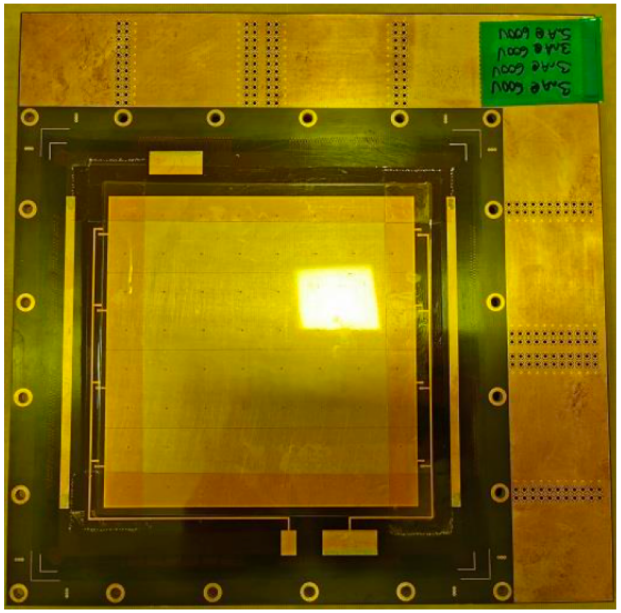
High-Rate uRWELL Prototypes

- Built a 10cm*10cm prototype with DLC+Cu for each of the two high-rate uRWELL schemes
- Observed signals with radioactive sources
- More testing is ongoing

Single-DLC layer uRWELL with fast grounding lines



Double-DLC layer uRWELL with SBU



Going for Large Size

A New sputtering system (Hauzer 850) is ready to make large-area DLC/DLC-Cu samples.

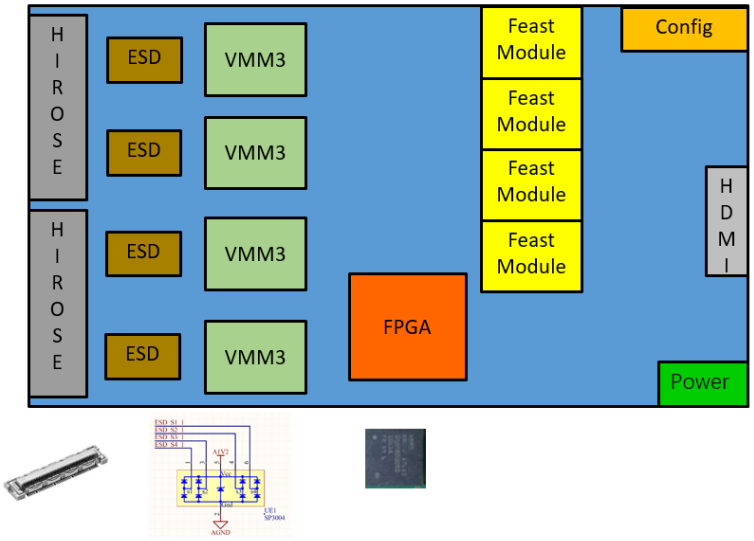
Chamber size: Φ800mm×900mm

Best Sample size (up to): 500mm×500mm (Rigid substrate), 500mm × 1900mm (Flexible substrate)

A VMM-based Readout

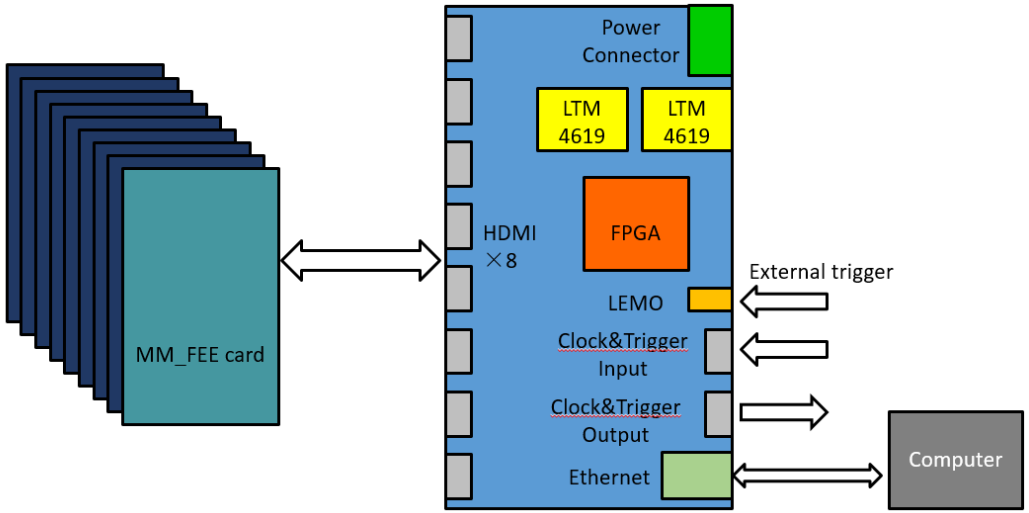
FEE card

- 4 VMM chips: 256 channels
- 64 4-channel ESDs (SP3004) for input protection
- HDMI (~340Mbps bandwidth) for output



DAQ board

- 8 HDMIs (8 × 256 channels), scalable.
- Receive and fan out the clock and trigger signal
- Both auto-trigger and external trigger available.



Integration and Testing

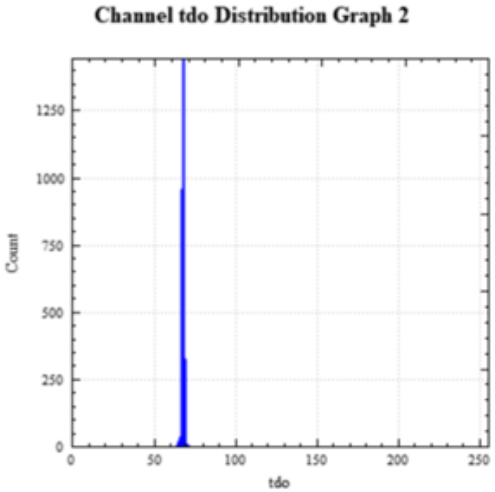
FEE noise:

Standalone: Vp-p<=4mV, Vrms<=800uV

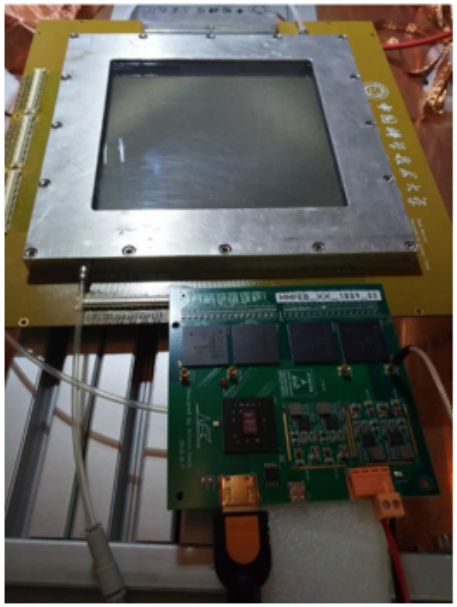
With detector: Vp-p<=20mV, Vrms<=3mV

Timing resolution:

RMS = ~0.5ns

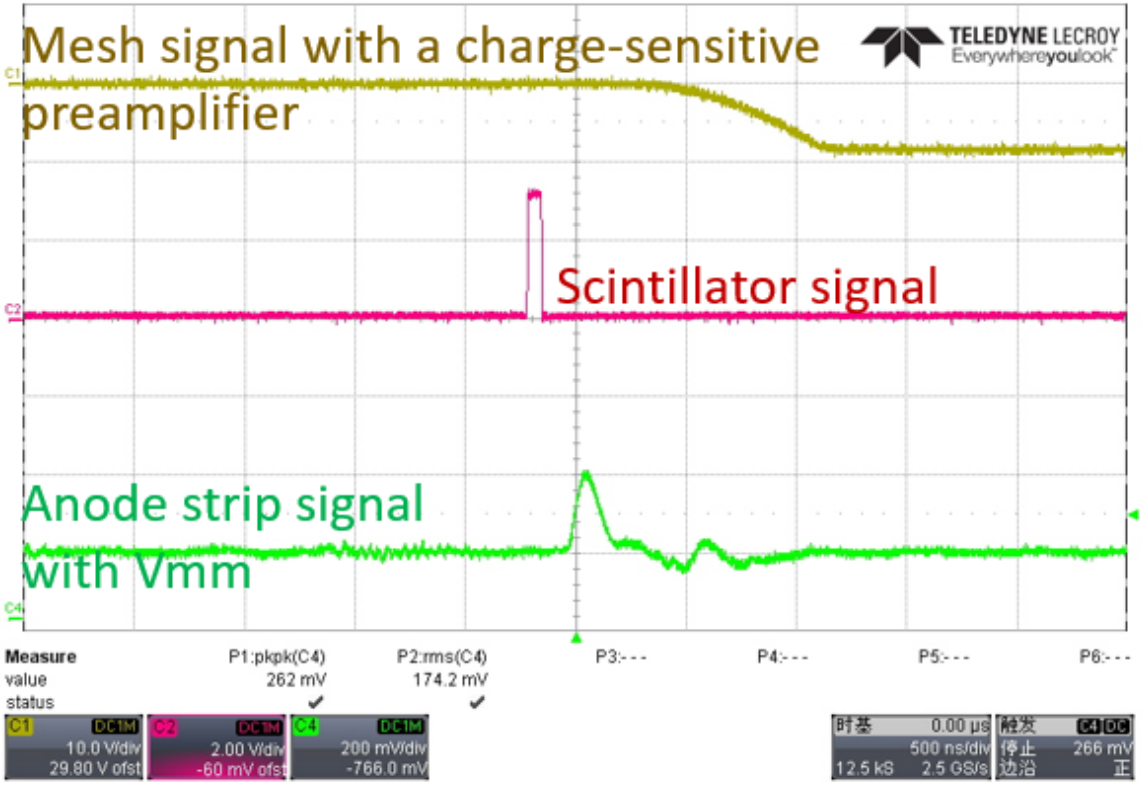


A Micromegas detector

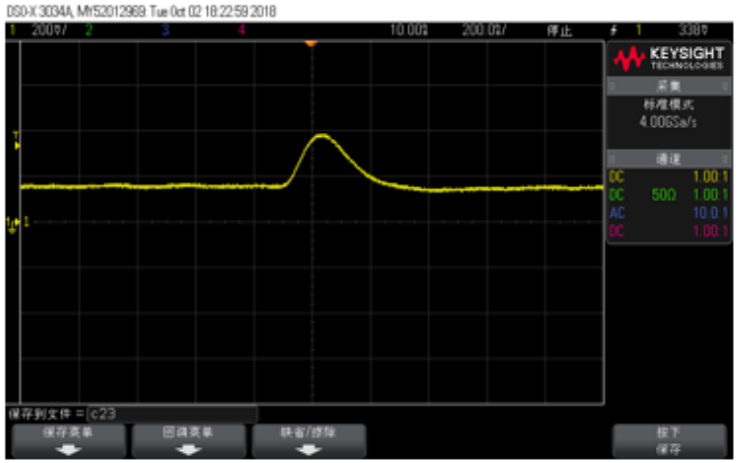


Signals with cosmic rays and X-rays

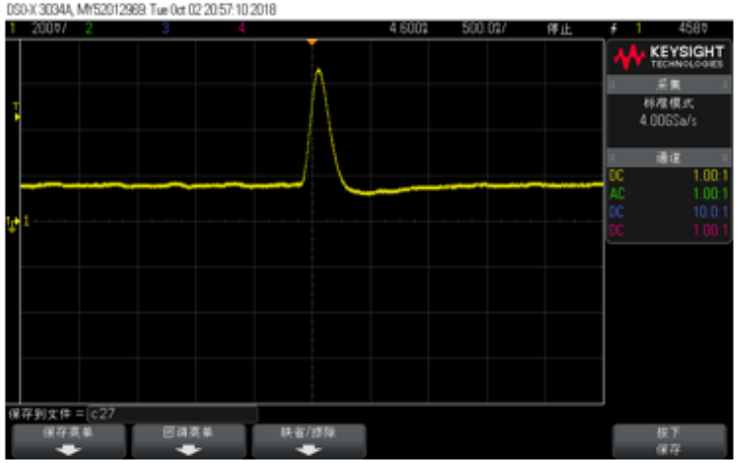
Testing with cosmic rays and 5.9keV x-rays



cosmic ray signal (anode)



X-ray signal (anode)



Summary

- uRWELL offers a promising alternative detector option for the SoLID tracker.
- A solid uRWELL R&D program in place at USTC
- Significant progress has been made on DLC resistive coating and high-rate uRWELL.
- VMM readout in development for high-rate MPGDs.