EIC Roman Pots / AC-LGAD

IJCLab Progress Report

BNL-IJCLab-OMEGA Meeting - May 6th, 2021

Dominique Marchand

on behalf of IJCLab team:

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- **Progress report on activities related to an AC-LGAD (strips) sensor wire-bonded by BNL onto an ALTIROC1_V2 (PCB #30)**

- **Outlook**

Progress report summary

• ASIC PCB B30 including an AC-LGAD (stripped) sensor wire-bonded by BNL team onto an ALTIROC1_V2 (only 17 channels wire bonded to 25 channel ALTRIROC1) received on March 23rd

• Installation of ALTIROC1_V2 specific software suite onto a dedicated "EIC" laptop under the guidance of Laurent Serin and Nikola Makovec, ATLAS/High Granularity Timing Detector (HGTD), April 7th and 13th.

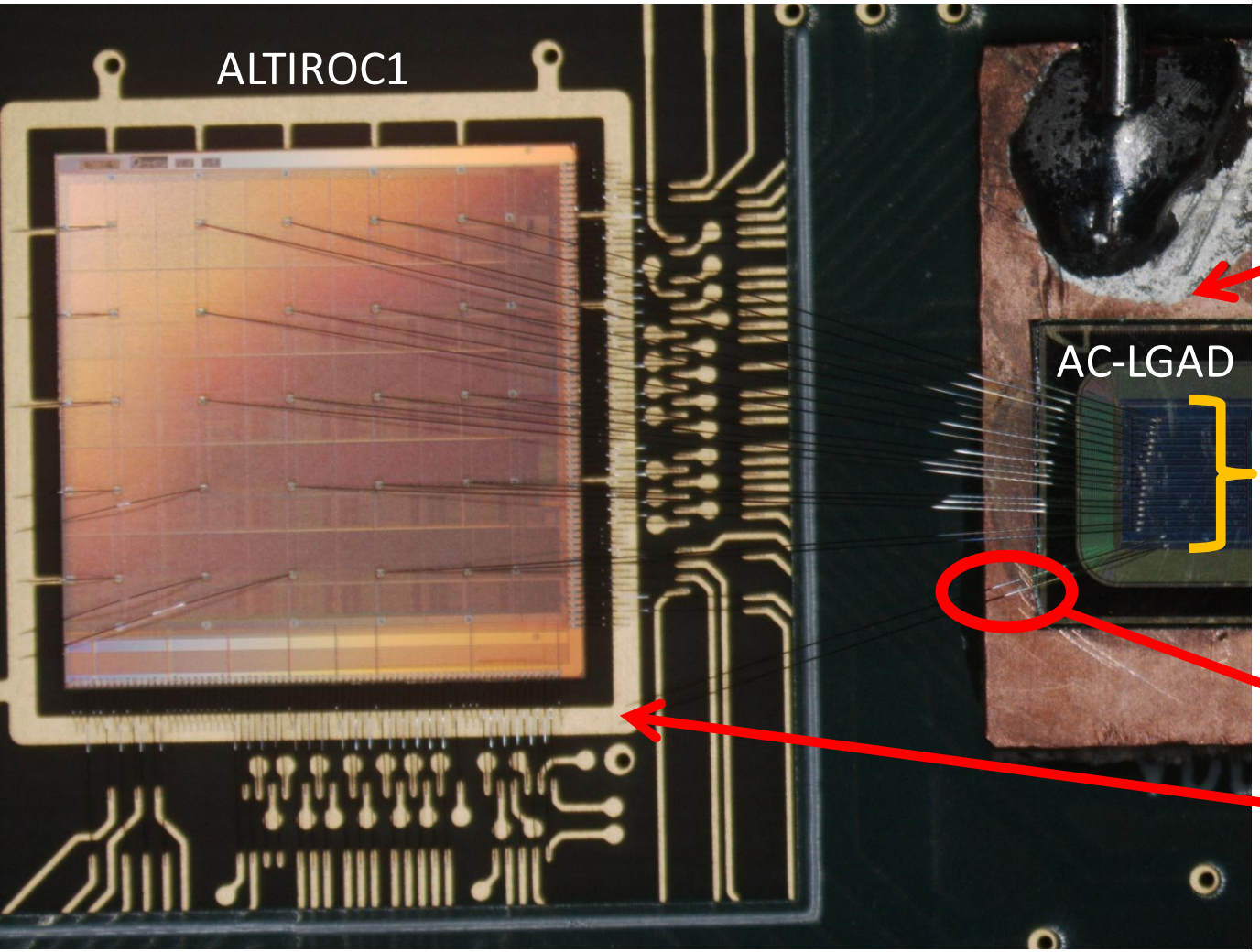
• Observation of some ALTIROC1 channels on scope => attempt to proceed to a depletion of AC-LGAD: leakage current observed much higher than expected (-10.5 µA for an applied voltage of -13 V, increasing with HV) => Measurements I = f(HV)

• under microscope and multimeter measurements: no obvious short ; 2 wires connected to the guard ring accidently damaged (1 unsoldered, 1 crooked)

• Attempt to use the Captinnov semi-automated probe station => requires a chuck adaptor or to use the manual one

• Observation on scope of the 25 individual ALTIROC1 PreAmplifier channels triggered by the ALTIROC1 command pulse => identification of the 17 channels wire-bonded / 8 channels connected to the ground.

Layout of OMEGA ALTIROC1 wire-bonded by BNL to an AC-LGAD (strips) on ASIC PCB #30



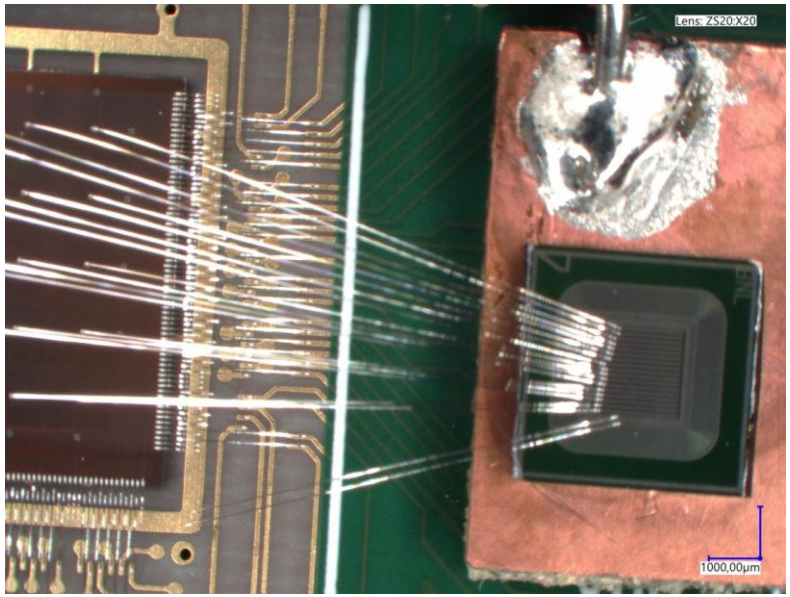
-HV probe touches here

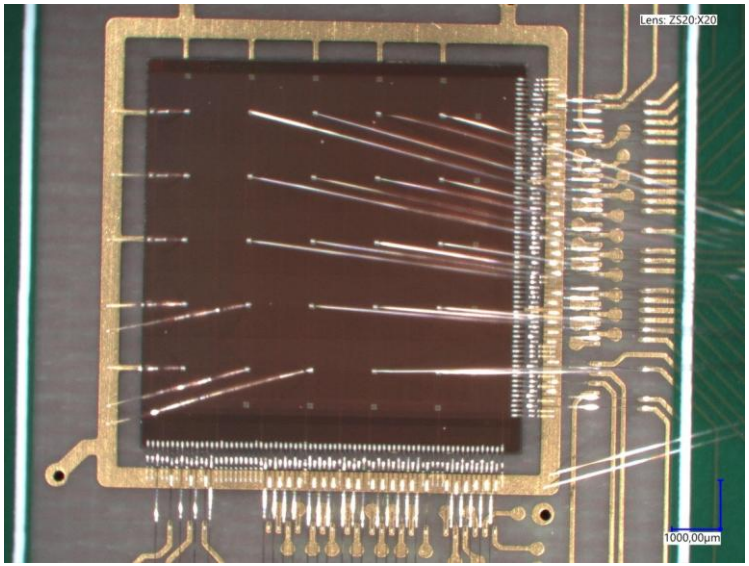
Whatever we do, these wires (Ac-pads and inputs of the ALTIROC) should stay ~ GND, as only 100nm of dielectric separates them from the n-pad at GND

Guard Ring & n-pad go to GND
So you can touch here:

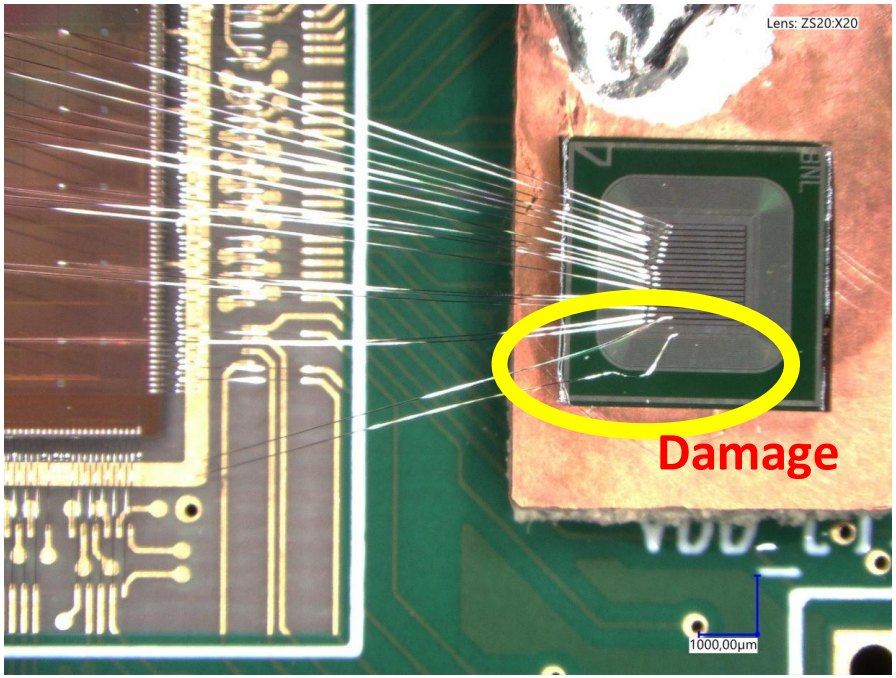
Microscope snapshots

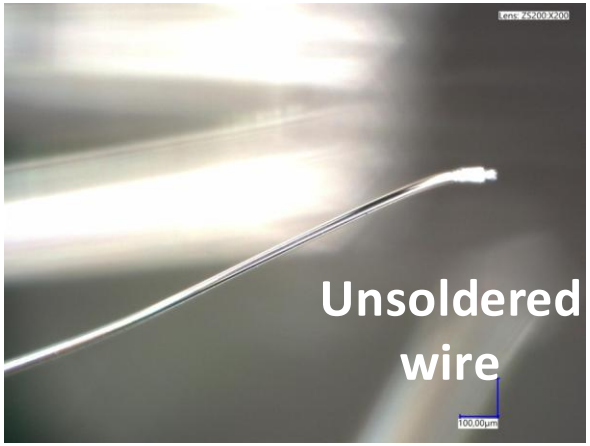
April 20th, 2021

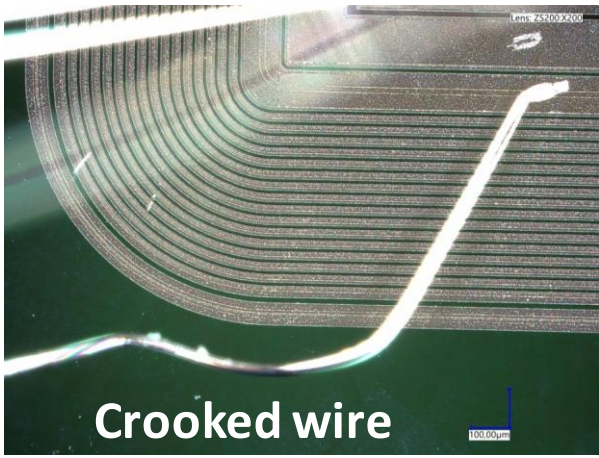




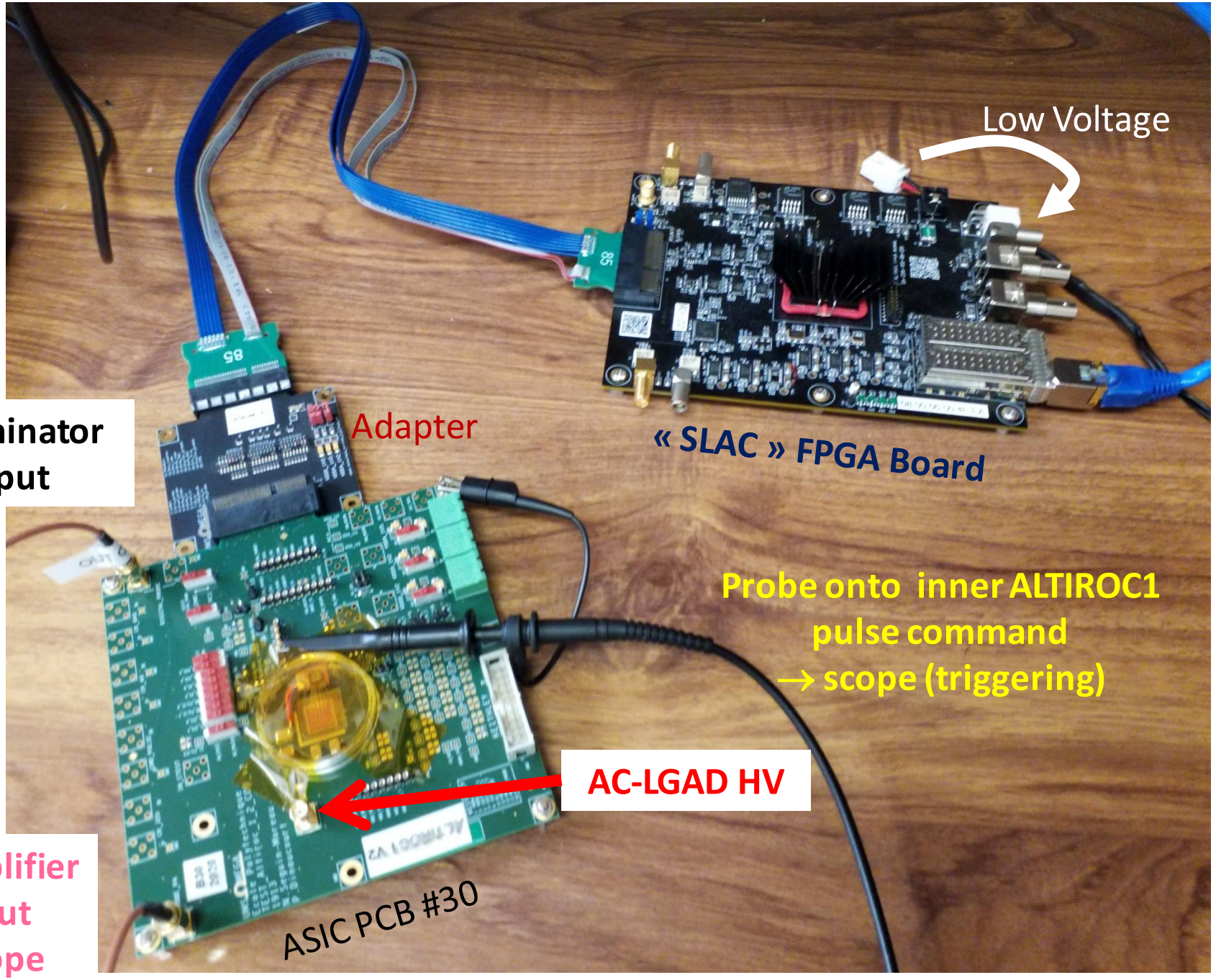
April 30th, 2021

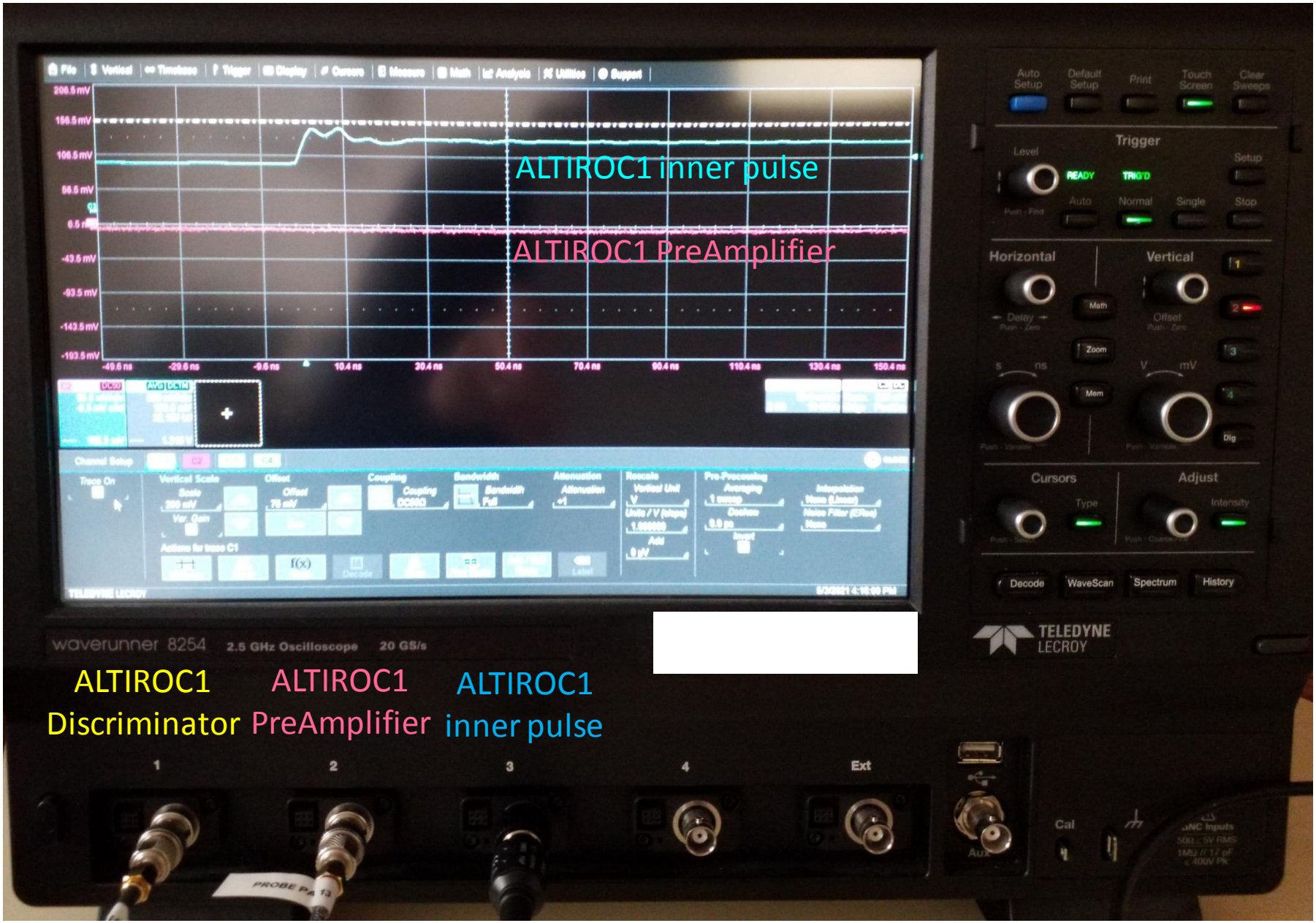




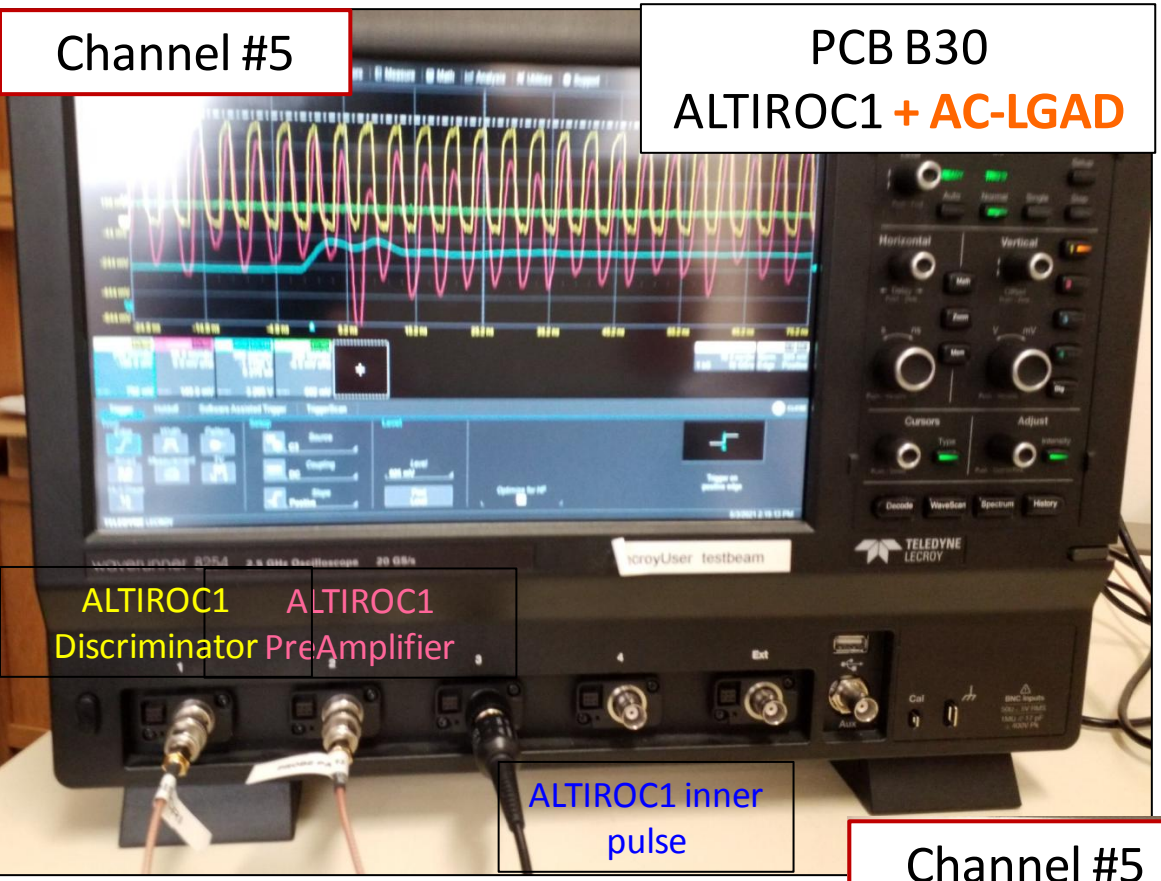


IJCLab, AC-LGAD testbench setup

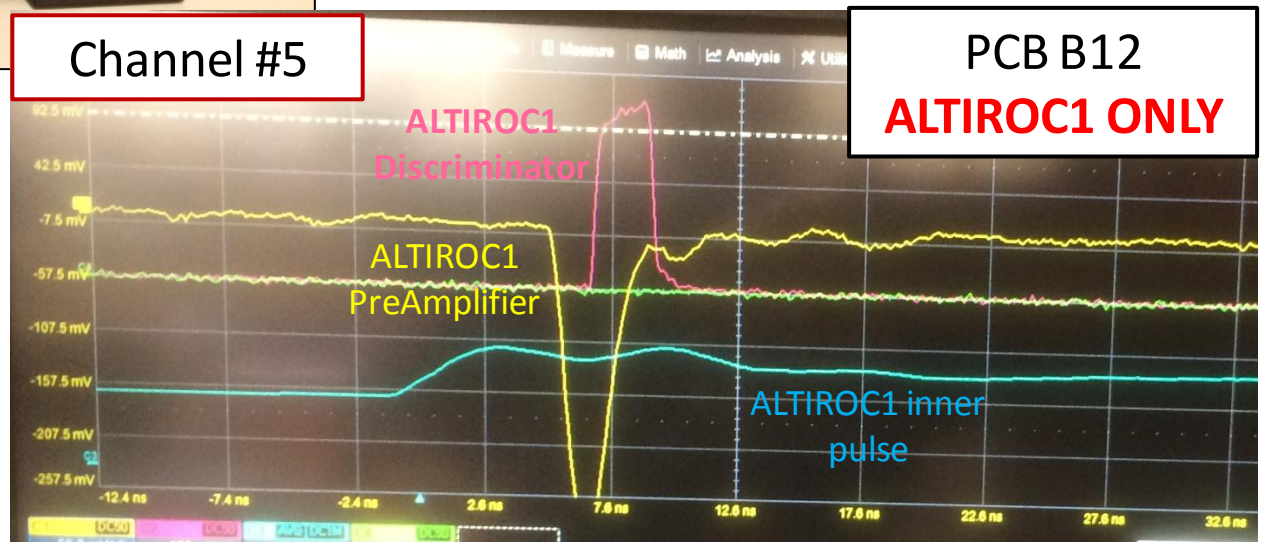



ALTIROC1 inner pulse
ALTIROC1 PreAmplifier
waverunner 8254 2.5 GHz Oscilloscope 20 GS/s
ALTIROC1 Discriminator
ALTIROC1 PreAmplifier
ALTIROC1 inner pulse
TELEDYNE LECROY

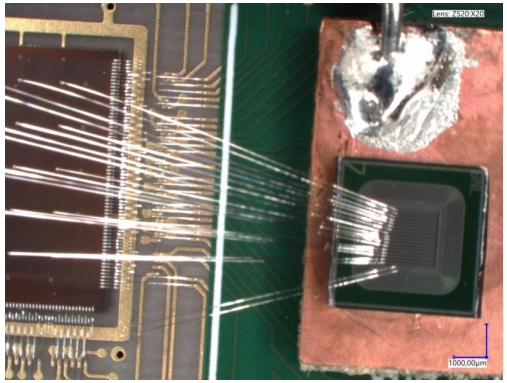
(ALTIROC1_V2 + AC-LGAD) typical observed output signals on scope: B30 and B12 PCBs



AC-LGAD sensor unpolarized
(No HV applied)



ALTIROC1_V2 mapping / identification of AC-LGAD wire-bonded channels

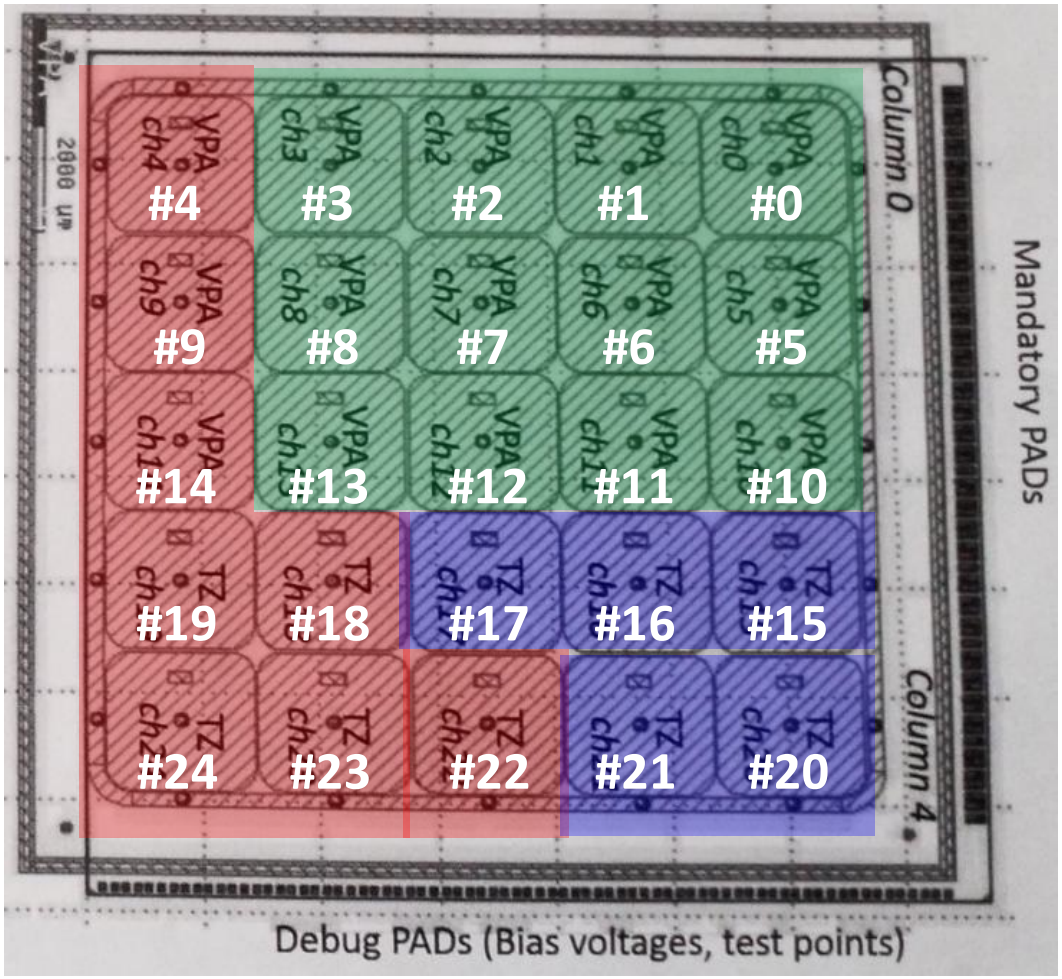


\# AC-LGAD channels connected to GND

\# AC-LGAD channels connected to an ALTIROC1 Voltage PreAmplifier channel

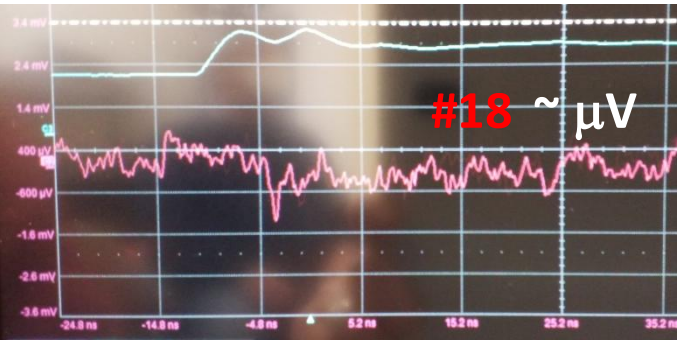
\# AC-LGAD channels connected to an ALTIROC1 TransImpedance PreAmplifier channel

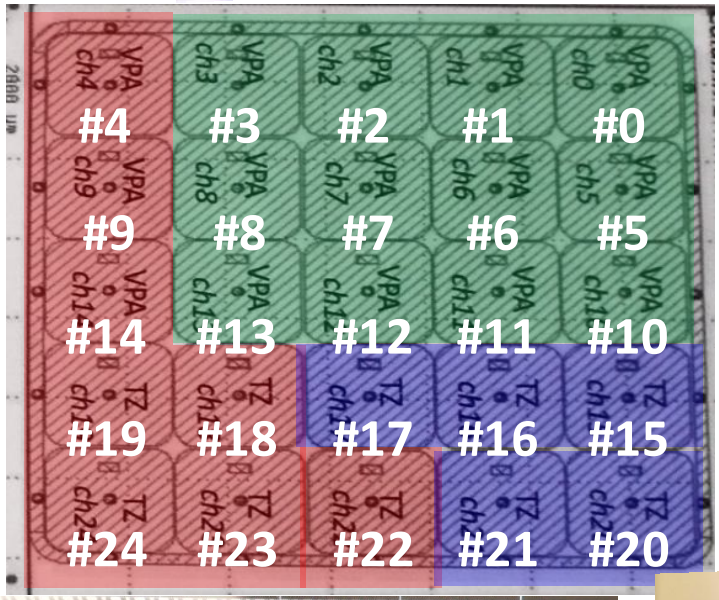
ALTIROC1_V2

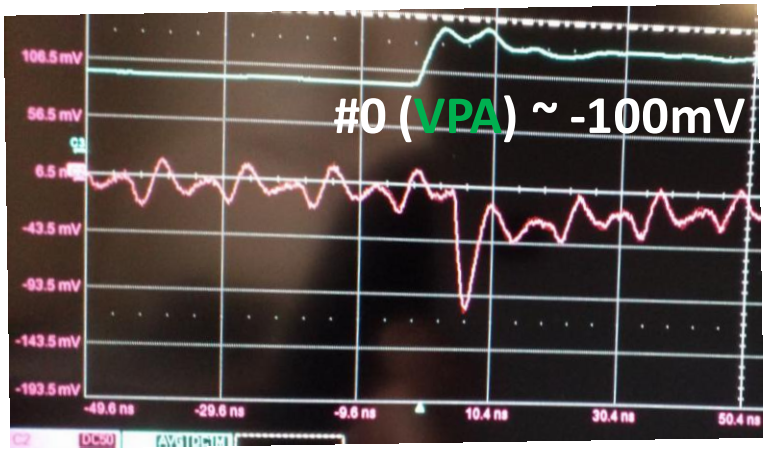


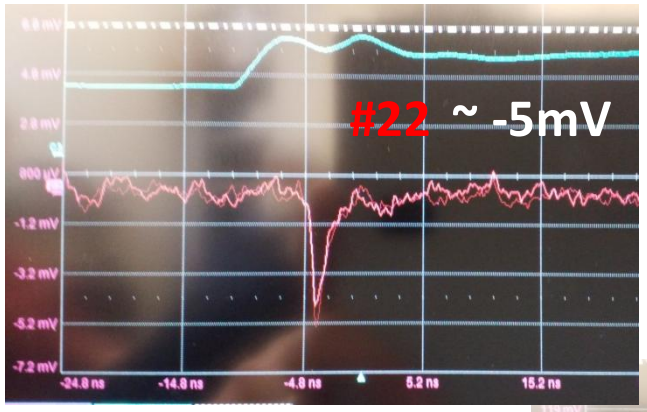
(ALTIROC1_V2 + AC-LGAD) typical observed output signals on scope

AC-LGAD sensor unpolarized (No HV applied)



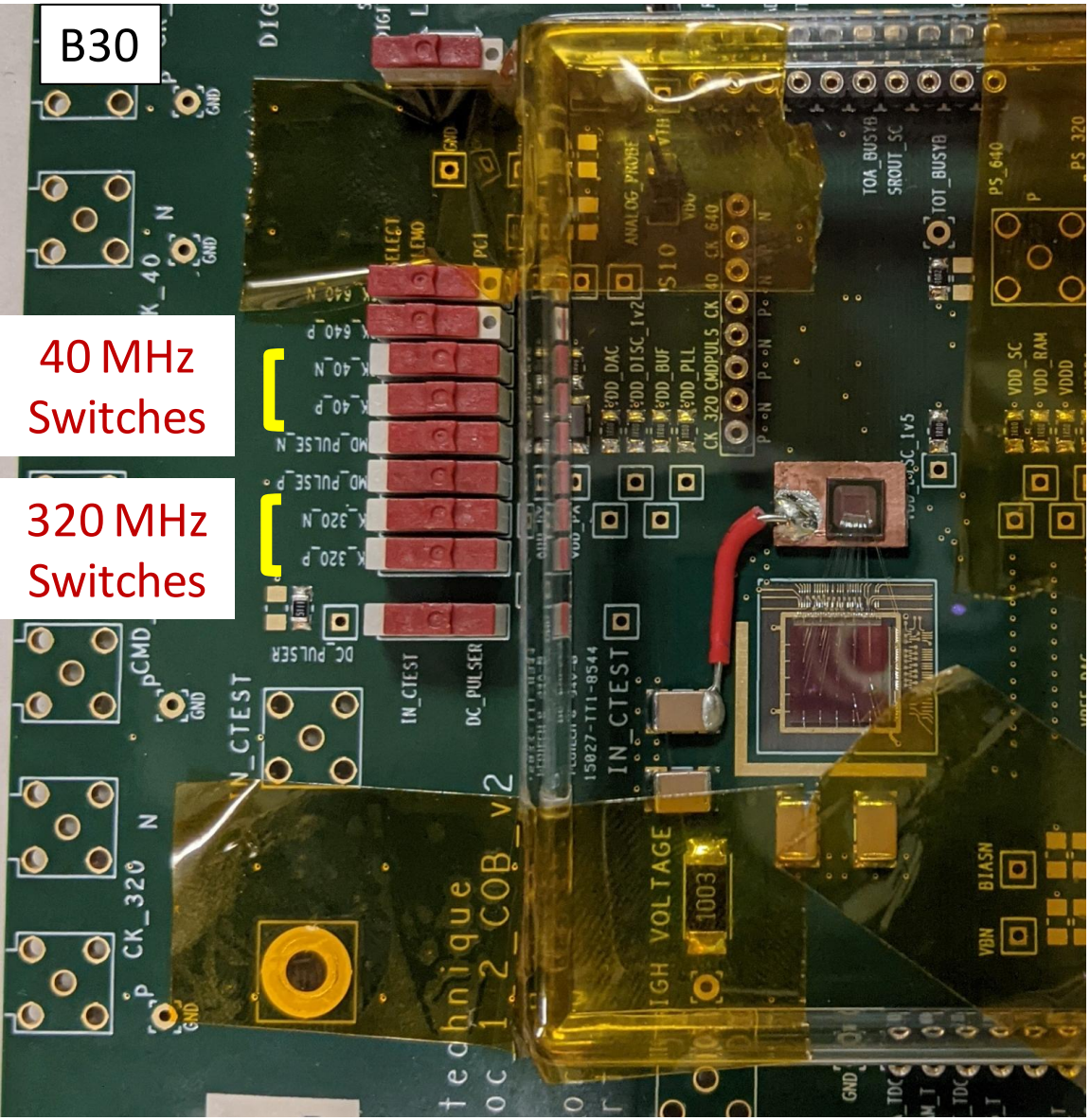






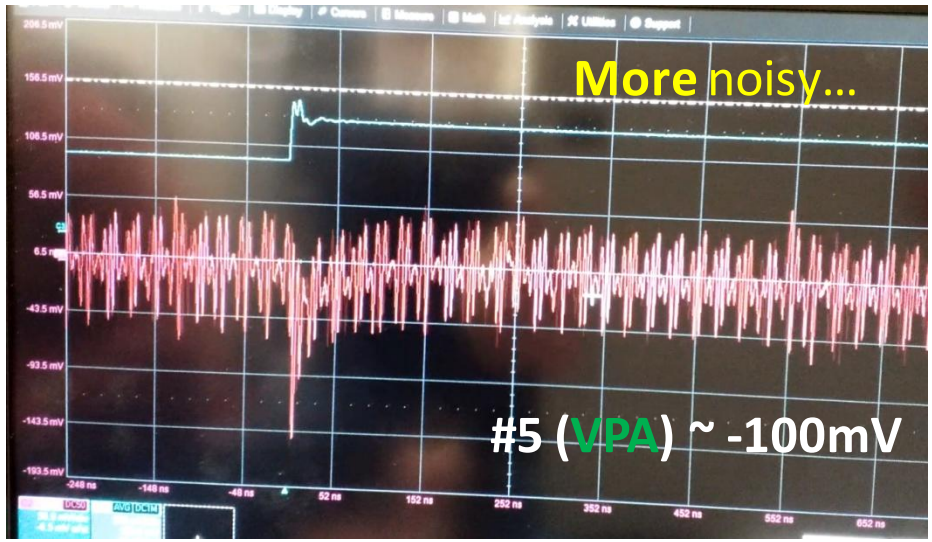
(ALTIROC1_V2 + AC-LGAD) observed output signals on scope : impact of 40MHz/320MHz clocks

AC-LGAD sensor unpolarized (No HV applied)



With 40MHz and 320 MHz clocks

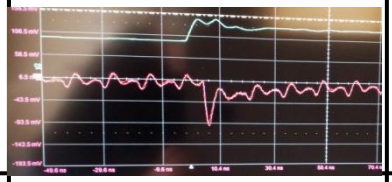
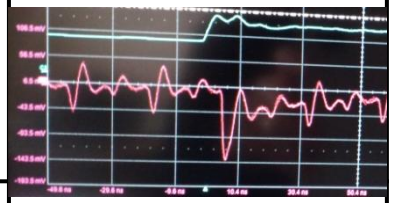
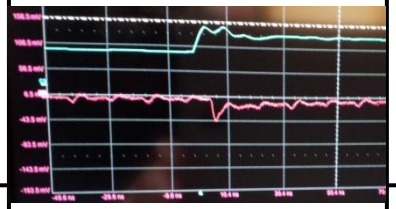
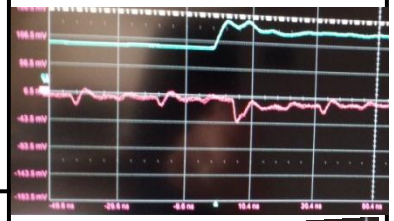
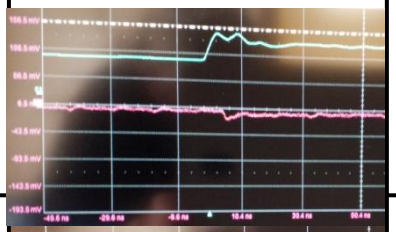
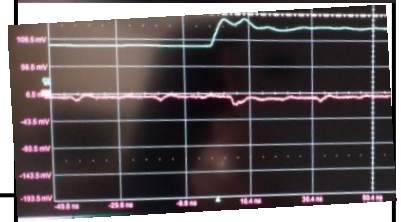
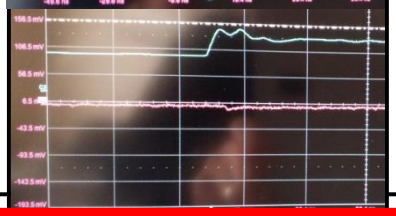
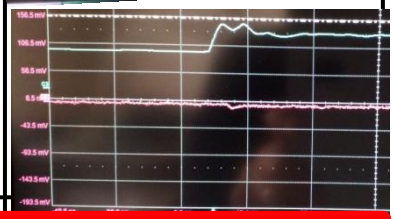
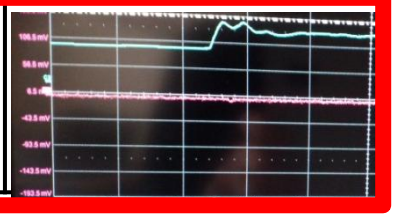
Without 40MHz and 320 MHz clocks



Measurements of B30 PCB including ALTIROC1_V2 + 17 channels wire-bonded LGAD-AC (strips)

Same scale for all **25** channels of ALTIROC1: (No additionnal capacitance - 0x0 ≅ 6 pF ; Discriminator output signal disabled)

✶vertical: -193.5 mV → 156.5 mV ; 50 mV / div. ✶ horizontal: -49.6 ns → 50.4 ns ; 20 ns / div.

#	0x1	#	0x2
0		5	
1		6	
2		7	
3		8	
4		9	

Signal Amplitude

-100 mV

-50 mV

-17 mV

-8 mV

Decrease of the signal amplitude with increasing channel number per column

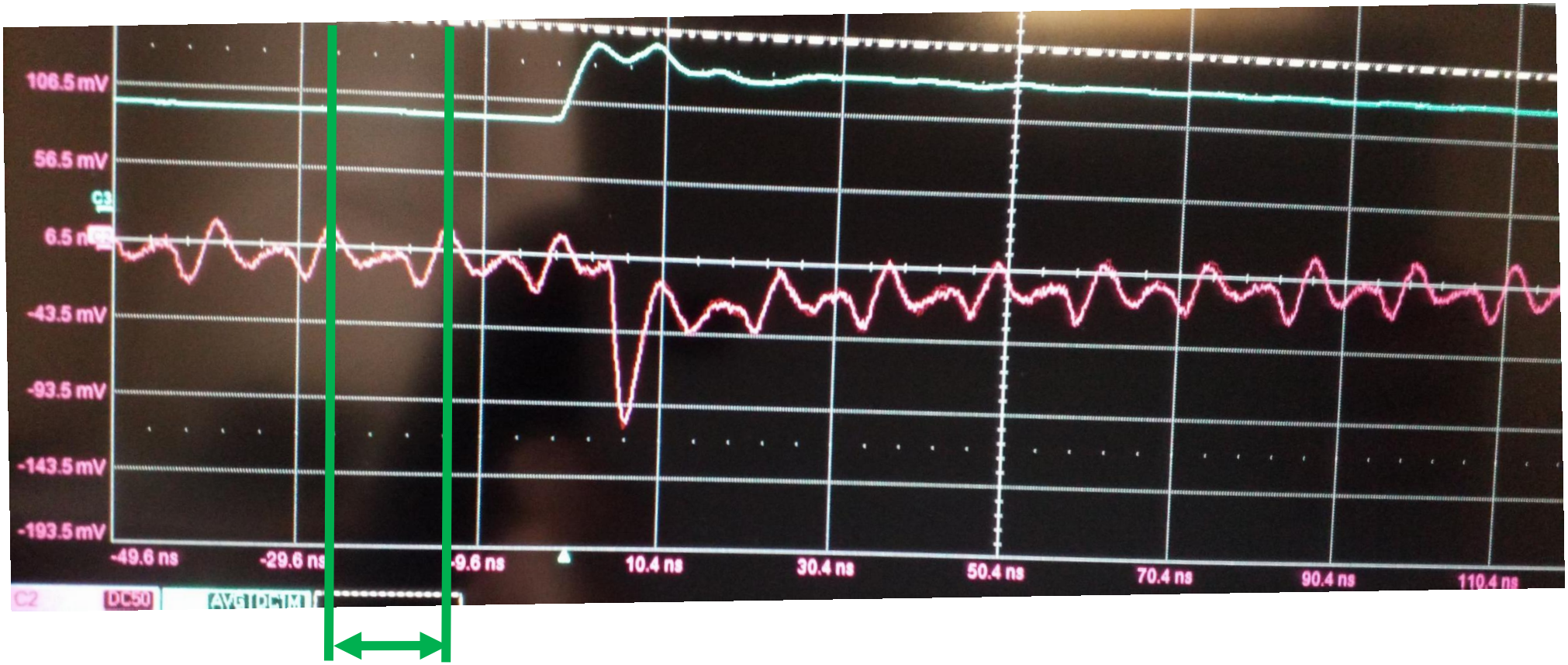
No wire-bonded channels

Command pulse signal (triggering) [Amplitude 0x3f = max]

PreAmplifier output signal

Channel #0 (ALTIROC1)

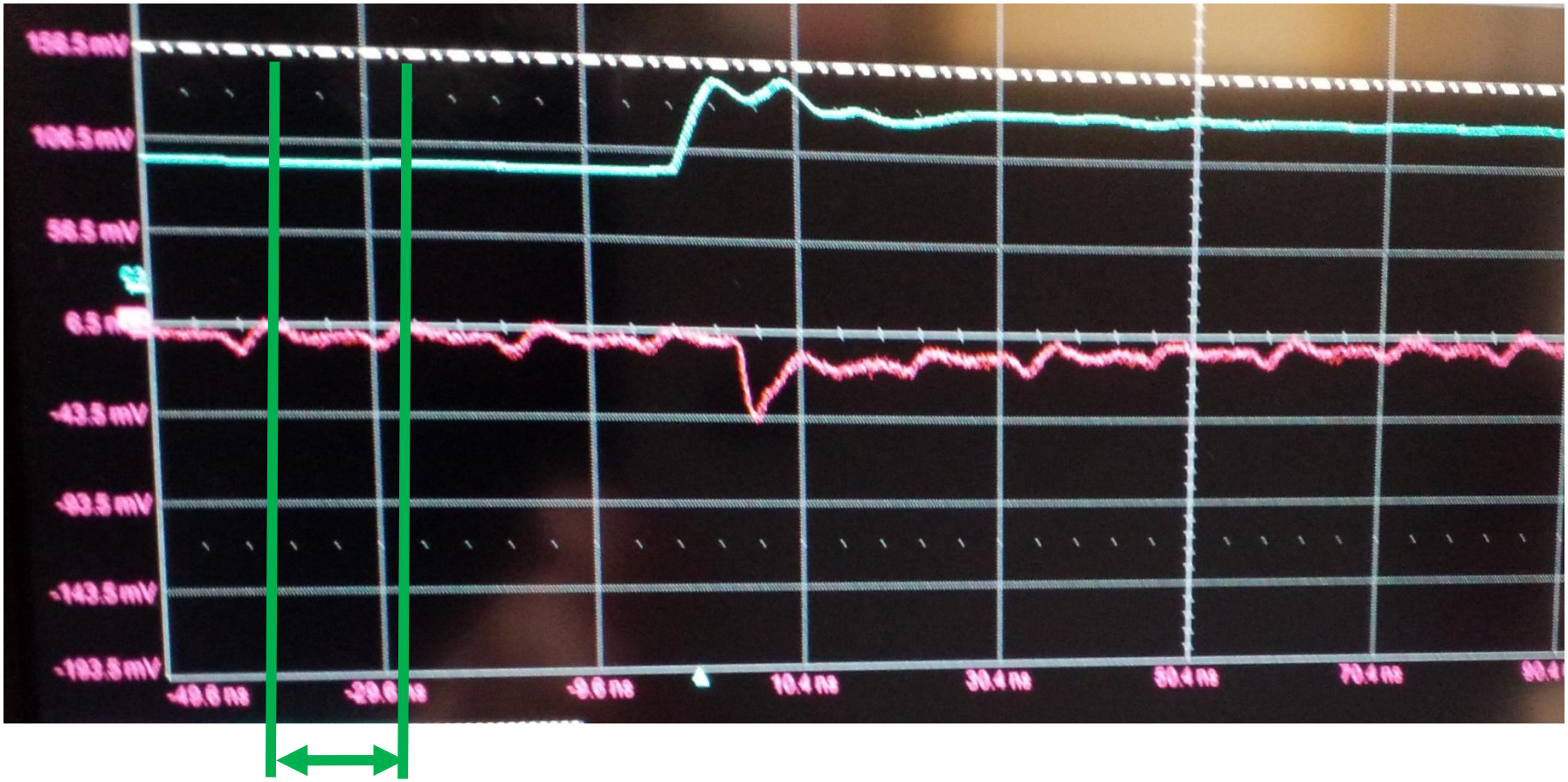
Amplitude of PreAmplifier output signal ≅ - 100 mV



~ 16 ns (≅ 62.5 MHz)

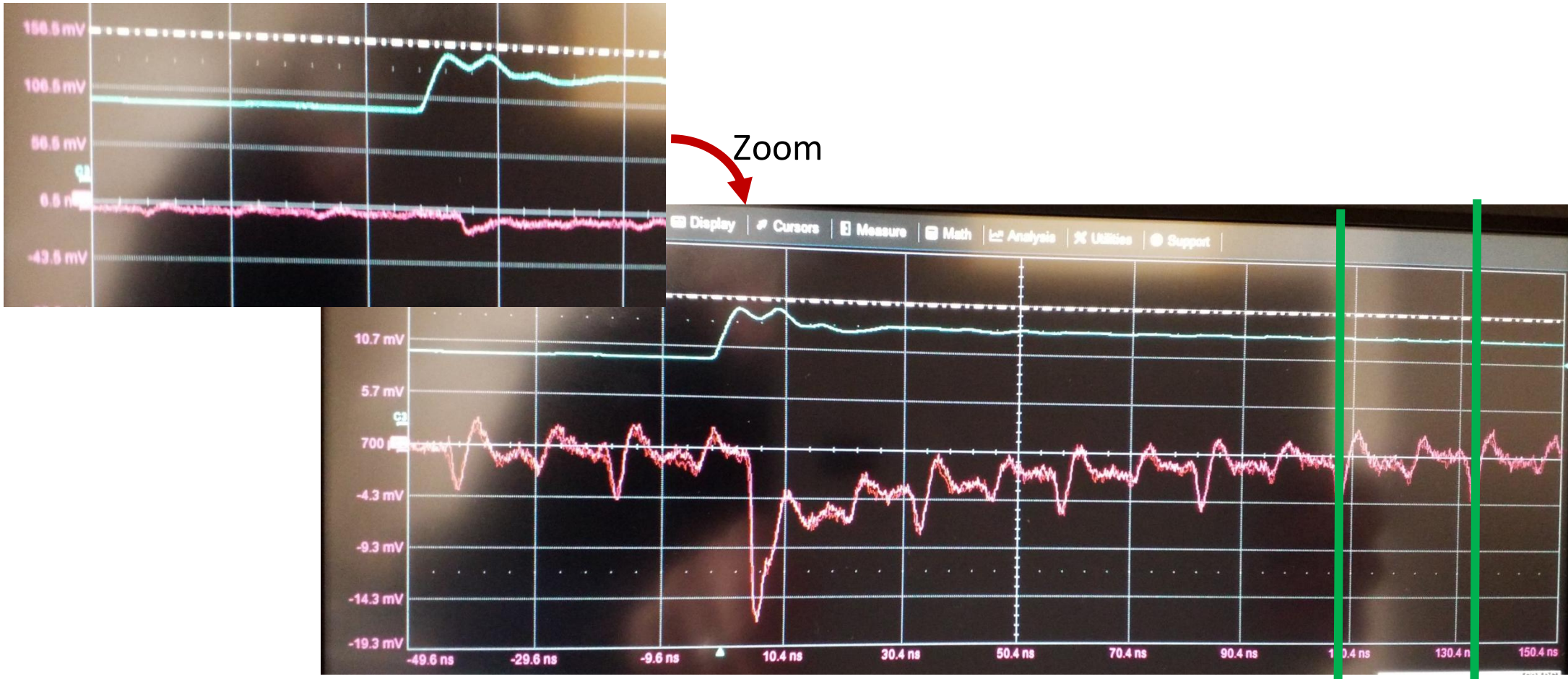
Channel #1 (ALTIROC1)

Amplitude of PreAmplifier output signal ≅ - 50 mV



~ 16 ns (≅ 62.5 MHz)

Channel #2 (ALTIROC1)



Amplitude of PreAmplifier output signal ≅ - 17 mV

~ 16 ns (≅ 62.5 MHz)

We measure impedance with ohm-meter between HV input and GND

Measurement > 10Mohms

Attempt to deplete AC-LGAD: measurement of the current versus HV applied

First exploration: **-10 µA** at -13V, current increasing with the HV applied

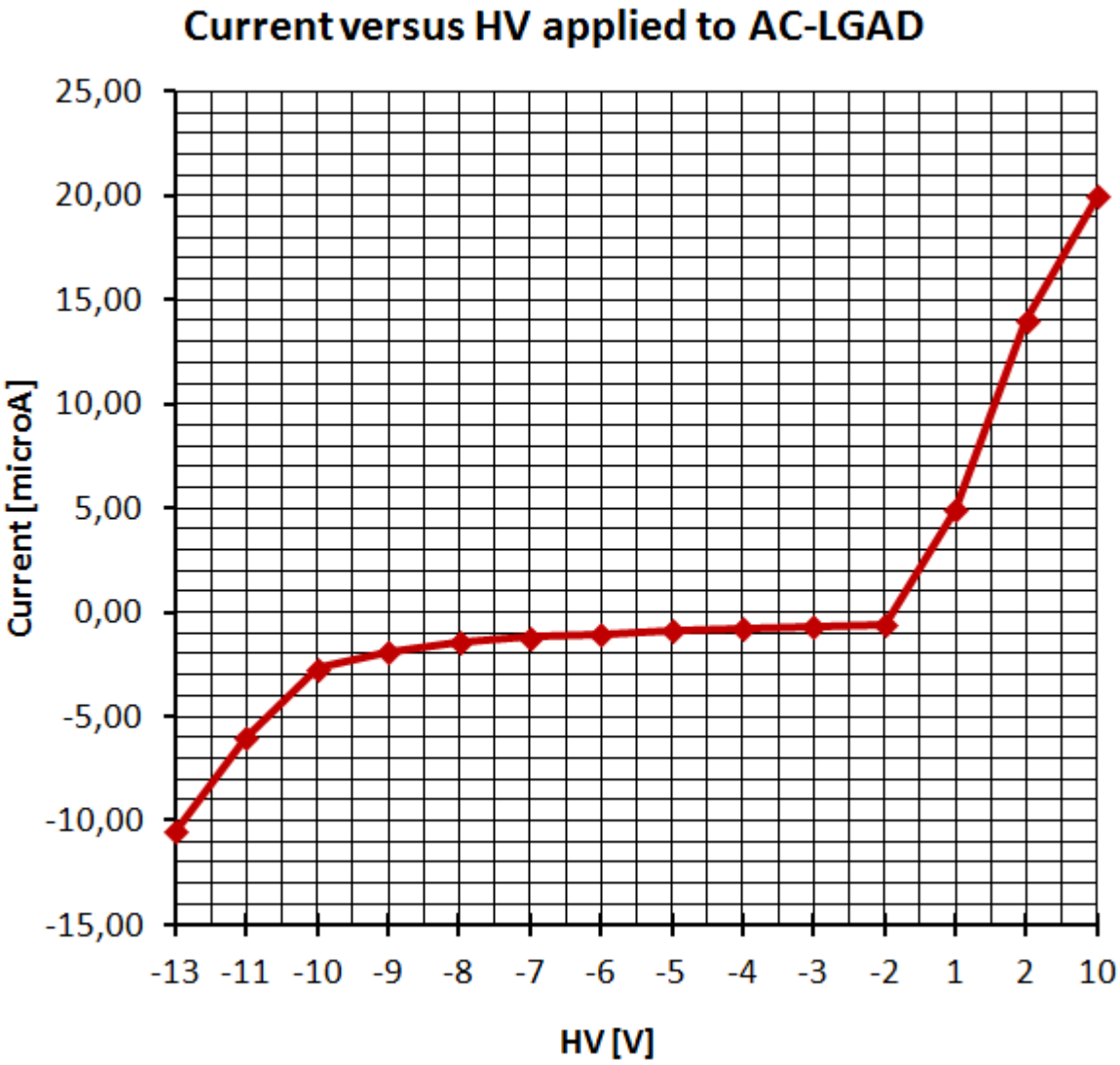
★ Measurements of the current in the HV range [**-13V** ; **+10V**]

Suspecting a bad polarization of the AC-LGAD P zone

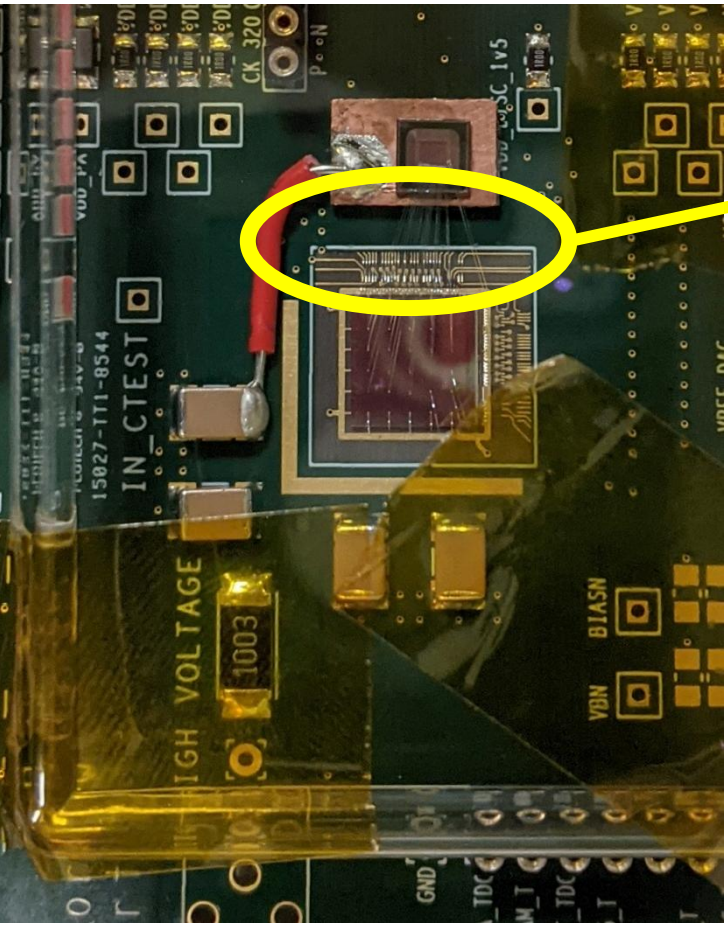
NO

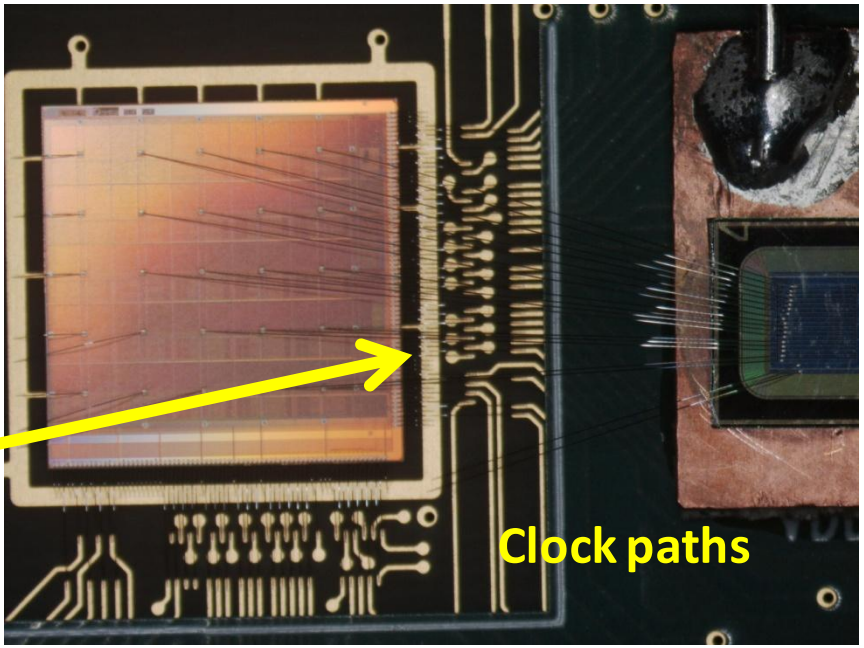
Observed leakage current too high

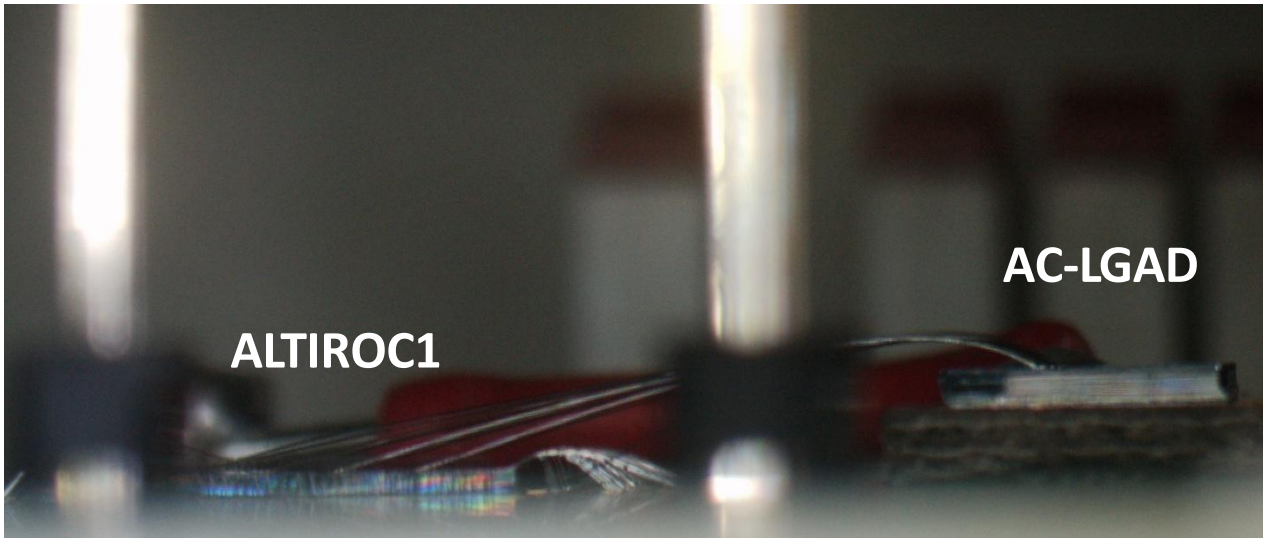
Reasons?



(ALTIROC1_V2 + AC-LGAD) Wire-bonding concerns (1/2)



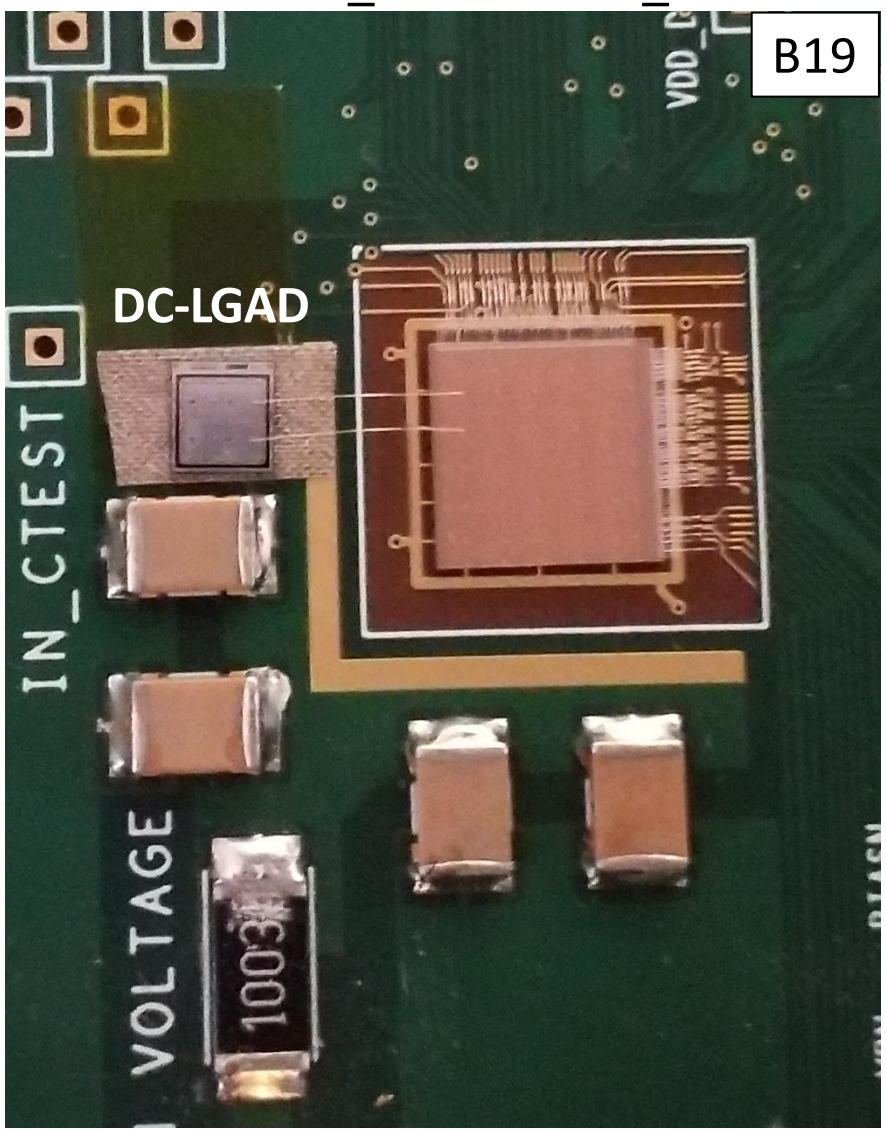


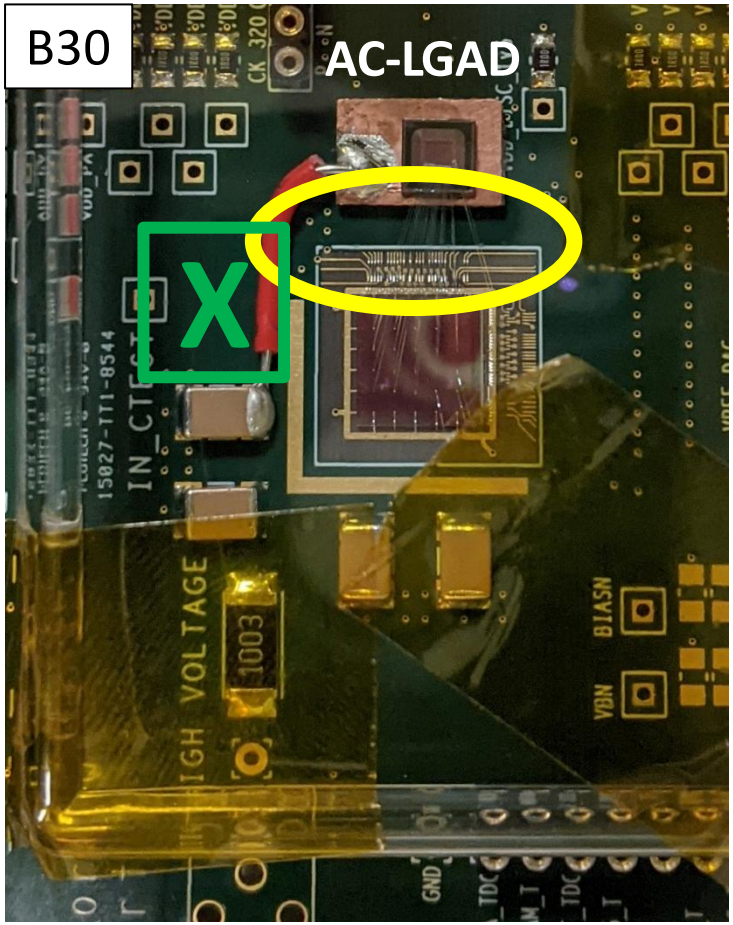


How the AC-LGAD sensor is connected to HV copper plate?
Conductor glue, adhesive tape?

(ALTIROC1_V2 + AC-LGAD) Wire-bonding concerns (2/2)

PCB **#19** (at IJCLab): example of an **DC-LGAD** wire-bonded onto an ALTIROC1_V2ALTIROC1_V2





Suggestion: displaced location of the wire-bonding / AC-LGAD to avoid clock paths

Summary

- 2 wires connected to guard ring have been accidentally damaged
- Observed AC-LGAD leakage current too high (no depletion)
- No obvious short cut observed
- Order of magnitude of PreAmplifier output signal amplitude not understood for AC-LGAD wire-bonded channels onto ALTIROC1_V2
- Coupling with a clock-like signal: ~60 MHZ??
- Removing 40 MHz and/or 320MHz clock(s) has no effect
- PreAmplifier output signal amplitude of AC-LGAD wire-bonded channels onto ALTIROC1_V2 decrease with increasing channel number per column (from #0 to #3 ; #5 to #8 ; #10 to #13 ; #15 to #17 ; #20 to #21
- Impact of PreAmplifier type (VPA / TZ) on output signals: less coupling with TZ
- Coupling with command pulse observed on AC-LGAD channels not wire-bonded to ALTIROC1
- Investigation on-going to design a dedicated support for the PCB enabling to use IJCLab probe station

Questions / suggestions

- Which typical signal should we observe? Amplitude order of magnitude?
- Prescription for connected AC-LGAD guard ring to Ground?
- How the voltage under the AC-LGAD capacitance defined?
- Should the wire-bonding be displaced?

Outlook?