EDIT 2015

INTERNATIONAL SCHOOL

FRASCATI - OCT.20-29

Laboratory course:
Day 4

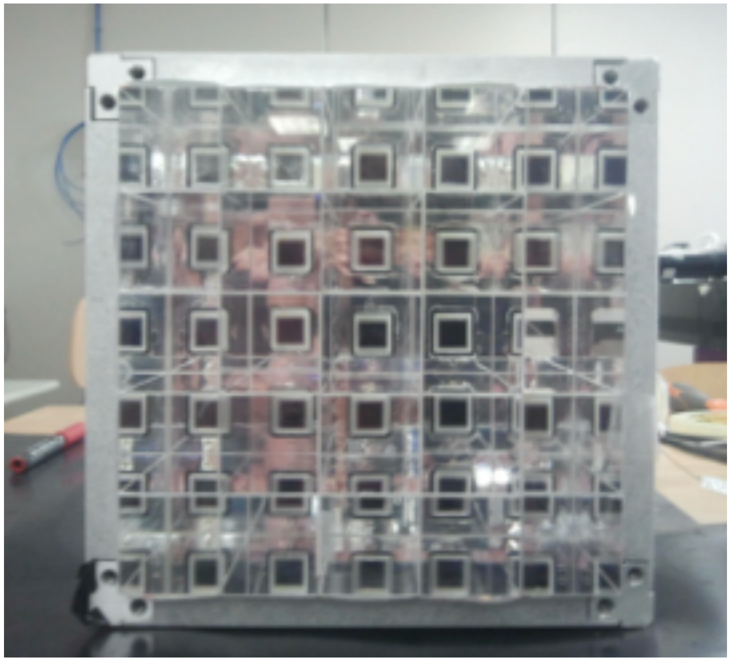
Electron Test Beam with the Mu2e LYSO+APD matrix prototype

Test Beam @ LNF: Layout of the prototype

- For this exercise we use the matrix prototype built for the Mu2 experiment

A MATRIX of 25 LYSO crystals

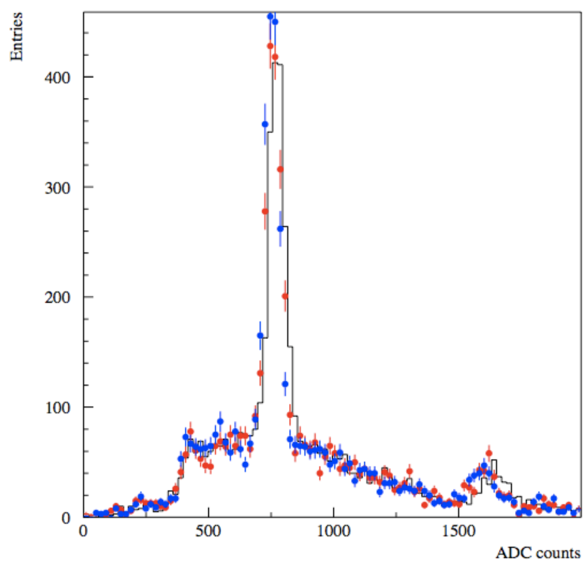
- LYSO from (Shanghai) SICCAS High Technology Corporation 30x30x130 mm^3
- Each crystal readout by one single 10x10 mm^2 **APDs** Hamamatsu S8664-1010
- Gapd = 50
- Each APD amplified by an AMP-HV chip: Gamp = 300
- Readout with 25 channels of 250 msps WFD from CAEN

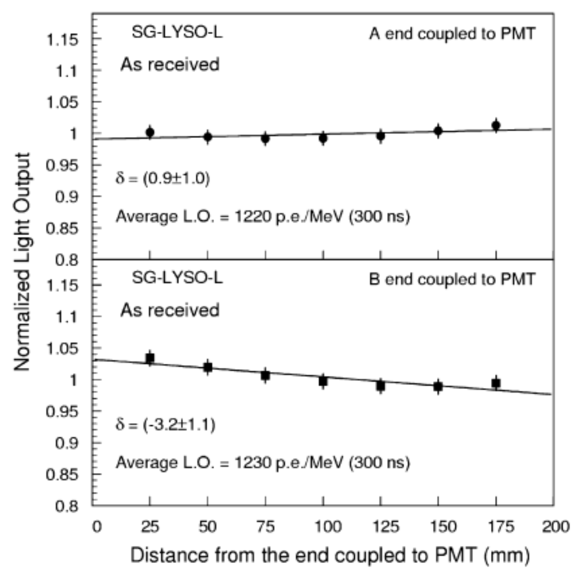


Crystals used: LYSO

- ❑ LYSO (Ce) =lutetium-yttrium oxyorthosilicate + Cerium doping
  - Density = 7.3 g/cm^3 , Radiation length = 1.14 cm, Moliere Radius = 2.1 cm
  - dE/dX = 10 MeV/cm, Refractive index = 1.8, Peak luminescence = 420 nm
  - Decay time = 40 ns, Light yield = 85 % of NaI, Hygroscopicity = None

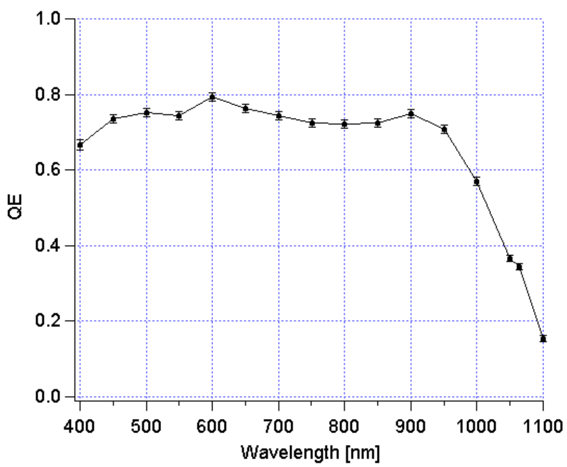
- ❑ All crystals produced by SICCAS in China
- ❑ All crystals characterized for LY with our test station and similar station in Caltech(USA)
- ❑ All crystals controlled for peak luminescence and longitudinal transmittance
- ❑ Good longitudinal uniformity measured on the 25 crystals used

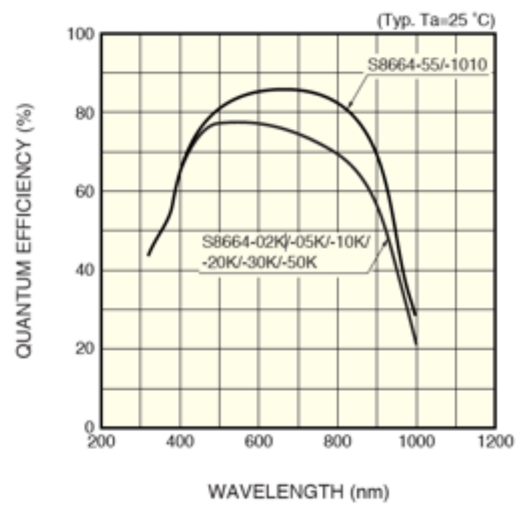




APD used : Hamamatsu S8664-55

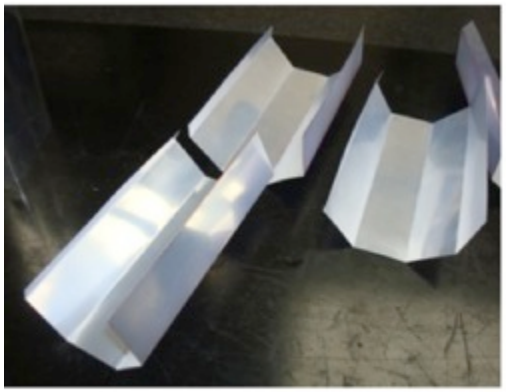
Properties	S8664-55	S8664-1010	S1315 (RMD)
Active area (mm^2)	5×5	10×10	13×13
QE (~ 405 nm)	0.65	0.65	0.65
I_d (nA)	5	10	Not measured
Capacitance Cd (pF)	80	270	120
Gain	50 @ 350 V	50 @ 350 V	100 @ 1700 V
Excess noise F	2.0 @ gain =50	1.38 @ gain =50	Not measured



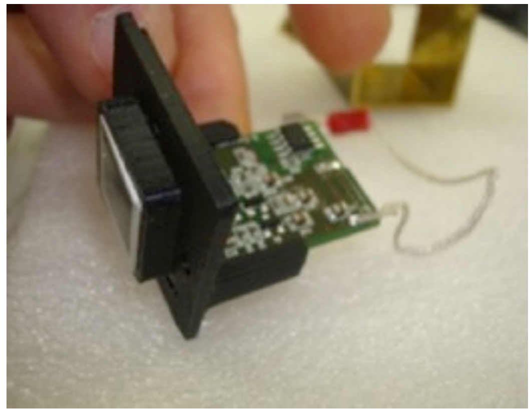


Matrix assembly: details of the matrix

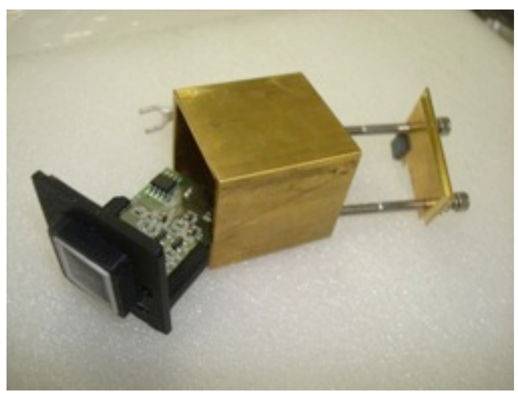
3M ESR 60 µm reflective wrapping → 20% more light output than Tyvek

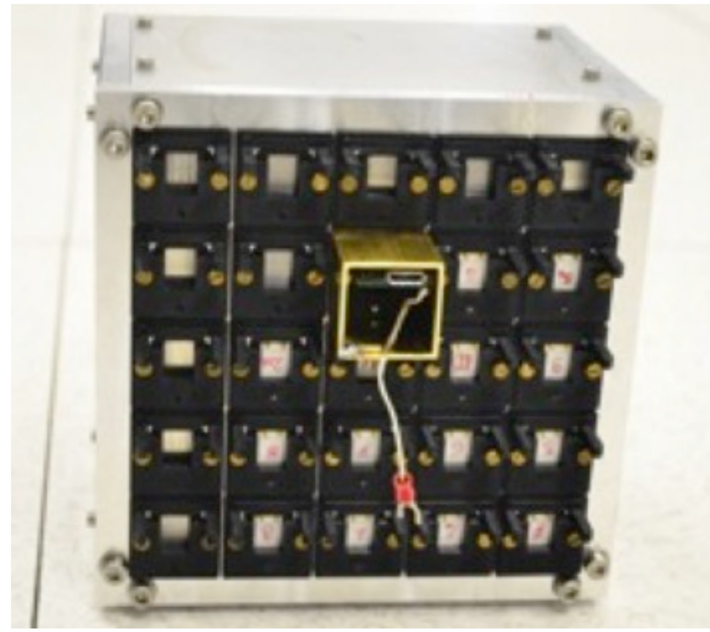


APD lodgments created with PVC 3D-printing



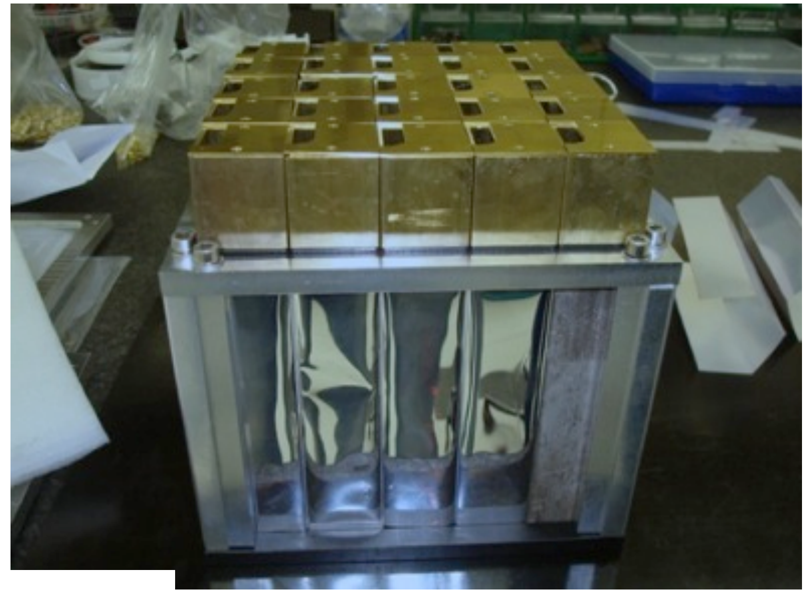
Faraday cup





Matrix assembly: FEE and cabling

- The project and the development of the FEE have been done at LNF by the SEA electronic department
- The Amp-HV is a multi-layer double-sided discrete component board that carries out the two tasks of amplifying the signal and providing a locally regulated bias voltage, thus significantly reducing the noise loop-area.

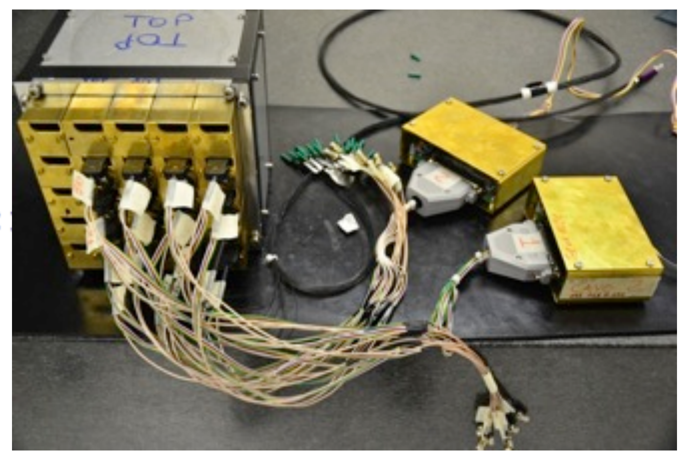


Amp.

Dynamic	2.5V
Bandwidth	70Mhz
Rise time	6ns
Polarity	Reversed
Output impedance	50 Ω
Stability with source capacity max	300pf
Coupling output end source	AC
Noise, with source capacity 1pf	1000 enc
Power dissipation	14mW
Power supply	6V
Input Protector over-Voltage	10mJ

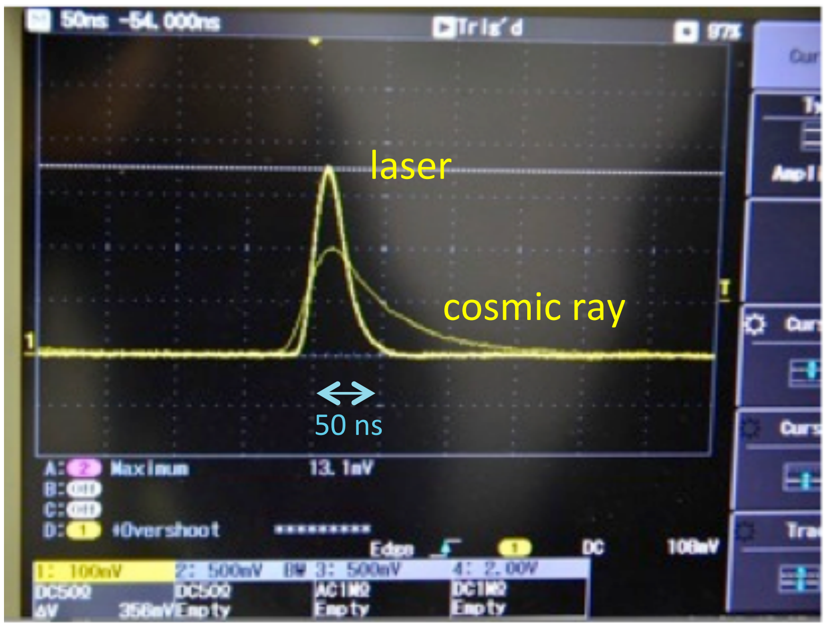
HV

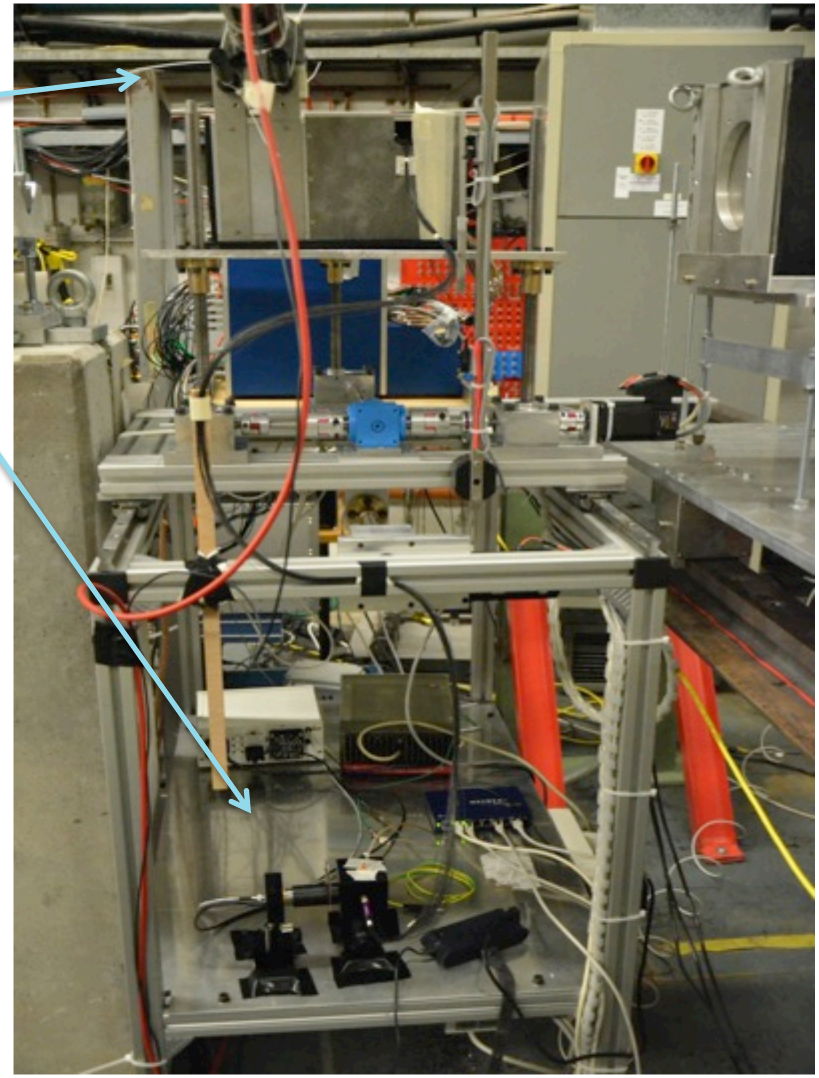
Adjustment range Vout	250V to 500V
Accuracy, reading and writing, Vout	16 bit
Current limiter can be adjusted	tpv. 300uA
Noise tot.	2mVpp
Long-term stability	100ppm
Settling Time	<500 us $\rho <$
Typical power dissipation	135mW
Double filter high Voltage, attenuation	56db



Cosmic Rays and Laser System used at MAMI

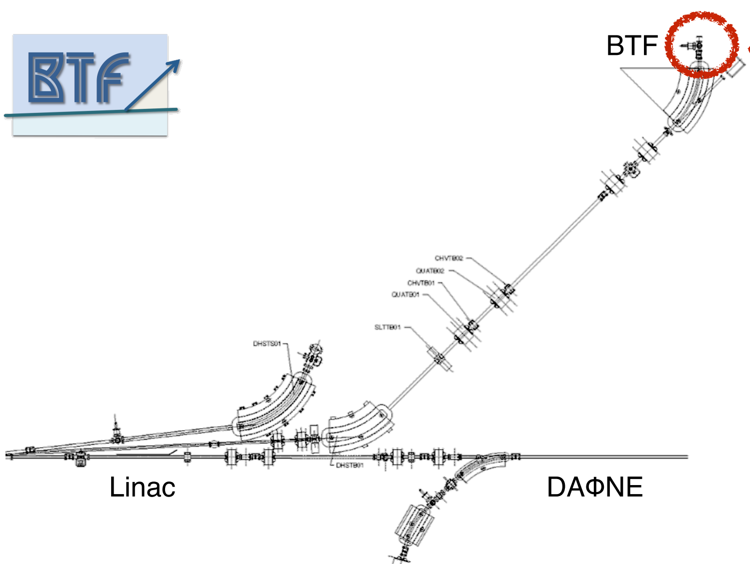
- One scintillator with double PM readout for the cosmic rays acquisition
- 1 green laser + diffusive sphere + 25 quartz fibers to monitor the APD+FEE stability

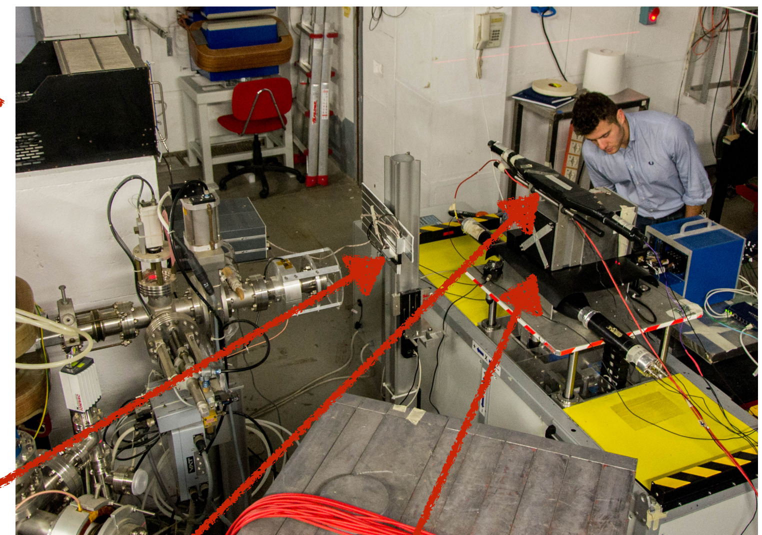




Layout used @ BTF (2014 w.r.t. EDIT)

- DAΦNE Linac accelerates, in a controlled hall, electron bunches 200 ps-long with a selectable energy.
- The beam trigger is given by two scintillating scintillation counters placed in front of the matrix.
- The intrinsic energy resolution of the beam is ~8% a 100 MeV.
- Same acquisition and read-out system used at MAMI.
- Cosmic ray trigger given by two scintillating palettes coupled to phototubes placed above and below the matrix.

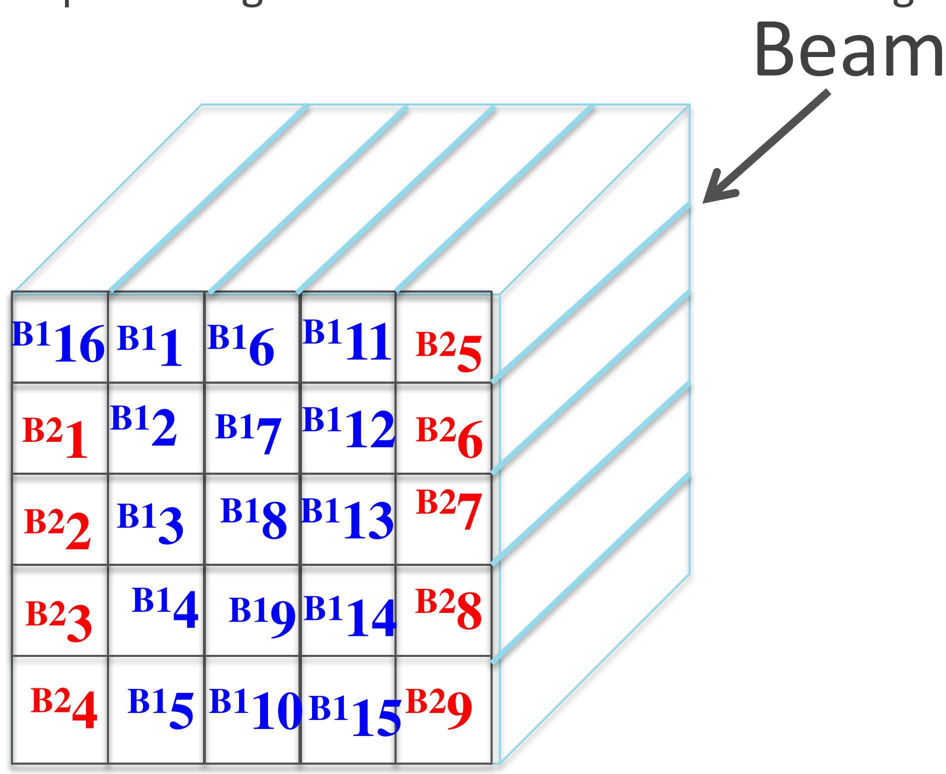




Differences: Giani is not in the layout. Finger scintillators are much closer to the matrix. We do not use the palette for CR

Layout of cabling

- FEE signal cables go from the calorimeter to the rear side of the "blue" box where two NIM-like boards (B1, B2) are located.
- In each board there is an arm-controller to read/set the HV of each individual calorimeter channel. This is done with a DELL PC in ethernet connection.
- From the boards the signals are repeated on coaxial cables that are then inserted in a FAN-IN/FAN-OUT unit to split the signal to the WFD and to the Analog Sum Unit.



Layout of WFD cabling

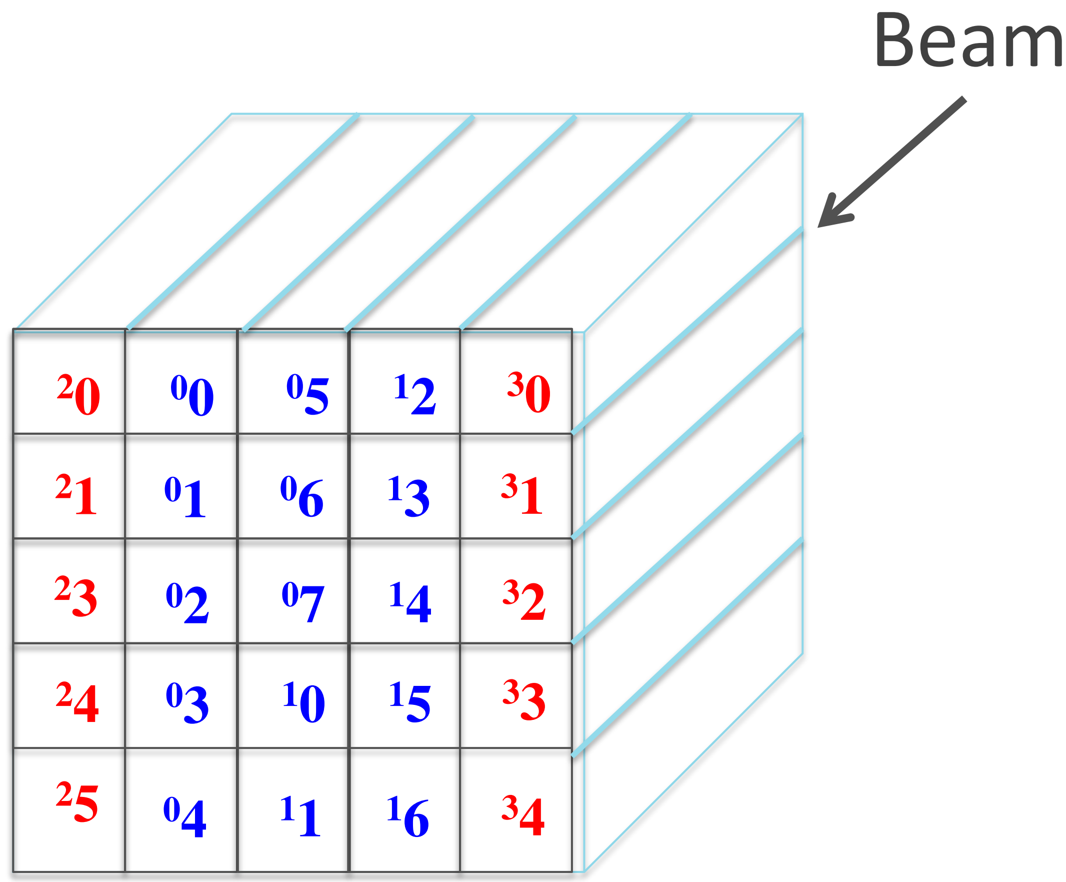
Digitizer boards Matrix:

0 → 8 chs

1 → 7 chs

2 → 5 chs

3 → 5 chs



$^{1}7$ → Sum 9

$^{2}6$ → RPC

$^{2}7$ → RPC

$^{3}5$ → Pin Diode

$^{3}6$ → Finger 1

$^{3}7$ → Finger 2

Hands on on the detector + fast analysis (1)

- **You will use a very simple trigger that works with the OR of two conditions:**

  → a double coincidence between the two plastic "finger" scintillators just in front of the calorimeter surface to delimit the beam spot and provide a good timing start.

  → The analog sum of the 9 innermost crystals
- The e- beam and the cosmic rays will generate signals inside the matrix.
- The e- beam will be provided at the desired energy around 100 MeV but with a multiplicity (typically > 1) that can be tuned by slit adjustement.
- A self-oscillating time unit will also drive at low rate the green laser in order to illuminate all cells and check stability of response along time.

For debugging purposes you can :

(1) Look to the calorimeter signals using the attenuated (1/2) signals from the Fan-In Fan-Out units at the scope.

(2) Display the waves from the root trees coming from the readout from the WFD

This is a good training in checking the hardware functionality

Data taking

- Once the beam is arriving to the calorimeter you can start the daq with the following instruction:

>> tcsh

>> source ~/setup_edit.csh

>> godaq

>> $DAQ_EDIT

To stop data taking .. qq (quit)

- The data files are in ascii format by dumping 1024 samples for all 32 channels and a very simple header to recognize the event number
- Root trees are generated with the following instruction

>> goroot; source doroot_edit.csh runXXXXX Nevent

>> root roottople/runXXXX.root (open the short size file)

>> root roottople/runXXXXfull.root (open the long size file with the waveforms)

- Charge is reconstructed in a fixed time window
- Time is reconstructed by fitting the line shape of the signal in the rise-time

Hand on on the detector + fast analysis (2)

- Starting from the digitized samples (baseline corrected) in mV vs ns units you can:
  - → Determine the charge from each channel
  - → Estimate the noise of each channel (in keV units)
  - → Sum up the calorimeter channels to get Etotal
  - → Estimate energy resolution (sigma/peak) and energy scale (pC/MeV)
  - → Estimate the Number of photoelectron/MeV
  - → Determine the timing and estimate the timing resolution (in ps)

- The HV setting used provide a reasonable equalized starting point for all channels
- We have provided to you trees and examples with reconstructed values but also trees with the full Waveform saved.
  - → You can copy a short root file in your notebook and play with that.
  - → If you like, you can improve the provided reconstruction by:
    - a) calculating the charge in a fixed window but around the sample with maximum height
    - b) provide a different fit to the waveform to estimate the timing
    - c) Enjoy it.