μRWELL Update

Florian Hauenstein
Main Contributors: Rafayel Paremuzyan, Bhawani Singh, Bob Miller, Ben Raydo, Stepan Stepanyan
Nov 19, 2026
CLAS Collaboration Meeting

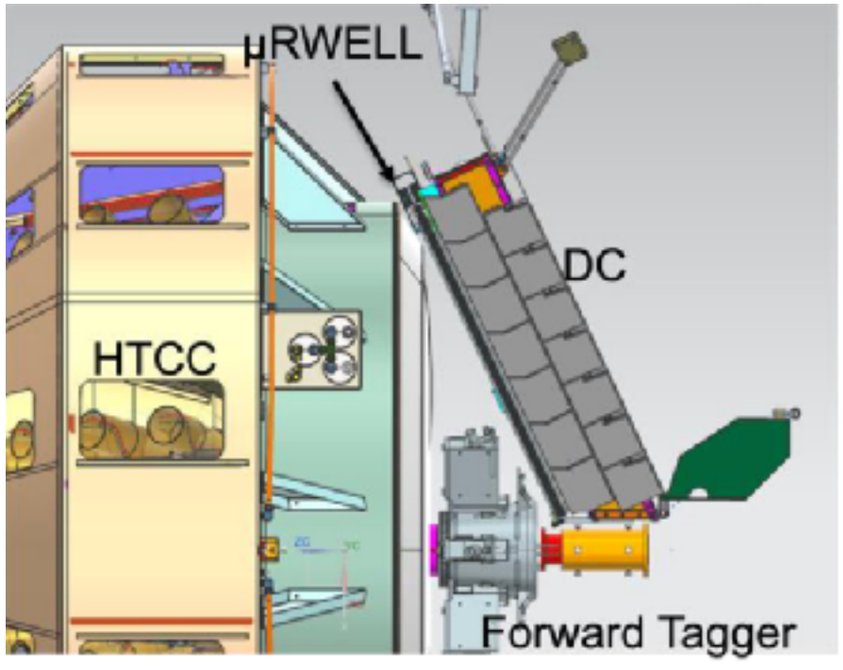
Jefferson Lab

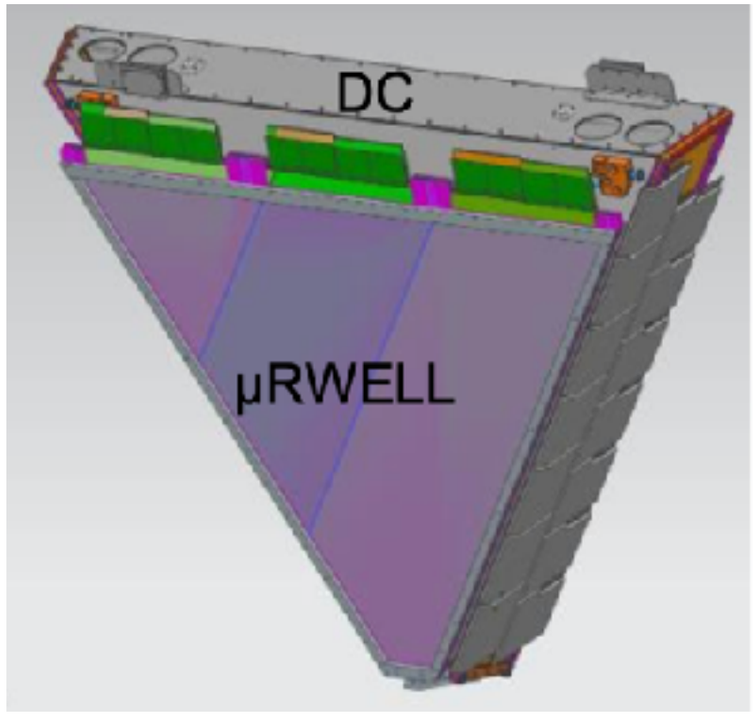
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Why an additional FD tracking detector

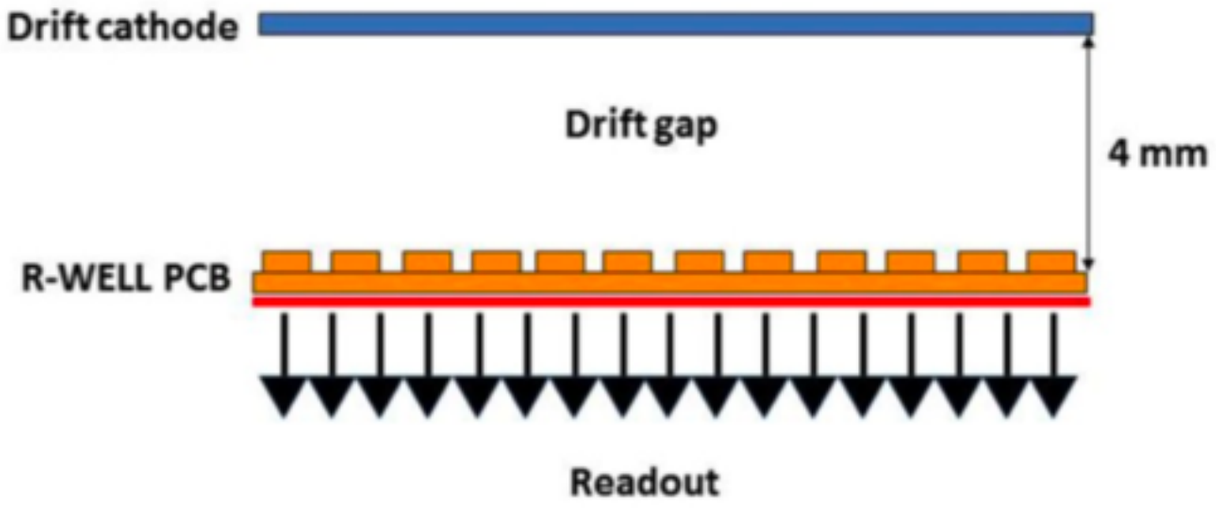
- **Luminosity upgrade to ~2-3*10^{35}cm^{-2}s^{-1} with charged particle reconstruction efficiency > 90%**
  - **Catchup on statistics (existing data about factor two lower statistics than expected)**
  - **Gain time for long remaining physics program**
  - **Opportunities for new, low-rate reactions**

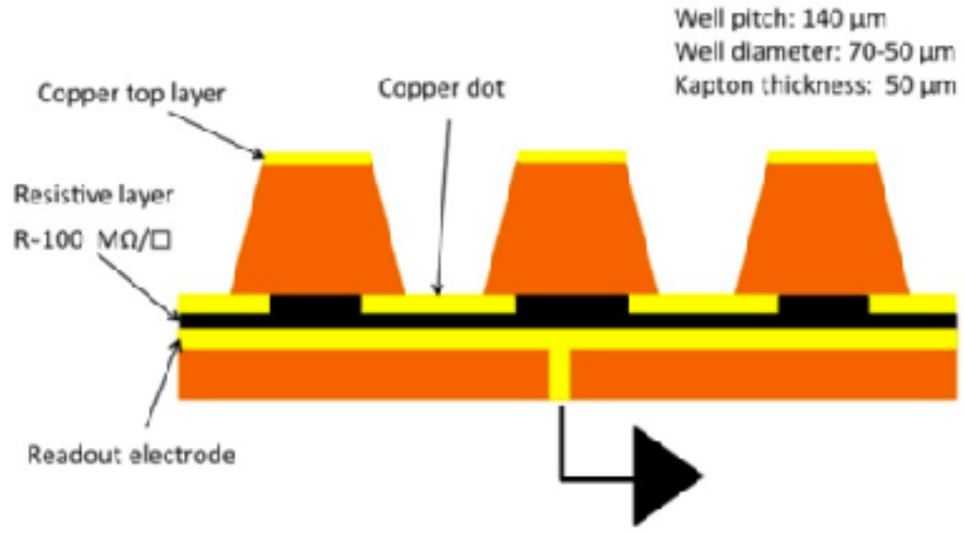
- **Solution:**
  - **Add low-mass, high-efficiency, fast tracker with good resolution (~100um) in front of DC to recover lost hits and reduce efficiency loss at high luminosities**



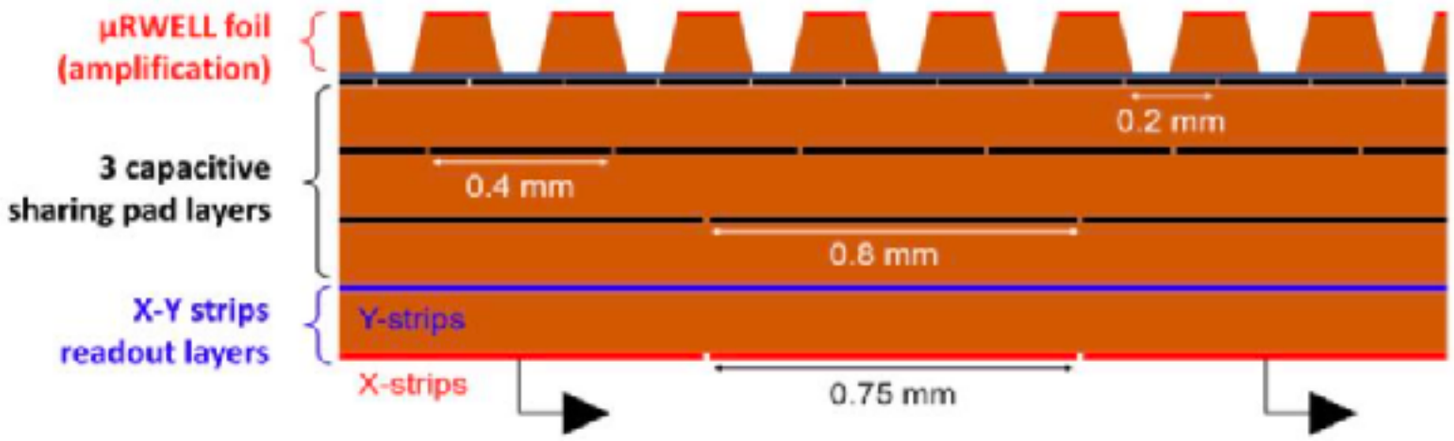


μRWELL Tracker





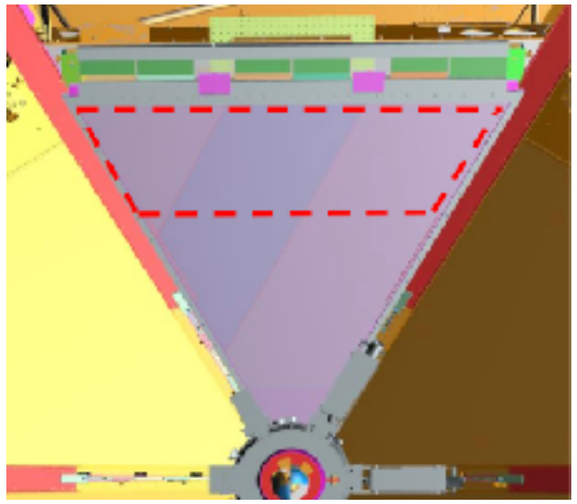
- **Micro-Pattern Gaseous Detector (MPGD)**
  - **Amplification in wells**
  - **Spark protection due to resistive layer**
  - **Low-mass, good spatial and timing resolution**
  - **Easier to assemble than GEMs**
- **2D capacitive sharing readout**

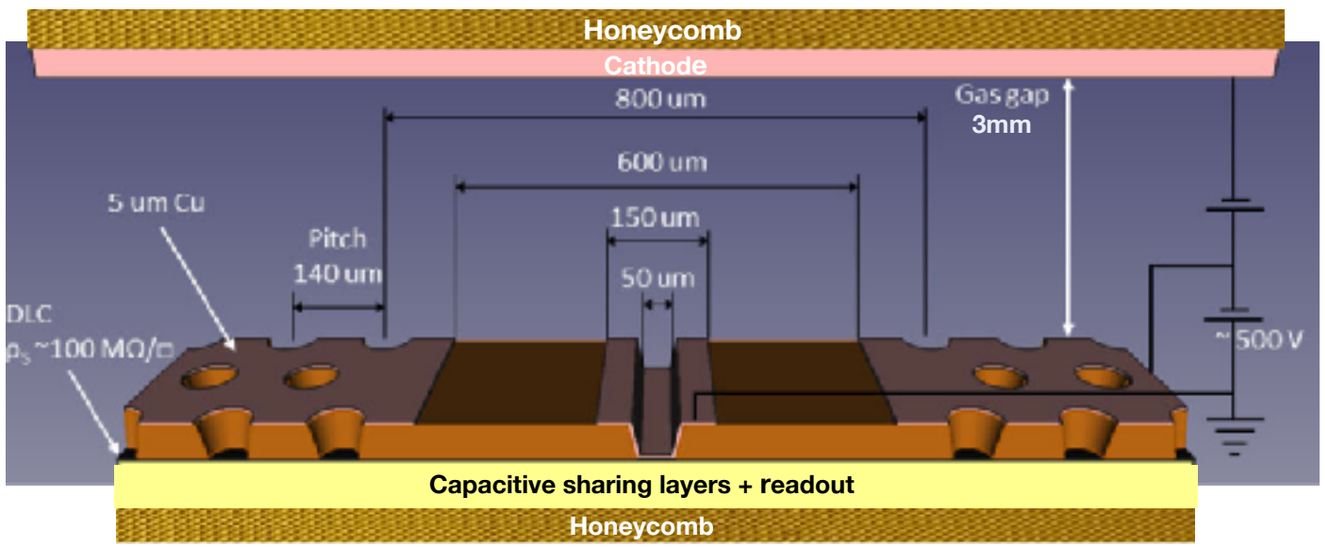


K. Gnanvo, NIM A1047, 167782 (2023)

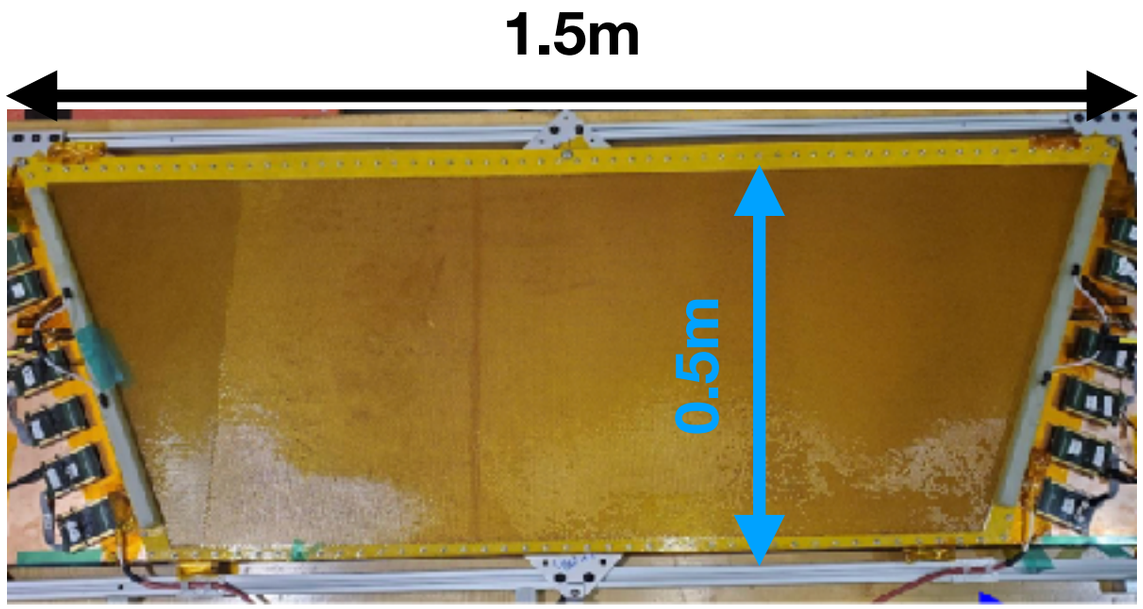
1st Prototype

- **Trapezoidal shape to match DC acceptance at large angles**
- **2D-U/V strip readout with 10 deg stereo angle**
  - **pitch 1mm**
  - **various strip widths (to find optimal combination)**
- **Capacitive sharing (3 layers)**
- **30 HV sectors with grounding lines in between**
- **Electronics APV25 and SRS**

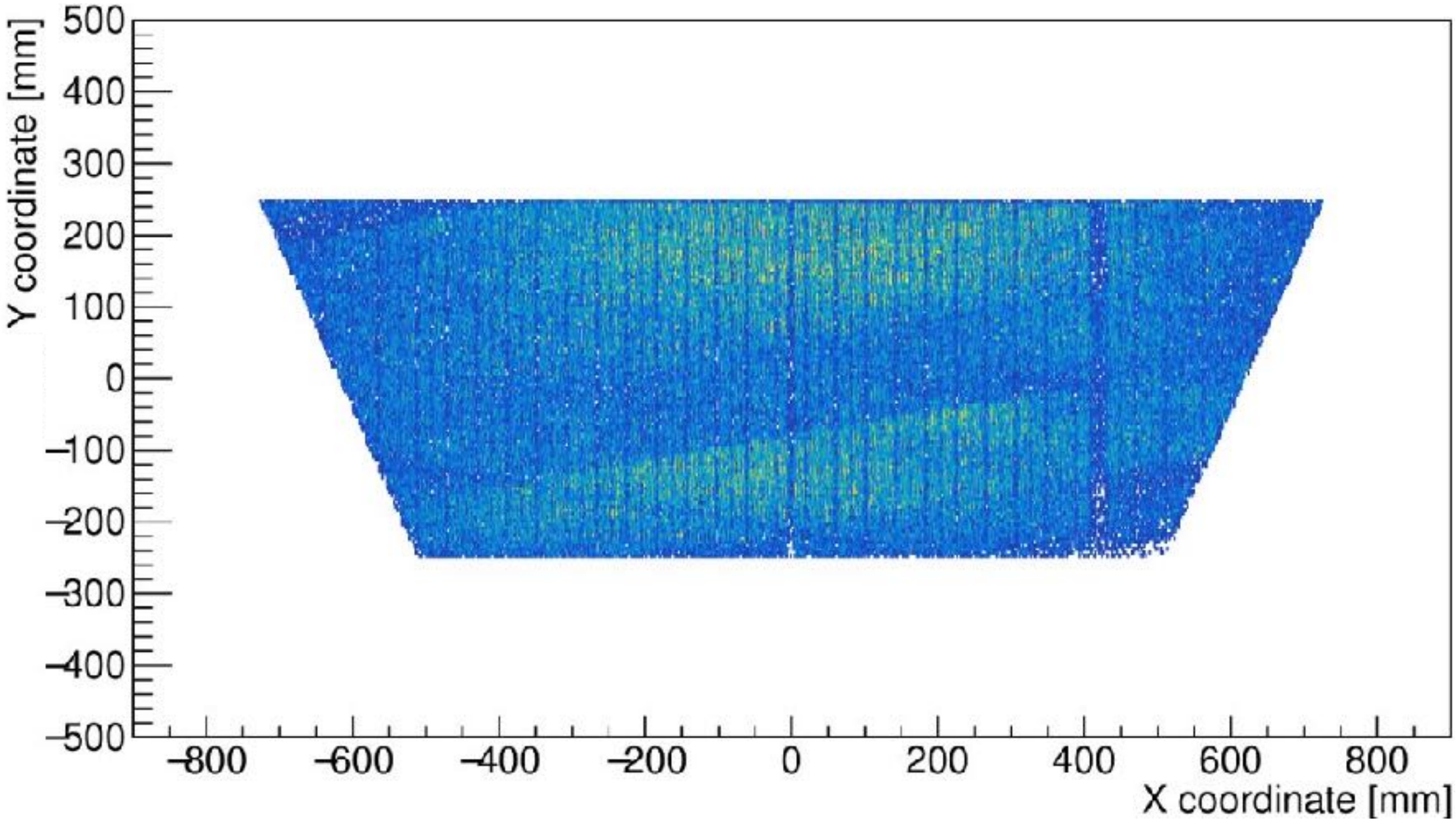




modified picture from M. Giovannetti talk



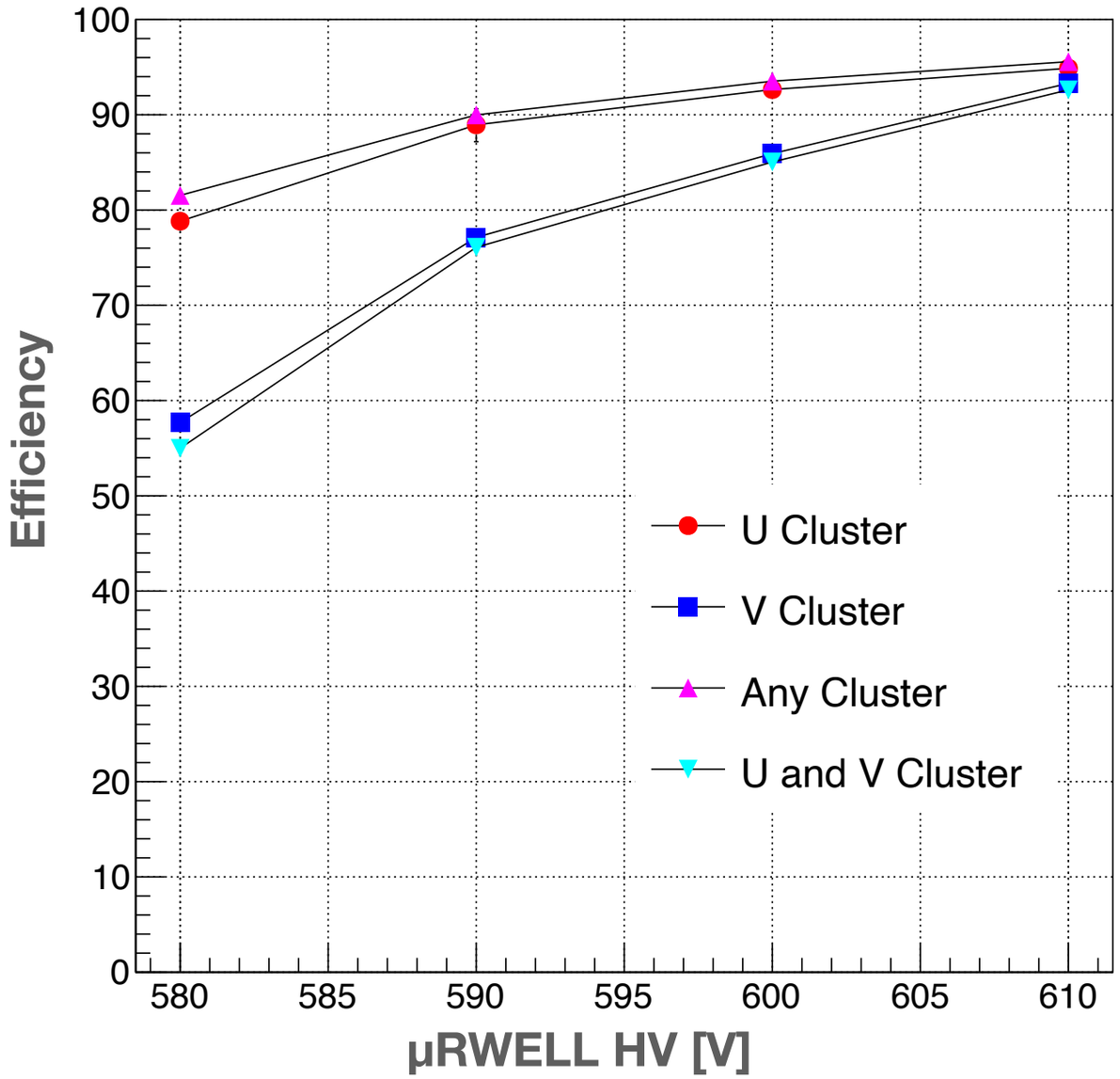
2D Hit Distribution - Detector works!



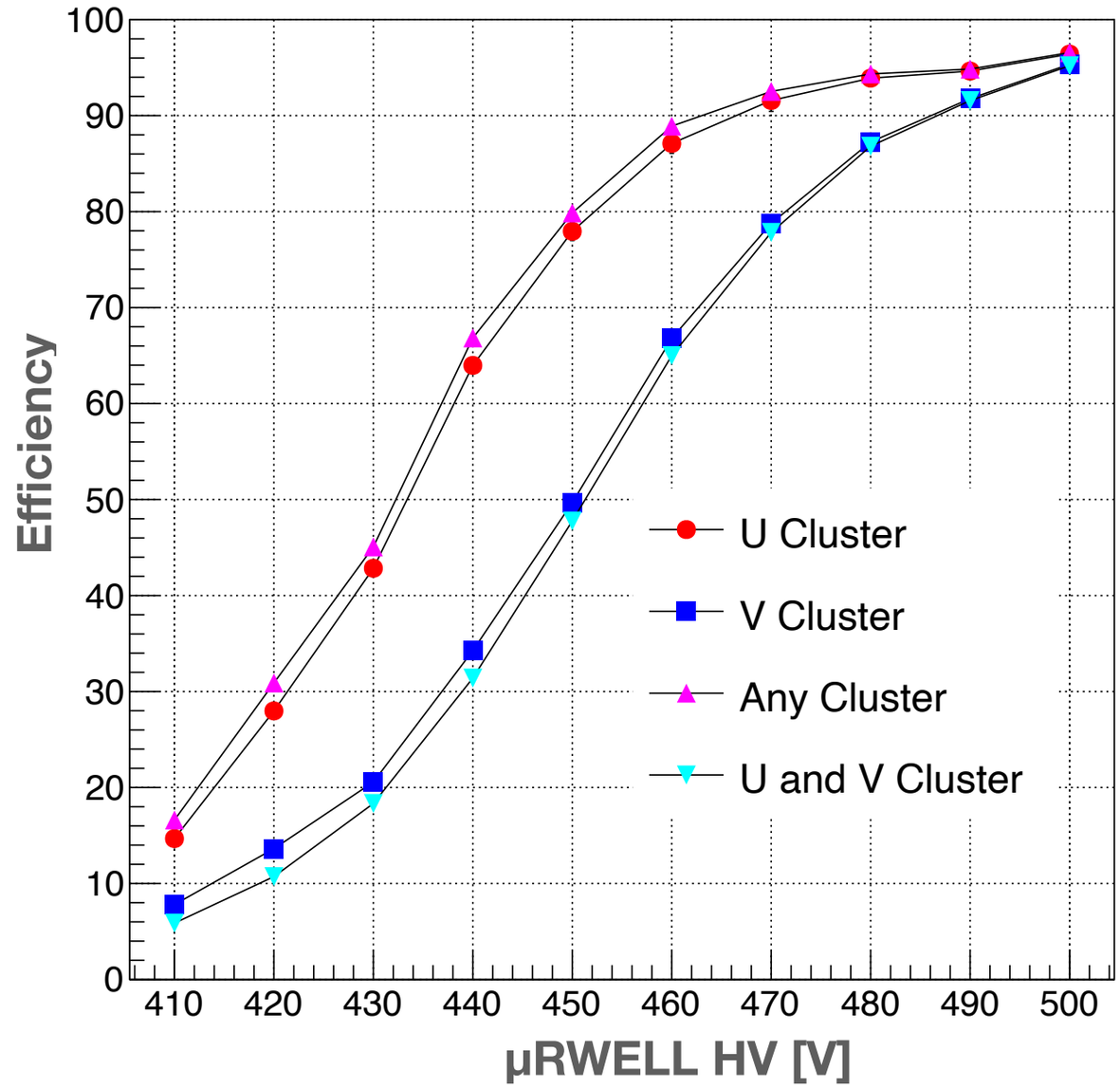
- **μRWELL at 570V, cathode at 1020V, Ar:CO_2 (80:20)**
- **Substructure from strips, HV segmentation and APVs visible**

1st Prototype Efficiency

Ar:CO_2 80:20



Ar:Isobutane 90:10

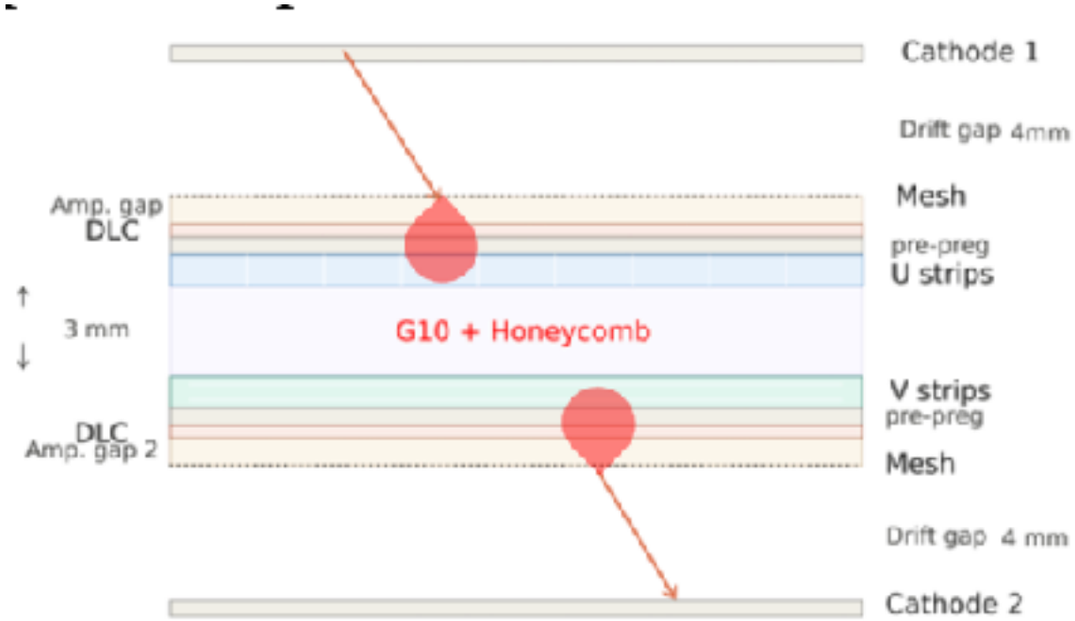


- **Reached >90% efficiency but detector very unstable at these HV values**
- **No stable plateau for head room**
- **No sufficient gain for U-V sharing readout**

—> New prototype with two 1D detectors instead of one 2D

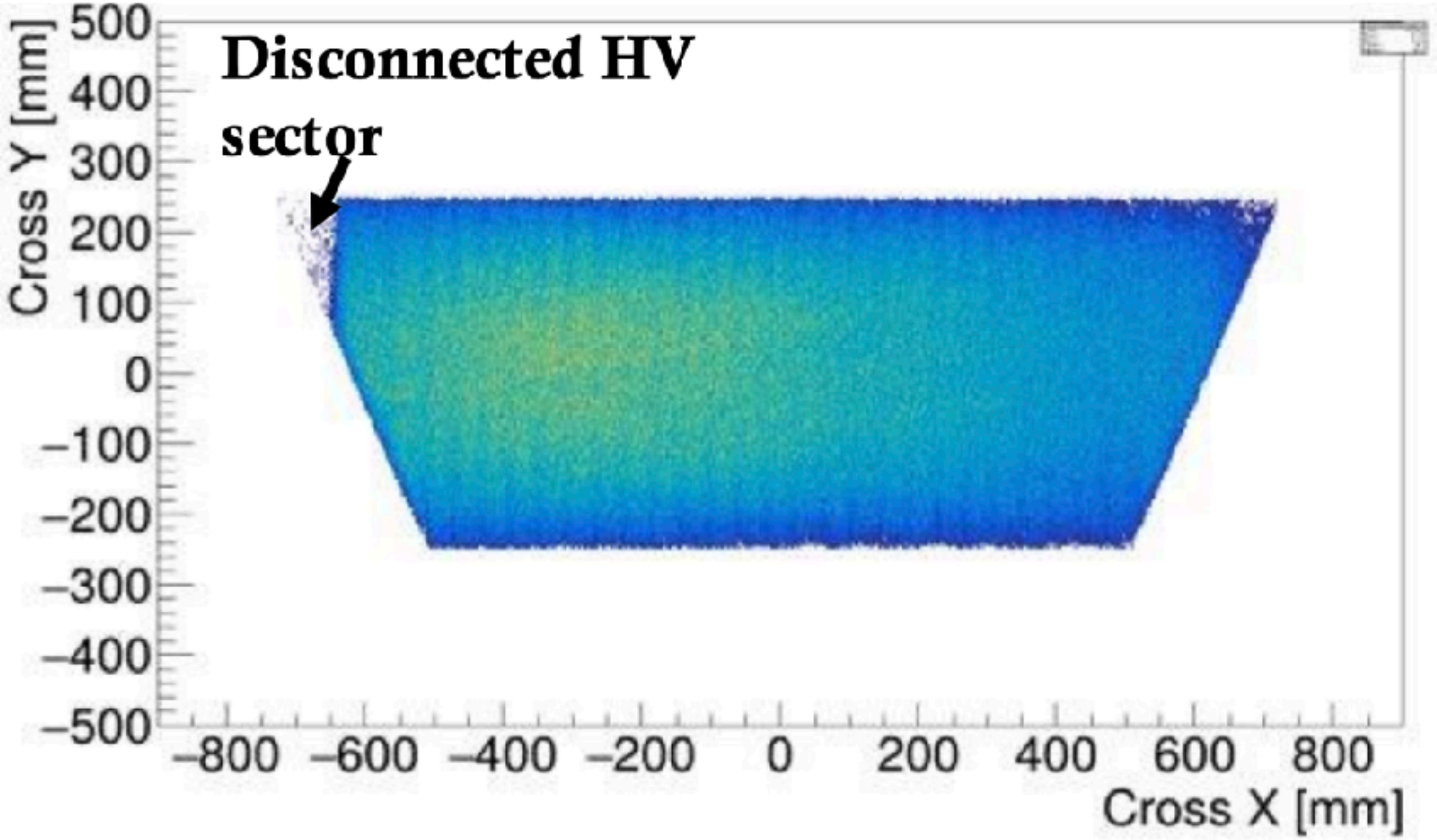
2nd Prototype

- **Same size as 1st prototype**
- **Two 1D μRWELL detectors sandwiched together**
  - **2 cathode foils**
  - **2 drift gaps**
  - **2 μRWELL PCBs**
  - **Pre-preg thickness: 28μm and 50μm**
- **Readout:**
  - **U or V strip readout with +/- 10 deg stereo angle**
  - **strip pitch 1mm**
  - **strip width 500μm**
- **Capacitive sharing (3 layers)**
- **32 HV sectors with grounding lines under DLC**

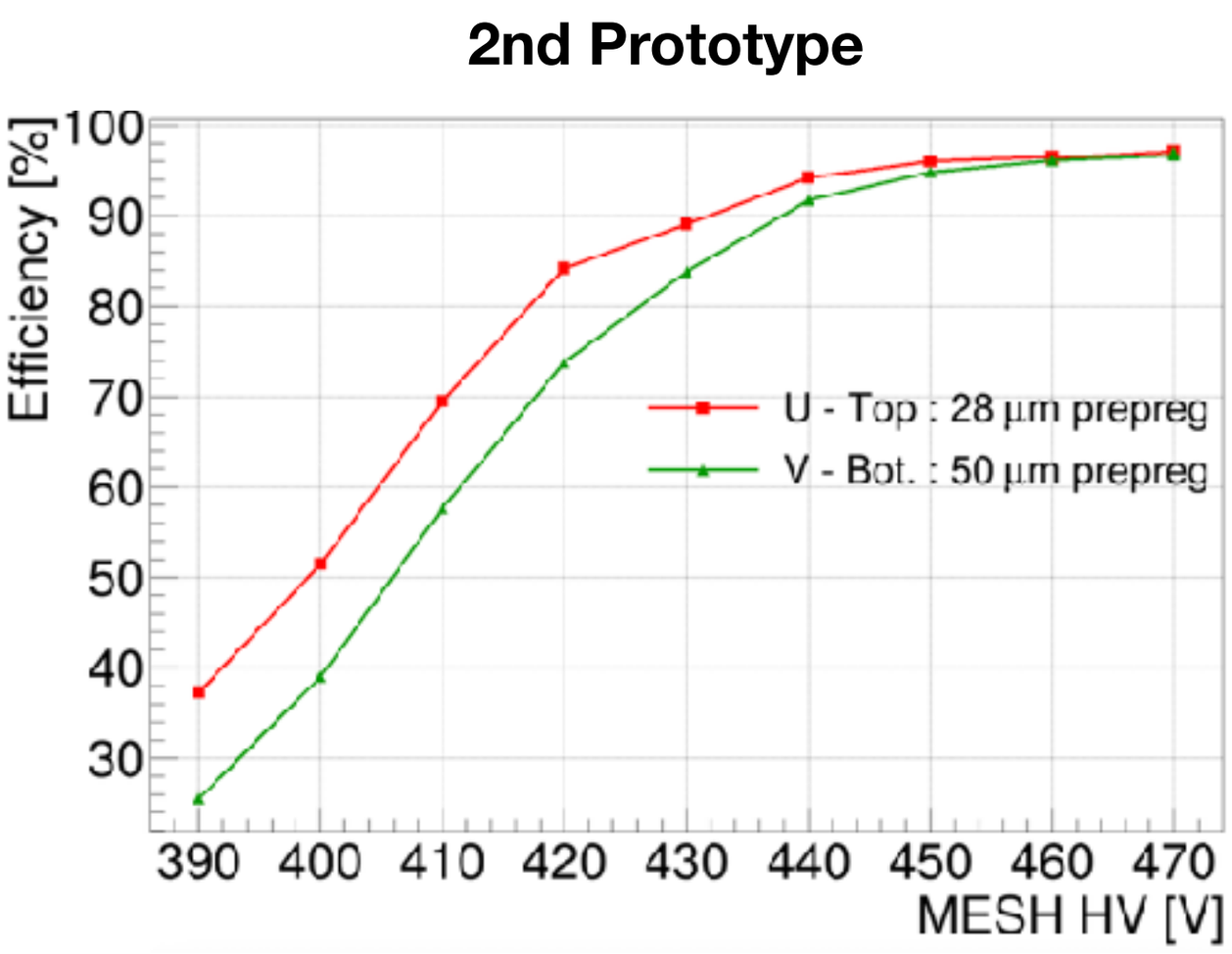


courtesy Rafo

Both Detectors work! - Combined 2D Hit Distribution



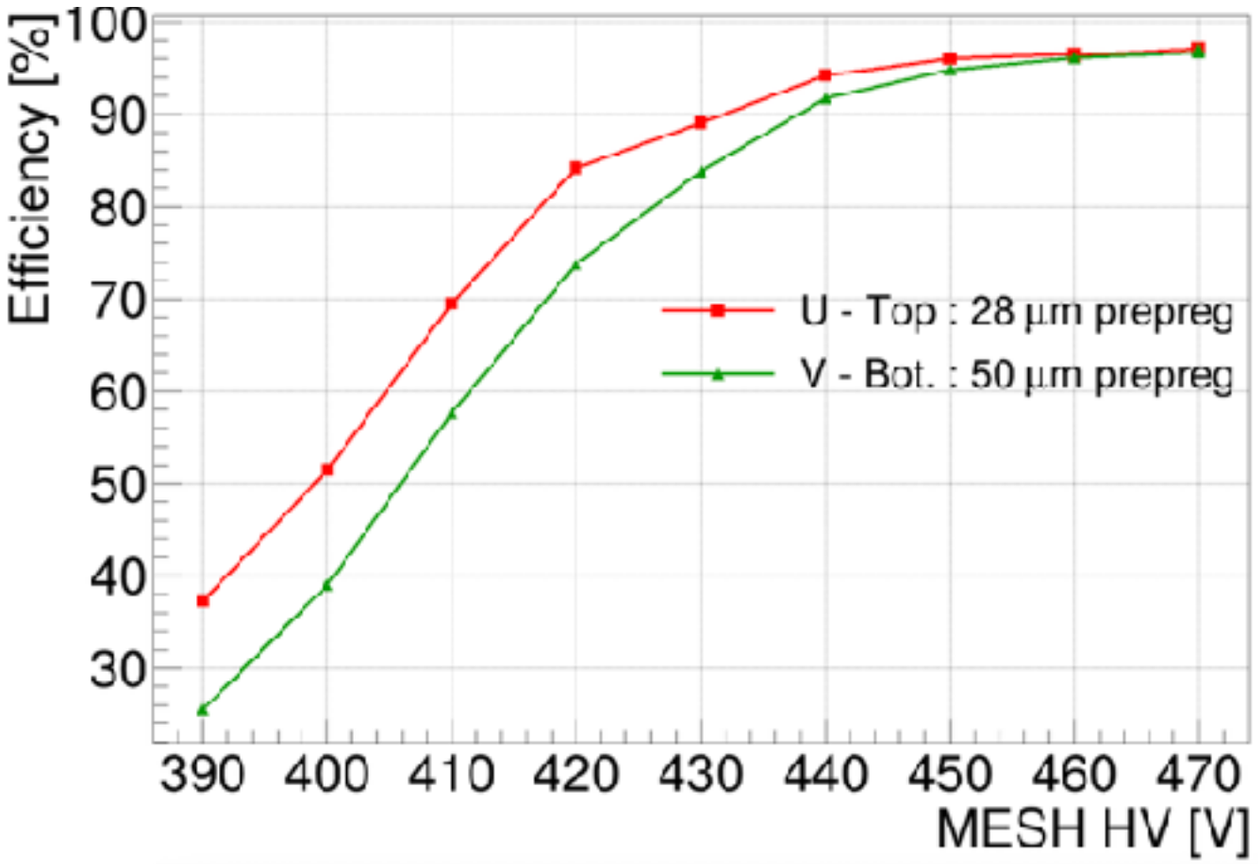
2nd Prototype Efficiency - Ar:Isobutane



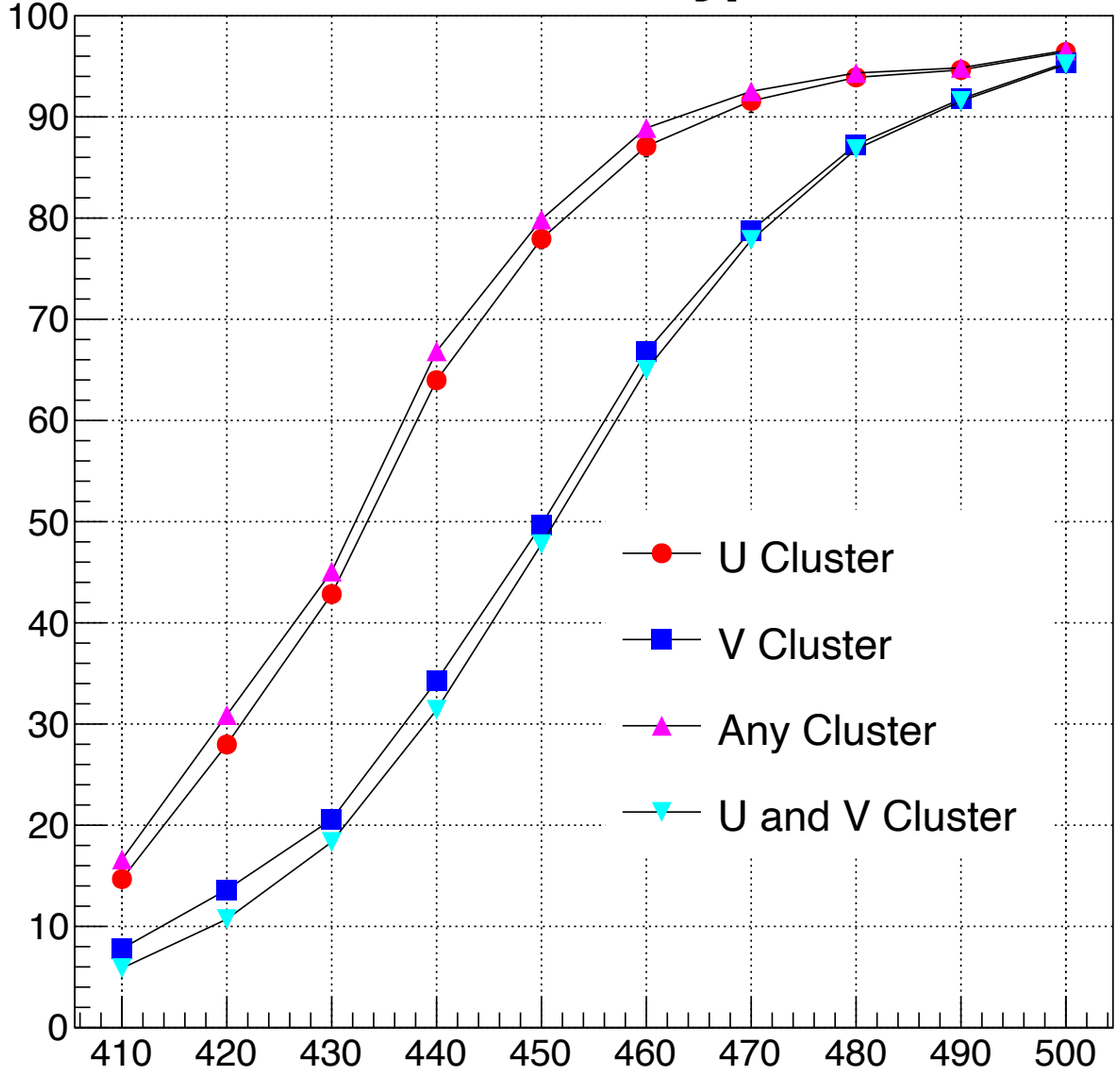
- **Efficiency plateau > 450V**
- **Larger efficiency at lower HV for smaller pre-preg thickness due to higher gain**

2nd Prototype Efficiency - Ar:Isobutane

2nd Prototype



1st Prototype

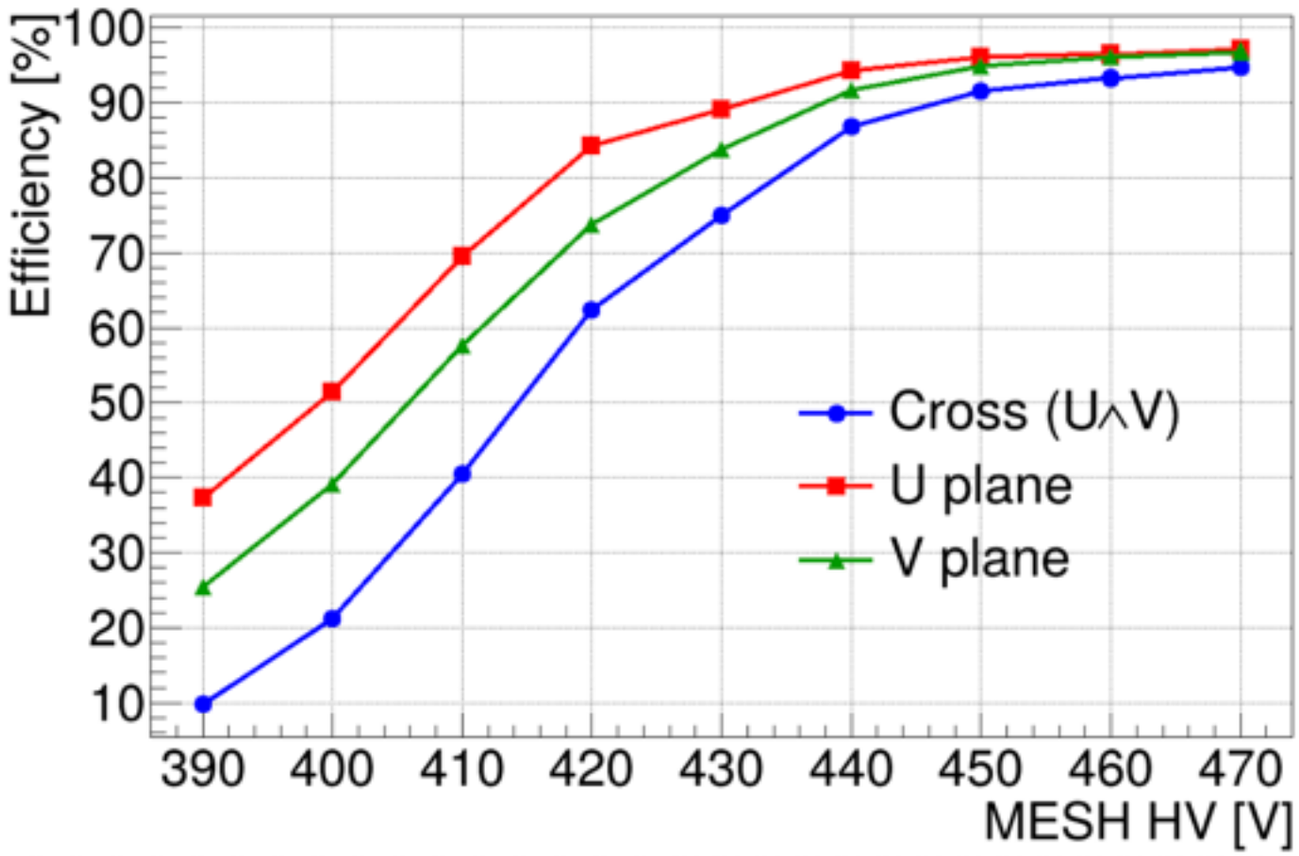


- **Efficiency plateau > 450V**
- **Larger efficiency at lower HV for smaller pre-preg thickness due to higher gain**
- **>90% efficiency reached at lower HV compared to first prototype (as expected)**

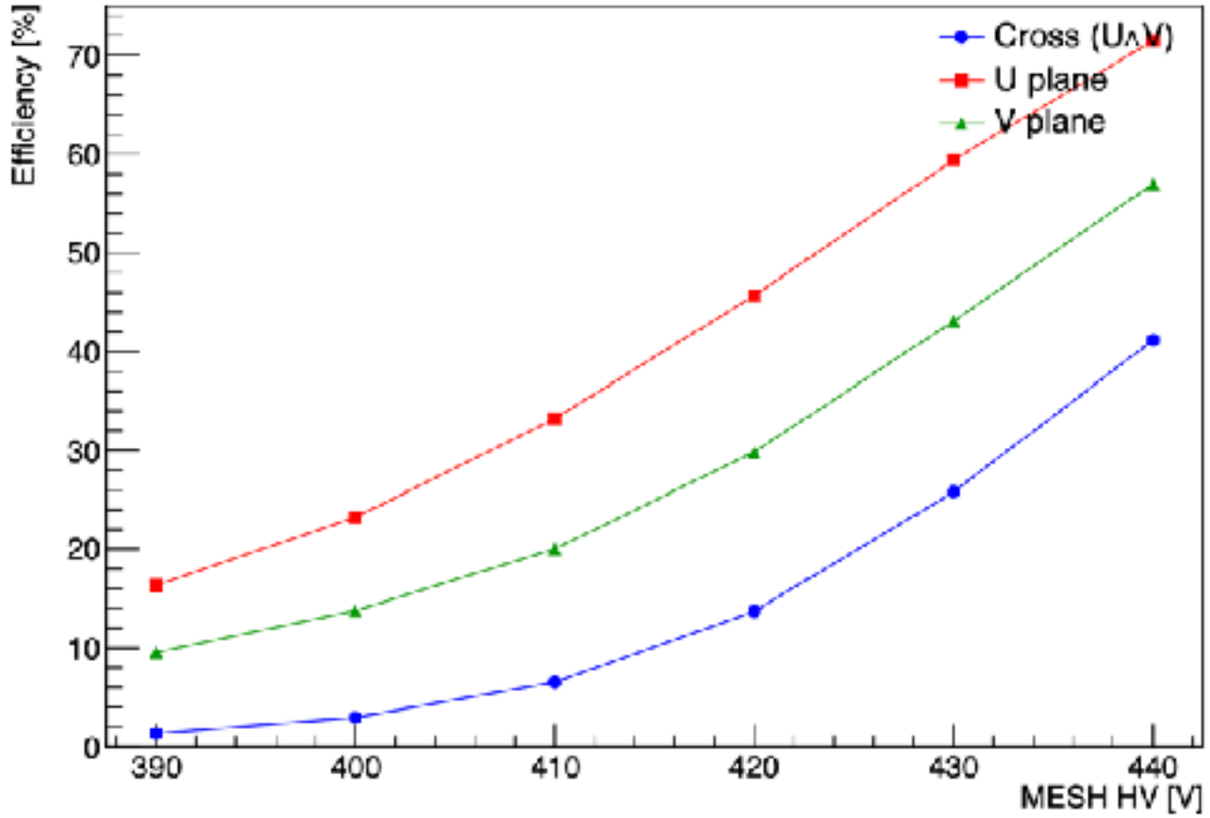
- **However: 1st prototype can operation stable at much higher HVs, 2nd prototype much more unstable already at 450V**

2nd Prototype Efficiency - Different Gases

Ar:Iso (90:10)

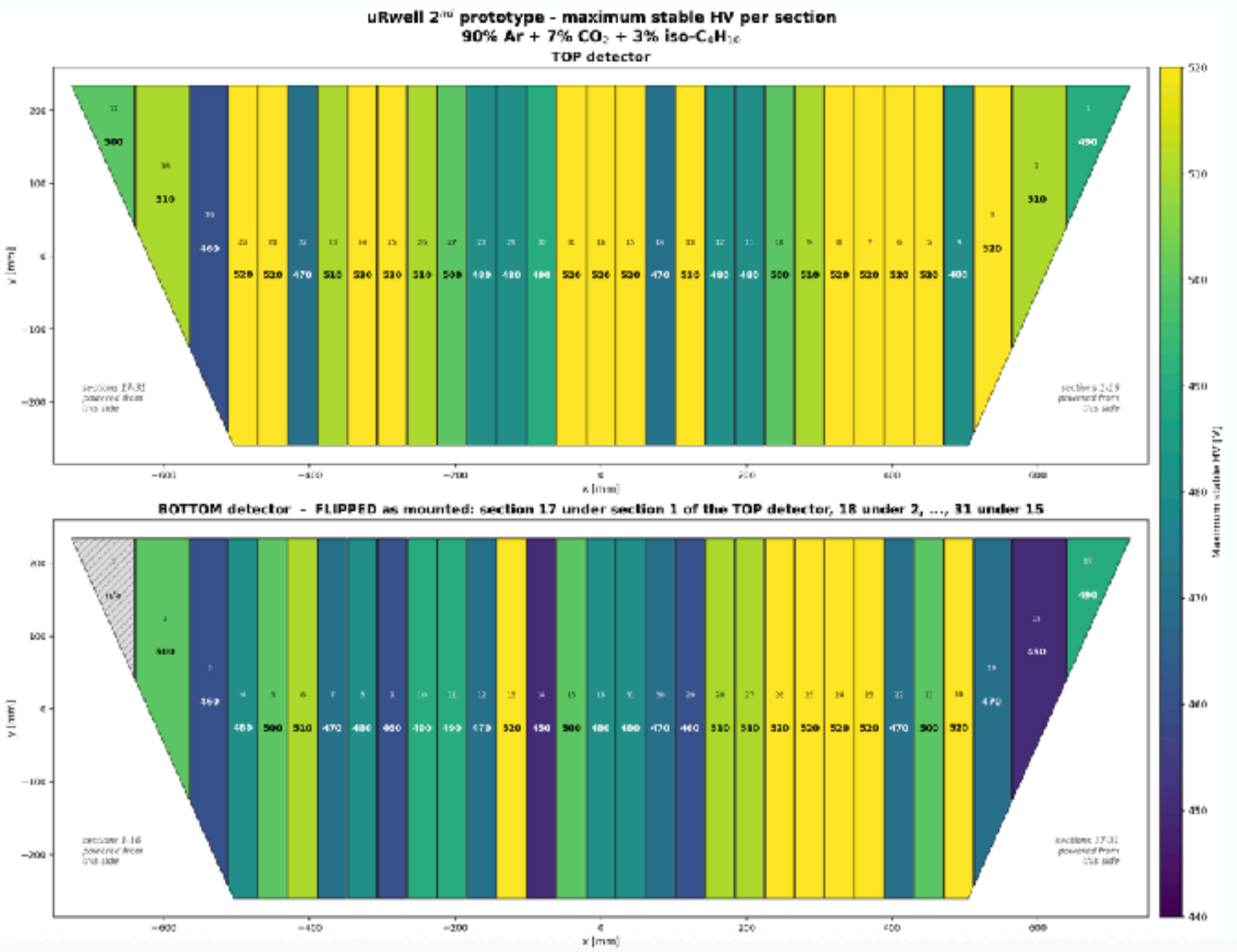


Ar:CO2:Iso (90:7:3)

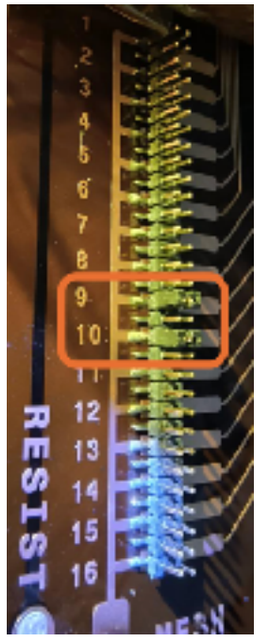


- **Ar:CO2:Iso lower gain and efficiency at same HV as Ar:Iso**
- **Couldn’t reach plateau for Ar:CO2:Iso due to HV instabilities starting at 440V**

Maximum HV Voltage per Sector at Ar:CO2:Iso

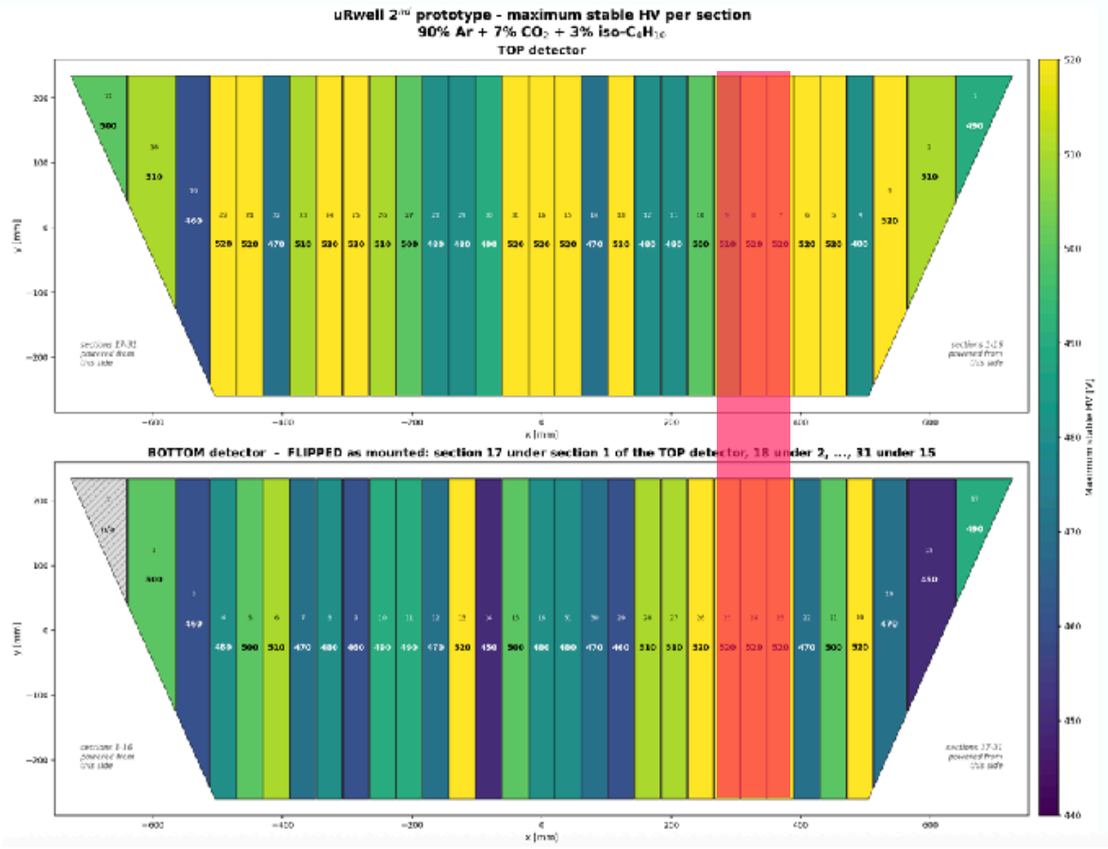


HV jumpers



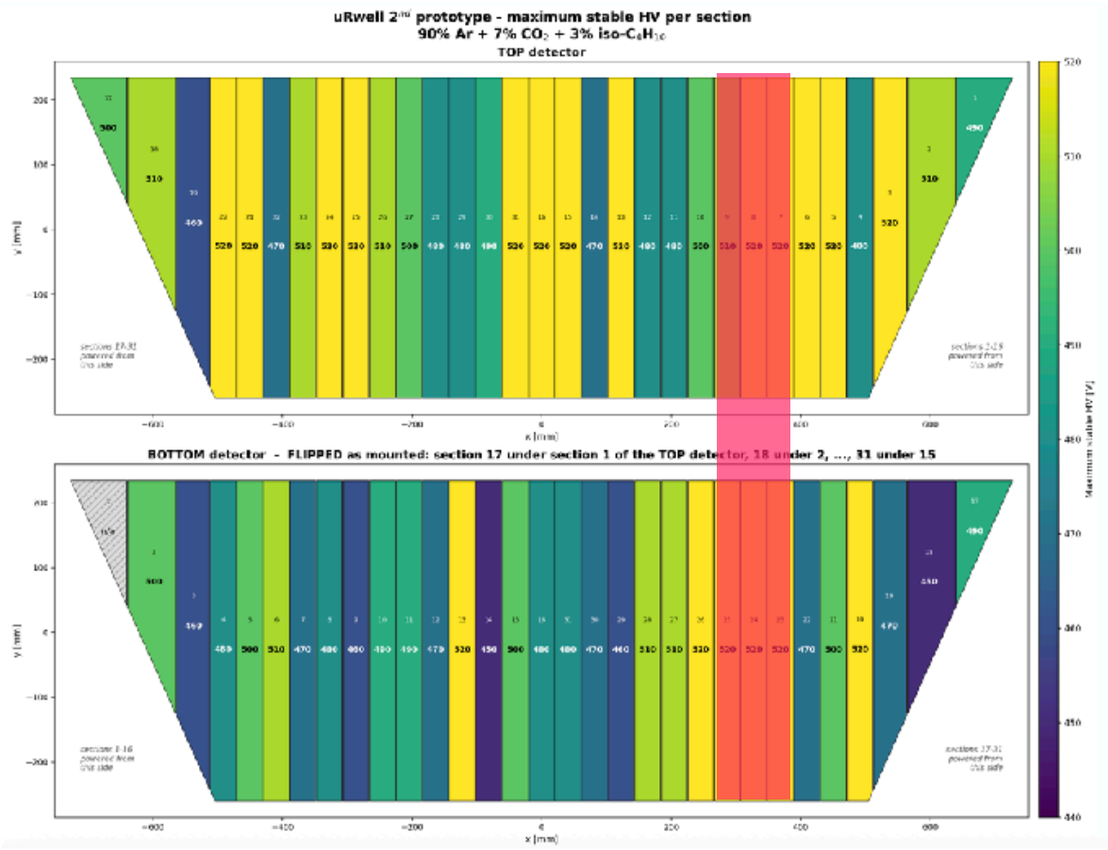
- **Rather strong variation between HV sectors**
- **More uniform max. voltage for TOP detector than BOTTOM detector**
- **Cause probably from non-uniform copper plating on top of wells —> use selective plating for next detector**

In Progress: Efficiency for different HV sectors



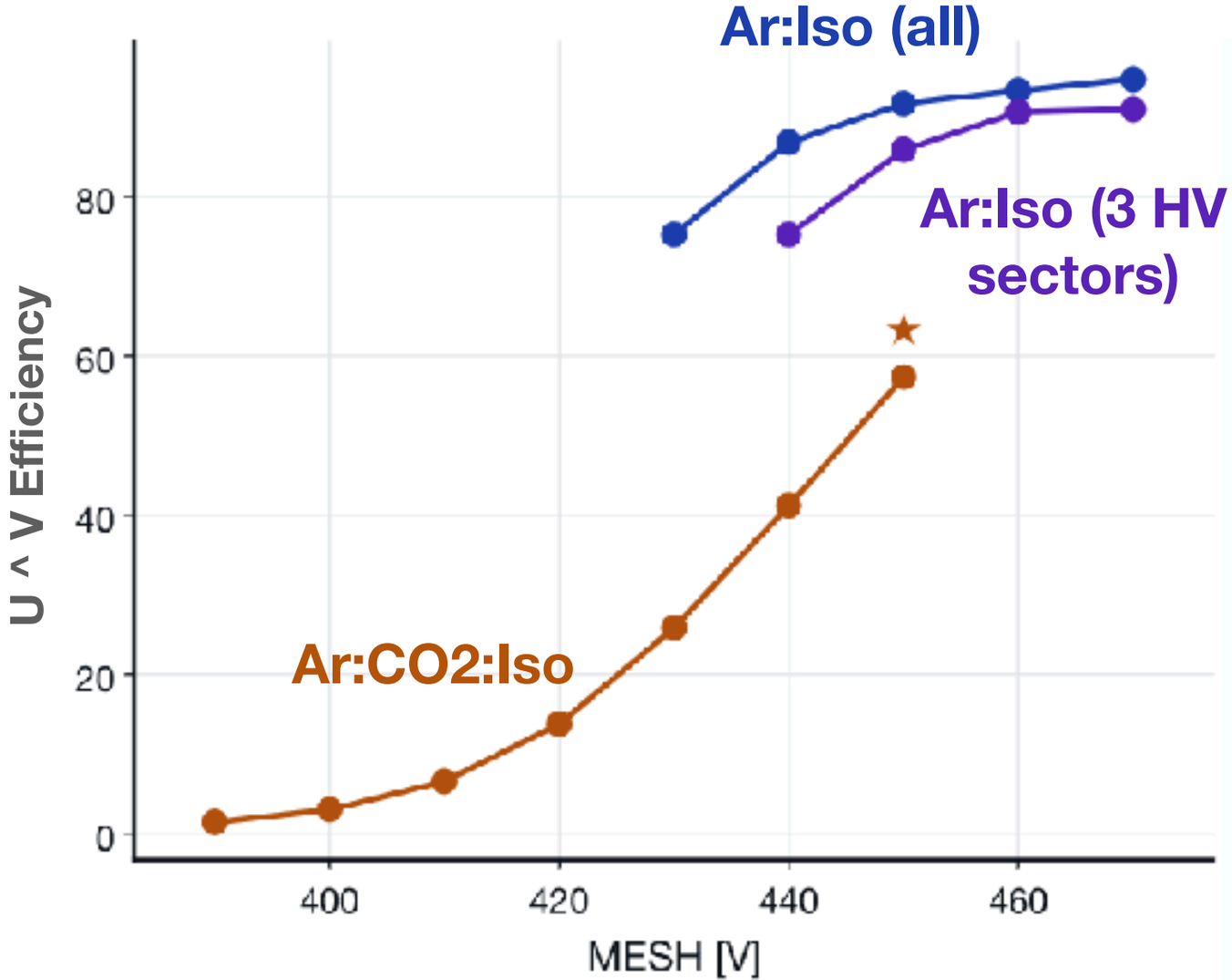
- **Redo MESH HV scan for 3 max HV sectors**

In Progress: Efficiency for different HV sectors



- **Redo MESH HV scan for 3 max HV sectors**

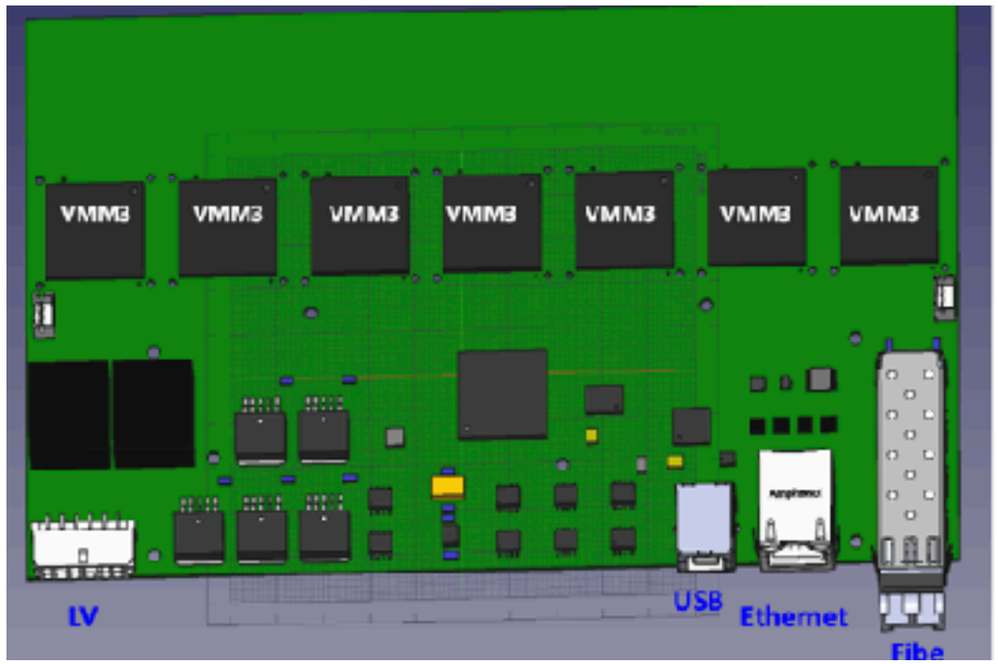
- **Decreased efficiency for max. HV voltage sectors**
- **More studies in progress**



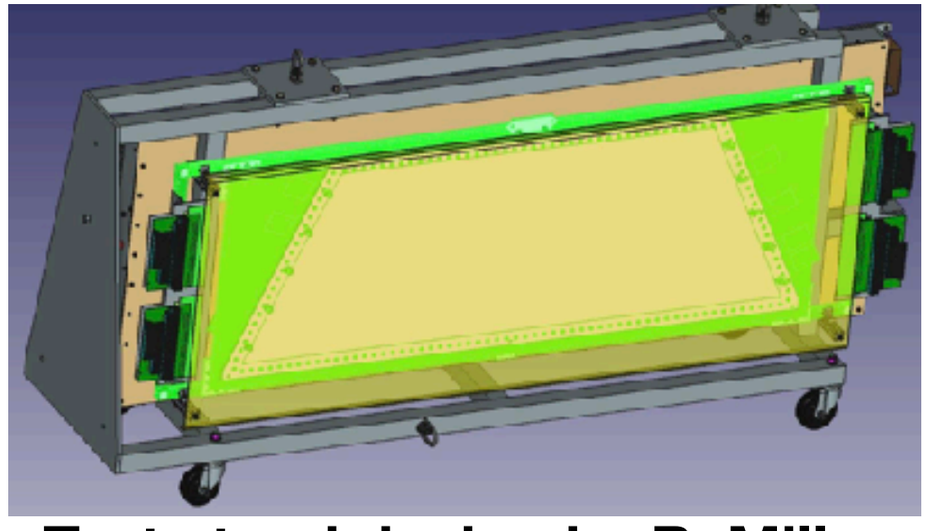
Next Steps with Current Prototype

- **Test of new VMM3 ASICS (APV readout incompatible with CLAS12 readout system)**
  - **first test boards expected in 1-2 weeks**
  - **Cosmic data testing in Jan-Mar 2027**

Board design by B. Raydo



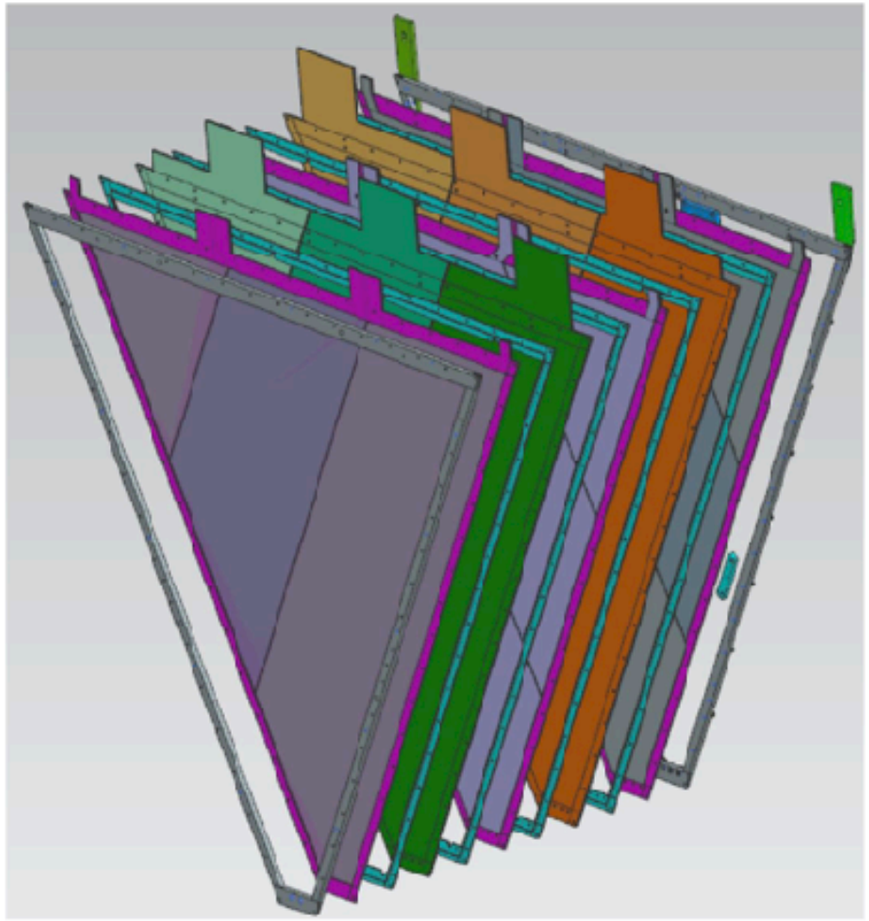
- **Real “beam” test next year behind ECAL (Sec1)**
  - **Check performance dependence at larger rates (compared to cosmic)**
  - **Test VMM3 readout integrate to CLAS12 DAQ**
  - **Can be parasitic to RGE data taking**

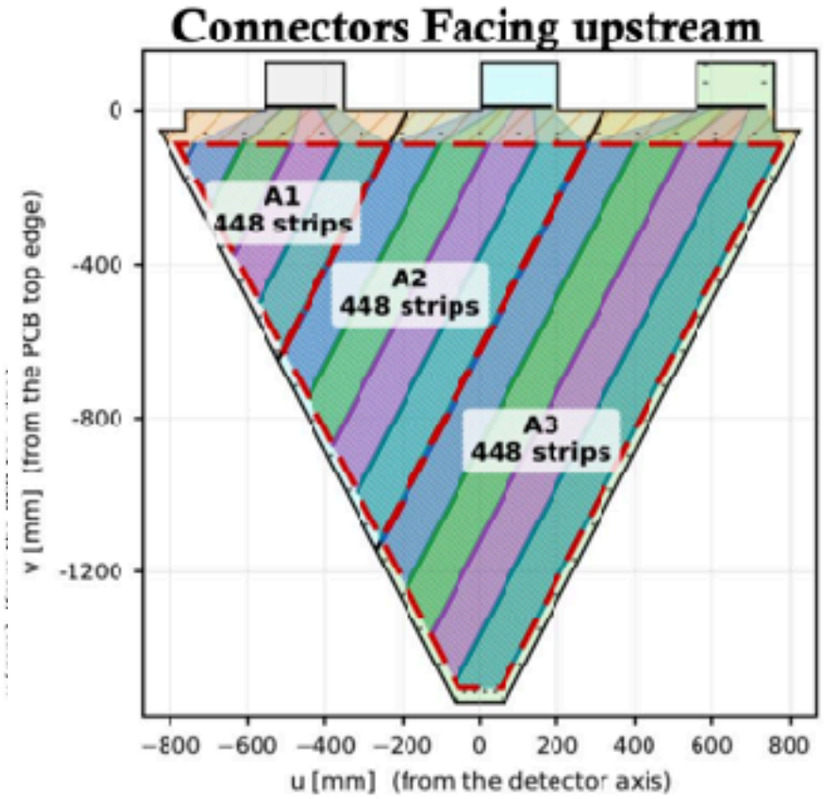


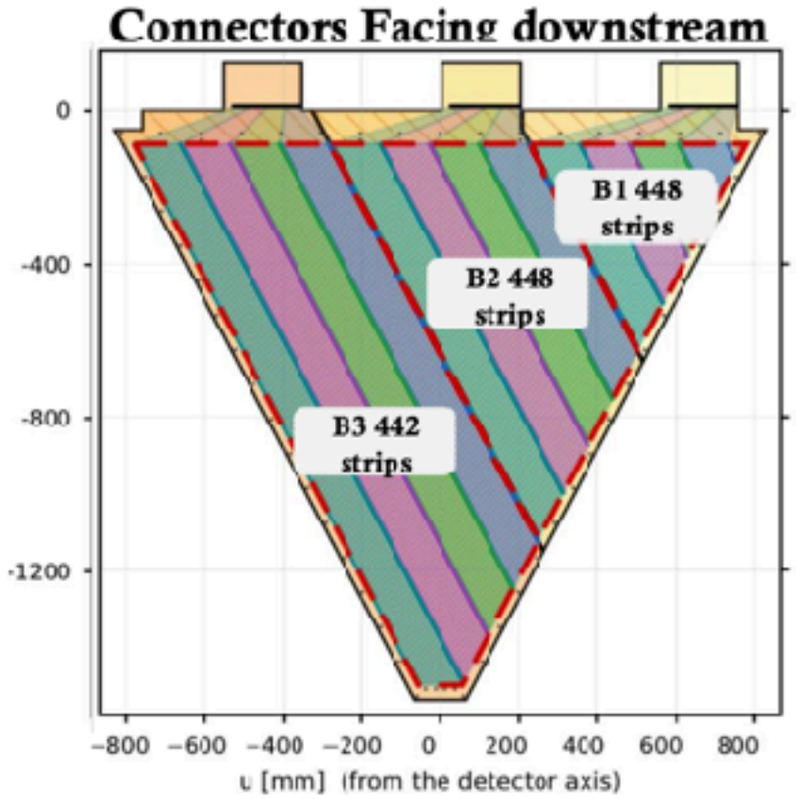
Test stand design by B. Miller

Full Size Prototype Development

- **Design almost finalized**
- **Each sector has 4 layers (ABBA schema) of μRWELLs e.g. 4 independent 1D detectors with separate cathodes, amplification and readout strips**
- **Each layer consists of 3 μRWELL PCBs with ~4mm gap to cover all of R1**
- **Readout strips parallel to sides —> +/-27.15 deg stereo angle, pitch 1mm**
- **Each layer is readout with 3 RO boards on the top of the detector**







Timeline for Full Size Prototype

Nov/Dec 2026 — **Finalize design and place orders for frames and μRWELL foils**

Dec 2026 – Spring 2027 — **Build frames and ship to CERN, Order second batch of readout boards and additional cables, tools**

Spring 2027 — **Assembly of prototype at MPGD workshop at CERN**

Summer 2027 — **Delivery to JLab and commissioning of detector with cosmics**

Aug/Sep 2027 (tentative) — **Possibly install in Hall B during high-luminosity test beam time (last week of beam operation)**

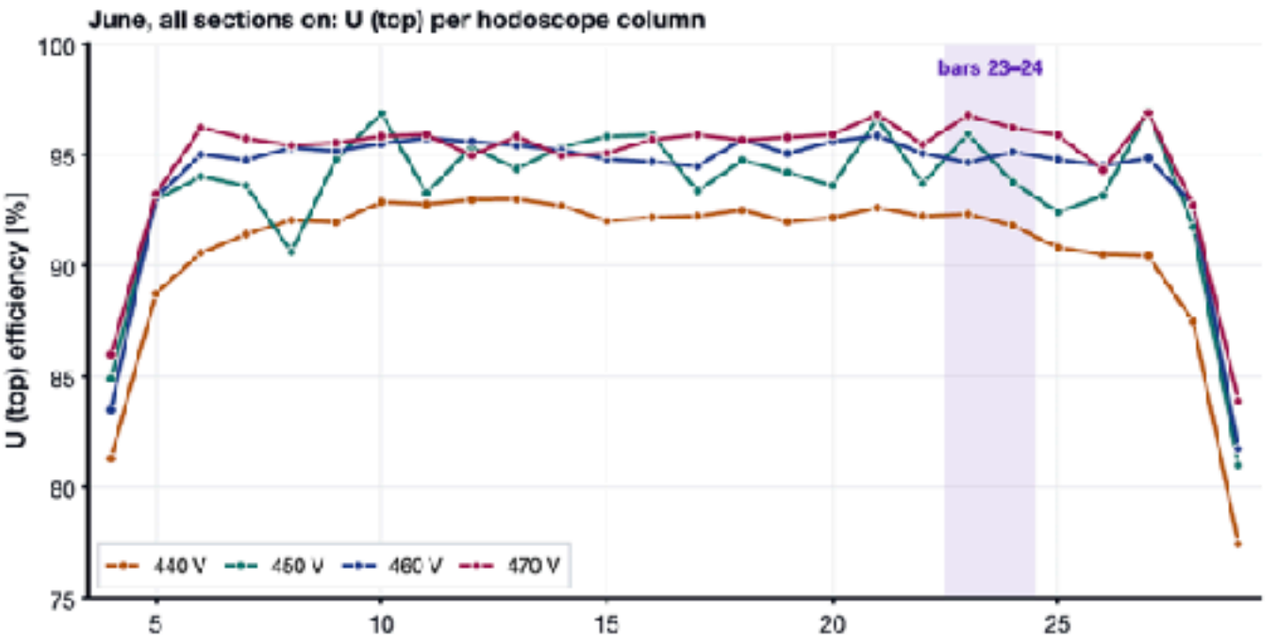
Summary

- **New µRWELL tracker in front of R1 DC allows to run comfortably with ~2-3*10^{35}cm^{-2}s^{-1} luminosity with a FD tracking efficiency > 90%**
- **Lession learned from 2nd prototype tests with cosmic**
  - **Higher efficiency and stable plateau with 1D readout**
  - **Ar:Isobutane (90:10) still preferred operation gas**
  - **Pre-preg thickness 28µm better**
  - **Stronger HV sector dependence possibly from used Cu plating process —> will be changed for next detector**
- **Full-size prototype design almost final**
- **Next year:**
  - **VMM3 tests**
  - **Beam tests in the hall with 2nd prototype behind ECAL**
  - **Test of full-sized prototype**

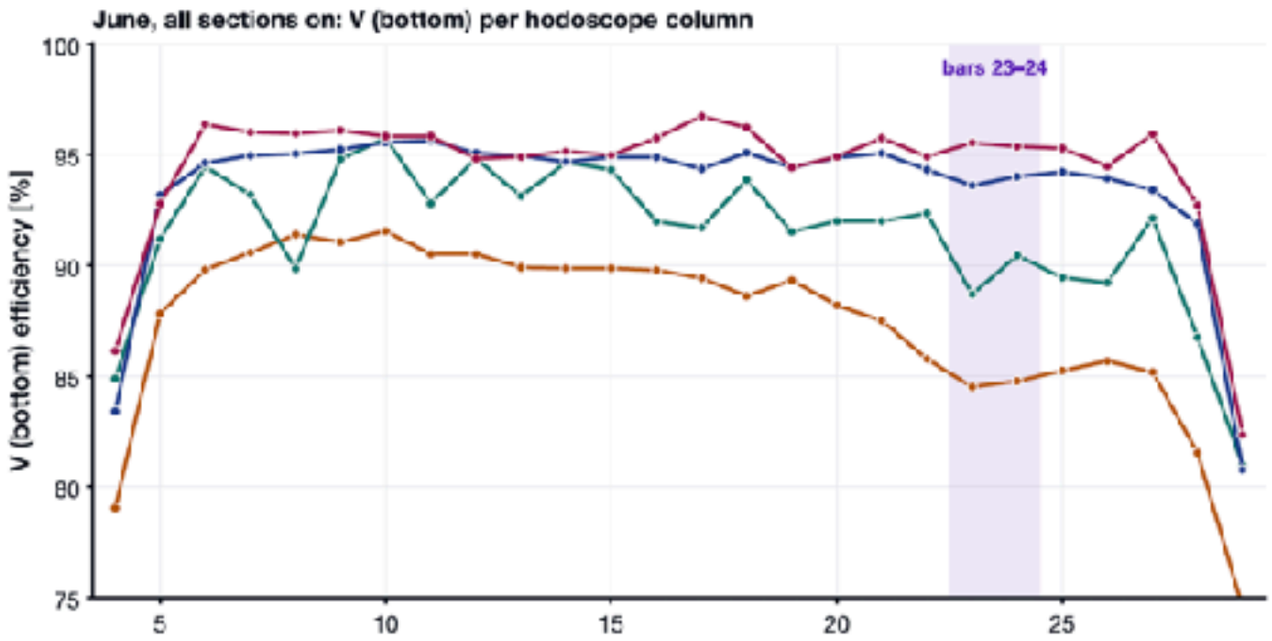
Questions?

Backup

2nd Prototype Efficiency across Detector



Hodoscope bar index



Hodoscope bar index

2nd Prototype Various Results from Mesh Scan

