Front-end Electronics of FoCal-E PAD detectors

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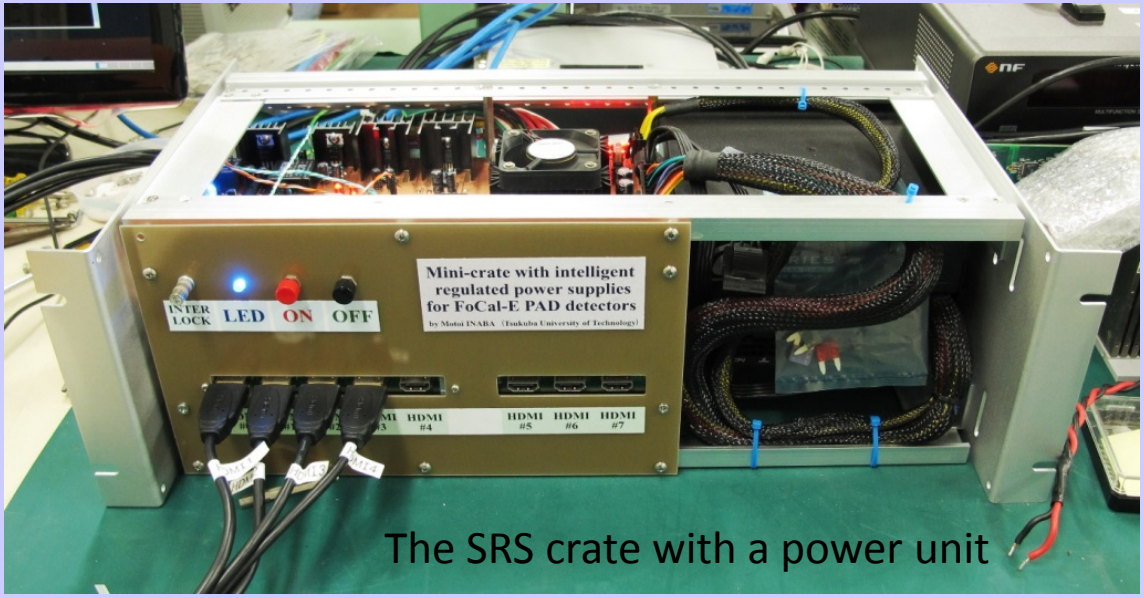
Background

As one of the ALICE detector upgrade plans, we are going on testing the FoCal-E PAD detector prototype and developing some peripheral electronics in 2014 and 2015.

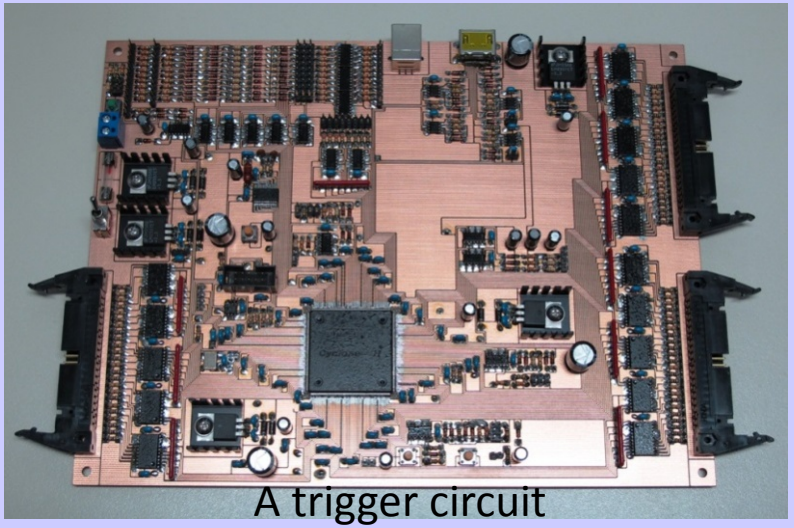
For example,

- The SRS crate with a power unit,
- Temperature monitors, (Automatic shutdown)
- Isolated regulated LV power circuits,
- Isolated HV generators,
- Trigger circuits, etc.

Temperature monitors

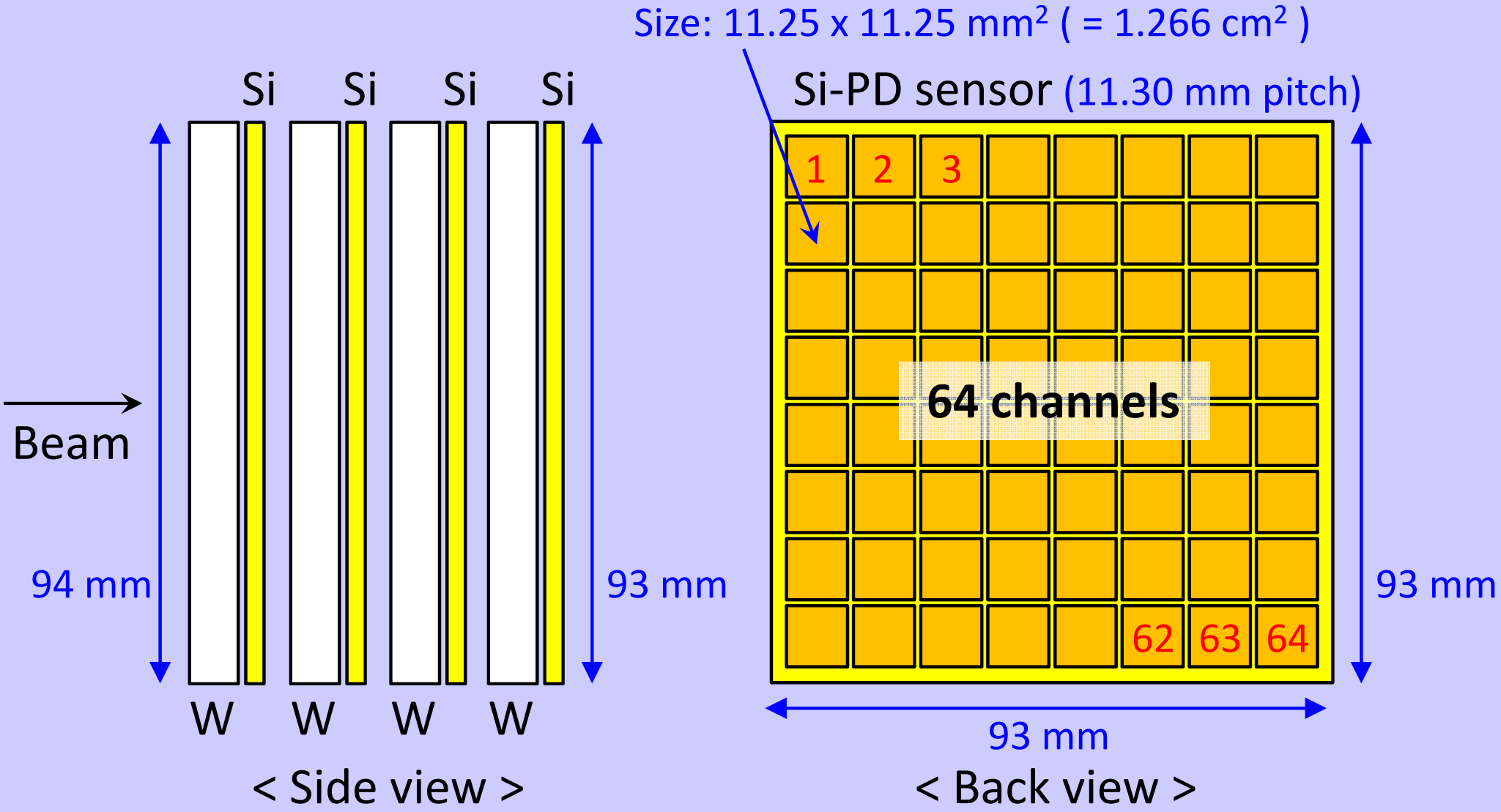


The SRS crate with a power unit


A trigger circuit

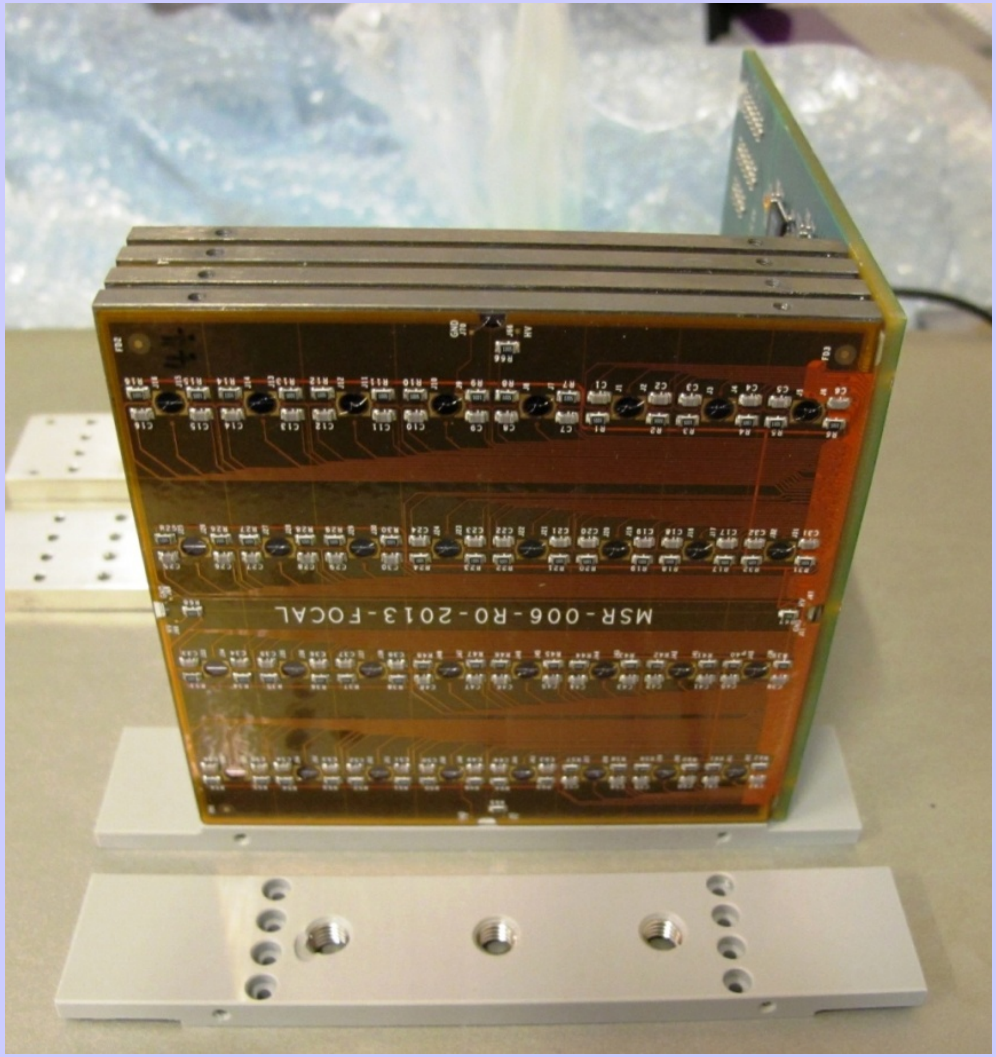
FoCal-E PAD module (prototype)

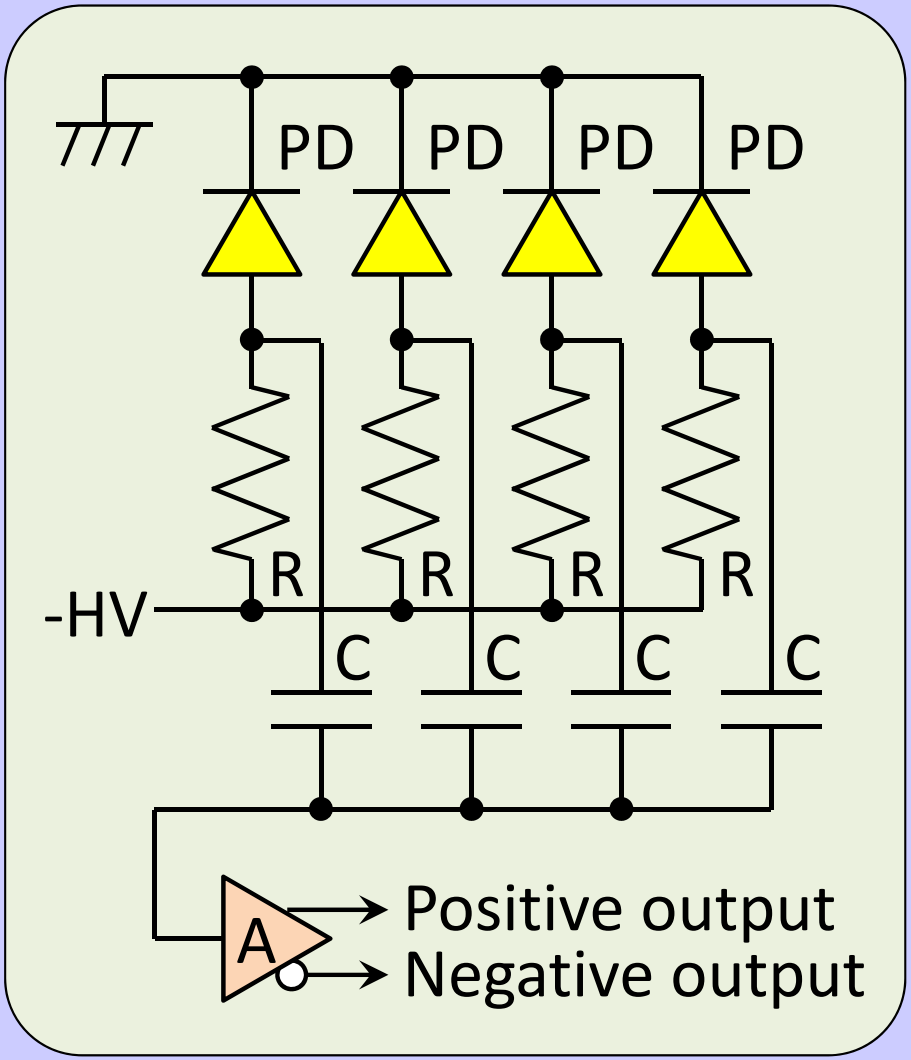
A FoCal-E PAD detector is the Si-W calorimeter. One module has 4 pairs of tungsten tiles (t = 3.5 mm) and Si-PD sensors (t = 0.5 mm).



FoCal-E PAD module (prototype)

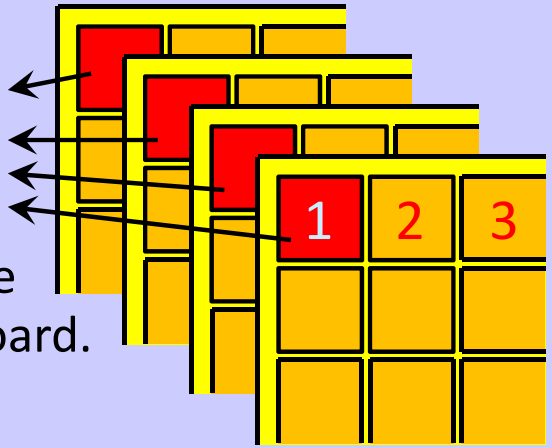
Signals of 4 Si-PDs are summed and amplified. And, it is given as two single-end signals with attenuation factors of 1/1 and 1/16.





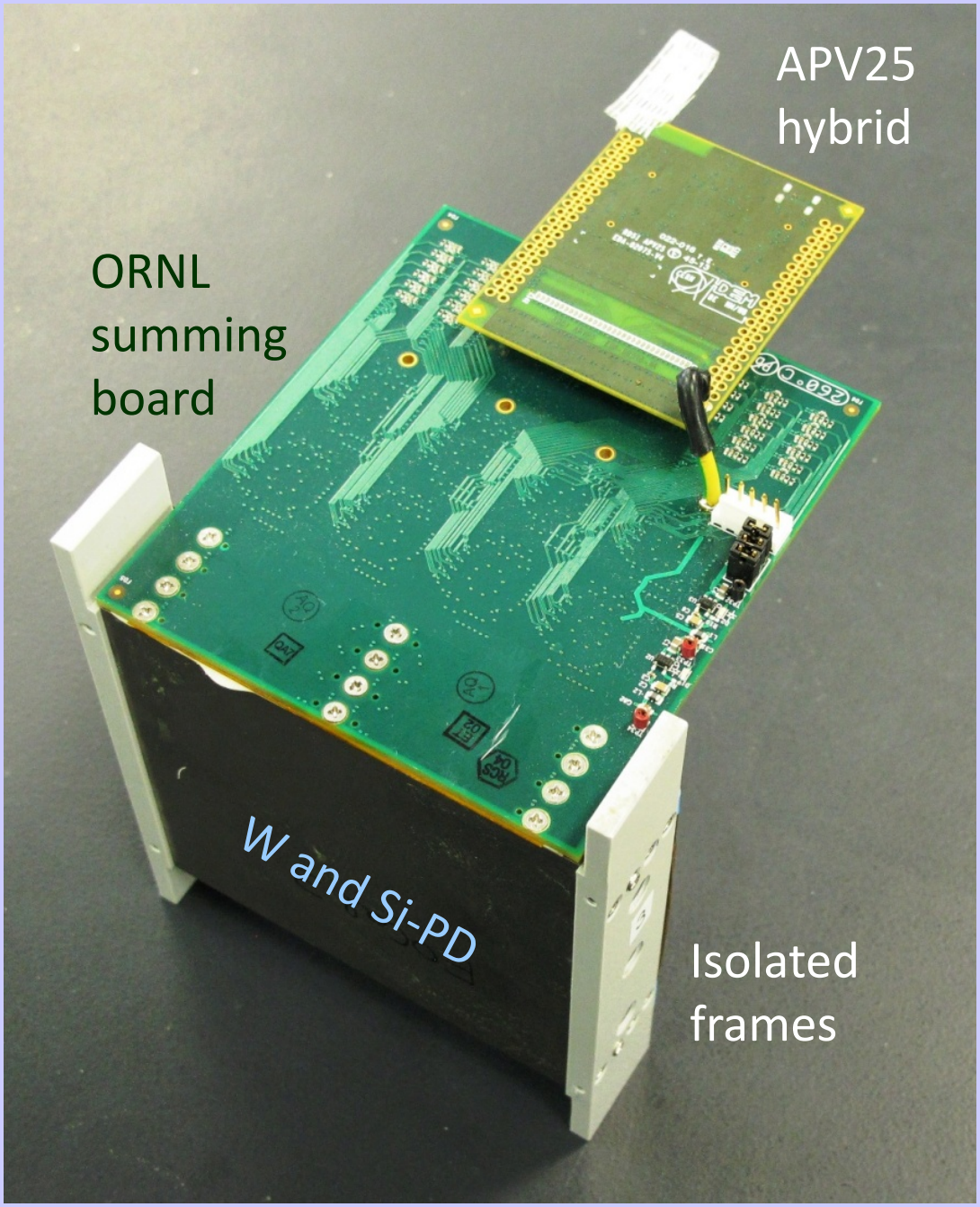
Readout system

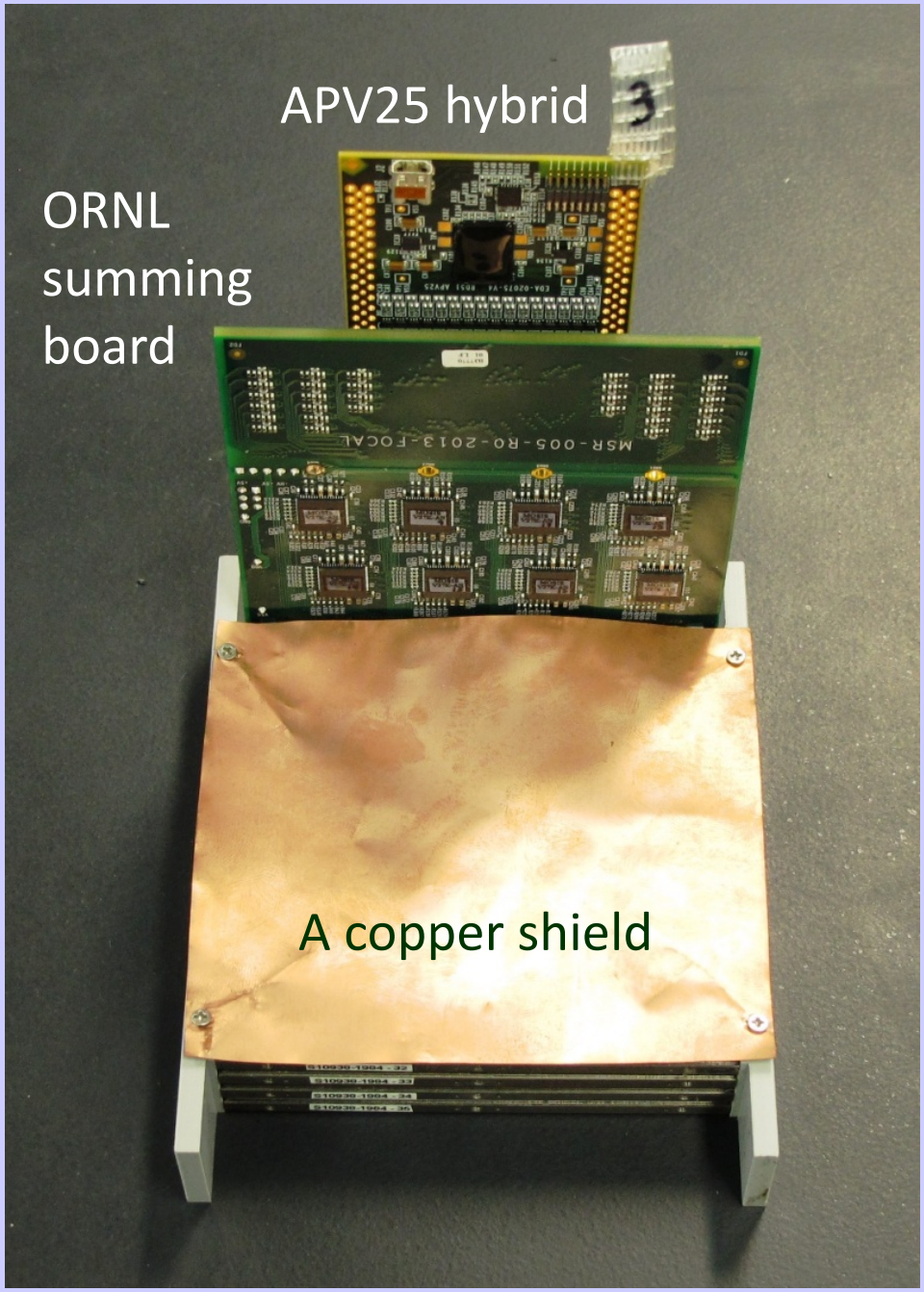
In order to readout waveforms of 64 analog signals per module, we used ORNL summing boards and SRS DAQ system with APV25 hybrid boards so far.



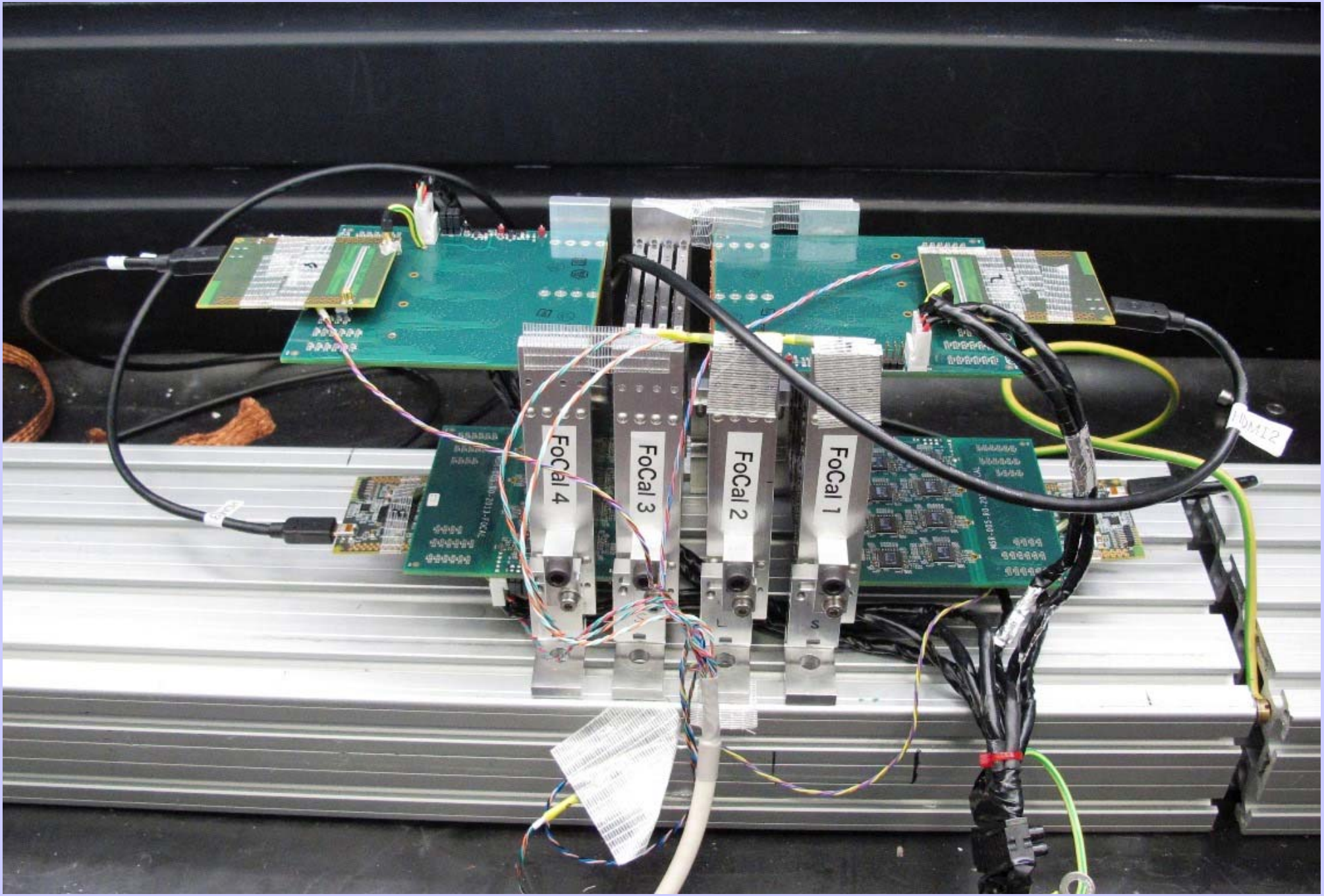
Signals of 4 Si-PD with the same channel ID on different layers are summed at the first stage of the ORNL summing board.

FoCal-E PAD module prototype

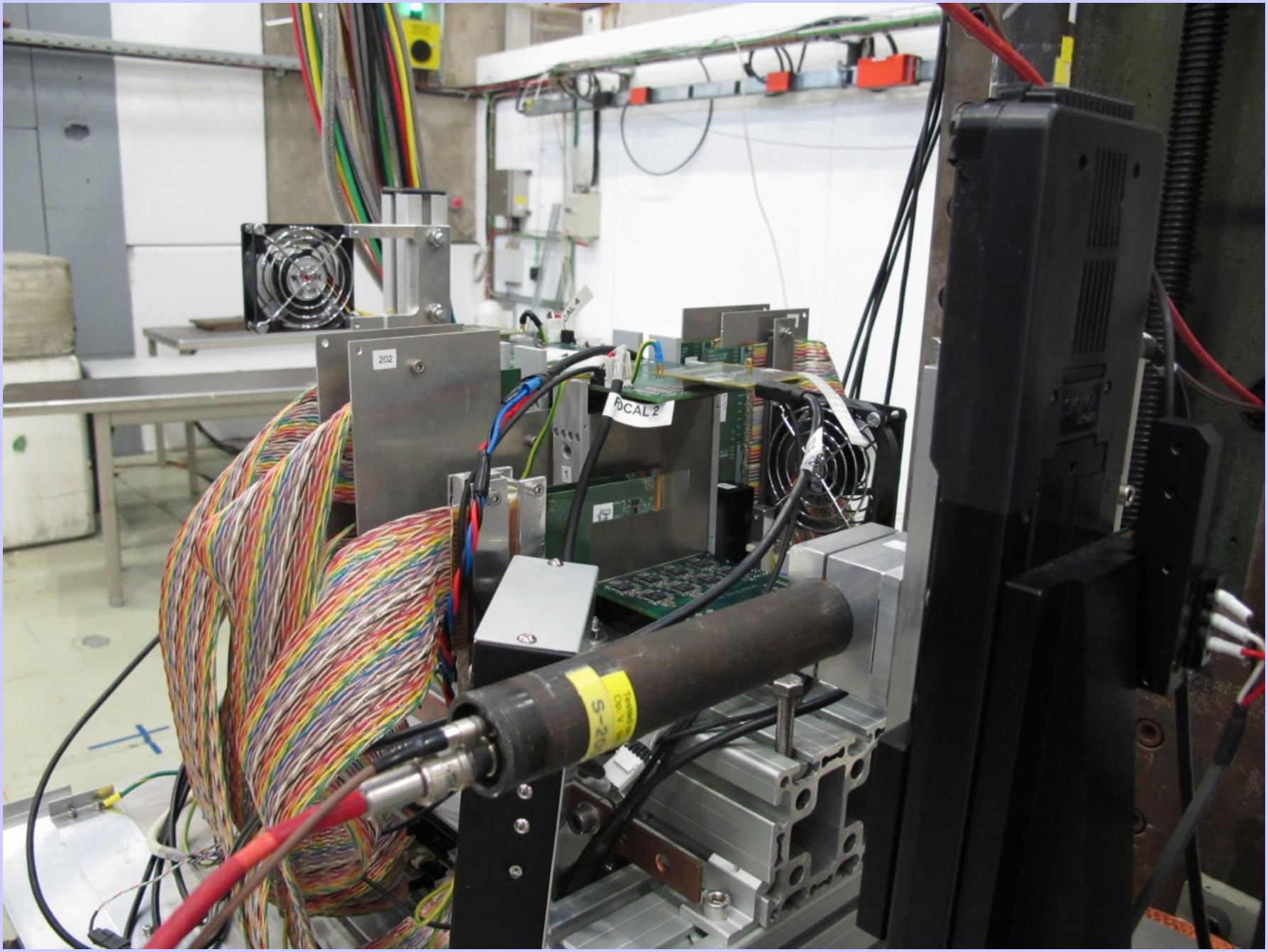




4 FoCal-E PAD modules

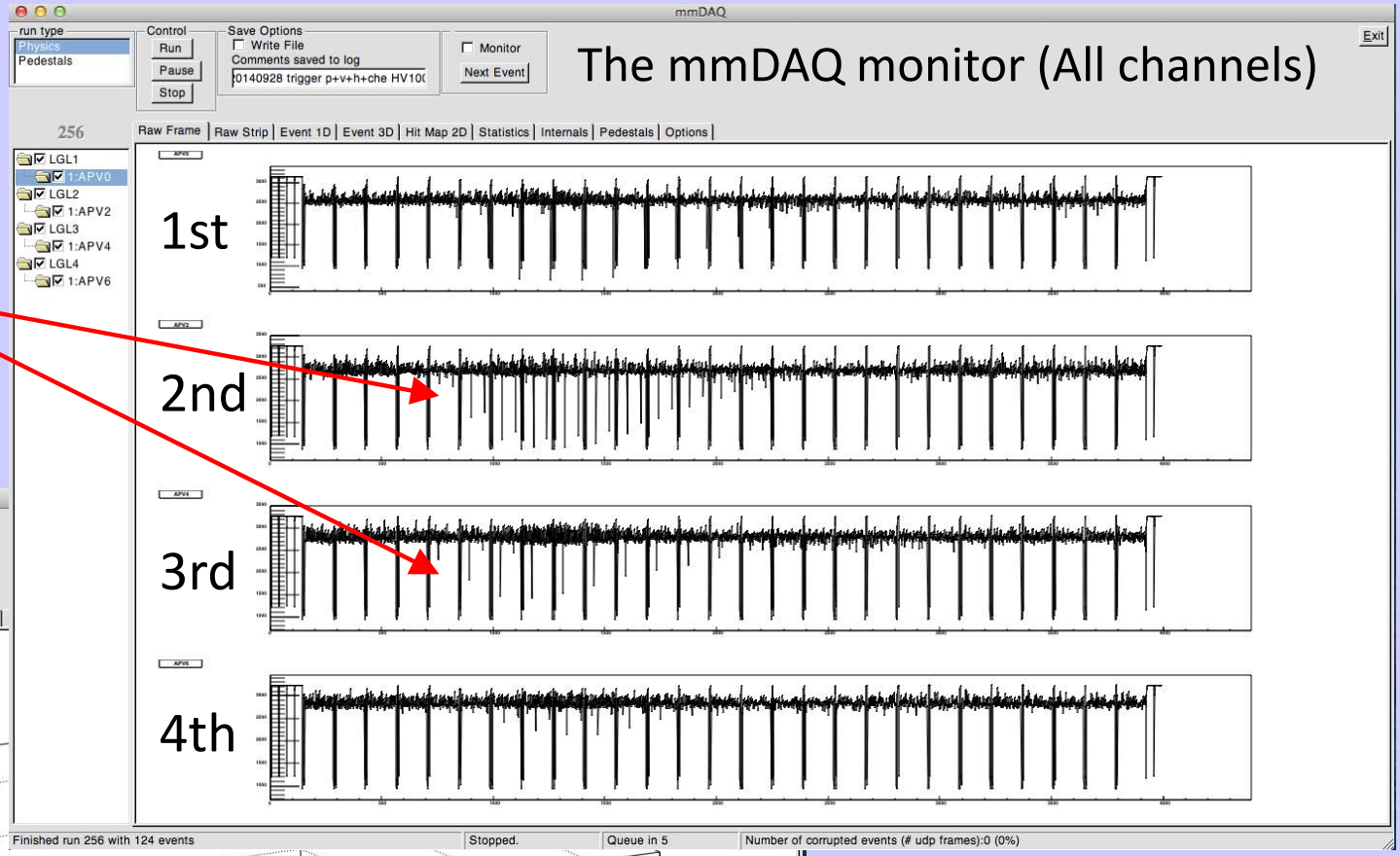


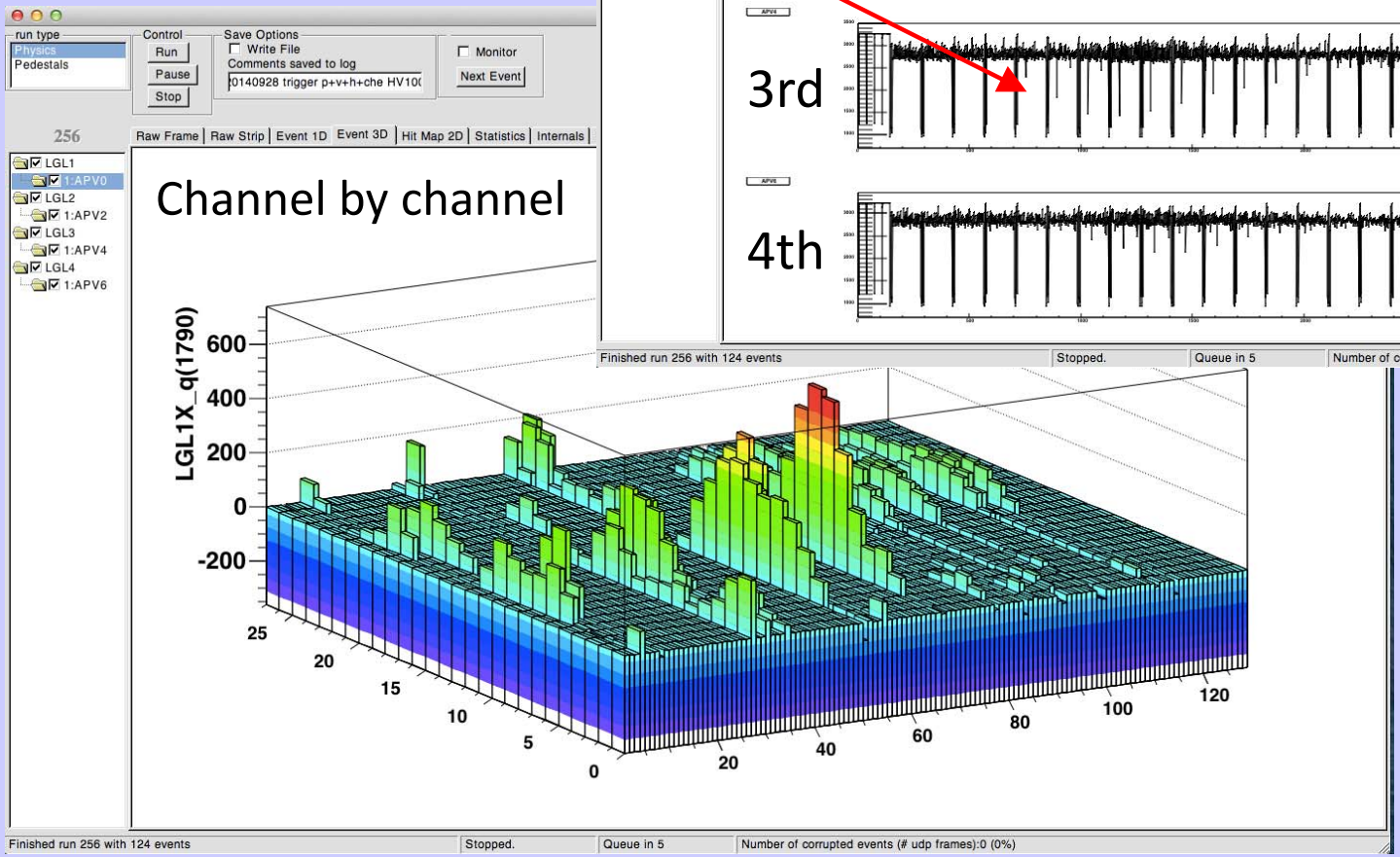
FoCal-E prototype at CERN PS complex



Signals (One trigger event data)

2nd and 3rd FoCal-E PAD modules had large signals according to the EM shower.



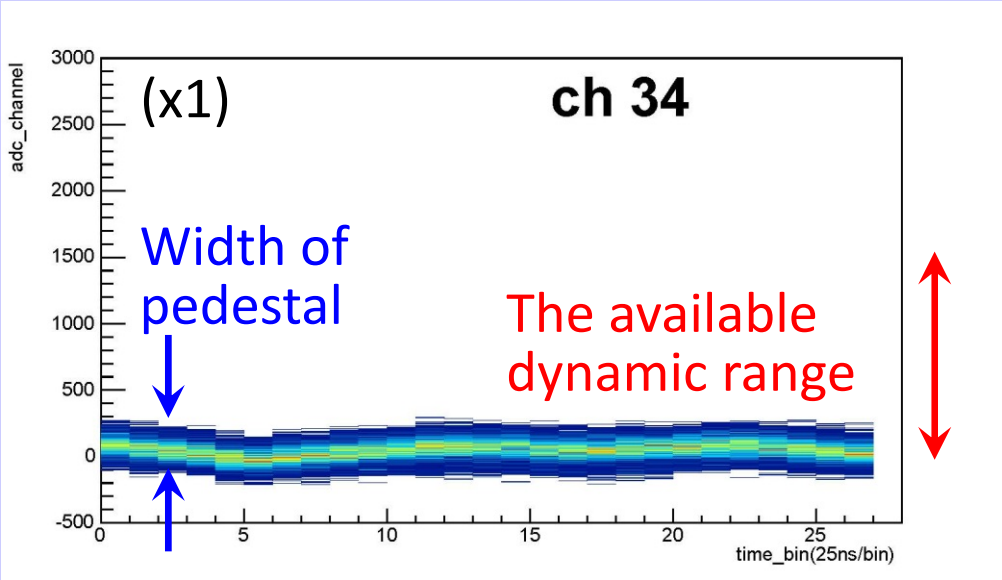


The APV25 hybrid has 128 input channels.

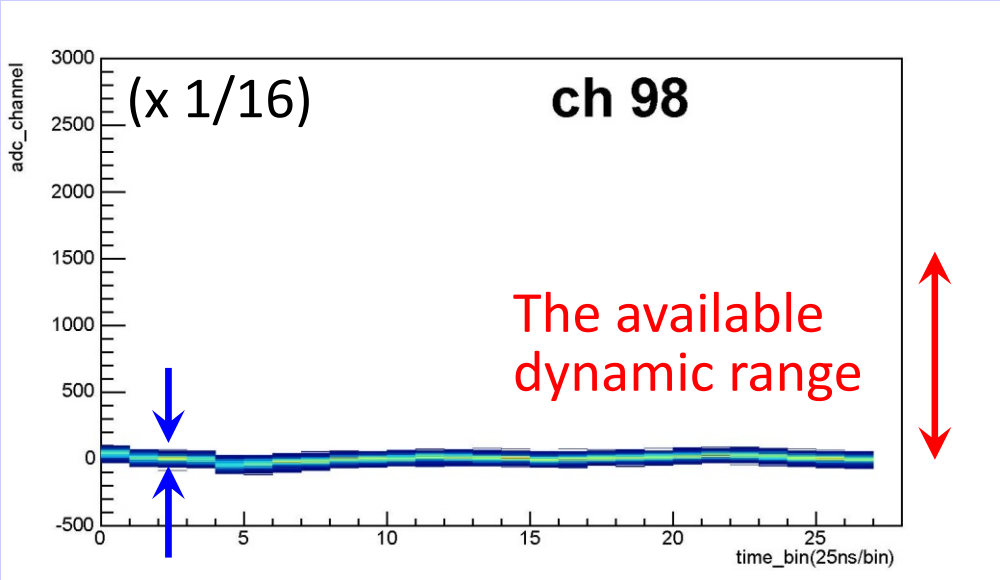
Ch.1 - Ch.64 :
Positive signals (1/1)

Ch.65 – Ch.128
Negative signals (1/16)

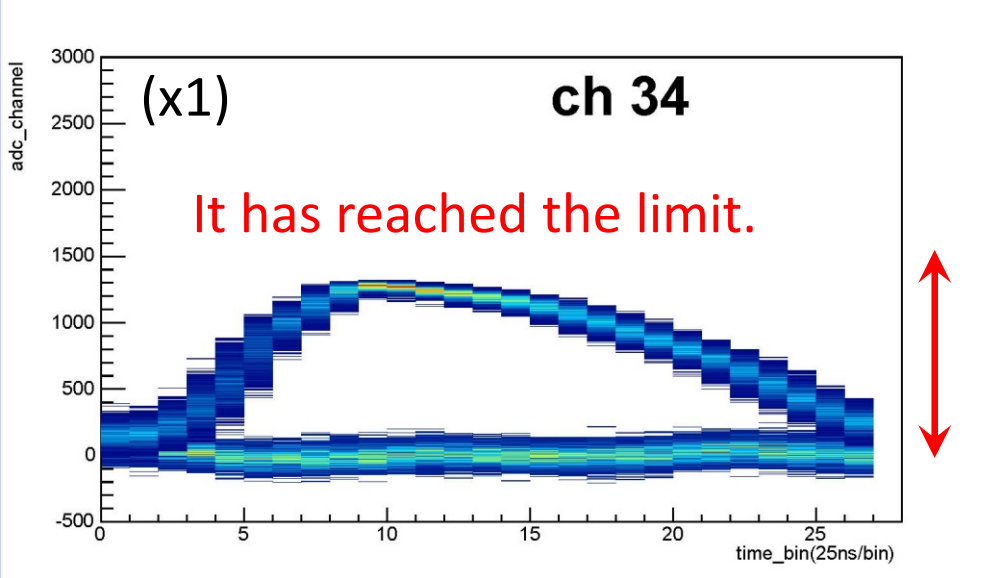
Signals (Multiple trigger events data)



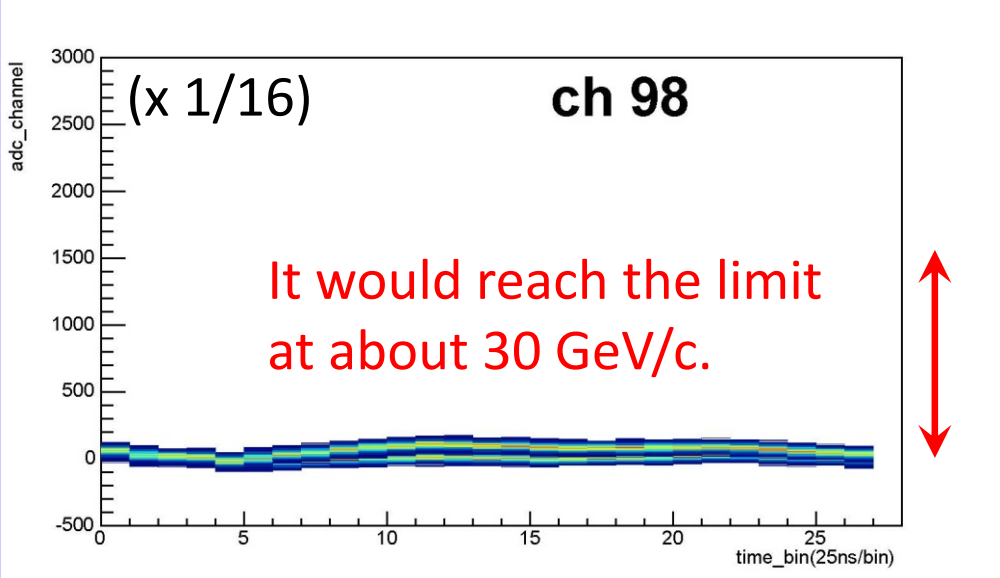
Positive signals (0.5 GeV/c)



Negative signals (0.5 GeV/c)



Positive signals (5.0 GeV/c)



Negative signals (5.0 GeV/c)

Wider dynamic range and better S/N

In order to measure larger signals under the higher energy, wider dynamic range is required.

It would need triple attenuation factors such as 1/1, 1/10 and 1/100 if APV25 hybrid boards are used for taking 500 Gev/c data.

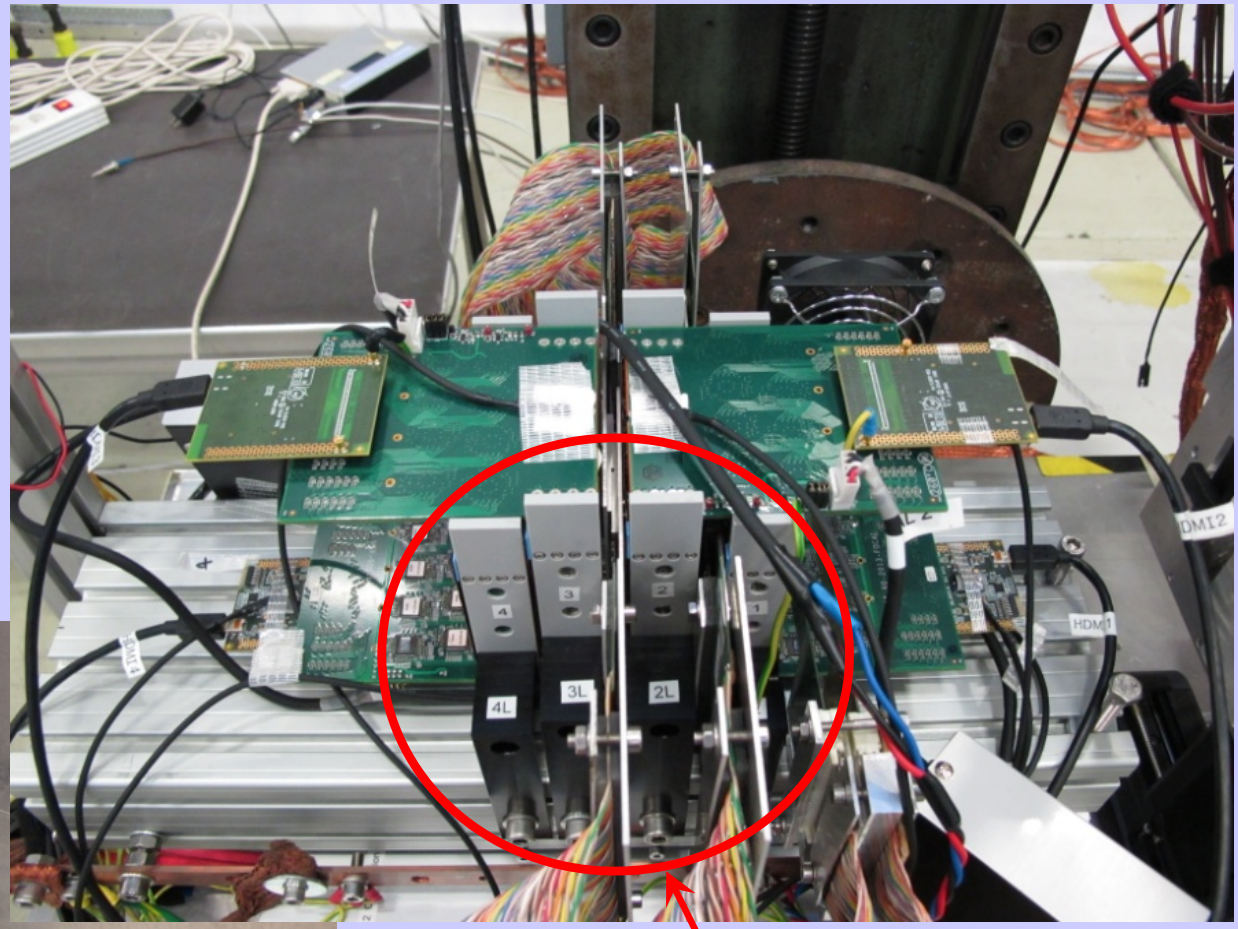
In order to measure smaller signals, it is necessary to reduce the noise level on signal lines. It would be strongly related with the energy resolution of the FoCal-E PADs.

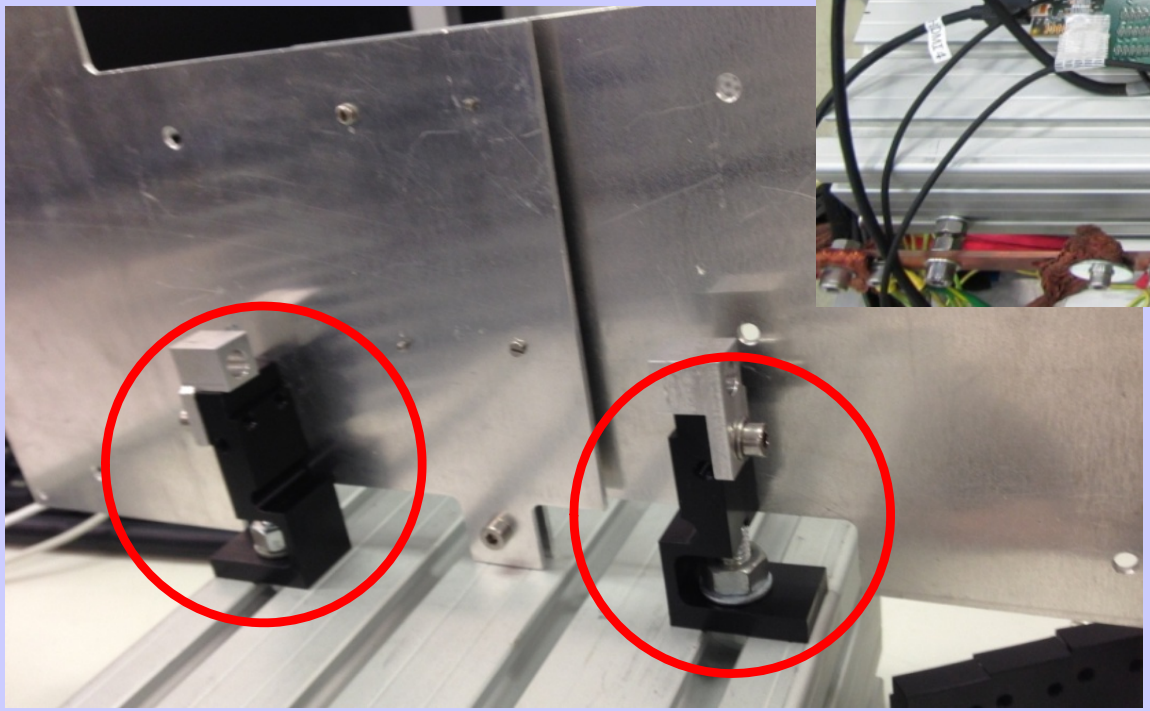
S/N was already improved to a certain extent using new isolated LV / HV circuits, new frames with the isolation coating (by Universiteit Utrecht) and better ground lines. However, we should make another attempt.

Through the advanced circuit simulation, some weak points were found in a current FEE design.

New frames for FoCal-E PADs

Much noise came from the ground frame to Tungsten tiles of the FoCal-E PAD modules that was connected with Cathode of Si-PD.





New frames with the Isolation coating fabricated by Universiteit Utrecht worked very well.

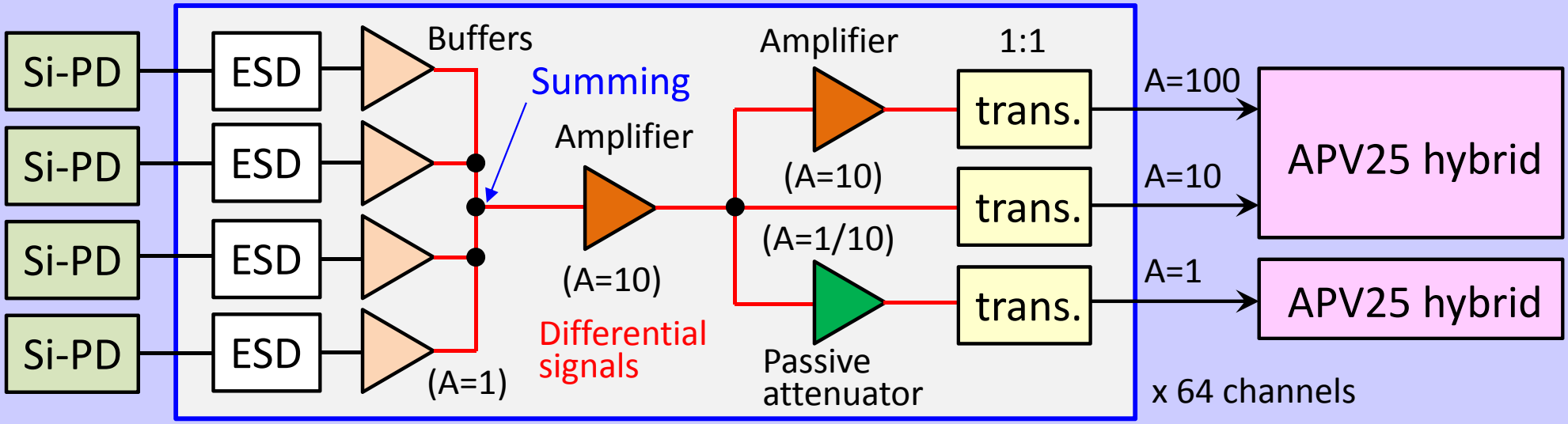
Other solutions

A summing board has a key to get the enough wide dynamic range.

➡ I started making **a new summing board** for the coming beam test at CERN SPS complex in September.

A new summing board includes

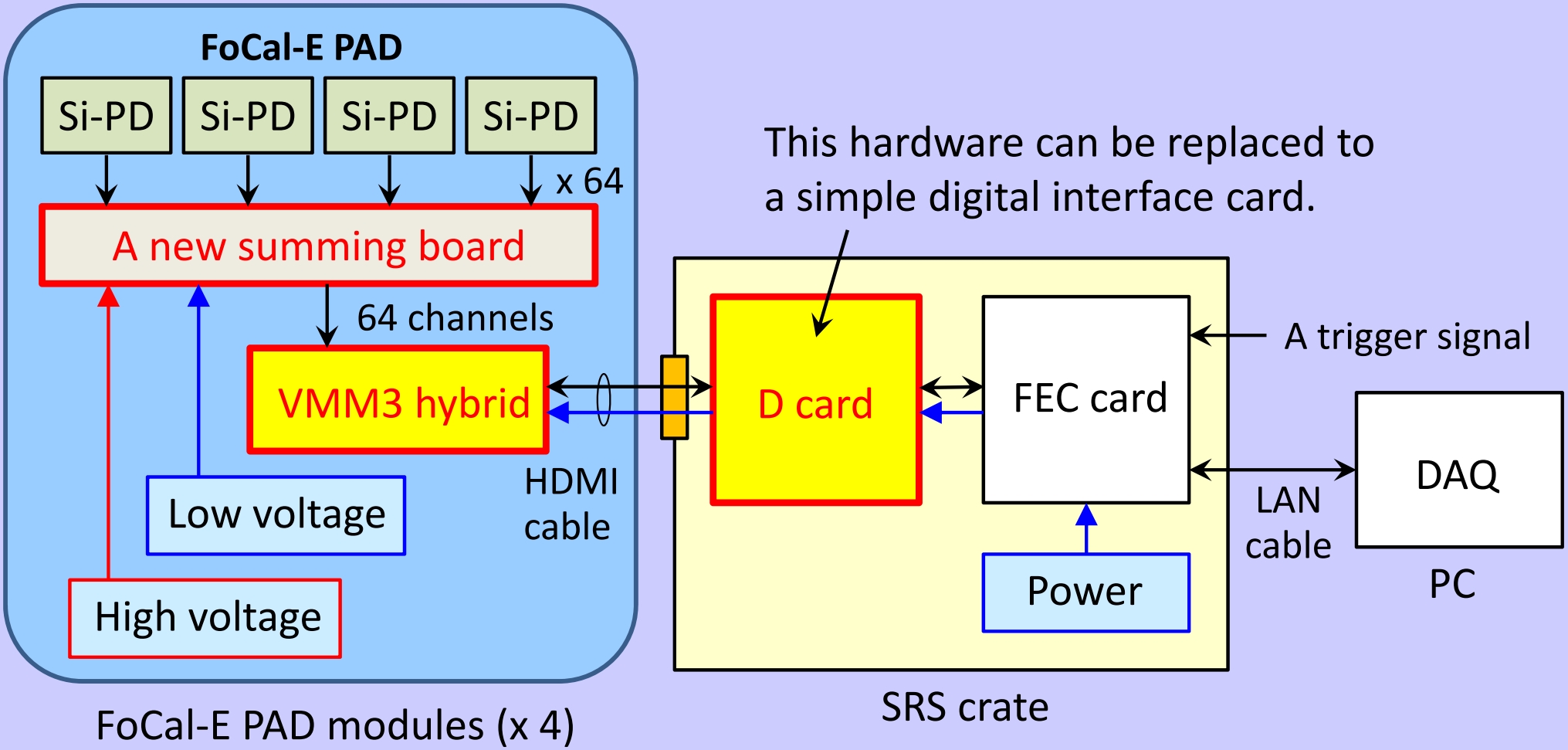
- voltage followers to improve the linearity of the summed signal
- triple amplification / attenuation factors (1, 10 and 100 times)
- the fully differential signal processing to improve S/N, and
- transformers to isolate the signal ground from the APV25 ground.



New readout system

As one of possibilities, we are thinking to use VMM3 hybrid boards instead of APV25 hybrid boards under CERN RD51 collaboration.

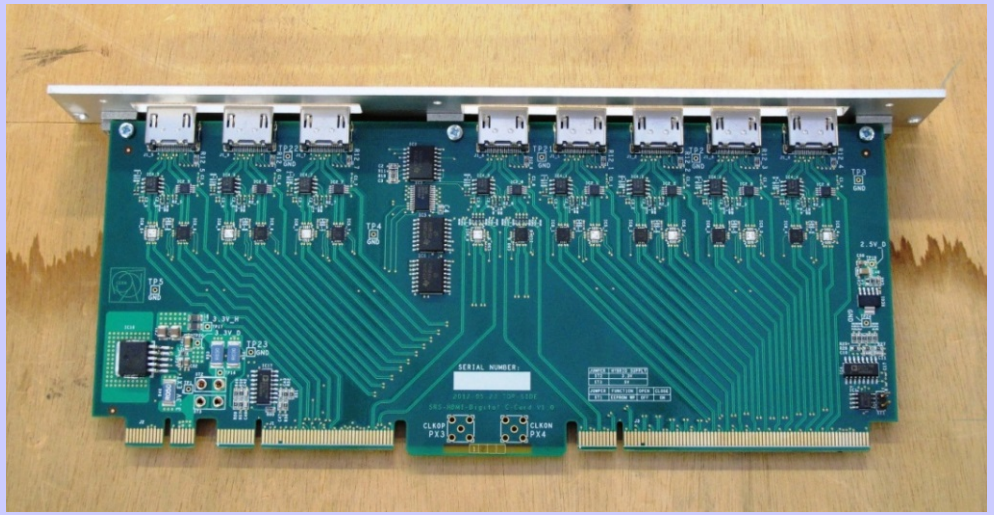
It is expected to obtain better S/N since the VMMx family ASIC has analog-to-digital converters.



VMM3 (after VMM2)

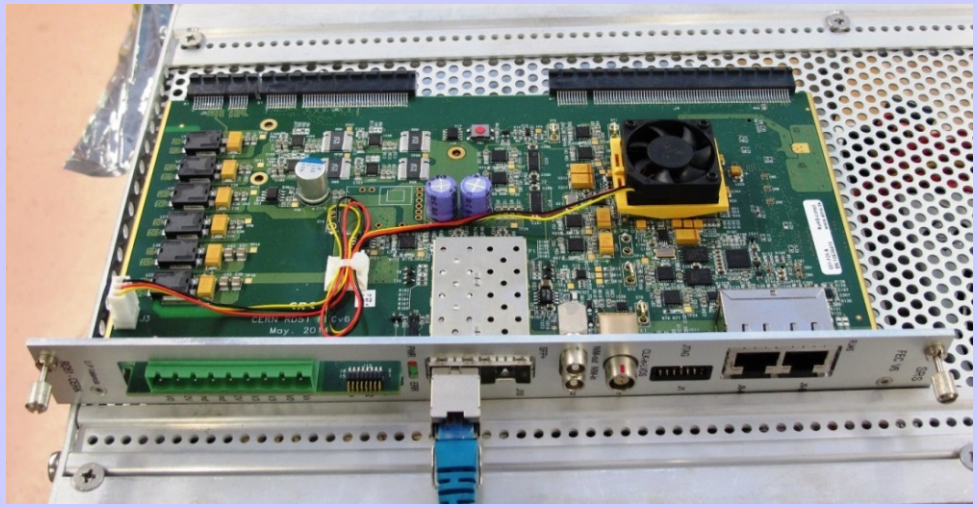
We can use the same FEC card continuously. The D cards (prototype) were reproduced in Japan in 2015. The new D cards will be available shortly.

The VMM2 hybrid prototype was tested in 2015 and the new VMM3 hybrid prototype for testing is under the fabrication.



D card

VMMx



FEC card

Thank you for your attention.