“PICOSEC Micromegas”
Test beam campaign May 2022

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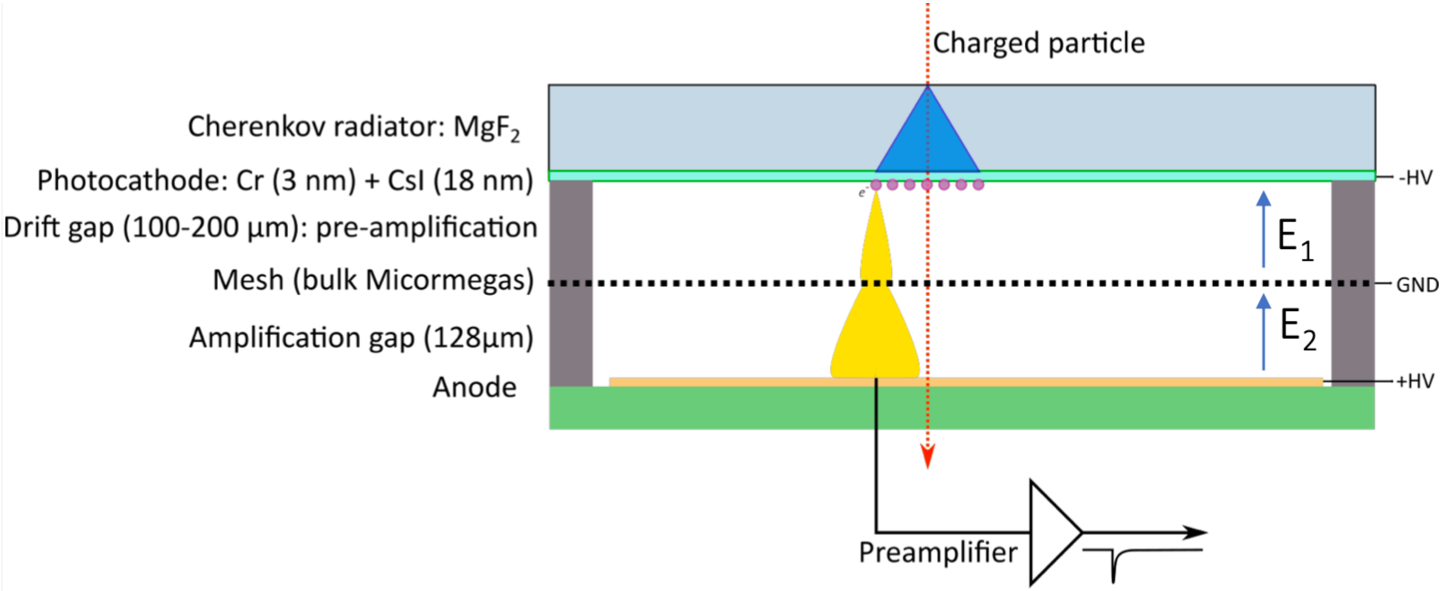
ON BEHALF OF THE CERN EP-DT-DD GDD GROUP
AND OF THE PICOSEC MICROMEGAS COLLABORATION

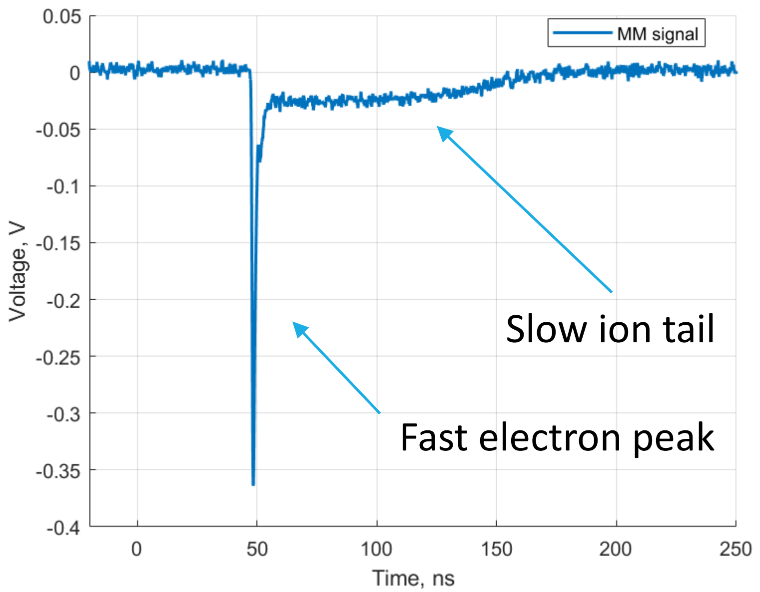
RD51 COLLABORATION MEETING, 17.06.2022

PICOSEC Micromegas

Introduction

- **PICOSEC Micromegas collaboration:** Gaseous detector with time resolution tens of picoseconds





J. Bortfeldt et al., NIM A, 903, 317-325 (2018)

- First single pad prototypes demonstrated time resolution below 25 ps → <u>Now we want to push the limits</u>

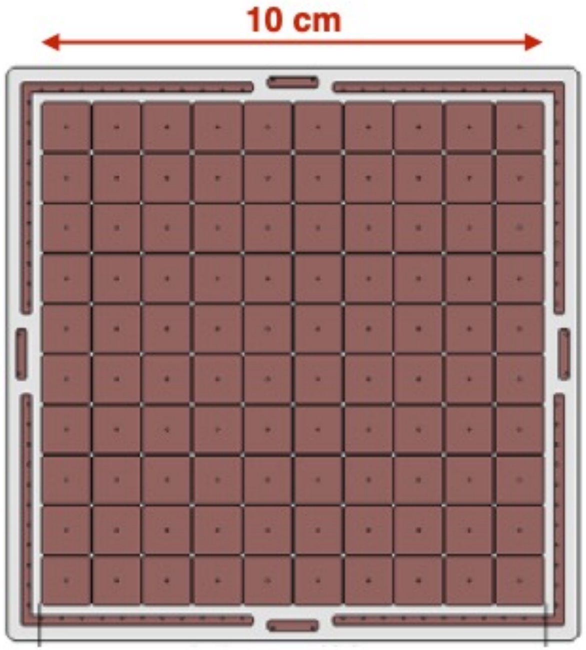
PICOSEC Micromegas

Developments towards applicable detector

- **Objective:** Tileable multi-channel detector modules for large area coverage

Single pad (2016)
⌀1 cm

Multi pad (2017)
⬡ 1 cm



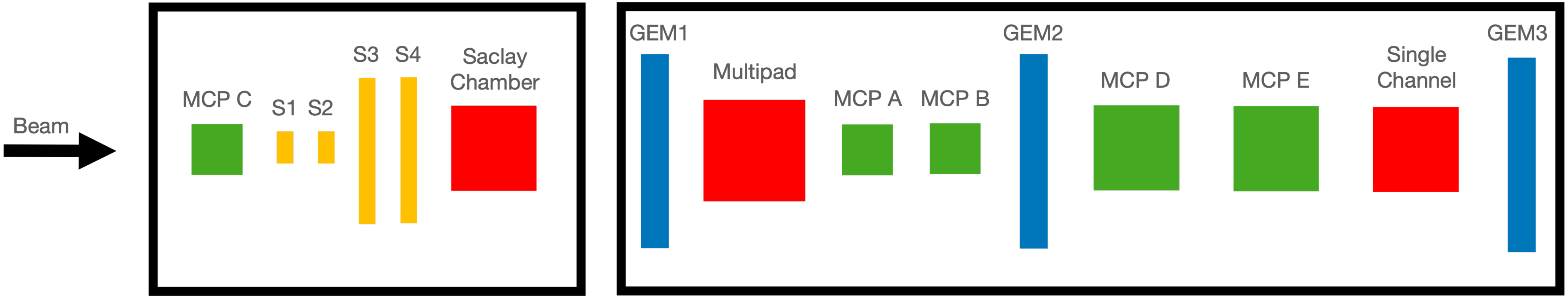
10x10 module
◻ 1 cm

Test beam campaign

Experimental setup

Beam type: CERN SPS H4 beam line, 80 GeV muon beam

- **Infrastructure:**
  - → **tracking**/**timing**/**triggering** telescope: **GEMs** + **MCP PMTs**
  - → **Devices Under Test:** Multipad + Single Channel + Saclay Chamber
  - → flammable gas mixture: Ne:CF_4:C_2H_6 (80:10:10)



MCP PMTs characterisation

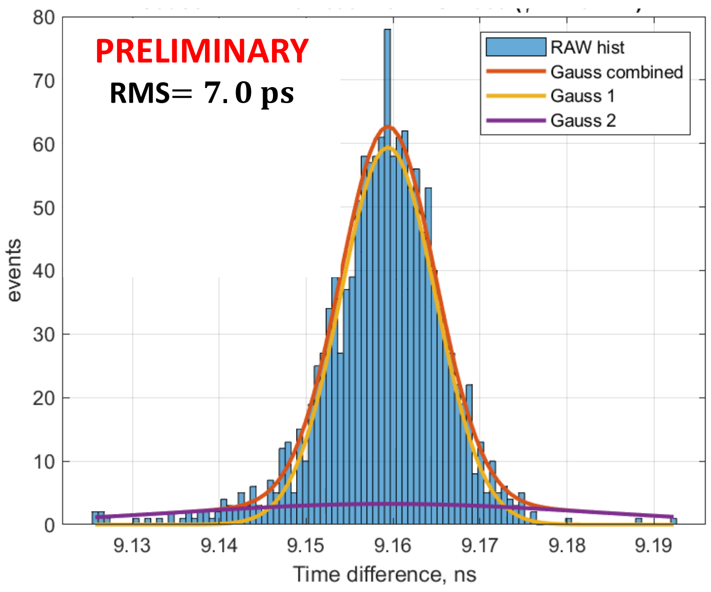
Reference devices

Small area Hamamatsu:

→ Active area 11 mm dia.

→ Time resolution <5 ps each

Combined time resolution of 2 Hamamatsu

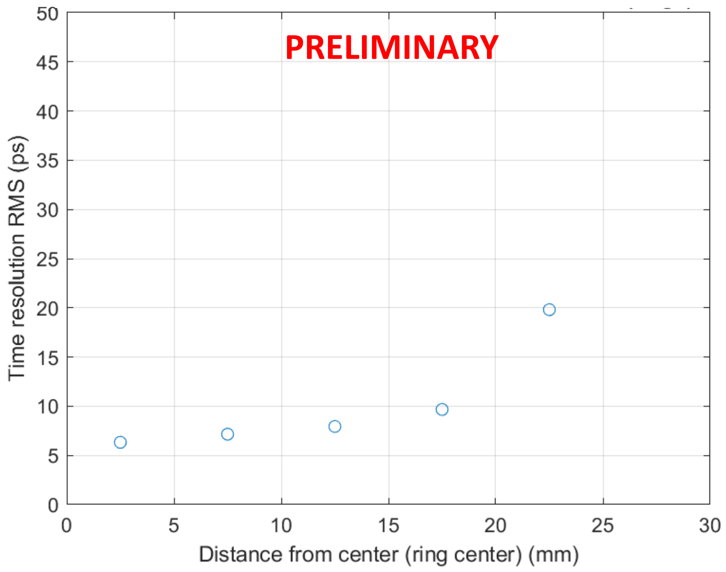


Large area Photek:

→ Uniform response up to ~30 mm dia.

→ Time resolution ~5 ps in the center

Time resolution of Photek vs Hamamatsu

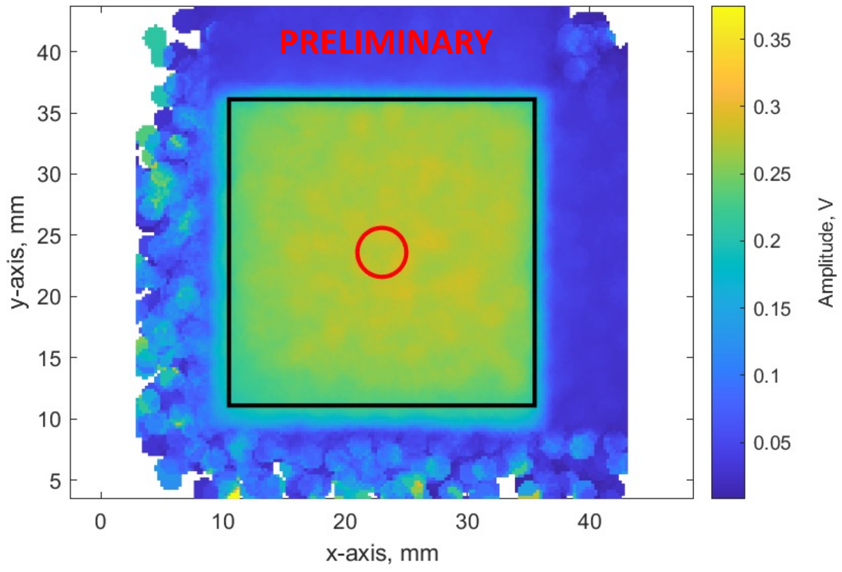


Large area ALICE FIT Planacon:

→ Remarkable flatness of each quadrant

→ Time resolution ~11 ps

Amplitude of ALICE FIT Planacon vs Photek



Detectors under test

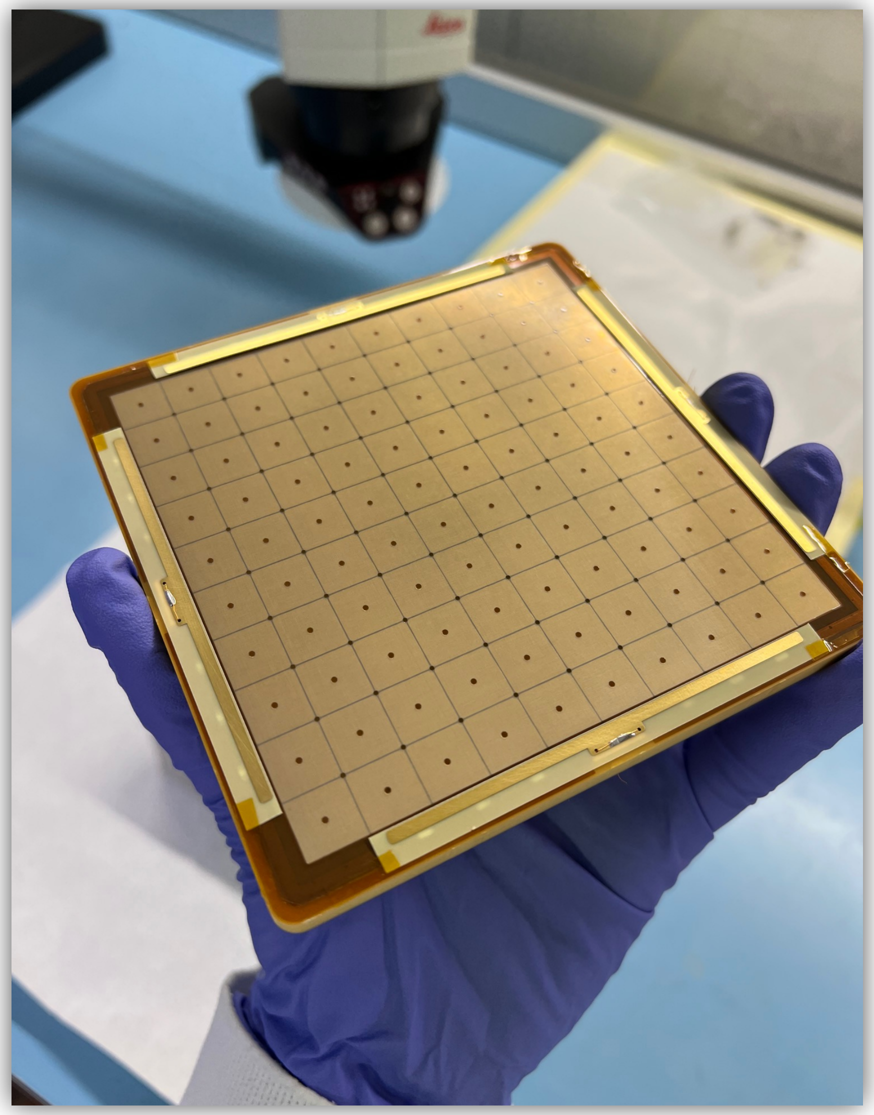
Multipad

- **100 square channel prototype with a uniform thickness of preamplification gap**

  → Characterisation of the time resolution over the multiple channels

  → Comparison of the standard and thin (220 µm vs 180 µm) preamplification gap

  → Test of custom-made preamplifiers and SAMPIC digitiser



Detectors under test

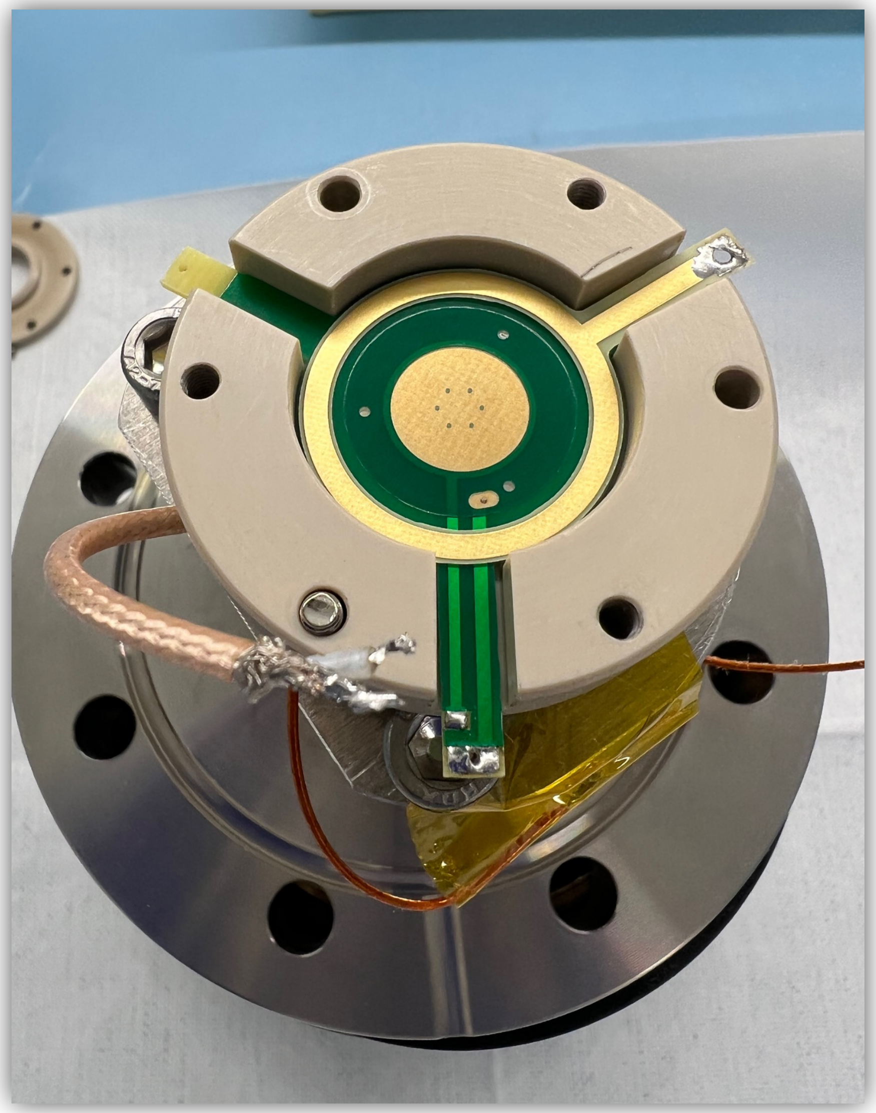
Single Channel

- **1 channel prototype with a thin mesh Micromegas**

  → Comparison of the standard and thin Micromegas (18 µm vs 12 µm) to obtain more uniform electric field in the preamplification gap

- **1 channel prototype with a resistive Micromegas**

  → Test of custom-made preamplifiers



Detectors under test

Saclay Chamber

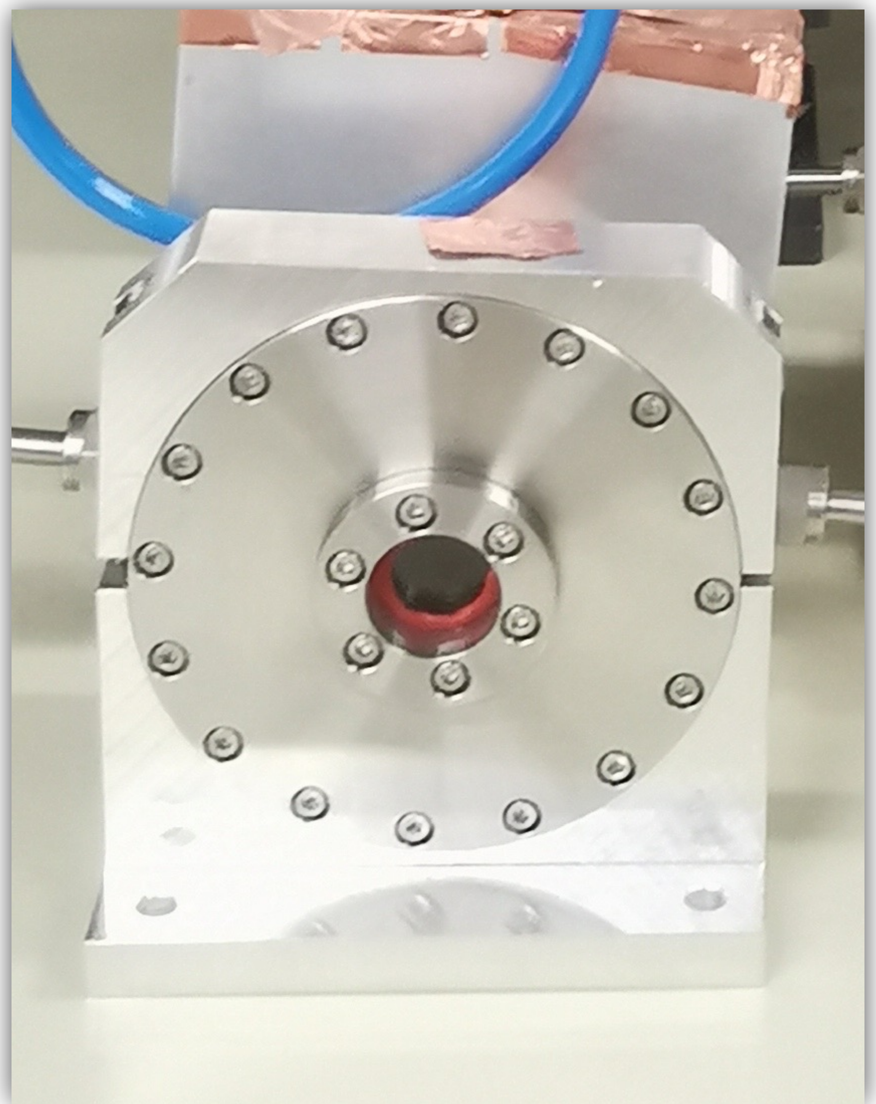
- **1 channel prototype with B_4C photocathode**

  → Studies on the robust photocathode materials

  as an alternative to CsI

- **1 channel prototype with a non-resistive Micromegas**

  → Test of custom-made preamplifiers



Electronics

Dedicated preamplifiers

- **Baseline:** Cividec

  → low-noise amplifier, analog bandwidth 2 GHz, gain 40 dB

  → not scalable to high channel counts

- **Custom made preamplifiers:**

  → different fast and slow preamplifier circuits

  → Multipad preamplification cards

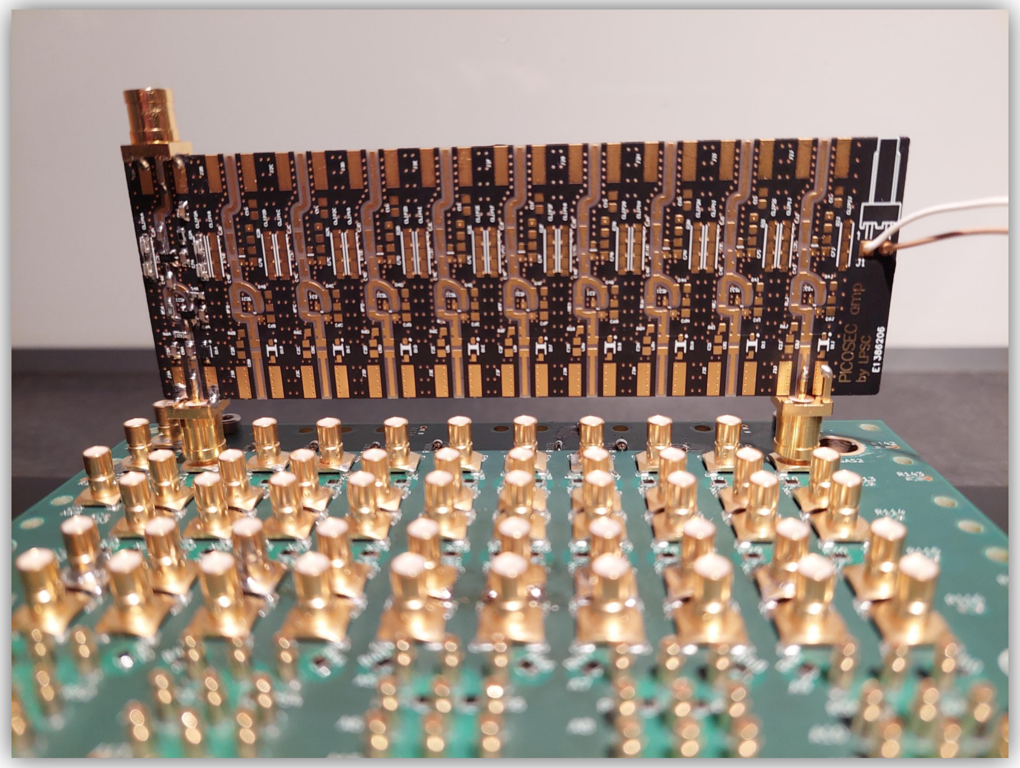
  (both P. Legou, CEA Saclay)

  → RF pulse amplifier cards optimised for PICOSEC

  (idea: C. Hoarau et al., optimized by CERN GDD and M. Kovacic)

  → charge sensitive preamplifiers

  (H. Müller, CERN)



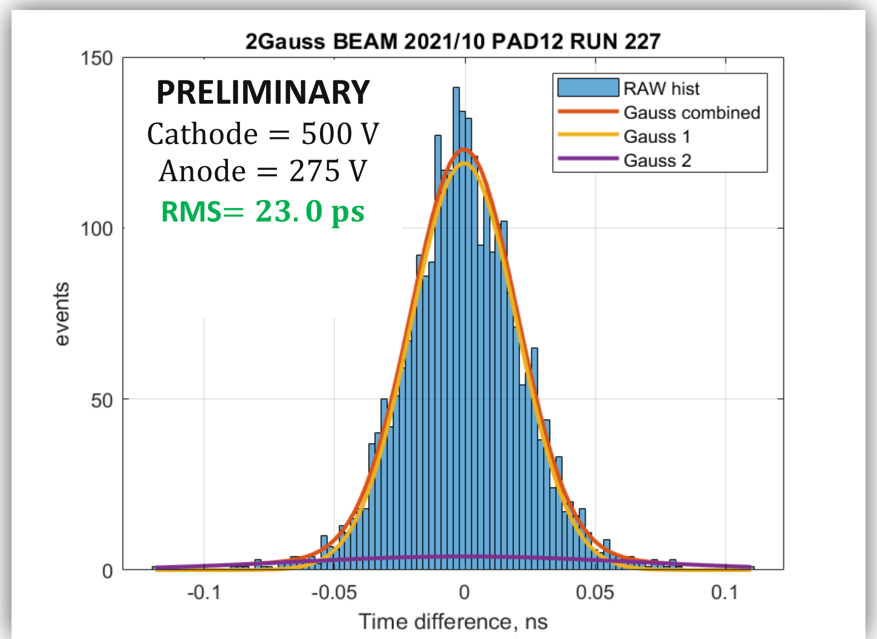
RF pulse amplifier for PICOSEC

Preliminary results

Comparison of the different drift gap thickness and electronics

- Time resolution → standard deviation of signal arrival time distribution
- **Multipad** with 220 µm drift gap, CsI and **Cividec preamp**:

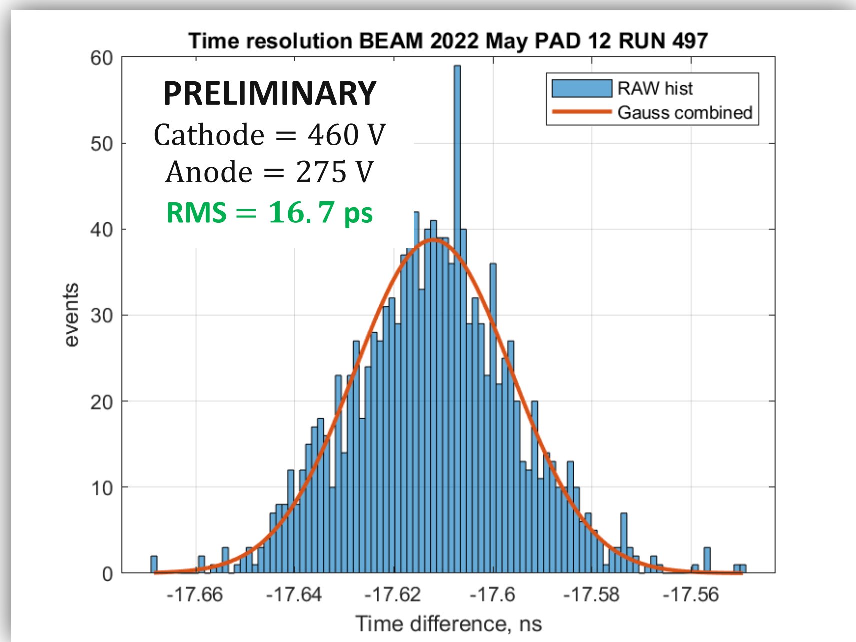
  → **Uniform time resolution below 25 ps** for all pads



A.Utrobicic:, VCI 2022 conference, https://indico.cern.ch/event/1044975/contributions/4663685/

- **Multipad** with 180 µm drift gap, CsI and **Custom preamp**:

  → **Time resolution below 18 ps** for all measured pads



A.Utrobicic:, RD51 CM, https://indico.cern.ch/event/1138814/contributions/4915978/

Electronics

Multi-channel digitisers

- **Baseline:** Oscilloscope

  → 4 channels, 10 GS/s sampling frequency

  → not scalable to high channel counts

- **SAMPIC digitizer:**

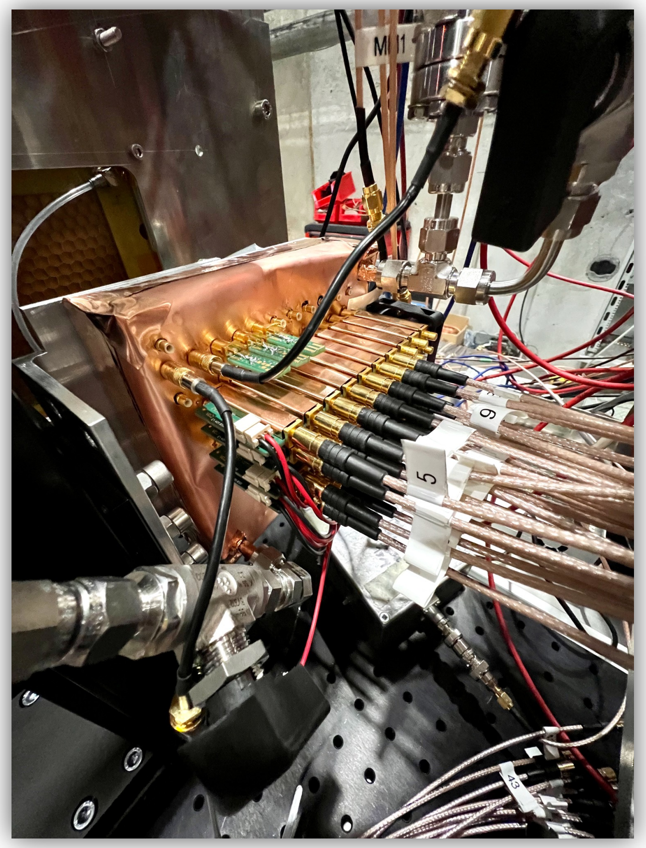
  → 64 channel SAMPIC under test

  (128 channel being developed)

  → 6.4 vs 8.5 GS/s sampling frequency

  (test of achievable timing precision)

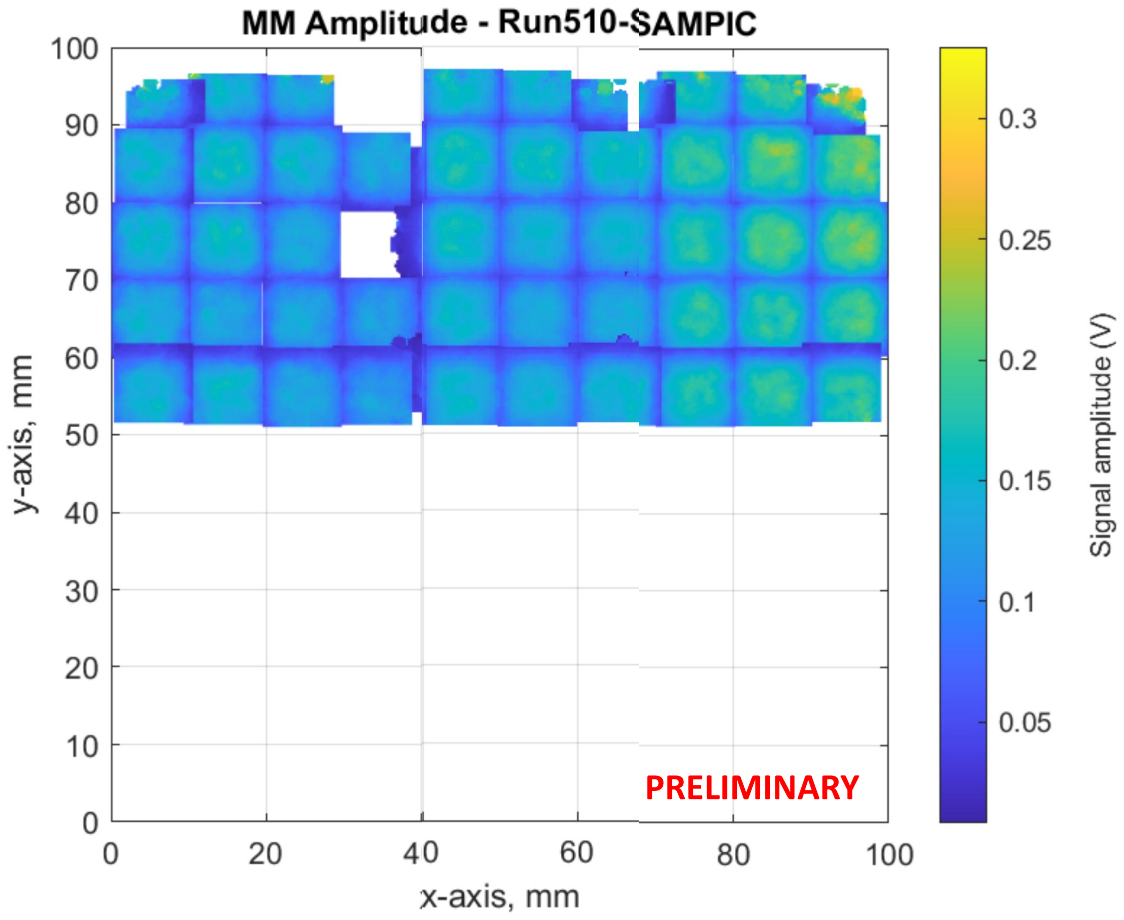
  → explore the possibility of multi-threshold readout with ToT measurement

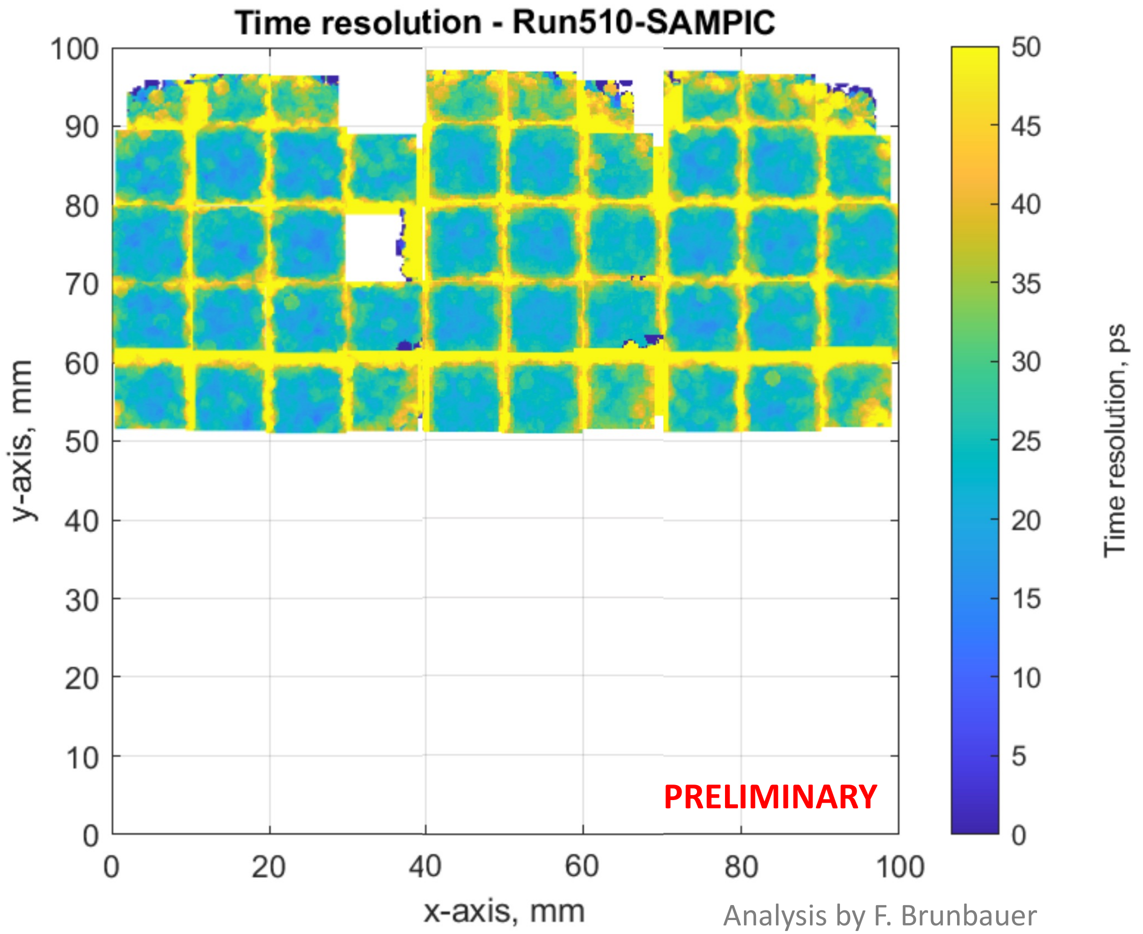


64 channel SAMPIC digitiser, J. Maalmi, D. Breton et al., CAE Saclay

Preliminary results

SAMPIC readout of full 50 Multipad channels





Analysis by F. Brunbauer

Summary

- Preliminary results for the 10x10 cm^2 PICOSEC Micromegas with 180 µm thin preamplification gap, CsI photocathode and custom-made preamplifiers → **Time resolution below 18 ps for all measured pads!**

- Proof of the principle to have a complete readout chain → **Successful readout of 50 Multipad channels!**

- Developments towards applicable detector are still ongoing!

Future perspectives

Test beam campaign July 2022

- **Stability** → Multipad with resistive Micromegas
- **Robustness** → Better understanding of robust photocathodes: DLC, B_4C
- **Electronics** → Complete readout of all 100 Multipad channels

Next steps

- **Integration** → Sealed detectors (clean, hermetically closed devices with high gas quality)
- **Scaling to larger area** → Tiling 10x10 cm^2 modules, development of 20x20 cm^2 prototype