Testbeam for resistive u-PIC

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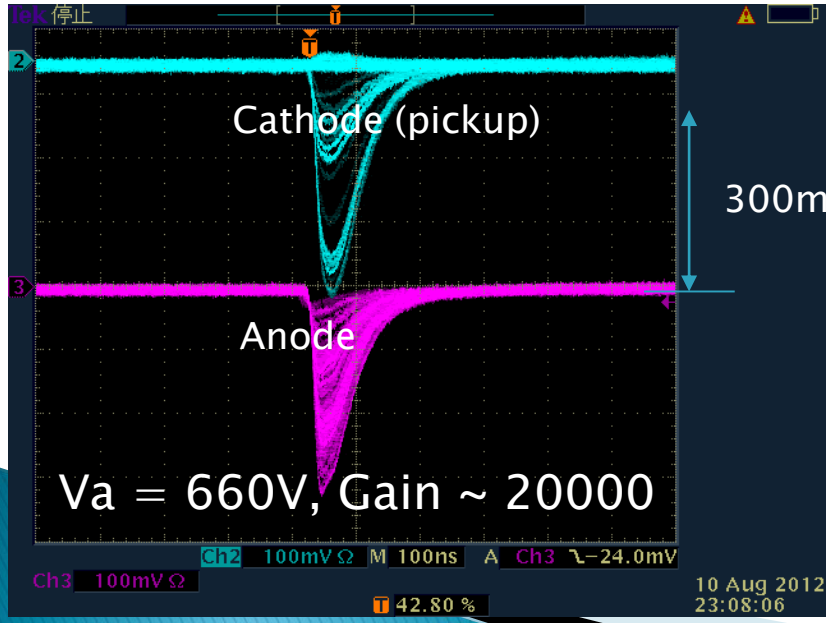
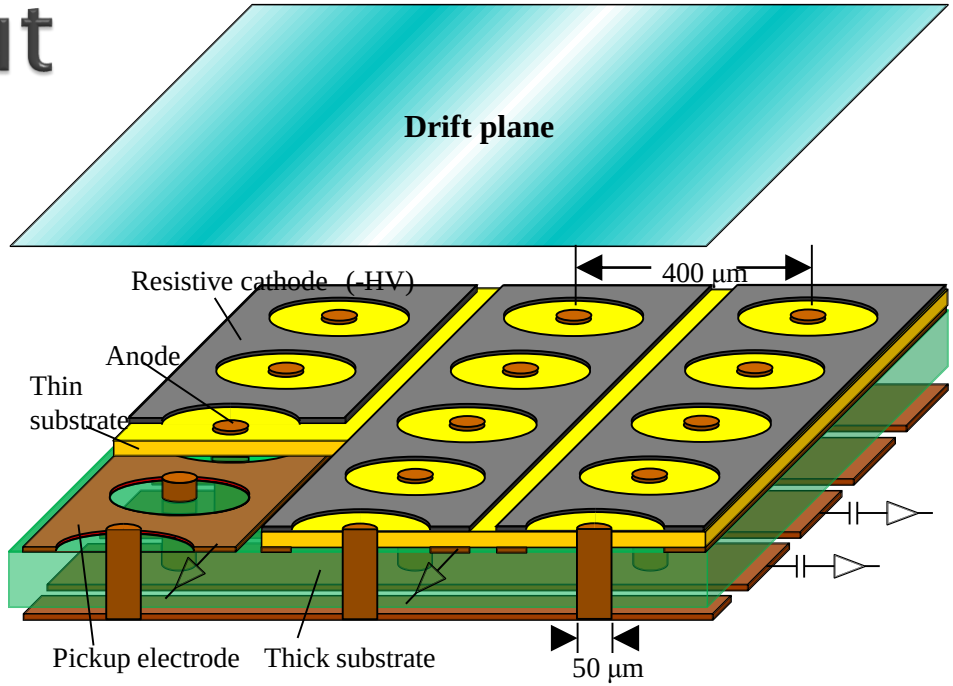
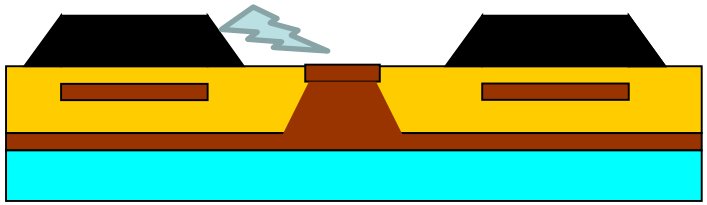
22/06/2018 RD51 WG7 @ TUM

μ-PIC with resistive cathode and capacitive readout

- Detector design
  - All cathodes are made from DLC foils
  - Pickup electrodes are lied under cathodes and insulator
  - We have two dimensional signals



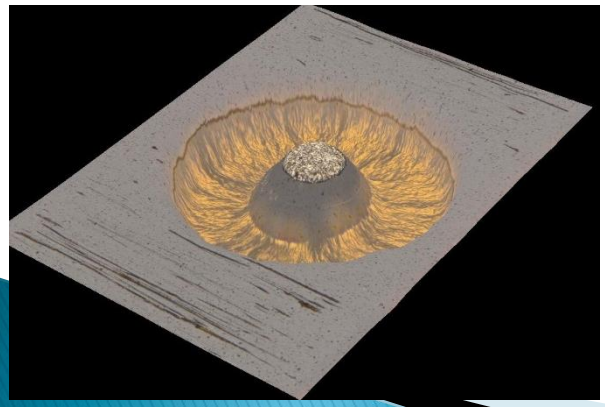


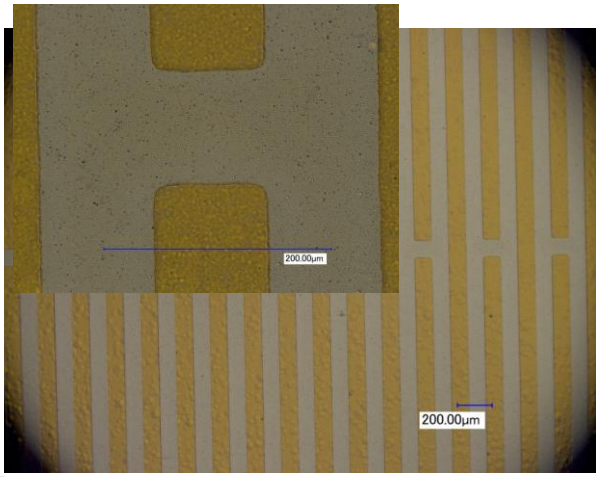


- Cathode signal on oscilloscope is inverted on opposite sign.
- Two dimensional signal is induced
- Not charge shareing.

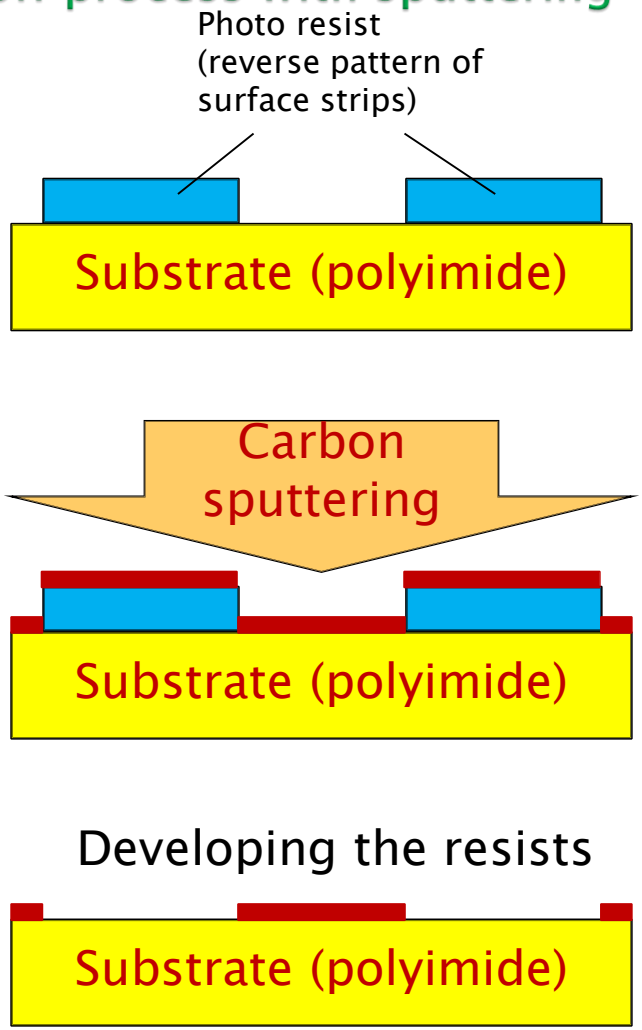
Resistive electrodes with DLC

- On beginning of 2013, we have developed resistive electrodes by DLC
  - Initially, it was developed for ATLAS MM resistive foils
  - Fine micro-patterning (um order) available → applying it for u-PIC electrodes



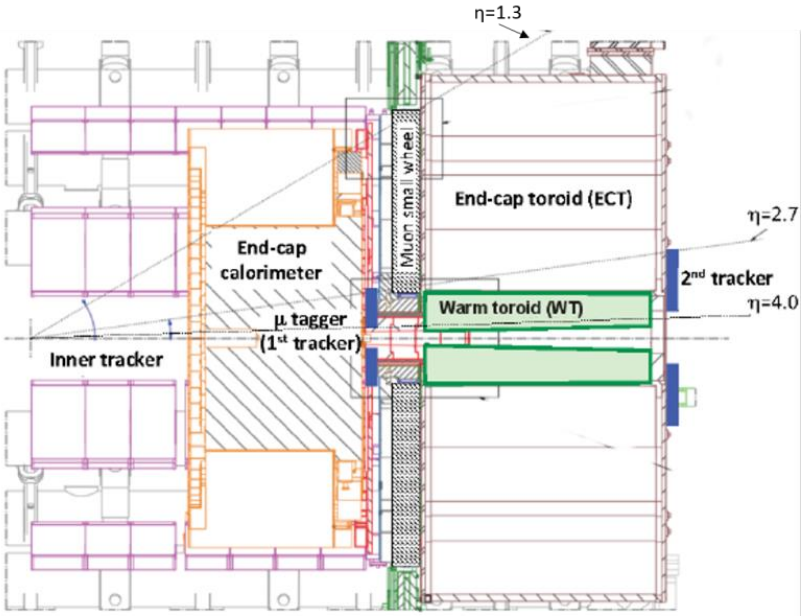


Liftoff process with sputtering



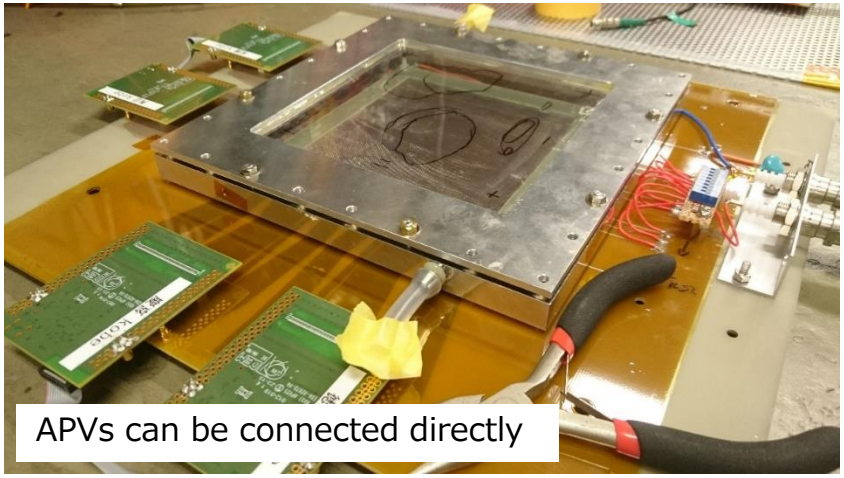
Main R&D target

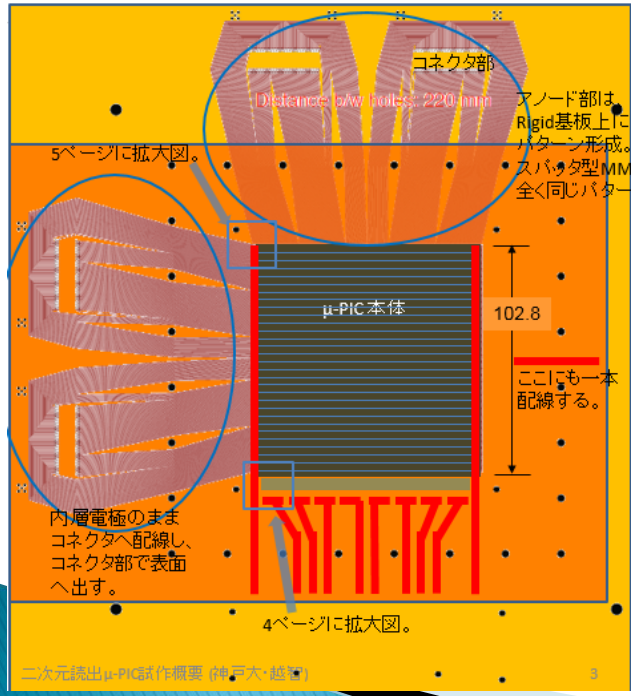
- For ATLAS muon tagger (High eta muon detector)
  - Proposed for Phase II upgrade 2023~
  - Need high position resolution ~ 0.1mm
  - BG rate > 10MHz/cm^2 (HIP, gamma) @ $\eta = 4.0$
- Rate tolerant
- 2 dimensional readout needed
- Muon TDR for phase II has just been approved
  - Four technology for muon tagger are described:
    - μ-PIC
    - Embedded MM
    - μ-RPWELL
    - Silicon

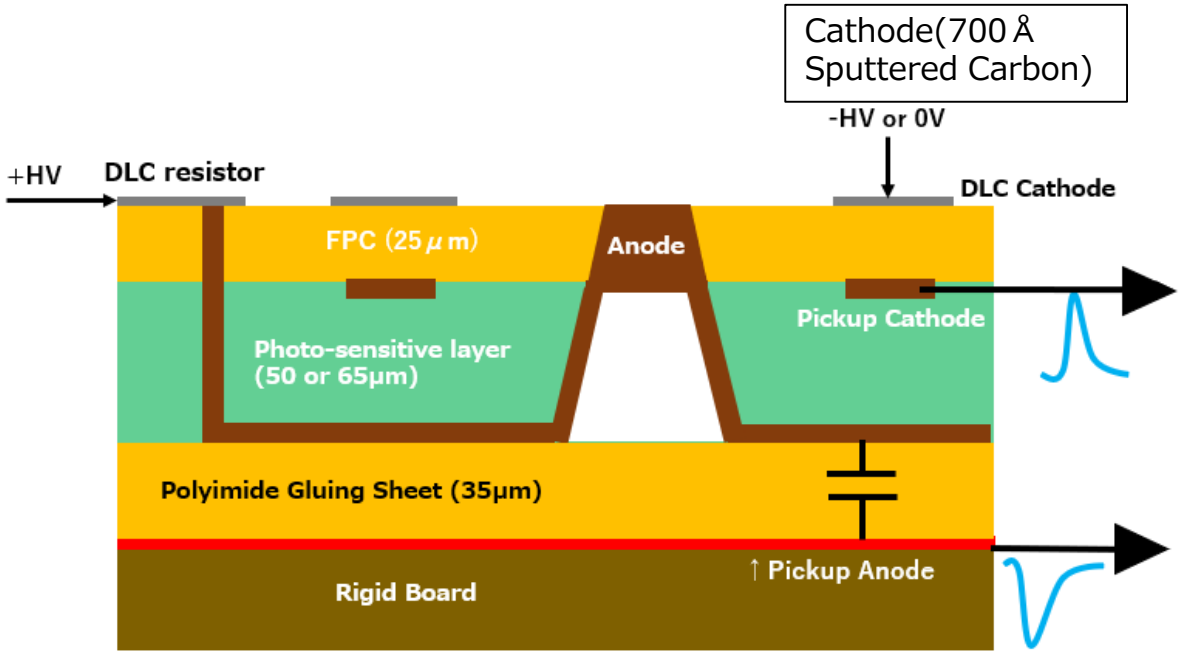


Prototype design

- To adopt SRS readout
  - Cathode signal is read by induced charge
  - For anodes, bias resister and coupling capacitor are needed for each channel.
- CR parts correspond to 512 strips are all put in the μ-PIC board





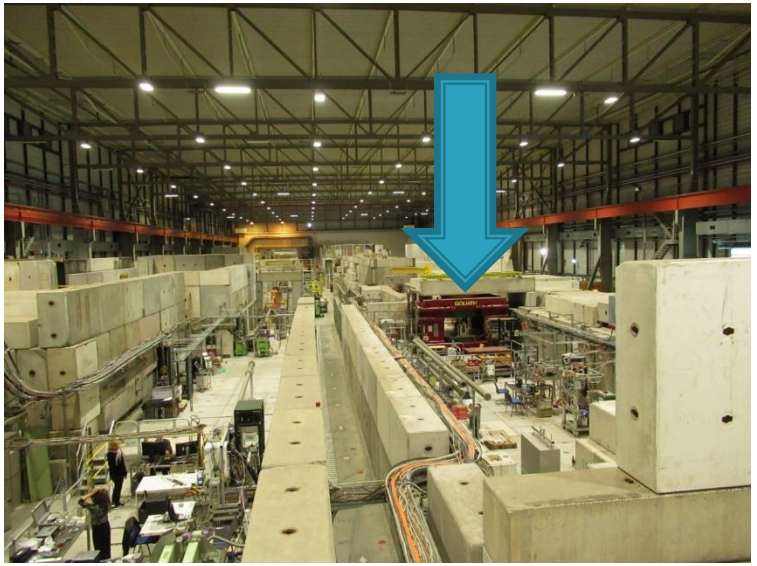


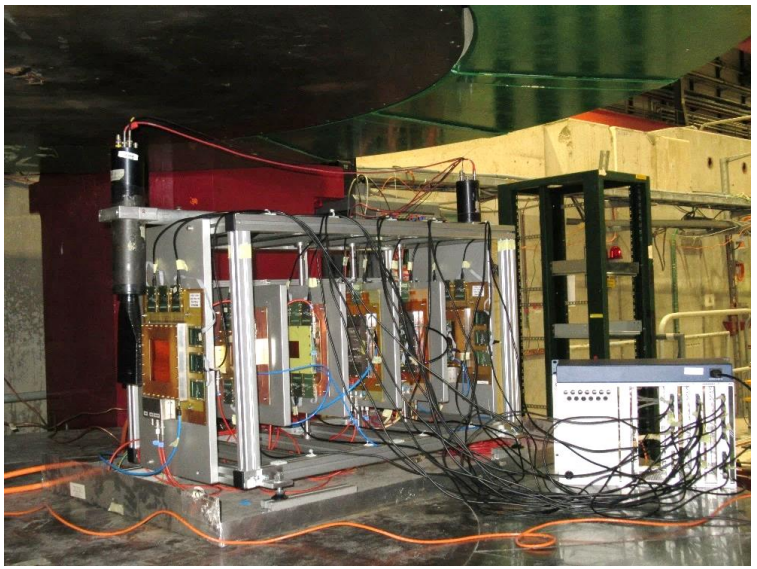
Testbeam using RD51 beamline

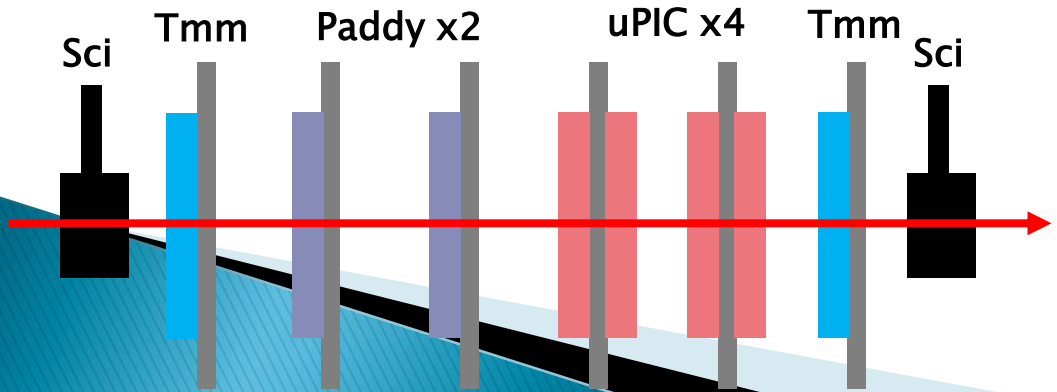
- Beamtime:
  - 9-16 October, 2017
    - Basic tracking test for MIP
      - Tracking efficiency
      - Position resolution for right angle
      - Comparison with two type of gas: Ar + CO2, Ar + C2H6
  - 2-9 May, 2018
    - Pre-test for inclined setup
      - Angular scan for inclined setup
      - Drift scan
      - Only Ar + CO2 gas used.
  - 8-22 August, 2018 (planned)
    - Main test for inclined setup
      - Similar menu as May testbeam
      - We will use Ar+C2H6 gas for higher gain

Testbeam of 150GeV μ/π (SPS H4 beamline)

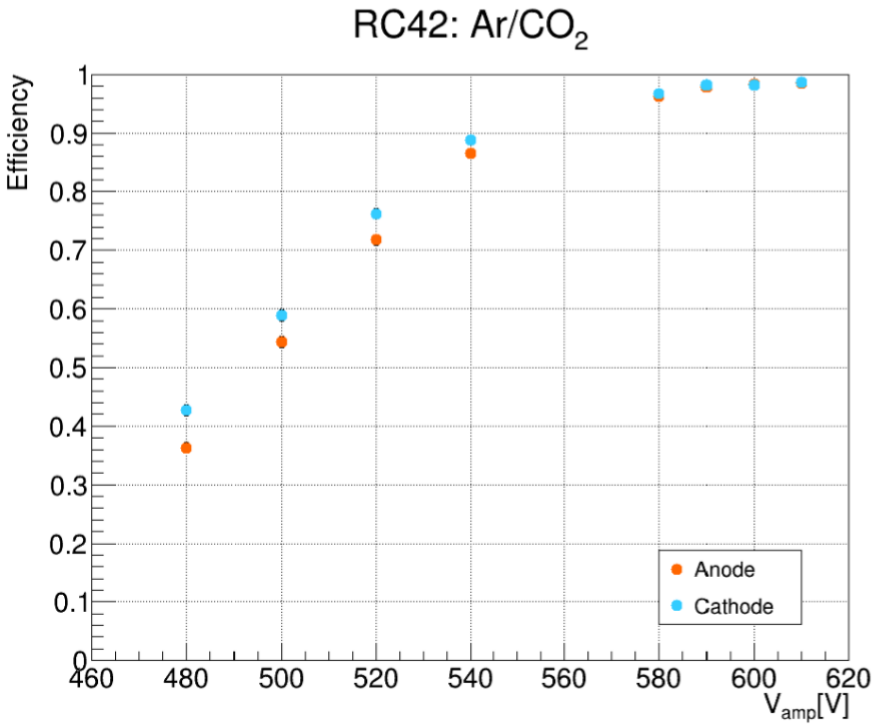
- Tracking test for MIP
- Beamtime: 9-16 October, 2017
- CERN-SPS/H4 (RD51 line)
- 150GeV/c μ/π (~4sec./spill)
  - Muon: ~10^5 /spill, ~8cmx8cm, 390Hz/cm^2
  - Pion: ~3x10^5 /spill, ~1cmx1cm or ~1cmx6cm, 75kHz/cm^2 or 12.5kHz/cm^2
- Detectors:
  - Trigger: Plastic scintillator x2
  - Telescope: Tmm (2D MM, 250umpitch, 10x10cm)
  - Test chambers: Resistive u-PIC x4, Paddy x 2
- U-PIC operation conditions
  - Gas: Ar 93% + CO_2 7% or Ar 70% + C_2H_6 30%
  - Readout: SRS with APV25

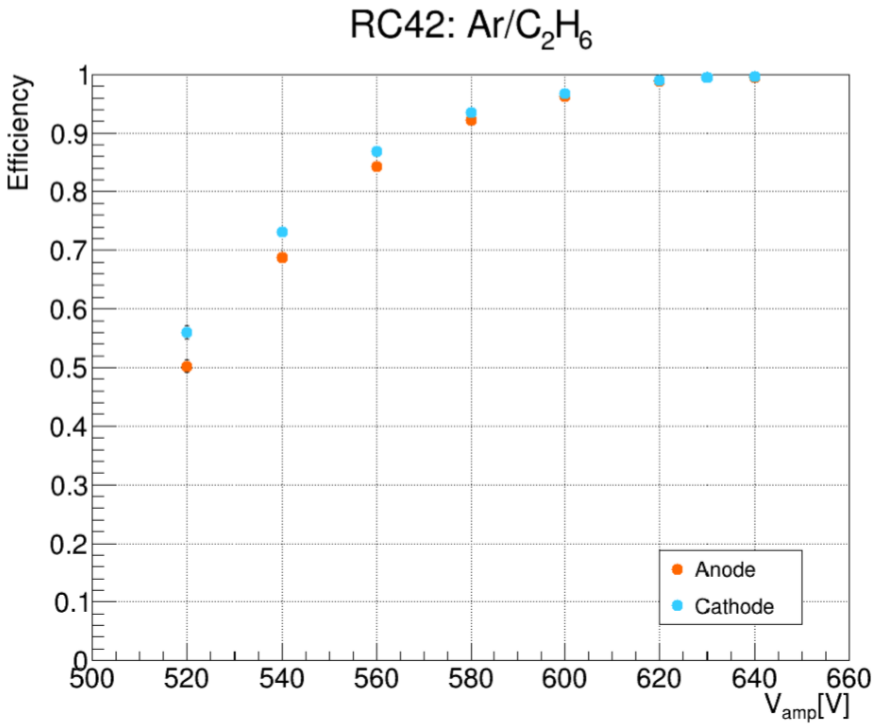






Tracking efficiency (muon)

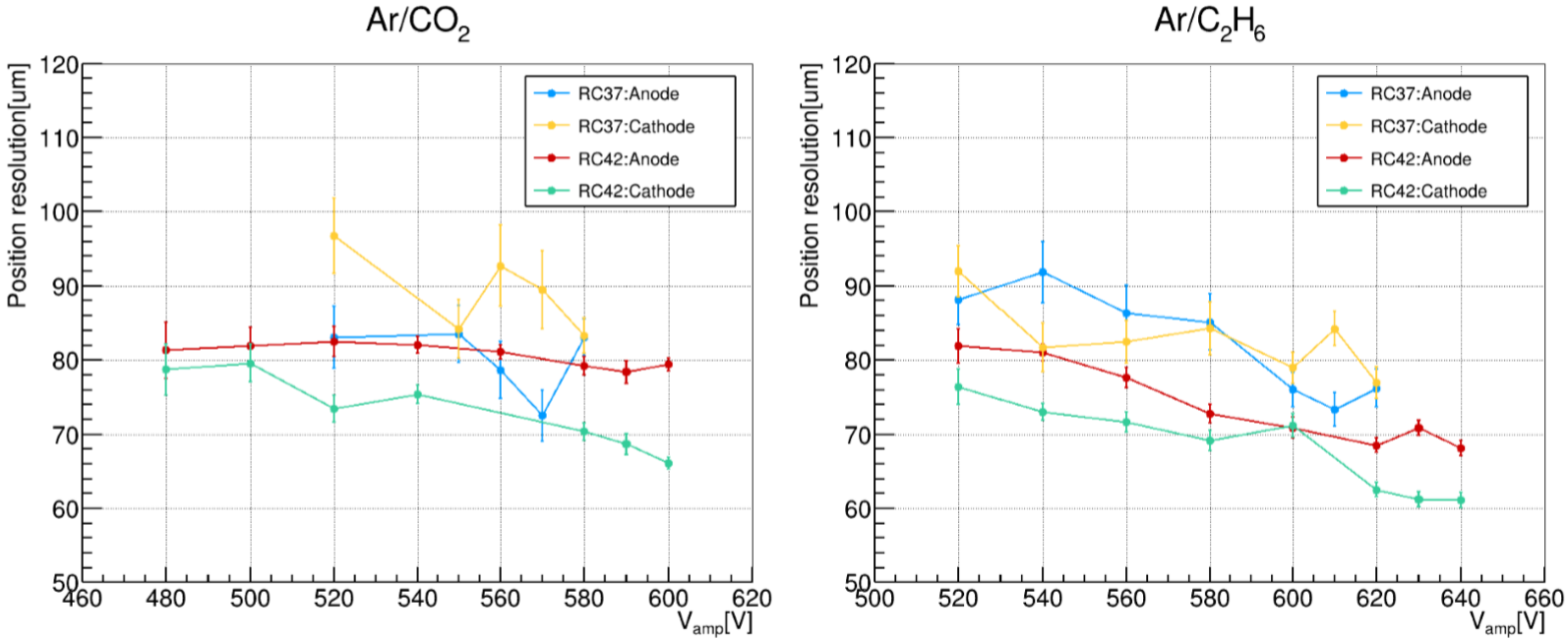




- More than 98% of efficiency is obtained using both Ar/CO2 gas and Ar/C2H6 gas
  - Operation is more stable in Ar/C2H6 gas

Position resolution (muon)

- Residual distributions are measured from two telescope MMs

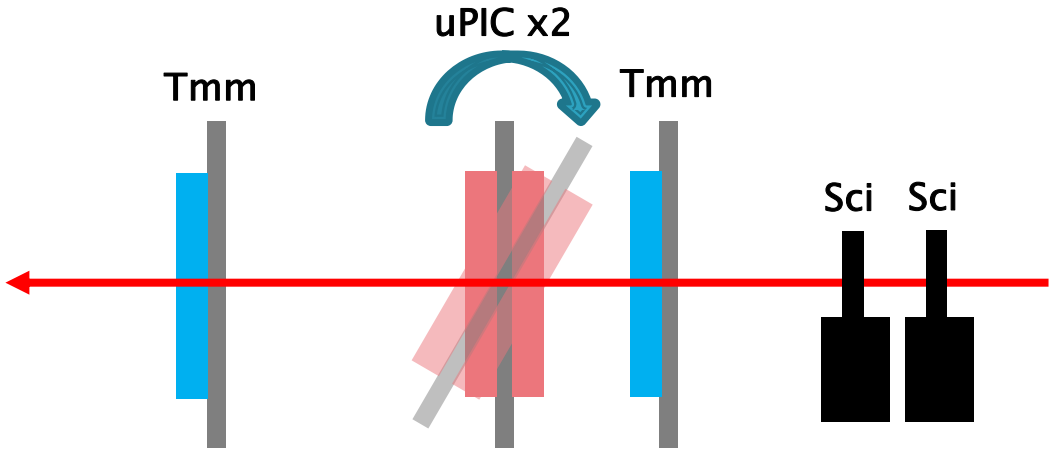


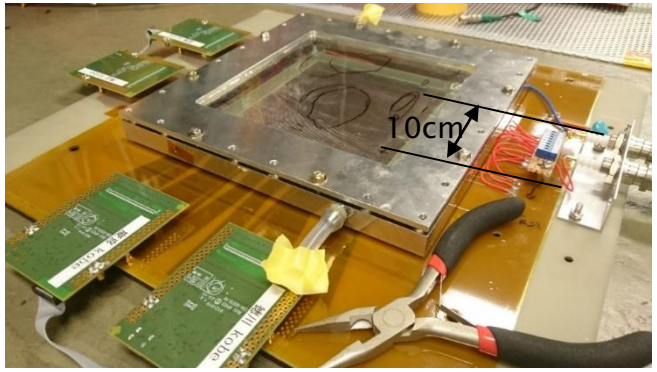
- Less than 70um of position resolution are attained on two dimensional readout using Ar/C2H6 gas

Testbeam on May 2018

- Position resolution measurements for angle scan (0-40 degree) and drift field scan were tested

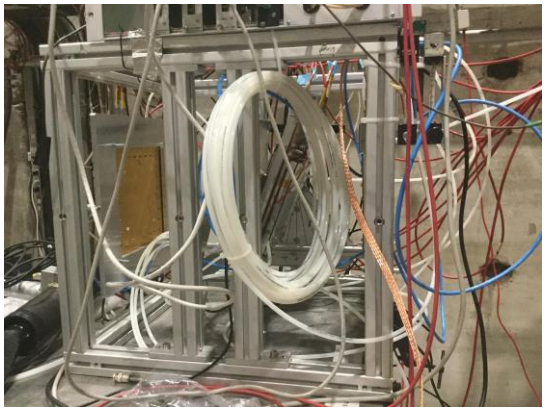
- The size of the detection area is 10cm x 10cm
- 2 u-PICs were installed on the beam line.
- Two chambers were set back to back on one stand.

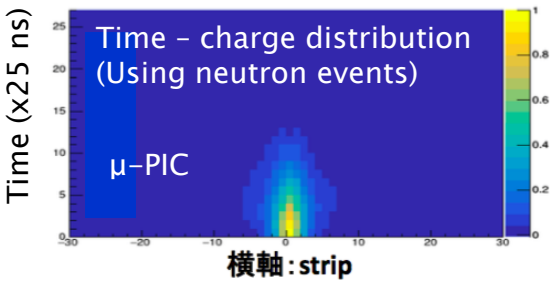


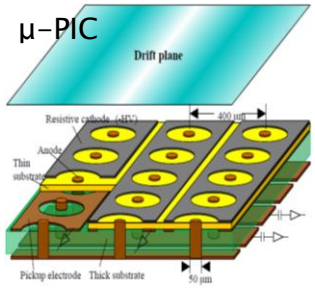


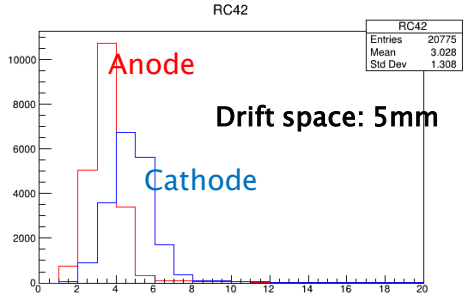
Why inclined beam?

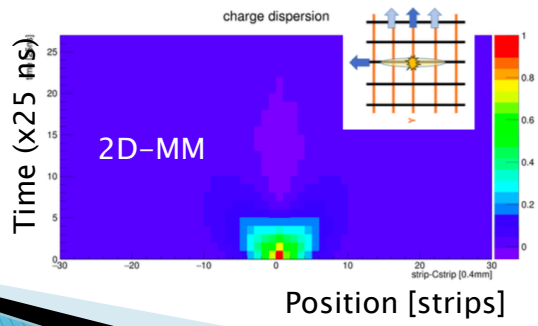
- Endcap detector
- Charge distribution on μ-PIC is very small for both (x and y) direction → Good TPC readout

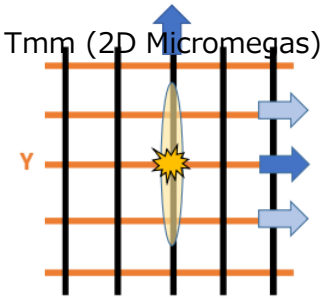


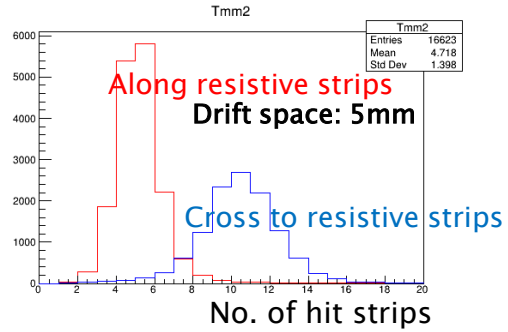






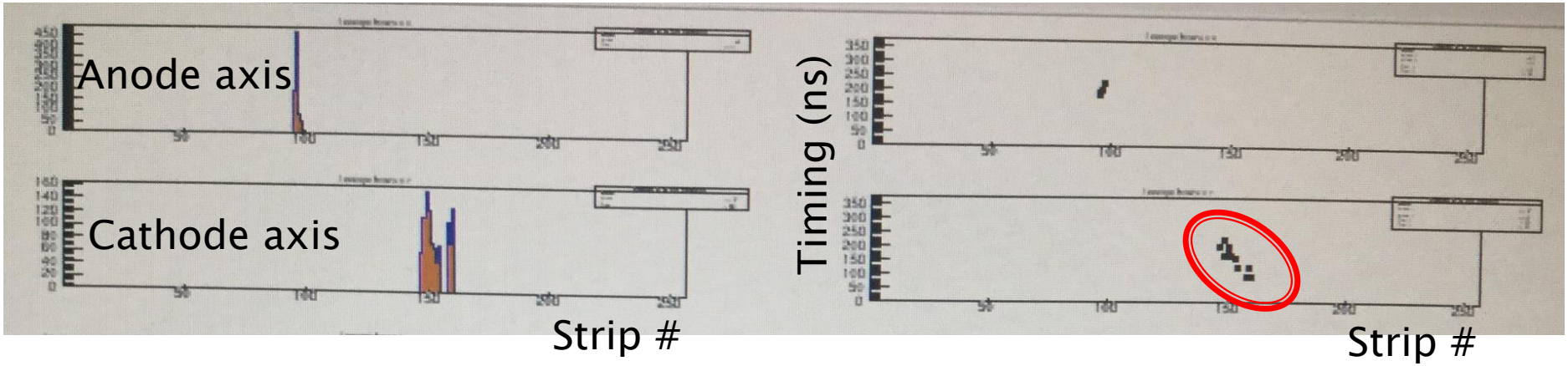






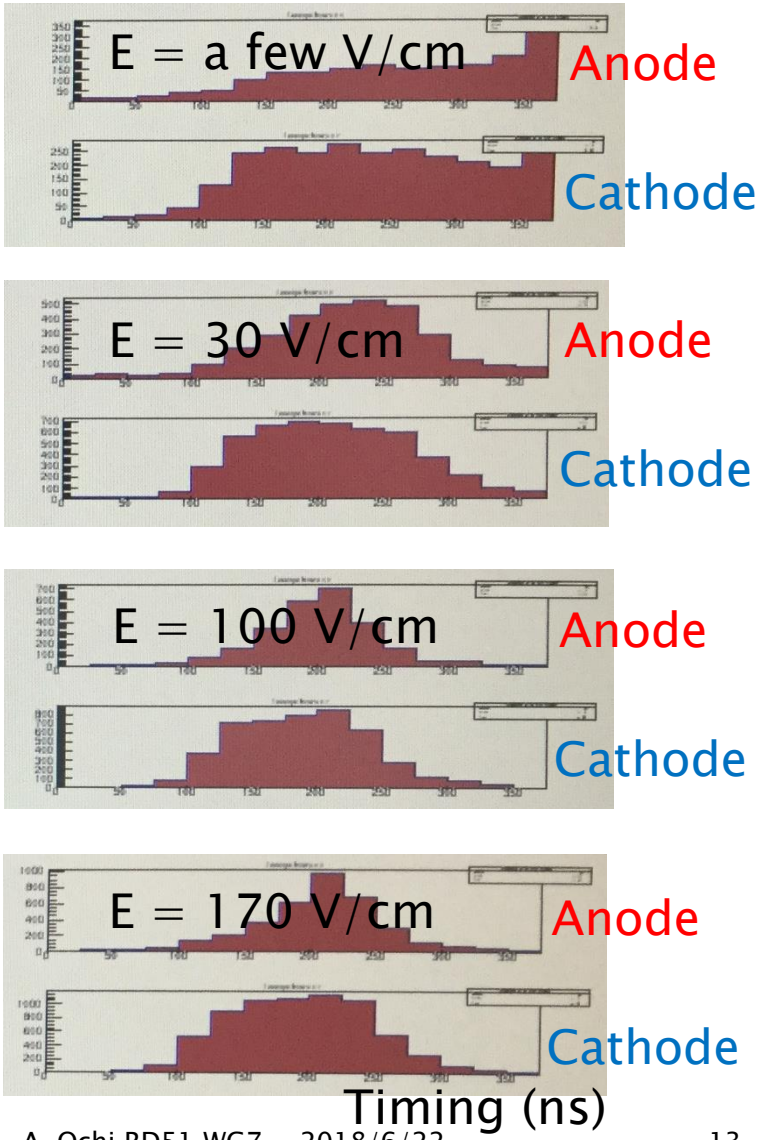
Results of tests … (Inclined setup)

- Data analysis is not started yet but …
  - TPC readout in 3mm drift gap on 40 degree inclined setup using muon beam (1kV/cm)



Results of tests … (drift scan)

- Also data is not analyzed yet
  - Only from online monitor …
  - Timing distribution of readout
- We are looking for operation conditions for next testbeam (August)



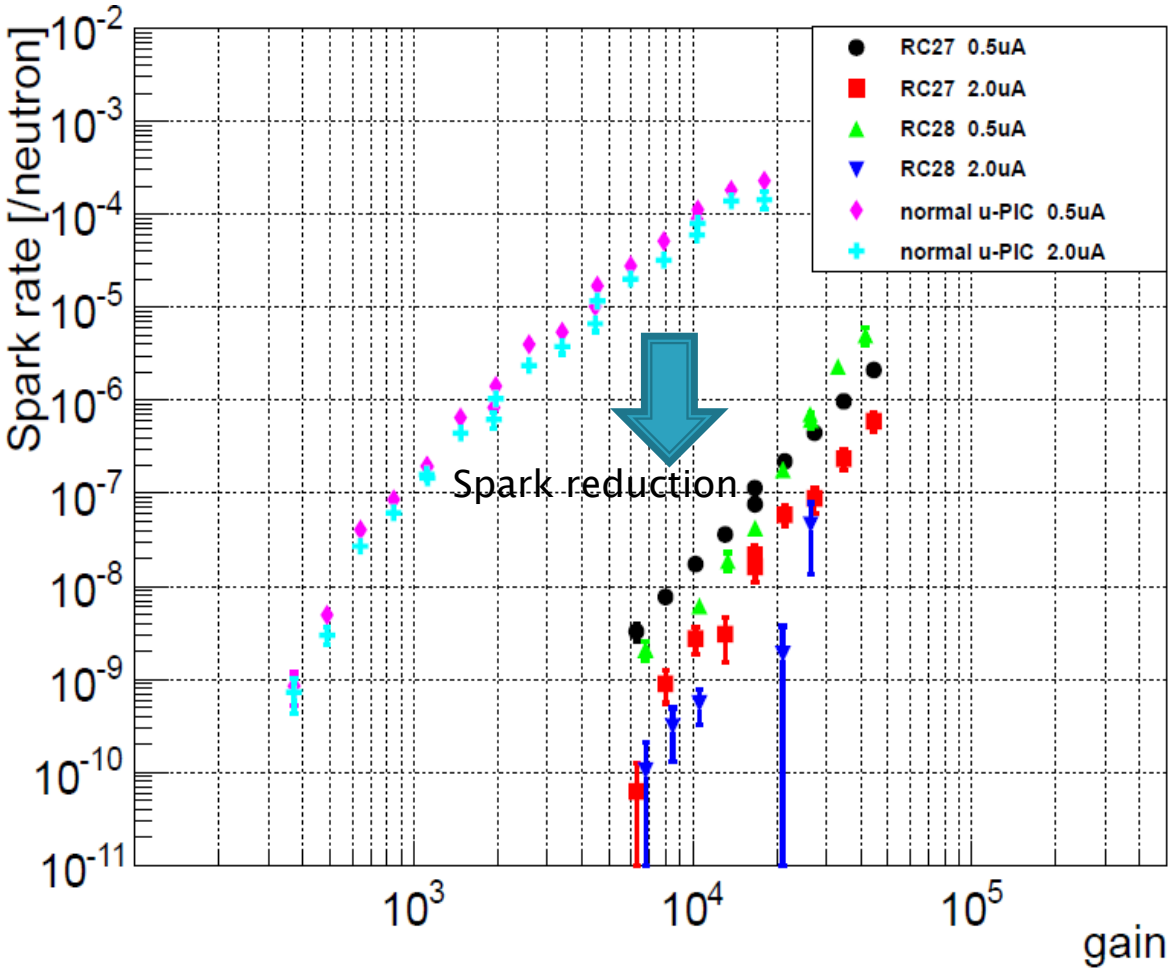
Summary

- RD51 testbeam for resistive μ-PIC
  - Basic performances … Oct. 2017
  - Pre-test for tracking … May 2018
- Good position resolution (< 70um) are obtained in both coordination
- In May beamtest, inclined beam and drift fields are scanned for determine next testbeam setup
  - Next test for tracking … Aug. 2018
- TPC readout on inclined beam will improve the position resolution
  - Data will be analyzed son

backup

It works well …

- Spark probability for fast neutron (~2MeV)
  - Conditions
  - Gas: Ar+C_2H_6 (7:3)
  - Drift field: 3.3kV/cm
  - Definition of the sparks:
    - Current monitor of HV module shows more than 2μA or 0.5μA.
  - Spark probability = [Spark counts] / neutron
  - The spark rates on normal μ-PIC are are also plotted as comparison (cyan, magenta plots).
  - Results
  - Reduction of sparks are obviously found. The rate was 10^{3-5} times less than normal μ-PIC case at same gas gain.



Resistive electrodes with DLC

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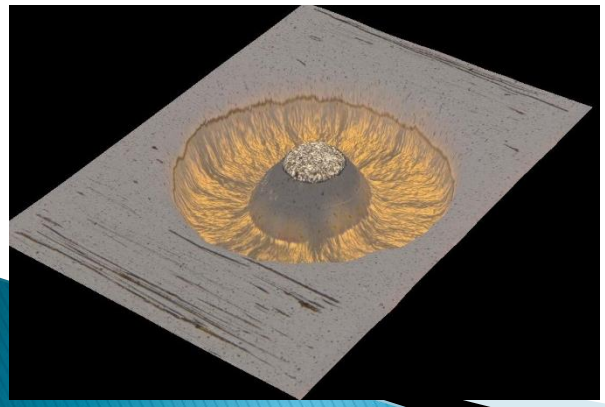
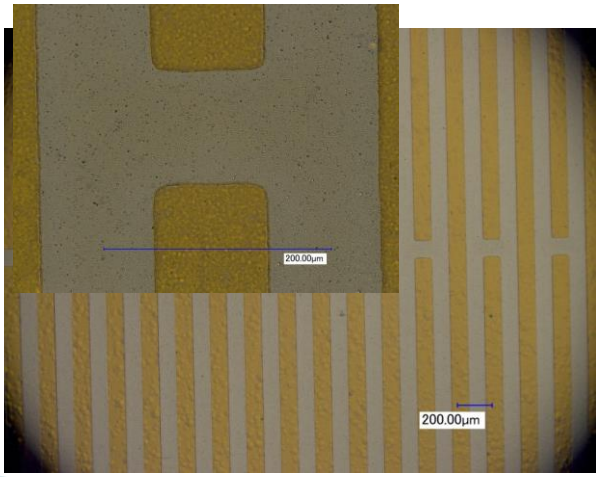
  - Initially, it was developed for ATLAS MM resistive foils
  - Fine micro-patterning (um order) available → applying it for u-PIC electrodes





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