Cathode boards defects detection method for sTGC chambers

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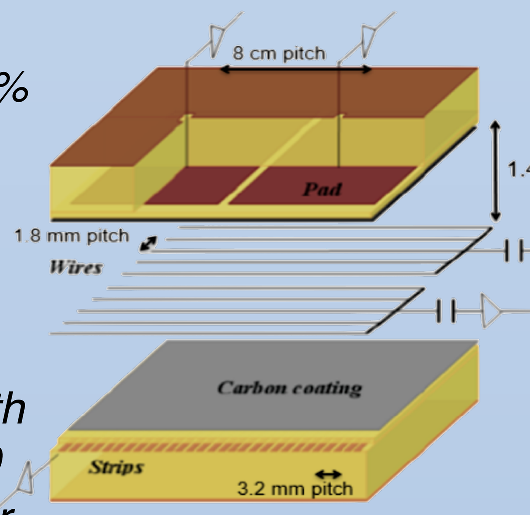
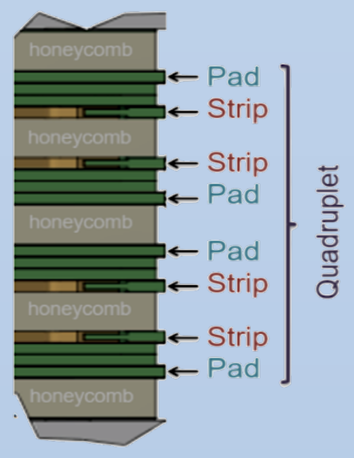
Abstract

The harsh radiation conditions, including the ones expected for the operation with High-Luminosity LHC, require detailed and careful quality control of any gas detector from the very beginning stage of assembly. The existing probe methods for cathode boards QC are able to find shorts to ground, shorts between pads and breaks in the readout line at the initial stage of manufacturing. The cosmic test requires fully assembled detectors and reveals pads with absent or low amplitude analog signals associated with resistance in the readout trace line. In current work we propose the direct method for such defect recognition for both bare cathode boards and fully assembled detectors and demonstrate the examples of a successful cure.

sTGC detectors

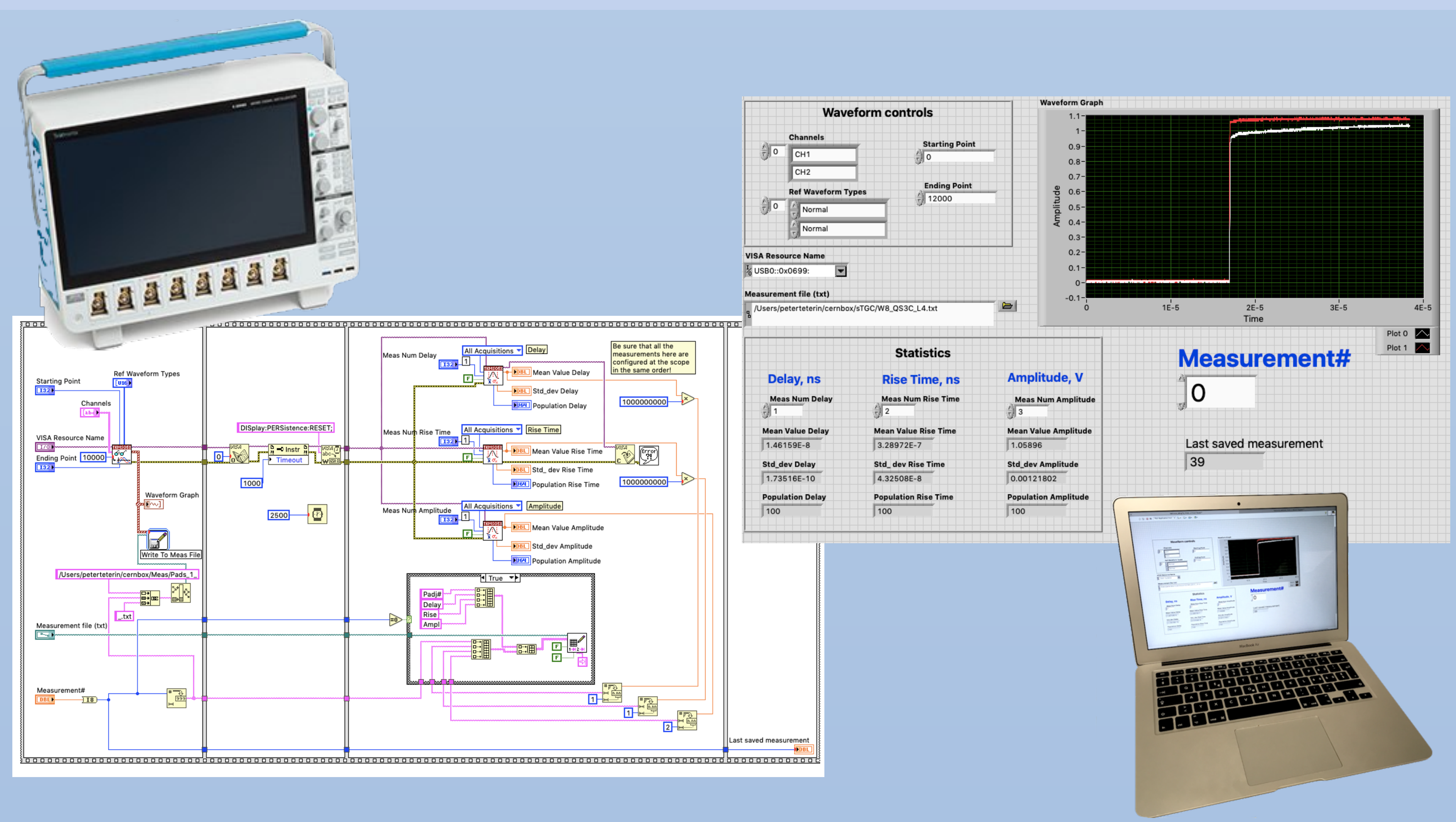
Operational gas: *CO_2 / n-pentane mixture, 55% / 45%*
Operational voltage: *2.9 kV*
Anode wires: *50 μm diameter gold plated tungsten*
Wire pitch: *1.8 mm*
Gap thickness: *1.4 mm*
Cathode plane: *100 or 200 FR4 with graphite-epoxy coating with R = 100 or 200 kΩ/□ (at the air on inner/outer layer, respectively)*
Electrodes: *strips (precise tracking) and pads (triggering "3 of 4 in quad")*





a *- The schematic diagram of the sTGC structure*
b *- the cross section of a quadruplet, the 4 layers of sTGCs*

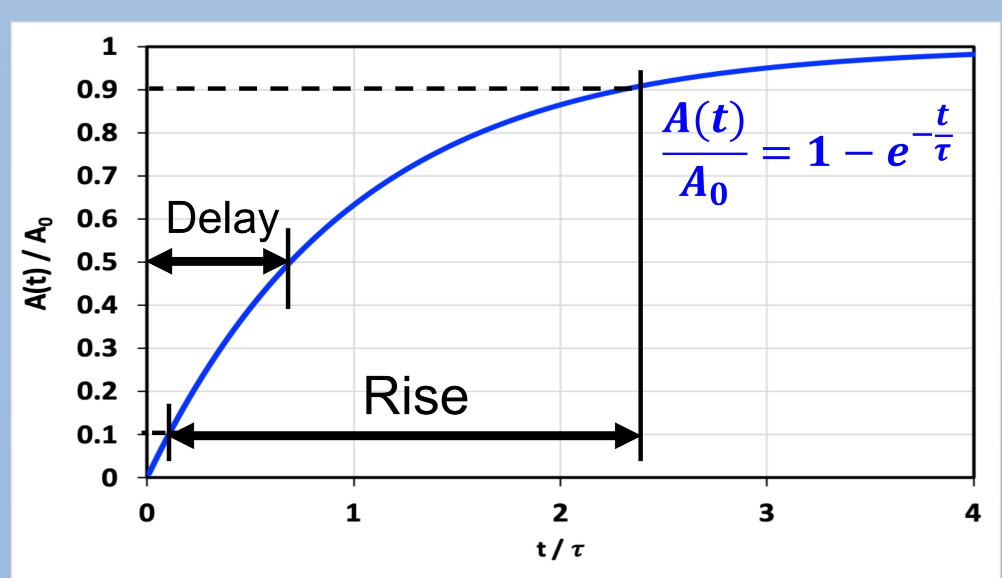
Experimental Setup



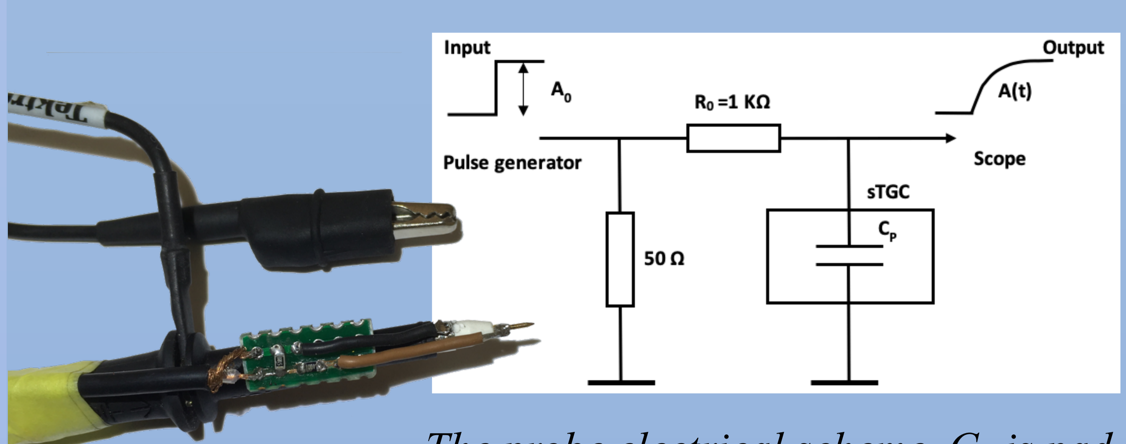
- Scope (Tektroinx MSO56, Keysight DSOX3034A)
- Pulse generator (preferably, built-in)
- DAQ (Laptop+NI LabView 18)

The method description

- If the resistance in trace line inside sTGC much less than R0 and the board is without graphite-epoxy coating the output signal is exponential $A(t)=A0\times e{-}t/\tau$, where $\tau = R_0C_P$
- The response for fully assembled detector is non-exponential but the parameters are meaningful anyway



The response function after pulse injection. We measure Rise and Delay time



The probe electrical scheme. C_p is pad capacitance

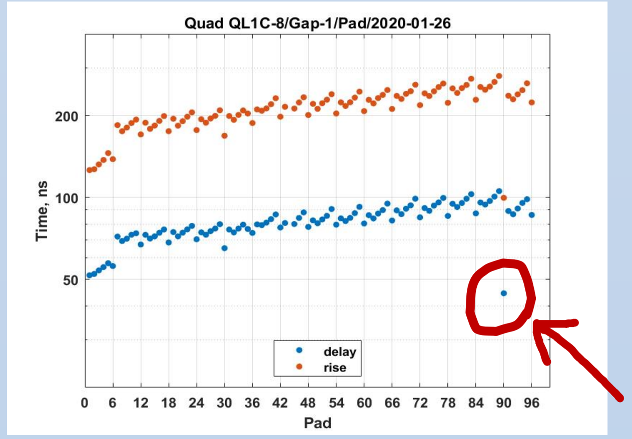
- Delay and rise time are the scope standard options
- The formulas for calculating capacity in case of exponential waveform are

$$C(delay) = \frac{Delay}{R_0 \times ln2}$$

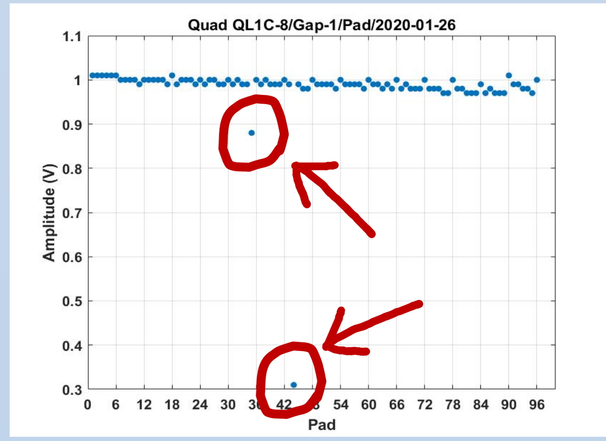
$$C(rise) = \frac{Delay}{R_0 \times ln2}$$

- The response for fully assembled detector is non-exponential but the parameters are meaningful anyway
- The method is not suitable for any resistance above 10 kOhm

Defect search example



Rise and Delay plot for single layer' pads



Amplitude plot

The next steps are:

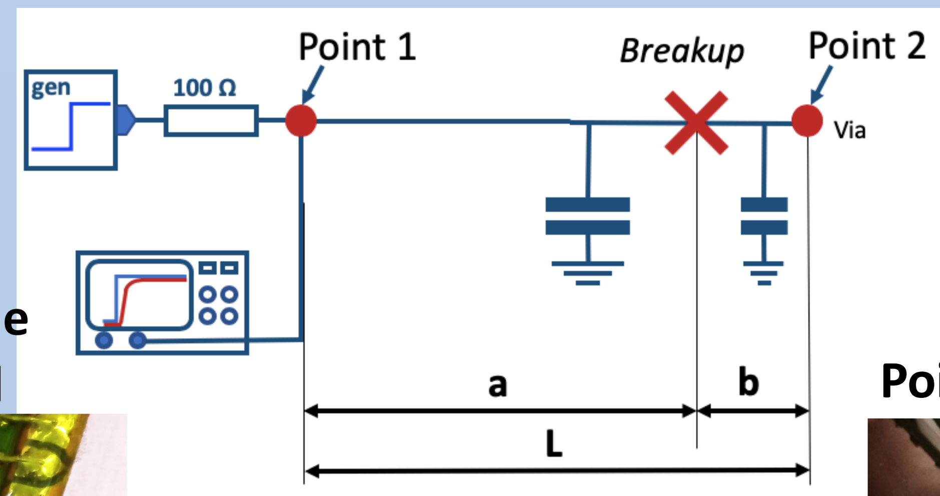
- Open the protection near via
- Remove the honeycombs - the grounding - the prepreg
- Measure trace line resistance by DVM

Pad #	Expected problem	Resistance	Cure
35	Shorted to ground	1 KΩ	No way
44	Shorted to ground	1 Ω	No way
90	Broken readout line	?	Open near via

Summary for the defective pads

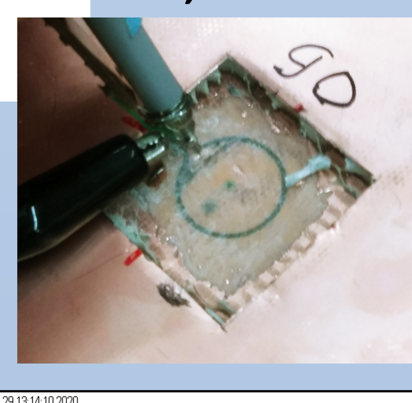
- Measured trace line resistance is 18 k***Ω***

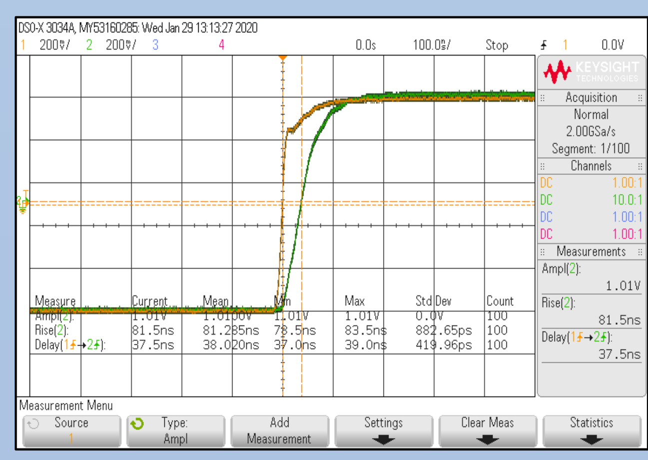
Breakup localization



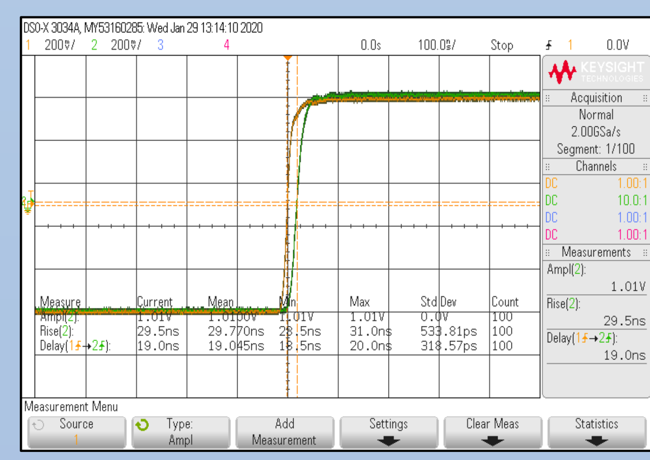
Point 1, near the adapter board

Point 2, near via



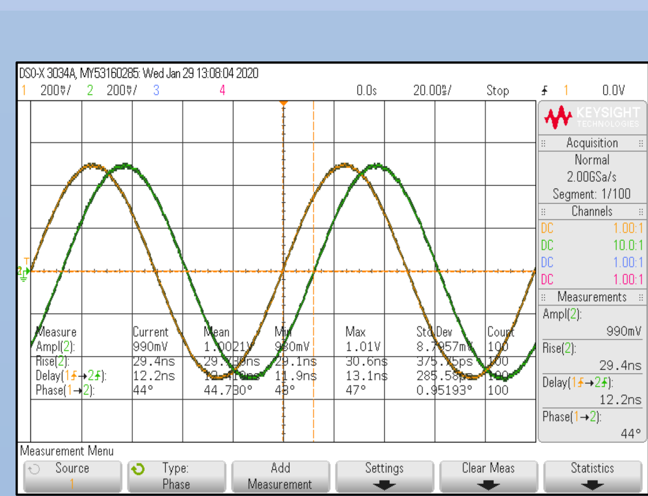


Delay and rise time measurement at point1

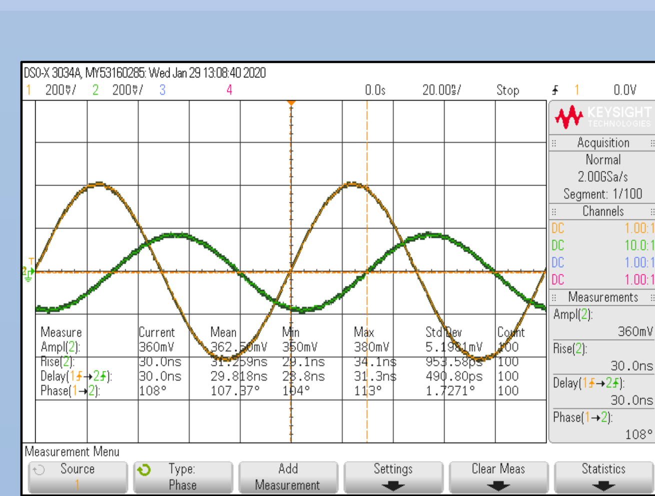


Delay and rise time measurement at point2

Option: input sine waveform



Amplitude and Phase measurement at point1

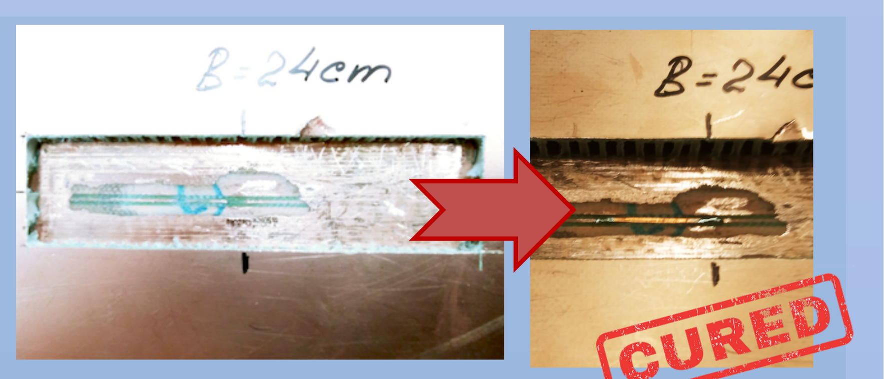


Amplitude and Phase measurement at point2

- Sine wave can be also used as input signal
- The meaning parameters for sine wave are Amplitude and Phase

Defect location prediction

Mode	Measured value	Calibration	Point 1	Point 2	a/L	b/L
Step	Delay (ns)	12.5	37.9	18.8	0.801	0.199
	Rise (ns)	17.9	80.9	29.2	0.85	0.15
Sine Wave 10 MHz	Amp (V)	1	0.362	0.866	0.83	0.17
	Phase	44.7	108.5	66.6	0.75	0.25



Before and after fixing of the trace line

Conclusions

- The method is suitable for check at every stage of mass-production:
  - Before the assembly (bare boards)
  - Singlets
  - Doublets
  - Quads+adapter boards
- The method is able to recognize:
  - Pads shorted to the ground
  - Disconnected pads (>10kOhm)
  - Trace line resistance (<10kOhm)
  - Interconnected pads
- It demonstrates a possibility for breakout localization and successful cure

"Instrumentation for Colliding Beam Physics" , Novosibirsk, Russia 24-28 Feb 2020