CBM TRD type 5 pre-production wire layer procedures

Philipp Kähler

content

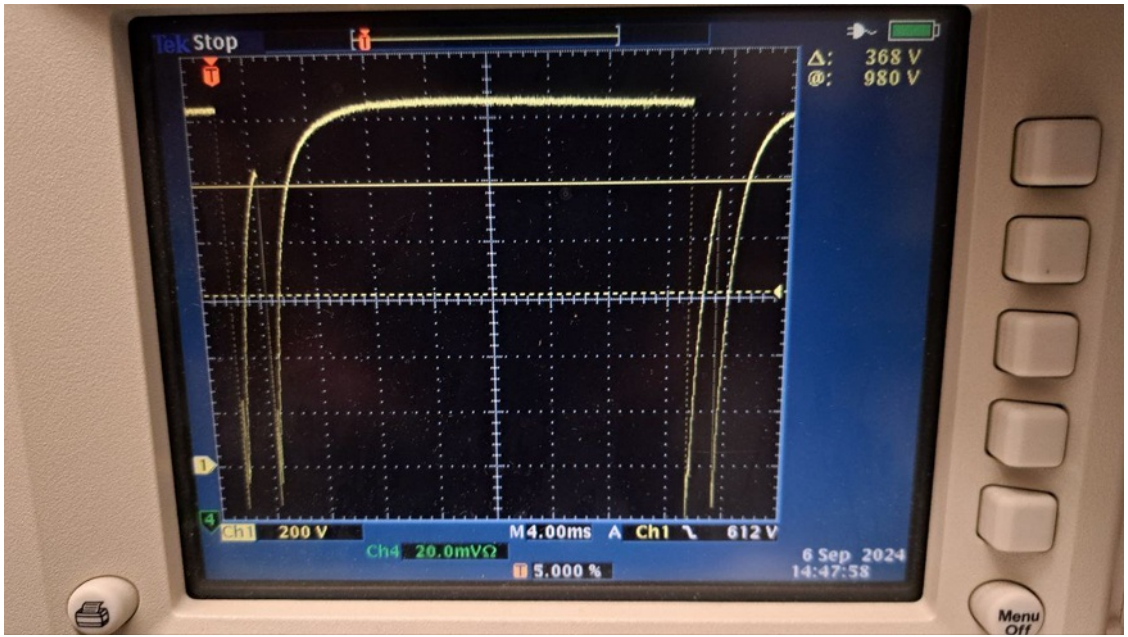
- **HV tripping behaviour of the 2 first pre-series chamber**
- **HV dark current systematics in 3rd pre-series chamber**

reminder: observed trip behaviour & “curing”

- both pre-series chambers (serial BP5-003 and BP5-004)
  - 7 out of 8 anode wire layer segments confirmed to nominal voltage + 10%
  - 1 segment trips at 1140...1200 V
  - “ignition”: see scope picture, repetitive onset

- after trip (and completed onset):
  Ohmic resistance of ~ 200 Ω
  - “removable” → disappearance (“burning”) at ~ 6 V, 30 mA
  - **switchable – reproduced > 10 times with BP5-003**
  - during mCBM operation of the chambers, no further localisation achieved (as mounted FEE hinders)

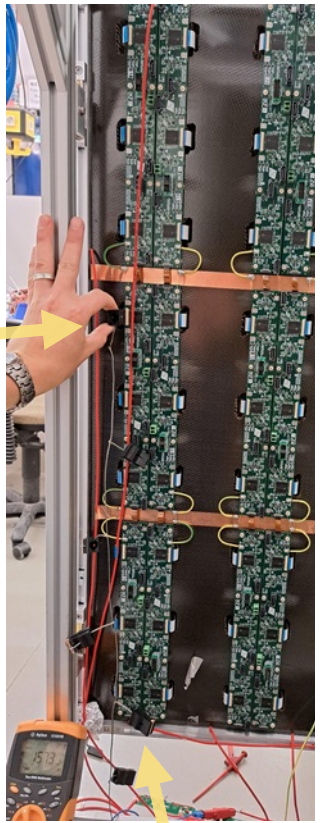
- trip avoided with floating cathode padplane
  - in chamber BP5-004: identified one cathode pad as trip partner



onset of trip, seen on chamber BP5-003, still in mCBM: trigger on breakdown of anode HV

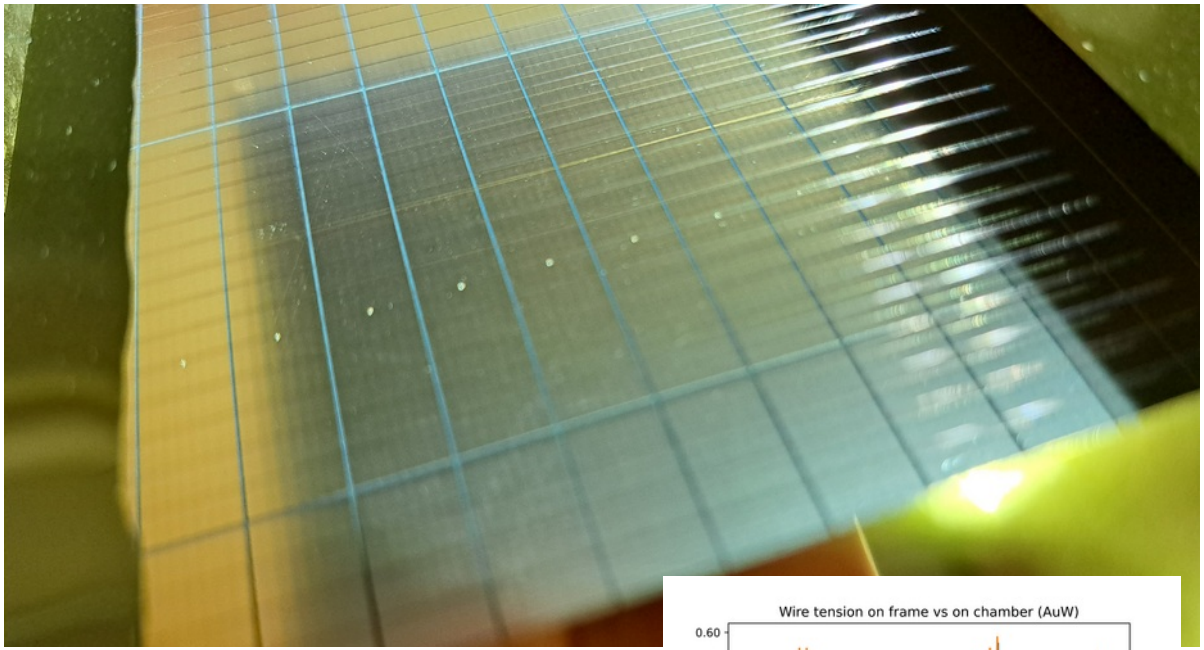
trip/conductivity localisation

- in BP5-003 was possible to localise the connection (with chamber in conductive state) to exactly 1 cathode pad
  - 2nd pad "row" from left (next-to border row), 6th (of 9) pad group, close to centre-of-wire
- measured conductivity between anode segment and cathode pad: 157 Ω
- pad position is in about 54 cm distance from anode layer contact ledge (bottom in photo, this slide)
  - calculate resistivity of 54 cm anode wire:
    $R = \rho \times A / l$
    $= 0.092\ \Omega\ mm^2/m \times 0.54\ m / 0.0003173\ mm^2$
    $= 156.6\ \Omega$
- **hypothesis: contact via anode wire**

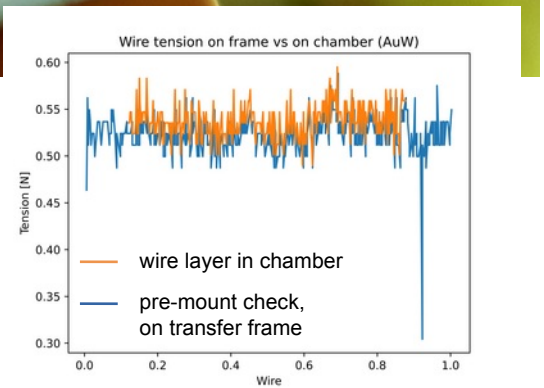


chamber opening & winding log enquiry

- **BP5-003** was opened
  by cutting the entrance window
- one anode wire found touching a cathode pad,
  while its ends appear properly glued
  in the wire ledge stacks
- new enquiry of wire tension measurement data
  in the winding log of this chamber production:
  insufficient tension
  already on winding (transfer) frame,
  routine failed to identify
- w.i.p.: inspect also chamber
  BP5-004 with same tripping behaviour
  – would suit tension error still in backside/
  "sibling" of same wire winding run,
  but not yet found in tension measurement,
  should exclude wire-to-ledge glueing
- **general, possible sources of insufficient tension:**
  - in tension regulation during winding (*Meteor*)
  - in wire glueing on transfer frame (*Technicoll*)
  - in wire ledge glueing in chamber (*Araldite*)



opened chamber BP5-003, view through remaining entrance window (surrounding), wire layers, cathode pads – one anode wire with insufficient tension



winding log data of same chamber, anode wire tension – see outlier

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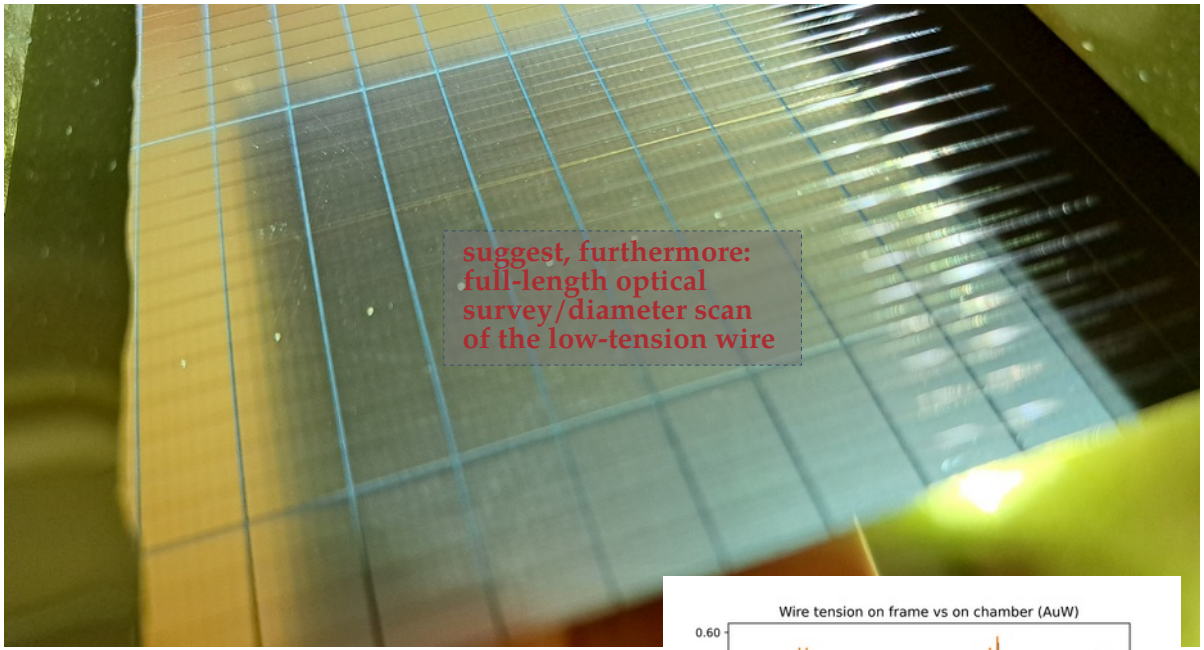

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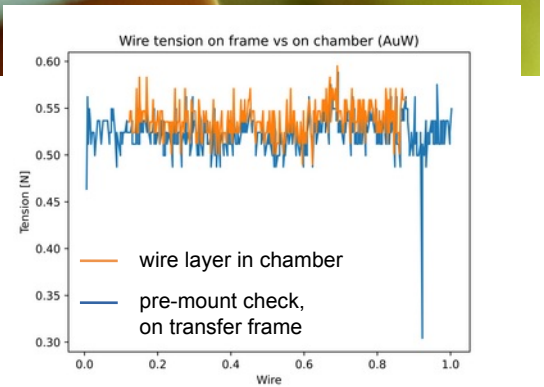

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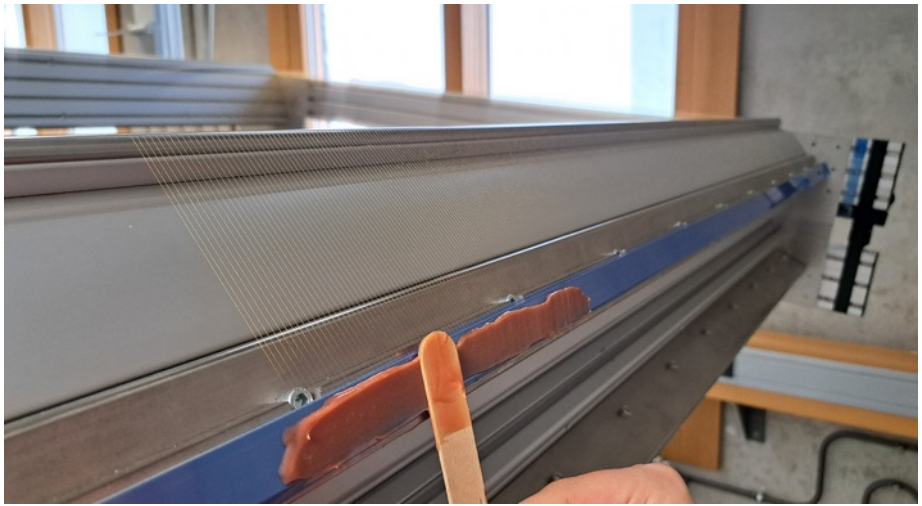
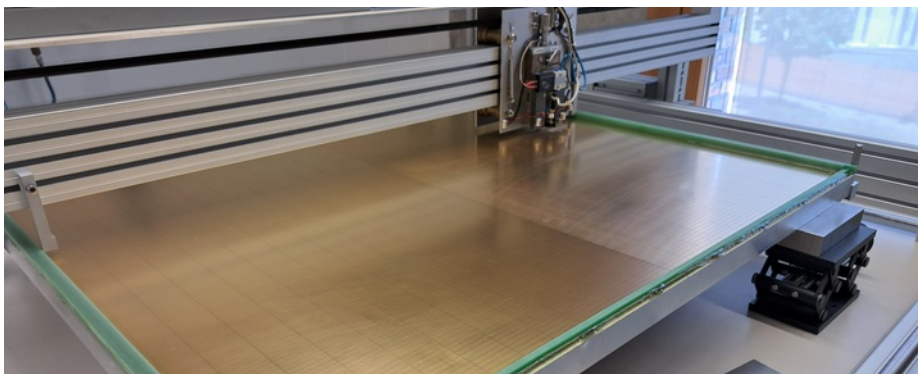
wiring routine improvements

- **learned for production process:** require & ensure wire tension within limits per wire as strict condition before proceeding to next step
  - for both tension measurements, i.e. i) on transfer frame and ii) in chamber
  - both wire layers
  - explicitly: exlclude overlooking of outliers, as presumably happened for one wire in BP5-003
- full maintenance for *Meteor* wire tension device
- improve wire tension measurement device
  - to reach outermost wires still in 2nd scan (wires within chamber)
  - add wire count and pitch (both available) to standard checks

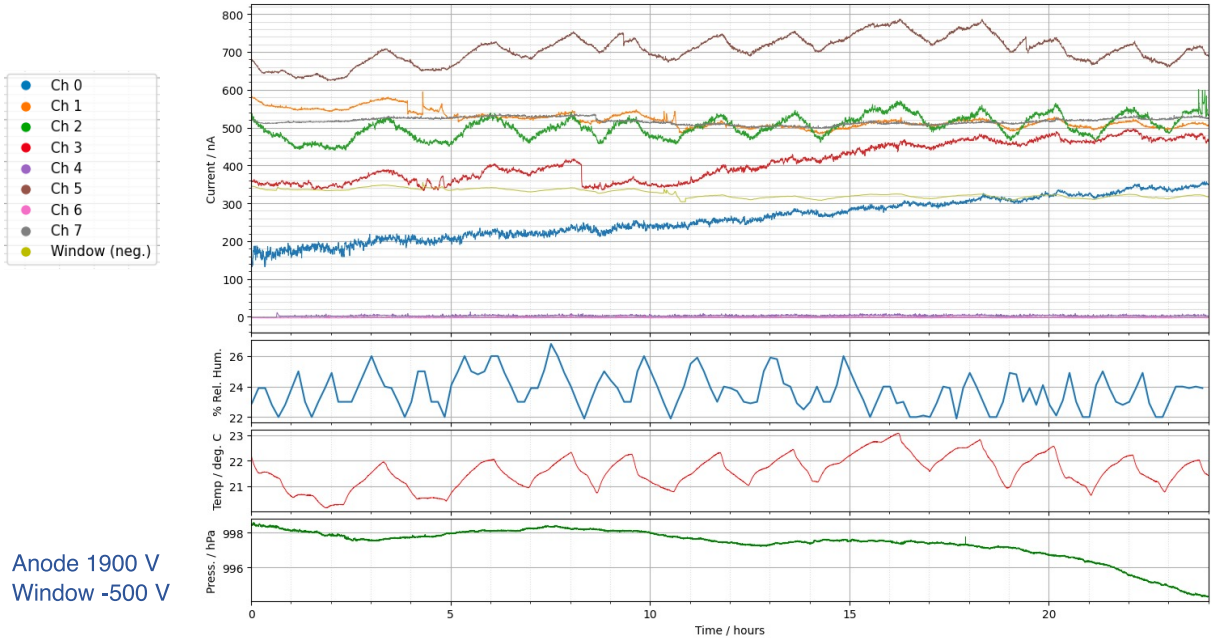




3rd chamber: dark currents

- a 3rd chamber was started to be wired
  with new measures as a reaction
  to the trip behaviour of the previous chambers
  - HV checks on/after
    every relevant working step
  - aiming for intensified cleaning
    with clean-air

- in contrary, new dark currents between anode and cathode wire layer found
  - no clear conditioning observed
  - amplification-like U-I charachteristics
  - only in detector gas, not in N_2



dark current characterisation measurements, trend over time, Dennis Spicker et al.

3rd chamber: dark currents

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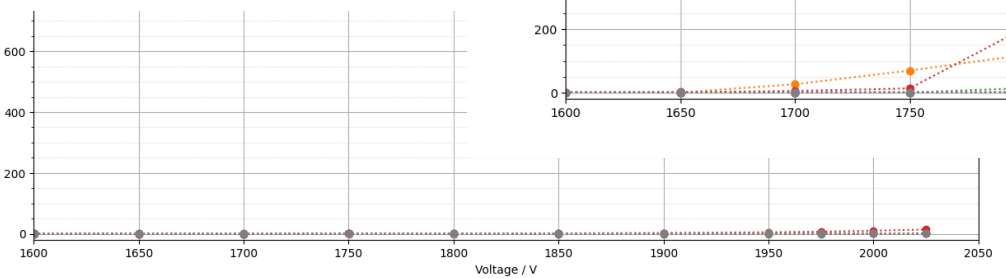
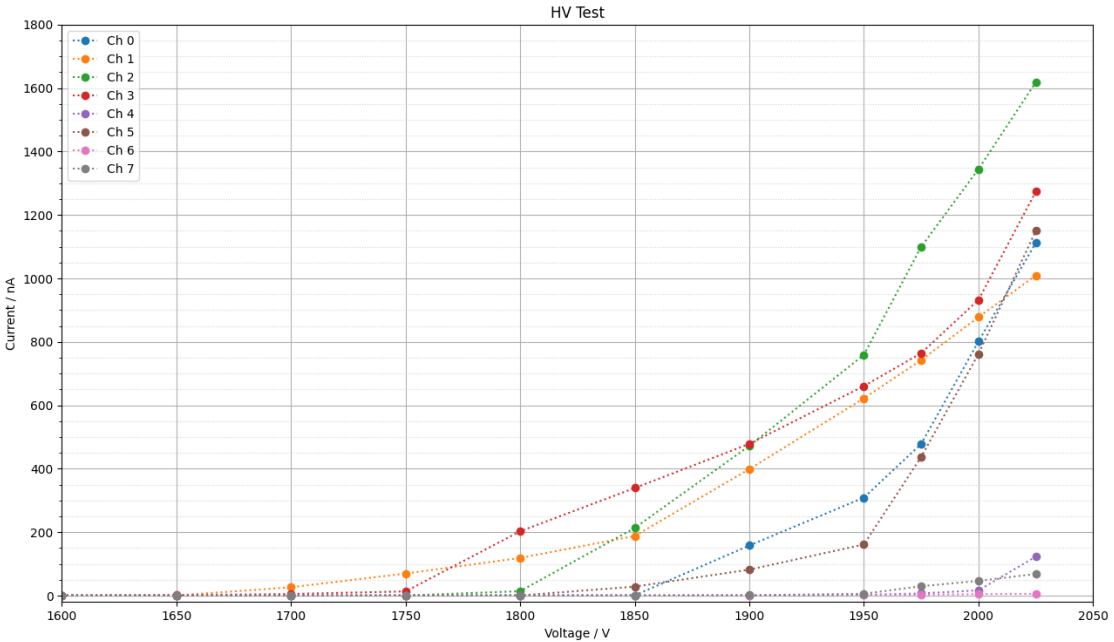
Argon / CO_2

- suspecting contaminations, leading to, e.g., Malter effect on cathode wires
  - issue with clean-air filter stages in lab
  - cleanliness of pre-mixed gas
- **restart wiring** excluding contamin.
- **suggest** i) opt. inspect. & ii) cleaning attempt of this cath. wire layer
- **in background,** develop procedure to re-use cathode backpanels

Nitrogen





dark current characterisation measurements, I-U dependence, Dennis Spicker et al.

last slide ↑

backup ↓

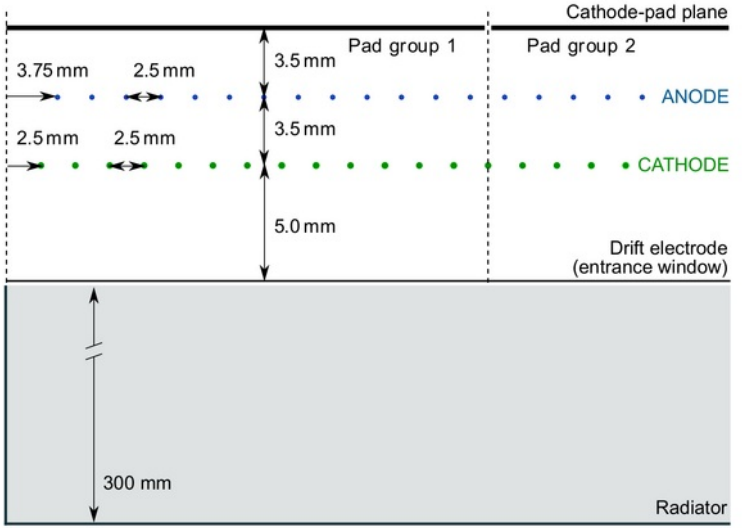
TRD HV geometry

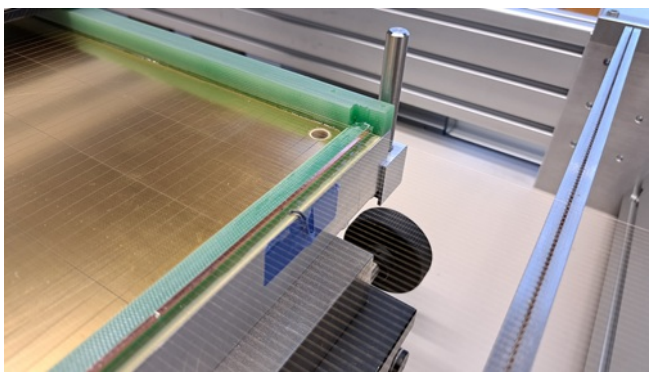
- wire spacing 2.5 mm (anode & drift layer)
- amplification region 3.5 mm x 2 (symmetrical)
- drift region 5.0 mm

- wire diameters 20 µm anode (+ 75 µm outermost)
  75 µm cathode

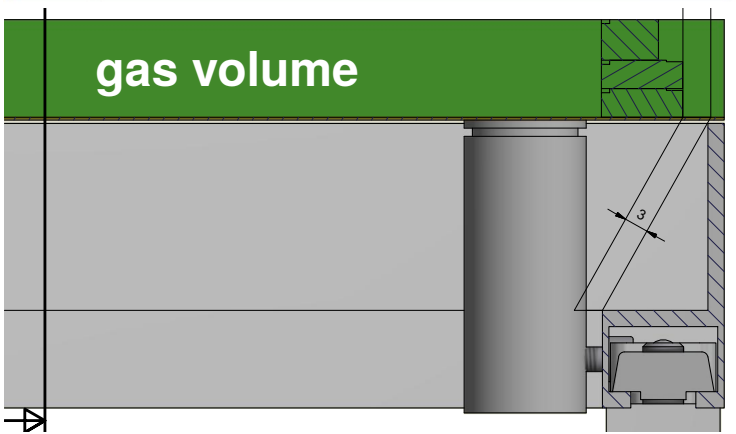
- wire tension 45 ... 50 cN anode
  100 ... 110 cN cathode

- nominal voltages ~ 1800 V anode for gain 2000...3000 (Xe/CO_2 85:15)
  -100 V/mm drift for < 300 ns signal collection time





anode layer
is electrically split
into 8 segments

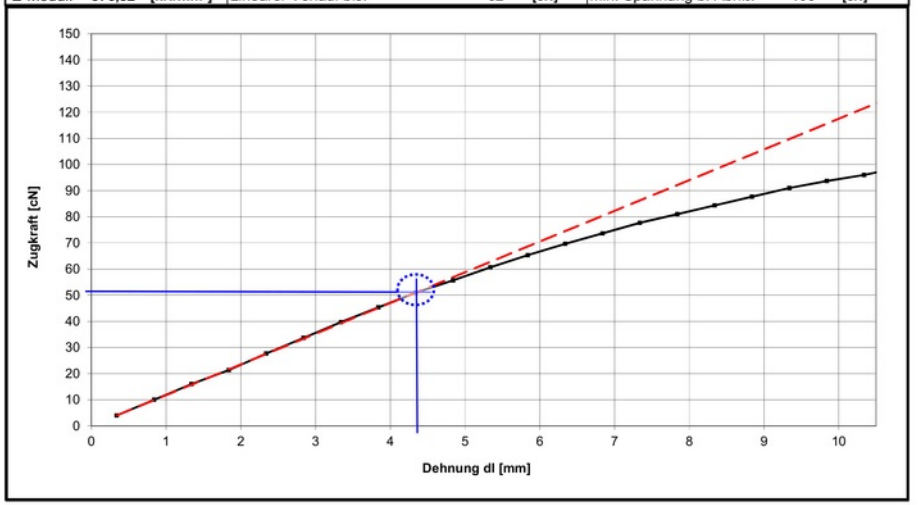


materials

- wire & distance ledges — EP GC 203 (Hgw 2372.4)
- epoxy glue — Araldite 2011 (* processing following)
- anode wires — 20 µm, WRe3 + Au, *Luma*
- cathode wires — 75 µm, CuBe2, *Elschukom*

Zugkraft-Dehnungs-Diagramm

Material:	Wolfram-Rhenium (vergoldet)		Hersteller:	LUMA Metall AB	Rolle:	165636	WE-NR.: --
Gemessen am:	07.06.2022		Durchmesser:	20,1 [µm]	Ausgangslänge:	1000	[mm]
Gemessen von:	J. Hehner / B. Fischer		Dichte:	19,32 [g/cm³]	Zugfestigkeit:	3305,45	[N/mm²]
E-Modul:	376,32 [kN/mm²]	Linearer Verlauf bis:		52 [cN]	Min. Spannung b. Abriß:	105	[cN]



Hehner-Münster Drahtspannung V01-001.xlsx

anode tensile test

BK BERNAUER KUNSTSTOFFE BK - KUNSTSTOFFE BERNAU GMBH

Technisches Datenblatt

EP GC 203 n. EN 60893

Hgw 2372.4 n. DIN 7735

Beschreibung
EP GC 203 besteht aus einem glasgewebeverstärkten Epoxidharz.
Es ist thermisch hoch belastbar und hat eine sehr niedrige Wasseraufnahme.

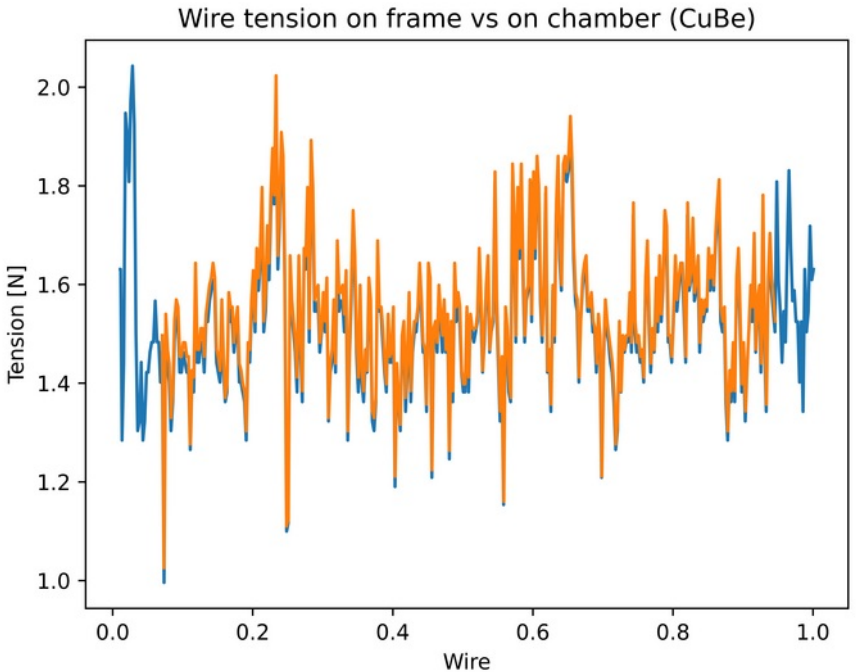
Technische Eigenschaften	Prüfungsnorm	Einheit	Wert nach DIN 7735	Typischer Messwert
Biegefestigkeit	DIN 53452	MPa	350	530
Biegefestigkeit bei erhöhter Temperatur	DIN 53452	MPa	175	295
Schlagzähigkeit	DIN 53453	kJ/m²	100	145
Kerbschlagzähigkeit	DIN 53453	kJ/m²	50	60
Zugfestigkeit	DIN 53455	MPa	220	320
Druckfestigkeit	DIN 53454	MPa	150	320
Spaltkraft	DIN 53463	N	3000	4200
Elastizitätsmodul	DIN 53452	MPa	$18 \cdot 10^3$	$28 \cdot 10^3$
Widerstand zwischen den Stöpseln	DIN 53482	Ω	$5 \cdot 10^{10}$	10^{12}
Hochspannungsfestigkeit ll / ⊥	DIN 53481	kV	40 / 40	80 / 70
Dielektrischer Verlustfaktor (bei 1MHz)	DIN 53483	-	0,05	0,03
Dielektrizitätskonstante	DIN 53483	-	5	5
Kriechstromfestigkeit CTI	DIN/IEC 112	-	200	210
Elektrische Korrosion	DIN 53489	-	AN 1,4	AN 1,2
Grenztemperatur	VDE 0304, T.21	°C	155	155
Wärmeleitfähigkeit	DIN 52612	W/(m·K)	0,3	0,25
Längenausdehnungskoeffizient	VDE 0304	10^{-6}/K	10-20	15
Wärmeklasse	VDE 0534	-	F	F
Glutbeständigkeit	DIN 53459	-	2a	2a
Rohdichte	DIN 53479	g/cm³	1,7-1,9	1,85
Wasseraufnahme (5mm Dicke)	DIN 53495	mg	30	15
Farbe	-	-	-	Grün

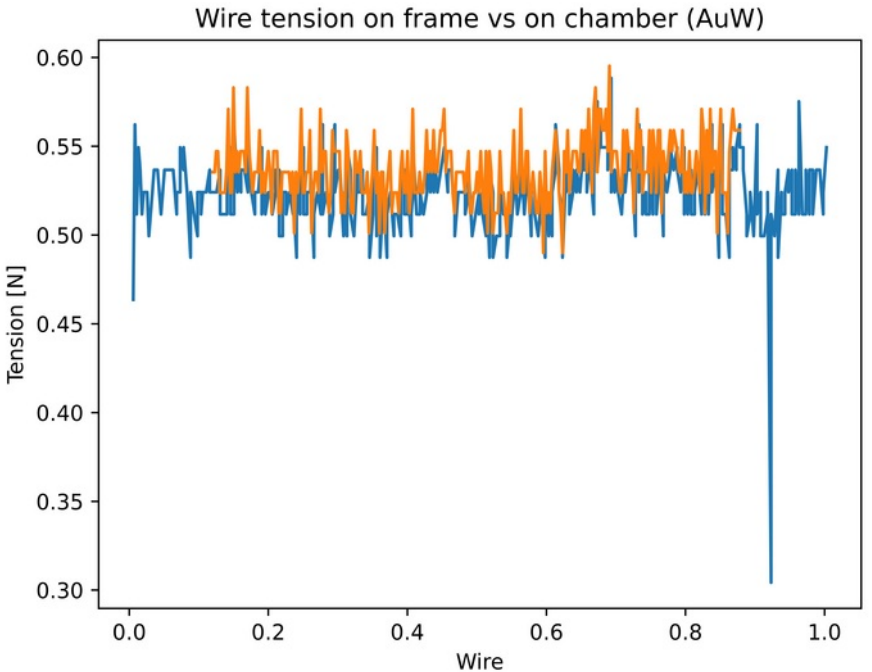
Bernau, Dezember 2013

ledge material data sheet

wire layer tension

- 1st measurement after winding,
  2nd measurement after glueing into chamber

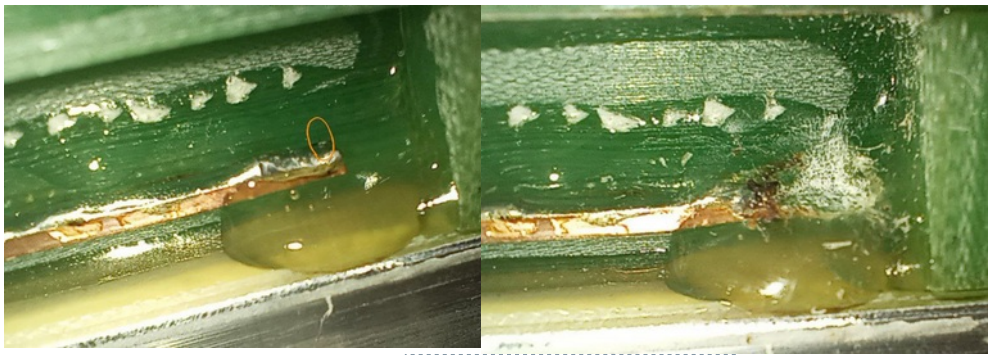




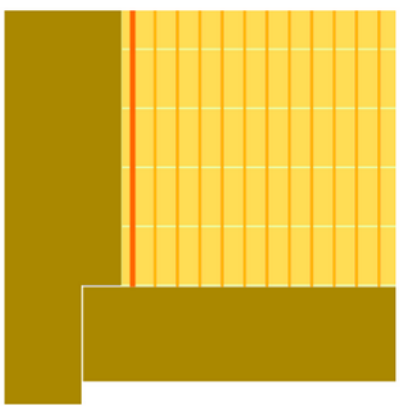
electrostatic wire deflection, ”outer wire hypothesis”

- outermost wire (diameter 75 µm, thicker, for field forming) was placed at ½-pitch from outer chamber border
  - returned to $^{3}/_{2}$-pitch as default for future, meanwhile
- measurement of electrostatic deflection of outermost wire → hypothesis of trip originating there

- **intervention completed at chamber BP5-003:** electrical disconnection of outermost wire → *no change of trip behaviour found*

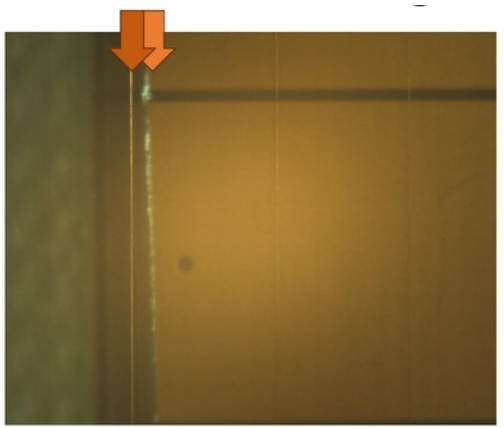


pre & after intervention



Gap: 1.25 mm

Gap: 3.75 mm



1200 Volt