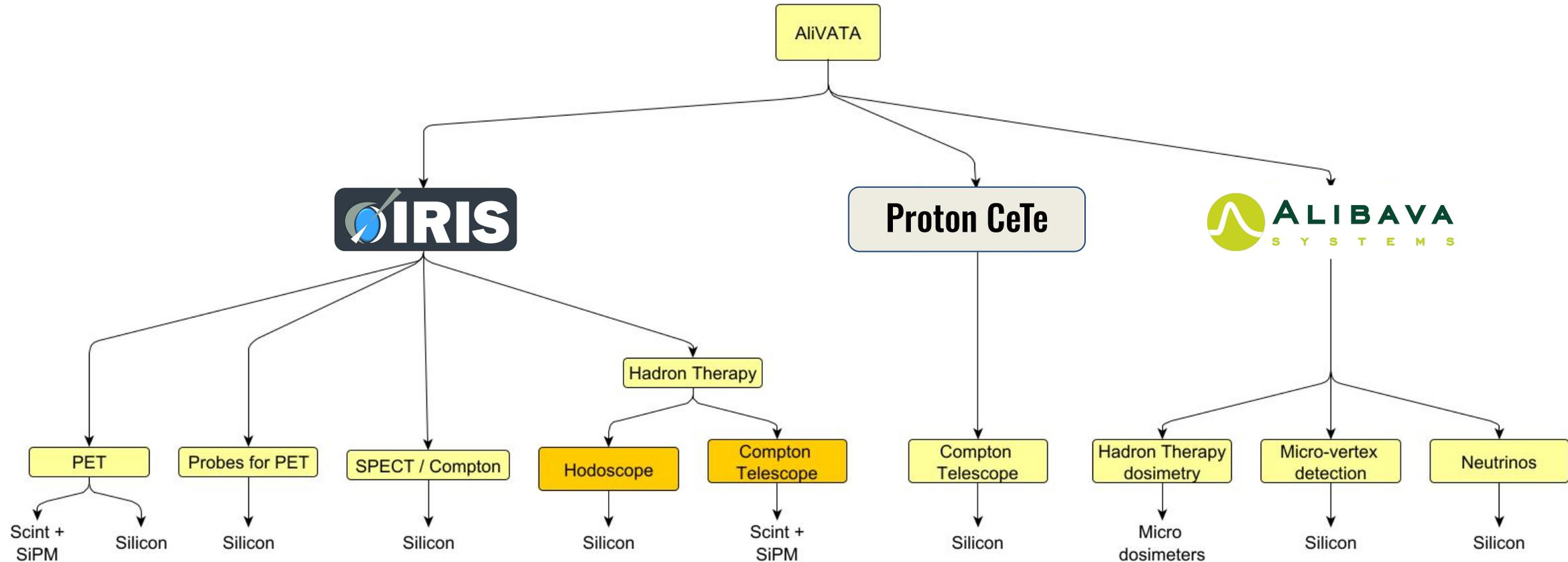

Sistema de adquisición para espectroscopía en Física Médica

Carles Solaz, Jose Vicente Casaña, Gabriela Llosá, Carlos Lacasta, Daniel López, David Hernández.

The AliVATA system



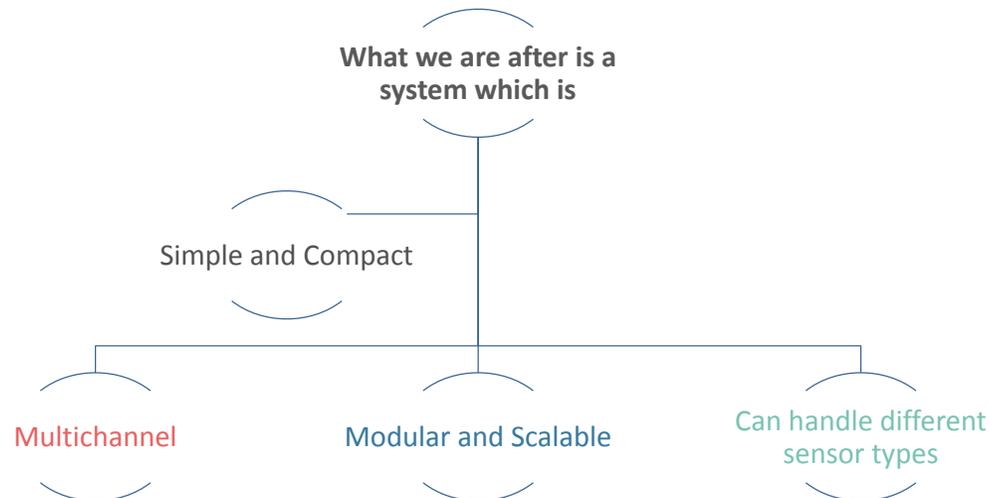
The AliVata system was born from a collaboration between ATLAS and IRIS groups @ IFIC.

They needed a DAQ system that could handle all of their different setups and sensor types.

Other applications took profit of the existing system which was customised for their specific requirements.

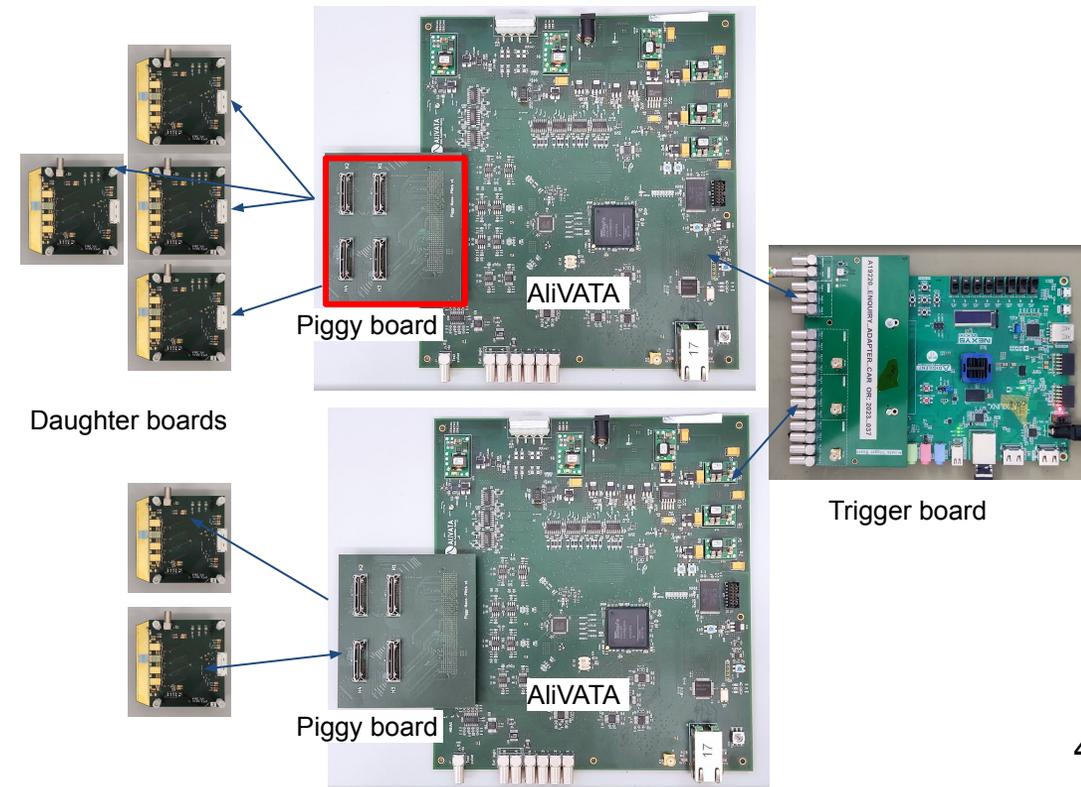
The AliVATA system

- Different applications with different requirements.
 - Different detector technologies with different
 - Number of channels
 - Number of detectors
 - Trigger strategies
 - Charge collected per channel (requiring different ASICs from same family)
 - **DAQ needs to be as flexible as possible**
- Development done under the different projects in the IRIS group and the Proton CeTe project at IFIC
 - Commercialization licensed to Alibava Systems



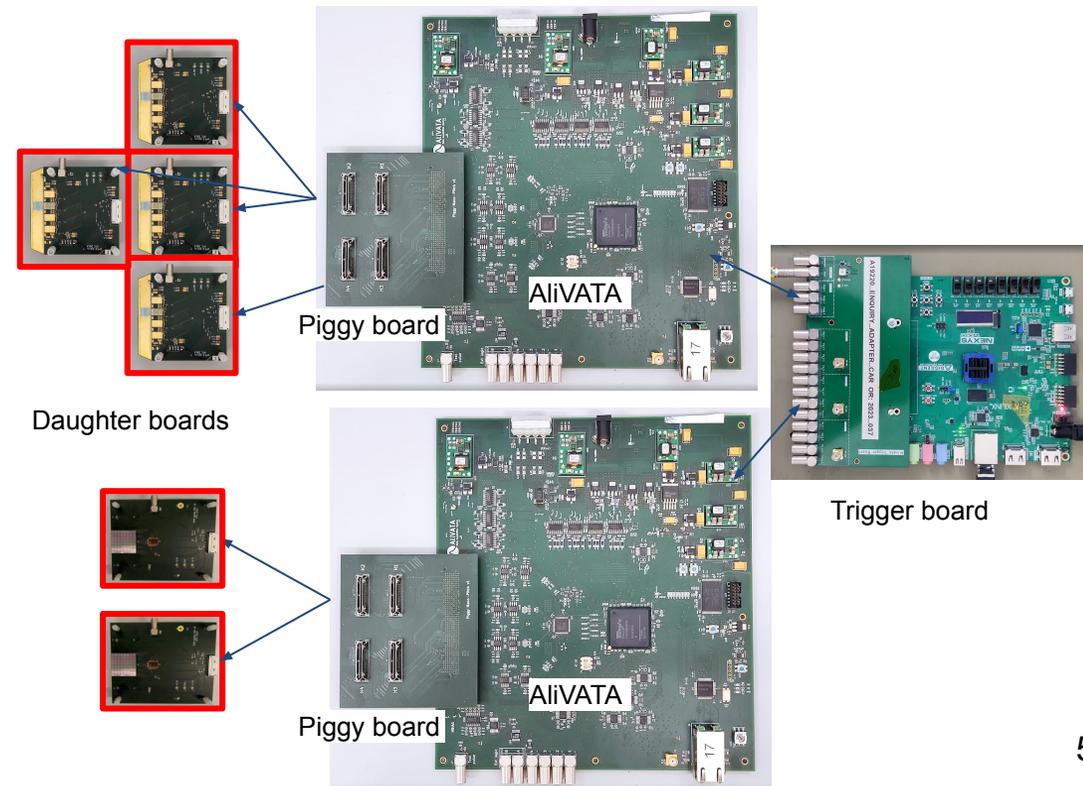
The AliVATA system

- Each AliVATA DAQ board has a high density connector for the piggy board that provides the connectors to the final application.



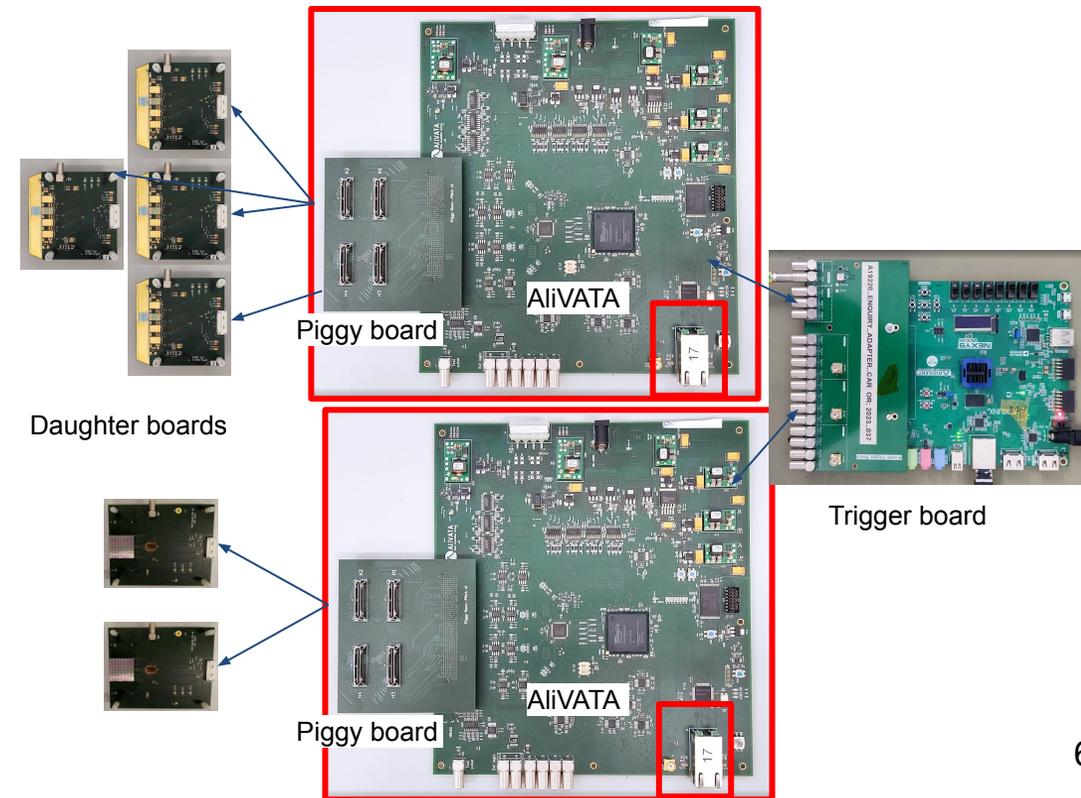
The AliVATA system

- Each AliVATA DAQ board has a high density connector for the piggy board that provides the connectors to the final application.
- The detectors and the readout ASICs are mounted on the Daughter boards.
- Up to 4 Daughter Boards (DB) can be connected to the AliVATA DAQ board.
 - The cables and connectors can be chosen depending on the application requirements.
- Each DB can host up to 16 daisy-chained ASICs to read out the detector, depending on the number of channels.



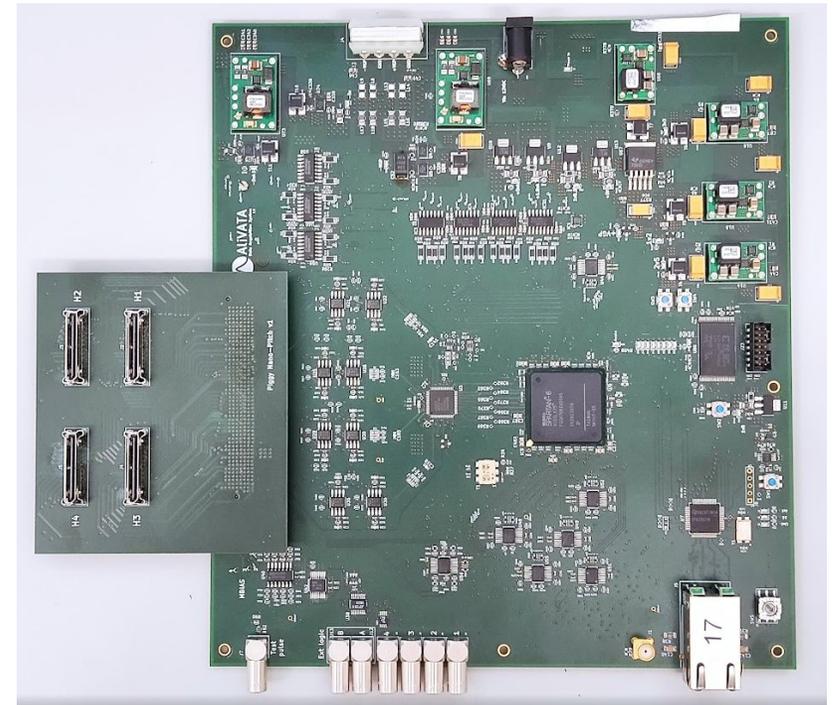
The AliVATA system

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- Each DB can host up to 16 daisy-chained ASICs to read out the detector, depending on the number of channels.
- Several AliVATA DAQ boards can be connected to a computer via Ethernet.



The AliVATA system

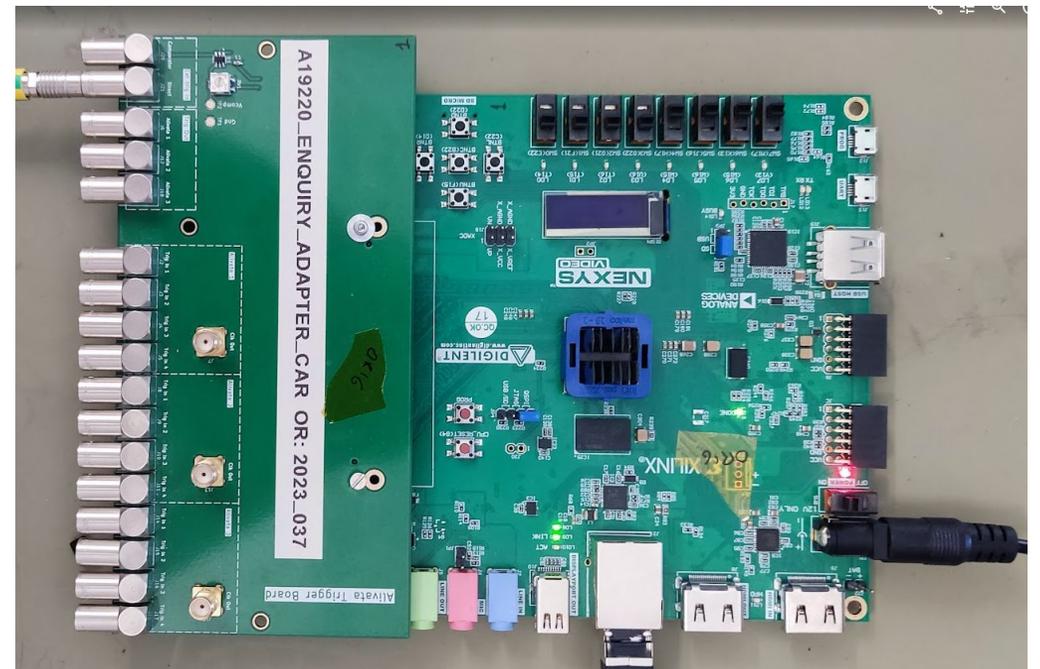
1. The board has a Spartan 6 FPGA that operates through Ethernet (UDP)
 - Receiving configuration and operating commands from the computer and sending formatted data packets to the computer
 - Amplitude of deposited charge per channel per event
 - Address of channel that fired the trigger (when applicable)
 - Time stamp
 - Event counter
 - Temperature
2. Hosts an 8-channel differential ADC
3. Logic level converters
4. DCDC voltage converters
5. High density connector for connection with DBs
6. Trigger output/input ports



New version of the board designed (Daniel Lopez) pending fabrication with modern FPGA.

The trigger board

- Developed by David Hernández (PTA, TileCal).
 - Can handle 3 AliVATA
 - For each AliVATA board:
 - 4 AliVATA trigger output (inputs in the trigger board)
 - 1 External trigger input (output in the trigger board)
 - 1 External clock
 - Has 2 additional trigger inputs with adjustable threshold for triggers coming from different hardware
 - Allows different trigger operations
 - AND
 - OR
 - “Majority” → trig = high if N trigger sources are fired
 - Configurable via Ethernet from computer
 - “N” for majority
 - Masking trigger sources
 - Choosing trigger operation
 - Latest update allows decoding of White Rabbit timestamp



The read out ASICs

The system works with the assumption that the ASICs

1. Produce a multiplexed output (rather than parallel)
2. Chip I/O can be daisy-chained (3/4)

The IDEAS VATA family work like this and have been used in first prototypes

GP7:

128 ch.
500 ns peak time
Range: ± 30 fC

GP8:

128 ch.
500 ns peak time
Range: 1 – 125 fC

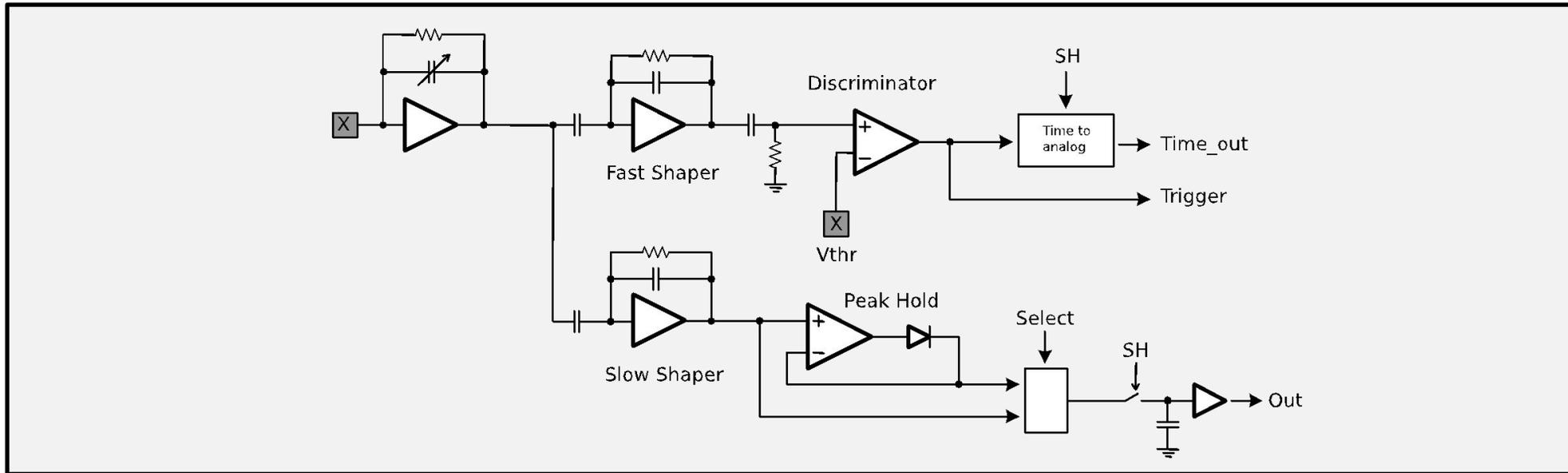
HDR16: (SiPM)

64 ch.
100 ns peak time
Range: ~ 20 pC

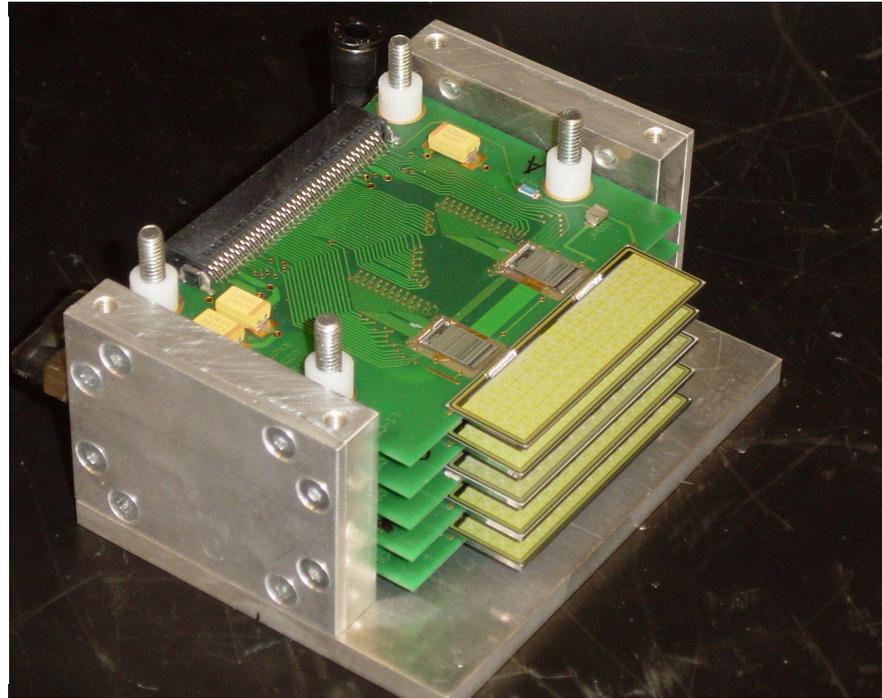
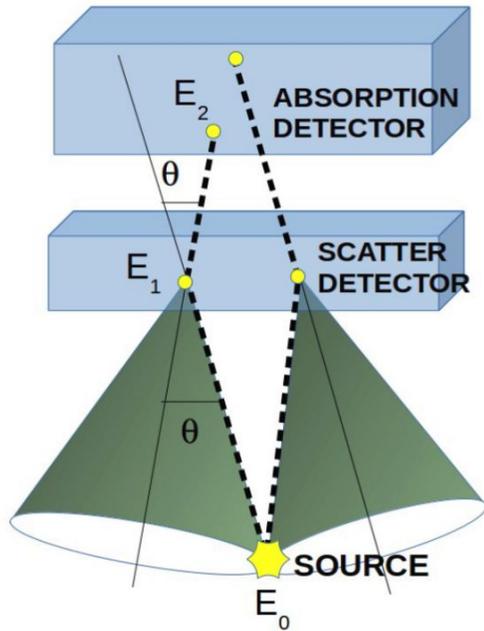
The read out ASICs

The system works with the assumption that the ASICs

1. Produce a multiplexed output (rather than parallel)
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Applications: Compton camera



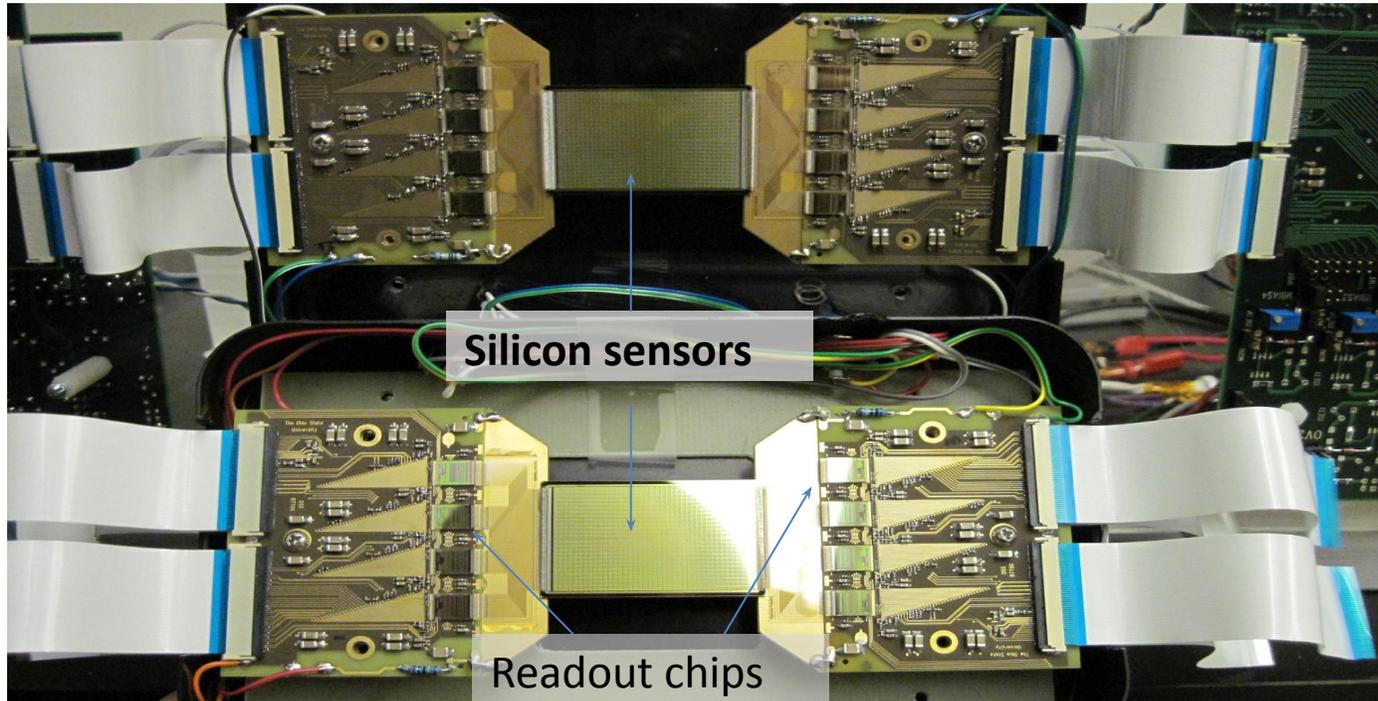
Stack of silicon pad detectors as scatterer for a Compton camera.

- 2 VATA-GP7 ASICs per plane
- 1 Trigger per plane
- 1 data stream per plane.

Need to

1. *timestamp* for event building,
2. Handle multiple data streams.

Applications: PET probe & Small Animal PET



Yet another stack of silicon pad detectors for a PET probe

8 VATA-GP7 ASICS per plane

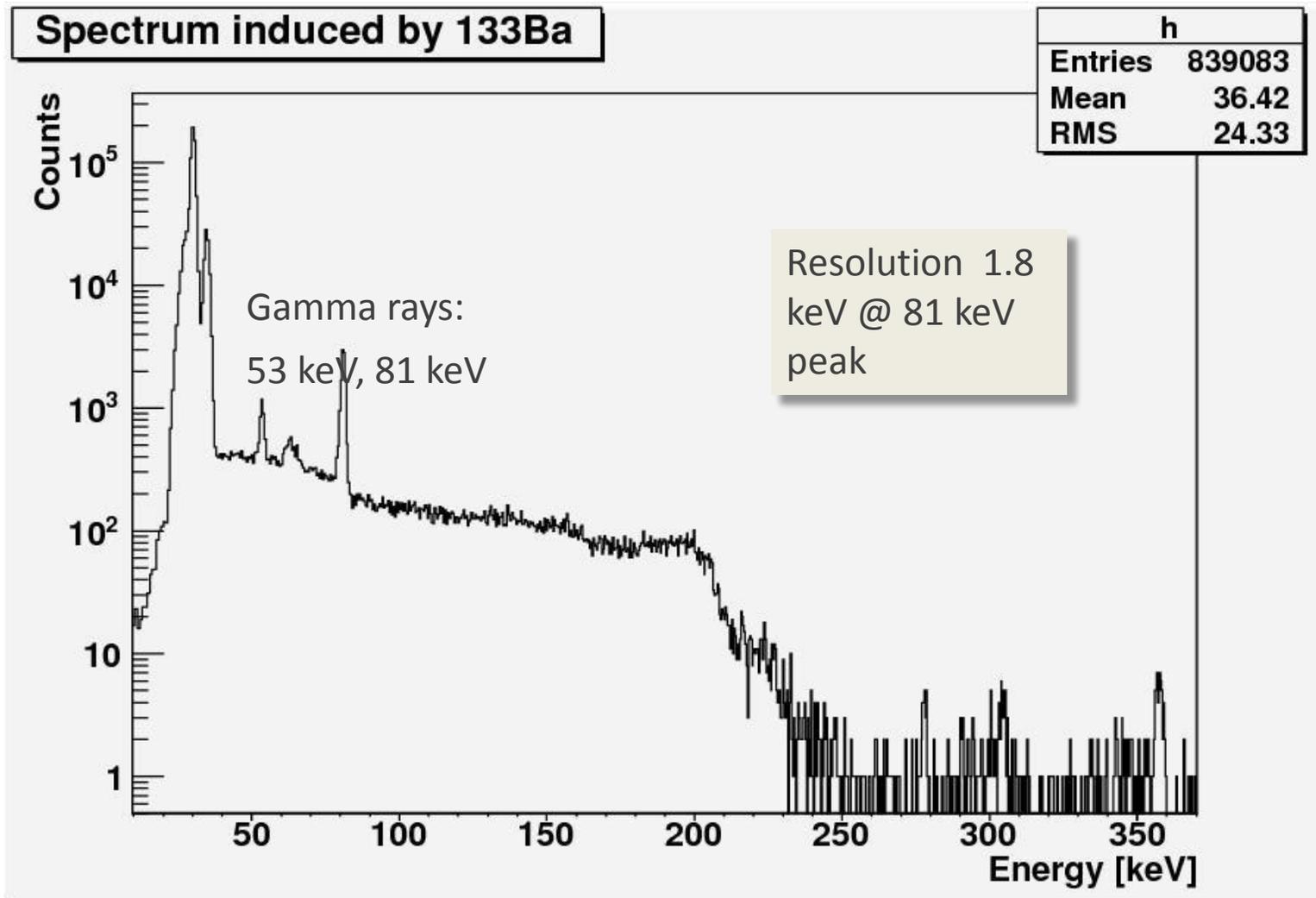
1 Trigger per plane

1 data stream per plane.

Need to

1. *timestamp* for event building,
2. Handle a large number of chips per data stream
3. Handle multiple data streams.

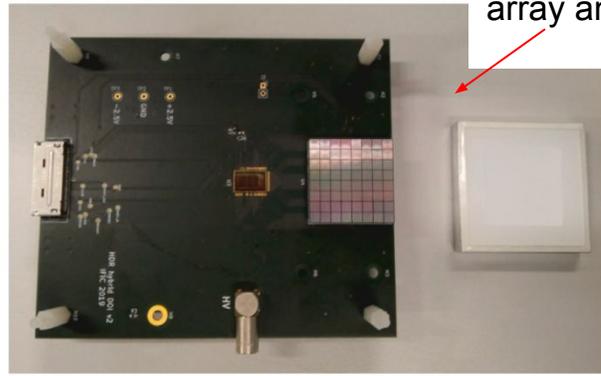
Applications: PET probe & Small Animal PET



Applications: Hadron therapy monitoring (MACACOIII)



Daughter board with a SiPM 8x8 array and a LaBr scintillator crystal



MACACO III

A stack of scintillator crystals+SiPM for a Compton Telescope to monitor hadron therapy.

- 1 VATA-HDR ASIC per plane
- 1 Trigger per plane
- 2 data stream per plane

Need to:

- Timestamping for coincidence building
- Different Sensor, different range

AliVATA

Trigger board



3 planes of SiPM detectors

Applications: Hadron therapy monitoring (MACACO)



Energy spectra
collected with
MACACO III

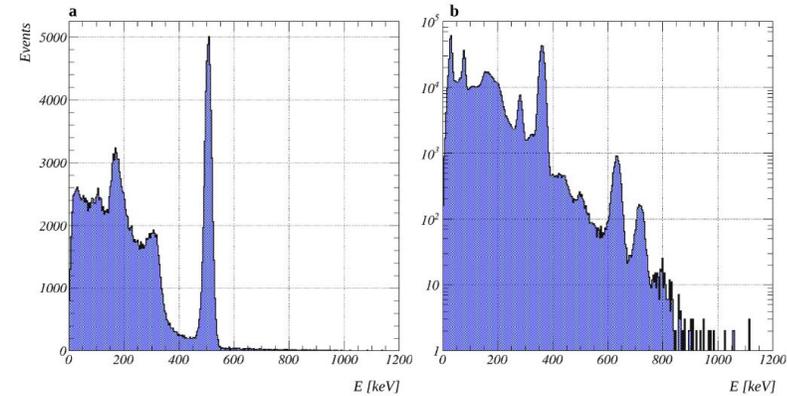


Fig. 3. Singles spectra acquired by the first CC plane with the (a) ^{18}F -FDG filled Derenzo-like phantom; (b) ^{131}I -NaI filled Derenzo-like phantom (logarithmic scale). The energy resolution at 511 keV measured with ^{18}F -FDG was found to be 6.1% FWHM.

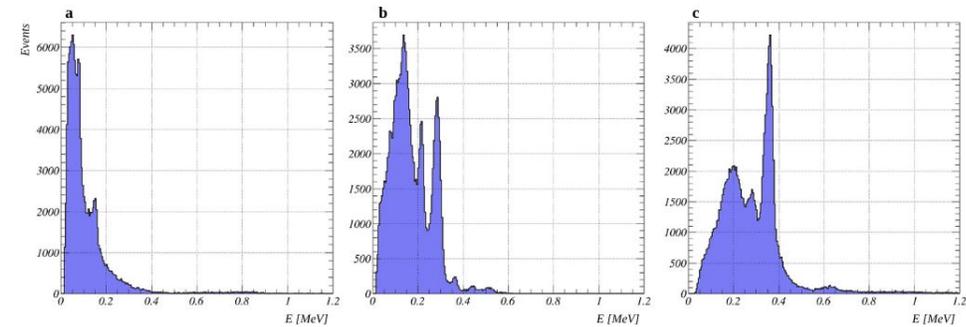
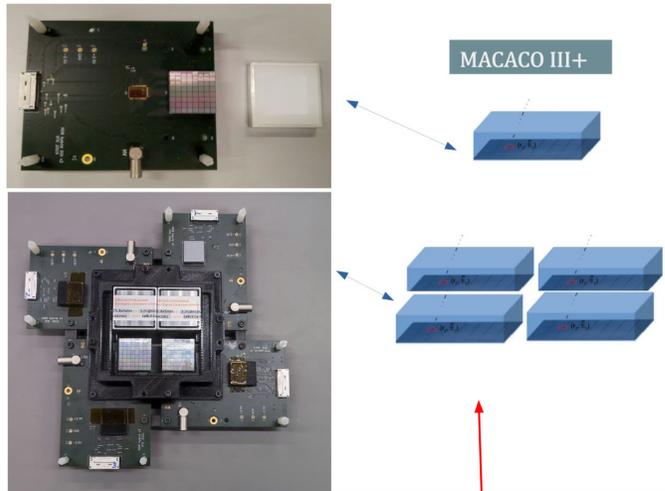
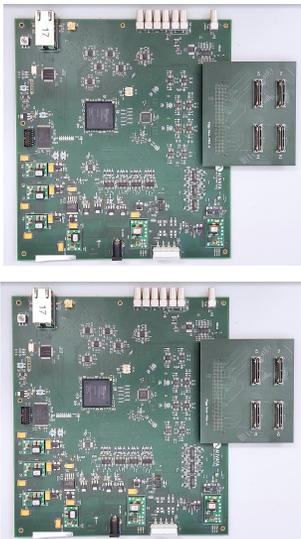


Fig. 6. Coincidence spectra measured in channel 12 of MACACO III with the ^{131}I -NaI filled Derenzo-like phantom (only 6 mm rod sector) in (a) the first detector; (b) the second detector; (c) summing the energies deposited in both detectors (sum spectrum).

Applications: Hadron therapy monitoring (MACACOIII+)



Daughter board with a SiPM 8x8 array and a LaBr scintillator crystal



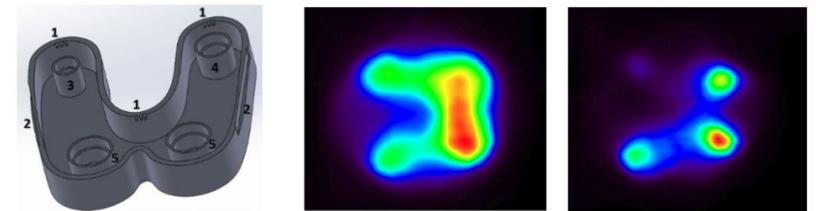
2 planes of SiPM detectors

A stack of scintillator crystals+SiPM for a Compton Telescope to monitor hadron therapy.

- 1 VATA-HDR ASIC per plane
- 4 Triggers in second plane plane
- 2 AliVATA

Need to:

- Timestamping for coincidence building
- External coincidence unit



Images obtained with MACACO III+ Phantoms filled with I-131.

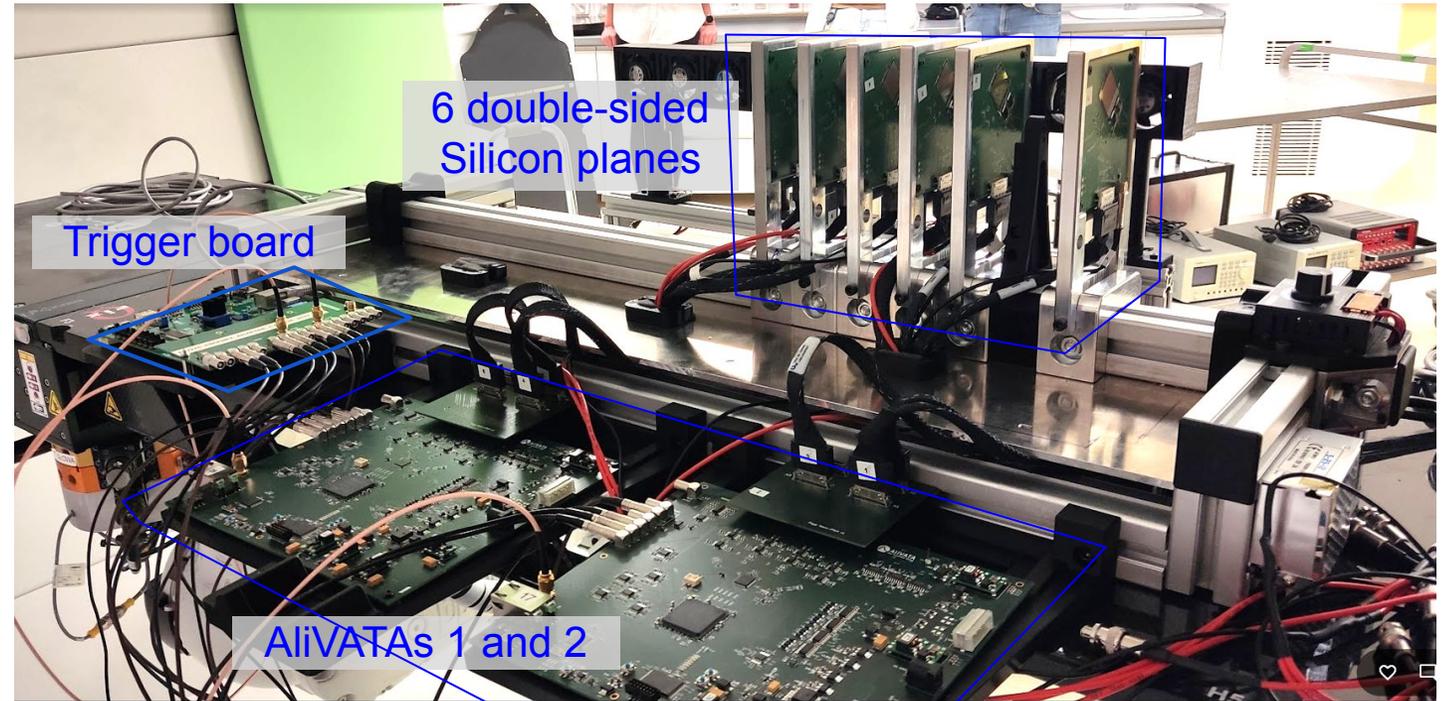
Applications: Hadron therapy monitoring (Proton CeTe)

Telescope for Proton CT

- 6 double-sided daughter boards
 - Each daughter board has 2 sensors back-to-back rotated 90°
- Strips silicon detectors
- 24 VATA-GP8 ASICs

Need to:

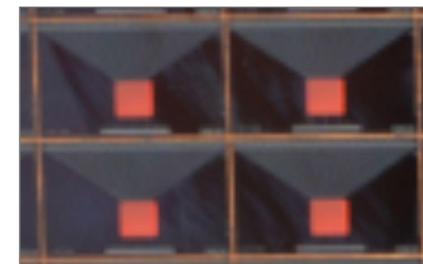
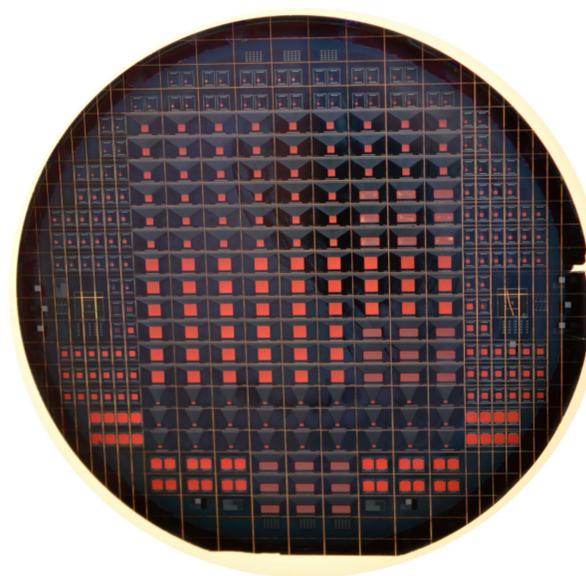
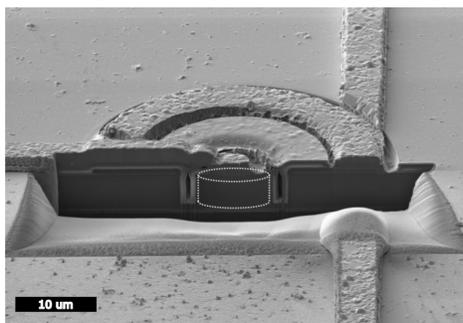
- Use external trigger board for trigger coincidence logic
 - 6 sources of trigger
 - Different trigger logic functions
- Timestamping for coincidence building



Applications: Micro dosimetry



Microdosimetry (cell volume) important to characterize hadron therapy for cancer.
The 3D microdosimeters designed at CNM-IMB are the first and only of their kind.



Array of 121 cells, ~5 μm thick, 200 μm pitch

Applications: Micro-vertex detection



- 4 “stations”
- Stations 1 and 2:
 - 1 pair of silicon strip sensors each
 - 256 strips of 80um width each
- Stations 3 and 4:
 - 2x2 sensors each
 - 128 strips of 160um width combined in pairs each.
- Use 16 VATA-GP8 ASICs and 2 AliVATA boards

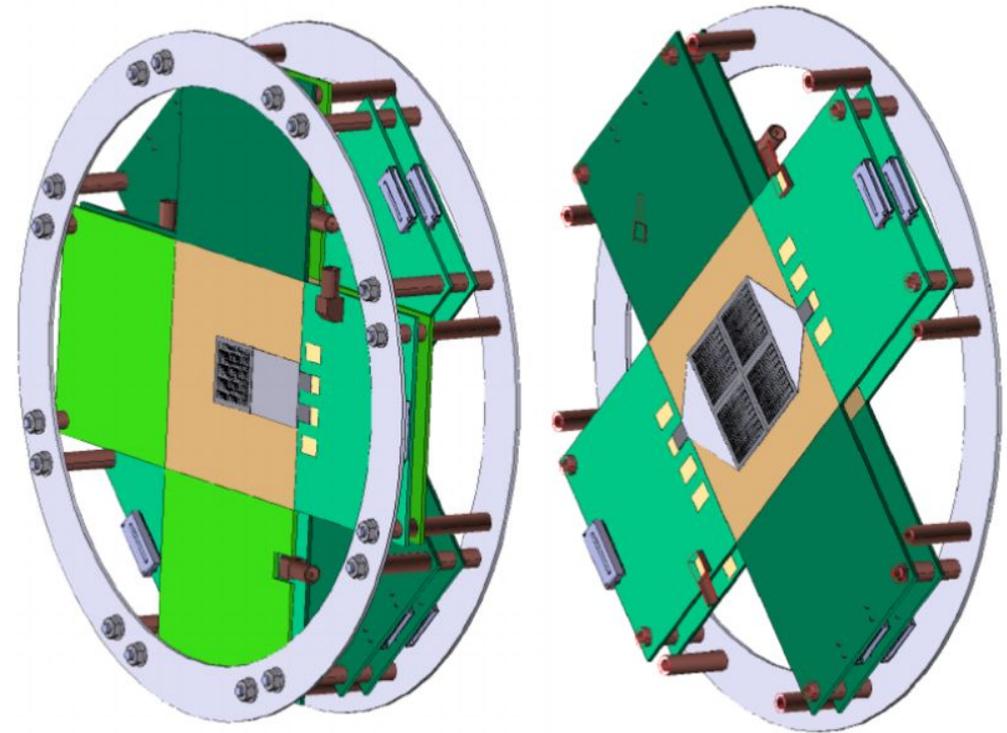


Figure 1: On the left, the layout of the micro-vertex detection system is shown in the tracking configuration, where the Station 1 is visible in the front. On the right, the setup when the Station 1 and 2 are removed so that Station 3 is visible. As an scale reference, the side length of the micro-strip silicon sensor is 2.06 cm.

- ✓ A readout system for spectroscopy
 - Several detector types (Silicon strips, pads or pixels, SiPM, etc.)
 - Self-trigger
 - External trigger input available
 - Time stamping
 - Really scalable (with the IDEAS GP7/GP8 chip, up to 8192 channels per motherboard)

Thank you for your attention