PADI for straw tube readout

and diamonds for MIPs and for high precision tracking

beam test – Jülich, Feb. 2015

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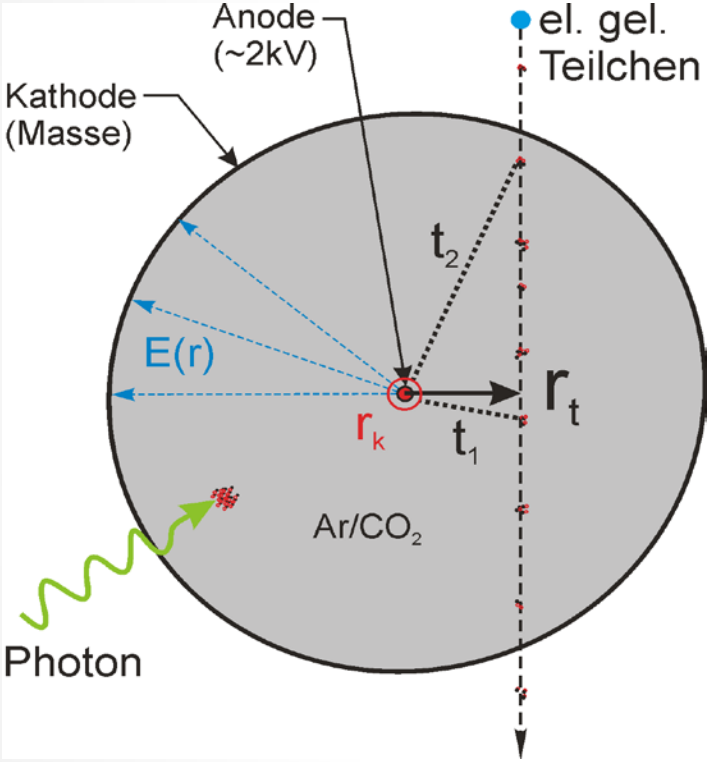
for the CBM Collaboration

Straw tube operation principle

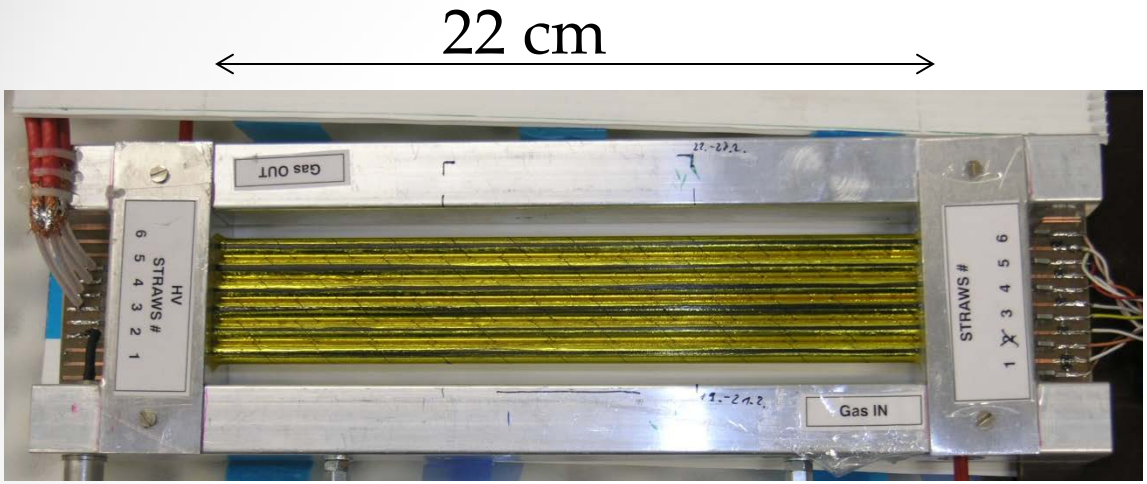


Straw tube cross section

Measures a distance of the track anode wire

- Determine the **drift time of electrons** →time measurement
- **Shortest drift times** of electrons from track to wire → precision
- **Drift velocity** depends on: pressure, gas mixture, HV, tube size ....
- **Drift velocity** can be experimentally measured (goal of this experiment) and also simulated

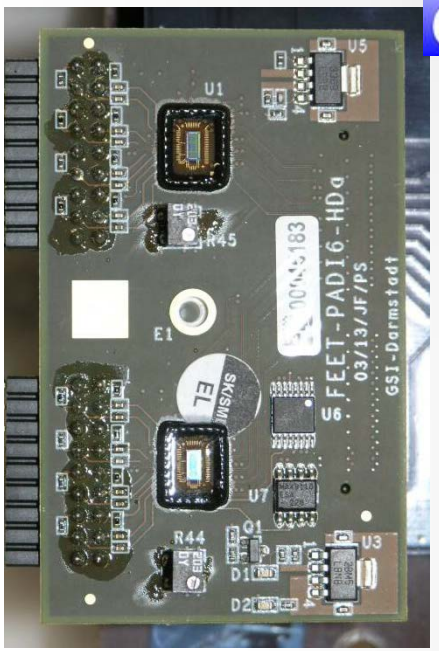
Hardware



Straw tube detector

- CBM-MUCH prototype
- 6mm diameter, ~22cm length
- detector gas: Ar/CO_2 (70/30)
- gas pressure: 1bar
- HV: 1800V
- AC coupling to PADI input: 400pF(straw), 2.2nF(PCB)
- Drift time: up to 40 ns

V. Peshekhonov et al., "Straw tube subsystem of the CBM muon detector", Physics of Particles and Nuclei Letters, March 2012, Volume 9, Issue 2, pp 172-179.

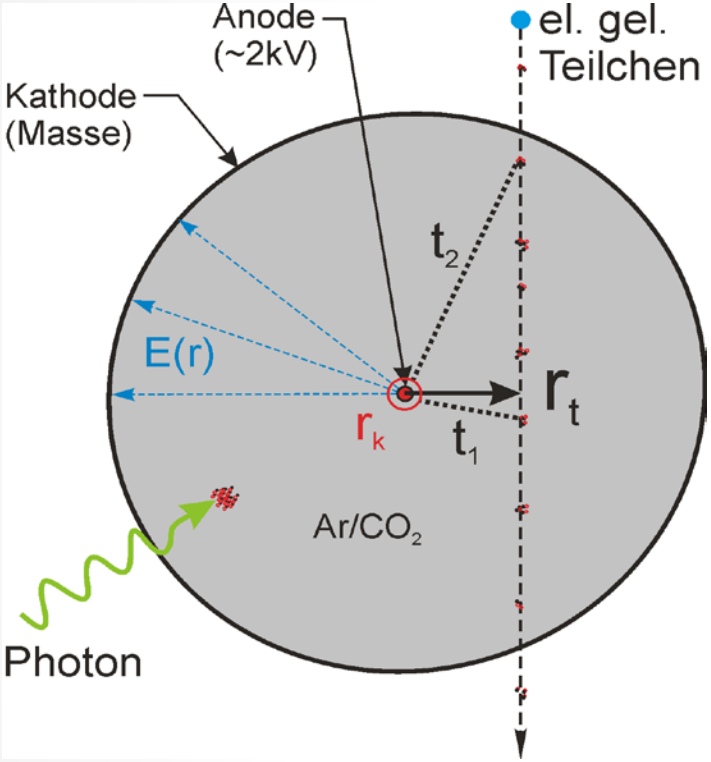


PADI6 ASIC

- 4 channel per ASIC, differential inputs
  8 channel on FEET-PADI6_Hda
- conversion gain: 35(17.5*)mV/fC
- voltage gain: 244
- BW: 416MHz
- time constant in setup: ~20ns

M. Ciobanu et al., "PADI, an ultrafast Preamplifier - Discriminator ASIC for Time of Flight Measurements", Nuclear Science, April 2014, IEEE Transactions ,Volume 61, Issue 2, pp 1015-1023.

Aim of the test



Can PADI6 ASIC be used for straw tube readout ?

Setup for test in Jülich (proton beam)

- CBM MUCH prototype 6mm diameter, ~22cm length
- AC coupling to PADI input: 400pF(straw), 2.2nF(PCB)
- and reference detector ....

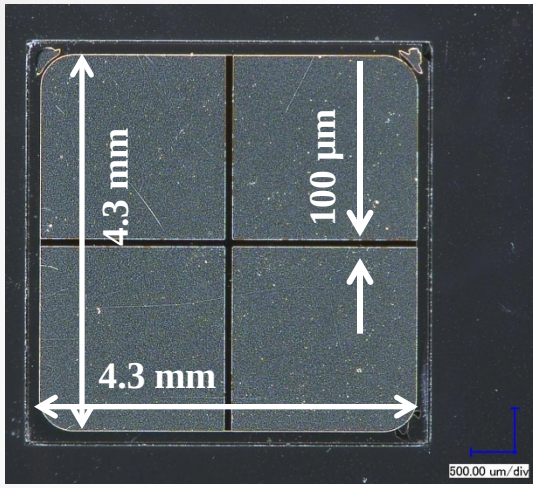
Reference detector requirements:

- Determione position of beam particle with resolution below 50 µm
- time resolution better 100 ps
- single particle mode for MIPs

→ scCVD diamond

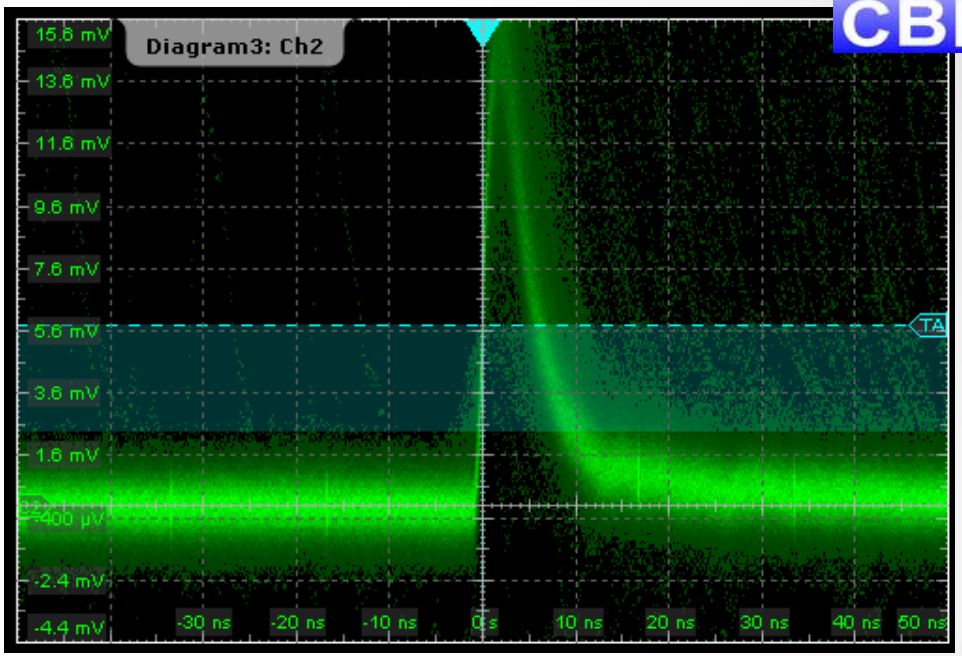
Experimental setup – reference detector

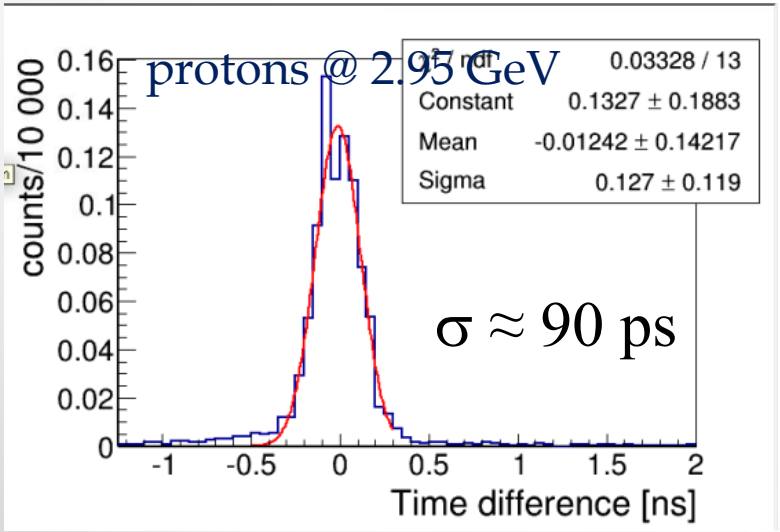
Reference, tracking, scCVD detector



- four channels – metallization
- 100µm space between electrodes
- time resolution below 100 ps

scCVD diamond signal for MIPs

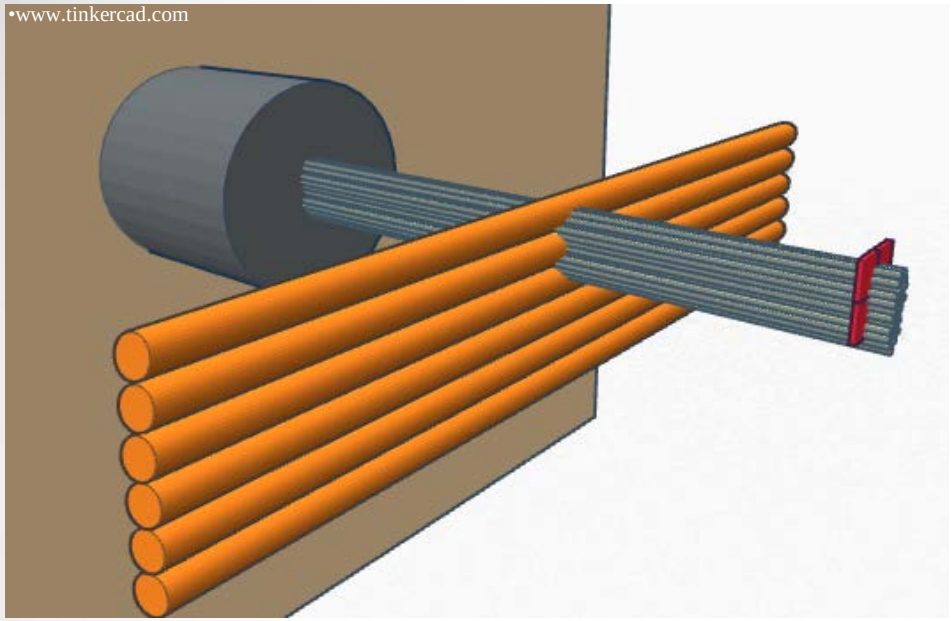




Used threshold: 7mV on each channel

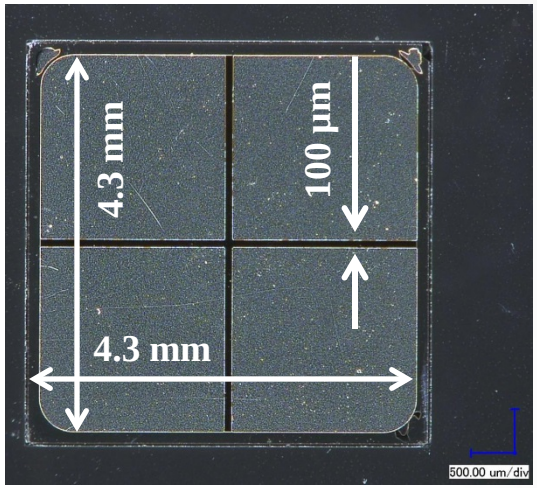
→ position better than 50µm

Experimental setup



- straw tubes connected to the PADI v6
- straw diameter: 6 mm
- Ar/CO_2: 70%/30%
- HV: 1800 V

Reference, tracking, scCVD detector



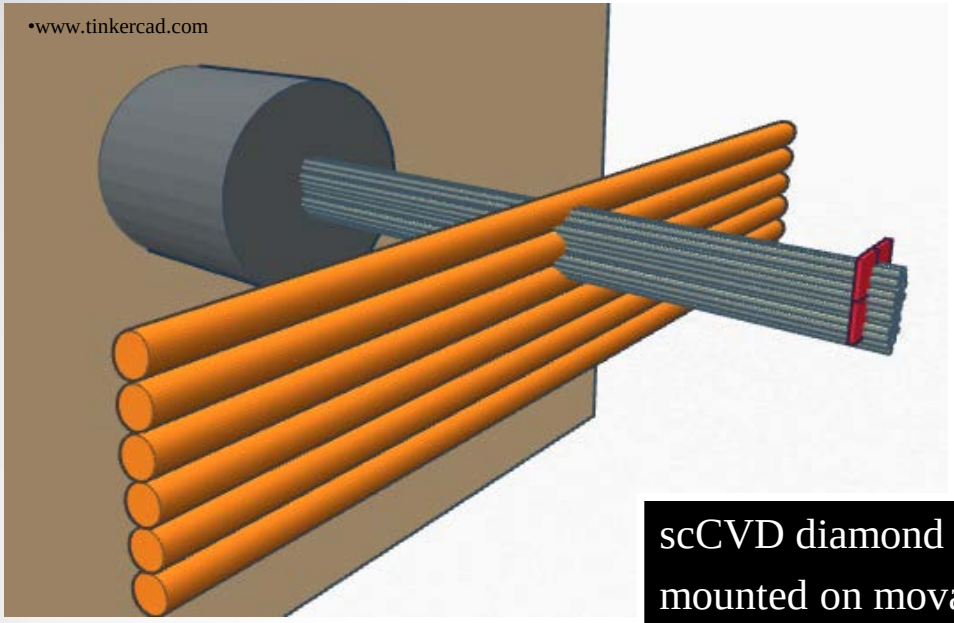
- four channels – metallization
- 100µm space between electrodes
- time resolution below 100 ps
- attached to a movable table, (µm step precision)

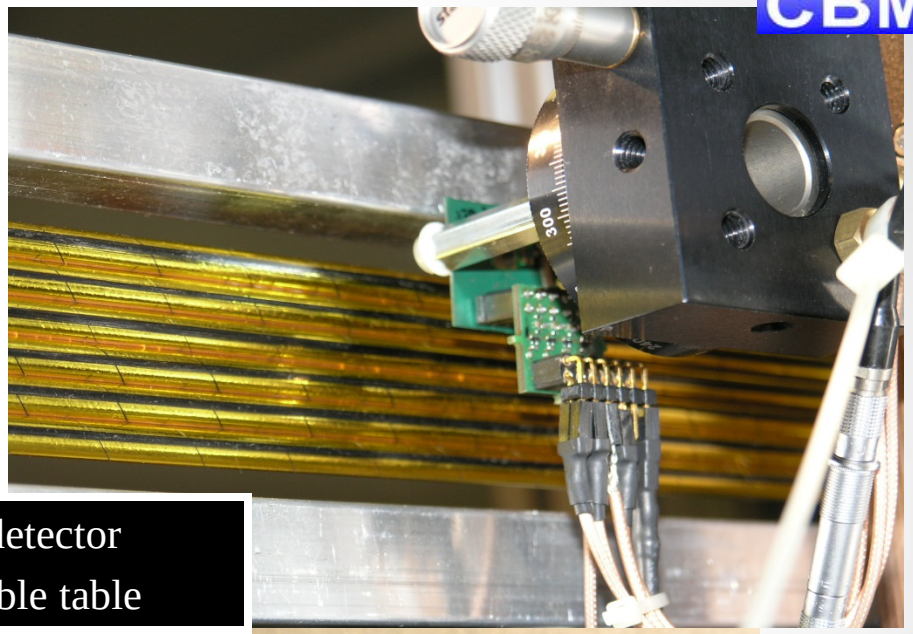
DAQ /Trigger:

- Oscilloscope used as a DAQ (R&S 1044)
- correlated signal in two diamond electrodes used as a trigger

→ proton in the 100µm gap between electrodes.

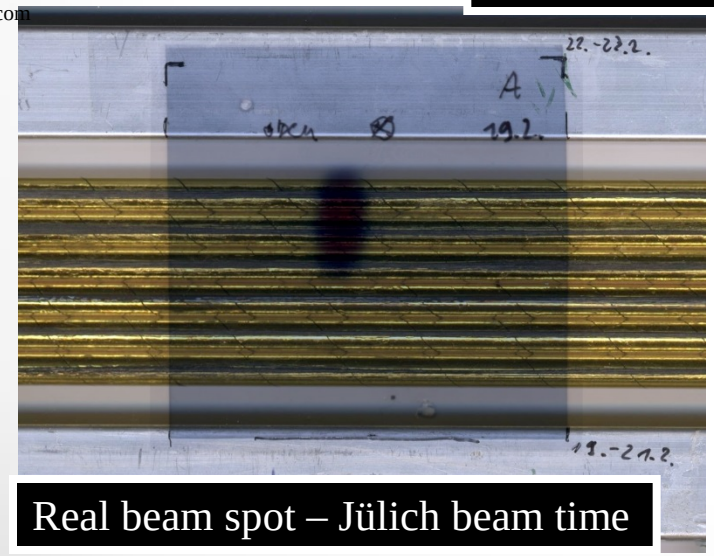
Experimental setup



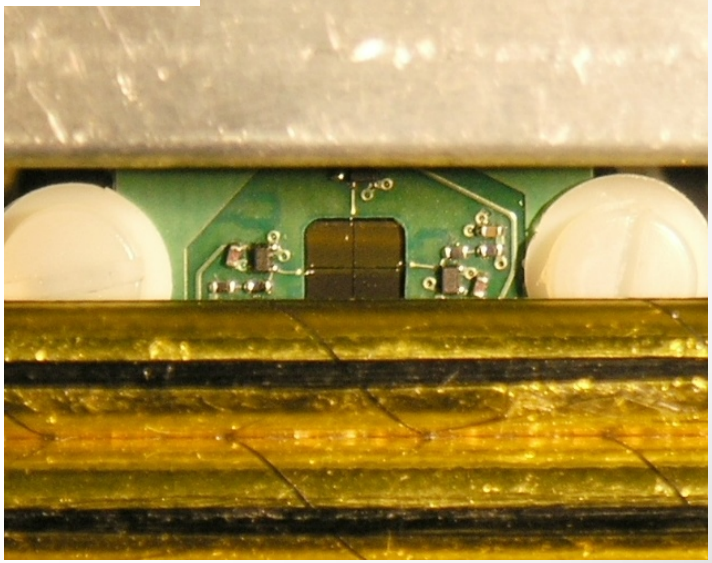


scCVD diamond detector mounted on movable table

•www.tinkercad.com



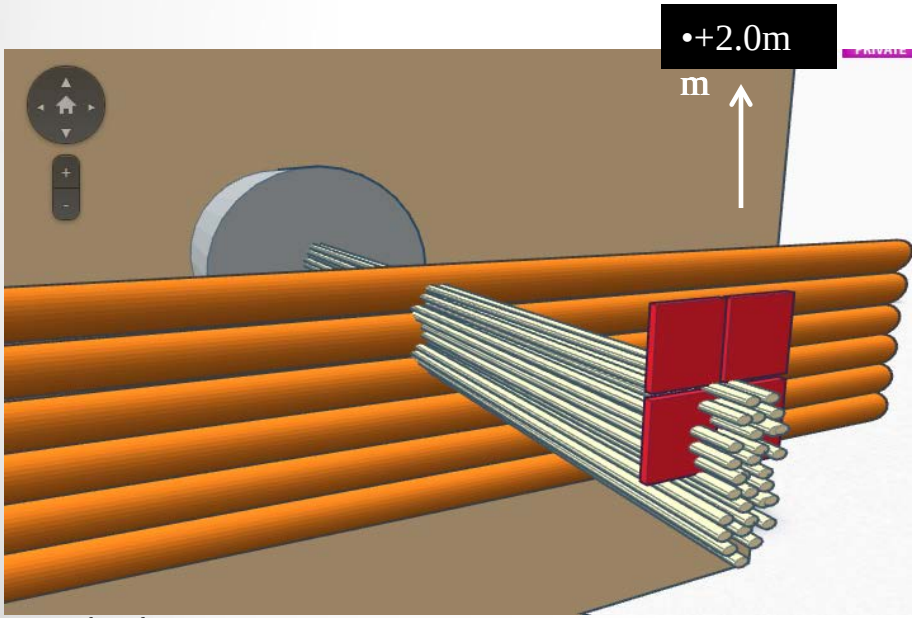
Real beam spot – Jülich beam time



Drift time measurement

Time difference between the scCVD diamond detector and Straw Signal from the PADI discriminator.

→ Drift time spectra (example for 5 positions)



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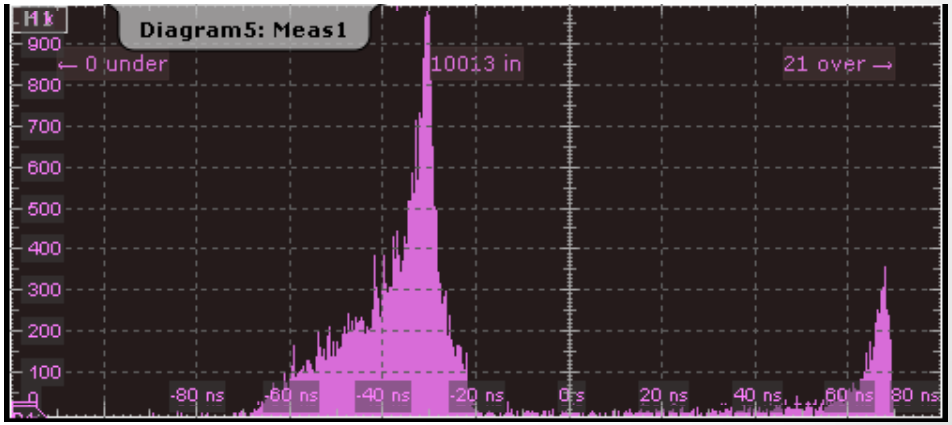
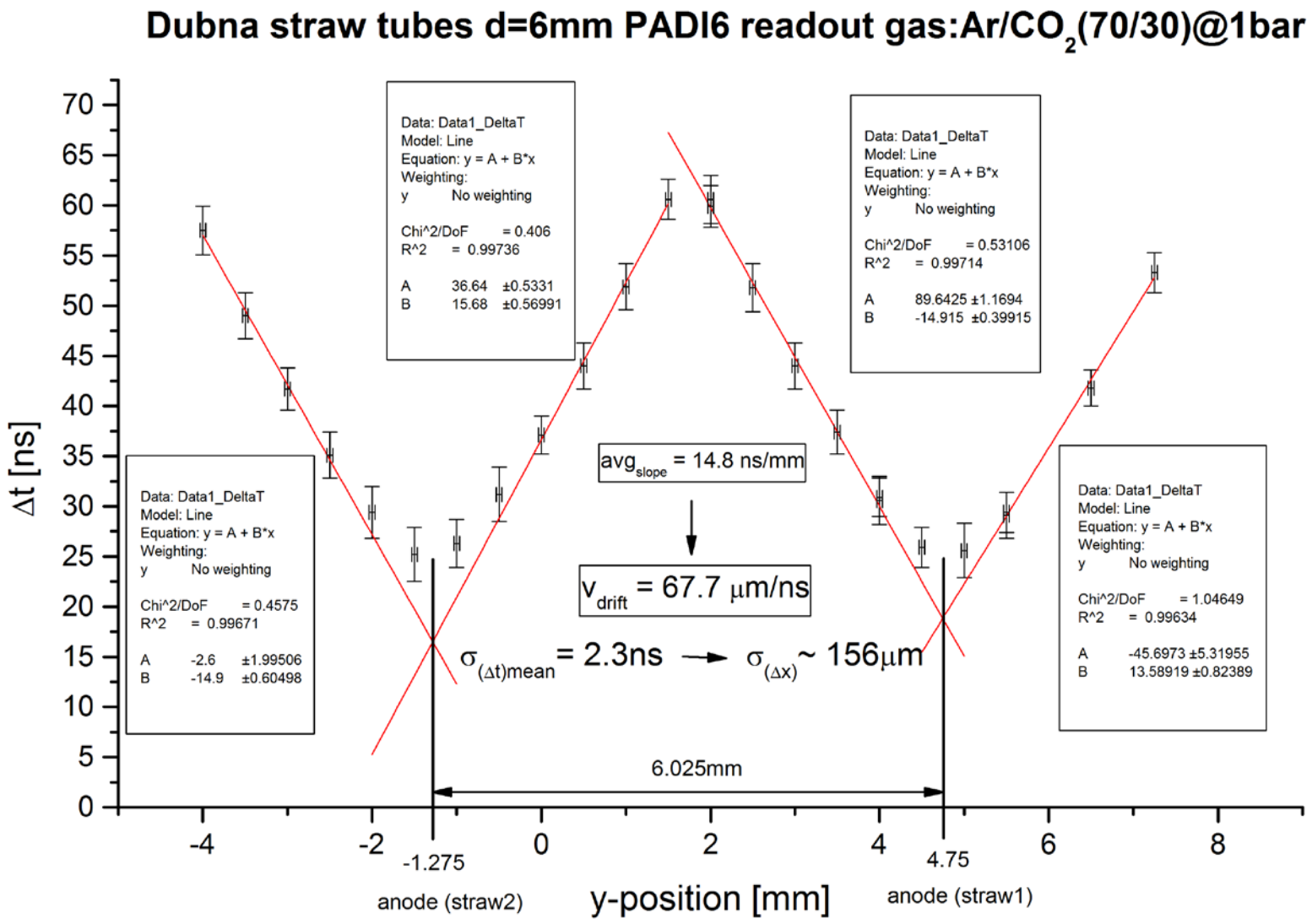
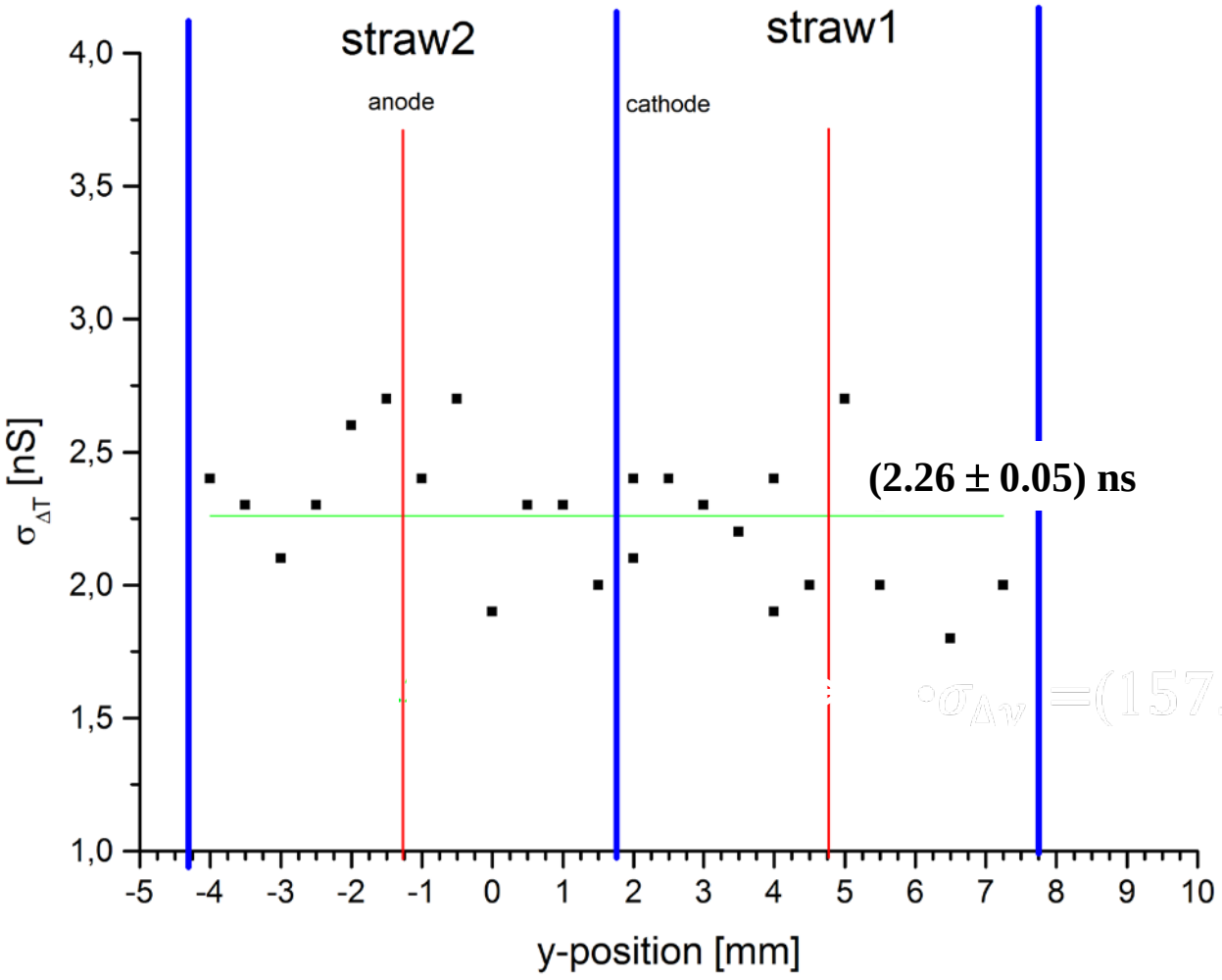


Drift velocity estimation



Time resolution



Summary

PADI chip for straw tube readout in CBM

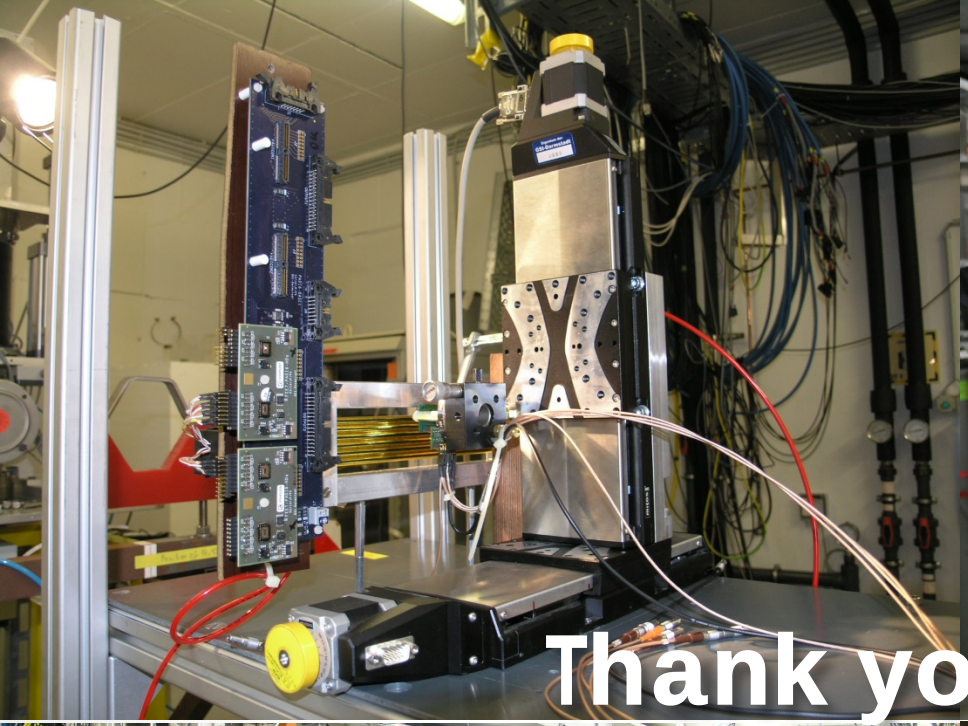
- PADI-6 connected to straw tubes successfully tested with p@2.95 GeV
- Measured straw tube position resolution: about 160 µm
- CBM-TOF and CBM-MUCH (Straw) – similar readout

  → impact on CBM readout

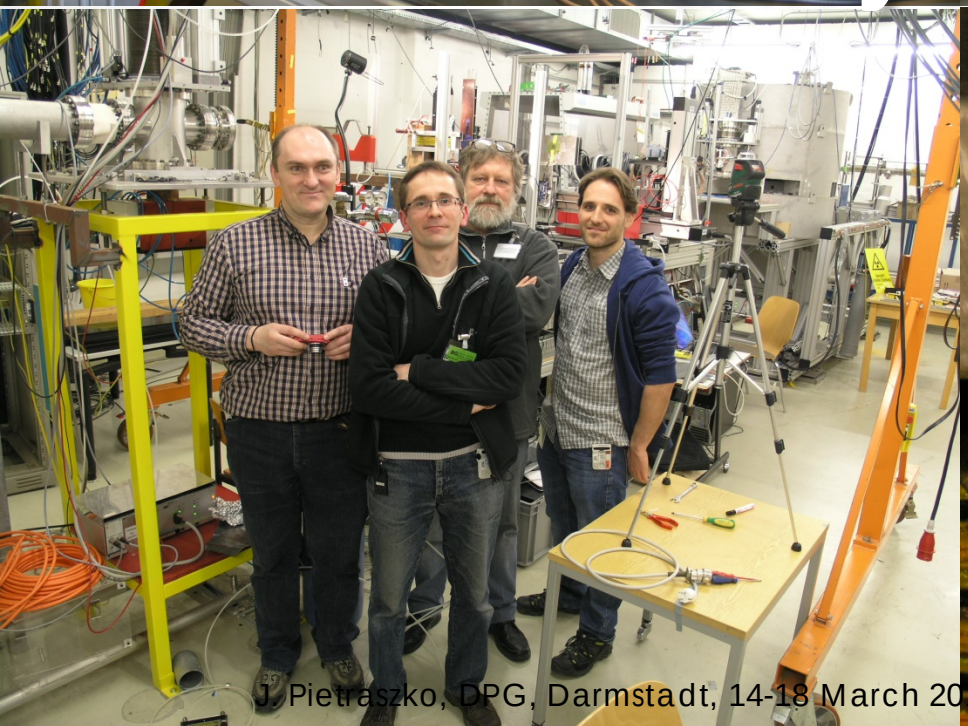
Diamonds for MIPs

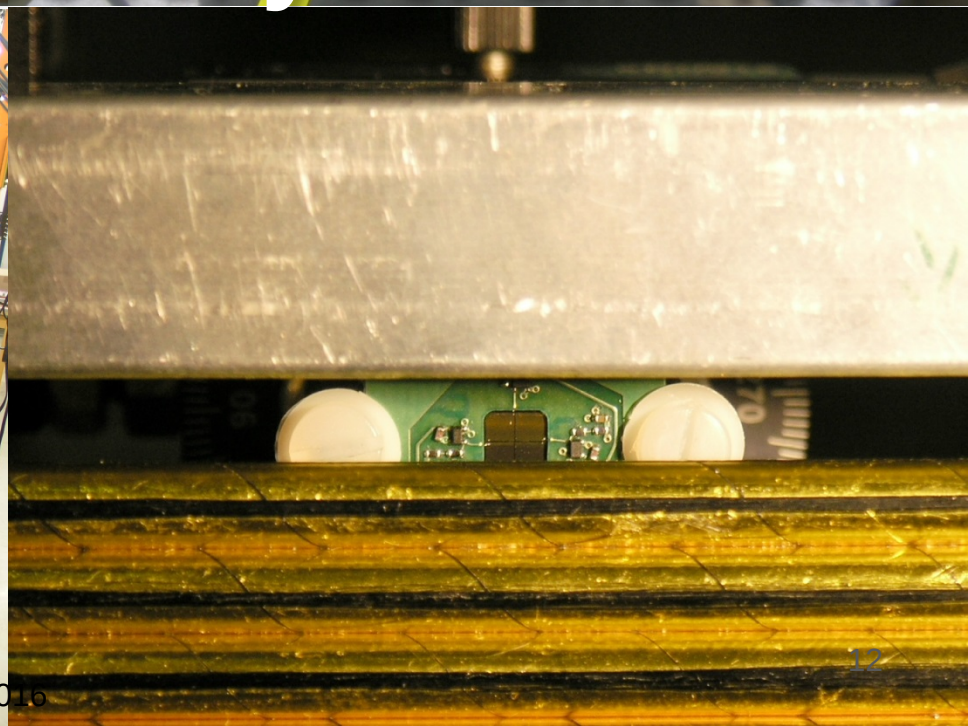
- Excellent time resolution for MIPs, below 100ps
- Position resolution better than 50 µm and can be improved (HV)
- Possible improvement – additional diamond in front of the setup → better background rejection

We would like to thank D. Prasuhn and the accelerator group of COSY for their extensive help.



Thank you for your attention!





Thank you