Test of LARASIC4 Cold Preamplifier Readout in Argontube

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LARASIC for Argontube

Timeline

- Following discussion with Veljko Radeka and Chen Hucheng
  - On February 21st we received 10 new LARASIC4 (IC127) including documentation.
- Visit of Dean Shooltz (Michigan State University) on March 18th.
  - Besides a lot of useful information, we got 2 host PCBs from BNL.
- Help was provided by Chen and Gianluigi to set up the BNL board and test it.
- LHEP, May 2013
  - A LARASIC controller is designed, produced and tested.
  - An ARGONTUBE frontend PCB is designed, produced and tested.

LARASIC for Argontube

Cold Tests in LAr

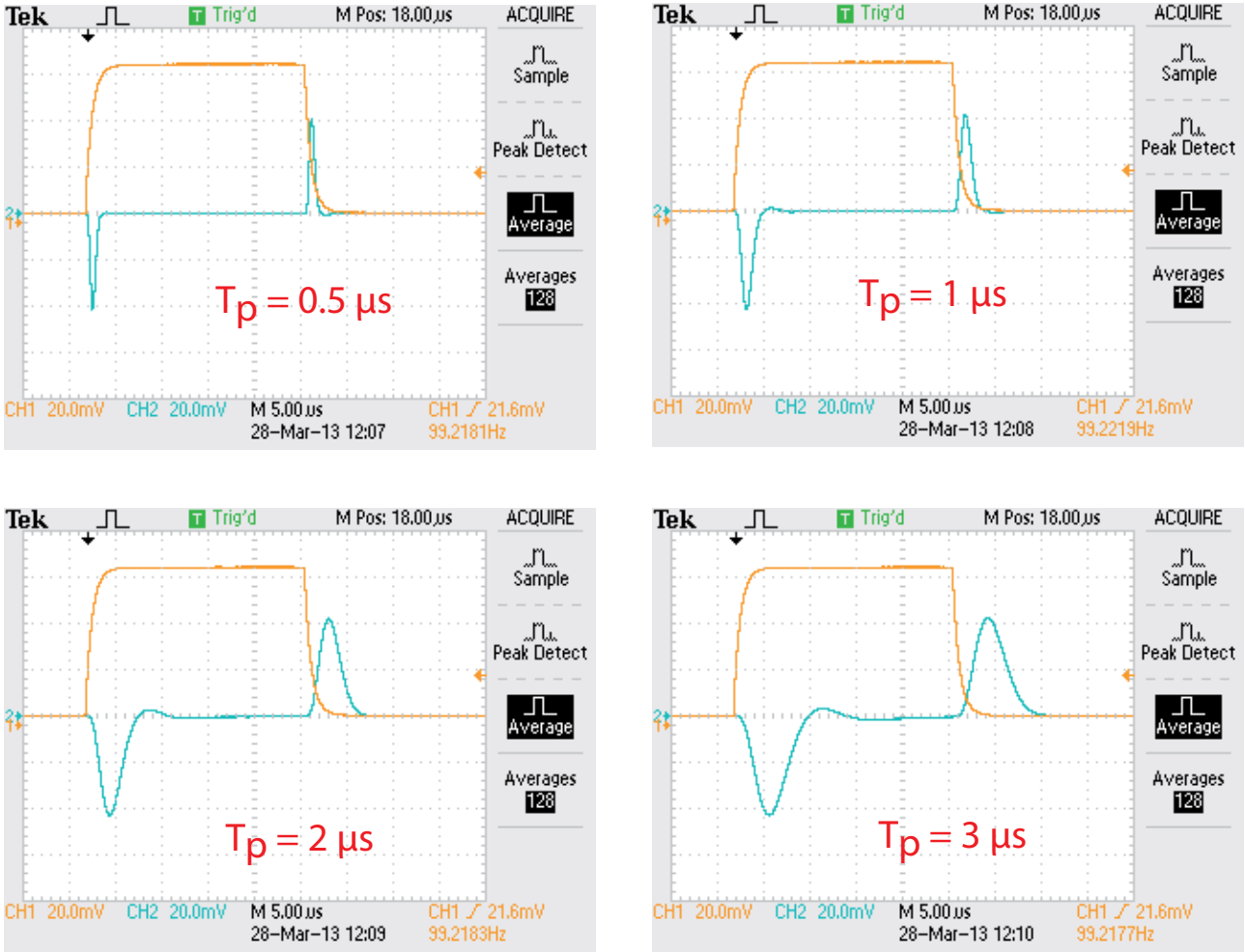


Figure 1: Response signals for different test pulses while chip is immersed in lAr.

LARASIC for Argontube

Cold Tests in LAr – Summary

- *Charge gain* $G = 25 \pm 1\,\mathrm{mV/fC}$
- *Transimpedance* @ $T_p = 1\,\mu\mathrm{s}$: $Z = 39 \pm 3\,\mathrm{mV/nA}$
- *Droop* (important for longitudinal tracks) $2\,\%/\mathrm{ms}$
- *Noise* with $C_{\mathrm{det}} \approx 1\,\mathrm{pF}$
  - @ $T_p = 0.5\,\mu\mathrm{s}$ RMS $= 194\,\mathrm{e}$
  - @ $T_p = 3\,\mu\mathrm{s}$ RMS $= 375\,\mathrm{e}$
- In Argontube, $C_{\mathrm{det}} \approx 7 - 10\,\mathrm{pF}$.

Perfect match to specifications.

Setup

- **Argontube LArTPC**
  - 4.76m drift distance.
  - Active volume $\approx$ 200 l.
  - HV by Cockcroft-Walton/Greinacher circuit.
  - 2 wireplanes with 3 mm wire pitch, 64x64 CH.
- **Preamplifier setup**
  - *Induction plane:* Brookhaven LARASIC4 cold preamps (64CH).
  - *Collection plane:* 'Warm' (54 CH) and LHEP cold preamps (10 CH).
  - *Readout modes:* Collection-induction, induction as collection, double collection (charge sharing).

Figure 2: The Argontube TPC.

Setup

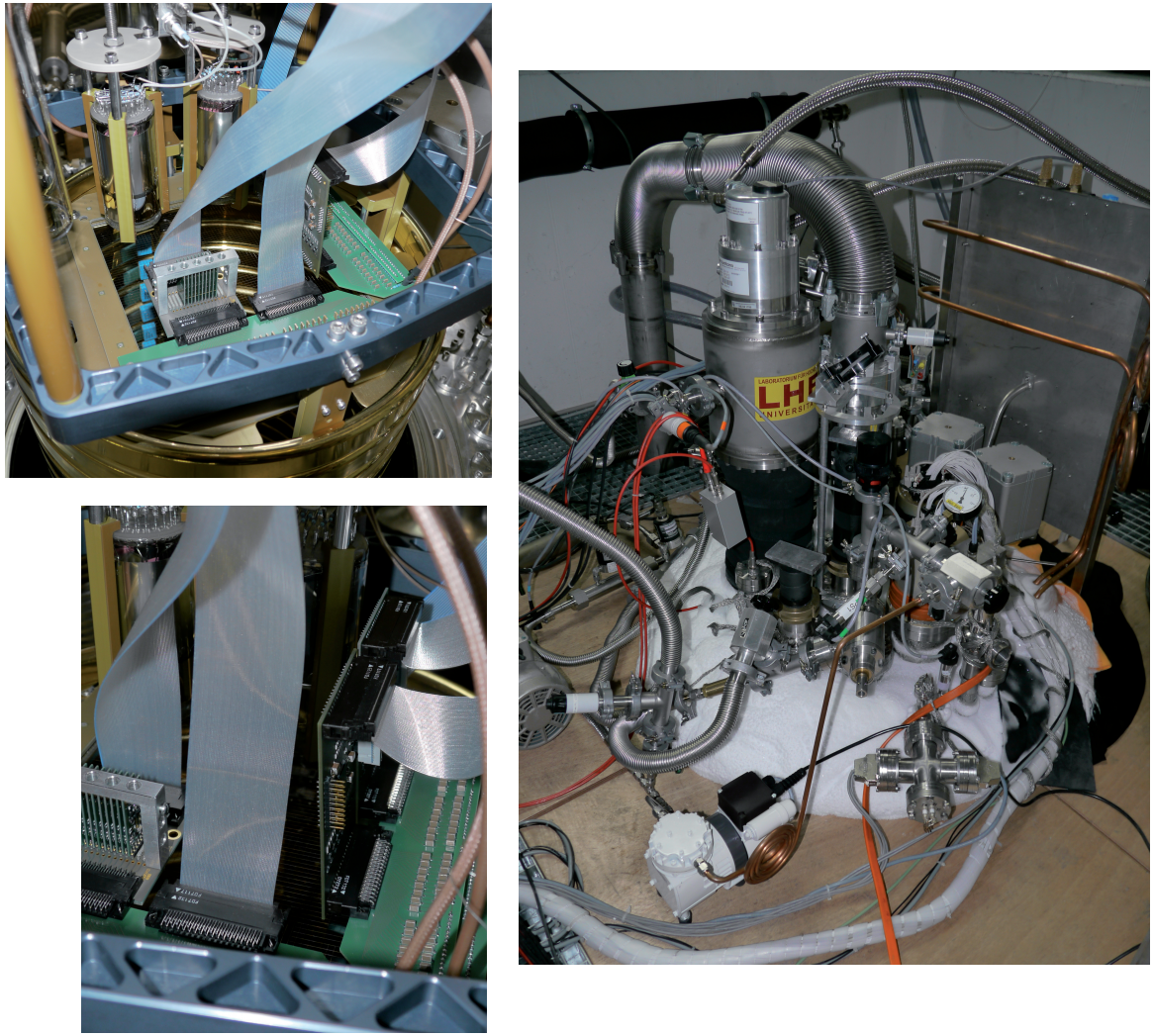


Figure 3: *Left:* LARASIC chips on host PCB attached to wireplane. *Right:* Ongoing test run.

Setup

LARASIC Readout in Argontube

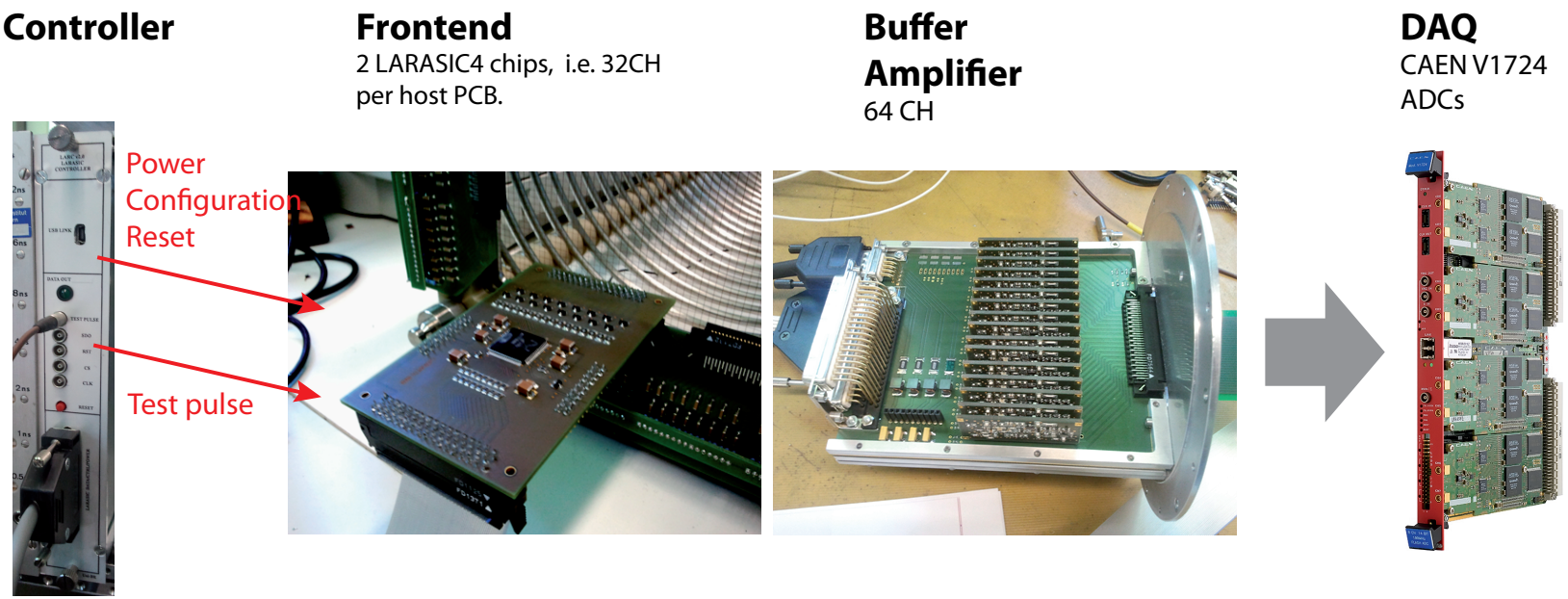


Figure 4: LARASIC controller NIM module (left) and full readout chain.

- **LARASIC parameter settings**
  - Charge gain $G = 25 \pm 1\,\mathrm{mV/fC}$
  - Peaking time $t_p = 3\,\mu\mathrm{s}$

Cold Electronics - Example Tracks

In Collection Mode I

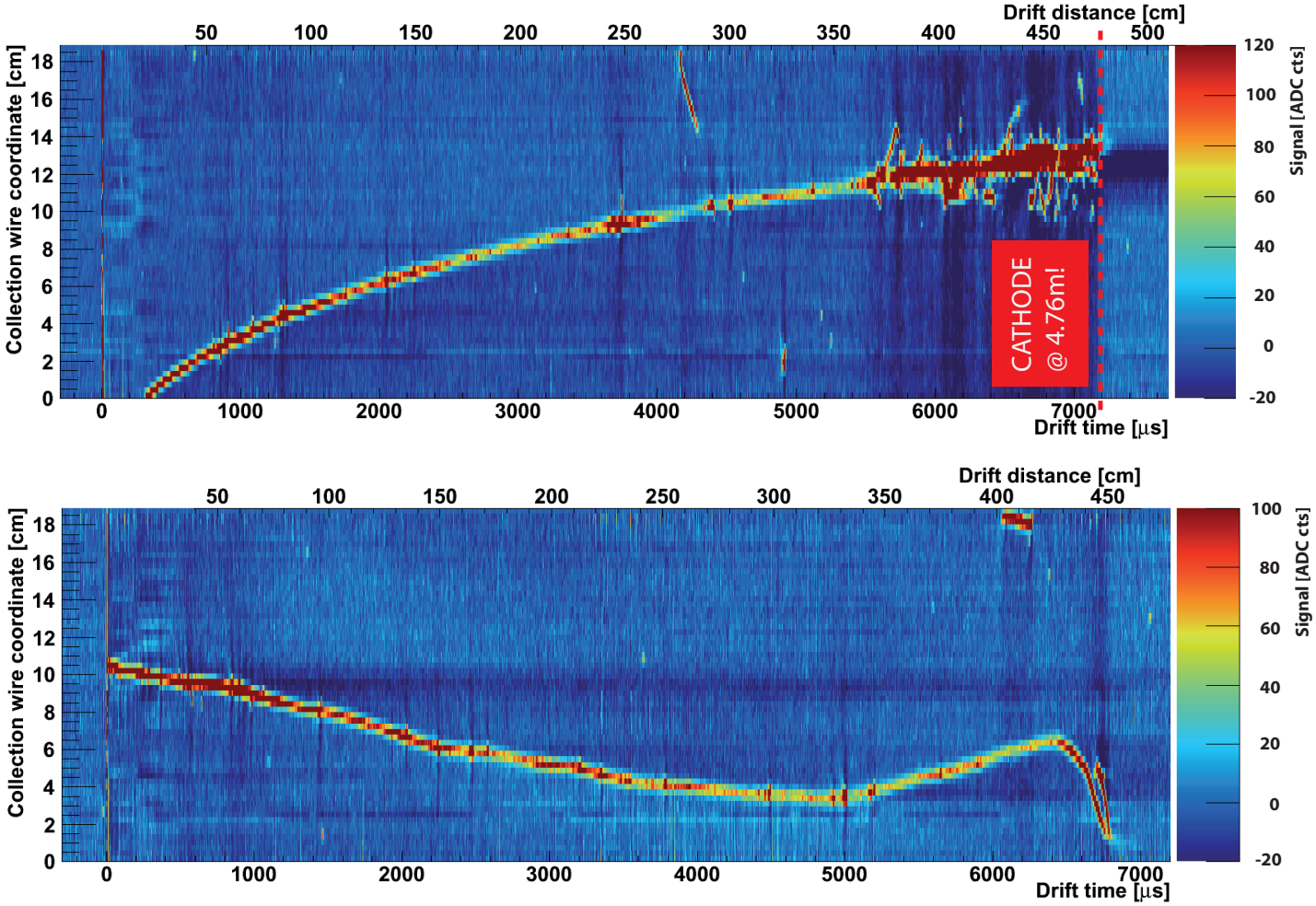


Figure 5: Full length tracks with cold preamps. *top:* Shower onto the cathode. *bottom:* μ decay near cathode.

Cold Electronics - Example Tracks

In Collection Mode II

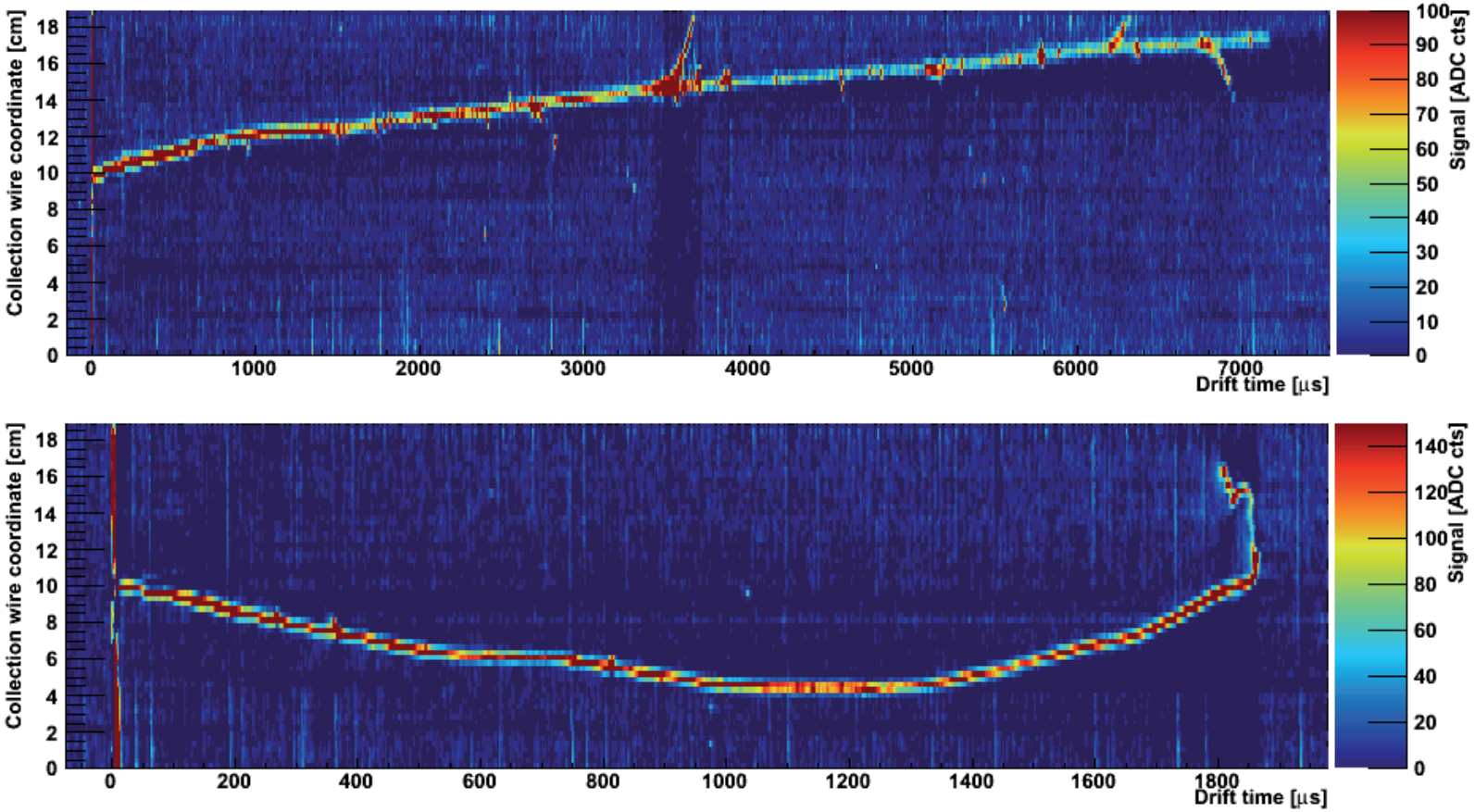


Figure 6: *top:* Full length μ track. *bottom:* μ decay.

Cold Electronics - Example Tracks

In Collection Mode III

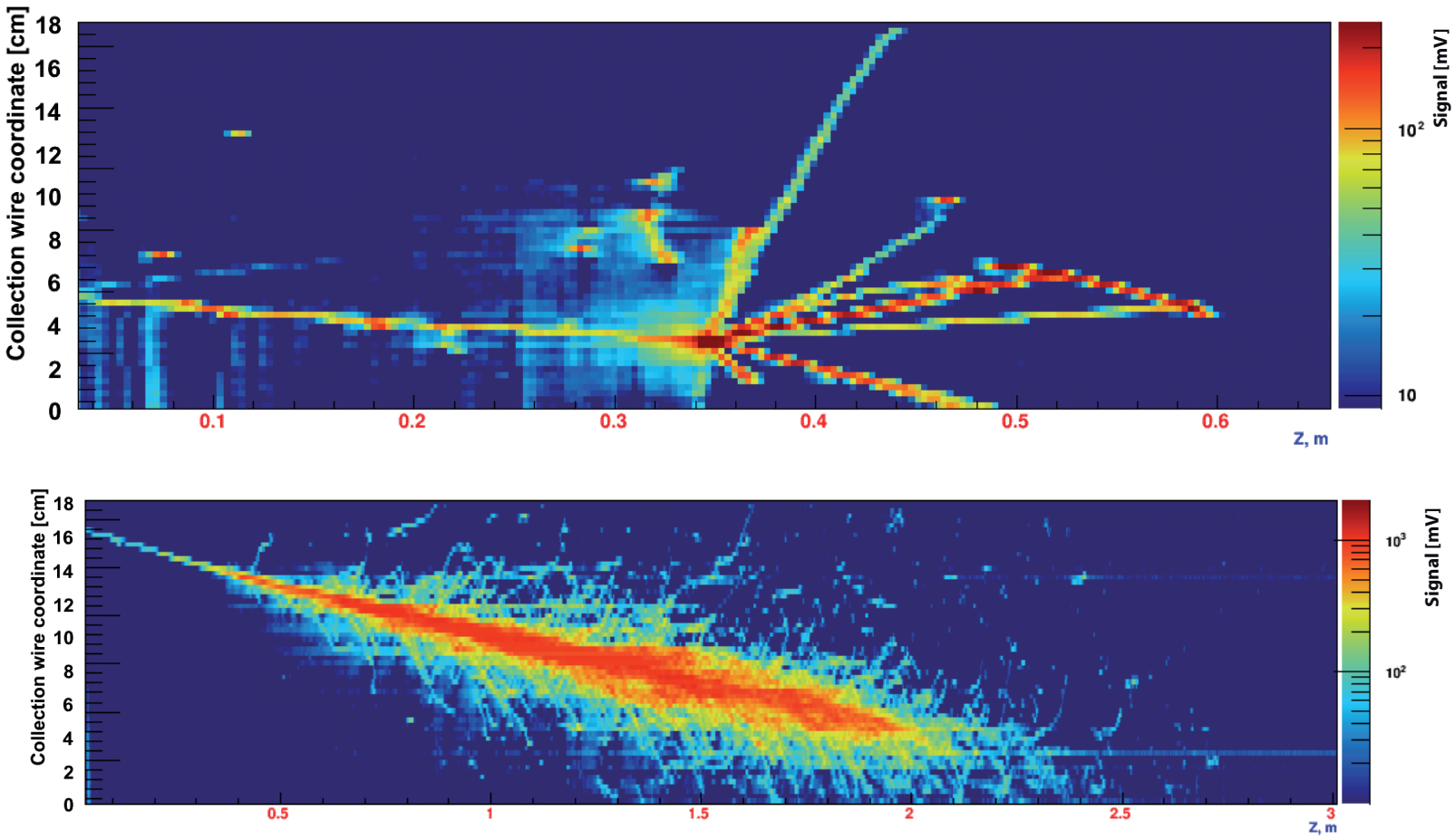


Figure 7: *top:* Hadronic interaction (log scale). *bottom:* Fully contained EM shower (log scale).

Cold Electronics - Example Tracks

In Induction Mode

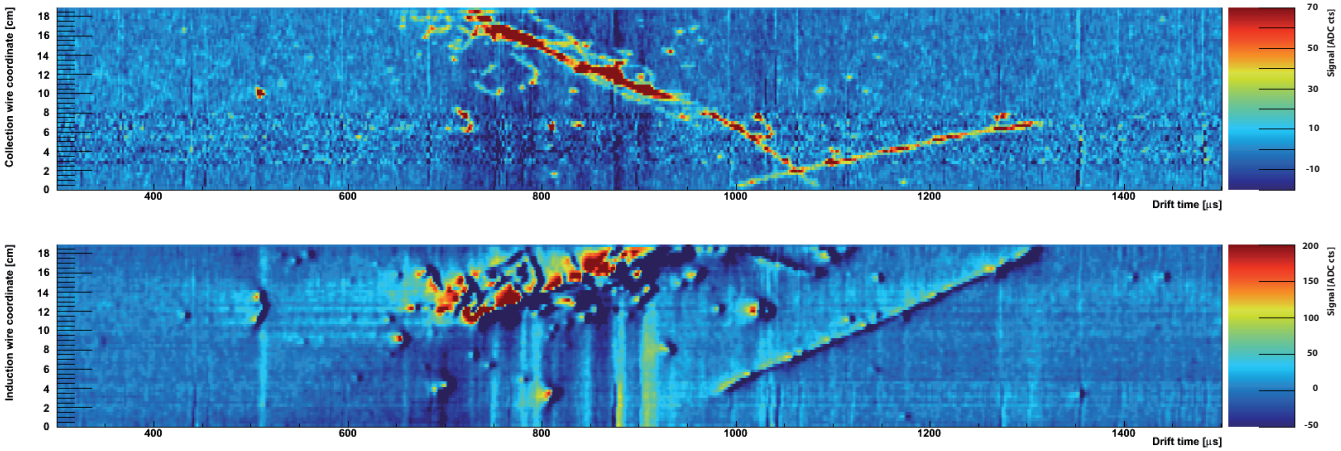


Figure 8: Shower. *top:* Mainly warm preamps in collection mode. *bottom:* Cold preamps in induction mode.

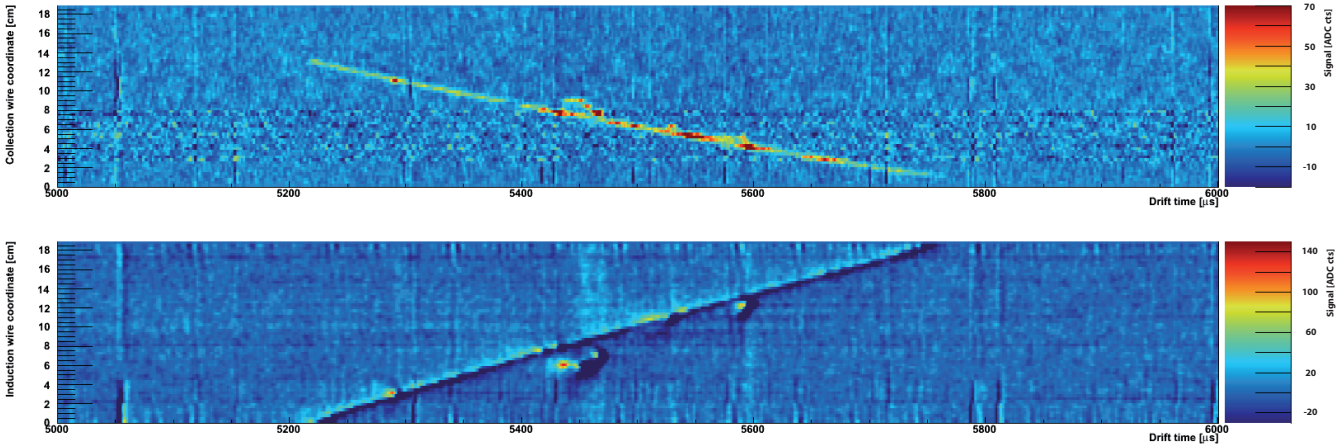


Figure 9: μ track. *top:* Mainly warm preamps in collection mode. *bottom:* Cold preamps in induction mode.

Comparison

Between Warm and Cold Preamps I

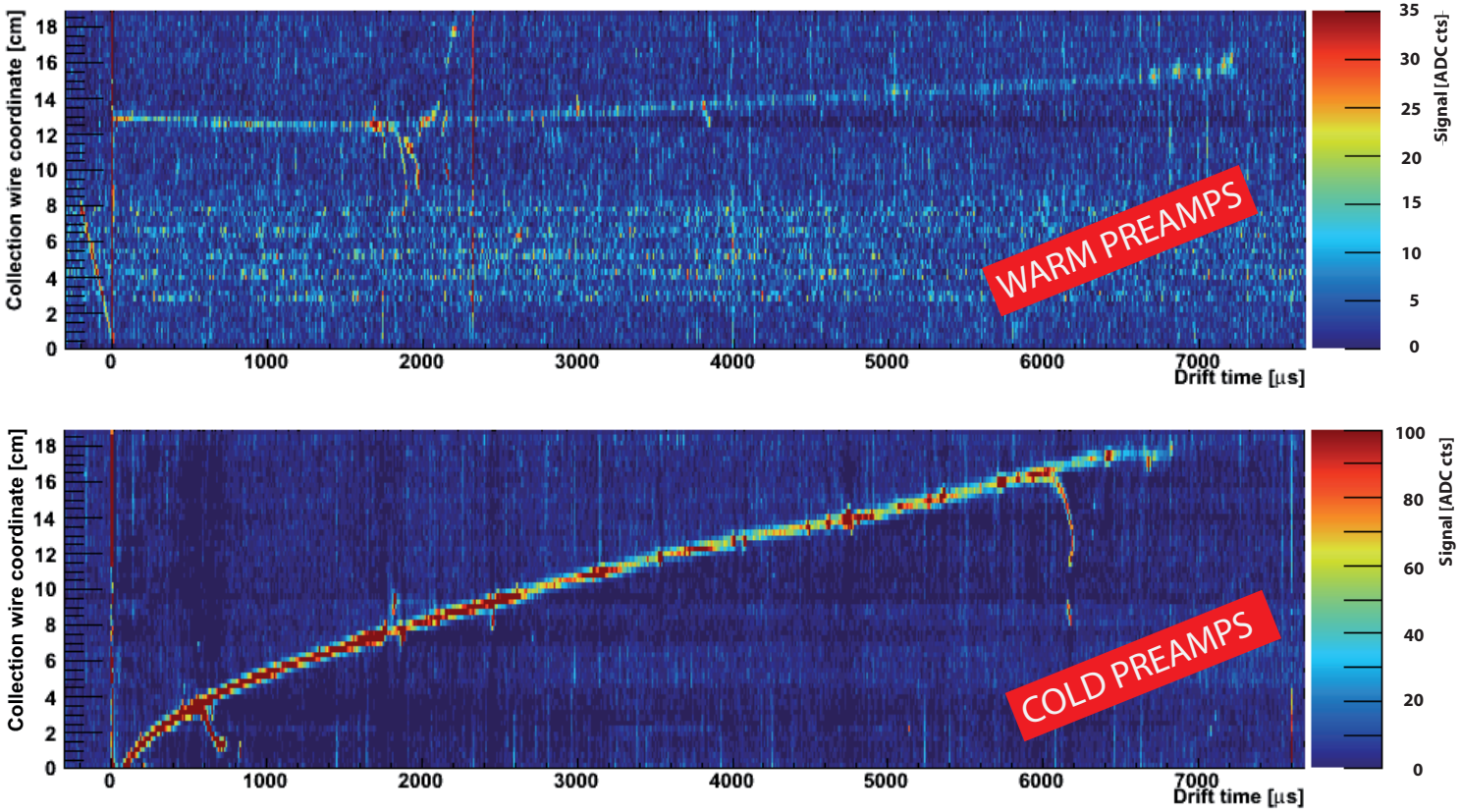


Figure 10: Full length μ track with warm (top) and cold (bottom) preamps.

Comparison

Between Warm and Cold Preamps II

- Amount of charge/mm expected from mip

  $\left(\frac{dE}{dX}\right)_{\text{mip}} \approx 0.21\,\text{MeV/mm},\ W_e \approx 23.6\,\text{eV},\ R \approx 0.35 \pm 0.04$ @200V/cm

$\Rightarrow$ $\mathbf{\frac{\Delta Q}{\Delta x} \approx 8'900\,e/mm}$

- Analyze transversal mip. tracks passing close to the readout plane.
- *RMS noise*

  $N_{\text{warm}} = 1.1 \pm 0.1\,\text{mV},$

  $N_{\text{cold}} = 2.1 \pm 0.1\,\text{mV} \approx 525e^{-}(ENC)$

- *MIP signal*

  $S_{\text{warm}} = 2.8 \pm 0.6\,\text{mV}$

  $S_{\text{cold}} = 33.0 \pm 7.9\,\text{mV} \approx 8'100\,\text{e/mm}$ (corrected for recomb.)

$\Rightarrow$ **Signal to noise ratios**

$S/N_{\text{warm}} = 2.6 \pm 0.6$ $\quad$ $S/N_{\text{cold}} = 15.7 \pm 3.8$

Droop Compensation

- Charge from longitudinal track is mainly deposited on one channel.
  $\Rightarrow$ Droop correction (2%/ms) must be applied.

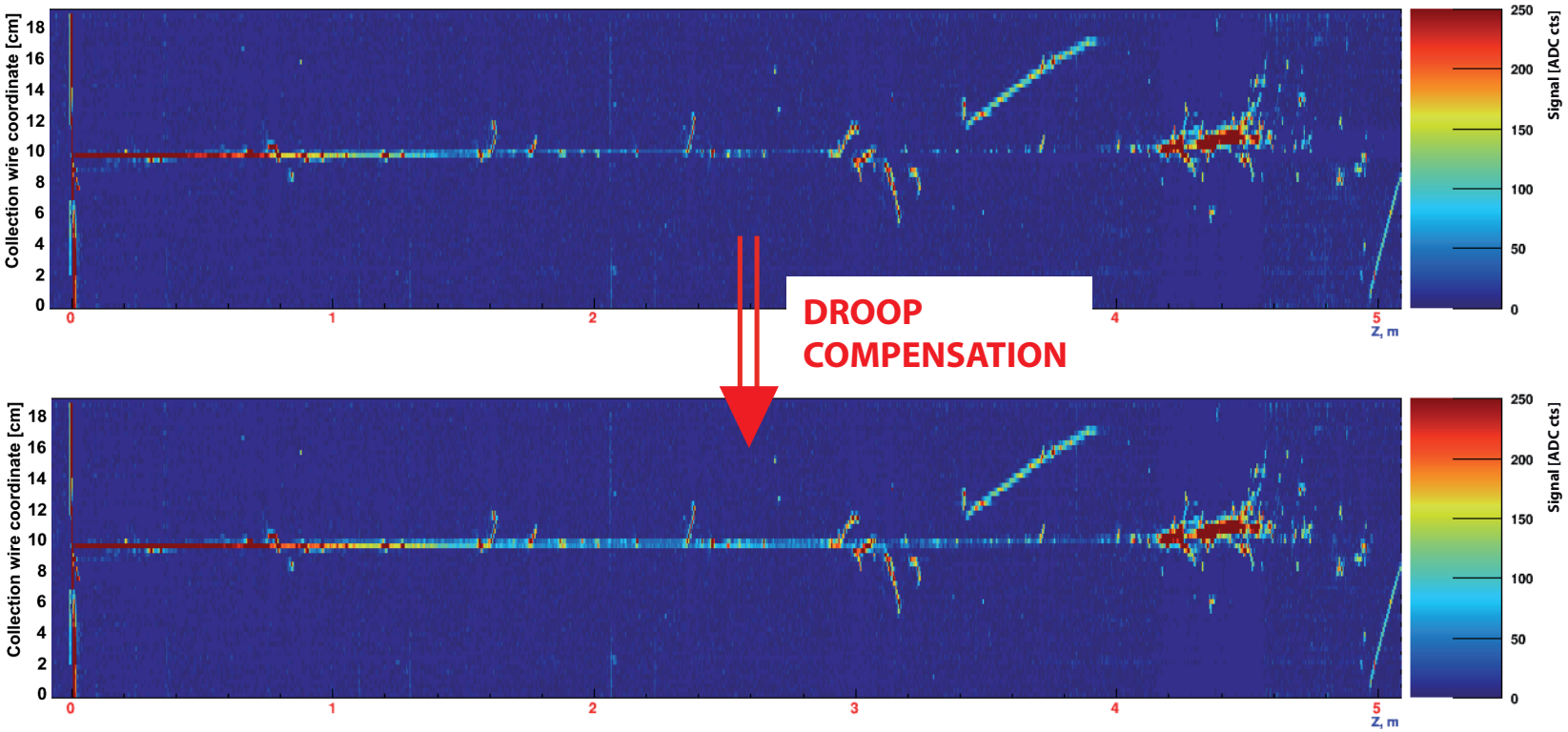
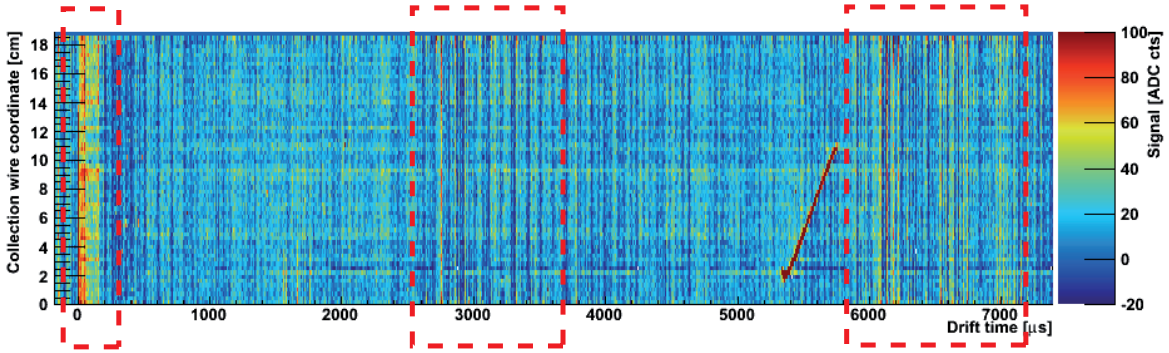


Figure 11: *top:* Longitudinal track mainly on *one* channel. *bottom:* Same event - corrected for preamplifier droop.

PMT Pickup

- PMTs induce signal on LARASIC chips (t_0 also visible on 'warm' channels, but weaker) $\Rightarrow$ need shielding.



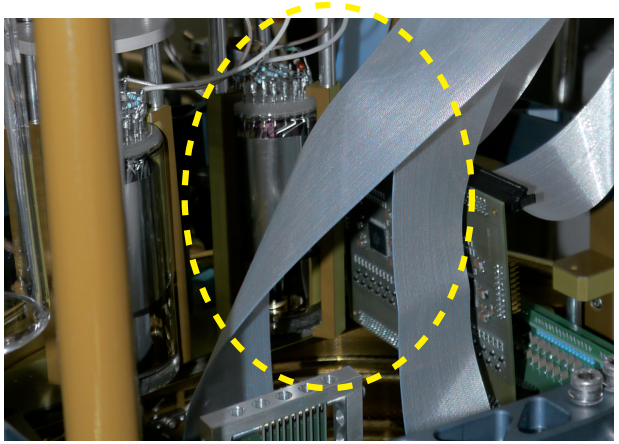


Figure 12: *top:* Signal induced by PMTs. *bottom:* Mounting of PMTs and LARASIC4.

Summary and Plans

- LARASIC4 cold electronics has been operated successfully in a long drift LArTPC.
- Increase in performance compared to warm preamps is striking! About a factor 6 improvement in S/N for mip. tracks.
- During the test run, loads of precious data have been collected.
- Many thanks to all the supporters!

- **Further plans**
  - Equip full wireplane (induction and collection).
  - Few issues (e.g. noise from PMTs) have to be solved.

Questions / Discussion