

ICARUS T600 TPC readout electronics

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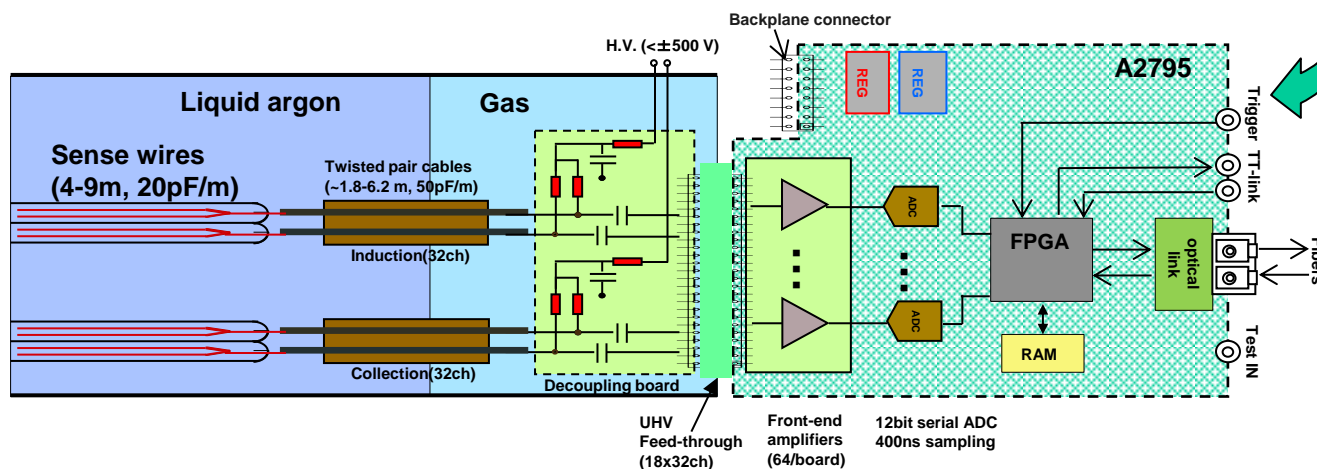
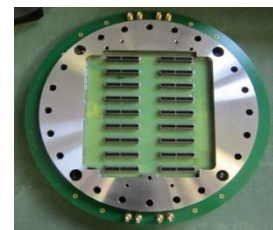
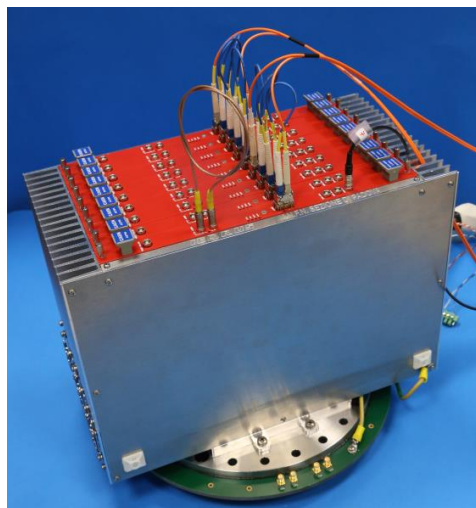
Icarus Collaboration Meeting, FNAL, 14 May 2018

Present W.G. : L. Bagby, A. Braggiotti, S. Centro, C. Farnese, A. Fava,
A. Guglielmi, G. Meng, M. Nicoletto (Elec. Lab. leader), F. Pietropaolo,
S. Ventura

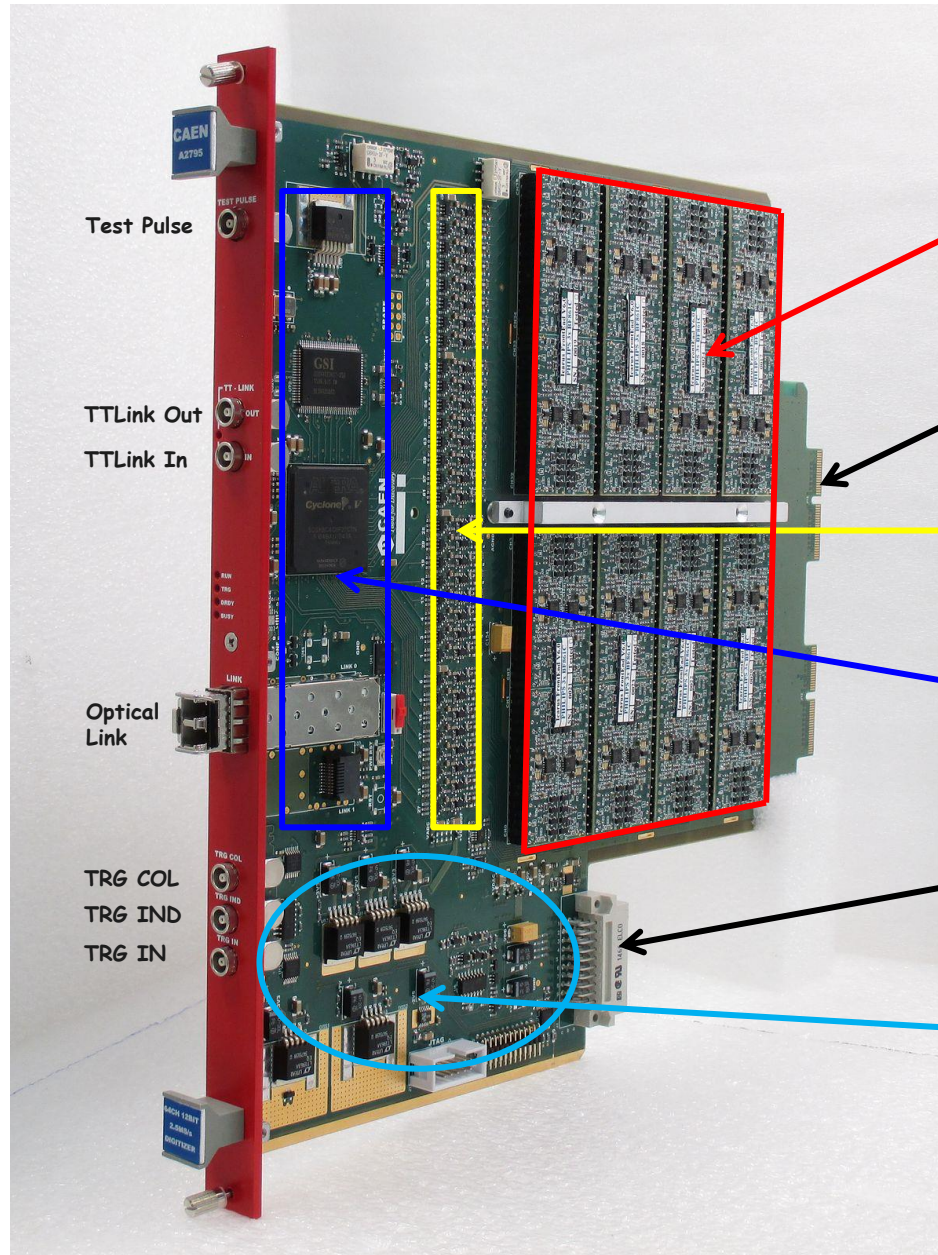
... more people welcome!

ICARUS readout electronics

- ❖ One mini-crate, mounted on the flange, can host 9 boards serving 576 channels, 64 channels each.
- ❖ The boards are directly connected to the proprietary flanges.
- ❖ Each board hosts 64 front-end low noise charge sensitive pre-amplifiers, 64 serial 12 bit ADC (2.5 MHz), 0-3.3V rail to rail input range, FPGA, memory, optical link interface...
- ❖ The backplane of the crate distributes the power supply and local control signals.



The 64-channel electronics board (A2795)



Eight preamplifier modules
(64 channels)

Signal connector from wires

64 serial ADC

Digital part: FPGA, memory,
optical link interface

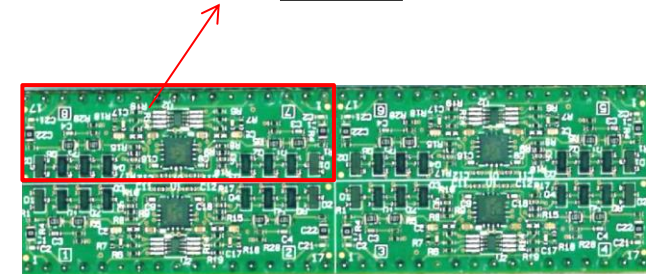
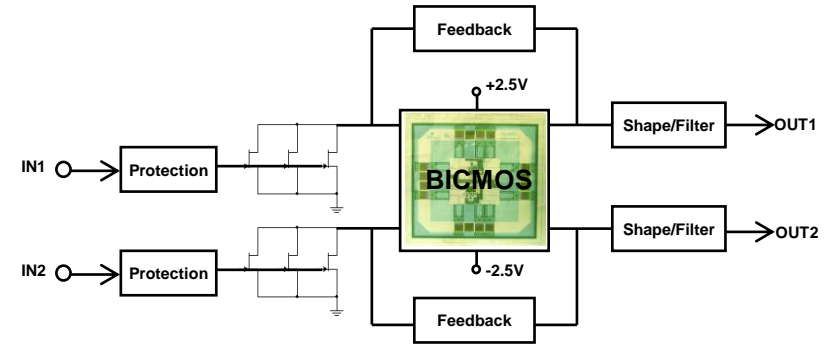
Backplane connector for PS
and local control signals

Voltage regulators

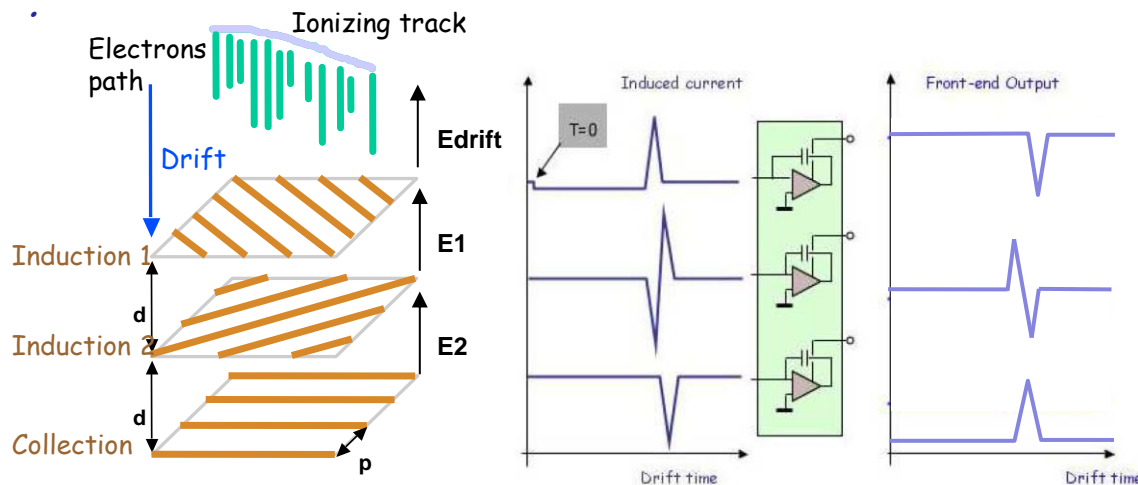
Shielding

ICARUS preamplifier and signals

- ❖ Three jFet are connected in parallel to obtain g_m in the order of 45 mS.
- ❖ Same pre-amp response (shaping peak time and gain) both for collection and induction signals.
- ❖ Adoption of a smaller package for the custom BiCMOS dual channel amplifier.
- ❖ The gain of the front-end amplifier and filter is $3V/300fC$. The 12bit ADC input range is 3.3V with a least count equivalent to ~ 500 electrons. This value matches with the amplifier noise of ~ 1000 electrons with an "equivalent" detector capacitance of $\sim 270pF$ (wires plus cables). Paper describing electronics in detail is ready: <https://arxiv.org/abs/1805.03931>



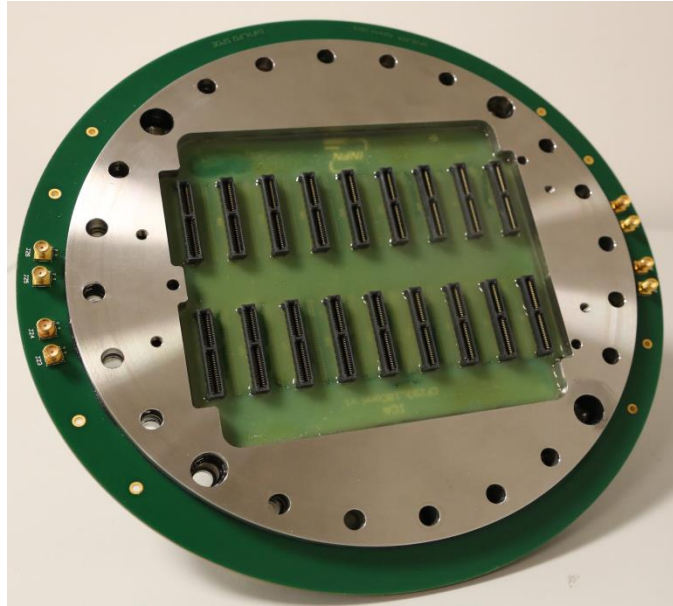
8-channel Preamplifier module



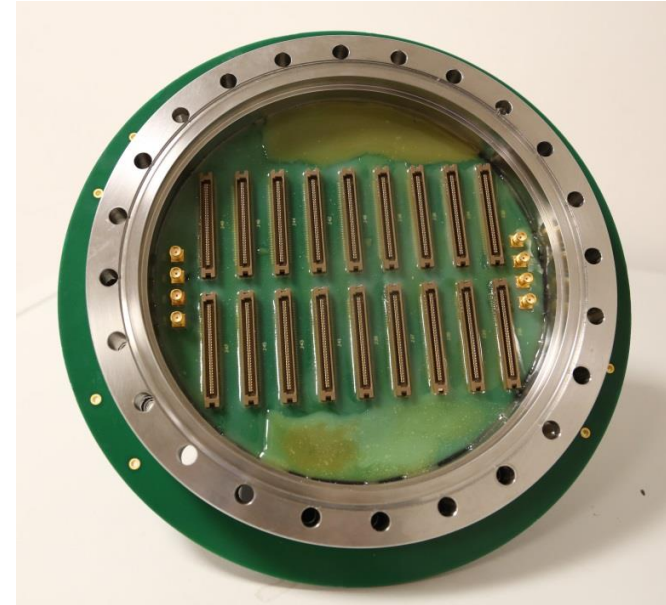
- ❖ All views (including Ind2) are read out with pole-zero cancellation circuit, shaping peak time $t = 0.6\mu s$ ($C_d = 0$).
- ❖ Short shaping peak time preserves bipolar signals allowing for numerical integration of the digitized output.

Flange

External side

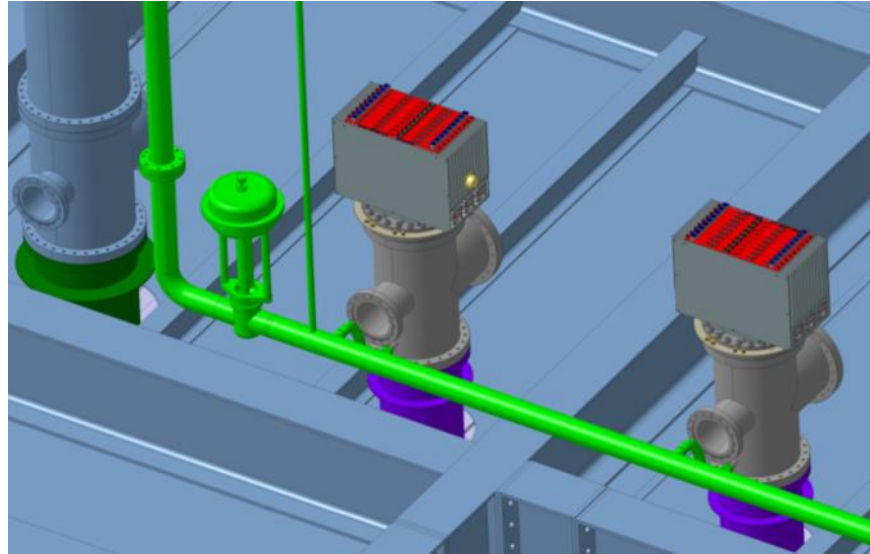
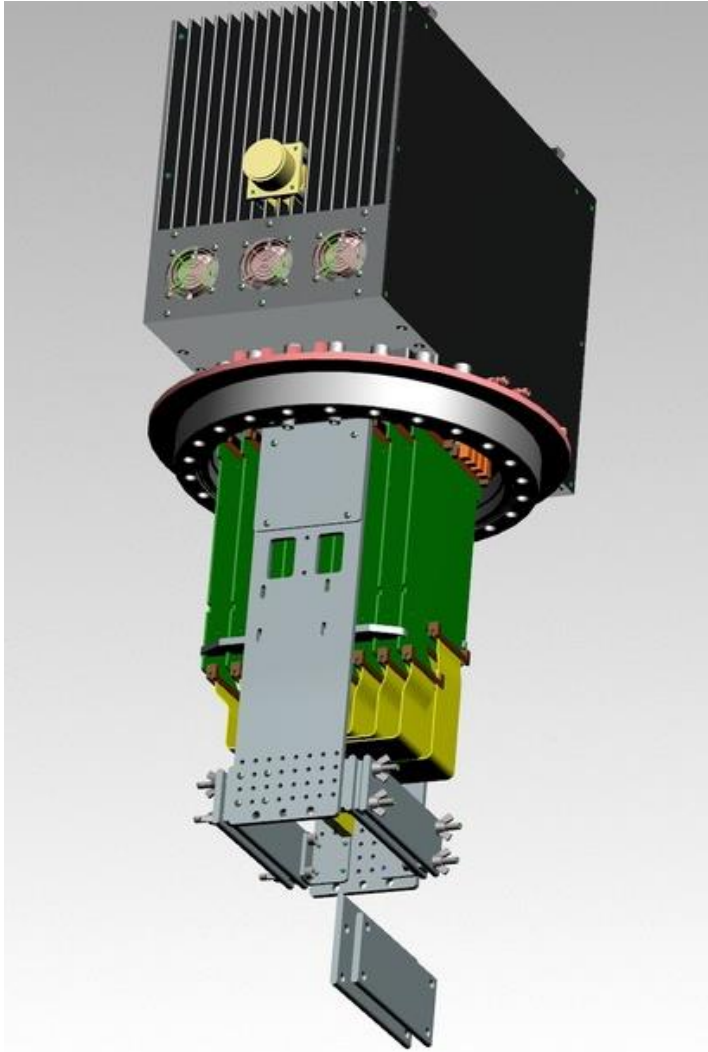


Internal side



- ❖ Custom made UHV high technology (no through-going holes, electrical connections through staggered PCB layers)
- ❖ 18 connectors (32 channels each) for a total of 576 channels.
- ❖ External side: connectors for CAEN boards insertion.
- ❖ Internal side: SMD connectors to receive decoupling boards or cables.
- ❖ 8 additional SMA connectors for test pulse distribution and wires biasing ($\sim \pm 500V$).

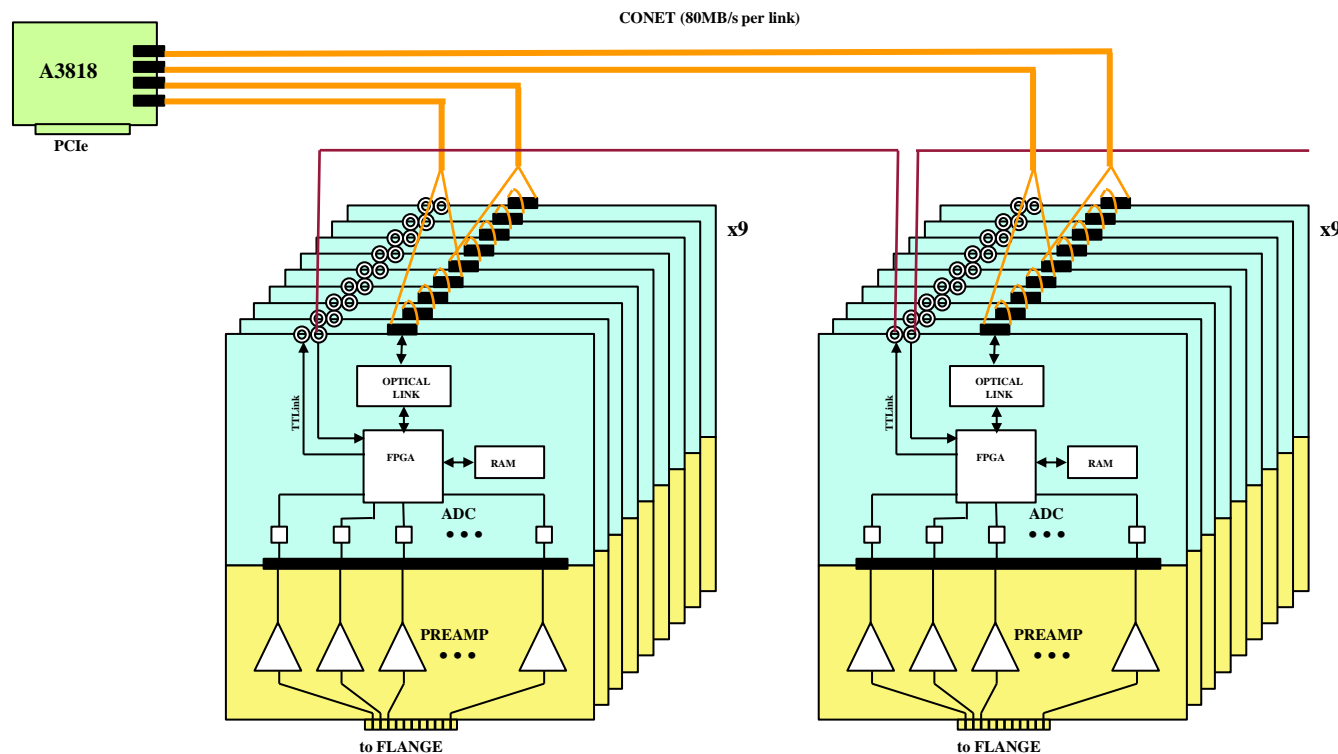
Flange rendering



- ❖ **Provisional test of decoupling boards and mechanics of the cards cadge (inner side of the flange).**

DAQ architecture

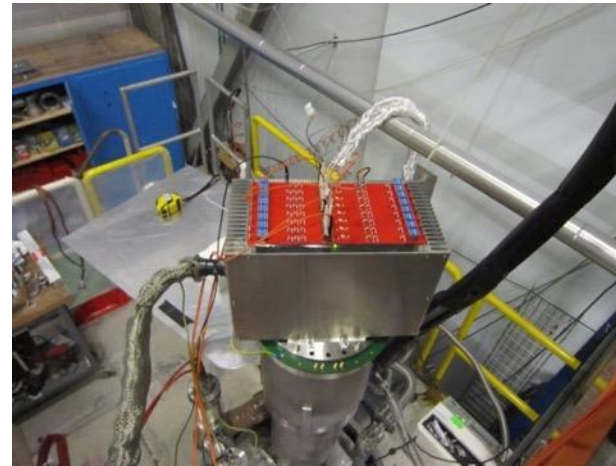
- ❖ The system provisionally uses the CONET transfer protocol.
- ❖ Each mini-crate (flange) will require two CONET loops.
- ❖ Each A3818 (CONET interface) can handle 4 loops (2 flanges).



Test facility in CERN (50 liter LAr TPC)



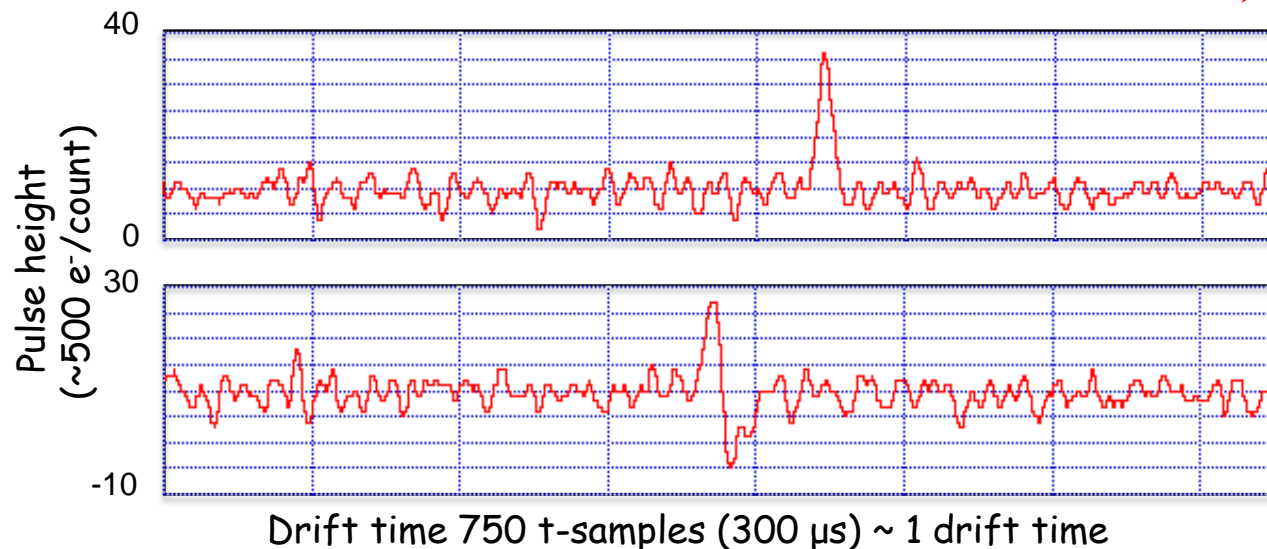
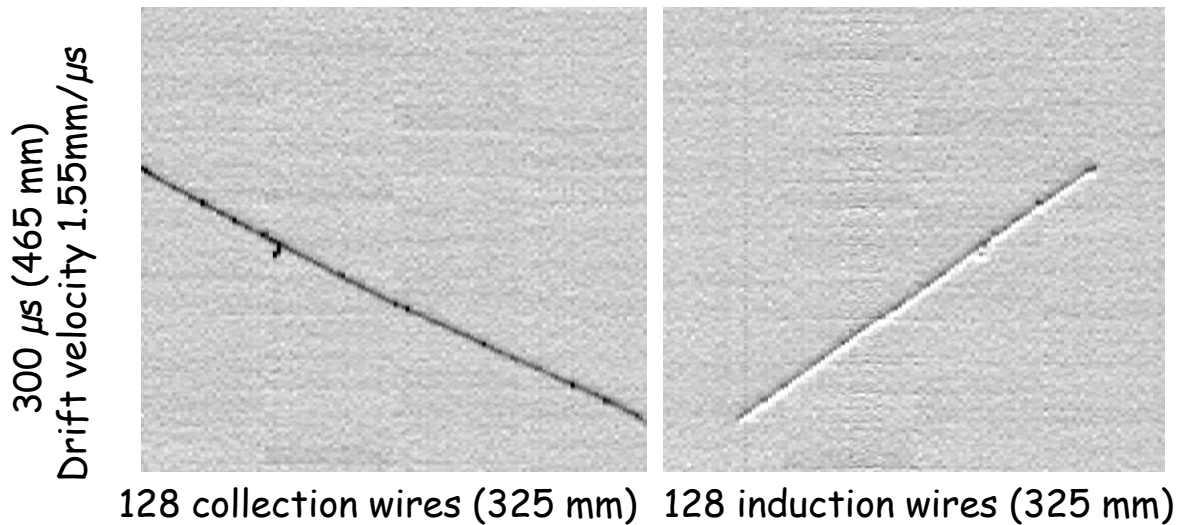
- ❖ 2 wire planes (ind, coll), 128 wires each;
- ❖ 2.54 mm wire pitch and 4 mm plane spacing
- ❖ 46.8 cm drift length, at 500V/cm.
- ❖ Cable length as in ICARUS collection plane, about 2.5m



Cosmic rays test @ 50 liter CERN LAr TPC

❖ Example of a single mip track event:

- Same ~ 2 ADC counts ($\sim 1000 e^-$) noise for both Collection & Induction;
- Unipolar Collection signal: ~ 25 ADC counts;
- Symmetric bipolar Induction signal with slightly reduced amplitude as expected.
- No filter applied to any data.

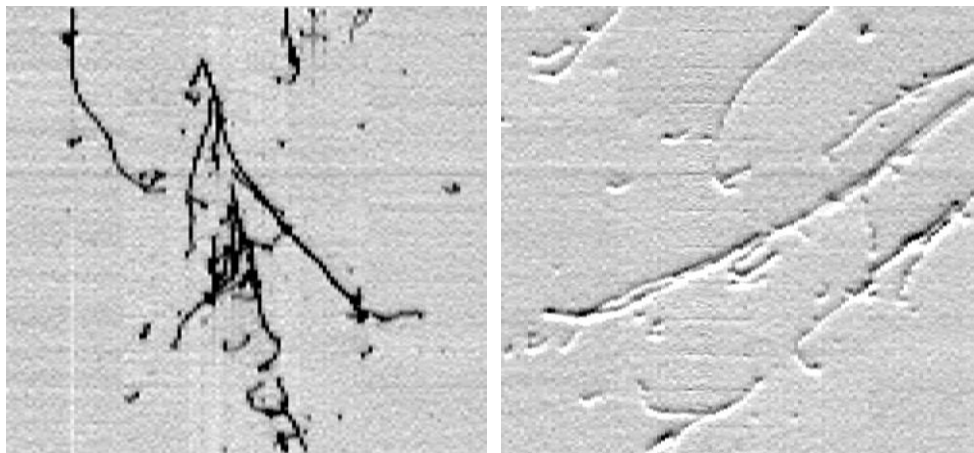


Collection signal (on a single wire)

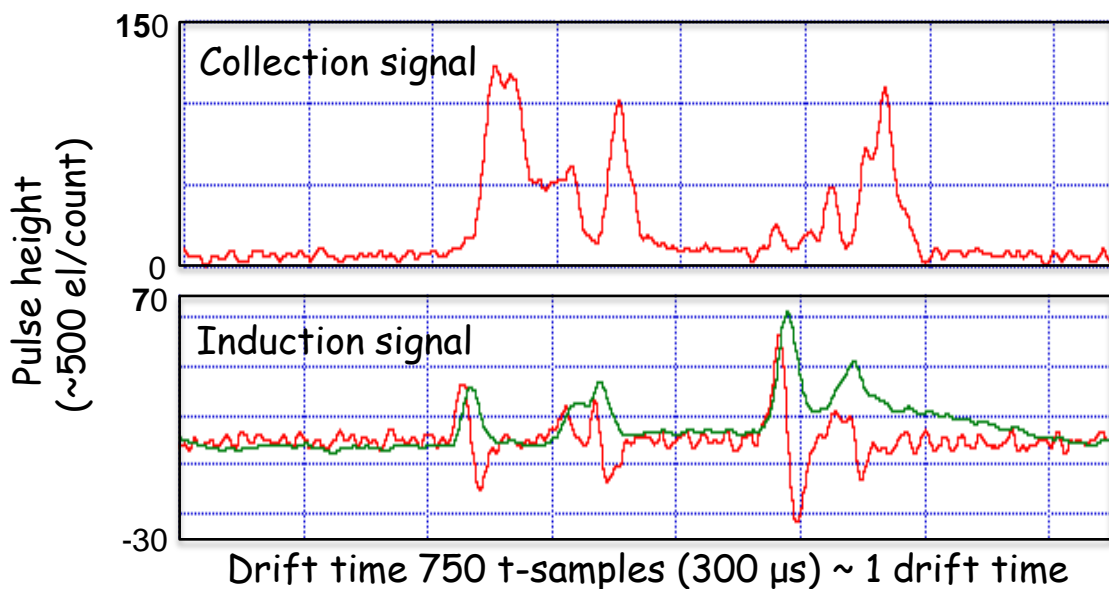
Induction signal (on a single wire)

Cosmic rays test @ 50 liter CERN LAr TPC

300 μs (465 mm)
Drift velocity 1.55mm/ μs



128 collection wires (325 mm) 128 induction wires (325 mm)

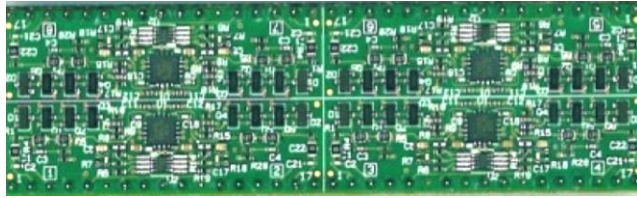


- ❖ A shower event developing along the drift direction in Collection;
- ❖ The optimized preamp architecture results in:
 - no signal undershoot even after large signals;
 - a very stable baseline;
 - unprecedented image sharpness and better hit position separation due to the faster shaping peak time.
- ❖ On induction plane, energy information easily recoverable with dedicated algorithms (e.g. running sum, green curve).
- ❖ No filter applied to any data.

Electronics Lab. facilities



Planning for parts delivery_1



❖ Amplifier status:

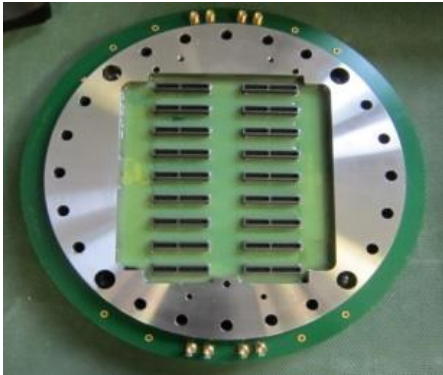
- ✓ 56,000 channels produced and tested in Elec. Lab. in Padova;
- ✓ 48,000 already delivered to CERN;
- ✓ 2,600 spares in production.



❖ A2795 delivery:

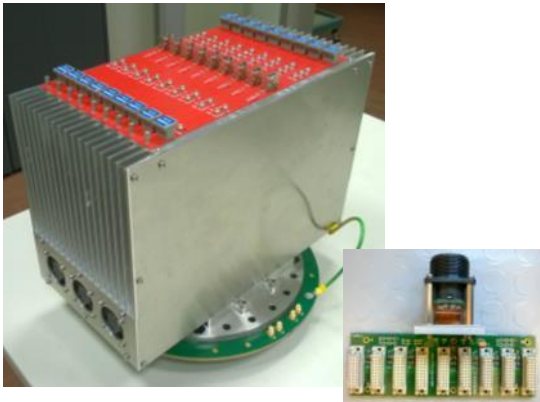
- ✓ 267 boards delivered, amplifiers mounted and fully tested;
- ✓ 150 boards now in CERN. Since 21 of May they will be equipped with amplifier and tested;
- ✓ A full T300 can be equipped;
- ✓ For the second T300 half of the boards will be delivered by October 2018.

Planning for parts delivery_2



❖ Flanges status:

- ✓ 40 ready;
- ✓ Full delivery in FNAL by August 2018.



❖ Mini crates and backplane status:

- ✓ 105 mini crates already delivered to CERN;
- ✓ All PCB backplanes will be delivered to CERN by June 2018;
- ✓ Backplane will be assembled and installed in mini crates by October 2018.

❖ Power Supply status:

- ✓ 24 will be ready by June 2018;
- ✓ Full production will be delivered to FNAL by November 2018.



Planning of activities

- ❖ Installation of the electronics in mini-crates, mounting of the decoupling boards cage inside the flange, wire cable interconnection and closing of the flange is a critical task to be performed at FNAL by qualified people.
- ❖ Power supply (low voltage and wire biasing) interconnection, together with fiber readout and trigger signals distribution (through fan-out) is another major task that needs contributions.
- ❖ From the moment one has a *working electronics* to the moment one has it installed and *working onto the detector* a major work has to be done!